

Types of Electric Motors

Electric Motors

DC Motors

Shunt motor

Separately Excited motor

Series Motor

Permanent Magnet DC (PMDC)

Compounded motor

AC Motors

Induction motor

Synchronous motor

Other Motors

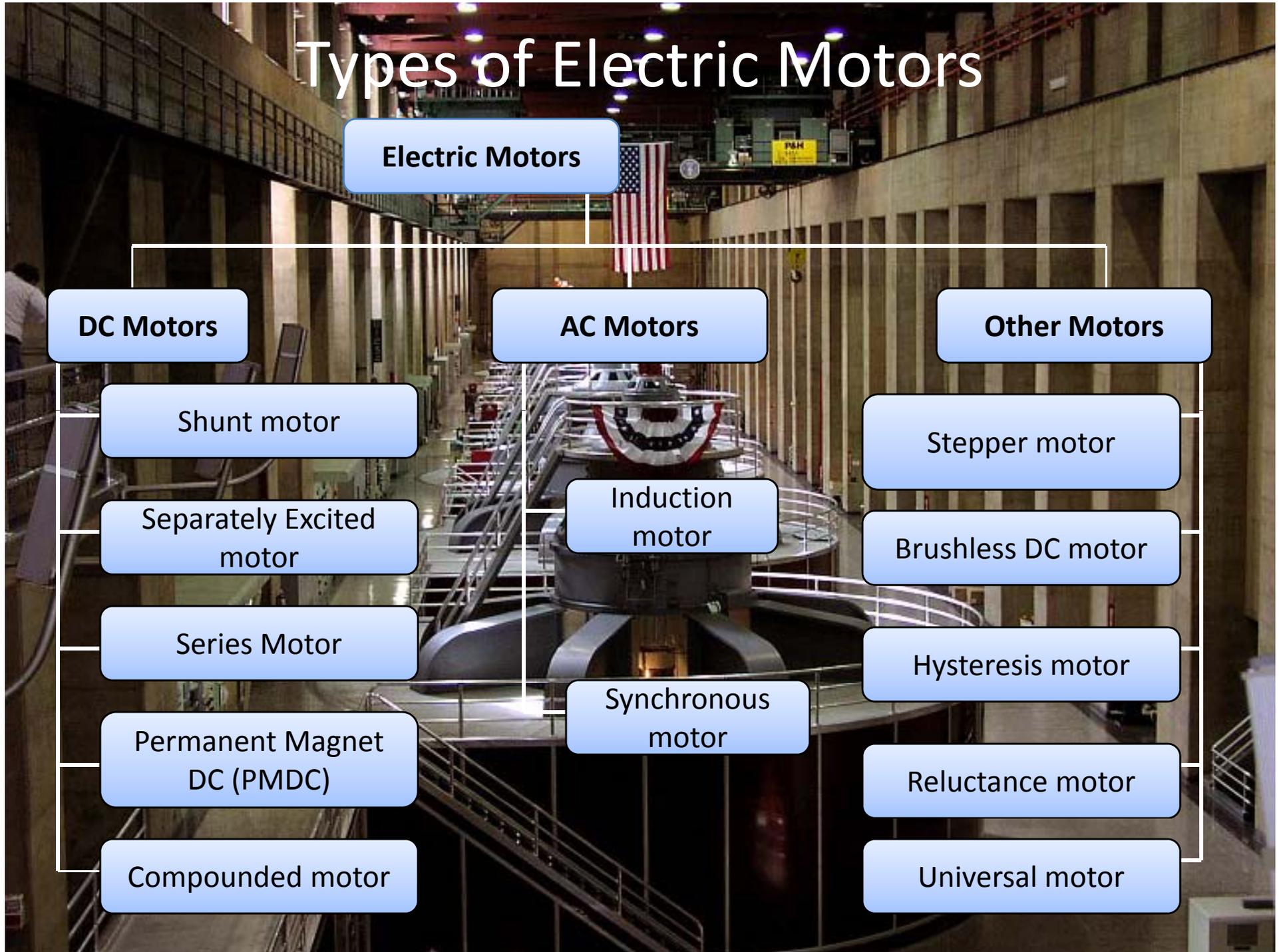
Stepper motor

Brushless DC motor

Hysteresis motor

Reluctance motor

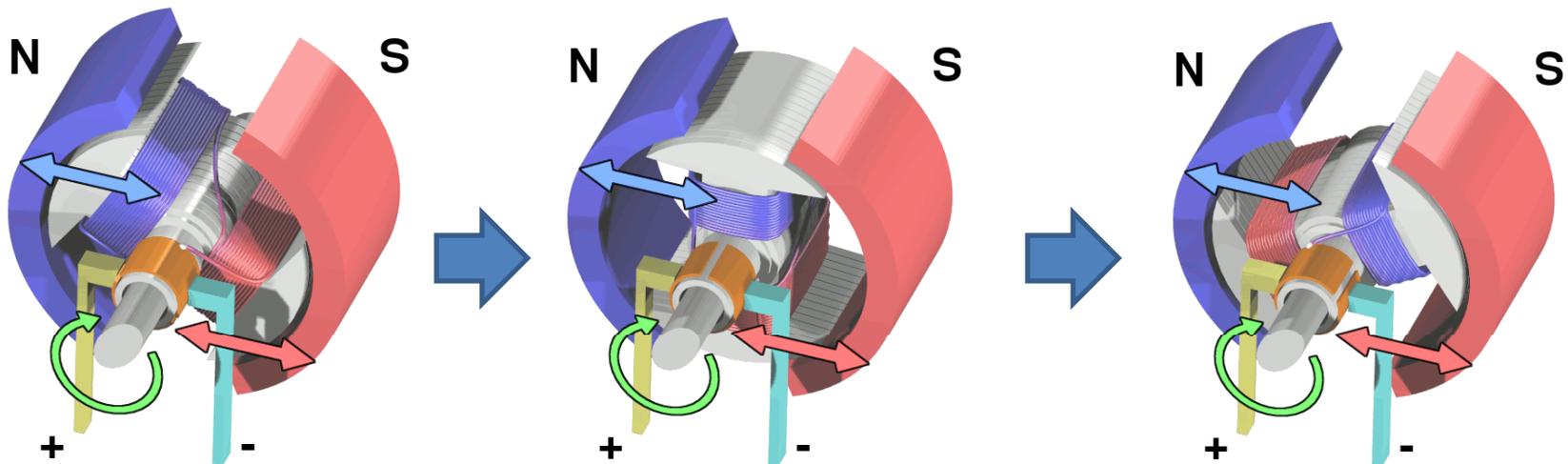
Universal motor



DC Motors

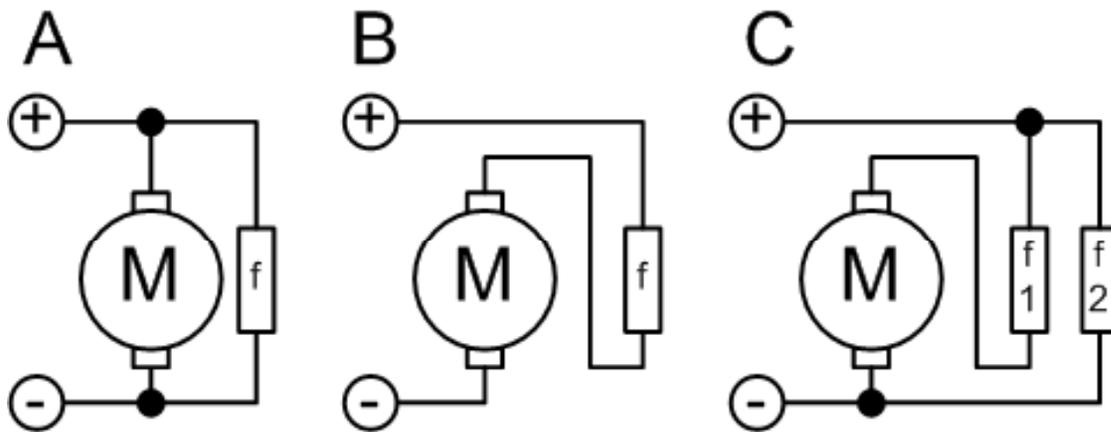
1. **Shunt DC motor:** The rotor and stator windings are connected in parallel.
2. **Sparately Excited motor:** The rotor and stator are each connected from a different power supply, this gives another degree of freedom for controlling the motor over the shunt.
3. **Series motor:** the stator and rotor windings are connected in series. Thus the torque is proportional to I^2 so it gives the highest torque per current ratio over all other dc motors. It is therefore used in starter motors of cars and elevator motors (*p. 563 Chapman, 4e, 2005 McGraw Hill*).
4. **Permanent Magnet (PMDC) motors:** The stator is a permanent magnet, so the motor is smaller in size.

