Simulate Lithium Batteries With A NiMH Cell

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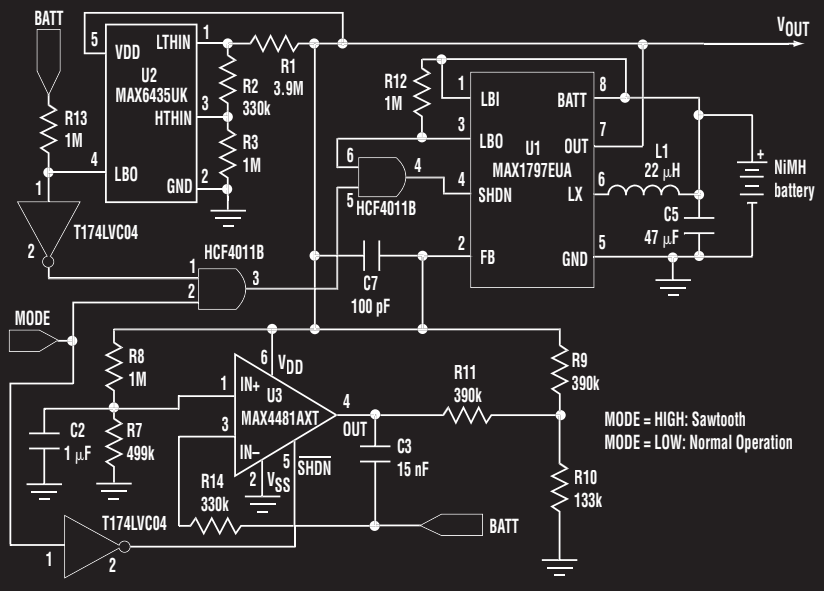
Lithium-based batteries are becoming standard in portable equipment. They have desirable characteristics, but lead times may be long unless you have a preferred-customer status with the battery manager. A backup alternative is desirable, especially for smaller companies. It should (ideally) provide the same performance, size, and cost as a lithium-type battery.

Nickel-metal-hydride (NiMH) batteries are still in wide use. They're much cheaper than lithium batteries, and they come in very small sizes (AAAA is now available). A proposed interface circuit should mimic the batteries' terminal voltage, which declines as the battery



1. Powered by a single NiMH cell, this circuit's output simulates the discharge characteristic of a lithium battery.

Don Tuite

APEC 2005 Report

The twentieth annual Applied Power Electronics Conference and Exhibition took place in Austin, Texas, last month. It was the most bustling conference I've seen since the days of the dotcom bubble. Conference Chair Jason Lai says total attendance was roughly 2500. Not counting exhibitors, reporters, and other related people, about 1000 power engineers came to Austin for the show.

Efficiency Challenge 2004, sponsored by the California Energy Commission's PIER program and the EPA's Energy Star program, was the most interesting event at the show. Power Integrations took the grand prize in the "market-ready" category for its prototype supply for cordless phones with an average efficiency of 69%. Grand prize in the "open" category, designs without cost or packaging constraints, went to Hong Kong Polytechnic University. Its standalone AA-battery charger exhibited 74% average efficiency and a no-load power drain of 0.16 W.

The university also took a "best-in-class" award for its open-category cordless phone supply. Other best-in-class winners included AcBel Polytec Inc. of Taiwan, the University of Illinois, Dartmouth College, the National Taiwan University of Science and Technology, and a team from Texas A&M that was mentored by Lite-On Technology. Details on the winners can be found at *www.efficientpowersupplies.org/winner_fact_sheet.pdf*.

APEC 2006 is set for next Feb. 19-23 in New Orleans. The call for papers was published in the 2005 proceedings. For details, go to *www.apec-conf.org*.

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discharges. The nominal terminal voltage for lithium batteries (3.6 V) is about three times that of NiMH batteries (1.2 V). As a simple approach, therefore, you can force the output of an efficient step-up converter to equal battery voltage times 3.6 V/1.2 V = 3.

