



MACHAKOS UNIVERSITY

University Examinations for 2021/2022

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:

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

b) The operating cost of two units are:

$$C_1 = 0.125P_1^2 + 50P_1 \text{ Sh/hr}$$

$$C_2 = 0.075P_2^2 + 60P_2 \text{ Sh/hr}$$

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:

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

- 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:
- Economically optimal unit commitment table for the system
 - Optimal and secure unit commitment table for the system
- (13 marks)

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

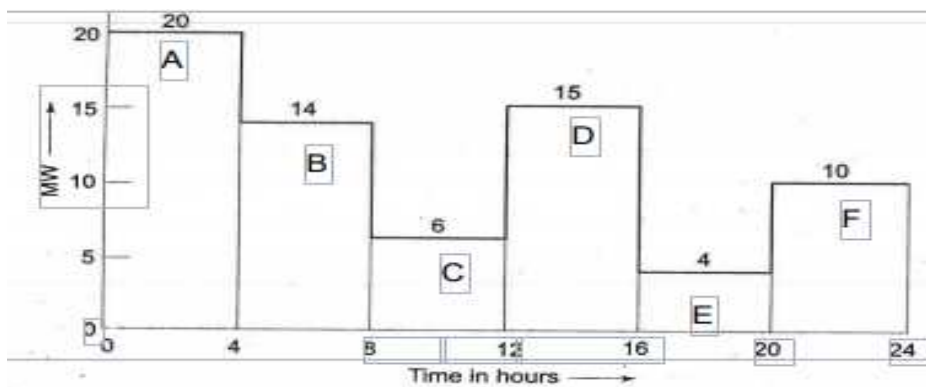


Fig Q1(c)

QUESTION TWO (20 MARKS)

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

$$C_1 = 780 + 79.7P_1 + 0.0482 P_1^2 \text{ shs/hr}$$
$$50 \leq P_1 \leq 200\text{MW}$$

$$C_2 = 3100 + 78.5P_2 + 0.0194 P_2^2 \text{ shs/hr}$$
$$100 \leq P_2 \leq 400\text{MW}$$

$$C_3 = 4590 + 64.8P_3 + 0.0128 P_3^2 \text{ shs/hr}$$
$$150 \leq P_3 \leq 600\text{MW}$$

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.

QUESTION THREE (20 MARKS)

- State any four advantages of interconnected power systems. (4 marks)
- With an aid of a schematic diagram, describe the operation of a voltage regulator and turbine governor in control of steam turbine generator. (8 marks)
- With the aid of a circuit diagram, describe the operation of ON – load tap changing transformer as a method of voltage control. (8 marks)

QUESTION FOUR (20 MARKS)

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

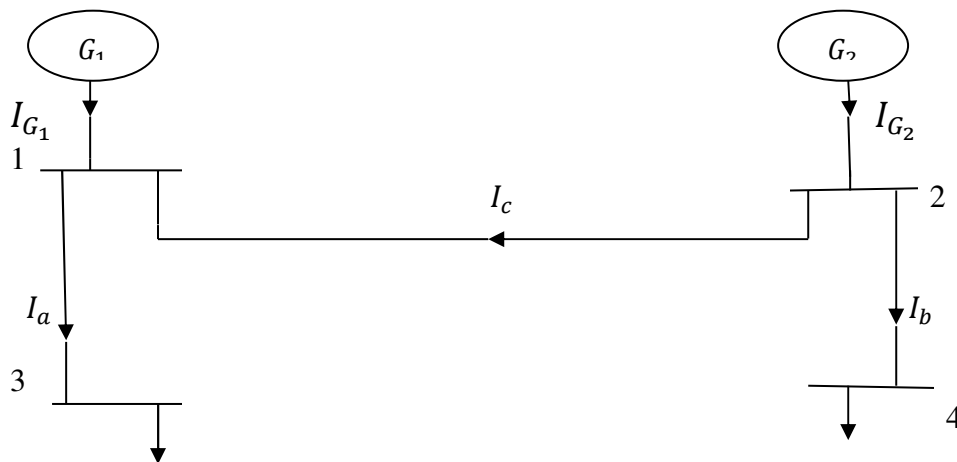


Fig 4(a) L_1

$$I_a = 1.0 - j0.15 \text{ p.u.}$$

$$I_b = 0.5 + j0.1 \text{ p.u.}$$

$$I_c = 0.2 - j0.05 \text{ p.u.}$$

L_2

$$Z_a = 0.02 + j0.015 \text{ p.u.}$$

$$Z_b = 0.03 + j0.015 \text{ p.u.}$$

$$Z_c = 0.02 + j0.25 \text{ p.u.}$$

- b) Differentiate between a constant speed governor and speed droop governor (4 marks)
- c) Two Alternators rated 100MW and 200 MW 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 machine. (6 marks)

QUESTION FIVE (20 MARKS)

- 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,

$$B_{11} = \frac{1}{|V_1|^2(\cos\phi_1)^2} \sum A^2 K_1 R_k, \quad B_{12} = \frac{\cos(\alpha_1 - \alpha_2)}{|V_1|^2(\cos\phi_1)^2} \sum A K_1 A K_2 R_k,$$

$$B_{22} = \frac{1}{|V_2|^2(\cos\phi_2)^2} \sum A^2 K_2 R_k \quad (10 \text{ marks})$$

- b) In a two plant system, the entire load is located at plant 2, which is connected to plant 1 by a transmission line. Plant 1 supplies 100MW of power with a corresponding transmission loss of 5MW. Take $\lambda = 15 \text{ kshs./MWhr}$ and incremental fuel cost for the two plants to be;

$$\frac{dc_1}{dp_{pg1}} = 0.01P_{g1} + 10$$

$$\frac{dc_2}{dp_{pg2}} = 0.02P_2 + 12$$

Determine;

- (i) The penalty factors for the two plants
- (ii) Power generated by each plant for minimal total fuel cost. (10 marks)