The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Egineering
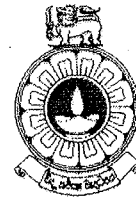
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Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	: **DMX4409 Sensors**
Academic Year	: 2021/2022
Date	: 10th February 2023
Time	: 14.00-17.00
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.

2. This question paper consists of **Eight (8)** questions in **Five (5)** 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 colour pen.

Question 01

a) Briefly describe the significance of sensors in industrial automation.

b) Briefly explain the **Open Loop** system and **Closed Loop** system with real world examples.

c) Explain components of the **Measurement System** by using block diagrams.

d) Explain the difference between **Sensor** and **Transducer** with necessary examples.

e) Briefly explain the importance of **Sensor Calibration** in the measurement system.

Question 02

Sensor selection is crucial in various applications such as industrial control, robotics, and data acquisition. The type of sensor selected for a particular application will determine the accuracy, reliability, and overall performance of the system.

a) What are the considerations for selecting a sensor for a specific application?

b) Explain the difference between **static** and **dynamic** characteristics of sensors.

c) Distinguish between **active sensors** and **passive sensors** using suitable examples.

d) Briefly explain the following static characteristics of the sensors.

    a) Accuracy

    b) Repeatability

    c) Linearity

e) A sensor has a digital output of 12bits. What is its dynamic range?

Question 03

Sensor time domain characteristics refer to the behavior of a sensor over time in response to changes in the physical quantity being measured.

a) Briefly describe the significance of **time domain** characteristics with a relevant example.

b) Briefly explain following time domain characteristics of the sensors.

    1) Peak time

    2) Settling time

    3) Rise time

c) Briefly state the reasons for studying **time domain** response and **frequency domain** response when selecting a sensor for an application.

d) A particular sensor has its unit step response (t) given by following equation. Determine the **percentage overshoot** of the sensor.

$$y(t) = 1 - e^{-2t} - 2te^{-2t}$$

Question 04

a) Assume you have to design and construct simple load cell using strain gauge for an exhibition for demonstrate operation principle of strain gauge.

    1) Draw a block diagram of your proposed system.

    2) Draw a simple circuit diagram. *(Hint: use Wheatstone bridge, Operational amplifies)*

b) You have to measure linear displacement of a shaft using **LVDT.**

    1) Draw a simple circuit diagram above application using a LVDT.

    2) Explain the working principle of the LVDT using an appropriate diagram.

    3) Draw a graph for displacement vs. output voltage of the LVDT of the above application.

Question 05

a) Briefly explain how the **Piezoelectric Sensors** can be used to measure heart rate.

b) Briefly explain operation principle of **Inductive Proximity Sensor.**

c) Briefly explain **Null Type Sensor/instrument** and what are the advantages of Null Type sensor?

d) Briefly explain operation principle of **Hall Effect Sensor** with necessary diagrams.

e) Explain the steps involved in analog sensor interfacing into a digital controller.

Question 06

a) A particular sensor has its transfer function given as follows. The input $u(t)$ is the measurand and the sensor output is $y(t)$. Determine the resonance frequency, useful frequency range and bandwidth of the sensor.

$$\frac{y(s)}{u(s)} = \frac{250}{s^2 + 20s + 250}$$

b) Obtain the transfer function X(s)/E(s) for the electromechanical vibration sensor shown in Figure Q6, assuming that the coil has back emf $E_b = K_1 \frac{dx}{dt}$ and the coil current I produces a force $F_c = K_2 I$ on the mass M
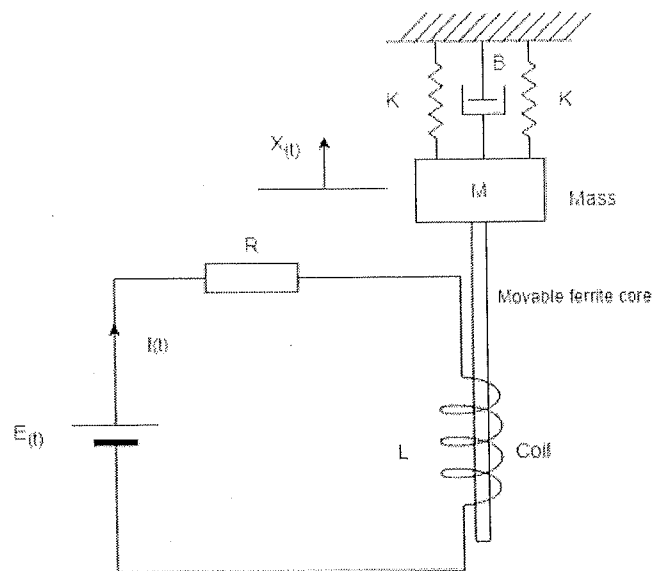
Figure Q6

Question 07

a) A capacitive type level sensor is used to measure the level of water (conducting) in a tank. With a neat labeled diagram, describe the construction of this sensor. Also, state the reason for the change in capacitance with the change in the level of water.

b) Describe the working of **RVDT** with a neat sketch.

c) Briefly explain **Absolute encoder** and **Incremental encoder**.

d) A displacement of ±12.5 mm results in a secondary voltage of 5V in an LVDT. If the then secondary voltage is 3.2V, determine the absolute value of the corresponding displacement.

Question 08

A wall tile manufacturer has decided to improve the quality of their 6" and 8" production line by installing an automatic system to inspect the quality of each tile on the conveyor before they are packaged. The quality parameters that need monitoring are each tile's length, width, and weight. The conveyor may carry either 6" or 8" tiles in batches at the rate of one tile every second. The tolerance allowed for either length is 2.0mm and for the weight is 25g (variation in weight indicates defects in density and thicknesses of tile, also same tolerance are applicable to both types of tiles). If a tile fails any of these tolerances, it has to be ejected from the conveyor belt by means of some actuators before it reaches the packaging station.

Next page

a) Identify suitable sensors, actuators, controllers, and other vital components for the above design. Elaborate on the significant characteristics of the selected components in the component selection stage.

b) Discuss any drawbacks of your design and propose ways of enhancing its performance.

END