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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

**FINAL EXAMINATION
(ONLINE)
SEMESTER II
SESSION 2020/2021**

COURSE NAME : ELECTRICAL MACHINES AND
DRIVE SYSTEM INTEGRATION
COURSE CODE : BBJ 21005
PROGRAMME CODE : BBJ
EXAMINATION DATE : JULY 2021
DURATION : 2 HOURS
INSTRUCTION : ANSWER ALL QUESTIONS

THIS QUESTION PAPER CONSISTS OF TEN (10) PAGES

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TERBUKA

SECTION A

- Q1.** The direction of rotation of a DC series motor can be changed by _____.
- A. interchanging supply terminals
 - B. interchanging field terminals
 - C. increase field resistance
 - D. increase armature resistance
- Q2.** What is the method which can be used for the speed control of induction motor from stator side?
- A. V/f control
 - B. Controlling number of stator poles to control N_s
 - C. Adding rheostats in stator circuit
 - D. All of these
- Q3.** The consequent pole method used for controlling the number of poles can be used for
- A. only squirrel cage type motors
 - B. only slip ring induction motor
 - C. for both squirrel cage and slip ring induction motor
 - D. none of these
- Q4.** In pole amplitude modulation method for controlling number of poles, practically, the wave used for modulation is _____.
- A. square wave
 - B. triangular wave
 - C. saw tooth wave
 - D. sinusoidal wave
- Q5.** The disadvantages of scherbius system used for speed controlling in 3 phase induction motor is _____.
- A. it cannot be used for slip ring induction motors
 - B. it cannot be used for squirrel cage induction motors
 - C. it can be used for large induction motors
 - D. none of these
- Q6.** In a three-phase induction motor, the mechanical load should be such that the equivalent load resistance referred to stator is equal to the _____.
- A. total leakage reactance of the motor referred to stator
 - B. total leakage reactance of the motor referred to rotor
 - C. total leakage impedance of the motor referred to stator
 - D. total leakage impedance of the motor referred to rotor

- Q7.** The advantage of the double squirrel cage induction motor over a single cage rotor is that its _____.
- A. efficiency is higher
 - B. power factor is higher
 - C. slip is larger
 - D. starting current is lower
- Q8.** Synchronous-induction coupled motors are required for _____.
- A. high starting torque applications
 - B. high pull-out torque applications
 - C. high running torques applications
 - D. none of the mentioned
- Q9.** The difference between online and offline PLC programming is _____.
- A. whether the PLC is running or stopped
 - B. whether the programming PC has internet connectivity
 - C. the type of programming cable used
 - D. where the edited program resides
- Q10.** Identify the problem in this motor control PLC program.

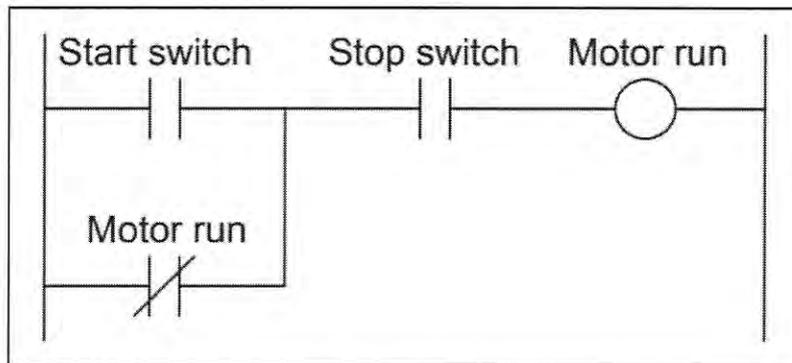


Figure Q14

- A. Coil
- B. Seal-in contact
- D. Stop contact
- E. Power source

Q11. The Boolean representation of this PLC program is _____.

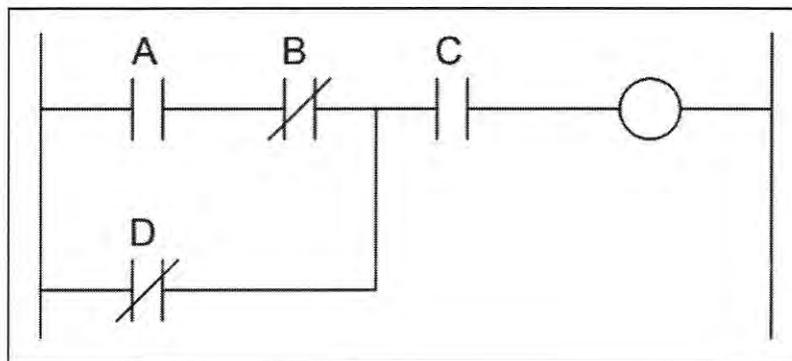


Figure Q15

- A. $ABC + D$
- B. $C + (A + B) D$
- C. $C + D (A + B)$
- D. $C (AB + D)$

Q12. An embedded _____ governs the overall operation of the VFD controller.

