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Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

**FINAL EXAMINATION
SEMESTER I
SESSION 2014/2015**

COURSE NAME	:	INTRUMENTATION AND MEASUREMENT
COURSE CODE	:	BEH 20403
PROGRAMME	:	2 BEJ
EXAMINATION DATE	:	DECEMBER 2014 / JANUARY 2015
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER ALL QUESTIONS

THIS QUESTION PAPER CONSISTS OF SEVEN (7) PAGES

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- Q1** (a) A $470\ \Omega \pm 10\%$ resistor has a potential difference of 12 V across its terminals. If the voltage is measured with an accuracy of $\pm 6\%$;
- (i) determine the power dissipation in the resistor. (5 marks)
- (ii) specify the accuracy of the result. (5 marks)
- (b) The Wien-bridge oscillator is shown in Figure **Q1(b)** as one of the most commonly used for audio oscillator which employs RC feedback networks. Given $R_1 = R_2 = 10\text{k}\Omega$, $R_3 = 15\text{k}\Omega$ and $R_4 = 20\text{k}\Omega$, analyse the values of C_1 and C_2 that cause the circuit to oscillate at 15 kHz. (10 marks)
- Q2** (a) Explain the difference between a sensor and a transducer. (4 marks)
- (b) A round steel bar, which the diameter is 0.02 m and 0.40 m in length as shown in Figure **Q2(b)**, is subjected to a tensile force of 33,000 kg, where $E = 2 \times 10^2 \text{kg/m}^2$.
- (i) Calculate the elongation, ΔL , in meters. (4 marks)
- (ii) Calculate the strain, G . (2 marks)
- (c) A strain gauge with gauge factor, $GF = 2.03$ and active gauge, $R_A = 350\ \Omega$ is used in the bridge of Figure **Q2(c)**. The bridge resistors are $R_1 = R_2 = 350\ \Omega$, and the dummy gauge has $R_D = 350\ \Omega$. If a tensile strain of $1450\ \mu\text{m/m}$ is applied;
- (i) Find the bridge offset voltage if $V_s = 10\text{V}$. (5 marks)
- (ii) Determine the relation between bridge off-null voltage and strain. (5 marks)

- Q3** (a) The worktable of a positioning system as shown in the Figure **Q3(a)** is driven by a ball screw whose pitch is 25mm. The ball screw is connected to the shaft of a stepper motor through a gearbox. An incremental encoder of 100 pulses/rev is connected to the end of the ball screw. The table must move a distance of 250mm from its present position.
- (i) Suggest the connection of an incremental encoder for the use of detecting forward and reverse motions with the help of diagram. (4 marks)
 - (ii) Calculate the resolution of the encoder. (3 marks)
 - (iii) Calculate how many pulses of the encoder are to be read to identify that the table is moved to the specified distance. (3 marks)
- (b) An integrator circuit as illustrated in Figure **Q3(b)** consists of a $70\text{ k}\Omega$ resistor and a $0.2\text{ }\mu\text{F}$ capacitor.
- (i) If the voltage applied to the integrator input is 1 V, determine the output voltage of the integrator after 1.25 seconds. (3 marks)
 - (ii) If the reference voltage, V_{ref} is applied to the integrator at time t_2 is 5 V, analyse the time interval from t_2 to t_3 . (3 marks)
 - (iii) Draw the output waveform of the integrator. (4 marks)
- Q4** (a) A resistive position transducer with a resistance of $10\text{ k}\Omega$ and a shaft stroke of 8 cm with a bridge circuit is used to measure the bumpiness of a roadway by moving it to the right as shown in Figure **Q4(a)**. (note: the initial position to be used as a reference point is when the shaft is at the middle of stroke).
- (i) Sketch the equivalent circuit of the system. (2 marks)

- (ii) Derive the formula for V_{out} in terms of the value resistor in the circuit. (2 marks)
 - (iii) Obtain the value of V_{out} when the shaft at initial position. (2 marks)
 - (iv) Analyse the value of V_{out} when the shaft reached point A. (4 marks)
- (b) An accelerometer in Figure **Q4(b)** has a seismic mass of 0.05kg and a spring constant of 3.0×10^3 N/m. Maximum mass displacement is ± 0.02 m (before the mass hits the stops).
- (i) Analyse the maximum measurable acceleration in **g**. (5 marks)
 - (ii) Find the natural frequency, F_N . (5 marks)

