National Exams December 2008

98-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- Discuss the effect of increasing conductor spacing, for the same conductor size, on the values of inductance and capacitance of transmission lines. What are the associated effects on operational characteristics of the line? [5 Points]

A transmission line is represented by the following parameters:

$B = 0.2\angle 85^\circ$ $C = 0.2\angle 85.4^\circ$

b- Find the parameter A. [5 Points]

The sending end voltage and current are specified as:

$V_s = 1.15\angle 9.1^\circ$

$I_s = 1.084\angle -27.6^\circ$

c- Find the values of the current, voltage, apparent power, active, and reactive power and power factor at the receiving end of the line. [10 Points]

Problem 2

a- Explain the differences between salient-pole and cylindrical rotor synchronous machines in terms of reactance and maximum power transfer values. [5 points]

b- A three phase salient pole synchronous generator is connected to an infinite bus bar. The quadrature axis and direct axis reactance are X_d = 12 Ω and X_q=9Ω. The line-to-line voltage of the infinite bus is 35 kV, and the line-to-neutral excitation voltage E is 30 kV. Determine the value of power angle δ corresponding to maximum active power delivered to the bus. Compute the value of maximum active power [15 points]

Problem 3

a- Explain the functions of insulating oils used in transformer tanks. [5 Points]

A 250-kVA, 2200/220 V, 60-Hz, single-phase transformer has the following equivalent-circuit parameters referred to the high-voltage side.

R_{eq} = 0.45 Ω X_{eq} = 2.1 Ω

G_c = 2.5 x10^{-4} S B_m = 4x10^{-4} S

Use the equivalent Cantilever model circuit of the transformer shown in Figure (1.)

b- Determine the magnitude of primary current and voltage when the transformer supplies a secondary side load of 180 kVA at 220-V and a lagging power factor of 0.8. [5 Points]

c- Determine the value of the apparent power at the primary of the transformer, the power factor at the primary side and the voltage regulation of the transformer under the conditions of part (b.) [5 Points] d- Assume that the primary current of the transformer is 120 A at 2200- V and 0.85 power factor lagging. Determine the value of the kVA load on the secondary, the efficiency, and the corresponding load power factor. [5 Points]

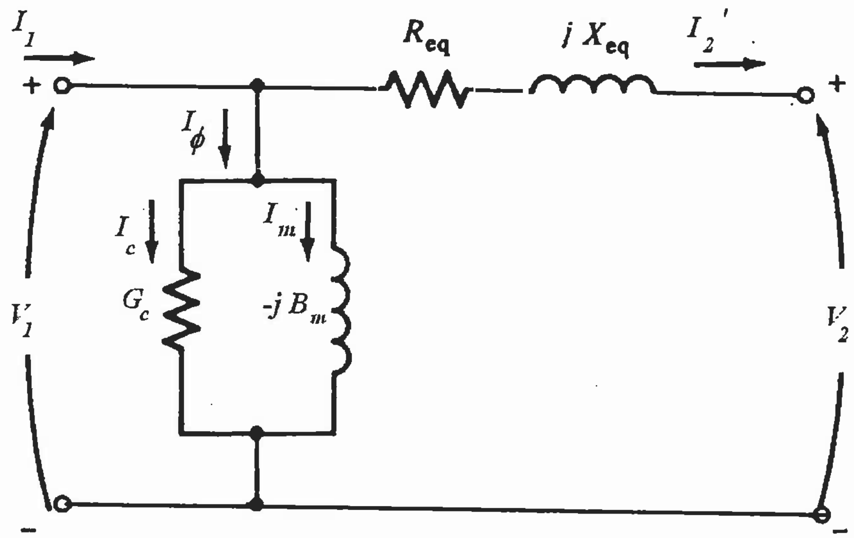

Figure (1) Equivalent Circuit of Transformer for Problem 3

Problem 4

a- The reactive power load at a bus is increased by an increment ΔQ, explain how to determine the corresponding change in voltage $|\Delta V|$. [3 Points]

