National Exams December 2012

07-Elec-B7, Power Systems Engineering

Open Book examination

3 hours duration

NOTES

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit, with the answer paper, a clear statement of any assumptions made.
2. Any non-communicating calculator is permitted. This is an Open Book examination. Note to the candidates: you must indicate the type of calculator being used, i.e. write the name and model designation of the calculator on the first inside left hand sheet of the exam work book.
3. Any five questions constitute a complete paper. Only the first five questions as they appear in your answer book will be marked.
4. All questions are of equal value.

Problem 1

Consider the network shown in Figure (1,) with a round rotor synchronous machine feeding a load through two parallel lines. Assume for the first line linking buses 1 and 2 that the parameters A and B in per unit are given by:

$$A_1 = 0.996 \qquad\qquad B_1 = j0.02$$

In addition, the per unit series impedance and shunt admittance parameters of the second line (represented by an equivalent pi) are $Z_2 = j0.05$ and $Y_2/2 = j0.02$

a- Convert the A_1 and B_1 parameters to equivalent pi network Z_1 and Y_1. **[5 points]**

b- Reduce the two parallel lines to one equivalent line represented by Z_{eq} and $Y_{eq}/2$ **[5 points]**

c- Suppose now that the magnitude of the voltage at bus 2 is 1.00 p.u. and that the active power load at bus 2 in per unit is 1.2 at 0.75 p.f. lagging. Determine the values of voltage, phase angle, active and reactive power at bus 1 (the synchronous machine terminals.) **[5 points]**

d- Find the required synchronous machine excitation voltage and power (torque) angle assuming that the machine's synchronous reactance is X_s= 0.03 p.u. Note that all power formulae in the text are given with bus 1 being the reference with phase angle =0.00 **[5 points]**

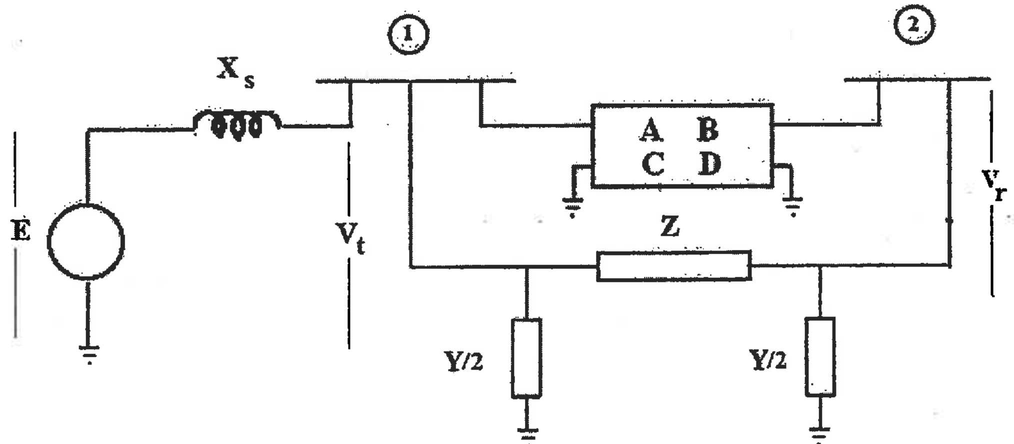

Figure (1) Electric network for Problem 1

Problem 2

A salient pole synchronous machine is connected to an infinite bus whose voltage is kept constant at 1.00 pu. The direct axis reactance is 0.95 pu.

a- To produce an active power of P = 1.1, the excitation voltage is E = 1.1 and the torque angle is given by $\delta = 30^{\circ}$. Determine the value of the quadrature axis reactance of the machine. **[4 point]**

b- Assume that X_q=0.6. Complete table (1) relating to four operating conditions of the machine (Q_2 is the reactive power at machine terminals.) Neglect armature reaction.

Table (1) Loading Conditions for Problem (2)

	P	Q_2	E	δ
Condition A [4points]	?	0.0	1.18	?
Condition B [4points]	1.85	?	?	45°
Condition C [4points]	?	?	1.15	37.5°
Condition D [4points]	1.25	?	1.18	?

Problem 3

Consider the 1100-kV, 400 km, bundle-conductor line shown in Figure (2.). Assume phase spacing D_1 = 17.5 m, bundle separation S = 48.0 cm, and conductor diameter is 3.65 cm.

a- Calculate the inductance in henries per m per phase. **[4points]**

b- Calculate the capacitance in farads per meter per phase neglecting earth effects. **[4points]**

c- Calculate the capacitance in farads per m per phase including earth effects with h_1 = 25.00 m. **[4points]**

d- Use the long line formula to calculate the *A and B* parameters of the line neglecting resistance and earth effects. **[4points]**

e- Calculate the receiving-end voltage magnitude (line-to-line,) when the sending end of the line delivers 450 MVA at 0.8 PF lagging at rated voltage. **[4points]**

