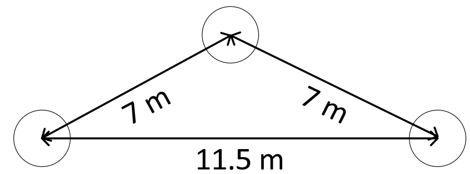
ENEL 487 | Winter 2019 | Quiz 2

Name: ID:

Problem 1

a) The Figure below shows the arrangement of a single-circuit three-phase transmission line being operated at 60 Hz. If the GMR (geometric mean radius) of the conductor used is 11.4 mm, find:

- The inductance per kilometer per phase. [3.5 marks]
- The inductive reactance per kilometer per phase. [1.5 marks]



b) A three-phase 60-Hz transmission line has its conductors arranged in a triangular formation such that two of the distances between conductors are 7.62 m and the third is 12.80 m. The conductors are ACSR Osprey. If the line is 200 km long, find the total capacitance to neutral in microfarads. The diameter of the Osprey line is 22.33 mm, and the permittivity of the medium is 8.85×10^{-12} F/m. [5 marks]

Problem 2

The sending-end voltage, current, and power factor of a three-phase transmission line are found to be 260 kV, 300A, and 0.9 lagging, respectively. The ABCD parameters are:

A = D = $0.8904\angle 1.34^0$ B = $186.82\angle 79.45^0$ Ω   C=$1.131\times 10-3\angle 90.41^0$ S

a) Calculate the corresponding receiving-end voltage and current [9 marks]
Hint: $\begin{bmatrix} A & B \\ C & D \end{bmatrix}^{-1} = \frac{1}{AD-BC}\begin{bmatrix} D & -B \\ -C & A \end{bmatrix}$
Hint 2: AD – BC = 1 for this line

b) Calculate receiving-end power factor [1 mark]

Constants/Conventions

ε	$8.85\text{x}10^{-12}$
r'	$0.7788 \cdot r$
D_{SL}	$\sqrt{D_S \cdot d}$ $\sqrt[3]{D_S \cdot d^2}$ $1.091\sqrt[4]{D_S \cdot d^3}$
D_{SC}	$\sqrt{r \cdot d}$ $\sqrt[3]{r \cdot d^2}$ $1.091\sqrt[4]{r \cdot d^3}$

General

Single Phase $\overline{\text{S}}$: $\overline{S} = \overline{V} \cdot \overline{I}^*$

Q for L and C: $Q_L = \frac{V^2}{X_L}$ $\quad Q_C = \frac{V^2}{X_C}$

Y Connection: $\overline{V_{ll}} = \sqrt{3}\angle 30^{\text{o}} \cdot \overline{V_\phi}$

Δ Connection: $\overline{I_l} = \sqrt{3}\angle{-30^{\text{o}}} \cdot \overline{I_\phi}$

3 Phase Power: $\overline{S_{3\phi}} = 3 \cdot \overline{V_\phi} \cdot \overline{I_\phi^*}$

$S = \sqrt{3} \cdot V_{ll} \cdot I_l$

$P = S \cdot pf \qquad S^2 = P^2 + Q^2$

Per Unit

Single Phase:

$S_{\text{base},1\phi} = P_{\text{base},1\phi} = Q_{\text{base},1\phi}$

$I_{\text{base}} = \frac{S_{\text{base},1\phi}}{V_{\text{base,L-N}}}$

$Z_{\text{base}} = R_{\text{base}} = X_{\text{base}}$

$Z_{\text{base}} = \frac{V_{\text{base,L-N}}}{I_{\text{base}}} = \frac{V^2_{\text{base,L-N}}}{S_{\text{base},1\phi}}$

Three Phase:

$S_{\text{base},3\phi} = 3 \cdot S_{\text{base},1\phi}$

$V_{\text{base,L-L}} = \sqrt{3}V_{\text{base,L-N}}$

$I_{\text{base}} = \frac{S_{\text{base},3\phi}}{\sqrt{3}V_{\text{base,L-L}}}$

$Z_{\text{base}} = \frac{V^2_{\text{base,L-L}}}{S_{\text{base},3\phi}}$

Change of Base: $Z_{\text{pu,new}} = Z_{\text{pu,old}} \left(\frac{V_{\text{base,old}}}{V_{\text{base,new}}}\right)^2 \frac{S_{\text{base,new}}}{S_{\text{base,old}}}$

Transmission Lines

Line Inductance:

$L = 2\text{x}10^{-7} \cdot \ln\frac{D}{D_s}$

or $L = 2\text{x}10^{-7} \cdot \ln\frac{D_{eq}}{D_S}$

or $L = 2\text{x}10^{-7} \cdot \ln\frac{D_{eq}}{D_{SL}}$

Line Capacitance:

$C_{an} = \frac{2\pi\varepsilon}{\ln\frac{D}{r}}$

or $C_{an} = \frac{2\pi\varepsilon}{\ln\frac{D_{eq}}{r}}$

or $C_{an} = \frac{2\pi\varepsilon}{\ln\frac{D_{eq}}{D_{SC}}}$

Line Equations: $\gamma = \sqrt{z \cdot y}$

$Z_c = \sqrt{\frac{z}{y}}$

$$I(x) = I_R\cosh(\gamma x) + \frac{V_R}{Z_c} \cdot \sinh(\gamma x)$$

$$V(x) = V_R\cosh(\gamma x) + I_R Z_c \sinh(\gamma x)$$

Nominal π Model:

$A = D = 1 + \frac{YZ}{2}$

$B = Z$

$C = Y(1 + \frac{YZ}{4})$

Eq π Model:

$Z\text{'} = Z\,\frac{\sinh(\gamma l)}{(\gamma l)}$

$\frac{Y\text{'}}{2} = \frac{Y}{2}\,\frac{\tanh\frac{(\gamma l)}{2}}{\frac{(\gamma l)}{2}}$

For: $x = a + jb,$

$\cosh(x) = \cosh(a)\cos(b) + j\sinh(a)\sin(b)$

$\sinh(x) = \sinh(a)\cos(b) + j\cosh(a)\sin(b)$

$$\begin{bmatrix} V_s \\ I_s \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix}\begin{bmatrix} V_R \\ I_R \end{bmatrix}$$