MACHAKOS UNIVERSITY

University Examinations for 2022/2023

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

FIFTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

EEE 552: POWER SYSTEM DYNAMICS AND CONTROL

DATE: **TIME:**

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**. Attempt any other two questions.

Do not write on the question paper.

QUESTION ONE (COMPULSORY) (30 MARKS)

a) State three advantages of static VAR compensators. (3 marks)

b) The area interconnected power system has two fuel units operating on economic dispatch. The variable cost of these units are given by:

$C_1 = 8\times 10^{-3}{P_1}^2 + 10P_1$ Sh/hr

$C_2 = 9\times 10^{-3}{P_2}^2 + 8P_2$ Sh/hr

Where P_1 and P_2 are outputs in Mwatts. The generator limits are:

$100\text{Mw} \leq P_1 \leq 600\text{Mw}$

$400\text{Mw} \leq P_2 \leq 1000\text{Mw}$

Determine:

(i) the economic loading of the two units when the load varies from 500Mw to 1500Mw.

(ii) The corresponding incremental operating cost.

(iii) The total operating cost.
(iv) The per annum saving in fuel cost for the economic distribution of total load of 1000Mw between the two units of the plant compared to equal distribution of the same total cost. (15 marks)

c) A two bus system is shown in Figure Q1(c). If 100MW is transmitted from plant 1 to the load, a loss of 10Mw is incurred. System incremental cost is shs. 30/Mwhr. Given that;

$\frac{dc_1}{dp_{g1}} = 0.02\ p_{g1} + 16.0$shs/MWhr

$\frac{dc_2}{dp_{g2}} = 0.04\ p_{g2} + 20.0$shs/MWhr

Determine;

(i) p_{g1}

(ii) p_{g2}

(iii) Power received by load. (12 marks)

Fig Q 1(c)

QUESTION TWO (20 MARKS)

a) Draw a fuel cost curve of thermal units. (4 marks)

b) The losses in a power system are given by;

$$P_{loss} = [P_1 \quad P_2 \quad P_3]\begin{bmatrix} 0.0676 & 0.00953 & -0.00507 \\ 0.00953 & 0.521 & 0.00901 \\ -0.00507 & 0.00901 & 0.0294 \end{bmatrix}\begin{bmatrix} P_1 \\ P_2 \\ P_3 \end{bmatrix}$$

Three generating units with the following characteristics are committed.

Unit 1: $C_1 = 0.00525{P_1}^2 + 8.6625P_1 + 328.125$ shs/hr
$50\text{Mw} \leq P_1 \leq 250\text{Mw}$

Unit 2: $C_2 = 0.006085{P_2}^2 + 10.04025P_2 + 136.9125$ shs/hr
$5\text{Mw} \leq P_2 \leq 150\text{Mw}$

Unit 3: $C_3 = 0.0059155{P_3}^2 + 9.7606P_3 + 59.155$shs/hr

$15\text{Mw} \leq P_3 \leq 100\text{Mw}$

Neglecting transmission line losses, and considering a load of 190Mw. Determine:

(i) Optimum load dispatch
(ii) The cost of supplying the load
(iii) The system loss. (16 marks)

QUESTION THREE (20 MARKS)

a) Explain four reasons for operating generators within a narrow range of frequencies. (8 marks)

b) An interconnected area has two generators rated 500MVA and 750 MVA and 60HZ, for which $R_1 = 0.04$ p.u and $R_2 = 0.05$ p.u based on their respective ratings. Each unit carries a 300MVA steady state load. The load on the system suddenly increases by 250MVA. Determine :
(i) β on 1000MVA base
(ii) change in frequency (Δf) on 60 hertz base. (8 marks)

c) State four reasons for optimal loading in power systems. (4 marks)

QUESTION FOUR (20 MARKS)

a) Determine the loss coefficients of the power network shown in Fig Q4(a) in p.u and on a base of 100MW. (12 marks)

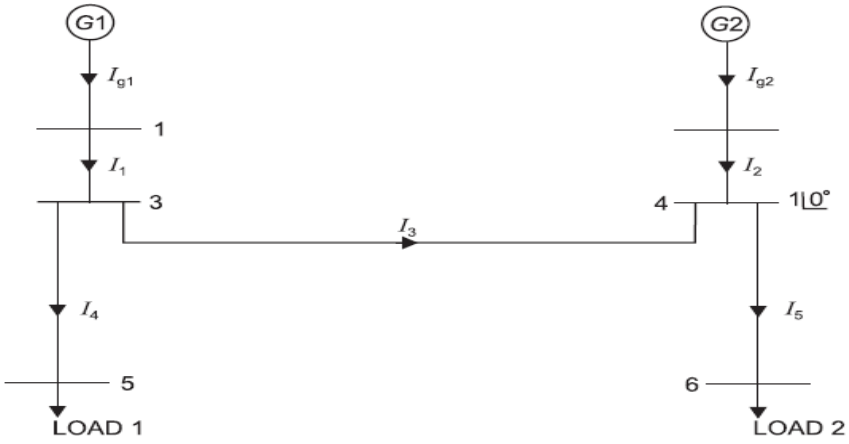

Fig Q4(a)

Z_1 = (0.03 +j0.12)p.u Z_2 = (0.03 +j0.12)p.u
Z_3 = (0.07 +j0.28)p.u Z_4 = (0.04 +j0.16)p.u
Z_5 = (0.025 +j0.10)p.u
I_1 = (1.3 - j0.5)p.u I_2 = (1.2 -j0.25)p.u
I_4 = (1.0 - j0.30)p.u I_5 = (1.5 -j0.45)p.u

b) Explain four reasons for maintain power system voltage within a narrow limits . (8 marks)

QUESTION FIVE (20 MARKS)

a) State three factors considered when determining unit security and merit order scheduling (3 marks)

b) A system has two plants with incremental cost given by;;

$\frac{dc_1}{d_{pg1}}$ = 0.01P_{g_1} + 20 shs/Mwhr
$\frac{dc_2}{d_{pg2}}$ = 0.015Pg_2 + 22.5 shs/Mwhr.
The system is running under optimal schedule with $P_{g1} = P_{g2}$ = 100Mw. If $\frac{\delta P_l}{\delta P_2}$ = 0.2, determine:
(i) The penalty factors for the two plants
(ii) $\frac{\delta P_l}{\delta P_1}$. (10 marks)

c) Two generators rated 100MW and 200MW have a governor droop characteristic of 4% from no load to full load. They are connected in parallel to share a load of 250MW. Determine the load shared by each generator. (7 marks)