Basic Electronic Circuits and Instrumentation

Rectifiers and power supplies: Block diagram description of a dc power supply, working and analysis of a Half wave and full wave bridge rectifier, capacitor filter (no analysis), working of simple Zener voltage regulator.

Electronic Instrumentation: Block diagram of an electronic instrumentation system, Digital Voltmeter (DVM), Cathode Ray Oscilloscope (CRO).

REGULATED POWER SUPPLY

An electronic circuit that produces a stable DC voltage of fixed value across the load terminals irrespective of changes in the load is known as regulated power supply. The primary function of a regulated power supply is to convert an AC power into a steady DC power. The regulated supply is sometimes called as a linear power supply. The block diagram of regulated power supply is shown in Fig.1.

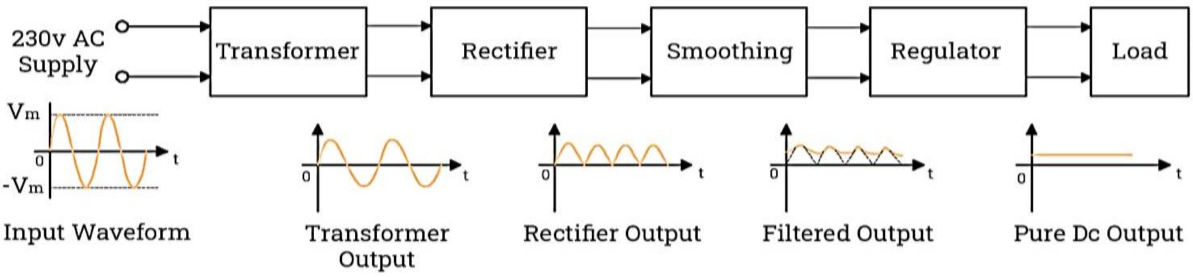


Fig.1 Block diagram description of a dc power supply

The basic building blocks of a regulated DC power supply are as follows:

1. Transformer
2. Rectifier
3. Smoother / Filter.
4. Regulator

Transformer:

A transformer modifies the alternating current (AC) mains voltage to a required value, and its primary function is to step up or step down the voltage. A step-down transformer, for example, is used in a transistor radio, while a step-up transformer is used in a CRT.

Rectifier:

The rectifier circuit is used to convert the input AC voltage into a DC voltage. The input to a rectifier is AC whereas its output is pulsating DC. Rectification process can be carried out for the entire cycle or only for half-cycle. Broadly there are two types of rectifiers such as i) half-wave rectifier, and ii) full-wave rectifier. Full-wave rectifier is used for full wave rectification and half-wave rectifier provides rectification for half-cycle.

Smoother/ Filter:

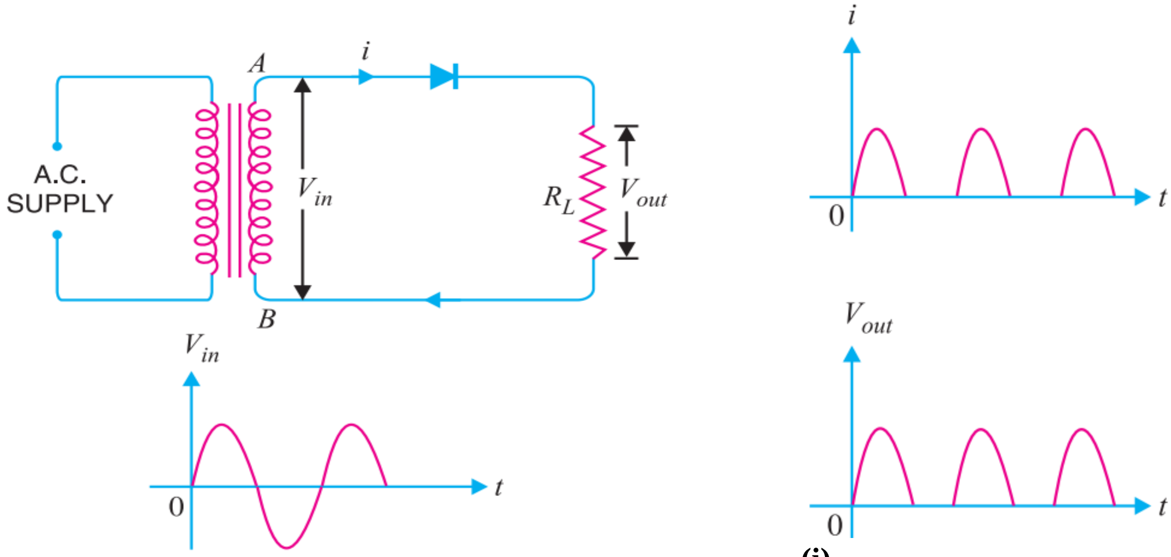
The rectifier's output is pulsating DC with large ripple content and hence, the rectifier's output is undesirable. A filter is used to provide a pure ripple-free DC. The filter circuit converts the pulsating DC voltage into a constant direct voltage with almost zero ripple content. Different types of filter circuits such as capacitor (C) filter, choke input (L) filter, CLC filter and LC filter.

Regulator:

The output voltage may change or fluctuate due to any change in the input ac voltage or the change in load or change in physical parameters such as temperature of the circuit. This problem can be eliminated with the help of a regulator. A regulator maintains the output constant even when changes at the input voltage or any other changes occur. Different types of regulator circuits such as Zener diode operating in Zener region, transistor in series and IC regulators are available.

HALF-WAVE RECTIFIER

In half-wave rectification, the rectifier conducts current only during the positive half-cycles of input a.c. supply. The negative half-cycles of a.c. supply are suppressed i.e. during negative half-cycles, no current is conducted and hence no voltage appears across the load. Therefore, current always flows in one direction (i.e., d.c.) through the load though after every half-cycle.



