Choose a Fuel Gauge with the Right Current Sensing for Your Battery System

Fuel gauging—at the heart of every battery management system—is a critical component of any mobile or IoT application (Figure 1). In a host-side fuel gauge battery system, the fuel gauge is not located inside the battery but is instead part of the application circuit, making the battery cheaper and easier to replace.

Figure 1. Mobile Devices Challenge Electronics Size and Battery Life

In addition to battery run-time duration, a major concern when choosing a fuel gauge is accurate reporting. Reporting accuracy depends in great part on the fuel gauge's ability to sense and measure the current flow in and out of the battery. This article discusses the tradeoffs between two common resistor-based current sensing techniques in a host-side battery system (Figure 2) and guides the system designer toward the best current sensing topology for the application.

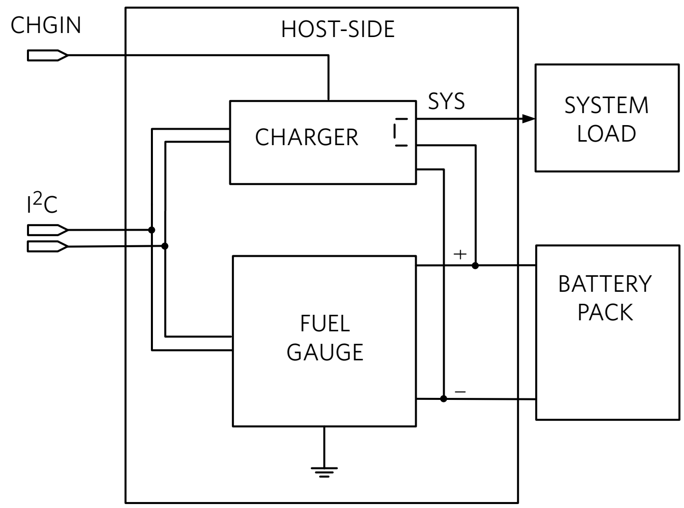

Figure 2. Host-Side Battery System

Low-Side Current Sensing

Low-side current sensing, in which the sense resistor is connected to ground, is simple to implement. Low-side current sensing has the advantage of monitoring current near ground, away from a power source which may be polluted by noise from switching converters that may exist in the system. Low-side current sensing simplicity comes at the cost of a more complex temperature reading circuitry. In Figure 3, the negative side of the battery pack is modulated by the variable current flowing through the current-sense resistor. The V_{THERM} voltage developed by the thermistor inside the battery floats on top of the sense resistor voltage drop. Reading the thermistor voltage without the error introduced by the sense resistor requires a more complex differential processing of the V_{THERM} signal.

