Solar XO Laptop

APSC-100 Project 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 has been copied in whole or in part from another source, with the possible exception of properly referenced material."

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Executive Summary

The “XO Laptop,” from the “One Laptop Per Child Foundation” is an inexpensive laptop intended to help children in third world countries express themselves for educational purposes (OLPC 1999). However, many of the regions where this laptop is intended for use do not have access to a viable power source. A solution to this problem must be inexpensive, durable, and easy to use because it will be distributed to children in third world countries.

Initial designs emphasise cost, durability, easy to prototype and simple to use. The design is being introduced to third world countries therefore it needs to be very cost effective. Since children are using it, the design must be simple enough to prototype and so that a child can use it. It also must be durable because it will be primarily used in the rugged outdoors.

Our final design is of a book nature. It opens and closes with solar panels on the inside. When opened, the user is intended to prop the design up so an optimal efficiency angle is met. This is done using a stick or pencil as a “shadow stick” allowing for optimal orientation. The design will use six solar panels that will output 12 watts of power at perfect efficiency (Solar Winds USA 2009) The overall cost of the design is approximately 106 dollars if the rapid prototyping machine is used.

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1.0 Introduction

Currently the One Laptop Per Child program opens up educational opportunities for children in undeveloped countries by equipping them with an inexpensive, reliable, and efficient XO laptop (OLPC 1999). These laptops are filled with amazing software that is able to grow with the child and includes advanced hardware such as mesh networking capabilities and flash memory(OLPC 1999). However, these laptops cannot function without electricity and therefore must incorporate a solar panel as an additional power source.

Solar panels are capable of converting energy into power by utilizing impure crystalline-silicone called negative type and positive type. By putting these two separate pieces of silicone in contact with one another an electric field forms. This makes the N side electrons rush over to the P side to fill the empty holes, but at the junction a barrier is formed. As a result, it becomes harder for N electrons to cross over to the P side. Once equilibrium is reached, an electric field acts as a diode, allowing P electrons to flow to the N side, but not the other way around. When energy, in the form of photons of light, hits a solar panel the photoelectric effect takes place and electron-hole pairs are freed. This disrupts the electric field equilibrium and N electrons do work as they flow to the P side. A current is created by this flow while the electric field causes a voltage resulting in power. (Toothman 2000).

The designs for the solar panel range from a simple yet expensive notebook to a more complicated yet affordable book style. The end result is a mixture of different concepts, which reduces rapid prototyping material cost, fits within the budget and is able to supply at least 10 watts of power to charge the XO Laptop.

2.0 Problem Formulation

The XO laptop is capable of expanding children's knowledge of the world and improving their way of life. However, despite the laptop's potential, it has one weakness. Some of the places where these laptops are being exported to do not have the electricity to run them. As a result, the project objective is to outfit one of these laptops with a solar panel that can provide an estimated 10 watts of power for under eighty dollars.

With this mission in mind, the design must possess several qualities. First of all, it must be rugged to survive in very remote areas and to avoid damage. Secondly, it must be lightweight and portable because some children travel long distances back and forth to school. Thirdly, the design should be able to be built in any rapid prototyping machine. This is because prototyping machines could be bought by towns and then used to produce the solar panel design themselves, which would reduce overall costs greatly. Last of all, it must be inexpensive because the XO is already very cost efficient. All of these criteria and more will be considered in the design of the solar panel power source.

3.0 Design Considerations

Table 1: Design Criteria

Criteria	Specifications
Cost	• Must fit within the $80.00 budget • Can be rapidly prototyped in a cost effective manner
Practicality	• Should be lightweight and portable • Must be able to be built by any rapid prototyping machine • Has to charge the laptop efficiently • Able to be set up easily • Can optimize angle of sunlight
Durability	• Must withstand abuse • Waterproof • All wires should be protected

