THIS MONTH'S PROJECTS

LEVEL RATING SYSTEM

To find out the level of difficulty for each of these projects, turn to our ratings for the answers.

●○○○ . . . . Beginner Level

●●○○ . . . . Intermediate Level

●●●○ . . . . Advanced Level

●●●● . . . . Professional Level

A SIMPLE DIGITAL TACHOMETER

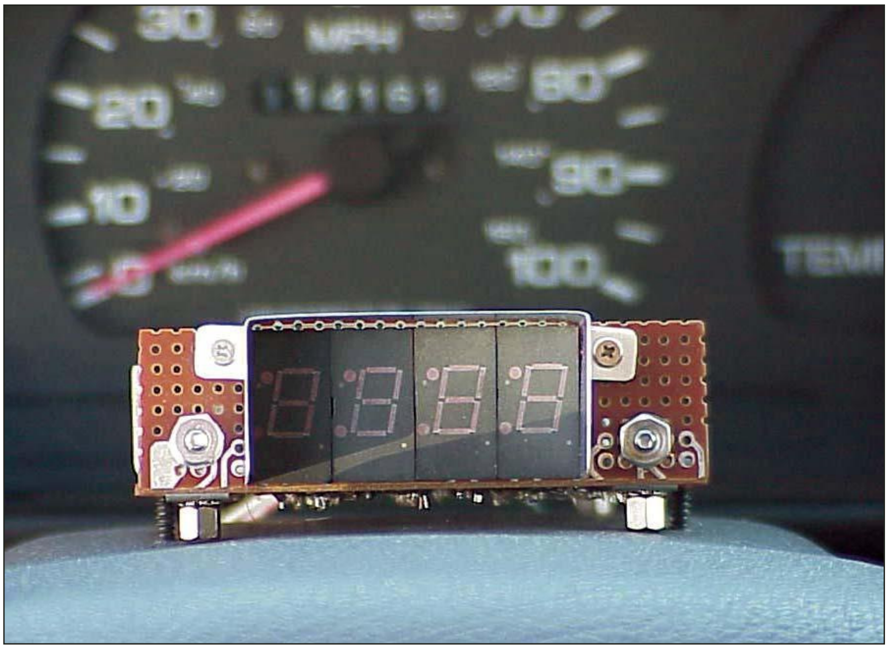
I bought a used Nissan pickup truck a few years back that had absolutely no bells or whistles on it when it rolled off the assembly line. I wanted to make some "improvements" to the engine, and I wanted a tachometer to help assess the results (for better or worse). The add-on tachometers available in auto parts stores didn't appeal to me, mostly because I knew I could make one myself if I put my mind to it.

What I really wanted was a *digital* tachometer.

The circuit would have to satisfy three objectives: it had to be relatively accurate (±100 RPM); it had to be built with parts I already had lying around; and it had to fit on top of the truck's steering column. The second objective ruled out using microcontrollers or multiplexed display drivers — the few of these I have are already in use! With these criteria in mind, I dusted off some TTL databooks, dug through my parts bin and came up with the circuit in Figure 1. The circuit consists of five functional blocks: a Hall-effect sensor; a divide-by-100 counter and latch; a timer to set the count interval; a four-digit display and drivers; and a power supply.

I decided I could live with an accuracy of ±100 RPM, so I could get away with only driving two digits (the two most significant digits, x1000 and x100) to save board space. By doing some simple arithmetic I calculated that counting sensor pulses for 0.6 seconds and multiplying the count by 100 would yield revolutions per minute. Multiplying the count by 100 was accomplished by adding two digits (x10 and x1) permanently wired as "0." This allows the circuit to have a reasonably fast refresh rate while still collecting enough pulses in each 0.6 second window to yield acceptable counting accuracy (for example, the difference

■ PHOTO 1. The Digital Tachometer.



