FAMU-FSU College of Engineering
Department of Electrical and Computer Engineering

Milestone #4 - Detailed Design Review and Test Plan

EEL4914/5C – ECE Senior Design Project II

Project title: **E-BIKE CHARGING AND DOCKING STATION**
Team #: 7

Student team members:

- **Seve Kim** Computer engineering (Email: sk10j@my.fsu.edu)
- **Jacob Knoblauch** Computer engineering (Email: jmk12h@my.fsu.edu)
- **Bryan Castro** Electrical engineering (Email: bzc10@my.fsu.edu)
- **Bilal Rafiq** Mechanical engineering (Email: bdr11b@my.fsu.edu)
- **Justin Johnson** Mechanical engineering (Email: jlj11d@my.fsu.edu)

Senior Design Project Reviewers:
-Dr. Frank -Dr. Hellstrom -Dr. Tung

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Executive Summary

The E-Bike charging and docking station being designed by Team 7 is intended to charge the electric bicycle provided by Efficient Systems LLC. and lock it securely with minimal user involvement. The overall design of the station has been modified, since the last proposal, after discussions with the project sponsor and careful re-evaluation of the project's subsystems. The new design still fulfills the goals and requirements of the project, while making the station more efficient and user friendly. The newest model that will be discussed in this report will be the prototype that will be physically built by the end of the semester. The previous design will now be considered the future model which will still be submitted to the sponsor. The bike will still be placed in the station rear wheel first due to various factors, such as reducing the complexity of the design.

The major subsystems that have been modified include: structure, locking mechanism, and communication. The structure of the station was changed from being positioned on the right side of the bike to being positioned directly behind it. The new structure design provides a more sleek and aesthetically pleasing look for the station. The locking mechanism was changed from a gripper arm to an electromagnetic lock. In terms of communication, it was decided to use an RFID in order to communicate the bike's presence and ID with the main controller of the station. Also, a speaker was added to the design in order to provide the user with a form of audio communication on whether or not the bike is being correctly stationed.

This project is intended to be an innovative solution to solving the design problem provided by Efficient Systems LLC. The design will provide an efficient method for wirelessly charging the E-Bike's battery, automatically locking the bike, and operating through minimal user input. The system-level design review encloses all the details and a full analysis of the project design.

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1 Introduction

1.1 Acknowledgements

The design team gives salutations to Fabio Vargas and Maximo Mendoza, owners of Efficient Systems, for their contribution through monetary means as well as close mentorship and guidance, technical help and advice, and unrelenting support. The team is also grateful for both the ECE and ME project advisors, Dr. Michael P. Frank and Dr. Eric Hellstrom respectively.

1.2 Problem Statement

The design team was assigned the task of designing and building a charging and docking station for the Efficient Systems electric bicycle. The e-bike has already been developed and a primitive charging and docking station has already been put into place. The problem with the primitive station design was that it required an excessive amount of user interaction. The interactions consisted of the need to manually plug a power source into the e-bike battery and use a manual lock to secure the e-bike. This creates a problem for the user in the sense of not being user-friendly and creating an inconvenience for the on-the-go commuter. The new design eliminate this problem by making the station for the e-bike to be an easy-to-use and quick way of charging and docking your e-bike. The station base will rear wheel orientated with a streamline design of an all inclusive, charge, lock, and dock in one centralized hub. When the rear wheel is backed into the station nook, a few processes take place. The structure design of the station allows the bike to be held steady and in place for an easy dock and undocking. The locking aspect is accomplished by an electromagnet on the underside of the station that will connect to the back wheel hub. The station will include an induction subsystem set up adjacent to the e-bike battery that will provide the e-bike charging.The main scope of the project from now till the end prototype is to design a model version that will be capable of achieving all the objectives described. The distinction between the new prototype model and the previous mass production model will be clarified throughout the report.

1.3 Operating Environment

The operating environment that will be described is for the mass production future model. The environment to which this station will be operating and tested in will be outside in our current location of Tallahassee, FL. The climate which will allow testing of the station will most likely be late winter to early spring, so that there is a good range of high and low temperatures. Of course the stations will have to withstand the environment year round and the station will have to adapt to changing locations and altering conditions. The station will have to withstand a minimum temperature of roughly 35ºF and a maximum temperature of roughly 95ºF.

The station will have to withstand rain at most for precipitation in our given conditions. The IP Code (International/Ingress Protection Marking) will be used for testing the liquid level of protection of the station. Specifically the station will have to meet the standards of IP4, which means it will be able to withstand a splash of water from any direction without having any harmful effects. The test duration will be 5 minutes with 10 L of water per minute at 80-100 kPa. The housing of the station base will be enclosed in a galvanized steel. The material will be put under a series of stress analyses to simulate any forces that the station will incur.
The prototype design will be a model of the future design and will not have the same capabilities for operating outdoors. It will be able to operate at room temperature in low humidity and will not be protected from any type of water contact.

1.4 Intended Use(s) and Intended User(s)

1.4.1 Intended Use(s)

The scope of the design project that was assigned includes the use of the station in the following processes: docking, locking, and charging the Efficient Systems electric bicycle. These intended uses will be applied to the designing and building of the station. As stated previously, the stations will be placed in a semi-public environment that will be accessible to the intended users. Currently, the presented scenario will be a company that owns Efficient System e-bikes and will make them accessible to their employees.

1.4.2 Intended User(s)

The intended users of the station will generally be owners of the e-bikes. These users could vary in age, computer competency, and nationality. For children to teens to use the station, the station will have to be easy enough to put into place. On the other hand there are elderly citizens that might not be as competent when it comes to computer usage or maybe a foreign speaker that can’t comprehend English, so the system will have to be as intuitive to use as possible.

1.5 Assumptions and Limitations

1.5.1 Assumptions

- All source components must meet the requirements to ensure minimal operation commitments:
    - The RFID tags attached to the e-bike will be sensed from a range of 100m when docked into the station.
    - The station structure housing will enclose all power and electrical components and efficiently protect from environmental constraints.
    - The station structure will include vertical support beams to improve stability and stress strength.
    - The main line wires will have a provided enclosure to and from the station to the source of power.

  - Inductive coils will need a large enough core to supply an efficient transfer of power.
  - The electromagnetic lock will have the capability to withstand 600 lbs (272 kg) of force.
- In order for the charging subsystem of the bicycle to work via induction, there must be an AC current flowing through the subsystem.

1.5.2 Limitations

- The station must provide an automatic locking mechanism. (REQF-01)
- The station must be able to charge the battery (rated at 36V and 8 or 14A) within 3-4 hours by induction. (REQF-02)
- The station must have a user interface including LEDs and speaker. (REQF-03)
- The electromagnetic has a strong enough force to harm the user, so the location of the lock on the station and on the bike will have to be considered for safety.

1.6 Expected End Product and Other Deliverables

1.6.1 Electric Bicycle Induction Charging Adapter (1)

This item is an adapter to the electric bicycle in order to enable inductive charging from the station to the e-bike battery. This eliminates the need for manual interaction from the user when placing the e-bike into the station. The adapter will have a 3D-printed casing to enclose the induction coil, core, AC/DC converter, RFID, and wires. The adapter will have a large surface area so when the bike is aligned with the station-side inductive plate, there is a clean juxtaposition of the inductive plates. The adapter will include the following items:

- Bike-side induction component (1)
- 3D-Printed housing (1)
- Battery-side plug (1)
- RFID tag(1)

1.6.2 Electric Bicycle Charging and Docking Station (1)

The charging and docking station will provide a seamless way for users to park their e-bikes and secure them safely while they charge at the same time. The provided end product will be fully operation of the exact specifications and requirements as a prototype design of the intended implemented station. The prototype station unit comes complete with the following items:

- Station-side induction component (1)
- RFID Sensor (2)
  - User RFID sensor (1)
  - E-bike RFID sensor (1)
- 600 lbf Electromagnetic lock (1)

2 System Design

The system design has changed in the mechanical components portion due to the over complexity of the design. The previous design will be classified as the future full production model whereas the new design will be classified as the prototype. This is further explained in the sections below. The prototype will serve as a model of what the future station will be capable of except for that it will not be able to sustain environmental conditions. The electrical components will be the same as discussed in the full production model.

2.1 Overview of the System

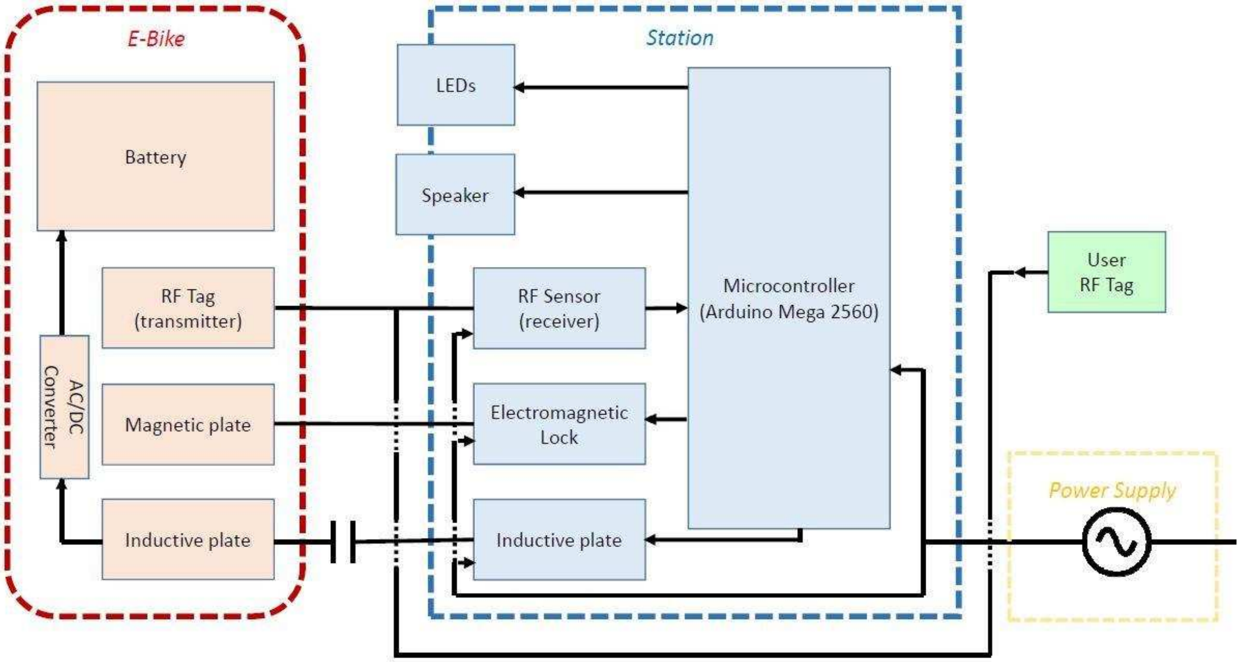


Fig. 2.1: Station Top Level Overview Design

The diagram above shows the internal system of the charging and docking station as well as the hardware components on the user, e-bike, and power source side. The station operates in the following manner:

- State 1: “Bike in use”
    - The Speaker, Lock, and Inductive plate are inactive when the RF Sensor does not sense the RF tag is not present. In short, if the e-bike is not in the station, nothing will operate.
    - The red LED will be lit to signify the bike is away from the station and in use.

