

SULIT



First Semester Examination
2022/2023 Academic Session

February 2023

**EEK474 – Electrical Machine Design
(Rekabentuk Mesin Elektrik)**

Duration : 2 hours
(Masa : 2 jam)

Please check that this examination paper consists of SEVEN (7) pages of printed material including appendix before you begin the examination.

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

Instructions : This paper consists of **THREE (3)** questions. Answer **ALL** questions.

Arahan : Kertas ini mengandungi **TIGA (3)** soalan. Jawab **SEMUA** soalan.]

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

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

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1. (a) What are the electrical losses that normally occur in transformers?
Apakah kehilangan elektrik yang biasanya berlaku dalam pengubah?
(15 marks/markah)

- (b) Why steel laminations of various thicknesses from 0.1mm to 0.5mm are used in the construction of transformers?

Mengapakah laminasi keluli pelbagai ketebalan dari 0.1mm hingga 0.5mm digunakan dalam pembinaan pengubah?

(15 marks/markah)

- (c) Figure Q1 shows the BH curve of steel used for the transformer core in comparison with that of iron and air. From this BH curve, what is the appropriate value of maximum flux density B_{max} in the core during the transformer design stage? Give your reason.

Rajah Q1 menunjukkan lengkung BH keluli yang digunakan untuk teras pengubah berbanding dengan besi dan udara. Daripada keluk BH ini, apakah nilai yang sesuai bagi ketumpatan fluks maksimum B_{max} dalam teras semasa peringkat reka bentuk pengubah? Berikan alasan anda.

(15 marks/markah)

- (d) Consider a step-up, three-phase transformer, Y/ Δ connected and core type. The transformer is designed for voltage range operation of 415V/3.3kV and frequency of 50 Hz. The material for transformer core is steel with the BH characteristic as shown in Figure Q1. Effective cross-sectional area of the transformer core is 225 cm². Assume that the maximum voltage drop is 5%, determine:

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Pertimbangkan satu pengubah tiga-fasa penaik voltan, sambungan Y/ Δ dan jenis teras. Pengubah tersebut direkabentuk untuk operasi julat voltan 415V/3.3kV dan frekuensi 50Hz. Bahan teras pengubah adalah keluli yang mempunyai ciri BH seperti ditunjukkan dalam Rajah Q1. Luasan keratan efektif bagi teras pengubah adalah 225 cm². Andaikan bahawa kejatuhan voltan maximum adalah 5%, tentukan:

- (i) the numbers of primary turns N_1 and secondary turns N_2 . Use the value B_{max} that you choose in part (c).

bilangan lilitan primer N_1 dan lilitan sekunder N_2 . Gunakan nilai B_{max} yang anda pilih di bahagian (c)

(35 marks/markah)

- (ii) the full-load current for primary and secondary, assuming the transformer's rated power is 100kVA.

arus beban penuh untuk primer dan sekunder, dengan mengandaikan kuasa kadaran pengubah adalah 100kVA

(20 marks/markah)

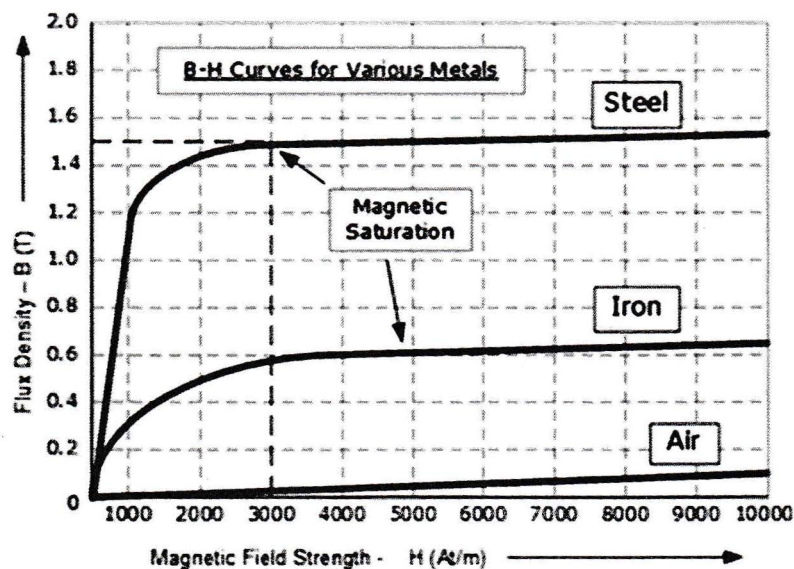


Figure Q1

Rajah Q1

2. (a) What are the differences between the three-phase permanent magnet synchronous motor and the 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 mula operasi.

(20 marks/markah)

- (b) What is cogging torque in the permanent magnet synchronous motor (PMSM)? Give several methods normally used to minimize this cogging torque.

Apakah tork penugalan di dalam motor segerak magnet kekal (PMSM)? Berikan beberapa cara yang biasa digunakan untuk meminimumkan tork penugalan ini.

(20 marks/markah)

- (c) Consider a three-phase permanent magnet synchronous motor to be used for the assisted steering wheel system in automotive applications. The winding arrangement is one of the important design keys in improving motor performance. If the motor is based on a 9-slot and 8-pole configuration, sketch the stator winding layout.

Pertimbangkan motor segerak magnet kekal tiga-fasa digunakan untuk sistem roda stereng bantuan dalam aplikasi automotif. Susunan belitan adalah salah satu kunci reka bentuk yang penting dalam meningkatkan prestasi motor. Jika motor berdasarkan konfigurasi 9-slot dan 8-kutub, lakarkan susunan belitan stator.

(40 marks/markah)

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- (d) Calculate the pitch factor K_p , the distribution factor K_d and the winding factor K_w for $n=1$ respectively for the stator winding used in part (c).

Kirakan faktor pic K_p , faktor taburan K_d dan faktor belitan K_w masing-masing untuk $n=1$ untuk belitan stator dalam bahagian (c).

(20 marks/markah)

3. Important dimensions and parameters of a three-phase, 9-slot/8-pole permanent magnet synchronous motor are given in Table Q3.

Dimensi-dimensi dan parameter-parameter penting bagi motor segerak magnet kekal tiga-fasa 9-alur/8-kutub adalah diberikan dalam Jadual Q3.

Table Q3

Jadual 3

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	1.18 T
Magnet relative permeability μ_r	1.05
Active length l_a	50 mm
Saturation flux density in iron B_{sat}	1.4 T

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

Kirakan lebar badan gigi 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 slot d_s dan luas slot A_{slot} .

(25 marks/markah)

- (c) Assuming that 0.75mm diameter of copper wire is used for the winding dan 45% packing factor, calculate the total number of winding turns per phase N_{ph} .

Andaikan bahawa diameter 0.75mm wayar tembaga digunakan untuk belitan dan 45% faktor muatan, kirakan jumlah bilangan belitan per fasa N_{ph}

(25 marks/markah)

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

Anggarkan voltage teraruh fasa E_{ph} jika motor dipusingkan pada kelajuan segerak 50Hz frekuensi.

(25 marks/markah)

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APPENDIX A

LAMPIRAN A

Question/Soalan	Course Outcome (CO)	Program Outcome (PO)
1	1	2
2	2	3
3	3	3