- A. reduced instruction set computer.
- B. central processing unit
- C. 64-bit
- D. microprocessor

Q13. As new types of _____ switches have been introduced, these have promptly been applied to inverter circuits at all voltage and current ratings for which suitable devices are available.

- A. condensed matter physics
- B. quantum mechanics
- C. physics
- D. semiconductor

Q14. The main microprocessor programming is in _____ that is inaccessible to the VFD user.

- A. BIOS
- B. read-only memory
- C. firmware
- D. operating system

- Q15.** Which of the following device is the most commonly used inverter circuits for Variable Frequency Drive (VFD)?
- A. Insulated-gate bipolar transistor
 - B. Bipolar junction transistor
 - C. Power MOSFET
 - D. Power semiconductor device
- Q16.** This starting method typically allows a motor to develop 150% of its rated _____ while the VFD is drawing less than 50% of its rated current from the mains in the low-speed range.
- A. torque
 - B. energy
 - C. force
 - D. angular momentum
- Q17.** Assuming no friction losses, if a VFD is operating a fan at 30Hz, $\frac{1}{2}$ the full speed, which of the following is the correct power consumption?
- A. 50% power consumption
 - B. 33% power consumption
 - C. 25% power consumption
 - D. 12.5% power consumption
- Q18.** If an RS-485 connection is wired between a VFD and a DDC controller, this control arrangement is known as which of the following?
- A. Remote Control
 - B. Closed Loop Control
 - C. Master/Slave Control
 - D. Serial Communications
- Q19.** One external switch is attached to the VFD. This switch is for starting and stopping the VFD. A potentiometer is also wired to the VFD and it changes the speed of the motor. This type of control arrangement is known as which of the following?
- A. Local or Hand Control
 - B. Remote Control
 - C. Cascade Control
 - D. Master/Slave Control

Q20. A fan, using a VFD, is described as a Closed Loop control arrangement. Which of the following must always be programmed in the VFD?

- i. A sensor must be wired to the VFD monitoring the feedback signal.
- ii. The VFD must be given a setpoint.
- iii. A Derivative setting must always be programmed.
- iv. Starting current of the VFD.

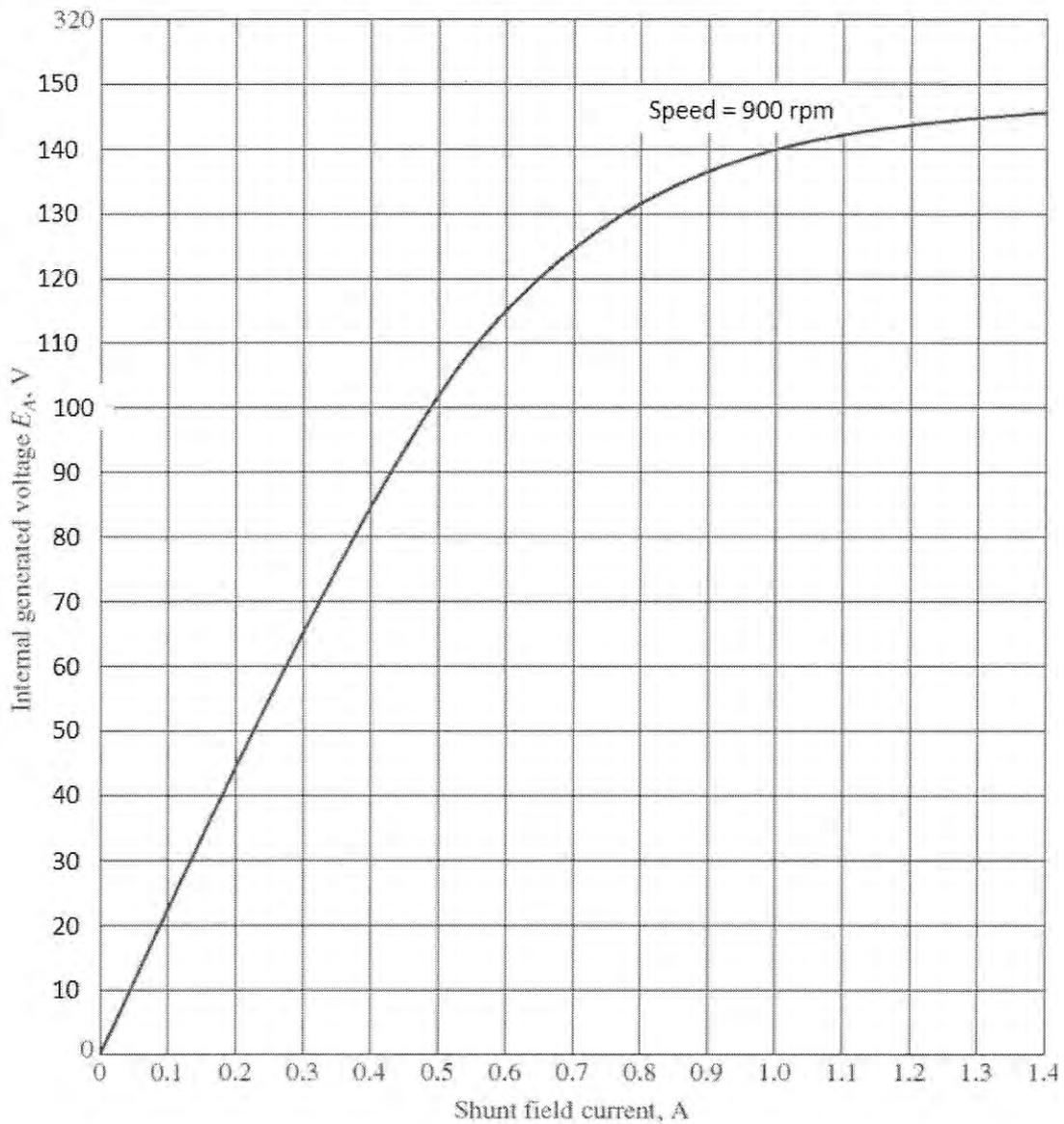
- A. i only
- B. i and ii only
- C. i, ii, and iii only
- D. i, ii, iii and iv

