White-LED driver operates down to 1.2V supply voltage

Dave Wuchinich, Modal Mechanics, Yonkers, NY

Many LED drivers, using both charge pumps and inductors, are available to boost the 1.2 to 2.4V available from single- and dual-cell NiMH (nickel-metal-hydride) batteries to the 3.6V that white LEDs require. However, most of these circuits, such as the Maxim (www.maxim-ic.com) MAX1595, require a minimum input voltage of approximately 2.5V to operate properly. The MAX1595 works with an input voltage of 2.4V but does not ensure an adequate output until the input voltage reaches approximately 3V. Furthermore, as the battery voltage decreases to the threshold level, the output becomes erratic. The circuit in **Figure 1** uses a flip-flop

to generate flux in an inductor, which then charges a capacitor in the common boost configuration. US Patent 4,068,149 describes the flip-flop's operation in an application for operating an incandescent safety lamp's flasher (**Reference 1**).

In **Figure 1**, R_1 provides a path for starting current through the base-emitter junctions of Q_1 and Q_2. Q_2 thus turns on and, in so doing, turns on Q_1, rapidly forcing both transistors into saturation. However, C_1 charges through R_2 to the battery voltage minus the base-emitter drop of Q_1 and the saturated collector-emitter voltage of Q_2, eventually causing Q_1 to turn off and thereby also turning off Q_2. C_1 then discharges through R_1 and R_2 and the forward-biased base-collector junction of Q_2. The R_2C_1 time constant determines the turn-on time, and $(R_1+R_2)(C_2)$ determines the turn-off time. C_2 acts as the capacitive input filter for the current flowing from L_1 when Q_2 is off and provides a substantially constant voltage to power D_2, a standard white LED.

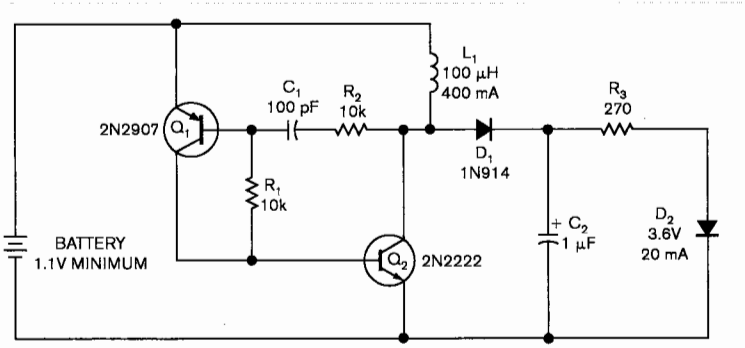

Figure 1 In this circuit, transistors Q_1 and Q_2 form a flip-flop that toggles at 60 kHz, providing a drive current for the output LED down to the 1V battery voltage.

The output voltage is proportional to the battery voltage.

With the component values in **Figure 1** and with L_1, a Coilcraft (www.coilcraft.com) MSS7341-104MLB, the operating frequency is approximately 60 kHz. With a battery voltage of 2.36V from two NiMH cells, approximately 20 mA of current flows through the LED. In tests simultaneously driving two LEDs, each with its own current-limiting resistor, R_3, the energy-conversion efficiency of the circuit at this battery voltage is approximately 80%. Operation continues with battery voltages of slightly more than 1V, and the delivered current diminishes but still provides usable illumination.

REFERENCE

1. Wuchinich, David G, "Flasher circuit with low power drain," US Patent 4,068,149, Oct 28, 1975, http://patft.uspto.gov.