CHAPTER 10

UNIT V

# DC Generators

**Syllabus :**

Concept of electromechanical energy conversion, DC machines, Types, Emf equation of generator, (simple numerical problems).

## 10.1 Concept of Electromechanical Energy Conversion :

- The meaning of the words electromechanical energy conversion is conversion of electrical energy into mechanical energy or mechanical energy to electrical energy.
- The conversion of electrical energy to mechanical energy is achieved by using some type of a motor. An electric energy is applied to a motor. The motor rotates and converts electrical energy to mechanical energy at the shaft as shown in Fig. 10.1.1(a).
- Depending on the type of source of electrical energy, the motor can be an AC motor or a DC motor.

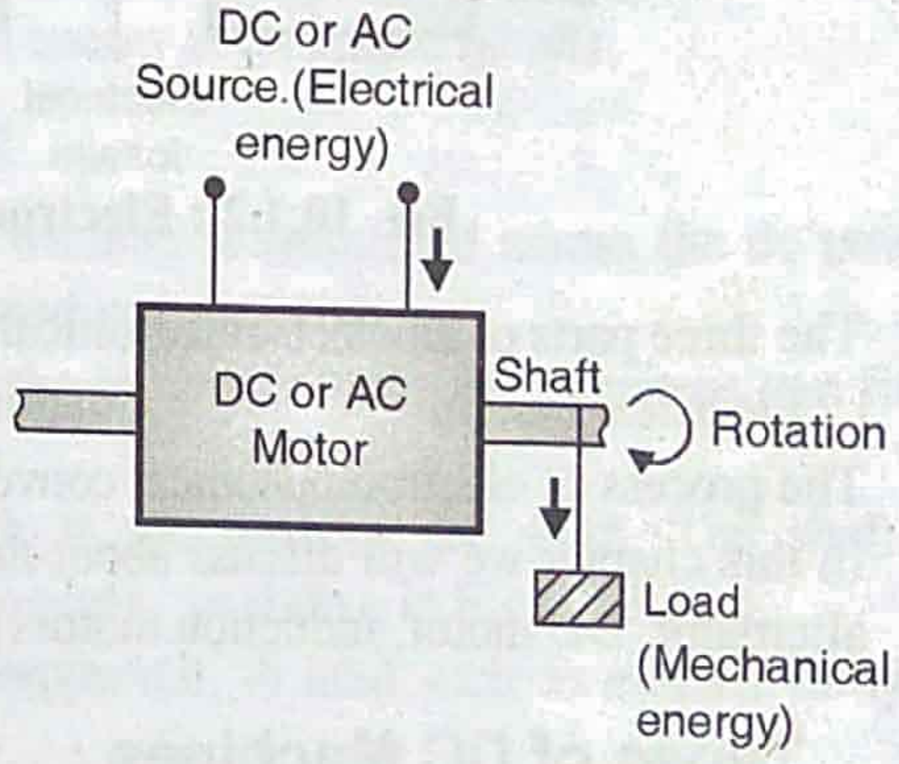



**Fig. 10.1.1(a) : Electrical to mechanical energy conversion**

- Various types of motors available are listed in Fig. 10.1.1(b).

