UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: March 2021

Module Number: EE3203 **Module Name: Electrical and Electronic Measurements**

[Three Hours]

[Answer **all questions**, each question carries **10 marks**]

Q1 a) A Permanent Magnet Moving Coil (PMMC) is the basic deflection mechanism used in most analog measuring instruments.

i) Give another application of PMMC.

ii) Graphically represent the effect of damping on the deflection of a PMMC meter pointer over time.

iii) State two differences between PMMC and Electrodynamic meter movements.

[2.5 Marks]

b) Most DC voltmeters use the PMMC as their basic deflection mechanism.

i) Draw a circuit diagram to show how a PMMC can be used to make a four-stage voltmeter.

ii) A PMMC instrument with sensitivity 1 kΩ/V and internal resistance 50 Ω is to be used in 1 V, 10 V, 50 V and 100 V ranges in the voltmeter mentioned in part b) i). Determine the values for the required multiplier resistors.

[3.5 Marks]

c) A PMMC instrument with full scale deflection (FSD) current $I_m = 50\ \mu A$ and coil resistance $R_m = 1.7\ k\Omega$ is used in the half wave rectifier based voltmeter circuit shown in Figure Q1 c). The silicon diode D_1 must have a minimum peak forward current of 100 μA when the measured voltage is 20% of FSD. The voltmeter is to indicate 50 V_{rms} at full scale. Calculate the values of R_{SH} and R_S.

[4 Marks]

Q2 a) i) Identify the bridge circuit shown in Figure Q2 a).

ii) Derive an expression for an unknown resistance R_4 in the bridge circuit in part a) i), assuming all other parameter values are known.

[2.5 Marks]

b) A slightly unbalanced bridge circuit is shown in Figure Q2 b). The battery voltage is 5 V and its internal resistance is negligible. The galvanometer has a current sensitivity of 10 mm/μA and an internal resistance of 100 Ω. Calculate the deflection of the galvanometer caused by the 5 Ω unbalance in arm BD.

[4 Marks]

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c) i) Identify the bridge circuit shown in Figure Q2 c).

ii) Derive expressions to determine the unknown series resistance R_S, series inductance L_S and the quality factor Q in the bridge circuit in part c) i).

iii) Given that, $R_1 = 470\ \Omega$, $R_2 = R_3 = 1\ \text{k}\Omega$ and $C_1 = 0.22\ \mu\text{F}$, determine the unknown impedance and its quality factor. The bridge is driven by a 2 kHz source.

[3.5 Marks]

Q3 a) i) State the two basic measurements of a Cathode Ray Oscilloscope (CRO).

ii) Suppose an unknown sinusoidal voltage signal is displayed on a CRO screen. If the peak to peak distance of the displayed waveform is 8 divisions of the vertical scale and its vertical deflection control is set at 5 V/div, determine the rms value of the voltage signal.

[2 Marks]

b) A 1 kHz triangular wave with peak amplitude 60 V is applied to the vertical deflecting plates of a CRO. A 500 Hz sawtooth wave with peak amplitude 100 V is applied to the horizontal deflecting plates. The CRO has a vertical deflection sensitivity of 0.1 cm/V and a horizontal deflection sensitivity of 0.06 cm/V. Assuming that the two inputs are synchronized, sketch the waveform display on screen.

[4.5 Marks]

c) A signal generator with signal amplitude 1 V and source resistance 600 Ω is connected to an oscilloscope with input resistance 1 MΩ in parallel with an input capacitance of 25 pF. The coaxial cable of the probe has a capacitance of 90 pF.

i) Calculate the signal amplitude at the oscilloscope terminals when the frequency is 50 Hz and the probe operates in the 1:1 mode.

ii) Calculate the frequency of the signal generator when the signal amplitude at the oscilloscope terminals is 3 dB below the signal amplitude at the signal generator.

iii) Determine the value of the compensation capacitor required when the same probe operates in the 10:1 mode.

