

Technical Note

Achieving High Sensitivity and Magnetic Stability without the Use of Chopper Stabilization in Latching Hall-effect Sensors for Brushless DC Motor Applications

1.0 INTRODUCTION

Brushless DC (BLDC) motor manufacturers have moved toward using chopper-stabilized latching sensors for electronic commutation; however, what is actually required is a high sensitivity part that is stable over its specified temperature range. There are several myths that have led designers to request chopper stabilized, latching Hall-effect sensors. This Technical Note provides other options that can more efficiently commutate the motor.

2.0 OVERVIEW

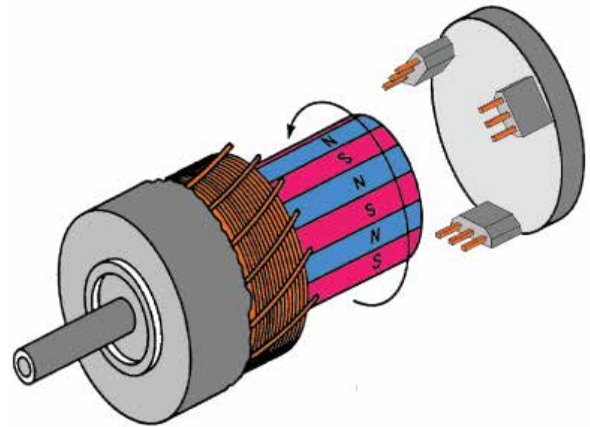
Historically, sensor manufacturers have achieved high sensitivity in latching Hall-effect sensor for BLDC motor applications by using chopper stabilization, which is a technique used to mitigate the issues of sensitivity and stability over temperature for a Hall element. As a result, chopper stabilization has become synonymous with high sensitivity and stability in Hall-effect sensors. Today, with new technologies and processes, magnetic sensor manufacturers can now achieve high sensitivity and magnetic stability without the use of chopper stabilization. This translates into improved sensor performance in terms of faster response time and better repeatability from the sensor.

3.0 WHAT ARE BRUSHLESS DC MOTORS?

Brushless DC motors differ from brush-type DC motors in that they employ electronic (rather than mechanical) commutation of the windings. Brushless DC motors differ from brush-type DC motors in that they employ electronic (rather than mechanical) commutation of the windings.

Figure 1 illustrates how this electronic commutation can be performed by three digital output latching sensors. Permanent magnets mounted on the rotor shaft operate the sensors. The sensors communicate the angular position of the shaft to a logic circuit, which encodes this information and controls switches in a driver circuit. The windings then alternate in polarity, in effect rotating in relation to the shaft position. The windings react with the field of the rotor's permanent magnets to develop the required torque.

Figure 1. Essential BLDC Motor Elements



Because no slip rings or brushes are used for commutation, friction, power loss through carbon buildup and electrical noise are eliminated. Electronic commutation also offers greater flexibility in interfacing directly with digital commands.

The long, maintenance-free life offered by BLDC motors makes them potentially suitable for applications such as portable medical equipment (kidney dialysis pumps, blood processing equipment, infusion pumps), ventilation blowers for aircraft, and marine submersible motors.

BLDC motors are highly efficient, delivering more energy per unit when compared to brush-type DC motors. They are growing in popularity due to the world's need for greater energy efficiency. BLDC motors use electronic commutation versus mechanical commutation in brush-type DC motors to control the power distribution to the motor. Latching Hall-effect sensors are used to measure the motor's position, which is communicated to the electronic controller to apply energy to the motor at the right time and right orientation. BLDC motors can be used in any application that needs an efficient and quiet motor, ranging from robotics and portable medical equipment to HVAC fans and appliances.

For more information about BLDC motors, see our [application note](#).

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4.0 MYTHS ABOUT CHOPPER-STABILIZED LATCHING HALL-EFFECT SENSORS

There are several myths that have led designers to request chopper-stabilized, latching Hall-effect sensors.

#1: Chopper Stabilization Technology

- Myth: Chopper stabilization is an ideal technology for latching sensors in BLDC motors.
- Truth: Although chopper stabilization can offer high sensitivity and more magnetic stability, it has several drawbacks including slower response time, accuracy error (due to sampling), and electrical noise generation.

Hall-effect sensors are operated by a magnetic field from a permanent magnet or an electromagnet, responding to North and South poles. These magnetic sensors measure the change in magnetic field and communicate the position of the motor shaft to a logic unit, which uses this information to determine when the current should be applied to the motor coils to make the magnets rotate at the correct orientation.

