Wireless Bidirectional Smart Electric Vehicle Charger (W. B. S. E. C)

Capstone – Group # 26

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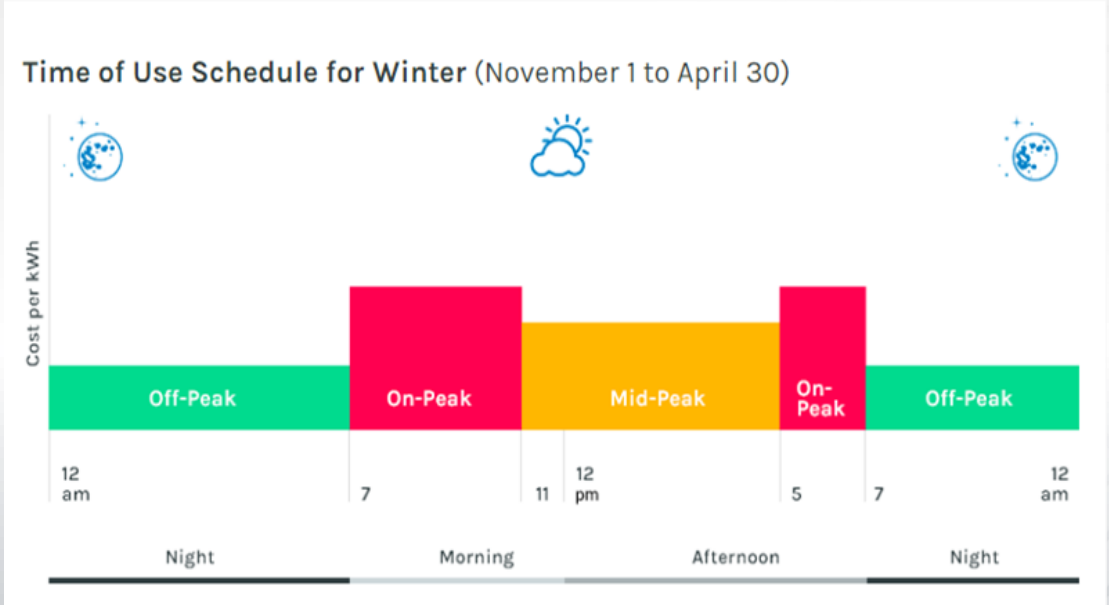
OntarioTech UNIVERSITY

Presentation Overview

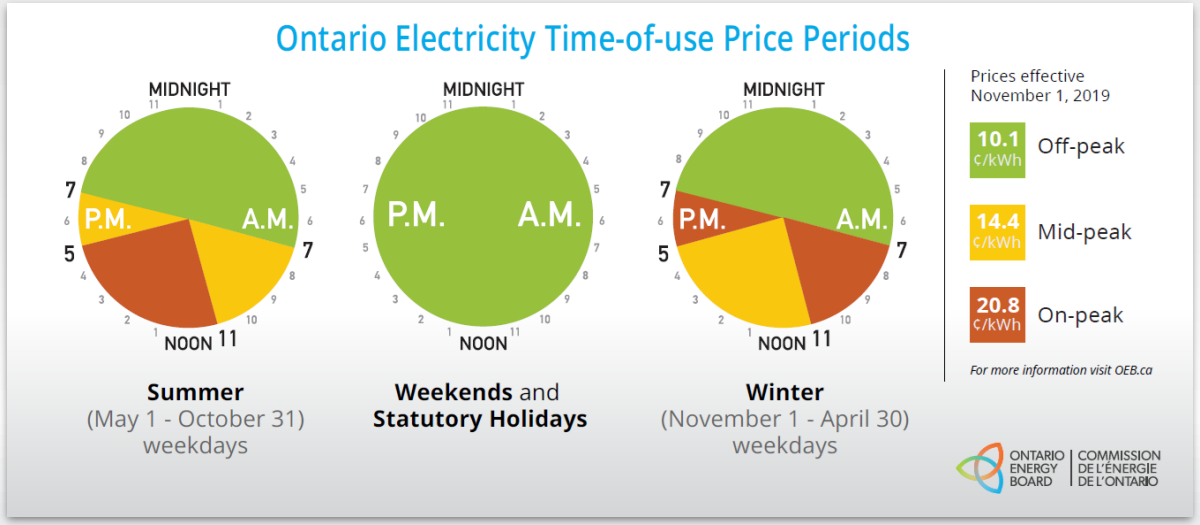
- **Problem Identification**
  - The Aging Power Grid
  - Existing Solutions
  - Project Objective
- **Our Solution**
  - W.B.S.E.C.
  - Why W.B.S.E.C. is Better
- **Core Requirements**
  - Market Requirements
  - Engineering Requirements
- **System Design & Architecture**
  - W.B.S.E.C. Ecosystem
  - Overall System Diagram
  - System Sub-components
- **Experimental Results**
  - Simulation Results
  - Hardware Testing Results
  - Developed Prototype Assembly
- **Significant Issues**
  - Market Cost Comparison
  - Safety Requirements
  - Ethical Considerations
- **Conclusion & Future Work**
- **Product Demonstration**

Problem Identification – Aging Power Grid

- Outdated Infrastructure – has higher failure rates, leading to customer interruption rates, which leads to higher maintenance costs and further repair and restoration costs.
  - Current power grid experiences various levels of demand throughout the day
  - This demand curve determines the cost of electricity during specific periods of the day



Existing Solutions



- Currently, intelligent charging procedures ensures that electric vehicles are charging when electricity costs are at their lowest
- This works well for savings electrical costs

Project Objective

Project Objective

"To create a Wireless Bidirectional Power Transfer System that interfaces with the grid to optimize the use of an Electric Vehicle in a way the benefits both the electric utility company and the vehicle owner."

