PROJECT OF THE MONTH

BY FORREST M. MIMS

A "MATCHBOX" LED OSCILLOSCOPE

REGULAR readers of the Experimenter's Corner are by now familiar with the design of simple solid-state oscilloscopes that employ an array of LEDs for a screen. Thanks to the new LM3914 dot/bar display driver, the design of such a scope can be simplified considerably. The result is a scope small enough to fit inside a pocket matchbox!

Figure 1 is the schematic diagram of a compact LED scope that uses only three ICs and consumes only 15 mA. Operation of the circuit is fairly straightforward, especially if you're already familiar with solid-state scope basics.

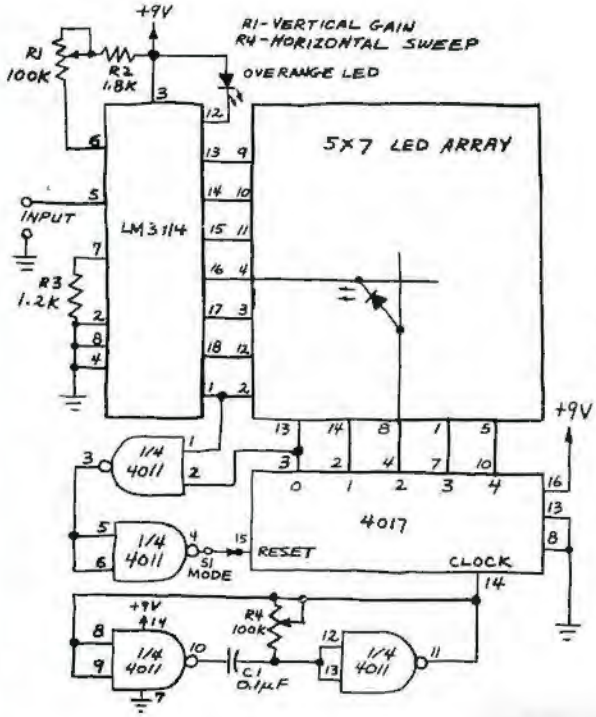

Fig. 1. Schematic diagram of matchbox LED oscilloscope.

The incoming waveform is applied directly to pin 5 of the LM3914, where its instantaneous amplitude is detected by a voltage divider/comparator chain. Decoding logic then drives one of the LM3914 outputs low.

Any LED in the row connected to the selected output is then eligible to glow. The remaining requirement is a positive voltage at the LED's anoda. This is obtained from a horizontal sweep circuit made from a 4011 quad NAND gate and a 4017 Johnson counter.

The 4011 performs two important functions, one of which is to provide a stream of clock pulses. This is accomplished by two gates connected as a free-running or astable oscillator. The frequency of oscillation is determined by the values of *R4* and *C1*.

The 4017 counter is unique in that it includes a 1-of-10 decoder. This eliminates the need for a separate decoder IC. Furthermore, because the activated output of the 4017 goes high when all other outputs remain low, the 4017 can be connected to the anode of an LED.

The remaining two gates in the 4011 form an AND gate that provides an automatic trigger. When MODE switch *S1* is closed, the gate resets (clears) the 4017 if the input voltage has sufficient amplitude to activate the lowest-order output of the LM3914 at the same time that the lowest-order counter output is high. This feature makes it relatively easy to freeze the waveform being displayed.

The "screen" of the scope is a single 5 × 7 dot-matrix LED display (Monsanto MAN-2A, Texas Instruments TIL305, Litronix DL-57 or equivalent). Although 35 LEDs provide very limited resolution at best, with experience it's possible to visualize square and triangle waves being displayed on the readout.

In case you're wondering where the current limiting resistors of the LED display are, they are not necessary! The LM3914 includes a novel feature that permits the current at the selected output to be externally programmed by a single resistor *R3* connected to pin 7. This pin provides a reference voltage of 1.2 to 1.3 volts, and the current through *R3* is 1/10 the LED current. According to Ohm's law, the current flowing through a resistor is the quotient of tha voltage across the resistor divided by the resistance in ohms. The current through *R3* is therefore 1 mA, which means that the LED current is 10 mA.

