# 2nd Generation Charging Station

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## Midpoint Review
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# Table of Contents

# 1.0 Introduction

Several objectives have been completed so far in this year's 2nd Generation Charging Station capstone project. All of the tasks that have been completed so far are explained more thoroughly in Section 3 of the report. Testing was also carried out on the charging station during the construction phase. However, more intricate testing will be done later on after the project has completed the construction. The testing that was done so far was power output and ease of use. All results were promising and a more detailed summary of the results can be found in Section 4. There is also a handful of tasks that still need to be completed so far in order to finish the project. The main task is building the display system for the charging station. All future tasks can be found in Section 5 of the report where design plans are also summarized.

# 2.0 Project Outline

This year's capstone team was assigned the task of completing and improving the 2nd Generation Charging Station that was originally started by last year's capstone team. The 2nd Generation Charging Station must be able to accomplish three requirements with the first requirement being that it must be mobile and therefore relatively lightweight. The second is that it must charge the majority of small electronic devices in a way that is more efficient than the 1st Generation Charging Station. The final requirement is that the station must have a way of displaying current information about the power being generated by the user.

# 3.0 Tasks Completed

Several large tasks have been completed between now and the last report submission. The first task completed was installing the alternator onto the bike stand. This was done in a way that emphasizes simplicity and ease of disassemble. The next job completed was the Electric Control System which was all installed into the newly built Enclosure. The last job was painting the entire system with NAU colors and adding decals to increase aesthetic appeal.

### 3.1 Alternator Mounting System

In order to install the alternator onto the purchased bike stand, the magnetic resistance module (of the bike stand) had to be removed. This then allowed us access to the mounting bracket that was already welded to the bike stand. The next step was to find the right hardware for installing the alternator to the mounting bracket. Also, some holes on the bracket had to be bored out so that larger, sturdier bolts could be installed. Below is a picture of the Alternator Mounting Bracket as it sits now.


*Figure 1 - Alternator Mounting System*

In (Figure 1) you can see how the alternator is positioned on the mounting system and how it connects with the rear wheel of the bike. The alternator rests on a bolt with large spacers. This keeps the alternator tight with the bike wheel while also allowing it to be easily disengaged from the system. In order to disengage, a single wingnut has to be removed a bolt must be pulled out of the mounting bracket. Another key feature of the mounting system is its ability to be converted from a stationary to a mobile position. The system portion can be easily lifted and rotated above the bike wheel where the removed bolt can then be used to secure the entire mounting system to the bike frame.

### 3.2 Electric Control System

The Electric Control System (ECS) is comprised of three main components. The first component is the 2 Farad Audio Capacitor purchased from Amazon.com. This part's main purpose is to stabilize the current coming from the alternator. This is done by storing a small amount of the energy inside the capacitor and connecting the component in parallel with the power source (alternator). It is very similar to a lead-acid battery however it can only store a minimum amount of energy which thus improves efficiency of the system greatly. The second component of the ECS is the DC to DC converter. This section lowers the 14-15VDC current coming from the capacitor and converts is to 5VDC which is the required voltage to charge almost all small electronic devices. The DC/DC converter used in this system is a USB car charger which inputs 12 volts from a car lighter plug and converts it to 5 volts outputting it to a USB port. Another DC/DC converter is also found in the third component of the ECS, the inverter. This piece is used in the system to convert the direct current (DC) voltage from the capacitor to 120 volts of alternating current (AC). This inverter we purchased is rated to provide power at up to 300 watts and comes with its own internal fail safes that will shut the inverter off in case the voltage at the input is too high. System is capable of providing up to 300 Watts of DC and AC electricity at the same time, although with this load, it would be very difficult to pedal due to heavy resistance in the alternator. Below is a picture of the current ECS which is being permanently housed in the Enclosure.


*Figure 2- Electric Control System (ECS)*

The long silver cylinder seen in (Figure 1) is the 2 Farad capacitor described earlier. The red rectangular box is the inverter and the small block where all the connections are running to is the terminal block that is used to connect the DC/DC converters to the capacitor.

### 3.3 Enclosure

In order to safely house the electronic components, an enclosure was designed and built. Material chosen for the enclosure include MDF (Medium Density Fiber Board) wood, varnish wood staining, and brass fasteners. To build the enclosure, dimensions of the bike frame were first taken. Next, the individual pieces were cut, sanded and then glued together. Afterwards, additional sanding was done to get the correct shape and then the inside and out were painted with the varnish to add protection. After the varnish dried, components were placed inside and then the enclosure was fastened to the bike frame. A door was added to one side of the box to create a maintenance access point in case any of the components failed in the future. Below is a picture of the enclosure as it looks now attached onto the bike frame.


*Figure 3 - Enclosure*

A latch was also added to the door to keep it securely shut so no accidental openings occurred while the station was in use. A lock may also be added in the near future to provide extra security to the system.

### 3.4 System Aesthetics

Northern Arizona University (NAU) colors represent the theme of the charging station which include navy blue and golden yellow. The bike frame was painted the navy blue while the alternator mounting system was painted the golden yellow. Decal stickers of Northern Arizona University were also added throughout the system to increase aesthetic appeal. New tires treads replaced the old worn ones currently on the bike to aid in traction with the alternator wheel as well as make the bike better looking overall. Below is a picture of the entire charging station with the new paint job and decals.

