

# Basic Induction (AC) Motor Operation

An AC motor has two basic electrical parts: a "stator" and a "rotor" as shown in Figure 8. The stator is in the stationary electrical component. It consists of a group of individual electro-magnets arranged in such a way that they form a hollow cylinder, with one pole of each magnet facing toward the center of the group. The term, "stator" is derived from the word stationary. The stator then is the stationary part of the motor. The rotor is the rotating electrical component. It also consists of a group of electro-magnets arranged around a cylinder, with the poles facing toward the stator poles. The rotor, obviously, is located inside the stator and is mounted on the motor's shaft. The term "rotor" is derived from the word rotating. The rotor then is the rotating part of the motor. The objective of these motor components is to make the rotor rotate which in turn will rotate the motor shaft. This rotation will occur because of the previously discussed magnetic phenomenon that unlike magnetic poles attract each other and like poles repel. If we progressively change the polarity of the stator poles in such a way that their combined magnetic field rotates, then the rotor will follow and rotate with the magnetic field of the stator.

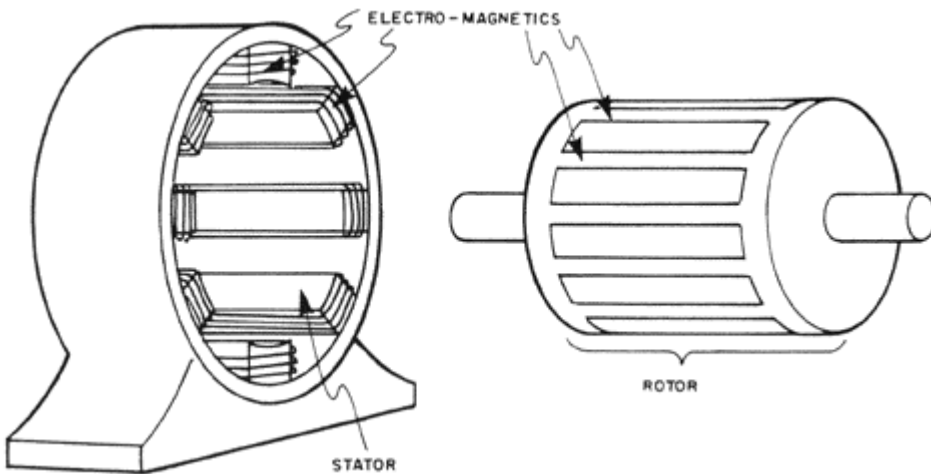


Figure 8 - Basic electrical components of an AC motor.

This "rotating magnetic fields of the stator can be better understood by examining Figure 9. As shown, the stator has six magnetic poles and the rotor has two poles. At time 1, stator poles A-1 and C-2 are north poles and the opposite poles, A-2 and C-1, are south poles. The S-pole of the rotor is attracted by the two N-poles of the stator and the N-pole of the rotor is attracted by the two south poles of the stator. At time 2, the polarity of the stator poles is changed so that now C-2 and B-1 and N-poles and C-1 and B-2 are S-poles. The rotor then is forced to rotate 60 degrees to line up with the stator poles as shown. At time 3, B-1 and A-2 are N. At time 4, A-2 and C-1 are N. As each change is made, the poles of the rotor are attracted by the opposite poles on the stator. Thus, as the magnetic field of the stator rotates, the rotor is forced to rotate with it.

