EC2351- Measurements and Instrumentation

UNIT I

Part - A

1. Define measurement.
   Measurement involves an instrument as a physical means of determining a quantity or variable.
2. What is secondary unit?
   Unit which is derived from the fundamental unit is called secondary unit. Eg: stress- N/m
3. What is the difference between accuracy and precision?
   Accuracy refers to the degree of closeness or conformity to the true value of the quantity under measurement. Precision refers to the degree of agreement within a group of measurements.
4. Define sensitivity.
   The ratio of output signal or response of the instrument to a change of input or measured variable.
5. What is the difference between resolution and threshold?
   The smallest change in measured value to which the instrument will respond. 6.

List the sources of errors in instruments.
   Gross errors, systematic errors, random errors.

7. Define instrumental error and limiting error.
   Circuit components are guaranteed within a certain % of their rated value. The limits of these deviations from the specified values are known as limiting errors.
   Instrumental error is error inherent in measuring instruments because of their mechanical structure.
8. Define random error and probable error.
   Random errors are due to unknown causes & occur even when all systematic errors have been accounted for. Probable error = + or - 0.6745□
9. List the different types standards of measurements.
   International, primary, secondary, working standard. 10.

Define working standard.
   These are the principal tools of a measurement laboratory

11. What are the limitations of Wheatstone bridge?
   Errors due to the resistance of leads, thermal emfs in the bridge circuit, heating effects of the bridge arm current, insufficient sensitivity of null detector. 12.

Give the conditions for bridge balance.
   The bridge is balanced when the impedance of all the arms are equal.
   The voltage drop is zero.

13. Name the bridges used to measure inductance.
   Maxwell Bridge, hay's bridge.
13. Name a bridge to measure frequency, capacitance.
   Frequency- Wien bridge, capacitance-Schering Bridge.
14. Why scale of gravity control is non- uniform ?
   The quantity to be measured is proportion to $\sin\Theta$ rather than Θ in gravity control which is not a uniform function. Hence the scale is non- uniform
15. What is the basic principle of PMMC instrument ?
   A Current carrying coil is placed in the permanent magnetic field experience a force proportional to the current it carries

16. What is loading effect?

Under practical conditions, it has been found that introduction of any element in a system results invariably in extraction of energy from the system thereby distorting the original signal. This distortion may take the form of attenuation, waveform distortion or phase shift. The incapability of the system to faithfully to measure, record and control the input signal in undistorted form is called loading effect.

17. What is important condition for Kelvin bridge to achieve perfect balance condition?

To eliminate the effect of lead and contact resistance, make the ratio of R1/R2 is equal to the ratio a/b

18. When static characteristics of an instrument are important?

When the quantities to be measured are slowly varying or constant

19. Define resolution

It is the smallest increment of quantity being measured which can certainly detected by an instrument

20. state two sources of error in MI instrument.

Temperature error, hysteresis error, stray magnetic field error, frequency error, eddy current error.

21. List out the errors in PMMC instrument.

Weakening permanent magnet due to ageing, temperature effects.
Weakening control spring due to ageing, temperature effects.

22. State the application MC and MI instruments

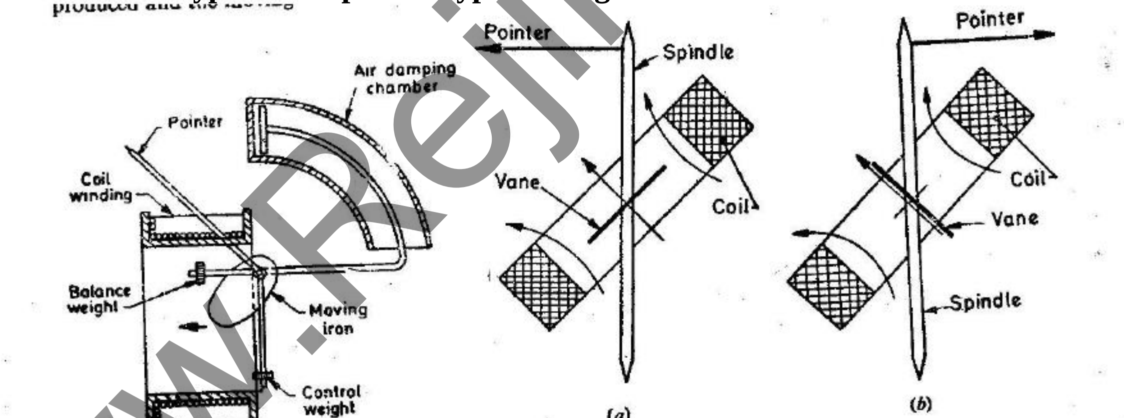
Moving Coil Instrument - DC measurements only
Moving Iron Instrument - both AC and DC

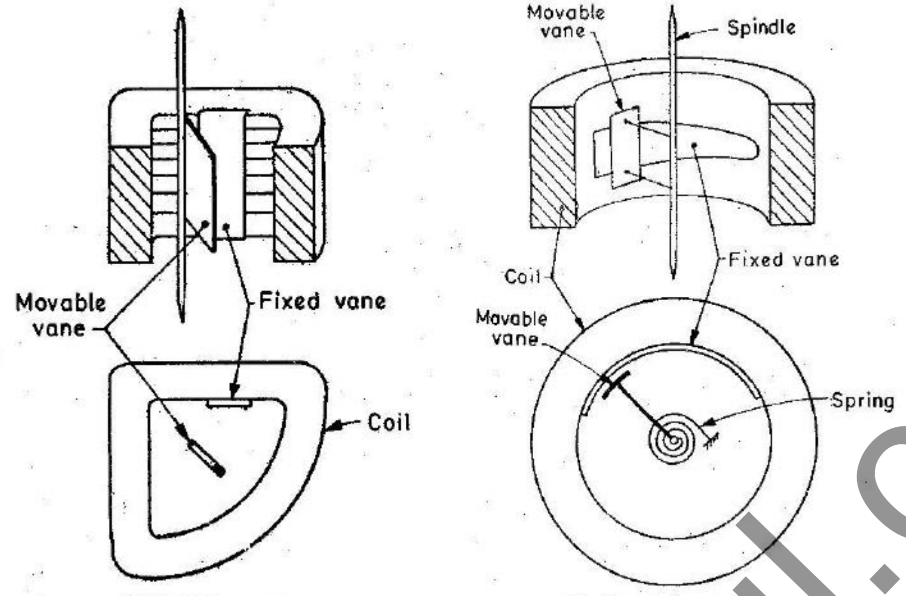
23. What are the types of detectors used in A.C bridges?

Headphones, Vibration galvanometer, Tunable amplifier detectors

Part - B

1. Attraction type and Repulsion type moving iron instruments.

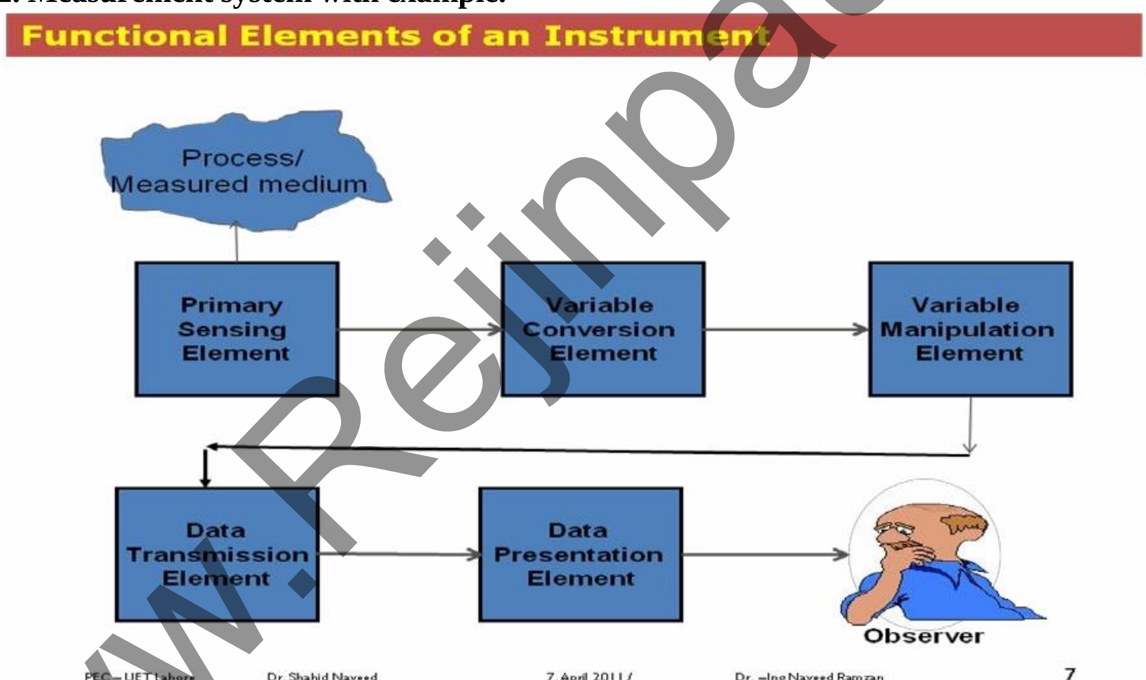




(a) Radial vane type. (b) Co-axial vane type.

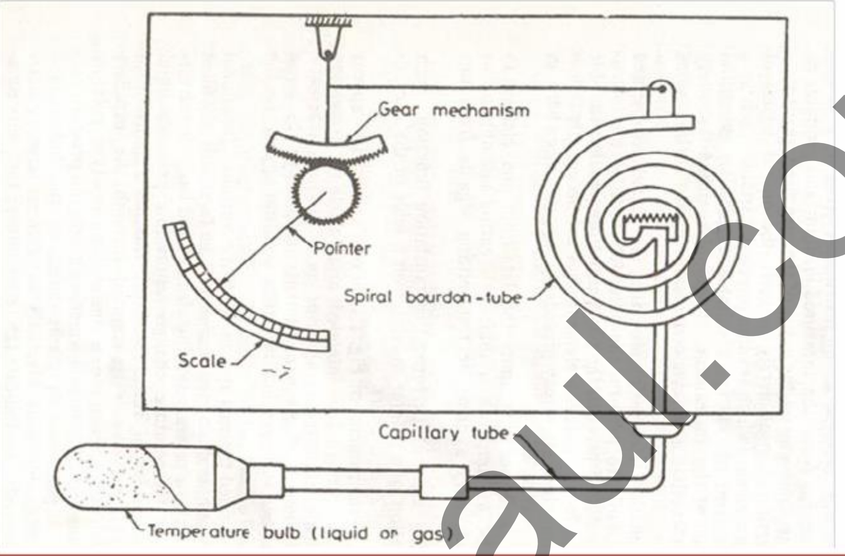
Fig. 8'29. Replusion type moving iron instruments.

2. **Measurement system with example.**

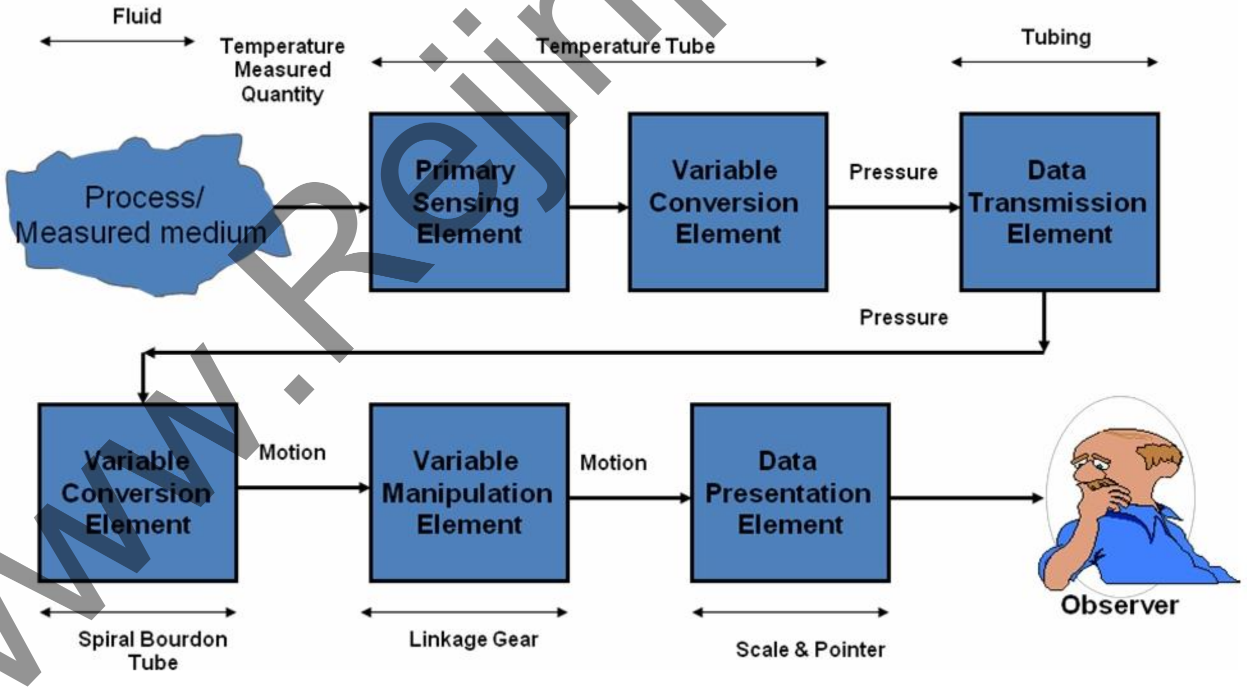


Functional Elements of an Instrument (Cont'd)

Typical Example:



Functional Elements of an Instrument (Cont'd)



UNIT II Part - A

1. What are the major functional blocks of CRO?
   Cathode ray tube, electron gun, vertical & horizontal plates, time base circuit, trigger circuit.
2. What are the major components of CRT?
   Cathode ray tube, electron gun, vertical &horizontal plates
3. Why is a delay line used in the vertical section of the oscilloscope?
   The electronics circuit causes a certain amount of time delay in transmission of signal voltages to deflection plates. To allow the operator to observe the leading edge of signal waveform, the signal drive for the vertical CRT plates must be delayed by at least the same amount of time.
4. What are the advantages of dual trace over dual beam?
   In dual trace method the same electron beam is used to generate two traces that can be deflected from two independent vertical sources. In dual beam it has two separate electron guns generating two separate beams.
5. What is sampling oscilloscope?
   The input waveform is reconstructed from many samples taken during recurrent cycles of input waveform.
6. Define deflection sensitivity
   Is defined as the deflection on the screen per volt of deflection voltage.
   $S = D/ E_d$
7. Define deflection factor
   Reciprocal of sensitivity $G = 1/ S = E_d/D$
8. What is called multi-range ammeter?
   The current range of a d.c ammeter can be extended by a number of shunts selected by a range selector switch. This meter is called multi-range ammeter.
9. What do you mean by hard beam?
   A highly accelerated beam possesses more kinetic energy & produces a brighter image on the CRT screen.
10. Explain about aquadag.
    The bombarding electrons striking the phosphor release secondary-emission electrons, thus keeping the screen in a state of equilibrium. These secondary - emission low -velocity electrons are collected by a conductive coating known as aquadag.
11. What do are types of sweep?
    Recurrent, triggered, driven,non saw tooth ,driven sweep.
12. How do you avoid parallax errors in CRT?
    The accuracy of these marks depends on how close the graticule marks can be placed to the actual phosphor to eliminate parallax.
13. What are the uses of Oscilloscopes?
    For the development of electronic circuit& that allows the amplitude of electrical signals, voltage or current or power to be displayed as a function of time.
14. How storage CRTs are classified?
    Bistable tubes & halftone tubes.
15. What do you mean by vector voltmeter?
    That indicates the quantity in a vector format that is both magnitude and direction.
16. What is CRT graticule.
    It is usually rectangular in form & is placed inside the display area to alloy correct measurements.
17. What are the different types of analog recorders?

Graphic recorders, oscillographic recorders, magnetic tape recorders.

18. What is the function of sampling oscilloscope?

It improves high frequency performance.

19. What are the advantages of digital storage oscilloscope?

It is the superior method of trace storage; the waveform to be stored is digitized, stored in a digital memory & retrieved for display. The stored waveform is continually displayed by repeatedly scanning.

20. Define Q factor of coil.

The ratio of power stored in the element to the power dissipated in the element

Or it can be defined as the ratio between reactance to impedance.

21. What are the applications of vector voltmeter?

Very high frequency applications, two port network parameters.

22. What is the function of vector voltmeter?

It measures the amplitude of a signal at two points in a circuit & simultaneously measures the phase difference between the voltage waveforms at these two points.

23. List the various parts of multimeter.

Current to voltage converter, D.C voltage attenuator, A.C voltage attenuator,A.C to D.C converter. Resistance to voltage converter, analog to digital converter, display devices.

24. Mention five major section of vector voltmeter.

Two RF to IF converters, an automatic phase control section, a phase meter circuit, voltmeter circuit.

