Single-Cell Flashlight Uses Any Type Of LED

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With this circuit, any type of LED can be driven from a single-cell supply in the range of 1.0 to 1.5 V *(see the figure)*. As a result, it can be used with alkaline, carbon-zinc, NiCd, or NiMH cells. The device was designed for use in LED flashlights. But here it serves as an astronomer's flashlight, operating in its red mode to prevent interference with night vision. Substituting white LEDs would create a good general-purpose flashlight.

This circuit may be used with LEDs from infrared (1.2 V) to blue/white (3.5 V). It tolerates LED voltage turn-on requirements and delivers relatively constant power. Some compensation for battery voltage also is included.

The best way to describe this circuit is as an open-loop, discontinuous, flyback, switch-mode boost converter. Q2 is the main switch. When conducting, it charges L2 with the energy to be delivered to the LED. When Q2 is turned off, the energy stored in L2 is dumped into the LED during the flyback cycle.

Q1, an inverting amplifier, drives Q2, an inverting switch. Feedback around the circuit is provided by R4, R5, and R2. Two inversions around the loop create a noninverting regenerative arrangement. If L2 were replaced with a resistance, the circuit would be bistable as in the classic flip-flop. As it prevents dc feedback, L2 allows ac feedback only. Therefore, the circuit is astable and will oscillate. Q2's on-time is determined by the time it takes L2's current to ramp up to the point where Q2 can no longer stay in saturation. When Q2 turns off, the circuit flips to the off state for the duration of the energy dump into the LED. Then, the process is repeated.

Since the inductor stores current flow, it essentially acts as a current source for the duration of the stored energy dump. Inductors will attain any voltage necessary to maintain their stored current flow. This property allows the circuit to be very compliant with the LED voltage requirement. Constant voltage devices (LEDs) are happiest when driven by current sources. The LED is actually being pulsed at a rapid rate.

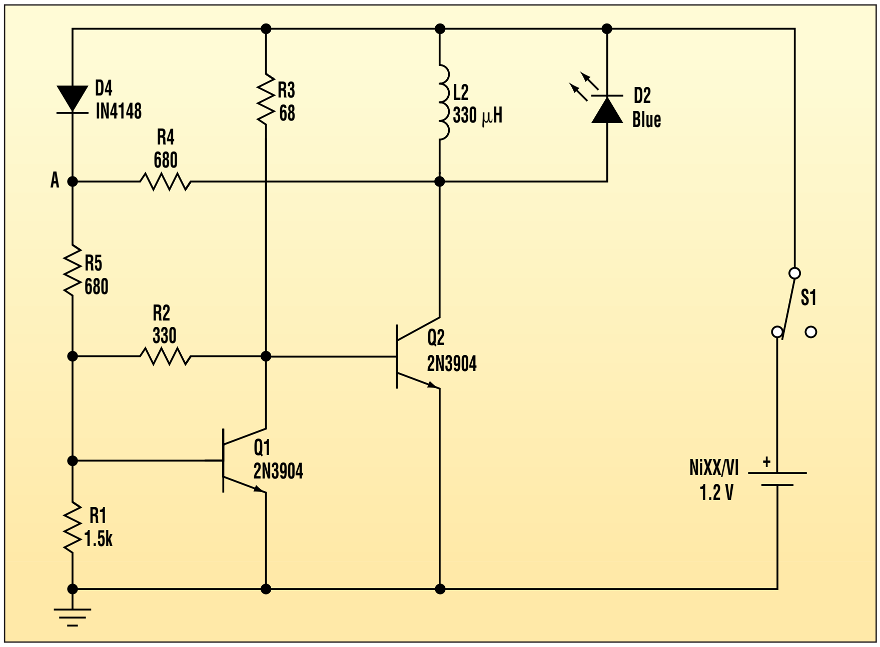
In this example, the inductor size is relatively unimportant as it only determines the oscillation frequency. If the inductor is too large (unlikely), the LED will flash too slowly and appear to flicker. If it's too small, switching losses will predominate and efficiency will suffer. Using the value shown causes the circuit to oscillate at about 50 kHz—not a bad compromise.

Diode D4 supplies compensation for varying cell voltage. Because of the voltage division at node A, D4 includes a variable-clipping operation. As the supply increases, the clipping level is raised and the feedback is decreased. Q1 inverts this clipping level so it can reduce the turn-on bias to Q2 at higher cell voltages.

Although the devices chosen here are 2N3904s, any small npns will do. Q2 runs at rather high currents at the end of the charging ramp. L2 also needs to handle this peak current without saturating. Internal resistance causes Q2's base-voltage requirement to rise. The R2/R1 divider at Q1's base raises its collector voltage to match that requirement, thereby controlling Q2's final current.

The LED drive current is a triangular pulse with about a 120-mA peak, averaging about 30 mA for a red LED and 15 mA for a white one. This gives a flashlight a nice brightness without unduly beating up the LED. The supply current is approximately 40 mA. A 1600-mA-hr NiMH AA cell will last approximately 40 hours.

In total, this circuit costs less than a white LED. It's possible to use higher-current devices and larger cells to run multiple LEDs. Such LEDs would be placed in series. If the LEDs are in parallel, sharing resistors should be used. Though uncontrolled, the circuit's output also can be rectified and filtered to offer a convenient dc supply for any number of uses. The amplified, noninverting feedback to Q1's base could provide regulation.



This LED flashlight circuit can drive any type of LED from a single-cell battery. In this application, the circuit operates over a battery voltage range of 1.0 to 1.5 V.