

37B

POWER SUPPLY AND SIGNAL GENERATING SYSTEMS

37.1 INTRODUCTION

In the previous lesson you have studied about some of the measuring devices like multimeter, CRO and display system. Now we shall talk of some familiar systems. You may be aware of most of the electronic gadgets around you such as TV, VCR, transistor, radio, telephone etc. (work with DC voltage.) If we use dry batteries for all these it will be very expensive as well as difficult. You know, the house supply is invariably AC input. To run some of these appliances from the house supply, it is necessary to convert the AC voltage into DC voltage.

In this lesson you will study about the basic principle and applications of such power supplies and signal generating devices. Besides the basic principle and construction of an inverter and a solar cell you will study about their importance and applications also.

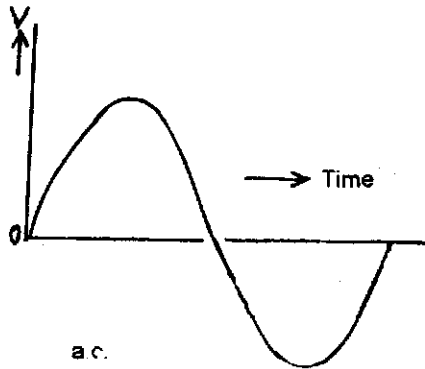
37.2 OBJECTIVES

After studying this lesson you should be able to:

- *describe the working principle and limitations of the power supply system used in various electronic appliances;*
 - *explain the principle of a signal generator;*
 - *recognise the utility of the frequency generators and power supplies in daily life;*
 - *describe the principle and construction of an inverter;*
 - *appreciate the importance of inverters in day to day life; and*
 - *explain the working and application of solar cells.*
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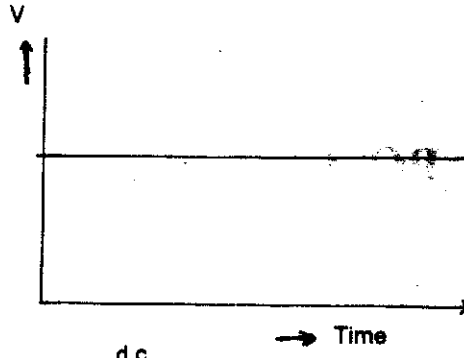
37.3 POWER SUPPLY

The systems which converts the a.c. input of 50Hz power line to d.c. out put voltage is known as power supply. The main component in the power supply is the rectifier, which normally is a silicon diode. As you have studied earlier in your fifth book, the diode conducts only when forward polarity of voltage is applied. An a.c. input that has +ve and -ve half cycles is converted into a d.c. output with a constant polarity. (Fig. 37.1)



a.c.

Fig. 37.1 (a) : a.c. input



d.c.

Fig. 37.1 (b) : d.c. output (ideal)

37.3.1 Working Principle and Limitation of Power Supply

As you have studied earlier basically only rectifying diode is needed to change the a.c. input to a d.c. output. However filter capacitors and inductors are also used to remove the pulsating variations from the d.c. output. In addition, a power transformer is generally used to step up or step down the voltage depending upon the requirement. Finally a voltage regulator is used to keep the output voltage constant when the dc load current changes. Otherwise, the dc voltage would tend to decrease as the load current is increased. Basic functions of a power supply is shown in fig.37.2

