How Far Did You Cycle Today?

BY ARTHUR V. CLARK

Low-cost electronic odometer indicates distance traveled in miles on a three-decade liquid-crystal display

WHETHER you pedal according to a strict exercise regimen or just for fun, you probably want to know how far you travel on your bicycle. Presented here is an electronic odometer for cyclists that allows you to do just that. Its design provides advantages lacking in many commercially available odometers. Wheel motion is sensed magnetically, obviating drag, slippage, noise generation, and sensitivity to misalignment, one or more of which can characterize the mechanical sensing systems employed in many commercial products.

Digital counters tally the number of wheel revolutions sensed and convert this number into the total distance (in miles) travelled. The counters, which can be reset to zero at the push of a button, drive a liquid-crystal display that is highly legible in the brightest daylight. Accuracy of the odometer is limited by the tenth-of-a-mile resolution of the display. Parts count is low, and, thanks to the use of CMOS ICs and a liquid-crystal readout, the circuit draws very little current from its self-contained battery power source.

About the Circuit. The Electronic Odometer is shown schematically in Fig. 1. Travel is measured by means of *S1*, a magnetically actuated reed or LC2 mercury-film switch mounted on the bicycle frame. Each time a magnet on the rim of the front bicycle wheel passes near the switch (which occurs once each time the wheel makes a complete revolution), the switch closes. Thus, a series of momentary switch closures is generated when the bicycle is in motion.

The reed switch is connected to the rest of the project by a short length of two-conductor cable terminated with subminiature phone plug *P1*. This plug is inserted into matching jack *J1*. When *S1* is open, the CLOCK input (pin 10) of 12-stage binary counter is at V_{DD}. During the brief interval that *S1* is closed, the counter's CLOCK input is at V_{SS}. It is in this manner that the series of switch closures is converted into a train of clock pulses that counter *IC2* can process.

This counter is triggered by the negative transition of each clock pulse. When it has counted 74 of them (equalling a tenth of a mile traveled for a bike with

