Q.2   a.   Differentiate between the direct and indirect method of measurement.
Answer:
There are two methods of measurement: 1) direct comparison with the standard, and 2) indirect comparison with the standard. Both the methods are discussed below:

1) Direct Comparison with the Standard

In the direct comparison method of measurement, we compare the quantity directly with the primary or secondary standard. Say for instance, if we have to measure the length of the bar, we will measure it with the help of the measuring tape or scale that acts as the secondary standard. Here we are comparing the quantity to be measured directly with the standard.

Even if you make the comparison directly with the secondary standard, it is not necessary for you to know the primary standard. The primary standards are the original standards made from certain standard values or formulas. The secondary standards are made from the primary standards, but most of the times we use secondary standards for comparison since it is not always feasible to use the primary standards from accuracy, reliability and cost point of view. There is no difference in the measured value of the quantity whether one is using the direct method by comparing with primary or secondary standard. The direct comparison method of measurement is not always accurate

2) Indirect Method of Measurement

There are number of quantities that cannot be measured directly by using some instrument. For instance we cannot measure the strain in the bar due to applied force directly. We may have to record the temperature and pressure in the deep depths of the ground or in some far off remote places. In such cases indirect methods of measurements are used.

The indirect method of measurements comprises of the system that senses, converts, and finally presents an analogues output in the form of a displacement or chart. This analogues output can be in various forms and often it is necessary to amplify it to read it accurately and make the accurate reading of the quantity to be measured. The majority of the transducers convert mechanical input into analogues electrical output for processing, though there are transducers that convert mechanical input into analogues mechanical output that is measured easily.

   b.   Define limiting errors. A 0-10A ammeter has an accuracy of 1.5% of full scale reading. The current indicated by the ammeter is 2.5 A. Calculate the limiting values of current and percentage limiting error.

Answer:

$$\delta A = \pm\ 1.5\ \%\ of\ full\ scale\ reading$$

$$= \pm \frac{1.5}{100} \times 10$$

$$= \pm\ 0.15\ A$$

Hence the limiting values of current are,

$$I = 2.5 \pm 0.15\ A = 2.35\ A,\ 2.65\ A$$

The percentage limiting error is,

$$\%\ e = \frac{\delta A}{A_S} \times 100 = \frac{0.15}{2.5} \times 100$$

$$= 6\ \%$$

Q.3   a.   A Kelvin's bridge is shown in Fig.1 below, the ratio of R_a to R_b is 1200 ohms R_1=10 ohms and R_1=0.5R_2. Calculate unknown resistance R_x.
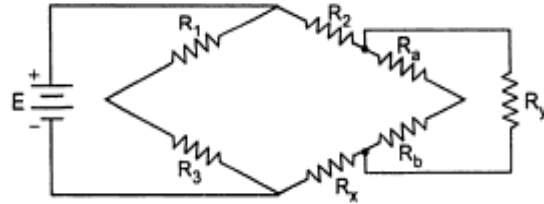

Fig.1

Answer:

$$\frac{R_x}{R_2} = \frac{R_3}{R_1}$$

For Kelvin's double bridge,

$$\frac{R_3}{R_1} = \text{ratio of resistances of ratio arms}$$

and

$$\frac{R_b}{R_a} = \text{ratio of resistances of second ratio arms}$$

$\therefore$

$$\frac{R_3}{R_1} = \frac{R_b}{R_a}$$

$\therefore$

$$\frac{R_x}{R_2} = \frac{R_b}{R_a} = \frac{1}{1200}$$

Now

$$R_1 = 10\,\Omega$$
$$R_1 = 0.5R_2$$

$\therefore$

$$R_2 = \frac{R_1}{0.5} = \frac{10}{0.5}$$
$$= 20\,\Omega$$

$\therefore$

$$\frac{R_x}{20} = \frac{1}{1200}$$

$\therefore$

$$R_x = \frac{20}{1200} = 0.0167\,\Omega$$

     b. An ac bridge has the following constants in Fig.2.

