Comprehensive Inductive System for Vehicle Misalignment Detection
Intended for Dynamic Wireless Charging Applications

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ABSTRACT

To overcome the range limitations associated with Electric vehicles (EV), the incorporation of dynamic wireless charging capabilities in EV is of paramount importance. Wireless Power Transfer (WPT) is sensitive to the alignment between the transmitter and receiver. A versatile misalignment detection system is thereby required to make the transmitter unit capable of adjusting the power transfer so that the vehicle receives uniform power irrespective of its misalignment with the transmitter pads. Misalignment detection can also be incorporated in the Intelligent Transportation System (ITS) as a mean of vehicle detection in general, which will help measuring the real time traffic constraints. This paper presents an comprehensive study and analysis of different coil structures for the detection algorithm along with their comparisons. A 4-coil system for vehicle misalignment detection for dynamic charging application were finally used. This detection system also incorporates image processing for Foreign Object Detection (FOD) to turn off the wireless power transfer when any hazardous material is placed on the transmitter pad. Based on the experimental results found after incorporating the system with a wirelessly charged E-bus system, successful operation of the system were proved.

SYSTEM OVERVIEW

- 12 V internal battery powered system
- 95 kHz switching frequency
- Integrated image-processed FOD system
- Driver accessible emergency ON/OFF control feature

<table>
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<th>Battery fully charged?</th>
<th>Foreign object detected?</th>
<th>Detection system output</th>
</tr>
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<tbody>
<tr>
<td>NO</td>
<td>NO</td>
<td>ON</td>
</tr>
<tr>
<td>NO</td>
<td>YES</td>
<td>OFF</td>
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<tr>
<td>YES</td>
<td>NO</td>
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<tr>
<td>YES</td>
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EXPERIMENTAL RESULT

- Various longitudinal and lateral misalignment conditions were experimented to create a grid of induced secondary coil voltages
- Different height conditions (attributed to different passenger loads on the vehicle) were characterized
- Microcontroller unit uses the voltage differences between coils to calculate the misalignment using our detection algorithm
- The main WPT controller takes the processed misalignment signal output from microcontroller and an Look Up Table (LUT) to adjust the WPT accordingly to ensure uniform power received by the vehicle.

SIMULATION MODEL

- Inverter, rectifier, compensator and envelop detector model were built using MATLAB Simulink
- Coupling coefficients for various lateral misalignment observed from the system characterization stage were used to simulate the effects of a moving vehicle

HARDWARE ASSEMBLY

- Inverter circuitry is mounted underneath the bus in a waterproof metal box.
- Plexiglass sheet is used to shield the primary coil from weather conditions. On the other side of the coil, metal sheet is used for magnetic shielding.
- FOD circuitry and camera is mounted at the front window inside the bus
- Secondary circuitry is installed under the roadway in a waterproof box

CONCLUSION

A novel algorithm for dynamic WPT misalignment detection is proposed. Image processed FOD input and a driver input for emergency turn-on/off of the WPT system were also incorporated for hazard free, flexible operation. Successful implementation of the system is incorporated with an E-bus system. For future works, 2-coil and 3-coil system are currently being investigated in detail for a better understanding of how to optimize the detection system size and algorithm complexity.