UNIVERSITI TEKNOLOGI PETRONAS

# FINAL EXAMINATION
# JANUARY 2025 SEMESTER

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| **COURSE** | : | **EEB4313 - ADVANCED ELECTRICAL MACHINES** |
| **DATE** | : | **12 APRIL 2025 (SATURDAY)** |
| **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 .

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

1. a. The torque of a 3-phase synchronous machine is given by

$$T = \frac{3}{\omega_{syn}} \frac{|V_t||E_f|}{X_s} \sin\delta$$

where $\omega_{syn}$, $V_t$, $E_f$, and $\delta$ are synchronous speed in radian per second, terminal voltage, field voltage and load angle, respectively. Synthesis the equation for improving the design of the machine.

[10 marks]

b. A low speed 3-phase, 10-pole, 50-Hz water turbine alternator has been designed for a micro-hydro power system. The alternator contains 144 slots, two-layer winding and 10 conductors/slot. The coil span is 150°. The fundamental flux per pole is 0.116 Wb. The 3rd, 5th and 7th harmonic fluxes are 11.5 %, 11 % and 2.8 % of fundamental flux respectively. Determine the total rms voltage of the alternator.

[15 marks]

2. a. With the aid of a diagram and formulas, analyse the characteristic of starting torque and maximum torque for induction motor.

[10 marks]

c. A 6-pole, 50-Hz, 3-phase induction motor running on full load develops a useful torque of 160 Nm when the rotor emf makes 120 complete cycle per minute. The mechanical torque lost in friction and that for core loss is 10 Nm. The total stator loss is given to be 800 W. The copper loss in the rotor windings must be considered. Determine the shaft power output and the efficiency of motor.

[15 marks]

3. Design a synchronous generator for pico-wind turbine power generation system at un-manned oil and gas platform. The generator shall be capable to deliver high efficiency, durability and reliability under varying operational conditions, while adhering to environmental sustainability practices and regulatory standards.

**Technical Specifications:**

- Rated Output Voltage : 3 kW
- Efficiency : 85 %
- Voltage Regulation : Within ± 88 % of nominal voltage

**Evaluation Criteria:**

- Basic design techniques in obtaining efficiency.
- Limiting factors in designing the generator.
- Process of optimization for each dimension of the generator.
- Process of obtaining voltage regulation for the generator.

[25 marks]

4. Develop a framework for designing a pico-linear generator for harvesting wave energy at unmanned oil and gas platform. The generator must comply with technical specifications (85 % efficiency and 1 kW nominal output power) and international standards including voltage and frequency. Evaluation criteria on the process of designing framework for linear generator are as follows:

   - Literature review on linear machines.
   - Problem statements
   - Methodology and process of optimisation in obtaining the best dimension.

[25 marks]

-END OF PAPER-