Digital Tachometer Module

First of a series of add-on modules for the Digital Measuring System displays engine rpm in cars, vans and boats

By Charles R. Ball

Commercial precision digital tachometers for cars, RVs, boats or any other powered vehicle are usually expensive. "Digitach" is a versatile digital tachometer you build yourself for only a fraction of the cost for a commercial tachometer.

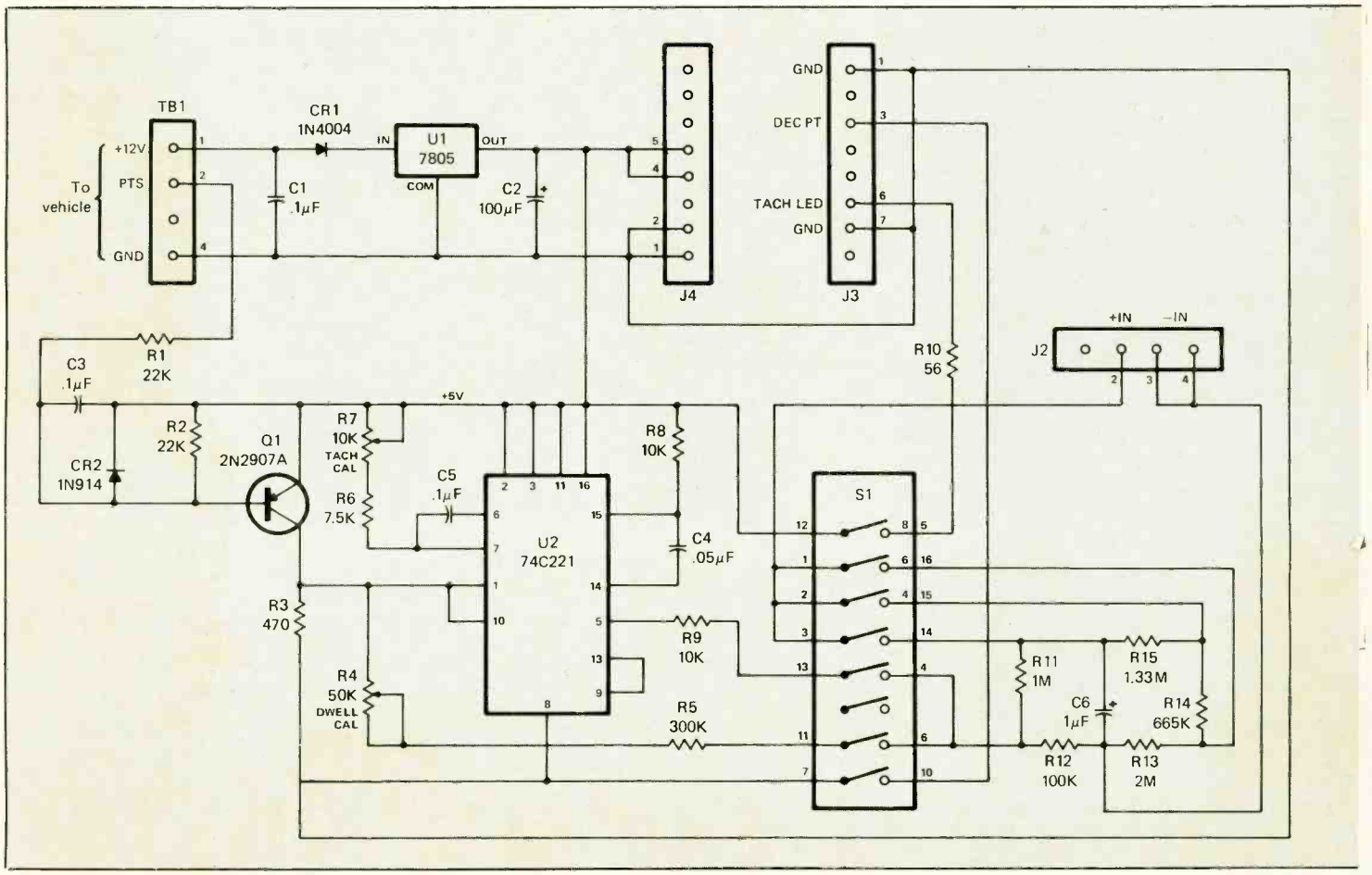
Designed to be used with the Digital Measuring System described last month, Digitach offers a range from 0 to 9999 rpm. With the proper sensor and scaling resistors, Digitach can also function as a digital speedometer, and internal switchable circuitry allows the project to be used as a dwell meter for tune-ups.

