Sonoma State University

Department of Engineering Science

Smart Table

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Project Web Page:
https://www.ssusmarttable.wix.com/table

Submitted to the Department of Engineering Science in partial fulfillment of the requirements for the degree of:

Bachelor of Science in Electrical Engineering

Abstract

Smart Table is an outdoor solar powered charge station, in the form of a picnic table, that also monitors and stores data of four environmental parameters: solar cell temperature, ambient temperature, light intensity, and humidity. These environmental parameters will be compared to the power production of the solar panel in the form of a visual easy-to-read graph. The optimal environment for solar panel power production is on a cool clear day with high light intensity and low relative humidity. These stored parameters will be of use to environmental studies at Sonoma State University for analysis, management, and preparing solutions of environmental issues such as emissions generated from fossil fuels. While this system is being placed on a charge station table at Sonoma State University, future productions of this system can be made to fit other renewable energy technologies or for other environments. The load of the solar panel is going to be a charge station for students, professors, professionals, and everyday people at Sonoma State University to charge their mobile devices. Portable devices such as cell phones, tablets, and laptops are limited by the charge of the batteries and often times need to be recharged. In addition the solar panel will provide rotatable shade similar to a normal shade provided picnic table. If the light intensity is low a red LED will display and tell the user to rotate the panel otherwise, a green LED will display for high intensity and a yellow for medium intensity. A personally designed and built picnic table will lay the platform for this project because it will involve the community and promote sustainable energy.

Acknowledgments

Our project would like to give special thanks to our faculty advisor, Professor Saeid Rahimi. We would also like to give thanks to the entire faculty in the Engineering Department at Sonoma State University. In addition we would like to offer special thanks to our off-grid specialist mentor and our manufacturing engineer mentor for their excellent mentorship in building the table and charge station. We also would to give thanks to Hanan Sedaghat Pisheh for offering help in building the table and charge station. We also would like to thank the people who took the time to survey our project.

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1 INTRODUCTION

Many people today walk around with a cell phone in their pocket or a laptop in their backpack. Mobile devices have become popular in modern times for communication, text messaging, emailing, weather reports, entertainment, research, school work, and social networking such as LinkedIn and Facebook. Portable devices have a limited charge and often times need to be recharged throughout the day. The Smart Table will provide a platform for students, professionals and everyday people to sit down and recharge their devices outside, in a location remote from an outlet power supply.

The goal of this project is to design and implement a Smart Table that will charge devices using green sources of energy which is environmentally friendly and will drive lower costs in energy consumption. Power will be provided to the charging station using solar energy to charge a battery. Solar energy is taking radiation from the sun and converting it into useful electrical energy. "A clean energy revolution is taking place across America, underscored by the steady expansion of the U.S. renewable energy sector (US Department of Energy). This shows that many energy consumers are considering the environment. The power supply for this project will be a Renogy Off-Grid Solar panel. The panel was selected because it features highly efficient silicon solar cells capable of providing a continuous supply of electricity, it has good performance in low light environments, and it can withstand wind (Renogy the Future of Clean Energy). [1] This will power our system, that is designed to display the temperature of the solar panel surface, the light intensity, the humidity, and the power being produced from the solar panel at the table.

The customer base is initially Sonoma State University as the table will be placed in an area on campus capable of receiving WiFi. Sonoma State has many outdoor tables but they serve no purpose other than to provide a place to sit. Students at other universities have built a solar powered charge station but it did not show any of these tables being used to power a system displaying weather information and informative information about the photovoltaic system (Illinois State University Stories: Solar Picnic Table Boosts Campus Sustainability). Sonoma State University students who study outdoors using electronic devices such as cell phones and smart tablets are limited by the charge in their device. Smart tables will eliminate this problem. After the first table has been designed and implemented, the smart systems stored information will be analyzed to expand the customer base or determine where to place more smart tables on campus. This information can also be used for environmental statistics as we are recording the light intensity and humidity. This initial table could be used as a marketing platform for national parks and corporations therefore expanding our customer base. The first step though is to design a smart table for the use of students at Sonoma State University.

There are many chances to involve the community with this project. One involvement was polling students on this project. This showed that students are interested in a toggle display of the solar cell temperature, light intensity, humidity, and power being produced. This project will also reach out to the community by laying a platform for personal use. Professor Don Estrich expressed his interest in using temperature sensors to monitor a solar powered shed he is building. We also are reaching out to the community for input on how to improve the table. Dr. Decker believes there electronic capabilities that can be used in many different ways. For example we could use electronic capabilities to help prevent vandalism of the table. Other suggestions were seat heaters and a cooler for storing water.