Wireless Bidirectional Smart Electric Vehicle Charging System :

- Incorporates both AC and DC power.
- Uses four logic controllers.
- Three physical component groups
- Uses both wired and wireless mediums to transfer both power and communication

W.B.S.E.C

Wireless Bidirectional Smart E.V. Charger - W.B.S.E.C (pronounced wib-sek) is an integration of smart, wireless & bidirectional charging

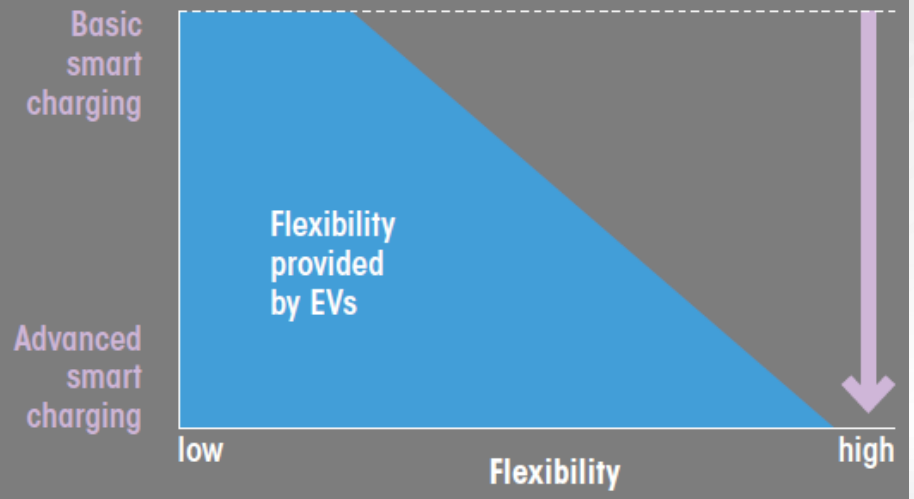
- Smart
  - The system must be able to detect peak hours and switch the charging direction (G2V/V2G) automatically without user interaction
- Wireless
  - Inductive Wireless Power Transfer system needs a high-frequency compensating network to comply with the resonant condition
- Bidirectional
  - The incorporated design must allow for the power to flow from the grid to the vehicle (G2V) and from the vehicle to the grid (V2G)

Why W.B.S.E.C. is Better?

1 BENEFITS

Smart charging of EVs enables:

- Reduce grid infrastructure investments
- Network congestion management
- Peak shaving
- Provision of ancillary services



