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The Solar Ham – part 3

by Don Dorward VA3DDN (May 2005)

Review, Improvements and changes since part 2

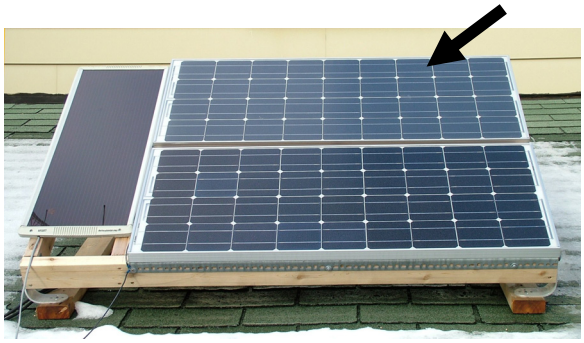
First I want to thank all those who have read the previous articles and asked questions of me. This feedback helps greatly to make the articles more useful to more folks. I have tried to include answers to all the questions received to date, in the paragraphs below.
Since Solar ham part 2, the main differences/improvements I have made to my home solar installation, are :

- A 3rd solar panel, rated at 80 watts, bringing total *installed* solar watts to 170. (15+75+80)
- A new solar charge controller, with PWM* float point control, and ability to "dump load"
- A power vent for the lead-acid batteries, and a solar panel monitor voltmeter.
- An expanded scale voltmeter to continuously monitor state-of-charge of the batteries
- Another marine battery added to the bank, making it a total of 400 A-H now, just right.

I admit I have not further pursued wind energy at this point - but still plan to do so later on.

New 80 Watt solar panel

Improvements in Solar Panel efficiency have made it practical to produce an 80 watt solar panel in the exact same area as a 75 watt unit. In fact, I think there is an 85 watt version in the same size. In November 2004 I purchased a Shell Ultra 80p solar panel, from Northern Arizona Wind and Sun, (www.wind-sun.com) for $317 US, and added it to my 2 existing panels.(the one on upper right) As you can see, I had to expand and rebuild the frame holding the panels. I also hinged it to allow adjustment for solar azimuth..



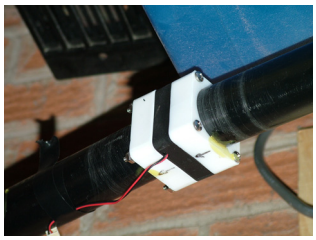
Solar charge controller, with pwm*

The charge controller I had first used was of the on-off variety, originally purchased at Canadian Tire as an ICP-7 amp charge controller. (left) It worked well with the single, almost useless 15 watt panel, but this controller is "rated" to handle up to 6, 15 watt solar panels, or 7 amps of current ! I wondered how can it do this in such a small package? Answer, it doesn't, very well -- This controller has an internal snap-acting bi-metal thermal sensor that **disconnects** the solar panel whenever the internal temperature of the controller gets too hot, resulting in continuous on-off cycling of the charge current which is actually unrelated to the state of charge of your battery bank, and is also very inefficient. I found that with the 3 panels, this controller spent more off time than it did charging the batteries, not to mention the annoying "clicking" of the thermal sensor.

I could have opted for a commercial charge controller, but decided instead to buy the 12 amp controller kit # SCC3 offered by CirKits, at $50 USF. This is a great little solid-state controller designed by Forrest Cook. The circuit board was professionally done and the kit was easy to build. It works very well and provides full charging current until the battery float voltage nears the chosen set-point, when the circuit starts to alternate on/off, or what the designer calls "*Analog Controlled Pulse Width Modulation".

The SCC3 also has an optional output you can use to control a “dump-load” circuit. When your batteries are fully charged, output from the solar panels is usually wasted, going unused. The SCC#3 provides a control signal that will allow you to “dump the load” of your PV panels into a resistive heater for example, to add heat to the house in winter, heat water, etc. whenever available power is not needed to charge batteries.

