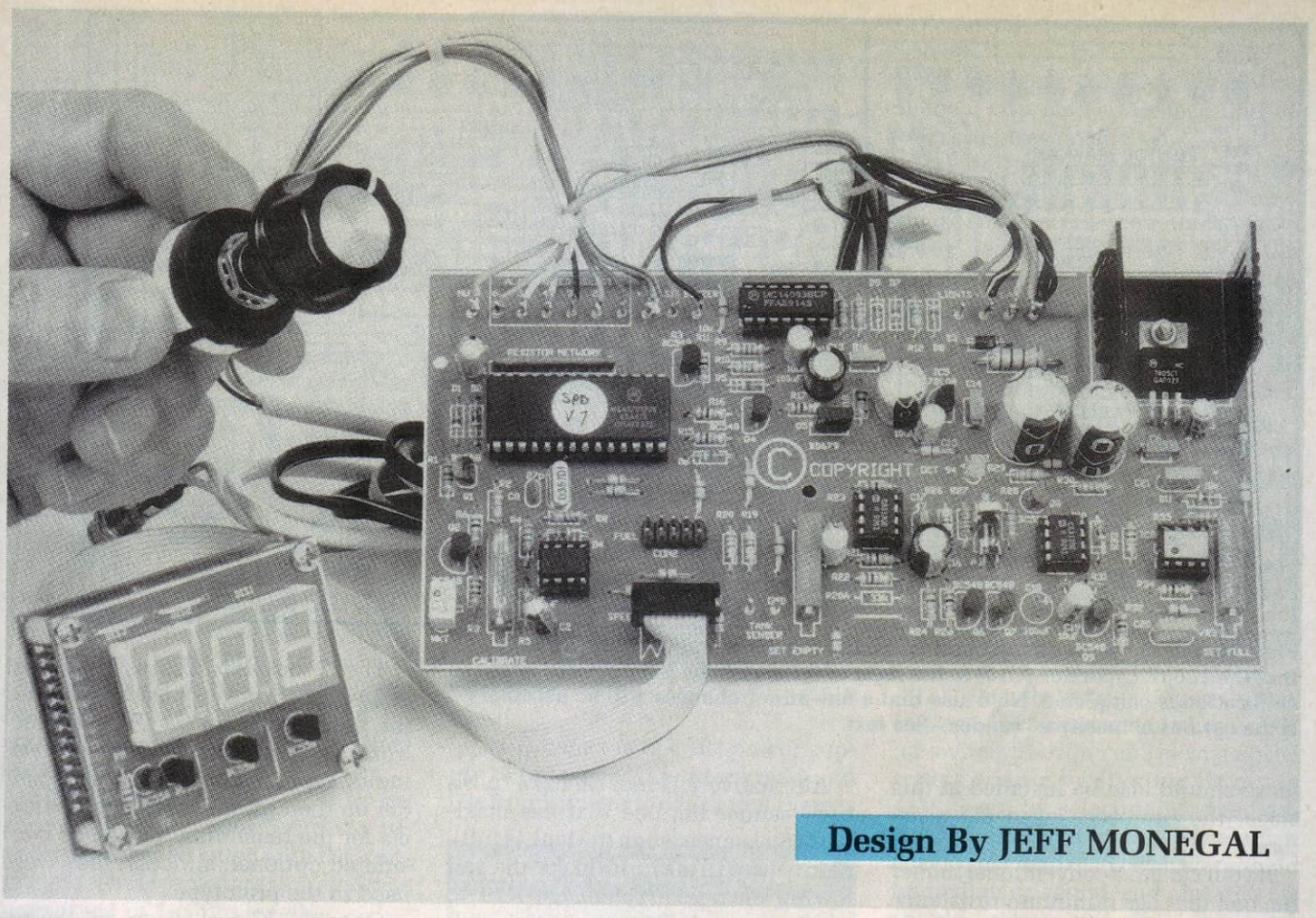


Design By JEFF MONEGAL

Digital speedometer & fuel gauge; Pt.2

Despite the circuit complexity, the digital speedometer and fuel gauge is straightforward to assemble. This month, we give the construction and calibration details.

All the parts for the main circuit and the A/D converter mount on a single main PC board, while the display module is built on two smaller boards which are mounted back to back on 12mm spacers.

