Second Generation Bicycle Recharging Station

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1.0 Introduction

This year's capstone team was assigned the task of designing and constructing an improved version of the First Generation Bicycle Recharging. This year's team has chosen to go a new direction with the power generation to improve reliability and simplicity. Design concepts were also added into the project which include an alternator for power generation, a capacitor for energy storage, and an inverter for producing an alternating current. Testing was also carried out on the charging station which helped demonstrate and record the capabilities of the new charging station.

2.0 Project Definition

The Second Generation Bicycle Charging Station needed to be mobile, efficient, user-friendly, and able to charge most small electronic devices. All main objectives for this capstone project were ways on improving the original design. The two largest objectives being increased efficiency and the ability for the entire station to be mobile.

2.1 First Generation

The first generation bicycle recharging station was built with lead-acid batteries that were used to store excess power from the generator as well as stabilize the oscillating current coming from the DC motor. The problem with this design is that the battery can lose some of its charge when not in use, lowering the overall efficiency. Also, the battery has a poor lifespan due to this type of application and therefore must be replaced every couple of years. Another drawback to the original design is its inability to change gears. This causes the rider to have to peddle at excessive speeds with little resistance, similar to riding a bike down a hill with a fixed single gear.

2.2 Project Goal

Our team's goal as stated in our UGRADS presentation is as follows; to design and improve a version of the first generation bicycle recharging station. This simple means that our main goal is to build and improved version of the first generation bicycle recharging station.

2.3 Objectives

Our first objective is that the bike should be able to power to small devices. Our aim is to enable the bike to produce power to in order to charge small electronics such as mobile phones and tablets. The charging should be able to power small or average sized laptops when plugged into the AC outlet.

Our second objective is that the bike should be durable, reliable and inexpensive. The Second Generation Bicycle Recharging Station must require little to no routine maintenance in order to stay operational. This means parts need to be made out of strong materials and there must be no bugs or flaws that may cause the station to break down or become non-operational.

Our third objective is that the bike should have an efficient energy storage system. The station requires an 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.

Our last objective is that 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 life will want to use it. This means that it must be appealing to the eyes and should be very easy to understand how to use it.

2.4 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.

For the first constraint, the charging station must be able to charge different electronic devices as well as different brands of devices. For example, the station must be able to charge the newer iPhones, Samsung's, and any laptop models. It is important to make the charging station practical with the technology that is currently out there. The second constraint requires the station to be easily mobile. This means that only a single person should be able to convert the bike into a mobile mode and move it anywhere they please. As for the third constraint, the power output must be easy for users to understand.

3.0 Final Design

The charging station design is made up of three main components. The first component is a mounting system on the rear wheel. This connects an alternator to the back wheel. The next component is the electrical system. It is a wooden enclosure that houses the electrical system that connects the power from the alternator to the display screens and the devices that will be charged. The last component is the display system which will hold the devices and the display screens. Figure 1 is a picture of the final design. The main components are marked by the arrows and labels.

Figure 1 - Final Design

3.1 Alternator Mounting System

The mounting system's goal is to hold the alternator and provide a way to make the bike mobile. The mounting system has the alternator attached to a bike stand. The bike stand can rotate around the back tire and lock into place.

3.1.1 Alternator

The alternator is a self-exciting single wire device. This means that it does not require an initial power source. Something like a battery is not necessary. The design becomes for viable because the battery will wear out over time and it will not last as long. As for safety devices, the alternator has its own shutoff mechanism. If the voltage created goes higher than its limit, it will automatically shut itself off. No more current will flow into the other devices. The device does supply an unsteady voltage. It will need to be regulated in order to safely charge devices. This is taken care of in the electrical system inside of the enclosure. An image of the alternator is in Figure 2.

Figure 2 - Alternator source:http://www.amazon.com/gp/product/B0081S9C16/ref=pe_344980_136521760_em_1p_0_ti

3.1.2 Mounting System

The mounting system is a bike stand that was purchased from Amazon.com. The alternator was attached to it with bolts. The bottom side of the alternator has a bolt that holds it up when it is engaged to back tire of the bike. The bike stand connects to the center of the wheel and raises it up off the ground. This makes it possible to ride the bike and spin the alternator while sitting in place. The alternator originally had a pulley attached but was removed. A small wheel was then manufactured to fit on the alternator and allow the best contact surface with the rear bike tire. Figure 3 is a side view of how the alternator and the wheel connect.

Figure 3 - Alternator Mounting System

3.2 Electrical System

The electrical system needs to deliver power to the devices and display screens and it also has to regulate the incoming alternator voltage. It is housed within the enclosure in the center of the bike. The electrical system has a capacitor and an inverter. A picture of the components is in Figure 4.

