UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: October 2019

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

[Three Hours]

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

Q1 a) A stationary, Permanent Magnet Moving Coil (PMMC) is the basic deflection mechanism used in most analog measuring instruments. They are commonly called as D'Arsonval movement meters.

i) Briefly explain the construction, operation and dynamic behavior of the PMMC mechanism.

ii) Why do we build a radial magnetic field in D'Arsonval movement meter construction?

[2 Marks]

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

i) Sketch a circuit diagram to show how a PMMC is used to make a three-stage ammeter in simple arrangement.

ii) A PMMC instrument with Full Scale Deflection (*FSD*) of 1 mA and internal resistance of 50 Ω is to be used in 1 A, 5 A and 10 A ranges in the ammeter mentioned in part b) i). Determine the values of the required shunt resistors.

[3 Marks]

c) The rectifier based AC voltmeter shown in Figure Q1 c) uses a 1 mA *FSD* meter movement with an internal resistance of 100 Ω. The shunt resistance R_{sh} across the movement is 50 Ω. Diodes D_1 and D_2 each have forward resistance of 100 Ω, zero cut in voltage and infinite reverse resistance.

i) What is the function of the shunt resistance R_{sh} across the meter movement?

ii) What are the drawbacks, if the diode D_2 is disconnected from the circuit?

iii) Calculate the values of series resistances R_1, R_2 and R_3 if it is required the meter ranges to be 10 V, 50 V and 100 V.

[5 Marks]

Q2 a) i) Explain the function of the Wheatstone bridge.

ii) Figure Q2 a) shows a single-element varying active bridge in which an op-amp produces a forced null, by adding a voltage in series with the variable resistor $R+\Delta R$. Assuming an ideal op-amp, show that the amplifier output voltage V_{out} is given by,

$$V_{out} = -V_b\left[\frac{\Delta R}{2R}\right]$$

[4 Marks]

b) The balanced bridge shown in Figure Q2 b) has following parameters.

$R_1 = 5\ \Omega$ $R_2 = 10\ \Omega$ $R_a = 200\ \Omega$ $R_b = 0.2\ \Omega$

i) What is the main advantage of this bridge compared to the Wheatstone Bridge?

ii) Calculate the value of unknown resistance R_X.

[3 Marks]

c) i) Derive expressions to determine the unknown series resistance R_S, series inductance L_S and the quality factor Q for the AC bridge shown in Figure Q2 c).

ii) Given that, $R_1 = 470\ \Omega$, $R_2 = 1\ k\Omega$, $R_3 = 2.2\ k\Omega$ and $C_1 = 0.47\ \mu F$, determine the unknown impedance and its quality factor. The bridge is driven by a 3 kHz source.

[3 Marks]

Q3 a) Sketch the basic construction of the Cathode Ray Oscilloscope (CRO) and explain briefly the operation of following sections.

i) Triode Section
ii) Focusing Section
iii) Deflection Section

[3 Marks]

b) A 500 Hz sinusoidal wave with peak to peak amplitude of 100 V is first passed through a full wave rectifier and then applied to the vertical deflecting plates of a CRO. A 250 Hz sawtooth wave with peak to peak amplitude of 120 V is applied to the horizontal deflecting plates. The CRO has a vertical deflection sensitivity of 0.05 cm/V, and a horizontal deflection sensitivity of 0.1 cm/V. Assuming that the two inputs are synchronized, determine the waveform display on the screen.

[4 Marks]

c) A signal generator with signal amplitude of 1 V and source resistance of 1 kΩ is connected to an oscilloscope with an input resistance of 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 signal frequency is 50 Hz and the probe operates in 1:1 mode.

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

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

iv) Hence, show that 10:1 probe offers accurate measurements in a wide frequency range than 1:1 probe.

[3 Marks]

Q4 a) i) Draw the complete circuit diagram of the fundamental suppression harmonic distortion analyzer using the Wien bridge given in Figure Q4 a).

ii) Briefly describe the operation of the rejection amplifier.