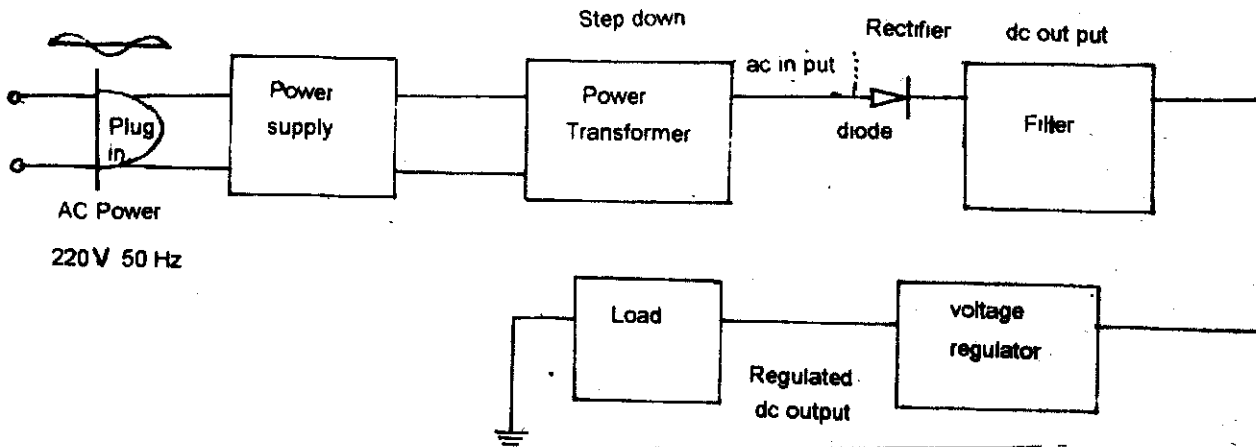


Fig. 37.2 : Basic functions of a power supply

Silicon diodes are generally used for rectification. The advantage it offers is a very low internal voltage drop of approximately 1 V where as in a typical vacuum tube it is 18 V. A schematic diagram of Si diode is shown in fig.37.3

Diode current flows only when the ac input provides forward voltage. The arrow shows the direction. A hole current which consists of +ve charges flows in direction opposite to that of electron. The ac input can supply one or the other alternate half cycles, but not both at the same time. A single diode, therefore, is half wave rectifier. It can conduct for only a half cycle of the ac input.

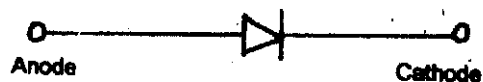


Fig. 37.3 :

Schematic diagram of diode

(a) Half Wave Rectifier

A half wave rectifier uses only one half cycle of the ac input for the dc output. Either +ve or -ve half cycle can be used depending upon the diode connection. Positive voltage at the anode and negative voltage at the cathode make the diode conduct. In the circuit shown in figure 37.4 (a) diode D conducts when ac voltages make its anode +ve. The current then can flow and one gets dc in the output circuit. When the ac input is negative, diode can not conduct and hence there is no dc output across the load as shown in Fig 37.4 (b).

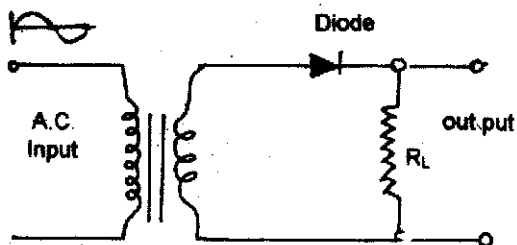


Fig. 37.4(a) : Circuit diagram for half wave rectifier

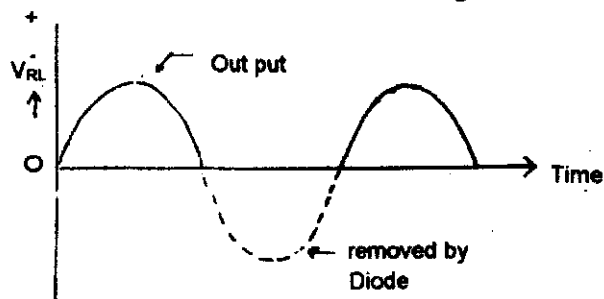


Fig. 37.4(b) : d.c. output of a half wave rectifier

(b) Full Wave Rectifier

In full wave rectifier two diodes are used to conduct both +ve and -ve half cycles of the ac input. Each diode is a half wave rectifier and each one has a common load as shown in figure 37.5 (a) For the conduction in either diode, the current flows through the load in the same direction as shown in Fig 37.5 (b).

