

Increased Electric Motor Content in HEV Subsystems Require Current Sensing

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This article explores recent applications in HEV and EV vehicle propulsion and passenger convenience systems. Allegro™ MicroSystems, LLC has developed a family of fully-integrated current sensing ICs that are ideally suited for such applications.

Introduction

To control the drive train in HEV and full EV vehicles, it is well-known that current sensing is required particularly in starter generator and main electric drive motor generator applications. However, even in mild hybrids, in order to maintain system operation when the internal combustion engine (ICE) is not in use, many subsystems have become fully electric. For instance, the heating, ventilation, and air conditioning (HVAC) systems must be operational during ICE idle periods if drivers and passengers are to remain cool in hot weather when sitting at a stoplight. Thus, these subsystems also require accurate current sensing to ensure efficient and accurate control of the electric motors. Allegro

MicroSystems, LLC has developed a family of fully-integrated current sensing ICs that are ideally suited for HEV subsystem applications.

Figure 1 shows a simple block diagram of a DC subsystem run off of the main battery through a DC-to-DC converter, and indicates potential current sensing applications. In transmission fluid and engine oil pumps, as well as in HVAC systems, peak load motor currents can be up to 150 A, and range from 20 to 50 A in normal operation. Parking brake motors typically run at 30 to 50 A peak, and at 10 to 20 A normally. For battery voltages far above 100 VDC, as in some HEVs and full EVs, sensing battery current and DC-to-DC converter current also requires galvanic (high voltage) isolation.

A Revolution in Hall-Effect Current Sensing

Conventional Hall-effect sensors, when used in current sensing applications, historically have exhibited general limitations in both accuracy and output signal bandwidth. However, Allegro MicroSystems has developed a broad family of

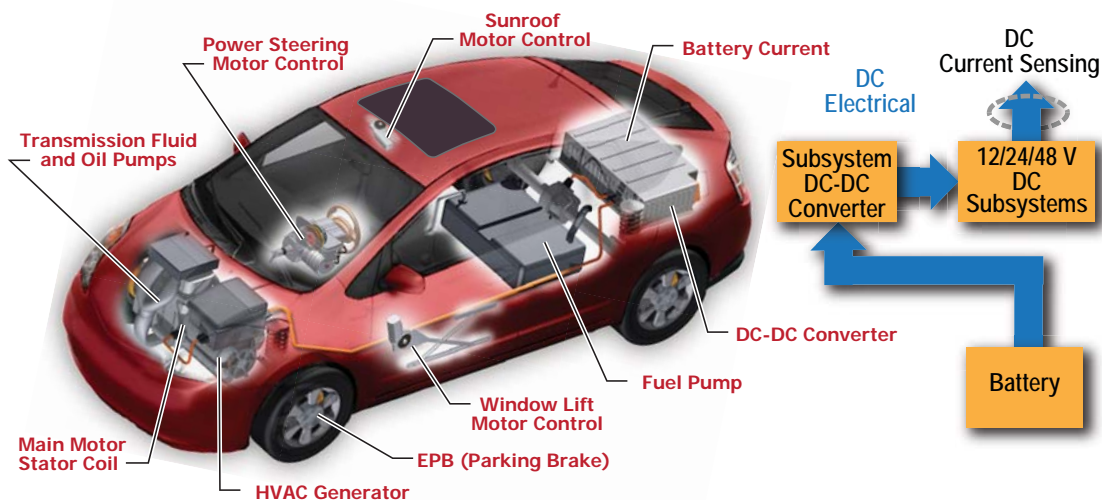


Figure 1. HEV and EV Current Sensing Applications

Hall-effect current sensor integrated circuits (ICs) that overcome these issues. The features and benefits of these industry-leading Allegro current sensors include:

- Signal processing and package design innovations enable > 120 kHz output bandwidth
- The highest current resolution, lowest noise spectral density Hall sensor ICs in the marketplace
- Proprietary, small footprint sensor IC packages with galvanic isolation
- Reduced power loss: through-hole and surface-mount low-resistance integrated conductor packages
- Precise factory programming of sensor IC gain and offset across full temperature range

A key advantage of the full integration of the current sensor IC is the testability of the device. The device is factory trimmed at both room and hot temperature to optimize the gain and offset of the sensor across operating temperature conditions. This provides a highly accurate solution in a very small package. Figure 2 depicts the wide range of proprietary package configurations in the Allegro current sensor IC family and displays the current magnitude that can be sensed using each package type.