[3.5 Marks]

Q4 a) i) Draw a block diagram of a fundamental suppression harmonic distortion analyzer.

ii) Briefly describe the operation of the rejection amplifier in part a)i) and sketch its gain response.

iii) Derive an expression to find the tuned frequency of the Wien bridge shown in Figure Q4 a) under the balanced condition.

iv) Assume that the bridge is balanced for $R_1 = 4.7\ \text{k}\Omega$, $R_3 = 1.5\ \text{k}\Omega$, $R_4 = 1.2\ \text{k}\Omega$, $C_1 = 4.7\ \mu\text{F}$ and $C_2 = 1\ \mu\text{F}$. Calculate the frequency of the signal source and the value of the resistance R_2.

[7 Marks]

b) i) Draw the block diagram of a Digital Frequency Counter.

ii) Explain the function of the schmitt triggers used in your diagram in part b)i).

[3 Marks]

Q5 a) Define the "resolution" of a measuring instrument.

[1 Mark]

b) Assume A and B are two quantities having their absolute error values ΔA and ΔB, respectively.

i) Derive an expression to calculate the absolute error in $A+B$.

ii) Derive an expression to calculate the absolute error in $A-B$.

iii) Stating any assumption you make, prove that the fractional error in $A \times B$ is given by $\pm\left(\frac{\Delta A}{A}+\frac{\Delta B}{B}\right)$.

[4 Marks]

c) Two resistors having nominal values of 100 Ω are connected in parallel. One has a ±5% tolerance, while the other has ±10%. Calculate the total resistance and its relative error.

[2 Marks]

d) Two currents I_1 and I_2 from different sources flow in opposite directions through a resistor. I_1 is measured as 79 mA on a 100 mA analog instrument with an accuracy of ±3% of full scale. I_2 is measured as 31 mA, with a digital instrument with an accuracy of ±100 μA. Calculate the maximum and minimum levels of the current through the resistor.

[3 Marks]

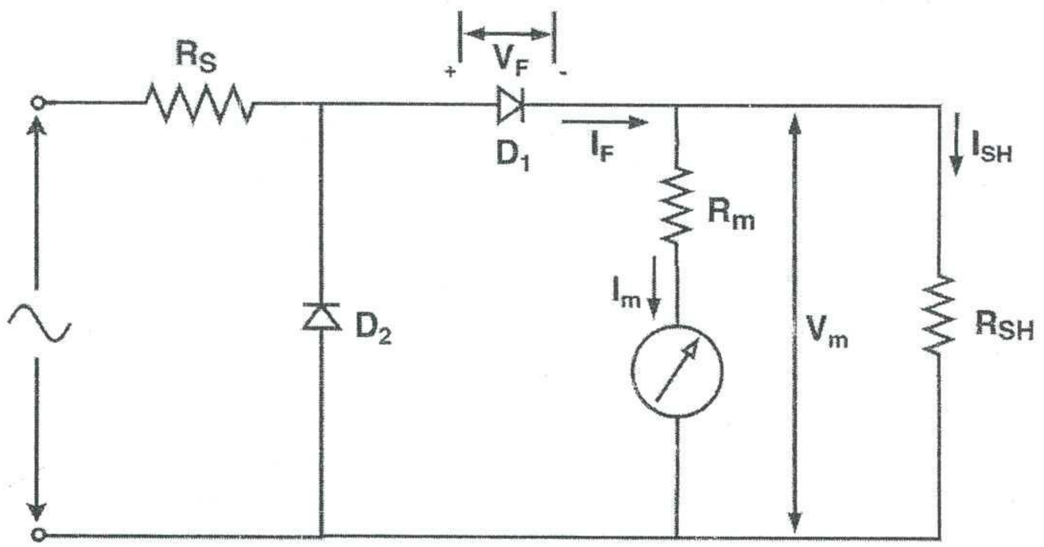

Figure Q1 c)

