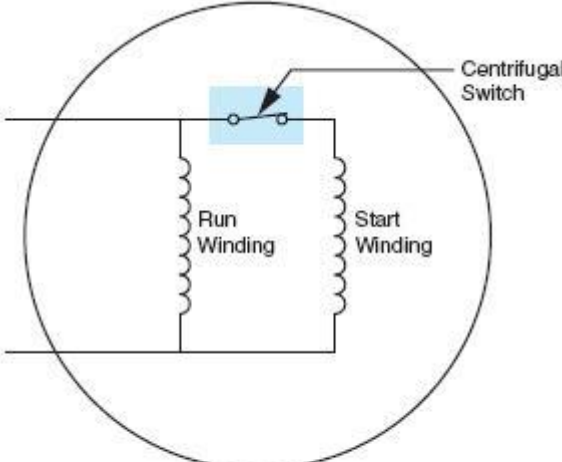
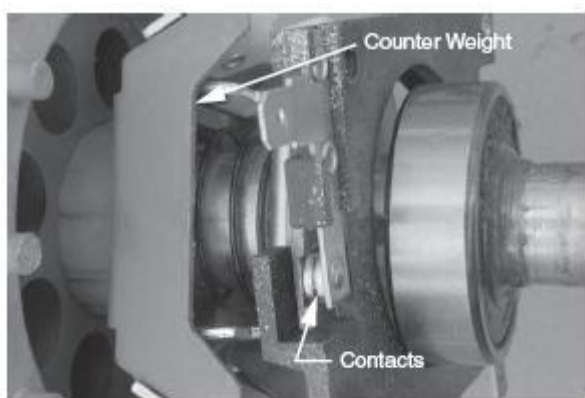
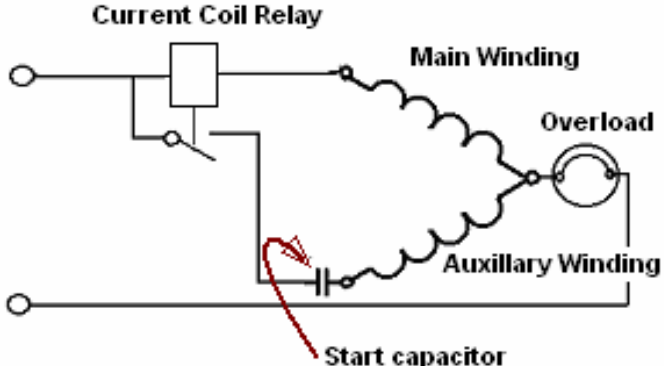


Refrigeration and Air Conditioning Motor Types

Compressor Starting Matrix	Motor Type	Overload Protector	Starting Device			Capacitors	
			Current Relays	Voltage Relays	PTC	Start	Run
	Split phase Induction Motor (RSIR)	Yes	Yes		Yes		
	Cap Start Induction Run (CSIR)	Yes	Yes			Yes	
	Resistance start Cap run motor (RSCR)	Yes			Yes		Yes
	Permanent Split Capacitor (PSC)	Yes					Yes
	Cap start Cap run CSCR	Yes		Yes		Yes	Yes
	Three phase motor (3Φ)	Yes					

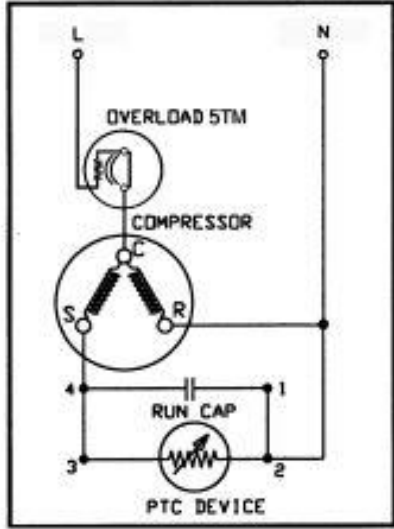
Type	Starting Device	Wiring diagram / Sample
Split Phase induction motors Resistance Start Induction Run (RSIR)	Current Relay or Solid State Small motors with low starting torque – ideal for capillary systems where system pressure equalizes on the off cycle.	

