UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 7 Examination in Engineering: July 2016

Module Number: EE7203 **Module Name: Power System Analysis**

[Three Hours]

[Answer **all questions**, each question carries **10 marks**]

Q1 a) Starting from the first principles, develop the sequence network diagrams for,

i) Single line to ground(L-G) fault

ii) Line to line to ground (L-L-G) fault.

[4 Marks]

b) A single line diagram of a power system is shown in Figure Q1. The neutrals of the generator and the transformers are solidly grounded. The neutral of the motor is grounded through a reactance of $X_n = 0.05$ per unit on the motor base.

i) Draw the per unit sequence network diagrams for the single line diagram shown in Figure Q1.

ii) Calculate the fault current for a line to line ground fault from phase '*b*' to phase '*c*' to ground at bus 2 in the power system shown in Figure Q1. Assume that the pre-fault voltage (V_F) at the generator is $1.05\angle 0^0$ per unit.

[6 Marks]

Q2 a) i) Explain the importance of power system stability studies in power system analysis.

ii) Define the terms "dynamic stability" and "transient stability".

iii) What are the factors which effect the stability of a power system on the occurrence of a fault?

[3 Marks]

b) A synchronous generator is delivering 0.5 of the maximum power that can be delivered to an infinite bus through a transmission line. A fault occurs such that the new maximum power reduces to 0.3 of the original maximum value. When the fault is cleared, the maximum power that can be delivered becomes 0.8 of the original maximum value.

i) Determine the critical clearing angle.

ii) If the fault is cleared at a clearing angle of 75^0, find the maximum value of torque angle for which the machine swings around its new equilibrium position.

[7 Marks]

Q3 a) i) Explain how the swing curve can be used to evaluate the transient stability of a power system.

ii) List the assumptions to be made in obtaining the numerical solution of the swing equation.

[3 Marks]

b) A 50 MVA, 60 Hz synchronous generator has a transient reactance of 0.2 per unit and an inertia constant of 5.66 MJ/MVA. The generator is delivering 50 MW to an infinite bus through a transformer and a double circuit transmission line as shown in Figure Q3. The resistance values of the system are neglected and the reactance values are expressed on a common MVA base. A three phase fault occurs at the middle of one transmission line. The fault is cleared in 0.2 seconds. Obtain the swing curve over a period of 0.15 seconds.

[7 Marks]

Q4 a) i) Briefly explain the objectives of load frequency and excitation voltage regulation in a power system.

ii) Draw the block diagram of an automatic voltage regulator of a generator.

iii) Draw the detailed block diagram of an Automatic Load Frequency Control (ALFC) loop.

[5 Marks]

b) A 125 MVA alternator operates on full-load at 50 Hz. A load of 50 MW is suddenly reduced on the machine. The steam valves to the turbine of the alternator commence to close after 0.5 seconds due to the time lag in the governor system. Assuming the inertia of the system to be constant which is equal to 6 kW-s per kVA of generator capacity, calculate the change in frequency that occurs during this time period.

[2 Marks]

c) The following data are given for a control area of a power system.

Total rated capacity	= 500 MW
Normal operating load	= 250 MW
Inertia constant	= 5 s
Speed regulation of the governor	= 2 Hz pu/MW
Operating frequency	= 50 Hz

Assume that the frequency characteristic is linear.

i) Calculate the steady state frequency drop, if the load is suddenly increased by 25 MW.

ii) Determine the increase in the generator output.

[3 Marks]

Q5 a) i) Explain the main features of a good protective system.

ii) Explain the overshoot time of a relay and its significance in protective system.

iii) Explain the operating principle of the current differential relay.

[4 Marks]

b) In order to provide the overcurrent protection to a three phase system shown in Figure Q5, two Inverse Definite Minimum Time (IDMT) relays are employed. CT ratios of the current transformers associated with the relays and current settings are as follow. Time Multiplier Setting (TMS) for relay R_A is 0.1. Assume that the circuit breaker operating time is 0.5 seconds.

Relay	CT ratio	Current setting
R_A	100:1	100%
R_B	3000:1	100%

i) If a three phase fault occurs at point F in the network shown in Figure Q5, calculate the fault current at point F.

ii) Determine the operating time of relay R_B, assuming a time grading margin of 0.5 seconds.

iii) Propose a suitable value for TMS of Relay R_B.