For the two bus system shown in Figure (2,) bus 1 is the reference (slack) bus with $|V_1| = 1.00$ and $\delta_1 = 0.0^\circ$. The load at bus 2 is 100 MW and 50 Mvar and the line impedance is $z_{12} = 0.12 + j0.16$ as shown in the figure. (Base MVA = 100) The expressions for active and reactive power at bus 2 are given by:

$$P_2 = -1.0 = 5\left[|V_2|\cos(126.87^o - \delta_2) + 0.6|V_2|^2\right]$$

$$Q_2 = -0.5 = 5\left[-|V_2|\sin(126.87^o - \delta_2) + 0.8|V_2|^2\right]$$

b- It is required to raise the magnitude of the voltage $|V_2|$ to 0.95 pu using a capacitor. Find the corresponding angle δ_2 [5 Points]

c- Find the MVAR rating of the capacitor. [5 Points]

d- Find the active and reactive powers at bus 1 [3 Points]

e- Find the active and reactive power loss in the line. [4 Points]

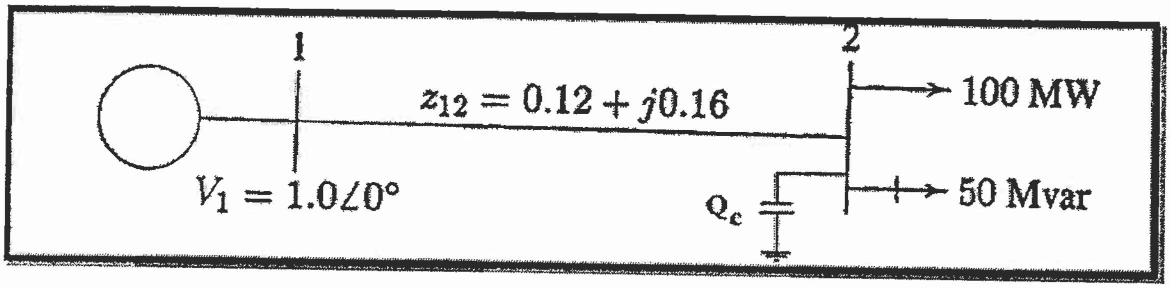

Figure (2) One-line Diagram for Problem 4

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 5. [5 Points]

b- Find the voltage at bus 4 under the fault conditions of part a [5 Points]