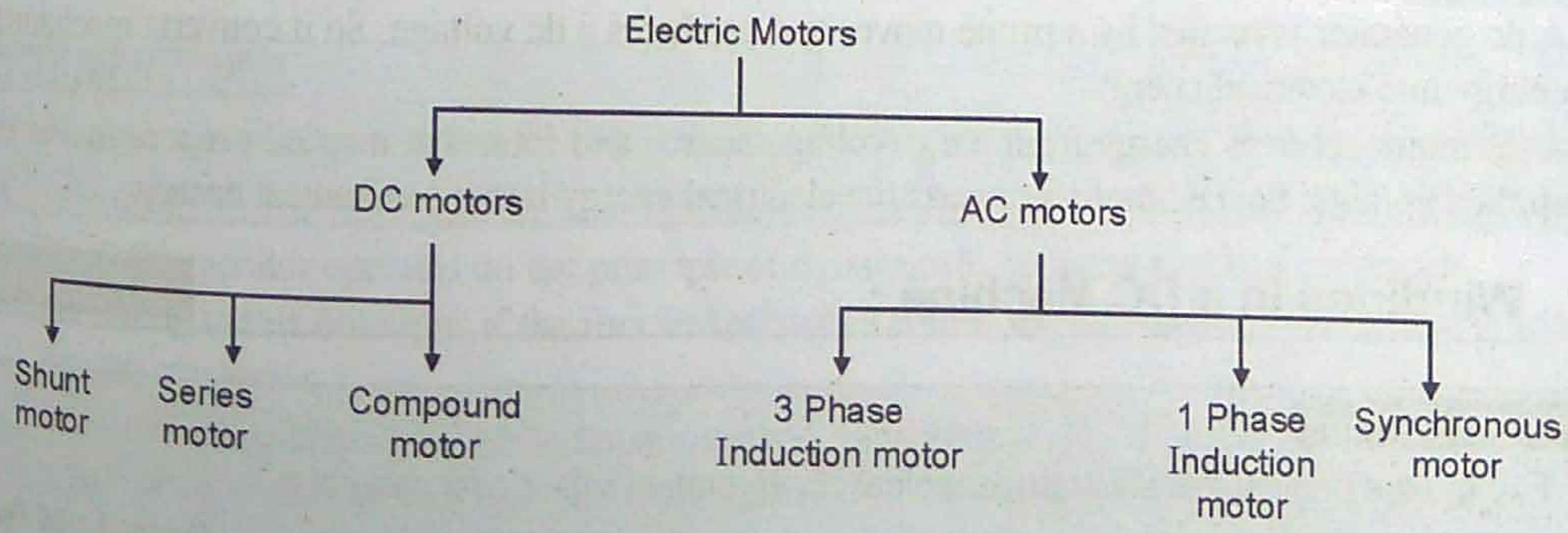



**Fig. 10.1.1(b) : Types of motors**

- The motors continuously convert the electrical energy into mechanical energy. But some other devices are used to produce translational forces. The examples of such devices are solenoids, relays, electromagnets etc.
- An electric generator converts the mechanical energy applied at its input to an electrical energy as shown in Fig. 10.1.1(c).
- A prime mover machine is required to be used to rotate the generator mechanically.

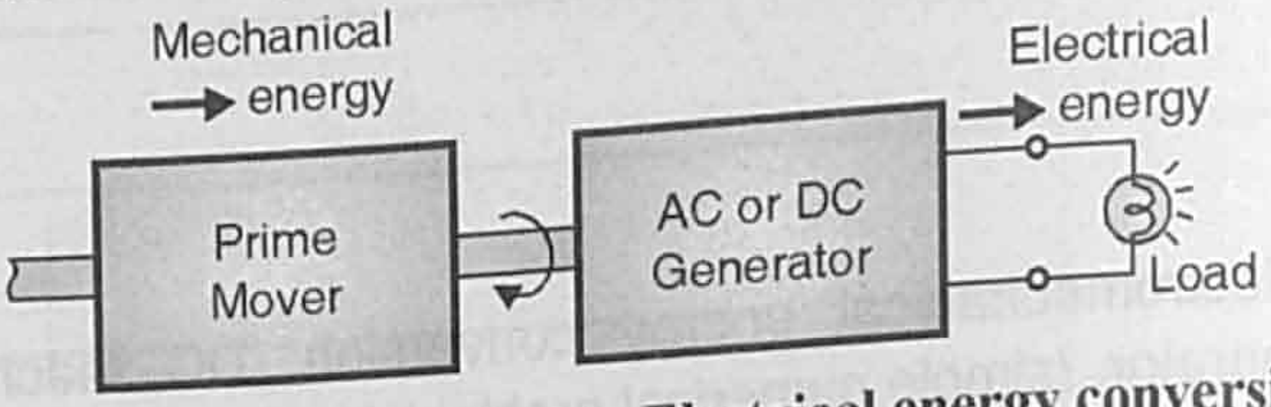



**Fig. 10.1.1(c) : Mechanical to Electrical energy conversion**

- At the output we get electricity, which can be applied to the electrical loads.
- The generators can be AC generators or DC generators. The AC generators are called as alternators.
- The block diagram of a general electromechanical conversion system is shown in Fig. 10.1.2.

