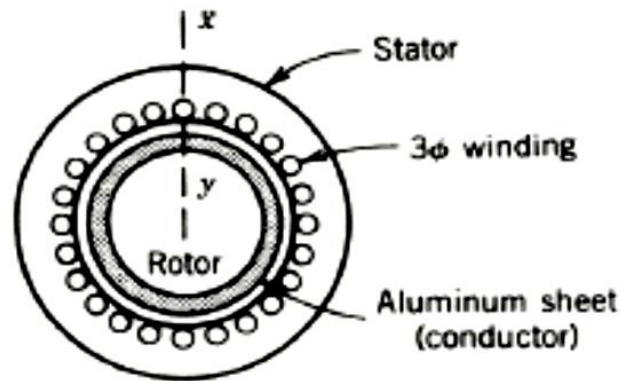


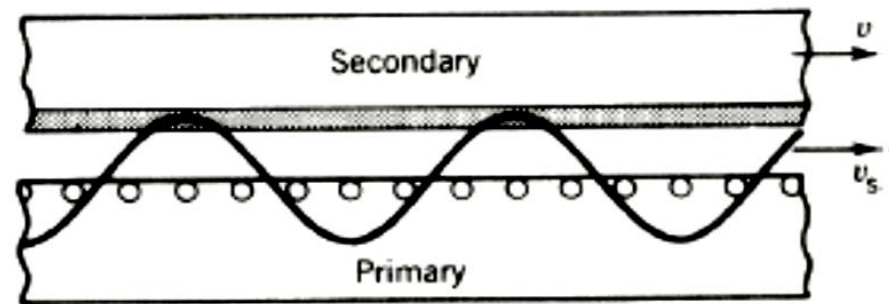
# LINEAR INDUCTION MOTOR (LIM)

- A linear version of the induction machine can produce linear or translational motion.
- Consider the cross-sectional view of the rotary induction machine shown in Fig. (a).
- Instead of a squirrel-cage rotor, a cylinder of conductor (usually made of aluminum) enclosing the rotor's ferromagnetic core is considered.
- If the rotary machine of Fig. (a) is cut along the line  $xy$  and unrolled, a linear induction machine, shown in Fig. (b), is obtained.



(a)

(a) Rotary induction motor.



(b)

(b) Linear induction motor (LIM).

# LINEAR INDUCTION MOTOR (LIM)

- Instead of the terms stator and rotor, it is more appropriate to call them primary and secondary members, respectively, of the linear induction machine.
- If a three-phase supply is connected to the stator of a rotary induction machine, a flux density wave rotates in the air gap of the machine.
- Similarly, if a three-phase supply is connected to the primary of a linear induction machine, a traveling flux density wave is created that travels along the length of the primary.
- This traveling wave will induce current in the secondary conductor.
- The induced current will interact with the traveling wave to produce a translational force  $F$  (or thrust).
- If one member is fixed and the other is free to move, the force will make the movable member move.
- For example, if the primary in Fig. (b) is fixed, the secondary is free to move, and the traveling wave moves from left to right, the secondary will also move to the right, following the traveling wave.

# LIM Performance

- The synchronous velocity of the traveling wave is

$$V_s = 2T_p f \text{ m/sec} \quad (1)$$

- where  $T_p$  is the pole pitch and  $f$  is the frequency of the supply.
- Note that the synchronous velocity does not depend on the number of poles.
- If the velocity of the moving member is  $V$ , then the slip is

$$s = \frac{V_s - V}{V_s} \quad (2)$$

- The per-phase equivalent circuit of the linear induction motor has the same form as that of the rotary induction motor

# LIM Performance

- The thrust–velocity characteristic of the linear induction motor also has the same form as the torque–speed characteristic of a rotary induction motor, as shown in Fig. (c).
- The thrust is given by

$$F = \frac{\text{air gap power, } P_g}{\text{synchronous velocity, } V_s}$$
$$= \frac{3I_2'^2 R_2' / s}{V_s} \text{ newtons}$$

(3)

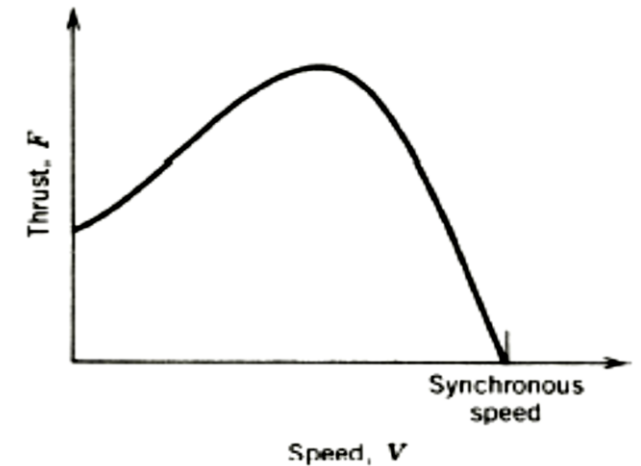


Fig (c) Thrust–speed characteristic of a LIM.

