2nd Generation Charging Station

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Team 13

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Document

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1.0 Introduction

The goal of our capstone project is to improve and complete the 2nd Generation Recharging Bicycle originally started from last year's capstone team. The objectives for this year's project are to design and build an electric control system, an interactive display screen, an enclosure, and a generator mounting system. In this final report, we will discuss topics ranging from all the way to the beginning of the school semester. An additional design concept was also added into our design which is the generator mounting system. Similar procedures like the rest of the concept designs were carried out including the decision matrix and final design summary.

2.0 Customer Needs

The 2nd Generation Bicycle Charging Station needs to be mobile, user-friendly, and capable of charging almost all 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 the new charging station. The team is required to design a control system that has the ability to power an interactive screen display as well as deliver the required power to the user's electronic devices. Our team is aiming to make the 2nd Generation Bicycle Charging Station more popular and interactive than the original 1st generation.

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

Below are in depth explanations on the objectives defined for this design project.

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 display 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 2nd Generation Charging Station must require little to no routine maintenance to stay operational. This means parts must 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 may have 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 which should display the following:
    1. Present Power Generated
    2. Power Generated over Time
    3. CO_2 Emissions Avoided
    4. Cost or Price of Power Generated

For the first constraint, the charging station must be capable of charging different electronic devices as well as different brands of devices. For example, the station must be able to charge the newer Apple, Samsung, and HTC 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 120VAC (Alternating Current). 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 but we have decided to scrap the design due to its flaws and come up with a new concept. As for the third constraint, the power output display 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 Concept Generation

The team has been asked to complete and improve the charging station since the current design has not yet been completed. Every engineering design should have ideas and steps, and this is called concept generation.

The concept generation is when a product development team comes up with conceptual ideas and designs, and is the most critical step in the engineering design process. The team has divided the concept generation into three categories which are Electric Control System, Interactive Display Screen, and Enclosure.

The electric control system must convert mechanical energy from the user into usable electricity and it must store unused electricity for later use as well as power the interactive display screen. The team has also developed some designs that will convert DC electricity to AC electricity for AC required devices and this feature may be utilized to charge devices such as laptops.

The second concept generation category is the Interactive Display Screen. It has to be capable of displaying generated power, calories lost, total distance traveled, as well as time duration. The interactive display screen needs to be easy to use so that it is user-friendly for all types of audiences. It must also be educational so that it can be used as a tool for teaching younger generations. This can be done by showing certain data outputs on a colorful graph over time. This will show the fluctuations in power and velocity as the rider slows and speeds up their peddling.

The third concept generation category is Enclosure which must house and protect the electric control system from any possible damage. For aesthetic purposes, the enclosure must also hide any loose wires they may not look appealing to the eye. It should also be built of a thin material or lightweight material to keep the gross weight of the bike to a minimum. One of the most important properties of the enclosure is to keep any water or outside moisture from seeping into the housing which could cause components of the electric control system to malfunction or even break down entirely.

7.1 Electric Control System

One component to the overall system is an electric control system. This electric control system will transfer power to the electronic devices and will also provide power to the interactive display.

7.2 Interactive Display Screen

Another important component to the system is the interactive display. The interactive display will show the user useful insight such as amount of power generated, calories lost, and distance traveled.

7.3 Enclosure

The final component is the enclosure on the bike. The enclosure will be the casing and protection of the wiring and electronic components. The enclosure should house the components in a way that will provide excellent protection so that the electronic parts last long.

7.4 Generator Mounting System (NEW)

The new design concept introduced during the last presentation is the Generator Mounting System. This design houses the generator during both charging and transportation modes. It will also be responsible for adjusting the tire to be of the floor when it is being operated, similar to a bicycle stand. The reason we decided to go with a new design it due to the significant flaws found in last year's design. Also weight reduction was needed for the previous year's bike stand to bring down the total weight of the bike.

7.4.1 Decision Matrix

Below is the decision matrix comparing both the previous year's design and the new proposed design. This tool was used to determine if a new design was necessary for the charging station.

