SV

(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS 2022/2023 ACADEMIC YEAR

SECOND YEAR SECOND SEMESTER EXAMINATIONS

FOR THE DEGREE OF BACHELOR OF TECHNOLOGY EDUCATION IN ELECTRICAL AND ELECTRONIC ENGINEERING

COURSE CODE: TEE 221

COURSE TITLE: ELECTRICAL MEASUREMENTS

DATE : 14TH APRIL 2023 **TIME: 12:00 NOON - 2:00 PM**

INSTRUCTIONS TO CANDIDATES

ANSWER QUESTION ONE AND ANY OTHER TWO QUESTIONS.
QUESTION ONE CARRIES 30 MARKS AND ALL OTHERS 20 MARKS EACH.

TIME: 2 Hours

MMUST observes ZERO tolerance to examination cheating

This Paper Consists of 4 Printed Pages. Please Turn Over.

Question 1 (30mks)

(a) *i)* List FIVE criteria for choosing the most suitable measuring instrument for a given application. [5mks]

ii) Defind the following terms with regards to instruments: [5mks]

i) Calibration

ii) Traceabilility

iii) Mesurand

iv) Sensor

v) Calibration chain

(b) A Rotary Variable Differential Transformer (RVDT) has the following data sheet information: [3mks]

Ranges:

$\pm 30°$ linearity error $\pm 0.5\%$ full range

$\pm 60°$ linearity error $\pm 2\%$ full range

Sensitivity: 1.1 $(mV/V\ input)$/deg

Impedance: primary 750Ω , secondary 2000Ω

Input voltage: 3V

For an angular displacement input of 40°, determine:

i) the error due to non-linearity [2mks]

ii) the output voltage reading [1mk]

(c) The bridge of Fig. 1 has the following components:

Arm AB:Unknown inductance L_1 with resistance R_1

Arm BC: $R2 = 200\Omega$; Arm CD: $R3 = 100\Omega$

Bridge balance is obtained when $L_4 = 50mH$ and $R_4 = 2\Omega$

i) Derive the equations for the unkown values L_1, and R_1 [4mks]

ii) Determine L_1, R_1 and Q factor for $f = 50\ Hz$. [3mks]

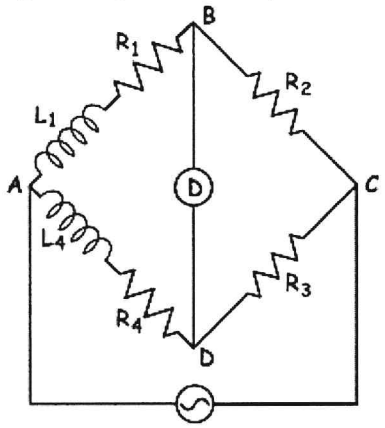


Fig. 1

(d) State the function of the following parts of a cathode ray oscilloscope: [4mks]

i) Cathode ray tube

ii) Trigger Circuit

iii) Time Base Generator

iv) Aquadag coating

(e) A voltmeter having a sensitivity of $1k\Omega/V$ reads 100V on its 150V scale when connected across an unknown resistor R_X in series with a milli-ammeter as shown in Fig. 2. Determine the value of R_X (in $k\Omega$) when the milli-ammeter reads 5mA. [5mks]

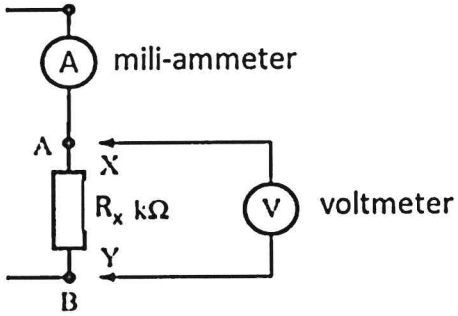


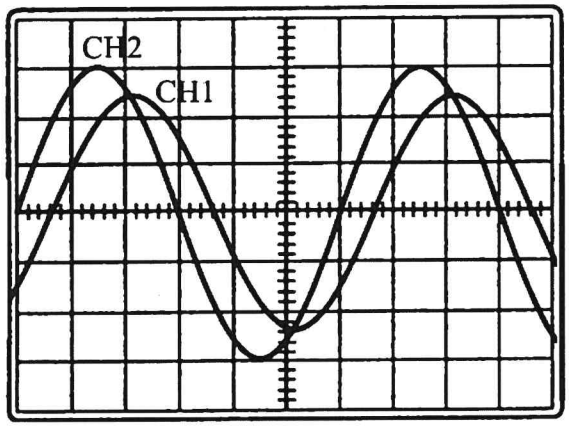
Fig. 2

Question 2 [20mks]

(a) Explain how a cathode ray oscilloscope (CRO) can be used to determine the dc voltage, rms voltage, current, phase difference and frequency of an ac signal. [8mks]

(b) State FOUR differences between dual trace and dual beam oscilloscopes. [4mks]

(c) The Fig. 3 shows the waveforms of a dual channel CRO with vertical sensitivity and timebase settings.



