Optical feedback extends white LEDs' operating life

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Regardless of its color, an LED's light output varies as a function of forward current and ambient temperature. As **Figure 1** shows, an LED's light output can vary by as much as 150% over its operating-current range. In response, a designer's first attempt to solve the problem focuses on driving the LEDs with a constant current. The most common white-LED-driver circuits use an inductor-based dc/dc boost-converter topology similar to the circuit in **Figure 2**. A current-feedback controller ensures that the voltage across current-sensing resistor R_1 remains constant. As a result, the controller varies the voltage across the entire string to maintain the LEDs' current constant without regard to

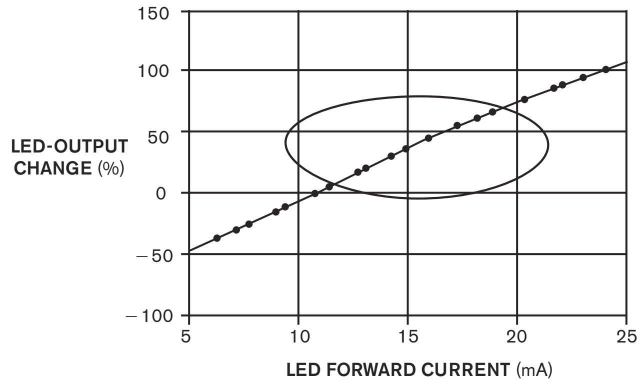


Figure 1 An LED's light output changes considerably as a function of its forward current, even within the sweet spot (oval area) of its nominal operating current.

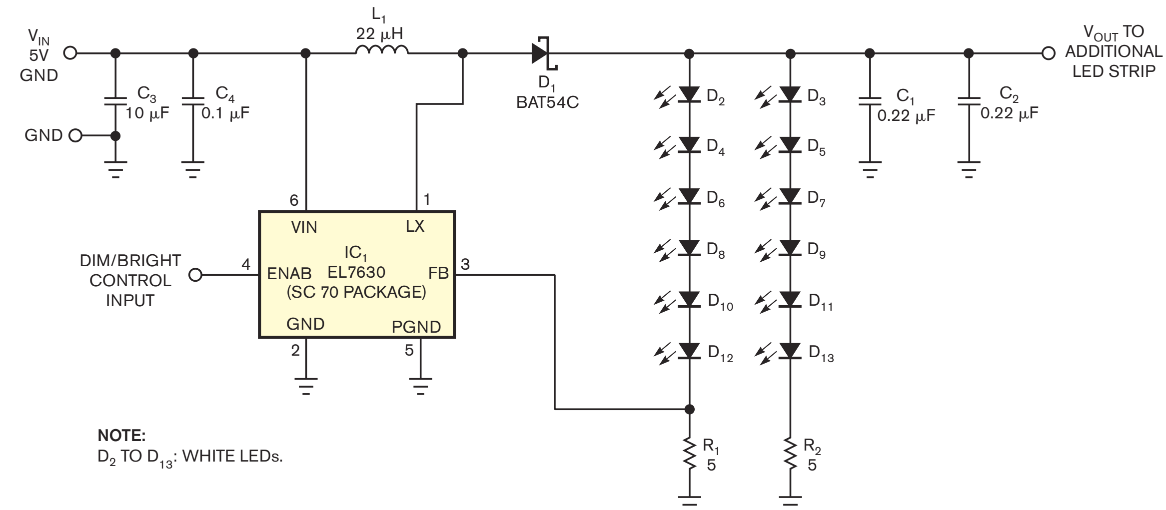
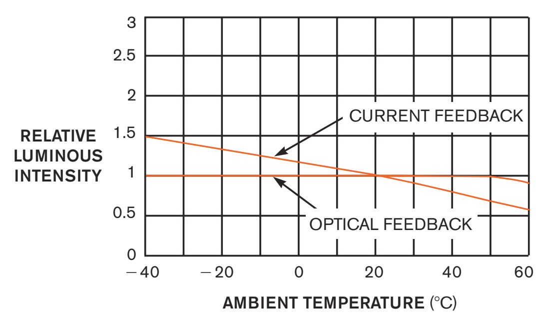


Figure 2 One method of driving an LED illuminator samples current through a string and adjusts the voltage across the entire string to maintain a constant current.

the LEDs' actual light output.

