

Switching USB Power Manager with PowerPath Control Offers Fastest Charge Time with Lowest Heat – Design Note 415

Dave Simmons

Introduction

Lithium-Ion and Lithium Polymer batteries are common in portable consumer products because of their relatively high energy density—they provide more capacity than other available chemistries within given size and weight constraints. USB battery charging is also becoming commonplace, as many portable devices require frequent interfacing with a PC for data transfer.

As portable products become more complex, the need for higher capacity batteries increases, with a corresponding need for more advanced battery chargers. Larger batteries require either higher charging current or additional time to charge to their full capacity. Most consumers look for shorter charge times, so increasing the charge current seems obviously preferable, but increasing charge current presents two major problems. First, with a linear charger, increased current creates additional power dissipation (i.e., heat). Second, the charger must limit the current drawn from the 5V USB bus to either 100mA (500mW) or 500mA (2.5W) depending on the mode that the host controller has negotiated.

PowerPath™ Controllers Deliver More Power to the System Load

There are two methods commonly used to extract power from a USB port. The first method uses a current limited battery charger directly between the USB port and the battery. This is referred to as a Battery Fed System because the system load is powered directly from the battery. Available power is given by $I_{USB} \cdot V_{BAT}$ because V_{BAT} is the only voltage available to the system load. When the battery is low, nearly half of the available power can be lost within the linear battery charger element. In low battery voltage protection mode, as little as 5% of the available power may be usable.

The second method develops an intermediate voltage between the USB port and the battery. This intermediate voltage bus topology is referred to as a PowerPath System. In PowerPath ICs, a current limited switch is placed between the USB port and the intermediate volt-

LT, LTC, LTM are registered trademarks of Linear Technology Corporation. PowerPath is a trademark of Linear Technology Corporation. All other trademarks are the property of their respective owners.

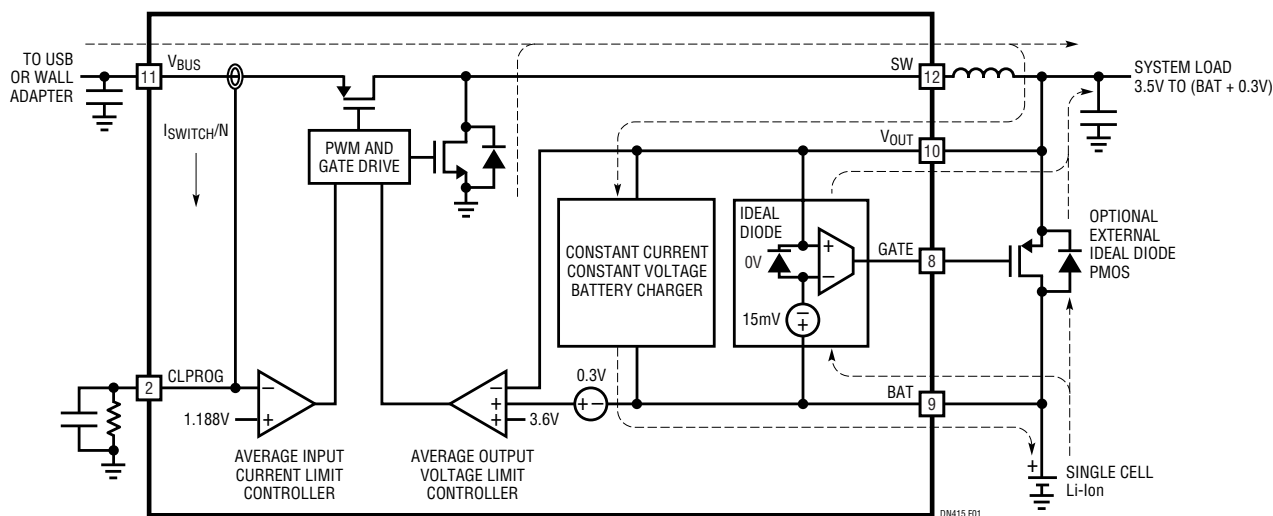


Figure 1. LTC4088 PowerPath Topology

age. The intermediate voltage, V_{OUT} , then powers both a linear battery charger as well as the entire portable product. By using the intermediate voltage bus topology, the battery is decoupled from the system load and charging can be carried out opportunistically. During charging with a PowerPath system, the full 2.5W from the USB port is made available to the system load as long as the input current limit has not been exceeded. In this case V_{OUT} is just under the input voltage (5V for example). However, since the battery voltage is much lower than the 5V input, significant power is still lost to the linear battery charger element.

