

DESIGN NOTES

New ICs Simplify Battery Charging from the USB – Design Note 320

John Shannon

Introduction

The USB is fast becoming the most popular way to attach peripherals to personal computers. An important feature of the USB standard is that it allows for power transmission over the USB cable, making it possible for a PDA or other handheld device to charge its battery while it is connected to a host PC.

The USB specification defines load current limits that USB peripherals can draw from the USB. Three operating modes are allowed:

- Suspend mode, where the USB peripheral draws less than $500\mu\text{A}$ from the USB cable
- Low power mode, where the current consumption can be up to 100mA
- High power mode, where the current is allowed to be up to 500mA

The USB specification also states that USB peripherals are not allowed to backfeed into the USB cable.

Figure 1 shows a minimum component solution to the USB battery charger problem. In this case, only five components including the LTC®4053, are required to achieve a fully compliant USB charger.

The charger is based on the LTC4053—a standalone timer-terminated constant current/constant voltage linear charger. The LTC4053 features a thermal loop which maximizes the charging rate under all conditions by regulating the maximum die temperature. Less sophisticated linear chargers must run lower charging rates or risk overheating, thus increasing charge times.

Operation of the LTC4053 is simple. The charge current is set by a resistor on the PROG pin, the termination timer period is set by a capacitor on the timer pin and float voltage is preset at 4.2V.

LTC, LTC and LT are registered trademarks of Linear Technology Corporation.

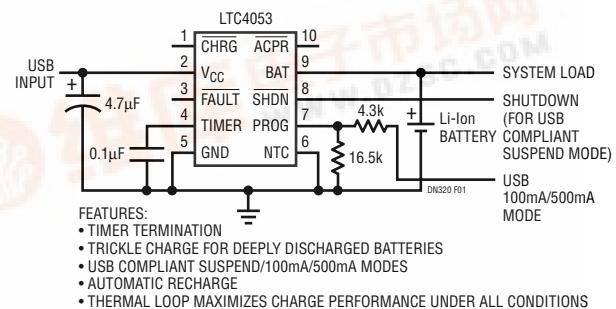


Figure 1. Minimum Component Count USB Compliant Li-Ion Charger

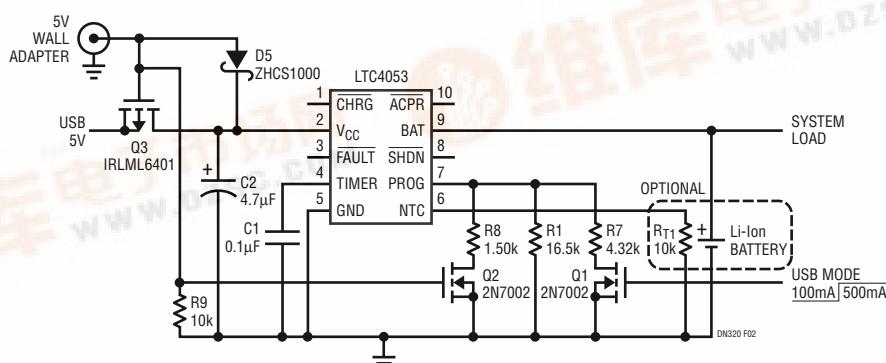


Figure 2. Dual Input Charger: 1A Fast Charging from Wall Adapter or 100mA/500mA from USB

Charging from USB or a Wall Adapter

USB charge current is limited to 500mA, but the LTC4053 is capable of higher output currents. This capability can be exploited by adding some additional components around the LTC4053 to allow for a higher charge rate from an alternate power source such as a wall adapter.

The circuit shown in Figure 2 requires only 12 components, is compliant with the USB specification and provides high rate charging from an adapter. The NTC feature of the LTC4053 is also implemented so that charging is inhibited if the battery is too hot or too cold.

Two things must happen to add high rate adapter-based charging. The first is that the USB input must be isolated from the adapter to prevent adapter power feeding into the USB. The second is that the higher charging rate must be selectable by changing the resistive load on the PROG pin.

A P-channel MOSFET, Q3, is used to select between USB or adapter power. Q3 is on if USB power is present and the adapter is absent since its gate is at ground (through R9) and its source is at 5V. As the wall adapter power comes up, the gate of Q3 is pulled high and Q3 turns off. A 1A charging current flows from the adapter through diode D5. The 1A charge rate is programmed by turning on Q2 when the adapter is present which alters the resistive load on the PROG pin.

Faster Charging with System in Full Operation

Both of these simple circuits draw system power directly from the battery. This makes for a simple solution but also reduces the total available power from the USB port. The USB port is capable of 2.5W (5V • 500mA). Placing the device system bus on the battery directly (normally 3.6V) only allows the system to extract 1.8W (3.6V • 500mA) from the USB cable before the 500mA limit is reached and the battery must supply any excess power. The lower the battery voltage, the less power is available to the system load. The solution is to power the system load directly from the USB, measure the system current consumption and back off the charger current as required to maintain USB compliance.

Figure 3 shows a compact seven component solution using the LTC4410 USB power manager. The system load is supported directly by the USB when the USB is present. This allows a maximum of 2.5W for the system load. The current flowing from the USB port is measured and the battery charging current is reduced in order to maintain USB compliance. When USB power is absent, the load is supported by the battery through the switch Q1. Compared to the solution shown in Figure 2, this solution more fully exploits the power available at the USB port, thus resulting in faster charging.

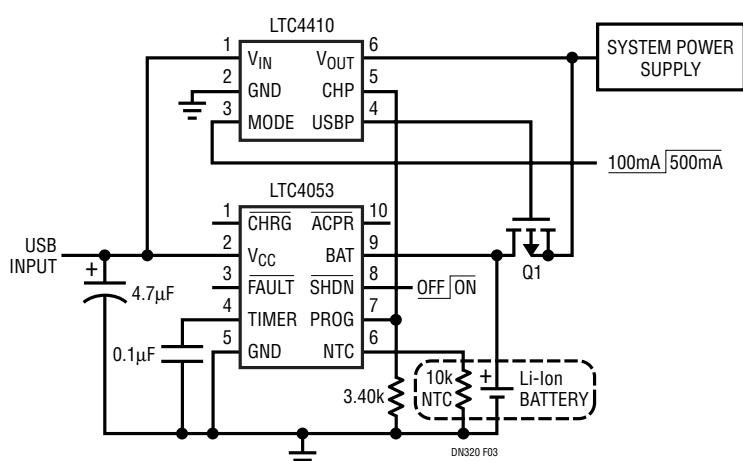


Figure 3. USB Compliant Charger Based on the LTC4410 Fully Utilizes the Power Available from the USB Input

Data Sheet Download

<http://www.linear.com/go/dnLTC4053>
<http://www.linear.com/go/dnLTC4410>

For applications help,
call (408) 432-1900, Ext. 2593