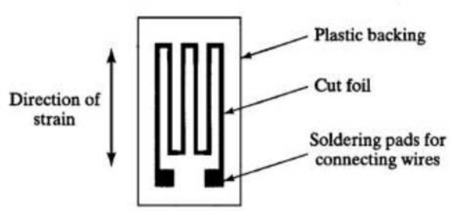
Q. P. Code: 26311

ELECTRONIC INSTRUMENTS & MESUREMENTS

S.E.(ELECTRONICS & TELE-COMMN Engg)(SEM III) (CBSGS)(Rev-2012)

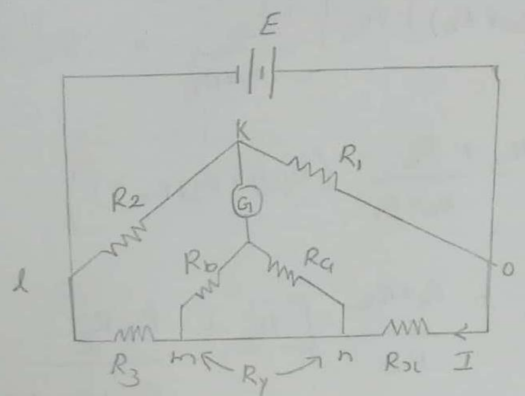
1a)	**Alternate mode** draws each channel alternately - the oscilloscope completes one sweep on channel 1, then one sweep on channel 2, a second sweep on channel 1, and so on. Use this mode with medium- to high-speed signals, when the sec/div scale is set to 0.5 ms or faster. **Chop mode** causes the oscilloscope to draw small parts of each signal by switching back and forth between them.
1b)	Acuracy:-It is the degree of closeness with which an instrument reading approaches the true value of the quantity to be measured.Accuracy is the ability of an instrument to show the exact reading. Percesion:-An equipment which is precise is not necessarily accurate. Defined as the capability of an instrument to show the same reading when used each time (reproducibility of the instrument). Sensitivity:-Defined as the ratio of change in output towards the change in input at a steady state condition. The sensitivity denotes the smallest change in the measured variable to which the instrument responds. Sensitivity (K) = $\Delta qo / \Delta qi$. Where Δqo: infinitesimal change in output; Δqi : infinitesimal change in input The sensitivity of an instrument should be high. Example : The resistance value of a Platinum Resistance Thermometer changes when the temperature increases. Therefore, the unit of sensitivity for this equipment is Ohm/°C.
1 c)	1. **Operating Principle:** The transducer are many times selected on the basis of operating principle used by them. The operating principle used may be resistive, inductive, capacitive , optoelectronic, piezo electric etc. 2. **Sensitivity:** The transducer must be sensitive enough to produce detectable output. 3. **Operating Range:** The transducer should maintain the range requirement and have a good resolution over the entire range. 4. **Accuracy:** High accuracy is assured. 5. **Cost & availability:** The transducer should be cost effective, easy availability, reliable & should have low maintenanace. 6. **Errors:** The transducer should maintain the expected input-output relationship as described by the transfer function so as to avoid errors.

1.d)	A deformation of the crystal structure (eg: squeezing it) will result in an electrical current.Changing the direction of deformation (eg: pulling it) will reverse the direction of the current.If the crystal structure is placed into an electrical field, it will deform by an amount proportional to the strength of the field.If the same structure is placed into an electrical field with the direction of the field reversed, the deformation will be opposite **Advantages:** 1. High frequency response. 2. Small Size 3. High output 4. Rugged construction **Disadvantages:** 1. Output affected by changes in temperature 2. Cannot measure static conditions **Applications:** 1. Accelerometer 2. Pressure cells 3. Ceramic microphones 4. Industrial cleaning apparatus 5. Under-water detection system
2a)	The strain gauge is a passive, resistive transducer which converts the mechanical elongation and compression into a resistance change.This change in resistance takes place due to variation in length and cross sectional area of the gauge wire, when an external force acts on it.  FIGURE 8.2 Foil strain gage. A tensile stress tends to elongate the wire & thereby increase its length & decrease its cross-sectional area. As a consequence of strain two physical qualities are of particular interest: (1) the change in gauge *resistance* and (2) the change in *length.* The measurement of the sensitivity of a material to strain is called the **gauge factor(GF)**.

