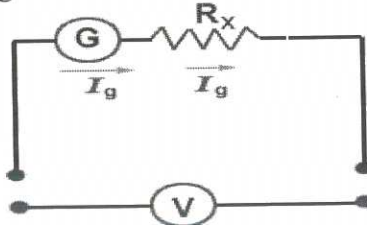
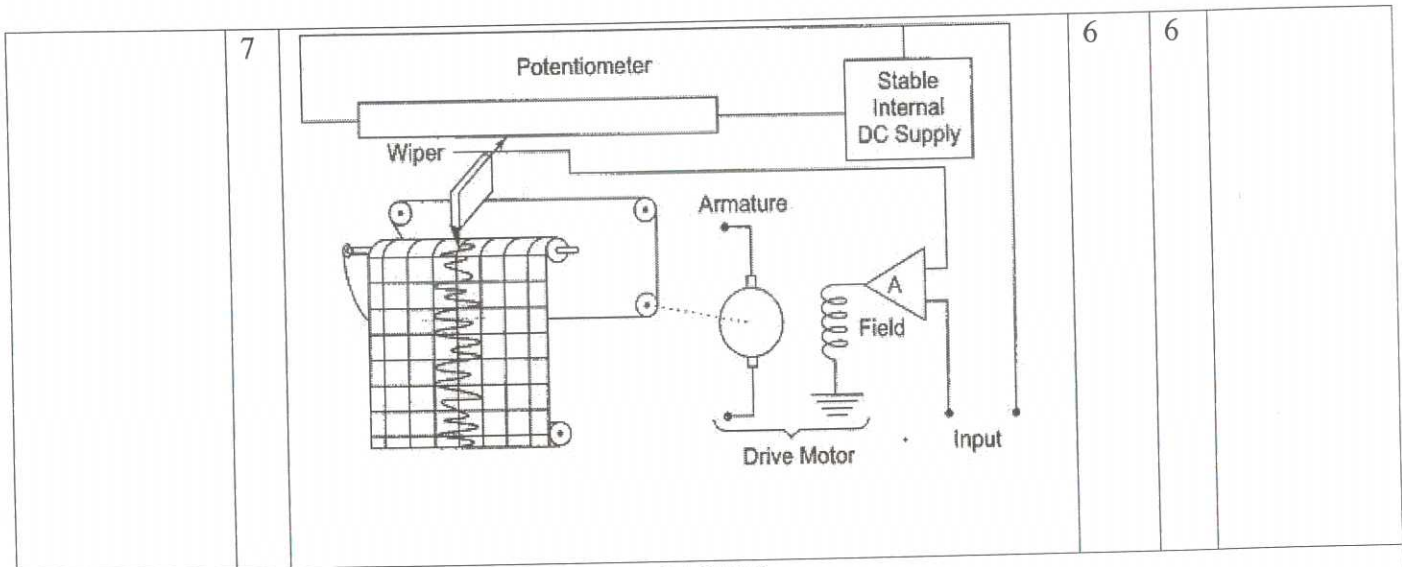


SCHEME OF VALUATION
(SCORING INDICATORS)

Revision 2015		Course Code:4041			
Course Title:Electronics Instruments & Measurements					
Quest No	SCORING INDICATORS	Score	Split Up	SubTotal	Total
PART A					
I	Part A				
	1	Smallest change in a measured variable to which an instrument will respond	2	2	10
	2	To measure amplitude, time period, frequency and phase of wave forms	2	2	
	3	Logic analyzers are test instruments that are widely used for testing complex digital or logic circuits.	2	2	
	4	Series Resonance, $X_L = X_C$	2	2	
	5	Telemetry is an automated communications process by which measurements and other data are collected at remote location and transmitted to receiving equipment for monitoring	2	2	
PART B					
II	1	<p>A basic Galvanometer can be converted into voltmeter, by connecting a very high resistance in series with the galvanometer.</p> 	2	6	30
			2		

	<p>If potential between the points to be measured = V and if galvanometer gives full-scale deflection, when current "I_g" passes through it. Then,</p> $V = I_g (R_g + R_x)$ $V = I_g R_g + I_g R_x$ $V - I_g R_g = I_g R_x$ $R_x = (V - I_g R_g) / I_g$ $R_x = \frac{V}{I_g} - R_g$ <p>Thus R_x can be found.</p>	2		
2	<p>*AC Voltage ±4% of full scale 0 - 10, 50, 250, 500 Volts Sensitivity 5k Ω/ V *DC Voltage ±3% of full scale 0 - 10, 50, 250, 500 Sensitivity 20k Ω/ V *Direct Current ±3% of full scale 0 - 250 mA *Resistance ±3% of scale length 0 - 5K, 50K, 500KΩ *Internal Battery 1.5V, size "AA" Fuse 0.15A *Operating Temperature -10 to 55°C</p>	6	6	
3	<p style="text-align: center;">Fig. 7.51 Digital Storage CRO</p>	6	6	
4	<p>The capacitive transducer is used for measuring the displacement, pressure and other physical quantities. The capacitive transducer works on the principle of variable capacitances. The capacitance of the capacitive transducer changes because of many reasons like overlapping of plates, change in distance between the plates and dielectric constant. The equations below express the capacitance</p>	3	6	

