Abstract

The Solar Scholars project has spanned three school years and has involved multiple projects. From the fall of 2006 to the spring of 2008 the project team focused mainly on the permanent, educational solar pavilion. This work included the research, design and implementation involved in installing a full scale photovoltaic system. In the fall of 2008 to the present the project work has focused on the solar demonstration cart. This multi-purpose cart was researched, designed and built to take the basic PV concepts the pavilion incorporated and compacted them into a mobile educational station.

Introduction

With the completion of the Solar Scholars pavilion at the end of last school year, the project seemed to be mostly wrapped up and ready for completion. However, during the summer the Oakes Museum came to the team with a new proposal. The museum had plans to incorporate the new pavilion into their tours and into their renewable energy curriculum. When the began to do this, they found it was difficult to present the pavilion concepts to a younger audience (elementary school) because of the large scale of the system and the inability to give hands-on or interactive lessons. The Solar Scholars team then had the challenge to make some kind of system that would demonstrate basic PV concepts to this younger crowd. After meeting with the Oakes Museum to brainstorm ideas the project suggested the need for a portable, concise unit that visually and tangibly demonstrated basic solar concepts to be used for a variety of audiences, young and old. During the past school year the Solar Scholars team was able to create a unit that correctly and safely accomplishes these goals.

Background

The Oakes Museum and the Solar Scholars projects share the same basic goal: education. When the museum first learned of the plan for the education pavilion they were very excited and eager to include it in their newest curriculum of renewable energies. Here they hope to teach and expose children to the expanding world of renewable resources. Unfortunately in the U.S., very little is being done to further our usage and research with theses technologies and that problem starts with the inability to educate people about them. Both the Oakes Museum and the Solar Scholars project realize this problem and have worked together in order to change this course. The Oakes Museum's desire for the demonstration unit arose when is became difficult to use the pavilion to explain basic concepts to young children. Such concepts as direct solar DC vs. battery backed solar DC are very difficult to explain using a full scale installation for reference. The Oakes Museum noted that tours and in order to raise awareness of solar power the pavilion proved a great resource, but not for basic concepts.

Most of the research needed for this new demonstration cart had been completed though the pavilion project. The same concepts applied to the pavilion as did the cart. The difference was the way in which these concepts were developed and presented.

<u>Narrative</u>

The first step of the project was to create a design which incorporated everything we found necessary to properly demonstrate the basic concepts of solar power. Throughout the process it was important to keep in mind that this cart would be used for education at a variety of levels. This included the youngest of elementary school children to graduating seniors, to visitors and staff. After many brainstorming sessions we created a list of essential concepts to include:

1. Parallel vs. Series
2. Angle Tilt

3. Direct DC
4. Battery Backed DC
5. AC

At this point the design split into two different needs: electrical system, cart design. The team split into different groups to handle the design of these two essential pieces to the project.

It was nice that we knew what the electrical system needed to do, but making it do what we wanted proved a difficult and tedious process. During brainstorming for the electrical design we decided that the more flexibility we had with the cart, the better our unit would be overall. This meant we designed to maximize our capabilities, and not hinder what we could do. We designed to make sure multiple pieces of the cart could be used at the same time. After multiple failed designs the first one-line drawing was completed (appendix A figure 1). This design incorporated a combiner box for our three panels. The box allowed us to hook up our panels in any configuration we desired; one parallel and two series; three series; two parallel and one series; etc. This design also allowed us to have multiple sources of power to go to different places in our system. The second half of the design includes the switches providing power to different components or loads. Depending on the configuration of the panels and the orientation of the switches, there are many options in how much and where the power is sent. We also made sure that it was impossible to configure our system in such a way to cause damage to the components.

Having the basic design then allowed us to search for the necessary components. We discovered that a charge controller and an inverter were available to use from a past project. This was great to cut down on cost of our system but did provide the challenge of designing our system to meet the needs of our components instead of buying components that met our design. BP Solar also donated seven fifty watt modules for the use of Energy Group projects which gave us free access to these as well. The only major component in our system we had to purchase was the battery. From this one line drawing we moved to another rough electrical drawing (appendix A figure 2) that placed our actual components to the design. The physical layout of the electrical system as still undetermined at this point since that largely depended upon the design of the cart.

