UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: February 2023

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

[Three Hours]

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

Q1 a) A moving-coil ammeter has a fixed shunt of 0.02 Ω. With a coil resistance of $R = 1000\ \Omega$ and a potential difference of 500 mV across it. Full-scale deflection is obtained.

i) To what shunted current does it correspond for 500 mV? [2 Marks]

ii) Calculate the value of R to give full-scale deflection when shunted current I is,

I 10 A [1 Mark]

II 75 A [1 Mark]

iii) Find out the value of R, at which 40% deflection obtained with I = 100 A. [2 Marks]

b) A basic D'arsonval movement with internal resistance, R_m = 100 Ω, and full scale current, I_{fsd} = 1 mA, is to be converted into a multirange DC voltmeter with voltage ranges of 0-10 V, 0-50 V, 0-250 V, and 0-500 V. The circuit arrangement is shown in Figure Q1. Compute the values of R_1, R_2 and R_3. [4 Marks]

Q2. a) i) Draw the general form of an AC bridge and derive the general equation for its balance. [2 Marks]

ii) Which type of bridge is used for measurement of frequency and capacitance? Explain in detail. [2 Marks]

b) Answer the following questions regarding Maxwell bridge

i) Explain how inductance can be measured by using a Maxwell bridge. [1 Mark]

ii) Draw the circuit diagram of Maxwell inductance capacitance bridge and derive the equation to determine its unknown quantities. [2 Marks]

iii) A Maxwell inductance capacitance bridge is used to measure inductance and impedance. The bridge constants at balance are $R_1 = 2235\,k\Omega$, $C_1 = 0.012\,\mu F$, $R_2 = 2.5\,k\Omega$ and $R_3 = 50\,k\Omega$. Find the series equivalent of the unknown impedance. [2 Marks]

iv) What are the advantages and disadvantages of Maxwell inductance capacitance bridge. [1 Mark]

Q3 a) Cathode Ray Oscilloscopes (CRO) are electronic instruments that are commonly used in the fields of electrical engineering, physics, and telecommunications to visualize and analyze various signals, such as voltage and current waveforms.

i) Name the key components of CRO and state the functions of each component. [2 Marks]

ii) Movement of an electron beam inside the CRO is shown in the Figure 3(a). The notations are as follows.

E_0 = Voltage of pre-accelerating anode in Volt.

e = charge of an electron in Coulomb.

m = mass of electron in Kg.

V_{ox} = velocity of the electron when entering into the deflecting plates in Meter per Second.

E_d = potential between deflecting plates in Volts.

d = distance between deflecting plate in the Meter.

t_d = length of deflecting plate in Meters.

L = Distance between screen and the mid of the deflecting plates.

D = Deflection of the electron beam on the screen in the Y direction.

Prove that the electron beam deflection on Y direction is,

$$D = \frac{eE_d t_d}{mdV_{ox}^2}\left(\frac{t_d}{2} + L\right).$$

[3 Marks]

b) A 2 V signal (V_s) with a source resistance $R_s = 500\ \Omega$ is connected via a 1: 1 probe to an oscilloscope which has an input impedance of $R_i = 0.5\ M\Omega$ in parallel with input capacitance $C_i = 100\,pF$. The capacitance of the coaxial cable is $C_{cc} = 200\,pF$. The signal frequency is 500 Hz.

i) Sketch the equivalent circuit with signal source, coaxial cable, and the connection with oscilloscope. [1 Mark]

ii) Calculate the signal voltage (V_i) at the oscilloscope terminals. [1 Mark]

iii) Determine the signal frequency if the probe that causes 3 dB reduction in the signal from the 500 Ω source. [1 Mark]

c) Spectrum analyzer is also an important tool in the field of electrical engineering, which is used to analyze and visualize the frequency spectrum of electrical signals. List out 4 advantages of spectrum analyzers.

[2 Marks]

Q4 a) There are several types of frequency meters. Figure 4(a) shows a block diagram of a digital frequency meter.

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

ii) Write down 4 advantages of digital frequency meter. [4 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 Harmonic distortion analyzer (HDA) is used for this purpose.

i) Sketch the block diagram of fundamental suppression HDA. [1 Mark]

ii) Explain the operation of HDA briefly with reference to b(i). [1 Mark]

iii) Define the term Total Harmonic Distortion (THD). [1 Mark]

iv) A 1 kHz, 3.5 V sine wave signal input is fed through a circuit and output is observed through a HDA which gives a graphical display of the amplitude of a few the harmonics as shown in Figure 4(b). Calculate the total harmonic distortion (THD) for the given distorted signal in Figure 4 (b). [3 Marks]

Q5 a) Knowledge of the performance characteristics of electrical and electronic instruments is extremely valuable for engineers in their professional work.

i) State the main two types of performance characteristics. [1 Mark]

ii) Explain the types briefly. [2 Marks]

b) A voltmeter has a sensitivity of 20 $k\Omega/V$ and a full-scale deflection current of 100 μA. The meter has an internal resistance of 1 $M\Omega$. The meter is used to measure the output voltage of a signal generator with an output impedance of 600 Ω. What is the error in the voltage measurement of the voltmeter once connected with the signal generator?