You can use Digitach with 4-, 6- and 8- cylinder, 2- and 4-stroke engines. Build the project into a case and add a battery pack, and you have a portable field-service instrument.

About the Circuit

This discussion is based on the premise that the Digitach is to be connected to and used with the Digital Measuring System's decoder/display and power supply modules described last month. However, it will also work with other basic digital panel meters that have the same input impedance and sensitivity as the DMS. If it is used with a DPM with different input impedance and sensitivity, the scaling network's accuracy will be adversely affected, throwing off the accuracy of the readings.

Though Digitach was designed primarily as a tachometer/speed-



ometer, it can also serve as a dwell meter to make it useful for tune-ups. The tachometer and dwell circuits share a common conditioning stage consisting of *C3*, *CR2*, *R1* and *R2* in Fig. 1. This stage filters and standardizes the height and shape of the electrical signals from the engine distributor or speedometer sensor.

In the tach/speedometer mode, the signal from *Q1*'s collector is sent to one half of dual nonretriggerable monostable (one-shot) multivibrator *U2*. This signal triggers *U2* with each input closure that brings the input low. Extraneous noise and point bouncing are eliminated with the second multivibrator in *U2*, which disables the first multivibrator when the points open to present a high input. A CMOS one-shot multivibrator is used in the Digitach because it does not have the inherent $V_{ce(sat)}$ offset that bipolar devices exhibit and, thus, permits true zeroing.

Output pulses from *U2* are routed via DIP switch *SW1* to the resistor scaling network for the cylinders selected. From here, the signal is routed to the DMS module through header *J2* to provide a numeric display of revolutions per second (rpm). The TACH LED is also selected with *SW1* and passed through *J3*.

In the dwell mode, *U2* is not used. Instead, the shaped and standardized waveform is routed to *SW1*, which is used to select the proper cylinder configuration via scaling resistors *R13*, *R14* and *R15*. The scaled signal is then averaged by *C6* for delivery to the DMS via *J2*.

Power for both the tach/dwell circuit and the DMS are provided by the vehicles's 12-volt battery. Rectifier *CR1* protects the system against accidental polarity reversal, and *U1* provides regulated 5-volt dc power for the system via *J4*.

Construction

Digitach's component count is low enough to permit perforated-board construction. However, if you plan to use the project with the Digital Measuring System's decoder/display module and power supply, it is best to assemble the circuit on a printed-circuit board. This will provide the compact dimensions required and precise mating between the DMS and Digitach.

You can fabricate your own pc board using the actual-size etching-and-drilling guide shown in Fig. 2. Alternatively, you can purchase a ready-to-wire pc board from the source given in the Note at the end of the Parts List.

Wire the board exactly as shown in the component installation guide given in Fig. 3. Pay careful attention to the orientations of *C2*, *CR1*, *U1* and *U2*'s socket. (Do not install *U2* in the socket until instructed to do so later on.) Headers are not required in th *J1* and *J5* locations since they are not used in this circuit. Headers at *J2* through *J4* should be cut for the numbers of pins as needed. Install these from the component side of the board, with the longer pins going into the board's holes. Capacitor *C6* is large and oval shaped. To conserve board space, mount *C6* on edge.

Make sure to use a small heat sink on *U1*. Bend one fin of the heat sink slightly outward. A socket is recommended for *U2* to facilitate testing the system after assembly. A photo of the wired tachometer board is shown in Fig. 4.

