Single Phase Induction Motor

In order for an induction motor to operate, we need to have a rotor with a short circuited winding inside a stator with a rotating magnetic field. The flux from the rotating field cuts through the rotor winding and induces a current to flow. The frequency of the current flowing is equal to the difference between the rotational speed of the stator field and the rotor. The rotor current causes a rotor magnetic field which is spinning relative to the rotor at the rotor current frequency and relative to the stator, at the same frequency as the stator field.

The interaction between these two magnetic fields generates the torque in the rotor. There must always be a small difference in speed between the stator field and the rotor in order to induce a current flow in the rotor. This difference in speed or frequency is known as the slip.

If we take a stator with a single winding, and apply a single phase voltage to it, we will have an alternating current flowing and thereby an alternating magnetic field at each pole. Unfortunately, this does not result in a rotating magnetic field, rather it results in two equal rotating fields, one in the forward direction and one in the reverse direction. If we have a short circuited rotor within the stator, it will carry rotor current induced by the stator field, but there will be two equal and counter rotating torque fields. This will cause the rotor to vibrate but not to rotate. In order to rotate, there must be a resultant torque field rotating in one direction only. In the case of the single winding and a stationary rotor, the resultant torque field is stationary.

If we now add a second stator winding, physically displaced from the first winding, and apply a voltage equally displaced in phase, we will provide a second set of counter rotating magnetic fields and the net result is a single rotating field in one direction. If we reverse the phase shift of the voltage applied to the second winding, the resultant magnetic field will rotate in the reverse direction.

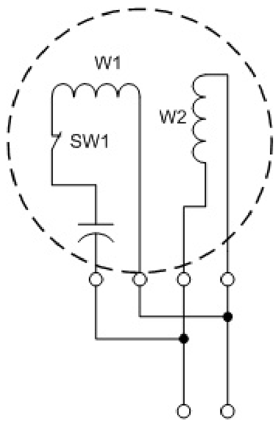
Once the rotor is up to full speed, it will continue to run with the second winding disconnected. This is because the rotor circuit is both resistive and inductive. If we consider the magnetic field rotating in the same direction as the rotor, the frequency of the current will be low, so the rotor current will be primarily limited by the rotor resistance. In the case of the counter rotating field, the frequency of the induced current will be almost twice line frequency and so the inductance of the rotor will play a much greater role in limiting the rotor current. In other words, once the motor is up to speed, it will lock on to one field only and the second winding can be disconnected. If the second winding remains in circuit, the displaced field reduces the magnetic fluctuations in the gap and therefore provides a more even torque and less vibration. Some "start" windings are only designed for intermittent operation and they must be disconnected at the end of the start. Continuous operation using these windings would cause a winding failure. Most single phase motors are fitted with a centrifugal switch to disconnect the start winding once the motor is close to full speed.

Capacitor Start

This configuration comprises two windings W1 and W2, a centrifugal switch SW1 and a capacitor.

The two windings are wound with a geometric offset, effectively making a second set of poles phase shifted within the stator. The capacitor provides phase shift to the current flowing in W1 and we therefore have a "two phase" motor while the switch is closed. When the motor is almost up to speed, the switch opens disconnecting W1 and the capacitor. The motor can be reversed by reversing the connections of either W1 or W2 (but not both!)

The start winding (W1) and the start capacitor provide for a rotating magnetic field in one direction enabling the motor to start.

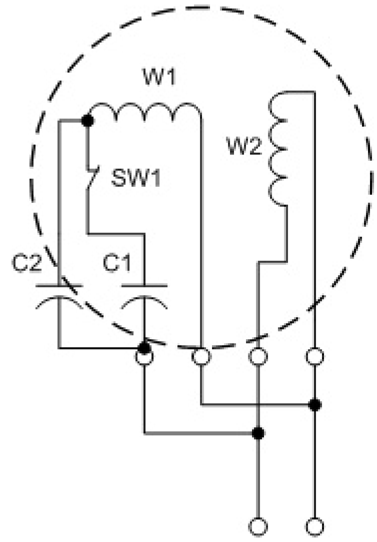


Capacitor Start Capacitor Run

This configuration comprises two windings W1 and W2, a centrifugal switch SW1 and two capacitors C1 and C2.