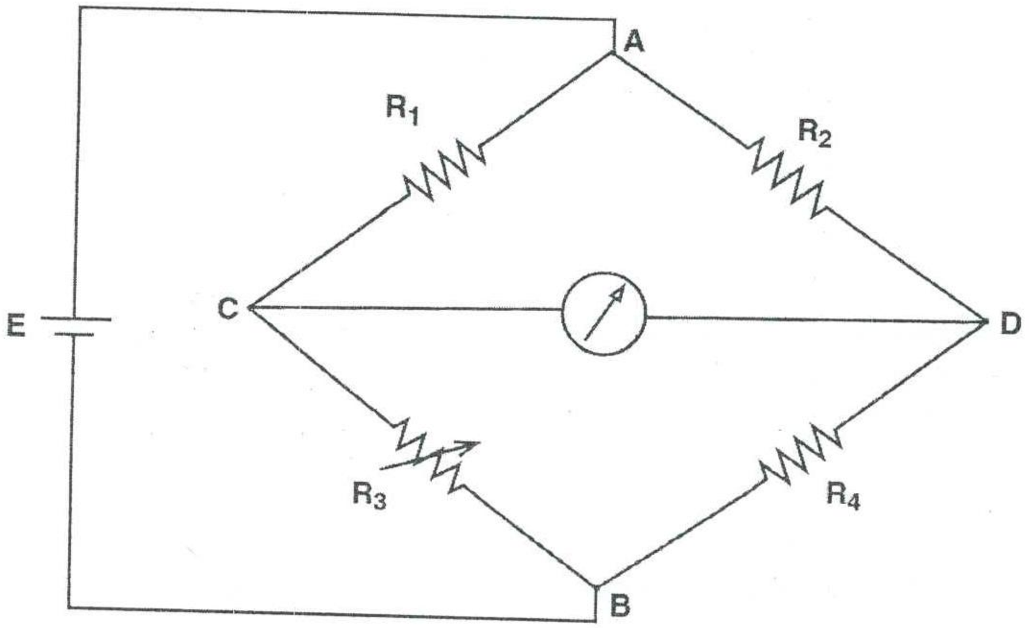

Figure Q2 a)

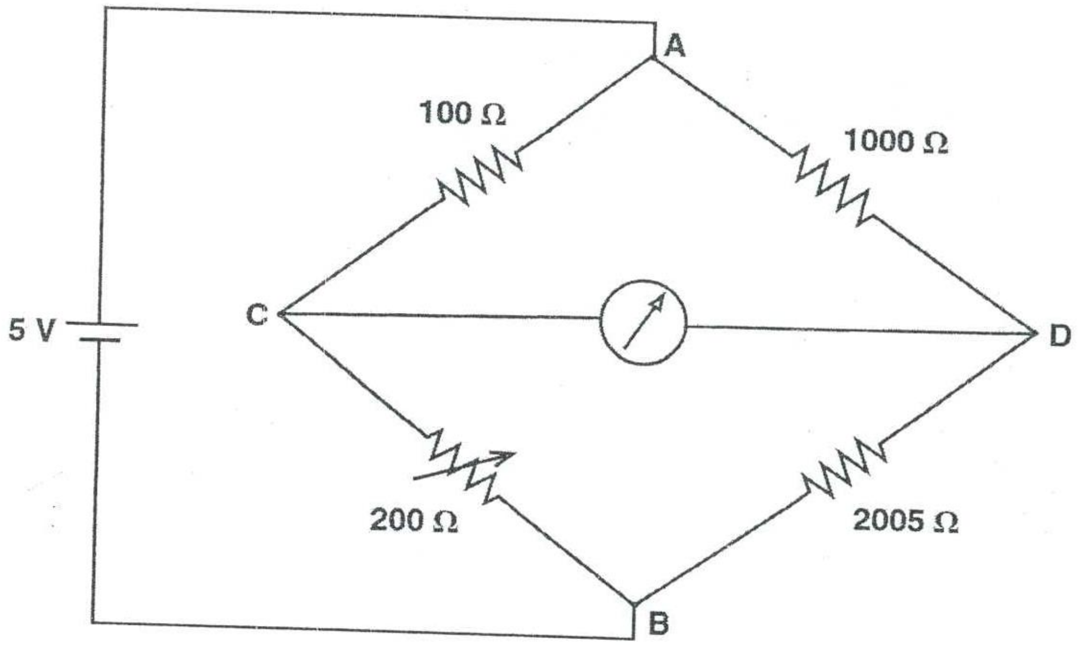

Figure Q2 b)

