Basics of Electrical & Electronics

Unit-V

DIGITAL MULTIMETER

A digital multimeter (DMM) displays the AC or DC voltages being measured directly as discrete numerals in the decimal number system. Numerical readout of DMM is very convenient and it eliminates observational error. The use of digital multimeters increases the speed with which the readings can be taken.

The DMM is a versatile and accurate instrument used in laboratories. On account of developments in the integrated circuits (IC) technology, it has become possible to reduce the size, power requirements, and cost of digital multimeters.

The basic function performed by a digital multimeter is an analogue to digital (A/D) conversion. For example, the voltage value may be changed to a proportional time interval, which starts and stops a clock oscillator. In turn, the oscillator output is applied to an electronic counter that is provided with a readout in terms of voltage. There are many ways of converting the analogue reading into digital form, but the most common way is to use ramp voltage. The operating principle of a ramp-type DMM is simple. A ramp voltage increases linearly from zero to a predetermined level in a predetermined time interval. The ramp voltage value is continuously compared with the voltage being measured. At the instant, the value of ramp voltage becomes equal to that of unknown voltage, a coincidence circuit called input comparator, generates a pulse that opens the gate as shown in Figure 9.42. The ramp voltage continues to decrease till it reaches the ground level. At this instance, another comparator generates a pulse and closes the gate. The time interval between the opening and the closing of gate is measured with an electronic time-interval counter. This count is displayed as a number of digits.