Disadv: only used for low torque applications



DC Motors

5. **Compounded motor:** the stator is connected to the rotor through a compound of shunt and series windings, if the shunt and series windings add up together, the motor is called **comulatively compounded**. If they subtract from each other, then a **differentially compounded motor** results, which is unsuitable for any application.



A: shunt

B: series

C: compound

f = field (stator) coil

http://en.wikipedia.org/wiki/Electric_motor

Disadvantages of DC motors

1. Brush wear: Since they need brushes to connect the rotor winding. Brush wear occurs, and it increases dramatically in low-pressure environment. So they cannot be used in artificial hearts. If used on aircraft, the brushes would need replacement after one hour of operation.
2. Sparks from the brushes may cause explosion if the environment contains explosive materials.
3. RF noise from the brushes may interfere with nearby t.v. sets, or electronic devices,..etc

Ref. Chapman p. 674-675

AC Machines

- **Induction Motor:** So called because voltage is induced in the rotor (thus no need for brushes), but for this to happen, the rotor must rotate at a lower speed than the magnetic field to allow for the existence of an induced voltage. Therefore a new term is needed to describe the induction motor: the slip.
- **Synchronous Motor:** So called because rotor tries to line up with the rotating magnetic field in the stator. It has the stator of an induction motor, and the rotor of a dc motor.



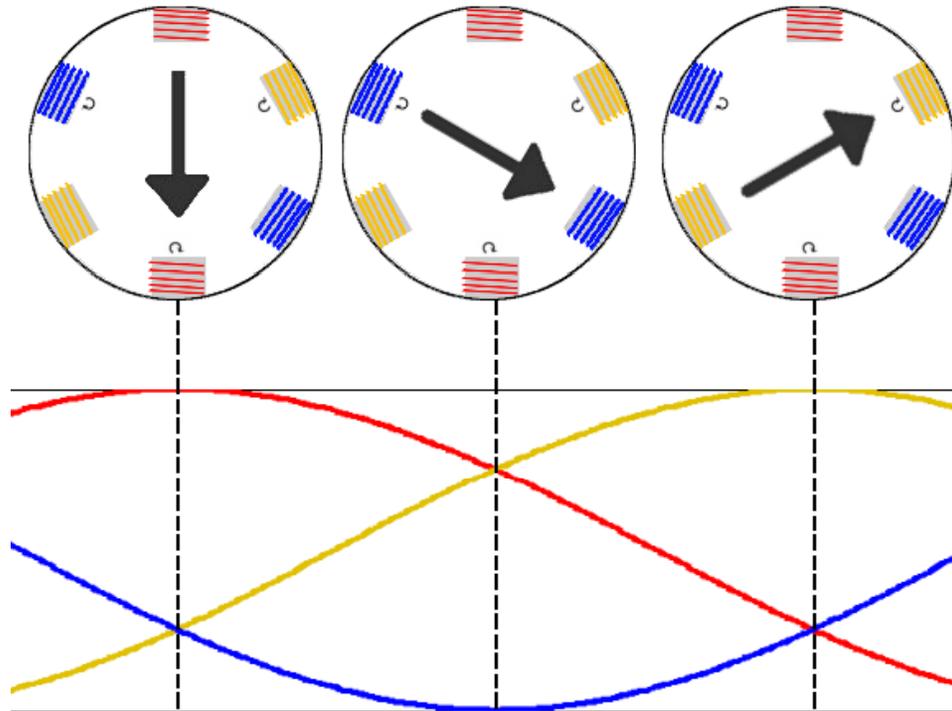
Squirrel cage Induction Motor

See it on:

http://en.wikipedia.org/wiki/Induction_motor

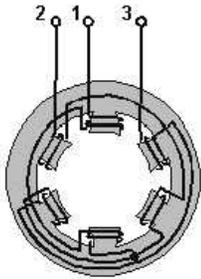
Note: Figure is misleading. The number of poles must be an even integer of the number of phases used. Thus this diagram should have 6 coils, but that would prevent one from imagining the rotation.