Part - B

1. (i) With a neat sketch, explain about CRT (8)

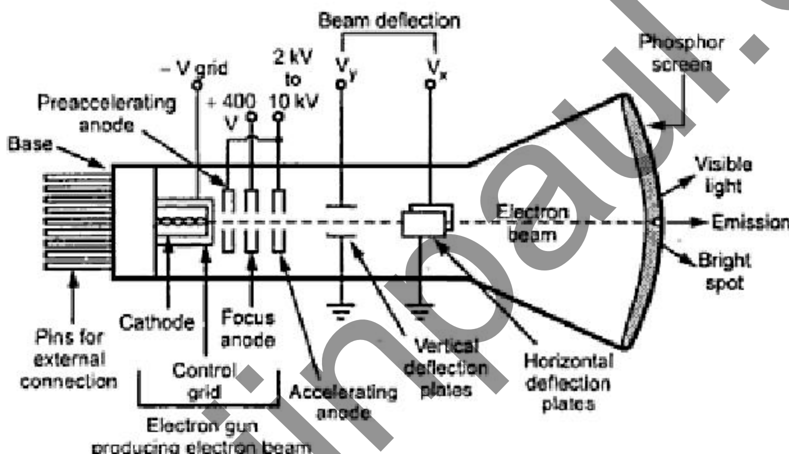
Cathode Ray Tube (CRT)

The cathode ray tube (CRT) is the heart of the C.R.O. The CRT generates the electron beam, accelerates the beam, deflects the beam and also has a screen where beam becomes visible as a spot. The main parts of the CRT are :

i) Electron gun ii) Deflection system iii) Fluorescent screen

iv) Glass tube or envelope v) Base

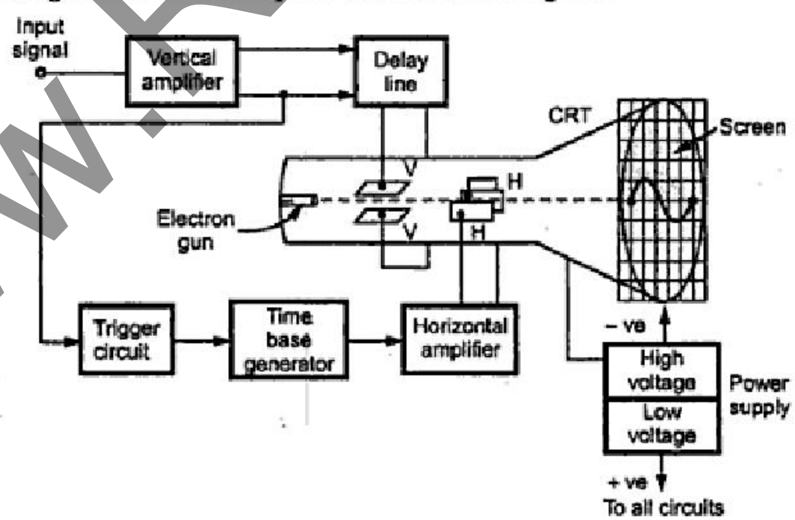
A schematic diagram of CRT, showing its structure and main components is shown in the Fig. 2.1.



(ii) Explain briefly about basic CRO with the necessary block diagram. (8)

Block Diagram of Simple Oscilloscope

The block diagram of oscilloscope is shown in the Fig. 2.5.



The various blocks of block diagram of simple oscilloscope are as follows :

2.4.1 CRT

This is the cathode ray tube which is the heart of C.R.O. It is used to emit the electrons required to strike the phosphor screen to produce the spot for the visual display of the signals.

2.4.2 Vertical Amplifier

The input signals are generally not strong to provide the measurable deflection on the screen. Hence the vertical amplifier stage is used to amplify the input signals. The amplifier stages used are generally wide band amplifiers so as to pass faithfully the entire band of frequencies to be measured.

Similarly it contains the attenuator stages as well. The attenuators are used when very high voltage signals are to be examined, to bring the signals within the proper range of operation.

The block diagram of a vertical amplifier is shown in the Fig. 2.6.

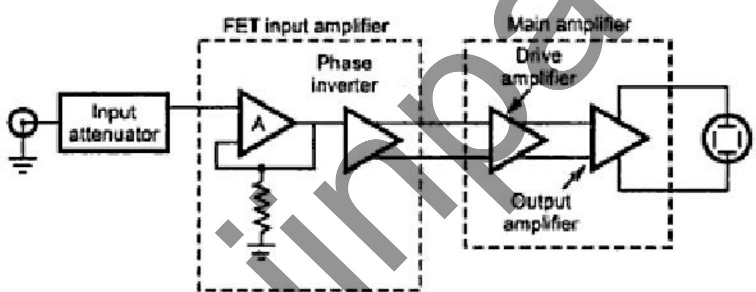


Fig. 2.6 Vertical amplifier

It consists of several stages with overall fixed sensitivity. The amplifier can be designed for stability and required bandwidth very easily due to the fixed gain.

The input stage consists of an attenuator followed by FET source follower. It has very high input impedance required to isolate the amplifier from the attenuator.

It is followed by BJT emitter follower to match the output impedance of FET output with input of phase inverter.

The phase inverter provides two antiphase output signals which are required to operate the push pull output amplifier.

The push pull operation has advantages like better hum voltage cancellation, even harmonic suppression especially large 2nd harmonic, greater power output per tube and reduced number of defocusing and nonlinear effects.

2.4.3 Delay Line

The delay line is used to delay the signal for some time in the vertical sections. When the delay line is not used, the part of the signal gets lost. Thus the input signal is not applied directly to the vertical plates but is delayed by some time using a **delay line** circuit as shown in the Fig. 2.7.

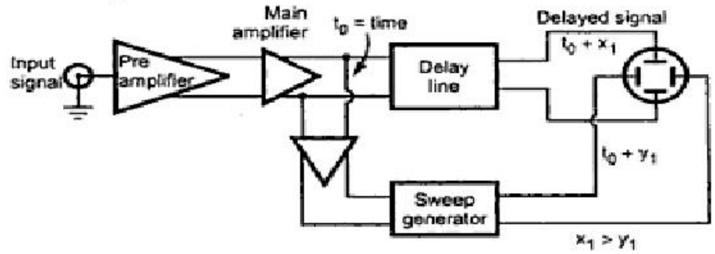


Fig. 2.7 Delay line circuit

Key Point : *As the signal is delayed, the sweep generator output gets enough time to reach to the horizontal plates before signal reaches the vertical plates.*

If the trigger pulse is picked off at a time $t = t_0$ after the signal has passed through the main amplifier then signal is delayed by x_1 nanoseconds while sweep takes y_1 nanoseconds to reach. The design of delay line is such that the delay time x_1 is higher than the time y_1. Generally x_1 is 200 nanoseconds while the y_1 is 80 nanoseconds, thus the sweep starts well in time and no part of the signal is lost.

True R.M.S. Responding Voltmeter

The r.m.s. value means root-mean-square value. As mentioned earlier it is obtained by squaring the input signal and then calculating square root of its average value. The r.m.s. value is also called **effective value**. It compares the heating effect produced by a.c. and d.c.

The true r.m.s. responding voltmeter produces a meter deflection by sensing the heating power of the waveform. This heating power is proportional to the square of the input r.m.s. value. The measurement of heating power is achieved by the use of thermocouple. The input voltage to be measured is applied to the heater. The heating effect of the heater is sensed by a thermocouple attached to the heater. The thermocouple generates the corresponding voltage. The a.c. input is amplified and then given to the heater element to achieve enough heating so that thermocouple can generate enough level of voltage to cause meter deflection. The output voltage is proportional to the r.m.s. value of the a.c. input.

For a thermocouple, $$\text{Power} = \frac{E^2_{rms}}{R_{heater}}$$

$$\therefore \quad E_0 \propto \text{heat} \propto \text{power}$$

$$\therefore \qquad E_o = \frac{KE^2_{rms}}{R_{heater}}$$

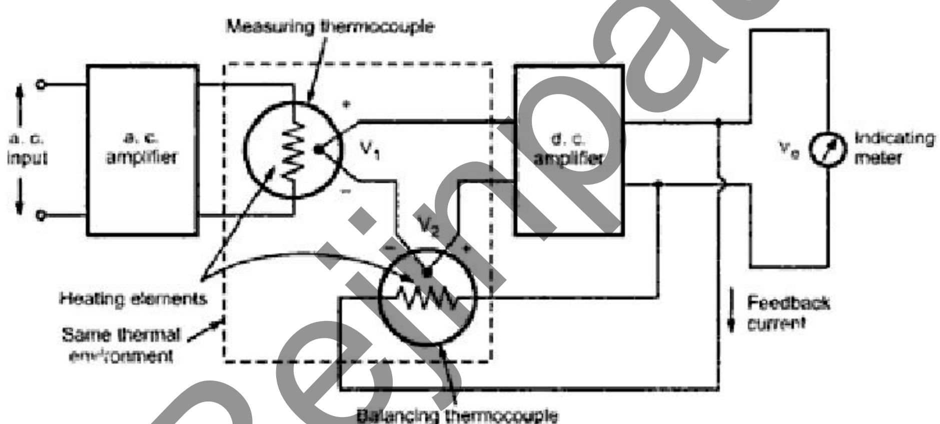
where E_{rms} = r.m.s. value of the a.c. input

E_o = Output voltage of thermocouple

K = Constant of proportionality

The value of K depends on the distance between the heater and the thermocouple and also on the materials used in the heater and the thermocouple.

The main difficulty in such a meter is the nonlinear characteristics of a thermocouple. In some instruments this difficulty is ovecome by placing two thermocouples in the same thermal environment. The effect of the nonlinear behaviour of the input thermocouple is cancelled by similar nonlinear effect caused by thermocouple in the feedback path. The input thermocouple is called **measuring thermocouple** while the thermocouple in the feedback path is called **balancing thermocouple.** The true r.m.s responding voltmeter using two thermocouples is shown in the Fig. 2.15.



True r.m.s. responding voltmeter

The two thermocouples, balancing and measuring forms a balanced bridge in the input circuit of the d.c. amplifier.

When the a.c. input is applied, the measuring thermocouple produces the voltage V_1 which upsets the balance of the bridge. The d.c. amplifier amplifies the unbalanced

$$\therefore \qquad E_o \propto \text{heat} \propto \text{power}$$

The two thermocouples, balancing and measuring forms a balanced bridge in the input circuit of the d.c. amplifier.

When the a.c. input is applied, the measuring thermocouple produces the voltage V_1 which upsets the balance of the bridge. The d.c. amplifier amplifies the unbalanced voltage. This amplified voltage is feedback to the balancing thermocouple, which heats the heater element to produce V_2 such that the balance of the bridge is re-established.

Thus the d.c. feedback current is the current which is producing same heating effect as that of a.c. input current i.e. the d.c. current is nothing but the r.m.s. value of the input current. The meter deflection is thus proportional to r.m.s or effective value of the a.c. input.

Vector Voltmeter

The vector voltmeter is basically a new type of amplitude and phase measuring device. It uses two samplers to sample the two waves whose amplitudes and relative phase are to be measured. It measures the voltages at two different points in the circuit and also measures the phase difference between these voltages at these two points.

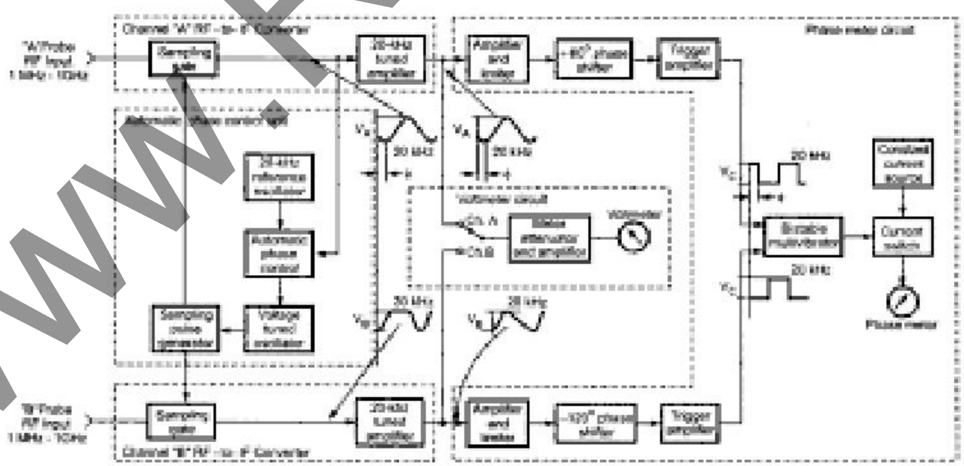
In this voltmeter, two RF signals of same fundamental frequency (1 MHz to GHz) are converted to two IF signals. The amplitudes, waveforms and the phase relations of IF signals are same as that of RF signals. Thus, the fundamental components of the IF signals have the same amplitude and phase relationships as the fundamental components of the RF signals. These fundamental components are filtered from the IF signals and are measured by a voltmeter and a phase meter.

The block diagram of the vector voltmeter is shown in the Fig. 2.59.

The instrument consists of four sections :

i) Two RF to IF converters ii) Automatic phase control circuit

iii) Phase meter circuit iv) Voltmeter circuit



The channel A and B are the two RF to IF converters. The RF signals are applied to sampling gates. The sampling pulse generator controls the opening and closing of the gates. The RF to IF converters and phase control circuit section produce two 20 kHz sine waves with the same amplitudes and the same phase relationship as that of the same amplitudes and the same phase relationship as that of the fundamental components of the RF signals applied to the channels A and B. The tuned amplifier extracts the 20 kHz fundamental component from these sine waves.

The pulse control unit generates the sampling pulses for both the RF to IF converters. The sampling pulse rate is controlled by voltage tuned oscillator for which the tuning voltage is supplied by the automatic phase control unit. This section locks the IF signal of channel A to a 20 kHz reference oscillator. Due to this, the section is also called **phase locked section.**

The tuned amplifier passes only 20 kHz fundamental component of the IF signal of each channel. Thus the output of each tuned amplifier maintains the original phase relationship with respect to the signal in the other channel and also its correct amplitude relationship.

To determine the phase difference, there exists a phase meter circuit. The signals from channel A and B are applied to the amplifier and the limiter circuit. Due to this the signals are amplified and limited i.e. clipped. This produces a square wave signal at the output of each amplifier and limiter circuit. These square waves are then applied to the phase shifting network.

The circuit in upper part i.e. channel A shifts the phase of the square wave by $+60°$ while the circuit in lower part i.e. channel B shifts the phase by $-120°$. The phase shifts are achieved by using capacitive networks and inverting, non-inverting amplifiers. The shifted square wave signals are then applied to trigger amplifers.

These trigger amplifiers convert the square wave signals to the positive spikes with very fast rise times. These spikes are used to trigger the bistable multivibrator.

The signal from channel A is connected to set input of the multivibrator while the signal from channel B is connected to the reset input of the multivibrator.

Now if the phase shift between the two signals is zero then the trigger pulses are $+60° - (-120°)$ i.e. $180°$ out of phase due to phase shift circuitry. Hence in such a case the bistable multivibrator produces a square wave which is symmetrical about zero.

Features of Vector Voltmeter

1) The vector voltmeters cover a 1000 to 1 frequency range accommodating inputs from few microvolts up to about 1 V without input attenuation. Thus it gives broad frequency range.
2) They allow voltage ratios to be measured over a 70 to 80 dB range within a few tenths of a decibel.
3) The phase to be measured to an accuracy of about 1°.
4) Due to self locking feature, there is automatic tuning of the local oscillator in each frequency range.
5) Easy to operate, as simple as normal voltmeters.

Applications of Vector Voltmeter

The vector voltmeter is useful in VHF applications for the following measurements:

1) Insertion losses
2) Complex impedance of mixers
3) Amplifier gain and phase shift
4) Filter transfer functions
5) 'S' parameters of transistors
6) Radio frequency distortions
7) Amplitude modulation index
8) Two port network parameters.

Q-Meter

The Q-factor is called **quality factor** or the **storage factor.** It is defined as the ratio of power stored in the element to the power dissipated in the element. It is the magnification provided by the circuit. It is also defined as the ratio of reactance to resistance of a reactive element. Thus for inductive reactance it is the ratio of X_L to R while for capacitance reactance it is the ratio of X_C to R.

The Q-meter is an instrument which is designed to measure some of the electrical properties of the coils and capacitors. It is a useful laboratory instrument.

Working Principle of Q-Meter

The working of the Q-meter is based on the characteristics of a series resonant circuit. The series resonant circuit has a characteristics that the voltage across the coil or capacitor is equal to the applied voltage times the Q-factor of the circuit.

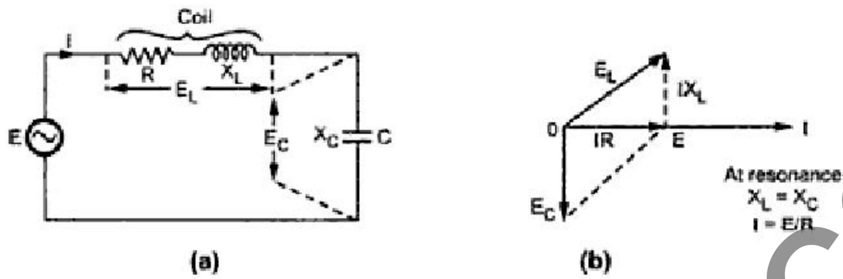


Fig. 2.60 Series resonant circuit

Thus if a fixed voltage is applied to the circuit, the voltmeter across the capacitor can be calibrated to read the Q value directly.

At the resonance,

$$\boxed{X_C = X_L}$$

$$E_C = I X_C = I X_L$$

$$E = IR$$

where

E = applied voltage

I = circuit current

E_C = voltage across capacitor

X_C = capacitive reactance

X_L = inductive reactance

R = resistance of coil

The Q-factor is defined as,

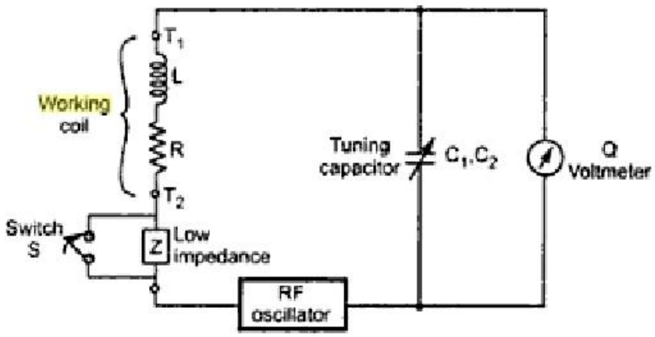
$$\boxed{Q = \frac{X_L}{R} = \frac{X_C}{R} = \frac{E_C}{E}}$$

From equation we can see that if the applied voltage E is maintained constant and at known level then a voltmeter across the capacitor can be calibrated directly interms of the circuit Q.

Direct Connection

The method discussed above in basic practical Q-meter, of connecting a component across the testing terminals is called direct connection in Q-meter. The circuit is resonated by either adjusting frequency or the tuning capacitor. The indicated value of Q is modified by setting of the 'multiply Q by' meter.

Series Connection



Measurement of low impedance by Q meter

The series connection is used to measure low impedance components, small resistances, small coils and large capacitors.

The series connection is shown in the Fig.

The component to be measured is denoted as Z. It is connected in series with the working coil, connected across the testing terminals T_1 and T_2. This working coil is available with the instrument itself. The switch S called **shorting strap** is provided across the low impedance. The two measurements are carried out with the meter :

i) First the low impedance is shorted using the switch S and the circuit is resonated to establish the reference condition. The corresponding values of the tuning capacitor C_1 and the circuit Q-meter Q_1 are noted down.

ii) Secondly the switch is kept opened. The circuit is resonated again with the help of tuning capacitor. The value of tuning capacitor C_2 and Q-meter Q_2 are recorded.

