UNIVERSITY OF ILLINOIS

Solar Powered Converter Educational Display

Project Proposal

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Introduction

Title

Solar Powered Educational Display

The project is a portable educational display that demonstrates topics in power electronics and renewable energy. This display will convert solar energy into 120 V AC power, connected to an appropriate load. The display will target beginning engineers who will be able to view various measurements in real time, as well as switching between the loads, on a portable device via Bluetooth technology.

Objectives

The goals of the project include implementing a solar panel to power a battery which will in turn power various loads. A heat lamp with a dimmer will be the heat source for the solar panel acting as the sun, having the ability to be at full output or perform at a lower output. Furthermore, a user would be able to tell the difference between electrical and mechanical power as one could change the charger for the battery to a hand crank, comparing the difference between a solar panel and human power. A buck converter will be used in the intermediate step between the battery and load in order to accurately convert the power.

Another aspect to the project is that the user will be able to control the display wirelessly. By using a wireless product, a cell phone, tablet computer or laptop for example, the user will be able to turn on and off the display, switch between the loads, and read strategic values. These values would include the duty cycle, amount of voltage from the solar panel and hand converter, the efficiency of the solar panel and the percentage of charge on the battery. This wireless display would also include a description of the process for each section so that a freshman would be able to understand the progression

Benefits for the end customer include:

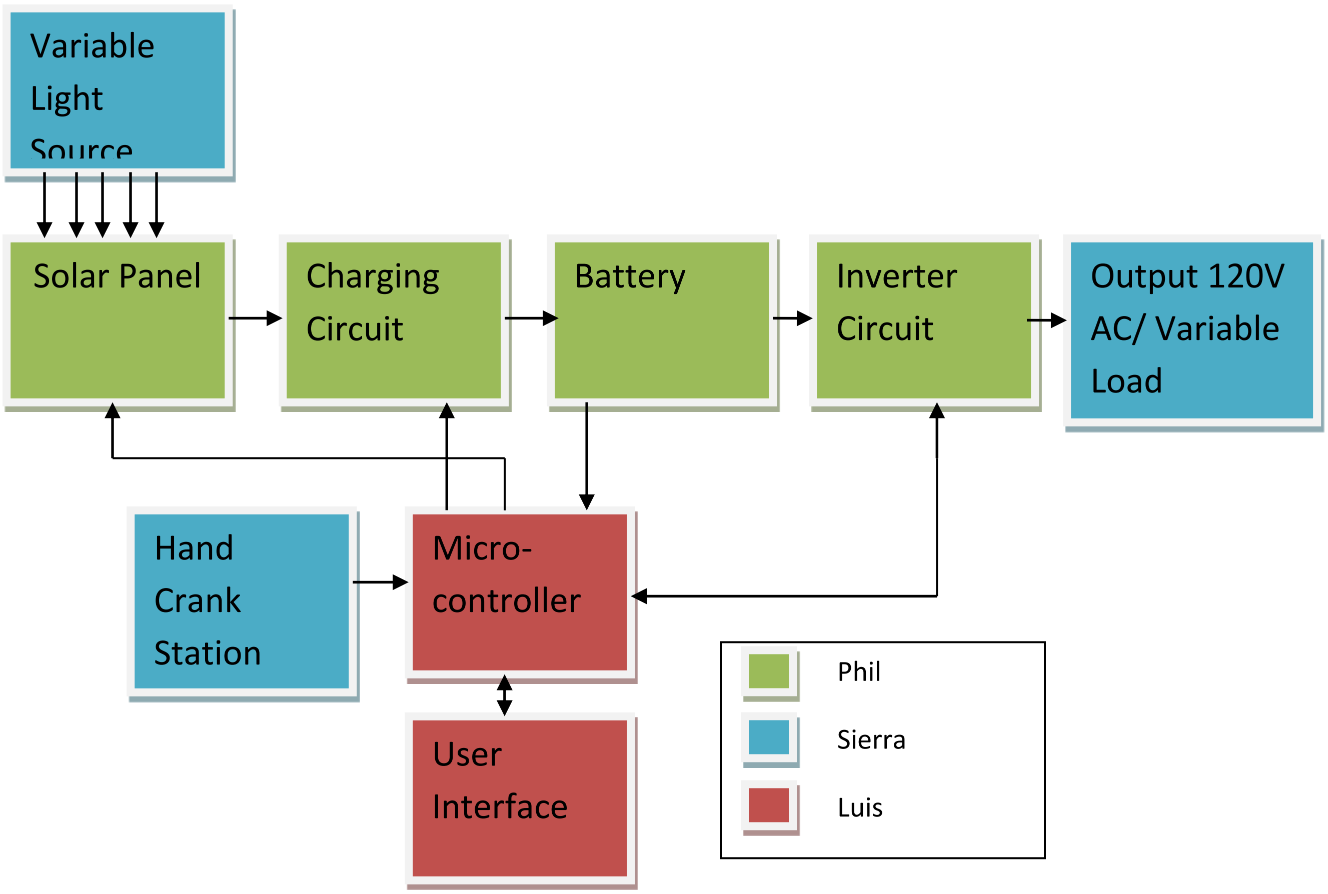
- Ability to examine the process of converting energy from a solar panel into usable power for a load
- Comprehensive description at each step of the process that provides students with a better understanding of power electronics
- Wireless control of the display at both the beginning, controlling whether or not the device is on as well as if it is using a traditional energy source or solar one, as well as controlling the load at the end
- Obtain real-time values of various power measurements
- A display that is easily portable and self-contained, easily constructed and destructed