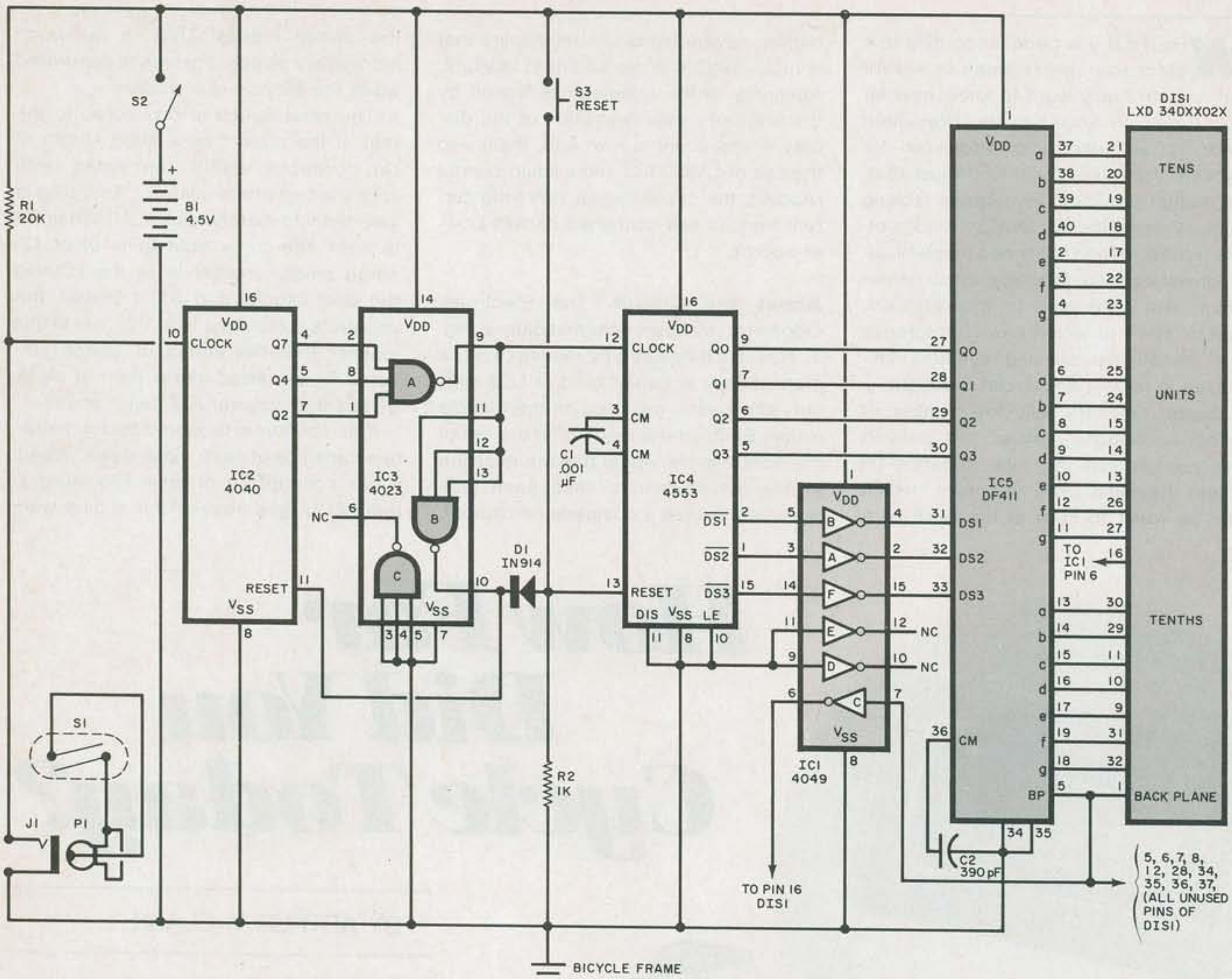


Fig. 1. Schematic diagram of the bicycle odometer. Counter IC2 converts closures of S1 into pulses representing distance traveled. These are tallied by IC3 and displayed by DIS1.

27-inch wheels), pins 4, 5, and 7 are at logic one (V_{DD}). These logic levels are applied to the three inputs (pins 1, 2, and 8) of NAND gate *IC3A* and cause its output (pin 9) to go to logic zero. This negative-going pulse clocks *IC4*, a three-decade counter/BCD decoder with multiplexed outputs. The pulse is also applied to NAND gate *IC3B*, which inverts it to provide a positive-going reset pulse for 12-stage binary counter *IC2*. The binary counter then starts to tally the clock pulses generated by *S1* during the next tenth of a mile.

Each clock pulse applied to pin 12 of *IC4* is counted and stored in the chip's latch, up to a maximum count of 999. Because each pulse corresponds to a tenth of a mile of travel, the maximum tally will signify a total distance of 99.9 miles. This stored information is time-division multiplexed and presented sequentially, one BCD digit at a time, at output pins 5, 6, 7, and 9.

PARTS LIST

B1—Three series-connected 1.5-volt alkaline or NiCd cells
C1—0.001-µF disc ceramic
C2—390-pF disc ceramic
D1—1N914 silicon switching diode
DIS1—LXD 34DXX02X liquid-crystal seven segment display
IC1—CD4049 hex inverter
IC2—CD4040 12-stage binary counter
IC3—CD4023 triple 3-input NAND gate
IC4—F4553 or MC14553 3-decade counter/BCD decoder with multiplexed outputs
IC5—DF411 multiplexed BCD-to-seven-segment decoder/liquid-crystal display driver
J1—Subminiature phone jack
P1—Subminiature phone plug
R1—20,000-ohm, ¼-watt, 10% carbon-composition resistor
R2—1000-ohm, ¼-watt, 10% carbon-composition resistor
S1—Normally open reed or LC2 mercury-film spst switch
S2—Spst toggle switch
S3—Normally open momentary pushbutton switch
Misc.—Printed circuit board, IC sockets or Molex Soldercons, suitable enclosure, No. 16 AWG brass wire, wood or aluminum block, two-conductor cable, hookup wire, battery holder, printed circuit board standoffs, solder, epoxy cement, permanent magnet, etc.

Note—The DF411 display driver is manufactured by Siliconix Inc., 2201 Laurelwood Road, Santa Clara, CA 95054. The LXD 34DXX02X liquid-crystal display is manufactured by Liquid Xtal Displays Inc., 24500 Highpoint Road, Cleveland, OH 44122. A suitable LC2 mercury-film normally open spst switch is manufactured by Fifth Dimension Inc., Box 483, Princeton, NJ 08540.

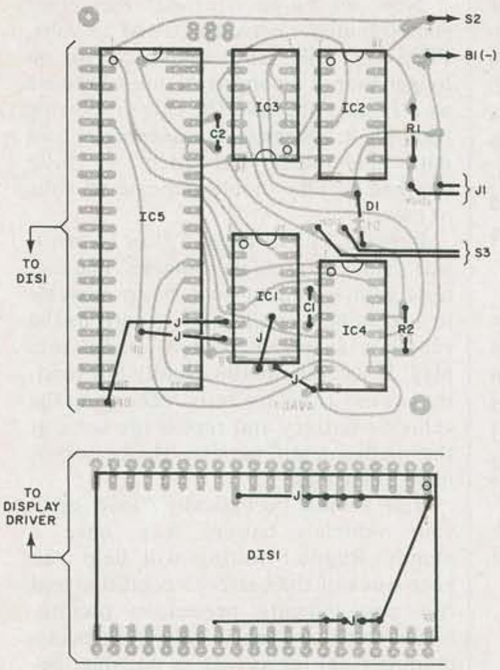


Fig. 2, Full-size etching and drilling guide for a suitable printed circuit board is at left.

