

UNIVERSITY OF SWAZILAND
FACULTY OF SCIENCE & ENGINEERING
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

MAIN EXAMINATION MAY 2013

TITLE OF PAPER:	INSTRUMENTATION SYSTEMS
COURSE CODE:	EE521
TIME ALLOWED:	THREE HOURS

INSTRUCTIONS:

1. Answer question **one** (1) and any other three (3) questions.
2. Each question carries 25 marks.
3. Marks for different sections are shown in the right-hand margin.

This paper has 5 pages including this page.

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THE INVIGILATOR.**

Question 1

A) A number of static and dynamic specifications must be considered in selecting a suitable instrument to measure the desired physical parameter. Define the following typical specifications:

- i) Range,
- ii) Resolution,
- iii) Precision,
- iv) Accuracy,
- v) Zero drift, and
- vi) Linearity.

(12 marks)

B) A high precision mobile robot uses a coil-type rotatory potentiometer attached to the drive wheel to record its travel during autonomous navigation. The potentiometer is connected to the drive wheel through a gear reduction of a ratio 10:1. The required resolution for robot motion is 1mm, and the diameter of the drive wheel of the robot is 25cm.

Determine

- i) the required resolution for the potentiometer, and
- ii) the number of turns in the coil that guarantee the required resolution. (8 marks)

C) A temperature transducer that outputs $10\text{mV}/^{\circ}\text{C}$ is used to measure the temperature that goes from 0 to 100°C . Can 8-bit A/D converter with a 3V full scale input be used to produce 0.5°C resolution? Explain your answer. (5 marks)

Question 2

A) Figure Q2 shows a signal-conditioning system for a Linear Variable Differential Transformer. The system measures displacement $x(t)$. Assume a transformer parameter denoted by r . Write equations for the amplifier and filter circuits and, using them, give expressions for the voltage signals v_1 , v_2 , v_3 , and v_o , which are marked in Figure Q2. (17 marks)

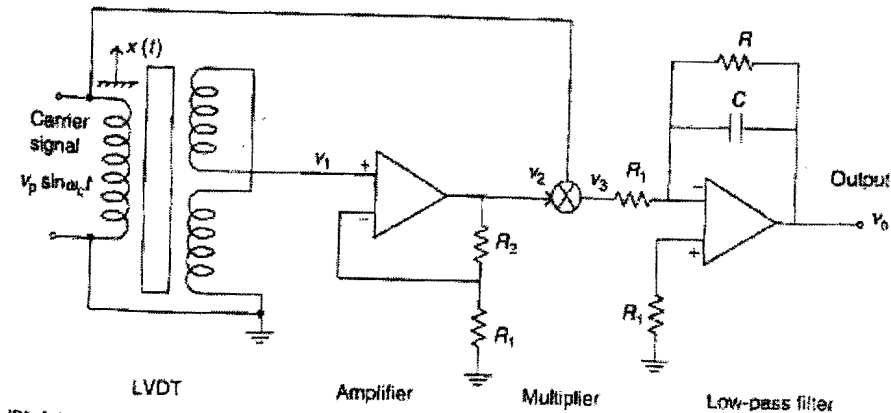


Figure Q2

- B) What will be the accuracy of an instrument for which the transducer has an accuracy of $\pm 2\%$, the signal conditioner an accuracy of $\pm 1\%$, and the display an accuracy of $\pm 0.5\%$? (2 marks)
- C) Give and explain three classes of sources of error that can occur with measuring systems. (6 marks)

Question 3

Design a telemetry circuit required to transmit temperature readings ranging from 0°C to 100°C .

A block diagram of the circuit is shown in Figure Q3 and the following are the specifications:

Temperature sensor circuit

The output of the sensor circuit is linear and gives the following readings:

0.8 volts at -10°C

0.2 volts at 120°C

Signal conditioner

The output of the signal conditioner should range from 0 volts to 10 volts.

The signal conditioner is supplied by a 12 volts dc source.

PWM

The PWM comprises of two 555 timers supplied with 12 volts dc source.

Oscillator: $T = 20$ msec and 50% duty cycle

Duration of the variable one shot: $t_p = 18$ msec

(25 marks)

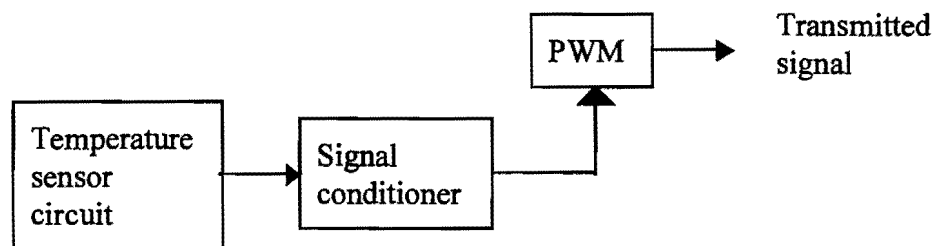


Figure Q3

Question 4

- A) Without sketching diagrams state the composition of modern data acquisitions? (5 marks)
- B) Analog signals can be categorized by their frequency but frequency can not be directly measured. When frequency is the most important piece of information, it is important to consider both accuracy and acquisition speed. Explain how frequency is measured so that the shape and frequency information can be preserved? (8 marks)
- C) Integrated microsensors refer to sensors or arrays of sensors that are developed using microfabrication technology. Explain the fundamental principles of piezoresistive sensing. (12 marks)

Question 5

A method for interfacing an incremental encoder to a digital processor is shown in Figure Q5. Explain the operation of this computer interface. (25 marks)

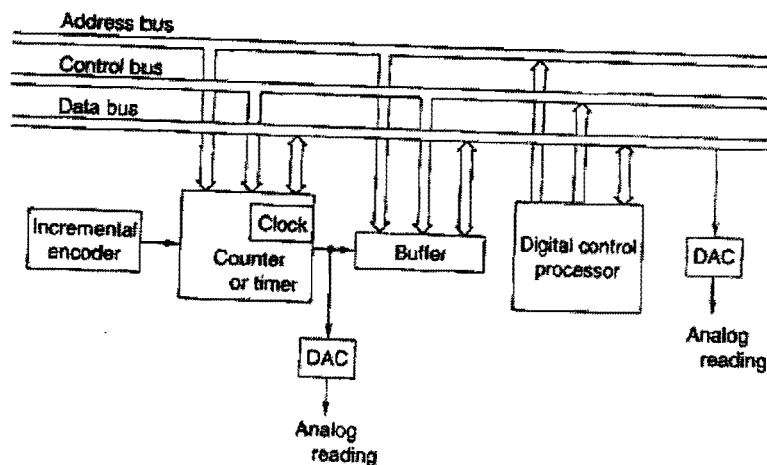


Figure Q5