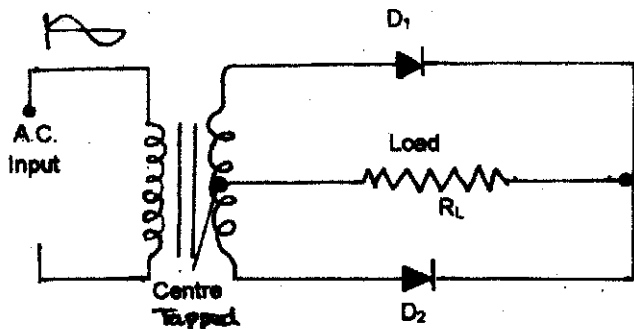


Fig. 37.5(a) : Circuit diagram for full wave rectifier

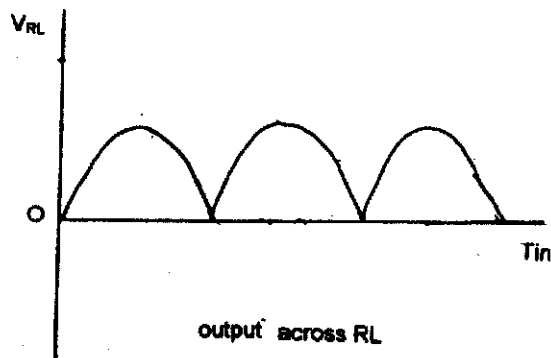


Fig. 37.5(b) : Output of a full wave rectifier

(c) Filters for Power Supplies

The dc output from a rectifier is unidirectional but it still varies in amplitude (fig 37.5 b). This pulsating voltage corresponds to an ac ripple superimposed on the average dc level. This ripple causes hum in the radio and TV sets. In TV video signal, the excessive ripple produces one or two pairs of dark and light horizontal bars drifting slowly up or down the screen. In order to remove the ripples, filters are used. Filtering is generally accomplished by connecting shunt capacitors and series chokes in the output circuit of the rectifier. They function as smoothing components for the dc supply. These filters are either L-type or π type depending upon the requirement. Series inductor, shunt capacitor and π section filter are shown in Fig 37.6

