First Semester Examination
2018/2019 Academic Session

December 2018/ January 2019

EEK474 – ELECTRICAL MACHINE DESIGN
(*Rekabentuk Mesin Elektrik*)

Duration : 3 hours
(Masa : 3 jam)

Please check that this examination paper consists of **SEVEN (7)** pages and appendices **ONE (1)** page of printed appendices material before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **TUJUH (7)** muka surat dan **SATU (1)** muka surat lampiran yang bercetak sebelum anda memulakan peperiksaan ini.]*

Instructions: This question paper consists of **FIVE (5)** questions. Answer **ALL** questions. All questions carry the same marks.

[***Arahan:*** *Kertas soalan ini mengandungi **LIMA (5)** soalan. Jawab **SEMUA** soalan. Semua soalan membawa jumlah markah yang sama.]*

In the event of any discrepancies, the English version shall be used.

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]

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1. Consider a step-up three-phase transformer, Y/Δ connected. The transformer is designed for voltage range operation of 415V/11kV and frequency of 50 Hz. The material for transformer core is steel that has BH characteristic as shown in Figure Q1. Effective cross-sectional area of the transformer is 250 cm^2. Assume that maximum voltage drop is 5%. Determine:

Pertimbangkan satu pengubah tiga-fasa langkah naik, sambungan Y/Δ. Pengubah tersebut direkabentuk untuk operasi julat voltan 415V/11kV dan frekuensi 50Hz. Bahan teras pengubah adalah keluli yang mempunyai ciri BH seperti ditunjukkan dalam Rajah Q1. Luasan keratan efektif pengubah adalah 250 cm^2. Andaikan bahawa kejatuhan voltan maximum adalah 5%. Tentukan:

(a) Primary and secondary number of turns.
Bilangan belitan primer dan sekunder pengubah.

(50 marks/*markah*)

(b) Maximum value of flux density in cross-sectional area of the transformer.
Nilai ketumpatan fluks maksimum pada luasan keratan pengubah

(50 marks/*markah*)

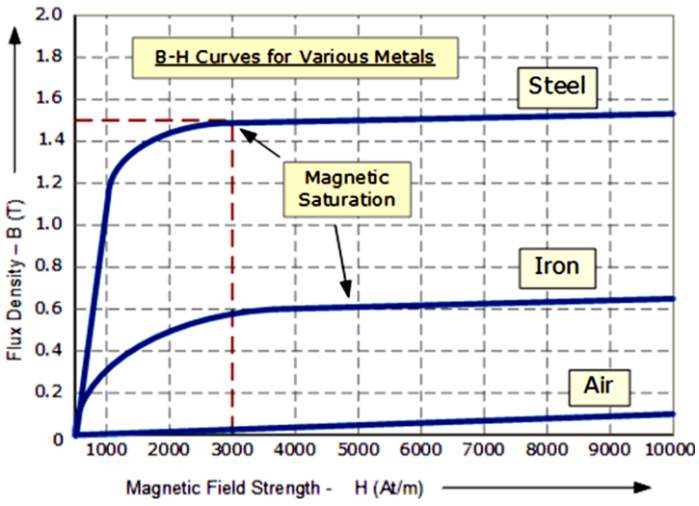

Figure Q1

Rajah Q1

2. Design a 100 kVA step-down, three-phase transformer of 11 kV to 415V cell type (constant K_t = 0.7) in Delta-Wye connection, and the operating frequency is 50 Hz. Steel core material has flux density of 1.2 Tesla as shown in Figure Q2, and the current density of AWG copper conductor is 2.6 A/mm^2. Assume that voltage regulation is 5% and efficiency is 90%.

Referring to Figure Q2, determine all dimensions of the transformer *(a, b, c, d, e and f)*. Calculate also total number of turns of the primary and secondary windings respectively.

Reka suatu pengubah tiga-fasa, langkah turun 100 kVA, 11 kV ke 415V jenis sel (pemalar K_t =0.7) sambungan Delta-bintang, dan frekuensi operasi adalah 50 Hz. Bahan teras pengubah adalah keluli yang mempunyai kepadatan fluks 1.2 Tesla seperti ditunjukan dalam Rajah Q2. Ketumpatan arus pada wayar tembaga AWG yang digunakan adalah 2.6 A/mm^2. Andaikan bahawa peraturan voltan adalah 5% dan kecekapan pengubah adalah 90%.

Merujuk kepada Rajah Q2, tentukan semua dimensi pengubah (a, b, c, d, e dan f). Kirakan juga jumlah bilangan belitan pada primeri dan sekundari masing- masing.

(100 marks/*markah*)

