Application Report
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Multicell Li-Ion and Li-Polymer Battery Gas-Gauge Host Side Application Using bq2750x

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Battery Management

ABSTRACT

The bq2750x family of gas gauges is designed to operate from a single-cell, lithium-ion or lithium-polymer battery. The applications that benefit from these gas gauges use two or more lithium cells in series where the battery voltage exceeds the single cell gas gauge bq2750x family battery voltage measurement capability, which normally is equal to or less than 5 V. This application report describes a low-component-count solution for using the bq27500, bq27501 and bq27505 with a multi-cell battery.

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1 Introduction

Host-side application of a single-cell gas gauge, bq2750x, requires direct battery voltage measurement from the battery pack. For a single-cell pack, the bq2750x uses the BAT pin to measure the pack voltage directly with the BAT pin internal translation circuits enabled. The maximum voltage that can be applied to the BAT pin is 5 V.

If a multicell battery pack is used, the bq2750x cannot directly measure the battery voltage because the pack voltage may be much higher than the maximum operating voltage on the BAT pin. An external resistive voltage divider circuit is required to divide down the battery voltage to the range equivalent to a single-cell battery.

Impedance Track is a trademark of Texas Instruments.

2 The Implementation

When the bq2750x BAT pin is enabled for direct voltage measurement, the internal translation circuit is turned on. This internal translation circuit has a built in 5:1 ratio resistive voltage divider. The total resistance of the internal voltage divider is approximately 100 kΩ. The actual ratio is calibrated at the device final test and stored in the device so that the direct voltage-measurement on the bq2750x BAT pin can achieve 1-mV accuracy. This voltage measurement accuracy is required by the Impedance Track™ algorithm to have less than 1% state-of-charge error.

When an external resistive voltage divider is directly connected to the BAT pin, the external voltage divider network interferes with the internal voltage divider network and causes the voltage divider ratio to change so that the voltage measurement is not accurate. To prevent the interference, a unity-gain operational amplifier is used to buffer the output of the resistive voltage divider and provide a BAT voltage that is equal to the external voltage divider output. The micro-power operational amplifier generally has much higher input impedance than the 100-kΩ internal voltage divider and reduces the voltage measurement error due to loading of the external voltage divider output.

The tolerance of the external voltage divider resistors has a direct impact on the voltage measurement error. A resistor with 0.1% tolerance is required. Considering the temperature range of the application, a temperature coefficient of 50 ppm/C or less is also needed. The resistors must be of the same kind and from the same manufacturer.

The capacitor at the output of the operational amplifier and the resistor of the BAT pin internal voltage divider form an RC decoupling circuit. This allows use of appropriate bypass capacitors at the BAT input, yet does not cause instability of the unity-gain amplifier due to capacitive load.

The bq2750x series gas gauge has typical current consumption of 100 µA under normal operation. The peak current can go up to 1 mA for a short period of time. The operational amplifier cannot provide enough current for bq2750x to work properly. A separate LDO is required to provide the power to VCC of the gauge. The required LDO can be powered up from the same battery voltage as the one-cell application does. The maximum input allowed for the LDO must be above 8.4 V for the two-cell application.

