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

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| Study Programme | : Bachelor of Technology Honours in Engineering |
| Name of the Examination | : Final Examination |
| **Course Code and Title** | : **DMX4410 Electrical and Pneumatic Machines** |
| Academic Year | : 2020/21 |
| Date | : 28th January 2022 |
| Time | : 1400hr – 1700hr |
| Duration | : **3 hours** |

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**General Instructions**

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Eight (8)** questions in **Eight (8)** pages.
3. Answer any **Five (5)** questions only. All questions carry equal marks.
4. Answer for each question should commence from a new page.
5. This is a Closed Book Test (CBT).
6. Answers should be in clear handwriting.
7. Do not use **Red** color pen.

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## Question 01

a) State the definition of Mutual Inductance. List three practical applications of mutual inductance.

[4 Marks]

b) State the three major parts of DC Machines. Briefly describe the function of each part.

[6 Marks]

c) State the EMF equation of a DC machine and define the notations.

[2 Marks]

d) An 8-pole lap wound DC generator has 1000 armature conductors, flux of 2mWb per pole and EMF generated is 400V. Determine the Speed of the machine.

[4 Marks]

e) Explain briefly why the Terminal voltage (V) of a DC machine is **equal** to the generated or back EMF (E) at no load condition (At No load: V = E).

[4 Marks]

## Question 02

a) State the speed control methods for the Separately Excited DC Motors.

[3 Marks]

b) State the three different types of Self-excited DC generators.

[3 Marks]

c) A 220V DC shunt motor has armature resistance of 0.2Ω and brush contact drop of 2V. Calculate the armature current which will flow when,

i. Back EMF is 215V

[3 Marks]

ii. Back EMF drops to 212V on increasing motor load.

[3 Marks]

d) A Separately-excited DC generator when running at 1200rpm supplies 200A at 125V to a circuit of constant resistance. Calculate the **current** when the speed is dropped to 1000rpm if the field current is unaltered. The Armature resistance is 0.04Ω and the total drop at brushes is 2V (Ignore change in the armature reaction).

[8 Marks]

## Question 03

a) Sketch the equivalent circuit for the DC Series Motor and explain its function.

[4 Marks]

b) Consider the 10kW, 120V DC series generator with armature resistance of 0.1Ω and a series field resistance of 0.08Ω given below in **Figure Q03(b).** Assume that the generator is delivering rated current at rated speed.

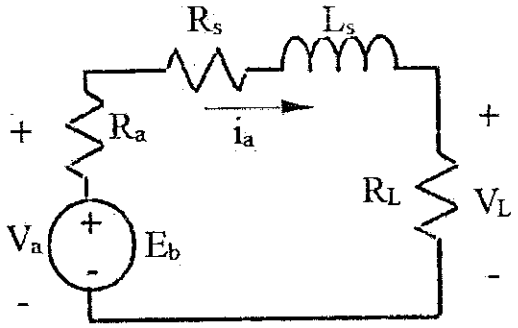


**Figure Q03(b)**

Calculate:

i. The armature current $\mathbf{i_a}$

[3 Marks]

ii. The generated voltage $\mathbf{E_b}$

[3 Marks]

c) A 10kW DC Series generator having an Armature circuit resistance of 0.65Ω and a Field resistance of 1.35Ω generates a terminal voltage of 250 V at full load as shown in **Figure Q03(c).** Determine the efficiency of the generator at full load, assuming the iron, friction and windage losses amount to 800W.

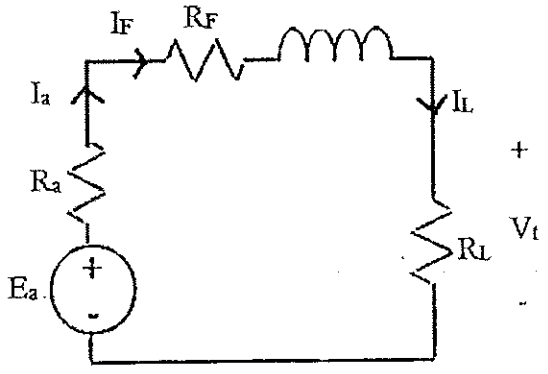


**Figure Q03(c)**

[10 Marks]

## Question 04

a) Draw the equivalent circuit of a synchronous motor. Explain how it can be different from a synchronous generator.

[4 Marks]

b) A 10kVA, 415V, 3 phase, Y-connected synchronous generator has a winding resistance of 0.3Ω and a synchronous reactance of 0.6Ω on a per phase basis.
Determine its voltage regulation at full load when the power factor is:

i. 75% lagging

[3 Marks]

ii. 75% leading

[3 Marks]

iii. Sketch the Phasor diagrams for both conditions in part (i) and part (ii).

