Battery-charger front-end IC improves charging-system safety

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Introduction

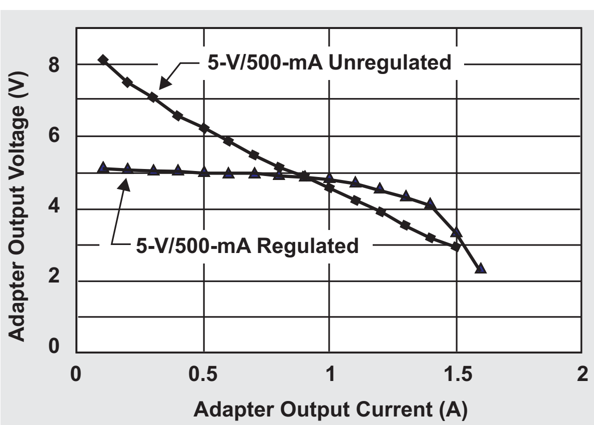
Battery-powered portable devices such as cellular phones have become an important part of people's daily lives in the past few years. Many types of adapters are available to charge the lithium-ion (Li-ion) battery and power the system, and their electrical specifications usually differ from one manufacturer to another. This challenges system designers to build portable devices that will meet safety and reliability requirements when used with different adapters. This article describes a new battery-charger front-end (CFE) IC, the Texas Instruments (TI) bq243xx, which is optimized to improve the safety of charging Li-ion-powered systems. Together with the battery-charger IC and the protection module in a battery pack, a charging system using the bq243xx CFE provides more robust system-level protection.

Main safety concerns in charging systems

Damage to the charging system can occur due to input overvoltage, input overcurrent, battery overvoltage, or reverse input voltage.

Input overvoltage can be caused by hot-plugging an adapter or using the wrong adapter; or by a transient or steady-state overvoltage condition. The most common occurrences are from hot plugging a charged, unregulated, or incorrect adapter; or from load transients. The unregulated adapter under no load will charge the adapter's output capacitor to the peak rectified AC voltage, about 1.4 times the rated DC voltage. This is often an issue with "low-voltage-process" (7-V-process) ICs. Figure 1 shows the output voltage of a typical regulated adapter versus an unregulated adapter.

Figure 1. Regulated- and unregulated-adapter load lines



Input-overcurrent challenges are not an issue with stand-alone chargers, since their constant-current mode limits the amount of current delivered to the output or battery. However, with power-path-management parts, which have a direct connection from the input to the system bus voltage, there is often no protection from excessive current draw. Lately there has been some concern over the safety of operating adapters in their current-limit mode and a desire for a programmable input-current-limit circuit to ensure that the adapter does not get into this mode.

Li-ion and Li-polymer battery packs are known for the potentially dangerous "flaming" condition that can occur if they are overcharged under high temperature. The key indication of overcharging is excessive cell voltage. To improve battery safety, many manufacturers are adding second-level overvoltage protection to remove the input power source when battery overvoltage is detected.

With universal connectors, it is a concern that an adapter with reverse polarity will be connected to the input. Without input reverse-polarity protection, the parasitic diode between the substrate and the IC will become forward-biased, causing a malfunction or damage to the IC. The two basic solutions to achieving input reverse-polarity protection are shown in Figure 2. The first solution is to add a diode in series with the input to block any reverse current. However, this will increase the power dissipation. The second solution is to use a low-$r_{DS(on)}$ MOSFET in series with the input to minimize the power dissipation.

Figure 2. Input-voltage reverse-polarity protection

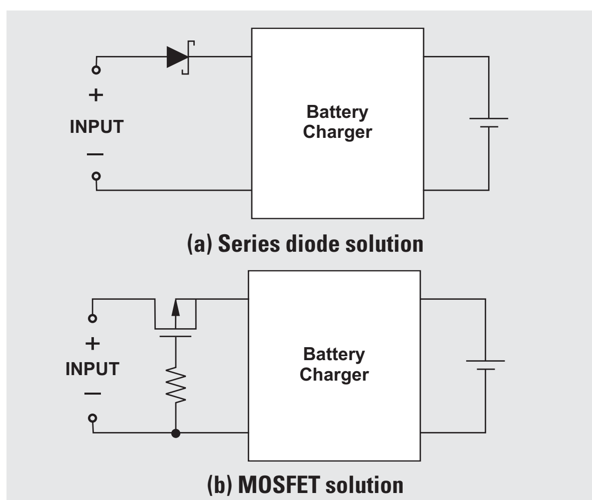
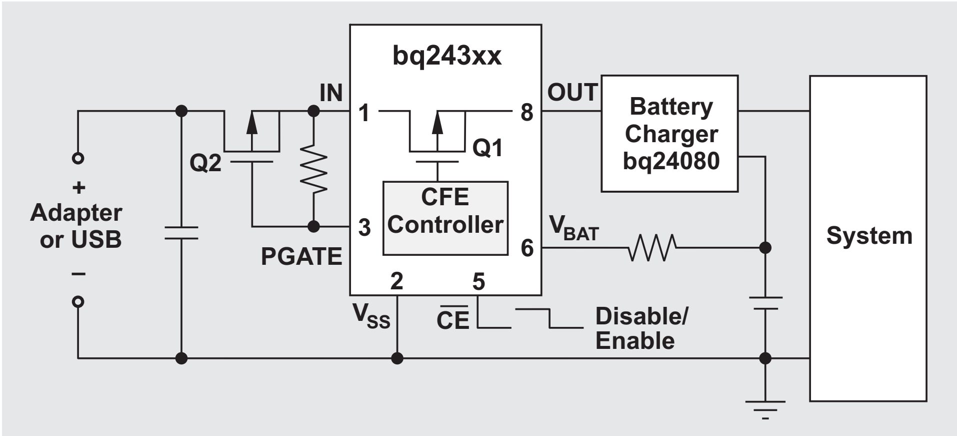


