S. KARAKI AMERICAN UNIVERSITY OF BEIRUT FALL 2008/ 2009

FACULTY OF ENGINEERING AND ARCHITECTURE

FINAL EXAM

FUNDAMENTALS OF POWER SYSTEMS ANALYSIS (EECE 471)

CLOSED BOOK (2.5 HOURS) February 3, 2009

PROGRAMMABLE CALCULATORS ARE NOT ALLOWED.
THIS QUESTION SHEET MUST BE RETURNED WITH THE ANSWER BOOKLET.

BRIEFLY EXPLAIN CALCULATIONS BY SHOWING FORMULAE USED.

NAME: ________________________ **ID#:** ________________________

1. It is required to perform an economic load dispatch study on a system of two generators supplying a load of P_D= 200 MW and connected by a transmission line and the system losses are approximated by: $P_L = 5\times 10^{-4}\times (P_D - P_{G2})^2$. The maximum and minimum active power limits of the units are given as: $0 \le P_{G1} \le 160$ and $0 \le P_{G2} \le 85$. The units have the following fuel-cost curves:

$$C_1(P_{G1}) = 250 + 30\,P_{G1} + 0.005\,P_{G1}^2 \ \ \$/h$$
$$C_2(P_{G2}) = 100 + 28\,P_{G2} + 0.02\,P_{G2}^2 \ \ \$/h$$

a) Write the objective function and the constraints of the economic dispatch of the system with losses and use the method of Lagrange to write the necessary optimality conditions defining the saddle point (i.e. the optimum point).

b) Describe an iterative procedure based on penalty factors to solve the optimality conditions developed above and determine the active powers provided by each units (P_{G1}, P_{G2}), the incremental cost (λ) and the total cost of operation at the given system demand. Carry out an iteration of this procedure starting at the lossless ELD solution and determine the incremental cost at nodes 1 and 2 and the power supplied by each generator at the end of the iteration.

2. In this problem it is required to examine the solution of the load flow problem of the system of Fig. 1 using the fast-decoupled load flow (FDLF).

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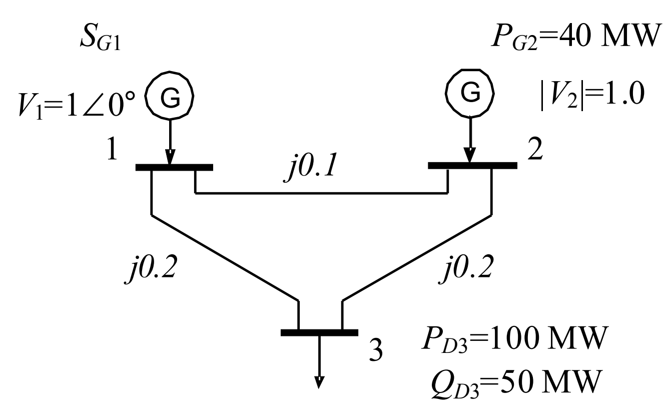

Fig. 1: Transmission system for FDLF analysis.

a) Form the nodal admittance matrix of the system shown in Fig. 1.

b) Identify the type of busbars and the unknown variables that we are solving for in the system shown in Figure 1. Write the active and reactive mismatch equations to be solved in order to determine these variables.

c) Briefly describe the main characteristics of the FDLF method and how it can be derived from the Newton-Raphson method. Write the iterative FDLF equations showing the elements of the approximate Jacobian matrices for the problem being solved.

d) Carry out an iteration of the FDLF method for the equations in Part c from a set of appropriate starting values.

3. In this problem it is required to carry out a fault level analysis of the system presented in Fig. 2. The generator transient, sub-transient and leakage reactances are given as 30%, 20% and 6% on rating. The generators are Y-connected with the neutral grounded with a reactance of 5% on rating and the Y-sides of the transformers solidly grounded. The zero sequence impedance of the transmission line is equal to 3 times its positive sequence one. The fault calculation is to be carried out at about 5-8 cycles following fault occurrence.

Generator G_1: 250 MVA, PF= 0.85, 13 kV, X_S= 120%.
Generator G_2: 120 MVA, PF= 0.85, 11 kV, X_S= 110%.
Transformers T_1 and T_2: 250 MVA, X_{T1}= X_{T2}= 12%
Transmission line: X_{Tl}= 60Ω
Load: 300+j120 MVA

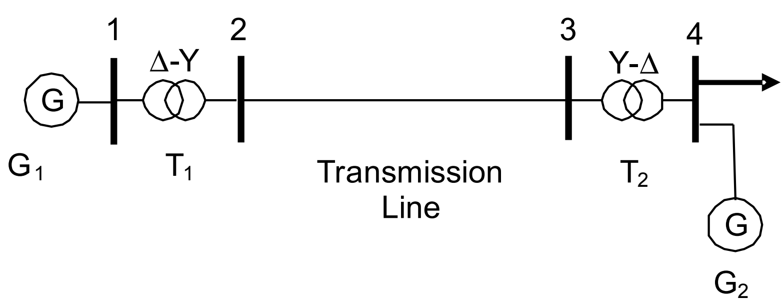

Fig. 2: Transmission system under analysis.

a) Calculate all reactance values in per unit on 100 MVA base. Show the details of calculation of the per unit values for one generator reactance, a transformer reactance, and the transmission line.

b) Draw the positive, negative and zero sequence networks of the system each labeled with the appropriate per unit reactance values.

c) Determine the Thevenin equivalent of the positive, negative and zero sequence networks for a fault at node 2.

d) Connect the equivalent sequence networks for a SLG, and a LLG faults at node 2 through a fault impedance of j0.1 per unit on 100 MVA base.

e) For the SLG fault determine the sequence currents (I_2^+, I_2^- and I_2^0) and voltages (V_2^+, V_2^- and V_2^0) at node 2 during the fault and deduce the phase voltages and currents.