	It is the ratio of the change in resistance to change in the length. Gauge factor(K)=ΔR/R ΔL/L Where K = the gauge factor R = the initial resistance in ohms (without strain) ΔR= the change in initial resistance in ohms *L* = the initial length in meters (without strain) *ΔL*= the change in initial length in meters

2b)

Kelvin Double Bridge



The ratio $\frac{R_1}{R_2}$ is kept same as $\frac{R_a}{R_b}$

The galvanometer reading is zero when potential at K & P are equal

$\therefore$ For zero deflection $E_{lk} = E_{lmp}$

$$E_{lk} = \frac{E \times R_2}{R_1 + R_2} \quad \text{—— (1)}$$

$$E = I\left[R_x + (R_y \,||\, (R_a + R_b)) + R_3\right] \quad \text{—— (2)}$$

Substituting eqn (2) in eqn (1)

$$E_{lk} = I\left[R_x + (R_y \,||\, (R_a + R_b)) + R_3\right] \times \frac{R_2}{R_1 + R_2} \quad \text{—— (3)}$$

lly

$$E_{lmp} = I\left[R_3 + \frac{R_b}{R_a + R_b}(R_y \,||\, (R_a + R_b))\right] \quad \text{—— (4)}$$

But $E_{lk} = E_{lmp}$

From eqn 3 & eqn 4

$$I\left[R_x + (R_y \parallel (R_a+R_b)) + R_3\right] \frac{\times R_2}{R_1+R_2} = I\left[R_3 + \frac{R_b}{R_a+R_b}(R_y \ldots\right.$$

$$= I\left[R_3 + \frac{R_b}{R_a+R_b}\left(R_y \parallel (R_a+R_b)\right)\right]$$

$$R_x + \frac{(R_a+R_b)R_y}{R_a+R_b+R_y} + R_3 = \frac{R_1+R_2}{R_2}\left[R_3 + \frac{R_b R_y}{R_y+R_b+R_a}\right]$$

$$R_x = \frac{R_1 R_3}{R_2} + \frac{R_1 R_b R_y}{R_2(R_y+R_b+R_a)} + \frac{R_b R_y}{(R_y+R_b+R_a)} - \frac{(R_a+R_b)R_y}{R_a+R_b+R_y}$$

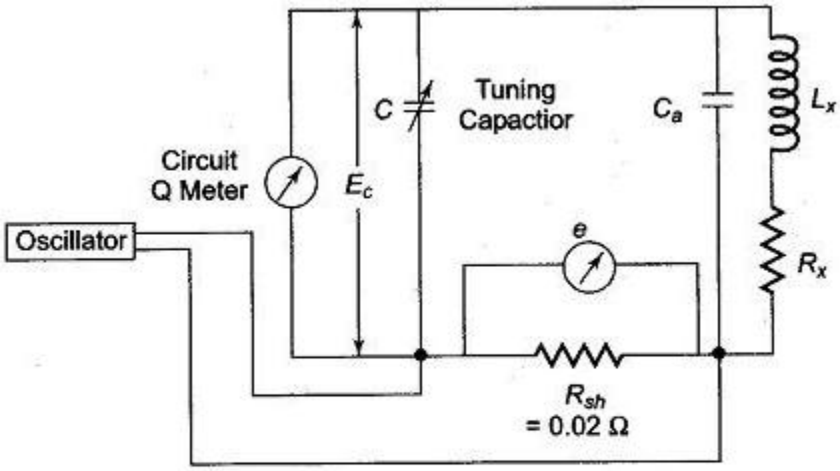
$$R_x = \frac{R_1 R_3}{R_2} + \frac{R_1 R_b R_y}{R_2(R_a+R_b+R_y)} - \frac{R_a R_y}{R_a+R_b+R_y}$$

$$R_x = \frac{R_1 R_3}{R_2} + \frac{R_b R_y}{R_a+R_b+R_y}\left(\frac{R_1}{R_2} - \frac{R_a}{R_b}\right)$$

It is given $\frac{R_1}{R_2} = \frac{R_a}{R_b}$, $\therefore \frac{R_1}{R_2} - \frac{R_a}{R_b} = 0$,

So 2nd term becomes 0.

