

Team #6

Expandable Computer Power Storage System

PROPOSAL

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Executive Summary

The sponsor currently has a problem keeping an Indian school's computer lab functioning correctly due to a constantly failing power system. By implementing an alternative power source/backup supply students and teachers alike will be able to make use of available technology on a more regular and dependable basis. We are proposing the implementation of a solar powered battery backup system as it will be able to supply the lab independently of the archaic power grid that currently powers it. Additionally, it would be easy to expand if there ever in the future became a need to add more computers.

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Introduction

The problem presented to our team lies with a school's computer lab in India that has an intermittent source of power. The power grid in India is very unreliable, and this results in blackouts for the computer lab frequently, sometimes for multiple hours a day. An estimated 27% of India's power is lost through transmission or theft^[1]. With no permanent fix in the foreseeable future, there is a need for a constant source of power. This requires the school to either turn on its diesel generator for power or to wait out the power outage. The erratic tendencies of the nation's power grid are detracting from the student's education by forcibly shutting down their computers, causing them to lose any unsaved data and by disconnecting them from the internet.

By implementing a more reliable power source the school would be able to make better use of existing technology and improve the student's overall educational experience. This power source will need to be able to power around ten low-power laptops for as long as the power is out, which may be up to five hours at a time. Ideally, the system will provide a custom power supply based on a specific laptop model to avoid power loss through transformers and inverters. This specific laptop model has been chosen by the sponsor, after receiving suggestions from the team. The sponsor has also indicated that the design should be easily expandable; if in the future there is an opportunity to add more computers to the system, the design should be able to accommodate the larger load. To help out with the ease-of-use for this system, a micro-controller will be added to the circuit to monitor the remaining charge of the batteries and display the time and percent charge remaining for the batteries. There is some interest from the sponsor in utilizing solar panels to charge the batteries in order to prolong their life while the power is out.

This design must also be reasonably reliable. The end users of this power supply will not have the technical knowledge to repair any damage that is sustained, so the power supply must be resistant to power surges and other electrical hazards. Because the computer lab that this will be housed in services around 30 students at a time, the final design must also be resistant to physical stress, such as bumps or drops from low heights. Also, because the end users will not have the expertise to repair the design if something goes wrong, maintenance of the design will be limited to mostly swapping out the batteries if they start to lose their ability to charge.

As lead-acid car batteries are readily available in India, the sponsor has suggested this as a possible method to store energy. This design choice also presents its own set of safety hazards. Improper handling of lead-acid batteries can result in either electrical shock or a battery acid spill. While the design cannot account for a leaking battery, it does need to be able to cover the terminals of the battery to keep the risk of electrical shock low. The design also needs to be able to keep the batteries mostly covered and physically stable to reduce the risk of any accidents.

Background

The idea for this project was brought about by our sponsor, Stephen Blosser, through his work with Asian Aid. Asian Aid is a program that serves by providing education to the disadvantaged (notably the blind and deaf), poor and needy. The main goal of their visit was to upgrade the existing school through a variety of different improvements. One of the sponsor's hopes was to expand an existing RCPD program that scans textbooks to aid disadvantaged students. After the textbooks are converted into a computer readable format, they then use voice-reading software to convert the scanned text into audio files. This is beneficial for both blind and illiterate students as they can now benefit from text books that were otherwise useless to them.

Even though the school has all of the technology necessary to continue this program, there lies a problem with India's poorly maintained power grid. It is common for the school to lose power daily for at least a few hours at a time. During this time none of the students or faculty can use the existing computer lab, rendering the project ineffective. In addition, sudden power losses can be detrimental to the condition of purchased equipment, while users also run the risk of losing unsaved data. To avoid this problem, there needs to be a way to power the computers independently of the power grid.

There are a variety of products that charge a single laptop with portable solar cells, but none are designed to charge more than a single laptop battery at a time. In regards to the lead acid battery chargers, there are numerous products that allow these to be charged at different rates from wall voltages, but we ran into a similar issue with recharging multiple batteries at once. We have not had any success locating complete systems for sale that meet the requirements of the sponsor, though other charitable organizations have accomplished similar designs for other applications. The project is unique in the scope of the required expandability for the system.

