Universiti Tun Hussein Onn Malaysia

# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION
## SEMESTER I
## SESSION 2015/2016

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|---|---|---|
| COURSE NAME | : | INSTRUMENTATION AND MEASUREMENT |
| COURSE CODE | : | BEH 10102 |
| PROGRAMME | : | BACHELOR OF ELECTRONIC ENGINEERING WITH HONOURS |
| EXAMINATION DATE | : | DECEMBER 2015 / JANUARY 2016 |
| DURATION | : | 2 HOURS |
| INSTRUCTION | : | ANSWER **ALL** QUESTIONS |

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

**Q1** (a) Draw the block diagram of an instrumentation system.

(4 marks)

(b) Differentiate analog and digital instruments by providing **three (3)** factor each.

(4 marks)

(c) Explain the meaning of the terms; instrument, measurement, accuracy, resolution, precision, expected value, error and sensitivity which referred to an instrumentation system.

(4 marks)

(d) Calculate the precision of the 7$^{th}$measurement of the 12 sets the resistance value measurement recorded, as given below:
202 Ω, 198 Ω, 201 Ω, 190 Ω, 200 Ω, 188 Ω, 203 Ω, 199 Ω, 191 Ω, 201 Ω, 199 Ω.

(4 marks)

(e) The **two (2)** voltage measurement are as below:
The first measurement voltage is $V_1$=120±1.5%
The second measurement voltage is $V_2$= 67±10%
Determine the sum of two voltage measurements and the difference of the two voltage measurements.

(4 marks)

**Q2** (a) Briefly describe the basic operation of a typical electrical transducer.

(5 marks)

(b) (i) Describe the working principle of a strain gauge.

(3 marks)

(ii) Draw the schematic diagram (with proper labeling) of a typical strain measurement circuit with temperature variation compensation.

(5 marks)

(c) A strain gauge with GF = 2.03 and active gauge, $R_A$=350Ω is used in the bridge of **Figure Q2(c).** The bridge resistors are $R_1$=$R_2$=350Ω, and the dummy gauge has $R_D$=350Ω. If a tensile strain of 1450μm/m is applied, find the bridge offset voltage if $V_s$=10V.

(7 marks)

**Q3** (a) For a Wheatstone Bridge as in **Figure Q3(a)**, $R_1$ = 1000 Ω, $R_2$ = 4000 Ω, $R_3$ = 100Ω and $R_4$ = 400 Ω when the bridge is balanced. Internal resistance of the galvanometer is 100Ω with its measuring sensitivity is 100 mm/μA.

(i) Find the current through the galvanometer using thevenin equivalent circuit

(10 marks)

(ii) Determine the deflection (mm) of the galvanometer caused by an additional resistor, $R_4$=1 Ω. (Hint: Use Thevenin's theorem due to imbalance in $R_4$)

(5 marks)

(b) (i) Name **three (3)** applications for capacitive transducers.

(3 marks)

(ii) An electrode-diaphragm pressure transducer has plates whose area is $5x10^{-3}$ $m^2$ and distance between plates is $1x10^{-3}$. Calculate its capacitance if it measures air pressure,

with k=1. [hint: $C = \frac{kA\varepsilon_o}{d}$ ]

(2 marks)

**Q4** (a) A numerical control (NC) worktable operates by closed-loop positioning as shown in **Figure Q4**. The lead screw has a pitch of 25mm and is coupled to the motor shaft with a gear ratio of 10:1 (Ten turns of drive motor for each turn of the screw). An incremental optical encoder generates 500 pulses/rev of its output shaft. Determine:

(i) The resolution of the NC worktable.

(2 marks)

(ii) Number of encoder pulses should be received by the control system to verify if the table has moved exactly 250mm.

(2 marks)

(iii) The encoder pulse rate if the table is to move at 500mm/min.

(2 marks)

(iv) The drive motor speed in terms of revolution per minute (RPM) if the table is moved at the speed as specified at Q4(a)(iii).

(4 marks)

(b) An engineer has decided to replace the incremental encoder as shown in **Figure Q4** with a linear absolute encoder along the shaft. Given the specification of the absolute encoder as stroke length 500mm, 12 bits, Gray code. The origin is defined when the table is at the most left and the encoder reads 0000 0000 0000 1100 Gray Code. The encoder value increases as the table moves to the right.