Power Vent for Lead-acid Batteries and PV Panel Monitoring

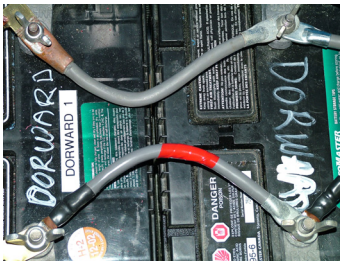


In the previous article I showed the enclosed battery bank with passive ventilation to the outside for hydrogen gas which is generated during charging, via a 1¼ “ PVC vent pipe. I have further improved on this setup by adding a small 12V DC fan to ensure that anytime during battery charging, there is air movement over the batteries to the outside. As you can see in the photo I have mounted the fan in-line with the PVC pipe, and turn it on whenever the PV panels are providing charging current.

In addition I find it useful to have some means of monitoring what the PV panels are doing. For example, if they are covered in snow, you will not be getting any charge current. There are lots of ways you could do this, like use a digital voltmeter, or an LED with a series zener diode, etc. In the end I opted for the simplest approach, to use an old-fashioned DC panel meter to directly indicate the output from the PV panels. The advantages are that it takes next to zero power, 0.1 mA, much less even than an indicating LED. And it looks good, particularly if you make a custom meter scale. More perhaps, on this in another article.

Connectors, Cables, terminals or “lugs”

Marine/RV batteries like the ones I used, come with “dual” connection battery posts that allow convenient electrical connection by means of a stud fitted with a wing-nut, using a ring or spade terminal lug. (they also have the larger posts with the big clamp type cable connectors as used in vehicles) In the picture I used ring-type crimp-on connectors which are readily available at various automotive or electrical supply stores. The photo above left shows an assortment of connectors available. Be sure that all the low voltage cabling from batteries to the inverter are sized based on the maximum expected ampere load. A good source of ready made heavy duty cables, is the battery cable section of various automotive stores where you can get an 18” pre-lugged cable, #4 or #6 AWG. I then cut this into 2 separate 9” pieces, and then strip the cut ends and add another lug connector. See photo at right. Homemade lugs can be made from flattened pieces of ½’ copper tubing. Homemade lugs should be soldered as well as crimped.



Fusing, the Class “T” revisited

The reason for the class T fuse seems to cause a lot of confusion. This special fuse is intended to protect the battery bank from a dead-short condition that could happen due to catastrophic inverter failure, or even the slip of a wrench across the high current DC buss wires. It’s a bit like the main fuse in your house, or the fusible link in a car. Properly rated and installed, the class T fuse is intended to prevent ***fire, melting of the battery cables or even***

rupture of the batteries with acid spill. It is the only kind of fuse approved under the Canadian Electrical Code for use in high capacity DC power systems. The class "T" rating means it is fast acting and can interrupt very high DC short circuit currents. Regulations require that It be located no further than 18" from the batteries and all loads must connect through it to the battery bank.

The particular class T fuse assembly I used was a Xantrex part number TBF300C fuse block with a TF300 fuse. I chose this not because it was anything special, just that I saw it on eBay at a good price, and it was complete with the fuse holder and plastic cover. (Xantrex is located in Vancouver) Otherwise such fuses and the holders can be purchased through most marine supply stores, (one good brand name is Blue Sea Systems), or at electrical trade type supply stores, as Bussman fuses and holders. The fuses and the fuse holders are available both as bolt-in or snap in types. There are also many web-based stores which cater to solar energy supplies and which are quite competitive and offer a lot of free information. If you have access to the internet, just type "Class T fuse" into your browser, and stand back.

Battery Condition Monitoring (expanded scale voltmeters)

It is a real good idea to have some simple means to monitor the relative condition or state-of-charge of your batteries. Measuring the specific gravity is messy and unnecessary for routine monitoring. The simplest and best method is to use battery terminal voltage to estimate the state-of-charge, *providing the battery has been at rest for several hours and is neither being charged or discharged*. For most battery types, full charge under these conditions is indicated by a resting voltage of 12.6 to 13.0 V. **Caution:** Never, ever, let your batteries discharge to a no-load voltage of less than 11.0 V!!

