Solar Charge Controllers:

June 2016

Note: *This section is for those who want more details and perhaps would like to mix and match solar parts for some reason in their field situation. This section is for more more sophisticated designers of custom solar systems. For most normal users, they would do better to simply read the Controller - Battery Combo Units section, and skip this part. The Combo Units are highly recommended to those who are in a hurry to deploy a solar system on the field and want "simplicity" and "robustness" first and foremost in their decisions.*

Due to rapid changes in solar radiation possible, the corresponding solar panel voltages fluctuate dramatically. The purpose of the controller is to condition the power coming from the solar panel and make this power acceptable for various battery chemistries to store electrical power, and without premature damage to the batteries, shortening their useful life.

The best batteries suitable for the variances in solar power, today, are the LFP technologies. Lead-Acid batteries, although extremely old tech and well known, are the worst possible chemistry for solar. Nice for automobiles; fragile in a solar system. Nickle-Metal Hydrid can also be used. In all these cases, the Charge Controller is the "watch man" or sentinel who makes sure that the batteries are receiving a good charge under the given solar conditions. Clouds come and go; rain storms hit; night time comes, and yet the controller does the right action to help the battery live a long and useful life.

All solar panels have a Maximum Power Point (MPP) and manufacturers proudly give specifications for this. It's the “knee in the power curve” where the total power is maximized at a certain specific voltage and certain specific current output in brilliant sunshine. This point changes with the different solar panel technologies. The Morningstar and the Xantrex controllers discussed here are trying to hold the solar panels at that optimum point for max power, and also regulate the charge current for what the battery really needs at the moment. The state of the battery is changing as it charges back up again, while the incident solar radiation is changing by the minute as well. Finally the netbook or “load” may or may not be in use. The controller then makes new and different decisions about the charge voltage and current applied. All this activity and decision making is to help your battery live a much longer and healthier life before replacement while performing its work function as well.

Best All Around Solar Controller: Xantrex C-12

Many previous designs were centered around this excellent controller that is still in production after many years. It is a printed circuit board (not in a sealed potted module) and therefore can be diagnosed and fixed by trained electronics technicians. It is field repairable, which is handy. It also tops out at 12 Amps, which covers a wide range of netbooks, laptops and old power-hungry laptops who can demand high current loads in use. So a good universal performer for many different kinds of laptop computers, old and new.

Quick Info: If you don't want more details, but want to purchase a complete system which is built around this controller than see: GTIS PowerMon Store

This box, nicely sealed from the elements, has the C-12 Controller inside plus fuses, plus a built-in voltage meter, plus three 72 Wh LFP battery packs. Fool-proof external connectors are mounted in the box. This will also be described in the *Controller - Battery Combo Units section*

Further Details:

This is the standard Xantrex C-12 controller box which can also be directly purchased from the Internet stores.   There is a metal Nema enclosure, and a repairable circuit board inside. Best of all, there are five individual pots or adjustment wheels to customize the charging cycle for your particular batteries. If you have Lead-Acid batteries, you want different settings, than if you are deploying LFP type batteries, although the settings are close enough. See advantages of various battery chemistries in the Battery Technology section.

Operating Principles

Beware of charge-recharge inefficiencies on your notebook batteries. It might be helpful to note here, that while charging a typical netbook's internal batteries, that this appears to be a most power inefficient mode. Charging currents go quite high, from 2.5 to over 6 amps at times, and often the energy conversion efficiency drops dramatically. If this scenario of charging/ recharging the netbook's internal batteries is required for daily use in the language program, then one would suggest increasing the solar panel size. It is better to simply run off the external battery pack that you are providing, and leave the internal batteries at an indicated 100%. You can, of course, use the notebook batteries as a "reserve" for when weather conditions are really, really abnormally bad that day.

If under normal conditions your solar system appears to be more than adequate, and you are always running the notebook batteries at an indicated 100%, then we would suggest removing the internal battery pack (usually a clip unit that is easily removed) completely. Place it on the shelf for emergencies later. Why?   Because prolonged overcharging the internal battery pack over months without using the battery pack, reduces the lifetime of those internal batterys. That's the reason why in the town situations with reliable mains power, we are still often replacing our internal battery packs after two years, even though we have hardly used them at all. We are overcharging them and slowly releasing electrolyte to the atmosphere.

But in solar setups, like mains power setups, the power is reliable. There is no real need to run the internal batteries all that much. Use the once in a while, and keep then healthy and exercised slightly.

Low Voltage Disconnect Issues (LVD/ LVR)

The Low Voltage Disconnect (LVD) should be set in a manner that protects the netbook user from overusing the battery and potentially discharging the battery too far for a given daily charge/ recharge solar cycle. Equally important is the Low Voltage Reconnect (LVR) setting. Once the load is disconnected with a hard-worked battery, the user must be “blocked” from continuing to drain the battery, until a suitable battery state is reached. For the fragile Lead-Acid battery we are suggesting here just below the standard “float” voltage or 13.6 volts, although the “Bulk” charge phase of the Xantex controller goes beyond this to 14.6 volts. Above the LVR point, the user could start working again or at least start charging the netbook's internal battery through the auto-adapter. See next section “Typical Charging Cycles”. Some consultants might consider a higher LVR setting. Obviously the user can still run, sometimes as long as 8 working hours, on the internal Li-Ion batteries of the netbook, but this is not recommended as "normal" practice due to inefficiencies in charging and recharging yet another battery in the system.