Figure 4 - Electrical System

3.2.1 Capacitor

The capacitor is a 2 Farad car audio system component. It has a few years of lifespan and will works well with this project. The capacitor helps to regulate the incoming voltage. If the voltage fluctuates it could damage the other components. The capacitor also work as yet another safety mechanism. If the voltage gets too high, the capacitor will shut itself off. The capacitor has a maximum output of 1,000 Watts. The design is not meant to go so high, but this ensures a high factor of safety. The power that is coming from the capacitor is DC.

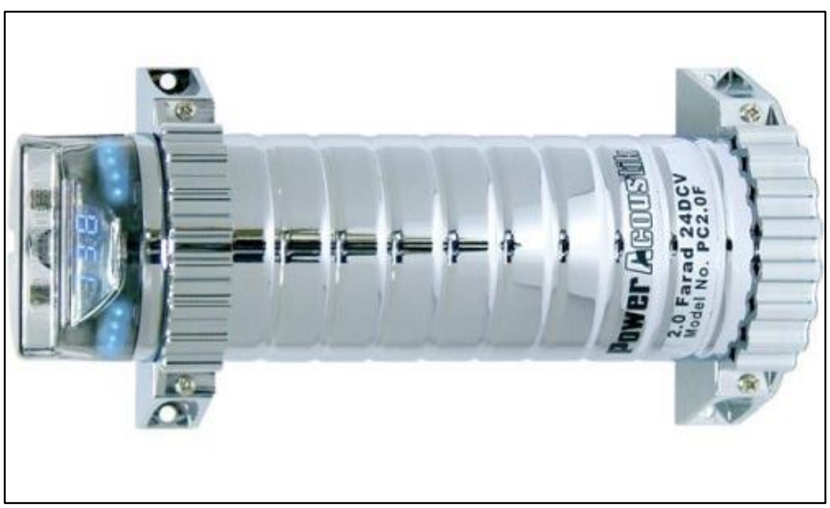

Figure 5 - Capacitor source:http://www.amazon.com/Power-Acoustik-Farad-Digital-Capacitor/dp/B000EOOU6M/ref=sr_1_13?ie=UTF8&qid=1429050127&sr=8-13&keywords=audio+capacitor

3.2.2 Inverter

The design of the system also calls for AC power. The inverter will change the power from DC to AC. It has a rating of 300 Watts. The inverter has a safety mechanism that will shut itself off as well. This adds more layers of safety to the system. The inverter has two USB outlets and two wall outlets. This will provide the required 120V supply to components that are plugged in for.

Figure 6 - Inverter source:http://www.amazon.com/BESTEK%C2%AE-Outlets-Inverter-Notebook-Motorola/dp/B004MDXS0U/ref=sr_1_1?s=automotive&ie=UTF8&qid=1429065590&sr=1-1&keywords=inverter

3.3 Display System

Our goal for the display system was to provide an interface that would allow the rider easy access to the electricity they were producing with real time data being shown. This was achieved by using common AC and DC outlets that can allow any type of chargers to be attached. In order to display live information to the rider, two display were installed that measure and show the voltage and current of each outlet. The display system was aimed at being as simple as possible so that anyone would be able to use it with little to no instructions. Below in Figure # a picture of the display system installed onto the charging station.

Figure 7 - Display System

3.3.1 AC and DC Outlets

The AC outlet used on the display system is a common outlet found in every American home. The user will be able to easily recognize the outlet and therefor will already know how to use it and what type of cords can be plugged in. The DC outlets installed on the display system were originally designed to go into a 12 volt car charger. This means that the outlet contains an internal DC to DC converter that that lowers the input voltage coming into the outlet to a steady and more usable 5 volts. The plugs used to power all common small electronic devices are called Universal Serial Bus (USB) cords which is what the DC outlet accepts. This type of setup prevents any person from not being able to charge their device since the built-in chargers aren't compatible. It also prevents any built in chargers from becoming obsolete when new chargers come out into the market. These were two problems present with the first generation recharging bicycle station.

3.3.2 Display Meters

The display meters used in this design are capable of measuring both voltage and amplitude of the current running through both types of outlets the AC display uses a magnetic ring to measure current running to the AC outlet while the DC display used a shunt device to measure the current going to the DC outlet. This type of device works by measuring the voltage drop across the shunt and relating it to the known resistance to find the amperage. Both displays are powered by the currents that they are reading and pull very small amps which increases overall efficiency of the charging station.

4.0 Testing Results

Three separate tests were used for the analysis, comprised of the speed requirements, battery charging rates, and the efficiency of the AC inverter. The first test measured the speed required at various power outputs. The second test measured the amount of battery charged within an hour. Lastly, the third test measured the efficiency of the AC inverter as the power output increased. During the three tests only a single Android cellular device was applied to the system for charging.

