Fit this to the dashboard of your car

Tacho/dwell meter with digital display

This digital tachometer with LCD readout is compatible with both electronic and conventional ignition systems and can be used with any 4, 6 or 8-cylinder petrol engine. At the flick of a switch, it also measures dwell angle to provide a quick check on engine tune.

by GREG SWAIN & JEFF SKEEN

No enthusiastic motorist would be without a tachometer to monitor gear change points, or to accurately set engine idling speed. Our new LCD Tacho/Dwell Meter is small enough to fit the dashboard of most cars, or can be built into a separate case for use only during engine tune-ups. With petrol prices now hovering around the 37 cents per litre mark, correct engine tune is more important than ever.

Main features of the unit include a 3½-digit LCD display and the ability to measure up to 12,000rpm, 8000rpm or 6000rpm on 4, 6 or 8-cylinder engines respectively. The corresponding dwell ranges are 0-90°, 0-60° and 0-45°. Note that the unit is calibrated during construction to suit only one particular engine category (either 4, 6 or 8-cylinder).

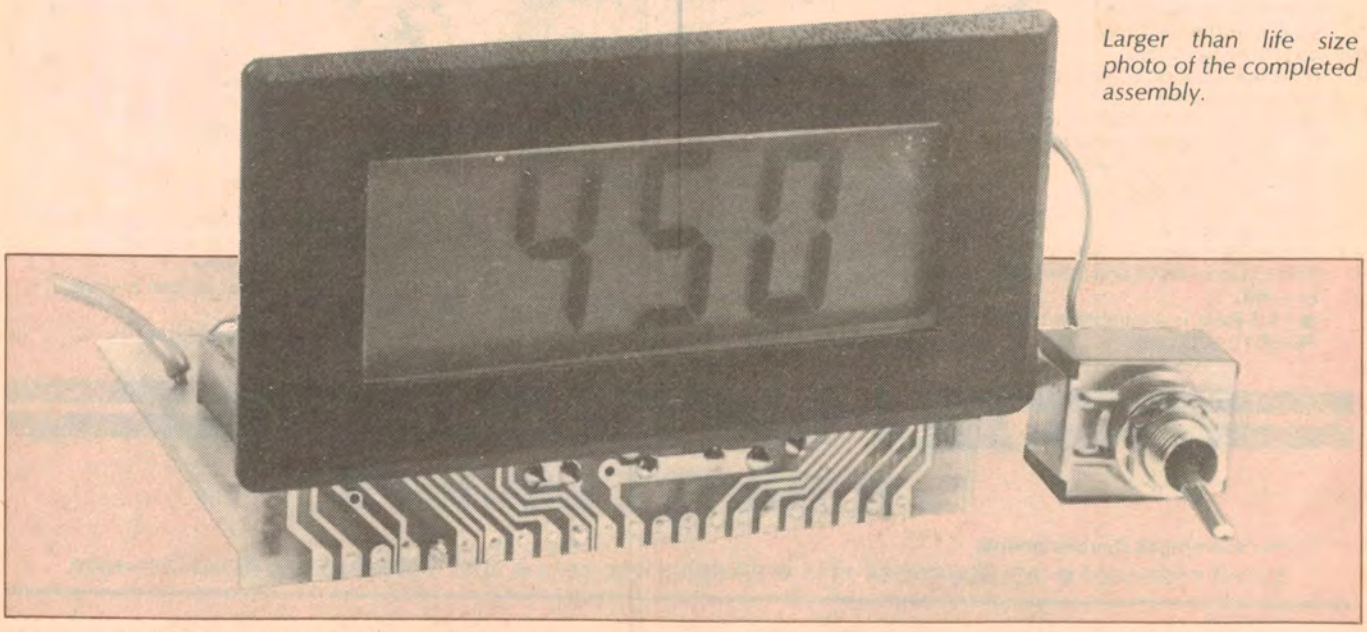
One important feature of the unit is that it is compatible with all current electronic ignition systems, including breakerless systems and transistor-assisted and capacitor discharge systems in which the points are retained. Only three leads are required to connect the unit for use: two to the power supply and the third to the points or to the transistor side of the ignition coil in the case of a breakerless system.

