the difference between

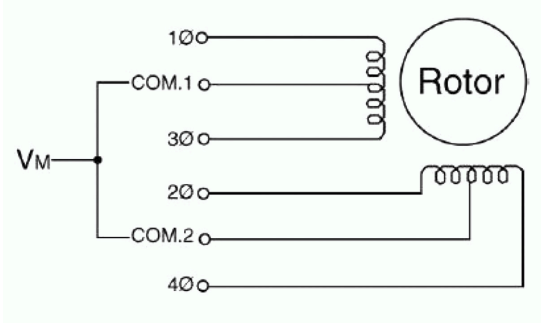
THE DIFFERENCE BETWEEN:

Unipolar and Bipolar Windings on Rotary Stepper Motors

STEPPER MOTORS convert electric pulses into mechanical movement in stepped increments. The rotation has a direct relationship with the applied pulses. The *sequence* of the pulses dictates the direction of the motor shaft rotation, the *frequency* of the pulses dictates the speed of the shaft rotation, and the *number* of input pulses applied is directly related to the distance of rotation.

There are many advantages to using stepper motors. Among others, they have full torque at standstill, offer excellent response to starting and stopping, and provide open loop control. Stepper motors also have step accuracies of between 3% and 5% of the step, which provides precise positioning and repeatability of movement. These features make it possible to achieve very slow speed synchronous rotation with a load directly coupled to the shaft—ideal for positioning applications such as laboratory operations where samples are dispensed to specific requirements, as well as pick-and-place operations.

Two-phase stepper motors are the most common type. They operate by alternating the magnetic field the windings produce by changing the direction of the current in the windings. Thus, attracting or repelling the magnetic poles of the rotor causes it to rotate in step with the incoming pulses. This changing of the direction of the current happens at one-quarter the frequency of the pulses driving the motor electronics.



1. A unipolar stepper motor is one where each phase has a center tap.

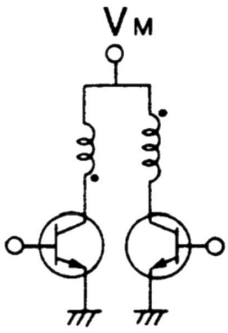
Two-phase steppers come in unipolar and bipolar versions. These each offer specific advantages and disadvantages for your application. This Difference Between article will further explain how these motors work and where they are best used.

Unipolar Stepper Motor Design

Unipolar stepper motors are wound using a single winding with a center tap for each phase *(Fig. 1)*. The typical arrangement is for there to be three leads per phase and six leads for the standard two-phase stepper motor. However, the center taps are sometimes tied together on the two phases, resulting in a five-wire motor arrangement.

By connecting a power source to the center tap and one end of the winding to the ground, current will flow one direction. Connecting the other end of the winding to the ground will cause the current to flow the opposite direction. Thus, the name Unipolar, which indicates that current is designed to flow one direction through each winding. This winding design does not require the current for one direction to fully decay before changing the current flow direction. As a result, the current flow and, in turn, the magnetic field are able to switch directions very quickly. The upshot is that the Unipolar winding is very good for high-speed applications.

Driving a Unipolar stepper motor is fairly straight-forward and simple. The center taps are connected to power and each of the motor



2. A typical drive electronics for a Unipolar stepper motor: a single MOSFET transistor is connected to each end of the phase and the center tap is connected to power.

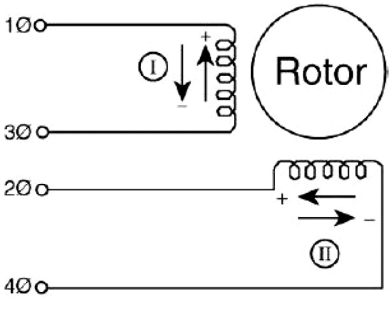
phases is connected to ground via a MOSFET transistor *(Fig. 2)*. As such, the Unipolar winding only requires 4 transistors to run the motor. This allows the drive circuit to be very simple.

Bipolar Stepper Motor Design

Bipolar stepper motors are designed so that there is only a single winding per phase *(Fig. 3)*. The typical arrangement is for there to be two leads per phase and four leads for the standard two-phase stepper motor.

Since there is only one winding, the current in the winding will need to be reversed so the magnetic field can be reversed. The name Bipolar comes from the fact that the current must flow in both directions through the windings. Since the current in one direction must fully decay before full current can be applied in the opposite direction, Bipolar motors are limited to a lower speed when compared to Unipolar motors.

A drive circuit called an H bridge,



3. Bipolar stepper motors incorporate only one winding per phase.

which uses four MOSFET transistors *(Fig. 4),* is required to allow the current to pass both directions through a winding. Since two H bridges are required to drive a Bipolar motor, eight MOSFET transistors are needed per motor, which is twice that of a Unipolar motor. Integrated circuits with single and dual H bridges are available, making the drive circuit design simple.

One of the major benefits of a Bipolar stepper motor is that they provide more torque at low speeds when compared to Unipolar stepper motors. This means that Bipolar stepper motors are best suited for applications that require high torque at low speeds.

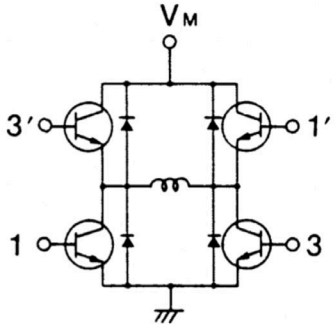
Additional Stepper Motor Considerations

As you can surmise based on the motor design elements mentioned above, compatibility between the motor and the driver are critical factors in any design. As such the popularity of a type of winding in your region, and thus the availability of supporting drivers, will be a factor in your selection.

Because of how these motors move in steps—whether standard stepping or microstepping—their operation appears "stiff" as it jumps from one step to the next. Adjusting microstepping rates to the motor can provide a smoother operation but also affects torque outputs. Therefore, tradeoffs between torque and speed in a stepper motor can become a major consideration during the design process.

Applications

Although stepper motors can operate in closed-loop applications, they are most often used in open-loop configurations. Because stepper motors offer high repeatability without a feedback loop, they are used in a lot of medical devices, including imaging machinery and laboratory automation applications. Stepper motors are also used in robotics systems, 3D printing machines, textile machines, CNC milling machines, welding equipment, and much more. The simplicity of implementing stepper motors into a design make them ideal for a broad range of applications.



4. Bipolar stepper motors use H bridge drivers to allow current to flow both directions through the winding.