You could drag out the digital voltmeter and use that to check the resting voltage of the battery bank. That's just great, but what if you want to leave it connected permanently, and be able to check the battery condition at a glance, anytime? Digital voltmeters need power to just to operate. However, the ordinary analog DC meter like the surplus 4½" Weston meter movement shown, consumes less than 0.1 mA of current (or about 1.4 milliwatts) at 14 V. It can be left connected permanently without fear of running down the batteries, is easy to see, and allows a quick check of system voltage while transmitting etc. The particular meter you see has been modified with a custom expanded scale, and reads from 11.0 to 16.0 V full scale. How this is done is an interesting but simple project in itself and may be the subject of a later article.

Battery types, sizes and ratings

Battery types

- Many Hams have used an old car battery and a small auto-store 120 V ac battery charger to power their 12 V rig, mainly because they had it available. There is nothing wrong with doing that, particularly where the power needs are modest, like 50 watts or less for short periods. However there are far better batteries and chargers around for the purpose.
- Battery types available
    1. Lead-acid automotive starting batteries are designed and optimized especially to start cars, to provide high cranking amperes, at current levels of 500 to 700 amperes for short periods. These are obviously not the best battery for your shack, if you are going to seriously discharge it. (But they will work in a lot of cases!).
    2. Special purpose, deep cycle batteries, are often sold as RV or deep cycle types off-the-shelf at most large retailers, like Walmart or Canadian Tire. These are ***low gassing*** or recombinant battery types like gel cell types, those marked as AGM (absorbed glass mat), or VRLA (valve regulated lead-acid), and are your best choice for use in solar power systems. (no hydrogen hazard)

3. Marine batteries tend to be a compromise between the automotive starting battery and the deep cycle battery. They do have to provide high cranking amps to start engines, but not usually at low temperatures like the automotive battery. Marine batteries are more tolerant of prolonged but lower discharge rates. (example: use for an electric trolling motor) They are a good choice for ham station power, and are lower cost than the specialty types.
4. Electric fork-lift or tow-motor batteries are another example of deep cycle batteries that can prove useful, and may be found as surplus.

Batteries, sizes and ratings

- Larger & heavier, generally = more ampere-hours of capacity. (and is *mostly a good thing*)
- Manufacturers build their batteries to an internationally adopted Battery Council International (BCI) group number (24, 26, 70, 75, etc.) specification, which is based on the physical case size, terminal placement and terminal polarity.
- Connect only batteries of ***similar type and age*** in series-parallel combinations
- Ampere-hour or capacity ratings are not as readily available from manufacturers as one might think, but the following chart lists some of the common sizes and their ratings:

LEAD-ACID BATTERY RATINGS

(Typical Ampere/Hour Ratings (Ah) for some common Batteries, single, 12V)

USE	GROUP SIZE	NOMINAL Ah RATING	REALISTIC Ah @ 75% OF MAX	REALISTIC USEABLE Amps/Hr.
Passenger car	24	40 - 85	64	2 - 4
	27	85 - 105	80	4 - 5
Heavy duty Commercial	4D	140 - 160	120	7 - 8
	8D	200 - 215	160	10 - 11

Ah Capacity = The *total* amperes a battery can supply in a 20 hour period.
Reserve Capacity = The # of minutes to discharge to 10.5 V @ 25 amperes

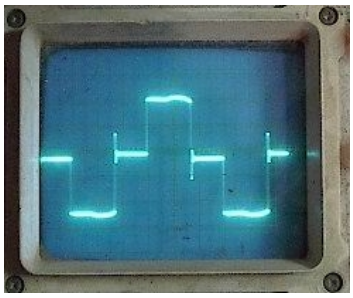
Note: For higher total Ampere hour capacity, use multiple paralleled batteries of ***similar types and age.***

Battery charging and "hum" concerns for the Amateur

- First, solar battery charging generates *no hum at all*. Period.
- So called "Hum" problems that hams are afraid will happen from the use of a 120V ac battery charger, while operating from a storage battery bank under charge, are greatly exaggerated. Unless of course your batteries are in terrible shape and cannot hold much of a charge. Storage batteries inherently act like **huge** filter capacitors.
- Look at mobile installations. Most problems with noise pick-up and alternator whine come from not powering the rig directly from the battery. The same is true for base installations using battery power.
- Fact – there are lots of hams out there who have been reported at various times as having "lots of hum on your audio!" They are usually found to be using defective power supplies, or low quality wall-wart dc chargers that inherently have high AC ripple. (another good discussion opportunity here, linear wall-warts vs switchers)

Inverters, Types, Characteristics & Recommendations

In my previous article, there was a discrepancy between the schematic shown and a photo which showed some wiring, as pointed out by a reader. My apologies, the schematic showed the correct connection of the inverter. The photo of the batteries in the box was for test purposes and just to show parallel connection of the batteries.



