Capacity of Transmission Lines

1 Power-handling capacity calculation of AC transmission lines

The power-handling capacity represents how much power the transmission line can handle without causing damage to transmission line. When line resistance is neglected, the power that can be transmitted depends upon (a) the magnitudes of voltages at the ends (E_s, E_r), (b) their phase difference δ, and (c) the total positive- sequence reactance X per phase, when the shunt capacitive admittance is neglected. Thus,

$$P = E_s E_r sin\delta/(L.x)$$

where P is power in MW, 3-phase, E_s, E_r = voltages at the sending-end and receiving end, respectively, in kV line-line, δ = phase difference between E_s and E_r, x = positive-sequence reactance per phase, ohm/km, and L = line length, km [1].

From consideration of stability, δ is limited to about 30°, and for a preliminary estimate of P,we will take$E_s = E_r = E$. For example, the power is transmitted over a distance of 1000 km at voltage levels of 400 kV. Given the positive-sequence reactance per phase is 0.327 ohm/km. The power capacity of transmission line is:

$$P = \frac{400^2 \times sin(30°)}{1000 \times 0.327} = 245 \quad \text{MW}$$

2 Positive-sequence reactance

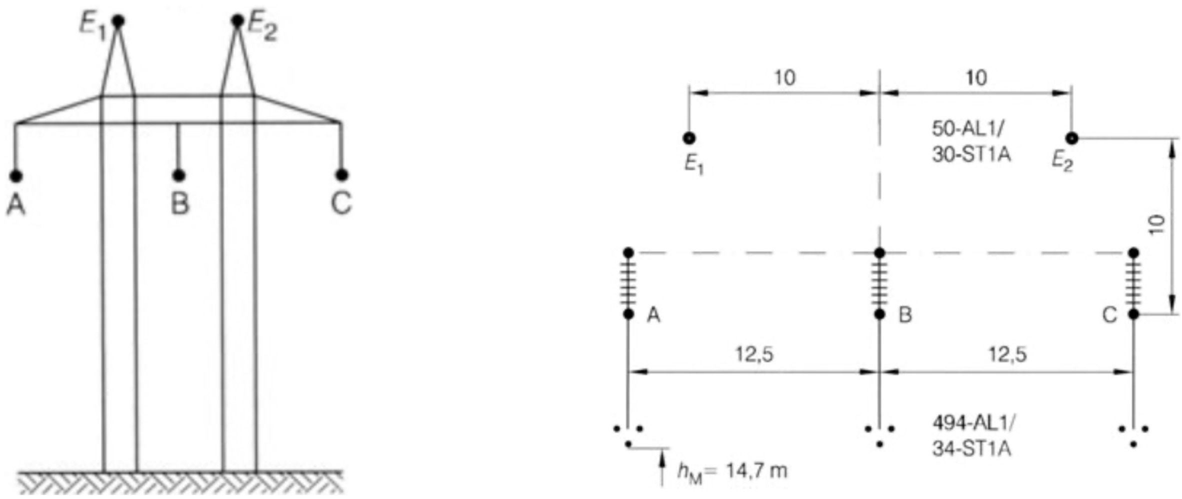
The positive-sequence inductive reactance of one kilometer of line and $f = 50$ Hz and single conductor it applies for the reactance per unit length is given by [2]:

$$x = 0.0628(ln\frac{D_M}{r} + \frac{1}{4}) \quad \text{ohm/km}$$

where D_M is geometric mean distance, r is subconductor radius. The commonly used conductor diameter is 29.9 mm. The radius is 0.01495 m. For a single-circuit line, the geometric mean distance is:

$$D_M = (D_{AB} \times D_{AC} \times D_{BC})^{\frac{1}{3}}$$

The phase conductor arrangement for single circuit lines is:



(a) Arrangement

(b) Tower top dimensions

Figure 1: Phase conductor arrangement for single- circuit lines

Geometric mean distance according to Fig 1 is:

$$D_M = (12.5 \times 25 \times 12.5)^{\frac{1}{3}} = 15.75 \quad \text{m}$$

3 Capacity of AC transmission lines at 161 kV

The positive-sequence inductive reactance is calculated by:

$$x = 0.0628(ln\frac{15.75}{0.01495} + \frac{1}{4}) = 0.453 \quad \text{ohm/km}$$

The power capacity of transmission line at 161 kV is:

$$P = \frac{161^2 \times sin(30°)}{L \times 0.453} \quad \text{MW}$$

where L = line length, km.

References

[1] Rakosh Das Begamudre. *Extra high voltage AC transmission engineering*. New Age International, 2006.

[2] Friedrich Kiessling, Peter Nefzger, Joao Felix Nolasco, and Ulf Kaintzyk. *Overhead power lines: planning, design, construction*. Springer, 2014.