USB Power Manager with High Voltage 2A Bat-Track Buck Regulator

by Nancy Sun

Introduction

Personal navigation devices, HDD-based media players, automotive accessories, and other handheld products draw on an array of power sources for recharging their batteries. These sources include USB (nominally 5V), low voltage wall adapters (4.5-5.5V), high voltage wall adapters (12V–24V), FireWire (8V–33V) and automotive batteries (nominally 12V). The large supply of available sources leads to an increasing need for handheld devices that can accept a wide range of multiple input voltages without the need for myriad external power adapters.

The LTC4090 is designed to accommodate both USB and high voltage sources by integrating a high voltage 2A switching buck regulator, a USB input, a PowerPath™ controller and a linear battery charger into a compact, thermally enhanced 3mm × 6mm package. Figure 1 shows a complete solution that fits into less than 3cm^2 with all components on one side of the PCB (Figure 2).

Complete PowerPath Controller

The LTC4090 is a complete PowerPath controller for battery powered applications. It is designed to receive power from a USB input (or 5V wall adapter), a high voltage source, and a single-cell Li-Ion battery. The PowerPath controller distributes the available power, with the load on the OUT pin taking precedence and any remaining current used to charge the Li-Ion battery. The high voltage input takes priority over the USB input (i.e., if both HVIN and IN are connected to power sources, load current and charge current are provided by the HVIN input). Figure 3 shows a simplified block diagram of the PowerPath operation.

USB Input Current Limit

Power supplies with limited current capability (such as USB) should be connected to the IN pin, which has a programmable current limit. The input current limit is programmed using a single external resistor, R_{CLPROG}, from the CLPROG pin to ground. In Figure 1, a 2.1kΩ CLPROG resistor has been chosen to program the input current limit to 476mA in high power mode (when the HPWR pin is pulled high) or 95mA in low power mode (when the HPWR pin is pulled low). This ensures that the application complies with the USB specification. The sum of battery charge current and the load current (which takes priority) will not exceed the programmed input current limit.

