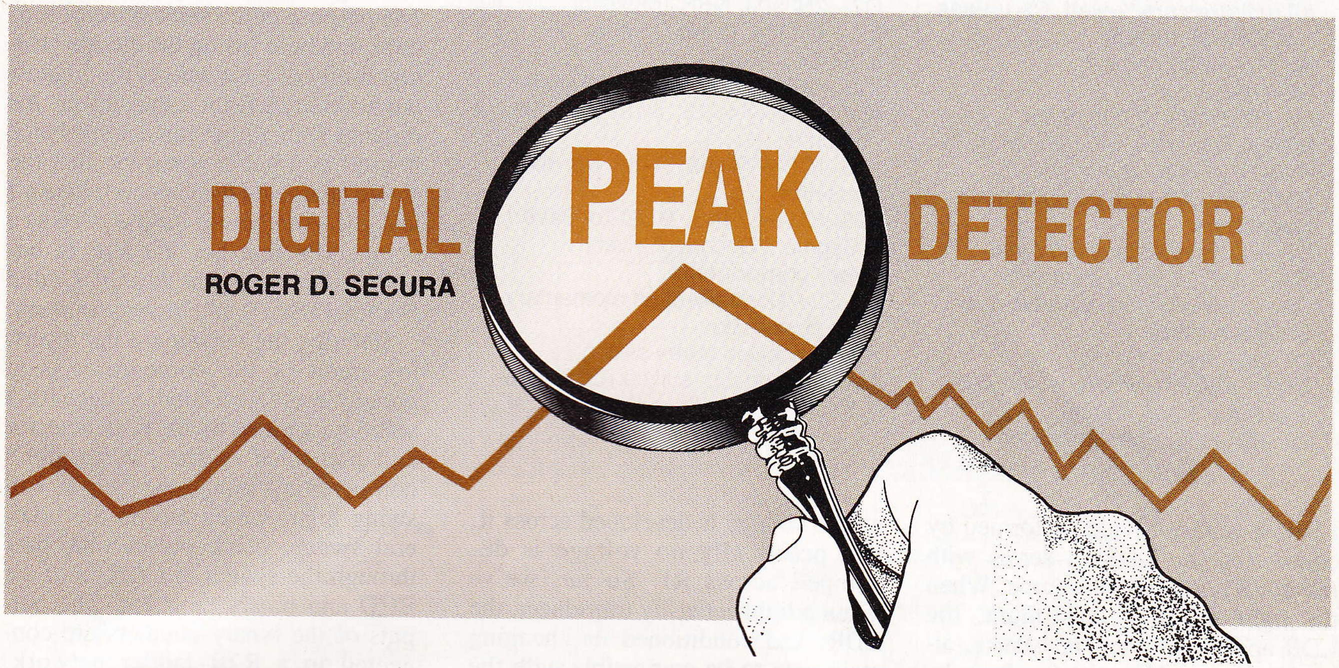

# DIGITAL PEAK DETECTOR

ROGER D. SECURA

*When you need to know the hottest, the fastest, the highest, or the absolute most, you need to build our peak detector.*

WHAT'S THE TOP WIND SPEED DURING A hurricane? What about that jumbo jet on final approach, flying 1000-feet over your home: Is the noise pollution higher than that allowed by law? How hot does beach-sand get under a blazing summer sun?

To answer those questions, you have to measure the relevant physical parameter, store the maximum event, and then display the result. To sense the relevant parameter, you need a *transducer*. To track and hold the maximum event, you need a *peak detector*. And to record the result, you need a *digital display*. Such a peak-detecting device should continuously track, hold, and display the maximum level of any physical parameter; for example, speed, loudness, temperature, pressure, position, flow rate, force, light intensity, and so on—you name it.

## Transducers

Getting the world of electronics to communicate with the physical world is like trying to mix oil with water—an almost impossible task, unless you have the right emulsifier. We know that emulsifiers work with oil and water, but what works with physical quantities and electronics? You can't shake them up in a bottle. To get them to mix you need a transducer. And their are literally hundreds of different types of transducers; each type mixing a specific physical parameter with electricity.

A transducer outputs an electrical signal that is proportional to the magnitude of the physical event it's detecting; an output can be a series of digital pulses, an analog voltage, a varying frequency, or a change in current or resistance.