     Arm AB – capacitor of 0.5 µF in parallel with 1kΩ resistance

     Arm AD – resistance of 2kΩ

     Arm BC – capacitor of 0.5 µF

     Arm CD – unknown capacitor C_X and R_X in series

     Frequency – 1 kHz

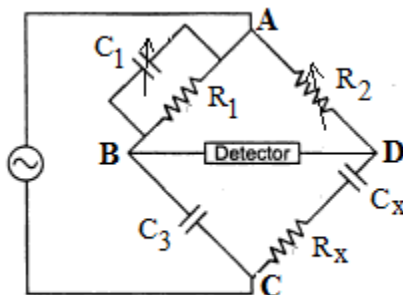   Determine the unknown capacitance and dissipation factor.

Fig.2

Answer:

$$\therefore \quad Y_1 = \frac{1}{R_1} + j\omega C_1$$

$$= \frac{1}{600} + j\left(2\pi \times 1000 \times 1 \times 10^{-6}\right)$$

$$= 1.66 \times 10^{-3} + j\,6.283 \times 10^{-3}$$

$$Z_2 = 100\,\Omega$$

$$Z_3 = 1000\,\Omega$$

$$Z_4 = R_x + j\,X_L = Z_x$$

From the basic balance equation,

$$Z_1 Z_4 = Z_2 Z_3$$

$$\therefore \quad Z_4 = \frac{Z_2 Z_3}{Z_1} = Z_2 Z_3 Y_1$$

$$= 100 \times 1000 \times [1.66 \times 10^{-3} + j\,6.283 \times 10^{-3}]$$

$$= 166 + j\,628.3\,\Omega$$

$$= R_x + j\,X_L\,\Omega$$

$$\therefore \quad R_x = 166\,\Omega$$

$$\therefore \quad X_L = 628.3 = 2\pi f\,L_x$$

$$\therefore \quad L_x = \frac{628.3}{2\pi \times 1000}$$

$$= 0.099\,H$$

Q.4   a. Convert a basic D'Arsonval movement with an internal resistance of 100 ohm and full scale deflection of 10mA into a multirange dc voltmeter with ranges from 0-5V,0-50V,0-100V.
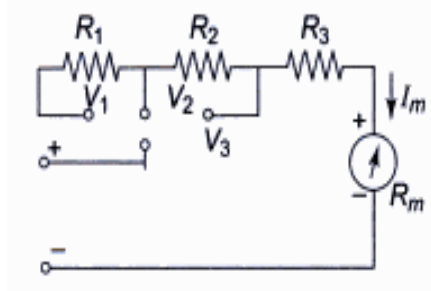

Fig.3

Answer:

Solution   Given $I_m = 10$ mA, $R_m = 100$ Ω

Step 1: For a 5 V (V_3) the total circuit resistance is

$$R_t = \frac{V}{I_{fsd}} = \frac{5}{10 \text{ mA}} = 0.5 \text{ k}\Omega$$

Therefore $R_3 = R_t - R_m = 500$ Ω $- 100$ Ω
$$= 400 \text{ }\Omega$$

Step 2: For a 50 V (V_2) position

$$R_t = \frac{V}{I_{fsd}} = \frac{50}{10 \text{ mA}} = 5 \text{ k}\Omega$$

Therefore $R_2 = R_t - (R_3 + R_m) = 5$ kΩ $- (400$ Ω $+ 100$ Ω $)$
$$= 5 \text{ k}\Omega - 500 \text{ }\Omega = 4.5 \text{ K}\Omega$$

Step 3: For a 100 V range (V_1) position

$$R_t = \frac{V}{I_{fsd}} = \frac{100}{10 \text{ mA}} = 10 \text{ k}\Omega$$

Therefore $R_1 = R_t - (R_2 + R_3 + R_m) = 10$ kΩ $- (4.5$ kΩ $+ 400$ Ω $+ 100$ Ω $)$
$$= 10 \text{ k}\Omega - 5 \text{ }\Omega = 5 \text{ k}\Omega$$

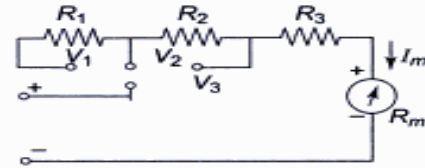Hence it can be seen that R_3 has a non-standard value.