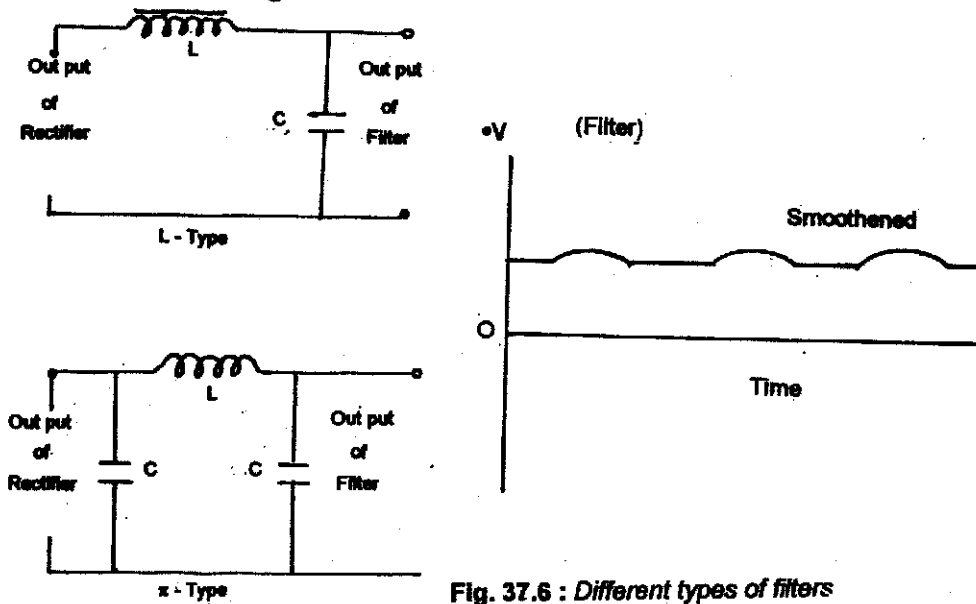


Fig. 37.6 : Different types of filters

37.3.2 Regulated Power Supply - Principle & Applications

An ideal voltage supply is one where voltage remains fixed irrespective of load conditions. However, in practice the voltage dips down (fig.37.7) as load current increases. This is the characteristic of unregulated power supply. In a regulated power supply, it is desired to bring back the ideal characteristic by incorporating some device or circuit. The simplest type of regulation is obtained with the help of zener diode where V-I characteristics are shown in fig.(37.8) and are quite similar to the requirements of ideal power supply.

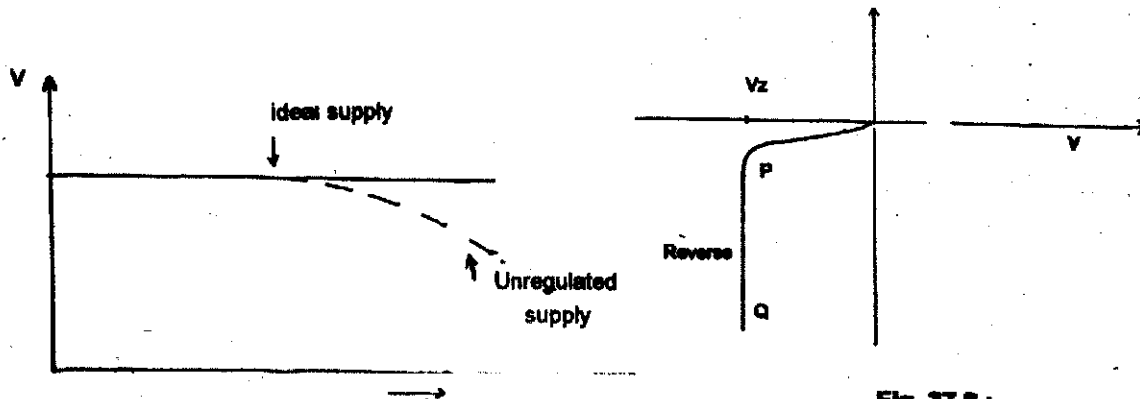


Fig. 37.7 : V-I characteristics of an unregulated power supply

Fig. 37.8 : V-I characteristics for a zener diode

In the reverse bias at zener break down, the voltage becomes constant and current increases very fast (PQ part of graph). Hence for large variation of current voltage is constant (zener voltage). This principle is used for regulation. Circuit has been shown in fig. 37. 9.

R_s is a series resistance chosen as per zener rating i.e. the power P_{Zmax} from zener should be $\leq V_z I_{Zmax}$

I_{Zmax} is known, V_z is known and R_s can be calculated from this.

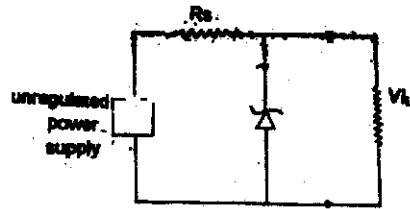


Fig. 37.9: Circuit diagram of a zener diode

INTEXT QUESTIONS 37.1

1. What is the polarity of the voltage at the anode of zener diode?
.....
2. What is the effect of ripple in T.V. ?
.....
3. What is the nature of the filtered output in full wave rectifier?
.....

37.4 FREQUENCY GENERATIONS

In our daily life, we come across a number of electrical and electronic gadgets like electrical iron, fridge, TV, VCR etc. In India, these gadgets work at 220V-50Hz frequency. In radio and television systems, r. f. waves and higher frequency waves are used for communication of signals from transmitting system to receiving systems. So a range of frequencies is required right from very low (0-50 Hz) to MHz and GHz depending upon the applications. A frequency generator is simply an oscillating circuit to give desired frequency. Frequency spectrum has been shown in fig. 37.9.

