Power Rangers Project Proposal

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1 Introduction

We are the Power Rangers. Members include Anjola Lanre-Ladenegan, Meaghan Hannon, Evan Syers and Sarah Ritter. As our group name suggests, our project deals with solving problems in the power and energy industry. We all have experience and interest in power electronics, systems and solutions and felt the need to pursue a senior design project along those lines. Our criteria for our project was that it had to be power related, safe, cheap and involving a microcontroller. We sought the guidance of Dr. Michael Lemmon who in turn exposed us to the problem at hand. This project would involve concepts from Alternative Energy Devices and Materials, Power Electronics, and Controls.

2 Problem Description

On a high level, the problem at hand is the changes that occur in the electrical generation and delivery model. As alternative energy sources are increasingly implemented, the traditional model will need to adjust to the changes. A specific example of a problem with solar generation is that it produces peak power at around 3 p.m., while the max demand on a distribution network typically occurs at 5 p.m. (Figure 1)

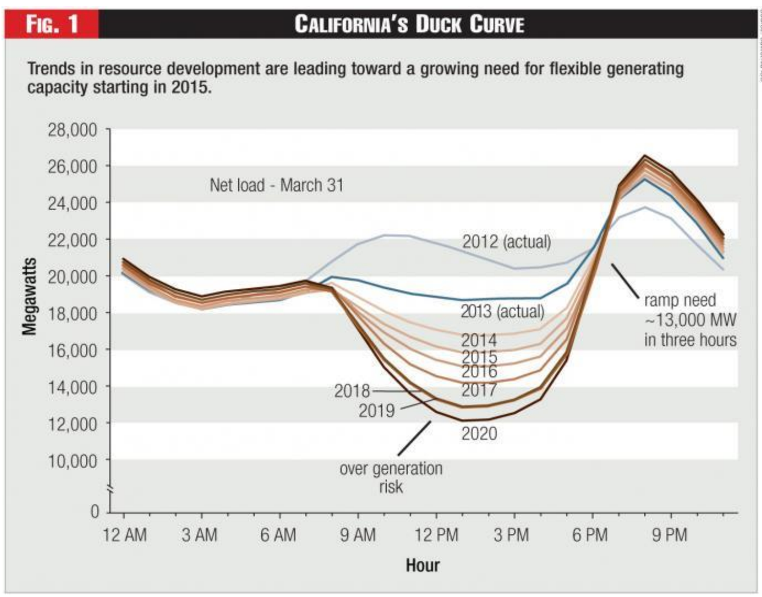

Figure 1: Typical Load of Distribution Network

There is no way a project could be done involving an entire distribution network, but the problem of how to effectively store solar energy is very central to solving this problem and could be achieved on a much smaller basis. Because efficiency is the most commonly used parameter to compare the performance of solar cells we will be working to maintain the maximum efficiency. Solar energy is difficult to work with because it gives off varying power that isn't consistent. Most solar cells have an efficiency around 20% which means a lot of energy is lost in the process. The IV characteristics of solar cells change depending on the time of the day. For instance, clouds cause shadowing which shifts the IV curve down (Figure 2) By maximizing the IV characteristics the battery would charge more efficiently.

