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Hybrid Solar PV and Wind Generation System for 452 Lab

PROJECT PLAN

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1 Introduction

1.1 PROJECT STATEMENT

Develop and expand the current solar generation to be more user friendly and educational for future EE 452 lab students.

1.2 PURPOSE

Recent technological advances have made solar and wind generation more economical and thus more common throughout the world. This increased demand of renewable energy produces a great demand for educated Electrical Engineers. Iowa state currently offers EE 452 Mechanical Drives and machines. This course discusses electromagnetic conversion, which is a key concept in renewable power systems.

Currently the class uses the Bio Renewables Lab, and there is an educational station for student to collect data from solar panels. This station is currently disorganized and limits what the students can test and measure. Our project would rebuild the station and software at the station to give the students a better and safer learning environment. We will generate more lab manuals so students will have more time with the equipment. We would like to also like to expand that system either via more panels, more batteries or a sun tracking system. This way the closed system will be more powerful and last longer. Giving every student an equal chance to collect good and meaningful data.

1.3 GOALS

1. Create a more compact, updated, and user friendly workstation for students to conduct lab.
2. Create lab material for future EE 452 labs.
3. Generate cost analysis solar tracking system that will move the panels to point squarely to the sun, thus getting maximum irradiance at all times of the day.
4. Generate ways to optimize small stand-alone systems to benefit those in remote areas.

2 Deliverables

Workstation: For the workstation, we first need to come up with a concept design. This can come in the form of a drawing or a 3D design. Next, we will physically move the equipment in the designed arrangement.

Solar Tracking System: Cost analysis comparing various tracking devices on the market as well as if we built one ourselves. We would also need survey the area to prospect new areas to place the

panels.

Lab Manuals: Lab instructions to cover a few weeks of lab. These instructions need to cover; purpose, theory, data, analysis and conclusion.

Additional Panels: Provide cost analysis and scope for adding more panels to the current system. A project plan for installation will be needed as well as site location. The final result will be new fulling integrated solar panels.

3 Design

First and foremost, we cannot begin implementing any of our main tasks until we have a complete working model of an isolated wind and solar power system. To do this, we will have separate designs for solar and wind and combine the two. This modeling is important not only for our understanding to the system, but we can use these models in our labs to help other students understand as well. These models will be used to create the lab manuals to make them more intuitive. Once we create the manuals we can test our work on Students and get their feedback. This will allow us the opportunity to refine our manuals and test again.

After the model is completed we can start cost analysis on adding more panels as well as a solar tracking system. When looking into add more panels we will need to conduct research to make sure that they will be compatible with our current system and possible future systems. We may also need to find another location to place the panels. This ties into the solar tracking goal because the current location the solar panels is not ideal for solar tracking.

The last goal to discuss is the new lab workstation. This begins by defining what we want to accomplish at this station. Once we understand this, we will start to evaluate what equipment is needed and how that equipment can fit in a given space.

3.1 PREVIOUS WORK/LITERATURE

$$I = I_{ph} - I_s \left[e^{\frac{q(V + IR_{se})}{AkT}} - 1 \right] - \frac{(V + IR_{se})}{R_{sh}}$$

where,

$$I_{ph} = I_{sc} \cdot \frac{I_{rr}}{1000} \cdot [1 + (T_{cell} - T_{ref}) \cdot K]$$

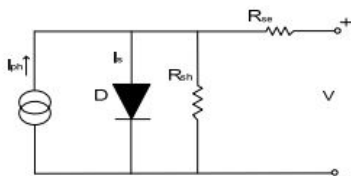


Figure 1 Single diode solar cell

There is a considerable amount of literature on PV cells, MPPT and modeling a solar cell. For designing a solar cell in Matlab we are using the single diode method used by G.Bhuvanawari and R. Annamalai⁽²⁾. The model and corresponding equations can be seen in figure 1. There are other methods and techniques that we may adopt later in the project. We will reference material from “MATLAB Based Modeling of Photovoltaic Array characteristics”⁽³⁾, “Design and Simulation of Photovoltaic Super System Using Simulink”⁽⁵⁾ and “Models for a Stand-Alone PV

System”⁽¹⁾ for modeling the system.