		$C = \epsilon A/d$ $C = \epsilon_r \epsilon_0 A/d$ Where between the plates of a capacitor A – overlapping area of plates in m ² d – the distance between two plates in meter ε – permittivity of the medium in F/m ε _r – relative permittivity ε ₀ – the permittivity of free space		3																																															
5	1.Study of RF spectrum in microwave instruemnt 2.Communication Radar 3.Oceanography 4.Biomedical fields 5.Industial instrumentation 6.Navigation			6																																															
6	<table border="1"> <tr> <td>Basis for comparison</td> <td>Open Loop System</td> <td>Closed Loop System</td> <td>6</td> <td>6</td> </tr> <tr> <td></td> <td>Non-feedback System</td> <td>Feedback System</td> <td></td> <td></td> </tr> <tr> <td>Defenition</td> <td>The system whose control action is free from the output is known as the open loop control system</td> <td>In closed loop, the output depends on the control action of the system.</td> <td></td> <td></td> </tr> <tr> <td>Accuracy</td> <td>Moderate</td> <td>Accurate</td> <td></td> <td></td> </tr> <tr> <td>Construction</td> <td>Simple</td> <td>Complex</td> <td></td> <td></td> </tr> <tr> <td>Stability</td> <td>Stable</td> <td>Less Stable</td> <td></td> <td></td> </tr> <tr> <td>Climate factor</td> <td>sensitive</td> <td>Insensitive</td> <td></td> <td></td> </tr> <tr> <td>cost</td> <td>low</td> <td>High</td> <td></td> <td></td> </tr> <tr> <td>bandwidth</td> <td>Small</td> <td>Large</td> <td></td> <td></td> </tr> </table>	Basis for comparison	Open Loop System	Closed Loop System	6	6		Non-feedback System	Feedback System			Defenition	The system whose control action is free from the output is known as the open loop control system	In closed loop, the output depends on the control action of the system.			Accuracy	Moderate	Accurate			Construction	Simple	Complex			Stability	Stable	Less Stable			Climate factor	sensitive	Insensitive			cost	low	High			bandwidth	Small	Large							
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Stability	Stable	Less Stable																																																	
Climate factor	sensitive	Insensitive																																																	
cost	low	High																																																	
bandwidth	Small	Large																																																	



PART C

III	(a)	<ol style="list-style-type: none"> 1. Accuracy The degree of exactness (closeness) of a measurement compared to the expected (desired) value. 2. Precision A measure of the consistency or repeatability of measurements, i.e. successive reading do not differ. (Precision is the consistency of the instrument output for a given value of input). 3. Sensitivity The ratio of the change in output (response) of the instrument to a change of input or measured variable. 4. Error The deviation of the true value from the desired value. 	2	8	15
	(b)		3		
		<p>Fig. 2.2 Modern D'Arsonval Movement</p>	2		

*Instrument consists of a circular or rectangular coil of very fine insulated wire with many turns usually wound on an aluminium frame or bobbin and suspended between the poles of a permanent magnet

- The coil is suspended by a phosphor bronze filament which acts as one lead-in for the
- The other lead-in wire is very flexible wire at the e bottom of the coil.
- The poles of the magnet are usually cylindrical in shape and a cylindrical soft iron core is placed between the poles and coaxial with them.
- When current flows through the coil, a deflecting torque proportional to the flex density, the coil current and the dimensions of the coil makes the coil rotate on its vertical axis
- The deflecting torque is opposed by the restraining force of the suspension filament so that the coil does not continue to rotate as in a motor but turns until the deflecting force is balanced by the restraining force.
- Since the deflecting torque is directly proportional to the coil current, the amount of deflection and hence the amount of current flowing through the coil can be indicated by a pointer attached to the moving element, moving over a calibrated scale

2

IV (a)

