

ELEMENTS OF ELECTRICAL ENGINEERING (22215)

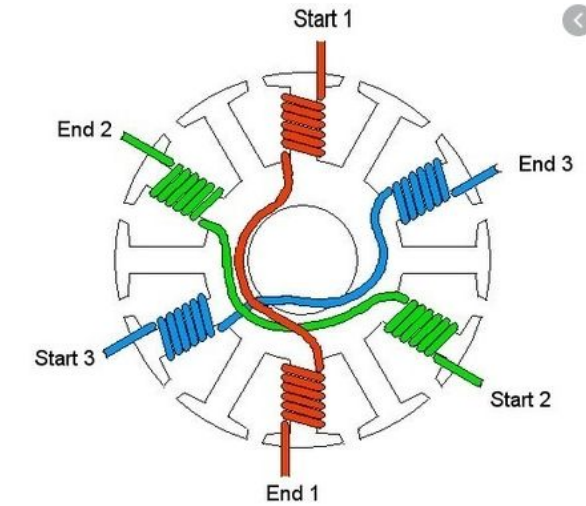
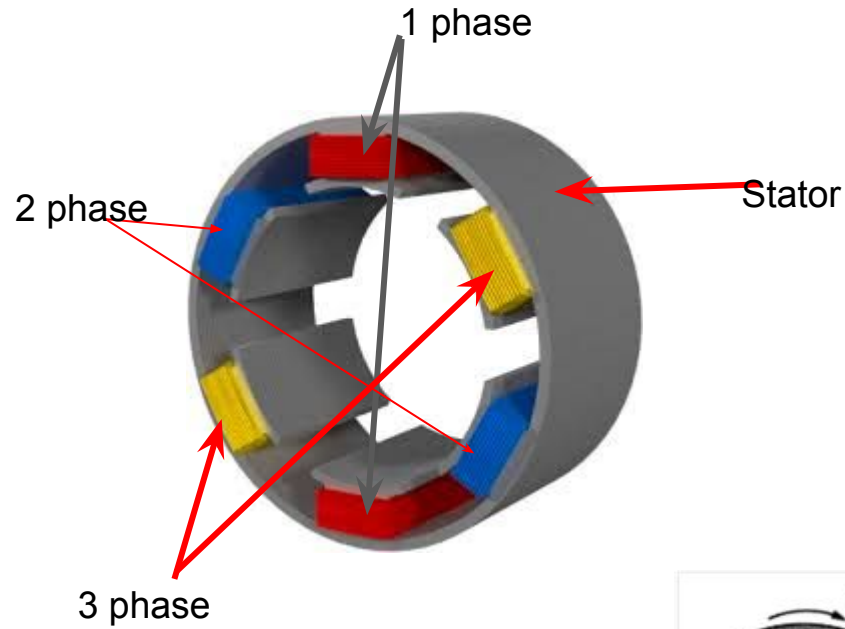
CHAPTER-5 Fractional Horsepower Motor(FHP)- 14 M

CO5 : Use FHP for diversified applications

By SAROJ DESAI

Content

Unit –V Fractional Horse Power (FHP) Motors	<p>5a. Explain the working principle of the given type of FHP motor.</p> <p>5b. Select relevant FHP motor for the given application with justification.</p> <p>5c. Describe the procedure to connect the given type of FHP motor for the given application with sketches.</p> <p>5d. Describe the procedure to connect stepper motor for the given application with sketches.</p>	<p>5.1 FHP: Schematic representation, principle of operation and applications of: split phase Induction motor, capacitor start induction run, capacitor start capacitor run and permanent capacitor motors. shaded pole motors</p> <p>5.2 Universal motor: principle of operation, reversal of rotation and applications</p> <p>5.3 Stepper motor: types, principle of working and applications</p>
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3 phase stator

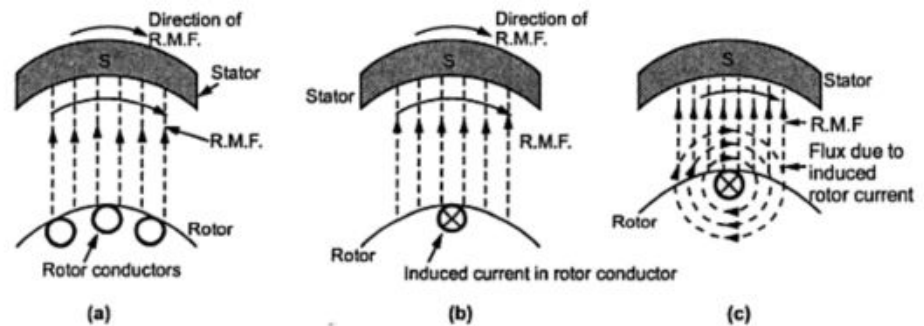
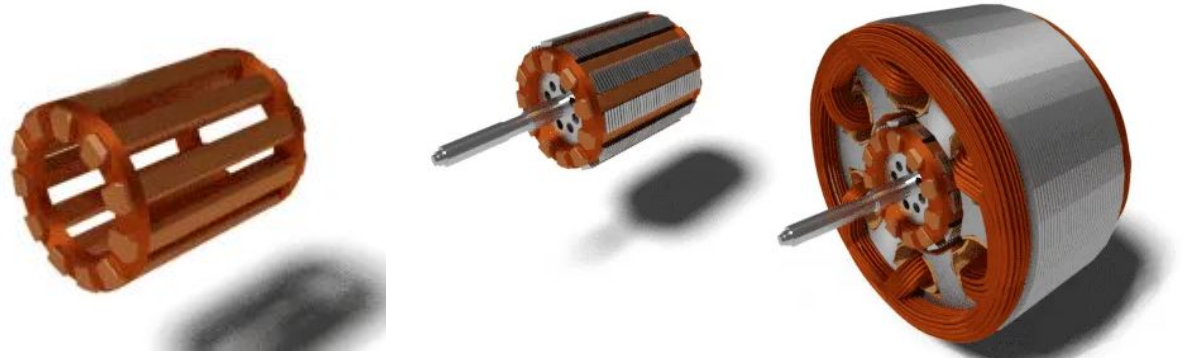
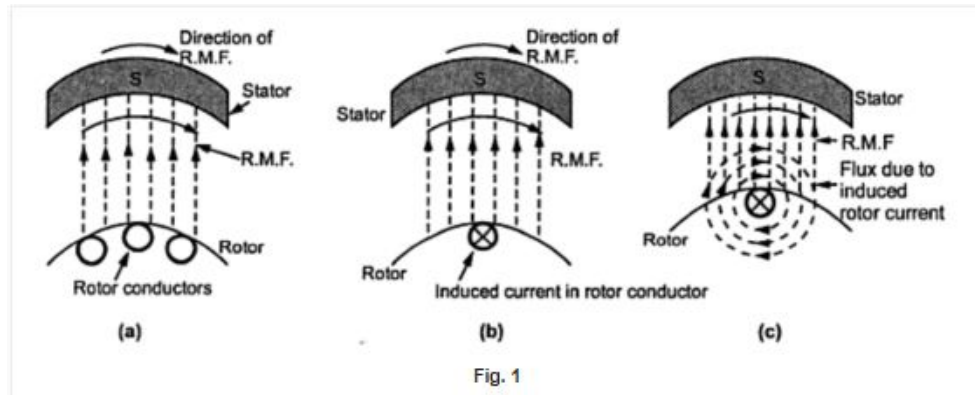


