THE OPEN UNIVERSITY OF SRI LANKA
Faculty of Engineering Technology
Department of Mechanical Engineering

Bachelor of Technology Honors in Engineering

Final Examination (2016/2017)
MEX4271: Sensors and actuators

Date: 09th November 2017 (Thursday) **Time: 9:30 am – 12:30 pm**

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) Describe the piezoresistive effect in silicon devices. [5 marks]

b) What is the Seebeck effect? How can this phenomena be used in sensors? Give an example. [5 marks]

c) What is the Peltier effect? Explain an application of Peltier effect. [5 marks]

d) A Quartz crystal has a charge sensitivity of 2.5 pC/N. The dielectric constant for the crystal is 5×10^{-11} F/m. Determine the voltage sensitivity of the crystal? [5 marks]

Q2.

a) Assume you have to select a sensor for a particular application. What are the factors take into consideration. Briefly explain using a suitable example. [5 marks]

b) Performance characteristics/parameters of a sensor can be broadly categorized as static and dynamic characteristics. Explain the difference between both types and give two examples for each. [5 marks]

c) Briefly explain any two static characteristics of a sensor. [5 marks]

d) An instrument has a 12-bit analog-to-digital converter (ADC). Calculate the dynamic range of the instrument. [5 marks]

Q3.

a) Figure Q3-a shows a simplified diagram of a sensing system used in a swimming pool. The system comprises Starting Block, Lane Pad A, Lane Pad B and Timer which are used to record the start and end times during the swimming events.

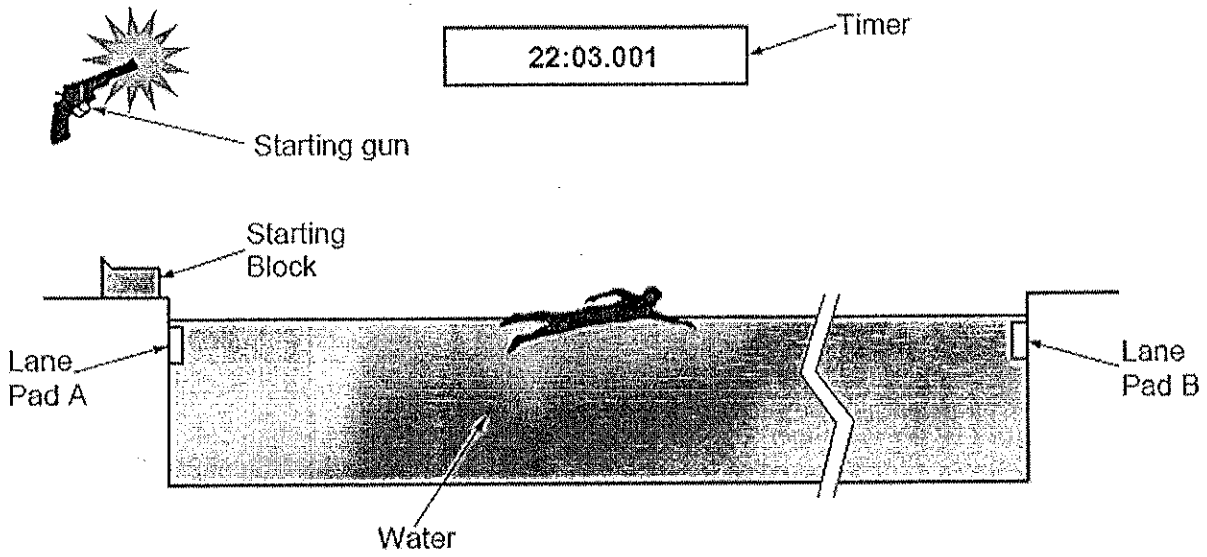


Figure Q3-a

A starting gun is used to start the race but false starts are an issue in this type of event. The sports agreed minimum reaction time of a competitor to the starting gun is 0.16 seconds.

i. Suggest a system that could detect if a competitor left the Starting Block within 0.16 seconds of the starting gun having been fired (false start). Draw a simple block diagram of your proposed system. [5 marks]

ii. State a suitable sensor that could be incorporated within the Starting Block that would suitable for the above system. Explain why you choose that sensor. [5 marks]

b) Assume you have to design a domestic washing machine. Suggest a suitable method to determine the mass of the laundry in a washing machine. [5 marks]

c) Assume you have to use a potentiometer for a displacement measuring application. Discuss the mechanical loading and electrical loading effect of it. [5 marks]

Q4.

a) 3-bit absolute gray code optical encoder is shown in Figure Q4-a. Determine the angular resolution of the encoder. [5 marks]

