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Brushless Motor Commutation Methods Comparison
Hall Effect verses Electro-Motive Force (EMF) Sensing

Introduction

This paper compares the difference between Hall Effect commutation and BEMF commutation when used to operate a BLDC motor.

Hall Sensor Commutation

The "hall effect principle" named after physicist Edwin Hall and discovered in 1879.

Mr. Hall, through arduous research found when a conductor with current flowing in one direction, and placed perpendicular to a magnetic field a voltage measures across the conductor. Advancements in semiconductor materials such as indium arsenide in the 1950's led to the first useable hall effect sensors. In the 1960,'s further development led to combinations of hall elements and integrated amplifiers. [1]

Hall sensors when placed in a permanent magnet field exhibited by a BLDC motor provide position feedback to the controller. This feedback enables the controller to switch the coils in sequence, and rotate the motor creating torque. Hall sensor commutation is not dependent on the motor BEMF feedback signal.

The hall sensors are not noise sensitive. This method of commutation requires an algorithm to determine which coils to power and when. Because the algorithm does not incorporate a BEMF signal, it is much simpler when compared to a sensor less commutated motor. Motor response relative to load variation and speed is less sensitive compared to sensor less commutation.

Hall Effect sensors have temperature limitations high temperature rated hall switches operate within -55C to +175C range. In addition, hall sensors might not operate reliably in the presence of a high ambient magnetic field.[2]

BEMF Commutation

BEMF commutation (sensor less) emerged in the 1990's due to advancements in microprocessors and software technology. This type of commutation is dependent on software programming integrating the sine wave signal generated by the motor as the means of position feedback. Enabling the controller to sense magnet position on the rotor and switching on the motor coil.

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Sensor less commutation involves reconstruction of the BEMF signal using an algorithm. The challenge of sensor less commutation is to reconstruct the BEMF signal in such a way enabling the signal to represent rotor position where PWM signal overlay the BEMF signals. The sensor less technique requires the controller to power the coils in sequence and commutate the motor coils essentially at the same time as sensing the magnet position.

The microprocessor programs to filter out high frequency PWM signals and measure the BEMF signal close to the time when the PWM signal crosses through zero volts. When one phase crosses neutral, the other two phases are at equal and opposite voltages, so the zero crossing point detects on one phase when the BEMF is exactly in the middle of the drive voltages of the other two coils.[3] The polarity of BEMF signal changes within the motor coil that is perpendicularly oriented to the rotor. The microprocessor uses this feedback to turn on the coil and rotate the motor.

Noisy signals used to determine the rotor position lead to commutation faults. Avoiding noise by signal conditioning or filtering by the software doing the commutation.[2] With the right signal conditioning BEMF commutation becomes as simple as hall effect commutation. The challenge is tweaking the motor and controller to operate within the system.

Magnet strength, number of windings in the coils, resistance, and inductance all influence the BEMF signal while the motor operates.

Conclusion

Hall Effect and BEMF commutation techniques are effective methods of switching motor coils and each has its advantages. In high torque applications, a sensor based BLDC motor can provide full torque immediately because the sensors know the location of the rotor. BEMF needs to jiggle the rotor, and generate a signal to let the microprocessor know the rotor position.[2]

Hall Effect commutation requires additional wiring and connectors and the hall sensors mount on a hall board. This adds cost to the motor and the motor assembly is more complicated. In high torque applications and ones requiring fast acceleration a hall effect sensor based system is preferred. In addition, applications that require accurate positioning a sensor based approach provides better results.[2]

BEMF based systems are less costly than hall based systems because wiring, connectors, hall sensors, and mechanical mounting are not required. Signal conditioning is more important with BEMF as this can cause commutation faults. BEMF commutation requires a minimum speed to work, and is most suited for applications such as fans and pumps. In these applications, the mechanical load does not vary and speed holds constant. Speed variation in these types applications should be avoided when using BEMF commutation. Writing the commutation algorithm is more difficult with BEMF than Hall sensors because the software is sensing and driving current into the motor coils at the same time.

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