If the generator is not connected across a load the circuit is incomplete and no current will flow to excite the field. The series field contains relatively few turns of wire.

"Shunt" generator field coils are connected across the armature circuit, forming a parallel or "shunt" circuit. Only a small part of the armature current flows hrough the field coils, the rest flowing through the load. Since the shunt field and the armature form a closed circuit independent of the load, the generator is excited even under " no load " conditions - with no load connected across the armature. The shunt field contains many turns of fine wire.

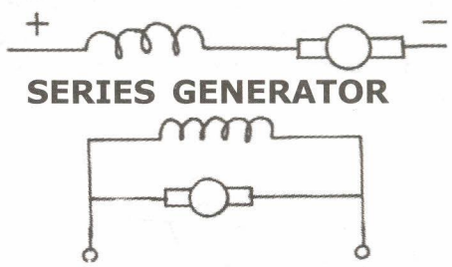



Fig: 10.2 Shunt generator

A " compound " generator has both a series and a shunt field, forming a series- parallel circuit. Two coils are mounted to each pole piece, one coil, series connected and the other shunt connected . The shunt field coils are excited by only a part of the armature current, while the entire load current flows through the series field. Therefore as the load current increases, the strength of the series field is increased.

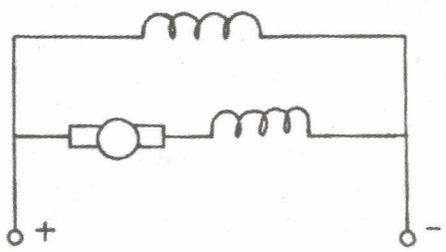



Fig: 10.3 Compound generator

## INTEXT QUESTION 10.1

a) Fill in the blanks:

1. Electricity can be generated by moving a wire through a _____.



2. The generated electricity is called an _____.
3. The method of generating voltage by cutting a magnetic field with a conductor is called _____.
4. The ends of the armature loop are connected to rings called _____.
5. _____ are classified according to the type of field connection used.

b) State true or false:

1. Electricity is generated when there is no motion between conductor & magnetic field. ( )
2. The pole pieces having the north pole and south pole. ( )
3. Shunt generator field coils are connected across the armature circuit only parallel circuit. ( )

## 10.4 DC MOTOR

DC motors & DC generators are essentially the same. In a motor electrical power forces the armature to turn and the moving armature. A DC motor converts electrical energy into mechanical energy.

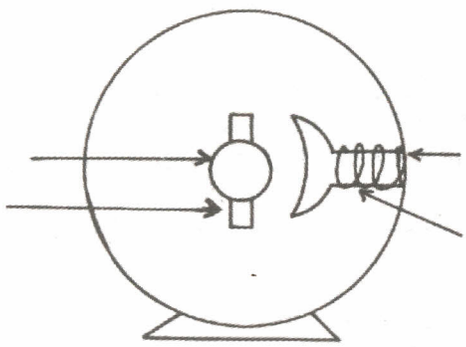


Fig: 10.4 D C Motor

Do you know on what principle motor works? when a current flows through the coils, a coil itself acts as a magnet & the coil is moved by the force between the magnetic field. This is the principle of operation of DC motors.

### Classification of DC motors

There are three main types of motors which are as follows :

1. Series Motor
2. Shunt Motor
3. Compound Motor

### 1) Series motor

The motor in which the field winding is connected in series with the armature, is called a series motor. The field winding consists of a few turn Sothic enameled copper wire as shown in figure:

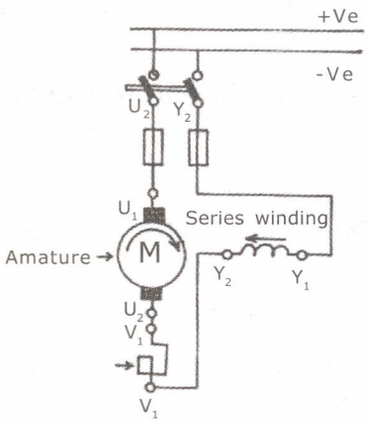
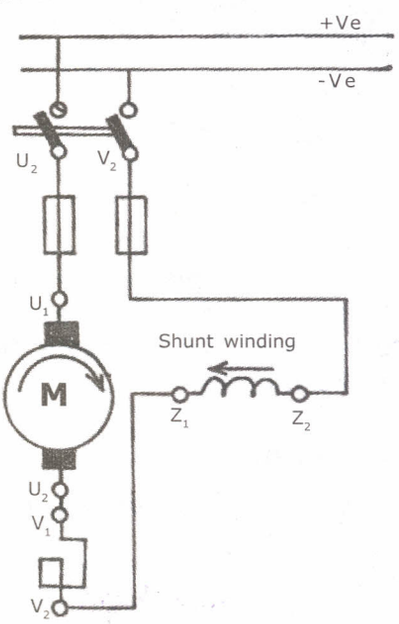


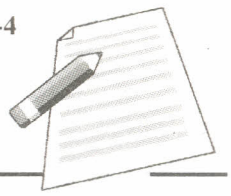

Fig: 10.5 Series Motor

A series motor should not be run without a load is necessary for controlling its speed or otherwise it will run at a very high speed. Therefore, it is used for such jobs in which a load is always present at the meter.

### 2) Shunt motor

The motor in which the field winding is connected across the armature is called a shunt motor. The field winding consists of a large number of turns of fine enameled copper wire to provide a high resistance as shown in figure







The speed of a shunt motor remains almost constant & is not effected by the load variations. The motor cannot be started with a heavy load. It is suitable for stable & light load.

### 3) Compound motor

The motor in which one part of field winding is connected in series & the other part is connected across the armature is called a compound motor.

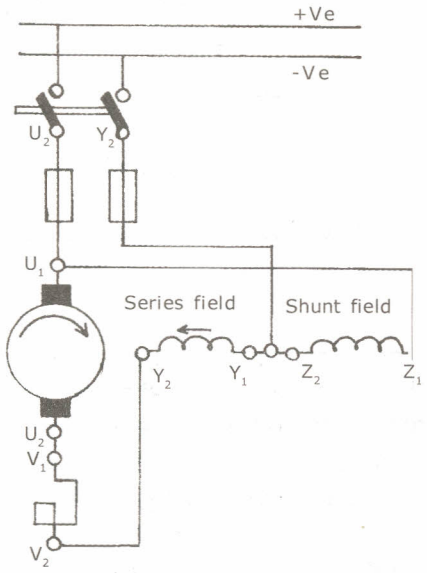



Fig: 10.7. Compound motor

## 10.5 STARTERS

### Necessity of Starter

In the starting of a motor the back e.m.f. is zero. It rises gradually with a rise in speed. In the absence of the back e.m.f. the motor will draw an excessive current which can burn the motor windings. Therefore, it becomes necessary to control the excess flow of current. For this purpose a variable resistor is connected in series with the field. As the motor speeds up the external resistance is gradually cut out of the circuit. At full speed the whole of the variable resistor is cut out of the circuit and the induced back e.m.f. controls the armature & field currents. The current controlling device is termed as a hand starter.

