

Revision: 2015

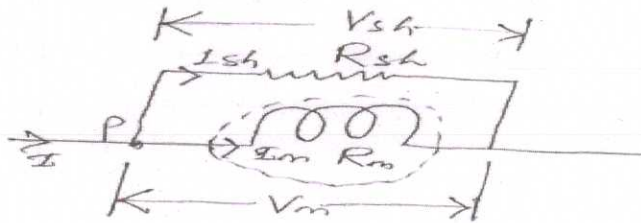
Course Title: Electronics Instruments & Measurements

Course Code: 4041

Qst No:	Scoring Indicator	Split up Score	Sub Total	Total	
					Part A
I	1.	<ul style="list-style-type: none"> In $3\frac{1}{2}$ digit display, there are 3 full digits and 1 half digit. The number obtained is from 0000 to 1999. In $4\frac{1}{2}$ digit display, there are 4 full digits and 1 half digit. The number obtained is from 00000 to 19999. 	2	2	10
	2.	<p>Electrostatic deflection sensitivity is defined as the amount of deflection of the electron spot produced when a voltage of one volt DC is applied between the corresponding deflection plates.</p> $S_d = d/V_d$	2	2	
	3.	<ul style="list-style-type: none"> Sine wave signals can be used to test the gain of an amplifier. Square wave signals can test low frequency and high frequency response of an amplifier. (or any two) 	1*2=2	2	
	4.	<ul style="list-style-type: none"> Strip chart recorders Galvanometric recorders X-Y recorders Potentiometric recorders 	$\frac{1}{2} * 4 = 2$	2	
	5.	<ul style="list-style-type: none"> Telemetry is the automatic measurement and wireless transmission of data from remote sources. Sensors at the source measure the physical data and converted to electrical voltages. A multiplexer combines the voltages for transmission to a remote receiver. Widely used in industrial, commercial, military etc 	2	2	

PART-B

1. Since Galvanometer is a very sensitive instrument therefore it can't measure heavy currents. In order to convert a Galvanometer into an Ammeter, a very low resistance known as "shunt" resistance is connected in parallel to Galvanometer. Value of shunt is so adjusted that most of the current passes through the shunt. In this way a Galvanometer is converted into Ammeter and can measure heavy currents without fully deflected.



Let R_m = Resistance of meter

R_{sh} = Resistance of shunt

I_m = Current through meter

I_{sh} = current through shunt

I = current to be measure

$$\therefore V_m = V_{sh}$$

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

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

Apply KCL at 'P' $I = I_m + I_{sh}$

$$\frac{I}{I_m} = 1 + \frac{I_{sh}}{I_m}$$

2(fig)+4

6

30

Apply KVL, $V = V_m + V_{se}$

$$\frac{V}{V_m} = 1 + \frac{V_{se}}{V_m} = \left(1 + \frac{R_{se}}{R_m} \right)$$

$$\therefore V = V_m \left(1 + \frac{R_{se}}{R_m} \right)$$

$$\left(1 + \frac{R_{se}}{R_m} \right) \rightarrow \text{Multiplication factor}$$

2.

Dual trace CRO	Dual beam CRO
It is used single electron beam to display two traces.	It is used two electron beams for displaying two signals.
A single vertical <u>amplifier</u> is used.	Two vertical amplifiers are used for two beams.
It is not able to capture two fast transient events.	It captures two fast transient easily.
It cannot switch quickly between traces, so simultaneous display becomes difficult.	It can display two traces simultaneously.
The two signals may or may not have same frequency.	The two signals must have the same frequency or they must be harmonically related.

1*6=6

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A single beam can be used for displaying multiple traces.

Multiple beams are used for displaying multiple traces.

Two signals can be displayed on a dual trace oscilloscope. But, the two signals cannot be displayed together in real time.

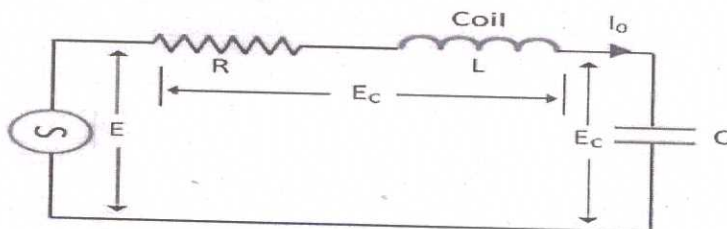
Two signals can be displayed simultaneously in real time.

3.

The instrument which measures some of the electrical properties of coils and capacitors is referred as Q-meter. The working principle of a Q-meter depends on the characteristics of a series resonance circuits, i.e., the voltage drop across the coil or capacitors is equal to the applied voltage times the Q factor of the circuit. Thus if the circuit subjected to a fixed voltage, the voltmeter connected across the capacitor is calibrated to indicate the Q value directly. A series resonance circuit and its voltage and current relationship at resonance conditions are illustrated in figure

3(fig)+3

6



Resonant RLC Series Circuit

Circuit Globe

At resonant frequency f_0 ,

$$X_C = X_L$$

The value of capacitance reactance is

$$X_C = \frac{1}{2\pi f_0 C} = \frac{1}{\omega_0 C}$$

At inductive reactance,

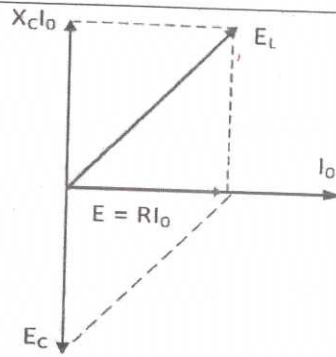
$$X_L = \frac{1}{2\pi f_0 L} = \frac{1}{\omega_0 L}$$

At the resonant frequency,

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

and current at resonance becomes

$$I_0 = \frac{E}{R}$$



Phasor Diagram Circuit Globe

The voltage across the capacitor is expressed as

$$E_C = I_0 X_C = I_0 X_L = I_0 \omega_0 L$$

Input voltage

$$E = I_0 r$$

$$\frac{E_C}{E} = \frac{I_0 \omega_0 L}{I_0 R} = \frac{\omega_0 L}{R} = Q$$

4.