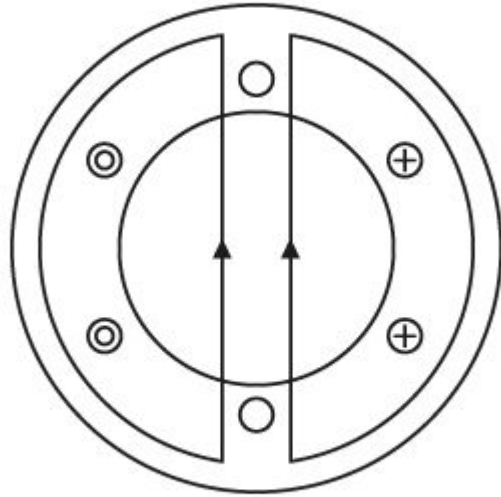
Fig. 1



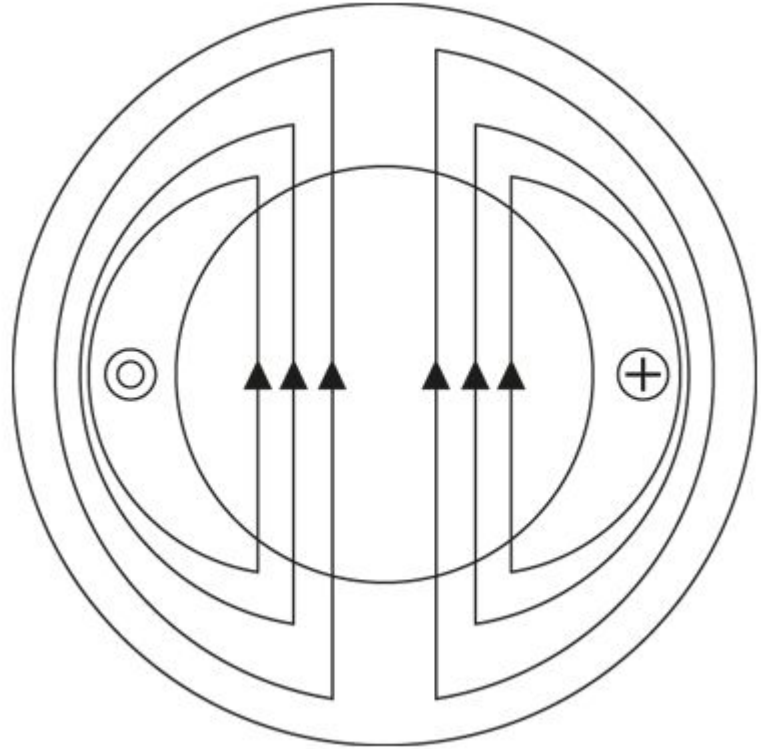
Squirrel cage rotor

3 phase stator





3 phase rotation



Single phase movement of conductor

Fractional Horsepower motor

The stator is a stationary part and it has laminated construction, which is made up of stampings. These stampings consists of slots on its periphery to carry the stator winding. This winding is excited with a single phase AC supply.

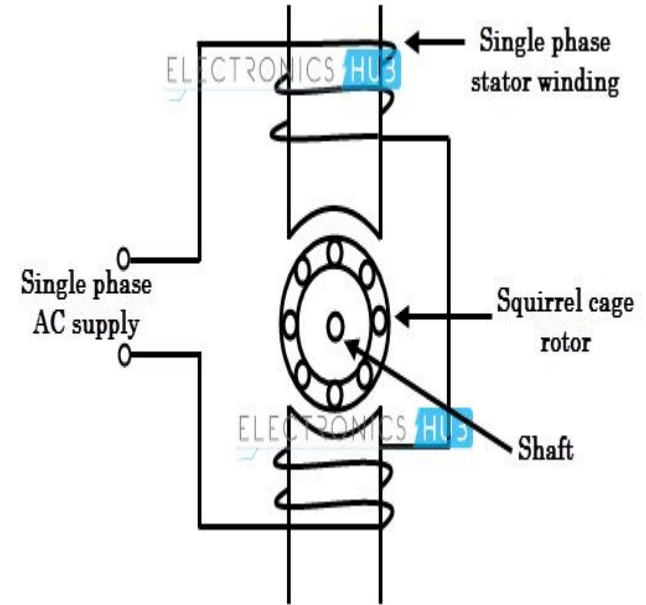
The rotor is a rotating part and its construction is of squirrel cage type. The rotor consists of uninsulated aluminum or copper bars which are placed in the slots.

These rotor bars are permanently shorted at both ends with the help of end rings as shown in figure.

There is no physical connection between the stator and rotor, but there is a small and uniform gap between them.