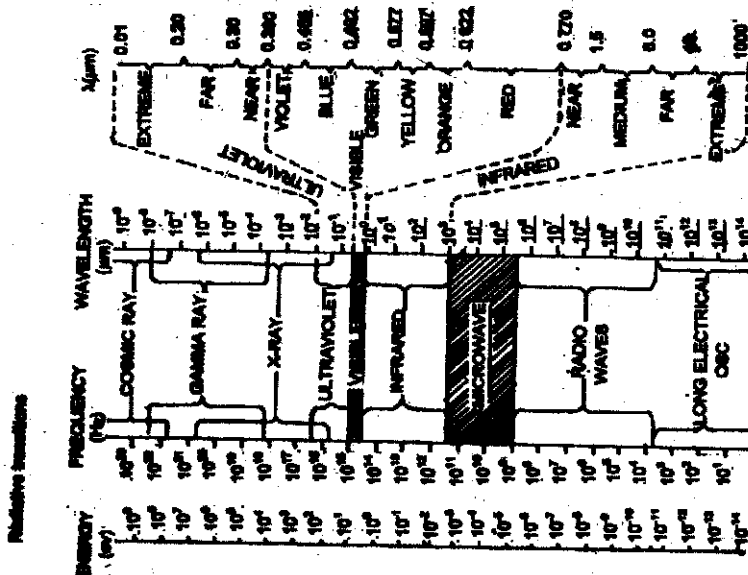


Fig. 37.10 : Frequency spectrum

37.4.1 Types of Frequency Generators

Frequency generators can be classified as follows.

- i) Low frequency generators (~ few Hz)
- ii) Audio frequency generators (20 Hz to 20 kHz)
- iii) Radio frequency generators (few kHz to MHz)
- iv) High frequency generators (0.1 MHz to 10 MHz and More)

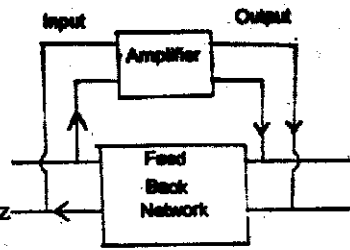


Fig 37.11: Block diagram of a frequency generator

Based upon these requirements different types of oscillating circuits are used which work on different mechanisms. However, the basic principle of working of a frequency generator is given below.

37.4.2 Working Principle of a Frequency Generator

The simple oscillator works on the principle that when a fraction of the output of amplifier is fed-back to the input (positive feedback) then the amplifier circuit becomes an oscillator. Because of electrical and other losses, the amplitude of the oscillation will decrease continuously (damping) if the loss is not compensated by the external sources (ac mains or any other power source). The basic block diagram is shown in fig. 37.11.

The main requirement for the oscillations is that the feed back should be positive. The final gain is given by

$$A_f = \frac{A}{1+A\beta}$$

Where A is gain (=output/input) of amplifier without feedback. β is fraction of output (+ve feedback) and

$$1+ A\beta = 0$$

for sustained oscillation $A_f \rightarrow \infty$

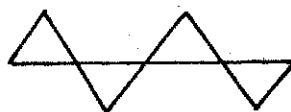
Some examples of various types of oscillators are Hartley Oscillator, Phase-shift Oscillators etc. and these are used for audio to radio frequency generation.

For higher frequency range (Microwave) Klystron and Magnetrons are used for high power applications where as Gunn and IMPATT diodes are used for high frequency- low power applications.

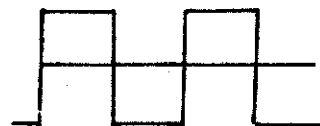
Function generators are also available giving sine wave, cosine wave, triangular wave, square waves (Fig 37.12).



(a) Sine/cosine wave



(b) Triangular wave



(c) Square wave

Fig. 37.12

37.4.3 Applications & Limitations of Frequency Generators

As previously mentioned the importance of the oscillations of different frequencies, some of the specific applications of frequency generators are given as follows :

(i) **Communication** - In the present day context a fast communication system is very essential to transmit and receive information. The system includes telephones, telefax, internet cellulers, pagers. The present day communications is based upon satellite communication system where high frequencies are used.