<p>Resistance Start Induction Run (RSIR)</p> <p>Vacuum pump motor</p>	<p>In non-hermetically sealed motors, the start winding is generally disconnected with a centrifugal switch. The contacts of the centrifugal switch are connected in series with the start winding. When the motor is at rest or not running, the contacts of the centrifugal switch are closed and provide a circuit to the start winding. When the motor is started and reaches about 75% of its rated speed, a counterweight on the centrifugal switch moves outward because of centrifugal force, causing the contacts to open and disconnect the start winding from power. The motor continues to operate on the run winding.</p>	<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>Figure 11-7 The centrifugal switch contacts are connected in series with the start winding. (Source: Delmar/Cengage Learning)</p> </div> <div style="text-align: center;">  <p>Figure 11-6 A centrifugal switch is used to disconnect the start windings when the motor reaches about 75% of rated speed. (Source: Delmar/Cengage Learning)</p> </div> </div>
<p>Capacitor Start Induction Run (CSIR)</p> <p>Current start relay and start capacitor</p>	<p>The start capacitor is connected to the start winding in the motor</p> <p>The motor starts using both windings, but as the motor in the CSIR system comes up to speed, the relay removes the start winding and the start capacitor from the circuit. This happens in about one-third of a second, and the motor then runs on the run winding alone with no capacitor.</p>	

Resistance Start Capacitor Run (RSCR)

Run cap stays in circuit after start up.

Similar to RSIR motor version but has a PTC solid state starting device and permanent connected run capacitor to improve efficiency.



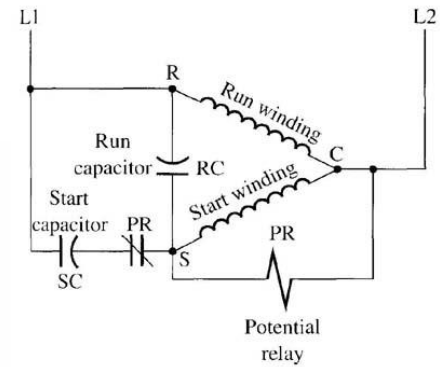
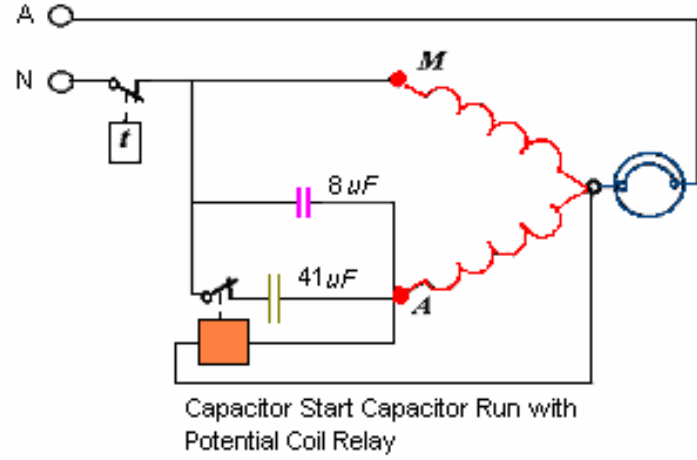
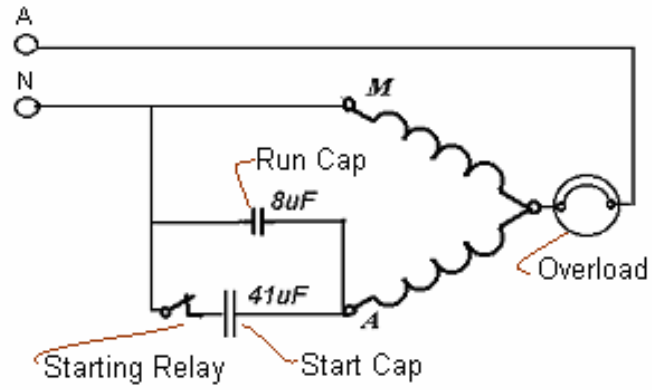
Capacitor Start Capacitor Run (CSCR)

Potential relay and adds a run capacitor to the start capacitor, which provides the motor with better torque characteristics when the motor is operating at full speed. The capacitor start, capacitor run motor is used primarily in starting large single-phase hermetic compressors

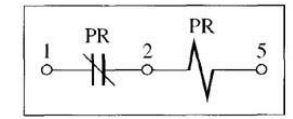
Prior to the motor's start, both the start and run capacitors are connected to the start winding.

Once again, the motor in the CSCR system reaches operating speed in about one-third of a second.