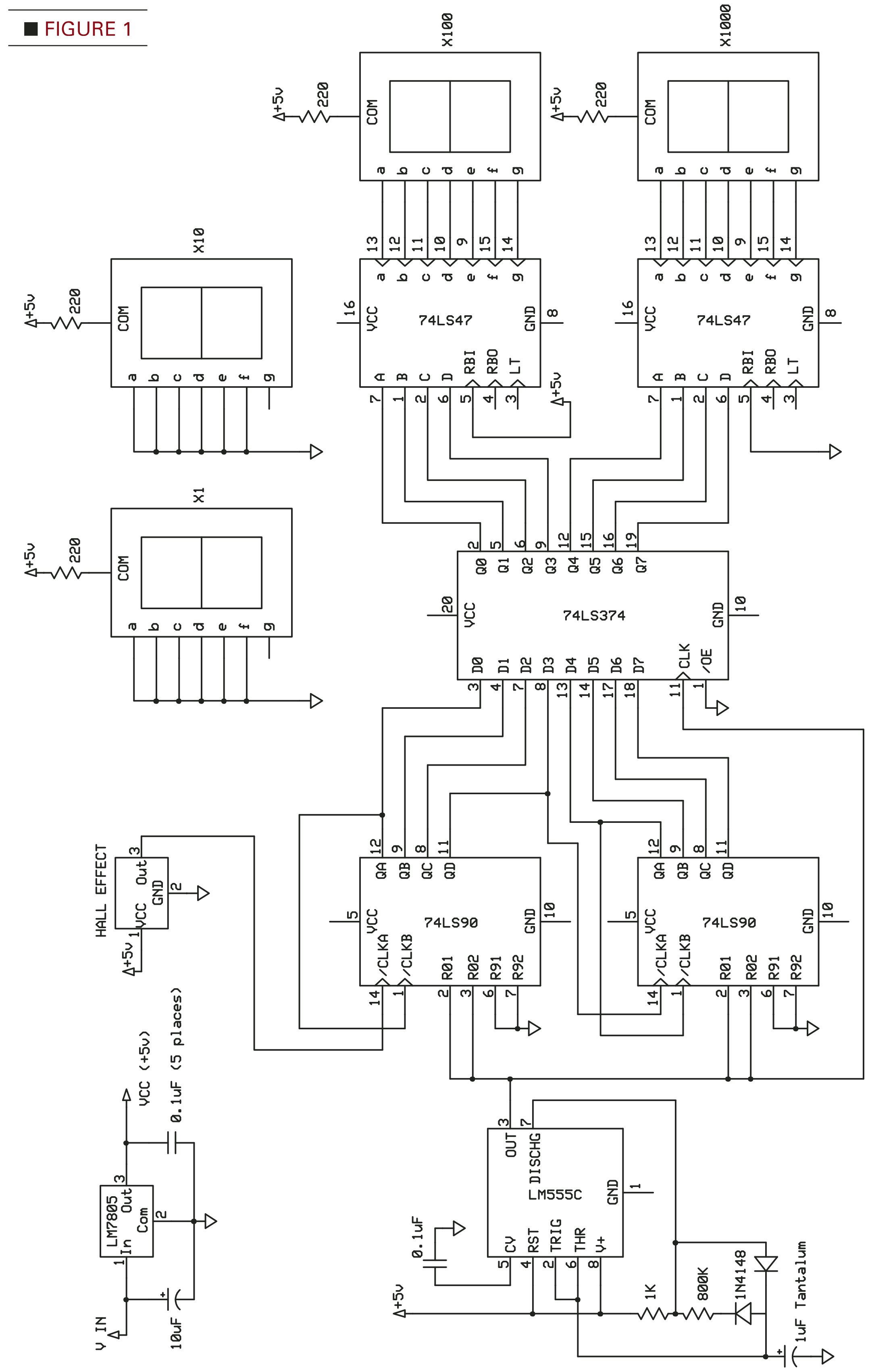
between 19 and 20 pulses is half the percentage difference between 9 and 10 pulses).