[4 Marks]

c) Figure 5 (c) shows a Wheatstone bridge circuit.

$R_1 = 200 \pm 0.25\% \ \Omega$

$R_2 = 1500 \pm 0.75\% \ \Omega$

$R_a = 400 \pm 0.5\% \ \Omega$

Find the unknown resistance R_x when the bridge is balanced.

[3 Marks]

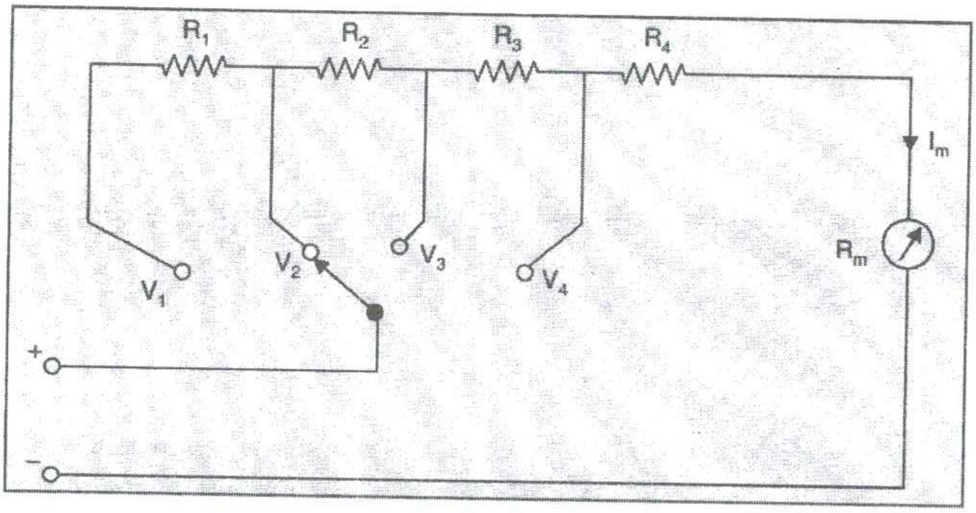

Figure Q1: Voltmeter

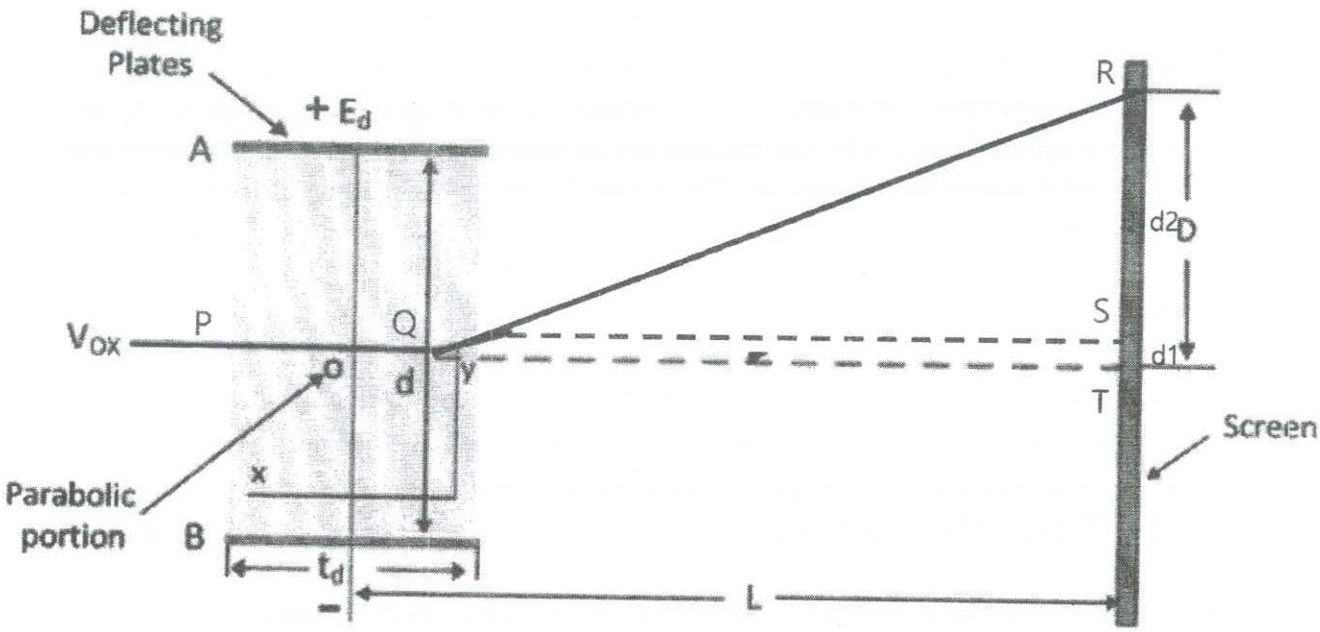

