EE 491

HW #2

6.2 Linnet conductor with wire temperature of $50^\circ C$

$$D_{eq} = \sqrt[3]{11.9\times 11.9\times 11.9\times 2} = 14.99\ ft$$

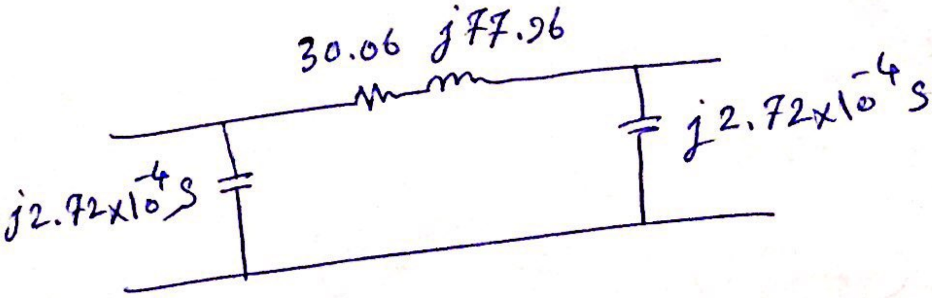
$$R = 0.3006\ \Omega/\text{mile} \times 100\ \text{mile} = 30.06\ \Omega$$

$$jx = j(0.491 + 0.3286)\times 100 = j77.96\ \Omega$$

$$\bar{Y} = j100\times\left(\frac{10^{-6}}{0.1040 + 0.0803}\right) = j5.43\times10^{-4}\ S$$

$$\bar{Z} = R + jX = 30.06 + j77.96 = 83.56\angle 68.91^\circ\ \Omega$$

a)



b) $\bar{A} = \bar{D} = 1 + \frac{\bar{Y}\bar{Z}}{2} = 0.9789\angle 0.48^\circ$

$\bar{B} = \bar{Z} = 83.56\angle 68.91^\circ\ \Omega$

$\bar{C} = \bar{Y}\left(1 + \frac{\bar{Y}\bar{Z}}{4}\right) = 5.37\times10^{-4}\angle 90.24^\circ$

2/

c) $\bar{I}_R = \dfrac{S}{\sqrt{3}\, V_{LL}} \angle -\cos^{-1}(0.8) = 240.6 \angle -36.87^\circ$

$$\bar{V}_{R,LN} = \frac{132\times10^3}{\sqrt{3}} = 76.21\times10^3 \angle 0 \ V$$

$$\bar{V}_S = \bar{A}\bar{V}_R + \bar{B}\bar{I}_R$$

$$\bar{V}_{S,LN} = 92.33 \angle 7.02^\circ \ kV$$

$$|\bar{V}_{S,LL}| = \sqrt{3}|V_{S,LN}| = 159.92 \ kV$$

$$\bar{I}_S = \bar{C}\bar{V}_{R,LN} + \bar{D}\bar{I}_R = 213.69 \angle -27.95^\circ \ A$$

$$\bar{S}_{3\phi} = 3\bar{V}_{S,LN} \times \bar{I}_S^* = 48.73 + j\,33.58 \ MVA$$

$\Rightarrow$ $P = 48.73$ MW

$Q = 33.58$ MVAr

$$p.f. = \cos\left(\tan^{-1}\left(\frac{Q}{P}\right)\right) = 0.82 \text{ lagging}$$

d) $$VR\% = \frac{V_S/A - V_{R,fl}}{V_{R,fl}} = \frac{92.33/0.9789 - 76.21}{76.21}$$

$$VR\% = 23.76\%$$

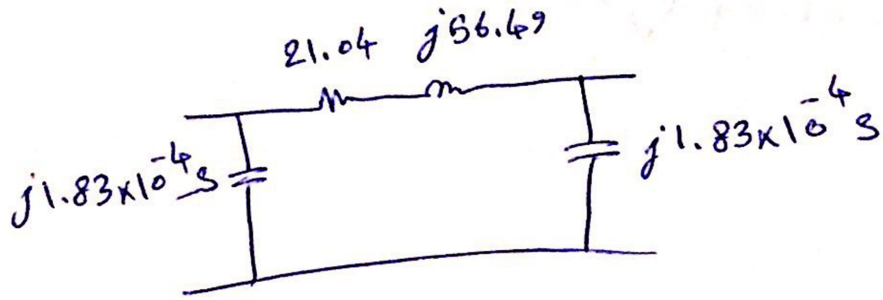
6.5 Linnet conductors

$$D_{eq} = \sqrt[3]{13\times13\times13\times2} = 18.9\ ft$$

a) $R = 0.3006 \times 70 = 21.04\ \Omega$

$$jx = j(0.451 + 0.336)\times 70 = j56.49\ \Omega$$

$$\bar{Y} = j70 \times \frac{10^{-6}}{0.1040 + 0.0872} = j3.66\times10^{-4}\ S$$



b) $\bar{A} = \bar{D} = 1 + \frac{\bar{Y}\bar{Z}}{2} = 0.9897 \angle 0.22^\circ$

whole line

$$\bar{B} = \bar{Z} = 21.04 + j56.49 = 60.28 \angle 69.57^\circ\ \Omega$$

$$\bar{C} = \bar{Y}\left(1 + \frac{\bar{Y}\bar{Z}}{4}\right) = 3.64\times10^{-4} \angle 90.11^\circ\ S$$