Readers who have fitted transistor-assisted ignition (TAI) to their cars can either connect to the points or to the ignition coil. However, while the tacho readings will be the same in both cases, the dwell readings will differ if the TAI has electronic dwell extension. In one position, the dwell meter will give the duty cycle of the points; in the other (ie to the coil), it will give the extended dwell reading.

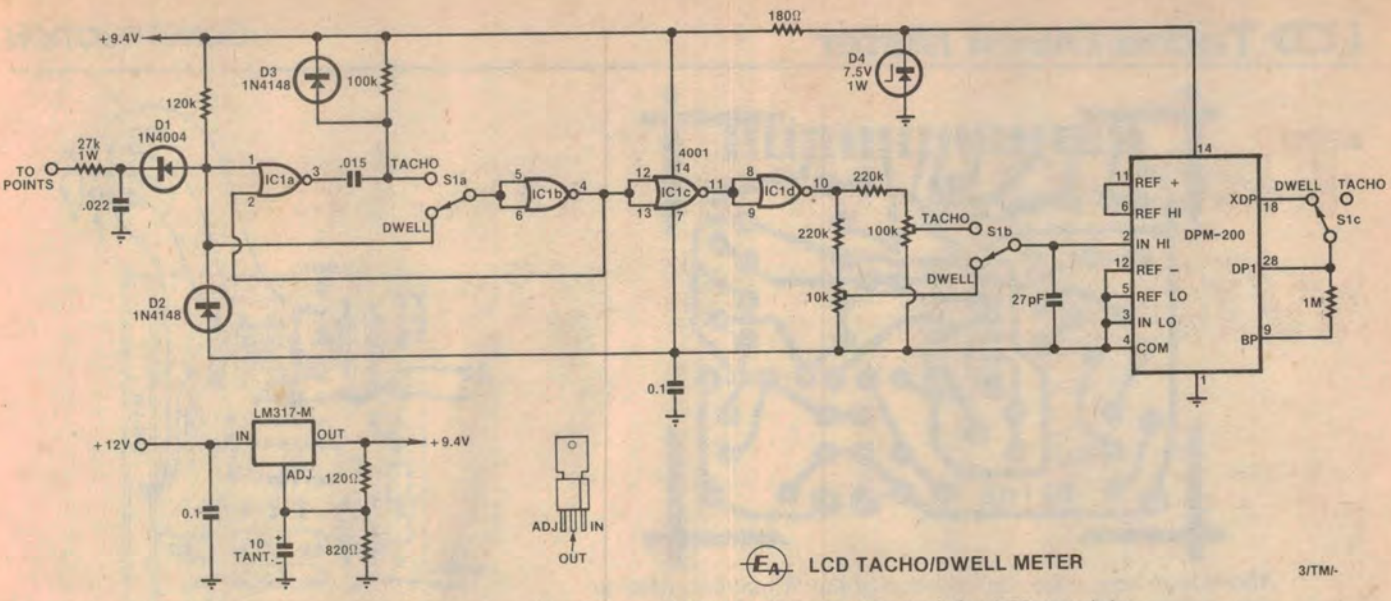
What is dwell?

Dwell is actually a measure of the duty cycle of the points and is defined as the angle through which the distributor shaft rotates while the points are closed. A 4-cylinder engine, for example, has four distributor cam lobes spaced 90° apart and this represents the maximum possible dwell angle (ie points permanently closed). Similarly, a 6-cylinder engine has 60° cam lobes, while an 8-cyclinder engine has 45° cam lobes.

In practice, the dwell angle is usually between one half and two thirds the cam lobe angle – typically 30°-35° for a 6-cylinder engine. The dwell angle should remain constant for all engine speeds (since the duty cycle remains the same), although a variation of one or



Larger than life size photo of the completed assembly.



The tacho circuit consists of a one-shot monostable (IC1a and IC1b), an integrator and the LCD module.

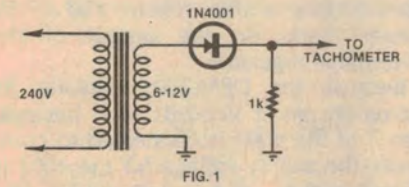


FIG. 1

Use this simple circuit to calibrate the tachometer range.