Product features include:

- Hand crank station
- 120 V AC receptacle
- Variable load
- Bluetooth connectivity
- Android application providing a user interface

Design

Block Diagram



Description

Variable light source: A variable light source will be used in order to provide adequate light for the solar panel. Since the solar panel will always be indoors, a light source other than the sun will be needed in order to charge the solar panel. The light source will vary in output to mimic the fact that the sun does not shine at a constant rate. A wall source of 120 V AC will be used to power the lamp and a dimmer will be used to control the output.

Hand Crank Station: The hand crank will be attached to the microcontroller in order to allow the user to compare the difference between the amount of power produced by a human and the amount produced by the solar panel. Because the hand crank is attached to the microcontroller the comparison will be displayed on the mobile device along with other values.

Solar Panel: The solar resource is the main focus of the educational display and as such the solar panels are a critical part. The panel should be able to perform a 10% charge of the battery system within the time frame of a 50 min class period in order to demonstrate the generation and storage of solar energy. The panel will interface with the charging circuitry to efficiently charge the battery as well as with the microcontroller in order to display useful educational information such as voltage at the terminals.

Charging Circuit: The charging circuit will take the output from the solar panel and match it to the desired input for charging the battery. It will utilize the microcontroller as a feedback loop to insure it meets the batteries charging specifications. Finally, it will provide reverse current protection so that power can only flow from the panel to the battery and not vice-versa.

Battery: The battery should be able to handle a load up to 100W for at least a 50 minute class period. It will take a charge input from the charging circuit and output power to the inverter. It will provide information to the microcontroller such as percent charge and voltage in order to be used by the charging circuit as well as be displayed for the user.

Inverter Circuit: The inverter is the final stage in the conversion process. It will take the output from the battery and convert it to 120VAC to drive two loads. It will be monitored by the microcontroller to provide useful information to the user.

Output 120VAC/Variable Load: The output will be a standard 120VAC outlet as well as a variable load station. The load station should be variable from 0-100W in order to demonstrate the effects of increased load on converter efficiency.

Microcontroller: The microcontroller will control all the components in the project from determining power measurements of the power generation and charging process to the efficiency of the solar panel power generation and the hand crank power generation. It will also provide PWM signal for the inverter circuit and the duty cycle for the charging circuit.

User Interface: The user interface for this project will be a Motorola droid phone for which an android app will be developed specifically to control all aspects of the project. The user will be able to switch between active loads, monitor duty cycle, efficiency, voltage, percent charge, and review a brief description on each project component. Connectivity between the droid phone and the microcontroller will be via Bluetooth, which will give the project a polished finished look without any unnecessary wires.

