UNIVERSITI TEKNOLOGI PETRONAS

FINAL EXAMINATION
JANUARY 2025 SEMESTER

COURSE	**:**	**EEB4333 - ADVANCED POWER SYSTEM**
DATE	**:**	**16 APRIL 2025 (WEDNESDAY)**
TIME	**:**	**9.00 AM - 12.00 NOON (3 HOURS)**

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions in the Answer Booklet.
2. Begin **EACH** answer on a new page in the Answer Booklet.
3. Indicate clearly answers that are cancelled, if any.
4. Where applicable, show clearly steps taken in arriving at the solutions and indicate **ALL** assumptions, if any.
5. **DO NOT** open this Question Booklet until instructed.

Note :

i. There are **FIVE (5)** pages in this Question Booklet including the cover page and appendix.

ii. **DOUBLE-SIDED** Question Booklet.

1. a. As a power system engineer, you are given a task to perform power flow study using Newton-Raphson iteration method for a three-bus power system in Pulau Tioman. **TABLE Q1** shows the per unit bus data for the power system. The per unit bus admittance matrix of the network is given by Y_{bus}. Determine all the bus voltages after the second iteration. Explain in detail all the assumptions underlying the analysis.

[24 marks]

TABLE Q1

Bus No.	Active power generated (P_G)	Reactive power generated (Q_G)	Active power demand (P_D)	Reactive power demand (Q_D)
1	Not specified	Not specified	0	0
2	1.5 pu	0	0	0
3	0	0	1.0 pu	0.5 pu

$$Y_{\text{bus}} = j\begin{bmatrix} -75 & 50 & 25 \\ 50 & -150 & 100 \\ 25 & 100 & -125 \end{bmatrix}$$

b. You have conducted a comprehensive power flow study for a large metropolitan area and have identified critical issues, such as voltage instability and overloading on key transmission lines, necessitating mitigation measures. Provide **ONE (1)** specific finding from your power flow study and propose **ONE (1)** plan for mitigating this issue. Explain how the solution would improve the grid's reliability and efficiency.

[10 marks]

2. A power system network consists of multiple protection zones, each equipped with overcurrent and earth fault (OCEF) protection relays. A fault occurs at a downstream feeder, and the protection system must ensure selective tripping while maintaining system stability. Proper relay coordination is required to ensure that the closest relay to the fault operates first, while upstream relays act as backups with appropriate time delays.

   a. Draw a simplified relay coordination diagram indicating the fault location and the affected relays. Label all key components, including circuit breakers, relays, and fault points.

   [8 marks]

   b. Using the time-grading principle, determine the required time multiplier setting (TMS) for three consecutive relays in the fault path. Assume known circuit breaker clearing times and justify your coordination settings using the standard inverse time characteristics. Show all relevant calculations and assumptions.

   [14 marks]

   c. Analyze how protection system reliability, sensitivity, and stability are balanced in this scenario. Provide a well-reasoned suggestion to improve protection coordination. Support your arguments with examples and justifications.

   [12 marks]

3. A manufacturing plant experiences frequent voltage sags that lead to costly production downtimes. As an electrical engineer, you are tasked with analyzing the root causes and proposing a comprehensive mitigation plan.

   a. Based on the concepts of power quality discussed in the lecture, identify and explain at least three possible sources of these voltage sags within the facility and from the utility supply.

   [8 marks]

   b. Propose and justify at least three different mitigation techniques or technologies that the plant can implement to minimize the impact of voltage sags. Your solutions should consider cost-effectiveness, technical feasibility, and long-term benefits.

   [10 marks]

   c. The plant is considering integrating distributed generation and energy storage as a solution. Critically evaluate how these options could improve power quality and discuss any potential drawbacks or challenges associated with their implementation.

   [14 marks]

-END OF PAPER-

APPENDIX

Jacobian Matrix

$$\mathbf{H}_{ii} = -\mathbf{Q}_i - |\mathbf{V}_i|^2 \, \mathbf{B}_{ii}$$

$$\mathbf{N}_{ii} = \mathbf{P}_j + |\mathbf{V}_i|^2 \, \mathbf{G}_{ii}$$

$$\mathbf{M}_{ii} = \mathbf{P}_i - |\mathbf{V}_i|^2 \, \mathbf{G}_{ii}$$

$$\mathbf{L}_{ii} = \mathbf{Q}_i - |\mathbf{V}_i|^2 \, \mathbf{B}_{ii}$$

$$\mathbf{H}_{ij} = - |\mathbf{V}_i||\mathbf{V}_j||\mathbf{Y}_{ij}| \, \sin(\theta_{ij} + \delta_j - \delta_i)$$

$$\mathbf{N}_{ij} = |\mathbf{V}_i||\mathbf{V}_j||\mathbf{Y}_{ij}| \, \cos(\theta_{ij} + \delta_j - \delta_i)$$

$$\mathbf{M}_{ij} = - |\mathbf{V}_i||\mathbf{V}_j||\mathbf{Y}_{ij}| \, \cos(\theta_{ij} + \delta_j - \delta_i)$$

$$\mathbf{L}_{ij} = - |\mathbf{V}_i||\mathbf{V}_j||\mathbf{Y}_{ij}| \, \sin(\theta_{ij} + \delta_j - \delta_i)$$