National Exams May 2019

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- Explain the meaning of the term "bundle conductor transmission line" and discuss the effects of its use on the electrical performance of a high voltage electric transmission line. [5 Points]

b- Consider an experimental 1800 kV three phase bundle-conductor line with parameters A= 0.95 and B= j 70. Determine the value of the parameter C of the line. [5 Points]

c- Assume that the line is delivering 2,000 MVA at receiving end whose voltage of 1750 kV and unity power factor. Determine the sending end voltage of the line. [5 points]

d- Determine the sending end current of the line. [5 points]

Problem 2

a- Explain why it is important to provide enough reactive power throughout an electric power system. List the major sources of reactive power in the system. [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 0.6 and 0.3 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	Q_2	E	δ
Condition A	2.05	?	?	45°
Condition B	?	?	1.27	47°
Condition C	?	0.0	1.35	?

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, and efficiency. [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}= 0.5 Ω $\quad$ X_{eq} = 3.0 Ω

X_m = 4,500 Ω $\quad$ R_c=30,000 Ω

Use the equivalent Cantilever model circuit 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.

b- Determine the following:
- i- voltage at the primary side,
- ii- current at the primary side,
- iii- active power input at the primary side,
- iv- reactive power input at the primary side,
- v- power factor at the primary side, and
- vi- efficiency of the transformer at this loading.

[15 Points]

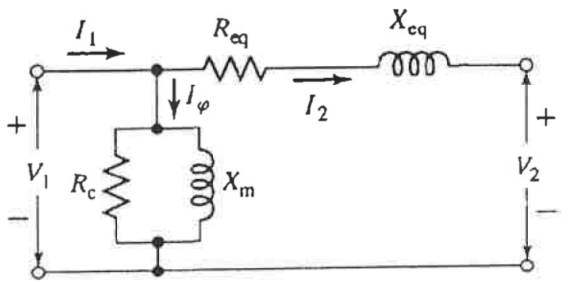

Figure (1) Equivalent Circuit of Transformer for Problem 3

Problem 4

a- List the types of buses in a conventional power flow problem formulation. For each type, identify the known and unknown variables. [5 points]

b- In the simple electric power system shown in Figure (2), complete the table below

	|V|	δ	P	Q	
Bus 1	1.00	0.0	?	?	[5 points]
Bus 2	?	-3.5	-2.5	?	[5 points]
Bus 3	1.05	5.5	?	?	[5 points]

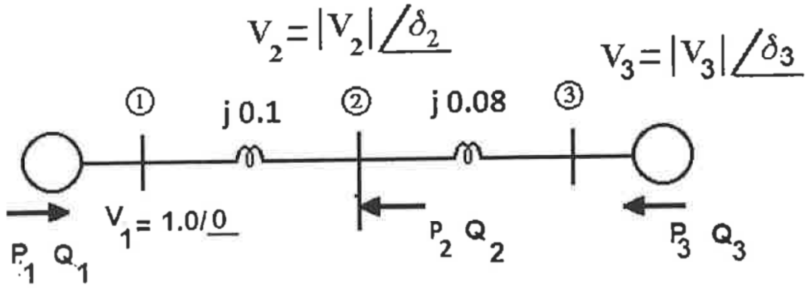

Figure (2) Circuit for Problem 4

Problem 5

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.

a- Find the fault current due to a bolted- three-phase short circuit at bus 3. [10 points]

b- Find the fault current supplied by each generator and the voltage at each of the buses 1 and 2 under fault conditions. [10 points]

