

Multicell Li-Ion and Li-Pol Battery Gas-Gauge Application Using the bq26500

Battery Management

ABSTRACT

The bq26500 is the first complete battery fuel gauge for handheld devices such as PDAs and cellular handsets. Many of these applications use only one Li-Ion or Li-Polymer cell in the battery, producing a nominal 3.6 V. Although optimized for single-cell applications, the bq26500 works well in systems using multicell battery packs, particularly two series-cell batteries producing 7.2 V. This application report describes implementation of multicell battery packs using bq26500 circuits.

Bottom-Cell Tap

To power the bq26500 using batteries higher than 4.5 V, a voltage regulator such as the TPS71501 is recommended. When programmed with the appropriate voltage-divider value, this low-dropout regulator supplies 4.205 V, keeping the bq26500 within its supply-voltage specification of 2.6 to 4.5 V while not allowing the BAT-pin voltage to exceed VCC by more than 0.3 V. The maximum output current of this regulator is 50 mA, more than sufficient to accommodate the device's maximum active operating current of 100 μ A. Low quiescent current allows operation at extremely low power levels.

To measure battery voltages greater than 4.5 V, connect the positive terminal of the bottom battery cell to the BAT pin. The example in Figure 1 has a two-cell Li-Ion battery. This recommendation applies to any multicell battery system as long as the cell connected to the BAT pin is always the bottom cell and that the total voltage of the battery does not exceed the input limitations of the voltage regulator being used. This ensures that the voltage measured by bq26500 is never greater than 4.5 V.