(i) Explain Gray Code using 4-bits binary.

(2 marks)

(ii) Explain the reason of using Gray Code.

(2 marks)

(iii) Calculate the minimum travel distance possible.

(2 marks)

iv) If the table is to move 250mm away from the origin, calculate the encoder value in Gray Code.

(4 marks)

**Q5** (a) A measurement of temperature using a sensor that outputs 6.5mV/°C with max temperature from 0 to 100°C. A 6-bit Analog to Digital Converter (ADC) with a 10V reference is used.

(i) Develop a circuit to interface the sensor and the ADC.

(10 marks)

(ii) Determine the temperature resolution.

(5 marks)

(b) A sensor signal is converted to a frequency that varies from 2.0kHz to 20kHz. This signal is to be converted into an 8-bit digital signal.

(i) Specify the count time, $T_c$.

(2.5 marks)

(ii) Determine the range of count output for the sensor signal's frequency range?

(2.5 marks)

**- END OF QUESTIONS -**

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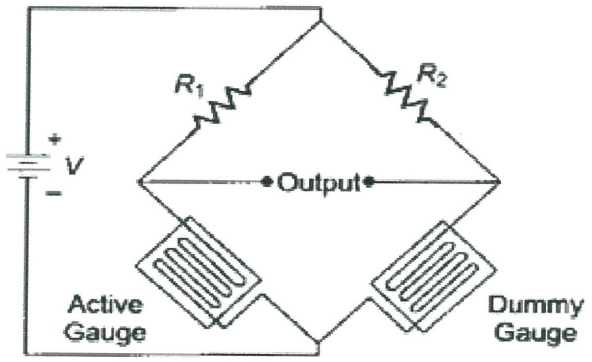


**FIGURE Q2(c)**

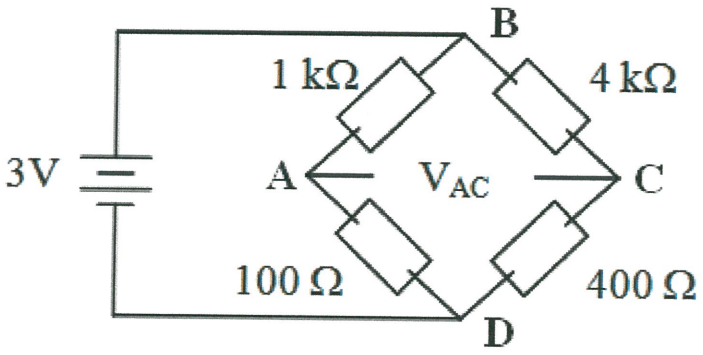


**FIGURE Q3(a)**

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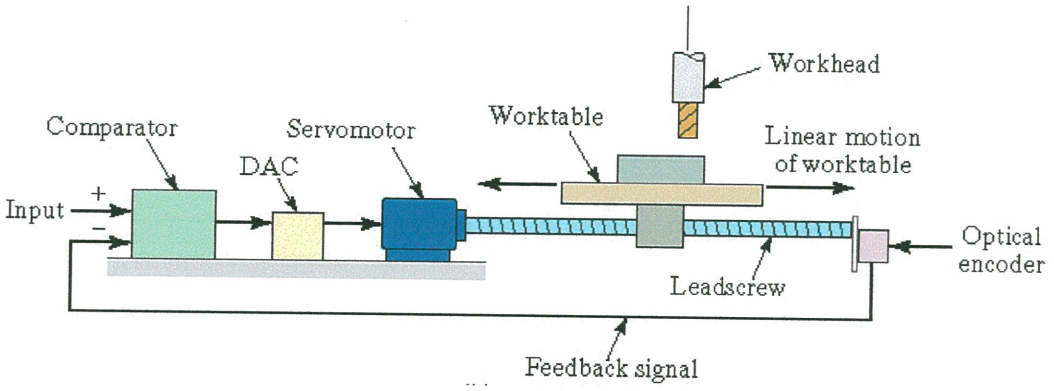


**FIGURE Q4**