One microcontroller pin drives two LEDs with low quiescent current

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The basis for this Design Idea is a circuit that uses three resistors and a microcontroller-I/O pin to work as input high impedance or output to independently drive two LEDs (**Reference 1**). The idea sounded good for this design, mainly because of the lack of spare I/O pins in the microcontroller and the simplicity of the implementation. Unfortunately, you cannot use the circuit in battery-powered designs because it exhibits a current leakage on the order of 2 mA even with both LEDs off. This Design Idea modifies that circuit, using only one I/O pin to drive the two LEDs but with a low current drain (**Figure 1**). Although the circuit uses a couple of diodes and a resistor, the price and the component count are low.

THE LEDs START DIMMING AT APPROXIMATELY 4V WITH A CURRENT OF 80 µA AND ARE FULLY ON WITH 4.4V AT A CURRENT OF 1 mA.

The basis for the operation of both circuits is the nonlinear characteristic of a diode, in which current grows exponentially with the voltage applied across it. To describe the operation, suppose that the microcontroller pin is configured as an input, leaving the pin in high impedance. In the first circuit, assume that LEDs need a voltage of approximately 1.5V to turn on and that the small-signal-diode voltage drop is approximately 0.6V (**Figure 1a**). So, to turn on both LEDs, you theoretically need 4.2V. In practice, the LEDs start dimming at approximately 4V with a current of 80 µA and are fully on with 4.4V at a current of 1 mA. With 3.3V, leakage current is merely 2.41 µA. The nominal voltage for this circuit can be slightly lower than 3.3V, but, in that case, you should use Schottky diodes.

The second circuit is for supply voltages greater than 5V (**Figure 1b**). Using the values in the **figure**, the LEDs start

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dimming with 7V at 74-µA current and are fully on with 8.5V at 1 mA, remaining off for a 5V supply at 1.53 µA.

To turn on the LEDs, you must configure the microcontroller's I/O pin as an output; an output value of one turns

on the lower LED, and a value of zero turns on the upper LED. If both LEDs must appear to be on, your program can cycle the port pin between one and zero with a frequency greater than 50 Hz. To calculate the value of the resistor in both cases, the following formulas apply: $R=(3.3V-V_D-V_{LED})/I_{LED}$ (Figure 1a), and $R=(V_{CC}-V_Z-V_{LED})/I_{LED}$ (Figure 1b), where I_{LED} is the desired LED-on current, V_D is the voltage across the diode when an I_{LED} current flows through it, V_Z is the zener-diode voltage, and V_{LED} is the forward voltage across the LED when an I_{LED} current flows through it. You should use a Schmitt trigger or an analog input for the I/O pin to avoid excessive current draw.EDN

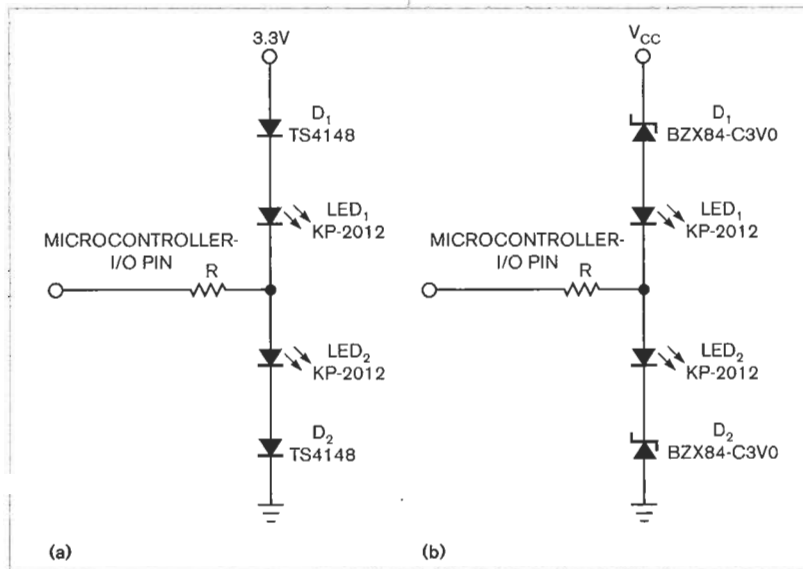**(a)**   **(b)**

Figure 1 In these simple circuits, the LEDs need a voltage of approximately 1.5V (a) or more than 5V (b) to turn on. The circuits allow a battery-powered microcontroller to control two LEDs with only one I/O pin.

REFERENCE
■ Pethany, Spehro, "Circuit Controls Two LEDs With One Microcontroller Port Pin," *Electronic Design*, April 1, 2002, http://electronicdesign.com/Articles/Index.cfm?AD=1&ArticleID=1683.