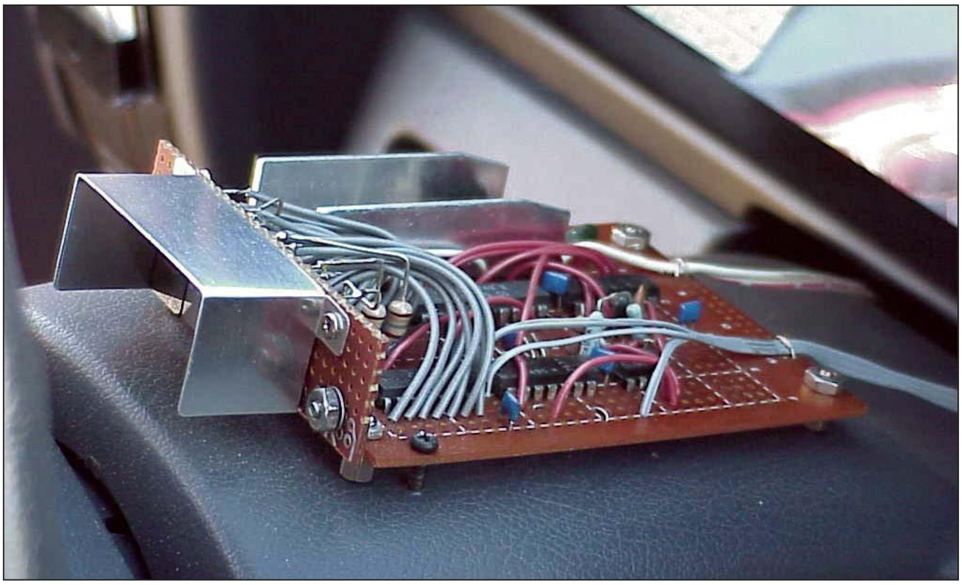
Circuit Design

To count the revolutions of the engine, I used a bidirectional Hall-effect sensor to sense the passage of a magnet I glued to the back of the crank pulley. The sensor I used came from an old floppy disc drive. The response of the sensor is dependent on the orientation of the magnet relative to the sensor. Simply passing the north or south pole of the magnet over the sensor caused it to toggle, but passing the magnet lengthwise over the sensor (so the sensor sees both poles in succession) produced a nice pulse.

The output pulse from the Hall-effect sensor is fed into the CP0 input on the first 74LS90 counter, U1. This counter is wired in a divide-by-ten configuration by connecting output Q0 to input CP1 and by grounding MS1 and MS2. Output Q3 of the first counter is connected to the CP0 input of the second counter, U2, also in a divide-by-ten configuration, which counts the overflow from U1. The binary-coded-decimal outputs from both counters are connected to the inputs of

■ FIGURE 1





■ PHOTO 2. A side view of the digital tachometer.

a 74LS374 eight-bit latch, U3.