An example of a practical transducer is a *L*ight *D*ependent *R*esistor or LDR, which is a resistor whose resistance changes in proportion to the amount of light striking its surface. (Cadmium-sulfide photocells are the most common LDR's.) But our peak detector can sense only voltage within the 0 to 5-volt range; it can't sense resistance at all! What's needed is a method to convert the LDR's resistance to an equivalent voltage. A typical LDR might have a light-to-dark resistance range of 100 ohms to 500,000 ohms. A circuit must be designed that transforms that resistance range into a voltage range between 0 to 5 volts. That conversion process is called signal conditioning.

As shown in Fig. 1, to condition the

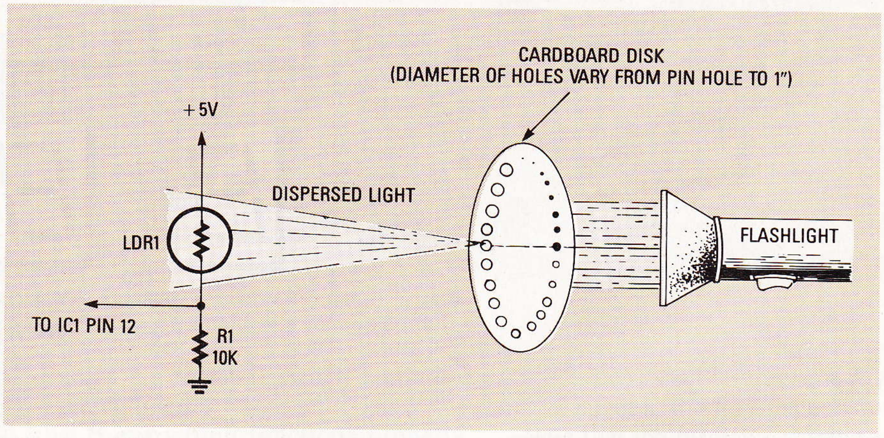


**FIG. 1—THE *L*IGHT *D*EPENDENT *R*ESISTOR (LDR1) IS A TRANSDUCER whose resistance changes in proportion to amount of light falling on its surface.**

## PARTS LIST

**All resistors are ¼-watt, 5% unless otherwise noted)**
R1, R7—1000 ohms
R2—100 ohms
R8, R9, R42—10,000 ohms
R3–R6, R10–R19—10,000 ohms, 1%
R20–R40—330 ohms
R41—250,000-ohm potentiometer

**Capacitors**
C1—22µF, 16 volts, electrolytic
C2—10µF, 16 volts, electrolytic
C3—.01µF, 50 volts, ceramic disc

**Semiconductors**
D1, D2—1N914 Diode
DISP1–DISP3—7 Segment LED Display (common anode)
Q1—2N3906, PNP Transistor
Q2—2N3904, NPN Transistor
IC1—LM324, Quad Op-amp
IC2—555, Timer
IC3—4066, Quad Bilateral Switch
IC4, IC5—74193, 4-bit up-down counter
IC6–IC8—74190, 4-bit up-down counter
IC9–IC11—7446, BCD-to-Seven-Segment Decoder/Driver

**Other components**
S1, S2—Normally-open momentary-on push button
S3—6 position rotary switch
LDR1—cadmium-sulfide (CdS) photocell

LDR, a voltage divider is formed by connecting the LDR in series with resistor R1 and a 5-volt source. When the light source is maximum, the LDR appears as a low resistance, allowing almost the entire 5 volts to be developed across R1. When the light source is minimum (dark), the LDR has its highest resistance, so almost all the voltage is developed across it, and practically no voltage is developed across R1. So far, we've taken a light-intensity transducer, the LDR, and conditioned its changing resistance to be compatible with the our peak detector's input requirement of 0 to 5-volts. Shortly, we'll see how to calibrate our transducer.

### How it works

Figure 2 shows a block diagram of our digital-readout peak-detector. The purpose of the peak detector is to track and hold (using the charge-storing ability of a capacitor) the highest output voltage from a transducer. An op-amp with a high input-impedance is used as a buffer to ensure that the stored charge on the capacitor doesn't leak off. Another op-amp is used as a comparator that has the task of enabling/disabling the *B*inary *C*oded *D*ecimal (BCD) and binary counters.

