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

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| 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 | : 2022/2023 |
| Date | : 05th February 2024 |
| Time | : 13:30 – 16:30 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 (4)** 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 colour 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: 50 V

Ammeter reading: 10 A

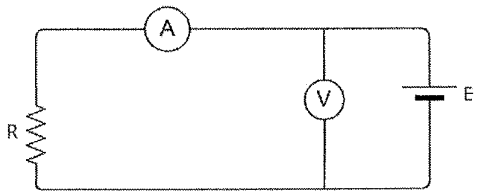



Figure Q1.1

I. Calculate resistance of the unknown resistor (R) using the meter readings. State any assumption/s you made. *(02 marks)*

II. Calculate the percentage error of the above measurement if the exact value of the resistance (R) is 4.5 MΩ. *(02 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. *(03 marks)*

Part B

A circuit diagram of the complete Kelvin Double Bridge is shown in Figure Q1.2.

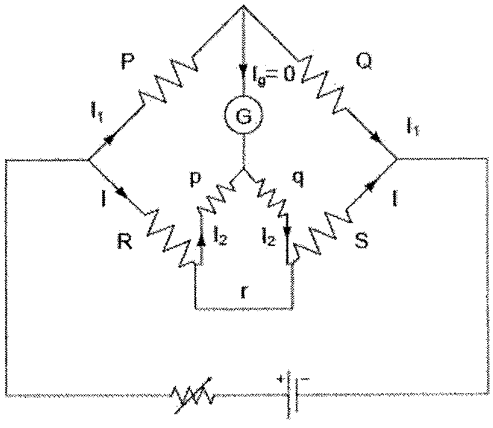



Figure Q1.2

I. Derive an expression to determine the resistance R. Assume that the outer ratio and the inner ratio of the bridge are kept equal. *(09 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 $8.854 \times 10^{-12} F/m$.

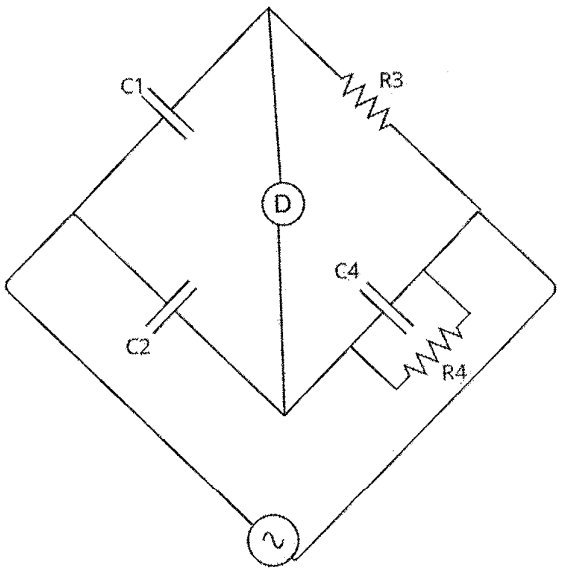



Figure Q4

I. At balanced condition, derive an equation for ESR of the capacitor C1. *(06 marks)*

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

**Question 05**

I. Define the terms 'Sensitivity' and 'Accuracy' of an AC bridge circuit. *(02 marks)*

II. Derive an expression for the sensitivity of a general four-arm AC bridge circuit indicating the assumptions. *(02 marks)*

III. Using the expression derived in 'II', obtain a condition for the maximum sensitivity of the four-arm bridge circuit. *(02 marks)*

IV. 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. *(04 marks)*

II. Calculate the unknown resistance, if the standard resistance (S) is 0.857 Ω and the outer ratio is 10 at the balanced condition. *(04 marks)*

**Question 02**

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

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

III. In an earth resistivity measuring experiment, the following parameters were recorded.

- Electrode spacing a = 6 m
- Electrode depth b = 0.25 m
- Measured voltage V = 100 V
- Measured current I = 2 A

Calculate the earth resistivity using the Wenner method for both approximated and original equations. State any assumption/s you make. *(06 marks)*

IV. Write two methods of earth electrode resistance measurement and explain one of them briefly. *(04 marks)*

**Question 03**

I. Explain the Hall effect and how it is useful in magnetic flux density measurement. *(06 marks)*

II. List down two methods used to measure the magnetic flux density in addition to Hall effect-based instruments. *(02 marks)*

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

IV. Explain how Maxwell's bridge can be utilized for measurement of iron loss and permeability. Clearly draw a diagram of the configuration. *(04 marks)*

V. A cube made of a conducting material has dimensions as 8 x 6 x 3 mm is used to measure 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)*

**Question 04 – Answer both Part A and Part B**

Part A

Explain the method of frequency measurement using Wein bridge and describe the restrictions of its usage. *(06 marks)*

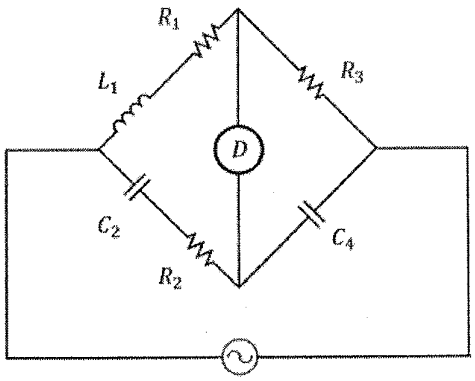



Figure Q5

V. Draw sketches to illustrate the locus of variation of out of balance voltage in the complex domain, when varying following parameter sets. *(06 marks)*

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

VI. Based on the locus of variations you have sketched in 'v', determine the most suitable pair of components to achieve the balanced condition. Justify your answer. *(04 marks)*

**Question 06**

I. Describe the method of increasing the voltage measuring range of a DC potentiometer using volt-ratio box. *(06 marks)*

II. Write two main types of AC potentiometers. *(02 marks)*

III. Illustrate the principle of accuracy increasing of an AC potentiometer using Kelvin - Varley slide wire. *(06 marks)*

IV. Describe the use of X-Y mode of the oscilloscope to plot the Hysteresis (B-H loop) of a magnetic specimen. *(06 marks)*

**Important equations**

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

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