

# HOBBY CORNER

## Realistic battery-voltage measurements

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BEFORE GETTING TO THE BUSINESS OF THE DAY, we want to thank each of you who has taken the time to write—and don't hesitate to write again. Your questions, comments, and suggestions have been quite interesting. We only regret that there isn't enough time to respond to each of you. For those of you who haven't written yet, why not get out the old pen and paper and let us know what you're doing.

### Testing dry-cell batteries

David Patterson has raised the very practical question of testing batteries under "loaded" conditions (when current is being drawn). We're sure that you, too,

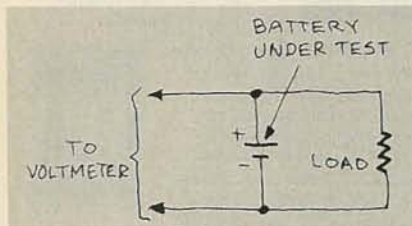


FIG. 1

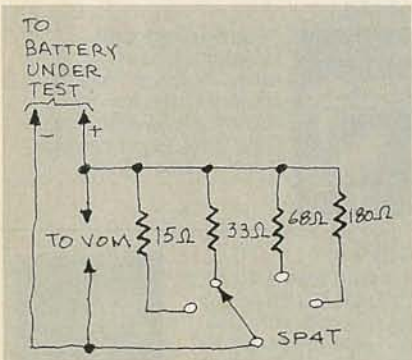


FIG. 2

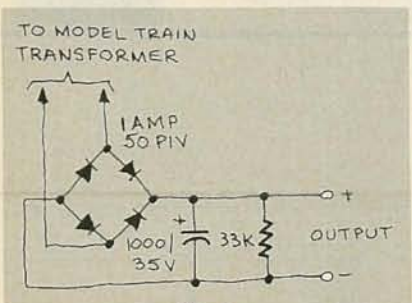


FIG. 3

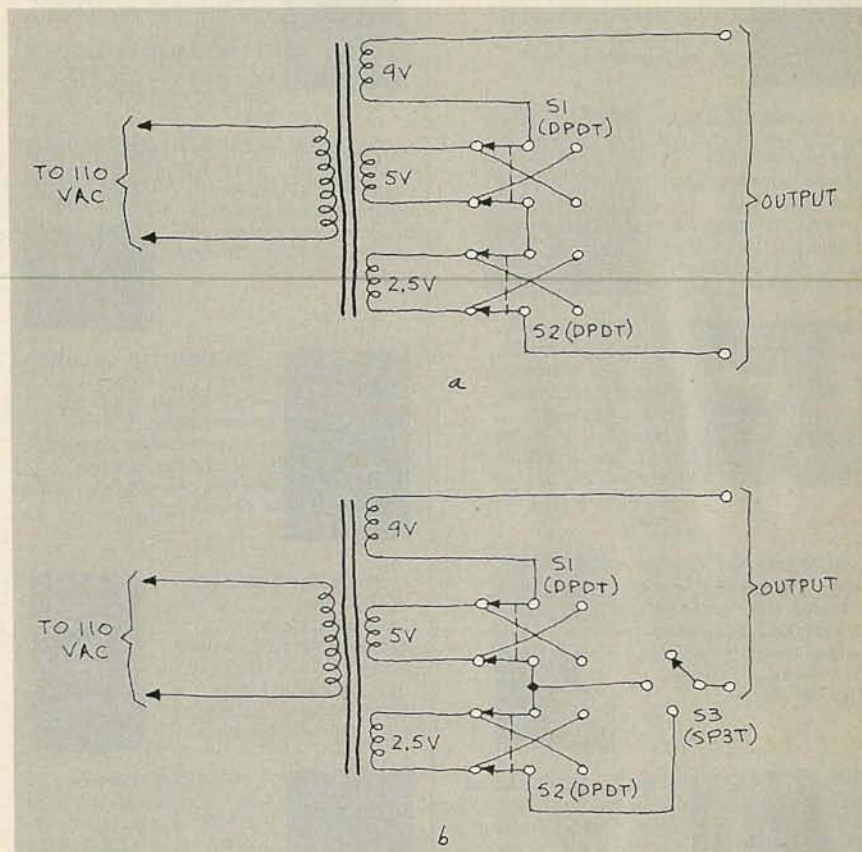


FIG. 4

have had the experience of having a battery die just a few minutes after it tested all right with a voltmeter. The reason for that is that a voltmeter has a high input impedance. As such, it draws no appreciable current from the device or circuit being tested.

In many situations that's a desirable characteristic, but not in this case. When measuring battery voltage using a meter (VOM, VTVM, etc.), the amount of current drawn is insignificant. In other words, the meter doesn't load the battery. Using a meter in that manner can produce very deceptive results. Without getting technical about battery chemistry, let's see what happens and why.

Within limits, carbon-zinc batteries have the ability to rejuvenate. Thus, after several hours, a nearly exhausted battery can muster up the strength to show a potential of 1.3 or 1.4 volts when measured

with a VOM. That's great, but the battery has no stamina and soon quits when large currents are drawn from it. Since the VOM requires the battery to do little work, the measured voltage can stay high for a long time thus giving a false indication of battery status.