- State 2: “Bike docked & charging”
    - Once the e-bike is brought into the proper docked position in the station, a few things will occur:
        - The Arduino Mega 2560 microcontroller will set the lock, and charge via inductive plate after it receives a signal from the RF Sensor that it has connected with the e-bike RF tag.
        - Before the electromagnetic lock turns on and connects to the magnetic plate on the bicycle, the speaker will notify the user, “Please keep hands and arms away from the station”. This ensures the safety of the user is taken into consideration.
        - The Arduino NEGA 2560 microcontroller will set the inductive plate to start charging the bicycle across plate-to-plate and will convert the AC power to DC and charge the battery.
        - The yellow LED lit up will indicate the e-bike is charging. While the e-bike is charging, the bike will not be able to be removed by a user.
- State 3: “Bike Ready”
    - Once the e-bike is fully charged, the green LED will light up.
    - The user will have his own RF Tag to notify the station to unlock the bike from the station.
    - This will disengage the electromagnetic lock and allow the user to take the e-bike.

2.1.2 Comparison Between Models

As the project design progressed, the limitations of our theoretical design came into view and it was recommended by the advisors and sponsors that the design is too complex for the prototype. The decision was made collectively to create a simpler version of the model while still fulfilling the objectives proposed by the sponsor. Figure 2.1.1 shows the design proposed previously which will now be considered and named the “Future Mass Production Model”. In figure 2.1.2 the latest design shows the differences and similarities of the new “Prototype Model”. The new prototype model has the same user interface communication features as the previous design. The orientation is slightly different to allow for easy access to the components during installation and troubleshooting repair.

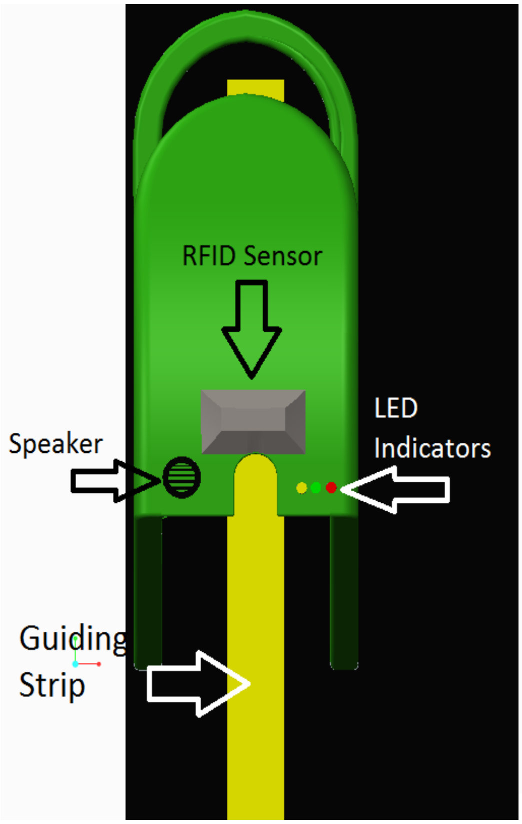


Figure 2.1.1: "Future Mass Production Model"

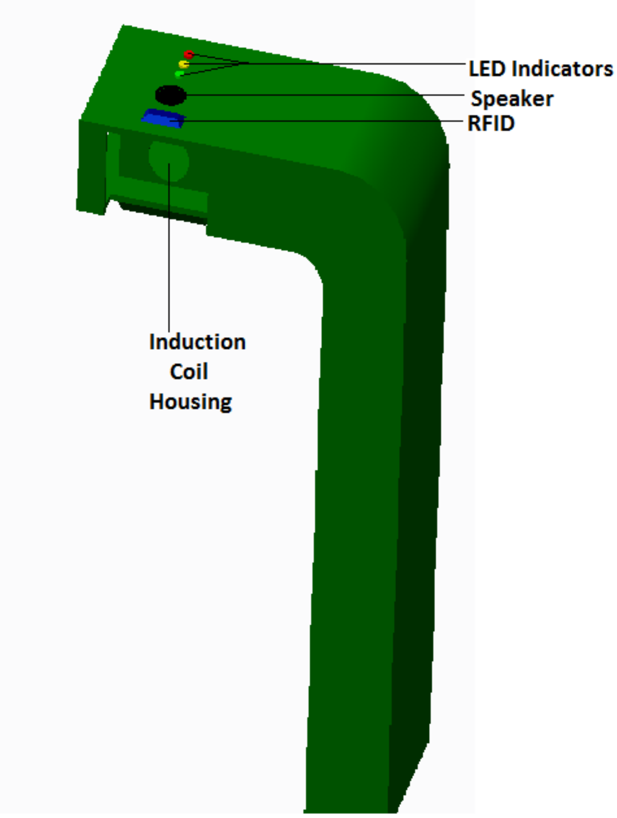


Figure 2.1.2: "Prototype Model"

2.2 Major Components of the System

2.2.1 Structural Material

The material chosen for constructing the prototype was selected on the constraints of budget and machining. Other options were explored aside from metals such as polymers which can be 3D printed. This option is much cheaper and easier to machine but will not give the structure the robust integrity needed. Although this will be an indoor model, the appearance should still yield an aesthetic and attractive appeal that plastics cannot achieve. Since it is going to be placed indoors, standard A500 structural steel will be utilized as the frame.

2.2.2 Overall Design of Structure

Since the change from the old model to the prototype model, the complexity of the physical design has changed drastically. It is not too simple but it is basic enough to execute the same capabilities as the future model. It will still deliver the message of efficiency and modernism for which the company demands as being their marketing outlook. The electric bikes are an innovative way of solving transportation issues while also reducing carbon emissions to the environment. The design was focused on communicating that message to the users. For marketing purposes, the design of station will be focused on providing the user with images and confidence that this is a modern day technology. Technology has always been appealing to people and the design of the station will communicate that feeling to the users.

2.2.3 Electro-Magnetic Lock

Along with charging the E-Bike, locking the bike securely and automatically is the highest priority of the project. After carefully re-evaluating multiple options for locking and docking the bike, it was chosen to return back to a previous solution that had been dismissed. Electromagnetic locks are the easiest means to lock and unlock the bike with minimal user interaction. Previous designs involved too much reliability on the user to lock the bike which could pose an issue where the user might dock and not properly lock the bike leaving it susceptible to theft. Although constant power supply is an issue, the sponsor has assured us that the risk will be mitigated by them in future applications.

2.2.4 Component Housing For The Bikes

The system designed demands that the bike must have an AC/DC converter as well as the receiving inductor to be placed and securely attached to the bike. This will need a housing to enclose and hold these components in place during operation. An enclosure was designed and placed in the rear side behind the battery. This is further visualized in the next section.

2.2.5 Induction Charging System

Charging the bike automatically in an efficient and safe manner is crucial to the success of the project. Induction was chosen to eliminate the need to plug in the bike or have exposed contacts on the battery and station. One coil will be housed within the station and recessed in order to provide a precise area that the bike coil will fit into. The bike coil will be placed within the component housing on the back of the bike, described above.

2.2.6 RFID Sensors

In order to lock and unlock the bike, a recognition system was needed to not only detect the presence and identification of the bike, but also the user's ID. The station will include an RFID sensor on the station, with RFID tags on the bike as well as for each user of the station. The user tags could have various options such as key ring fobs or stickers.

2.2.7 User Interface

In order to communicate with the user, the system will have a set of three LEDs as well as a basic speaker to generate tones. The LEDs will each correspond to the states described in Section 2.1: State 1 corresponds to Red, State 2 to Yellow, State 3 to Green. The speaker will play 400-800Hz tones to notify users that the bike may be incorrectly docked.

2.2.8 Microcontroller

A central device is needed to control all of the above systems. For this project, the Arduino Mega 2560 microcontroller will be used to regulate the user interface, the RFID sensor, the power supply to the station’s induction coil, and power to the electromagnetic lock. The microcontroller will also keep track of all data on each bike and interface with an external website to receive and send information on each of the bikes.

2.3 Subsystem Requirements

This section specifies detailed requirements (including quantitative specifications and constraints) on all of the major subsystems.

2.3.1 Structural Material

The future model will consist of the material described as galvanized steel. This type of steel metal is resilient against weathering and provides the strength needed to keep the structure intact. The gauge sizes for the sheet metal are used to describe the thickness but as the gauge increases, so does the costs. The gauge size was tested under FEA(Finite Element Analysis) to find the optimum gauge needed with also allowing a safety factor of 4. A factor of safety was not provided by the sponsor but it was concluded that the overall structure should be capable of withstanding greater forces than the station might encounter. Also, the hardness of the sheet metal is dependent on the gauge and will be tested after the thickness is selected to ensure it meets the requirements. The forces used to run the FEA analysis were taken from research that was conducted to observe the average human pulling and pushing force. The average male can provide a pulling force from a static position of about 200 lbf and less for a female. So the upper limit that will be tested to provide a factor of safety of 4 will be 800 lbf [2].

The prototype model will be placed indoors so the material used can be of any but needs to at least support the electrical and other components. Although a 3D printer could be used to make sections and then combine them, this can be tedious and will not have the same aesthetic look as smooth A500 steel. Also the polymer used in the 3D printers can be chosen to withstand different conditions and stresses but will increase the price of building drastically. For future construction different PLA The figure 2.3.1 below shows the rectangular tube that will be purchased and angled to form the structure needed. Although no analysis of stress was done, it can be seen that the structure can withstand high stress.

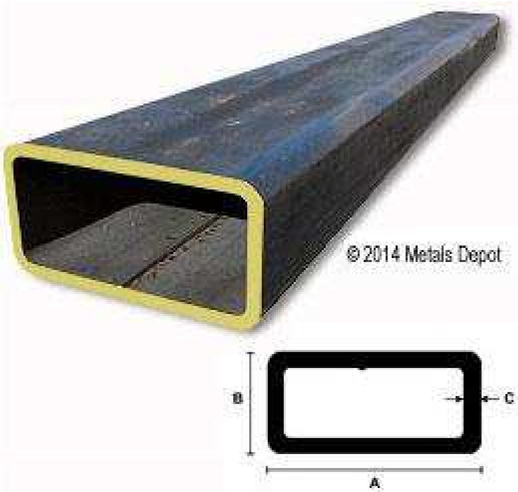


Figure 2.3.1: *Rectangular Steel Tube*

2.3.2 Overall Design of Structure

The structural design for both the prototype and future model needs to be sleek and deliver the message that this is innovative technology. The forming to get the unique design of the structure will be difficult and tedious. Also while bending galvanized steel, the zinc coating can crack where the pressure has been applied making susceptible to corrosion. Since the projected plan is to paint the station, the paint will be selected to have corrosion resistive properties to compensate for those areas needed.

