MACHAKOS UNIVERSITY

University Examinations for 2023/2024 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

FIFTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING

EEE 552: POWER SYSTEM DYNAMICS AND CONTROL

DATE: **TIME:**

INSTRUCTIONS

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

a) State the three objectives of automatic gain control in power system units. (3marks)

b) The operating cost of two units are:
$C_1 = 0.125{P_1}^2 + 50P_1$ Sh/hr
$C_2 = 0.075{P_2}^2 + 60P_2$ Sh/hr

Where P_1 and P_2 are outputs in Mwatts. The system load varies as shown below:

00:00 hrs – 06:00 hrs	60Mw
06:00 hrs – 21:00 hrs	200Mw
21:00 hrs – 24:00 hrs	60Mw

Each unit is subject to the inequality constraint $10 \leq P \leq 150$ Mw. Determine:

(i) the economic loading of the two units during peak and off-peak periods.

(ii) If it would be more economical to keep both units operating during the whole 24 hour period or shut down unit 2 during low load period. A cost of shs. 400 is incurred in taking the unit off and returning it to service.

(iii) Total savings per annum on optimal load sharing as compared to equal load distribution. (14marks)

c) Table 1 displays an optimal unit commitment table for four generator units. If the four units have an identical failure rate of 1/year, repair rate of 99/year and a maximum tolerable insecurity level of 0.005. Use the daily load curve of Fig Q1(c) to draw the:

(i) Economically optimal unit commitment table for the system

(ii) Optimal and secure unit commitment table for the system (13marks)

Table 1.

Load range	*Unit number*			
	1	2	3	4
1–5	1	0	0	0
6–13	1	1	0	0
14–18	1	1	1	0
19–48	1	1	1	1

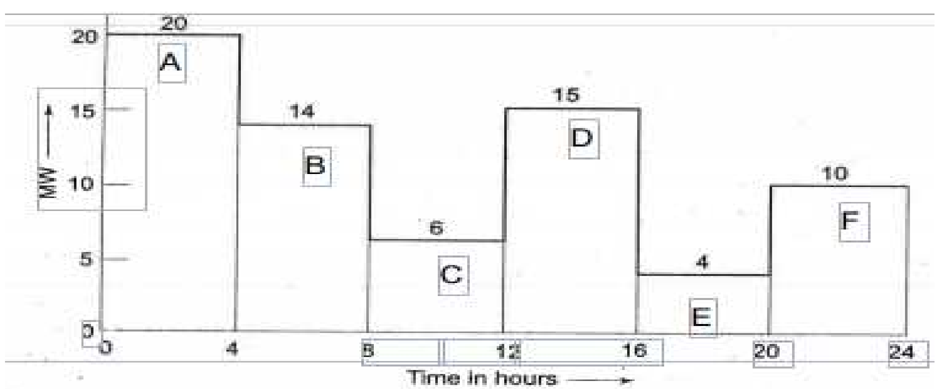

Fig Q1(c)

QUESTION TWO

a) Three thermal units deliver a total load of 850MW. Their cost functions and generator limits are as follows:

$C_1 = 780 + 79.7P_1 + 0.0482\,P_1^2$ shs/hr

$50 \leq P_1 \leq 200$MW

$C_2 = 3100 + 78.5P_2 + 0.0194\,P_2^2$ shs/hr

$100 \leq P_2 \leq 400$MW

$C_3 = 4590 + 64.8P_3 + 0.0128\,P_3^2$ shs/hr

$150 \leq P_3 \leq 600$MW

Where P_1, P_2 and P_3 are the outputs of the units 1, 2 and 3 respectively in MW. Determine the economic operation point for the three units and their corresponding incremental cost. (10marks)

b) With the aid of a schematic block diagram, describe the function of each block of an automatic load dispatch using digital computer. (10marks)

QUESTION THREE

a) State any four advantages of interconnected power systems. (4marks)

b) With an aid of a schematic diagram, describe the operation of a voltage regulator and turbine governor in control of steam turbine generator. (8marks)

c) With the aid of a circuit diagram, describe the operation of ON – load tap changing transformer as a method of voltage control. (8marks)