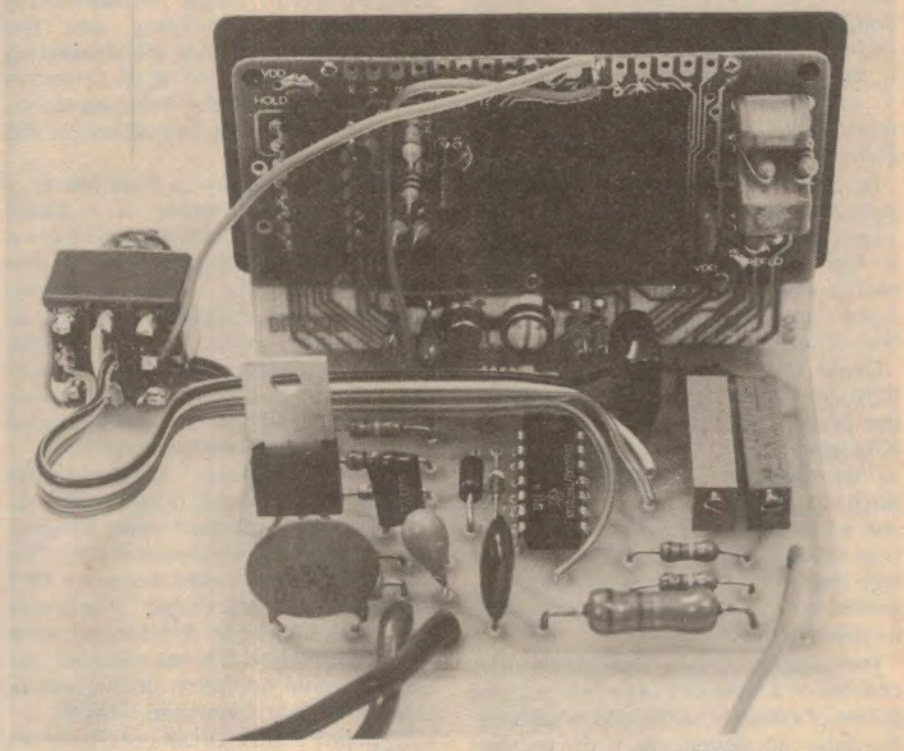
two degrees is usually encountered. Anything greater than that could indicate points bounce or a worn distributor.

Correct adjustment of the dwell angle is important to engine performance, and is a compromise between points life at low rpm and spark energy at high rpm. All you have to do is adjust the points gap until the correct reading is indicated on the display. This done, ignition timing adjustments can be carried out with the aid of the tachometer range.

How it works

Heart of the circuit is the DPM-200 LCD voltmeter module as used previously in the Digital Thermometer and the LCD Digital Capacitance Meter. Apart from the module itself, the design uses just one IC, a 3-terminal regulator and a handful of other components.

Signal input for both the tacho and dwell ranges is taken from across the points (or switching transistor) and passes firstly via an RC filter consisting of a 27kΩ 1W resistor and a .022μF capacitor. The job of the filter is to attenuate the large initial positive voltage spike from the coil, as well as coil primary oscillations. Following the RC filter are two silicon diodes (D1 and D2) and a 120kΩ pull-up resistor which translate the voltage across the points to a 5.3V (approx) peak square wave signal.