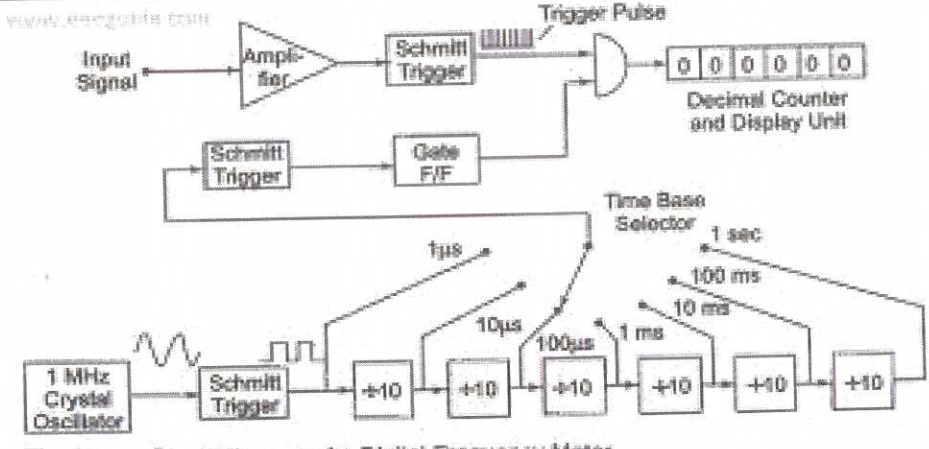


Fig. 8.7 Block Diagram of a Digital Frequency Meter

The block diagram of a digital frequency meter is shown. The assembly consisting of two F/Fs and two gates is called a gate control F/F. The input signal is amplified and converted to a square wave by a Schmitt trigger circuit. In this diagram, the square wave is differentiated and clipped to produce a train of pulses, each pulse separated by the period of the input signal. The time base selector output is obtained from an oscillator and is similarly converted into positive pulses. The first pulse activates the gate control F/F. This gate control F/F provides an enable signal to the AND gate. The trigger pulses of the input signal are allowed to pass through the gate for a selected time period and counted. The second pulse from the decade frequency divider changes the state of the control F/F and removes the enable signal from the AND gate, thereby closing it. The decimal counter and display unit output corresponds to the number of input pulses received during a precise time interval; hence the counter display corresponds to the frequency.

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(b)

Figure shows the ac voltmeter section of a multimeter. To measure ac voltage, the output ac voltage is rectified by a half wave rectifier before the current passes through the meter. Across the meter, the other diode serves as protection. The diode conducts when a reverse voltage appears across the diodes, so that current bypasses the meter in the reverse direction.

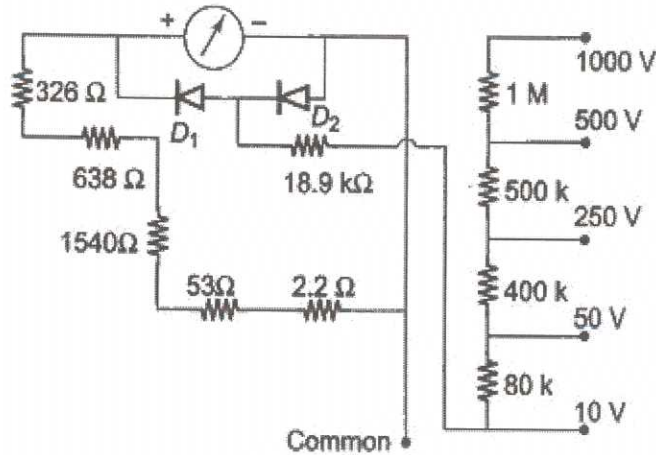


Fig. 4.37 AC Voltmeter Section of a Multimeter

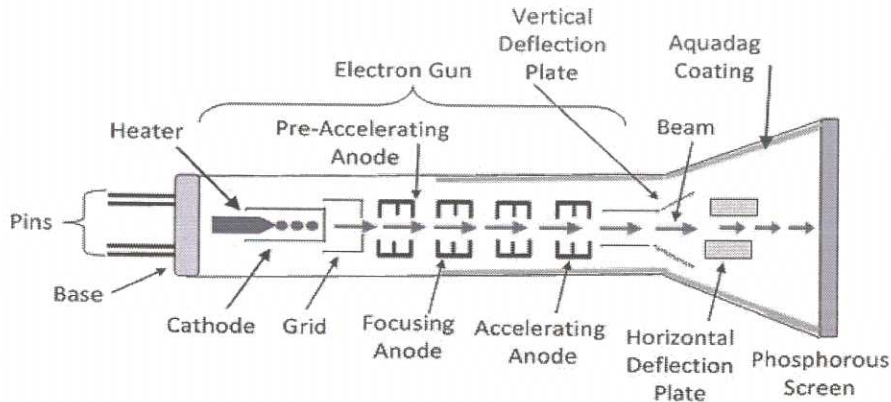
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V

a



Cathode Ray Tube

Circuit Globe

The Electrons Gun Assembly, Deflection Plate Assembly, Fluorescent Screen, Glass Envelope, Base are the important parts of the CRT. The electron gun emits the electron beam, and through deflecting plates, it is strikes on the phosphorous screen.

The electron gun is the source of the electron beams. The electron gun has a heater, cathode, grid, pre-accelerating anode, focusing anode and accelerating anode. The electrons are emitted from the highly emitted cathode. The beam is focused by focusing anode. The accelerating and focusing electrodes are

4

cylindrical in shape which has a small opening in the centre of each electrode. Two pairs of deflecting plates allow the beam of electrons. An electric field between the first pair of plates deflects the electrons horizontally, and an electric field between the second pair deflects them vertically. Screen is coated with special type of fluorescent material. Fluorescent material absorbs its energy and re-emits light in the form of photons when electron beam hits the screen