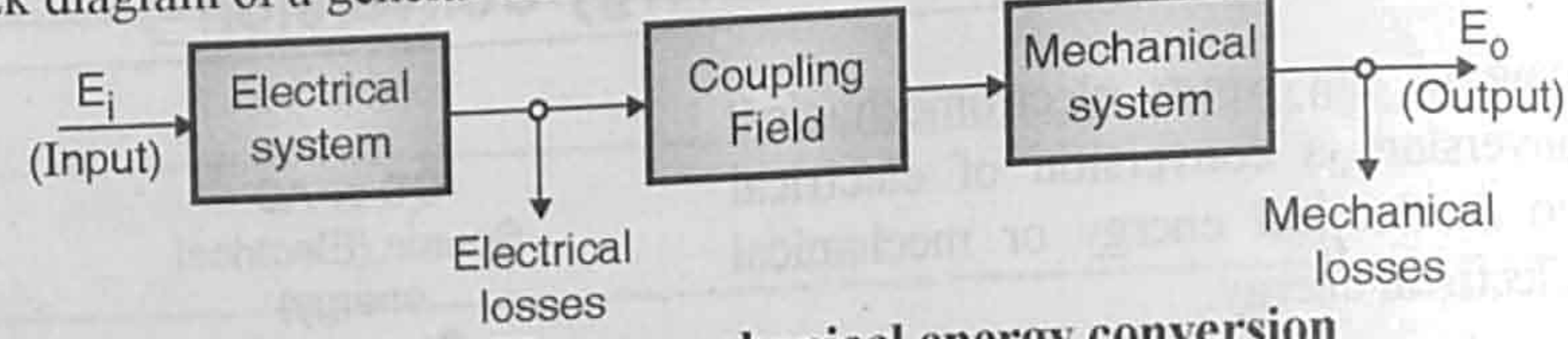



**Fig. 10.1.2 : Electromechanical energy conversion**

- The three parts of an electromechanical energy conversion devices are :
  1. Electrical system 2. Coupling field 3. Mechanical system
- The process of electromechanical conversion is a reversible process.
- In this chapter we will discuss about the DC generators and in the following chapters, about the alternator, DC motor, induction motors and synchronous motor.

## 10.2 Types of DC Machines :

- DC machines are basically of two types :
  1. D.C. generator 2. D.C. motor.
- A dc generator is rotated by a prime mover and produces a dc voltage. So it converts mechanical energy into electrical energy.
- A dc motor receives energy from a d.c. voltage source and rotates at a speed proportional to the applied voltage. So a dc motor converts the electrical energy into a mechanical energy.

