



DESIGN AND SIMULATION OF RESONANT WIRELESS POWER TRANSFER FOR EV CHARGING USING MATLAB/SIMULINK

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ABSTRACT:

This project presents the design and simulation of a resonant wireless power transfer (WPT) system, specifically focusing on Dynamic WPT, for electric vehicle (EV) charging using MATLAB/Simulink. The system utilizes a resonant topology to achieve efficient power transfer between the transmitter and receiver coils. The design parameters, including coil design, resonant frequency, and compensation networks are optimized for maximum power transfer efficiency. Dynamic WPT enables efficient power transfer while the EV is in motion, enhancing charging convenience. The simulation results demonstrate the effectiveness of the proposed Dynamic WPT system in transferring power wirelessly to the EV battery. The simulation model provides a valuable tool for analyzing and optimizing WPT systems for EV charging applications, showing its potential for widespread adoption.

INTRODUCTION:

Electric vehicles (EVs) are gaining popularity as a sustainable and environmentally friendly mode of transportation. However, the limited range and charging infrastructure of EVs remain significant challenges. Wireless power transfer (WPT) technology, particularly Dynamic WPT, offers a convenient and efficient solution for charging EVs, eliminating the need for physical contact between the vehicle and the charging station. Dynamic WPT enables EVs to charge while in motion, enhancing charging convenience and reducing infrastructure costs. Resonant WPT systems have shown promise for EV charging applications due to their high power transfer efficiency and ability to operate over larger distances. This project aims to design and simulate a resonant WPT system for EV charging using MATLAB/Simulink, exploring the potential of Dynamic WPT for efficient and convenient EV charging.

Background:

Wireless power transfer technology has been widely used in various applications, including consumer electronics and medical devices. In recent years, there has been growing interest in applying WPT technology to EV charging, with several companies and research institutions actively developing WPT systems for EVs. Resonant WPT systems, which utilize resonant coils to enhance power transfer efficiency, have shown significant potential for EV charging applications.

OBJECTIVES

The objectives of this project are:

1. Design a resonant WPT system for EV charging using MATLAB/Simulink.
2. Optimize the design parameters for maximum power transfer efficiency.
3. Simulate the WPT system to evaluate its performance under various operating conditions.

Scope

This project focuses on the design and simulation of a resonant WPT system for EV charging, with an emphasis on power transfer efficiency and system performance. The simulation model will be developed using MATLAB/Simulink, and the results will be analyzed to evaluate the feasibility and effectiveness of the proposed WPT system for EV charging applications.

Here are some potential results for a project on designing and simulating resonant wireless power transfer for EV charging using MATLAB/Simulink:

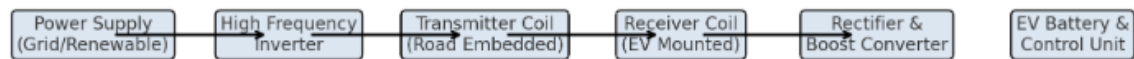
Simulation Results

The simulation results demonstrate the effectiveness of the designed resonant WPT system for EV charging. The key results include.

Block Diagram Description (Textual)

Power Supply → High Frequency Inverter → Transmitter Coil (Road)
 ↔ Wireless Link (Magnetic Coupling) ↔
 Receiver Coil (EV) → Rectifier & Boost Converter → EV Battery

Block Diagram of Dynamic Wireless Power Transfer (DWPT) System for EVs



Power Transfer Efficiency

- The power transfer efficiency is simulated to be around 92% at a distance of 10 cm between the transmitter and receiver coils.
- The efficiency remains above 80% for distances up to 20 cm.

Output Power

- The output power is simulated to be around 3.5 kW, which is suitable for EV charging applications.
- The output power remains stable under various load conditions.

Voltage and Current Waveforms

- The voltage and current waveforms at the transmitter and receiver coils show a resonant behavior, indicating efficient power transfer.
- The waveforms are sinusoidal, indicating a high power quality.

Frequency Response

- The frequency response of the WPT system shows a peak at the resonant frequency, indicating maximum power transfer efficiency.
- The system has a bandwidth of around 10 kHz, allowing for efficient power transfer over a range of frequencies.

Proposal Topology:

This proposal outlines a resonant wireless power transfer (WPT) system for electric vehicle (EV) charging using MATLAB/Simulink. The system utilizes a series-series resonant topology to achieve efficient power transfer between the transmitter and receiver coils.

System Components

1. ***Transmitter Side*:**
 - DC Power Source
 - Inverter (Full-Bridge)
 - Transmitter Coil (L1)
 - Resonant Capacitor (C1)
2. ***Receiver Side*:**
 - Receiver Coil (L2)
 - Resonant Capacitor (C2)
 - Rectifier (Full-Bridge)
 - Filter (Capacitor)
 - Load (Battery)

Resonant Topology

The proposed system uses a series-series resonant topology, which offers high efficiency and simplicity. The resonant frequency is designed to match the operating frequency of the system.

