National Exams December 2003

98-Elec-B7, Power Systems Engineering

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 "transposed line" and why is it needed. [5 Points]

A 600-km, 765-kV, 60 Hz three phase transmission line has a series impedance z=0.02 + j 0.32 Ω/km and a shunt admittance y = j 5x10^{-6} S/km. The full load at the receiving end is 2000 MVA at a lagging power factor of 0.85 and at 97.5% rated voltage. Determine:

b- The ABCD parameters of the line using the exact long line hyperbolic expressions. [7.5 Points]

c- The sending end voltage, current, power factor and transmission efficiency. [7.5 Points]

PROBLEM 2

a- List the different types of losses in a transformer and explain possible ways of reducing them. [5 points]

A 5000-kVA 115/13.8-kV single-phase power transformer has a per unit resistance of 1 percent and a per unit reactance of 5 percent. The following data pertain to an open-circuit test performed on the low-voltage side of the transformer:

V_{OC} = 13.8 kV $\quad$ I_{OC} = 15 A $\quad$ P_{OC} = 45 kW

b- Find the elements of the equivalent circuit of the transformer in ohms referred to the low-voltage side. Use the equivalent circuit shown in Figure 1. [5 points]

c- If the voltage on the secondary side is 13.8 kV and the power supplied is 4,500 kW at 0.9 PF lagging, find the primary voltage, current, power factor, and efficiency of the transformer under these conditions. [10 points]

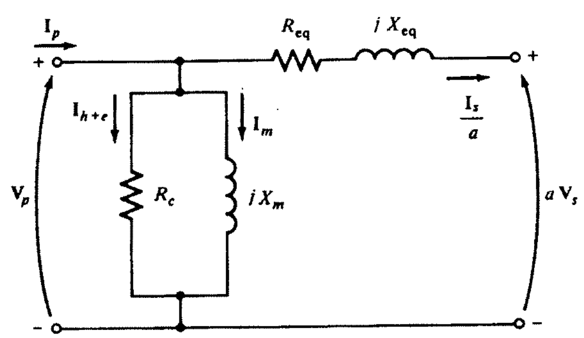

Figure 1 Equivalent Circuit of Transformer for Problem 2

PROBLEM 3

a- Explain the differences in features and uses between a salient pole and a round rotor synchronous machine. [5 Points]

The reactances x_d and x_q of a salient-pole synchronous generator are 0.95 p.u. and 0.35 p.u. respectively.

b- Suppose that the excitation voltage is 1.6 p.u., and that the machine terminal bus voltage is maintained at 1 p.u. Compute the active and reactive power supplied to the infinite bus for a power angle δ of 30°. [7.5 Points]

c- Evaluate the excitation and machine terminal bus voltages when the generator is supplying a load of 1.3 p.u. at unity power factor for a power angle δ of 27°. [7.5 Points]

PROBLEM 4

Consider the system shown in the single-line diagram of Figure 2. All reactances are shown in per unit to the same base. It is required to find the following:

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

b- The voltage magnitude and its phase angle at bus 3. [5 Points]

c- The active and reactive power of the load at bus 3. [5 Points]

d- The active and reactive power generation at bus 4. [5 Points]

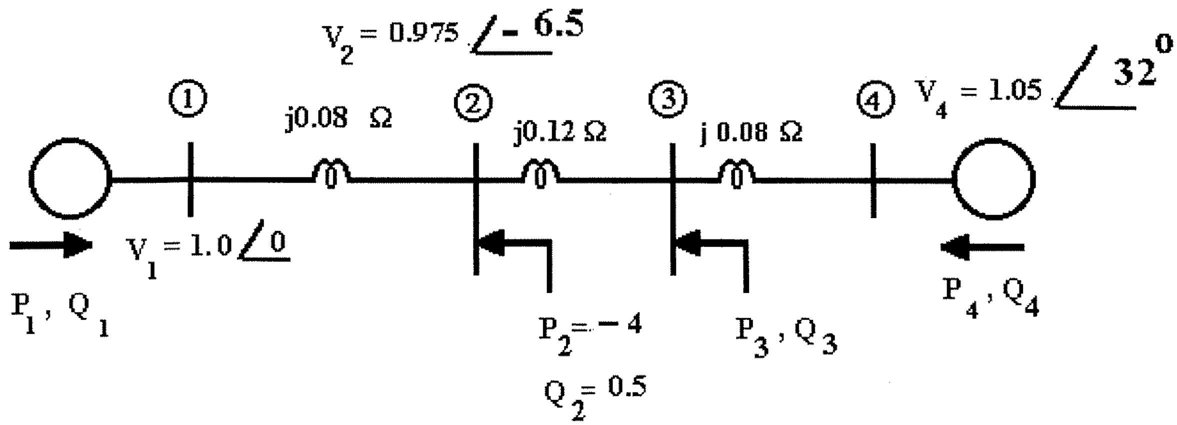

Figure 2 Single-line diagram for Problem 4

PROBLEM 5

a- Discuss the consequences of short circuit faults on 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 in the middle of line 3-4. [5 Points]

d- Find the voltages at buses 2 and 4 under the fault conditions of part c above [5 Points]

