VEHICLE BATTERY

Karel Walraven

This design is a follow-up to the triumphant 'Battery Revitaliser' project published in the September 2001 issue of *Elektor Electronics*. From numerous reader responses, it appears that defective batteries are a common problem. Since prevention is naturally better than cure, here we present a circuit that can keep your battery in shape in a simple but effective manner.

JOGGER keep your battery fresh and young

The quality of lead-acid storage batteries has always been an awkward subject. Motorcyclists among our readers will be the first to agree with this. The most common example is a motorcycle that's put in storage for the winter and proves to have battery problems when spring comes. This involves more than just the fact that the battery has become partially discharged, since in many cases the battery has also noticeably deteriorated. That can be seen from the fact that even immediately after being charged, it performs poorly and quickly loses it charge.
This is also true for all situations in which lead-acid batteries are not used for an extended length of time. You might immediately think of cars 'put away' for the winter, but this problem also occur in other situations, such as batteries in backup power supplies (UPSs) that are not used for a while, batteries used with voltage inverters (in caravans), and batteries in pleasure boats that simply sit around doing nothing for most of the year after the boating season is over. It's thus easy to think of situations in which lead-acid batteries age prematurely due to lack of use. The inset provides additional information about the background of the process responsible for all of this, which is called 'sulphation'.

Idleness is deadly

For the purpose of this article, it's actually not necessary to know exactly why unused batteries deteriorate. It's sufficient to note that a bit of exercise at the right time can help keep them in shape. And that's what the circuit described here provides.
Unlike the 'Battery Revitaliser' described in the September 2001 issue of *Elektor Electronics*, this design is not intended to resuscitate apparently defective batteries, but instead to prevent premature aging due to lack of use. To avoid possible misunderstandings, it should be noted that this circuit cannot counteract normal aging or other conditions that can lead to defects.
As the whole idea is to keep the battery a little bit active, the circuit does not require a separate power supply. The necessary energy is simply taken directly from the battery itself. In the process, sulphation is prevented by loading the battery with a hefty current (40 A) for a short interval (50 µs) approximately every two minutes. Of course, this will ultimately cause the battery to discharge more quickly, but a fully charged car or motorcycle battery will easily make it through the winter. After all, the current consumption at 12 V is only around 2 mA.

Operation

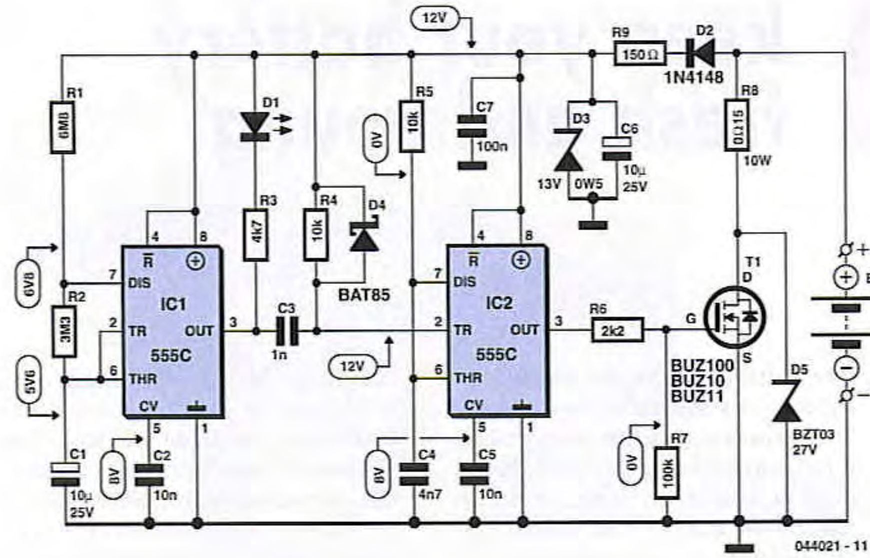
The first 555 timer (IC1 in **Figure 1**) operates as an astable multivibrator and generates a continuous stream of pulses. The second 555 is a monostable multivibrator that is triggered on each negative edge of the pulses coming from its companion. As a result, it generates short pulses that drive power FET T1 fully on. The FET connects the battery directly to a power resistor, causing a heavy current to flow. The size of this current is primarily determined by the value of resistor R8.
The FET is intentionally driven here via a gate stopper resistor with a relatively high value. This causes it to switch on and off somewhat more slowly, which reduces the amount of interference generated. In this case, 'slow' means a few microseconds; a FET that's driven hard switches within a few nanoseconds. Here it isn't necessary to switch quickly, and there's no need to be concerned about a bit of extra power dissipation. Despite the relatively slow switching, rather large voltage spikes can occur when the FET switches off. It is thus essential to connect a **fast** Zener diode (D5) across the FET for protection.