The rotor acts as a conductor which when placed in the stator magnetic field, an emf is induced in it, produces its own magnetic field which further interacts with stator field to produce the torque. Whenever a single phase AC supply is given to the stator winding, an alternating magnetic field is produced around the stator.

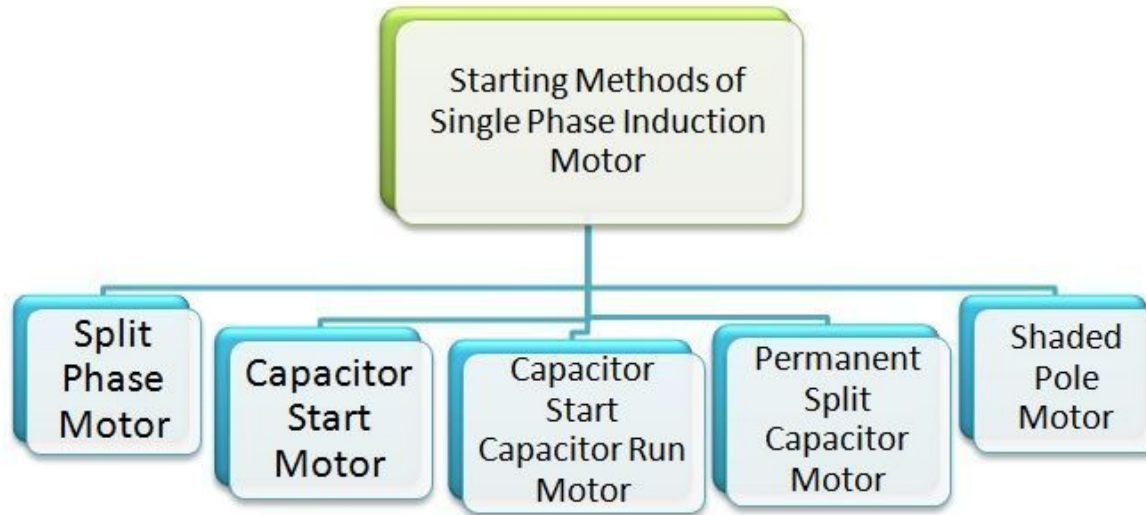
Due to the pulsating nature of the field which reverses for every half-cycle, cannot produce rotation in a stationary squirrel cage rotor.



Single phase induction motor

- The **Single Phase Motor** is not self starting and hence needs an auxiliary means or equipment to start the single phase induction motor.
- Mechanical methods are impractical and, therefore the motor is started temporarily converting it into two phase motor.
- Single phase Induction motors are usually classified according to the auxiliary means used to start the motor. They are classified according to the starting methods.

Types of single phase induction motor



Types of single phase induction motor -split phase

- The **Split Phase Motor** is also known as a **Resistance Start Motor**.
- It has a single cage rotor, and its stator has two windings known as main winding and starting winding.
- Both the windings are displaced 90 degrees in space.
- The main winding has very low resistance and a high inductive reactance whereas the starting winding has high resistance and low inductive reactance
- The Connection Diagram of the motor is shown in fig a

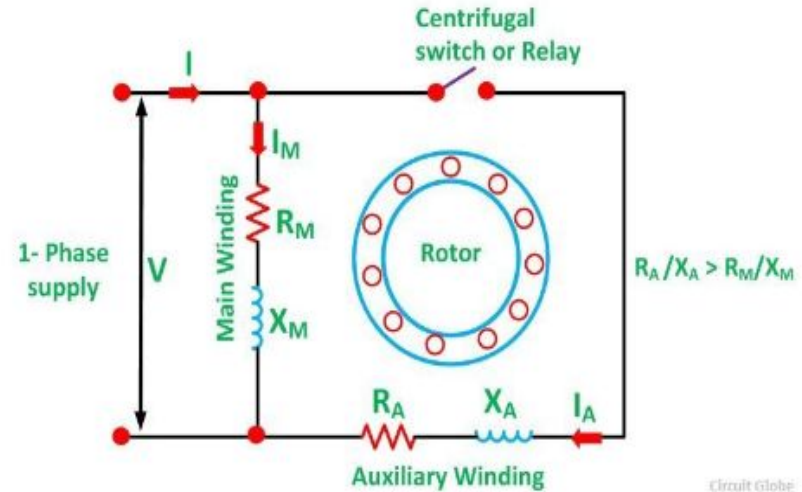


Fig.b Split phase IM

Types of single phase induction motor -split phase

Motor Characteristics:

The starting torque of a resistance-start induction motor is about 1.5 times full-load torque. The maximum or pull-out torque is about 2.5 times full-load torque at about 75% of synchronous speed. The split-phase motor has a high starting current which is usually 7 to 8 times the full-load value.

Applications:

Split-phase motors are most suitable for easily started loads where the frequency of starting is limited, and these are very cheap.

1. These motors are used in washing machines.
2. These are used in Air conditioning fans.
3. Used in food mixers, grinders, floor polishers, blowers, centrifugal pumps,
4. These are used in small drills, lathes, office machinery, etc.
5. Sometimes they are also used for drives requiring more than 1kW.

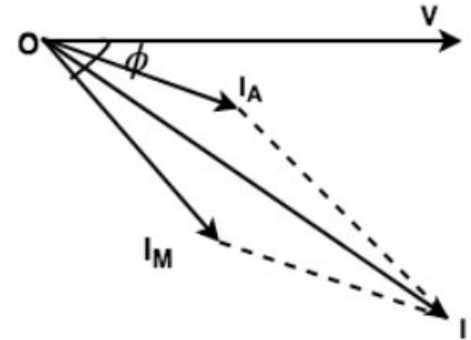


Fig.c Split phase IM

Types of single phase induction motor -Capacitor-start motor

The capacitor-start motor develops a much higher starting torque, i.e. 3.0 to 4.5 times the full-load torque. To obtain a high starting torque, the value of the starting capacitor must be large, and the resistance of starting winding must be low. Because of the high VAR rating of the capacitor required, electrolytic capacitors of the order of 250 μF are used. The capacitor C_s is short-time rated.

These motors are more costly than split-phase motors because of the additional cost of the capacitor.

