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The Solar Ham – part 1

by Don Dorward VA3DDN

The Blackout

Ever since the big blackout during August of 2003, I vowed I would not be caught without some form of on-going emergency power again. As it was, my ICOM 706 (consuming 16 watts just on receive) continued to function as normal, as it was already powered from a big 150 AH deep cycle marine battery, which was maintained by a small 1.5 amp AC operated “smart” trickle charger. However, during the blackout, I first found I needed light in the shack, and so immediately hooked up an old 12 volt, 6 watt florescent camping light, and soon after a 15 watt 110 v compact florescent, running from a 110 v , 150 watt inverter. This arrangement got me through the blackout quite comfortably, as it only lasted 24 hours for me. But it started me thinking…., what if the power outage had lasted longer?

The Solar Panel

A local ‘auto parts’ store was offering what seemed to me to be a good price for a 15 watt solar panel (an ICT PRO15W). So I thought, 15 watts at 14 volts = ~1.1 amp! Sounds good. Maybe I could retire the AC charger ? Measuring only 12” wide by about 36” long, it was easy to mount up on the roof of the deck.

The Charge controller

Also offered on sale at the same time, was a small solar charge controller, an ICT #10014, rated to handle up to 7 amps, or up to 100 watts of solar power. The charge controller is an essential item, which protects the battery system from over charging. Note that the solar panel when exposed to the sun, can generate up to 17 volts open circuit. The rating of this particular controller will also allow me to expand my system later by adding additional panels. A charge controller, is a simple solid-state on-off regulator, which allows the panel to charge anytime the battery voltage is <13.0 volts, and stopping charging whenever the battery voltage exceeds 14.2 v.

Reality

Surprise ! I found out solar panels are rated for “ideal” conditions. This means full sun, always perpendicular to the panel, clean glass. Bottom line, you are <u>not</u> going to get 15 W out of a 15 W rated panel, except maybe once, on your birthday, and providing that was in June or July, and at high noon. The main rascals which will limit the solar efficiency of your panel are :

1. Solar Azimuth, meaning the east – west angle of the sun relative to that new solar panel you bought, as the sun travels across the sky during the day. You can’t do anything about this, unless you opt for an expensive solar azimuth tracking unit. The default is to make sure your panel faces true south.
2. Solar Declination, the height in the sky relative to the horizon of the sun, which changes in different seasons of the year. You can manually adjust the angle of your panel according to the season, or just leave it at a default fixed declination angle equal to your latitude. (approximately 43 degrees for Toronto)
3.

