Design and Implementation of a Small Scale Standalone Hybrid Solar PV and Wind Energy System

PROJECT PLAN

Team Number:
19
Client/Advisor:
Venkataramana Ajjarapu
Team Members/Roles:
Christopher Goodrich
Taylor Mullen
Kenny Nguyen
Damon Stubbs
Andrew Wassenaar

Team Email:
sddec18-19.sd.ece.iastate.edu
Team Website:
sddec18-19.sd.ece.iastate.edu

Revised:
2/11/2018 V1

Table of Contents

List of Figures

Include a **LIST** of all figures used. Be sure images throughout paper have same indexing.

*(example)*Figure 1: Proposed Design Diagram

List of Tables

ex. Table 1: Timeline of proposed work schedules for the Spring semester.

List of Symbols

List of Definitions

Please include any definitions and/or acronyms the readers would like to know.

example: ASA: American Standards Association

NOTE: Due to weather related issues, Group could not meet with professor to receive full details on what is required for the project. Project plan will be adjusted and revised according when meeting with the professor next week.

1 Introductory

1.1 Acknowledgement

We must acknowledge the previous senior design team who worked on the same lab before us. They left us their final deliverables fully outlining the initial design of the lab. Professor Ajjarapu has also helped us a great deal by providing us with equipment and funding for the lab design. Pranav Sharma, an assistant to Professor Ajjarapu has helped us by providing technical guidance and suggestions regarding the technologies involved in the lab.

1.2 Problem Statement

The problem that needs to be solved by our group revolves around the EE 452 Solar Power Lab. The lab currently in place is of insufficient quality to properly demonstrate the qualities of solar panels and the MPPT (Maximum Power Point Tracking) software that is used in conjunction with the panels.

Our solution is multi-faceted to address several issues in the lab. Primarily, the lab does not generate enough solar power. This is because the panels are located in the courtyard of Coover Hall. To solve this, we will add another pair of solar panels to the system. Another issue is with the DC load. The current lab does not have a DC load large enough to show the characteristics of the solar panels. We will implement a new, larger load, as well as a convenient display to measure all relevant values. There are also a number of shorts in the current setup, so our final task is to design a proper organization and protection for all involved wires.

1.3 Operating Environment

The solar panels are permanently located outside, accordingly, they will be exposed to all types of weather conditions. The rest of the lab will be located inside the lab room, but only used once each year. Because of the large amount of time sitting idle, it will need to withstand dusty conditions and not require constant maintenance.

1.4 Intended Users and Intended Uses

The final product's main use will be in the EE 452 Lab. This lab is closed off to outside students and all who have access will be familiar with power electronics. It will be used by EE 452 students learning about power electronics, specifically PV (Photovoltaic) cells. Due to the technological advances in wind and solar energy, renewable energy has been

more common throughout the world. Thanks to this, there is an increase in demand for renewable energy thus Electrical Engineers need to understand concepts, processes, and challenges in renewable energy.

1.5 Assumptions and Limitations

Assumptions: The project will only be used in the school laboratory; It will be used under supervision by qualified students.

Limitations: Sunlight is required for successful use of this lab; It cannot be used for many consecutive hours, as the lab is dependent on charge in the batteries.

1.6 Expected End Product and Other Deliverables

Deliverables required by client has not yet been specified. Deliverables that assumed required by client will be improvement of specific labs in class of 452. Improving the current standalone PV system created by the prior senior project group. Possibly improving the current system and if time allows, implementing wind energy into lab. Outline of revised lab and documentation of lab that has been revised or created for future students to complete. An outline of concepts that is needed to complete the lab that outlines ideas of solar and wind energy.

In addition to improving the lab, we are intending to add an interactives load that will show the function of the MPPT. This will include a design of variable loads the show the max power characteristics of the MPPT. This design will be limited in complexity depending on time constraints.

