The Small Computing on Solar (SCOS) Handbook

Tools for National Language Workers

Brian Chapaitis
Summer Institute of Linguistics
Papua New Guinea Branch
July 2010

Abstract:

For the first time in recent memory, advances in solar technology and computer laptop technology have converged such that the goal of language work performed by PNG Mother Tongue Language Workers (MTLW) can be realized in a relatively cost-effective manner by themselves and for themselves – with minimal oversight. This paper primarily concerns itself with hardware issues, while briefly mentioning useful language software tools under development by SIL and other agencies. It does not address national training issues. It is meant as a "handbook" or a guide to collect in one place all the relevant technical issues and potential hardware suppliers useful to SIL administrators who want to set up unassisted, long term, national coworker projects with minimal mentor contact. In short, it is an effort to outline the application of technologies for a sustainable MTLW program and represents the present "state of the art.".This is a constantly moving target since technology changes so rapidly. Be sure to read the latest version available of this document.

Picture: *Dominic Pusai (Goiniri language) helps Joseph Aputa (Barupu language) as Joe checks out the team's first Asus Eee 1101HA netbook computer. Physically smaller than the translators' old Toshiba laptops (see inset), netbooks typically use only about 1/4 the power, making our solar-charged batteries last far longer. Aitape West Multi-Language translation project, north coast, Papua New Guinea (11 languages in progress).*

Introduction

In year 2009, during a time of world-wide financial recession, the netbook was born. The marketplace literally exploded with small form-factor "netbooks" that weighed around 1.5 kilos, and cost US$ 300-400. And the marketplace responded to these inexpensive devices. Intel reported record revenues by 4Q, 2009 with the integration of their ATOM processor line. Along with relatively inexpensive prices, business and private users alike also discovered the wonder of "all day" computing. The ATOM processor line also represents a big break-through in the concept that "low power consumption" might be a highly desirable feature, if one can work at a coffee shop and do all day computing tasks without plugging into mains power outlets. These were decidedly simple tasks, to be sure, like Word Processing and eMail and Web Browsing. But isn't that enough?

At the same time huge advances occurred in new thin-film and poly-crystalline solar technologies within the same year. This produced the first commercial grade solar panels that were beginning to approach the US$ 3 per watt level (as compared to $8 per watt before). These light-weight panels got a tremendous boost by the OLPC (One Laptop Per Child) movement when a major supplier produced small 10 watt panels for approximately US$ 26 each. Combined with the extreme low power of the first generation XO machines, one began so see the realized potential of "low power consuming" netbooks supported by inexpensive solar panels as a new frontier in our work.

This paper represents the state of the art for SIL considering the merging of these two powerful trends in the industry and toward new Third-World applications. We are actively developing significant "laymen" tools that, once placed on sustainable hardware, would empower national citizens to consider doing portions of the language development task. And this includes, the Bible Translation task.

Summary: SCOS Goals and Objectives

> **"Define a complete system of hardware, a tool, suitable for third-world national coworkers to consider doing language development work for themselves and by themselves. To build reliable, self-contained, and low maintenance hardware systems, where there is no readily available mains power."**

> "SCOS defines a sustainable platform by which suitable national language tools can be implemented by laymen in the field"
>
> — Brian Chapaitis

Beyond the scope of this "handbook" is the requirement of suitable ***national training programs*** for a successful implementation within a Branch or Entity of our organization. That exercise is the subject of another paper and also would be integral to a far larger, comprehensive Branch Strategy plan.

(Items in blue represent additions since the last major publication)

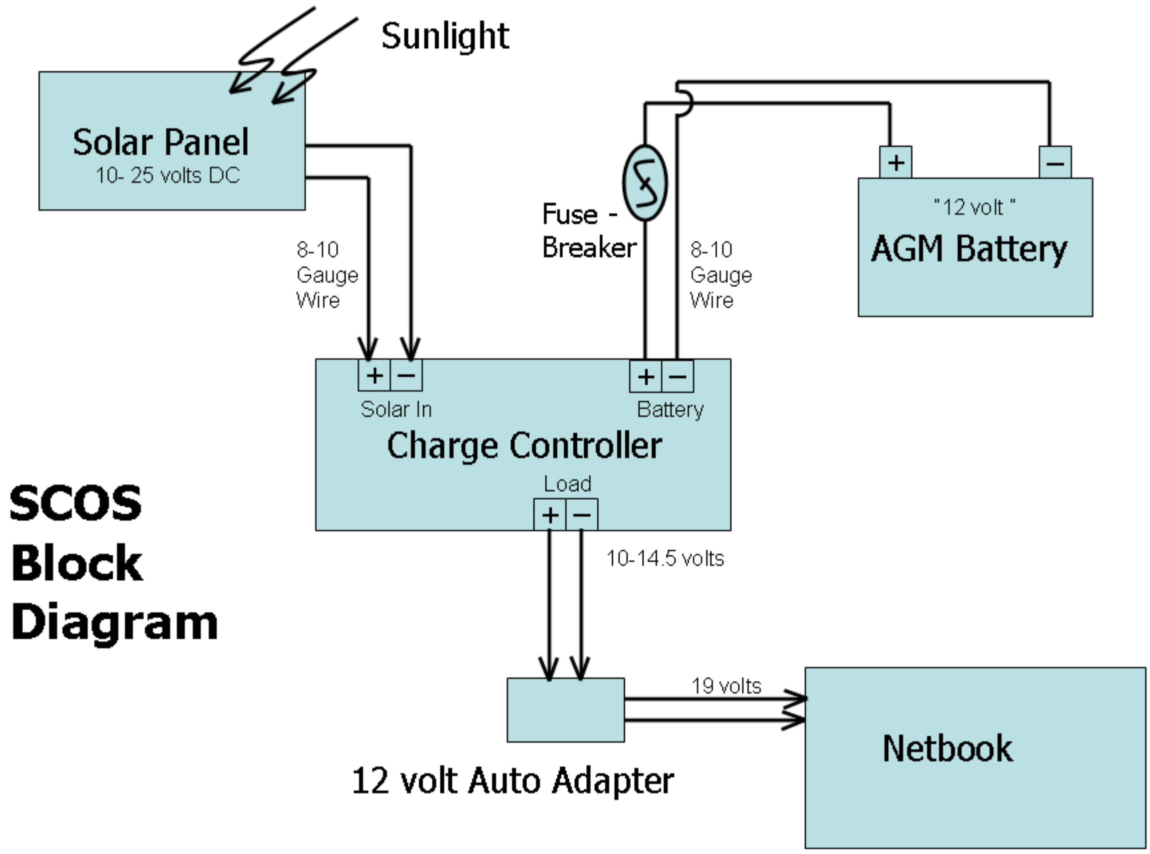
Summary: Main Points

For those who want to read the main points (and not the reasons why):

- *Best Netbook: Asus 1001PE or 1005PE or present equivalent (Atom N450; 6 cell battery)*
- *Best Solar Controller: Xantrex Model C-12; 2nd choice: Morningstar SS-10L or SS-6L*
- *Best Low Voltage Cutoff Setting: 12.5 volts measured at the battery terminals (not the solar controller)*
- *Best style of Battery: Sealed Lead-Acid (SLA); AGM construction; avoid old style "Gel Cel"*
- *Best Gauge Wire: 10 gauge or larger (smaller gauge number)*
- *Good Battery Lifetime while in use: 3 years (plan now on replacement cycle)*
- *Best Solar Panel: With Present 10 watt netbooks – Rule of Thumb is 4 X or 40 watts - minimum*
- *Size of Battery: If planning for regular 8 hr, day-time work: 4-7 Ah; If planning for regular evening work: 18-21 Ah Rule of thumb: Battery Ah rating is 3 X the hours of work required - minimum*

System Overview

Block Diagram of a Complete Solar System



Description of Components

Note: Although the manufacturers of the solar controllers below say the order of connection of parts does not matter – the general wisdom says that under full sunlight, the converted energy of the sun's radiation should have a good place to go. Therefore always connect the battery first, or disconnect the battery last during assembly of the parts.

Solar Panel:

A flat device, sometimes called a photo-voltaic (PV) panel that converts incident solar radiation into electrical energy. Manufacturers include Gold Peak (GP) and Global Solar (GS) mentioned in this paper.

Solar Charge Controller:

Due to rapid changes in solar radiation possible, the 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 lead-acid battery chemistry to store electrical power, and without premature damage to the batteries, shortening their useful life. Popular high-efficiency circuit designs include Pulse Width Modulation (PWM) and Maximum Power Point Tracker (MPPT).

Battery:

An electro-chemical energy storage device. Many battery chemistries exist including Lithium Ion used in mobile phones, and laptops and Nickel-Metal Hydride, often used in laptops and LED flashlights. All can be re-charged. Lead-Acid is a relatively old technology, and well understood. It is favored in solar applications primarily due to relatively low cost, compared with the newer, high-performance technologies.

Fusible Link:

A circuit component, that is designed to break, or burn, when a relatively high current is applied and thus save further damage to equipment attached to a power source. Examples are an automotive in-line fuse (which must be replaced when used once) and a mechanical circuit breaker which can be reset by the user. Please do not skimp here and not bother with some sort of fuse or breaker in your solar setup. There is more than enough energy stored in a typical solar setup to create a spark that burns a village house down, or a direct sustained short of battery terminals leading to a battery explosion. The price of an automotive style fuse holder and fuse is very inexpensive insurance.

Automotive Adapter:

Actually a voltage conditioner and regulator, netbooks would normally use these to condition the transients found in automotive 12 volt electrical systems, saving the netbook power supply from undue stress. In solar netbook applications these devices protect the netbook input power supply from voltage swings present from the solar controller charging the battery. These range from 10-14.5 volts DC, where the given netbook wants a steady 12.3 volts or 19.5 volts supplied at all times. These adapters are very energy efficient and superior to use in comparison to an AC inverter.

Netbook:

A new class of notebook computer that can run a major Operating System like Linux or Windows. These range in size from the early Asus 701 series at 7 inches wide – all the way to the Asus 1201HA which is 12 inches wide. 10 inch netbooks are large enough for many to touch type easily on their keyboards. 11 inch is about optimal. Popular makes of netbooks come from Asus, Acer, Dell, Toshiba, Lenovo, Samsung, MSI and others. Asus is considered the most reliable by far, only to be rivaled by Apple Computer.[1]

Language Software:

Briefly mentioned here, but designed with national lay-workers in mind, these would include the OS environment called Balsa, and applications like WeSay, BibleEdit, Paratext, any Word Processor, eMail, and a suitable, as-yet-unspecified national literacy tool.

Solar Panels

Different Solar Technologies

The ***maximum energy*** we could ever expect from average solar radiation to the ground (or insolation) would be around 1,000 Watts/m^2

on the earth's surface perpendicular to the Sun's rays at sea level on a clear day. But of course that would be in the ideal since there are many other factors involved where one is located. Insolation from the words ***in**cident* *sol*ar radi*ation*. Is often expressed regionally on maps as kilowatt-hours per square meter per day (kW·h/(m²·day)).[2] Look for insolation maps for your region which can be quite helpful for planning purposes. Obviously this has a bearing on photovoltaic (PV) or "solar" panels, but solar panels are never 100% efficient.

Monocrystalline technology. The highest efficiency ratings have been achieved on monocrystalline silicon cells (c-Si) which are very expensive to produce since one must grow silicon crystals in cylindrical "boules" and sliced into thin wafers. Hence such panels made from such cells often have an array of circular cells mounted on a substrate. The highest recorded commercial efficiency appears to be 22%

Thin Film technologies can sometimes reach 18% and "multiple junctions" higher than that. Most of the commercial production of thin film solar is based upon another compound CdTe (cadmium telluride) with an efficiency of 11%. These are of interest today because of greatly reduced manufacturing costs, and you notice their rectangular nature when placed on a substrate of some kind, or perhaps a flexible roll.

"The selected materials [of thin film] are all strong light absorbers and only need to be about 1 micron thick, so materials costs are significantly reduced. The most common materials are **amorphous silicon** (a-Si, still silicon, but in a different form), or the **polycrystalline materials**: **cadmium telluride** (CdTe) and **copper indium (gallium) di-selenide** (CIS or CIGS).

Each of these three is amenable to large area deposition (on to substrates of about 1 meter dimensions) and hence high volume manufacturing. The thin film semiconductor layers are normally deposited on to either coated glass or stainless steel sheet."[3]

Example of a US$ 26, Thin-Film 10 watt solar panel from Gold Peak. Our involvement with the OLPC movement in the Pacific led to their solar panel manufacturer in China who then produced custom panels for SIL. 20 watt panels sold to members for US$ 75, or approximately $3.75 per watt (landed cost).

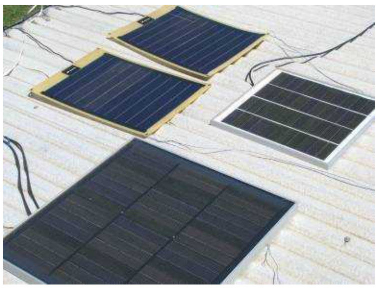
Triple Junction Thin Film Technology

While building a partnership relationship with the OLPC (One Laptop Per Child) group here in the Pacific we asked for their source for those flexible substrate, Gold Peak (GP) solar panels they re-sell at US$ 2.6 per watt. An astoundingly low price, or at least was astounding in the first quarter of 2009. The year 2010 is another matter as we shall see in this report.

Nonetheless, we have managed to get a few custom GP ***20*** watt solar panels made for us, and shipped to Papua New Guinea for solar experiments. At present a 20 watt GP solar panel will cost approximately US$ 85 landed in our country. You will need two panels for present netbooks, however, one panel will power the upcoming "smartbooks" and the newly announced Apple iPAD "tablet" style computer if you can make that kind of computer work for you.

Wondrously light weight (2.5 lbs), these panels are very easy to ship by small aircraft (20½ W x 30¼ L x 1/16 inches). They have grommet holes suitable for permanent mounts, but some are considering raising and lowering these during the day via ropes to increase security from theft.

Best of all, these panels have great "low light" or shade performance. It is not uncommon to be generating a suitable charge for the solar controllers even when skies are completely overcast.



Solar on Roof: Global Solar 30 watt panel (bottom) in aluminum frame. Two Gold Peak 20 watt panels on upper left (fiberglass?)