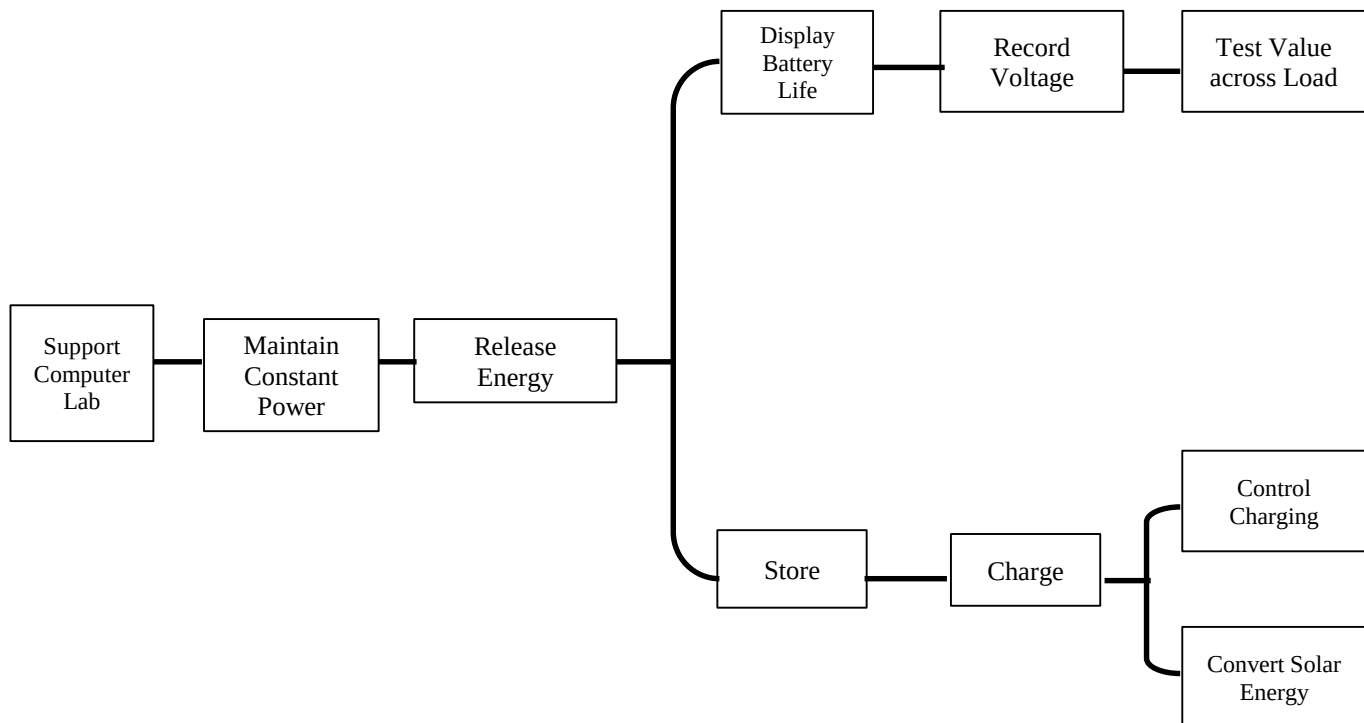
Objectives

Our design will be capable of providing an uninterrupted, alternative energy source for multiple laptops using lead-acid batteries as a storage device. The system will need to be expandable in order to meet a variable energy demand. The primary goal for the system is to supply the computers for up to five hours. In order to meet this there will have to be an easy way to add more battery cells based on the growth of the computer lab, as the sponsor has indicated that there could be up to 30 computers in the future.

Since the existing power grid is unreliable at best, there needs to be some external supply of energy in order to make the system completely independent. Considering the available solar resources in southern India, solar energy is an excellent choice due to its ease of installation and availability.

The system should also have a display for the users to provide current status of the system. It is necessary to keep track of the usage and the status of the batteries, so that no battery will be overcharged or discharged to prevent damage as well as providing important information to the users.

FAST Diagram



Proposed Design Solution

Since 12 V lead-acid batteries are readily available in India (and the rest of the world) we have decided to incorporate these into our design. The sponsor initially mentioned using automotive batteries to store the charge from solar cells, but upon further investigation it became clear that deep cycle batteries were the better choice for this application. Automotive batteries are designed to provide large amounts of instantaneous current and cannot be discharged more than 20% of their capacity without causing damage. The main advantage to using deep-cycle batteries is their ability to discharge around 80% of their capacity regularly. Though they cannot supply the same instantaneous current that automotive batteries can, it is the lasting current draw that makes them perfect for this application.

