Brushless DC Motors Roll On

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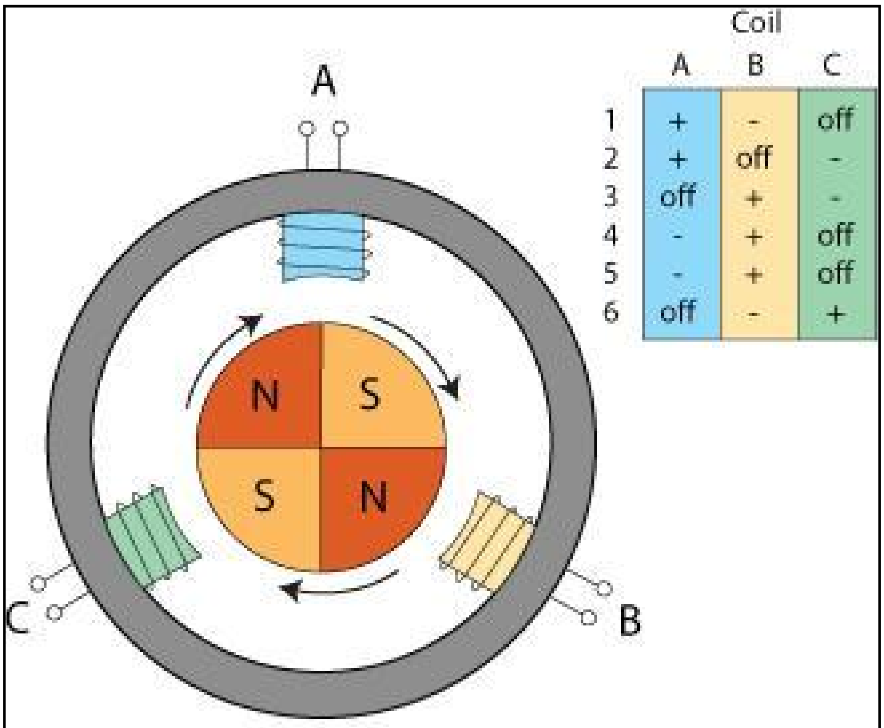
Before you use a BLDC motor, you should understand how it works.

You can find brushless-DC motors in appliances, medical instruments, and industrial equipment because they offer advantages over their brushed-DC-motor siblings. But before you can use a brushless-DC (BLDC) motor you need to understand how it works, and that leads to a quick review of DC-motor construction.

A brushed-DC motor relies on coils of wire on a rotor, and a rigid motor frame--or stator--that positions permanent magnets around the rotor. Current through the windings creates a magnetic field that either attracts a winding to a magnet or repels it from a magnet. Contacts on the rotor, and brushes on the stator select the windings to power as the rotor turns.



Six commutation phases "move" the electromagnetic field, which causes the permanent magnets on the rotor to move the motor shaft.

In a BLDC motor the rotor provides the permanent magnets and the coils form the outside of the motor. Again, attraction and repulsion of the permanent magnets and the coils causes the rotor to spin. But in a BLDC motor, no commutation occurs on the spinning shaft.

Although BLDC motors cost more than their brushed-DC relatives, they offer advantages. The external coils better dissipate heat than those on a rotor. BLDC motors have no brushes or commutators to wear out or require regular maintenance, so they can operate unattended for long times. And BLDC motors do not generate electromagnetic interference (EMI) from mechanical commutators.

Instead of using a mechanical commutator, BLDC motors use electronic commutation to switch coils on or off. This type of commutation falls into two categories: sensor-based or sensorless.

In a sensor-based motor, Hall-effect sensors placed within a motor's coils senses the location of the rotor's permanent magnets. A microcontroller (MCU) reads the sensors' states and uses an algorithm to determine which coils to power and when. On the other hand, a sensorless motor requires that an MCU measure the back electromotive force (EMF) generated across the coils by the magnets on the spinning rotor. The back EMF (BEMF) determines the positions of the magnets.

The sensorless technique faces a challenge, though, because a controller also must power the coils in sequence to cause the motor to turn (see Figure). So, how can you separate the pulse-width modulation signals that drive the coils from the back EMF signals? You program the MCU to filter out the high-frequency PWM signals and measure the back EMF close to the time when the PWM signals cross through zero

Volts. The back EMF depends on many factors, such as the strength of the magnets on the rotor, the number of windings in the coils, resistance of the coils, and so on.

According to an application note from Renesas, in a typical sensorless BLDC motor, when one phase crosses neutral, the other two phases are at equal and opposite voltages, so you can detect the zero crossing point on one phase [coil] when its measured voltage [back EMF] is exactly in the middle of the drive voltages for the other two coils.

Don't let the complexity of the back-EMF technique deter you from investigating this commutation mode. Many MCU vendors such as Renesas, Luminary Micro, and Microchip have ready-to-use development kits as well as sample code for sensor-based and sensorless BLDC-motor investigations. So, control algorithms already exist and might require only a bit of fine tuning on your part.

Each type of BLDC motor has advantages and disadvantages. During a recent conversation with Scott Eckles, an application engineer, and Mike Moore, director of marketing at Emerson Electric's Hurst Division they offered the following points.

If a motor will operate at high temperatures, it may exceed the temperature ratings of Hall-effect sensors, and Hall-effect sensors might not operate reliably in the presence of high ambient magnetic fields. Eliminating sensors also reduces the number of connections with a motor. Consider sensorless commutation for applications that require a constant speed.

In high-torque applications, a sensor-based BLDC motor can provide full torque right away because the sensors "know" the location of the rotor at power up. The BEMF technique needs a slight movement of the rotor to generate a back EMF signal and let the MCU locate the rotor. Thus you must accept some rotor "jitter" and a short delay in rotation at power-up of a sensorless BLDC motor.

Use the BEMF technique in light-load applications that don't require accurate positioning. When you have a motor application that requires accurate positioning, typically the sensor-based approach provides better results than the back_EMF technique. So, if you must move an apparatus to a specific location, use a BLDC motor with Hall-effect sensors.

For further reading

"Driving of a 3-phase BLDC Motor by 120-Degree Trapezoidal Wave Commutation using Hall sensors," Application Note REU05B0074-0101. Renesas, tinyurl.com/knflw4.

"AVR492: Brushless DC Motor Control using AT90PWM3/3B," Atmel, tinyurl.com/2hruvn.

"Brushless DC (BLDC) Motor Fundamentals," AN885. Microchip, tinyurl.com/nqp73v.