UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	POWER SYSTEM ANALYSIS
COURSE CODE	:	BEV20703
PROGRAMME CODE	:	BEV
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER ALL QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ Closed book 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES.

Q1 (a) Discuss briefly **TWO (2)** examples of modern power system.

(6 marks)

(b) List **TWO (2)** characteristics of rotor and stator in synchronous generator.

(4 marks)

(c) A 40 MVA, 30 kV, 3-phase, 50 Hz synchronous generator has a synchronous reactance of 10 Ω per phase and a negligible resistance. The generator is delivering a rated power at 0.8 power factor lagging to an infinite bus.

(i) Calculate the excitation voltage per-phase, E and the power angle, δ.

(5 marks)

(ii) The excitation held constant at the value found in answer Q1(c)(i), where the driving torque is reduced until the generator delivers 30 MW power. Determine the armature current, I_a and the power factor, pf.

(3 marks)

(iii) Determine the steady-state power maximum power, P_{max} of the machine before losing synchronism.

(1 marks)

(iv) If the generator delivers 40 MW power with the terminal voltage of 30 kV, and the excitation voltage in answer **Q1(c)(i)** decrease to 70%. Determine the new power angle, δ armature current, I_o and power factor, pf.

(4 marks)

(v) Determine the minimum excitation voltage, E_{min} and the armature current, I_a it the generator will lose synchronism.

(2 marks)

Q2 (a) List **THREE (3)** power system buses and state the parameters use for initially specified and the unknown parameters to be determined for each of the buses.

(3 marks)

(b) **Figure Q2(b)** shows the single line diagram of a 3-bus power system. The parameters for this system are given in **Table Q2(b)(1)** and **Table Q2(b)(2)**

(i) Compute the Y_{BUS} in polar form.

(2 marks)

(ii) Using the *Gauss-seidel* method, determine the phasor value of the voltage at bus 2 and 3. (Perform up to second (2) iterations).

(10 marks)

(iii) Calculate the real and reactive power of the slack bus after the second (2) iteration.

(2.5 marks)

(iv) Determine the power flow and line losses after second (2) iteration.

(7.5 marks)

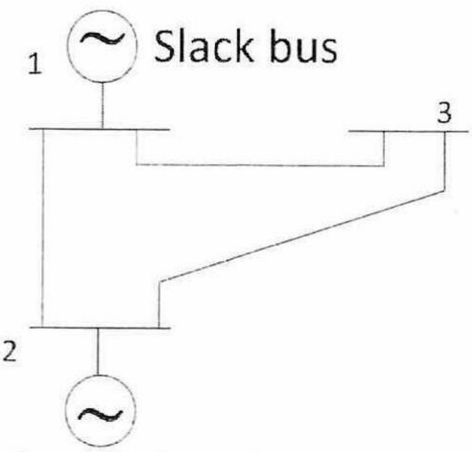

Figure Q2(b): 3-phase bus power system.

Table Q2(b)(1) Scheduled generation and load and assumed bus voltage for the power system.

Bus code i	Assumed bus voltage	Generation		Load	
		MW	MVAR	MW	MVAR
1 (Slack bus)	$1.05 + j0.0$	–	–	0	0
2	$1.00 + j0.0$	50	30	305.6	140.2
3	$1.00 + j0.0$	0.0	0.0	138.6	45.2

Table Q2(b)(2) Line impedances.

Bus code i-k	Assumed bus voltage
1-2	$0.02 + j0.04$
1-3	$0.01 + j0.03$
2-3	$0.0125 + j0.025$

Q3 (a) Explain the concept of optimal generation dispatch.

(4 marks)

(b) The fuel cost functions for three thermal plants in \$/h are given by:

$$C_1 = 500 + 41\,P_1 + 0.15\,P_1^2$$
$$C_2 = 400 + 44\,P_2 + 0.10\,P_2^2$$
$$C_3 = 300 + 40\,P_3 + 0.18\,P_3^2$$

where P_1 , P_2 and P_3 are in MW.

(i) Assuming the initial value of λ is 50, determine the optimal dispatch to meet the total load requirement of 850 MW using iterative method with gradient technique. Consider the following generators limit:

$$125 \le P_1 \le 300$$
$$175 \le P_2 \le 350$$
$$100 \le P_1 \le 300$$

(18 marks)

(ii) Calculate the total fuel cost in RM/h.

(3 marks)

Q4 Fault analysis and stability of power systems are closely related and hold significant importance in the field of electrical power engineering. They are crucial for ensuring a reliable and uninterrupted supply of electricity.

(a) An electrical circuit diagram representing a three-phase system with an impedance load and a Thevenin's equivalent circuit is shown in **Figure Q4(a).** Each generator is represented by an emf behind the transient reactance. All impedances are expressed in per unit on in common MVA base. Assume all resistances and shunt capacitances are neglected. The generator is operating on no load at their rated voltage with emfs in phase. The current $I_f(F)$ is a fault current flowing at the bottom of the diagram and V_{th} is the Thevenin's equivalent voltage source.

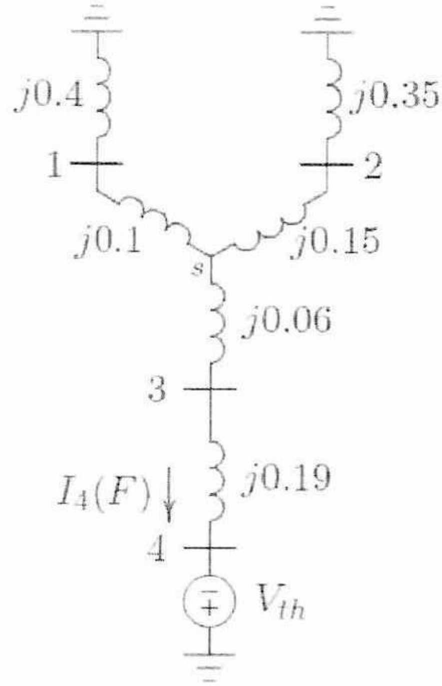

Figure Q4(a)

(iii) Calculate the fault current in per unit.

(6 marks)

(iv) Calculate the bus voltages during fault in per unit.

(9 marks)

(v) Calculate the line currents during fault in per unit.

(4 marks)

(b) Explain the differences between steady-state stability and transient stability in power system network.

(6 marks)

- END OF QUESTIONS -