5+5+7+3 = 20 points

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ECE 476
HW 7

Problem 1

5 points

5 buses ⇒ Y_{bus} is 5×5 matrix

row 3 ⇒ Need admittances connected to bus 3

$Y(3,3)$ = Sum of admittances connected to bus 3

$$= \frac{1}{R_{34}+jX_{34}}$$

$$= \frac{1}{0.00075+j0.01}$$

$$= 7.46 - j99.4 \text{ p.u.}$$

$Y(3,1) = Y(3,2) = Y(3,5) = 0$ (No connection between these buses)

$Y(3,4) = -Y(3,3) = -7.46 + j99.4$ p.u.

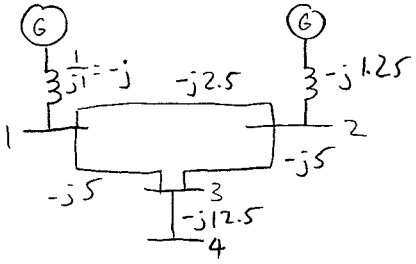
$$\therefore \boxed{\overline{Y}(3,*) = [0 \quad 0 \quad 7.46 - j99.4 \quad -7.46 + j99.4 \quad 0]}$$

1 point per answer

Problem 2

5 points

$Y = \frac{1}{Z}$

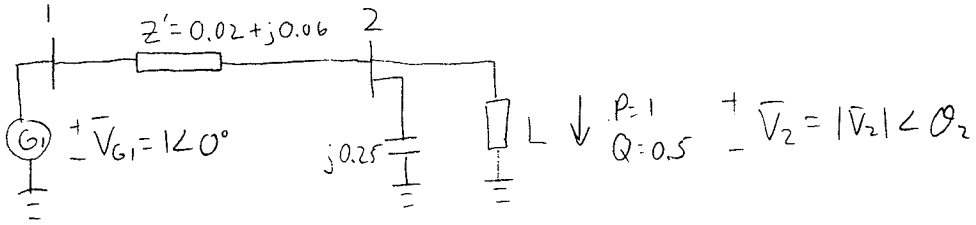


$$\overline{Y}_{bus} = \begin{bmatrix} -j8.5 & j2.5 & j5 & 0 \\ j2.5 & -j8.75 & j5 & 0 \\ j5 & j5 & -j22.5 & j12.5 \\ 0 & 0 & j12.5 & -j12.5 \end{bmatrix}$$

-1 for each wrong answer in matrix

Problem 3

7 points



1 point a) See Figure above

b) Two buses $\Rightarrow$ Y_{bus} is 2x2, $Y' = \frac{1}{Z'} = 5 - j15$

2 points $Y_{bus} = \begin{bmatrix} 5-j15 & -5+j15 \\ -5+j15 & 5-j14.75 \end{bmatrix}$

c) Bus 1:

4 points $P_1 = |\bar{V}_{G1}|^2 [5\cos(\theta_1-\theta_1) - 15\sin(\theta_1-\theta_1)] + |\bar{V}_{G1}||\bar{V}_2|[-5\cos(\theta_1-\theta_2) + 15\sin(\theta_1-\theta_2$

$\boxed{P_1 = 5 + |\bar{V}_2|[-5\cos(\theta_2) - 15\sin(\theta_2)]}$; since $\theta_1 = 0$, $|\bar{V}_{G1}| = 1$

$Q_1 = |\bar{V}_{G1}|^2 [5\sin(\theta_1-\theta_1) + 15\cos(\theta_1-\theta_1)] + |\bar{V}_{G1}||\bar{V}_2|[-5\sin(\theta_1-\theta_2) - 15\cos(\theta_1-\theta_2)]$

$\boxed{Q_1 = 15 + |\bar{V}_2|[5\sin(\theta_2) - 15\cos(\theta_2)]}$

Bus 2:

$P_2 = |\bar{V}_2|^2 [5\cos(\theta_2-\theta_2) - 14.75\sin(\theta_2-\theta_2)] + |\bar{V}_2||\bar{V}_{G1}|[-5\cos(\theta_2-\theta_1) + 15\sin(\theta_2-\theta_1)$

$\boxed{P_2 = 5|\bar{V}_2|^2 + |\bar{V}_2|[-5\cos(\theta_2) + 15\sin(\theta_2)] = -1}$

↳ given load real power

$Q_2 = |\bar{V}_2|^2 [5\sin(\theta_2-\theta_2) + 14.75\cos(\theta_2-\theta_2)] + |\bar{V}_{G1}||\bar{V}_2|[-5\sin(\theta_2-\theta_1) - 15\cos(\theta_2-\theta_1)$

$\boxed{Q_2 = 14.75|\bar{V}_2|^2 + |\bar{V}_2|[-5\sin(\theta_2) - 15\cos(\theta_2)] = -0.5}$

Note: P_2 is '-1' because the load draws 1 p.u. of real power $\Rightarrow$ injects -1 p.u. into bus 2.

Problem 4

3 points

Effects on $\bar{V}_2$: with the new line, $|\bar{V}_2|$ increase

Line Loadings: All other lines have % loading that decreased except for line 4-5

Real Power Losses: There's less real power losses (decreased)

For details, see table below.

	Before Addition of Line	After Addition of Line
Bus Voltage V_2 [p.u.]	0.834	0.953
Total real power losses [MW]	34.8	18.3
Branch b/w bus 1-5 (% loading)	68.5	63.1
Branch b/w bus 2-4 (% loading)	27.3	17.5
Branch b/w bus 2-5 (% loading)	49.0	25.4 (both lines)
Branch b/w bus 3-4 (% loading)	53.1	45.7
Branch b/w bus 4-5 (% loading)	18.8	22.1