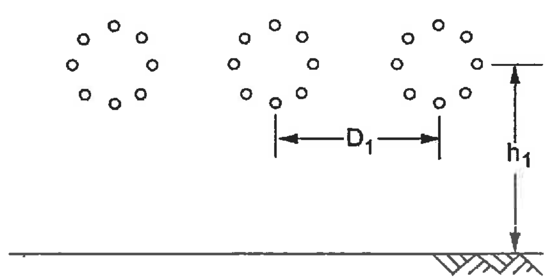

Figure (2) Line configuration for Problem (3)

Problem 4

Consider the system of Figure (3.) Treat the motor load at bus 4 as a generator. The reactances of all components in pu are indicated in Table (2)

a- Sketch and label carefully the positive, and negative, equivalent networks for this system. **[5 points]**

b- Sketch and label carefully the zero sequence equivalent network. **[5 points]**

c- Assume that a single line to ground fault takes place at bus 2. Find the fault current through phase A. **[5 points]**

d- Assume that a three phase ground fault takes place at bus 2. Find the fault current. **[5 points]**

Table (2) Component reactance's in per unit

	Generators G_1, G_2 & M_1	Transformers T_1, T_2 and T_3	Lines L_1, L_2 & L_3
Positive sequence reactance X_+	0.15	0.12	0.15
Negative sequence reactance X_-	0.15	0.12	0.15
Zero sequence reactance X_o	0.05	0.05	0.20

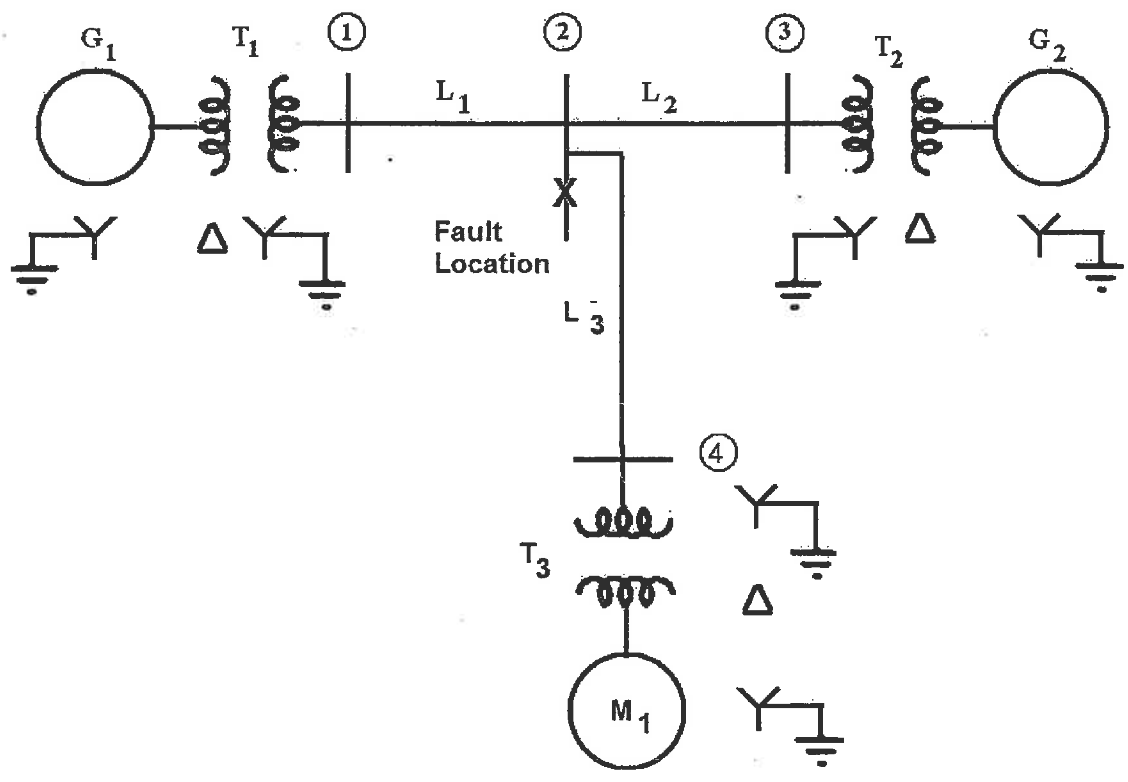

Figure (3) One-line diagram for Problem (4)

