QID -3284

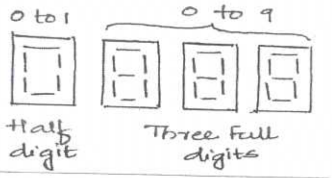
TED (15) : 4041
(Revision – 2015)

DIPLOMA EXAMINATION IN ENGINEERING / TECHNOLOGY

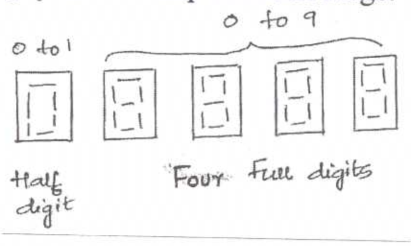
ELECTRONICS INSTRUMENTS AND MEASUREMENTS

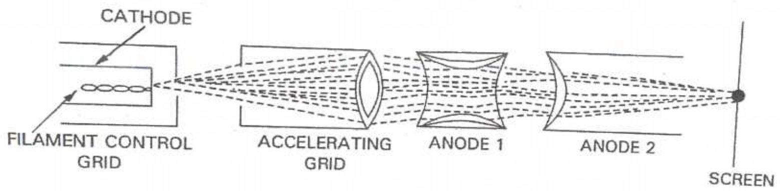
SCHEME OF VALUATION

Q n N o.	Scoring Indicator	Split up Score	Sub total	Total
I	PART : A			
1	Instrument Accuracy: closeness or nearness to which an instrument can read the true value or actual value of the quantity. Resolution: smallest change int he value measured for which the measuring instrument will respond.	1+1	2	10
2	Any two: (i) Display of waveshapes (ii) Measurement of voltage and current (iii) Measurement of frequency/time period (iv) Comparison of two frequencies	1+1	2	
3	(i) DC Bridges Ex: Wheatstone bridge & Kelvin bridge (ii) AC Bridges Ex: Maxwell's bridge, Hay's bridge, Schering's bridge, Wien Bridge	1+1	2	
4	Any two: (i) sliding contact devices (ii) wire resistance strain gauge (iii) thermistors (iv) thermocouple	1+1	2	
5	Any two: (i) in temperature recorder (ii) Sound level recording (iii) recording amplifier drift	1+1	2	
II	PART B			5*6=30
1	Measurement is the process of comparing an unknown quantity with an accepted standard quantity. The degree to which a measurement nears the expected value is expressed in terms of the error of measurement. Error may be expressed either as absolute or as percentage of error. Absolute error may be defined as the difference between the expected value of the variable and the measured value of the variable. $E= Y_n - X_n$ where E=absolute error Y_n= expected value X_n= measured value There are two types of errors: (i) Static error: the numerical difference between true value of an quantity. It is categorised into gross error or human error, systematic error and random error. (ii) Dynamic error: Errors caused by the instrument not responding		6	

<table>
<tr><td></td><td>fast enough to follow the changes in a measured variable.</td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>The resolution of digital meters depend on the number of digits used in the display. The three digit display for 0-1 v range can indicate the values from 0 to 999 mV with the smallest increment of 1mV.
<u>3 1/2 digit display</u>: Practically, one more digit which can display only 0 or 1 is added. This digit is called half digit and display is called 3 1/2 digit display.


In such a display, the meter can read the values above 999 upto 1999 to give the overlap between the range. This process is called over ranging.

<u>4 1/2 digit display:</u> There are 4 full digits and 1 half digit. The number obtained is from 0 to 19999. The resolution of 4 1/2 digit display is better than 3 1/2 digit display while the accuracy is 10 times better. In such a display, the meter can read the values above 9999 to 19999 to give the overlap between range.


</td><td>3
+
3</td><td>6</td><td></td></tr>
<tr><td>3</td><td>The convergent electron beam from accelerating electrode has a tendency to spread because of the mutual repulsion between the electrons. Some focussing device is required to bring the beam to a sharp focus at the screen.
Two methods of focussing are:
(i) Electrostatic focussing (ii) Magnetic focussing
<u>Electrostatic Focussing</u>:
The anodes 1 and 2 provide an electron lens system for focussing the beam into a spot on the flurescent screen. Anode 2 is kept at a higher positive potential than anode 1. The final anode 2 has a central aperture so as to permit only a well defined beam to pass through it. The divergent electron tends to converge into a narrow beam and this beam tends to pass through the hole at the centre of the elctrode.


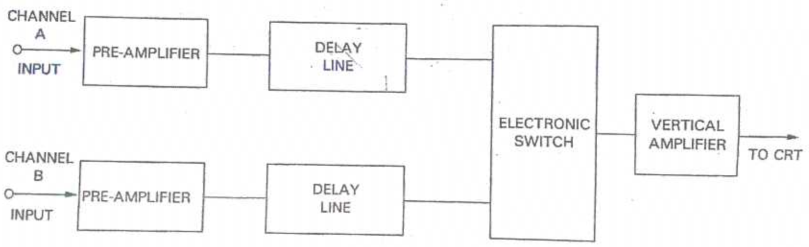
The high velocity electrons may not remain in the narrow</td><td></td><td>6</td><td></td></tr>
</table>

beam, as they are similarly charged and hence repel each other. They require to be brought into sharp focus, so that they strike against the screen at a sharp, clearly defined spot by using focussing electrodes. Thus, focussing of the electron beam is achieved.