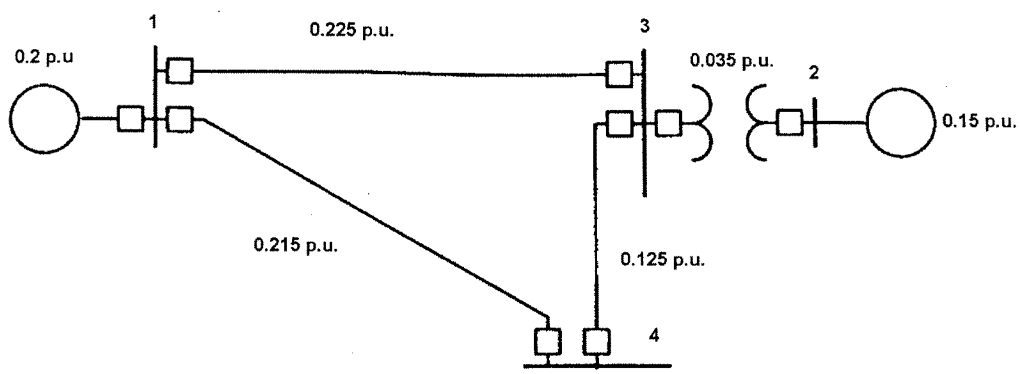

Figure 3 Single-line diagram for Problem 5

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	$X_1 = X_2 = 0.25$	$X_o = 0.04$
G2	$X_1 = X_2 = 0.2$	$X_o = 0.08$
Transformers	$X_{T1}= 0.04$	
	$X_{T2}= 0.05$	
Lines: Positive and Negative Sequence	$X_{12}= 0.10$	
	$X_{13}= X_{23} = 0.12$	
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 bus 3. [7.5 Points]

c- Determine the fault currents in phases B and C in per unit for a line to line fault between phases B and C at bus 3. [5 Points]

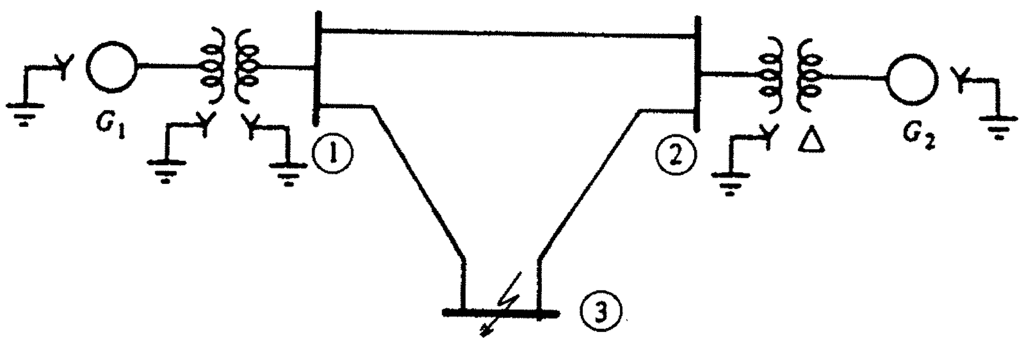

Figure 4 Single line diagram for Problem 6

PROBLEM 7

Consider the circuit shown in Figure 5. Assume that E = 1.6 p.u., and V = 1.00 p.u. The reactive component of the load on the circuit is 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 active 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]

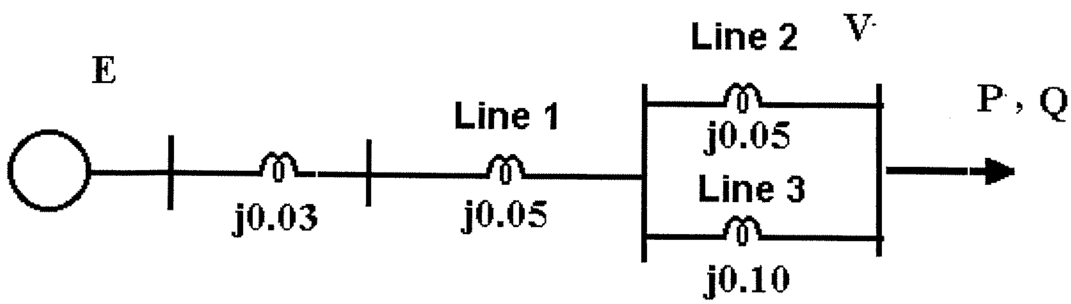

Figure 5 Circuit for Problem 7