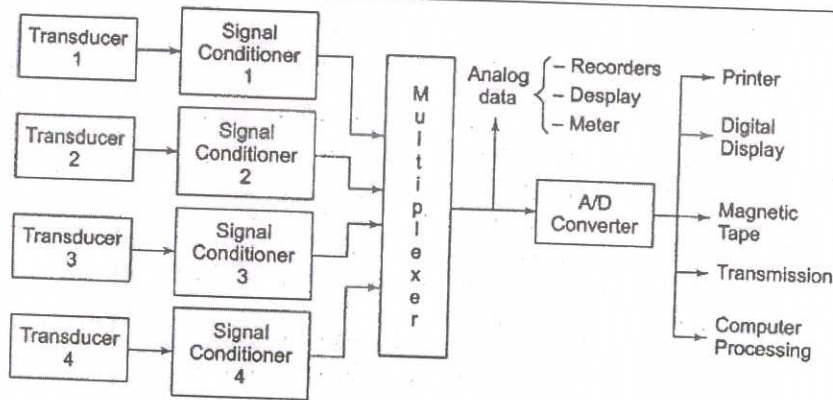


Fig. 17.1 Generalised Data Acquisition System

1. Transducer:-

A transducer is used to convert the physical parameters coming from the field into electrical signals or it is used to measure directly the electrical quantities such as resistance, voltage, frequency, etc.

2. Signal Conditioner:-

Usually the output signals of the transducer will be of very low level (weak) signals which cannot be used for further processing. In order to make the signals strong enough to drive the other elements signal conditioners are used such as amplifiers, modifiers, filters etc.

3. Multiplexer:-

The function of the multiplexer is to accept multiple analog inputs (after signal conditioning) and provide a single output sequentially according to the requirements.

3+3

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		<p>4. A/D Converter:- The analog-to-digital (A/D) converter is generally used to convert the analog data into digital form. The digital data is used for the purpose of easy processing, transmission, digital display and storage.</p> <p>5. Recorders and Display Devices:- In display devices the data is displayed in a suitable form in order to monitor the input signals.</p>																				
5.	<table border="1"> <thead> <tr> <th>M.C Instruments</th> <th>M.I Instruments</th> </tr> </thead> <tbody> <tr> <td>1. MC type instruments are more accurate.</td> <td>1. MI type are less accurate than MC type.</td> </tr> <tr> <td>2. Manufacturing cost is high.</td> <td>2. Cheap in cost.</td> </tr> <tr> <td>3. Reading scale is uniformly distributed.</td> <td>3. Non-uniform scale (scale cramped at beginning and finishing)</td> </tr> <tr> <td>4. Very sensitive in construction & for input.</td> <td>4. Robust in construction.</td> </tr> <tr> <td>5. Low power consumption</td> <td>5. Slightly high power consumption.</td> </tr> <tr> <td>6. Eddy current damping is used.</td> <td>6. Air friction damping is used</td> </tr> <tr> <td>7. Can be used only for D.C measurements.</td> <td>7. Can be used for A.C as well as for D.C measurements.</td> </tr> <tr> <td>8. Controlling torque is provided by spring.</td> <td>8. Controlling torque is provided by gravity or spring</td> </tr> </tbody> </table>	M.C Instruments	M.I Instruments	1. MC type instruments are more accurate.	1. MI type are less accurate than MC type.	2. Manufacturing cost is high.	2. Cheap in cost.	3. Reading scale is uniformly distributed.	3. Non-uniform scale (scale cramped at beginning and finishing)	4. Very sensitive in construction & for input.	4. Robust in construction.	5. Low power consumption	5. Slightly high power consumption.	6. Eddy current damping is used.	6. Air friction damping is used	7. Can be used only for D.C measurements.	7. Can be used for A.C as well as for D.C measurements.	8. Controlling torque is provided by spring.	8. Controlling torque is provided by gravity or spring	1*6	6	
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6.	<p>The main functional elements of a measurement system are:</p> <ul style="list-style-type: none"> i) Primary sensing element ii) Variable conversion element iii) Variable manipulation element iv) Signal conditioning element v) Data transmission element vi) Data presentation element. 	1*6	6																			

Primary sensing element

The quantity or the variable which is being measured makes its first contact with the primary sensing element of a measurement system. The measurement is thus first detected by primary sensor or detector. The measurement is then immediately converted into an analogous electrical signal. This is done by a transducer.

Variable conversion element

The output signal of the variable sensing element may be any kind. It could be a mechanical or electrical signal. It may be a deflection of elastic member or some electrical parameter, such as, voltage, frequency etc. Sometimes, the output from the sensor is not suited to the measurement system. For the instrument to perform the desired function, it may be necessary to convert this output signal from the sensor to some other suitable form while preserving the information content of the original signal.

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.

Signal conditioning element

The output signal of transducers contains information which is further processed by the system. This signal could be contaminated by unwanted signals like noise due to an extraneous source which may interfere with the original output signal. The operations performed on the signal, to remove the signal contamination or distortion, is called Signal Conditioning.

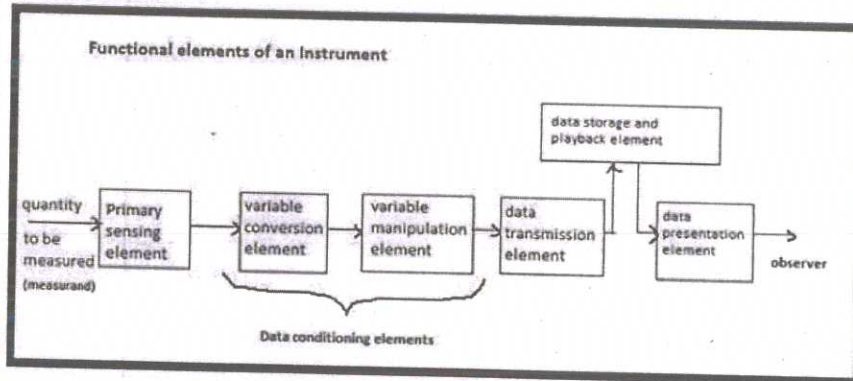
Data transmission element

There are several situations where the elements of an instrument are actually physically separated. In such situations it becomes necessary to transmit data from one element to another. The element that

performs this function is called a Data Transmission Element

Data presentation element

The function of data presentation element is to convey the information about the quantity under measurement to the personnel handling the instrument or the system for monitoring, control, or analysis purposes.