The wooden enclosure was also stained a dark mahogany color to contribute to the NAU Lumberjack theme. Lastly, a seat cushion was added to improve the look on the worn original seat while also provide extra comfort for the rider.

# 4.0 Testing Results

The testing for the bicycle was done by the entire team. Every team member had input to describe, qualitatively how the bike rode with the alternator attached. The power output was tested by putting different amount of loads on the inverter and measuring how much power was produced by the alternator.

### 4.1 Ease of Use

The bicycle's stand provides enough stability for the rider to pedal safely; there is no concern of tipping or the stand breaking due to excessive weight or speed. Originally, we calculated the start-up speed to be around one mile per hour. This turned out not be the case.  This is most likely because the diameter of the alternator wheel and the diameter of wheel used in calculations are not the same. The estimated diameter was only one inch while the actual wheel is around two to three times greater. Because of this, it makes our start up speed approximately 3 mph instead of one. This however is still not a significant amount of speed and can be accomplished by the majority of users. When the alternator is activated, the pedaling becomes more difficult due to the increase in resistance. It is recommended to keep a steady normal pace and to avoid riding very fast or slowing down quickly while operating the charging station. When devices were plugged into the system, the riding became more difficult as the load increased. A limit on how much power can pulled from the station will be created once more testing has been done on where this difficulty threshold lies.

### 4.2 Power Output

From the alternator, the DC output received by the capacitor reads approximately 14-15 volts when there is a load on the system. However, if there is no load on the system, then the voltage displayed will be around 18 volts. The inverter has a safety feature that shuts down the capacitor if the input voltage goes over 15V. As of now, the testing revealed that the inverter will not operate if no load is set up on the charging station. In the future, a permanent small load may be added to avoid this problem. Using a DC ammeter, the measured current coming from the alternator was as high as 20 amps. Multiplying this by that 15 volts at the alternator output, we get an energy production of around 300 watts. No picture was taken during this load testing so future tests will be needed to prove these numbers officially.

## 5.0 What Needs to Be Completed

There are still a few important jobs that need to be finalized before the project can officially be deemed complete. These tasks are the display system, a new alternator wheel, a preventative maintenance procedure, safety features, and De-Bugging of the system as a whole. These will all be completed within the following month. The Display system and new alternator wheel will be the highest priorities since the rest can't be completed until these two are done.

### 5.1 Display System

Since there is only a limited amount of time left to complete the project, we have decided to go a different route with the 2$^{nd}$ Generation Charging Station. The original design employed a microcontroller that would use sensors to read the voltage and current of the system and transfer the data to the touch display screen using Bluetooth module. But do to time constraints, the system design has been simplified without losing any of the desired data. The new design incorporates to display screens that read out both the voltage and current of whatever the module has been attached to. One of the displays will be used to show the AC voltage and current. The other display will show the voltage and current readings of the DC portion of the electric control system. Below is a rough diagram of what the display system will look like once it has been put together.

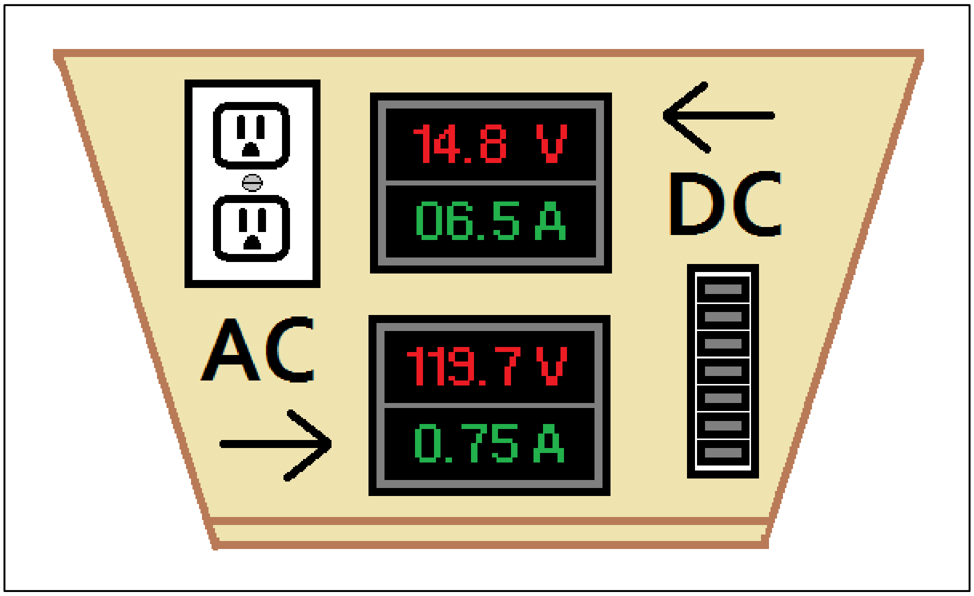
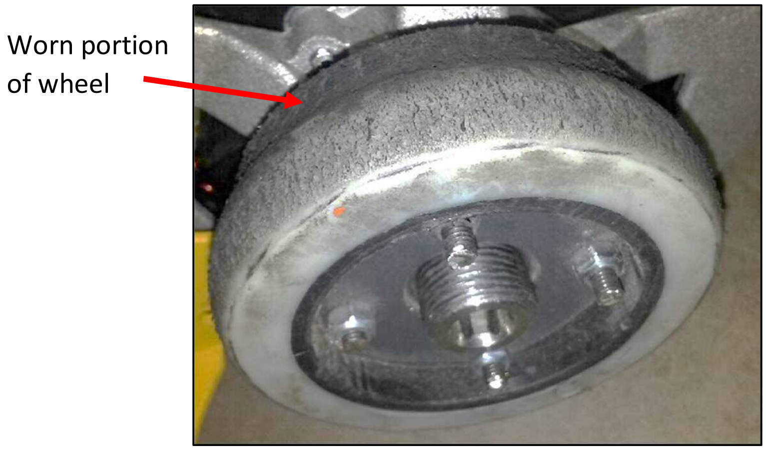



