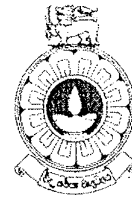


The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering



Study Programme	: Bachelor of Science Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	: DMX4410 Electrical and Pneumatic Machines
Academic Year	: 2023/2024
Date	: 02 nd March 2025
Time	: 09.30-12.30
Duration	: 3 hours

General Instructions

1. Read all instructions carefully before answering the questions.
2. This paper consists of five (5) questions on five (5) pages.
3. The answer for each question should commence from a new page.
4. This is a Closed Book Test (CBT).
5. Answers should be in clear handwriting and do not use a red pen.
6. Clearly state your assumptions, if any.
7. Answer to all questions.

Q1

- a) Compare the basic operating principles of EMRs and SSRs. How does each achieve electrical isolation between control and load circuits? [04]
- b) Explain the purpose of using H-bridge circuits for DC motor control. Draw a H-bridge circuit and explain how it provides bi-directional control. [08]
- c) A PWM-controlled DC motor drive has a supply voltage of 48V and a PWM switching frequency is 20 kHz. Calculate the required duty cycle to achieve an average voltage of 30V. [08]

Q2

- a) A series DC machine is consumed 6.5kW when armature current 12.5A flows through the armature and field resistance of 3.3Ω and 2Ω respectively. Assume stray losses of 1.2kW. Calculate the following:
- Terminal voltage, V_T [03]
 - Back EMF (E_a) [03]
 - Net torque, given that the speed is 3560rpm [03]
 - Efficiency of the machine [03]
- b) A 250V DC shunt motor with compensating windings has an armature resistance of 0.06Ω . The field circuit resistance is $R_{adj} + R_F = 50\Omega$, which produces a no-load speed of 1200 rpm.

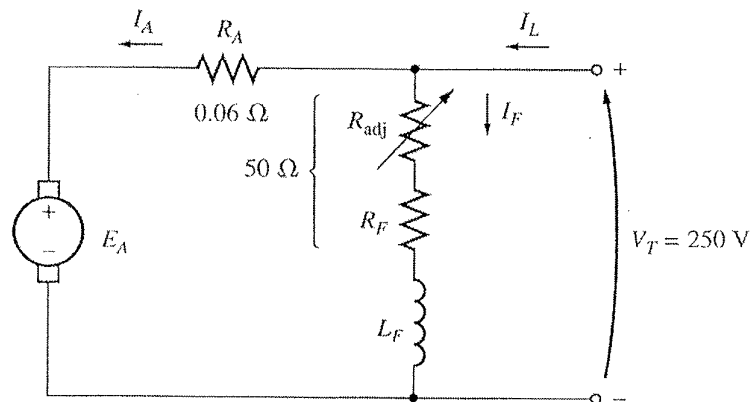


Figure Q02

- Find the speed of this motor when its input current is 100A. [04]
- Find the induced torque when its input current is 100A. [04]

Q3

- Explain the operation of a three-phase Direct Online Starter (DOL) and draw its circuit diagram. Label all essential components in the diagram. [04]
- What is the primary function of the three contactors in a star-delta starter circuit and draw the flow chart illustrating the sequence of their activation during motor start-up. [04]

- c) A three-phase, 460 V, 60 Hz, 20 kW induction machine draws 25 A at a power factor of 0.9 lagging when connected to a three-phase, 460 V, 60 Hz power supply. The core loss is 900 W, stator copper loss is 1100 W, rotor copper loss is 550 W, and friction and winding loss is 300 W. Calculate:

i) The air gap power, P_{ag} . [02]

ii) The mechanical power developed, P_{mech} . [02]

iii) The output in horsepower. [02]

iv) The efficiency. [02]

- d) Explain and draw the circuit diagram to change the direction of the single-phase induction motor. [04]

Q4

- a) Explain the working principle of a variable reluctance (VR) stepper motor. [04]
- b) Discuss the advantages and disadvantages of a VR stepper motor compared to a permanent magnet stepper motor. [04]
- c) Figure Q4 illustrates the operation of a 4-phase, 8-poles, single-stack, variable reluctance stepper motor. Explain the different modes of operation and calculate the step angles for following energizing sequences.

