
**DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING**

**EEL-4921C**
**SENIOR DESIGN II FINAL REPORT**

**SPRING 2023**

# ELECTRIC VEHICLE WIRELESS CHARGING ALIGNMENT SYSTEM

**TEAM 2**


| | | |
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**Mentor: Dr. Arif Sarwat / Milad Behnamfar**


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# Acknowledgement

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# Abstract

**The Electric Vehicle Wireless Charging Alignment System uses magnetic induction to wirelessly charge electric vehicles. It comprises a transmitter and a receiver, with the transmitter connected to a power source and the receiving coil generating a magnetic field. Magnetic field sensors are used to help guide the transmitting coil directly underneath the receiving coil. Once aligned, the transmitter sends a high-frequency electric current to charge the electric vehicle. This system is cost-effective, efficient, and eliminates the need for charging stations. It is user-friendly and easy to install, making it a great way to make electric vehicles more accessible and convenient.**

# [1] EXECUTIVE SUMMARY

| Team Number: 2 | |
|---|---|
| **Team Member Names** | **Date** |
| Andy Alvarez | 4-17-2023 |
| Maximiliano Mauna | 4-17-2023 |
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***Summarized Problem Statement***

Inductive Power Transfer (IPT) is a technology that enables the transfer of power from one system to another across a relatively large air gap between two loosely coupled coils with no physical contact. IPT provides a clean and safe way of transferring power. However, the current obstacle associated with this technology is the misalignment between the coils. Our project is about designing an electric vehicle alignment mechanism that will detect a charging coil under the electric vehicle. It will then align the transmitter coil directly below the charging coil allowing maximum power transfer and improving the wireless charging efficiency.

*1) Objectives*

The objectives for our project are:

1.1. Efficiency
   a) The alignment mechanism should maximize power transfer.
   b) The alignment mechanism should return to its reference point.

1.2. Marketability
   a) The alignment mechanism should be quick.
   b) The alignment mechanism should fit under a standard vehicle chassis.

1.3. Accessibility
   a) The alignment mechanism should signal to the user when it has been properly aligned.

*2) Constraints*

The constraints for our project are:

2.1. The alignment mechanism should not expose conductors.
2.2. The alignment mechanism must withstand being exposed to rough conditions.
2.3. The alignment mechanism should be cost-efficient.

***Sections***

Critical sections within our proposal include Risk Analysis, Operating Environment, Background, End Product Description, and Budget. These sections help to outline the need for the project, the end goal of the project, and how project risks will be managed, as well as how much the project will cost. Additionally, the Operating Environment section provides an overview of the existing environment in which the project will take place, such as the technology, infrastructure, and personnel that will be used.

*3) Feasibility and Risk Analysis*

The Risk Analysis section provides an overview of the potential risks associated with the project, including potential delays, budget overruns, or other unexpected outcomes. It also outlines the strategies and procedures that will be used to mitigate these risks. The feasibility analysis measures whether or not our project is feasible using technical, resource, schedule, economical, marketing, legal, and cultural factors.

*4) Operating Environment*

The Operating Environment section provides an in-depth look at the existing environment in which the project will take place. It should include details such as existing technology, personnel, and other resources that will be needed to complete the project.

*5) Background*

The Background section provides an overview of the project's purpose, objectives, and objectives. It also includes existing documentation and research that is relevant to our project.

*6) End Product Description*

The End Product Description section outlines the end goal of the project and details what will be delivered upon completion. It should also include the timeline and other expectations for the project.

*7) Budget*

The Budget section provides an overview of the project's cost and details how the budget will be allocated. It also includes any contingencies for potential budget overruns.

To conclude, these sections provide a comprehensive overview of the needs and expectations for the project, as well as a detailed assessment of the potential risks associated with the project. They also provide an outline for the budget for the project and the expected deliverables. By including all these sections in our proposal, the team can ensure that all stakeholders are on the same page and that the project is well-structured and well-prepared.

## II. PROBLEM STATEMENT

Engineering often involves applying complex mathematical equations and heavy scientific theory to solve real-world problems. However, engineers must first define the problem and identify who is affected by it, along with the importance of solving it. This section will describe the problem the team must solve.

Inductive Power Transfer (IPT) is a technology that enables the transfer of power from one system to another across a relatively large air gap between two loosely coupled coils with no physical contact. IPT provides a clean and safe way of transferring power. However, the current obstacle associated with this technology is the misalignment between the coils. Our project is about designing an electric vehicle alignment mechanism that will detect a charging coil under the electric

vehicle. It will then align the transmitter coil directly below the charging coil allowing maximum power transfer and improving the wireless charging efficiency. The alignment mechanism should be able to return to its initial reference point. The alignment mechanism should also be quick and not need external input from the user. The alignment mechanism must also be able to fit under a standard vehicle chassis.

***Project Objectives***

The objectives for our project are:

1) *Efficient*
   *a) The alignment mechanism should maximize power transfer.*
   *b) The alignment mechanism should return to its reference point.*

2) *Marketability*
   *a) The alignment process should be quick.*
   *b) The alignment mechanism should fit under a standard vehicle chassis.*

3) *Accessibility*
   *a) The alignment mechanism should signal to the user when properly aligned.*

***Constraints***

The constraints for our project are:

4) *The alignment mechanism should not expose conductors.*
5) *The alignment mechanism must withstand being exposed to rough conditions.*
6) *The alignment mechanism should be cost-efficient.*

In conclusion, IPT is an effective and safe method of transferring power. However, for it to be marketable and efficient, it must meet specific criteria, specifically proper alignment between the coils. Our project will ensure that the aligning process meets the objectives and constraints listed in this section.

## III. ASSUMPTIONS AND LIMITATIONS

This section will list the assumptions and limitations that the project could face going into the design and implementation phases. Assumptions and limitations are essential factors that need to be weighed in any engineering project. Assumptions result from decisions made by the team and affect the end-product design and implementation but are not bound by physical limits. Limitations are physical limits that are imposed by the technology used or physical laws, which we have no control over but must consider in our end-product design and implementation.

***Assumptions***

The assumptions for our project are:

1) *The electric vehicle will be stationary.*
2) *There will be a charging coil installed on the ground as the transmitter.*
3) *There will be a receiving coil installed under the electric vehicle chassis as the receiver.*
4) *The alignment mechanism will only detect one charging coil.*

***Limitations***

The limitations of our project are:

5) *The alignment mechanism will only move in an x-y plane.*
6) *The alignment mechanism will only be used for an electric ground vehicle.*
7) *The alignment mechanism will only align itself to one vehicle at a time.*
8) *The alignment mechanism will be low-power.*

In conclusion, our project must consider assumptions and limitations that will be encountered as they are an integral part of the design. Assumptions were made by the team and detailed the electric vehicle alignment system design and implementation bounds. Limitations were also made over elements over which the team has no physical control.

# IV. NEEDS FEASIBILITY ANALYSIS

This section will outline the importance of the Needs Feasibility Analysis and its contributions to the final product. The Need Analysis phase of our project is to show clearly and convincingly that a valid operational need exists for a significant upgrade to the existing electric vehicle charging infrastructure. A Need Analysis will also create a well-grounded instructional design process to prevent higher long-term costs. We will use a Client-User-Designer triangle, a crucial design methodology, to collect information from our sponsor, the user, and ourselves. We will filter and narrow the information obtained from the client-user-designer process to list and explain the project objectives.

***Need Analysis***

*1) Client*

The client's needs are crucial as they identify the core problem that needs to be addressed. The team conducted an interview with the client to collect data about the project design, requirements, and implementation. Table 1 lists the attributes collected from the client interview.

TABLE I. CLIENT INTERVIEW ATTRIBUTES

| Source | Attribute |
|---|---|
| Client | The alignment mechanism will align the transmitting coil directly underneath the receiving coil. |
| Client | The alignment mechanism will not be taller than 20 centimeters. |
| Client | The alignment mechanism will position itself within an x-y plane. |
| Client | The alignment mechanism will use a microcontroller. |
| Client | The alignment mechanism will use magnetic sensors to detect magnetic flux density. |

*2) User*

The next step is gathering information from our product's potential users and market needs. We conducted a survey weighing different consumer needs and wants as well as the product's marketability. Table II lists the attributes collected from the user survey.

TABLE II. USER SURVEY ATTRIBUTES

| Source | Attribute |
|---|---|
| User | The alignment mechanism should be cost-efficient. |
| User | The alignment mechanism will have a minimal negative quality of life impact. |
| User | The alignment mechanism should be reliable and resistant to the elements. |

*3) Team Input*

After obtaining information from the client interview and user survey, the team will analyze the results and introduce new ideas not presented by the user or client. This will further expand and improve the product design. We will try to further unfold the root of the problem through a Fishbone diagram. A Fishbone diagram is used to identify and organize a problem's possible causes. Figure 1 shows the Fishbone diagram created by the team.

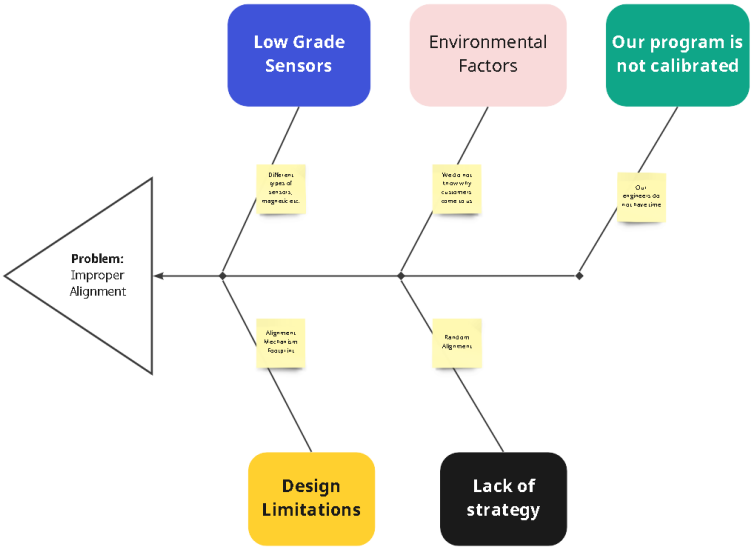



Fig. 1. Fishbone Diagram

The Fishbone diagram lists sensors, design limitations, environmental factors, lack of strategy, and an uncalibrated program as possible causes of improper alignment within our project. With these potential causes, we can derive new objective attributes from the brainstorming process. This extra layer of contribution will improve the project design. Table III lists the characteristics derived from the team.

TABLE III. TEAM ATTRIBUTES

| Source | Attribute |
|---|---|
| Team | The alignment mechanism will signal to the user when it is properly aligned. |
| Team | The alignment mechanism will only detect one charging coil. |
| Team | The alignment mechanism will require low power. |
| Team | The alignment mechanism should return to its initial starting point. |
| Team | The alignment mechanism will only be used for ground electric vehicles. |

*4) Project Attributes*

After the client interview, user survey, and team brainstorming processes, we can filter and narrow down the project objectives by combining the similar attributes and separating the project constraints, limitations, and assumptions. The team will group and generalize similar attributes and create sub-groups. The combination of attributes is listed in Table IV.

TABLE IV. COMBINED ATTRIBUTES

| Source | Attribute |
|---|---|
| Client | The alignment mechanism will align the transmitting coil directly underneath the receiving coil. |
| Client | The alignment mechanism will not be taller than 20 centimeters. |
| Client | The alignment mechanism will position itself within an x-y plane. |
| Client | The alignment mechanism will use a microcontroller. |
| Client | The alignment mechanism will use magnetic sensors to detect magnetic flux density. |
| User | The alignment mechanism should be cost-efficient. |
| User | The alignment mechanism will have a minimal negative quality of life impact. |
| User | The alignment mechanism should be reliable and resistant to the elements. |
| Team | The alignment mechanism will signal to the user when it is properly aligned. |
| Team | The alignment mechanism will only detect one charging coil. |
| Team | The alignment mechanism will require low power. |
| Team | The alignment mechanism should return to its initial starting point. |
| Team | The alignment mechanism will only be used for ground electric vehicles. |

Using Table IV, objectives and constraints are deduced, allowing the team to narrow down essential features and retract out-of-reach and impractical parts. The implementations and uses of the project are filtered out of the Need Analysis Section and will be described in later sections in greater detail. Many factors will have to come into play to determine the best design to implement. The ideas and contributions of the client, user, and ourselves help to expand our thinking and narrow down details that will prove most beneficial in declaring objectives.

*5) Problem Statement*

The project is about designing an electric vehicle alignment mechanism that will detect a charging coil under the electric vehicle. It will then align the transmitter coil directly below the charging coil allowing maximum power transfer and improving the wireless charging efficiency. The alignment mechanism should be able to return to its initial reference point. The alignment mechanism should also be quick and not need external input from the user. The alignment mechanism must also be able to fit under a standard vehicle chassis.

***Objectives***

6) *Efficiency*

*a) The alignment mechanism should maximize power transfer.*

*b) The alignment mechanism should return to its reference point.*

7) *Marketability*

*a) The alignment process should be quick.*

*b) The alignment mechanism should have a small footprint.*

8) *Accessibility*

*a) The alignment mechanism should signal to the user when it is properly aligned.*

***Constraints***

The constraints for our project are:

9) *The alignment mechanism should not expose conductors.*

10) *The alignment mechanism must withstand being exposed to rough conditions.*

11) *The alignment mechanism should be cost-efficient.*

In conclusion, a Need Analysis was performed to assess the project and its constraints. A Client-User-Designer triangle was used to collect information from the client, user, and team. The client interview identified the core problem, and the user survey identified a market need for the project. This information allowed the team to analyze the evolution of essential features, considerations, and implementations for the final design objectives and attributes.

### *Need Specification*

This section will focus on translating standard language into measurable engineering specifications that can be realized. Specifications are detailed, exact statements of particulars that prescribe materials, dimensions, and the quality of work for something to be built, installed, or manufactured. They are established after the objectives and the client's needs are determined, and it is critical to assign specifications to these objectives and their attributes. Specifications will also incorporate the design's constraints, limitations, assumptions, uses, and operating environment. They are used significantly if we are building the product correctly. Specifications also inform the client and users about the product's capabilities and reliability. Specifications provide context for the client on areas where there are possibilities to improve the design and criteria for acceptance. These criteria should consider necessary tradeoffs implied by design choices and evaluate their consequences for success. The team and the client will translate the objectives into measurable and quantifiable parameters and use these parameters to transition into the implementation phase to collect tangible results. Specification values will also be determined by the performance and user perception of the product.

Table V provides an overview of the objectives and their respective specifications and justification.

TABLE V. NEED SPECIFICATION

| Objective | Specification | Justification |
|---|---|---|
| 1.a | Efficiency should be between 85-90%. | To compete with wired charging, there must be efficiency. |
| 1.b | Properly code alignment mechanism to map environment and return to starting reference. | Every vehicle will have a different structure layout, and the alignment mechanism should have a constant starting location. |
| 2.a | The average alignment process should not exceed 2 minutes. | Reasonable alignment time compared to a manual connection. |
| 2.b | Dimensions should not exceed more than 36” x 36” x 12” | The alignment mechanism should fit under typical vehicle chassis. |
| 3.b | Programming should be properly coded to signal to the user the status of the alignment mechanism | To compete with a wired connection, user quality of life should be factored in and measured. |

**Objectives:**
1) Efficient
a) The alignment mechanism should maximize power transfer.
b) The alignment mechanism should return to its reference point.

2) Marketability
a) The alignment process should be quick.
b) The alignment mechanism should fit under a typical vehicle chassis.

3) Accessibility
a) b) The alignment mechanism should signal to the user when it is properly aligned.

In conclusion, we established the specification for our project. This was accomplished by assigning precise quantitative values to the various natural language objectives and constraints obtained from client interviews and group brainstorming during the needs analysis process. We determined the multiple requirements and justified them. The operating condition requirements, as well as the physical dimensions, were also considered. As our project progresses into the implementation phase, we will continually reference these values as a guide and check on our designs and testing procedures.

### *Feasibility*

A feasibility analysis is essential to any engineering design project because it determines if the project can be done. The analysis will evaluate and measure the success and risk exposure of the project. The analysis is also used to meet the project's Preliminary Design Review (PDR), which is used to ensure the project can move forward to the design and concept development phase.

The team will measure the project's feasibility using the following seven types of feasibility: Technical, Resource, Economic, Schedule, Cultural, Legal, and Marketing. We will provide a score between 1 and 5 to assess each feasibility type. We will create a table based on the importance of the feasibility types to one another and obtain a weight to measure the scores. After these calculations, a final score is developed to determine the project's feasibility. If the score exceeds the value of 3, the project is feasible and can be completed. Marketing feasibility will be discussed in more detail in the next section.

#### *12)Technical Feasibility*

The technical feasibility is analyzed to help the team determine if existing technology can be used, and if we cannot, then it will determine if new inventions are required.

TABLE VI. TECHNICAL FEASIBILITY

| Attributes | Score | Why? | Solution |
|---|---|---|---|
| **Does the Technology Exist** | 5.00 | It exists. | No solution is needed. |
| **Can it be obtained?** | 5.00 | It can be obtained. | Obtained through sponsor. |
| **Are fundamentally new inventions required?** | 4.00 | No new inventions are required. | No solution is required. |
| **How much Technical Risk is there?** | 4.00 | Integrating all the different technologies into a functioning system. | Exposure and experience will help the team with implementation. |
| **Total** | 18.00 | | |
| **Average** | 4.50 | | |

For our project, all the technology needed already exists, the only issue that can occur is during the implementation of the different components. The average score obtained from this section is 4.50, as seen in TABLE VI.

#### *13)Resource Feasibility*

The resource feasibility is analyzed to determine if the team is competent and qualified enough to complete the project. The team's resources, skills, and abilities are measured.

TABLE VII. RESOURCE FEASIBILITY

| Attributes | Score | Why? | Solution |
|---|---|---|---|
| **Do we have sufficient skills?** | 3.00 | Team will need to learn robotics and other skills. | Exposure and experience. |
| **Do we have sufficient equipment?** | 5.00 | Components and testing equipment is provided by sponsor. | No solution is required. |
| **Do we have enough people?** | 5.00 | Team consists of 3 Electrical Engineers and 2 Computer Engineers. | No solution is required. |
| **How much Resource Risk is there?** | 3.00 | Team will need to operate equipment safely to not damage it. | Practicing and help from our mentor will help the team with testing. |
| **Total** | 16.00 | | |
| **Average** | 4.00 | | |

For our project, the team meets and exceeds the resource feasibility criteria to move forward with this project. The average score obtained from this section is 4.00, as seen in TABLE VII.

### *14)Economic Feasibility*

The economic feasibility is analyzed to help the team determine if the project is financially and economically viable. The primary goal of any project is to be profitable, and an economic feasibility analysis is done to measure the cost and profit of our project.

TABLE VIII. ECONOMIC FEASIBILITY

| Attributes | Score | Why? | Solution |
|---|---|---|---|
| **Is the project possible, given budget constraints?** | 5.00 | Sponsor will help the team acquire components and other materials. | No solution is required. |
| How much Economic Risk is there? | 4.0 | Components could get damaged if operated under abnormal conditions. | Team will undergo safety and operating training. |
| **Total** | 9.00 | | |
| **Average** | 4.50 | | |

With the help of our sponsor, the team meets and exceeds the economic feasibility criteria. The average score obtained from this section is 4.50, as seen in TABLE VIII.

### *15)Schedule Feasibility*

The schedule feasibility analysis is used to help the team determine if we will meet project deadlines and achieve milestones. This is a crucial step in the feasibility analysis due to the time constraint and time management by all team members.

TABLE IX. SCHEDULE FEASIBILITY

| Attributes | Score | Why? | Solution |
|---|---|---|---|
| **What are the chances of meeting the intermediate milestones?** | 4.50 | High chance since weekly job tasks are noted and met by all team members. | No solution is required. |
| **What are chances of meeting PDR?** | 4.50 | High chances since team holds weekly meetings and proper feedback is given for the design. | Continue to meet weekly with each other and mentor. |
| **What are chances of meeting CDR?** | 4.50 | High chances since team will use PDR as backbone for CDR | Continue to meet weekly with each other and mentor. |
| **How much Schedule Risk is there?** | 5.00 | Team meets after class and schedules weekly meetings with mentor. | No solution is required. |
| **Total** | 18.5 | | |
| **Average** | 4.63 | | |

For our project, the team will continue to schedule weekly meetings to meet the project's deadlines and reach our milestones. The average score obtained from this section is 4.63, as seen in TABLE IX.

### *16)Cultural Feasibility*

The cultural feasibility analysis is used to help the team understand the cultural, both local and global, impact of the project. It is the team's goal to achieve a positive impact since it is essential for a successful product. Our project supports the transition from fuel driven internal combustible vehicles to greener electric ones.

TABLE X. CULTURAL FEASIBILITY

| Attributes | Score | Why? | Solution |
|---|---|---|---|
| **Will there be a positive impact on the local culture?** | 5.00 | The current trend is pushing for greener, mor efficient vehicles. Our product enforces this trend. | No solution is required. |
| **Will there be a positive impact on global culture?** | 4.00 | Many other countries are also transitioning to electric vehicles, however, less developed countries are not currently as capable ttransition. | Good marketing of our product along with emphasis on newer technology. |
| **Will there be any potential labor objections?** | 5.00 | No labor objections. | No solution is required. |
| **How much Cultural Risk is there?** | 5.00 | There is minimal risk since project will use safe and environmentally friendly technology. | No solution is required. |
| **Total** | 19.00 | | |
| **Average** | 4.75 | | |

For our project, the team meets and exceeds the cultural feasibility criteria to move forward with this project. The average score obtained from this section is 4.75, as seen in TABLE X.

### *17)Legal Feasibility*

The legal feasibility analysis is used to inform the team of any rules or regulations in place that can restrict or limit the project. If the project does not conform to the law or standard, the project will inevitably fail. The team must also ensure that there will be no infringement on any existing patents.

TABLE XI. LEGAL FEASIBILITY

| Attributes | Score | Why? | Solution |
|---|---|---|---|
| **Are there any organizational conflicts and policies?** | 5.00 | No policies or conflicts. | No solution is required. |
| **Are there any laws or regulations impeding the project?** | 5.00 | No federal or state law impeding the project. | No solution is required. |
| **Are there any laws or regulations limiting the project?** | 5.00 | No federal or state law limiting the project. | No solution is required. |
| **Total** | 15.00 | | |
| **Average** | 5.00 | | |

For our project, the team meets and exceeds the legal feasibility criteria to move forward with this project. The average score obtained from this section is 5.00, as seen in TABLE XI.