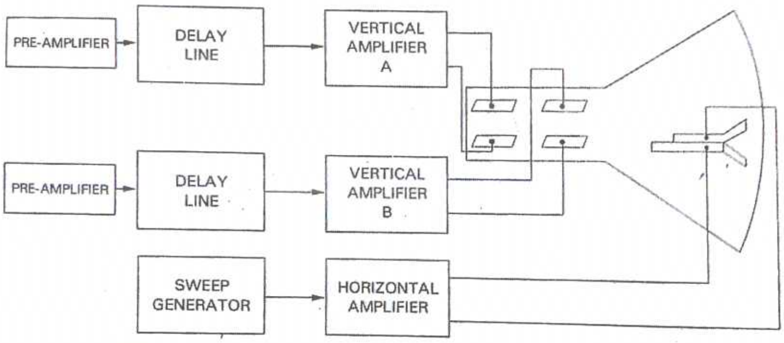
4

Dual-trace CRO	Dual-beam CRO
1. Only one vertical amplifier is used. 2. Only one electron gun and one beam. 3. Two signals are switched to a single vertical amplifier. 4. Different display modes such as alternate, chopped, add are possible. 5. Cost is less.	1. Contains two separate vertical amplifiers for two channels. 2. Two separate electron guns produce two beams. 3. Two signals are fed to two separate vertical amplifiers to get two separate images. 4. Does not have many display modes. 5. Cost is more.

6



Dual trace CRO



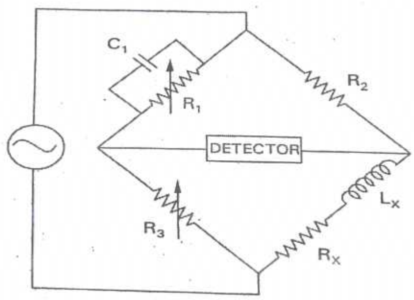
Dual-beaam CRO

5 <u>Maxwell's Bridge:</u>

Mawell's bridge measures an unknown inductance interms of a known capacitor. The use of standard arm offers the advantage of compactness and easy shielding. One arm has a resistance R1 in parallel with C1 and it is easier to write thte balance equation using admittance of arm 1 instead of impedance.

<u>Advantages</u>: Measurement is independent of frequency, balance equation is independent of losses associated with inductance.

<u>Disadvantages</u>: Cannot be used to measure very low Q or high Q values and since measurements are independent of frequency, the properties of coil under test vary frequency which can cause error.



6

The general equation for bridge balance is

$$Z_1 Z_x = Z_2 Z_3$$

i.e. $$Z_x = \frac{Z_2 Z_3}{Z_1} = Z_2 Z_3 Y_1 \qquad \text{...... (1)}$$

Where $Z_1 = R_1$ in parallel with C_1 i.e. $Y_1 = \frac{1}{Z_1}$

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

$$Z_2 = R_2$$

$$Z_3 = R_3$$

$Z_x = R_x$ in series with $L_x = R_x + j\omega L_x$

From Eq. (1) we have

$$R_x + j\omega L_x = R_2 R_3 \left(\frac{1}{R_1} + j\omega C_1\right)$$

$$R_x + j\omega L_x = \frac{R_2 R_3}{R_1} + j\omega C_1 R_2 R_3$$

Equating real terms and imaginary terms we have

$$R_x = \frac{R_2 R_3}{R_1} \text{ and } L_x = C_1 R_2 R_3$$

Also $$Q = \frac{\omega L_x}{R_x} = \frac{\omega C_1 R_2 R_3 \times R_1}{R_2 R_3} = \omega C_1 R_1$$

6 Telemetry is an automated communications process by which measurements and other data are collected at remote or inaccessible points and transmitted to receiving equipment for monitoring. The word is derived from Greek roots: tele=remote and metron=measure.

Telemetry is automated measurement and wireless transmission of data from remote sources. Telemetry works in the following way: Sensors at the source measure either electrical data(such as voltage or current) or physical data (such as temperature or pressure). These measurements are converted to specific electrical voltages. A

	multiplexer combines the voltages along with toming data into a single data stream for transmission to a remote receiver. Upon reception, the data stream is separated into its original components and the data is displayed and processed according to user specifications. A telemetry transmitter consist of a set of measuring instruments, an encoder that translated instrument readings into analog or digital signals, a modulator, and a wireless transmitter with an antenna. The receiver consist of an antenna, a set of radio frequency (RF) amplifiers, a demodulator and recording devices. Mainframe computers were used to process and storre the received information. Telelmetry applications include measuring and transmitting data from sensors located in automobiles, smart meters, power sources, robots and even wildlife in what is commonly called the Internet of Things (IoT).		6	
7	(see table below)		6	

Circular Chart Recorder	Strip Chart Recorder
1. Easy to handle. 2. Circular in shape with varying size from 100mm to 250mm diameter. 3. Shows all the information at a glance. 4. Low intial cost. 5. Chart speed is limited 6. It is possible to simultaneously record on the full chart range up to four sepaarate variables.	1. Very easy to handle. 2. Curvillinear in shape and available in the form of long strips rolled on to a drum. 3. Unrolled the chart to see past records. 4. High cost. 5. Chart speed is much higher. 6. It is possible to record up to 4 to 6 points simultaneously and thus afford saving a lot of panel space.

PART – C

III				8+7=15
a	<u>Conversion of galvanometer into ammeter</u>: The D'Arsonaval galvanometer is a moving coil ammeter. The coil winding of a basic movement is very small and light it can carry very small value of currents. When the large currents are to be measured it is necessary to bypass the major part of the current through a low resistance called shunt resistor. The shunt resistor is connected parallel with D'Arsonaval movement. The ammeter is always connected in series with the load in the circuit. The resistance of the shunt can be calculated by circuit analysis. Where Rm=internal resistance of the movement coil Rsh=resistance of the shunt Im=full scale deflection current of the movement Ish=shunt current I= current to be measured Since the shunt resistance is in parallel with the meter movement, the voltage drop across the shunt and movement is the same.	4		

