Using a USB Power Supply With Standalone Chargers for Two-Cell Li-Ion Batteries

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ABSTRACT

This application report shows a solution using bq24103 to charge two-cell Lithium-ion batteries with standalone chargers, while varying the charge current for a regular high-current DC source, like a wall adapter, and a current-limited voltage-boosted USB 2.0 supply.

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1 Introduction

1.1 Standalone Chargers

The standalone chargers do not have a communication interface. They are useful in applications which do not have a MCU available to regulate the charging process.

The charge current is set through external resistors and does not require intervention from another device.

1.2 bq24103 Overview

The bq24103 is a highly-integrated Li-ion and Li-polymer switch-mode charge management device targeted at a wide range of portable applications. It comes in a small, thermally-enhanced QFN package and offers:

- Integrated synchronous PWM controller
- Four power FETs
- High-accuracy current and voltage regulation
- Charge preconditioning, charge status, and charge termination

The bq24103 charges the battery in three phases: conditioning, constant current, and constant voltage. Charge is terminated based on the user-selectable minimum current level. A programmable charge timer provides a safety backup for charge termination.

The device automatically restarts the charge cycle if the battery voltage falls below an internal threshold. The device automatically enters sleep mode when the VCC supply is removed.

1.3 Operation

The typical charging profile is shown in Figure 1.

