TECHNICAL UNIVERSITY OF MOMBASA

FACUULTY OF ENGINEERING AND TECHNOLOGY

ELECTRICAL ENGINEERING DEPARTRMENT

UNIVERSITY EXAMINATION FOR:

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING

EEE 2414: ELECTRICAL MACHINES IV

SPECIAL/SUPPLEMENTARY EXAMINATION

SERIES: SEPTEMBER 2018

TIME: 2 HOURS

DATE: SEPTEMBER 2018

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of **five** Questions; Question ONE is compulsory. In addition attempt any Other TWO Questions.

Do not write on the question paper.

Question ONE (Compulsory 30 marks)

a)

i. Distinguish between transient, steady state and dynamic stability in synchronous machines

ii. Explain the consequence of loss of stability by a synchronous machine in a grid system

iii. State any FIVE advantages in paralleling of synchronous machines on the grid

(9 Marks)

b) Show with the aid of a sketch that the swing equation of a synchronous machine can be expressed as:

$$M\frac{\partial^2\delta(t)}{\partial t^2} + D\frac{\partial\delta(t)}{\partial t} = P_m - P_e = P_a$$

(7 Marks)

c) A 10MW, 50HZ synchronous machine is supplying a 1.0pu load when a switching event reduces the load by 20%. The output frequency increased steadily to 52Hz in time t=30cycles. Calculate the:

i. Inertia constant H
ii. Kinetic energy of rotating masses
iii. The rotor angular displacement at a time t=10cycles
iv. The rotor speed after t=10cycles

(9 Marks)

d) Use a P-Q operating chart to show the FOUR operating limits of a synchronous machine

(5 Marks)

Question TWO

a)

i. highlight how TWO different kinds of synchronous machine rotors are applied to improve system stability
ii. explain with aid of sketches the effect of multiple machines on the overall system moment of inertia

(9 Marks)

a) THREE synchronous machine are connected in a multi-machine system are shown Fig Q2 below:

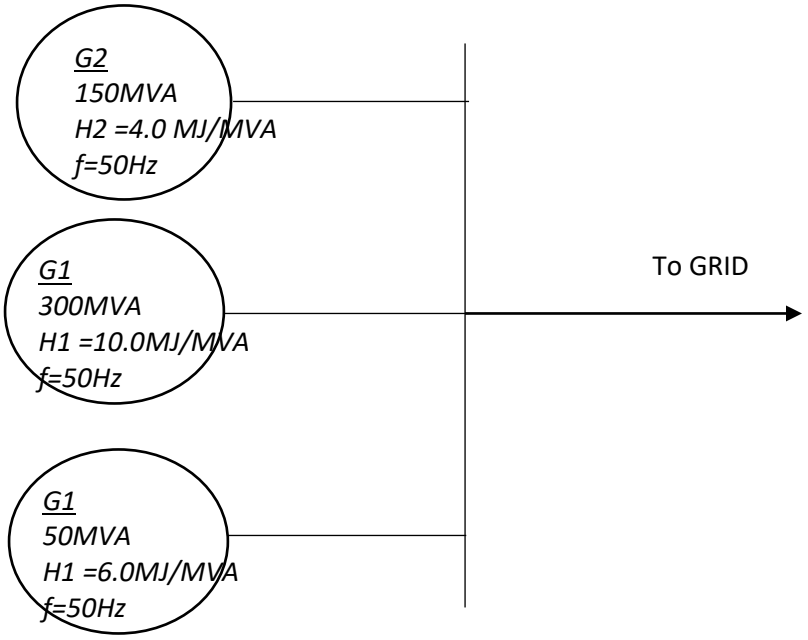

Fig Q2

Take the equivalent damping constant (D_{eq}) of the system is 0.2pu, and the equivalent frequency regulation constant (R_{eq}) of 10% based on largest unit rating, to find the equivalent moment of inertia M and the steady frequency of the system when mechanical power suddenly reduces by ¼. The inertia constants are based on corresponding generator ratings.

(11 Marks)

Question THREE

a)

i. With the aid of a sketch, explain the equal area principle in machine stability analysis

ii. State the reasons why only the first swing of synchronous machine is considered in stability analysis

(8 Marks)

b) A machine is rated 1.5pu is delivering 1.0pu power when suddenly mechanical input power increases by 0.2 pu.

i. Determine the maximum swing angle δ for the first swing

ii. Explain whether the machine is stable following the disturbance

(12 Marks)

Question FOUR

a)

i. Show that the power output of the generator is given by:

$$P = \frac{EV}{X_s} sin\delta$$

ii. From equation (i) above explain how synchronous machine rotor angle stability may be improved

(8 Marks)

b) A synchronous machine having synchronous reactance of 1.2Ω is supplying a 3 Phase, 11kV,12.5MVA, 0.8pf lagging load. Given that the transmission line has a reactance of 0.8Ω. Find

i. E behind the synchronous reactance

ii. The active power delivered

iii. The operating load angle

iv. Maximum possible power output of the machine

(12Marks)

Question FIVE

a)

i. Describe the hunting Phenomena in synchronous machines

ii. State any THREE causes and any THREE ways of minimizing hunting in synchronous machines

iii. Sketch the generator droop characteristics showing the influence of a governor

(10 Marks)

b) The turbine governor valve system transfers functions of a 12pole, 50Hz generator system are given by:

$$K_V = \frac{1}{(s+1)}$$

Given that the generator moment of inertia M=1.2 and Damping D=1 and regulating constant R=10% . Suddenly mechanical power decrease by 50% occurs.

i. Sketch the system arrangement in control canonical form

ii. Determine the steady state speed of the rotor

iii. The steady state frequency error

(10 Marks)