Driving series-connected white LEDs with a current source relies on the assumption that, at constant current, an LED's light output remains constant. Unfortunately, all LEDs exhibit a nonlinear decrease in brightness as a function of operating time. Although less obvious in colored LEDs that find use as indicators, the decrease in brightness of a white-LED-illuminator-array source becomes noticeable over an extended period. Brightness also varies as

Figure 3 Even at a constant forward current, an LED's light output correlates strongly with temperature and can vary by as much as 100% over the entire operating-temperature range (upper curve).



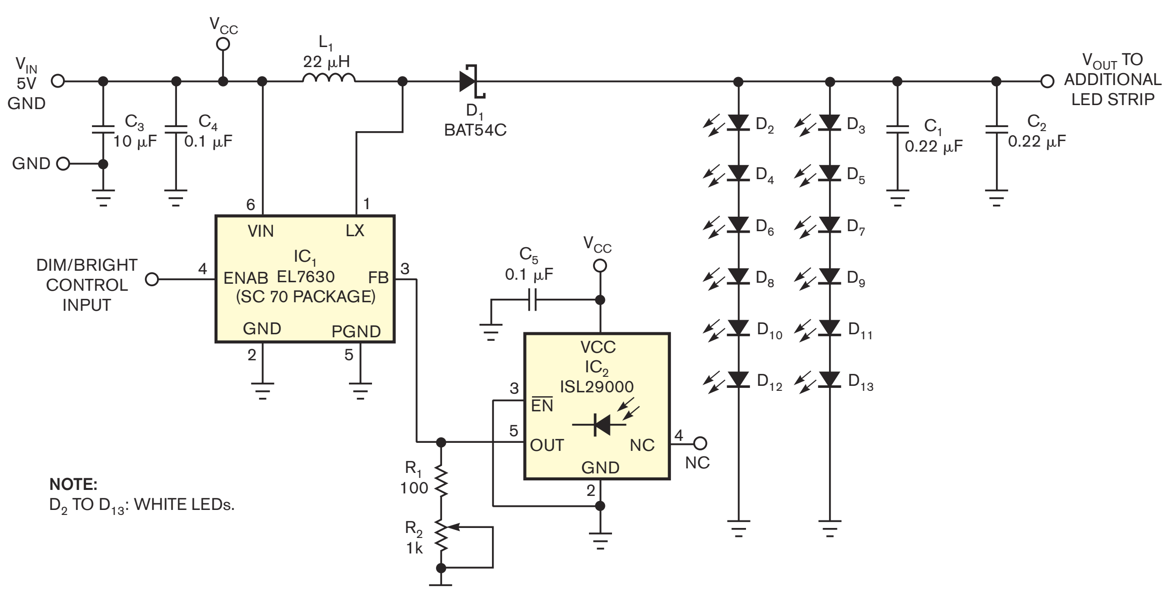


Figure 4 Photosensor IC_2, an Intersil ISL29000, resides near an LED to detect brightness fluctuations and provides compensating feedback to IC_1, the current controller, which is an Intersil EL7630 pulse-width regulator.

a function of temperature, which can affect an illuminator's performance over an extended-temperature range (upper curve, **Figure 3**).

To compensate for LED-output variations due to aging and temperature fluctuations, the control loop needs more information in addition to voltage or current data. Adding an ambient-light sensor and optical feedback to the control loop can ensure that a white LED's light output remains uniform and consistent over time and temperature variations. An optical sensor can measure the LED's light-output intensity and provide a feedback signal for the control loop, which can adjust the current to produce a relatively constant light output. As the LEDs' light outputs decrease, increased current compensates for aging and temperature-induced variations (lower curve, **Figure 3**).

The circuit in **Figure 4** includes an optical-feedback loop based on Intersil's (www.intersil.com) ISL29000 light-to-current optical sensor, IC_2, which senses changes in the LEDs' light output and decreases the feedback voltage applied to IC_1, the current controller, an Intersil EL7630. The pulse-width-modulated controller then increases the LED-drive current's duty cycle, boosting the LED current until the feedback voltage reaches its nominal value. As ambient temperature decreases, the LEDs' light output tends to increase, and IC_2 delivers a higher feedback voltage to the controller, which responds by lowering the duty cycle to decrease the LEDs' current and thereby compensates for the decrease in temperature. EDN