0136

The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Electrical and 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	:	2024/25
Date	:	31st January 2026
Time	:	0930-1230h
Duration	:	3 hours

General instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Six (6)** questions in **Six (6)** pages.
3. Answer **any Five (5)** questions.
4. All questions carry equal marks.
5. Answer for each question should commence from a new page.
6. This is a Closed Book Test (CBT).

Question 01

Part A Figure Q1.1 shows an experimental setup to be used to measure the value of an unknown resister, R. Internal resistance of the Voltmeter is 1 kΩ. Observations are as follows,
Voltmeter Reading – 54 V
Ammeter Reading – 6 A

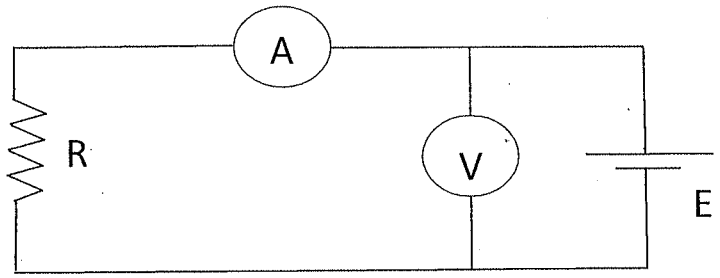


Figure Q1.1

I. Calculate the 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 method if the exact value of the resistance is 5 Ω. (02 marks)

III. Briefly describe the most probable reason/s caused for the above error. (02 marks)

IV. Suggest a modification to the circuit shown in figure Q1, to minimize the error. Calculate the new error percentage for the circuit you have suggested. (03 Marks)

Part B Later, the unknown resistor (R) was measured using a Kelvin Double Bridge circuit. A circuit diagram of the complete Kelvin Double Bridge is shown in Figure Q1.2.

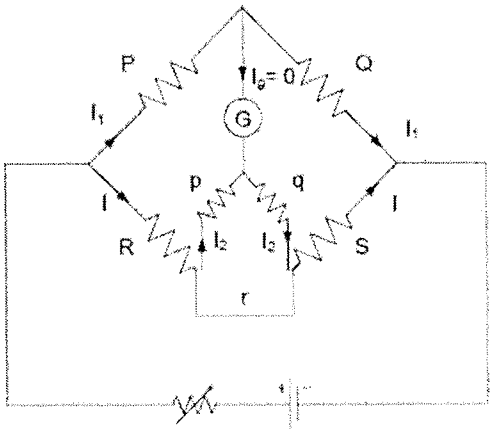


Figure Q1.2

I. Derive an expression to determine R, Assume that the outer ratio and the inner ratio of the bridge are equal. (09 marks)

II. Calculate the unknown resistance if the standard resistance is 0.671 Ω and the outer ratio is 10. (02 Marks)

Question 02

a. List down two restrictions of Wein Bridge Frequency measuring method. (02 Marks)

b. Draw the circuit diagram of Wien's bridge, which can be used to determine an unknown frequency. Use standard notations to mark bridge components. (05 marks)

c. Derive a simplified formula to determine the frequency at the balanced condition, clearly show steps of simplification, and mention conditions to be satisfied by arm 3 and 4 elements. (08 marks)

d. In a certain Wien Bridge, the arms are as follows. Top left arm is a resistance of 300 Ω in parallel with a capacitance of 5 μF, top right arm is a resistance of 200 Ω, bottom right arm is a resistance of 600 Ω and bottom left arm is a resistance R_2 in series with a capacitance of 5 μF. Calculate the resistance of R_2 and frequency of the supply at balance condition. (05 marks)

Question 03

PART A

I. Draw the complete equivalent circuit of a practical capacitor and describe how it can be simplified to the series model. (02 Marks)

II. State the reason why the regular De Sauty's bridge requires a modification to measure practical capacitors. (02 Marks)

PART B The circuit shown in figure Q3 is a Schering Bridge used to measure the permittivity of a specimen. A parallel plate capacitor C_1 has a specimen with thickness of 4.0 mm and area 400 cm^2. The remaining arms in conventional notation have, R_3 a non-reactive resistor of value 2 kΩ, R_4 a non-reactive resistor 5 kΩ in parallel with a fixed capacitor C_4 of value 470 pF and C_2 a fixed capacitor of 120 pF. Frequency of the supply is 300 rad/s. Permittivity of Vacuum is 8.854×10^{-12}F/m.