Solar panels will charge the deep-cycle power bank. Southern India provides a large amount of solar resource, and harnessing this would ensure that the system is completely independent of the existing grid. This will be a major advantage because, even if the grid is out for days, the system will be able to charge the computers for some amount of time. As life expectancy is also a major concern of our design, solar panels have the qualities necessary to support a long life as they retain a minimum of 80% efficiency after 25 years of use. Solar cells typically last 25-40 years and require minimal maintenance. The largest drawbacks to solar power sources are initial purchase price and cost of installation, but when considering long term savings, solar panels will ultimately pay for themselves as all future energy provided will come at no cost. The sponsor has also assured us that solar panels have become much more attainable in recent years to third world countries, and that there are a number of skilled workers there to aid in their installation.

A charging controller will be used to control the power distribution of the solar panel, since overcharging or over-discharging can permanently damage the batteries. The specific charging controller we plan to implement also features “Maximum Power Point Tracking” (MPPT), a technique used to get the maximum power from one or more photovoltaic devices regardless of the weather. This feature will help ensure that our system is as efficient as possible by maximizing the output of the solar panels.

A microcontroller will be programmed to read battery voltage and display the charge status via LCD screen. One of the design features is that the status of the battery bank needs to be available for users to see and understand. To accomplish this task, the MSP430 Launchpad microcontroller from Texas Instruments was selected, along with a 16x2 character display. The voltage of the battery bank will be monitored by the microcontroller, and after some calculations involving the max voltage of the bank at full charge and the measured voltage, the percent charge

left and remaining time will be displayed on the LCD. This ensures that the users will know when the battery bank should be recharged and laptops should be disconnected from the design.

Testing the design will consist of ensuring multiple deep-cycle batteries can be charged from the solar panels, verifying the accuracy of the proposed battery monitor, and making sure that multiple laptops can be charged safely from the battery bank. Firstly, the circuit will be tested by using a solar panel to charge the batteries. Then the circuit that is used to charge the laptops from the batteries will be tested by connecting a “dummy” load to the circuit to ensure that they are charging correctly. After precautions are taken to protect the laptops, we will safely verify that the laptops charge correctly. Throughout these tests, the microcontroller will be tested by having it connected to the batteries and monitoring their life. If all of these functions are considered working after they have been thoroughly tested, the design will be considered a success.