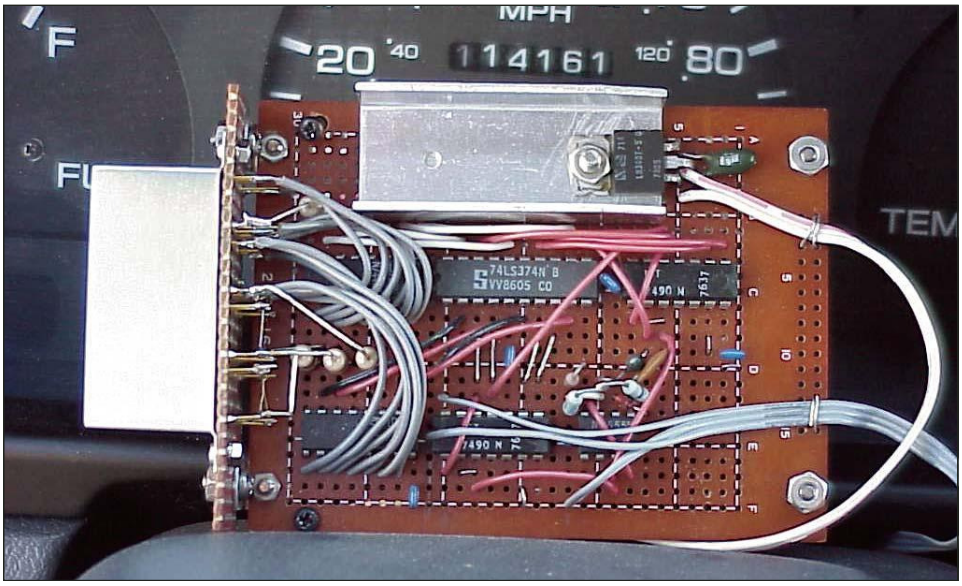
In order for the tachometer (or any frequency counter) to count accurately, it needs a “gate” signal to define the interval during which the counters count pulses. This signal is provided by the 555 timer U4 which is configured to produce a short pulse every 600 ms. The output of the timer is fed to the clock pulse input of the latch and the MR1 and MR2 reset inputs on the counters. The 74LS374 is an edge-triggered device, while the 74LS90 is a level-triggered device, so at the end of each 600 ms interval the count is latched just before the counters are reset. The reset pulse is kept short (a few milliseconds) to minimize the chance of missing a pulse from the Hall-effect sensor. The two diodes allow the timer to operate with this very low duty cycle. A tantalum timing capacitor is recommended for improved frequency stability over a wide temperature range.

The latched count data is fed to the inputs of two 74LS47 common-anode seven-segment LED display drivers, U5 and U6. Data from U1 is fed to the x100 driver U5, while data from U2 is fed to the x1000 driver U6. The ripple blanking input of U5 is held high so that the x100 digit will read “0” when power is first applied. The RBI of U6 is held low to blank a leading zero. As mentioned earlier, the x10 and x1 digits are permanently wired to display “0” by grounding segment inputs “a” through “f.” I chose to use a single current-limiting resistor for each display to save space. This causes the display brightness to vary slightly depending on the number being displayed, but the effect is minor as long as low-current displays are used.

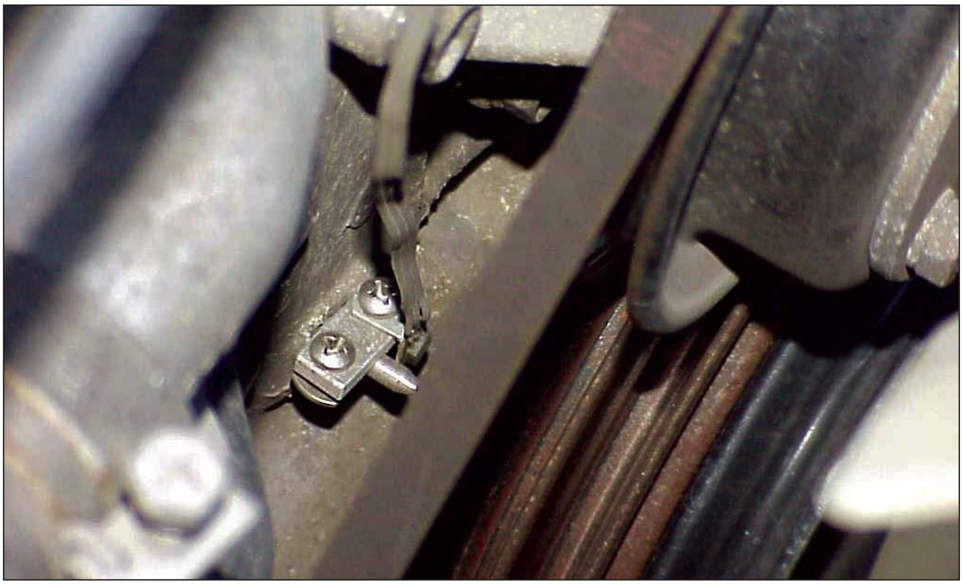
The power supply for the circuit is a standard 7805 linear regulator in a TO-220 package. Since vehicles can produce a lot of electrical noise, you may need more bypass capacitors than the schematic indicates. Ferrite RF chokes may also be needed on the power and sensor cables. I used a total of five 0.1 uF capacitors spread around the circuit board to ensure glitch-free operation. The regulator is dropping 12-14 V down to 5 V, so adequate heatsinking is a must.