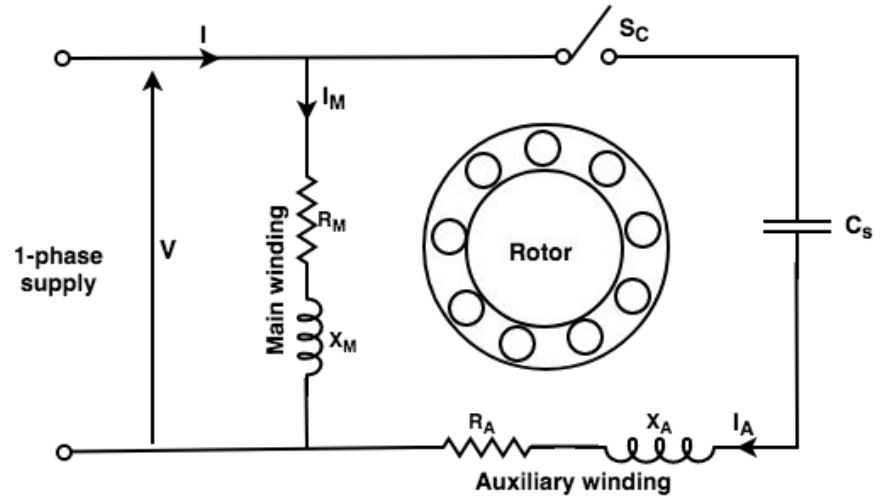


Fig.d capacitor start IM

Types of single phase induction motor -Capacitor-start motor

Applications:

1. These motors are used for heavy loads where frequent start required.
2. These motors are used for pumps and compressors, so these are used as a compressor in the refrigerator and air conditioner.
3. They are also used for conveyors and some machine tools.
4. These motors have high starting torque; hence they are used in conveyors, grinders, air conditioners, compressors, etc. They are available up to 6 kW.

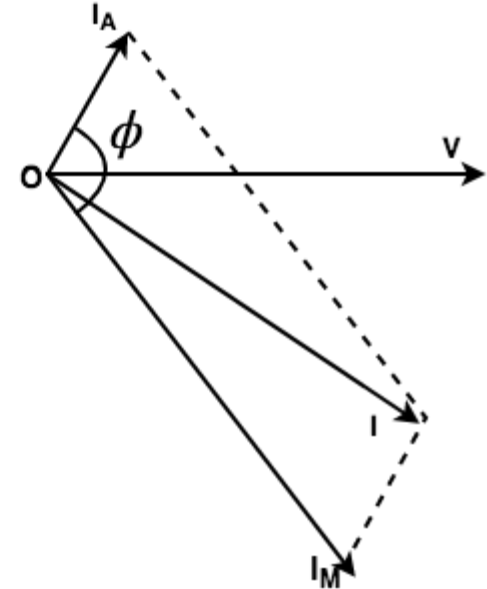


Fig.e capacitor start IM

Types of single phase induction motor - **Permanent split -single value capacitor motor**

It has a cage rotor and stator. The stator has two windings – main and auxiliary winding. It has only one capacitor in series with starting winding. It has no starting switch.

Advantages:

- No centrifugal switch is needed.
- It has higher efficiency
- It has higher power-factor because of a permanently-connected capacitor.
- It has higher pull-out torque.

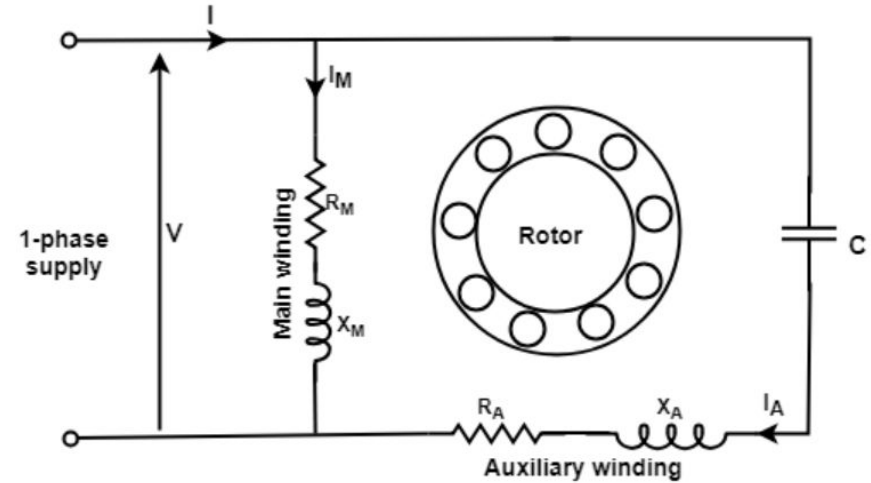


Figure: Permanent-split capacitor motor

Fig.f single value capacitor IM

Types of single phase induction motor -Permanent split -single value capacitor motor

Applications of Permanent Split Capacitor Motor

- It finds applications in fans and blowers
- It is also used to drive office machinery.
- These motors are used for fans and blowers in heaters.
- It is used in air conditioners and heaters.
- It is used to drive refrigerator compressors.
- It is also used to operate office machinery.