The cart design team had many constraints to work with. We took into consideration the weight of the entire unit, the size of the unit, the space the unit offered, maneuverability, panel framing, adjusting the panel tilt angle, etc. There were many designing considerations before beginning the process. As most of our project did, the design started with many brainstorming sessions. We answered all the important questions before beginning the design so we knew something important was not forgotten. We were again able to recycle from a prior project and obtained our cart frames. The frames defined a set width to our cart, but allowed us to control the length and customize the shelving and storage space. The major task was the framing and tilt mechanism for the panels. We wanted to use three modules for our system so we devised a way to have two removable panels (appendix A figure 4). We also wanted everything involved in using the cart to be stored within the cart (no extra parts or panels laying around in random rooms) so shelving on the bottom for the two panels made for a convenient way to store the removed panels. The center panel remained fixed to the cart with an adjustable arm, hinge, and pinning mechanism to set the desire angle of the panels (appendix A figure 5). The bottom half of the cart was designed to store the panels but the upper half remained open for the storage and operation of our electrical system.

We knew the unit had to be very interactive due to the switches and multiple functions, so a control board was designed to give the user a visually interactive way to use the unit (appendix A figure 6). The board was designed to have all of the plugs and switches at a central location, easy to access and easy to see where power is coming from and where it is going to. We also designed the control board to hinge down and open to expose the wiring for easy maintenance and also to show the wiring if more technically minded people would like to see the innards of our system (appendix A figure 7).

One interesting challenge we experienced was the lack of higher voltage DC electrical components. Since solar power alternatives have not yet become a very popular route in the U.S. it is very difficult to find basic electrical components such as switches, without getting something custom made at an expensive cost. We found a way around this problem by developing a switching system of our own. Using amp power connectors we designed the control board so that you physically remove a connector from a certain line of power, and connect it into the desired line of power. This removed the need for expensive DC switches and also made the operator more aware of where power is being transferred throughout the system.

Project Plan

Phase Anylsis:

Our project is almost complete. All of the phases have been entered (research, design, etc.) and all but one: sustainability has been completed. The sustainability of the project includes finishing the operations manual and developing a users operational certification program, or something similar to ensure the correct and safe usage of our demonstration unit.

Schedule:

The timeline created for this project at its beginning was unfortunately lost in the great wiki-tastrophe of 2009. However, I can easily comment on how we followed this schedule until losing the actual timeline. The project was proposed to be finished by the end of the fall semester and using J-term for tweaking the final pieces and wrapping up odds and ends. Because of various designing problems and time conflicts with group members the project experienced a variety of delays. The unit was finished an operational mid-way through the spring semester with the sustainability phase underway and still in progress.

Resource Analysis:

We no longer need resources for this project since all of the work on the unit itself has been completed.

Budget:

Since most of our project was reused from past projects and donated by BP solar, we were able to keep costs relatively low. However, the many electrical connectors and over hardware for the cart drove prices pretty high, not to mention our very large battery which cost us very much. Here is a breakdown of the fund allocations:

- Battery: $230
- Hardware: $225
- Electrical: $145
- Breakers: $138
- Loads: $65

Total: $803

Future Work:

To completely wrap up the work for the demonstration unit the operations manual must be completed. In conjunction with this manual a safety and operations course should be developed to make sure the future operators of this unit use it correctly and safely. There is not more work to be done on the unit itself. Future work could include making a second version of the cart utilizing more basic electrical and mechanical design for ease of operation and ease of long distance portability.

Reflection:

Our portable demonstration unit is a completed success in showing the various uses and capabilities of solar energy. The cart has already been used in many educational functions such as the campus wide sustain-a-fest festival as well as other college visits to our facilities. Taking time in the beginning to brainstorm and thoroughly design allowed us to create exactly what we envisioned from the beginning. Of course we had our backups and tieups which caused delays in our timeline, but overall the time taken planning at the start allowed for a clear view of the work that needed to be done during the entire process. This project will continue to be used for years in demonstrating the diverse and applicable uses of solar energy and will better prepare the scholars of tomorrow for the technology that is likely to revolutionize the energy industry.

