# Checking batteries AND battery connections in your system using a multimeter

Ralph Hiesey
Bogart Engineering
April 30, 2011

The method suggested here is most useful when you have a battery system with at least two or more batteries connected "in series". If you have a 12V system that uses only 12V batteries (connected in parallel), then this method will not be so useful, except for checking connections as described below.. However, if you are using 6V batteries in your 12V system you need to connect them "in series" to get 12V. Most 24V or 48V systems use either 2V, 6V or 12V batteries in series. If you suspect you may have a problem with your battery system, this application note gives suggestions for diagnosing some problems using a hand held multimeter, such as you can purchase from Radio Shack. The basic idea is that when you have two or more batteries connected in series, it is unusual to have all batteries in a series string go bad at the same time--so by looking for anomalus differences in battery voltage it is often possible to quickly spot battery problems. For doing this kind of test I suggest using a digital model-- that means a multimeter that shows the numbers on a digital readout, not the older analog type with a needle that swings high or low to indicate a reading. And for checking battery connections, a "millivolt" scale, that shows volts down to 0.1 millivolt (which is 0.0001 volt) is useful.

**What symptoms would make you want to check batteries or connections?**
1. ---If batteries don't hold a charge. ---If inverter goes off, or voltage drops low (shown by TriMetric) when "Percent full" on the TriMetric battery monitor indicates a percent value that used to indicate that energy was still left in the batteries. The TriMetric judges "percent full" of the battery based on measuring the charge that has gone in, and gone out of the batteries, so the "percent full" that is shown by the TriMetric is a value that assumes that your batteries are functioning properly. One reason that the TriMetric can be showing an OK "% full" charge when your batteries appear to depleted, is that your batteries have decreased their ability to hold a charge.

2. Volts (on battery monitor) are OK when there are no or very light loads on, but when moderate or high loads are running the voltage goes lower than it used to.

3. Inverter won't stay on when a some loads are turned on.

**A few comments about multimeters:** If you want really good quality unit, you can buy a "Fluke" multimeter, any of which are fine for this purpose but they will cost well over $100. You can also get a multimeter from Radio Shack for $30-$60, or even less which will be quite satisfactory. One caution with the Radio Shack models is that for at least some models it is easy to blow the fuse (inside the multimeter) which of course will stop it from working if you (accidentaly) attempt to measure "voltage" across a battery while it is in the "amps" or "current" measuring mode. This can be avoided by making sure the switch on the meter is set to "volts", "millivolts" or "mV" , and not set to measure "mA", or "amps" or "amperage". If it is set to "amps" when you attempt the measurements described below or you will blow the fuse.

**Notes on battery volts:** To measure the battery voltage, the multimeter should be switched to "volts." One probe should go to the + terminal and the other probe to the minus terminal (as shown on page 2 of this note). Battery voltage depends on both your battery "state of charge" (how well charged it is, or high "percent full"), and also the loads that are on your battery. A more well charged battery will have a higher voltage. However the value of volts also depends on whether you are CHARGING or DISCHARGING your batteries, or whether they are standing there not either being charged or discharged. Charging will push the voltage up, and discharging will pull it down. The application note on the BogartEngineering web site called "Using the TriMetric to maintain your battery system" has a chart that gives some approximate voltage values for 12 or 24V lead acid batteries--but you don't need to know those exact voltages for the tests to be described. With a battery system that has a number of batteries that are properly working together, each battery in the system should be about the same voltage as the others--they should all go up and down in unison as they are charged or discharged.

**There are two types of problems that can produce similar symptoms** indicated in the first part of this application note:
(1) One or more batteries have become defective or weak
(2)Battery connections have developed resistance because of corrosion or have become loose.

It is obviously much cheaper to fix connections than to purchase batteries, so you should always make sure connections are OK before buying new batteries.