The two windings are wound with a geometric offset, effectively making a second set of poles phase shifted within the stator. The capacitors provide a phase shift to the current flowing in W1 and we therefore have a "two phase" motor. When the motor is almost up to speed, the switch opens disconnecting the capacitor C1. C2 remains in circuit to provide a continued second phase, reducing torque pulsations and noise. The motor can be reversed by reversing the connections of either W1 or W2 (but not both!)

The start winding (W1) and the capacitors provide for a rotating magnetic field in one direction enabling the motor to start.

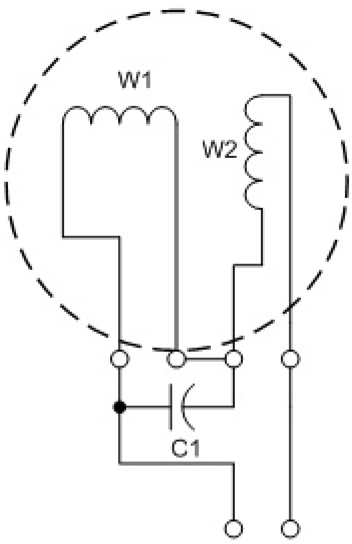


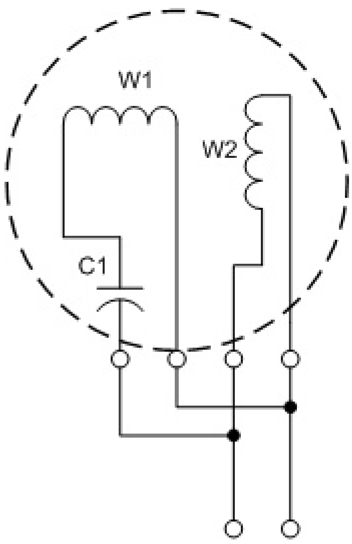
Capacitor Start/Run

This configuration comprises two windings W1 and W2 and a capacitor C1.

The two windings are wound with a geometric offset, effectively making a second set of poles phase shifted within the stator. The capacitor provides a phase shift to the current flowing in W1 and we therefore have a "two phase" motor. C1 remains in circuit to provide a continued second phase, reducing torque pulsations and noise. The motor can be reversed by reversing the connections of either W1 or W2 (but not both!)

The start winding (W1) and the capacitor provide for a rotating magnetic field in one direction enabling the motor to start.



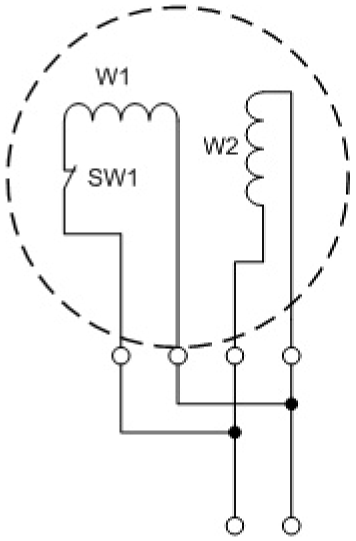


Induction Start (Split Phase)

This configuration comprises two windings W1 and W2 and a centrifugal switch SW1.

The two windings are wound with a geometric offset, effectively making a second set of poles phase shifted within the stator. The winding W1 has resistance to provide a phase shift to the current flowing in W1 and we therefore have a "two phase" motor while the switch is closed. The motor can be reversed by reversing the connections of either W1 or W2 (but not both!)

The start winding (W1) provides for a rotating magnetic field in one direction enabling the motor to start.



Reference:

http://www.lmphotonics.com/single_phase_m.htm