Using the bq2058

Improving Immunity to False Overcurrent Shutdown

Overview

For battery pack protectors using the bq2058, BENCHMARQ recommends a Schottky diode in series with the bq2058's power rail. This additional component allows correct operation in case of a severe overload, such as a catastrophic short circuit. Early BENCHMARQ designs show the diode (D1) placed in series with Vcc (Figure 3). However, this circuit is susceptible to false overcurrent shutdown if significant voltage transients appear across the battery terminals. Moving the Schottky diode to the bq2058's Vss rail (Figure 5) dramatically improves the protector's susceptibility to false overcurrent shutdown. This simple change dramatically improves the performance of the circuit without adding cost.

Introduction

A typical 18650 Li-Ion cell has more than 100nH of series inductance, as determined from the impedance curve in Figure 1. High di/dt through this inductance can create significant voltage transients at the battery terminals. Transients are produced, for example, if the battery is inserted into a system and engages bouncing battery contacts to charge a capacitative load. Since a discharged capacitor appears as a momentary short circuit, its effect on the battery pack can be demonstrated by brushing the pack terminals together. As shown in Figure 2, a 2S-1P Li-Ion battery (18650 cells) experiences significant undershoot and overshoot of its terminal voltage. These transients can trigger an overcurrent shutdown of the discharge FET in a pack protector as shown in Figure 3.

