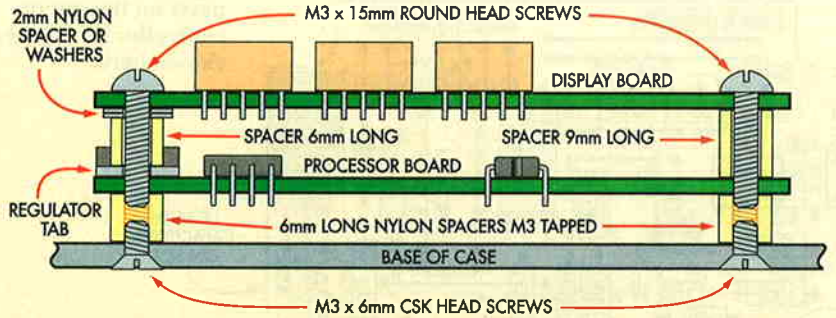
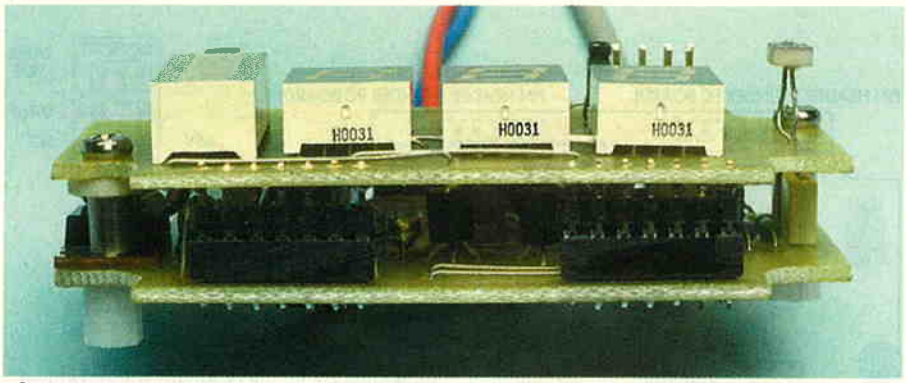


Fig.5: this diagram shows how the two PC boards are stacked together and secured to the bottom of the case using screws, nuts and spacers. Be sure to use nylon spacers and washers where specified.



This is the completed board assembly, ready for mounting in the case. The top of the LDR should be about 3mm above the displays.

The microcontroller board is next. Being by installing the nine wire links, then install the resistors. Table 1 lists the resistor colour codes but we recommend that you check each value using a digital multimeter, just to be sure.

Note that the seven 150Ω resistors at top right are mounted end-on.

Trimpot VR1 can go in next, followed by a socket to accept IC1 – make sure this is installed the right way around but don't install IC1 just yet. IC2 is soldered directly to the board – install this now, followed by zener diode ZD1 and transistors Q2-Q5.

Watch out here – Q5 is an NPN BC337 type, while Q2-Q4 are all PNP BC327s. Don't mix then up.

REG1 is mounted with its metal tab flat against the PC board and its leads bent at right angles to pass through their respective holes. Make sure that its tab lines up with the mounting hole in the PC board.

The capacitors can go in next but make sure that the electrolytics are mounted with the correct polarity. **Note that the 10µF capacitor below VR1 must be a low-leakage (LL) type.** It is installed so that its body lies horizontally across the adjacent 680Ω resistors. It's a good idea to bend its leads at rightangles using needle-nosed pliers before mounting the capacitor on the board.

Similarly, the two electrolytic capacitors below REG1 must be installed so that their bodies lie over the regulator's leads (see photo).

Crystal X1 mounts horizontally on the PC board and can go in either way around. It is secured by soldering a short length of tinned copper wire to one end of its case and to a PC pad immediately to the right of Q3.

Finally, you can complete the assembly of this board by fitting PC stakes to the external wiring points and installing the three 7-way in-line sockets. The latter are made by cutting down two 14-pin IC sockets into in-line strips. Use a sharp knife or a fine-toothed hacksaw for this job and clean up any rough edges with a file before installing them.

Before plugging in IC1, it's a good idea to check the supply rails on its socket. You don't need to have any other circuitry connected to the microcontroller board to do this – just connect a 12V supply to the board and check that there is +5V on pins 4 & 14 of the socket.