*18)Marketing Feasibility*

The marketing feasibility analysis is similar to the cultural feasibility. It is used to determine the project's overall success and measure public approval. Through our client and user interview, the project was deemed successful, and a clear market need was identified.

TABLE XII. MARKETING FEASIBILITY

| Attributes | Score | Why? | Solution |
|---|---|---|---|
| **Will the general public accept the product?** | 5.00 | Our product is a great improvement to the current EV infrastructure and improves quality of life for EV owners. | No solution is required. |
| **How much marketing risk is there?** | 4.00 | Potential pushback from established industries. | Improve marketing for a wider approach. |
| **Total** | 9.00 | | |
| **Average** | 4.50 | | |

For our project, the team meets and exceeds the marketing feasibility criteria to move forward with this project. The average score obtained from this section is 4.50, as seen in TABLE XII.

*19)Ranking of the Feasibility Analysis*

The team will now obtain geometric mean and weighted values based on the following rubric signaling a feasibility type's importance relative to each other.

1. Equal Importance 1
2. Moderately more important 3

3. Strongly more important 5
4. Extremely more important 7

The geometric mean is calculated using the formula below:

$$GM = \sqrt[n]{\prod_i a_i}$$

$a$ *are the attribute*
$n$ *is the total number of attributes*

The weight is calculated using the formula below:

$$Weight = \frac{GM}{Total}$$

Table XIII shows the values of the geometric mean and weight values for each feasibility type used in analyzing our project.

TABLE XIII. FEASIBILITY WEIGHTS

| | **Technical** | **Resource** | **Economic** | **Schedule** | **Cultural** | **Legal** | **Marketing** | **GM** | **Weight** |
|---|---|---|---|---|---|---|---|---|---|
| **Technical** | 1 | 3 | 1 | 5 | 3 | 3 | 3 | 2.36 | 0.12 |
| **Resource** | .33 | 1 | .33 | 3 | 5 | 1 | .20 | 0.85 | 0.08 |
| **Economic** | 1 | 3 | 1 | 5 | 3 | 3 | 1 | 2.02 | 0.12 |
| **Schedule** | .20 | .33 | .20 | 1 | 5 | 1 | .20 | 0.54 | 0.07 |
| **Cultural** | .33 | .20 | .33 | .20 | 1 | 1 | .20 | 0.37 | 0.11 |
| **Legal** | .33 | 1 | .33 | 1 | 1 | 1 | 1 | 0.73 | 0.13 |
| **Marketing** | .33 | 5 | 1 | 5 | 5 | 1 | 1 | 1.70 | 0.10 |
| **Total** | | | | | | | | 8.57 | |

With the weights and average scores obtained we can now calculate the weighted score using the following formula:

$$Weighted\ Score = Weight * Score_{avg}$$

Table XIV shows the values of the weighted scores for each feasibility type used in analyzing our project. The total average score is above 3, which is the minimum threshold for a project to be deemed feasible.

TABLE XIV. WEIGHTED SCORE

| | **Weight** | **Score** | **Weighted Score** |
|---|---|---|---|
| **Technical** | 0.12 | 4.50 | 0.54 |
| **Resource** | 0.08 | 4.00 | 0.32 |
| **Economic** | 0.12 | 4.50 | 0.54 |

| | | | |
|---|---|---|---|
| **Schedule** | 0.07 | 4.63 | 0.32 |
| **Cultural** | 0.11 | 4.75 | 0.52 |
| **Legal** | 0.13 | 5.00 | 0.65 |
| **Marketing** | 0.10 | 4.50 | 0.45 |
| **Total** | 0.73 | 31.88 | 3.34 |
| **Weighted Average** | | | 4.56 |

Table XIV shows the values of the weighted scores for each feasibility type used in analyzing our project. The total average score is above 3, which is the minimum threshold for a project to be deemed feasible.

In conclusion, a feasibility analysis is done to help the team determine if the product will be feasible and successful. Although this score approximates the project's success, the team is confident in our ability and motivation to follow the created plan and learn the required skills to complete this project.

***Marketability***

Designing a product in a way that appeals to the target audience determines its marketability. In addition to meeting the client's needs, the product should also appeal to the public or private sectors, which are confronted with the same issues that initially motivated the project. At a price that most people can afford, The Electric Vehicle Wireless Charging Alignment System offers extraordinary versatility to any customer in the automobile sector. We must first research potential competitors and consumer segments to make our project successful. When examining competing products on the market and gaining knowledge about fundraising, the company Kickstarter is an excellent resource. To raise money, this company offers multiple levels of benefits. If a project is not adequately funded through the platform within the allotted time, it poses no risk to the investor and fails to receive the anticipated investment. While there are not any specific projects that are exactly like ours, we were able to compare two that are similar

*20)Aim Charge*

*a) Project summary*

A company named Kinglink, committed to creating the best wireless charger that enhances user experience, initially launched Aim Charge on March 31, 2021, and provided funding until April 30, 2021. Using smart tracking technology, Aim Charge modernizes and innovates the wireless charging stand and ensures that wireless charging will always occur at a maximum speed no matter where the phone is placed. The charging coil within the smartphone is detected, and Aim Charge guides the charging coil to the proper location using a circular LED indicator before beginning to charge the device wirelessly.

Fig. 2.

*b) Fundraising strategy:*

The goal and motivation behind their product are explained in detail. A video is provided highlighting all the features of the product and how it works. Their strategy included:

- Interactive video
- Engaging/unique content showcasing the product
- Incentives for early investments
- Providing comparison to competitors
- Displayed the product's adaptability

*c) Technological Overview*

Due to its Auto-alignment Technology, 20W Fast Charging Speed, and Universal Compatibility, Aim Charge is compatible with any phone with wireless charging capabilities. With the help of Auto-Alignment Technology, fast charging can be achieved while ensuring that the temperature stays below 131°F (55°C). This prevents overheating of the phone's battery and the resulting damage. As many as 2,600 power data sets are collected and compared by an inbuilt MCU when Aim Charge attempts to align the receiver and transmitter coils. The middle point is then located by locating the highest transmission power. Within less than 4 seconds, this entire process is completed with a positioning inaccuracy of just 0.18mm, or about 36% of the diameter of the coil.


Fig. 3. CHANGE FIGURE NAME

*d) System description*

In most wireless chargers, the coils are not visible; therefore, you must keep trying to charge your phone. The Aim Charger eliminates misalignment, low-speed charging, overheating, and other less convenient features. Additionally, a misalignment could cause the phone to overheat and damage its battery. Upon placing the device on the Aim Charge, the device is instantly recognized, located, and tracked for fast and precise wireless charging. Its location is indicated by a luminous ring that moves along with the coil. Next time the same phone is placed on it, the coil stays in the same position for an instant, quick, and easy wireless charging. It also has smart charging technology that can precisely monitor the battery level and charging status depending on the type of phone being used. It can then send the proper amount of power, up to 20W, to the appropriate device during the entire process. Aim Charge charges any gadget the quickest and safest, regardless of the type, and promotes restful sleep by eliminating beeps, bothersome lights, and other distractions by the LED indication. The stand's compact size makes it perfect for bedside tables, and the small light on the front also shows the device's charge level when it is placed on it.

*21) Aim Charge 2*

*a) Project summary*

Aim Charge 2 was created and developed by a company named Kinglink, which is committed to making the best wireless charger that enhances user experience. Initially, Aim Charge 2 launched on September 30, 2021, and provided funding until October 30, 2021. After the success of the Aim charge, an upgraded model based on the first generation was created, including better features. Aim Charge 2 is a charging dock that organizes your desktop and eliminates the issue of not having enough power outlets or charging adapters. It has been improved to include a double-sided, portable, wireless charging bar in addition to the original auto-align feature. It also features extended charging connections for laptops and other devices. All devices can now receive power from it simultaneously.

Fig. 4.

*b) Fundraising strategy:*

The goal and motivation behind their product are explained in detail. A video is provided highlighting all the features of the product and how it works. Their strategy included:

- Interactive video
- Engaging/unique content showcasing the product
- Incentives for early investments
- Detailed specifications
- Displayed the product's adaptability

*c)* Technological Overview

Finding a wireless charging coil with this device is much simpler than other wireless chargers. Aim Charge 2 can power up a phone 22% faster than standard chargers due to its auto-align technology, which can instantly locate the phone's wireless charging coil. Extensive charging ports are an additional Aim Charge 2 update. There is one Type-C and two USB-A ports for charging laptops, tablets, speakers, lamps, and other devices. All electrical devices can be powered up at once due to these charging connectors. Additionally, a PD100W Type-C power input connection is present. If you have a PD100W adapter, Aim Charge 2 will perform to its full potential and quickly charge all gadgets.


Fig. 5.

*d) System Description*

Aim Charge 2 maintains its ergonomic phone stand design, much as the prior generation. It organizes a desktop while charging with it. No more unsightly charging cords that are unwieldy, and no more power outlets or converters that are insufficient, making sure that laptops, tablets, phones, and earbuds are all charging at the same time. Using just one Aim Charge 2 and up to three charging cables, all devices may be charged simultaneously and wirelessly. Samsung, Xiaomi, iPhone, and Apple Watch are all compatible with Aim Charge 2. Additionally, the side of the dock features a tracking light so that when the device has begun charging, it can be seen.

Following a thorough evaluation of both Kickstarter projects, we could brainstorm better. We also realized that the similarities between both projects and the project we are developing are similar. Consequently, if a community has marketability and interest, then the positive aspects of each fundraising campaign can be used and applied. Despite being hypothetical, our actions would enable us to conduct a successful campaign to ensure the success of The Electric Vehicle Wireless Charging Alignment System**.** To launch a fundraising campaign, we would follow the following guidelines:

1. **Define the objective:** Assessing the resources required to create the product should be the first step. Although we are still in the concept development stage, a budget of $250.00 provides a good starting point for acquiring the necessary components. The actual expenses would have been critical if we had chosen to fundraise not to underestimate our project's costs and build it correctly. As we have complete funding, it is best to order as realistic and cost-effective as possible components.

2. **Define rewards:** Kickstarter's reward system is a fantastic tool for motivating investors and encouraging donations. By doing so, it turns into a win-win situation for the investor. Examples of rewards include:

- If you donate $10 or more, you will receive a thank you note and team information.
- In the case of a donation of $20 or more, the sponsor's name will be displayed on the website.
- A $50 or more donation entitles you to early access to the product.
- At $100 or more, a heavily discounted product or a complimentary gift may be offered depending on the final cost of the product.

3. **Create an interactive video:** Content that is interesting is the key to successful marketing and launches. Video content is currently among the most interesting and assists in visually showcasing a project.

4. **Encourage investment:** Monroe's motivated sequence is an effective strategy for persuading people to invest or donate. Educating them about the advantages and technological improvements offered by our project increases their confidence to participate.

The marketability of a product determines the success or failure of many initiatives. Launching successfully depends on knowing how to appeal to the general audience, setting realistic expectations, and ensuring profit for you and your investors. Automotive companies and individuals who own electric vehicles will need The Electric Vehicle Wireless Charging Alignment System to ensure proper alignment and receive the quickest charge.

# V. RISK ANALYSIS

Risks are defined as the possibility of suffering loss by involving uncertainty. A risk analysis is essential to any engineering design project because it determines the risks associated with the project. The analysis will allow us to evaluate and measure our project's success and risk exposure. This analysis also helps the team minimize losses and mitigate consequences by foreseeing and preventing potential challenges that could arise throughout different project stages.

The team will measure the project's risk using the following seven categories used in the Feasibility Analysis: Technical, Resource, Economic, Schedule, Cultural, Legal, and Marketing. The team will create a fault tree diagram to showcase the risks associated with each type and possible prevention methods. We will then determine risks that have a high likelihood of causing damage to the project's development and will require active monitoring as a prevention method. Risks that have a lower possibility of causing damage will require less active tracking.

The following list includes all the risks posed on our project:

1. Technical
    a. Materials and components must meet specifications.
    b. Keystone Design requires software and hardware literacy.
2. Resource
    a. Integrating Software and Hardware components
3. Economical
    a. Potential to exceed project budget
    b. Damaging components and re-supplying can cause exponential losses.
4. Schedule
    a. Procrastination
    b. Research and Development
    c. Team Member Scheduling
5. Cultural
    a. Adhering to local and global cultures
    b. Awareness of exposure to hazardous substances and adhering to RoHS.
6. Legal
    a. Rules & Regulations
    b. Client-Designer contracts
7. Marketing
    a. User friendly product
    b. Cost Effectiveness
    c. Hannover Principles

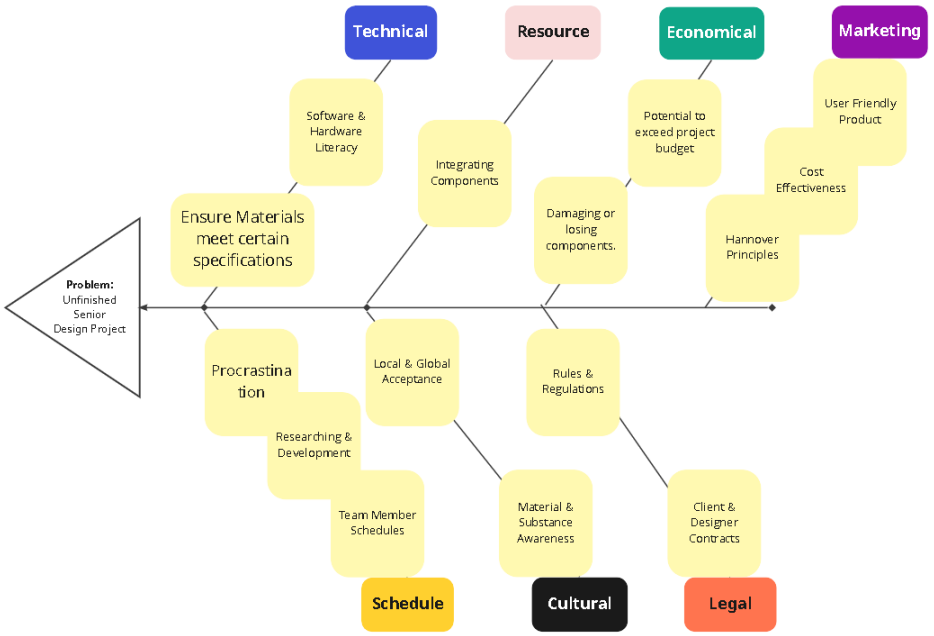



Fig. 6. Fault Analysis Tree

Figure 6 shows the risk associated with each Risk type. A clear and concise diagram is used to appropriately manage a project to mitigate these risks. Our technical risk was ensuring the team had enough technical background or could learn before the project's deadline. The resource risk involves ensuring the team can coordinate the assembly and programming of the project with suitable equipment. The main economic risk was ensuring we do not exceed the budget constraints. The marketing risk was to produce a product that could sell and be cost-effective. The schedule risk involved the entire team's schedule and availability in meeting project deadlines and milestones. The cultural risk was to ensure our product would be accepted locally and globally. And finally, the legal risk was to ensure the product adheres to rules and regulations the Authority Having Jurisdiction (AHJ) set.

The Fault Analysis allows us to create a risk assessment. This assessment includes a risk exposure matrix to properly interpret the risk. We will classify each risk into classes I, II, III, or IV. Class I is a risk below the risk acceptance and requires no active management. Class II has a risk that lies on the threshold and requires active monitoring. Class III has a risk that exceeds the threshold and requires immediate attention. Class IV has a risk that significantly exceeds the threshold and requires proactive management. We will classify the risk from our Fault Analysis diagram as very likely, possible, and unlikely.

TABLE XV. RISK ASSESMENT TABLE

| Likelihood of Occurance | | | | |
|---|---|---|---|---|
| | **Very Likely** | **Possible** | **Unlikely** | **Legend** |
| **Class IV** | | T1, T2 | L1,L2,M3 | Catastrophic |
| **Class III** | | | E1,E2,C2,M2 | Severe |
| **Class II** | S1 | R1 | S2,S3,C1,M1 | Moderate |
| **Class I** | | | | Low |

Table XV risk shows how the team's risk categories are classified. Although no types were classified as catastrophic, many were considered severe if not managed. Technical, Economic, Cultural, Legal, and Marketing each have a severe risk that requires active management and attention. Class II category needs us to be, at the very least, aware of the consequences and monitor each risk. We will now discuss the proper actions the team can take to mitigate any effects of each risk type.

TABLE XVI. ACTIONS

| Actions | |
|---|---|
| S3 | Required Meetings (In Person or Online) |
| C1, S2 | Research global and local cultures |
| M1 | Simplify Design as Needed |
| R1, E2, T2 | Training on properly operating equipment |
| S1 | Set goals with deadlines with room for error, strict schedule |
| E1, M2 | Discuss alternative approach to complete project. |
| C2, L1, M3 | Research laws and regulations and serve the intended users as designed |
| T1 | Research key components |
| L2 | Discuss with the client our contractual obligations. |

Table XVI shows the actions we can take to minimize each risk. Planning for the worst and looking at all variables will be one of our greatest assets. Most of our risks can be minimized or prevented, and having an action plan in place will only benefit our group and project.

To conclude, we created a Fault Analysis diagram to record potential risks associated with our project correctly. We then created a risk exposure matrix to discuss how each risk type and associated risk could hinder our project, classifying their likelihood and severity levels. Using this risk exposure matrix, we created a list of actions to assess the risk and mitigate any detriment to the project's success.

## VI. Operating Environment

In this section, the operating environment is one of many factors to consider for the project, as it's an essential aspect of engineering specification. With this in mind, we can observe how the project will function in the environment or increase the probability of failures or mishaps should the domain prove too much. Safety is our main concern for the product and the user.

For the electric vehicle wireless alignment system to perform as intended, the electromagnetic coil will be housed inside a square-shaped robot with wheels, its sensors will detect and locate the electromagnetic coil installed in the electric vehicle, and its programming will operate on simple commands and navigate in the x-y plane. The electric vehicle wireless charging alignment system will have to withstand temperatures of -30°C to 50°C, have wheels durable enough to tolerate various surfaces, and a lasting body to house and protect the electromagnetic coil that is used to detect the electromagnetic signal from the electric vehicle.

In closing, the temperature, the surface, and electromagnetic waves will play a role in operating the electric vehicle wireless charging alignment system. There may be factors outside our expectations, but we will overcome them.

## VII. Intended User(s) and Intended Use(s)

In this section, the intended user(s) and intended use(s) have a role in the product's design and development. The intended user(s) targets a particular demographic that designers keep in mind and the intended use(s) appertain to how specific people will use the product.

### *Intended User(s)*

The intended user(s) for the Electric vehicle wireless charging alignment system are consumers with electric vehicles, businesses with garages or parking lots that want to utilize a parking space designated for electric vehicles, and automotive manufacturers selling electric vehicles.

### *Intended Uses(s)*

The Electric vehicle wireless charging alignment system will help the user by charging their electric vehicle without using both commercial and residential charge stations.

In conclusion, the intended user(s) and intended use(s) are concepts creators use to target specific people in the market and how the consumer will utilize them.

# VIII. BACKGROUND

This section examines other products or proposed technologies related to self-aligning mechanisms for wireless power transfers (WPT), better known as wireless chargers. Electric vehicles (EVs) are becoming increasingly popular due to their environmental benefits. However, some people argue that charging the battery is inconvenient due to the cables associated with the charging process. Therefore, the purpose of researching other technologies is to learn about various research or, better yet, realized products that could aid in the creation of a successful solution. Furthermore, this research aims to provide detailed information about this up-and-coming technology's advantages, disadvantages, limitations, and implementation techniques.

### *Self Aligning Capability of IPT Pads for High-Power Wireless EV Charging Stations*

*1）Project Summary*

This project is a research article published by A. Namadmalan, R. Tavakoli, S. M. Goetz, and Z. Pantic **on March 11, 2022**, in the IEEE Transactions on Industry Applications [1]. It explains the theory of the magnetic forces involved in IPT systems and proposes novel solutions. The first novel solution is a method employing the bifurcation operation mode of the system and unloaded resonating receiver to maximize the attractive force. However interesting or effective this may be, analyzing the second proposed solution provides more value for the presented product. This research article proposes a mechanism to perform the alignment of the coils in the IPT system. The magnetic forces are analyzed, modeled, and simulated to find the optimal design parameters for the hypothetical implementation of a 100 kW IPT with an operating frequency of 20 kHz. The self-aligning ability, however, was experimentally demonstrated on a downscaled prototype of the hypothetical solution. This prototype is an 11 kW IPT system, but it operates using the same frequency of 20 kHz. The prototype was tested in a laboratory experiment and showed promising results.

*2）Technology Overview*

The proposed solution uses the magnetic forces between the coils to align itself. In other words, the IPT system does not require additional circuitry for the self-aligning feature to work. Since the receiver (Rx) coil is fixed underneath the chassis of the electric vehicle, the transmitter (Tx) coil is placed on a plexiglass substrate in which the whole structure sits on top of roller ball bearings inserted into ferrite tiles so that it can move freely. The Tx will be embedded into the road along with its corresponding power electronics, and the ferrite core behind the Tx will cover the enclosure. The wires from the power electronics will connect to the Tx via an insulated moving arm. This moving arm does not control the movement of the Tx. Instead, the arm moves with the Tx as the magnetic forces move it. Since this methodology is not a realized product and has only been researched, little detail has been given regarding which specific components were used. Another reason for the minor detail in the components is that this approach does not need any additional circuitry for the self-alignment process. The experiment explained in the system description section did not use other circuitry, but they plan to add a regulation controller in future work. The figure below shows the conceptual design and the general components needed.

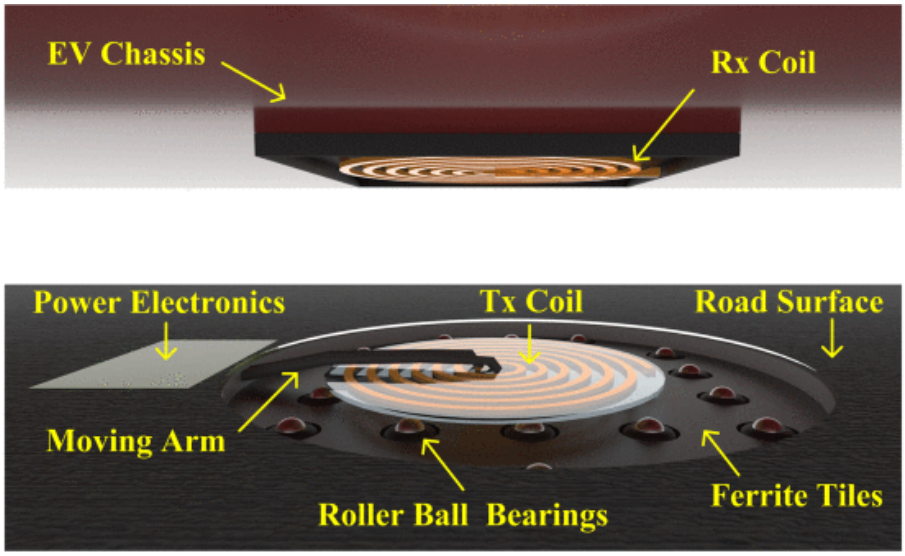



Fig. 7. Self-Aligning Capability of IPT Pads for High-Power Wireless EV Charging Stations (Namadmalan et al., 2022)

*3) System Description*

The article evaluates lateral misalignments from 0cm (no misalignment) to 24 cm. For a misalignment of 24 cm, the simulation shows that although the coupling factor decreases to 0.08, the attractive force is around 2.8 newtons (N). Furthermore, the article claims that the coefficient of static friction of the mounted ball bearings is 0.02, and the total mass of the movable structure is expected to have a mass of 5.95 kg. Considering this, the attractive force needed for the system to overcome static friction should be around 1.16 N. Therefore, according to the simulation, the proposed structure would work for misalignments between 0 and 24 cm as the attractive force is slightly over twice as much as the required force needed to move the system.

