

# DESIGN NOTES

## Handheld High Power Battery Charger

Design Note 393

Mark Gurries

### Introduction

As the performance of many handheld devices approaches that of laptop computers, design complexity also increases. Chief among them is thermal management—how do you meet increasing performance demands while keeping a compact and small product cool in the user's hand?

For instance, as battery capacities inevitably increase, charge currents will also increase to maintain or improve their charge times. Traditional linear regulator-based battery chargers will not be able to meet the charge current and efficiency demands necessary to allow a product to run cool. What is needed is a switching-based charger that takes just about the same amount of space as a linear solution—but without the heat.

### Small PCB Footprint

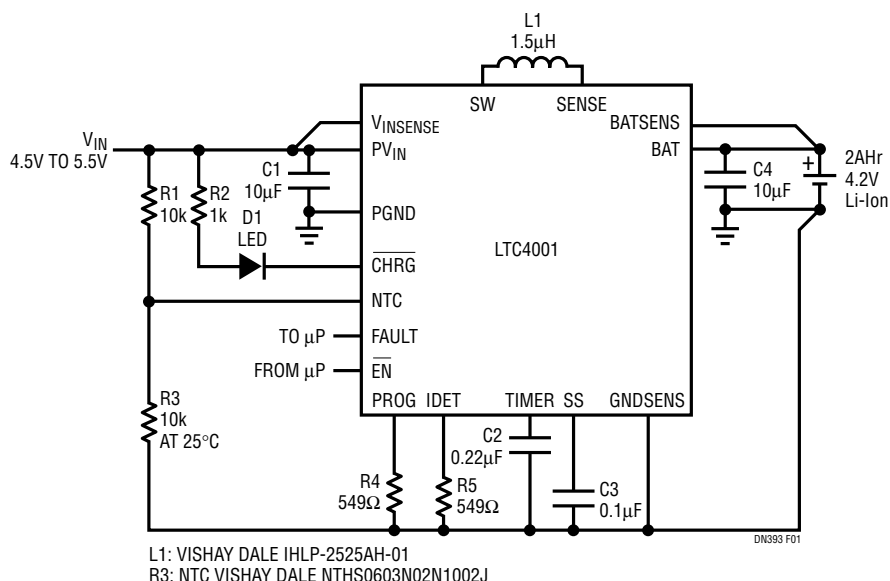
Figure 1 shows how simple a feature-laden LTC®4001-based charger solution can be. This switching-based charger only requires the IC, a small 1.5μH inductor, two

small 1206-size 10μF ceramic capacitors, and a few other tiny components. Furthermore, even simpler configurations are possible (see Figure 2). This monolithic 2A, 1.5MHz synchronous PWM standalone battery charger is packaged in a 4mm × 4mm 16-pin QFN package, which contains the built-in switching MOSFETs and charge termination controller. Figure 3 shows an actual PCB solution.

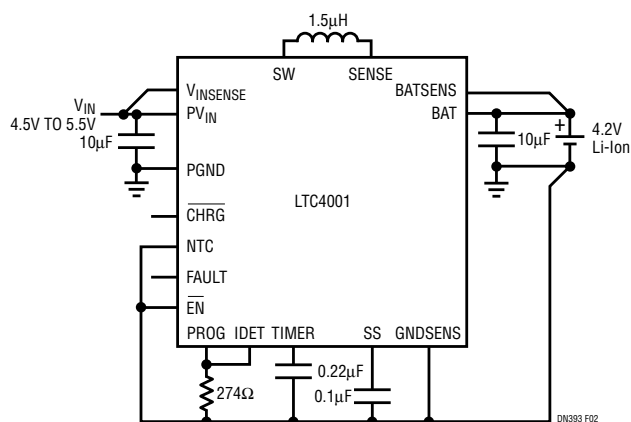
### Advanced Features and Functions

One of the more unique features of the LTC4001 is its full remote voltage sense capability which permits faster charge rates by bypassing voltage drops in narrow PCB traces, EMI filters or current sense resistors for gas gauge related support; this is placed on the system side of the battery connector. Eliminating these losses in the sense circuit can significantly shorten the constant voltage phase of the overall charge time.

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**Figure 1. Li-Ion Battery Charger with 3-Hour Timer, Temperature Qualification, Soft-Start, Remote Sensing and C/10 Indication**



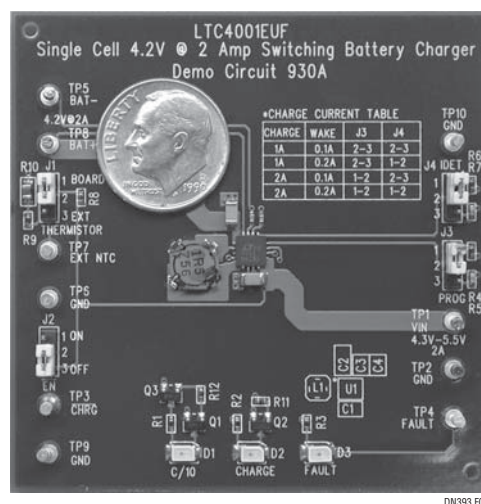
### Figure 2. Simple 2A Battery Charger

Another important feature is programmable soft-start, which requires only a small ceramic capacitor on the SS pin. Soft-start saves design time and cost by simplifying the power source requirements, precluding the need to handle fast start-up load transients commonly found with switching power supplies.

Other advanced features include: 50mA trickle charge recovery of over-discharged batteries below 3V/cell; adjustable charge timer via a single capacitor on the TIMER pin; and automatic restart of a charge cycle when the battery voltage falls below 100mV of the full charge voltage.

Two signals provide status. First is the FAULT pin, which in conjunction with the LTC4001 thermistor circuit, reports an out-of-range temperature situation. When a temperature fault occurs, the charge process is stopped immediately. Charging a battery when it is out of its normal temp range can damage it. Second, the CHRG pin shows three states relating to the charge state of the battery or charger. In addition to the normal OFF indication, it also indicates when the battery is below its user programmable  $I_{DET}$  threshold or when in bulk charge mode.

The  $\overline{\text{EN}}$  (Enable) pin allows for shutdown of the charger, thus reducing its  $V_{\text{IN}}$  quiescent current below  $50\mu\text{A}$  and the battery drain current to less than  $3\mu\text{A}$ . Shutdown also occurs automatically if  $V_{\text{IN}}$  falls to less than  $250\text{mV}$  above the current battery voltage.



**Figure 3. Actual LTC4001 Demo Board Showing a Compact Footprint (Height  $\leq 1.8\text{mm}$ )**

## Flexible Options

The LTC4001 provides a number of flexible options in its small package. Bulk charge current is programmable via the PROG pin and a simple resistor, from 2A and below. A separate resistor on the I<sub>DET</sub> pin is all that is required to set the full charge current termination or indication threshold independently of the bulk charge current setting. Typically the I<sub>DET</sub> threshold is set to 1/10 (C/10) of the bulk charge current, which equates to a battery being about 95% to 98% full. Raising the I<sub>DET</sub> current trip threshold significantly reduces charge time by having a full charge indication occur sooner in exchange for a slightly lower full state of charge. Likewise, increasing the trip threshold extends the timer to approach a 100% state of charge if there are no serious time constraints. The type of charge termination is also flexible. In addition to timer-based termination, the charge can be terminated when the I<sub>DET</sub> threshold is reached or charge termination can be defeated all together to allow an external power manager to decide.

## Conclusion

The LTC4001 is the charger of choice for the next generation of handheld devices with its tiny solution size, unmatched power capability, high efficiency, protection features and flexible options.

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