National Exams December 2017

16-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

Consider a 220-kV, 3-phase, 200 MVA transmission line with the following series impedance and shunt admittance:

$$Z = 17 + j\,125\ \Omega \qquad Y = j\,6x10^{-4}\ S$$

a- Determine the A, B, and C parameters of the line assuming a long line model. [10 points]
b- Suppose that the receiving end voltage is 205-kV for a load of 175 MVA at 0.8 power factor lagging. Determine the sending end voltage, active and reactive power for these conditions. [10 points]
c- Determine the MVAR value of a three-phase capacitor bank to improve the sending end power factor to 0.85 lagging. [5 points]

Problem 2

a- Explain using your own word the meaning of armature reaction in a synchronous machine. [5 points]

b- Explain the conditions under which a synchronous machine appears as a source of reactive power to the electric network. [5 points]

c- 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 0.3 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.

	P	Q_2	E	δ	
Condition A	?	0.0	1.15	?	[5 points]
Condition B	2.75	0.0	?	?	[5 points]
Condition C	?	?	1.05	37.5°	[5 points]

Problem 3

The turns ratio of a step-up single-phase transformer is 1:4 (primary: secondary). The r equivalent circuit of the transformer is shown in Figure (2.) Assume the following parameters (referred to the primary side:)

$R_{eq} = 0.05\ \Omega$ $X_{eq} = 0.225\Omega$ $R_c = 75\ \Omega$ $X_M = 20.00\ \Omega$

The load on the secondary side draws 5 A at power factor 0.8 lagging if the secondary voltage is 200 V. Determine:

a- The primary voltage and current. [5 points]
b- The active and reactive power at the primary side. [5 points]
c- The power factor at the primary side. [5 points]
d- The transformer efficiency. [5 points]
e- The transformer voltage regulation. [5 points]

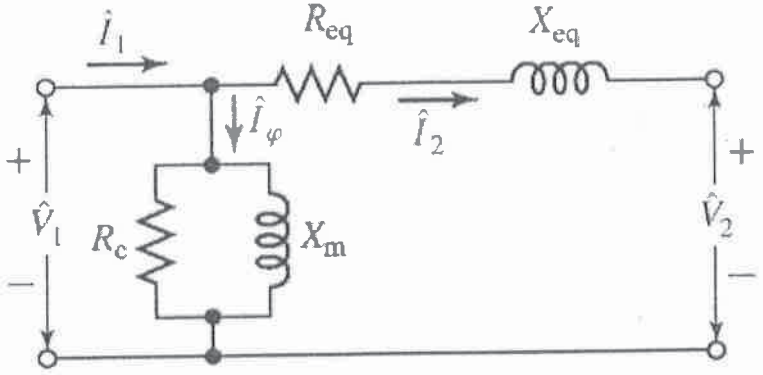

Figure (1) Transformer Equivalent Circuit for Problem (3)

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- Explain the meaning of the term "Fast Decoupled Power Flow" [5 points]
c- 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	-2.4	?	[5 points]
Bus 3	1.02	5.00	?	?	[5 points]

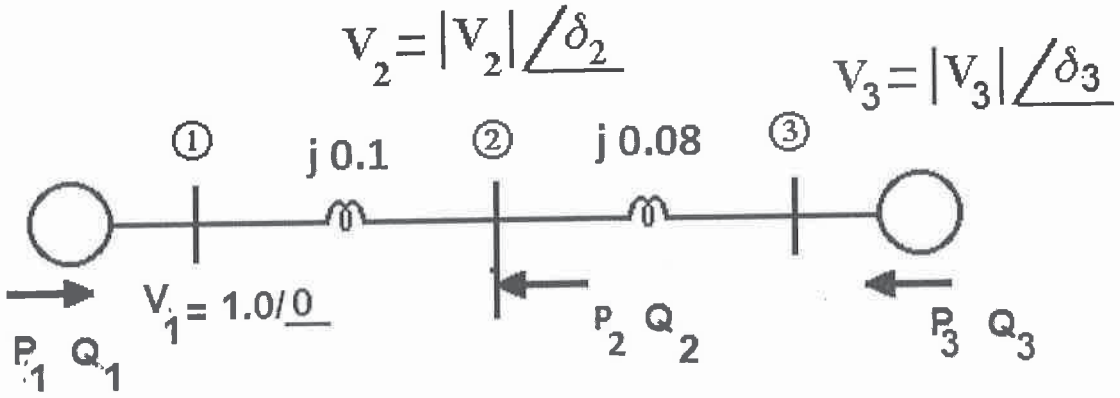

Figure (2) Circuit for Problem 4

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 the 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 voltage at bus 2 under the fault conditions of part c above [10 Points]