Initially, the voltage on the inverting input of the comparator is at ground level. As a small voltage (0–5 volts) is captured by the peak detector and presented to the comparator's non-inverting input, the output will swing high, which asserts the bilateral switch; clock pulses now pass through the switch to clock both the BCD and binary counters. The outputs of the binary counters are connected to a R2R ladder network, which functions as a digital-to-analog converter. As the binary count increases, the R2R ladder voltage also

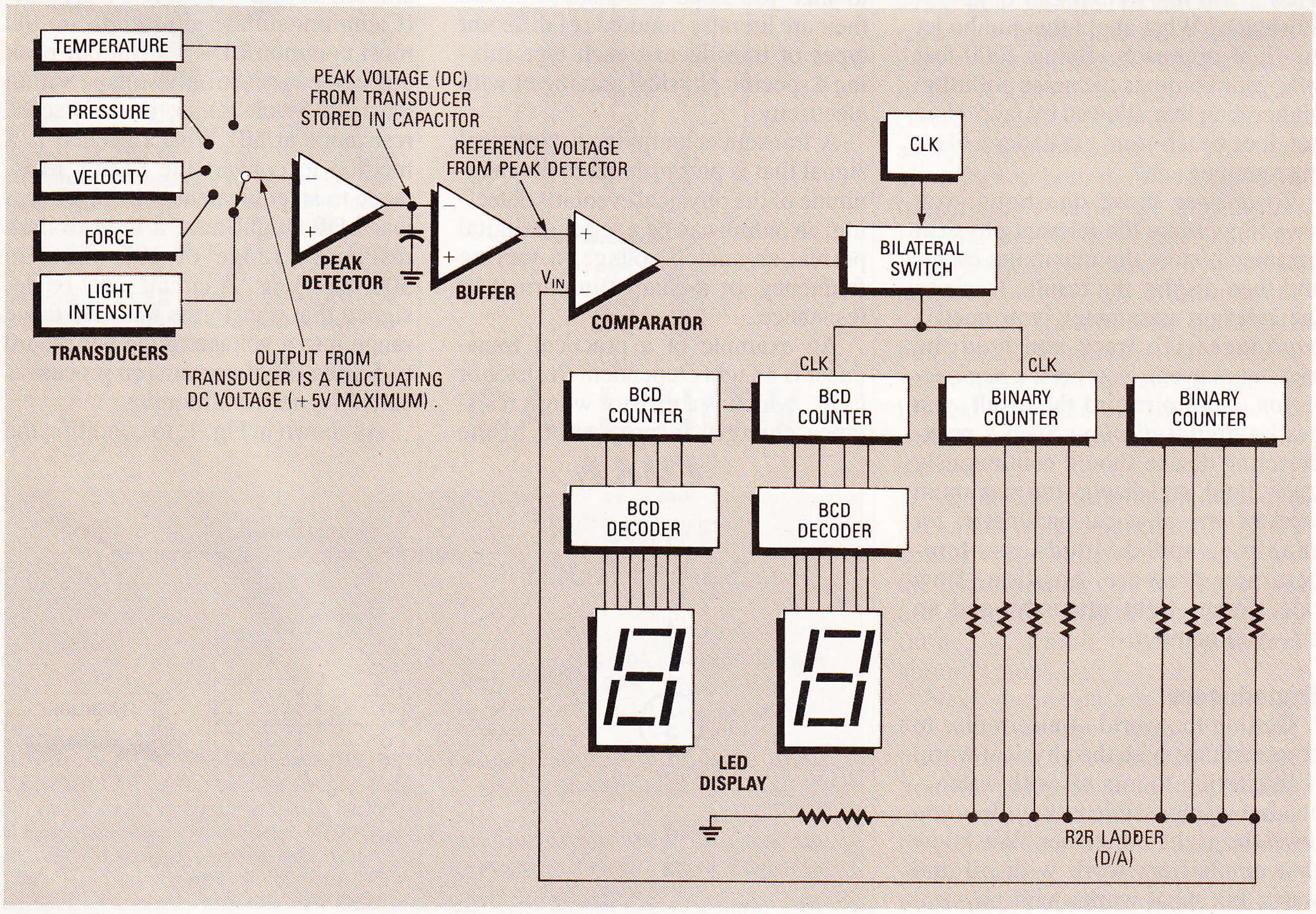


**FIG. 2—THE TRANSDUCER, PEAK DETECTOR, AND DISPLAY are the main components of a digital-readout peak-detector.**

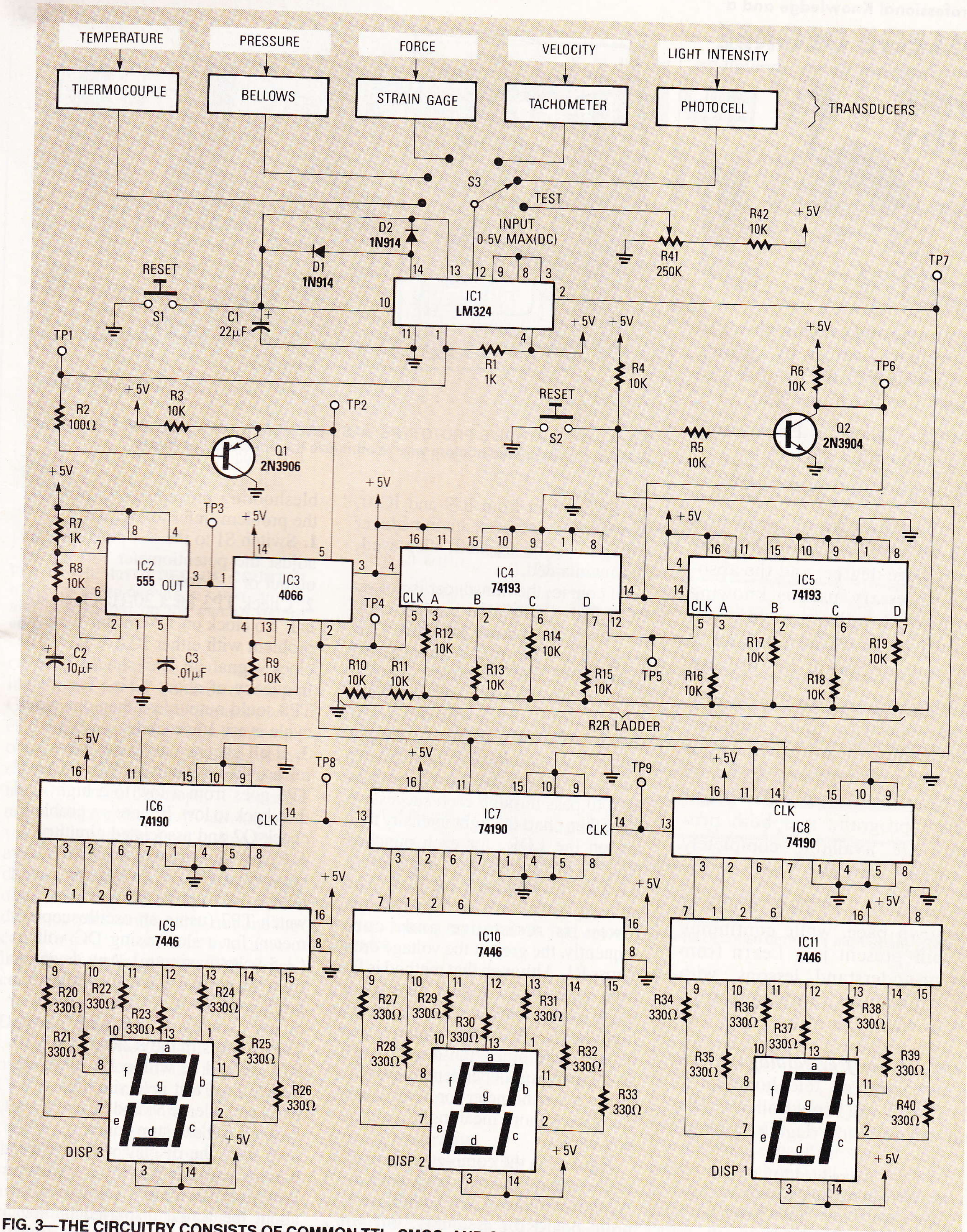


**FIG. 3—THE CIRCUITRY CONSISTS OF COMMON TTL, CMOS, AND OP-AMP IC'S. When switch S3 is in the test position, varying R41 simulates a transducer's voltage output.**

increases until it reaches a point slightly above the voltage of the peak detector; at that instant, the comparator output swings low, which disables the bilateral switch and stops the counters.

