ELECTRONIC INSTRUMENTS

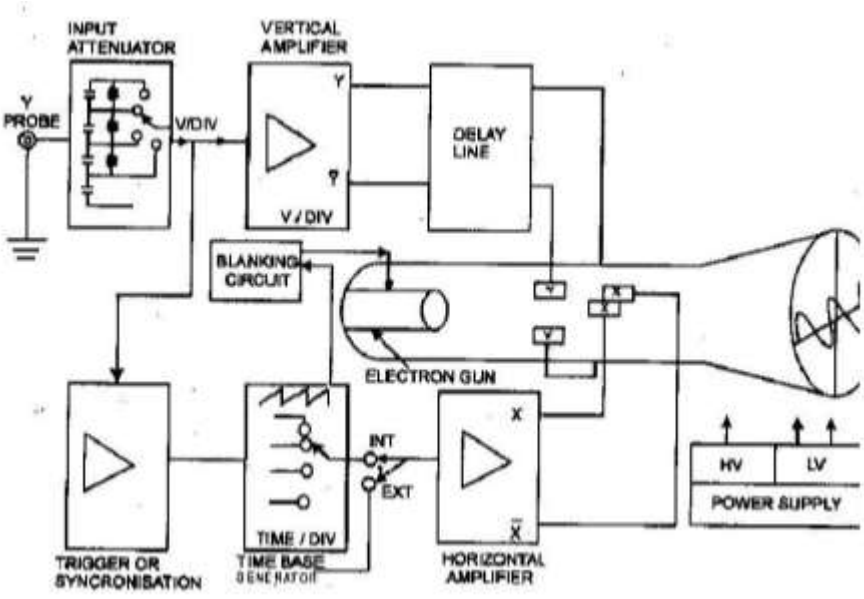
Different types of instruments used in laboratory. Out of this Cathode Ray Oscilloscope (CRO) is an extremely useful and versatile instrument used for display, measurements and analysis of signal or waveforms. CRO's are basically very ***fast XY Plotter*** that displays an input signal versus another signal or time. CRO is mostly used for displaying waveforms. When properly used it is capable of measuring all electrical quantities such as voltage, frequency, phase, observation of waveforms etc.

Block Diagram of CRO

Explain working of CRO with block diagram.

An oscilloscope consist of following essential constituents- It consist of

1. Cathode Ray Tube (CRT)
2. Vertical deflection system
   a) Input attenuator b) Vertical amplifier c) Delay line circuit
3. Horizontal deflection system
   a) Time base or sweep generator b) Horizontal amplifier c) Trigger circuit
4. Blanking circuit or gate amplifier
5. Power supply



1. Cathode Ray Tube – (Write a note on CRT)

The CRT is an evacuated container with an Electron Gun that shoots a focused electron beam at a phosphor-coated screen which absorbs the energy of the electrons and re-emits it as visible light. The High Voltage Supply produces the voltage needed to accelerate the electron beam toward the screen. The Deflection Amplifiers move the electron beam in the desired pattern.

The Electron Gun starts with the Heater (or Filament) which uses an electric current in order to heat it up to incandescence. However, instead of using the Heater to directly produce electrons, it heats up a separate element, the Cathode, to produce the electrons.

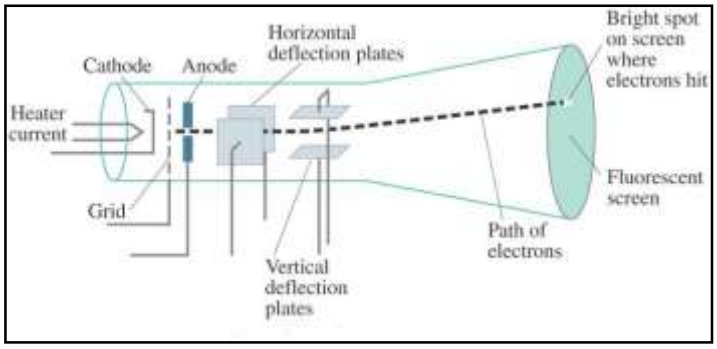
The Control Grid (G) is operated with a negative bias with respect to the Cathode and acts to repel the electrons coming from the Cathode.

