

**FINAL**  
Examination Paper

(COVER PAGE)

Session : April 2019

Programme : Diploma In Mechanical Engineering (DMEN)

Course : EEE2115 : Electrical Power and Machines

Date of Examination : 28 July 2019 (Sunday)

Time : 5:00pm – 7:00pm Reading Time: Nil

Duration : 2 Hours

Special Instructions :

This paper consists of **SIX (6)** questions. Answer any **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks.

Materials permitted : Calculator

Materials provided : Nil

Examiner (s) : Alan Wong Kam Mun and Dennis, Koh Mui Siang

Moderator : Dr Jeya Gopi Raman

*This paper consists of 6 printed pages, including the cover page.*

DIPLOMA IN MECHANICAL ENGINEERING PROGRAMME (DMEN)  
 EEE2115: ELECTRICAL POWER & MACHINES  
 FINAL EXAMINATION: APRIL 2019 SESSION

**Instructions:** This paper consists of **SIX (6)** questions. Answer any **FOUR (4)** questions in the answer booklet provided. All questions carry equal marks.

**Question 1**

- (a) A Direct Current (D.C) shunt motor is rated for 230 V, 1350 rpm, 10 hp,  $I_L = 37.5$  A, and  $I_f = 0.75$  A. It is known that  $R_a = 0.35 \Omega$  and rotational losses = 519 W at rated speed. Determine:
- (i) the developed torque (4 marks)
  - (ii) counter-emf  $E_a$  (2 marks)
  - (iii) efficiency at rated condition (2 marks)
  - (iv) For operation at 230 V, with  $I_L = 20$  A and field current  $I_f = 0.75$  A, calculate the value of developed torque and speed. (11 marks)
- (b) A four pole D.C motor is wave wound with 540 conductors. The armature current is 60 A and the armature circuit resistance is  $0.5 \Omega$ . If the flux per pole is 25 mWb, calculate the speed when the motor is connected across a 500 V supply. (6 marks)

**Question 2**

- (a) A dc motor drives a 100kW generator having an efficiency of 87%.
- (i) What should be the minimum kW rating of the motor? (2 marks)
  - (ii) If the overall efficiency of the motor-generator system is 74%, what is the efficiency of the motor? (2 marks)
  - (iii) What is the losses at the motor and generator respectively if the generator is operating at full rating ? (4 marks)
- (b) A 600 V dc motor drives a 60 kW load at 900 rpm. The shunt field is  $100 \Omega$  and the armature resistance is  $0.16 \Omega$ . If the motor efficiency is 85%, determine:
- (i) the speed at no-load and the speed regulation. (10 marks)
  - (ii) the rotational loss. (7 marks)

**Question 3**

- (a) A 750 kW, 11 kV, 3-phase, star-connected synchronous motor has a synchronous reactance of  $35 \Omega$  per phase and negligible resistance. Determine the excitation voltage per phase when the motor is operating on full-load at 0.8 power factor leading with an efficiency of 93%.  
(10 marks)
- (b) A 100 hp, 3-phase, star-connected, 60 Hz, 420 V, 4-pole cylindrical rotor synchronous motor is operating at rated conditions and at 80 percent power-factor leading. The efficiency, excluding field and stator losses, is 96 percent, and the synchronous reactance is  $2.72 \Omega$ /phase. Determine the:
- (i) Developed torque (4 marks)
  - (ii) Armature current (5 marks)
  - (iii) Excitation voltage (4 marks)
  - (iv) Power angle (2 marks)

**Question 4**

- (a) A 1000 kVA, 6.6 kV, 3-phase, star connected synchronous generator has a synchronous reactance of  $25 \Omega$  per phase. It supplies full-load current at 0.8 lagging power factor and at rated terminal voltage.
- (i) Compute the excitation voltage,  $E_f$ . (9 marks)
  - (ii) Compute the new terminal voltage  $V_T$  for the same excitation as computed in (i) above when the generator supplies full load current at 0.8 leading power factor. (6 marks)
- (b) A factory takes 600 kVA at 0.6 lagging power factor. A synchronous motor is to be installed to raise the power factor to 0.9 lagging when the synchronous motor is taking in 200 kW. Calculate the corresponding apparent power (in kVA) taken by the synchronous motor and the power factor at which it operates.  
(10 marks)