Fig. 4.3(a)

   b. Explain with the diagram solid state voltmeter using Op-Amp.
Answer: Page Number 87 of Text Book II

Q.5   a. Explain with the help of a neat diagram the working of a Universal
         Counter for measurement of frequency and time period.
Answer:

Universal Counter

The universal counter is a counter which can measure time period and frequency in one circuit itself. Various circuits for the time measurement, frequency measurement, ratio measurement etc. are connected to form one single generalized block which is known as the universal counter. The block schematic of universal counter is as shown in the Fig

Block diagram of universal counter-timer
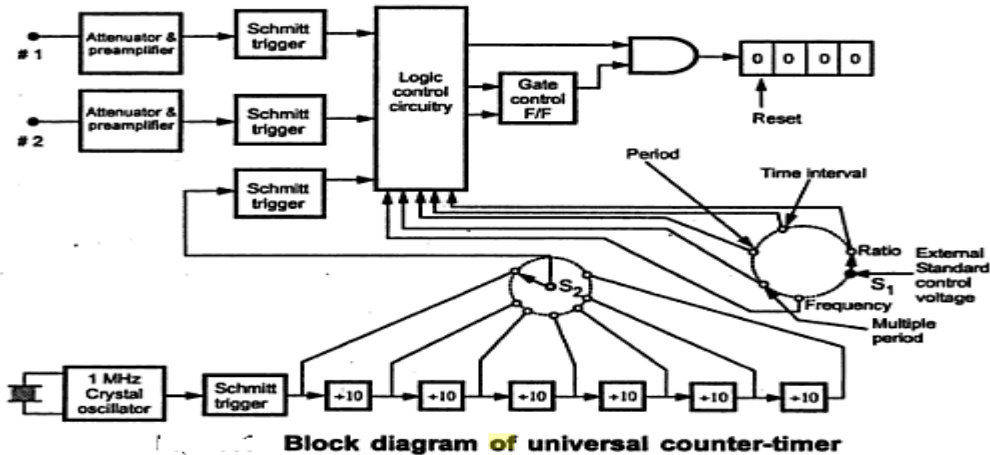
The selection of measurement mode is done by properly selecting front panel switch. This switch is known as function switch. As shown in the block diagram time period measurement, frequency measurement, ratio measurement, time interval measurement is possible using the function switch. According to the mode of measurement selected, the particular circuitry in the universal counter is selected. This circuitry is known as logic gate circuitry.

Consider that the function switch is in the frequency mode. The control voltage is applied to the specific logic gate circuitry. Then input signal gets connected to the counted signal channel of the main gate. At the same time, the selected output from time base dividers is gated to the gate control flip-flop. Accordingly the main gate gets enabled or disabled. The logic circuitry allows all this to operate in proper way.

The functioning of all the blocks in the universal counter is same as those are used in various measurement block diagrams. The logic gate circuitry is the main part in the universal counter circuit. Because it connects the particular input to the main gate according to the mode of measurement selected and ensures the complete operation in proper sequence.

   b. Draw the labelled circuit diagram and explain working of a Q-meter. Write its applications.

Answer:
The principle of operation of the Q meter is based on the series resonant LC circuit. At resonance, if the circuit is efficient, the inductive and capacitive reactances are equal but of opposite sign, and very much larger than the loss resistance. Because of their opposite phases, the voltages across the inductor and capacitor cancel, leaving the applied voltage to appear across the loss resistance. This establishes the current which flows around the circuit, generating much larger voltages across the capacitor and inductor than across the loss resistor, and the circuit thus exhibits a voltage gain .If the losses are reduced, the voltage gain and selectivity of the circuit will further improve. This brings us to the best definition of Q, and explains how the Q meter works:
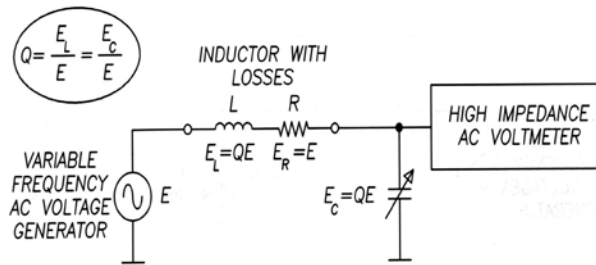
Q METER SERIES CIRCUIT AT RESONANCE