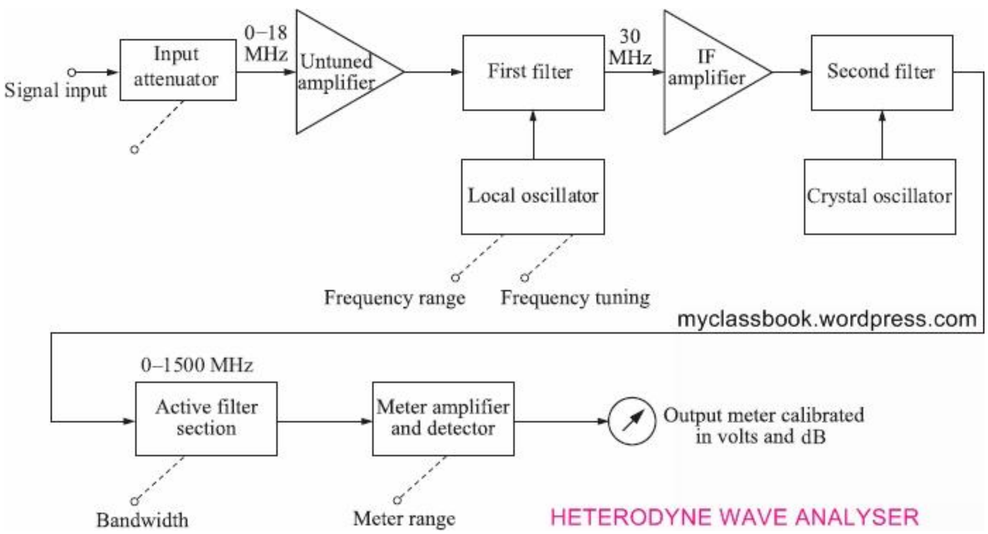
$$\therefore R_x = \frac{R_1 R_3}{R_2} \quad //$$

3a	 The quality factor or Q-factor of a resonant circuit is a measure of the “goodness” or quality of a resonant circuit. A higher value for this figure of merit corresponds to a narrower bandwidth, which is desirable in many applications. More formally, Q is the ratio of power stored to power dissipated in the circuit reactance and resistance A practical application of “Q” is that voltage across L or C in a series resonant circuit is Q times total applied voltage. In a parallel resonant circuit, current through L or C is Q times the total applied current.
b)	**Energy :** Energy is the total power delivered or consumed over a time int (Energy = Power × time). Electrical energy developed as work or dissipated heat ov interval of time t is expressed as: $W = \int vi\, dt$. **Power :** The power taken by a load from a d.c. supply is given by th and voltage. (P=VI). In case of alternating currents, the instant continuously. However, we are interested in average value of power of instantaneous value of power.

4a) A wave analyzer is an instrument designed to measure relative amplitude of signal frequency components in a complex waveform .basically a wave instruments acts as a frequency selective voltmeter which is tuned to the frequency of one signal while rejecting all other signal components. wave analyzer, in fact, is an instrument designed to measure relative amplitudes of single frequency components in a complex waveform. Basically, the instrument acts as a frequency selective voltmeter which is used to the frequency of one signal while rejecting all other signal components. The desired frequency is selected by a frequency calibrated dial to the point of maximum amplitude. The amplitude is indicated either by a suitable voltmeter or CRO.

This instrument is used in the MHz range. The input signal to be analysed is heterodyned to a higher IF by an internal local oscillator. Tuning the local oscillator shifts various signal frequency components into the pass band of the IF amplifier. The output of the IF amplifier is rectified and is applied to the metering circuit. The instrument using the heterodyning principle is called a heterodyning tuned voltmeter.

The block schematic of the wave analyser using the heterodyning principle is shown in fig. above. The operating frequency range of this instrument is from 10 kHz to 18 MHz in 18 overlapping bands selected by the frequency range control of the local oscillator. The bandwidth is controlled by an active filter and can be selected at 200, 1000, and 3000 Hz.



