Don't get caught with a flat battery

Build this car battery monitor

A flat battery is inconvenient to say the least. This simple electronic voltmeter lets you monitor the condition of your car's battery so that you can act before getting stranded.

by JOHN CLARKE

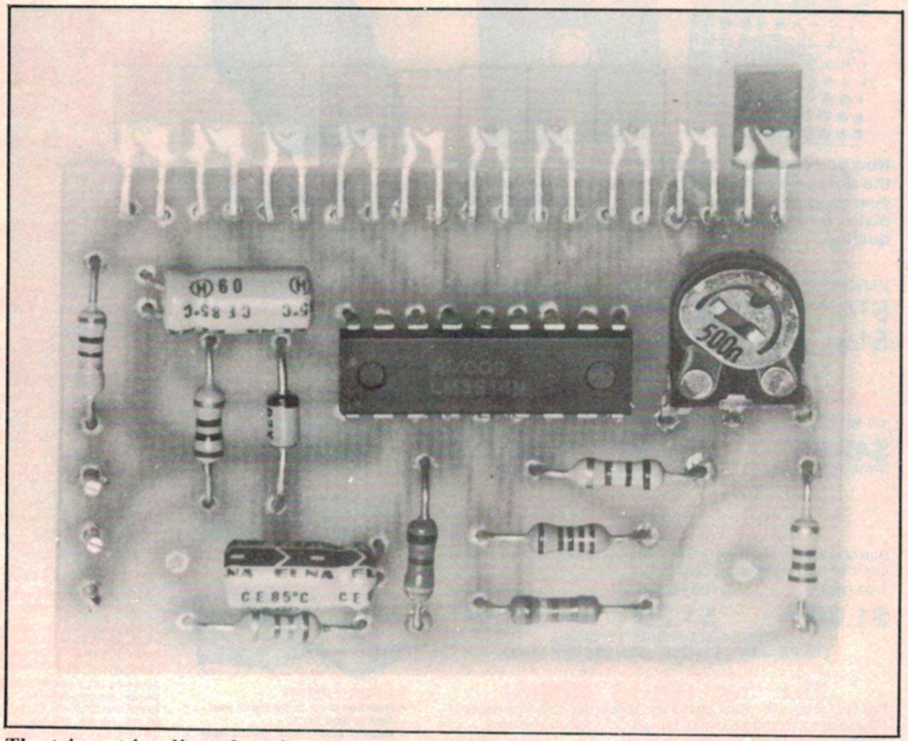
Most new cars these days are fitted with a voltmeter but there are many older cars (and still quite a few new ones) which lack this important accessory. A voltmeter allows you to monitor the condition of your car's battery and will quickly show up potential problems.

By far the most useful sort of voltmeter is the expanded scale type, with a range from about 11-15V DC. With this type of voltmeter, you can tell at a glance whether the battery is charged correctly, whether it is overcharging, or whether its voltage is low.

Our new Car Battery Monitor is of the expanded scale type but, instead of using an expensive mechanical meter with suppressed zero, it is fully electronic. The readout consists of 10 rectangular LEDs arranged as a bar graph. Three different LED colours are used to indicate "low", "normal" or "overcharging".

The first three LEDs in the sequence are yellow and these indicate the low condition, ranging from 11-12V (approx). Following these are six green LEDs which indicate the normal range from 12-14.4V. A single red LED completes the lineup and lights when the battery voltage exceeds 14.4V to indicate overcharging.

If the battery voltage is less than 11V, none of the LEDs light and you've really got trouble.



The trimpot is adjusted so that the red LED lights when the voltage reaches 14.4V.

What to look for

One of the most frustrating battery problems is when the vehicle will not start because the battery voltage is too low. The symptoms are easy to recognise: the motor struggles to turn over when cranked and refuses to "fire" because the ignition system cannot provide a satisfactory spark.

