White Paper

Simplifying BLDC Commutation and Feedback System

Description

In a Brushless DC (BLDC) motor system, an electronic mechanism is required to commutate the system. Unlike a Brush DC motor system, the permanent magnet is located at the rotor and the windings are located at the stator. As a result of this setup arrangement, the windings are required to energize in sequence, enabling smooth commutation. For the electronic system to determine which windings to energize, Hall sensor feedback is used to get the current location of the windings with respect to the rotor magnet. When using the Hall sensor, the manufacturer is required to add an additional printed circuit board and magnet, thus increasing the cost. Furthermore, an additional 2-channel or 3-channel positional encoder is required for servo application that will further increase the complexity of the BLDC motor system. This problem can be resolved by using the Broadcom® 6-channel optical encoder, where the positional encoder and commutation feedback are combined into one module. In addition, the module is effective in simplifying the motor alignment processes and improving switching accuracy. As a result, using Broadcom's modular solution greatly reduces the motor package complexity and cost.

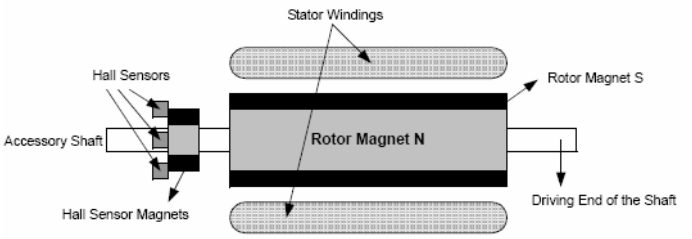
I. Introduction

A Brushless DC motor (BLDC) system is one of the most popular motor types used in the market (besides Stepper motors, DC motors, and so on). The internal structure of BLDC motors consists of a permanent magnet located at the rotor and the windings located at the stator. Unlike DC motors, the stator windings are required to energize in sequence to enable smooth commutation within the BLDC motor. As a result, electronic and sensor feedback is required to make the location of the stator windings known with respect to the rotor magnet. A BLDC motor can be configured to be 2-phases or 3-phases regardless of the number of stator windings and the number of pole-pairs that are also configurable. Conventional BLDC motors use the Hall sensor as a feedback system to identify the location of the stator windings with respect to the rotor. This information enables the electronics system to determine which winding to energize, to commutate the motor.

The Hall sensor is normally embedded into the stator or the non-driving end of the BLDC motor. An additional printed circuit board (PCB) is required to place the Hall sensors in alignment with the rotor magnet. For servo applications, required position feedback is provided by an additional position encoder, which significantly increases the complexity and cost of the entire motor package. An example of the BLDC motor is shown in Figure 1.

To solve this problem, equivalent Hall sensor commutation outputs are integrated into the position encoder to significantly reduce the complexity and cost of the entire motor package. In addition, this feature will reduce alignment time and improve switching accuracy due to lower hysteresis, as compared to a conventional Hall sensor device.

Figure 1: BLDC Motor Example

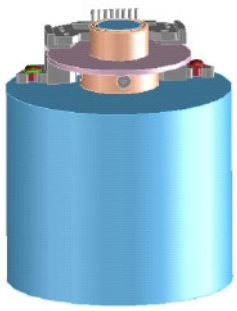


II. Overview of the 6-Channel Optical Encoder

The Broadcom state-of-the-art 6-channel optical encoder has been designed to help motor manufacturers easily assemble the Brushless DC motor (BLDC) system. The optical encoder provides channel A, channel B, and channel I as position feedback, and channel U, channel V, and channel W to emulate the Hall sensor feedback for commutation. All of these output signals are generated from the optical sensors, where the number of pole-pairs can be configured to the codewheel pattern without any change to the complicated hardware design. This feature significantly reduces the motor manufacturer's design time-to-market. In addition, the switching accuracy of the Broadcom 6-channel optical encoder, with a commutation accuracy rated at ±1° mechanical, is much better than that of conventional Hall sensors.

The Broadcom 6-channel optical encoder is available from 1000 CPR to 2500 CPR, and the shaft diameter is available from 3 mm to 10 mm. An alignment tool is also available to assist the manufacturer in aligning the 6-channel optical encoder to the motor shaft. An example of the Broadcom 6-channel optical encoder mounted BLDC motor is shown in Figure 2.