The electron beam is further accelerated by Focusing grid; the Focus Grid also focuses the beam.

The final acceleration of electrons can be increased with the help of accelerating anodes.

Two pairs of parallel plates are mounted in the CRT. A voltage applied across the Vertical Plates will deflect the electron beam vertically and voltage applied across the Horizontal Plates will deflect the electron beam horizontally.

The resulting beam strikes the phosphor-covered screen which absorbs the energy of the electrons and re-emits it as visible light.



2. *Attenuator and Vertical amplifier* - The signal waveform to be observed on CRO is applied to vertical amplifier through an attenuator. The sample signal is taken from input signal by vertical attenuator. The gain of this amplifier is set by calibrated input attenuator by using VOLT / DIV control on front panel. This is calibrated in terms of deflection sensitivity, it is defined as *the amount of displacement of spot on the screen when potential of one volt is applied to its deflection plates,*

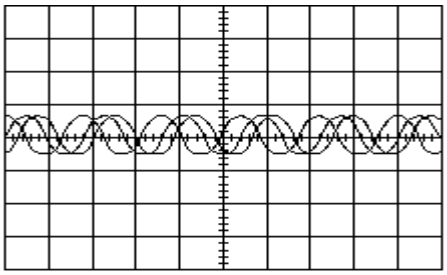
$$Unknown\ voltage = \frac{Shift\ of\ spot}{Deflection\ sensitivity}\left(when\ sensitivity\ is\ in\frac{div}{volt}\right)$$

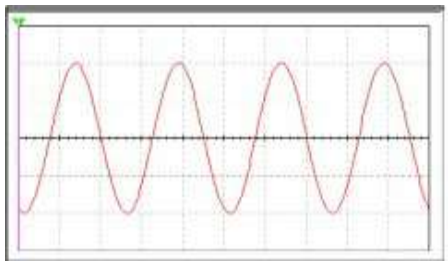
$$Unknown\ voltage$$

$$= Shift\ of\ spot\ x\ Deflection\ sensitivity\ \left(when\ sensitivity\ is\ in\ \frac{volts}{div}\right)$$

3. Delay Line- The delay line is used to delay the arrival of input signal at vertical deflection plates until trigger and time base circuit have a chance to sweep electron beam. It produces a delay of 80 nano second.

4. Trigger Circuit – This circuit produces a saw tooth waveform. Input waveform is fed to the trigger circuit which produces a trigger pulse at some point of input waveform; this pulse is used to start time base generator circuit.





5. Time base generator – *The* need of time base generator is to represent time on x axis which will cause repetitive movement of spot from left to right with particular rate. This circuit produces saw tooth waveform. The positive going part of this wave is linear and its rate is adjusted by TIME / DIV control on front panel.

6. Horizontal amplifier – It amplifies the horizontal x input. The gain of horizontal amplifier is greater than vertical amplifier because horizontal deflection sensitivity is smaller than vertical deflection sensitivity. This amplifier includes phase inverter which produces two simultaneous output waveforms.

7. Blanking circuit - During the retrace time of saw tooth spot moves from right to left, may cause retrace line on screen. Thus retrace should be eliminated or blanked out by applying high negative voltage to the grid, during the fly back period.