- Q5** (a) A measurement of temperature using a sensor that outputs $6.5\text{mV}/^\circ\text{C}$ must measure up to 100°C . A 6-bit ADC with a 10-V reference is used.
- (i) Determine the required gain that need to develop a circuit to interface the sensor and the ADC (5 marks)
 - (ii) Sketch the circuit. (5 marks)
 - (iii) Analyse the temperature resolution (5 marks)
- (b) A sensor signal is converted to a frequency that varies from 2 kHz to 20kHz. This signal is to be converted into a 8-bit digital signal. Specify the count time, T_c . Analyse the range of count output for the sensor signal's frequency range. (5 marks)

- END OF QUESTION-

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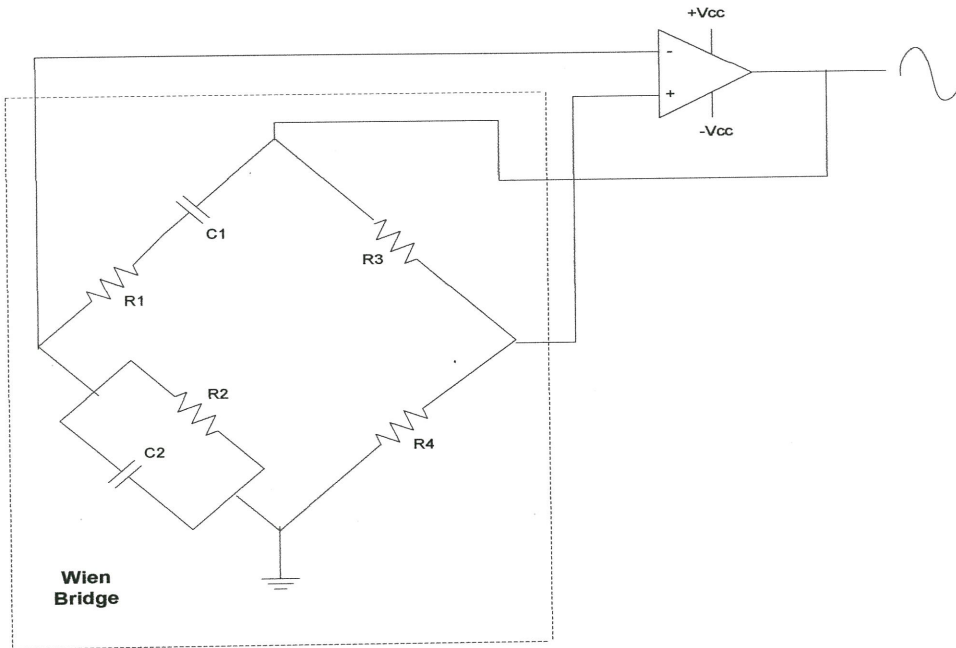


FIGURE Q1(b)

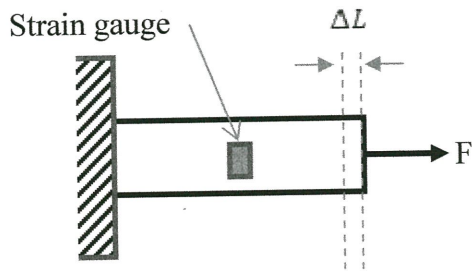


FIGURE Q2(b)

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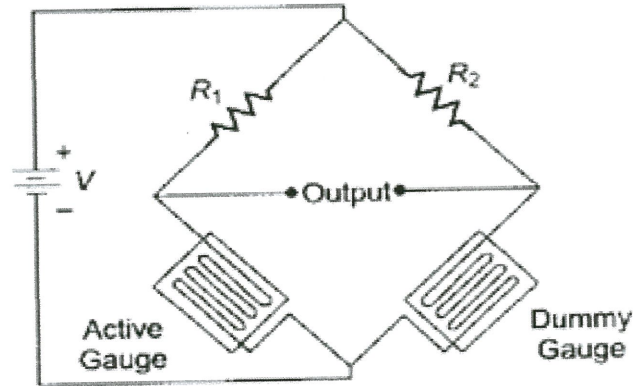


FIGURE Q2(c)