This also is how a crystal set works. A very small AC voltage from the aerial is selected and magnified by the tuned circuit, appearing much enlarged across the tuning capacitor where it is rectified and applied to headphones. As the diagram shows, we measure it using a calibrated wide range RF signal generator (to generate the input voltage E) and a high impedance AC voltmeter to measure the voltage across the tuning capacitor. If E is known and fixed then we can calibrate the AC voltmeter directly in terms of Q.

Q.6   a. Describe with the help of a neat block diagram the operation of an AF Sine wave generator.

Answer:

SW1 : Function selector switch
A1 : Sine wave amplifier
A2 : Square wave amplifier
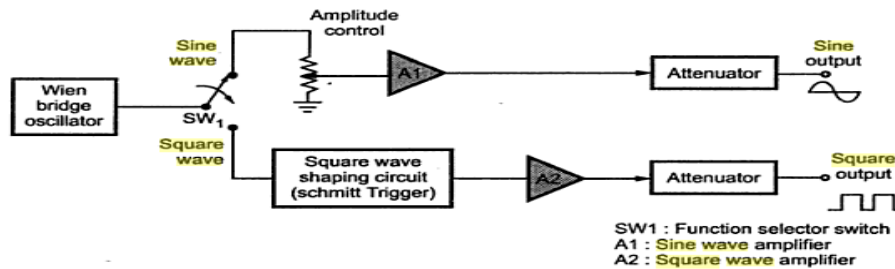
Basically bridge circuit, called **Wien bridge oscillator** is the heart of an **AF sine-square wave generator**. Depending upon the position of switch, we get output as square wave output or sine wave output. The Wien bridge oscillator generates a sine wave. Depending upon the position of switch, it is switched to either circuit. In the square wave generation section, the output of the Wien bridge oscillator is fed to square wave shaper circuit which uses schmitt trigger circuit. The attenuators in both the sections are used to control output signal level. Before attenuation, the signal level is made very high using sine wave amplifier and square wave amplifier.

4.6.1 Specification of A.F. Sine and Square Wave Generator

The specifications of typical AF signal generator are as follows.

1. Frequency range is from 10 Hz to 1 MHz. The frequency is variable over almost 5 decades continuously.
2. The amplitude of square wave output can be varied from 5 mV to 5 V (rms).
3. The amplitude of square wave output can be varied from 0 - 20 V (peak).
4. The square wave symmetry is adjustable from 30% to 70%.
5. The output is taken from push-pull amplifier with low output impedance of 600 Ω.
6. At 220 V, 50 Hz, AF signal generator requires 7 W of power only.

b. Explain any four features of CRT.

Answer:

In a dual beam oscilloscope we are using two separate electron beam for producing different wave forms. But in a dual trace oscilloscope the same beam is used for producing two different wave forms

Q.7 a. Explain the working of Heterodyne Wave Analyzer. Write its applications.

Answer:

Applications of Wave Analyzer

The wave analyzer can be used in the following applications :

i) To measure the harmonic distortion of an amplifier. The contribution of each harmonic to the total distortion also can be determined.

ii) It can be used to separate and display about 50 harmonics.

iii) To measure relative amplitudes of single frequency components in a complex waveform.

iv) To obtain fine spectrum analysis to display various discrete frequencies and resonances related to the motion of machines. Hence ways and means can be found out to eliminate such sources of sound and vibrations causing resonances.

v) To measure the amplitude in the presence of noise and other interferring signals.

vi) To measure the signal energy with the well defined bandwidth.

vii) To carry out complete harmonic analysis.

Q.8 a. Write the importance of Recording Data. Explain the working and application of X-Y recorder.

