UNIVERSITY of DAYTON
The ETHOS Center

Hybrid Ultra-Capacitors

Colton Foster Selco Foundation

Abstract

Over the 2017 summer, an immersion was held to Bangalore, India to work with the Selco Foundation with for an electrical engineering internship. The primary focus of this internship dealt with the analyzation and improvement of the hybrid ultra-capacitor (HUC) solar system. The systems were implemented with two different battery types, lead acid as well as lithium ion battery integrations. Through data analysis of over 30 locations input, several modifications were made to the existing systems in order to better capture the HUC's characteristics and to confirm its correct performance. In addition, an efficiency test was implemented to analyze the efficiency of the Mesha HUC charge controller. Analyzing the field data lead to the conclusion that there needed to be a modified data logger attached to the system. The analyzation of the efficiency lead to a further examination of the functionality of the Mesha system. In addition, a Matlab code was developed to reduce the time it would take to analyze future field data. The project is an ongoing research effort therefore it did not come to a conclusion during the internship's time parameters.

Introduction

Selco Foundation

This summer the partner for Bangalore, India was the Selco Foundation, a large organization with nearly 600 employees across India. It started as a social enterprise, started in 1995, with the intent to provide sustainable energy options to the lower tier of the socio-economic pyramid in India, both individuals as well as businesses (1). Selco's goal is not only to provide a technical solution to the needs of these people, but also to determine the best option for them in the economic setting their needs were surrounded by. In addition, they also work with the financing side of the business, working with banks to help provide the collateral for loans for their clients, so that they may begin to develop a credit score. The key here is that Selco works to customize each client's experience to specifically tailor to their specific scenario, which then builds trust between Selco and the user. Once the product is implemented, Selco then provides service technicians that upkeep the product, in order to further build the trust between Selco and the user, as well as between the user and the technology.

Indian Culture and Climate

India is located in southern Asia, and Bangalore is in central, southern India where this internship took place. India hosts many different kinds of climates, from humid rainforests to cool, even frigid mountain side cities up in the Himalayas. However, besides a few exceptions, they go through a monsoon season for 3 months of the year, from June through August. Because of this arid and dry environment, many of the people whom are farmers in India, around 25%, have difficulty having enough income for year round, causing many to slip into poverty (2). This weather fluctuation causes many of the 1.2 billion people of India to lose income often. Because farming is one of the largest available occupations, millions of others create businesses centered around the farming income, causing a cascading effect when weather conditions aren't favorable to farming. But despite these conditions, the country is growing and developing its infrastructure so that many more occupations are becoming available. However, this still leaves the small farmers and those in their villages in the lower tier of the pyramid.

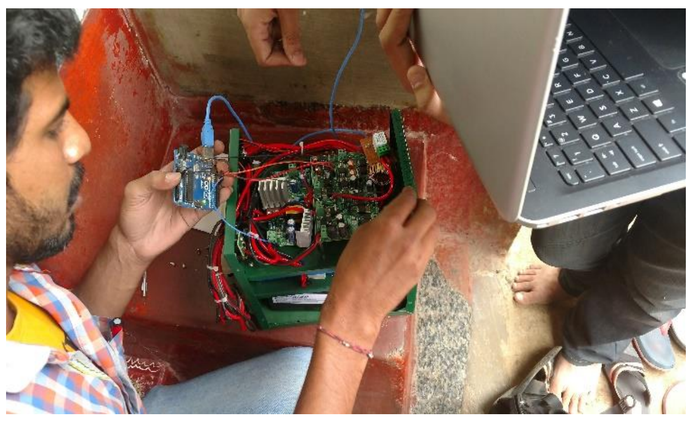
Technical Information

The initial premise of this internship was to implement electrical engineering skills to analyze and assist in the installation and development of the hybrid ultra-capacitor system as well as collaborate with various contractors in organizing the forward progress. The University of Dayton's Engineers in Technical Humanitarian Opportunities of Service helped organize the collaboration between Selco Foundation and ETHOS, allowing for this 10 week internship to be possible. By focusing upon developing the HUC system, the hope is to increase the efficiency of the system and therefore decrease the size of the battery accompanied by the solar solutions by nearly 30 percent. This would transition to great savings to the consumer as the battery is one of the most expensive parts of the total photovoltaic (PV) system.

Project Description

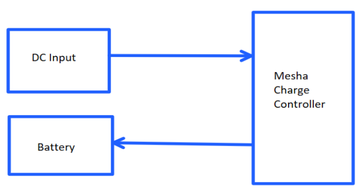
While at Selco the primary project that will be focused upon is the HUC battery sewing machine application. The primary reason this project came about was because of the large costs associated with oversizing the battery in order to make up for the inefficiencies of the system. The primary goal of this system is not only to reduce the size of the system but also to increase the performance of the system on overcast days. The primary characteristics of a HUC is that it has a higher power density, with quick charge and discharge times. It also can withstand higher discharge rates, as well as extremely long life cycles. These would be associated with the high starting current of the sewing machine, which would help remove that subsequent strain on the battery. In addition, there are micro charging cycles that come from the input DC current from the solar cells, which over time these small cycles wear on the battery. The hybrid ultracapacitor would also be able to with stand and absorb these micro-cycles generated, which once again would reduce the strain on the battery.