Carefully recheck installation of all components and all soldered connections. If everything appears to be okay, thoroughly clean away all solder flux from the board with flux solvent or alcohol. Failure to do this will cause leakage that can result in

PARTS LIST

Semiconductors
CRI—1N4004 or equivalent rectifier diode
CR2—1N914 or 1N4148 switching diode
LED1,LED2—Light-emitting diode
Q1—2N2907A transistor
U1—7805 + 5-volt regulator
U2—74C221

Capacitors
C1,C3—0.1-μF, 25-volt ceramic
C2—100-μF, 16-volt electrolytic
C4—0.05-μF, 50/100-volt Mylar
C5—0.1-μF, 50/100-volt Mylar
C6—1.0-μF, 100/200-volt metallized Mylar or polyester

Resistors (¼-watt)
R1,R2—22,000 ohms, 5%
R3—470 ohms, 5%
R5—300,000 ohms, 5%
R6—7,500 ohms, 5%
R8,R9—10,000 ohms, 5%
R10—56 ohms, 10%
R11—1 megohm, 1%
R12—100,000 ohms, 1%
R13—2 megohms, 1%
R14—665,000 ohms, 1%
R15—1.33 megohms, 1%
R4—50,000-ohm pc-type trimmer potentiometer (Bourns No. 3352H-1-503 or similar)
R7—10,000-ohm pc-type trimmer potentiometer (Bourns No. 3352H-1-103 or similar)

Miscellaneous
SW1—8-position DIP switch (see text) Header (AP Products No. 929834-04—cut to size needed); Terminal board (OK Industries No. TS-4); socket for U2; heat sink for U1; printed-circuit board (see text); front panel (see text); ¼" spacers; machine hardware; solder; etc.

Note: The following items are available from Ballco Inc., P.O. Box 1022, Snellville, GA 30278-1022: Solder-plated silk-screened pc board No. DTH-PC for $8.95 ppd; complete kit (less headers and TB1) No. DTH-K for $22.95 plus $2.50 PH. Headers and TB1 are available from Digi-Key Corp., P.O. Box 677, Thief River Falls, MN 56701.

Fig. 1. Overall schematic diagram of tachometer module used with Digital Measuring System's decoder/display and power-supply modules.

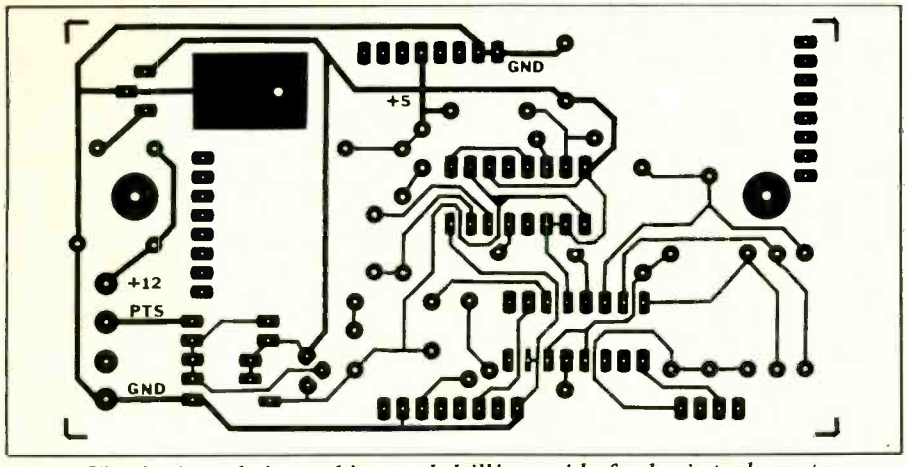


Fig. 2. Actual-size etching-and-drilling guide for basic tachometer.

