TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

UNIVERSITY EXAMINATION FOR:

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING

EEE 2514: POWER SYSTEM ANALYSIS II.

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 q**uestions. Attempt Question 1, **Compulsory** and any other **TWO** Questions.

Do not write on the question paper.

Question ONE

a) Derive the equation of the relationship between power transfer and reactive power injection in a power system network. [6 MARKS]

b) Using well labeled diagrams explain the following types of excitation systems.

   i. DC excitation systems

   ii. AC excitation systems [8 MARKS]

c) Explain how reactive power compensation is achieved though the following methods

   i. Synchronous compensators

   ii. Static shunt capacitors [8 MARKS]

d) A 132kV line is fed through an 11/132kV transformer from a constant 11kV supply. At the load end of the line the voltage is reduced by another transformer of nominal ratio 132/11kV. The total impedance of the line and transformers at 132kV is (25+j66) Ω. Both transformers are equipped with tap changing facilities which are arranged so that the product of the two off-nominal settings is unity. If the load on the system is 100MW at 0.9pf lagging, calculate the settings of the tap changers required to maintain the voltage of the load bus bar at 11kV. Use a base of 100MVA.

[8 MARKS]

e) Using the incremental cost curves for a **TWO** generator system show that for minimum operational cost the per unit incremental cost must be equal

<u>Question TWO</u>

a) Using equations show how inclusion of transmission losses and the penalty factor is achieved in the generation dispatch[6]

b) Show that the VArs absorbed by overhead lines and transformers is given by

$$VArs = \frac{VA_l^{\,2}}{VA_{TX}}$$

[8 MARKS]

c) Three supply points A,B and C are connected to a common busbar M. Supply point A is maintained at a nominal 275kV and is connected to M through a 275/132kV transformer (0.1pu reactance) and a 132kV line of reactance 50Ω. Supply point B is nominally at 132kV and is connected to M through a 132kV line of 50 Ω reactance. Supply point C is nominally at 275kV and is connected to M by a 275/132kV transformer (0.1 pu reactance) and a 132kV line of 50Ω reactance. If at a particular system load, the line voltage of M falls below its nominal value by 5kV, calculate the magnitude of the reactive volt ampere injection required at M to re establish the original voltage. The pu values are expressed on a 500MVA base and resistance maybe neglected throughout.

[12 MARKS]

Question THREE

a) Using elaborate equations describe how voltage control in distribution circuits is achieved by use of tap changing of transformers. [10 MARKS]

b) A synchronous generator (75MVA, 0.8pf, 11.8kV and X=1.1pu) is connected through an 11/275kV tap chining transformers (75MVA, $X_T = 0.15 pu$, tap change=+/-20%) to a very large 275kV power system.

i. What is the value of internal emf and power angle of the generator when it exports 60MW of active and zero MVAr of reactive power to the system?

ii. With the transformer tap at neutral position, what is the value of the reactive power output at the generator terminals?

iii. What is the value of the transformer tap at which 20MVAr is imported from the 275kV system, if the terminal voltage of the generator V is maintained at 1 pu when the generator does not export any active power.

[10 MARKS]

Question FOUR

a) Elaborate how distribution and transmission network security is achieved in power system networks. [6 MARKS]

b) Explain how general benders decomposition is used in system optimization [6 MARKS]

c) Briefly explain using equations how the following are achieved [8 MARKS]

i. Optimal power flow

ii. OPF objective function for fuel cost minimization

Question FIVE

a) What is the economic dispatch for a three generator system with the following parameters assuming that the total load supplied by the units varies between 90MW and 1250MW?

$$C_1(P) = \frac{0.8}{2}P_1^2 + 10P_1 + 25KSh/hr$$
$$C_2(P) = \frac{0.7}{2}P_2^2 + 5P_2 + 20KSh/hr$$
$$C_3(P) = \frac{0.95}{2}P_3^2 + 15P_3 + 35KSh/hr$$

Assume that the generation limits lies within the following

$$30MW \le P_1 \le 500MW$$
$$30MW \le P_2 \le 500MW$$
$$30MW \le P_3 \le 250MW$$

[10 MARKS]

b) PD1 and PD2 for a two generator system is 300MW and 70Mw respectively. The incremental fuel cost of two generator system is given as

$$IC_1 = (0.35p_{g1} + 41)Rs/MWhr$$
$$IC_2 = (0.35P_{g2} + 41)Rs/MWhr$$

The penalty factor is $P_l = 0.001(P_{g2} - 70)^2 MW$ Determine the optimal scheduling and power loss of the transmission link. [10 MARKS]