

FORMULAS

INDUCTANCE :

$$L = 0.05 + 0.2 L_n \left(\frac{k \cdot s}{r} \right) \text{ [mH/km]}$$

Where : In trefoil formation: $k=1$
In flat formation: $k=1.26$
 s = distance between conductor axes (mm)
 r = conductor screen radius (mm)

INDUCTIVE REACTANCE :

$$X = 2\pi f \frac{L}{1000} \text{ [\Omega/km]}$$

Where : f = frequency (Hz)
 L = inductance (mH/km)

CAPACITANCE :

$$C = \frac{\epsilon}{18 L_n \left(\frac{d_o}{d_i} \right)} \text{ [\mu F/km]}$$

Where : ϵ = relative permittivity of the insulation (for XLPE insulation $\epsilon = 2.3$)
 d_o = external diameter of the insulation (mm)
 d_i = diameter of conductor including conductor screen (mm)

IMPEDANCE :

$$Z = \sqrt{R_{ac}^2 + X^2} \text{ [\Omega/km]}$$

Where : R_{ac} = AC resistance of conductor (Ω /km)
 X = reactance (Ω /km)

ELECTRICAL FIELD :

$$\text{Conductor screen : } E_i = \frac{U}{r_i \ln\left(\frac{r_o}{r_i}\right)} \quad [\text{kV/mm}]$$

$$\text{Insulation screen : } E_o = \frac{U}{r_o \ln\left(\frac{r_o}{r_i}\right)} \quad [\text{kV/mm}]$$

Where : r_i = radius of conductor screen (mm)

r_o = radius of XLPE insulation (mm)

U = voltage across insulation

SHORT CIRCUIT CURRENT :

$$\text{Copper conductor : } I_s = 226 \frac{S}{\sqrt{t}} \sqrt{\ln \frac{t_f + 234.5}{t_i + 234.5}} \quad [\text{A}]$$

$$\text{Aluminum conductor : } I_s = 148 \frac{S}{\sqrt{t}} \sqrt{\ln \frac{t_f + 228}{t_i + 228}} \quad [\text{A}]$$

Where : S = cross section (mm²)

t = short circuit duration (sec)

t_i = initial temperature before the short circuit (90°C for XLPE cables)

t_f = final temperature after the short circuit (250°C for XLPE cables)

CHARGING CURRENT :

$$I_c = U_0 \omega C = U_0 2\pi f C 10^{-3} \quad [\text{A/km}]$$

Where : U_0 = voltage (kV)

$\omega = 2\pi f$

f = frequency (Hz)

C = capacitance (μF/km)

DIELECTRIC LOSSES :

$$W_d = \frac{U^2}{3} 2\pi f C \cdot \tan(\delta) \text{ [W/km]}$$

Where : U = rated voltage (kV)
f = frequency (Hz)
C = capacitance ($\mu\text{F}/\text{km}$)
 $\tan(\delta)$ = loss angle

TEMPERATURE CORRECTION FACTORS FOR CONDUCTOR RESISTANCE :

FOR COPPER CONDUCTORS :

$$k_t = \frac{254.5}{234.5 + t} \quad R_t = \frac{R_{20}}{k_t} \times \frac{L}{1000}$$

FOR ALUMINUM CONDUCTORS :

$$k_t = \frac{248}{228 + t} \quad R_t = \frac{R_{20}}{k_t} \times \frac{L}{1000}$$

Where :

k_t is the temperature correction factor ;
 R_{20} is the conductor resistance at 20°C, in Ω/km ;
 R_t is the conductor resistance at t°C, in Ω/km ;
L is the length of cable, in m .