CIGS Solar Panels

Another promising technology are the new CIGS panels, or Copper Indium Gallium di-Selenide technology. This is considered in the class of “poly-crystalline thin film”.

We have been experimenting with the Global Solar 30 watt panel model GSE-30 in our latest netbook experiments.[4] The MPP (Maximum Power Point) appears to be 1.7 A at 17.5 volts, and the unit weighs 11 lbs. Dimensions 25 x 25 x 1.3 inches

This panel is relatively heavy, but ruggedly built and the active elements appear to be mounted behind tempered glass, and within a solid aluminum frame. Designed specifically for “off grid” use, these panels are made for high reliability in very rural applications. Just what we would want. The cost is normal however at US$ 184.00 or approximately US$ 6 per watt.

The Ideal Solar Panel

We have found these 30 watt CIGS panels to be excellent “low light” performers as well but 30 watts is barely enough for a working Asus netbook with solar charge controller in “overcast” conditions. There will be a small trickle charge for the AGM lead-acid battery if the netbook is fully charged, and connected to the controller. In this scenario, we are only consuming 0.8 amps (approx. 10.4 watts), while doing useful work.

However, what is really desirable for overcast conditions, where the user is planning to work for an 8 hour work-day every day of the work week… is ***really 40 watts***. One alternative while using 30 watts is to count on some overcast workdays of only 6 hours, after many continuous overcast days. This assumes you are using the AGM lead-acid battery configuration and that the battery capacity is near 100% (i.e. A new battery).

Recently we have found Gold Peak 20 watt panels similar to the thin-film panels used for the OLPC XO systems. Experimental panels proved to be great low-light performers. Using 2 x 20 watt panels was more than enough to adequately power a common netbook in the field.

If using the “battery-less” configuration… then (we hope) the 30 Watt panel will probably work very well due to increased efficiency. In this configuration, the primary power storage is the internal Li-Ion battery itself, which could run as long as 10 hours. The Li-Ion chemistry is not fragile like the lead-acid chemistry, and more robust in this application.

Operating Procedure Notes

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, up to 3.5 amps at times, and somehow the energy conversion efficiency drops dramatically. If this scenario of charging and recharging the netbook’s internal batteries is required for daily use in the language program, then one would suggest larger or more solar panels than 40 watts.

Also we have now seen village allocations where the gauge of wire used from the roof top to the solar controller within the village house is way too high or “too small” in diameter. The user should start by thinking about 10 gauge wire as a minimum and definitely move to 8 gauge wire if available and affordable. Otherwise considerable power is wasted due to resistive losses in the length of wire required, typically 5-10 meters.

Do not neglect the problem of over heating any PV solar panel. When the sun is overhead, or traversing into the afternoon, panels mounted on metal roof-tops may get very hot and this condition will decrease panel output. Sandia Laboratory reports: "The voltage of crystalline cells decreases about 0.5 percent per degree centigrade temperature increase."[5] For this reason we have tilted panels slightly to the east to catch more direct morning sunlight while the roof and panels are relatively cool. Using wood blocks to raise panels on corrugated iron roofs allows for increased air-flow, and a cooling effect. A crystalline solar panel could decrease its power output by as much as 12% overall. This effect combined with power losses via relatively long power wires to the solar controller can be significant.

Blocking Diodes: In the old days, charge controllers were not that sophisticated and a series blocking diode was placed in the solar panel wiring such that during the night, the fully charged batteries would not discharge back through the panel. This is not a problem with modern solar charge controllers since their circuitry typically disconnects the solar panel at night.

However, there is discussion about the new solar panel technologies, like CIGS and Thin Film technologies and whether two panels wired in parallel need blocking diodes or not. The issue is during a brilliant sunny day, and if shade from a nearby tree were to cover one panel, while the sun illuminates the other. The fear is that a high enough potential energy will flow back through the shaded panel, and might overheat this panel with damage.

However, note that the Sandia National Labs Solar Technologies Department (US government) says that this is not an issue in their excellent report.[6]

What size solar panel do I really need? The general rule of thumb is that during the worst-case overcast or rainy conditions that you expect in your locale, that the energy output of the panel equal the energy consumed by the netbook. In our labs in the Highlands of PNG, that spells out to about a 40 watt panel for a 10 watt netbook, or a factor of four (4x). So, if I operate a netbook on a 12 volt system and then measure a current load of 0.8 amps at the terminals of my lead-acid battery, I would want a solar panel that produces the same current under worst case day conditions. This works because language workers typically do not work constantly all day on their machines, and a typical day does indeed have patches of great sunshine to recharge batteries. Overcast sometimes means "bright" overcast, producing 2x more power than what is needed to run the netbook.

Can one make a 30 watt solar panel suffice? Yes, but there must be increased vigilance on the part of the user to give adequate watch care to all batteries, both the external lead-acid battery and the internal Li-Ion battery pack of the netbook.

However, the next generation netbooks (Atom N450 based) are now weighing in at the 6 to 8 watt working power level, which means a 30 watt panel meets the 4x rule easily. At 5 watts we can consider one of the lightweight Gold Peak 20 watt solar panels (now at US$ 75) as sufficient.

Where to Purchase Solar Panels

There has been a brief period where JAARS Inc. purchased at quantity 100 units, the same flexible Thin-Film technology from Gold Peak (GP) that is used to supply the OLPC XOs in various countries around the world. We had asked for 20 watt panels instead of their standard 10 watts. These arrived for deployment and were promptly re-sold in PNG and around the world, but we do not know if a re-order through JAARS is pending or not. The Thin-Film on a flexible substrate panels have a supreme advantage in lowered shipping costs. They are great, low-light performers.

An example of a US$ 100, Anodized aluminum frame, 40 watt, mono-crystalline solar panel. This should weight in at around 5 kg. or less. As seen on eBay.com. Beware of very high shipping costs to Third-World locations.

Recently (2010), regular aluminum frame panels, in either amorphous, poly-crystalline CIGS, or straight mono-crystalline have been seen for sale on Amazon.com and also eBay.com. Prices are around $2.5 to $3 per watt. However, the enormous cost of shipping these heavy framed, but durable panels is enormous. Shipping costs to the Third-World could be as high as 2 to 3 times the cost of the panel itself. Reducing this cost, or finding a supplier that can ship overseas inexpensively is a far more significant factor in the "landed cost" of a solar panel. We found one California supplier that was willing to DHL their panels anywhere in the world.

Note: Do not be afraid to consider old-style mono-crystalline solar panels. In PNG one of the best performing panels by HQRP, in low light conditions, is a mono-crystalline design. Some of the most highly efficient silicon cells are mono-crystalline, but previous to now, crystalline solar cells were very expensive to produce. We think that the retail cost of mono-crystalline has fallen in response to the fierce competition of the other technologies now going into mass production. Always consider the specs of a given panel before purchase, and certainly ask questions of the retailer. We have found a so-called 40 watt panel that actually should have been rated 45 watts.

Recent leads via Amazon.com on solar panels:

DM Solar (min order qty 20)
http://www.dmsolar.com/solar-module-4.html

Beanworthy (qty 1) (features World Wide shipping)
http://www.beanworthy.com/ALL-New-45W-Solar-Panel-Monocrystalline/A/B002RF003I.htm#wbaCustomersReviewsWidget

Atlantic Renewable Energy & Engineering Services, Inc (qty 1)
http://store.areegs.com/monocrystalline-solar-panel-sp440.html

GudCraft (qty 1)
http://www.amazon.com/dp/B003OI9IQ2/ref=asc_df_B003OI9IQ21161588?tag=the004-20&creative=380333&creativeASIN=B003OI9IQ2&linkCode=asn

GeoKing (qty 1)
http://store.ordermo.com/ge40wposopa.html

Recent leads via eBay.com on solar panels:

LaVie Solar ($115)
http://cgi.ebay.com/40W-solar-panel-40-watt-solar-panel-Special-sale-/280529274901?cmd=ViewItem&pt=LH_DefaultDomain_0&hash=item4150d90815

Serpenlion2008 ($120)

http://cgi.ebay.com/40W-solar-panel-40-watt-solar-panel-Special-sale-/320556987179?cmd=ViewItem&pt=LH_DefaultDomain_0&hash=item4aa2af732b

ML Solar ($109)
http://cgi.ebay.com/40W-40-Watt-Solar-Panel-Cells-Made-Japan-Quality-/170510581348?cmd=ViewItem&pt=LH_DefaultDomain_0&hash=item27b338fe64

HIDNY ($100)
http://cgi.ebay.com/40-watts-Mono-Solar-Panel-2-50-W-UL-25-Year-Warranty-/260629005794?cmd=ViewItem&pt=LH_DefaultDomain_0&var=&hash=item826324ca99

Note: (I think) LaVie Solar indicated on email that they would ship DHL anywhere in the world. Shipping costs are non-trivial, and a slightly more expensive panel might be less expensive to ship to your country.

What do warranties tell us? We do not think that in five year's time, a given company might still be in business, but the manufacturer placing a 25 year warranty on a part, indicates some degree of pride in the quality of workmanship for the given panel.

A great performing panel, the HQRP 50 watt mono-crystalline, has now risen from US$ 150 to $200 on Amazon.com, and therefore we cannot recommend it. Forces of "supply and demand" must be in play here. It was too heavy to ship anyway, at around 18 lbs. (8.2 kg.)

Netbook Characteristics

Netbook Charging Curve

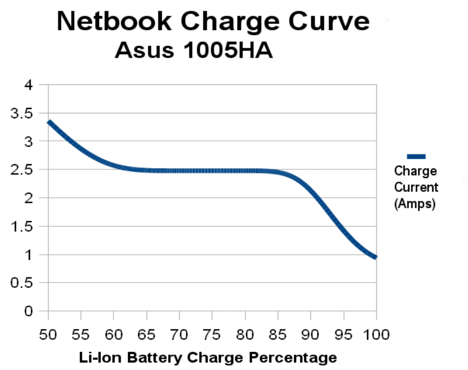
The typical steady-state load for an Atom based netbook, running Microsoft Windows at "idle" is typically around 0.6 to 0.8 amps at 13 volts (battery terminals 12.88V in a solar setup). Factors include the technology for the video driver, the LED back light (vs fluoro), and various user decisions, such as whether wireless devices are on and in use, or whether the screen brightness is turned up or down all the way.

A recent study for an exhausted Asus 1005HA was conducted. The netbook was allowed to run down its Li-Ion battery pack to around 50% and then recharge from a fully charged 21 Ah lead-acid battery.

Common Stats with the Netbook Li-Ion Battery Pack at 47% discharge:

- *47% charge - machine charging with lid closed/ sleep* — *2.67A*
- *47% charge - Win 7 OS startup* — *3.65A*
- *47% charge - Win idle, full bright screen, wifi off* — *3.34A*
- *100% charge - lid closed/ sleep (very nice)* — *0.08A*

Note that these figures imply that the box is only consuming 0.67A at 12.88V to run itself.



Typical Netbook Charge Characteristics. Approximately 98 minutes.

During the charging response from 50% to 100% fully charged, we noted a band of operation where the charge current was pretty flat. At around 50% the load demanded 3.36A (idle with screen bright), but tapered off quickly. By 60% and up to around 93% the charge current was fairly steady at 2.48A (+- 0.06 A). By 96% charge, the current had dropped to 1.21A. Finally by 100%

the initial charge current was .94A and then around 15 minutes later settled to the expected 0.64-0.70A.

The time to fully charge from 50% was around 98 minutes.

Note: This uses the eBay purchased, "Lee262" Asus 12-19 volt auto adapter, (DC to DC converter- see below) consuming about 0.02A, which is remarkably low.

The screen LED backlight Low-to-High brightness power differential is 0.06A at 12.88 volts at the Lead-Acid battery terminals. (0.77W)

So the basic power foot print of the Asus 1005HA is around 8.5 watts while using Windows for light duty work, such as Word Processing. This, of course changes if the user is doing "heavy lifting" such as showing a 3 hour video. However, 8.5W is not the case while using the netbook and while recharging the Li-Ion battery at the same time. Netbooks based on Atom older N280 technologies are not as conservative as the newer N450 based models, like the Asus 1001P model.

Solar Charge Controllers

Purpose

The reason for the solar controller is to condition the power from the solar panels (sometimes called a Photo Voltaic (PV) Panel) to be acceptable for lead-acid batteries. 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 lead-acid 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 to help your battery live a much longer and healthier life before replacement while performing its work function as well.

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 lead-acid battery, until a suitable battery state is reached. For LVR 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.

Morningstar SunSaver Model SS-10L

A very popular solar controller, and sold on many solar oriented web sites and stores. This is a sealed "potted" module making repair service a bit more difficult, and with mounting brackets with large terminal posts. JAARS Inc. and Amazon.com also have these for sale at approximately US$ 50. Some very nice features (over competitors) are the smaller size and a solid "low voltage disconnect", but unfortunately the built-in LVD setting at under 12.0 volts, is ***too low*** for our purposes. See the section: "Lead-Acid Battery Life Issues" following. Because the cost of the batteries can easily exceed US$ 50 to replace, the Xantrex controller is favored for an additional US$ 35. Never purchase the Morningstar SS-10 model as that does not do any LVD function at all.

Morningstar SunSaver SS-10L

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 wire gauge, 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 terminals. This might explain the thinking of Morningstar, however their design is a compromise of possible conditions at best.

It might be possible that with experimentation we can alter the Morningstar LVD to be more usable, but this research has not happened to date, by adding an appropriate external circuit.

Note: It wrong to fear a "deep discharge" if there is an immediate re-charge cycle back to full charge. This means that the Morningstar controller and even controllers that have no LVD function, could function well enough, simply by starting work before dawn and finishing for the day by around 2:00 pm. Operating procedures have a direct bearing on overall solar specification and a profound affect on cost. See topic below: "Typical Work Day Cycle".

Also, there is research in a "battery eliminator" circuit (removing the necessity for the Lead-Acid battery altogether) which for some field settings may be adequate. Obviously such users could not run village house lights… and it would be best to work during sunlight hours. However a system replacing the Morningstar Controller that easily maintained the netbook's internal 8 hours lithium ion battery during the day, would obviously reduce total system cost by well over US$ 150 from the total cost of the system. That might be worth the effort and the change of work life-style for the project. This also removes one extra maintenance battery, ***plus a prime object of theft*** in the village.

