National Exams May 2004

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 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:

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

Assume that:

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

Suppose that the apparent power load at the receiving end of the line is 1.2 pu, at 0.8 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- Sketch the reactive capability curve of a synchronous machine, and explain the underlying principles for its various segments. [5 points]

b- A round rotor synchronous machine is connected to an infinite bus whose voltage is kept constant at 1.00 pu. The synchronous reactance of the machine is 0.375 pu. 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	Q_2	E	δ
Condition A	?	0.0	1.12	?
Condition B	2.25	0.0	?	?
Condition C	?	?	1.25	37.5°

Problem 3

a- List the different types of losses in a transformer and explain possible ways of reducing them. [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.

$R_1 = 3.0\ \Omega$	$R'_2 = 3.0\ \Omega$
$X_{l1} = 12\ \Omega$	$X'_{l2} = 12\ \Omega$
$X_m = 20{,}000\ \Omega$	$R_c = 50{,}000\ \Omega$

The transformer is supplying 17.5 kVA at 220-V and a lagging power factor of 0.8. Use the equivalent Cantilever model circuit of the transformer shown in Figure (1). Determine:

b- The magnitude of the required primary voltage. [7.5 points]

c- The power factor of the primary side, the input kVA, and the efficiency of the transformer. [7.5 points]

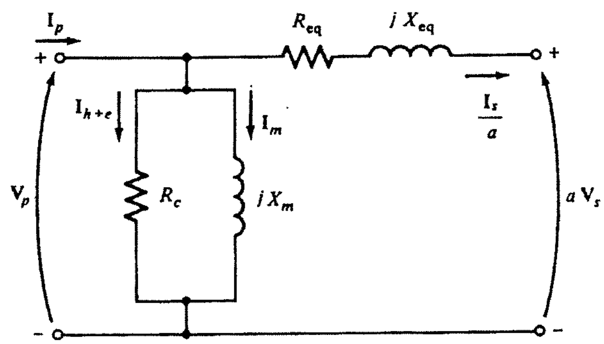

Figure 1 Equivalent Circuit of Transformer for Problem 3

Problem 4

a- What are the advantages and disadvantages of applying shunt capacitors in electric power systems. [5 points]

Consider the system shown in the single-line diagram of Figure 2, where the line admittance between bus 1 and 2 is the same as that between bus 1 and 3 as: $Y_L = 4 - j5$. It is required to:

b- Find the voltage V_2 and its phase angle exactly given that $S_{D2} = 0.8 + j0.6$. [5 points]

c- Find the voltage V_3 and its phase angle exactly given that $S_{D3} = 0.4 + j0.3$ [5 points]

d- Find the value of S_{G1} and the generator power factor. [5 points]

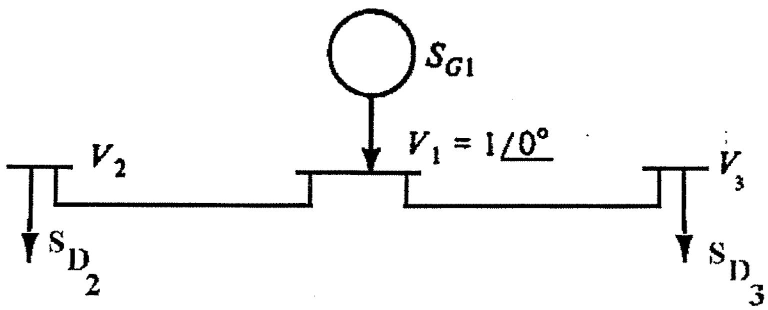

Figure 2 Single-line diagram for Problem 4

Problem 5

a- Discuss the main causes for short circuit faults on Canadian electric power systems. [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.

b- Find the voltage at bus 1 due to a bolted- three-phase short circuit on line 1-3 at F1 as indicated in Figure (3-a). [7.5 points]

c- Assume that line 1-3 is opened as a result of the fault condition F1. Subsequently a bolted- three-phase short circuit takes place on line 1-4 at F2 as indicated in Figure (3-b). Find the voltage at bus 1 under fault conditions. [7.5 points]

