National Exams May 2010

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

a- List five advantages of using shunt capacitors in electric power systems.[5 points]

A 500-kV, 60 Hz three-phase transmission line is modeled using the exact A, B, C, and D parameters. It is known that:

$$A = 0.98 / \underline{0.3^o} \qquad\qquad Z = 105 / \underline{87.^o}$$

Z is the total series impedance of the line.

b- Find the values of the parameters B and C. [10 points]

c- Suppose that the load at the receiving end of the line is 750 MVA at a lagging power factor of 0.85 at rated voltage. Determine the sending end voltage, current, active and reactive power and power factor. [5 points]

Problem 2

a- Explain the meaning of the terms over-excited and under-excited with respect to synchronous machines, and explain how a synchronous machine can be operated to appear as a source of reactive power. [5 points]

b- A salient pole synchronous machine is connected to an infinite bus whose voltage is kept constant at 1.10 pu. The direct and quadrature axis reactances of the machine are 0.5 and 0.25 pu respectively. The table given below relates to three operating conditions of the machine. (Q_2 is the reactive power at machine terminals) Complete the table neglecting armature reaction. [15 points]

	P (pu)	**Q_2 (pu)**	**E (pu)**	δ
Condition A	?	?	1.00	27.5.0°
Condition B	1.5	?	?	25°
Condition C	?	0.10	1.05	?

Problem 3

a- A 500 KVA, 2300/230 V single phase transformer delivers full rated KVA at 0.9 p.f. lagging to a load at rated secondary voltage. The primary voltage magnitude is 2400 V under these conditions and the efficiency is 0.92. Find the equivalent circuit parameters of this transformer neglecting the no load circuit. [10 Points]

b- Consider a 2300/230 V single phase transformer whose equivalent series impedance referred to the high voltage side is Z=0.25 + j 0.4 Assume that the load on the secondary of the transformer is 400 kVA at 0.95 p.f. lagging with the receiving end voltage maintained at 225 V. Find the active power input at the primary side. [10 Points]

Problem 4

a- List the advantages and disadvantages of using shunt capacitors on electric power transmission lines. [5 points]

Consider the system shown in the single-line diagram of Figure 1. It is suggested that the converged solution for the bus voltages gives $V_2 = 1.00057 - j\,0.03669$ pu and $V_3 = 1.0297 + j\,0.0246$ pu. It is required to:

b- Write down the elements of the bus admittance matrix Y. [5 points]

c- Using the converged solution, verify the values of active and reactive power at the load bus 2. [5 points]

d- Using the converged solution, find the values of active and reactive power at the slack bus 1. [5 points]

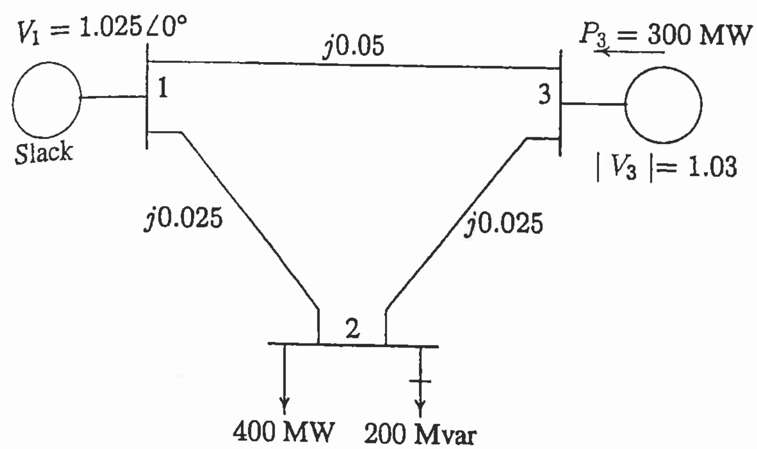

Figure 1 Single-line diagram for Problem 4

Problem 5

Consider the system shown in the single-line diagram of Figure 3. 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 1. [10 points]

b- Find the fault current supplied by each generator and the voltage at each of the buses 2 and 3 under fault conditions. [10 points]