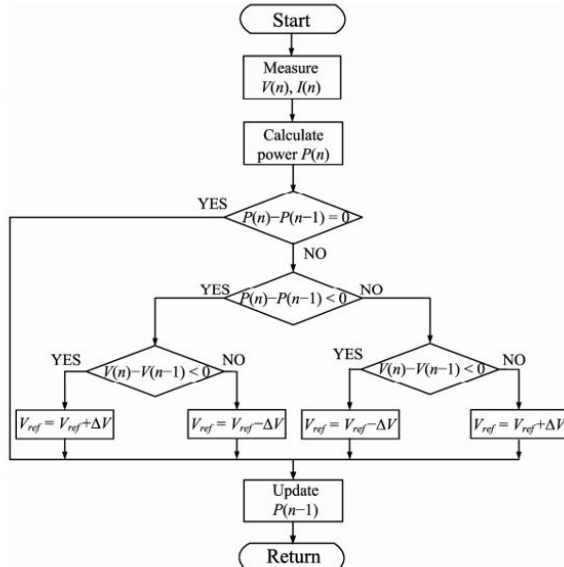


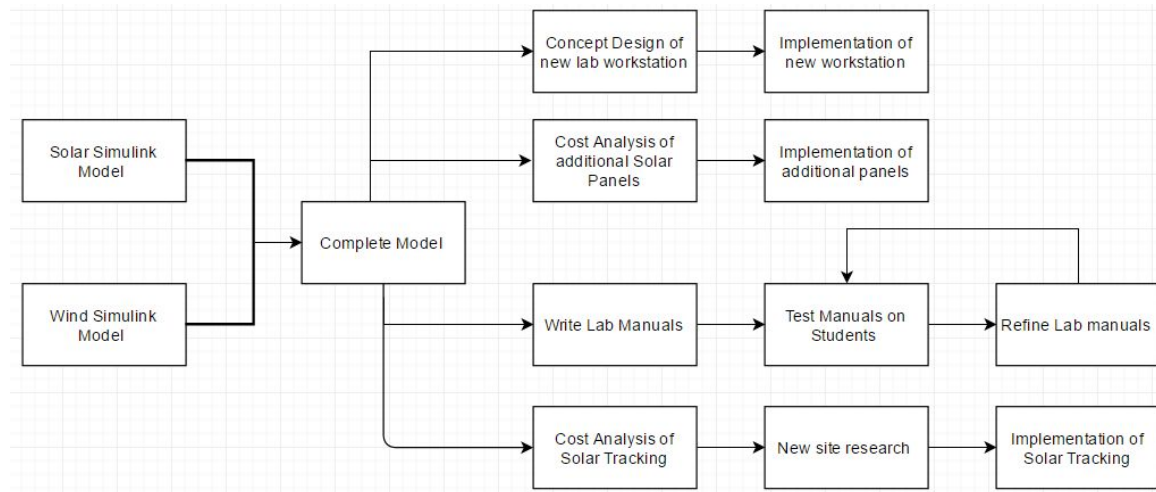
Figure 2 Perturbation and Observation Method

For general knowledge on stand-alone wind and solar systems, “Performance of Stand-alone Hybrid Wind-Photovoltaic System with Battery Storage” will be our go to documentation⁽⁴⁾. This document covers models of lead-acid batteries and PV cells. It has flowcharts and IV characteristics that make understanding the system more intuitive.

For deciding a MPPT algorithm, we will reference “Study on Maximum Power Point Tracking algorithms for Photovoltaic systems”⁽⁵⁾. This paper references three different methods for MPPT with Pros and cons of each method. For each method there are flowcharts that describe the algorithm, see Figure 2 as an example.

There have been other Senior Design groups as Iowa state that have worked on this project. We have some of their documentation and designs. We will use these as references, but will ultimately start from scratch when modeling our design. There is one group that is currently in the second semester phase of this project. We will meet with them regularly to answer questions as well as learn from their mistakes. This should speed up our progress significantly.

3.2 PROPOSED SYSTEM BLOCK DIAGRAM



To achieve our deliverables, we will follow the designed path seen above. We will be working with the simulations of Solar and Wind systems in Simulink. Once this is complete we can begin to work directly towards our deliverables.

3.3 ASSESSMENT OF PROPOSED METHODS

After we complete the modeling of the system, our priorities of work become less clear. Our first order of business may be to create the new workstation. However, if we or Professor Ajarapu would rather add new equipment it may be best to wait. The same applies with creating lab manuals. We don't want to be in a situation where we have to write new manuals because we changed the equipment. It may also be to possibility that the other group creates all of the lab manuals and we won't have to do any at all. Ideally we would like to create the workstation, either add more panels or integrate a solar tracking system and then create labs. Overall, we are going to have to be flexible with our goals and priorities.