b

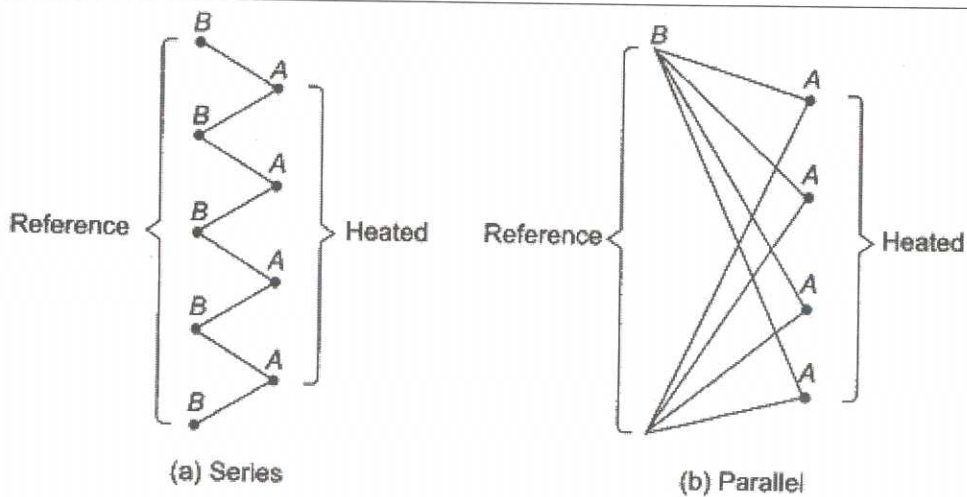


Fig. 13.48 Thermocouples in Series and Parallel (Thermopile)

Thermocouples are sometimes connected in series or parallel to provide increased voltage or current. In Fig. four thermocouples are connected in series, with wire A being positive and B being negative in each thermocouple installation. The total emf between points 1 to 5 is the sum of individual thermocouple emf. An arrangement of this type is called a *Thermopile* and is used to obtain increased sensitivity and greater absolute emf from a thermocouple installation. Figure shows four thermocouples in parallel. This arrangement provides a large current but emf is same as that of any one thermocouple.

VI

a

1 Direct Probe:

The simplest types of probe (one can hardly call it a probe) is the test lead. Test leads are simply convenient lengths of wire for connecting the CRO input to the point of observation. At the CRO end, they usually terminate with lugs, banana tips or other tips to fit the input jacks of the scope, and at the other end have a crocodile clip or any other convenient means for connection to the electronic circuit.

Since a CRO has high input impedance and high sensitivity, the test leads should be shielded to avoid hum pickup, unless the scope is connected to low impedance

high level circuits. Although the input impedances of most CROs are relatively very high compared to the circuits where they are connected, it is often desirable to increase their impedance to avoid loading of the circuits or causing unstable effects.

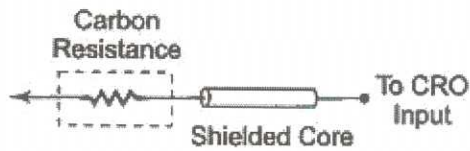


Fig. 7.44 Isolation Probe

2. Passive Voltage (High Z) Probe

If the probe head consists of passive elements, then it is called passive probe.

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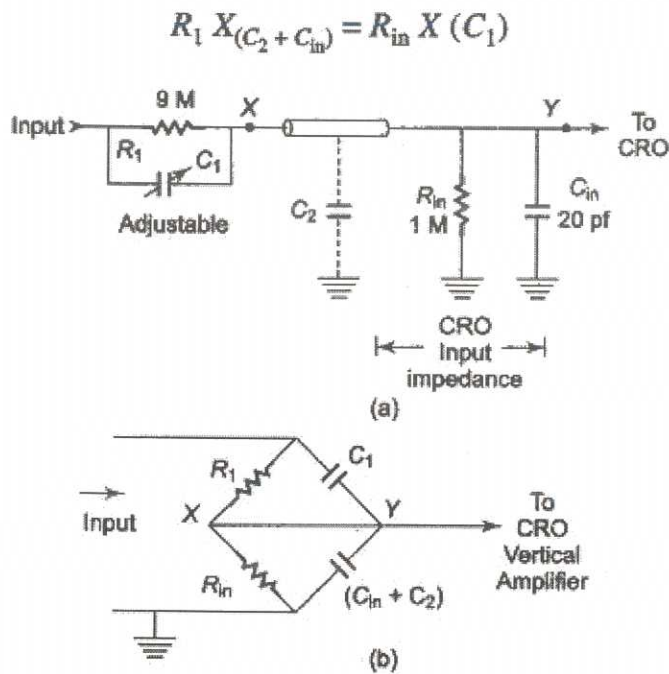


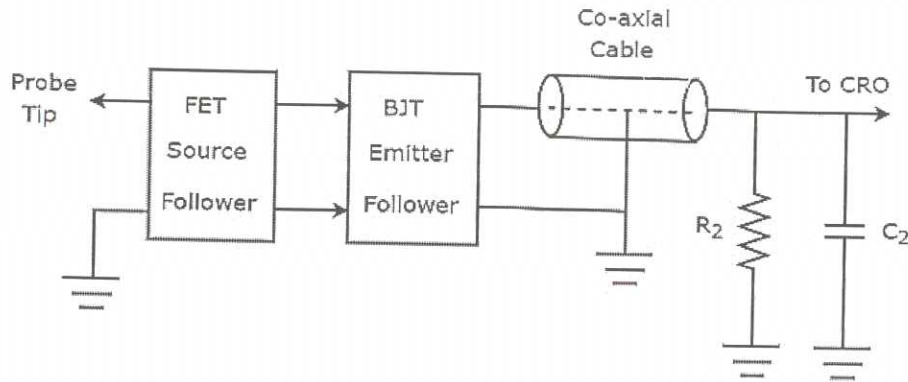
Fig. 7.45 (a) 10 : 1 Probe (b) Equivalent Circuit of 10 : 1 Probe

Figure shows a 10 : 1 probe. Figure (b) shows the equivalent circuit. The capacitor is adjusted so that the elements of the bridge are balanced. Unwanted effect of stray capacitance can be nullified by the use of variable capacitance C_1 and C_{in} of the CRO.