*Figure 4 - Display System*

In (Figure 2), you can also see how the power will be available to the rider. For the AC side, a common wall outlet will be used to provide AC electricity to the user. They will be able to charge any device that has an AC plug by simply plugging it into the display system's outlet. For the DC side, a USB outlet will be used. The rider can plug into the system any cord that would normally plug into a computer. These types of outlets help give the rider a wide range of electronic devices that they will be able to charge or provide power to. It also overcomes the problem of new types of plugs being developed that would cause older plugs to become obsolete. The only downside to the design is that the rider will have to provide their own power cord for what they want to charge. A small lip will also be designed on the bottom of the display system so that the rider can set their phone or small tables onto the display while charging.

### 5.2 New Alternator Wheel

A rubber and plastic wheel with steel plates for reinforcement was manufactured to fit on the alternator. There was an issue with slipping however in our last tests which caused the rubber on the wheel to start deteriorating and increasing the distance between the wheel and the rear bike tire. Below is a photo of the deteriorated alternator wheel.




At the moment, we believe this was an issue with the setup of the alternator mounting system which caused the wheels to not be compressed as tightly with one another. We plan to manufacture two more wheels so that we can test them and find out if this will still be a viable design. If it isn't, then we will have redesign how the bike wheel is attached to the alternator.

### 5.3 Preventative Maintenance Procedure

In order to use the charging station, we decided that we will come up with a preventative maintenance procedure checklist. The checklist is just to ensure that the user sets up the bike properly and helps prevent early degradation of the alternator wheel. Some steps will include checking that the pressure of the rear tire is at the proper level. If the pressure is too low, then the wheel will not make sufficient contact with the alternator. Another step will be to secure the alternator mounting system to the rear bike frame so that the entire bicycle does not rock back and forth. This checklist will all be what the user must do before actually operating the charging station.

### 5.4 Safety Features

A few safety components will be installed into the system to ensure the safety of the rider as well as any nearby observers. The first component will be an inline fuse located near the positive terminal of the alternator. This fuse will be rated to 25 Amps which is also the maximum amps that the cable is rated for. This component will disconnect the alternator to the rest of the system in case of a short circuit somewhere inside or outside of the system. Another fuse may be installed near the positive terminal of the capacitor to prevent an unwanted discharge in the case of a short circuit. Another safety component to be installed is an emergency shut off switch that will be located near the enclosure or display system, whichever is more suitable.

### 5.5 De-Bug and Touch Up Aesthetics

For the final weeks left in this project, the team will focus on debugging the system and continuing to improve its aesthetics. To debug the system, many tests will be performed repeatedly to fully understand what the charging station is capable of and to discover if there are any risks associated with plugging too many electronic devices into the AC power and USB ports. As for the aesthetics, most of the work has been completed. However, there is still work to be done in areas such as touching up poorly spray painted surfaces on the bike frame, adding a proper NAU Engineering Capstone logo to the bike, and making the display appropriately tied into the rest of the theme. As for the handlebars, bike grip tape still needs to be added to improve the original. Additional aesthetics may include a newly designed handlebars if the original does not fasten well with the display, also a new seat cushion will be purchased if the current seat cover does not provide a reliable and comfortable ride for the user.

# 6.0 Conclusion

In conclusion, major work has been done in the building of the 2$^{nd}$ Generation Charging Station. The system is capable of powering electronic devices and all components of the ECS have been tested and proven to be compatible with one another. Large strides have also been made in the task of making the entire system aesthetically completed with the painting of the bike and mounting system and the addition of decal stickers throughout the station. The next major task is to build and install the display system which will now be much less difficult and time consuming with the introduction of the new display system design. Other small tasks will also need completing such as the new alternator wheel and safety features. De-bugging of the system may also take a large amount of time depending on the problems that may be encountered. From the testing so far however, this does not seem likely. In total, the tasks that still need to be completed will be done within the next few weeks and little to no setbacks are expected.

# 7.0 References

No outside photos, data, or information has been used in the making of this report. All photos were taken by members of the capstone team.