Obviously oscillators are required for this purpose. The whole system will collapse if communication fails.

(ii) **Electronic Instruments** - In computers, speed of processing is controlled by clock frequency which can be increased as per our requirements. These days 80486 and Pentium processing fast computers are used.

(iii) **Entertainment** - In most of the entertainment electronic instruments such as Radio, TV, VCR or multimedia kit in computers, oscillators are essential parts of the system.

(iv) **High Frequency Applications** - Microwave generators are used in radars for detecting and guiding planes, in microwave ovens for cooking and in satellite communication

INTEXT QUESTIONS 37.2

1. *What is the principle of working of an oscillator?*
.....
2. *If value of inductor in the tank circuit $L = 50 \text{ mH}$, capacitor $C = 0.2 \text{ mF}$, what will be the frequency of the oscillator ?*
.....
3. *What do you mean by V.H.F. and U.H.F. and what are their ranges?*
.....

37.5 INVERTER

During summers, you should have observed power cuts and load shedding due to shortage in electricity generation. Because of these power cuts the work comes to a stand still affecting students, businessmen and work at office, factories etc. Depending upon the requirements people have the stand-by systems like diesel-petrol ac generators which make a lot of noise and also pollute the environment. For a small family, where one may need a few tube lights and fans, quiet noiseless solid state power generator also called inverter is used.

Basically it is a power device by which dc power can be converted into ac power of desired frequency and voltage. For household applications, generally a 220V ac with 50-60 Hz frequency is required.

37.5.1 Working Principle of Inverter

An inverter generally consists of dc batteries (as per required load & for required continuous operation for a given period of time 4h-6h-10h) with a battery charger and a converter to convert dc to ac power of 50-60 Hz frequency. The basic block diagram is given in fig. 37.13

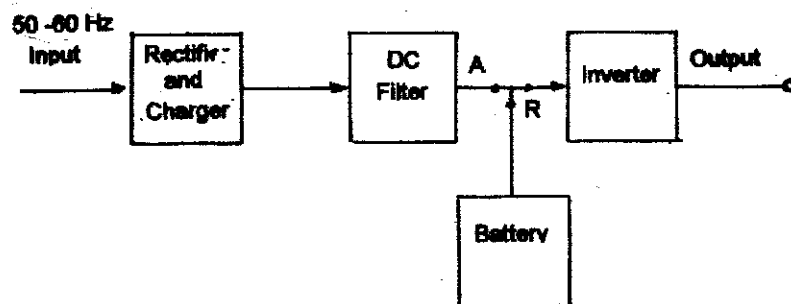


Fig. 37.13 : Block diagram of an inverter

The ac input of 50-60Hz is first of all rectified to dc (depending upon battery requirement). The dc is obtained (after filtering) at A. The relay R connects the battery to the ac input through rectifier and the battery gets charged. (Overcharge protection is used for safety)

When there is a load shedding the relay R connects battery to the inverting circuit. This circuit has an oscillator which converts dc power from battery to 220V ac at 50-60 Hz. The output of the inverter is connected to the mains/ fans or tube-lights which may work (during load shedding) until the battery gets discharged.

The complete inverter system gives desired output (220V, 50-60 Hz). It is also provided with a regulator and change-over switch so that when regular supply is on, the system automatically changes over from battery to ac mains input. The latest systems have over-load protection, battery overcharge protection, emergency light system etc. Cheaper inverters give square wave output. For Sine wave cost is higher. (Sine wave is ideal). Square wave can spoil gadgets.

The system is mainly maintenance free and the only precaution required is to maintain water-level in the battery.

37.5.2 Applications of Inverters

Inverters have variety of applications. To mention few, an inverter can be used - :

- as stand by system for small power applications;
- for speed control of induction and synchronous motors;
- for uninterrupted power supply system which is very important in computers and circuits having memory systems;
- for induction heating;
- in non-conventional energy sources where dc is obtained in wind power, solar cells. This dc can be converted to desired 220V, 60 Hz ac using inverters.