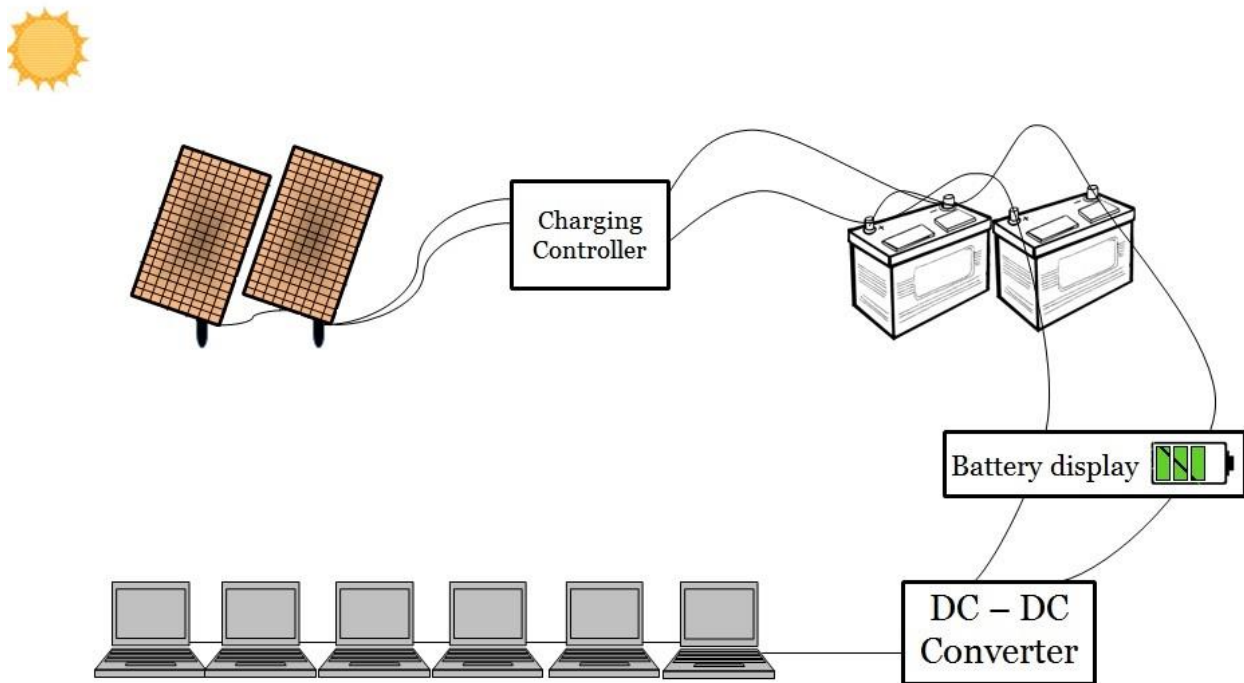


Figure 1: The proposed design

Risk Analysis

As this design involves large currents and charging of lead-acid batteries, there are certain risks that need to be considered. One of the main risks is that overcharging the lead-acid batteries through either the battery charger or the solar panels poses a major safety hazard. This leads to the battery either leaking acid or exploding. This high risk will be mitigated by the use of a charging controller to ensure that the batteries will not be overcharged.

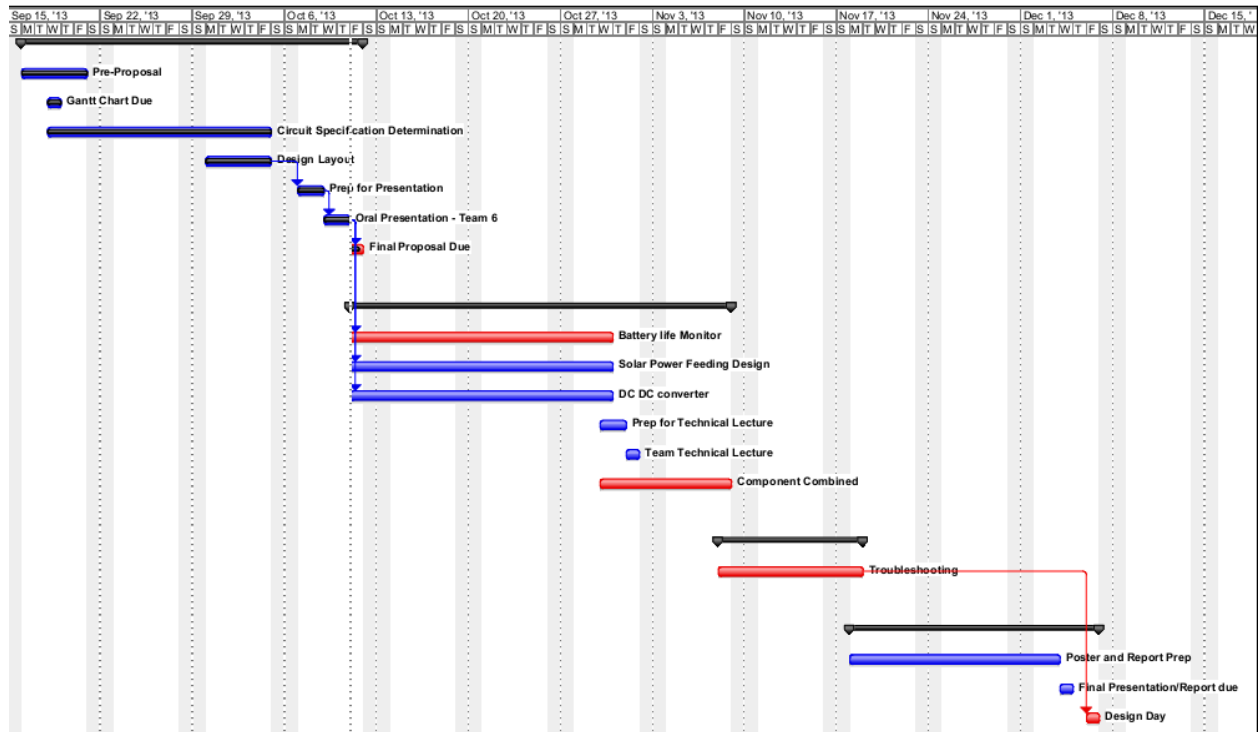
A second risk is that the boost converter can burn out if the current going through the converter is higher than its limit. The result of this happening is that the converter could short circuit or open circuit, and the system will not be charged. However, since the voltage will only be 12V, it will not damage the computer if it shorts out.

