2^{nd} Generation Charging Station

By
Jasem Alhabashy, Riyadh Alzahrani, Brandon Gabrelcik,
Ryan Murphy and Ruben Villezcas

Team 13

Problem Definition and Project Plan
Document

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Department of Mechanical Engineering
Northern Arizona University
Flagstaff, AZ 86011

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1.0 Clients:

For this Capstone project, there are two main clients but only one that we will be answering to directly.

1.1 NAU Green Fund

The NAU Green Fund is an organization that provides funding for projects that reduce NAU's negative impact on the environment and aides in creating a culture of sustainability on campus. Green Fund sponsored the Capstone project last year by funding $1600 for the 2nd Generation Charging Bike. This year we are not contacting them directly over customer needs but are still using parts and products purchased with their funding.

1.2 Srinivas Kosaraju, Ph.D.

Dr. Kosaraju is our direct client for this project. He is the person who will be answering any questions regarding the customer requirements for the project.

2.0 Customer Needs:

The 2nd Generation Bicycle Charging Station needs to be mobile, user-friendly, and obviously able to charge most small electronic devices. The team aims to make the charging station easy to use and understandable for all users. The current design has not yet been completed, so the team has been asked to finish as well as improve new charging station. The team is required to design a control system that has the ability to power a touch screen display and also deliver required power to the user's electronic devices. Team 13 is aiming to make the 2nd Generation Bicycle Charging Station more popular and interactive than the original 1st generation station.

3.0 Project Goal:

Our team's goal for this project is to complete and improve the 2nd Generation Bicycle charging system. The capstone team of 2013-1014 did not complete the project so we must to complete the station while also making additional improvements to the station. The 2013-2014 capstone team were able to complete the configuration of bike and also installed a generator but they could not produce a working control system with an interactive display. Our team will work on designing a control system that can power a touch screen display as well as charging an energy storage system that will deliver required power to charge small electronic devices such as iPhones, Androids, and Tablets.

4.0 Objectives:

4.1 The bike should be able to power to small devices:

Our aim is to enable the bike to supply power to charge small electronics such as mobile phones and tablets. The charging should be able to power small or average sized laptops when plugged in.

4.2 The touch screen should be able to sustain heavy use:

Since the aim of the project is to make this charging system user friendly for all ages. The touch screen that we install must be able to sustain heavy usage over long periods of time.

4.3 The bike should be durable and reliable:

The 2^{nd} Generation Charging Station must require little to no routine maintenance to stay operational. This means parts need to be made out of strong material and there must be no bugs or flaws that may cause the station to break down or become non-operational.

4.4 The bike should have an efficient energy storage system:

The bike requires and adequate energy storage system. This allows the control system to pull power from a stable, non-fluctuating energy source. This also creates a buffer zone between the generator and electronic devices, preventing any unwanted high power surges going into the sensitive electronics.

4.5 The control system should be inexpensive:

Since we are the second team to be working on this project, most of our funding has already been spent. This means that we must first utilize all of the parts and pieces already last year by the previous team. This will keep our budget to a bare minimum.

4.6 The system should look aesthetically pleasing:

Since this project is aimed at the main public, the charging station must look friendly and not confusing or complicated so that all walks of like will want to use it. This means that it must appealing to the eyes and should not show too much of the complicated internals unless when shown for learning purposes.

5.0 Constraints:

Constraints will be useful for the engineering design process since it confines the problem with limitations. These limitations and restrictions capture what is allowed and what must be accomplished. The following focus points represent the constraints for this project:

1. The charging station must be capable of charging electronic devices
2. It must be mobile and transported easily around campus to be used in various buildings and for different events.
3. The power output information must be displayed in an easy to understand and educational manner.
4. It must contain an interactive touch screen display that shows:
    1. Power generated
    2. Power used
    3. Calories lost
    4. Distance traveled
    5. Total power generated over lifetime of the charging station

For the first constraint, the charging station will be able to charge different electronic devices and different brands of devices. For example, the station must be able to charge the newer iPhone, Samsung, and Laptop models. It is important to make the charging station practical with the technology that is currently out there. Ideally, the charging station should be able to supply up to 100 Watts of power with a standard voltage of 19V. This quantity will be enough power to charge and run most laptops that are low on battery. The second constraint has already been provided for the team from the previous year. The rear of the bike has a stand that can be used to keep the bike stationary or moveable when the stand is pivoted upwards and locked into place. As for the third constraint, the power output must be easy for users to understand. It also should be educational in providing useful information suggested in the fourth constraint. The interactive touch screen should display the power generated for single and lifetime use, power used, calories lost, and distance traveled. Quantifying these values will require the use of algorithms within the code of the interactive display. The power will be evaluated through testing while the distance traveled and calorie lost will be calculated by the speed and circumference of the bike’s tires. These interactive display constraints are set into place to guarantee that the customer’s needs are not only met, but also to cause users to be interested and enjoy the charging station.