This problem could be due to a faulty cell in the battery or, alternatively, a bad battery contact. Quite often, a battery monitor will reveal any such faults before they become serious enough to disable the vehicle. Initially, an abnormally low battery voltage would be displayed when the battery is under load; eg, when starting or with the headlights on.

A more subtle battery problem can occur on a rainy night with the headlights, windscreen wipers, ventilation fan and other accessories all operating. If, in these conditions, the engine spends long periods at idle, as in heavy traffic, the alternator may not be able to cope with the load.

The result is a flat battery and a stalled car. As before, this problem can be prevented by monitoring and acting on the fall in battery voltage. In this case, it's simply a matter of turning off as many accessories as possible to reduce the load, and keeping the engine at a fast idle while the vehicle is stationary.

Another possible cause of battery problems is a broken alternator belt.

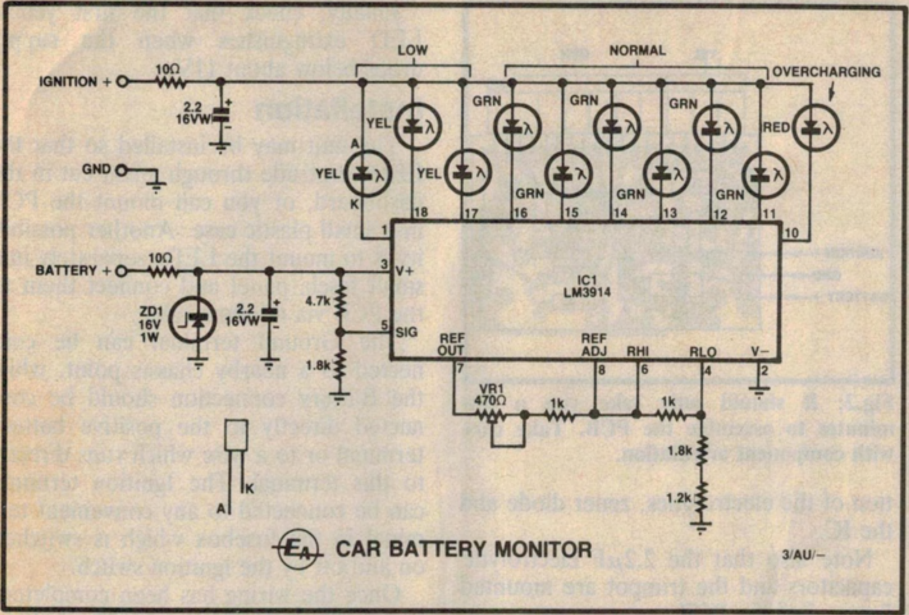


Fig.1: the circuit is based on an LM3914 dot/bar display driver IC.

While this problem should be immediately indicated by the alternator warning light, the battery monitor can provide useful reinforcement to alert the driver.

Finally, the battery monitor will detect if the regulator is faulty. If the regulator does not limit the voltage of the battery to 14.4V, then the final LED on the monitor will light to indicate overcharging. Note that overcharging will eventually lead to battery overheating, resulting in water loss and damaged cells.

How it works

The circuit is very simple and is based on an LM3914 dot/bar display driver IC. This IC monitors the analog input voltage and indicates the level on a LED display.

In this circuit, pin 9 has been left open circuit so that the IC operates in dot display mode; ie, it lights only one LED at a time. Alternatively, the IC can be made to operate in bar mode by connecting pin 9 to V+ (pin 3). In this mode, a column of LEDs will light to indicate the battery voltage.

Let's assume that the IC is wired in the dot display mode, as in our circuit. Here's what happens:

The incoming battery voltage is fed via a 10Ω resistor to pin 3 and is also clamped by 16V zener diode ZD1 which removes any potentially damaging voltage spikes. The voltage on pin 3 is then fed to a voltage divider network (4.7kΩ and 1.8kΩ) to derive a signal voltage which is fed to pin 5.