The prototype model will be a simple rectangular steel tube that will be angled at 90 degrees to reach out to lock and charge the bike. The prototype will also be painted to include the logo of efficient systems as well as painting the entire station green.

2.3.3 Electromagnetic Lock

The locking device needs to sustain a grip of greater than 200 lbs while also unlocking and locking in the quickest and most convenient way possible. The previous design incorporated levers or moving arms that would latch onto some part of the frame of the bike. The main issue was that the tolerances for attaching the bike were so small that the user would have to place the bike the exact spot or the locking device would not function correctly. The main focus of this project is to lock and unlock with minimal user input which our previous failed to meet. Switching to a electromagnetic lock eliminated most of the reliability for the user to properly place the bike and allowed for a quicker lock to unlock state and vice versa. Also the EM lock used should be sufficiently strong to hold up against theft and other outside forces. To meet a factor of safety of 4 the rated force should be 600 lbf. The lock should also consume power under 100 watts to keep the operating cost low. Also, during power failure, the EM will attain its power from a backup power source that will be discussed later in risks. The prototype will still utilized the same EM concept as proposed for the future model design.

2.3.4 Bike Mounted Case

The case for the bike will need to house both the AC/DC converter as well as the receiving induction coil on the bike. In order to do this, a unique case was created using Creo Parametric and this will be submitted to the machine shop to be 3D print the case.

2.3.4 Induction Charging

The two induction coils need to maintain as close contact as possible in order to provide efficient power transfer. Additionally, because the AC/DC converter requires an input of at least 100V, the coils need to provide at least 50% efficiency in order to feasibly convert from 110V, assuming a turn ratio of 2:1 or less. The wires used in the coils also need to be small enough to allow the number of turns needed on each side, but also large enough to provide the current needed. Providing enough current should not be an issue as most circuit breakers have a maximum current of 15A, and the current drawn from the AC/DC converter is less than 3A, so even a turn ratio of 2:1 will draw well under the maximum current rating.

2.3.5 RFID Sensor/Tags

Each bike will be assigned their own unique ID in order to track which bike is rented out, which is being returned, and in the case of damage or theft of the bike, a history of the previous renters. In order to accomplish this, the Mifare MFRC522 RFID Reader/Writer module will be added to the Arduino Mega. Both the reader and the tags need to operate at 13.56MHz.

Furthermore, RFID tags can come in nearly any shape or form, making them easy to fit into the specific needs of the design. For instance, the planned RFID tag for the bike is a sticker that can be attached below the seat of the bike and that can be read when the bike seat gets close to the RFID scanner on the station. The user tags can come in whatever form they would like and could be available in an assortment for them to select.

2.3.6 User Interface

The main purpose of the user interface is to let the user know in clear terms whether the bike at a station is available for undocking, or if the station is empty and the user can dock the bike.

2.3.7 Networking

The station must be able to communicate to an existing website to know when a bike is schedule to undocking and to send information when the bike is docked. This requires that the station have internet access through ethernet, which will be used with an Ethernet Shield on the microcontroller.

2.4 Performance Assessment

The E-Bike station consists of various components and systems whose performance needs to be assessed in order to fulfill certain needs and requirements of the design. Each system was originally designed to achieve the tasks required of the station.

2.4.1 Station Structure

The structure of the station for the project will be a sleek design that can house all components that are to be attached, in order to make it appear as an undivided system. It will be a simpler structure than the design of the full production model, yet it will still fulfill all the requirements and be just as efficient. The design will accomplish the need for aesthetic appeal. Its steel structure will also be able to sustain strong enough forces to eliminate the concern of damaging the station itself, as well as the components being housed within it, during general use.

2.4.2 Component Housing Case

The case will be housing the bike-side induction coil and AC/DC converter in order to fulfill the need for aesthetic appeal of the station. Both these components will be completely enclosed by the case, which is to be made of a plastic material.

2.4.3 Induction Charging

The induction charging system will meet the needs and requirement for the station to charge the E-bike battery with no metal to metal contact. The system will provide power to the battery by wirelessly charging it using inductance coils. One inductance coil will be designated for the station side and the other for the bike side. It will also be able to provide a full charge in within 4 hours. The configuration of the inductance coils and the selection of the magnetic cores will be able to produce as high of efficiency as possible given the setup of the system. The inductance coils will receive AC power from the main supply of the power system.

2.4.4 Electromagnetic Lock

The electromagnetic lock will meet the requirement of making sure the bicycle is locked when placed into the station and will fulfill the need for the bicycle to remain stationary once in place, as well as the need for operating with minimal user input. It will provide a 600 pound holding force. The lock will attach at a 60 degree angle to better distribute the forces along the contact, as well as the reaction forces throughout the station. The orientation will be critical to achieving its optimum force. It will be able to operate with low power consumption and a low operating cost.

$$P = I * V \quad I = 0.25\, Amperes \quad V = 24\, Volts$$

$$Power\ Consumed = 6\, Watts$$

2.4.5 Power System

The power system will provide sufficient power for the electromagnetic lock, the micro controllers, and the station-side induction plate. Furthermore, the micro controller will provide power to the LEDs, the speaker, and the Mifare MFRC522 RFID Reader/Writer module. This system will be designed as energy efficient as possible. The main power lines will be enclosed by the station structure and the main power source will be a standard wall socket providing 120V/60 Hz. Another important part of the system is the AC/DC converter which will provide the power conversion from AC power, being outputted by the induction coils, to DC power required for the battery.

2.4.6 Network System

The network system will be able to provide the requirement of intelligence for the station and will interconnect most of the components. The Arduino Mega will control both the speaker and the LEDs on the station. The Mifare MFRC522 RFID Reader/Writer module will be connected to the microcontroller and it will be able to read the bike and user RFID at the correct proximity. When the RFID is read the signal will be sent to the Arduino Mega, which will also be connected to the electromagnetic lock, and it will be able to send a signal to the lock to engage or disengage it.

2.5 Design Process

The physical design has changed a numerous amount of times to meet the demands of the sponsor. The design went from having a mechanical lock to a electro-magnetic lock to limit the interactions from the user to the station. The overall structure has changed to become more simple from the complex designs previously. The electrical components will remain the same in the structure and function.

2.5.1 Structural Design

The rectangular steel tube utilized will have the dimensions of 8” x 4” and 0.25” thick with a total length of 4 feet. Its made out of A500 steel structural rectangle tube and it will be formed to produce a 90 degree angle to achieve the ideal and sleek shape.

2.5.2 Bike Mounted Case

The case that will be mounted to the bike has been designed to fit and be compact enough to be least invasive as possible. It will be designed using Creo Parametric 2.0 which the detailed sketch sheet will be submitted to the machine shop 3D printer to be constructed.

2.6 Overall Risk Assessment

2.6.1 Technical Risks

2.6.1.1 Technical Risk 1: Electromagnetic Lock Failure

Description

The electromagnetic lock will be the sole mechanism keeping the e-bike secure and preventative of theft. The electromagnetic lock will require 12VDC/24VAC in order to for the magnet to provide a continuous magnetic force. In the event that the main power source is cut due to a power surge in a storm possibly, or damage is done to the main line and wires, the lock is prone to failure. The e-bike will have no way of being secured and is open to theft.

Probability: Moderate

The stations will be placed in public areas that make it open to unpredictable environmental occurrences such as storms. Another possibility could be damage to the wiring or the actual source which will cause the lock to fail.

Consequences: Severe/Catastrophic

The e-bike itself costs close to $1300 USD. The cost of replacement alone shows for the loss of the consumer as well as for the company.

Strategy

The idea of the station locations will be near high rise buildings. Most of these high rise builds have a back up power generator. It would be an investment to inquire about a monthly charge to utilize these back up power generators to ensure that this risk does not occur. Another plan would be to have an internal battery supply for back up in the event of a power failure.

2.6.1.2 Technical Risk 2: RF-ID Failure

Description

The subsystems of the station heavily rely on the fact of whether or not the bike is in the station. The RF-ID tag and sensor are the reason the station can detect this. In the event that the sensor or the RF-ID tag malfunction or get damaged at all, the station will not lock the e-bike or allow an already locked e-bike to be released for use.

Probability: High

The RF-ID tag on the bike could possibly get damaged from use of the e-bike. The tag has the possibility of getting knocked off the e-bike. The RF-ID sensor has the possibility of malfunctioning when the tag isn't in the range of the sensor.

Consequences: Moderate

Since the station cannot operate without the status of the bike presence, the e-bike will be vulnerable to a user mistakenly leaving the e-bike unknowingly that it is not secured. On the flip side the e-bikes can't be unlocked and used. This can create an extreme amount of troubleshooting for ensuring the bikes are available to use and charged and locked.

Strategy

In the event that these components do fail, it is best to have the system analyze the RF components and ensure the user is notified when the e-bike is not detected or locked after an attempted dock. If the bike is locked status and the RF-ID User tag is not functioning properly, the user will also have to be prompted the unlocking attempt has failed. Making the station user-friendly and responsive will be very important to this risk.

2.6.1.3 Technical Risk 3: Induction Coils Misalignment

Description
In order for the battery to receive a charge from the power source, the induction coils need to align to induce the most effective transfer possible. If these plates do not align correctly, the use of the e-bike is jeopardized.
Probability: Moderate
Given that there is a properly positioned electromagnetic lock with the ability to hold a force up to 600 pounds, this should not be much of an issue in theory because the bike will remain stable. However, considering that the user does not move the e-bike into the proper position, the charging and locking can not operate.
Consequences: Severe
If this risk were to occur there would be a severe impact on the overall performance of the project because it is depended on whether or not the station can efficiently charge the bike's battery wirelessly. Given that the coils are not correctly aligned, it takes away from the station's ability to ensure that the bike is ready for us on a fully charged battery.
Strategy
This can be prevented by making sure that the electromagnetic lock secures the bike at a position where the coils are correctly aligned. It should also be confirmed that the bike will not be able to move once locked, so that the coils do not become misaligned. Another strategy to be used is to make the coils large enough to not be greatly affected by slight misalignment.

2.6.1.4 Technical Risk 4: Structure Failure

Description
The overall structure of the station should remain rigid and must not collapse or bend under an appropriate amount of force. It houses most components for the charging, the intelligence, and the lock. If the structure were to fail, then the internal components will be exposed and prone to damage.
Probability: Low
The probability that the structure fails is low because the prototype model will not encounter a force high enough to bend or damage the structure. The material of the model will be A500 structural steel which can easily withstand push or pulling forces of an average human.
Consequences: Severe
If this risk were to occur there would be a severe impact on the project because it will expose all the internal components and it could damage the components if the structure fails in the area where they are being housed.
Strategy
The strategy to be used for this risk is to ensure that the structure material is strong enough to not be affected by human forces before building the model with it. Another approach to take is to

place the components in a separate housing within the structural frame so that if the structure becomes damaged the components remain intact and protected.