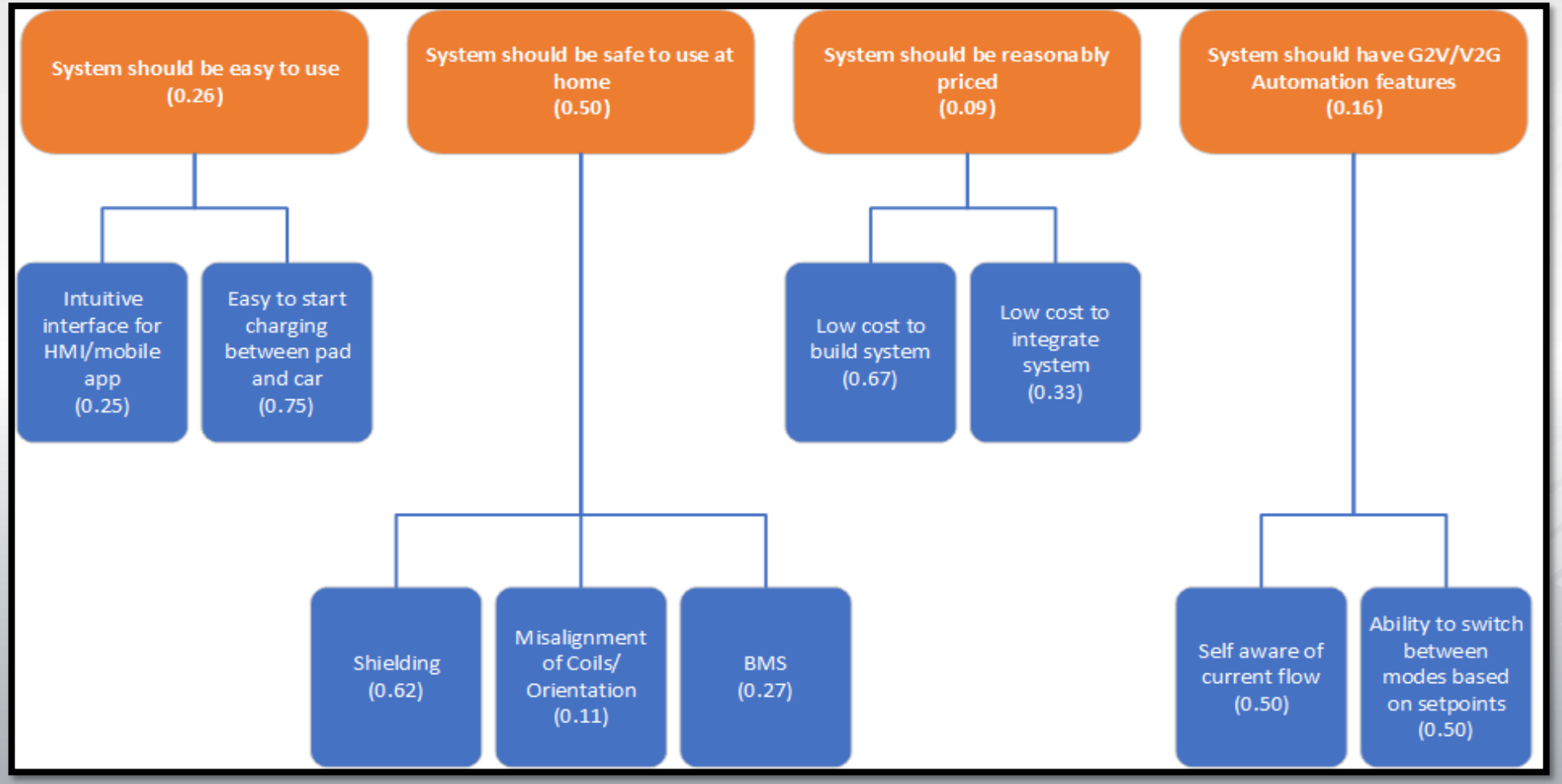
2 KEY ENABLING FACTORS

- Charging infrastructure development and deployment
- ICT control and communication protocols
- Define roles and responsibilities of stakeholders
- Design regulation for vehicle-grid integration
- Big data and artificial intelligence for smart charging

3 SNAPSHOT

- 5.6 million EVs on the world's roads as of the beginning of 2019
- 5.2 million EV chargers in 2018 (540 000 publicly available)
- Smart charging of EVs can significantly reduce the peak load and avoid grid reinforcements, at a cost of 10% of the total cost of reinforcing the grid