This signal voltage is equal to the reference high (RHI) input on pin 6 when the battery voltage is 14.4V, and equal to the reference low (RLO) input on pin 4 when the battery voltage is 10.8V.

What this means in practice is that the LEDs only light for input voltages greater than 10.8V. As soon as the 10.8V level is exceeded, the first yellow LED in the series lights. Each LED then lights in turn and the previous LED goes out as the battery voltage increases. The final LED in the sequence at pin 10 lights when the battery voltage exceeds the RHI voltage on pin 10.

The reference voltages are set using the Ref Out voltage at pin 7 to source current to a voltage divider consisting of a 1kΩ resistor between RHI and RLO and a 3kΩ resistor (1.2kΩ and 1.8kΩ in series) from RLO to ground.

The series 1kΩ resistor and 470Ω trimpot between Ref Adj and Ref Out set the current through the voltage divider to about 1mA. This gives the required 3V at RLO and 4V at RHI.

The supply for the LED anodes is derived from the ignition switch and decoupled with a 10Ω resistor and 2.2μF capacitor. Note, however, that the supply for IC1 is derived directly from the battery. This arrangement is used so that the circuit will not be affected by any voltage drop between the battery and ignition switch.

Construction

The parts for the Car Battery Monitor are all mounted on a small PCB coded 87vm3 and measuring 58 x 39mm. Follow the overlay diagram (Fig.2) carefully when installing the parts on the PCB and note the orienta-

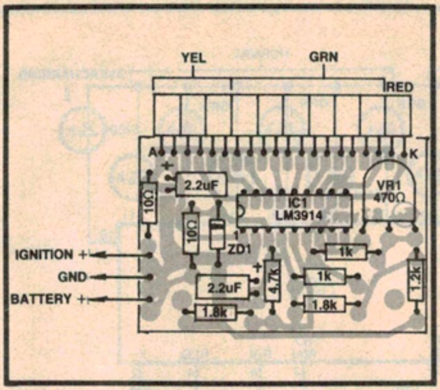


Fig.2: it should only take you a few minutes to assemble the PCB. Take care with component orientation.

tion of the electrolytics, zener diode and the IC.

Note also that the 2.2μF electrolytic capacitors and the trimpot are mounted flat against the PCB.

The LEDs should be installed so that they all line up to make a neat display. Make sure that they are all oriented correctly (see circuit diagram for pinouts) and initially solder only one lead first so that they can be easily adjusted. Once the LEDs are correctly aligned, the remaining leads can be soldered.

We used PC stakes for the three wiring terminal points, but these can be considered optional.

Testing

To test the unit, you will require a variable power supply (11 to 15V) and a multimeter. Connect the Ignition and Battery terminals of the monitor to the supply positive, and the Ground terminal to supply negative. This done, connect your multimeter across the power supply and adjust VR1 so that the red LED just lights at 14.4V.

Finally, check that the first yellow LED extinguishes when the supply drops below about 11V.

Installation

The unit may be installed so that the LEDs protrude through a slot cut in the dashboard, or you can mount the PCB in a small plastic case. Another possibility is to mount the LEDs separately in a small fascia panel and connect them to the PCB via rainbow cable.

The Ground terminal can be connected to a nearby chassis point, while the Battery connection should be connected directly to the positive battery terminal or to a wire which runs directly to this terminal. The Ignition terminal can be connected to any convenient terminal in the fusebox which is switched on and off by the ignition switch.

Once the wiring has been completed, the monitor should display the battery voltage whenever the ignition is on. Make sure that you don't disturb the setting of VR1 during installation otherwise you'll upset the reference voltages.