6.0 Testing Environment:

There are two different types of testing environments that will be used to analyze our charging station. We will be conducting tests to find the maximum power output of the station as well as the average power output. Other tests will be conducted to analyze the durability and reliability of the system.

6.1 Laboratory Experiment

For the laboratory experiment, we will plug in the outputs of the charging station into multimeters that will test voltage, amperage, and wattage. The charging station will also be plugged into a computer that will log the power output overtime, calculating the oscillations as well as the mean power output of the generator.

6.2 Field Test

For the Field Test, we will be testing the charging station in the real world environment. This will be done by riding the bicycle around campus to test its mobility. Volunteers will also be asked to use the station to charge their small electronic devices. This test will analyze how user friendly the interactive display screen is. It will also analyze how comfortable the station is when using it. After multiple volunteers have used the station, the bike will be analyzed to find if there were any damages done due to the heavy or continued use. The findings will be used to make the station low-maintenance with very few repairs needed.

7.0 Quality Function Deployment (QFD)

A QFD is a method of transforming qualitative user demands into quantitative parameters. It is designed to help planners focus on characteristics of a new or existing product or service from the viewpoints of technology-development needs. It is then turned into a table where it can be understood and analyzed with relative ease. Here is the QFD designed for out project, Table 1.

Table 1

Legend:
1 = Weak
2 = Moderate
3 = Strong

Customer Requirements	Importance	Weight	Power Output	Cost	Maintenance	Accuracy
Accessibility/Ease of Use	7	1		1	1	
Interactive Display	10	1		3	1	2
Power Generation	10	2		2	2	3
AC Power Capability	6	1	2	1	1	1
Mobility	7	1		1		
Aesthetic Design	8			1		
Multiple Charging Outputs	7			2		2
Power Storage System	9	1		3	3	3
Output Displays	10		1		1	3
	Score:	59	22	119	80	127
	Relative Weight:	14%	5%	29%	20%	31%
	Units of Measure:	lbs	Watts	$	Hours	% error

8.0 S.O.T.A Research:

The 2nd generation bike needs a control system with interactive display and an energy storing device. Currently, the team has two computers/microcontrollers at their disposal. The Raspberry Pi and the Arduino. The bicycle also needs some sort of capacitor to draw energy from.

The Raspberry Pi and the Arduino are two small computer boards that are capable of running just like a computer would. The websites offer their respective operating systems for the devices as a free download. The Raspberry Pi offers the *New Out Of the Box Software* or NOOBS. The Arduino software is *Arduino* IDE. In order to run commands, the devices must be programmed. The Raspberry Pi uses Python. Python is a programming language. The Arduino uses C++ as a default programming language.

Both languages have textbooks that teach a beginner how to program. These books make it easy for someone to learn the language. Another place to find help with the language are C++ and Python websites. They offer free pdf files of how to start coding their language. Using these sources, the team will learn how to code the chosen device.

In order for the bicycle to draw energy it needs an energy storage device. For this, something like a lithium ion battery or a super capacitor can be useful. A super capacitor has a long cycle life compared to other batteries. According to *Battery University*, it can last about 10-15 years in an automobile. This makes it a viable choice for a capacitor in the 2nd generation bicycle. Another option is the lithium ion batteries. Even though they have a low life cycle relative to super capacitors (about 5 years), they do have a high discharge time and are dense batteries. This means they can hold a bigger charge.

8.1 S.O.T.A Research References:

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[4] Payne, James, Beginning Python 3.0 : Using Python 2.6 and Python 3.1, 1st. ed. Indianapolis: Wiley, 2010.

[5] Yosifovich, Pavel, Mastering Windows 8 C++ App Development, 1st ed. Birmingham: Packt Publishing, 2013.

[6] BU-209: Supercapacitor, Battery University, [online] 2014, http://batteryuniversity.com/learn/article/whats_the_role_of_the_supercapacitor (Accessed: 26 September 2014).

