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**UNIVERSITI TUN HUSSEIN ONN MALAYSIA**

**FINAL EXAMINATION  
(ONLINE)  
SEMESTER II  
SESSION 2019/2020**

COURSE NAME : ELECTRIC DRIVES  
COURSE CODE : BEF 35803  
PROGRAMME CODE : BEV  
EXAMINATION DATE : JULY 2020  
DURATION : 3 HOURS  
INSTRUCTION : ANSWER **ALL** QUESTIONS.  
**OPEN BOOK EXAMINATION**

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

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- Q1** (a) List and explain **FOUR** (4) types of common DC motors. (8 marks)
- (b) DC series motor with 230 V voltage rating runs at 1500 rpm (clockwise). The motor requires an armature current of 150 A when driving a load with a constant torque. It has  $0.5 \Omega$  of armature and field windings resistances, respectively. Assume the magnetic circuit is linear.
- (i) Determine the flux ( $\phi$ ) torque ( $T$ ) and speed ( $\omega_m$ ) expression of a DC series motor. (6 marks)
- (ii) Calculate the armature current if the motor terminal voltage is in reversed and the number of turns in field winding is reduced to 70%. (5 marks)
- (iii) Calculate the magnitude and direction of motor speed for the case of Q1(ii). (6 marks)
- Q2** (a) The speed of separately excited DC motor is controlled by chopper as shown in **Figure Q2(a)**. The DC supply voltage is 120 V, the armature circuit resistance  $R_a = 0.5 \Omega$ , the armature circuit inductance  $L_a = 20$  mH, and the motor constant is  $K_a \Phi = 0.05$  V/rpm. The motor drives at constant-torque load requires an average armature current of 20 A. Assume that motor current is continuous.
- (i) Identify the range of the duty cycle,  $\alpha$  (2 marks)
- (ii) With turn-on and turn-off interval of chopper circuit, sketch the waveforms of,
- a) input voltage ( $V$ ),  
b) average DC voltage ( $V_t$ ) and  
c) armature current ( $I_a$ ) (6 marks)
- (iii) Identify the range of speed control (9 marks)
- (iv) Identify the range of the duty cycle,  $\alpha$  (2 marks)

- (b) A DC shunt motor takes current of 80 A on 480 V supply and runs at 960 rpm. The armature resistance is  $0.25 \Omega$  while the field resistance is  $120 \Omega$ . A chopper is used to control the speed of the motor in the range of 400-750 rpm having constant torque. The on-period of the chopper is 3 ms. The field is supplied directly from 480 V supply. Determine the range of frequency of the chopper. (6 marks)

**Q3 (a)** As an electrical engineer in ABABA industry, you are required to developed a control scheme for the transfer function given in **Figure Q3(a)**.

- (i) Determine the type of DC Motor and illustrate the close-loop speed control block diagram with the given transfer function in **Figure Q3(a)**. (4 marks)

- (ii) Based on the open-loop block diagram shown in **Figure Q3(a)**, find the new transfer function of load torque disturbance without the back e.m.f. signal  $E_g(s)$ . (6 marks)

- (b) If the transfer function shown in Figure Q3(a) has the following parameters:

No-load speed,  $\omega = 1700 \text{ rpm}$

Full load,  $\Delta T_L = 280.87 \text{ N.m}$

Back e.m.f. constant,  $K_v = 0.91$

Armature resistance,  $R = 0.1 \Omega$

Armature inductance,  $L = 0.5 \text{ H}$

Viscous friction constant,  $B = 0.3$

Armature Inertia,  $J = 0.01$

Speed sensor,  $K_s = 0.91$

- (i) Calculate the full-load speed in rpm for a reference,  $V_r = 6v$ . (7 marks)

- (ii) Determine the speed regulation of the system. (3 marks)

- (iii) The speed of a DC motor could be adjusted by varying the armature voltage. Briefly describe the way of speed variation can be implemented with the aid of a separately excited DC motor circuit diagram. (5 marks)