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

iv) Given that $R_2 = 1\ k\Omega$, $R_3 = 1.5\ k\Omega$, $R_4 = 1.2\ k\Omega$ and $C_1 = 4.7\ \mu F$, calculate the required capacitance value C_2 to tune the bridge at 50 Hz and determine the value of the resistance R_1.

[6 Marks]

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

ii) Briefly explain the operation of the gate circuit in a frequency counter.

iii) What does it mean by "± Count Error" in conventional frequency counters?

[4 Marks]

Q5 a) Write short notes on the following under the performance characteristics of measuring instruments.

i) Static and Dynamic performance characteristics

ii) Accuracy and Precision

iii) Resolution

iv) Fidelity

[4 Marks]

b) A resistive network built up with equal resistors is shown in Figure Q5 b). Given that $R = 120\ \Omega \pm 5\%$, determine the equivalent resistance of the network and its relative error.

[3 Marks]

c) A resistor has a potential difference of 25 V across its terminals, when the current through it is 63 mA. The voltage is measured on a 30 V range analog instrument with an accuracy of ± 5% of full scale. The current is measured on a digital instrument with ± 1 mA accuracy. Calculate the value of the resistance and specify its accuracy.

[3 Marks]

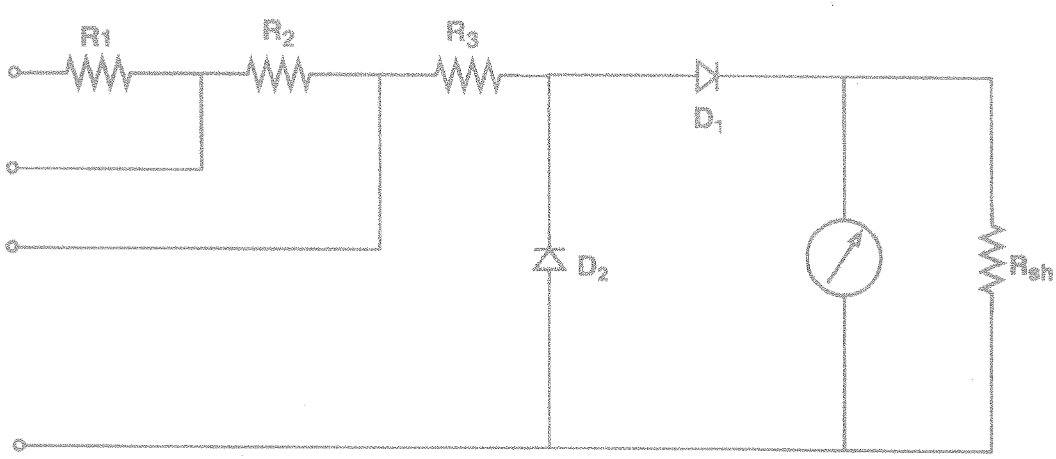

Figure Q1 c)

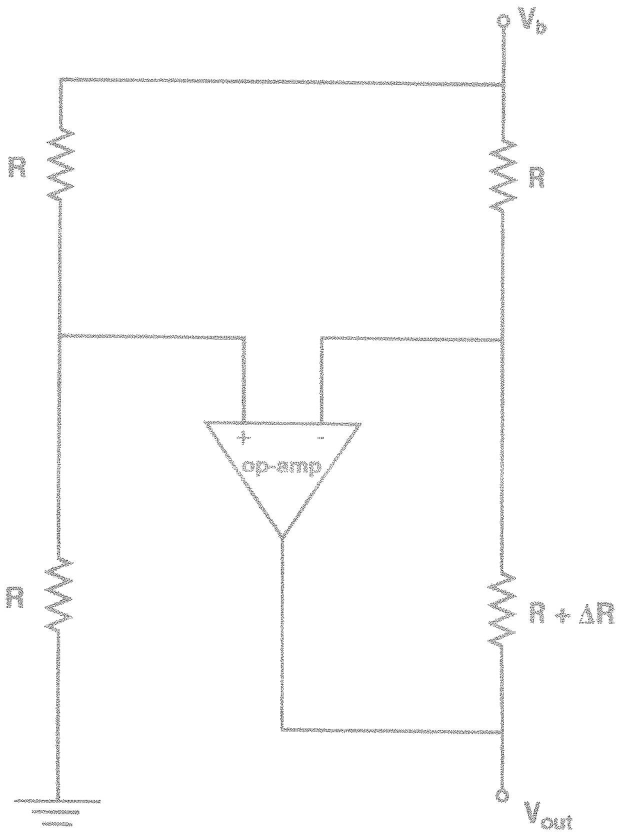

Figure Q2 a)

