"Universal" Tacho uses HT pickup

Here is a low cost portable electronic tachometer designed to work with almost any kind of ignition system — conventional, transistor-assisted, CDI, breakerless, magneto or what-have-you. It uses a standard tachometer IC, but feeds it from a special shielded capacitive HT pickup.

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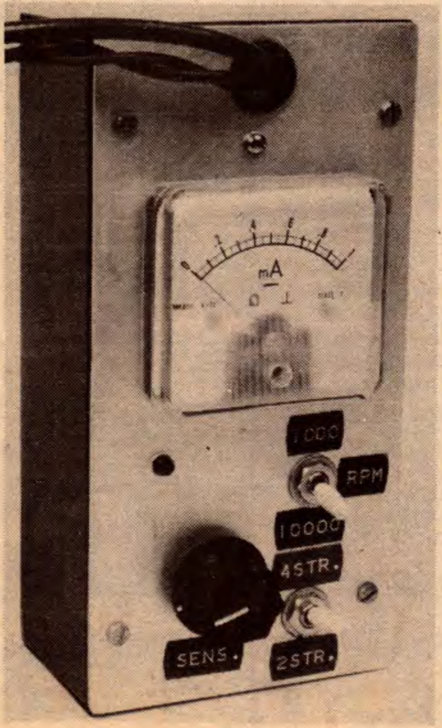
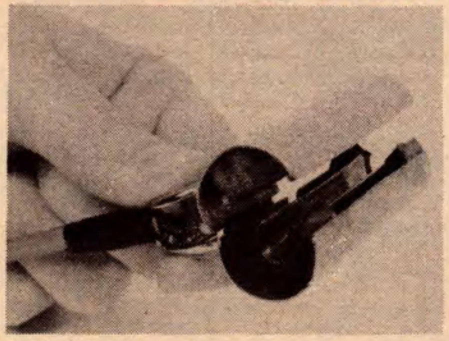
This tachometer has been developed to check the speeds of modern petrol engines. Ignition systems today are many and various; some have no breaker points, while twin cylinder 4-stroke motor cycle engines can have firing on each cylinder as each piston reaches top dead centre. Some multi-cylinder engines divide the ignition lead between two systems. Capacitor discharge ignition systems are in use both in marine outboard engines and in motor cycles. Some have high tension distributors, others use a separate coil for each cylinder.

From all the complexity indicated above, almost the only common factor is high tension feeding a spark plug. Even here there are variations, for spark plugs can have resistors built into them and can have either metal conductor or resistive suppressor-type high tension leads attached.

In view of these complications, it was decided that the tachometer would need to use a capacity-type pickup from the spark plug lead, in order to cope with the widest range of situations. However, when a simple capacity pickup was tried, it was found that false triggering could be produced due to coupling from nearby leads. The HT pulses have short risetimes, and can couple significant energy even via stray capacitance. In order to overcome this problem, a shielded capacity probe has been developed.

Reference to the circuit diagram will show that the coupling capacity pickup is required to charge firstly the self-capacity of the pickup itself and shielded connection cable. This cable is approximately 1½ metres long, giving a self-capacity of 100pF. The coupling capacity of the pickup to a 7mm high tension lead is in the order of 10pF, thus providing a capacitive divider of about 10:1 ratio for the ignition pulses. Should accidental contact be made to the ignition high tension, then provision is made, by means of a spark gap, to limit the voltage rise.





At left is the author's prototype tacho, made using parts on hand. If you are building from scratch, a larger meter and case could be used to advantage. Above is a close-up of the shielded capacitive pickup probe, partly opened.

