Overhead Inductive Wireless EV Charging System

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QKOIL

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Mission/SOW

QKOIL requested that NMSU research, design, and develop a prototype for an automated EV charger capable of moving in three dimensions to accurately position itself over the receiver coil on an electric vehicle's hood.

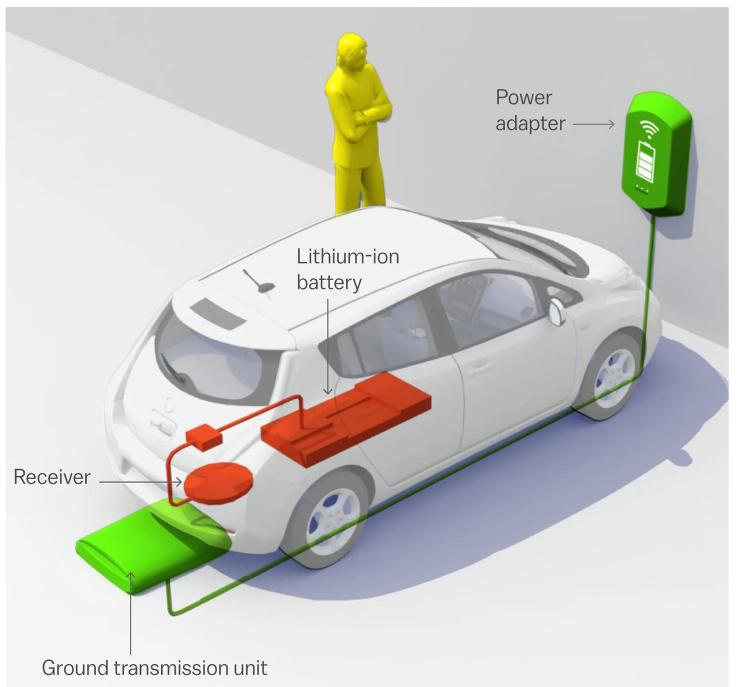
The project SOW-parameters were:

- Develop an overhead, fully automated
- Enable movement in the x, y, and z directions
- Position coils at an optimal distance for efficiency
- Comply with codes and safety standards
- Develop software to automate gantry functions
- Integrate various of sensors and charging components

Through research, design, and testing, our capstone team developed a functional prototype that not only met but exceeded the client's needs, demonstrating the feasibility of automated overhead wireless EV charging and advancing future innovations in efficient and adaptable charging solutions.

Research

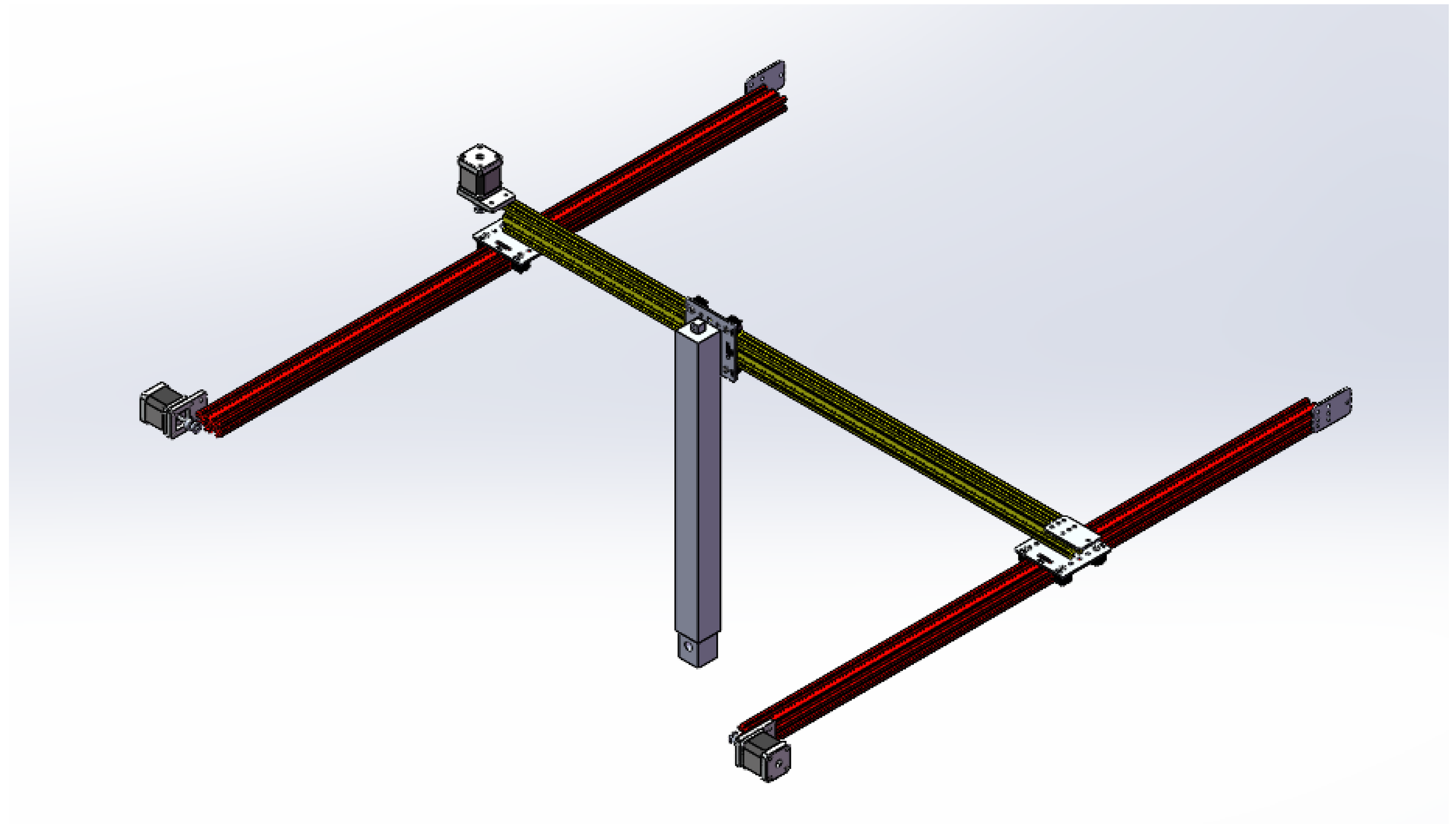
- Research focused on multi-axis movement that enabled precise position in x, y, and z directions for optimal charging alignment.
- Identification of current charger limitations where existing wireless EV chargers can only charge one vehicle at a time, reducing scalability.
- Research on automated positioning, V-slot rail systems that provide smooth precise motion control that are similar to 3D printer mechanics.
- Researched a Cartesian motion framework that allows for controlled linear movement along multiple axes, ensuring repeatable and accurate adjustments, and stability.



