Small Scale Solar Photo-Voltaic Module

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Abstract

The objective of this project was to learn the basic principles of renewable energy generation and utilization in electrical form, create and test the algorithm for wireless communication with the module, and get familiar with the parts used to build the module while learning how to build it and carry out the integration and final testing. This was done through building a device that used Bluetooth to communicate how much power was being generated by the solar panel. Different resistors were tested to find which one would yield the most power, and the 220 Ω resistor was found to be the most efficient. A correlation was also found between the peaks of power the time of day.

Background

This research project focused on building a basic PV module that can record data from a solar panel, which gets its power from the sun, to gauge how much power is generated in certain conditions. This can be accomplished by using an Arduino, current sensor, and a Bluetooth device. With the Arduino, you can write and upload C++ code to the Bluetooth device that will output the information needed to the Bluetooth terminal that is being used. The current sensor is able to read current and voltage. Using this data, we were able to use the equation:

$$P = I \times V$$

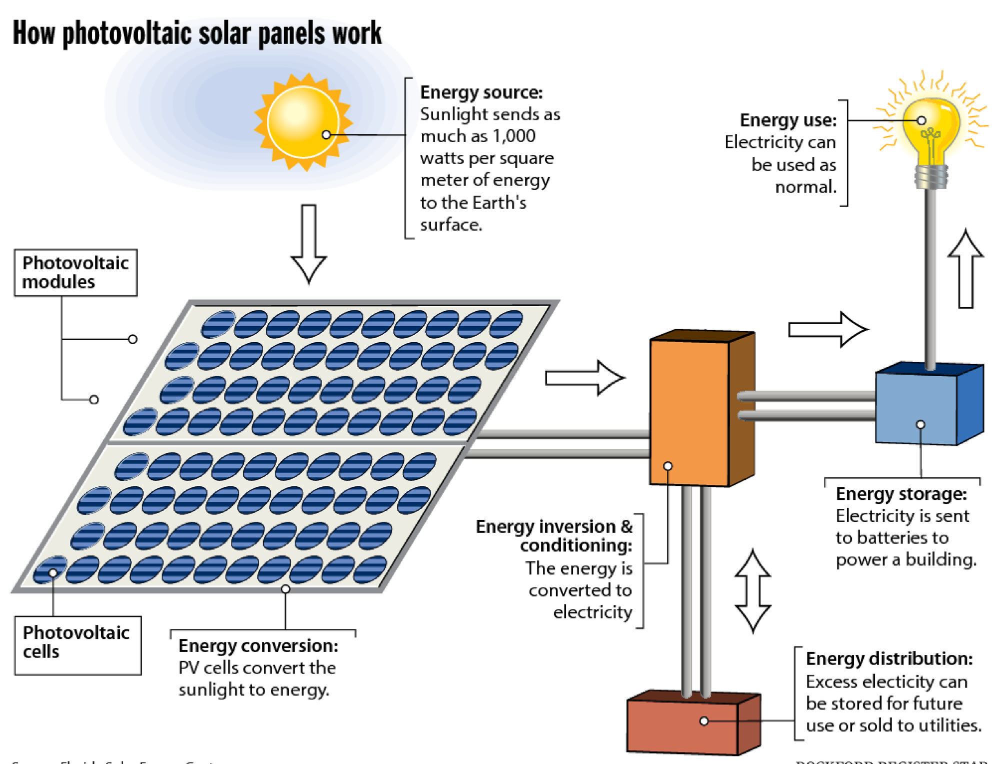

Figure 1: Photovoltaics

to determine how much power the solar panel is producing using the energy provided by the sun. The solar panel uses photovoltaics to produce electricity. It can do this because of a semiconductor wafer that is specifically treated to be positive on one side and negative on the other. Once light strikes the cells of the solar panel, the electrical field provided by the wafer gives the light stimulated electrons direction and momentum, resulting in a flow of current.

Materials and Methods

Materials:

Wires, PV solar panel, resistors, led lights, current sensor, multimeter, Arduino board, HC-05 Bluetooth device, breadboard, battery, and an acrylic box.