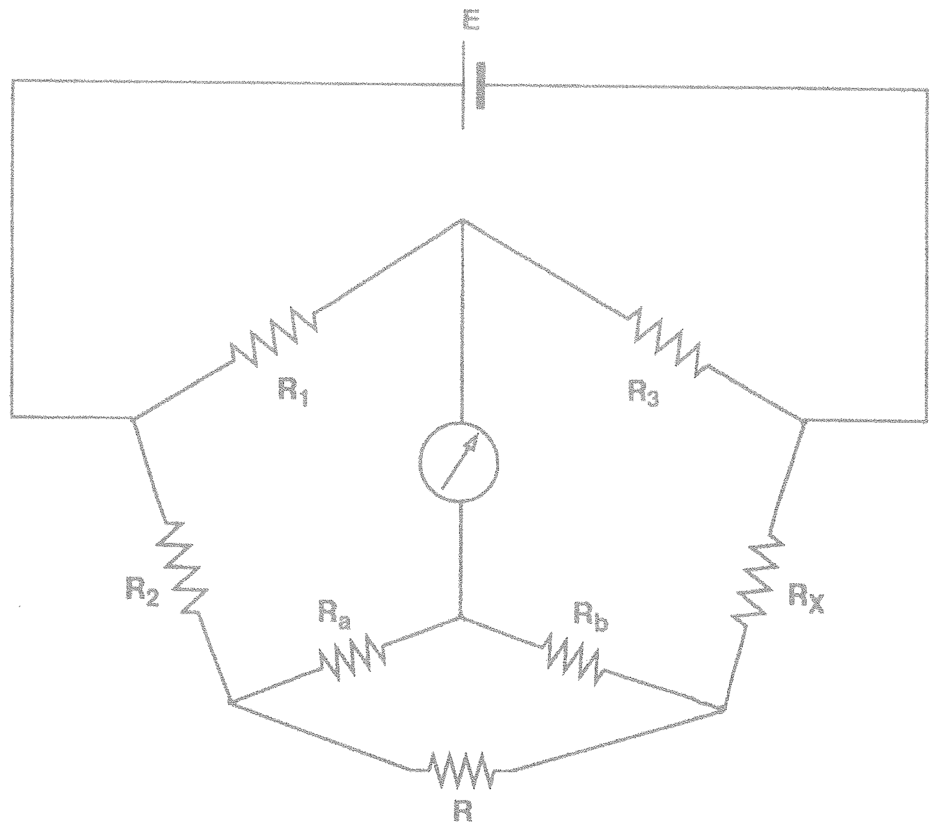

Figure Q2 b)