INTEXT QUESTIONS 37.3

1. What is inverter and what is its main application?
-

2. Does an inverter convert ac into dc or dc into ac?

3. What are the specifications of ac mains (voltage, current and frequency) for household supply?

37.6 SOLAR CELL

Solar cell is a semiconductor device which converts the light energy directly into electricity. This phenomenon is known as *photovoltaics*. The energy received by this method is free from pollution and unlimited in the sense that solar energy will continuously be received by the earth for thousands of years. Other conventional sources like coal, wood, petrol, diesel, are exhausting very fast. Particularly, in India where sun shines for more than 300 days in a year the relevance of solar energy becomes all the more important. The electrical energy thus received with the help of solar cells can supplement the present day energy requirement. In space there is no other source of energy than the sun, therefore, on space vehicles and satellites solar panels are preferred rather than nuclear energy systems to make system pollution free.

37.6.1. Working Principle of Solar Cells

A typical p-n junction solar cell has been shown in fig. 37.14 . p-n junction is made on p-type substrate (silicon semiconductor). On the top finger / grid structure is made to take contact & anti-reflection coating is just below it to allow the light to fall on top n layer of the cell.

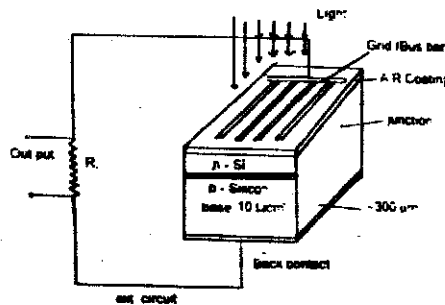


Fig. 37.14 : p-n junction solar cell

When light of suitable wavelength ($\lambda \approx 12345 / V A^0$) falls on semiconductor, electron & hole pairs are generated. They are not allowed to recombine due to the junction barrier and made to flow in an external circuit. The output can be taken across the load R_L . This is known as photo voltage and the current produced is known as photocurrent.

The diode's *I-V* characteristics (dark and illuminated) have been shown in the fig 37.15.

The shaded area shows region of power generation by solar cell. Two important parameters V_{oc} (open circuit voltage) and I_{sc} (short circuit voltage) are shown in the figure. The efficiency of the solar cell is nearly 20%

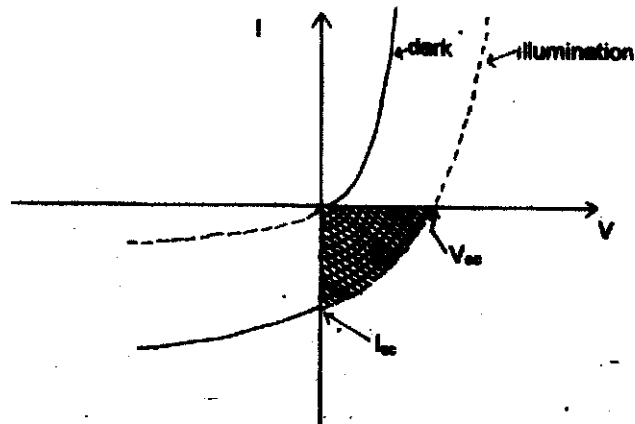


Fig. 37.15: I-V characteristics of a solar cell

37.6.2 Applications and Limitations of Solar Cell

Solar Cell has both the terrestrial and space applications. In India, in many parts of our country (remote hilly areas) where either it is not possible to install a power station or it becomes highly uneconomical to carry power through transmission lines, solar cell has proved to be a boon. Many stand alone systems (independent with chargeable battery - charged by solar panel of solar cells) have been installed e.g. in Leh and other remote areas with the advantage of practically being maintenance free. In many villages, community TV centres and water pumping systems have been installed in our country, which work on photovoltaics. CEL (Central Electronics Limited, Sahibabad near Delhi) is producing solar panels on commercial scale. Solar driven car, autorickshaw is not merely a dream now.

