Novel Contactless Current Sensors for HEV-EV and Renewable Energy Applications

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Electrical currents can either be measured by resistive shunts or by magnetic sensors. Magnetic sensors offer system level advantages, such as contactless operation, and no requirement for galvanic isolation between the current conductor and the sensor. They also transform very little electrical power into heat, saving thermal management cost and trouble.

Hall-effect based magnetic sensors can also be integrated with electronic circuits to provide high-level output signals with the ability to program a calibrated output. These devices can communicate with other circuits by linking with standard interfaces.

Unlike coils in current transformers (CT), which measure the magnetic flux time-derivative, magneto-resistive sensors and Hall sensors yield signals proportional to the flux density, applicable for both DC and AC current measurement.

With widespread use of electronics in automotive applications, renewable solar and wind power conversion, power supplies, motor control, and overload protection, more reliable, isolated, high speed, and low-cost current measurement techniques are now available for these applications.

One open-loop Triaxis Hall-effect current transducer, the MLX91205, exhibits rapid response times <10 microseconds, galvanic isolation to avoid issues related to HF common mode voltages, thermal isolation, 5V operation, robustness, and machine mountable standard packaging. Housed in compact surface mount SOIC-8 package, this current sensor features linear output voltage highly sensitive and proportional to magnetic fields parallel to the chip surface, zero power loss in primary circuits, excellent nonlinearity, wideband (DC to 100 kHz), very low offset and offset drift, and very low noise. Fabricated using a standard CMOS process, this current sensor has an additional ferromagnetic layer, also known as the integrated magnetic concentrator (IMC), which amplifies and concentrates the magnetic field on the Hall elements.

Approximating the size of the integrated circuit and sensitive to parallel magnetic fields, the IMC and sucks-in” the external magnetic flux lines in its vicinity, concentrating them onto the Hall elements, which are approximately one tenth the size of IMC (Figure 1), amplifying the flux density about six fold.

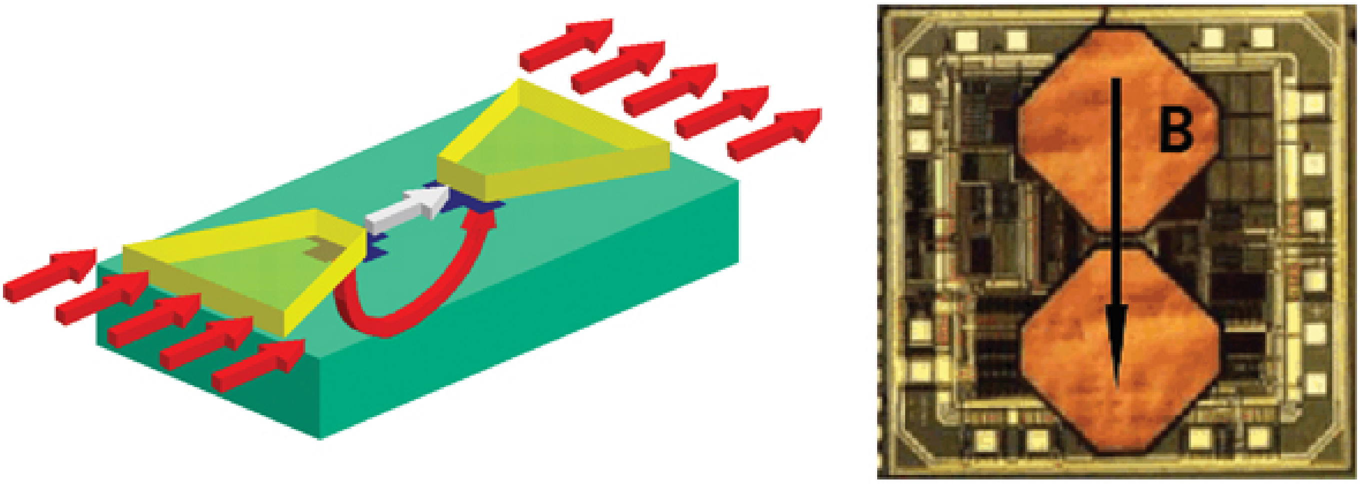

Figure 1 – Left: The IMC-Hall ASIC with integrated magnetic concentrators is sensitive to a magnetic field parallel to its surface. Right: Top view photograph of the current sensor ASIC with the two integrated magnetic concentrators, each about 800µm long. The Hall elements are positioned underneath the gap in the center. The total size of the die is about 1.8mm x 1.8mm.

The measured current is sent either directly through a current track on the PCB under the sensor (Figure 2, right), or the sensor is mounted at a given distance from a larger current conductor (Figure 2, left). The sensor's current range is only limited by the geometry of the conductor and the shield. The current range may be increased easily by increasing either the cross-section of the bus bar, or the distance between the sensor and current conductor. It is designed to monitor currents from 5 A to 100 A on PCBs or up to 1000 A on bus bars.

