design ideas

Edited by Bill Travis

Rechargeable flashlight obsoletes lantern battery

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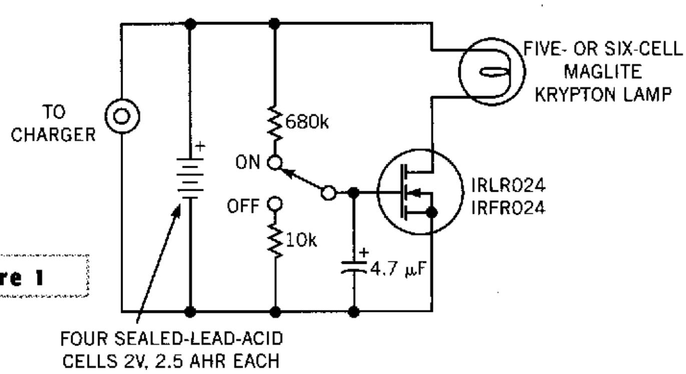
This Design Idea describes a high-intensity, rechargeable flashlight system that you can build from a 6V lantern-type flashlight. The rechargeable battery comprises four 2V, 2.5-Ahr (ampere-hour) SLA (sealed lead-acid) cells, similar in size to a standard D-sized battery. SLA cells are especially well-suited to powering flashlights because of their low self-discharge rate. NiCd (nickel-cadmium) or NiMH (nickel-metal-hydride) cells can lose as much as 1% of their charge per day, compared with less than 0.2% per day for SLA cells. SLA cells are also easy to charge and can withstand abuse. The flashlight in this design uses a krypton high-intensity lamp. Maglite (www.maglite.com) makes this lamp as a replacement lamp for its line of flashlights. The lamps are extremely bright; have a standard miniature-flange-base, built-in lens; and are available in five- or six-cell versions. (Manufacturers typically rate flashlight lamps by the number of alkaline cells the flashlight uses.) The lamp's operating voltage is approximately 1.25V per cell, which makes the lamp voltage of a six-cell lamp equal to 7.5V. This design uses a six-cell lamp for this flashlight, although you could also use a five-cell, 6.25V lamp. A five-cell lamp provides approximately 30% more light output but has a shorter lamp life. To increase lamp life, this flashlight includes the soft-start circuit in **Figure 1**.

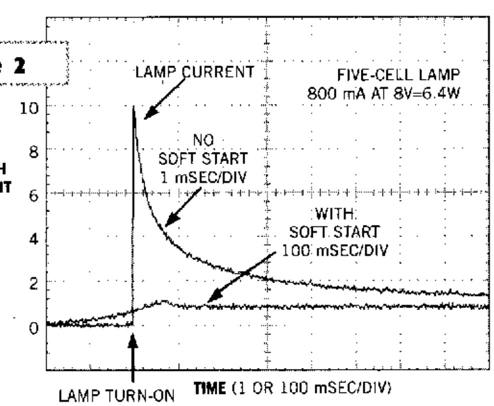
Figure 1



This soft-start circuit reduces inrush current, thereby prolonging lamp life.

Incandescent lamps inherently draw large start-up currents because of the filament's relatively low resistance when it is cold. A tungsten filament's resistance is typically 10 times lower when cold than it is when at normal operating temperature. When the full battery voltage suddenly hits a cold filament, the inrush current is typically 10 times the normal operating current, and this instant is when a lamp is likely to fail. Adding a soft-start circuit nearly eliminates this large inrush current, allowing for a higher power lamp and reducing the probability of the lamp's failure at turn-on. The soft-start circuit consists of an n-channel MOSFET in series with the lamp, which ramps the lamp voltage up at a controlled rate to reduce the inrush current. A gate-to-source capacitor controls the ramp speed. The lamp turns on in approximately 2 sec. **Figure 2** shows the dramatic reduction in lamp inrush current when you use the soft-start circuit.

Figure 2



Using the soft-start circuit in Figure 1 provides a dramatic decrease in inrush current.