3.4 VALIDATION

To verify that our solution works, we will need to test randomly selected Electrical Engineers to complete our lab manuals at our workstation. After they complete the labs, we will test their knowledge to gauge if the lab manuals taught the intended material. A survey will then be given to provide feedback on the workstation. Validation should be conducted more than once throughout the design the process to ensure that the design is on the correct path.

4 Project Requirements/Specifications

4.1 FUNCTIONAL

Modeling solar panel and DC/DC converter in Simulink with visually representation of their respective characteristics. Also modeling MPPT algorithm in conjunction with the converter and solar panel. Integration of a battery bank and load into a solar PV/wind generation system while maintain power quality from the power supply. Combining new PV panels with existing panels and use of MPPT and other control techniques through real time controller. Calculating wind speed with use of a wind sensor also emulate wind turbine generation energy in the lab. Combination of pv panels and turbine connected to the load and battery bank.

4.2 NON-FUNCTIONAL

Understanding of modeling a solar cell along with I-V, P-V curves plotted from the model. Proficient knowledge of maximum power point tracking its relationship to P-V, I-V curves and different algorithms used to attain max power from a solar panel. The physics of a charging/discharging battery and the advantage of using a rectifier, inverter and chopper in a standalone power generation system. Further it is required that ideas are generated about how this project can be used for other applications. Ideas can be proposed throughout the semester regardless of how outlandish or reasonable they seem at the time. The details will be worked out if the advisor is pleased with an idea proposal.

4.3 STANDARDS

A variety of standards can be applied to this project. Since Wind and Solar power are relatively new sources of power standards are still being developed there are however IEEE standards that should be applied to the project. There are IEEE standards for the sizing, installation, and maintenance of lead acid batteries. There is also a IEEE standard that involves measuring different parameters for wind turbines. Standards are always important to follow regardless of the application so that it is easier for others to understand. Even if the project never has a use outside of the 452 lab educating college students it is important to design it as if it will which is why applying all applicable standards is especially important. It is also important that we follow the city of Ames Standards when importing solar energy into the grid. Even though there is no plan for this power to be connected to the grid following the method put forth by the city of Ames should be observed for the possible application at a later date. Ethical issues that may apply will the safety of the students that will be interacting with the equipment in the lab. It is absolutely necessary that the measuring

equipment is safe as some of the voltages and the current have potential to be fairly high. it is our responsibility to make sure all the equipment is safe and if it is not the user must be aware of it.

5 Challenges

communications with the client may hinder the project development. Several issues cropped up in the first weeks and it will be a problem that should be resolved step by step as the understanding of the group and the advisor come closer together. This will however slow the project development down. Another issue that may be of concern could be cost. A large amount of the work that will be done will be in cleaning up the system that has been built and making it a more usable system. Buying measuring equipment as well as cables and other devices will be expensive if the system is to be upgraded. The budget has not been told to us this could cause problems later through the semester. The last item that is cause for concern is the ambiguity of the project. There has been many general ideas about what we need to do but focusing in on one may be difficult in part because of the communication and the generalness involved the client has communicated several things that he would like done but has not made any specific comments. .

6 Timeline

Here we outline a timeline for our project some of the major goals that we will be pursuing here will be implementing new solar panels, workstation equipment and a solar tracking module. These are expected to be the ideas that take the most time and effort to complete. The Gantt chart is located in appendix A.

6.1 FIRST SEMESTER

First semester they are challenges with getting accustomed to Simulink but goals that should be done regarding Simulink are a working model of our complete solar panels generation system from MPPT, voltage inverter and DC/DC converter. Another accomplishment as a team is get a good understanding of how MPPT, affects the system as a whole. Also a completed wind generation system in Simulink (). Then having incorporated both solar and wind generation models in Simulink. Coming up with a workstation design format regarding the lab the entire system will be incorporated into. Also getting familiar with the hardware we have available from limitations to the cost of the hardware.

6.2 SECOND SEMESTER

Implementing the workstation design from the previous semester then coming up with a lab manual write up for student to test provide feedback. From the feedback give improvements to the lab manual while also getting total cost of additional panels. After that acquiring the most feasible panel then implementing with the existing panel. Get a cost analysis of panel tracking then implement it into the lab while conducting research for another site for the hybrid generation system.

7 Conclusions

Sum up your project plan. Briefly re-iterate your goals for the project and the plan your team has put in place to achieve these goals.