Appendix A

Figure 1

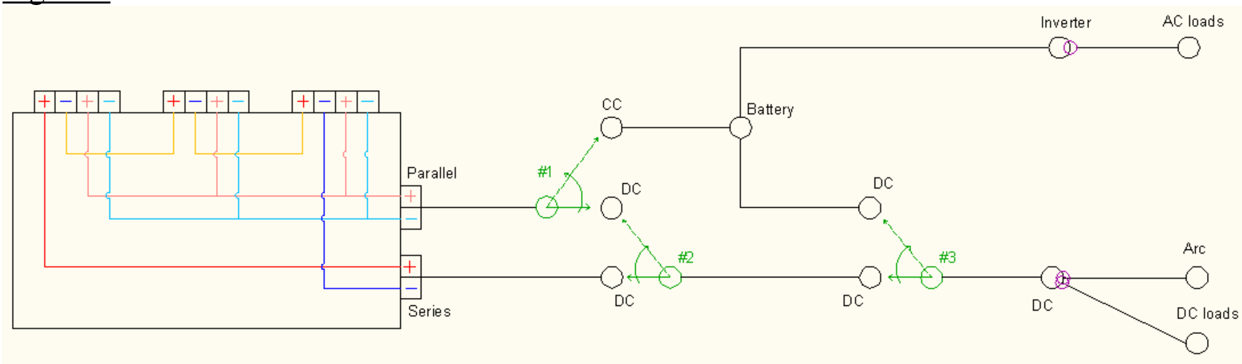


Figure 2

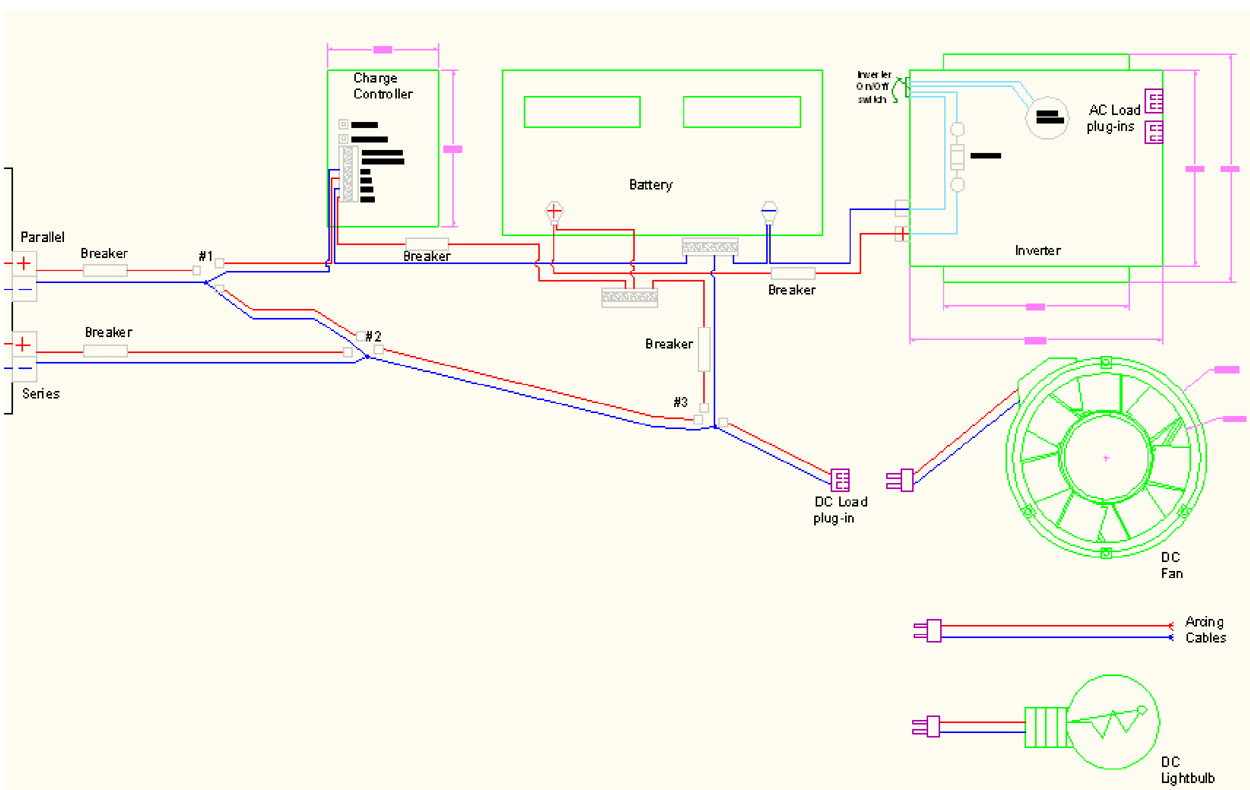