Construction and Testing

Circuit board layout is not critical, but the arrangement of the displays should be thought out first. If you intend to mount the tachometer on a vertical surface, the displays can be mounted on the board just like the ICs. If the tachometer will be mounted on a horizontal surface, right-angle sockets mounted on the front of the board simplify display installation. Alternatively, cut another small piece of circuit board, mount the displays on it, and attach the display board to the main board with small right-angle brackets. Make sure the displays are placed in the proper order, with the x1000 digit on the left and the x1 digit on the right. A sun shade for the displays is recommended to



■ PHOTO 3. View of the top of the digital tachometer.



■ PHOTO 4. Here's a look at the tachometer sensor.

prevent them from "washing out" in direct sunlight.

Before installing the Hall-effect sensor, power up the circuit from a clean 12 V power supply and check for smoke. The display should read "000" with the x1000 digit blanked. Apply a 10 Hz squarewave signal to the CP0 input of U1 where the Hall-effect sensor will be attached. The display should read "600" consistently. Next, apply a 100 Hz squarewave signal to the CP0 input, and the display should read "6000" consistently. If the displayed values are stable but incorrect, the values of the timing resistors and capacitor for U4 may need to be adjusted. If the display is erratic or garbled, check your wiring and make sure the ICs are not defective. This is also a good time to make sure the heatsink is sufficient to keep the 7805 regulator cool.

Installation

First, a few words of caution. Installing the tachometer in your vehicle may void your warranty, damage the vehicle, or injure you. *Please* use all applicable safeguards when working on the vehicle, and make sure the key is out of the ignition before proceeding!

Install the tachometer in your vehicle where it is easily visible but does not obstruct any other instruments or controls. Power for the circuit can be obtained from the cigarette lighter socket or any other switched power connector that is readily accessible. Use a three-wire shielded cable to connect the circuit board to the Hall-effect sensor and thread the sensor and cable through an available hole in the firewall, routing the cable away from existing wiring and any hot and/or moving engine components.

Find a suitable mounting location on the front of the engine near the crank pulley and fashion a stable mounting bracket for the Hall-effect sensor to hold it parallel to the back of the pulley. Glue the magnet to a flat surface on the back of the pulley near the outside edge, making sure that the orientation of the magnet is correct to generate a pulse from the sensor as it passes. If possible, use a plastic-coated magnet so that it does not rust, and keep the size of the magnet small to avoid unbalancing the pulley. Make sure that the sensor will not collide with the magnet (or anything else) but is close enough to sense the magnet's passing.

Start the vehicle and check for a reasonable RPM reading on the display. If the display is erratic now but worked fine during calibration, you probably need more bypass capacitors and/or RF chokes on the power supply and sensor leads.

Well, good luck and happy cruising! **NV**

Author Bio

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PARTS LIST

(All available through Digi-Key, 1-800-344-4539)

- ❑ U1, U2 — 74LS90 decade counter
- ❑ U3 — 74LS374 tri-state octal latch
- ❑ U4 — 555 timer
- ❑ U5, U6 — 74LS47 BCD to seven-segment decoder/driver
- ❑ Bidirectional Hall-effect sensor
- ❑ 7805 5 V linear regulator, TO-220 pkg.
- ❑ (4) Common-anode seven-segment LED displays
- ❑ (2) 1N4148 diodes
- ❑ (4) 220 W, 1/2 W resistors
- ❑ 800 k W, 1/2 W resistor
- ❑ 1 k W, 1/2 W resistor
- ❑ 1 uF tantalum capacitor
- ❑ 10 uF electrolytic capacitor
- ❑ Several 0.1 uF ceramic disk capacitors