Figure 2: Broadcom 6-Channel Optical Encoder



III. Comparison to Conventional Feedback System

A conventional BLDC motor system uses a Hall sensor to detect the location of the stator with respect to the rotor. In other words, the Hall sensors' output is related to the motor back EMF. Figure 3 shows the relationship between the motor back EMF and Hall sensors' output.

For a 3-phase BLDC motor, three Hall sensors are placed on a separate PCB, spaced 120° apart. A conventional Hall sensor device is offered with an open-collector configuration that requires a pull-up resistor for each Hall sensor. This configuration will further increase the motor system bill of materials, thus increasing the entire motor package cost. Figure 4 shows the conventional system with Hall sensor commutation feedback.

Figure 3: Motor Back EMF to Hall Sensor Relationship

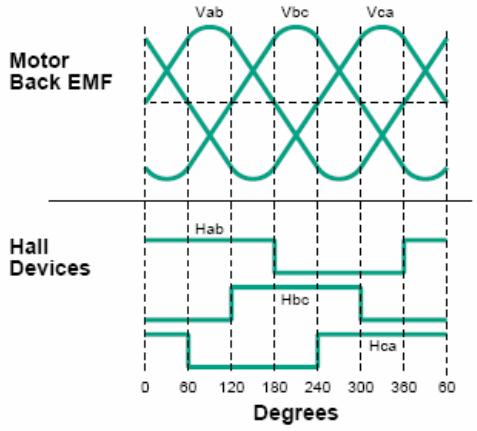
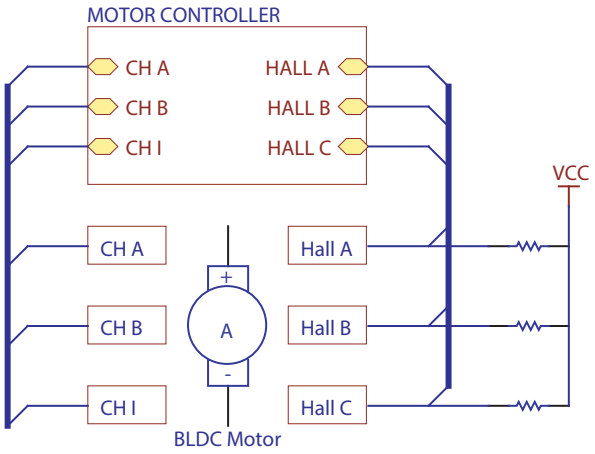


Figure 4: BLDC with Hall Sensors



With the 6-channel optical encoder with integrated commutation outputs, only an optical encoder and codewheel are needed as feedback for the BLDC motor. Figure 5 shows a simplified version of the same BLDC motor design as shown in Figure 4 with the 6-channel optical encoder.

By comparison, the illustration in Figure 5 clearly shows that the 6-channel optical encoder system is not as complex as the system shown in Figure 4, which uses the Hall sensor device. Table 1 shows the comparison between the bill-of-materials for the 6-channel optical encoder and Hall sensor device.

Figure 5: 6-Channel Optical Encoder System

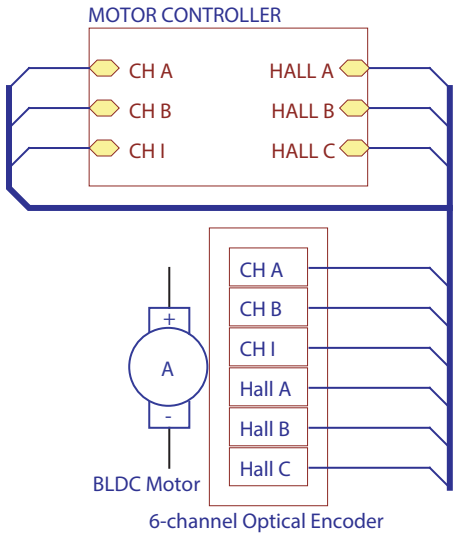


Table 1: Bill-Of-Materials Comparison

6-Channel Optical Encoder System		Hall Sensor System	
Component	**Qty**	**Component**	**Qty**
6-Channel Optical Encoder	1	Hall Sensor	3
Codewheel	1	Pull-up Resistor	3
		Positional Encoder	1
		Hall Sensor PCB	1

IV. Conclusion

The Broadcom 6-channel optical encoder provides position feedback for servo applications and commutation feedback, thereby significantly simplifying BLDC motor design.

References

1. Brushless DC (BLDC) Motor Fundamentals, Microchip Application Note AN885.
2. Introduction to Motor Control Technology, Industrial Device Corporation.