+

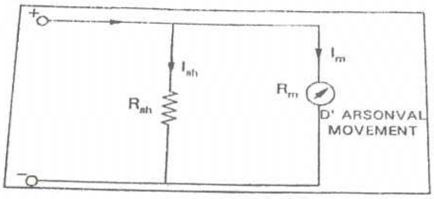


Fig. 1.5 DC Ammeter

8

$$V_{shunt} = V_{movement}$$

$$I_{sh} R_{sh} = I_m R_m$$

$$R_{sh} = \frac{I_m R_m}{I_{sh}}$$

that $I_{sh} = I - I_m$, so we can write

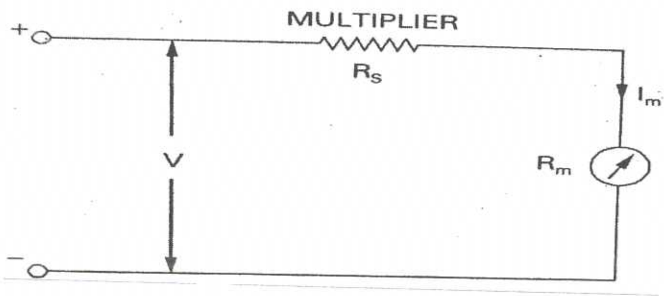
$$R_{sh} = \frac{I_m R_m}{I - I_m}$$

<u>Conversion of galvanometer into voltmeter</u>:

Voltmeter is used for measuring voltage or the potential difference. The high resistor is connected in series with galvanometer. This resistor is called multiplier. The multiplier limits the current so that it does not exceed the full scale deflection current. The voltmeter is always connected across the source of emf or a circuit.

Rm=internal resistance of the movement coil
Rs=multiplier resistance
Im=full scale deflection current of the movement
V=full range voltage of the instrument

V=Im(Rs+Rm)

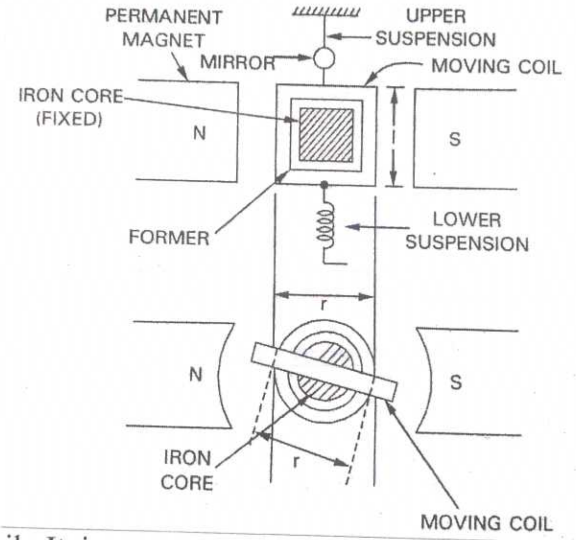


4

Rearranging,

Rs=(V-ImRm)/Im

b Galvanometer is an instrument used to indicate the presence, direction or strength of a small electric current. A typical galvanometer is a sensitive instrument used in laboratory, mainly to detect and compare currents. It makes use of the fact that an elctric current flowing through a wire sets up a magnetic field aaround the wire.

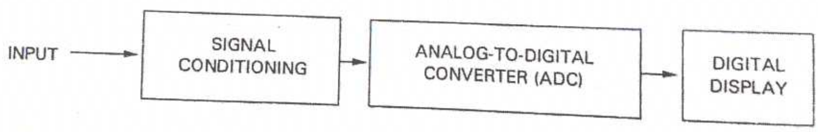


Moving coil: It is current carrying element. It is rectangular or circular in shape and consists of a number of turns of fine wire. It is arranged in a uniform, radial, horizontal magnetic field in the air gap between pole pieces of a permanent magnet and iron core.
Damping: it is obtained by connecting a low resistance across the galvanometer terminals.
Suspension: coil is supported by a flat ribbon suspension which also carries current to the coil.
Indication: the suspension carries a small mirror upon which a beam of light is cast. This beam of light is reflected on to a scale upon which the deflection is measured.
Working: Galvanometer works on the principle of conversion of electrical energy into mechanical energy. When a current or voltage flows in a magnetic field, it experiences a magnetic torque. If it is free to rotate under a controlling torque, it rotates through an angle proportional to the current flowing through it. 7

IV 8+7=15

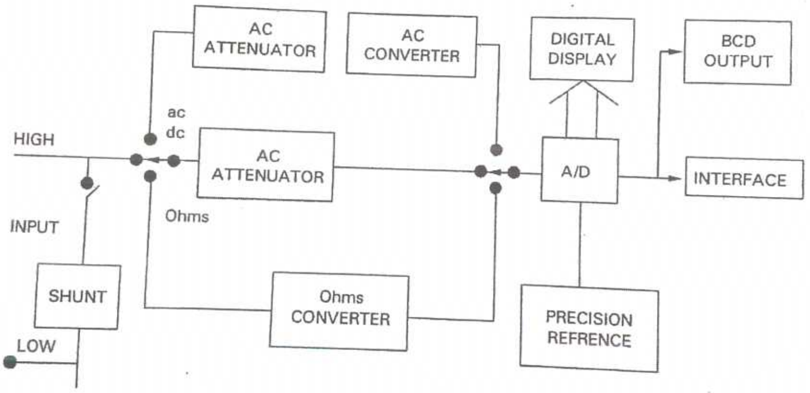
a Digital multimeter (DMM):