For the reference condition,

$$X_{C1} = X_L$$

$$\therefore \quad \frac{1}{\omega C_1} = \omega L \quad \text{... (1)}$$

Neglecting the resistance of the measuring circuit,

$$\boxed{Q_1 = \frac{\omega L}{R} = \frac{1}{\omega R C_1}} \quad \text{... (2)}$$

In the second measurement, unknown coil is in series with the working coil.

$$\therefore \quad X_s = X_{C2} - X_L$$

$$\therefore \quad X_s = \frac{1}{\omega C_2} - \omega L$$

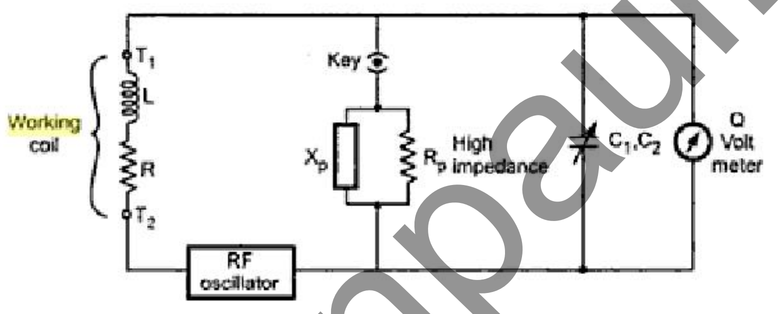
$$\therefore \quad X_s = \frac{1}{\omega C_2} - \frac{1}{\omega C_1}$$

$$\boxed{X_s = \frac{C_1 - C_2}{\omega C_1 C_2}}$$

Parallel Connection

The parallel connection is used to measure high impedance components such as high value resistors, certain inductors and small capacitors. The unknown component is connected in parallel with the measuring circuit.

The parallel connection is shown in the Fig. 2.63.



Measurement of high impedance by Q meter

Advantages

The advantages of the sampling oscilloscope are :

i) Very high frequency performance can be achieved.

ii) High speed electrical signals can be analysed.

iii) The technique allows the design of the oscilloscope with wide bandwidth, high sensitivity even for low duty cycle pulses.

iv) A clear display is produced.

v) Controlling the size of the steps of the staircase generator, the number of samples and hence the resolution can be controlled.

The only limitation of the sampling oscilloscope is that it cannot be used to display the transient waveforms.

Multiple Trace Oscilloscopes

This oscilloscope uses a single electron gun and produces multiple traces by switching the Y deflection plates from one input signal to other.

The Y channel is time shared by many signals in this case.

The eyes interpret this as a continuous simultaneous display of the input signals although it is a sampled display.

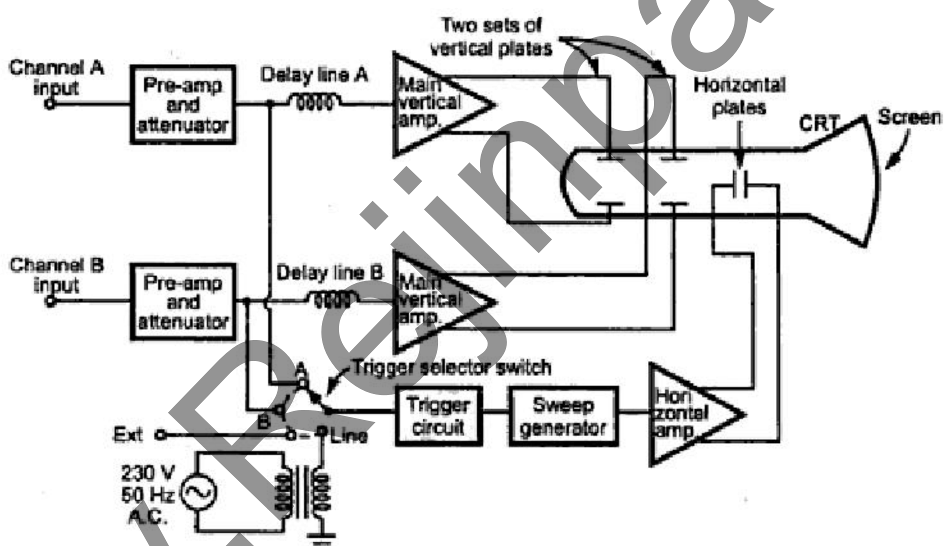
This method reduces the cost of manufacturing multiple channel oscilloscopes.

Dual Beam Oscilloscope

Another method of studying two voltages simultaneously on the screen is to use special cathode ray tube having two separate electron guns generating two separate beams. Each electron beam has its own vertical deflection plates.

But the two beams are deflected horizontally by the common set of horizontal plates. The time base circuit may be same or different. Such an oscilloscope is called **Dual Beam Oscilloscope.**

The block diagram of dual beam oscilloscope is shown in the Fig.



Dual beam oscilloscope

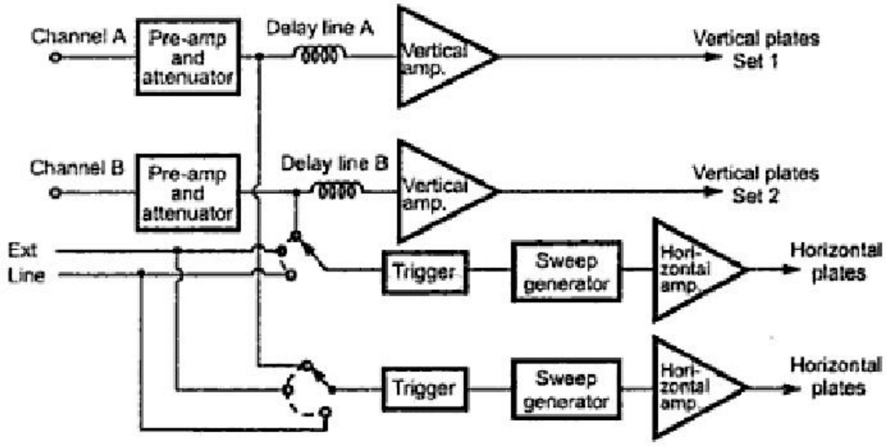


Fig. Dual beam CRO with separate time bases

Storage Oscilloscope

The conventional cathode ray tube has the persistence of the phosphor ranging from a few millisecond to several seconds. But some times it is necessary to retain the image for much longer periods, upto several hours. It requires storing of a waveform for a certain duration, independent of phosphor persistence. Such a retention property helps to display the waveforms of very low frequency.

Mainly two types of storage techniques are used in cathode ray tubes which are :

i) Mesh storage and ii) Phosphor storage

Mesh Storage

Basically mesh storage consists of a dielectric material deposited on a storage mesh. This is called storage target. It is placed between the deflecting plates and the phosphor screen. The writing beam i.e. normally focused electron beam charges the dielectric material of storage target positively where hit.

Now the low velocity electrons are bombarded on storage target from the flood gun. The positively charged storage target material allows these electrons to pass through, to the phosphor screen. Thus the image stored with the help of storage mesh gets reproduced on the screen. Thus the storage technique has both storage target and a phosphor display target used for storing and displaying the image.

The construction of storage cathode ray tube is shown in the Fig.

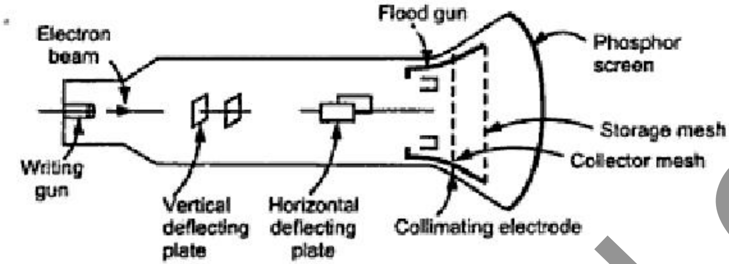


Fig. Mesh storage CRT

Phosphor Storage

In this technique of storage, the tube used is a bistable storage tube. The same material is used for both the storage target and the display phosphor. Infact the thin phosphor layer acts as storage target as well as the display target hence the name bistable tube.

The target structure of bistable storage tube is shown in the Fig. !

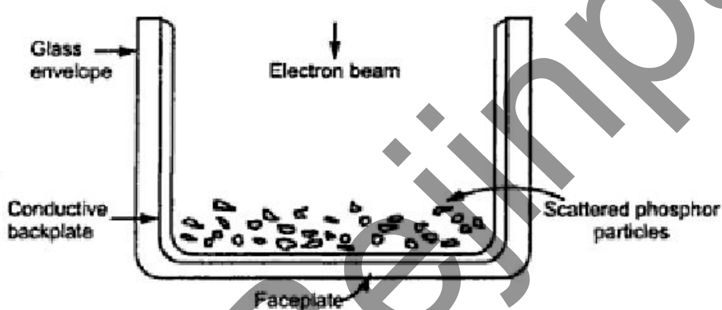


Fig. Target structure of bistable storage tube

The bistable nature of the tube means that the trace is either stored or it is not i.e. the brightness is thus on or off. For this purpose, the **split screen** version is used. Two independent conductive plates are depositive, one covering the upper half portion of CRT while other the bottom half portion of CRT. The upper half is operated at about 150 V while the lower half at about 50 V. Hence the upper portion acts as a storage tube while the lower half as a standard refreshed phosphor display.

The schematic view of a bistable phosphor storage tube is shown in the Fig.

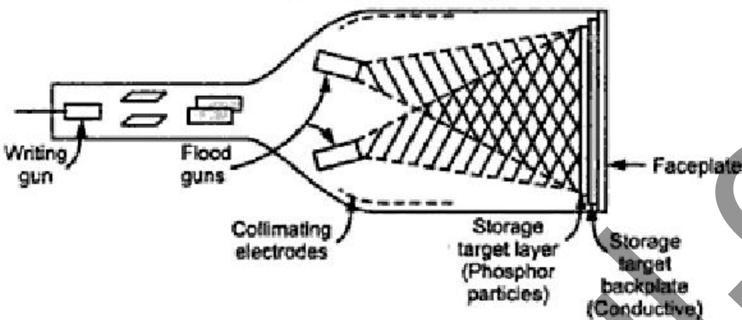


Fig. Bistable phosphor storage tube

	Mesh Storage	Phosphor Storage
1.	Based on the dielectric material deposited on a storage mesh.	Based on the principle of bistable storage nature of the tube.
2.	Storage target and display target are different.	Storage and display target is same
3.	There is no possibility of reduction in the light output with use.	It is susceptible to light output reduction with the use.
4.	Variable persistence is possible.	Variable persistence is not possible.
5.	Grey scales or half tones are possible.	Halftones are not possible.
6.	Continuous persistence control is possible.	Continuous persistence control is not possible.
7.	The material used for storage target and display target is different.	The same material mostly P1 phosphor is used for both storage as well as display target.
8.	Relatively long CRT life.	Relatively short CRT life.
9.	Comparison of previous waveform and present waveform is not possible.	Comparison of previous waveform and present waveform is possible due to split screen feature.

Digital Storage Oscilloscope

There are certain disadvantages of storage cathode ray tube due to which there is need of digital storage oscilloscope. The **disadvantages** of analog storage cathode ray tube are as follows :

i) The waveform can be preserved for finite amount of time only and eventually the waveform will be lost.

ii) As long as image is required to be stored, the power must be supplied to the tube.

iii) The trace obtained from the storage tube is not fine as compared to the conventional oscilloscope tube.

iv) The writing rate of storage tube is less than that of conventional cathode ray tube. This limits the speed of the storage tube.

v) The storage cathode ray tube is very much expensive than conventional cathode ray tube.

vi) The storage cathode ray tube requires additional power supplies.

vii) Only one waveform can be stored in storage tube. If two traces are to be compared, they are required to be superimposed on the same screen and must be displayed together.

viii) The stored waveform cannot be reproduced on the external device like computer.

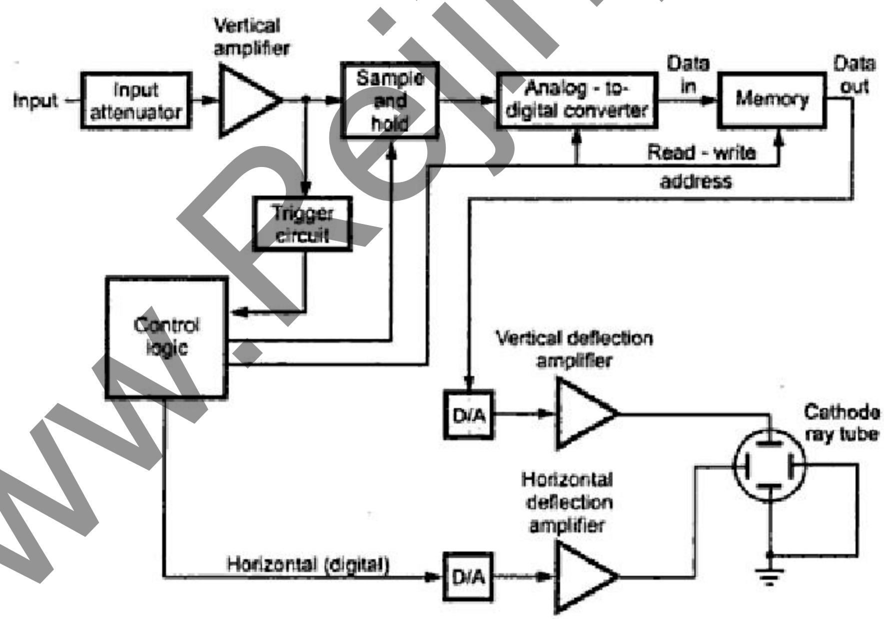


Fig. Block diagram of digital storage oscilloscope

As done in all the oscilloscopes, the input signal is applied to the amplifier and attenuator section. The oscilloscope uses same type of amplifier and attenuator circuitry as used in the conventional oscilloscopes. The attenuated signal is then applied to the vertical amplifier.

To digitise the analog signal, analog to digital (A/D) converter is used. The output of the vertical amplifier is applied to the A/D converter section. The main requirement of A/D converter in the digital storage oscilloscope is its speed, while in digital voltmeters accuracy and resolution were the main requirements. The digitised output needed only in the binary form and not in BCD. The successive approximation type of A/D converter is most oftenly used in the digital storage oscilloscopes.

The digital storage oscilloscope has three modes of operation :

i) **Roll mode :** Very fast varying signals are displayed clearly in this mode. In this mode, the input signal is not triggered at all. The fast varying signal is displayed as if it is changing slowly, on the screen in this mode.

ii) **Store mode :** This is called refresh. In this case input initiates trigger circuit. Memory write cycle starts with trigger pulse. When memory is full, write cycle stops. Then using digital to analog converter, the stored signal is converted to analog and displayed. When next trigger occurs the memory is refreshed.

iii) **Hold or save mode :** This is automatic refresh mode. When new sweep signal is generated by time base generator, the old contents get over written by new one. By pressing hold or save button, overwriting can be stopped and previously saved signal gets locked.

Advantages

Let us summarize the **advantages of the digital storage oscilloscope :**

i) It is easier to operate and has more capability.

ii) The storage time is infinite.

iii) The display flexibility is available. The number of traces that can be stored and recalled depends on the size of the memory.

iv) The cursor measurement is possible.

v) The characters can be displayed on screen along with the waveform which can indicate waveform information such as minimum, maximum, frequency, amplitude etc.

vi) The X-Y plots, B-H curve, P-V diagrams can be displayed.

vii) The pretrigger viewing feature allows to display the waveform before trigger pulse.

viii) Keeping the records is possible by transmitting the data to computer system where the further processing is possible

ix) Signal processing is possible which includes translating the raw data into finished information e.g. computing parameters of a captured signal like r.m.s. value, energy stored etc.

UNIT III

Part - A

1. Define duty cycle.

It is the ratio of the average value of pulse over one cycle to the peak value of the pulse.
Duty cycle= pulsewidth/period.

2. Define pulse repetition rate.

Period is known as pulse repetition rate.= pulse width / duty cycle.

3. Mention the application of wave analyzers

In the fields of electrical measurements& sound & vibration analysis.

4. Mention the types of wave analyzers

Frequency-selective wave analyzer, Heterodyne wave analyzer. 5.
Define harmonic distortion.

Distortion may be a result of inherent nonlinear characteristics of transistors in the circuits. Nonlinear behaviour of circuit elements introduces harmonics of fundamental frequency in the output waveform,this distortion is harmonic distortion

6. Mention the application of spectrum analyzers.

To examine pulse modulation,harmonic distortion,asymmetrical spectra,frequency& amplitude modulation.

7. What is the difference between single frequency generator and sweep frequency generator?

Single o/p frequency was generated at a known & stable frequency,sweeping source of frequency is required for measuring the frequency response of amplifier,filter.

8. Give the application of sweep frequency generator

It applications are to determine the frequency response of amplifiers,filters.

9. What are types of synthesizing?

Direct & indirect.

10. What is the function of spectrum analyzer?

It provides a calibrated graphical display on its CRT with frequency on horizontal axis & amplitude on vertical axis.

11. What is reference source?

It is very accurate & stable frequency source mostly it is quartz crystal oscillator.

12. explain programmable divider

It is a logic element that divides the frequency of VCO by an integer that can be entered via programming switches.

13. Define VCO

Voltage -controlled oscillator is the source of o/p frequency & has the ability to be tuned electronically, usually by applying a variable voltage. 14.
Enumerate phase detector.

Phase detector provides an analog o/p that is a function of the phase angle between the two inputs.

14. Define signal generator.

Signal generator is to supply signals of known frequencies.& to supply known signals levels at very low levels for testing & evaluating receivers. 16.
Classify signal generators.

Function generator, pulse & sweep generator.

17. Give the formulae for resonant frequency.

The f = 1 / 2□□ LC.

Part - B

1. With a neat sketch, explain the working of a Function generator.

FUNCTION GENERATOR

A function generator produces different waveforms of adjustable frequency. The common output waveforms are the sine, square, triangular and sawtooth waves. The frequency may be adjusted, from a fraction of a Hertz to several hundred kHz.