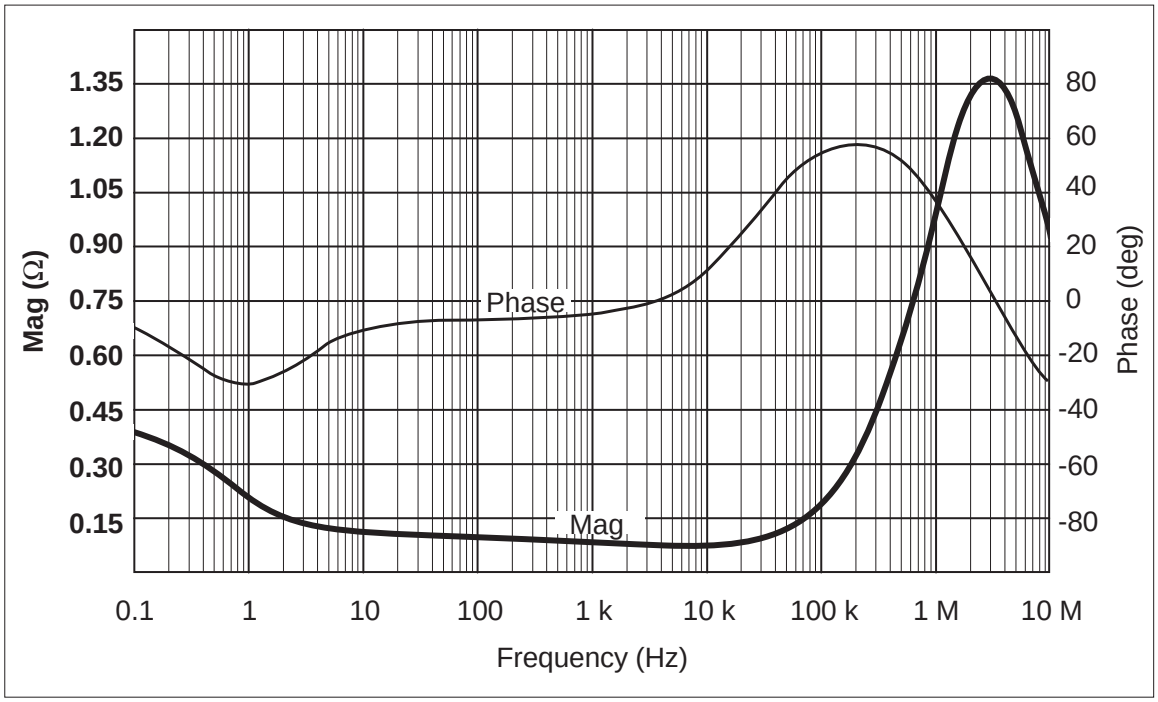


Figure 1. Typical 18650 Li-Ion Battery Impedance

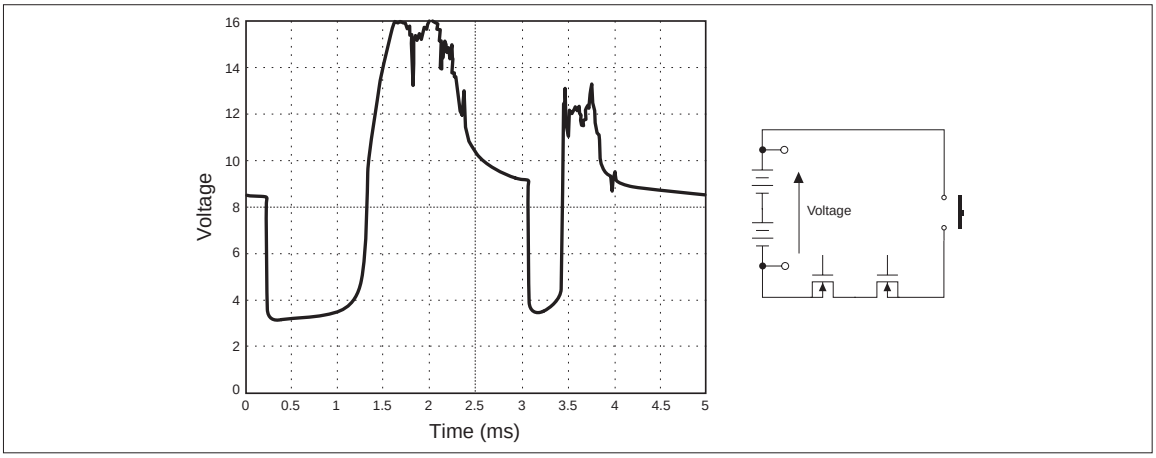


Figure 2. Voltage Transient Across a 2S-1P Li-Ion Battery

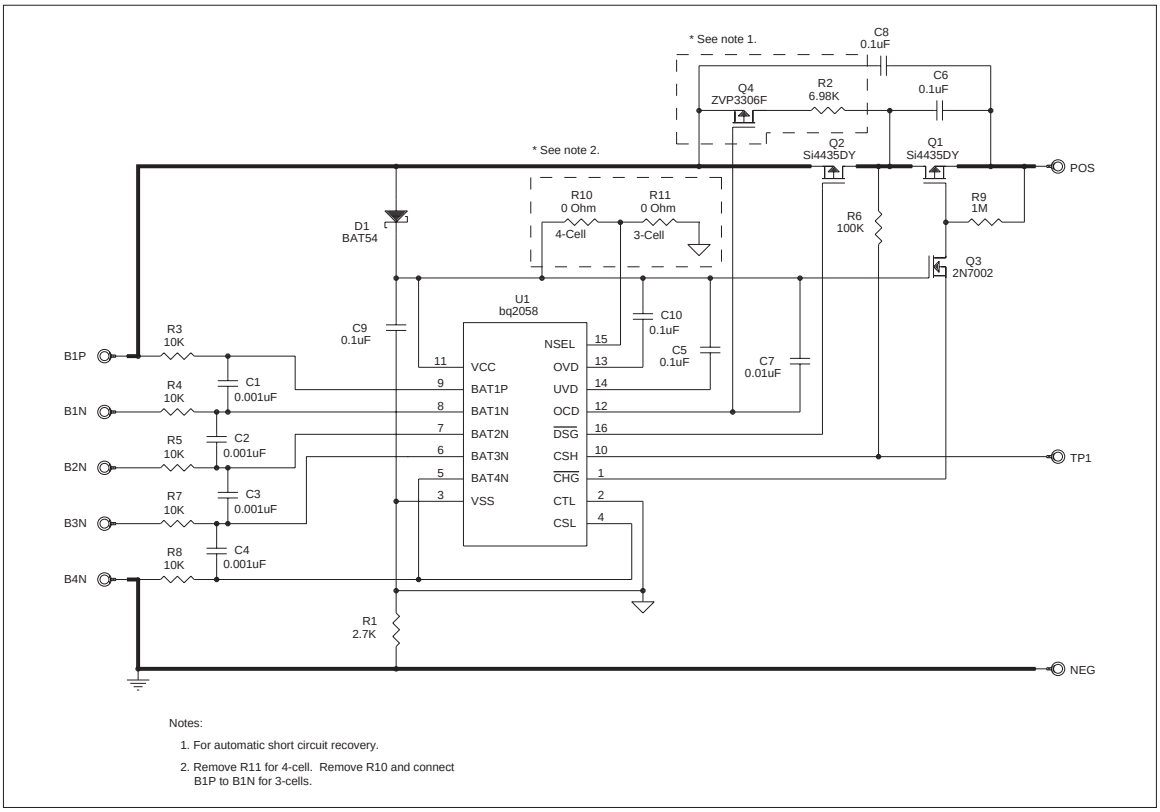


Figure 3. Earlier bq2158 3- to 4-Cell Li-Ion Protector

Circuit Operation

Excessive voltage between BAT1P and Vcc can corrupt the internal 160mV voltage reference of the bq2058's high-side current comparator. This condition occurs if the battery voltage collapses because D1 decouples BAT1P from Vcc. Overcurrent shutdown of the discharge FET occurs if the reference voltage, implemented as a switched capacitor circuit, fails to recover before the OCD timer expires. Figure 4 shows a collapse in the bottom cell voltage of a 3-cell protector triggering an overcurrent shutdown of the circuit in Figure 3. A signal generator with a DC offset simulates the bottom cell, while the top two cells are Li-Ion cells.

Can D1 be removed to reduce susceptibility to voltage transients? Yes, but D1 is also needed to guarantee protector operation in the case of a severe overload. A severe overload, such as a short circuit at the pack terminals, can collapse the battery voltage below the operating voltage of the bq2058. Loss of power to the bq2058 makes control of the charge and discharge FETs impossible and may cause their destruction. D1 ensures continued operation in a severe overload by allowing C9 to power the bq2058. Collapse of battery voltage causes a reverse bias in D1, preventing the load from discharging C9.

V_{OUT} is greater than zero volts when overcurrent shutdown occurs because the automatic short-circuit recovery circuit places a 6.98K resistor, R2, in series with the load.

Circuit Solution

BENCHMARQ recommends the protector implementation in Figure 5 because of its increased immunity to false overcurrent shutdown. This implementation is identical to the circuit in Figure 3, except that D1 is in series with the bq2058's Vss rail. The circuit retains its ability to function properly in case a severe overload collapses the battery voltage.

The combined DC voltage across R1 and D1 is less than 0.6V to prevent turn-on of the bq2058's substrate diode. To meet this criterion, a Schottky diode is selected for D1 because of its low forward voltage.