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

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

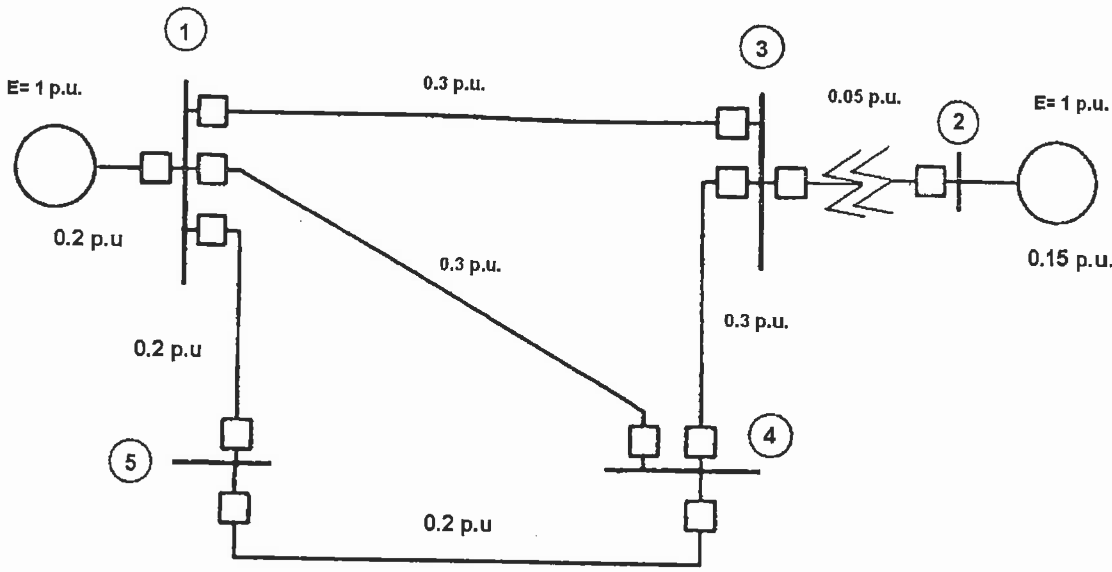

Figure (3) Single-line diagrams for Problem 5

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 and G2	$X_1 = X_2 = 0.20$	$X_o = 0.05$
Transformers	$X_{T1} = X_{T2} = 0.05$	
Lines: Positive and Negative Sequence	$X_{13} = X_{12} = X_{23} = 0.10$	
Lines: Zero Sequence	$X_{12} = X_{13} = X_{23} = 0.30$	

The neutral of G_1 is grounded through a reactance of $X_n = 0.05$ in per unit.

a- Draw the zero-, positive-, and negative- sequence reactance diagrams. [5 Points]

b- Determine the The'venin's equivalent of each sequence network as viewed from the fault bus 3. [10 Points]

c- Determine the fault current in per unit for a single line to ground fault at bus 3. [5 Points]

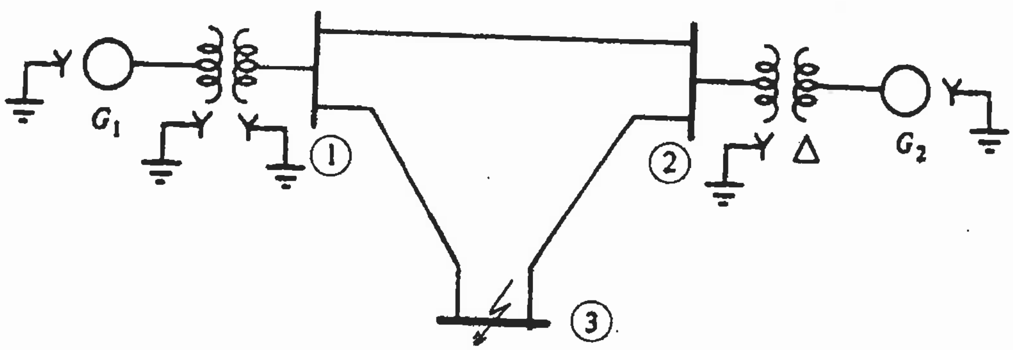

Figure (4) Single line diagram for Problem 6

PROBLEM 7

Consider the circuit shown in Figure (5.) Assume that E = 1.5 p.u., and V = 1.00 p.u. The active component of the load on the circuit is 3.8 p.u., when a three phase short circuit takes place in the middle of transmission line 3.

a- Find the initial power angle δ. [5 Points]

b- Will the system remain stable under a sustained fault? [15 Points]

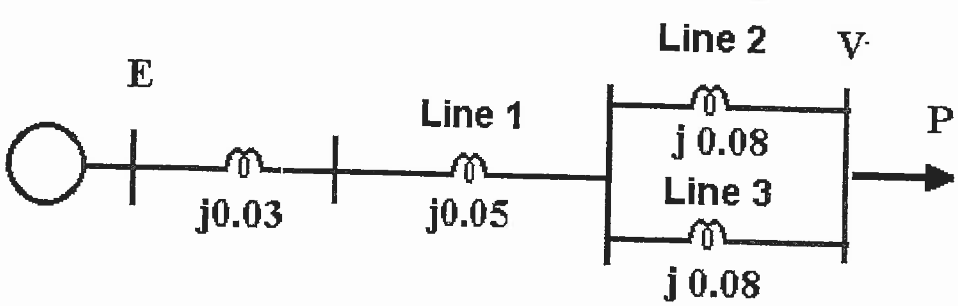

Figure (5) Circuit for Problem 7