And once again, the start capacitor is removed from the circuit, just as in the CSIR motor. In this case, however, the run capacitor and the start winding remain in the circuit, and the motor runs using both windings.



(a) Diagram of potential relay connected to a capacitor start, capacitor run motor



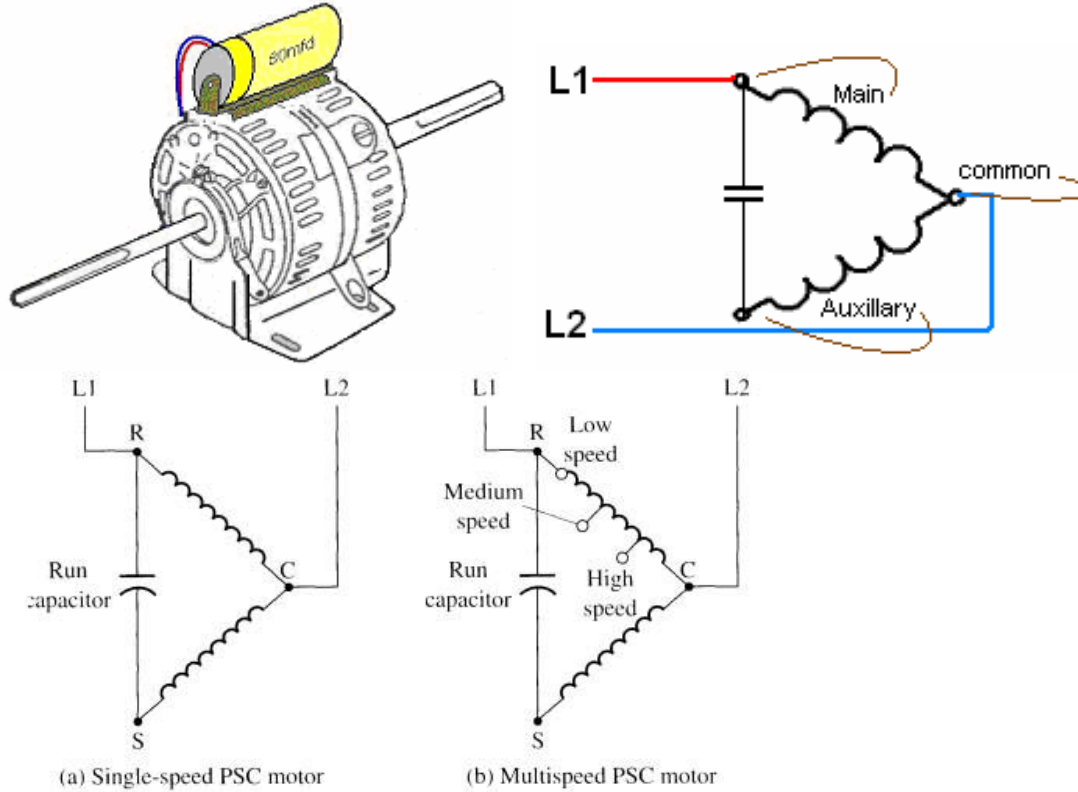
(b) Diagram of potential relay

Permanent Split Capacitor (PSC)

Single winding
- no relay, low torque

The permanent split-capacitor (PSC) motor uses only a run capacitor in parallel with the windings to provide the phase shift required to start the motor.

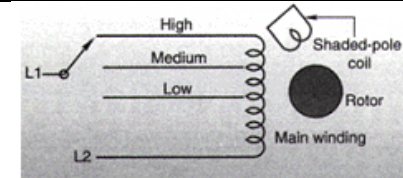
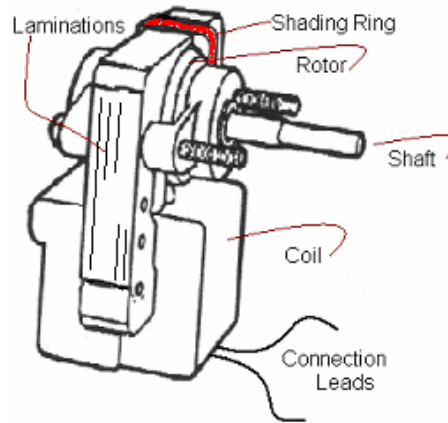
Commonly used as evaporator fans in ducted AC units.



