The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	Bachelor of Technology Honours in Engineering
Name of the Examination	:	Final Examination
Course Code and Title	:	**MEX4271 – Sensors and actuators**
Academic Year	:	2015/16
Date	:	17th November 2016
Time	:	0930hr-1230hr
Duration	:	3 hours

General instructions

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

Question 01

(a) Distinguish between active sensors and passive sensors. Elaborate with suitable examples. [6 marks]

(b) Explain the following terms briefly

i. Hysteresis error
ii. Accuracy
iii. Precision [9 marks]

(c) What is a Resistance Temperature Detector (RTD)? Explain the relationship between resistance and temperature in a RTD using resistance vs. temperature curve? [5 marks]

Question 02

(a) You have to choose a suitable sensor among potentiometer and linear variable differential transformer (LVDT) for a particular displacement measurement application. Discuss the advantages and disadvantages of both sensor. [8 marks]

(b) Figure Q2-b shows a schematic diagram of a simplified signal conditioning system for an LVDT. Explain the functions of the various components in the system. [6 marks]

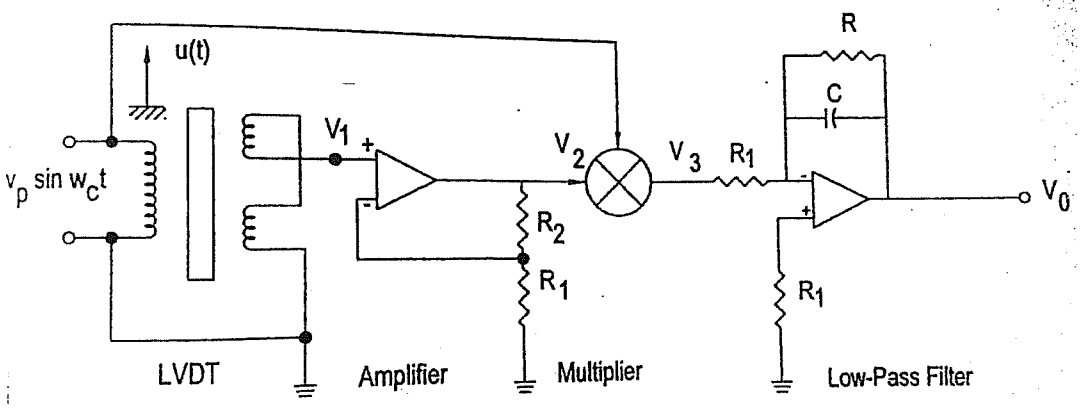


Figure Q2-b

(c) It is known that some of the factors that should be considered in selecting an LVDT for a particular application are linearity, sensitivity, response time, size and weight of core, size of the housing, primary excitation frequency, output impedance, phase change between primary and secondary voltages, null voltage, stroke, and environmental effects (temperature compensation, magnetic shielding, etc.).
Explain any four factors (why and how each of these factors is an important consideration). [6 marks]

Question 03

(a) Explain the working principle of piezoelectric sensor. [3 marks]

(b) A barium titanate crystal has a charge sensitivity of 150.0 pC/N (Pico Coulombs per Newton). (Note: 1 pC = 1 x 10^{-12} coulombs = farads x volts). The dielectric constant for the crystal is 1.25 x 10^{-8} F/m (farads per meter). What is the voltage sensitivity of the crystal? [3 marks]

(c) Explain the operation of an ultrasonic sensor in distance measuring application. [3 marks]

(d) Figure Q3-d illustrates a cut away view of an optical incremental encoder.

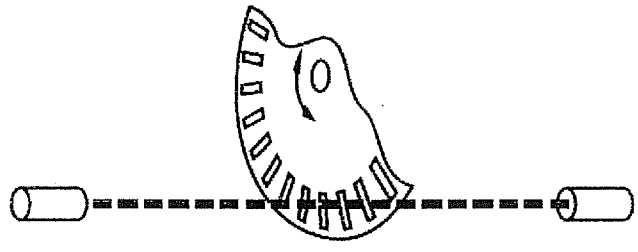


Figure Q3-d

i. Describe the type of signal generated by this device. Sketch the output signal.

[3 marks]

ii. How you can modify the above encoder to determine the direction of rotation.
[4 marks]

iii. State another type of optical encoder and mention the major differences compared to the incremental encoder. [4 marks]

Question 04

Figure Q4 illustrates a simplified lift system used to transport spare parts in a lift cage between the stores level and the workshop level in a maintenance workshop. The system is controlled by a microcontroller.

