National Exams May 2018

16-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. Attempt all parts of all questions. A complete paper (perfect score of 100%) corresponds to 100 points scored out of the total possible 140 points.
4. All seven questions are of equal value.

Problem 1

a- Describe the changes of the power factor of power system equipment (such as transformers and induction motors) over their operational range. [5 points]

A 250 km, completely transposed 60 Hz, three phase transmission line the phase conductors are arranged in a flat horizontal configuration with spacing of 10 m between adjacent phases. Each phase consists of a bundle conductor with four sub-conductors each with outside radius of 0.01 m, a sub-conductor GMR of 0.0115 m, and a bundle spacing S= 0.4 m.

b- Calculate the series inductance of the line . [5 Points]

c- Calculate the shunt capacitance of the line (neglecting earth effects). [5 Points]

d- Assume that the X/R ratio of the series impedance of the line is 8 and that shunt conductance is negligible. Find the. A and B parameters of the line using the long line model [5 Points]

Problem 2

a- Sketch the reactive capability curve of a synchronous machine, and explain the underlying principles for each of its 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	?	-0.1	1.25	?
Condition B	1.35	0.0	?	?
Condition C	?	?	1.3	40°

Problem 3

a- A 50-Hz transformer is operated from a 60 Hz supply. Assume that the load does not change. Discuss the corresponding effects on its flux, reactive power requirements, losses, efficiency, and primary power factor. [5 points]

A 50-kVA, 2400/240 V, 60-Hz, single-phase distribution transformer has the following equivalent-circuit parameters referred to the high-voltage side.

R_{eq}= 1.5 Ω Xeq = 2.0 Ω

X_m = 4,500 Ω R_c=30,000 Ω

Use the equivalent Cantilever model circuit of the transformer shown in Figure (1).

Assume that the load on the secondary of the transformer is 40 kVA at 0.8 p.f. lagging with the receiving end voltage maintained at 240 V. It is required to determine:

b- the voltage and current at the primary side, [5 points]

c- the active and reactive power input at the primary side, [5 points]

d- the efficiency and power factor at the primary side. [5 points]

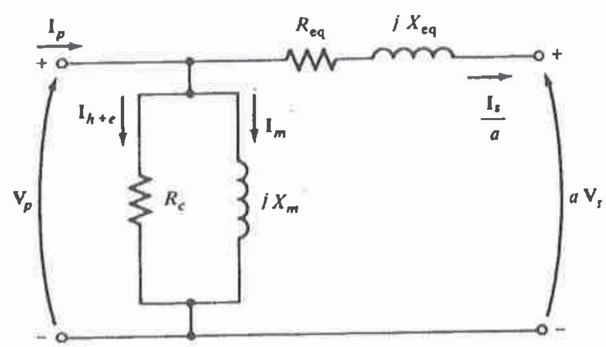

Figure 1 Equivalent Circuit of Transformer for Problem 3

Problem 4

a- From a strictly mathematical point of view, one generator bus is designated as a reference with known voltage magnitude and angle (for convenience, $|V| = 1$ and $\theta =$ zero). Explain why in practice, this bus is referred to as the slack bus. [5 Points]

Consider the three-bus electric power network shown in Figure (2.) All lines have identical series admittances $y_L = -j\ 8.0$ pu.

b- Determine the voltage magnitude at bus 2. [10 Points]
c- Determine the active power injected into the network at bus 2 [5 Points]

	|V|	θ		|V|	θ
Bus 1	1	0.0	Bus 3	1.1	7.5 °

	|V|	θ	P	Q
Bus 2	?	-8°	?	-2.1

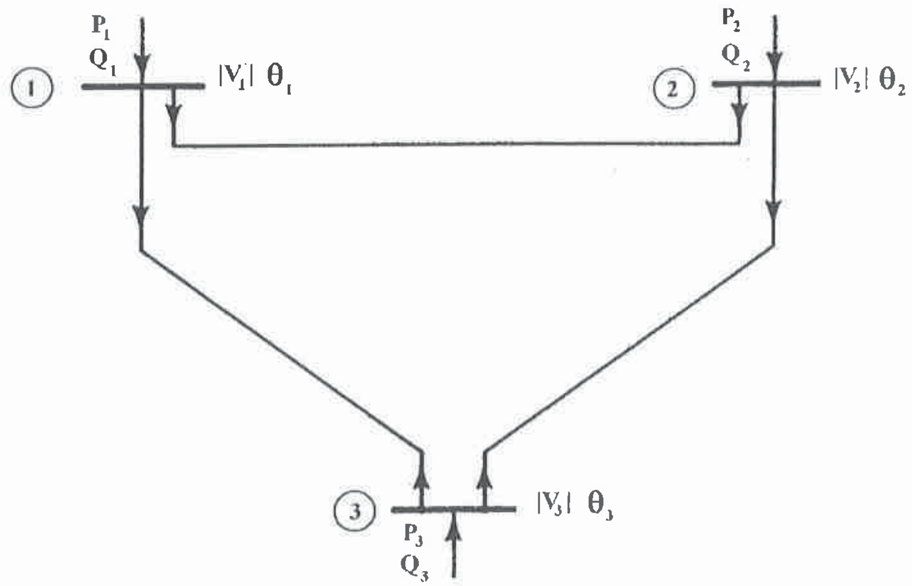

Figure 2 Circuit for Problem 4

Problem 5

a- Name three protection schemes employed for High Voltage Transmission lines in an electric power system. [5 points]

b- 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, find the voltage at bus 3 due to a bolted- three-phase short circuit in the middle of line 1-4 at F1 as indicated in Figure (3). [15 points]