Many problems need to be addressed before implementation of this project such as vandalism. One simple way to solve this is by placing the smart table in a secure location on campus but this does not resolve the issue completely. An important marketing requirement is that we make the table comfortable for the user and this could be a problem if the battery under the table is not tucked away from users. In addition there are mechanical issues such as structural integrity and keeping the solar panel secure while building it above the table. Another aspect of this project is that environmental studies will be interested in data-logging the temperatures and humidity over a longitudinal study at Sonoma State to find out patterns in our climate. The data management must be efficient for this purpose. While this system is extremely useful there are many electrical designs that will be challenging such as the power storage and consumption. The placement of the solar panel is important for efficiently producing power throughout the day. The battery will be a SOLAR series 12V, 100Amp/Hr. battery which is sufficient enough for powering our sensors, microcontroller, and the charging of cell phones and tablets. A potential problem is cloudy days occurring for a long period of time and we will need to incorporate a system that ensures the battery is not over charging. With the systems that we are integrating, power consumption will be of concern if users want to use this table for larger devices than cell phones such as refrigeration. There must be a priority for charging phones because that is what this table is defined to do. If there is not enough power we need to put a priority interrupt system in place or a warning system. Another issue is environmental factors such as insects, dust, wind, rain and moisture. The smart system will need to be protected from these conditions for the system to be reliable.

Our project provides a comfortable place for students and professionals to study together. In todays society being comfortable often times incorporates technology that. Our smart table will charge devices, monitor the solar cell temperature, humidity, light intensity, and power production.

1.1 Literature Review

This project has been built before by solar teams and students at other Universities for National Parks and college campuses but this has never been designed and built by Sonoma State University students. This research shows that their projects approach is different than ours because our primary concern is making the table smart to benefit students rather than just providing a charging station. In addition we would like to make it more affordable than some of the higher price ranges listed in this table below.

1.1.1 Existing Products

Product	Price	Details
Solar Power Doc	$13,000	- Produced by Enerfusion Inc. - Used for Universities. - 110 vac 60 Hz GFCI outlets. - (4) USB Type A power outlets. [2] - High intensity LED lighting. - 235Watts power generation.
TX61U-IT	$40	- Operating voltage: 2.5V+. - Transmission range: 200 feet (60.96 m) in open space. - LCD to display temperature in Fahrenheit.
Soofa Solar Bench	$4,000+	- Provides 2 charging outlets. [3] -8 hours of charge per day.
Croatia Solar Bench	NA	- LED lights for paths at night. - Internet hot spot. [4] - Air sensors.
Mobotix M15 dual lens	$7,500+	- Wireless. - Solar powered security system. [5] - Requires only 5Watts to operate.
Solar Power Solutions	Request Quote	- Large Corporation. [6] - Government and Residential. - 240Watt Solar Panels.
Integrated Solar Design	Request Quote	- Sealed from rain and wind. [7] - Allows 15% of natural light to pass through.
GW Hatchet	$5,000	- Able to charge 23 cell phones for 31 days. - Able to charge 23 lap tops for 2 days. [8] - Charging station.
Picnic Table	$15,000	- Boost campus sustainability. [9] - Charges devices.
PHAT Energy	Request Quote	- Power used to heat water. - 345Watt solar panels. [10] - 21% efficiency

Table 1: Literature Review.

1.2 Problem Statement

Mobile electronic devices are limited by the charge in their battery. This is inconvenient because these devices are used by students, professors, professionals, and everyday people. It can be argued that being comfortable today means having a cell phone and a laptop with you. Modern society thrives with the use of electronic devices. These high-tech devices are essential for communication applications. such as GPS navigation, weather updates, face-time, emails, and social networking. Despite the importance of charged devices there is a lack of power access in remote areas and often times it is inconvenient for people to find a power outlet. Current outside tables at Sonoma State University serve to support people both socially and physically but they have no support for charging devices. It is also a problem to have an off-grid power supply that does not monitor the power production. It is important that people with remote power supplies to know if the system is functioning properly because photovoltaic systems can be affected by outside conditions. Certain weather parameters can also influence the performance of off-grid power supplies.

It is not unheard of someone turning off their device to save energy for a few hours so the device has battery life for a more critical time, such as driving in an unfamiliar area without a car charger. Buying additional charging devices adds up financially, and people still purchase these charging devices because it is inconvenient to find a power outlet at school or work. People need charged devices to take a picture of something important or make an emergency phone call. Laptops are also important because of their mobility. It carries all of the documents and tools people need to survive in college or at work. Modern technology has easy to access information, encourages innovation and creativity, improves communication, makes traveling more convenient, improves housing and lifestyle, improves entertainment, improves business production, provides more educational tools, and makes it more simple to keep in touch with old friends (Use of Technology). [**?**]AD) This emphasizes the importance of electronic devices and how them being limited by the charge in the battery is inconvenient.

Charge stations today do not tell people whether or not the system is working. The stations also lack a sensor network that can be used for environmental and photovoltaic studies. As a result many people today lack an understanding of renewable energy because most applications are not educational. By using sensors that monitor environmental conditions on solar panel production, the panel is being characterized in ways that have not been done before. Most consumers are familiar with factory specs of a given solar panels performance but this project compares how the panel works everyday for years under different conditions. This is critical for off-grid power production analysis. People who make systems that are designed to power sensors remotely need to model the panels performance over years for analytical research.

