Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2017/2018

COURSE NAME	:	ELECTRICAL MACHINE AND DRIVES
COURSE CODE	:	BNR 31403
PROGRAMME CODE	:	BND
EXAMINATION DATE	:	JUNE/JULY 2018
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 (a) A terminal characteristic of a machine is a plot of the machine's output quantities versus each other. For a motor, the output quantities are shaft torque and speed, so the terminal characteristic of a motor is a plot of its output torque versus speed.

(i) Draw and label clearly the speed-torque characteristic of a series and shunt DC motor.

(3 marks)

(ii) Based on your drawing in **Q1(a)(i),** explain clearly the main disadvantages of DC series motor as can see from the speed-torque characteristic.

(2 marks)

(iii) Suggest **ONE (1)** solution to avoid the problem stated in **Q1(a)(ii)** to happen.

(1 marks)

(b) A 50 hp, 250 V, 1200 r/min, DC shunt motor with compensating windings has an armature resistance which including the brushes, compensating windings, and interpoles of 0.06 Ω. Its field circuit has a total resistance $R_{adj}+R_F$ of 50 Ω, which produces a no load speed of 1200 rpm. There are 1200 turns per pole on the shunt field winding as shown in **Figure Q1(b)**.

(i) Find the speed of the motor when the input current is 100 A.

(3 marks)

(ii) Find the speed of the motor when the input current is 300 A.

(3 marks)

(iii) Plot the torque-speed characteristic of this motor.

(7 marks)

(c) A series-connected DC motor has an armature resistance of 0.5 Ω and field winding resistance of 1.5 Ω. In driving a certain load at 1200 rpm, the current drawn by the motor is 20 A from a voltage source of 220 V. The rotational loss is 150 W. Find the output power and efficiency.

(6 marks)

Q2 (a) Explain how a synchronous motor starts up. When should the DC excitation be applied.

(6 marks)

(b) A 100 kW synchronous motor has the parameters as shown in **Figure Q2(b)**. Draw the phasor diagram and determine :

(i) Active power per phase
(ii) Apparent power per phase
(iii) The AC line current
(iv) The value and phase of E_o
(v) Draw the phasor diagram

(10 marks)

(c) A plot of I_A versus I_F for a synchronous motor is called as a synchronous motor v curve, for the obvious reason that is shaped like the letter V.

(i) Draw and label clearly the synchronous motor v curve corresponding to different real power levels.

(3 marks)

(ii) Based on your drawing in **Q2(c)(i)**, label where is the minimum armature current, lagging and leading power factor occurs.

(3 marks)

(iii) Explain, the relationship between I_F and I_A to determine either the reactive power is being supplied to or by motor.

(3 marks)

Q3 (a) Explain the operating principles of an induction motor using diagram as shown in **Figure Q3(a)**.

(5 marks)

(b) Using appropriate diagram discuss the effect of rotor resistance in a squirrel-cage induction motor. Hence conclude your explanation.

(5 marks)

(c) (i) Calculate the approximate values of full-load current, starting current and no-load current of an 80 hp, 4 kV, 1000 r/min, 3-phase 50 Hz induction motor.

(ii) Calculate the nominal full-load speed and torque knowing that the slip is 2 %.

(8 marks)

(d) An induction motor rotates at 1120 rpm has a power flow as shown in **Figure Q3(d)**. The vertical arrow indicates the losses at several stages in the motor. Analyse the diagram hence determine :

(i) the efficiency of the motor given the slip is 6.67 %.

(ii) the torque at the given speed.

(7 marks)

Q4 (a) Sketch the brushless exciter synchronous generator system and label the main components clearly.

(5 marks)

(b) **Figure Q4(b)** shows the 2-poles synchronous generator operating at no-load driven at a constant speed by turbine and its no-load saturation curve. Analyse the diagrams and discuss the characteristic.

(4 marks)

(c) A 480 V 200 kVA 0.8 power-factor-lagging, 60 Hz two-pole Y-connected synchronous generator has a synchronous reactance of 0.25 Ω and an armature resistance of 0.03 Ω. At 60 Hz, its friction and windage losses are 6 kW, and its core losses are 4 kW. The field circuit has a dc voltage of 200 V, and the maximum IF is 10 A. The resistance of the field circuit is adjustable over the range from 20 to 200 Ω. The OCC of this generator is shown in **Figure Q4(c)**. Determine:

(i) the field current required to make terminal voltage, V equal to 480 V when the generator is running at no load.