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9.0 Project Planning:

Our team chose to use Gantt Project Software to organize our deadlines and project planning. This has made it much easier to visualize and understand with just a quick glance at the chart. On the following page is a screen shot of our current Gantt chart timeline separated into two pieces for easier readability

Name	Begin date	End date
Project Assessment	9/10/14	9/19/14
SOTA (State of The Art) Research	9/10/14	9/19/14
Previous Project Analysis	9/10/14	9/19/14
Presentation #1	9/17/14	9/17/14
Report #1	9/19/14	9/19/14
Concept Generation	9/19/14	10/17/14
Hardware and Electronics Selection	9/19/14	10/8/14
Coding Research	9/19/14	10/17/14
Presentation #2	10/15/14	10/15/14
Report #2	10/17/14	10/17/14
Engineering Analysis	10/17/14	11/12/14
Coding	10/17/14	11/7/14
Control System	10/17/14	11/7/14
Electrical Efficiency Analysis	10/17/14	11/12/14
Presentation #3	11/12/14	11/12/14
Report #3	11/14/14	11/14/14
Project Proposal	11/14/14	12/3/14
Project Finalization	11/14/14	12/3/14
Final Presentation	12/3/14	12/3/14
Final Report	12/5/14	12/5/14

Figure 1

As you can see in Figure 1, the timeline is broken up into four main categories. They are as follows; Project Assessment, Concept Generalization, Engineering Analysis and Project Proposal. Each section contains its own milestones which are deadlines determined by the capstone professor. Each section has a presentation and a report milestone that is due near the end of the section time period.

Figure 2 seen below represents the visual aspect of the Gantt Chart. The black brackets represent the four sections described above. The colored bars represent different priorities that need to be met during each of the four sections. The small black diamonds represent the deadlines or milestones and as you can see there are two for each of the sections.

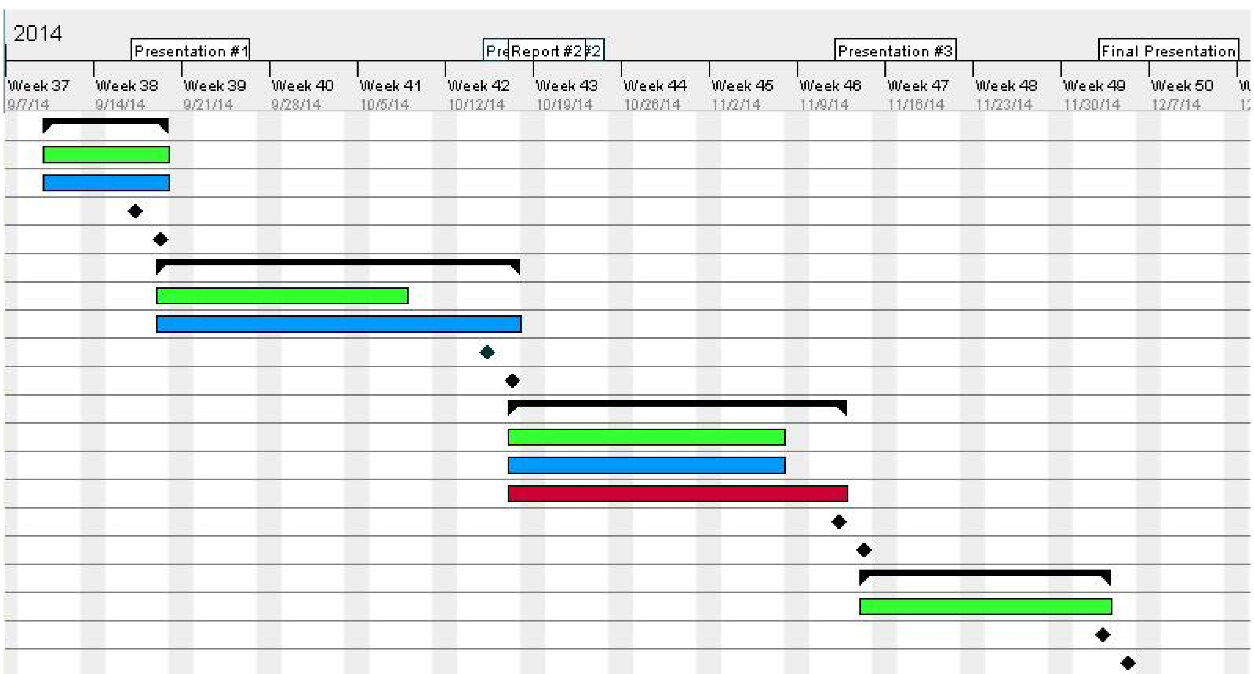

Figure 2

10.0 Conclusion:

In conclusion, the needs of the customer are for the 2nd Generation Charging Station to be a "New and Improved" version of the 1st Generation Charging Station. This means that the project needs to possess mobility, which was lacking in the previous generation, and it also needs an interactive display that is user friendly for all ages. Our main constraints come from making sure the station outputs an adequate amount of power capable of charging the majority of small electronic devices as well as making the station functional so that all types of people, big or small, old or young, will be able to use and learn from the design.