Multimeter - Block diagram

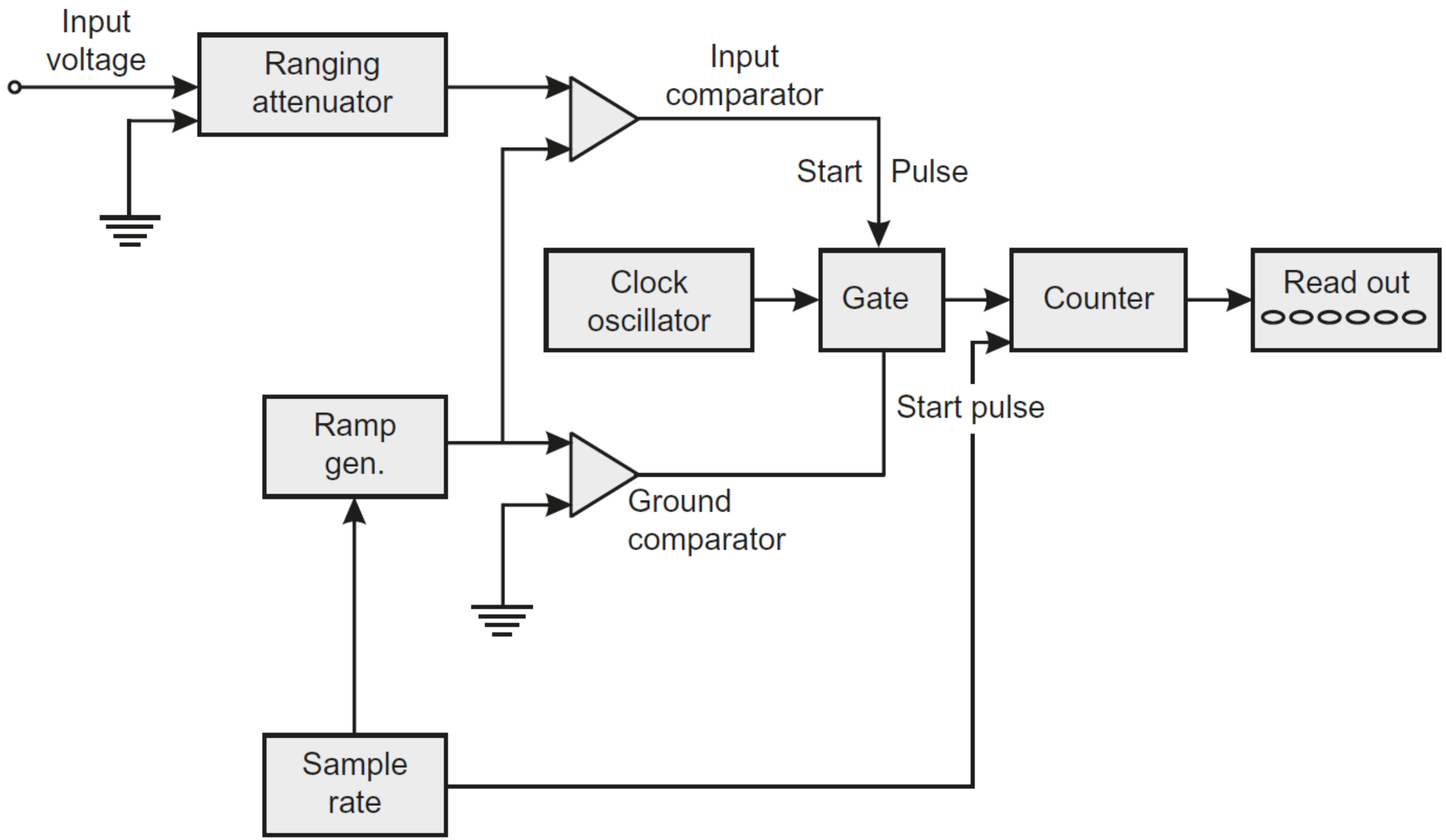


Fig. 9.42 **Block diagram of a digital multimeter**

Digital Multimeter – Outer view

Figure 9.43 shows the pictorial view of a DMM.

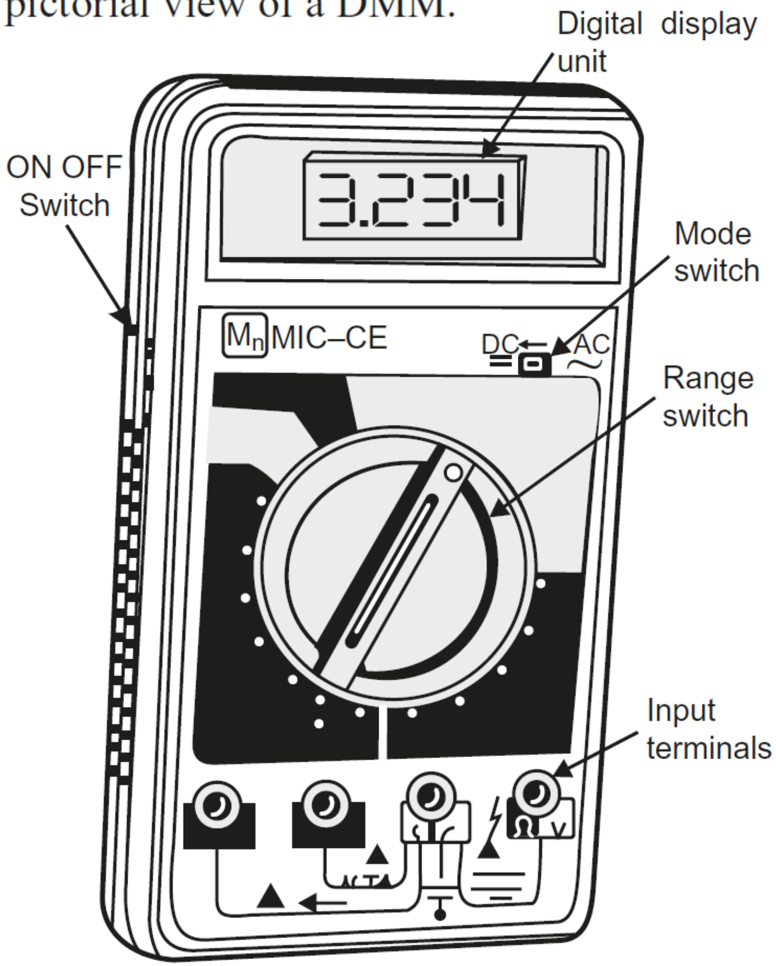


Fig. 9.43 Outer view of a digital multimeter

Digital Multimeter – main parts on panel

The main parts on the panel are as follows:

1. **Digital display unit:** It displays the reading in digits.
2. **ON–OFF switch:** It is used to switch ON and OFF the power of battery.
3. **Input terminals:** There are four sockets; one of them is common to which black lead is inserted. The other three sockets to which red lead is connected are: (a) V – for measurement of DC and AC voltage and resistance; (b) A – for measurement of DC and AC current up to 2 A; and (c) 10A – for measurement of DC and AC current up to 10 A.
4. **Mode switch:** For measurement of either DC or AC voltage or current, this switch is used to select the mode.
5. **Range switch:** The central switch is used to select the range of quantity (voltage, current, or resistance) to be measured.