Xantrex Model C-12 with NEMA box cutouts for wires. Flashing LED indicates battery condition. Some mount an inexpensive LCD digital panel meter to this box at around US$ 10

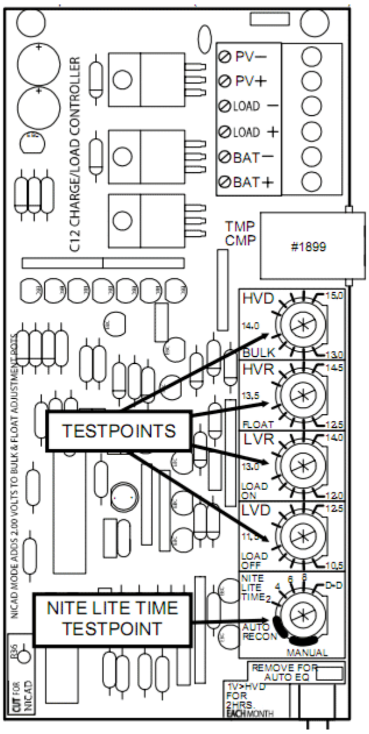
Xantrex Model C-12

With a much larger physical dimensions (16.5 x 11 x 4 cm)[7] and a discrete circuit board with easily serviceable electronic parts[8] – the more expensive Xantrex C-12 controller (approx US$ 85) has significant advantages in ease of service, should something fail in the system. However one of its greatest and most desirable features is a programmable LVD cut-out of the netbook "load" when the operating voltage of the AGM battery falls below a user setting. Typically we want no lower than 12.5 volts as the maximum “depth of discharge” point. See section: “Lead-Acid Battery Life Issues” for more details on this issue.

Note in the drawing (right), the five user setting controls, specifically the Low Voltage Disconnect and the Low Voltage Re-Connect. Best of all, the control knobs themselves can be removed to further discourage changes later.

Convenient Digital Voltmeter (DVM) probe points are provided to make accurate threshold settings.

Unlike the Morningstar Controller, it is now possible to compensate for field conditions. In reality, many users are not using a proper gauge 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. ***As high as 3 tenths of a volt.*** So for a desired LVD of 12.5 volts at the battery, the controller might have to wait for 12.2 volts at its sense terminals. Finally, we can accurately set the solar controller to maximize run times for the netbook, while at the same time, using the minimum Depth of Discharge (DoD, see section below) to greatly extend useful life of the relatively expensive batteries. Once proper settings are established by an expert consultant, the control knobs can be removed and front panel sealed, reducing “tinkering” later.



Inside the Xantrex Model C-12. Notice too, the field serviceable standard components on a conventional Printed Circuit board.

C-12 Quick Start:

Typical Setting for the Panasonic LC-XC1221P “deep cycle” battery:

C-12 Pots	*Desired Voltage*	*Test Point Setting*
HVD	14.7	1.7 V
HVR	13.7	1.2 V
LVR	13.2	1.2 V
LVD	12.3 **	1.8 V
NLT	Auto-Recon	

HVD is the “bulk mode” voltage; HVR is the “float” voltage; LVR is the “Low Voltage Re-connect”; LVD is the “Low Voltage Disconnect”; NLT is “Night Light Time” (not used)

** Note: The desired voltage at the battery TERMINALS is actually 12.5 volts, however, due to resistive losses in the wires to the C-12 controller, this setting is reduced by 0.2 volts, which is a compromise at best. It is always best to measure at the terminals and observe the LVD happening at the point you plan for the given battery manufacturer's specifications. See further discussion below.

HQRP 10 Amp Solar Controller
Morningstar SunGuard SG-4

In Papua New Guinea, we experimented with a new solar controller popularly found on Amazon.com. In the lab this performed well with the exception of the extremely low LVD point, of 11.1 volts. It's main reason for inclusion here is it's very low cost at US$ 27. A very nice feature is the manual push button that can disconnect the load at any time. However, with certain users, a simple alarm circuit (see section below) could be added as a monitor, and then procedurally one could very easily disconnects with this device. It is the AUTOMATIC load disconnect that

HQRP 10 Amp Solar Controller, produced by Osprey-Talon.

would not work, but the cost of this unit is very desirable. Another severe limitation is the very small terminal lugs.

On the other hand, the lower end, Morningstar SG-4 controller, at 4.5 amps, can be inexpensively found if you are ***planning to not use*** the LVD feature anyway (US$ 32). But realize that the price differential between the SS-10L (above) and the SG-4 to the right, is US$ 18, minus the cost of the alarm circuit and its construction.

Inexpensive Morningstar Controller which could be used with a suitable alarm circuit, save costs. 4.5 amps can handle a 50 watt solar panel.

The HQRP Solar Charge Controller regulates at 14.4 Volts; Low voltage Disconnect: 11.1 volts; Low voltage Reconnect: 13.1 volts; It features PWM & State of charge (SOC) monitoring; 4 Stages: equalization, PWM, Boost and Float, with option for temperature compensated charging; Electronic protections: Short circuit and over current-solar and load; Reverse current at night; Limits high voltage to protect loads; Lighting protection; Terminals: for wire sizes to 2.5 mm2; Self-consumption: 0.006A maximum.

Digital Panel Meters

Particularly with the Morningstar controllers you might want to invest in a US$ 5-10 self-powering Digital Panel Meter. These can be found via any number of suppliers on eBay. Look for a 7v to 20v design and that does not require an additional battery to power up. We have found the units from "yabargain" to work well. However the units from "gorgeoustone" can be shipped anywhere in the world. Search for "LCD Digital Volt Panel Meter Voltmeter 7.5V-20V"

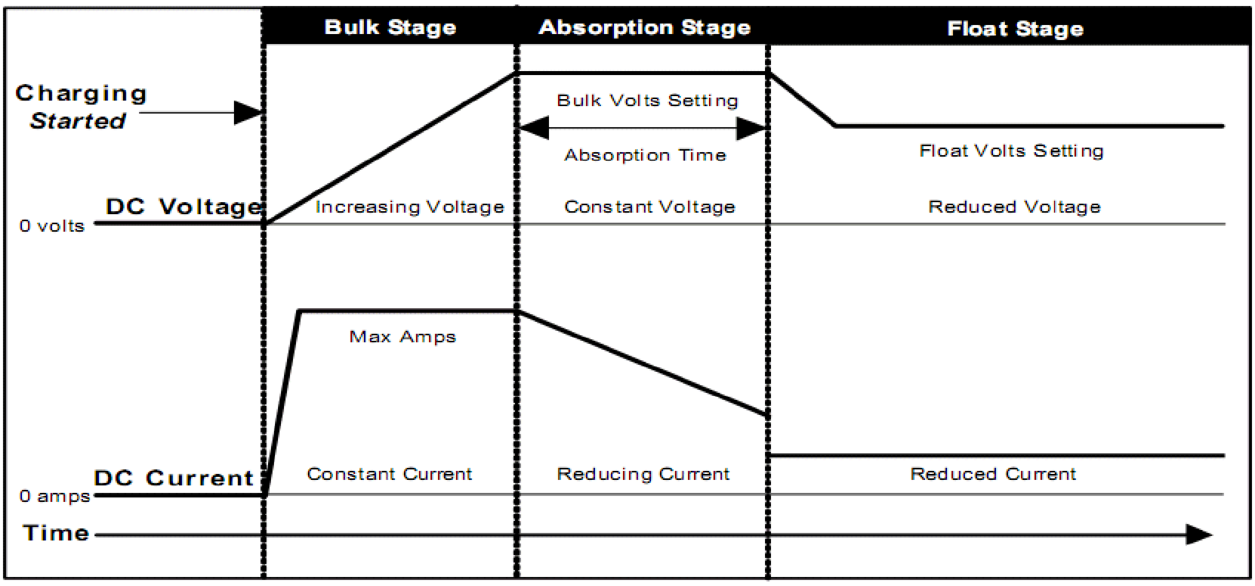

An inexpensive digital panel volt meter that can be mounted just about anywhere in the solar system. Be sure to find a 'self-powering' model.

As with any eBay purchase, make special note of where the part originates from. This will affect any plans on shipping delay times. Parts from China in particular, are not quickly received. Also parts from China tend to under-value the part, and over-specify the shipping cost, so watch for this in any landed-cost price comparisons with perhaps a USA or UK supplier. A $12 panel meter might have free shipping to where you are.

These units are worthwhile if you plan to monitor the general state of charge of your Lead-Acid battery and make useful decisions, particularly in extended rainy weather. They can also be useful to determine when the battery is "old" and needs replacement. Note that some Digital panels can be optimistic by as much as 0.5 volts at the battery terminals, and you need to confirm their overall accuracy with a professional grade voltmeter. These are very low power devices, even with the back-lit electroluminescent display turned on all the time. Otherwise wire in a momentary contact push-button switch to read out a voltage when desired. This panel meter can be mounted permanently in the Xantrex C-12 controller box assembly and there is plenty of space for this.

Typical Charging Cycles

The Xantrex solar charge controller, like the older Trace Inverter chargers, follow a typical three phase charging method in three distinct phases: "Bulk, Absorption, Float". The battery voltage will vary during the ***three stage charging process***, as follows:



- ***BULK****— The first stage of 3-stage battery charging. During this stage the PV (solar) array is allowed to charge at its full output. Once the voltage of the battery reaches the BULK voltage setting, the controller goes to the next stage. Current is sent to batteries at the maximum safe rate they will accept until voltage rises to near (80-90%) full charge level. Voltages at this stage typically range from 10.5 volts to 15 volts. There is no "correct" voltage for bulk charging, but there may be limits on the maximum current that the battery and/or wiring can take.*
- ***ABSORPTION****— The 2nd stage of 3-stage battery charging. During this stage the voltage of the battery is held at the BULK voltage setting until a timer accumulates 1 hour (C-12). Voltage remains constant and current gradually tapers off as internal resistance increases during charging. It is during this stage that the charger puts out maximum voltage. Voltages at this stage are typically around 14.2 to 15.5 volts.*
- ***FLOAT****— The 3rd stage of 3-stage battery charging. During this stage the voltage of the battery is held at the FLOAT voltage setting. Full current from the PV array can still be delivered to the loads during this stage during the day powering the netbook. After batteries reach full charge, charging voltage is reduced to a lower level (typically 13.6V) to reduce gassing and prolong battery life. This is often referred to as a maintenance or trickle charge, since it's main purpose is to keep an already charged battery from discharging.*[9]

Both controllers here use PWM, or "pulse width modulation" where the controller or charger senses tiny voltage drops in the battery and sends very short charging cycles (pulses) to the battery. This may occur several hundred times per minute. It is called "pulse width" because the width of the pulses may vary from a few microseconds to several seconds.

If the voltage of the battery drops below the FLOAT setting for a cumulative period of one hour, a new BULK or ABSORPTION cycle will be triggered (C-12). This typically occurs during each night. If the battery is full at the start of the day, it will receive only an ABSORPTION charge for 1 hour and then be held at the FLOAT setting for the remaining period of the day unless the battery is discharged.[10] Note that the voltage levels of both the Bulk Mode and the Float mode are settings one can control on the Xantrex, unlike with the less expensive Morningstar SS-10L model. The Morningstar does not do the "float" mode shown here, but nicely limits charge current to .10 to .20A.

Typical Battery Charging Voltages by Type

There are many different chemistries and construction types for lead-acid batteries. For the best information on your particular battery, please consult the manual from your particular manufacturer. Be particularly careful with Gel Cell models, since they have the largest variance from "normal" and are often abused, fail, overheat or worse – if not charged properly.

Sadly the chart on the right doesn't included "flooded lead acid" batteries, or the kind one typically finds in automobiles that need refills with distilled water from time to time. As of this writing, we are not sure what the correct charge voltages are for such a battery. See chart at right.[11] (Sb= Antimony; Ca= Calcium)

It is our opinion that SLA AGM batteries ***should not be equalized*** which means you should turn off the "auto-equalize" function on the Xantrex C-12 controller if you are using that style of battery. See "Battery Technologies" section.

Battery Type Ca=Calcium Sb=Antimony	Absorption Charging Voltages	Float Charging Voltages	Equalizing Charging Voltages
Wet Standard (Sb/Sb) Deep Cycle	14.5	13.2	15.5
Wet Low Maintenance (Sb/Ca)	14.4	13.2	15.8
Wet "Maintenance Free" (Ca/Ca)	14.8	13.2	15.8
AGM (Flat Plate) VRLA	14.3	13.6	15.6*
AGM (Spiral Wound) VRLA	14.6	13.6	Not Applicable
Gel Cell (Ca/Ca) VRLA	14.1 or 14.4*	13.8 or 13.2*	Not Applicable

Typical Battery Charging Voltages at 80 Degrees F (26.7 Degrees C). Asterisk marks say: "Verify with Battery Manufacturer"

Battery Technologies

AGM or Absorbed Glass Mat Batteries

A newer type of sealed battery uses "Absorbed Glass Mats", or AGM between the plates. This is a very fine glass mat composed of Boron-Silicate fiber. These type of batteries have all the advantages of gelled, but can take much more abuse. Panasonic, Lifeline, PowerSonic, Yuasa and all the rest manufacture AGM batteries. These are also called "starved electrolyte", as the mat is about 95% saturated rather than fully soaked. That also means that they will not leak acid even if broken – very important to the aviation industry, and therefore considered "non-hazardous" cargo. Therefore they are more easily transported.

AGM batteries have several advantages over both gelled and flooded (liquid filled), and were more expensive than gelled in the past. But recently prices have fallen such that now they are completely replacing gelled altogether, and rapidly closing in on "flooded" batteries.

Advantages of AGM

Since all the electrolyte (acid) is contained in the glass mats, they cannot spill, even if broken. This also means that since they are non-hazardous, the shipping costs are lower. In addition, since there is no liquid to freeze and expand, they are practically immune from freezing damage, which is admittedly more important in northern Canada, not sub-Sahara Africa.

Nearly all AGM batteries are "recombinant" - that is - the Oxygen and Hydrogen recombine INSIDE the battery. These use gas phase transfer of oxygen to the negative plates to recombine them back into water while charging and prevent the loss of water through electrolysis. The recombining is typically 99+% efficient, so ***almost no water is lost***.