The Smart Table group firmly believes in using this platform as an education tool. Most people have heard of solar panels but have not used one themselves. This project gives students a hands on example of the green energy revolution that modern society is undergoing. It also shows students that while they are outside they can charge their electronic devices. As a results the Smart Table provides a platform to learn and grow in ways that is novel and smart. People have the ability to learn more at this table than an ordinary table on campus. With sensor systems and an increasing production of renewable technologies, consumers need to be aware of what impacts they have and they need to be able to interact with the technologies. This smart system of storing weather parameters and comparing them to the power production can be implemented in other environments for the use of testing. Other countries around the world are in need of renewable energy for everyday things that some people take for granted. Other people in different environments need to have a way of knowing what weather parameters in their environment are going to affect the performance of the off-grid system. In addition to consumers, researchers and environmental studies at Sonoma State University are interested in having data for environmental analysis. By combining a charging station and a sensor network into one fully integrated smart system this project can offer people an educational way of charging devices and it can offer photovoltaic and weather data for analysis. By adding a wireless data environment people can access our data remotely so people do not need to be at the site to view the data collected over a long period of time.

Data acquisition and the Internet of Things, IoT, are huge industries that many engineers are getting jobs in. There is a trend in technology with an estimate of seventy-five billion devices being connected to the Internet in the next five years. Our smart table will be able to pull in environmental data by using specialized sensors and then make the data accessible through the internet. By tapping into the existing power for the charge station the electronic sensor system can be powered in an efficient way. These secondary features makes the Smart Table more desireable to a wider range of people. Thus we have improved the form, fit and function of table design. The Smart Table will provide a place to gather with a small group of people and charge devices such as laptops, tablets, and cell phones. This revolutionary combination of electronics will change the way people utilize tables by providing immediate access to charging at an outdoor location. Students are currently limited to only being able to charge their devices using power grid but with the Smart Table students can remotely charge their devices with renewable energy.

1.3 Preliminary Work

Preliminary work included surverying students at Sonoma State University about the project. It also included designing and building a picnic table for the charge station. The table was designed for Sonoma State University. It contains Redwood, recycled metal, and a solar panel umbrella. Preliminary work also included testing a power simulation system.

1.3.1 Surveying

A survey was taken to help discover if this product was found useful by students and professors at Sonoma State University. It also was helpful to change a rough prototype into a revised prototype with key features that students and faculty are interested in and that still solves the problem. After interviewing and taking a survey it was discovered that people are interested in the charge station. By talking to the students it appeared many people favor studying with a group of other students and they also prefer to be outdoors if shade is provided. This was helpful to determine how many people the table should fit, how many charge ports should be provided and how to design the rooftop of the table to provide shade. It also showed that people are interested in monitoring the air quality in addition to the weather parameters already being provided for data analysis. It showed that students find the charging aspect of the table to be a top priority.

1.3.2 Table Design and Build

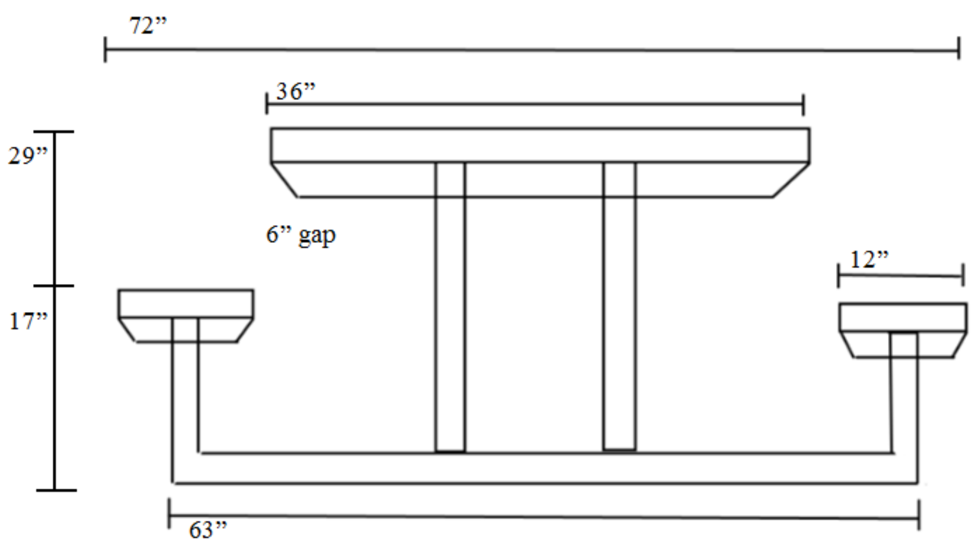

Figure 1: Table Design.

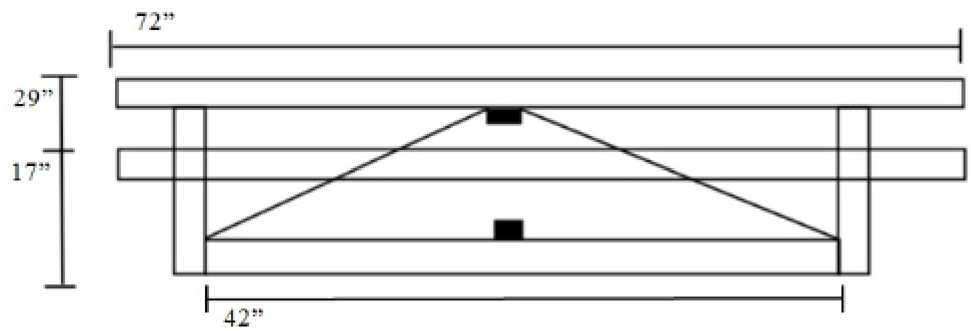

Figure 2: Table Design.