As indicated in an accompanying panel, a complete kit of parts for this design (minus the case) is being offered by CTOAN Electronics. No special assembly techniques are required apart from the use of a good quality fine-tipped soldering iron. The PC boards are all solder masked to help stop solder runs and carry screened printing to show the parts placement.

Fig.4 shows the parts layout on the main PC board. Note that a few minor changes were made to the circuit after the board design was finalised. As a result, the following changes should be made:

(1). the positions indicated for resistor R1 and diodes D1 & D2 should be left vacant;

(2). Q1 should be omitted and a wire link connected between what were its collector and emitter terminals; and

(3) R2 should be increased to 1.5kΩ.

Begin by installing PC stakes at the external wiring points and 10-way IDC pin headers at the CON1 and CON2 positions. This done, install the resistors, capacitors and diodes, taking care to ensure that all polarised parts are correctly oriented. There are also a number of wire links on the board and

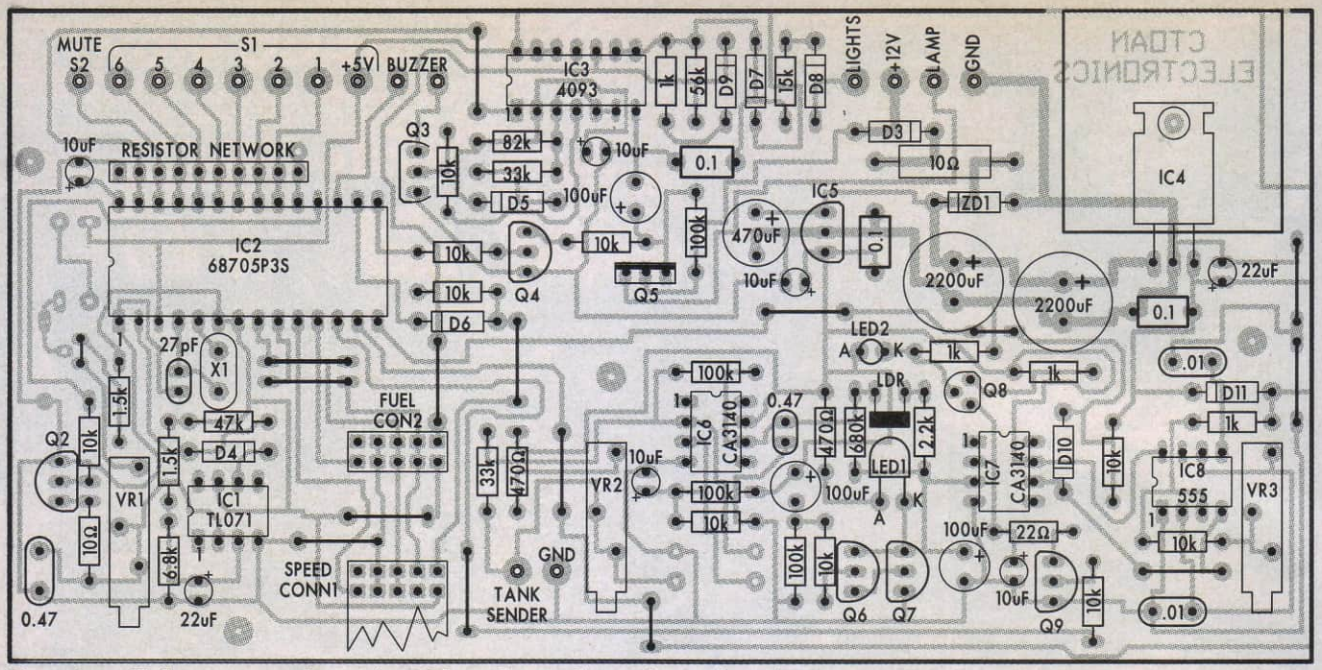


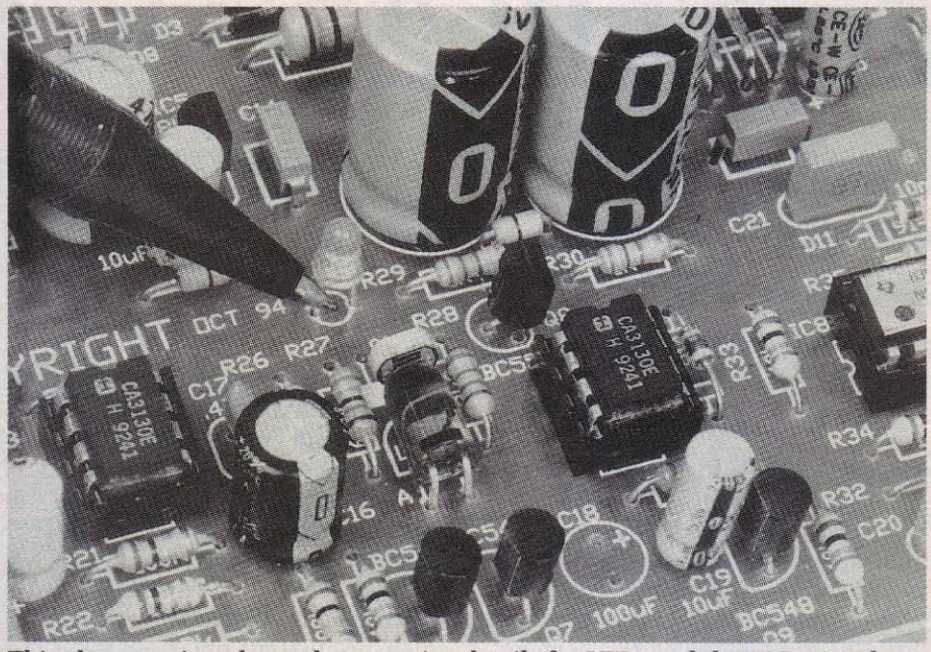
Fig.4: install the parts on the main PC board exactly as shown here but note that the 100µF capacitor (C18) to the right of Q7 should be left out until after the calibration is completed. Note also that a few minor changes will be necessary if the car has a "positive" sender – see text.

these should also be installed at this stage (the prototype used 0Ω resistors).

If your car has a conventional sender (ie, one that has minimum resistance when the fuel tank is full), install the parts exactly as shown in Fig.4. Make sure that R19 is 470Ω (not 820Ω as marked on the PC board). Both R20A and the adjacent wire link should be omitted.

Alternatively, if your car has a "positive" sender (ie, one that has maximum resistance when the tank is full), then you will need to make the following changes: (1) change R19 to 820Ω; (2) omit R20; and (3) install R20A (33kΩ) and the adjacent wire link.

