The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	Diploma in Technology/Bachelor of Technology (Engineering)
Name of the Examination	:	Final Examination
Course Code and Title	:	**MEX4271 – Sensors and actuators**
Academic Year	:	2012/13
Date	:	23rd July 2013
Time	:	0930hr-1230hr
Duration	:	3 hours

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper has eight questions.
3. Answer five questions only.

Q1.

(a) The binary optical shaft encoder shown in figure Q1 is attached to a motor. White represents logic 0 and black represents logic 1.

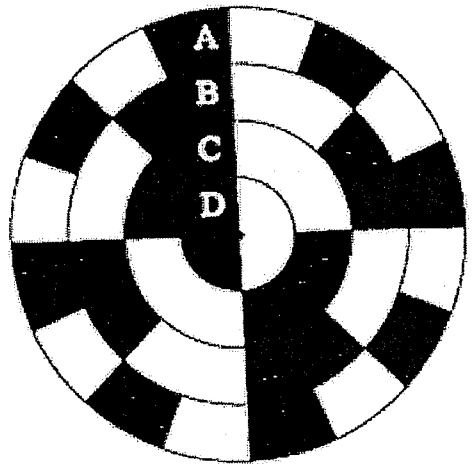


Figure Q1

i. Explain why the inner ring D represents the most significant bit of the binary value?

ii. Show that the angular resolution of the encoder is 22.5°.

iii. How many rings would be needed if the angular resolution were to be approximately 2.8°?

(b) The binary outputs from the encoder when the motor at stationary is 1011 and after 0.1 s the binary output is 0110.

i. What is the smallest angle that the motor could have rotated?
ii. Explain whether the direction of rotation is clockwise or anticlockwise.
iii. If the motor continues to rotate at this rate, calculate its speed in revolutions per second.

Q2.

(a) Compare the advantages and disadvantages of thermocouple, RTD, thermistor and infrared temperature sensor.

(b) A customer wants to measure temperature of a metal plate, but cannot decide whether to use a thermocouple or IR sensor. The plate has a coefficient of emissivity equal to 0.7. Quick temperature response and long life are required. What is the best sensor? Justify your answer.

(c) A customer has two thermistors. Both have a base resistance of 1kΩ, but each have different resistance versus temperature curves. Can one resistor replaced with other resister? Briefly explain your answer.

Q3.

(a) Name two most common electrical transducers?

(b) With the help of diagrams explain the function of potentiometer.

(c) What is a linear variable differential transformer (LVDT)? Describe briefly how it works. Is the output analogue or digital?

(d) A linear variable differential transformer has a moving core, and a primary winding excited by a sine wave current $\boldsymbol{i = Isin(\omega t)}$ the coupling coefficients to the two secondary coils are k1 and k2 respectively. Derive an expression for the output voltage v_0. What happens as the core moves through the central position between the two secondaries? Draw a sketch graph showing the relationship between output voltage (y-axis) and linear position of the moving core (x-axis). How can a system be set up to distinguish between positions on the two sides of the central position? How can your graph be modified to take this into account?

Q4.

A 3-phase induction motor having a synchronous speed of 1200rpm draws 80kW from a 3-phase feeder. The copper losses and iron losses in the stator amount to 5kW. If the motor runs at 1152rpm, calculate the following:

(a) The active power transmitted to the rotor.
(b) The rotor I^2R losses.

(c) The mechanical power delivered to the load, knowing that the windage and friction losses are equal to 2kW.
(d) The efficiency of the motor.

Q5.

(a) Compare hydraulic and pneumatic systems for actuating a mechanical device. Sketch a valve which could be used in either a hydraulic or a pneumatic system for controlling the force on a mechanical device in two opposite directions.
(b) Sketch a circuit which could be used to control the motion of a DC permanent-magnet electric motor in two directions.
(c) A hydraulic piston and cylinder, with a radius of 50 mm, is used to move a work piece through a distance of 200 mm in 15 seconds. A force of 50 kN is needed to move the work piece. Calculate the required hydraulic pressure and liquid flow rate.

Q6.

Figure Q6 shows four orientations (A, B, C, D) of the coil of a DC motor. The coil can be assumed to be a single wire which is in a uniform magnetic field parallel to the coil when in the orientation-A as shown in figure Q6. The coil is attached to a commutator, to which current is passed by brushes (not shown in the figure Q6).

