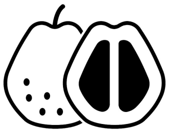
EE 396 Smart Campus Energy Lab
Weatherbox Project Final Report
Fall 2017

Team Guava



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I. Abstract

This semester, the members of team Guava are trying to implement the new Atmega1284 on a breadboard circuit with various meteorological sensors. This can be especially beneficial to the University of Hawai'i at Manoa by saving energy in ways such as turning off the air conditioning when the weather is already cool. The state of Hawaii plans to switch to 100% renewable energy sources by the year 2045. The Smart Campus Energy Lab hopes to assist this goal by working on ways to implement energy-efficient techniques and alternatives to power generation for small communities, such as the University of Hawaii at Manoa.

II. Introduction

Oahu, Hawai'i is a relatively isolated island in the middle of the Pacific Ocean. This isolation creates a significant challenge regarding energy supply and as a consequence, Hawai'i has a big dependence on oil. In fact, Hawai'i meets 85% of its energy needs by burning petroleum [1]. This leads a great threat to not only the environment, but to the community as well. This threat causes people to shift their attention to renewable energy. However, renewable energy sources are intermittent. Intermittent renewable energy sources are challenging because renewables disrupt the power grid’s operation in a number of ways. Despite this, Hawaii has a Hawaii Clean Energy Initiative (HCEI) with a goal to rely on 100% renewable energy by 2045 [1]. With this in mind, our main objective is to get data on environmental conditions that can help with forecasting of renewable energy resources.

We wanted to improve the existing weatherbox designs by integrating a new processor in the remodeled environmental sensor node. The meteorological data collected will then further assist in planning future renewable energy installations on rooftops across the University of Hawai'i at Manoa campus. We also want to maximize efficiency in our design which should also minimize the cost. The weatherbox is a small module that uses a variety of sensors (temperature, solar irradiance, humidity, and pressure) to collect reliable weather data in order to find optimal places across campus for things such as solar panels. In order to implement the desired weatherbox, this project is composed of two main components which consists of the printed circuit board (PCB) design, and the housing design.

III. Main Body

This semester, the members of team Guava worked together to implement the new Atmega1284 on a breadboard circuit with various sensors. This included finding the Atmega1284 pin assignments, bootloading the processor, and deciding on the sensors that will be used for the final product. The sensors are the BME280 pressure/temperature/humidity sensor, the GPS V3 breakout board, and the Apogee 215 solar irradiance sensor. The team then designed a schematic and PCB for the system. A prototype housing was designed for the board as well. Since this is our second semester working together as a team, we worked together on every task. More specifically, throughout the project, all team members worked on testing the sensors, Kenneth and Sawinna worked on the PCB design, Riley worked on the housing with design inputs from all team members, Riley and Kenneth did the parts order, and Kenneth and Sawinna worked on the bill of materials. Below is the Gantt chart for the Fall semester of 2017.

Figure 1: Team Guava Gantt Chart

A. PCB Design

To start creating our own printed circuit board (PCB) for our weatherbox, we started off by creating a schematic which we based off of the generic weatherbox schematic that was provided to us last semester. We first added all of the capacitors, resistors, and power sources we needed which we easily found in the Adafruit library. After downloading the Sparkfun library, we started adding more parts to our schematic such as pin headers, all while making sure that our parts were organized in a way so that we knew where each component belonged. We switched out the Atmega328P Eagle part to the Atmega1284P part. Since the Atmega1284 and 1284P are near identical, the part can be used to symbolize the 1284 in the schematic. We decided to use headers for our design instead of building the breakout directly onto our PCB. This way, we can cut down on the design phase of the project without causing any negative effects to the design. Along with our sensor headers, we added an ISCP header for bootloading the Atmega1284, as well as an FTDI header for programming. We used two voltage regulators to convert the voltage from the charging chip into a consistent 3.3 volts. One voltage regulator will go to all of the sensors, while the second voltage regulator will be dedicated to our XBee transceiver. This way, the XBee will have ample current to operate on. We added the headers for the sensors in a way where it would hang over the processor, that way we can minimize the size of the board. Four debugging LEDs were added as well as a power and bootloading LED. The physical switch is for programming the board. When programming, the switch will be turned on so that the XBee isn't connected to the RX/TX pins of the processor. After labeling all the connections properly and assigning values to elements such as resistors, we organized our schematic a bit more to include borders separating sections of our schematic and text to label the different sections (Figure 1).

Figure 2: *Eagle* Schematic

We then proceeded to create our PCB based off of our schematic and were able to come up with a board layout that minimized the trace lengths. We wanted to position the parts in a way to help minimize route lengths and complexity in order to decrease any unwanted resistance when passing through a trace. We put our XBee in the corner of our board due to the antenna and then added the other main parts such as the ATMEGA and sensors. Then we surrounded those parts with their corresponding capacitors and resistors by comparing our board to our schematic. We rotated and smashed some parts to rearrange them to make our board more efficient and compact. Talking to other 396 and 496 teams helped us make some board layout decisions such as adding a new plane for the charging chip power and minimizing plane bottlenecks throughout the board, which we wouldn’t have known otherwise. When it came to routing, we used a combination of 0.01 and 0.16 route widths across our board. We made sure not to have any right angle or ‘Y’ traces in our board and no overlap of our routes. One way we reduced our trace lengths and number of vias was by utilizing our top and bottom layers, which were 5V and ground (GND) respectively. When we finished routing our board, we ran the design rule check (DRC) and fixed any errors we had such as two routes being too close together. Lastly, we added our team name, logo, and version number to the middle of the board. In the end, we ended up with a 2.8” by 3.3” PCB (Figure 2).

