King Saud University
Department of Electrical Engineering
Power Systems Operation and Control (EE 585)

First Semester 1434/1435 | Final Exam Makeup | Time Limit: 3 hours

الرقم: الاسم:

Question 1:

Three generating units have MVA ratings and speed-droop characteristics as follows:-

Unit1: 500 MVA, speed-droop 4%,

Unit 2: 400 MVA, speed-droop 5%

Unit 3: 300 MVA, speed-droop 6%

Units 1 and 2 are operating in parallel at 60 Hz to supply the loads as shown in Fig 1 while unit 3 is running at 60 Hz as stand-by (not connected).

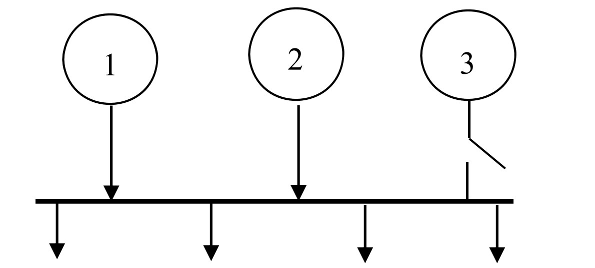

Fig. 1

The incremental fuel cost for the units are

$\lambda_1 = 0.009\ Pg_1 + 7.0$

$\lambda_2 = 0.008\ Pg_2 + 8.0$

$\lambda_3 = 0.007\ pg_3 + 9.0$

a) Determine Pg_1, Pg_2, and Pg_3 for economic operation.
   Assume all units are operating all the time.

b) If the load "200 MW" is disconnected, determine the new frequency and the new values of Pg_1, Pg_2, and Pg_3 according to speed-droop characteristics.

c) Which units are operating economically after load disconnection.

Question 2:

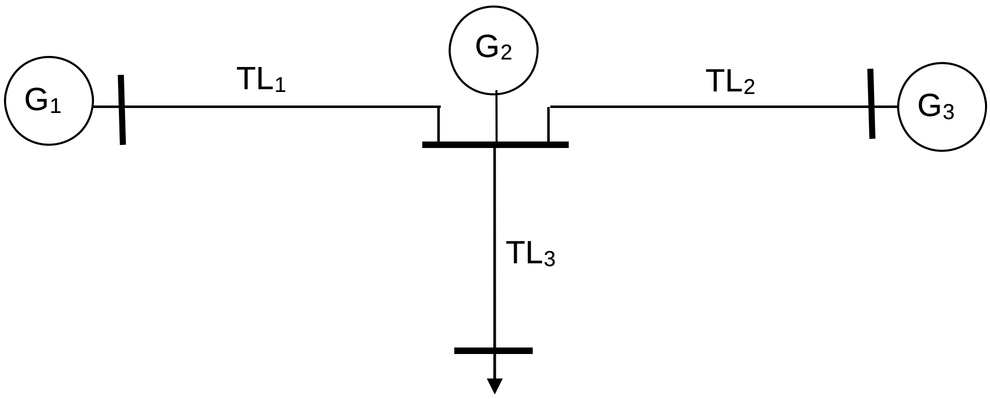

Fig. 2

The power system shown in Fig. 1 consists of two generating units *G_1*, and *G_2* with fuel costs as follows:-

F.C of $G_1 = 600 + 11\ P_{G1} + 0.04\ P_{G1}^2$ SR/hour.

F.C of $G_2 = 400 + 13\ P_{G2} + 0.03\ P_{G2}^2$ SR/hour.

F.C of $G_2 = 300 + 15\ P_{G3} + 0.02\ P_{G3}^2$ SR/hour.

Transmission line losses ar given by:

Transmission line 1:

$$P_{TL1} = 6\times10^{-5}\ P_{TL1}^2$$

Transmission line 2:

$$P_{TL2} = 8\times10^{-5}\ P_{TL2}^2$$

Transmission line 3:

$$P_{TL3} = 4\times10^{-5}\ P_{TL3}^2$$

a) Determine total transmission line losses in terms of P_{G1}, P_{G2}, and P_{G3}.

b) For a total system demand of 900 MW, write (on paper) a MATHCAD program to determine P_{G1}, P_{G2}, and P_{G3} for economic operation.

