

Complete battery-pack design for one- or two-cell portable applications

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 Portable Power Management Applications

Introduction

Although voltage measurement alone has been used in many portable products to approximate the remaining capacity of the battery, this method may have an error of up to 50%. The relationship between cell voltage and capacity will vary as a function of discharge rate, temperature, and cell aging. For example, a high discharge rate results in a greater voltage drop than a low discharge rate for the same depletion in capacity. Similar characteristics can be noticed when a cell is discharged at varying temperatures.

With the growing demand for products with longer run times, system designers need a more accurate solution. Using a gas-gauge IC to measure the charge that enters or leaves a battery will provide a much better estimate of battery capacity over a broad range of application power levels.

Gas-gauging principle

A gas gauge is an IC that autonomously monitors the capacity of a battery, which it reports to a processor that makes system power-management decisions. A good gas gauge requires at a minimum the means to measure battery voltage, pack temperature, and current; a microprocessor; and a proven gas-gauging algorithm.

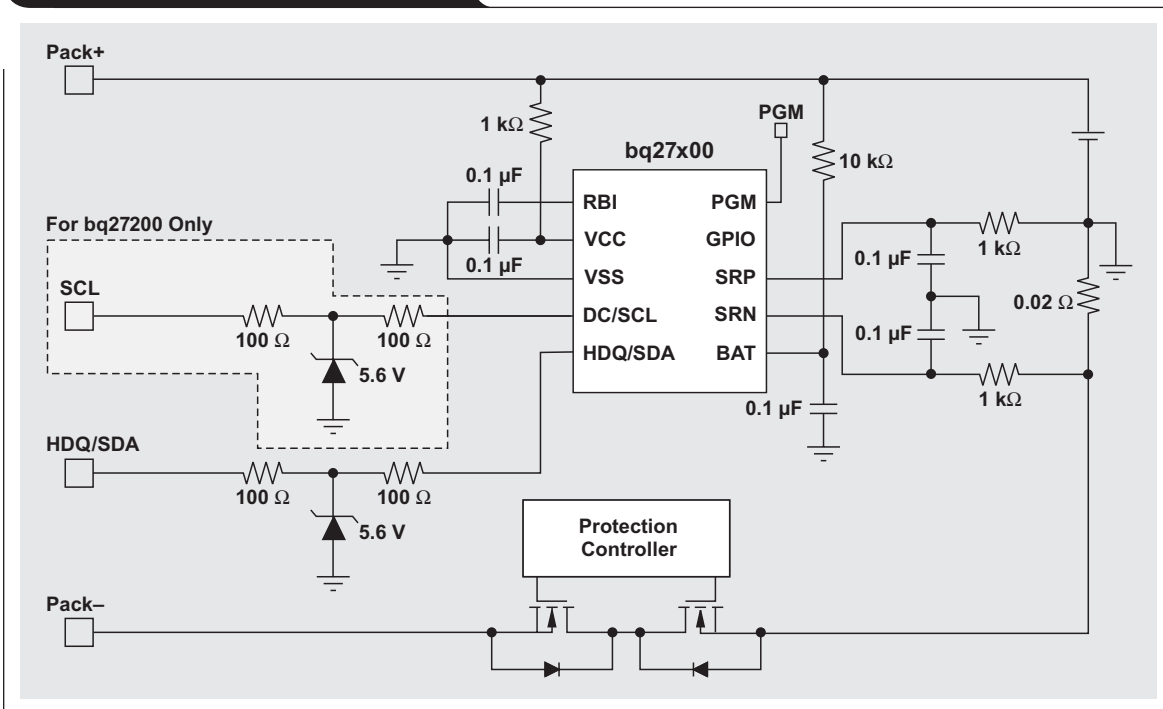
The bq2650x and bq27x00 are complete gas gauges that have an analog-to-digital converter (ADC) for voltage and temperature measurements, and another ADC for current and charge sensing. These gas gauges also have an internal microprocessor that runs Texas Instruments (TI) gas-gauging algorithms. These algorithms compensate for self-discharge, aging, temperature, and discharge rate in lithium-ion (Li-ion) cells. The microprocessor frees the host system processor from constantly making these calculations.

The gas gauges have information such as “Remaining State of Capacity,” and the bq27x00 family provides “Run Time to Empty.” The information is available any time the host queries. It is up to the host to notify the end user of the battery information either by means of LEDs or messages displayed on a screen. Using the gas gauges is very easy, as the system processor needs only an I²C or an HDQ communication driver.

Battery-pack circuit description

Figure 1 depicts the application circuit within the battery pack. The battery pack will have at least three to four external terminals available depending on which gas-gauge IC is used.