(1 marks)

(ii) the internal generated voltage of this machine at rated conditions.

(4 marks)

(iii) the field current required to make VT equal to 480 V when the generator is running at rated conditions.

(3 marks)

(iv) the power and torque supplied by the prime mover.

(6 marks)

(v) the efficiency of the generator at rated load.

(2 marks)

Q5 (a) The physical layout of three single-phase transformer is illustrated in **Figure Q5(a)**. Analyse the layout and sketch the corresponding three-phase schematic diagram for the primary and secondary sides of the transformer.

(6 marks)

(b) A 80 kV: 13.2 kV three-phase transformer connected in Y-Y configuration is supplying a commercial building in a city. The load draws 90 MW of power at a lagging power factor of 81 %. Analyse the circuit and calculate :

(i) The apparent power drawn by the load

(2 marks)

(ii) The apparent power supplied by the HV line (consider losses in transformer is small)

(2 marks)

(iii) The current in both HV and LV line

(3 marks)

(iv) The current in primary and secondary winding

(3 marks)

(c) Discuss advantages of three-phase autotransformer.

(5 marks)

(d) Sketch the equivalent circuit of an induction motor and label all parameters completely.

(4 marks)

- **END OF QUESTIONS –**

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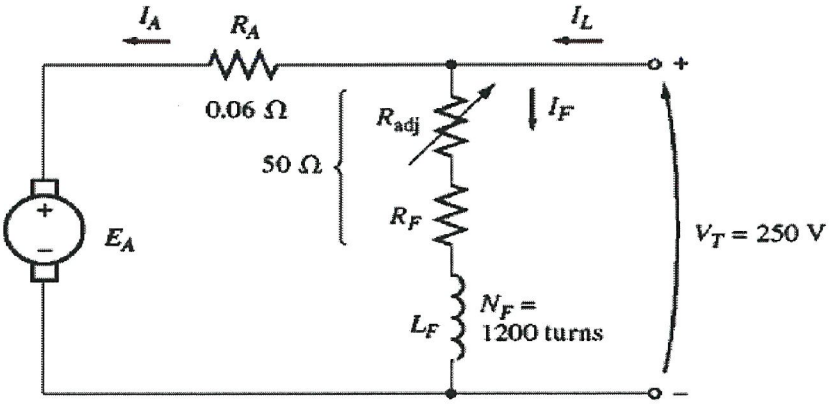
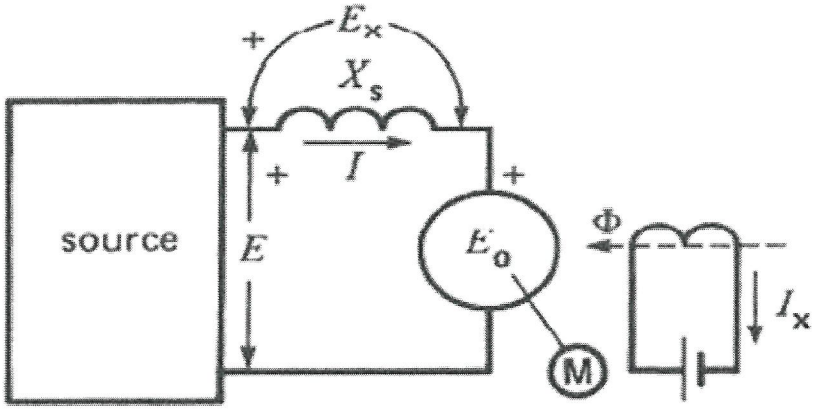


Figure Q1 (b)



E = 2.4 kV

X_s = 3 Ω

Power factor = 0.85 leading

Figure Q2 (b)