### 3 Point starter

A three point starter is used with shunt motors. It consists of variable resistance no-volt & over load release coil as shown in figure 10.8 :

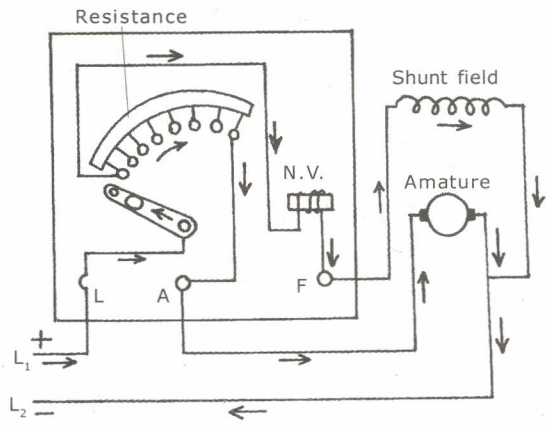



Fig. 10.8. point starter

These two coils are known as protective devices.

### A) No-volt coil

It consists of an electromagnet which is magnetized by the field winding current. The handle of the starter has a piece of soft iron fitted in it. The spring of the handle keeps it in OFF opposition. When the handle is brought to ON position then the electromagnet attracts the handle & holds it firmly against the tension of spring. In the event of supply failure the electromagnet is demagnetized & the handle returns back to OFF position under the action of spring. In this way the whole arrangement protects the motor against any damage which may be caused due to supply failure & the re-establishment of supply.

### B) Overload coil

It consists of an electromagnet which is connected to the line & the handle. Its coil consists of a few turns of thick copper wire. There is a metallic leaf near the electromagnet. It can short circuit current the two N.V.C. terminals close to it. If the load & thus the supply current exceeds release coil attracts the metallic leaf which short circuits the no-volt coil & thus disconnects the motor from the supply.

In neither case can the motor be re-started without the starting resistance being in the armature circuit & therefore, any damage to the motor windings is prevented.

### C) Function of starter

As the starter handle is moved in a clock wise direction it comes into contact with first stud. At this stage the full starting resistance is connected in series with the circuit, which reduces the armature current. The resistance in the armature circuit is gradually cut out as the motor speeds up, & the back e.m.f. replaces the starting



resistance. When the starter handle is at 'ON' the starting resistance is completely cutout of the circuit & by this time the motor achieves its full speed. Now, the starting resistance is no more required. At 'ON Position', the starter handle is attracted by the no volt coil magnet against the spring, & is firmly held by it.

If the supply has failed or the motor is over loaded then the no-volt coil is demagnetized & the starter handle is released to reach at 'off' position, under the action of spring. The motor can be re-started, If the supply has re-stored or the overloading has finished.

### D) Care

The starter handle should be moved gently in the clockwise direction from 'off' to 'ON' positions. The armature winding can burn if the starter handle is rotated quickly.

## INTEXT QUESTIONS 10.2

**a) Fill in the blanks:**

1. D.C motor converts electrical energy into _____.
2. D.C motor classified in _____, _____, _____ motor.
3. A Series motor should not be run without _____.
4. Shunt motors speed remains _____.
5. When we start the motor back e.m.f. is _____.

**b) State True or False:**

1. The motor in which field winding is connected across the armature is called series motor. ( )
2. The motor in which the field winging is connected in series with the armature, is called Compound motor. ( )
3. If there is absence of back e.m.f. the motor winding can burn. ( )
4. Overload coil consist of an electromagnet which is connected to the line & handle. ( )
5. Starter handle moved in Clock-wise direction. ( )

## 10.6 WHAT YOU HAVE LEARNT

In this lesson we have understand the principle of operation of generator self-excited generators what is a D.C. motor's principle, what is a starter and how it works, what care should be given while handling the starter.

Module-4

Notes

## 10.7 TERMINAL QUESTIONS

1. Explain the principle of operation of generator with appropriate figure.
2. Write a short note on D.C. Motor and self excited DC generator.
3. Classify the D.C. Motor and describe with figure.

## 10.8 ANSWER TO INTEXT QUESTIONS

**10.1**

a)

1. Magnetic field
2. Induced Voltage
3. Induction
4. Slip rings
5. Self excited generators

b) True or False.

1. False 2. True 3. False

**10.2**

a)

1. Mechanical energy
2. Series motor, shunt motor, compound motor
3. Load
4. Constant

b) True or False

1. False 2. False 3. True 4. True 5. True

11

# A. C. GENERATORS & MOTORS

## 11.1 INTRODUCTION

My dear friends, in previous lesson we have discussed on D.C. Generators and Motors. In present days, D.C. Supply is not generated, transmitted or distributed in our country. So in this lesson we will discuss about AC Generators and Motors.

## 11.2 OBJECTIVES

After reading this lesson, you will be able to understand:

- Alternating current.
- Advantages of Alternating current.
- Elementary Alternator.
- Operation of alternator.
- Working principle of alternator.
- Construction of alternator.
- A. C. Motor - Principle of A. C. Motor.
- Types of A. C. Motor.
- 3- Phase Motor.
- Starter- D. O. L. Starter.

## 11.3 ALTERNATING CURRENT ( A. C.)

In this the direction and amplitude of the current flow change at regular intervals. The current in this type of circuits is supplied from

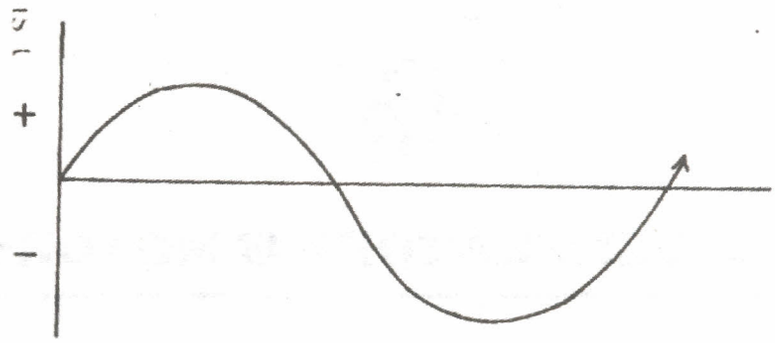



Fig. 11.1 Wave line of Alternating current

an A. C. Voltage source. The polarity of an A. C. Source change at regular intervals resulting in a reversal of the circuit current flow.