If this is correct, disconnect power and install IC1 in its socket, making sure that it is oriented correctly.

Display board assembly

Now for the display board. Install the eight wire links first (note: six of these mount under the displays), then install the three 7-segment LED displays. Make sure that these are properly seated and that their decimal points are at bottom right before soldering them

The LED bargraph can go in next – this mounts with the corner chamfer at bottom right (ie, labelled side towards the edge of the PC board). This done, install LDR1 so that its top face is about 3mm above the displays.

The remaining parts, including the 5-way DIL pin header, can now be installed. The shorting jumper can be installed in the "OFF" position (at right) for safe keeping, at this stage.

The three 7-way pin headers are installed on the copper side of the PC board, with their leads just protruding above the top surface. You will need a fine-tipped soldering iron to solder them in. Note that you will have to slide the plastic spacer along the pins to allow room for soldering, after which the spacer is pushed back down again.

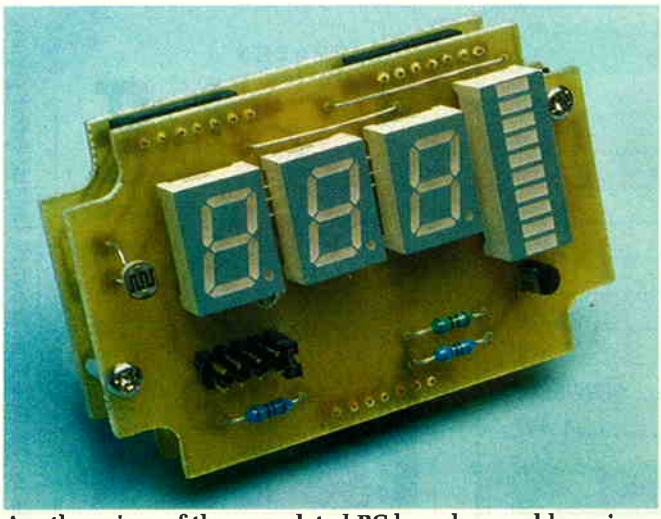
Final assembly

Work can now begin on the plastic case. First, remove the integral side pillars with a sharp chisel, then slide the microcontroller board in place. That done, mark out two mounting holes – one aligned with REG1's metal tab and the other diagonally opposite (to the bottom left of IC2).

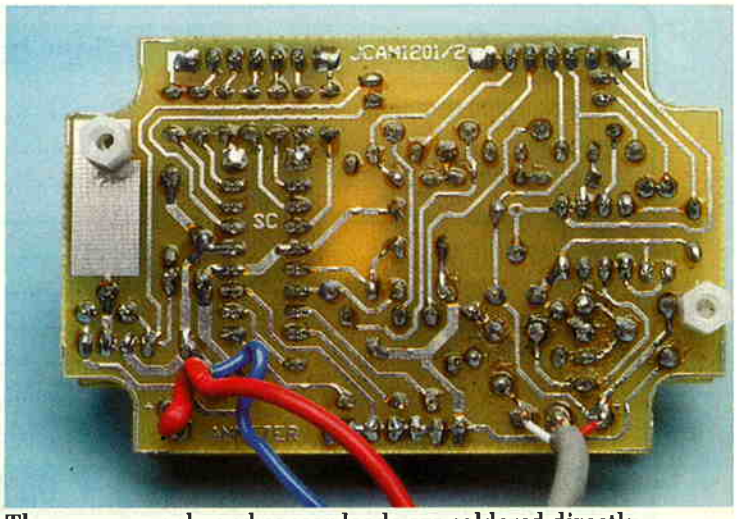
Now remove the board and drill the two holes to 3mm. They should be slightly countersunk on the outside of the case to suit the mounting screws.

In addition, you will have to drill two holes in the bottom of the case to accept the power leads and the shielded cable for the Hall effect sensor. These two holes should be located so that they line up with the relevant PC stakes.

The display board can now be plugged into the microcontroller board and the assembly fastened together and installed in the case as shown in



Another view of the completed PC board assembly, prior to mounting in the case. Make sure that the displays are oriented correctly (decimal point to bottom right).



The power supply and sensor leads are soldered directly to their respective terminals on the back of the microcontroller board.

