# MACHAKOS UNIVERSITY

**University Examinations for 2019/2020Academic Year**

**SCHOOL OF ENGINEERING AND TECHNOLOGY**
**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**FIFTH YEAR SECOND SEMESTER EXAMINATION FOR**

**BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING**

**EEE 552: POWER SYSTEM DYNAMICS AND CONTROL**

**DATE: 22/10/2020** **TIME: 8.30-10.30 AM**

**INSTRUCTIONS**

***Answer Question One and Any Other Two Questions***

**QUESTION ONE (30 MARKS)**

a) The heat rate of a 100MW fuel fired generator unit is measured as follows:

25% of rating : 10Mkcal/MWhr

50% of rating : 8.6Mkcal/MWhr

100% of rating : 8Mkcal/MWhr.

Cost of fuel is kshs. 500 per Mkcal. Determine:

i. Fuel cost function

ii. The fuel cost when100% loaded, 50%loaded and 25% loaded

iii. The incremental cost

iv. The exact cost of fuel to deliver 105MW. (12 marks)

b) State any four objectives of reactive power management in power system units. (4 marks)

c) 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. 200 is incurred in taking the unit off and returning it to service. (14 marks)

**QUESTION TWO (20 MARKS)**

a) State the four accepted philosophy for interconnected power systems. (4 marks)

b) The fuel costs for three generating units and their generating limits are as follows:

$C_1 = 0.00525P_1{}^2 + 8.6625P_1 + 328.125$ shs/h

$50 \leq P_1 \leq 250\ MW$

$C_2 = 0.006085P_2{}^2 + 10.04025P_2 + 136.9125$ shs/hr

$5 \leq P_2 \leq 150\ MW$

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

$15 \leq P_3 \leq 100\ MW$

The losses in the power system are given by:

$$P_{LOSS} = [P_1 \quad P_2 \quad P_3]\begin{bmatrix} 0.0676 & 0.00953 & -0.00507 \\ 0.00953 & 0.0521 & 0.00901 \\ -0.00507 & 0.00901 & 0.0294 \end{bmatrix}\begin{bmatrix} P_1 \\ P_2 \\ P_3 \end{bmatrix}$$

Determine,

i. Optimum dispatch, neglect losses.

ii. The total cost of supplying a load of 190MW.

iii. The total system losses (16 marks)

**QUESTION THREE (20 MARKS)**

a) State the four main methods of reactive power injection. (4 marks)

b) 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)

c) 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)

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,

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

$$B_{22} = \frac{1}{|V_2|^2(COS\Phi2)^2}\sum A^2K_2\,R_k$$ (12 marks)

b) State any four roles of AGC in frequency control (4 marks)

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

## QUESTION FIVE (20 MARKS)

a) Three generating units operating in parallel at 60HZ have ratings of 300MW, 500MW and 600MW and have speed droop of 5%, 4% and 3% respectively. Due to a change in load an increase in system frequency of 0.3HZ is experienced before any supplementary control action occurs. Determine:

(i) The change in system load

(ii) The change in generation of each unit to absorb the load change. (10 marks)

b) A two bus power system is shown in FigQ5(b). Incremental fuel costs of the two generators are given by

$I_{C1}$ = (0.35$P_{g1}$ + 41) shs/MWhr

$I_{C2}$ = (0.35$P_{g2}$ + 41) shs/MWhr

The loss expression is $P_L = 0.00005{P_{g1}}^2 + 0.00008{P_{g2}}^2$ MW

Determine the optimal scheduling and power loss of the transmission link, when the area λ = 109.2shs/hr . (10 marks)

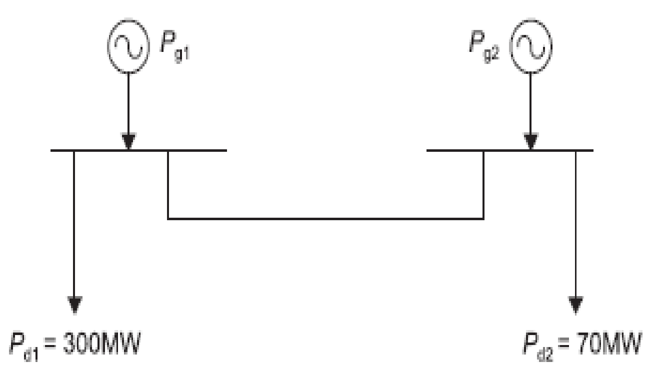


Fig Q5(b)