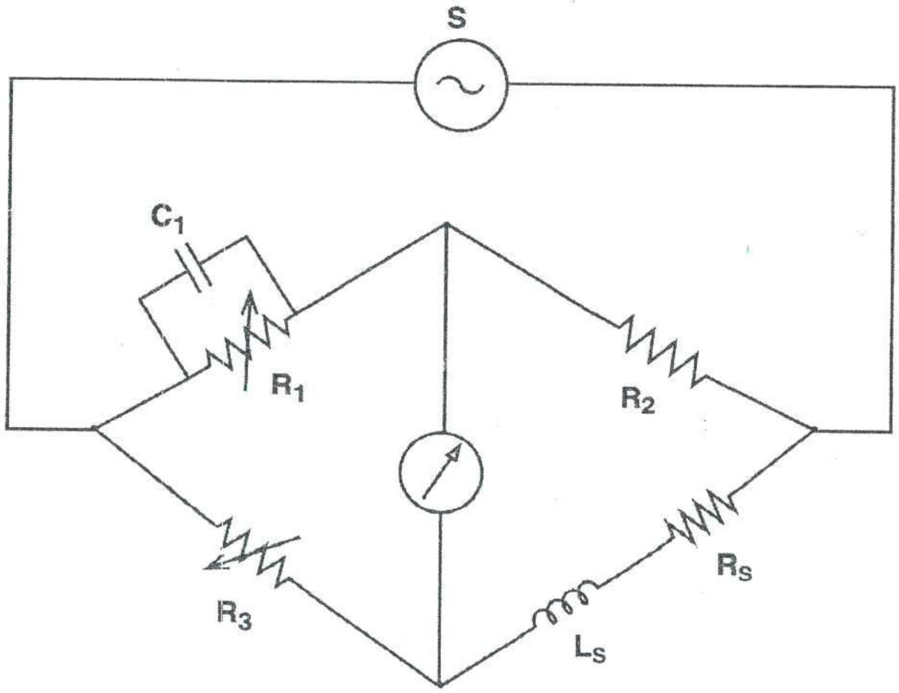

Figure Q2 c)

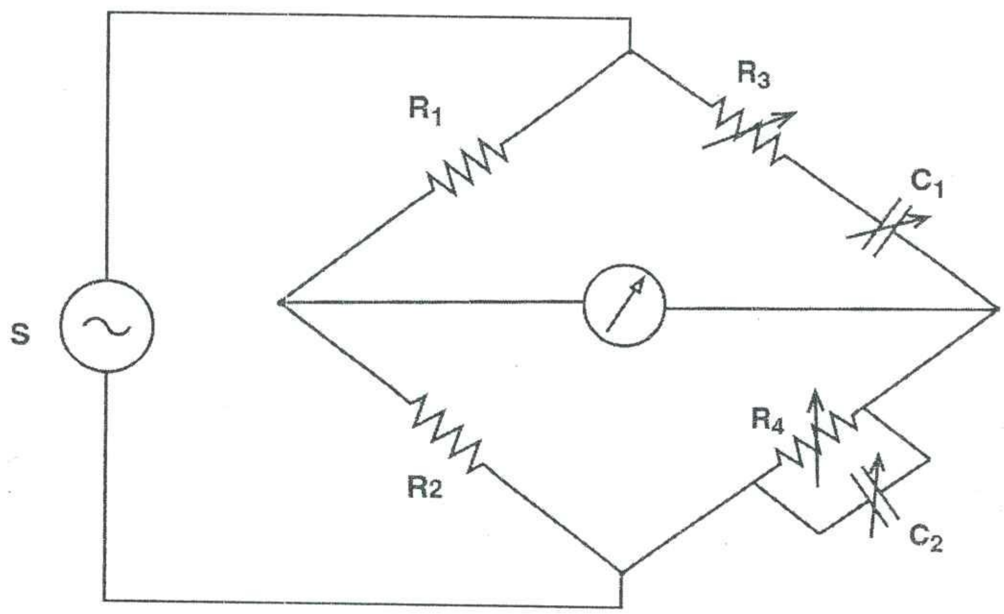

Figure Q4 a)