New Dual Input USB/AC Linear Li-Ion Battery Chargers

by Alfonso Centuori

Introduction

Digital Cameras, PDAs, mobile phones and MP3 players all use batteries that are commonly charged via either a wall adapter or through the USB. The LTC4076 and LTC4077 lithium-ion battery chargers are specifically designed to detect power at the inputs and automatically select the appropriate source for charging. Using a constant current/constant voltage algorithm, the chargers can be programmed to deliver up to 950mA of charge current with a final float voltage accuracy of ±0.6%. The LTC4076 and LTC4077 include an internal P-channel power MOSFET and thermal regulation circuitry with no blocking diode or external sense resistor required. Thus, the basic dual-source charger requires only three external components.

The LTC4076 offers a programmable current based termination scheme. The CHRG open-drain status pin can be programmed to indicate the battery charge state according to the needs of the application. The PWR open-drain status pin indicates that enough voltage is present at one of the inputs to charge a battery. With power applied on both inputs, LTC4076 and LTC4077 can be put into shutdown mode, reducing the DCIN supply current to 20µA, the USBIN supply current to 10µA and the battery drain current to less than 2µA.

Internal thermal feedback regulates the charge current to maintain a constant die temperature during high power operation or high ambient temperature conditions.

USB Compatibility

The HPWR pins of the LTC4076 and LTC4077 provide an easy method to choose between two different USB power modes: high power (usually ≤500mA) and low power (usually ≤100mA). With the LTC4076, a logic high on the HPWR pin sets the charge current to 100% of the current programmed by the IUSB pin resistor, while a logic low on the HPWR pin sets the charge current to 20% of the current programmed by the IUSB pin resistor.

With the LTC4077, a logic high on the HPWR pin sets the charge current to the value programmed by the IUSB pin resistor, while a logic low on the HPWR pin sets the current to the value programmed by the IUSBL pin resistor.

Programmability

The LTC4076 and LTC4077 provide a great deal of design flexibility including programmable charge current and programmable current termination. The charge currents are programmed using a resistor from the IDC, IUSB and IUSBL (LTC4077 only) pins to ground as indicated in the following equations:

\[
I_{CHG} = \frac{1000V}{R_{IDC}} \quad \text{(Wall Adapter Present)}
\]

\[
I_{CHG} = \frac{1000V}{R_{IUSB}} \quad \text{(USB HPWR = High)}
\]

\[
I_{CHG} = \frac{200V}{R_{IUSB}} \quad \text{(USBHPWR = Low, LTC4076 Only)}
\]

\[
I_{CHG} = \frac{200V}{R_{IUSBL}} \quad \text{(USBHPWR = Low, LTC4077 Only)}
\]
Both the LTC4076 and LTC4077 terminate the charge cycle based on the battery current. For the LTC4076 the current threshold is programmable and for the LTC4077 the current threshold is fixed, as described below.

For LTC4076, the programmable current detection threshold, $I_{\text{TERM}}$, is set by connecting a resistor, $R_{\text{ITERM}}$, from $I_{\text{TERM}}$ to ground. The following formula programs the termination current:

$$I_{\text{TERM}} = \frac{100V}{R_{\text{ITERM}}}$$

For the LTC4077 the termination current is fixed at 10% of the programmed charge current as set by IDC or IUSB (HPWR = High). When HPWR in its low state, the termination current is 50% of the current programmed by $R_{\text{USBL}}$.

The condition of the CHRG pin indicates the charge state. A strong pull-down on the CHRG pin indicates that the battery is charging. When the current termination threshold is reached the CHRG pin assumes a high impedance state.

### Avoiding Unnecessary Charge Cycles

LTC4076 and LTC4077 are designed to avoid unnecessary charge cycles to extend the life of Li-Ion batteries. When power is first applied or when exiting shutdown, the LTC4076 and LTC4077 check the voltage on the BAT pin to determine its initial state. If the BAT pin voltage is below the recharge threshold of 4.1V (which corresponds to approximately 80%–90% battery capacity), LTC4076 and LTC4077 enter charge mode and begin a charge cycle. If the BAT pin is above 4.1V, the battery is nearly full and the charger does not initiate a charge cycle and instead enters standby mode. When in standby mode, the chargers continuously monitor the BAT pin voltage. When the BAT pin voltage drops below 4.1V, the charge cycle is automatically restarted. This feature eliminates the need for periodic charge cycle initiations, ensures that the battery is always fully charged, and prolongs battery life by reducing the number of unnecessary charge cycles.

### Conclusion

LTC4076 and LTC4077 are complete Linear Li-Ion battery chargers compatible with portable USB applications. They are designed to accommodate charging from both a wall adapter and a USB input. The versatility, low quiescent current, simplicity, high level of integration and small size of the LTC4076 and LTC4077 provide an ideal choice for many portable USB applications. LTC4076 and LTC4077 are available in a small 10-lead low profile 3mm × 3mm DFN package.

---

**For further information on any of the devices mentioned in this issue of Linear Technology, use the reader service card or call the LTC literature service number:**

1-800-4-LINEAR

Ask for the pertinent data sheets and Application Notes.