The article created a downscaled version of the original 100-kW IPT system. This experimental version of the IPT system is an 11-kW system with an operating frequency of 20 kHz. It uses a nominal coupling factor of 0.25, which occurs for an air gap of 10 cm, and is set up to measure the coupling factor and attractive force depending on the magnitude of the misalignments. The coils in this prototype are wounded coreless, which is said by the article to be the 'worst case.' Because the theoretical solution requires the movable mechanism to be embedded into the road, this exact implementation cannot easily be replicated in a laboratory setting. Therefore, rather than having the Tx move like in the proposed design, Rx is hung from a strand so it can move freely, while Tx is fixed in place and is moved manually to create the misalignment. The figure below shows how the experimental prototype was set up to measure the attractive force. The inverter and the Tx compensating capacitor ($C_t$) are part of the power electronics seen in the figure above.

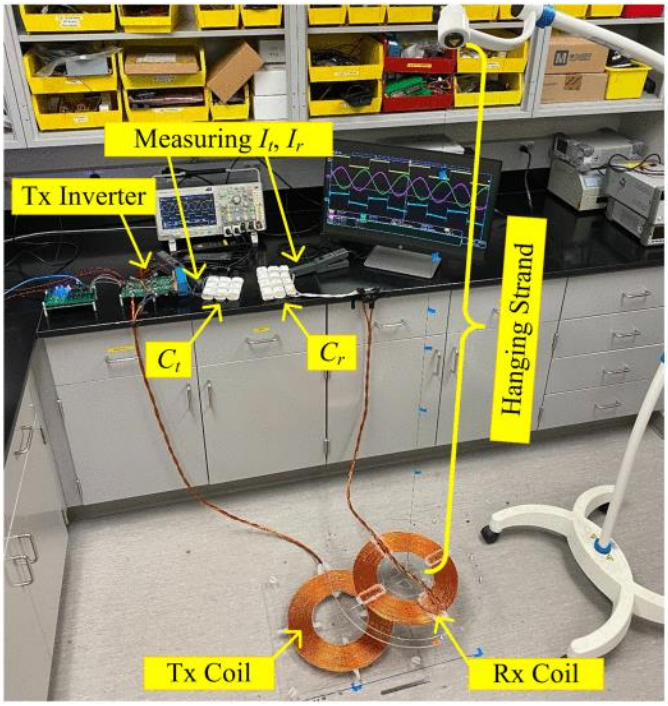



Fig. 8. Self-Aligning Capability of IPT Pads for High-Power Wireless EV Charging Stations (Namadmalan et al., 2022)

The hanging coil and its plexiglass substrate weigh about 1.5 kg, so using the same coefficient of static friction of 0.02 for the ball bearings; the attractive force would need to be at least 0.29 N for 5 – 10 cm of misalignments to move the structure. The experiment proved that the prototype coils generated at least 0.29 N of attractive force despite the coils being wounded coreless. The article vaguely points out that the realized alignment system will contain a force and position controller for future implementation to regulate the alignment process. Below is a block diagram that very abstractly shows how the alignment process will be controlled by the force and position controller as described by the paper.

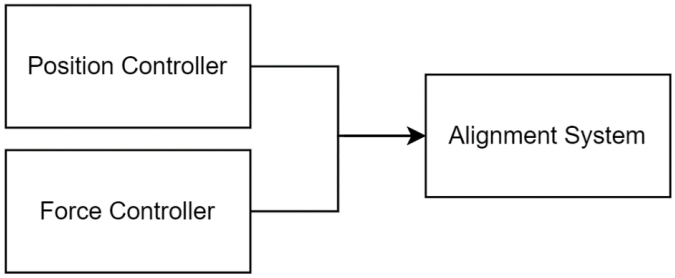



Fig. 9. Block driagram for alignment system regulation

This design has several notable advantages and disadvantages. The advantages are that the design is very low profile as it integrates well with the road. The drawbacks are that the range of the alignment capability is limited to the attractive force generated by the coils. Recall that the maximum misalignment where the force is still strong enough to move the coil structure is 24 cm, as said by the theoretical calculations of the 100-kW IPT (5-10 cm for the 11-kW system). This implies that if the misalignment were too significant (greater than 24 cm), the force would be too small and thus would not be able to move the coil structure. In addition, this design has no room

for alterations because of its insertion into the road. For example, if the intended users wish to move the location of the charging station, this design would need to be removed and assembled elsewhere, resulting in a time-consuming and costly process.

***Magnetic Alignment Detection Using Existing Charging Facility in Wireless EV Chargers***

*4) Project Summary*

This project is a research article published by Y. Gao, A. A. Oliveira, K. B. Farley, and Z. T. H. Tse on January 5, 2016, in the Journal of Sensors [2]. The article states that the motivation for EV wireless chargers is due to the growing numbers of hybrid and electric vehicles and the inconvenience of plug-in charging. As explained in the last research paper, this paper also explains that the single most significant factor determining the effectiveness of wireless charging is coil alignment. For these reasons, the authors propose a novel alignment system to aid the driver of an EV in parking. The alignment system uses the frequency tracking control electronics of existing wireless charging stations to determine the distance between the two coils. The system also contains four smaller auxiliary coils on the secondary charging pad to handle directions and perform fine adjustments. The direction is detected using triangulation, and the adjustments are made when the two pads are close to complete alignment. A user interface containing the alignment information was also created to display to the driver while parking. The research also consists of a prototype test that shows "acceptable measurement correctness" and low error for ten trials. In addition, the authors provide advice on what they believe is the most effective method for alignment detection. They also mention other technologies and methods for alignment and highlight some advantages and disadvantages.

*5) Technology Overview*

Although this research has not yet been realized into a product, the authors did list some components that were used for the experiment. Wireless chargers use a technology called wireless power transfer (WPT). However, the alignment system in this implementation uses what the authors call the "magnetic method," which consists of a sensor that detects the magnetic field generated between two coils. These two coils, the primary and secondary coils, are the central part of the system. The primary coil (P) is the charging pad placed underneath the vehicle, while the secondary coil (S) is the pad fixed beneath the EV chassis. Additionally, there is a digital signal processor (DSP) controller, an ultrasonic sensor, two half-bridge insulated gate bipolar transistors (IGBT), a rectifier connected to the car's battery, and a National Instrument (NI) Data Acquisition (DAQ) card containing wireless communication modules. The FF100R12K4 by Infineon is used to implement the half bridge IGBT modules, the MaxSonar-EZ2 ultrasonic sensor by MaxBotix Inc. is used, and the specific NI DAQ card is the NI CompactRio-9075.

*6) System Description*

The novel aspect of this design is the undertaking of the four small coils and the ultrasonic sensor. Besides these two components, the rest of the hardware already exists in wireless charging stations. For this reason, this method is cost-effective. The way it works is that the system will measure the distance between the two coils by the phase-angle feedback and the frequency characteristics of misalignment. The four symmetrically mounted small coils detect their distance from the primary coil's center when the two coils start to overlap and instruct the driver in which direction it needs to move. The actual strength and distribution of the magnetic field differ from the computational value. So, when the two big coils are close enough, the minor coils' distance is outputted by matching the instantaneous value with the experimental data space. The ultrasonic sensor measures the height. Then, once the alignment is complete, the DSP controller changes the frequency of the PWM signals to find the optimal switching frequency concerning the phase-angle

feedback and the battery's state of charge. Upon the discovery of the optimal switching frequency, the car begins charging. The figures below show the components' flow and the secondary coil with the four smaller auxiliary coils.

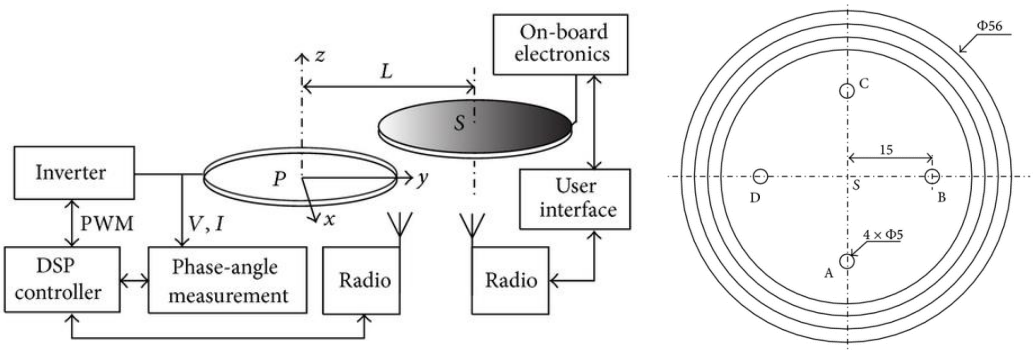



Fig. 10. Magnetic Alignment Detection Using Existing Charging Facility in Wireless EV Chargers (Gao et al., 2016)

The approach begins with a calibration process that builds a multidimensional data space from 25 sets of misalignment and resonant frequencies for each height. There is a step of 1 cm which means that the total calibration range is 25 cm for each height. The misalignment value is assumed to change linearly with the resonant frequency between two points. By this assumption, the formula $L = L_i + \frac{f-f_i}{f_{i+1}-f_i}, i \in [0, D)$ can be used to find the misalignment. Below are the algorithm flowcharts for the lateral distance detection and operation planning of the magnetic alignment system, respectively.

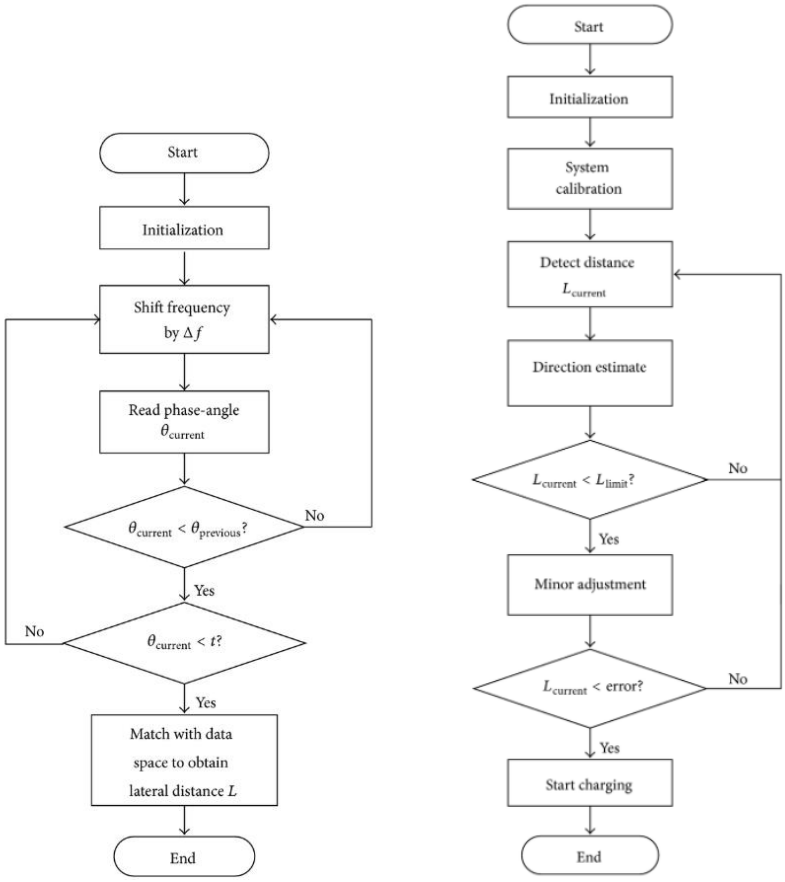
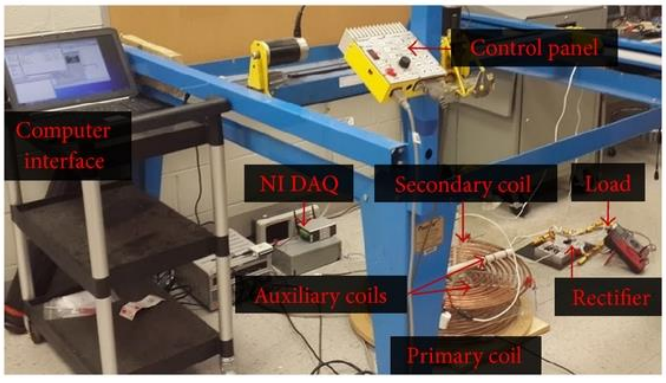
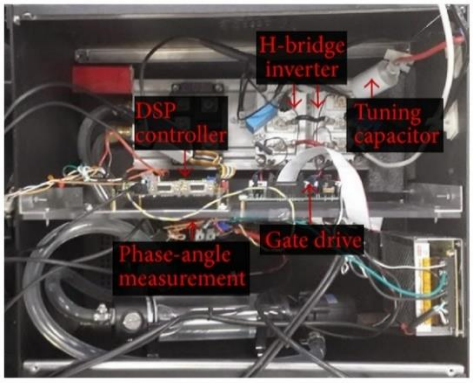



Fig. 11. Magnetic Alignment Detection Using Existing Charging Facility in Wireless EV Chargers (Gao et al., 2016)

The experimental 3-axis platform to validate the proposed system is made from a modified DHC PlasmaCAM CNC. The platform has a width of 1.75 m, a height of 1.65 m, and a depth of 1.65m with a speed of 25 m/min in the horizontal direction and 2 m/min in the vertical direction. The horizontal plane has a range of 1.2 m x 1.2m, and the vertical plane has a range of 0.6 m. Below is the physical implementation of the experimental setup, the frequency control electronics, and the auxiliary coil, respectively.



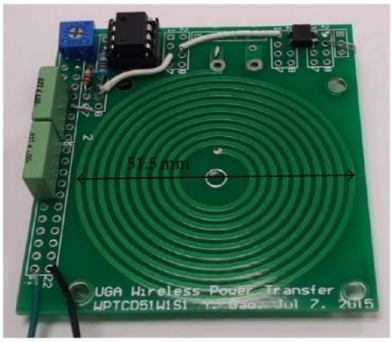



Fig. 12. Magnetic Alignment Detection Using Existing Charging Facility in Wireless EV Chargers (Gao et al., 2016)

The experiment used 20 kHz as the resonant frequency and compared the measured and actual values. The system's calibration used an air gap of 12 cm. The results showed that the mean error is 0.2 cm for an air gap of 12 cm and 0.34 for an air gap of 11.5 cm. It is worth noting that when the coils are too close (<2cm apart), the measurement error is more significant because the magnetic coupling is similar when the coils are close to perfect alignment, causing the resonant frequency to vary slightly. Nonetheless, the system can still endure small misalignments if the navigation error is lower than 10 cm for the typical wireless EV charger.

Additionally, the error in the alignment system was 0.2, 0.25, and 0.12 for the lateral distances between the coils of 5 cm, 10.5 cm, and 15 cm, respectively. Each of these measurements was repeated ten times for each lateral distance. Regarding the adjustments by the auxiliary coils, the experiment was repeated three times for each starting position. The mean error was 0.9 cm, 1.1 cm, and 1.2 cm when the starting positions were (0, 15), (15, 15), and (-15, 15), respectively. These errors were satisfactory as they fell within the acceptable range of misalignment of 1.2 cm for typical wireless EV chargers.

***An Autonomous Coil Alignment System for the Dynamic Wireless Charging of Electric Vehicles to Minimize Lateral Misalignment***

*7）Project Summary*

This project is a research article published by K. Hwang, J. Cho, D. Kim, J. Park, J. H. Kwon, S. I. Kwak, H. H. Park, and S. Ahn **on March 7, 2017**, in Energies as a particular issue. The authors of this article begin by highlighting other research and their approaches to EV wireless charging alignment technology and explain that they have many drawbacks in practice due to the electric vehicles' limited installation space, weight constraints, and driving environment. Also, due to the nature of specific approaches, they tend to have limitations like the decay in the magnetic field strength with distance for RFIDs. The required solutions for this decay result in higher construction costs or bulkier sensor hardware. For these reasons, the authors chose to utilize an autonomous coil alignment system. Previous research showed promising results using a version of ACAS. However, despite their successful experiment, the plan was only compatible with a specific DWC system, and its algorithm needed to be more straightforward to improve system reliability. For these reasons, the authors proposed an autonomous coil alignment system (ACAS) with dynamic wireless charging (DWC), which significantly improved over the previous design. The new design consists of a novel sensor coil design where an analysis of the results showed that 26% more energy could be transferred during DWC with the ACAS by aligning the coils.

*8）Technology Overview*

The proposed solution uses novel ACAS and DWC technologies, and the system description explains the concept. The DWS system is made up of only the source coil, but the ACAS consists of three elements:

- Sensor Coil Unit: Composed of a single coil unit that is wound around the middle of the load coil. Each coil consists of ferrite cores. The source coil has type A and B ferrite cores, while the load coil unit has only type A. The figures below show the coil and ferrite cores properties.

| Parameter | Source Coil | Load Coil | Sensor Coil |
|---|---|---|---|
| Dimensions (W × L × H) | 19.0 cm × 54.0 cm × 1.5 cm | 8.0 cm × 16.0 cm × 2.0 cm | 2.0 cm × 2.5 cm × 2.5 cm |
| # of turns | 20 | 42 | 10 |
| inductance | 590.00 μH | 186.15 μH | 2.45 μH |

Fig. 13. Coil Properties. An Autonomous Coil Alignment System for the Dynamic Wireless Charging of Electric Vehicles to Minimize Lateral Misalignment (Karam et al., 2017)

| Parameter | Ferrite Block Type A | Ferrite Block Type B |
|---|---|---|
| Dimensions (W × L × H) | 10.0 cm × 10.0 cm × 1.0 cm | 10.0 cm × 4.0 cm × 1.0 cm |
| Material | Manganese-Zinc (Mn-Zn) | |
| Permeability ($\mu$) | 3200 | |
| Saturation flux density ($\mathbf{B_S}$) | 520 mT | |

Fig. 14. Ferrite Core Properties. An Autonomous Coil Alignment System for the Dynamic Wireless Charging of Electric Vehicles to Minimize Lateral Misalignment (Karam et al., 2017)

- Lateral Position Detection Unit: Composed of a voltage comparator, a digital voltmeter, an XOR gate, and a lateral position estimator.
- Fuzzy Steering Controller

The lateral position detection unit and the fuzzy steering controller were programmed onto a microcontroller that was not specified. Additional circuitry is also required, which uses a 20 kHz inverter as the primary voltage source and includes an active non-inverting low-pass filter, a voltage comparator, a full bridge rectifier, a digital voltmeter, and a steering motor. The figure below shows the value for each component.

| Component | Symbol | Value |
|---|---|---|
| Source/load coil components to match resonance @ 20 kHz | $L_S$ | 590.00 μH |
| | $R_S$ | 170 mΩ |
| | $C_S$ | 107.33 nF |
| | $L_L$ | 186.15 μH |
| | $R_L$ | 103 mΩ |
| | $C_L$ | 328.11 nF |
| Rectifier smoothing capacitor | $C_{smooth}$ | 3200 μF |
| Low-pass filter (LPF) components | $R_{LPF}$ | 919 Ω |
| | $C_{LPF}$ | 9.8 nF |
| Load resistance for first experiment (static load) | $R_L$ | 10 Ω |
| Load resistance for second experiment (experimental vehicle load) | $R_L$ | 2~3 Ω (varying load due to motor operation) |

Fig. 15. Ferrite Core Properties. An Autonomous Coil Alignment System for the Dynamic Wireless Charging of Electric Vehicles to Minimize Lateral Misalignment (Karam et al., 2017)

*9) System Description*

The ACAS is a novel form of magnetic tracking which tracks the vehicle's misalignment position by measuring the voltage in the load coil of the vehicle. This method uses the DWC system and therefore does not use any external magnetic or RFID markers. The authors claim that the lack of external parts causes a significant cost reduction. DWC is a new technology that charges EVs while on the road by embedding devices in the road. It consists of embedding coils beneath the road, forming a track or lane capable of charging EVs while stationary or driving. However, the DWC lane faces problems of misalignment due to driver error. It could also become unsafe because the driver may get distracted and ignore oncoming traffic or obstacles to maintain the car aligned with the track, hence introducing the fuzzy controller.

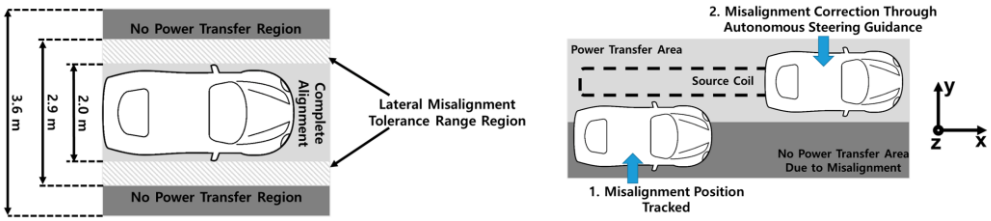



Fig. 16. DWC. An Autonomous Coil Alignment System for the Dynamic Wireless Charging of Electric Vehicles to Minimize Lateral Misalignment (Karam et al., 2017)

The sensor coil unit estimates the lateral misalignment position by detecting the phase difference. The lateral misalignment detection unit then converts the detected values into information the fuzzy steering controller can process. Then, based on the detected misalignment, the fuzzy steering controller will instruct the EV's electronic power system (EPS) to steer itself back into alignment. The user will be able to cease the operation of the ACAS in case of an obstruction on the road.