Figure 3(a): Movement of an Electron Beam inside the CRO

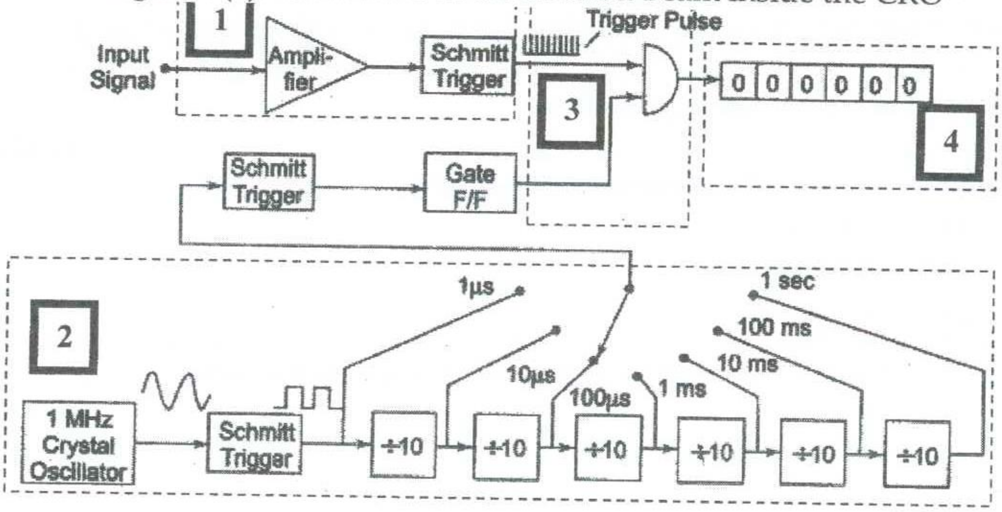

Figure 4 (a): Block Diagram of a Digital Frequency Meter

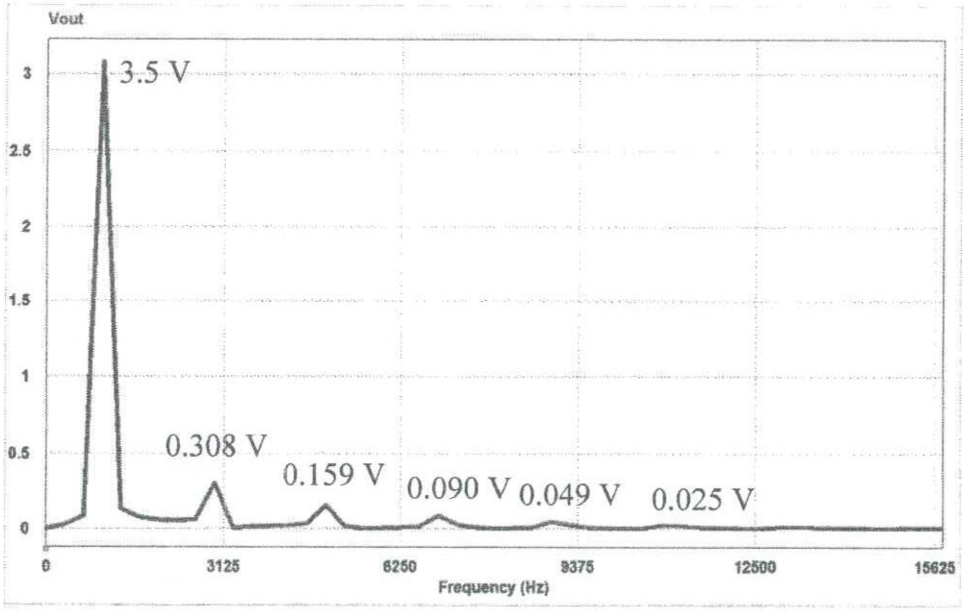

Figure 4 (b): Frequency spectrum of Signal Voltage

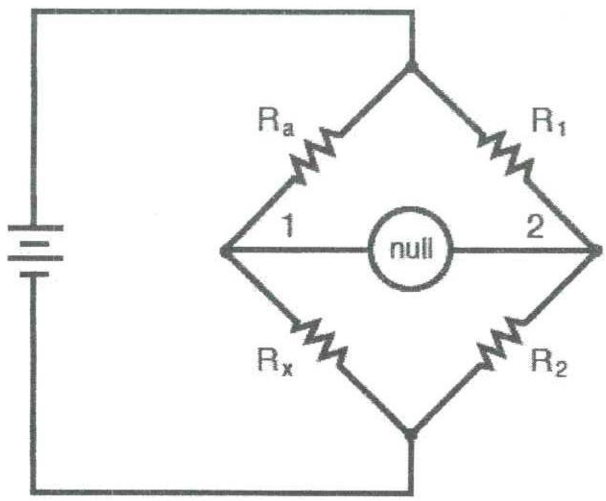

Figure 5(c): Wheatstone Bridge Circuit