Core Requirements – Marketing Requirements

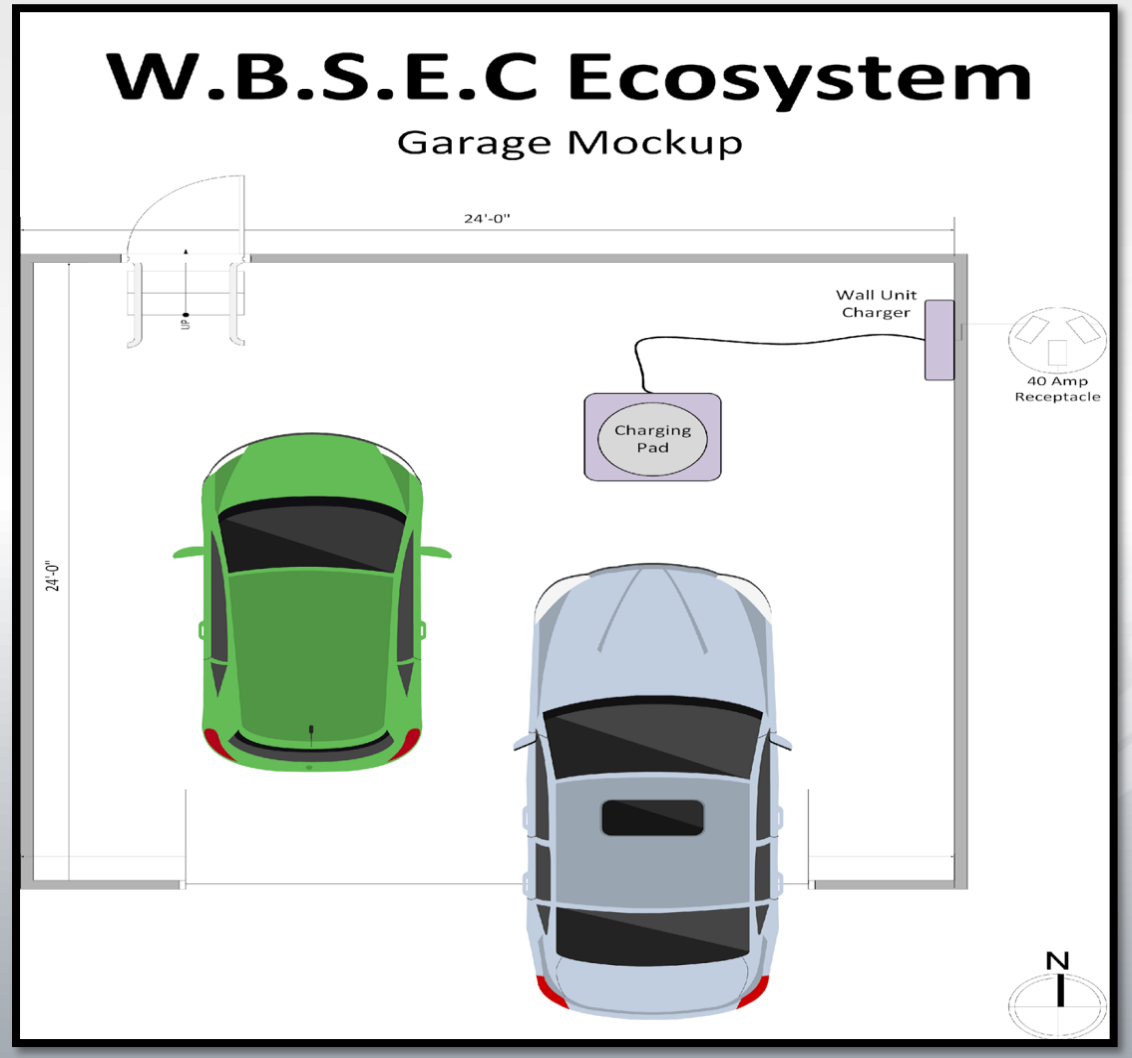


Core Requirements – Engineering Requirements

1. Technology Used – Inductive coils with a Q factor used for efficient wireless charging
2. Product Design – Design casing with a minimum specified wall thickness
3. Wireless Range – Distance between the coils will be less than 2cm
4. Production Cost - Cost of production will be less than $1000
5. Functionality – Create an algorithm for bidirectional charging

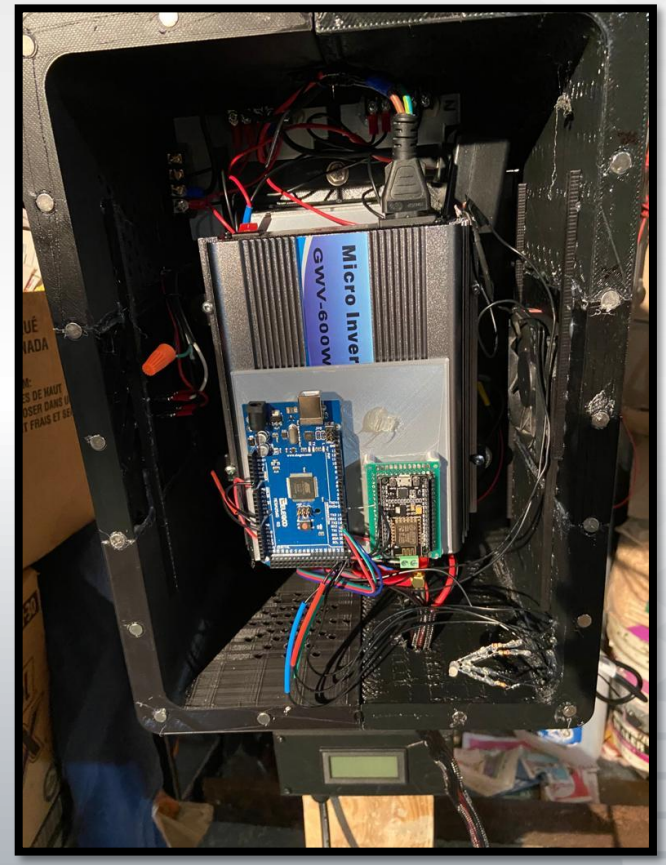
System Design & Architecture

- **Wall Unit Charger**
- **Charging Pad**
- **Battery Charger Module**



System Design & Architecture – Wall Charger

- **Wall Unit Charger**: houses the Main Controller, the Time Controller and the AC converters. This unit would get power from a 40A receptacle.
    - Main Controller
    - Time Controller
    - Grid Tie Inverter
    - Variable Power Supply



System Design & Architecture – Charging Pad

- **Charging Pad**: this pad sits on the garage floor under the front end of the car, centered between the two front tires. This pad houses the grid side coil and the Charging Pad Controller
    - PWM/Frequency Generator
    - Switching Circuit
    - Charging Pad Controller & Magnetic Sensor
    - Transmitting PCB