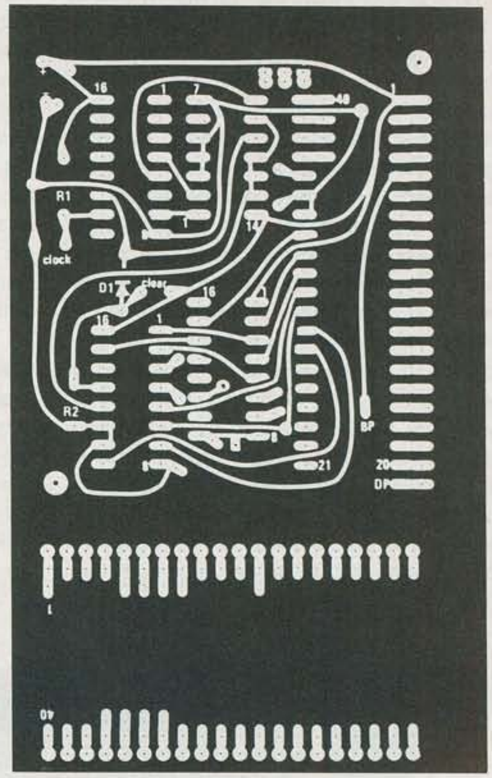


Fig. 3. Component layout for the printed circuit board is at right.

An on-chip oscillator, whose frequency is determined by the value of *C1*, governs the multiplexing of the BCD digits and provides DIGIT SELECT control pulses at pins 2, 1 and 15 of *IC4* for the multiplexed LCD driver. Logic levels appearing on these stobe lines are inverted by *IC1A*, *IC1B* and *IC1F* to be compatible with the levels required by *IC5*. The BCD numbers presented at pins 5, 6, 7, and 9 of *IC4* are applied to the input terminals (pins 27 through 30) of *IC5*, a BCD-to-seven-segment decoder/latch/multiplexed driver designed for use with a liquid-crystal display.

This complex chip's multiplexing function and the ac drive required by the liquid-crystal display are generated by an internal oscillator whose operating frequency is determined by the value of *C2*. The outputs of *IC5* drive directly the active segments of *DIS1*, a three-digit liquid-crystal display. At the same time, the common back plane of the display is driven by a voltage that is 180° out of phase with respect to the voltage applied to the activated segments of the display. In accord with good design practice, the unused inputs of CMOS logic chips *IC1* and *IC3* are committed to logic zero.

Power for the Odometer circuit is provided by *B1*, the series connection of three 1.5-volt alkaline or rechargeable NiCd cells. Because the circuit's current demand is very modest, long alkaline cell life (or, in the case of NiCd batteries, extended intervals between recharges) can be expected.

Construction. The use of a printed circuit board is recommended because it results in a compact, rugged assembly. A full-size etching and drilling guide for a suitable board is shown in Fig. 2. The corresponding component placement guide is shown in Fig. 3. This board calls for some close work, so be sure to use a fine-tipped soldering pencil and small-diameter solder. When soldering component leads to the board, apply the minimum amounts of heat and solder needed for good connections.

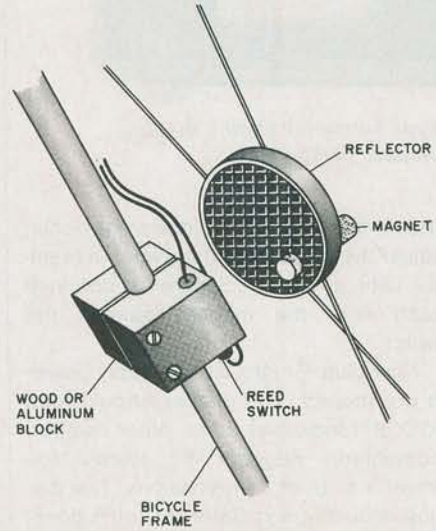


Fig. 4. Details of the author's actuating magnet/motion sensor switch assembly.

A single-sided printed circuit board is employed to simplify its fabrication. This means, however, that several insulated jumpers must be used. These jumpers must be installed first, because components will be mounted on top of them. Next, install the fixed resistors, capacitors and convenient lengths of flexible hookup wire that will be used to connect the circuit board to the battery holder, switches, and phone jack.