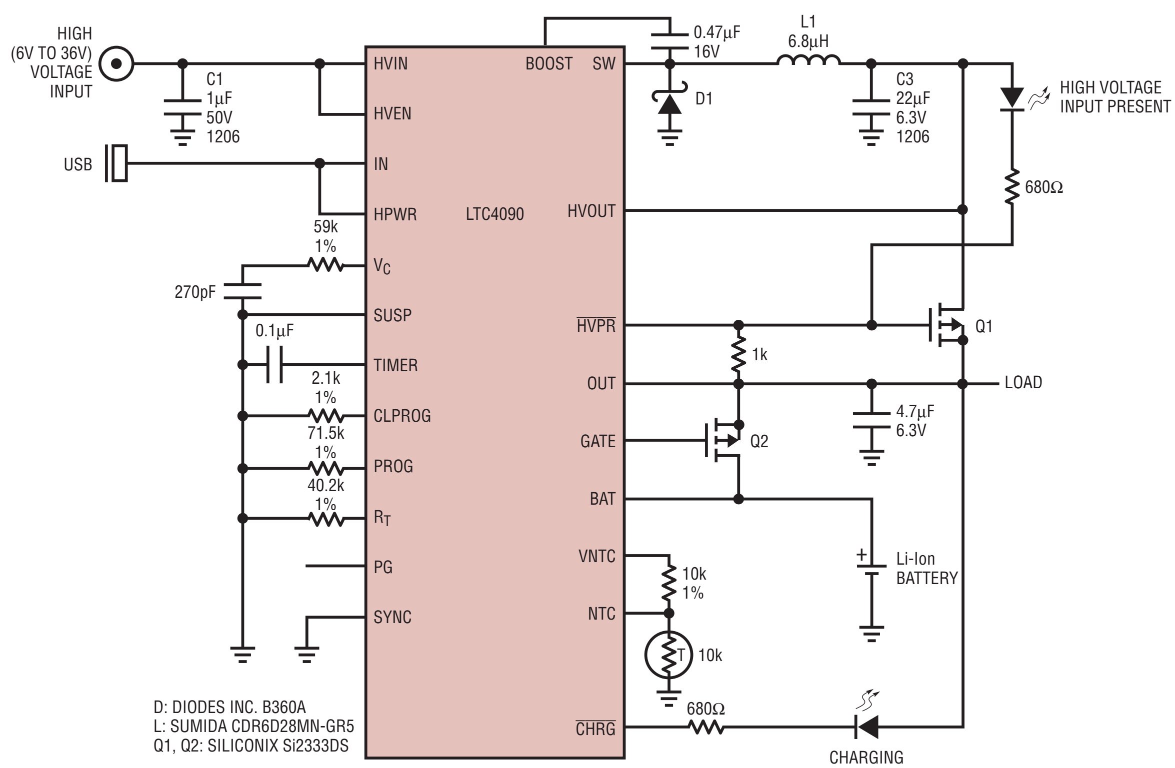

Figure 1. Li-Ion battery charger accepts both USB and high voltage inputs

Ideal Diode from BAT to OUT

An ideal diode function automatically delivers power to the load via the ideal diode circuit between the BAT and OUT pins when the load current exceeds the programmed input current limit or when the battery is the only supply available. Powering the load through the ideal diode instead of connecting the load directly to the battery allows a fully charged battery to remain fully charged until external power is removed. The LTC4090 has a 215mΩ internal ideal diode as well as a controller for an optional external ideal diode. In Figure 1, an external P-channel MOSFET, Q2, is shown from BAT to OUT and serves to further increase the conductance of the ideal diode.

High Voltage Buck Regulator

The LTC4090 has an operating input voltage range of 6V to 36V and can withstand voltage transients of up to 60V. The buck converter output, HVOUT, maintains approximately 300mV across the battery charger from OUT to BAT so that the battery can be efficiently charged with the linear charger. The minimum V_{HVOUT} is 3.6V to ensure the system can operate even if the battery is excessively discharged. As shown in Figure 1, an external PFET, Q1, between HVOUT and OUT is controlled by the $\overline{HVPR}$ pin and allows OUT to supply power to the load and to charge the battery. The buck converter is capable of up to 2A of output current.

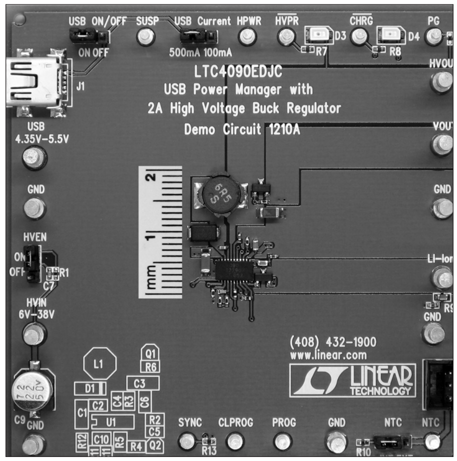

Figure 2. A complete LTC4090-based USB Power Manager with a 2A high voltage buck regulator fits into $3cm^2$.

Battery Charger Features

The LTC4090 battery charger uses a unique constant-current, constant-voltage, constant-temperature charge algorithm with programmable charge current up to 1.5A and a final float voltage of 4.2V ±0.8%. The maximum charge current is programmed using a single external resistor, R_{PROG}, from the PROG pin to ground. In Figure 1, a 71.5k PROG resistor programs the maximum charge current to 700mA. However, in the case where only a USB input is present, charge current is reduced to ensure that the programmed input current limit is not exceeded. For the circuit in Figure 1, when only a USB input is present, the actual maximum charge current is reduced to 476mA.