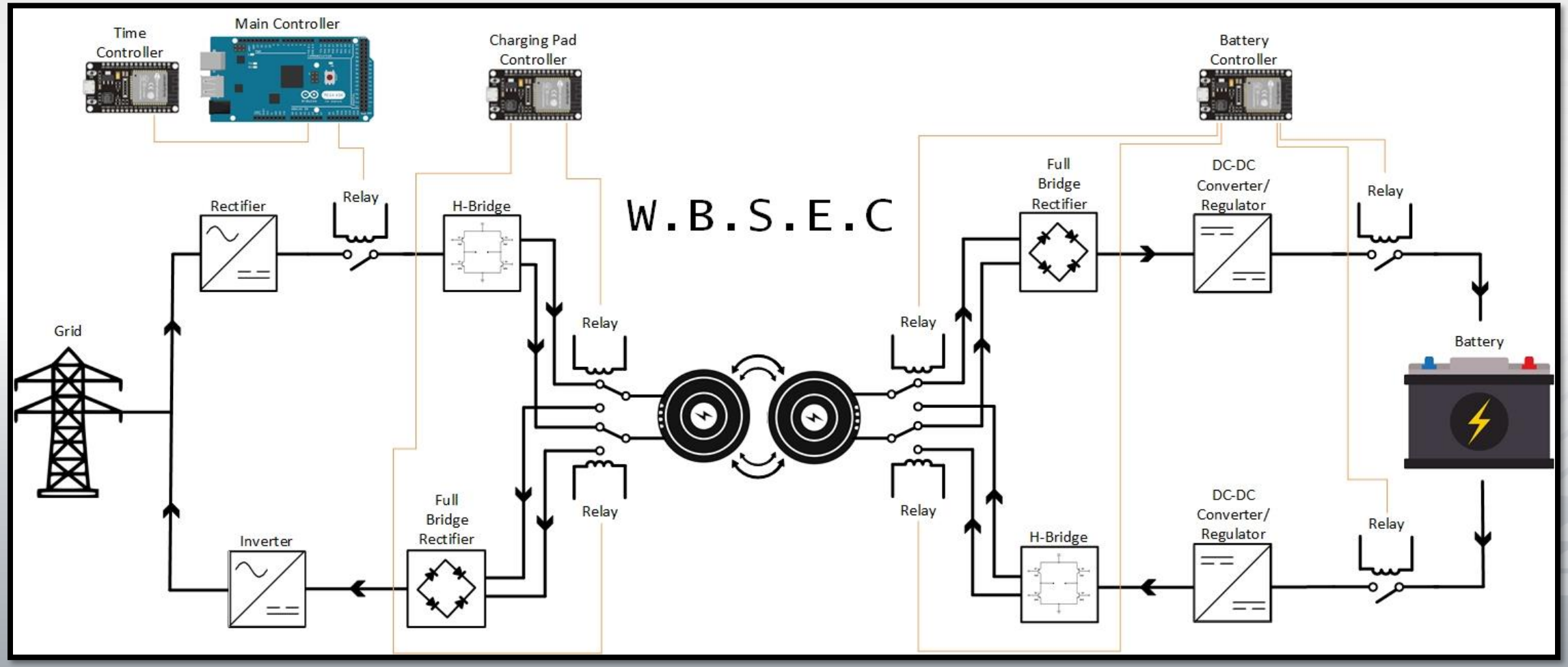
System Design & Architecture – Battery Charger Module

- **Battery Charger Module**: This module will contain the battery side coil, the charging Battery Management System and the Battery Controller. The communication between the Charging Pad and the Battery Charger Module will be done via radio signal.

  - 42V Battery
  - Battery Charging Circuit
  - Battery Controller and Monitoring
  - Wireless Power Transfer Components