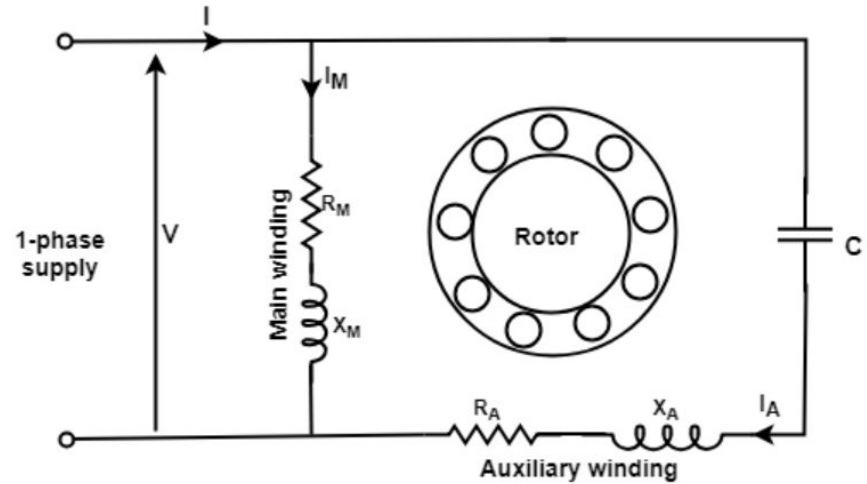


Figure: Permanent-split capacitor motor

Fig.f single value capacitor IM

Types of single phase induction motor -**Shaded pole type**

- A shaded-pole motor is a simple type of self-starting single-phase induction motor. It consists of a stator and a cage-type rotor. The stator is made up of salient poles. Each pole is slotted on the side, and a copper ring is fitted on the smaller part. This part is called the shaded pole. The ring is usually a single-turn coil and is known as shading coil.

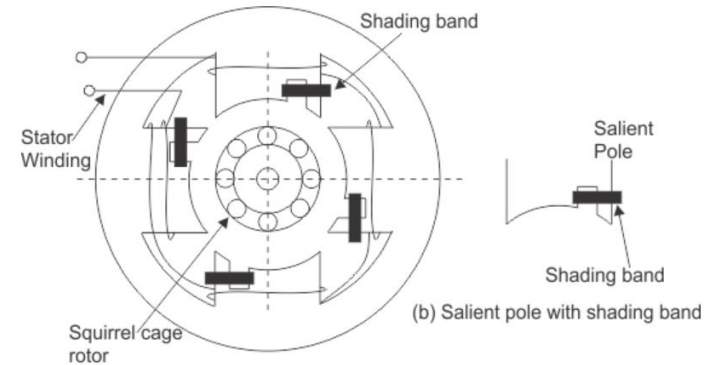


Fig.g Shaded pole motor

Types of single phase induction motor -Permanent split -single value capacitor motor

Applications of shaded pole Motor

1. Shaded-pole motors are used to drive devices which require low starting torque and reasonable cost, these motors are mostly employed in small instruments, hairdryers, toys, record players, small fans, electric clocks, etc. These motors are usually available in a range of 1/300 to 1/20 KW.
2. These motors are very suitable for small devices like relays, fans of all kinds, etc. because of their low initial cost and easy starting.
3. The most common application of these motors is in table fans, exhaust fans, hair dryers, fans for refrigeration and air-conditioning equipment, electronic equipment, cooling fans, etc.

Universal motor

A universal motor is a special type of motor which is designed to run on either DC or single phase AC supply. These motors are generally series wound (armature and field winding are in series), and hence produce high starting torque (See characteristics of DC motors here).

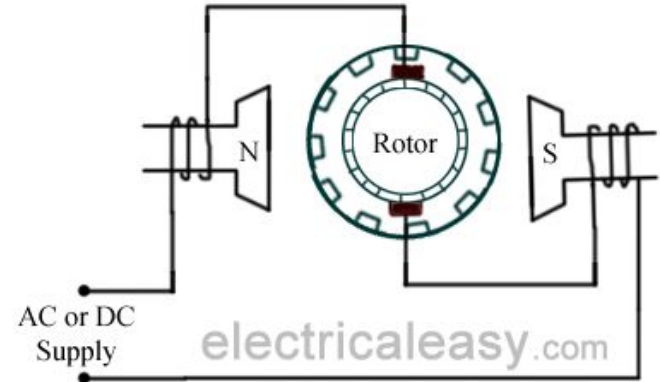
That is why, universal motors generally comes built into the device they are meant to drive.

Most of the universal motors are designed to operate at higher speeds, exceeding 3500 RPM. They run at lower speed on AC supply than they run on DC supply of same voltage, due to the reactance voltage drop which is present in AC and not in DC.



Universal motor- working

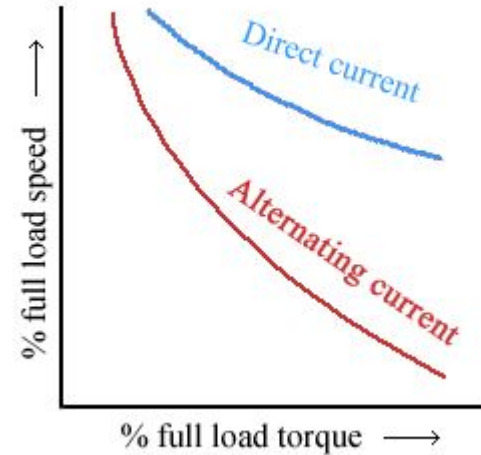
A universal motor works on either DC or single phase AC supply. When the universal motor is fed with a DC supply, it works as a DC series motor. (see working of a DC series motor here). When current flows in the field winding, it produces an electromagnetic field. The same current also flows from the armature conductors. When a current carrying conductor is placed in an electromagnetic field, it experiences a mechanical force. Due to this mechanical force, or torque, the rotor starts to rotate. The direction of this force is given by Fleming's left hand rule.



Universal motor- working

When fed with AC supply, it still produces unidirectional torque. Because, armature winding and field winding are connected in series, they are in same phase. Hence, as polarity of AC changes periodically, the direction of current in armature and field winding reverses at the same time.