Block schematic of a heterodyne wave analyser

Applications of Wave Analyzers:

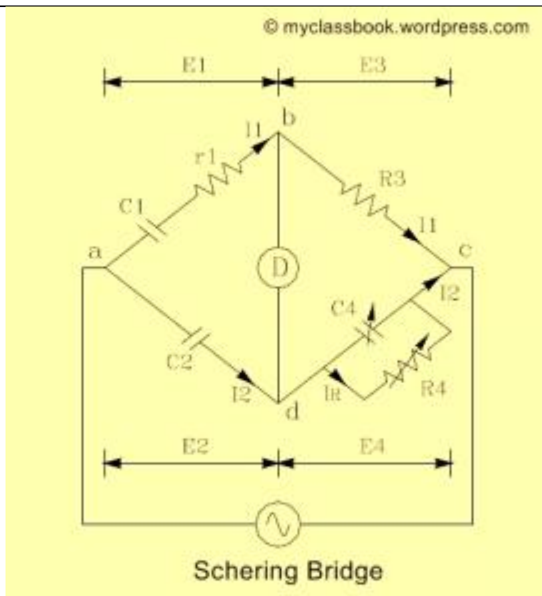
Wave analyzers have very important applications in the following fields:

1) Electrical measurements

2) Sound measurements and

3) Vibration measurements.

b)



Schering Bridge Circuit

Let

- C1= capacitor whose capacitance is to be determined,
- r1 = a series resistance representing the loss in the capacitor C1
- C2 = a standard capacitor
- R3 = a non – inductive resistance
- C4 = a variable capacitor
- R4 = a variable non-inductive resistance in parallel with variable capacitor C4

Now when the Schering Bridge is balanced, then

$$\left[r_1 + \frac{1}{j\omega\ C_1}\right]\left[\frac{R_4}{1 + j\omega C_4\ R_4}\right] = \frac{1}{j\omega C_2} \cdot R_3$$

$$\left[r_1 + \frac{1}{j\omega\ C_1}\right] R_4 = \frac{R_3}{j\omega C_2}\ \left(1\ + j\omega C_4\ R_4\right)$$

$$r_1\ R_4\ - \frac{jR_4}{\omega C_1} = -\ \frac{jR_3}{\omega C_2} + \frac{R_3\ R_4\ C_4}{C_2}$$

By equating real and imaginary part of the equation we get,

$$r_1 = \frac{R_3\ C_4}{C_2} \qquad and\ C_1\ \frac{C_2\ R_4}{R_3}$$

Two independent balance equations are obtained if C4 and R4 are chosen as the variable elements.

The dissipation factor is given by:

$$D_1 = \tan\ \delta = \omega C_1\ r_1$$

$$= \omega \left(\frac{C_2\ R_4}{R_3}\right) \times \left(\frac{R_3\ C_4}{C_2}\right) = \omega\ C_4\ R_4$$

Therefore values of capacitance C1 and its dissipation factor are obtained from the values of bridge elements at balance.

Permanently set up Schering bridges are sometimes arranged so that balancing is done by adjustment of R3 and C4 remaining fixed. Since R3 appears in both the balance equations and therefore there is some difficulty in obtaining balance but it has certain advantages which are explained as follows:In the above equation value of R4 and C2 are fixed therefore the dial resistor R3 may be calibrated to read the capacitance directly.

Advantages of Schering Bridge:

- 1) The balance equation is independent of frequency.
- 2) It is used for measuring the insulating properties of electrical cables and equipment.

5A

- Resistor ladder networks provide a simple, inexpensive way to perform digital to analog conversion (DAC)
- The most popular networks are the binary weighted ladder and the R-2R ladder. Both devices will convert digital voltage information to analog, but the R-2R ladder has become the most popular due to the network’s inherent accuracy superiority and ease of manufacture
- Figure shown below is a diagram of the basic R-2R ladder network with N bits. The “ladder” portrayal comes from the ladder-like topology of the network
- Note that the network consists of only two resistor values; R and 2R (twice the value of R) no matter how many bits make up the ladder. The particular value of R is not critical to the function of the R-2R ladder

