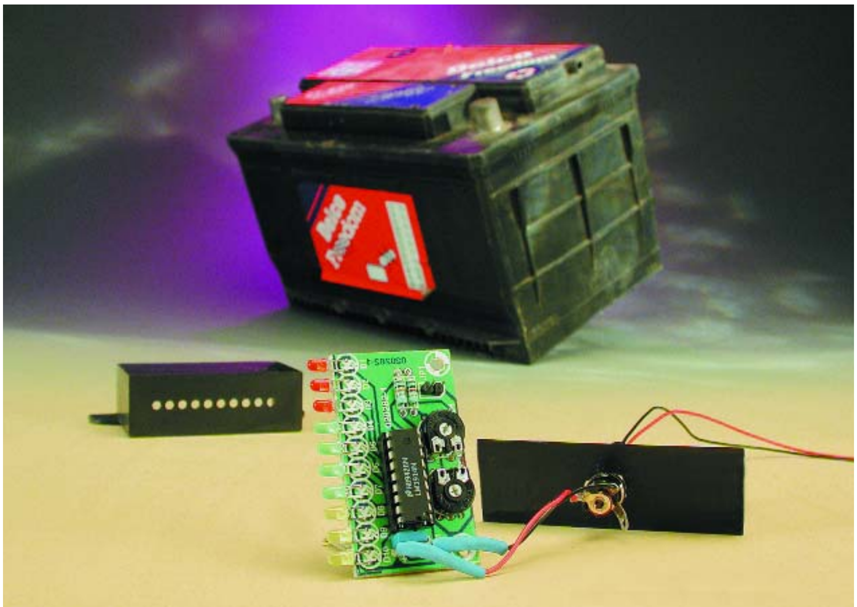
Battery Voltage Guard

adjustable to any voltage

Design by A. Schilp

This month's Mini Project may be used to guard any voltage ranging from a minimum of 3 V to a maximum of 25 V. It can, therefore, be used to keep a constant eye on the voltage of a car battery. But it can also be used with the receiver batteries of a radio-controlled model, for example.



Even though this is an extremely simple electronic circuit, the voltage guard, equipped with a 10-segment LED display, offers a number of distinct advantages. Firstly, this circuit is very compact, it can therefore easily be built into a suitable case — the circuit board is no bigger than a matchbox and there will generally be no problem to find some space for it. Secondly, the circuit (especially when in 'dot-mode') is very thrifty with current. The third, and by no means the least important advantage, is that the circuit can be used in a large number of different applications, because the voltage range that can be guarded can be varied over quite a wide range. A voltage of 3 V is the minimum (the circuit doesn't work below that) and 25 V is the maximum (it will break down above that level). But within that range, the guard voltage can be freely chosen with the aid of two potentiometers. As a consequence, the application need not be limited to a voltage guard for a car battery — the circuit may also be used as an indicator for the batteries used in radio-controlled models, battery-powered drills and lawn mowers, etc. It may also be used as a battery tester, but only with batteries having a terminal voltage of 3 V or higher; testing of individual 1.5 V cells is not possible.

LM3914

The circuit has been designed around the integrated display driver type LM3914, which — we can safely assume — is familiar to *Elektor Electronics* readers. This IC by itself is actually a complete voltmeter circuit because it was designed to indicate a varying input voltage directly on an LED scale. Internally, the LM3914 contains 10 comparators with a current source output, plus a reference source and a ladder shaped voltage divider that provides the necessary reference voltages.

Figure 1 illustrates that the circuit contains hardly any more components than the LM3914 and the ten (high-efficiency) LEDs. The lower limit of the measuring range, at which the first LED of the scale (D10) will light, is adjustable with P2. The upper limit is set with P1. Every LED in the scale represents one tenth of the measuring range. If the voltage remains below the lower limit then no LED will be on. When the voltage is higher than the upper limit, D1 will remain on.

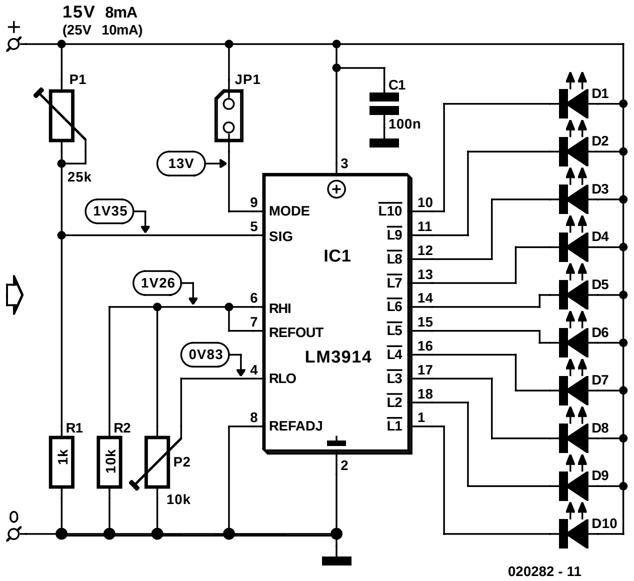


Figure 1. All that is required for the battery guard is already present in the LM3914.

which therefore also acts as the power supply for our circuit. A nice feature is that by making use of the reference voltage of 1.25 V on pin 7, the measurement value indicated by the LEDs always corresponds to the power supply voltage to be measured, without affecting the accuracy.

Indeed, the brightness of the LEDs is not affected by the power supply voltage either — a consequence of the above mentioned current source outputs. The load presented by the parallel combination of R2 and P2 to pin 7 defines the operating point of these current sources. When calculating the current through the LEDs, you'll find that this current is about 10 times greater than the current through R2 and P2. Because the voltage at pin 7 is 1.25 V, the current for each LED amounts to 1.25/5000 = 2.5 mA. That is exactly the current to suit a high-efficiency LED. If required, the current may be increased by lowering the value of R2.

