EDITED BY CHARLES H SMALL
AND FRAN GRANVILLE

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READERS SOLVE DESIGN PROBLEMS

Microcontroller functions as voltmeter

Noureddine Benabadji,
University of Sciences and Technology, Oran, Algeria

The circuit in **Figure 1** is an extension of a previous Design Idea on how to use an analog input in a microcontroller lacking a built-in ADC, and it takes into account tricks from another Design Idea on how to drive a seven-segment LED display without external switching transistors (**references** 1 and 2). This circuit adds a serial link and needs only a twisted pair to send each measurement to a compatible PC. The serial link was tested using a Microsoft (www.microsoft.com) Hyper Terminal configured at 115,200 baud; at 8, N, and 1; and with no flow control.

Briefly, the software drives one seven-segment LED display at a time, through lines RA0 and RB7. Setting the RA0 output high and RB7 as the

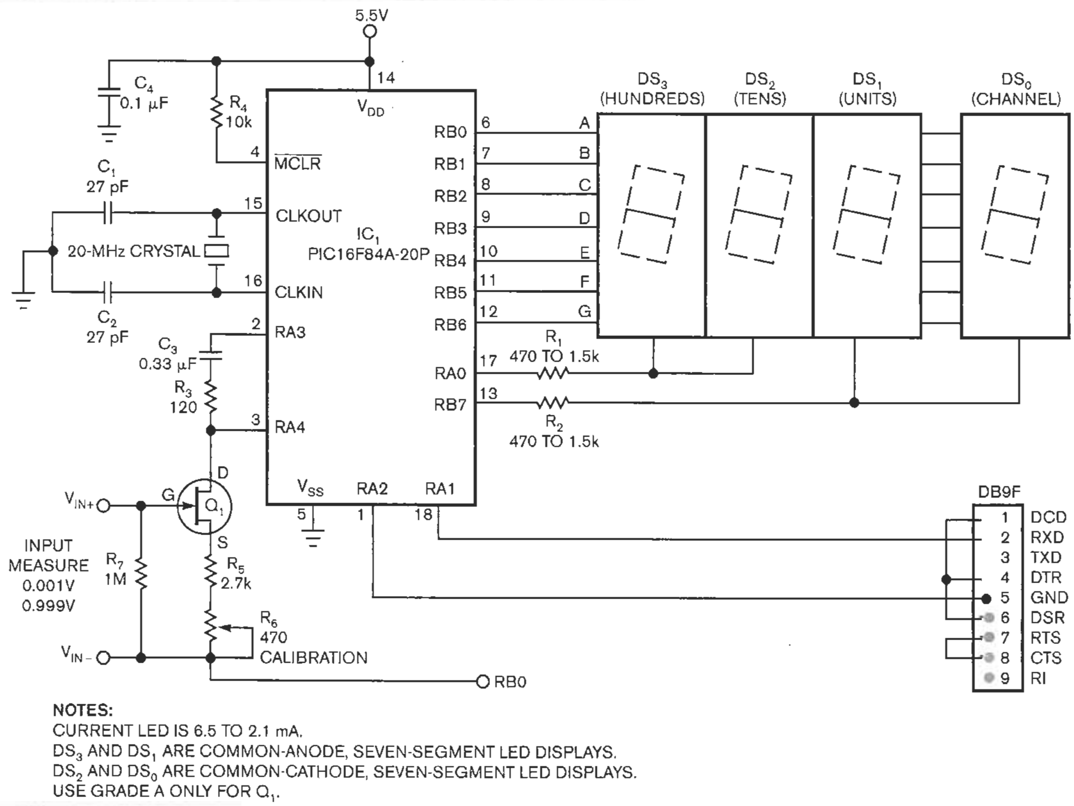

Figure 1 By using common-anode and common-cathode, seven-segment LED displays, the I/O ports of a microcontroller can drive the displays without using additional external components.

input activates common-anode display DS_3. Setting the RA0 output low and RB7 as the input activates common-cathode display DS_2. With RA0 as the input, setting the RB7 output high activates common-anode display DS_1, and, with RA0 as the input, setting the RB7 output low activates common-cathode display DS_0. While successively activating one display, only one line, RB0 to RB6, is configured as an output to drive one LED segment. This design no longer is limited to a V_{DD} of 3V or lower, because LEDs inversely connect in parallel, so the forward voltage of one diode limits the reverse voltage of the other. Using a red-diode display requires 1.6V.