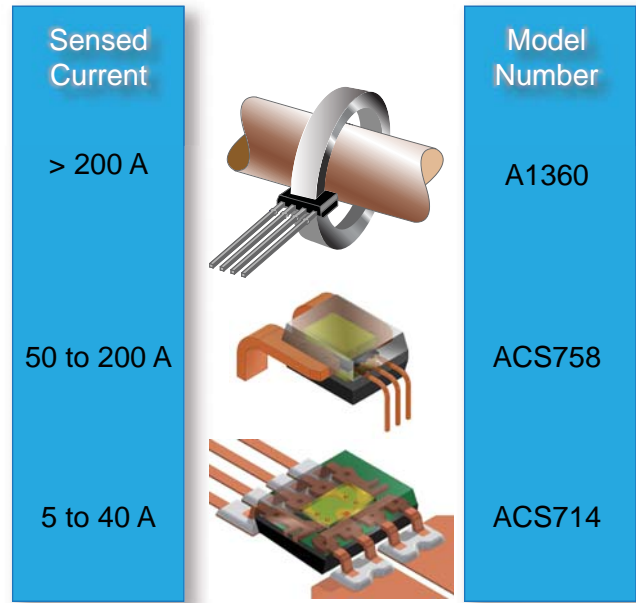


Figure 2. Allegro Current Sensor IC Packages

Fully Integrated Current Sensor ICs

The required current sensing and isolation voltage ranges determine the optimum Allegro current sensor IC solution. In low current applications, such as fuel pumps or plug in vehicle chargers, fully integrated surface mount sensors ICs can be employed, for example, the SOIC8 package shown in figure 2. Flip chip technology is employed in these surface mount sensor ICs and they have integrated 1.2 mΩ conductor resistance for low power loss. The flip chip construction improves the magnetic signal coupling and provides isolation because the die is located above the primary current conductor, and plastic mold compound fills the space in between.

For medium current sensing, between 50 and 100A, the ACS758 family of devices in the CB package can be employed. The ACS758 can be used in HVAC as well as oil and transmission fluid pumps. Figure 3 shows the unique construction of the CB package. The device incorporates a 100 μΩ conductor, a ferromagnetic core, and a Hall-effect linear sensor IC into a small form factor, galvanically isolated package. This package is capable of operating at the higher

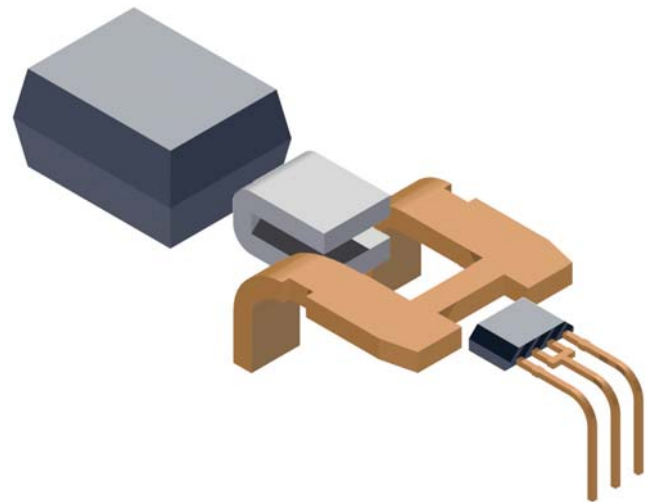


Figure 3. Allegro ACS758 CB Package

HEV battery voltages: it can survive standard UL type testing for 60 seconds at 4800 VRMS applied between the current leadframe and the signal leads. This sensor IC has been used in DC-to-DC converters, as well as main inverter motor stator coil applications at battery voltages exceeding 350 VDC. Motor stators are typically made with expensive rare earth magnets such as nickel-plated neodymium. Replacing the stator with a coil not only eliminates exposure to rare earth metal price and supply fluctuations, but also provides a means of taking active control of the stator, which improves motor efficiency and torque profiles in HEVs.

For sensing currents above 200 A, an Allegro current sensor IC Hall linear device can be employed in the gap of a ferromagnetic core designed to meet the desired current sensing range of the application. This technique is most often employed in the main inverter and is shown in the top of figure 2. No matter what current sensing range is required, an Allegro Hall sensor IC can be employed.

Summary

Allegro's latest generation Hall-effect current sensor IC technologies offer significant advantages for sensing currents in HEV subsystems. Allegro's integrated packages with galvanic isolation enable low power loss, small footprint current sensing solutions capable of sensing up to 200 A continuous current. Recent improvements in Hall technology by Allegro MicroSystems have also resulted in the development of industry leading high bandwidth, high resolution current sensing ICs.

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