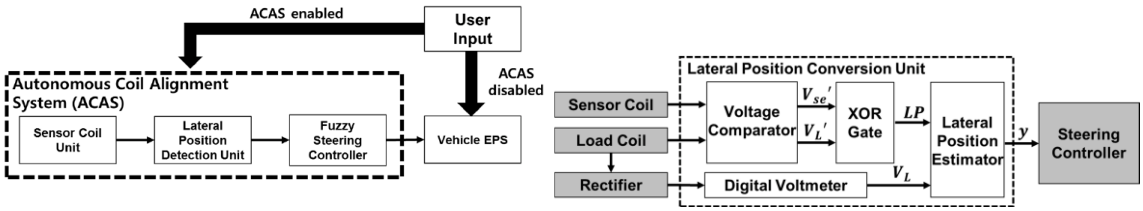



Fig. 17. ACAS Block Diagram. An Autonomous Coil Alignment System for the Dynamic Wireless Charging of Electric Vehicles to Minimize Lateral Misalignment (Karam et al., 2017)

The experiment conducted consisted of creating a laboratory-scale vehicle and track. The vehicle carried the ACAS, load, and sensor coil attached under the chassis and extra circuitry and was placed above the source coil DWC track. Additional circuitry aided in removing noise which increased measurement accuracy. Two experiments were done; the inverter was adjusted to generate 90 W and 10 W at the load for the first and second experiments. The load coil was moved from -8 cm (left) to 8 cm (right) with a step of 1 cm in the first experiment. The load coil in the second experiment was only moved from -5 cm to 5 cm due to the power reduction. The experiments justified the concept of the ACAS, and the fuzzy steering controller demonstrated that it could output steering values corresponding to the lateral misalignment position, thus confirming the feasibility of the autonomous steering control concept.

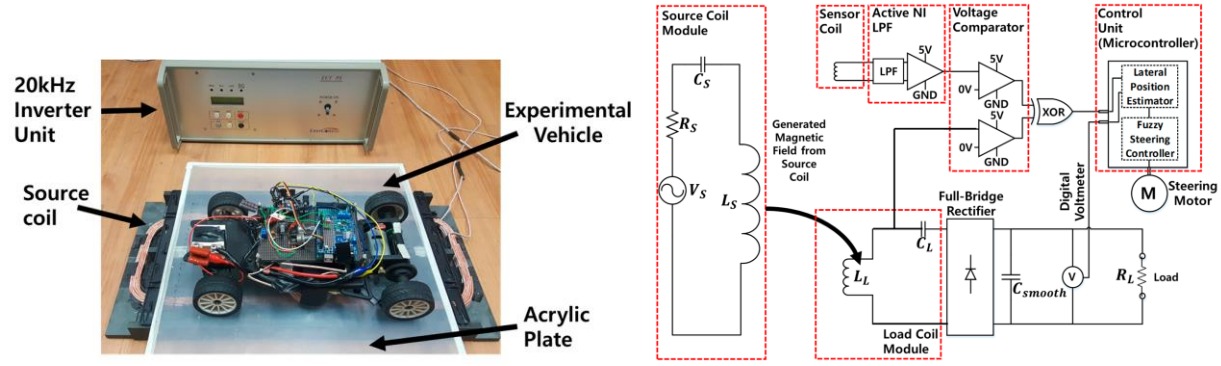



Fig. 18. Experimental Setup and Circuitry. An Autonomous Coil Alignment System for the Dynamic Wireless Charging of Electric Vehicles to Minimize Lateral Misalignment (Karam et al., 2017)

The experiments showed that the accumulated energy at the 30-second mark was 0.067 Wh for the vehicle without the ACAS and 0.091 for the vehicle with the ACAS. If the scenario continued at this rate for an hour, the energies would be 8.04 and 10.92 for the vehicle without the ACAS and the ACAS, respectively. In conclusion, the vehicle with the ACAS received 26% more energy than the vehicle without it.

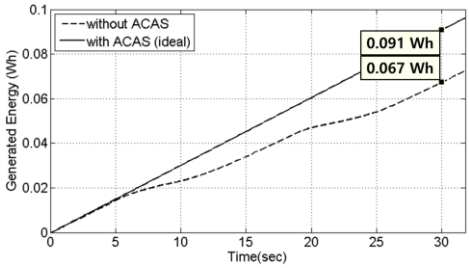



Fig. 19. Results. An Autonomous Coil Alignment System for the Dynamic Wireless Charging of Electric Vehicles to Minimize Lateral Misalignment (Karam et al., 2017)

## IX. INTELLECTUAL PROPERTY

To avoid possibly infringing patents of other creators' claims, it is important to properly research similar projects or end up in a lawsuit as a result. Patents protect the creator from having their inventions from being stolen and profited off without consent.

In this section, three patents will be reviewed that bear semblance to our project and demonstrate how our project does not infringe the patents and inventions of the creator's claims.

***Charging device and method for aligning charging device with vehicle for charging: Patent # US 11,440,425 B2***

*1) Overview:*

This patent was filed by Triple Win Technology (Shenzhen) CO.LTD. on September 17, 2022 and invented by Szu-Chi Peng and Chang Liang-Kao.

*2) Patent Summary:*

The objective of this patent is to use at least one processor and a storage device to detect whether the electric vehicle is parked in a parking space where the charging device is located, it captures an image of the vehicle's position and determines its coordinates and relay the data to the charging device to align itself to the electric vehicle.

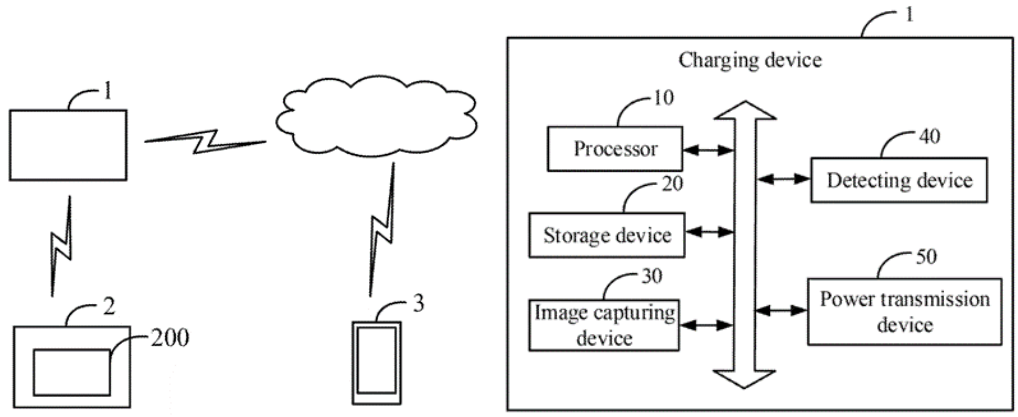



Fig. 20.

*3) Claims Summary:*

There are fourteen claims for this patent that uses a method for aligning a charging device with an electric vehicle including detecting whether or not the electric vehicle is parked in the parking space where the charging device is located

*4) Non Infringement*

Our project does not infringe on the Charging device and method for aligning the charging device with the electric vehicle for charging. Although both systems take into account the position of the electric vehicle, the approach is different.

**Methods and systems for automatic electric vehicle identification and charging via wireless charging pads: Patent # US 11,427,101 B2**

*5) Overview:*

This patent was filed by Emerging Automotive, LLC on July 14, 2020, and invented by Angel A. Penilla and Albert S. Penilla.

*6) Patent Summary:*

A system comprised of charging a battery of an electric vehicle using inductive charge transfer through a charging pad, configured with components that enable wireless communication, an alignment system in the pad, and a computer issuing commands to execute operations for communicating the charging pad to the electric vehicle components. a computer acts as a detector if the charging pad and electric vehicle are aligned.

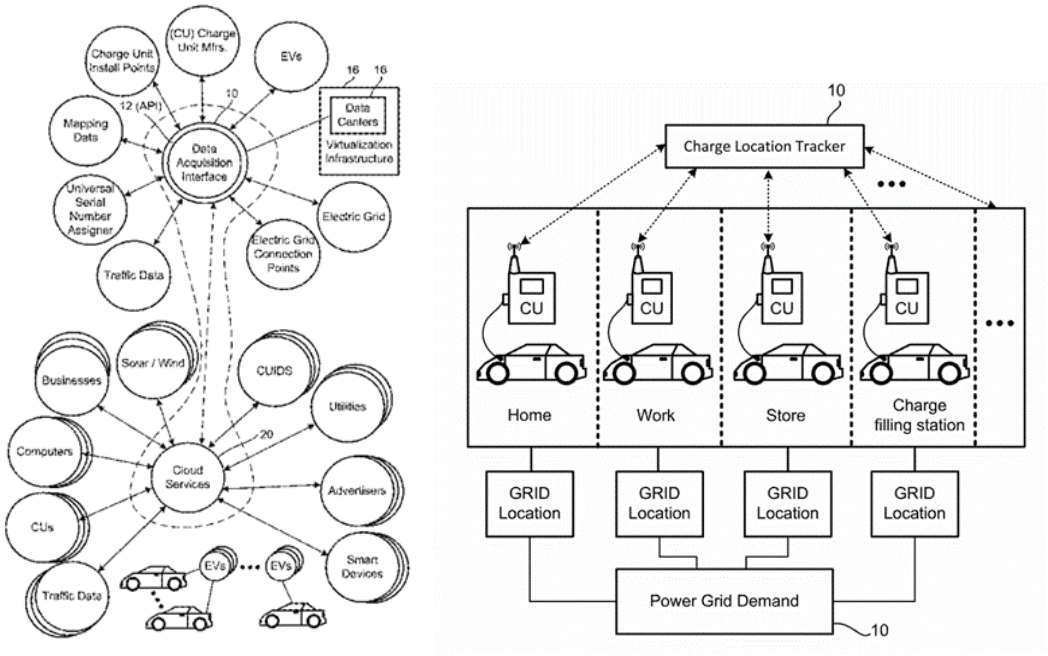



Fig. 21.

*7) Claims Summary*

There are thirteen claims for a system for charging a battery of an electric vehicle using inductive charging that includes a charging pad for inductive charge transfer. A computer associated with the charging pad configures and executes commands to enable charging of the electric vehicle. An application attached to a user's account will receive updates on the charge status of the electric vehicle.

*8) Non-Infringement*

Our project does not infringe on Methods and systems for automatic electric vehicle identification and charging via wireless charging pads, although both systems use electromagnetic induction, our project does not use a computer associated with the charging pad to configure for position.

**Wireless Charging System: Patent # US 11,427,095 B2**

*1. Overview*

This patent was filed by ABB Schweiz AG on January 27, 2020, and invented by Fabio Tombelli.

*2. Patent Summary*

The invention claimed a wireless charging system for electric vehicles uses an AC to DC converter connected to an electric AC grid and an inductive coil interconnected with a DC to AC converter, two controllers manage DC link voltage, and voltages via signal line.

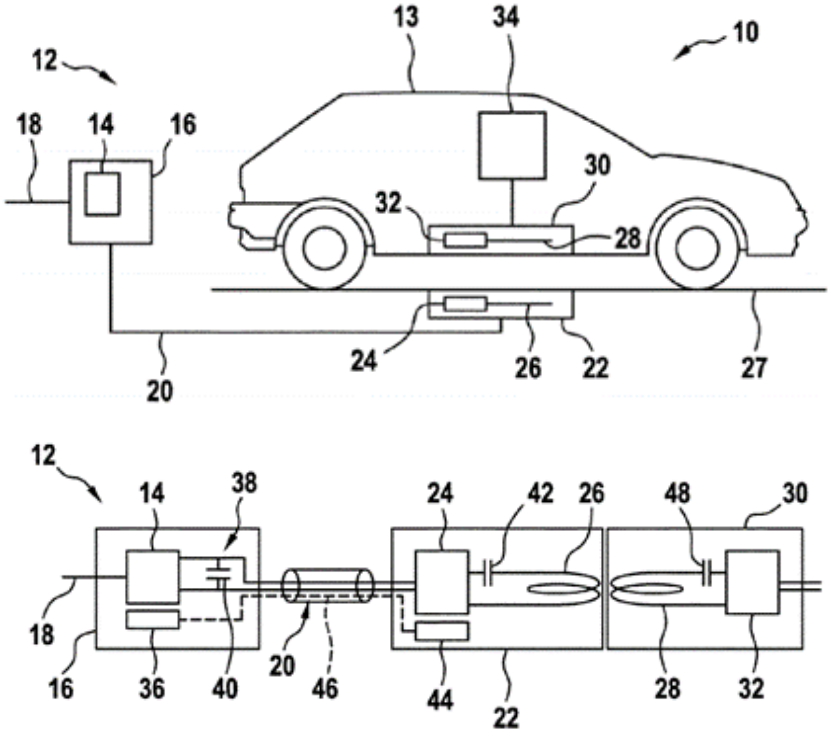



Fig. 22.

*3. Claims Summary*

There are twenty claims for a wireless charging system for electric vehicles that includes an AC to DC converter connected to an electric grid, a DC to AC converter interconnected to the AC to DC converter of the first inductive coil, and a second inductive coil for power transfer via an air gap.

*4. Non-Infringement*

Our project does not infringe on the Wireless Charging System, for our project uses AC to AC converter, and robotics is utilized to align the electromagnetic coil with the electric vehicle.

# X. GLOBALIZATION

Globalization is an essential aspect of a successful project because a successful project sells, and a product that can sell internationally is an attribute only successful projects can attest to. With globalization, many companies compete to create the most successful products. Globalization also allows people to trade information and goods. Due to this, our project must also meet these principles and attain global acceptance.

The team will discuss global principles that are common throughout successful products and introduce the World Trade Organization and its influence on the global economy. We will also discuss trading barriers and their impact on trade that can determine if a product can be successful overseas, and finally we will introduce international contacts and their perspective on our product's outcome.

### *World Trade Organization (WTO)*

The World Trade Organization is the only global international organization dealing with trade rules between nations. It comprises 164 member states representing over 96% of global trade and GDP. Its primary function is to ensure trade flows as smoothly, predictably, and freely as possible. It has specific guidelines that try to ensure all members use this function. The guidelines are:

1. Most-favored-nation (MFN): treating other people equally; countries cannot discriminate between their trading partners
2. National treatment: Treating foreigners and locals equally; Imported and locally produced goods should be treated equally.
3. Free trade: gradually, through negotiation; Lowering trade barriers is one of the most apparent means of encouraging trade.
4. Predictability: Sometimes, binding and transparency, promising not to raise a trade barrier, can be as important as lowering one because the promise gives businesses a clearer view of their future opportunities.
5. Promoting fair competition is where the system does allow tariffs and, in limited circumstances, other forms of protection. More accurately, it is a system of rules dedicated to open, fair and undistorted competition.
6. Encouraging development and economic reform is the WTO system that contributes to growth. On the other hand, developing countries need flexibility in the time they take to implement the system's agreements.

We will also aim to adhere to these six principles in our design and implementation to ensure a globally accepted product.

### *Trading Barriers*

Trading Barriers are used to either restrict or allow a certain product to enter a county's border. Ensuring our product meets trade barrier guidelines and does not violate any laws. One way of ensuring free and smooth trade is adhering to trade standards. Standards and technical regulations impact up to 93% of global trade because they are used to measure if a certain product meets commercial and safety regulations. Common trade symbols and standards are:

- The American National Standards Institute (ANSI) is a private, non-profit organization that administers and coordinates the U.S. voluntary standards and conformity assessment system.
- ISO Mark: A very significant thing that is involved in improving device marketability and removing many trading barriers.
- CE Mark: "Coriformity Europeenne" is also another global conformity mark that is used for evaluating the performance of a device and its safety standards.
- UL Listing: UL Solutions partners with customers and stakeholders in more than 100 countries to help solve safety, security, and sustainability challenges

***International Contacts***

To ensure global acceptance, we must have reliable feedback, and thus we must contact international students and faculties from universities to learn about their perspectives on our product. This gives us a firsthand look at how our product will be perceived, and we can then determine if our product is successful in foreign cultures. For international success, we must meet the needs of possible clients and markets, obtain global acceptance, and minimize trade barriers.

***Collaboration Tools***

Our team uses collaboration tools that allow us to work closely together even when out of state or even out of the country. As the world becomes more digital and technology continuously improves, we maintain constant contact. Our principal form of contact was using text messaging application, WhatsApp, for quick mobile messaging. For video calling, we used Discord and Zoom to share screen and have round table discussions. We used Microsoft's SharePoint site to share and organize files while working simultaneously.

Aside from the software stated above, we still have access to each other's emails and phone numbers. Typically, we use emails to arrange formal meetings with our mentor and client. We also use email to arrange meetings with our instructor and upload work assignments to our Canvas portal.

Out of collaboration tools, the most critical lecture we take from this is the importance of communication. Fortunately, our modern society has improved communication methods, that allow us to stay interconnected no matter where you are in the world.

To conclude, Globalization is an essential concept for our team and project because of the direct impact it has on our product's development and marketability. These pressures are closely linked to the standards set by organizations and that are being used to provide safety and ensure that all products will not cause any harm to their users. We will discuss our Standards Consideration in the next section.

## XI. STANDARDS CONSIDERATIONS

This section discusses the importance of standard considerations and what standards will be followed for the project. Standard considerations are necessary because they provide guidelines for best practices in quality control, safety, and environmental protection. They also promote international trade by providing a common language that companies can use to compare products and services. If there are no standards, then there is no way to measure quality or progress; this would make improving the quality of products or services very difficult. The type of standards the product falls under is generally Mandatory and De Jure standards. Mandatory standards are incorporated into laws or technical regulations to protect public health, safety, and the environment; or when incorporated into contractual agreements between buyers and sellers. De Jure standards are legally protected or enforced, but also those that an official standards organization has endorsed.

For the electrical vehicle wireless charging alignment system to be a successful product, it must be able to adhere to standards as a priority. Some organizations have standards that guide acceptable means within the industry's market. The Institute of Electrical and Electronics Engineers, Society of Automotive Engineers, and International Organizational for Standardization are examples of organizations vital to upholding standards in the market. Carefully reviewing the product, we considered adhering to the following criteria:

### *IEEE 1848-2020 IEEE STANDARD FOR TECHNIQUES AND MEASUREMENT TO MANAGE FUNCTIONAL SAFETY AND OTHER RISKS WITH REGARDS TO ELECTROMAGNETIC DISTURBANCES*

A set of methods for helping to manage the levels of risk due to electromagnetic disturbances throughout the life cycles of electronic equipment. This includes the consequences of errors, malfunctions, or failures in products, equipment, and systems utilizing modern electronic technologies. It is supplemented by achieving functional safety of electrical and electronic systems, including equipment regarding electromagnetic phenomena, by providing practical techniques and measures to minimize risks caused by electromagnetic disturbances. These measures are used in the management, specifications, design, implementation, verification, and validation, and through life operation, maintenance, repair, refurbishment, upgrading, and eventual dismantling for disposal of equipment and systems employing digital electronic techniques for both hardware and software.

### *SAE J2954 WIRELESS POWER TRANSFER FOR LIGHT-DUTY PLUG-IN/ELECTRIC VEHICLES AND ALIGNMENT METHODOLOGY*

The SAE J2954 standard established industry-wide acceptance criteria for interoperability, electromagnetic compatibility, electromagnetic force, minimum performance, safety, and testing for wireless power transfer of light-duty plug-in electric vehicles. This specification defines various charging levels based on the levels mentioned in SAE J1772, conductive AC charge levels 1, 2, and 3, with some variations. The standards for wireless power transfer are based on the levels that enable the selection of a charging rate for the vehicle's requirements. Hence, allowing for better vehicle packaging and ease of customer use for supporting private and public wireless charging.

### *ISO 45001:2018 OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT SYSTEMS*

ISO 45001:2018 is a standard that specifies requirements for an occupational health and safety management system. It guides its use to enable organizations to provide a safe and healthy workplace by preventing work-related injury and ill health and proactively improving occupational health and safety performance. It applies to an organization that desires to establish, implement, and maintain occupational health and safety management systems to improve occupational health and safety, eliminate hazards, and minimize risks. This standard can be incorporated as a part or whole to improve occupational health and safety management systematically.

After carefully reviewing these standards, we will adhere to the criteria provided by the Institute of Electrical and Electronic Engineer, Society of Automotive Engineers, and International Organizational for Standardization as an integral part of the design process for the project. They will be of great significance, and we will comply with the following standards:

- IEEE 1848-2020
- SAE J2954
- ISO 45001:2018

# XII. HEALTH AND SAFETY CONSIDERATIONS

The Health and Safety Considerations discusses the importance of working in a healthy and safe environment. Health and safety measures must be a priority when it comes to creating and designing a product. In the process of marketing products, it is important that products sold to the public are manufactured and designed in accordance with Health and Safety in mind. Therefore, there exists specific laws and regulations to preserve and protect people from any risks or harm that may come about with a product or in the manufacturing of a product. After careful analyzations of the risks, our Electric Vehicle Wireless Charging Alignment System has shown not to face any harm to health or safety. However, it is still essential to discuss the health and safety concerns with our product.

### *Health*

The World Health Organization defines health as a state of complete physical, mental, and social welling being. We have a similar goal of keeping that definition with our product. Our Electric Vehicle Wireless Charging Alignment System is purposed to provide users with more convenience than they would have had with a normal wireless charging system for EVs. We strive to give our customers the best experience that they could have. That requires that their health is accounted for. Our Electric Vehicle Wireless Charging Alignment System aims to relieve a user from additional physical, mental, and social stresses that they may have. Our product will ensure that an EV is properly aligned with a wireless charger, which is usually an additional step that users would have been tasked with without an alignment system. The Electric Vehicle Wireless Charging Alignment System takes the additional step and the stress that comes from this step away to promote a healthier lifestyle. A health concern that many electronic devices contribute to is the effects of e-waste. E-waste has been on the increase in recent years due to technological advancements and improper handling of old materials. There exists a danger to health with some of the toxic materials that come about with e-waste. Some of these substances are Lead, Mercury, Cadmium, and lithium. Exposure to these metals can cause individuals to suffer from various health problems like cancer, congenital disabilities, memory loss, irritation, poisoning, and damage to specific bodily organs. Though our design does not use batteries, there are some components that have these toxic substances in low amounts. We ensure that the manufacturing of our product and our finished product algins with the laws and regulations that are set to sustain a healthy lifestyle for all people who use and manufacture our product.

### *Safety*

Safety is very important for all people and must be a priority in designing and releasing a product. We want to make it a priority that our product gives people the ability to enjoy life without fear of harm, danger, or threats. A way of promoting safety with our product is to comply with safety standards during the design process. One of behaviors we adopted for compliances is to be mindful of wearing metals while working with exposed wires to decrease the risk of electric shock. We also strive to work with at least another person in the electrical designs of the system to have some accountability. We also were careful with soldering to avoid inhaling the harmful fumes. These are some examples of the measures that we took in order to put the safety of ourselves as a priority.

