

DESIGN NOTES

Universal Li-Ion Battery Charger Operates from USB and 6V to 36V Input in Just 2cm² – Design Note 395

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Introduction

There are a number of advantages to offering USB and high input voltage power and battery-charging capability in handheld devices such as GPS navigators, PDAs, digital still cameras, photoviewers and MP3 players. For instance, charging and operation from USB offers the obvious convenience of not requiring a travel adapter. High voltage sources, such as Firewire and 12V to 24V adapters are even better, since they provide faster charging than USB and allow charging in more places, such as in the car. Nevertheless, there is an important design consideration with high voltage power sources: the voltage difference between the high voltage source and the battery in the handheld is very large. Since a linear charger cannot handle the power dissipation, a switching charger is required.

The LTC[®]4089 and LTC4089-5 (see Figure 1) conveniently integrate a high voltage and wide input range (6V to 36V with 40V absolute maximum) monolithic 1.2A buck switching regulator and a USB power manager/charger into a compact thermally enhanced

3mm × 6mm DFN package. The LTC4089's buck regulator output voltage tracks the battery voltage to within 300mV. This Bat-Track™ feature minimizes overall power dissipation. The LTC4089-5 has a fixed 5V at OUT when power is applied at HVIN. When power is supplied from the USB port, the power manager maximizes the available power to the system load; up to the full USB available power of 2.5W. It automatically adjusts the Li-Ion battery charge current with respect to the system load current to maintain the total input current compliance within the USB limits. The total solution size is less than 2cm² with all components on one side of the PCB.

Adaptive High Voltage Buck Minimizes Total Power Loss

The LTC4089's buck converter output voltage V_{OUT} tracks the battery voltage V_{BAT} . It is always 0.3V higher than V_{BAT} , so that the battery can be charged quickly while

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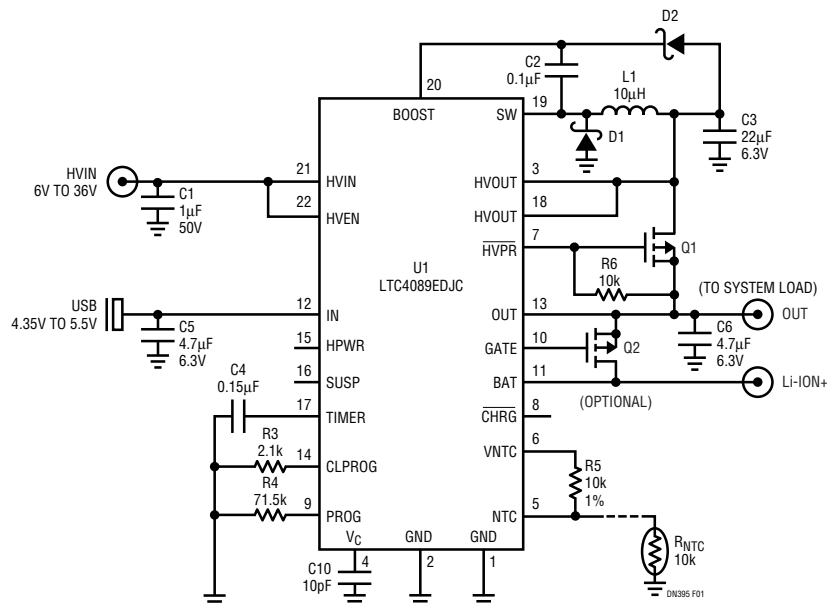


Figure 1. The LTC4089 Schematic Illustrates Multiple Input Voltage Capability

minimizing overall power dissipation. Figure 2 shows the overall efficiency at various input voltages, where the total power dissipation is less than 1.1W. Furthermore, if the battery is excessively discharged and V_{BAT} falls too low, the minimum V_{OUT} is 3.6V to ensure continuous system operation.

USB Power Manager Maximizes Power Available to the System

In a traditional dual input device, the input charges the battery and the system's power is directly taken from the battery. This creates a number of problems. One of these is that the system's available power is reduced by the low-battery voltage when there is USB power present. For example, when $V_{BAT} = 3.3V$, the available power to the system is only 1.65W while the USB itself supplies 2.5W. The balance is dissipated as heat. The LTC4089 successfully solves this problem by providing an intermediate voltage V_{OUT} to power the system load.

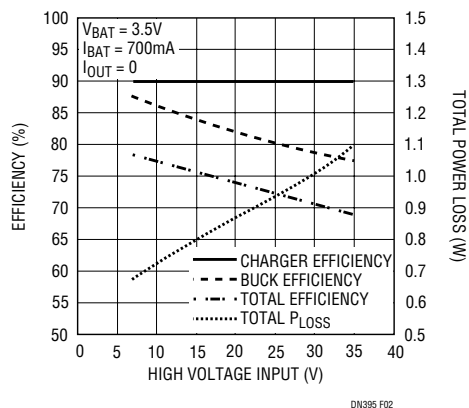


Figure 2. The LTC4089 High Voltage Charger Efficiency and Total Power Loss

This V_{OUT} is independent of the battery voltage and equal to the USB voltage, thus the full USB power is available to the system load. Table 1 shows the advantages of the LTC4089 power manager over the traditional dual input configuration.

Small Footprint

With all the necessary components on the same side of the PCB, the total solution size is less than $2cm^2$ ($11.3mm \times 17.5mm$) as shown in Figure 3.

Summary

The LTC4089 integrates a high voltage wide input monolithic switching regulator, USB power manager and Li-Ion battery charger into a $3mm \times 6mm$ DFN package and improves the functionality of USB-based and multiple power input portable devices.

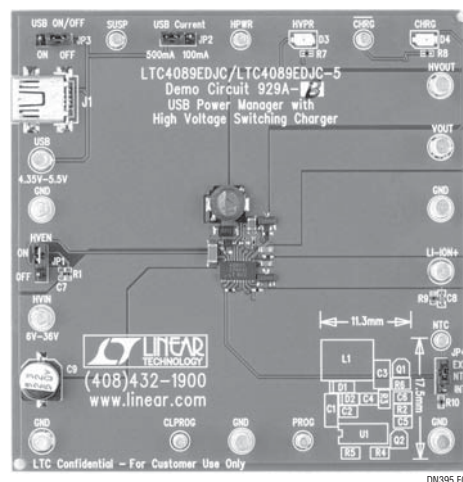


Figure 3. The LTC4089 Demo Circuit with Layout in Bottom Right Corner

Table 1. Comparison of Traditional Dual Input Charger and Linear Technology's LTC4089 Power Manager/Charger for USB Charging

| SCENARIO | TRADITIONAL DUAL INPUT CHARGER | LTC4089 POWER MANAGER/CHARGER |
|---|---|---|
| Battery voltage is below trickle charging voltage | Available current to system is only trickle charge current (50mA to 100mA), which may not be sufficient to start the system | Full adapter/USB power is available to system, although battery is in trickle charge |
| Battery is not present | Most chargers consider this as a fault. The system cannot start | Full adapter/USB power is available to system |
| $V_{BAT} = 3.3V$ at USB input | Available power to system is only 1.65W. The system power cannot be greater than this | Full 2.5W USB power is available to the system |
| System consuming close to the input power limit | Cannot distinguish the available charging current. Charger timer runs out before the battery is fully charged | Charger time proportionally increases with less available charge current. The battery is always fully charged |

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