### Advantages of A. C. Current

There are many good reasons for the choice of A. C. over D.C. for electric power transmission. Alternating current voltage cannot be change easily, also there are more power losses in D.C. with respective A. C. Supply. It is easy to transmit electric power at very high voltage, with small amount of current.

At the power station, the voltage is stepped up about 400000V by a step up transformer and sent to the transmission line.

Then, the end of another line other transformer step down the voltage values, which can be used in lighting and power.

## 11.4 ELEMENTARY ALTERNATOR

A basic AC generator consists of a loop of wire in a stationary magnetic field. When it is rotated in this magnetic field it causes an induced current in the loop. Sliding contacts are used to connect in order to an external circuit in order to use the induced current.

The pole pieces are the north and south poles of the magnet which supplies the magnetic field. The loop of wire which rotates through the field is called the armature. The ends of the armature loop are connected to rings called slip rings which rotate with the armature. Brushes ride up against the slip rings to pick up the electricity generated in the armature and carry it to the external circuit.

### Operation of alternator

Here is the way the elementary generator works. Assume that the armature loop is rotating in a clockwise direction and that its initial position is at A (zero degrees). In position 'A', the loop is perpendicular to the magnetic field and the black and white conductors of the loop are moving parallel to the magnetic field. If a conductor is



moving parallel to a magnetic field it does not cut through any lines of force and no e. m. f. can be generated in the conductor. This applies to the conductors of the loop at the instant they go through position A - no e. m. f. is induced in them and therefore, no current flows through the circuit. The current meter registers zero.

As the loop rotates from position A to position B, the conductors are cutting through more and more lines of force until at 90 degrees (position B) they are cutting through a maximum number of lines of force. In other words, between zero and 90 degrees the induced e.m.f. in the conductors build up from zero to a maximum value. Observe that from zero to 90 degrees the black conductor cuts down through the field while at the same time white conductor cuts up through the field. The induced e. m. f. in both conductors are therefore in series adding and the resultant voltage across the brushes (the terminal voltage) is the sum of the two induced e. m. f. or double that of one conductor since the induced voltages are equal other. The current through the circuit will vary just as the induced e. m .f. varies being zero. At zero degrees and rising up to a maximum at 90 degrees. The current meter deflects increasingly to the right between positions A and B indicating that the current through the load is flowing in the direction shown. The direction of current flow and the polarity of the induced e. m. f. depend upon the direction of the magnetic field and the direction of rotation of the armature loop. The wave form shows how the terminal voltage of the elementary generator varies from position A to position B. The simple generator drawing on the right is shown shifted in position to illustrate the relationship between the loop position and the generated waveform.

As the loop continues rotating from position B(90 degrees) to position C (180 degrees) the conductors which are cutting through a maximum number of lines of force at position B cut through fewer lines until at position C they are moving parallel to the magnetic field and no longer cut through any lines of force. The induced e. m. f. therefore will decrease from 90 to 180 degrees in the same manner as it increased from zero to 90 degrees. The current flow

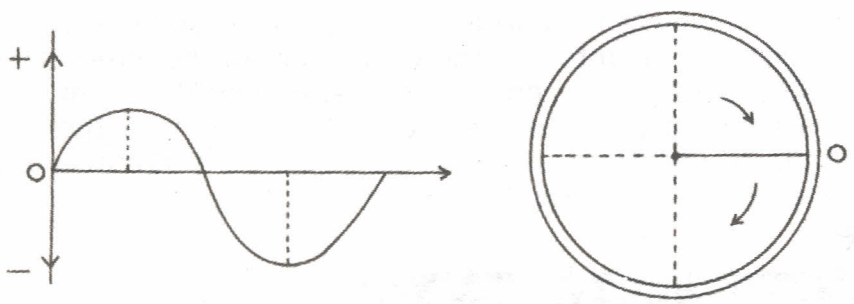
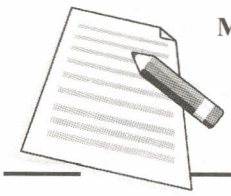



Fig. 11.2 A. C. Cycle





will similarly follow the voltage variations. The generator action at position B and C is illustrated.

From zero to 180 degrees the conductors of loop have been moving in the same direction through the magnetic field and therefore the polarity of induced e. m. f. has remained same. As the loop starts rotating beyond 180 degrees back to position A the direction of the cutting action of the conductor through the magnetic field reverses. Now, the black conductor cuts up through the field and the white conductor cuts down through the field. As a result the polarity of the induced e. m .f. and the current flow will reverse. From position C through D back to position A, the current flow will be in the opposite direction that from positions A through C. The generator terminal voltage will be the same as it was from A to C except for its reversed polarity. The voltage output waveform for the complete revolution of the loop is as shown.

### Working principle of alternator

The alternator works on the same principle of DC that is Faraday's Laws of Electromagnetic Induction.

### Construction of alternator

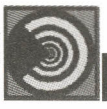
Alternator consists of Rotor, Starter, Exciter.

1) **Rotor -** The rotating part of alternator is known as rotor. It is made from a solid steel piece. To house the field winding slots are cut on the outer surface. The ends of winding are held by retaining ring of non- magnetic steel.

There are silent pole type rotor and cylindrical type rotor is used in alternator.

2) **Stator -** The stator is built of stamping insulated on one side with paper or varnish and housed in a frame which is usually fabricated from steel plates- electrically welded. Slots to take the winding are cut round the inner surface.

3) **Exciter -** The exciter is generally a DC shunt or compound generator whose voltage is up to 250V. In small alternators the exciter is mounted on the same shaft of the alternators. A variable resistance is connected in series with the shunt field of the exciter which varies the exciter voltage to vary the output voltage of the alternator. For high voltage alternators separately excited generators are used.



### INTEXT QUESTIONS 11.1

A) Fill in the blanks:

1. The alternator works on the laws of _____.



2. There are_____and _____ rotor is used in alternator.
3. Exciter has voltage up to _____.
4. The rotating part of alternator is known as _____.
5. It is easy to transmit electric power at very high voltage with small amount of current with the help of _____.

## 11.5 AC MOTOR

The motor which operates with AC supply is called AC Motor. It transfers the electrical energy into mechanical energy.

The Induction motor is the most commonly used AC Motor, because of its simplicity its rugged construction and its low cost. It has a rotor and a stator. The induction motor, rotor is made up of a high grade steel laminated cylindrical with slots in its surface. The squirrel cage winding is made up of heavy copper bars connected together at each end by a metal ring. The air gap between the rotor and stator is very small to obtain maximum field strength.