Fig.4. Be sure to use a 2mm nylon washer (or spacer) in the location shown.

Once it's all together, check that none of the leads on the display board short against any of the parts on the microcontroller board. Some of the pigtails on the display board may have to be trimmed to avoid this.

The front panel artwork can now be used as a template for marking out and drilling the front panel. You will need to drill a hole for the LDR plus a series of small holes around the inside perimeter of the display cutout.

Once the holes have been drilled, knock out the centre piece and clean up the rough edges using a small file. Make the cutout so that the red Perspex window is a tight fit. A few spots of superglue along the inside edges can be used to ensure that the window stays put.

That done, you can affix the front panel label and cut out the holes with a utility knife.

Testing

Before testing the unit, you have to connect the Hall sensor leads to the microcontroller board. These connections, along with the power supply connections are made on the copper sides (see photo).

Now apply power – the display should show two dashes (- -). After about 5 seconds, the display should then show a value on the 7-segment LED displays and one or more LEDs should light in the bargraph. If this doesn't happen, check the voltages on the Hall effect sensor. There should be +5V on pin 1, 0V on pin 2 and nominally 2.5V on pin 3 (this could be between 2.25V and 2.75V, depending on the particular sensor).

You can test the dimming feature by holding your finger over the LDR. Adjust VR1 until the display dims to the correct level. This trimpot is best adjusted when it's dark, to obtain the correct display brightness.

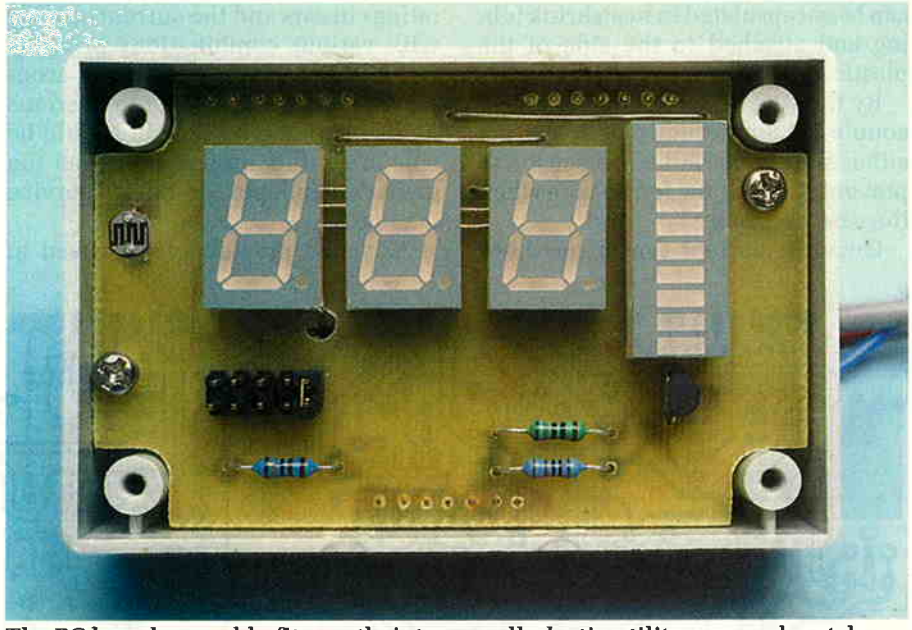
Calibration

The first calibration setting to be made is for the quiescent Hall effect output level. This is done by placing the jumper shorting plug across the "0" DIL launcher located on the display PC board. Just make sure the sensor is not located near any magnets when this is done.

The display should indicate "CAL" and the 0A LED should be lit on the bargraph display. Now remove the shorting plug after about one second and place it in the off position. The display will now return to normal operation and show a "0". Note that the off position is just a position to store the shorting plug and it does not form any connection to the circuit.

The unit must now be calibrated using a known current flow. The first step is to position the Hall effect sensor in the air gap of the ferrite core as shown in Fig.7.

In this case, the ferrite core is sim-



The PC board assembly fits neatly into a small plastic utility case and matches the style of our previous PIC-based automotive projects.