Dot or bar

The LM3914 can operate in either dot- or bar-mode. In the first case, only one LED will be lit. In the second case all the LEDs below the relevant LED will also be on. The selection between the two modes is made using pin 9: if this is left open then the IC operates in dot-mode. When jumper JP1 is in place, bar mode is selected. Keep in mind that the current consumption and power dissipation of the IC are considerably higher in bar-mode. This is not much of an issue with voltages up to 15 V. However when the input voltage is 25 V, the dissipation increases to 625 mW and at that level the LM3914 will become quite hot.

The current consumption of the circuit amounts to about 6 to 7 mA, to which the LED current has to be added. All current is obtained from the voltage source to be guarded,

COMPONENTS LIST

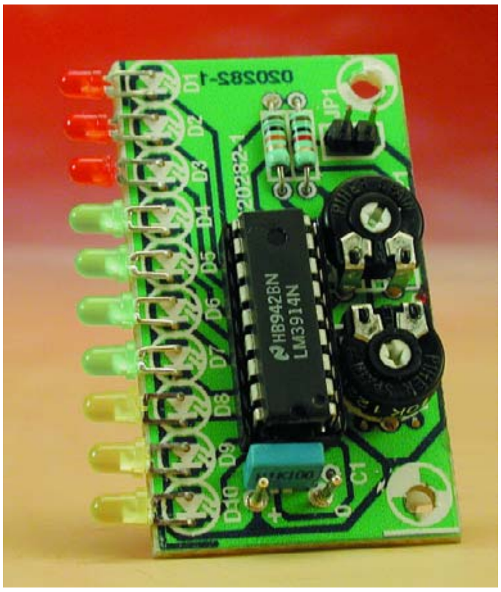
Resistors:
R1 = 1kΩ
R2 = 10kΩ
P1 = 25kΩ preset
P2 = 10kΩ preset

Capacitors:
C1 = 100nF

Semiconductors:
D1-D10 = high-efficiency LED
IC1 = LM3914N

Miscellaneous:
JP1 = jumper

PCB layout also available from www.elektor-electronics.co.uk (Free Downloads)



Construction

Figure 2 shows the layout for the small circuit board designed for the voltage guard. This board is unfortunately not available ready-made. As you can see, every component has been given a suitable place on the board, and because there are so few of them, there is very little to say about the construction. In practice it is handy to use LEDs of a few different colours, for example, red for voltages that are too low, green for correct and yellow for values that are too high. That way, in one glance you can determine if there are grounds for concern.

Another detail worth noting: on the circuit board near P1 and P2 there are a number of additional holes. The purpose of these is to

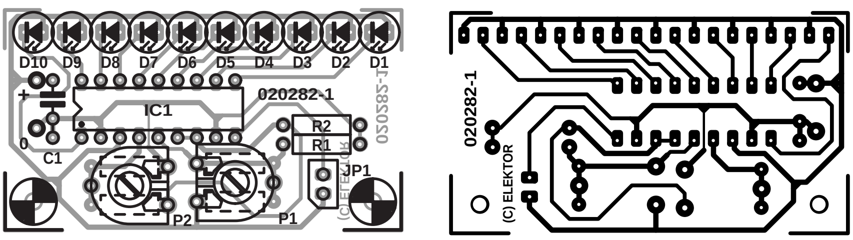


Figure 2. The printed circuit board is so small that building it into a suitable case should not present a problem.

allow the option of replacing the trimpots with fixed resistors, once the correct value has been determined and does not have to be adjusted any more. The advantage is that fixed resistors are much more stable than trimpots and are affected to a lesser extent by dust and ageing.

Adjustment

P1 and P2 allow practically any desired measuring range to be set. We will use a car battery as an example. Because the charging voltage is typically about 14.4 V, it is appropriate to set the upper limit with P1 to about 15 V, for example. This is easily done by temporarily connecting the circuit to a regulated power supply and turning P1 until D1 lights. Make sure that during this adjustment P2 is turned fully clockwise, otherwise undesirable side effects may occur.

Next, we need to determine which voltage the lowest LED should indicate. If, for instance, we would like steps of 0.5 V per LED, the series becomes 15-14.5-14-13.5-13-12.5-12-11.5-11-10.5. We now set the regulated power supply to 10.5 V and turn P2 until the lowest LED is lit. Done!

In exactly the same way it is possible, of course, to make steps of only 0.33 V or 0.25 V, or larger steps of 1 V. Start by first turning P2 fully clockwise, adjust the upper voltage with P1, followed by the lower voltage with P2. You will observe that with very small steps, 1/10 V for example, the LEDs will turn on and off slowly; it is possible therefore, that at a certain voltage two LEDs will be on at the same time.

Measuring

Keep in mind that an unloaded battery, even when nearly fully drained, can still present a terminal voltage that is close to a full battery. So, in order to obtain a sensible measurement, it is always necessary to test the battery while it is connected to its normal load.

Connecting the indicator to a car battery can be done very easily without touching any of the car's wiring. The cigarette lighter socket is eminently suitable for this purpose. The special plug is widely available, the outside springs are connected to the 'negative' of the battery and the centre pin is connected to the 'positive'.

A final closing remark: because the power supply voltage of the battery guard is equal to the value to be measured, it is, in this case, not possible to add a series diode to protect against reverse polarity. So, each time when connecting the battery to be tested, make e sure the plus and minus terminals are not reversed!

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