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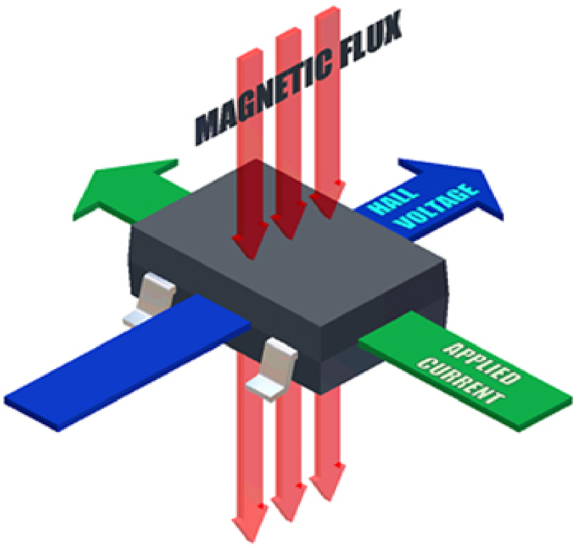
Chris Warner, Executive Editor

Hall-effect Sensors Measure Up

For the last half-century, sensors based on the Hall effect have provided a low-cost, solid-state option for sensing any object that incorporates a magnetic field. Hall effect sensors are based on the discovery by Dr. Edwin H. Hall in 1879. He found that a thin conductive material, placed in a magnetic field, formed a difference in potential (voltage) at the opposite edges that was proportional to the current flowing through the conductor and the magnetic field's flux density.[1] Their main benefit is non-contact measurement, and since their signal conditioning elements can be incorporated on a single chip along with the sensor, they have become common in numerous applications across many industries. This article will provide an overview of Hall effect ICs, with an emphasis on recent offerings for the automotive industry, and some of the basics for incorporating Hall effect products into a design.

Well Positioned for Numerous Applications



Some of the common uses for Hall-effect sensors are position sensing, speed sensing, and current sensing. Hall-effect devices provide position sensing for industrial applications such as pressure diaphragms, flow meters, damper controls, and brushless DC motors. They also offer a myriad of automotive uses such as throttle angle sensing, piston detection, in door interlock and ignition systems, shift selectors, seat belt buckle switches, seat position sensors, and power window systems.[2] In consumer products, they are used to detect lens position in auto focus cameras and cellular flip phones. Recently, a linear micropower Hall effect sensor was designed into the heel of a running shoe, in which a motor was used to modulate the stiffness of the sole, measuring the deflection of the heel as the runner took each step.

Hall effect vendors continually improve the magnetic structures for devices with 360-degree and x-y sensing capabilities. Melexis' Triaxis Hall technology, for example, is sensitive to the flux density applied parallel to the IC's surface. Deposited onto the CMOS die is an Integrated Magneto Concentrator (IMC), which Vincent Hiligsmann, product marketing manager of Melexis' Sensor division says, "extends all the applications you can imagine for the Hall effect sensor," such as linear and angular travel plus joystick and even complete 3-D sensors. (Note: Just before this article went to press, austriamicrosystems filed a patent infringement lawsuit against Melexis, seeking unspecified damages.)

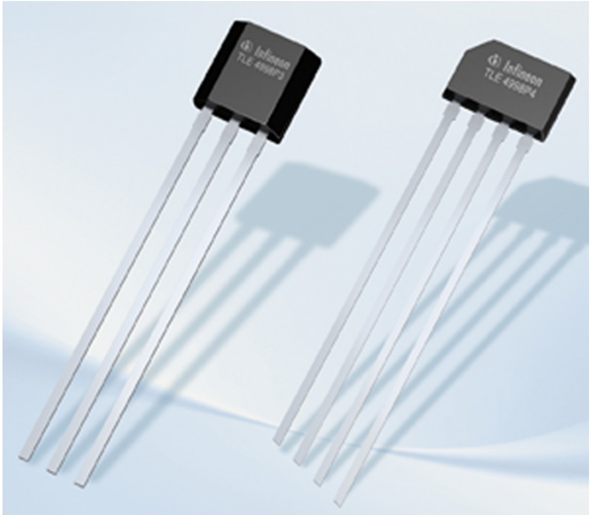
Current and Speed Detection
When you want to measure a magnetic field created by an electric current, energy savings is most likely your goal. "Whether it's appliances, motors, you name it — efficiency is very important, observes Mike Doogue, director of strategic marketing for Allegro MicroSystems Inc. The company integrates an inductor into its Hall effect current sensor package, rivaling or replacing transformers, shunt resistors and op amps. "We sense the magnetic field created by the current flowing through that inductor, but one of the main benefits in any application for these Hall Effect current sensors, is that the conductor can be very low resistance," he explains. "So you tend to save some power using Hall effect current sensors."