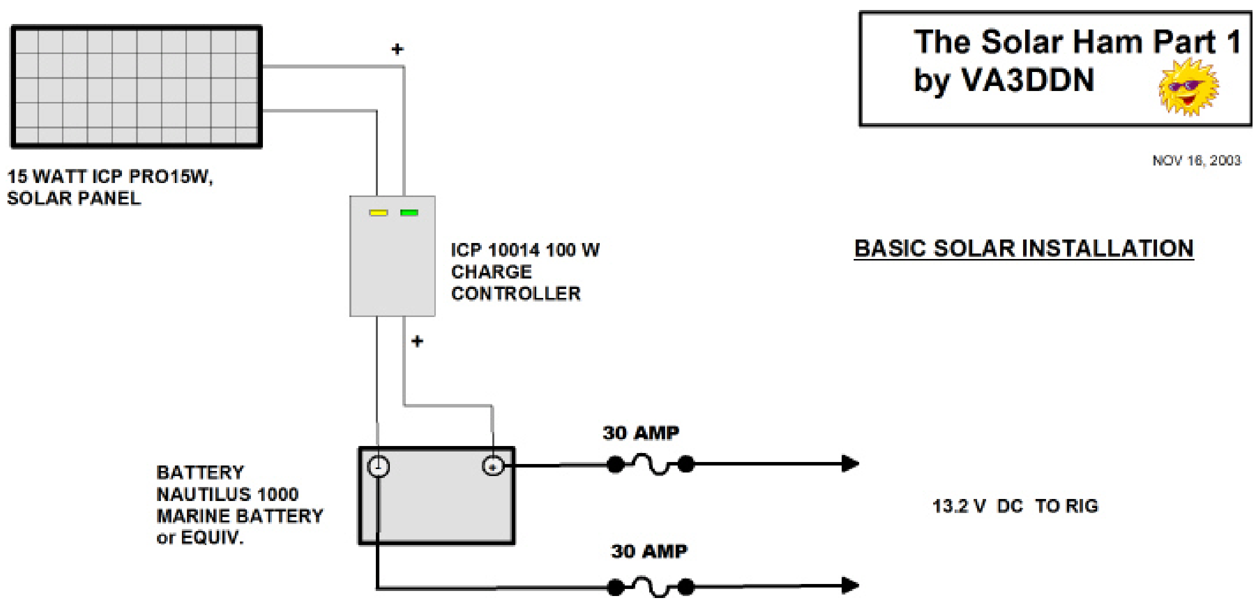
Guidance

Combined, solar efficiency variances due only to the azimuth and declination settings of your panel, can affect solar cell output by as much as 40%. Now your 15 watt panel may only produce 9 watts or less. Throw in air born dirt, dust and bird s..t, and you have got a practical source of solar energy, but which will be only about 50 to 60 % of what the panel rating is.

Facts
In November, over a number of days, I observed the following: on cloudy days , my 15 watt panel was charging at about 50 - 75 mA (yielding only about 0.6 – 0.9 watt). However, on other days in full sun, I measured charging at 580 mA or almost 9 watts.

Solar Ham Part 2 to follow, will deal with my experience in adding and additional and larger solar panel, a 75 watt rated Siemens' unit.

73 Don Dorward VA3DDN
(Reference and plug for Home Power Magazine: The best resource I know of for Solar and alternate energy sources is Home Magazine. Go to http://www.homepower.com/)



The Solar Ham – part 2 *by Don Dorward VA3DDN (March 04)*

Review of Part 1

The purpose of these articles is to share with other hams some real experiences in trying to use solar energy to run an amateur station, and find out quickly what's practical and what isn't. In part 1 we checked out the performance of a low cost 12 v, 15w rated solar panel (Photo-Voltaic Array, or just "PV"), and quickly learned that published ratings are somewhat optimistic, and are just not realistic to depend on for our every day applications. My conclusion was that a 15 watt rated solar panel is not sufficient to charge and maintain a battery system which may regularly have to supply up to 100 watts or more. On the other hand, the 15 watt panel by virtue of its portability, could be easily teamed up with a small gel-cell "brick" or motorcycle type battery and used for QRP operation, especially with manual adjustment for azimuth and declination. Other good applications of such a panel together with charge controller would be for RV or boating use where the batteries must be maintained in top shape but where land or shore power is not available during periods of disuse. Obviously, best performance will be had in the solar friendly months of June, July and August.