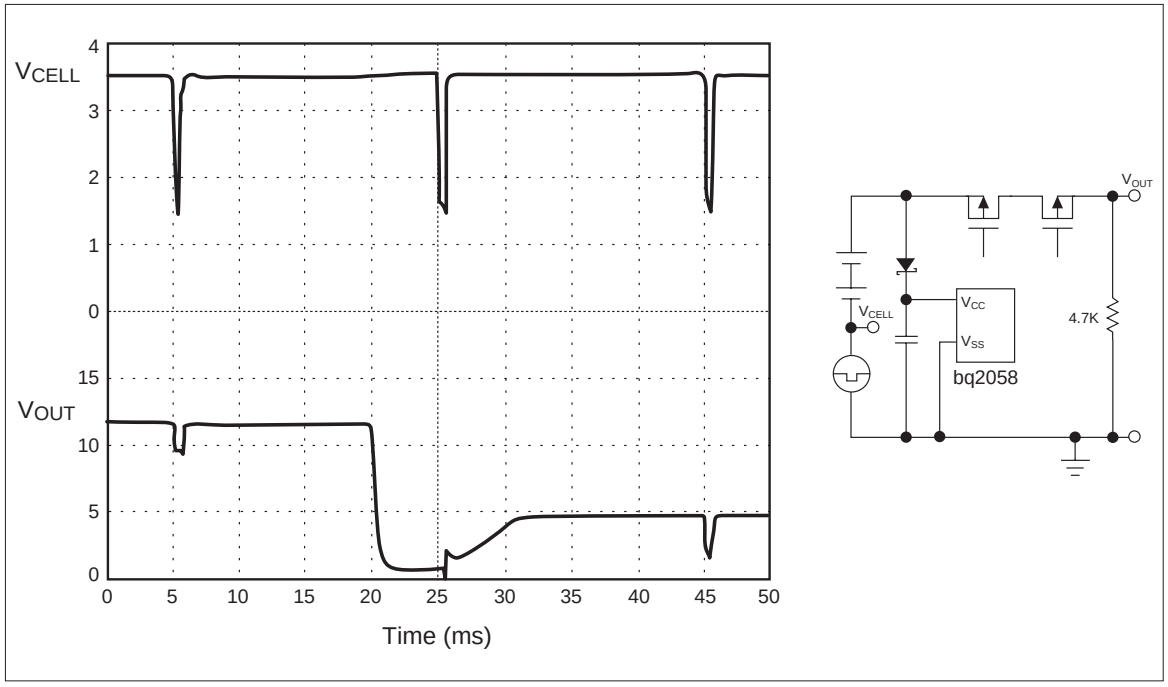
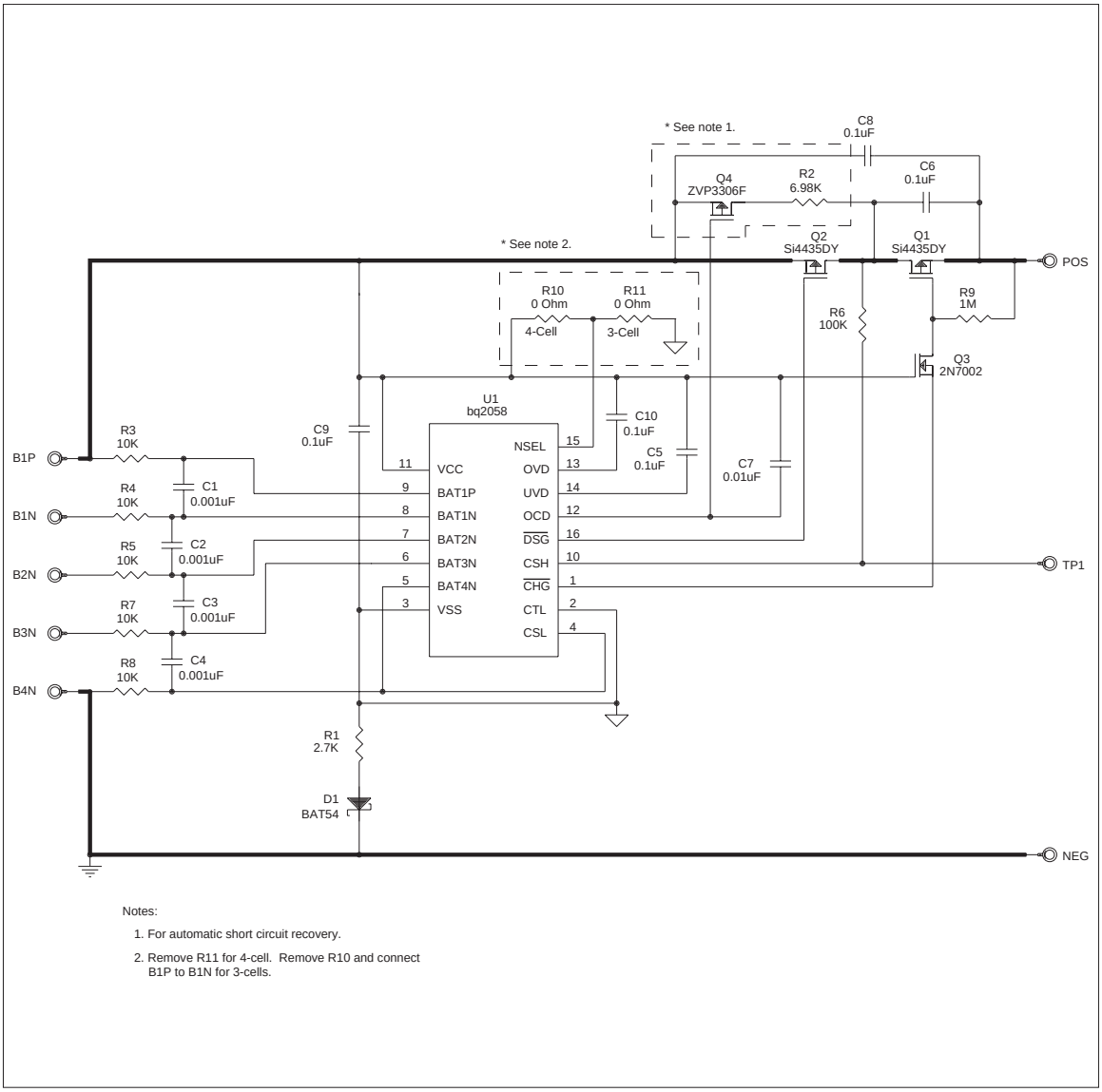


Figure 4. Over-Current Shutdown Induced by a Voltage Transient



Notes:

1. For automatic short circuit recovery.
2. Remove R11 for 4-cell. Remove R10 and connect B1P to B1N for 3-cells.

Figure 5. Improved bq2158 3- to 4-Cell Li-Ion Protector

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