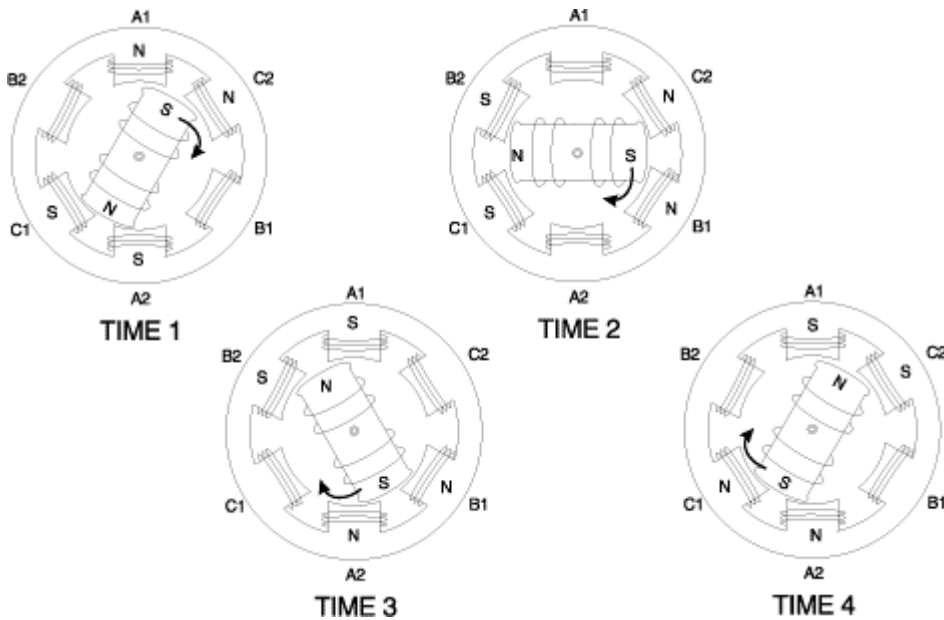


Figure 9 - The rotating magnetic field of an AC motor.

One way to produce a rotating magnetic field in the stator of an AC motor is to use a three-phase power supply for the stator coils. What, you may ask, is three-phase power? The answer to that question can be better understood if we first examine single-phase power. Figure 7 is the visualization of single-phase power. The associated AC generator is producing just one flow of electrical current whose direction and intensity varies as indicated by the single solid line on the graph. From time 0 to time 3, current is flowing in the conductor in the positive direction. From time 3 to time 6, current is flowing in the negative. At any one time, the current is only flowing in one direction. But some generators produce three separate current flows (phases) all superimposed on the same circuit. This is referred to as three-phase power. At any one instant, however, the direction and intensity of each separate current flow are not the same as the other phases. This is illustrated in Figure 10. The three separate phases (current flows) are labeled A, B and C. At time 1, phase A is at zero amps, phase B is near its maximum amperage and flowing in the positive direction, and phase C is near to its maximum amperage but flowing in the negative direction. At time 2, the amperage of phase A is increasing and flow is positive, the amperage of phase B is decreasing and its flow is still negative, and phase C has dropped to zero amps. A complete cycle (from zero to maximum in one direction, to zero and to maximum in the other direction, and back to zero) takes one complete revolution of the generator. Therefore, a complete cycle, is said to have 360 electrical degrees. In examining Figure 10, we see that each phase is displaced 120 degrees from the other two phases. Therefore, we say they are 120 degrees out of phase.

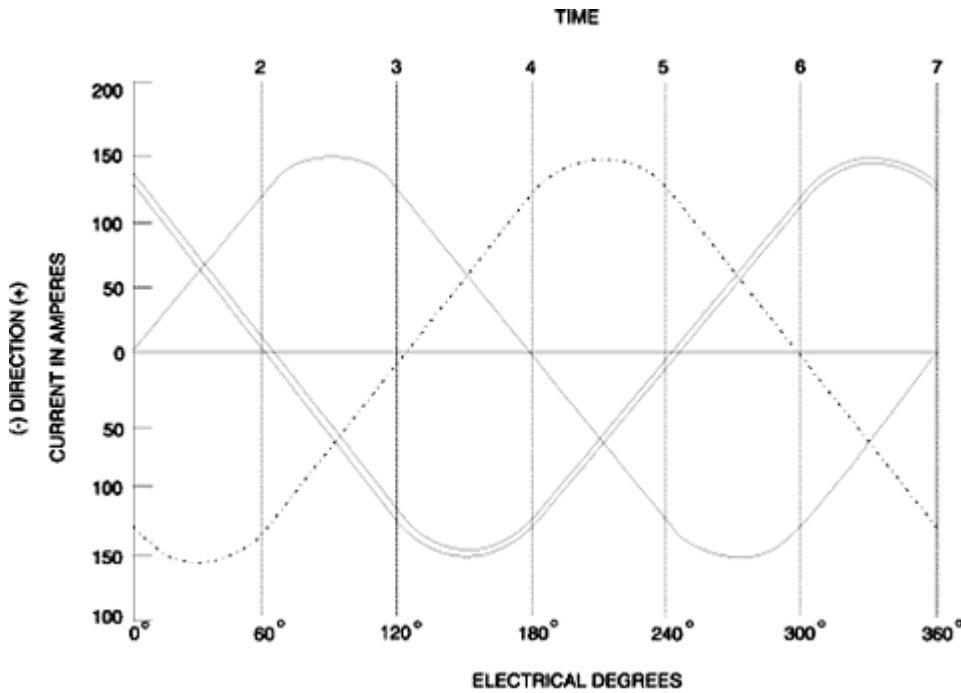


Figure 10 - The pattern of the separate phases of three-phase power.