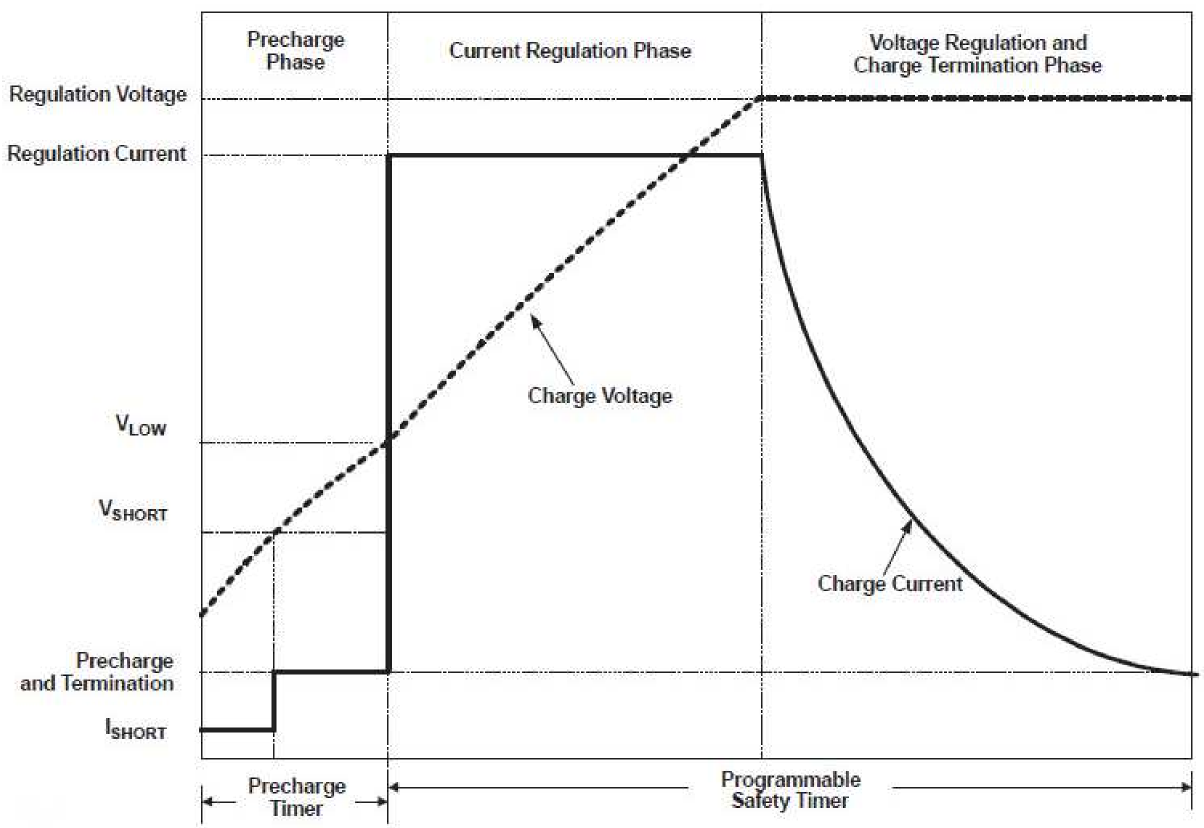


Figure 1. Charging Profile

2 Application

Many portable devices, such as POS handheld terminals, tablets, and so forth, use higher capacity 2-cell Li-ion rechargeable batteries as the energy storage source. These devices typically charge through wall adapters or a USB interface.

Assuming USB 2.0 compatibility, the bq24103 provides a charging arrangement through the USB port, without the use of additional charge management devices.

Consider the following for charging a device:

- The AC wall adapter can supply a higher charge current of 1 to 2 A (typical), whereas the USB 2.0 interface is current limited.
- The fast charge and termination current values are set using external resistors, which need to be modified for setting different values.

This application report details a method to selectively connect resistors in series as set resistors (R_{ISET1} and R_{ISET2}), depending on the availability of the AC adapter power supply.

Assuming a typical 8.4-V Li-ion battery pack, a 12-V, 2-A wall adapter, the user first boosts the 5-V USB supply to a sufficiently high voltage of 9.5 V.

For the boost application, the design can be completed with the help of online WEBENCH designer tool, available on www.ti.com.

3 Component Value Calculation

Assuming a nominal converter efficiency of 80%, the 9.5-V boosted voltage has a current supply limit of about 210 mA. The specifications for charging are set as follows:

- With an AC adapter: Charge current of 1.5 A and termination current of 100 mA
- With an USB source: Charge current of 200 mA and termination current of 50 mA

The battery charge current, $I_{OCHARGE}$, is established by setting the external sense resistor, R_{SNS}, and connecting the resistor, R_{ISET1}, to the ISET1 pin. To set the current, first choose R_{SNS} based on the regulation threshold VIREG across this resistor. Better accuracy is achieved when the VIREG is between 100 and 200 mV. If the result is not a standard sense resistor value, choose the next larger value. Using the selected standard value, solve for VIREG. Once the sense resistor is selected, the ISET1 resistor can be calculated using the following equations:

$$R_{SNS} = \frac{V_{IREG}}{I_{OCHARGE}} \tag{1}$$

$$R_{ISET1} = \frac{K_{ISET1} \times V_{ISET1}}{R_{SNS} \times I_{OCHARGE}} \tag{2}$$

The termination current level is selected by the value of programming resistor, R_{ISET2}, connected to the ISET2 pin

$$I_{TERM} = \frac{K_{ISET2} \times V_{TERM}}{R_{ISET2} \times R_{SNS}}$$

where

- R_{SNS} = 0.1 Ω
- K_{ISET1} = 1000
- V_{ISET1} = 1
- For: $I_{OCHARGE}$ = 1.5 A, R_{ISET1} = 6.67 kΩ
- For: $I_{OCHARGE}$ = 200 mA, R_{ISET1} =50 kΩ
- R_{SNS} = 0.1 Ω
- K_{ISET2} = 1000
- V_{TERM} = 100 mV
- For: I_{TERM} = 100 mA, R_{ISET2} = 10 kΩ
- For: I_{TERM} = 50 mA, R_{ISET2} = 20 kΩ (3)

4 Schematic

Refer to Figure 2 to selectively choose between the two values of R_{ISET1} and R_{ISET2}.

When the AC adapter supply is present, the MOSFET is on, and R_{ISET1} and R_{ISET2} are bypassed.

The effective R_{ISET1} and R_{ISET2} are 6.8 and 10 kΩ respectively. When only the USB (boosted) supply is present, the MOSFET is turned off and the effective resistances are 50 and 20 kΩ, respectively.