For the safety of our users, we want to design our product to also be in compliance with laws and safety regulations for the public to use. This will enable our products to be safe for all people to use. It also holds us accountable for any unsafe components of our alignment system. We also want the users to use our product in a safe manner. Ideally the users will almost never have to be

physically involved with our system, but even if they were we have designed it to be safe when used properly. A good to ensure safe practices while using our product, we have decided to include a user manual with our product. This will educate the user in how our alignment system works, the proper ways to use our product and the potential hazards that it has. It is essential for our team to educate our users in using our products correctly for their safety and the safety of others. We also do not want our product to be used in a manner that can bring danger to others. Therefore, our product will only be used for the purpose of alignment of electric vehicle wireless chargers.

***Labilities***

It is important for the designers of a product to understand the liabilities that come about with the release of a product. Previously for a seller-buyer relationship, the doctrine of caveat emptor was adopted. This meant that the buyer would take up liabilities. However, in our current time, the doctrine has shifted to have the seller. Therefore, in accordance with the current ways in which the seller-buyer relationship works we must discuss the necessary liability that comes with the release of our Electric Vehicle Wireless Charging Alignment System. Product liabilities can allow users to file lawsuits against the developers and manufacturers of a product, especially if it causes harm or injury to a user or an environment. To discuss product liability, we will reference The American Law Institute and some of the rules that they have created to ensure the safety of individuals.

Three areas that our team has focused on in this matter are manufacturing, design, and product warnings. In the area of manufacturing, some things that may come about are product defects. Product defects are caused when components are not of the quality that they should be at, resulting in undesired outcomes and performance. Therefore, it is important for our team to take measures in testing our products to be of the desired quality. In relation to the area of design, it is important to design a product in a way that will have it performing in a safe and efficient manner. For this the team will ensure that safety standards are met and followed in the making of the product so that there will not be any issues to health and safety caused by our designs. Finally, our product should educate the users on product safety and our team aims to fulfill this need by implementing a product manual that will include how to properly use our product and the warnings and potentials hazards that may go with it.

Overall, health and safety are essential topics and priorities that need to be discussed and implemented. As engineers, the aims of our designs and the work that we do are to aid people's lives and provide a better and sustainable future. To ensure this, steps towards health and safety need to take place. Our team acknowledges the risk and responsibilities associated with the designs and marketing of our Electric Vehicle Wireless Charging Alignment System and made our product with health and safety in mind for all people in all parts of the designing, manufacturing, and using of our product.

# XIII. ENVIRONMENTAL CONSIDERATIONS

Humans can impact the environment in various ways. Most of the actions caused by humans directly harm the environment and cause negative impacts that last for a long time. Since there exists rapid increase in development and advancements in technology, industrial waste and e-waste are contributing to a lot of environmental pollution. Most of the pollution is toxic and harms the environment. Therefore, it is vital for our team to design and build in a way that does not harm our environment.

### *Restriction of Hazardous Substances Directive (RoHS)*

The adherence of the Restriction of Hazardous Substances, or RoHS, is one way to effectively design in a way that is safe for the environment. RoHS is responsible for forming regulations that should be followed when designing a product to ensure the safety of the people and the environment. With RoHS there exist certain hazardous substances that have been restricted on electronic products to protect the environment. These products are Cadmium, Lead, Mercury, Hexavalent Chromium, Polybrominated Biphenyls, Polybrominated Diphenyl Ethers, Bis(2-Ethylhexyl) phthalate, Benzyl butyl phthalate, Dibutyl phthalate, and Di isobutyl phthalate [5]. These substances are harmful to people and the environment. Therefore, it is best practice to avoid using these materials and follow the RoHS initiatives. Our Electric Vehicle Wireless Charging Alignment System does not include any of these substances and is in accordance with RoHS regulations.

### *Easy Disassembly*

To offer a more sustainable and reusable product it is important to have a way of installing and disassembling components in the product. Our team aims to get parts that are easy and safe to attain and make them into a useable format for our Electric Vehicle Wireless Charging Alignment System. This will make it easier to assemble, but also easy to disassemble. Therefore, if there was ever a case where the product becomes damaged or if a specific component fails, there would be a way to disable the Electric Vehicle Wireless Charging Alignment System and have the part or component to be replaced so that the Electric Vehicle Wireless Charging Alignment System can continue working. This will allow our product to last for a long time and be more cost efficient for people. Also, if there was a case where Electric Vehicle Wireless Charging Alignment System can be used in the future for more products and a longer time, the easy disassembly can be used to replaced needed parts or to be reconfigured. This is very important to sustainability and a better overall product.

### *Life Cycle Assessment (LCA)*

The Life Cycle Assessment (LCA) is a method used to evaluate the environmental influence of a product in all its life cycle. The Electric Vehicle Wireless Charging Alignment System has a lot of hardware materials that can affect the environment in different ways. Some of these materials come from microcontrollers, wires, and motors. The environmental impact that the Electric Vehicle Wireless Charging Alignment System has is low because it has parts that are sustainable and don’t do a lot of harm to the environment. There are some plastics and materials that can contribute negatively to the environment, but it is not as harmful if repurposed and disposed of correctly. Even that the end of the product’s life, many of the parts can be recycled and reused for other purposes.

### *The Hannover Principles*

Hanover principle are concepts that are created to guide engineers, designers, and creators on how to develop products that are more environmentally sustainable. They were presented in the

City of Hannover, Germany in 2000 at EXPO 2000. These principles were prepared by William McDonough and Dr. Michael Braungart in 1992. Their aim was to introduce aims and a new way of thinking so that sustainability could be a priority for future designs. These are not regulations or requirements, but they are a way of thinking to promote sustainability. These principles were important for our team to keep in mind when designing and making our project.

*a) The Hannover Principles are as follows:*

1. Insist on rights of humanity and nature to co-exist in a healthy, supportive, diverse and sustainable condition.

2. Recognize interdependence. The elements of human design interact with and depend upon the natural world, with broad and diverse implications at every scale. Expand design considerations to recognizing even distant effects.

3. Respect relationships between spirit and matter. Consider all aspects of human settlement including community, dwelling, industry and trade in terms of existing and evolving connections between spiritual and material consciousness.

4. Accept responsibility for the consequences of design decisions upon human well-being, the viability of natural systems and their right to co-exist.

5. Create safe objects of long-term value. Do not burden future generations with requirements for maintenance or vigilant administration of potential danger due to the careless creation of products, processes or standards.

6. Eliminate the concept of waste. Evaluate and optimize the full life-cycle of products and processes, to approach the state of natural systems, in which there is no waste.
7. Rely on natural energy flows. Human designs should, like the living world, derive their creative forces from perpetual solar income. Incorporate this energy efficiently and safely for responsible use.

8. Understand the limitations of design. No human creation lasts forever and design does not solve all problems. Those who create and plan should practice humility in the face of nature. Treat nature as a model and mentor, not as an inconvenience to be evaded or controlled.

9. Seek constant improvement by the sharing of knowledge. Encourage direct and open communication between colleagues, patrons, manufacturers and users to link long term sustainable considerations with ethical responsibility, and re-establish the integral relationship between natural processes and human activity.

To conclude, our role in sustaining and protecting our environment is very important. This responsibility also falls into our hands when we are designing and implementing new technologies for the world. Keeping the environment clean and safe should be a priority for designers and developers when creating a product. As engineers it is our job to uphold our environment in the work that we do. Therefore it is important to have strong principles and to

adhere to laws and regulations when designing and manufacturing a product. Our team has also taken the initiative to follow these thing discussed in this section to sustain and protect the environment in designing the Electric Vehicle Wireless Charging Alignment System.

## XIV. SUSTAINABILITY CONSIDERATIONS

The design of an object of long-term value requires a few key considerations. First, the object should be designed with durability in mind. This means using materials that can withstand wear and tear and resist corrosion and other environmental factors. Additionally, the object should be designed with functionality in mind. This means that all components should be optimized for the intended use, and the design should be simple and intuitive. Finally, the object should be designed with aesthetics in mind. The form and color should be cohesive and pleasing to the eye. By considering all these factors, an object of long-term value can be designed that is both functional and aesthetically pleasing.

Our electric vehicle wireless charging alignment system for a sustainable future is the perfect solution for EV owners who need reliable, efficient, and cost-effective charging. Our system uses an innovative approach to align and charge any EV wirelessly without requiring wires or charging posts. The system is based on an EV receiver and a charging station. The EV receiver is a small device attached to the EV and connected to the battery. This device enables the EV to be wirelessly charged. The charging station is the other component of our system and consists of a series of coils that generate a magnetic field. When a compatible EV is parked correctly, the receiver will detect the magnetic field and automatically align the EV to the charging station. Our system is reliable, efficient, and cost-effective, and our charging stations are designed to be fast, with charging speeds up to 10 times faster than traditional charging posts.

Additionally, the system is more cost-effective than traditional charging posts, as no wires or cables need to be purchased and installed. Finally, our EV wireless charging alignment system for a sustainable future is designed to meet the needs of EV owners and contribute to a more sustainable future. With our system, EV owners can enjoy the convenience of wireless charging without worrying about the cost and complexity of traditional charging posts. Furthermore, our system enables EV owners to reduce their emissions, which is more efficient than conventional charging options.

# XV. MANUFACTURABILITY CONSIDERATIONS

The term "I design it and you build it" is no longer applicable and can be a detrimental approach to the success of any product or project. This phrase implies that the designer is only responsible for designing the product or project, while the builder is solely responsible for assembling the physical components. This approach does not take into consideration the collaborative nature of the modern product or project development. Instead, successful product or project development requires collaboration between both the designer and the builder, where roles and responsibilities are determined together. The designer and builder must work together to ensure that the product or project meets all design, performance, and safety criteria. Considering manufacturing issues early in the design phase, allows us to shorten product development time, minimize development costs, and ensure a smooth transition into production for quick time to market. We will elaborate on principles of Minimal Design, Modularity, and Testability.

### *Minimal Design*

A simple design allows the team to approach the project with an open mind and to emphasize functionality and marketability. By minimizing the design of our Electric Vehicle Wireless Charging Alignment System, we can focus on the components necessary for the system to function. This includes the wireless charging pad, the receiver, the power source, and the control circuitry. We can also minimize the size of the system by reducing the size and weight of components, as well as by removing any unnecessary materials. We can also minimize the amount of wiring and cables needed to connect the devices and the amount of power needed for the system by optimizing the power consumption of each component. By taking a minimalist approach to the design of our product, we can create a more efficient and marketable system that can sell. We can also reduce the cost of the system and make it more accessible to consumers. Furthermore, we can ensure the system is easy to use and install, making it more attractive to potential customers. Finally, this approach will also help us maintain a high level of safety and reliability.

### *Modularity*

Modular components are essential because they allow for more flexibility in the design of systems. Breaking down a complex system into small, discrete pieces makes it easier to customize the system to specific needs. This makes it easier to add, remove, and modify individual components as needed. Moreover, according to Anderson’s Law, modular components can be obtained through off-the-shelf parts saving the team time considering the time to design, document, administer, build, and test. They are also less expensive, and these components' suppliers are more experienced. Modular components also make troubleshooting and upgrading systems easier as they underperform or become outdated. Modular components are also beneficial because they are often more cost-effective than creating a custom system from scratch. Modular components can also help improve system performance, as they are designed to work together efficiently. The microcontroller, magnetic field sensors, and motors for the pad could all be interchanged with different part numbers or suppliers to meet other specifications. This makes it easier for the team to find the application's components that will work best.

### *Testability*

We must also design our product so that it can be tested and evaluated. This includes designing our product so that it can be tested for functionality, usability, performance, and reliability. Additionally, we should design tests to ensure that the product meets customer requirements and

expectations. Finally, we should develop a plan to evaluate the effectiveness of our product and make changes as needed.

To conclude, designing for manufacturability should be incorporated into any design project, and emphasized during the early stages to avoid exceeding the project's dedicated budget. This requires a comprehensive understanding of the manufacturing process, as well as an awareness of the available resources and capabilities. Additionally, we must consider the principles of Minimal Design, Modularity, and Testability, to ensure that a design can be quickly and efficiently realized. By following these guidelines, a product can be manufactured quickly and with the highest quality, all while staying within budget.

## XVI. Ethical Considerations and Social Impact

Ethical considerations and social impacts are important to discuss in the creation of a new product. It is important to take into account the intentions for the product, the purpose of a product, and the impact a product will have on society and the environment. There is a responsibility as the developers of the product to create it in a way that prioritizes the safety of individuals and that will not be a hindrance to society or its individuals. The IEEE Code of Ethics is a key guideline to adopt to create and design products in a manner that emphasizes the highest ethical and professional conducts. There exists an obligation to treat all people with respect and with the highest standards of integrity. We have committed to building a product that guarantees the best for society, its individuals, and our environment.

### *Ethical Considerations*

The IEEE Code of Ethics was developed to serve as fundamental rules and guidelines that engineers follow in the process of creating and designing products and innovations. It aims to create a mindset for engineers to have that stresses the importance of one's integrity, responsibility, and ethical conduct in the field of engineering. Therefore, most of the engineering community aims to adhere to the IEEE Code of Conduct. We also have followed the IEEE Code of Ethics to ensure that we created a product in a manner that emphasizes the highest ethical and professional conduct.

Since we have committed to the IEEE Code of Ethics, we must consider ethical dilemmas that may impact society and the environment. One ethical dilemma that was encountered in the design and creation of The Electric Vehicle Wireless Charging Alignment System is that there exists the possibility of our product encouraging users to park their electrical vehicles incorrectly. The Electric Vehicle Wireless Charging Alignment System is a very convenient system for its users. While wireless charging for electric vehicles can be helpful, it requires that the transmitter coil and the receiver coil be properly aligned for the most efficient and optimal method of wireless charging. This can be difficult to accomplish for users because the alignment would have to be done by the user. This can lead to many instances of inefficient and suboptimal wireless power transfer for wireless charging. The Electric Vehicle Wireless Charging Alignment System aims to make this alignment process convenient. This system is advantageous for users because the user will not have to think about aligning the transmitter coil and receiver coil. However, this comfortability may lead users to be careless about parking correctly. This incorrect parking will make situations that are disadvantageous and unsuitable for surrounding individuals that may also need to park. This hindrance is harmful and unacceptable according to the IEEE Code of Ethics. To aid in avoiding this problem from convenience, we have used the Ethical Theory Model to help analyze this situation and come up with a solution.

TABLE XVII. SOLUTIONS FOR ETHICAL DILEMMAS

| Options | Description |
|---|---|
| 1 | Ignore the possibility of the problem |
| 2 | Inform the buyer about parking within the lines, no help is offered |
| 3 | Inform the buyer when users park incorrectly |
| 4 | Constrain the product to limit charging incorrectly parked vehicles |
| 5 | Hire people to ensure correct parking |

TABLE XVIII. WEIGHTED POTENTIAL SOLUTIONS

| Options | Theories | | | | Score |
|---|---|---|---|---|---|
| | Utilitarianism | Egoism | Rights | Kantian | |
| 1 | 0.00 | 1.00 | 0.00 | 0.00 | 1.00 |
| 2 | 0.25 | 0.75 | 0.25 | 0.50 | 1.75 |
| 3 | 0.50 | 0.25 | 0.50 | 0.50 | 1.75 |
| 4 | 1.00 | 1.00 | 0.75 | 0.75 | 3.50 |
| 5 | 1.00 | 0.00 | 1.00 | 0.50 | 2.50 |

By using the Ethical Theory Model, it was apparent to the team that the option to design the product in a way that constrains the wireless charging to vehicles that are properly parked. This option will generate the least amount of harm to individuals that are affected by improper parking. This option will also ensure that the product will not cause any harm to individuals and promotes the product in a positive light. This option is also one that can be followed by others to solve similar issues. It also respects users and nonusers of the product and treats them fairly.

### *Social Impact*

There exists a social impact when a product is released into society from a local to a global degree. It is very crucial to consider the design and creation of products from a social perspective because society is affected when products are introduced. Most products are made for the good of people and for their benefit. However, there may be products that are created for the good of people that may lead to a negative social outcome. There are also products that are created that do not consider social outcomes and that do not benefit the people. To avoid these situations, it is important to design and create products with the right intentions and for the benefit of all people.

In our current culture, there has been a demand and push for the use of Electric Vehicles. Car manufacturers have also started making more electric models to satisfy these demands. This trend and surge of EVs hint at a future and oncoming reality where most of the vehicles on the road will be electrically powered. This increase in Electric Vehicles has also led to an increased demand for electric vehicle chargers. The Inductive Power Transfer (IPT) systems can add another layer of convenience to charging an electrical vehicle. This technology can be easier to use than a traditional plug-in charger where a user will have to manually plug-in an EV charger

into it. An Inductive Power Transfer system would only require the user to have the EV on top of a charging pad. An IPT system would be more inclusive than most traditional plug-in chargers because the system would not require a unique manufacture plug for a charger, which is a present problem many EV owners face. IPT systems would offer a lower risk of vandalism and can have safer operations because there would not be a need for a cable. Our current product also adds the convenience of aligning the transmitter coil and receiver coil to ensure the best charging to an IPT system.

The local culture in the United States that we have will have a great benefit to having an IPT system that includes an alignment system. Since there is a demand for electrical chargers due to the increase in electric vehicle users, our alignment system will be advantageous to many users. The Electric Vehicle Wireless Charging Alignment System would make charging an Electrical Vehicle a comfortable experience. Currently, EV users charge by manually plugging in their vehicles. This is an additional step that needs to be taken with the ownership of an EV. This step can easily be forgotten and can lead to situations that are not favorable to the user of an EV. By using an IPT system with our Wireless Charging Alignment System, this step does not need to be considered. Therefore, ownership of an EV can be more favorable. The Wireless Charging Alignment System would also have a smaller footprint. Therefore, it would be easier to include the system in many parking lots and garages. The current chargers must account for the cable and the system is mostly aboveground which takes up a lot of space and can limit how many an area can have. This would also contribute to better access to charging for EV users and decrease the need to wait for a charger. As a result, The Electric Vehicle Wireless Charging Alignment System would provide EV users with a more comfortable lifestyle.

Many perks of The Electric Vehicle Wireless Charging Alignment System also transfer to the global culture. Many counties in Europe and China have increased sales of EV in recent years. Therefore, this is a global push and demand for EV and an even greater push for EV charging system. These places where there is a demand of Electric Vehicles will also benefit from the wireless charging alignment system. Many countries are pushing to have most of their car sales be electric cars. However, areas that do not prioritize Electric Vehicles will not have the same benefit from this product. There are areas where it is not possible and practical to have an Electrical Vehicle. The Wireless charging system will not be useful in these areas and will not impact society to a high degree due to its inaccessibility and non-necessity. However, for EV users globally, this technology will be very convenient.

Ultimately, The Electric Vehicle Wireless Charging Alignment System is designed with the proper ethical considerations and created in a manner that impacts the social culture in a positive manner. When taking in these fundamental elements, it proposes many challenges to overcome. However, as engineering developers, it is our responsibility and duty to find solutions to these challenges to ensure the best is given to the users of our product and to impact society in effective ways so that it will not create harmful situations.

# XVII. Concept Development

Transformation and enhancement of projects begin with great concepts. There has never been a greater need for creative thinking and creative skills. While today's sophisticated technology has made it possible to generate quality project concepts, a substantial percentage of these concepts never move forward due to the ineffective execution of concept development. To ensure the approach to achieving our ideas is clear and feasible, several aspects must be considered when brainstorming. As we develop concepts, it is crucial to create an alignment mechanism design that meets market demands. It is only through market testing that we can determine whether our product will be accepted by users. By receiving feedback, we can confirm whether our product is a good fit for the market, validate our concept, and make any necessary changes. Our design must be refined with the help of users and clients to get the public support we need at this point. Our product's complexity and accessibility must be balanced when designing. Even though our design must be intricate to avoid duplication, it also must be affordable for customers to purchase in the future. Performing extensive research at this stage is critical if we want our product to function correctly and adhere to set-up restrictions.

The objective of this section is to make a concept fan of all possible options for implementing the project. We will analyze all the different implementations of this project to obtain an option that is viable and fits the needs of the client. It will need to meet our objectives and constraints most efficiently while taking our assumptions and limitations into consideration. After analyzing all the alternate options, we will construct a concept selection table with a weighted average to select the best concept to follow. Figure 23 shows the concept fan developed by the team to evaluate the possible different design methods. While we do not consider every possible combination, we will consider the two most practical and representative combinations for what we are attempting to achieve.

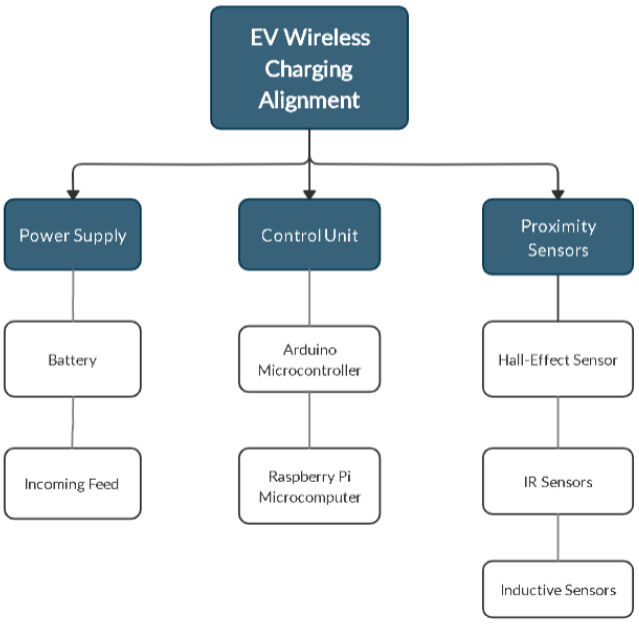



Fig. 23. Concept Fan

***Design I: Battery, Arduino Board, Hall-Effect Sensors***

The first design option the team analyzed is for the alignment mechanism to have a battery as the input power supply, an Arduino as the control unit, and the use of hall-effect sensors. This design option is shown in Figure 23. This option has its own advantages and disadvantages, and each must be considered for a successful project.

