Keywords: current-sense, amplifier, ADC, monitoring, CSA, internal sense element, sense resistor, dynamic range

APPLICATION NOTE 6565

CURRENT SENSING DEVICES USED IN BATTERY MANAGEMENT OF PORTABLE APPLICATIONS

Abstract: This application note focuses on current sensing amplifier used in power management of portable devices. It describes how to solve the problems of estimating remaining battery life and implementing protection for battery charging circuit with simple and high precision, space-saving and ultra-low-power devices such as a current-sense amplifier and ideal diode.

Introduction

Smartphones, tablets, and other kinds of portable devices are requiring increasingly smaller form factors and lower rates of power consumption. They are also becoming much more complex and the number of features they incorporate continues to grow. A huge challenge with this trend, however, is that the space and power available to accommodate each function is diminishing at an amazing rate.

This application note presents simple, space-saving methods for addressing some common features that portable applications require. First, the document describes a highly accurate, ultra-low-power solution for estimating remaining battery life. Then, it details a compact, power-saving solution for protecting the circuitry and Li+ battery from overcurrent conditions.

Li+ Battery-Current Sensing

The remaining Li+ battery life can be estimated by accurately measuring load current. A typical application involves inserting a small sense resistor between the Li+ battery and the load, which produces a voltage proportional to load current. A current-sense amplifier can then be used to sense this small voltage (typically several tens of mV) and to amplify it to produce an output voltage that fits within the dynamic range of an analog-to-digital converter (ADC). Such a converter is typically inside the RF chipset or power-management integrated circuit (PMIC).

Two main requirements for portable devices are low power consumption and small size. For small current ranges, a fixed precision sense resistor can be used for the entire range. However, some portable devices require large dynamic current ranges. For a current sense system with an external sense resistor, considering input-offset voltage, the sense resistor must be big enough to increase the power dissipation of the sense resistor.

Figure 1 represents the MAX40016 current-sense amplifier integrated with an internal sense element. The entire current-measuring path is trimmed in the factory, which saves space and is less expensive than incorporating a high-power precision current sense resistor. The MAX40016 is packaged in an ultra-small, 1.98mm x 1.31mm, 15-bump wafer-lever package (WLP). An internal sense element ensures a maximum voltage drop of 60mV at 3A from voltage input to load output. When the current-sense amplifier is not in use, the device has a low-power mode function, reducing total supply current to below 10μA.

The MAX40016 can sense current in a range from less than 300μA to greater than 3A, with a gain error of only 1%. Measured current goes through a current mirror control circuit inside the device. This mirrored sense current is connected to one of three paths controlled by the digital input pins SEL0 and SEL1. One of three paths—ISH, ISM, or ISL—is selected based on the current sense range.

Figure 1 shows a typical application. A typical current from the MAX40016's ISH, ISM, and ISL is 2mA/A, with a 3A sensed current and the ISH high current sense range enabled; the ISH current is 6mA. With a 160Ω RISH, input voltage of the internal amplifier is 960mV. The internal amplifier has a gain of 1.5V/V. Output voltage is 1.44V, which is within the full-scale range of the ADC. For a lower current range, with ADC's high resolution and internal PGA function, a small current can be sensed and measured on the ADC side.

