Second Generation Bicycle Charging Station

By

Jonathan Jerome, Michael Klinefelter, Connor Kroneberger, Kori Molever, and Robert Rosenberg

Team 22B

Concept Generation and Selection

Document

Submitted towards partial fulfillment of the requirements for

Mechanical Engineering Design I – Fall 2013

Department of Mechanical Engineering

Northern Arizona University

Flagstaff, AZ 86011

Table of Contents

Project Statement

The goal of our team is to "Provide students with a way to understand and compare the amount of energy required to power and charge electronic devices with the amount of energy produced by pedaling a bicycle."

Recognizing the Need

The client for the 2nd Generation Bike Charging Station is Marilla Lamb, a member of the 1st Generation Bike Charging Station team. She received her Bachelors of Science of Environmental Engineering, and is currently a graduate student in the Mechanical Engineering program at NAU. In 2011, a grant was proposed to the NAU Green Fund to build a bicycle generator that students could use to charge small electronics, while simultaneously demonstrating how much physical effort is required to generate small amounts of electricity. In 2012, the Green Fund approved the grant request. The 1st Generation Bicycle Generator was designed and built shortly after. The purpose of the bicycle charging station is to provide students with an avenue to understand and compare the amount of energy required to power and charge electronic devices with the amount of energy produced by pedaling a bicycle in a controlled indoor setting. The first generation bike, however, does not meet all of the needs of the customer. The following are shortcomings identified within the first generation bike:

- The bike is not compatible with all major cell phones or laptops.
- The bike cannot readily be transported to different locations.
- The current display system is not user friendly and does not display adequate information.
- The bike is not comfortable or adjustable for the user.
- There is no consideration towards varying human power inputs (gearing and resistance).

Concept Generation

Working within the mechanical components of the second generation bicycle generator, our team has come to many stopping points where we had to make a decision on a how a component of the bicycle would be designed and built. Decisions were made on how to make the bike more portable, adjustable for user comfort, how to gear the bike, and how to store the power generated.

Portability

Two concepts were generated in order to make the bike easier to transport. One idea was to make a collapsible frame that could fold up into a case or split into two separate cases. The cases could then be picked up and carried to the new destination. The collapsible frame can be seen below in Figure 1.

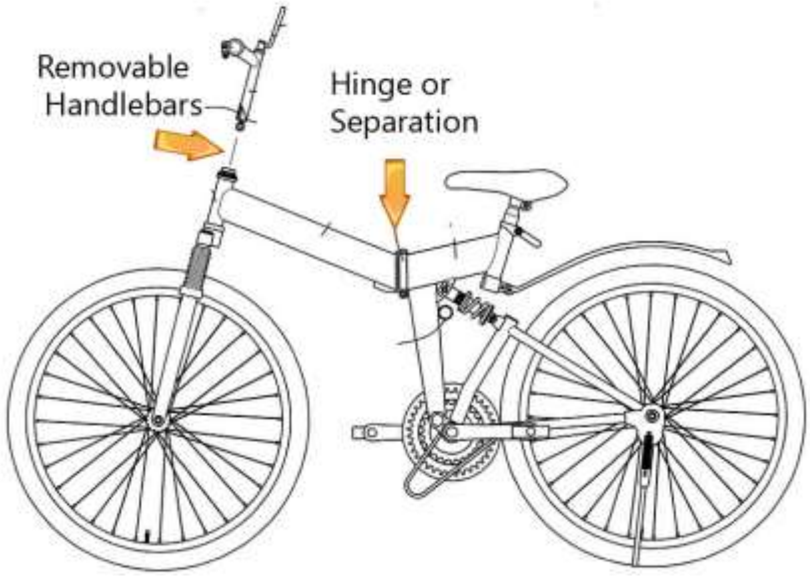

Figure 1 - Collapsible Frame [1]

Separating the bike into two pieces that fit inside their respective portable cases will make it possible to easily transport the station around campus. Another option to make the charging station portable would be to maintain the ability to ride it as a regular bicycle. This could be achieved by mounting the generator and necessary electrical components on a rear stand that can rotate 180 degrees and lock above the rear wheel. The Rear Wheel Stand can be seen below in Figure 2.

