

bq25012 single-chip, Li-ion charger and dc/dc converter for Bluetooth® headsets

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Introduction

Highly integrated charger and dc/dc converter ICs have become more and more desirable as portable power management technology continues to advance. These ICs not only support size reduction of portable devices but also incorporate more functionality and enhance performance in diagnostics, monitoring, control, and protection.

As an example, a typical Bluetooth headset needs a rechargeable battery (and thus a battery charger) and a 1.8-V dc/dc converter to power the core chip. With small size, light weight, and low cost being the major concerns, the bq25012 is an ideal solution for this application. A single-chip 3.5 × 4.5-mm QFN package incorporates a linear charger with dual inputs for both the ac adapter and the USB, and a dc/dc converter with integrated FETs saves board space and reduces system design time. Figure 1 shows a typical application circuit with a 1.8-V, 100-mA power converter and a 500-mA linear battery charger using the bq25012.

Single-cell, Li-ion battery charger

The bq25012 offers an integrated power MOSFET and charge controller with programmable charge current up to 500 mA for single-cell, Li-ion battery applications. It

charges the battery and powers the system from either the ac adapter or the USB with autonomous power-source selection. When the V_{CC} supply is removed, the bq2501x automatically enters sleep mode with reverse blocking protection to extend the battery runtime.

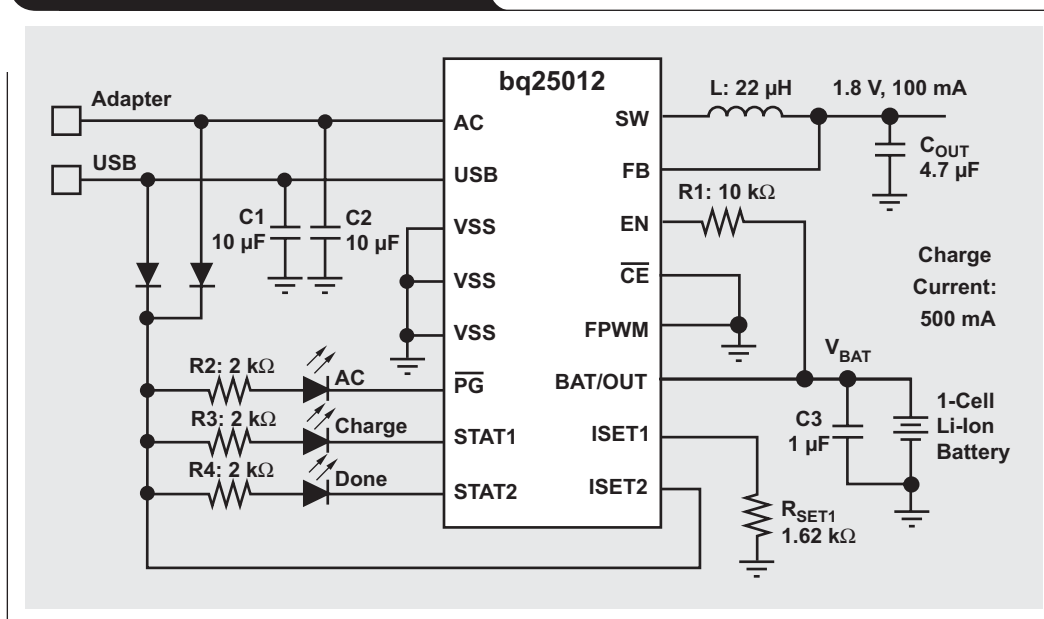
The bq25012 charges the battery in three phases with high-accuracy current and voltage regulation: precharge, constant current, and constant voltage. Charging is terminated based on minimum current. An internal charge timer provides an additional safety feature for charge termination. The bq2501x automatically recharges the battery if the battery voltage falls below an internal voltage threshold, which is 100 mV below the voltage regulation point.

The STAT1 and STAT2 open-drain outputs indicate various charger and battery conditions, while the \overline{PG} pin indicates whether the ac adapter is present. The digital input (\overline{CE}) is used to enable and disable the charging process.

High-efficiency dc/dc converter

The high-efficiency, synchronous switching dc/dc converter with integrated power MOSFETs is capable of supplying up to 150 mA. The bq25012 has fixed dc/dc converter output voltage at 1.8 V, while the bq25010 has adjustable output voltage from 0.7 to 4.2 V. They use the battery voltage, V_{BAT} , as their input. The synchronous pulse width modulation (PWM)

Figure 1. bq25012 application circuit



controller operates at 1 MHz, minimizing the size of the filter inductor and capacitor. The undervoltage lockout circuit prevents the converter from turning on the switch or rectifier MOSFET at low input voltages or under undefined conditions.