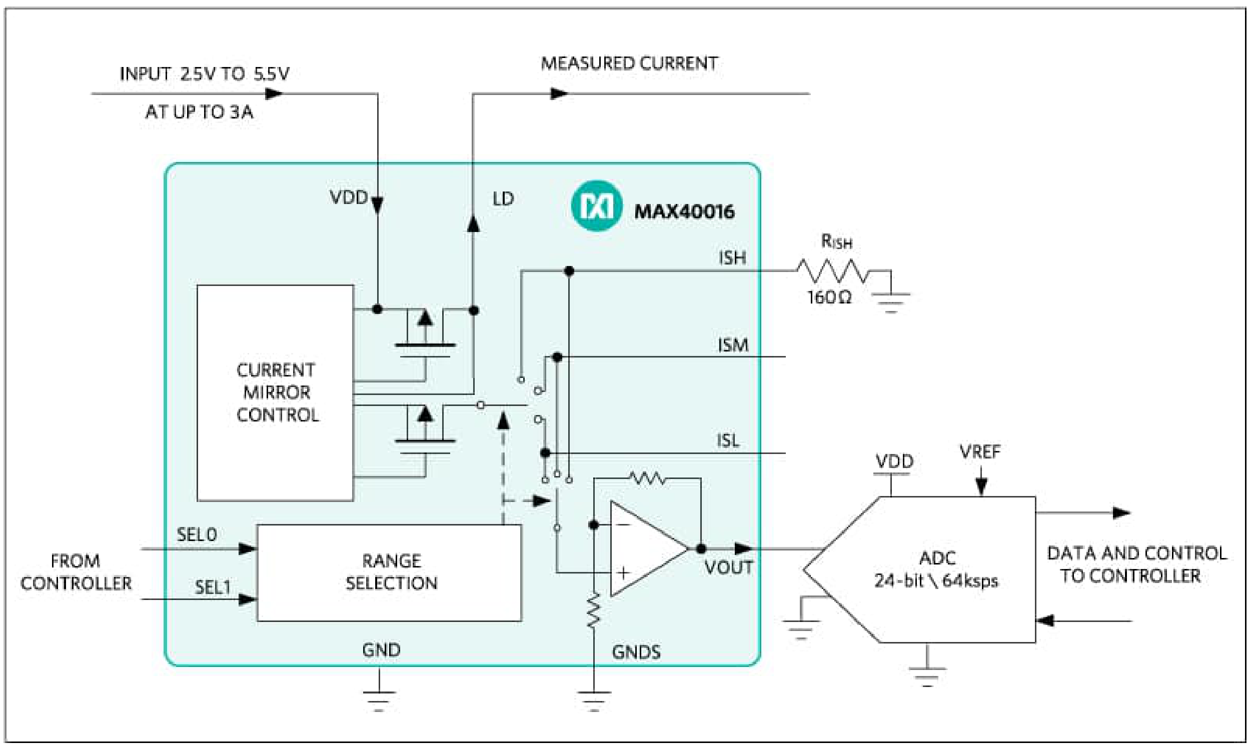

Figure 1. MAX40016 current-sense amplifier with high-resolution ADC to convert output voltage for current-monitoring.

Three scaling resistors can be implemented if a lower resolution ADC is used. As shown in **Figure 2**, a 12-bit ADC is connected to V_{OUT} through an RC filter. The scaling resistors are R_{ISH} = 160Ω, R_{ISM} = 5.36kΩ, and R_{ISL} = 160kΩ, and their values split the sense current ranges in the region of 30:1. For a sense current in the range of 300μA to 3mA, a mirrored current is in the range of 0.6μA to 0.006mA. When ISL is selected, the output voltage at R_{ISL} is from 96mV to 1V. For a sense current in the range of 3mA to 93mA, the output voltage at R_{ISM} is from 32mV to 1V. For a sense current in the range of 93mA to 3A, the output voltage at R_{ISH} is from 30mV to 1V.

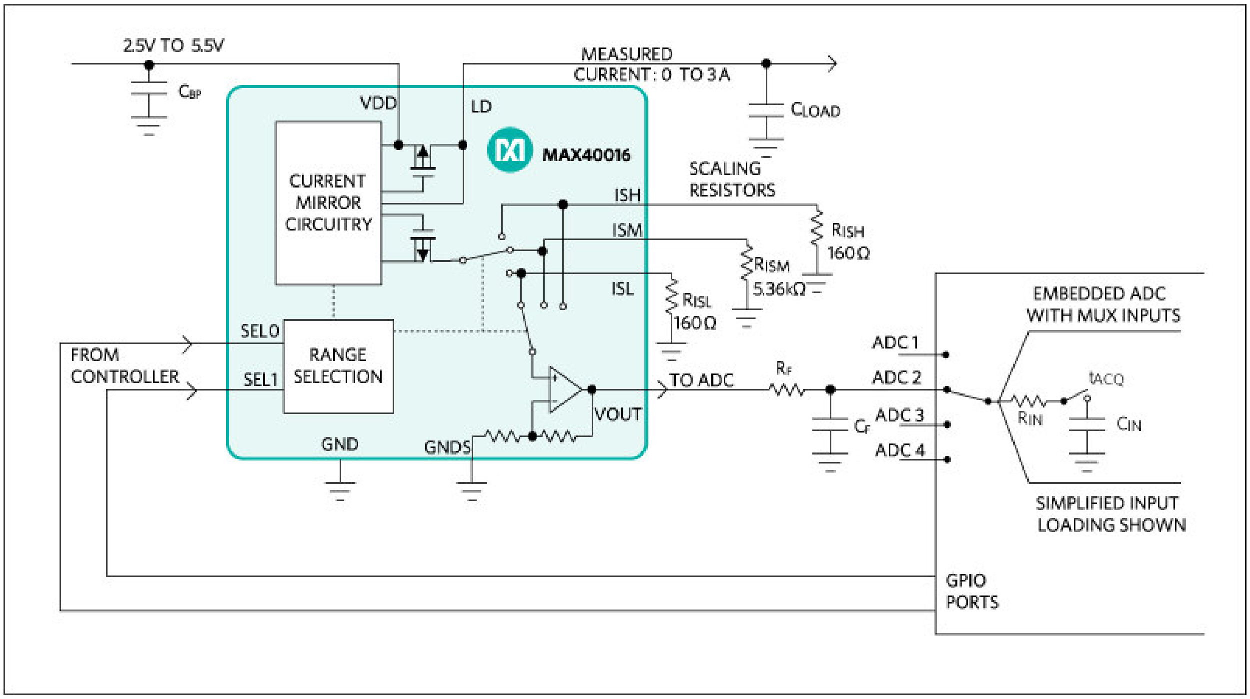

Figure 2. MAX40016 current-sense amplifier is used to measure battery current, while a low-resolution ADC is used to convert output voltage for current monitoring.