Methods:

- Research Arduino, current sensor, and Bluetooth device.
- Make a basic series circuit connecting current sensor and Bluetooth device to Arduino.
- Perform experiment to indicate which resistor yields max power with the solar panel.
- Upload C++ code that multiplies current and voltage together to output power.
- Collect data and create graphs.
- Analyze graphs.

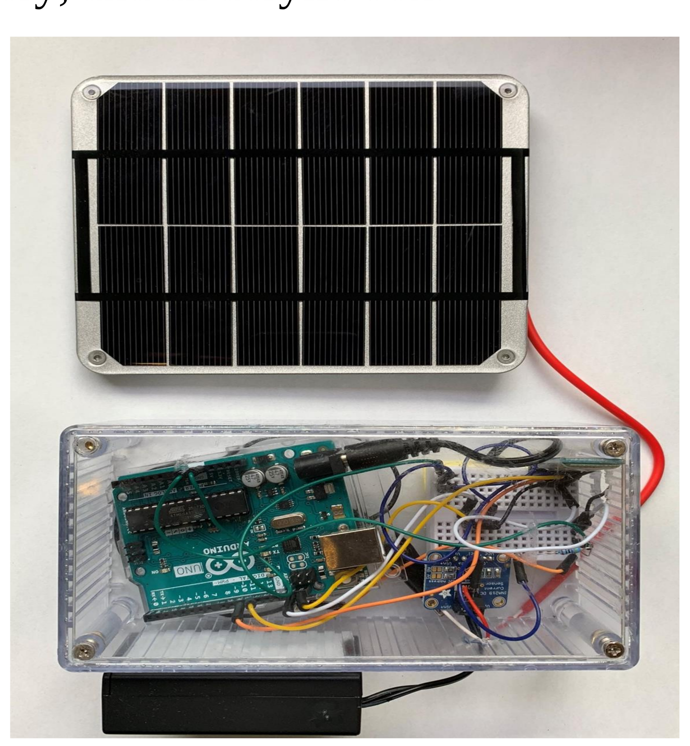

Figure 2: Complete device.

Max Power Activity

To see which resistor would yield the most power, multiple resistors were tested in a series circuit with the solar panel. When power was calculated , the 22,000 Ω resistor was determined to yield the most power.

R (ohms)	V (volts)	I (amps)	P (mW)
20	0.004	0.0002	0.0000008
100000	3.412	3.41E-05	0.0001164
1000000	2.475	2.48E-06	6.126E-06
47000	3.143	6.69E-05	0.0002102
10	0.002	0.0002	0.0000004
470	0.092	0.000196	1.801E-05
47	0.009	0.000191	1.723E-06
2200	0.415	0.000189	7.828E-05
220000	3.435	1.56E-05	5.363E-05
22000	2.692	0.000122	0.0003294
4700	0.897	0.000191	0.0001712
10000	1.788	0.000179	0.0003197
220	0.043	0.000195	8.405E-06
100	0.02	0.0002	0.000004
1000	0.196	0.000196	3.842E-05
470000	3.49	7.43E-06	2.592E-05

