# LED drivers minimize power dissipation

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One option for driving high-brightness LEDs uses the standard stepdown buck converter (**Figure 1**). The sense resistor, $R_S$, generates a feedback voltage, $V_{FB}$, that sets the desired LED current, $I_{LED}$, according to the equation $R_S=V_{FB}/I_{LED}$. Unfortunately, most buck converters require a relatively high feedback

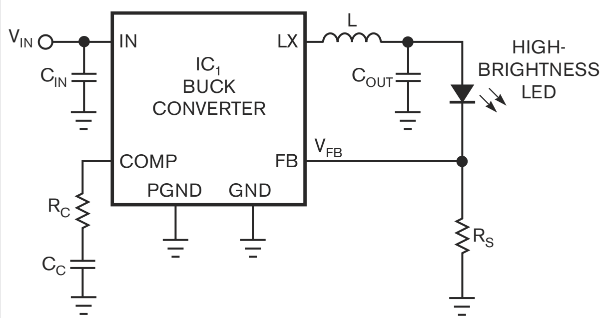


Figure 1 A generic buck converter, $IC_1$, provides constant-current drive for a high-brightness LED.

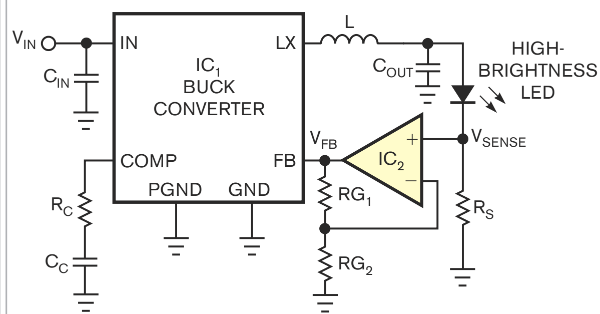


Figure 2 An op amp, $IC_2$, increases the LED-current error signal and reduces power dissipation in the sense resistor.

voltage on the order of 1V, which dissipates high power in the sense resistor ($P_{SENSE}=V_{FB}/I_{LED}$). Reducing the sense resistor's value and adding an op amp to boost the sensed voltage reduces the power penalty (**Figure 2**). In some cases, you can eliminate the op amp by using a stable reference voltage, which is available on some converter ICs, to pull up the sense voltage (**Figure 3**).

**THE VARIATION OF LED CURRENT AVERAGES APPROXIMATELY 5 mA OVER AN INPUT-VOLTAGE RANGE OF 4 TO 5.5V.**

The switching converter, a Maxim (www.maxim-ic.com) MAX1951, requires a feedback voltage of 800 mV and provides a 2V reference voltage at the reference pin. Connecting $R_1$, a 50-kΩ resistor, between $R_S$ and $V_{FB}$, and $R_2$, a 100-kΩ resistor, between the reference and the feedback pins shifts the operating point from 200 mV at $R_S$ to 800 mV at the feedback pin:

$$V_{FB} = V_{REF}\frac{50k}{50k+100k} + V_{SENSE}\frac{100k}{50k+100k} = 0.667V + {}^{2}/_{3}(V_{SENSE}).$$

Thus, for $V_{SENSE}$=0.2V, V=0.8V. For the cost of two inexpensive resistors, power dissipation in the sense resistor diminishes by a factor of four.

Using the Luxeon K2 LED from Lumileds (www.lumileds.com), power measurements on the circuits of **figures 1** and **3** illustrate how the feedback adjustment influences power that the LED driver delivers. Two graphs illustrate LED currents and voltages as a function of input voltage for a half-load of 400 mA (**Figure 4**) and a full load of 800 mA (**Figure 5**). As you would expect, the current regulation deteriorates at half-load. The variation of LED current averages approximately 5 mA over an input-voltage range of 4 to 5.5V and 1 mA for the circuit

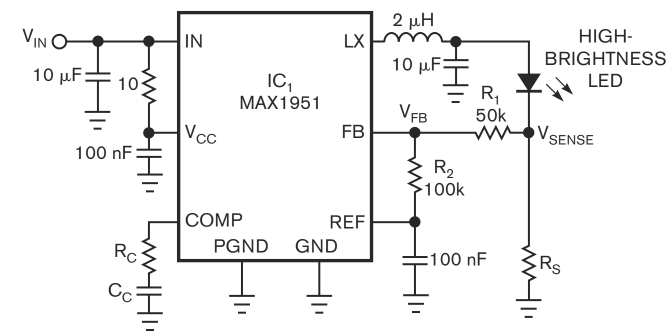


Figure 3 Adjusting the feedback signal improves the efficiency in this buck-converter driver for high-brightness LEDs.