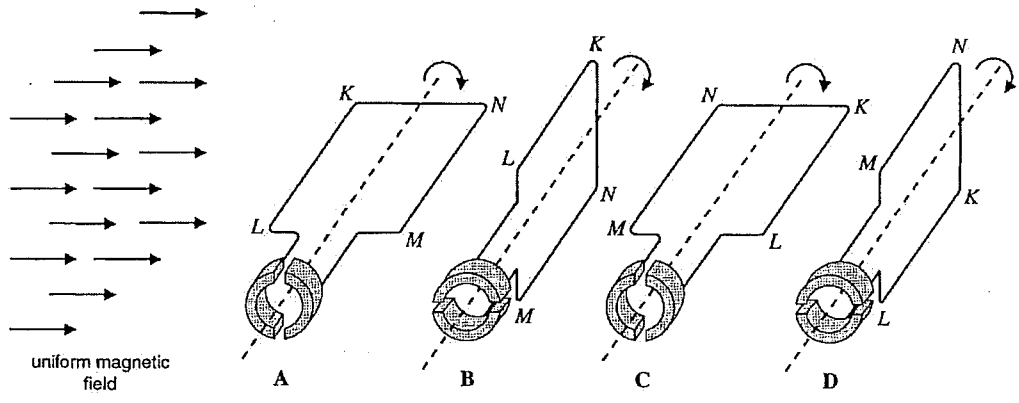


Figure Q6

(a) For the coil shown in orientation A of the figure Q6, in which direction is the current flowing in the side KL?

(b) If the magnetic field has a magnitude of 1.5 T, what is the magnitude of the current in the coil for the following cases?

i) The coil is at rest with the orientation shown in diagram A of the figure Q6.
ii) The coil is at rest with the orientation shown in diagram B of the figure Q6.
Consider side KL of the coil is 0.10 m long, and a magnetic force of 0.60 N acts on it.

(c) Explain what would happen, in each case, if current is allowed to flow in the coil.

Q7.

(a) What are two types of windings are used in electrical machines? Which type is not used in permanent-magnet? Why not?

(b) In what application dc motors be more advantageous than ac motors?

(c) A 50-hp shunt-connected dc motor has the magnetization curve shown in Figure Q7.1 and equivalent circuit is shown in Figure Q7.2. The dc supply voltage is $V_T = 240V$, the armature resistance is $R_F = 10\Omega$, and the adjustable resistance is $R_{adj} = 14\Omega$. at a speed of 1200 rpm, the rotational loss is $P_{rot} = 1450W$. If this motor drives a hoist that demands a torque of $T_{out} = 250Nm$ independent of speed, determine the motor speed and efficiency.

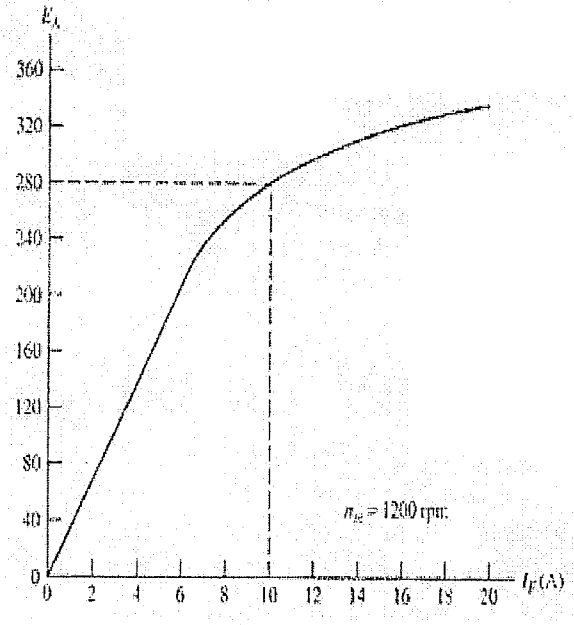


Figure Q7.1

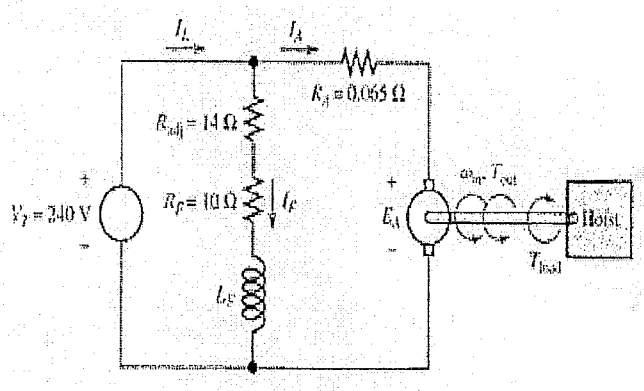


Figure Q7.2

Q8.

(a) Describe the basic details of ;

i. a poppet valve
ii. a shuttle valve.

(b) Draw the symbols of following valves

i. A pressure relief valve
ii. A 2/2 valve which has actuators of a push-button and spring
iii. A 4/2 valve

(c) Design a pneumatic valve circuit to give the following sequence A+, followed by B- and then similarly followed by B+ and A-.

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