2.1 INTRODUCTION

Power supply is the basic requirement of any working circuit or device. We know that the electronic circuit uses semiconductors and so the circuit requires only DC power supply for its smooth working and good performance. So in this chapter, we shall study the conversion of AC voltage into proportional DC voltage, using the technique of rectification process. Since AC mains voltage source is cheap and convenient rather than the DC source of batteries, we shall use AC mains voltage like 230V, 50Hz source used particularly in India. There varieties of mains voltage source on global level. *Refer the endnote*[xx]*)*, but the explanation of the circuits given in this chapter is equally applicable on global level.

2.2 CONCEPT OF AC VOLTAGE

AC voltage is generated on the principle of Faraday's law of electromagnetic induction. Consider a simple model of generator as shown in *Fig: 2.1*. Suppose a rectangular coil is rotating, in anticlockwise direction, on a fixed axis within the strong magnetic field of two permanent magnets *(left figure)*. Then AC voltage is produced across its two end points A-B. The voltage thus, produced at each position is given in the graph *(right figure)*.

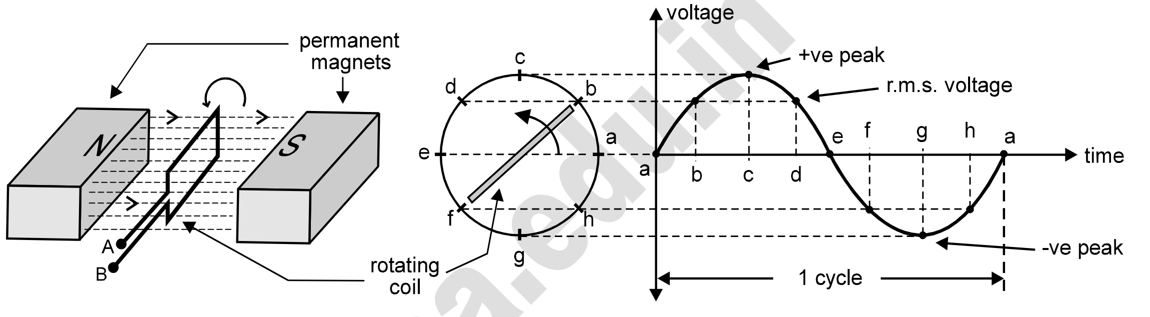


Fig: 2.1, Basic concept of generation of AC voltage using electromagnetic induction

Suppose the rotation of the coil starts from point 'a'. At point 'a' the coil and the magnetic field are parallel to each other. So voltage produced in the coil is zero[xxi]. When coil rotates through an angle of 45°, at point 'b' the coil and the magnetic field are becoming perpendicular to each other. So the voltage in coil increases and attains the voltage known as r.m.s. voltage. When it comes to point 'c' by sweeping an angle of 90°, then it is exactly perpendicular to magnetic field. So maximum positive voltage is produced across it. In the same way, at 'd' the voltage is again r.m.s. voltage and at point 'e', its half rotation is complete and it is now parallel with the magnetic field. So again its voltage is zero. This completes positive half cycle of the AC voltage.

During next half rotation same process takes place, only negative half cycle of AC voltage is obtained. Because direction of induced e.m.f. in the coil is opposite to the previous direction. Hence, we get half cycle in IV quadrant. And lastly when the coil completes one rotation, it comes at point 'a' and the voltage induced in it will be zero, again.

> In each case, the value of voltage generated depends on the number of turns of the coil, the strength of magnetic field and the speed at which the coil is rotating within the magnetic field.
> It we rotate the magnetic field by rotating magnets, keeping the coil steady, even though same effect is observed. It means that relative motion between magnetic field and coil is necessary.

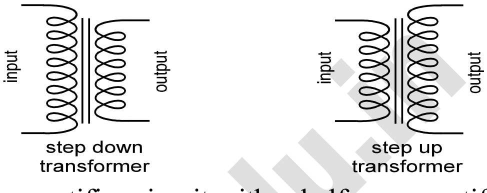
2.3 RECTIFICATION

A rectifier is an electrical device that converts AC voltage, which periodically reverses its direction, into DC voltage, which flows in only one direction. This process of conversion is known as rectification.

2.3.1 Block diagram of DC power supply

A DC power supply consists of 4 stages. The first stage is the transformer, which either reduces or increases its output voltage into required value. Generally, the electronic circuits run on small DC voltage. So in such power supply the transformer is used to obtain small AC voltage. Mainly there are two types of transformers:

> **Step down transformer:** it has less number of turns of secondary than primary. Hence, its output voltage is less than mains input voltage.
> **Step up transformer:** it has more number of turns of secondary than primary. Hence, its output voltage is greater than mains input voltage.



The second stage is known as rectifier circuit, either half wave rectifier *(using single diode),* full wave rectifier *(using two diodes)* or bridge rectifier *(using four diodes)*. This circuit converts AC voltage into "impure" DC voltage.

