Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2015/2016

COURSE NAME	:	INSTRUMENTATION AND MEASUREMENT
COURSE CODE	:	BEH 10102
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JUNE/JULY 2016
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS PAPER CONSISTS OF **EIGHT (8)** PAGES

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

(2 marks)

(b) Explain the meaning of measurement, resolution and sensitivity.

(3 marks)

(c) Three resistors that are connected to each other are shown in **Figure Q1(c).** Each resistor has a nominal resistance value of 270 Ω with tolerance of ± 10 % for R_1, ± 5 % for R_2 and ± 15 % for R_3. These resistors are specified at 25 °C and their temperature coefficient is 500 ppm/°C. By applying appropriate measurement error combination formula, calculate the total resistance, R_T of the circuit and its tolerance.

(10 marks)

(d) **Table Q1(d)** shows one set of recorded voltage measurements obtained after 8 times repetition measurement. Calculate the precision of the 4th measurement.

(5 marks)

Q2 (a) The strain gauge is an example of a passive transducer that uses electrical resistance variation in wires to sense the strain produced by a force on the wires. With the help of diagram, explain the 2 types of strain gauge in terms of their advantageous and disadvantageous.

(5 marks)

(b) **Figure Q2(b)** shows a strain gauge applied in a bridge circuit. All resistors including the strain gauge have a resistance of 250 Ω. During a load test, the strain gauge undergoes a change of 1.02 Ω. If the applied tensile strain is 1450μ, determine:

(i) The gauge factor.

(2 marks)

(ii) The bridge offset voltage, V_{out} if V_S is 12 V.

(3 marks)

(c) A parallel-plate capacitor has plates with area of 4×10^{-3} m^2. The distance between the plates is 5×10^{-4} m. Determine the capacitance (in nF) if the dielectric is ceramic (k= 1000) and the permittivity, ε is 8.854×10^{-12}.

(2 marks)

(d) **Figure Q2(c)** shows a photoconductive cell circuit with its corresponding illumination characteristics. The photoconductive cell is used to control the relay. When the cell is illuminated at 50 lm/m^2, the circuit delivers 1 mA at 25 V setting whereas the circuit becomes deenergized when the cell is dark. By referring to the illumination characteristics graph, calculate:

(i) The required series resistance.

(4 marks)

(ii) The level of the dark current.

(4 marks)

Q3 (a) **Figure Q3(a)** shows the Wheatstone bridge circuit. The resistance values for R_1, R_2, R_3 and R_4 are 1 kΩ, 1.6 kΩ, 3.5 kΩ and 7.5 kΩ respectively.

(i) With a clear justification, analyse whether or not the bridge is balanced.
(2 marks)

(ii) If the internal resistance of the galvanometer is 200 Ω, determine the current through the galvanometer using Thevenin equivalent circuit.
(10 marks)

(iii) Determine the deflection (mm) of the galvanometer's pointer if the sensitivity of the detector is 2.5 mm/μA.
(2 marks)

(b) A Kelvin double bridge is shown in **Figure Q3(b)**. Compute the value of R_x when R_a is 1200 Ω, R_a is $1600R_b$, R_1 is $800R_b$ and R_1 is $1.25R_2$.
(6 marks)

Q4 (a) An instrumentation engineer has decided to use a potentiometric sensor to measure the bumpiness of a roadway by moving it to the right as shown in **Figure Q4(a)**. The potentiometric sensor, which consists of a resistive position transducer (resistance of 10 kΩ) and a shaft stroke (movable arm) of 8 cm, is connected to a bridge circuit. Assuming the initial position is when the shaft is at the mid stroke:

(i) Derive the formula for V_{out} in terms of the value of the resistors in the circuit.
(2 marks)

(ii) Calculate the V_{out} when the shaft of the transducer is at initial position.
(2 marks)

(iii) Determine the V_{out} when the shaft has reached point A.
(6 marks)

(b) A numerical control (NC) worktable as shown in **Figure Q4(b)** is scheduled for a preventive maintenance of its incremental optical encoder. During the preventive maintenance procedure, the appointed engineer has to ensure that the control system should receive 6000 pulses when the table is moved by 300 mm. If the lead screw has a pitch of 30 mm and is coupled to the motor shaft with a gear ratio of 12:1 (twelve turns of drive motor for each turn of the screw), calculate:

(i) The pulses/rev that the incremental encoder can generate of its output shaft.
(2 marks)

(ii) The resolution (in mm/pulses) of the NC worktable.
(2 marks)

(iii) The encoder pulse rate (pulses/sec) if the table is moved at 600 mm/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 in **Q4(b)(iii)**.
(4 marks)

Q5 (a) Draw the logic NOR gate and its truth table.