SECTION B

Q1. Given DC motor with specifications as below;

- | | |
|--------------------------------------|--------------------------------------|
| $P_{\text{rated}} = 10 \text{ hp}$ | $I_{L,\text{rated}} = 70 \text{ A}$ |
| $V_T = 240 \text{ V}$ | $N_F = 2000 \text{ turns per pole}$ |
| $n_{\text{rated}} = 900 \text{ rpm}$ | $N_{SE} = 20 \text{ turns per pole}$ |
| $R_A = 0.5 \Omega$ | $R_F = 150 \Omega$ |
| $R_S = 0.05 \Omega$ | $R_{\text{adj}} = 100 - 500 \Omega$ |

Rotational loss = 1900W at full load. Magnetization curve is shown in figure below;



- (a) Draw equivalent circuit of synchronous motor and separately excited DC motor with complete variables. (10 marks)
- (b) Calculate the no-load speed of the separately excited motor if;
- (i) $R_{adj} = 190 \Omega$ and $V_A = 120 \text{ V}$
 - (ii) $R_{adj} = 190 \Omega$ and $V_A = 180 \text{ V}$
 - (iii) $R_{adj} = 190 \Omega$ and $V_A = 240 \text{ V}$
- (8 marks)
- (c) What is the maximum no-load speed attainable by varying both V_A and R_{adj} ? (7 marks)
- (d) List down three (3) advantages of DC motor and two (2) advantages of AC motor. (5 marks)
- Q2.** A 50 hp, 60 Hz, 3-phase, wye-connected induction motor operates at full load at a speed of 1764 rpm. The rotational losses of the motor are 950 W, the stator copper losses are 1.6 kW and the iron losses are 1.2 kW. Assume the synchronous speed is 1800 rpm.
- (a) Draw power flow in the induction motor. (10 marks)
- (b) What is the output power, P_o at full load? (2 marks)
- (c) Calculate value of developed mechanical power, P_d . (3 marks)
- (d) Considering slip, s of the motor is 2% at normal operating point, calculate air gap power, P_g . (3 marks)
- (e) Calculate input power, P_{in} . (4 marks)
- (f) What is the efficiency, η of the motor? (3 marks)

- Q3.** (a) Draw Variable Frequency Drive (VFD) schematic representation. (7 marks)
- (b) Explain how does a Variable Frequency Drive (VFD) affect speed of a motor. (2 marks)
- (c) Give two (2) differences between Variable Frequency Drive (VFD) and Variable Speed Drive (VSD). (4 marks)
- (d) Explain how does a Variable Frequency Drive (VFD) reduces energy consumption. (3 marks)
- (e) A VFD can be used to control multiple induction motors at one time and can save cost. However, there are few disadvantages of doing this approach. List three (3) of the disadvantages? (3 marks)
- (f) What is the meaning of slip, s in induction motor? Write the basic formula. (3 marks)
- (g) Why would an induction motor experience more slip when a load is added onto it? Explain the situation. (3 marks)

-END OF QUESTIONS -

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List of Formulas – DC motor	
$I_F = \frac{V_T}{R_{adj} + R_F}$	$E_A = V_T - I_A (R_A + R_S)$
$I_A = I_L - I_F$	$\frac{E_A}{E_{Ao}} = \frac{n}{n_o}$
$I_F^* = I_F - \frac{AR}{N_F}$	$SR = \frac{n_{nl} - n_{fl}}{n_{fl}} \times 100\%$
$I_F^* = I_F + \frac{N_{SE}}{N_F} I_A$	
List of Formulas – Induction motor	
$P = hp \times 746$	
$P_d = P_o + P_{rot}$	
$P_g = \frac{P_d}{1-s}$	
$P_m = P_g + P_{cu_stator} + P_{core}$	
$\eta = \frac{P_o}{P_m} \times 100\%$	