The stator is made of a laminated slot in it. The two windings are placed in the slot, that windings is known as running winding and starting winding. Both windings are placed at 90 electrical degrees in the slot.

### Principle of AC Motor

When a single phase AC motor is connected to the AC supply the rotating magnetic field generated in the stator induces a magnetic field in the rotor, the two fields interact and cause the rotor to turm.

On the basis of phases, the AC Motors may be divided in two groups:

two groups — Single phase motor
two groups — Three phase motor

### Types of single phase motor

1. Split Phase Induction Motor
2. Capacitor Induction Motor
3. Universal Induction Motor
4. Shaded Pole Induction Motor

### 1) SPLIT PHASE INDUCTION MOTOR

Split phase motor is an AC motor of fractional horsepower and is used to operate washing machine and small pumps. The motor consists of a rotating part called rotor. A stationery part called stator and plates and centrifugal switch. Its rotor is like squirral cage type i.e. having bar winding. Stator has two types of windings knwon as running and starting Winding.

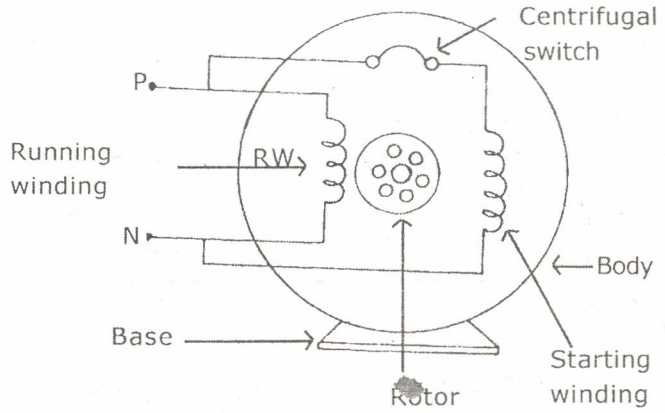



Fig. 11.3 Split phase induction motor

### Working of AC Motor

At the start the current flowing through both the running and starting windings causes a magnetic field to be formed insight the motor. This magnetic field rotates and induces a current in the rotor winding which in turn causes another magnetic field.

This magnetic combine in such manner as to cause rotation of the rotor. A starting winding is necessary at the start in order to produce the rotating magnetic field (RMF) after the motor is running the starting winding is no longer needed and is cut out of the circuit by means of the centrifugal switch.

## 2) CAPACITOR INDUCTION MOTOR

The capacitor motor operates on alternating current and it is available from 1/20 hp to 3 hp. It is widely used to operate refrigerator, compressors, washing machines, pumps and air conditioners.

### Operation of capacitor induction motor

The capacitor start motor is connected to the supply. Current start to flow through the running and starting torque, which in turn to produce rotation of the motor. When the motor reaches approximately 75% of full speed the centrifugal switch opens. This action cut the both the winding and the capacitor from the supply. The motor runs on the running winding only.

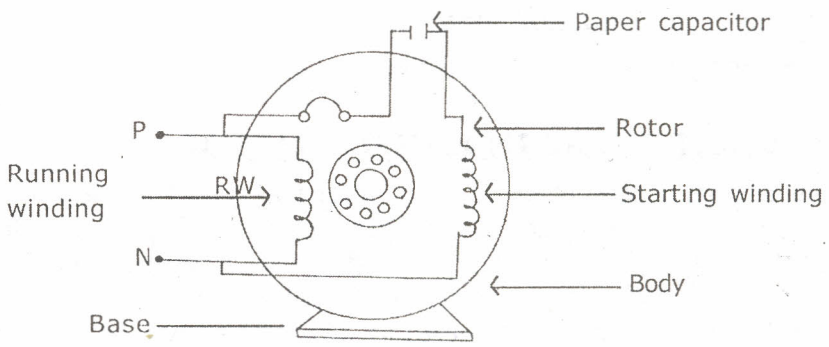



Fig:11.4 Operation of capacitor induction motor



There are three types of capacitor motor:

a. Capacitor start motor

b. Capacitor run motor

c. Capacitor start and run motor

d. In ceiling fan capacitor run motor is used.

## 3) UNIVERSAL MOTOR

A universal motor is one which can be operated on either direct current or single phase alternating current. This motor is used in vacuum cleaner, food mixer, drills and sewing machine.

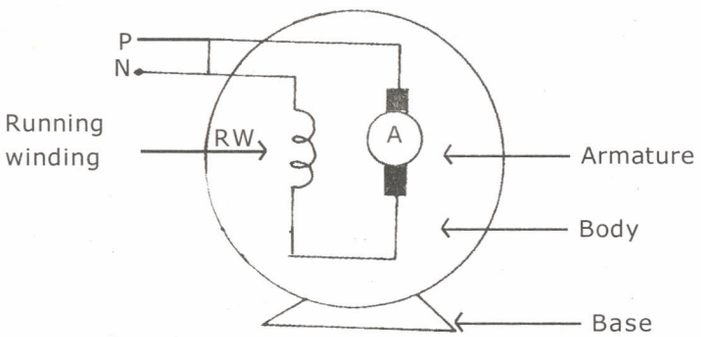



Fig: 11.5 Construction of Universal Motor

## CONSTRUCTION OF UNIVERSAL MOTOR

Universal motor consists of frame which is a rolled steel or aluminum. The field polls are generally held in frame by means of bolts. Field core is constructed of lamination which are tightly pressed together and held by reverts.

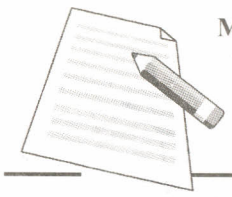
The armature is similar to that of small DC motor. It consists essentially of a laminated core having slots and a commutator to which the leads of armature winding are connected. The end plates are located on the ends of frame and held in place by screw. The plates house the ball bearings or sleeve bearings in which the armature shaft revolves.

### Operation of universal motor

The universal motor is so constructed that when the armature and field coils are connected in series and the current applied the magnetic lines of force created by the fields will react with the lines of force created by the armature and cause rotation. This is true regardless of whether the current is alternating or direct. As it can be operated on A.C. or D.C supply so it is called Universal motor.

## 4) SHADED POLE INDUCTION MOTOR

The shaded pole motor is single phase AC motor varying from approximately 1/100 to 1/20 hp. It is used for applications required very low starting torque such as small fans and blowers.