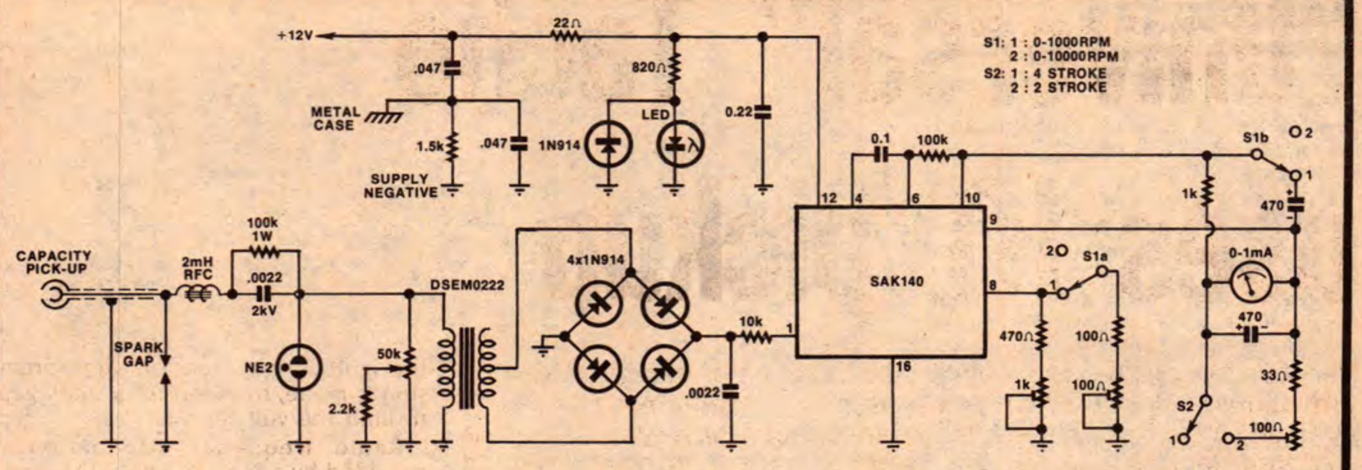
Radio frequency attenuation is provided by a 2mH RF choke. The particular choke used had low self-capacity, being made up of 3 "pies" on a ferrite core. It is suggested that this be the type used. The choke is followed by a 100k/1W resistor which is by-passed by a .0022uF capacitor having a 2kV rating. High voltage will be applied across this capacitor only when accidental contact is made to the ignition high tension. The primary of the coupling transformer is protected by an NE2 neon connected across it, together with a 50k pot. connected to give variable loading, and hence act as a sensitivity control.

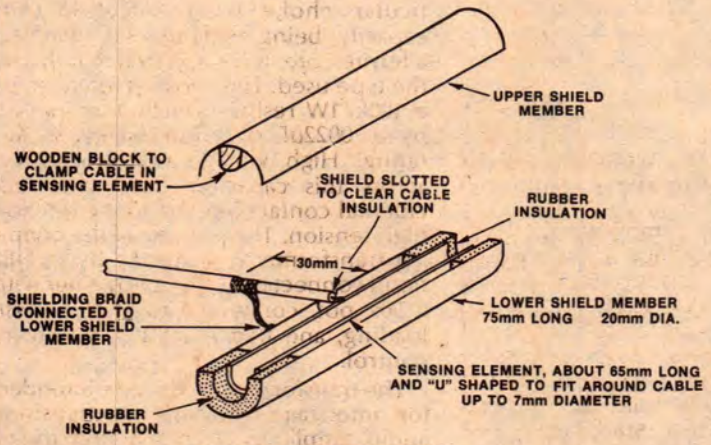
The transformer used is one intended for interstage coupling in transistor audio amplifiers. It has a primary of nominal 3k impedance, and a centre-tapped secondary of the same impedance from end to end. The transformer I used came from Dick Smith Electronics, and is listed in their catalog as M-0222.

Half of the secondary is used, to give a 2:1 step down to a full wave bridge rectifier made up of four 1N914 diodes. The output is thus made up of positive pulses no matter what polarity the high tension pulses may be.

A .0022uF capacitor at the output of the bridge rectifier is designed to suppress any RF spikes that may get through. Further protection to the input of the SAK 140 tachometer IC is provided by a 10k resistor. The circuitry around the IC is arranged to make use of non-critical components and to provide ease of calibration. The 100k resistor between pins 10 and 6 and the 0.1uF capacitor between pins 6 and 4 determine the duty cycle. This duty cycle does not exceed 0.8 even at maximum RPM in the two-stroke position.

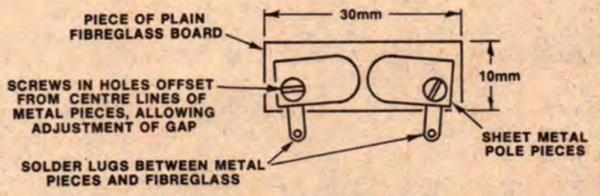
In the 0-10,000 RPM position, only one 470uF capacitor is connected across the meter. This allows rapid response without excessive needle flicker. However, in the 0-1000 RPM range, flicker becomes very obvious with only 470uF in circuit. This is overcome by switching in an extra 470uF between pins 9 and 10 and arranging extra current drive for calibration in this range by switch S1a. Shunting for





CAPACITIVE PICKUP PROBE DETAIL

The complete circuit for the tachometer is shown above. As you can see it uses a standard tacho IC, the SAK 140, with additional circuitry to drive it from the capacitive HT pickup. The spark gap and neon protect the IC against accidental contact with the HT wiring. At left is the detail drawing of the pickup, with the detail of the protective spark gap shown below.



