QN1 [30mks]

(a) i) State and explain the principle of operation of the following transducers: [4mks]

i) Strain gauge loadcell

ii) Linear Potentiometer

iii) Eddy current sensor

iv) Thermocouple

ii) Explain the following types of errors in measurements and provide ONE technique of averting the errors in each category.

i) Systematic errors [2mks]

ii) random errors [2mks]

iii) Gross errors [2mks]

(b) A strain gauge bonded load cell has a Young's modulus $E = 2 \times 10^{11} N/m^2$ and cross-section of $15cm^2$. The strain gauge of gauge factor $G = 2.5$ and nominal resistance $R_0 = 300\Omega$ is aligned in the direction of tension and connected into a wheatstone bridge whose other arms have equal resistance of 300Ω, and supply voltage $V_s = 10V\ dc$. If the output voltage is $3mV$, determine the following:

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

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

(c) With the aid of a well labelled circuit diagram, describe how a LVDT transducer can be used to measure changes in displacement. [6mks]

(d) Consider the circuit of Fig. 1.

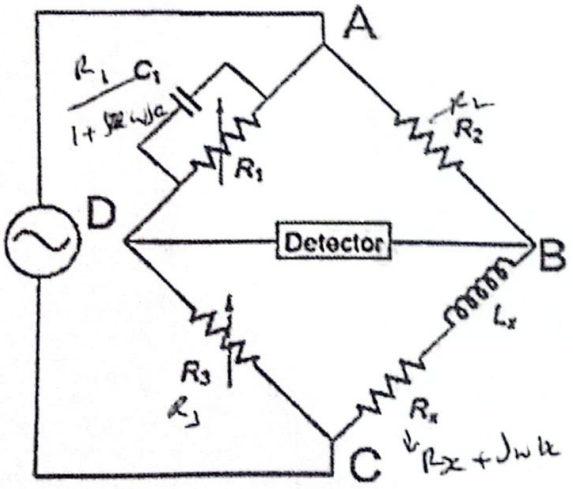

Fig. 1

i) Derive the equations for R_x *and* L_x under balanced conditions [4mks]

ii) If the bridge parameters at balanced conditions are: [2mks]

$C_1 = 0.01\mu F, R_1 = 470k\Omega, R_2 = 5.1k\Omega, R_3 = 100k\Omega$, determine the values R_x *and* L_x.

QN 2 [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) A Piezoelectric crystal of charge sensitivity = 2pC/N, area = $1cm^2$, thickness $t = 0.1$ cm and $\varepsilon_r = 5$, is subjected to a force of 5N. Two metal electrodes measure changes in voltage in the crystal. Take $E = 9 \times 10^{10} Pa$, and $\varepsilon_0 = 8.85 \times 10^{-12}\ F/m$. Calculate:

i) the voltage across the electrodes [3mks]

ii) the change in crystal thickness [4mks]

(c) A series circuit of Fig. 2 is connected to a 250V dc source. Resistor R_2 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]

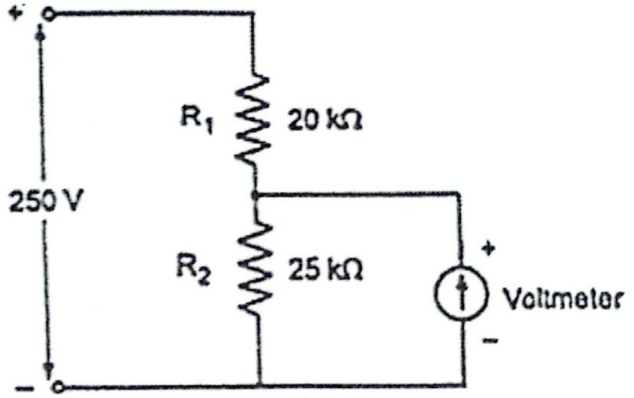

Fig. 2

QN 3 [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.

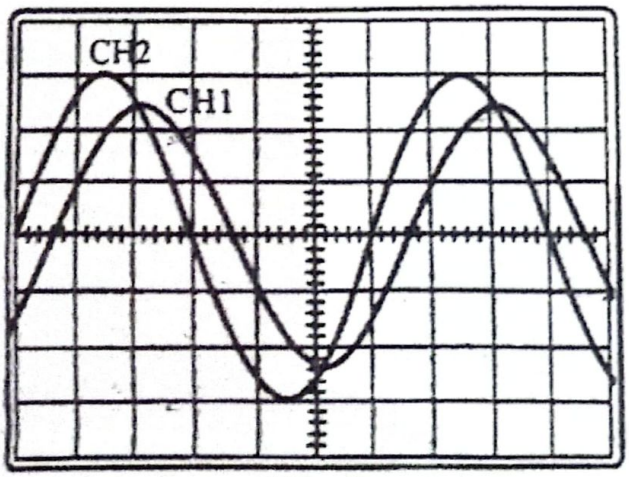

Fig. 3

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

Timebase setting:
$5ms/div$

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 V_2 [2mks]

QN 4 [20mks]

(a) With the aid of a circuit diagram, explain how the Q-meter measures the quality factor of an unknown coil at radio frequencies. [6mks

(b) The bridge of **Fig. 4** 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

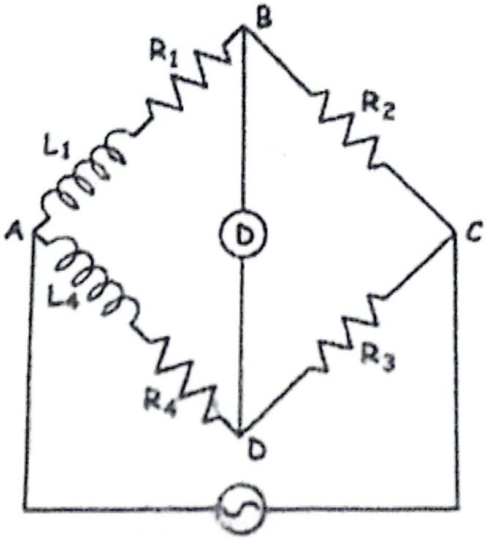

Fig. 4

(c) With the aid of a circuit diagram, describe how digital multimeters are used in measurement of d.c. and a.c. voltages, currents and resistance. [7m

QN 5 (20mks)

(a) *i)* State FIVE differences between active matrix and passive matrix displays [5mk

ii) Describe with the aid of diagrams how a 5 × 7 dot matrix type of LED display can be used to display any three characters of the alphabet. [7mk

iii) Briefly explain the working principle of plasma displays [2mk

(b) A coil of resistance 10Ω is connected in the Q-meter circuit. Resonance occurs at a frequency of 1MHz with the tuning capacitor set to $45pF$. Calculate the percentage error introduced in the calculated Q-value if a shunt resistance of 0.02Ω is used to stabilize the input voltage. [6mk