Formulas of electrotechnic and electronic

Cross-section for **single wire round**

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

Cross-section for **bunched wire**

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

Diameter for
single wires cross-section

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

Diameter for **bunched wires**

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

q = cross-section (mm^2)
D = conductor diameter (mm)
d = single wire diameter (mm)
n = number of wires

Conductor Resistance

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

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

R = Electrical direct-current resistant (Ohm)
R_{Loop} = Resistance of a complete circuit
q = cross-section (mm^2 or q mm)
κ (Kappa) = Conductivity
ρ (Rho) = Specific resistance ($\rho = \frac{1}{\kappa}$)
l = Conductor length (m)

Materials	Conductivity $\frac{m}{\Omega \cdot mm^2}$	Spec. resistance $\frac{\Omega \cdot mm^2}{m}$
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: $R = R_1 + R_2 + R_3 + \ldots + R_n$

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

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

Parallel connection

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

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

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

Equivalent resistance of 2 parallel connected resistance

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

Mutual capacity (C)

- coaxial cable $C = \frac{\xi r \cdot 10^3}{18 \cdot \ln \frac{Da}{d}}$ (nF/km)
- parallel core $C = \frac{\xi r \cdot 10^3}{36 \cdot \ln \frac{Da}{d}}$ (nF/km)
- shielded twisted pair

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

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

I = current intensity (Amps – A)
R = electrical resistance (Ω)
U = electrical voltage (V)

Conductance

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

S (Siemens) = reziprocal value of a resistance is used as **conductance**
1 Siemens = 1/Ohm
G = electrical conductance

Capacitance

- Single core against earth

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

- Unshielded symmetrical twisted pair

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

- Coaxial pair

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

- Shielded symmetrical twistet pair

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

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

at high frequencies

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

Inductance of coaxial cable

at high frequencies

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

Da = distance between two conductors – mid to mid of both conductors
r = radius of a conductor
ξr = dielectric constant

Impedance (Z)

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

D = diameter over insulation
d = conductor diameter

for communication cable

at low frequencies $Z = \sqrt{\frac{R}{\omega C}}$ (Ω) · $\tan \varphi = 1$, $\varphi = 45°$

at high frequencies $Z = \sqrt{\frac{L}{C}}$ (Ω)

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 dB = 0,1151 Np = $\frac{1}{10}$ Bel
1 Bel = 10 dB = 1,1513 Np