(i)

(ii)

Fig.2

Circuit details:

Fig. 2(i) shows the circuit where a single crystal diode acts as a half-wave rectifier. The a.c. supply is given through a transformer and it can be used to step up or step down the a.c. input voltage & also isolates the rectifier circuit from power line and thus reduces the risk of electric shock.

The a.c. supply $V_{in} = V_m \, Sin(t)$ is applied across the secondary winding of the transformer in series with the diode of resistance R_f and load resistance R_L.

Operation:

The a.c. voltage across the secondary winding AB changes polarities after every half-cycle. During the positive half-cycle of input a.c. voltage, end A becomes positive w.r.t. end B. This makes the diode forward biased (acts as a closed switch) and hence it conducts current. Apply KVL to the circuit, which gives $V_{out} = V_{in}$ & $I_{out} = I = V_{out} / R_L$. It indicates that, the output follows the input and is shown in Fig. 2(ii).

During the negative half-cycle, end A is negative w.r.t. end B. Under this condition, the diode is reverse biased (acts as an Open switch) and it conducts no current, then V_{out} & $I_{out} = 0$.

Therefore, current flows through the diode during positive half-cycles of input a.c. voltage only; it is blocked during the negative half-cycles is shown in Fig. 2(ii). In this way, current flows through load R_L always in the same direction. Hence d.c. output is obtained across R_L. It may be noted that output across the load is pulsating d.c. These pulsations in the output are further smoothened with the help of filter circuits.

DC Power:

The output current is pulsating direct current. Therefore, in order to find d.c. power, average current has to be found out.

$$I_{avg} = I_{dc} = \frac{\text{Area under curve over the full cycle}}{\text{base length over the full cycle}} \quad (1)$$

$$\text{Area} = \int_0^{2\pi} i.dt = \int_0^{\pi} i.dt + \int_{\pi}^{2\pi} i.dt = \int_0^{\pi} i.dt + 0 = \int_0^{\pi} \frac{V_m \sin t}{R_f+R_L}.dt = \frac{2V_m}{R_f+R_L} \quad (2)$$

From eqn (1) and (2),

$$\mathbf{I_{avg} = I_{dc} = \frac{1}{2\pi} * \frac{2V_m}{R_f+R_L} = \frac{I_m}{\pi}} \quad (3)$$

Where, $I_m = \frac{V_m}{R_f+R_L}$

$\therefore$ DC output power, $P_{dc} = {I_{dc}}^2 * R_L = \left(\frac{\mathbf{I_m}}{\boldsymbol{\pi}}\right)^{\mathbf{2}} * R_L$ (4)

AC Power: The a.c. power input is given by,

$$P_{ac} = {I_{rms}}^2 * (R_f + R_L) \quad (5)$$

RMS value of load current can be obtained as,

$$I_{rms} = I_{ac} = \sqrt{\frac{\text{Area under squared curve over the full cycle}}{\text{base length over the full cycle}}}$$

$$\mathbf{I_{rms} = \sqrt{\frac{1}{2\pi}\left(\int_0^{\pi} i^2.dt + \int_{\pi}^{2\pi} i^2.dt\right)} = \sqrt{\frac{1}{2\pi}\left(\int_0^{\pi} (I_m \sin t)^2.dt\right)} = \frac{I_m}{2}} \quad (6)$$

From eqn (5) and (6),

$$\therefore \quad P_{ac} = \left(\frac{I_m}{2}\right)^2 * (R_f + R_L) \quad (7)$$

Rectifier Efficiency:

The ratio of d.c. power output to the applied input a.c. power is known as rectifier efficiency.

$$\eta = \frac{\textbf{dc power output}}{\textbf{Input ac power}} = \frac{\left(\frac{I_m}{\pi}\right)^2 * R_L}{\left(\frac{I_m}{2}\right)^2 * (R_f + R_L)} = \frac{\mathbf{0.406}\, R_L}{(R_f + R_L)} = \frac{\mathbf{0.406}}{\mathbf{1+}\frac{R_f}{R_L}} \quad (8)$$

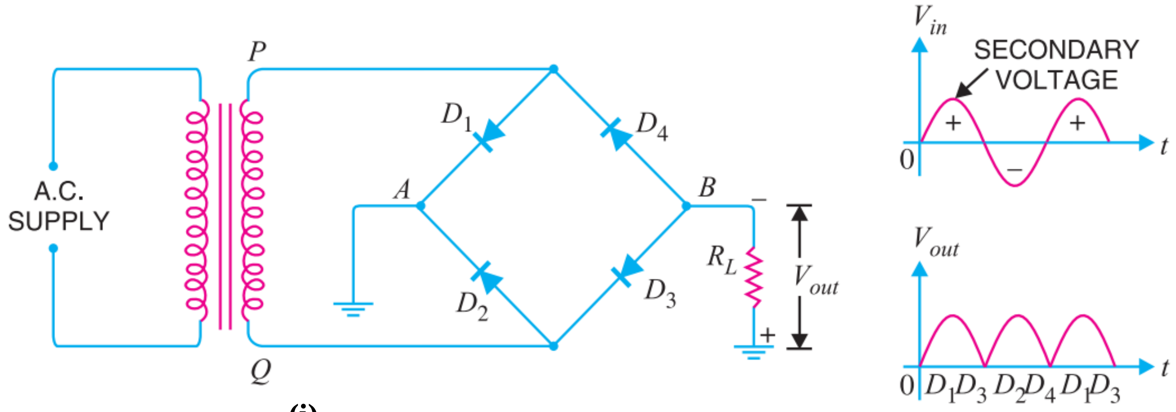
The efficiency will be maximum if R_f is negligible as compared to R_L.

$\therefore$ **Max. rectifier efficiency = 40.6%**

This shows that in half-wave rectification, a maximum of 40.6% of a.c. power is converted into d.c. power.