7.

A **fiber optic sensor** is a sensor that uses optical fiber either as the sensing element ("intrinsic sensors"), or as a means of relaying signals from a remote sensor to the electronics that process the signals ("extrinsic sensors"). Fibers have many uses in remote sensing. Depending on the application, fiber may be used because of its small size, or because no electrical power is needed at the remote location, or because many sensors can be multiplexed along the length of a fiber by using light wavelength shift for each sensor, or by sensing the time delay as light passes along the fiber through each sensor. Time delay can be determined using a device such as an optical time-domain reflectometer and wavelength shift can be calculated using an instrument implementing optical frequency domain reflectometry.

Fiber optic sensors are also immune to electromagnetic interference, and do not conduct electricity so they can be used in places where there is high voltage electricity or flammable material such as jet fuel. Fiber optic sensors can be designed to withstand high temperatures as well.

6

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PART C

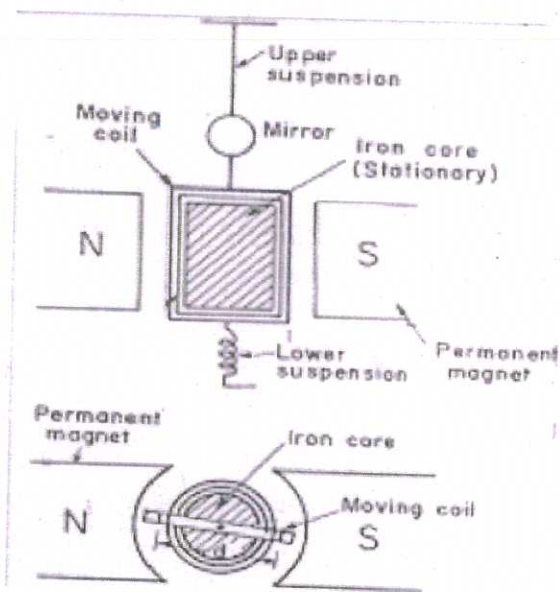
III

a

Moving coil galvanometer is an electromagnetic device that can measure small values of current. It consists of permanent horseshoe magnets, coil, soft iron core, pivoted spring, non-metallic frame, scale, and pointer.

Principle

Torque acts on a current carrying coil suspended in the uniform magnetic field. Due to this, the coil rotates. Hence, the deflection in the coil of a moving coil galvanometer is directly proportional to the current flowing in the coil.



It consists of a rectangular coil of a large number of turns of thinly insulated copper wire wound over a light metallic frame. The coil is suspended between the pole pieces of a horseshoe magnet by a fine phosphor – bronze strip from a movable torsion head. The lower end of the coil is connected to a hairspring of phosphor bronze having only a few turns. The other end of the spring is connected to a binding screw. A soft iron cylinder is placed symmetrically inside the coil. The hemispherical magnetic poles produce a radial magnetic field in which the plane of the coil is parallel to the magnetic field in all its positions. A small plane mirror attached to the suspension wire is used along with

3+6

9

15

		a lamp and scale arrangement to measure the deflection of the coil.																								
III	b	<table border="1"> <thead> <tr> <th>BASIS FOR COMPARISON</th> <th>ACCURACY</th> <th>PRECISION</th> </tr> </thead> <tbody> <tr> <td>Meaning</td> <td>Accuracy refers to the level of agreement between the actual measurement and the absolute measurement.</td> <td>Precision implies the level of variation that lies in the values of several measurements of the same factor.</td> </tr> <tr> <td>Represents</td> <td>How closely result agree with the standard value?</td> <td>How closely the results agree with one another?</td> </tr> <tr> <td>Degree</td> <td>Degree of conformity</td> <td>Degree of reproducibility</td> </tr> <tr> <td>Factor</td> <td>Single factor</td> <td>Multiple factors</td> </tr> <tr> <td>Measure of</td> <td>Statistical bias</td> <td>Statistical variability</td> </tr> <tr> <td>Concerned with</td> <td>Systematic Error</td> <td>Random Error</td> </tr> </tbody> </table>	BASIS FOR COMPARISON	ACCURACY	PRECISION	Meaning	Accuracy refers to the level of agreement between the actual measurement and the absolute measurement.	Precision implies the level of variation that lies in the values of several measurements of the same factor.	Represents	How closely result agree with the standard value?	How closely the results agree with one another?	Degree	Degree of conformity	Degree of reproducibility	Factor	Single factor	Multiple factors	Measure of	Statistical bias	Statistical variability	Concerned with	Systematic Error	Random Error	1*6	6	
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IV	a	<p>Digital frequency meter is a general purpose instrument that displays the frequency of a periodic electrical signal to an accuracy of three decimal places. It counts the number events occurring 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 the counter reset to zero. Various types of instruments are available</p>	3+6	9	15																					

