National Exams May 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

a- Explain the meaning of the term "line transposition" and why is it needed. [5 Points]

b- Consider a three-phase transmission line modeled using the ABCD parameters as follows:

$$V_s = AV_r + BI_r$$
$$I_s = CV_r + AI_r$$
$$A^2 - BC = 1$$

Assume that:

$$C = 0.18\angle 87^\circ$$

Suppose that the apparent power load at the receiving end of the line is 1.25 pu, at 0.8 power factor lagging while the receiving end voltage is 1.05 pu. The sending end current is found to be $I_s = 1.1\angle -28^\circ$. Find the values of the line parameters A, and B. [5 Points]

c- Find the sending end voltage, power factor, and efficiency of transmission under the operating conditions of part (b). [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 $X_d = 12.5\ \Omega$ and $X_q = 9.75\ \Omega$. 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 effects of frequency on different types of losses in an electric transformer. [5 points]

A 25-kVA, 2200/220 V, 60-Hz, single-phase transformer has the following equivalent-circuit parameters referred to the high-voltage side.

$R_1 = 2.6\ \Omega$ $R'_2 = 2.6\ \Omega$

$X_{l1} = 10.5\ \Omega$ $X'_{l2} = 10.5\ \Omega$

$X_m = 25{,}000\ \Omega$ $R_c = 40{,}000\ \Omega$

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

b- A short circuit test is conducted on the transformer with 22 volts applied to the secondary side with the primary short circuited. Determine the readings of the ammeter and wattmeter connected to the secondary side for this test. [5 points]

c- An open circuit test is conducted on the transformer with 2,200 volts applied to the primary side with the secondary side left open. Determine the readings of the ammeter and wattmeter connected to the primary for this open circuit test. [5 points]

d- The transformer is supplying 15 kVA at 220-V and a lagging power factor of 0.85. Determine the primary voltage. [5 points]

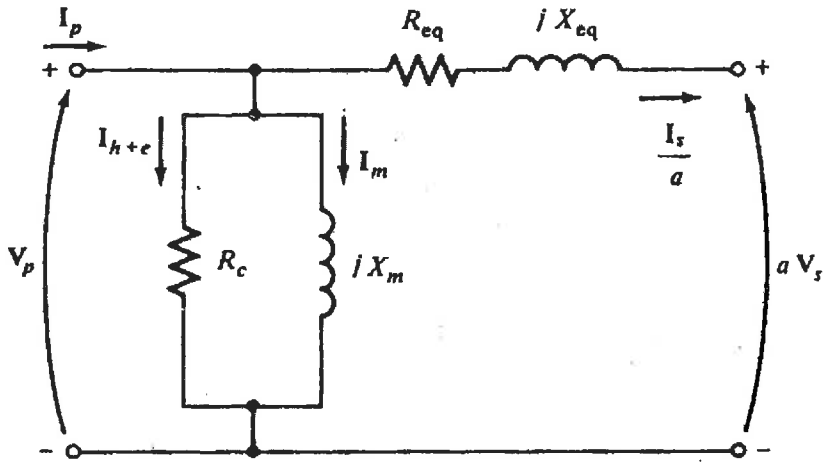

Figure (1) Equivalent Circuit of Transformer for Problem (3)

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 (2.) It is suggested that the converged solution for the bus voltages gives $V_2 = 1.01\underline{/-2.1^0}$ pu and $V_3 = 1.03\ \underline{/1.37^\circ}$ 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]

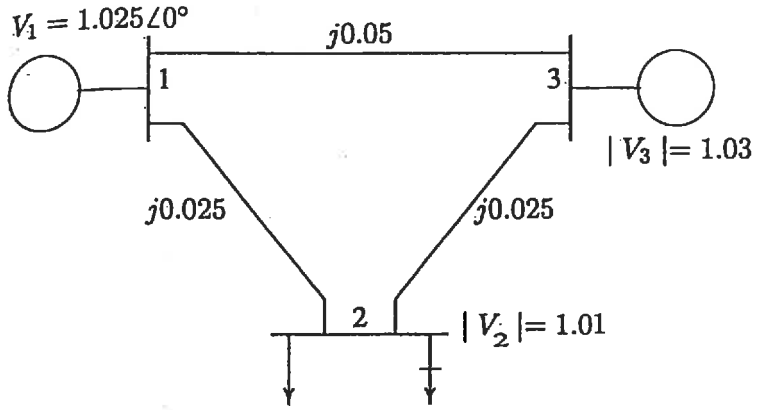

Figure (2) Single-line diagram for Problem (4)

Problem 5

a- Discuss the consequences of short circuit faults on an electric power systems [5 points]

b- Protective schemes are routinely used for electric power transformers. Name at least three different types of transformer protective schemes (by function) and explain briefly their principles of operation. [5 points]

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.