FULL-WAVE BRIDGE RECTIFIER

In full-wave rectification, current flows through the load in the same direction for both half-cycles of input a.c. voltage. This can be achieved with two diodes working alternately. For the positive half-cycle of input voltage, one diode supplies current to the load and for the negative half-cycle, the other diode does so; current being always in the same direction through the load. Therefore, a full-wave rectifier utilises both half-cycles of input a.c. voltage to produce the d.c. output.



(i)

(ii)

Fig.3

It contains four diodes D_1, D_2, D_3 and D_4 connected to form bridge as shown in Fig.3(i). The a.c. supply to be rectified is applied to the diagonally opposite ends of the bridge through the transformer. Between other two ends of the bridge, the load resistance R_L is connected.

Operation:

During the positive half-cycle of secondary voltage, the end P of the secondary winding becomes positive and end Q negative. This makes diodes D_1 and D_3 forward biased while diodes D_2 and D_4 are reverse biased. Therefore, only diodes D_1 and D_3 conduct. These two diodes will be in series through the load R_L as shown in Fig. 4 (i). The conventional current flow is shown by dotted arrows. It may be seen that current flows from A to B through the load R_L.

During the negative half-cycle of secondary voltage, end P becomes negative and end Q positive. This makes diodes D_2 and D_4 forward biased whereas diodes D_1 and D_3 are reverse biased. Therefore, only diodes D_2 and D_4 conduct. These two diodes will be in series through the load R_L as shown in Fig. 4 (ii). The current flow is shown by the solid arrows. It may be seen that again current flows from A to B through the load i.e. in the same direction as for the positive half-cycle. Therefore, d.c. output is obtained across load R_L.

(i) **(ii)**

Fig.4

DC Power:

The output current is pulsating direct current. Therefore, in order to find d.c. power, average current has to be found out.

$$I_{avg} = I_{dc} = \frac{\text{Area under curve over the full cycle}}{\text{base length over the full cycle}} \tag{9}$$

$$\text{Area} = \int_0^{2\pi} i\,.\,dt = \int_0^{\pi} i\,.\,dt + \int_{\pi}^{2\pi} i\,.\,dt = \int_0^{\pi} \frac{V_m \sin t}{R_f+R_L}.\,dt + \int_{\pi}^{2\pi} \frac{V_m \sin t}{R_f+R_L}.\,dt = \frac{4V_m}{R_f+R_L} \tag{10}$$

From eqn (9) and (10),

$$\mathbf{I_{avg} = I_{dc} = \frac{1}{2\pi} * \frac{4V_m}{R_f+R_L} = \frac{2I_m}{\pi}} \tag{11}$$

Where, $I_m = \frac{V_m}{R_f+R_L}$

∴ DC output power, $P_{dc} = {I_{dc}}^2 * R_L = \left(\frac{2I_m}{\pi}\right)^2 * R_L$ (12)

AC Power: The a.c. power input is given by,

$$P_{ac} = {I_{rms}}^2 * (R_f + R_L) \tag{13}$$

RMS value of load current can be obtained as,

$$I_{rms} = I_{ac} = \sqrt{\frac{\text{Area under squared curve over the full cycle}}{\text{base length over the full cycle}}}$$

$$\mathbf{I_{rms} = \sqrt{\frac{1}{2\pi}\left(\int_0^{\pi} i^2.\,dt + \int_{\pi}^{2\pi} i^2.\,dt\right)} = \sqrt{\frac{1}{2\pi}\left(\int_0^{\pi}(I_m \sin t)^2.\,dt + \int_{\pi}^{2\pi}(I_m \sin t)^2.\,dt\right)} = \frac{I_m}{\sqrt{2}}} \tag{14}$$

From eqn (5) and (6),

$$\therefore \quad P_{ac} = \left(\frac{I_m}{\sqrt{2}}\right)^2 * (R_f + R_L) \tag{15}$$

Rectifier Efficiency:

The ratio of d.c. power output to the applied input a.c. power is known as rectifier efficiency.

$$\eta = \frac{\textbf{dc power output}}{\textbf{Input ac power}} = \frac{\left(\frac{2I_m}{\pi}\right)^2 * R_L}{\left(\frac{I_m}{\sqrt{2}}\right)^2 * (R_f + R_L)} = \frac{\mathbf{0.812}\, R_L}{(R_f + R_L)} = \frac{\mathbf{0.812}}{\mathbf{1+}\frac{R_f}{R_L}}$$

The efficiency will be maximum if R_f is negligible as compared to R_L.

∴ **Max. rectifier efficiency = 81.2 %** (16)

This is double the efficiency due to half-wave rectifier. Therefore, a full-wave rectifier is twice as effective as a half-wave rectifier.

RIPPLE FACTOR

The ratio of r.m.s. value of a.c. component to the d.c. component in the rectifier output is known as ripple factor (RF) i.e.,

$$\text{Ripple factor (RF)} = \frac{\text{RMS value of a.c component}}{\text{value of dc component}} = \frac{I_{ac}}{I_{dc}} = \sqrt{\left(\frac{I_{RMS}}{I_{dc}}\right)^2 - 1}$$

The output of a rectifier consists of a d.c. component and an a.c. component (also known as ripple). The a.c. component is undesirable and accounts for the pulsations in the rectifier output. The effectiveness of a rectifier depends upon the magnitude of a.c. component in the output; the smaller this component, the more effective is the rectifier.

(i) For Half – wave rectifier:

$$I_{rms} = \frac{I_m}{2} \; ; \; I_{dc} = \frac{I_m}{\pi}, \text{ then Ripple factor} = 1.21 = 121\ \%.$$

It is clear that a.c. component exceeds the d.c. component in the output of a half-wave rectifier. This results in greater pulsations in the output. Therefore, half-wave rectifier is ineffective for conversion of a.c. into d.c.

(ii) For Full – wave rectifier:

$$I_{rms} = \frac{I_m}{\sqrt{2}} \; ; \; I_{dc} = \frac{2I_m}{\pi}, \text{ then Ripple factor} = 0.48 = 48\ \%.$$

This shows that in the output of a full-wave rectifier, the d.c. component is more than the a.c. component. Consequently, the pulsations in the output will be less than in half-wave rectifier. For this reason, full-wave rectification is invariably used for conversion of a.c. into d.c.