The various outputs of the generator can be made available at the same time. For example, the generator can provide a square wave to test the linearity of an amplifier and simultaneously provide a sawtooth to drive the horizontal deflection amplifier of the CRO to provide a visual display.

Capability of Phase Lock

The function generator can be phase locked to an external source. One function generator can be used to lock a second function generator, and the two output signals can be displaced in phase by adjustable amount.

In addition, the fundamental frequency of one generator can be phase locked to a harmonic of another generator, by adjusting the amplitude and phase of the harmonic, almost any waveform can be generated by addition.

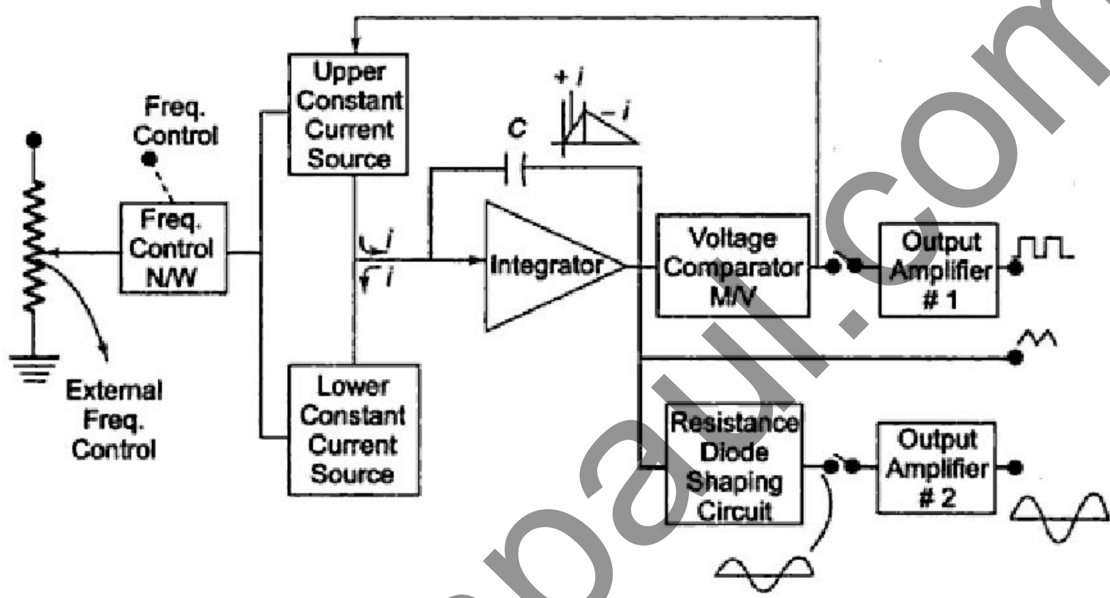
The function generator can also be phase locked to a frequency standard and all its output waveforms will then have the same accuracy and stability as the standard source.

The voltage comparator multivibrator changes states at a pre-determined maximum level of the integrator output voltage. This change cuts off the upper current supply and switches on the lower current supply.

The lower current source supplies a reverse current to the integrator, so that its output decreases linearly with time. When the output reaches a pre-determined minimum level, the voltage comparator again changes state and switches on the upper current source.

The output of the integrator is a triangular waveform whose frequency is determined by the magnitude of the current supplied by the constant current sources.

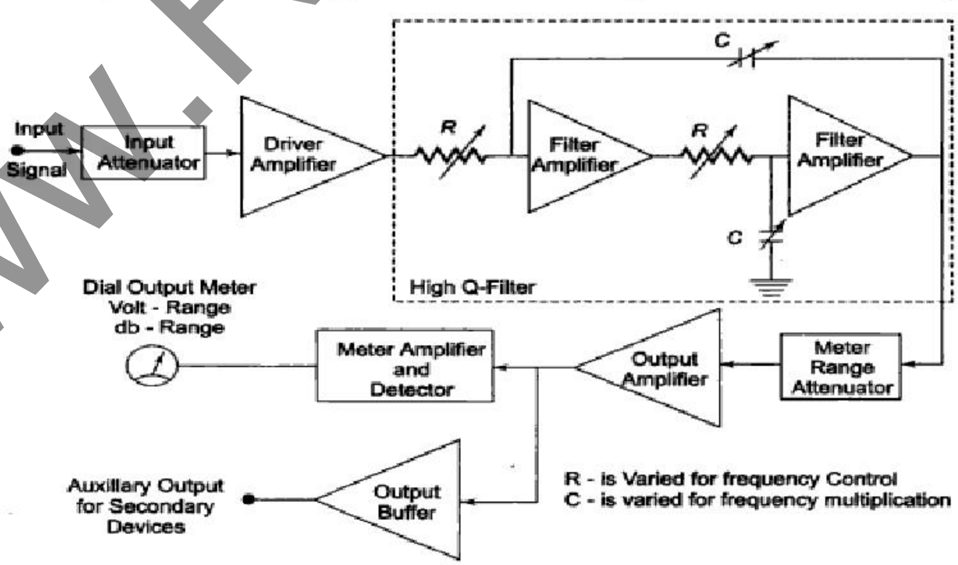
The comparator output delivers a square wave voltage of the same frequency. The resistance diode network alters the slope of the triangular wave as its amplitude changes and produces a sine wave with less than 1% distortion.



2. Explain about Frequency selective wave analyzer and heterodyne wave analyzer.

FREQUENCY SELECTIVE WAVE ANALYZER

The wave analyzer consists of a very narrow pass-band filter section which can be tuned to a particular frequency within the audible frequency range (20 Hz - 20 kHz). The block diagram of a wave analyzer is as shown in Fig. 9.1(b).



The complex wave to be analyzed is passed through an adjustable attenuator which serves as a range multiplier and permits a large range of signal amplitudes to be analyzed without loading the amplifier.

The output of the attenuator is then fed to a selective amplifier, which amplifies the selected frequency. The driver amplifier applies the attenuated input signal to a high-Q active filter. This high-Q filter is a low pass filter which allows the frequency which is selected to pass and reject all others. The magnitude of this selected frequency is indicated by the meter and the filter section identifies the frequency of the component. The filter circuit consists of a cascaded RC resonant circuit and amplifiers. For selecting the frequency range, the capacitors generally used are of the closed tolerance polystyrene type and the resistances used are precision potentiometers. The capacitors are used for range changing and the potentiometer is used to change the frequency within the selected pass-band, Hence this wave analyzer is also called a Frequency selective voltmeter.

The entire AF range is covered in decade steps by switching capacitors in the RC section.

The selected signal output from the final amplifier stage is applied to the meter circuit and to an untuned buffer amplifier. The main function of the buffer amplifier is to drive output devices, such as recorders or electronics counters.

The meter has several voltage ranges as well as decibel scales marked on it. It is driven by an average reading rectifier type detector.

Heterodyne wave analyzer is shown in the Fig. 10.3.

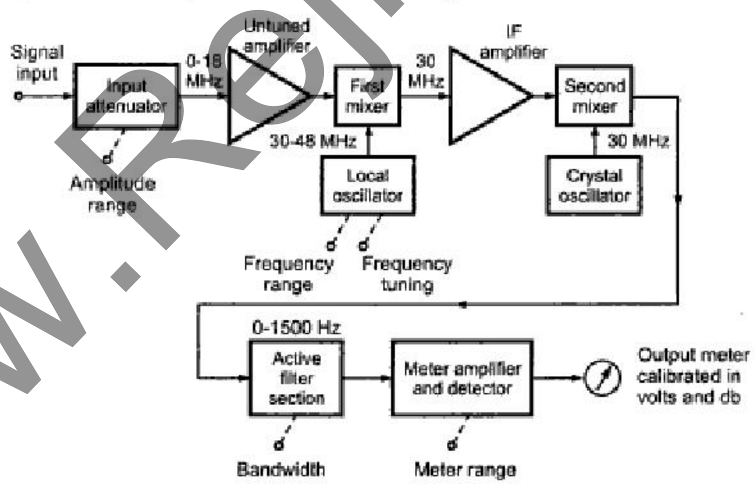


Fig. 10.3 Heterodyne wave analyzer

The operating frequency range of the 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 3000Hz.

The input is applied first to the attenuator section. This gives the output frequency in the range of 0 to 18 MHz. The untuned amplifier amplifies this signal and gives it to the first mixer.

The first mixer, heterodynes the input with the frequency from local oscillator. This oscillator has frequency range 30-48 MHz. The output of the first mixer is difference frequency of 30 MHz.

The IF amplifier, amplifies this signal to give to second mixer. The second mixer, heterodynes this signal with a 30 MHz frequency crystal oscillator. Thus at the output of second mixer the zero difference frequency is obtained.

The active filter having controlled bandwidth and symmetrical slopes of 72 dB per octave, then passes the selected component to the meter amplifier and detector. The output from the meter detector is then used to obtain final indication on the output meter which is having a decibel calibrated scale. Such an output from detector may be applied to a recording device.

Applications of Wave Analyzer

The wave analyzer can be used in the following applications :

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

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

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

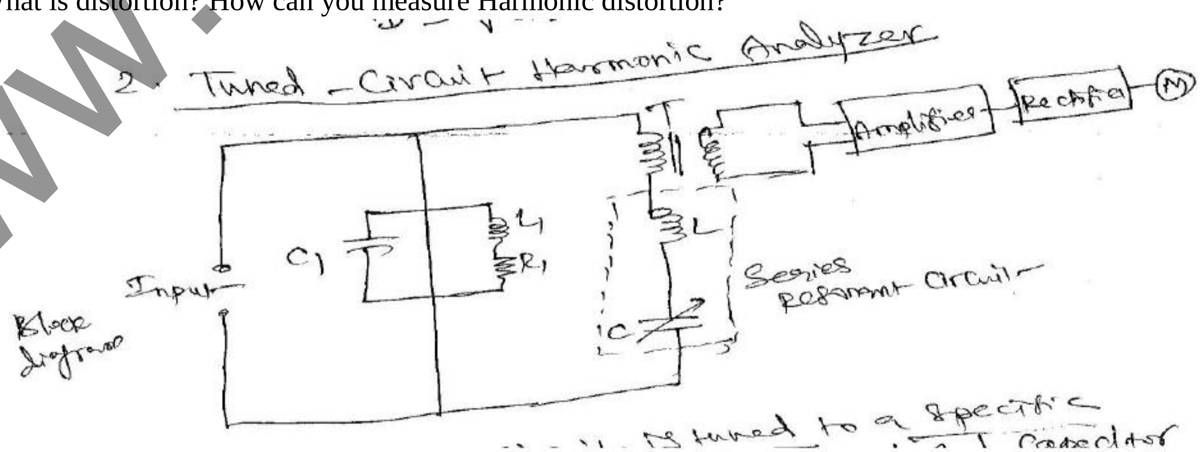
iv) To obtain fine spectrum analysis to display various discrete frequencies and resonances related to the motion of machines. Hence ways and means can be found out to eliminate such sources of sound and vibrations causing resonances.

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

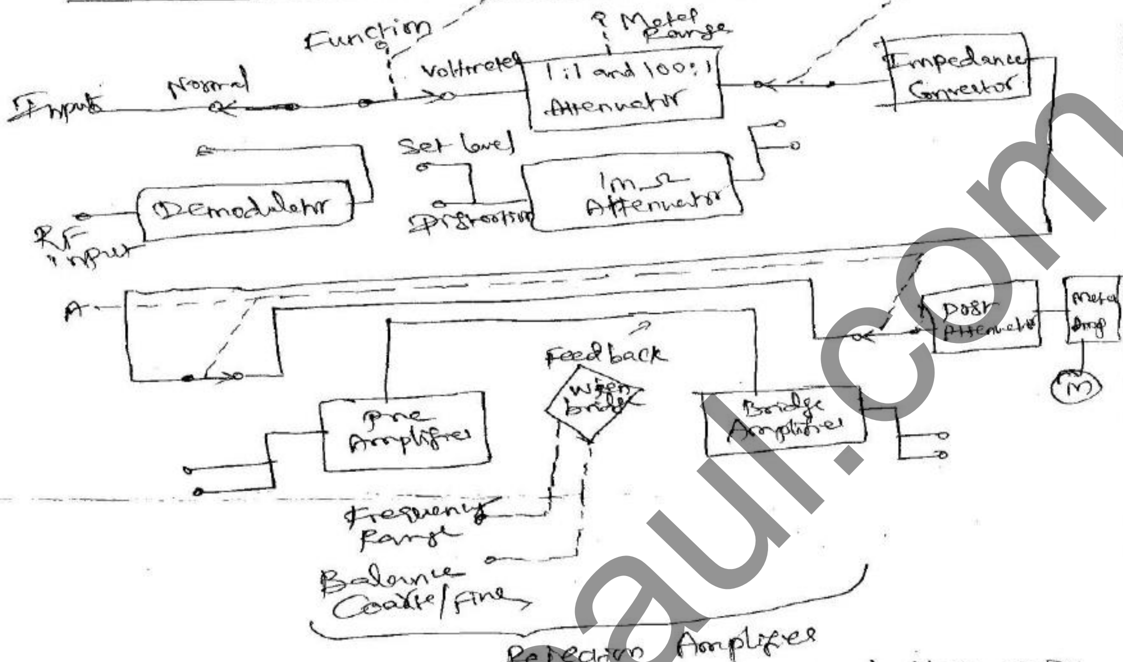
vi) To measure the signal energy with the well defined bandwidth.

vii) To carry out complete harmonic analysis.

3. What is distortion? How can you measure Harmonic distortion?



Fundamental-Suppression Harmonic Distortion Analyzer



... Total Harmonic

Harmonic Distortion Analyzer

Introduction

(i) Whenever an input signal is applied to a system (amplifier) the output is not an exact replica of the input waveform because of various types of distortions that may occur.

(ii) Distortion may be a result of the inherent non-linear characteristics of different components used in an electronic circuits.

(iii) Non linear behaviors of circuit elements introduce harmonics in the output waveform and the resultant distortion is often referred to as harmonics distortion (HD).

7. Explain about Pulse and Square wave generators.

SQUARE AND PULSE GENERATOR (LABORATORY TYPE)

These generators are used as measuring devices in combination with a CRO. They provide both quantitative and qualitative information of the system under test. They are made use of in transient response testing of amplifiers. The fundamental difference between a pulse generator and a square wave generator is in the duty cycle.

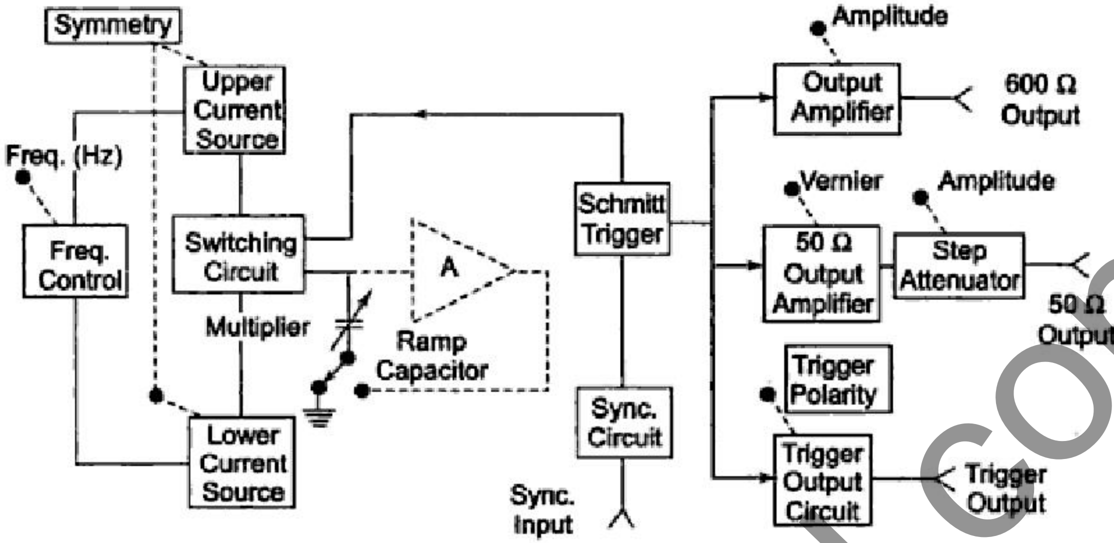
$$\text{Duty cycle} = \frac{\text{pulse width}}{\text{pulse period}}$$

A square wave generator has a 50% duty cycle.

5. Some pulse generators can be triggered by an externally applied trigger signal; conversely, pulse generators can be used to produce trigger signals, when this output is passed through a differentiator circuit.
6. The output impedance of the pulse generator is another important consideration. In a fast pulse system, the generator should be matched to the cable and the cable to the test circuit. A mismatch would cause energy to be reflected back to the generator by the test circuit, and this may be re-reflected by the generator, causing distortion of the pulses.
7. DC coupling of the output circuit is needed, when dc bias level is to be maintained.

The basic circuit for pulse generation is the asymmetrical multi-vibrator. A laboratory type square wave and pulse generator is shown in Fig. 8.6.

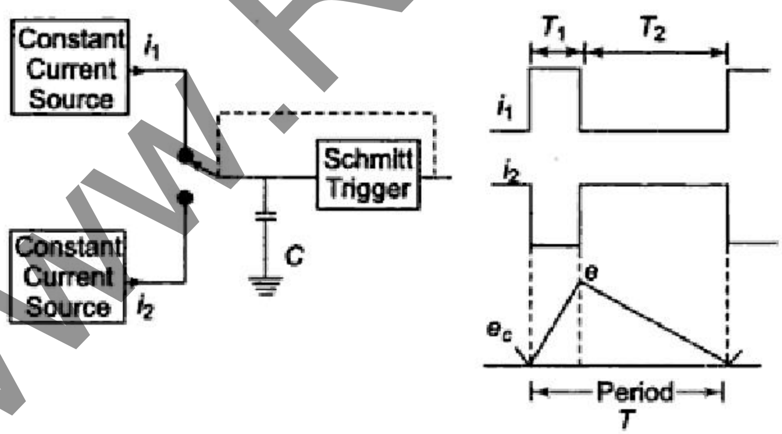
The frequency range of the instrument is covered in seven decade steps from 1 Hz to 10 MHz, with a linearily calibrated dial for continuous adjustment on all ranges.