The charging voltage profiles are the same as for any standard battery – no need for any special adjustments or problems with incompatible chargers or charge controls as with the older Gel Cell type batteries. And, since the internal resistance is extremely low, there is almost no heating of the battery even under heavy charge and discharge currents.

Amazingly the AGM batteries have no charge or discharge current limits (not sure that one should test this however).

AGM's have a very low self-discharge rates – from 1% to 3% per month is usual. This means that they can sit in storage for much longer periods without charging than standard batteries. AGM batteries can be almost fully recharged (95% or better) even after 30 days of being totally discharged (but please don't do this, nonetheless, as discussed more fully in this paper).

AGM's do not have any liquid to spill, and even under severe overcharge conditions hydrogen emission is far below the 4% max specified for aircraft and enclosed spaces. The plates in AGM's are tightly packed and rigidly mounted, and will withstand shock and vibration better than any standard battery.

Even with all the advantages listed above, there is still a place for the standard flooded deep cycle battery. AGM's will sometimes cost 2 to 3 times as much as flooded batteries of the same capacity, although recently we have seen a dramatic price reduction. In many installations, where the batteries are set in an area where you don't have to worry about fumes or leakage, a standard or industrial deep cycle is a better economic choice. The AGM battery's main advantages are ***no maintenance***, completely sealed against fumes, Hydrogen, or leakage, non-spilling even if they are broken, and can survive most freezes. Not everyone needs these features.

No Equalization Charging. Unlike the more "Flooded" type batteries, equalization charging to extend the life-time of the batteries that some charge controllers allow for "automatically" ***are not to be used***. In fact, ***this will decrease the lifetime of AGM batteries due to electrolyte loss*** via the vented valves supplied. Once electrolyte is expelled it is lost forever. However, this is one less maintenance headache for the end user. Plus there is no need to ever refill the batteries with distilled water, for the lifetime of the battery.

So when considering solar systems for our national colleagues to use, the combinations of increased safety, easier transport, no-refilling and no equalization charging are considered great advantages.

Consider Manufacturing Date Codes

Each manufacturer of lead-acid batteries has their own system of stamping on the unit for the date of manufacture. This becomes important for AGM style batteries especially as their capacity generally degrades in time "just sitting around" on the shelf. This can be an important factor in a third-world setting, where the supplier in a port town, has had stock sitting around for a very long time, and the store-reseller has not taken the time to maintain a trickle charge of the batteries while waiting for sale.

Note: If possible, contact the manufacturer of the given part directly on email and convince them (if possible) to tell you their system of date code stamping. Then you can easily verify the claim that the given stock you are about to purchase indeed has been manufactured recently.

Valve Regulated Batteries

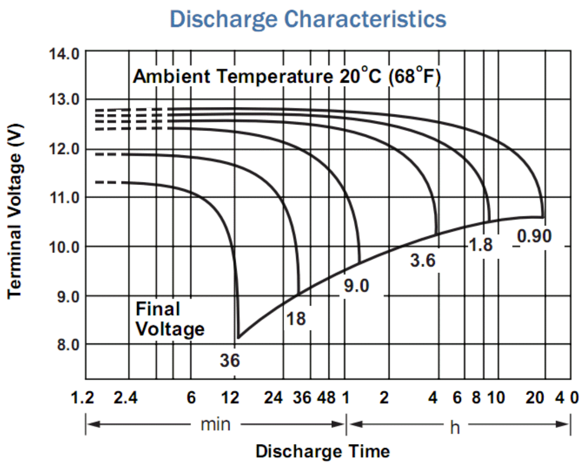
All gelled (Gel Cell) are sealed and are "valve regulated", which means that a tiny valve keeps a slight positive pressure. Nearly all AGM batteries are also sealed valve regulated (commonly referred to as

"VRLA" - Valve Regulated Lead-Acid). Most valve regulated batteries are under some pressure - 1 to 4 psi at sea level.

Amp-Hour Capacity

"All deep cycle batteries are rated in amp-hours. An amp-hour is one amp for one hour, or 10 amps for 1/10 of an hour and so forth. It is amps x hours. If you have hardware that uses 20 amps, and you use it for 20 minutes, then the amp-hours used would be 20 (amps) x .333 (hours), or 6.67 Ah. The accepted Ah rating time period for batteries used in solar electric and backup power systems (and for nearly all deep cycle batteries) is the "20 hour rate". This means that it is discharged down to 10.5 volts over a 20 hour period while the total actual amp-hours it supplies is measured. Sometimes ratings at the 6 hour rate and 100 hour rate are also given for comparison and for different applications. The 6-hour rate is often used for industrial batteries, as that is a typical daily duty cycle. Sometimes the 100 hour rate is given just to make the battery look better than it really is, but it is also useful for figuring battery capacity for long-term backup amp-hour requirements."[12]

So what is our expected performance per average netbook? How long can we reasonably expect to supply power to a netbook while in use in the day? Consider this graph from Power-Sonic (right).[13] Reading the chart to the right, let us consider a typical low power Asus 1101 HA netbook, that is running at 0.80 amps and while in use during the day. To reach the LVD point of 12.5 volts (see "depth of discharge"–next section) one would expect a "run time" of approximately 6 hrs. But this assumes that there is no supplemental solar energy also going to power the device even during heavily overcast days. Reality can yield much better performance than indicated in this pure load chart. With some of the new third generation solar panels, the "shade" performance is quite exceptional. It is not uncommon to see on an "overcast" day, enough solar energy to be completely sustaining a netbook, via the solar charge controller alone, while leaving a small "trickle charge" left over for charging the battery at the same time.



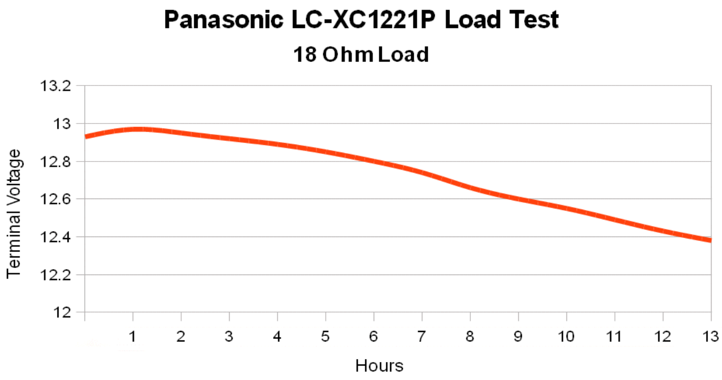
Power-Sonic's expected performance for a typical 18Ah AGM battery. Some working conditions might necessitate a 35 Ah battery instead. This chart is based on the "20 hour rate" of discharge. Note the logarithmic axis. Power-Sonic Model PS-12180. Very similar performance has been shown by the recommended Panasonic LC-XC1221P model (21Ah).

So, does one need to specify an 18 Ah battery, or a 35 Ah battery for everyday use? The answer depends upon the number of expected work hours for the end user, and also the number of expected "totally overcast" days, per average week. If the realities of village life means that one can only expect 4 hours of good day-time work, due to village level obligations to family members, then probably an 18 Ah battery would suffice. If the user is going to truly work 8 hrs a day, and perhaps 3 of those hours will be into the evening, then certainly consider purchasing a 35 Ah battery instead. If 12 volt house lights are in the equation, then go further, but also go for larger solar panels than 40 watts.

Remember that if one constrains the work to only during the day, it is possible with a 30 or 40 watt solar panel to completely remove the battery from this circuit entirely (in theory). The panel, even in overcast conditions, would charge the netbook's internal battery, and certain netbooks are capable of running 8-10 hours now on their internal

Lithium Ion batteries. Such a "battery eliminator" circuit might be advantageous to fight off potential familial demands to use the battery elsewhere, a perennial problem in the field.

Panasonic Load Tests



We shipped brand new Panasonic "Deep Cycle" 21 Ah AGM batteries to test. The model LC-XC1221P is highly recommended because it is designed for golf-cart applications, representing deep and regular charge/ discharge cycles. Load tests are shown here:

This battery shows wonderful discharge characteristics. Rest voltage, fully charged with no load is 13.35v. With a sustained netbook load (simulating an Asus 1001P at 0.68A) the starting load voltage is 12.93 volts, somewhat higher than the expected 12.8 volts of other batteries. Then the discharge curve travels rather linearly down to 12.38 volts within 13 hours. If one wanted to protect this battery for long life, then we should disconnect this load, in the ideal, at 12.6 volts (12.9-0.3 volts) for a 30% Depth of Discharge (see next topic). That would yield a useful life of approximately 9 hours of work for a 21 Ah battery. Please don't expect more.

Finally for the purposes of evaluating capacity after the fact, in this experiment, the no-load voltage was reported to be 12.51 volts after the 13 hour trial once the load was disconnected.

Lead-Acid Battery Life Issues

Depth of Discharge

A very important factor for battery lifetime is the average level of discharge over the lifetime of the project. Basically lead-acid batteries are ***designed to be fully charged at all times***. While using the batteries, the overall level of discharge should be keep to a minimum, and still achieve daily work goals that are practical for the given work conditions. Consider this chart: [14]

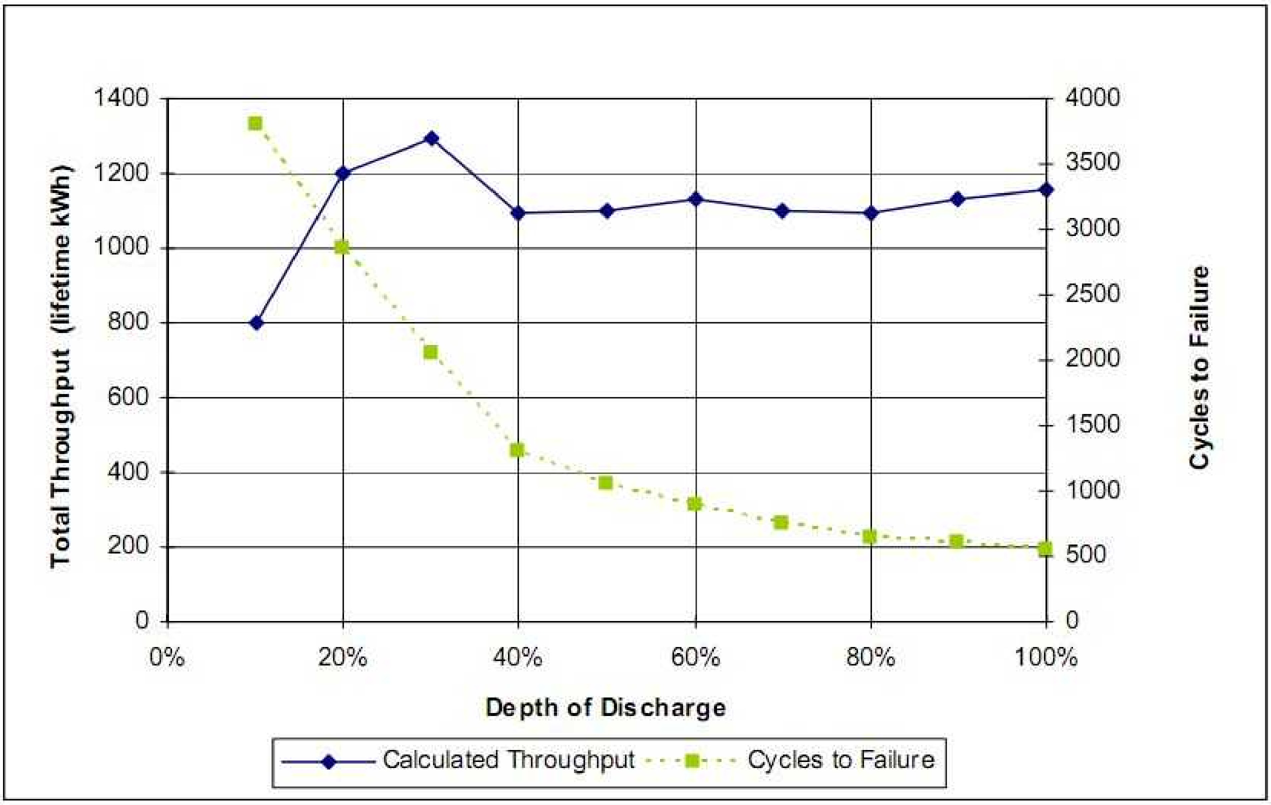
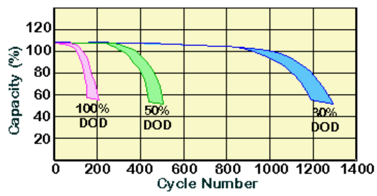


Figure 7 Cycles to Failure and Total Throughput for a Flooded Flat Plate Battery based on data supplied be the manufacturer

A consistent "depth of discharge" (DoD) of 50% (above) will yield a standard lifetime of 1000 charge/ discharge cycles per battery. If the user is constantly using the system each day, and recharging via solar, one would only expect their lead-acid batteries to live for approximately 3 years. This discharge level corresponds to 50% of the usable electrolyte solution and an operating voltage at the terminals of 12.5 volts.

However, if the user consistently discharges to the 30% level, or approximately 12.7 volts then the battery lifetime jumps to 2000 charge/ discharge cycles. Suddenly lifetime moves out to 6 years without the need for battery replacement.

Since the price of solar and netbooks is rapidly decreasing, but lead-acid batteries are not, this DoD issue needs to be monitored closely. Note too that "total lifetime kWh" peaks at the 30% discharge level.



Another chart showing battery lifetime in relation to use. Here 30% DoD goes beyond 1200 cycles or four years if worked every day.

Adjusting the Controller for Best Low Voltage Disconnect

There is really only one Solar Controller recommended here that allows you to adjust the LVD (low voltage disconnect) to anything reasonable to meet the battery manufacturer's suggested cut-off point. The Morningstar controller is fixed with this regard and considered low. Other controllers tested are even WORSE.