Construction

It's important to ensure that the ICs and IC sockets are fitted with the correct orientation. The sockets usually have a notched or bevelled corner, and the ICs have a dimple in the package. As seen from above, the topmost pin to the left of this marking is pin 1. It's best to use CMOS versions of the ICs, since this will keep the standby current consumption as low as possible. Several different manufacturers make the CMOS version of the 555, so type numbers such as TLC555, ICM7555 and LMC555 (as well as many others) all refer to the same kind of IC. However, the NE555, SE555 and LM555 are not CMOS types. They can also be used, but the current consumption will then be quite a bit higher (more than 10 mA).
Most of the current is actually used by the LED, so you should use a low-current type here (also referred to as a '2-mA LED'). When fitting it to the circuit board, make sure the long lead goes next to the triangle marking.
The capacitors in the circuit (except for the electrolytic capacitors) are ceramic types. That's because component value tolerance is not terribly important in this case, and a bit of temperature dependence also doesn't particularly matter.
New electrolytic capacitors also have one lead that's longer than the other one. That's usually the positive lead. On the circuit board, it must be placed next to the open rectangle. There's usually also a white stripe with minus (–) signs printed on the case of the capacitor. This marks the negative lead, which is indicated on the circuit board by a solid rectangle (the open rectangle is the + terminal).

Safety

Most people don't realise that despite the modest voltage, working with vehicle batteries can be quite hazardous. This is because such batteries can deliver especially high currents. That means you have to be especially careful with metal objects in the vicinity of a charged battery. A dangerous short circuit can be caused not only by a simple screwdriver or wrench, but also by dangling jewellery and wristwatches, both of which are notorious causes of avoidable suffering.



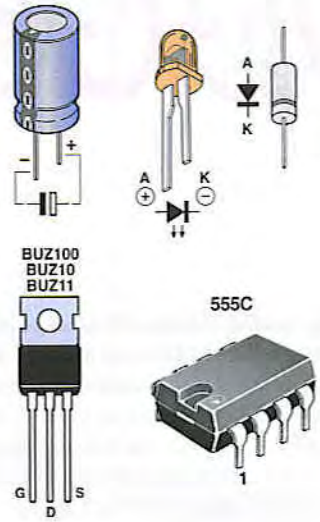
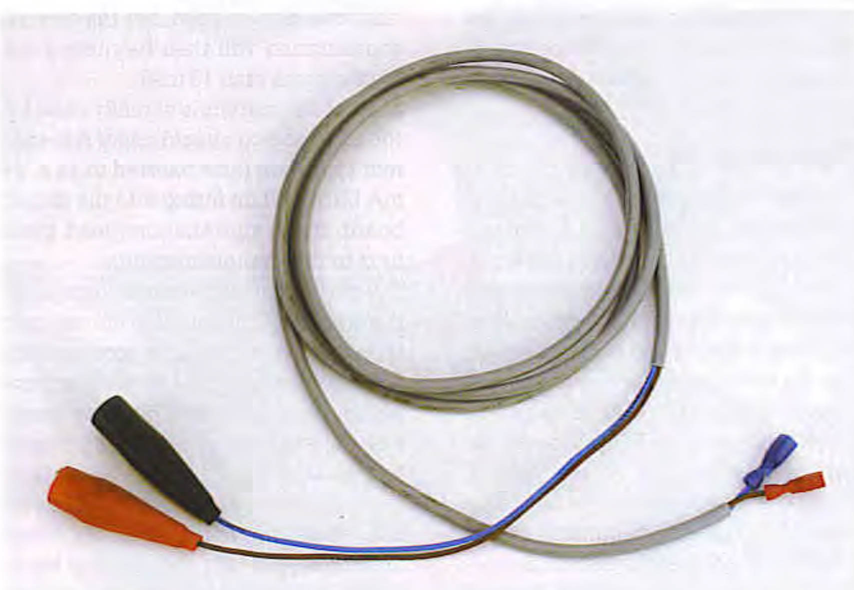


Figure 1. The general-purpose 555 once again proves its merits.