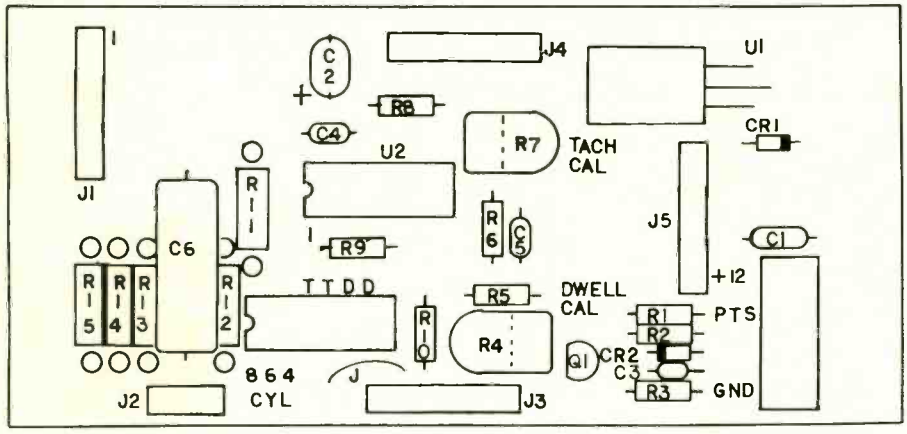


Fig. 3. Components location/orientation guide for basic tachometer.

severe errors in readings because of the tach's high input impedance.

When using Digitach with the DMS board, the latter requires a small LED board to be wired to it. The LED circuit is shown schematically in Fig. 5. The actual-size etching-and-drilling guide and components-placement diagram for this circuit's board are shown in Fig. 6. Note that the pc board is *very* small. If you plan to fabricate your own boards, it is best to etch and drill both on the same pc blank and then cut them apart. Otherwise, to simplify handling during construction, you might want to use a piece of perforated board the same size as the pc board for the LED circuit.

Install *LED1* and *LED2* with enough lead length to permit them to be bent flat against the board's surface and overhang the respective edges. Strip ¼" of insulation from both ends of three 2" lengths of hookup wire, preferably color coded for easy identification. Solder one end of each of these wires to the three pads on the LED board. Then, using machine hardware and a ¼" spacer, mount the LED board on the DMS board. Solder the free ends of the three wires to pins 6, 7 and 8 of *J3* on the DMS board, referring back to Fig. 5 for which to connect where. The finished assembly is shown mounted on the DMS in Fig. 7.

Test & Calibration

Before attaching Digitach to the DMS, and with *U2* still not in its socket, connect a 12- to 15-volt dc power source to the +12V and GND points of *TB1*. Use a voltmeter to check the voltage between pins 1 and 4 of *J4*. If you obtain a reading of 5 volts ±5%, remove the power source from Digitach. Install *U2* in its socket, making sure it is properly oriented before pushing it home. Then align the headers on Digitach with those on the DMS and use ¼" spacers and machine hardware to secure the two to each other.

Once again, connect the 12- to 15-volt dc power source to the +12V and GND points on *TB1*. With no connection to the POINTS terminal on *TB1*, the DMS display should indicate zero. Set *SW1* position 3 (4 cylinder) and positions 6 and 7 (dwell) to on. Temporarily jumper POINTS to GND at *TB1*. Adjust

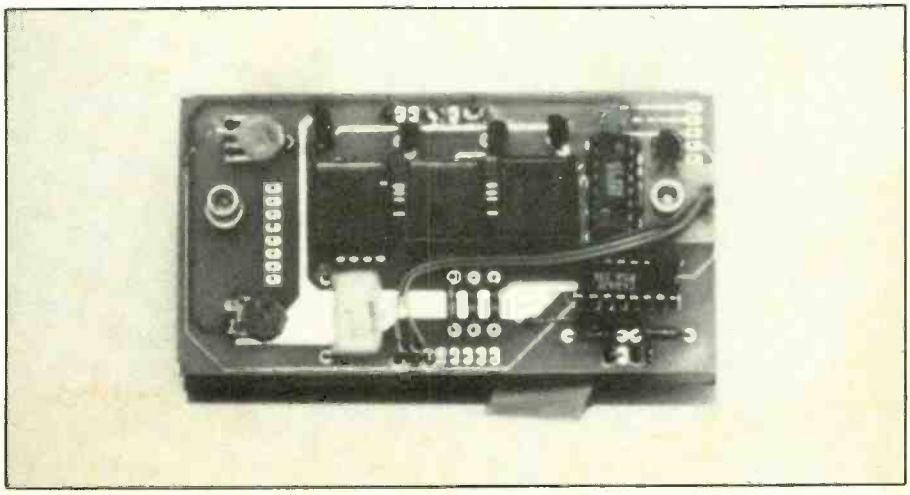


Fig. 4. Assembled tachometer module board.