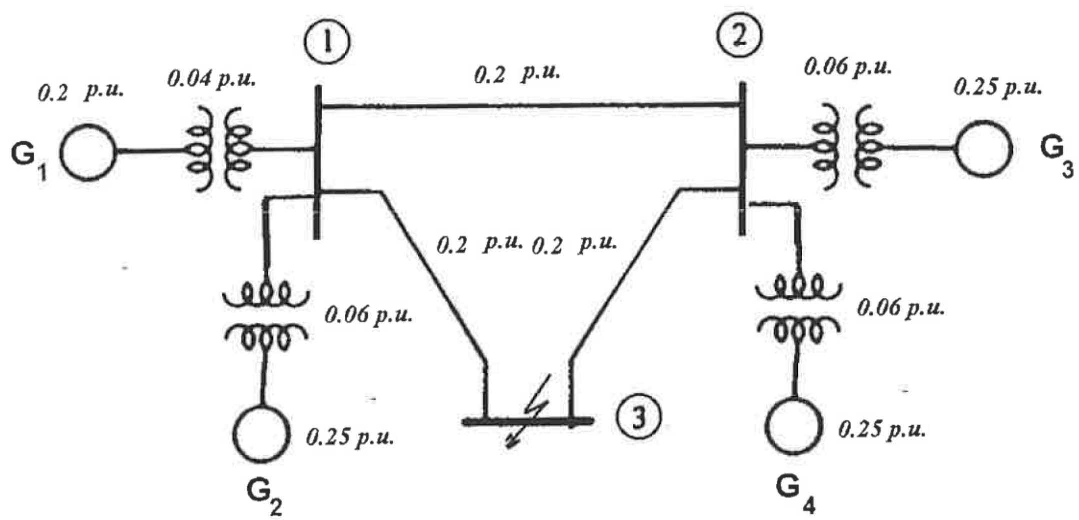

Figure (3) Single-line diagram for Problem 5

Problem 6

a- Explain the reasons for applying system grounding in electric power systems. [4 points]

Consider the industrial plant distribution bus which is supplied by a utility source with per-unit sequence reactances as shown in Figure (4-a). Assume that all reactances are given on a 5,000-kVA base, and that the plant's bus voltage is 4,160-V.

b- Determine the fault current for a single line to ground fault on phase A of the bus. [4 points]

Assume now that an ungrounded 5,000 kVA generator is added at the distribution bus as shown in Figure (4-b). [4 points]

c- Determine the fault current for a single line to ground fault on phase A of the bus. [4 points]

Assume now that the utility transformer is grounded through a 8 Ω grounding resistor as shown in Figure (4-c.)

d- Determine the value of the grounding resistor in per unit. [4 points]

e- Determine the fault current for a double line to ground fault on phases B and C of the bus. [4 points]