Table 3: Typical Lamp Ratings In Cars

Parking lights (front)	5W
Tail lights	5W
Licence plate	5W
Dashboard parking indicator	1.4W
Reversing lights	21W
Main brake lights	21W
High level brake light	18.4W
Dashboard brake indicator	1.4W
Headlights (high beam/low beam)	60W/55W
Dashboard high beam indicator	1.4W

Table 4: Total Load With Lights On (Typical)

Parking Lights + licence plate	25W (2.1A)
Reversing Lights	42W (3.5A)
Main brake Lights	42W (3.5A)
Main brake light + high level brake light	60.4W (5A)
Headlights (high beam, no low beam) + all brake lights + parking + licence plate	205.4W (17A)
Headlights (high beam with low beam) + all brake lights + parking + licence plate	315.4W (26A)

Fig.6: this is the full-size artwork for the front panel.

ply a voltage spike protector which is designed to clip over power leads to limit noise spikes. This unit uses a split core encased in a plastic housing that can be opened to accept the lead and then clamped shut again.

Fig.7 and the accompanying photos show how the Hall effect sensor is installed sandwich fashion between the two ferrite cores. The sensor board can be encapsulated in heatshrink tubing and attached to the side of the plastic case using a cable tie.

By the way, it's good idea to glue a couple of 1.5mm-thick plastic spacers either side of the Hall effect sensor, to prevent stressing the ferrite core when the case is closed.

Once the current sensor has been made up, clamp it to the battery lead(s). You can now calibrate the ammeter using either of two methods: (1) the "rough 'n ready" way using the current drawn by the car's headlights; or (2) the precise way by winding turns through the core to simulate a higher current.

We'll look at the rough 'n ready way first. Tables 3 & 4 show typical lamp ratings in cars and the currents drawn with various combinations of lights switched on. If you want better accuracy, check the ratings for the various lights in your vehicle, You should be able to get this information from the owner's handbook or from a service manual.

As stated previously, you need to calibrate at either 17A, 25A or 30A. From Table 3, you can see that if you switch on the headlights at high beam along with the brake lights and the parking lights, you will get a total current drain of about 26A (assuming a 12V battery).

This value should be satisfactory for calibrating the unit at 25A – just place the shorting jumper into the 25A position. The display will show "CAL" and the 25A discharge LEDs will light on the bargraph. That done, remove the jumper plug and replace it in the OFF position.

And that's it – the calibration is completed!

Note: some cars switch the low-beam lights off when the headlights are at high-beam and so the total current will only be around 17A. In this case, you calibrate the unit by placing the shorting plug in the 17A position.

Precise calibration

A more accurate calibration can be

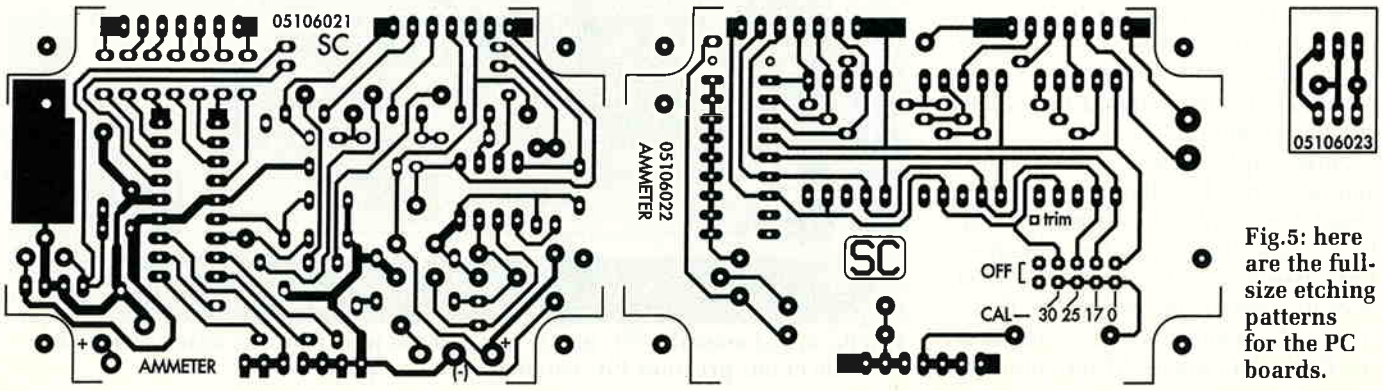


Fig.5: here are the full-size etching patterns for the PC boards.