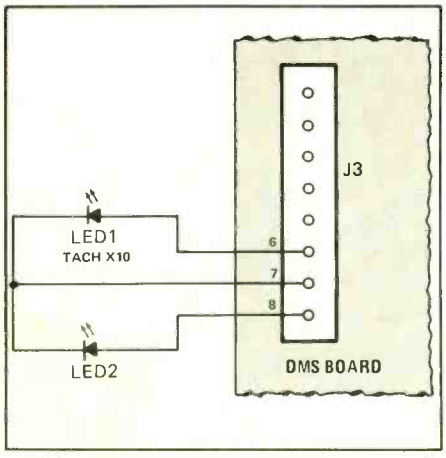


Fig. 5. LED display circuit.

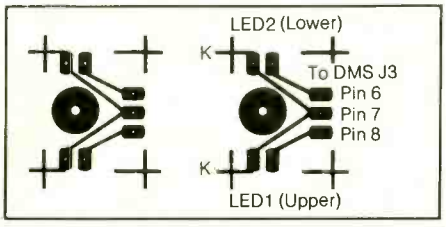


Fig. 6. Actual-size etching-and-drilling guide for LED circuit (left) and wiring diagram (right).

DWELL CAL trimmer *R4* for a display of 90.0 ± 1 count.

Disconnect the power source and set position 3 of *SW1* to off and position 2 (6 cylinder) to on. Reconnect the power source and observe that the DMS now displays 60.0 ±1 count. Power down once again and set position 2 of *SW1* to off and position 1 (8 cylinder) to on. Reconnect the power source and now note that the DMS displays 45.0 ± 1 count. Any deviation from these counts can be traced back to the *R13/15* divider network.

You need a square-wave signal to test the tachometer function of Digitach. If available, use a square-wave generator with 50-ohm output impedance to calibrate and check the circuit's linearity. Otherwise, you can put together the circuit shown in Fig. 8 to provide 60-Hz square waves. Make sure you connect the zener diodes back to back as shown and use a transformer with a 15- to 25-volt secondary.

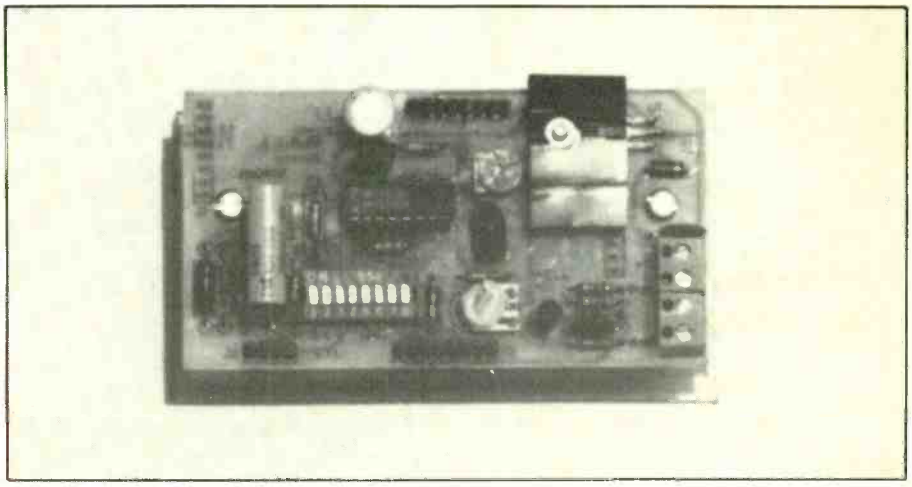


Fig. 7. LED board mounted on DMS board.

Set all dwell switches in *SW1* (positions 4 through 7) to off. Then set position 1 to on to select 8 cylinders. (Positions 2 and 3 should be off at this time.) Apply a 60-Hz square-wave signal from the generator or Fig. 8 test circuit between the POINTS and GND terminals of *TB1*. Adjust TACH CAL trimmer *R7* for a display of 80 on the DMS.