FILTER CIRCUITS

A filter circuit is a device which removes the a.c. component of rectifier output but allows the d.c. component to reach the load.

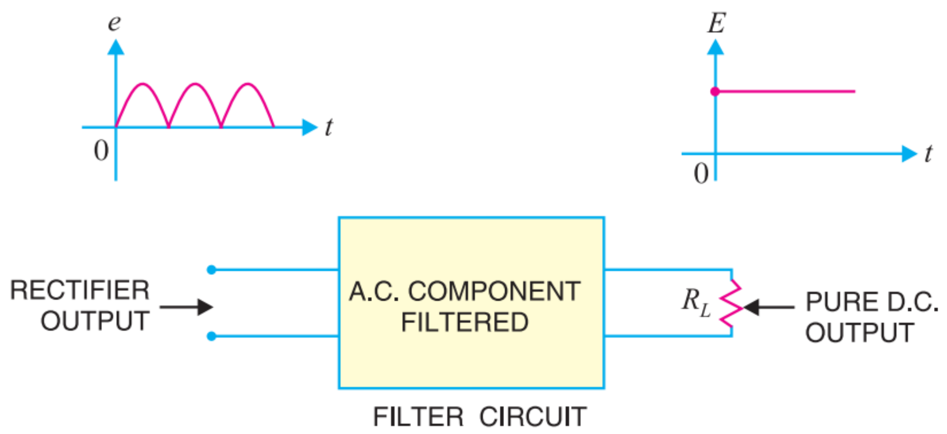
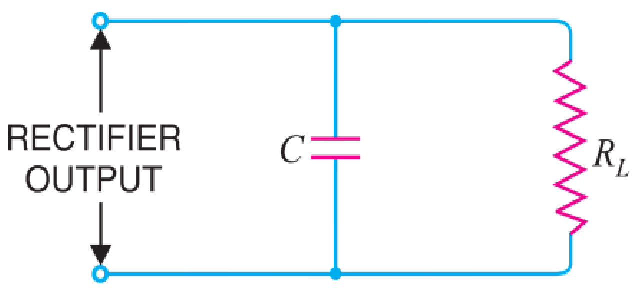


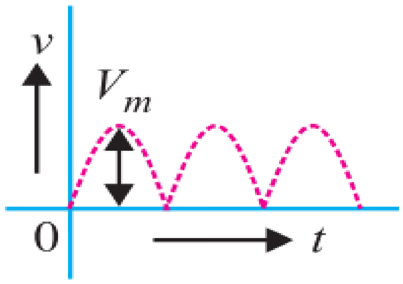
Fig. 5

A filter circuit should be installed between the rectifier and the load as shown in Fig. 5. A filter circuit is generally a combination of inductors (L) and capacitors (C). A capacitor passes a.c. readily but does not pass d.c. (For d.c., f = 0, ∴ capacitive reactance (X_c) = 1/2πfc = ∞) at all. On the other hand, an inductor opposes a.c. but allows d.c. to pass through it.

Capacitor (C) filter:

Fig. 6(i) shows a typical capacitor filter circuit. It consists of a capacitor C placed across the rectifier output in parallel with load R_L. The pulsating direct voltage of the rectifier as shown in Fig. 6(ii) is applied across the capacitor.





(i)

(ii)

Fig.6

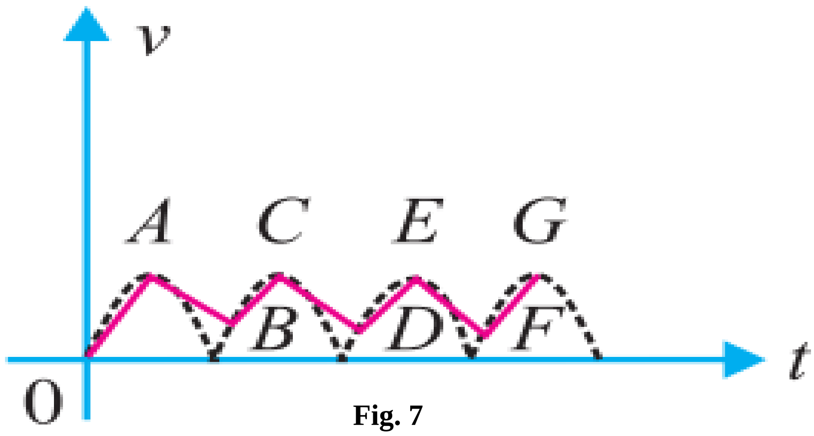


Fig. 7

As the rectifier voltage increases, it charges the capacitor and also supplies current to the load. At the end of quarter cycle [Point A in Fig. 7], the capacitor is charged to the peak value V_m of the rectifier voltage. Now, the rectifier voltage starts to decrease. As this occurs, the capacitor discharges through the load and voltage across it (i.e. across parallel combination of R-C) decreases as shown by the line AB in Fig. 7. The voltage across load will decrease only slightly because immediately the next voltage peak comes and recharges the capacitor. This process is repeated again and again and the output voltage waveform becomes ABCDEFG. It may be seen that very little ripple is left in the output. Moreover, output voltage is higher as it remains substantially near the peak value of rectifier output voltage.