[4 Marks]

c) A Synchronous generator has a stator reactance of 200Ω, the internal EMF at open circuit is 40kV as line to line, the machine is connected to infinite bus of 40kV as line to line, find the Maximum Active Power generated by the Machine.

[6 Marks]

## Question 05

a) State the two types of three phase AC Induction motor rotors. Give one advantage of each.

[4 Marks]

b) Explain why a single-phase induction motor is unable to start itself without special auxiliary windings.

[4 Marks]

c) A 7.5kW, 230V, 3 phase, 50Hz, 6 pole squirrel cage induction motor operates at a full-load slip of 4% when rated voltage frequency is applied. Determine:

i. Full-load speed.

[2 Marks]

ii. Full-load shaft torque in **Nm**.

[2 Marks]

iii. Frequency of rotor current under this condition.

[2 Marks]

d) A 4 pole, 3 phase, Induction motor develops a gross power of 7.5kW at a Speed of 1440rpm when supplied from a 3 phase, 400V, 50Hz main. If the power factor is 0.8, Calculate for this load:

i. Slip

[2 Marks]

ii. Gross Torque

[2 Marks]

iii. Rotor Copper loss/Phase

[2 Marks]

## Question 06

a) List the 8 basic components of pneumatics system.

[4 Marks]

b) Explain the operation of the 5/2 way directional control valve in the pneumatic circuit given below in **Figure Q06(b)**.

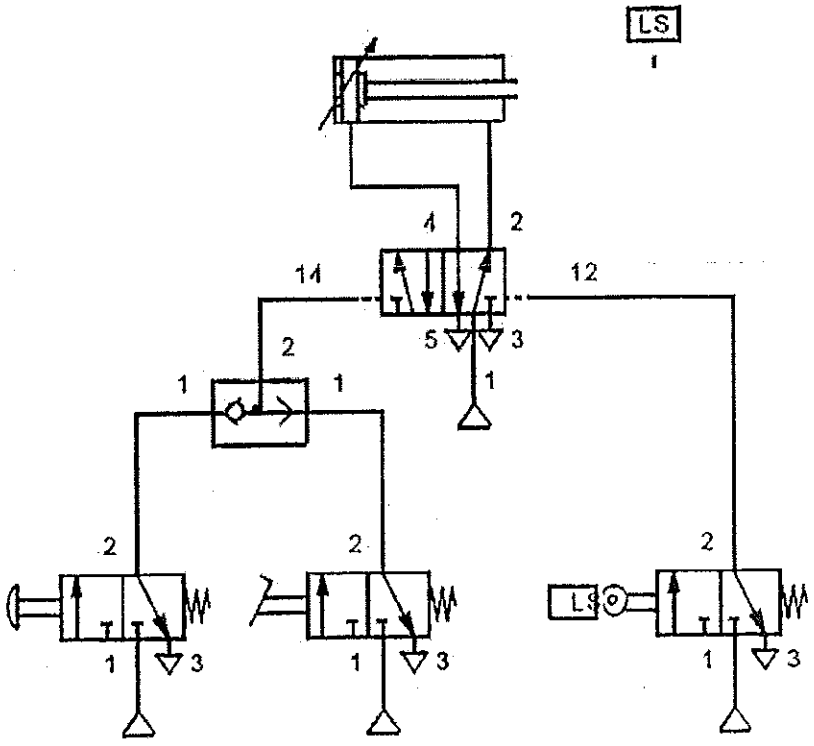


**Figure Q06(b)**

[6 Marks]

c) Consider the diagram given below in **Figure Q06(c)** which shows the **Clamping of a Workpiece.**
In this diagram the workpiece has been positioned on the drill stand by hand and it is clamped using a single acting cylinder, which is operated through a pedal valve. Upon releasing the pedal, the cylinder returns to its original position. The workpiece is removed by hand. Draw the pneumatic circuit diagram, label all the components in it, and explain its operation.

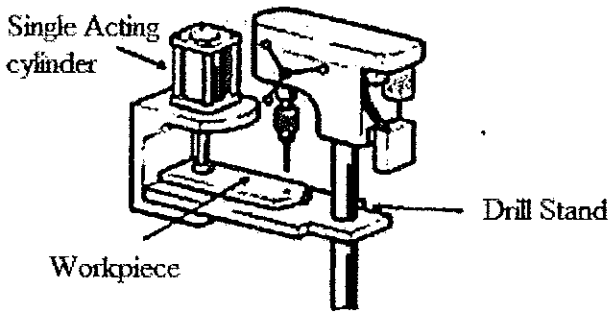


**Figure Q06(c)**

[10 Marks]

## Question 07

a) List three advantages of Electro-pneumatic systems.

