Off-grid Photovoltaic Generator

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1 Introduction

1.1 Objective

With today's increase in technological dependence, humans require power for more purposes than ever before. Some people are drifting away from the use of fossil fuels and are pursuing a greener solution. Figure_1 [1] shows how the use of renewable resources has grown over the years, meaning there are more potential users for our idea as years pass. Our project offers the user an easier way to convert to green electricity.

Many people are skeptical about switching to renewable energy due to the unfamiliarity of the tools and its capabilities. Our product will act as a development kit for customers to use in order to quantify the advantages of renewable energy.

1.2 Background

Generators have existed for a long time and are used for all sorts of purposes. Some of which include backup power for home use, Trailer/RV setups for camping/traveling, & remote power for temporary events such as festivals. However, typical generators take fossil fuels to operate and therefore require physical interaction and have a large carbon footprint. Smaller home projects such as smart gardens, sheds/workshops, dog houses and outdoor lighting usually don't require quite as much energy as some of the previously mentioned examples and therefore it is rather unreasonable to use a typical generator for these situations. The homeowner then is faced with the decision of whether they should run electricity out to the project, or run an extension cord and hope that nothing goes wrong.

Aside from this, the number of homes installing solar has steadily been rising in the past decade. One issue holding back the increase in solar homes is the cost of the PV systems.

Our solar generator offers the perfect stepping stone for wary homeowners who are considering upgrading to a full home solar system. It offers them an opportunity to go partially green and to see the capability and reliability of a PV system by watching it operate in real time via wifi access to the real time data. It also can serve as a solution for the lower energy home projects mentioned before, allowing the user to have remote monitoring and control of their chosen loads.

1.3 High-Level Requirements

- The unit must provide 200W solar power with 100Ah battery storage for use of low power appliances.
- The unit must transmit data to the user depicting the performance of the solar panels, charge of the battery & draw from the loads.
- The user must be able to control the power being supplied to the outlets & add load preferences in order to optimize the power being delivered.

2 Design

2.1 Block Diagram

As shown in Figure 2.1, this system consists of six main sections. The Solar System/Battery section will consist of the photovoltaic array connected to battery through a charge controller. The power will be fed out of the battery through a DC to AC Inverter to the Relays/Outlets section. The Relay/Outlets section will consist of two solid state relays controlling two outlets based on output from the microprocessor to implement the load balancing. The Monitoring Circuit section will contain all the circuits necessary to monitor the current battery charge, solar panel output, and the power draw the individual loads. It will then step down the readings to readable measurements for the microprocessor to use. The Microprocessor/Bluetooth section will perform all the necessary calculations to make the readings human readable then send the data to the raspberry pi via bluetooth. It will also do the necessary calculations to perform power optimization based on the users input. The Raspberry Pi and Web/UI sections will work together to act as a server storing and then displaying the measured values and take in the user input then transmit that to the microprocessor.

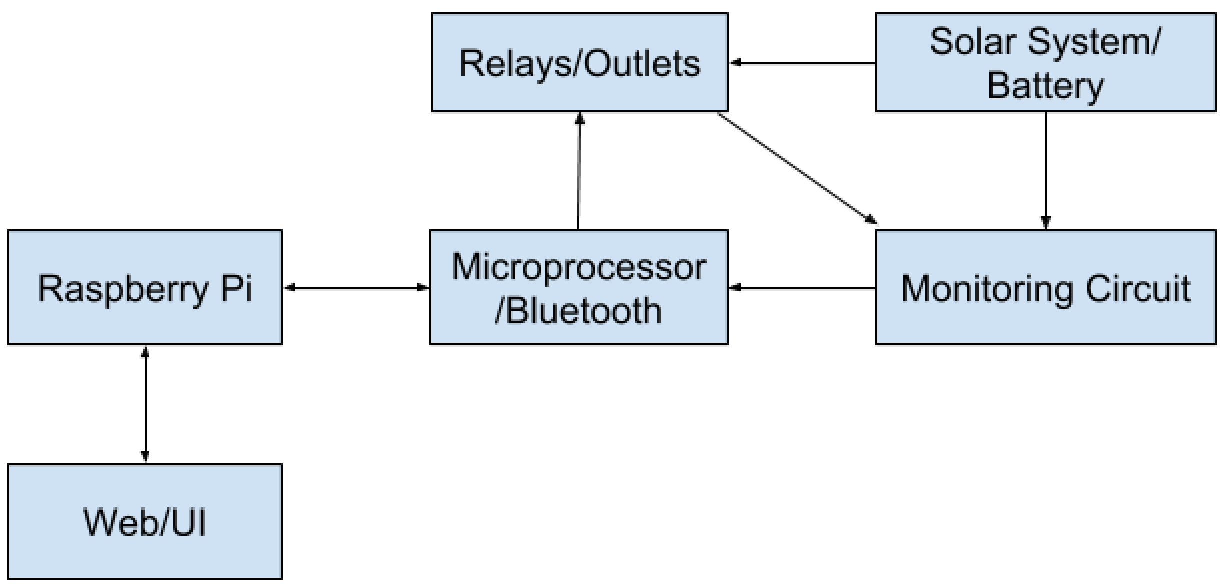

Figure 2.1: Block Diagram

2.2 Physical Design

The panels will have fold out legs to hold them up while still allowing for relocation and some portability. The main components will be housed in a large plastic container to protect against rain and snow. Inside the container we will mount the battery, charge controller, and inverter. We will also build a housing for our circuit board that will be mounted to the side of the container to keep it safe from accidental movement.