(2 marks)

(b) A first year student is assigned to design an interface circuit of a temperature sensor to an 8-bit of Analog to Digital Converter (ADC). This sensor is able to sense from 5 °C to 125 °C using a single positive supply. Meanwhile, the output voltage of temperature sensor has a linear scale factor of + 5.5 mV/°C. If 5 V is used as voltage reference:

(i) Determine the sensor output (in voltage) at minimum and maximum temperature that the sensor can sense.

(3 marks)

(ii) Calculate required gain at 125 °C.

(4 marks)

(iii) Determine the temperature resolution at 125 °C.

(6 marks)

(c) A sensor signal is converted to a frequency that varies from 2 kHz to 20 kHz.

(i) If this signal is to be converted into 6-bit digital signal, determine the count time, T_c in second when the frequency is at maximum.

(2.5 marks)

(ii) Determine the pulses count output when the frequency is at minimum in 6-bit binary form.

(2.5 marks)

- END OF QUESTIONS -

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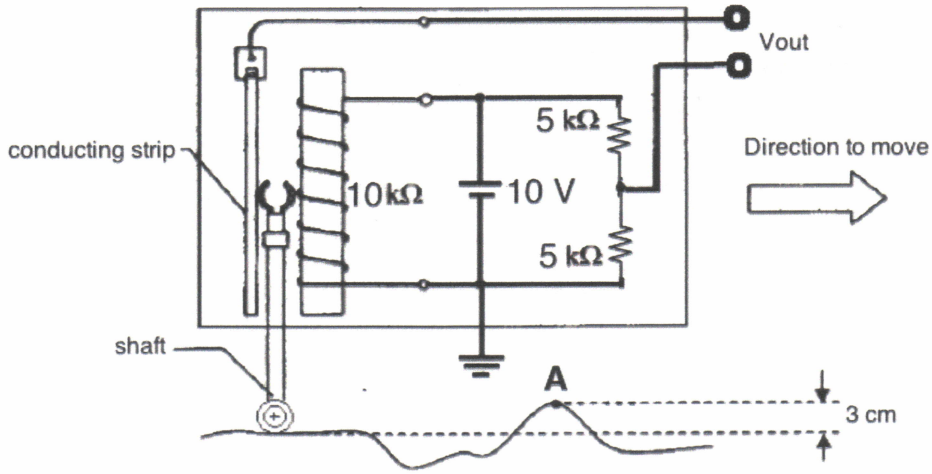

Figure Q4 (a)

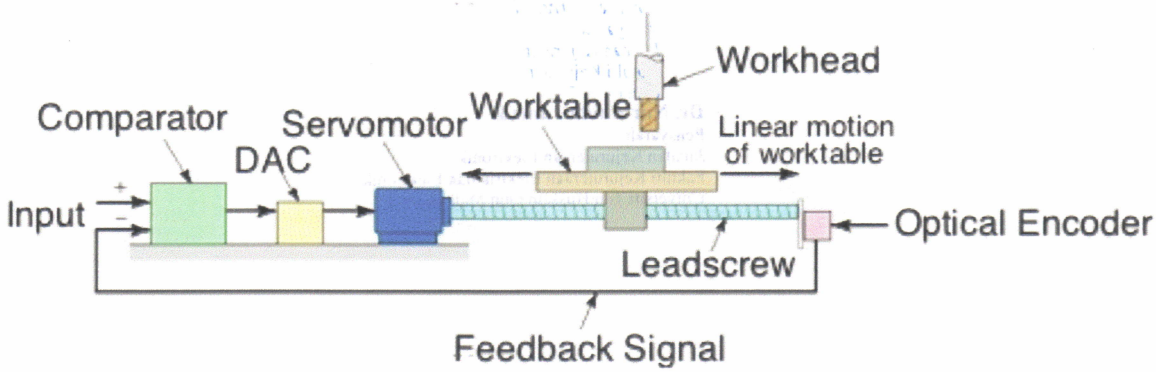

Figure Q4 (b)