Microcontroller drives logarithmic/ linear dot/bar 20-LED display

Dhananjay V Gadre and Anurag Chugh,
Netaji Subhas Institute of Technology, New Delhi, India

Available for more than 20 years, National Semiconductor's (www.national.com) venerable LM3914 dot/bar-display driver still enjoys wide popularity among designers. The LM3914 can sense an analog voltage level and display it on 10 LEDs by illuminating one of 10 in dot mode or by progressively illuminating LEDs in bar-graph mode. Recently, an application needed an analog-input-voltage display capable of displaying more than 10 levels in linear- and logarithmic-scale formats. According to the LM3914's data sheet, you can cascade multiple 3914s to display more than 10 levels (**Reference 1**), but, even so, the LM3914 offers only linear displays of its input voltage. (**Editor's note:** National Semiconductor also offers the LM3915, a logarithmic, 3-dB-per-step version, and the LM3916, which displays its input in volume units, for audio applications.)

This application required more flexibility than the LM3914 offers, and it uses a circuit based on an Atmel (www.atmel.com) AVR-family ATTiny13 microcontroller, which features 1 kbyte of program memory; a four-channel, 10-bit ADC; and six general-purpose I/O pins. Altering the circuit's firmware allows linear or logarithmic scaling of the 0 to 5V input-voltage range.

The circuit in **Figure 1** continuously displays the input voltage in 20 levels. When closed, switch S_1 freezes the displayed reading at its then-current level. Five of the microcontroller's six I/O pins control all 20 LEDs and the switch. Configured as an ADC-input channel, the remaining I/O pin receives the analog-input voltage. The microcontroller uses Charlieplexing, a method of using I/O lines to drive as many as $N\times(N-1)$ LEDs, to drive 20 LEDs with only five I/O pins (**references 2** through **4**).

The firmware is written in C and compiled using AVR-GCC, a freeware C compiler and assembler available in Windows and Linux versions at www.avrfreaks.net. It uses the Tiny13's internal 10-bit ADC operating in free-

DIs Inside

What are your design problems and solutions? Publish them here and receive $150! Send your Design Ideas to edndesignideas@reedbusiness.com.

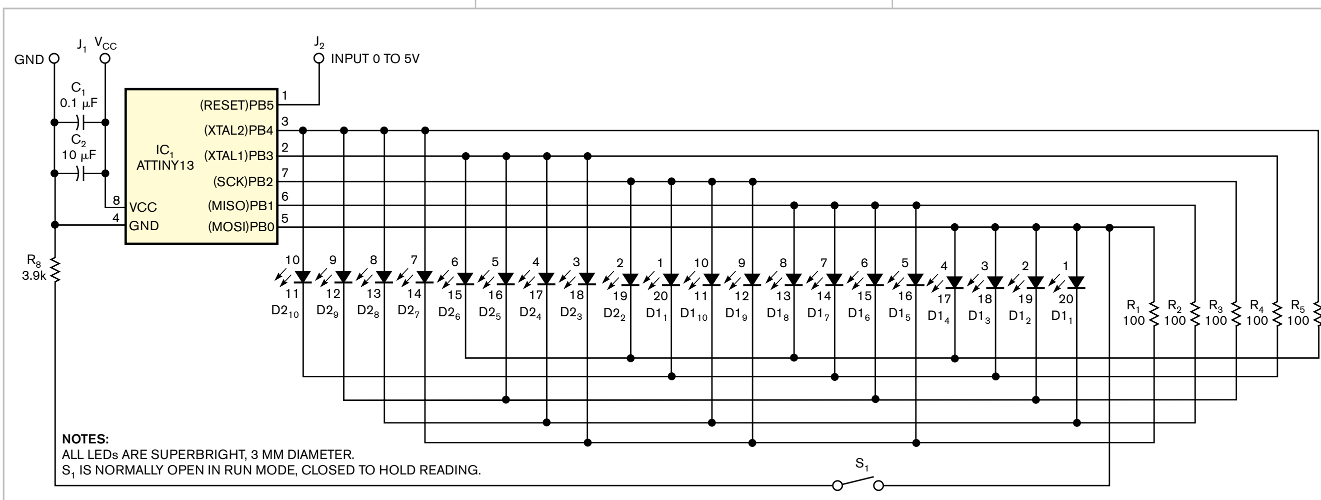

Figure 1 Based on a low-cost microcontroller, this dot/bar LED driver operates in linear or logarithmic modes.

running, interrupt-driven mode to convert the analog-input voltage into a digital number. Upon completion of each conversion, the ADC generates an interrupt that a subroutine reads; the interrupt stores the ADC's converted output in a shared variable.