The generated project plan is to continue developing a simple understanding of the concept, model, design, proposal, implementation, and testing. This design method will be applied to the three goals which will be attempted. These are redesigning lab equipment, implementing additional solar panels, and implementing a sun tracking system. These three ideas should occupy the entirety of the two semesters along with the documentation and paperwork that will be involved in the process. Hindrances along the way will be communication as well as budget and understanding. We have laid out the methods and time line the group must follow in order to develop and expand the current solar and wind generation to be more user friendly and educational for future EE 452 lab students.

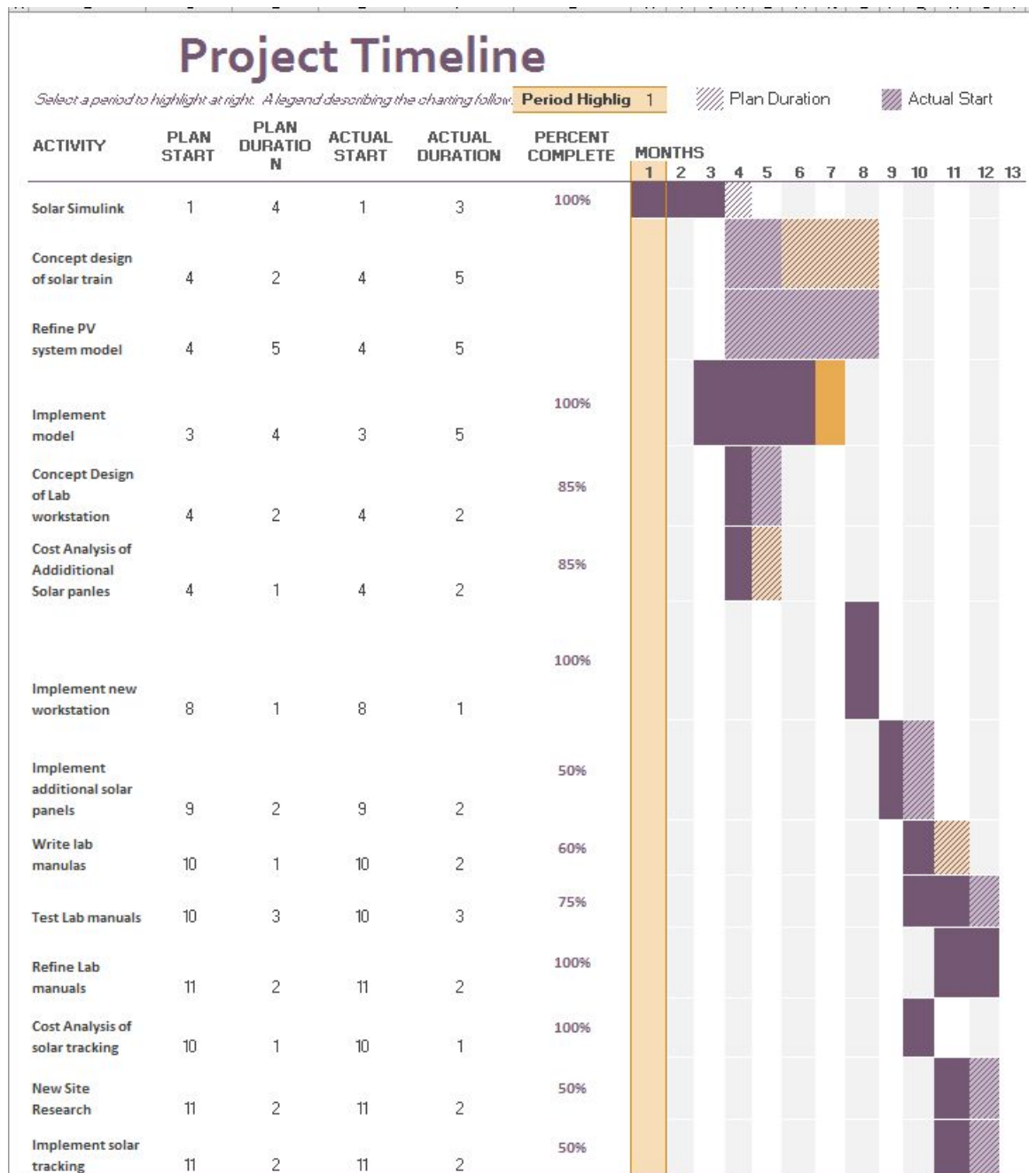
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"City of Ames, IA." City of Ames, IA : Solar Energy. N.p., n.d. Web. 23 Feb. 2017.

9. 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.



B. Simulink Work

