Standalone Solar PV Energy Generation System

Design Document

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System Requirements

Our project is a Hybrid Wind and Solar system. In order to create a system that can run on both of them we had to evaluate the criteria that was asked. Our system will be first created in a simulation using Simulink/Matlab and then implemented in the hardware aspect.

1. Design and modeling of solar PV panel and maximum power point tracking (MPPT) algorithm using electronic converters.

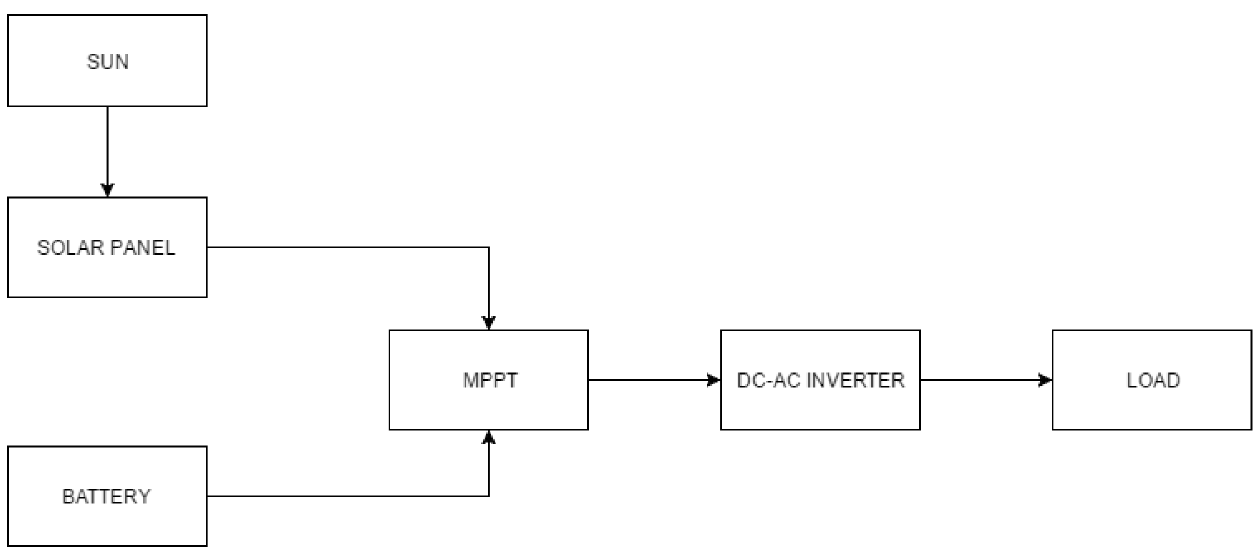
2. Design and modeling of voltage inverter and its switching mechanism to convert solar DC power to AC.

3. Loads, battery bank and their integration to the energy generation system.

Because this project has been worked on by past groups, we also have to understand the system that has been already created. This means that we must take the past data and documents that have been given and be able to run what has already been done.

Interpretation of System

This system can be best described using a flow chart of what is happening. Each step can be represented as a step that needs to be taken in order to receive the output that we are wanting.



Project Design

Overview

For our project, we have been tasked to create a standalone solar generation system. This system should be able to produce electricity without being connected to any grid. This will be useful for remote parts of the world or third world countries where electricity is not easily available.

Interface Specifications

For our solar system we are currently using oscilloscopes and sensors to read the data from each component. The use of these tools is very tedious and the data can only be read at the time when a group member is present. In order to combat this we have attempted to hook up a sensor which will allow us to read data from the system consistently throughout the day.

We need to be able to present the data in a clear manor and extract the information that is useful to us. Because this is an almost strictly hardware system we need to be able to make sure that nothing is abnormal.

Hardware Specifications

Our system is using solar energy to generate electricity but under some conditions the solar panel may not be able to generate enough power to accommodate the load. In this case our system also consists of a set of batteries. The batteries are not only a resource that can supply power when solar panels are not producing enough power, but also the power supply for the inverter. Also, in order to make the system work at its maximum power rate, our group uses a MPPT (maximum power point tracking) among connections of solar panel, battery and inverter.

PV system

Our solar system has three main components, Photovoltaic Array (solar panels), a MPPT device (Maximum Power Point Tracking), and an inverter. These components are attached to a battery and a load to demonstrate the system.

Photovoltaic Array

For our array we are using two Kyocera Model KD135GX-LPU solar panels in series (1.5m by .668m). The output for these arrays are dependent on the solar irradiance that is received by each solar cell. The nominal voltage of the two panels in series is 17V, and 7.63A. It gives a nominal power of 270W at peak irradiance.

The Photovoltaic arrays work by transferring the energy from the solar irradiance into a current. Since these arrays do not follow the linear VI curve, we work with them by attempting to draw the maximum amount of Power from the system. Depending on the load attached to the solar array, the system will draw a certain amount of current or voltage from the array, depending on the solar irradiation and temperature values present.

Maximum Power Point Tracking (MPPT)

In order to draw the largest amount of power from the PV cells we need to attach a device that finds out what the maximum is. There are many different ways of locating the ratio between voltage and current in order to maximize the power output but for our system we used a device especially for this task. This device uses a boost converter in order to step up the voltage from the solar cells. The boost converter is dependent on a duty cycle created, through power electronics and the voltage and current differences, which runs an internal IGBT.