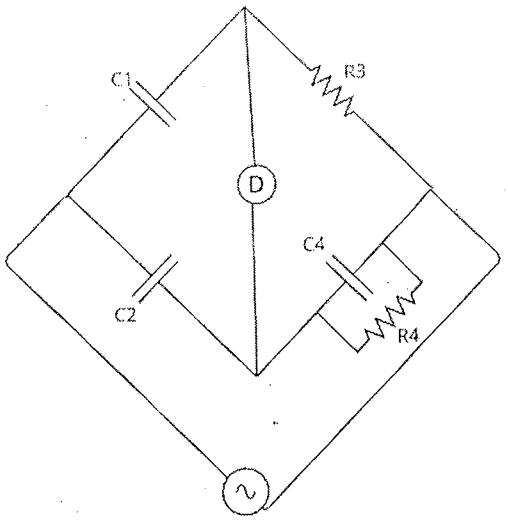


Figure Q3

I. Derive an equation for the equivalent series resistance of the capacitor under test. (06 marks)

II. With derivation of required equations, determine the relative permittivity of the dielectric and its dissipation factor. (10 marks)

Question 04

a. Draw the electrode placement configurations for both the Wenner method and the Schlumberger method. (04 marks)

b. An experiment was conducted to calculate the earth resistivity using Wenner method. The readings are as follows,

Total span between the electrodes at the two ends – 8 m

Electrode depth – 0.3 m
Measured voltage –100 V
Measured current –3 A

I. Calculate the earth resistivity using Wenner's full equation. (03 Marks)

II. Recalculate the earth resistivity using the Wenner's approximated equation indicating the neglected parameters appropriately. (02 Marks)

III. Compare Wenner method with the Schlumberger method, considering Two of their differences. (04 marks)

IV. State Three factors that affect the earth resistivity and briefly describe how they affect the earth resistivity. (03 Marks)

V. Briefly describe the two methods 'Fall of potential' and 'Dead Earth' of measuring earth resistance. With the help of appropriate diagrams, state which of the methods gives the more accurate measurement. Give reason(s). (04 Marks)

Question 05

a. Compare the construction and applications of the following types of potential transformers:

I. Single-phase vs. three-phase (02 marks)

II. Indoor vs. outdoor (02 marks)

III. Electromagnetic vs. capacitive (02 marks)

b. Explain the working principle of a potential transformer (PT) and derive the voltage ratio equation for an ideal PT. (06 marks)

c. A PT with a turns ratio of 100:1 is connected to a 33 kV power line. Calculate the secondary voltage. If the PT is rated for 50 VA and the connected load draws 40 VA, is this operation safe? Justify your answer. (04 Marks)

d. A substation uses three single-phase PTs (each 11000/110 V) to monitor a 3-phase line. Explain with two reasons why single-phase units are preferred over a three-phase PT in this case. (04 marks)

Question 06

Part A Design a multi range DC ammeter using a basic moving coil instrument with an internal resistance R_m = 50 Ω and a full-scale deflection current I_m =1 mA. (05 marks)

The ranges required are 0-10 mA; 0-50 mA; 0-100 mA and 0-500 mA.

Part B

a. With a comprehensive diagram, explain the working principle of an induction type energy meter. You need to indicate all the main parts of the energy meter in the diagram. (10 marks)

b. A balanced three-phase load supplied at 400 V draws a line current of 20 A. The wattmeter readings using the two-wattmeter method are 5.5 kW and 2.5 kW.

I. Calculate the total power (01 Marks)

II. Determine the power factor of the load (02 Marks)

III. State whether the load is inductive or capacitive. Give the Reason (02 Marks)

Important equations

Wenner's full equation for earth resistivity calculation.

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

a = space between electrodes

b = depth of the electrodes

R = measured resistance

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