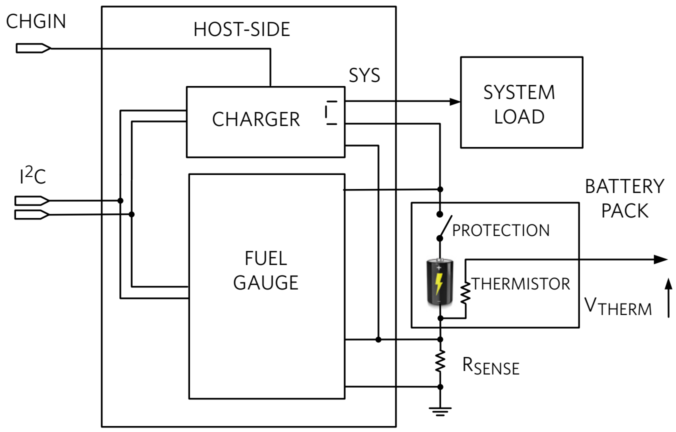

Figure 3. Low-Side Current Sensing

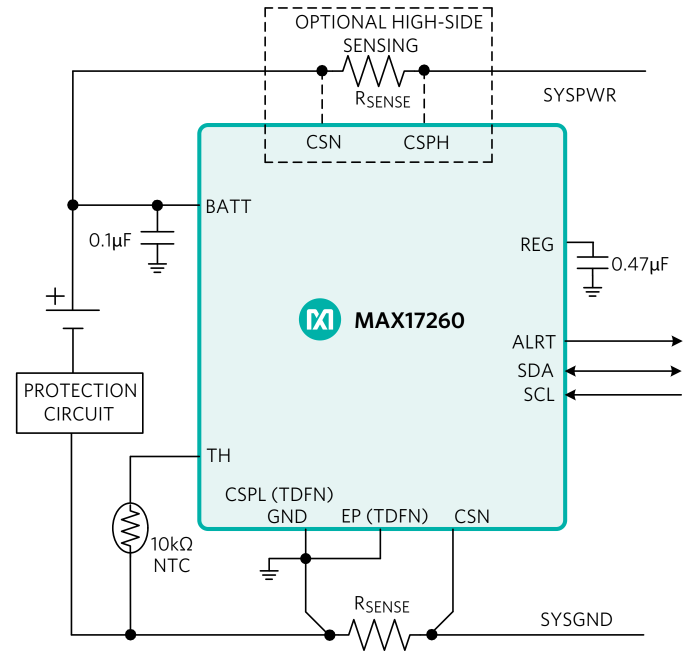

Figure 5. High-Side or Low-Side Current Sensing

High-Side Current Sensing

High-side current sensing has the advantage of protecting against a load short to ground. In high-side current sensing (Figure 4) the sensed signal rides on top of a large common-mode voltage (V_{SYS}). The current sensing IC offsets this potential inconvenience by utilizing additional circuitry for common-mode rejection. Some chargers sense the current using an external resistor, which can also be shared with the fuel gauge. High-side current sensing is a must in applications using a distributed ground, where using low-side current sensing is impractical.

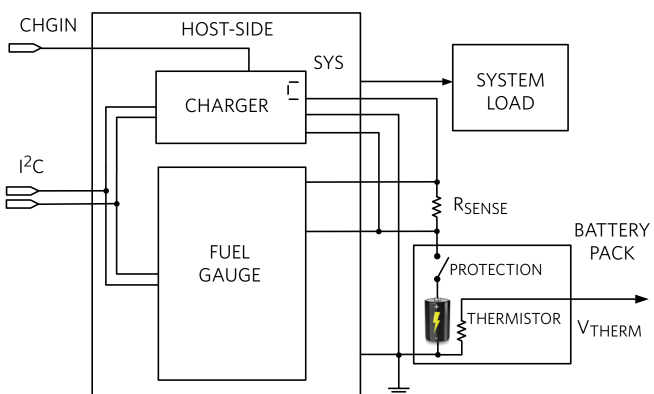

Figure 4. High-Side Current Sensing

High-Side/Low-Side Current Sensing IC

Figure 5 shows an example of an ultra-low-power fuel gauge IC that monitors a single-cell battery pack and supports both high-side and low-side current sensing. The advantage of having both sensing techniques on board is that a single part number can be stocked for use in multiple applications.

High-Side Integrated Current Sensing Resistor

WLP packaging technology has made it possible to integrate a high-side sense resistor into the fuel gauge IC to achieve minimal space occupancy and the smallest BOM (Figure 6).