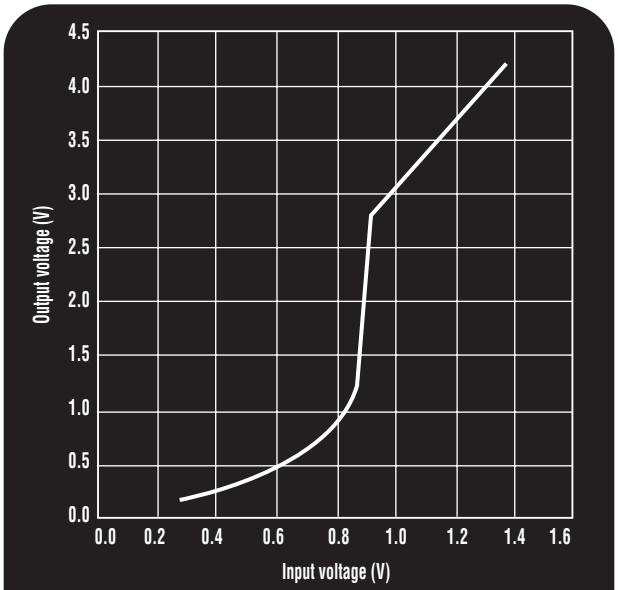
However, allowing the circuit to run constantly during shutdown consumes unnecessary power. The NiMH circuit's equivalent leakage (its quiescent current) can be as a high as 200 mA, which is unacceptable. Only a power-control capability must be provided while in shutdown.

Instead of maintaining a three-times NiMH voltage while in shutdown, you can run the circuit in burst mode, activating the step-up converter only when the circuit output drops below a certain threshold. When it reaches the upper threshold, the step-up shuts down, allowing the output capacitor to discharge through the output load plus the NiMH circuit. Thus, the output voltage forms a sawtooth wave. On the other hand, if battery voltage falls below a lower limit, the circuit remains deactivated to protect the batteries from depletion.

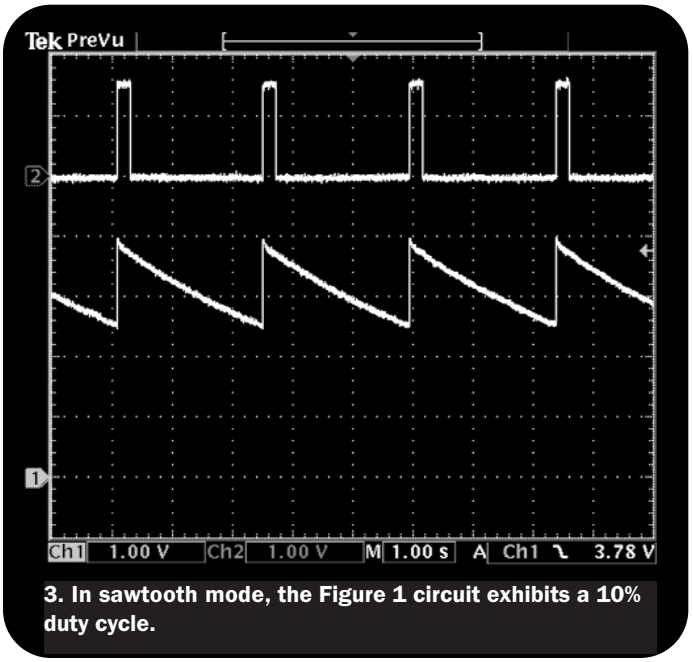
The circuit of Figure 1 implements these ideas by providing an interface between a NiMH battery and a lithium-optimized power-management circuit. The state of the circuit is controlled by the MODE input (HIGH gives the sawtooth, and LOW gives 3 × V_{BATT}). The integrator-connected op amp multiplies the battery voltage by driving U1's feedback node to produce an output three times that voltage *(Fig. 2)*.

A large integrator time constant is necessary to avoid interaction with U1's internal error comparator, as well as to provide noise filtering. In low-power mode, a mP-supervisor IC (U2) monitors the output voltage and controls U1. The resistor string associated with U2 sets approximate 2.4- and 4-V thresholds for that device.

Finally, the step-up converter must always be shut down when battery voltage drops below a threshold, which is usually 0.9 V. That shutdown is accomplished by the converter's own internal comparator, and the Tiny Logic network selects the correct operating mode according to the state of the MODE control input, the ramp threshold detector (U2), and U1's internal battery comparator. To ensure startup from 1.0 V when the output is 0 V, the logic network must be supplied directly from the battery. The logic family shown (ULP) functions down to 0.9 V; below that, the battery is nearing depletion.



2. For normal operation of the Figure 1 circuit (i.e., $V_{IN} \geq 0.9$ V), $V_{OUT} = 3 \times V_{IN}$.



3. In sawtooth mode, the Figure 1 circuit exhibits a 10% duty cycle.

With the components as shown, the sawtooth duty cycle is 10% *(Fig. 3)*. Note that the circuit has a potential lock-up state. When running in sawtooth mode, the upper threshold of U2 must always be less than U1's maximum output. Otherwise, U2 doesn't shut down U1. U1's maximum output is set by the R9-R10 resistor string at its FB node. (Because the op-amp output is at high impedance in low-power mode, it doesn't pull current from the node.)