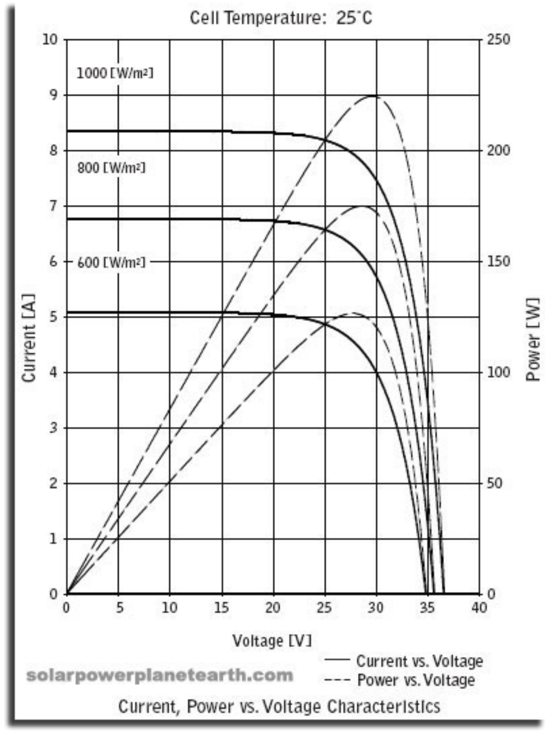

Figure 2: IV Characteristics Curve

3 Proposed Solution

Our solution to ensure maximum power is transferred from the solar cell to a battery is to use a DC-DC converter. It will be a variable Boost converter that will track the power coming in and will utilize a microcontroller to implement the feedback loop. We will develop a Microcontroller-based photovoltaic maximum Power Point Tracking system. This is used to maximize the photovoltaic array output power to make sure the solar array is always generating maximum power. The variable DC-DC converter will charge at optimum voltage. The microcontroller will vary the output voltage to achieve the highest efficiency. We will be seeking the point on the IV curve that maximizes the Fill Factor. If we are successful this could be very important in demonstrating how to store solar energy effectively. It would be relevant and useful for researchers in the Solar Power industry.

4 Demonstrated Features

4.1 Power Point Tracking

A main feature of our project would be to track the power curve of the photovoltaic so as to maximize the Fill Factor. Maximum Power Point Tracking (MPPT) would allow us determine when to charge the battery. We would be demonstrating the ability of our microcontroller to determine when the PV array is producing maximum power.

4.2 Microcontroller Functionality

In order to solve the problem, our microcontroller would need to implement a feedback loop. The controller should also be able to determine the maximum output voltage for maximum power through a series of signals and calculations. We would be demonstrating the ability of our microcontroller to calculate the appropriate time for maximum power transfer and communicate with the converter appropriately.

4.3 Battery Charging Efficiency

Finally, the goal of this project is to achieve better battery charging efficiency. In order to do that we would be comparing battery charging efficiency without our setup with charging with our setup to show improvement in the overall charging efficiency . Also along the lines of efficiency, is being able to determine when the battery charging is full and stopping charge at this point. We would be demonstrating how determining the maximum power from the PV array and controlling the frequency of the Buck circuit, we can charge the battery efficiently. We would also be determining when the battery is full and stopping charge at this point.

5 Available Technologies

At this time, Dr. Lemmon has two Ramsond 100 Watt Mono-Crystalline Solar Panels. We will be utilizing these solar panels for our project along with the Sun Xtender Battery that Dr. Lemmon also has on the solar panel cart (Figure 3). In order to make a DC-DC converter, we use a combination of capacitors, inductors, diodes and MOSFETs. In the case of insufficient inductor sizes, we will use magnetic cores and copper wires to wind our own inductors. The last major component of this project will be the microcontroller used to implement the Power Point Tracking and conduct the feedback of information in this system. While most of the major components of this project have already been acquired by Dr. Lemmon we will still need to buy and assemble the parts for the DC-DC converter and the microcontroller.

Figure 3: Ramsond Solar Panel and Cart

6 Engineering Content

One of the major components of this Senior Design Project will be the DC-DC converter that will transfer power from the Ramsond Solar Panels to the Sun Xtender Battery. This DC-DC converter will be a combination of a variable buck converter, depending on the voltages and currents of the solar arrays and batteries. We will have to design this converter, acquire the necessary components and then build the converter.

Another element of this project is the Power Point tracking technology. In order for this to function, sensors will be utilized to identify the current state of the solar arrays and the output power. This output power is then used by a microcontroller to directly control the DC-DC converter. Therefore, we will also need to build a microcontroller that can handle the processing logic of this Power Point tracking.

This project will also involve a component that will stop the solar panels from continuously charging the battery after a full charge is reached. We will have to determine the level of charge in the battery in order to provide feedback to the system. This information can then be used with logic through the microcontroller in order to prevent the battery from overloading.

7 Conclusions

The issue of efficiency is one that has plagued the world of photovoltaics. One main problem is storing power from photovoltaics at the optimum time to achieve good storage efficiency. Solar energy is maximized during the day when power demand is low. A system of efficiently determine when solar power is at its maximum and storing maximum power would be instrumental in the use of photovoltaics. Our project aims at utilizing a microcontroller to implement maximum power transfer from a photovoltaic array to a battery to improve the overall efficiency of solar energy storage. This should prevent the waste of energy and make the idea of using photovoltaics in homes and offices more viable. Under the guidance of Dr. Lemmon, we, the Power Rangers, swear an oath to improve the landscape of power and energy in the world by finding way to improve already existing systems and thinking about new solutions to the energy crises.