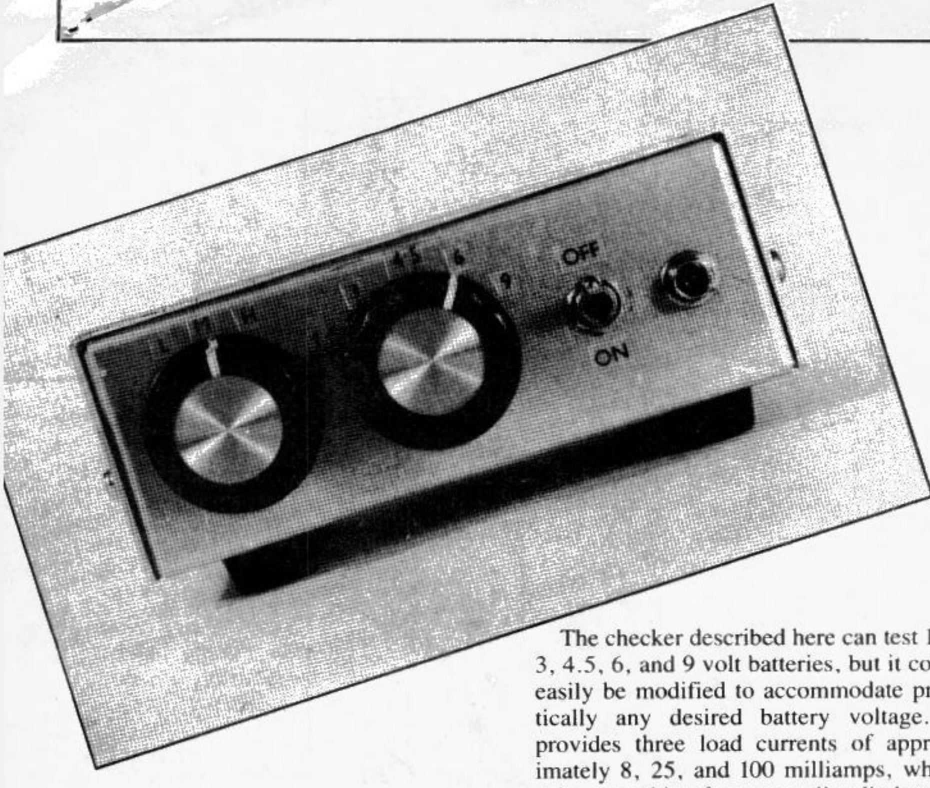
Household Battery Checker

Testing ordinary dry cell batteries with a multimeter is deceptive, because the normal load current is not present. This battery checker provides the right environment for checking them accurately.

By Robert Schmidt



BEING PRESENTED with batteries to be tested is somewhat of an occupational hazard for any electronics hobbyist. It would seem that this would be a deceptively easy task to perform; a simple voltage check with a multimeter is all that is required. A voltage test will confirm that a battery is exhausted if the measured voltage is well below the stated battery voltage, say about 75% or less. On the other hand, the battery might produce a potential which is quite close to its rated voltage, but could nevertheless be completely unusable in most pieces of equipment.

The cause of ambiguous results of this kind is the drop in battery voltage which occurs when high load currents are drawn. A battery might provide a perfectly respectable voltage when removed from the equipment in which it has been used, but could give as little as 50% of its rated voltage when replaced in the equipment and put to use.

One way around the problem is to always measure the voltage while the battery is in the equipment and the latter is operating, so that a loaded reading is obtained and any voltage drop the loading produces will be readily apparent. Although this might seem like the ideal solution it's not possible if you are only given the batteries and not the equipment from which they were taken, and in practice it can often be difficult to measure the battery voltage under operating conditions. This is just about impossible with flashlights for example. A more practical approach is to measure the voltage while using a resistor to load the battery with an appropriate current drain or, better still, to build a proper battery checker.

The checker described here can test 1.5, 3, 4.5, 6, and 9 volt batteries, but it could easily be modified to accommodate practically any desired battery voltage. It provides three load currents of approximately 8, 25, and 100 milliamps, which suits everything from a small radio battery to a large torch cell. The unit is very simple to operate, and a LED is used to indicate whether or not the battery under test is serviceable or exhausted.

Internal Resistance

The drop in voltage that occurs is something that can be rather puzzling to beginners in electronics, but it always occurs when power is drawn from any voltage source, including such things as the output of a hi-fi amplifier or the supply from an AC outlet. The cause of the voltage drop is internal resistance within the voltage source. Fig. 1 shows a voltage source loaded with a resistance Rb. Ra represents the internal resistance of the battery, and although in reality this is a resistance within the fabric of the battery, and dispersed throughout the battery, the effect is just the same as if it was a resistor connected in series with one of the output leads.