2 Proposed Approach and Statement of Work

2.1 Objective of the Task

The goal is to improve, revise, and expand the standalone PV system. Create, revise, improve labs that combines concepts learned in class relate to experiments in labs. Have labs reflect the importance of renewable energy. Lab manuals needs to be clear and concise, can be completed in 3-hour time period, reflects course concepts and materials, and have relative relation to real world problems. Lab should reflect ideas of fundamentals of MPPT, Power measurements, PV cells, Buck/Boost Converters, Irradiance and temperature dependences. Improvement on the work station created by prior group may need to be updated to be organized, intuitive, safe and reliable for students taking the course. All materials need to be well organized, explained, and be intuitive to students. Labs will be updated and revised if new applications are used or newer version of software is used.

As we progress into next semester, we will be mostly focused on improving the stability and usability of the lab. This is our clients main focus and we are making this our priority.

2.2 Functional Requirements

The functional requirements of this lab include being able to model all the components used in the lab in Simulink. Using those models, we are going to need to be able to test the system in a safe. This is to protect the students and the equipment. We also need to provide an interactive interface that allows the students to see what is happening within the system, while using different load. This includes providing displaces that show voltage, current, and power at different points in the system. Or focus areas are solar input, battery input, MPPT input, MPPT output, DC output, and AC output. These things can be expounded upon if time allows.

2.3 Constraints Considerations

Understand how to model a solar cell with I-V, P-V curves plotted from model. Have proficient knowledge on how maximum power point tracking relationship to I-V, P-V curves and how different algorithms used to attain max power from a solar panel. The idea of charging/discharging battery and the pros and cons of using a rectifier, inverter, boost/buck chopper in the standalone power system.

Standards will comply with the IEEE standards. Standards are still being developed for solar power energy due to it being a relatively new power source. IEEE standards include sizing, installation, and maintenance of lead acid batteries. If wind energy is implemented in the project, standards for measuring different parameters of wind turbines will be included. Standards for the city of Ames when importing solar energy will be also included. Ethnical issues will include the safety of students using the lab equipment. The equipment needs to be safe due to the possibility of measuring high amounts of voltage and current. Each lab manual needs to include a MUST README, that informs the students the possibility of measuring high voltage or current and safety precautions that needed to be taken. Informing the student of safety precaution is our responsibility.

2.4 Previous Work And Literature

Include relevant background/literature review for the project.

– If similar products exist in the market, describe what has already been done.

– If you are following previous work, cite that and discuss the advantages/shortcomings.

– Note that while you are not expected to “compete” with other existing products / research groups, you should be able to differentiate your project from what is available.

Detail any similar products or research done on this topic previously. Please cite your sources and include them in your references. All figures must be captioned and referenced in your text.

2.5 Proposed Design

Various different improvements to the lab exist. One design includes rewiring the buck/boost chopper to be able to connected to any dc load, rather than currently just being hard wired into one load. An additional display will also be added to correctly display DC load characteristics. This display will be similar to the ones that already exist, and it will offer the user an easy way to view power, voltage, and current.

2.6 Technology Considerations

Arduinos have been implemented into the current setup and will need to be improved to display necessary conditions. The Arduino, like any technology, has limits in processing speed, so the speed tradeoff vs the amount of information it displays will need to be considered. Arduinos are very easy to code compared to regular microprocessors, and as a result, are not as in depth with as many options as the alternatives.

2.7 Safety Considerations

There are serious safety considerations with the project. Since it is for a lab of mostly unexperienced students, we must be sure to keep circuits closed off as much as possible and write a detailed instructions manual to keep students from becoming injured.

2.8 Task Approach

We will be creating flowcharts and block diagrams to outline the circuitry needed. This will allow us and future students to understand what is happening and allow improvements to be easily added. Additionally, a similar layout to be put on the system is possible for ease of use and safety by the lab.

2.9 Possible Risks And Risk Management

One risk of this project is the differences of opinions of the three major people we are designing the system for: the instructor, the client, and the board. When taking on any proposed design of any kind, we must consider all three. We may take upon tremendous time implementing an idea, to have the result be rejected by one of them. To manage this risk, we are persistent upon coming up with numerous ideas and considering the feasibility of all of them before working on them.

