XO Laptop Solar Charger

APSC -100 Project Final Proposal

by

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Honesty Statement

“We do hereby verify that this written report is our own individual work and contains our own original ideas, concepts, and designs. No portion of this report had been copied in whole or in part from another source with the possible exception of properly referenced material.”

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February 17, 2010

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Executive Summary

One Laptop per Child is a charitable organization with the goal of creating “educational opportunities for the world’s poorest children”. The way they achieve this lofty goal is by distributing a cheap subnotebook laptop called the *XO Laptop*. Their current model the XO Laptop is the latest iteration of what has been a constantly evolving process of different designs for the laptops. The laptop is “about the size of a small textbook” and has built in wifi as well as many other features that make it fantastic for children in developing countries. The only major problem is that it requires access to a power source like a power outlet that some communities do not have.

The objective of this project is to investigate, design and if possible create a working solar power alternative to power the XO Laptop. The design must be durable, portable and functional yet cost effective to be a viable solution. Also if possible the proposed design must esthetically match the XO Laptop itself.

Many attempts have been made to create such a product however all of the designs have failed to succeed at truly satisfying all the conditions for a successful product. Some were too expensive, others to large and others still not durable enough to work.

The original proposed design involved heavy use of a rapid prototype, however due to budget restraints a second “proof of concept” design is also proposed and was in fact manufactured for testing. Both designs are viable solutions to the problem and are possible using the RepRap rapid prototyping machine instead of a commercial grade rapid prototyper.

The original proposed solar solution uses a clamshell design with a hinge. In total, 6 polycrystalline solar panels would be used and would be arranged in sets of three on a folding apparatus. To protect the solar panels, an acrylic screen would be placed on top of the panels and is fitted into the clamshell housing. This provides roughly 12 watts of power, which more than satisfies the need to charge or use the laptop using the panels.

The “proof of concept” solution is very similar except that acrylic is also used as a backing and the only part that is rapid prototyped is the overall shell shape.

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1.0 Introduction

One Laptop per Child is a charitable organization with the goal of providing poor children, often in developing countries, with small subnotebook laptops in order to give them educational opportunities. The current model of laptop they distribute is called the XO Laptop. It is a small, durable, and inexpensive and energy efficient laptop that has been completely revolutionizing communities in Africa and many other places in the developing world.

Although great care was taken to design a product that is suitable for all places, unfortunately the XO Laptop is still an impractical solution in many parts of the developing world due to its need of electricity. Many solutions to this problem have been proposed including, a since discontinued, crank powered solution[1] that was deemed impractical for use in schools. Many of the solutions have involved the use of Photovoltaic cells to produce energy from the ample amounts of sun light that many of these locales receive. Unfortunately all of the solutions were inherently flawed in the durability, portability or cost of the apparatus.

A useful solar powered charger for the XO Laptop would need to be durable. The charger would be distributed to children, and would have to be as drop and crack proof as possible. It would need to withstand harsh environments from desserts to rainforests without damaging the circuitry and any moving parts.

It would also need to be portable. As most of the children receive these laptops through their schools, a solar charger would need to be portable enough to allow the children to travel between their homes and their schools to be a viable solution. This also dictates that the charger be small and lightweight in order to facilitate ease of transport.

Furthermore the charger would have to be as cheap as possible. The solar charger could not cost anymore and preferably less than the laptop as many of the communities who are receiving the laptops do not have large sources of income. The laptops would become too expensive if in order to charge them, a $100+ charger was required.

2.0 Problem Formulation

2.1 Project Objective

The XO Laptop is a fantastic technology that is changing the world for many people in developing countries. However due to the availability of electricity in many communities, the use of the XO Laptop is impractical. A possible solution is the use of solar energy to power the laptops; however a viable solar solution is yet to be found.

The objective of this project is to design and implement a solar solution for the XO Laptop. A viable solution must be affordable to those in developing countries, portable, durable and above all else functional. In order to work the charger would have to produce at least 9 watts of power consistently to charge or run the laptop. It would have to be small and roughly the size of the laptop itself in order to be portable but also rugged enough to function under less than prime conditions.

