Drive 16 LEDs with one I/O line

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Over the last few years, several Design Ideas have described how to use just a few microcontroller I/O pins to drive many LEDs (**references 1** through **7**). The circuit in **Figure 1** can drive 16 LEDs with just one pin and two shift registers. You can use the circuit to drive long-dot-bar or two seven-segment-digit displays. Adding multiplexing to the same circuit enables it to drive eight seven-segment LED digits.

The microcontroller drives the shift registers' clock inputs. That signal also passes through an RC filter and drives data inputs A and B. A 100-kΩ resistor, R, and the A and B input pins' capacitances form the RC filter (**Figure 2**), producing time delay of approximately R×C×ln2=100 kΩ×(5 pF+5 pF) ×0.7=0.7 µsec.

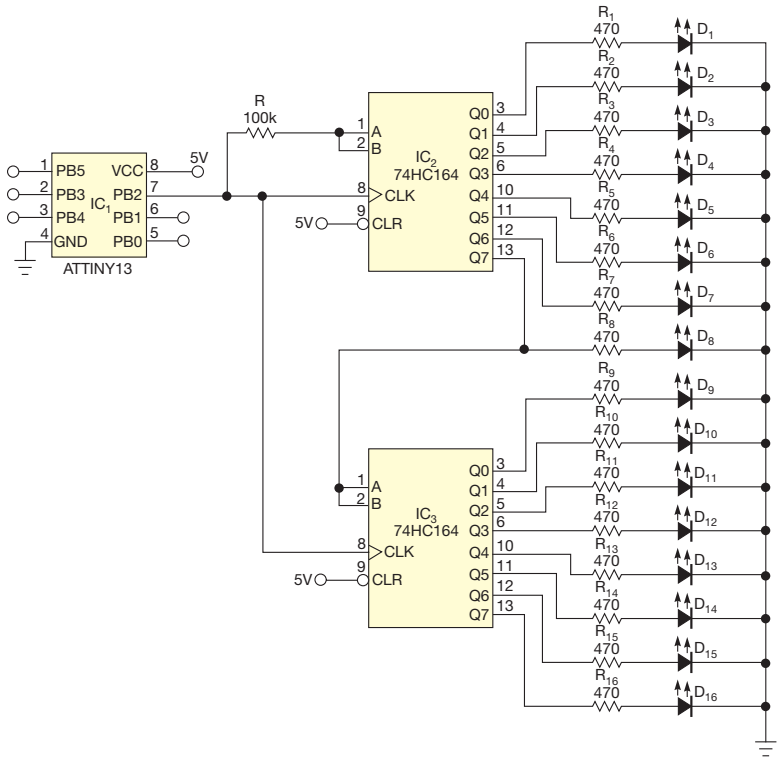

Figure 1 A 16-LED dot-bar/bar-graph display uses two 8-bit serial-input/parallel-output shift registers.

To write a logic zero to the shift register, the microcontroller holds a low level for approximately 2 µsec, which is longer than the time delay. It then sets the signal to a logic one, or high, level. To write a logic one, the microcontroller holds the high level for longer than the time delay. The MCU then makes negative pulses of approximately 0.25 µsec, or two CPU cycles, which is shorter than the time delay and which doesn't change the logic level at the data inputs.

Figure 3 shows the clock signal in Channel 1 (yellow) and the data signal in Channel 2 (blue). The oscilloscope is a Tektronix (www.tektronix.com) DPO4034 with TPP0850 high-voltage probes. These probes have 40-MΩ input resistance and only 1.5-pF input capacitance, minimizing distortion.

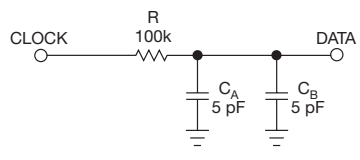

Figure 2 An RC filter provides a 0.7-µsec delay.

A rising edge on the clock signal clocks the shift registers. This edge corresponds to the data signal's local minimum. **Figure 3** also shows that the minimum data-signal voltages for logic zero and logic one are 1.3 and 3.1V, respectively. The shift register's logical threshold is 2.5V.

These voltages guarantee sufficient voltage margins. If your design requires higher margins, vary the signal timing and use a higher resistance for R in **Figure 1**. This circuit stores 16 bits in shift registers in approximately 35 µsec.

You can view a short video of the circuit in operation and download a code listing, in C, at the online version of this Design Idea at www.edn.com/4368093. The software turns on the LEDs one by one every 500 msec until all LEDs are on. It then turns off all the LEDs and repeats the cycle. EDN

REFERENCES

1 Anonymous, "Microcontroller provides low-cost analog-to-digital conversion, drives seven-segment displays," *EDN*, May 10, 2007, pg 80, http://bit.ly/hrcp8g.
2 Raynus, Abel, "Squeeze extra outputs from a pin-limited microcontroller," *EDN*, Aug 4, 2005, pg 96, http://bit.ly/gX723N.

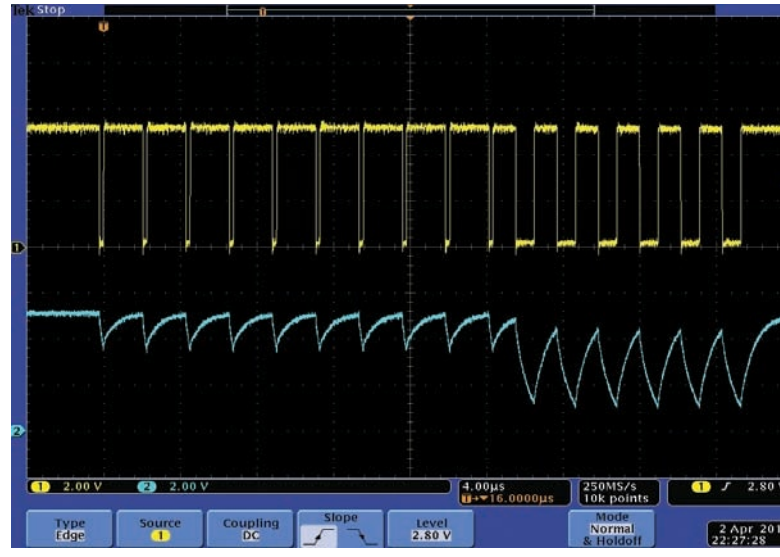

Figure 3 The waveform shows the circuit writing the pattern 1111111111000000 for the display. The upper, yellow trace is the clock signal, and the lower, blue trace is the data signal.

[3] Jayapal, R, “Microcontroller’s single I/O-port line drives a bar-graph display,” *EDN*, July 6, 2006, pg 90, http://bit.ly/fjb0MU.
[4] Lekic, Nedjeljko, and Zoran Mijanovic, “Three microcontroller ports drive 12 LEDs,” *EDN*, Dec 15, 2006, pg 67, http://bit.ly/dRIIBN.
[5] Gadre, Dhananjay V, and Anurag Chugh, “Microcontroller drives logarithmic/linear dot/bar 20-LED display,” *EDN*, Jan 18, 2007, pg 83, http://bit.ly/hJCs3j.
[6] Benabadji, Noureddine, “PIC microprocessor drives 20-LED dot- or bar-graph display,” *EDN*, Sept 1, 2006, pg 71, http://bit.ly/kzjQqv.
[7] Laissoub, Charaf, “Arrange LEDs as seven-segment displays,” *EDN*, May 26, 2011, pg 55, http://bit.ly/iVGYqH.