Figure 2 - Rear Wheel Stand [2]

As seen in Figure 2, with the generator components locked above the wheel, the bicycle can be ridden as usual. A system will have to be designed so that the generator is not engaged with the wheel with the rack in the top position. It is preferable to ride the bike from location to location than carry two cases.

Adjustability

Another decision that we faced was how to make the bike adjustable to comfortably accommodate a wide variety of users. We considered a traditional upright frame versus a recumbent frame for maximum comfort. The upright frame can be seen below in Figure 3.

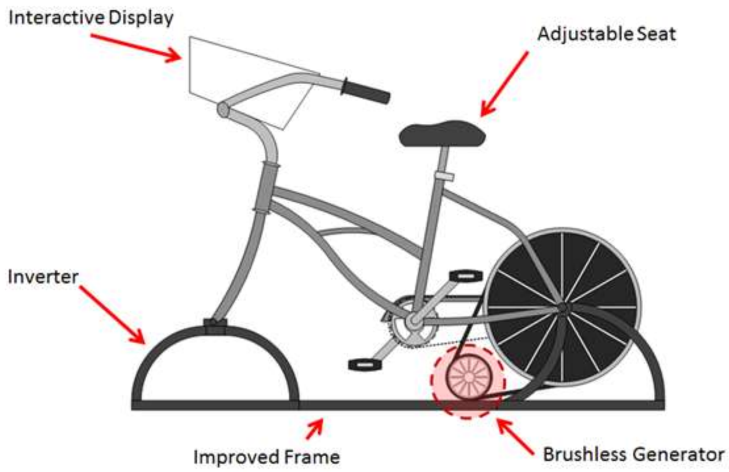

Figure 3 - Upright Frame [3]

As seen in Figure 3, the upright frame will have an adjustable seat that will allow users of different heights to sit comfortably and maximize their ability to pedal easily. The upright position will be familiar to most users and allow them to pedal fast due to the natural bike orientation.

The recumbent frame can be seen in Figure 4.

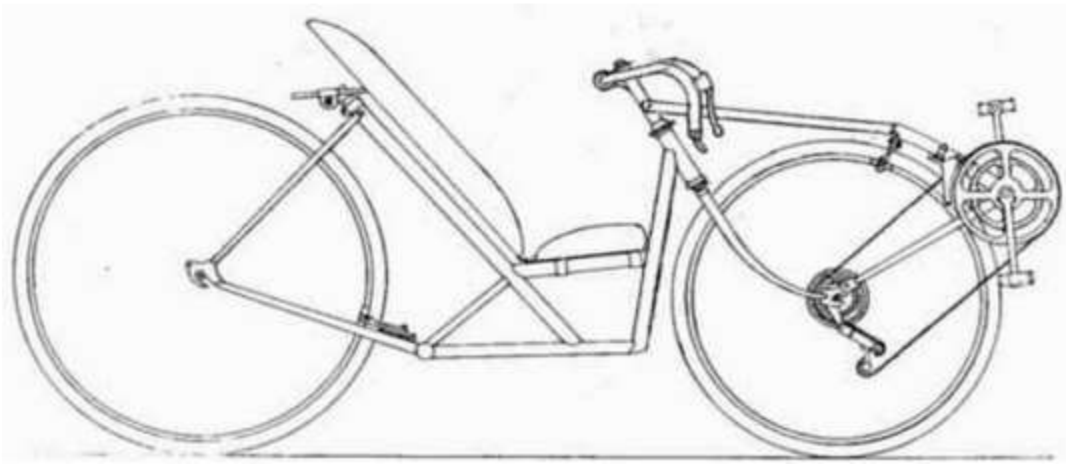

Figure 4 - Recumbent Frame [4]

This frame allows the user to recline into a very comfortable position. It would also be adjustable for a variety of body sizes. Although the recumbent frame would most likely be more comfortable than the upright frame, it may be more difficult to reach higher rpms due to the relaxed position. It also imposes greater complications in the design and construction of the bike frame.

Gearing

The decision on whether to gear the bike or not arose after riding the First Generation Charging Station. A single speed bike is cheaper and less complex, yet it becomes difficult to maintain a high rotational speed due to the decrease in pedal resistance. Gearing the bike will increase user comfort by allowing greater resistance while pedaling, however it may cost more. Depending on if the generator is variable speed, gearing the bike may also increase power generation.