AC Machines



Accurate representation of
a 6 pole 3-phase AC
induction motor

[http://en.wikipedia.org/wiki/
/File:Rotatingfield.png](http://en.wikipedia.org/wiki/File:Rotatingfield.png)

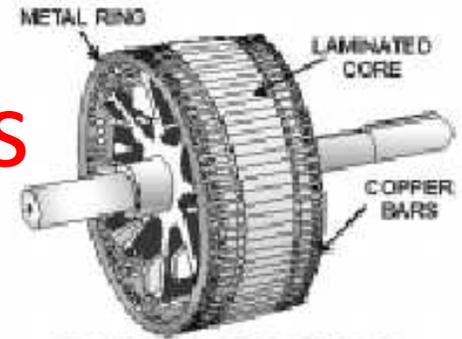


Synchronous Machines

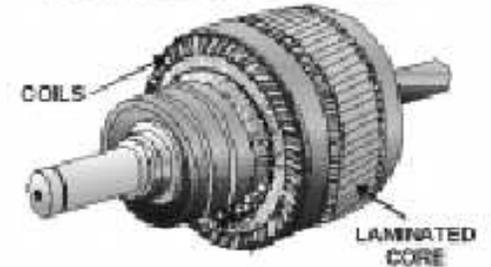
4-17 **THREE-PHASE ROTATING FIELDS** require three pairs of windings 120° apart, energized by voltages that also have a 120-degree phase displacement.

SYNCHRONOUS MOTORS are specifically designed to maintain constant speed, with the rotor synchronous to the rotating field. Synchronous motors require modification (such as squirrel-cage windings) to be self-starting.

[Text and figures on top half of page from http://www.tpub.com/content/neets/14177/css/14177_101.htm](http://www.tpub.com/content/neets/14177/css/14177_101.htm)



SQUIRREL-CAGE ROTOR



WOUND ROTOR

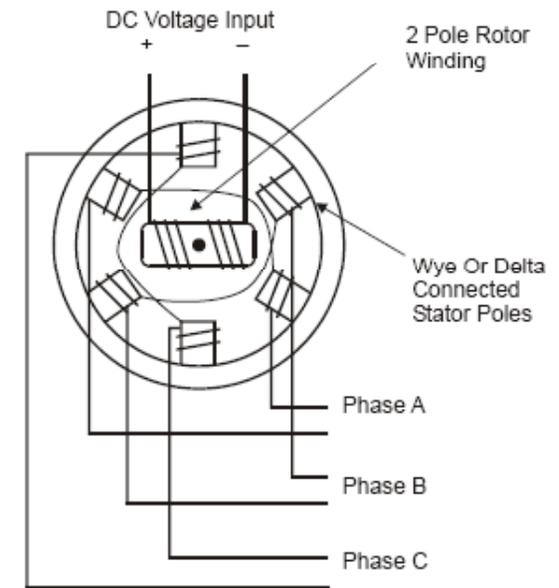
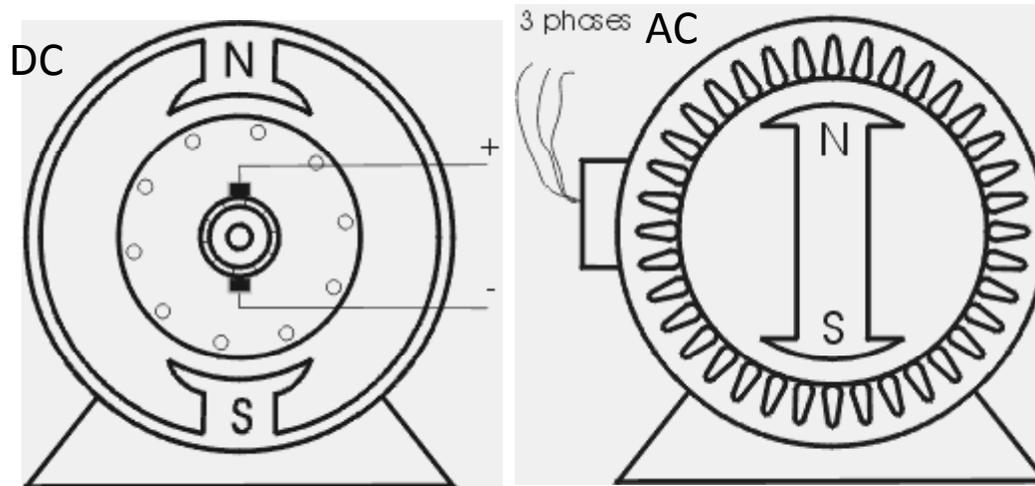