Active Probes

Active probes are designed to provide an efficient method of coupling high frequency, fast rise time signals to the CRO input. Usually active probes have very high input impedance, with less attenuation than passive probes. Active

devices may be diodes, FETs, BJTs, etc. Active probes are more expensive and bulky than passive probes, but they are useful for small signal measurements, because their attenuation is less. The FET source follower provides high input impedance and low output impedance. Whereas, the purpose of BJT emitter follower is that it avoids or eliminates the impedance mismatching. The other two parts, such as co-axial cable and termination circuit remain same in both active and passive probes.



3

b A better term for a sensor is a transducer. A transducer is any physical device that converts one form of energy into another. So, in the case of a sensor, the transducer converts some physical phenomenon into an electrical impulse that can then be interpreted to determine a reading. A microphone is a sensor that takes vibrational energy (sound waves), and converts it to electrical energy in a useful way for other components in the system to correlate back to the original sound. An actuator operates in the reverse direction of a sensor. It takes an electrical input and turns it into physical action. For instance, an electric motor, a hydraulic system, and a pneumatic system are all different types of actuators.

7

	sensor	actuator
Basic	Used to measure the continuous and discrete process variables.	Impel continuous and discrete processes parameters.
Placed at	input	output
Outcome	Electrical signal	Heat or motion
Example	Magnetometer, Cameras, Accelerometer, microphones.	LED, Laser, Loudspeaker, Solenoid, motor controllers

VII

a

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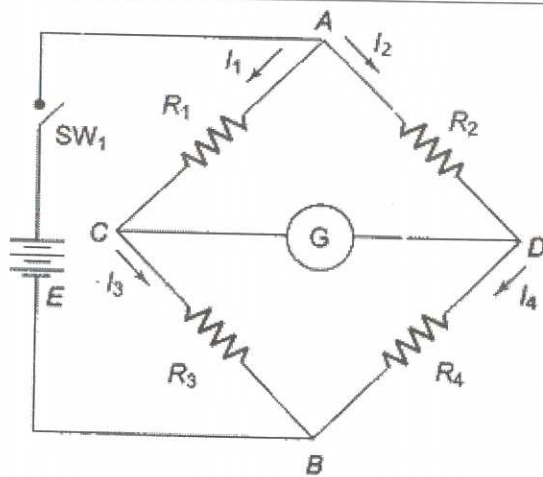


Fig. 11.1 Wheatstone's Bridge

A Wheatstone Bridge Circuit in its simplest form consists of a network of four resistance arms forming a closed circuit, with a dc source of current applied to two opposite junctions and a current detector connected to the other two junctions,

Wheatstone's bridge is the most accurate method available for measuring resistances and is popular for laboratory use. The circuit diagram of a typical Wheatstone Bridge Circuit is given in Fig. The source of emf and switch is connected to points A and B, while a sensitive current indicating meter, the galva-nometer, is connected to points C and D. The galvanometer is a sensitive microammeter, with a zero centre scale. When there is no current through the meter, the galvanometer pointer rests at 0, i.e. mid scale. Current in one direction causes the pointer to deflect on one side and current in the opposite direction to the other side. When SW1 is closed, current flows and divides into the two arms at point A, i.e. I_1 and I_2 . The bridge is balanced when there is no current through the galvanometer, or when the potential difference at points C and D is equal, i.e. the potential across the galvanometer is zero. To obtain the bridge balance equation, we have from the Fig. 11.1.

$$I_1 R_1 = I_2 R_2 \quad (11.1)$$

For For

the galvanometer current to be zero, the following conditions should be satisfied.

$$I_1 = I_3 = \frac{E}{R_1 + R_3} \quad (11.2)$$

$$I_2 = I_4 = \frac{E}{R_2 + R_4} \quad (11.3)$$

Substituting in Eq. (11.1)