3.1 Design One: Cover

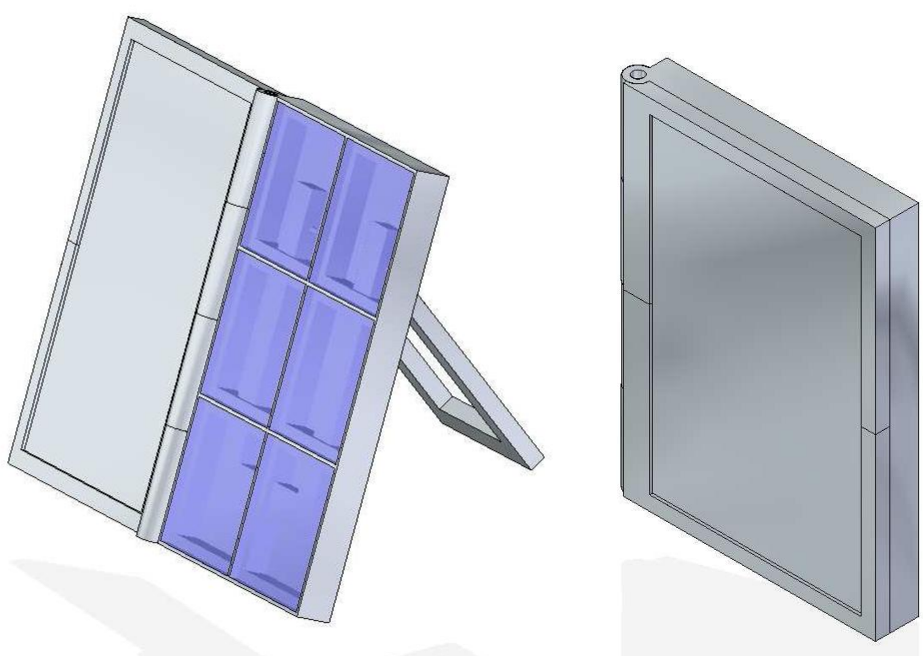

Figure 1.1: Design One

The main criterion behind this design is simplicity. It involves a base that will hold six solar panels, a cover to protect the solar panels and a stand that will allow the solar panel to be tilted, allowing for an optimal efficiency(Karcira 2003). The base is trimmed down so that minimal material is required to make it. It will be divided into two halves, so that it can be produced in a rapid prototyping machine. One half will have a region of slightly smaller dimensions so it can be inserted into the other half. Two screws and silicon sealant will join the halves of the base.

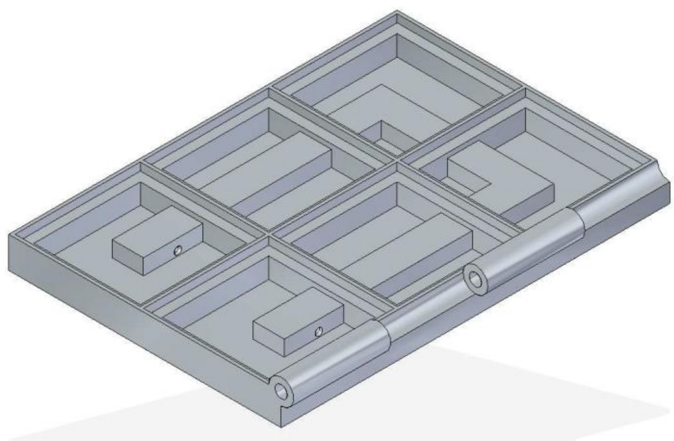

Figure 1.2 : Design One Base

A protective foam layer will be placed beneath each solar panel to prevent the solar panels from breaking. Each solar panel will then be placed in its proper position. The six solar panels will produce twelve watts of power and will be connected in a parallel fashion to ensure cloud cover will have a minimal effect. If one panel is covered by a shadow, the other panels will still be allowed to perform(Karcira 2003). The cover is made from a frame, which will be produced by the rapid prototyper in two halves, with a plastic sheet that will be inserted into this frame.

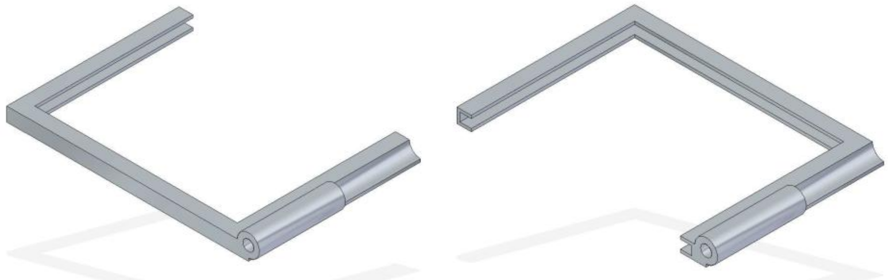

Figure 1.3 : Design One Cover

Sheet plastic is inexpensive(Home Hardware 2010) so this will reduce the over all cost of the design. This cover can be seen as having excess material, however, it is less expensive to use sheet plastic than rapid prototyped material. This makes the overall design less expensive than putting solar panels on two separate panels. The stand is attached to the back of the base in the area allotted for it.