## 10.3 Windings in a DC Machine :

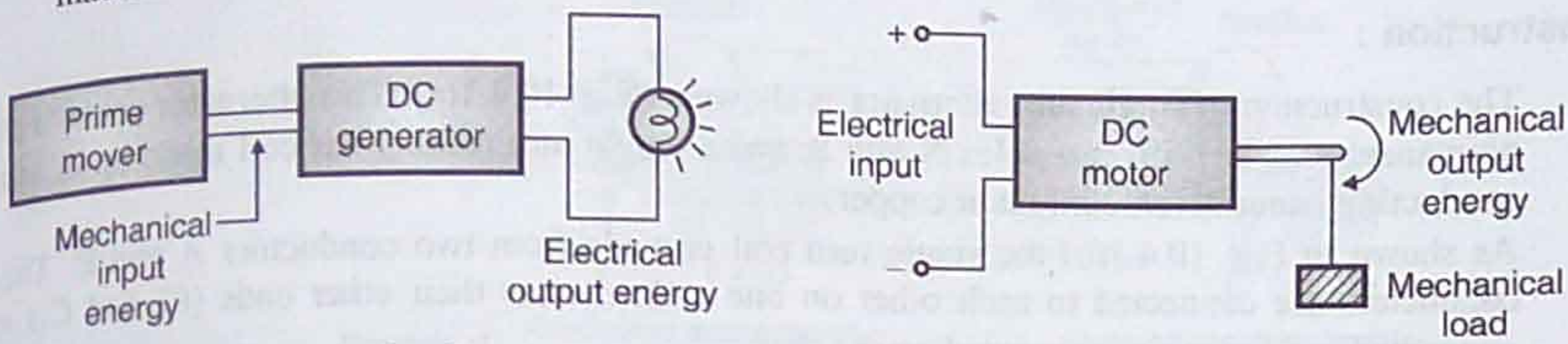
UPTU : 05-06

**University Questions**

Q. 1 Explain the principle of electromechanical conversion in motor and generator. (Sem.-I : 05-06)

Q. 2 Explain the principle of operation of electromechanical energy conversion. (Sem.-II : 05-06)

- In any dc machine, (motor or generator) there are two windings :
  1. Field winding 2. Armature winding.
- Out of these, the field winding is stationary which does not move at all and the armature winding is a movable winding.
- The armature winding is mounted on a shaft. So it can rotate freely.
- The construction of a dc generator and dc motor is the same. That means we can use the same dc machine either as a generator or as a motor.




**(a) Energy conversion in generators** **(b) Energy conversion in motors**

**Fig. 10.3.1**

- As shown in Fig. 10.3.1(a), a prime mover supplies mechanical energy to the DC generator which generates electrical output energy.
- Fig. 10.3.1(b) shows the operating principle of a DC motor. It accepts the energy in the electric form from D.C. source and converts it into mechanical energy at its output (shaft).

**Connection of windings for operation as generator :**

- To operate the dc machine as a generator, the field winding is connected across the dc power supply. A dc current starts flowing through the field winding.
- The field winding then produces a magnetic field in the air gap between the armature and field windings.
- The armature winding is a rotating winding which is mounted on the shaft. The shaft is mechanically coupled to another machine called prime mover as shown in Fig. 10.3.1(a).
- And the connection of the armature winding are brought out. A load such as electric lamp is connected across the armature winding.
- The dc generator thus takes the mechanical energy as an input energy from the prime mover and delivers an electrical energy to the load.

## 10.3.1 Principle of Operation of a DC Generator : MTU : 11-12

**University Questions**

Q. 1 Explain the generator action of a DC machine. Also describe the open circuit characteristics of DC generator. **(MTU : 11-12)**

- The DC generator operates on the principle of dynamically induced emf in a conductor.
- According to this principle, if the flux linked with a conductor is changed, then an emf is induced into the conductor.
- In case of a DC generator, when armature winding is rotated by the prime mover, the flux linked with it changes and an emf is dynamically induced into the armature winding.
- This is the principle of operation of a generator.
- The prime mover can be a water turbine, steam engine, steam turbine or diesel engine etc.