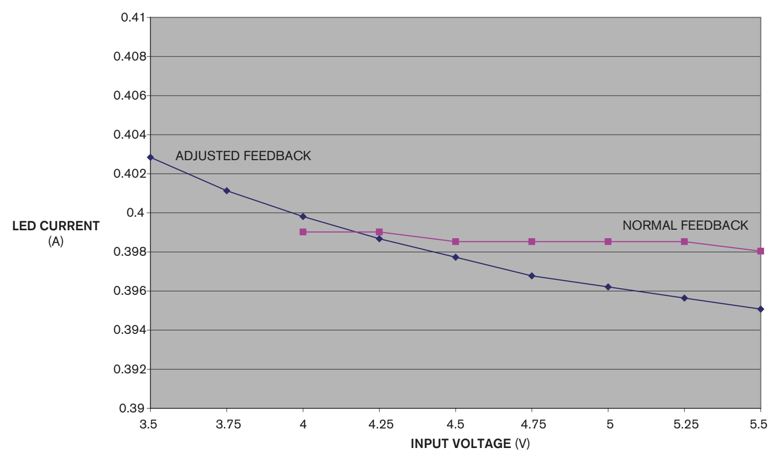


Figure 4 This graph shows LED current as a function of input voltage at half-load for the circuit of Figure 3.

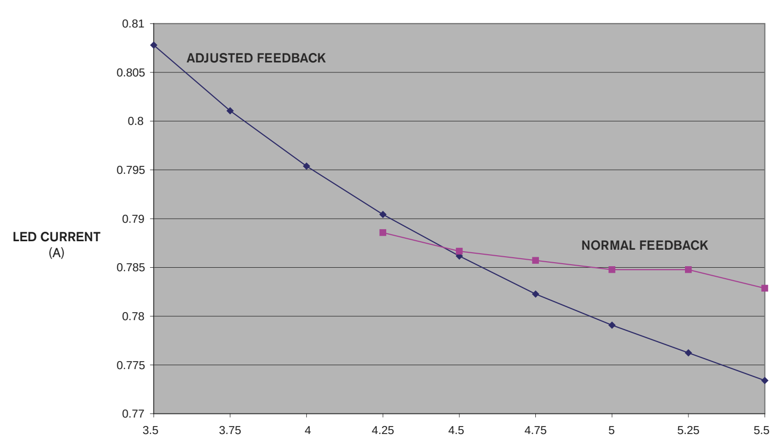


Figure 5 This graph shows LED current as a function of input voltage at full load for the circuit of Figure 3.

with normal feedback. The input-voltage range, however, increases by more than 0.5V. Regulation also deteriorates for full load, and the variation increases to approximately 22 mA versus 6 mA for the circuit with normal feedback (**Figure 6**). Again, the adjusted-feedback circuit of **Figure 3** increases the input-voltage range.

You can define the improvement in efficiency, η, as follows:

$$\eta = \frac{V_{LED} \times I_{LED}}{V_{IN} \times I_{IN}}.$$

The buck converter's power-conversion efficiency and power dissipated in the sense resistor determine the circuit's efficiency. As **Figure 5** shows, the adjusted feedback of **Figure 3** increases the efficiency more than 10% at either half-load or full load. Assuming that the sense voltage doesn't change, efficiency improves for lower output-current loads because the sense resistor dissipates less power. **EDN**

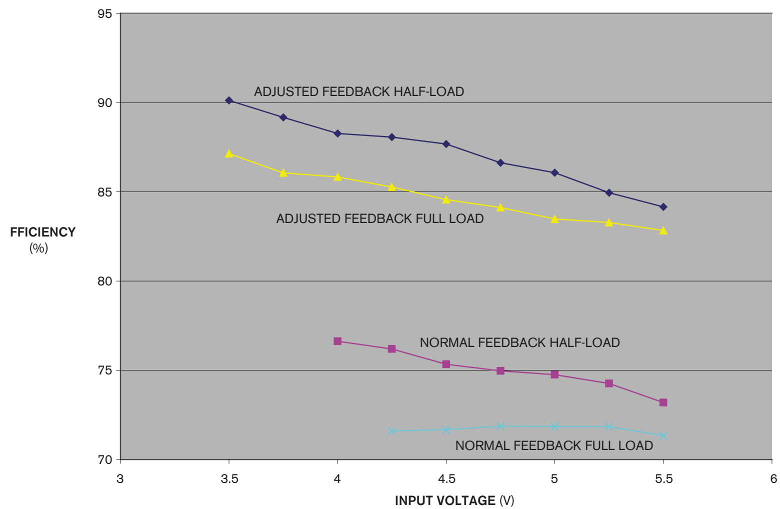


Figure 6 A comparison of a normal-feedback circuit (Figure 1) and an adjusted-feedback circuit (Figure 3) shows significant improvements in overall efficiency at half-loads and at full loads.