

# **bq27426 Gauging Design for Applications With 2-S Li-Ion Battery**



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## **ABSTRACT**

The bq27426 gas gauge 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 bq27426 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 bq27421, bq27426, and bq27441 with 2-S (2 cells in series) battery.

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## 1 Introduction

Host-side application of a single-cell gas gauge, bq27426, requires direct battery voltage measurement from the battery pack. For a single-cell pack, the bq27426 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 2-S battery pack is used, the bq27426 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 of a single-cell battery.

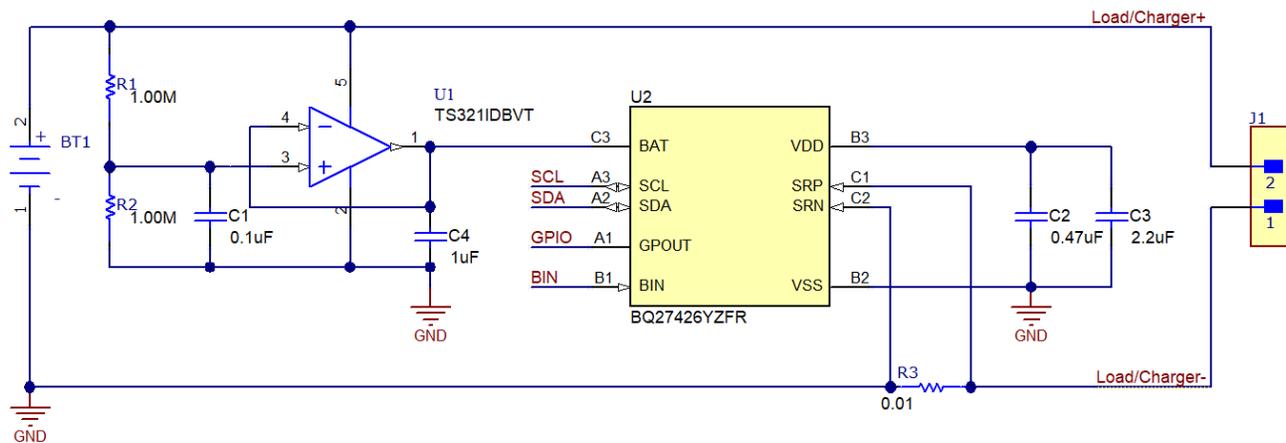
## 2 Implementation

The bq27426 BAT pin is designed not only for 2.45V to 4.50V directly voltage measurement with internal voltage divider enabled, but also it's the internal LDO regulator input pin. It's required to connect an 1- $\mu$ F capacitor to achieve 1-mV accuracy of voltage-measurement on the bq27426 BAT pin. This voltage measurement accuracy is required by the Impedance Track™ algorithm to have less than 1% state-of-charge error.

If 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 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 bq27426 gas gauge has typical current consumption of 50  $\mu$ A under normal operation. The peak current at start up can go up to 8 mA for a short period of time. To ensure the bq27426 starts up properly, the 1- $\mu$ F capacitor on the BAT pin is necessary, and so the operational amplifier shall have the capability to drive a high-capacitance load. With consideration of size, cost, and power consumption, TI's TS321IDBV is selected for this application.



**Figure 2-1. External Voltage Divider Using Operational Amplifier**

### 3 Voltage Calibration and Accuracy

The internal voltage divider in the bq27426 is factory-calibrated to have a 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 bq27426 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 bq27426 for 2-S reference design evaluation module is built with this voltage divider circuit. Test is implemented with voltage input from 8.4 V down to 6 V with 200-mV increments at  $-10^{\circ}\text{C}$ ,  $25^{\circ}\text{C}$  and  $50^{\circ}\text{C}$ . The voltage measurement error across the temperature and voltage range after calibration is shown in the following table. The maximum voltage error due to the voltage divider is in the 1- to 2-mV range after calibration.

**Table 3-1. Voltage Divider Accuracy After Calibration**

$-10^{\circ}\text{C}$				$25^{\circ}\text{C}$				$50^{\circ}\text{C}$			
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 bq27426 Configuration and Learning Process

The gas gauge configuration and learning process is identical to that of a single-cell application. Equivalently, the bq27426 is operating from a single cell. Gauge current sensing is not affected by a 2-S battery. The battery internal impedance calculation is still valid. The total capacity of the 2-S 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 2-S battery 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 2-S configuration.

## 5 Cell Balancing Consideration

The bq27426 device has no cell-balancing capability, and the use of a voltage divider does not provide any individual cell information. Therefore, is up to the pack maker and the original equipment manufacturer to make sure that the 2 cells in series are not out of balance and that the safety of the pack is maintained.

## 6 Revision History

<b>Changes from Revision * (December 2017) to Revision A (September 2022)</b>	<b>Page</b>
• Updated the numbering format for tables, figures, and cross-references throughout the document.....	<a href="#">1</a>
• Updated schematic error showing high side sense resistor.....	<a href="#">2</a>

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