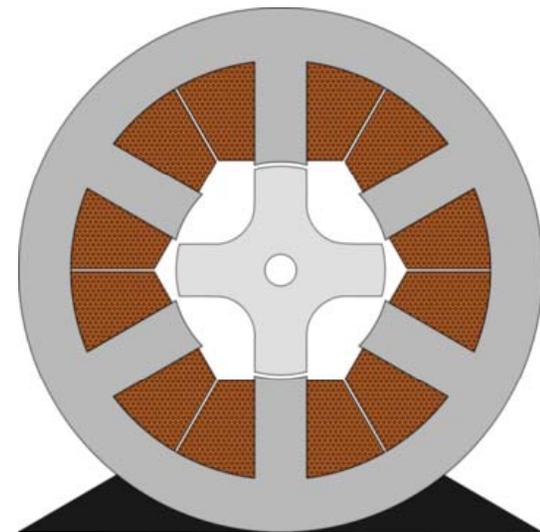
Figure 3-41. AC synchronous motor diagram

Dave Polka Chapter 3 of AC Motors: IEC Ratings

http://www.motcointernational.com/sy_motors.htm

Reluctance motors

1. **Reluctance motor:** A synchronous-induction motor. The rotor has salient poles and a cage so that it starts like an induction motor, and runs like a synchronous motor.
2. Uses soft magnet rotor that is magnetized by the application of current in the stator coils
3. The magnet is spun by a 3 phase AC motor with no rotor voltage
4. The gear teeth are designed to increase the magnetic flux driving the rotor while providing asymmetry that gives it the rotational acceleration
5. Permeability of the rotor provides a significant increase in inductive power
6. Full solution of Faraday's law with time and velocity dependence.



http://wapedia.mobi/en/File:Switched_reluctance_motor_6-4.svg

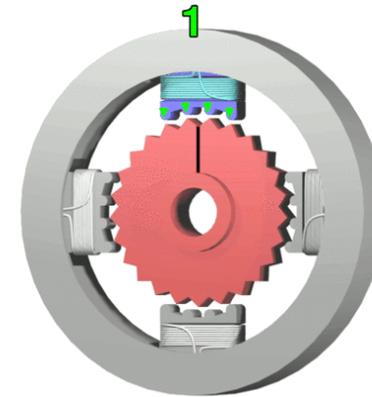
Other motors

1. **Reluctance motor:** A synchronous-induction motor. The rotor has salient poles and a cage so that it starts like an induction motor, and runs like a synchronous motor.
2. **Hysteresis motor:** hysteresis produces the torque, can be very tiny, used as the driver for electric clocks (Chapman, p.669).
3. **Stepper motor:** a special type of synchronous motors. Rotates a number of degrees with each electric pulse.
4. **Brushless DC motor:** a close cousin of a permanent magnet stepper motor with electronic controllers
5. **Universal motor:** If a series dc motor has a laminated stator frame, it can run effectively from an ac supply as well as dc, this is the universal motor.



Brushless DC
(actually a
pulsed AC
motor)

<http://en.wikipedia.org/wiki/File:Poles.jpg>



<http://upload.wikimedia.org/wikipedia/en/6/67/StepperMotor.gif>

Quiz Yourself

- Question: at the same power, W which has a higher efficiency, the synchronous motor or the induction motor?
- Sol: the synchronous motor, because the lack of brushes to connect the rotor of the induction motor makes its magnetic field run through an air gap, which has a much higher reluctance.