2.2 Solar Power Background

Solar panels are a collection of photovoltaic cells that are arranged in parallel and series circuits in order to create useful electrical power. Photovoltaic cells are made from semiconductors, typically silicon, which are then “doped” with impurities to cause internal electric fields. When sunlight hits these cells, some of the energy is absorbed by the cell, knocking electrons loose from the valence shell of the silicon atoms. These loose electrons are then pushed across the electric fields caused by the doping which creates a current. This current is harnessed by conductive metals layered across the cells, which is then used as electricity.[2]

2.3 XO Laptop Specifications

The XO Laptop (Figure 1) was designed to be durable, usable and energy efficient. Its approximate dimensions are 242mm×228mm×32mm and it weighs approximately 1.45 Kg with the LiFeP Battery and 1.58 Kg with the NiMH battery. It runs a modified version of the open source operating system Linux,

Figure 1: The XO Laptop

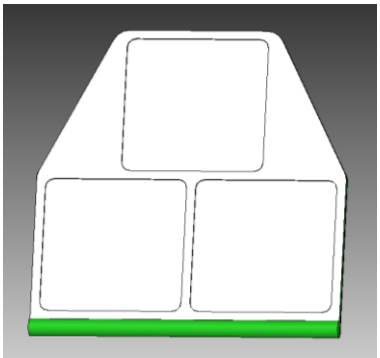
called *Sugar.* Amongst many of the revolutionary features of the laptop, one that stands out is the capability of mesh networking. This allows for a whole community to connect to the internet as long as one of the networked XO Laptops has an internet connection. It requires a minimum of 9 watts to charge or run off the power adapter [1].

3.0 Design Considerations

The ideal mass produced design for the solar charger was created in consideration of all of the problems that the solar panels could encounter in all areas the laptop could be used. The terrain of these locations differed, though the same design would need to be used for every country. The solar panels would ideally be easy to build and assemble, as if maintenance needed to be performed, the children could find someone to fix the solar panels should anything happen to them. To create this ease, the solar panels will be encased in a hard-like plastic material. This material would also be able to be constructed easily if damaged due to a clam shell-like design.

This clam-like structure would cover the front and back of the solar panels separately, and then be fastened together. Each panel of the clamshell will be made up of 2 halves (*Figures 2.1 and 2.2)*, one to support and hold the panels and another to cover and secure them. The thickness of each shell will be 2 millimetres, and while this may seem thin, there is an internal rib structure to maintain the integrity of the unit.

The rib structure will have thin pieces of the acrylic material we will use to cover the panels themselves running along the inside of the unit in a grid like pattern. This will allow a place for each panel to sit on while providing increased rigidity. Another possible issue is what will be utilized to manage shock absorption. We will likely utilize foam inserts within the grid itself and underneath each panel as well to ensure that the solar panels endure as little shock as possible.



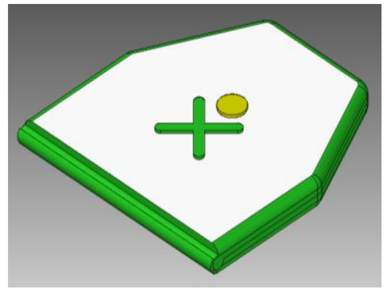


Figure 2.2: Inside View *Figure 2.1: Top View of Proposed Design*

To hold the unit together we will likely use screws, as they ensure that the design can be disassembled easily for maintenance. However to ensure that no tinkering takes place by the users it would be ideal to use security bits, so that people who are able to fix them, can, and people who try to use them in ways that are now intended, are not able to.

The solar panels need to be both water and dust proof, as the water and dust could corrode the wiring of the solar panels. The dust could cause unexpected wear of any part of the design if it were to get into the actual solar panels or the interior of the outer portion. With regards to waterproofing the unit, this will be done using silicon caulking. It is a simple solution that can be used around any seams, such as the ones created around the solar panels, and can also line the seams where the 2 shells fit together, so that the pressure keeping the unit closed creates the seal.

The solar panel design did not have to be portable, though it would be ideal if it was. To create a solar panel design that would be portable, the size and weight of the panels must be kept to a minimum. The expected users of these solar panels may have to walk long distances, and the weight of or the inconvenient size of the design could hinder the children. To accomplish this, the solar panels would ideally need to be roughly the size of the laptop, which could be a problem due to the wattage needed to power the laptop. The laptop would need to be powered by a certain number of solar panels, and the optimum level that had been determined for the design was six panels.