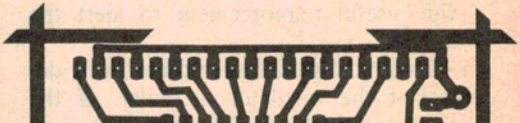
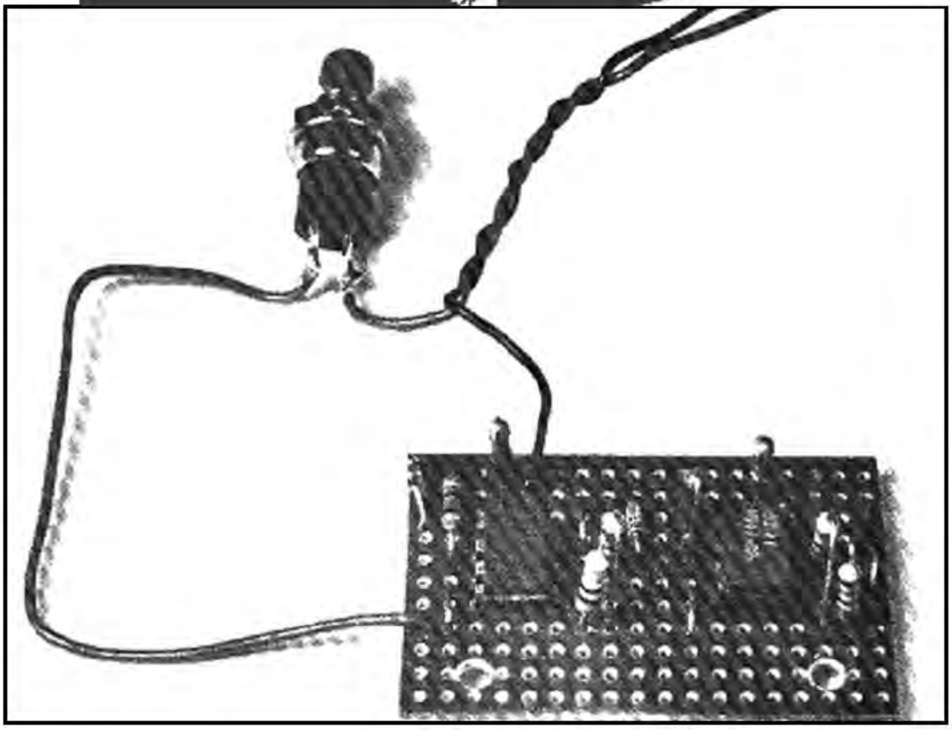


Fig.3: actual size PCB pattern. You can either etch your own board or buy a ready-etched board from from the usual retail outlets.

CAR BATTERY MONITOR

by Robert Penfold

* Check your battery condition instantly



This circuit, in common with the other five in the series which are featured in this issue, uses a multicolour LED. These are a fairly new development and will probably be unfamiliar to most readers, but they are basically little more than a red LED and a green LED in a single encapsulation. The type used in this series of projects have a common cathode connection and separate anode lead out wires, as can be seen from the lead out diagram of Figure 1. The light output of the component is viewed via a diffuser so that with both the red and green sections operating at once the two colours mix and a yellow output is obtained (or orange if the red light level is stronger than the green one). By operating just one section a red or green output can be obtained, and these LED's are therefore capable of producing three colours.

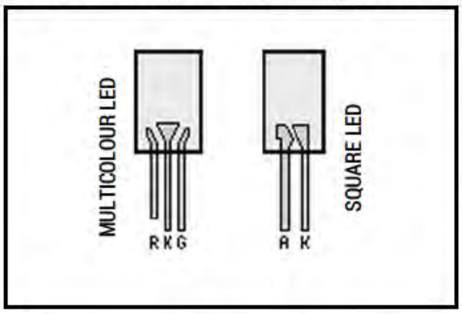


Figure 1. Multicolour LED lead outs.

This first project is a battery state indicator for use with 9 volt battery operated equipment, although it can easily be modified for use with a 12 volt car battery if preferred. If the battery is reasonably fresh and has a potential of about 8.2 volts or more the LED gives a green indication. If the battery is nearing exhaustion but is still usable, and has a potential of between about 7.5 and 8.2 volts a yellow indication is produced by the LED. A battery voltage of between about 5 volts and 7.5 volts produces a red light from the LED and indicates that the battery is overdue for replacement. Below about 5 volts the battery is inadequate to operate the device and the LED will fail to light at all!