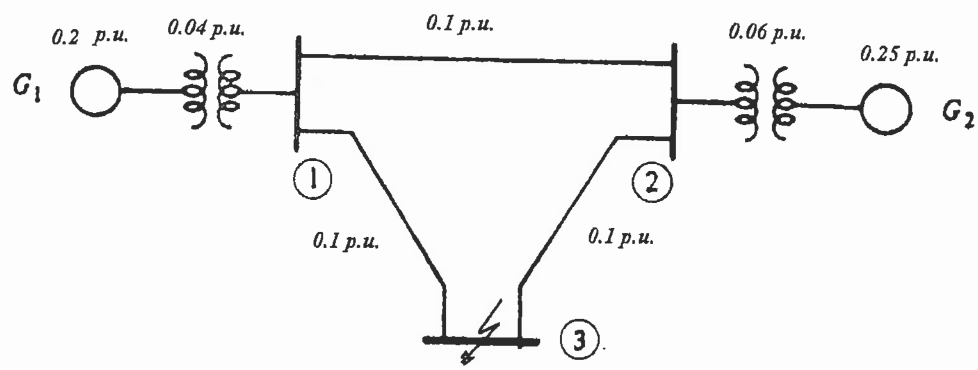

Figure 2 Single-line diagram for Problem 5

Problem 6

Consider the system shown in the single-line diagram of Figure 4. The required sequence reactances in per unit to the same base are as follows:

G_1	$X_1 = X_2 = 0.20$	$X_o = 0.1$
G2	$X_1 = X_2 = 0.25$	$X_o = 0.1$
Transformers	$X_{T1} = 0.04$	
	$X_{T2} = 0.06$	
Lines: Positive and Negative Sequence	$X_{12} = 0.10$	
	$X_{13} = X_{23} = 0.15$	
Lines: Zero Sequence	$X_{12} = 0.25$	
	$X_{13} = X_{23} = 0.30$	

a- Draw the zero-, positive-, and negative- sequence reactance diagrams. [7.5 points]

b- Determine the Thevenin's equivalent of each sequence network as viewed from the fault location in the middle of line 1-3. [7.5 points]

c- Determine the fault current in per unit for a single line to ground fault at the fault location in the middle of line 1-3. [5 points]

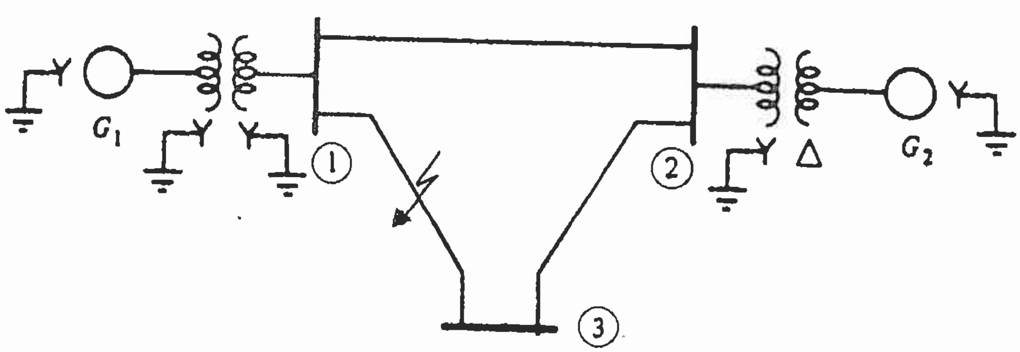

Figure 3 Single line diagram for Problem 6

Problem 7

Consider the circuit shown in Figure 5. Assume that E = 1.5 p.u., and V = 1.00 p.u. The active power of the load on the circuit is 2.4 p.u., when a three phase short circuit takes place in the middle of transmission line 3.

a Find the initial power angle δ and the reactive component of the load. [5 Points]

b Show analytically that the system will remain stable under a sustained fault. [5 Points]

c Determine the maximum angle of oscillation under a sustained fault. [10 Points]

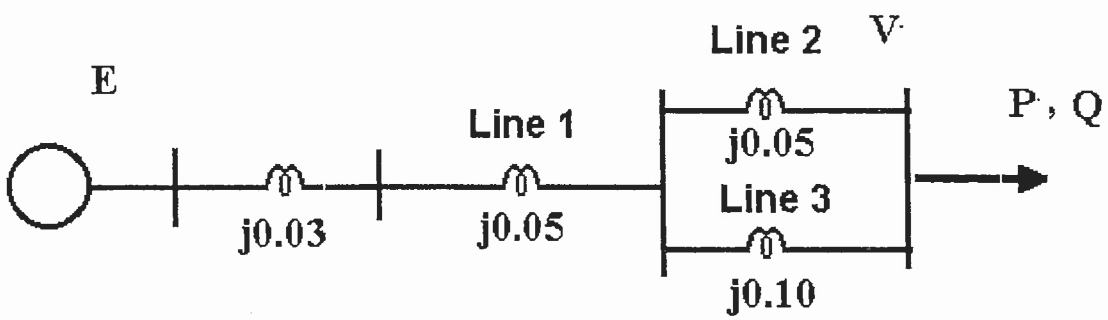

Figure 4 Circuit for Problem 7