Power Storage

When power is produced by pedaling the bike, it must be properly stored and discharged. The First Generation Bicycle Charging Station utilizes a lead-acid battery. This configuration is not ideal because the battery must be charged before devices can be powered from the station. The battery also loses charge over time. The Second Generation station will utilize a capacitor in place of a battery. Capacitors allow for rapid charging and discharging. This means that devices can be immediately charged by the power provided by pedaling the bike.

Concept Selection

The following weighting matrix shows the relative importance of various specifications compared to each other. These weights will be used in the decision matrix in order to determine which concepts will be chosen for the final design.

Table 1 - Relative Weight of Specifications

Design Option	Assembly Time (sec)	Weight (lb)	Range of Adjustability (inches)	Cost ($)	RPM	Maintenance (hours)	Total
Assembly Time (sec)	-	0	0	1	0	0	1
Weight (lb)	1	-	0	1	0	1	3
Range of Adjustability (inches)	1	1	-	1	0	1	4
Cost ($)	0	0	0	-	0	1	1
RPM	1	1	1	1	-	1	5
Maintenance (hours)	1	0	0	0	0	-	1

Below is the decision matrix determining the concepts to be designed for the final deliverable. For convenience of readability, all concepts have been included in one table. The designs chosen are highlighted in red. The rear wheel stand, upright frame, geared system, and capacitor power delivery system will be used. Due to the independence of the components considered, there does not need to be consideration into individual concept interactions.

Table 2 – Decision Matrix

Scale: 1-unfavorable 5-favorable	Assembly time (sec)	Weight (lb)	Range of Adjustability (inches)	Cost ($)	RPM	Maintenance (hours)	Total
Collapsible	5	2	1	1	1	2	23
Rear Wheel Stand	5	2	1	3	1	2	25
Upright Frame	5	1	5	4	3	1	48
Recumbent Frame	2	2	5	2	1	2	37
Geared	1	1	3	4	5	3	48
Single Speed	1	1	2	1	5	1	39
Battery	1	1	1	4	1	1	18
Capacitor	1	4	1	4	1	1	27
Relative Weight	1	3	4	1	5	1	

Project Planning

Throughout NAU's 2013 fall semester, certain deliverables are required leading up to the final project proposal. A Gantt chart, as seen below, shows when these deliverables will be worked on and turned in (Figure 5).