Problem 5

Consider the three-bus electric power network shown in Figure (4.) It is required to find the following:

a- The active and reactive power generated at bus 1. **[7 points]**

b- The active and reactive power load at bus 2. **[7 points]**

c- The active and reactive power load at bus 3. **[6 points]**

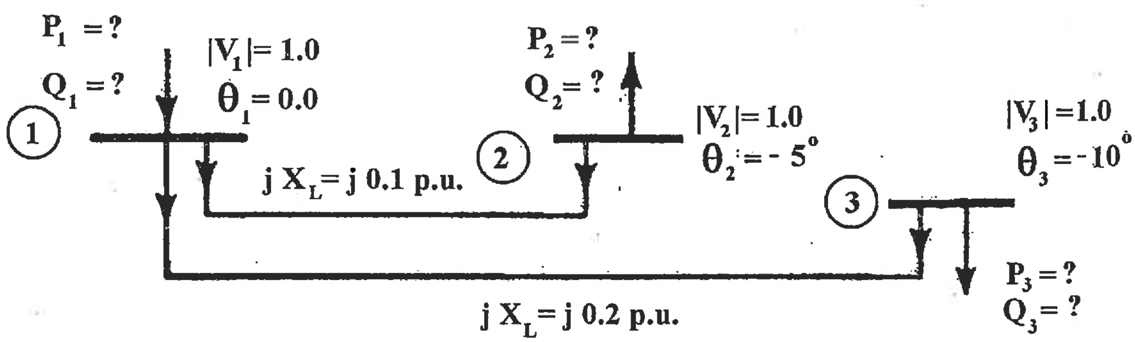

Figure (4) Circuit for Problem 5

Problem 6

Consider the system shown in the single-line diagram of Figure (5.) All reactances are shown in per unit to the same base. Assume that the voltage at both sources is 1 p.u.

a- Find the fault current due to a bolted- three-phase short circuit at bus 4. **[5 Points]**

b- Find the voltage at bus 5 under the fault conditions of part a **[5 Points]**

c- Find the fault current due to a bolted- three-phase short circuit at bus 3. **[5 Points]**

d- Find the voltage at bus 2 under the fault conditions of part c **[5 Points]**

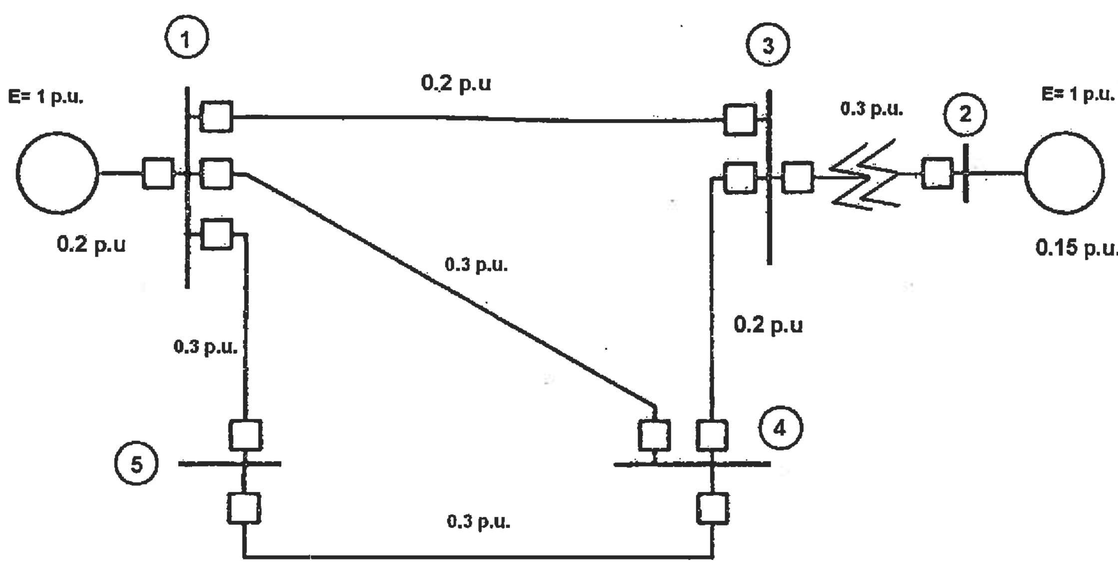

Figure (5) Single-line diagrams for Problem 6

Problem 7

Consider the circuit shown in Figure (6) Assume that E = 1.1 p.u., and V = 1.05 p.u. A three phase short circuit takes place in the middle of transmission line 3.

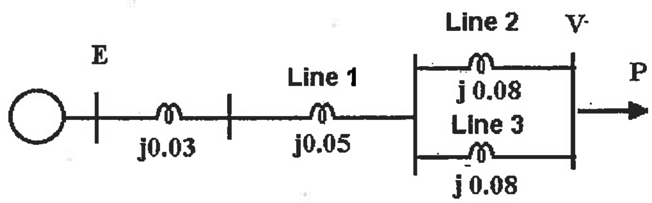

Figure (6) Circuit for Problem 7

a) Assume that the active component of the load on the circuit is 2 p.u., when the fault takes place. Verify that the system will be stable under sustained fault conditions. **[6 points]**

b) Assume now that the active component of the load on the circuit is 3 p.u., when the fault takes place. Will the system be stable under sustained fault conditions? **[7 points]**

c) Assume that for the conditions of part (b,) the fault is cleared at $\delta_c = 90^o$ by opening the circuit breakers at both ends of line 3. Carry out the necessary calculations to show that the system will remain stable under these conditions. **[7 points]**