National Exams December 2010

07-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 450-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 5×10^{-6} S/km. The full load at the receiving end is 2250 MVA at a lagging power factor of 0.8 and at 98 % of 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- Sketch the reactive capability curve of a synchronous machine, and explain the underlying principles for its various segments. [5 points]

b- A salient pole synchronous machine is connected to an infinite bus whose voltage is kept constant at 1.00 pu. The direct and quadrature axis reactances of the machine are 0.75 and 0.20 pu respectively. 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 (pu)	Q_2 (pu)	E (pu)	δ
Condition A	?	?	1.2	27.5°
Condition B	2.1	?	?	22.5°
Condition C	?	0.00	1.15	?

Problem 3

a- List five different transformer types used in the electric power system. [5 points]

Consider a three-winding transformer, as shown in Figure 1, with the following particulars:

Z_p= 0.01+j 0.08 Z_s= 0.01+j 0.08 Z_t= 0.01+j 0.08

V_2=440 $I_2=100\angle{-25^\circ}$ $I_3=80\angle{-35^\circ}$

Assume that V_2 is the reference phasor, calculate:

(a) The intermediate voltage V_0 (3 points)

(b) The primary current I_1 and the primary voltage V_1. (3 points)

(c) The tertiary voltage V_3 referred to the primary side. (3 points)

(d) The apparent powers and power factors at the primary, secondary and tertiary terminals. (3 points)

(e) The transformer efficiency. (3 points)

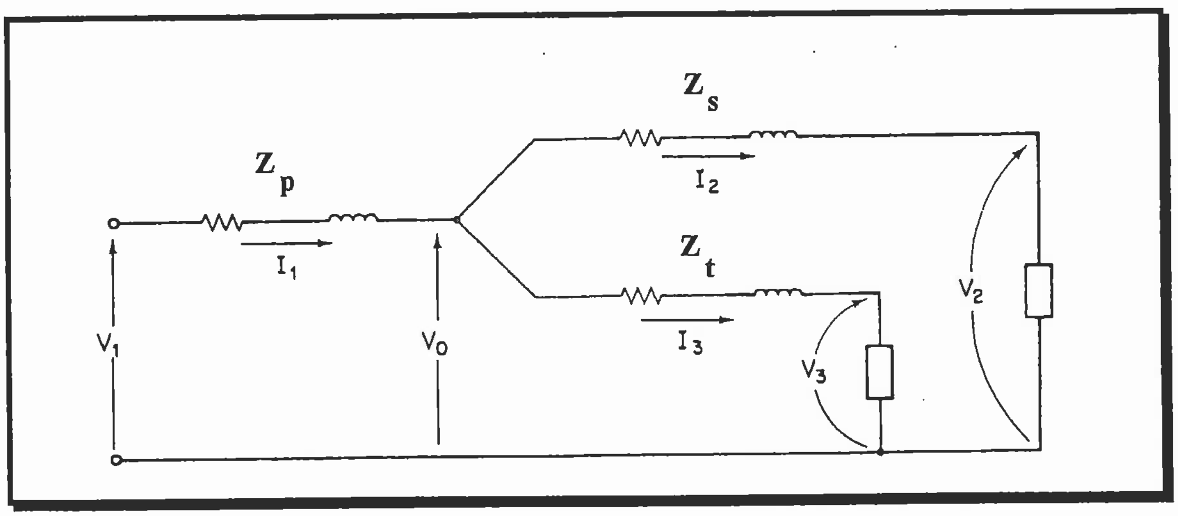

Figure (1) Three Winding Transformer Equivalent Circuit for Problem 3

Problem 4

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

Consider the system shown in the single-line diagram of Figure 2, where all line admittances are identical and have the same value of $Y_L = -j6$.

b- Write the bus admittance matrix of the system Y. What are the primary unknowns for the power flow problem for the system? [5 points]

c- Write the power flow equations assuming that bus 1 is the slack bus whose voltage is unity and whose angle is zero. Bus 2 is maintained at a voltage of 1.05 [5 points]

d- Evaluate the Jacobian Matrix required for Newton Raphson iterations at a flat start initial guess (all voltages are unity at zero angle.) [5 points]

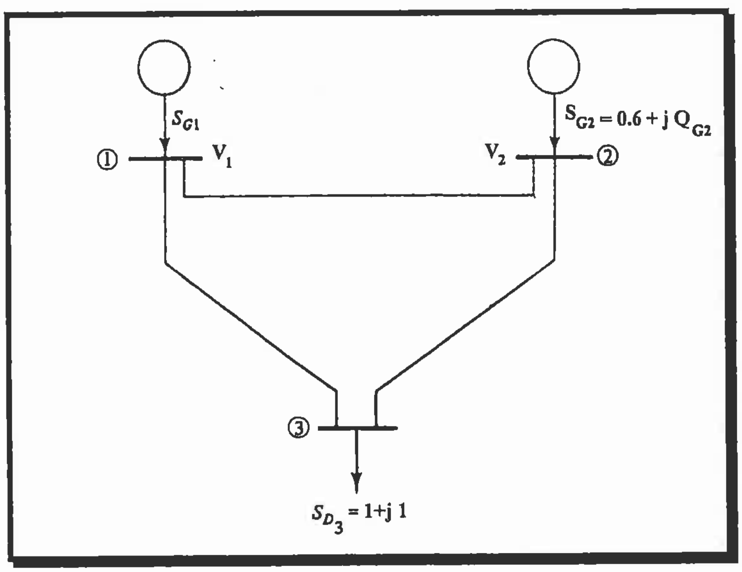

Figure (2) Single-line diagram for Problem 4

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 in the middle of line 1-3. [5 points]

d- Find the voltages at buses 1 and 2 under the fault conditions of part c above [5 points]

