Use A Boost Converter To Create An Auto-Dimmable LED Flashlight

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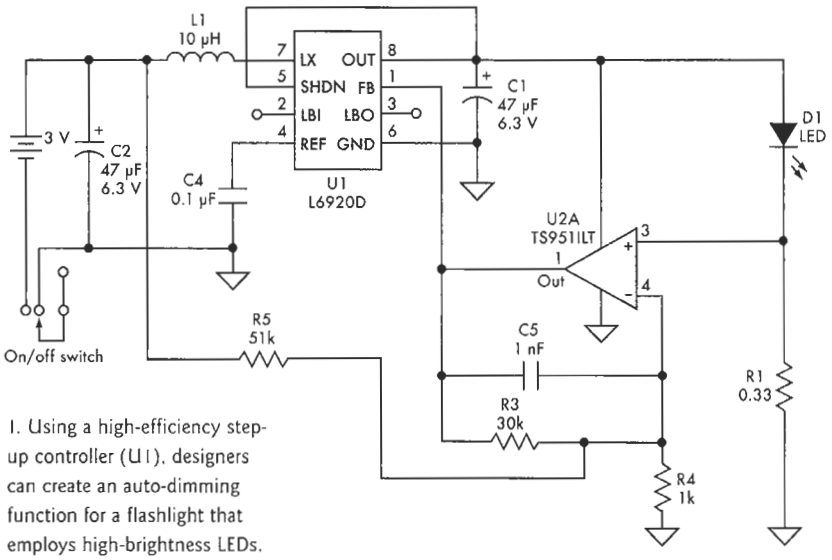


1. Using a high-efficiency step-up controller (U1), designers can create an auto-dimming function for a flashlight that employs high-brightness LEDs.

Due to their light output and long life, high-brightness LEDs are well-suited for use in flashlights. Typically, the LEDs are driven with a constant current. So when the battery voltage drops, the flashlight just stops working. In some situations, this could be dangerous. It would be nice to have a flashlight that would automatically dim when the battery voltage drops. Just like a traditional flashlight, it would indicate a low-battery condition and would last longer.

Typically, the forward voltage of a white LED is 3 to 5 V. Therefore, if the input voltage drops below 3 V, a boost converter can drive the LED. Figure 1 shows such a boost converter with automatic dimming based on battery voltage.

The L6920D is a high efficiency step-up controller requiring very few external components to convert the battery voltage to the selected output voltage or current. The device will start up at 1 V and operate down to 0.6 V. Its quiescent current is only 10 µA. The device also includes an internal synchronous rectifier implemented with a 120-mΩ P-channel MOSFET, which replaces the conventional boost diode, to improve the efficiency.

In this circuit, the LED current (I_{LED}) is a function of the battery voltage (V_{FB}). When the battery voltage drops, the LED current drops. In this way, the battery can last longer, and the flashlight will offer dimming characteristics. Assuming V_{FB} = 1.23 V, determined by the L6920D:

$$V_{FB} = I_{LED} \times R1 \times \left(1 + \frac{R3}{R5||R4}\right) - \frac{R3}{R5} \times V_{IN}$$

If R5 >> R4, then R5||R4 ≈ R4, then:

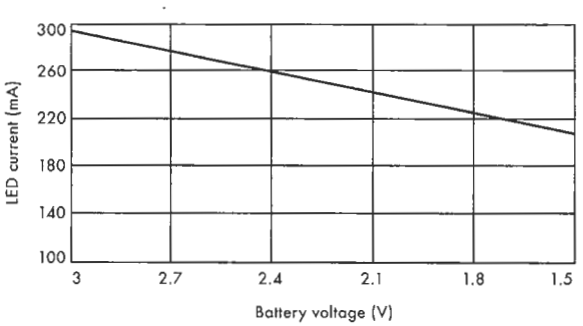
$$V_{FB} = I_{LED} \times R1 \times \left(1 + \frac{R3}{R4}\right) - \frac{R3}{R5} \times V_{IN}$$

Finally:

$$I_{LED} = \frac{V_{FB} + \frac{R3}{R5} \times V_{IN}}{R1 \times \left(1 + \frac{R3}{R4}\right)}$$

Figure 2 shows the resulting LED current calculated using the resistance values in the example circuit.

We compared a constant LED flashlight and this auto-dimming version, using two AAA batteries. Running times were 50 and 90 minutes, respectively. The auto-dimming function nearly doubled the battery life and provided a warning when the battery voltage dropped.



2. For the resistance values in Figure 1, the equation for I_{LED} produced this graph showing how the current drops as the battery voltage decreases.

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