CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Manjit Ruprem

Project Number

35055

Project Title

Frequency-Distance Analysis of Two- and Four-Coil Based Wireless Power Transfer Systems under Resonance

Abstract

Objectives/Goals

In my previous research, I studied the scientific theory and technical design of Wireless Power Transfer (WPT) Systems. In WPT, efficiency is achieved through impedance matching. The purpose of this project is to demonstrate a frequency-distance analysis of WPT under resonance. In resonant systems, several configurations are possible. The goal was to consider two dedicated configurations: (a) two-coil based WPT, and (b) four-coil based WPT with two sub-configurations (step-up/step-down and step-down/step-up). In order to meet the objective in designing the transmitter and receiver resonators, the guiding question is #what innovative design methods are feasible to achieve at least 50% power transfer within 5% of the resonant frequency and at a minimum distance of 10% of transmitter coil diameter?#

Methods/Materials

Following appropriate technical design methods and procedure, I developed the desired configurations and tested the hypotheses that (a) the electrical parameters of the transmitting and receiving coils determine the design criteria to attain the required power level, (b) under resonance, maximum power transfer occurs, and (c) more power at the transmitting coil results in more received power. Inductance and capacitance of the Tx and Rx coils played a role in WPT design. Keeping C constant, the Ls of the Tx and Rx coils were calculated (using AWG, axial length, and radius) to determine the natural frequency so that resonance will occur to attain the required power level.

Results

In two-coil configuration, resonance occurred at 6.0kHz (designed at 5.0kHz). The max. received power was 1.457W at 6.0kHz at 5 cm (25% coil dia.). Received power was above 50% of I/P power between 4.3-7.5kHz (53% of the resonant freq.). In the four-coil configuration resonance occurred at the calculated freq. of 100kHz. The max. received power for step-up/step-down was 11.1W at 100kHz at 12cm (60% coil dia.). Received power was above 50% of I/P power between 96-103kHz (7% of the resonant freq.). The max. received power for step-down/step-up was 10.72W at 100kHz at 5cm (25% coil dia.). Received power was above 50% of I/P power between 96-104kHz (9% resonant freq.). The new results agree with the hypotheses.

Conclusions/Discussion

Among four-coil configurations, step-up/step-down is more efficient. Future work will include design of a charging circuit with a focus on exceeding the minimum power loss.

Summary Statement

Considering efficiency of Wireless Power Transfer Systems, two- and four-coil based configurations were demonstrated through frequency-distance analysis.

Help Received

Used lab equipment at California State Univ., Fresno (Industrial Technology). No professional guidance was received.; Brother helped in plotting the 3-D curve using MATLAB; Parents helped in printing the board