Solar panel testing and repair

By Donald Koehler

This article will discuss the testing, repair and troubleshooting of photovoltaic panels. We will look primarily at those panels constructed of circular silicon cells, covered by a transparent, resilient rubber-like coating with fiberglass backing. Some panels are found covered with a plexiglass™ like material, others may be backed with a phenolic-like material. Most of the newer panels I have worked with have a backing of metal or are flexible. Some have been made of a cloth-like material and could be rolled up. I will concentrate on the older panels most likely to show up as surplus. Let's start with some basics.

Tools for testing

If you buy used panels, they should first be tested for output. The tools for testing range from simple to complex. I use a digital voltmeter, an accurate ammeter and an auto headlamp. A rheostat is used to put a variable load on the panel. It also allows the panel to be sized (determine its power output). A load of some kind is required for any troubleshooting.

Normally a panel is sized by testing for both voltage and current outputs under a full sun. The panel's voltage at no load vs. max load (highest current) is important to know. Power is simply determined by use of the math formula P= I x E where P is power in watts, I is current in amps and E is voltage. It's as simple as P I E.

I use an inexpensive digital voltmeter, a high quality 0-8 amp. ammeter, and a rheostat to provide a variable load. Analog (pointer needle) voltmeters are fine but as I describe troubleshooting later on, you will begin to see the advantage of a digital voltmeter. Radio Shack offers several fine units at low cost, making them a worthwhile investment for even those on a limited budget. Any meter you choose should allow for both AC and DC measurements and have a bail or handle to hold the meter upright. This allows you to read the meter while your hands are full of wires and test leads.

An ammeter can be made from some types of old meter movements, however I prefer the high precision type to allow exact measurement of the current available from the panel under test. Automotive 0-15-0 charge meters are all but worthless since most panels under test are less than 4 or 5 amps. Readable accuracy at these levels is virtually impossible. An external meter shunt will allow the use of a common multimeter (VOM) to measure currents up to many hundreds and in some cases thousands of amps. A shunt basically acts as a very tiny resistor placed in line that allows a voltage drop that is proportional to the current passed through it. In most cases a dedicated 0-8 ampere range meter is most useful for testing and general system use.

The bottom line is that more accurate test equipment equals better data. You make the choice.

The rheostat I use is nothing more than a huge wire wound variable resistor in a vented case. When using a rheostat, initially set the resistance to maximum (highest) resistance, then lower it until the current no longer increases. At this point the voltage across the rheostat, and the current passing through it will give you the actual power produced. With power disconnected the resistance of the rheostat can be measured and recorded for future reference.

When troubleshooting, any kind of load will do, I use an old 12 VDC headlamp.

Troubleshooting

The panel under test should be where you can move it about and see the output leads. At this point you don't need to know the ratings of the panel. Locate the output leads, hopefully marked as "+" and "-" or "Red" and "Black." Prop up the panel or have a friend hold it (much better) and attach the load (head lamp or rheostat) with a set of test clips. Polarity is not important since the load doesn't care. Now attach your voltmeter across the load. In this case polarity does matter. Most digital voltmeters won't be harmed if connected backwards but an analog could be damaged. Be careful. To avoid harm to an analog meter, you can turn the panel away from the sun or set the meter to a high voltage range and look at the direction the needle takes. If it tries to move backwards or beyond zero you have the polarity reversed. Once you have determined polarity and other data, remove the load and record the voltage with no load or as it is commonly known "open circuit voltage."

Note: Ammeters are polarity sensitive. They must be connected so that current goes through them. They become part of the current path. Never connect one across a panel or load. Damage will result.

Troubleshooting a panel is easy but requires some patience on your part. A panel with low output current and usable (high enough to charge a battery, etc) voltage may be usable as is. A panel with low voltage and current will need to be repaired to be usable. To troubleshoot a panel you will need the voltmeter and load described earlier, as well as several long (3 inch) needles, some clip leads and a pair of heavy gloves or ViseGrip pliers. A good magnifying glass will help also.

Connect the sick panel to a load such as the auto headlamp. Connect the negative (black or —) lead of your voltmeter to the panel (observe polarity) and with the panel facing toward you determine which cell is

last in the string to be connected to the ground or negative terminal. (Hint: The cells are connected like tiny batteries, some in series strings to increase voltage, and some connected in parallel to increase current. Cells are normally connected together with a foil like conductor.) With your pliers, insert a needle into the transparent covering until the needle just touches the foil conductor at this first cell. Now connect the positive lead from the voltmeter to a needle with a clip lead. Insert needle through covering to make contact with positive side of cell. Expose the panel to the sun and if the cell is good you should see about .6VDC or just over half a volt. Now you can see the value of a digital voltmeter.