ZENER DIODE AS VOLTAGE REGULATOR/STABILISER

Equivalent Circuit of Zener Diode:

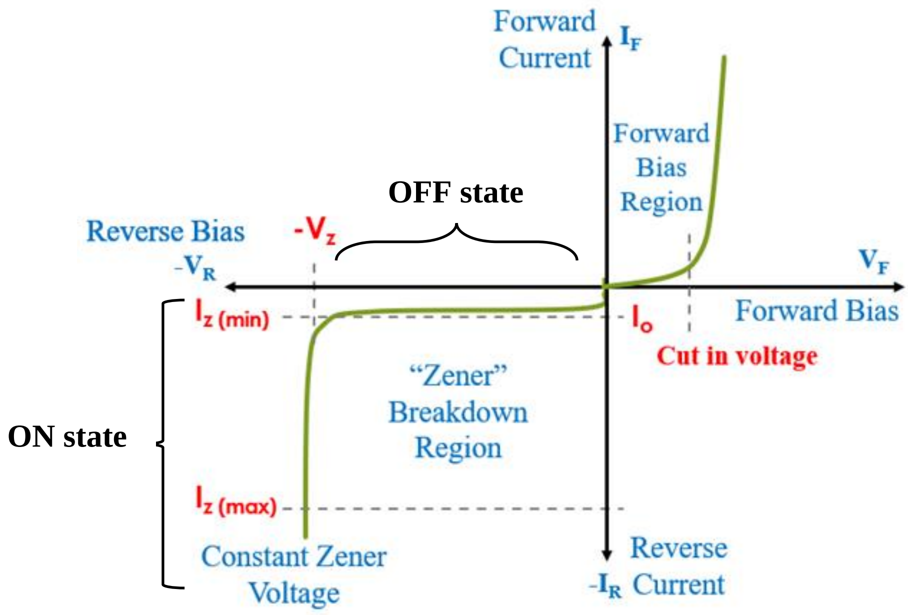


Fig. 8 Zener Diode Characteristics

(i) "On" state:

When reverse voltage across a zener diode is equal to or more than break down voltage V_Z, the current increases very sharply as shown in Fig. 8. In this region, the curve is almost vertical. It means that voltage across zener diode is constant at V_Z even though the current through it changes. Therefore, in the breakdown region, an ideal zener diode can be represented by a battery of voltage V_Z as shown in Fig. 9(ii). Under such conditions, the zener diode is said to be in the "ON" state.

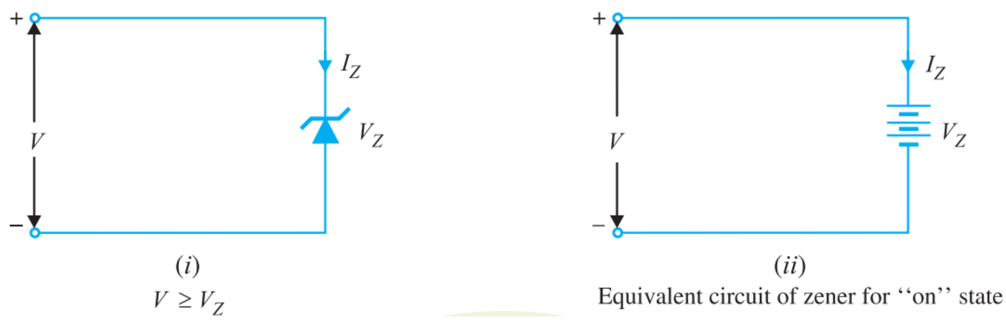


Fig. 9

(ii) "OFF" state:

When the reverse voltage across the zener diode is less than V_Z but greater than 0 V, the zener diode is in the "OFF" state. Under such conditions, the zener diode can be represented by an open-circuit as shown in Fig. 10(ii).

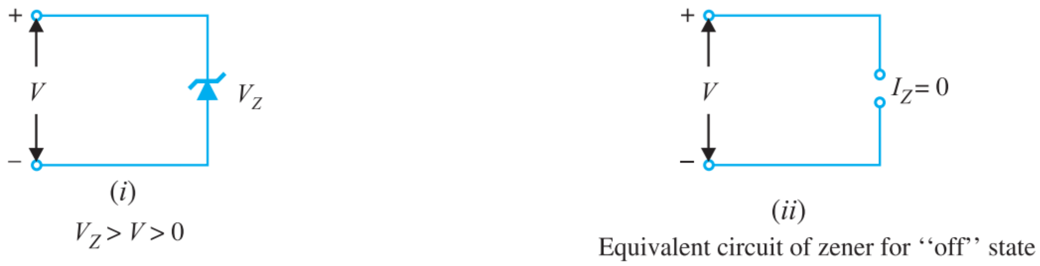


Fig. 10

Voltage Regulator functioning:

A zener diode can be used as a voltage regulator to provide a constant voltage from a source whose the input voltage E_i and load resistance R_L may vary over a wide range. The circuit arrangement is shown in Fig. 11(i). The zener diode of zener voltage V_Z is reverse connected across the load R_L across which constant output is desired. It may be noted that the **zener will maintain a constant voltage V_Z (= E_0) across the load so long as the input voltage does not fall below V_Z.**

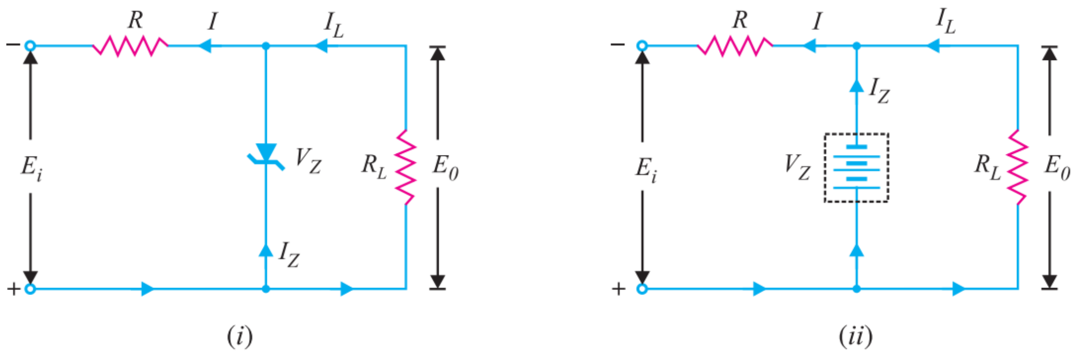


Fig. 11

(i) Suppose the input voltage increases. Since the zener is in the breakdown region, the zener diode is equivalent to a battery V_Z as shown in Fig. 11(ii). It is clear that output voltage remains constant at V_Z (= E_0). The excess voltage is dropped across the series resistance R. This will cause an increase in the value of total current I. The zener will conduct the increase of current in I while the load current remains constant. Hence, output voltage E_0 remains constant irrespective of the changes in the input voltage E_i.