2.6.2 Schedule Risks

There are many unplanned schedule related risks possible during the course of the project that can directly impact the project being completed on time. Some possible risks include availability of components on the market, delivery time of components, availability of technical support, personal emergencies and illnesses, and change of design.

2.6.2.1 Schedule Risk 1: Component Availability

Description

Some of the necessary components for the design may not be in stock on the internet or in stores and could delay the schedule for testing of any subsystems or creating the prototype. Also, one of the components may need to be custom built and could take some time to become available to the group. Lack of availability may also risk one of the reports being completed on time. For example, a section in the report may need to analyze one of the systems that has a missing component so it would not be possible to fully complete that section.

Probability: Low

The probability of a component not being available to the group is low because one can usually find the same component on various websites or in various stores. The only main factors for causing this risk would be a component being out of stock or having to be custom built.

Consequences: Severe

If this risk were to occur there would be a severe impact on the overall performance of the project because most of the components play a vital part in one of the subsystems of the design. If one of the components were not available it would hinder the progress of testing and prototyping the subsystem it is a part of. It could also impact the amount of details available in a report when writing about a subsystem missing a component.

Strategy

The strategy to be used to manage this risk is finding all components in various places to order from, if possible, and ordering them in a timely manner. Also, it would be helpful to only use components readily available on the market and avoid anything that needs to be custom built.

2.6.2.2 Schedule Risk 2: Component Delivery Time

Description

Some of the components for the design may not be in stock or it may be shipping from a far state or country. Also, they may not be available for expedited shipping if the component is needed last minute and it could delay implementing the component into the subsystem it is needed for.

Probability: Moderate

The probability of a component not being delivered in a timely manner is moderate because some components needed are not very common and usually ship from somewhere across the country or out of the country. There is also no way to control the efficiency of the delivery company so if there are any problems with the shipment nothing can be done to speed up the process.

Consequences: Moderate

If this risk were to occur there would be a moderate impact on the overall performance of the project because most of the components play a vital part in one of the subsystems of the design. However, it is different from the component not being available because the component will still be received, but not in the expected time frame. If one of the components were received late it may hinder the progress of testing and prototyping the subsystem it is a part of.

Strategy

The strategy to be used to manage this risk is placing all orders well ahead of time so that if there are any problems there is still time to make up for any loss time. Also, it would be helpful to order components from the closest location possible in order to cut down on delivery time.

2.6.2.3 Schedule Risk 3: Technical Support Availability

Description

The lack of availability of technical support could be a risk in terms of building the structure of the station. The machine shop will be needed to correctly weld and put together the steel structure of the station. If it is not available then it would not be possible to put together the station's structure given the lack of experience of the group with welding steel.

Probability: Low

The probability of technical support not being available is low because if there is no personnel or space available for using the machine shop at the College of Engineering to weld the steel structure, then the group can reach out to a local machine shop to complete the given tasks.

Consequences: Catastrophic

If this risk were to occur there would be a catastrophic impact on the overall performance of the project because it would not be possible to correctly build the structure of the station given the lack of machinery and personnel with experience.

Strategy

The strategy to be used to manage this risk is coordinating with the machine shop well ahead of time to use it for building the station's structure. It could also be avoided by having a backup plan to use a local machine shop to build the steel structure.

2.6.2.4 Schedule Risk 4: Illnesses/Personal Emergencies

Description

The possibility of one of the group members becoming ill during the year or dealing with a personal emergency could be a risk for completing tasks. If one of the members becomes very ill or has to handle an emergency, and is not able to work on the project, then the tasks given to that member have to be delegated amongst everyone else. This adds a larger work load to all members and could affect the ability to complete certain tasks on time.

Probability: Low

The probability of a group member becoming ill is low because everyone is in relatively good health and they maintain a healthy lifestyle. There is always the small possibility of at least one member becoming sick during this time period from an illness going around, especially during the winter time. Also, the probability of facing a major personal emergency is low, but anything can happen at any given moment.

Consequences: Minor

If the risk were to occur there would be a mild impact on the overall performance of the project because it would cause other group members to take responsibility of the tasks not able to be completed by the absent member. If the tasks are fairly distributed in a timely manner, then there should be a very small impact of this risk on the group's performance.

Strategy

The strategy to be used to manage this risk is to avoid becoming sick during this time period by staying healthy and avoiding any airborne diseases. It is also important to become aware of an ill group member as soon as possible so that they can start fighting off the illness and so their tasks can be divided amongst the rest of the group. In terms of personal emergencies, all should be treated equally for any group member. The member dealing with the emergency should alert the group of it so that planning can be executed within a reasonable amount of time.

2.6.2.5 Schedule Risk 5: Change of Design

Description

The possibility of having to make a small or large change of design could be a risk in terms of completing certain tasks for the project. For example, if the locking mechanism design has to be changed, then the whole subsystem has to be reanalyzed, tested, and prototyped. This process could take a while depending on the severity of the change and it could delay the completion of the prototype or even one of the reports. The point in time during which a change could occur also plays a huge factor on the risk's effect.

Probability: Low

The probability of a change of design during the course of the project is low because most design ideas have been thoroughly analyzed and are projected to work as expected; therefore, the design should not be changed until proven otherwise. There is the possibility that one of the design ideas does not produce the intended result once prototyped, and in that case a change has to occur.

Consequences: Severe

If the risk were to occur there would be a severe impact on the overall performance of the project. It would delay the completion of certain tasks like building the prototype and finishing any reports that encompass details of the design. If the change were to occur during the prototype phase, it would impact the ability to complete this task in a timely manner because the change would have to be reanalyzed and tested. If new components have to be ordered the delivery time could cause a delay as well.

Strategy

The strategy to be used to manage this risk is to minimize the possibility of having a change of design by thoroughly analyzing all design ideas the first time around so that when all subsystems for the project are being built there is no need to replace any of them. All design ideas should be planned to work as expected.

2.6.3 Budget Risks

There are many unplanned budget related risks possible during the course of the project that can directly impact the project and produce budget overruns. Some possible risks include additional support costs, unexpected component costs, and mismanagement of budget.

2.6.3.1 Budget Risk 1: Additional Support Costs

Description

There is the risk of having to add costs to the budget for additional support. This would be an unexpected addition to the budget since it is not planned to have any part of the budget set aside for additional support. For example, if the plan to use the machine shop at the College of Engineering falls through, then additional costs have to be added for using a local machine shop.

Probability: Low

The probability of having additional support costs is low because it is not deemed necessary to need any type of additional support except from a machine shop, which is planned to be used in the College of Engineering. As long as it is scheduled to be used ahead of time there should be no problem with using the school’s machine shop.

Consequences: Minor

If the risk were to occur there would be a minor impact on the overall performance of the project because another local machine shop could be used to construct the station’s structure. The project is also well under budget so adding an additional cost for support would not be a problem.

Strategy

The strategy to be used to manage this risk is avoiding it by planning to use the machine shop ahead of time. The time to use it will be scheduled at least a month in advance to avoid any conflicts.

2.6.3.2 Budget Risk 2: Unexpected Component Costs

Description

There is the risk of having to add costs for any unexpected components. This could occur if any necessary components were forgotten on the budget list or if there is a change of design and new components need to be ordered. Also, if the quantity of any of the components are incorrect, then more components would need to be ordered.

Probability: Low

The probability of having costs from unexpected components is low because all components that will be needed to build the station and its subsystems were added to the budget list. Any small number of components that need to be added to the list can be added without having an impact on the budget.

Consequences: Minor

If the risk were to occur there would be a minor impact on the overall performance of the project because other components can be easily added to the budget list. The project is well under budget so adding any additional cost for unexpected components would not be a problem.
Strategy
The strategy to be used to manage this risk is making sure all components needed for the project are already on the budget list, and adding any other components as soon as they are found to be necessary for the project.

2.6.3.3 Budget Risk 3: Budget Mismanagement

Description
There is the risk of budget mismanagement by not correctly adding anything that needs to be purchased to the budget list and taking it out of the given budget.
Probability: Very Low
The probability of budget mismanagement is low because time has been taken to meet with the advisor, sponsor, and group as a whole to overview and manage the budget.
Consequences: Minor
If the risk were to occur there would be a minor impact on the overall performance of the project because the overall project budget is well under the given budget by the sponsor.
Strategy
The strategy to be used to manage this risk is keeping an itemized list to keep record and periodically checking it on a weekly basis to ensure that past purchases are taken into account for future ones.

2.6.4 Summary of Risk Assessment

Many potential risks including technical, schedule, and budget risks have been identified for the project, but they are all well understood. There is a set strategy to handle all of these risks if they pose a problem for completing the project. All of the proposed risks are ready to be managed by the group through proper planning.

3 Design of Major Components

In this section the various mechanical components will be shown and described. This will include all the components involving the prototype model as described as before. The project’s mechanical design has changed drastically over the duration of the last few weeks. The mechanical design section details the components for physical frame, the electro-magnetic lock, the case for electrical components, and the installation of all the components. The electrical component section details the design portion of the RFID sensors, the micro controller, the speaker, the LED lights, and the induction coils. The differentiation between the now developed prototype design and the previous design will be explicitly portrayed in the system overview. The drastic changes in the mechanical concept occurred due to the complexity of the physical design and the need to further develop the aesthetic appeal by incorporating a product and marketing specialist. Therefore the design was constructed to be less complex achieve the same objectives as the past design has. The previous design will be considered a future implementation through further development.

3.1 Mechanical Components

3.1.1 Overall Design of Structure

The new prototype model has an overall structure that is less complex than the previous future mass production model. In figure 3.1.1 the various components on the station side and the bike side can explicitly be seen. The figure shows a transparent view of what the inside placement of the components will look like. There will be hinged doors that can swing open during troubleshooting states. The electrical components housing located near the end of the station will contain everything that will be installed to the station.This allows the components to be organized and secured such that during operation or installation all the components stay in place and wires don't come apart.

Recalling that the distance between the coils is proportional to efficiency at a rate of $\frac{1}{R^3}$. To maximize efficiency of power transfer, the coils need to be as close as possible. The previous design required the actuation of the plate on the station side to move it closer to the bike side induction coil. In this design, it can be seen in figure 3.1.1 that the user will guide the bike in through the passageway that is cut out of the rectangular beam. The induction coils will be enclosed by a plastic housing to secure the iron core and the coils and when brought as close as possible, there will be no metal to metal contact hence fulfilling the requirement. Although the bike will first come in contact with the EM lock to stop it instead of the coils so they don't get damaged. The cut out portion will also act as a guider so when the user brings the bike back, they can easily orient the bike and guide it into its lock state.