Figure 3. Typical application circuit with CFE



CFE solution for improving battery-charger safety

Figure 3 shows a typical circuit for a battery-charging system with a bq243xx CFE. The CFE protects the system from input overvoltage by isolating high input voltage from the low-voltage charger and system. The bq243xx family offers a soft-start function to avoid inrush current and can provide input-current regulation and protection, output-voltage limiting/regulation, or battery overvoltage protection. Also available are optional features such as PGATE to drive an external FET for reverse-polarity protection; fault-status indication; a programmable input-current limit; and enable/disable input power.

Figure 4 shows the typical response of the bq24314 CFE to input overvoltage. The internal MOSFET switch immediately turns off with less than a 1-µs delay once the input voltage reaches the predetermined input-overvoltage threshold.

When the system load exceeds the input-current limit, the CFE activates the input-current regulation loop and provides the maximum current limit set by the CFE. At a certain overcurrent blanking time, the CFE will turn off the MOSFET and may enter hiccup mode or latch mode after overcurrent protection is activated 15 times, depending on the IC version. The typical hiccup and latch response of the bq24314 CFE to input overcurrent is shown in Figure 5.

Figure 4. Protective response of bq24314 to input overvoltage

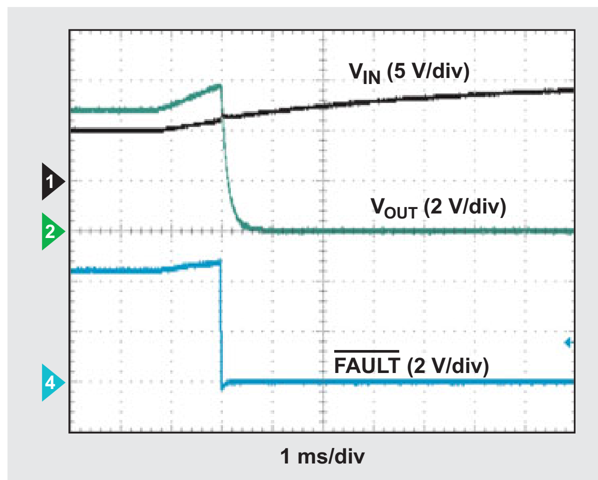
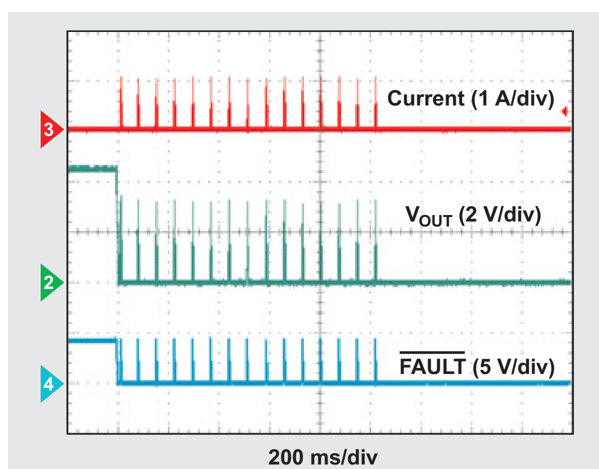


Figure 5. Protective response of bq24314 to input overcurrent



Another important function of the CFE is to achieve battery second-level overvoltage protection for improved safety, although the battery pack itself achieves cell over-voltage protection by turning off the protection MOSFET in series with the cell. When the battery is overcharged due to any failure of the battery charger or protection MOSFET, the CFE will turn off its output with a 176-µs delay time and will recover when the battery is no longer experiencing overvoltage. The typical response of the bq24314 CFE to battery overvoltage is shown in Figure 6.

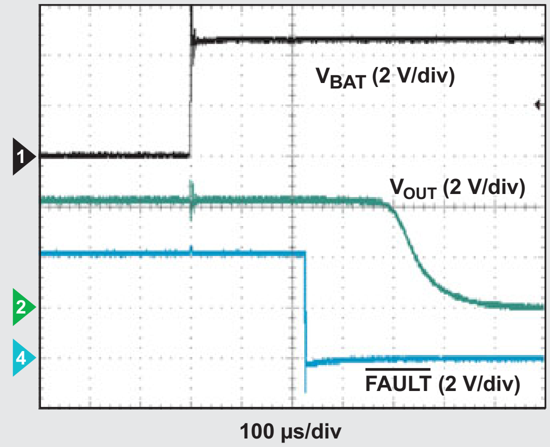
Summary

The CFE can significantly improve the safety of battery-operated systems by fully integrating protection from input overvoltage, input overcurrent, battery overvoltage, and reverse input polarity.

Related Web sites

power.ti.com
www.ti.com/sc/device/*partnumber*
Replace partnumber with bq24080, bq24300, bq24304, or bq24314

Figure 4. Protective response of bq24314 to battery overvoltage



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