In this example the internal resistance is 10R, and the load resistance is 90R. By a straightforward potential divided action, one tenth of the battery voltage is dropped across the internal resistance, causing the output voltage to drop from 9 volts to 8.1 volts. Although these figures are only given as a simple mathematical example, a voltage drop of this order is quite typical for a 9 volt radio battery when it is operated at high volume levels. With a small 9 volt battery when nearing exhaustion the internal resistance can be as much as 50R. For something like a freshly charged high capacity NiCad battery the internal resistance could be as low as a few milliohms. Internal resistance is an important factor since it limits the maximum voltage and current that a battery can provide, and it renders certain types of battery unusable in some applications. A small radio battery could not provide the high currents needed to drive flashlight bulbs for instance.

Checker Operation

There are really two separate sections in the circuit; one to place a controlled load on the battery, and the other to check whether or not the battery voltage is higher than a certain threshold level. The load is provided by a constant current generator. This is more convenient than using a load resistor as it prevents any significant change in load current even with very large changes in the battery voltage. This avoids the need to have numerous switched load resistors with a separate resistor for each test voltage, and a separate set of resistors for each load current. As explained previously, three load currents are provided so that the current drain can be matched to suit the capacity of the test battery.

The voltage tester is built around a voltage comparator and a highly stable 1.15 volt reference source. The output of the precision voltage source is connected to the inverting input of the voltage comparator. The output of the comparator goes to virtually the negative supply potential if inverting (-) input is at a higher voltage than the non-inverting (+) input, or to virtually the full positive supply potential if the comparative input levels are reversed. An indicator LED is connected from the output of the voltage comparator to the positive supply rail. The LED therefore switches on if the non-inverting input is taken below 1.15 volts, or switches off if the non-invert-

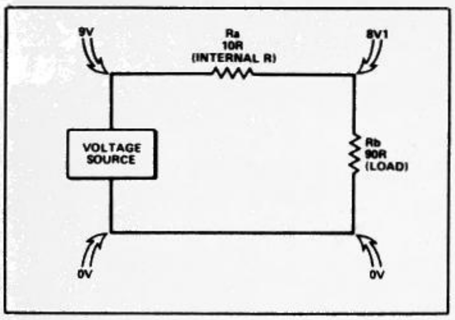


Fig. 1 A diagram representing the voltage drop when a voltage source is loaded.

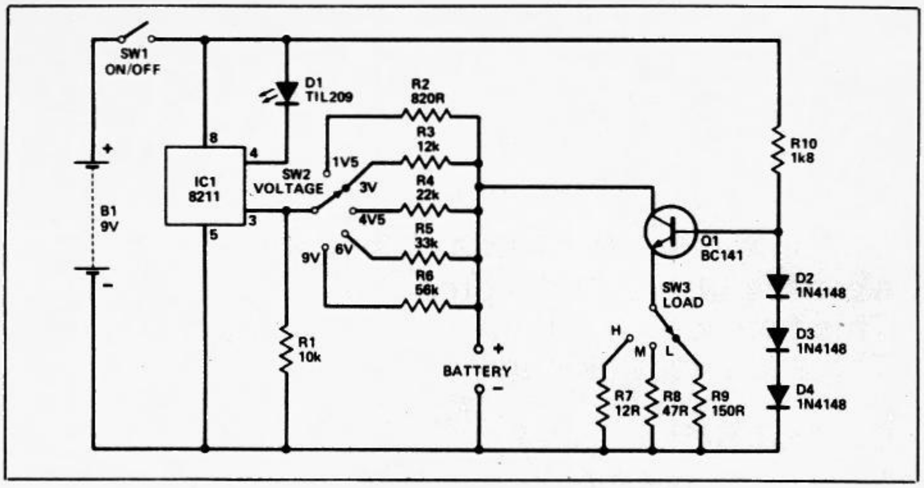


Fig. 2 The circuit is built around IC1, a precision voltage detector which gives a reliable reference voltage against which the battery voltage is checked.

ing input is taken to a higher potential than 1.15 volts.

The non-inverting input is fed with the output voltage of the battery, but via an attenuator which reduces the battery voltage to a suitable level. For instance, a 6 volt battery when under load and in usable condition would provide a potential of about 5 volts or more. The attenuator resistors would therefore have values calculated to give an output voltage of 1.15 volts with an input potential of 5 volts. If the battery voltage was above the 5 volt threshold level the voltage fed to the comparator would be more than 1.15 volts and the LED indicator would switch off to indicate that the battery was serviceable. If the battery potential was below the 5 volt threshold then the input voltage to the comparator would be less than 1.15 volts, and the LED would stay lit up to indicate that the battery was exhausted.