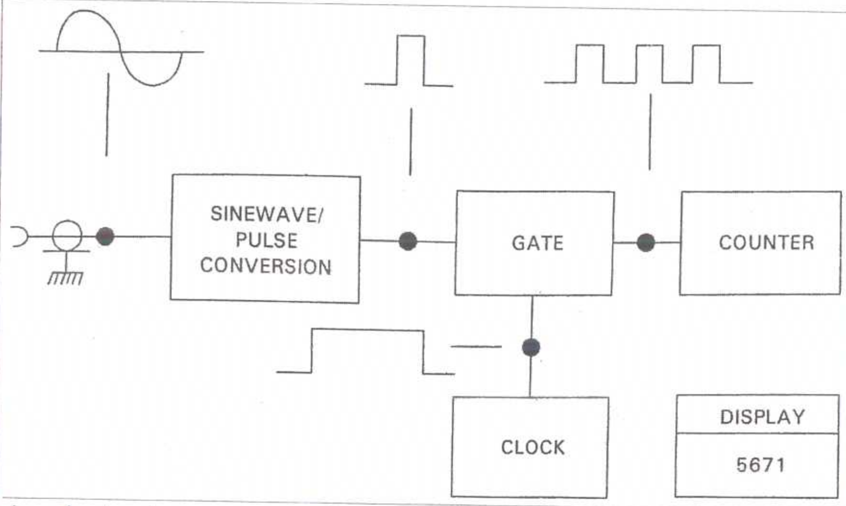
A digital multimeter displays the quantity measured as a number, its eliminated parallax errors.



The information from analog input signal passes through the various analog signal conversion circuits which convert the measured quantity to a dc voltage equivalent. Then the A/D converts the dc value to digital form and display unit display the value. The DMM is made up of following three basic elements: a) Signal conditioning b) A/D converter c) Numeric digit display.

The main features of any DMM is the type of measurement and the ranges overwhich it will operate. The basic measurements will 8

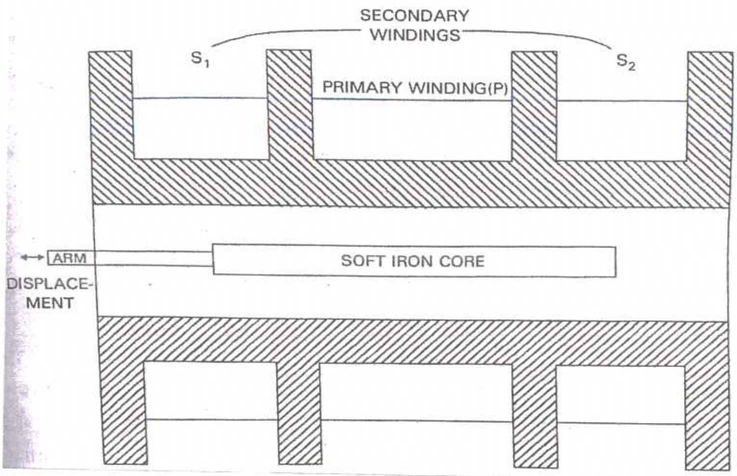
	include: a) Current (DC) b) Current (AC) c) Voltage (DC) d)Voltage (AC) e) Resistance. The block diagram of DMM :  <u>Advantages of DMM</u>: 1. DMM offer high measurement accuracy. 2. These instruments have a high input impedence. 3. They are smaller in size. 4. These meters eliminate observational, parallax and approximation errors.		
b	<u>Digital frequency meter:</u> it is general purpose instrument that displays the frequency of a periodic electrical signal to an accuracy of three decimal places. It counts the number events occuring within the oscillations during a given interval of time. As the preset period gets completed, the value in the counter display on the screen and counter reset to zero. <u>Operating principle:</u> A frequency meter has a small device which converts the sinusoidal voltage of the frequency into train of unidirectional pulses. The frequency of input signal is the displayed count, averaged over a suitable counting interval out of 0.1,1 or 10 seconds. These three intervals repeat themselves sequentially. As the ring counting units resets, these pulses pass through the time-base-gate and then entered into the main gate, which opens for a certain period of time interval. The main gate acts as a switch when the gate is open, pulses are allowed to pass. When the gate is closed, pulses arre not allowed to pass that means the flow of pulses get obstructed.	7	

	 An electronic counter at the gate output that counts the number of pulses passed through the gate while it was open. As the next divider pulse is received at main gate flip-flop,the counting interval ends and divider pulses are locked out. The resultant value displayed on a display screen which has the ring counting units of scale-of-ten circuits and each unit is coupled to a numeric indicator which provides the digital display. As the rest pulse generator is triggered, ring counters get rest automatically and the same procedure starts again.			
V				8+7=15
a	<u>Measuremnet using CRO:</u> <u>(i) Measurement of voltage:</u> To display a signal on the CRO screen, the signal is applied to the vertical input terminals. A CRO can display both AC and DC signals. The DC voltage to be measured is applied to the vertical input terminals. The height of the trace on the screen is measured. This height of the trace multiplied by the deflection factor gives the value of the DC voltage. In case of AC Voltage, the height of the trace gives the peak-to-peak value of the AC voltage. Dividing this value by $2\sqrt{2}$, we get RMS value of the applied voltage. <u>(ii) Measurement of Current:</u> The CRO is a voltage measuring equipment. To measure a current it is passed through a known resistor. The resulting voltage across the resistor is measured on the CRO. This voltsge divided by the resistance gives the current value. Dividing this value by $2\sqrt{2}$ gives the RMS current. <u>(iii) Measurement of Time period:</u> Apply the signal to the vertical input. Measure the horitontal distance between two peaks and multiply with time-base. This gives the time period (T). <u>(iv) Measurement of Frequency:</u> Apply the signal to the vertical input. Measure the horizontal distance between two peaks and mutiply with time-base. This gives the time period. The reciprocal of the time period gives the frequency of the signal. <u>(v) Measurement of Phase</u> The two signals whose phase difference is to be determined are		8	

applied to the two channels of a dual-beam CRO. The same trigger is used for the sweep voltages. The phase difference between the two waveforms displayed on the CRO screen can be found from the time base.

