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USB Charger Provides Battery Backup And Load Switching With Easy, Low-Cost Design

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This circuit idea solves a specific, very real battery-backup problem for devices that consume relatively low current. Specifically, it addresses the situation where a small load is normally being powered by a USB port (or equivalent power source), but then must take power from a back-up battery if the USB power goes away.

The circuit described here takes power from the USB port and uses it to both power a low-current consumption device and charge a 1-cell Lithium-ion (Li+) battery. Then when the USB power drops out, the circuit switches the load over to the battery backup. The circuit also disconnects the battery when the terminal voltage drops to a user-determined voltage to prevent excessively discharging the battery. Fuel-gauge management is not a function performed by this circuit.

The original application for this design was an RF system. And in fact, any mobile device with low power consumption, such as a device which periodically transmits radio packets, will find this circuit useful.

Consisting of just a few ICs and some external components, this design represents an integrated solution. Now, we should acknowledge at the outset that there are numerous solutions that support both the switching of the load current and battery charging. This design, however, has several advantages. It is an easy-to-implement, analog-based standalone design. That means it needs no microcontroller and therefore requires no coding. At the same time, the design is flexible and low cost. This design presents an ultra-small footprint that accommodates the needs of space-constrained applications.

Another benefit of this circuit is its robustness in the face of input-voltage variations or transients. Most USB chargers accept only 4 V to 7 V, and may be damaged if the input exceeds 7 V. This design starts to function when the input voltage is below 7 V, but it can sustain an input voltage all the way up to 28 V.

Design Specifics

The circuit shown in the figure includes a linear, 1-cell charger that accepts a dc power source to charge a 1-cell Li+ battery. The power source provides load current while also charging the 1-cell battery. To do this, the circuit performs resistor-limited current sharing. The maximum current available is programmed by R_{SET} and that amount of current will primarily drive the load. When the load does not require the full maximum current, the remaining current is available to charge the battery.

For the case where the dc source is not available and the cell voltage drops to a user-determined level, a voltage monitor activates an ultra-low-resistance switch to disconnect the cell from the load. This operation avoids a deep discharge of the cell.

U1 (the MAX8814), a linear Li+ battery charger, accepts 4.25 V to 7 V, which covers the USB range. The input of U1 can sustain a source voltage of up to 28 V, but the output of U1 is disabled when the dc source exceeds 7 V. The charge voltage for U1 is factory fixed to be 4.2 V. The maximum charge current is user-adjustable to I_{CHARGE} = 1596 V/ R_{SET}. Maximum charge current is 570 mA when R_{SET} is 2.8 kΩ.

U2 (the MAX9646), a low-power comparator with a 0.2-V integrated reference connected to the noninverting input, monitors the cell voltage to provide a push-pull output. V_{TRIP} is 0.2 V × (R1 + R2)/R2. The trip voltage is 3.5 V with R1 = 82.5 kΩ and R2 = 5 kΩ. The output of U2 turns off U3 (the MAX14680), a 0.01-Ω battery switch, to disconnect the cell from the load when the cell voltage drops to 3.5 V.

The circuit is space-saving as U1 is 2 mm x 2 mm, U2 is 1 mm x 1 mm, and U3 is 1.3 mm x 1.7 mm. Besides these ICs, this design requires only five external components.

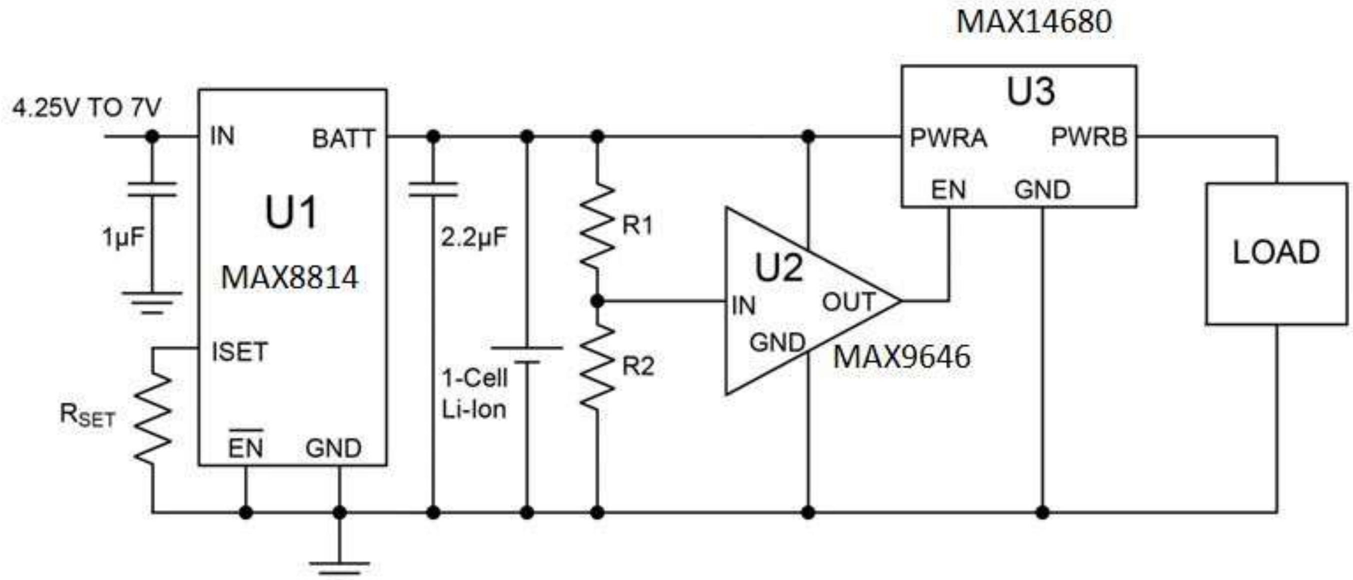

Figure. Operating from a USB power source, this circuit powers a small load, charges a back-up Li-ion battery, and then switches to the battery backup when the USB source drops out. This design is small, low-cost, and easy to implement since it requires no coding. Plus, it's robust since the input of U1 can tolerate voltages as high as 28 V.

About The Author

Budge Ing has been an applications engineer with Maxim Integrated for 16 years. He received his MSEE from San Jose State University.

For further reading on the design of battery charging circuits, see the How2Power Design Guide, select the Advanced Search option, go to Search by Design Guide Category and select "Battery Chargers" in the Power Supply Function category. Also try "Battery Powered & Portables" in the Application category.