Figure 3: Building Charge Station.

1.3.3 Preliminary Testing

Testing included building a power simulation system. By inputting two voltages into a PIC microcontroller a power value can be simulated by including a known resistance value embedded in the code. This required analog to digital conversion to output a value on an LCD display. To simulate changing voltages from a solar panel two potentiometers were used. The results showed that by use of a voltage divider, the voltage from a solar panel can be inputted into the microcontroller for the use of calculating power. In this project a high side DC current sensor will be used to monitor power directly from the solar panel.

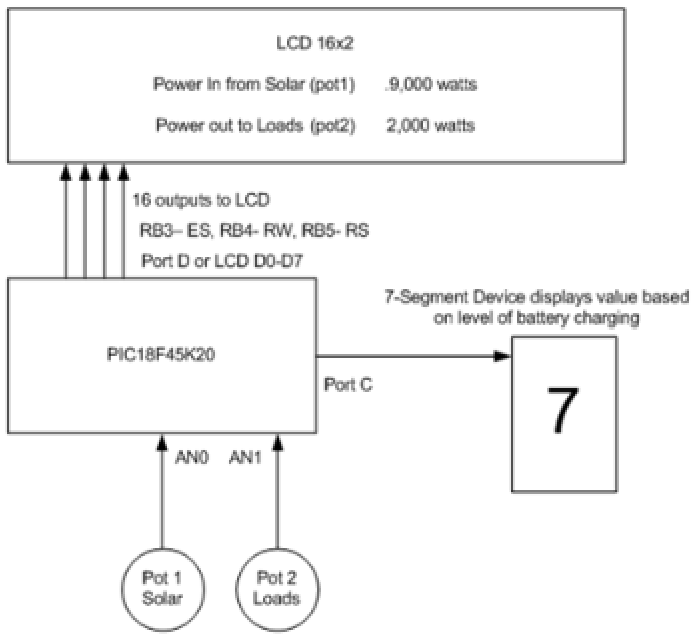

Figure 4: Monitoring Power Simulation.

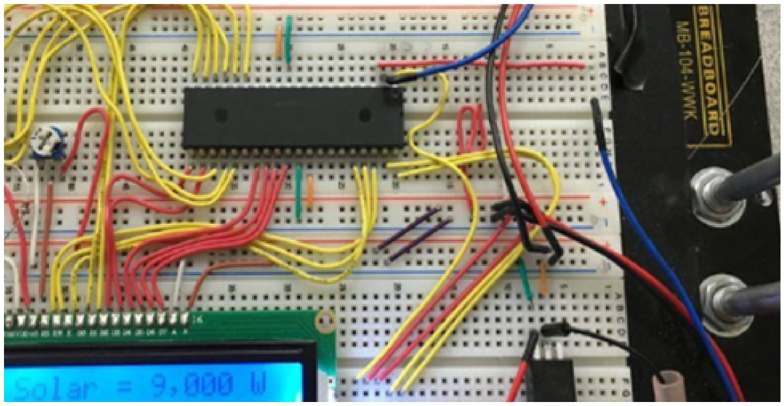

Figure 5: Results of Simulation.