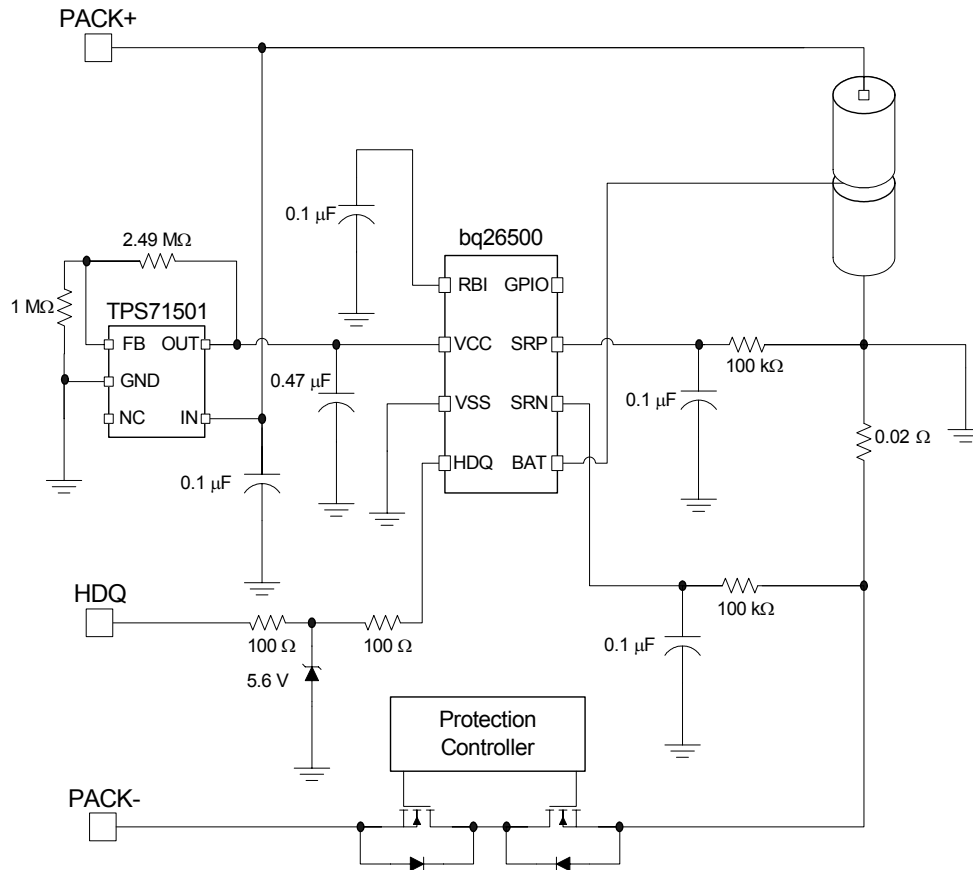


Figure 1. Bottom-cell Tap Application Circuit

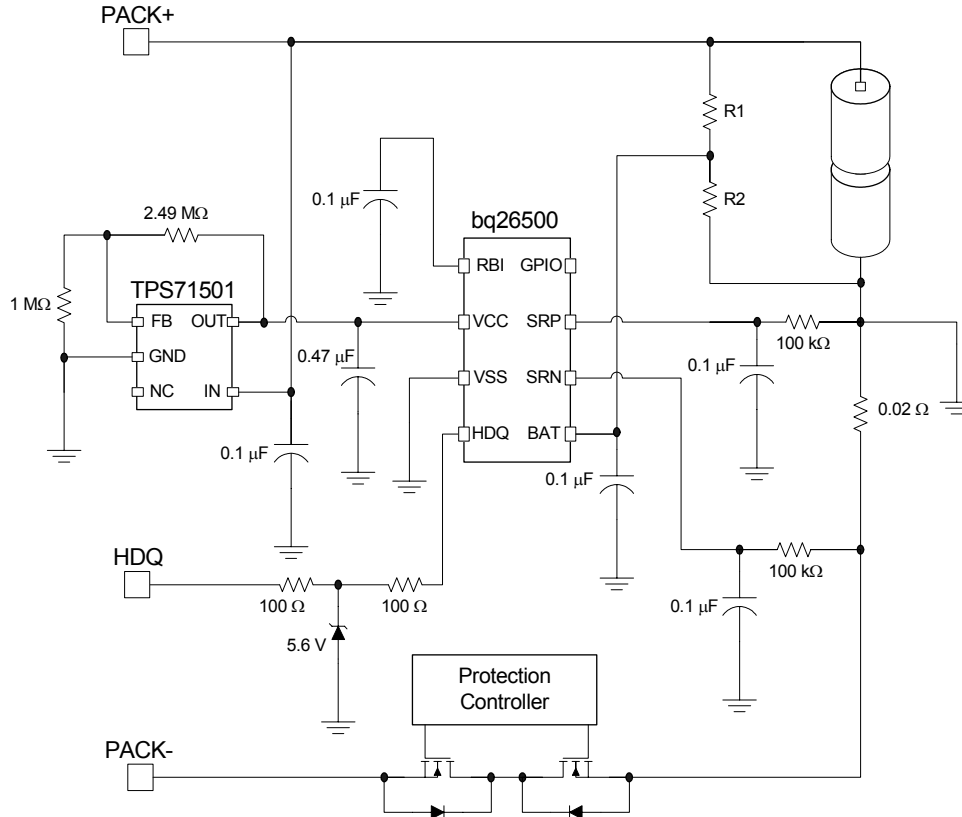
When developing code for the host, the battery cell ratios must be considered for calculating the voltage of the battery. The total battery voltage is determined with the following equation:

$$Total\ Battery\ Voltage = N \times Bottom\ Cell\ Voltage$$

where N is the cell count of the battery.

The accuracy of the total battery voltage calculated depends on the balance between all the cells. Since the leakage current on the BAT pin is negligible, measuring one cell voltage causes no cell imbalance. The values for EEPROM registers are the same as for a single cell.

Voltage Divider



An alternative circuit for a multicell bq26500 solution is a voltage divider. In this circuit, a 0.01- μF or 0.1- μF capacitor is recommended at the BAT pin input to supply the AC current drawn by the BAT pin.

In a final product design, the bottom-cell tap circuit is recommended over the voltage divider because current flows through the resistors even when the device is in sleep mode. This 10- μA current is acceptable in many applications. Figure 2 is an example application circuit.

Figure 2. Voltage Divider Application Circuit

The total battery voltage is calculated with the following equation:

$$\text{Total Battery Voltage} = \frac{V_{R2}}{R_2} (R_1 + R_2)$$

The recommended values for R1 and R2 are $R1 = R2 = 400\text{ k}\Omega$. To determine the maximum error of the voltage sensed by the BAT pin, visualize the voltage divider as shown in Figure 3. This representation includes the minimum impedance of $10\text{ M}\Omega$ at the BAT pin. If the true total voltage of the battery cells is 7.2 V , then the voltage at the BAT pin can be no lower than 3.494 V when using resistors with a 1% tolerance. Given these values, the error for measuring a voltage of 7.2 V (expected voltage under normal operation of a two-cell Li-Ion pack) is about 3%, with a current drawn by the voltage divider of about $10\text{ }\mu\text{A}$. Other values may be selected, but keep in mind the compromise between the accuracy of the voltage measurement and the amount of current drawn by the voltage divider. Lower resistor values increase the accuracy of the battery measurement but result in higher currents. By selecting higher resistor values the current is decreased, but so is the accuracy of the voltage measurement. The maximum error is calculated by:

$$\% \text{ error} = (2\% + \text{tolerance } \%)$$

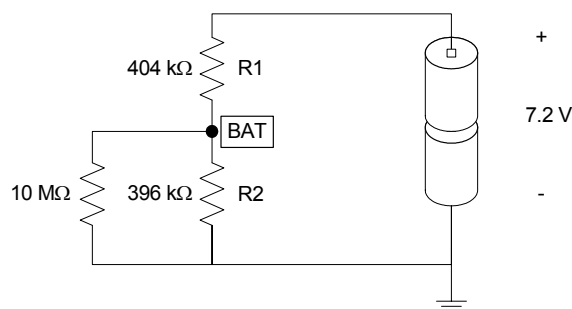


Figure 3. Voltage Divider

EEPROM Programming

When using the bottom-cell tap circuit or the voltage divider with equal resistors, EEPROM programming is similar to that for a single-cell application. Only three locations are related to voltage measurement—the QV1 and QV2 bits in register $0x7C$, the SEDV1 in register $0x78$, and the SEDVF in register $0x77$. The values programmed in these locations depend on the characteristics of the bottom cell. For example, in a two-cell battery pack with a true EDVF value of 6.0 V , the SEDVF is programmed for 3.0 V , the voltage of the bottom cell when the battery pack reaches EDVF threshold. These same considerations apply when programming the end voltage for charge termination at QV1 and QV2 bits and for programming the SEDV1 threshold.

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Mailing Address: Texas Instruments
Post Office Box 655303 Dallas, Texas 75265