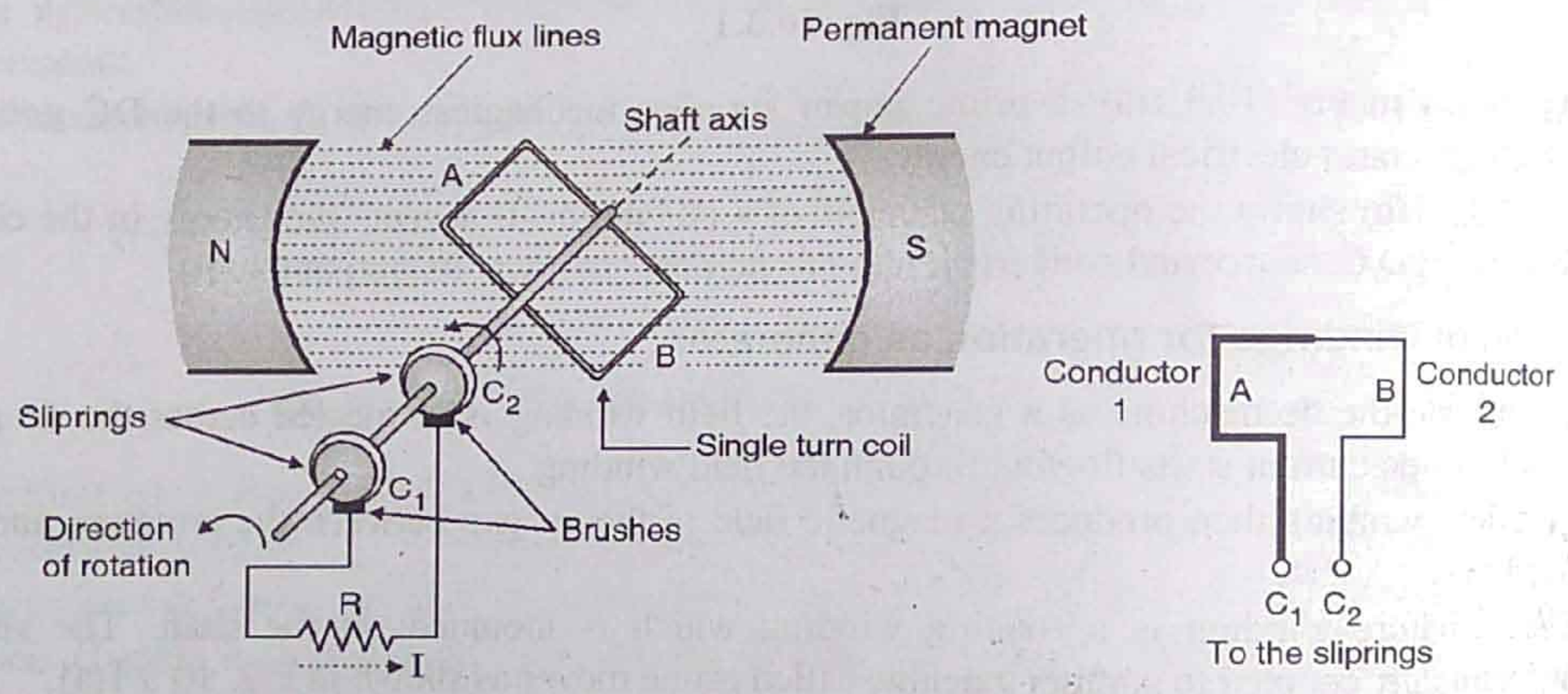
- The direction of induced voltage in the armature winding is given by the Fleming's Right hand rule.

## 10.4 Single Turn Alternator :

Let us now see the generation of the sinewave using the simplest type of alternator called **single turn** or **single loop alternator**.

**Construction :**

- The construction of single turn alternator is shown in Fig. 10.4.1(a). This alternator consists of a permanent magnet with two poles N and S, and a single turn rectangular coil made up of some conducting material (aluminium or copper).
- As shown in Fig. 10.4.1(b) the single turn coil is made from two conductors A and B. These conductors are connected to each other on one end whereas their other ends ($C_1$ and $C_2$) are connected to the slip rings mounted on the shaft.




**(a) A single turn alternator** **(b) A single turn coil**

**Fig. 10.4.1**

- The coil can rotate around its own axis in clockwise or anticlockwise directions. The slip rings $C_1$ and $C_2$ are connected to the coil.
- The sliprings rotate alongwith the shaft. The brushes do not rotate. They are stationary and resting on the sliprings.
- Electrical connections are made to the brushes. As shown in Fig. 10.4.1(a) a resistance R is connected between the two brushes.

### 10.4.1 Generation of AC Voltage :

- Refer Fig. 10.4.1(b). This single turn coil is rotated in the anticlockwise direction in the flux produced by the permanent magnet.
- Due to rotation, the conductors A and B cut the magnetic lines of flux produced by the permanent magnet.
- According to the Faraday's law of electromagnetic induction, an emf is induced into the rotating conductors.

- Due to this induced emf, current flows through the external resistance R.
- The induced emf in the single turn coil is given by,

$$e = B l v \sin \theta$$

- Hence the shape of the induced voltage and the corresponding positions of the single turn coil are shown in Fig. 10.4.2.
- Thus the single turn alternator produces a sinusoidal voltage.