1.3.4 Project Timeline

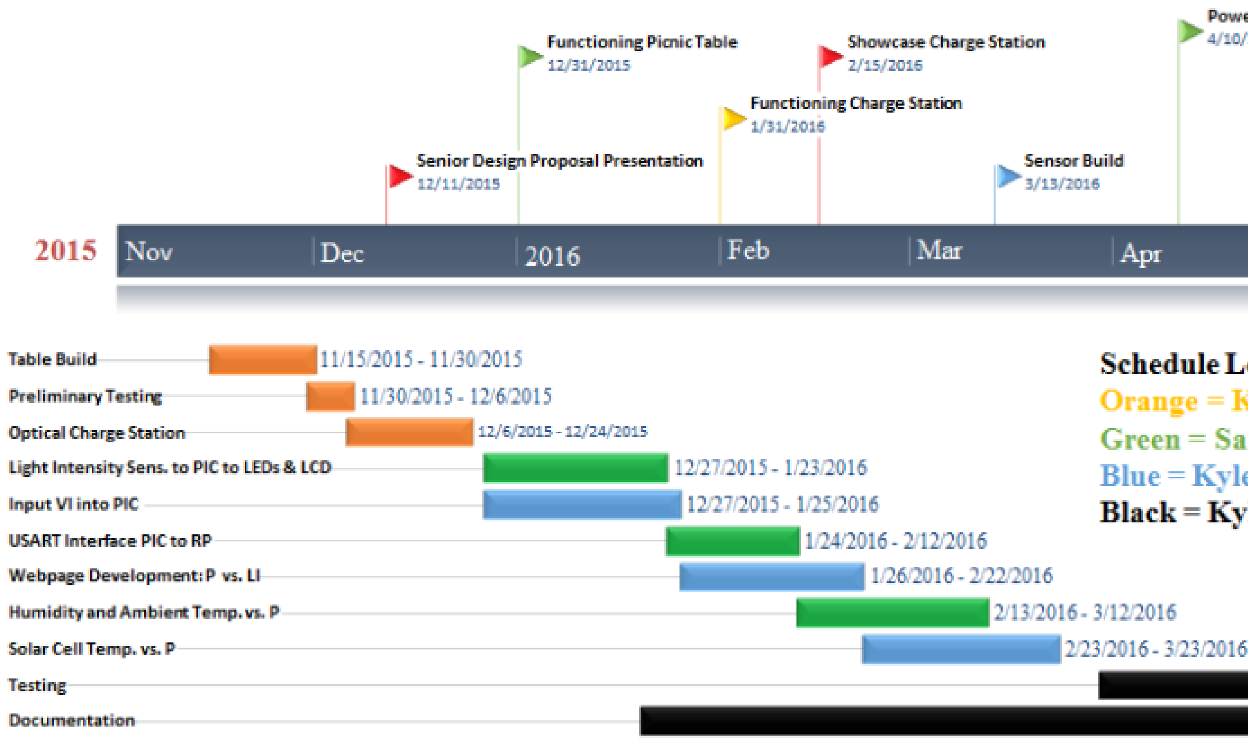

Figure 6: Project Timeline.

1.4 Budget

Budget overview:

- Table including solar panel mount: $268.86
- Electrical: $291
- Electronics: $108.82
- Estimated Cost of Project: $668.68
- SOURCE Award: $500

1.4.1 Electronics

The electronics parts are the major parts helping compare the power production of solar panel to the selected weather parameters. They include the weather sensors and a current sensor. Most of these parts were ordered from Adafruit Industries. The sensors were carefully selected to be consistent with I2C interface. The light intensity sensor selected can only support I2C, so all of the sensors must also support I2C. Most of the weather sensors are digital because of attenuation from analog to digital interface.

Part	Quantity	Unit Cost	Cost
BME280 Humidity and Ambient Temperature Sensor.	1	$19.95	$19.95
TSL2561 Digital Luminosity Sensor.	1	$5.95	$5.95
MCP9808 Surface Temperature Sensor.	1	$4.95	$4.95
INA219 High Side DC Current Sensor.	1	$9.95	$9.95
LM3671 3.3V Converter.	1	$4.95	$4.95

Table 2: Budget of Electronics.

1.4.2 Electrical

The electrical parts consists of the major parts required to build a charging station. The parts selected are durable for outside weather conditions.

Part	Quantity	Unit Cost	Cost
RNG 100D Solar Panel.	1	$137	$137 [11]
Renogy Charge Controlller.	1	$79	$79
12V Vmax battery.	1	$45	$45
Inverter.	1	$45	$45

Table 3: Budget for Electrical.

1.4.3 Table

The table parts consists of all of the major parts to build a picnic table as a platform for the charge and weather sensor station. This table was built for Sonoma State University so the table has been built to be appeasing to the eyes as well as durable to last from outside weather conditions. Recycled steel metal was used in addition to Redwood for longevity.

Part	Quantity	Unit Cost	Cost
2x12 - 8' Rdwd Con Hrt Rough	1	$29.54/board	$29.54
2x12 - 12' Rdwd Con Hrt Rough	2	$44.31/board	$88.62
Galvanized Lag Screws	20	$0.43/screw	$8.60
Galvanized Lag Screws 5/16	20	$0.17/washer	$8.60
Black Rust Oleum Protective	2 qt	$8.37/qt	$16.74
Angle Iron 1.5x1.5x1/8in.	20 ft	$21.90/20ft	$21.90
Angle Iron 1in	40 ft	$22/20ft	$44
Nuts 1/4in	12	$0.14/nut	$1.68
Bolts 1/4in x 4in	4	$0.69/bolt	$2.76
Bolts 1/4in x 1in	8	$0.23/bolt	$1.84
Washers 1/4in flat	24	$0.12/washer	$2.88
Sheet Metal	2ft x 4ft	N/A	$10
Battery Box	1	$15/box	$15

Table 4: Budget for Table.

1.5 Challenges

- Monitoring the power output of the solar panel. It will require circuitry to down step voltages before inputting these into a microcontroller.
- Designing the table and rooftop in such a manner that the photovoltaic system can be built on and the electronic wiring can be accomplished.
- We need to make sure the heat from the solar panel does not damage any of our sensors or create a liability issue.
- A key challenge with this project is vandalism.
- Understanding how much energy can be provided and for how long.
- Making a system that is reliable because people want a charging station that can charge multiple devices on efficiently. Outside environmental conditions such as rain, wind, dirt, dust, and bugs can hinder this reliability.
- Environmental conditions.
- We have to consider some mechanical issues such as being able to withstand wind because of how fragile the solar panels are. There has to be structural integrity of the bench.
- Other challenges are related to installation such as how to wire a sensor sitting on the solar panel to the microcontroller.
- UL safety certification.