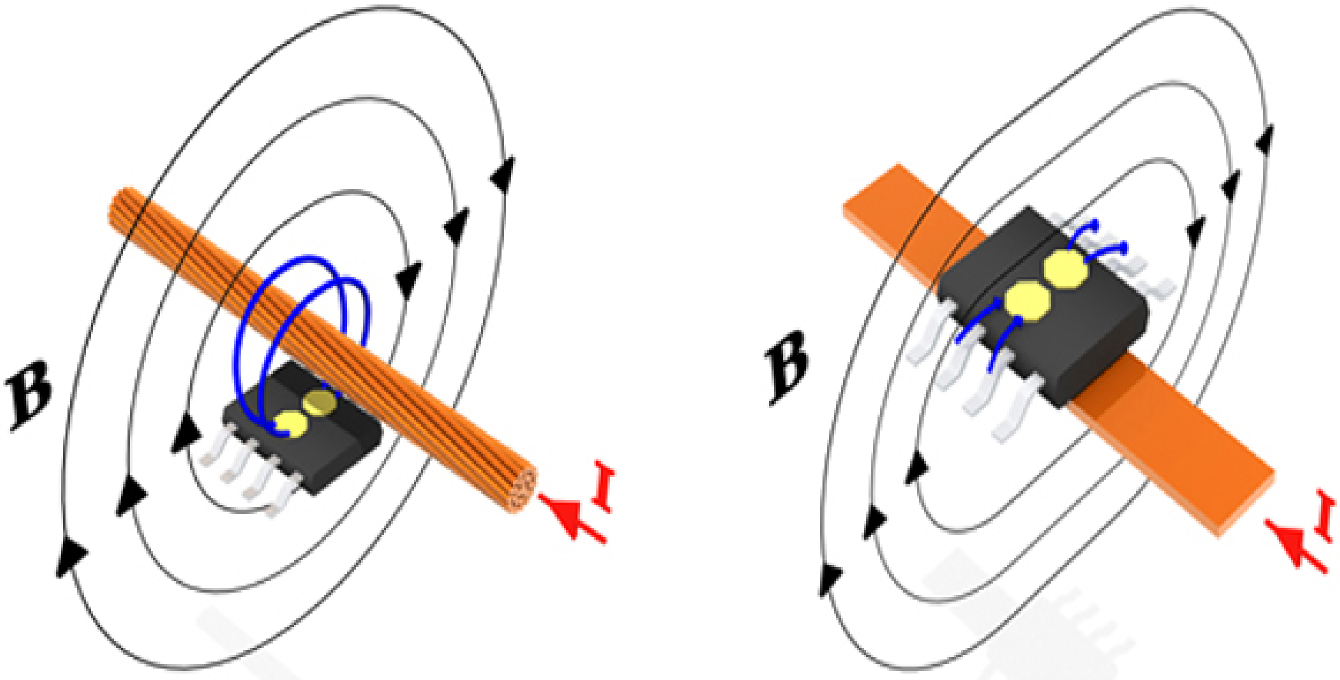

Figure 2 – The current sensor is packaged in a standard SOIC-8 plastic package. Current range is defined by the geometry of the current conductor.

Applications and Benefits

To compete with fossil fuel generated electricity, the energy transfer from solar and photovoltaic cell arrays must be optimized by precisely monitoring the current and voltage produced. Current sensors directly monitor the current flowing within a PCB track, constantly ensuring the optimal efficiency of solar power converters.

These devices are used widely in motor control systems, such as cooling fans, water pumps, and automotive inverters that drive traction motors in hybrid electric vehicles (HEVs) or electric vehicles (EVs). By detecting fault conditions and controlling torque, these sensors effectively protect motors and improve reliability. Intelligence may also be included in order to prevent trapping.

Triaxis sensor current-monitoring can also optimize DC-DC and AC-DC power converter efficiencies by controlling output voltages and currents in real-time. In data storage systems, servers and telecommunication equipment, current sensors can optimize performance and efficiency by minimizing power dissipation. DC power supplies are typically only about 70 percent efficient. Google requires 90 percent efficiency. The added cost of higher efficiency is easily offset by reduced power consumption over a power supply’s lifetime.

The smart grid is another application that can benefit from Triaxis-Hall current sensors. By monitoring the current and power usage inside homes via smart meters, home owners can reduce power consumption between five and 15 percent per month, save money, and potentially reduce global warming.

Google is developing the Google Power Meter to show consumers their electricity consumption in near real-time by displaying information received from utility smart meters and energy management devices. Today, CTs are mostly used in this application. The Triaxis current sensor is an attractive alternative because of its small SO-8 package, wide current sensing ranges, very high bandwidths, rapid response times, and resolution less than or equal to 0.1 percent of the full scale range.

Critical to portable electronic devices, battery management extends battery life. These devices are integrating smart fuel gauges to monitor and supervise battery charging and discharging. Lithium-ion battery packs designs typically rely on over-current protection. Unlike shunts with Op amps or iron-core based current sensors, Triaxis current sensors provide many advantages. Contactless, non-intrusive current sensing with very good isolation for high and low side measurements, also delivers good linearity, high stability versus current peaks, high immunity against fast dv/dt, high bandwidth and fast response times in a miniature, low-cost package.

A new member recently added to this Triaxis-Hall sensor family, the MLX91206, is fully user-programmable. This sensor offers an additional benefit. It can be calibrated in-situ after the sensor is fixed with respect to the current conductor, providing a pre-determined, custom calibrated current sensitivity programmed to meet the specifications required by a particular application.

Conclusion

Contactless current sensors are designed to offer current monitoring from 5 to 100 A on PCBs and up to 1000 A on bus bars. They impart unique and useful performance characteristics, providing a compact, robust, flexible and economical solution for applications such as battery current monitoring, renewable power conversion, motor control inverters for HEVs, load management, and over-current fault protection.

See more on the MLX91206 Series here [1].

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