

National Exams December 2011
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- List and explain three causes of unbalances in a high voltage transmission system. [5 Points]

Consider an experimental 2000 kV three phase bundle-conductor line with the following parameters:

$$A = 0.97$$

$$B = j56\Omega$$

$$A = \cosh \theta$$

$$B = Z \frac{\sinh \theta}{\theta}$$

$$\theta = \sqrt{ZY}$$

- b- Determine the value of the parameters Z , Y and C , then calculate the sending-end voltage, sending-end current, power, and power factor when the receiving end is delivering 17,500 MVA at 0.8 PF lagging at 2,200 kV. [15 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 p.u. The synchronous reactance of the machine is 0.4 p.u. 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	2.1	0.0	?	?
Condition B	?	?	1.1	40°
Condition C	?	0.0	1.18	?

PROBLEM 3

a- Explain the functions of insulating oils used in transformer tanks. [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.

$$R_{eq} = 6.5 \, \Omega$$

$$X_{eq} = 28 \, \Omega$$

$$G_c = 2 \times 10^{-5} \, S$$

$$B_m = 5 \times 10^{-5} \, S$$

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 22 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 efficiency of the transformer under the conditions of part (b) [5 Points]
- d- Assume that the power input to the primary of the transformer is 18 kW at 2200- V and 0.85 power factor lagging. Determine the value of the kVA load on the secondary and the corresponding power factor. [5 Points]

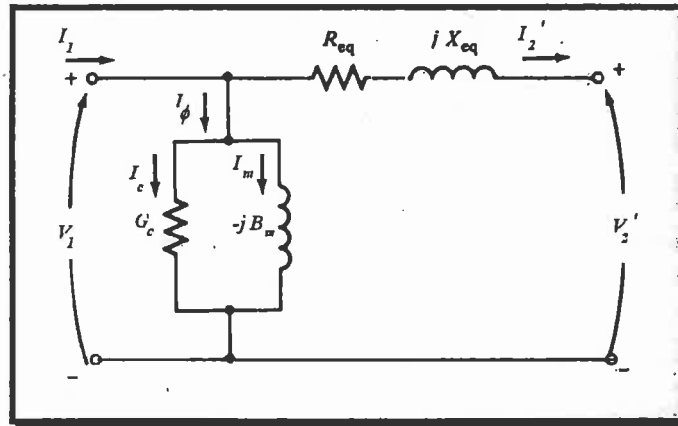


Figure (1) Equivalent Circuit of Transformer for Problem 3

PROBLEM 4

Consider the power system shown in Figure (2.)

- Assume that the reactive shunt compensation is $Q_{G2} = 0.0$. Show that it is not possible to serve the load S_{D2} under this condition [7 points]
- Find the voltage V_2 exactly when we set $jQ_{G2} = j3.0$. [7 points]
- Find the value of Q_{G2} to obtain $|V_2| = 1$. [6 points]

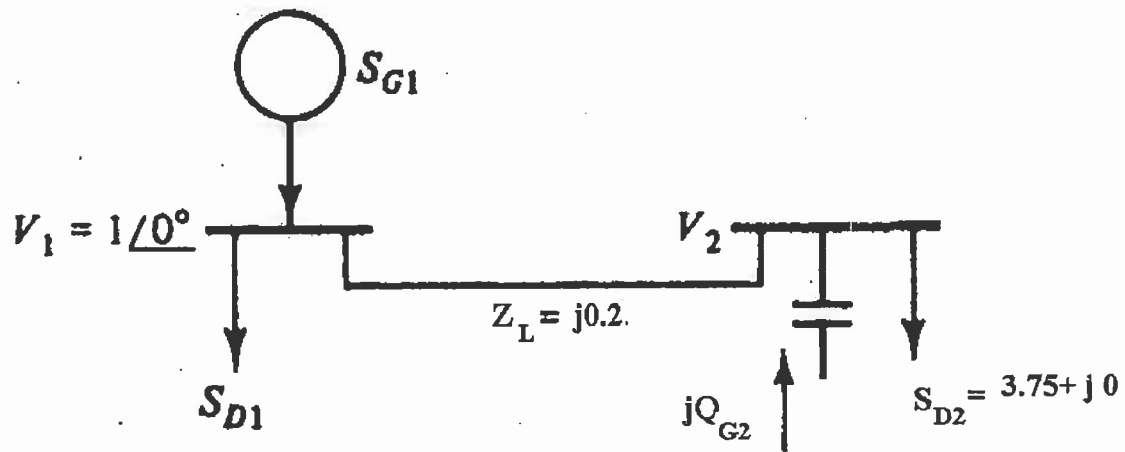


Figure (2) Single-line diagram for Problem 4

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 B. [5 Points]
- d Find the voltages at buses 2 and 3 under the fault conditions of part c above [5 Points]