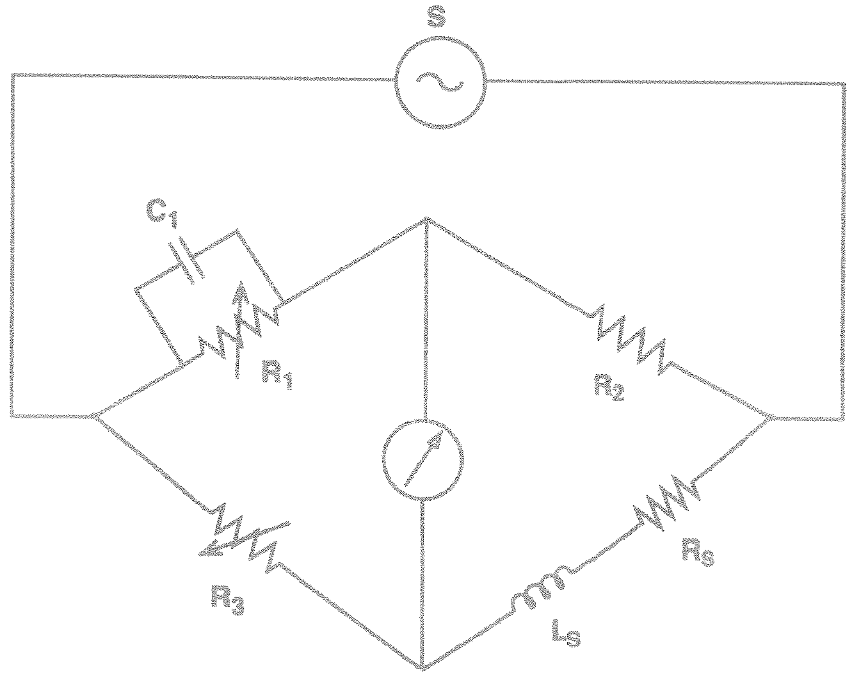

Figure Q2 c)

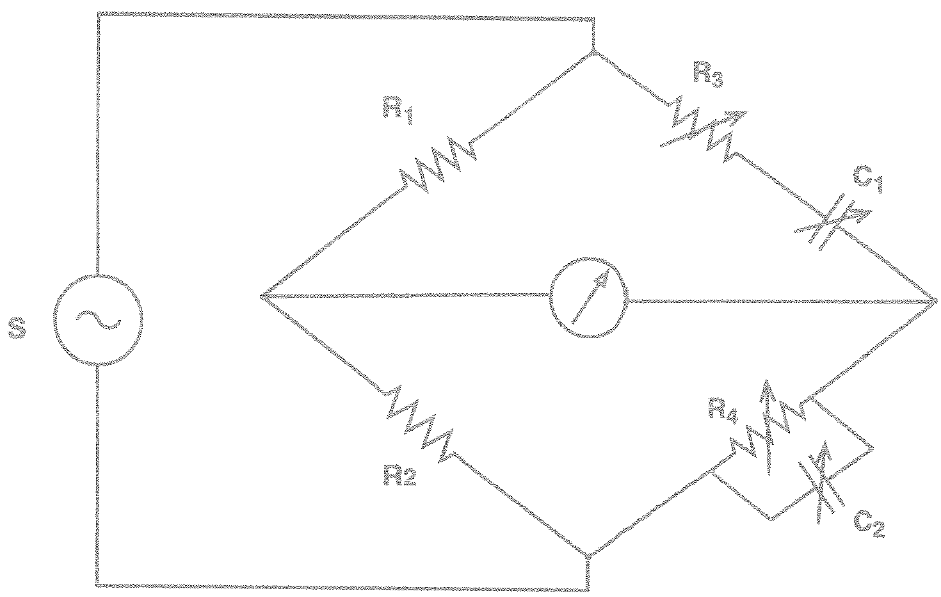

Figure Q4 a)

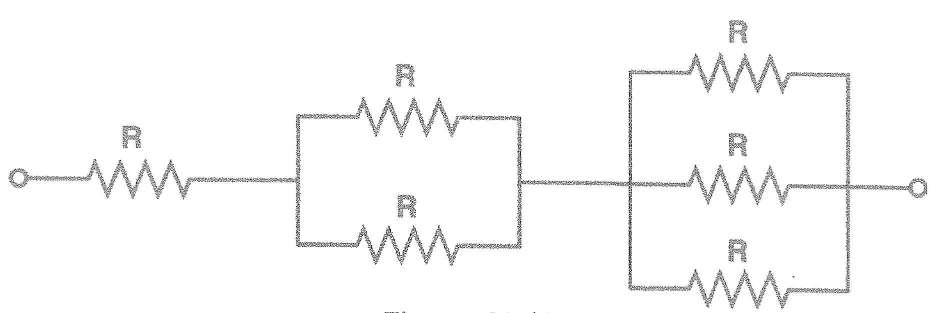

Figure Q5 b)