### Construction of shaded pole motor

It consist of stator or field frame, a rotor and end plates stator is usually of the concentrated field type and has a laminated core consisting of salient field poles on which a coil of wire is placed. The poles are provided with a slot near one end in which a solid copper coil of one turn is placed. This coil is called the shaded coil which act as starting winding. The shaded pole motor have the squirrel cage rotor.

### Operation of shaded pole motor

On starting, a current is induced into the shaded poles from the main poles. The shading coils establish a magnetic field which is out of phase with that established by the main fields and a shifting field is produced sufficient to give the desired starting torque. When the motor reaches speed, the effect of the shading coils are negligible.

## 3. PHASE MOTOR

Three phase AC motors that are designed for three - phase operation. Three phase motors vary from fractional horsepower size to several thousand horsepower. These motors have a fairly constant speed characteristic and are made in designs giving a variety of torque others a low starting torque. Some are designed to draw a normal starting current. They are made for practically every standard voltage and frequency and are very often dual voltage motors. Three-phase motors are used to drive machine tools pumps, elevators, fans, cranes, hoists, blowers and may other machines.

### Construction of 3 - Phase Motor

3-Phase motor consists of stator, windings, rotor and end plates. The stator is consist of a frame and laminated steel core and a winding form of individual coils placed in slots. The rotor may be a dicast aluminum, squirrel cage type. In these types a laminated core pressed on a shaft. Its construction of rotor is same as split phase rotor motor.

The end plates are bolted to each side of the stator frame and contain the bearings in which the shaft revolves.

### Operation of 3 - Phase Motor

When 3-phase winding is connected to the supply it produces the rotating magnetic field this magnetic field induces a current in the rotor winding which in turn causes another magnetic field. These magnetic field combine in such manner as to cause rotation of the rotor.

## 11.6 NECESSITY OF STARTER

If an AC motor is stated on full voltage it will draw from two to six times its normal running current. Because the motor is constructed to withstand the shock of starting no harm will be caused by this



excessive flow of current. However, in very large motors it is generally desirable to take some measure to reduce the starting current otherwise damage may be done to the machinery driven by the motor and line disturbances may be created that affect the operation of other motors on the same line.

**Direct On Line Starter (D. O. L)**

It is a simple and ordinary starter suitable for squirrel cage induction motors having a capacity up to 5 hp. Push buttons are used in place of a hand le. The green push button starts the motor while the red push button switches off the motor. A latch fitted near the red push button can be adjusted over it so that the motor may not be started. This provision is used only when the motor is defective.

Mainly it consists of contact system thermal relay unit and a solenoid coil. The contact system consists of silver tipped contacts which provide a quick ON-OFF system. The bi-metallic elements of the thermal relay protect the motor from overload. The solenoid coil is an electromagnet which works as an operating level for the contact system.

Fig. shows the pictorial view of the D. O. L. starter and its main components.

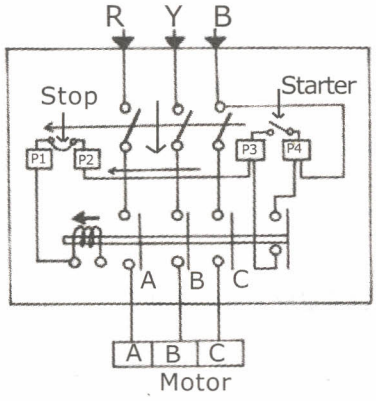



Fig: 11.6 D. O. L. Starter

The solenoid coil or no-volt coil (NVC) is connected across the two phases (it can be connected between a phase and neutral if it is designed to work at 440V) The overload release or thermal relay unit is connected in series with the outgoing ends of each phase from the starter.

On pressing the 'START' button (green push button), the solenoid coil becomes magnetized and it attracts the iron plunger which closes all the contact points. In this way the supply terminals $L_1$, $L_2$ and $L_3$ are connected to the motor terminals $M_1$, $M_2$ and $M_3$ and the motor operates by completing its circuit through the thermal relay coils. To stop the motor, 'STOP' button (red push button) is pressed. It breaks the solenoid coil circuit and finishes its magnetism. As a result, the plunger is released and the contact points become open. The thermal relay protects the motor by breaking the solenoid coil circuit through thermal relay switch which is placed in series with the operating coil.

As the motor becomes overload, it draws more current and the bi-metallic strips of the thermal relay unit brings the thermal relay switch to the 'OFF' position. The size of a starter depends on the hp capacity of the motor

## INTEXT QUESTIONS 11.2

a) Fill in the blanks:

1. The induction motor, rotor is made of _____.
2. Stationary part of motor is called _____.
3. The rotating part of motor is called _____.
4. For refrigerator _____ motor is used.
5. For food mixer _____ motor is used.

b) State True or False:

1. Split phase motor runs on running and starting winding.( )
2. Capacitor is connected in series with running winding. ( )
3. Armature is a part of universal motor. ( )
4. Shaded pole motor has squirrel cage rotor. ( )
5. A thermal relay is used in D. O. L. starter for safety of motor. ( )

## 11.7 WHAT YOU HAVE LEARNT

In this lesson we learnt about A. C. Generators and A. C. Motors and Principles of a motor, operations of A. C. Motor, types of A. C. Motors, necessity of starter, 3-phase motor, D. O. L. starter.

## 11.8 TERMINAL QUESTIONS

1. Write an essay on the AC Generators motor.
2. Explain the operation of alternator with figure.

## 11.9 ANSWER TO INTEXT QUESTIONS

**11.1**

1. Electromagnet Induction
2. Silent type rotor and Cylindrical type rotor



3. 250V
4. Rotor
5. AC Current

**11.2 (a)**

Fill in the blanks

1. High Grade Steel Laminated
2. Stator
3. Rotor
4. Capacitor Motor
5. Universal Motor

**(b)**

1. False 2. False 3. True 4. True 5. True

12

# TRANSFORMER AND SEMI CONDUCTORS

## 12.1 INTRODUCTION

In previous lesson we studied about AC generator and AC motor, which converts the electrical energy into mechanical energy. We have also studied about classification of AC Motors, its construction and operations, 3- Phase motor, starter, D. O. L. Starter etc. Now we are going to discuss the transformer which is used to convert high voltage into low voltage or low voltage into high voltage. We will also talked about semi conductors, diodes transistors and IC's (integrated circuits).

## 12.2 OBJECTIVES

After reading this lesson, you will be able to-

- Describe the Transformer.
- Understand the Working principle of transformer.
- Construct of transformer
- Understand the semi conductors and its types.

## 12.3 TRANSFORMER

**A static device used for transforming electrical energy from one A.C. circuit to another, without any change in the frequency, is called a transformer**

It changes the voltage from high to low or low to high with corresponding increase or decrease in current. If it increases the voltage, then it is termed as step up transformer and if it decreases the voltage, then it is termed as step down transformer. A transformer does not produce electricity and neither it affects the frequency nor the power.