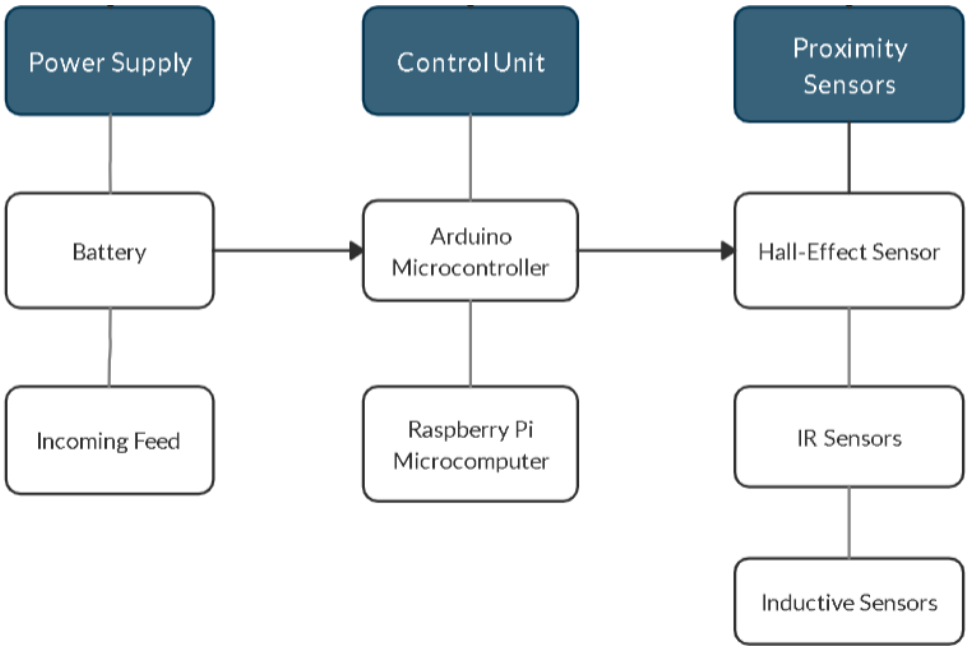



Fig. 24. Option 1

*1) Advantages*

*a) Hall Effect sensors can detect magnetic field intensity, B.*

*b) Hall Effect sensors are suitable for high-speed applications and allow to pre-program certain position angles.*

*c) Arduino board is more economical.*

*d) Battery allows for a smaller physical size.*

*2) Disadvantages*

*a) Batteries will need to be replaced or recharged.*

*b) Hall effect sensors would have to be moved to a known location and reset if system loses power.*

***Design II: Incoming Feed, Rasberry Pi, and Inductive Sensors***

The second design option the team analyzed is for the alignment mechanism to have transmitter source as the input power supply, a Raspberry Pi as the control unit, and the use of inductive sensors.

This design option is show on Figure 24. This option has its own advantages and disadvantages, and each must be considered for a successful project.

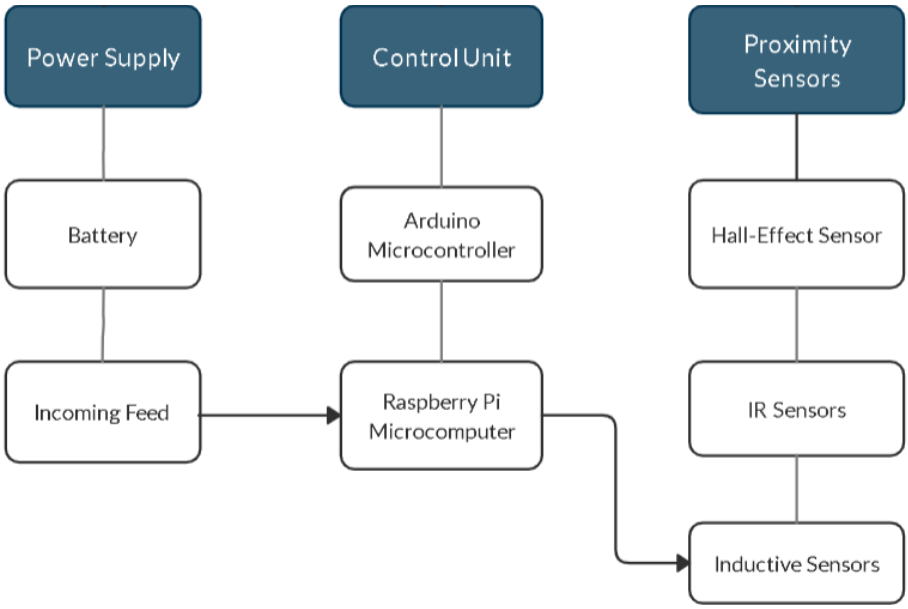



Fig. 25. Option 2

*3) Advantages*

*a) Constant power supply.*

*b) Rasberry Pi has more capabilities than an Arduino.*

*c) Inductive sensors can be installed in rougher environments where water, dirt, grease, grit, sand, and vibration may be encountered.*

*4) Disadvantages*

*a) The Rasberry Pi is more expensive than an Arduino.*

*b) Inductive sensors only detect metallic objects.*

### *Concept Selection*

Now that we have the two options for our design, we need to determine which of the two will be more suitable and practical. We can achieve this by making a concept selection table where we compare the weights of the different objectives and constraints that we must take into consideration for the outcome of our design as follows:

| | **Power Efficiency** | **Marketability** | **Accessibility** | **Safety** |
|---|---|---|---|---|
| **Power Efficiency** | 1 | 3 | 7 | 9 |

| | | | | |
|---|---|---|---|---|
| **Marketability** | 1/3 | 1 | 3 | 7 |
| **Accessibility** | 1/7 | 3 | 1 | 3 |
| **Safety** | 1/9 | 1/7 | 1/3 | 1 |

TABLE XIX. CONCEPT SELECTION IMPORTANCE SCORE

Importance: 1 = equal, 3 = Moderate, 5 = Strong, 7 = Very Strong, 9 = Extreme

TABLE XX. CONCEPT SELECTION WEIGHT CALCULATOR

| | **Power Efficiency** | **Marketability** | **Accessibility** | **Safety** | **G. Mean** | **Weight** |
|---|---|---|---|---|---|---|
| **Power Efficiency** | 1.00 | 3.00 | 7.00 | 9.00 | 3.70779275 | 0.55699614 |
| **Marketability** | 0.33 | 1 | 3.00 | 7.00 | 1.62249478 | 0.2437362 |
| **Accessibility** | 0.14 | 3.00 | 1 | 3.00 | 1.05947969 | 0.15915833 |
| **Safety** | 0.11 | 0.14 | 0.33 | 1 | 0.2669984 | 0.04010933 |
| **Total** | | | | | 6.6567656 | 1 |

**G. Mean** = $\sqrt[n]{(A \times A \times \ldots \times A)}$ **Weight** = G. Mean/Total

TABLE XXI. CONCEPT SELECTION TOTAL SCORES

| | | **DesgnI** | **Design II** |
|---|---|---|---|

| **Constraints** | | | | | |
|---|---|---|---|---|---|
| The alignment mechanism should not expose conductors. | | YES | | YES | |
| The alignment mechanism must withstand being exposed to rough conditions. | | YES | | YES | |
| The alignment mechanism should be cost-efficient. | | YES | | YES | |
| **Objective** | W | | | | |
| Power Efficiency | 0.55 | 7 | 3.85 | 3 | 1.65 |
| Marketability | 0.24 | 5 | 1.2 | 5 | 1.2 |
| Accessibility | 0.16 | 5 | 0.8 | 7 | 1.12 |
| Safety | 0.04 | 9 | 0.36 | 9 | 0.36 |
| Total Score | | | 6.21 | | 4.33 |

After the analysis of the table, it is clear to conclude that Design I is a better design for The Electric Vehicle Wireless Charging Alignment System. According to the weight system, importance was given to each of the categories. After the importance was measured, it was rated again with the weighted metrics so that the total score would reflect the better option in relation to the alternative's rating and the importance of the categories.

## XVIII. End Product Description and Other Deliverables

This section intends to educate the reader on every aspect of the end product. After reading this section, the reader will understand how this product works and what problems it solves. It includes describing what modules it uses, the components needed for those modules, and how they work together to accomplish the tasks. The reader will also learn about the necessary specifications of the modules and components. This section also highlights other required deliverables in addition to completing the project.

Scientists are constantly working to innovate and advance technology to meet the market's demands. Nowadays, wireless technology is a heavily sought-after technology for consumers. In recent years, much research has been done in the EV industry, particularly in finding a way to wirelessly charge hybrid and electric vehicles to meet the market's demands and ditch the wires. As mentioned in the background section, the most extensive hurdle EV wireless charging faces is misalignment. When a hybrid or electric vehicle with a receiving charging pad attached to the underside of the chassis parks in a parking spot, that pad is a coil susceptible to having a current induced through it if a magnetic field presents itself. Thus, a transmitter charging pad must be introduced into the environment to generate a magnetic field to induce a current on the receiving charging pad. Due to the large size and poor visibility in cars, especially on the underside of a vehicle, it is difficult for drivers to park perfectly overtop of something. For this reason, a transmitter pad can not simply be placed on the floor or in the center of the parking space.

The Electric Vehicle Wireless Charging Alignment System is a novel, cost-effective solution to the obstacle of misalignment presented when wirelessly charging electric and hybrid vehicles. Our product can carry and autonomously move the transmitting pad directly to the position right under the receiving pad so that the two coils can be aligned and provide optimal charging to the vehicle.

***Block Diagram (Level 0):***

A level 0 block diagram is the most basic version of a block diagram because it only shows the inputs and the output of the alignment system. Because it omits information regarding the modules within it, it allows the reader to understand how the system works without knowing the details of the modules and components and how they work together. For example, from the block diagram shown below, it is possible to understand that the system needs a power supply to turn on and operate and a magnetic field input signal for the alignment process. From the inputs, the system will output movement, meaning that the system will physically move position to fix misalignment caused by human error when parking.

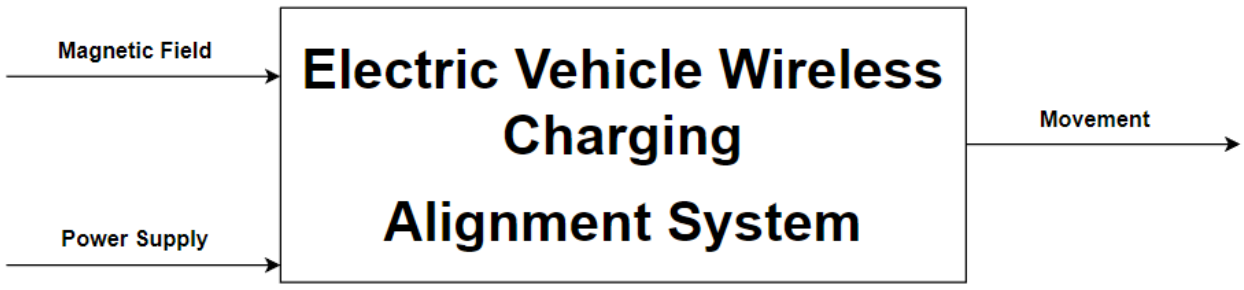



Fig. 26. Level 0 Block Diagram

The table below highlights and briefly explains the main parameters of the entire system, which are the inputs and the output, and the system's functionality. The magnetic field signal will come from the magnetic field generated by the two coils in the environment.

| **Module** | **EV Wireless Charging Alignment System** |
|---|---|
| Input | – Magnetic Field Strength Signal: The magnetic field generated by the two coupled coils.<br>– Power Supply: Atleast 12 V of DC to power the device. |
| Output | – Movement: System will move itself and the transmitting coil directly under the receiver coil |
| Functionality | Based on the strength of a magnetic field, the system will move to the location where the strongest magnetic field is present. |

Fig. 27. Level 0 Module Description Table

***Block Diagram (Level 1):***

A level 1 block diagram is an extension of the level 0 diagram in which it includes the modules that will interact with the inputs to generate the output described previously. The figure below shows the three main modules that the system contains in order to work. First, the magnetic field strength detection unit (MFSDU) detects a magnetic field and measures its strength. The microcontroller then reads the strength values measured by the MFSDU and contains an algorithm that tells the movement system how and where to move depending on the strength of the existing magnetic field. The movement system is the hardware that allows the structure to move and takes instructions from the microcontroller.

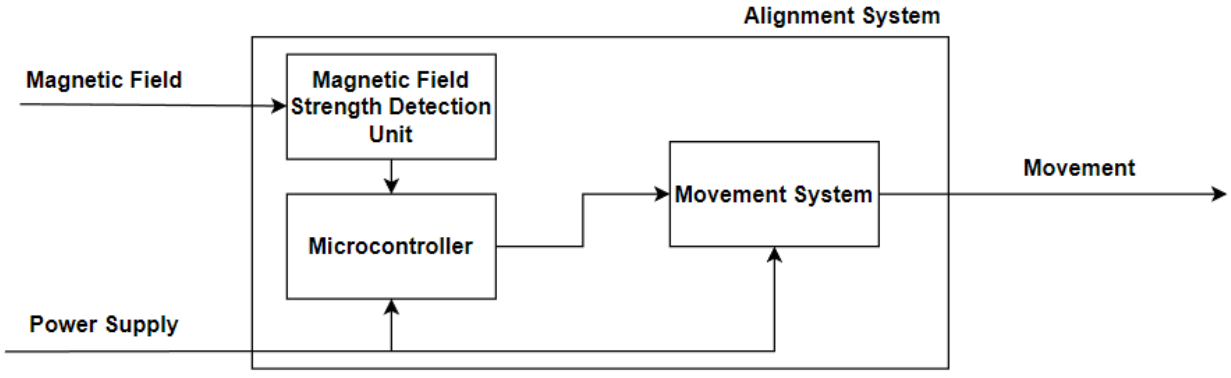



Fig. 28. Level 1 Block Diagram

The table below displays how the modules interact with each other and what they do by showing the inputs and outputs of each module and their functions. The inputs show what information one module is reading and from which module it is receiving. Similarly, the output of one is the input of another; this relationship shows how the modules communicate and work with each other.

| Module | Magnetic Field Strength Detection Unit | Microcontroller | Movement System |
|---|---|---|---|
| Input | Magnetic Field | Magnetic Field Strength Signal | Instruction signal from microcontroller |
| | | Power Supply | Power Supply |
| Output | Magnetic Field Strength Signal | Instruction signal to control movement system | Movement to a position |
| Functionality | Detects and measures the strength of the existing magnetic field | Reads from the MFSDU and uses those values to control the movement system module | Implements the instructions received into physical movement to move to specified positions. |

Fig. 29. Level 1 Module Description Table

***Block Diagram (Level 2):***

The previous level 1 diagram and its module description table described at an abstract level how each module work since it only provided its inputs, outputs, and a brief description of their function. The level 2 diagram allows a more detailed analysis of how each module works because it shows its components and requires a lower-level explanation. Therefore, each module will have its own level 2 block diagram.

The first level 2 diagram is for the MFSDU, partially showing how the magnetic field exists and how the strength changes. As mentioned before, the two coils need to be aligned with each other so that the magnetic field can be at maximum strength, allowing maximum power transfer from the transmitter coil to the receiving coil. While the receiving coil is fixed to the car, which means that our system will have no control over its position, it is essential to note that it still affects the magnetic field strength. For this reason, the magnetic field is taken as an input, and the receiver coil is not included in the MFSDU. The transmitter coil, however, is included in the MFSDU because our product carries the structure of the transmitter coil. Our team did not take part in designing or manufacturing the transmitter coil and its power supply. Our product must integrate with any coil and power supply as long as it meets the size and weight specifications, as our product depends upon a transmitter coil to operate. The transmitter coil is mounted on our product, and our sensor will measure the strength of the magnetic field caused by the coupling between the two coils. These measurements will be the output of the MFSDU for another module to use.

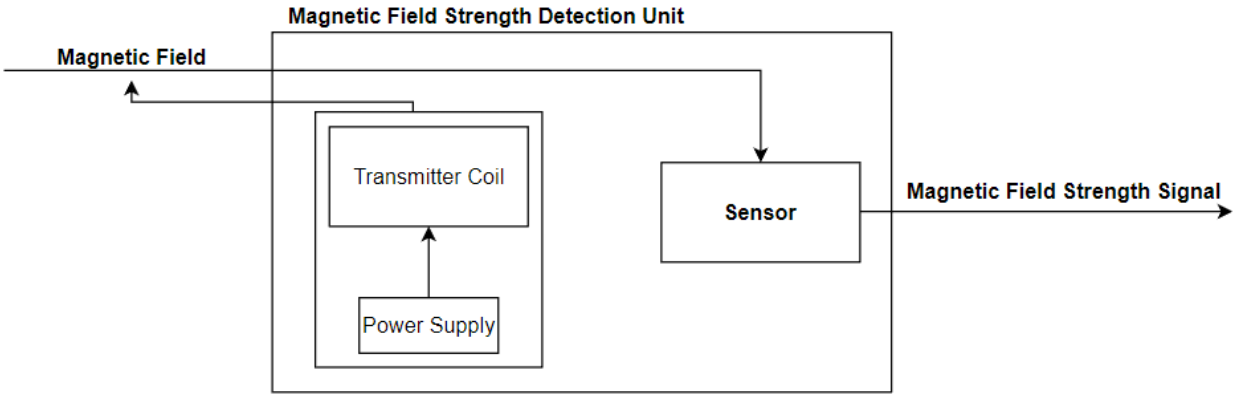



Fig. 30. Level 2 Block Diagram of the MFSDU

The last module is the movement system which contains a motor driver shield and the dc motors that will spin the wheels. The motor driver shield is a component that can easily interface the microcontroller to the dc motors. The movement system will take in the instructions sent by the microcontroller as input, and the motor shield driver will translate these instructions so that it can control the dc motors, which will control the wheel, which will, in turn, cause the structure to move to specified locations.

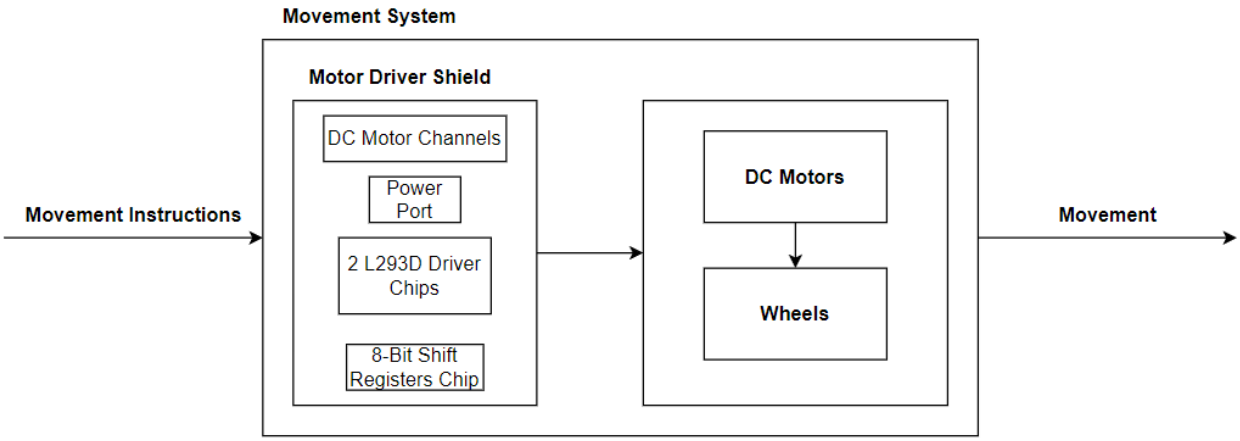



Fig. 31. Level 2 Block Diagram of the Movement System

| Module | Magnetic Field Strength Detection Unit | Microcontroller | Movement System |
|---|---|---|---|
| Input | Magnetic Field | | Analog signal for speed (0-255) |

| | | | |
|---|---|---|---|
| | | Analog magnetic field strength data | Rotation Direction |
| | | | Rotation Duration |
| | | Power Supply (24 V DC) | Power Supply (24 V DC) |
| Output | Analog magnetic field strength data | Analog signal for speed (0-255) | Movement to a position |
| | | Rotation Direction | |
| | | Rotation Duration | |
| Functionality | Detects and measures the strength of the existing magnetic field | Reads from the MFSDU and uses those values to control the movement system module | Implements the instructions received into physical movement to move to specified positions. |

Fig. 32. Level 2 Module Description Table

***Other Deliverables***

In addition to the final working prototype of the end product, our team is also expected to provide more deliverables, including the final project proposal, a final PowerPoint presentation, and a user manual. The final proposal is the complete version of this document containing more critical information about the product and our team. The final presentation will highlight all information from start to finish that satisfies the requirements. The information will be presented in a user-friendly way that will allow any user, sponsor, or client to understand all aspects of our project clearly. The user manual will contain information about the product, like all of its features, capabilities, and limitations. It will also contain information on how to use the product efficiently and safely. This will ensure that our users are safe when using our product and get the most value for their money.

# XIX. PLAN OF ACTION

To achieve the goals of a project, it is essential to construct a plan to complete the necessary elements promptly. A plan of action allows the aspects of the project to be broken down into smaller tasks to deal with. These tasks can be assigned to different team members, and deadlines can be made to be done within the allotted time. Many engineers use the plan of action tool to manage projects better. The team has also made a plan of action to break down the needed tasks and create deadlines to handle this project as best as possible.

***Statement of Work (SOW)***

A Statement of Work provides an overview of the tasks that need to be completed and an outline of how the individual team members will be responsible for each of the tasks that need to be completed. The Statement of Work will discuss the scope of work that needs to be done and the job's requirements, the location of the work, the time period when the work will be done, and the responsibilities.

*1) Scope*

The scope of the work is to create an alignment system that will align the transmitter coil of an Electric Vehicle Wireless Charger to a receiver coil located at the bottom of an electric vehicle. The focus is on the alignment system. This system will sit on top of a parking space. It will be small enough to fit under a car. When an electric vehicle with a receiver coil parks in the parking spot, the alignment system will detect a magnetic field and align the transmitter coil underneath the receiver coil, and the wireless charging will initiate. Magnetic field sensing sensors will be programmed to detect a strong magnetic field. The alignment system with then move its motors to the best position to have strong wireless charging.

*2) Location*

Much planning, research, design, and software development will be done in a remote setting. For assembly, testing, and optimization of the product will mainly be done in the Engineering Center of Florida International University. The team has access to a laboratory where the work will be done at the engineering center.

*3) Period*

The project started in late August of 2022 and has taken until May 2023 to complete this project. Most of the research, preliminary testing, design, and analysis are done from August 2022 to December 2022. During this time the team focused on the feasibility of the project and how to bring the idea into a reality. Testing and researching parts are also done at this stage. From January 2023 to May 2023, the assembly of the alignment tool and the programming of the sensors are done and optimized to completion.

*4) Responsibilities*

The individual members of the team are assigned roles and responsibilities to complete the different tasks required and to finish them by the given deadlines.