Adding a 75 w Solar Panel

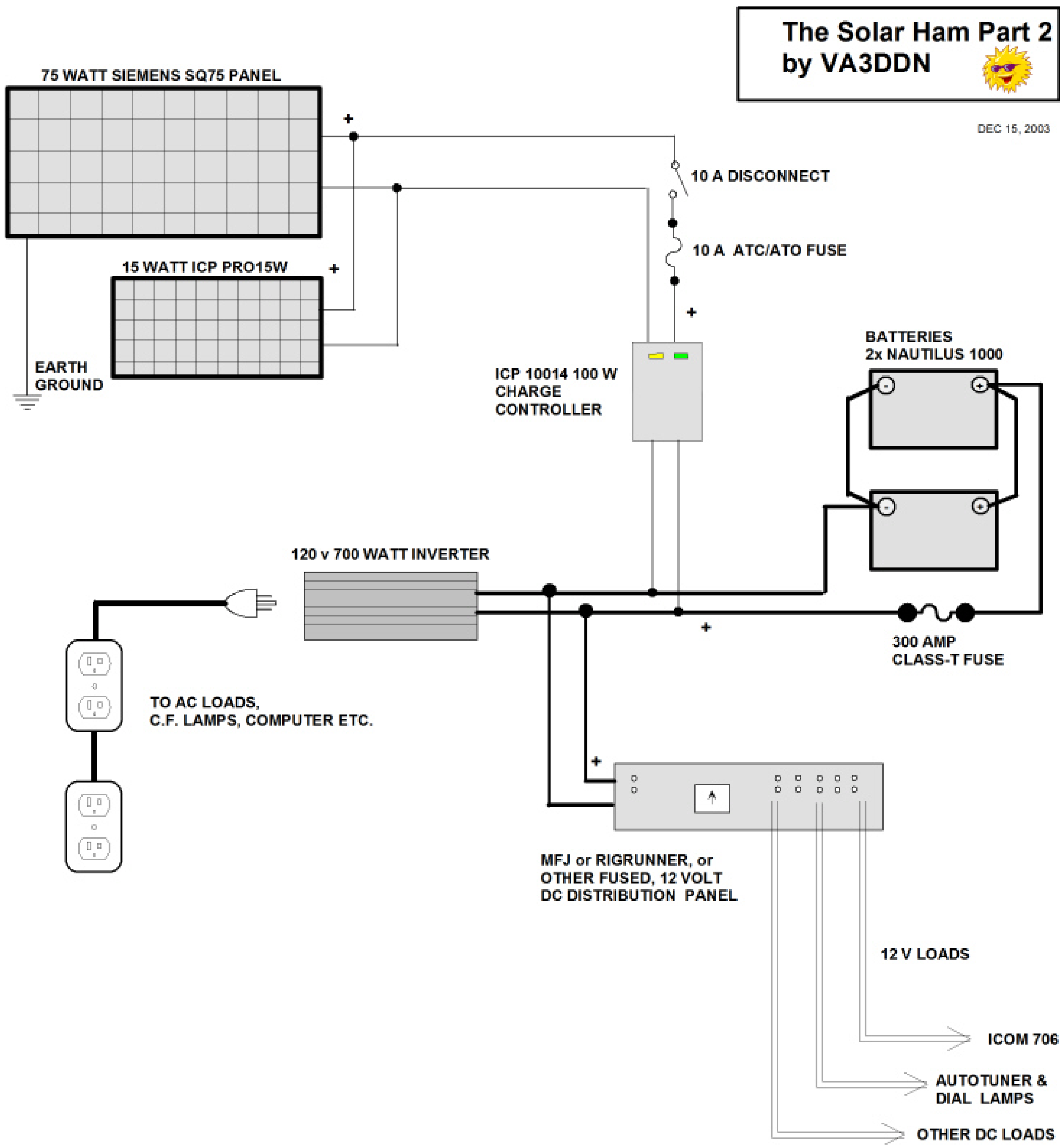
The Siemens SQ75 shown on the right side of the old panel, came to me new, by way of eBay. My plan was to add it in parallel with my existing 15 watt panel, for a total of 90 potential solar watts. Note that the new panel while rated at 75 watts, is **5x** the power rating of my original 15 watt panel - Yet size wise, it is only 2.3 x larger **!** (47" x 21"). It comes complete with a weatherproof junction box on the back to make connections a snap. You can tell while handling it, that this is a more serious PV panel. There is something about the weight and feel of it, the professionalism of the connections and terminations. Very nice!!

Mounting Considerations

As mentioned in 'The Solar Ham Part 1', a south facing solar panel orientation is needed in the Toronto area, and also a declination angle approximating our latitude, or about 42 degrees relative to the horizon. For me, the roof of my deck works well - as it is almost south facing, and already has a slope of about 20 degrees. To mount the panel I have used 1.5" x 1.5" galvanized steel, punched and slotted angle iron, to build a simple frame. The frame allows me to further adjust the declination angle according to the season, and provides a secure 4-point support to secure the panel during the high winds we sometimes get. The slotted angle iron is readily available at local building stores.