## Working Principle of Transformer

According to the Faraday's Laws of electromagnetic induction, a current carrying conductor is surrounded by a magnetic field. If a switch is placed in the circuit and it is put to ON and OFF alternately, then the magnetic field around the conductor will start to vary. Now if a second conductor connected with a galvanometer is placed near the first conductor, then it will cut the varying magnetic field of the first conductor. Thus, an e. m. f. is induced in the second conductor. Which is verified by the deflection of galvanometer. In other words, the transformer works on the Principle of mutual induction. Hence, P is called the primary and S the Secondary Circuit.

A transformer does not work on D.C., Since the magnetic flux must be varied so as to obtain mutually induced e. m. f. If the Coils are used in place of conductors, then the coil connected to the source of supply is called a Primary Coil, while the other coil from which the output is taken, is called a secondary coil.

If A. C. is supplied to a transformer, then an alternating magnetic field is set up around the primary coil, without making or breaking the circuit by a switch. The Primary and Secondary Coils are wound on laminated cores. The A.C. e.m.f. applied to the Primary Coil produces an alternating magnetic field. The field is cut by the Secondary Coil resulting in an e.m.f. to be induced in it. The secondary voltage depends on the ratio of the secondary turns to the primary turns.

## Construction of Transformer

In this stage we consider about a small transformer, which is known as moonlight transformer or bell transformer. It consist of body laminated iron core, bobbin, two windings.

**Body -** It is made up of bakelite. It is used to hold the terminals and protection for windings. The core is made of high grade silicon steel lamination. In this type of transformer E and I types of laminations are used. The laminations are used to complete the magnetic path, with minimum losses; A Bobbin is made of presto paper, bakelite or nylon. The winding wire is wound on this bobbin. Bobbin is used to support the windings. In this transformer there are two windings. The

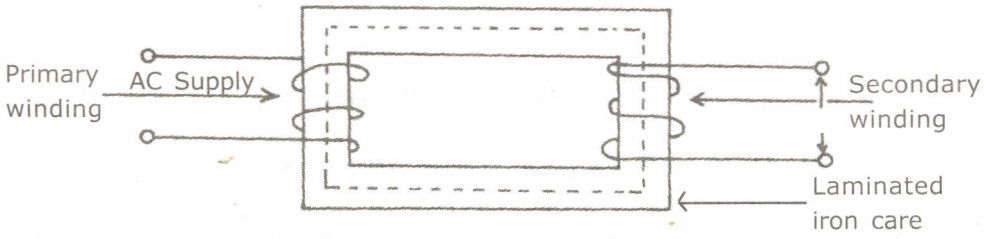



Fig: 12.1 Transformer

windings which is connected to the supply is known as Primary winding and which is connected load is known as secondary winding. 6 V, 3 w lamp is connected 230 V, 50 Hz A. C. Supply. Due to mutual induction 6 V a. c. supply is induced in secondary winding.

The transformer are used to distribute electricity known as distribution transformer which are installed in substation. The power transformers are used in transmission line. The construction of this transformer is basically same as above explained transformer.

## 12.4 SEMI CONDUCTORS

You have studied about conductor and insulator but there is another material which is known as semi conductors. Conducting materials are good conductors and insulating material are bad conductor of electricity. A semi-conductor is a material which has a resistance in between that of a conductor and insulator. In semi-conductors the Valence electrons are normally bond but can be set free by supplying a small amount of energy.

### Atomic Structure

Germanium (Ge) and Silicon (Si) are examples of semi-conductors. Fig 12.2 (A) shows a germanium atom. In the centre is a nucleus with 32 protons. The revolving electrons have distributed themselves in different orbits. There are 2 electrons in the first orbit and 8 electrons in the second orbit and 18 electrons in the third orbit. The four orbit is the outer or Valence orbit which contains 4 electrons.

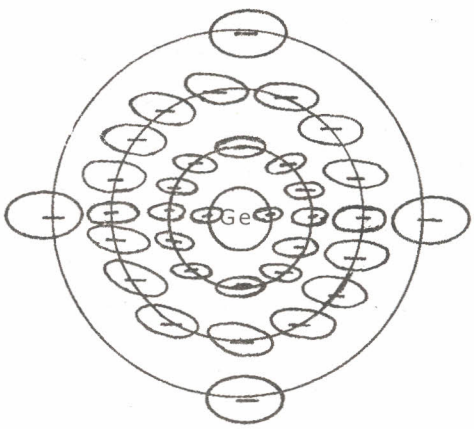



Fig: 12.2 (A) Germanium

Figure 12.2 (B) shows a silicon atom. It has 14 protons in the nucleus and 14 electrons in orbit. There are 2 electrons in the first orbit and 8 in the second orbit. The remaining 4 electrons are in the outer or the valence orbit.

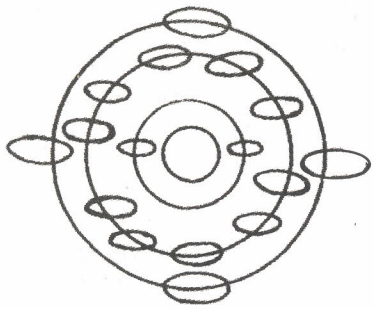


Fig: 12.2 (B)

In semiconductor materials, the atoms are arranged in an orderly pattern called a crystal lattice structure. If a pure Silicon crystal is examined, we find that the four electrons in the outer (Valence) shell of an atom is shared by the neighboring atoms.

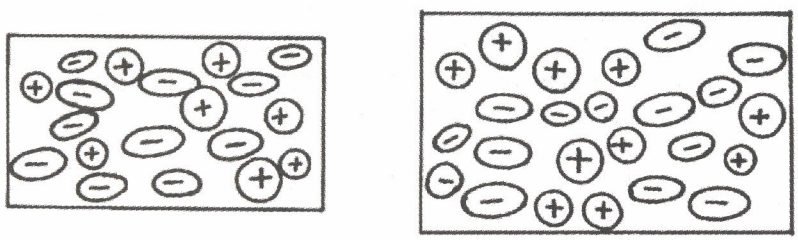


Fig: 12.3 Sharing of Atom

The union of atoms sharing the Valence electron being shared by two adjacent atoms. Each atom appears to have a full outer shell of eight electrons.