The duty cycle can be varied from 25 – 75%. Two independent outputs are available, a 50 Ω source that supplies pulses with a rise and fall time of 5 ns at 5 V peak amplitude and a 600 Ω source which supplies pulses with a rise and fall time of 70 ns at 30 V peak amplitude. The instrument can be operated as a free-running generator, or it can be synchronised with external signals.

The basic generating loop consists of the current sources, the ramp capacitor, the Schmitt trigger and the current switching circuit, as shown in Fig. 8.7.

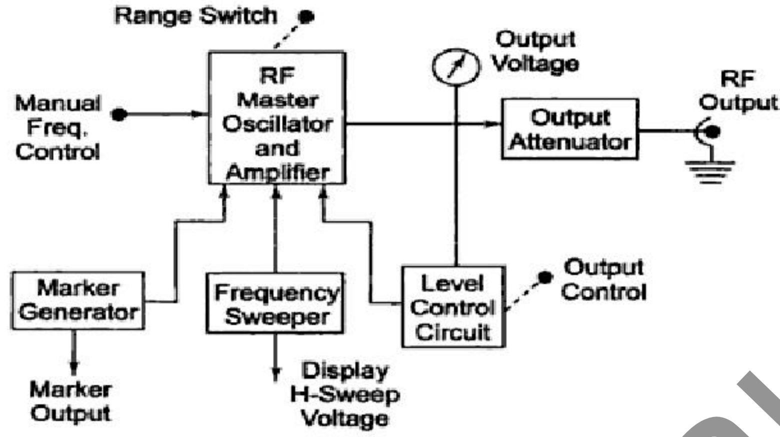
The upper current source supplies a constant current to the capacitor and the capacitor voltage increases linearly. When the positive slope of the ramp voltage reaches the upper limit set by the internal circuit components, the Schmitt trigger changes state. The trigger circuit output becomes negative and reverses the condition of the current switch. The capacitor discharges linearly, controlled by the lower current source. When the negative ramp reaches a



Basic Generating Loop

predetermined lower level, the Schmitt trigger switches back to its original state. The entire process is then repeated. The ratio i_1/i_2 determines the duty cycle, and is controlled by symmetry control. The sum of i_1 and i_2 determines the frequency. The size of the capacitor is selected by the multiplier switch.

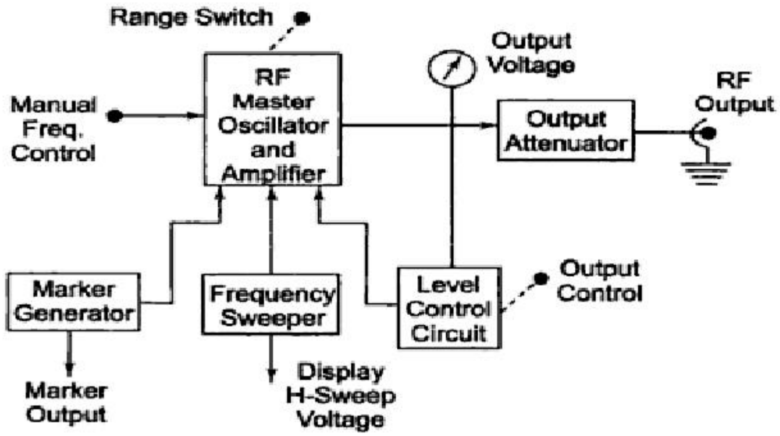
The unit is powered by an internal supply that provides regulated voltages for all stages of the instrument.



SWEEP GENERATOR

It provides a sinusoidal output voltage whose frequency varies smoothly and continuously over an entire frequency band, usually at an audio rate. The process of frequency modulation may be accomplished electronically or mechanically.

It is done electronically by using the modulating voltage to vary the reactance of the oscillator tank circuit component, and mechanically by means of a motor driven capacitor, as provided for in a modern laboratory type signal generator. Figure 8.10 shows a basic block diagram of a sweep generator.



The frequency sweeper provides a variable modulating voltage which causes the capacitance of the master oscillator to vary. A representative sweep rate could be of the order of 20 sweeps/second. A manual control allows independent adjustment of the oscillator resonant frequency.

The frequency sweeper provides a varying sweep voltage for synchronisation to drive the horizontal deflection plates of the CRO. Thus the amplitude of the response of a test device will be locked and displayed on the screen.

To identify a frequency interval, a marker generator provides half sinusoidal waveforms at any frequency within the sweep range. The marker voltage can be added to the sweep voltage of the CRO during alternate cycles of the sweep voltage, and appears superimposed on the response curve.

The automatic level control circuit is a closed loop feedback system which monitors the RF level at some point in the measurement system. This circuit holds the power delivered to the load or test circuit constant and independent of frequency and impedance changes. A constant power level prevents any source mismatch and also provides a constant readout calibration with frequency.

UNIT IV

Part - A

1. Define automation in digital voltmeters

Digital instruments are designed to have automatic polarity display,automatic decimal point positioning, automatic ranging & automatic zeroing. 2. Classify digital voltmeters.

Analog to digital converter, Digital to analog converter voltmeter.

3. Which type of DVM is fastest?

The parallel A/D conversion voltmeter.

4. Compare period and time interval measurement.

Period measurement determines the time required for a signal to complete one full cycle of oscillation. Time interval mode of operation measures the time elapsed between two events.

5. Compare period and pulse width measurement.

Period measurement determines the time required for a signal to complete one full cycle of oscillation. Pulse width measurement is to measure the leading edge is selected as the start & the trailing edge as the stop signal.

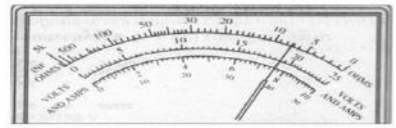
6. What is the accuracy & range of DVM?
   Accuracy is a measure of the closeness with which an instrument measures the true value of a quantity.the range of an instrument describes the limits of magnitude which a quantity may be measure
7. List the various time interval measurements.
   Single mode time interval,time -interval averaging mode (multiple time interval mode),pulse-width measurement. What is frequency counter?.
8. A frequency counter is a device that counts selected input signal transition for a fixed period of time & displays the resultant frequency.
   Mention display devices.
9. Digital meters use either LED or LCD displays.
   Name two different ramp techniques used in DVM
10. linear ramp , staircase ramp type DVM
    What is the resolution of 3 ½ digit voltmeter
11. 1/1000 = .001
    List out any two advantages of DVM
12. Parallax error are reduced
    Input impedance is very high
    Which mode of measurement is preferable for low frequency measurement and
13. why ?
    Time period measurement is preferable. Because the gating error will be less
    List out the various errors in digital measurement
14. Gating error, Time base error, Systematic error, Trigger error
    What is virtual instrument?
15. With virtual instrumentation, software based on user requirements defines general-purpose measurement and control hardware functionality. Virtual instrumentation combines mainstream commercial technologies, such as the PC, with flexible software and a wide variety of measurement and control hardware, so engineers and scientists can create user-defined systems that meet their exact application needs. With virtual instrumentation, engineers and scientists reduce development time, design higher quality products, and lower their design costs.

15. Why is virtual instrumentation necessary?
    Virtual instrumentation is necessary because it delivers instrumentation with the rapid adaptability required for today's concept, product, and process design, development, and delivery. Only with virtual instrumentation can engineers and scientists create the user-defined instruments required to keep up with the world's demands.
16. What is meant by automatic polarity indication?
    When the polarity of a measurand changed, it will be indicated.
17. What is the advantage of computer controlled test system?
    A computer can monitor the system continuously without any break, hence whenever the deviation created in the process computer will take the control action.

Part - B

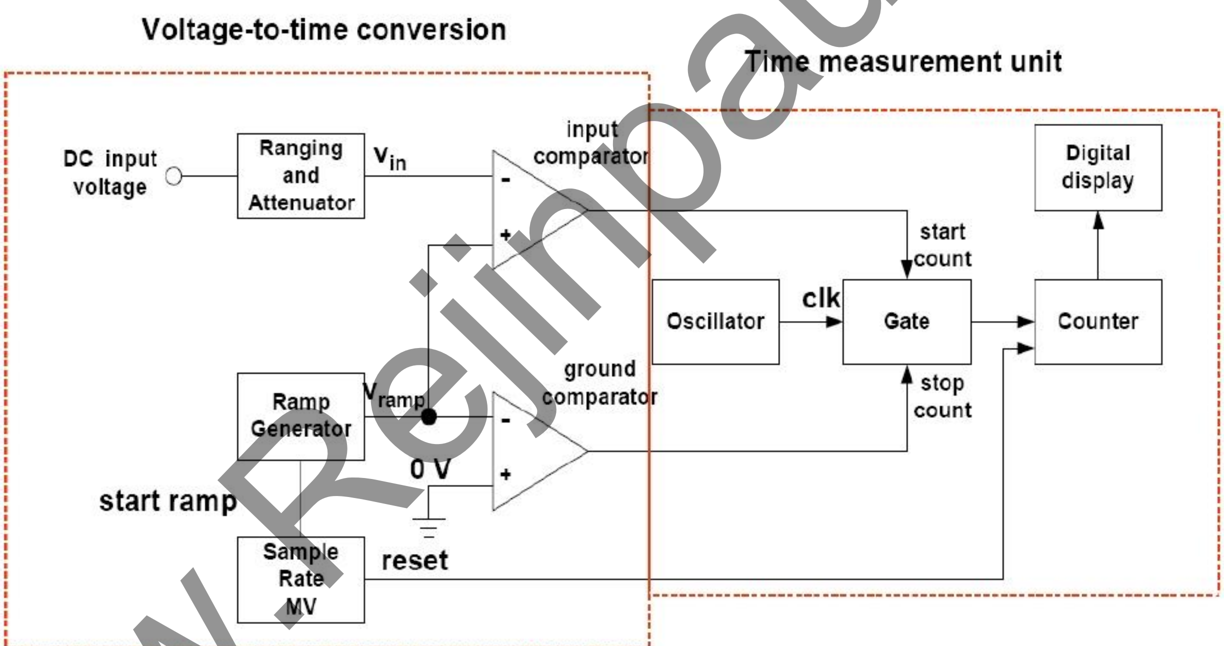
Part - B

1. Compare the Advantage and disadvantage of the Digital instrument with the Analog instrument.



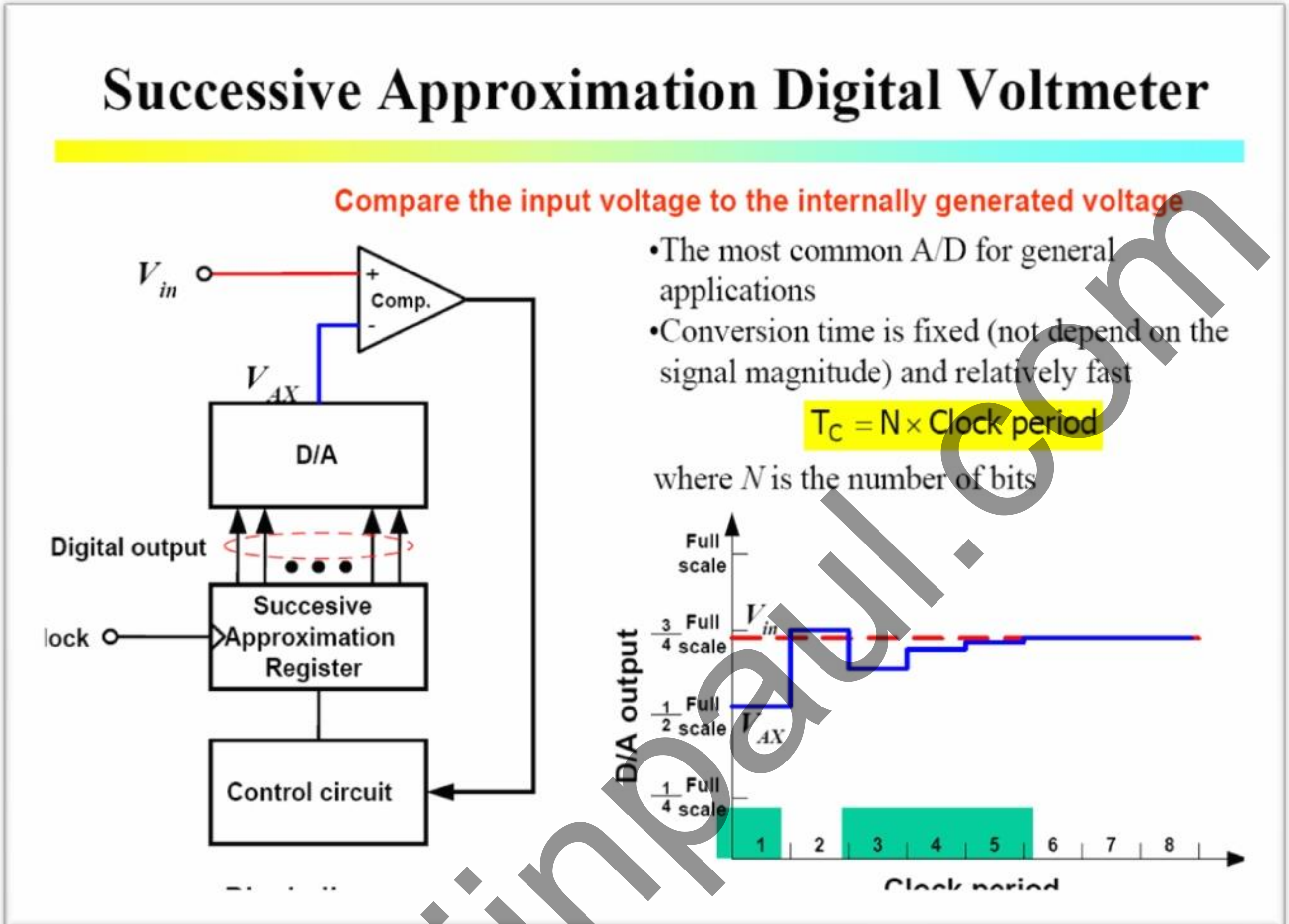
Digital meter	Analog meter
Leaves no doubt about the measured quantity.	Wrong scale might be used or might be read incorrectly.
Superior resolution and accuracy. (±0.5% or better)	Inferior resolution and accuracy. (±3% in common)
Indicates a negative quantity when the terminal polarity is reversed	Pointer attempts to deflect to the left when the polarity is reversed
No usually damaged by rough treatment	Can be damaged when dropped from bench level

2. With a near sketch and timing diagram, explain the working of Ramp Type DVM.



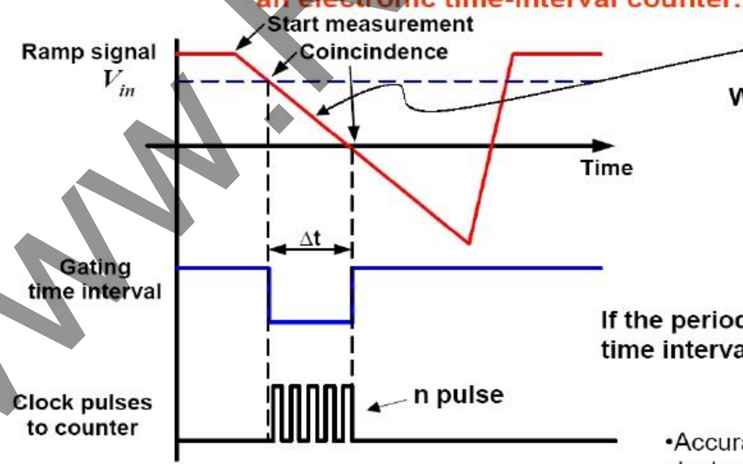
Block diagram of a ramp-type digital voltmeter.

3. With a near sketch, explain about Successive approximation DVM.



(also called single slope)

Operation principle: The measurement of the time it takes for a linear ramp voltage to rise from 0 V to the level of the input voltage, or to decrease from the level of the input voltage to zero. This time interval is measured with an electronic time-interval counter.



Voltage-to-time conversion using gated clock pulses.

$V_{ramp}(t) = V_o - m\,t$

Where m is the ramp rate

$V_{ramp}(t_1) = V_{in} = V_o - m\,t_1$

$V_{ramp}(t_2) = 0 = V_o - m\,t_2$

$\Delta t = t_2 - t_1 = V_{in}/m$

If the period of the clock is T, then during the time interval Δt_1, the number of pulses is

$\Delta t \approx nT$ or $V_{in} \approx nmT$

•Accuracy depends on both the ramp rate and clock period.

4. With a neat sketch, explain the working of DMM.

The digital multimeter is an instrument which is capable of measuring a.c. voltages, d.c. voltages, a.c. and d.c. currents and resistances over several ranges. The basic circuit of a digital multimeter is always a d.c. voltmeter as shown in the Fig.

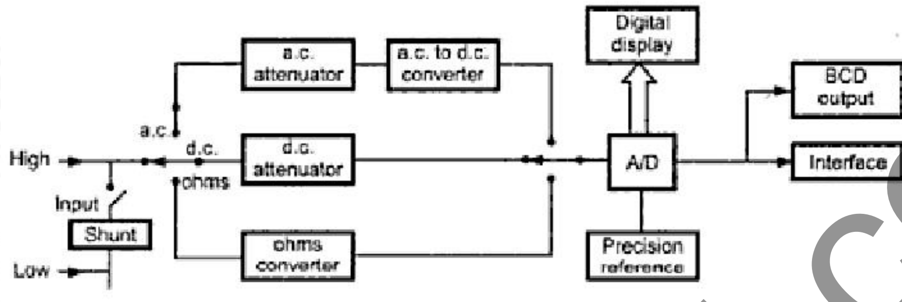


Fig. Basic scheme of digital multimeter

The current is converted to voltage by passing it through low shunt resistance. The a.c. quantities are converted to d.c. by employing various rectifier and filtering circuits. While for the resistance measurements the meter consists of a precision low current source that is applied across the unknown resistance while gives d.c. voltage. All the quantities are digitised using analog to digital converter and displayed in the digital form on the display. The analog multimeters require no power supply and they suffer less from electric noise and isolation problems but still the digital multimeters have following **advantages** over analog multimeters :

i) The accuracy is very high.

ii) The input impedance is very high hence there is no loading effect.

iii) An unambigious reading at greater viewing distances is obtained.

iv) The output available is electrical which can be used for interfacing with external equipment.

v) Due to improvement in the integrated technology, the prices are going down.

vi) These are available in very small size.