Another high risk is that because the computers draw large currents, exposed wires become extremely dangerous. This risk will be mitigated by covering up any exposed wires and making sure that the battery terminals are covered.

A final risk is that due to power surges or faulty wiring, the laptops might be charged at a higher voltage than normal operating conditions. This medium risk can be solved by adding fuses to the circuit to ensure that there are no power surges.

Project Management Plan

ID	Task Name	Duration	Start	Finish
1	Proposal Stage	20 days?	Mon 9/16/13	Fri 10/11/13
2	Pre-Proposal	5 days?	Mon 9/16/13	Fri 9/20/13
3	Gantt Chart Due	1 day?	Wed 9/18/13	Wed 9/18/13
4	Circuit Specification Determination	13 days?	Wed 9/18/13	Fri 10/4/13
5	Design Layout	5 days?	Mon 9/30/13	Fri 10/4/13
6	Prep for Presentation	2 days?	Mon 10/7/13	Tue 10/8/13
7	Oral Presentation - Team 6	2 days	Wed 10/9/13	Thu 10/10/13
8	Final Proposal Due	1 day	Fri 10/11/13	Fri 10/11/13
9				
10	Hardware Stage	21 days?	Fri 10/11/13	Fri 11/8/13
11	Battery life Monitor	14 days?	Fri 10/11/13	Wed 10/30/13
12	Solar Power Feeding Design	14 days?	Fri 10/11/13	Wed 10/30/13
13	DC DC converter	14 days?	Fri 10/11/13	Wed 10/30/13
14	Prep for Technical Lecture	2 days?	Wed 10/30/13	Thu 10/31/13
15	Team Technical Lecture	1 day?	Fri 11/1/13	Fri 11/1/13
16	Component Combined	8 days?	Wed 10/30/13	Fri 11/8/13
17				
18	Testing Stage	7 days?	Fri 11/8/13	Mon 11/18/13
19	Troubleshooting	7 days?	Fri 11/8/13	Mon 11/18/13
20				
21	Final Stage	15 days?	Mon 11/18/13	Fri 12/6/13
22	Poster and Report Prep	12 days?	Mon 11/18/13	Tue 12/3/13
23	Final Presentation/Report due	1 day?	Wed 12/4/13	Wed 12/4/13
24	Design Day	1 day?	Fri 12/6/13	Fri 12/6/13



Personnel and Tasks

Alan Everdeen – Webmaster, Document Prep. Research on the best type of laptop for the design to power. Installation and programming of microcontroller and related circuit.

Siyang (Leon) Liang – Presentation Prep. In charge of solar panel research, designing the battery charging circuit, and all efficiency issues related to these topics.

Danny (Tommy) MacBeth – Lab Coordinator. Design and implementation of the DC-DC converters and power delivery to laptops.

Tim Wang – Manager. Involved with the design and implementation of the circuits that deal with both the solar panel, power grid, and charging of the laptops.

Budget

Our proposed budget is as follows:

Component	Quantity	Price
Solar Panels	2	\$300 + Shipping
Charging Controller	1	\$86 + Shipping
Microcontroller + LCD Screen	1	\$25 + Shipping
DC to DC Boost Converter	4	\$44 + Shipping
Misc. Integration Components		\$50
Deep Cycle Batteries	2	\$200
		Total Price = \$705

We hope to save the most money by avoiding shipping costs associated with the solar panels. To do this we will have to purchase them from a supplier within driving distance. Another area where we are reducing costs is by utilizing the Texas Instruments MSP430 Launchpad Microcontroller to monitor the battery life as each team member has one from the lab associated with ECE 480.

“Miscellaneous integration components” includes any and all components required for connectivity. This includes, but may not be limited to: wiring for all parts of the circuit, battery terminal end connectors, DC input jacks for laptop connectivity, power diodes, etc.

References

[1] R. Singh & R. Katakey, “Worst India Outage Highlights 60 Years of Missed Targets,” August 1, 2012. [Online]. Available: <http://www.bloomberg.com/news/2012-08-01/worst-india-outage-highlights-60-years-of-missed-targets-energy.html>