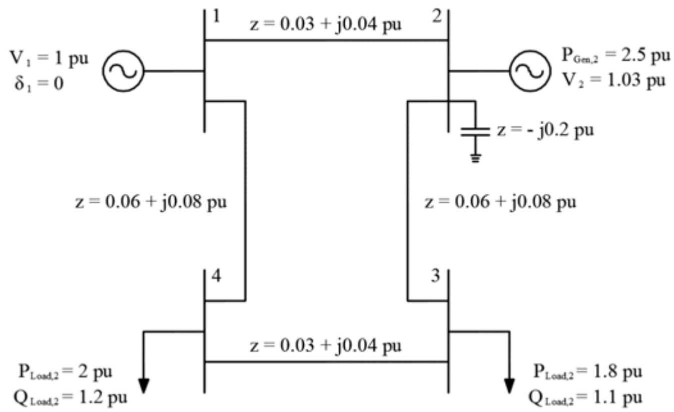
ENEL 487 | Winter 2019 | Quiz 3

Name: ID:

1) Consider the system below:



a. Fill out the following table for this system. The answer(s) should be selected from terms in the brackets. [3 marks]

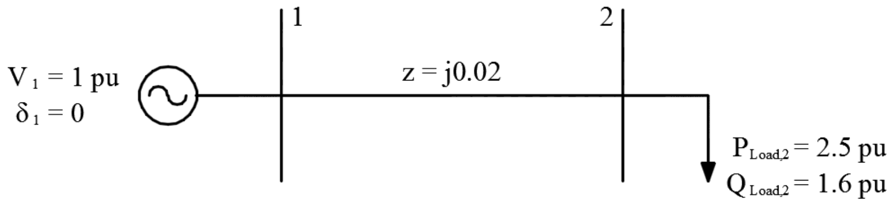
Bus Number	Bus Type (Load, Gen, Slack)	Known Variable (Pgen, Qgen, V, δ, Pload, Qload)	Unknown Variable (Pgen, Qgen, V, δ, Pload, Qload)

b. Create the X vector for this system (in the form of X = [-----]^T). [4 marks]

c. Create the admittance matrix Y_{bus} for system. Also, provide the B_{bus} and G_{bus} matrices. [4 marks]

d. If all the branches in the system were <u>lossless</u>, how much <u>real power</u> is injected by the slack bus? [1 mark]

2) Consider the two bus system below:



a. Create the Ybus for this system. [1 mark]

b. Create the X vector for this system. [1 mark]

c. Write the real and reactive power flow equations for bus 2. Plug in all the known values and simplify as much as possible. [3 marks]

d. If the optimal value of δ_2 = -0.05211 radians, what is the optimal voltage at bus 2? [3 marks]

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:	$Q_L = \frac{V^2}{X_L} \qquad Q_C = \frac{V^2}{X_C}$
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:	$Z' = Z\,\frac{\sinh(\gamma l)}{(\gamma l)}$ $\frac{Y'}{2} = \frac{Y}{2}\,\frac{\tanh\frac{(\gamma l)}{2}}{\frac{(\gamma l)}{2}}$

For: $x = a + jb$,

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

Power Flow

$$f_i = P_{gen,i} - P_{load,i} - \sum_{k=1}^{N} V_i V_k G[i,k]\cos(\delta_i - \delta_k) - \sum_{k=1}^{N} V_i V_k B[i,k]\sin(\delta_i - \delta_k)$$

$$f_{N+i} = Q_{gen,i} - Q_{load,i} - \sum_{k=1}^{N} V_i V_k G[i,k]\sin(\delta_i - \delta_k) + \sum_{k=1}^{N} V_i V_k B[i,k]\cos(\delta_i - \delta_k)$$