UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER II
SESSION 2020/2021

COURSE NAME	:	INSTRUMENTATION & MEASUREMENT
COURSE CODE	:	BEJ10702
PROGRAMME CODE	:	BEJ
EXAMINATION DATE	:	JULY 2021
DURATION	:	2 HOURS
INSTRUCTION	:	ANSWER ALL QUESTIONS OPEN BOOK EXAMINATION

THIS PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 (a) (i) Define transducer in instrumentation and measurement.
(2 marks)

(ii) Show a block diagram of a transducer.
(2 marks)

(b) Using the help of a diagram, explain the working principle of a strain gauge.
(4 marks)

(c) A simple force transducer is illustrated in **Figure Q1(c)**. A round steel bar, 0.02m in diameter and 0.40m in length, is subjected to a tensile force, **F** of 33,000kg, where the steel Young Modulus, $\mathrm{E} = 2 \times 10^{12}\ kg/m^2$.

(i) Calculate the elongation of the round steel bar, ΔL, in meters.
(4 marks)

(ii) Calculate the strain.
(3 marks)

(iii) Given that the strain gauge with a gauge factor of 2 is fastened to the round steel bar and the original resistance value of the gauge is 130Ω. Calculate it's change in resistance if a strain obtained in **Q1(c)(ii)** is observed.
(5 marks)

(iv) Using the same strain gauge stated in **Q1(c)(iii)**, sketch an electrical circuitry deploying Wheatstone Bridge to measure the force. (Propose the suitable values for all resistors.)
(5 marks)

Q2 (a) A typical Wheatstone bridge is shown in **Figure Q2(a).**

(i) Explain the use of Wheatstone bridge in instrumentation and measurement.
(2 marks)

(ii) Illustrate the formulation steps of the equation of the resistors when it is balanced.
(5 marks)

(iii) Given that $R_1 = 12k\Omega$, $R_2 = 15k\Omega$, $R_3 = 32k\Omega$, R_4 = unknown. Calculate R_4 when the galvanometer read null.
(2 marks)

(b) Another Wheatstone circuit is shown in **Figure Q2(b).** The Wheatstone bridge is slightly unbalanced. The galvanometer resistance, $R_g = 125\Omega$, and is a current sensitivity of $1\text{mm}/\mu\text{A}$.

(i) Draw Thevenin's equivalent circuit across terminal 'b' and 'c'.

(5 marks)

(ii) Calculate Thevenin's equivalent voltage, E_{TH} and Thevenin's equivalent resistance, R_{TH}, across terminal 'b' and 'c'.

(6 marks)

(iii) Calculate the current through the galvanometer.

(3 marks)

(iv) Calculate the deflection in mm of the galvanometer.

(2 marks)

Q3 An AC bridge is shown in **Figure Q3**. It has an AC excitation input and four arms of impedances, labelled as Z_1, Z_2, Z_3 and Z_4 and a null detector.

(a) Identify the criteria for 'balanced' condition.

(2 marks)

(b) Give three examples of null detectors applicable in the circuit.

(3 marks)

(c) Select three applications using an AC bridge for instrumentation and measurements.

(3 marks)

(d) Illustrate the formulation of balanced condition using the labels, Z_1, Z_2, Z_3 and Z_4.

(6 marks)

(e) Given that the components of each impedance as:
Z_1 consists of $R_1 = 400\Omega$
Z_2 consists of $R_2 = 200\Omega$ and $L_2 = 15.92\text{mH}$
Z_3 consists of $R_3 = 300\Omega$ and $C_3 = 0.4\text{uF}$
Z_4 is unknown.

(i) If the input, $E = 6\text{V}$ and frequency, $f = 1\text{kHz}$, calculate the unknown Z_4.

(4 marks)

(ii) If the input, $E = 6\text{V}$ and frequency, $f = 100\text{kHz}$, calculate the unknown Z_4.

(4 marks)

(iii) Discover the effect of frequency as obtained in **Q3(e)(i)** and **Q3(e)(ii)**.
(3 marks)

Q4 (a) Explain the working principle of a rotary encoder for positioning purpose.
(2 marks)

(b) Explain the conversion of linear length when a rotary encoder of m pulses/rev is being attached to a roller of diameter, d.
(4 marks)

(c) A caddy packing machine would apply a rotary encoder to read the length of the package. Mechanically a rotary encoder is attached to the main shaft of the rotary rollers as simplified in **Figure Q4(c)**, in order to convert rotary measurement into linear measurement. The rest of the mechanism for packaging is not shown. The rollers, A and B, clamp firmly the caddy bar and feed it into the rotary cutter. Given that the encoder has 1000 pulses/rev; roller A and B are identical and its diameter is 200mm. (Assuming no slip happens between the rollers and the caddy.)

