UNIVERSITY OF RUHUNA

Faculty of Engineering

End Semester 3 Examination in Engineering: March 2026

Module Number: EE3252 Module Name: Electrical and Electronic Measurements (C-18)

[3 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 D'Arsonval movement meters.

i) Briefly explain the construction and operation 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 a 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 Q1 b) i). Determine the values of the required shunt resistors.

[4 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.

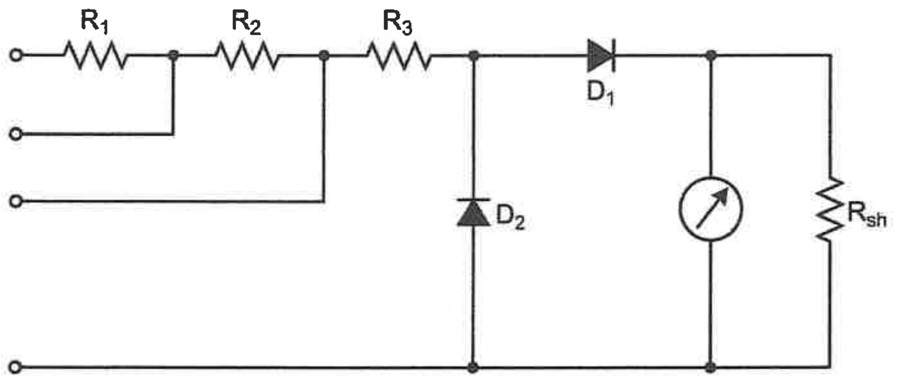

Figure Q1 c): The rectifier-based AC voltmeter.

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.

[4 Marks]

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

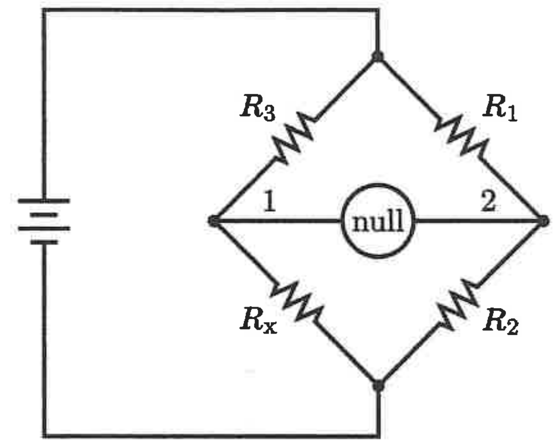

Figure Q2 a): Bridge circuit I.

ii) Derive an expression for an unknown resistance R_x in the bridge circuit in part Q2 a) i), assuming all other parameter values are known.

[3 Marks]

b) i) Identify the bridge circuit II shown in Figure Q2 b).

[1 Mark]

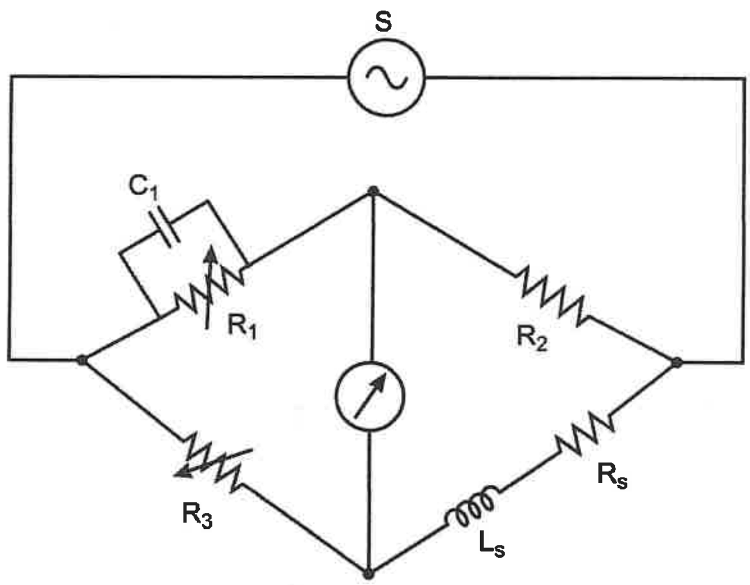

Figure Q2 b): Bridge circuit II.

ii) What does it mean by a quality factor (Q) of an inductor?

[1 Mark]

iii) 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 Q2 b) i).

[3 Marks]

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

[2 Marks]

Q3 a) An analog oscilloscope uses a sawtooth waveform for the horizontal sweep. Briefly explain the role of the following sections in an analog oscilloscope's sweep and trigger system.

i) Sweep generator (time base circuit).

ii) Trigger circuit.

[2 Marks]

b) Describe how a Digital Storage Oscilloscope (DSO) captures and stores a waveform. In your answer, include the role of the Analog-to-Digital Converter (ADC) and the concept of sampling rate.

[2 Marks]

c) Two sinusoidal signals of the same frequency are applied to the X and Y inputs of an oscilloscope operating in XY mode. Draw and describe the **Lissajous patterns** you would expect to observe for the following frequency ratios (X:Y): 1:1, 1:2, 1:3, 2:3.

[2 Marks]

d) i) A technician is measuring a 5 mV, 800 MHz signal from a sensitive RF circuit. Explain whether a passive probe or an active probe is more suitable for this measurement, justifying your answer with reference to bandwidth, input capacitance, and loading effect.

ii) Explain probe compensation in a **10X** passive probe and describe what happens to the displayed waveform when the probe is over-compensated and under-compensated.

