Chapter 10

AC MOTORS

Should an aircraft only be fitted with a DC electrical system, then only DC motors can be used. DC motors are particularly useful for high torque, variable speed and reversing functions.

Should an aircraft be fitted with an AC electrical system as its primary electrical supply, the designer will then have the option of using AC or DC motors depending on the amount of electrical power available and the function required.

All AC motors rely on electro-magnetic induction for their function. Usually AC motors are of the brushless type, which is preferred as brushes often produce sparking or arcing. As previously stated, brushes with commutators or slip-rings wear fairly rapidly and this increases the maintenance costs of these systems. There are two types of AC motors in general use on aircraft which are :

a). the squirrel cage induction motor, and

b). the synchronous motor.

A third AC motor, known as an AC series motor which is often used in electric drills and domestic appliances is not the subject of these notes.

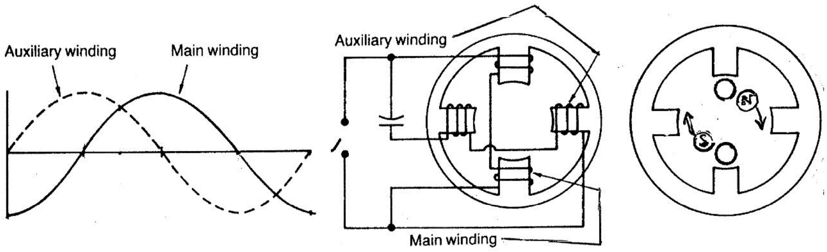
The squirrel cage induction motor and the synchronous motor use a similar field arrangement so before each device is considered, the field functionality needs to be discussed.

Stator Fields

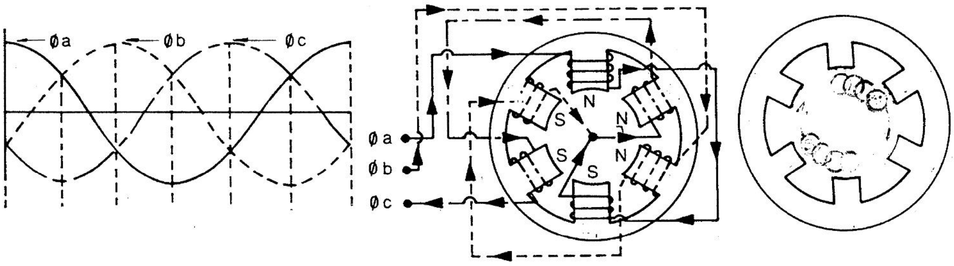
The stationary outer casing of the motor, contains the field coils wound around magnetic cores which focus the magnetic flux. The windings that remain stationary are referred to as the stator. The magnetic poles are formed in pairs and create north and south poles diametrically opposite when energized.

Fed with single phase AC, this field is not functional, as the AC causes each pole simply to alternate between north and south and there is no effective field rotation. To generate a rotating field, the stator windings need to be progressively wound in sets of two or three. When two sets are used, single phase AC can be supplied directly to one set and via a capacitor to the other set. Because the capacitor shifts the phase of the current by 90°of phase rotation angle, the second set of windings now forms its poles 90° after the first set and the field now effectively rotates.

This field is generated in two phases and is used in two phase or split phase motors. Should the stator be wound in sets of three windings, it can be supplied by three phase AC power.



TWO (SPLIT) PHASE ROTATING FIELD

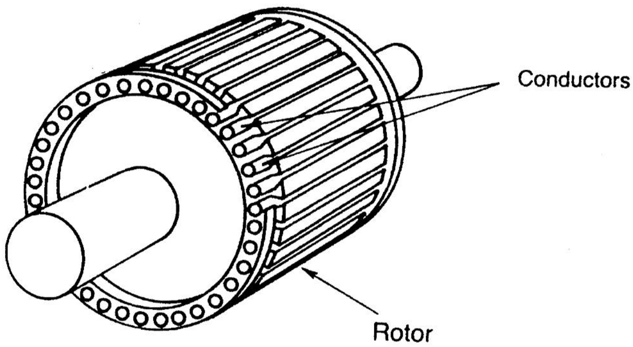


THREE PHASE ROTATING FIELD

The rotating stator field for both squirrel cage and synchronous motors as described, are similar. The rotors of these motors are quite different.

The Squirrel Cage Induction Motor

The rotor of this device is constructed of heavy conductive bars supported by conductive end plates. It appears similar in construction to a metal squirrel cage.



A SQUIRREL (POSSUM) CAGE INDUCTION MOTOR

When the rotor is placed inside the stator cavity and the AC is supplied to create the rotating field, an EMF is inducted into the bars of the squirrel cage and current circulates in the conductors, to form magnetic fields in the rotor. These induced magnetic poles react with the rotating field, causing the rotor to rotate.

For an induction motor to function, the speed of rotation of the rotor must be less than the rotation of the field. This is known as **slip** and is about 3% 'OFF LOAD' and up to 10% 'ON LOAD'. If the motor was to rotate at the field rotation rate, no induction would occur and the rotor reactive fields would not exist and it would slow until the field was re-induced

To understand the speed of the field rotation, and therefore the rotor RPM, the frequency and the number of pole pairs in the stator must be known. A domestic AC supply of 50Hz applied to a two pole stator would produce a flux rotation rate of 3000 RPM.

$$\frac{\text{frequency Hz x 60 seconds}}{\text{pole pairs}} = \text{RPM}$$

$$\frac{50 \times 60}{1} = 3000 \text{ RPM}$$

A four pole stator (2 pole pairs) on a 50 Hz supply would produce a field rate of:

$$\frac{50 \times 60}{2} = 1500 \text{ RPM}$$

This is the field synchronous rotation rate; a squirrel cage motor will not turn at this speed because it will have a significant slip rate. Aircraft constant frequency AC power is always regulated at 400Hz.

The synchronous flux rate for an eight pole (four pole pairs) induction motor with 5% slip will be:

$$\frac{400 \times 60}{4} = 6000 \text{ RPM } (-\ 300)$$

$$= 5700 \text{ RPM}$$

Three phase and single (split phase) squirrel cage induction motors are widely used in industry and aviation.

The use of **three phase** squirrel cage induction motors means a significantly greater amount of **power** is produced and consequently more torque is available than in a single phase motor. A three phase motor can also suffer the loss of one phase and will still continue to operate, but its speed will be reduced to about 60% of normal RPM.

Motor direction of rotation is easily controlled by switching the phase rotation. Three phase AC squirrel cage induction motors are often found in:

- fuel pumps
- hydraulic pumps
- auto pilot servos
- gyro rotors
- AC Actuators

Synchronous Motors

The rotating field principle and synchronous flux rate have been discussed. The rotor of a synchronous motor is a magnet or electromagnet strong enough to spin up to and 'lock' to the rotating field. When turning at the field rate it is said to synchronized and therefore rotates without slip.

Unfortunately, this motor will not self start, because the field rotates much too quickly to overcome inertia, and is easily physically over loaded. When over loaded it may stall and need restarting. Synchronous motors have limited application but are sometimes found on small air compressors that run continuously. They are low power devices.