- A linear induction motor requires a large air gap, typically 15–30 mm, whereas the air gap for a rotary induction motor is small, typically 1–1.5 mm.
- The magnetizing reactance  $X_m$  is therefore quite low for the linear induction motor.
- Consequently, the excitation current is large, and the power factor is low.

# LIM Performance

- The LIM also operates at a larger slip.
- The loss in the secondary is therefore high, making the efficiency low.
- The LIM shown in Fig. (b) is called a single-sided LIM or SLIM.
- Another version is used in which primary is on both sides of the secondary, as shown in Fig. (d).
- This is known as a double-sided LIM or DLIM.

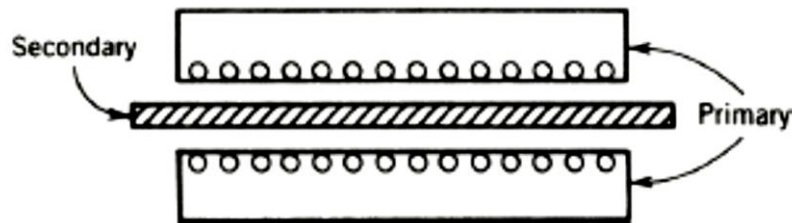


Fig (d) :Double-sided LIM (DLIM).

# Applications

- An important application of a LIM is in transportation.
- Usually a short primary is on the vehicle and a long secondary is on the track, as shown in Fig. (e).
- A transportation test vehicle using such a LIM is shown in Fig. (f).
- A LIM can also be used in other applications, such as materials handling, pumping of liquid metal, sliding-door closers, and curtain pullers.

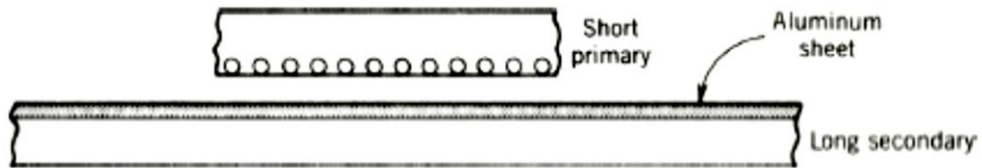


Fig (e): LIM for a vehicle.

Fig (f); Transportation test vehicle using LIM.



# Single Phase Motors

- A large number of fractional-kW a.c. motors are designed to operate from a single-phase supply.
- Although three-phase motors can be designed and built in small sizes, their initial cost precludes their common use.
- In addition, wherever fractional kW a.c. motors are required to do the useful work, as for example in homes, offices, business premises etc., only single-phase supply is usually available.
- The annual production of fractional-kW a.c. motors may be as high as 80% of the total numerical annual production of all types of both single-phase and three-phase machines.

# Single Phase Motors

- Numerous types of fractional-kW a.c, motors have been developed to meet the requirements of the various applications.
- For example, single-phase induction motor is needed where constant speed drive is required.
- Single-phase series motor is used where high-starting torque is required and so on.
- **Types of Single-Phase Motors**

It may be classified into the following four basic types:

## 1. Single-phase induction motors

(i) split-phase type (ii) capacitor start type (iii) capacitor start capacitor run type  
(v) shaded-pole type

## 2. A.C. series motor or universal motor

## 3. Repulsion motors

(i) Repulsion-start induction-run motor (ii) Repulsion-induction motor

## 4. Synchronous motors

(i) Reluctance motor (ii) Hysteresis motor



# Single Phase Induction Motors

- When 3-phase supply is given to a polyphase induction motor, a rotating air-gap field is produced and starting torque is developed.
- If a 3-phase induction motor, carrying less than half-rated load, has its one supply line disconnected, the motor continues running though at a slightly reduced speed' and with increased stator current.
- With one supply line disconnected; the two remaining phases constitute, in effect, a single-phase supply and, therefore, only pulsating stator mmf wave is produced.
- The single phase motor so obtained from a 3-phase motor has poor pf, lower capacity and reduced efficiency.
- As is already known, a 3-phase induction motor with rotating air-gap field is self-starting one.
- But a single phase induction motor with pulsating air-gap field is not a self-starting motor