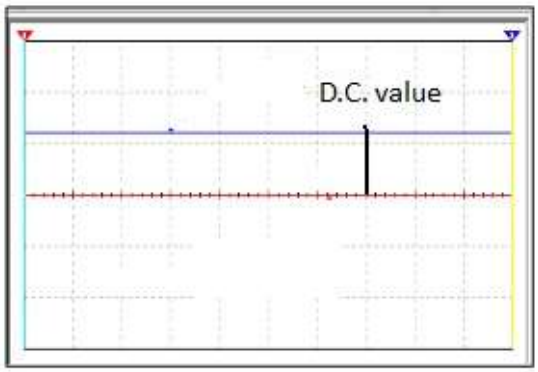
8. Power supply – There are two power supplies used in CRO, called as high voltage (HL) and low voltage (LV). For final anode voltage in CRT is of the order of 1 – 2 KV. And for other circuitry low voltage power supply are used.

Applications of CRO –

Explain the use of CRO for measurement of Ac and Dc voltage.

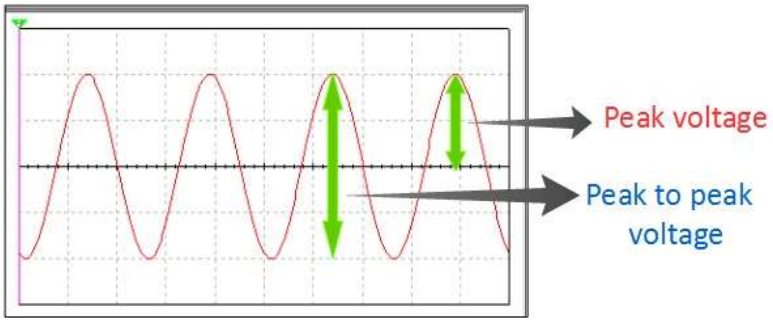
DC Voltage measurement –

1. First short the input terminals of CRO. A horizontal straight line will seen on the screen of CRO, adjust this line on X axis by using Y – position knob.
2. Connect unknown input voltage, now line is shift from its original position. If line is not seen on the screen, adjust volt / division knob so that it will within the screen.
3. Measure number of divisions and multiply it by volt / div. scale.



AC Voltage measurement –

1. Keep selector switch on AC position.
2. Connect unknown input voltage and adjust waveform on the screen of CRO.
3. Measure vertical divisions from peak to peak and multiply it by volt / div. scale
4. Calculate peak voltage dividing it by 2.
5. $V_{r.m.s.} = \frac{V_p}{\sqrt{2}} = 0.707\ V_p$



Frequency measurement (Direct method) –

How the unknown frequency is measured with the help of CRO by direct method and Lissajous figures method?

1. Keep horizontal sweep knob on CAL position, connect unknown signal to Y plate of CRO.
2. Adjust one or two waveforms on the screen of CRO by using time / div knob.

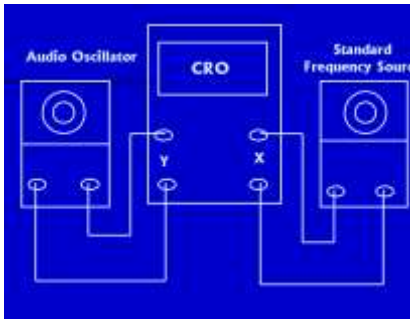
3. Measure number of horizontal divisions for one complete cycle and multiply it by time / div knob.
4. It will give period; take reciprocal to get frequency.

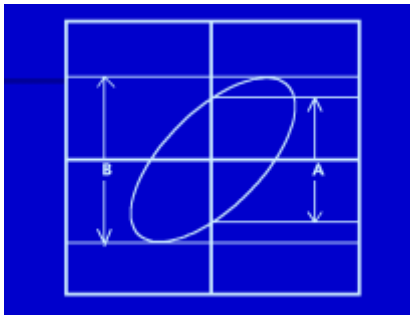
Frequency measurement by Lissajous figures method –

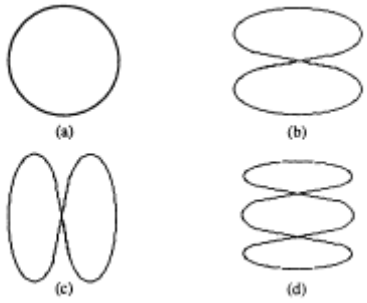
Lissajous figures method is useful for phase and frequency determination.