Answer:

x-y recorder is an instrument which gives a graphic record of the relationship between two variables. In x-y recorder's emf is plotted as a function of another emf. This is done by one self balancing potentiometer which controls the position of paper or chart roll while another self balancing potentiometer controls the position of the recording pen. The emf used for the operation of x-y recorders not necessarily measure only voltage. The measure emf may be the output of the transducer which may be measure of displacement, force, pressure, strain or any other physical quantities.
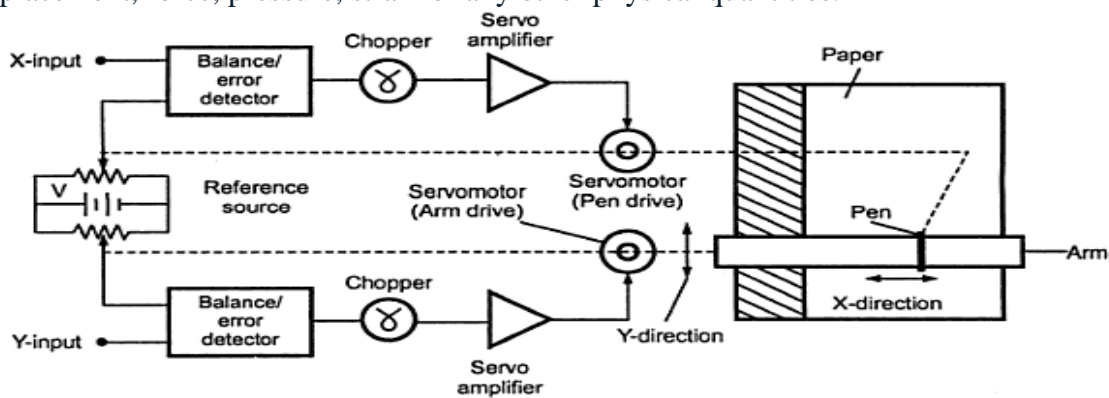
b. Discuss the advantages and limitation of digital data recording.

Answer:

Objectives and Requirements of Recording Data

i) The recording of any physical quantity is done in order to preserve the details of that quantity time to time. This helps in analyzing that quantity with some other quantities or parameters.

ii) The recorder provides display of any quantity with respect to time as well as with respect to other quantity.

iii) In many applications, there are some critical parameters of the process or equipment. For better performance of process or equipment these parameters are recorded for taking necessary action time to time.

iv) The performance of the unit, equipment or the process can be overviewed by just looking at the recorded chart.

v) The recorded chart also reflects the necessary action taken by the operator for better performance of process or equipment.

vi) The efficiency of process or equipment can be determined easily by using recorded chart.

vii) The answers to the problems come up with the product quality can be obtained by analysing the permanent record charts.

viii) The permanent record charts also helps in analysing the process or the equipment completely form the point of view of preventive maintenance.

ix) The recorded chart indicated the performance of the equipment as per the specifications provided by the manufacturer.

x) The accuracy of the recording must match the accuracy of measurement so as to obtain good results.

xi) The record must be maintained properly.

Q.9   a. Explain working of LVDT. Where it is used and what are its advantages.

b. (i) Calculate the strain in a specimen if the attached strain gauge gas a strain factor of 2, a resistance of 120ohms and the change in resistance measured is 0.1ohms.

(ii) Calculate the gauge factor of a strain gauge made from a material that acts like a perfectly incompressible material deforming elastically at small strain. (Assuming the resistivity doesn't change with strain)

Answer:

$$\varepsilon = \frac{1}{F}\frac{\Delta R}{R}$$

$$\varepsilon = \frac{1}{2} \times \frac{0.1}{120}$$

$$\varepsilon = 4.1667 * 10^{-5}$$

A.
$$F = 1 + \mu$$

For a perfectly incompressible material deforming elastically at small strain,

$$\mu = 0.5$$
$$F = 1 + 2*0.5$$
$$F = 2$$

Text Books

1. A Course in Electrical and Electronic Measurements and Instrumentation, A.K Sawhney, Dhanpat Rai & Co., New Delhi, 18th Edition 2007

2. Electronic Instrumentation, H.S Kalsi, Tata McGraw Hill, Second Edition 2004