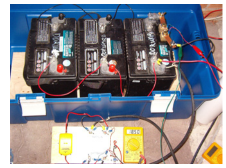
Connecting and Paralleling the panels

Nothing to it, providing the panels already have internal series blocking diodes, to prevent one panel from loading or driving another. Both my panels had the built in diodes, but if you do need to add them, make sure they are low forward voltage drop schottky types, rated for the maximum current of your panel. All that is required to do is to physically connect the panels in parallel, preferably with the wiring inside of a protective junction box, and run the combined panel output to your charge controller. (see schematic) For outdoor use, I have used 14/2 CSA FT-2 water resistant flexible cable, both to connect the panels and for the run to the charge controller. For the solar panel disconnect, I used a 10 amp toggle switch, and a 10 amp automotive in-line fuse, mounted in a weather-proof junction box outside.


The Solar Ham Part 2
by VA3DDN
DEC 15, 2003
75 WATT SIEMENS SQ75 PANEL
15 WATT ICP PRO15W
EARTH
GROUND
10 A DISCONNECT
10 A ATC/ATO FUSE
ICP 10014 100 W
CHARGE
CONTROLLER
BATTERIES
2x NAUTILUS 1000
120 v 700 WATT INVERTER
300 AMP
CLASS-T FUSE
TO AC LOADS,
C.F. LAMPS, COMPUTER ETC.
MFJ or RIGRUNNER, or
OTHER FUSED, 12 VOLT
DC DISTRIBUTION PANEL
12 V LOADS
ICOM 706
AUTOTUNER &
DIAL LAMPS
OTHER DC LOADS

Connecting and Paralleling batteries

To increase your available ampere-hours, you can easily connect more than 1 battery in parallel as shown in the schematic. Suitable battery interconnection cables complete with lugs for screw terminals are available in various lengths at automotive stores. Best results will be had when using similar batteries. Don't mix different types, sizes or ages of batteries. Also be aware of the increased hazards created in paralleling batteries. (see the section below on fusing)



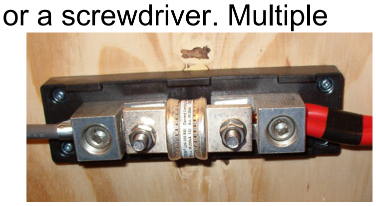
Battery Selection and Battery Gassing Hazard

This is a large subject indeed and is beyond the scope of this discussion. However, amateurs are advised where possible to utilize low gassing or recombinant battery types like gel cell types, those marked as AGM (absorbed glass mat), or VRLA (valve regulated lead-acid), that are now readily available. These batteries are usually sold as RV and deep cycle types off-the-shelf at most large retailers, like Walmart or Canadian Tire. In my case, I am using several marine grade starting batteries, simply because they were easily available to me. These are "Nautilus 1000" batteries, rated 80 AH, & 115 reserve minutes, and are manufactured by Exide as type XXHD-M-24 (group 24D). Although a compromise with the automotive starting battery, and a step toward true deep cycle batteries, marine starting batteries are still wet-cell and will emit hydrogen gas during charging, especially during heavy charging after deep discharge. Note that hydrogen gas in air concentrations of more than a few percent, can be both flammable and explosive. Therefore multiple battery installations should be located away from ignition sources like furnaces and water heaters, and should be vented to the outside*. As you see from the photos I used a Rubbermaid 2156 'Totelocker' with a hinged lid to contain the batteries and to convection vent any accumulated hydrogen to the outside via 1.25" ABS plastic pipe.

(*Note:If you are only using one battery, just to run your rig, and have modest recharge cycles that can be handled by a small 1.5 amp charger in a few hours, I doubt that there is much risk from accumulated hydrogen without venting, provided there is normal good air re-circulation in the room)