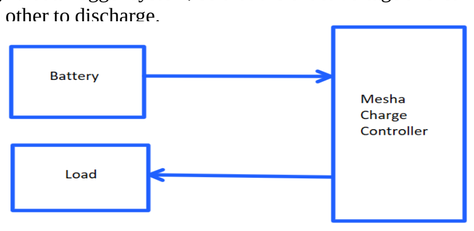
This system was put into 14 different field locations in order to collect data to test it's effectiveness. The data was then collected from the field locations and then analyzed to read the device's performance.



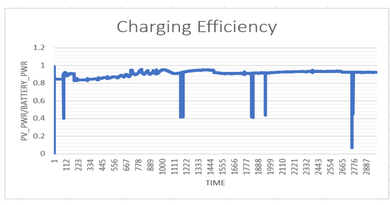
Results & Discussion

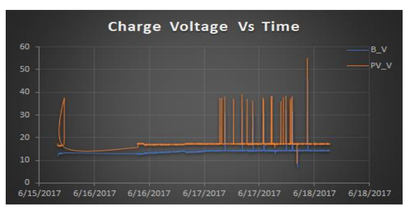
The system was designed such that it imitated that which is out in the field. The system included the DC input, the Mesha Charge controller, a lead acid battery, and then a 40W load. Each connection was run through a data logger system, so that the exact voltage and current could be recorded. There were two set ups, one designed to only charge and the other to discharge.

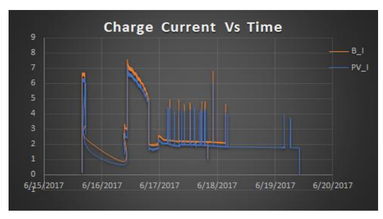




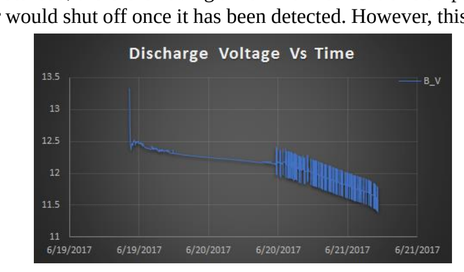
The results of the test are shown below. The system was put through one complete cycle, with a fully discharged battery. Overall it resulted in a 90.9% efficiency of the charge controller. However, there were several discrepancies that raised several questions. Below are the graphs of the efficiency, charge current and voltage, and discharge voltage and current. The efficiency was calculated by taking the output power divided by the input power.

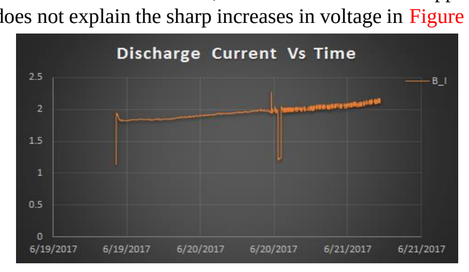






It was determined that the fluctuations in current were because of the design of the charge controller. The system was configured to be set for a 40 watt load, therefore having a maximum current of 6 amps it could handle. Therefore, when the current would approach that line the controller would shut off once it has been detected. However, this does not explain the sharp increases in voltage in Figure 9 or 10.





Looking at the resulting graphs from the discharging data, it is almost as you would expect except once it hits June 20th. Then there is an erratic fluctuation in the voltage as well as well as in the current.

From these results two primary actions had been taken. First, Mesha provided a Sewing Machine System for Selco to test. These will be a complete system with the most updated hardware and software These systems will be put through cycles of testing, and this shall either confirm the abnormalities discussed in the results, or show they were an inconsistency. Secondly Mesha shared their testing procedures with Selco so that common practices could be developed.

Recommendations

Moving forward, it was then a suggestion that the lab develop an automated testing station, so that these time consuming results of the system analysis can be conducted in the most time efficient way possible, as well as having the charging and discharging cycles automatically happen. With a recommendation from a past coworker, it was suggested that this system would be possible by using an Arduino system to control the switches and then a board similar to the Adafruit INA219, which has power monitoring capabilities which are suitable for the test system (3)

In addition to creating a cycling test set up, an automatic Matlab analysis was being constructed which would take the large data of the new dataloggers in the field. This system would automatically graph the voltage, current and power versus time graphs as mentioned above, but in addition it would find the maximum power consumed as well as calculate the total power consumed per day. This system was beginning to be constructed, however it was passed along to a full time employee because of the ending of the 10 week period.

Acknowledgements

A generous thank you to all of the tech team, for helping guide me throughout my first immersion, to my supervisor Pratim for helping ensure that I had an excellent mentor and friend. To Brother Arokiadoss and the other brothers and fathers hosting me for being my first friends in India. To the 24 other interns at Selco, Cris, Tim, Sanket, Matti, Progati, Bukelwa just to name a few, for helping me immerse myself in India's beautiful culture and always ensuring I always had a friend to join me for an adventure. And last but certainly not least, the ETHOS team of Rob, Alyssa, Jill and Malcolm for making this opportunity far exceed my expectations.

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