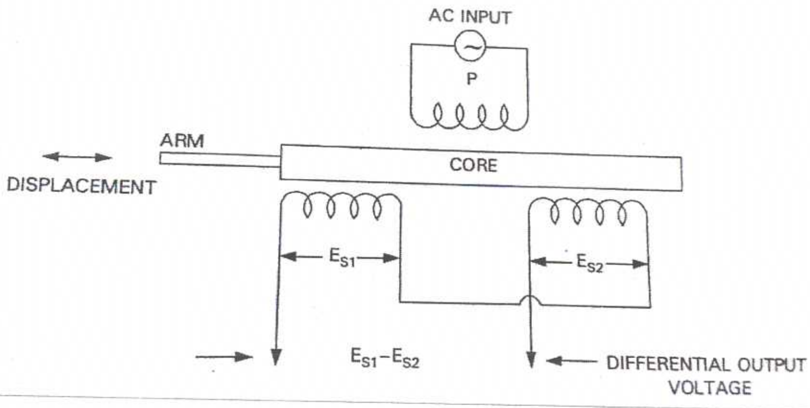
b LVDT:

The differential transformer is a passive inductive transformer also known as a Linear Variable Differential Transformer (LVDT). The transformer consists of a single primary winding P and two secondary windings S1 and S2 wound on a hollow cylindrical former. The secondary windings have an equal number of turns and are identically placed on either side of the primary windings. The primary winding is connected to an AC sources. AC movable soft iron core slides within the hollow former and affects the magnetic coupling between the primary and the two secondaries. The displacement to be measured is applied to an arm attached to the soft iron core.

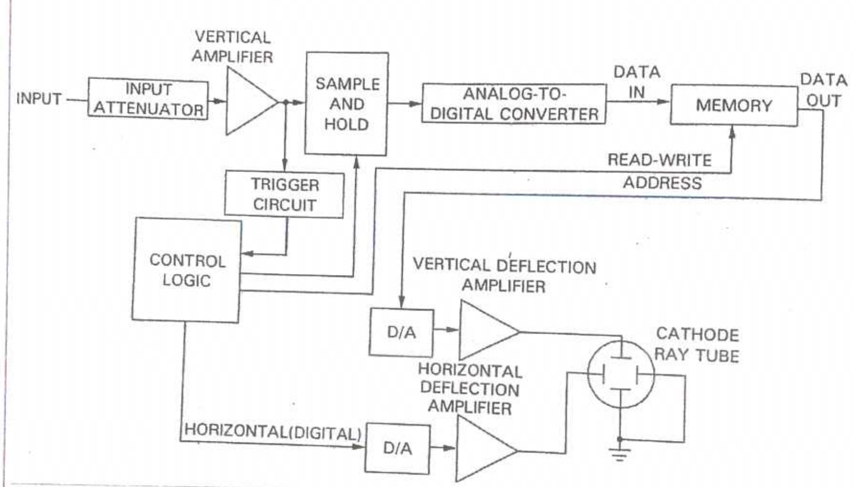


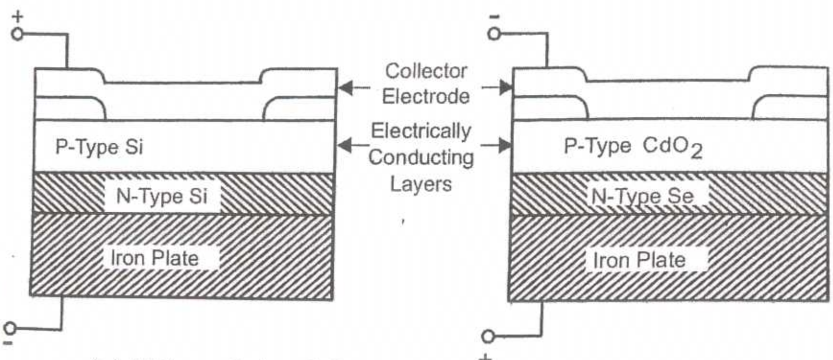
7

When the core is in its normal position, equal voltages are induced in the two secondary windings. The frequency of the AC applied to the primary winding ranges 50Hz to 20KHz.

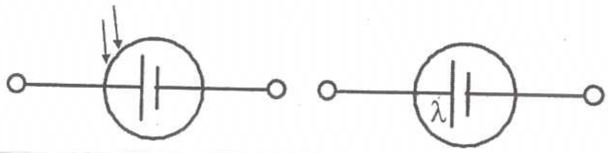


The output voltage of the transducer is the difference of the two voltages. The differential output voltage Eo= E_{s1}-E_{s2}. When the core is at its normal position, the flux linking with both secondary windings is equal and equal emfs are induced in them ie Es1=Es2. If the core is moved to the left of null position, more flux links with

	windings S1 and less with winding s2 ie. Es1>Es2. The amount of voltage change in either secondary winding is proportional to the amount of movement of the core. There is a indication of the amount of linear motion.			
VI a	<u>Digital Storage Oscilloscope</u> The DSO eliminates the disadvantages of the analog storage oscilloscope. In DSO, the waveform to be stored is digitised and then stored in a digital memory. The conventional CRT is used in this oscilloscope hence the cost is less. The power to be applied to memory is small and can be supplied by small battery. Due to this the stored image can be displayed indefinitely as long as power is supplied to memory. Once the waveform is digitised then it can be further loaded into the computer.  The input signal is applied to the amplifier and attenuator section. The attenuated signal is then applied to the vertical amplifier. The vertical input after passing through the vertical amplifier is digitised by an A/D converter to create a data set that is stored in the memory. The data set is processed by the microprocessor and then sent to the display. The digitised output needed only in binary form. The digitising the analog signal means taking samples at a periodic intervals of the input signal. The sampling rate and memory size are selected depending upon the duration and the waveform to be recorded. Once the input signal is sampled, the A/D converter digitises it. The signal is then captured in the memory. Once it is stored in the memory, many manipulations are possible as memory can be read out without being erased.		8	8+7=15
b	<u>Photo – voltaic cells:</u> Solar cells operate on the principle of photo voltaic effect, i.e. conversion of incident light into electrical energy. The thermo – nucleus process inside the sun gives the solar radiation. The solar cell on the earth accepts this radiation and gives an electrical power.			