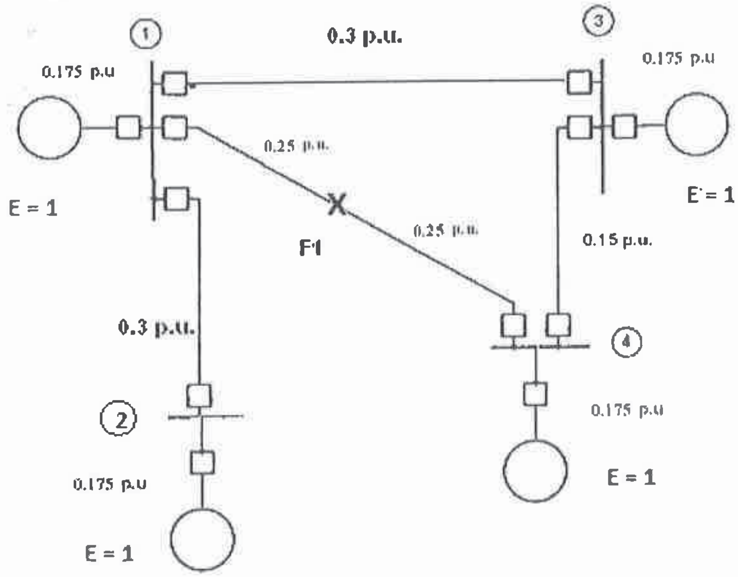

Figure 3 Single-line diagram for fault F1 in Problem 5

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	$X_1 = X_2 = 0.12$
G2	$X_1 = X_2 = 0.24$
G3	$X_1 = X_2 = 0.12$
Transformers	$X_{T1} = X_{T2} = 0.12$
Lines: Positive and Negative Sequence	$X_{13} = X_{12} = 0.20$

a- Draw the positive-, and negative- sequence reactance diagrams. [6 Points]

b- Determine the The'venin's equivalent of each sequence network as viewed from a fault in the middle of line 1-3. [7 Points]

c- A line to line fault on phases B and C takes place in the middle of line 1-3. Determine the fault currents in phases B and C in per unit. [7 Points]

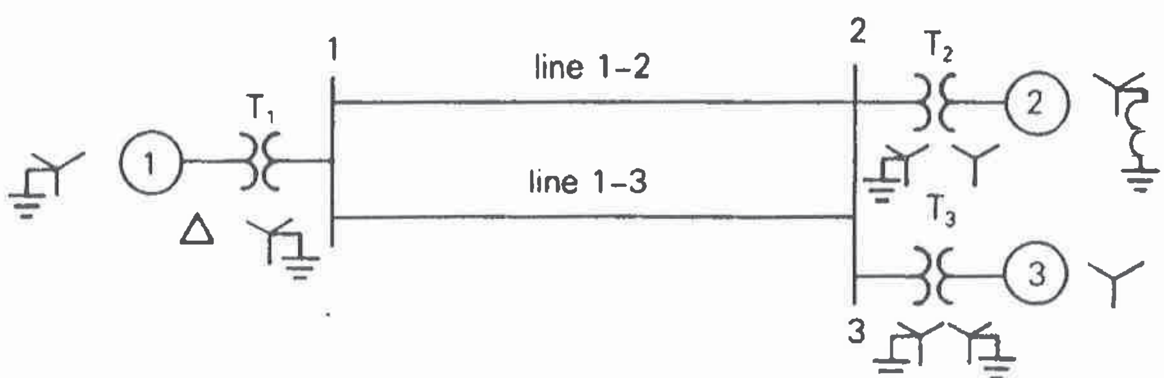

Figure 4 Single line diagram for Problem 6

Problem 7

Consider the circuit shown in Figure (5.) Assume that E = 1.2 p.u., and that V = 1.00 p.u. A three phase short circuit takes place in the middle of transmission line 3.

a- Assume that the active component of the load on the circuit is 6 p.u, determine the initial power angle. Will the system remain stable under a sustained fault? [10 Points]

b- Assume that the active component of the load on the circuit is 8 p.u, determine the initial power angle. Will the system remain stable under a sustained fault? [10 Points]

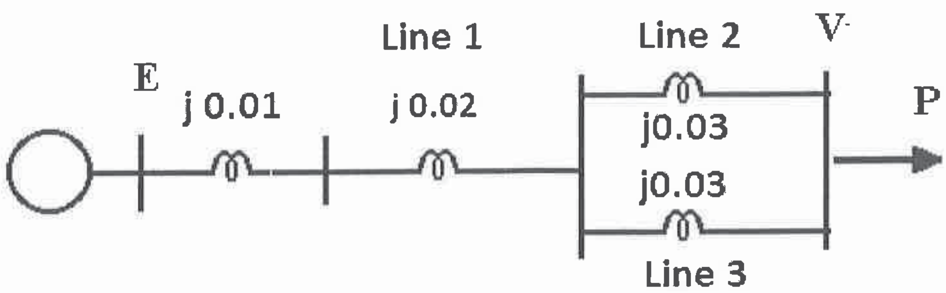

Figure 5 Circuit for Problem 7