2.10 Project Proposed Milestones and Evaluation Criteria

Key milestones for this project include the following:

- Lab Setup Functions Correctly and Within Reason for Completion of Lab
- Checking Components for Functionality
- Re-soldering wires if needed (Needed due to Shorts and some LCD screens not producing accurate data)

- Adding Additional Components to Improve Stability of System and Adding Longevity to Lab allowing night time students to complete lab at the same conditions as Day time students
- Overall Making sure the lab is intuitive for Students

Tests that will be ran are running the prior groups lab to make sure that all lab requirements can be demonstrated and obtain correct values. While running the lab, group notice that there were sparks and shorts all around the circuits and some displays were showing up wrong values for given measurements. Re-soldering the wires and making sure all values measured are accurate and feasible. To test the battery life of the battery would to apply the heaviest load into the lab setup and see how much time it would take for the battery to completely drain. Allowing for an estimated time the setup can be experimented on before all energy is used.

2.11 Project Tracking Procedures

GroupMe will be used to keep track of contacting group members on the progression of the project and allowing us other to have a similar means to contact one another. Currently a Cybox is used in order to keep track of all materials and coursework for the project.

2.12 Expected Results and Validation

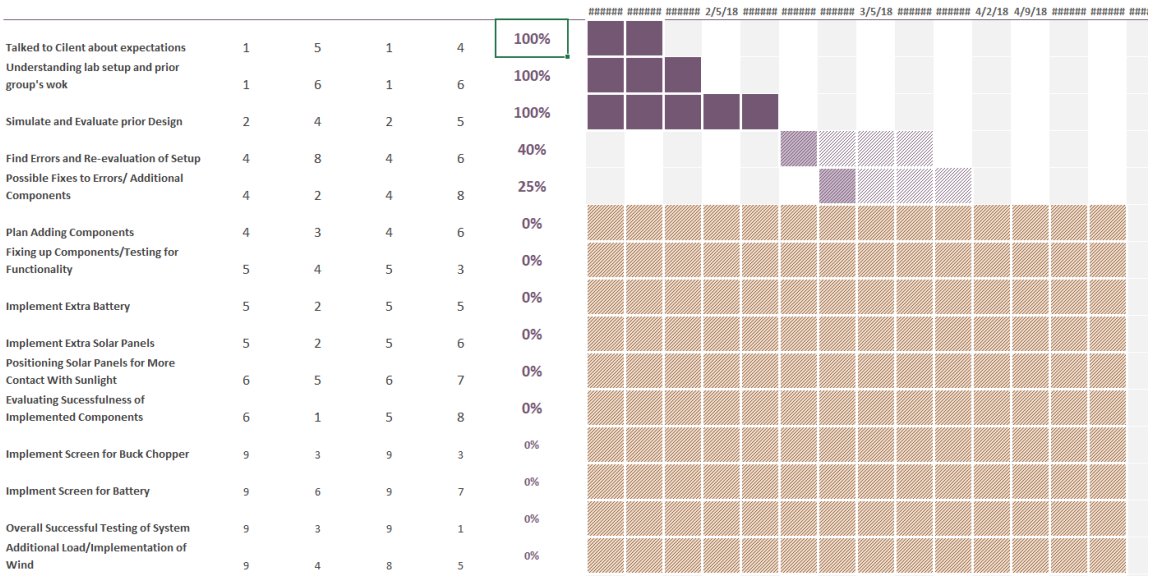
Desire outcome for project is to satisfy the client by having an intuitive lab that is easily accessible to students. Furthermore, to maintain stability of overall systems without system having shorts and being able to last through all lab experiments so all students have the same lab experiment. All readings on the setup are accurate and reflect the same results on the simulated system on SIMULINK.

2.13 Test Plan

A test plan will be implemented after components are added to the system. System will be first simulated using SIMULINK in MATLAB to find simulated results and then produced on the setup to compare and contrast the results to verify feasibility of setup. More test plans will be included as additional project components are confirmed for implementation.

3 Project Timeline, Estimated Resources, and Challenges

3.1 Project Timeline



The following project timeline is dated from the start of 1/18/2018 and ending in the start of May of this semester. The overall continuation of the project timeline will be created afterwards but details of adding components to current setup are included in the project timeline.