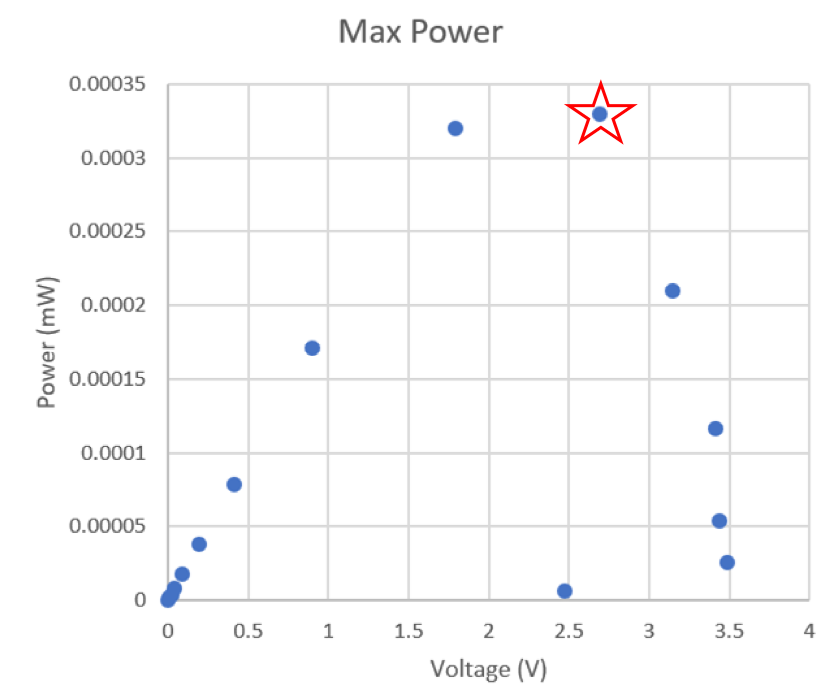

Figure 3 and 4: Data collected and calculated, Voltage VS. Power

Solar Cell Data

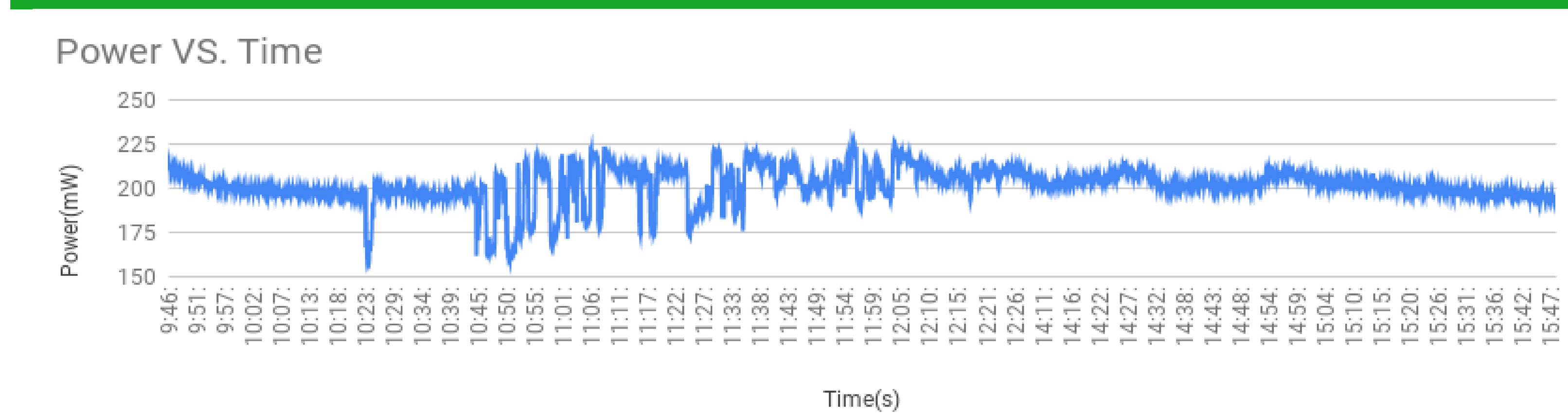

Figure 5: Partially cloudy, 220 Ω resistor, flat, 201.66 mW mean power

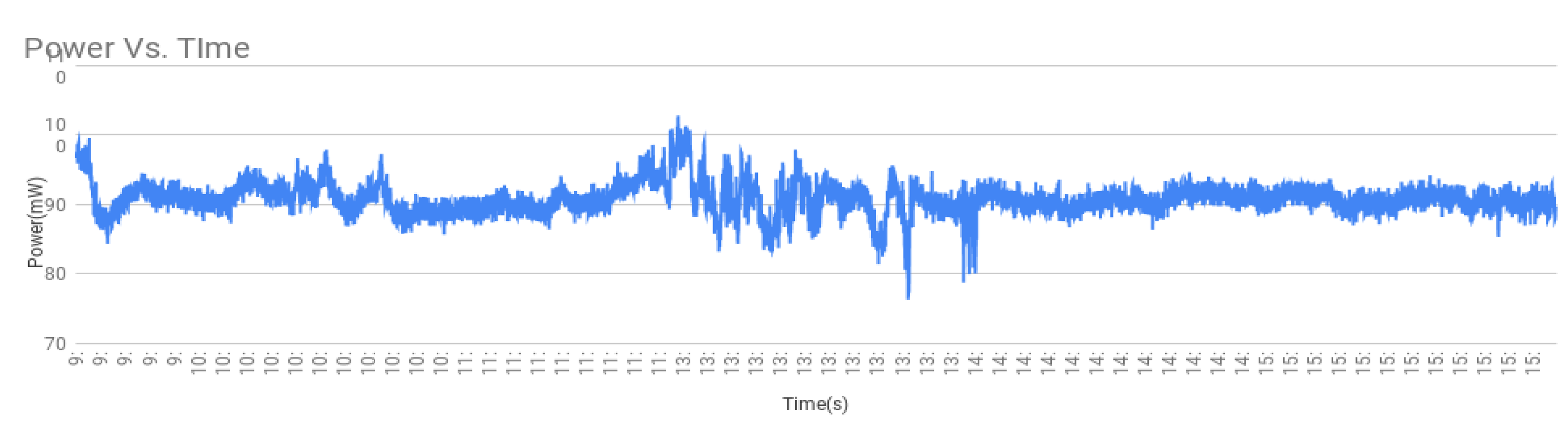

Figure 6: Partially cloudy, 470 Ω resistor, flat, 90.82 mW mean power

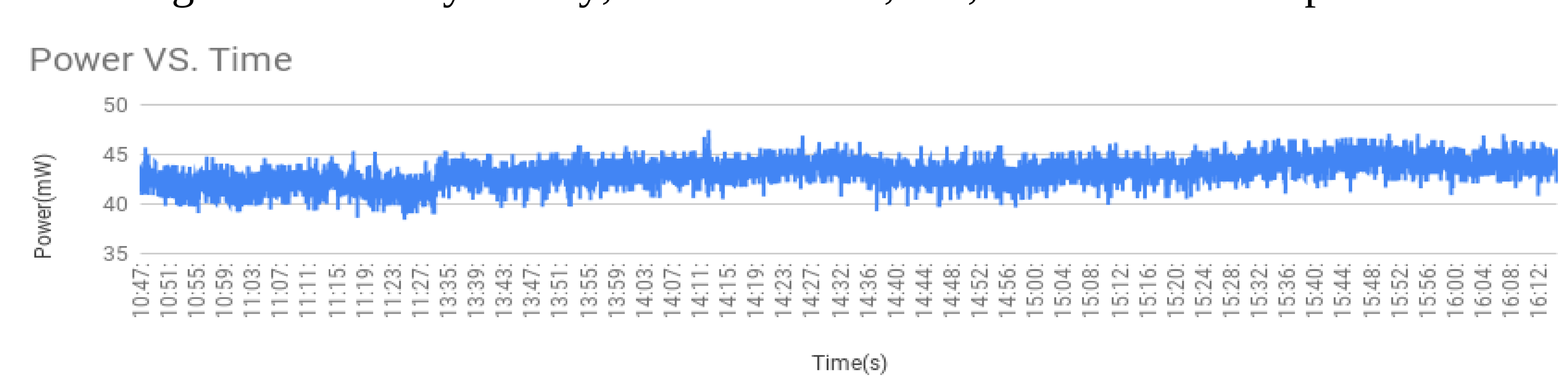

Figure 7: Sunny, 1,000 Ω resistor, flat, 43.16 mW mean power

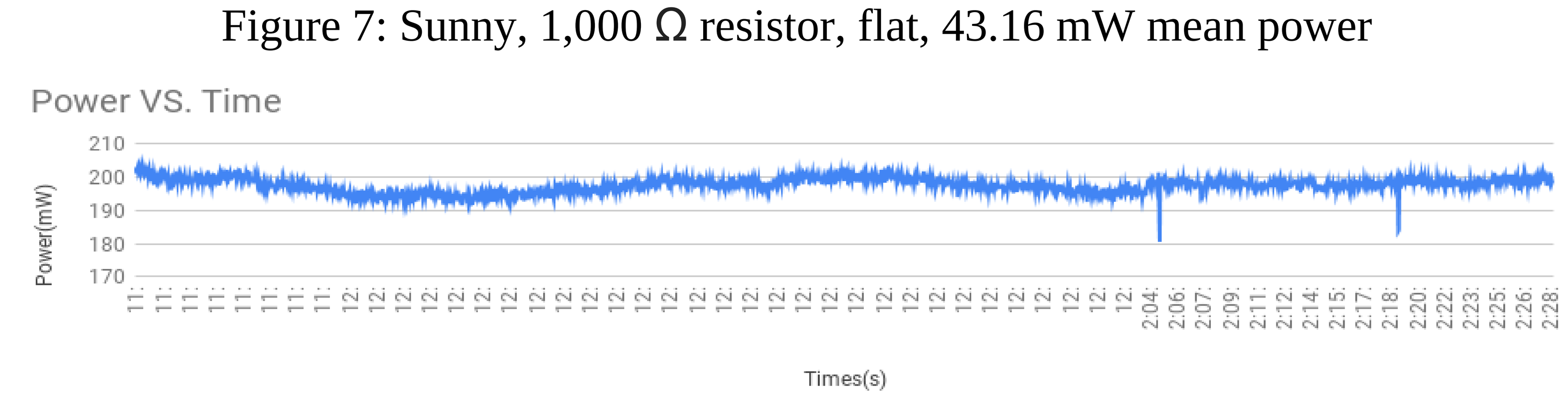

Figure 8: 220 Ω resistor, angled to be perpendicular to sun and facing the direction of the sun in the sky, 197.12 mW mean power

Results

- The current sensor used could only read data when the resistor used was between 200 Ω and 1,000 Ω. After testing multiple resistors between these two limits, we have found that the 220 Ω resistor yields the most power.
- For each resistor, there is a peak in power at approximately 12pm-1pm.
- Partially cloudy days had more periods of varied power.
- Sunny days were more consistent in power.