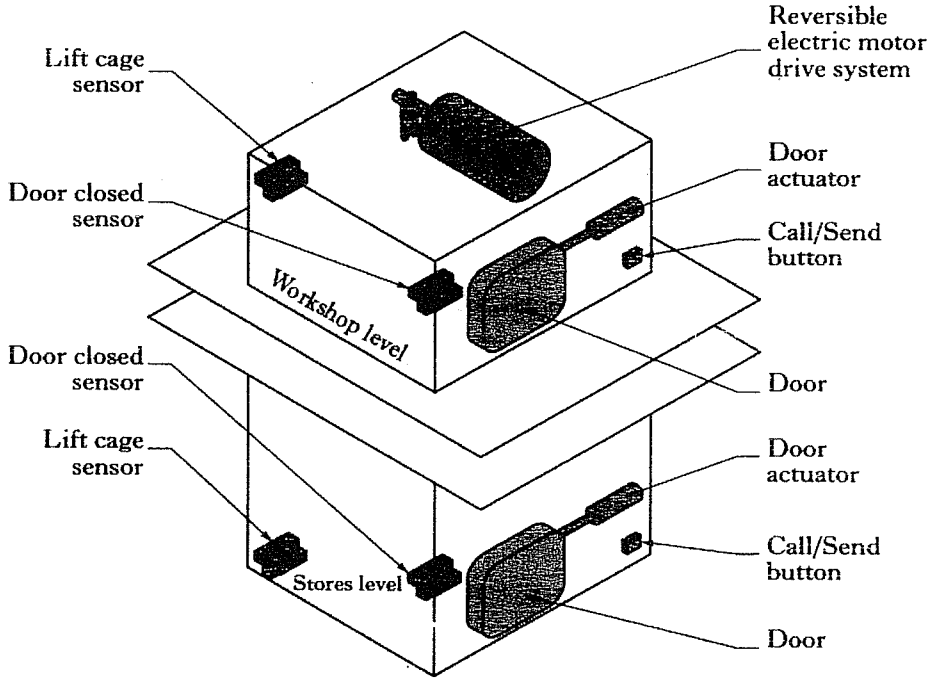


Figure Q4

The system uses a cable mechanism driven by a reversible electric motor drive system to move the cage between the two levels.
On each level:
- There is a Call/Send button to control the movement of the lift.
- There is a lift cage sensor that informs the microcontroller about the cage presence.
- There is a door closed sensor linked to the door mechanism.
- The door is automatically opened on arrival and automatically closed before the departure of the lift cage.

(a) List the inputs on the lift system that would require interfacing to the microcontroller. [3 marks]

(b) List the outputs on the lift system that would require interfacing to the microcontroller [3marks]

(c) The lift has a maximum load carrying capacity of 100 kg. Describe a suitable sensing system that could be incorporated into the lift system to prevent the load capacity being exceeded. [3 marks]

(d) Briefly describe a suitable sensor for the door closed sensor. [3 marks]

(e) The lift doors are to be opened/closed by linear actuators. State one type of linear actuator and give a reason why you consider this a suitable choice of actuator. [3 marks]

(f) Describe two safety concerns applicable to this type of mechatronic system and suggest a potential solution for each safety concern that could be incorporated into the lift system. [5 marks]

Question 05

(a) Discuss the difference between unifilar and bifilar windings of the stepper motor. [5 marks]

(b) Briefly explain the three step modes which use to operate the stepper motor. [6 marks]

(c) List any four solid state switches used in industry. [4 marks]

(d) Discuss the applicability of solid-state switches and electromechanical switches with using suitable applications. [5 marks]

Question 06

(a) State three main functions of a pneumatic air service unit. [3 marks]

(b) Draw symbols of following pneumatic components. [4 marks]

i. 5/2 way directional control valve
ii. 4/2 way directional control valve

(c) State any four advantages of pneumatic systems? [4 marks]

(d) State any two disadvantages of pneumatic systems? [2 marks]

(e) Using a single acting cylinder, two work piece are to be bonded each other. The piston rod is to extend when a push button is pressed and return to the start position when the push button is released. Draw a pneumatic circuit to control this single acting cylinder using a directional control valve. [7 marks]

Question 07

(a) Briefly explain following dc motor types.

i. Self-excited dc motor
ii. Separately excited dc motor
iii. Permanent magnet dc motor [9 marks]

(b) A 50-hp shunt – connected dc motor has the magnetization curve shown in Figure Q7-a. The dc supply voltage is V_T = 240 V, the armature resistance is R_A = 0.065 Ω, the field resistance is R_F = 10 Ω, and the adjustable resistance is R_{adj} = 14 Ω. At a speed of 1200 rpm, the rotational loss is P_{rot} = 1450 W. If this motor drives a hoist that demands a torque of T_{out} = 250 Nm independent of speed, determine the motor speed and efficiency.