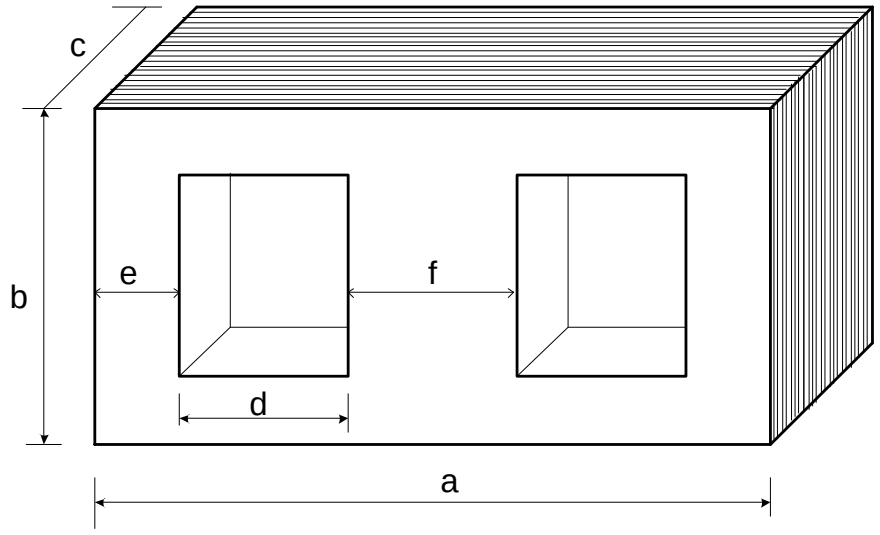

Figure Q2

Rajah Q2

3. (a) What are the differences between three-phase permanent magnet synchronous motor and three-phase induction motor? In terms of basic constructions and also methods of starting.
Apakah perbezaan antara motor segerak magnet kekal tiga-fasa dan motor aruhan tiga-fasa? Dari segi asas pembinaan dan juga cara-cara pemulaan operasi.

(25 marks/*markah*)

(b) What is cogging torque in permanent magnet synchronous motor? Give three methods to minimize this cogging torque.
Apakah tork penugalan dalam motor segerak magnet kekal? Berikan tiga kaedah untuk meminimumkan tork ini.

(25 marks/*markah*)

(c) What are the electrical losses and mechanical losses that are present in electrical motor?
Apakah kehilangan elektrik dan kehilangan mekanik yang terdapat pada motor elektrik?

(25 marks/*markah*)

(d) Explain with the aid of diagram, how short-pitched coil can successfully minimize harmonics in induced phase back-emf. Derive the expression showing how the induced phase back-emf is affected by this short-pitching and generalize this to include all harmonics. For what other reasons is the coil ever short-pitched?

Terangkan dengan bantuan gambarajah, bagaimana gegelung jarak-pendek boleh mengurangkan harmonik dalam voltan teraruh fasa. Terbitkan persamaan yang menunjukkan bagaimana voltan teraruh fasa boleh dipengaruhi oleh gegelung jarak-pendek dan kembangkan persamaan tersebut untuk meliputi semua harmonik. Di samping itu, apakah sebab-sebab lain mengapa sesuatu gegelung dijarak-pendekkan?

(25 marks/*markah*)

4. Important dimensions and parameters of a three-phase 9-slot/8-pole permanent magnet synchronous motor are given in Table Q4.

Dimensi-dimensi dan parameter penting bagi motor segerak magnet kekal tiga-fasa 9-alur/8-kutub adalah diberikan dalam Jadual Q4.

Table Q4

Jadual Q4

Stator outer radius R_{so}	60 mm
Stator inner radius R_{si}	35 mm
Rotor outer radius R_r	31 mm
Magnet thickness l_m	3 mm
Airgap thickness l_g	1 mm
Magnet remanance B_r	1.26 T
Magnet relative permeability u_r	1.05
Active length l_a	50 mm
Saturation flux density in iron B_{sat}	1.6 T

(a) Calculate the tooth body width W_{tb} and stator yoke height W_{sy}

Kirakan lebar badan gigi stator W_{tb} dan tinggi yoke stator W_{sy}

(25 marks/*markah*)

(b) Calculate the tooth tip height W_{tt} , slot depth d_s and slot area A_{slot}

Kirakan tinggi tip gigi W_{tt}, kedalaman alur d_s dan luas alur A_{slot}

(25 marks/*markah*)

(c) If 0.75mm diameter of copper wire is used for the winding with 35% packing factor, calculate total number of winding turns per phase N_{ph}

Jika diameter 0.75mm wayar kuprum digunakan untuk belitan dengan 35% faktor muatan, kirakan bilangan jumlah kitaran belitan per fasa N_{ph}

(25 marks/*markah*)

(d) Estimate the induced phase voltage if the motor is rotated at synchronous speed of 50Hz frequency.

Anggarkan voltage teraruh fasa jika motor dipusingkan pada kelajuan segerak 50Hz frekuensi.

(25 marks/*markah*)

5. Consider a three-phase permanent magnet synchronous motor with 18-slots and 2-poles.

Pertimbangkan motor segerak magnet kekal tiga-fasa dengan 18-alur dan 2-kutub.

(a) Show the winding schematic for the motor if a single-layer winding and full-pitched coil are used

Tunjukkan susunan belitan untuk motor tersebut jika belitan selapis dan gegelung jarak-penuh digunakan

(25 marks/*markah*)

(b) Show the winding schematic for the motor if double-layer winding and full-pitched coil are used

Tunjukkan susunan belitan untuk motor tersebut jika belitan dua-lapis dan gegelung jarak-penuh digunakan

(25 marks/*markah*)

(c) Show the winding schematic for the motor if double-layer winding and "short-pitched by one slot" are used.

Tunjukkan susunan belitan untuk motor tersebut jika belitan dua-lapis dan "gegelung jarak-pendek oleh satu alur" digunakan.

(25 marks/*markah*)

(d) For parts (a), (b) and (c) above, which winding schematic is the best one? Why?

Untuk soalan bahagian (a), (b) dan (c) di atas, manakah susunan belitan yang terbaik? Kenapa?

(25 marks/*markah*)

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APPENDIX

LAMPIRAN

QUESTIONS	CO	PO
Q1	2	2
Q2	3	3
Q3	1	2
Q4	3	3
Q5	2	2