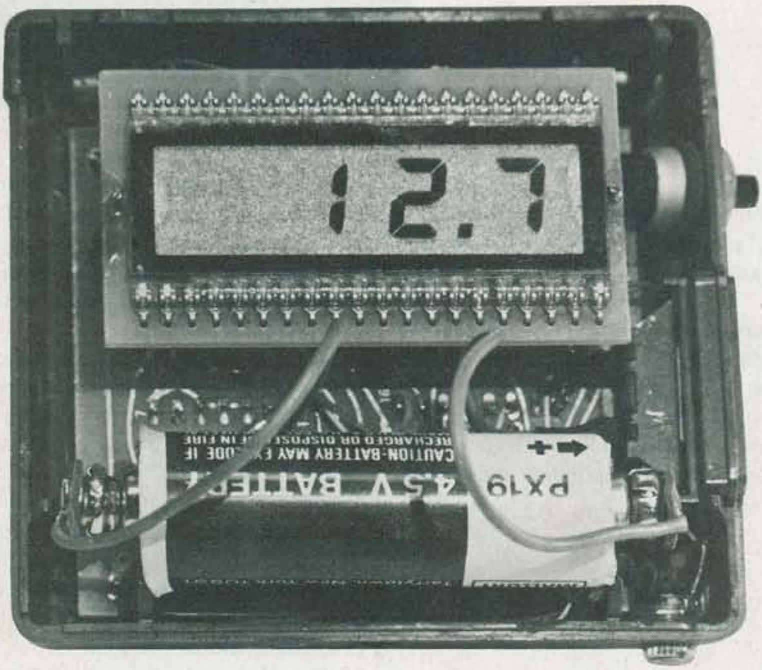
The last components to be installed are the semiconductors and the display. Be sure to orient each semiconductor carefully, observing its polarity and pin basing. Follow the standard procedure for handling MOS devices. The use of IC sockets or Molex Soldercons will minimize the risks posed to the chips by improper handling, the application of excessive heat during soldering, etc. Be sure to inspect your work carefully for solder bridges.

In the author's prototype, that portion of the circuit board containing the liquid-crystal display was sawed and separated from the rest of the board. It was then interconnected with the display driver using convenient lengths of flexible hookup wire (using Fig. 3 as a guide) and was stacked above the printed circuit board by two slender rods made from No. 16 AWG brass wire running through holes drilled in the board and through corresponding holes in the display board. This assembly was secured together by means of epoxy cement.

An enclosure for the project was made from the case of a defunct calculator by cutting it in half and cementing the end cap back on with epoxy. A threaded bolt was run through a hole drilled in the case and cemented to it with epoxy. This bolt and a matching wing nut permit quick, easy installation and removal of the project from the bicycle's front reflector bracket. Connection of the circuit common to the bicycle frame is accomplished by the mounting bolt, wing nut, a solder lug and the reflector bracket.

inserted into this hole and secured with epoxy cement. A drawing of the complete switch and magnet assembly devised by the author appears in Fig. 4. Note that the switch block was cut in half after drilling a hole in it corresponding to the diameter of the bicycle fork's tubing. This allows the block to be secured to the fork by means of retaining screws. Note also that the reed switch was installed in another hole drilled in the block.

Checkout and Use. Connect the probes of an ohmmeter to *P1* and lift the bicycle frame so that the wheel to which the actuating magnet has been attached can turn freely. Rotate the wheel and note the ohmmeter reading. It should indicate an open circuit until the actuating magnet passes near the reed switch, at which point a short-circuit reading



Internal view of the author's prototype odometer shows display, circuit board and battery fit in a compact plastic case.

The wheel-motion sensor switch is installed by securing a normally open reed switch to a block of wood or aluminum with epoxy. This block is then secured to one of the bicycle forks. Either the front or rear fork can be used, but installing it on the front fork permits the use of a shorter cable (terminated in subminiature phone plug *P1*) to connect the switch to the rest of the circuit.

The actuating magnet is installed by drilling a suitable hole in the plastic reflector of the appropriate wheel. A strong permanent magnet should be

should be seen. If this does not occur, adjust the position of the switch assembly until a switch closure is obtained each time the magnet passes the switch.

Now plug *P1* into *J1* and apply power to the project. The display should read 00.0. If it indicates some other number, momentarily depress *S3*. Rotate the wheel a total of 74 revolutions. The display should now register 00.1. If it does, the project is working properly, and you are now ready to take your first bicycle trip with an Electronic Odometer. ◇