Since all readings in the tach mode are multiplied by 10, indicated by the TACH ×10 (upper) LED coming on, actual rpm is 900. Displayed values are derived from the formula: display = (600 × test signal frequency)/sparks per second at 600 rpm for an 8-cylinder, 4-stroke engine. The Table shown elsewhere in this article gives pertinent engine ignition information.

After calibrating Digitach, place a small drop of plastic cement or nail enamel on the adjust slots of trimmers *R4* and *R7* to prevent vibration from changing the settings.

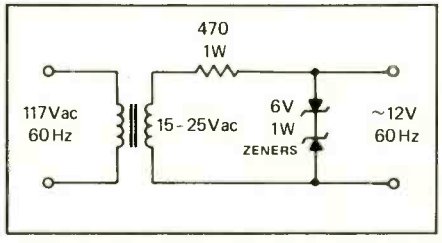


Fig. 8. Square-wave signal circuit used for testing tach function.

Installation

Digitach lends itself well to a variety of installation options. For example, you can install the project in a box mounted under the dashboard or in place of your vehicle's present tachometer.

Digitach's electrical connections are relatively simple. The GND terminal of *TB1* connects to any convenient chassis point that is at ground

Ignition Information

Parameter	Two-Cycle			Four-Cycle			
Number of cylinders	2	4	6	2	4	6	8
Sparks/revolution	2	4	6	1	2	3	4
Sparks/second at							
600 rpm	20	40	60	10	20	30	40
6000 rpm	200	400	600	100	200	300	400
Cam degrees/spark	180	90	60	180	90	60	45
Crank degrees/spark	180	90	60	360	180	120	90

For 2-cylinder engines, multiply rpm displayed by 2.

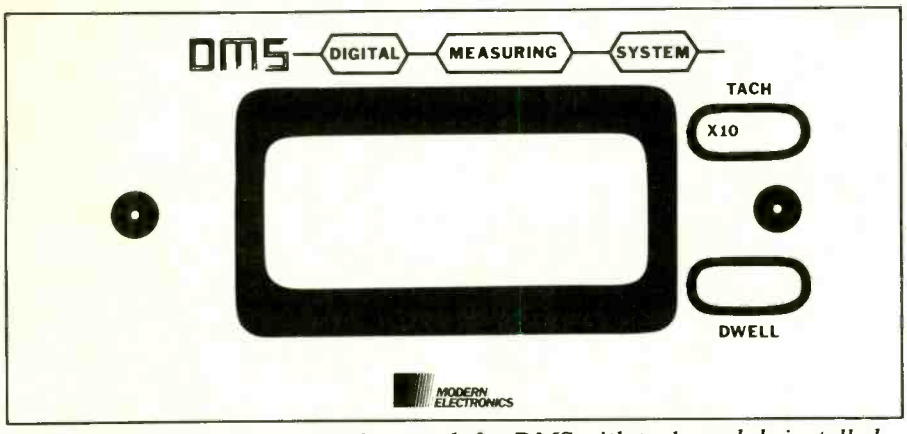


Fig. 9. Actual-size front-panel artwork for DMS with tach module installed.

potential. (Keep in mind that a metal piece on a Corvette or a boat is not necessarily at ground potential. To be certain that you have the proper ground in such situations, you must connect *TB1*'s GND terminal to the negative post of the battery.)

Connect the +12V terminal of *TB1* to any point in the electrical system that is powered only when the ignition is switched on. Consult your vehicle's shop manual or use a voltmeter to find an appropriate tie-in point. Connect the POINTS terminal of *TB1* to the points (or their electronic equivalent) terminal in your vehicle.

Three popular wiring schemes for Digitach are shown in Fig. 9. Select the one that matches your vehicles's electrical system.

If you decide to install your Digitach inside a box, you may want to equip it with the front panel shown actual-size in Fig. 10. You can make this panel from a piece of ⅛"-thick Lexan or Plexiglas with a nameplate overlay using the overlay procedure described in "Dress Up Your Projects" in the September 1985 issue of *Modern Electronics*. Of course, to do this, you must obtain a same-size film negative of the artwork from a print shop or lithographer.