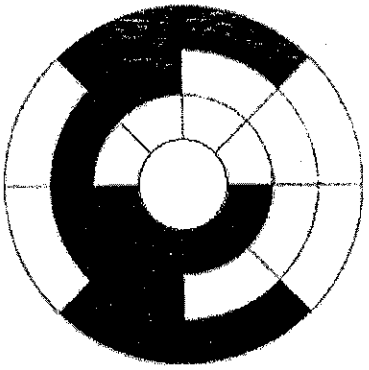


Figure Q4-a

b) What is the advantage of gray code over binary code used in the encoder? [5 marks]

c) Explain how the angular resolution of the encoder can be improved to 5.625°.[5 marks]

d) Discuss the differences between incremental and absolute encoder. [5 marks]

Q5.

a) What are the common three types of stepper motors? Briefly explain each type. [5 marks]

b) Single stack three phase variable reluctance stepper motor is illustrated in Figure Q5-b. Number of rotor teeth(n_r)=8 and number of stator teeth (n_s)=12. If the switching sequence of the phase winding is **1-3-2-1** determine the direction of rotation and the step angle. [5 marks]

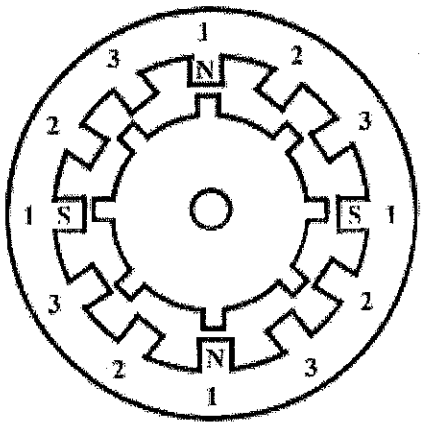


Figure Q5-b

c) Two-phase six-pole permanent magnet stepper motor is illustrated in Figure Q5-c. Determine the full step angle of the motor. [5 marks]

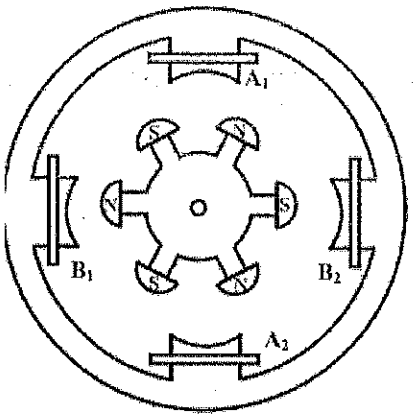


Figure Q5-c

d) Discuss the differences between unipolar and bipolar stepper motor with respect to winding arrangements. [5 marks]

Q6.

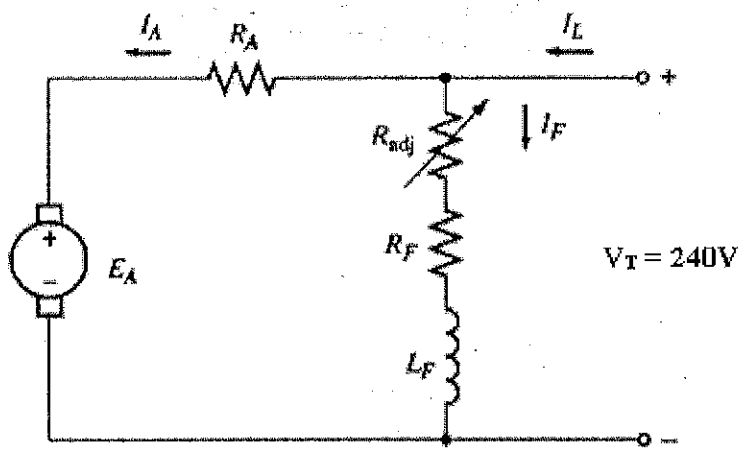
a) Briefly explain the operation of followings pneumatic components. [6 marks]
   i. Air service unit
   ii. Air compressor
   iii. Air dryer
   iv. Pressure sequence valve.

b) An object has to move using a double acting cylinder. The piston rod is to extend when a push button is pressed and return to the start position when the push button is released. Speed of the forward motion should be adjustable and quick backward motion is expected. Draw a pneumatic circuit to perform the operation. [7 marks]

c) Draw a hydraulic circuit to operate a double acting cylinder. The piston rod is to extend when a hand-lever valve is operated and return to the start position when the lever is released. [7 marks]

Q7.

a) A DC shunt motor with compensating windings has an armature resistance of 0.1Ω. Its field circuit has a total resistance Radj + R_F = 40Ω, which produces a no-load speed of 1200 rpm. Find the speed of this motor when its input current is 206 A. [11 marks]



b) What are the three common types of dc motors. Briefly explain. [9 marks]

Q8.

a) A three-phase wye connected induction motor connected to a 400Vrms,50Hz three-phase source. It draws 20A at a power factor of 75% lagging. The total stator copper losses are 300W and the total rotor copper losses are 100W. The rotational losses are 600W. Determine;

i. the power crossing the air gap
ii. the developed power
iii. the output power
iv. efficiency

[12 marks]

b) Briefly explain the following single-phase induction motor types. [8 marks]

i. capacitor-run motor
ii. split-phase motor

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