Thus, direction of magnetic field and the direction of armature current reverses in such a way that the direction of force experienced by armature conductors remains same. Thus, regardless of AC or DC supply, universal motor works on the same principle that DC series motor works.



$$X_L = 2 \cdot 3.14 \cdot f \cdot L$$

Universal motor- Application

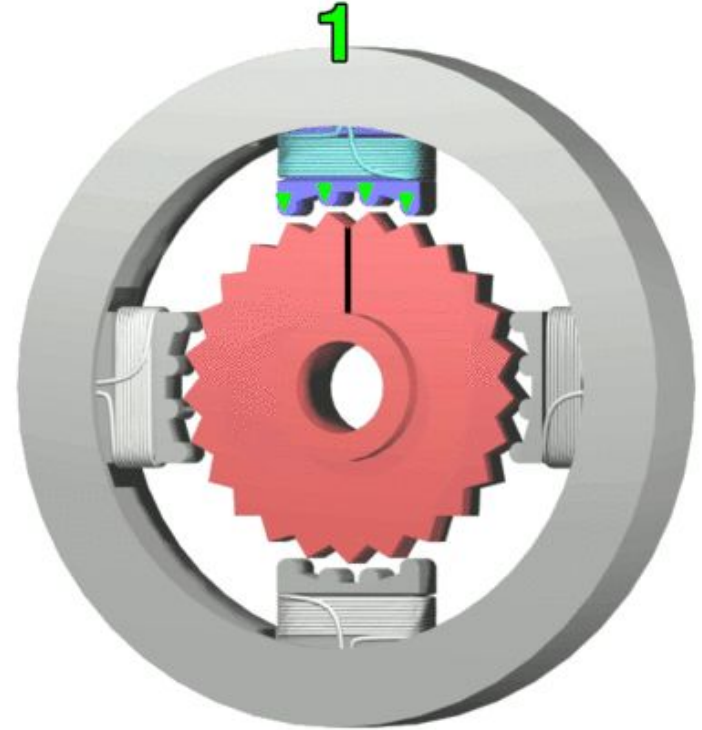
Applications Of Universal Motor

- Universal motors find their use in various home appliances like vacuum cleaners, drink and food mixers, domestic sewing machine etc.
- The higher rating universal motors are used in portable drills, blenders etc.

<https://youtu.be/0PDRJKz-mqE> - ANIMATION FOR
UNIVERSAL MOTOR

Stepper motor

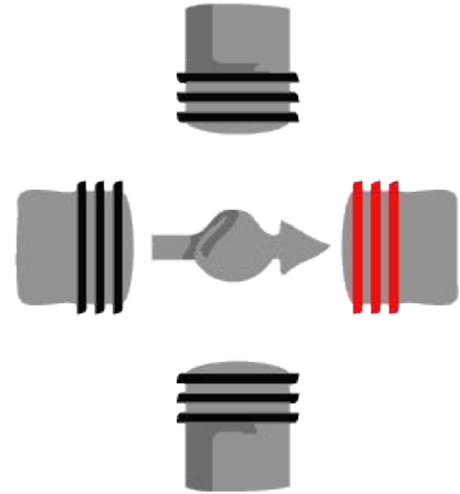
- Stepper motors are often an extremely important component in a motion control system
- Stepper motors are similar to legacy AC induction-type motors in that they have both a stator and a rotor; however, that's where the similarities end.
- Stepper motors are a type of DC synchronous motor. Whereas the rotation of an induction motor is largely uncontrollable, the rotation of a stepper motor can be controlled with a remarkable degree of precision.
- Stepper motors can produce full, instantaneous torque - even from a standstill. This makes them very useful for motion control applications, where accuracy, repeatability, and power are paramount.



Stepper motor-

Stepper motors are DC motors that move in discrete steps. They have multiple coils that are organized in groups called “phases”. By energizing each phase in sequence, the motor will rotate, one step at a time.

With a computer controlled stepping you can achieve very precise positioning and/or speed control. For this reason, stepper motors are the motor of choice for many precision motion control applications.

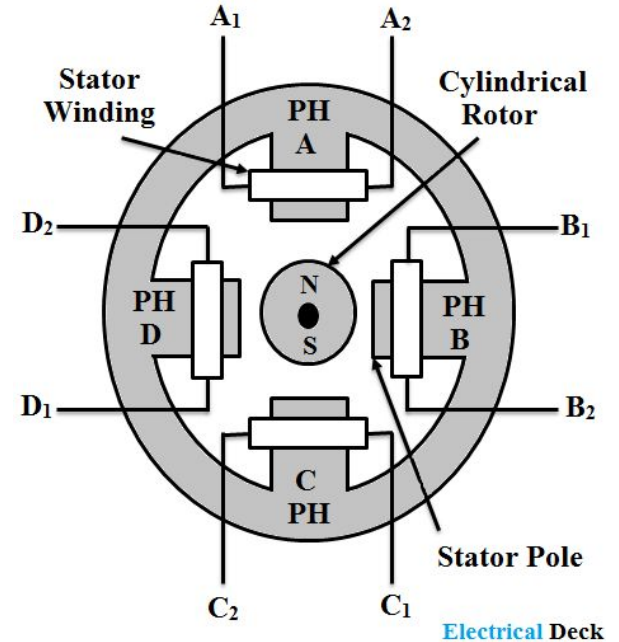


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Stepper motor- types

There are three main types of stepper motors:

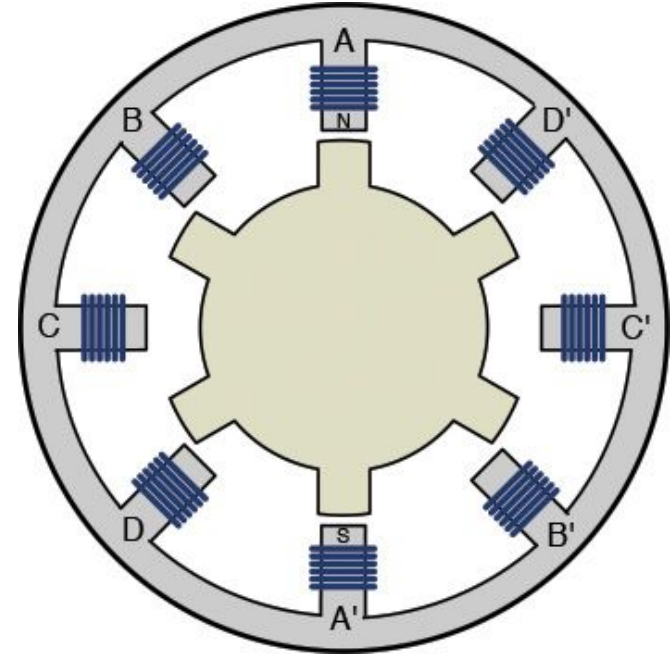
1. Permanent Magnet Stepper. PM steppers have rotors that are constructed with permanent magnets, which interact with the electromagnets of the stator to create rotation and torque. PM steppers usually have comparatively low power requirements and can produce more torque per unit of input power.