The station itself will be mounted to a wood board at ground level approximately 1” inch thick and about 6’ x 3’ ft. They will be bolted to the board using a 1/2 in. -13 tpi x 6 in. Zinc-Plated Hex Bolt [7]. This will allow the station to be disassembled and transported to campus after it has been constructed.

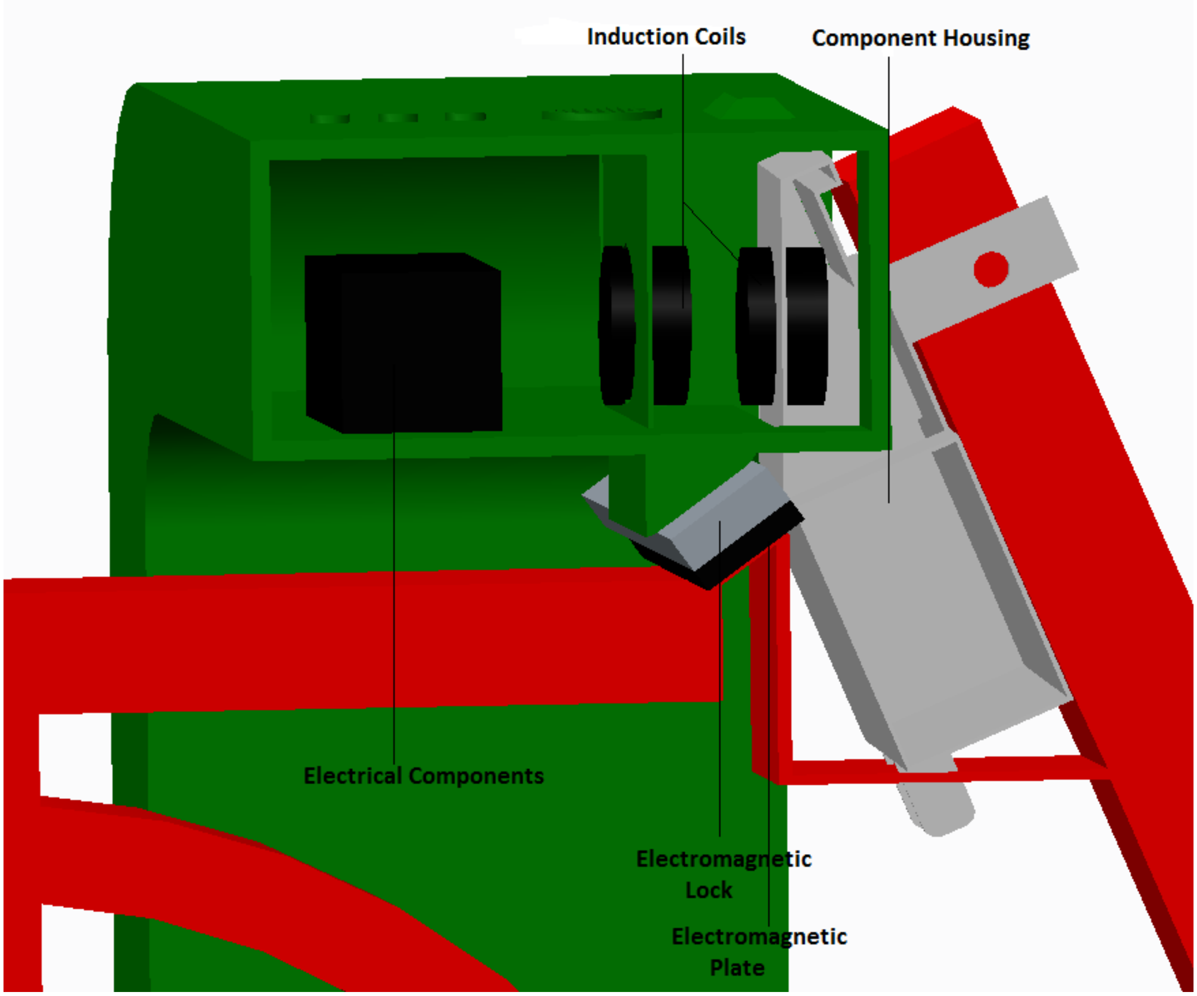


Figure 3.1.1: *Inside Look of Assembled Components in Locking Position*

3.1.2 Electromagnetic Lock

The EM lock chosen for the previous design was specifically chosen for its holding force rating and its properties that made it defensive against environmental conditions. Since the prototype design will act as a model and will only be place indoors, the need for an indoor EM lock was chosen. The electromagnetic lock chosen is the Seco-Larm 600 lbf E-941SA-600 [6]. The lock will be mounted from above onto a triangular piece that will protrude from the bottom surface of the station structure as seen in figure 3.1.1.

The dimensions on figure 3.1.3 confirm that the plate and the EM lock will fit precisely into their allocated spaces. Further manipulation during installation process may be needed to adjust the angle to ensure a smooth contact.

The EM lock will still be mounted at an angle. The exact angle is conceptually going to be 30 degrees from the horizontal but will change slightly during installation.

Figure 3.1.2: *Seco-Larm 600 lbf EM Lock*

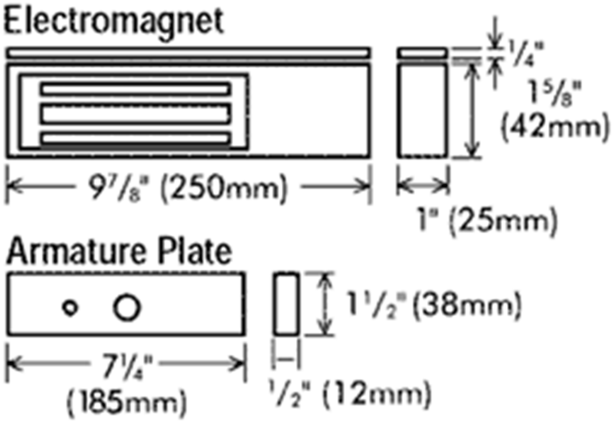


Figure 3.1.2: *Dimensions of the Seco-Larm 600 lbf*

3.1.3 Bike-Mounted Case

The housing for the AC/DC converter and the induction coil on the bike needed to be uniquely built to fit the specific dimensions of the space that has been decided to be directly behind the battery. In figure 3.1.4 it can be seen that the station has an open side, this is for ease of installation of the two components. Separate plates will also be 3D printed to close this area and securely fasten the components. On the bottom of the case, seen in figure 3.1.4, the two plates that come out will be used to mount the case to the bolts that also mount the rear rack of the bike. This was the easiest and strongest area for the case to be mounted to. There are no holes because the holes will be created during installation to ensure a tight fit. The cut out for the induction will allow for simple routing of the wires to the battery port. Since the port should be a dual function, the wires will be connected behind the port. These wires will be exposed to the outside and could potentially be a safety issue. To solve this problem, a extended plate will cover the wire but will have a round cut out so the standard port can still be accessible if the user would like to charge while not at a charging station.

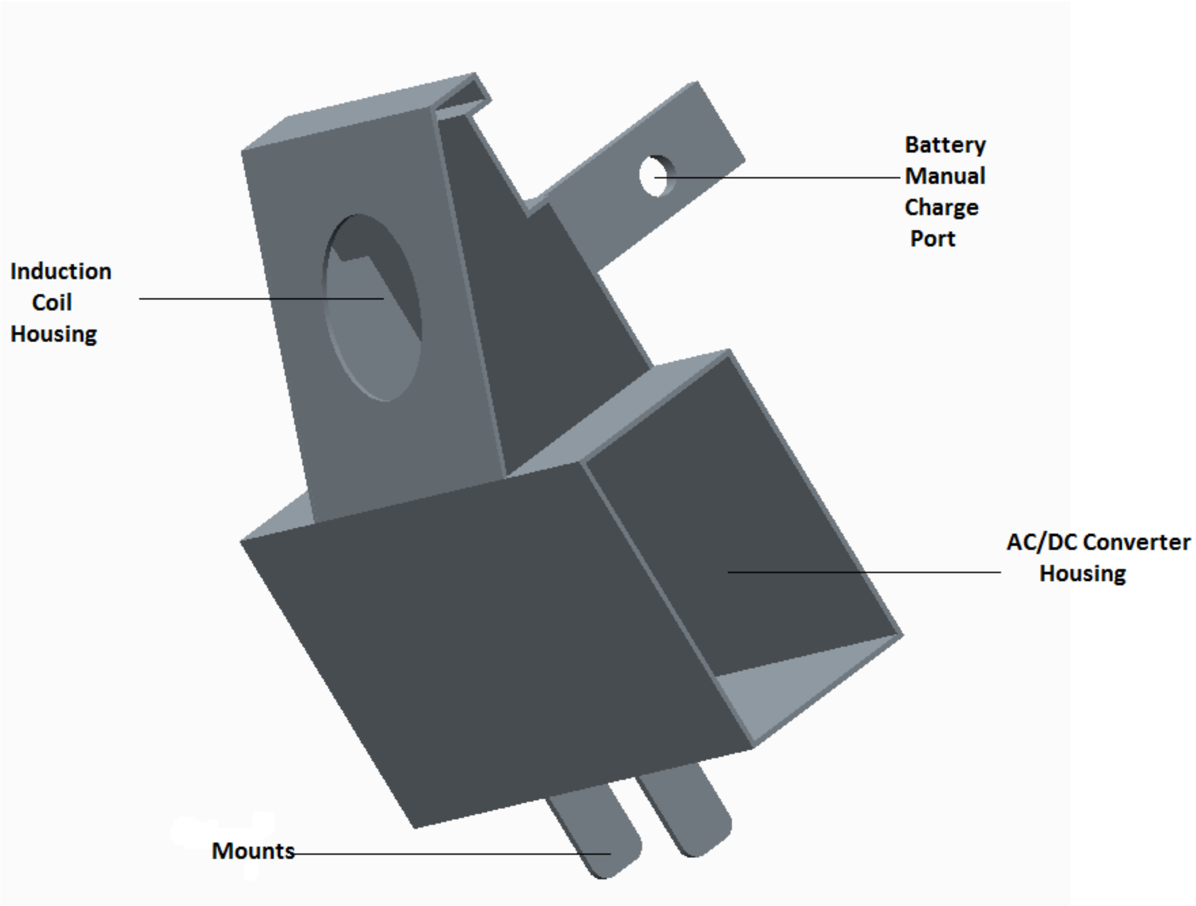


Figure 3.1.4: *Bike Case to House the AC/DC Converter and Induction Coil*

3.2 Electrical Components

3.2.1 Induction Coils

The induction system is a key part of the current design and was chosen because one of the top goals of the project was to charge the bike wirelessly. This requires that the induction system have a relatively high efficiency in order to provide enough power for the AC/DC converter that will reside on the bike.