In typical operation, the charge cycle begins in constant-current mode. A strong pull-down on the $\overline{CHRG}$ pin indicates that the battery is charging. In constant current mode, the charge current is set by R_{PROG}. When the battery approaches the final float voltage of 4.2V, the charge current starts to de-

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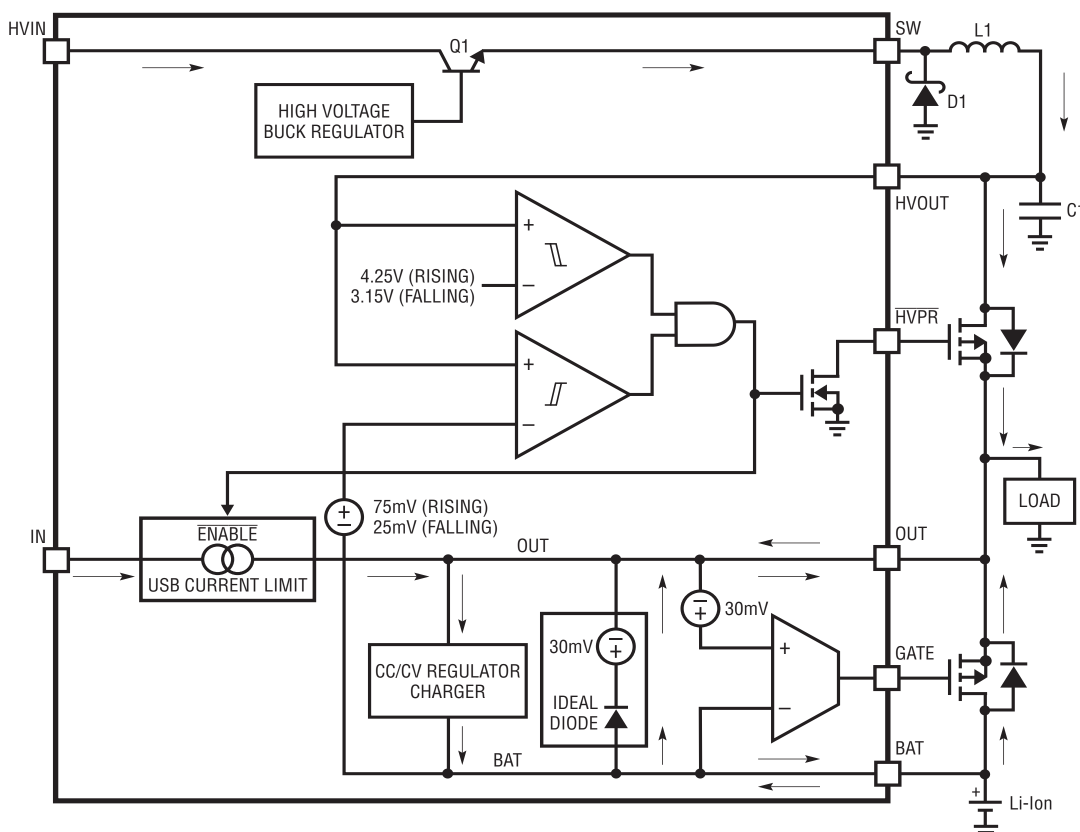

Figure 3. Simplified block diagram of the LTC4090 PowerPath operation

time while preventing both the upper and lower MOSFETs from conducting simultaneously.

The LTC4444 is configured for two supply-independent inputs. The high side input logic signal is internally level-shifted to the bootstrap supply, which may function at up to 114V above ground. Furthermore, this part drives both upper and lower MOSFET gates over a range of 7.2V to 13.5V.

The LTC4444 is offered in a thermally enhanced MSOP-8 package.

3.3V 20Mbps 15kV RS485/RS422 Transceivers

The LTC2850, LTC2851 and LTC2852, are the latest additions to Linear Technology's family of rugged 3.3V RS485/RS422 transceivers. These devices offer a variety of advanced features for industrial, medical and automotive applications with high speed operation to 20Mbps.