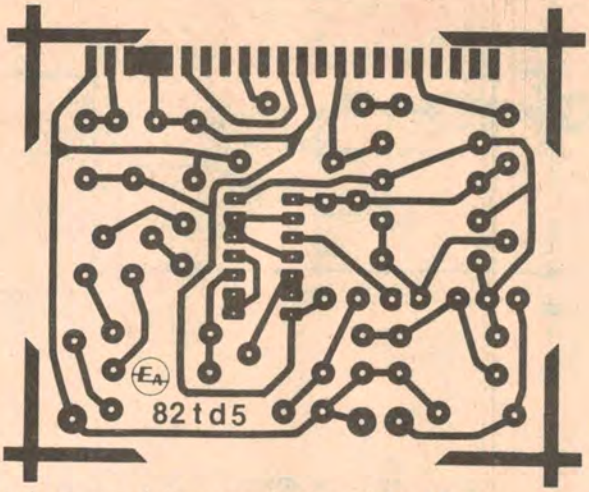


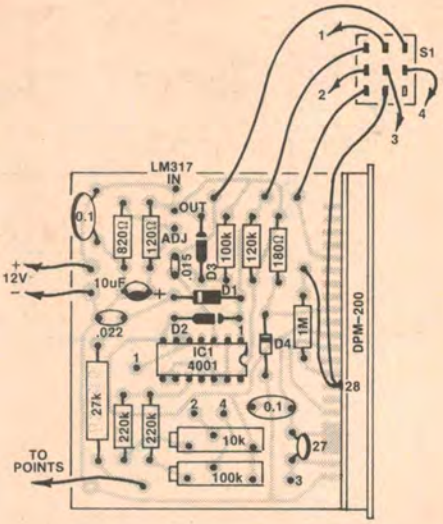
Rear view of the prototype. Note the wiring to the top of the DPM-200 module.

This voltage translation takes place as follows. When the input is at +12V (ie the points are open), D1 is reverse biased and the 120kΩ resistor pulls pin 1 of IC1a to the positive supply rail (+9.4V). When the points are closed, D1 and D2 are forward biased and pull pin 1 to +4.1V, or 0.6V below the common level (COM) of IC1. Note: the DPM-200 module maintains its common pin (pin 4) at Vcc – 2.8V = +4.7V.

In the tachometer mode, the "cleaned-up" points signal triggers a one-shot monostable consisting of NOR gates IC1a and IC1b. Let's assume initially that the points are closed and that the input to pin 1 of IC1a is low. Since the period of the monostable is quite short, it follows that the output of the monostable (pin 4) and pin 2 are also low, and that pins 3, 5 and 6 are all high (ie the .015μF capacitor is discharged).

When the signal input to IC1a subsequently goes high, pins 3, 5 and 6 are all pulled low, and the output of the monostable switches high. The .015μF capacitor now charges via the 100kΩ resistor towards the positive supply rail





Above is an actual-size reproduction of the PC pattern, while at right is the wiring diagram.

and, when it reaches the threshold voltage of IC1b, pin 4 switches low to end the monostable timing period. Finally, the points close again, pulling the pin 1 of IC1a low and resetting the monostable ready for the next positive-going trigger pulse.

Because it is connected directly to the output of the monostable, pin 2 is high whenever the output of the monostable is high. This step ensures that the monostable can not be retriggered by noise during the timing period (ie while the .015μF capacitor is charging).

Diode D3 ensures that the input of IC1b does not go more than 0.6V above the positive supply rail when pin 3 of IC1a goes high. It also ensures that the .015μF capacitor has sufficient time to discharge before the points open again and a new timing period begins. In practice, there is some loss of accuracy at high engine speeds, the unit reading approximately 2.5% low at 8000rpm on a 6-cylinder engine.

The output of the monostable thus consists of a train of brief positive-going pulses of constant width and amplitude, the pulse rate depending on the number of times the points open and close. These pulses are buffered by inverters IC1c and IC1d and applied to a voltage divider consisting of a 220kΩ resistor and 100kΩ trimpot. A 27pF capacitor then integrates the pulses to produce a steady DC voltage on the input of the DPM-200 module.

The voltage appearing on pin 2 of the DPM-200 will be proportional to the monostable pulse rate and can thus be directly related to engine speed. By suitably adjusting the 100kΩ trimpot, we can therefore calibrate the unit to read directly in rpm.

Compared to the tachometer circuit, operation of the dwell circuit is relatively straightforward. Dwell measurements are made by switching out the monostable and feeding the cleaned-up points signal direct to IC1b. Inverters IC1b,c,d buffer and invert this signal, the output of IC1d going high whenever the points are closed.

The output of IC1d is then fed to a voltage divider consisting of a 220kΩ resistor and a 10kΩ trimpot, and thence to the 27pF integrating capacitor. In this case, however, the voltage produced across the 27pF capacitor is proportional to the duty cycle of the output waveform of IC1d, and thus to the duty cycle of the points. The 10kΩ trimpot allows the circuit to be calibrated to read the dwell angle directly in degrees.