Inverter

Attached to the other end of the MPPT is the inverter which converts the 24V DC voltage to a steady 120V 60Hz AC voltage (US values). This device uses pulse-width-modulation in order to regulate the output.

Load

In our system we want to be able to control a variety of loads in order to show the usefulness. Right now the system is connected to a purely resistive load consisting of a few lightbulbs. In order to create a system that can run on other loads, we will have to examine the complex powers of other loads and make sure that we do not exceed any power ratings for our system.

Battery

Also attached is a battery which will run the system when the PV and Wind systems are not fully able to produce the power that is needed. Two 12V batteries are to be connected in series to achieve the desired 24V for the battery bank. The battery bank will be connected in parallel to the inverter and load in order to store charge at the desired level of voltage and feed the load when necessary. A switching mechanism will be used to determine which of the generation systems is charging the battery, and when to disconnect the battery when fully charged.

Future Revisions

Access to data

We would like to create a way for the system to be monitored while running during the day. Using LabVIEW we can view the real time output of both systems but we would like to create a better way to present the values of different aspects of the system.

Optimization

Because the components that we are using an very expensive and not very practical for real world applications, we plan on possibly recreating the entire system using parts that can be purchased for the minimum amount of money.

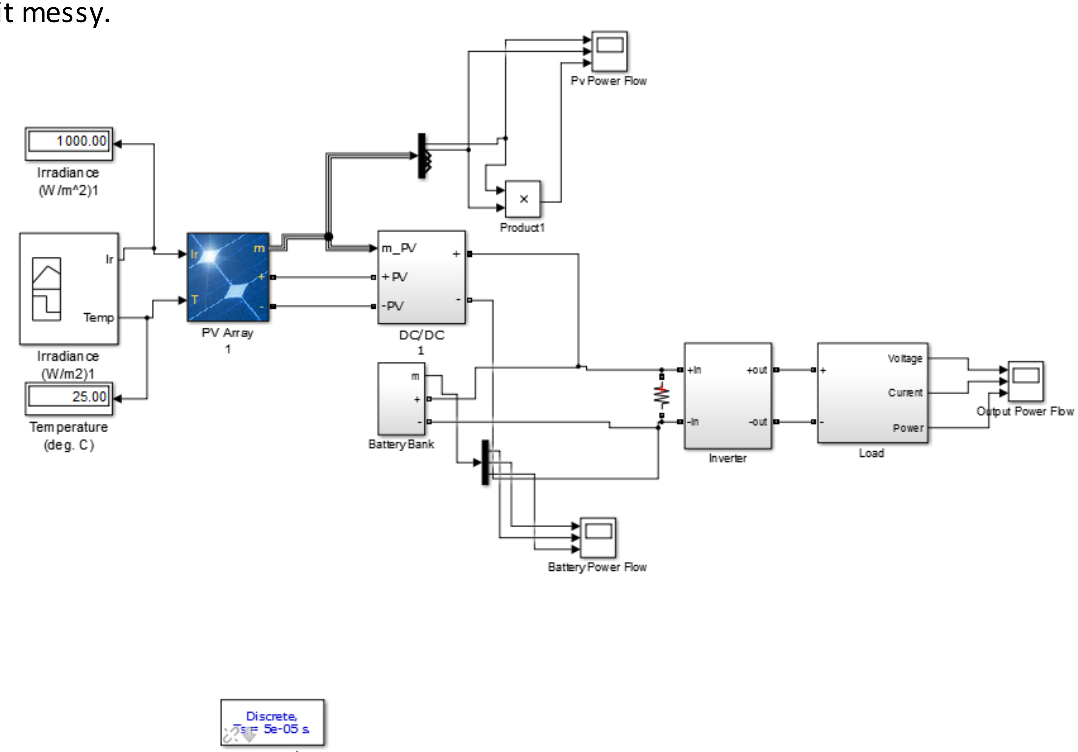
Load

Our load that we are using will not handle a large amount of power because it is confined to the output of the PV and Wind systems. In many homes we can use a lot more electricity than 270W. So by changing either the battery or the way the load is presented we can better optimize our complete system.

Simulation/Modeling

Solar

The PV system can easily be modeled in Simulink and simulated to observe how the system works. We have the model from the previous group to work with and as you can see is a little bit messy.



Our system takes given values of the solar panel characteristics and then simulates them through the PV panel. In a new simulation we hope to use a model with the same specifications as our own solar panels. This then goes through a MMPT controlled boost converter that feeds into an inverter. This is also connected to a battery to control the voltage that is fed into the inverter. This inverter then delivers an AC current onto our load.

Implementation issues/challenges

Because of the lack of knowledge with each system it will be a large obstacle to overcome understanding the components that need to go into the system. It will take more time to understand the components and then apply the knowledge that we have gained to be able to complete the project

We also have issues with some of the ways of measuring data. There are restrictions for us to what we can use in actual hardware implementation. Laws prohibit us from working with a wind generator on top of any of the buildings in campus. This means that we will have to wait until the very end of the project if everything is designed and implemented to create and run the system.

Testing

Because we want to make sure that our system can handle the next change that we want to implement we must first simulate our system. After simulation takes place, we attach the hardware version of each system together. Each aspect of the system is connected to a different sensor to observe the output at each step of the process. We use Hall Sensors to measure the voltages at the different components, these are connected to an oscilloscope to observe the behavior. On the output we have a Wattmeter in order to make sure we do not go over the rating of the system.