Do not install C18 (100µF) at this stage. That step comes later, following the calibration procedure.



This close-up view shows the mounting details for LED1 and the LDR. Note how the LED is bent over so that it directly faces the surface of the LDR, so that its resistance reduces to just a few hundred ohms when power is first applied.

The IC sockets can be installed next. A 28-pin IC socket must be used for the microprocessor, as CTOAN Electronics will not accept chips for testing or reprogramming that have solder on their pins. The use of IC sockets for the remaining ICs can be considered optional, although they were used in the prototype.

Once the IC sockets are in, the remaining parts can all be installed. Note particularly the arrangement for LED 1 (red) and the LDR. The leads of the LED must be bent at right angles before installing it, so that it sits against the LDR as shown in the photo. Take care with the LED polarity – its anode lead will be the longer of the two.

The yellow LED (LED 2) is mounted on the board in the conventional manner, as shown.

A small heatsink is required for the 7805 3-terminal regulator and this is bolted to the board as shown in the photo. Smear the metal tab of the regulator with heatsink compound before bolting the assembly together.

Display modules

Fig.5 shows the parts layout on the display module PC boards. As indicated earlier, you will have to build two such display modules – one for the speed display and the other for the fuel display.

Install the parts on the PC boards as shown, taking care to ensure that the displays are all oriented with their decimal points at bottom right. Note that resistors R1-R7 & R9 on the IC

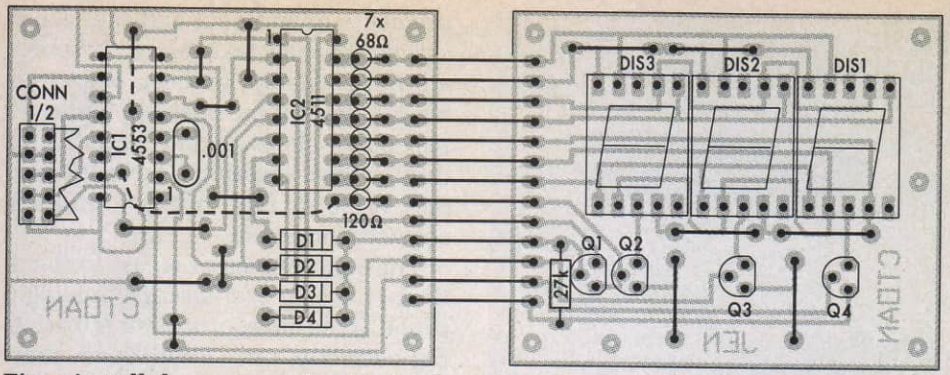


Fig.5: install the parts on the display boards as shown in this diagram. Note that the two ICs face in opposite directions and don't forget to install the insulated wire link (shown dotted) on the board at left.