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- Q4** (a) List **THREE (3)** techniques to control the speed for induction motor. (6 marks)
- (b) Sketch the Torque/Speed Curve of an induction motor and its load with the following information:
- Starting Torque,  $T_s = 500 \text{ N.m.}$  ,  $T_L = 200 \text{ N.m.}$   
Maximum Torque,  $T_{\max} = 1000 \text{ N.m.}$  ,  $T_L = 400 \text{ N.m}$  at 1000 rpm.  
No Load Speed at 1100 rpm ,  $T_L = 600 \text{ N.m.}$
- (6 marks)
- (c) A 3-Phase, 3 pair of poles, 100 kW, 240 V, 50 Hz, induction motor is running at 800 rpm full-load speed. Determine the frequency of the rotor current under full load condition. (7 marks)
- (d) For the modern application motor control can be applied using a microcontroller. It is where the instructions and control command can be developed without any addition equipment's. Tabulated all the equipment's that need to be used in this modern application. (6 marks)

– END OF QUESTIONS –

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Figure Q1(a)

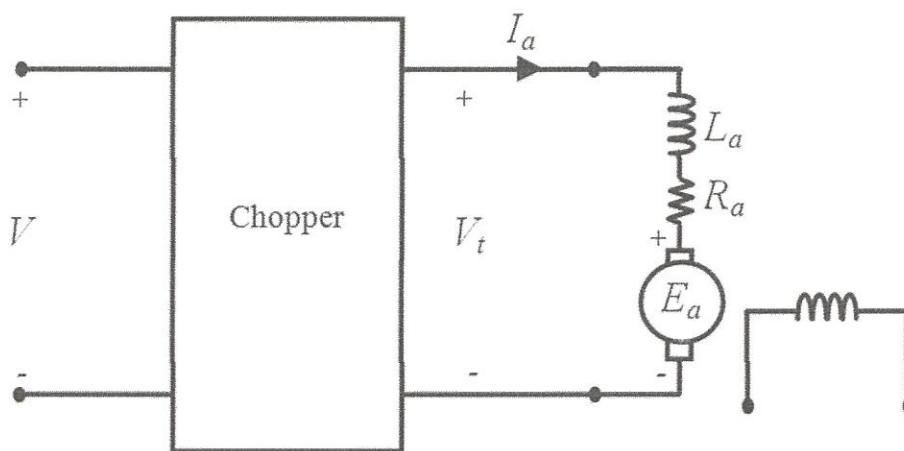
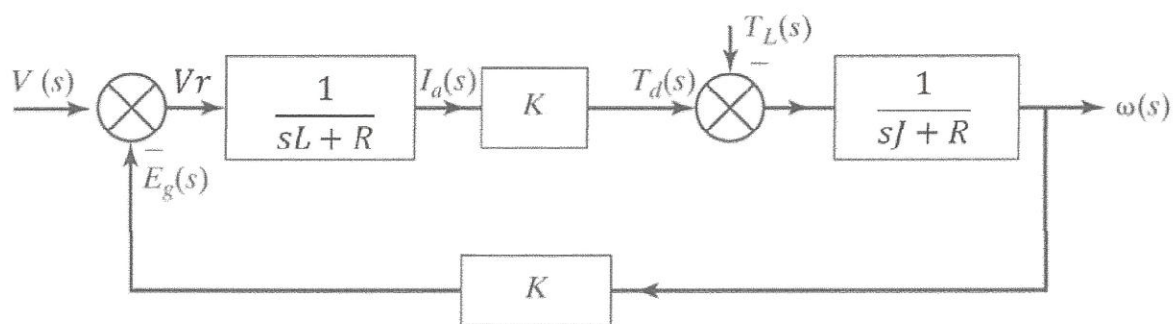


Figure Q3(a)



$$\frac{\omega(s)}{V(s)} = \frac{K}{s^2LJ + s(LB + RJ) + RB}$$

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