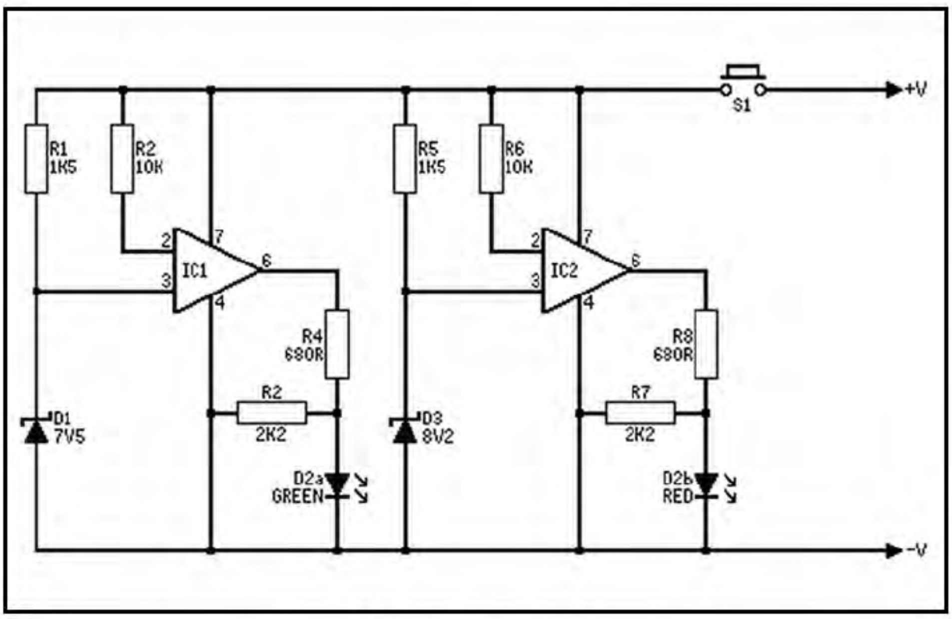


Figure 2. Battery monitor circuit diagram.

The Circuit

Figure 2 shows the circuit diagram of the Battery Monitor, and this is based on two 741C operational amplifiers which are used as voltage comparators in this application.

The green section of LED indicator D2 must switch on only if the supply voltage is above 7.5 volts since it should be off for voltages below this level when the red section alone must be switched on. D2a is driven from the output of IC1 by way of R4 and will be switched on when IC1's output goes high. The inverting input of IC1 is held at 7.5 volts by the zener stabiliser circuit which consists of R1 and DI, and the non-inverting input is taken to virtually the positive supply voltage due to the coupling through R2. Thus, assuming the supply

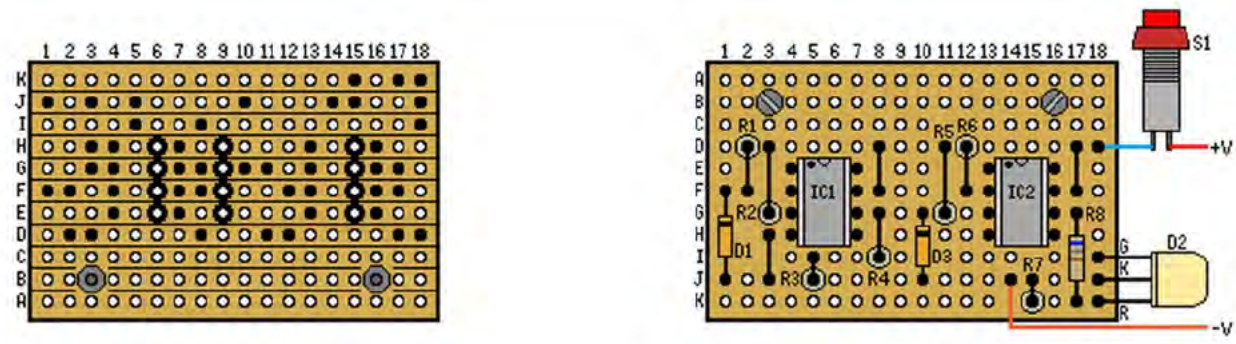


Figure 3. Veroboard layout for the battery monitor.