But at what point should the LVD be set? The answer depends upon your setup and the battery you have chosen for the work. If the fully charged battery under a netbook load starts out at 12.8 volts (wait 5 minutes), then ideally one would set the LVD point to 12.8-0.3 volts or 12.5 volts, but the desired voltage would be measured AT THE BATTERY TERMINALS, not the Xantrex C-12 controller sense terminals. Due to the resistance of the wires from the battery to the controller, and the gauge size of the wire, the voltage drop from the battery terminals as measured with a voltmeter in comparison to the Xantrex terminals could be as high as 0.3 to 0.5 volts depending upon the charge condition of the Li-Ion battery pack within the Netbook itself. Higher charging currents yields a greater differential here. ***In other words, at any one moment the sensor at the Xantrex controller might be in error and the error factor is changing, and not static.***

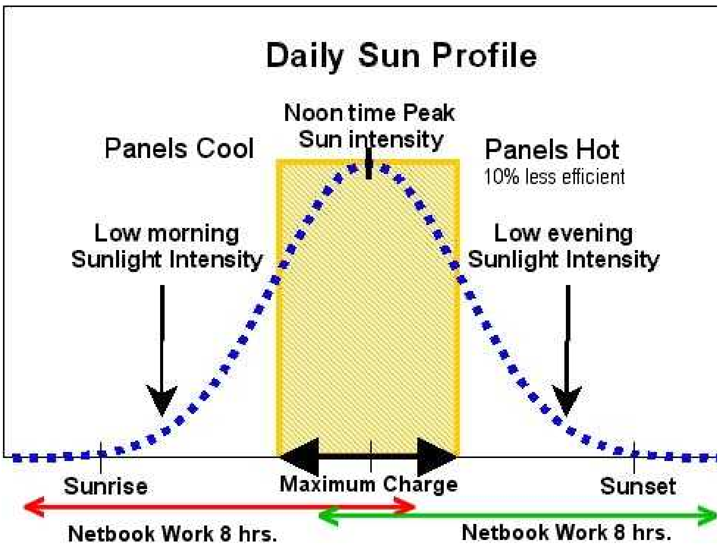
We would suggest a compromise setting of an additional 0.2 volts here. So for the observed 12.8 volts initial load point of the battery from its fully charged state, then subtract 0.5 volts instead. Therefore in this example, use 12.8-0.5 volts or 12.3 volts as your LVD setting. Set correspondingly if your battery starts out at 12.9 volts.

Note: whenever adjustments are performed on the Xantrex controller, remember that the control knobs can be removed to prevent others from changing these set points.

Typical Work Day Cycle

How one works during the day can have a profound effect on battery longevity, beyond the depth of discharge issue. Basically ALL Lead-Acid batteries are designed to be fully charged at all times. This means that how one works is important for battery life.

Consider the two work scenes pictured here. One is where the village user gets up early before dawn (many do in third world cultures) and proceed to work on their netbook. They plan for an 8 hr. computing work day, and end their labors by 2:00 pm. They started early in the morning depleting the energy stored in the lead-acid battery, but most importantly they ended the work day with a fully charged battery, because during the day there was ample sunshine (even when overcast- 40 watt panel). Without a load in the late afternoon, the remaining decreasing sunshine still charged up the lead-acid battery. As night falls, the lead-acid battery is quite "happy" because it rests fully charged as it was designed to be.



Daily sun radiation pattern with peak solar energy around noon-time. Note the primary advantage of working early (red line) in the day, is that the lead-acid batteries end their typical day, "fully charged" as they were designed to be. Such batteries will live long and content lives and might not need to be replaced at all.

Now consider the other scene. The user starts work in late morning and works for 8 hours into the early evening time. The sun has already set completely. The best early morning sunlight hours, when the panels were coolest and most efficient were wasted. By mid afternoon there is plenty of sunlight to both charge the lead-acid battery and power the netbook. But by late afternoon and into the evening, stored energy from the fully charged lead-acid battery, must now be consumed to support the netbook. Depending upon the capacity of the lead-acid battery, one might safely work from 2 hours (7Ah battery) to 8 hrs (21 Ah battery) into the night-time. But at the end of this day, the battery voltage will have dropped to approximately 12.3 volts or less.

Now the battery waits for a full recharge, but has to wait the evening hours for the sun to rise again. It is this "delay" to recharge, that is probably the most important reason for premature lead-acid battery failure. It is not strictly a "depth of discharge" issue. ***All the battery manufacturers expect the user to immediately recharge a discharged battery after use.*** Lead-Acid batteries cannot wait around to be fully recharged. It is for this reason that one should consider other battery chemistries for the standard solar powered application.

Keep in mind that unlike the West, a typical third-world work-day can indeed start as early as 4:00 am. It is not uncommon for people without lights in their homes to get up early before sunrise and head for their gardens. It is therefore not unusual in this cultural context to start one's day's work before dawn.

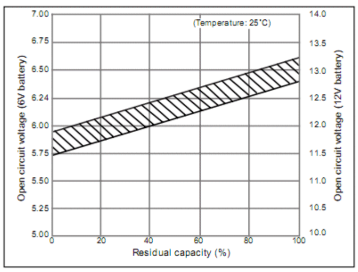
In summary the "rule of thumb" is:

"Maximize your solar energy gathering at the end of a daily work cycle"

Capacity Monitoring

The goal of the solar controller is to protect the lead-acid battery, while allowing useful work to be done as required from the battery. As we have seen, the total number of solar cycles for the lifetime of the battery is dependent upon the average LVD cut-off (there are other factors as well). "Capacity" or the ability to store a given amount of energy is 100% for a newly acquired battery, but diminishes over time. Capacity can be monitored in the evenings for a "no load" situation. Using a Digital Voltmeter (DVM) at the battery terminals, turn off all loads including the netbook, any lights and anything else attached to the battery (you can leave the solar controller connected), and then refer to this chart on the right to see your present battery status.[15]

Open circuit voltage vs. Residual capacity 25°C



Battery Capacity chart. Source: Panasonic

Let's say that when my battery was new we noticed that the no-load, fully charged and rested battery voltage was 13.4 volts. So if today, our battery was held at a float voltage of 13.7 volts during the day in good sunshine, but at dusk with no load, the voltage at the terminals was found to be 13.0 volts or less – then one can conclude that our battery is now at 80% of its normal capacity. It has "aged" that much, where age is relative term here, and not based on the actual number of days of use. Note that temperature has an effect here, but is beyond the scope of this particular paper. See reference for such details.

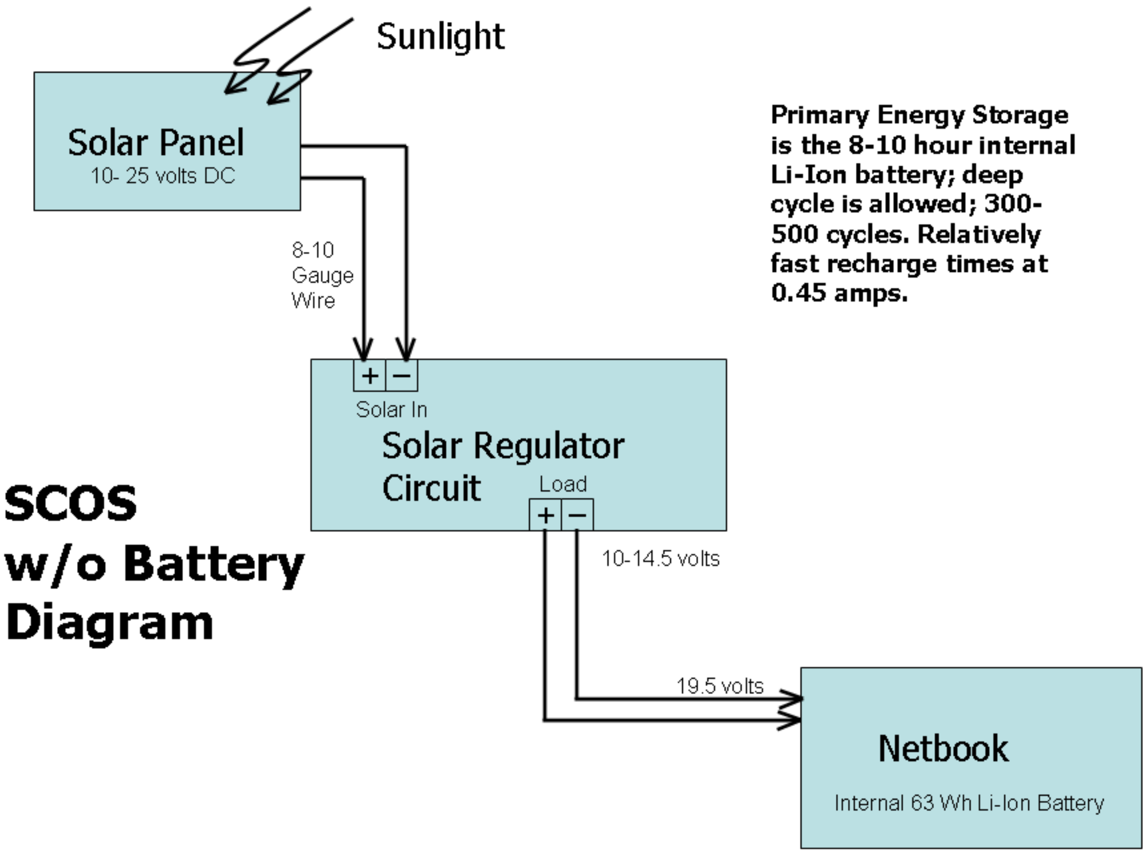
Other Battery Chemistries

A very interesting technology, yet to be fully tried in field situations, are NiMH (Nickel Metal Hydride). They are considered far more expensive to implement than lead-acid chemistries. However, one must note that this chemistry can undergo a full, repeated and cycled discharge, up to a 1000 cycles and also discharge levels can be to practically the zero volt level without harm. Since lead-acid batteries must be "over-specified" to work successfully (LVD at 12.5 volts), and therefore greatly reduce their "working capacity", it might be economically better to "under-specify" NiMH batteries since they have a much better "depth of discharge" capability.

In other words, we may be by-passing NiMH technologies because of an "apparent" cost differential that is perceived as way too high, when the reality is different for a given low power application. This would require further research and perhaps a different kind of solar controller.

Lithium Ion technologies – common in laptop computers themselves for their high energy density – are so far ignored due to former safety issues. There are innumerable reports of charger circuits failing and abused Li-Ion batteries going up in flames. However, newer Lithium-Polymer batteries have even greater charge capacity and are considered safer to use. It is possible that this chemistry is now ready to be used in solar applications, but the necessary solar charge controller would have to be created as well. The charge characteristics are different than Lead-Acid batteries.

“Battery-Less” Configurations



Why Consider Removal of the Lead-Acid Battery

There is a search in the “PNG Labs” for a replacement set of sub-systems that will eliminate the need for the AGM lead-acid battery entirely. Advantages include:

- *No lead-acid battery useful for other tasks and “borrowed” or stolen in the village setting. Social Pressure issues.*
- *No fragile battery chemistry to protect due to harsh solar conditions.*
- *Greatly reduced cost and less complexity.*
- *Smaller solar panel requirements.*

The Primary Disadvantage is:

- *No ability to run “village lightning” systems such as the new 12 volt LED lamps available everywhere.*

The manufacturer’s of Lead-Acid batteries never seem to give the specs of usable life when the lead-acid battery is discharged, even to the 50% capacity level (12.5 volts) and then ***left discharged for extended periods of time.*** Most “deep cycle” charts assume that once the battery has done its work, there is a system to immediately recharge the battery to full service, once again. This is clearly NOT the solar scenario. The battery can be run down and depleted for days at a time if the weather does not cooperate. Even in the best case scenario, there is a large 12 hours period of night-time, non-solar activity waiting for the dawn. It is our opinion that this is the primary reason for premature “death” of lead-acid chemistry batteries in the field. It is not exclusively a “depth of discharge” (DoD) issue. For this reason, it is questionable that lead-acid is even appropriate in this context, even though it is considered “conventional wisdom”.

What About Evening Work?

The user is allowed to work in the evenings, but they will be using the energy storage of the netbook's internal Li-Ion battery. Many modern netbooks, such as the Asus 1101HA can run 8 hours under normal work loads, such as entering language text (not while running videos).

The "poor man's" Battery-less Solution – Reduce the Size of your Battery

This might seem counter intuitive at this point, but an enormous amount of concern in this handbook has been directed toward saving the external Lead-Acid battery under "conventional wisdom". What if we ignored this constraint and saved considerable cost?

Since the average netbook can run 8 to even 14 hours on its internal Lithium Ion batteries, we now have another suitable energy storage device at our disposal.

We could purposely plan to destroy a small-capacity Lead-Acid battery in these circuits and even let them deep discharge all the time. A 7Ah AGM battery is pretty common, since these are popularly placed into most small-capacity UPS units that support devices in Third-World countries. These batteries are common and can be purchased for as little as US$ 20. So a "poor man's" circuit might simply be a standard configuration, but with the smallest Lead Acid battery we can find. The one of ***least capacity***. This works because now we are intentionally trying to use the large capacity and deep cycle characteristics of the built in Li-Ion technology already found in the netbook.

We have seen the result of a "totally dead" AGM battery placed on the Xantrex C-12 controller. That is, we have a working controller that then compensates for no useful AGM battery storage, and all available solar panel energy goes to the netbook. But with a dead or expired AGM battery (or for that matter a small but new, 2-4Ah AGM battery) a simple 40 watt panel is ***more than sufficient*** to adequately charge the netbook in overcast conditions. The small battery simply allows the controller to continue to make intelligent decisions redirecting solar power and not shut down.