Final Design

The design includes :

- V- Slot rails in X and Y axes for two degrees of freedom in horizontal movement.
- The X and Y axes will utilize a linear belt actuator to move the gantry plates.
- Linear actuator at the center enables vertical movement along the Z-axis.
- Wooden frame mounted on actuator to safely house the wireless charger.
- NEMA 17 stepper motors to move the gantry plates



Mechanical Testing

Load Testing:

V-Slot Linear Rails:

- V-Slot rail assembly was tested to support a static load that ranged from 20-30lb, without any permanent deformation of the rails.
- Results confirmed that the system works efficiently under load, without any noticeable signs of reduction in mechanical performance.
- The timing belt was able to move the load without getting tangled or stuck on the rails.

Movement Testing:

NEMA 17 Stepper Motors:

- NEMA 17 stepper motors move gantry plates along rails in the X and Y directions.
- We were able to make the motors move at different speeds.
- The motors did not struggle to move the 20-30lb used for testing.

Linear Actuator:

- We used a linear actuator to extend the transmitter coil to the receiver coil.
- The linear actuator retracts when charging is finished to ensure the transmitter coil is out of the way.

Electrical Testing

Sensor Testing:

Mechanical Endstop Limit Switch Module:

- Installed on the timing belt to detect the line's end and prevent motors from pushing the charging system when no movement is possible.
- Successfully tested for responsiveness under various loads and motor speeds for consistent alignment.

Arducam Mini Module Camera with OV2640 (2MP):

- Captures real-time snapshots of incoming vehicles.
- Provides a grid overlay for locating vehicle hoods.
- Tested for clarity, latency, field of view, and accuracy to ensure reliable charger placement.

Ultrasonic Sensor Module for Arduino R3 Mega2560:

- Stops the linear actuator from extending when sensor comes within 5 cm of an object.

Charging System Testing:

- 1 kW charging system
- We were able to charge a battery
- Gives data on voltage, current, power, and temperature of battery

Concept Development

During the design phase, multiple conceptual approaches for the EV charging system were meticulously explored. A design had to be chosen carefully to achieve maximum overall efficiency and performance of the system. Below are some of the different key mechanisms designs that were considered:

Component	Original Designs	Final Choice	Reason
Linear Rails	Linear Actuators or leading screws	Timing belt and pulley system	The timing belt is a lot less expensive than leading screws and more efficient than linear rails
Charging System	High-power charging system designed by the team	Premade charging system purchased from Wibotic	Making a charging system ourselves would cost thousands of dollars and would require a huge power source.
Housing Unit	Aluminum box	Wooden box	The box must be insulated

Final prototype design was developed after evaluating and refining these design concepts. It combined the best options for each component.

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