$$\frac{E \times R_1}{R_1 + R_3} = \frac{E \times R_2}{R_2 + R_4}$$

$$R_1 \times (R_2 + R_4) = (R_1 + R_3) \times R_2$$

$$R_1 R_2 + R_1 R_4 = R_1 R_2 + R_3 R_2$$

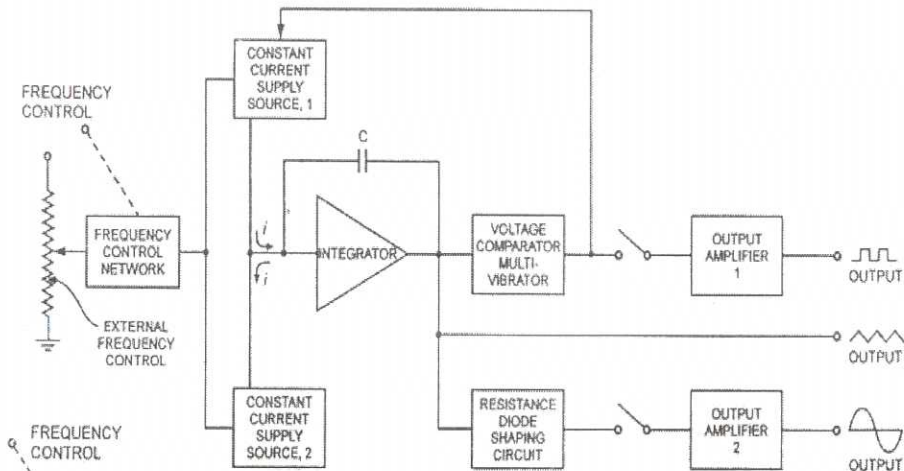
$$R_4 = \frac{R_2 R_3}{R_1}$$

This is the equation for the bridge to be balanced. In a practical Wheatstone Bridge Circuit, at least one of the resistance is made adjustable, to permit balancing. When the bridge is balanced, the unknown resistance (normally connected at R4) may be determined from the setting of the adjustable resistor, which is called a standard resistor because it is a precision device having very small tolerance.

Hence

$$R_x = \frac{R_2 R_3}{R_1} \quad (11.4)$$

b



Block Diagram of Function Generator

The block diagram of a function generator is given in the figure. In this instrument, the frequency is controlled by varying the magnitude of the current that drives the integrator. This instrument provides different types of waveforms (such as sinusoidal, triangular and square waves) as its output signal with a frequency range of 0.01 Hz to 100 kHz.

The frequency controlled voltage regulates two current supply sources. Current supply source 1 supplies a constant current to the integrator whose output voltage rises linearly with time. An increase or decrease in the current increases or

reduces the slope of the output voltage and thus controls the frequency.

The voltage comparator multivibrator changes state at a predetermined maximum level, of the integrator output voltage. This change cuts-off the current supply from supply source 1 and switches to the supply source 2. The current supply source 2 supplies a reverse current to the integrator so that its output drops linearly with time. When the output attains a pre-determined level, the voltage comparator again changes state and switches on to the current supply source. The output of the integrator is a triangular wave whose frequency depends on the current supplied by the constant current supply sources. The comparator output provides a square wave of the same frequency as output. The resistance diode network changes the slope of the triangular wave as its amplitude changes and produces a sinusoidal wave with less than 1% distortion.

VIII

a

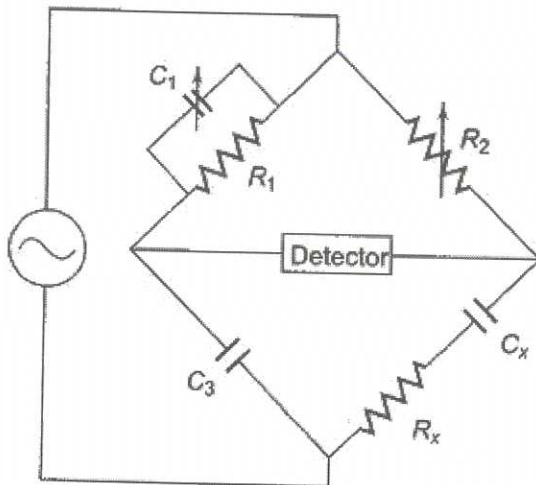


Fig. 11.25 Schering's Bridge

A

very important bridge used for the precision measurement of capacitors and their insulating properties is the Scherings Bridge. Its basic circuit arrangement is given in Fig. 11.25. The standard capacitor C3 is a high quality mica capacitor (low-loss) for general measurements, or an air capacitor (having a very stable value and a very small electric field) for insulation measurement.

For balance, the general equation is

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

where $Z_x = R_x - j/\omega C_x$

$$Z_2 = R_2$$

$$Z_3 = -j/\omega C_1$$

$$Y_1 = 1/R_1 + j \omega C_1$$

Equating the real and imaginary terms, we get

$$R_x = \frac{R_2 C_1}{C_3} \quad [11.20(a)]$$

$$C_x = \frac{R_1}{R_2} C_3 \quad [11.20(b)]$$

b

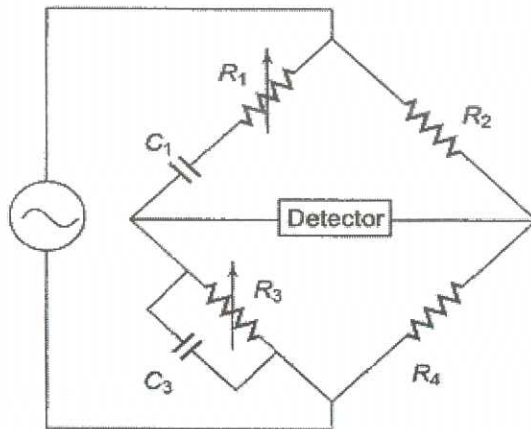


Fig. 11.27 Wien's Bridge

The Wien Bridge Circuit Diagram shown in Fig. 11.27 has a series RC combination in one arm and a parallel combination in the adjoining arm. Wien's bridge in its basic form, is designed to measure frequency.