To provide a flicker-free display, an internal timer generates a 1875-Hz interrupt derived from the 9.6-MHz system clock to drive the multiplexed LEDs at a rate exceeding 90 Hz. Dividing the ADC count by a constant yields a linear display of the input voltage. A look-up table scales the ADC count to produce a logarithmic display. **Figure 2** shows the logarithmic-conversion curve that defines the look-up table's values. Versions of the ATTiny13's control programs for linear and logarithmic scales are available for downloading from the online version of this Design Idea at www.edn.com/070118di1. You can modify the source code to display only a particular subrange of the input voltage of 0 to 5V. For example, you can specify a linear-display range spanning 1 to 3V or a logarithmic scale for input voltages of 2 to 3V. EDN

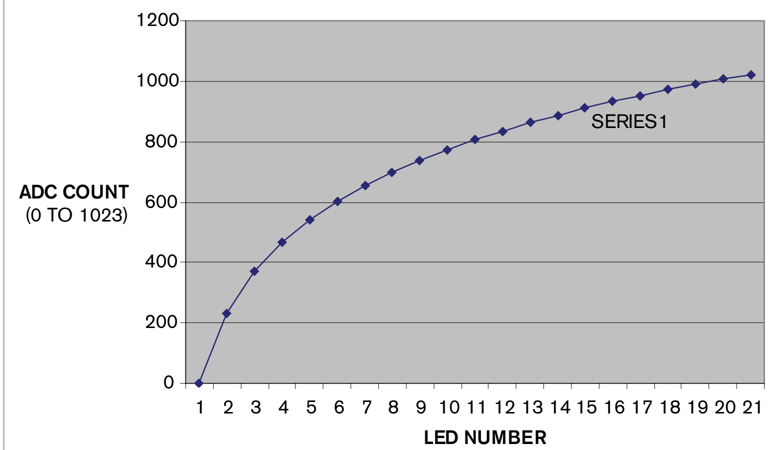

Figure 2 A linear-to-logarithmic-conversion curve defines the input voltage required to illuminate a particular LED.

REFERENCES

1. LM3914 data sheet, www.national.com/pf/LM/LM3914.html.
2. Lancaster, Don, "Tech Musings," August 2001, www.tinaja.com/glib/muse152.pdf.
3. "Charlieplexing: Reduced Pin-Count LED Multiplexing," Maxim Application Note 1880, Feb 10, 2003, http://pdfserv.maxim-ic.com/en/an/AN1880.pdf.
4. Benabadji, Noureddine, "PIC microprocessor drives 20-LED dot- or bar-graph display," *EDN*, Sept 1, 2006, pg 71, www.edn.com/article/CA6363904.

Optical feedback extends white LEDs' operating life

Bjoy Santos, Intersil Corp, Milpitas, CA

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

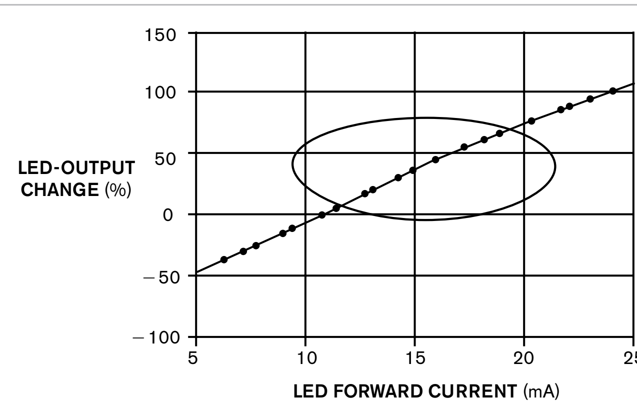

Figure 1 An LED's light output changes considerably as a function of its forward current, even within the sweet spot (oval area) of its nominal operating current.