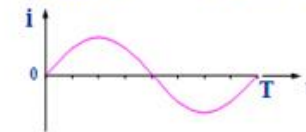
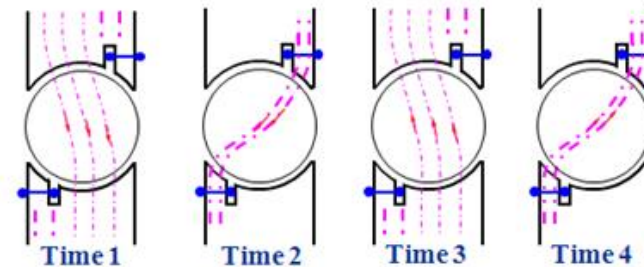
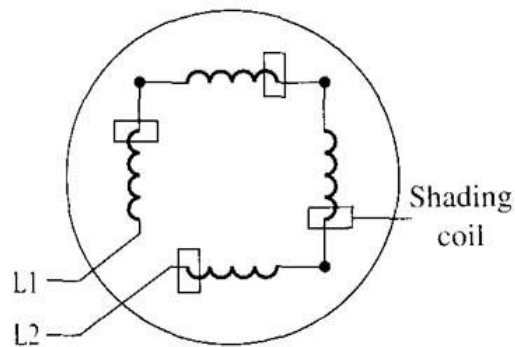
Shaded Pole

Commonly found in applications that require light-duty fans such as small window air conditioners, evaporators and exhaust fans used in rest rooms.

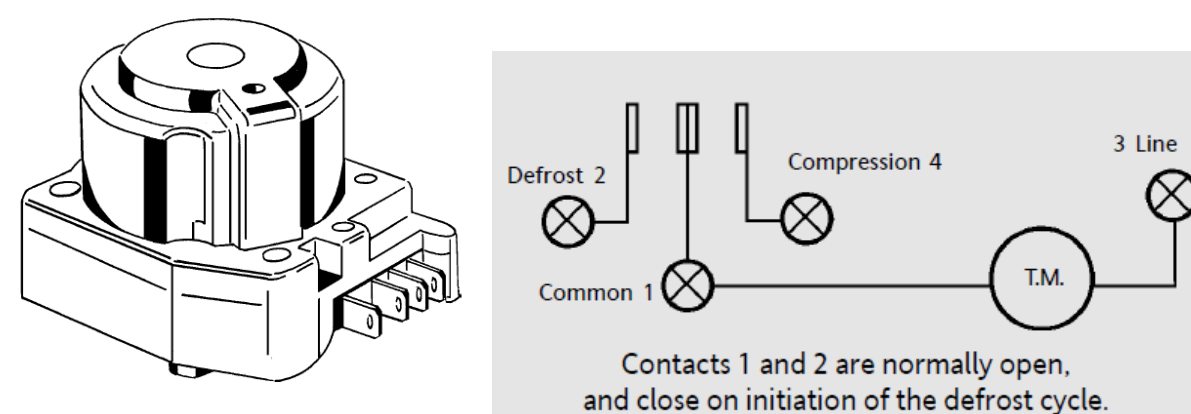
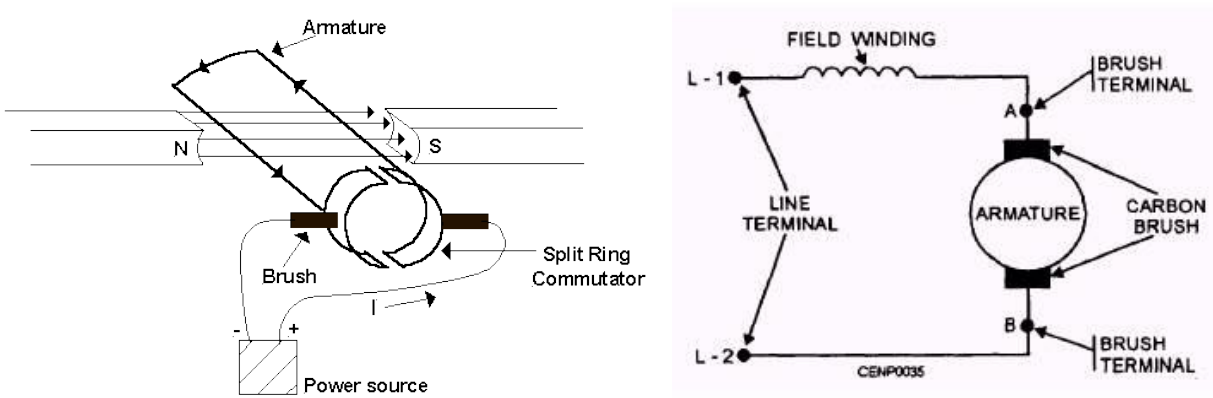
Note that the motor has only one winding. It doesn't have a start winding and a run winding like other single-phase motors.