The impedance of one arm is

$$Z_1 = R_1 - j/\omega C_1$$

The admittance of the parallel arm is

$$Y_3 = 1/R_3 + j \omega C_3$$

Using the bridge balance equation, we have

$$Z_1 Z_4 = Z_2 Z_3$$

Therefore

$$R_2 = R_4 \left(R_1 - \frac{j}{\omega C_1} \right) \left(\frac{1}{R_3} + j\omega C_3 \right)$$

$$R_2 = \frac{R_1 R_4}{R_3} - \frac{j R_4}{\omega C_1 R_3} + j \omega C_3 R_1 R_4 + \frac{C_3 R_4}{C_1}$$

$$R_2 = \left(\frac{R_1 R_4}{R_3} + \frac{C_3 R_4}{C_1} \right) - j \left(\frac{R_4}{\omega C_1 R_3} - \omega C_3 R_1 R_4 \right)$$

Equating the real and imaginary terms we have

$$R_2 = \frac{R_1 R_4}{R_3} + \frac{C_3 R_4}{C_1} \text{ and } \frac{R_4}{\omega C_1 R_3} - \omega C_3 R_1 R_4 = 0$$

Therefore $\frac{R_2}{R_4} = \frac{R_1}{R_3} + \frac{C_3}{C_1}$ (11.21)

and $\frac{1}{\omega C_1 R_3} = \omega C_3 R_1$ (11.22)

$$\therefore \omega^2 = \frac{1}{C_1 R_1 R_3 C_3}$$

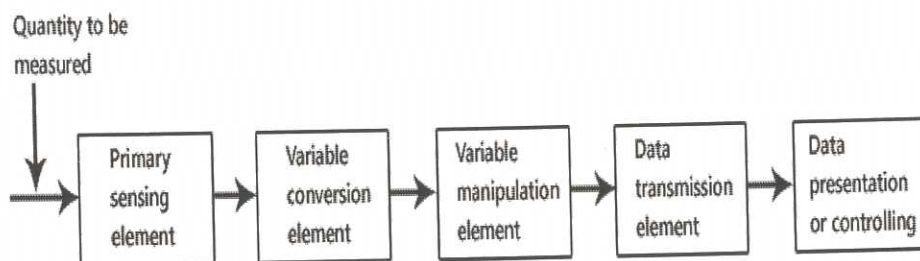
$$\omega = \frac{1}{\sqrt{C_1 R_1 C_3 R_3}}$$

as $\omega = 2\pi f$

$$\therefore f = \frac{1}{2\pi \sqrt{C_1 R_1 C_3 R_3}} \quad (11.23)$$

IX

a



The block diagram shown above is of basic instrumentation system. It consist of primary sensing element, variable manipulation element, data transmission

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element and data presentation element.

Primary sensing element

The primary sensing element is also known as sensor. Basically transducers are used as a primary sensing element. Here, the physical quantity (such as temperature, pressure etc.) are sensed and then converted into analogues signal.

Variable conversion element

It converts the output of primary sensing element into suitable form without changing information. Basically these are secondary transducers.

Variable manipulation element

The output of transducer may be electrical signal i.e. voltage, current or other electrical parameter. Here, manipulation means change in numerical value of signal. This element is used to convert the signal into suitable range.

Data transmission element

Sometimes it is not possible to give direct read out of the quality at a particular place (Example – Measurement of temperature in the furnace). In such a case, the data should transfer from one place to another place through channel which is known as data transmission element. Typically transmission path are pneumatic pipe, electrical cable and radio links. When radio link is used, the electronic instrumentation system is called as telemetry system.

Data presentation or controlling element

Finally the output is recorded or given to the controller to perform action. It performs different functions like indicating, recording or controlling