SPARK GAP DETAIL

calibration in two-stroke mode (or one ignition per rev) is provided by S2.

As the unit draws less than 20 milliamps it can be powered by eight penlight cells in a suitable carrier. The meter is thus portable and can be used even for engines with no battery system. Pickup can be taken from any plug's high tension lead. If the separate battery method is used, a jumper lead will be required between engine and battery negative.

Note that a metal case must be used for the instrument and is connected to the negative supply by means of a 1.5k resistor by-passed by a .047uF capacitor.

The prototype was built with what the author had to hand but constructors starting from scratch could use a large meter and case with advantage. However, the general layout of the prototype should be followed with the input leads and filter systems above the meter and the switches, sensitivity control, transformer and integrated circuit below the meter. This is to give maximum separation between input and meter circuits.

Some knowledge of metalworking is required for the construction of the capacity pickup. Use a metal that is readily solderable of approximately 24g. The inner sensing element is "U" shaped, with the diameter such that a 7mm high tension lead slides easily inside the "trough".

The two semicircular halves of the outer shield overlap when closed. The overall length is 75mm and the lower member has a 20mm inside diameter. Two pieces of rubber tubing, each 15mm long were cemented into the lower member and suitably cut to accept the sensing element. Contact cement was used to secure the rubber and to mount the sensing element centrally in the lower member. The rubber is flush with each end of the lower member but the sensing member will be 5mm in from each end.

The clamping mechanism is derived from a 50mm (2in) paper clip, with the jaws cut back and suitably bent. The shielded cable should be prepared as follows:

The prepared cable can be slid under the spring of the paper clip and the cable end soldered to the sensing element. Solder the lower jaw of the paper clip to the lower shield members.

The illustration of the capacity pickup will show that there is a piece of timber 75mm long cemented by epoxy to the upper member. A piece of waterproof plywood was used in the prototype and so shaped that with 7mm high tension cable in the sensing element, the upper shield member just overlapped the lower member. The sides of the piece of plywood were filed away to allow a 4mm cable to be gripped. This is the smallest diameter cable likely to be encountered.

It may be necessary to slot the upper member to clear the cable soldered to the sensing element. With no high tension cable in the sensing element, the piece of plywood can be cemented to the upper member and the remaining jaw of the paper clip soldered to the upper member. It helps to tie the units in position with wire because of the spring loading of the paper clip. The wire ties can be removed after soldering.

Anchorage and earthing of the cable braid is as follows: a tongue of metal about 4mm by 25mm long is soldered to the lower finger grip of the paper clip and faces away from the sensing unit. To this is soldered also the earthing braid of the shielded cable. Then the whole is reinforced by an insulating sleeve and securely taped to the tongue of metal.

If the insulating plastic sleeve can be forced over the tongue of metal, so much the better. The plastic sleeve can be about 65mm long. Its sole purpose is to provide strain relief.

Construction of the indicating unit follows normal practice with the proviso that inlet leads and functions be separated by the meter dimensions as indicated earlier.

The spark gap is a simple device made up from two pieces of metal mounted on a plain piece of fibreglass board as shown.

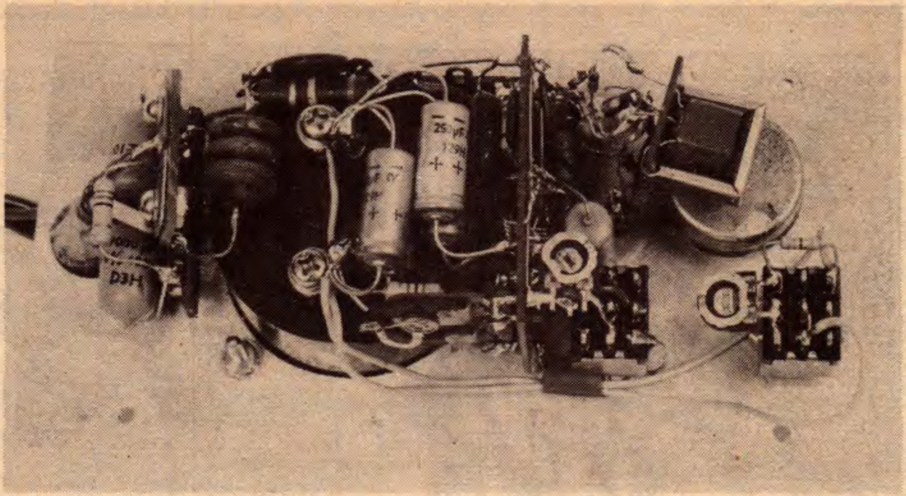
Because the screws are offset, the rounded ends of the plates can be brought close together by slight rotation of each plate. The gap should be made 0.04mm (.0015in) using a feeler gauge. The plates are mounted away from the surface of the fibreglass board by the thickness of the solder lugs. The resulting air gap reduces surface leakage.