Fusing, Circuit-breakers, Wiring

The schematic attached shows 3 levels of fusing, the first starting at the panels, the second following the battery(s), and finally for general distribution to the various DC loads. It is important that only DC rated fuses or circuit breakers be used. The most important fuse in the system however, is the class-T fuse , a special *fast-acting* type designed specifically to interrupt a major DC short circuit. The class-T fuse performs a similar function to the "fusible link" in an automobile. Even a single 80 – 100 AH battery is capable of delivering more than a 1000 amps during a short, enough to melt most things, even a wrench handle or a screwdriver. Multiple battery systems however, contain significant amounts of stored energy and if shorted can result in serious damage, burning or even battery rupture. Therefore, the class-T fuse should be located within 18" of the batteries and connected as shown in the schematic so that all energy to and from the battery must pass through it. These fuses are available in a variety of ratings. Just make sure that yours is rated higher than your maximum DC load, but lower than the cold cranking rating of your battery. Although a 100 amp rated class-T fuse would suffice for the installation illustrated, I am actually using a 300 amp rated class-T fuse, partly because it was available to me and partly because it allows for expansion of my AC loads. (existing 700 W inverter can draw up to 50 amps if fully loaded) All wiring between the batteries and up to the



class-T fuse should use #4 AWG or heavier gage wire. Remaining wiring should be sized according to load.

DC Voltage Distribution in the shack

Connecting and individually fusing your various DC loads to the battery system can prove challenging. Both MFJ and Rigrunner, as well as several marine suppliers, provide compact and convenient, fused DC distribution panels which make the task relatively easy.

Estimation of Daily Loads

You can estimate your power consumption as volt-amps, watts or simply amp-hours from the battery bank. It doesn't really matter but you need to pick one measurement system that works best for you. I prefer to think of amp-hours going into or out of the battery bank at a nominal 12.5 v for simplicity. From the table below you can see that my daily station usage is approximately 20 amp-hours @ 12.5 volts, and would be still less if I cut down on station lighting. One 70 watt (equivalent) compact fluorescent lamp is more than enough to illuminate the station operating area comfortably.

Since the combined solar panels easily charge at 3 - 4 amps, for about 5 hours on sunny days even in the non-solar friendly winter months of this latitude, I am close to breaking even on amp-hours used vs amp-hours replaced. In the spring – summer period, I would expect up to 5 amps for at least 6 hours, or 30 amp-hours.

Simple Load Chart

Load Item	Amps @ 12.5 v	x Usage hrs	Effective Amp-Hours
Icom 706, receive only	1.2	3.5	4.2
Icom 706 transmit @ 50W	10	0.3	3.0
Icom 706 transmit @100W	20	0.15	3.0
Dial scale illumination of SWR meters, etc	0.18	3.5	0.6
120 Vac inverter, average load with with 2 C.F. 15w lamps (140 w equivalent)	2.7	3.5	9.5
Total daily Amp-Hours			20.3

Actual Performance

The newly added 75 watt panel made an immediate and very noticeable difference. When I had only the little 15 watt panel, I was lucky to get a full a battery charge on the brightest, sunniest day, and using only one 80 AH marine battery, slightly used. (the single battery which was usually used to power the ICOM 706).

After installing the additional 75watt panel, I am getting a full battery charge by noon, every day, even on part cloudy days, and even while using 3 paralleled 80 AH batteries.

(since my boat is in winter storage, I have to find some place to store and maintain its 2 batteries, hence the sudden boost from 1 to 3 batteries for the shack!)

However, it is also clear that if I want to increase my DC or AC solar loads in the future, I will have to add additional charging capacity either in more solar panels, or perhaps a wind generator.

System Cost Summary

Item	Cdn $	US $
Siemens SQ75, 75 watt solar panel	$376	$289
ICP PRO15W 15 watt solar panel	$160	$123
Mastercraft 11-1838-6, 700W modified sine Inverter	$99	$76
Misc. cables, connectors etc	$75	$58
Class T fuse and holder	$68	$52
ICP 100147 amp charge controller	$40	$31
Battery enclosure and venting	$35	$27
Totals:	$853	$656

Solar Ham Part 3 has not been fully planned yet. My thoughts are to write part 3 to follow up on actual system performance with what I have, as well as in cleaning up the installation, and possibly addressing any questions which come up from readers. Down the road too, may be a home-brew wind generator, to assist the PV panels and provide a bit more, useable, alternate energy. I am open to suggestions.

73 Don Dorward VA3DDN

*(Reference to Home Power Magazine: Still the **best** resource I know of for Solar and alternate energy sources is Home Magazine. Go to http://www.homepower.com/)*