Figure 3

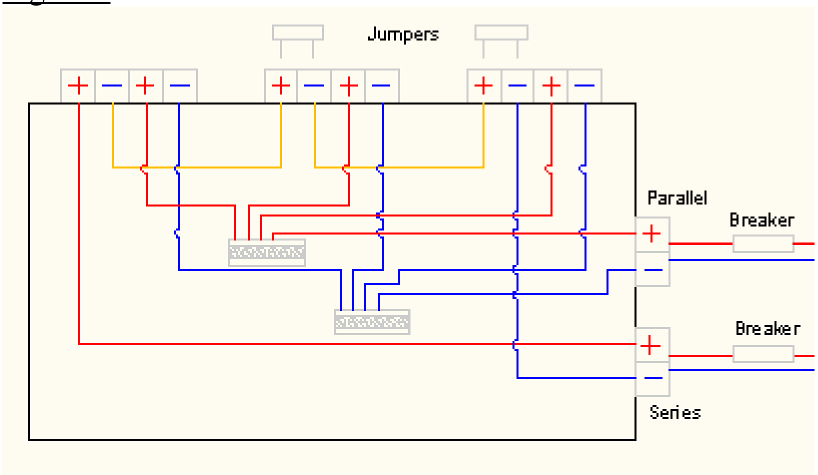


Figure 4

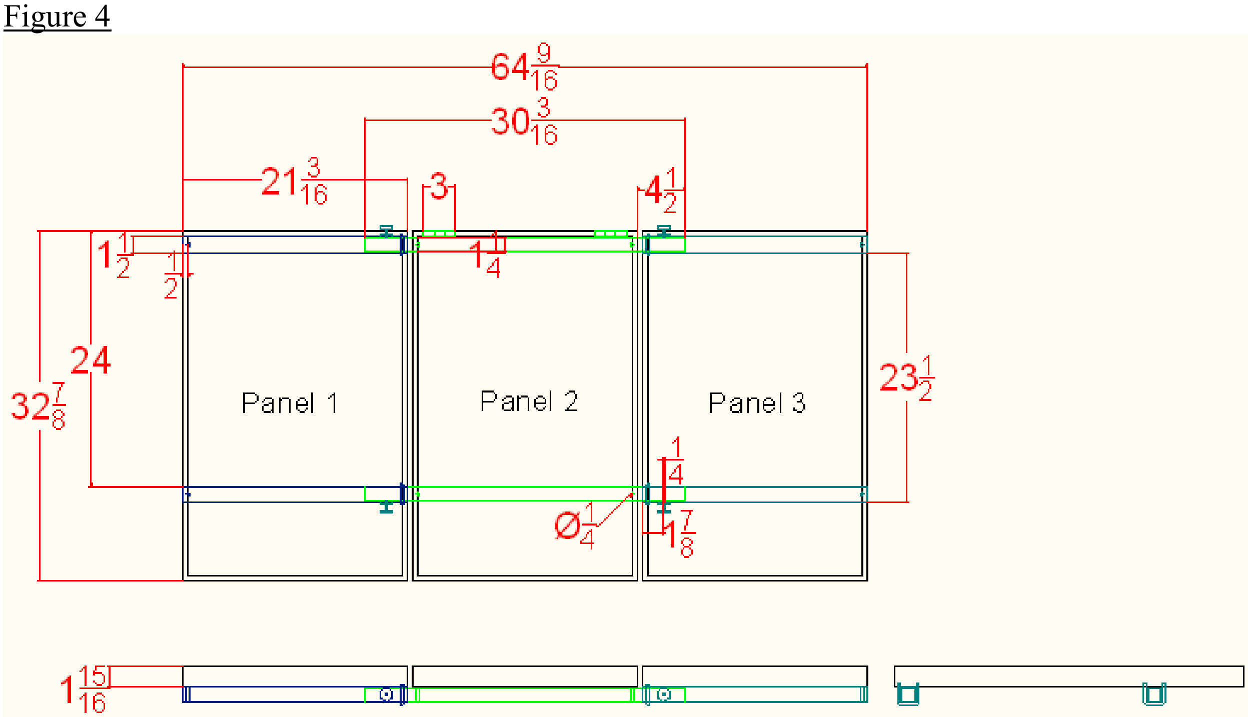


Figure 5