1. Make the internal time base cut off by operating CRO on XY mode.
2. Connect unknown input signal to x plates of CRO having frequency F_x.
3. Connect known signal to y plates of CRO using function generator.
4. Measure the number of loops or points touching to X axis and Y axis.
5. Determine unknown frequency by using formula

$$\frac{F_x}{F_y} = \frac{no.of\ loops\ cut\ by\ X\ axis}{no.of\ loops\ cut\ by\ Y\ axis}$$







The phase difference between two sine waves can be calculated by using Lissajous figures method

A circle can be formed only when amplitudes of both signals is same and phase difference is 90^0 or 210^0.

An ellipse can be formed only when amplitudes of both signals is slightly different and phase difference is 30^0 or 330^0 and 150^0 or 270^0.

Straight line is formed when phase difference is 180^0.

In medical field – Number of transducers is used to obtained patients body signal and these signals are displayed on CRO. For example heart beats rate, EEG, ECG etc. These signals are compared with standard signals to detect trouble with patient.

In RADAR – RADAR is Radio Detection and Ranging. It is used to detect and give position of distant objects. In this method high frequency radio waves are transmitted in the direction of object and receiver receives reflected signal. Both reflected and transmitted signals are given to

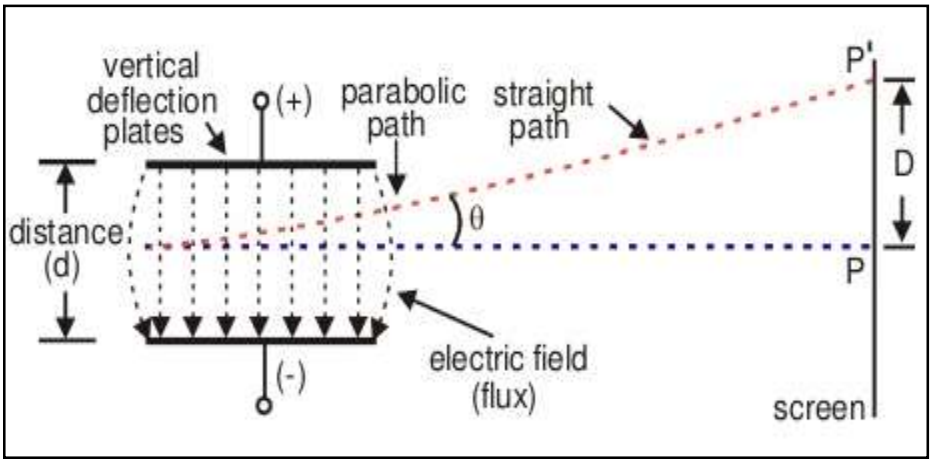
CRO. Time differences between two signals are measured and from this distance can be calculated.

Write a note on electro static and electromagnetic deflection system.

Electro static deflection system –

A cathode ray can be deflected either by electric field or magnetic field. To obtain deflection of beam or spot on screen in vertical direction, deflecting voltage are applied to Y plates. The electrons are negatively charged are attracted towards positive plate and acquire vertical velocity. Similarly voltage applied to X plates deflects the beam or spot on screen in horizontal direction.