New Section: Generator Mounting System		Criterias:					
		Cost/Expenses:	Efficiency:	Ease of Build:	Weight:	Reliability:	Total Score:
Designs:	Weighted Score:	1	1.5	1.5	3	3	10
	Current Design:	5	6	9	5	6	60.5
	Proposed External Mounting System:	8	9	7	9	9	86

Figure 1- Mounting System Decision Matrix

7.4.2 Final Design Summary

From the Decision Matrix, you can see that the chosen design was the External Mounting System. This design looks similar to a bicycle stand except it has a generator attached near the back of the rear wheel. There will be a gear on the generator that will make contact with the tire via a swiveling device that will allow it to engage and disengage. The entire stand will also be able to spin up above the tire and lock into place for transportation

8.0 Engineering Analysis

Below are brief explanations or the proposed designs that will be used for this project. It will consist of some engineering data in regards to specifications but will not contain experimental data from testing which will be done next semester.

8.1 Electric Control System

The electric control system's main goal is to turn mechanical energy from the pedaling of the rider into usable electrical energy. This is what will provide power for charging the rider's electronic devices as well as power the interactive display. The system will be made up of three main components: alternator, capacitor, and the inverter. The alternator will convert the mechanical energy and send it to the capacitor. The capacitor will then regulate the power and transfer it to the car usb chargers and the small inverter. The car charger will convert the 12VDC electricity into 5VDC which will then be used to charge the small electric devices. The inverter will convert the electricity to 120VAC current that can then be used to power devices that would normally plug into an average household outlet.

8.2 Interactive Display Screen

The interactive display screen will be how the rider views all of the data coming from the sensors on the bike. It will give the rider charts of power output over time, digital gauges displaying the real time voltage, and wattage and current output coming from the charging station. We propose a design where the power outputs at different locations on the bike are measured by sensors and can each be accessed via the interactive display screen. The screen will also be durable and user friendly for the rider so that they can quickly understand how to use it.

8.3 (IDS) Alternative Design

An alternative design idea for the interactive display screen is the Wireless Home Power Electric Meter. It is a small illuminated display screen that displays several different data values. Some of the possible values are power produced directly, power produced overtime, money saved, and CO_2 emissions avoided. It can display several values desired for our project. The downside is that it is not touch screen and there is no type of interaction. It receives all data from a wireless transmitter that attaches directly to the power cables.

8.4 Enclosure

The enclosure will be the section of the design that houses and protects all of the components in the electric control system. It must be large enough to fit all of the parts inside while also not obstructing the rider from operating the charging station. The enclosure must also have a built in system that keeps the internal temperature of the housing at a low operating temperature. All of these requirements must be met while still maintaining a waterproof structure to prevent the electric components from getting wet.

8.5 Generator Mounting System (NEW)

The purpose of replacing the old mounting system is to reduce the weight and to make it more user friendly when transporting the bike. Instead of making the mounting system out of steel, like the previous design, the system will be made out of aluminum. Also, the alternator will be attached to the mounting system to provide a higher gear ratio, 25:1 to 30:1, which will allow people to charge their electronics at a slower pedaling pace. Anywhere in this gear ratio range, people will be able to reach enough RPM's for the alternator to function properly. It is important to attach the alternator in a way that supports the alternator and belt during time of operation and down time. Reliability must be high when multiple individuals with different weights will be using the system. The mounting system should look aesthetically pleasing and maintain a similar theme to the entire bike system. It should also avoid any interference with the rider so that the rider is not uncomfortable or unable to pedal the bike. Lastly, a pivot system will be added to allow the alternator to engage and disengage when needed.

9.0 Bill of Materials

The table below represents the bill of materials for the overall project. As parts are ordered costs may vary slightly depending on if the materials work to the teams' standards, however, the estimated cost should stay around $500.