[3 Marks]

e) Describe the operating principle of a **Superheterodyne Spectrum** Analyzer. In your answer, explain the function of the following components: Input Attenuator, Mixer, Local Oscillator, and IF Filter.

[1 Mark]

Q4 a) There are several types of frequency meters. Figure Q4 a) shows a block diagram of a digital frequency meter.

i) List down four main components (1 to 4) of the digital frequency meter shown in Figure Q4 a).

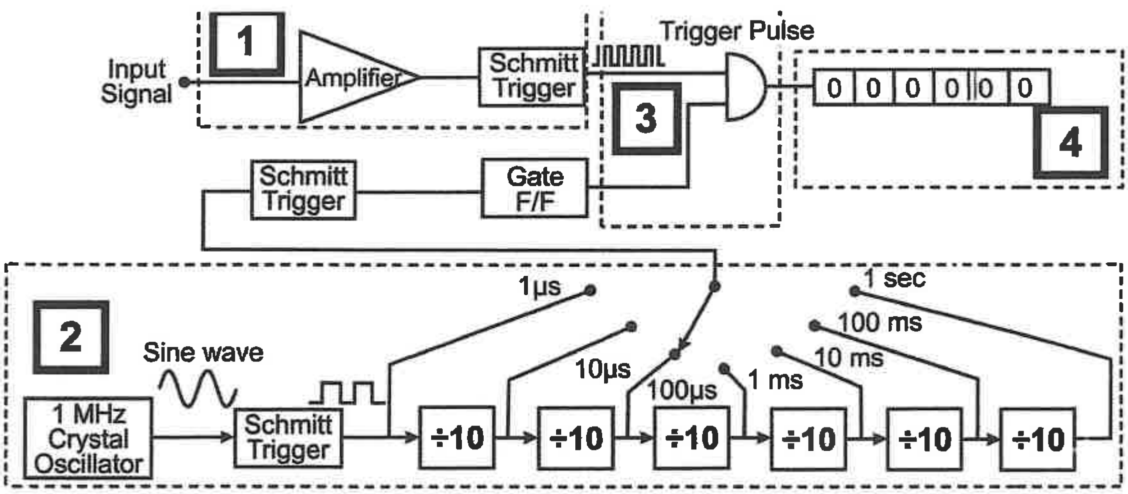

Figure Q4 a): Block diagram of a digital frequency meter.

ii) Write down two (2) advantages of a digital frequency meter.

[3 Marks]

b) Harmonic distortion analysis is an important aspect of electrical engineering that is used to identify and quantify the presence of harmonic distortion in electrical signals. An electronic instrument called a Harmonic Distortion Analyzer (HDA) is used for this purpose.

i) Sketch the block diagram of fundamental suppression HDA.

[1 Mark]

ii) Briefly explain the operation of HDA in part Q4 b) i).

[2 Marks]

iii) Define the term Total Harmonic Distortion (THD).

[1 Mark]

iv) A 1 kHz, 3.5 V sinusoidal input signal is applied to a circuit, resulting in a distorted output that is analyzed using a HDA as shown in Figure Q4 b). Using the spectral data provided in the graphical display, which illustrates the amplitudes of the fundamental frequency and its subsequent harmonics, calculate the THD for the output signal.

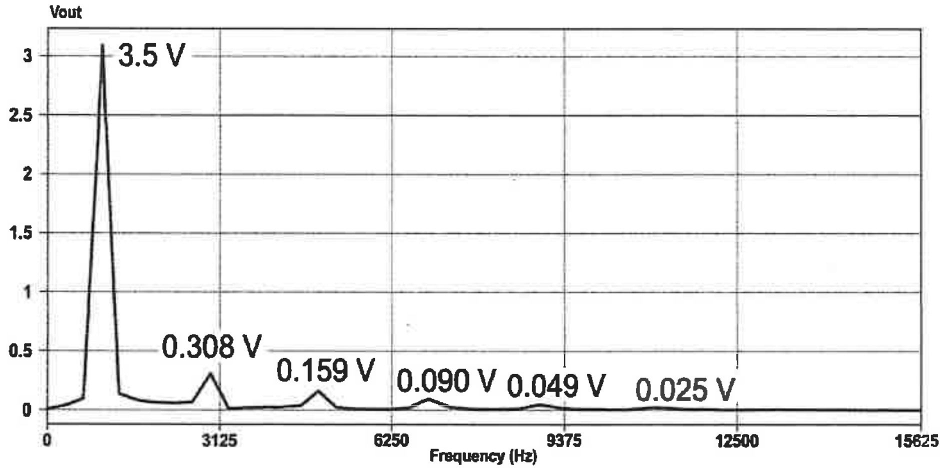

Figure Q4 b): Frequency spectrum of input signal voltage.

[3 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) Range and span

[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.

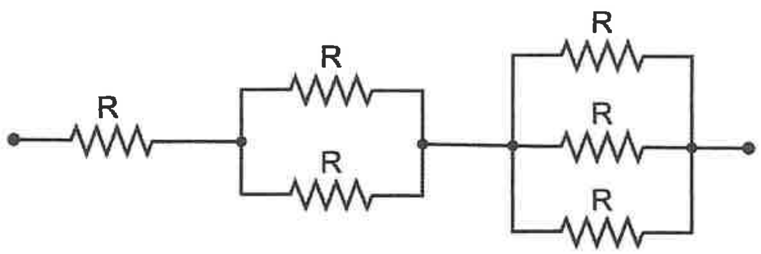

Figure Q5 b): A resistive network.

[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]