Note as stated already in the Battery Technologies section, the LiFePO4 (LFP) battery chemistry is a much more forgiving technology for solar use. Typically the "Bulk" phase setting is set around 14.4 volts, and the "Float" setting is around 13.6 volts. There is a sharp drop-off beyond the "knee" of the LFP discharge curve and so anything below 12.3 volts is recommended for the LVD seeting, say 11.5-12.0 volts. But it could be lower than that, because the curve is so steep at that point. The LVR is typically 0.8 volts above that, but around 12.5 would be good.

If all this sounds too complicated, please don't trouble yourself on these points. Proceed to the *Controller - Battery Combo Units* section and simply purchase the Villager-III model, and leave all these settings the same as GTIS applied.

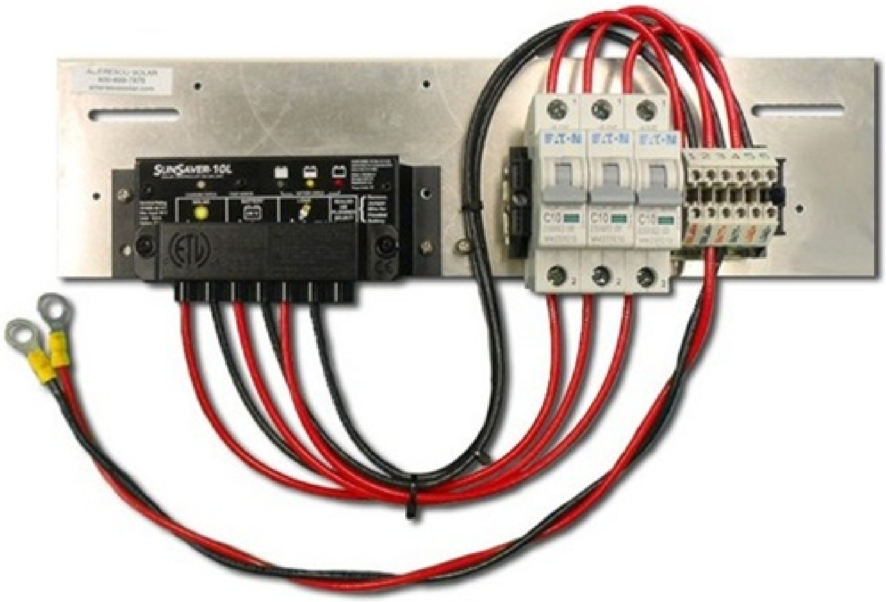
Morningstar SunSaver Model SS-10L

The SS-10L is a very popular solar controller, and sold on many solar oriented web sites and stores. It has a very solid look and feel when held in one's hand. This 10 Amp controller with LVD function, is a sealed “potted” module with mounting brackets and terminal posts, making repair service a bit more difficult. GTIS also has these units at 20 A (SS-20L) for sale at approximately US$ 80. See: GTIS PowerMon Store

See: Amazon Store but note that at 10 A (SS-10L) then the GTIS store is really the place to shop here.

Some very nice features are the smaller size and a solid “low voltage disconnect”, but unfortunately the built-in LVD setting at under 12.0 volts, is way too low for Lead-Acid purposes, but would be acceptable for LFP batteries. See the Battery Technologies section. The Xantrex C-12, 12 A controller is favored, because it is adjustable, but many would never change the adjustments to begin with. Never purchase the ordinary Morningstar SS-10 model as that does not have any LVD function at all. A large advantage to the SS-10L is that it is very small, in comparison to the C-12, with its large PC Circuit Board.

(Click for zoom)



However, there is a possible reason for the lower than expected LVD of the Morningstar Controller. In field testing many users are not using a proper gauge of wire, running from roof-top to controller, and especially from controller to battery. There can be a significant difference between the recorded voltage at the battery terminals and what is “sensed” by the controller, even for short wire run lengths. So for a desired LVD of 12.3 volts at the battery, the controller might have to wait for 12.0 volts at its sense terminals. The voltage drop is created by the high enough load currents and the typically small diameter wire that some people use. This might explain the thinking of Morningstar, however their design is a compromise of possible conditions at best. The C-12 Controller allows the savvy technician person to make fine adjustments for each unique installation in the field.

Picture: EcoDirect.com A very nice mounted Morningstar Controller, with three mounted 10A DC circuit-breakers and terminal block nearby. This company wanted fuse protection on the solar panel side, the battery side, and the load side of the controller circuit. This is a great looking setup. Also note the insulated cover plate over the normally exposed contacts of the Morningstar. Falling metal objects are less likely to short out this arrangement. For more about fuses and breakers, see the Fuses section.

Morningstar SunGuard SG-4 Controller

This discussion would not be complete if we didn't include the heart of the GTIS Half-Pint system here. The SG-4 is for "light duty" solar applications, and is inexpensive at around $30. However, with the new 2016 netbooks on the scene, this controller is more than large enough to supply energy. The new netbooks would draw a maximum of 2.5 watts, to put this in perspective.

The only problem with the SG-4 is the lack of any LVD cut-off. It's up to the user to determine when to turn the solar system off, and stop supporting the netbook. In the Half-Pint system box, there is space for an alarm circuit, which for an additional $5 or so, would be well worth the installation. We are presently working on a good modification to the present Half-Pint at this time. See the Controller Battery section for more details on the GTIS "Half-Pint" system.