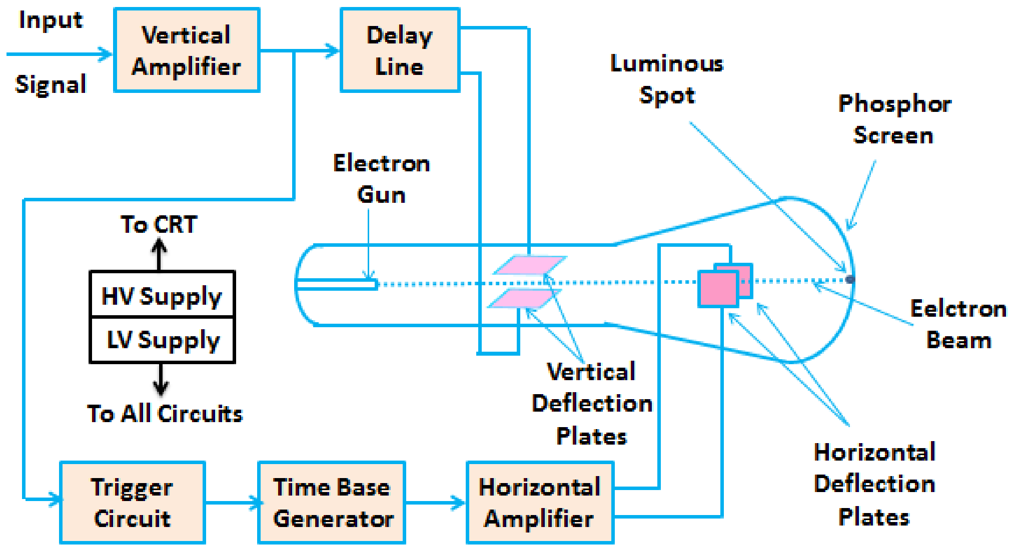
Oscilloscope

CRO is widely used for trouble shooting radio and television receivers as well as for laboratory research and design.

Using a CRO , the wave shapes of alternating currents and voltages can be studied. It can also be used for measuring voltage, current, power, frequency and phase shift. Different types of oscilloscopes are available in the market for various purposes.

Block Diagram of CRO (Cathode Ray Oscilloscope)

The figure below shows the block diagram of a general purpose CRO .



Block Diagram of Cathode Ray Oscilloscope (CRO)

As we can see from the above figure above, a CRO employs a cathode ray tube (CRT) ,which acts as the heart of the oscilloscope.

In an oscilloscope, the CRT generates the electron beam which are accelerated to a high velocity and brought to focus on a fluorescent screen. This screen produces a visible spot where the electron beam strikes it. By deflecting the beam over the screen in response to the electrical signal, the electrons can be made to act as an electrical pencil of light which produces a spot of light wherever it strikes.

For accomplishing these tasks various electrical signals and voltages are needed, which are provided by the power supply circuit of the oscilloscope.

Low voltage supply is required for the heater of the electron gun to generate the electron beam and high voltage is required for the cathode ray tube to accelerate the beam. Normal voltage supply is required for other control units of the oscilloscope.

Horizontal and vertical deflection plates are fitted between the electron gun and the screen so that these can deflect the beam according to the input signal.

To deflect the electron beam on the screen in horizontal direction i.e. X-axis with constant time dependent rate, a time base generator is provided in the oscilloscope.

The signal to be viewed is supplied to the vertical deflection plate through the vertical amplifier, so that it can amplify the signal to a level that will provide usable deflection of the electron beam.

As the electron beam is deflected in X-axis as well as Y-axis, a triggering circuit is provided for synchronizing these two types of deflections so that horizontal deflection starts at the same point of the input vertical signal each time it sweeps.

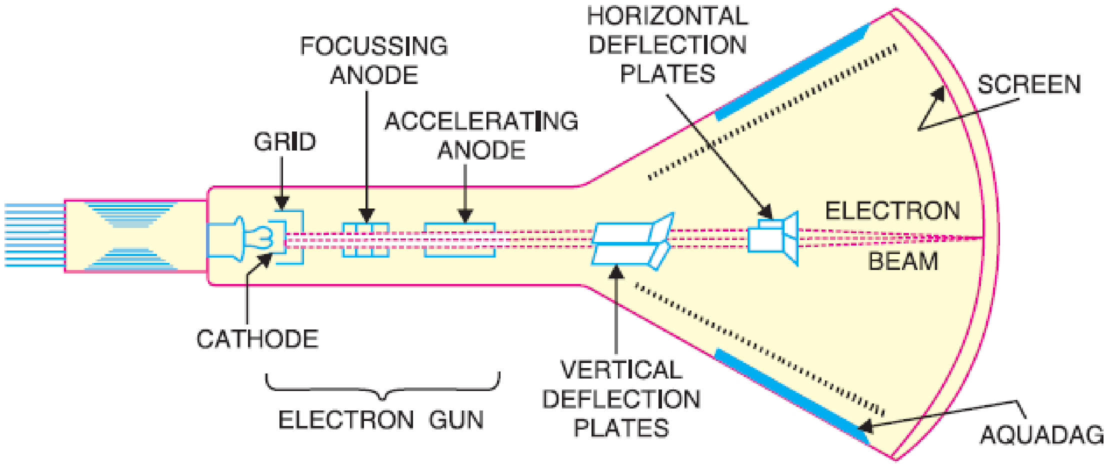
Since CRT is the heart of the oscilloscope, we are going to discuss its various components in detail.