2.3 Functional Overview

2.3.1 Microprocessor/Bluetooth

This block will be entirely implemented on a group designed PCB which with house an ATmega328 microprocessor and a bluetooth module to communicate with other blocks. It will also contain the power circuit needed to take the 12v output from the battery to the 5.5v input needed to run the microprocessor and other components.

2.3.2 Solar System/Battery

The solar array will consist of 2 100W monocrystalline panels and the battery will be a 12V, ~100Ah deep cycle lead acid battery. Between the battery and the solar array, there will be a 30 amp PWM charge controller to take care of making sure the battery charges properly. Attached to the battery will be a 1000W 12VDC to 120VAC inverter that will feed to the Relays/Outlets

2.3.3 Relays/Outlets

We will have 2 outlets that will be controlled through solid state relays mounted on our group designed PCB. These relays will be controlled by the microprocessor to implement our load balancing and control what load is currently operational.

Requirement 1: The relays must be able to handle up to 120v without failure so the loads are not limited by our control circuits.

2.3.4 Monitoring Circuit

The monitoring circuit will require 2 30 amp non-invasive current AC current sensors and 1 30 amp DC current sensor. It also will require resistors, and capacitors for the current sensing circuits as well as a voltage divider circuit for safely monitoring the charge of the battery. The current sensors & their required circuitry will have direct connections or adapters on our PCB.

2.3.5 Raspberry Pi and Web/UI

These blocks will work together to collect the monitoring data output by the processor and display it. It will use bluetooth to interface with the microprocessor and collect the monitoring data then store it to be displayed in human readable format such as graphs. There will also be a user input feature that allows users to control the loads and prioritize them implemented in these blocks.

2.4 Risk Analysis

The biggest risk in the project is creating the data monitoring system. Our unit must be able to collect many data points like current and power. Since we are using such a high wattage battery we must step down the power in order to pass the data for the microprocessor so utilize.

3 Ethics and Safety

Our project will provide high wattage power that can cause some damage if misused. This is why we plan on insulating all the electronics and finding the safest placement for each component in order to reduce risk. The overall project will follow the following IEEE Code of Ethics [2].

Code 1: All of our electrical components, minus the solar panels, will will be stored in a weather proof container that will have all the dangers of high power batteries insulated.

Code 2: This code does not apply since this project is for ECE 445 and we do not have any conflicts of interests.

Code 3: We provide quantitative claims with ranges due to the variability of our idea, but plan on building and testing all of our components before finalizing product claims.

Code 4: The project is not sponsored so we will not be accepting any bribery.

Code 5: The reason for pursuing our idea is for society to have the knowledge and access to renewable energy.

Code 6: Every member of our group has successfully completed the lab safety module and all offer experience in fields required to successfully implement this idea.

Code 7: This code is satisfied by the TA's and professor's comments and criticism while helping us properly complete our project.

Code 8: Our team consist of diverse members with different backgrounds and experience who offer a unique point of view for all aspect of our project.

Code 9: The safety of everyone is always a concern for our group and we plan on creating our idea properly and following all suggested guidelines.

Code 10: Our team is motivated to achieve our goals and understand that knowledge share and skills development is required by all of us to successfully build our idea.

References

[1] “Home.” *CRYPTO News*, www.stupen.com/markets-news/the-world-set-a-new-record-for-renewable-power-in-2017-but-emissions-are-still-rising/.

[2] “IEEE Code of Ethics”, *ieee.org*, 2017. [Online]. Available: http://www.ieee.org/about/corporate/governance/p7-8.html

Figures

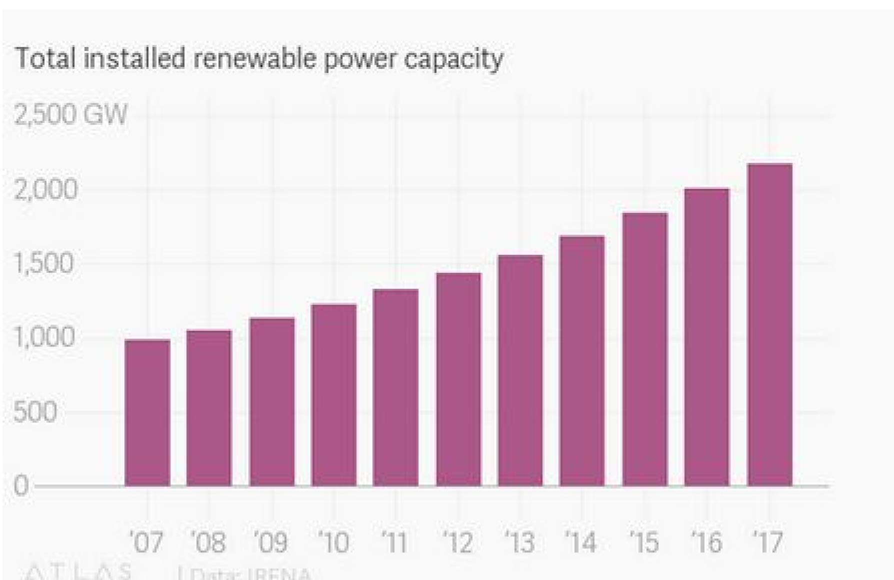

Figure_1: Growth of Renewable Power Capacity