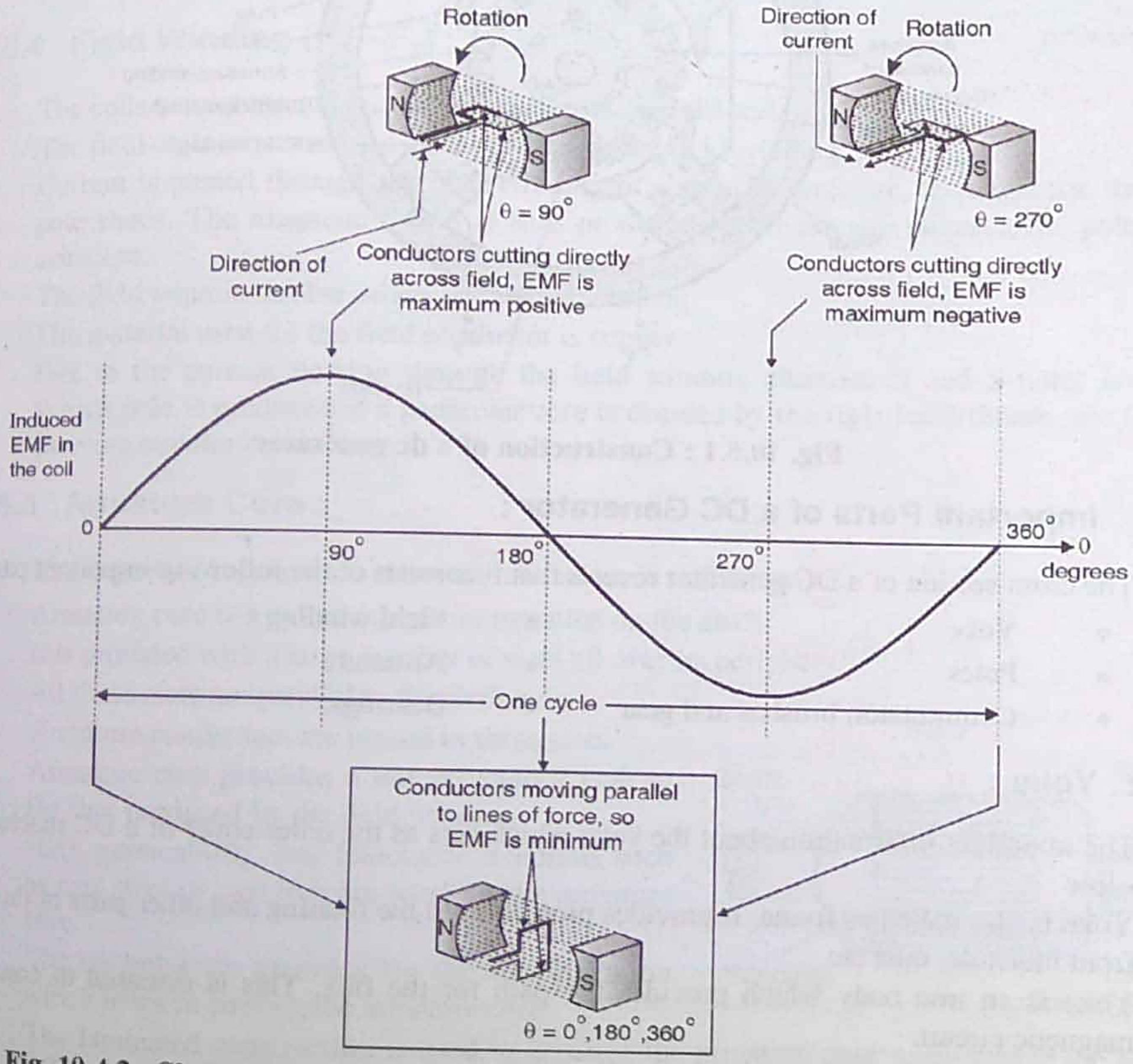



**Fig. 10.4.2 : Shape of induced emf and corresponding positions of single turn coil**

- In the practical dc generator also, the alternating waveform is generated internally. It is then rectified to produce the unidirectional DC voltage. This is achieved by replacing the slip-rings by a **commutator**.

10.5