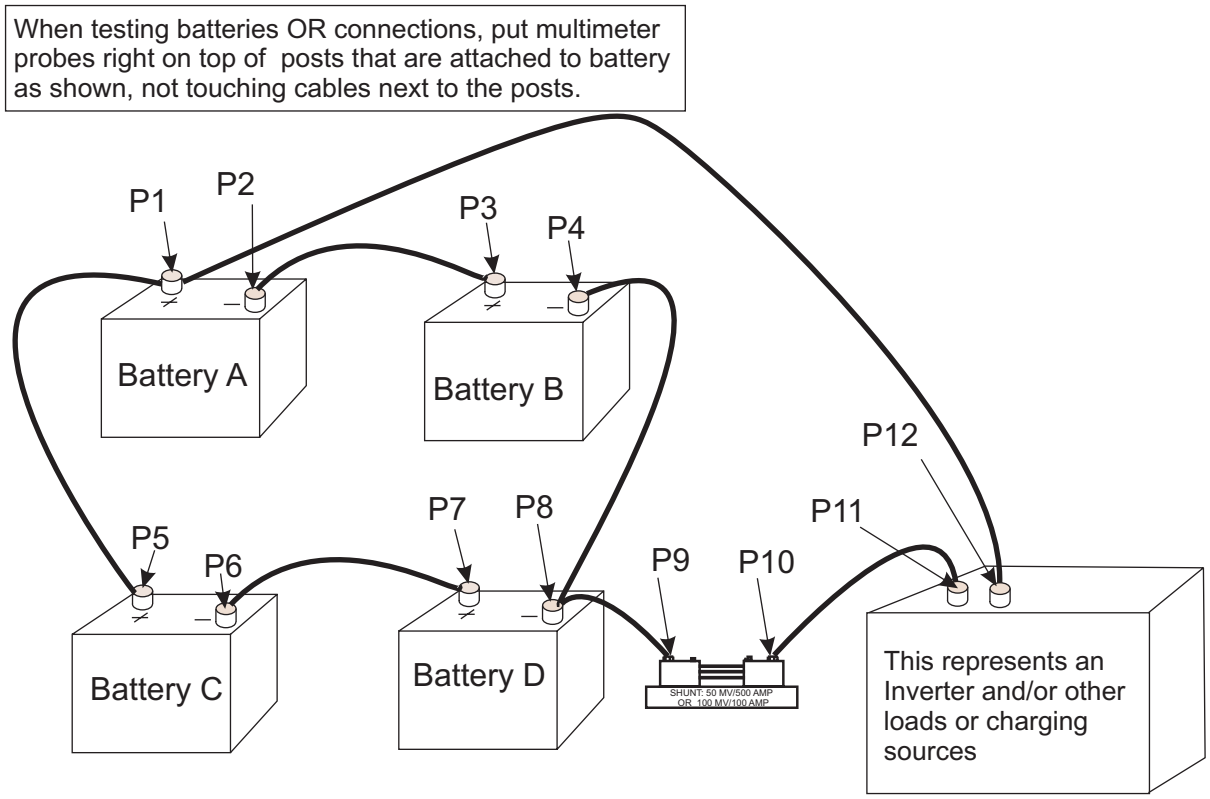
**This following section explains some simple checks** you can make using a multimeter to check both connections and batteries. Refer to figure 1 on next page.

1. Place a load on your system so your batteries are subjected to a load of at least 10 amps or so. A higher load will give a better test. Use the TriMetric "amps" reading--(NOT the multimeter) and turn on some loads to get at least this number of amps (shown on the TriMetric "amps" as a negative value) flowing from your battery system.

2. Set your multimeter to measure "volts" and measure across each battery in your system. Be sure to put the probes on your multimeter so they touch on the actual battery posts, as shown in the diagram below. This is to avoid any errors caused by weak connections. Make and record one measurement between P1 and P2 for battery A, another between P3 and P4 for battery B, then P5 and P6 for Battery C, etc for as many batteries as you have.
Then compare all these readings. If your batteries (and connections) are OK, all readings should be "reasonably close." You will be looking for some that seem somewhat higher or lower than the others (typically 1/2 volt or more). If you find one that has a lower value would be a sign of a bad cell in that battery. Though more inconvenient, if you have "liquid electrolyte" batteries (not the sealed type) you might also want to check further using a battery hydrometer to check the specific gravity of the acid in each cell in the battery.

3. **CHECKING CONNECTIONS IN THE SYSTEM:** Be sure to do this with the same loads on that you set up for step 2. Switch to the "millivolt" option on your meter if you have one--possibly indicated by "mV" as a possible selection. Then measure the voltage between points that are supposed to be connected together by your battery cables. See figure below. For example, measure from P1 and P5, then P2 and P3, P4 and P8, P8 and P9, P10 and P11, etc. Ideally you would measure very close to 0 volts at all these places if the connections were good, and if the cables had zero resistance. With a "millivolt" scale you should be able to measure down to 0.1 millivolt--if you don't have a millivolt scale, you should be able to measure down to 0.001 volt, which is 1 millivolt. With some current flowing (as you set up in step 1) there will always be a small voltage drop in these connections--perhaps 0.2 to 5 millivolts (That is .0002 to .005 volts). But they should all be LOW and reasonably equal. If you see one that is considerably higher than the rest, like 20 millivolts (0.020 V) that is a sign that the connection should be fixed by cleaning or tightening the connection as necessary so as to reduce the voltage. Typically you should see 0.01 volt or less between connections. But the values should be low--if one is a lot more than the rest, then that should arouse suspicion. However keep in mind that the longer cables will show a voltage that will be a little higher because they will have more resistance--also it is normal that this voltage will go up if you have a higher load drawn from the batteries.

**REPLACING BATTERIES:** If one battery appears to be bad, it is often recommended to replace the entire set-- on the basis that if one goes bad it may be an indication that the others are also nearing their end of life assuming they were all installed at the same time. However since batteries are costly it may be expedient to put new ones in just one series string. In this case keep records of the dates that each string was replaced. However it is always bad practice to put a new battery in the same series string with one or more older ones. If you replace one battery with a new one, be sure to replace ALL batteries in the same series string. Batteries in series act like the links of a chain. If one link is weak the entire chain is compromised, even if the other ones are good. A weaker one in series with a good ones can cause the good ones to be poorly charged, thus decreasing their life.




Your system may have more or fewer batteries.
Figure 1