Buck regulator controls white LED with optical feedback

Dhananjay V Gadre, Netaji Subhas Institute of Technology, New Delhi, India

There is much interest in LED-based lighting due to the availability of high-power, high-efficiency white—and other-color—LEDs (Reference 1). Because an LED is a current-controlled device, typical control circuits regulate the current through the LED to maintain uniform intensity. To optimize available power, users often operate the LEDs with a switching-converter circuit—either a buck or a boost converter—depending on the input-dc voltage. Figure 1 illustrates the configuration of typical buck- and boost-converter white-LED-driver circuits. Adding the resistance, R, in series with the white LED sets the current through the LED. The value of the resistance depends on the desired LED current and the feedback voltage that the buck/boost converter requires. For example, the required resistance is 12Ω for a 100-mA average current through the LED and a 1.23V feedback voltage.

To reduce the power dissipated in the series resistance, engineers often employ the circuit configurations in Figure 2. In this configuration, the amplifier's gain reduces the power dissipated in the series resistor by a factor equal to the gain (Reference 2).

The circuit configurations in figures 1 and 2 work well in regulating

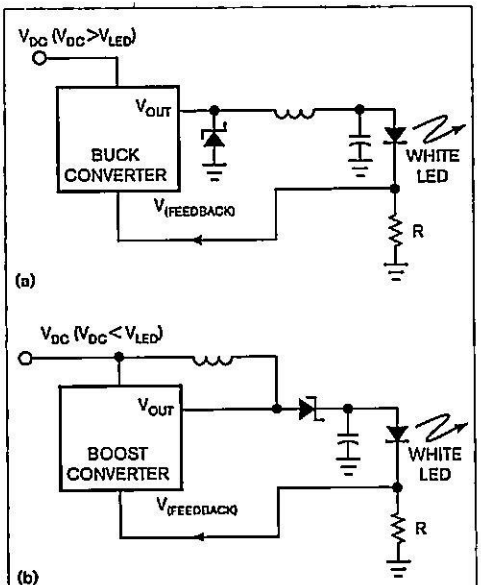

Figure 1 Depending on the input voltage, buck (a) or boost (b) regulators drive high-intensity white LEDs.

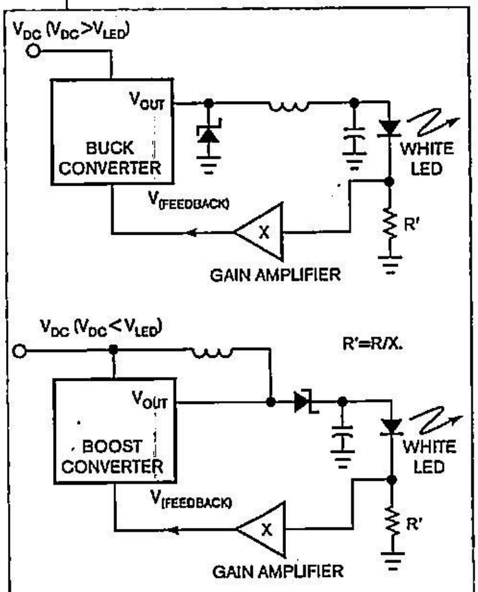

Figure 2 In these circuits, an amplifier gain reduces the power dissipated in the series resistor by a factor equal to the gain.

the current through the LED, provided that the ambient temperature remains constant. However, white and other-color LEDs exhibit significant variation in luminosity as a function of temperature (references 2 and 3). Typical figures for variation in luminosity range from 40 to 150% for a 100°C change in temperature. Thus, if you expect the ambient temperature to vary, regulating only the current through the LED is an inefficient way to control the LED. An alternative is to use optical feedback to control the LED (Reference 3).

However, rather than use an expensive light sensor and amplifier circuit, you can use a suitable LED as a light sensor (Reference 4). **Figure 3** illustrates a controller for a white LED using an inexpensive buck-regulator IC, an adjustable LM2575. A 3-mm red LED in a transparent package senses the light from a 10-mm white LED. The white-LED spectrum is wide enough to excite the red LED as a sensor. For a test current of 60 mA through the white LED, the red-LED-sensor voltage is approximately 40 mV. Because the circuit uses the red-sensor LED's voltage as a feedback to the buck regulator, you must use an amplifier with a gain of approximately 30 because the internal reference voltage of the LM2575 buck regulator is 1.23V. Resistors R_1, R_2, and R_3 control the gain of the amplifier, which comprises an inexpensive LM358 dual op amp. The input-dc voltage powers the op amp. Resistors R_1, R_2, and R_3 have values of 270, 560, and 10 kΩ, respectively. Because R_2 is a variable resistor, changing its setting changes the gain and, thus, the current through the white LED. Thus, R_2 acts as brightness control. The amplifier gain ranges from 28 to 84, depending on the setting of R_2.

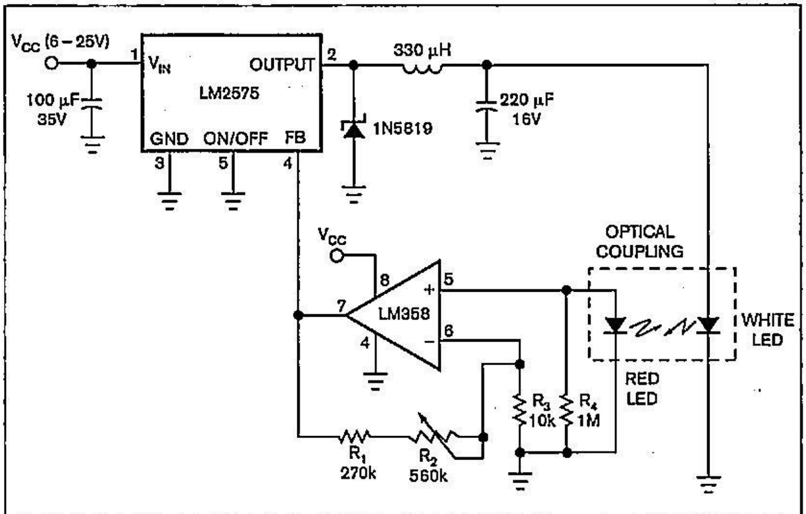

Figure 3 Use an inexpensive buck regulator and a red LED as a sensor for optical feedback to control the intensity of a white LED.

The red LED as a sensor mounts on the side of the white LED itself, thereby using only a fraction of the emitted light from the white LED. File the 3-mm red LED's top to get a flat surface, and then use a drop of superglue to secure the 3-mm red LED onto the side of the white LED.

The LM2575 buck regulator works by changing its duty cycle to regulate the output voltage. If the white-LED output light falls because of increased temperature, the red-LED sensor's voltage falls proportionately. The output of the red-LED sensor connects to the feedback input (Pin 4) of the regulator IC, and, in response, the regulator IC increases the duty cycle of the output voltage you apply to the white LED, thus stabilizing the light. In case of a decrease in ambient temperature, the white-LED light increases, and the regulator reduces the output voltage, which stabilizes the white-LED light. EDN

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