### Types of Semi Conductors

A pure semiconductor is called an intrinsic semiconductor. For example, a silicon crystal is an intrinsic Semi conductor because every atom in the crystal is a silicon atom. One way to increase conductivity in a semiconductor is by 'doping'. This means adding impurity atoms to an intrinsic semi conductor. The doped semi-

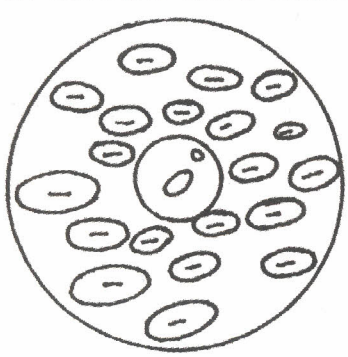


Fig: 12.4 Free electron

conductor is known as an extrinsic semi conductor. It has two types. a) N-type semi conductor b) P-type semi conductor

The residual heat at room temperature (300k) is sufficient to make a Valence electron of an intrinsic semi conductor to move away from the covalent bond and the electron becomes a free electron to move in the crystal.

When an electron breaks a covalent bond and moves away, a vacancy is created in the broken covalent bond. This Vacancy is called a 'hole'. A hole has a positive charge when a free electron is liberated, a hole is created.

**N-type semi conductor**

A semi conductor with excess of electrons is called N-type. To obtain excess free electrons, the element doped with the semiconductor material is arsenic, or antimony or phosphorus. Each of these atoms has five electrons in its outer orbit.

As the outer orbits of the atoms can hold eight electrons, no hole is available for the fifth electron in the arsenic atoms to move into. It, therefore, becomes a free electron. The number of such free electrons is controlled by the amount of arsenic added to the crystal.

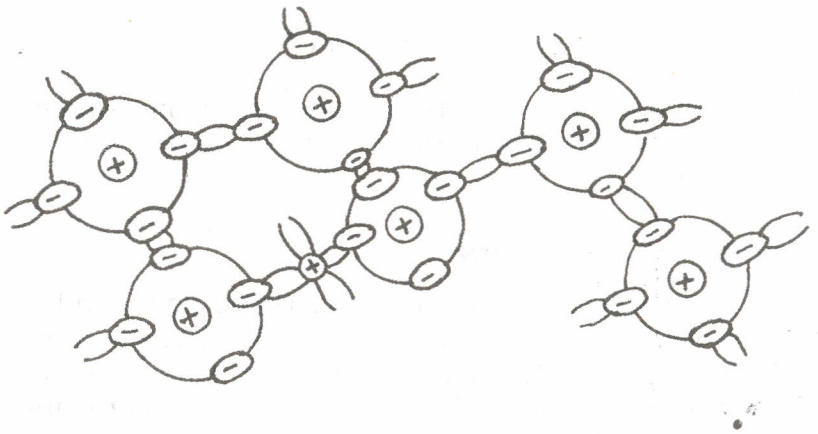


Fig: 12.5 Formation of N-type semi conductor.

In N-type, the free electrons are called majority carriers and the holes minority carriers.

**P-type semi conductor**

To obtain more holes, a pure silicon crystal is doped with elements such as aluminum or boron or gallium. The atoms of each of these elements have three electrons only in their outer orbit. Adding gallium to pure silicon crystals allows the atoms of the two elements to share seven electrons.

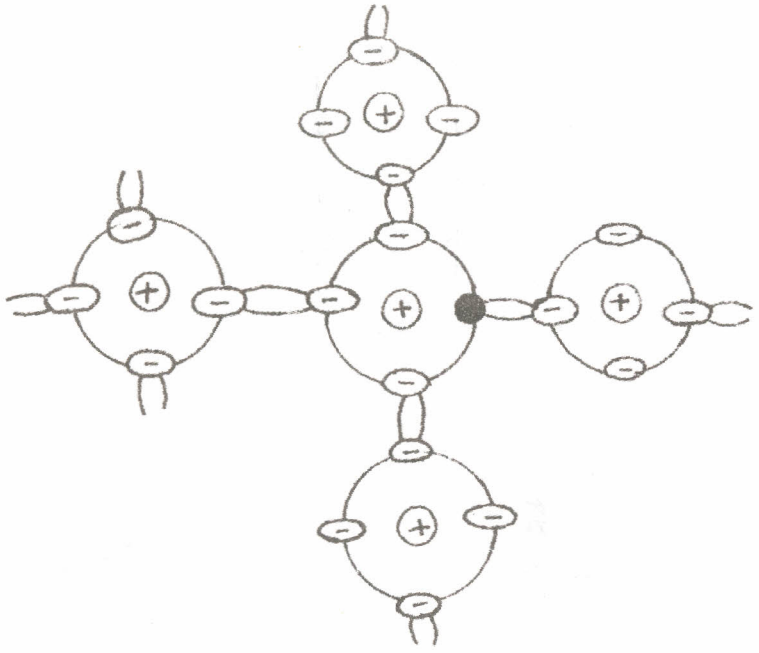


Fig: 12.6 P type semi conductor

A hole is created in the place of the eight electron. Now that the number of holes exceeds the number of free. P-type material. The holes in P-type are the majority carriers and the free electrons are the minority carriers.

**PN Junction**

A PN Junction is formed by combining P and N type materials. The surface where they meet is called the PN Junction.

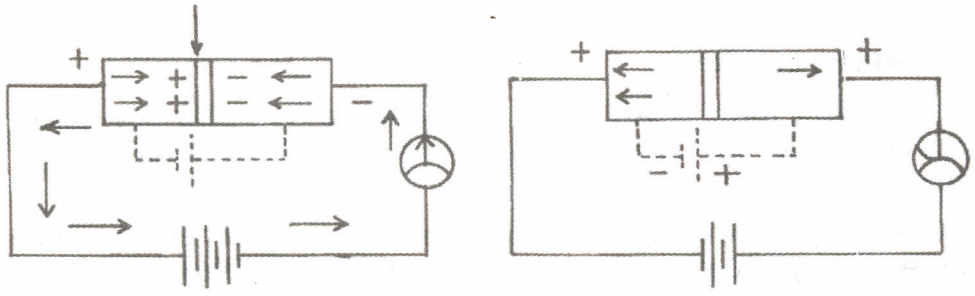


Fig: 12.7 PN Junction

The free electrons in the N-regions diffuse across the junctions into the P-region. The free electrons lose energy and recombine with the holes in the P-region. This recombination when the electron moved from the N-region and diffused across the junction, it leaves the atom to be a positive ion. The positive ion is not balanced by a negative charge in the N-region. The hole is eliminated