Six solar panels would create twelve watts of power to the laptops, yet they could be moved around to achieve the small size. The six solar panels would also help to minimize cost, as the expected audience of the solar panels is not wealthy. The cost would mean a lot to these children, since they already have so little. Using these panels to minimize the size of the actual design, the idea to have a folding shell for the panels was proposed(*Figure 2.3)*. Based on this idea, there would be three solar panels on each side

(*Figure 2.4)*, and the design would fold so that the panels would face each other when not in use. This would protect the solar panels should any damage occur. The two sides of the solar panel unit will be connected with a hinge.

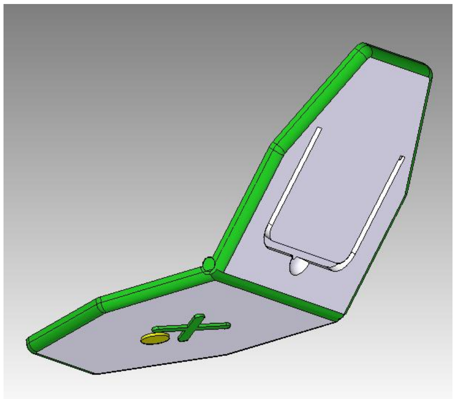


Figure 2.3: Bottom Open View

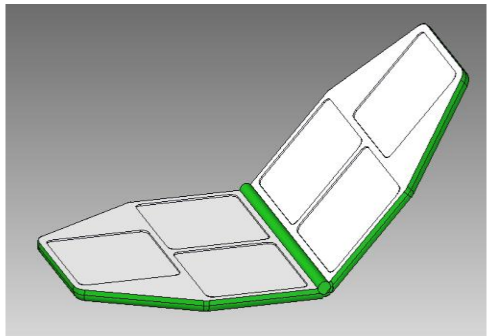


Figure 2.4: Inside Open View

The hinge for the clamshell will be located at the wider end of each panel so as to ensure the strength of the unit. The hinge will be created in four pieces with two on each panel. The hinge will be thick so as to ensure that it will not break easily. The pin inside the hinge will also be set up so that it is easily removable for maintenance purposes. This will be done by using a 2 part pin, with one piece that runs the length of the design and the other end being an end cap that can be removed via a screw.

For ease while carrying, the solar panel unit will attach onto the laptop itself. Our design will be fastened to the laptop using three Velcro straps. Two will be located on either side of the narrow end of the folded laptop to loop through the holes on either side of the handle. One will also be located on the side of the unit and will be wrapped width wise around the laptop itself to prevent it from swinging and banging against it.

The appearance of the solar panel unit is that of a triangle, and is split into two sides. Each panel is triangular in shape to minimize the plastic used and increase the overall strength of the unit itself, as having the square corners would provide potential points at which the unit could chip or break. A colour scheme is needed for each unit, as this is what creates the sense of unity with the laptop. The main portions of the solar panel unit will be white and the sides will be painted green to match the sides of the laptop. There will be a decorative piece of plastic that would come out of the top of the solar panels in the shape of the XO laptop logo. This is an “x” with a circle over it, symbolizing a child. These details will be painted green, with the circle painted yellow. The colours of this decorative design are not important, and may be changed to a variety of options.

There will be no stand on the unit, as the solar panels are meant to lie flat on the ground, or on any other relatively flat surface. This simplicity will help the children using it to easily and quickly set up the solar panel unit. This absence of a stand to prop up the solar unit will also minimize the amounts of materials and parts needed, as well as the cost. The lack of a stand also allows for the back of the unit to be sturdier, as the stand would need to have holes and depressions milled into the plastic clam shell. This would have created a weakness, as the plastic would be thinner in that area.

It was determined that the cost of rapid prototyping the ideal initial design would be far too high as it was intended that both shells would be constructed using the rapid prototyper. It was then decided that the rapid prototyper could instead be used to just construct the outside border of the shell (*Figure 2.5*). This would allow the construction time to be reduced significantly while still being cost effective and could be further reinforced.

Figure 2.5: The Outside Border of the Shell

The acrylic shielding used to cover the solar panels would instead be used as the front and back of each of the two main panels of the unit. The cost of the acrylic is low. In comparison to the original design made entirely of the prototyping plastic, it is a small fraction of the price. The acrylic would allow the sun’s rays to pass through and reach the solar panels beneath while ensuring the integrity of the unit.