(ii) Now suppose that input voltage is constant but the load resistance R_L decreases. This will cause an increase in load current. The extra current cannot come from the source because drop in R (and hence source current I) will not change as the zener is within its regulating range. The additional load current will come from a decrease in zener current I_Z. Consequently, the output voltage stays at constant value.

ELECTRONIC INSTRUMENTATION SYSTEM

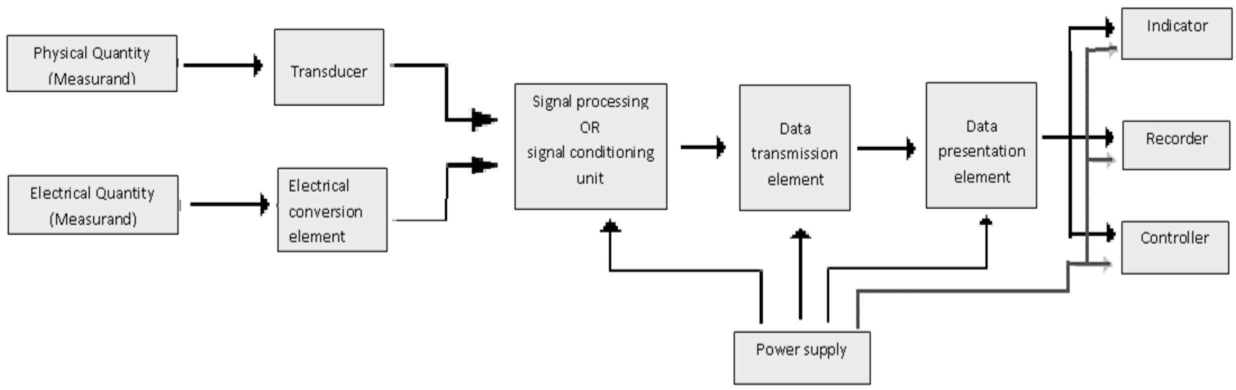


Fig.12 Block diagram of an electronic instrumentation system

The block diagram of generalized electronics instrumentation system as shown in Fig., in which number ofelements worked together to perform a desired function accurately i.e. to measure the measurand quantity and display it or record it.

Measurand (physical quantity or electrical quantity):

- The physical or electrical quantity which is to be measurand is called as measurand. If the input to the instrumentation is parameter like pressure, force, level, strain, displacement, temperature, flow, velocity etc. then these parameters are physical measurand. These measurand are applied to the transducer element.
- If the input is current, voltage and frequency then these parameters are called electrical measurand. These measurand are applied to the electrical conversion element.

Transducer and electrical conversion elements:

- If the measurand is physical quantity then it is converted into equivalent electrical signal with help of element which is called transducer.
- If the measurand is electrical signal like voltage, current or frequency then it is given to the electrical conversion element which convert the signal into more suitable form of signals.

Signal processing or signal conditioning:

- In electronic instrumentation system, filter, modulator, A/D converters, D/A converter, amplifiers, integrators, differentiators are the important signal conditioningcircuits.
- This stage is required to convert the transducer output into an electrical quantity suitable for proper operation of the last stage or indicator.

Data transmission element:

- This element provides a transmission path for the modified signals to travel from transducer element to the rest of instrumentation elements like recorders, controllers, displays etc.
- In electronic instrumentation system, typically the transmission path is a conducting line (i.e. electrical cables).

Data presentation element:

- Function performed by this stage may be demodulation, amplification, filtering, A/D conversion etc.
- This element modifies the signals in such a way that the signals are accepted by recorders, displays, indicators, printers, announcing systems etc. The output of the

data presentation element is provided to the recorders, controllers, and indicators as per the requirement of the user or operator or observer.

Output devices:

- The last stage of instrumentation system is required to provide the information about the measurand for immediate reorganization by the operator whatever output is presented on indicator.
- If the system is control system in that case the measured data not only displayed or recorded but also compared with some reference value and control action is generatedwhich is used to remove the error.

Power supply:

- This is a common unit for all instrumentation system. This provides power to all elements working in the instrumentation setup.

DIGITAL VOLTMETER (DVM)

Voltmeter is an electrical measuring instrument used to measure potential difference between two points. The voltage to be measured may be AC or DC. Two types of voltmeters are available for the purpose of voltage measurement i.e. analog and digital.

Analog voltmeters generally contain a dial with a needle moving over it according to the measure andhence displaying the value of the same. Digital voltmeters display the value of AC orDC voltage being measured directly as discrete numerical instead of a pointer deflection on a continuous scale as in analog instruments. A digital voltmeter (DVM) displays the value of a.c. or d.c voltage being measured directly as discrete numerals in the decimal number system.

The use of digital voltmeters increases the speed with which readings can be taken. Also, the output of digital voltmeters can be fed to memory devices for storage and future computations. A digital voltmeter is a versatile and accurate voltmeter which has many laboratory applications. On account of developments in the integrated circuit (IC) technology,it has been possible to reduce the size, power requirements and cost of digital voltmeters. In fact, for the same accuracy, a digital voltmeter now is less costly than its analog counterpart. The decrease in the size of DVMs on account of the use of ICs, the portability of the instruments has increased.