Question 3:

a) For the system shown in Fig 3, write formulas for P_1, P_2, and Q_2 in terms of variables and parameters shown on Fig 3.

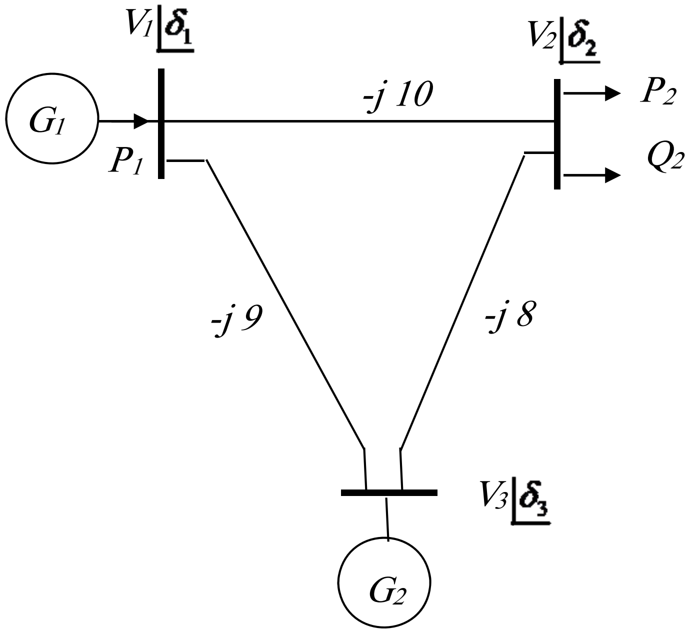

Fig 3.

b) For the system shown in Fig 3, determine the admittance matrix, Y_{bus}.

c) For the system shown in Fig 3, assume $P_{G2} = 1.2$, $P_2 = 2$, and $Q_2 = 1$ all pu. Use DC load flow to find values of δ_2 and δ_3

Question 4 :

a) For the system shown in Fig 4, all transmission losses are neglected and all voltages are assumed 1 pu.

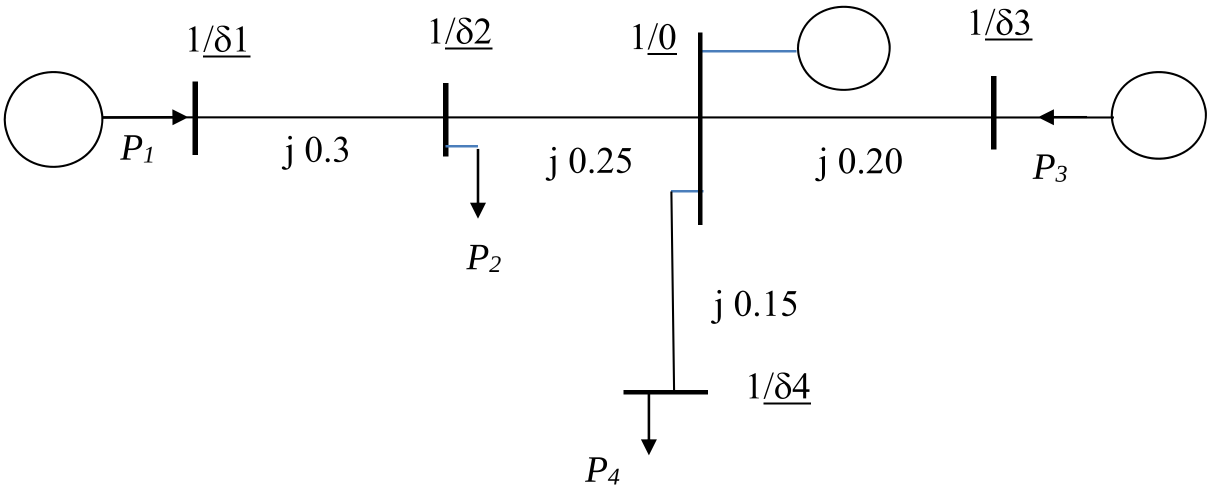

Fig. 4

Given:

$P_1 = 1$ p.u, $P_2 = 1.80$ p.u, $P_3 = 1.50$ p.u, and $P_4 = 2$ p.u. Determine δ_1, δ_2, δ_3, and δ_4.