The third stage converts impure DC voltage into pure DC voltage by using filter circuits. And the fourth stage regulates the fluctuating pure DC voltage into a constant value irrespective of changes taking place in AC mains voltage. The general-purpose block diagram of such power supply is given in *Fig: 2.2*, as shown below.

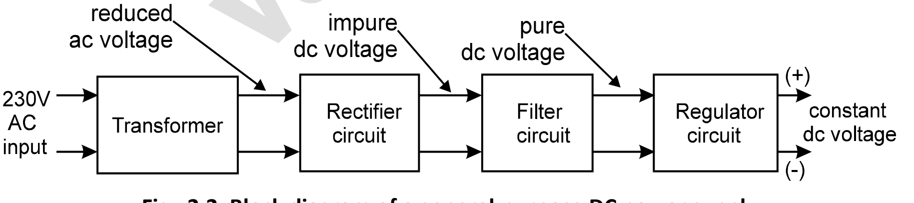


Fig: 2.2, Block diagram of a general-purpose DC power supply

2.3.2 Half wave rectifier

As the name implies, it rectifies only half cycle *(half wave)* of the AC voltage. The remaining half cycle is cutoff during rectification process. Thus, the circuit may either rectify positive half cycle of AC voltage or the negative half. In any case, the one half of the complete wave of AC voltage will be cutoff in this circuit. As shown in following *Fig: 2.3*, the circuit uses a single diode as D_1 with step-down transformer and a load resistor* R_L.

* A load resistor may be any type of device like a small bulb, a battery connected for charging, an electronic circuit or any other device which runs on DC power supply. Thus, the word "load resistor" has an extensive sense of indications and meaning.

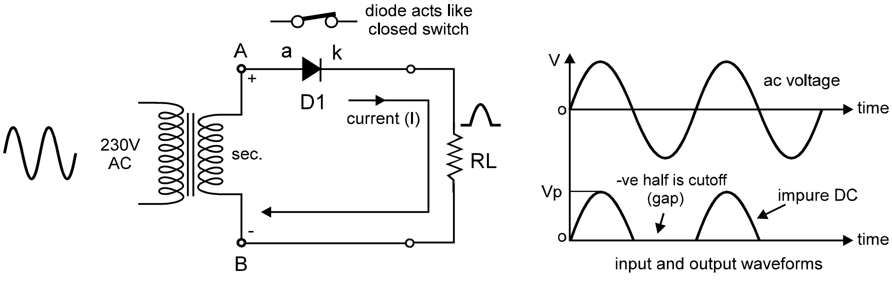


Fig: 2.3, Circuit of half wave rectifier and its wave diagram

Features: When AC mains voltage *(230V)* is switched on, the transformer produces small AC voltage V_{ac} across its secondary terminals A and B. During positive and negative half cycles of this voltage the polarity at A and B will change with a frequency of 50Hz. The diode D_1 is connected in series with the load resistor R_L. So the amount of current flowing through D_1 will depend on the value of R_L.

Working: During positive half cycle of AC voltage, suppose terminal A is positive with respect to terminal B. Therefore diode D_1 is forward biased for all voltages greater than its forward voltage (say 0.7V*). Thus, the diode acts like a closed switch with practically zero resistance[xxii]. So current flows through the circuit following the path A-D_1-R_L-B and we get positive half cycle across R_L. When current flows through R_L we get DC voltage, known as V_{dc} across the load.

But during negative half cycle of AC voltage, terminal B is positive and A is negative. So anode becomes negative with respect to cathode and the diode is reverse biased. Now the diode acts like an open switch. Current cannot flow through the circuit and output voltage is zero.

Output voltage: It is the product of current I and value of load resistor R_L i.e. $V_o = IR_L$. This voltage is also equal to the average DC voltage of the circuit given as:

$$V_{dc} = V_o = \frac{V_p}{\pi}$$

Where,
Vp = peak secondary voltage

Peak Inverse Voltage (PIV): The diode must withstand for this voltage when it is in reverse bias. During negative half cycle of AC voltage, cathode is negative and anode is positive. So diode must withstand this voltage and should not be damaged. This is known as PIV rating of diode.

Ripple factor: Ripple means variations in DC voltage at the output. It is defined as the ratio of r.m.s. AC voltage to DC voltage. It is expressed in percentage (%). Thus:

$$RF = \frac{V_{rms}}{V_{dc}} \times 100$$

r.m.s. voltage: The r.m.s. voltage V_{rms} and peak voltage V_p of AC cycle are related with the equation, as follows:

$$V_{rms} = \frac{V_p}{\sqrt{2}}$$

Ripple frequency: It is defined as the number of ripples present in DC voltage per second. Since frequency of AC voltage is 50Hz, the ripple frequency of HWR is also 50Hz.

---

* Here we assume that the diode D_1 is a silicon diode. The potential barrier of silicon diode is 0.6V to 0.7V.