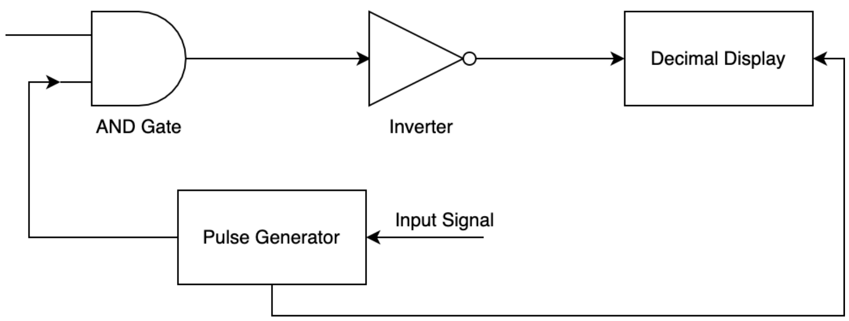


Fig.13 Block diagram of a Digital Voltmeter (DVM)

Working:

- Unknown voltage signal (I/P) is fed to the pulse generator which generates a train of rectangular pulse whose width is proportional to the input signal.
- Output of pulse generator is fed to one leg of the AND gate and the input signal to the other leg of the AND gate is a train of pulses.
- AND gate gives high output only when both the inputs are high. When a train pulse is fed to it along with rectangular pulse, it provides us an output having train pulses with duration as same as the rectangular pulse from the pulse generator. Then, Output of AND gate is positive triggered train of duration same as the width of the pulsegenerated by the pulse generator.
- The positive triggered train is fed to the inverter which converts it into a negative triggered train.
- Output of the inverter is fed to a counter which counts the number of triggers in the duration which is proportional to the input signal i.e. voltage under measurement.

CATHODE RAY OSCILLOSCOPE (CRO)

Cathode Ray Oscilloscope is an versatile laboratory instrument used for studying wave shape of alternating current and voltage as well as for the measurement of voltage, power and frequency. The waveform is generated in such a way that the amplitude of the signal is represented along Y-axis and the variation in the time is represented along X-axis. Essentially, an oscilloscope consists of the following components as shown in Fig.14.

1. Cathode ray tube (CRT)
2. Low and high voltage (LV & HV) power supply
3. Time base generator
4. Vertical and horizontal amplifiers

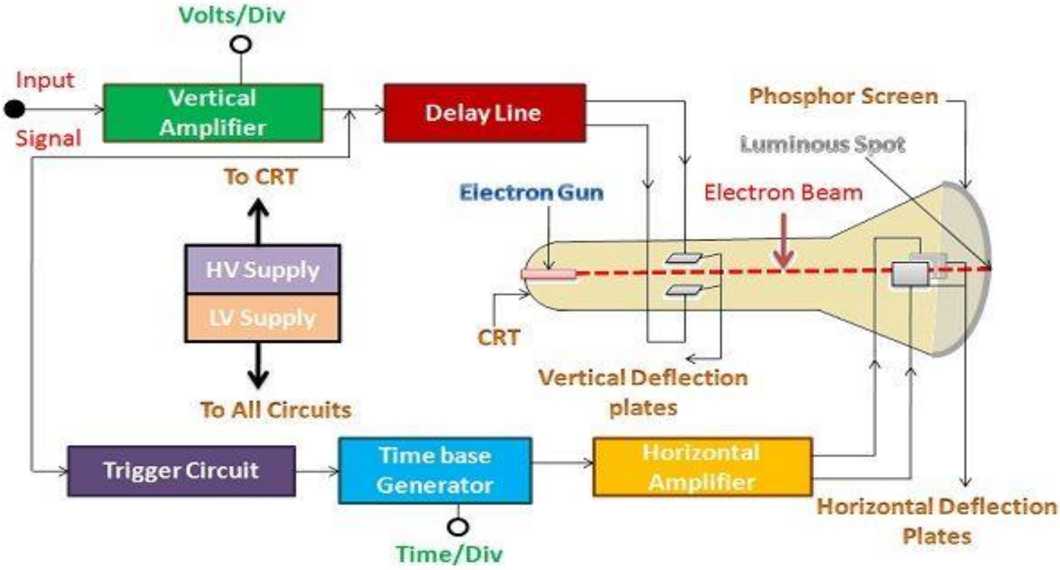


Fig.14 Block diagram of a CRO

1. CATHODE RAY TUBE

It is the heart of a CRO. It is used to bombard electrons towards the fluorescent screen. CRT is an evacuated tube where an electron gun is fitted, which emits electrons towards the fluorescent screen. A detailed representation of a CRT is given in Fig.15. The major components of CRT are electron gun, deflection system, fluorescent screen and evacuated glass envelop.

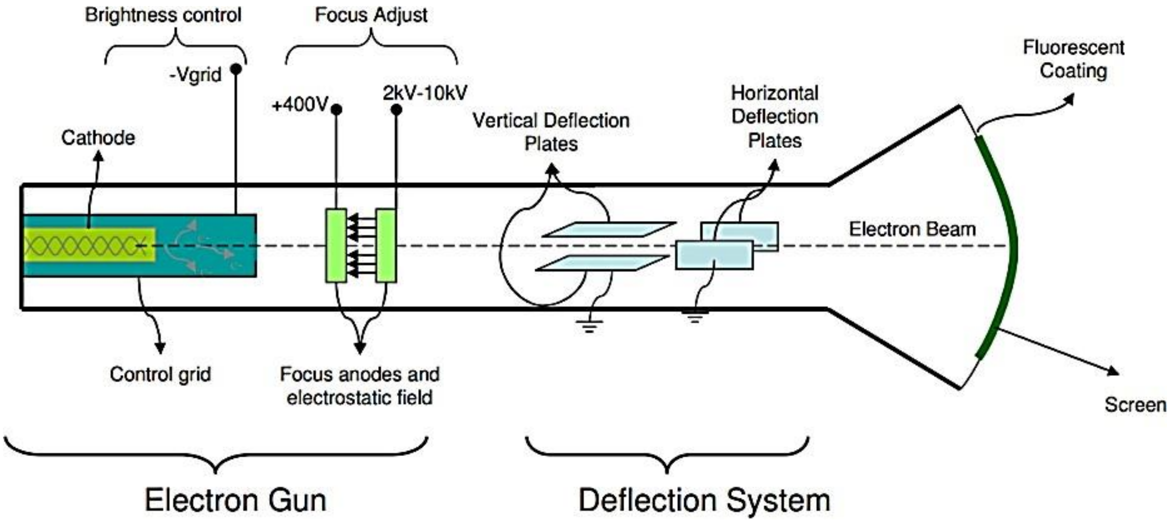


Fig.15 Schematic of cathode ray tube (CRT)

a) Electron Gun:

Electron gun is a source of electrons. It provides a sharply focused electron beam directed towards the fluorescent coated screen. It consists of a heated cathode, control grid, pre-accelerating anode, focusing anode, and an accelerating anode. The thermally heated cathode emits electrons in many directions. The control grid provides an axial direction for the electron beam and controls the number and speed of electrons in the beam. The momentum of the electrons determines the intensity or brightness of the light emitted from the fluorescent coating due to the electron bombardment. Because electrons are negatively charged, a repulsion force is created by applying a negative voltage to the control grid, to adjust their number and speed. A more negative voltage results in a smaller number of electrons in the beam and hence decreased brightness of the beam spot. Since the electron beam consists of many electrons, the beam tends to diverge. This is because the similar (negative) charges on the electrons repulse each other. To compensate for such repulsion forces, an adjustable electrostatic field is created between two cylindrical anodes, called the focusing anodes. The variable positive voltage on the second anode cylinder is therefore used to adjust the focus or sharpness of the bright spot.

(b) Deflection System:

The deflection system consists of two pairs of parallel plates, referred to as the vertical and horizontal deflection plates. One of the plates in each set is permanently connected to the ground (zero volt), whereas the other plate of each set is connected to input signals or triggering signal of the CRO and the electron beam passes through the deflection plates. As shown in Fig.16, a positive voltage applied to the 'Y' input terminal causes the electron beam to deflect vertically upward, due to attraction forces, while a negative voltage applied to the 'Y' input terminal causes the electron beam to deflect vertically downward, due to repulsion forces.

Similarly, a positive voltage applied to the 'X' input terminal will cause the electron beam to deflect horizontally toward the right, while a negative voltage applied to the 'X' input terminal will cause the electron beam to deflect horizontally toward the left of the screen. The amount of vertical or horizontal defection is directly proportional to the corresponding applied voltage. When the electrons hit the screen, the phosphor emits light and a visible light spot is seen on the screen. Since the amount of deflection is proportional to the applied voltage, actually the voltages V_y and V_x determine the coordinates of the bright spot created by the electron beam.

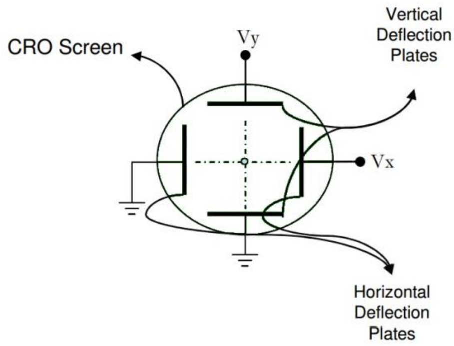


Fig. 16 CRO Screen

(c) Fluorescent Screen:

The light produced by the screen does not disappear immediately when bombardment by electrons ceases i.., when the signal becomes zero. The time period for which the trace remains on the screen after the signal becomes zero is known as persistence. The persistence may be as short as a few microseconds, or as long as tens of seconds or even minutes. The screen is coated with a fluorescent material called phosphor which emits light when bombarded by electrons. There are various phosphors available which differ in colour, persistence and efficiency.

(d) Evacuated Glass Envelope:

All the components of a CRT are enclosed in an evacuated glass tube called envelope. This allows the emitted electrons to move about freely from one end of the tube to the other end.

2. LOW AND HIGH VOLTAGE POWER SUPPLY

The power supply block provides the voltages required by CRT to generate and accelerate an electron beam and voltages required by other circuits of the oscilloscope like horizontal amplifier, vertical amplifier etc.

There are two sections of a power supply block. The high voltage section and low voltage section. The high voltages of the order of 1000 to 1500V are required by CRT. Such high negative voltages are used for CRT. The low voltage is required for the heater of the electron gun, which emits the electrons. This is a positive voltage of the order of few hundred volts.

3. TIME BASE GENERATOR

The generator which generates a wave form which is responsible for the movement of a spot-on screen horizontally is called time base generator or sweep generator. This produces a saw-tooth wave form which is used as horizontal deflection voltage of CRT.

4. VERTICAL AMPLIFIER

The vertical amplifier receives the input from the signal which is to be measured and then amplifies it so that the signal of high intensity is supplied to the vertical deflection plate.

If a low-intensity signal strikes the vertical deflection plate, the electron beam will not be deflected effectively to create the bright spots on desired points on the screen. Thus, the vertical amplifier is a significant device.

5. HORIZONTAL AMPLIFIER

The horizontal amplifier generates the signal which provides voltage to horizontal deflection plates. The horizontal deflection plates deflect the beam along the horizontal direction. This is helpful to create the waveform along with the time domain.

The horizontal amplifier is the crucial part. This is because the deflection of the electron beam in the horizontal direction will be effective only when the signal applied from the output of the horizontal amplifier is high enough to create the bright spots at the desired location on the phosphor screen.

6. DELAY LINE CIRCUIT

When the signal from the vertical amplifier is fed to the vertical deflection plates, then some part of the amplified signal is supplied to the time base generator. This trigger pulse generated from the time-based generator is amplified with the help of the horizontal amplifier.

After this, it is fed to horizontal deflection plates. This process requires approximately 100ns. Thus, it is crucial to delay the signal generated by the vertical amplifier too in order to maintain synchronization.