QUESTION FOUR

a) Determine the loss coefficients of the power network shown in Fig Q4(a) in p.u and on a base of 100MW. (10marks)

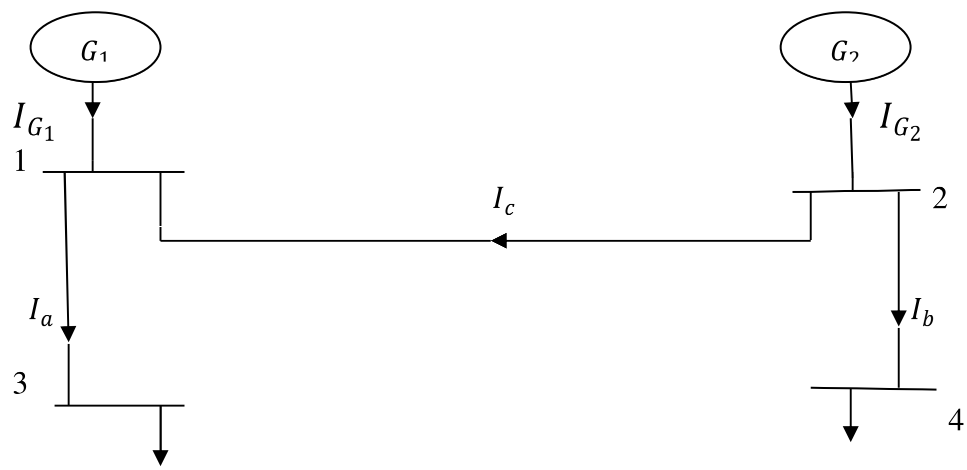

Fig 4(a) L_1 L_2

I_a = 1.0 – j0.15 p.u Z_a = 0.02 + j0.015p.u

I_b = 0.5 j 0.1 p.u Z_b = 0.03 + j 0.015p.u

I_c = 0.2 – j0.05p.u Z_c = 0.02 + j 0.25 p.u

b) Differentiate between a constant speed governor and speed droop governor (4marks)

c) Two Alternators rated 100MW and 200 MW have a governor droop characteristics 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 machine. (6marks)

QUESTION FIVE

a) With an aid of diagrams, show that the power system loss formula is given by:

$$P_L = B_{11}{P_1}^2 + 2B_{12}P_1P_2 + B_{22}{P_2}^2$$

Where,

$$B_{11} = \frac{1}{|V_1|^2(COS\Phi1)^2}\sum A^2K_1\,R_k, \quad B_{12} = \frac{\cos(\alpha_1 - \alpha_2)}{|V_1|^2(COS\Phi1)^2}\sum AK_1\,AK_2R_k,$$

$$B_{22} = \frac{1}{|V_2|^2(COS\Phi2)^2}\sum A^2K_2\,R_k$$

(10marks)

b) A two bus system is shown in Fig 1Q(a). If 100MW is transmitted from plant 1 to Load, a transmission loss of 10MW is incurred. The incremental costs of the two plants are given below:

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

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

Determine the:

i. Required generation for each plant and the power received by the load when the system λ is 25shs/MWhr.

ii. The optimal load distribution between the two plants when the losses are included but not coordinated.

iii. The optimal load distribution between the two plants when losses are Coordinated.

iv. Savings in shillings per hour when losses are coordinated. (10marks)

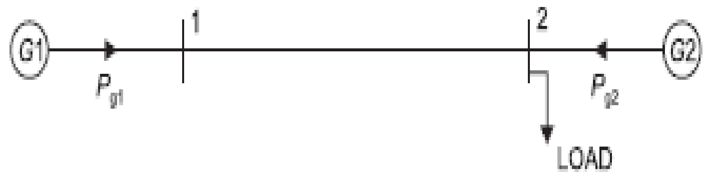

Fig 5Q(b)