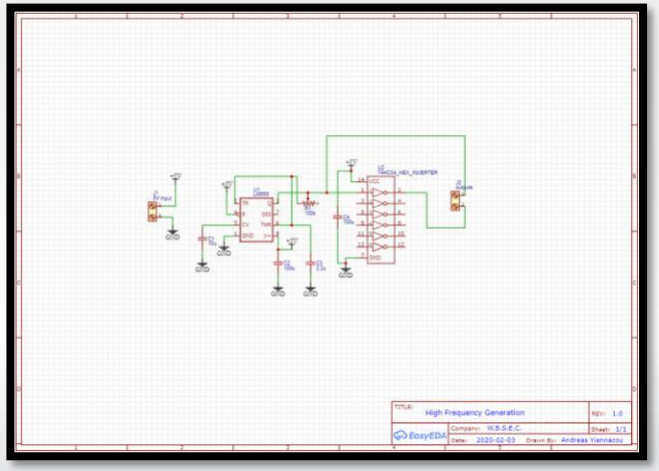
System Design & Architecture

Overall System Block Diagram

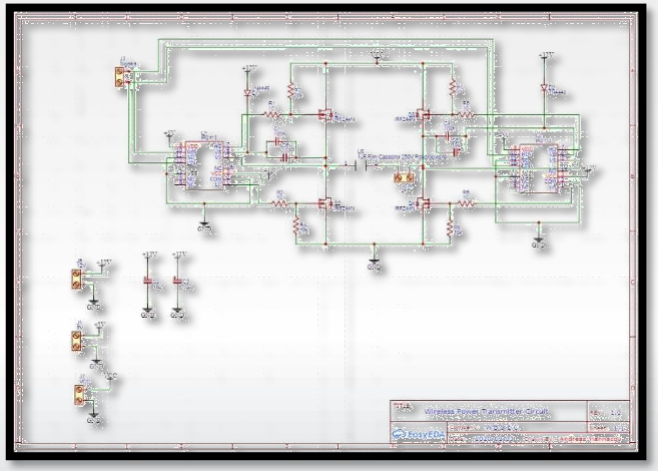


System Design & Architecture

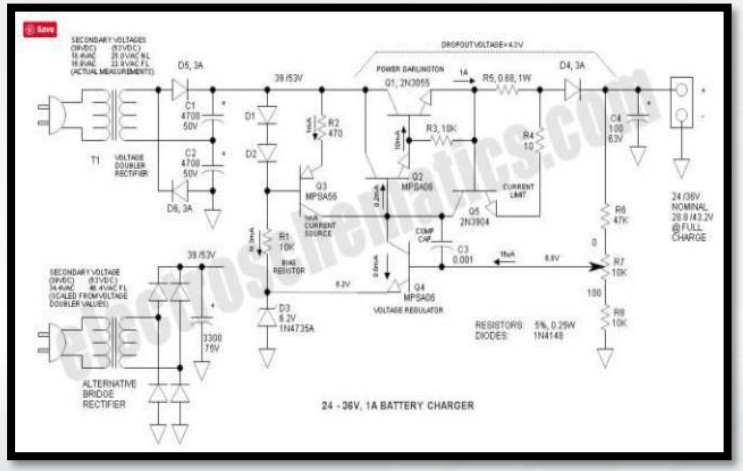
Schematics of Important Sub-Components



Frequency Generation Circuit



Wireless Power Transfer Circuit



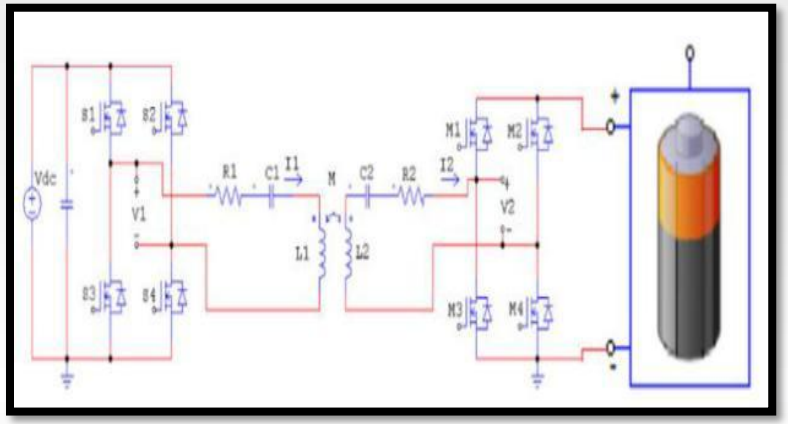
Battery Charging Circuit

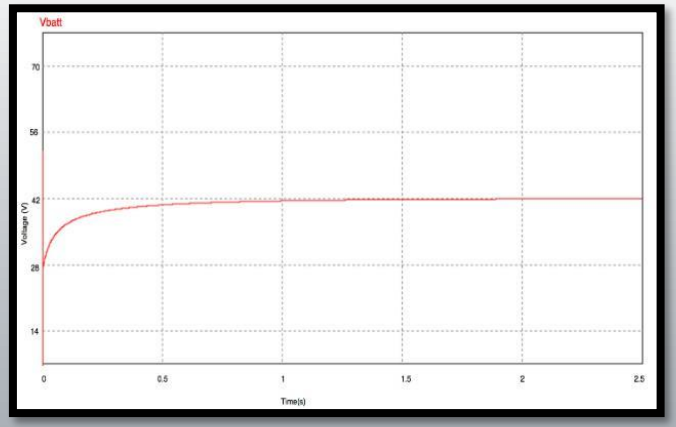
Please direct your attention to the video link shared in the Google Meets chat. Please let us know when you are done.

Thank You

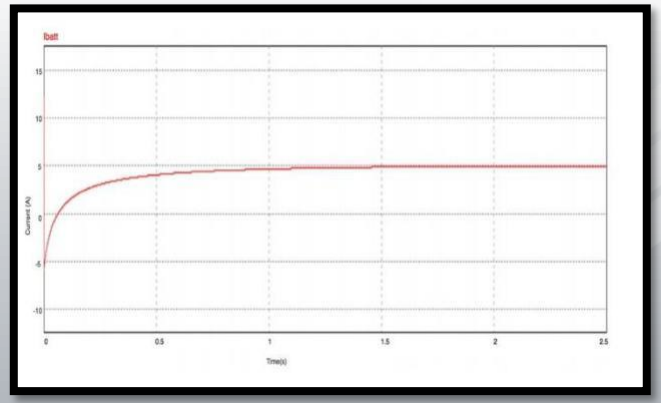
PSIM Simulation Results

Bidirectional Converter for Wireless Power Transfer





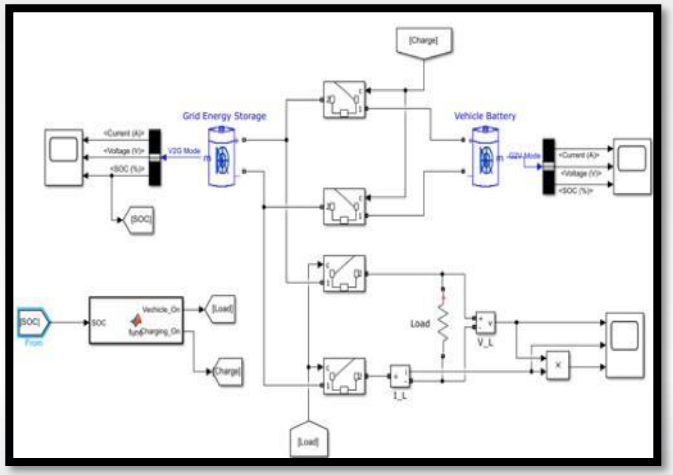
Battery Voltage for the 42V Battery Charger