The tasks were chosen in this manner so that we can test and complete each additional component added to the lab and to verify the stability of the setup. Each component is a task in itself so that it can be simulated both in Simulink and experimentation to verify that the results are the same. This will allow for checks on safety of the lab due to dealing with high voltages. Other than validating that the setup works and each component function correctly, safety is at upmost importance when additional components are added and the setup is re-soldered and check.

3.2 Feasibility Assessment

The process which is required to finish the project will consist of adding an additional battery and/or another solar panel, adding another display or two providing additional information about the electrical system, evaluating internal connections of system to reduce the possibility of electrical shock and general safety of the students and finally reevaluating the lab document for the additional components added to the lab. Foreseen challenges seen consist of not having enough room on the shelf that the system is on for another battery. There don't seem to be any foreseen challenges for adding an additional solar panel in the court yard of Coover as it is not widely used. The challenge for analyzing

connections within the electrical system could pose as an issue since we are unaware of where the sparks are coming from in the system and may need to rebuild the entire electrical system connections if we are unsuccessful in finding the sparks. There also do not seem to be any foreseen challenges in adding addition documentation to the lab document for the lab since by the time we have the lab running in the state it should be, we will have a firm grasp of how the electrical system is connected as well as how it works.

3.3 Personnel Effort Requirements

The given table below goes through each of the tasks throughout the timeline and gives a brief explanation of the task and the amount of effort (Low, Medium, or High)

Tasks	Explanation	Effort
Talked to client about expectations	Talked about the problems that the lab has and what needs to be done to improve the lab	Low
Understanding lab setup and prior group's work	Look into previous group's documentation about the system in the lab and look at the system ourselves	Low
Simulate and evaluate prior design	Test the prior team's Simulink simulation	Medium
Find errors and re-evaluation of setup	Look at the system to find possible issues with the current setup	Medium
Possible fixes to errors/additional components	After finding issues regarding the setup, come up with ideas to resolve these issues	Low
Plan adding components	Discuss ideas of extra components for the system (solar panel, battery, displays)	Low
Fixing up components/testing for functionality	Fix connection issues within the electrical system	High
Implement extra battery	Add an extra battery to the electrical system	Medium
Implement extra solar panels	Add an extra solar panel to the electrical system	Low
Positioning solar panels for more contact with sunlight	Move the solar panels in the court yard of Coover so that they have access to more sun throughout the day	Medium
Evaluating successfulness of implemented components	Review and test the additions we made and evaluate their effectiveness	Medium
Implement screen for buck chopper	Add a screen for the current buck chopper	Medium
Implement screen for battery	Add a display to monitor the batteries in the electrical system	Medium

3.4 Other Resource Requirements

The resources required for this project will be additional displays for the system, wires for extra components and rewiring current components if necessary, and possibly and extra solar panel or battery for the stability of the lab.

3.5 Financial Requirements

No current financial resources to report.

4 Closure Materials

4.1 Conclusion

This project is to improve the EE452 photovoltaic system in the lab for future students by improving stability of the electrical system with additional solar panels and/or batteries and internal connections within the system as well as additional displays and finally additional documentation within the lab document. This project will in turn help future EE452 students with how a photovoltaic system works with the additional displays as well as the added documentation in the lab document. The project will also help prevent electrical shock as well as any harm that may come to the students with using the photovoltaic system.

4.2 References

List all the sources you used in understanding your project statement, defining your goals and your system design. This report will help you collect all the useful sources together so you can go back and use them when you need them.

– This component shall completely identify any material taken from other sources and used in the development of the project to date or are known that will be used during the remainder of the actual project

– These references shall be complete so that any member of the plan's audience could find them

- Have these on a separate page.

4.3 Appendices

If you have any large graphs, tables, or similar that does not directly pertain to the problem but helps support it, include that here. You may also include your Gantt chart over here.

– Any additional information that would be helpful to the evaluation of the project plan or should be a part of the project record shall be included in the form of appendices

– Examples of project documentation that might be included are property plat layouts or microprocessor specification sheets germane to the proposed project.