DESIGN NOTES

A Very Low Cost SOT-23 Li-Ion Battery Charger Requires Little Area and Few Components – Design Note 250

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The LTC®1734 is a low cost, single cell Li-Ion battery charger with constant voltage and constant current control. The small quantity and low cost of the external components results in a very low overall system cost, and with the IC's 6-pin SOT-23 package, provides a compact design solution. Previous products usually required an external current sensing resistor and blocking diode, but these functions are now provided within the LTC1734. Other features include:

- 1% accurate 4.1V or 4.2V float voltage
- Programmable constant current range of 200mA to 700mA
- Charging current monitor and manual shutdown for use with a microcontroller
- Automatic shutdown with no battery drain after wall adapter removal

Applications include portable devices such as cellular phones, digital cameras and handheld computers. The LTC1734 can also be used as a general purpose current source or for charging nickel-cadmium and nickel-metal-hydride batteries.

A Simple Low Cost Li-Ion Charger

A battery charger programmed for 300mA in the constant current mode with a charge current monitoring function is shown in Figure 1. The PNP is needed to source the charging current and resistor R1 is used to program the maximum charging current. The I_{SENSE} and BAT pins are used to monitor charge current and voltage, respectively, while the DRIVE pin controls the PNP's base. Note that no external current sense resistor or diode to block reverse current is required. For most other chargers a blocking diode, in series with the supply, is required to prevent draining the battery should the unpowered supply input become a low impedance. When the supply is opened or shorted to ground, the charger shuts down and only a few nanoamps of leakage current flows from the battery to the charger. This feature extends battery life, especially if the portable device is off for long periods of time. The supply voltage can range from 4.75V to 8V, but power dissipation of the PNP may become excessive near the higher end, especially at higher charging current levels. The PNP's power dissipation will require attention to adequate heat sinking. Refer to the PNP manufacturer's data sheet for heat sinking requirements.

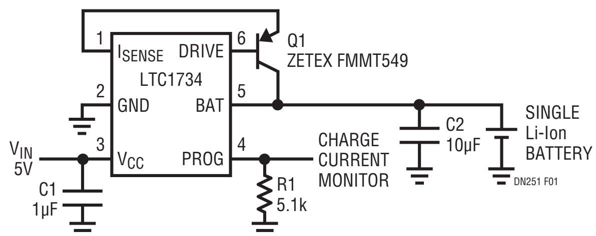

Figure 1. Low Cost Li-Ion Charger Programmed for 300mA

With the supply voltage near its low end, the PNP's saturation voltage becomes important. In this case a low V_{CESAT} transistor, such as those shown in the figures, may be required to prevent the PNP from heavily saturating and demanding excessive base current from the DRIVE pin.

To maintain good AC stability in the constant voltage mode, a capacitor is required across the battery to compensate for inductance in the wiring to the battery. This capacitor (C2) may range from 4.7µF to 100µF, and its ESR can range from near zero to several ohms depending on the inductance to be compensated. In general, compensation is best with a capacitance of 4.7µF to 22µF and an ESR of 0.5Ω to 1.5Ω. In the constant current mode, good AC stability is realized by keeping capacitance on the PROG pin to less than 25pF. Higher capacitive loading, such as from a lowpass input filter to an ADC, can be easily tolerated by isolating the capacitance with at least 1kΩ of resistance.

If the input supply is hot plugged, a ceramic input capacitor (C1) should be avoided because its high Q can cause voltage transients of up to twice the DC supply level and possibly damage the charger. If using such a low ESR capacitor, adding a resistance of 1Ω to 2Ω in series with C1 will sufficiently dampen these transients.

The programming pin (PROG) accomplishes several functions. It is used to set the current in the constant current mode, monitor the charging current and manually shut down the charger. In the constant current mode, the LTC1734 maintains the PROG pin at 1.5V. The program resistor value is determined by dividing 1.5V by R1's desired current while in the constant current mode. The charging current is always 1000 times the current through R1 and is therefore proportional to the PROG pin voltage. The PROG pin voltage drops below 1.5V as the constant voltage mode is entered and charging current drops off. At 1.5V the charging current is the full 300mA, while at 0.15V the current is 1000 • (0.15/5100) or about 30mA. If the grounded side of R1 is pulled above 2.15V or is allowed to float, the charger enters the manual shutdown mode and charging ceases. These features support charging the battery to its full capacity by allowing a microcontroller to monitor the charging current and shut down the charger at the appropriate time. An internal 3μA pull-up current will pull the floated PROG pin up. By design, this current adds no error, but does set a minimum current through the program resistor of 3μA.

While charging in the constant voltage mode, currents produced by active dynamic loads may create excessive transient levels on the PROG pin. If desired, these transients can be filtered with a simple RC lowpass filter. Connect a 1k resistor to the PROG pin with its opposite end connected to a 0.1μF capacitor with its other end grounded. Monitor the filtered PROG voltage at the RC common node. Load transients are not reflected onto the PROG pin if the charger remains in the constant current mode.

A Programmable Constant Current Source

An example of a programmable current source is shown in Figure 2. To insure that only the constant current mode is activated, the BAT pin is tied to ground to prevent the constant voltage control loop from engaging. Control inputs (CONTROL 1, CONTROL 2) either float or are pulled to ground. This can be achieved by driving them from the drains of NMOS FETs or from the collectors of NPNs. When both inputs are floating, manual shutdown is entered. Connecting Control 1 to ground causes 500mA of current while Control 2 results in 200mA of current. When both control inputs are grounded the current is 700mA. The choice of the PNP depends upon its power dissipation. A voltage DAC, connected to the PROG pin through a resistor, could also be used to control the current. A PWM source, connected to a control input, can be used to modulate the current. Pulse width modulation is useful for wide range or fine control of the average current and can be used to extend the constant current range to below 200mA. Applications include charging nickel-cadmium or nickel-metal-hydride batteries, driving LEDs or biasing bridge circuits.

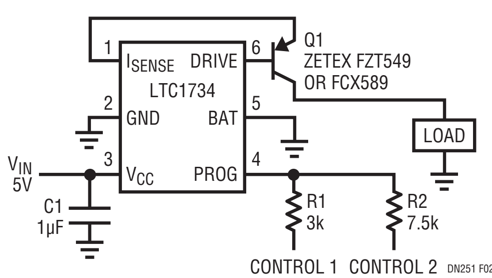

Figure 2. Programmable Current Source with Output Current of 0mA, 200mA, 500mA or 700mA

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