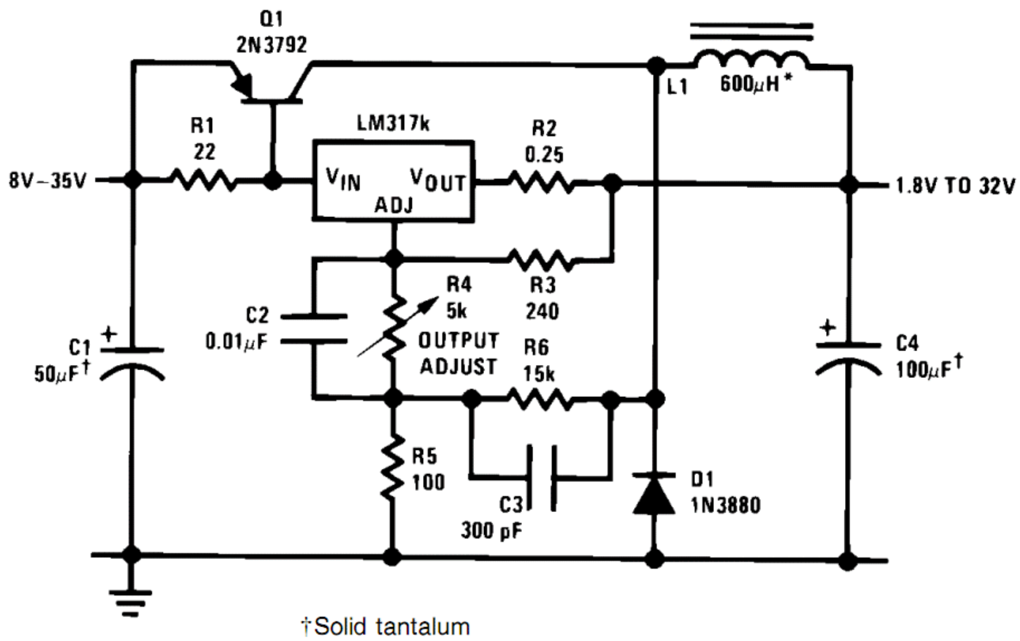
Cost Reduction: Decreased battery cost up to $80 or more. We will still need the Xantrex or Morningstar controller, however. If you now choose the Morningstar option and forget about LVD and deep cycle concerns (because your battery is going to be "beat up" anyway), then you can save an additional $35 with the less expensive Morningstar controller. ***Those of you without deep pockets, take note of this***. Over the lifetime of the language project, I can replace a 7Ah Lead-Acid battery five times for the cost of a single, nice 21Ah Panasonic battery. I just periodically show up at the language site, and replace the inexpensive 7Ah battery commonly found for sale in the county. I simply plan to do this periodically.

What about a "Direct Drive" Circuit to the Netbook?

If one can accept the scenario of only doing language work on a netbook mostly in daylight hours, and not powering village level lights, there is the possibility of yet another cost reduction. Eliminate the solar charge controller altogether, the battery, and the auto-adapter. This is an attempt to build a "black box" that effectively does what an OLPC XOs normally do with aplomb in the field. Like an XO, we “Direct Connect” the solar panel to the netbook.

Here is the present circuit under consideration in “the labs” at this moment:

Low Cost 3A Switching Regulator



†Solid tantalum

*Core—Arnold A-254168-2 60 turns

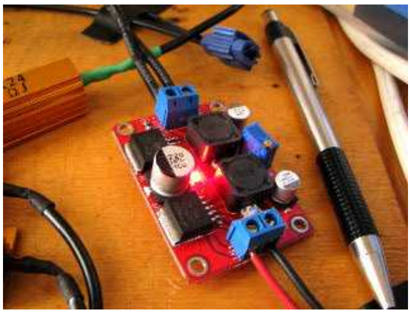
This is an ***ancient*** Linear Schematic, found in the the classic primer for Linear Circuits and their incorporation, by National Semiconductor, circa 1970’s. It is pretty well understood and incorporates all the modern day principles of switching (fly back) circuits as found in most of our tiny, yet powerful universal AC power bricks on our AC mains powered laptops. But in our application there is no AC mains power; instead we are converting available energy from a rated 40 watt solar panel, anywhere from 8 volts to 25 volts, (5-22 watts) to a regulated 3 amp, 19.5 volts which is what most netbooks require today (3 amps is the upper limit that the circuit is rated for– not the maximum output of a 40 watt panel).

Further Cost reductions: $50-$85 by eliminating the Xantrex ($85) and Morningstar ($50) controllers. $10 eliminating the 12 volt to 19 volt auto-adapter. $20 of a small, AGM 7Ah Lead-Acid battery. However, one must hasten to add that someone has to actually “build” such a box for us in limited quantities, so there would be labor costs in the construction of such a unit. Would this be worth the effort to save $100 per user? Probably yes, and therefore we need to research this further. SIL could easily contract this work out. JAARS Inc. would most likely help us, when the cost reductions are this profound.

“Boost-Buck” Circuits as a Solar Controller

In the electronics world of modern switching circuits, there is something called a “Boost-Buck” switcher. A “switching” power supply is the product of year's of electrical engineering research and is the reason why high efficiency and very small and light-weight AC “power bricks” are found on all modern laptops. The small DC-DC converter, known as the automotive adapter for a netbook, is a “boost only” switching power supply. It boosts the 12 volt DC supply from an automobile in-dash receptacle to the 19 volts required by most netbooks and laptops.

The “boost-buck” is a much more rare circuit, in that it attempts to handle a broad range of acceptable input voltages. In our case, a solar panel would offer a range of voltages from a low at dawn of 8 volts to a high at noon of potentially 24 volts. All conditions must be converted and regulated to a tight 19.0 volts, up or down.



An experimental “boost-buck” 3 amp controller board found in China. It costs about US$ 5 to purchase, and around $15 to ship. When it “turns on” it regulates solidly to 19.0 volts and output is adjustable. However, it fails to work under low light conditions.

We have been searching for a suitable circuit to do this job. An additional bonus, when eliminating the need for the Lead-Acid Battery, includes potential theft reduction because there is no battery to steal, and also the shipping costs are reduced, because batteries are heavy.

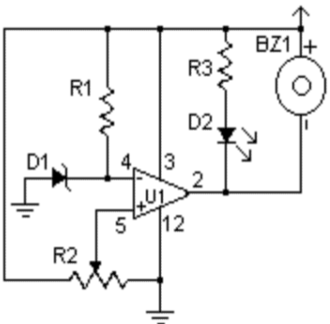
Laboratory Results thus far: The circuit as shown here, works as advertized under bright sunlight. However, it has trouble in shade conditions and shuts down at inappropriate times (solar panel input below 15 volts). It works well on an adjustable lab power supply bench, from 8 volts up beyond 24 volts. Research is on-going and other circuits are on the way to the lab.

At this point, it would be far better and more reliable today to simply use a Morningstar SS-10L controller (US$ 50) and the smallest possible lead acid battery one can find (US$ 20) as discussed above. Just plan on “throwing away” the Lead-Acid battery and create one with “zero storage”. Utilize the Netbook storage instead.

Accessory to the Morningstar Controller

Since the Morningstar controller was so popular in times past, one might want to revisit that mainstay device, and improve upon the circuit as given. It is a “potted” module which is nice for weather-proofing, but more difficult to go inside the box and make threshold changes to the LVD circuit. Instead, consider an external modification here.

Simple Adjustable Alarm Circuit[16]



Part	Total Qty.	Description
R1, R3	2	1K 1/4W Resistor
R2	1	5K Pot
U1	1	LM339 Voltage comparator IC
D1	1	1N5233B Zener Diode
D2	1	LED
BZ1	1	Piezo Buzzer
MISC	1	Board, wire, socket for IC

• The circuit will operate from 9 volts to 14 volts (tops out at 36 volts)

• Adjust R2 until the alarm goes off at the correct voltage

• The “Buzzer” part can be easily replaced with a 5 or 10 amp reed relay and then would perform the “load disconnect” or adjustable LVD function that we wish the Morningstar already provided.

• The most expensive part, could be the LM339 at US$ 0.50 or perhaps the Piezo Buzzer. Labor to put this together is far more expensive than the components.

Appropriate Wire Sizes

Wire Diameter Sizes

For relatively long runs, such as the roof top solar panel to the solar controller inside the house, care must be taken to have a suitably large enough wire diameter. This is to minimize the loss of solar energy due to heat or resistance losses. The chart at the right[17] is for a 2% voltage drop for runs of copper wire as measured in feet. Other kinds of metal wire have a different resistance.

We are recommending #10 gauge (6 mm^2) or #8 gauge (10 mm^2) copper wire runs, but obviously this increases cost per foot (or meter) if you use more expensive #8 gauge wire. If you must use #12 or #14 gauge, then be sure to adjust the Xantrex C-12 controller accordingly to get the right results ***at the battery terminals***, where it counts – NOT the controller terminals where it doesn't count. Feel free to adjust as necessary, the LVD, RVD, LVR and HVR levels for the battery type you are considering.

Amps	#14	#12	#10	#8
1	45	70	115	180
2	22.5	35	57.5	90
4	10	17.5	27.5	45
6	7.5	12	17.5	30
8	5.5	8.5	11.5	22.5
10	4.5	7	11.5	18

A nice "low current" chart suitable for what one would expect for a 1-3 amp, netbook setup. Some users will want larger panels and batteries to accommodate 12 volt village lighting systems, hence higher current requirements. Chart numbers are in feet.

Wire Size Comparison between AWG (American Standard) and Euro Standard (mm^2)

AWG	Euro Std mm^2	AWG in mm^2	AWG	Euro Std mm^2	AWG in mm^2
16	1.5	1.31	6	16.0	13.30
14	2.5	2.08	4	25.0	21.15
12	4.0	3.31	2	35.0	33.62
10	6.0	5.26	1	50.0	42.41
8	10.0	8.38	0	50.0	53.49
			00	70.0	67.43

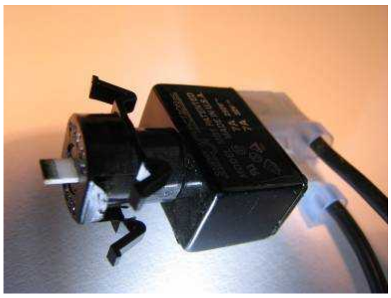
Conversion chart between USA and European wire diameter conventions.

Wire Gauge Conversions

If you are purchasing wire from the USA, then diameter is measured by AWG number. However Europeans and other Commonwealth countries often sell wire by the square millimeter. Here is a rough conversion chart to help at upper right.[18]

Fusible Links

Circuit Breakers



A nice circuit breaker, similar to a fuse, except that it can trip and then be reset easily. Here the white plunger (left side) needs to be pushed in. This 32 v, 7 amp unit came from the back panel of an old UPS and is perfect for this solar application.

Circuit Breakers are designed to interrupt the circuit when a short-circuit of some kind has occurred. An example would be a wrench or screw-driver falling into powered electrical equipment. Or perhaps a short across the exposed Morningstar Controller connectors. Usually they are wired in series near the battery's positive terminal.

This 7 amp unit (see right) was found on the back panel of a broken UPS unit, and was scrounged before heading to the rubbish tip.

On eBay see: "Potter & Brumfield Reset Circuit Breaker W58-XB1A4A-5" US$ 3.99 and "Seachoice 13051 Boat Circuit Breaker" US$ 6.10

Automotive Style In-Line Fuses

Ebay "Potter and Brumfield" - 5 Amp

Inline fuses are similar to what you see in automotive fuse panels. There is typically a style of holder with wires that can be attached. They are relatively common, but once they are used to protect equipment they must be replaced with spares. Not having a spare available, encourages one to bypass the fuse altogether to carry on with the work. Not recommended for sustainable national coworker systems. In the store

"Radio Shack" (USA) this common part is "20-Amp Inline Blade-Type Fuse Holder" Model: 270-1213 US$ 2.69

Automotive Adapters

12 Volt Netbooks

Most netbooks are 19 volts input, however, in the beginning of the Asus line there were 12 volt input models. Originally this was thought to be a profound advantage, because perhaps an auto-style DC adapter might not be necessary. In the end, it was still required to clamp solar panel voltages to a solid 12.3 volts coming off the solar controller and battery. Such a suitable adapter was found for under $20, and could handle certain amounts of user abuse, such as short-circuits and reverse polarity.

Small automotive 12 volt charger adapter with proper connector already supplied for the Asus Line of 19 volt netbooks. Suitable for the 11 inch Asus 1101HA and similar models.

19 Volt Netbooks

All netbooks today are 19.5 volt models. It appears to be the product of easier rechargeable cell stacking, where cells do not have to be so tightly "matched" as in the 12 volt design. We have found a very nice inexpensive 3 amp, 19.5 volt auto-adapter for under $10, shown here. The goal of this final stage is further conditioning of the 10-14.5 volt output from the solar controller to the required 19 volts for the netbook to run and charge its batteries. This would be called a 12 volt DC to 19 volt DC converter in engineering terms – a type of "boost" circuit.

The unit (right) is a relatively small box (3.25" L x 1.4" W x 1.1" H 85mm x 34mm x 27mm) with a charge indicator LED and found on eBay.[19] Just search for: "Battery Car Charger Cable for Asus Eee 1101HA". The seller in the USA is "hey262mobile"; In Australia: "Lee262mobile" This unit has the correct DC connector for the machine's DC input jack (and those would be otherwise very hard to find). Rated: DC 11-14VDC OUTPUT: 19VDC 2.1A. We have stressed this to 2.8 amps and the box stayed cool to the touch.

Netbooks

The Ultimate Box: OLPC XO

The goal of the INSPIRE Project now before SIL International is a self-contained, self-powered "jungle box" that is inexpensive enough that Third-World citizens and organizations within that country can be empowered with technologies that will make them successful in the vernacular language development task. A dream of that project is that within four years time, the hardware necessary will fall ***below US$ 500***.

But today that box already exists! It is found in those ubiquitous lime-green "One Laptop Per Child" XO machines around the world. They "appear" like toys, but in reality they are highly sophisticated boxes. With their bullet-proof and rugged design, and their wondrously readable full-sunlight screens, they can be superior to anything else in certain settings.

Best of all, they can accommodate a single Gold Peak 20 watt solar panel (see far above) and "direct connect" (no external solar controller required; no external lead-acid battery required) to their internal Lithium battery pack for continuous charging while working on the machine at the same time.

With the solar panel at $85 and the XO boxes found on eBay around $350 or so.... a $10 adult size USB keyboard makes this box totally superior to the AlphaSmart Neo units that are so popular in Papua New Guinea. Combined with ***Balsa (Basic Language Software Appliance)*** (see below), a complete linguistic and language environment boots off of an SD card.... and one is "good to go" for language work with a completely automated backup of precious language data.

So, don't be "put off" by lime-green.... this totally beats the original Mark IV units that we built circa 1978 (remember those?) The Mark IV was far from a "low power" device.

Asustek Netbooks Preferred

From the beginning of the netbook phenomena Asustek has been producing their Asus Eee line of netbooks. The CTS dept. at PNG Branch (tech repair) had found these to be well built machines, and a PC-Magazine (on-line subscription) recently gave top honors to Asus with a mere 6% return rate by users, within the first year of service. This high reliability rate is exceeded only by Apple's line of notebooks. Meanwhile Dell and Toshiba lines continue with an approximately 23% return rate.[20]

Recently our CTS department has begun to look at the Dell line for overall construction and ease of repair, although still not yet popular at least by end user sales in the Branch.

