Since the length is less than 80 km, it is a short line. So short line model will be used to solve the question

This is the receiving end power factor i.e. cos(theta_R). Note that it is lagging so "theta_R" will be negative

Transmission Line Models Tutorial Questions

1. A 60 km three-phase overhead line that draws power from Edmonton Load Centre is used to transmit 1800 MW to a load in Fort McMurray whose power factor is 0.8 lagging. If the voltage at Fort McMurray end is 400 kV at full load and the phase parameters of the line are given as r = 0.0191 Ω/km at 50°C; x_L = 0.25 Ω/km, calculate:

This is V_R(line to line). You need to convert this line to line voltage to phase voltage to be able to use the short line equations. Also, this voltage is the receiving end voltage at full-load.
Also note that voltages given for three phase lines are line to line otherwise stated. The active power given is three phase power.

P_R=the receiving end active power. Note that it is a three phase power

   (a) The magnitude of the required sending-end voltage.
   (b) Voltage regulation of the line.

Answer

1. **Given:**

$$x_L = 0.25\frac{\Omega}{\text{km}};\ \ r = 0.0191\frac{\Omega}{\text{km}};\ \ |V_{R(L-L)}| = 400\text{ kV};\ \ P_R = 1800\text{ MW};\ \ \cos\theta_R = 0.8\text{ lag};$$

$$l = 60\text{ km}$$

Required: $[X_L, R, Z, V_R, |I_R|, |V_{S(L-L)}|,\ \text{Voltage regulation}]$

$$X_L = x_L * l = 0.25 * 60 = 15\ \Omega$$

$$R = r * l = 0.0191 * 60 = 1.146\ \Omega$$

$$Z = R + j\,X_L = 1.146 + j15 = 15.04\langle 85.63^o\ \Omega$$

$$V_R = \frac{|V_{R(L-L)}|}{\sqrt{3}}\langle 0^o = 231\langle 0^o\text{ kV}$$; The receiving end taken as the reference.

$$|I_R| = P_R/(\sqrt{3} * |V_{R(L-L)}| * \cos\theta_R) = \frac{1800\times 10^6}{\sqrt{3}*400\times 10^3*0.8} = 3247.6\text{ A}$$

$$I_R = |I_R|\langle -\cos^{-1} 0.8 = 3247.6\langle -36.87^o\text{ A}\ ;$$

Note: We have used negative sign because the power factor is lagging. If it is leading power factor, we use a positive angle. If it is unity power factor, the angle is zero.

Since the line length is less than 80 km, the short line model is appropriate for calculating the sending end voltage. Thus,

$$V_S = V_R + I_R Z = 231000\langle 0^o + (3247.6\langle -36.87^o) * 15.04\langle 85.63^o$$

$$V_S = 231000 + j0 + 32198.6 + j36728.41 = 263198.6 + j36728.41$$

$$V_S = 265.75\langle 7.94^o\text{ kV}$$

$$|V_{S(L-L)}| = \sqrt{3} * |V_S| = \mathbf{460.3\ kV}$$

$$\% \mathbf{V.R} = \frac{|V_S| - |V_R|}{|V_R|} \times 100$$

$$= \frac{265.75 - 231}{231} \times 100 = \mathbf{15.04}\,\%$$