		<p>which operates at a fixed or variable frequency. But if we operate any frequency meter at different frequencies than the specified range, it could carry out abnormally. For measuring low frequencies, we usually use deflection type meters. The deflection of the pointer on the scale shows the change in frequency. The deflection type instruments are of two types: one is electrically resonant circuits, and other is ratio meter.</p> <p>Operating Principle of Digital Frequency Meter</p> <p>A frequency meter has a small device which converts the sinusoidal voltage of the frequency into a train of unidirectional pulses. The frequency of input signal is the displayed count, averaged over a suitable counting interval out of 0.1, 1.0, or 10 seconds. These three intervals repeat themselves sequentially. As the ring counting units reset, these pulses pass through the time-base-gate and then entered into the main gate, which opens for a certain interval. The time base gate prevents a divider pulse from opening the main gate during the display 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 are not allowed to pass that means the flow of pulses get obstructed.</p> <p>The functioning of the gate is operated by the main-gate flip-flop. An electronic counter at the gate output that counts the number of pulses passed through the gate while it was open. As the main gate flip-flop receives next divider pulse, 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 couples to a numeric indicator, which provides the digital display. As the reset pulse generator is triggered, ring counters get reset automatically, and the same procedure starts again.</p> <p>The range of modern digital frequency meter is between the range from 10^4 to 10^9 hertz. The possibility of relative measurement error ranges between from 10^{-9} to 10^{-11} hertz and a sensitivity of 10^{-2} volt.</p>			
IV	b	<ul style="list-style-type: none"> • AC/DC Voltage Range: .5/1.5/3/5/12/15/30/50/120/150/300/500 V • AC/DC Current Range :200μA/2/20/200mA/1A/10A • Input impedance:11MΩ for AC and DC • Resistance Range: .2Ω to 100 MΩ • Accuracy:±3% 	1*6	6	

• Frequency Response: 500 kHz

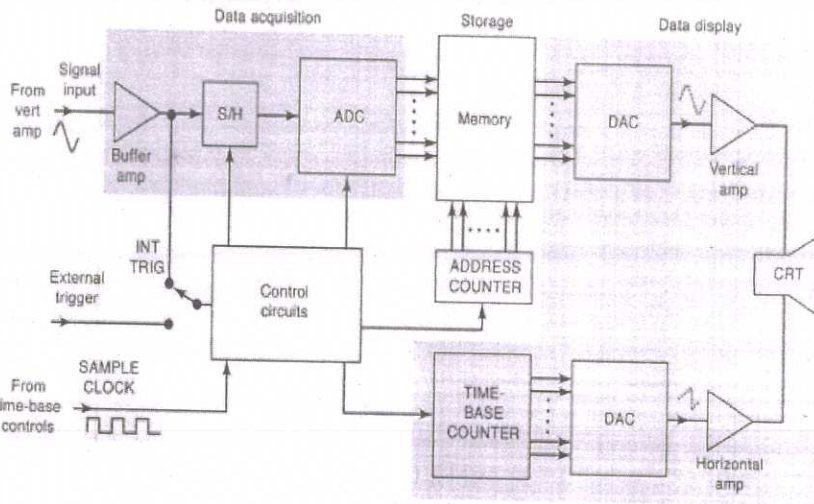
V

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4+5

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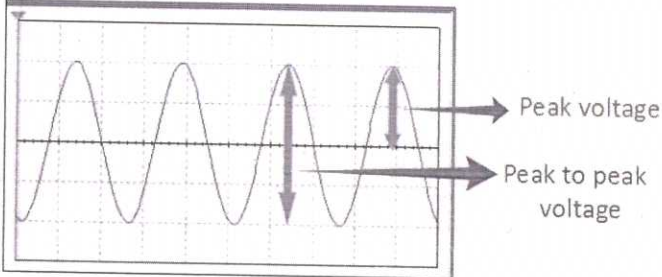
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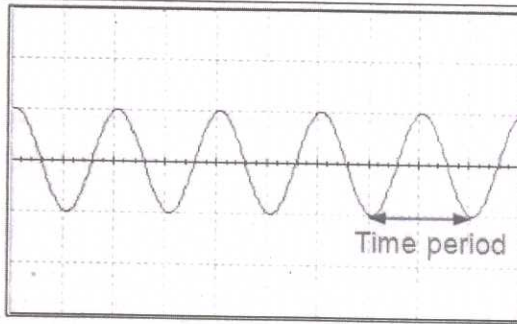


The block diagram of digital storage oscilloscope is shown in above figure. In this method, the waveform to be stored is digitized, stored in a digital memory and retrieved for display on the storage oscilloscope. The stored waveform is continuously displayed by repeatedly scanning the stored waveform and a conventional CRO tube can be used for the display. The stored display can be displayed indefinitely as long as power is applied to the memory, which can be supplied with a small battery. The input is amplified and attenuated with input amplifiers.

The output of the input signal amplifiers feeds an analog to digital converter (ADC). There are numbers of ADC available. But the selection of ADC is depends on the speed of converters, because the conversation of analog to digital signal should be in fast rate. A digital storage oscilloscope digitizes the input signal, so that all subsequent signals are digital. The storage occurs in electronic digital memory.

The input signal is digitized and stored in memory in digital form. In this state it is capable of being analyzed to produce a variety of different information. To view the display on the CRT, the data from memory is reconstructed in analog form. Digitizing occurs by taking a sample of the input waveform at periodic intervals. In order to ensure that no information is lost, the sampling rate must be at least twice as fast as the highest frequency in input signal. If this is not

		<p>done then aliasing will result.</p> <p>This requirement for a high sampling rate means that the digitizer must have fast conversion rate. Hence requires flash analog to digital converters, whose resolution decreases as the sampling rate is increased. Hence bandwidth and resolution of a <u>digital oscilloscope</u> depends on analog to digital converters.</p>			
V	b	<ul style="list-style-type: none"> The oscilloscope screen consists of the grids which can be external or internal to the screen of CRO, which divides both the horizontal axis (voltage) and the vertical axis (time) into divisions which will be helpful in making the measurements. <p>MEASUREMENT OF VOLTAGE</p>  <ul style="list-style-type: none"> To measure the ac. voltage of sinusoidal waveform. The input ac. signal is applied from the signal generator to a channel of CRO. The voltage/div switch (Y-plates) and time base switch (X-plates) are adjusted such that a steady picture of the waveform is obtained on the screen. The vertical height (L) i.e. peak-to-peak height is measured. When this peak-to-peak height (L) is multiplied by the voltage/div. (voltage deflection sensitivity 'n') we get the peak-to-peak voltage (2V_o). From this we get the peak voltage (V_o). The rms voltage V_{rms} is equal to. This rms voltage V_{rms} is verified with rms voltage value, measured by the multimeter. <p>MEASUREMENT OF FREQUENCY</p> <p>Using time-period:</p> <p>From the trace the time period of the input signal is equal to 't' times the value of time/div setting. Suppose that the time period of the input signal is T. As we know frequency is the reciprocal of time period. Then, the frequency of the signal = 1/T</p>	3*2	6	