Hall-effect current sensors extend into the green sector, as well. "People who have solar panels on the roof may not know if it's really efficient or not, says Hiligsmann. "Current sensors can be used to make sure that what they're actually producing is effective and it's not simply for getting some energy down from the sun with no real payback in the wallet." He points to Google's partnership with GE for a Smart Grid, which is intended to speed the flow of information between customers and suppliers. "Of course, you'll need really accurate and fast current sensors."

Hall effect speed sensors, as the name implies, measures the speed of rotation of their target. Examples include the drum of a washer and dryer in white goods. However, they are most prevalent in automotive applications, where they measure a multitude of rotating devices such as wheels, gear teeth, rotor blades, crankshaft, anti-lock brakes and transmission speed.

Hall Sensors Make the Road Their Home
You'll find dozens of Hall-effect sensors in today's cars. Two new linear Hall sensors from Infineon promise highly accurate rotation and position detection. The TLE4997 and TLE4998 are suited for pedal and throttle positioning, suspension control,

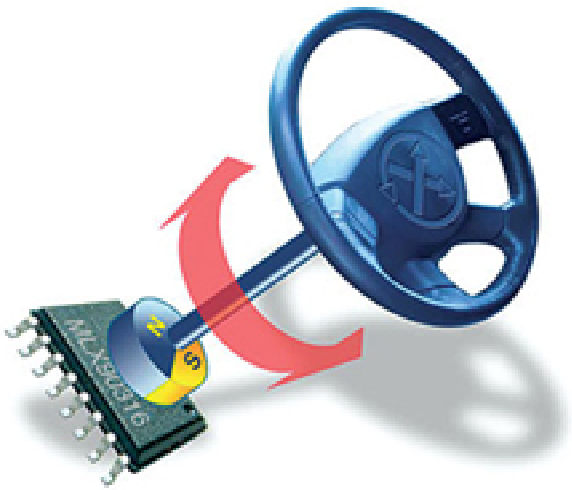
torque sensing, and gear stick position detection. The TLE4997 touts unique temperature compensation characteristics, and the TLE4998 sensor is said to add unique compensation of stress over lifetime.



Allegro Microsystems added a programmable linear sensor to its Hall-effect lineup, targeting absolute position sensing in automotive applications. It offers two operating modes — normal and low power. The A1386's normal mode features ratiometric output, while the low power mode can reduce power consumption by disengaging its internal components. While the device may lose some accuracy during low power, it still functions as a region indicator (north or south pole of a rotating ring magnet).

Late last year, Micronas announced its HAL 880 programmable linear Hall-effect sensor to complement its existing HAL 8xy products. It uses digital technology but also offers a linear analog output for compatibility with existing sensor designs so users can build custom-calibrated sensor assemblies. The company also addresses the SENT (Single Edge Nibble Transmission) interface with its HAL 2830. This protocol is intended for low-cost automotive sensors in high-noise environments. While similar to PWM, the company describes SENT as providing "a reference calibration pulse at the beginning of the signal and a checksum at the end to detect errors."[3]

Belgian company Melexis is also producing Hall effect products for the SENT protocol. They claim to be first-to-market with an angular sensor featuring SENT that's been incorporated in a Daimler vehicle.[4] Another recent Melexis product — the MLX90316 Hall-effect rotary position sensor — is suited for a host of automotive applications such as engine torque, pedal position and fuel level, to name a few.



