FINAL
ALTERNATIVE ASSESSMENT

(COVER PAGE)

Session	:	**April 2020**
Programme	:	Diploma in Mechanical Engineering (DMEN)
Course	:	**EEE2115: Electrical Power & Machines**
Date of Examination	:	3 August 2020 (Monday)
Time	:	4.00pm – 6.15pm Reading Time : Nil
Duration	:	2 Hours 15 Minutes

Special Instructions :

This paper consists of **FOUR (4)** questions. Answer all **FOUR (4)** questions. All questions carry equal marks.

Material permitted :

Non-Programmable Scientific Calculator

Materials provided :

Nil

Examiner(s)	:	**Mr Alan Wong Kam Mun, Mr Koh Mui Siang**
Chief Moderator	:	Mr Manickam

*This paper consists of **4** printed pages, including the cover page*

DIPLOMA IN MECHANICAL ENGINEERING PROGRAMME (DMEN)
EEE2115: ELECTRICAL POWER AND MACHINES
FINAL ALTERNATIVE ASSESSMENT: APRIL 2020 SESSION

Instructions: This paper consists of **FOUR (4)** questions. Answer all **FOUR (4)** questions. All questions carry equal marks.

Question 1

(a) Data obtained from short-circuit and open-circuit tests of a 75 kVA, 4600/230 V, 50 Hz transformer are:

Open-circuit Test	**Short-circuit Test**
(Low-voltage side Data)	(High-voltage side Data)
$\boldsymbol{V}_{OC}$ = 230 V	$\boldsymbol{V}_{SC}$ = 160.8 V
$\boldsymbol{I}_{OC}$ = 13.04 A	$\boldsymbol{I}_{SC}$ = 16.3 A
$\boldsymbol{P}_{OC}$ = 521 W	$\boldsymbol{P}_{SC}$ = 1200 W

(i) Calculate for the core-loss resistance ($R_{fe,LS}$) from open-circuit test data. (4 marks)

(ii) Calculate for the magnetizing reactance ($X_{M,LS}$) from open-circuit test data. (6 marks)

(iii) Determine the transformer windings resistance ($R_{eq,HS}$) from short-circuit test data. (4 marks)

(iv) Determine the transformer windings reactance ($X_{eq,HS}$) from short-circuit test data. (4 marks)

(b)

(i) Determine the voltage regulation of the transformer operating at rated load and 0.75 power factor lagging. (7 marks)

Question 2

(a) A DC shunt motor has input voltage 200 V, R_a = 0.116 Ω and R_{shunt} = 75 Ω. It is found that the motor draws a line current of 165.16 A with a shaft speed of 500 rpm. Sketch the diagram and calculate the output mechanical power.

(9 marks)

(b) A 240 V_{dc} separately excited motor has an armature resistance of 0.68Ω and draws a full current of 24 A at a speed of 100 rpm. Calculate :

(i) The emf, Ea. (4 marks)

(ii) The output power developed. (4 marks)

(iii) The torque developed. (4 marks)

(iv) If the pole flux is reduced by 20%, calculate the new speed. (4 marks)

Question 3

A 3-phase, 4000 V, 60 Hz, 500 hp, 4-pole induction motor is operating at rated condition. The breakdown of losses are: stator copper loss =12.4 kW, rotor conductor loss = 19.9 kW, core loss = 11.1 kW, stray power = 10.2 kW, fiction and windage = 18.2 kW.

(i) Sketch the power flow diagram with its values. (5 marks)

Calculate the following:

(ii) Shaft speed. (7 marks)

(iii) Shaft torque. (3 marks)

(iv) Developed torque. (4 marks)

(v) Input power to stator. (3 marks)

(vi) Overall efficiency. (3 marks)

Question 4

(a) A 20 kW, 3–phase, Y-connected, 50 Hz, 400 V, 4-pole synchronous motor is operating at rated condition. It operates with a power angle of 50° and an efficiency of 95 %. The motor has a synchronous reactance of 3 Ω per phase. Determine:

(i) The active input power, P_{in}. (2 marks)

(ii) The excitation voltage, E_F. (4 marks)

(iii) The armature current, I_a. (4 marks)

(iv) The effect of increasing the field excitation on the performance of a synchronous motor. (5 marks)

(b) A factory takes 600 kVA at 0.60 lagging power factor. A synchronous motor is to be installed to raise the power factor to 0.90 lagging when the synchronous motor is taking in 200 kW.

(i) Calculate the corresponding reactive power (in kVAR) taken by the synchronous motor. (7 marks)

(ii) The power factor at which the synchronous motor operates. (3 marks)

~The End~

USEFUL FORMULA

TRANSFORMER

1 horsepower = 746 W

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

$I_o = I_{fe} + I_M$

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

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

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

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

$$P_{mech} = E_a I_a$$

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

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