1.6 Marketing Requirements

- The overall design of the table is ergonomic and good to look at.
- The charging station should enhance its environment.
- An economically friendly table that has sun shade provided to the user.
- A durable electrical and table design that is liability free.
- The charging station must be reliable.
- The station can charge devices during daylight hours.
- The charging station is able to charge cell phones and laptops.
- The station can charge more than one device at a time.
- A reasonable charge rate must be provided.
- The weather parameter display at the table must be visible in daylight conditions.
- The graph of weather parameters versus power production must be easy to read.
- The graph of the performance of the photovoltaic system is educational.
- The data must be organized in a manner for environmental studies analysis.
- The data must be over a longitudinal amount of time for the use of knowing how the photovoltaic system is performing.
- The system must be protected from weather.
- The systems that are designed for the table must have updates done throughout the year to optimize the tables efficiency and standards.
- To protect the Intellectual property of this design, a patent.
- Sonoma State University is clearly seen imprinted on the charging station.

1.7 Engineering Requirements

- The humidity, ambient temperature, solar surface temperature and light intensity all need to be digital sensors, due to the distance from the MCU. Capable of communicating over 6 feet.
- Reads the input voltage of solar panel and converts it to a 3 volt resolution scale that can be inputted to PIC18F45K20 adc for data analysis.
- Note: The light intensity sensor will be connected to the PIC18F45K20. We will be comparing the light intensity with three threshold voltages at the I2C port.
- If the light intensity is at peak operation a GREEN LED will be visible by the users at the table notifying them that the solar panel is positioned correctly.
- If the light intensity is poor, a RED LED needs to light up telling users to immediately reposition the Solar Panel to charge the battery.
- 120 Volts AC needs to accessible at the charging outlet for students to charge their devices.
- DC current from the battery needs to be converted to AC, this can be done by using an inverter.
- Data sampling must be every 5 minutes. The data being collected must include the following and display in a graph:

  Surface Temperature of Solar Panel

  Ambient Temperature

  Power produced by Solar Panel

  Humidity

  Light Intensity
- Use a PIC18F45K20 as the microcontroller.
- Temperature, light intensity and humidity sensors must operate at 3.3V.
- Raspberry Pi needs to have a low power Wi-Fi dongle to communicate to the Internet
- Rugged and weather proof design.
- LCD Display for users to see sensor data at table location. This is interfaced with the Raspberry Pi.
- LCD display from the PIC to let users know that the table needs to be rotated.

2 HARDWARE DESIGN

2.1 Methodology

This project has been divided into three main phases: electrical, electronics, and webpage development. In the electrical phase the charging station will be built and in the electonic phase weather parameters will be compared to power production. In phase three of the project there will be a a grahpical display for users.

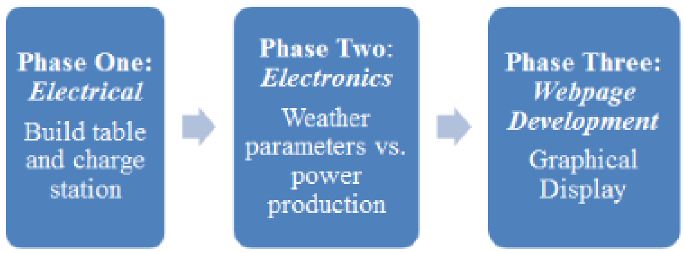

Figure 7: Project Phase Overview.

2.2 Power vs. Weather Parameter Design

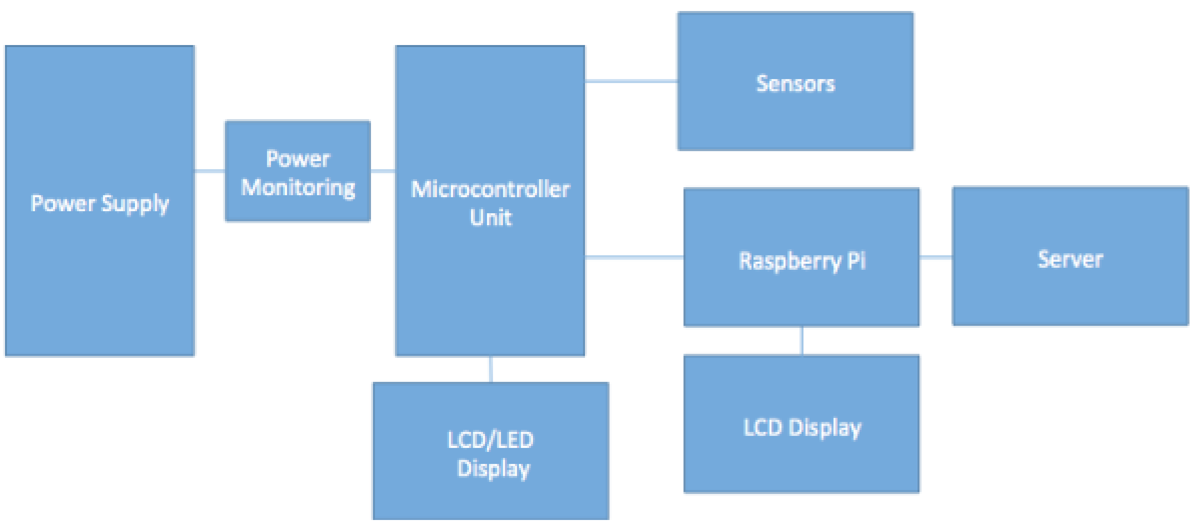

Figure 8: Project Overview.