Vertical sensitivity:
$V_1: CH1 = 2V/div$
$V_2: CH2 = 5V/div$

Timebase setting:
$5ms/div$

Fig. 3

i) Determine the period and frequency of V_1 and V_2 [2mks]

ii) The peak to peak value of V_1 and V_2 [2mks]

iii) The rms value of V_1 and V_2 [2mks]

iv) The phase angle of V_1 relative to $\mathbf{V_2}$ [2mks]

Question 3 (20mks)

(a) With the aid of a circuit diagram, explain how Eddy current sensors can detect variations in thickness of a moving aluminium sheet. [6mks]

(b) Four Piezoelectric crystals of charge sensitivity = 2pC/N, area = $1cm^2$, 0.1 cm thickness and relative permittivity of 5, arranged in parallel under a platform and subjected to a force of 24N. Two metal electrodes measure changes in voltage in each crystal. Young's modulus of the crystal material is $E = 9 \times 10^{10} Pa$, and $\varepsilon_0 = 8.85 \times 10^{-12} F/m$

i) the voltage across the electrodes [3mks]

ii) the change in crystal thickness [4mks]

(c) A series circuit of Fig. 4 is connected to a 250V dc source. If R2 is measured by voltmeters A and B having sensitivities of $500\Omega/V$ and $10k\Omega/V$ respectively. If both meters are used on the 150V range, determine the percentage error for each voltage measurement. [7mks]

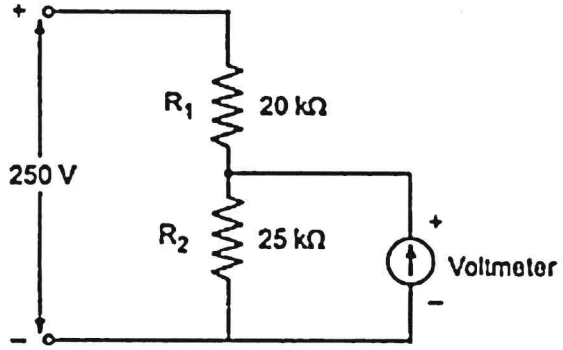


Fig. 4

Question 4 (20mks)

(a) With the aid of a well labelled block diagram, describe how current, voltage and resistance measurements can be obtained with a digital multimeter. [8mks]

(b) An R-L-C series circuit is tuned using a Q-meter. The oscillator frequency is $500kHz$, shunt resistance is 0.5Ω, and variable capacitor set to $350pF$.If the Q-value is 90, Calculate: [4mks]

i) Effective inductance

ii) Coil resistance at resonance

(c) Briefly describe with illustrations how Lissajous patterns can be used to determine the phase difference between two progressive waves. [8mks]

Question 5 (20mks)

(a) The circuit in Fig. 5 is used to determine the inductance of the choke coil L_1, R_1 . When the bridge is fed from a source of 500Hz, balance is obtained under the following conditions:
$R_2 = 2410\Omega\ R_3 = 750\Omega\ C_4 = 0.35\mu F, R_4 = 64.5\Omega$

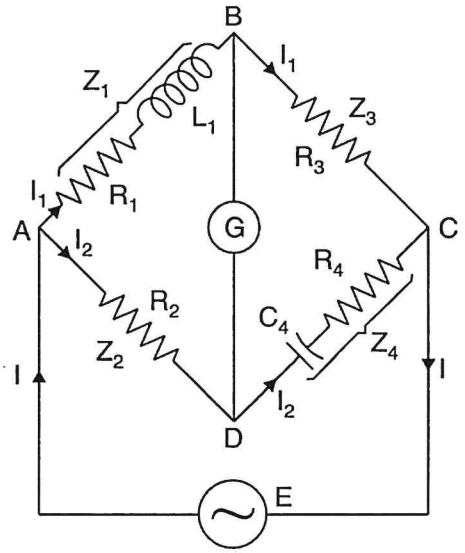


Fig. 5

i) Derive the equations for the choke coil at balance conditions. [5mks]

ii) Calculate the resistance and inductance of the choke coil. [3mks]

(b) The specifications of a strain gauge bonded load cell are given as:

Modulus of elasticity (E)	$E = 120Mpa$
Load cell diameter	$3.5cm$
Strain gauge nominal resistance	600Ω
Gauge factor	$G = 3$
Bridge voltage supply	$V_s = 6V\ dc$

The strain gauge is aligned in the direction of tension and connected into a wheatstone bridge whose other arms have equal resistance of 300Ω. A galvanometer with current sensitivity of $5mm/\mu A$ and an internal resistance of 500Ω gives an offset of $3mV$. If the load cell is subjected to a compressive axial force, determine the following:

i) Percentage change in gauge resistance due to the applied force [4mks]

ii) The magnitude of the applied force on the load cell [4mks]

iii) Galvanometer deflection [4mks]