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FINAL EXAMINATION QUESTION BOOKLET

COURSE CODE	: BET 3053
COURSE	: POWER SYSTEM AND CONTROL
SEM/SESSION	: 1 - 2023/2024
DURATION	: 3 HOURS

Instructions:

1. This booklet contains **4** questions. Answer **ALL** questions.
2. All answers should be written in answer booklet.
3. Write legibly and draw sketches wherever required.
4. If in doubt, raise your hands and ask the invigilator.

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO

THIS BOOKLET CONTAINS 7 PRINTED PAGES INCLUDING COVER PAGE

QUESTION 1

a) Define power system SCADA. (3 marks)

b) Supervisory Control and Data Acquisition (SCADA) is an important system in monitoring and control of power system. Explain two (2) function of SCADA used in power system. (2 marks)

c) Explain the operation of SCADA system in industry. (6 marks)

d) SCADA system have evolved in parallel with the growth and sophistication of modern computing technology. Explain the SCADA-AGC (Automatic Generation Control) system complete with diagram. (4 marks)

e) Compare between SCADA-Steady-state security analysis and SCADA-Online load flow system. (4 marks)

f) SCADA system have three generations, explain each generation below.
   i. Monolithic.
   ii. Distributed.
   iii. Network. (6 marks)

QUESTION 2

a) Define economic dispatch (ED) (2 marks)

b) Consider one generation facility consists of two generators PG1 and PG2. Cost curves for each is listed as follows:

$$C1\ (PG1) = 1000 + 20PG1 + 0.01PG1^2 \text{ RM/h}$$
$$C2\ (PG2) = 400 + 15PG2 + 0.03PG2^2 \text{ RM/h}$$

The total generated power from PG1 and PG2 is 500MW (PG1+PG2=500MW=PD).

i. Find the incremental cost (λ) in RM/h. (2 marks)

ii. For optimal dispatch to meet PD = 500MW, match cost must similar ($\lambda 1 = \lambda 2$). (2 marks)

iii. Classify the output of each generator at optimal dispatch PG1, PG2. (2 marks)

iv. Find the total cost of operation, C_T. (2 marks)

c) The fuel cost in (RM/h) for three thermal plants of a power system are as follows:

$$C_1 = 200 + 7.0P_1 + 0.008P_1^2$$
$$C_2 = 180 + 6.3P_2 + 0.009P_2^2$$
$$C_3 = 140 + 6.8P_3 + 0.007P_3^2$$

where the powers are in MW. The plant outputs are subject to the followings limits

$$10 \text{ MW} \le P1 \le 85 \text{ MW}$$
$$10 \text{ MW} \le P2 \le 80 \text{ MW}$$
$$10 \text{ MW} \le P3 \le 70 \text{ MW}$$

Calculate the optimal dispatch of generation when the total system load is 150 MW (Assume initial lambda, λ=6.5). (7 marks)

QUESTION 3

a) In an interconnected power system, most generators operate in parallel to others. List three (3) advantages of connecting the generators in parallel at power system. (3 marks)

b) A hydraulic turbine at a speed of 300 rpm is connected to a synchronous generator. If the induced voltage has a frequency of 60 Hz, identify the poles does the rotor. (3 marks)

c)

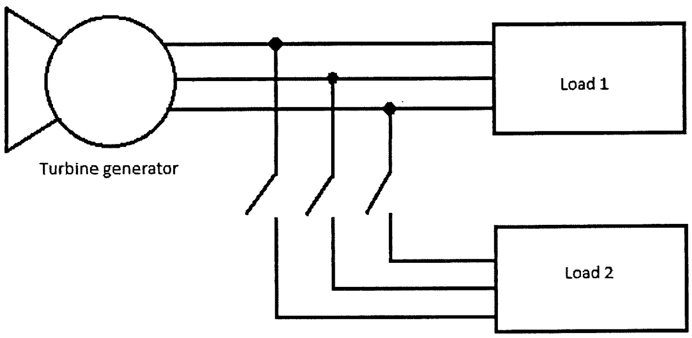

Figure 1

Figure 1 shows the turbine generator is connected with two loads. Generator with no load frequency of 65 Hz and a slop Sp of 0.4 MW/Hz is connected to Load 1 consuming 2 MW of real power at 0.8 power factor lagging. Load 2 (to be connected to the generator) consumes a real power of 0.4 MW at 0.707 power factor lagging.