(a) Silicon Solar Cell (b) Selenium Solar Cell



It consists of a base plate made from iron or steel. This acts as positive electrode. The P-type selenium layer is placed above the base layer. This is sensitive to light particles. Above this, an electrically conducting layer of cadmium oxide is present. The collector electtrode is placed at the top surface.

Operation: Above the collector elctrode, a thin glass layer is placed. When the light is incident, it will br transferred to the lower side. The cadmium oxide layer is also transparent to light. The photons reach the selenium layer. The absorption of photons takes place. This will create some electrons. The number of electrons is proportional to the amount of incident light intensity. These electrons are collected by the collector electrode and the current passes through the external circuit.

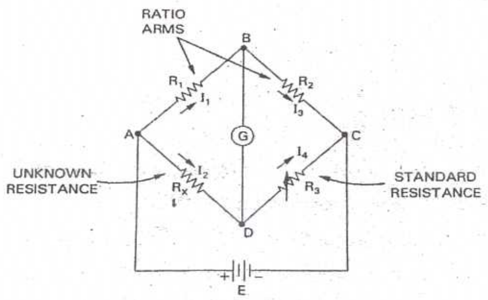
Applications: Solar cells are used as independent power systems, solar house, alarm and monitoring systems, military applications, water pumping and purification, rural electrification etc.

7

VII. a

8+7=15

Wheatstone Bridge: The bridge consists of four resistive arms together with a source of emf and a null detector. The arms consisting the resistances R1 and R2 are called ratio arms. The arm consisting the standard known resistance R3 is called standard arm. The resistance Rx is the unkown resistance to be measured.



The battery is connected between A and C while galvanometer is connected between B and D.

8

When the bridge is balanced, the galvanometer carries zero current and it does not show any deflection. Thus bridge works on the principle of null deflection or null indication. To have zero current through galvanometer, the points B and D must be same as the potential across arm AD.

$$I_1R_1=I_2R_x \quad ....(1)$$

As galvanometer current is zero, $I_1=I_3$ and $I_2=I_4$. ....(2)

At balanced condition,

$$I_1=I_3=E/(R_1+R_2) \quad ....(3)$$

$$I_2=I_4=E/(R_3+R_x) \quad ....(4)$$

using eq (3) & (4) in (1),

$$E/(R_1+R_2)*R1=E/(R_3+Rx)*R_x$$

$$R_1(R_3+R_x)=R_x(R_1+R_2)$$

$$R_1R_3+R_1R_x=R_1R_x+R_2R_x$$

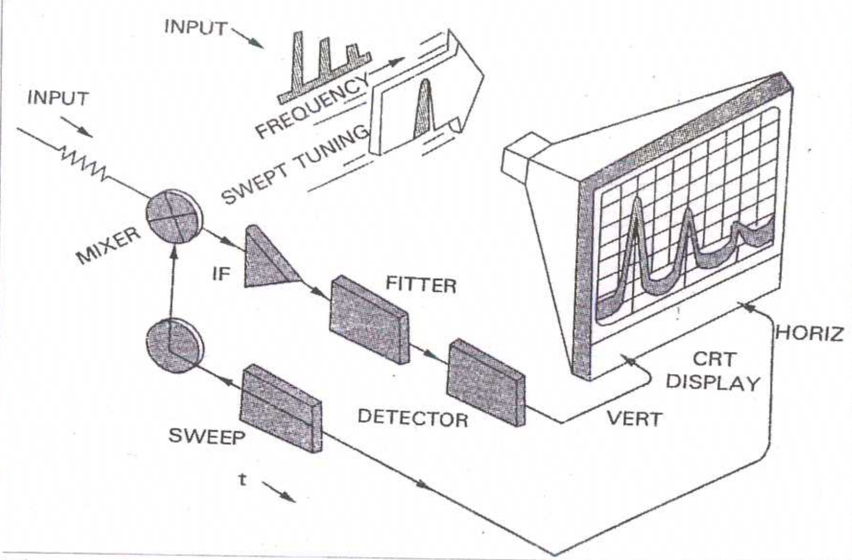
$$R_x=(R_1R_3)/R_2$$

This is required balance equation condition of wheatstone bridge.

Applications: Wheatstone bridge is a DC bridge and used to measure the resistances in the range 1 ohm to low megaohm. It is used to measure the dc resistances of various types of wires for the purposes of quality control of wire. It is used to measure the resistance of motor winding, relay coils etc. It is used by the telephone companies to locate the cable faults.

b Spectrum analyzer: 7

A spectrum analyzer or spectral analyser is a device used to measure the magnitude of an input signal within the full frequency range. The main purpose of the spectrum analyser is to measure the power of spectrum of "known" and "unknown" signals. The input signal a spectrum analyser measures is electrical.



The spectrum analyser is an instrument that brings together a supêrhetrodyne radio receiver with a swept frequency local oscillator and an oscilloscope to present a display of amplitude versus frequency. The block diagram consists of input mixer, sweep oscillator, filter, detector and display.