(i) Calculate the length of the caddy being fed if a pulse is read.
(5 marks)

(ii) If the caddy bar is to be cut into 20mm, calculate the number of pulses signalled by the rotary encoder.
(4 marks)

(iii) If the caddy bar is to move at 10000mm/min and the cut size is 20mm, calculate the number of cut per minute.
(5 marks)

(iv) Calculate the encoder pulse rate if the caddy bar is to move at 10000mm/min.
(5 marks)

- END OF QUESTIONS -

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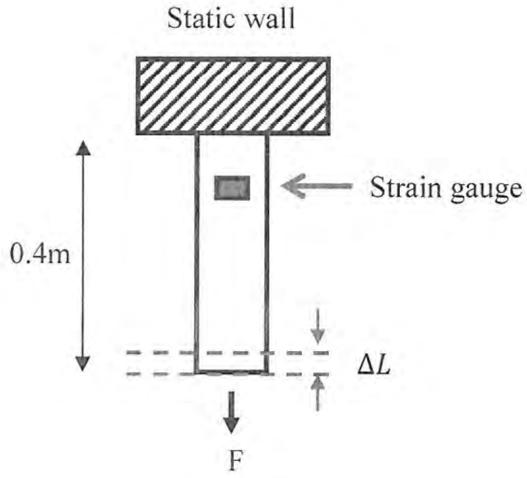

Figure Q1(c)

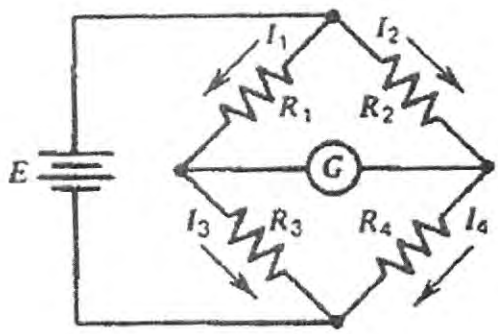

Figure Q2(a)

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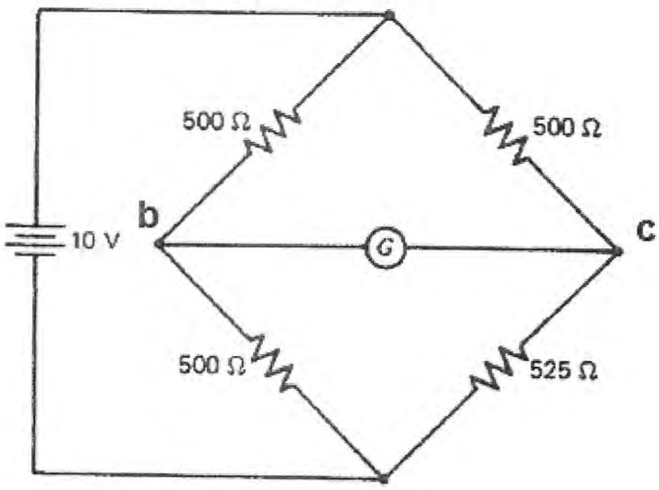

Figure Q2(b)

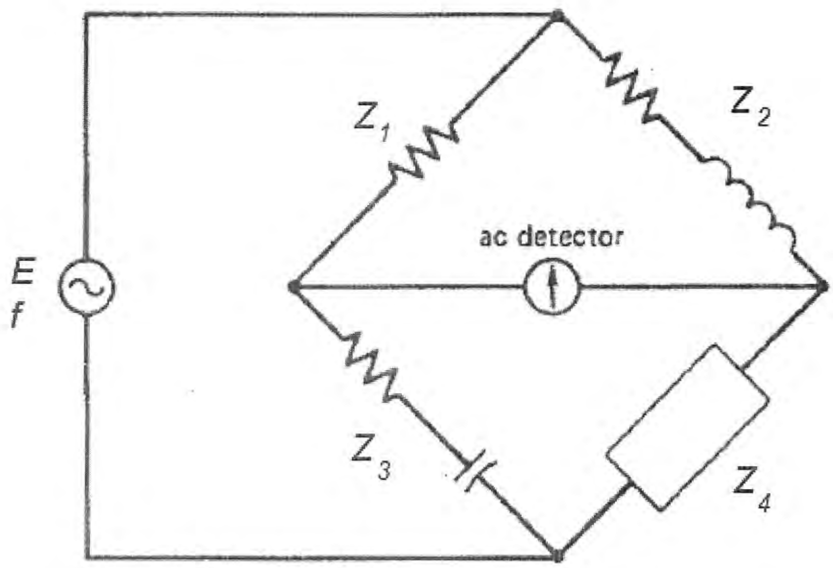

Figure Q3

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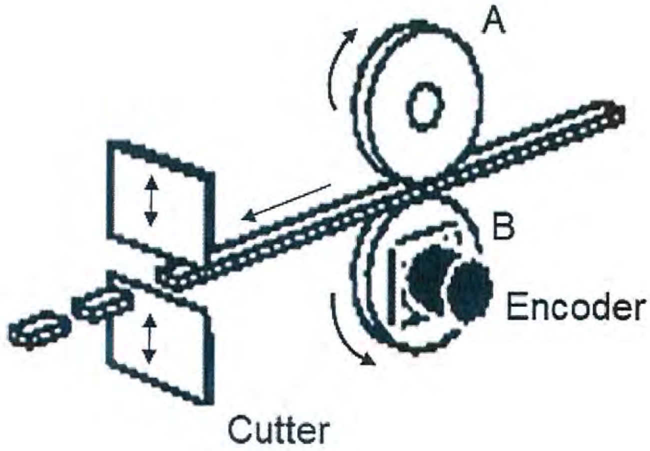

Figure Q4(c)