Dynamic Wireless Power Transfer System

Introduction

With continuous developments in technology, it should be seen that in recent years that two main problems have presented themselves as a threat to the world as whole: global warming and climate change. To combat these issues, one particular market that contributes to most carbon emissions must make change for a better world tomorrow. Throughout today’s automotive industry, it is seen that electric vehicles (EVs) will soon be choice in transportation in the near future. With California’s goal to have zero-emission vehicles by 2035, we believe this technology will be beneficial to all to adopt with the sole intention of saving the world from greenhouse gases. [1]

The goal of the Dynamic Wireless Charging Project is to create a charging infrastructure that can revolutionize the automotive industry by providing a charging solution that allows an EV to be charged while driving (dynamic) instead of being plugged-in or static charging. With wireless technology used hand-in-hand with multiple coils, it is essential to create a system that is cost-effective, efficient, and accessible for all to use in the future.

Methodology

Overall, the schematic of the Wireless Charging System consists of four main sections: Input Rectifier, H-Bridge Inverter, LLC Resonant Tank, and Output Converter. An AC voltage coming from the grid would then be rectified to DC voltage once again to be delivered to our desired conductance where the AC voltage would then be rectified to DC voltage. The LCC Resonant Tank would then increase the input rectifier where it will be converted to a DC voltage coming from the grid would be inputted into the Input Rectifier, H-Bridge Inverter, LLC Resonant Tank, and Output Converter. In order to control the H-bridge and secondary side of the rectifier PWM anthoropology is used. Using only eight PWM channels on the TMS320F28379D board both control systems can be implemented.

Ansys Q3D: To create a charging system that is efficient, it is important to prevent various factors such as inductance, overvoltage, and short-circuit currents from happening. Importing a sample board provided by Professor Badawy to Ansys, sources/sinks were designated to components to determine the flow of current throughout each net. By using Q3D, the amount of resistance, capacitance, and inductance of parasitics could be seen between each net to help prevent factors such as thermal issues, power loss, and signal integrity among all of the components. We are currently in the process of applying this software to the system’s Gate Driver and Receiver (seen on the top right).

Icepack: High temperatures detrimentally affect electrical performance of printed circuit boards (PCB). In order to increase the performance and efficiency of the new PCB, Ansys icepack analysis tool is used. icepack analysis shows the concentration of heat around the circuit board. These analysis allow us to efficiently layout the components on the board to mitigate thermal influences between components.

Maxwell: The transmitter and receiving coils were designed on ANSYS Maxwell since we are able to assign parameters such as current excitations, and implement real life materials to produce precise real-life results. The materials chosen are aluminum for the shielding, ferrites for the cores, and copper for the coil windings.

PWNM

In order to control the H-bridge and secondary side of the rectifier PWM anthoropology is used. Using only eight PWM channels on the TMS320F28379D board both control systems can be implemented.

The PWM signals are what regulate the power being transferred in the H-bridge. In Code Composer Studio the signals are generated using three different settings. The first setting is count up the second setting is count down, and the last setting is a count up and down. The count up setting is shown below.

Coils

The following displays the coupling coefficient as a function of X, where the receiver coil “slides” across the transmitter coil.

As one can see, the optimal coupling coefficient is achieved when the coils are directly on top of each other, and the fact that the simulation displays successful results proves that dynamic application is possible.

Analysis and Results

PWM

To display the PWM signals generated using code composer the DSP controller board and breakout board was needed. Using a ADAM2000 device and the software Scoppy a digital oscilloscope was obtained. Furthermore, by following the cCard pinout and connecting wire 1+ to pin out 49 and wire 1- to pinout 51 the following waveform was generated.

Coils

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Ansys Q3D: After running the sample board through Q3D, a solution frequency of 300kHz with a linear step sweep was performed on the board. The following is the solution data below that shows the capacitance, resistance, and inductance between every net within the board file:

Icepack: An icepack analysis are performed on the sample board shared by Prof. Badawy as practice. We can see that the heat is concentrated at one point on the board and how that the heat reach upward to 640 degrees C. From this result one can decide to add a fan to the compartment surrounding the board or a heatsink on the components where the heat is concentrated.

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Acknowledgements

Our team would like to thank Professor Badawy Mohamed and fellow graduate students for dedicating their time to teach and guide our team throughout this Dynamic and guiding our team in the Dynamic Wireless Charging project and we look forward to helping as much as possible in the future.

Key References