i. Find the operating frequency of the system BEFORE the switch is closed. (3 marks)

ii. Find the operating frequency of the system AFTER the switch is closed. (3 marks)

iii. Explain the appropriate action of the operator to restore the system frequency to 60 Hz after both loads are connected to the generator. (3 marks)

d) Two generators are set to supply the same load. Generator 1 has a no load frequency of 61.5 Hz and a slope S_{P1} of 1 MW/Hz. Generator 2 has a no-load frequency of 61.0 Hz and a slope S_{P2} of 1MW/Hz. The two generators are supplying a real load of 2.5 MW at 0.8 power factor lagging.

i. Find the system frequency and power generated by G1 and G2. (4 marks)

ii. Assuming that an additional 1 MW load is attached to the power system. Match the new system frequency and power supplied by each generator. (5 marks)

iii. With the additional load attached (total load of 3.5 MW), calculate the system frequency and the generator powers, if the no-load frequency of G_2 is increased by 0.5 Hz. (5 marks)

e) Infinite bus is also known as the power grid. Explain the infinite bus concept. (4 marks)

QUESTION 4

a) State the meaning of power factor. Use a phasor diagram to illustrate power factor improvement. (5 marks)

b) A 415 V 50 Hz installation at Factory X supplies the loads as in table 1:

Table 1

Load	Description
A	Lighting 25 kW at unity power factor
B	An induction motor of full load efficiency 82%, Power output 40 HP (take 1 HP = 746 W)
C	Other consumable loads 25 kVA at 0.78 power factor lagging
D	Capacitance loads 6 kVAr leading

If the overall system power factor is 0.8 lagging,

i. Find the power factor of the induction motor in per unit. (7 marks)

ii. Calculate the line current. (3 marks)

c) If the overall power factor in Q4(b) is to be corrected to 0.95 lagging.

i. Find the required total leading kVAr. (4 marks)

ii. Calculate the values of capacitors (in microfarads) required to supply the kVAr if the capacitors are connected in star and delta. (6 marks)

...END OF QUESTION..................................

LIST OF FORMULA

$$(C_i) = \sum_{i=1}^{NG} (\alpha_i + \beta_i P_i + \gamma_i P_i^2)$$

$$P_{G1} + P_{G2} = P_D$$

$$P_i = \frac{\lambda - \beta_i}{2\gamma_i}$$

$$Ft = F1 + F2$$

$$\Delta P = P_o - \sum_{i=1}^{3} P_i$$

$$\lambda^{k+1} = \frac{\Delta P^k}{\Sigma \frac{1}{2\gamma_i}}$$

$$\lambda,\ \lambda^{k+1} = \lambda^k + \Delta\lambda^{(k)}$$

$$ns = \frac{120f}{p}$$

$$f_{sys} = f_{nl} - \frac{P}{S_P}$$

$$P_{load} = P_1 + P_2 = S_{P1}(f_{nl,1} - f_{sys}) + S_{P2}(f_{nl,2} - f_{sys})$$

$$\cos\theta = \frac{P}{S}$$

$$\sin\theta = \frac{Q}{S}$$

$$\tan\theta = \frac{Q}{P}$$

$$\eta = \frac{P_{out}}{P_{in}}$$

$$I_L = \frac{P_{in}}{\sqrt{3}V_{LL}}$$

$$X_C = \frac{V^2}{Q}$$

$$C = \frac{1}{2\pi f X_C}$$

$$V_{dc} = \frac{3\sqrt{2}}{\pi} V_{LL} \cos\alpha$$

$$I_{dc} = \frac{V_{dc}}{r}$$

$$P_o = i_{o(rms)}^2 r$$

$$PF_{in} = \sqrt{\frac{2\pi + 3\sqrt{3}\cos(2\alpha)}{4\pi}}$$