ROHM SEMICONDUCTOR

Innovations Embedded

Applications for Hall Effect IC Switches in Portable Applications

White Paper

Applications for Hall Effect IC Switches in Portable Electronics

19th century magnetic technology merged with 21st century ultra-small IC package innovation offers beneficial alternative to mechanical devices

According to the Semiconductor Industry Association, consumer electronics became the largest user and primary driver of semiconductors in 2004 and continues to increase over the corporate market segment. In consumer electronics, portable products are the fastest growing area. With cell phones alone projected to grow from over a billion units in 2007 to almost 1.5 billion in 2010 according to market research firm Gartner Dataquest, it should be no surprise.

While providing high volume opportunites for suppliers of the right components, consumer electronics and especially the portable consumer electronics portion places high demand on suppliers, requiring small size, high functionality, low power consumption and low cost as the major criteria for acceptance. In this highly competitive arena, the Hall effect, a magnetic technology discovered in the 19th century and popularized in the latter part of the 20th century through its implementation using large-scale integrated circuit (LSI) technology and advanced packaging is proving to be the right solution for adding functionality to cellular phones, portable computers, digital cameras, navigation systems, electronic toys and more.

In portable consumer electronic products, Hall effect sensors provide an effective alternative to mechanical switches with increased reliability as well as cost and/or performance advantages over other non-contact technologies. Using integrated bipolar sensing and CMOS logic circuitry with highly reliable semiconductor packaging and a small magnet, the Hall integrated circuit (IC) provides several useful functions.

Applications in Portable Electronics

In consumer electronics, product acceptance is increasingly determined by:

- the user interface, where sensors provide awareness
- the overall user experience, where a subtle feature can become a wow factor.

The use of Hall effect IC switches are contributing to product acceptance in several of these applications.

Open/Close Detection

Portable computers and flip or jack-knife style phones and other portable devices with a rotating hinge and clam shell design (see Figure 1) have historically used mechanical switches to indicate an open or closed position. Knowing whether the device is open or closed is essential for applying power to sleeping circuitry and returning to the sleep mode to conserve power.

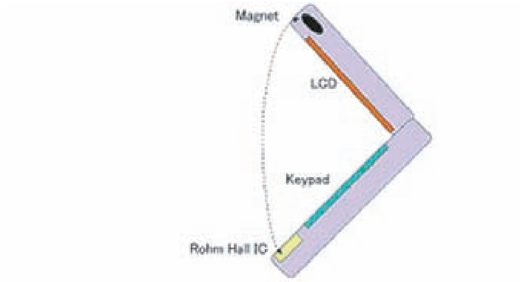

Figure 1. Hall IC switch detects presence of magnet when the phone cover is closed

The Hall effect IC switch detects the presence or absence of a magnetic field and outputs a digital signal for ON/OFF. In contrast to a mechanical switch with its potential wear-out mechanism, the Hall approach is a non-contact, long-life solution. In many cases, the

Hall effect switch can simplify the location of the sensor compared to a mechanical switch.

Some newer cell phones, digital cameras and other portable instruments use a sliding mechanism (Figure 2) where linear motion reveals the display or even a keyboard normally covered when the unit is in a standby mode. In this application, a Hall effect IC switch / magnet combination is commonly used.

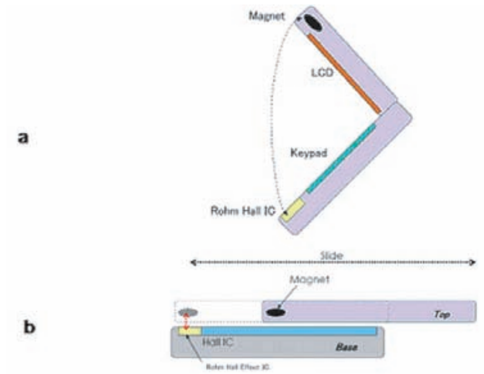

Figure 2. Hall IC switch detects presence of magnet when the phone cover is closed

In these applications, the use of a Unipolar Hall effect IC is commonly used. Unipolar Hall IC switches only operate when a magnetic field of sufficient strength and polarity is detected. S-pole detecting devices are most common but N-pole detecting devices are also available.

Hall effect IC switches capable of detecting a magnetic field of either polarity (Omnipolar) can also be used in this application. The unipolar devices typically require less power to operate but require the magnet to oriented properly while the omnipolar devices will operate without regard to magnet orientation.