The solar panels would then be glued onto Styrofoam (*Figure 2.6*) and secured to the acrylic sheet used as the back of the panel using hot glue. The Styrofoam would help to absorb any shock or stress and protect the fragile solar panels.

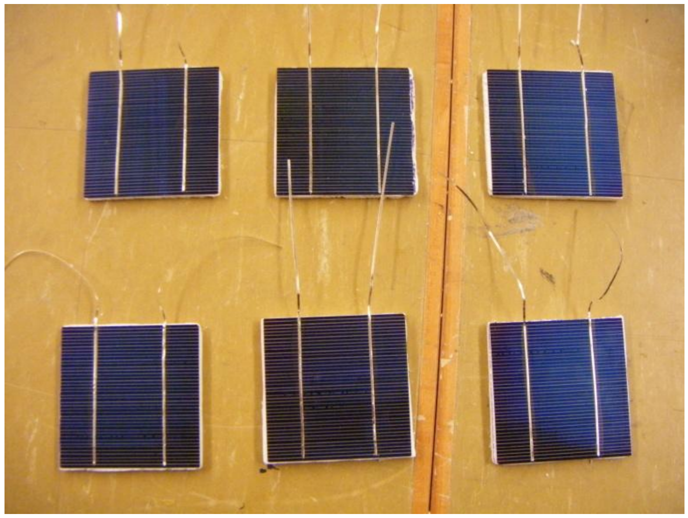


Figure 2.6: Solar Panels Glued to Stryofoam

Acrylic sheeting would also be used as dividers between the three solar panels. The dividers would also be used to raise the acrylic sheet from the surface of the solar panels providing extra protection for each of the solar panels.

Around the solar panels, there is foam to help absorb shock and protect the solar panels. This also provides protection for the wires and the circuit in general, as any damage to the circuit would render the unit useless. Grooves have been cut out of the supporting acrylic pieces and holes have been drilled out of the plastic to allow for the wires to run throughout the unit. These grooves were an idea that allowed for easier access to the wiring in the solar panels. The wires could be more easily repaired than in the original design, as well as reassembled.

This proof of concept design (*Figure 2.7*) although different in appearance would be just as functional and would also provide an alternative design when rapid protoryped plastic is unavailable.

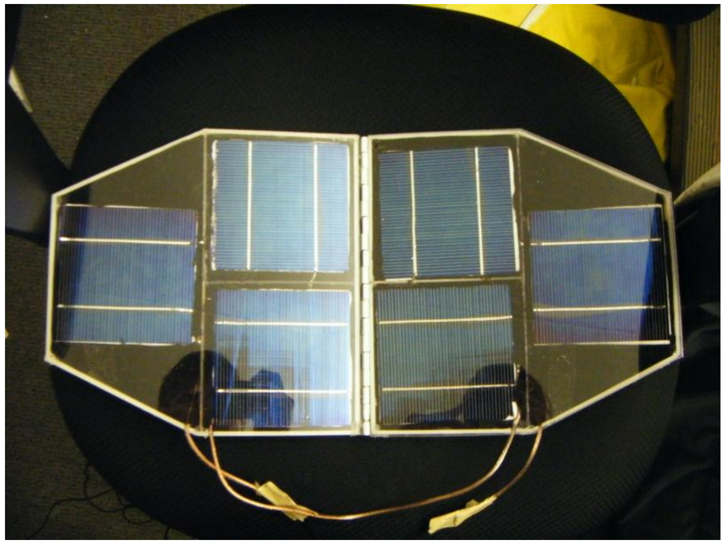


Figure 2.7: The Final Prototype

4.0 Discussion

Due to weather constraints, no testing was completed before the writing of this report. However, a current was successfully carried by the built prototype implying successful manufacturing. Assuming there are no defects with the solar panels and enough light is present, the proposed design should successfully carry out its purpose, to charge the XO Laptop.

5.0 Economics/Budget

The prototype costs $6 per cubic inch of material. If the charger is estimated to be 2 shells of dimensions 8.75" by 8.75" by 1½'' with a 4mm thickness then the total cost would be ~$280. This cost will be reduced when mass produced and with the use of the RepRap rapid prototype which is significantly cheaper than the rapid prototype that will construct the prototype. If the RepRap was used, the material ABS costs $10.48 per pound with a density of .0376 pounds per cubic inch. The charger shell is approximately 40 cubic inches. This brings the cost down to $15.76. The acrylic that will be used for the protective shielding has to be bought in a large 4' by 2' piece. This cost can be spit up by sharing the acrylic with another group. The solar panels can be bought for $3.46 each but when bought in bulk will cost $2.32; six of these are needed per charger.