Using Lissajous figure:

- When two signals having some frequency are applied to input terminal of CRO and get superimposed perpendicularly (when A/B or B/A is pressed), then a pattern of closed figure is obtained which is known as LISSAJOUS FIGURE.
- This is easily done on an oscilloscope in XY mode.
- The signal whose frequency to be measured is given on vertical plate and signal whose frequency is given to horizontal plate.
- Now the known frequency is adjusted such that a Lissajous pattern can be obtained, which depends on the ratio of the two frequencies.

VI

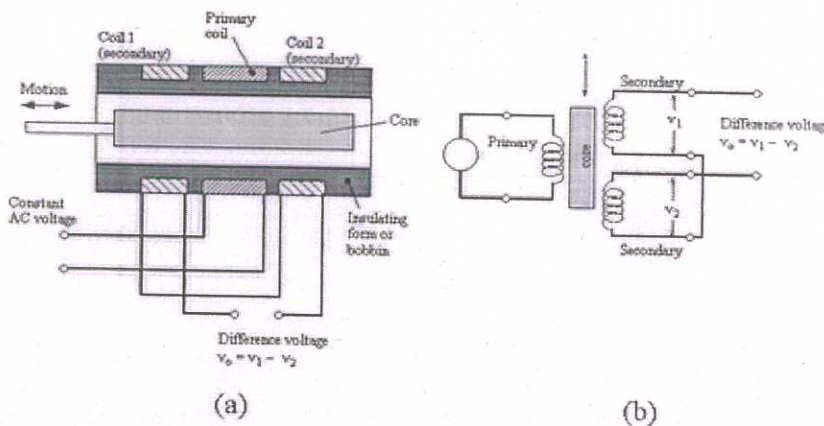
a

The LVDT full form is “Linear Variable Differential Transformer” is LVDT. Generally, LVDT is a normal type of transducer. The main function of this is to convert the rectangular movement of an object to the equivalent electrical signal. LVDT is used to calculate displacement and works on the transformer principle.

3+6

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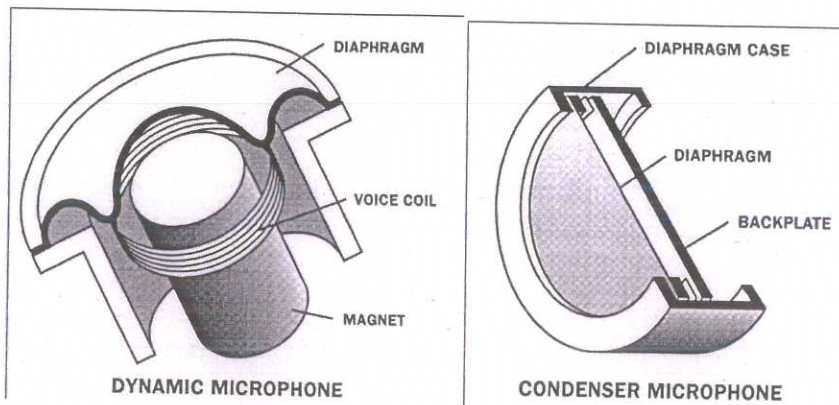


LVDT Construction

LVDT comprises of a cylindrical former, which is bounded by one main winding in the hub of the former and the two minor LVDT windings are wound on the surfaces. The amount of twists in both the

		<p>minor windings is equivalent, but they are reverse to each other like clockwise direction and anti-clockwise direction. For this reason, the o/p voltages will be the variation in voltages among the two minor coils. These two coils are denoted with S1 & S2. Esteem iron core is located in the middle of the cylindrical former. The excitation voltage of AC is 5-12V and the operating frequency is given by 50 to 400 HZ.</p> <p>Working Principle of LVDT</p> <p>The working principle of the linear variable differential transformer or LVDT working theory is mutual induction. The dislocation is a nonelectrical energy that is changed into an <u>electrical energy</u>.</p> <p>Working of an LVDT</p> <p>The working of LVDT circuit diagram can be divided into three cases based on the position of the iron core in the insulated former.</p> <ul style="list-style-type: none"> • In Case-1: When the core of the LVDT is at the null location, then both the minor windings flux will equal, so the induced e.m.f is similar in the windings. So for no dislocation, the output value (e_{out}) is zero because both the e_1 & e_2 are equivalent. Thus, it illustrates that no dislocation took place. • In Case-2: When the core of the LVDT is shifted to up to the null point. In this case, the flux involving with minor winding S1 is additional as contrasted to flux connecting with the S 2 winding. Due to this reason, e_1 will be added as that of e_2. Due to this e_{out} (output voltage) is positive. • In Case-3: When the core of the LVDT is shifted down to the null point, In this case, the amount of e_2 will be added as that of e_1. Due to this e_{out} output voltage will be negative plus it illustrates the o/p to down on the location point. 			
VI	b	<p>Operating principle - The type of <i>transducer</i> inside the microphone, that is, how the microphone picks up sound and converts it into an electrical signal. The two most common types are Dynamic and Condenser.</p>	6	6	