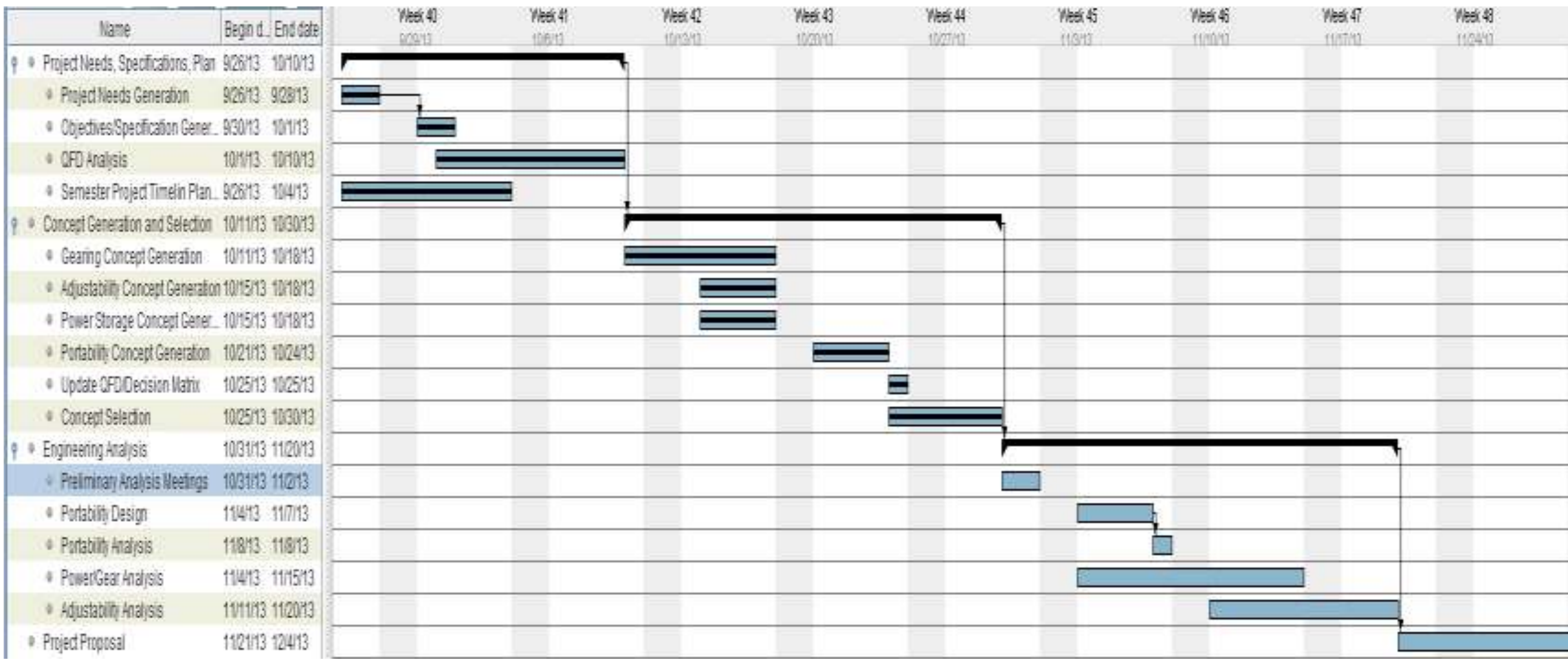

Figure 5- Gantt Chart Fall 2013

These deliverables are structured and timed to guide the engineering decision process in the completion of the problem at hand. This report is in fulfillment of the project needs, specifications, and planning. The remainder of the project includes:

- Concept Generation and Selection: During this process, our team will brainstorm a variety of ideas to meet the constraints and objectives. While consulting the Quality Function Deployment matrix, ideas will be ranked based on ability to meet or optimize specifications. Selection of a design will then take place and a plan to implement will be formulated
- Engineering Analysis: Having chosen a design, a comprehensive engineering analysis of the system will be completed showing proper configurations to maximize objectives while allowing for a product that is safe, reliable, and durable.
- Project Proposal: The project proposal will be the final deliverable this semester and will outline the build plan for the Spring 2014 semester. All materials, needs, costs, outlines and designs will be included for the successful building and implementation of the project, as well as the expected outcomes.

Conclusions

The need of the client was identified as to provide students with an avenue to understand and compare the amount of energy required to power and charge electronic devices with the amount of energy produced by pedaling a bicycle.

This led to outlining the problem by defining the goal, objectives, and constraints. The goal of the project is to design an improved bicycle powered charging station that will produce power to charge small electronics while teaching about power generation. Objectives include improving the station's efficiency, making it easier to use and transport, and more versatile.

There are constraints on the display as well as the budget and compatible devices. The display must show power generated, power used, total power generated at station and total number of users. The budget is $1600 and the station must generate enough power to charge a laptop.

References

[1] "Background of the Invention." *Bike Handle Securing Device for a Collapsible Bike Frame*. N.p., n.d. Web. 30 Oct. 2013.

[2] "Bicycle Forest Wanderer." Www.bikecad.ca. N.p., n.d. Web. 30 Oct. 2013.

[3] Lamb, M., First Generation Bicycle Generator Design & Build Team. Personal communication. 2013

[4] Lamb, M., The NAU Green Fund Addendum Application for Second Generation Charging Station. Feb. 2013.

[5] Lamb, M., First Generation Bicycle Generator Design & Build Team. Personal Communication. 2013

[6]"Mccreavy." Mccreavy. N.p., n.d. Web. 30 Oct. 2013. <http://mccreavy.com/1837/how-does-a-capacitor-work>

[7] "Shimano 9-Speed Bike Gear Cassette." | Meijer.com. N.p., n.d. Web. 30 Oct. 2013.

[8] "So You Want to Design a MBB : The French Expertise - BentRider Online Forums." *So You Want to Design a MBB : The French Expertise - BentRider Online Forums*. N.p., n.d. Web. 30 Oct. 2013.

[9] "SPI LCD Module (Arduino Compatible)." - Emmeshop Electronics. N.p., n.d. Web. 30 Oct. 2013.

[10] "12 Volt 20 Ah Sealed Lead Acid Rechargeable Battery with Insert Terminal."BatteryMart.com. N.p., n.d. Web. 30 Oct. 2013.