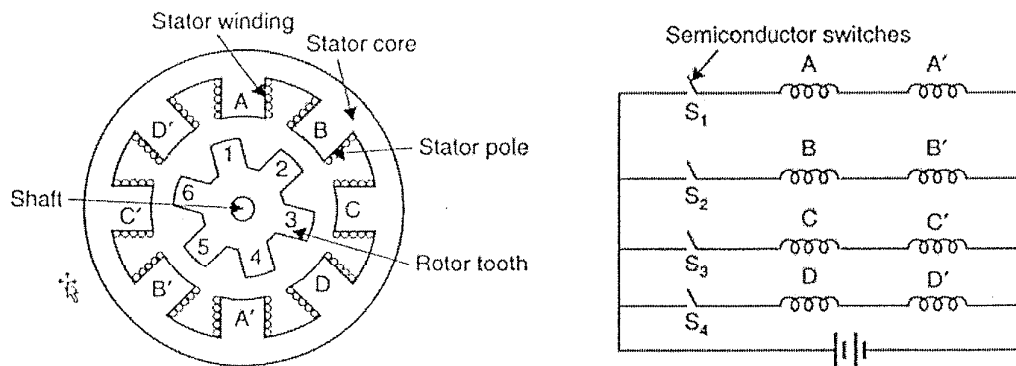


Figure Q04

i) A+B, B+C, C+D, D+A, A+B..... [06]

ii) A, A+B, B, B+C, C, C+D, D, D+A, A..... [06]

Q5

- a) Two cylinders are used to transfer parts from a magazine onto a chute shown in figure Q5a.

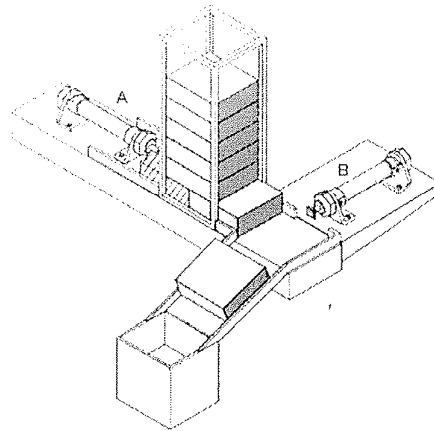


Figure Q05a

When a start button is pressed, the first cylinder extends. Push the part from the magazine and position it in preparation for transfer by the second cylinder onto the out-feed chute. Once the part is transferred, the first cylinder retracts, followed by the second. Confirmation of all extended and retracted positions is required. Write down the actuation sequence of the cylinders and draw the motion diagram. [08]

- b) A sorting station is depicted in Figure Q5b, designed for sorting boxes based on their height.

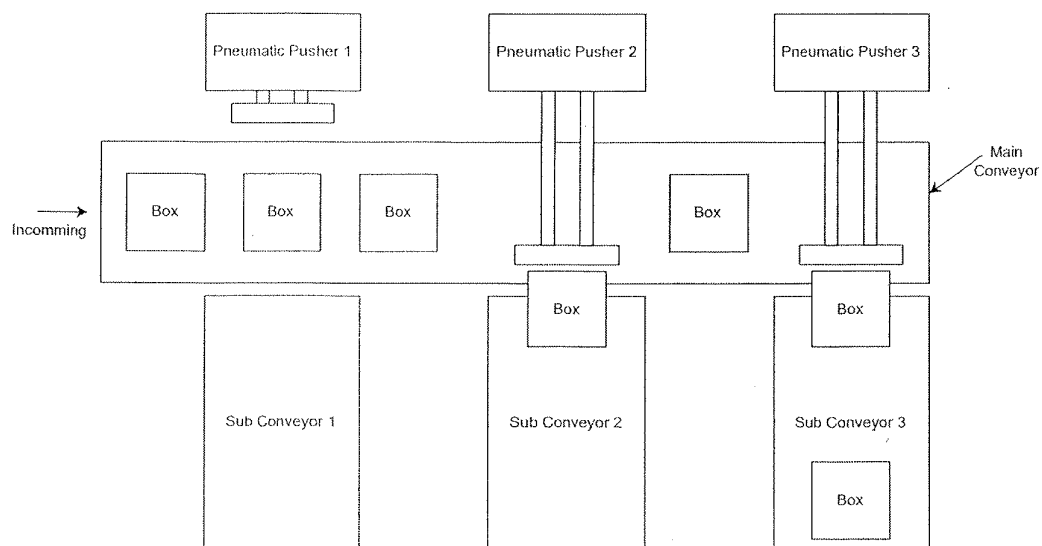


Figure Q5b

A main conveyor is utilized to transport the boxes, and three sub-conveyors are employed for the sorting process. There are three pneumatically actuated pushers, and three conveyors are utilized to sort the boxes according to their sizes, which are determined by their heights: small, medium, and large. Each box size corresponds to one pusher and one conveyor. Three proximity/optical sensors are employed to detect the size of each box. When the size of the respective box reaches the respective sub-conveyor, the pusher should be activated to move the box to the appropriate sub-conveyor.

Actuation process: The piston rod is to extend when a particular sensor is activated and the retracts. The speed of the forward motion should be adjustable and quick backward motion is expected.

- i) List of constraints and assumptions. [02]
- ii) List down the details of the components. [02]
- iii) Draw a complete electro pneumatic circuit to perform the task by labeling all the components. [08]

END