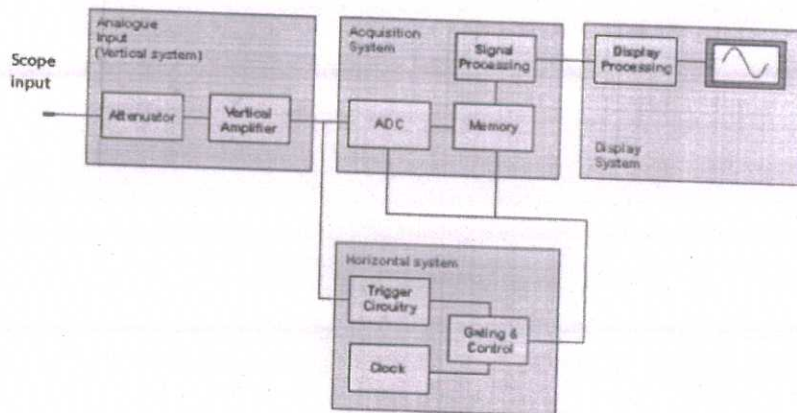
Dynamic microphones employ a diaphragm/ voice coil/magnet assembly which forms a miniature sound driven electrical generator. Sound waves strike a thin plastic membrane (diaphragm) which vibrates in response. A small coil of wire (voice coil) is attached to the rear of the diaphragm and vibrates with it. The voice coil itself is surrounded by a magnetic field created by a small permanent magnet. It is the motion of the voice coil in this magnetic field which generates the electrical signal corresponding to the sound picked up by a dynamic microphone.



Condenser microphones are based on an electrically-charged diaphragm/backplate assembly which forms a sound-sensitive capacitor. Here, sound waves vibrate a very thin metal or metal-coated-plastic diaphragm. The diaphragm is mounted just in front of a rigid metal or metal-coated-ceramic backplate. In electrical terms this assembly or element is known as a capacitor (historically called a "condenser"), which has the ability to store a *charge* or voltage. When the element is charged, an electric field is created between the diaphragm and the backplate, proportional to the spacing between them. It is the variation of this spacing, due to the motion of the diaphragm relative to the backplate, that produces the electrical signal corresponding to the sound picked up by a condenser microphone.

VII

a



3+4+2

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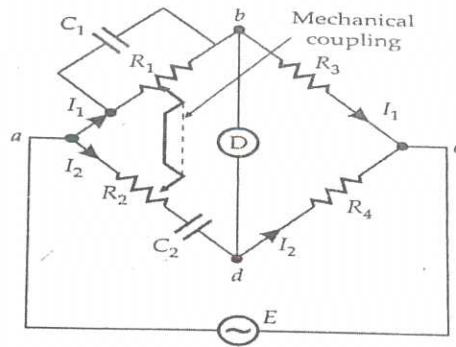
The logic analyzer is an advanced instrument that displays the content of numerous digital data streams simultaneously and in various formats. It can capture state-mode data, and with a high channel count, it has greater analytic depth and insight. The oscilloscope, in contrast, has high sample rate and bandwidth, permitting it to capture and display a greater number of data points over a longer time period. Compared to the logic analyzer, amplitude and frequency can be displayed in greater detail and measured more accurately. The user can see signal transitions, transient events and temporally small increments. The oscilloscope can better capture details including ringing, overshoot, rising edge roll-off, and other periodic aberrations. Digital oscilloscopes and logic analyzers are both based on sampling techniques. Signal measurements are transformed into digital value by a high-speed analog-to-digital converter and stored in memory at regular intervals defined by the instrument sampling clock. But a logic analyzer displays signals as binary values, according to whether the measured voltage is above or below a conventional voltage level called threshold value. In the logic-state-analysis mode, the logic analyzer makes use of clock signals that come from within the equipment under investigation. Data is sampled and stored in memory as it is synchronized within the connected equipment. A binary or hexadecimal display is created. This method is an example of synchronous measurement and, in contrast to the logic timing analysis mode, it addresses software problems. In the state analysis mode, data is displayed as a list or graph. In the timing analysis mode, the user sees a logic timing diagram potentially consisting of input from the full number of connected channels.

Application:

1. Hardware/Software debugging
2. Parametric/mixed signal testing
3. Hardware simulation and stimulus response testing
4. Complex debugging with deep memory

VII

b



3+3

6

At balance

$$\left(\frac{R_1}{1 + j\omega C_1 R_1} \right) R_4 = \left(R_2 - \frac{j}{\omega C_2} \right) R_3$$

or

$$\frac{R_4}{R_3} = \frac{R_2}{R_1} + \frac{C_1}{C_2} + j \left(\omega C_1 R_2 - \frac{1}{\omega C_2 R_1} \right)$$

Equating the real and imaginary parts,

or

$$\frac{R_4}{R_3} = \frac{R_2}{R_1} + \frac{C_1}{C_2} \quad \dots(16)$$

and

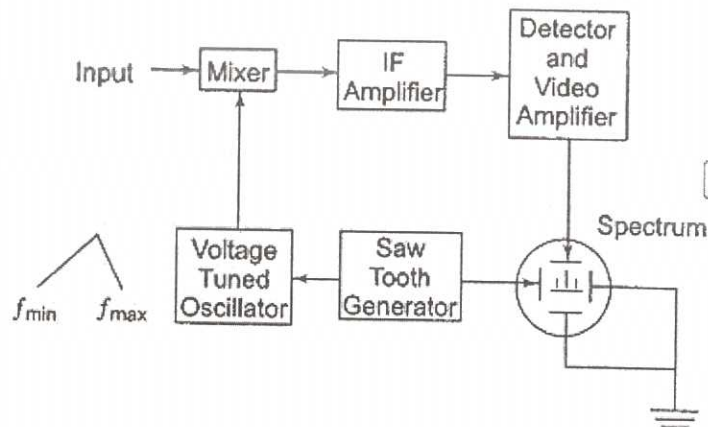
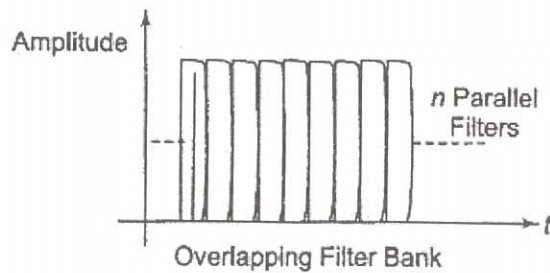
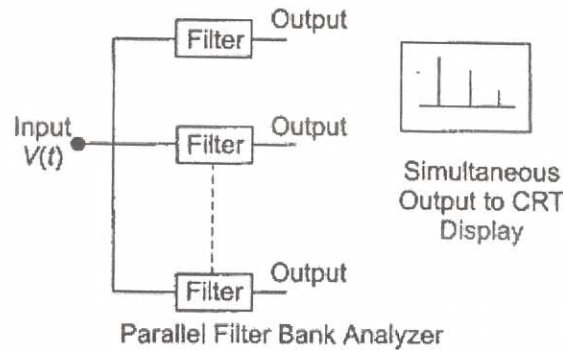
$$\omega C_1 R_2 - \frac{1}{\omega C_2 R_1} = 0$$

