THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND COMMUNICATIONS ENGINEERING

SEMESTER ONE FINAL EXAMINATION (2022)

EE414 – ELECTRICAL POWER SYSTEMS II

FINAL YEAR ELECTRICAL ENGINEERING – POWER (BEEP 4)

TIME ALLOWED: 3 HOURS

INFORMATION FOR STUDENTS:

1. You have **TEN (10) MINUTES** to read the paper.
   You must not begin writing during this time.

2. There are five (5) questions in this Examination.

3. **Answer all questions.** All answers must be written in the **ANSWER BOOK** supplied.

4. **COMPLETE THE DETAILS REQUIRED ON THE FRONT COVER OF YOUR ANSWER BOOK – DO THIS NOW, & SIGN ON THE SPACE PROVIDED.**

5. Only drawing instruments, calculators and pens are permitted on your desk. NO phones allowed.

6. If you are found cheating in the Examination, the penalties specified by the University shall apply.

7. **TURN OFF** all Mobile Phones and place them on the floor under your seat before the start of Examination.

Question 1 (20 marks)

A plant has 3 generators and their capacity and cost functions are as follow:

Unit 1:

$C_1 = 564 + 7.82\ P_1 + 0.008562\ P_1^2$ K/h $\quad 150 \leq P_1 \leq 600$ MW

Unit 2:

$C_2 = 320 + 7.75\ P_2 + 0.00794\ P_2^2$ K/h $\quad 100 \leq P_2 \leq 400$ MW

Unit 3:

$C_3 = 96 + 9.66\ P_3 + 0.006784\ P_3^2$ K/h $\quad 50 \leq P_3 \leq 200$ MW

What unit or combinations of units could the supply most economically a load of 800MW? Tabulate your results.

Question 2 (30 marks)

An area of an interconnected power system has two fossil-fuel units operating on economic dispatch. The variable operating cost of the units are given by

$$C_1 = 12P_1 + 6x10^{-3}P_1^2 \quad K/hr$$

$$C_2 = 10P_2 + 7x10^{-3}P_2^2 \quad K/hr$$

where P_1 and P_2 are in MW.

(a) Determine the power output of each unit, the incremental operating cost, and the total operating cost C_T that minimizes C_T as the total load demand P_T varies from 500 MW to 1500 MW in steps of 200MW. (Neglect inequality constraint).

(b) Taking into account transmission loss for the system in **Part (a)** to be

$$P_L = 2x10^{-4}P_1^2 + 2x10^{-5}P_1P_2 + 3x10^{-5}P_2^2 \quad MW$$

where P_L, is the line losses in MW.

Determine the output of each unit, total transmission losses, total load demand, and the total operating cost C_T when the area λ = 16.00 K/MWhr.

Question 3 **(15 marks)**

One generator of an interconnected 50-Hz power system has three turbine generators units rated 1000, 800, and 600 MVA, respectively. The regulation constant of each unit R = 0.06 per unit based on its own rating. Each unit is originally operating at one-half of its own rating, when the system load suddenly increases by 300 MW. Determine:

(a) the per-unit area frequency response characteristic β on a 1000 MVA base. (Hint: $\beta = 1/R$. For a system with several units $\beta = 1/R_1 + 1/R_2 + \ldots\ldots 1/R_n$).

(b) the steady-state drop in area frequency, and

(c) the increase in the turbine mechanical output of each unit.

Use the equation:

$$\Delta P_{T,0} = \Delta P_{ref,0} - \frac{1}{R}\Delta f_0$$

Assume the reference power setting of each turbine-generator remains constant. Neglect losses and dependency of load on frequency *D*.

Comment on your answers in (c).

Question 4 **(15 marks)**

A 50-Hz power system consists of two interconnected areas. Area 1 has 1200 MW of generation and an area frequency response characteristic $\beta_1 = 500$ MW/Hz. Area 2 has 1800 MW of generation and $\beta_2 = 800$ MW/hz. Each area is initially operating at one-half its total generation, at $\Delta p_{tie1} = \Delta p_{tie2} = 0$ and at 50 Hz, when the load in area 1 suddenly increases by 500 MW. Determine the steady state frequency error and the steady-state tie-line error Δp_{tie} of each area. Assume that the reference power settings of all turbine-governors are fixed. That is LFC is not employed in any area. Neglecting losses and the dependence of load on frequency.

Question 5 **(20 marks)**

(a) Sketch the block diagram of an automatic load frequency control and provide the transfer functions. Describe how frequency is controlled in a power system. Discuss the benefits of a multi-area power system.

(b) Sketch the block diagram of the AVR and provide the transfer functions. Describe how voltage is controlled in a power system. Enumerate other methods of voltage control in power system operations.

END OF EXAMINATION