A less expensive alternative is to cut out the Fig. 10 artwork and then the areas for the numberic displays and LEDs and cement it to the plastic sheet. If you go this route, protect the artwork with two or more coats of clear acrylic spray *before* you cement it to the plastic sheet. **ME**

Speedometer Applications

Speedometer applications for Digitach require a bit more work than the tach/dwell applications do. You must first determine the number of revolutions of the speedometer cable at a given speed, say 60 mph. This information is usually available from shop manuals, or you can determine it experimentally using a hand tachometer and a dynamometer.

Once the rpm-to-mph ratio is derived, a transducer can be fabricated using magnets and Hall-effect devices or a small permanent-magnet dc motor. The output of the selected device is then fed to the scaling resistor network. Some scaling modification may be necessary. In the case of 60 mph, the DMS wants to "see" 600 mV at its input with the decimal point placed using the DIP switch.

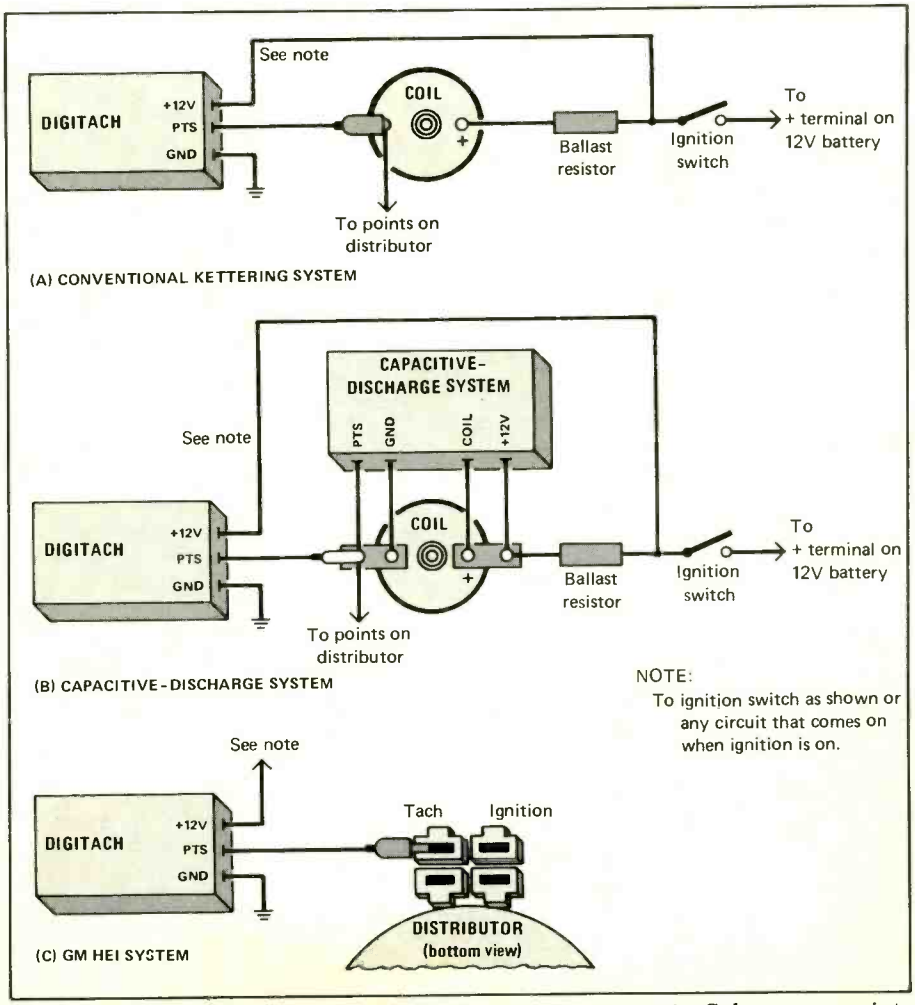


Fig. 10. Connect project to points indicated in your vehicle. Select appropriate arrangement for your vehicle's particular ignition system.