<https://youtu.be/eyqwLiowZiU>

Stepper motor- types

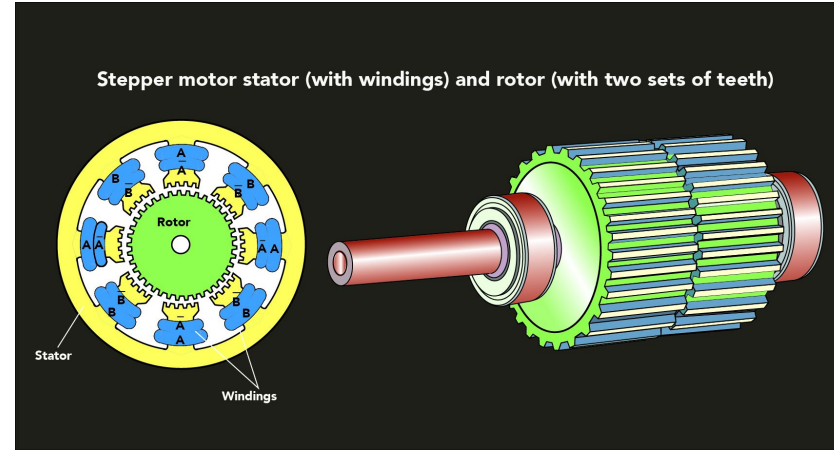
2. Variable Reluctance Stepper. VR stepper rotors are not built with permanent magnets. Rather, they are constructed with plain iron and resemble a gear, with protrusions or “teeth” around the circumference of the rotor. The teeth lead to VR steppers that have a very high degree of angular resolution; however, this accuracy usually comes at the expense of torque.



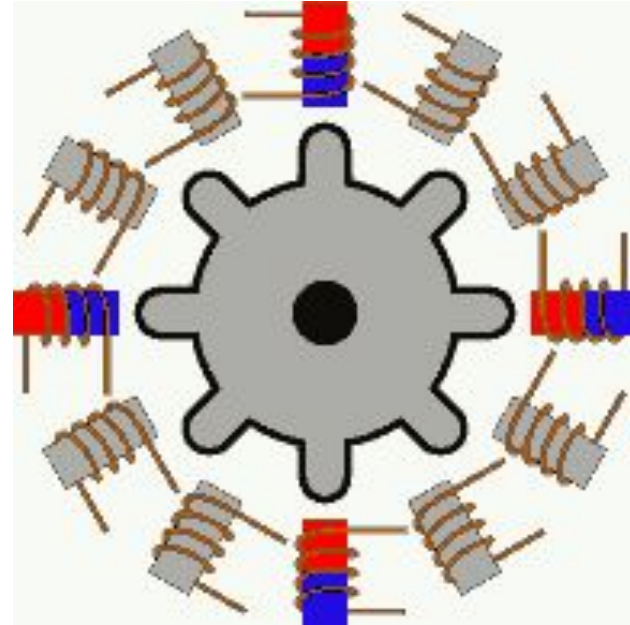
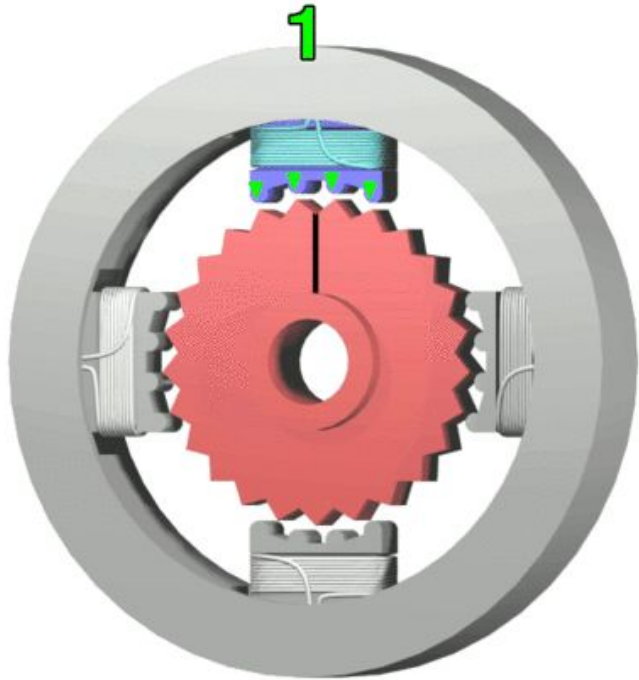
<https://youtu.be/eyqwLiowZiU>

Stepper motor- types

3. Hybrid Stepper. HS stepper rotors use the best features of both PM and VR steppers. The rotor in an HS motor has a permanent magnet core, while the circumference is built from plain iron and has teeth. A hybrid synchronous motor, therefore, has both high angular resolution *and* high torque.



<https://youtu.be/eyqwLiowZiU>



<https://youtu.be/TWMai3oirnM>

Stepper motor- Operating Modes

Stepper motors have three main operating modes. Using a rotor with 200 teeth as a basic example, the operating modes are:

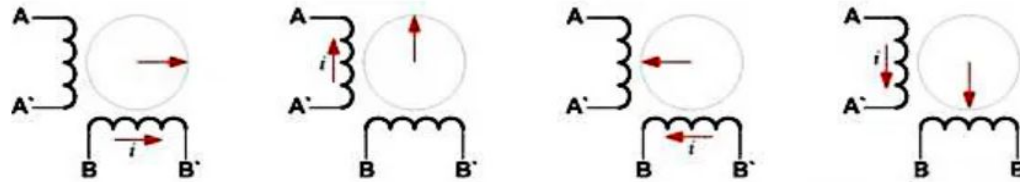
1. Full Step Mode. For each 360° rotation of the motor shaft, the rotor proceeds through 200 distinct steps, each exactly 1.8° . During full step operation, two of the phases on the stator are always energized. This provides maximum torque, but angular resolution is limited by the number of teeth on the rotor.
2. Half Step Mode. For each 360° rotation of the motor shaft, the rotor proceeds through 400 distinct steps, each exactly 0.9° . During half step operation, there is an alternation between having one or two phases on the stator energized. This provides twice the level of angular resolution for increased positioning accuracy but comes at the expense of torque.
3. Micro Step Mode. For each 360° rotation of the motor shaft, the rotor proceeds through 51,200 distinct steps, each exactly 0.007° . During micro-step operation, phases on the stator can be either energized, de-energized or partially energized. This mode is used in applications where highly accurate positioning is needed, although torque rating can be reduced by as much as 30%.

