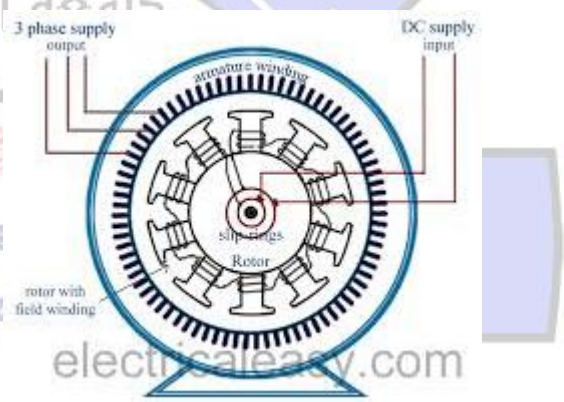
# AC Machines II

# Synchronous Machines

## 1-1 Introduction:

A synchronous machine is an A.C. machine in which the rotor moves at a speed, which bears a constant relationship to the frequency of the current in the armature winding. As a motor, the shaft speed must remain constant irrespective of the load, provided that the supply frequency remains constant. As a generator, the speed must remain constant if the frequency of the output is not to vary. The field of a synchronous machine is a steady one. In very small machines this field may be produced by permanent magnets, but in most cases the field is excited by a direct current obtained from an auxiliary generator, which is mechanically coupled to the shaft of the main machine.




## 1-2 Types of Synchronous Machines:

The armature or main winding of a synchronous machine may be on either the stator or the rotor. The difficulties of passing relatively large current at high voltages across moving contacts have made the stator wound armature the common choice for large machines. Stator-wound armature machines fall into two classes :(a) salient-pole rotor machines, and (b) non-salient-pole, or cylindrical-rotor, machines The salient-pole machine has concentrated field windings and generally is cheaper than the cylindrical-rotor machine when the speed is low, (less than 1,500 rev/min). Salient-pole alternators are generally used when the prime mover is a water turbine or a reciprocating engine. In the round or cylindrical rotor case, the held winding is placed in slots along the rotor length. The diameter is relatively small (I-1.5 m) and the machine is suitable for operation at high speeds (3000 or 3600 rpm) driven by a steam or gas turbine. Hence it is known as a turbo generator.

The frequency of the generated e.m.f, and speed are related by:
$F=np/60$
Where n is speed in rpm, and p is the number of pairs of poles.

A hydraulic turbine rotating at 50-300 rpm, depending on type. Thus needs many pole pairs to generate at normal frequencies.

**Synchronous machines can be categorized into several classifications:**

***According to the arrangement of the field and armature windings***, synchronous machines may be classified as ***rotating-armature type*** or ***rotating-field type***.

***Rotating-Armature Type:*** The armature winding is on the rotor and the field system is on the stator.

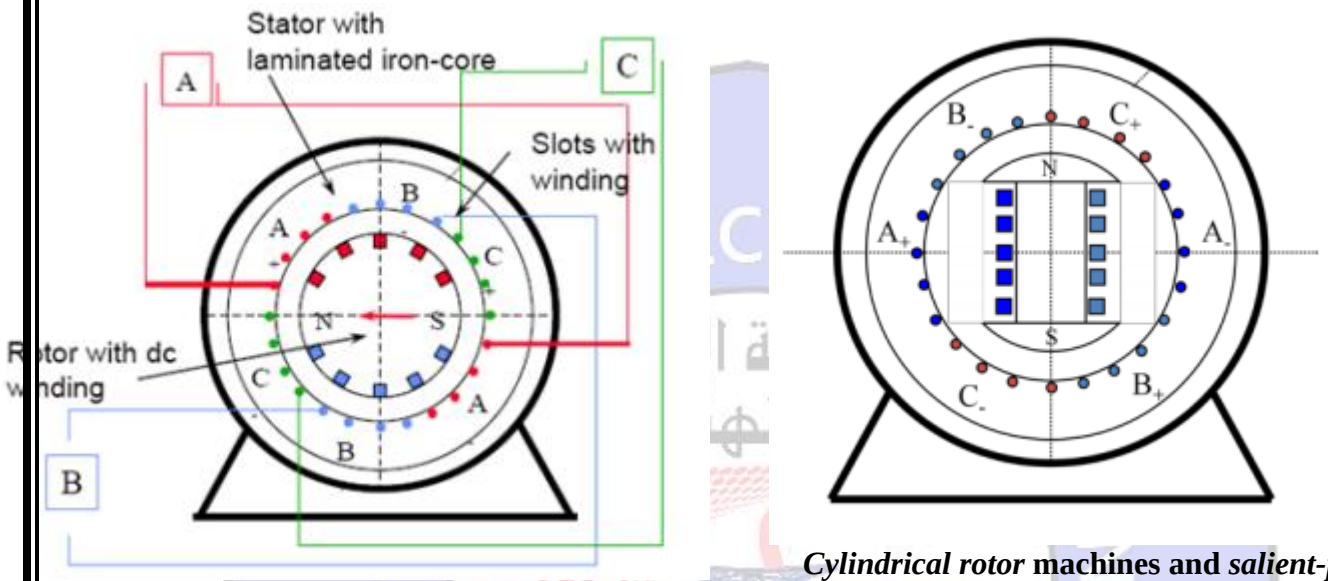
***Rotating-Field Type:*** The armature winding is on the stator and the field system is on the rotor.

**ADVANTAGES OF ROTATING FIELD OVER ROTATING ARMATURE**

1. As everywhere A.C. is used, the generation level of A.C. voltage may be higher as 11 kV to 33 kV.
2. This gets induced in the armature. For stationary armature large space can be provided to accommodate large number of conductors and the insulation.
3. It is always better to protect high voltage winding from the centrifugal forces caused due to the rotation. So high voltage armature is generally kept stationary.
4. This avoids the interaction of mechanical and electrical stresses.
5. It is easier to collect larger currents at very high voltages from a stationary member than from the slip ring and brush assembly.
6. The voltage required to be supplied to the field is very low (110 V to 220 V d.c.) and hence can be easily supplied with the help of slip ring and brush assembly by keeping it rotating.
7. The problem of sparking at the slip rings can be avoided by keeping field rotating which is low voltage circuit and high voltage armature as stationary.
8. Due to low voltage level on the field side, the insulation required is less and hence field system has very low inertia.
9. It is always better to rotate low inertia system than high inertia, as efforts required to rotate low inertia system are always less.
10. Rotating field makes the overall construction very simple.
11. With simple, robust mechanical construction and low inertia of rotor, it can be driven at high speeds. So greater output can be obtained from an alternator of given size.
12. If field is rotating, to excite it by an external d.c. supply two slip rings are enough. One each for positive and negative terminals.
13. As against this, in three phase rotating armature, the minimum number of slip rings required is three and cannot be easily insulated due to high voltage levels.
14. The ventilation arrangement for high voltage side can be improved if it is kept stationary.

15. Due to all these reasons the most of the alternators in practice use rotating field type of arrangement.
16. For small voltage rating alternators rotating armature arrangement may be used.

**According to the shape of the field**, synchronous machines may be classified as ***cylindrical-rotor* (*non-salient pole*) machines** and ***salient-pole machines***.




***Cylindrical rotor* machines and *salient-pole machines*.**

## According to the operation mod:

Synchronous Generator (Alternators)& Synchronous Motors