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b

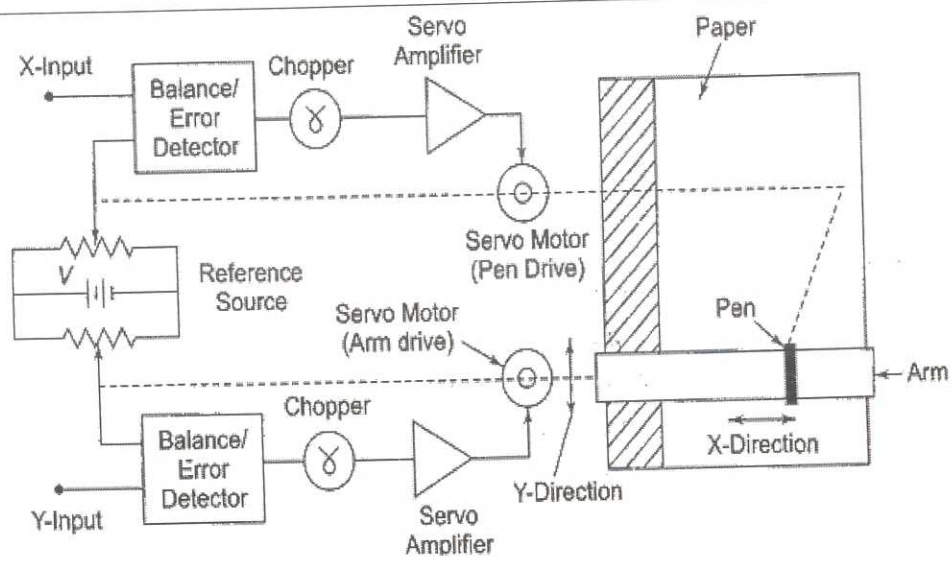


Fig. 12.9 Basic X-Y Recorder

Application

- 1.Speed-torque characteristics of motors.
- 2.Regulation curves of power supply.
- 3.Plotting characteristics of active devices such as vacuum tubes, transistors, zener diode, rectifier diodes, etc.
- 4.Plotting stress-strain curves, hysteresis curves, etc.
- 5.Electrical characteristics of materials, such as resistance versus temperature.

3

X

a

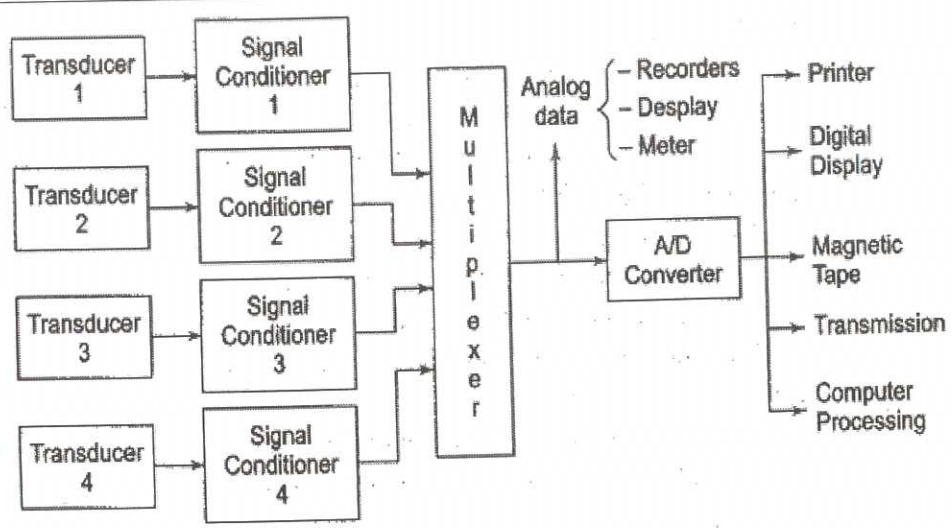


Fig. 17.1 Generalised Data Acquisition System

A digital data acquisition system may include some or all of the elements shown in Fig. The essential functional operations within a DAS include handling of analog signals, carrying out of measurements, conversion and handling of digital data and internal programming and control.

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1. Transducer translates physical parameters (such as temperature, pressure, acceleration, velocity, weight displacement etc.) into electrical quantities (such as voltage, resistance or frequency etc.). Electrical quantities also may be measured directly.
2. Signal conditioner usually includes the supporting circuitry for the transducer. This circuitry may provide excitation power, balancing circuits and calibration elements. Strain-gauge bridge balance and power supply unit is an example of a signal conditioner.
3. Scanner or multiplexer accepts multiple analog inputs and sequentially connects them to one measuring instrument,
4. ADC converts the analog voltage to its equivalent digital form. The output of ADC may be displayed visually and is also available as voltage outputs in discrete steps for further processing or recording on a digital recorder.
5. Digital recorder records digital information on punched cards, perforated paper tape, magnetic tape, typewritten pages or a combination of such systems.

4

b

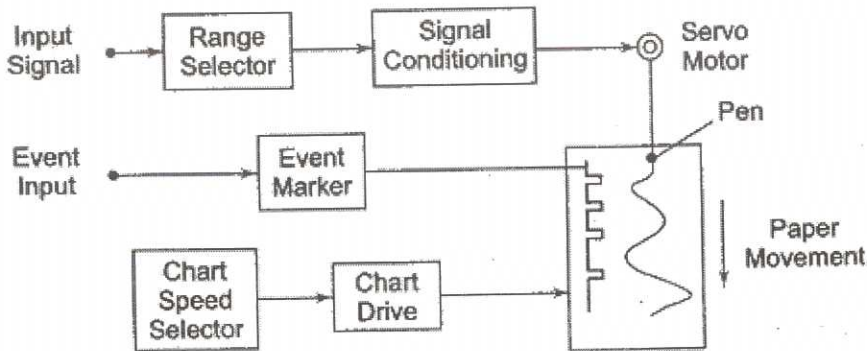


Fig. 12.1(a) Basic Strip Chart Recorder

Strip Chart Recorder Working Principle are those in which data is recorded on a continuous roll of chart paper moving at a constant speed. The recorder records the variation of one of more variables with respect to time. The basic element of a Strip Chart Recorder consists of a pen (stylus) used for making marks on a movable paper, a pen (stylus) driving system, a vertically moving long roll of chart paper and chart paper drive mechanism and a chart speed selector switch. Most recorders use a pointer attached to the stylus, so that the instantaneous value of the quantity being recorded can be measured directly on a calibrated scale.

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