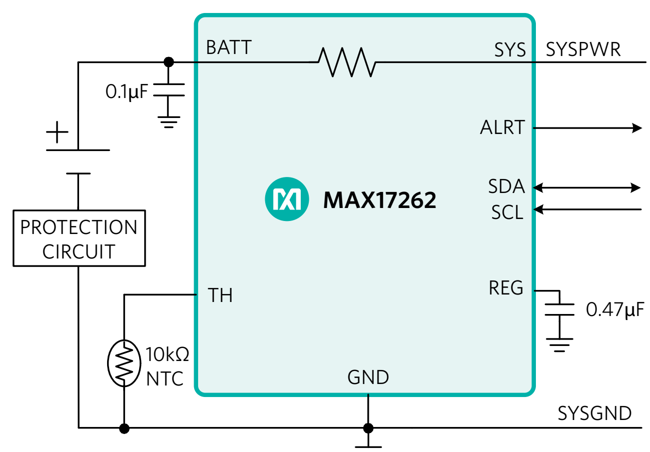

Figure 6. High-Side Integrated Current Sensing

The integrated resistor R_{SNS} = 7mΩ (Figure 7) is made with a very careful design using copper redistribution layer (RDL) residing on top of the silicon die. R_{INS} = 10mΩ is the total resistance including parasitics (Rp) beyond R_{SNS} that the application will see, while the current measurement is done across R_{SNS} by the IC. The example IC can sense up to 2.4A DC (10% life duty) and 3.1A transient.

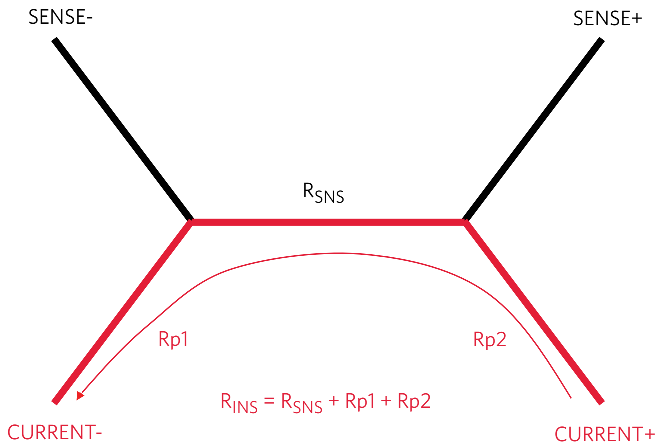

Figure 7. Integrated R_{SENSE}

Summary

Table 1 summarizes the main features and application space of a family of fuel gauge ICs that supports all these current-sensing topologies. Multi-cell, low-side current sensing, is available for applications like tablets, drones, and detachable displays. Single/multi-cell high-side, low-side current sensing is available for speakers, drones, power tools, battery backup devices, headlamps, and torches.

Table 1. Fuel Gauge ICs

Device	Cells	I_{SENSE}	Package	Apps
MAX17260	Single Cell	HS/LS	WLP-9, TDFN-14	Wearables: Smart Watch, Hearables, Smart Glasses
MAX17261	Multi-Cell	LS	WLP-9, TDFN-14	Tablets, Drones, Detachable Displays
MAX17262	Single Cell	HS Inte-grated	WLP-9	Wearables: Smart Watch, Hearables, Smart Glasses
MAX17263	Single/ Multi-Cell	HS/LS	TDFN-14	Wearable/ Tablets

Conclusion

The accuracy of a fuel gauge depends on its ability to sense and measure the current flow in and out of the battery. We discussed the tradeoffs of two resistor-based current sensing schemes in a host-side battery system and a WLP technology that enables the integration of a high-side sense resistor for minimal space occupancy and the smallest BOM. These features can be found in a family of fuel gauges ICs that covers a wide spectrum of applications by offering the best possible resistor-based current sensing solution for the system at hand.

Learn more:

MAX17260 5.5µA 1-Cell Fuel Gauge with ModelGauge m5 EZ and Optional High-Side Current Sensing

MAX17261 5.5µA Multi-Cell Fuel Gauge with ModelGauge m5 EZ

MAX17262 5.5µA 1-Cell Fuel Gauge with ModelGauge m5 EZ and Internal Current Sensing

MAX17263 Single/Multi-Cell Fuel Gauge with ModelGauge m5 EZ and Integrated LED Control

MAX1726x ModelGauge m5 EZ User Guide

MAX1726x Software Implementation Guide

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