Performance Requirement

- At least a 25 foot range for the wireless Bluetooth technology
- 60% efficiency for the solar panel
- 0-100 W Variable load

Verification

Testing Procedure

In order to test the solar panel, a resistor will be attached to the output of the solar panel and then measure the voltage to ensure that the output follows the manufacturer's I-V curve. A plot of the I-V curve will be included.

The charging circuit will be tested by connecting the charging input to a power supply in the lab and test the circuit over a ranged input that is expected from the solar panel. A table will be created with these values and the duty cycle will be calculated.

The inverter circuit will be tested with the lab bench equipment. A DC input will be connected to the inverter over the range of expected values from the battery and the output will be connected to an oscilliscope in order to test the voltage with the image from the oscilliscope used in the results.

To test the microcontroller, the outputted values will be tested with lab equipment and a chart will be created in order to ensure each of the parts are working correctly. Confirmation that the Bluetooth is sending and receiving will be completed by using test text to check connectivity.

Tolerance Analysis

Batteries have tight voltage regulations when charging and as such the charging circuit must have a strictly regulated output. This means that the converter in the charging circuit will need to have a small voltage ripple in order to insure safe charging. This can be designed for through PSPICE in the early stages of the design and can be tested and verified using a bench power supply and oscilliscope once the circuit has been built.

Cost and Schedule

Cost Estimate

Parts

Part	Cost	Quantity	Total
Motorola Droid phone	$125.00	1	$125.00
Battery Model 718065F2 12V	$28.00	1	$28.00
Blue SMiRF Gold Bluetooth Chip	$64.95	1	$64.95
Universal Power Group Solar Panel	$40.00	1	$40.00
PIC 18LF2610	$6.02	1	$6.02
Electronic Components	$30.00	1	$30.00
Hand Crank	$25.00	1	$25.00
Dimmer	$15.00	1	$15.00
Lamp	$23.00	1	$23.00
DC Motor	$10.00	1	$10.00
		Total	$366.97

Labor

Philip	$30/hour	2.5	13.5 weeks	12 hours/week	$12,150
Sierra	$30/hour	2.5	13.5	12	$12,150

			weeks	hours/week	
Luis	$30/hour	2.5	13.5 weeks	12 hours/week	$12,150
				Total	$36,450

Labor + Parts = $36,450 + $366.97 = $36,816.97

Schedule

			Philip	Sierra	Luis
Week 1	2/5/2012	2/11/2012	Block Diagram	Introduction/Description	Proposal Description
Week 2	2/12/2012	2/18/2012	PSPICE simulation for Buck and inverter	Order Parts, Sign up for Design Review	PIC circuit design, Bluetooth coding
Week 3	2/19/2012	2/25/2012	Design Review, Build and test Buck converter	Design Review	Design Review
Week 4	2/26/2012	3/3/2012	Build and test inverter circuit	Test solar panel, PSPICE 5V circuit	PSPICE 5V circuit
Week 5	3/4/2012	3/10/2012	Compile solar power, battery, and inverter	Build hand crank	Complete Android App
Week 6	3/11/2012	3/17/2012	Individual Progress Report	Individual Progress Report	Individual Progress Report
Week 7	3/18/2012	3/24/2012	SPRING BREAK	SPRING BREAK	SPRING BREAK
Week 8	3/25/2012	3/31/2012	Mock Demo	Mock Presentation	Packaging design
Week 9	4/1/2012	4/7/2012	Interface with microcontroller	PCB fabrication design	Interface with microcontroller
Week 10	4/8/2012	4/14/2012	Testing power circuit	Revise PCB as necessary	Testing interface
Week 11	4/15/2012	4/21/2012	Final Presentation, Presentation sign-up	Final Presentation	Final Presentation, Demo sign-up
Week 12	4/22/2012	4/28/2012	Final Paper	Final Paper	Final Paper
Week 13	4/29/2012	5/5/2012	Editing final paper	Editing presentation	Editing final paper