Figure 3: *Eagle* Printed Circuit Board

B. Housing

For our housing design we used *Google Sketchup*, a three dimensional designing program that we previously used for our team Chocolate Cosmos weatherbox house in Spring 2017. Since we already familiarized ourselves with the modeling software last semester, we were able to make a more complex housing design for team Guava. The process also took a shorter amount of time since we had previous experience designing a weatherbox. Although still relatively simple, our housing design this semester is an improved version of the Chocolate Cosmos box shown in Figure 3. The improvements include fewer entries for water to access our box and an interior shelf to organize the contents of our weatherbox.

We started our design by making a 3”x7”x3.5” rectangular prism with .125” thick walls and with one open side facing up as shown in Figure 4. We added overhanging ledges to keep rain out and also provide a flat surface to attach the lid and solar panels to. We added 3 ventilation slits on one of the sides to increase airflow in the box to allow the batteries to cool off. To allow our antenna, which is connected to the XBee located at the bottom left corner of our PCB, to stick out from our weatherbox, we made a hole of diameter .75” on another side of our housing design. Above that circle, we made a hole of diameter .5” for the chord of the irradiance sensor. We added a shelf, shown in Figure 5, that can be easily placed in our box in order to organize the contents of our weatherbox. Our idea was that the chords would be located underneath the shelf with the PCB and batteries located on either side of the wall on top of the shelf. We created a semicircle and a circle in the shelf to allow for the chords to pass through the different compartments. Figure 6 shows the lid we made for our box which slides onto the flaps of our weatherbox. We made a hole on the lid to secure it and prevent it from slipping off which we will secure with a part that we have not made yet. This other part that we have yet to make will connect the solar panels to the lid of our housing. Due to lack of time, we were unable to finalize the preliminary housing design or do any 3D printing of our first draft of our housing. Therefore, we couldn’t test our housing design’s weather-proofing capabilities.

Figure 4: Chocolate Cosmos Housing Design

Figure 5: Outer Housing Design

Figure 6: Housing Design Shelf

Figure 7: Housing Design Lid

C. Problems Encountered

A lot of the problems that we encountered happened during the PCB designing phase. A lot of our traces weren't optimally traced. For example, the traces cut off a lot of the power plane on the PCB top layer. This would have caused multiple bottlenecks in the power signals throughout the board. We fixed this by creating relief zones where the power plane had a much wider surface area so that the voltage signal can pass through without being bottlenecked. Another problem that we encountered is that we have the incorrect voltage regulator attached to the XBee. The XBee needs at least 3.7 volts to run correctly and consistently. Instead, we misinterpreted the datasheet and thought the XBee device would be fine working with 3.3 volts. To fix this, we would need to solder on a 5 Volt regulator instead of the planned 3.3 Volt regulator.

Many of our problems were related to the PCB design because of the team's collective lack of experience with the Eagle software and the PCB designing process. However, the team learned a lot through their mistakes during the course of the designing phase of this board. With this learned information, the team will be able to create a better version of the board and apply the new techniques to fix and adjust the existing board design as needed.

D. Future Work

The team still has to print and test the PCB, as well as write the software to run the sensor module. Housing still has to be refined into a final product. Once preliminary testing and debugging has been completed, the team will use data from the board to calculate a theoretical power budget. From there, they will decide if further improvements have to be made or if the design is ready to be deployed. Some improvements to the current design include changing the working voltage from 5 Volts to 3.3 Volts, since most of the components on the board can work with 3.3 Volts.

IV. Conclusion

Throughout this project, each member in the Guava team gained practical and technical skills that we'd never experience in a classroom. We were able to practice and learn more about hardware skills and PCB designing. Team Guava was also able to apply what we learned in EE160, EE260, EE211, EE213, EE315, and EE296 into upgrading the current weatherbox model. Not only did this project improve our technical skills but also advanced each person's communication, leadership, and presentation skills. This project consisted of a total of four presentations. Throughout each presentation, each individual's public speaking skills improved. Even though we encountered some issues while improving the weatherbox, we were able to overcome each problem as a team. Although we weren't able to complete our weatherbox fully in a sense that we still need to print out our board and housing, we contributed our best effort as a team into this project this semester. We hope that we'll continue with this project next semester and make a lot of improvements on the weatherbox design.

VI. References

[1] OurWorld20. "Hawaii." *Our World*. N.p., n.d. Web. 06 May 2017. <https://ourworld.unu.edu/en/Hawaiis-clean-energy-challenge>.