board are all mounted end-on to conserve space. In addition, an insulated wire link must be installed on the back of this board (shown dotted).

Once the board assemblies have been completed, they can be mounted back-to-back on 12mm spacers and secured using machine screws and nuts. Finally, the two boards in the assembly are wired together by installing 13 wire links between them along one edge.

The completed display modules are connected to the main board via 10-way ribbon cables fitted with IDC connectors. These cables are supplied preassembled in 1-metre lengths.

Testing

The unit can now be tested by following this step-by-step procedure:

(1). Connect a link across the fuel sensor inputs;

(2). Connect a display module to the speed connector (CON1) on the main board using one of the supplied 10-way ribbon cables. The photos show the connector orientations (no damage will result if you do plug the cable in the wrong way around – the display just won't work).

(3). Install all the ICs except for the microprocessor (IC2) on the main board.

(3). Connect a 12V DC power supply to the power input terminals and use a multimeter to check that there is +5V on pin 3 of the microprocessor socket.

(4). Short pin 1 of IC3 to the +5V rail using a clip lead and check that the buzzer pulses on and off.

(5). If all these checks are OK, switch off and install the microprocessor (make sure that it is correctly oriented).

(6). Reapply power and check that the display shows 00 after a few seconds. If it does, switch off and connect an oscillator to the speed input (labelled "SIG" on the PC board). Set the oscillator frequency to about 50Hz and the signal amplitude to 5V (make sure that the amplitude in not greater than 5V, otherwise you could damage IC2).

(7). Reapply power – the display should now show a reading. Check that this reading can be varied by adjusting the oscillator frequency. Check also that the reading can be varied by adjusting VR1 on the main board.

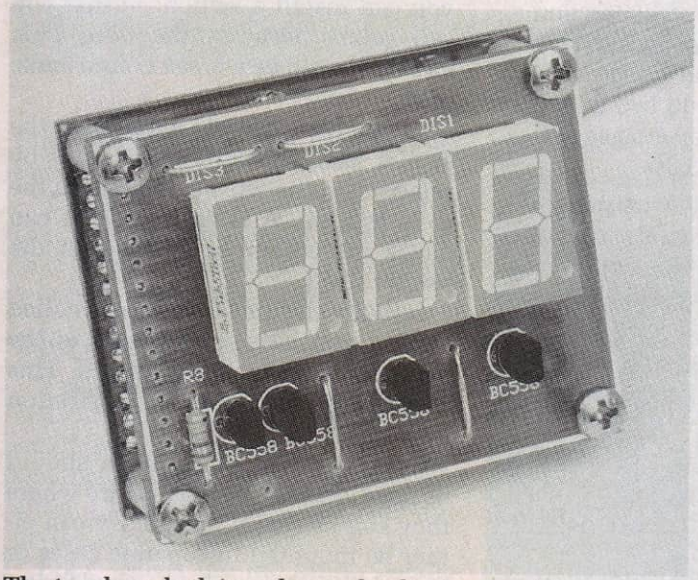
(8). Test the various speed alarm settings. If you haven't already wired up switch S1, you can select a speed setting simply by shorting its pin to +5V. Begin by selecting 62, then adjust the oscillator so that the reading goes higher than 62. The buzzer should immediately sound and the display should flash on and off.

Now press the mute button. The buzzer should stop but the display should continue to flash. Now check the other speed settings in turn.