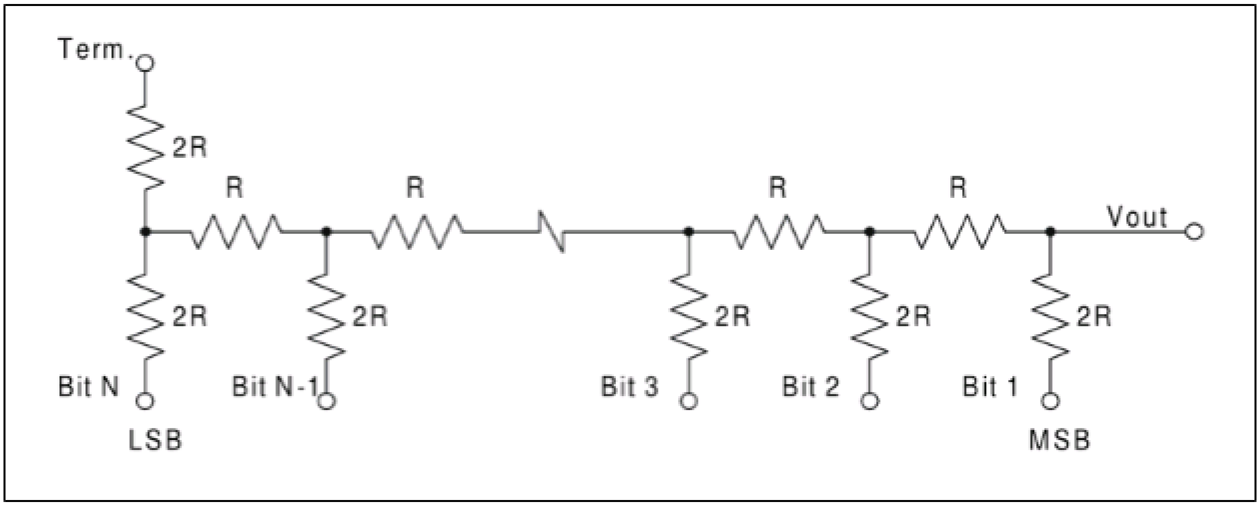


Figure - R-2R Ladder of N bits

- -2R ladder networks provide a simple means to convert digital information to an analog output
- Although simple in design and function, applying an R-2R resistor network to a real application requires attention to how the device is specified. Output errors due to resistor tolerances are often overlooked in the design of the digital to analog conversion (DAC) circuit and in the selection of the R-2R ladder itself

Working -

- It uses Kirchhoff’s current law, which states that the sum of currents entering a node must be equal to the sum of the currents leaving a node
- In the ladder, at each node, the current is split in half. By switching the currents into each node, the total current flowing is binary weighted

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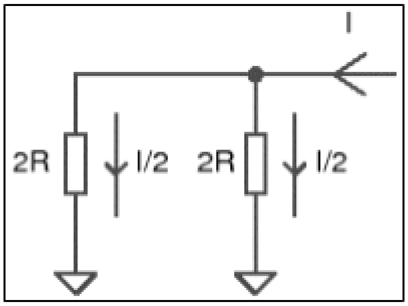

Figure - Current split into half

- Using the principle of superposition, when you add more current into a resistance the total voltage appearing is the sum of the voltages caused by all the individual currents i.e. as each bit is activated, so the voltage increases at the output. This results in the conversion of the input digital stream in analog value
- For example, consider the applied binary word to be 101, with reference voltage V_RVR=10V and resistance R=10kΩ
  - The output current I_oIo will be given as