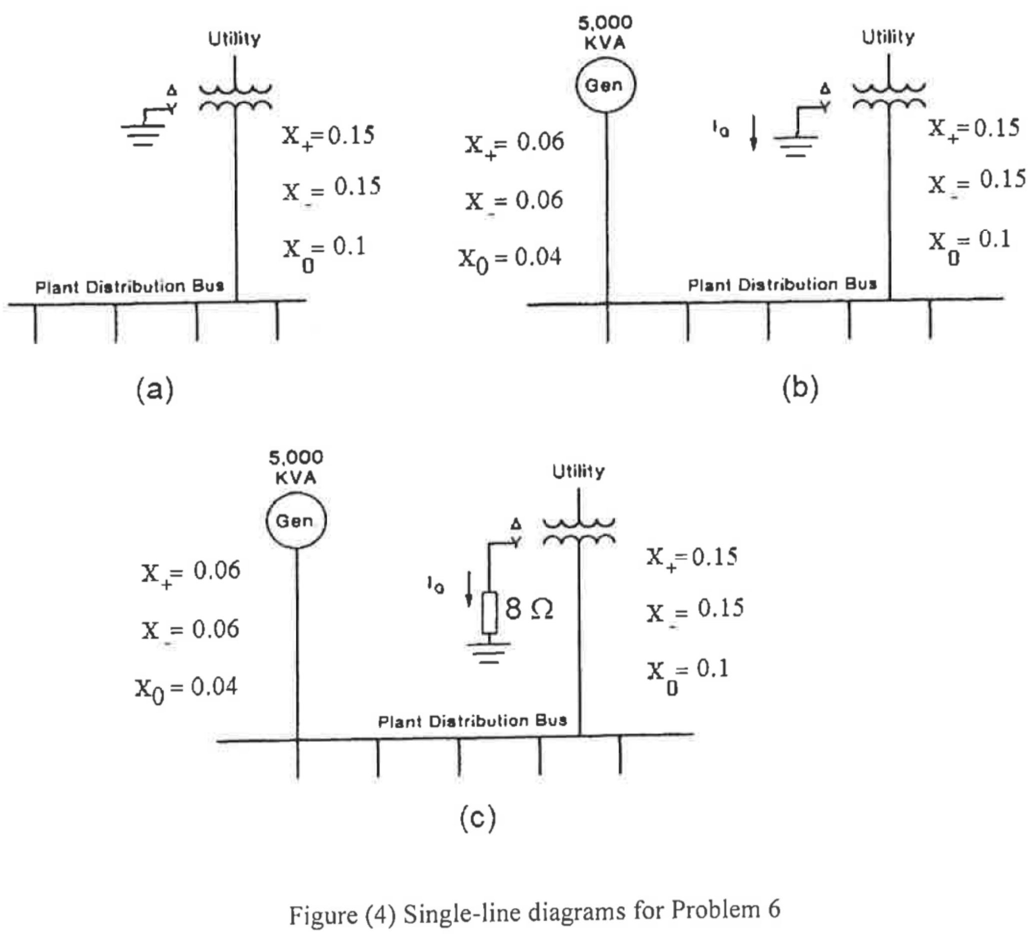

Figure (4) Single-line diagrams for Problem 6

Problem 7

Consider the circuit shown in Fig. (5) Assume that E = 1.25 p.u., and V = 1.00 p.u.

a- Assume that the active component of the load on the circuit is 0.6 p.u. Find the initial power angle δ. [5 points]

b- With the value of the load set at 0.6 p.u., a three-phase short circuit takes place in the middle of transmission line 1. Will the system be stable under a sustained fault? [5 points]

c- Assume that the active component of the load on the circuit is 0.3 p.u. Find the initial power angle δ. [5 points]

d- With the value of the load set at 0.3 p.u., a three-phase short circuit takes place in the middle of transmission line 1. Will the system be stable under a sustained fault? [5 points]

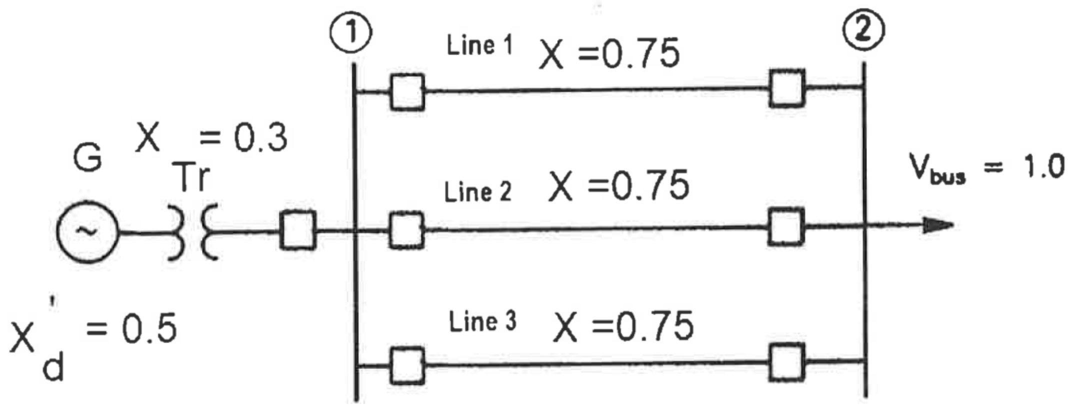

Figure (5) Circuit for Problem (7)