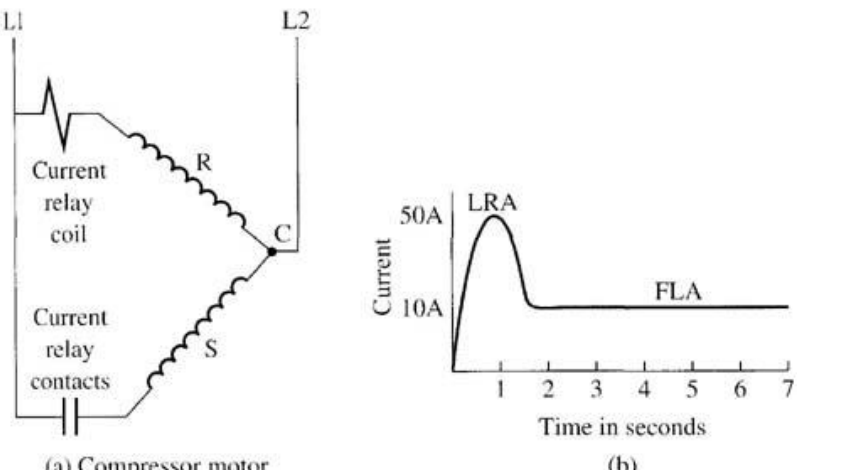

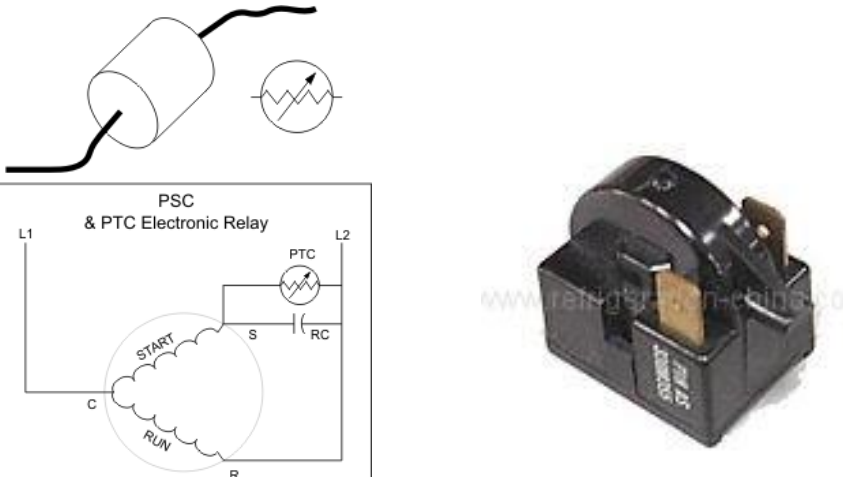



Shaded pole motor. Can be single-speed, or tapped multispeed as shown here. Electrically and mechanically simple, it is inexpensive, but has poorest efficiency and starting torque. Best uses are usually household rather than industrial.



johnsonmotor.com

<p>Synchronous</p>	<p>When using fixed frequency AC these motors maintain constant speed and are therefore used in clocks and other devices requiring a constant rate of rotation</p> <p>Defrost Timers are designed to control the defrost cycle of a refrigerator or a freezer</p>	 <p>http://www.toolbox.invensyscontrols.com/appliance/linkedElements/DefrostTimers.pdf</p>
<p>Universal (commutator)</p>	<p>ac or dc Universal motors are used in vacuum cleaners, sewing machines, food mixers and portable tools.</p>	 <p>http://www.tpud.com/ceb/109.htm</p>

<p>Current Relays</p>	<p>In series with the run winding and operates a set of contacts in the start winding.</p> <p>The high current at start up energises the coil to close the contacts and allow current to flow through the start winding</p>	 <p>(a) Compressor motor</p> <p>(b)</p>	
<p>Positive Temperature Co-efficient (PTC) Relays</p>	<p>A PTC solid state starting device is placed in series with the start winding and normally has a very low resistance.</p> <p>On startup, as current starts to flow to the start winding, the resistance rapidly rises to a very high value thus reducing the start winding current to a trickle and effectively taking that winding out of operation.</p>	 <p>PSC & PTC Electronic Relay</p>	

http://www.hvacinfo.com/Tecumseh_bulletins/compressor.pdf

3 Phase Motors

Wiring Diagrams and connections

- excellent starting torque
- a wide operating voltage range
- no ancillary starting devices (relays, capacitors)