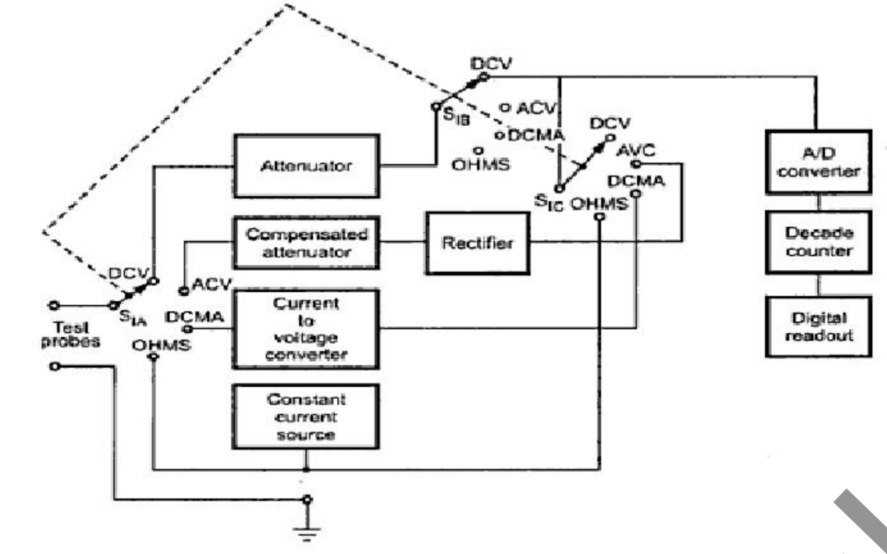


Fig. Block diagram of a digital multimeter

This circuit uses a Dual slope ADC • It has a 31/2 digit LCD or LED display

Display Digits and Counts

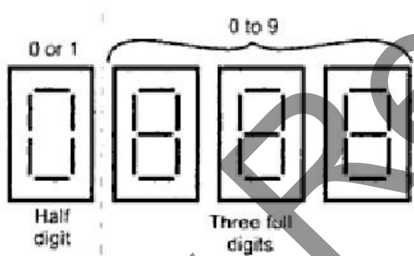


Fig. $3\frac{1}{2}$ digit display

The resolution of digital meters depends 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 1 mV.

Practically one more digit which can display only 0 or 1 is added. This digit is called **half digit** and display is called $3\frac{1}{2}$ digit display. This is shown in the Fig.

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

5. Explain about Auto ranging and Auto zeroing in digital instruments.

Automatic Ranging

2. Automatic Ranging

The object of automatic ranging is to get a reading with optimum resolution under all circumstances (e.g. 170 mV should be displayed as 170.0 and not as 0.170). Let us take the example of a 3½ digit display, i.e. one with a maximum reading of 1999. This maximum means that any higher value must be reduced by a factor of 10 before it can be displayed (e.g. 201 mV as 0201). On the other hand, any value below 0200 can be displayed with one decade more resolution (e.g. 195 mV as 195.0). In other words, if the display does not reach a value of 0200, the instrument should automatically be switched to a more sensitive range, and if a value of higher than 1999 is offered, the next less sensitive range must be selected.

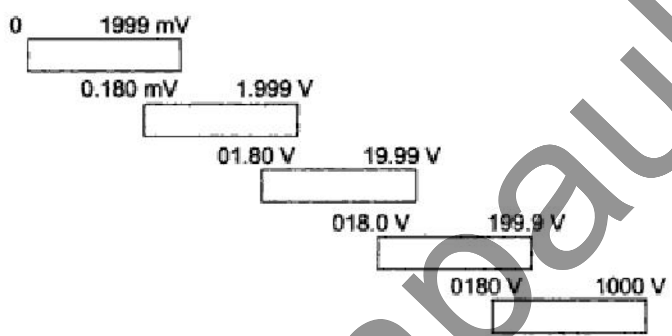


Fig. 6.22 Example of Overlapping Ranges in Automatic Ranging Instruments

Generally the lower limit is taken lower than 0200 (example 0180). Otherwise, a voltage exhibiting slight fluctuations around 2000 would be displayed successively as 1999.9, 0200 and 0201, which would be confusing. By introducing an overlap in the ranges (see Fig. 6.22), we ensure that all values are displayed in the same range (in the above example, as 0199, 0200 or 0201). Values around 0180 also give a stable display e.g. 1798, 1800 and 1807).

The design of an automatic ranging system is indicated in the block diagram in Fig. 6.23.

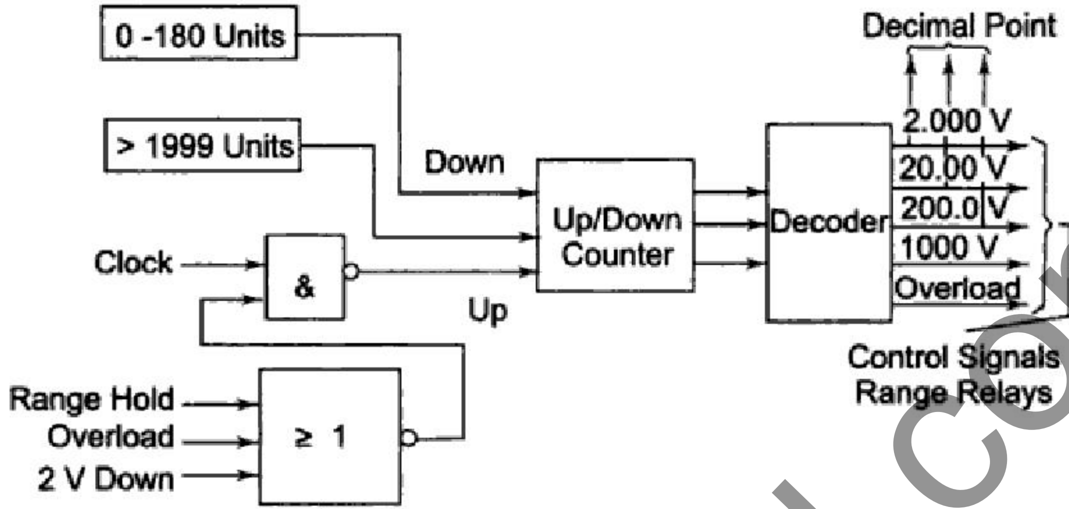


Fig. 6.23 Block Diagram of Automatic Ranging System

The information contained in the counter of the ADC yields a control pulse for down ranging when the count is less than 180 and one for up ranging when the count exceeds 1999 units. The Up/Down counter of the automatic ranging circuit reacts to this information at the moment that a clock pulse (a pulse at the end of the measuring period, also used to transfer new data to memory), is applied, and the new information is used to set the range relays via the decoder. At the same time the decimal point in the display is adapted to the new range, when more than range step has to be made, several measuring periods are needed to reach the final result. Clock pulses, and so automatic ranging, can be inhibited, for example, by a manual range hold command, by a signal that exceeds the maximum range (only for up counts), and course by reaching the most sensitive range, but then only for down counts.

3. Automatic Zeroing

Each user of a voltmeter expects the instrument to indicate zero when the input is short-circuited. In a digital voltmeter with a maximum reading of 1999, a zero error of 0.05% of full scale deflection is sufficient to give a reading of 0001. For this reason, and in the interests of optimum accuracy with low valued readings, a zero adjustment is necessary. To increase the ease of operation, many instruments now contain an automatic zeroing circuit.

In a system used in several multimeters, the zero error is measured just before the real measurement and stored as an analog signal. A simplified circuit diagram of a circuit that can be used for this purpose is given in Fig. 6.24, for a dual slope ADC.

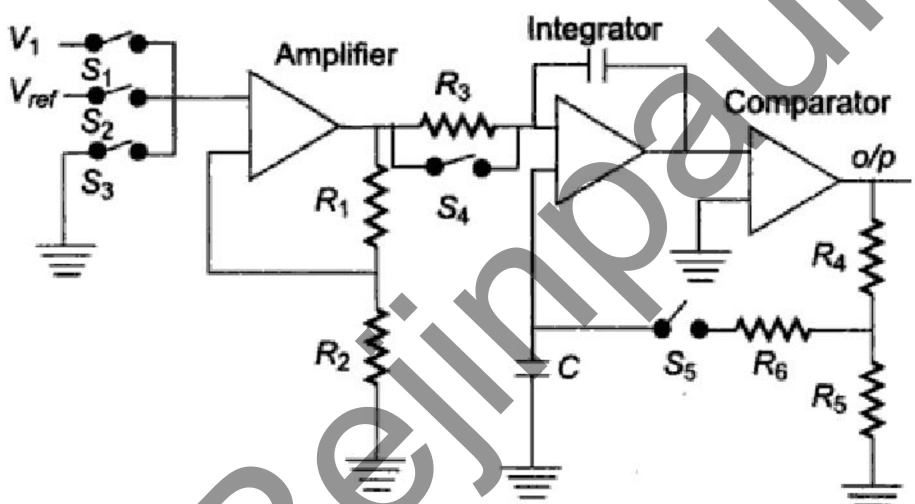


Fig. 6.24 Simplified Circuit Diagram of Automatic Zeroing Circuit that can be Used With Dual Slope ADC

Optimum accuracy for low valued readings – zero adjustment is necessary i.e. short circuit may read 0001
Zero error before real measurement and stored – in integrating type i9t is stored in capacitor

Before the real measurement is made, switches S_3, S_4 and S_5 are closed, say for 50 ms, thus grounding the input, giving the integrator a short RC time, and connecting the output of the comparator to capacitor C. This capacitor is now charged by the offset voltages to the amplifier, the integrator and the comparator. When switches S_3, S_4 and S_5 are opened again to start the real measurement, the total offset voltage of the circuit (equal to zero error) is stored in this capacitor, and the real input voltage is measured correctly.

7. Explain how frequency can be measured using the digital instrument.

DIGITAL FREQUENCY METER 6.3

Principle of Operation The signal waveform is converted to trigger pulses and applied continuously to an AND gate, as shown in Fig. 6.4. A pulse of 1 s is applied to the other terminal, and the number of pulses counted during this period indicates the frequency.

The signal whose frequency is to be measured is converted into a train of pulses, one pulse for each cycle of the signal. The number of pulses occurring in a definite interval of time is then counted by an electronic counter. Since each pulse represents the cycle of the unknown signal, the number of counts is a direct indication of the frequency of the signal (unknown). Since electronic counters have a high speed of operation, high frequency signals can be measured.

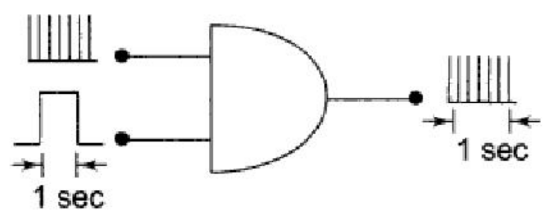


Fig. 6.4 Principle of digital frequency measurement

6.3.1 Basic Circuit of a Digital Frequency Meter

The block diagram of a basic circuit of a digital frequency meter is shown in Fig. 6.5.

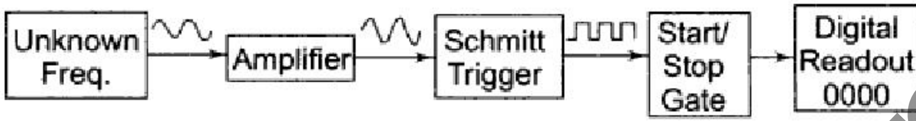


Fig. 6.5 Basic circuit of a digital frequency meter

The signal may be amplified before being applied to the Schmitt trigger. The Schmitt trigger converts the input signal into a square wave with fast rise and fall times, which is then differentiated and clipped. As a result, the output from the Schmitt trigger is a train of pulses, one pulse for each cycle of the signal.

The output pulses from the Schmitt trigger are fed to a START/STOP gate. When this gate is enabled, the input pulses pass through this gate and are fed directly to the electronic counter, which counts the number of pulses.

When this gate is disabled, the counter stops counting the incoming pulses. The counter displays the number of pulses that have passed through it in the time interval between start and stop. If this interval is known, the unknown frequency can be measured.

6.3.2 Basic Circuit for Frequency Measurement

The basic circuit for frequency measurement is as shown in Fig. 6.6. The output of the unknown frequency is applied to a Schmitt trigger, producing positive pulses at the output. These pulses are called the counter signals and are present at point *A* of the main gate. Positive pulses from the time base selector are present at point *B* of the START gate and at point *B* of the STOP gate.

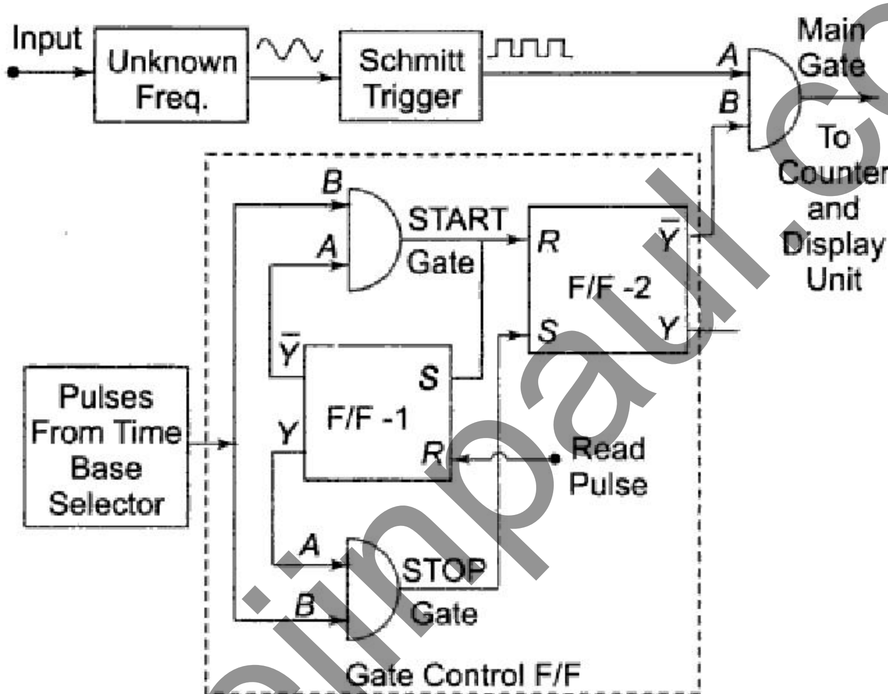


Fig. 6.6 Basic circuit for measurement of frequency showing gate control F/F

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.

8.Explain how the frequency range can be increased in Digital Instruments?

6.3.3 High Frequency Measurement (Extending the Frequency Range)

The direct count range of digital frequency meter (DFM) extends from dc to a few 100 MHz. The limitations arises because of the counters used along with the DFM. The counters cannot count at the speed demanded by high frequency measurement.

This range of a few 100 MHz covers only a small portion of the frequency spectrum. Therefore, techniques other than direct counting have been used to extend the range of digital frequency meters to above 40 GHz. The input frequency is reduced before it is applied to a digital counter. This is done by special techniques. Some of the techniques used are as follows.

1. Prescaling The high frequency signal by the use of high speed is divided by the integral numbers such as 2, 4, 6, 8 etc. divider circuits, to get it within the frequency range of DFM (for example synchronous counters).

2. Heterodyne Converter The high frequency signal is reduced in frequency to a range within that of the meter, by using heterodyne techniques.

3. Transfer Oscillator A harmonic or tunable LF continuous wave oscillator is zero beat (mixed to produce zero frequency) with the unknown high frequency signal. The LF oscillator frequency is measured and multiplied by an integer which is equal to the ratio of the two frequencies, in order to determine the value of the unknown HF.

4. Automatic Divider The high frequency signal is reduced by some factor, such as 100:1, using automatically tuned circuits which generates an output frequency equal to 1/100th or 1/1000th of the input frequency.

9. With the necessary sketch, explain how Time interval can be measured?

DIGITAL MEASUREMENT OF TIME 6.4

Principle of Operation The beginning of the time period is the start pulse originating from input 1, and the end of the time period is the stop pulse coming from input 2.

The oscillator runs continuously, but the oscillator pulses reach the output only during the period when the control F/F is in the 1 state. The number of output pulses counted is a measure of the time period.

6.4.1 Time Base Selector

It is clear that in order to know the value of frequency of the input signal, the time interval between the start and stop of the gate must be accurately known. This is called time base.

The time base consist of a fixed frequency crystal oscillator, called a clock oscillator, which has to be very accurate. In order to ensure its accuracy, the crystal is enclosed in a constant temperature oven. The output of this constant frequency oscillator is fed to a Schmitt trigger, which converts the input sine wave to an output consisting of a train of pulses at a rate equal to the frequency of the clock oscillator. The train of pulses then passes through a series of frequency

divider decade assemblies connected in cascade. Each decade divider consists of a decade counter and divides the frequency by ten. Outputs are taken from each decade frequency divider by means of a selector switch; any output may be selected.

The circuit of Fig. 6.8 consists of a clock oscillator having a 1 MHz frequency. The output of the Schmitt trigger is 10^6 pulses per second and this point corresponds to a time of 1 microsecond. Hence by using a 6 decade frequency divider, a time base with a range of 1 μs – 10 μs – 100 μs – 1 ms – 10 ms – 100 ms – 1 s can be selected using a selector switch.

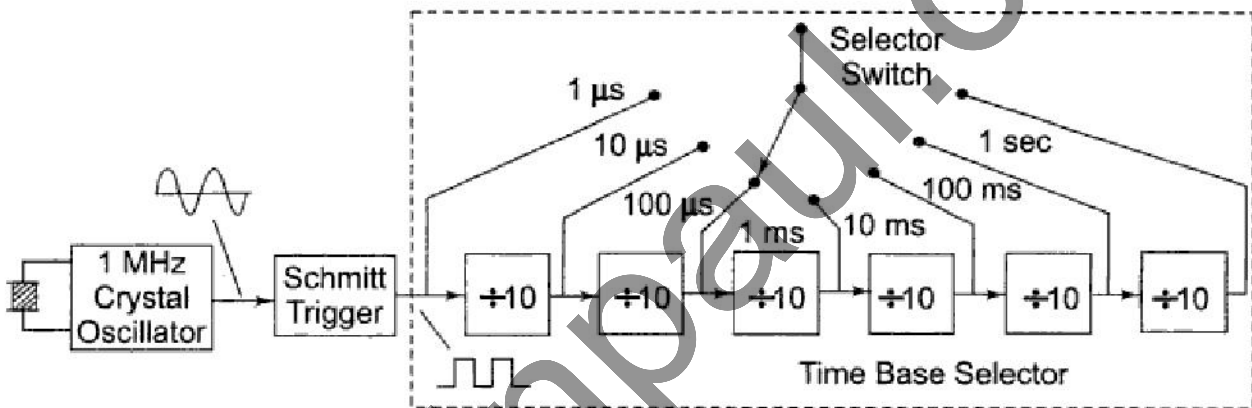


Fig. 6.8 Time base selector

6.4.2 Measurement of Time (Period Measurement)

In some cases it is necessary to measure the time period rather than the frequency. This is especially true in the measurement of frequency in the low frequency range. To obtain good accuracy at low frequency, we should take measurements of the period, rather than make direct frequency measurements. The circuit used for measuring frequency (Fig. 6.7) can be used for the measurement of time period if the counted signal and gating signal are interchanged.