Figure 2 illustrates the new aspects of this Design Idea. Q_1, R_5, and R_6 act as an equivalent variable resistor, R_X, which charges capacitor C_3. Instead of pulling R_X to ground, just connect it to one I/O—RB0, for example—of the microcontroller. If RB0 is an output with a low state, then the first analog channel activates, and the measure subroutine counts pulses of charge as high as 66% of V_{DD}; then, a look-up table converts this time delay to a three-digit millivolt value. To expand the number of analog inputs, you can connect as many, as seven variable-resistor circuits in a parallel configuration—that is, each one connects between C_3 and one I/O line, RB1 through RB7. Notice that I/O lines connect to the display and also activate or deactivate the analog channels. When one analog-input channel activates through one I/O line with the output in the low state, the other lines are high-impedance inputs, which deactivate all other channels. Meanwhile, the display is off.

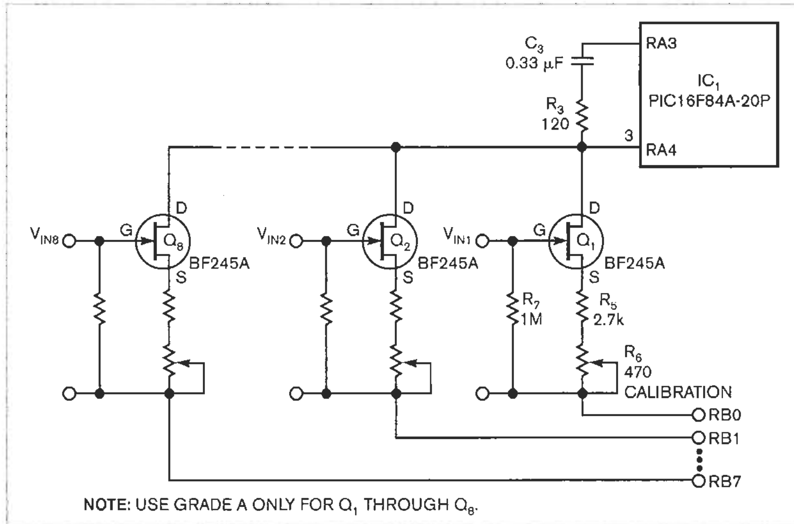

Figure 2 You can expand the number of voltages measured in Figure 1 by multiplexing additional transistor circuits.

The circuit in **Figure 1** also adds a simple serial link with no added components. If you connect two I/O lines, RA1 and RA2, configured as outputs, to RXD (Pin 2) and GND (Pin 5) of an RS-232 connector, you can reproduce, by software, positive and negative voltages with respect to ground of the PC's RS-232 port. When RA1 is high and RA2 is low, then RXD has a positive voltage of 5V with respect to ground of the PC's RS-232 port. When RA1 is low and RA2 is high, then RXD has a negative voltage of −5V with respect to ground of the PC's RS-232 port. **Listing 1**, available at www.edn.com/070510di1, gives a practical example with a PIC16F84A-20P. It is not optimized but is fully commented to make it easy to translate to another Microchip (www.microchip.com) midrange device, such as a PIC16F628A, that supports a frequency of 20 MHz with more I/O lines. EDN

REFERENCES

1. Benabadji, Noureddine, "Microcontroller, JFET form low-cost, two-digit millivoltmeter," *EDN*, June 22, 2006, pg 71, www.edn.com/article/CA6343251.
2. Benabadji, Noureddine, "Ultralow-cost, two-digit counter features few components," *EDN*, Aug 17, 2006, pg 69, www.edn.com/article/CA6360316.