[6 Marks]

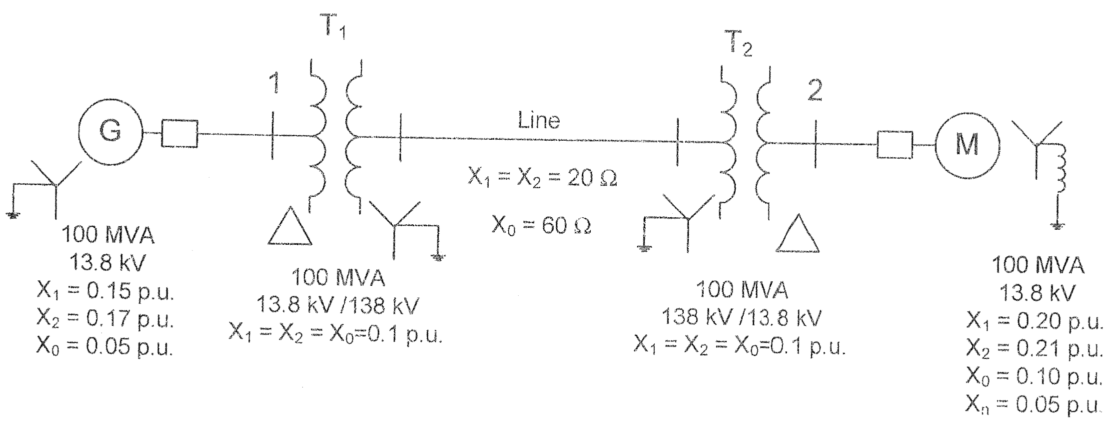

Figure Q1

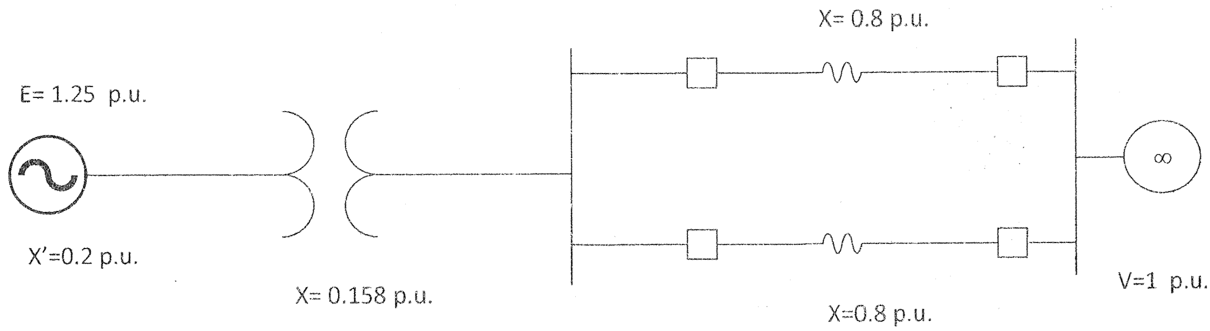

Figure Q3

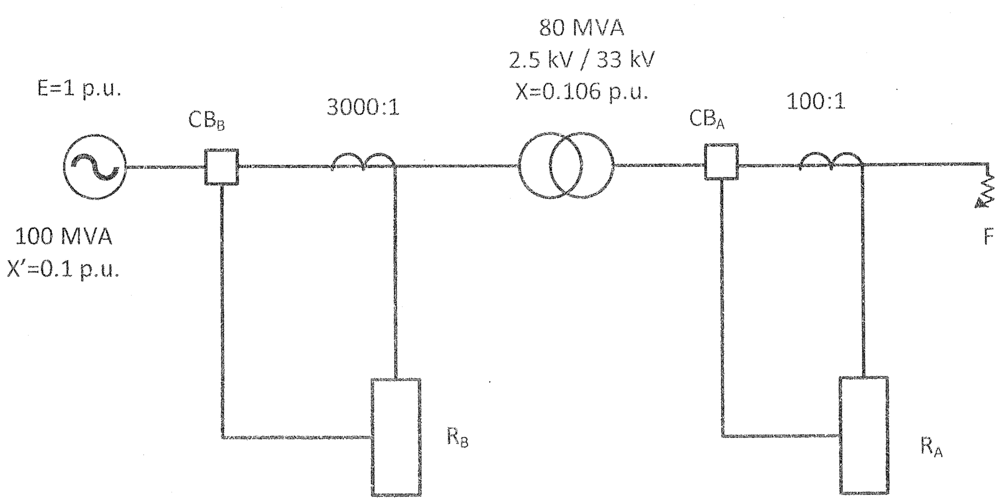

Figure Q5