Homework Set 1 - Solutions

ECE 530

September 9, 2015

1

The gist of Obama's Clean Power Plan is to reduce carbon pollution from power plants to take action regarding climate change.

The fundamental requirement of a power system is to provide a reliable supply of energy at least cost and least environmental impact. The system must be able to track load continuously, keeping the balance between supply and demand. When we shut down coal-fired plants, that generation needs to be made up using other resources, probably variable renewable sources like wind and solar. These sources are dependent on current weather conditions and cannot always be relied upon to balance supply and demand. In the event of system disturbances, if these variable resources are unable to maintain normal operating conditions, blackouts may occur.

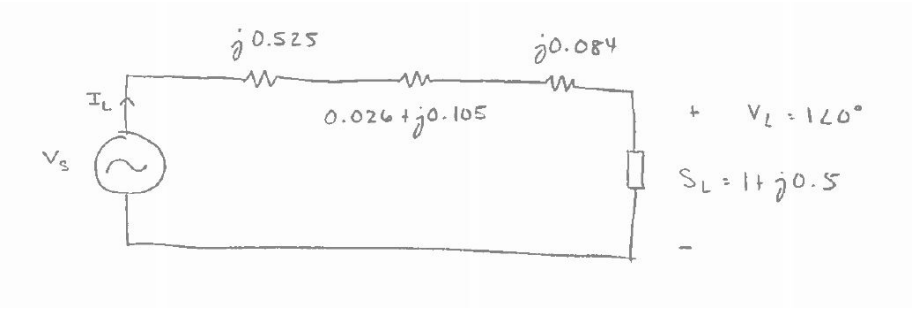
2

$S_{B,3\phi} = 100MVA \quad V_{1B} = 13.8kV \quad Z_{1B} = \frac{Z_{1B}^2}{S_{B,3\phi}} = 1.9044\Omega$

$V_{2B} = 138kV \quad Z_{2B} = \frac{Z_{2B}^2}{S_{B,3\phi}} = 190.44\Omega$

$V_{3B} = 69kV \quad Z_{3B} = \frac{Z_{3B}^2}{S_{B,3\phi}} = 47.61\Omega$

$S_L = 1 + j0.5 p.u. \quad V_L = 1.0\angle 0^\circ$



$$I_L = \left(\frac{S_L}{V_L}\right)^* = 1.118\angle -26.565^\circ$$

$$V_Z = I_L(Z_{1,pu} + Z_{2,pu} + Z_{3,pu}) = (1.118\angle -26.565^\circ)(0.026 + j0.714) = 0.799\angle 61.35^\circ$$

$$S_G = (V_Z + V_L)I_L^*$$

$$= (0.799\angle 61.35^\circ + 1.0\angle 0^\circ)(1.118\angle 26.565^\circ)$$

$$= (1.73\angle 53.45^\circ)$$

$$S_{G,actual} = 103.2 + j139.3MVA$$

3

$$\text{Ybus} = \begin{bmatrix} -j9.9 & j10 \\ j10 & -j9.9 \end{bmatrix}$$

The power injection is $S_2 = -2 - j1.268$, so $P_{D,2} = 2$ and $Q_{D,2} = 1.268$

$$P_2 = |V_2|(10\sin(\theta_2)) = P_{G,2} - P_{D,2} = -2$$

$$Q_2 = |V_2|(-10\cos(\theta_2)) + |V_2|^2(9.9) = Q_{G,2} - Q_{D,2} = -1.268$$

Let $V_2 = x_1$ and $\theta_2 = x_2$: $\quad \text{J} = \begin{bmatrix} 10\sin x_2 & 10x_1\cos(x_2) \\ 19.8x_1 - 10\cos(x_2) & 10x_1\sin(x_2) \end{bmatrix}$

$V_2 = 0.8246$ and $\theta_2 = -0.2450$ rad

Matlab Code

```
error = [1.e8; 1.e8];

P2 = inline('x1*10*sin(x2)+2');
Q2 = inline('x1*-10*cos(x2)+x1^2*9.9+1.268');

iterations = 0;
maxiter = 1000;
criteria = 1e-4;

syms x1 x2
Jac = jacobian([x1*10*sin(x2)+2, x1*-10*cos(x2)+x1*x1*9.9+1.268], [x1,x2]);
x1 = 1;
x2 = 0;

while(norm(error,inf) >= 1e-4)
    iterations = iterations+1;
    J = [10*sin(x2), 10*x1*cos(x2);
        (99*x1*cos(x2))/5-10*cos(x2), 10*x1*sin(x2)];
    f = [P2(x1,x2);Q2(x1,x2)];
    deltax = -inv(J)*f;
    x = [x1;x2] +deltax;
    error = [P2(x(1,1),x(2,1));Q2(x(1,1),x(2,1))];

    x1 = x(1,1)
    x2 = x(2,1)

end

iterations
error
xFinalVal = [x1;x2]

iterations =
     5
error =
   1.0e-04 *
    0.0000
   -0.1045
xFinalVal =
    0.8246
   -0.2450
```

$$\text{Ybus} = \begin{bmatrix} 6.25 - j18.695 & -5.00 + j15.00 & -1.25 + j3.75 & 0 & 0 \\ -5.00 + j15.00 & 12.92 - j38.67 & -1.667 + j5 & -1.25 + j3.75 & -5.00 + j15.00 \\ -1.25 + j3.75 & -1.667 + j5 & 5.417 - j16.19 & -2.5 + j7.5 & 0 \\ 0 & -1.25 + j3.75 & -2.5 + j7.5 & 5.417 - j16.19 & -1.667 + j5 \\ 0 & -5.00 + j15.00 & 0 & -1.667 + j5 & 6.67 - j19.97 \end{bmatrix}$$

$y_{33} = 7.417 - j16.19$, no other values change

$B_{shunt} = 75MVar = V_{nom}^2 B \quad V_{nom} = 1 \implies B = 0.75pu$
$Y = G + jB$
$y_{44} = 5.417 - j15.44$