- For the day that we angled the panel, the power at the beginning of the hour was the highest, and as the hour went on, the power started to decrease. Despite this, the data collected was still more consistent throughout the day than when the panel was laid flat.

Challenges

- Finding an app that met our needs. Because we wanted to create graphs that showed power over time, we wanted the app to be able to give us a reading for power as well as a timestamp for when that reading was taken.
- There were days that we lost data because the app would delete hours worth of data at a time. We soon figured out that the app could only keep record of about three hours worth of data at a time, so we started uploading every hour.
- The Bluetooth device disconnecting from the app from time to time, which erased a lot of data.
- In order to keep the entire device working without it being connected to a computer, we connected it to a 9V battery to keep it going. Unfortunately, we were unable to tell how long the battery would last. As a result, there was more loss of data when the battery died. To solve this we started connecting it to a portable charger.
- Weather is a big factor that we must consider when recording, because our device isn't 100% waterproof. On days that it rained, were not able to record any data.
- Limited resources. If we were able to use three different solar panels, we would be able to compare the data more accurately.

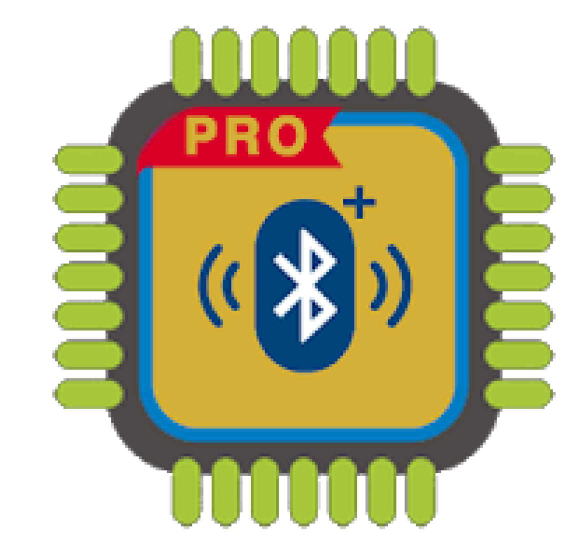

Figure 9: Logo of best app found.

Conclusion

- The 220 Ω resistor yielded the most power as shown in figure 5 with an average of 201.66 mW.
- When the LED was used in the series circuit, the power is decreased because of how much power is required for the LED light to stay turned on, which will therefore skew the data.
- Figure 8 was expected to have a larger mean than figure 5, because the panel is directly facing the sun. However, this was not reflected in the data collected. This is a good example of how data can be skewed when the day to day conditions are not exactly the same.

Acknowledgements

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