- Andy Alvarez - Electric Engineer
    - Andy took an initial role in developing the hardware needed. He researched the required hardware needed for the chassis. Due to a sudden switch in location, Andy's responsibility has shifted to software development. Andy programmed the sensors and other hardware to work as intended.
- Maximiliano Mauna - Electric Engineer
    - Maximiliano was tasked with sensor and simulation research to gather information required to have a roadmap of the hardware that is needed and how the alignment tool should work. Maximiliano took leadership in hardware design on a chassis.
- Ivan Mendoza - Computer Engineer
    - Ivan focused on the hardware design and assembly of the physical components of the alignment system. Ivan has also contributed to the research and aided in programming and optimization.
- Christopher Prasad - Computer Engineer
    - Christopher was focused on integrating the hardware with the software. He made sure that the hardware that is provided will work as intended and the hardware is ready for software development. He also ensured that the code works well with the hardware and aided in optimization.
- Rodolfo Ramos - Electric Engineer
    - Rodolfo oversaw the robotic components and the electrical design to make all the systems communicate electrically. Rodolfo also aided in the hardware design and the implementation of the hardware design with software.

Though all the members had their own responsibilities and tasks, they all still assisted in different areas to share the burden of work and to get a better outcome in a more efficient manner.

***Work Breakdown Structure (WBS)***

The Work Breakdown Structure is a method to see the work that needs to be done visually. It is a hierarchical list of project phases, tasks, and milestones. The WBS is split into a breakdown of tasks or activities that need to be done to finish the whole project. Each block within a WBS diagram contributes to a percentage of the total 100 percentage completion. Splitting up the

phases and the tasks or requirements that are needed will visually show what needs to be done to complete the whole project.

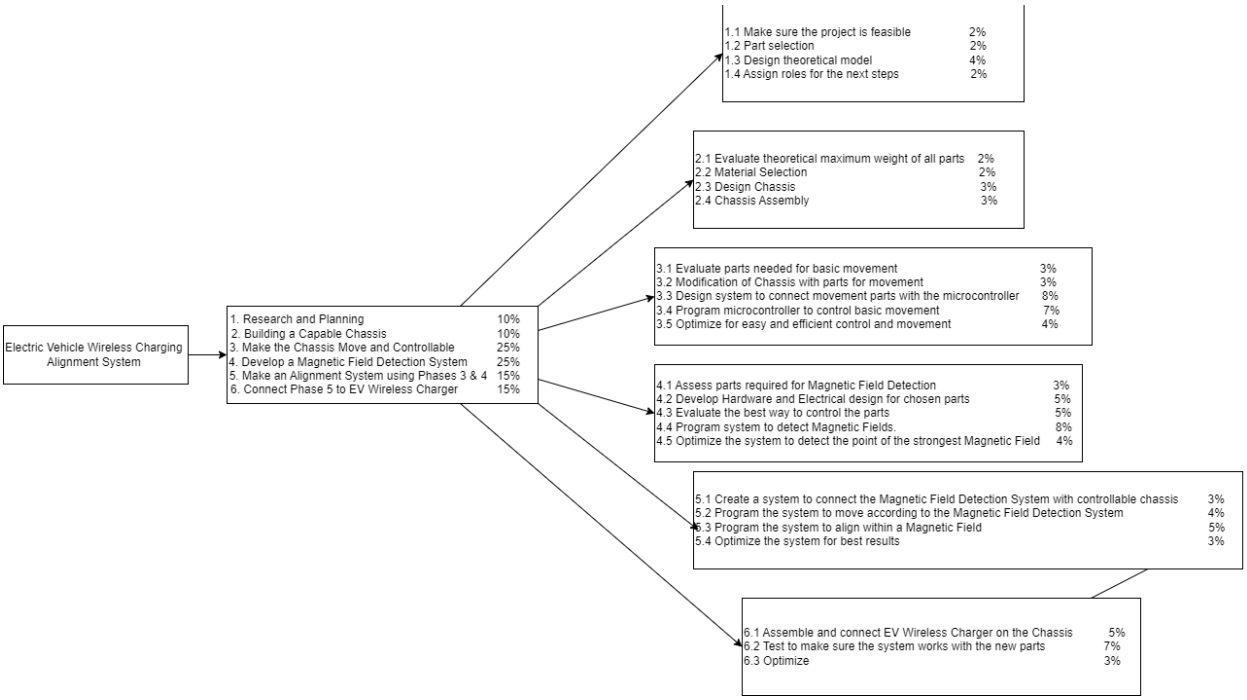



Fig. 33. Work Breakdown Structure (WBS)

Phases of the Electric Vehicle Wireless Charging Alignment System:

*5) Research and Planning*

- *Objective:*
    - The objective is to gather as much information as possible to evaluate the project's feasibility and determine the roadmap to completing the project. Time will be spent determining how to design the project and distribute responsibilities.
- *Approach:*
    - To complete this objective, the team had multiple meetings with each other and the mentors to understand the project and its requirements. The team also discussed the parts needed and what a theoretical model of the project will be. The team also evaluated the skills of each member and how to distribute work most efficiently.
- *Expected Results:*
    - The team will be well prepared to know thing tasks and phases that need to get done and who is responsible for the tasks assigned. The team also understands what is required and the theoretical design of the project.

*6) Building a Capable Chassis*

- *Objective:*

- The objective is to understand the stress the chassis will go through and figure out the correct materials and design to have a fully functioning foundation. After understanding the knowledge, the team built the chassis.

- *Approach:*
  - The team evaluated all the parts that are needed for an alignment tool to function. Then the team figured out the theoretical maximum weight that the chassis will need to support and then picked a material that will be the best. The team then assembled the chassis.
- *Expected Results:*
  - The team will have a functioning chassis that will serve as a strong foundation for the rest of the project.

7) *Make the Chassis Move and Controllable*

- *Objective:*
  - The objective is to understand how to make the chassis move and what parts are needed to have movement. The team also needs to design a way to make the chassis move and controllable.
- *Approach:*
  - The team picked and installed all the parts that are required for the chassis to move. Then the team designed a system that will control the movement of the chassis. Finally the team programed the parts to work together to make it controllable.
- *Expected Results:*
  - The team will have a moving and controllable chassis.

8) *Develop a Magnetic Field Detection System*

- *Objective:*
  - The objective is understand the parts needed to create a Magnetic Field Detection and to design a system that can accurately sense and give nesscary outputs on a magnetic field.
- *Approach:*
  - The team picked and designed a system that is able to sense Magnetic Fields. The team then connected this system to a controller that can give and recive data about magnetic fields. The team finally programmed a system that will give the needed values for Magnetic Fields.
- *Expected Results:*
  - The team will have a Magnetic Field Detection System that give data outputs for futher connection.

9) *Make an Alignment System using Phases 3 & 4*

- *Objective:*
  - The objective is to connect the moveable Chassis with the Magnetic Field Detection system and find a way to create a system that can align itself with a Magnetic field.
- *Approach:*

- The team gathered the data values that are given by the Magnetic Filed Detection System and created a program that will move the chassis according to the strongest field detection.

- *Expected Results:*
  - The team will have a working alignment tool that will move to a stong magnetic field.

*10)Connect Phase 5 to EV Wireless Charger*

- *Objective:*
  - The objective is to modify anything required to be able to fit an EV wireless Charger ontop of the chassis and have it fully function.
- *Approach:*
  - The made sure that there is a good amout of area where a transmitter coil can be place and room for the sensors to continue to fucntion properly with a transmitter coil.
- *Expected Results:*
  - A completed alignment tool that will change when a charging coil is placed near the alignment system.

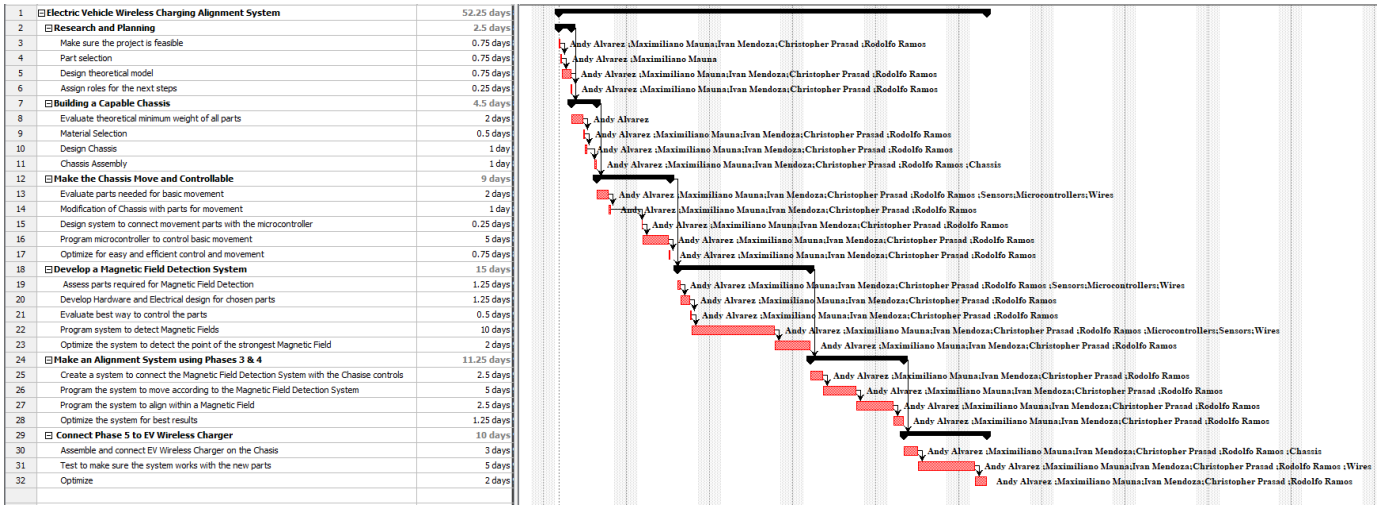
***Project Milestones***

Project milestones are goals that mark a significant change in a stage of development. Creating Project Milestones is useful to keep track of the progress made from the project and to be on time with things that need to get done. Milestones also serve as goals that need to be attained by a certain deadline. Here are some Milestones that our project had:

- Complete initial planning and research by November 1st, 2022
  - The team needed to understand all aspects of the project to determine its feasibility and what steps are needed to create a project that is the most beneficial.
- Make a working chassis by December 26th, 2022
  - Since most of the time is spent on researching and planning the development of the board in the first half, it was important for the team to have a good foundation to work on.
- Get a Prototype of an Alignment tool by April 15th, 2023
  - The team wants to be in a position where most of the project is functioning by April and the rest of the time is spent on optimizing and connecting the project with an electric vehicle wireless charger.

***Gantt Chart***

A Gantt Chart is a chart that is a visualization tool made by Henry Gantt to show the breakdown and time frame of a project. The breakdown includes the phases and tasks that are needed to complete the whole project. It also shows how long these phases and tasks need for it to be complete. The figure below shows the Gantt Chart for the Electric Vehicle Wireless Charging Alignment System:



| | | |
|---|---|---|
| 1 | **Electric Vehicle Wireless Charging Alignment System** | 52.25 days |
| 2 | **Research and Planning** | 2.5 days |
| 3 | Make sure the project is feasible | 0.75 days |
| 4 | Part selection | 0.75 days |
| 5 | Design theoretical model | 0.75 days |
| 6 | Assign roles for the next steps | 0.25 days |
| 7 | **Building a Capable Chassis** | 4.5 days |
| 8 | Evaluate theoretical minimum weight of all parts | 2 days |
| 9 | Material Selection | 0.5 days |
| 10 | Design Chassis | 1 day |
| 11 | Chassis Assembly | 1 day |
| 12 | **Make the Chassis Move and Controllable** | 9 days |
| 13 | Evaluate parts needed for basic movement | 2 days |
| 14 | Modification of Chassis with parts for movement | 1 day |
| 15 | Design system to connect movement parts with the microcontroller | 0.25 days |
| 16 | Program microcontroller to control basic movement | 5 days |
| 17 | Optimize for easy and efficient control and movement | 0.75 days |
| 18 | **Develop a Magnetic Field Detection System** | 15 days |
| 19 | Assess parts required for Magnetic Field Detection | 1.25 days |
| 20 | Develop Hardware and Electrical design for chosen parts | 1.25 days |
| 21 | Evaluate best way to control the parts | 0.5 days |
| 22 | Program system to detect Magnetic Fields | 10 days |
| 23 | Optimize the system to detect the point of the strongest Magnetic Field | 2 days |
| 24 | **Make an Alignment System using Phases 3 & 4** | 11.25 days |
| 25 | Create a system to connect the Magnetic Field Detection System with the Chasise controls | 2.5 days |
| 26 | Program the system to move according to the Magnetic Field Detection System | 5 days |
| 27 | Program the system to align within a Magnetic Field | 2.5 days |
| 28 | Optimize the system for best results | 1.25 days |
| 29 | **Connect Phase 5 to EV Wireless Charger** | 10 days |
| 30 | Assemble and connect EV Wireless Charger on the Chasis | 3 days |
| 31 | Test to make sure the system works with the new parts | 5 days |
| 32 | Optimize | 2 days |



Fig. 34. Gantt Chart

## *PERT Chart*

A PERT chart, or Program Evaluation Review Technique chart, provides a visual representation to help manage a project. Very similar to the Gantt chart, the PERT chart shows all the tasks that need to be completed in a certain time period. The PERT chart focuses more on the individual tasks that need to be done. By doing this the priority of each of the tasks are shown and users can get an idea of the things that need to get done before another task can get started. The figure below shows the PERT chart for the Electric Vehicle Wireless Charging Alignment System:

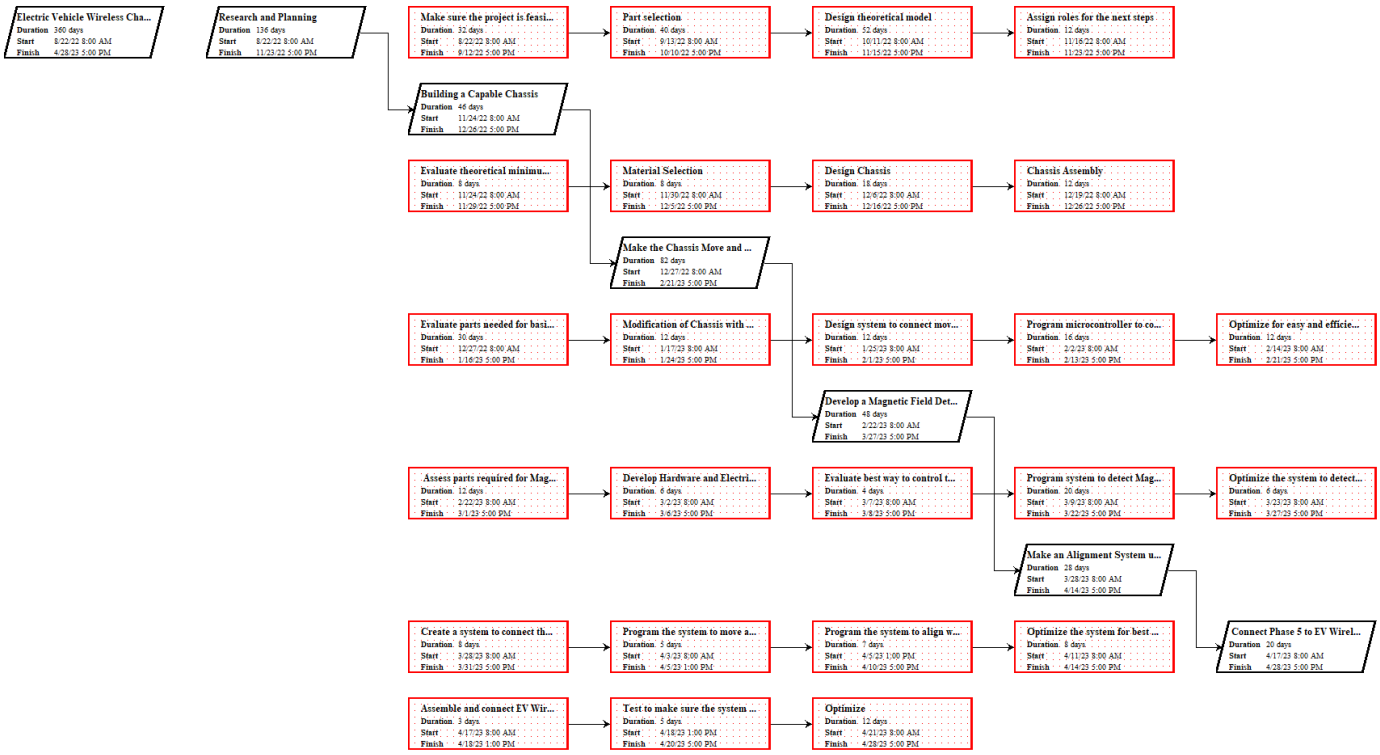



Fig. 35. PERT Chart

## XX. MULTIDISCIPLINARY ASPECTS

Multidisciplinary refers to the combination of different academic disciplines or professional specializations when working in a group to complete a project. A multidisciplinary team is vital when completing a project or designing and creating a product. Understanding each person's strengths and weaknesses is essential because this helps with task delegation. For example, someone with related experience in something new would learn a new skill quicker than another member without any exposure to that task. This section highlights each member's soft and technical skills and how they contribute to the team and complete tasks. This section also explains team management and what measures we put in place to avoid delays in completing the project.

***Team Members***

- Andy Alvarez
    - Electrical Engineer
    - Biliterate: English and Spanish
    - Experience Programming Embedded Systems in C/C++
    - Connections to Hardware Manufacturing Assistance
- Maximiliano Mauna
    - Electrical Engineer
    - Circuits Design Experience
    - Biliterate: English and Spanish
- Ivan Mendoza
    - Computer Engineer
    - Experience Programming Embedded Systems in C/C++
    - Biliterate: English and Spanish
    - Experience Programming
- Christopher Prasad
    - Computer Engineer
    - Primary liaison between team and client/mentor
    - Experience programming embedded systems in C/C++
    - Team Organization Skills
- Rodolfo Ramos
    - Electrical Engineer
    - Experience with robotics
    - Circuit Design Experience
    - Electronic Equipment Maintenance

***Team Management***

Although there is no official team leader, we all take the initiative in our ways and play essential roles in accomplishing tasks. We each work on a specific portion of the task and check on each other to ensure everything is on track. Our team has concluded that we must use the break between the two semesters to allow us plenty of time to perfect our product in the second semester. In addition, using this break will allow us to minimize delays caused by any issues or obstacles that may present themselves along the way. We will achieve this by taking preventative measures that include communication and staying active.

*a) Communication*

Our team has had great success so far due to our communication. We have scheduled virtual or in-person weekly team meetings with our client to discuss any updates on what each of us has been working on and goals for the following week. Since this has resulted in much success, we will continue to do this throughout the break. These weekly team meetings will ensure that each of us has clear tasks to accomplish and provides the motivation necessary to complete the task to present it to each other every week. It will also allow feedback on each individual's task to optimize so that the product meets the team's quality standard and the client's requested features and capabilities.

*b) Staying Active*

Staying active is the goal of our communication measure. We must stay active and continue making progress toward our end product. Even if something we tried did not work, that is still progress because it allows us to eliminate one option. This way, we can continue finding the optimal working solution so that when the new semester begins, we can focus on making the product work more efficiently rather than just getting it to work.

In conclusion, our team will continue communicating with each other by having weekly virtual or in-person meetings and remaining active. By the end of this semester and the break, we will have assembled and programmed the basic hardware to function and complete basic tasks. This will allow us to focus only on creating and optimizing the working algorithm, which is the essence of the project. Our team is confident that we will complete our tasks within the desired timeline with these measures.

# XXI. PERSONNEL

This section serves as a concise resume for each team member, highlighting their experience, education, and qualifications. In addition to drawing from our personal experiences, the multidisciplinary aspects that build our team were also covered in the preceding section. Our distinct perspectives and experiences influence how well we work together and how each of us contributes in our own unique ways. Our paths diverged significantly despite having similar degrees.

# Maximiliano Mauna

maxmauna1997@gmail.com | 786-488-5321 | Miami, FL

## Education

**Florida International University** — Miami, FL
BS IN ELECTRICAL ENGINEERING — Expected Spring 2023
GPA: 3.37

## Work Experience

### Eaton Corp.

SWITCHGEAR MODERNIZATION INTERNSHIP – HOUSTON, TX — May 2022 – August 2022

- Service, repair, and recondition customer power circuit breakers.
- Initiated a Kanban management system used to track and quantify inventory and consumables.
- Designed & built a testing box for Eaton VCP-W, Magnum DS, and DS circuit breakers.

POWER SYSTEMS ENGINEERING INTERNSHIP – REMOTE — May 2021 – December 2021

- Perform Arc Flash and Short Circuit studies to evaluate incident energies, arc flash boundaries and equipment AIC ratings.
- Create Time Current Curves to coordinate overcurrent protective devices and equipment damage curves.
- Conform with NEC, IEEE 1584, and AHJ power system study guidelines.
- Created a Medium Voltage Arc Flash report evaluating incident energy using different calculation methods.

FIELD SERVICE ENGINEERING INTERNSHIP – ALBUQUERQUE, NM — May 2019 – August 2019

- Installation and preventative maintenance of low, medium, and high voltage equipment.
- Analyze electrical diagrams used in planning LOTO procedures and ensuring appropriate PPE is used based on incident energy hazards.
- CPR and Eaton Level 1 Field certifications.

### Power Depot, Inc

SALES ENGINEER – MIAMI, FL — October 2019 – May 2021

- Analyze Mechanical, Electrical, & Plumbing Plans (MEP) to configure customer specific Emergency Power System equipment.
- Use Kohler Power Solutions Center (PSC) to size generator sets to meet specific voltage & frequency dips requirements.
- Residential, Commercial, Industrial, and Mobile Emergency Power System Certifications.
- Engage in Manufacturer's Monthly Round Table Discussion to address customer questions or concerns.
- Coordinate freight logistics and ensure products arrive from manufacturer to warehouse in a cost-effective manner.

### Florida International University

CALCULUS - ALGEBRA LEARNING ASSISTANT – MIAMI, FL — August 2018 – April 2019

- Ensure students learn and build a mathematical intuition alongside subject content.
- Prepare students for Calculus by introducing and applying concepts of functions.

## Skills

- AutoCAD
- Wolfram Mathematica
- C Language (Beginner)
- MATLAB (Beginner)
- Kohler Power Solutions Center
- SKM (Beginner)
- Microsoft Office
- Spanish Proficiency (Speak & Write)

## Extracurricular and Club Activity

- Abriendo Puertas — 2015 – 2017
- Institute of Electrical and Electronics Engineers (IEEE), — 2017 – Present
- Society of Hispanic Professional Engineers (SHPE), — 2017 – Present
- Society of Women Engineers (SWE), — 2018 – Present

# Andy Alvarez

andydalvarez30@gmail.com — 786-416-1806 — 579 East 55th St Hialeah, Florida 33013

## Summary of Qualifications

- Biliterate electrical engineer student with exceptional responsibility and leadership skills
- Effective communicator, creative, and collaborative team player
- Intermediate knowledge with hardware and software techniques.