Inverters, 12 or 24 v DC to 120vAC, are a very large subject in themselves and I will have to limit discussion of them here. Usually, the need is to convert your 12 or 24 volt battery power into normal 120 VAV sine-wave current, to power your TV, computers, and other appliances, depending on power demands.

Advice: buy the highest power rating inverter you can afford in a true sine- wave type. The lower cost inverters are not true-sine. If cost is still the major issue, then go for a modified sine-wave type from a reputable supplier, again in as high a power rating as you can afford. The performance differences between true-sine and modified-sine inverters are great. The photo here (courtesy of VE1SOL) shows the typical "modified-sine" wave shape, which is not always well tolerated by all AC loads, like some TV's, VCR's or DVD's..

Snow on the Panels – what to do?

Obvious eh? – brush it off whenever it accumulates on the panels !! Unfortunately, that is almost every time it snows heavily and is not easy to do. Snow will definitely block most all solar charging, even if only a thin layer. The photo at left shows part of the solar panel installation of Charles VE1SOL, in Yarmouth NS. The panels here look like they are mounted at about 60°, which would maximize efficiency in the January-February time period. Charles was kind enough to send in this photo as well as the one of the modified sine inverter shown above.

Although light snow will often melt off the panels, as they do generate some heat when charging, Charles suggests waxing the panel faces, or at least spraying with a silicone lubricant, to encourage snow to just slide off. This works some of the time, but look at the photo!!

Wind Generators, commentary

So far my experience with wind power has been quite disappointing. It appears to me that both in North America and in Europe, we are so wasteful of electric power in general, that we have focussed only on larger scale wind generators of greater than 400 watts, with the thought that anything less is useless. Such larger wind generators prove to be simply *not practical* to employ in smaller urban settings.

Yes I have seen small but relatively e*xpensive* units ($900US) made for yachts in this range, but nothing commercial that is manufactured in volume to bring down costs for the average homeowner or ham (in the range of 100 - 200 watts with a blade diameter of less than 1.5 meters, and a cost of $400 Cdn)

The smallest commercial wind generator available in North America now is approximately 400 watts. I think that here is a huge opportunity for some handy entrepreneur.

(There are more wind turbines installed in Inner Mongolia China, than in any other region of the world. Approximately 140,000 turbines, all low power, together with low cost batteries, provide electricity for about 1/3 of the non-grid connected households in this region.)

Websites related, and of interest

Home Power Magazine: http://www.homepower.com
Northern Arizona Wind and Sun: http://www.windsun.com/
CirKits of Boulder Co.: www.cirkits.com

Xantrex Vancouver: http://www.xantrex.com/

Contributors:

I want to acknowledge the very useful contributions of readers who have sent information, photos and data to me on their own PV systems. Special recognition goes to Charles, VE3SOL of Yarmouth NS, who has shared much of his solar and wind generation experience with me. The photo showing snow on the panels and the inverter waveforms were contributed by Charles.

Biography:

Don Dorward, 63+++, widower, licenced since 2002, basic & advanced. Main equipment used is Icom 706 MkII, Yaesu FT-8800R, VX-7R, assorted others. Presently working in Medical Electronics R & D at OTHOREHAB in Pickering, Ontario. Also worked with Philips Canada, Magna International, Tectrol, and others in R & D, and Quality Assurance (ISO9001/ISO13485). Hobbies are power boating, aboard Antares on Lake Simcoe and the Trent-Severn waterway system, Ham Radio stuff of course, electronics fooling around, digital photography, solar and wind energy. Member of SPARC, VHARC, ARRL, IEEE. Collect and restore older Astatic microphones, Palm Pilot PDA's and……?
Previous articles, Solar Ham part 1, Solar Ham Part 2, and .