In order for the motor to be as efficient as possible, this mechanism needs to be able to determine the rotor's position as accurately as possible. The longer it takes for the sensor to respond to the changes in magnetic field, the less accurate this position is, resulting in lower motor efficiency and issues commutating the motor at higher frequencies.

Chopper stabilization, which is continually averaging the induced voltage across the Hall elements to determine the output signal, slows down how fast a sensor switches. As a result, a chopper-stabilized device typically switches at a delayed magnetic field level due to the slower response. As the motor spins faster, the delay time of the chopper-stabilized device results in greater accuracy errors. In addition to a slower response time, chopper stabilization adds electrical noise to the circuit each time the switches used for this technique open and close. This translates into additional design time, the need for more filtering, and higher cost. By eliminating the need for chopper stabilization, the latching sensor has a faster response time. This means the motor is commuted at or closer to the correct time, translating into higher accuracy, which ultimately leads to a more efficient motor. Another benefit of a non-chopper-stabilized sensor is that it does not generate additional electric noise, thus eliminating the need for additional filtering and simplifying the design.

#2: Chopper Stabilization and Stability

- Myth: Chopper stabilization is the only way to achieve stability over the operating temperature range for a Hall-effect sensor.
- Truth: There is a misconception that non-chopper-stabilized devices are not stable. In reality, one of the most important factors contributing to the stability of the sensor starts with the Hall element used by the manufacturer.

Many sensors today use single- and dual- Hall-effect elements which are susceptible to wide ranges of magnetic performance due to packaging stresses. In order to mitigate these stresses, most manufacturers use an averaging process (chopper stabilization) to provide a more stable operation over voltage and temperature. Another way to realize stability is to start with a more stable Hall-effect element. A quad Hall-effect element is less susceptible to stress-induced error because the voltage is measured in four directions, cancelling the offsets in each element to provide stable operation over the operating temperature range. A quad Hall-effect element offers more stable sensor performance requiring less averaging correction than chopper stabilization provides. In addition, Hall-effect sensors using this technology are not larger than their single- or dual-Hall-effect element counterparts using chopper stabilization.

#3: Chopper Stabilization and High Sensitivity

- Myth: Chopper stabilization is required to achieve high sensitivity in latching Hall-effect sensors for BLDC motor commutation.
- Truth: Chopper stabilization is not the only way to achieve high sensitivity. Other technologies and processes are available to manufacturers for high sensitivity magnetic sensing.

As an alternative to chopper stabilization, Honeywell Sensing and Productivity Solutions, for example, has developed a high sensitivity, latching sensor by combining a quad Hall-effect element and proprietary programming without chopper stabilization. This programming is used to adjust the magnetics to account for the effects of packaging stresses, contributing to the high sensitivity of the sensor.

This new design offers the required high sensitivity and stable magnetics for BLDC motors together with additional benefits of faster response time, repeatability, improved jitter performance (which is critical for BLDC motor efficiency), and no additional electric noise generation.

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4.0 HONEYWELL'S LATCHING HALL-EFFECT SENSOR ICs

Honeywell offers several Hall-effect Sensor ICs that provide high magnetic sensitivity of 30 Gauss (G) typical (55 G maximum) over the temperature range of -40 °C to 150 °C [-40 °F to 302 °F] without chopper stabilization of the Hall element. Combined with a faster latch response time and the capability to handle higher frequencies, these latching Hall-effect sensor ICs significantly contribute to higher motor efficiency. Initial customer feedback indicates a five percent increase in motor efficiency when compared to a competitive chopper-stabilized part.

- **SS360NT, SS360ST, SS360ST-10K, SS460S, SS460S-T2** High Sensitivity Latching Digital Hall-effect Sensor ICs
- **SS360PT, SS460P, SS460P-T2** High Sensitivity Latching Digital Hall-effect Sensor ICs with Built-in Pull-up Resistors
- **VF360NT, VF360ST** High Sensitivity Latching Digital Hall-effect Sensor ICs (AEC-Q100 qualification allows for potential use in automotive applications)

Technology has come a long way to make a highly sensitive latching Hall-effect sensor that is very stable over the wide temperature range needed for BLDC motors. When deciding on the right technology, design engineers need to understand both the positives as well as the drawbacks of chopper stabilization and take these into consideration in order to design the most efficient motor for their customers.

Find out more

To learn more about Honeywell Sensing and Productivity Solutions' products, call +1-815-235-6847 or 1-800-537-6945, visit sensing.honeywell.com, or e-mail inquiries to info.sc@honeywell.com

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005949-6-EN IL50
December 2015
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