THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY
DEPARTMENT OF ELECTRICAL AND COMMUNICATIONS ENGINEERING
SECOND SEMESTER EXAMINATION (2021)
EE324: ELECTRIC MACHINES DRIVES AND CONTROLS

TIME ALLOWED: 3 HOURS

INFORMATION FOR STUDENTS

1. You have **TEN (10) MINUTES** to read the paper.

   You must not begin writing during this time.

2. 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**.

3. Only drawing instruments and calculators are permitted on your desk.

4. Answer all questions.

5. Total available mark is 50.

6. If you are found cheating in the Examination, the penalties specified by the University shall apply.

7. **TURN OFF** all mobile phone and place them on the floor under your sit before the start of examination.

QUESTION 1

a. A 250 V, four-pole shunt motor has wave winding with 500 conductors. The armature circuit resistance is 0.25Ω, field resistance is 100Ω and the flux per pole is 0.02 Wb. Armature reaction is neglected. If the motor draws 14.5 A from the mains, then compute

    (i) Speed

                                           2marks

    (ii) The torque developed in the armature

                                           2marks

    (iii) The brake horse power ignoring all losses

                                           1mark

b. Electric drives are increasingly being used in most sectors of the economy and their application capacity range of power and speed are up to 100MW in power and up to 80,000 rpm in speed. Some of these application areas are in process industry and machining

    i. What is an electric drive?

                                           2marks

    ii. Draw the general block diagram of electric drive system and label all the components.

                                         3mark

QUESTION 2

Three phase induction motors are the most commonly used AC motors in the industry because they have simple and rugged construction, low cost, high efficiency, reasonably good power factor, self-starting and low maintenance cost. Almost more than 90% of the mechanical power used in industry is provided by three phase induction motors

a. Draw the torque-speed characteristic curve of a three phase induction motor and label all the important operating points on the curve.

3 marks

b. The resistance of the rotor of a 3-phase, 6-pole, 50 Hz, induction motor is to be varied to control its speed. Its slip at full load is 4% and the rotor resistances per phase as 0.3 ohm. The torque of the motor remains constant and is expressed in terms of slip s, and the rotor resistance R_2 as;

$$T = \frac{K}{R_2} s$$

k represents all motor constants and sX_{2s}, is neglected.

When the external resistance is connected to the rotor, the total rotor resistance is expressed as (R_2+r) where r is the value of the external resistor.

Determine the value of the external resistor to be connected in series with each phase of the rotor to reduce the speed by 10%.

7marks

QUESTION 3

A DC motor can obtain its source directly from battery or from a chopper or from a rectifier.

(a) State the function of a chopper in a motor drive system

2marks

(b) If a 60V chopper drives a resistive load of 12Ω at a frequency of 1 kHz and switch on time of 0.2ms, calculate the values of:

i. Average load current

3marks

ii.   The rms value of the load currents

2marks

ii.   Load power

3marks

QUESTION 4

The converter shown in Figure Q4 is a 6-pulse converter which is connected to a transformer that produces a secondary line voltage of 40kV, 60Hz. The load draws a DC current of 450Amps. If the firing angle is 75%, calculate the following:

a.   The DC output voltage

3marks

b.   The effective value of the secondary line current

2marks

b.   The active power drawn from the ac line

3marks

d.   The reactive power absorbed by the converter
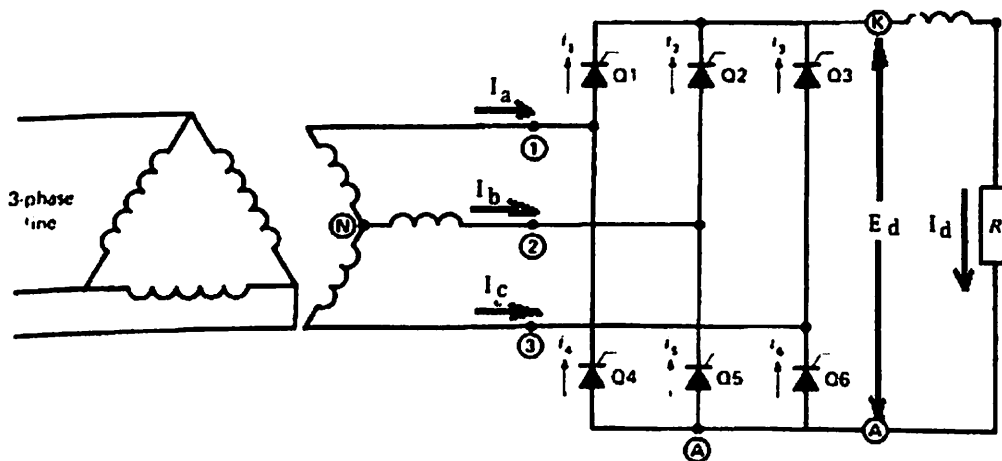
2marks

Figure Q4

QUESTION 5

(a)   What is the function of the controller in the motor drive and control system?

2Marks

(b)   Draw a block diagram of the controller of a motor drive system, labeling all the state variables it is able to control.

3Marks

(c)   For the system in Figure Q5 below

i.   Write the expression for the transfer function

3marks

ii.   Name the resistor that would be used to calibrate as a potentiometer to control the gain of this circuit. Provide a short explanation for your answer.
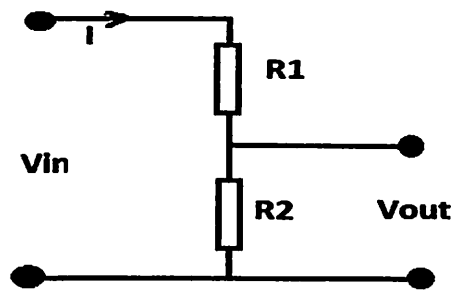
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Figure Q5