Cathode Ray Tube

The cathode ray tube or CRT is a vacuum tube of special geometrical shape which converts an electrical signal into a visual one.

A CRT makes available a large number of electrons which are accelerated to high velocity and are brought to focus on a fluorescent screen where it produces a spot when strikes it. The electron beam is deflected during its journey in response to the applied electrical signal. As a result, the electrical signal waveform is displayed visually.

The figure below shows various parts of a cathode ray tube (CRT) .



Now we will discuss each part of the CRT in detail.

(i) Glass Envelope

It is a conical highly evacuated glass housing which maintains vacuum inside it and supports various electrodes.

The inner wall of CRT between the neck and screen are usually coated with a conducting material known as aquadag. This coating is electrically connected to the accelerating anode so that the electrons which accidentally strike the walls are returned to the anode. This prevents the walls from charging to a high negative potential.

(ii) Electron Gun Assembly

The electron gun assembly consists of an indirectly heated cathode, a control grid, a focussing anode and an accelerating anode and it is used to produce a focused beam of electrons.

The control grid is held at negative potential w.r.t. cathode. However, the two anodes are held at high positive potential w.r.t. cathode.

The cathode consists of a nickel cylinder coated with oxide coating and provides a large number of electrons.

The control grid encloses the cathode and consists of a metal cylinder with a tiny circular opening to keep the electron beam small.

By controlling the positive potential on it,the focusing anode focuses the electron beam into a sharp pin point.

Due to the positive potential of about 10,000 V on the accelerating anode which is much larger than on the focusing diode, the electron beam is accelerated to a high velocity.

In this way, the electron gun assembly forms a narrow, accelerated electron beam which produces a spot of light when it strikes the screen.

(iii) Deflection Plate Assembly

It consists of two sets of deflecting plates within the tube beyond the accelerating anode and is used for the deflection of the beam.

One set is called as vertical deflection plates and the other set is called horizontal deflection plates.

The vertical deflection plates are mounted horizontally in the tube. On application of proper potential to these plates, the electron beam can be made to move up and down vertically on the screen.

The horizontal deflection plates are mounted vertically in the tube. On application of proper potential to these plates, the electron beam can be made to move right and left horizontally on the screen.

(iv) Screen

The screen is coated with some fluorescent materials such as zinc orthosilicate, zinc oxide etc and is the inside face of the tube.

When high velocity electron beam strikes the screen, a spot of light appears at the point of impact. The colour of the spot depends upon the nature of fluorescent material.

Working of Cathode Ray Tube

As the cathode is heated, it produces a large number of electrons.

These electrons pass through the control grid on their way to the screen.

The control grid controls the amount of current flow as in standard vacuum tubes. If negative potential on the control grid is high, fewer electrons will pass through it. Hence the electron beam will produce a dim spot of light on striking the screen. Reverse will happen when the negative potential on the control grid is reduced.

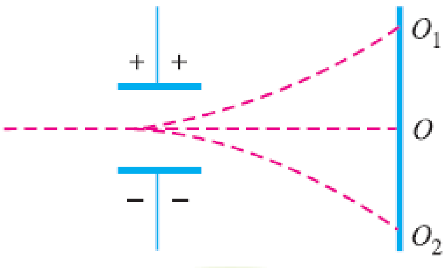
Therefore, the intensity of the light spot on the screen can be controlled by changing the negative potential on the control grid.

After leaving the control grid, the electron beam comes under the influence of focusing and accelerating anodes.

Since, the two anodes are at high positive potential, therefore, they produce a field which acts as electrostatic lens to converge the electron beam at a point on the screen.

After leaving the accelerating anode, the electron beam comes under the influence of vertical and horizontal deflection plates.

When no voltage is applied to these deflection plates, the electron beam produces a spot of light at the centre as shown by point O in fig below on the screen.



If the voltage is applied to the vertical deflection plates only, the electron beam and so as the spot of light will be deflected upwards i.e. point O1. Ans if the potential on the plates is reversed, the spot of light will be deflected downwards i.e. point O2.

Similarly, the spot of light can be deflected horizontally by applying voltage across the horizontal deflection plates.