Figure 1. Typical application circuit



The VCC and BAT pins will tap into the cell voltage for IC power and battery-voltage measurement. A low-value sense resistor is placed at the ground end of the battery cell so that the voltage across the sense resistor can be monitored by the gas gauge's high-impedance SRP and SRN inputs. The current through the sense resistor helps determine the amount of energy that has been charged to or discharged from the battery. When selecting a sense resistor value, the designer must consider that the voltage across it should be no more than 100 mV. A resistor value that is too low may introduce errors at low currents. A board layout must ensure that the connections from SRP and SRN to the sense resistor are as close as possible to the sense resistor's ends; i.e., they are Kelvin connections.

The HDQ/SDA and SCL pins are open-drain devices that each require an external pull-up resistor. The resistor should be on the host or main application side so that the sleep function of the gas gauge is enabled whenever a battery pack is disconnected from the portable device. A recommended pull-up resistor value is 10 k Ω .

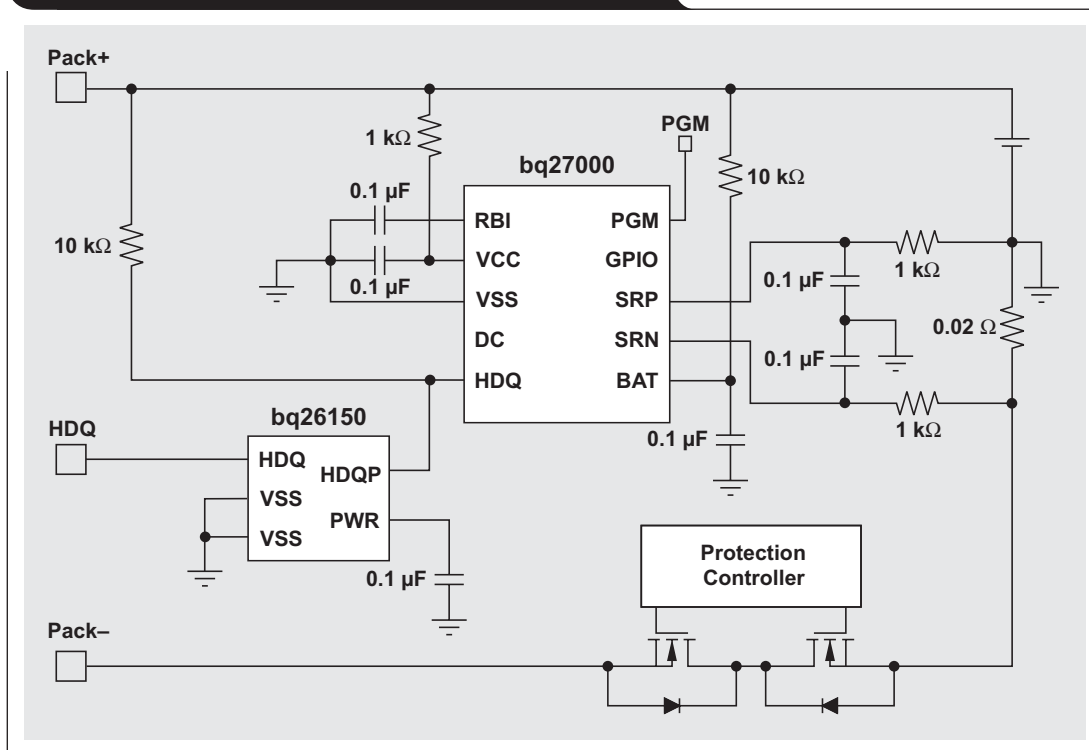
Battery-pack authentication

Rechargeable batteries for a portable device must be replaced before the life of the device expires. This has opened up a huge market for counterfeiters to supply cheap replacement batteries that may not have the safety and protection circuits required by the original equipment manufacturer.

Therefore, in addition to gas-gauging functionality, a battery pack may include an authentication feature (see Figure 2). The host challenges the battery pack, which contains an IC (TI's bq26150) that calculates a cyclic redundancy check (CRC). This CRC is based on the challenge and the CRC polynomial secretly defined within the IC. The host also calculates the CRC and compares values to determine if authentication is successful. If not, the host decides whether to try again or disallow powering of the system through the battery.

Once the battery is authenticated, the bq26150 is given a command to ensure that all communication through the data line is relayed between the host and the gas gauge.

Figure 2. Circuit with bq27000 and authentication IC



From that point on, the host can follow up on the gas gauge's functionality. The whole authentication process must be repeated upon disconnection from and reconnection to the battery.

Two-cell applications

Figure 3 shows the typical application circuit for supporting two Li-ion cells with the bq26500. An adjustable voltage regulator is added for multicell support. The BAT pin of the gas gauge is connected to the positive side of the bottom cell for a scaled battery-pack voltage measurement.

