Portable devices derive 3.3V and 5V power supplies from USB ports

The universal serial bus (USB) port provides power in addition to its communication channel (D+, D-). While connected to the USB port for communications, battery-powered devices such as digital cameras, MP3 players, and PDAs can utilize USB power to charge their battery. **Figure 1**'s circuit utilizes USB power to produce 3.3V and 5V supply rails and to charge a lithium (Li+) battery. U1 charges the battery, U2 steps up the battery voltage (V_{BATT}) to 5V, and U3 steps down the 5V output to 3.3V.

U1, a Li+ battery charger, draws power from the USB port to charge the battery. Pulling its SETI terminal

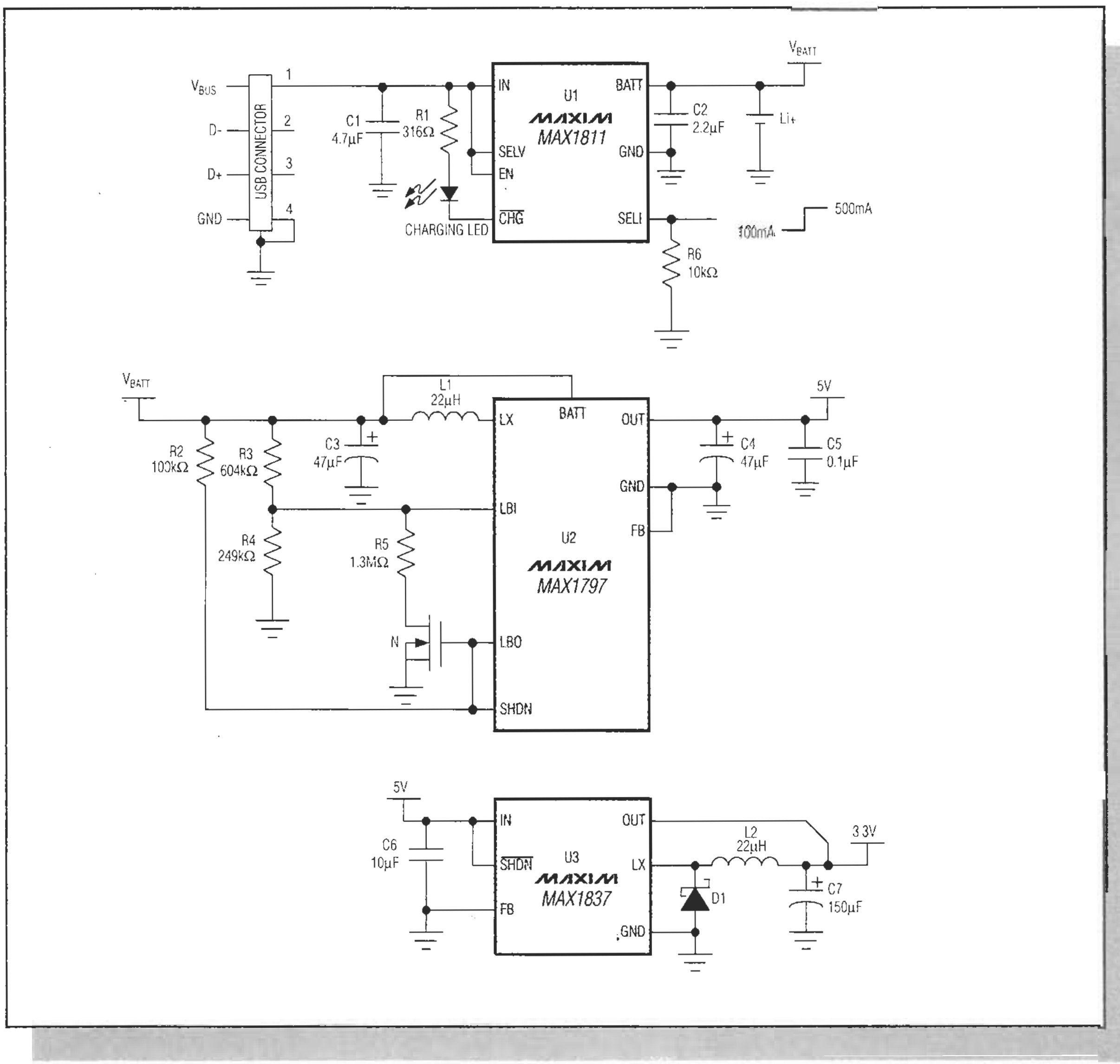

Figure 1. This circuit generates 5V and 3.3V supply voltages for portable applications while drawing power from the USB port.

low sets the charging current to 100mA for low-power USB ports, and pulling SETI high sets 500mA for high-power ports. Similarly, pulling SETV high or low configures the chip for charging a 4.2V or 4.1V Li+ battery. To protect the battery, U1's final charging voltage exhibits 0.5% accuracy. The $\overline{\text{CHG}}$ terminal allows the chip to illuminate an LED during charging.

U2 is a step-up DC-DC converter that boosts V_{BATT} to 5V and delivers up to 450mA of current to its load. Its low-battery detection circuitry and true shutdown capability protect the Li+ battery. By disconnecting the battery from the output, "true" shutdown limits battery current to less than 2µA. The low-battery trip point is set by an external resistive divider between V_{BATT} and GND, connected to LBI. Connecting the low-battery output (LBO) to shutdown (SHDN) causes U2 to disconnect its load in response to a low-battery voltage.

The internal source impedance of a Li+ battery makes U2 susceptible to oscillation when its low-battery detection circuitry disconnects a low-voltage battery from its load. As the voltage drop across the battery's internal resistance is removed, the battery voltage increases and turns U2 back on. For example, a Li+ battery with 500mΩ internal resistance (while sourcing 500mA) drops 250mV across its internal resistance. When the U2 circuitry disconnects the load, the battery current drops to zero and the battery voltage increases by 250mV.

The N-channel FET at LBO eliminates this oscillation by adding hysteresis to the low-battery detection circuitry. Figure 1's circuit is configured for a low-battery trip voltage of 2.9V. When V_{BATT} drops below 2.9V, LBO opens and allows SHDN to be pulled high, turning on the FET. With the FET turned on, the parallel combination of 1.3MΩ and 249kΩ eliminates oscillation by setting the battery turn-on voltage to 3.3V.

$$V_{BATT(TURN-OFF)} = V_{LBI} \times \frac{R3 + R4}{R4}$$

where $V_{LBI} = 0.85V$, and

$$V_{BATT(TURN-ON)} = V_{LBI} \times \frac{R3 + R'4}{R'4}$$

where

$$R'4 = \frac{R4 \times R5}{R4 + R5}$$

Finally, a step-down converter (U3) bucks 5V to 3.3V, and delivers up to 250mA to its load with efficiency exceeding 90%.

A similar idea appeared in EDN.

USB POWER

- A low-power USB port provides 4.4V to 5.25V at 100mA.
- A high-power USB port provides 4.75V to 5.25V at 500mA.
- Due to voltage drops across USB cables and connectors, a USB device must be able to operate with 4.35V.
- A USB device must ensure that its maximum current consumption is 100mA, until configured for high power through software.