from which

$$\omega = \frac{1}{\sqrt{R_1 R_2 C_1 C_2}}$$

and frequency,

$$f = \frac{1}{2\pi \sqrt{R_1 R_2 C_1 C_2}} \text{ Hz.}$$

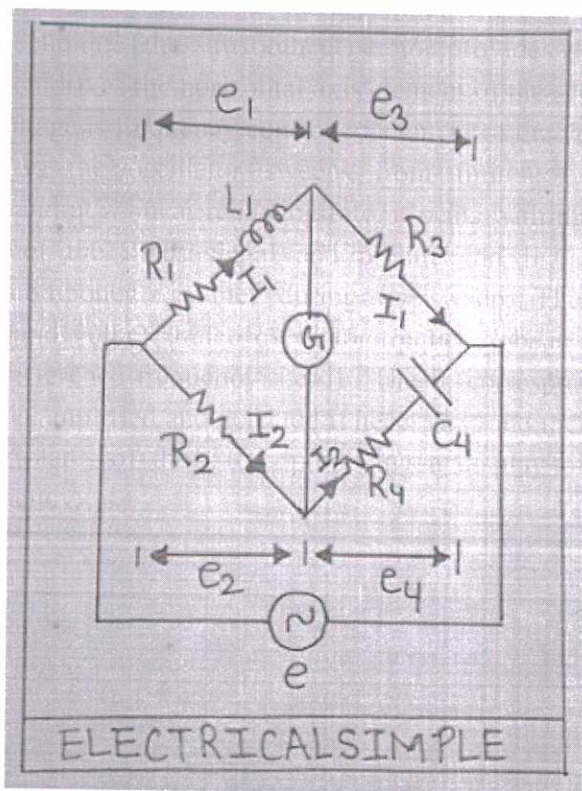


The most common way of observing signals is to display them on an oscilloscope, with time as the X-axis (i.e. amplitude of the signal versus time). This is the time domain. It is also useful to display signals in the frequency domain. The instrument providing this frequency domain view is the spectrum analyzer. A Spectrum Analyzer Block Diagram provides a calibrated graphical display on its CRT, with frequency on the horizontal axis and amplitude (voltage) on the vertical axis. Displayed as vertical lines against these coordinates are sinusoidal components of which the input signal is composed. The height represents the absolute magnitude, and the horizontal location represents the frequency. These instruments provide a display of the frequency spectrum over a given frequency

band. Spectrum analyzers use either a parallel filter bank or a swept frequency technique. The sawtooth generator provides the sawtooth voltage which drives the horizontal axis element of the scope and this sawtooth voltage is frequency controlled element of the voltage tuned oscillator. As the oscillator sweeps from f_{min} to f_{max} of its frequency band at a linear recurring rate, it beats with the frequency component of the input signal and produce an IF, whenever a frequency component is met during its sweep. The frequency component and voltage tuned oscillator frequency beats together to produce a difference frequency, i.e. IF. The IF corresponding to the component is amplified and detected if necessary, and then applied to the vertical plates of the CRO, producing a display of amplitude versus frequency.

VIII

b



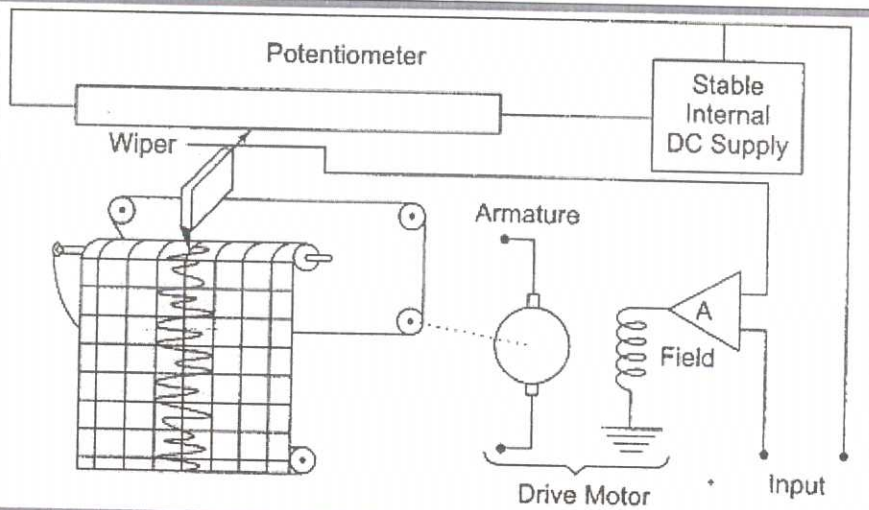
Hay's bridge circuit

where,
 L_1 = unknown inductance having resistance R_1
 R_2, R_3, R_4 = known non-inductive resistances
 C_4 = standard capacitor