Meanwhile, a new technology by TT electronics' Optek Technology rivals Hall effect devices in automotive applications. According to the company, a stationary PCB, populated with electronic components, "communicates" with a second PCB that is allowed to move with the mechanical component whose relative position is being measured. The complete sensor generates an

output signal with 12-bit accuracy over a full 360 degrees of rotation or across a defined linear distance.[5] Mike Wills, Optek's automotive group business development manager, observes success in applications greater than 1" and even up to 12" in length. "It's not affected by magnetic fields in its proximity, said Wills, noting that using a Hall effect, "obviously you have to be careful if you put it on the end of a motor to make sure you're putting in a field or you shield it, so that the motor's magnetic field is not affecting the Hall sensor. We don't have that restriction," he asserts.

Don't Forget The Basics

While Hall-effect sensors have been around for decades, engineers shouldn't forget the basics when incorporating them into a design. Know the application and its requirements. Vince Hiligmann lists speed, output protocol, and performance as key parameters when specifying a Hall-effect device, starting with the question, "What is the application?" From there, "Is it speed sensing? Is it a switch-type function? Is it a compass? Do I need to program? Or can I live with a non-programmable sensor?"

Mike Doogue stresses a basic understanding of the application's expected minimum and maximum magnetic fields, "even as a function of mechanical tolerances in a mechanical system. Some of our sensors are programmable, which would allow you to program out mechanical variations in a system, but others are not. The last thing you want is a case where you're trying to get a nice linear position measurement out of a system, but the output of your device is saturated," Doogue cautions. "A lot of mechanical designers don't have Gauss meters…in their lab, so they might just pick their Hall sensors by trial and error."

Hall-effect temperatures are designed with a wide temperature range (-40°C to 150°C) for  industrial and automotive applications, but turbocharger and wheel speed applications can generate extreme heat. At that point, the magnetic structure begins breaking down.

With extreme temperatures or other design challenges, it's always best to work with the Hall-effect IC vendors to ensure nothing's been overlooked. Mike Doogue notes, "We see a lot of people designing parts and only looking at them at room temperature. The parts go into production and problems are found at some of the extremes of the application, be it temperature or mechanical misalignment, and as a company, that's the job of our applications engineers-- to help customers through those types of issues." Other times, designers faced with current sensing applications often assume that a Hall-effect sensor won't be able to resolve small currents. "As long as we put samples in people's hands, we have good design end-success," says Doogue.

Of course, Mike Wills points out there's one area that all buyers and vendors must address: "You obviously still see cases where the wish list doesn't correlate with the purchasing wishes for low cost….to find the happy medium between the two, is probably one of the more difficult tasks that we face."

References

1 "Hall Effect Sensing and Application," p. 3. Honeywell Sensing and Control Application Note; http://content.honeywell.com/sensing/prodinfo/solidstate/technical/hallbook.pdf [1].

2 "Hall Effect Sensing and Application," p. pp. 62-76. Honeywell Sensing and Control Application Note; http://content.honeywell.com/sensing/prodinfo/solidstate/technical/hallbook.pd.f [2]

3 Micronas press release, May 5, 2008; http://www.micronas.com/pressroom/press_releases/articles/PR0806/index.html?ne

wslang=1 [3].

4 Interview with Vincent Hiligsmann, March 11, 2009.

5 www.optekinc.com/automotive/autopad.aspx [4].

Hall-effect diagram courtesy of Allegro Microsystems.

Links:
[1] http://content.honeywell.com/sensing/prodinfo/solidstate/technical/hallbook.pdf
[2] http://content.honeywell.com/sensing/prodinfo/solidstate/technical/hallbook.pd.f
[3] http://www.micronas.com/pressroom/press_releases/articles/PR0806/index.html?newslang=1
[4] http://www.optekinc.com/automotive/autopad.aspx