Screen Orientation

In another variation, the screen pivots allowing the front or back face of the display to be viewed and the system has to discern which side of the display is facing the viewer. This application is also commonly found on PDAs, digital cameras, or tablet-style PCs. There are even some flat panel displays for desktop computers can rotate to view a portrait versus a landscape mode.

In these applications, it is necessary to use a Hall effect IC sensor, not only capable of detecting the magnetic field but also of discriminating the polarity of the field. (Figure 3)

Omnipolar Hall effect IC switches equipped with dual outputs make it possible to control screen orientation and other similar functions with a single device.

Function Selection and Control

An increasingly important function in multi-function cell phones is the jog wheel or track ball (Figure 4), a human interface allowing the user to scroll through a list, increase or decrease the volume or implement another function. Some lower cost MP3 players use a jog wheel that moves clockwise or counterclockwise to select MP3 songs or scroll through a list of menu items.

Capacitive and even resistive touch sensing are also used for these applications, but the Hall effect sensor provides a lower cost solution.

Figure 3. Polarity-discriminating Omnipolar Hall effect IC switches can be used to control the operation and orientation of multiple displays

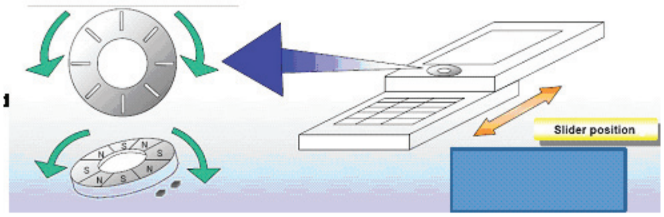

Figure 4. Bipolar Hall IC switches detect the presence of alternating polarity magnetic fields to discern CW or CCW movement

This application requires the use of two Bipolar, latching Hall ICs. The jog wheel has a series of alternating n-pole and s-pole oriented magnets. The two Hall ICs operating in combination are used to detect either clockwise or counterclockwise rotation of the wheel.

In more advanced applications in phones, computers and game handsets use a track ball that moves up and down and right and left. The design uses four Hall effect switches to determine the direction and how fast the ball is moving.

While mobile phones use Hall sensors for a variety of functions, some of these same applications can easily be found in portable computers, digital still cameras, digital video cameras, video game controllers, navigation systems, electronic toys and more.

Hall Effect Technology Basics

Current flowing in a conductor perpendicular to a magnet field causes a voltage, known as the Hall voltage on opposite sides of the conductor. While this has been known since 1879 when Edwin Hall discovered the phenomena, semiconductor technology has reduced the size of the Hall effect devices and added several key features that make Hall effect switches, sensors, and other products extremely useful in many applications. As shown in Figure 5, a magnetic field perpendicular to the plane of the semiconductor package, and the chip inside it, causes a low level Hall voltage. The Hall element is configured as a Wheatstone bridge, requiring additional circuitry including amplification and offset voltage compensation.

Design considerations for the various Hall effect sensing applications include magnetic strength and proximity of the magnet. For the smallest sensing system, neodymium magnets are recommended over ferrite magnets. A 4 x 4 mm neodymium magnet of 1 mm or 3 mm thickness operates with a separation of 7.66 mm to 10.4 mm between the magnet and the Hall IC. Increasing the detection distance requires increasing the thickness, sectional area or both.

For some cell phones, MR (magnetoresistive), GMR (giant magnetoresistive) or AMR (anisotropic magnetoresistive) sensing has also been used. The field direction is opposite to the Hall effect, which requires an orthogonal magnetic field. In general, the magnet strength needs to be about twice as large as a Hall effect device. However, prior to the introduction of chip scale packaging for Hall effect sensors, the MR packaging was smaller. With newer, smaller Hall effect ICs such as ROHM's products in the 1.1 x 1.1 x 0.5 mm chip scale package, the MR package size advantage has essentially disappeared especially since designers can save space and cost by using a smaller magnet.

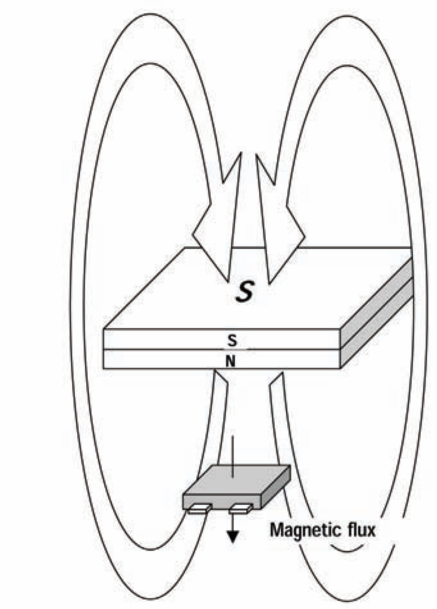

Figure 5. A Hall voltage results from current flow in the semiconductor material when a magnet is located perpendicular to the flow