Figure 6.9 shows the circuit for measurement of time period. The gating signal is derived from the unknown input signal, which now controls the enabling and disabling of the main gate. The number of pulses which occur during one period of the unknown signal are counted and displayed by the decade counting assemblies. The only disadvantage is that for measuring the frequency in the low frequency range, the operator has to calculate the frequency from the time by using the equation $f = 1/T$.

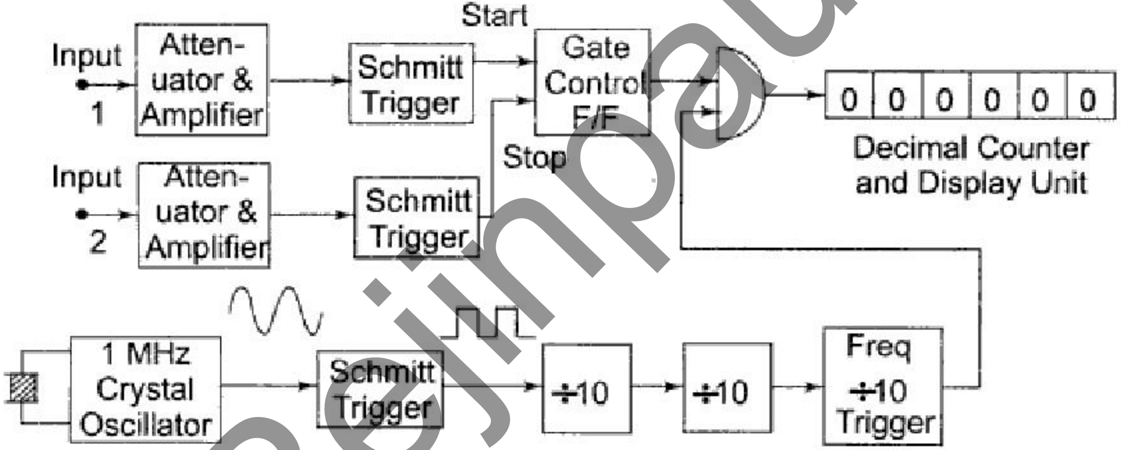


Fig. 6.9 Basic block diagram of time measurement

Figure 6.10 show the multiple average mode of operation. In this circuit, five more decade dividing assemblies are added so that the gate is now enabled for a much longer interval of time than it was with single DDA.

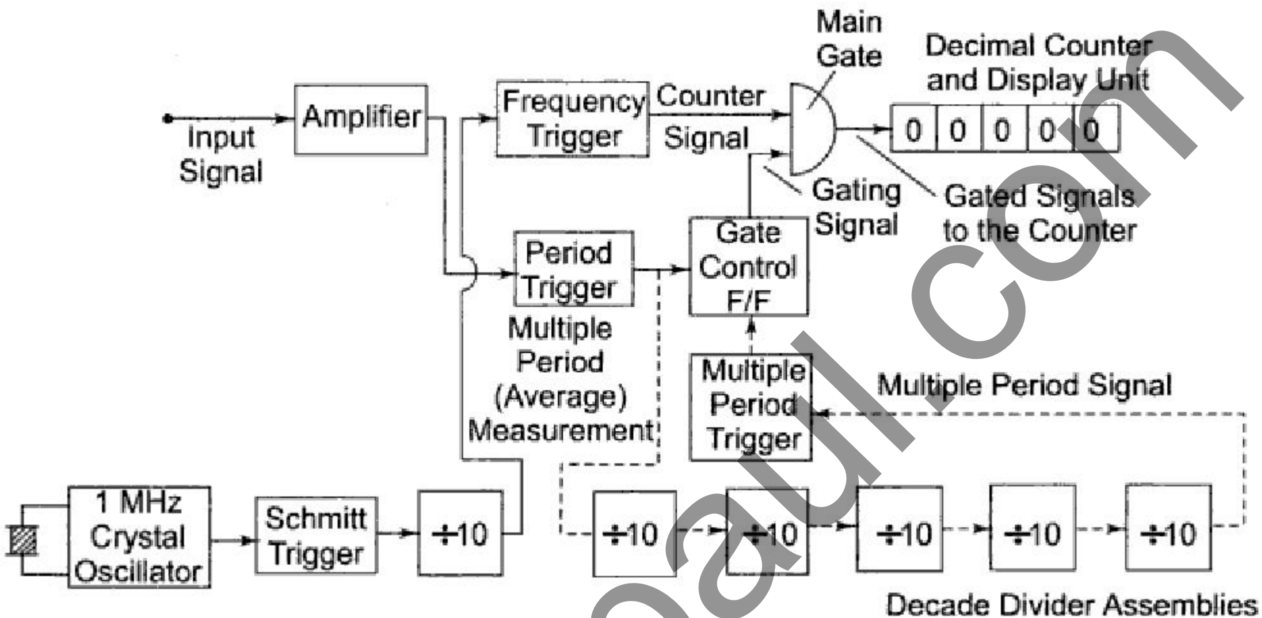


Fig. 6.10 Block diagram of a single and multiple period (average) measurement

For example, when measuring the period of a 60 Hz frequency, the electronic counter might display 16.6673 ms, hence the frequency is

$$f = \frac{1}{T} = \frac{1}{16.6673 \times 10^{-3}} = 59.9977 \text{ Hz.}$$

The accuracy of the period measurement and hence of frequency can be greatly increased by using the multiple period average mode of operation. In this mode, the main gate is enabled for more than one period of the unknown signal. This is obtained by passing the unknown signal through one or more decade divider assemblies (DDAs) so that the period is extended by a factor of 10,000 or more.

UNIT V Part - A

1. What is meant by cone of acceptance?
   The angle of incidences for which total internal reflection is effected
2. What is the method for testing an audio amplifier.
   For testing an audio amplifier, the stimulus is the application of an audio input signal. Determine the response of the amplifier involves measuring the power o/p or harmonic distortion with a wattmeter or distortion analyzer.
3. What is ATE
   Automatic test equipment
4. What is the IEEE 488 bus system?
   The interface for computer operated test equipment.
5. What limits the data rate in the IEEE 488 system?
   Based on bit data words.
6. What are the divisions of interface system?

Data bus & control or status lines.

7. Define interface signal lines..

To transmit data necessary for the operation of system but separate from measurement parameters.

8. What is the function of radio receiver?

Navigation computers require.

9. List the instruments used in computer control instrumentation.

Power supply, signal generator, amplifier under test, distortion analyzer, computer.

10. What does signal generator do in computer controlled measurement.

It used to provide the RF input signal & modulation.

11. Mention the significant advantage of computer measurements.

The significant advantage of computer measurements is that the measurements can be made faster or less expensively because of reduction of labour costs. 12. Expand the term SINAD.

Signal plus distortion to distortion.

12. Mention the tasks performed by computer.

The tasks performed by computer :it supplies stimulus to the unit under test & determine the response of unit under test to that stimulus, then the response is analysed & the data is presented in various ways.

13 .Mention the components of computer controlled measurement system for testing an audio amplifier.

Power supply, signal generator, amplifier under test, distortion analyzer, computer.

14. Mention the components of computer controlled measurement system for testing an Radio receiver.

Power supply, RF signal generator, receiver under test, SINAD meter 15. Give any two application of microprocessor based measurement.

Real time monitoring, Real time data storage.

16 . What is GPIB

General Purpose Interface Bus

17. What is the function of SRQ command.

Service request . any device that needs to transfer data on the bus asserts the SRQ low

18. What is the function of NRFD command.

Not ready for data . Asserted by the listener to indicate that it is not ready for data

20. which method is used for measurement of system loss in optical fiber

Optical time domain reflecto meter

Part - B

1. With a neat sketch, briefly explain about the Digital Data Acquisition system.

9.6 Data Acquisition System

The typical data acquisition system consists of sensors, appropriate signal conditioning devices, data converters, data processors, multiplexers, data handling and transmission, storage and display units. The modern electronic instrumentation is now becoming very sophisticated because of tremendous development in micro-electronic devices, op-amps, multiplexer, digital converters, microprocessors and microcontrollers. The data measurements and process controls are becoming really flexible and more programmable because of day to day modifications in microprocessors.

In the data acquision system the data is first collected from the source and then it is converted to the digital form so that it can be processed, transmitted, displayed and stored. The data acquision relates to the process of acquiring the data in the digital form very rapidly, accurately and economically.

9.6.1 Objectives of Data Acquisition System

i) The data acquisition system must acquire the necessary data at correct speed and at the correct time.

ii) It must use all the data efficiently to inform the operator about the state of the plant.

iii) It must monitor the operation of complete plant so that optimum online safe operations are maintained.

iv) It must provide effective human communication system which helps in identifying the problem areas. This minimises unit availability and maximises the unit output at lower cost.

v) It must be able to collect, summarise and store data properly for diagnosis and record purpose of any operation.

vi) It must be able to compute unit performance indices using online real time communication.

vii) It must be flexible. Also the expansion facility for the future requirement must be provided by it.

viii) It must be reliable and should not have a down time greater than 0.1%.

The data acquisition systems are basically used to measure and record the signals obtained in two ways. Firstly the signal may be originating from direct measurement of an electrical quantity such as ac or dc voltage, frequency, component value such as resistance, capacitance etc. Such signals are always found in electronic component testing, environmental studies etc. Secondly the signal may originate from the transducers such as pressure transducers, thermocouples.

The data processing involves a variety of operations ranging from simple comparison to complicated arithmetical manipulations. This can be used to collect various data or information, perform some operations if required, convert this information to the suitable form using converters, perform more number of calculations to remove unwanted noise signal, gather results to be displayed and so on. The transmission of data can take place over very long distances or very short distances. The results which are gathered may be displayed directly on the digital panel or may be on CRT. The data stored may be permanent or temporary.

To collect data rapidly, shift digitiser or some high resolution devices may be used. For converting analog signal to digital, additional transducers, amplifiers and multiplexers are used. The use of sample and hold circuit increases the speed with which accurate conversion of information is possible.

The data acquisition system is mainly classified as analog data acquisition system and digital data acquisition system. The analog data acquisition systems mainly deal with the measurement information which is in the analog form. An analog signal is the continuous signal such as voltage versus time or displacement due to the pressure. While the digital data acquisition system may consists of number of discrete and

9.6.2 Analog Data Acquisition System

The basic components used in the analog data acquisition system are as follows,

1. Transducer

The transducer is used to convert the physical quantity into an electrical signal. The transducers such as strain gauge, thermocouples, piezoelectric devices, photosensitive are most widely used. The transducer generates a voltage proportional to the physical quantity being measured. This voltage is applied as a input to the data acquisition system. Apart from this some special sensors produce frequency which can be counted by an electronic counter. This frequency forms the integral part of the quantity being measured. Otherwise the signal may be modulated then voltage level is reduced with the help of discriminator.

2. Signal Conditioner

This device includes the supporting circuitry for the transducers. It allows the output voltage of transducer to amplify upto desired level. It also converts the output voltage to the desired form so that it is accepted by the next stage. It produces the conditions in transducers so that they work properly. It also provides excitation power and balancing circuits.

3. Multiplexers

It allows a single channel to share it with more than one input quantity. It accepts multiple analog inputs. With the help of multiplexer we can transmit more than one quantity using same channel. The multiplexers are mostly used when many quantities are to be transmitted. Also when the distance between the the transmitting end and receiving end is more, the multiplexers are used. Multiplexers reduce the cost of installation, maintenance and periodic replacement of channels if those are used for separate input signals.

4. Calibrating Equipment

Before each test, the calibration is carried out. This is called pre-calibration. Similarly after each test calibration is carried out and it is called post-calibration. It usually consists millivolt calibration of all input circuits and shunt calibration of all bridge type transducers.

5. Integrating Equipment

This block is used for integration or the summation of a quantity. The digital techniques are normally used for integration purposes.

6. Visual Display Devices

These are necessary to monitor the input signal continuously. These devices include panel meters, numerical displays, single or multichannel CROs, storage CRO etc.

9.6.3 Digital Data Acquisition System

The simple, generalised block diagram for digital data acquisition system is as shown in the Fig. 9.5.

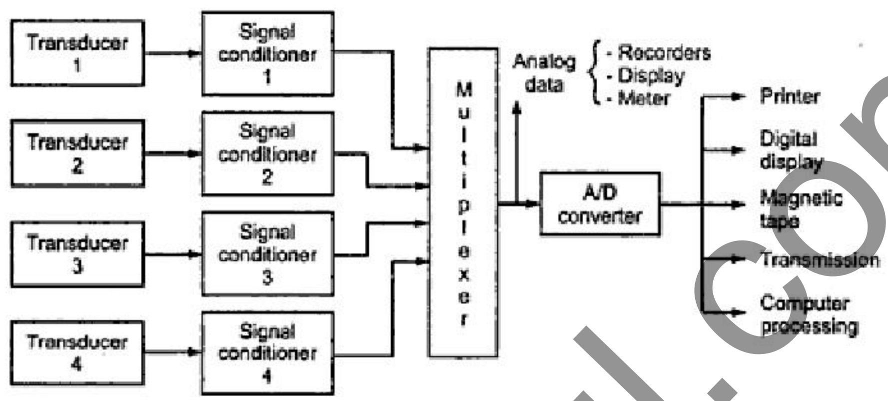


Fig. 9.5 Generalised data acquisition system

The digital data acquisition system includes all the blocks shown in the figure. It may use some additional function blocks. The essential functions of a digital data acquisition system are as follows,

i) It handles the analog signals

ii) It performs measurement

iii) It converts analog signal into digital data and handles it.

iv) It performs internal programming and control.

The various components of the digital data acquisition system are as follows.

2. With a neat sketch, explain how a transducer can be interfaced with a Processing device. 3. Explain about Microprocessor based Temperature measuring system.

4. With a neat sketch, explain the application of MUX and De- MUX in a Digital Data Acquisition system.
5. Write a short note on Computer controlled Measurement / Instrumentation system. 6. What is IEEE 488 bus? Explain it with a neat block diagram.

Introduction:
In the early 1970's, Hewlett-Packard came out with a standard bus (HP-IB) to help support their own laboratory measurement equipment product lines, which later was adopted by the IEEE in 1975. This is known as the IEEE Std. 488-1975. The IEEE-488 Interface Bus (HP-IB) or general purpose interface bus (GP-IB) was developed to provide a means for various instruments and devices to communicate with each other under the direction of one or more

master controllers. The HP-IB was originally intended to support a wide range of instruments and devices, from the very fast to the very slow.

The IEEE-488 bus was developed to connect and control programmable instruments, and to provide a standard interface for communication between instruments from different sources. Hewlett-Packard originally developed the interfacing technique, and called it HP-IB. The interface quickly gained popularity in the computer industry. Because the interface was so versatile, the IEEE committee renamed it GPIB (General Purpose interface Bus).

Description:

The HP-IB specification permits up to 15 devices to be connected together in any given setup, including the controller if it is part of the system. A device may be capable of any other three types of functions: controller, listener, or talker. A device on the bus may have only one of the three functions active at a given time. A controller directs which devices will be talkers and listeners. The bus will allow multiple controllers, but only one may be active at a given time. Each device on the bus should have a unique address in the range of 0-30. The maximum length of the bus network is limited to 20 meters total transmission path length. It is recommended that the bus be loaded with at least one instrument or device every 2 meter length of cable (4 meters is maximum). The use of GP-IB extenders may be used to exceed the maximum permitted length of 20 meters.

Electrical Interface:

The GP-IB is a bus to which many similar modules can be directly connected, as is shown in Figure 1. A total of 16 wires are shown in the figure - eight data lines and eight control lines. The bus cables actually have 24 wires, providing eight additional for shielding and grounds. The GP-IB defines operation of a three-wire handshake that is used for allhave 24 wires, providing eight additional for shielding and grounds.