Switch S1 selects between the tachometer and dwell ranges, with S1c switching in the decimal point annunciator (DP1) for dwell measurements. The 1MΩ resistor connected between DP1 and the backplane pin (pin 9) prevents noise from turning on the decimal point annunciator when it is not required, yet allows normal operation of the annunciator when it is connected to XDP.

The power supply circuit consists of an LM317 3-terminal adjustable regulator, which provides a regulated 9.4V rail to power the CMOS IC. Supply decoupling is provided by a 0.1μF ceramic capacitor on the input of the regulator, while the 10μF capacitor connected to the ADJ terminal improves the ripple rejection of the supply to 80dB. The DPM-200 module is powered from a 7.5V rail derived from a 180Ω resistor and a 7.5V zener diode on the output of the 3-terminal regulator.

Because the DPM-200 maintains its common pin at Vcc-2.8V, and because pin 7 of the 4001 is connected to common, the supply voltage for the 4001 is therefore 9.4 – (7.5 – 2.8) = 4.7V. The 0.1μF capacitor on the common pin bypasses any noise which might otherwise affect the reading.

We estimate that the current cost of components for this project is

$54

This includes sales tax.

Construction

All components except the switch are mounted on a small PCB which is soldered at right angles to the DPM-200 display module. The two connector strips on the edges of the PCB and the module take care of most of the necessary connections, thus keeping wiring to a minimum.

Assemble the PCB (code 82td5) according to the wiring diagram, taking care to ensure that all polarised components are correctly oriented. Observe the usual precautions when soldering in the 4001 CMOS IC: avoid handling the pins; connect the barrel of your soldering iron to the common track on the PCB using a clip lead; and solder pins 7 and 14 first to enable the internal static protection circuitry.

When the PCB is complete, it can be soldered component side up to the display module. Butt the two together at right angles with the lower edge of the display module overlapping the PCB by about 2mm. Now solder the two outermost connections. Adjust the assembly as necessary, then solder the remaining connections.

Connections to the 3-pole switch can be run using rainbow cable, but the points lead should be rated at 240V in order to achieve acceptable insulation rating. The 22kΩ input resistor should be

PARTS LIST

1 printed circuit board, code 82td5, 67 × 53mm
1 DPM-200 LCD module
1 3-pole 2-position toggle switch

SEMICONDUCTORS
1 LM317M or LM317T 3-terminal adjustable voltage regulator
1 4001 quad NOR gate
2 1N4148 diodes
1 1N4004 diode
1 7.5V 1W zener diode

CAPACITORS
1 10µF 25VW tantalum
1 0.1µF greencap ("COM" bypass)
1 0.1µF ceramic (supply bypass)
1 .022µF greencap
1 .015µF greencap
1 27pF ceramic

RESISTORS (¼W, 5% unless stated)
1 x 1MΩ 2 x 220kΩ, 1 x 120kΩ, 1 x 100kΩ, 1 x 27kΩ 1W, 1 x 820Ω, 1 x 180Ω, 1 x 120Ω, 1 x 100kΩ multiturn trimpot, 1 x 10kΩ multiturn trimpot.

MISCELLANEOUS
Hook-up wire for power supply connections and points lead, 15cm 8-way rainbow cable, solder, automotive spade connectors etc.

rated at 1W. Use automotive hook-up wire for the power supply connections – red for the positive, black for earth.

Calibration

Once construction is complete, connect the unit to a suitable 12V supply and proceed with the calibration. The tachometer is calibrated by using the mains as a frequency reference. Apply a half-wave rectified signal from a 6-12V AC transformer (see Fig. 1) and adjust the 100kΩ trimpot so that the display reads 1500rpm for a 4-cylinder engine, 1000rpm for a 6-cylinder engine, or 750rpm for an 8-cylinder engine.

The dwell calibration is even easier. All you have to do is short the points lead to earth and adjust the 10kΩ trimpot for a full-scale reading: 90° for a 4-cylinder engine, 60° for a 6-cylinder engine, or 45° for an 8-cylinder engine. The display should read 00.0 with the points lead open circuit.

Installation should present few problems, although the task may be rather time consuming. Probably the best approach is to fit the assembly into a suitable case, which can then be mounted on the dashboard. The earth connection can be made to any convenient point on the chassis, while the +12V should be taken from the ignition switch or from an appropriate point on the fuse panel.