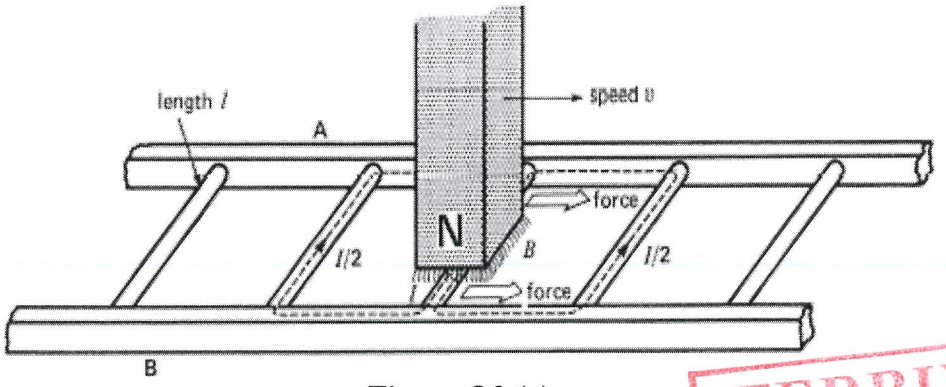


Figure Q3 (a)

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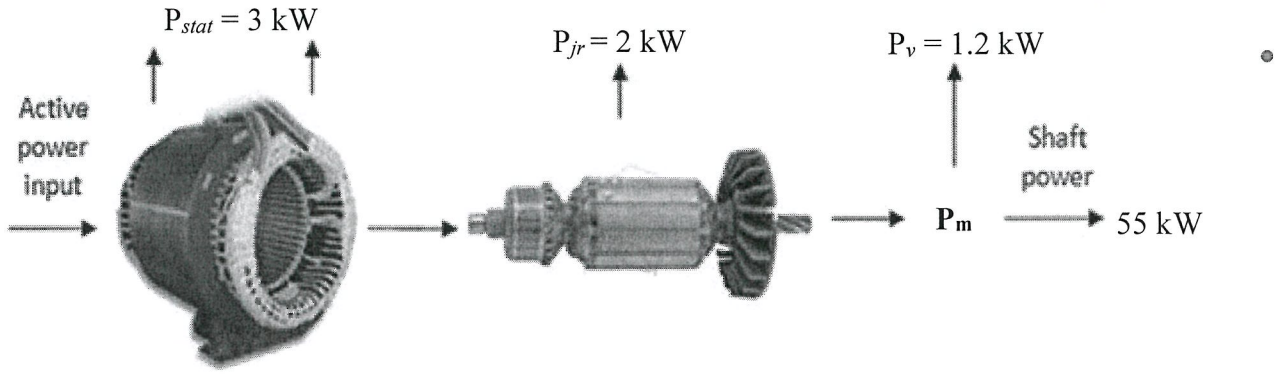
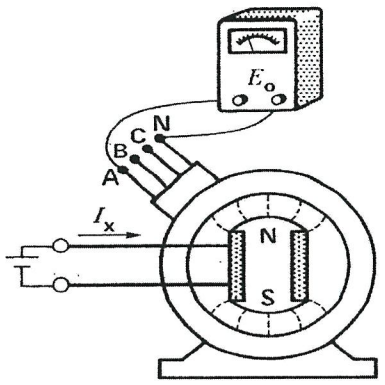
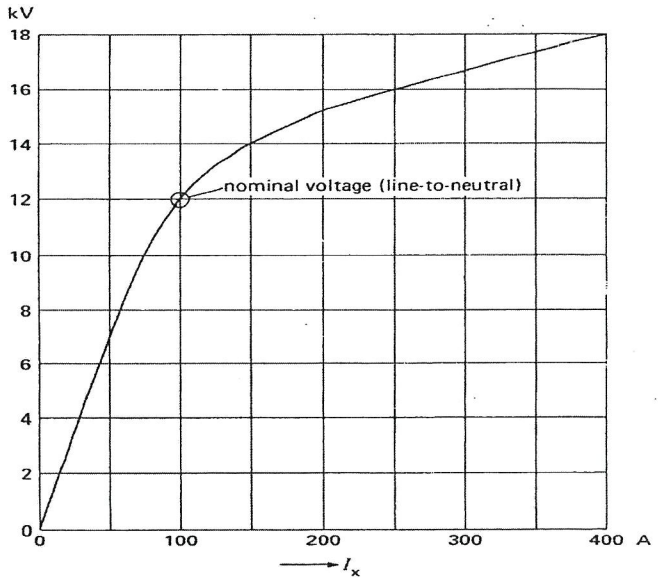