[11 marks]

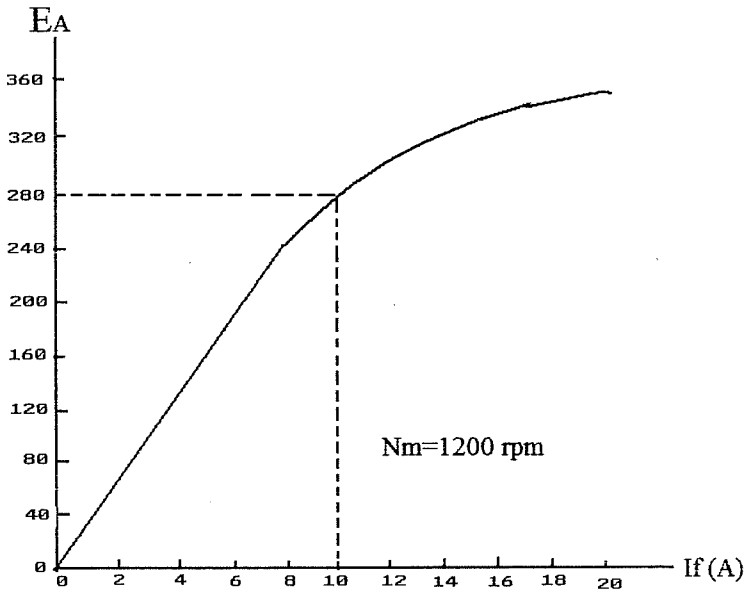


Figure Q7-a

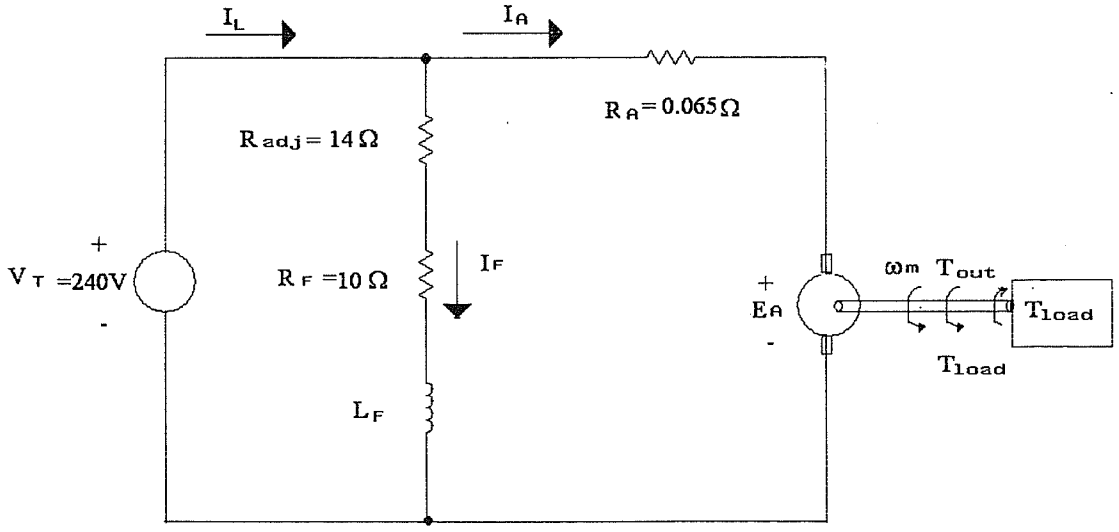


Figure Q7-b

Question 08

a) A three-phase induction motor is wound for four poles and is supplied from a variable frequency driver with 35 Hz.
Calculate;

i. the synchronous speed,
ii. the speed of the rotor when the slip is 2% , and
iii. the rotor frequency when the speed of the rotor is 500 rpm. [10 marks]

b) A three-phase induction motor has;
phase current Is = 21.7A, current in one phase of the rotor Ir′ = 19.88A, stator resistance Rs=1.2 Ω, rotor resistance R′r=0.6Ω, slip = 0.03, rotational losses= 900W.
Determine;

i. copper losses in the stator and rotor
ii. developed power in the motor
iii. input power
iv. output power [10 marks]

- END –