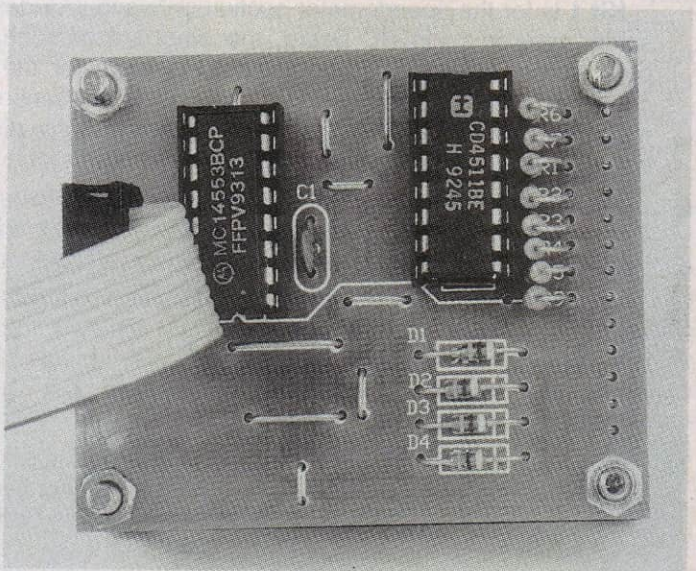
(9). If everything checks OK so far, adjust VR1 so that the speed display shows the incoming oscillator fre-

TABLE 1: CAPACITOR CODES

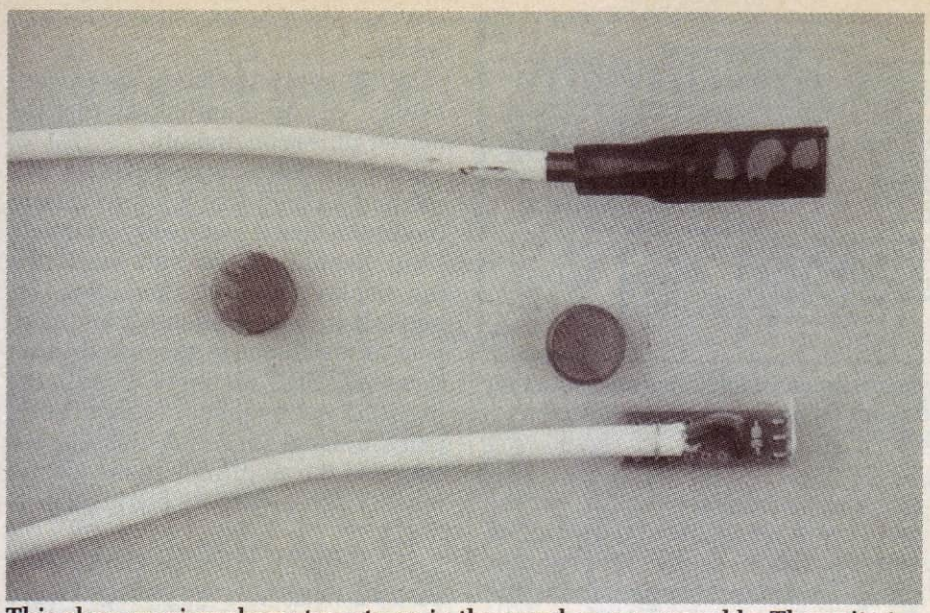
❑	Value	IEC Code	EIA Code
❑	0.47µF	470n	474
❑	0.1µF	100n	104
❑	.01µF	10n	103
❑	.001µF	1n0	102
❑	27pF	27p	27



The two boards that make up the display module are mounted back-to-back on 12mm-long spacers and the assembly secured using machine screws and nuts.



This view shows the rear of the completed display module. Note the direction from which the cable enters the pin header on this board.



This close-up view shows two stages in the speed sensor assembly. The unit at top shows what the sensor looks like after the parts have been mounted on the Veroboard, while at bottom is the finished sensor after it has been covered in heatshrink tubing and sealed with silicone sealant.

quency. This is not the final calibration but is a good starting point.

(10). Connect the second display module to the fuel socket (CON2 on the main board). With the shorting link still in place, the display should show some figure above 30. Adjust VR2 and confirm that the display reading varies, then do the same with VR3.

(11). Replace the shorting link with a 1kΩ resistor and check that the display now shows a reading of less than 20. If not, try adjusting VR2.

(12). Adjust VR2 so that the display reads less than 10. After a few seconds, the low fuel lamp should start to increase in brilliance.

Troubleshooting

If all is correct so far, then the project is operational and fuel gauge calibration can take place. If things are not as stated, go back over your work carefully for possible faults. In particular, check that all parts are in their correct locations, have the correct value or type number, and are correctly oriented.