The project's induction system provides some unique challenges: First, the system must be able to handle high voltages and somewhat high current, operating around 110V and 3A. This means that the wires must have a certain diameter in order to safely provide the current going through the coil. In addition, a single core between the two coils cannot be used, as the bike and station coils must obviously not be connected. Furthermore, the system is planned to work off of the 60Hz, which is a very low frequency compared to most non-power applications. Because of the relatively low documentation of systems with these conditions, much of the the work for this section of the project will come from testing various setups.

Currently, two pot cores are being used, one to be placed on the bike and one on the station. These have the advantage of being two separate cores but with little air gap between them when aligned properly, fitting the needs of the project quite well. However, the largest commercially available pot cores have only a 40mm inner diameter which is likely too small for the needs of the project, so a custom core will likely need to be manufactured in order to produce an acceptable efficiency.

Recent tests with the current cores and 10 turns on each coil have resulted in significantly lower efficiency than needed, about 2%, though several improvements can be made to increase the number of turns, which will both provide a better coupling and also raise the inductance of each coil, making it more suitable for the low frequency at which the coils are being driven.

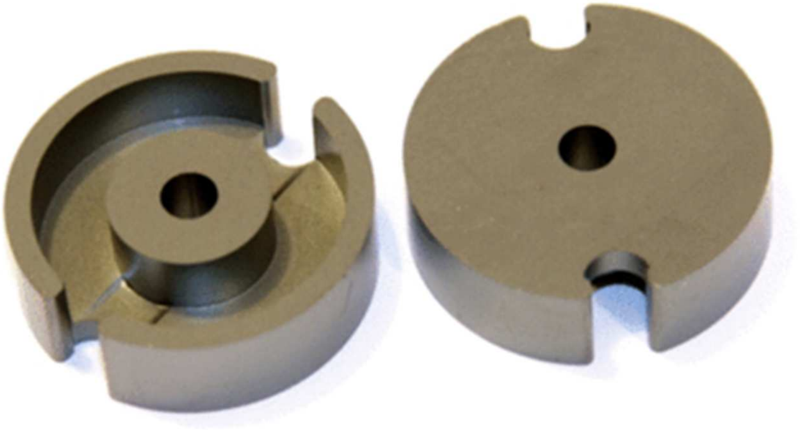


Figure 3.2.1: *Picture of the pot cores currently in use*

3.2.2 AC/DC Converter

Due to the complexity of the circuit of the AC/DC converter that is used with the battery, the existing converter will be used to provide the correct voltage and current to the battery. The converter will be stored within the bike-mounted case, with the input connected to the bike-side induction coil and the output to the battery.

Figure 3.2.2: *AC/DC Converter*

3.2.3 RFID Reader and Tags

An RFID reader will be used to allow identification of the user and the bike, as well as a check for the presence of the bike so that it can be locked and charged. The RFID reader chosen is the Mifare MFRC522, which operates at 13.56 MHz. The reader will send the ID information to the Mega, which will then check against the list of bike/user ID’s stored on either the website (slower, no memory requirement) or locally (faster, moderate memory requirement).

Figure 3.2.3: *RFID reader and example tags*

3.2.4 User Interface

The user interface decided upon was chosen for primarily for simplicity of the design and consists of three LEDs and a speaker. The LEDs correspond to each state described in Section 2.1, and will be turned on and off directly by the microcontroller. The speaker will generate tones between 500Hz and 1kHz to notify the user of a significant problem, such as detecting the bike but not being able to charge (i.e. out of alignment) or unlocking a bike and not removing it from the station.

3.2.5 Microcontroller

The Arduino Mega will be used as the microcontroller for the system. The microcontroller will be responsible for controlling all of the peripherals of the station as well as interfacing out to the existing website with information on each bike’s status. The specifications of the Mega in particular provide more than enough memory and processing power to meet the needs of the project.

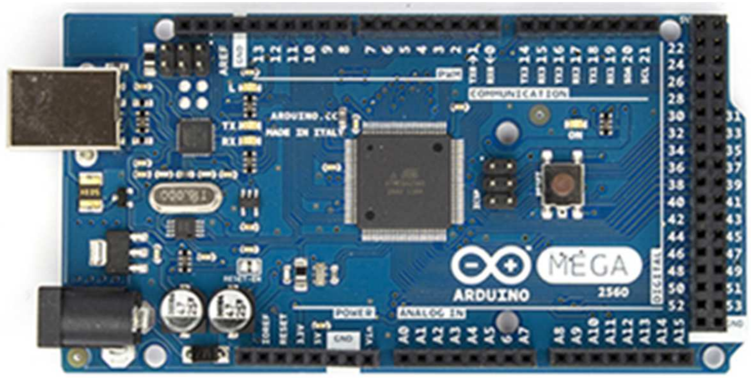


Figure 3.2.4: *Arduino Mega 2560*

3.2.5.1 Code

Most of the code for networking and RFID will be utilizing existing libraries. These functions have been well-established and should not take a significant amount of time to adapt the code to the needs of the project. Code will need to be written, however, for the control of the speaker and LEDs, switching the induction coil power on and off, engaging the electromagnetic lock, and overall management of the data for each of the bikes. The station will need to keep track of which state it is in (see Section 2.1) and carry out the tasks associated with each state.

3.2.5.2 Input/Output

Managing the I/O pins used on a microcontroller is often of concern for various projects. However, for this project, the number of I/O pins on the Mega is not a limiting factor. The only conflict that may occur is that both the RFID reader and the Ethernet Shield communicate through SPI, so the two devices will have to share communication through the bus. Table 3.2.1 details the number of pins needed for each of the peripherals. Note that digital pins do not require any specific pin to operate, so they can be used on any one of the 54 digital pins that is free on the Mega.

Device	Ports Needed
LEDs	3 digital
EM Lock	1 digital
Speaker	1 digital
RF Reciever	2 digital, 3 SPI
Ethernet shield	2 digital, 3 SPI

Table 3.2.1: A listing of the number of pins needed

4 Test Plan

4.1 System and Integration Test Plan

4.1.1 Overall Structure

The overall structure with the station being bolted to the base board will be tested with minimal impulse force on all sides by a human. No specific rating needs to be reached but the station needs to stay upright and robust during docking and undocking states.

4.1.2 Electromagnetic Lock

The electromagnetic lock is expected to perform as described from the manufacturer. It will not be tested for the amount of force it can actually hold compared to what the manufacturer has described. It will tested to hold in different directions and it will also be tested where it is being mounted.

4.1.3 Bike Mounted Case

The housing for the AC/DC converter and the bike side induction coil will be tested to ensure it does not allow the components to move drastically to potentially damage them. The case will also be tested for its strength to ensure it will not fall off the bike while in motion. It will also be tested to allow for a small passage of ventilation to allow the components to release heat.

4.2 Test Plan for Major Components

This section will describe the procedural methods that will be conducted to test each component of the system designed. Each component contains a test sheet that will be carried out by the individual team member selected to test each component.

4.2.1 Structural Integrity

Test Item: Material
Tester Name: Bilal Rafiq
Tester ID No: 1911
Test Date: 3/4/15
Test No: 1
Test Time: 4:00 PM
Test Type: Test
Test Location: College of Engineering Lab
Test Result: TBA

Test Objective:
To test the structural integrity to endure forces and movements no greater than what an average human can push or pull.

Test Description/Requirements:
By applying an impulse force on each side of the station and as well as pulling/pushing the bike while it is in .

Anticipated Results:
The charging station should remain intact when an outside force is placed upon it.

Requirement for Success:
The required result for this test is for the station to keep all internal parts safe and remain standing upright with no permanent damage being done to it.

Actual Results:
TBA

Reason for Failure:
TBA

Recommended Fix:
TBA

Other Comments:

4.2.2 Electromagnetic Lock

Test Item: Electromagnetic Lock
Tester Name: Justin Johnson
Tester ID No: 1912
Test Date: 3/4/15
Test No: 1
Test Time: 4:00 PM
Test Type: Test
Test Location: College of Engineering Lab
Test Result: TBA

Test Objective:
To test locks capabilities to remain locked under a certain amount of force.

Test Description/Requirements:
By applying a force in all directions from the plate side of the electromagnetic lock.

Anticipated Results:

We expect the lock to remain locked up to a force of 600 pounds.

Requirement for Success:
The lock should remain locked and keep the bike safe up until 600 pounds of force are exerted upon it.

Actual Results:
TBA

Reason for Failure:
TBA

Recommended Fix:
TBA

Other Comments:

4.2.3 Bike Mounted Case

Test Item: Bike Mounted Case
Tester Name: Justin Johnson Tester ID No: 1912
Test Date: 3/4/15 Test No: 1
Test Time: 4:00 PM Test Type: Test
Test Location: College of Engineering Lab Test Result: TBA

Test Objective:
The bike mounted case should fit snugly onto the bike and securely hold the AC/DC converter and the induction coils in place.

Test Description/Requirements:
To test this component the bike will be driven to determine if it will securely hold in place under normal use.

Anticipated Results:
We expect the case to remain in its original position and still be able to charge after being driven.

Requirement for Success:
The case should not move around and the coils should line up and be able to charge the bike after use.

Actual Results:
TBA

Reason for Failure:
TBA

Recommended Fix:
TBA

Other Comments:

4.2.5 Network System

In this section the network components of the system will be described for testing procedures and forms that will be used during testing.

4.2.5.1 Microcontroller

Test Item: Arduino Mega microcontroller

Tester Name: Seve Kim	Tester ID No:
Test Date: TBA	Test No:
Test Time: TBA	Test Type: Test
Test Location: College of Engineering Lab	Test Result: TBA

Test Objective:
The objective of this test is to ensure functionality and connection to all components and extensions.

Test Description/Requirements:
Requirements:
1- Arduino MEGA microcontroller
2- USB connection adapter

Process:
The proper voltage input will be applied to ensure the board is operational. The digital I/O ports including the PWM ports will be utilized for connections to other components. A sample code will be ran on the Arduino. The reset button will be pressed to ensure its functionality.

Anticipated Results:
The Arduino Mega should turn on when connected to the power source. All digital I/O ports should be active when tested, as well as the PWM ports. The sample code should run and produce the correct results. The reset button should reset the system.

Requirement for Success:

The requirement for success is that the input voltage for the microcontroller is 7-12 V. All ports should be active when connected. The reset button will reset the system when pressed.

Actual Results:
TBA

Reason for Failure:
TBA

Recommended Fix:
TBA

Other Comments:

4.2.5.2 RFID & RFID Reader

Test Item: Mifare RC522 Card Read Antenna RF Module RFID Reader IC Card Proximity Module

Tester Name: Seve Kim
Tester ID No:
Test Date: TBA
Test No:
Test Time: TBA
Test Type: Test
Test Location: College of Engineering Lab
Test Result: TBA

Test Objective:
The objective of this test is to test proximity range for RFID tag to reader as well as RFID card to reader and ensure locking system engages and disengages respectively.