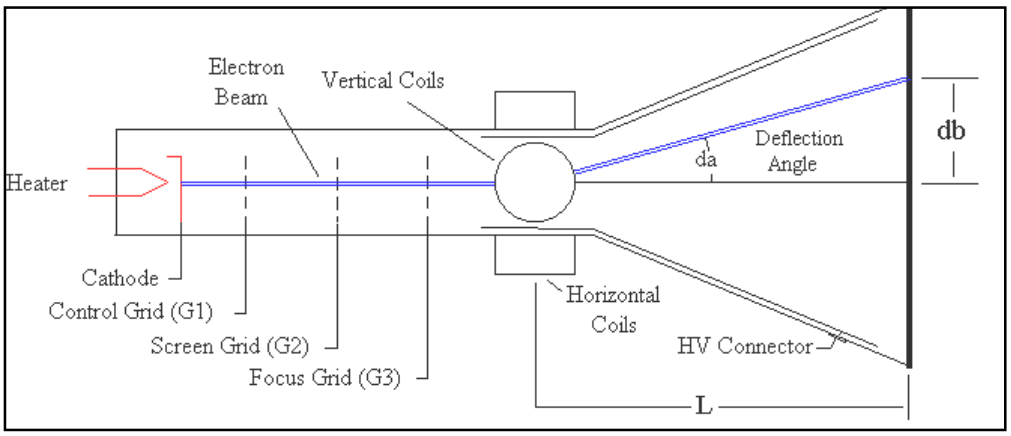
The advantage of electro static deflection system is its high frequency operation and deflection plates are mounted inside the tube thus saving space.



Electromagnetic deflection system –

It is normally used if electron beam is to be deflected over a considerable distance. For example TV picture. The electron beam is deflected over a screen by means of two pairs of coils. The beam is deflected by means of magnetic force. The two pairs of coils are placed outside the tube. One pair for vertical deflection and other pair for horizontal deflection.

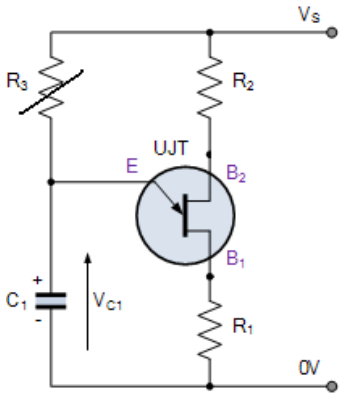
The magnetic deflection system is more often used in TV picture tubes, RADAR dispay, video display unit of computers.



Time base generator –

With neat diagram explain working of time base generator.

All time base generators are derived from multi vibrator. The switching devices like UJT, triac, diac are also produce saw tooth waveforms. Sweep generator is nothing but the circuit used for charging a capacitor with time rate. During charging spot moves from left to right and switches capacitor to discharge suddenly. The charging portion is called as 'ramp' voltage or 'trace' and discharging portion is called as 'fly back' or 'retrace'.



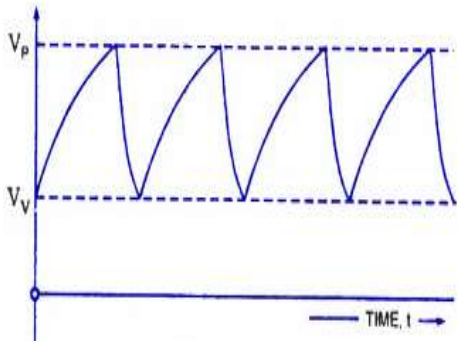


Figure shows UJT saw tooth oscillator as time base generator. When supply made ON capacitor starts charging exponentially through resistor R, emitter voltage of UJT rises towards V_{BB}. When V_E reaches to peak voltage; emitter base diode becomes forward bias and capacitor discharges through base -1. Emitter voltage decreases suddenly and becomes less than 0.6 V and emitter base diode becomes reverse bias. This process repeats continuously. This cycle of charging and discharging repeats and saw tooth wave forms are generated.

Front panel controls of CRO –

Give function of any four front panel controls of CRO.