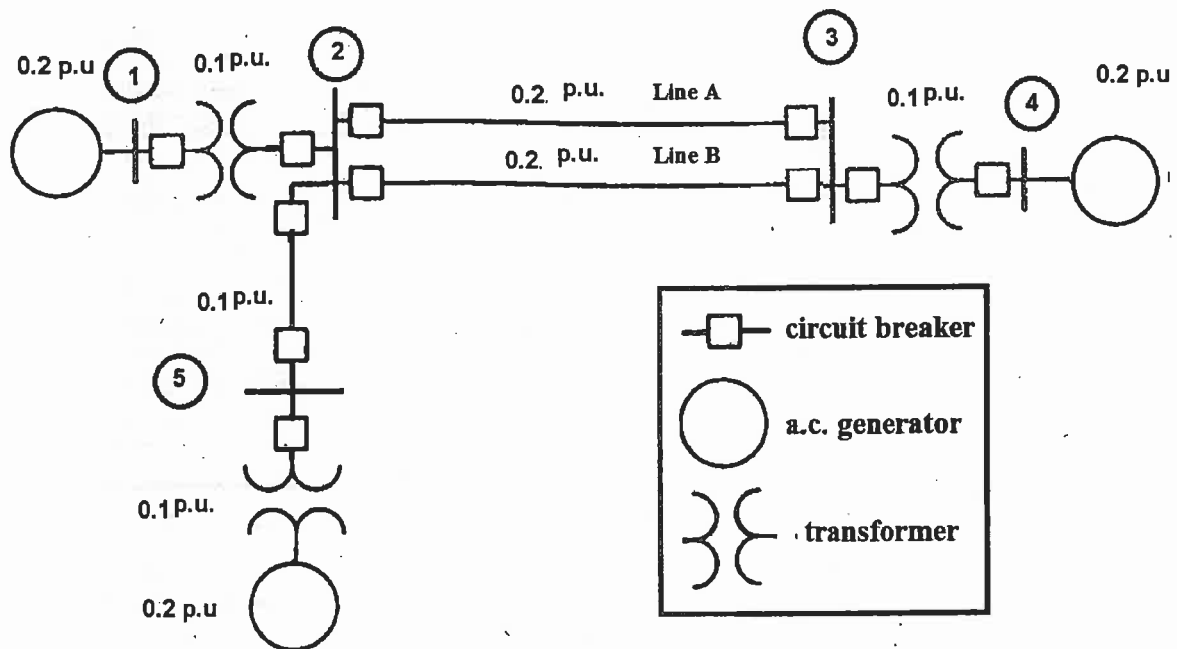


Figure (3) Single-line diagram for Problem 5

PROBLEM 6

Consider the currents seen at breaker B3 due to faults that take place at bus 4, 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 unbalanced 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]

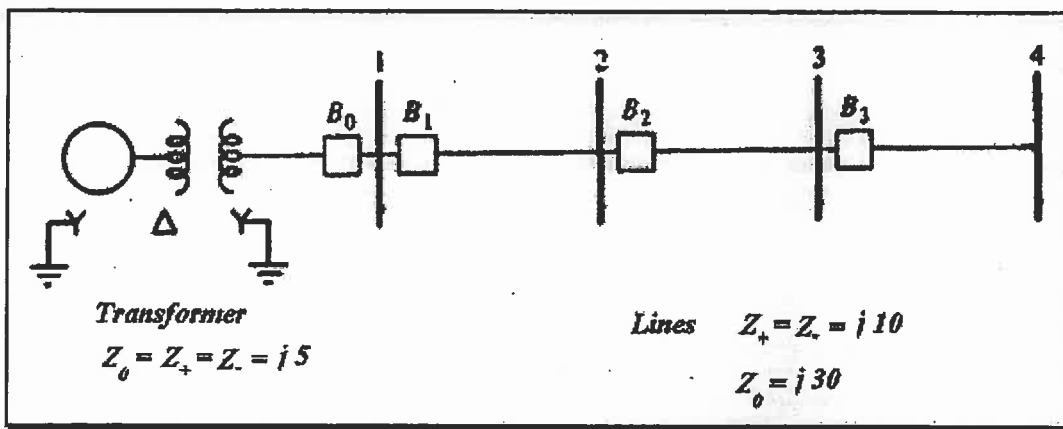


Figure (4) Single line diagram for Problem 6

PROBLEM 7

Consider the circuit shown in Figure (5.) Assume that $E = 1.2$ p.u., and $V = 1.00$ p.u. The active component of the load on the circuit is 3.2 p.u., when a three phase short circuit takes place in the middle of transmission line 3.

- a) Verify that the system will be unstable under sustained fault conditions.
- b) Assume that for the conditions of part (a.) the fault is cleared at $\delta_c = 85^\circ$ by opening the circuit breakers at both ends of line. Carry out the necessary calculations to show that the system will remain stable under these conditions.
- c) Determine the maximum angle of oscillations δ_{max} under the assumptions of part (c.)

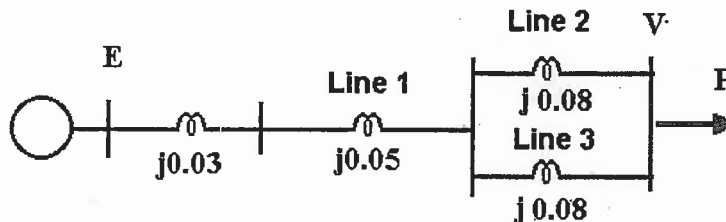


Figure (5) Circuit for Problem 7