Test Description/Requirements:
Requirements:
1- RC522 chip
2- RFID module
3- Electromagnetic Locking system
5- Arduino Mega controller

Process:
The RC522 chip will be programmed to sync with the RFID module. The RFID module will be connected to the Arduino MEGA controller to send a signal to the Electromagnetic locking system to lock and unlock the bike.

The RFID tag will be placed at a distance of 12 inches and slowly moved closer by increments of 1 inch until the correct proximity distance is found. This will be repeated 10 times and averaged for an accurate measurement. This process will also be done for the RFID card. The correct proximity distance will be applied and the RFID tag will be placed on the bike in a proper location. The bike will be pushed into the station and placed into the docked position.

Anticipated Results:
After the bike is in docked position, the RFID module should recognize the presence of the bike and engage the electromagnetic lock. While the bike is in the locked position, the RFID card will be tested from a user stance and placed at the correct proximity. The electromagnetic lock should disengage at this point.

Requirement for Success:
The requirement for success is that the RFID module needs to read the RFID card and tag within the measured proximity from the test results.

Actual Results:
TBA

Reason for Failure:
TBA

Recommended Fix:
TBA

Other Comments:

4.2.6 Power System

The power system components testing procedure will be described in this section as well as the forms that will be utilized to note down testing results.

4.2.6.1 Inductance Charging

Test Item: Inductance core & coils
Tester Name: Jacob Knoblauch
Test Date: 02/08
Test Time: TBA
Test Location: College of Engineering Lab

Tester ID No:
Test No:
Test Type: Test
Test Result: TBA

Test Objective:
The objective of this test is to test the efficiency and power transfer of the inductance charging system as a whole.

Test Description/Requirements:
Requirements:

1- Pot cores
2- Copper coils
3- Function Generator
4- Voltmeter
5- Alligator clips

Process:
The station side coil and core will receive an AC signal from the function generator. The voltmeter will be connected to the bike side coil and core to get a reading of the output voltage for the system. The scope of the project requires that there be no metal to metal contact, so the inductance coils will be measured to get the closest proximity they can have without touching and still provide efficient power transfer. All of the connections from the function generator and from the voltmeter will be connected using the alligator clips.

Anticipated Results:
The anticipated results are an efficiency of at least 75% as well as providing power transfer with no metal to metal contact through the inductance system.

Requirement for Success:
The requirements for success are that the inductance charging system is set up with the best possible coil configuration considering coil turn ratio, pot core diameter, and proximity between both cores.

Actual Results:
TBA

Reason for Failure:
TBA

Recommended Fix:
TBA

Other Comments:

4.2.6.2 AC/DC Converter

Test Item: AC/DC Converter	
Tester Name: Bryan Castro	Tester ID No:
Test Date: TBA	Test No:
Test Time: TBA	Test Type: Test
Test Location: College of Engineering Lab	Test Result: TBA

Test Objective:

The objective of this test is to ensure that the component can convert AC power to DC power.

Test Description/Requirements:
Requirements:
1- AC/DC Converter
2- Function Generator
3- Voltmeter
4- Alligator clips

Process:
The input side of the component will be hooked up to the function generator and it will provide an AC signal of 150 V. The voltmeter will be connected to the output side of the converter in order to check the DC voltage for the system. All of the connections from the function generator and from the voltmeter will be connected using the alligator clips.

Anticipated Results:
The anticipated results are that the system converts the AC power to DC power.

Requirement for Success:
The requirement for success is that the AC/DC converter delivers DC power.

Actual Results:
TBA

Reason for Failure:
TBA

Recommended Fix:
TBA

Other Comments:

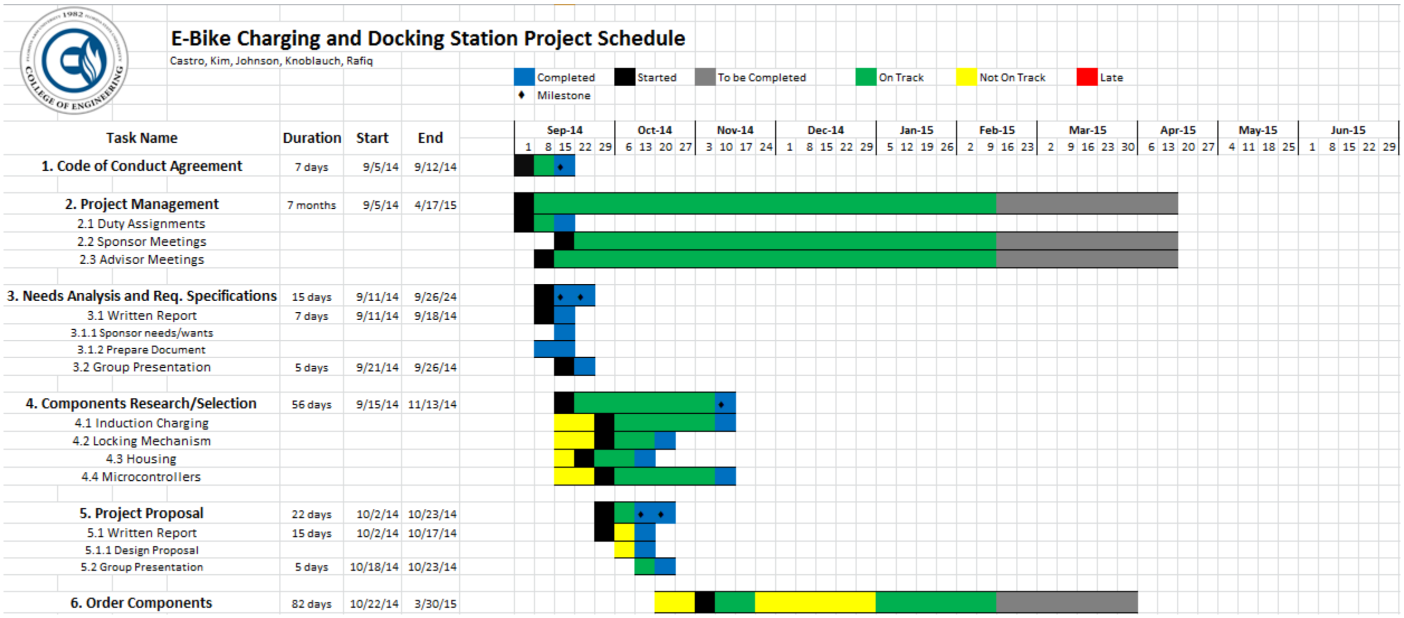
4.3 Summary of Test Plan Status

Component Tested	Tester	Date Completed	Test Attempt #	Result (Pass/Fail)
Structural Integrity				
Electromagnetic Lock				

Bike Mounted Case				
Microcontroller				
RFID & RFID Reader				
Inductance Charging				
AC/DC Converter				

Table 4.3.1: Status of Components Testing

5 Schedule

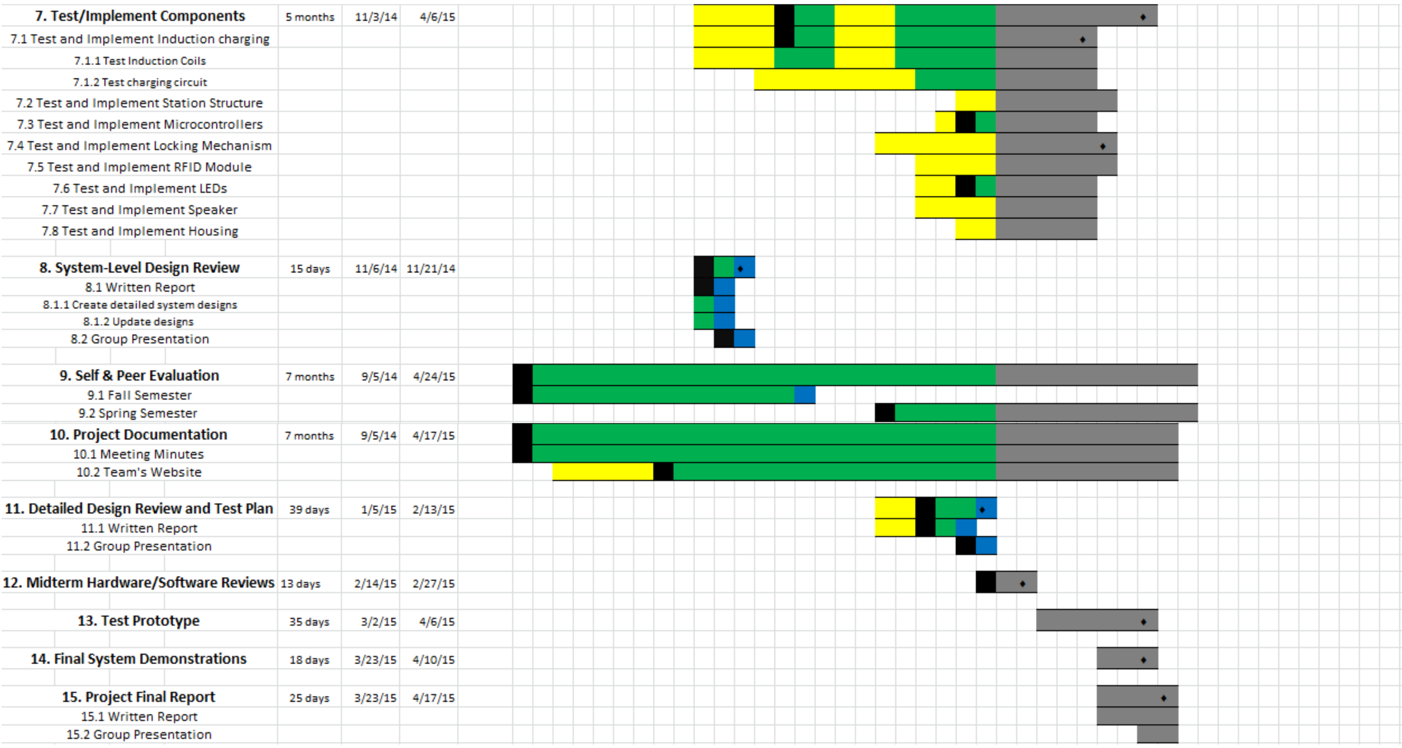


E-Bike Charging and Docking Station Project Schedule

Castro, Kim, Johnson, Knoblauch, Rafiq

🟦 Completed ■ Started ▨ To be Completed 🟩 On Track 🟨 Not On Track 🟥 Late
♦ Milestone