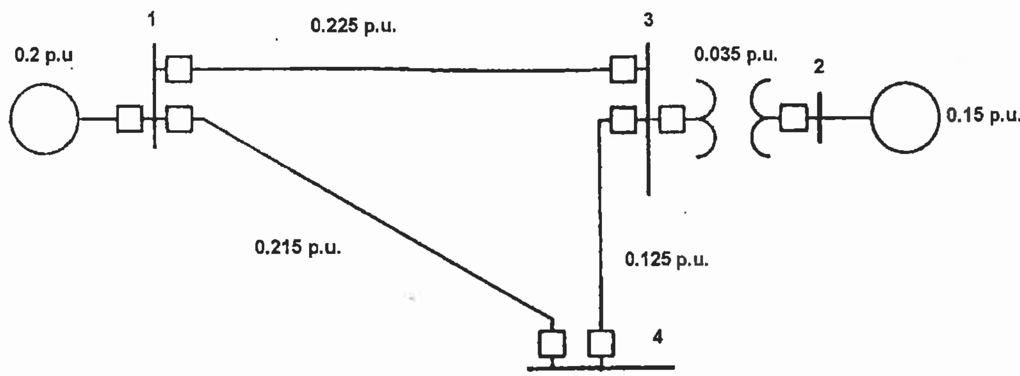

Figure (3) Single-line diagram for Problem 5

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	$X_1 = X_2 = 0.20$	$X_o = 0.05$
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 bus 3. [7.5 points]

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

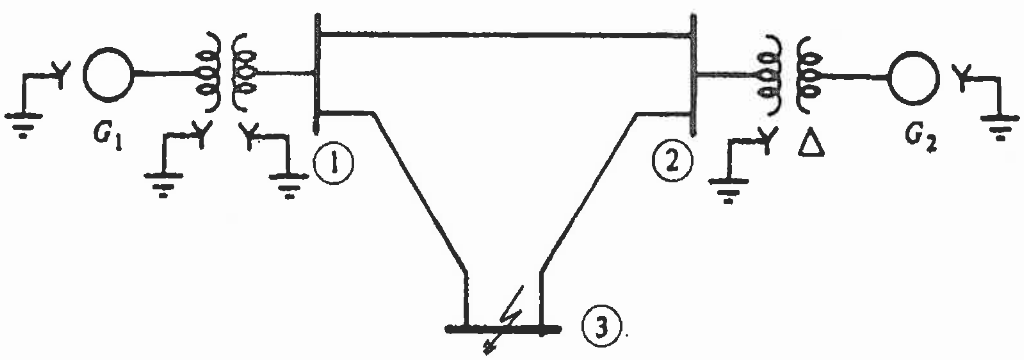

Figure (4) Single line diagram for Problem 6

Problem 7

a) List three techniques of enhancing stability performance of electric power systems [5 Points]

Consider the circuit shown in Figure (5.) Assume that E = 1.2 p.u., and V = 1.00 p.u. The active component of the load on the circuit is 3 p.u., when a three phase short circuit takes place in the middle of transmission line 3.

b) Find the initial power angle δ . [5 Points]

c) Will the system remain stable under a sustained fault? [10 Points]

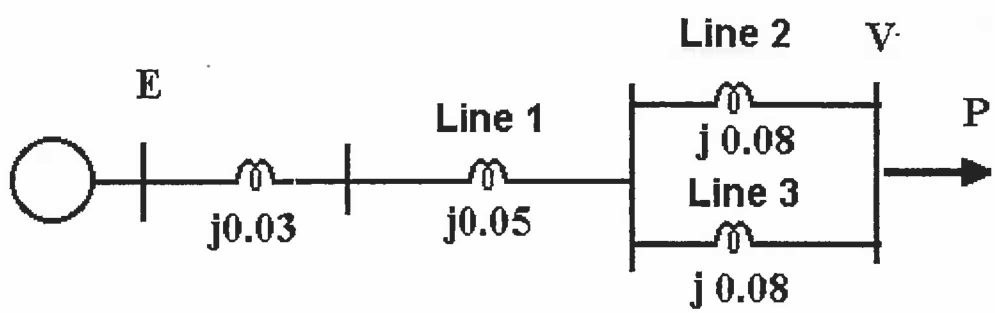

Figure (5) Circuit for Problem 7