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National Exams May 2013

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- Discuss the effects of increasing the ambient temperature on the series impedance Z and the shunt admittance Y of the line. [5 Points]

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

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

Assume that:

$$A = 0.98\angle 0.2^o$$

Suppose that the apparent power load at the receiving end of the line is 1.25 pu, at 0.85 power factor lagging while the receiving end voltage is 1 pu. The sending end voltage is found to be $V_s = 1.15\angle 9^o$. Find the line parameters B, and C. [5 Points]

c- Find the sending end *current, power factor, and efficiency* of transmission under the conditions cited in part (b). [10 Points]

Problem 2

a- Explain the meaning of the term "transposition of a line," and describe how it is done. [5 Points]

b- A salient-pole synchronous machine with negligible armature resistance has the following parameters all expressed in the per unit system:

$$X_d \approx 1.15 \qquad X_q = 0.95$$

The machine is connected to a transmission line represented by:

$$A = 0.98\angle 0.2^o \qquad B = 0.2\angle 85^o$$

The load at the end of the line draws a current of 1 pu at a voltage of 1 pu. The load power factor is unity. Calculate the apparent power output of the machine. [10 Points]

c- Calculate the required excitation voltage and torque angle. [5 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.

$R_{eq.} = 0.475\ \Omega$ $\qquad$ $X_{eq} = 2.15\ \Omega$

$G_c = 2.5 \times 10^{-4}$ S $\qquad$ $B_m = 4 \times 10^{-4}$ 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 125 A at 2200- V and 0.8 power factor lagging. Determine the value of the kVA load on the secondary, the efficiency, and the corresponding load power factor. [5 Points]

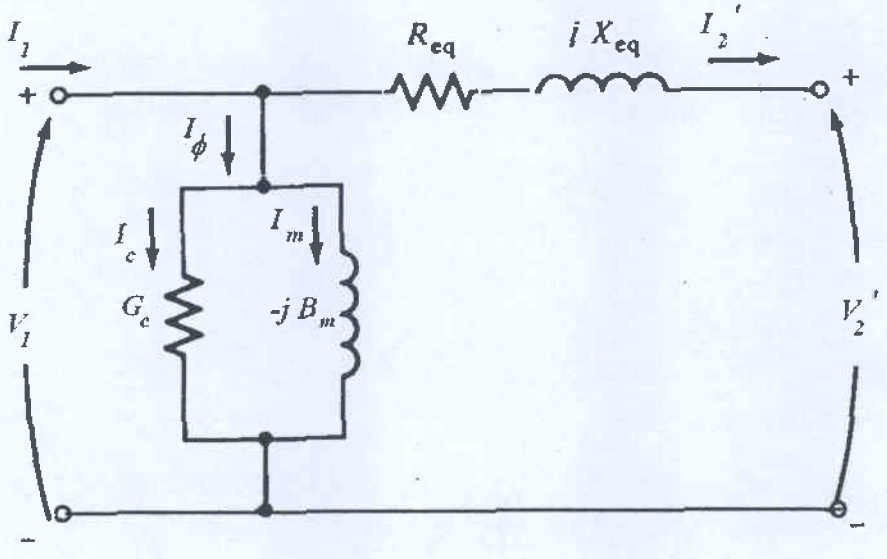

Figure (1) Equivalent Circuit of Transformer for Problem 3

Problem 4

a- List the types of buses in a conventional power flow problem formulation. For each type, identify the known and unknown variables. [5 Points]

In the simple electric power system shown in Figure (2), it is required to find the following:

b- The voltage magnitude and the reactive power injection at bus 2 assuming that the voltage angle is -8.5°. [5 Points]

c- The active and reactive power generated at bus 1. [5 Points]

d- The active and reactive power generated at bus 3. [5 Points]

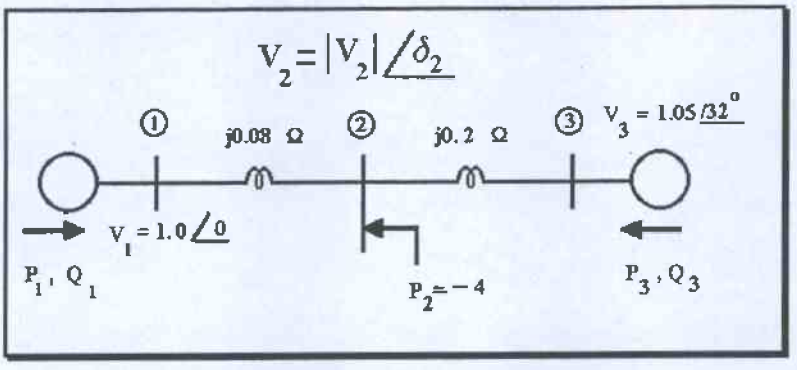

Figure (2) Circuit for Problem 4

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 3. [10 points]

b- Find the fault current supplied by each generator and the voltage at each of the buses 1 and 2 under fault conditions. [10 points]