DEVICE - B

DEVICE - A

The GP-IB defines operation of a three-wire handshake that is used for all data transfers on the bus. The bus
operation

Explain briefly about OTDR

3. Explain briefly about Optical Time Domain Reflectometry.

Introduction:

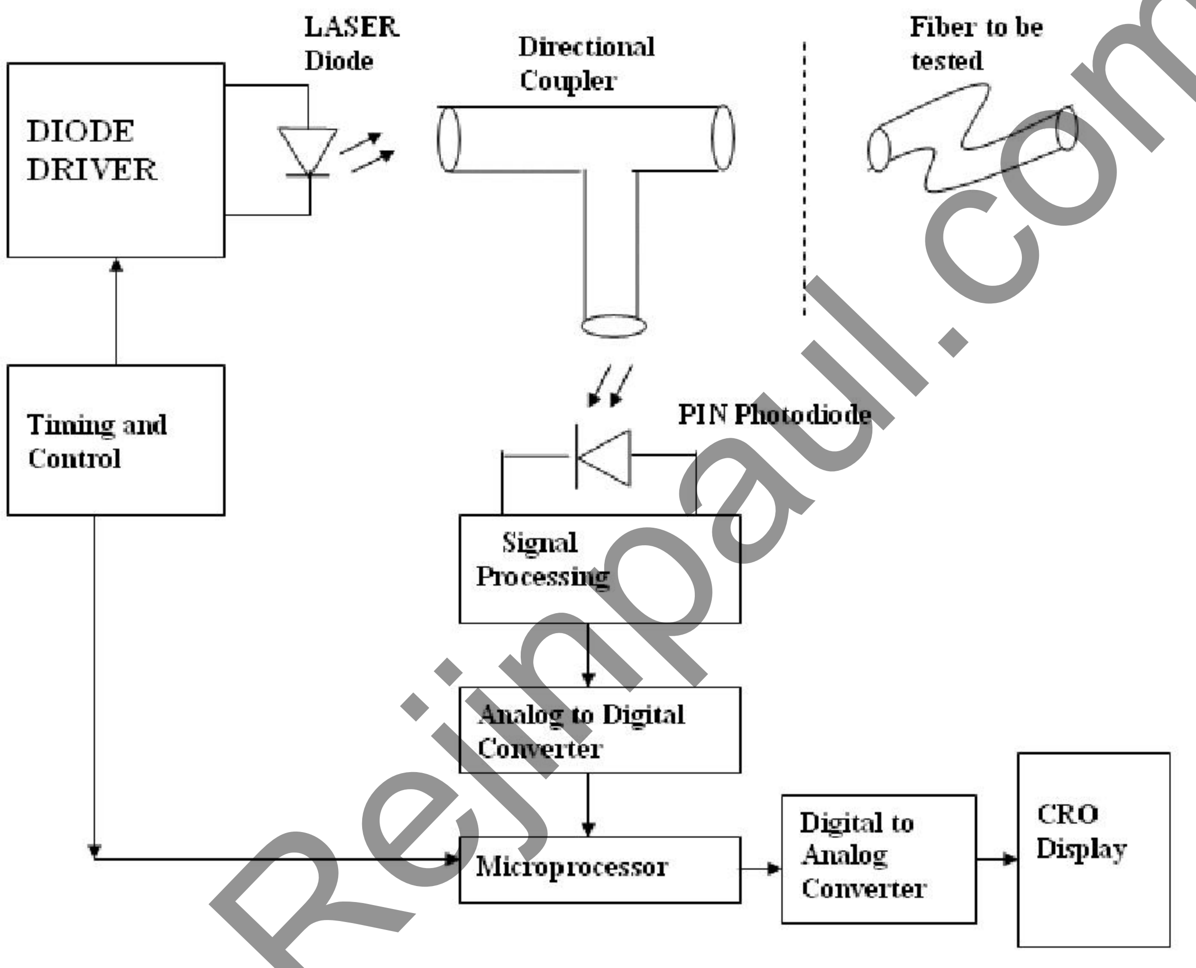
A very powerful tool in the maintenance and installation of a fiber optics system is the optical time - domain reflectometer (OTDR). This device analyze the reflected light energy in a fiber installation to determine the existence and location of breaks in the fiber, losses at splices and connectors, and the total loss of the system. OTDRs are always used on OSP cables to verify the loss of each splice.

Principle :

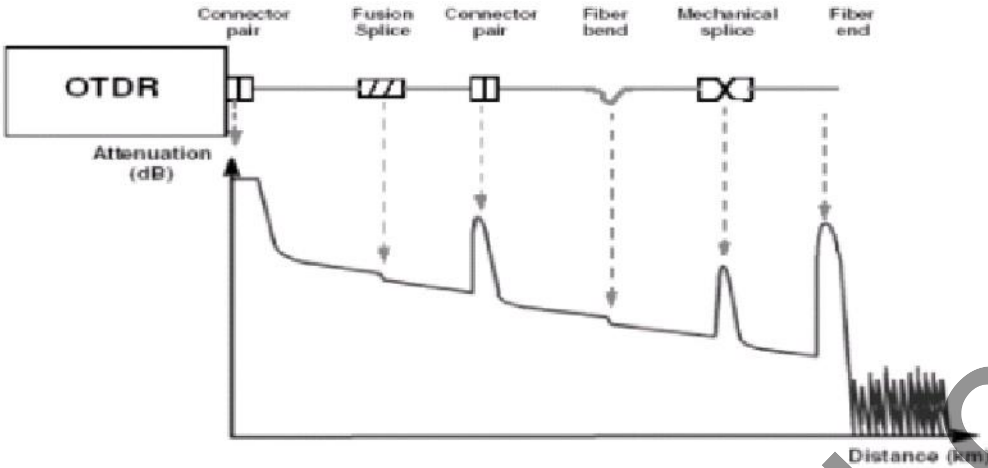
Unlike sources and power meters which measure the loss of the fiber optic cable plant directly, the OTDR works indirectly. The source and meter duplicate the transmitter and receiver of the fiber optic transmission link, so the measurement correlates well with actual system loss. The OTDR, however, uses backscattered light of the fiber to imply loss. The OTDR works like RADAR, sending a high power laser light pulse down the fiber and looking for return signals from backscattered light in the fiber itself or reflected light from connector or splice interfaces. At any point in time, the light the OTDR sees is the light scattered from the pulse passing through a region of the fiber. Only a small amount of light is scattered back toward the OTDR, but with sensitive receivers and signal averaging, it is possible to make measurements over relatively long distances. Since it is possible to calibrate

the speed of the pulse as it passes down the fiber, the OTDR can measure time, calculate the pulse position in the fiber and correlate what it sees in backscattered light with an actual location in the fiber. Thus it can create a display of the amount of backscattered light at any point in the fiber.

Block Diagram:



Since the pulse is attenuated in the fiber as it passes along the fiber and suffers loss in connectors and splices, the amount of power in the test pulse decreases as it passes along the fiber in the cable plant under test. Thus the portion of the light being backscattered will be reduced accordingly, producing a picture of
the actual loss occurring in the fiber. Some calculations are necessary to convert this information into a display, since the process occurs twice, once going out from the OTDR and once on the return path from the scattering at the test pulse. There is a lot of information in an OTDR display. The slope of the fiber trace shows the attenuation coefficient of the fiber and is calibrated in dB/km by the OTDR. In order to measure fiber attenuation, you need a fairly long length of fiber with no distortions on either end from the OTDR resolution or overloading due to large reflections. If the fiber looks nonlinear at either end, especially near a reflective event like a connector, avoid that section when measuring loss.



Typical OTDR trace

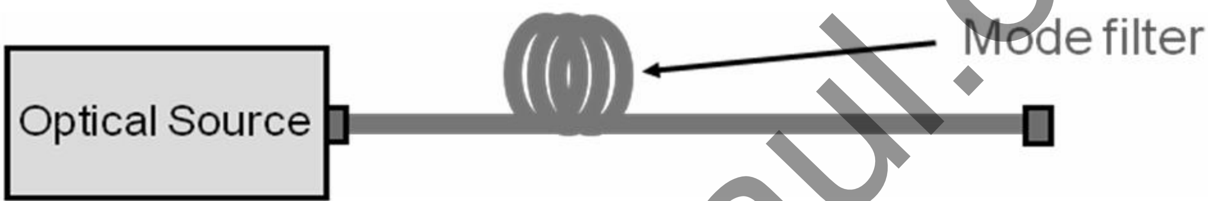
7. Write short note on Fiber optic based power and system loss measurement.

- Measured loss values for say connectors are small (0.1 dB to 0.5 dB)
- Any fluctuations in the source and/or leads will directly affect attenuation measurement
- Source:
  - Ideally use a source with a stability ten times better than lowest attenuation to be measured
  - Eg. to measure down to 0.1 dB use a source with a stability better than 0.01 dB
  - Perform a periodic reference check every 1-2 hours to eliminate long term drift
  - For very high stability use a splitter and power meter to monitor reference continuously
- Leads
  - Use high quality test leads
  - Keep leads clean and perform periodic checks
  - Consider fixing leads in place to eliminate random bend fluctuations
  - Consider using a fixing jig for test lead adapters

Launch Conditions (Multimode)

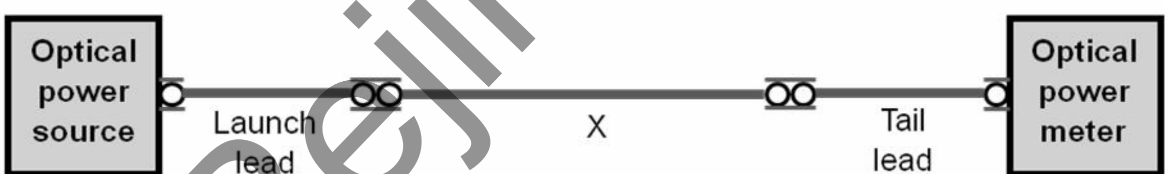
Launch Conditions (Singlemode)

- In use in real systems patchcords, connectors etc. are normally distant from the transmitter
- When measurements are undertaken with launch leads devices under test will be close to the source.
- Multiple modes may exist close to the source, inaccurate results
- Using long singlemode leads to achieve equilibrium is difficult
- A mode filter consisting of two or more 40-50 mm diameter loops in the source lead should ensure that the DUT sees a true singlemode signal



Loss Measurement Length of fibre only

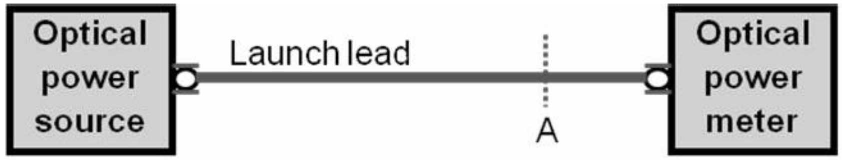
Attenuation for a length of fibre only (connectors not included)



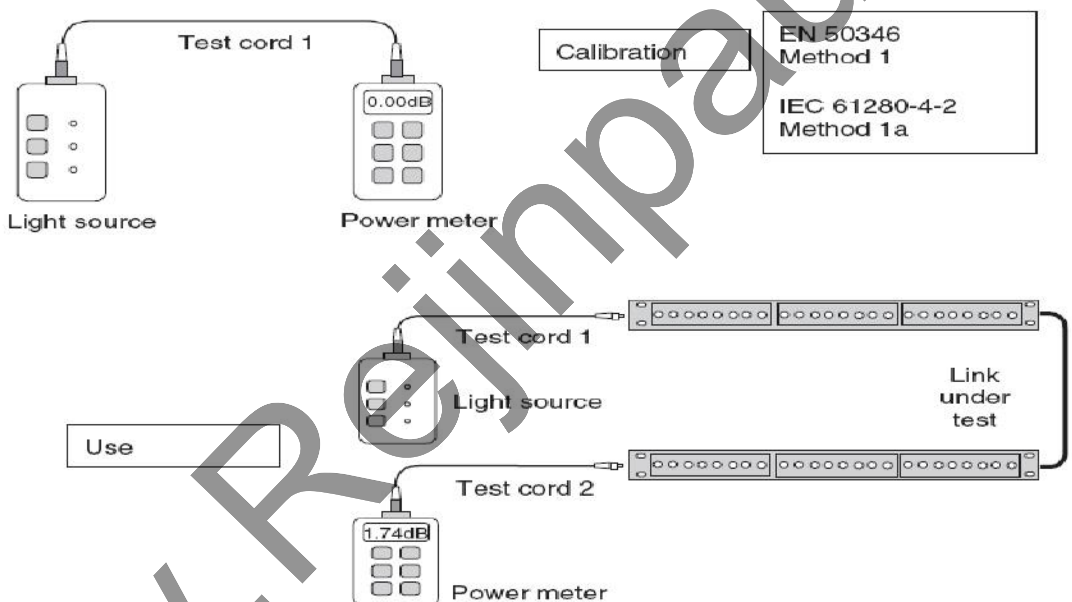
- A short reference lead is used for X and the received power P1 is recorded
- The lead X is replaced by the length of fibre and received power P2 is recorded
- Attenuation in the fibre length is P1 - P2
- Fibre length under test and the reference lead must have the same geometry and connectors from the same manufacturer
- Most power meters incorporate a dBr (dB relative) function to assist in measurements

Loss Measurement Patch-panel to Patch-panel

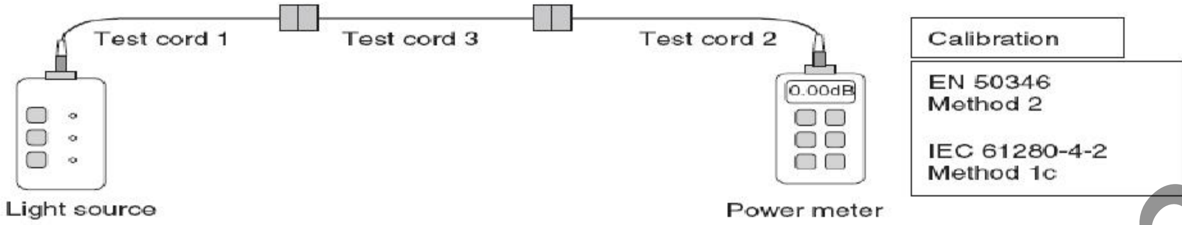
Setting reference

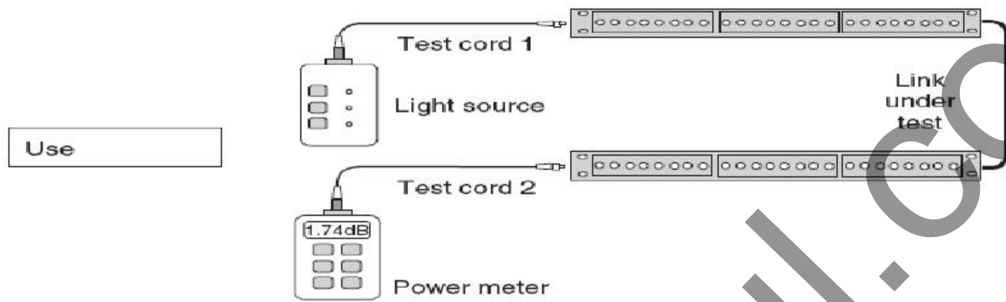


- A launch reference lead is connected as shown and the optical power P1 is recorded
- The power P1 represents the power in the launch lead at point A
- The launch lead from the source is connected to the local patch panel
- The power meter is taken to the remote patch panel and connected by a reference tail lead
- The power level P2 is then measured and the loss between A and B is P1 - P2
- Fibre under test and the reference lead must have the same geometry and connectors from the same manufacturer

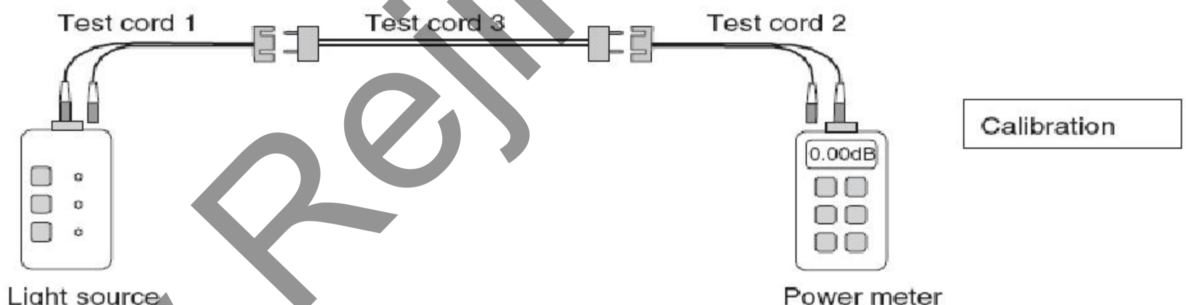


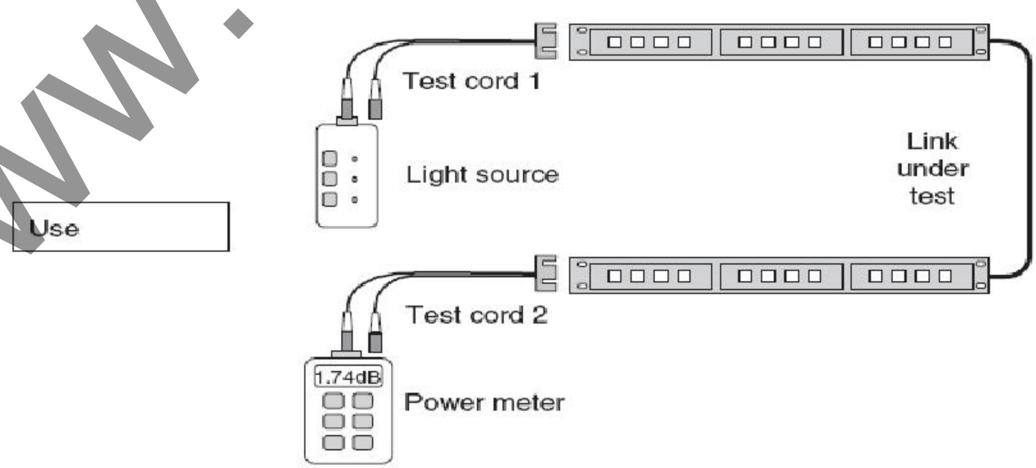
Patch-panel to Patch-panel with non standard connectors



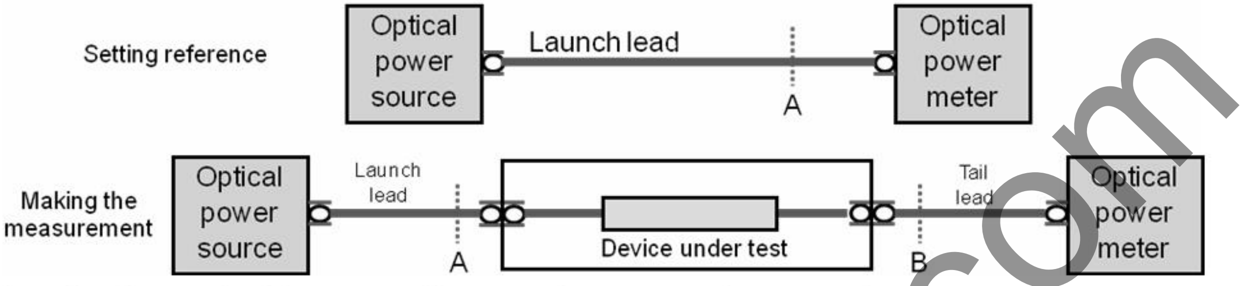


Patch-panel to Patch-panel with non standard connectors





Total Loss Measurement: Connectorised Device



- A launch reference lead is connected between the source and meter as shown
- The optical power P1 is recorded
- The power P1 represents the power in the launch lead at point A
- The launch lead from the source is connected to the device input
- The power meter connected to the device output by a reference tail lead
- The power level P2 is then measured and the loss between A and B is found as P1 - P2
- Fibre under test and the reference lead must have the same geometry and connectors