Prevent short circuits; make sure you use a properly insulated cord!

If something goes wrong with the circuit, there's thus an especially good chance that something will be destroyed. Normally, the victim will be the power resistor, the FET (see the inset) or a track on the circuit board. It's certainly possible for this to be accompanied by the release of heat, or even a bang and a bit of smoke. Consequently, you should always fit the circuit in an enclosure and ensure that no flammable materials are in the vicinity. Disconnect the circuit before charging the battery in the usual manner. Use flexible mains cable with a reasonably large cross-section (2×0.75 mm^2, for example) for the connections to the battery.

Everything OK?

For initial testing, we recommend leaving C1 off the circuit board and tem-

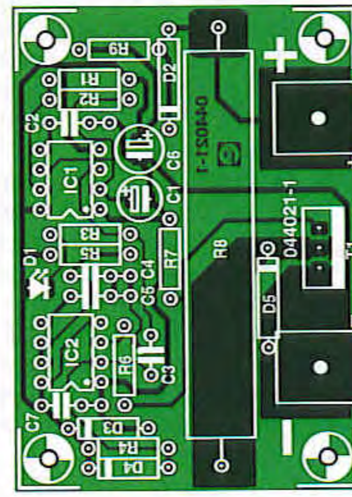
Figure 2. The circuit can be safely built using this printed circuit board design. Copper track layout available from our website.

COMPONENTS LIST

Resistors:
R1 = 6MΩ8
R2 = 3MΩ3
R3 = 4kΩ7
R4,R5 = 10kΩ
R6 = 2kΩ2
R7 = 100kΩ
R8 = 0Ω15, 5W or 10W
R9 = 150Ω

Capacitors:
C1,C6 = 10µF 25V, radial
C2,C5 = 10nF
C3 = 1nF
C4 = 4nF7
C7 = 100nF

Semiconductors:
D1 = LED, low current
D2 = 1N4148
D3 = zener diode, 13V 0.5W
D4 = Schottky diode, e.g., BAT43, BAT85
D5 = fast zener diode, e.g., BZT03 24V, 27V or 33V)
T1 = BUZ10, BUZ11, BUZ100 or IRF540
IC1,IC2 = 7555 (CMOS)
PCB, ready-made, order code **044021-1** (see Readers Services page). PCB layout available from Free Downloads section on www.elektor-electronics.co.uk



FETs

We have listed several options for FET T1, but the choice here is not critical. It's also unnecessary to make any changes to the circuit if you use it at 6 V. Still, in this case the preferred type for T1 is the IRF540. That's because this type of FET works with a lower gate voltage than the FETs in the BUZ family. For the same reason, FETs designated as 'logic-level FETs' are more suitable if you want to use the circuit at 6V, but they aren't essential. In principle, you can thus use any desired type of n-channel power FET that can handle at least 20 A at 50 V.

You're probably wondering how a FET rated at 20 A can handle a current of 40 A or more. To understand why this is possible, have a look at the 'Safe Operating Area' chart for the BUZ10 (**Figure 3**). It shows how much current can flow continuously (20 A), and how much current can flow for a short time. As the FET only conducts for a few tens of microseconds each time, the maximum allowable current during this short interval is just under 100 A. This information can also be obtained from the 'Absolute Maximum Ratings' in the date sheet, which specify 23 A and 92 A respectively.