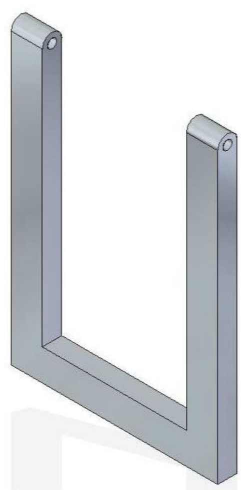

Figure 1.4 : Design One Fixed Stand

An ultraviolet protected acrylic sheet will be placed over the solar panels to increase their lifetime. This protects them from weathering such as scratches and water damage. A silicon sealant will be used to affix the acrylic sheet.

3.2 Design Two: Stand

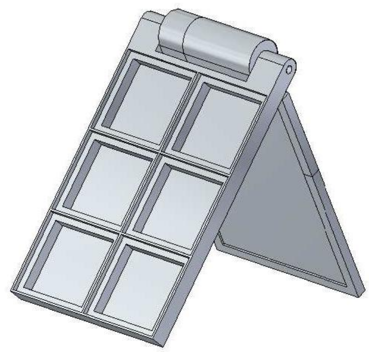

Figure 2 : Design Two

The next design, depicted above, was thought of due to its multifunctional capabilities. It was hopeful that by combining the lid and the stand functions into one piece that less materials would be used in the product. However, this design turns out to be just as, if not more expensive, than the others due to the hinge needed to allow for the complete revolution of the front casing.

As well, the hinge in the picture would be almost impossible to make using the rapid prototyping machine. Therefore, the design would require a redesigned hinge, which would reduce time spent on the overall design.

This design cut cost by featuring a plastic frame fitted with acrylic sheeting. However, this might require supporting material to be used when making these parts, which would increase overall costs.

For these reasons, this model in theory would work very well, but does not abide by all required criteria for this project.

3.3 Design Three: Book

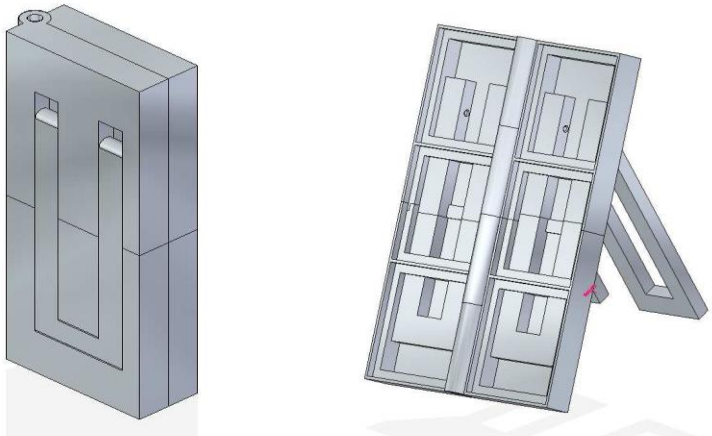

Figure 3 : Design Three

The open book design contains two columns, each of three solar panels which fold into each other when not in use. This allows for maximum durability when the solar panels are not in use. In addition, this design is more compact as it is half the size of the other designs when not in use. It is much easier to transport than the other designs, and much easier to store.

Unfortunately, it is more difficult to change the angle of the solar panel with the open book model than the others and more plastic is used in the rapid prototype. In order to connect the two solar panel columns, one must connect them outside of the design which allows for a greater chance of the wires being broken.

The design uses approximately 18 cubic inches of plastic when rapid prototyping and costs around $120.00(Queen's University Faculty of Applied Science 2001). Foam is needed to hold the solar panels in place and provide cushioning to protect them. UV protected acrylic will also be used to protect the solar panels. Hinges will connect the panels together and holes will be drilled in the sides of the casing to allow wires to pass through and connect the panels to the laptop. A sealant will also be needed to waterproof the design.