**Question 5**

- (a) Define synchronous speed of a three-phase induction motor. What are the factors that influence synchronous speed? (3 marks)
- (b) A 240 V, 10 hp, 4-pole, 50 Hz, star-connected induction motor has a full load slip of 6 %. Determine the :
- (i) Synchronous speed of the motor (2 marks)
  - (ii) Rotor speed at the rated load (2 marks)
  - (iii) Rotor voltage frequency at the rated load (3 marks)
  - (iv) Shaft torque at the rated load (3 marks)
- (c) Explain about breakdown torque and locked- rotor torque of an induction motor. Under what condition will the rotor of an induction motor be locked ? (4 marks)
- (d) The power input to the rotor of a 415 V, 50 Hz, 6-pole , 3-phase induction motor is 75kW . The rotor voltage is observed to make 120 complete alternations per minute. The stator losses is negligible. Determine the :
- (i) Slip (2 marks)
  - (ii) Rotor speed (2 marks)
  - (iii) Rotor copper loss (2 marks)
  - (iv) Mechanical power developed (2 marks)

**Question 6**

(a) An air cooled transformer is found to be heated up slightly when the primary winding is connected to 240 V ac under no load condition at the secondary winding.

(i) Name the two main transformer losses under no load condition. (4 marks)

(ii) Give the typical no load current for large power transformer (in term of % of full load current) ? (2 marks)

(iii) Give the typical no load current for very small distribution transformer (in term of % of full load current) ? (1 mark)

(b) A 50 kVA , 2000 V/ 240 V, 60 Hz single phase transformer has the following parameters expressed in Ohms :

$$R_{LS} = 0.006, R_{HS} = 1.244, X_{LS} = 0.0121$$

$$X_{HS} = 2.42, R_{fe} = 35000, X_M = 5400$$

The transformer is operating in the step-down mode, delivering power to full rated load, at rated voltage and 0.94 power factor lagging.

(i) Draw the equivalent circuit with respect to the High Side (HS) for the above transformer operation. (6 marks)

(ii) Determine the equivalent impedance of the transformer referred to the high voltage side. (5 marks)

(iii) Determine the input impedance of the combined transformer and load. (5 marks)

(iv) Determine the actual input voltage on the high voltage side. (2 marks)

USEFUL FORMULA

TRANSFORMER

1 horsepower = 746 W

$E_p = 4.44 N_p f \phi_{max}$

$I_o = I_{fe} + I_M$

$a = \frac{N_{HS}}{N_{LS}} = \frac{V_{HS}}{V_{LS}}$

$Z_{load,HS} = a^2 \cdot Z_{load,LS}$

$voltage\_regulation = \frac{E - V_{rated}}{V_{rated}}$

INDUCTION MOTOR

$n_s = \frac{120 f_s}{P}$

$S = \frac{n_s - n_r}{n_s}$

$P_{gap} = \frac{P_{rcl}}{S}$

$P_{mech} = P_{gap} (1 - S)$

$\eta = \frac{P_{shaft}}{P_{in}}$

$F_p = \frac{P_{in}}{S_{in}}$

SYNCHRONOUS MOTOR

$V_T = I_a jX_s + E_f$

$P_{in,3\phi} = 3V_T I_a \cos\theta = \sqrt{3}V_L I_L \cos\theta$

$P_{losses} = P_{stray} + P_{f,w} + P_{core} + P_{scl} + P_{fcl}$

$P_{mech} = \frac{-3V_T E_f}{X_s} \sin\delta$

DC MACHINE

$E_a = \frac{nPz\phi_p}{60a} = n\phi_p k$

$T_D = B_p I_a k$

motor  $n = \frac{V_T - I_a R_{acir}}{\phi_p k}$  where  $\phi_p \neq 0$

$P_{mech} = E_a I_a$

$T_{D,shunt} \propto I_f I_a$

$P_{losses} = P_{acir} + P_b + P_{fcl} + P_{core} + P_{f,w} + P_{stray}$

**-THE END-**