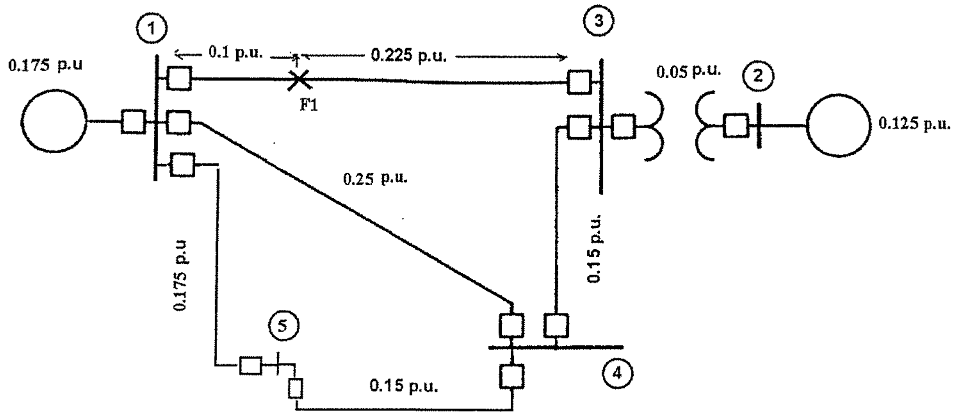

Figure 3-a Single-line diagram for fault 1 in Problem 5

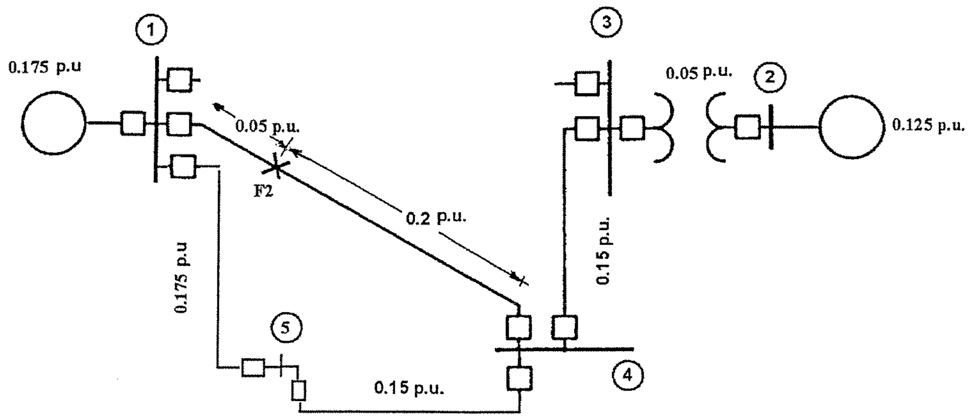

Figure 3-b Single-line diagram for fault 2 in Problem 5

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	$X_1 = X_2 = 0.20$	$X_o = 0.05$
G2	$X_1 = X_2 = 0.25$	$X_o = 0.075$
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]

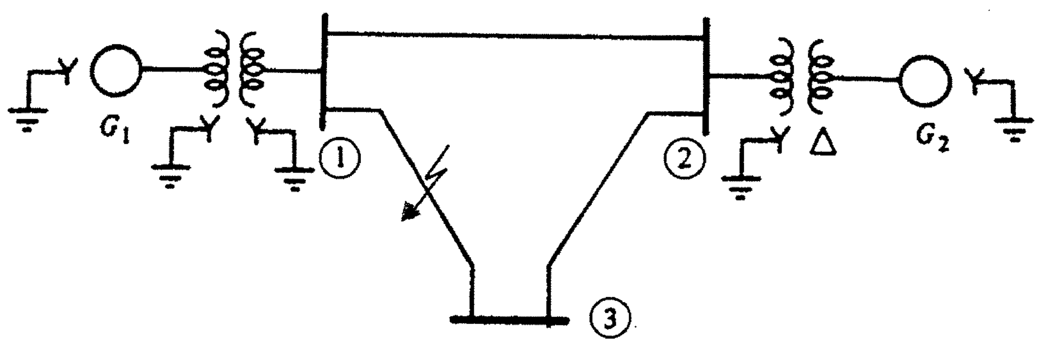

Figure 4 Single line diagram for Problem 6

Problem 7

Consider the system shown in the single-line diagram of Figure 5. Here, a 60-Hz synchronous generator having a transient reactance of 0.15 pu. is connected to an infinite bus through a transformer whose reactance is 0.1 p. u. and a double circuit transmission line with circuits having a reactance of 0.6 p.u. each as indicated in the figure. The generator delivers a real power of 0.9 pu. to bus 1. The magnitude of the voltage at bus 1 is 1.05 pu. The infinite bus voltage is 1.0 pu with an angle zero.

a- Determine the excitation voltage of the generator under these conditions. [10 points]

b- A three phase fault occurs at the middle of one transmission circuit as shown. Assume that the generator excitation voltage remains constant at E'= 1.14 pu. Let the parameter (a) be 0.25 (i.e. the fault is close to bus 1). Will the system remain stable under sustained fault conditions? [10 points]

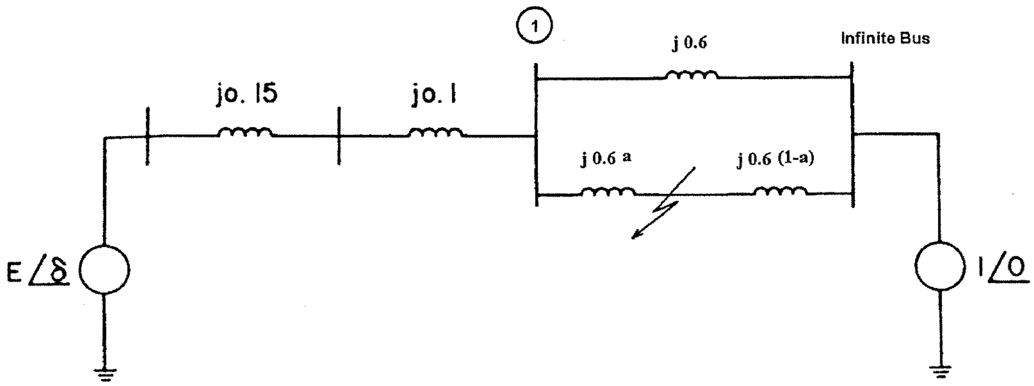

Figure 5 Circuit for Problem 7