b) For the system shown in Fig 5,

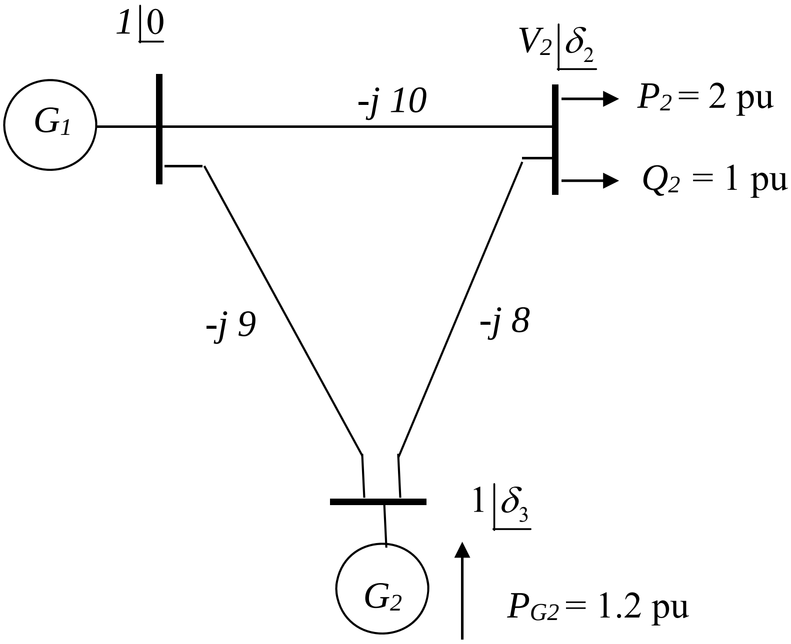

Fig 5

i) Use Decoupled N-R Method to determine δ_2 and δ_3. Two iteration only.

ii) Use Decoupled N-R Method to determine V_2. Three iterations only

Question 5:

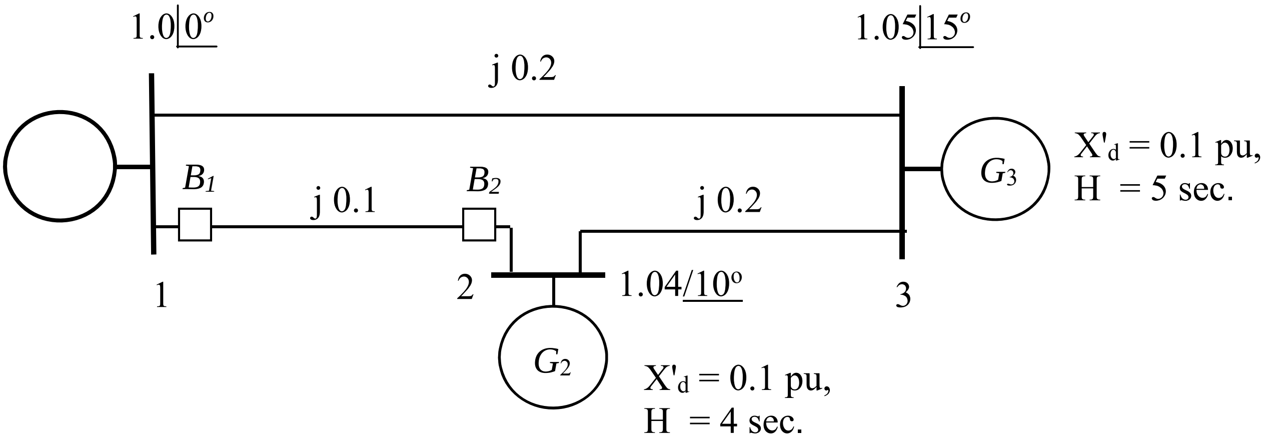

Fig. 6

The system shown in Fig 6 was operating at steady-state.

i) Determine the internal voltages of G_2 and G_3.

- For a <u>3-phase</u> fault at $t=0$ very close to circuit breaker B_2 (effectively on Bus 2)

ii) Write the swing equation of G_2 and G_3 for $t > 0$.

iii) Write (on paper) Mathcad program to solve the swing equations.

- After fault is cleared at $t = tc$ (by opening circuit-breakers B_1 and B_2),

  iv) Write the swing equation of G_2 and G_3 for $t > tc$.

v) Write (on paper) a Mathcad program to solve the swing equations.