Reduced starting load on any individual phase, and minimal impact on nearby lighting, etc. The use of a three phase compressor may be essential to comply with local regulations relating to starting current limits. A suitable contactor, preferably incorporating thermal protection, is necessary to switch a three phase compressor. A three phase reciprocating compressor is designed to run in either direction, therefore phase connections can be made in any sequence

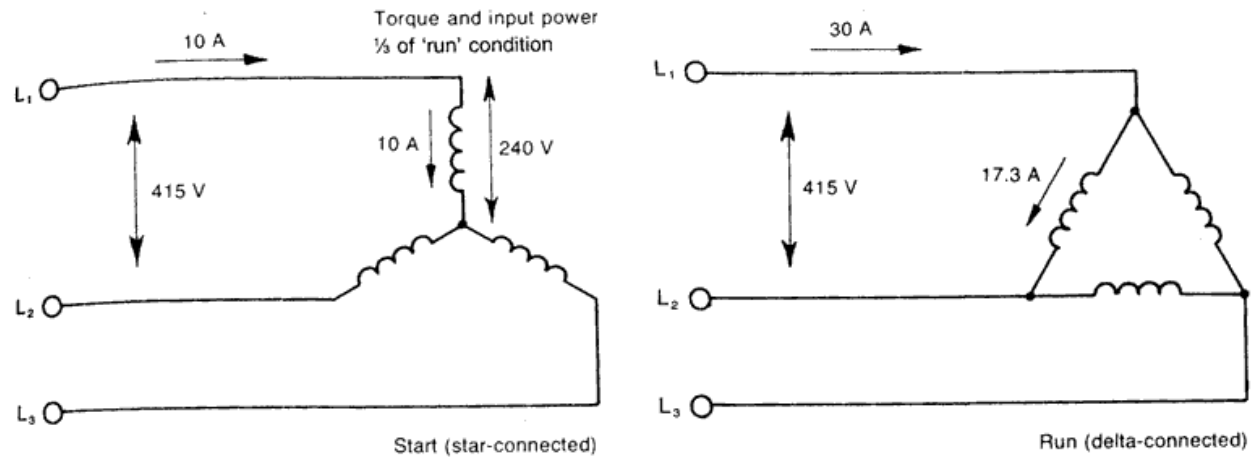
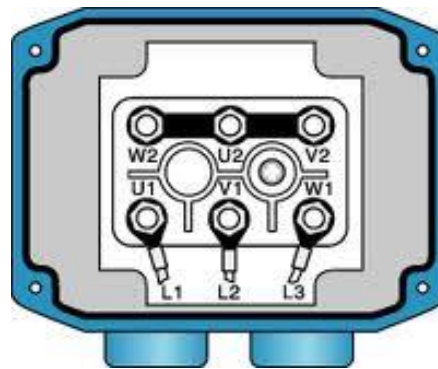
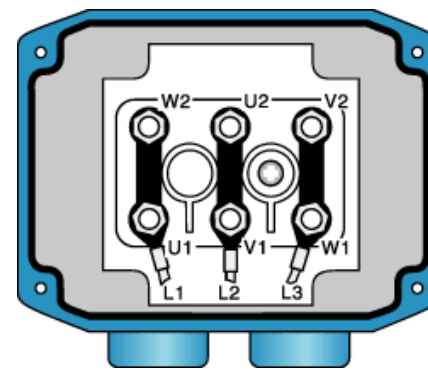


Fig. 13.1 Comparison of star and delta starting

patchn.com



Star Connection



Delta Connection (<http://www.johnson-pump.com/Horticulture/quickstart-motor.htm>)

$$n \text{ (rpm)} = \frac{120f}{p}$$

Single phase motor speed formula:

Where n is the synchronous speed in rpm, f is the frequency of applied voltage in hertz, and p is the number of poles in the stator.

Windings

The Start winding which is high resistance and low inductance made for thin wire, and the Run winding which is low resistance and high inductance made for thick wire. The 2 windings are set skewed about 30 degrees on a twist.