David's question shows us how we can get a meaningful voltage measurement. That is, to see how a battery will stand up under normal conditions, measure the voltage when the battery is "under load" and some current is being drawn.

There's no trick to loading a battery—all that you need to do is connect a resistor and a meter in parallel across the battery terminals as shown in Fig. 1. The resistor draws current from the battery so that a realistic battery-voltage measurement may be obtained. You've probably noticed that one small detail has been omitted; the load-resistor's value hasn't

been specified. The "trick" of the procedure is determining that value. Fortunately, it's not difficult to do.

A wide range of resistor values will suffice but we want to avoid the extremes. The idea is to draw enough current to simulate a real situation. Too great a value, and the resistor might as well be omitted—too small a value and you can drain the battery.

Let's suppose that we want to measure the voltage of a D-size cell. The first thing we have to determine is how much current is normally drawn from such a cell. That, of course, depends on the device that is to be powered. For example a battery-operated toy will draw several times more cur-

rent than a flashlight. For our purposes, let's use a rate of about 40 or 50 mA.

With that information and our old friend, Ohm's Law ( $R = E/I$ ), we can easily determine the needed resistor value. Dividing the battery voltage, 1.5 (E), by the current, 0.050 (I), we get a resistor value of 30 ohms. A standard 33-ohm resistor will perform admirably, drawing about 0.045 A. Now, we have just one more calculation to make: the resistor wattage. Using the formula  $P = IE$ , we have  $0.045 \text{ A} \times 1.5 \text{ V} = 0.0675 \text{ watts}$ . A  $\frac{1}{4}$ -watt resistor will handle the job with plenty to spare.

Obviously, the amount of loading on the battery can be set to any desired level

simply by choosing the proper resistor value. If a non-standard value is needed, a combination of standard values in series and/or parallel will do the job. Now that we have all this information at our fingertips—why not design a circuit for a battery-test jig? In doing so, first consider the fact that 45 mA is a pretty heavy current for a little AAA-size cell to deliver. The smaller the battery, the less current it should be required to produce (that's why they make several sizes). So, let's make the loading variable by including several loading resistors.

### Battery-test jig

Figure 2 shows a schematic for a battery-test jig consisting of four resistors and an SP4T switch. Reading from the smallest to the largest resistor specified there, the switch positions can be labeled 100, 45, 22, and 8 mA. You are now ready to realistically evaluate any standard-size dry-cell battery with that setup.

There's one other battery size that's frequently used—the familiar rectangular 9-volt battery. As long as you're making a test jig, you might as well include provisions to measure it, too. A typical small transistor radio draws about 3 or 4 mA from a 9-volt battery.

Following the previous calculations, a standard 680-ohm resistor pulls 13 mA and a 1000-ohm resistor will pull 9 mA. Either value will work fine. It can be substituted for one of the original four resistors, or you can use a five-position switch and add it to the others. Just don't forget to change the meter range when measuring a 9-volt battery. Well, there you have it. Now you can test your batteries under operating conditions.

### Variable power supply

Glenn Anderson asks about building a variable power supply. Every experimenter should have a variable voltage source and you can build one without great expense. My first variable supply was homebrew and it's still used occasionally when just one more "odd-ball" voltage is needed. That supply is nothing more than a small box and an old model-train transformer. The transformer has an output that's variable from 0 to 18 volts in two ranges.

The box has a pair of terminal posts on each end and contains a full-wave bridge rectifier (similar to Radio Shack 276-1161), a filter capacitor, and a small bleeder resistor. The components are connected as shown in Fig. 3. When an odd voltage is needed, the transformer is connected to the input terminals on the box. The output terminals of the box are connected to a VOM and the circuit to be powered. The transformer is then adjusted to provide the desired voltage. That's all there is to it.

Of course, you can fancy it up with a

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built-in meter for voltage and another for current, but that won't make it perform any better. You can build in more filtering for the rectified voltage, but that's seldom needed. When additional filtering is necessary, you can just connect the parts to the output side of the supply.

That's well and good, you say, but what if you don't have an old train transformer? There are a couple of reasonable alternatives—one, of course, is a Variac. The other substitute is a multi-secondary low-voltage transformer (or several small transformers).

Take a look at Fig. 4-a, it shows a transformer with three low-voltage secondary-windings (there could be more). There, double-pole double-throw (DPDT) switches are wired so that the leads from two of the windings can be reversed. By the setting of the switches, you can make the individual windings add or subtract their voltages from the total output.

For example, suppose you have three secondary windings for 9, 5, and 2.5 volts. With the addition of those switches, you now have a choice of 16.5, 11.5, 6.5, and 1.5 volts. If you add a SP3T switch, as shown in Fig 4-b, you'll have three more choices: 4, 7.5, and 14 volts. Of course, the specific voltages available will depend on the particular transformers used and the way in which the switches are wired. If you use the multiple-winding approach to build a variable power supply, we suggest that you put the transformers, rectifier, and filter in a box.

Well, that's it Glenn. Now, there's no reason why you and every other experimenter can't have a variable power supply on your workbench.