Description of Material	Cost
New Car Alternator	$76.99
2 Farad Audio Capacitor	$43.96
400 Watt Inverter	$26.65
Terminal Block	$4.45
Treated Plywood Material and Clear Coating	$47.00
Wire and Terminal Clips	$12.00
Google Nexus 7	$199.00
Ventilation Fan and Filtration Material	$12.00
External Mounting System Material	$75.00
TOTAL:	**$497.05**

Figure 2 - Cost of Materials

The following pie chart represents the component cost breakdown for the project. This provides the team with an understanding of where costs are primarily being spent.

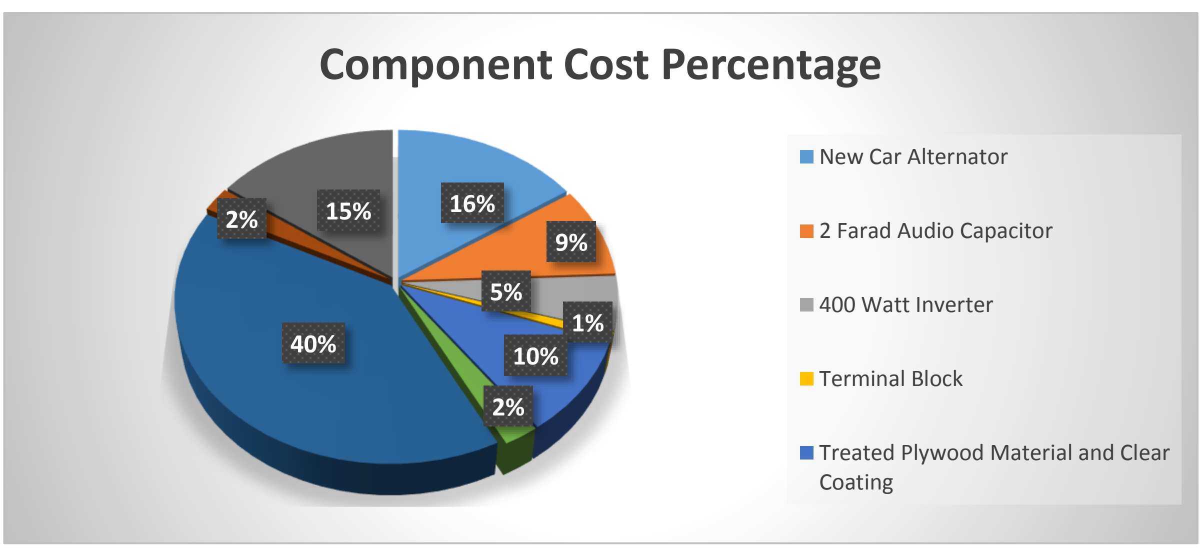

Figure 3 - Component Pie Chart

10.0 Fabrication and Testing

The fabrication will consist of making the bike stand, the enclosure and the display stand. The bike stand will be made of aluminum to be lightweight. The bike stand will have the alternator attached. The alternator (as seen in figure?) will be on the outside of the tire. When not in use, the stand can be removed easily or flipped up into a locking position. The enclosure and the display stand will both be made from treated plywood.

All of the manufacturing of these parts will be done by the team in the machine shop at NAU campus. This will mean that there are no third party manufacturing for this project. For that reason, there will be no manufacturing cost. However, there will be a time log of all of the manufacturing to estimate man-hours.

For testing, the team will use engineering building resources. In order to test voltage outputs from the alternator, a load bank will be used from the Electrical Engineering resources. Any coding can be tested using NAU servers which have LabVIEW downloaded. Again, no third party resources will be used for testing.

11.0 Conclusion

In conclusion, this year's capstone team will be doing a complete redesign of last year's attempt at the 2nd Generation Charging Bicycle Station. The electric control system, interactive display screen, enclosure, and generator mounting system will be built from the ground up with little input or cross compatibility with last year's design. This was done after noting the major flaws in the previous design and comparing the cost and complications of solving all of the flaws compared to redesigning the bike altogether. This year's team has designed a simple and easy to build charging station that will contain little to no build problems while still accomplishing all goals defined in the objectives and constraints