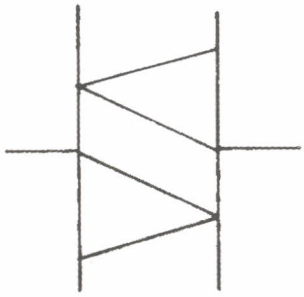


Fig: 12.12 Diac & its sumbol

**Triac**

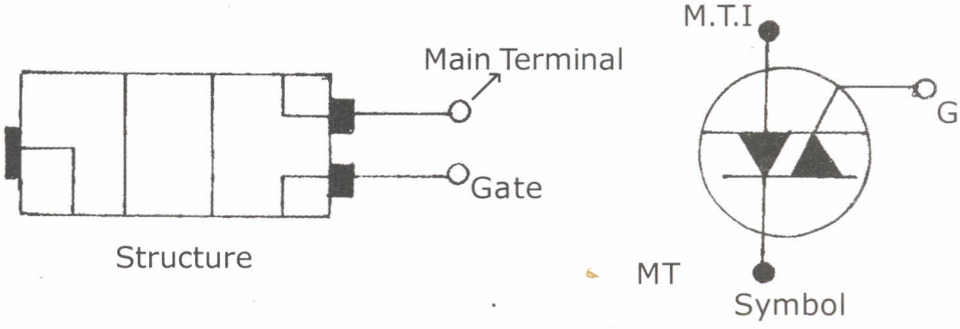



Fig: 12.13 Triac

A triac is also a semi-conductor device with three leads like two SCRs in parallel. The triac can control the circuit in either direction.

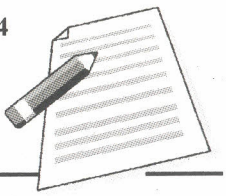
**Bridge rectifier or diode bridge**

It is a single package of four semi-conductor diodes connected in bridge circuit. The input AC and the output DC leads are marked and terminated. It has two doped regions with three leads and has one emitter and two bases.

**Half wave rectifier**

This simplest form of AC to DC converter is by using one diode such an AC to DC Converter is known as half-wave rectifier as shown in.

A diode D, and a load resistance $R_L$ in series are connected across the secondary of a step down transformer (fig 1a). The transformer steps up or steps down the supply voltage as needed. Further the transformer isolates the power line and reduces the risk of electrical shock. During the positive half-cycle of the input line frequency, (fig 1b) the diode anode is made positive with respect to the cathode. The diode D, Conducts because it is forward-biased. Current flows from the positive end of the supply through diode D, and RL. During the negative half cycle of AC input line frequency, the diode is reverse biased. Practially no current flows through the diode and the load $R_L$ and there is no voltage output.





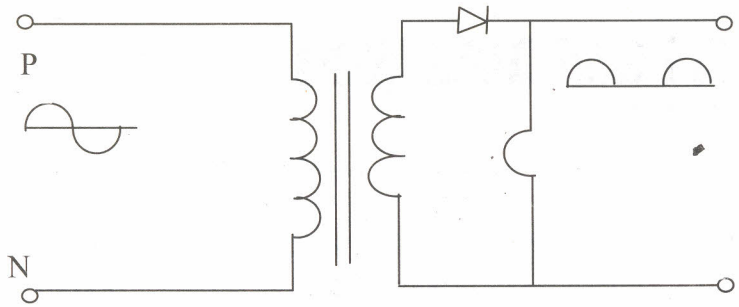



Fig 12.14 Half Wave Rectification

**Full-Ware rectifier (FW)**

A full-ware rectifier circuit is shown in Fig 3. The Secondary winding of the transformer is centre-tapped. The secondary voltage is divided equally into two halves, one end of the load $R_L$ is connected to the centre tap and other end of $R_L$ to the diodes.

It is seen that two half-ware rectifiers conducting on alternate half cycles of the input AC.

During the positive half cycle of the secondary voltage, diode D, is forward-biased and diode $D_2$ is reverse-biased. The current flows through the load resistor $R_L$, diode $D_1$ and the upper half of the secondary winding.

During the negative half cycle of secondary voltage, diode $D_2$ is forward-biased and diode $D_1$ reverse-biased. Therefore, current flows through the load resistor RL diode $D_2$ and the lower half of the secondary winding.

The load current is in same direction during both the half-cycles of the AC input.

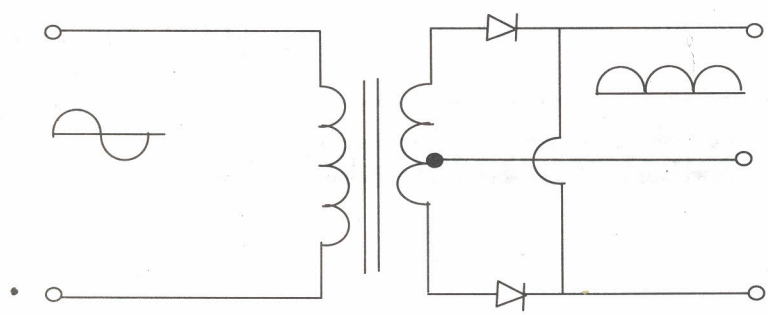
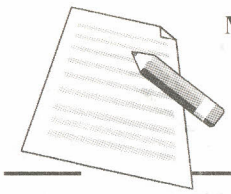


Fig 12.15 Full Wave Rectification





## INTEXT QUESTIONS 12.1

(A) Fill in the blanks:

1. _____and _____ are the examples of semi-conductor.
2. A semiconductor with excess of electrons is called _____.
3. A pure semiconductor is called an _____ semiconductor.
4. Diac is a _____ switching device.
5. Bridge rectifier is a single package of _____ semiconductor diodes.

(B) State True or False:

1. In N-type the free electrons are called minority carriers. ( )
2. A PN junction is formed by combining P and N type materials. ( )
3. The holes in P-type are the majority carriers. ( )
4. Conducting materials are bad conductors. ( )
5. A semiconductor is a material which has a resistance in between that of a conductor and insulators. ( )

## 12.5 WHAT YOU HAVE LEARNT

Semi conductors types of semi-conductors, P-type semi conductor, N-type semi conductor, Active components, Diac, Triac, What is rectifier bridge rectifier, Uni- junction transistor, Field effect transistor, half wave rectifier what is full-ware rectifier, this also we learn.

## 12.6 TERMINAL QUESTIONS

1. Write the short note on N-type semiconductor with figure.
2. Write the short note on P-type semiconductor with figure.
3. What are the active components?
4. What do you mean by Half Ware rectifier and Full Ware rectifier?

## 12.7 ANSWER TO INTEXT QUESTIONS

Fill in the blanks

1. Germanium and Silicon
2. N-type



3. Intisic
4. Bidirectional
5. 4 semiconductor diodes

True or False

1. False
2. True
3. False
4. False
5. True.