1. **ON / OFF switch –** It is a toggle switch used to make mains power ON / OFF, it has LED indicator.
2. **Intensity / brightness –** By operating this knob clockwise or anticlock wise one can change the brightness of electron beam. Internally it changes negative grid bias of CRT to control the flow of electrons from cathode to screen. To increase the life of screen keeps this knob on minimum position.
3. **Focus –** The electron beam can be made sharp by operating this control clockwise or anticlock wise direction. It is just optical lens system; there is electronic lens system in CRT consisting of three focusing anodes.
4. **Vertical position (Y – pos) –** To shift the waveforms vertically upward or down wards this control is used. Internally variable DC voltage is applied to the vertical deflecting plates.
5. **Horizontal position (X – pos) -** To shift the waveforms horizontally left or right this control is used. Internally variable DC voltage is applied to the horizontal deflecting plates.
6. **Volts / div –** It also known as vertical deflection sensitivity. It selects the Y scale. Internally an attenuator is connected with band switch to attenuate the signal voltage applied to Y plates.
7. **Time / div –** The time required to move electron beam from left to right is adjusted by this control. It selects the X – scale. It is calibrated in terms of sec / div, milli sec / div, micro sec / div. It has another smooth variable control marked with 'VAR' it is fine control used with time base generator.
8. **Trigger –** It is used to get stable waveform on the screen. It has two positions auto and manual. If CRO is not triggered properly it shows number of waveforms or running waveform on screen. By operating this control one can get single and stable waveform.

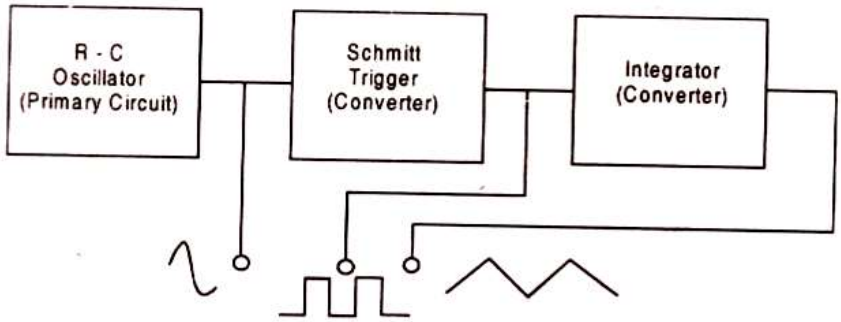
   In addition to this there are some other controls are also used such as HOR input, EXT sink, AC – DC – GND etc.

Function Generator –

Draw the block diagram of practical function generator and explain each block in brief.

A function generator is the source of various signals, which produces typical standard waveforms required to test different electronic circuits.

Basic principal – Function generator is capable of producing sine, square and triangular wave signals, any one of this waveform is used as primary wave and remaining waveforms are generated by respective circuits by applying waveform to them.



With the help of RC oscillator as primary waveform generator three signals can be easily generated but it has following drawbacks.

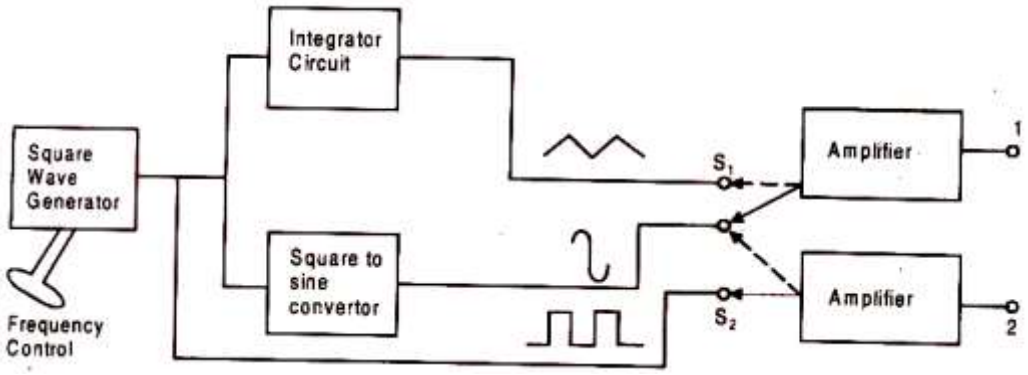
1. Limited frequency range.
2. Poor frequency stability.
3. Poor amplitude stability.