## Education

**Bachelor of Science in Electrical Engineering** — June2019 - Present
Florida International University, Miami, FL

- GPA: 3.50
- Florida Bright Futures Medallion Scholarship
- Pursuing a master's degree in Computer Engineering for Machine Learning and Computing System and VLSI Design via the 4 + 1 program.

## Projects

**Temperature Display with FPGA** — May 2022 - July 2021
Embedded Computing, Electrical Engineering; FIU

- Led a two-person team by planning and executing tasks as well as coordinating the presentation.
- Created the hardware connections between the FPGA board and block design using Vivado.
- Developed the C code for the operation and integration of a temperature sensor an OLED display.
- Created diagram for visualization of shifter operation

**Applied Machine Learning Models** — August 2021 – April 2022
Advanced IoT Applied Machine Learning and Deep Learning, Electrical Engineering; FIU

- Predicted the net hourly electrical energy output of a combined cycle power plant with the lowest root mean squared error and highest correlation coefficient achieved being 2.109 and 0.968 respectively.
- Developed a compared various machine learning models to classify password strengths with a lowest root mean squared error and highest accuracy of 0.189 and 0.97 respectively.
- Developed and compared several multi-layer perceptrons for detecting phishy websites with the highest accuracy recorded being 0.917.
- Wrote a paper in IEEE format explaining the procedures and results for each project.
- Presented projects using PowerPoint slides within a 10-minute time frame.

**Speaker Amplifier Circuit** — March 2021 - April 2021
Electronics I Laboratory, Electrical Engineering; FIU

- Assembled a common emitter amplifier circuit using an NPN power transistor.
- Calculated and measured a voltage gain of 76 (V/V) and a current gain of 100 (A/A).
- Assembled the circuit so the transistor operated in the active region with 3.1 V between the common-base terminals.

## Work Experience

**Florida International University, Miami, Florida** — June 2021— August 2022
Student Research Assistant, Internship

- Enhanced the wideband performance of a Leaf-Shaped Antenna in Ansys HFSS by implementing novel designs
- Created a code to modify files to csv files for the importation to MatLab, HFSS, and Jupyter Notebooks
- Created graphs using Matlab and Python to present results and antenna progress in weekly meetings

## Skills

- Python, VHDL, React Native, C, and C++
- Ansys HFSS
- MatLab
- Biliterate in English and Spanish
- Microsoft Certified: Azure AI Fundamentals
- Microsoft Office Specialist
- Codepath iOS Development Certified
- Affinity Designer
- Vivado, Vitis IDE

# Ivan Mendoza

imend041@fiu.edu
Miami, FL
Mobile: (786)-508-3561


## Education

**Florida International University,** Miami, FL (2019 – Present)

**Expected Graduation Date**: Spring 2023

**GPA:** 3.5: / 3.420

## Work Experience

**Data Vision System Import Export, 2018-Present**.

Manage Inventory and invoicing with QuickBooks software. As of 2021, part of the sales department

## Projects

**Car Parking System with FPGA**

EEL4740 Embedded Systems, Florida International University, May 2022-July 2022

## Skills

**Personal Attributes**

- Problem Solving abilities
- Communication skills
- Computer Proficiency
- Time management
- Multitasking
- Adaptability
- Attention to Detail
- Self-motivation

**Technical**

- Mathematics
- Research skills
- Typing skills
- Writing and Editing

**Languages**

- English (fluent)
- Spanish (fluent),
- Italian (beginner)

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**Software**

- QuickBooks by Intuit
- Microsoft Office
- Xillinx Vivado
- Xilinx Vitis
- MATLAB
- Wolfram Mathematica
- C/C++
- HTML and CSS (beginner)
- Java (Beginner)
- VHDL

# RODOLFO RAMOS

Phone: +17863071132
Email: rolloxphobia@gmail.com
Address: Princeton, FL 33032

"Dedicated technician and individual contributor, able to operate complex systems in all types of environments and conditions and accomplish organizational goals with accountability and confidence. Skilled at identifying and diagnosing problems, following detailed procedures in technical manuals and publications, performing minor maintenance and repairs, and determining need for specialized repair services."

**Skills**

Aircraft Launch and Recovery Specialists,Aircraft Launch And Recovery Equipment Maintenance Technician,Arresting Gear Operator,Aircraft Launch and Recovery Technician,Aviation Boatswain''s Mate Launching & Recovery Equipment,Aviation Boatswain''s Mate,Making Decisions and Solving Problems,Judging the Qualities of Things, Services, or People,Interpreting the Meaning of Information for Others,Interacting With Computers,Handling and Moving Objects,Guiding, Directing, and Motivating Subordinates,Coordinating the Work and Activities of Others,Controlling Machines and Processes,Installation,Equipment Maintenance,Critical Thinking,Coordination,Active Listening,Active Learning,Training and Teaching Others,Mathematics,Monitoring,Science,Time Management
( 2 Years )

Performing General Physical Activities,Repairing and Maintaining Mechanical Equipment,Handling and Moving Objects,Identifying Objects, Actions, and Events,Inspecting Equipment, Structures, or Material,Monitor Processes, Materials, or Surroundings,Operating Vehicles, Mechanized Devices, or Equipment,Repairing and Maintaining Electronic Equipment,Thinking Creatively,Training and Teaching Others
( 2 Years )

**Experience**

Navy ( Sep 2012 > Sep 2016 )
Seaman
ABE - Aviation Boatswain's Mate - Equipment

**Education**

Florida International University( Aug 2020 > Current )
Bachelor of Science
Studied: Electrical and electronics engineering

Miami Dade College( Jan 2017 > Apr 2020 )
Associate of Arts
Studied: Electrical and electronics engineering

**Awards & Honors**

Navy Good Conduct Medal
The oldest Good Conduct Medal, the Navy version is given to members of the U.S. Navy who display exemplary behavior and fidelity in active federal military service.

National Defense Service Medal
The oldest 'service medal' in the United States, this military honor recognizes those who served honorably during a designated time period of which a 'national emergency' had been declared during a time of war or conflict.

Global War on Terrorism Service Medal
Military honor to recognizes those military service members who have performed service in the War on Terror from September 11, 2001, to a date yet to be determined.

Navy Rifle Marksmanship Ribbon
Presented upon successful completion of a weapons qualification course or high achievement in an official marksmanship competition.

Navy Pistol Marksmanship Ribbon
Presented upon successful completion of a weapons qualification course or high achievement in an official marksmanship competition.

# Christopher Prasad

Davie, Fl | christopherprasad2001@gmail.com | 954-655-0976

## COURSE PROJECTS

Snacks by the Price – Vending Machine Price Display on a FPGA board

- Displays the price of a snack based on its location on a 3x3 grid using VHDL code on a Zybo Z7-10

MQTT Air Quality Monitor

- Embedded systems project using Arduino software, NodeMCU ESP8266 development board, DHT22 temperature and humidity sensor and Losant IoT software to make an air quality monitor

Beagle Bone Black

- Made a custom distribution of Linux, built a Toolchain to cross-compile, worked on U-boot at the source level, developed device drivers, a made a root file system

## EDUCATION

**Florida International University** **Miami, FL**

*Bachelor of Science in Computer Engineering* *Estimated May 2023*

- **Honors:** Florida Bright Futures Medallion Merit Scholarship, FIU Raise.Me Scholarship, AICE Cambridge Diploma
- **Relevant Coursework:** C & C++ Programming for Embedded Systems, Embedded Operating Systems, Circuit Analysis, Logic Design, Computer Design, Intro to Digital Forensics, Intro to Ethical Hacking and Countermeasures, Intro Malware & Reversal Engineering

## PROFESSIONAL EXPERIENCE

**NextEra Energy, Inc. - Florida Power & Light** **Miami, FL**

*Power Delivery Engineer – FIU Internship Program* *June 2022 – Present*

- Apply practical applications of engineering principles, practices, and procedures while providing constant updates and action plans to prevent elevated calls.
- Working on projects supporting local service centers throughout all FPL service territories and responsible for managing high volume work.
- Training colleagues of Power Delivery with applications such as WMS, CIS, RSV, while promoting safety.

**Florida International University** **Miami, FL**

*Student Technician Assistant - Engineering Information Technology Center* *December 2021 – June 2022*

- Provide high quality, responsive ticketing, desktop support, troubleshooting, and customer service to students, faculty, and staff of the college.
- Set up, configure, and install software/hardware in desktops, laptops, printers, set up conference rooms.
- Maintain documentation of all work tickets and status.

**Believers Assembly of South Florida** **Davie, FL**

*Music Leader/Audio/Video Associate/Youth Leader Volunteer* *July 2014 – Present*

- Music Leader: Lead music for church meetings
- Youth Group Leader: Set up, plan, and lead monthly youth group meetings and events
- Southeast Youth Retreat Leader: Set up, plan, and lead an annually held offsite retreat event for 90+ attendees
- Audio/Video Associate: Setup, maintain, and manage technology at the church building

**Berean Group International** **Miramar, FL**

*Administrative Assistant* *December 2017 – December 2019*

- Assisted payroll processing by calculating employee pay using Microsoft Excel and QuickBooks. Processed employee work contracts and documents. Managed incoming and outgoing cash, checks, and mail
- **OneDrive Project -** Convert accounting workflow from a single-user workflow to a multi-user workflow by using OneDrive. This project allowed multiple users to access and work with multiple files at the same time to improve efficiency

## SKILLS & CERTIFICATIONS

**Technical Skills:** Microsoft Office Suite (Excel, Word, PowerPoint); Google Workspace; C, C++, VHDL, Java, Python; Audio/Video editing; Wolfram Mathematica; Assembling Hardware; Windows/Linux OS Management and Troubleshooting
**Certifications:** Digital Forensics Fundamentals Skills

Our educational and professional experiences, as well as our goals for our careers, are all very different, according to our resumes. By diversifying our team, we can enhance the project's overall results and the backgrounds of our team members. By bringing our strengths to each other, we can counterbalance each other's weaknesses. Having a broad network later in life can be helpful for any professional, regardless of their profession.

# XXII. BUDGET

A new product's development is always driven by a great purpose. The problem is that the product would not exist without the necessary funding to produce it. To be successful, our product must be profitable; otherwise, we will not be able to anticipate wealth in return for further developing it. We require a budget in order to understand how our product will impact our financial situation. How our funds will be managed is detailed in the sections below.

TABLE XXII. BUDGET BY PHASE

| **Electric Vehicle Wireless Charging Alignment System** | **$16090** |
|---|---|
| **Research and Planning** | **$615** |
| Make sure the project is feasible | $225 |
| Part selection | $90 |
| Design theoretical model | $225 |
| Assign roles for the next steps | $75 |
| **Building a Capable Chassis** | **$970** |
| Evaluate theoretical minimum weight of all parts | $120 |
| Evaluate theoretical minimum weight of all parts | $150 |
| Design Chassis | $300 |
| Chassis Assembly | $400 |
| **Make the Chassis Move and Controllable** | **$2970** |
| Evaluate parts needed for basic movement | $870 |
| Modification of Chassis with parts for movement | $300 |
| Design system to connect movement parts with the microcontroller | $75 |
| Program microcontroller to control basic movement | $1500 |
| Optimize for easy and efficient control and movement | $225 |
| **Develop a Magnetic Field Detection System** | **$5040** |
| Assess parts required for Magnetic Field Detection | $645 |
| Develop Hardware and Electrical design for chosen parts | $375 |
| Evaluate best way to control the parts | $150 |
| Program system to detect Magnetic Fields | $3270 |
| Optimize the system to detect the point of the strongest Magnetic Field | $600 |
| **Make an Alignment System using Phases 3 & 4** | **$3375** |
| Create a system to connect the Magnetic Field Detection System with the Chassis controls | $750 |
| Program the system to move according to the Magnetic Field Detection System | $1500 |
| Program the system to align within a Magnetic Field | $750 |
| Optimize the system for best results | $375 |
| **Connect Phase 5 to EV Wireless Charger** | **$3120** |

| | |
|---|---|
| Assemble and connect EV Wireless Charger on the Chassis | $1000 |
| Test to make sure the system works with the new parts | $1520 |
| Test to make sure the system works with the new parts | $600 |

TABLE XXIII. BUDGET BY RESOURCE

| | Hours/Use | Cost per Unit | Total |
|---|---|---|---|
| Andy Alvarez | 209 | $15/hour | $3135 |
| Christopher Prasad | 198 | $15/hour | $2970 |
| Maximiliano Mauna | 201 | $15/hour | $3015 |
| Ivan Mendoza | 198 | $15/hour | $2970 |
| Rodolfo Ramos | 198 | $15/hour | $2970 |
| Sensors<br>• Program system to detect Magnetic Fields<br>• Evaluate parts needed for basic movement<br>• Assess parts required for Magnetic Field Detection | 3 | $50 | $150 |
| Chassis<br>• Assemble and connect EV Wireless Charger on the Chassis<br>• Chassis Assembly | 2 | $100 | $200 |
| Microcontrollers<br>• Assess parts required for Magnetic Field Detection<br>• Evaluate parts needed for basic movement<br>• Program system to detect Magnetic Fields | 3 | $200 | $600 |
| Wires<br>• Assess parts required for Magnetic Field Detection<br>• Test to make sure the system works with the new parts<br>• Evaluate parts needed for basic movement<br>• Program system to detect Magnetic Fields | 4 | $20 | $80 |
| | | **Grand Total** | **$16,090** |

## XXIII. RESULTS EVALUATION

This section explains how the results at the end of senior design will be evaluated. This document presented various requirements, standards, constraints, and goals with plans to accomplish them. When the final product is completed, the team will evaluate the prototype to check if it did indeed satisfy the requirements set previously by the team, the client, the mentor, and the user needs. In practice, this is the most critical aspect: ensuring that all needs are met safely, effectively, and efficiently. Evaluating the project with the initial requirements will show the senior design showcase judges, the client, and the mentor which requirements were and were not met. Having suitable methods for evaluation and a plan of action for the next steps shows potential sponsors that they can be confident in investing in our team and product.

Our project will be evaluated based on the following three aspects:

***1) Budget:***

To complete this project, our team was given a budget of two hundred fifty dollars to cover the cost of the required materials. This budget, although generous, required us to be mindful while spending it. For this reason, we made it our goal to purchase the needed materials while staying within our budget. Being below our budget for this project will not only show how cost-effective our product is, but it will also show our clients that we were responsible.

***2) Quality:***

The quality of a project is what makes it stand apart from other similar projects. Products that have high quality last longer and are more saw out. For those reasons, we want to ensure that our project is of the best quality. Our project must show attention to detail, as it directly reflects our work. To monitor and evaluate our project, we will compare our product to our initial design and inspect it for any possible mistakes that must be corrected.

***3) Client's Objectives Approval:***

While working on our project, we wanted the client's vision to be properly showcased. To ensure this is the case for this project, we will check in with our client to show them our progress. During these check-ins, we hope to receive their feedback and make the necessary corrections to improve the product. Working with the client throughout this project will serve as guidance and help make the product the best version it can be.

This semester we have worked hard on establishing our ideas to be able to present a working product in the coming semester. Our work during this semester will help us evaluate our product next semester. We will use our objectives and processes described throughout this paper to evaluate our product thoroughly. Each objective will be rated between 1(very weak) and 10 (outstanding) according to how closely it met the description. Doing so will quantify our data and help us better understand how well we did.

## XXIV. Life-Long Learning

The development of an electric vehicle wireless charging alignment system would require a significant investment in time, energy, and resources to bring it to fruition. First and foremost, it would require a team of engineers, software developers, and scientists to collaborate to develop the technology. They would need to create a system that can accurately align the charging pad with the vehicle and ensure that it can handle the electrical load for a safe and efficient charging process.

Additionally, the system would need to be designed with safety and cost-effectiveness in mind. The team would also need to develop a production system that can be used to manufacture the wireless charging alignment system. This would involve the selection of materials, production methods, and quality control processes. Furthermore, the system would need to be tested to ensure that it meets industry standards and regulations.

Finally, to ensure that the wireless charging alignment system is a viable and sustainable product, a marketing plan would need to be developed. This would involve researching the market, identifying potential customers, and creating a strategy for how to best reach them. Additionally, it would be necessary to secure funding to support the production of the system and its ongoing development. Overall, the development of an electric vehicle wireless charging alignment system is a complex process that requires a significant investment of resources. However, if successful, it could revolutionize the way people charge their electric vehicles, making it an essential product that will continue to shape the future.

# XXV. CONCLUSION

The idea for the Wireless Charging Alignment System for Electric Vehicles caught our team's interest ever since it was initially introduced. Because we identified the potential enhancement we could bring to it as a team, we included this project as the first option in our three-topic presentation. We all went to the lab to examine the actual transmission coil and better comprehend its functioning in order to come up with ideas on how to complete this project. Our mentor and the laboratory staff were very helpful in addressing our questions and concerns. They also made it clear what they wanted from us in terms of the end product. Our team conducted research and brainstorming sessions to come up with a cohesive concept. We discovered the goals of our project as a result. Our team carefully investigated and evaluated each element and aspect of our proposal in order to create a workable product that will successfully complete its duty. Together, we had numerous in-person and online discussions about our concepts and discoveries as well as approaches to further simplify our design. The outcomes of this project will be assessed based on how well our final product performs. It will be necessary to test the finished product to make sure it is fully working. How this project was handled to get the results it promised will determine how well our team performed.

The Electric Vehicle Wireless Charging alignment system will significantly benefit society as a cost-effective and efficient method of charging electric vehicles. This method of charging electric vehicles avoids the need for costly and inconvenient charging stations. The system is additionally made to be straightforward and simple to install, enabling quick installation and maintenance. With the help of this method, charging electric vehicles is now more practical than before.

Through this project, we have been able to use our collective engineering skills to address practical problems. Additionally, it has taught us the value of teamwork, how to work together to accomplish a common objective, and the professionalism and work ethics required to succeed. We are eager to advance this project and significantly impact the scientific community by offering a product.

## XXVI. REFERENCES


[2] A. Namadmalan, R. Tavakoli, S. M. Goetz and Z. Pantic, "Self-Aligning Capability of IPT Pads for High-Power Wireless EV Charging Stations," in IEEE Transactions on Industry Applications, vol. 58, no. 5, pp. 5593-5601, Sept.-Oct. 2022, doi: 10.1109/TIA.2022.3158636.

[3] Yabiao Gao, Aleff Antonio Oliveira, Kathleen Blair Farley, Zion Tsz Ho Tse, "Magnetic Alignment Detection Using Existing Charging Facility in Wireless EV Chargers", Journal of Sensors, vol. 2016, Article ID 5670510, 9 pages, 2016. https://doi.org/10.1155/2016/5670510

[4] Hwang, Karam, et al. "An Autonomous Coil Alignment System for the Dynamic Wireless Charging of Electric Vehicles to Minimize Lateral Misalignment." *Energies*, vol. 10, no. 3, Mar. 2017, p. 315. *Crossref*, https://doi.org/10.3390/en10030315.

[5] "RoHS Guide," RoHS 10 Restricted Substances. [Online]. Available: https://www.rohsguide.com/rohs-substances.htm. [Accessed: 23-Dec-2022].

[6] W. McDonough, "The hannover principles - william mcdonough," *The Hannover Principles Design for Sustainability*. [Online]. Available: https://mcdonough.com/wp-content/uploads/2013/03/Hannover-Principles-1992.pdf. [Accessed: 03-Dec-2022].

# XXVII. APPENDICES

### *Team Name and Mission*

1. Electric Vehicle Wireless Alignment System
2. Our mission is to create an alignment system in which a transmitting coil is aligned directly underneath a receiving coil to enable wireless power transfer.

## *Membership*

1. The team consists of Maximiliano Mauna, Andy Alvarez, Christopher Prasad, Rodolfo Ramos, and Ivan Mendoza.
2. Dr. Arif Sarwat – ECE Mentor
3. Milad Behnamfar – Technical Support and EPS lab instructor.

## *Roles and Responsibilities*

1. Maximiliano Mauna – Electrical and Hardware development
2. Andy Alvarez – Hardware and Software development
3. Christopher Prasad – Hardware and Software integration
4. Rodolfo Ramos – Robotic development and Electrical design
5. Ivan Mendoza – Physical design and fabrication lead.

## *Team Relationships*

The team will be respectful and considerate towards each other.

The team will be organized and responsible for their responsbilities.

### *Joint Work*

1. Joint Work
    a. Work will be distributed evenly and each member will be expected to participate and contribute.
    b. Team members will not be demeaning, procrastinate, or form a hostile or uncomfortable work environment.
2. Team Meetings
    a. Meetings will be held through Zoom. Days will be agreed upon a weekly basis to accommodate schedules.
    b. Meetings will be conducted to discuss present and upcoming work to meet our expected deadlines.
    c. Each member will be responsible for his/her work report.

### *Individual Work*

1. Work responisibilities will be distrubuted based on experience and preference.
2. The team will be responsbile for quality testing each component and verifying respectable results.
3. Due date will be established with a team meeting and our mentor will be notified of these dates.

### *Documentation and Communication*

1. Members will maintain accurate a nd updated documentations of their contribution.
2. The team will keep a shared logbook and drive with all collective documentation.

### *Conflict Resolution*

1. The team will strive to resolve all conflicts that arise between each other. Conflicts will be prepared for and discussed in meetings to meet a resolution.
2. The team will not jeopardize the team dynamic nor the quality of our work.
3. Conflicts shall be discussed with our mentor to ensure a resolution can be met.

### *Amendments*

1. The team contract will be uploaded to the shared drive and each member will have his/her own copy.

2. Contract ammendments must only take place when the majority of the team members vote towards an ammendment.
3. Mentor approval is required to ammend contact.

# XXVIII. SIGNATURES

Course Number: EEL 4921C Semester: Spring Year: 2023

Mentor Name: Arif Sarwat / Milad Behnamfar

Senior I Instructor's Name: Dr. Wilmer Arellano

| Name | PID | E-mail Address | Phone Number |
|---|---|---|---|
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| | PRINT | SIGNATURE | DATE |
|---|---|---|---|
| **Team Member** | Chritopher Prasad |  | 4/17/2023 |
| **Team Member** | Ivan Mendoza | Ivan Mendoza | 4/17/2023 |
| **Team Member** | Andy Alvarez | Andy Alvarez | 4/17/2023 |
| **Team Member** | Rodolfo Ramos |  | 4/17/2023 |
| **Team Member** | Maximiliano Mauna |  | 4/17/2023 |
| **Mentor** | Arif Sarwat | | |
| | Milad Behnamfar | | |