High receiver input resistance supports up to 256 nodes on a single bus, while meeting RS485 load requirements. Failsafe operation guarantees a logic-high receiver output state when the inputs of the receiver are floating, shorted or terminated, but not driven. Current limiting on all driver outputs and a thermal overload shutdown feature provide protection from bus contention and short circuits. Bus pin protection on all parts exceeds ± 15kV for ESD strikes with no latchup or damage.

The LTC2850 provides half-duplex operation and the LTC2851 and LTC2852 are full-duplex. They are pin-compatible with the 5V LTC485, LTC490 and LTC491 parts, respectively. Specified over commercial and industrial temperature ranges from –40C to 85C, these parts are available in SO and MSOP packages as well as tiny leadless DFN packages.

New Member Added to the LTC2908 6-Supply Monitor Family

The LTC2908-C1 is a new addition to the LTC2908 6-supply monitor family available in tiny 8-pin TSOT and DFN packages. The LTC2908-C1, along with the previously available A1 and B1 versions, provides complete, precise, space-conscious, micropower and general purpose voltage monitoring solution for any application. The inputs can be shorted together for monitoring systems with fewer than six supply voltages, and the open drain $\overline{\text{RST}}$ output of two or more LTC2908 can be wired-OR together for monitoring systems with more than six supply voltages.

The LTC2908-C1 is designed to monitor 2.5V and five positive adjustable voltages. The previously available LTC2908-A1 is designed to monitor 5V, 3.3V, 2.5V, 1.8V and two positive adjustable voltages while the LTC2908-B1 is designed to monitor 3.3V, 2.5V, 1.8V, 1.5V and two positive adjustable voltages. The LTC2908 features a low voltage positive adjustable inputs (+ADJ) with nominal threshold level at 0.5V, and a low quiescent current on the main supply (the greater of V1 or V2) of 25µA typical.

The LTC2908 also features ultra-low voltage pull downs on the $\overline{\text{RST}}$ pin. The open drain $\overline{\text{RST}}$ output is guaranteed to be in the correct state as long as V1 and/or V2 is 0.5V or greater. The LTC2908 inputs have a tight 1.5% threshold accuracy over the whole operating temperature range (–40°C to 85°C) and glitch-immunity to ensure reliable reset operation without false triggering. The common $\overline{\text{RST}}$ output remains low until all six inputs have been above their respective thresholds for 200ms.

LTC4090, continued from page 31

crease as the battery charger switches to constant-voltage mode. When the charge current drops to 10% of the full-scale charge current, commonly referred to as the C/10 point, the open-drain charge status pin, $\overline{\text{CHRG}}$, assumes a high impedance state. An external capacitor on the TIMER pin sets the total minimum charge time. In Figure 1, a 0.1µF capacitor on the TIMER pin gives a 2.145hr minimum charge time. When this time elapses, the charge cycle terminates and the $\overline{\text{CHRG}}$ pin assumes a high impedance state, if it has not already done so.

Charge Time is Automatically Extended

The LTC4090 has a feature that automatically extends charge time if the charge current in constant current mode is reduced during the charging cycle. Reduction can be due to thermal regulation or the need to maintain the programmed input current limit. The charge time is extended inversely proportional to the actual charge current delivered to the battery. The decrease in charge current as the LTC4090 approaches constant-voltage mode is due to normal charging operation and does not affect the timer duration.

Trickle Charge and Defective Battery Detection

At the beginning of a charge cycle, if the battery voltage is below 2.9V, the charger goes into trickle charge reducing the charge current to 10% of the full-scale current. If the low battery voltage persists for one quarter of the programmed total charge time, the battery is assumed to be defective, the charge cycle is terminated and the $\overline{\text{CHRG}}$ pin output assumes a high impedance state. If for any reason the battery voltage rises above ~2.9V the charge cycle is restarted.

Conclusion

The LTC4090 combines a high voltage switching buck regulator, a full-featured Li-Ion battery charger, and a PowerPath controller in a tiny 3mm × 6mm DFN package. Its wide input voltage range, high programmable charge current, and small footprint