What is the best photovoltaic solution for Gridware?

Introduction

This summer, I was placed as a hardware engineer at Gridware, a startup developing devices that monitor the grid to detect electric faults in real time. Specifically, I worked on powering the devices by developing the most optimal photovoltaic solution. This project required me to answer big questions involving size constraints, testing, mounting, and orientation.

In order for the devices to excel at detecting faults in real-time, they need to have sufficient power at all times. This means the solar system needs to be as optimal as possible to meet and even surpass the goals set in our power budget.

Results

After building a testing circuit and using it to run tests on the five sample panels that I ordered, I was able to generate around 40 P-V curves that detailed the performance of each panel under a large variety of conditions. These curves paved the way for some very interesting discoveries, like learning that one of the sample panels I ordered was producing over twice the power as the company’s old panels, even though they were the same size.

I also built a simulator for one of my sample panels using the equivalent circuit model for solar cells. This was useful in terms of seeing how the Gridware devices’ circuitry responds to the panel. After extracting the shunt and series resistance from the panel’s full I-V curve, I was able to build the equivalent circuit using silicon diodes and create an artificial I-V curve that was essentially just a more idealized version of the panel’s actual curve.

In the final two weeks of my internship, I worked on building a device that can record solar panel data across a full day. I initially wanted to compare panel performance when facing South, East, and West, but some technical difficulties with the West-facing device meant that I only got an accurate comparison of South vs. East.

Figure 1. Example of P-V curve under low-light conditions.

Figure 2. Actual and simulated panel I-V curves.

Figure 3. Performance of South and East facing panels throughout the day.

Materials and Methods

To survey the market and find the best solar panels for our purposes, I mainly researched major solar distributors like ENF Solar and Alibaba. When gathering electrical parts to build the testing circuit, I predominantly used Digi-Key Electronics. The testing circuit was built such that the panel voltage could be varied by turning a potentiometer. Then, I could measure the current at each voltage and generate the P-V curves.

To generate all of these curves under different conditions, I designed experiments that varied time of day, shading, angle from vertical, and orientation. To test the panels under low-light conditions, I ran tests at 9am and 5:30pm because those times were equidistant from solar noon, which was about 1:15pm. When conducting partial shading tests, I would compare the panel’s performance when the left half is shaded to its performance when the bottom half is shaded. This allowed me to gain insight into how the individual cells are strung together within the panels. These P-V curves are significant, because they provide the company with the information needed to set the optimal panel voltage to achieve maximum power.

To build my device for the full day solar panel test, I used a Raspberry Pi, current sensor, and a modification of the testing circuit I built before. Then, I programmed the device such that it would record time, voltage, current, and power into a .csv file every minute, starting from the moment it is powered on.

References