00194

The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Electrical & Computer Engineering

Study Programme	: Bachelor of Science Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: EEX3331 Electrical Measurements and Instrumentation**
Academic Year	: 2023/2024
Date	: 09th February 2025
Time	: 09:30 – 12:30 hrs.
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Six (6)** questions in **Five (5)** pages.
3. Answer any **Five (5)** questions. All questions carry equal marks.
4. Answer to each question should commence from a new page.
5. Some important equations are provided.
6. This is a Closed Book Test (CBT).
7. Answers should be in clear handwriting.
8. Do not use Red color pen.

Question 01 – Answer both Part A and Part B

Part A

Figure Q1.1 shows an experimental setup used to measure an unknown resistor (R). The internal resistance of the voltmeter is 2 MΩ. The readings of the two meters are as follows.

Voltmeter reading: 60 V

Ammeter reading: 12 A

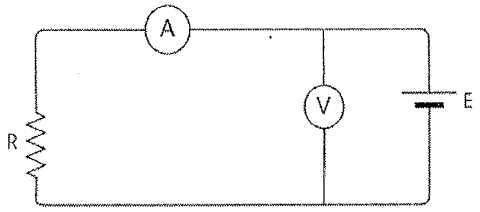


Figure Q1.1

I. Calculate the resistance of the unknown resistor (R) using the meter readings. State any assumption/s you made. *(03 marks)*

II. Calculate the percentage error of the above measurement if the exact value of the resistance (R) is 4.8 Ω. State the possible reason for this error. *(03 marks)*

III. Suggest a modification to the circuit shown in Figure Q1.1 to reduce the error in the measurement. Draw the modified circuit and justify your answer. State any assumptions you made. *(04 marks)*

Part B

Figure Q1.2 shows a circuit diagram of Wheatstone bridge.

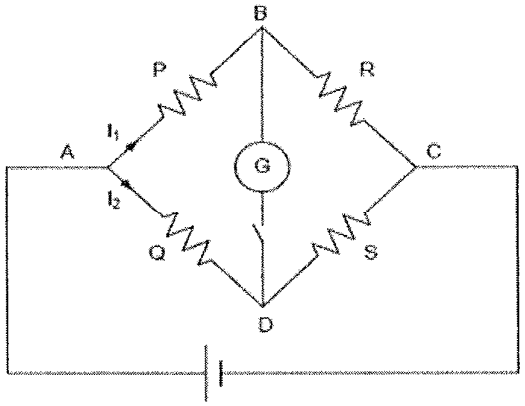


Figure Q1.2

I. **Derive** an expression to obtain the relationship between P, Q, R, S resistors at the balance condition of the bridge circuit. *(06 marks)*

II. How do you monitor the balance condition of this circuit? *(02 marks)*

III. Using the relationship you have obtained in part I, calculate the unknown resister value Q. Given that P = 10 kΩ, R = 100 kΩ, S = 360 kΩ. *(02 marks)*

Question 02

I. Draw sketches of the Electrode Placement of Wenner and Schlumberger methods of earth resistivity measurement and compare **one** advantage and disadvantage of each of them. *(04 marks)*

II. State four (04) factors affecting the earth's resistivity. *(02 marks)*

III. Write two methods of earth electrode resistance measurement and mention their accuracy level (high or low) comparing with each other. *(02 marks)*

IV. The following are measurements of an earth resistivity measurement conducted using the Wenner method.

- Electrode spacing 'a' = 10 m
- Electrode depth 'b' = 0.3 m
- Measured voltage V = 50 V
- Measured current I = 1.25 A

Calculate the earth resistivity,

a. Using standard formula *(04 marks)*

b. Using simplified formula. *(04 marks)*

V. The following are measurements of an earth resistivity measurement conducted using Schlumberger method. Calculate the earth resistivity. *(04 marks)*

- Spacing between voltage electrodes = 3 m
- Spacing between voltage and current electrodes = 8 m
- Electrode depth b = 0.3 m
- Measured voltage V = 35 V
- Measured current I = 1.25 A

Question 03

Part A

I. List down four methods to measure magnetic flux density. *(02 marks)*

II. Describe the Hall effect and explain how it is useful in flux density measurement. *(04 marks)*

III. Explain the hysteresis loss occurred in a magnetic material. *(04 marks)*

IV. A cube made of a conducting material has dimensions as 8 x 6 x 3 mm is used to measure the flux density. The material has a Hall coefficient of 0.8 $\Omega m T^{-1}$. Find the flux density if the developed emf is 0.5 V with a current of 50 mA. *(04 marks)*