Therefore sine wave as primary waveform generator is not used.

Practical function generator –

It uses square wave as primary waveform generator and then respective circuit generate remaining waveforms. It uses three basic elements as (1) primary waveform generator, (2) integrator circuit and (3) square to sine wave converter circuit.

Square wave generator like IC 555 astable multi-vibrator or Op AMP comparator is used as primary generator square wave. The second stage is an integrator circuit that generates triangular wave. Third stage is square to sine wave converter. Two waveforms are obtained simultaneously by using two switches.



Features of function generator –

1. It is a source of signals.
2. It provides sine, square, triangular and sometimes saw tooth wave.
3. Wide frequency range from 1 Hz to few hundred KHz.
4. Variable amplitude facility.
5. Provide two outputs simultaneously.
6. With the help of switch it can be adjusted to particular function waveform.

Digital Multi Meter (DMM) –

Draw neat block diagram of DMM and write the function of each block in brief.

DMM basically converts an input analog quantity into digital signal by means of ADC and then display input quantity in the form of digital display by using electronic counter. ***DMM is nothing but digital voltmeter.***

DMM consist of following essential constituents- It consist of

1. AC / DC attenuator
2. Current to DC voltage converter
3. Resistance to voltage converter
4. Analog to digital converter (ADC)
5. Electronic counter and digital display

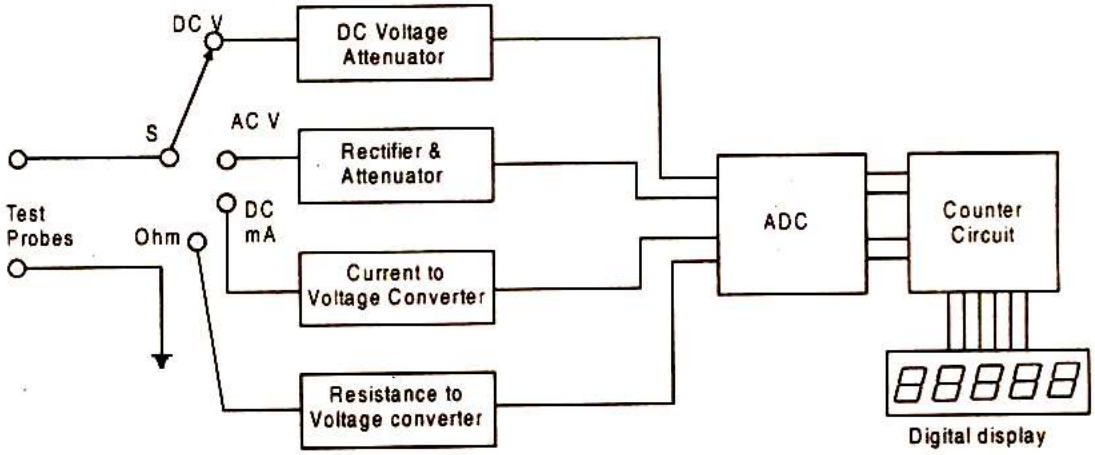
1. DC attenuator – When Dc voltage is applied across its input probes then it is selected by DC attenuator. DC attenuator is nothing but potential divider arrangement made up of resistances connected in series.

2. Current to voltage converter – When DMM selects current measurements it passes unknown current through known shunt resistance and proportional voltage is produced so that ADC and counter circuit measures voltage.

3. Resistance to voltage converter – The unknown resistance is connected in Op Amp circuit through which constant current is passed. It produces voltage drop across unknown resistance, which is measured by usual method.

4. Analog to digital converter (ADC) – It is an interface between analog input and digital instrument. ADC converts Dc voltage into digital signal or binary signal in order to drive counter and display. Practically *dual slope ADC* is most widely used in digital multimeter because of better accuracy and high input impedance.