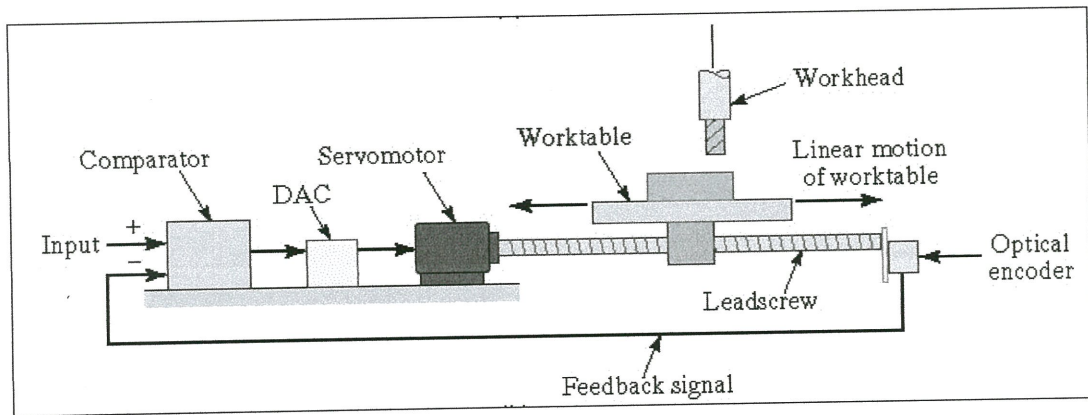


FIGURE Q3(a)

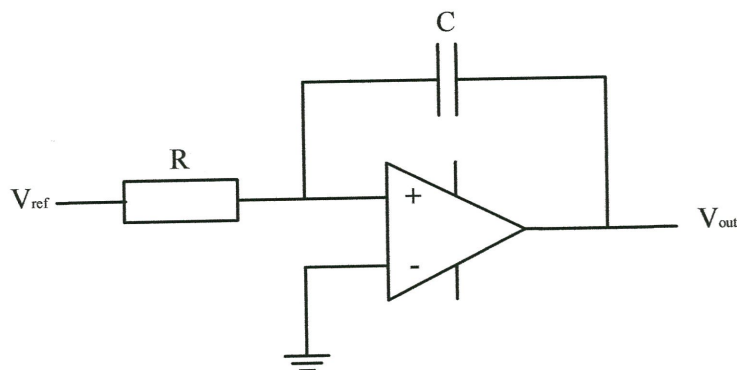


FIGURE Q3(b)

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Resistive position transducer

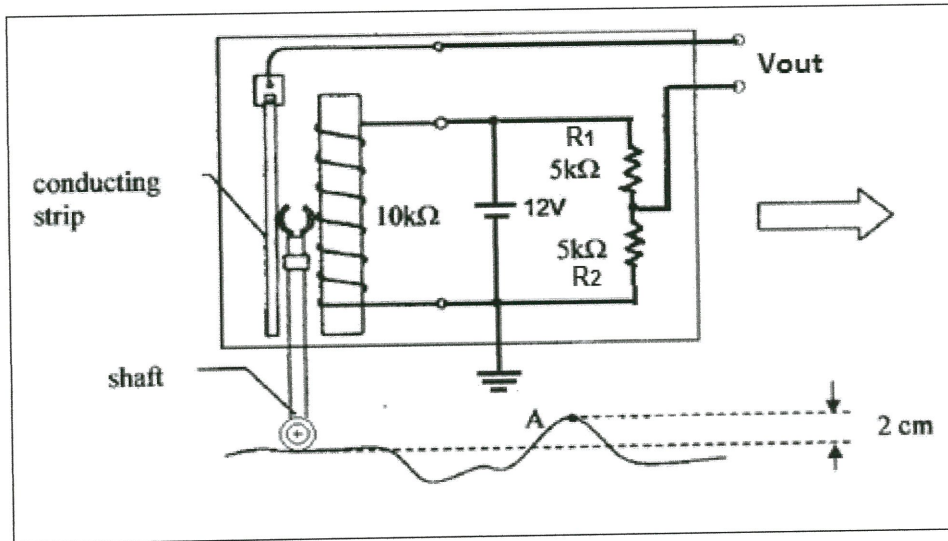


FIGURE Q4(a)

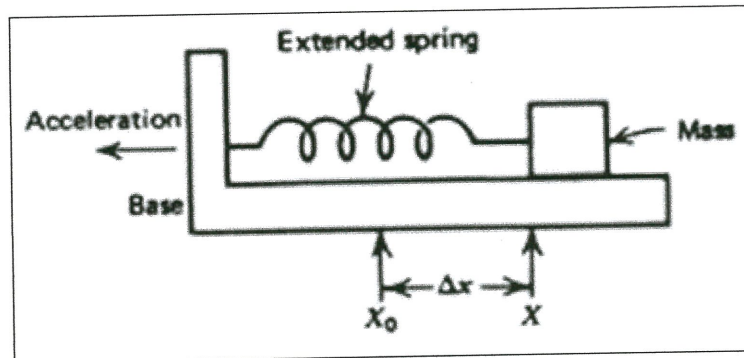


FIGURE Q4(b)