To produce a rotating magnetic field in the stator of a three-phase AC motor, all that needs to be done is wind the stator coils properly and connect the power supply leads correctly. The connection for a 6 pole stator is shown in Figure 11. Each phase of the three-phase power supply is connected to opposite poles and the associated coils are wound in the same direction. As you will recall from Figure 4, the polarity of the poles of an electro-magnet are determined by the direction of the current flow through the coil. Therefore, if two opposite stator electro-magnets are wound in the same direction, the polarity of the facing poles must be opposite. Therefore, when pole A1 is N, pole A2 is S. When pole B1 is N, B2 is S and so forth.

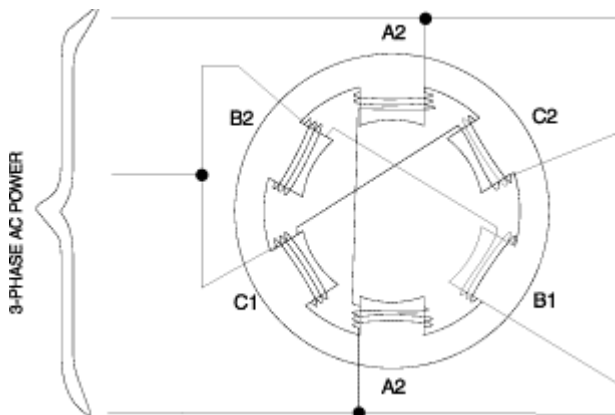


Figure 11 - Method of connecting three-phase power to a six-pole stator.

Figure 12 shows how the rotating magnetic field is produced. At time 1, the current flow in the phase "A" poles is positive and pole A-1 is N. The current flow in the phase "C" poles is negative, making C-2 a N-pole and C-1 is S. There is no current flow in phase "B", so these poles are not magnetized. At time 2, the phases have shifted 60 degrees, making poles C-2 and B-1 both N and C-1 and B-2 both S. Thus, as the phases shift their current flow, the resultant N and S poles move clockwise around the stator, producing a rotating magnetic field. The rotor acts like a bar magnet, being pulled along by the rotating magnetic field.

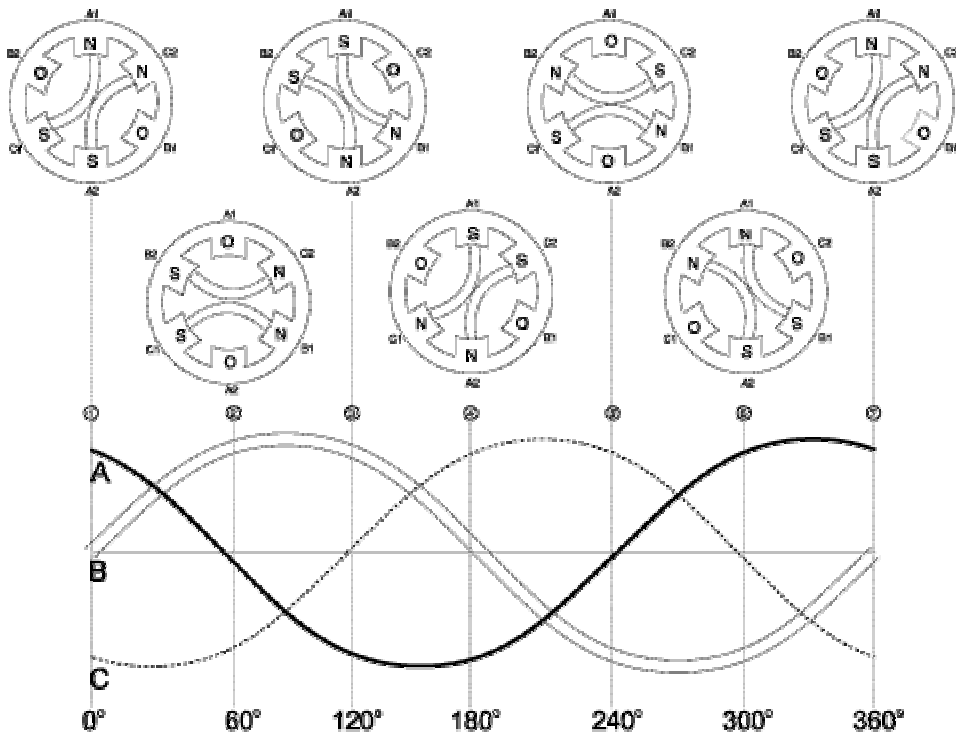


Figure 12 - How three-phase power produces a rotating magnetic field.