The spectrum analyser is a superhetrodyne receiver in which local

oscillator is sweep generator. A low frequency sawtooth wave is applied to both the sweep oscillator and the horizontal deflection plates of the CRT. The lowest frequency is represented by left side of the trace while highest frequency is represented by right side of the trace. The sweep is from left to right.
The input signal is mixed with local oscillator to produce the IF signal. The output signal at the detector will have a strength that is proportional to the frequency that the local oscillator is converting to the IF at that instant. The display will then contain "poles" that represent the amplitudes of the various input frequency components.

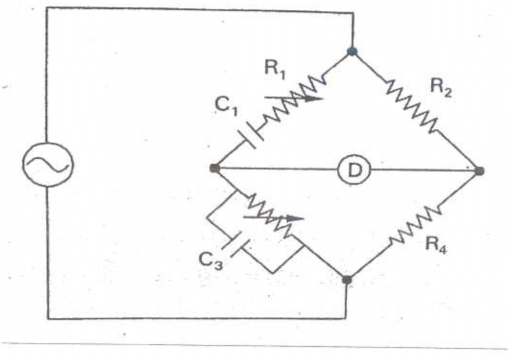
VIII 8+7=15

a

Wien bridge

The wien bridge is primary known as a frequency determining bridge. It has a series RC combination in one arm and a parallel RC combination in the adjoining arm. This bridge circuit was used for measuring capacitance of capacitors and their losses. The bridge circuit is frquency sensitive. The general equation of the bridge,

$$Z_1Z_4=Z_2Z_3$$



8

Admittance in branch 3 is given by

$$Y_3=1/Z_3$$

then, $$Z_1Z_4Y_3=Z_2 \quad ....(1)$$

$$Z_1=R_1-j/wC_1$$

$$Z_2=R_2$$

$$Y_3=1/R_3+jwC_3$$

$$Z_4=R_4$$

Substituting all in eq (1),

$$\{R_1-j/wC_1\}R_4\{1/R_3+jwC_3\}=R_2$$

$$R_1R_4/R_3 + jwC_3R_1R_4 - jR_4/wC_1R_3 + R_4C_3/C_1 = R_2$$

Comparing real terms on both sides of above equation,

$$R_2 = R_1R_4/R_3 + R_4C_3/C_1$$

$$R_2/R_4 = R_1/R_3 + C_3/C_1 \quad ....(2)$$

Comparing imaginary term,

$$wC_3R_1R_4 - R_4/wC_1R_3 = 0$$

$$wC_3R_1R_4 = R_4/wC_1R_3$$

$$w^2 = 1/(C_1C_3R_1R_3)$$

$$w=1/\sqrt{(C_1C_3R_1R_3)}$$

where $w=2\prod f$

$$f=1/2\prod\sqrt{(C_1C_3R_1R_3)} \quad ....(3)$$

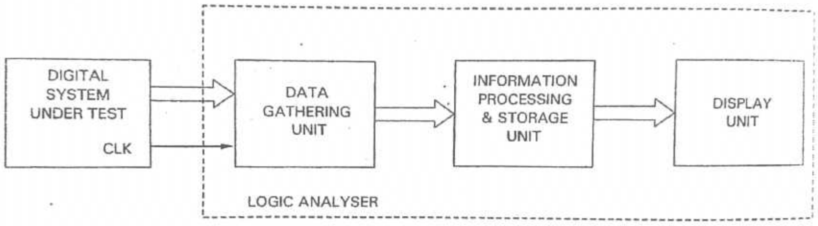
The equation (2) determines the resistance ratio, R_2/R_4 and equation (3) determines the frequency of the applied voltage. When the

circuit components $R_1=R_3$ and $C_1=C_3$,then equation (2) is $R_2/R_4=2$ and equation (3) is $f=1/2\prod RC$.
This is the general expression of the frequency of the wien bridge.

Wien bridge is used for measuring the frequency in audio range, harmonic distortion analyser etc.

b <u>Logic Analyser:</u>

There are two drawbacks of oscilloscope in digital design such as high speed random pulses cannot be observed easily and it cannot monitor a few signal lines simultaneously. For these reasons, the logic analysers has been developed. It operates on a slightly different principle than that of an oscilloscope. There are many signal lines in a digital system, the data is changing rapidly on each line, a logic analyser must take a snap shot of the activities on the lines and store the logic state of each signal in memory for eachcycle of the system clock. The conditions under which the snapshot is taken aare determined by triggering circuits which can respond to various combinations of events. The logic analyser enables the activity of many digital signal points to be recorded simultaneously and then examined. The information is recorded with respect to a clock signal to determine whether they are HIGH or LOW with respect to a defined threshold voltage. This information is stored in memory and is then available for detailed analysis via logic analyser's display. The clock signal can be internally or externally. 7



It has a data gathering unit, information processing and storage unit and a display unit. The data gathering unit has a pod slot for carrying data from the digital system under test to the logic analyser and a keypad. The keypad is used to enter commands and setup the parameter that logic analyser will use. The display unit is a cathode ray tube that displays the command menu for the operator and also displays the output data.

<u>Applications:</u> hardware/software debugging, parametric/mixed signal testing, hardware simulation and stimulus-response testing and complex debugging with deep memory.

IX

a <u>Any eight:</u> 8+7=15

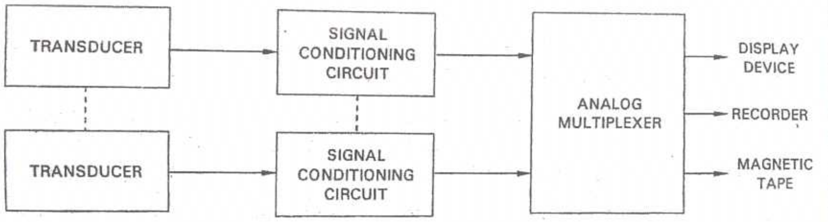
Sl no.	Open Loop	Closed Loop
1	Any change in output has no effect on input	Change in output affects the input
2	Output measurement is not required for operation of	Output measurement is necessary.

	system.	
3	Feedback element is absent	Feedback element is present.
4	Error detector is absent	Error detector is necessary
5	Inaccurate and unreliable	Accurate and reliable
6	Highly sensitve to disturbances	Less sensitive to disturbances
7	Highly sensitve to environmental changes	Less sensitive to environmental changes
8	Bandwidth is small	Bandwidth is large
9	Simple construct and cheap	Complicatednto design and costly
10	Stable in nature	Instable
11	Highly affected by non linearities	Reduced effect on nonlinearities

8

b <u>Analog Data acquistion sytem:</u>

Data acquisition systems are used to measure and record signals obtained in two ways. The instrumentation systems can be classified into analog and digital system. Analog systems deal with measurement information in analog form.