The microprocessor is easy to check if you have an oscilloscope or a logic probe. If the microprocessor is operating correctly, pin 18 will have short positive pulses occurring every 0.75-2 seconds. You should also see various pulses on pins 9, 10 and 11. If these pulses are there, then the microprocessor is operating correctly.

Installation

It is important that this unit be installed in a professional manner, so as not to compromise the reliability of the car's existing wiring. In particular, make sure that any power supply connections are run via suitable fuses. The +12V supply to D3 must be derived via the ignition switch and the fusebox is probably the best place to make this connection. Be sure to connect to the fused side of the switched supply.

Similarly, the connection to the car's lights (from D8) can also be made at the fusebox (eg, to the supply for the tail lights).

The connection to the fuel sender can be made by disconnecting the appropriate lead to the existing fuel gauge and connecting it to the main PC board instead (ie, your existing fuel gauge must be disconnected). Alternatively, you can install a switch, so that you can select between the two. This switch should be a break before make type.

If you have trouble identifying the sender lead, check its colour code by referring to the wiring diagram in the car's manual. Alternatively, you can check the colour of the lead at the sender itself.

Initially, the unit should be installed so that you have easy access to the trimpots on the main PC board. This is necessary to allow final calibration later on.

The two display modules should be positioned on the dashboard where they can be easily read. They can either be mounted in separate cases or mounted side-by-side in a single case, with red Perspex used for the display windows. Be sure to mount the low-

Where To Buy A Kit Of Parts

Kits for this project will be available from CTOAN Electronics. The details are as follows:

Kit 1 is for the speedometer section only and includes a screened and solder-masked main PC board, the on-board components (including a programmed microprocessor but not the parts for the fuel gauge A-D converter), the buzzer, S1 and S2, a Hall Effect sensor and two button magnets. This kit also includes all the parts for a single display module (PC boards plus on-board components. The cost of this kit is $73.00.

Kit 2 includes the additional components required to build the fuel gauge, including a display module and the parts for the A-D converter. The cost of this kit is $20. Additional display modules are available for $13 each.

In addition to the above kits, CTOAN Electronics is also offering fully built and tested main PC boards for $130.00 ($140 if the fuel gauge A-D converter is required), plus fully tested display modules for $20.00 each. A repair service is also available for a minimum cost of $20.00 (does not include replacement of the microprocessor).

Kits can be ordered over the phone using a credit card (Bankcard, MasterCard or Visa), or by sending a cheque or money order to: CTOAN Electronics, PO Box 211, Jimboomba 4280, Qld. Phone (07) 297 5421. Please add $5.00 for postage and packing with each order.

Note: copyright of the PC boards associated with this design is retained by CTOAN Electronics.

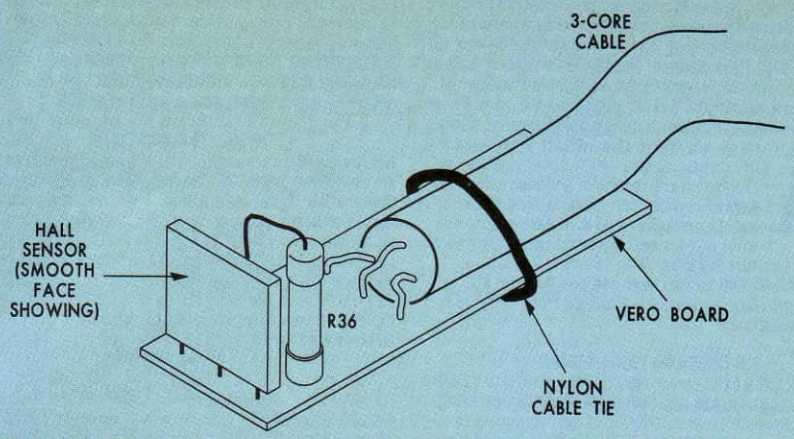


Fig.6: the Hall Effect sensor, along with R36 (10kΩ), is mounted on a piece of Veroboard. This assembly is then waterproofed by covering it in heatshrink tubing and applying silicone sealant to any gaps.