Task Name	Duration	Start	End
1. Code of Conduct Agreement	7 days	9/5/14	9/12/14
2. Project Management	7 months	9/5/14	4/17/15
2.1 Duty Assignments			
2.2 Sponsor Meetings			
2.3 Advisor Meetings			
3. Needs Analysis and Req. Specifications	15 days	9/11/14	9/26/24
3.1 Written Report	7 days	9/11/14	9/18/14
3.1.1 Sponsor needs/wants			
3.1.2 Prepare Document			
3.2 Group Presentation	5 days	9/21/14	9/26/14
4. Components Research/Selection	56 days	9/15/14	11/13/14
4.1 Induction Charging			
4.2 Locking Mechanism			
4.3 Housing			
4.4 Microcontrollers			
5. Project Proposal	22 days	10/2/14	10/23/14
5.1 Written Report	15 days	10/2/14	10/17/14
5.1.1 Design Proposal			
5.2 Group Presentation	5 days	10/18/14	10/23/14
6. Order Components	82 days	10/22/14	3/30/15



7. Test/Implement Components	5 months	11/3/14	4/6/15
7.1 Test and Implement Induction charging			
7.1.1 Test Induction Coils			
7.1.2 Test charging circuit			
7.2 Test and Implement Station Structure			
7.3 Test and Implement Microcontrollers			
7.4 Test and Implement Locking Mechanism			
7.5 Test and Implement RFID Module			
7.6 Test and Implement LEDs			
7.7 Test and Implement Speaker			
7.8 Test and Implement Housing			
8. System-Level Design Review	15 days	11/6/14	11/21/14
8.1 Written Report			
8.1.1 Create detailed system designs			
8.1.2 Update designs			
8.2 Group Presentation			
9. Self & Peer Evaluation	7 months	9/5/14	4/24/15
9.1 Fall Semester			
9.2 Spring Semester			
10. Project Documentation	7 months	9/5/14	4/17/15
10.1 Meeting Minutes			
10.2 Team's Website			
11. Detailed Design Review and Test Plan	39 days	1/5/15	2/13/15
11.1 Written Report			
11.2 Group Presentation			
12. Midterm Hardware/Software Reviews	13 days	2/14/15	2/27/15
13. Test Prototype	35 days	3/2/15	4/6/15
14. Final System Demonstrations	18 days	3/23/15	4/10/15
15. Project Final Report	25 days	3/23/15	4/17/15
15.1 Written Report			
15.2 Group Presentation			

Any tasks that fall behind schedule will be addressed by coming together as a group and focusing on the given tasks. The quickest and most efficient method to get on track will be established as a group and all subtasks will be divided equally amongst each other. Early completion of tasks will be capitalized on by concentrating on any tasks that are behind or starting on another task with an approaching end date. Also, the tasks with the highest priority will be taken into consideration first.

6 Budget Estimate

Original Budget (Full Production Model)

A. Personnel			
Engineer	**Hours**	**Hourly Pay**	**Total Pay**
Bryan Castro	348	$30.00	$10,440.00
Seve Kim	348	$30.00	$10,440.00
Bilal Rafiq	348	$30.00	$10,440.00

Justin Johnson	348	$30.00	$10,440.00
Jacob Knoblauch	348	$30.00	$10,440.00
		Personnel Subtotal	**$52,200.00**
B. Fringe Benefits		**29% of Personnel**	**$15,138.00**
C. Total Personnel			**$67,338.00**
D. Expenses			
Item/Description	**Quantity**	**Price/Unit**	**Total Price**
Galvanized Steel Sheet Metal (1.41 m$_{--}^{2}$)	1	$88.48	$88.48
A36 Hot Rolled Steel (8 ft, 1 in Diameter)	1	$32.00	$32.00
FPC-SS800-G 800 lbs Outdoor and Gate Electromagnetic Lock CE Listed	1	$87.73	$87.73
Arduino UNO Rev3	1	$24.97	$24.97
Arduino MEGA 2560 Rev3	1	$43.70	$43.70
Arduino Ethernet Shield Rev3 (without PoE Module)	1	$36.21	$36.21
Mifare RC522 Card Read Antenna RF Module RFID Reader IC Card Proximity Module	1	$5.36	$5.36
Wall Adapter Power Supply (9VDC, 650mA)	1	$5.95	$5.95
3” Diameter Speaker (8 ohm, 1 Watt)	1	$1.95	$1.95
Tool Storage Spring Terry Clips (1 in)	1	$10.19	$10.19
18 AWG Copper Magnet Wire (1 lb, 201 ft)	1	$16.50	$16.50
14 AWG Copper Wire (25 ft)	1	$14.00	$14.00
LED R/Y/G	1	$2.75	$2.75
		Expenses Subtotal	**$369.79**

E. Total Direct Costs		**Personnel + Expenses**	**$67,707.79**
F. Overhead Costs		**45% of Direct Costs**	**$30,468.50**
G. Total Project Cost			**$98,176.29**

Updated Budget (Prototype Model)

A. Personnel			
Engineer	**Hours**	**Hourly Pay**	**Total Pay**
Bryan Castro	348	$30.00	$10,440.00
Seve Kim	348	$30.00	$10,440.00
Bilal Rafiq	348	$30.00	$10,440.00
Justin Johnson	348	$30.00	$10,440.00
Jacob Knoblauch	348	$30.00	$10,440.00
		Personnel Subtotal	**$52,200.00**
B. Fringe Benefits		**29% of Personnel**	**$15,138.00**
C. Total Personnel			**$67,338.00**

D. Expenses			
Item/Description	**Quantity**	**Price/Unit**	**Total Price**
A500 Steel Structural Rectangle Tube (4 ft)	1	$123.60	$123.60
½ in. - 13 tpi x 6 in. Zinc-Plated Hex Bolt	10	$1.57	$15.70
Seco-Larm E-941SA-600 Enforcer Electromagnetic Lock with 600lb Holding Force	1	$68.96	$68.96

3D Printed Components Housing	1	$0.00	$0.00
Arduino MEGA 2560 Rev3	1	$43.70	$43.70
Arduino Ethernet Shield Rev3 (without PoE Module)	1	$36.21	$36.21
Mifare RC522 Card Read Antenna RF Module RFID Reader IC Card Proximity Module	1	$5.36	$5.36
Wall Adapter Power Supply (9VDC, 650mA)	1	$5.95	$5.95
3” Diameter Speaker (8 ohm, 1 Watt)	1	$1.95	$1.95
18 AWG Copper Magnet Wire (1 lb, 201 ft)	1	$16.50	$16.50
14 AWG Copper Wire (25 ft)	1	$14.00	$14.00
LED R/Y/G	1	$2.75	$2.75
		Expenses Subtotal	**$334.68**
E. Additional Costs (Components + Support)			**$300.00**
F. Total Direct Costs		**Personnel + Expenses+ Additional Costs**	**$67,972.68**
G. Overhead Costs		**45% of Direct Costs**	**$30,587.70**
H. Total Project Cost			**$98,560.38**

The total costs for components of the prototype model amounted to $634.68 given a budget of $1000; however, $300 of the total costs was added in case any other additional components or technical support have to be purchased during the building of the prototype.

7 Conclusion

The time has come for the backend research and detailed design to do its work. The process has come to the point of ensuring that the final design of the end product agreed with the scope from the sponsor as well as approval from the advisors on the project. The design will be a prototyped version of the commercialized product in mind. The entire team has distributed the test plan on their respective parts and all that needs to be done is the ground work. The work is now locked in and this documentation proves the team has thoroughly processed the design review as well as the testing plans.

8 References

[1] Mornhinweg, Manfred. "Transformers and Coils." *Homo Ludens*. N.p., n.d. Web. 14 Nov. 2014. <http://ludens.cl/Electron/Magnet.html>.

[2] http://msis.jsc.nasa.gov/sections/section04.htm#_4.9_STRENGTH

[3] http://www.galvanizeit.org/design-and-fabrication/fabrication-considerations/bending

[4] Pellitteri, F., V. Boscaino, A. O. Di Tommaso, R. Miceli, and G. Capponi. "Wireless Battery Charging: E-bike Application." (n.d.): n. pag. Web.

[5]http://www.pololu.com/blog/277/new-nema-17-stepper-motor-with-optional-integrated-lead-screw

[6] http://www.seco-larm.com/E-941SA-600.htm

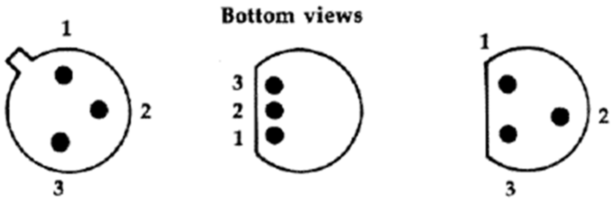
[7]http://www.homedepot.com/p/Unbranded-1-2-in-13-tpi-x-6-in-Zinc-Plated-Hex-Bolt-801056/204633235?N=5yc1vZc26w

[8] http://www.instructables.com/id/Very-Simple-Arduino-Electric-Lock/?ALLSTEPS

Appendices

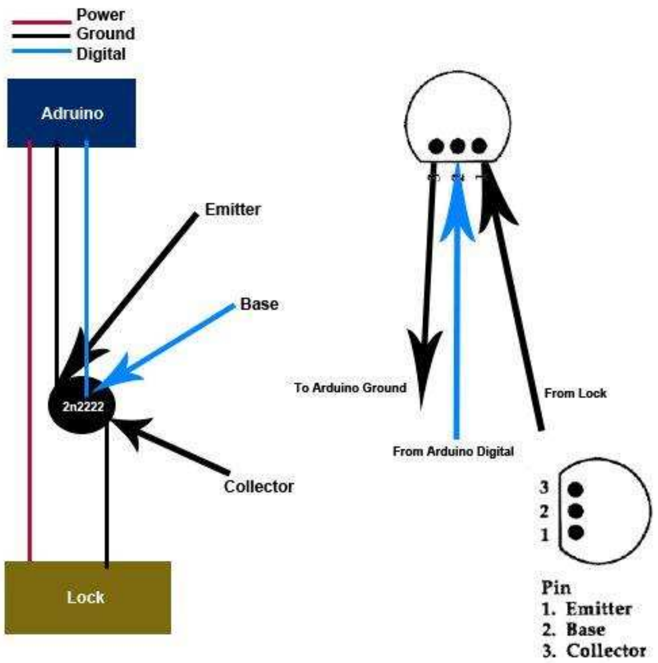
APDX 1.1 Arduino Electromagnetic Lock Code

Figure 8-1. Pin Diagrams for Typical 2N2222 NPN Transistors



Pin
1. Emitter
2. Base
3. Collector

Here are three of the most common 2N2222 NPN transistor configurations you'll find.



Arduino to BJT to Lock configuration

The code takes any data from the serial port of the Arduino and sends signal to the port, delays then ends the signal.

```
/*Test to use serial port to open/close lock*/

int inByte = 0;

void setup()
{
  //Start serial
  Serial.begin(9600);
  pinMode(3,OUTPUT);
}

void loop()
{
//check for connection
if (Serial.available() > 0)
  {
  inByte = Serial.read();
   digitalWrite(3,HIGH);
   delay(1000);
   digitalWrite(3,LOW);
 }
}
```