Driving LEDs at a regulated current from low supply voltages can be difficult because minimal overhead voltage is available for control circuits. A current-mirror architecture is suitable but usually works only with ICs with well-matched transistors and in which the silicon substrate holds them at one temperature. However, high currents—approximately 100 mA—are not normally possible. A thermal runaway can occur in circuits using unfavorable combinations of discrete bipolar transistors. In this scenario, one LED-driver transistor becomes slightly hotter than the others, its gain increases, and it takes more current and gets even hotter until it self-destructs. This Design Idea shows how you can avoid this problem for pulsed-current-mirror applications.

The current mirror comprises Q₄ through Q₇ with connected bases and emitters, and the collector current of Q₃ is the control output (Figure 1). Resistor R₃ converts Q₃’s collector current to a feedback voltage. Transistors Q₁ and Q₂ form a voltage-difference amplifier. The control-transistor current after feedback is 1.2V/R₃, and the LEDs have a similar current. Because of the pulsed operation—say, 25% duty at 3 Hz—the transistor temperature does not reach a stable value and cools again toward the ambient temperature during the off period. The thermal-runaway effect does not have time to develop.

The capacitor prevents transient oscillations at switch-on or -off. Use the same transistor type for Q₄ through Q₇ and mount all of them on the same part of the PCB (printed-circuit board). The supply voltage can be as low as 2.5V for certain LEDs, especially infrared types, and the collector current can exceed 100 mA per LED.