The charger is a 200-kHz step-down switching regulator using current-limited constant voltage to charge the battery (**Figure 3**). When a discharged battery connects to the charger, the charge cycle starts in a 1A constant-current mode. As the battery accepts charge, the battery voltage increases until it reaches the programmed charge voltage of 2.5V/cell (10V total). At this point, the charge cycle enters constant-voltage mode. During constant-voltage mode, the charge current drops exponentially. When the charge current reaches approximately 10% (100 mA) of the programmed current, the charge voltage drops to a float voltage of 2.35V/cell

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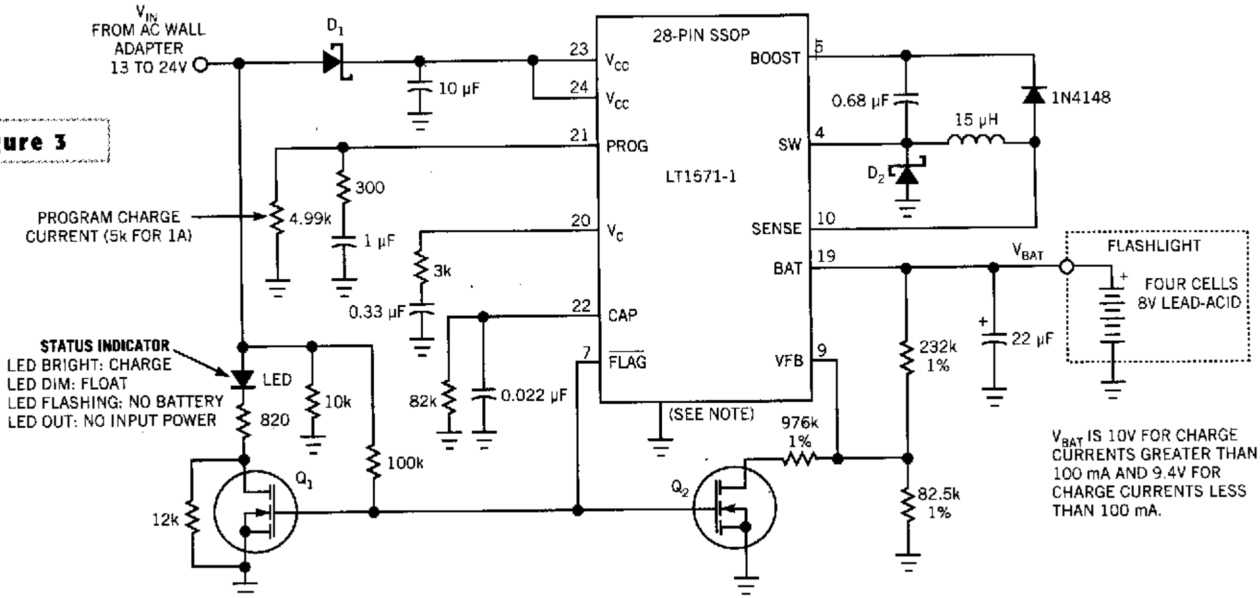
Figure 3



NOTES:
GROUND PINS 1, 2, 3, 11, 12, 13, 14, 15, 16, 17, 18, 25, 26, 27, AND 28 TO GENEROUS AMOUNTS OF PC-BOARD COPPER FOR BEST THERMAL AND ELECTRICAL PERFORMANCE.
Q_1 AND Q_2 ARE VN2222s, OR 2N7002s.

D_1 AND D_2 ARE 1A ,30V SCHOTTKY DIODES.

This battery charger uses current-limited constant voltage to charge the lead-acid cells in the flashlight.

(9.4V total). This dual-voltage approach provides a faster charge and also provides an LED indication when the battery is nearly fully charged. The charger keeps the battery at this float voltage, thus keeping the battery in a fully charged condition. You can leave the charger indefinitely connected to the battery without damage to the battery, although battery damage can result if it is fully discharged—when the battery voltage is less than 1.8V/cell—either through use or self-discharge. The FLAG pin is an open-collector output that indicates when the charge current has dropped to approximately 10% of the full programmed charge current.

A wall adapter with an output from 13V, 1A to 26V, 0.5A provides power to the charger. This design uses all surface-mount components to reduce the overall size of the charger. The pc-board layout should include wide ground traces that expand to larger copper areas to minimize the possibility of overheating the IC. The flashlight housing features a 3- to 4-in. reflector and has a handle on top; it is readily available from Radio Shack (www.radioshack.com) and other electronics outlets. The light is designed for a 6V lantern battery, but this design replaces the lantern battery with four D-sized, SLA cells. The cells leave enough room for the soft-start circuitry. Other modifications include replacing the switch with a high-quality SPDT switch and soldering all the connections for increased reliability. A dc power jack connects the flashlight to the charger.□