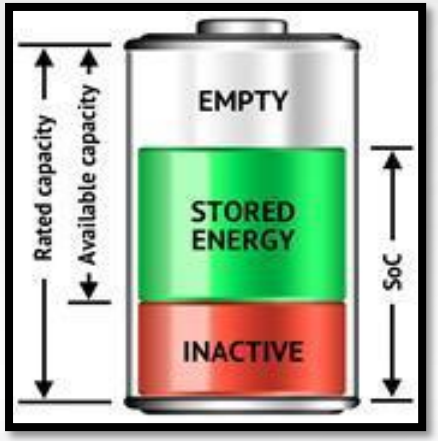


Battery Current for the 42V Battery Charger

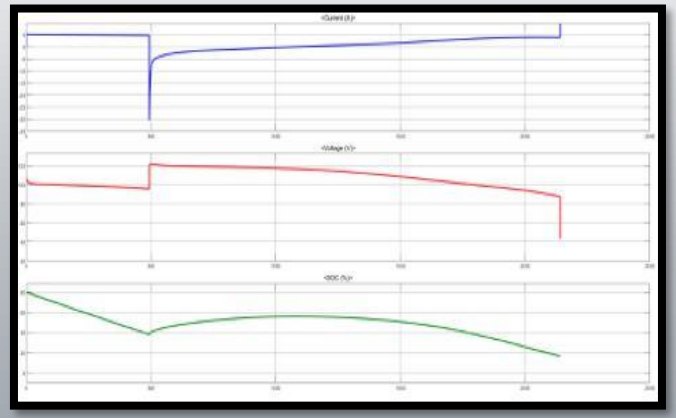
Simulation Results

Battery Charging Based on SoC Variation in SIMULINK

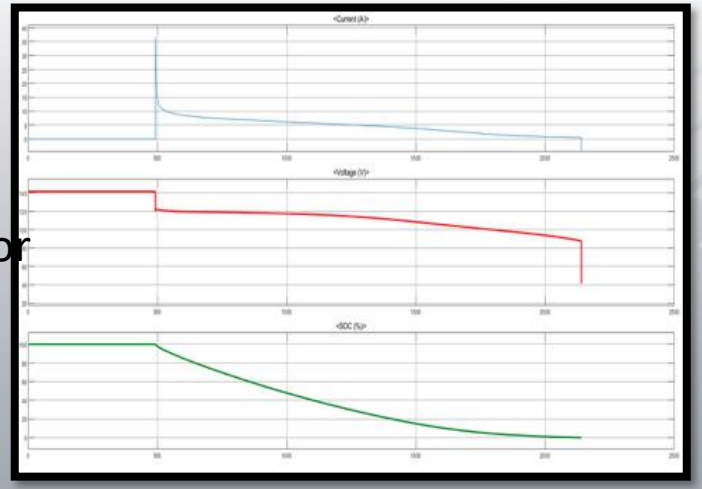




G2V Simulation for variation of SoC



V2G Simulation for variation of SoC



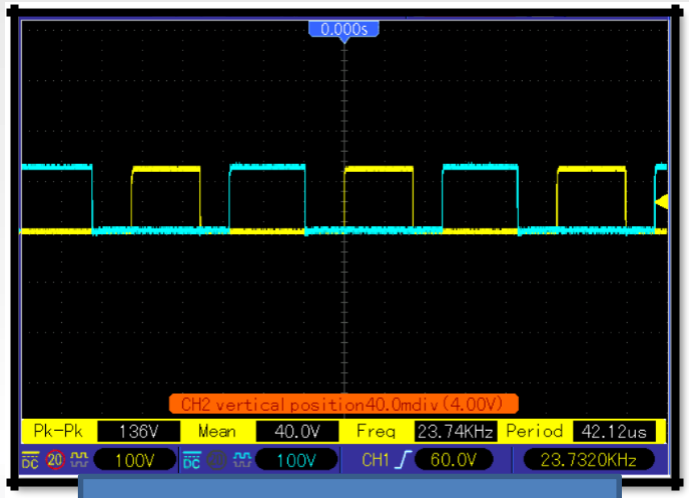
Hardware & Testing Results

Wireless Power Transfer Analysis

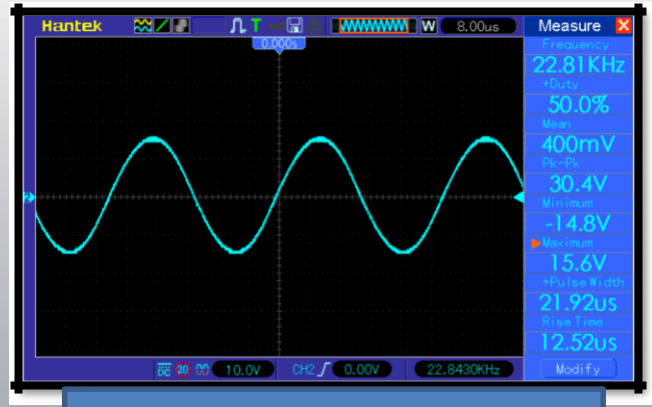
Input power

Output power

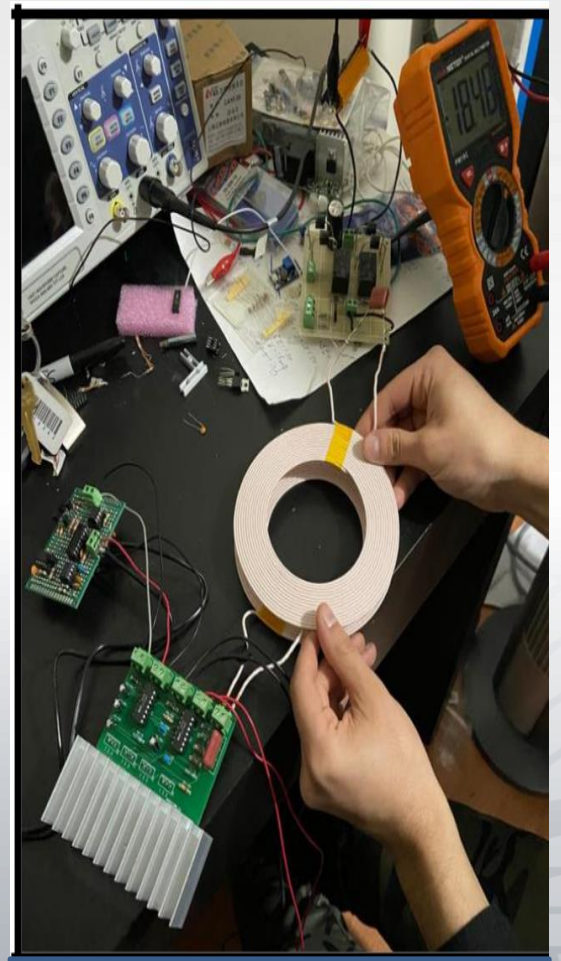
Calculated efficiency: 69%



40% duty cycle PWMs



Received no load voltage



Experimental Setup

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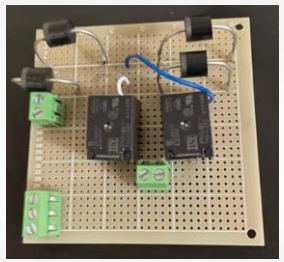
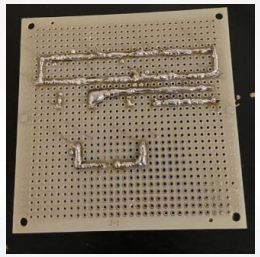
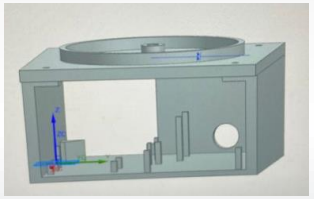
DEVELOPED PROTOTYPE ASSEMBLY

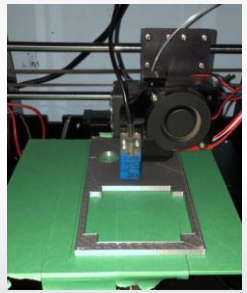
Stage 1 – Build circuits

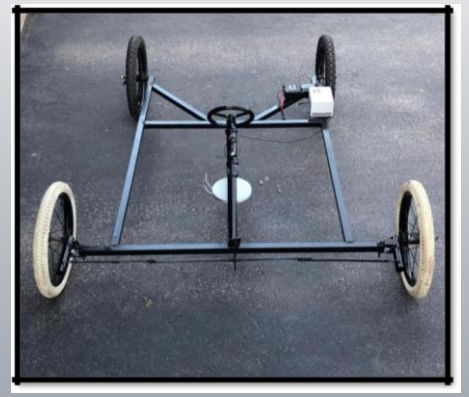




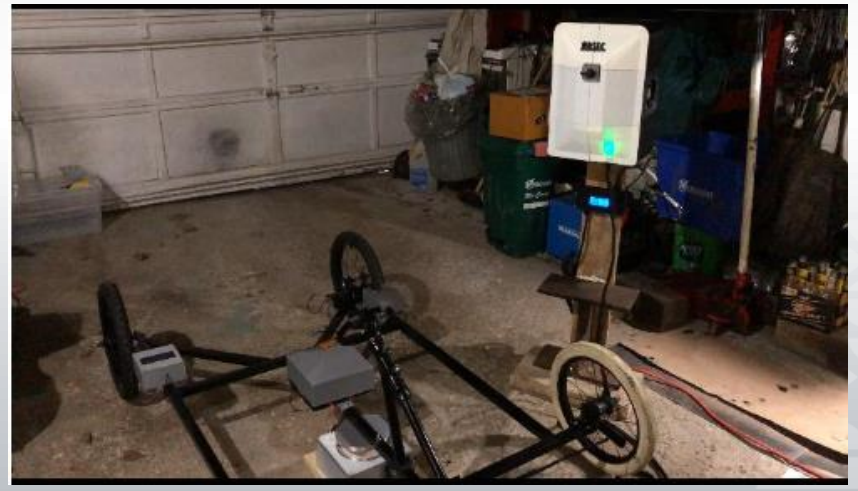
Stage 2 – Design, 3D print circuit boxes and build prototype car







Stage 3 – Assemble the system



Significant Issues

- Market Cost Comparison Comparing with a TESLA Model S charger, delivering 7.2kW of power with a maximum 51 miles of range per hour of charge, costs about $ 3,500 CAD

- Safety Requirements: Level of safety requirements for using WPT come from the operating frequency. Under 100kHz- 200kHz the level of exposure to ionizing EM radiation is relatively low to cause any significant health ailments.

- Environmental Benefits: From an environmental standpoint, Wireless Power Transfer could replace disposable cords, reducing dangerous chemicals and potential for poisoning communities. Resonant inductive coupling also has health benefits and with no need for cords would eliminate the hazards of wiring

FUTURE WORK

FUTURE WORK:

- Positioning of car exactly on top of charging pad?
- Impedance matching techniques?
- Detecting foreign objects in air gap?

Thank you for your attention

Questions ?