4.1 Speed Requirements

Results of the speed requirement test showed that there is a direct, linear relationship between the power output and the required speed to charge electronic devices. As the power output increases, the required speed also increases. However, this increase in required speed is a relatively low percent change. For example, when the power output increased by 70 Watts, the required speed only increased by 7 mph. This translates to an estimated 1 mph increase in required speed with every 10 Watts of power added to the minimum startup output. The speed was measured by a speedometer attached to the rear tire while the power was measured by a voltmeter attached to the alternator. Also, the speed of the rider never approached a limit that would make it too difficult to ride for the average person. Figure 8 shows the graph of the power output versus required speed below.

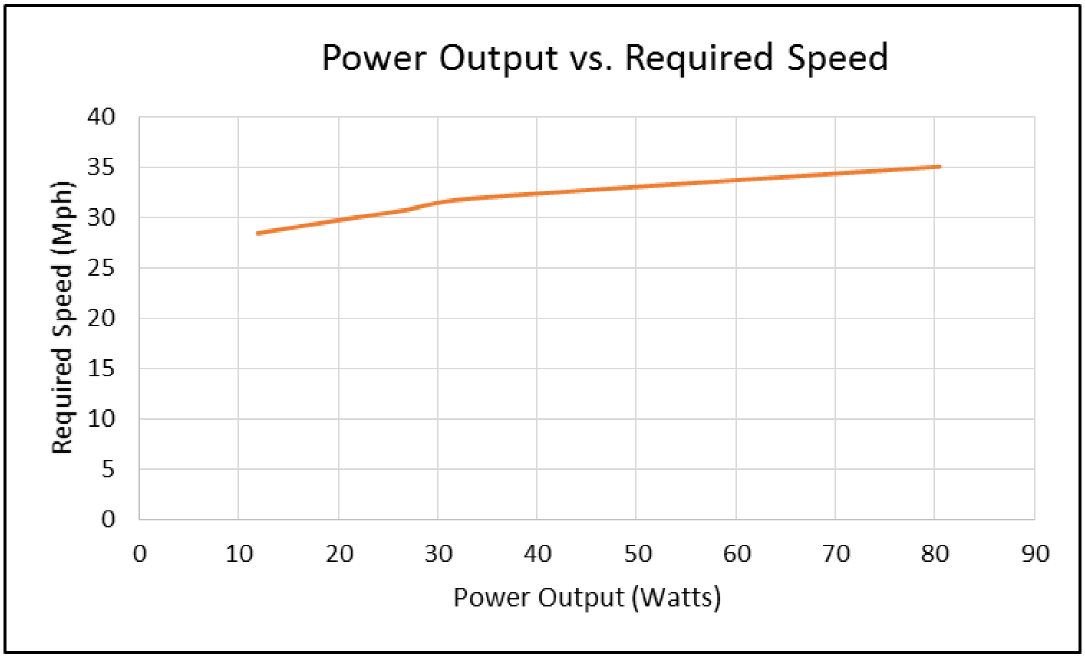

Figure 8: *Power Output versus Required Speed to Charge Devices*

4.2 Battery Charge Rate

The testing results for charging a battery demonstrated that the charging station charges devices at a similar rate as an average wall outlet. Throughout the period of an hour, the charging station charged a single device by 46%. In contrast, an average wall outlet would have charged the same device by about 50% in the hour. The overall estimated time for the charging station to charge a single device from “dead” state (0%) to full charge (100%) was calculated to be in the range of 125-130 minutes. The graph of the charge time versus percent change in battery life can be seen below in Figure 9.