Figure Q3(d)



(a) Generator operating at no-load. I_x is the generator variable exciting current



(b) No-load saturation curve of a 36 MVA, 21kV 3-phase generator

Figure Q4 (b)

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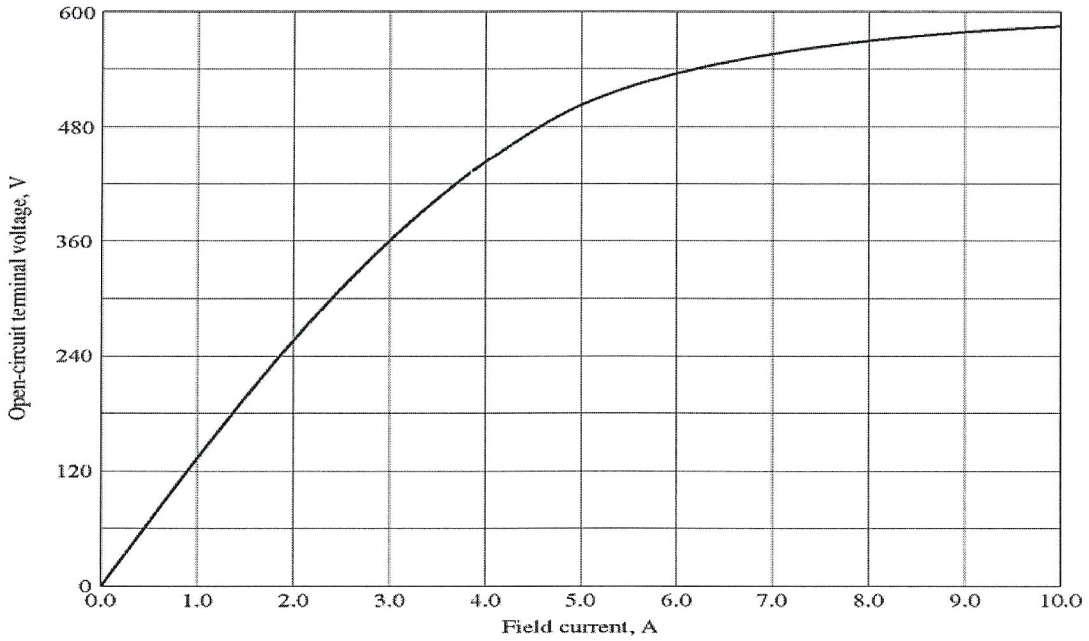

Figure Q4 (c)

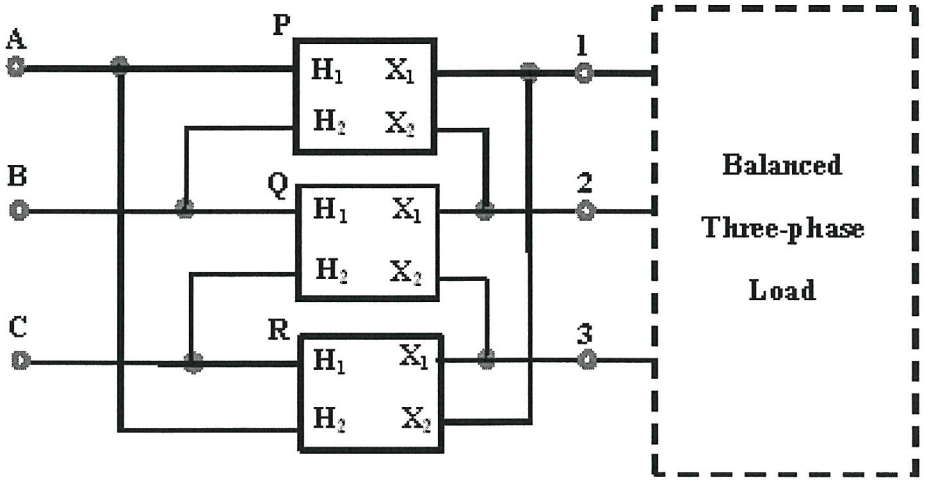

Figure Q5 (a)