voltage is more than 7.5 volts, IC1's non-inverting input will beat a higher voltage than the inverting input so the output goes high and switches on D2a. If the supply potential falls below about 7.5 volts D1 no longer conducts significantly and has no effect on the circuit. As the voltage drop through R1 is less than that through R2, due to the higher value of the latter, the inverting input is at the high voltage. This results in the output going low and D2a switching off. R2 ensures that the voltage fed to D2a with IC1's output in the low state is not sufficient to cause D2a to operate at low brightness, which it might otherwise do.

It is necessary for the red section of D2 to switch off if the supply voltage is over about 8.2 volts, as only the green section is then needed. This is achieved using a circuit which is virtually the same as that used to control the green section of D2. Zener diode D3 has an operating voltage of 8.2 volts rather than 7.5 volts so that the threshold voltage of this section of the circuit is set at the required level. Also, the inputs of IC2 have the opposite method of connection to those of IC1 so that with the supply voltage above the 8.2 volt threshold level the inverting input is the one at the higher voltage. The output therefore goes low and D2b is switched off. If the supply potential falls below 8.2 volts the input states are reversed, IC2's output goes high, and D2b is switched on.

The circuit has a current consumption of around 10 mA which could result in a serious reduction in battery life if it were to be left operating all the time the main equipment was switched on. It is therefore connected to the supply lines via push button switch S1, and this is briefly operated in order to test the battery's condition. This method gives a negligible increase in the battery drain.

Construction

Like all six projects in this series, the Battery Monitor is constructed on a 0.1 inch matrix Veroboard, and in this case a board measuring 11 copper strips by 18 holes is required. Cut out a board of this size using a hacksaw and then file the sawn edges to a neat finish. Next drill the two 3.3 mm diameter mounting holes (which accept M3 or 6BA fixings) and make the twelve breaks in the copper strips at the points indicated in the layout diagram which is shown in Figure 3. There is a special tool available for making the breaks in the strips, but they can also be made using a modelling knife or a small twist drill.

Next solder the components and link wires into place, leaving the two integrated circuits and LED until last. The link wires are made from 22 swg tinned copper wire, and these can simply consist of pieces of wire trimmed from the component lead out wires.

Ideally the unit should be built into the main piece of equipment, and this will probably not be difficult in many instances. However, it can be built as a separate unit if necessary, and connected to the main unit via a twin insulated lead.

If the unit is required as a car battery monitor it is merely necessary to change D1 to a 10 volt component (a BZY88C10V) and D3 to a 12 volt component (a BZY88C12V). The LED will then be red for supply voltages below about 10 volts, yellow for voltages between approximately 10 and 12 volts, and green for supply potentials in excess of about 12 volts. S1 is not essential if the unit is used as a car battery monitor since the current drain of the circuit is insignificant when compared to the high charge capacity of a car battery.

PARTS LIST FOR THE BATTERY MONITOR

Resistors - all ¼ watt 5% carbon

R1, R5	1K5 Brown Green Red (2 off)
R2, R6	10K Brown Black Orange (2 off)
R3, R7	2K2 Red Red Red (2 off)
R4, R8	680R Blue Grey Brown (2 off)

Semiconductors

IC1, IC2	741C (8-pin DIL) (2 off)
D1	BZY88C7V5
D2	Two Colour LED
D3	BZY88C8V2

Miscellaneous

S1	Push to make non locking switch
	Veroboard 11 strips x 18 holes
	Interconnecting Wire