It consists of transducers, signal conditioners, multiplexer and output devices such as display, recorder and magnetic tape. Transducers are used for translating physical parameter into electrical signals. The output of the transducer is to signal conditioning circuit where the signal is amplified and modified to the required level.

The analog multiplexer selects of the several input signals and the output the multiplexer is given to a display device or a recorder or a magnetic tape. The characteristics of the data acquisition system depend on both the properties of the analog data and the processing carried out. Based on the environment, the data acquisition system is classified into types as those suitable for favorable environments and those intended for hostile environments. The data acquisition system are designed based on the following factors:

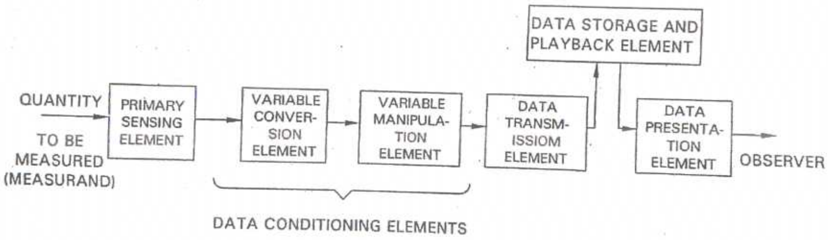
1. Accuracy and resolution
2. Number of channels to be monitored
3. analog or digital signal
4. Single channel or multichannel
5. Sampling rate per channel
6. Signal conditioning require of each channel
7. Cost

7

X 8+7=15

a **Basic Instrumentation System:**

the operation of a measuring instrument or a system could be described in terms of functional elements. Each functional element is made up of a component or groups of components which perform required and definite steps in the measurement.



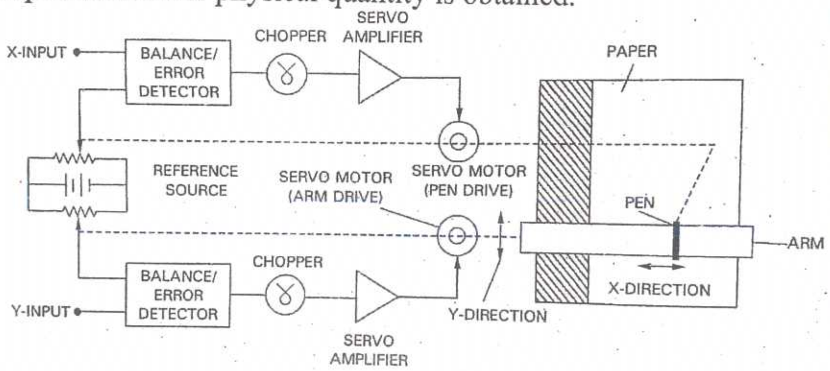
The main functional elements of a measurement system are: 8

1. Primary sensing element : the quantity which is being measured makes its first contact with the primary sensing element. The measurement is first detected by primary sensor or detector. Then immediately converted into an analogous electrical signal. This is done by a transducer.
2. Variable Conversion element : the output signal of the variable sensing element may be any kind. It may be ncessary to convert this output signal from sensor to some other suitable form while preserving the information content of the original signal.
3. Variable manipulation element : Variable manipulation means a change in numerical value of the signal. The function of a variable manipulation element is to manipulate the signal presented to this element while preserving the original nature of the signal.
4. Signal conditioning element : The output signal of transducer contains which is further processed by the system. This signal is contaminated by unwanted signals like noise. The operation performed on the signal to remove the signal contamination or distortion is called signal conditioning.
5. Data transmission element : it transmit data from one element to another.
6. Data presentation element : It convey the information about the quantity under measurement to the personnel handling the instrument or the system for monitoring, control or analysis purposes.

b **X-Y Recorder:**

In X-Y recorder, one variable is plotted against another variable. In this recorder, pen is moved in either X or Y direction on a fixed graph paper. The writing assembly movement is controlled by using either servo feedback system or self balancing potentiometer. X-Y recorder plots one voltage as a function of other voltage.

Operation: The signal from appropriate transducer is applied to the attenuator. The attenuator attenuates this signal, so that the recorder works properly in the dynamic range. The self balancing circuit compares attenuated signal to the fixed reference voltage. The output of error detector is a difference between the variation in input signal and reference voltage. This voltage is dc voltage. Using chopper circuits, dc signal is converted to ac signals. As the ac signal level is very low, it is necessary to boost up the level of signal so that it can drive the writing assembly mounted on arm. The servo amplifier amplifies low ac signal to the appropriate signal level. This amplified signal is applied to servomotor so that writing assembly moves in proper direction reducing the error signal. When the input signal to be recorded varies, the writing assembly moves across fixed graph paper, so that the signal is recorded by keeping system in balanced condition. The same action exactly takes place in both axes simultaneously. Record of one physical quantity with respect to another physical quantity is obtained.



Advantages: zero offset adjustments are available

Applications: Used to measure speed-torque characteristics of motor, regulating curves of power supply, plotting strain stress curve etc.

7