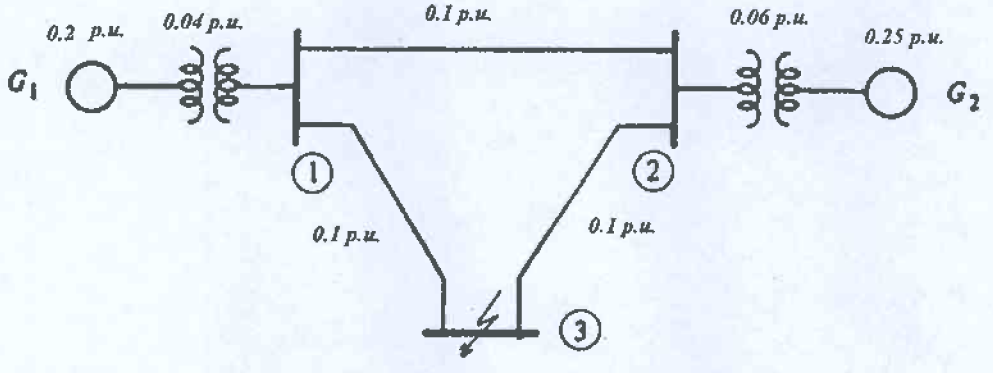

Figure 2 Single-line diagram for Problem 5

PROBLEM 6

Consider the currents seen at breaker B2 due to faults that take place at bus 3, in the system shown in the single-line diagram of Figure (4.) The source voltage is 34.5 kV, line-to-line. Determine the fault currents for the following faults:

a- Symmetrical three phase fault. [3 points]

b- Single line to ground fault. [5 points]

c- Double line to ground fault [5 points]

d- Line to line fault. [5 points]

e- Which fault involves the smallest fault current? [2 points]

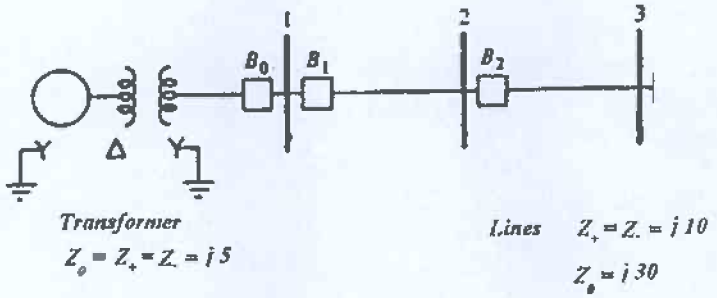

Figure (4) Single line diagram for Problem 6

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 3.1 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]

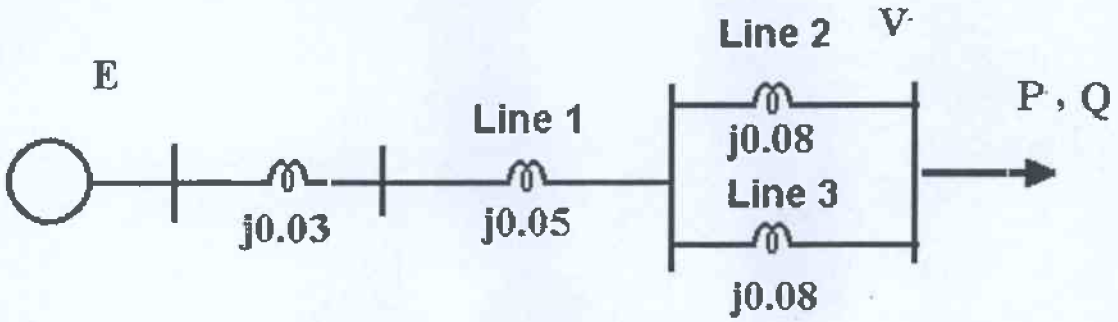

Figure (5) Circuit for Problem (7)