Cost of Prototype	
Prototyper (no tax)	40in^3 x $6/in^3
Solar panels	6 x $3.46
Acrylic plastic	$2.40
Velcro	$10.00
Silicon caulking	$1.00
tax	3.75
total	$277.92

Table 1.1: Prototype Cost Analysis

Since the construction of the prototype is far too expensive to create, some changes were made to the prototype. Though the new prototype would not be the product we would want to produce, it does act as a proof of concept. The new prototype uses only 8.8 cubic inches of prototyping material. This was done by decreasing the thickness of the prototyped material and using more of the acrylic. This limits the cost of construction.

Cost of “proof of concept” Prototype	
Prototyper (no tax)	4.2in^3 x $6/in^3
Solar panels	6 x $3.46
Acrylic plastic	$7.20
Velcro	$10.00
Silicon caulking	$1.00
tax	$4.20
total	$68.36

Table 1.2: Proof of Concept Cost Analysis

It was decided that the construction of the charger would be more localized. Sending out RepRaps as well as the materials to specific areas would then allow the people to not only repair the charger if it breaks but also make other products. If it is assumed the manufacturer were to sell the chargers for $41.72, then they would start to make profit after the first 42 sold. The product could be sold to the general public through One Laptop Per Child for a marked up price which profits would go towards helping lower the cost of materials and RepRaps for other countries. The marketing would probably go through One Laptop Per Child.

Cost of mass produced Prototype	
RepRap Materials	$15.76
Solar panels	6 x $2.32
Acrylic plastic	$2.40
Velcro	$0.60
Silicon caulking	$1.00
tax	$3.44
total	$34.72

Table 1.3: Mass Produced Cost Analysis

6.0 Conclusion

The XO Laptop is a revolutionary technology that is changing the way people in developing countries learn as well as live. Unfortunately many communities without access to constant electricity cannot take advantage of what the laptop has to offer.

Many attempts have been made to solve this problem, including a crank that generates electricity as well as many attempts at solar power, however none of these solutions worked. They were either too expensive, not portable, to fragile or just not functional for the task at hand.

The design described in this proposal is rugged, portable, functional, and made with the right materials and prototyper, cheap. This is a viable solution to the problem of how to power the laptop without a consistent source of electricity.

The proof of concept design constructed for testing purposes shows promise and should successfully prove that the design is sound as soon as testing completes. It also poses a secondary option to serve the same purpose.

The XO Laptop is a fantastic item that is opening doors for poor children around the world. With this design of a solar charger, hopefully this wonderful technology will become available to even more people

7.0 Works Cited

[1] One Laptop per Child. One Laptop per Child. [Online]. http://laptop.org/en/index.shtml

[2] Jessika Toothman and Scott Aldous. (2000, April) How Stuff Works. [Online]. http://www.howstuffworks.com/solar-cell.htm

[3] SPI. Solar Panel Info. [Online]. http://www.solarpanelinfo.com/

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8. 0 Personal Contributions

Joey Frohlinger

I was responsible for most of the primary research and design. I created both presentations using materials provided by other members of the group and compiled and edited both proposals from contributions from the group. I organized and help facilitate the final construction of the prototype as well as was heavily involved in the preliminary parts of the building process (cutting, gluing and making sure everything fit).

David Ward

In my group I was involved in the initial design process and helped conceive the initial and final design. I aided in preparing the design portions of both the proposal and final report, and helped complete team assignment 2. I also helped film the elevator proposal video and completed the construction of the solar panel unit.

Alex Bond

I was a major part in the construction of the prototype. I made the Styrofoam padding for the solar panels and the supports in the casing as well as assisting with the assembly of the prototype. For the report, I did all of the economics and budget. I was also heavily involved in the conception and production of the video.

Laura Cane

I helped with the initial design and planning of the initial design. I was responsible for all of the CAD designs as well as all revisions leading up to the final design. I took part in the video and contributed to the design portion of both reports and presentations.