For calibration, a 12V 50Hz supply is required as well as a source of 12V DC such as the eight penlight cells previously mentioned. Apply 12V in the correct polarity and the LED should light.

Set the range switch to 10,000 RPM and the function switch to 4-stroke. Apply the 12V 50Hz across the .0022uF capacitor at the output of the diode bridge, via a 10k ½W series resistor.

Set the 1k trimpot to give a reading of 6000 (0.6 on the 1mA scale). Now set the function switch to 2-stroke and set the 100 ohm trimpot of the meter circuit to give a reading of 3000 (0.3 on the scale).

The 0-1000 RPM calibration requires that the unit be taken to a vehicle. If the vehicle is fitted with a six-cylinder engine then proceed as follows. Connect the battery leads of the tachometer to the battery terminals of the vehicle in the correct polarity. The LED should now be lit. Clip the capacity pickup to the lead coming from the high tension of the coil to the distributor. Set the range switch to 10,000 and the function switch to 4-stroke.



Here is a shot of the interior of the author's prototype, showing the general construction. The layout may be varied if desired, but it is advisable to keep the input circuitry and spark gap well away from the IC.

Start the vehicle engine and set the speed so that 6000 RPM are indicated. Because the ignition coil is delivering pulses to the six cylinders in firing order, the tachometer reads this as one cylinder having a speed of 6000 RPM when in fact the engine is set at a speed of 1000 RPM.

With the engine still running, transfer the capacity pickup to any one cylinder high tension lead and the reading should drop to 1000 RPM on the 0-10,000 RPM scale. Switch to 0-1000 and in all probability the meter will read close to full scale. At this stage set the function switch to 2-stroke and set the 100 ohm trimpot associated with S1a to read 500 RPM (0.5 on the scale).

You will note that the calibration method tries to keep readings as close to the initial setting on 12V 50Hz as possible. This reduces the possibility of errors and keeps readings in the mid scale area as accurate as possible. This is the area where the majority of readings will be taken.

If a 4-cylinder engine is used for the low range calibration, then the engine would be set to read 4000 RPM with the capacity pickup on the ignition coil high tension lead. Similarly, 8000 RPM would be used in the case of an eight-cylinder engine. In all cases the sensitivity control is adjusted to obtain readings that are steady.

PARTS LIST

1 Metal case with metal front panel
4 Rubber feet
1 Rubber grommet
1 0-1 milliamp meter
1 Miniature switch, DPDT
1 Miniature switch, SPDT
1 50k ohm potentiometer
1 Knob
1 Capacity pickup (see text)
2 crocodile clips
1 RF Choke 2mH (see text)
1 Spark gap (see text)
1 Transformer, DSE M-0222 or similar
1 LED
1 NE2 Neon
5 1N914 diodes
1 SAK 140 tachometer IC

RESISTORS
2 100 ohm trimpots
1 1k ohm trimpot
1 100k 1W
¼W or ½W 5%:
1 x 22 ohm, 1 x 33 ohm, 1 x 100 ohm, 1 x 470 ohm, 1 x 820 ohm, 1 x 1.5k, 1 x 2.2k, 1 x 10k, 1 x 100k

CAPACITORS
1 .0022uF 2kV ceramic
2 470uF 10VW electro
1 .0022uF 100VW polyester
2 .047uF 100VW polyester
1 0.22uF 100VW polyester
1 0.1uF 100VW polyester

MISCELLANEOUS
Mounting hardware, tap strips, plain Veroboard, PC board pins, solder; 1½ metres of 4mm plastic covered shielded cable, 60pF per metre maximum; 1½ metres each of red and black 2.5mm hookup wire.