A most important feature for the Asus line is the "Boot on SD Card" capability. Basically a suitably prepared SD card can have a complete Operating System environment on board, and if the SD Card is made properly the netbook can boot up a completely different OS with a custom and simplified user environment. See the discussion on Balsa in another section.

Where do I Purchase a Netbook?

Netbooks are ubiquitous now and countless makes and models are coming out from Asus to Acer… from Samsung to HP… from Toshiba to Dell to Lenovo. Name a manufacturer that doesn't make a netbook of some kind besides Apple? (which makes the iPad instead).

Assuming you've done your research – then on the Internet head for DealNews.com and a "Netbook" search.[21] Then look for all the "deals of the day" of all the online stores and all the makes and models of netbooks. The best system at the best price is a daily moving target.

Be sure to work with a reputable store that you have worked with before: Good companies include: buy.com, bestbuy.com, newegg.com, frys.com, amazon.com, (any major office supply store), dell.com, tigerdirect.com, mwave.com and B & H Photo. There are others of course. Also look for deals that include extra installed main memory, especially if you are doing Windows and not Linux.

10 Inch Asus Eee

Today's recommended netbook entry is the Asus Eee 1001P series which represented a 19 volt input system, but a potentially limiting 10 inch 1024 x 600 pixel screen. Backlighting is bright and LED powered, which helps it reach a standard steady-state operating current of 0.6 amps at 13 volts coming from the solar controller. It was based on the the newer Intel Atom N450 series. Highly prized for its “matte” style screen, there is improved readability in high glare situations, such as those found in village houses. 10 inch netbooks are considered the minimum for comfortable touch typing with a slightly reduced keyboard than “normal”.

A typical 10 inch wide, Asus Netbook. See on-line stores for latest model.

The Asus 1005PR series features a higher resolution display at 1366 x 768, but typically cost US$ 100 more. Always purchase units with a 6 cell battery pack included and not 3 cell for less money.

11 Inch Asus Eee

There is no adequate 11 inch recommendation at this time.

Problem: Discontinued Asus 1101HA model at the end of 2009; replaced by 12 inch models at are much higher power consumers than we would like to see. Also, this is the one netbook that cannot do Balsa/ Linux due to an unusual choice of video chipset purchased by Intel at the time.

Lenovo’s “Skylight” smartbook was one of the first real designs announced at the CES conference, January 2010. It represents the best of ARM technologies at this point. ARM processors have the potential to yield 2 watt systems.

ARMed for the Future?

In 2010 we witnessed the advent of significant new designs representing the convergence of mobile phones and netbooks, sometimes called “smart-books”. The best designs are ARM processor based which is the most popular mobile phone architecture and present in the wildly popular Apple iPhone and the just announced iPad. These “smartbooks” represent power consumptions of a mere 2 watts compared to the 8-10 watts of Intel Atom based Netbooks. Ultimately this would translate to much smaller solar panels and much lower costs per user.

One problem with the ARM architecture is that Windows will not normally be found there but another OS such as Linux, Moblin, MeeGo, Android or something else (for now). However, besides lower power consumption, these “smartbooks” feature an “instant on” capability, like mobile phones and for some that can be an distinct advantage.

When the day arrives that smartbooks reach the $250 price point, and are 5 watts or less, then we can begin to think about deployments easily with a mere 20 watt solar panel. Today’s netbooks require 40 watts to be a really comfortable working environment in adverse weather conditions (continuous 8 hour workdays).

*HP – Compaq and its first 10 inch smartbook, the **Airlife 100**, before the Mobile World Congress, February 2010. The smart-book will use a 16GB flash drive and its battery life is 12 hours of run time and 10 days in standby. It has “instant on” boot, and is Android OS based.*

Don’t be confused by “only having” a run time of 12 hours. If the Li-Ion battery packs in use are greatly reduced in size then the amount of energy consumed by the smartbook and the amount of energy required to recharge the batteries can be reduced dramatically. Energy consumed while doing useful work, is really the issue for solar applications, not the standard run time of the box on its internal batteries.

Tools for National Language Work

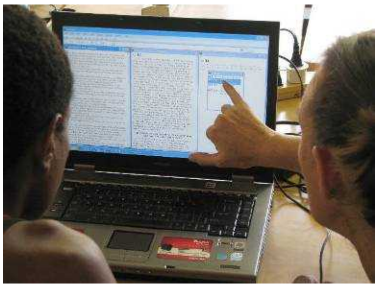
Balsa

Designed to be a complete software environment for lay men and women to complete aspects of the language development task, Balsa or “Basic Language Software Appliance” is designed to have a very easy to use interface for people who have not had any prior experience with a computer before within their cultural frame of reference. The present popular Operating Systems such as Windows, Mac OS X, or Linux are considered way to complicated, demanding a knowledge and experience “bar” that is set way too high for average citizens of the third-world. All necessary language development software to assist in translation, literacy and language documentation tasks are present to use.

Balsa is a complete working environment with all tools necessary for work included and localized. Periodic updates will be supplied on future SD cards, and easily plugged back into systems.

The environment is “bootable” and can be hidden from the user when placed in total onto an SD card and inserted into the machine. In fact, machines can be set up without the user even knowing the SD card is in place. Advantages to the environment include:[22]

- *Outside Mentor Adjustments*
- *Language Localization Capabilities*
- *Presentation Modifications (User Icons hidden or displayed)*
- *Robustness (When the system is corrupted, simply insert a new SD card)*
- *Extremely easy historical backup of data, in multiple places*



Aitape West Translation Team members working with Paratext in the village. Note simultaneous multiple windows open and hence netbooks with 600 pixel size vertical can be a problem. Better netbooks have 768 pixels.

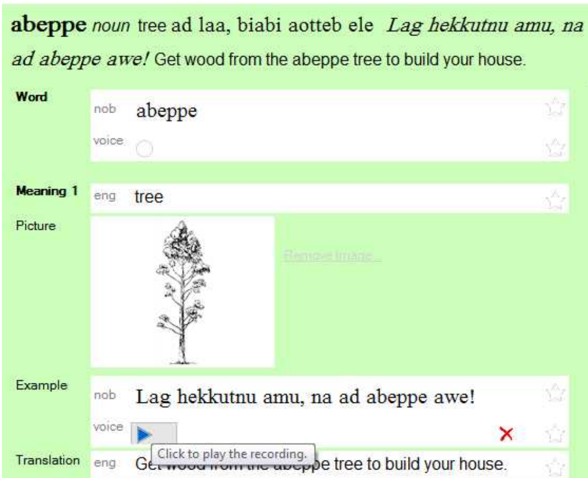
Paratext (Windows)

Paratext is a popular Bible Translation tool in use in the field by SIL members and national coworkers alike. At present, it is only Windows based. A very exciting new collaboration feature in version 7.x allows for simultaneous work by more than one worker, across networks, the Internet and also removable USB “memory sticks”. When on a network the differential changes to the database are manageably small, hence updates to the database can be made using very slow communications links on the Internet. This has been shown to work across HF-Radio email links.

WeSay

WeSay[23] is a vernacular dictionary program designed from the beginning with “ease of use” in mind and for national citizens to utilize well, without significant prior training. Particularly targeted are vernacular users who may not have encountered a computer before to document their own unique language.

“WeSay helps non-linguists build a dictionary in their own language. It has various ways to help native speakers to think of words in their language and enter some basic data about them (no backslash codes, just forms to fill in). The program is customizable and task-oriented, giving the advisor the ability to turn on/off tasks as needed and as the user receives training for those tasks. WeSay uses a standard xml format, so data can be exchanged with linguist-oriented tools like FieldWorks. Users can collaborate via USB flash drive, email, and (soon) via



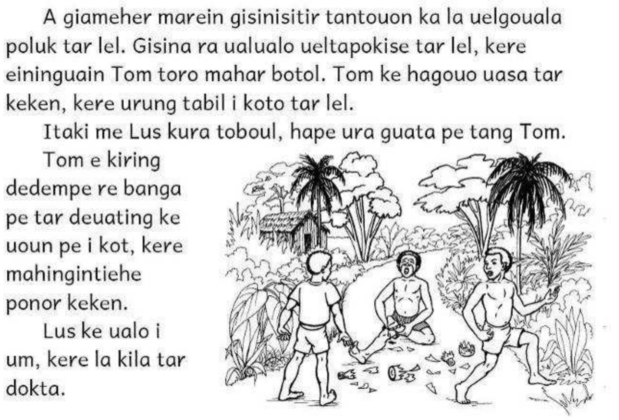
WeSay – National Coworker Dictionary Creation Software with simplified interface. The language worker used a gallery of drawings from the “Art of Reading” digital library to illustrate his word and is about to “click” to make a vernacular audio recording. (Developed by SIL including John Hatton of SIL PNG Branch) network connections or the Internet. Users are able to make local, simple printouts for local use, checking, and PR work."[24]

Vernacular Literacy: Bloom?

The "Book Loom" tool, is under-development, but not widely publicized.

The "ideal" Literacy Application has a similar targeted audience to WeSay. It is recognizing a huge need in counter-response to the software industry's pressure for more complex and powerful Desktop Publishing (DTP) systems. This is the opposite of our need here.

This app would create a low-training, high-output system where mother tongue speakers and their advocates work together to foster both community authorship and access to external material in the vernacular.[25]


A giameher marein gisinisitir tantouon ka la uelgouala poluk tar lel. Gisina ra ualualo ueltapokise tar lel, kere eininguain Tom toro mahar botol. Tom ke hagouo uasa tar keken, kere urung tabil i koto tar lel.

Itaki me Lus kura toboul, hape ura guata pe tang Tom.

Tom e kiring dedempe re banga pe tar deuating ke uoun pe i kot, kere mahingintiehe ponor keken.

Lus ke ualo i um, kere la kila tar dokta.

In the "Brukim Botol" story one child cuts his foot badly due to the folly of another. The third child runs to get the local doctor for assistance. Note how for this page the Nehan vernacular text must move around the graphic object easily and for a different target language one might have more or less words on this page. The interface for laying out a new book must be simple and easier to use than our present tools allow today.

Like WeSay, there are two intended users:

- *The primary user is a Mother Tongue Literacy Worker. He/She has basic computer skills, and little access to technical help.*
- *The secondary user is the Advisor/Advocate. He or she has more advanced computer skills and easy access to technical help.*

Templates: Keeps things simple by replacing many of the operations of normal Page Layout applications (flow, size, format, crop, etc.) with ready-made templates. Templates can be "blank" or content-based standard templates can be brought to the work for re-use or for making derivative works.

Library: Works by others can be accessed easily in a re-usable library. Derivative works can be published without concern based on a Creative Commons license for the work. All works entered into the Library have all permissions granted for re-use by others.

Citation Management: Necessary author permissions are recorded for future reference (and proof of Creative Commons license permission, when asked).

Text Sizing: Designed with easy to use controls, for both text and illustrations, to facilitate composition differences between languages.

Illustrations: Royalty free illustrations can come from a pre-existing library, although custom drawings can easily be incorporated with simple to use controls. New illustrations must be "free" before re-submission into a common library.

Publishing Mode: Various common printing and collation formats are supported, and again with ease of use in mind. Example: Half A4 center stapled, with backed sides (duplex).

Our Word

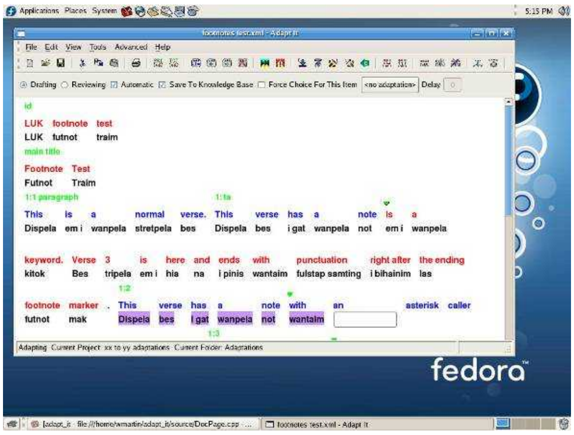
Created by John Wimbish, and sponsored by "The Seed Company", "OurWord! is a Bible Translation software program designed for national translators, who are translating the Scriptures into the world's minority languages, and who typically have not had significant computer experience.”[26]

“Using a concept called ‘manual adaptation’ to refer to OurWord's process. the computer replaces words from one language with words in the other language in order to produce an initial draft. The translator still relies on the source language, but rather than receiving word-by-word suggestions from the computer, the translator crafts the translation himself ” mostly at the paragraph level filling in a prearranged form template with fields to fill in. “Thus he is able to address such things as resolving collocational clashes, deciding on appropriate idioms, etc.. By using a good source text, many man-years are saved that would otherwise be spent on activities such as exegesis and decisions on how to represent concepts within the language family and culture.”

Bible Edit (Linux)

Created by Teus Benschop, this GNU license program[27] has many similar features as Paratext, but is less refined at this point. There would not be the collaborative team features of Paratext 7.x, for instance. However, it is the best Bible Translation software for Linux at the moment and the only tool of its kind to be found in the Balsa system since Balsa is based on Linux and a “free to give away, unencumbered” system. A companion tool is “BibleTime” a Bible Study program.

Adapt It



Adapt-It screen shot. Words and word phrases are stored by the user as they progressively translate source text to target language text. The software memorizes key terms and phrases as you go, to be suggested later.

Adapt It was originally created by Bruce Waters in 1999, and from 2002 he was assisted by Bill Martin who now leads the development team. It is a Windows/ Linux based package that provides tools for translating either text or scripture from one language which you know, to another related language known to you or a coworker. No linguistic analysis is performed. Thus it can be an appropriate tool for native speakers who have no linguistic training. It has an easy-to-use interface designed for users not normally familiar with computers before.

Language Documentation

In line with the latest push for “language documentation” as opposed to “language analysis”, the Linguistic community, world-wide is working on a few good tools for such a task. The typical netbook has adequate microphones and microphone line-in jacks, such that they can become a powerful language data acquisition and storage device with unlimited memory. The best tools will no doubt be found in the Balsa environment and certainly run under MS Windows as well.