If everything functions properly, the number displayed on the 7-segment LED's will represent a value equivalent to the transducer's output. Note that the display's reading is not an actual voltage reading, but simply

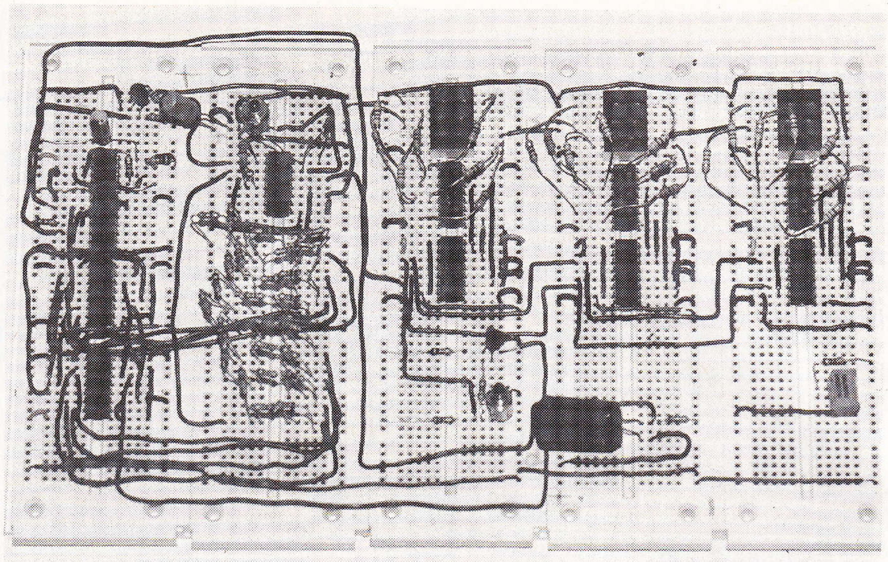

**FIG. 4—THE AUTHOR'S PROTOTYPE WAS ASSEMBLED ON A SOLDERLESS BREADBOARD. Use insulated hookup wire to minimize the possibility of shorts.**

the BCD count from IC9 and IC10. Any further increase in transducer voltage will be tracked, displayed, and maintained.

Of course, the transducer is not yet calibrated. Calibration implies comparison with a known standard. Getting into the mathematics of footcandles can be pretty complicated, so we'll develop our own standard—albeit crude for our light sensor. As shown in Fig. 1, simply punch holes of increasing diameter into a cardboard disk to allow extra light to pass through each successive hole; then chart the light intensity falling on the LDR, for each punched hole, by measuring the voltage across R1 and the display's reading. The more light that falls on the LDR, the lower its resistance and, consequently, the greater the voltage drop across R1. Although that method is far from scientific, it should give you a rough scale with which to compare lilght levels. The same technique can be used with other transducers, such as temperature-dependent resistor's. Using a thermometer for comparison can give a more meaningful calibration curve.

Figure 3 is the complete schematic of the digital-readout peak-detector. As shown in Fig. 4, the author used a proto-board for assembly, but you may just as easily use a prototype PC-board and wire-wrap all connections.

## Testing

If your circuit fails to respond after construction, use the following troubleshooting procedures to pinpoint the problem (refer to Fig. 3):

**1.** Switch S1 to the test position, and adjust the potentiometer R41 for an output of 2.5 volts.

**2.** Check TP3 for a 30-Hz clock signal. No clock on TP4 means there's a problem with either IC2 or IC3. The clock signal at TP5 should have a frequency of about 1 Hz. Test Point TP8 sould output less than one clock cycle every 16 seconds.

**3.** If all checks out so far, press and release the reset button (S2) and see if TP6 goes from a low to a high, and then back to low. If there's a problem, check Q2 and associated circuitry.

**4.** Check the output of the R2R ladder network at TP7. To do that, press and release S2 to reset the counters, and watch TP7 (using an oscilloscope or meter) for a slow rising DC voltage (+5-volts maximum). Any deviation from the normal ascension indicates a problem in the R2R ladder network or binary counters IC4 and IC5. Note: The resistors in the R2R ladder, R10-R19, should be within 1% tolerance.

**5.** The final test is to simultaneously press and release S1 and S2, then wait for the LED's to stop counting. When they stop, the display will register a number equivalent to the 2.5 volts on R41 potentiometer. (Don't worry about the actual displayed number.) Repeat that procedure a few times. The same number should re-appear on each test. Next, turn the test potentiometer R41 up to three volts. The LED's should start counting up to some number and then stop. **R-E**