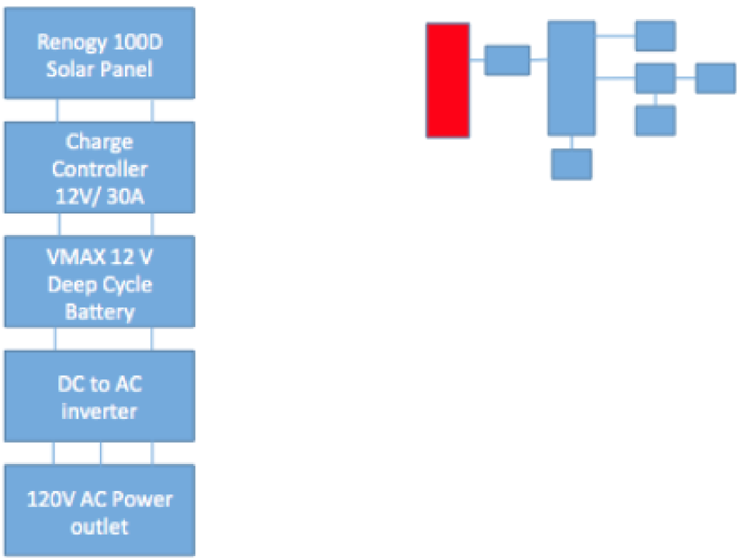

Figure 9: Electrical Design.

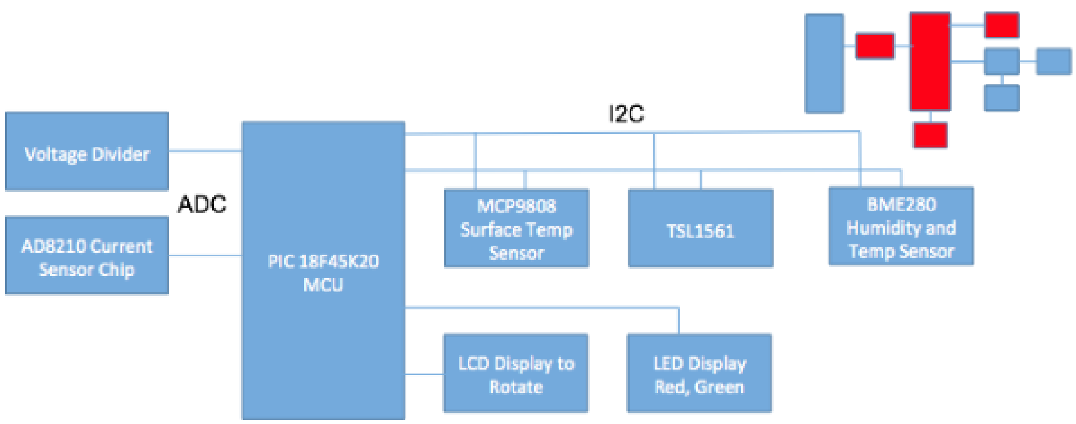

Figure 10: Sensor Unit.

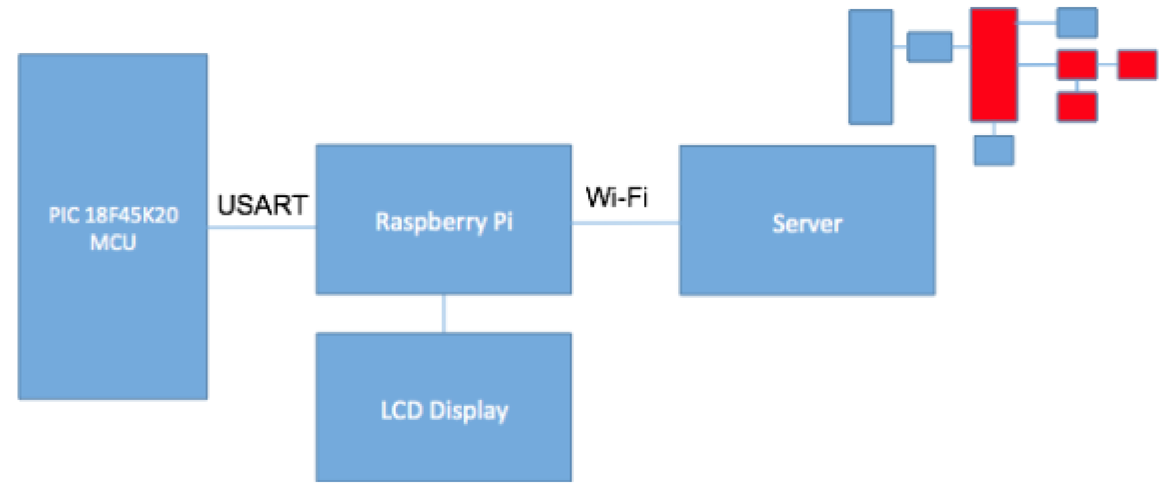

Figure 11: Networking Unit.