3+3

6

		<p>The bridge is balanced when current through galvanometer becomes zero, then $e_1 = e_2$ and $e_3 = e_4$ or $Z_1 Z_4 = Z_2 Z_3$ $(R_1 + j\omega L_1)[R_4 - (j/\omega C_4)] = R_2 R_3$</p> <p><u>Multiplying and equating real and imaginary parts</u> $R_1 R_4 + (L_1/C_4) = R_2 R_3 \dots(1)$ and $j\omega L_1 R_4 - (jR_1/\omega C_4) = 0 \dots(2)$</p> <p><u>Solving (1) and (2)</u> $L_1 = R_2 R_3 C_4 / (1 + \omega^2 C_4^2 R_4^2)$ $R_1 = \omega^2 C_4^2 R_2 R_3 C_4 / (1 + \omega^2 C_4^2 R_4^2)$</p>			
IX	a	<p>The disadvantage of the galvanometer recorder can be eliminated by using an amplifier between the test terminals and the moving coil meter. However this reduces the accuracy of the record. In a potentiometric recorder the accuracy is improved by a process of comparison of input signal with a reference voltage. The reference voltage will be supplied from an internal source of the recorder itself. When the input signal is given it is applied in series with the reference signal such that the difference of the input signal and the reference signal will produce an error. If the input is lower than the reference voltage the error can be taken as negative. If the input is more than the reference voltage the error can be taken as positive. Only in one condition when the input equals the reference voltage the error will be zero.</p> <p>The error signal will be given to the amplifier. The amplifier output will control a motor. The speed and direction of rotation of the motor depend on the output of the amplifier which is the error signal. Self balance is obtained by sliding the slider of the potentiometer to get a null output. Reversible motors are used in the D.C. system. In A.C. system a two phase motor is used.</p> <p>(a) Constructional Details of Self Balancing Recorder (Block Diagram):</p>	3(fig)+6	9	15



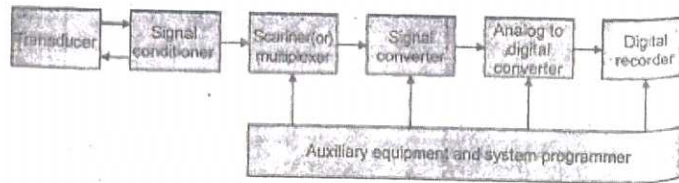
Potentiometric recorder block diagram

The self balancing type recorder is also called the potentiometric recorder. The constructional details are shown in figure. From the block diagram shown, it can be seen that the input signal is applied to the amplifier in series with the part of the potentiometer. The potentiometer is supplied with a reference voltage derived from an internal power supply. The output of the internal power supply is made stable. The field coil of the motor is energized by the output of the amplifier. The output of the amplifier is the error signal. The variable arm/slider/wiper of the potentiometer is connected to the armature of the motor. The wiper carries a pen. The paper feed mechanism moves the paper with a constant speed.

IX	b	<p>Strip Chart Recorder:</p> <ul style="list-style-type: none"> • Also known as X t plotter • Input variable is plotted as a function of time • Paper is kept rotating • Zero offset adjustments are not available <p>X-Y Recorder</p> <ul style="list-style-type: none"> • Also known as X Y plotter • One input variable is plotted as a function of other • Paper is held stationary • Zero offset adjustments are available • 	1*6	6
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X

a



3+6

9

15

In general analog DASs are used for measurement systems with wide bandwidth. But the accuracy is less. So digital DASs which have high accuracy, low perchannel cost and narrow bandwidth (slowly varying signal) are designed. Figure shows the block diagram of a digital data acquisition system. The function of the digital data acquisition system include handling analog signals, making the measurement, converting and handling digital data, internal programming and control. Block diagram of a digital data-acquisition system Here, the transducer translates physical parameters to electrical signals acceptable by the acquisition system. The physical parameters include temperature, pressure, acceleration, weight, displacement, velocity etc. Electrical quantities such as voltage, stance, and frequency may be measured directly. The signal conditioner includes the supporting circuitry for the transducer. This circuit may provide excitation power, balancing circuits and calibration elements and an example of this is a strain-gauge bridge lance and power supply unit The scanner or multiplexer accepts multiple analog inputs and sequentially connects them to one measuring instrument. The signal converter translates the analog signal to a form acceptable by the analog to digital converter like an amplifier used for amplifying low-level voltages generated by thermocouples or strain gauges. The analog to digital converter (ADC) converts the analog voltage to its equivalent digital form. The output of the ADC may displayed visually and is also available as voltage outputs indiscrete steps for further processing or recording on a digital recorder. The auxiliary section contains instruments for system programming and digital data processing such as linearizing and limit comparison. These functions may be performed by individual instruments or by a digital computer. The digital recorder records digital information on punched cards, perforated paper tape, magnetic tape, typewritten pages or a combination of these systems. Digital recorder may be preceded by a coupling unit that translates the digital information to the proper form for entry into particular digital recorder selected.

X	b	<p><u>Effect of output</u></p> <ul style="list-style-type: none"> – An open loop control system acts completely on the basis of input and the output has no effect on the control action. – A closed loop control system considers the current output and alters it to the desired condition. The control action in these systems is based on the output. <p><u>Reaction to Internal and External Disturbances</u></p> <ul style="list-style-type: none"> – An open loop control system works on fixed operation conditions and there are no disturbances. – A closed loop control system doesn't encounter and react on external disturbances or internal variations. <p><u>Stability</u></p> <ul style="list-style-type: none"> – Open loop control systems are mostly stable. – In closed loop control systems stability is a major issue. <p><u>Effect on gain</u></p> <ul style="list-style-type: none"> – There is no effect on gain. – There is no-linear change in system gain. <p><u>Implementation</u></p> <ul style="list-style-type: none"> – The structure of open loop control system is rather easy to construct. These systems can be easily implemented. – The working principle and structures of closed loop control systems are rather complex and they are often difficult to implement. <p><u>Cost</u></p> <ul style="list-style-type: none"> – As an open loop control system is easy to implement, it needs lesser number of components to be constructed. Such systems need good calibration and lesser power rating. The overall cost of these systems is 	1*6	6	
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		<p>low.</p> <p>– As the principle is complex, a closed loop control system needs larger number of components than an open loop control systems. These systems comparatively need less calibration and higher power rating. The overall cost of these systems is higher.</p>			
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