ROHM Hall Effect Technology

ROHM's Hall ICs use a single monolithic silicon chip with built in circuitry to provide additional functions and ease of interfacing. Also, instead of an analog output that is always on, ROHM pioneered the use of CMOS logic at the output to provide low power consumption. Today, all ROHM Hall effect switches use CMOS push-pull logic to provide a digital output that eliminates the need for an external pull up resistor required for the single FET output common in other Hall effect switches. The CMOS output interfaces directly to microcontrollers. Figure 6 shows the Hall effect element with the additional circuitry common to all ROHM Hall ICs that includes timing logic (SW), dynamic offset cancellation, amplification, sample and hold, comparator, oscillator, latch and the push-pull output. Some of ROHM's Hall sensors have two push-pull outputs for even greater functionality

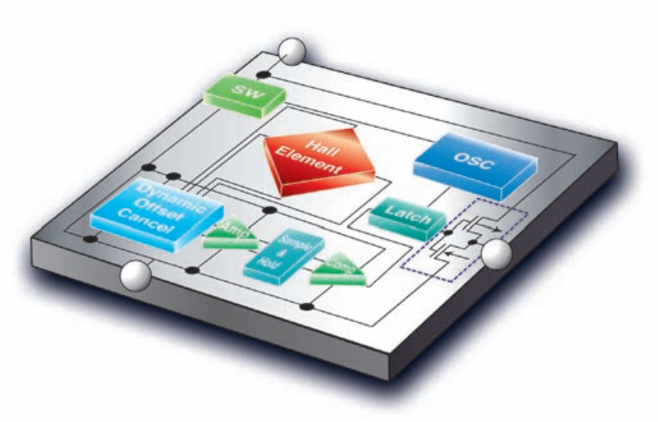

***Figure 6.** The block diagram of ROHM Hall effect shows the additional circuitry integrated with the Hall sensor that makes it easy to interface in sensing applications.*

Sample and hold circuitry reduces power consumption for power conscious battery-powered applications. ROHM's Hall ICs typically have a sampling period of 50 milliseconds. As shown in Figure 7, the device wakes up for a 48 µs sample of the magnetic field and then returns to sleep. As a result, the typical operating current is only 8 µA for 2.7V applications and an even lower 5 µA for 1.8V operation. Since ROHM Hall ICs were designed for battery powered applications, they can operate from voltages as low as 1.65 to 3.3V.The bipolar Hall ICs

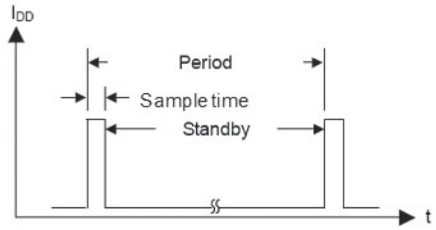

***Figure 7.** The typical sample time of 48 µs for each 50 ms period reduces the average current draw to 8µA or even 5 µA.*

designed for jog wheel or track ball applications have a much faster sampling period (0.5 ms).

The design of the sensing element and circuitry in ROHM Hall effect ICs ensures high electrostatic discharge (ESD) tolerance with ratings of up to 8 kV as measured in the human body model (HBM). Operating over a temperature range of -40°C to 85°C, the monolithic silicon Hall sensor has a high level of magnetic flux density detection stability versus temperature. In addition, many models have a high sensitivity with typical operating point of 3.7 mT (3.0 mT on ICs designed for 1.8V operation). Dynamic offset cancellation eliminates the differential in the Hall element Wheatstone bridge for improved accuracy and a hysteresis comparator increases the noise resistance.

With a mounting area of 1.1 x 1.1 x 0.5 mm, ROHM's VCSP5OL1 chip scale package (CSP) provides the smallest Hall effect sensor for the most demanding, space limited applications. The image below shows the CSP compared the HVSOF5 surface-mount (SMT) package.

***Figure 8.** ROHM Hall ICs are offered in the surface-mount HVSOF5 package with a footprint of just 1.6 x 1.6 mm and in the even smaller VCSP5OL1 1.1 mm square, chip scale package.*

DOCKET ALARM

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts

Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research

With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips

Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.

WHAT WILL YOU BUILD? | **sales@docketalarm.com** | **1-866-77-FASTCASE**

fastcase® Smarter legal research.