There is a very narrow range of battery voltages that gives an indeterminate output state from the comparator and something less than full brightness from the LED indicator. If the LED should only partially switch off it is best to take this as an indication that the battery is no longer reliable and to replace it, but in use an indeterminate LED stage may never be obtained as the range of voltages that give this effect is so restricted. It is more likely that the LED would switch off initially, and then turn on again as the battery voltage gradually falls below the threshold level under load. Again, it is probably best to take this as an indication that the battery is no longer usable and to renew it.

In practice there are five switched resistors in the upper arm of the attenuator, enabling the unit to check batteries of five different voltages. A current generator is included at the output of the comparator, but this merely sets the LED current at a suitable figure and does not play any active role in the operation of the unit.

Circuit Operation

A precision voltage detector integrated circuit (IC1) is at the heart of the unit, and it permits a very simple circuit to be used. The full circuit diagram of the checker appears in Figure 2.

IC1 contains the reference voltage generator, voltage comparator, and the constant current generator which sets the 'on' current of LED indicator D1 at a nominal figure of 7 milliamps. The attenuator is formed by R1 and whichever one of the five switched resistors (R2 to R6) is selected using SW2. For the record, the theoretical threshold voltages are 1.2443, 2.53, 3.68, 4.945 and 7.95 volts. R1 to R6 are all closer tolerance (1%) resistors, and coupled with the precision of the reference source of IC1 this gives good accuracy and reliable results without the need for any adjustment to the finished unit.

The circuit is not powered from the battery under test, but is powered from its own internal 9 volt battery. This gives better reliability and enables a wider battery voltage range to be accommodated. It is quite easy to calculate the series resistor value for voltages not included here if you wish to change the battery voltages covered by the unit. Simply multiply the required threshold voltage by 8.7 and then deduct 10. This gives the value of the series resistor in kilohms. It is unlikely that the required value will coincide precisely with a preferred value, and it is then a matter of either choosing the nearest preferred value or making up the required value from two or three resistors connected in series. Remember that the loaded output voltage of a battery which is in usable condition but nearing exhaustion is generally about 15% or so less than its stated output voltage.

The constant current generator which provides the load for the test battery uses Q1 in a conventional constant current generator circuit. R10 and the series of three diodes provide a potential of about 1.9 volts at the base of Q1, and taking into account the voltage drop across the base-emitter junction of Q1 this gives a potential of about 1.2 volts across the emitter resistor selected using SW3. The three switched resistors (R7 to R9) give three different emitter currents. The battery under test feeds direct into the collector circuit of Q1, and as the collector current of a transistor is virtually identical to the emitter current, the current drain on the battery is mainly determined by the emitter resistance of Q1 and is largely independent of the test battery's voltage.

In Use

When the completed unit is switched on the LED indicator should light up. If it does not, switch off immediately and thoroughly recheck the wiring (including the polarity of D1 which can only light up if connected properly).

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PARTS LIST

Resistors
(All 0.4W 1% metal film)

R1	10k
R2	820R
R3	12k
R4	22k
R5	33k
R6	56k
R7	12R
R8	47R
R9	150R
R10	1k8

Semiconductros

IC1	8211
Q1	2N2297
D1	TL209 or similar panel LED
D2,3,4	1N4148

Miscellaneous

SW1	SPST sub-min toggle switch
SW2	6 way 2 pole rotary with end stop (set for 5 way)
SW3	3 way 4 pole rotary
B1	9 volt

Printed circuit board; case about 133 x 102 x 38mm, two control knob, battery connectory, 8 pin DIL IC holder, 3.5mm jack socket and test leads, wire solder etc.

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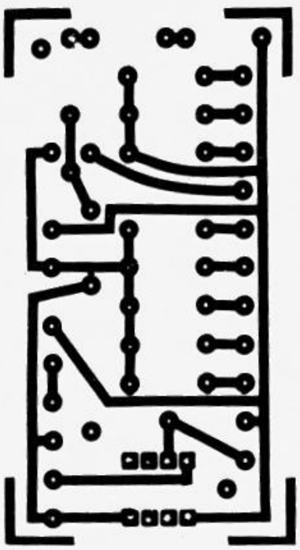

The PCB for the Battery checker.