An interface for lithium-battery charging isn't included. However, that function can be implemented with a p-channel MOSFET in series with the charger and the battery, plus the addition of an op amp to servo the charger side of the MOSFET to 3 3 V_{BATT}.

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Use Throwaway Camera Parts For A High-Voltage Flash Unit

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Camera shops usually will give disposable flash units away for free. The flash capacitor, output rectifier, and transformer are de-soldered easily for use in the new circuit.

Parts of a throwaway camera's flash unit can be salvaged to build a 280-V capacitor charger for a flash unit that uses six or nine batteries *(see the figure)*. Camera shops usually will give them away for free. The flash capacitor, output rectifier, and transformer are easily de-soldered for use in the new circuit.

Many circuits are available for such flash units. But the transformers are hard to get or can only be obtained in large quantities, and they work at just one voltage. Because the units in disposable cameras are designed for blocking oscillators with a 1.5-V supply, they have very low primary inductance, and peak primary current can easily exceed 2 A. But because the switching frequency will be very high, they can't be used in a blocking oscillator at high voltage without an expensive high-speed, low-saturation transistor or MOSFET. The switching transistor in the flash units can't be used with a 6-V battery because they only have a 25-V breakdown rating.

In the circuit shown, a low-cost Darlington transistor is driven by a 5-ms on-time astable oscillator formed with an NE555 timer, preventing transformer saturation. This reduces peak currents, and the 1.6-kHz frequency reduces transistor overheating. Low peak currents also will prolong rechargeable battery lifetimes.

Capacitor voltage regulation is achieved with a 280-V "zener diode" made with two reverse-biased 1N914 diodes operating in voltage breakdown. During zener operation, the NE555 is stopped by transistor Q2 being driven into saturation by the zener current. Charging will resume once some charge has leaked from output capacitor C1.

These 100-V diodes will typically have a 140-V breakdown, but some have been measured at 170 V. The total capacitor voltage should not exceed the 300-V rating of the flash capacitor used. A lower voltage also will prolong lamp and capacitor lifetimes.

Resistor R5 and capacitor C4 must be included to limit the current peak that's produced when the diodes break down. Otherwise, transistor Q2 will be destroyed. The astable oscillator directly drives the switching transistor, with turn-off voltage drive provided by the transformer secondary.

The maximum reverse voltage is limited by the forward voltage of D1. It also provides a charging path for the charging current. No heatsinking for the switching transistor is necessary because the peak and average currents are low. An LED indicates when the capacitor voltage is reached. With a 45-second charging time, average current is approximately 40 mA. ED

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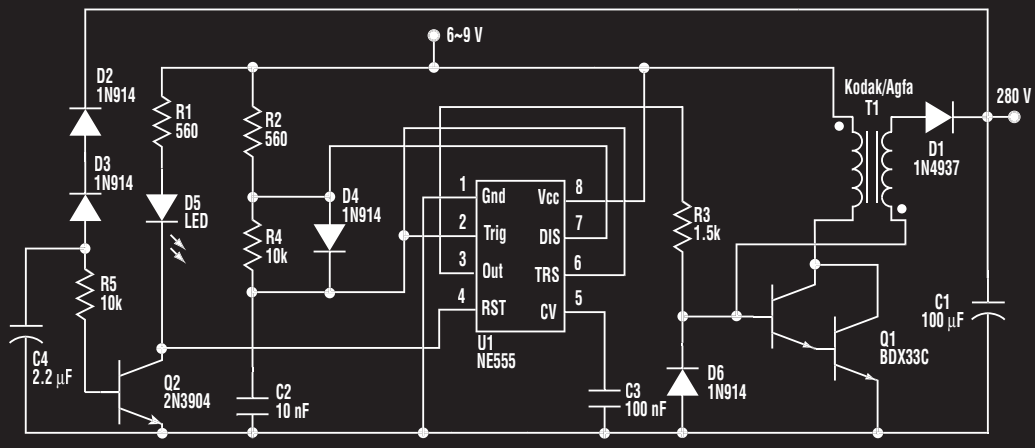

Using parts salvaged from a throwaway camera (T1, D1, and C1), this capacitor charger for a high-voltage flash unit operates from 6- or 9-V batteries.

ELIO MAZZOCCA, technical consultant, received a B.App.Sc from the University of Adelaide, Australia.