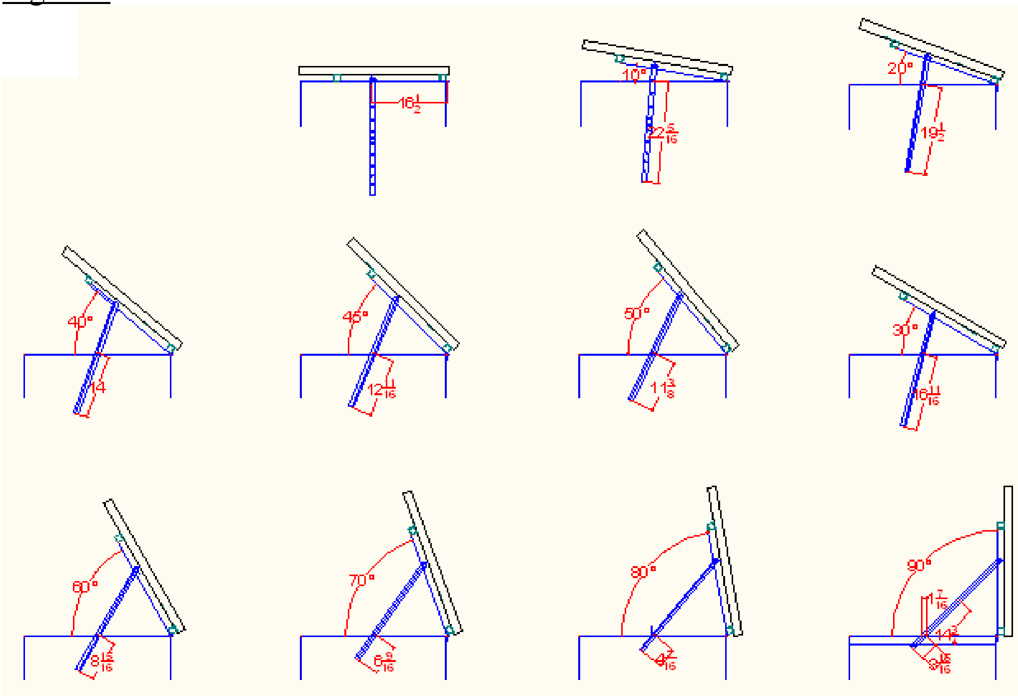


Figure 6

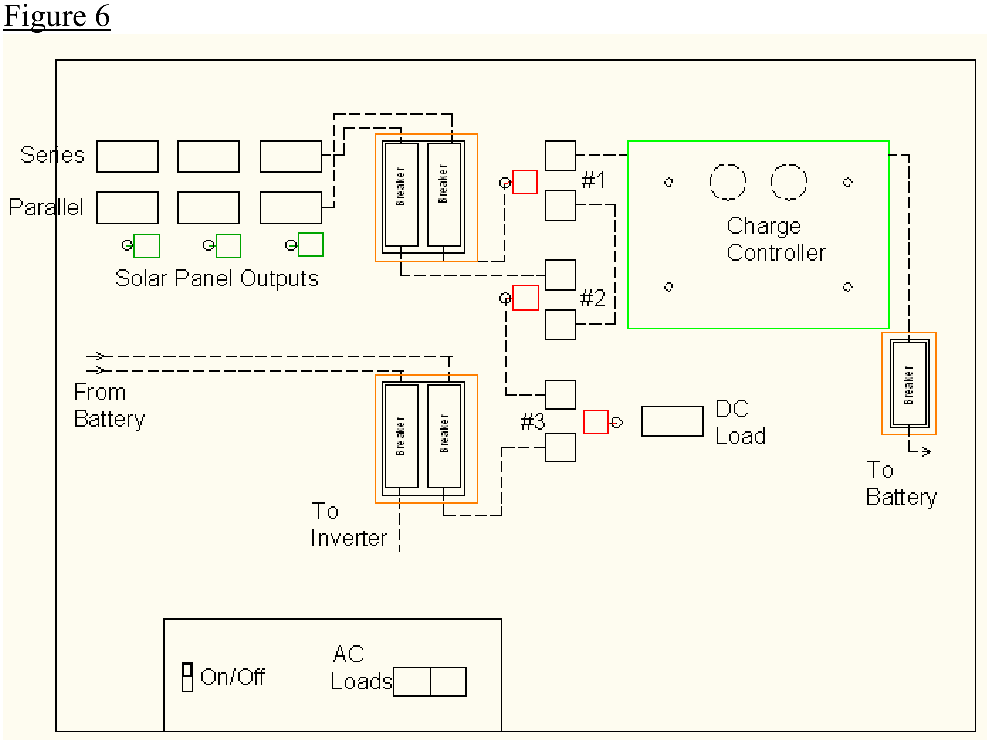
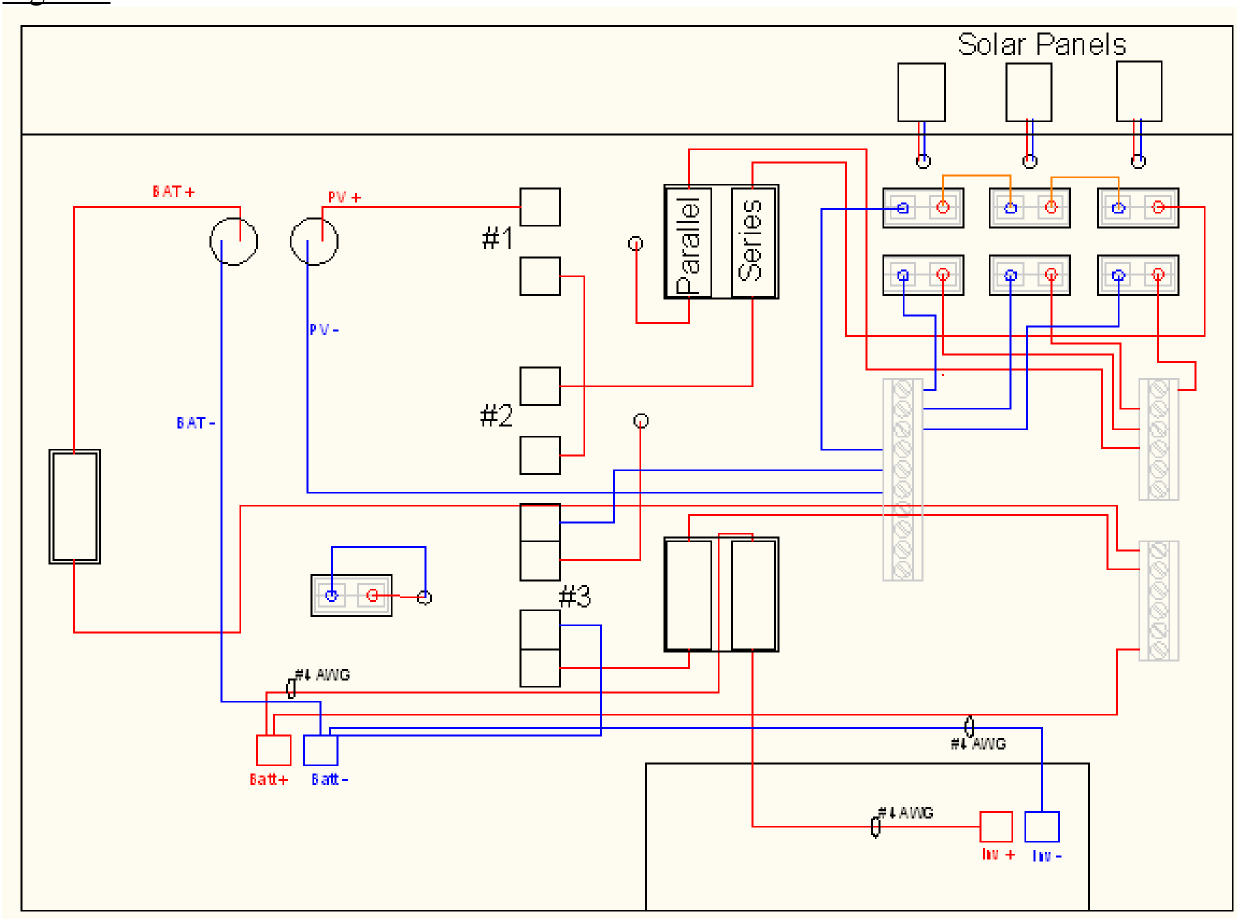


Figure 7



Solar Panels
BAT +
PV +
#1
Parallel
Series
PV -
BAT -
#2
#3
#4 AWG
Batt+
Batt -
#4 AWG
#4 AWG
Inv +
Inv -