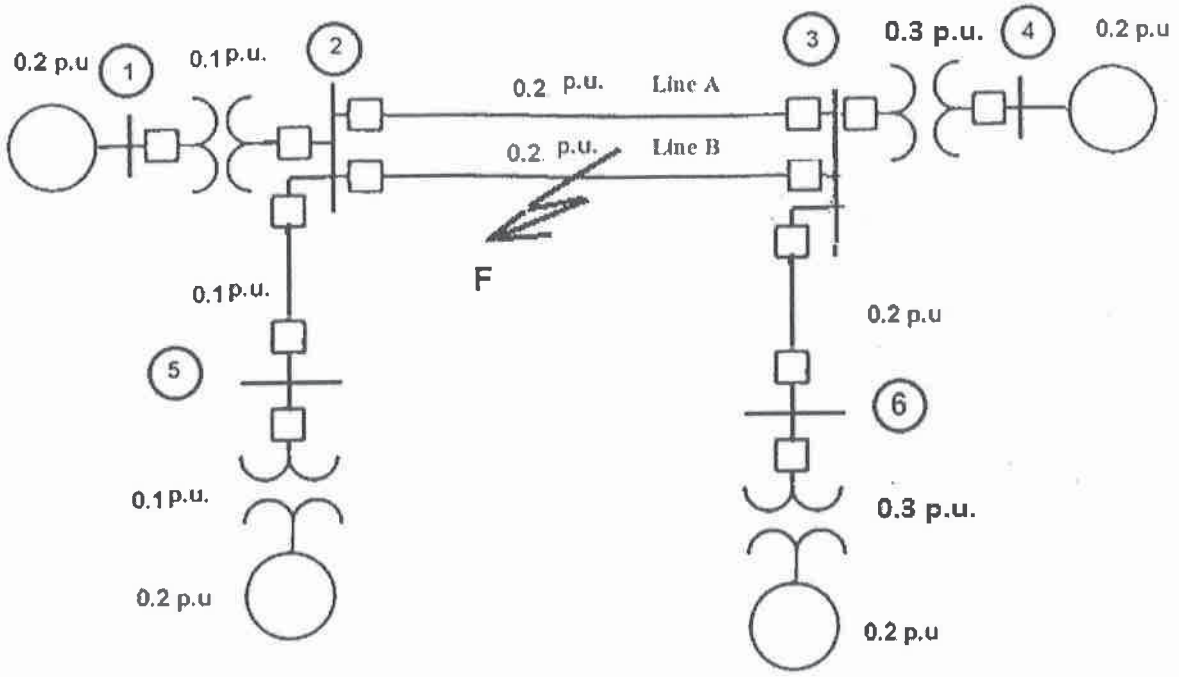

Figure (3) Single-line diagram for Problem (5)

PROBLEM 6

The positive, and negative sequence network representations of a simple electric power system are shown in Figure (5.) All values are given in per unit at 100 MVA. A line to line fault takes place in the middle of the line between buses W and V. It is required to determine:

a- The current to the fault. [10 points]

b- The value of each phase voltage at buses W and V [15 points]

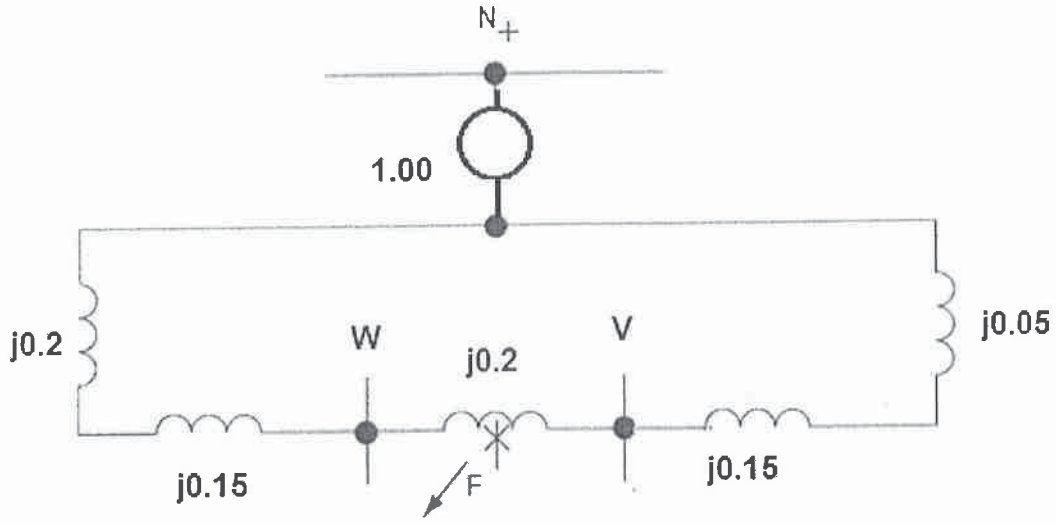

Figure (4)
Positive and negative Sequence Network Representation for Problem (6)

Problem 7

A synchronous generator is connected to an infinite bus through a transformer and a double circuit transmission line such that the maximum active power capacity is 12.50 p.u. The initial active component of the load at the infinite bus is 4.5 p.u. Under fault conditions, the maximum active power capacity is reduced to 4.7 p.u.

a- Find the initial power angle δ.

b- Will the system remain stable under a sustained fault?