Homework #2 – ECEN 667 Fall 2025

Due September 25, 2025 at 8 AM

Problem 1. Consider a two-bus case in which there is a classical synchronous generator at each bus. The transmission line connecting them has $R = 0.05, X = 0.15$. The generator at Bus 1 has $H = 2.3, X'_d = 0.18$, and is producing 50 MW with a terminal voltage magnitude of 1.02 per-unit. The generator at bus 2 has $H = 4.3, X'_d = 0.21$, with a terminal voltage magnitude of 1.04 per-unit, and is the slack (reference) bus.

a. Create the case in PowerWorld and solve the power flow to get the voltage phasors and complex powers for each of the two generators.
b. Find **Y** and **Yaug** for this system, for the initial conditions given.
c. List all the variables and equations for the dynamical system.
d. Find the initial conditions of all variables and verify that the system is in steady state.

Answers

a. $\bar{V}_1 = 1.02\angle 4.813°;\ \bar{V}_2 = 1.04\angle 0$

b. $\bar{Y} = \begin{bmatrix} 2 - j6 & -2 + j6 \\ -2 + j6 & 2 - j6 \end{bmatrix}$;

$\bar{Y}_{aug} = \begin{bmatrix} 2 - j11.55 & -2 + j6 \\ -2 + j6 & 2 - j10.76 \end{bmatrix}$ (OK for sign error in Yaug calcs based on slides)

c. Variables: $\bar{V}_1, \delta_1, \omega_1, E_{p1}, P_{m1}, \bar{V}_2, \delta_2, \omega_2, E_{p2}, P_{m2}$

Equations: $\dot{\delta}_1 = \omega_s \omega_1 \qquad \dot{\omega}_1 = \frac{1}{2(2.3)}\left(\frac{P_{m1}}{1+\omega_1} - \frac{E_{p1}}{(0.18)}(V_{r1}\sin\delta_1 - V_{i1}\cos\delta_1)\right)$

$\dot{\delta}_2 = \omega_s \omega_2 \qquad \dot{\omega}_2 = \frac{1}{2(4.3)}\left(\frac{P_{m2}}{1+\omega_2} - \frac{E_{p2}}{(0.21)}(V_{r2}\sin\delta_2 - V_{i2}\cos\delta_2)\right)$

$$\begin{bmatrix} 2 - j11.55 & -2 + j6 \\ -2 + j6 & 2 - j10.76 \end{bmatrix}\begin{bmatrix} \bar{V}_1 \\ \bar{V}_2 \end{bmatrix} = \begin{bmatrix} \frac{E_{p1}}{j0.18}\angle\delta_1 \\ \frac{E_{p2}}{j0.21}\angle\delta_2 \end{bmatrix}$$

d. $\delta_1 = 10.005° = 0.175, \omega_1 = 0, E_{p1} = 0.975, P_{m1} = 0.5,$
$\delta_2 = -5.061° = -0.0883, \omega_2 = 0, E_{p2} = 1.11, P_{m2} = -0.4850$

Problem 2. Using PowerWorld with the AGL37_TS case, change the contingency to a zero impedance, three-phase fault on the line between buses 28 and 31 at the bus 31 end. Assume this fault is cleared by opening the line.

a. What is the max fault duration such that the frequency remains below 60.3 Hz?
b. What is the max fault duration such that no generator loses synchronism?
c. Repeat 2.a and 2.b with a fault midway down the line.

Answers

a. 0.091 seconds (some variation accepted)
b. 0.44 seconds
c. 0.12 (some variation accepted) and 0.32 seconds

Problem 3. Consider a generator, similar to the example discussed in class, except that the terminal voltage of the generator is $\bar{V}_s = 1.0261\angle 25.39°$ and it is producing 200 MW and 57.24 Mvar (assuming a 100 MVA base). Assume a GENSAL model is used with parameters H=3.0, D=0, R_a = 0,

X_d = 2.1, X_q = 2.0, X'_d = 0.3, X''_d=X''_q=0.2, X_l = 0.13, T'_{do} = 7.0, T''_{do} = 0.07, T''_{qo} =0.07, S(1.0) =0.02, and S(1.2) = 0.1. Manually calculate the following.

a. Saturation function coefficients
b. Initial values of all state variables
c. Field voltage

Answers

a. A=0.838, B=0.762
b. $\delta = 1.51; \omega = 0; E_q' = 1.0872; \psi_d' = 0.7511;\ \psi_q'' = -0.8094$
c. $E_{fd} = 4.697$