Stepper motor- Operating Modes

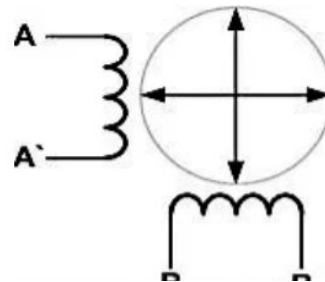
1. Full Step Mode.

FULL-STEP DRIVE

During the full-step drive, the stepper motor driver energizes the two coils of the two-phase stepper motor in a pulse/direction command. Each pulse of this drive mode causes the motor to move a basic step angle. The following figure shows the sequence of the motor stator current in the whole step drive mode:

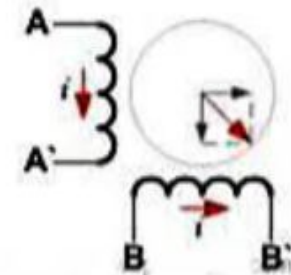
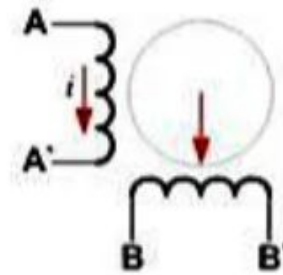
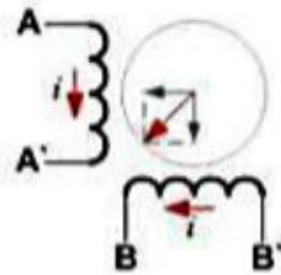
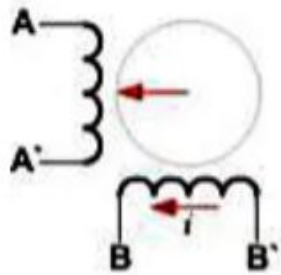
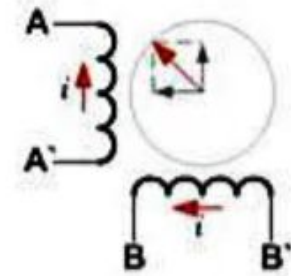
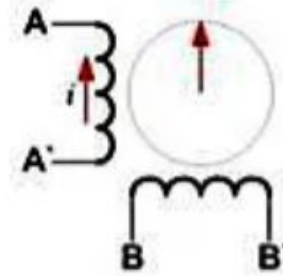
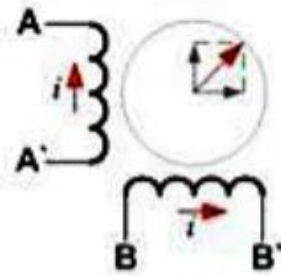
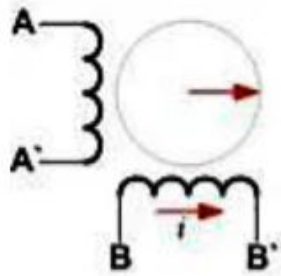


Below is the current vector segmentation diagram:



Stepper motor- Operating Modes

1. Half Step Mode.



Louver for air-conditioners



Security Camera



Printer/Fax



Health care



Scanner



Robots



Power Tools



FA



Amusement



ATM



Stepper motor- applications

The **stepper motor** is used for

- As the stepper motor are digitally controlled using an input pulse, they are suitable for use with computer controlled systems.
- They are used in numeric control of machine tools.
- Used in tape drives, floppy disc drives, printers and electric watches.
- The stepper motor also use in X-Y plotter and robotics.
- It has wide application in textile industries and integrated circuit fabrications.
- The other applications of the Stepper Motor are in spacecrafts launched for scientific explorations of the planets etc.
- These motors also find a variety of commercial, medical and military applications and also used in the production of science fiction movies.
- Stepper motors of microwatts are used in the wrist watches.
- In the machine tool, the stepper motors with ratings of several tens of kilowatts is used

Fractional Horse power- motor-IMPORTANT LINKs

https://youtu.be/_nS3OeLY-s - induction motor

<https://youtu.be/0PDRJKz-mqE> - ANIMATION FOR uNIVERSAL MOTOR

<https://youtu.be/eyqwLiowZiU> - stepper motor

<https://youtu.be/TWMai3oirnM-> STEPPER MOTOR TYPES AND WORKING

A capacitor start, capacitor run single phase induction motor is basically a ____

- A. ac series motor
- B. dc series motor
- C. 2 phase induction motor**
- D. 3 phase induction motor.

The starting torque of a capacitor start motor is _____

- A. zero
- B. low**
- C. same as rated torque
- D. more than rated torque.

The starting capacitor of a single phase motor is ____

- A. Electrolytic capacitor**
- B. Ceramic capacitor
- C. Paper capacitor
- D. plastic film capacitor

The starting capacitor of a single phase motor is ____

- A. **Electrolytic capacitor**
- B. Ceramic capacitor
- C. Paper capacitor
- D. plastic film capacitor

A universal motor is one which _____

- A. Is available universally
- B. Can be marketed internationally
- C. Can be operated either on dc or ac supply**
- D. Runs at dangerously high speed on no-load

The direction of rotation of universal motor can be reversed the by reversing the flow of current through _____

- A. Armature winding
- B. Field winding
- C. Either armature winding or field winding**
- D. neither armature winding nor field winding

Which of the following is not a type of stepper motor?

- A. Variable Reluctance type
- B. Hybrid type
- C. permanent magnet type
- D. shaded pole type**

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- A. Variable Reluctance type
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