$I_o=(-10V)\Omega[1(2_0\times10_3)+0(2_1\times10_3)+1(2_2\times10_3)]=-0.125$Io=(−10V)Ω[1(20×103)+0(21×103)+1(22×103)]=−0.125 A
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The **digital storage oscilloscope** is defined as the oscilloscope which **stores and analysis the signal digitally**, i.e. in the form of 1 or 0 preferably storing them as **analogue signals**. The digital oscilloscope takes an input signal, store them and then display it on the screen. The digital oscilloscope has advanced features of storage, triggering and measurement. Also, it **displays** the signal **visually** as well as **numerically.** The digital oscilloscope digitises and stores the input signal. This can be done by the use of CRT (Cathode ray tube) and digital memory. The block diagram of the basic digital oscilloscope is shown in the figure below. The digitisation can be done by taking the sample input signals at periodic waveforms.
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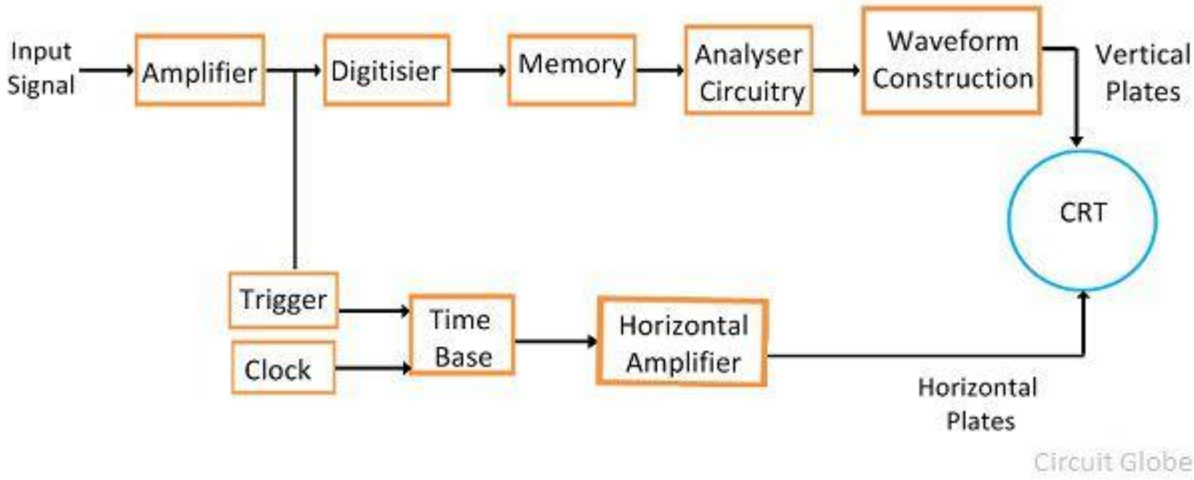


The maximum frequency of the signal which is measured by the digital oscilloscope depends on the two factors. Theses factors are the

1. Sampling rate
2. Nature of converter.

Sampling Rate – For safe analysis of input signal the sampling theory is used. The sampling theory states that the sampling rate of the signal must be twice as fast as the highest frequency of the input signal. The sampling rate means analogue to digital converter has a high fast conversion rate.

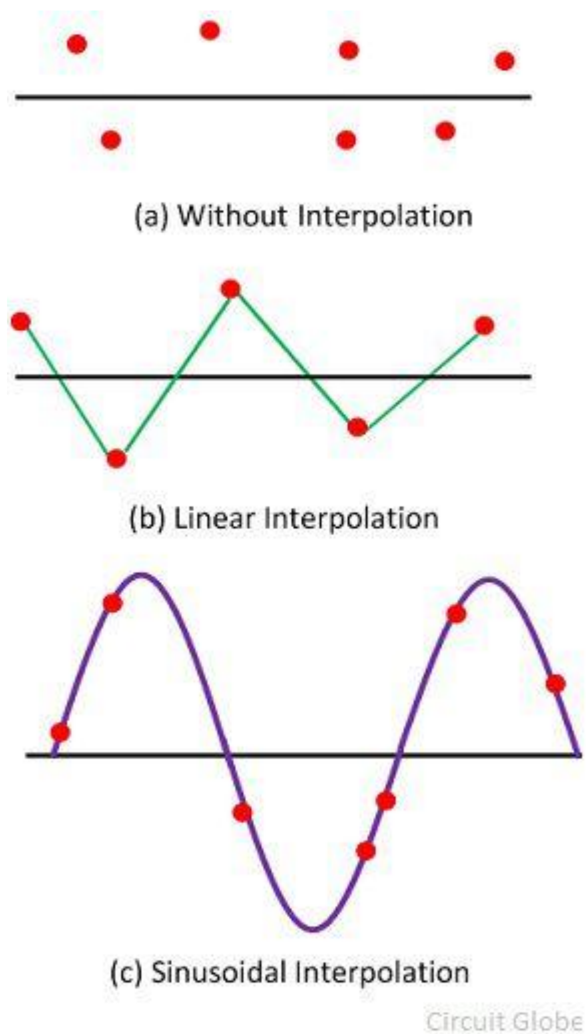
Converter – The converter uses the expensive flash whose resolution decreases with the increases of a sampling rate. Because of the sampling rate, the bandwidth and resolution of the oscilloscope are limited.