Up to this point not much has been said about the rotor. In the previous examples, it has been assumed the rotor poles were wound with coils, just as the stator poles, and supplied with DC to create fixed polarity poles. This, by the way, is exactly how a synchronous AC motor works. However, most AC motors being used today are not synchronous motors. Instead, so-called "induction" motors are the workhorses of industry. So how is an induction motor different? The big difference is the manner in which current is supplied to the rotor. This is no external power supply. As you might imagine from the motor's name, an induction technique is used instead. Induction is another characteristic of magnetism. It is a natural phenomena which occurs when a conductor (aluminum bars in the case of a rotor, see Figure 13) is moved through an existing magnetic field or when a magnetic field is moved past a conductor. In either case, the relative motion of the two causes an electric current to flow in the conductor. This is referred to as "induced" current flow. In other words, in an induction motor the current flow in the rotor is not caused by any direct connection of the conductors to a voltage source, but rather by the influence of the rotor conductors cutting across the lines of flux produced by the stator magnetic fields. The induced current which is produced in the rotor results in a magnetic field around the rotor conductors as shown in Figure 14. This magnetic field around each rotor conductor will cause each rotor conductor to act like the permanent magnet in the Figure 9 example. As the magnetic field of the stator rotates, due to the effect of the three-phase AC power supply, the induced magnetic field of the rotor will be attracted and will follow the rotation. The rotor is connected to the motor shaft, so the shaft will rotate and drive the connection load. That's how a motor works! Simple, was it not?

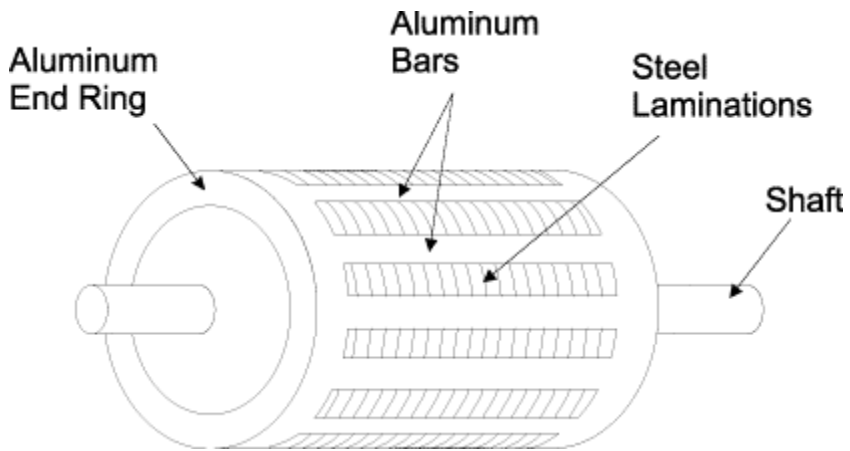


Figure 13 - Construction of an AC induction motor's rotor.

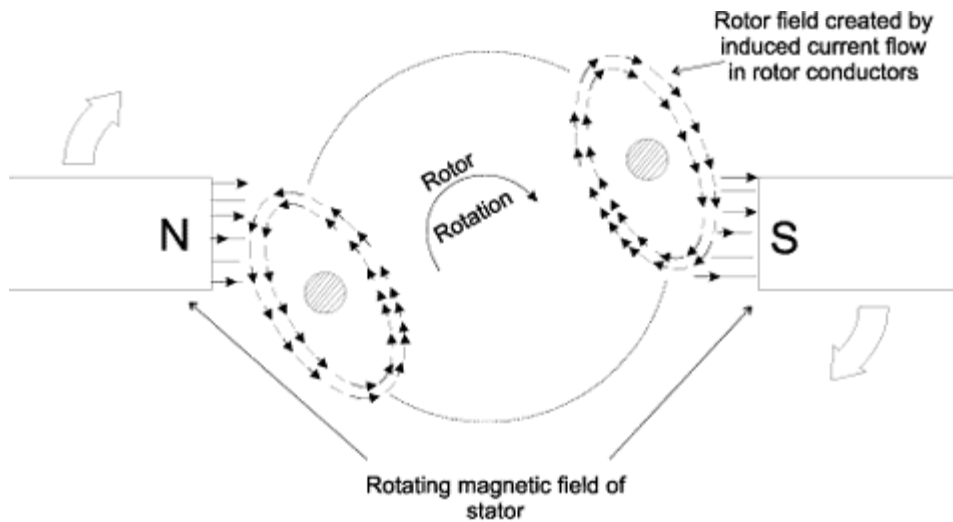


Figure 14 - How voltage is induced in the rotor, resulting in current flow in the rotor conductors.