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

d- Find the voltages at buses 1 and 3 under the fault conditions of part c above [5 points]

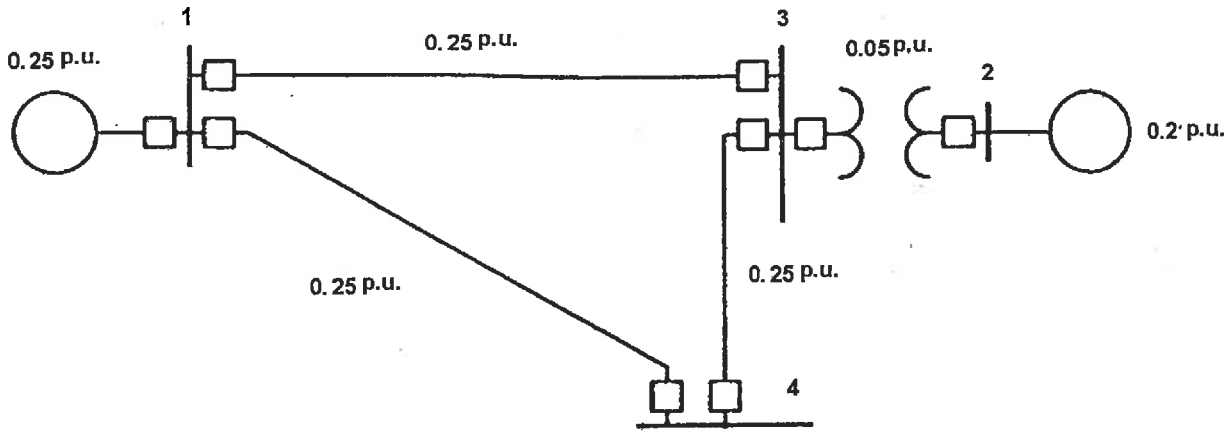

Figure (3) Single-line diagram for Problem (5)

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 and G2 $X_1 = X_2 = 0.20$ $X_o = 0.05$

Transformers $X_{T1} = X_{T2} = 0.07$

Lines: Positive and Negative Sequence $X_{13}=X_{12}=X_{23} = 0.27$

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]

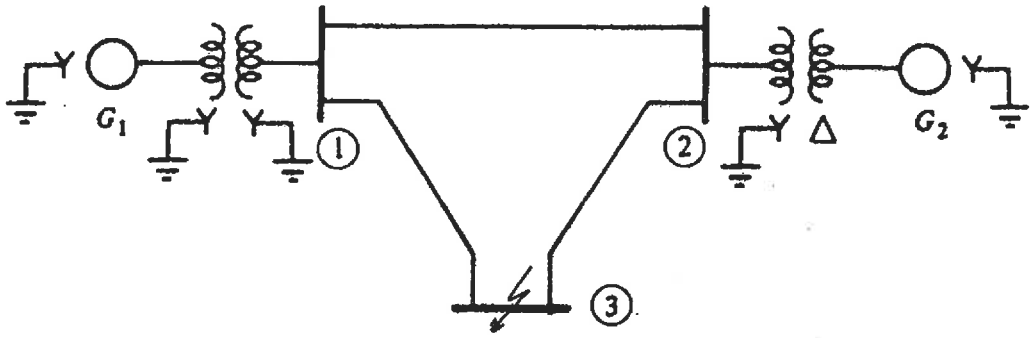

Figure (4) Single line diagram for Problem (6)

Problem 7

Consider the circuit shown in Figure (5.) Assume that E = 1.25 p.u. and V = 1.00 p.u.

a Find the initial power angle δ when the active component of the load on the circuit is 2.8 p.u. [5 points]

b A three phase short circuit takes place in the middle of transmission line 3. Determine whether the system will remain stable or not when the fault is sustained. [10 points]

c Determine the maximum angle of oscillation under a sustained fault. [5 points]

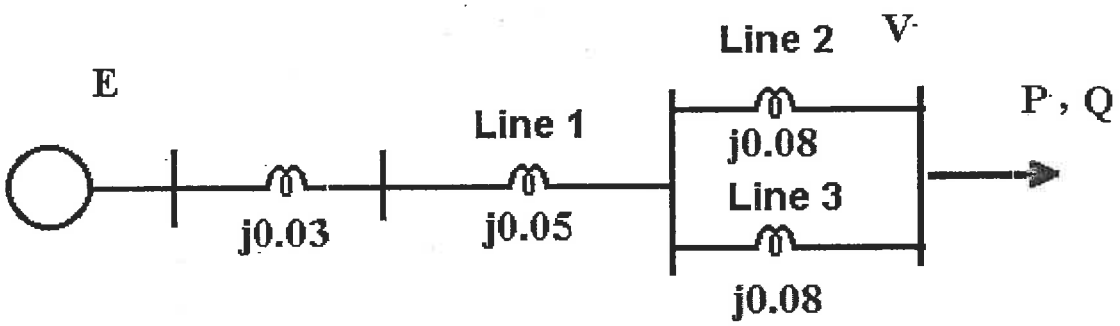

Figure (5) Circuit for Problem (7)