Miscellaneous Items

Solar Powered Flashlights (Torches)

If you want an incredibly durable flashlight (torch) for village level work, then look no further than “Solar Light”™ put out by www.hybridlight.com and sold on Amazon.com in black for US$ 17.

These torches have a powerful LED light, and powerful solar cell for recharging quickly. With a dual mode sealed push button switch the second mode switches to two CR2032 Lithium backup batteries, for emergencies when you have depleted the stored solar battery energy. Both modes have LED light indicators (Yellow-solar; Green-Lithium; Red sufficient sunlight to charge)

It is built with a durable, rubberized plastic, including the clear window that would be difficult to break. It is waterproof and floats in water. One would not hesitate to drop this, say 5 meters. It would simply bounce. Highly recommended as a gift.

Look for: "Hybrid Light LLC Solar Flashlight"

An incredibly durable solar powered flashlight. Highly recommended at $17 in black.

Summary

On the Threshold of a Dream

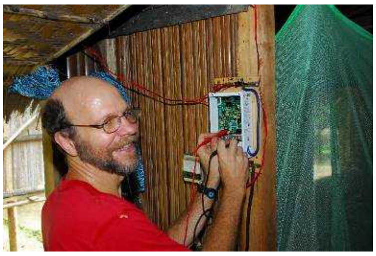
We are on that threshold where appropriate and robust technology may launch us into a new era of involvement by third-world nationals that would not otherwise be able to participate in the work of vernacular Language Development. The dream is to provide the tools (and training) necessary to encourage native speakers of a given vernacular to take pride in their own language and culture; to begin to document their mother tongue for themselves and to consider the translation task as well. Given in the harsh realities of our limited expatriate man-power to complete the task, it is time for the citizens of the third-world to enter into this exciting work as well. Using new methods, it may be possible for national citizens to be encouraged to join us in the work.

About the Author

Brian Chapaitis originally studied electrical engineering at Cornell University, USA. He is comfortable with programming embedded micro-controller systems, and thus is a "hardware and software" man, although he considers "real programmers" to only work in assembly code.

Together with wife Helen (physician), they have served in a variety of positions in the SIL Papua New Guinea Branch for over 20 years.

Brian presently works out of the Language Software Services office in the SIL LCORE department building at Ukarumpa, in the Eastern Highlands Province, Papua New Guinea. He can often be found way off center, ministering within the church in the local village context. He shares the growing vision of empowering national counterparts to do aspects of the Language Development task hitherto thought impossible, with self-sufficiency, using the latest new appropriate technologies, both hardware and software.



Testing a new installation of a Xantrex C-35 solar controller and two ancient Siemen's 55 watt poly-crystalline solar panels. A major discovery was the improper gauge wire used to deliver power from the roof that greatly reduced power transfer. West Aitape Multi-Language Project. SIL consultant Beth Fuller's house, North Coast, PNG.

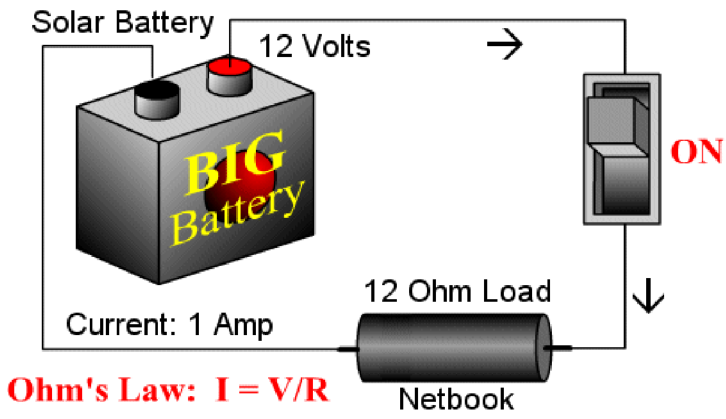
Brian Chapaitis,
SIL PNG Branch, Papua New Guinea

Email: brian_chapaitis(at)sil.org use: @ (this reduces spam)

Appendix

Ohm's Law

In my travels with SCOS and counseling others (both expatriates and PNG Nationals) I have found most people from the West either didn't have technical High School science classes, or worse, they fell asleep in class because they didn't see any relevancy to "electricity" as a concept. Therefore, most seem to not know Ohm's Law at all. It has much relevancy when talking about solar projects.



Circuit Diagram useful in Ohm's Law Discussion.

In the diagram at the right, the battery of some kind (a device that stores electrical energy) must be connected by wires to other objects from terminal to terminal to complete a circle of connections. This is said to complete a "circuit" in English and the circle must be maintained for current to flow. The "R" is the resistive load, and the " I " or current is often expressed in Amperage or "Amps" for short.

For solar projects there are really two electromotive devices: The lead-acid battery we use to store electrical energy and another device, the photo-voltaic (PV) panel, often called merely a "solar panel".

So when one talks about a netbook as the "load" in a lead-acid battery circuit, it represents a certain resistance to the battery while doing useful work in computing. In this Handbook when the Asus model 1000HE is connected to a 12 volt lead-acid battery, it often draws 0.8 amps, through a complete circuit provided by the solar controller (not shown in this picture). There is then a linear relationship between Volts, Amps and Resistance as expressed here:

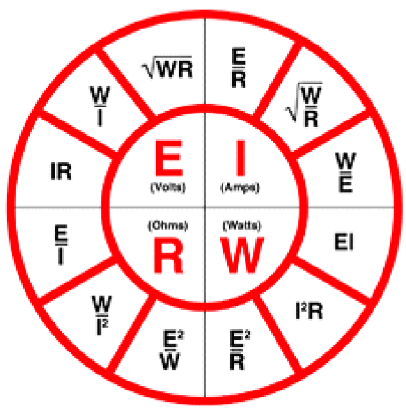
$$V = IR \quad \text{or} \quad I = \frac{V}{R} \quad \text{or} \quad R = \frac{V}{I}$$

If I have a 12 volt battery or source of "force", then I can push a current of 1 amp, through a 12 Ohm load. If the load were to increase to 24 Ohms, then current would reduce to 0.5 amps, a reciprocal and linear relationship. I will leave the math to the user here. Can you calculate the resistive load of the Asus 1000HE since the current was 0.8 amps? (Answer: 15 ohms)

Power

Concepts of "Work" and "Power" are where things get confusing for people. Here's a standard "Power" formula to consider:

$$P = \frac{W}{t} = \frac{E}{t}$$



Power Formulas. Note: E = V, or "Electromotive force" is Voltage

Power is often expressed as the amount of "Work" done per unit of time. Also related to electrical circuits "Work" is expressed in terms of Units of "Energy" or "E" above performed per unit of time.

Power is often expressed in the unit "Watts" which you may have heard before, especially when we think about light bulbs around a house.

In a solar installation, we see small or large lead-acid batteries, and these often have capacities given to them in "Amp-Hours" or "Ah". So what is an Amp-Hour and how does this relate at all?

If battery manufacturers were scientists and mathematicians then they would label their products in "Watts" or units of power. But they don't. They tend to ignore the "voltage" in our equations and think in terms of circuits of all one voltage. So a 12 volt battery drives a 12 volt load, such as a netbook or an automobile starter motor. The "Amp-Hour" rating then becomes an easy way to predict how long a battery can sustain a like-minded load in a circuit.

If I have a 12 volt, 18 Amp-Hour (Ah) battery, and my netbook draws exactly 1.0 amps while I am doing useful work, then I can expect the battery to sustain the netbook (to its total, complete death) in around 18 hours. The battery can supply useful energy for that long a time, to that kind of load. Of course, if I move to a "smartbook" that only needs 0.5 amps, then in theory the battery could sustain the "smartbook" for twice as long a period.

I must hasten to add, however in the technical discussion of the Handbook, we saw that ***TOTAL*** battery capacity is not a very useful thing to think about, since for the survival of the lead-acid battery, we need to watch that "Depth of Discharge" issue (if you want the battery to live longer). We are suggesting only depressing the battery charge to around 30% of its capacity during each charge and recharge daily cycle. That means that the 18 Ah lead-acid battery can only usefully sustain the netbook at 1.0 amps, for 30% of that 18 Amp-Hour capacity, or about 6 useful hours.

The pure scientists in life will insist that we must talk about watts in this situation, and not "Amp-Hours" but basically if both the battery is at 12 volts and the load or netbook through an auto-adapter is at 12 volts, then we can safely ignore "watts" for the moment. Suddenly graphs and charts for a 12 volt battery specification from Panasonic or Power-Sonic, or Yuasa, or Ritar, begin to make more sense.

Power Loss due to Resistance

We talked about the resistance of the load device where useful work is being performed by the circuit, but there is another place to think about resistance that is not so useful. The wires and their length. Consider:

$$P = I^2 \cdot R = \frac{V^2}{R}$$

The above relationships occur when we substitute Ohm's Law with the Power equations. Note that this is no longer a "linear" relationship. The wires in a circuit in an appliance are often short, and therefore energy loss due to the length of the wires is low. However, in solar applications the lengths of some wires are quite significant, say the distance from the solar panel to the solar controller, or the solar controller to the lead-acid battery. The resistance of the wires, fights the electromotive force of the battery or solar panel, and the loss of energy comes out as "heat" energy in the wire itself escaping into the atmosphere. Work is being performed. Just not useful work. It is for this reason that we specify large diameter wires in solar installations, and not tiny, thin and consequently inexpensive wires. Of course as the number gauge of the wire goes down, meaning a thicker wire diameter, your cost goes up per meter. There has to be a balance somewhere and that appears to be around the 10 gauge mark for 12 volt solar systems.

Note however, that some professional solar installations move to 24 volts and 48 volt photo-voltaic arrays, and not 12 volts. Why is this? Because if the voltage quadruples at the source, the current passing the energy to the battery, decreases by one forth (Ohm's Law). But the power loss over the meters of long wires from the solar array to the battery storage device is not a quarter, but rather a 1/16 as much (1/4 squared). That is the reason that many users of household solar systems go to 48 volt panels and then convert (perhaps) to 12 volt batteries later. There is one well-known solar controller that does this by Outback Power Systems, made in Australia.

So, the bottom line here is that due to the "square" losses of power in longer wire runs, be mindful of the wire-gauge you specify in your application of solar. Choose the largest wire diameter, or the smallest gauge number for the wire, that you can reasonably afford. Also, choose copper wire over aluminum since the resistance is less per meter.

[1] PC-Magazine, pg. 54-55, November, 2009 (on-line: http://www.pcmag.com/article2/0,2817,2352798,00.asp)
[2] Far more than you ever wanted to know about "insolation" can be found at http://en.wikipedia.org/wiki/Insolation
[3] Solar Buzz. See http://www.solarbuzz.com/technologies.htm
[4] See AltE store: http://www.altestore.com/store/Solar-Panels/1-to-50-Watt-Solar-Panels/Global-Solar-Energy-Global-Solar-30W-12V-Framed-Solar-Panel/p5573/ Download spec sheet here as well.
[5] See http://photovoltaics.sandia.gov/docs/PVmodules.html third paragraph.
[6] See: http://photovoltaics.sandia.gov/docs/PVmodules.html "Photovoltaics Modules" 4th paragraph. Apparently parallel configuration of whole solar panels is fine. The issue is on a cell-by-cell basis within a panel, and we cannot control that anyway. Problems occur only with higher voltage configurations above 24 volt systems.
[7] www.xantrex.com/web/id/405/docserve.aspx (Brochure)
[8] www.mrsolar.com/pdf/xantrex/C12.pdf (Manual)
[9] Elements of this text taken from the very nice solar reference: "WindSun Deep Cycle Battery FAQ"; See http://www.windsun.com/Batteries/Battery_FAQ.htm
[10] From the Xantrex Manual: "C12 Charge/Load/Lighting Controller Owner's Manual" – March 2005; 975-0130-01-01 Rev. D; www. xantrex.com
[11] From the web site: http://www.batteryfaq.org See section 9: "How do I charge (or equalize) my battery?" which has considerable specific charging cycle graphs by lead-acid battery type.
[12] "WindSun Deep Cycle Battery FAQ"; See http://www.windsun.com/Batteries/Battery_FAQ.htm
[13] From the Powersonic Spec Sheet. See: http://www.power-sonic.com/site/doc/prod/95.pdf (18Ah) also compare with (35 Ah) at www.power-sonic.com/site/doc/prod/99.pdf
[14] "RISO – Lifetime Modelling of Lead Acid Batteries" Henrik Bindner, Tom Cronin, Per Lundsager, James F. Manwell, Utama Abdulwahid, Ian Baring-Gould; Risø-R-1515(EN); Risø National Laboratory Roskilde Denmark April 2005, pg 22
[15] "Panasonic Sealed Lead-Acid Batteries Technical Handbook '99" Matsushita Battery Industrial Co. Ltd. Pg 18, January 2000; http://www.battery-service.de/daten/bleiakku.pdf
[16] From the free circuit library at http://english.cxem.net/guard/guard23.php
[17] See http://www.affordable-solar.com/wire.charts.htm
[18] From the paper: "Introduction to Batteries and Charging Systems" pg 17, Ralph E. Scheidler, Sure Power Industries, Inc. See http://www.surepower.com/pdf/ebr_int.pdf
[19] See: http://cgi.ebay.com/Battery-Car-Charger-Cable-for-Asus-Eee-1101HA-11-6-11_W0QQitemZ270445530809QQcmdZViewItemQQptZLH_DefaultDomain_0?hash=item3ef7cf4eb9
[20] PC-Magazine, pg. 54-55, November, 2009 (on-line: http://www.pcmag.com/article2/0,2817,2352798,00.asp)
[21] See http://dealnews.com/categories/Computer/PC-Computers/PC-Laptop/Netbooks/535.html
[22] Details of Balsa can be found at the official Balsa website: http://balsa.kkoncepts.net/
[23] WeSay See: http://www.wesay.org/blogs/ for more thoughts by the present software development team. Also under consideration is the ability to easily record vernacular text for annotation later. OLPC XOs machines have very good stereo audio recording capabilities.
[24] See http://www.wesay.org/wiki/Main_Page for a good description of the goals and objectives.
[25] For further interest in such a tool, consider writing to the SIL Literacy Department, SIL International.
[26] See http://www.codeplex.com/OurWord/
[27] See http://sourceforge.net/projects/bibledit/