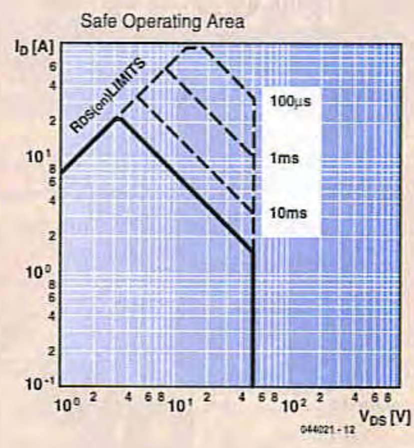
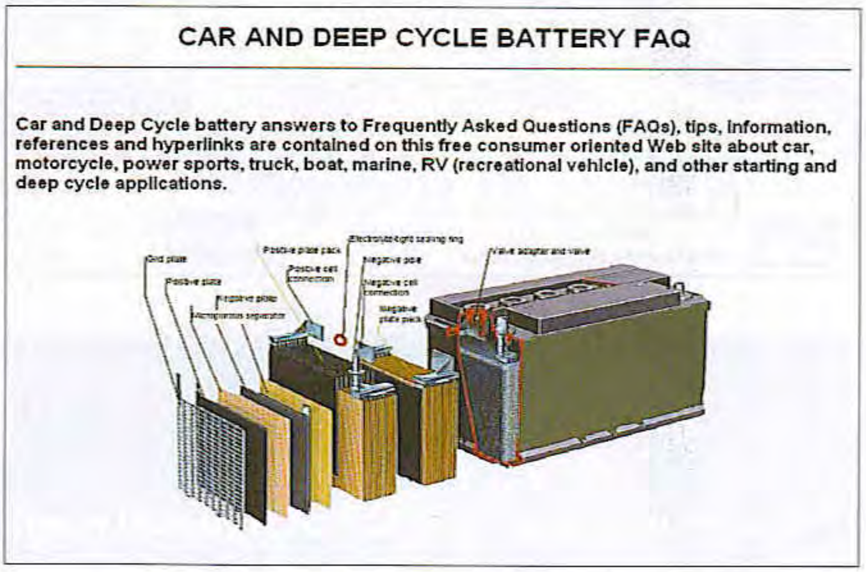


Figure 3. Safe Operating Area: maximum currents and voltages for the BUZ10.

porarily soldering a 100-nF capacitor to the board in its place. The LED should then flash approximately once a second. With a 10-µF capacitor fitted in this position, the period is a lot longer (2 to 3 minutes), and that's not so nice for testing. If the lamp blinks, you can confidently solder the 10-µF capacitor in place on the circuit board.

Voltages are marked at various places on the schematic diagram. If the circuit does not immediately work the way it should, you can compare your circuit with our tried & tested prototype by measuring these voltages. Here we should note that if you make measurements on pen 2, 6 or 7 of IC1, proper operation of IC1 will temporarily be disturbed, and you may have to wait a little while for the reading to stabilise. The stated values were measured using an electronic multimeter (10 MΩ impedance).



You can learn a lot more about lead-acid batteries and the dreaded sulphation process (among other things) at www.uuhome.de/william.darden/.

Six volts too

Many old-timers (vintage cars and motorcycles) use 6-volt batteries. Strictly speaking, this voltage is usually bit on the low side for switching a FET fully on. As a result, in practice the current through T1 will be a bit smaller, but it will still be sufficient to ensure obtaining the proper effect (keeping the battery fresh). It's thus not necessary to reduce the value of R8, since the circuit is designed to be used with 6-volt and 12-volt batteries without any modifications.

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Sulphation

The capacity of a lead-acid battery gradually decreases during its service life due to normal wear and tear, for a variety of reasons. However, the aging process is considerably accelerated if an uncharged battery is stored for longer than a week at a temperature below 10 °C or remains unused (while charged) for an extended length of time. That's because in such situations, a layer of non-conductive lead sulphate ($PbSO_4$) forms on and around the electrodes. This reduces the effective surface area of the electrodes, thus decreasing the capacity of the battery. This process is difficult or impossible to reverse by normal charging and discharging.

However, it is possible to break down sulphate crystals into lead and sulphuric acid by using high (or very high) charging currents. This method can be used to restore at least part of the lost capacity (see 'Lead-acid battery revitaliser' in the September 2001 issue). Still, it's better to prevent the formation of sulphate. One way to do this is to periodically apply a load to the idle battery. The circuit described in this article is especially suitable for this purpose.