The host is required to interpret the scaled pack voltage measured by the gas gauge to determine the end-of-discharge threshold and charge termination. Information such as "Remaining State of Capacity" can be used as it is reported by the gas gauge.

Conclusion

The bq2650x and bq27x00 provide battery manufacturers a simple alternative for battery-capacity reporting. The host can obtain a remaining-capacity value just by reading a register from the gas gauge and can then display the result to the end user. By using a gas gauge, the end user can use as much of a battery's charge as possible without being very conservative, because the capacity estimate will be more accurate than that obtained by just measuring cell voltage. The gas gauges can be used in different configurations, permitting authentication features and operation within two-cell applications.

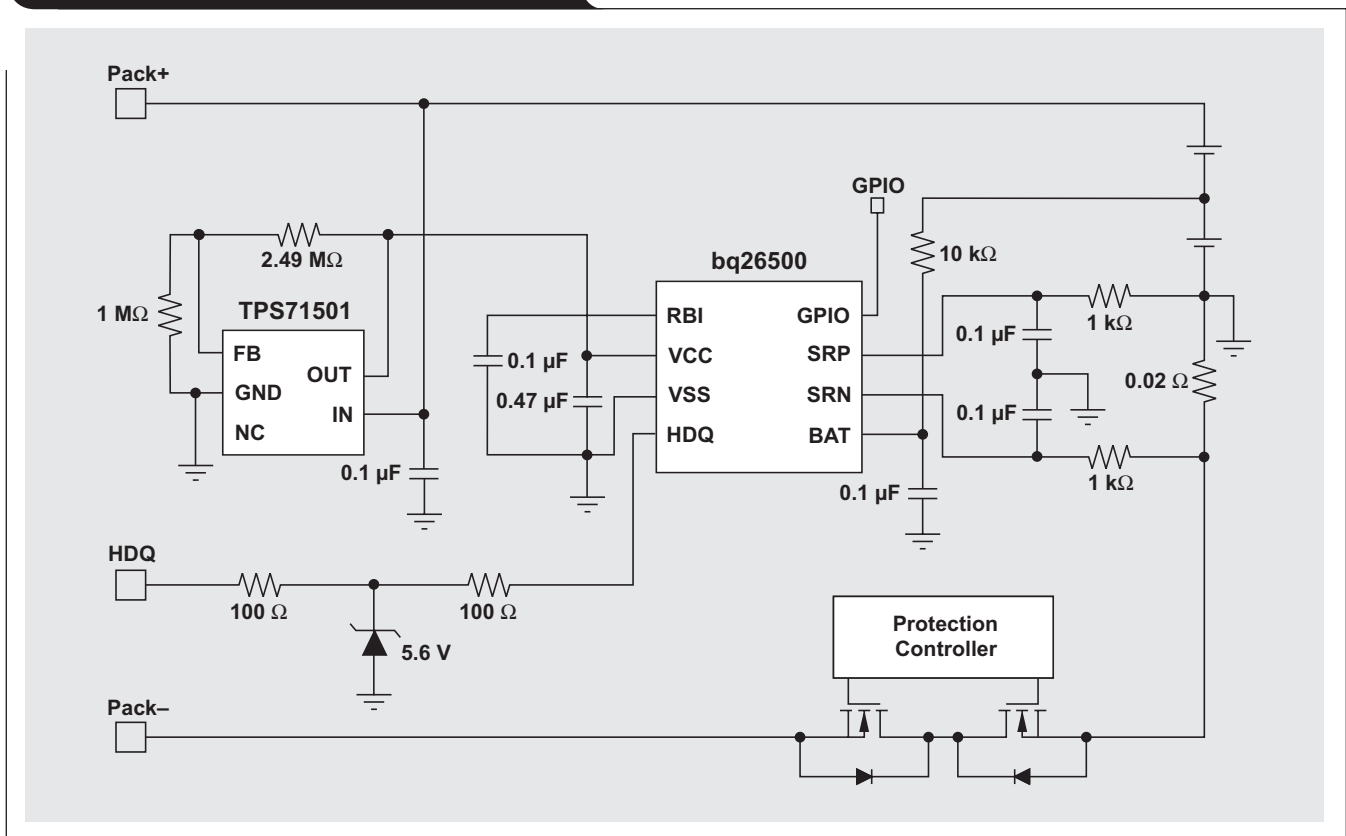
Related Web sites

power.ti.com

www.ti.com/sc/device/partnumber

Replace *partnumber* with bq26150, bq26500, bq27000, bq27200, or TPS71501

Figure 3. Two-cell application with bq26500



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