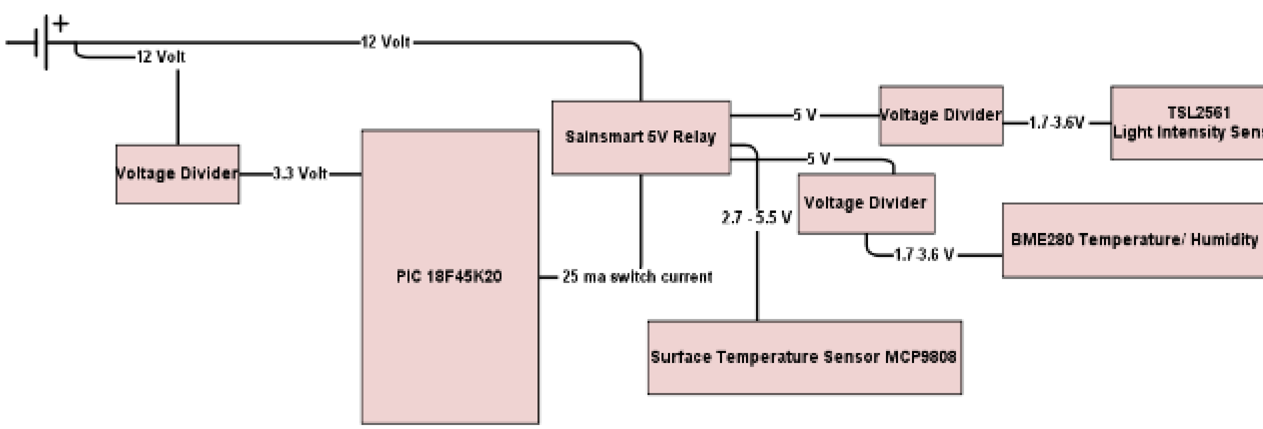

Figure 12: Power Distribution.

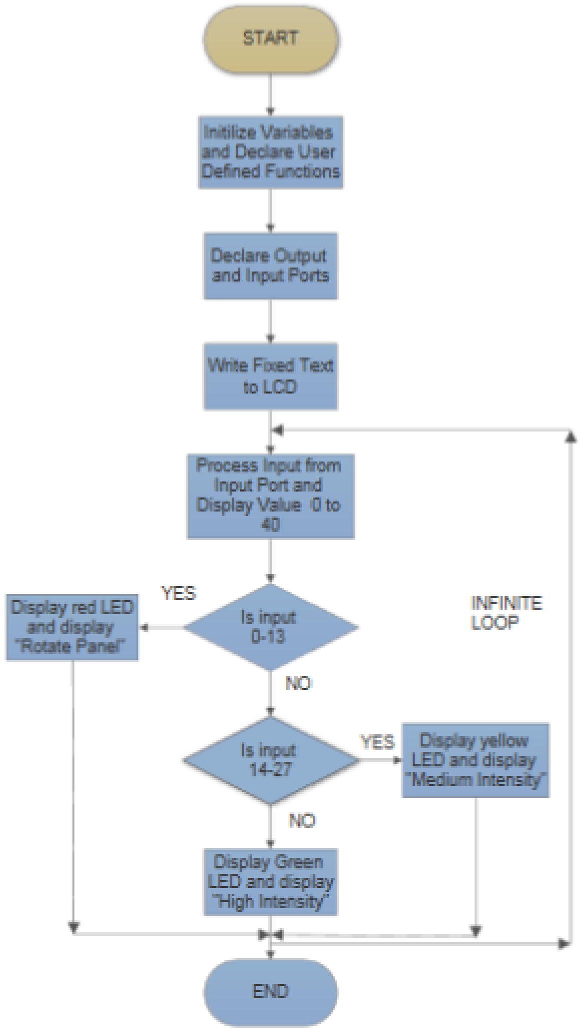

Figure 13: Light Intensity Flow Chart.

2.3 Funding and Support

This project received financial funding from the SOURCE Award in the amount of $500. This support enabled the initial phase of this project, getting the table built, to be completed by November. By getting the initial phase done before the Spring semester we are able to execute the rest of the steps on the projects timeline. In addition this financial support is funding required components from all phases of the project. It also permitted higher quality materials which is important for a long lasting product that the community of Sonoma State University can enjoy using.

Support was also offered from the client, Saeid Rahimi, for the solar panel, battery, and charge controller.

2.3.1 Supporting Courses

- CS115 Programming
- ES310 Microcontrollers
- ES465 Networking
- ES445 Photonics

2.3.2 SRJC Students

The Smart Table group is looking to receive help on the project from students attending Santa Rosa Junior College, SRJC. SRJC students can help this project by adding additional secondary functionalities to the table. In addition they can help by assisting monitoring the power production of the solar panel. The Smart Table team is looking for students who have the following qualities

- Works well on a team.
- Takes on challenges and can yield positive results.
- Basic understanding of electrical engineering principles.
- Good communication.
- Preferred computer programming skills in any programming language.

2.3.3 Special Thanks

Our project would like to give special thanks to our faculty advisor, Professor Saeid Rahimi. We would also like to give thanks to the entire faculty in the Engineering Department at Sonoma State University. In addition we would like to offer special thanks to our off-grid specialist mentor and our manufacturing engineer mentor for their excellent mentorship in building the table and charge station. We also would to give thanks to Hanan Sedaghat Pisheh for offering help in building the table and charge station. We also would like to thank the people who took the time to survey our project.

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