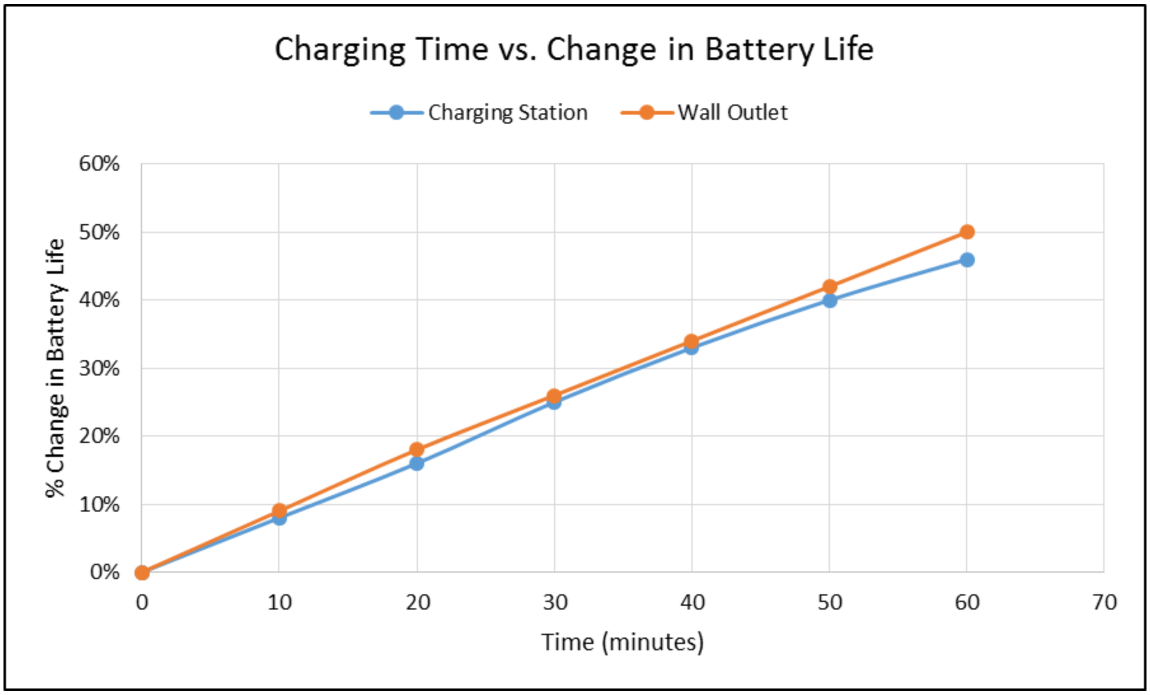

Figure 9: *Time to Charge versus Percent Change in Battery Life*

4.3 AC Inverter Efficiency

The last test performed on the charging station was the power output versus the AC inverter efficiency. Figure 3 shows the direct relationship of this comparison. As the power output increases the AC inverter efficiency increases. When the power output is at least 90 Watts the system is considered to be efficient since the efficiency of the AC inverter is at 80%. However, when the power output is less than 90 Watts the system is considered to be inefficient due to the lower percent efficiency rating. Therefore, the more power output the AC inverter consumes, the more efficient it becomes, as long as the power output is less than or equal to the allowable power output of 300 Watts.

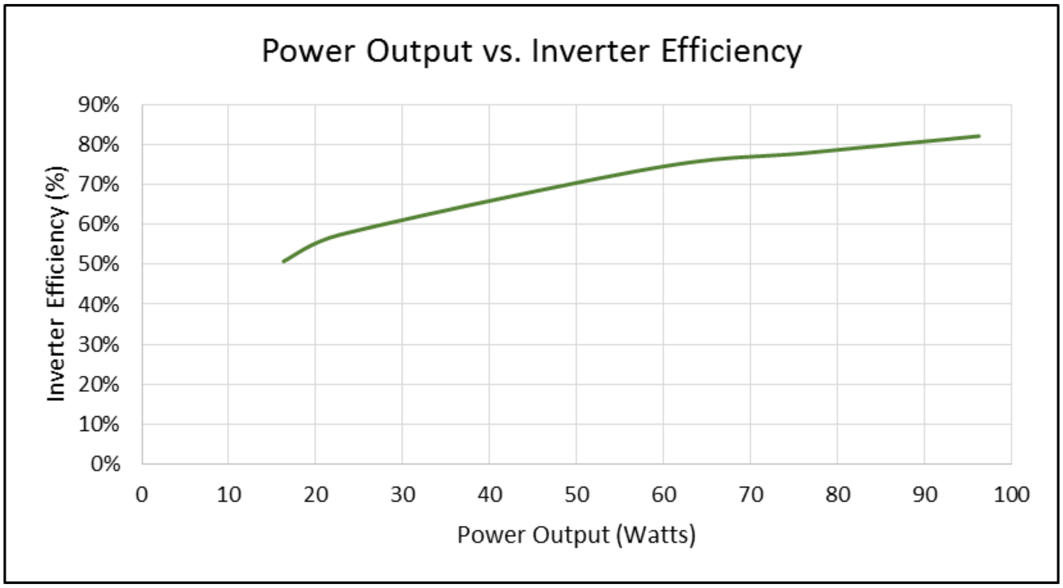

Figure 10: *Power Output versus AC Inverter Efficiency*

6.0 Conclusion

In conclusion, after extensive testing and research, the Second Generation Bicycle Recharging Station has finally been completed and has proven to complete the objectives described earlier. The charging station is able to charge several small electronic devices, not only one or two. The station can also provide up to 300 watts of AC power that can be used to charge laptops or other devices that aren't compatible with the DC outlets provided in the display system. The design can be mobile by simply detaching the alternator and rotating the mounting system above the rear wheel. This allow the whole station to be easily moved to wherever is desired. It can also still be ridden as a regular bike although the weight distribution may make it more difficult. Finally, the entire design utilizes several different technologies that allow the station to be much more efficient than its predecessor while also providing power to a much wider array of electronic devices.

7.0 References

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