[3 Marks]

b) Draw the symbols for **Normally Open, Normally Closed** and **Change over** push buttons.

[3 Marks]

c) Draw the symbols of the following **Directional Control Valves (DCV).**

i. 3/2-way DCV Single solenoid with manual override with spring return

[2 Marks]

ii. 5/2-way DCV Double solenoid with double manual override

[2 Marks]

d) Describe the sequence of operation for the following electro-pneumatic control system given below in **Figure Q07(d).**

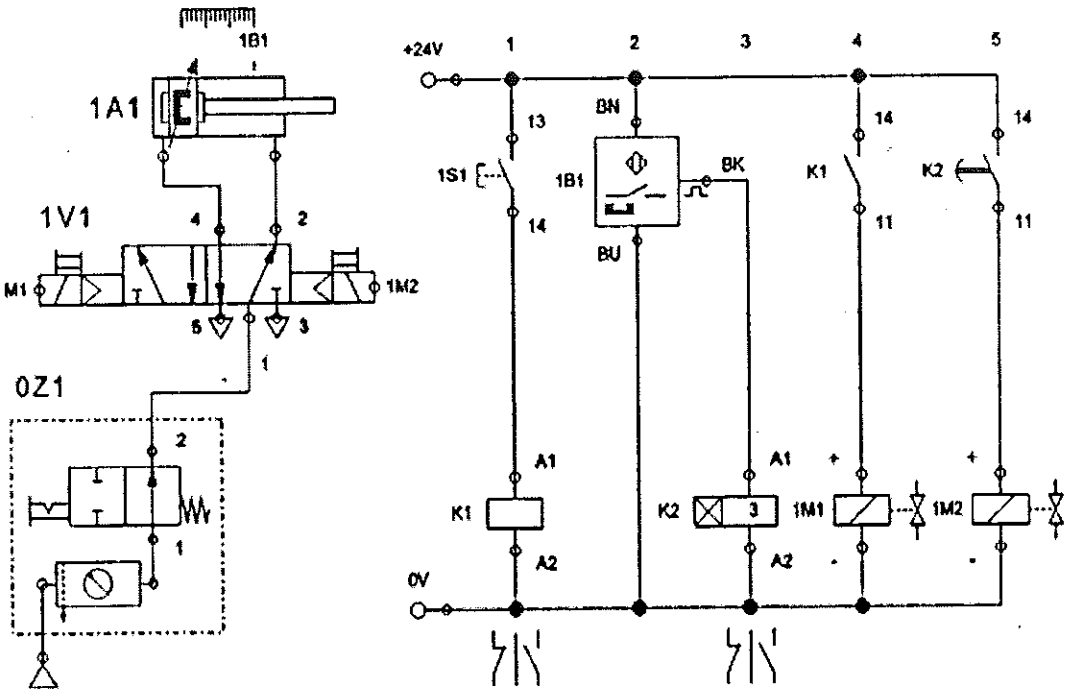


**Figure Q07(d)**

[10 Marks]

## Question 08

a) Explain using a circuit diagram the principle of a **Latching Relay Circuit.**

[4 Marks]

b) Steel bolts are to be pressed using a double-acting cylinder which is given below in **Figure Q08(b).**
In order to meet safety requirements, a two-hand safety control valve is to be used. This means that to obtain a signal, the two push buttons must be pressed within a period of 0.5 seconds. The cylinder rod is to retract immediately when one or both push buttons are released. Design the equivalent pneumatic circuit diagram and label all the devices used.

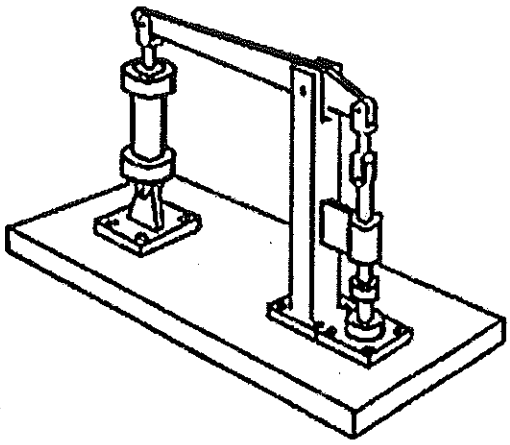

**Figure Q08(b)**

[8 Marks]

c) Consider a cylinder of a pneumatic actuator which has an internal diameter of 60mm and operates at a gauge pressure of 2500kPa. Calculate the force on the ends of the cylinder.

[8 Marks]

**END**