Part B

I. Using an appropriate example, briefly explain the terms "Accuracy" and "Precision" of a measurement. *(02 marks)*

II. Classify all types of errors which may occur in measurements. *(04 marks)*

Question 04 – Answer both Part A and Part B

Part A

I. State the reason why the regular De Sauty's bridge is not suitable to measure practical capacitors. *(02 marks)*

II. Draw the circuit diagram of 'Modified De Sauty's Bridge' for measuring capacitance and derive expressions for the unknowns considering the balanced condition. *(05 marks)*

Part B

The circuit shown in Figure Q4 is a Schering Bridge used to measure the permittivity of a specimen. A parallel plate capacitor C_1 is formed using the above specimen which has a thickness of 4.0 mm, and the plate area is 200 cm^2. The remaining arms in conventional notation have, R_3 =2.5 kΩ, R_4 = 6 kΩ, in parallel with a fixed capacitor C_4 = 540 pF and C_2 a fixed capacitor of 220 pF. The frequency of the supply is 300 rad/s. Permittivity of vacuum is $8.854 \times 10^{-12} F/m$.

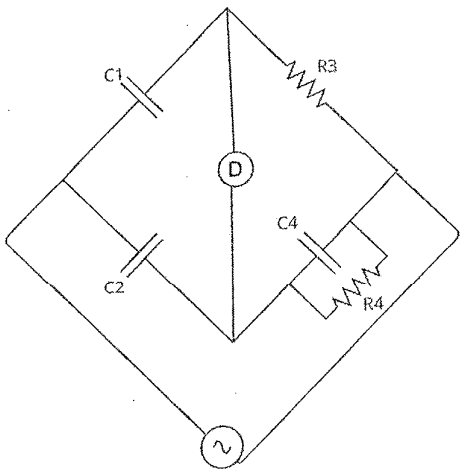


Figure Q4

I. At balanced condition, derive an equation for Equivalent Series Resistance (ESR) of the capacitor C1. *(05 marks)*

II. Determine the relative permittivity of the specimen and the loss angle. *(08 marks)*

Question 05

I. Write **one** application (usage) for each of the following measuring methods.

a. Loss of Charge method
b. Anderson bridge
c. Wien bridge
d. Carey-Foster bridge

(04 marks)

II. Figure Q5 shows the circuit diagram of Owen's Bridge where $L1$ and $R1$ represent the inductance and resistance of the inductor to be measured. Derive an expression for the out of balance voltage of Owen's bridge. *(05 marks)*

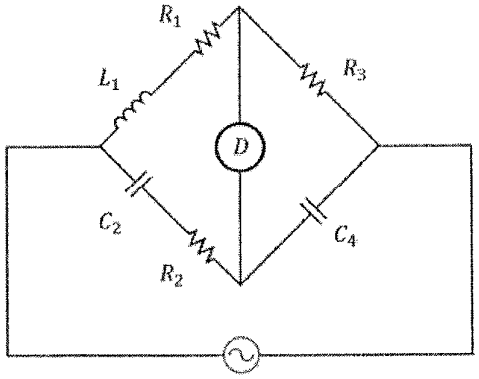


Figure Q5

III. Draw sketches to illustrate the locus of variation of out of balance voltage in the complex domain, when varying following parameter sets in the expression you have derived in part II. *(08 marks)*

a. C2 and $R2$
b. $C4$ and $R3$
c. $R2$ and $R3$

IV. Based on the locus of variations you have sketched in 'III', determine the most suitable pair of components to achieve the balanced condition. Justify your answer. *(03 marks)*

Question 06

I. Write **four** applications of AC potentiometer. *(04 marks)*

II. Write **four** applications of DC potentiometer *(04 marks)*

III. What is the purpose of Volt- Ratio Box in measurements? *(04 marks)*

IV. Write the **two** main types of AC potentiometer. *(02 marks)*

V. Write the **two** methods (with diagrams) of measuring the phase shift between two signals using the oscilloscope *(06 marks).*

Important equations

$$\rho = \frac{4\pi aR}{1 + \frac{2a}{\sqrt{a^2 + 4b^2}} - \frac{2a}{\sqrt{4a^2 + 4b^2}}}$$

$$\rho = \pi \frac{c.(c+a)}{a}.R$$