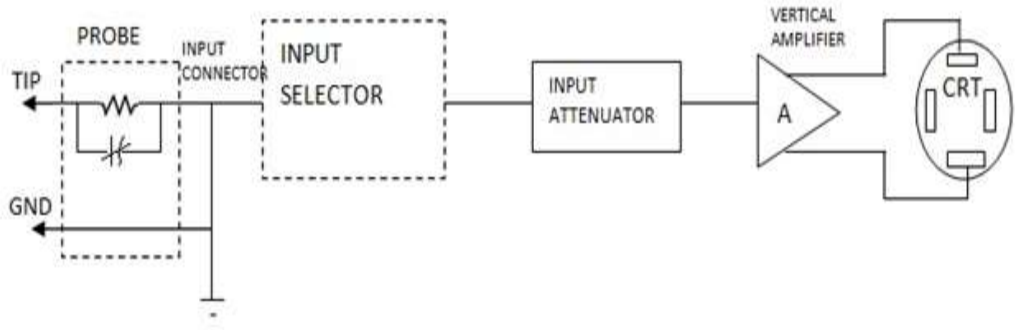
5. Counter and display unit – After converting input quantity into digital signals with the help of ADC it is applied to this unit for specific time interval. The gate circuit decides the time interval. Counter has seven segment display units. Each display indicates numbers from 0 to 9. It has several displays with separate decoder and counter circuits.



Features of DMM –

1. Small size and easy operation
2. Maximum accuracy due to minimum loading effect.
3. Used to measure AC / Dc voltage, AC /DC current, resistance and component testing.
4. Audio visual indication for continuity and component testing.
5. Automatic polarity indication.
6. Auto zero setting.

Block diagram of Vertical Deflection System –



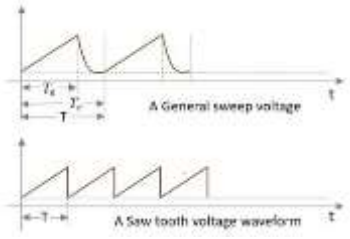
Horizontal Deflection System

The horizontal deflecting system of the cathode ray oscilloscope (CRO) consists of the following stages.

1. Sweep generator or time base generator.
2. The horizontal amplifier,
3. The trigger circuit.

For an oscilloscope to display the waveform under study a voltage which is linearly increasing with time is required. Also the voltage has to fall in its amplitudes at time periods that are equal or multiples of the input signal time periods. This voltage which is of the saw tooth waveform is applied to the horizontal deflecting plates to sweep the beam horizontally. Hence the names sweep voltage or time base voltage.

A sweep generator is used to produce this sweep voltage. The sweep voltage will be employing an R.C. charging circuit. The capacitor after acquiring a predetermined value of charge will be discharged using a voltage operated switch. Charging of the capacitor is done through a constant current generator. The sweep voltage waveform is shown below Figure.



The linearly increasing portion of the voltage is called 'ramp' voltage, The beam is swept from left of the screen to the right during the rise period of the sweep voltage T_s. The time taken by the voltage to fall to the initial value from the maximum, T_r is called the retrace period of fly back period. During this retrace period the electron beam is cutoff, in order to blank the display of the retrace on screen.

The sweep generators may employ vacuum tube circuits, transistors or ICs. Normal sweep generators apply their sweep voltage through the horizontal amplifier to the deflecting plates. This does not required any start signal for the sweep to generate its ramp voltage.

An advantage can be derived in displaying signals of short duration, stretched over a large area of the screen, by controlling the sweep generators output to be present only at our command. This is done by applying what is called a TRIGGER PULSE that triggers or starts the sweep voltage. The trigger pulse can be derived from the waveform under observation

The horizontal amplifier in CRO deals only with the sweep frequency signals. Hence its band width requirements are not critical as that of the vertical amplifier. The horizontal amplifier handles signals of considerable amplitudes. However the gain of this amplifier must be large. The reason is the low deflection sensitivity of the horizontal deflecting plates. The gain of this amplifier must be sufficient that it produces the required sweep over the screen.