$$\bar{V}_{R,LN} = \frac{V_{R,LL}}{\sqrt{3}} = 132.8 \angle 0\ kV$$

4

$$\bar{I}_R = \frac{S}{\sqrt{3}\, V_{R,LL}} \angle -\cos^{-1}(0.8) = 188.26 \angle -36.87^\circ$$

$$\begin{bmatrix} \bar{V}_{S,LN} \\ \bar{I}_S \end{bmatrix} = \begin{bmatrix} \bar{A} & \bar{B} \\ \bar{C} & \bar{D} \end{bmatrix} \begin{bmatrix} 132.8 \text{ kV} \\ 188.26 \angle -36.87^\circ \end{bmatrix}$$

$$\bar{V}_{S,LN} = 141.14 \angle 2.69^\circ \text{ kV} \Rightarrow V_{S,LL} = 244.46 \text{ kV}$$

$$\bar{I}_S = 162.09 \angle -22.83^\circ \text{ A}$$

$$\bar{S} = 3 \bar{V}_{S,LN} \times \bar{I}_S^* = 61.94 + j29.37 \text{ MVA}$$

$P = 61.94$ MW

$Q = 29.37$ MVAr

$$\text{P.f.} = \cos\left(\tan^{-1}\left(\frac{Q}{P}\right)\right) = 0.90 \text{ Lagging}$$

$$\text{c) } \%VR = \frac{\frac{|V_S|}{|A|} - |V_{R,FL}|}{|V_{R,FL}|} \times 100 = \boxed{7.39\%}$$

5

6.12 225-mile-long

$$\bar{V}_{R,LN} = \frac{220}{\sqrt{3}} = 127\,kV$$

$$\bar{I}_R = \frac{S}{\sqrt{3}\,V_{LL}} = 116.6\angle -25.84^\circ\ A$$

a) short line

$$\bar{Z} = (35 + j140) \times \frac{225}{175} = 45 + j180\ \Omega$$

$$\bar{Y} = (930\times10^{-6}\angle 90^\circ) \times \frac{225}{175} = 1196\times10^{-6}\angle 90^\circ\ S$$

$$\bar{A} = \bar{D} = 1 \ ;\ \bar{B} = \bar{Z} \ ;\ C = 0$$

$$\begin{bmatrix} \bar{V}_S \\ \bar{I}_S \end{bmatrix} = \begin{bmatrix} \bar{A} & \bar{B} \\ \bar{C} & \bar{D} \end{bmatrix} \begin{bmatrix} \bar{V}_{R,LN} \\ \bar{I}_R \end{bmatrix} = \begin{bmatrix} 141.85\angle 6.72^\circ\ kV \\ 116.6\angle -25.84^\circ\ A \end{bmatrix}$$

$$V_{S,LL} = \sqrt{3}\, V_{S,LN} = 245.7\ kV$$

b) Medium line

$$\bar{A} = \bar{D} = 1 + \frac{\bar{Y}\bar{Z}}{2} = 0.8928\angle 1.73^\circ$$

$$\bar{C} = \bar{Y}\left(1 + \frac{\bar{Y}\bar{Z}}{4}\right) = 1.13\times10^{-3}\angle 90.82^\circ$$

$$\bar{B} = \bar{Z}$$

6

$$\begin{bmatrix} \bar{V}_S \\ \bar{I}_S \end{bmatrix} = \begin{bmatrix} \bar{A} & \bar{B} \\ \bar{C} & \bar{D} \end{bmatrix} \begin{bmatrix} \bar{V}_R \\ \bar{I}_R \end{bmatrix} = \begin{bmatrix} 128.77 \angle 8.94^\circ \text{ kV} \\ 104.04 \angle -24.04 \text{ A} \end{bmatrix}$$

$$V_{S_{LL}} = \sqrt{3} \times V_{S,LN} = 223 \text{ kV}$$

c) Long line

$$\bar{Z}_c = \sqrt{\frac{\bar{Z}}{\bar{Y}}} = 393.87 \angle -7^\circ \ \Omega$$

$$\overline{\gamma l} = \sqrt{\bar{Z}\bar{Y}} = 0.4711 \angle 82.98^\circ$$

$$\bar{A} = \bar{D} = \cosh(\overline{\gamma l}) = \frac{e^{\overline{\gamma l}} + e^{-\overline{\gamma l}}}{2} = 0.8949 \angle 1.66^\circ$$

$$\bar{B} = \bar{Z}_c \sinh(\overline{\gamma l}) = \bar{Z}_c \frac{e^{\overline{\gamma l}} - e^{-\overline{\gamma l}}}{2} = 178.96 \angle 76.49^\circ$$

$$\bar{C} = \frac{1}{\bar{Z}_c} \sinh(\overline{\gamma l}) = 1.15 \times 10^{-3} \angle 90.52^\circ$$

$$\bar{V}_{S,LN} = \bar{A}\bar{V}_{R,LN} + \bar{B}\bar{I}_R = 128.27 \angle 8.71^\circ \text{ kV}$$

$$V_{S_{LL}} = \sqrt{3} V_{S,LN} = 222.17 \text{ kV}$$

6.18

$$\bar{Z}' = \bar{Z}_c \frac{\sinh(\overline{\gamma l})}{\overline{\gamma l}} = \cancel{379.7 \angle} \ 178.96 \angle 76.49^\circ$$

$$\frac{\bar{Y}'}{2} = \left(\frac{\bar{Y}}{2}\right) \frac{\tanh\left(\frac{\overline{\gamma l}}{2}\right)}{\overline{\gamma l}/2} = 6.09 \times 10^{-4} \angle 89.74^\circ$$