UNIVERSITI
TEKNOLOGI
PETRONAS

FINAL EXAMINATION
MAY 2012 SEMESTER

COURSE	:	**EAB 4313 – ELECTRICAL MACHINES II**
DATE	:	**6TH SEPTEMBER 2012 (THURSDAY)**
TIME	:	**9.00 AM – 12.00 NOON (3 HOURS)**

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions in the Question Booklet.
2. Begin **EACH** answers 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.
5. Do not open this Question Booklet until instructed.

Note : There are **SIX (6)** pages in this Question Booklet including the cover page.

1. a. i. In designing an alternator, what are the effects of the pitch factor and distribution span factor on the output voltage and harmonics waveform?

[4 marks]

ii. In order to produce optimum design in rotational motor, outline briefly the design criteria in determining the slot dimension of the stator.

[4 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 3^{rd}, 5^{th} and 7^{th} harmonic fluxes are 11.5 %, 11 % and 2.8 % of fundamental flux respectively. Evaluate :

i. The winding factors for the fundamental and the three harmonics, and

[6 marks]

ii. the induced phase emf for the fundamental and the three harmonics.

[6 marks]

2. a. i. Prove that the distribution factor, k_d , of a synchronous machine is given by

$$k_d = \frac{\sin\frac{1}{2}m\gamma}{m\sin\frac{1}{2}\gamma}$$

where m and γ are slots/pole/phase and slot angle, respectively.

[4 marks]

ii. **FIGURE Q2** shows a 3-phase, two-pole synchronous motor with sinusoidal currents. If any two supply terminals are interchanged, prove that the direction of rotating mmf wave is reversed, though its amplitude remains unaltered.

[4 marks]

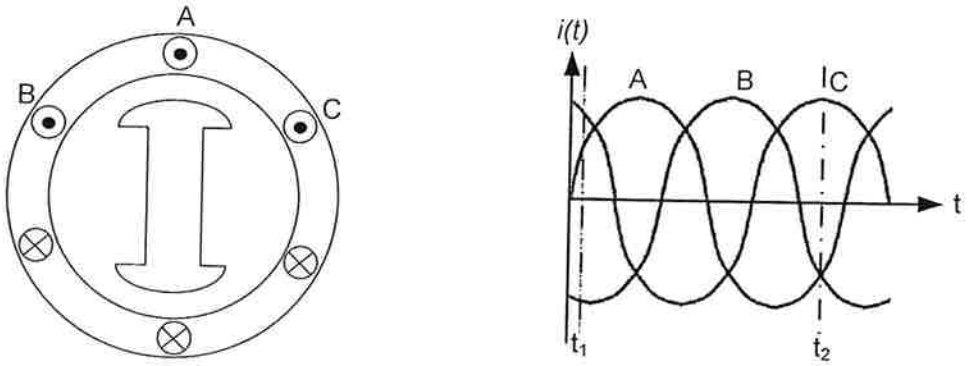

FIGURE Q2

b. A 11-kV, 3-phase star-connected synchronous motor draws a current of 45 A. The effective resistance and synchronous reactance per phase are 0.9 Ω and 28 Ω respectively.

i. Calculate the power supplied to the motor and induced back emf for 0.8 p.f lagging and 0.8 p.f leading. Analyse your answer.

[8 marks]

ii. If power factor is reduced 20 % in **part b(i)**, what would happen to the induced back emf? Justify your answer.

[4marks]

3. a. i. Outline the factors that determine the number of poles in designing a synchronous motor.

[4 marks]

ii. Justify with appropriate diagram, the effect of armature reaction in the performance of a synchronous machine.

[4 marks]

b. A 3-phase, 12-kV, 15-MVA, 60-Hz, salient pole synchronous motor is run from a 12 KV, 60 Hz balanced three phase supply. The machine's reactances X_d and X_q are 1.2 pu and 0.6 pu, respectively. Neglect rotational losses and armature resistance losses.

i. If maximum power input is obtained with no field excitation, determine the value of this power, the armature current, and the power factor for this condition.

[6 marks]

ii. If rated power output is obtained with minimum excitation, determine this minimum value of excitation emf.

[6 marks]

4. a. Sketch the torque-speed characteristic of 3 phase induction motor. Show the regions of stable and brake modes of operation. What will be the effect to the torque for the following operations:

i. If applied voltage with normal frequency is reduced to half, and

[4 marks]

ii. if both applied voltage and the frequency are reduced to half.

[2 marks]

b. A 460-V, 25-hp, 60-Hz, four-pole, Y-connected wound-rotor induction motor has the following impedances per phase referred to stator circuit:

$R_1 = 0.641\ \Omega$ $R_2 = 0.332\ \Omega$ $X_M = 26.3\ \Omega$

$X_1 = 1.106\ \Omega$ $X_2 = 0.464\ \Omega$

i. Determine maximum torque.

[5 marks]

ii. Determine starting torque.

[5 marks]

iii. If the rotor resistance is doubled by adding an external series resistance, determine the new full load torque of the machine.

[4 marks]

5. a. A synchronous motor is connected to an infinite bus and supplying constant torque and operates at unity power factor. If the field current is increased, explain what happen to the magnitude of armature currents and its power factor.

[5 marks]

b. Three existing steam generators in a power mill in providing process steam and also to use some its waste products as an energy source. Since there is an extra capacity, the mill has installed three 5 MW turbine generators to take advantage of the situation. Each turbine generator is a 4160 V 6250 kVA 0.85 pf lagging two-pole Y-connected synchronous generator with a synchronous reactance of 0.75 Ω and an armature resistance of 0.04 Ω. Turbine Generators 1 and 2 have a characteristic power-frequency slope of 2.5 MW/Hz, and Generator 3 has a slope of 3 MW/Hz.

i. If the no-load frequency of each of the three generators is adjusted to 51 Hz, how much power will the three generators be supplying when actual system frequency is 50 Hz?

[5 marks]

ii. Determine the total power for the three generators that can be supplied without exceeding the rating?

[5 marks]

iii. What would have to be adjusted to get all three generators to supply their rated real and reactive powers at an overall operating frequency of 50 Hz? Justify your answer.

[5 marks]

-END OF PAPER-