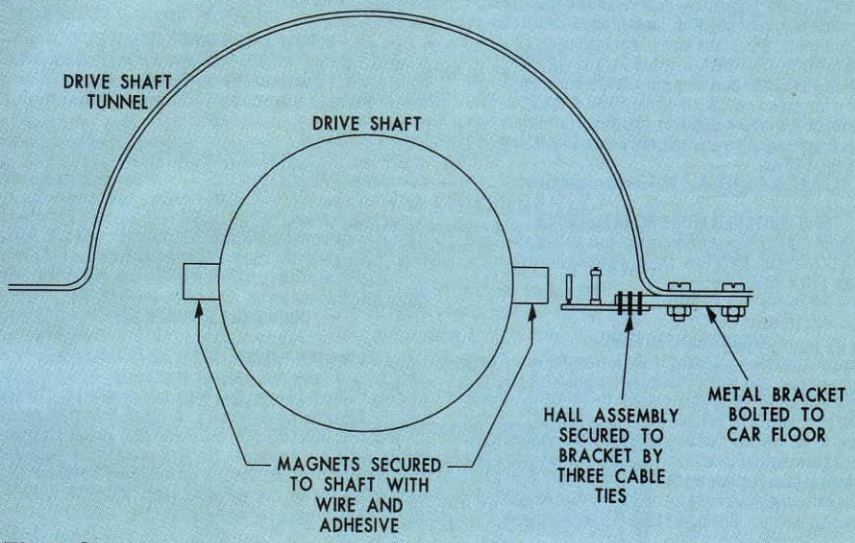


Fig.7: the mounting details for the Hall Effect sensor and its companion magnets. Note that the magnets must be oriented so that alternate poles pass by the sensor; ie, one magnet is mounted with its north pole closest to the sensor while the other is mounted with its south pole closest to the sensor.

fuel warning lamp in a conspicuous location.

The speed alarm selection switch (S1) and the alarm mute pushbutton (S2) should be mounted in locations where they are easy to use.

Hall effect sensor

The Hall Effect sensor, along with resistor R36 (10kΩ), is mounted on a small piece of Veroboard (Fig.6). This assembly is then waterproofed by covering it in heatshrink tubing and applying silicone sealant to any gaps.

Fig.7 shows the mounting details for the Hall Effect sensor and its companion magnets. Note that the magnets are mounted on the tailshaft (or on a driveshaft in a front-wheel drive car) and are oriented so that alternate poles pass by the sensor; ie, one magnet is mounted with its north pole closest to the sensor while the other is mounted with its south pole closest to the sensor.

Calibration

Calibration of the speed display is best carried out with the help of a second person. The procedure is straightforward – simply drive along a road at a known steady speed and have the other person adjust VR1 until the display reads the same as the existing speedometer.

Calibration of the fuel display is also quite straightforward. The easiest way is to use a sender that's been obtained from a wrecking yard. Note that this sender must be the same type as the one used in the car.

To calibrate the display, temporarily connect this second sender to the main PC board (disconnect the sender in the car), set it to the "empty" position, and adjust VR2 so that the display reads "00". If the display cannot be zeroed, try adjusting the value of R19 (this should rarely be necessary). This done, set the sender to the "full' position and adjust VR3 to obtain the correct reading (ie, 100% or the capacity of the tank in litres or gallons).

For example, if the car has a 65-litre tank, adjust VR3 so that the fuel display reads "65" (sender at "full"). Alternatively, adjust VR3 so that the display reads "100" for 100%.

The above procedure should now be repeated two or three times to obtain the final calibration. This is necessary because there is some interaction between the two adjustments.

Note that, in some cars, the engine may cut out due to fuel starvation before the sender actually quite reaches minimum resistance. However, the above procedure should be accurate enough for all practical purposes. In any case, it's not a good idea to let the fuel run out completely, as this can lead to rubbish clogging the fuel injectors or the jets in the carburettor.

If you are unable to obtain a sender from a wrecking yard, then it may be possible to remove the sender from the fuel tank and use this for calibration instead. Be warned, however, that disturbing the existing sender might cause the tank to leak later on (even if you replace the gasket) and this could mean a new fuel tank. We don't recommend this option unless you know exactly what you are doing.

Another way of calibrating the fuel display is to calibrate it against the existing fuel gauge. However, this method is only viable if you have installed a switch to select between the two. Note that the two units cannot be operated in parallel as this will lead to wildly incorrect readings.

Once calibration has been completed, install C18 (100µF) on the main PC board and complete the installation. Don't forget to reconnect the fuel gauge sender if you calibrated the unit using a second external unit. **SC**