During PWM operation, the converter uses a unique, fast-response voltage-mode-controller scheme with input voltage feedforward to achieve good line and load regulation, allowing the use of small ceramic input and output capacitors. As the load current decreases, the converter enters power-save, or pulse frequency modulation (PFM), mode. In this mode the converter operates with reduced switching frequency and with a minimum quiescent current to maintain high efficiency. However, in cases when PFM is not desirable, driving the forced PWM pin high overrides power-save mode and forces the dc/dc converter to remain in the PWM mode.

Figure 2 shows measured dc/dc converter efficiency when the bq25012 EVM is used.

Design example

Requirements

Adapter voltage: 5 V

Battery pack: Single Li-ion, 1800 mAh

Battery regulation voltage: 4.2 V

Fast-charge current: 500 mA

Precharge and termination current: 50 mA

dc/dc converter output voltage: 1.8 V/100 mA

Determine the inductor L

Given 40% ripple current, the inductance when

$V_{IN} = V_{BAT_max}$ and $V_{IN} = V_{BAT_min}$ is

$$L = \frac{V_{BAT_max} - V_{OUT}}{\Delta I_L} \times \frac{V_{OUT}}{V_{BAT_max}} \times \frac{1}{f_S} = 25.7 \mu\text{H}.$$

Select $L = 22 \mu\text{H}$.

The inductor saturation current should be larger than the peak current to prevent inductor saturation. Select the Taiyo Yuden LBC2016T220M inductor (22 μH , 165 mA, 0806).

Determine the output capacitor C_{OUT}

To achieve optimum loop stability, the resonant frequency f_0 , composed of the inductor and output capacitor of the dc/dc converter, is approximately 16 kHz.

$$C_{OUT} = \frac{1}{(2\pi f_0)^2 L} = 4.5 \times 10^{-6} \text{ (farads)}$$

Select a 4.7- μF , 6.3-V, 0603 ceramic capacitor.

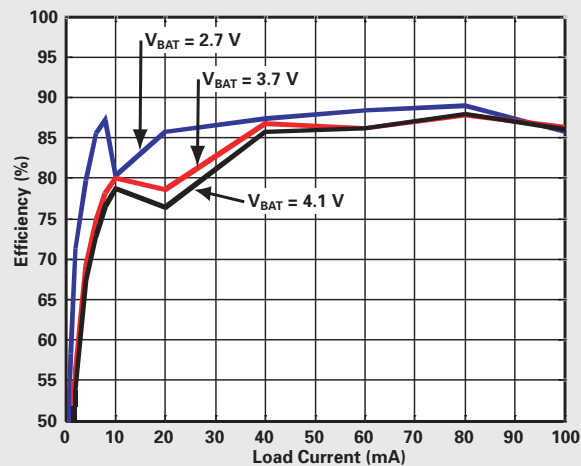
Determine current setting resistor R_{SET1}

With $V_{SET} = 2.5 \text{ V}$ and $K_{SET} = 320 \text{ V/A}$,

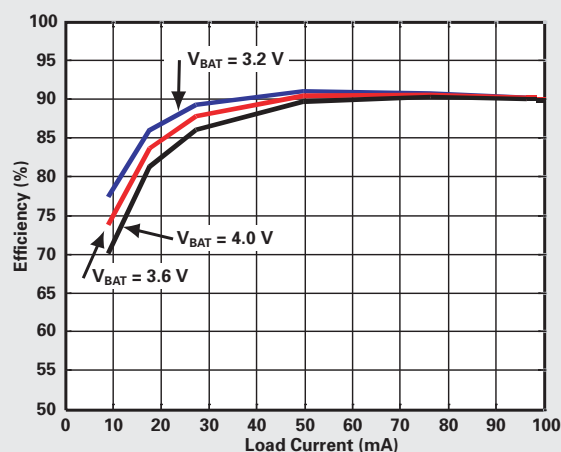
$$R_{SET1} = \frac{V_{SET} K_{SET}}{I_{Fast-charge}} = \frac{2.5 \times 320}{0.5} = 1.6 \text{ k}\Omega.$$

Select 1%, 1.62-k Ω resistors.

Figure 2. Efficiency vs. I_{OUT}



(a) Power-save mode ($V_{OUT} = 1.8 \text{ V}$, $T = 27^\circ\text{C}$)



(b) Forced PWM ($V_{OUT} = 1.8 \text{ V}$, $T = 22^\circ\text{C}$)

Determine USB charge current

The ISET2 pin determines the charge current for the USB port (high = 500 mA, low = 100 mA, high-Z = disable USB charge).

Conclusion

The bq25012 fully integrates a single-cell Li-ion battery linear charger up to 500 mA and a high-efficiency, 1-MHz, synchronous switching step-down dc/dc converter. The small size, high efficiency, and easy design make this a simple and versatile IC to use for many portable power applications such as Bluetooth headsets and MP3 players.

Related Web sites

power.ti.com

www.ti.com/sc/device/bq25010

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