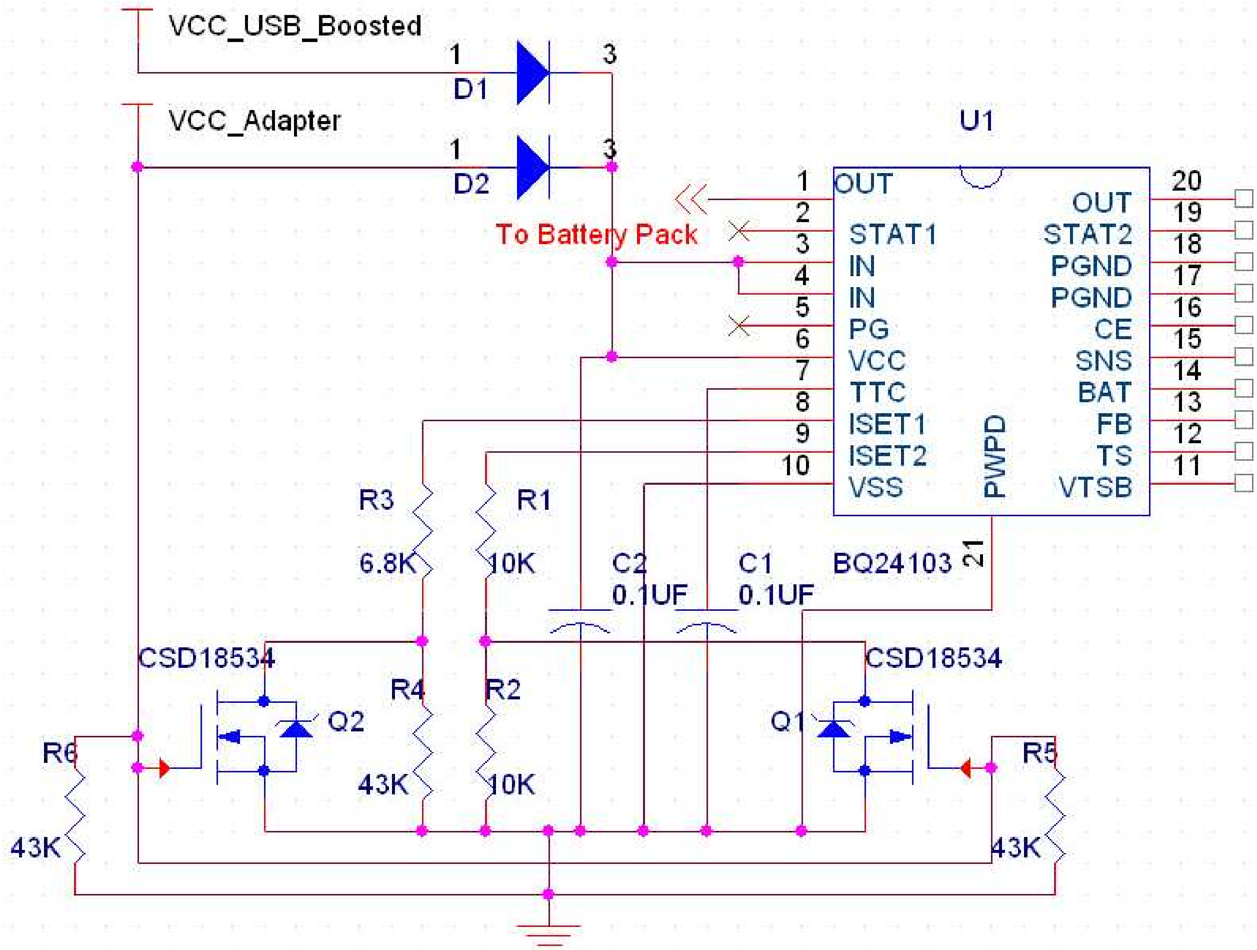


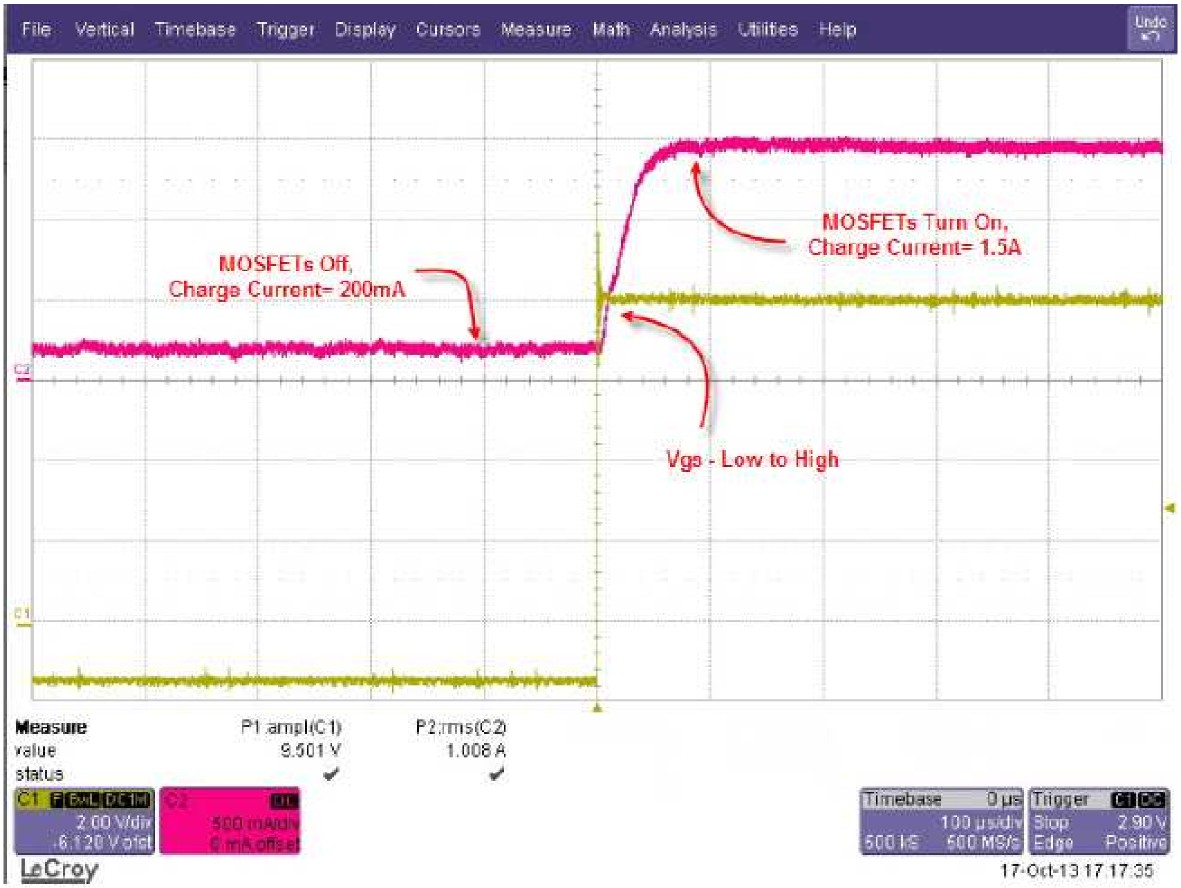
Figure 2. Schematic With Resistor Settings and MOSFET Arrangement

5 Test Results

The bq24103 evaluation board is used to measure the performance of the proposed arrangement.

Figure 3 shows the transition of the charge current from 200 mA to 1.5 A when the MOSFETs turn on.

The Vgs supply is derived from the high current source (wall adapter); when this supply is available, charge current can be increased.



Ch1 : MOSFET Vgs

Ch2: Charge Current

Figure 3. Charge Current Transition With MOSFET Turn On

6 Conclusion

The proposed arrangement allows the change of charge current on the go, depending on source selection.

A voltage boosted USB 2.0 power supply can be used along with other supplies such as wall adapters.

The additional circuitry is simple and can be used with other similar devices.

7 References

bq24103 data sheet, available on www.ti.com

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