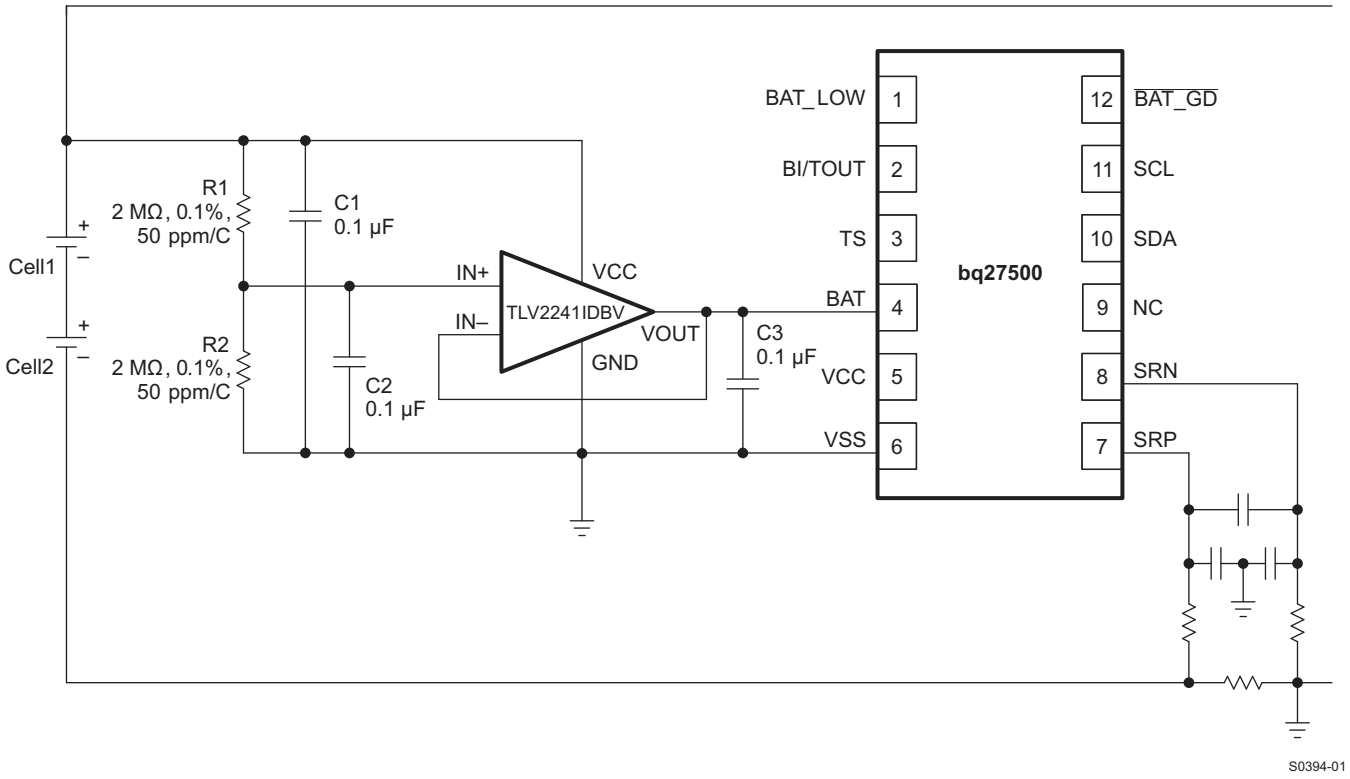

Figure 1. External Voltage Divider Using Operational Amplifier

3 Voltage Calibration and Accuracy

The internal voltage divider inside bq2750x has been calibrated at the factory to have 1-mV accuracy. The external voltage divider requires additional calibration.

For calibration, a calibrated voltage meter with resolution better than 1 mV is used. Apply a constant 8 V to the positive input of the voltage divider and read the voltage measured by the bq2750x gauge. The expected voltage should be 4 V. The difference is the offset error, and it can be stored in data flash inside the gauge.

To further investigate the impact of temperature and input voltage on the voltage divider offset and gain, a bq27500 evaluation module is built with this voltage divider circuit and tested with voltage input from 8.4 V down to 6 V with 200-mV increments at –10°C, 25°C and 50°C. The voltage measurement error across the temperature and voltage range after calibration is shown in Table 1. The maximum voltage error due to the voltage divider is in the 1- to 2-mV range after calibration.

Table 1. Voltage Divider Accuracy After Calibration

–10°C				25°C				50°C			
Pack Voltage	Divided Voltage	Abs. Error	After Cal. Error	Pack Voltage	Divided Voltage	Abs. Error	After Cal. Error	Pack Voltage	Divided Voltage	Abs. Error	After Cal. Error
8.401	4.193	0.015	–0.001	8.401	4.192	0.017	0.001	8.401	4.192	0.017	0.001
8.201	4.093	0.015	–0.001	8.201	4.092	0.017	0.001	8.201	4.092	0.017	0.001
8.000	3.992	0.016	0.000	8.000	3.992	0.016	0.000	8.000	3.992	0.016	0.000
7.800	3.893	0.014	–0.002	7.800	3.892	0.016	0.000	7.800	3.892	0.016	0.000
7.600	3.792	0.016	0.000	7.600	3.792	0.016	0.000	7.600	3.792	0.016	0.000
7.400	3.693	0.014	–0.002	7.400	3.692	0.016	0.000	7.400	3.692	0.016	0.000
7.200	3.592	0.016	0.000	7.200	3.592	0.016	0.000	7.200	3.592	0.016	0.000
7.000	3.492	0.016	0.000	7.000	3.492	0.016	0.000	7.000	3.492	0.016	0.000
6.800	3.392	0.016	0.000	6.800	3.392	0.016	0.000	6.800	3.392	0.016	0.000
6.600	3.292	0.016	0.000	6.600	3.292	0.016	0.000	6.600	3.292	0.016	0.000
6.400	3.192	0.016	0.000	6.400	3.192	0.016	0.000	6.400	3.192	0.016	0.000
6.200	3.093	0.014	–0.002	6.200	3.093	0.014	–0.002	6.200	3.092	0.016	0.000
6.000	2.993	0.014	–0.002	6.000	2.993	0.014	–0.002	6.000	2.992	0.016	0.000
Unit: volts											

4 bq2750x Configuration and Learning Process

The gas gauge configuration and learning process is identical to that of a single-cell application. Equivalently, the bq2750x is operating from a single cell. Gauge current sensing is not affected by multiple cells in series. The cell internal impedance calculation is still valid. The total capacity of the cells in series is the same as that of a single-cell capacity. If a 1-mV accuracy voltage measurement is maintained, the overall accuracy of the gauge for multiple cells is the same as for a single cell. The data flash configuration and the learned data flash image from a single cell can be used for the same cell in a multicell configuration.

5 Cell Balancing Consideration

None of the bq2750x devices have cell-balancing capability, and the use of a voltage divider does not provide any individual cell information. It is up to the pack maker and the original equipment manufacturer to make sure that the cells in series are not out of balance and that the safety of the pack is maintained.

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