The main limitation of the solar cell is its poor efficiency. The power obtained by solar cell is very expensive. However the cost may be reduced by developing new material and related technology. The solar cell is used in low power consuming gadgets like calculators, wrist watch, solar radio/ transistors very commonly.

Now a days amorphous solar cells (low cost) have been developed for terrestrial applications.

INTEXT QUESTIONS 37.4

1. *Solar cells converts which energy into which other form of energy?*
.....
2. *What do you mean by frequency of suitable light as regards material of solar cell is concerned?*
.....
3. *What type of material is used for making of solar cells ?*
.....
4. *Can you use solar cell as detector ?*
.....

37.7 WHAT YOU HAVE LEARNT

- you have been made familiar with power supply system, its working and applications. you have also got an idea of regulated power supply and its need.
- you have been given an idea of signal or frequency generators of various frequencies and shapes which find application in communication/electronic gadgets etc.
- The principle, and application of inverters and their importance in daily life.
- working principle of solar cells.

37.8 TERMINAL QUESTIONS

1. What is the need of power supply in any instrument? Give examples.
2. What is the need of regulated power supply? Give examples.
3. What frequency ranges are used for communication of information? Give names of a few.

4. How many hours on inverter will work if its specifications are as under 400 watt battery used in 24 volt at 5 ampere load as 200 watt only.
5. What is the working principle of solar cell? Mention some applications.
6. What are the functions of an inverter?
7. What is the function of a solar cell? Generally which type of material is used to make it?
8. What type of output wave form you get from inverter generally installed in houses?
10. Under what conditions an amplifier can act as an oscillator?
11. What devices are used for microwave generation?

ANSWER TO INTEXT QUESTION

Intext question 37.1

- (i) Polarity of voltage at anode is negative as zener is reverse biased.
- (ii) Due to ripple the display on the screen will be distorted and horizontal lines will appear.
- (iii) Filtered output of an ideal full wave rectifier should not have ripples. It should appear as shown in figure. 37.6

Intext question 37.2

- (i) When a fraction of output is fed back positively to an amplifier, it starts behaving as oscillator
- (ii) The frequency = $\frac{1}{2\pi\sqrt{LC}}$
- (iii) V.H.F. stand for very high frequency around 10^8 Hz
U.H.F. stand for ultra high frequency around 10^{10} Hz
Frequency of UHF > frequency of VHF

Intext question 37.3

- (i) As the name suggests inverter is a device which converts d.c. into a.c. The main application is in emergency light and stand by power applications.
- (ii) Inverter converts d.c. into a.c.
- (iii) Specifications of a.c. main in India for household supplies are as under
Voltage 220 Volts. a.c.
Current 5 ampere (light), 15 ampere (power) frequency 50 Hz.

Intext question 37.4

- (i) Solar cell converts light energy into electrical energy.
- (ii) From suitable frequency we mean that the energy should correspond to band gap of semiconductor used in solar cell.
- (iii) Semiconductor materials like Silicon and Gallium Arsenide (Ga As) are used in making solar cell.

- (iv) Yes. It can detect light radiation. If properly calibrated it can be used as luxmeter or intensity meter.

Terminal Questions

1. Every electrical electronic instrument (Medical, Household, entertainment Computer) needs specific power inputs. Power supply is designed to cater this need and supplies desired voltage and desired current to the instrument in use.
2. Regulated power supply is required for very sensitive semiconductor devices and integrated circuit. A regulated supply give constant voltage constant current irrespective of load and hence the device work faithfully.
3. Radio frequency to V.H.F. depending upon audio, video transmission reception.
4. $6 \frac{1}{2}$ h. or 6.5 hour
5. When light of suitable frequency fall on a semiconductor junction (p-n junction) the electrons and holes thus generated can be separated (before they recombines) and can be made to flow in the output to give photo current and photo voltage.