Battery Protection Circuit

As shown in **Figure 3**, when a wall-supply is connected, the battery must be disconnected from the load to prevent the wall adapter power from flowing back into the battery. The wall-supply can usually handle additional power losses of a normal diode, so one is connected between the wall adapter with load. The MAX40200 is an ideal diode, losing only 30mV when powering the load from battery. This increases battery life between charge cycles.

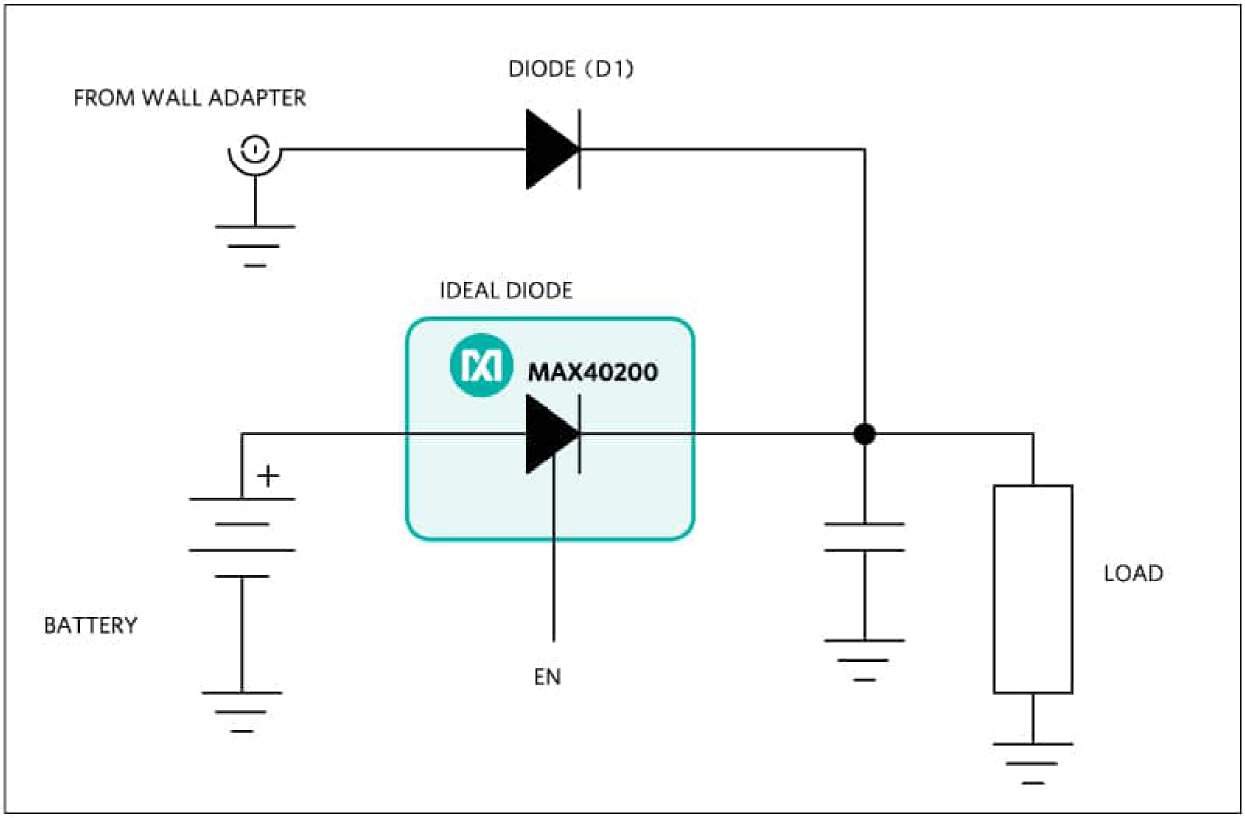

Figure 3. Diode ORing circuit

Related Parts		
MAX40016	4-Decade Current Sense Amplifier with Integrated R_{SENSE}	Free Samples
MAX40200	Ultra-Tiny Micropower, 1A Ideal Diode with Ultra-Low Voltage Drop	Free Samples

More Information
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