LTC4088 Makes Charging More Efficient

The LTC[®]4088 replaces the current limited switch in traditional PowerPath systems with a 2.25MHz buck mode synchronous switching regulator, as shown in Figure 1. The intermediate voltage, V_{OUT} , is regulated to just above the battery voltage. Because power is conserved in a switching regulator, the available output current is higher than the input current.

LTC4088 Reduces USB Charge Time

This additional current can be used to power the portable product and charge the battery more quickly. Figure 2 shows the typical improvement in charge current versus a linear charger when powered from a 500mA USB port.

LTC4088 Eases Thermal Constraints

The second benefit of the switching regulator is heat reduction. Power lost by inefficient charging can cause

the external case of a portable product to become uncomfortably warm, and in extreme cases, it can cause thermal limiting of the battery charger. Figure 3 shows the typical efficiency and power savings of the LTC4088 relative to a linear charger when connected to a 500mA USB port.

The LTC4088 also includes a mode designed for use with AC powered wall adapters, in which the maximum input current is limited to 1A. Available current to the system load and battery charger ranges somewhere between 1A and 1.8A, depending on the battery voltage. Many higher capacity batteries are capable of charging at these higher rates, but with a volt or more difference between the wall adapter and the battery, the accompanying dissipative heating cannot be tolerated. Until now, these applications simply had to settle for a lower than optimal charge rate, and accompanying longer charge time.

Conclusion

The LTC4088 offers a dramatic advancement in battery charging and power path management technology, with its reduction in both heat generation and battery charge time. Designed specifically for portable applications, its high switching frequency and internal compensation require only a small inductor and output capacitor. Only the LTC4088's unique topology of a buck mode switching regulator working in tandem with a linear battery charger can give this unparalleled performance.

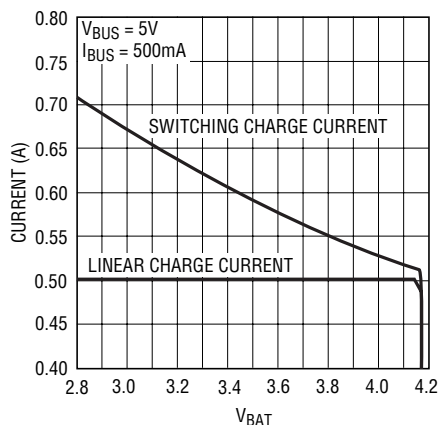


Figure 2. Typical Charge Current for LTC4088 vs Linear Charger When Powered from a 500mA USB Port

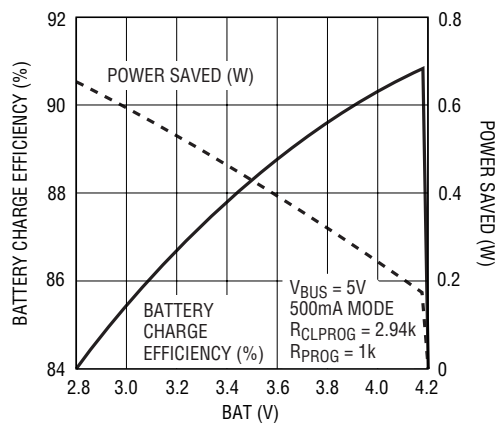


Figure 3. Battery Charger Efficiency and Power Savings Relative to a Linear Charger When Charging from a USB Port

Data Sheet Download

www.linear.com

For applications help,
call (408) 432-1900, Ext. 2364