The need of the analogue to digital signal converters can also be overcome by using the shift register. The input signal is sampled and stored in the shift register. From the shift register, the signal is slowly read out and stored in the digital form. This method reduces the cost of the converter and operates up to 100 megasample per second.

The only disadvantage of the digital oscilloscope is that it does not accept the data during digitisation, so it had a blind spot at that time.

Waveform Reconstruction

For visualising the final wave, the oscilloscopes use the technique of inter-polarization. The inter-polarization is the process of creating the new data points with the help of known variable data points. Linear interpolation and sinusoidal

	interpolation are the two processes of connecting the points together. 
6a	• Being the simplest form of a capacitor, it has two parallel conducting plates that are separated by a dielectric or insulator with a permittivity of E (for air). Other than paper, vacuum, and semi-conductor depletion region, the most commonly used dielectric is air • Due to a potential difference across the conductors, an electric field develops across the insulator. This causes the positive charges to accumulate on one plate and the negative charges to accumulate on the other • The capacitor value is usually denoted by its capacitance, which is measured in Farads. It can be defined as the ratio of the electric charge on each conductor to the voltage difference between them The capacitance is denoted by C. In a parallel plate capacitor,

$C=([A\times E_r\times E_o])D$C=([A×Er×Eo])D
Where

A – Area of each plate (m)

d – Distance between both the plates (m)

E_rEr – Relative Dielectric Constant
E_oEo – Dielectric constant of free space = 9.85×1012×(F/M)
From the equation it is clear that the value of capacitance C and the distance between the parallel plates d are inversely proportional to each other. An increase of distance between the parallel plates will decrease the capacitance value correspondingly. The same theory is used in a capacitive transducer. It is used to convert the value of displacement or change in pressure in terms of frequency.

Working of Capacitive Transducer –

As shown in the figure below, a capacitive transducer has a static plate and a deflected flexible diaphragm with a dielectric in between. When a force is exerted to the outer side of the diaphragm the distance between the diaphragm and the static plate changes. This produces a capacitance which is measured using an alternating current bridge or a tank circuit.