If the cell is good continue on up the cell string. As each good cell is added the voltage will rise about .6 volts. You may find an entire cell string that is good with a bad cell in an adjacent string causing trouble. If a bad cell is found place a needle above and below the cell and use a clip lead to jumper around it. Mark all bad cells with a magic marker or any opaque washable marker. Once all bad cells have been marked and jumpered test the panel output. This will give you worst case output assuming the cells or connections cannot be repaired. On panels with plexiglass™ type covering the needle may have to be inserted from the rear of the panel. Be careful not to tear the foil conductor between cells. Use this information and common sense for checking other types of panels.

Damaged panels

Panels with obvious damage, corroded conductors or backs that are de- laminating are rarely worth the effort to fix. If the panel has a gunshot hole through a single cell it may be worth the hassle to repair. Some panels may be thermal damaged at the cell interconnects but have good cells. This thermal damage is caused by the covering and backing having different thermal expansion rates that cause a movement that pulls the foil conductors from the cells. Repair in this case is tedious but inexpensive. If you have the patience, older panels can be repaired.

Additional tools and material will be needed—a pencil eraser (pink), a small piece of fine grit sandpaper, a sharp X-ACTO knife or razor blade, a low wattage soldering iron with low temperature rosin core solder, and small pliers or tweezers. In addition you will need some glue or fingernail polish. To seal work when finished use clear silicon RTV or bath tub caulk. I prefer to work indoors so I use a 100 watt spot lamp as my sun substitute.

Your first step in repairing any panel is to isolate the fault. In a panel with the older resilient transparent covering take a magnifying glass and carefully look at the suspect cell and connections. Is the cell broken. Is the foil conductor lifted from the cell or broken. If the cell is broken (i.e. bullet hole) or has major cracks, it most likely is not repairable. To try and replace with a new cell is really not worth the hassle. If you only have some broken connectors or only minor cell cracks and want to bring the panel back to life, proceed to the next step in the repair process.

Repairing panels

Take a knife and expose the bad joint by making a shallow cut in the surface of the panel about ½ inch square. Take the magnifying glass and look closely to ensure the cut surrounds the bad spot. Carefully peel the covering off in small layers. Don't get in a hurry or the covering will come off in chunks and possibly break a good cell. Once the cell edge or foil has been exposed, use the knife edge to scrape the last of the covering away from the edge of the foil. Now you must prepare the bad joint for repair. Take a pencil eraser or small piece of sandpaper and lightly buff the area on both sides of the break. If the foil has lifted from the cell, buff the small silver edge of the cell with the eraser. You are now ready to repair the bad joint. You make repairs by forming a solder bridge over the break. Before you proceed be aware that the solder and panel covering, both produce toxic fumes when they are heated. Ventilate your work area. This is a common hazard in all electronic repair and serves as a warning to those who may not have been told about it in shop class. Now you can shape a small piece of copper wire into a U shape and pre-tin it with solder. Pre-tinning goes a long way in reducing the time the iron spends in contact with the cell. High temperatures can destroy a cell. Also remember that the backing may also not tolerate high heat. Apply a small amount of solder to the tip of your iron. Just apply enough to form a bead that will not drip with the iron held vertically, with the tip down. Place the U-shaped piece of wire on the area to be bridged with a pair of tweezers and apply the iron. Just as soon as you see solder flowing, remove the iron. Once the solder cools examine the bridge with the magniying glass. If the solder did not bridge the gap apply another small bead of solder. Do not hold the iron on the work area any longer than it takes to flow the solder. Wait for the area to cool completely before applying the iron a second time. You can now test the repair with the voltmeter as the panel is exposed to the sun or bright light. If the cell repair is working you can proceed to the next step.

Once the repaired area has cooled completely, seal it with fingernail polish or Crazy glue. Just a light coat will do. When this has dried, apply the silicon RTV to fill in the hole in the panel covering. Bead the RTV just above the covering and once it starts to firm up, smooth off even with the top of the panel. The fingernail polish was first applied to prevent corrosion of the conductor by the mild acid the RTV excretes. You now should have a panel that will give you good service and usable power. Δ