3.4 Final Design: L-Book

The L-Book is extremely similar to the book design, but with each side of the 'book' having three solar panels in the shape of an 'L'. It has all the benefits of the book design, but may be made in the rapid prototyping machine with just two pieces instead of four (the machine can only make parts in a 10 by 10 inch box(Queen's University Faculty of Applied Science 2001)). In order to fix the problem of changing the angle of the solar panels, the large base may allow the design to be placed up against a rock or the side of a house for support. In addition, a shadow stick may be inserted into a hole in the design to help the user find the optimal angle for the solar panel at any time of day.

One of the visible downsides about the design is that both sides of the book must be connected externally somehow. This poses a potential problem as it is much easier to sever the circuit, rendering half of the solar panels useless until repair.

The design uses approximately 16 cubic inches of plastic when rapid prototyping. Foam is needed to hold the solar panels in place and provide some cushioning to protect them. UV protected acrylic will also be used to protect the solar panels. Hinges will connect the panels together and holes will be drilled in the sides of the casing to allow wires to pass through and connect the panels to the laptop. Some sort of sealant will be needed to waterproof the design. If the design is not rapid prototyped, the casing may be replaced by some strong acrylic or another rigid material which reduces costs substantially

4.0 Economic Analysis

Table 2: Materials and Cost

Material	**Cost**
Prototyping Plastic	$96
Hinges (2)	$4
Foam Padding(BestPrice 2010)	$5
Acrylic Sheet(Home Hardware 2010)	$1
Screws/Washers/Bolts(Home Hardware 2010)	$2
Sealant(Home Hardware 2010)	$1
Velcro (Home Hardware 2010)	$1
Total	**$110**

The cost to prototype the chosen design excluding the solar panels is approximately $110. In addition, there are a few other costs that need to be considered in the manufacturing of the initial design including wiring, soldering, and adhesive to connect all the parts.

Although the total predicted cost exceeds the given budget, approximately 90% of the cost is made up by the extremely expensive rapid prototyping. It costs $6 per cubic inch to create the plastic casing for the solar panels. With a design that is 16 cubic inches the overall cost will be much more expensive. It is predicted that if the design is not chosen for rapid prototyping, this $96 can be reduced to almost $10, simply by using an alternative material. In addition, a strong acrylic layer or another material may replace the bottom base of the design thus reducing design cost.

6.0 Conclusion

In conclusion, the XO laptop has a high demand for an alternative power source despite its amazing features and durability. Since these laptops will be exported to areas without access to electricity an external solar panel is a simple solution.

After much research it was determined that the device must be easily prototyped at a cheap cost, durable, and simple to use. It must be inexpensive because the product is being shipped to undeveloped countries. The design must also be easy to rapid prototype since in the future these machines can be exported to countries and the people could replicate the design themselves. Last of all, it must be durable and simple to use since children are the main users of this product.

The final design encompasses all necessary design criteria. It is essentially two "L" shaped halves that fold together like a book. Despite having no stand, the design still incorporates a shadow stick so that the unit can be angled to optimize the sun angle. Overall, the six solar panels are estimated to provide the twelve watts needed to charge the XO laptop while having an overall rapid prototyping cost of approximately 110 dollars.

7.0 References

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*Note: 2008 Word for mac does not come with a numerically based referencing system. There are also no downloads on the internet that do not require changing internal components of the program. Thus, IEEE format was not used for the referencing system in this report. Turabian Format was used because it seemed to match IEEE format most closely.

8.0 Individual Contribution

Everyone Contributed equally to the creation of the designs and the reasoning behind the designs.

8.1 Adam Hall

I wrote up the Executive summary and the explanation of design 1. I also helped with the overall formatting of the report including the table of contents, referencing, and the title page.

8.2 Eric Ross

So far in this project I have helped research background information on solar panels and the XO laptop. I also contributed to potential designs and helped determine their pros and cons. As well, I did research on the economics and helped set up a prototyping cost analysis for most of the designs. For the proposal presentation I covered the economics, short and long term, and the design criteria of the project. As for the proposal report I wrote the Introduction, Problem Formulation and the Conclusion. I also contributed to the Title Page, Table of Figures and References.

8.3 Alex Pierratos

I wrote up the Economic Analysis, the explanation for Design 3, and the explanation for our Final Design.

8.4 Alexander Monahan

I created all the solid edge models seen in this report and others that were not used. I also wrote up the explanation for Design 2.