THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND COMMUNICATIONS ENGINEERING

SECOND SEMESTER EXAMINATION (2023)

EE324 ELECTRICAL MACHINES & DRIVES

BEEP 3

TIME ALLOWED: 3 HOURS

INFORMATION FOR STUDENTS:

- You have TEN (10) minutes to read the paper. You must NOT begin writing during this time.
- All answers must be written in the ANSWER BOOK supplied. COMPLETE THE DETAILS REQUIRED ON THE FRONT COVER OF YOUR ANSWER BOOK. DO THIS NOW.
- Drawing instruments and calculators are permitted.
- Answer ALL FIVE (5) questions.
- All questions carry equal marks. Total marks available is 100 marks.
- If you are found cheating in the examination, the penalties specified by the University shall apply.
- Switch OFF all mobile phones.

QUESTION ONE **[2+2+2+2+12 = 20 Marks]**

A. Cite the differences between a ***cylindrical*** and a ***salient-pole*** rotor in synchronous generators. **[2 marks]**

B. The synchronous speed of a 12-pole generator is 500 rpm. What is the frequency of its operation? **[2 marks]**

C. Why is the d-axis reactance larger than the q-axis reactance in a salient-pole alternator? **[2 marks]**

D. Explain floating in parallel operation of alternators. **[2 marks]**

E. A 48-slot, 8-pole, three-phase synchronous generator is wound using the double-layer winding. **[12 marks]**

Determine;

I. the pitch factor,

II. the distribution factor,

III. the winding factor,

IV. the phase voltage, and

V. the line voltage.

QUESTION TWO **[3+5+12 = 20 Marks]**

A. Define ***damper winding*** and state how it help to minimize ***hunting*** in synchronous motors? **[3 marks]**

B. Why is it necessary to improve the overall power factor of a manufacturing plant? How can this be achieved with a synchronous motor? If a synchronous motor is dedicated to improving the power factor, it is called a _____?
[5 marks]

C. A manufacturing plant uses 100 kVA at 0.6 pf lagging under normal operation. A synchronous motor is added to the system to improve the overall power factor. The power required by the synchronous motor is 10 kW. **[12 marks]**

I. Determine the overall power factor when the synchronous motor operates at 0.5pf leading.

II. What must be the power factor of the motor to improve the overall power factor to 0.9 lagging?

QUESTION THREE **[20 marks]**

The per-phase equivalent circuit parameters of a 208-V, 4-pole, 60-Hz, three-phase, Y-connected, induction motor are $R_1 = 0.4\ \Omega$, $X_1 = 0.8\ \Omega$, $R_2 = 0.3\ \Omega$, $X_2 = 0.9\ \Omega$, and $X_m = 40\ \Omega$. The core loss is 45 W, and the friction and windage loss is 160 W.

When the motor operates at a slip of 5%, determine;

I. the input current,

II. the power input,

III. the air-gap power,

IV. the power developed,

V. the power output,

VI. the shaft torque, and

VII. the efficiency of the motor.

VIII. Draw its power-flow diagram

QUESTION FOUR **[3+3+5+11 = 20 Marks]**

A. At what speed does the revolving field rotate in an induction motor? How can it be determined? **[3 marks]**

B. What is the rotor frequency when the rotor is; **[3 marks]**

   I. locked and

   II. rotates at 5% slip?

C. ***Rotor Resistance Control*** is one method used to control the speed of a three phase induction motor. **[5 marks]**

   I. Explain how this is achieved

   II. State three (3) disadvantages associated with this speed control method

D. A 120-V, 60-Hz, 6-pole, Δ-connected, three-phase induction motor has a stator impedance of 0.1 + j0.15 Ω/phase and an equivalent rotor impedance of 0.2 + j0.25 Ω/phase at standstill. **[11 marks]**

   I. Find the maximum power developed by the motor and the slip at which it occurs.

   II. What is the corresponding value of the torque developed by the motor?

QUESTION FIVE **[9+11 = 20 Marks]**

A. The rotor speed of a 440-V, 50-Hz, 8-pole, three-phase induction motor is 720 rpm. **[9 marks]**

Determine;

I. The synchronous speed

II. The slip

III. The rotor frequency

B. A 2-hp, 120-V, 60-Hz, 4-pole, three-phase, Y-connected, salient-pole, synchronous motor delivers the rated power at 0.8 pf lagging. If X_d = 2.5Ω/phase and X_q = 1.7 Ω /phase, and P_r = 80 W. **[11 marks]**

Determine;

I. The excitation voltage

II. The power angle

III. The power developed

IV. The torque developed

v. The efficiency of the motor