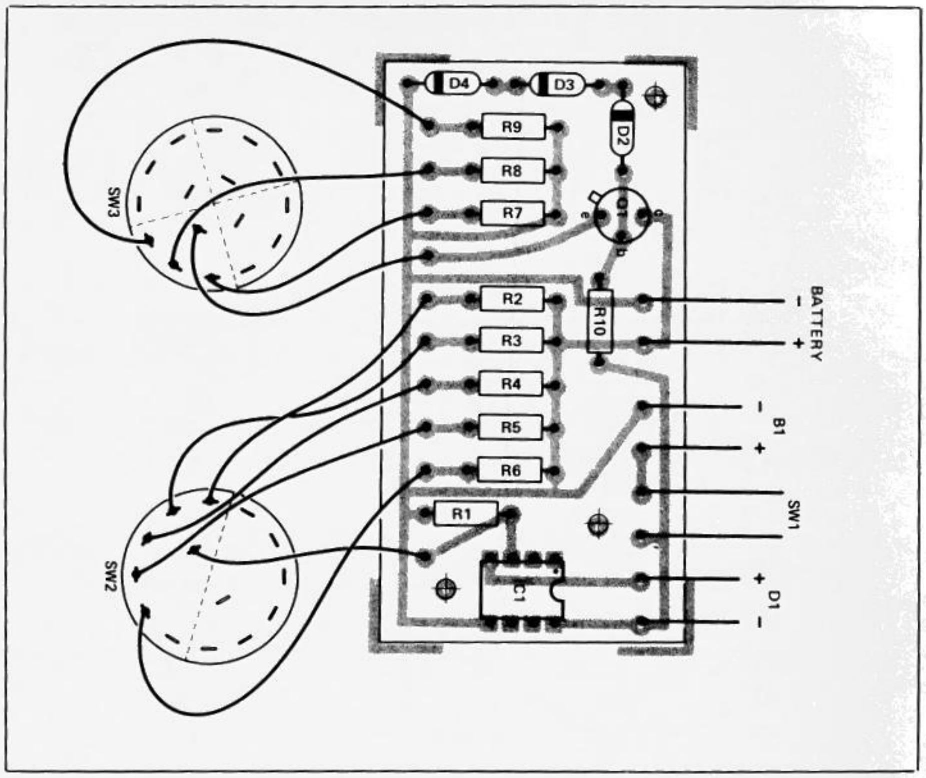

Fig. 3 The PCB layout. Use an IC socket to protect the 8211. The battery under test is connected via leads to a jack socket on the rear of the case.

If D1 does switch on, try connecting a fresh battery to the input of the unit with SW2 and SW3 set at appropriate positions. This should, of course, result in D1 switching off while the battery is connected. If you should inadvertently connect a battery to the unit with SW2 at the wrong voltage setting this will not result in any damage to the checker provided the battery has a nominal voltage of 9 volts or less.

The load current used depends on the capacity of the battery you are testing. 1.5 volt cells are capable of quite high load currents and should be tested with SW3 in the 'high' position, as should high capacity 9 volt batteries and types that are really just comprised of series connected 1.5 volt cells. Medium sized 9 volt batteries require a 'medium' load current, and small 216-types require a 'low' load current setting.

Battery checking is perhaps more of an art than a science, and things are not always straightforward. I have two calculators which run from regular size 9 volt batteries, one an LCD type which requires very little current and the other a LED type which consumes a moderately high current. When the battery in the LCD calculator seems to be failing it does in fact seem to be perfectly satisfactory when subjected to any accepted form of battery checking, and will happily power the LED calculator for months. One might expect an almost exhausted battery from the LED calculator to power the low current LCD type for some time before failing completely, but not the other way round. The cause of this paradox seems to be that the display circuit of the LCD calculator is very voltage conscious, and fails to operate properly once the battery voltage has fallen slightly due to normal ageing, even though there is still plenty of power left in the battery. The moral of the story is that when testing batteries, where possible, you should take into account the requirements of the equipment they are used to power. Some circuits require reasonably fresh batteries in order to function well, others will operate from batteries which, by most standards, are flat. Although with the current high cost of batteries it is tempting to squeeze every last bit of power from them, it is not a good idea to use virtually exhausted cells which could leak and ruin expensive electronics. ■

3attery Tester

3. N. Soar.

'his circuit was designed as a simple ester for 1.5 and 9 volt batteries.

It uses a cheap 500μA recording evel meter of the kind used in cassette ecorders, costing around 80p.

The scale is as indicated in the diagram nd can be interpreted as follows–

BLACK–Replace battery
RED–Weak battery
GREEN–Good battery

new battery should give a full scale eflection.