Figure 2 is a photograph of a miniature,

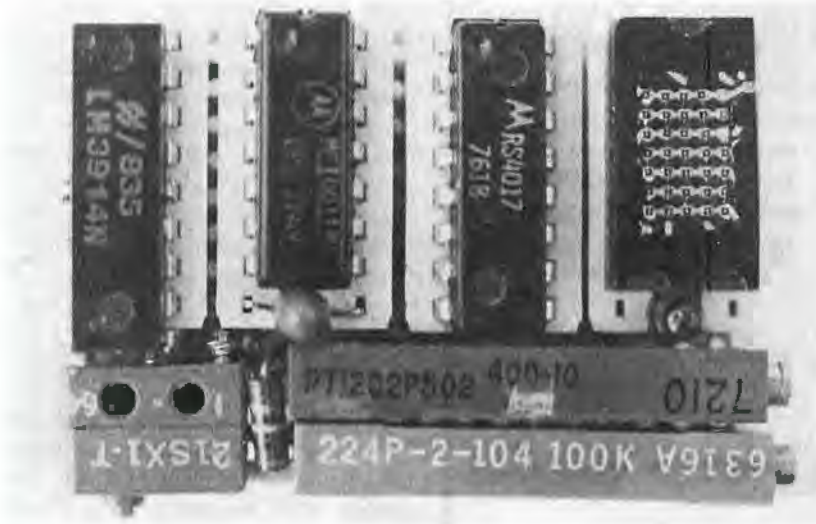

Fig. 2. Photograph of the wrapped-wire prototype LED oscilloscope assembled on a small piece of perforated board about 1.2" × 1.2".

Wire-Wrapped prototype scope that I assembled on a perforated board measuring 1.2" × 1.9" (about 3 cm × 5 cm). Notice that pins 9 and 10 of the LM 3914 extend over the lower end of the socket. The small capacitor installed in the two unused pin positions of the 4011 socket is *C1*. The overrange LED is installed below the 5 × 7 LED array. Components *R1*, *R4* and *S1* are attached to the circuit board with cyanoacrylate adhesive. I used a miniature Micro Switch™ pushbutton switch as *S1* because I had one on hand, but any other spst switch is suitable.

Some typical display patterns I have obtained are shown in Fig. 3. Often, the displayed pattern will bear little resemblance to the actual wave. Sometimes it's easier to visually integrate the approximate shape of a wave by switching off the automatic trigger and adjusting *R4* until the waveform slowly parades across the display.

For some interesting visual effects, try connecting a radio or audio amplifier to the input of the scope. Music and voice signals will stimulate a dynamic, miniaturized light show. For best results, leave the trigger switch off.

Finally, remember that it's relatively easy to expand the scope's display. You can add a second 5 × 7 display or make a 10 × 10 display from individual LEDs or 10-element LED bars. If you're really ambitious, you can add additional LM3914's and 4017's and make a scope having 20 × 20 or more LEDs. ◇

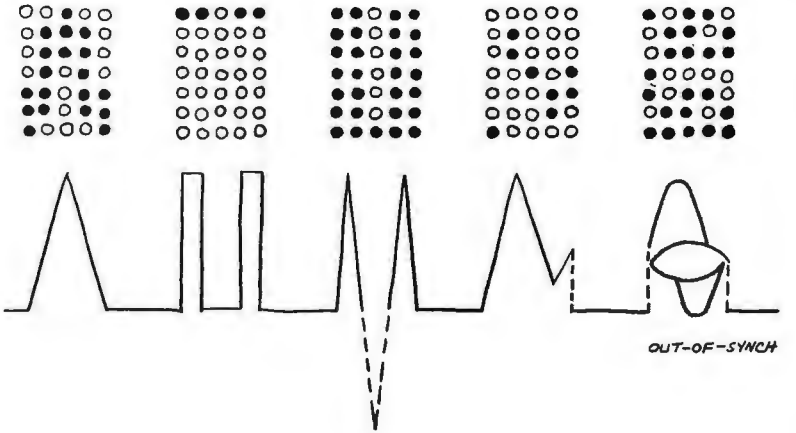

Fig. 3. Some typical display patterns obtained on a 35-element LED scope. Sometimes, the pattern bears little resemblance to the actual wave.