# Single Phase Induction Motors

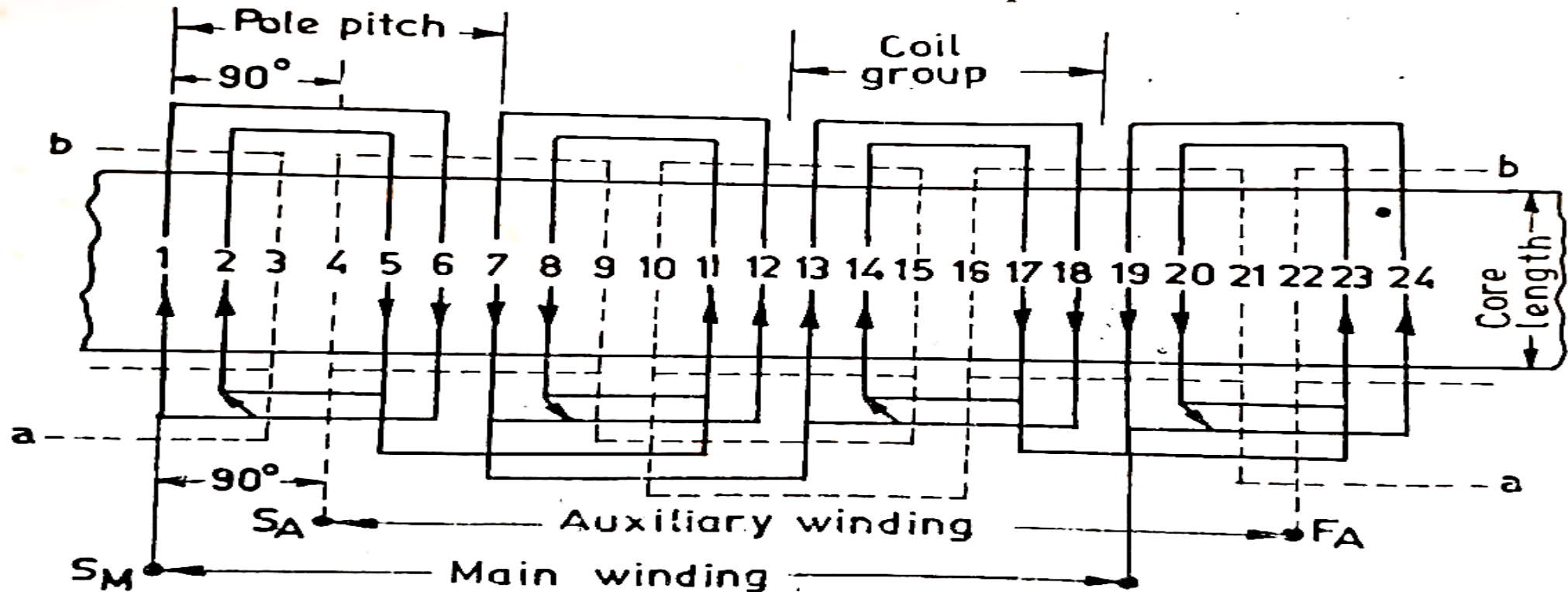
- **Constructional Features**

- ✓ The rotor of a single phase induction motor is exactly similar to the squirrel-cage rotor of a 3-phase induction motor.
- ✓ A wound rotor with slip rings is rarely used in these motors because it increases cost of the machine and, is therefore, seldom in demand.
- ✓ The stator of a single phase induction motor carries two windings.
- ✓ namely main (or running) winding and auxiliary (or starting) winding.
- ✓ Both windings are of the single layer concentric type.
- ✓ The main winding is distributed along the stator periphery in about two-thirds of the total slots, because no advantage is achieved if all the stator slots are wound.
- ✓ Since the stator periphery is not fully utilised, a single phase induction motor has lower power output than a 3-phase induction motor of the same size in which all the stator slots are wound.

# Single Phase Induction Motors

- **Constructional Features**

- ✓ Fig. illustrates both main and auxiliary windings for a 4-pole, single-phase induction motor with 24 stator slots.
- ✓ In this figure, 16 slots are utilized by the main winding and the auxiliary winding is housed in the remaining 8 slots.



# Single Phase Induction Motors

- **Constructional Features**

- ✓ In actual practice, however, some slots may contain coil-sides belonging to both the main and auxiliary windings.
- ✓ If the main winding is traversed from  $S_M$  to  $F_M$ , it is seen that movement of concentric coils is first clockwise, then anti-clock-wise and so on.
- ✓ Same is true for auxiliary winding  $S_A$ ,  $F_A$ . Examination of Fig. also reveals that concentric coils in one coil-group are traversed from outside to inside
- ✓ in the adjacent coil group from inside to outside and so on.
- ✓ Same is also true for auxiliary winding having more than one coil in one coil group.
- ✓ It must be noted that the space angle between  $S_M$  and  $S_A$  is  $90^\circ$ , i.e. the magnetic axes of main and auxiliary windings are in space quadrature.

# Single Phase Induction Motors

- **Constructional Features**

- ✓ Split-phase single-phase induction motors have centrifugal switch mounted on the motor shaft and connected in series with the auxiliary winding.
- ✓ In these motors, both the main and auxiliary windings are in circuit at the time of starting and the purpose of centrifugal switch is to disconnect the auxiliary winding when rotor attains 70 to 80 per cent of synchronous speed.