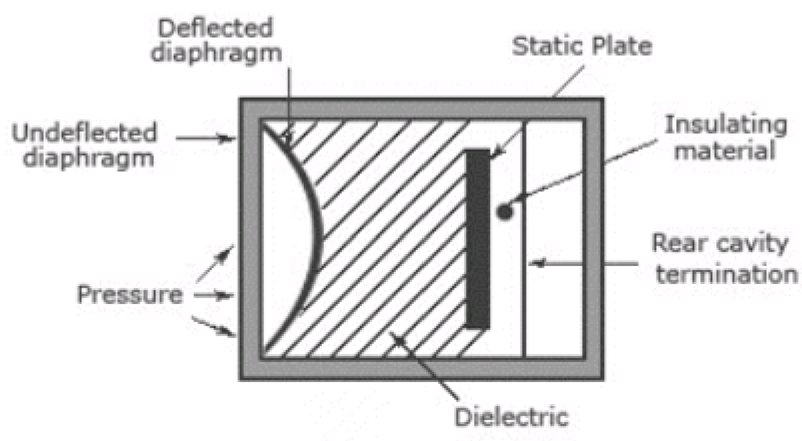


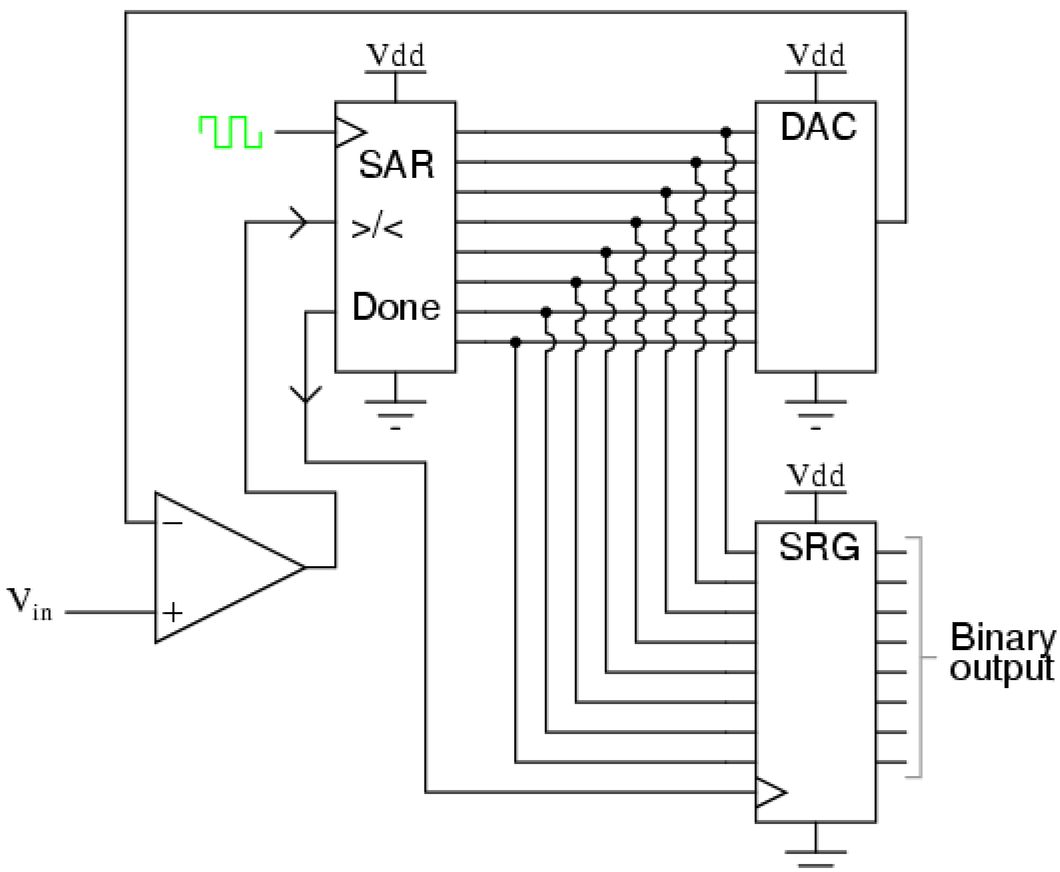
Figure - Capacitive Transducer

A tank circuit is more preferred because it produces a change in frequency according to the change in capacitance. This value of frequency will be corresponding to the displacement or force given to the input.

Advantages –

- It produces an accurate frequency response to both static and dynamic measurements

Disadvantages –

	• An increase or decrease in temperature to a high level will change the accuracy of the device • As the lead is lengthy it can cause errors or distortion in signals.
6b	One method of addressing the digital ramp ADC's shortcomings is the so-called *successive-approximation*ADC. The only change in this design is a very special counter circuit known as a *successive-approximation register*. Instead of counting up in binary sequence, this register counts by trying all values of bits starting with the most-significant bit and finishing at the least-significant bit. Throughout the count process, the register monitors the comparator's output to see if the binary count is less than or greater than the analog signal input, adjusting the bit values accordingly. The way the register counts is identical to the "trial-and-fit" method of decimal-to-binary conversion, whereby different values of bits are tried from MSB to LSB to get a binary number that equals the original decimal number. The advantage to this counting strategy is much faster results: the DAC output converges on the analog signal input in much larger steps than with the 0-to-full count sequence of a regular counter. Without showing the inner workings of the successive-approximation register (SAR), the circuit looks like this: 

	It should be noted that the SAR is generally capable of outputting the binary number in *serial* (one bit at a time) format, thus eliminating the need for a shift register