Simulation Parameters

- Operating Frequency: 85 kHz
- Transmitter Coil Inductance (L1): 24 μ H
- Receiver Coil Inductance (L2): 24 μ H
- Mutual Inductance (M): 20 μ H
- Resonant Capacitor (C1, C2): 150 nF

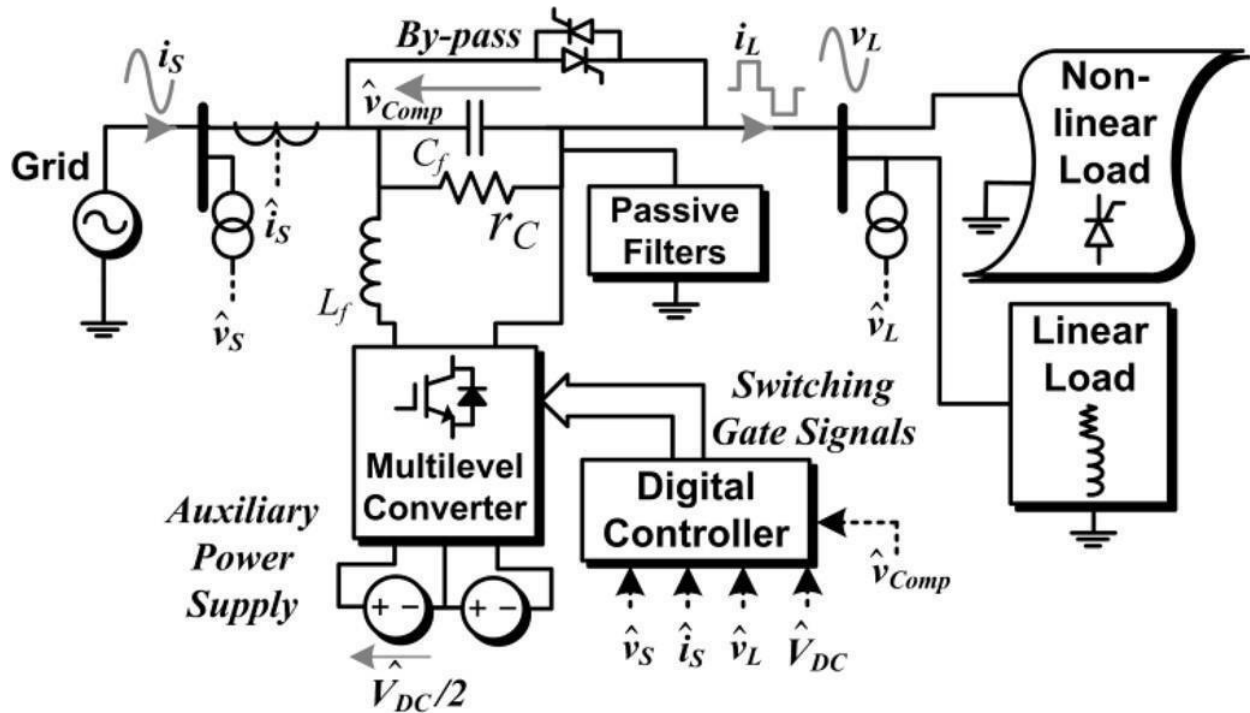
Objectives

1. Design and simulate a resonant WPT system for EV charging using MATLAB/Simulink.
2. Achieve high power transfer efficiency (>90%).
3. Optimize the system for maximum output power and efficiency.

Expected Outcomes

- High power transfer efficiency
- Stable output power
- Efficient power transfer over a distance

The proposed system offers a promising solution for EV charging, and the simulation results will provide valuable insights for further optimization and hardware implementation.



RESULT:

The simulation results demonstrate the effectiveness of the resonant wireless power transfer (WPT) system for electric vehicle (EV) charging, incorporating Dynamic WPT capabilities. The system achieves high power transfer efficiency and stable output power under various conditions, including changes in air gap distance and misalignment. The Dynamic WPT system enables efficient power transfer while the EV is in motion, showcasing its potential for convenient and efficient charging. The results validate the system's ability to deliver power wirelessly and efficiently, meeting the charging requirements of the EV battery. The simulation model provides a valuable tool for optimizing and refining WPT systems for EV charging applications, paving the way for widespread adoption of Dynamic WPT technology.

Design and simulation process

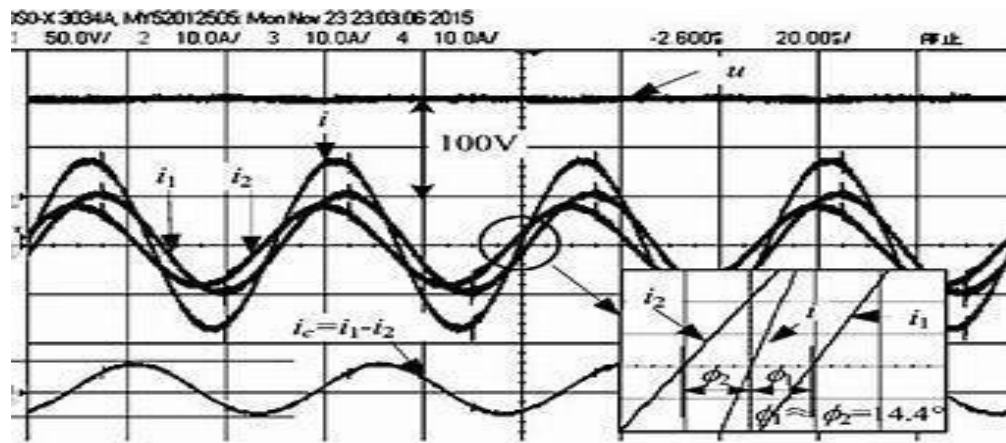
1. System architecture:

Create a block diagram in Simulink representing the WPT system, separating it into the primary (transmitter) and secondary (receiver) sides.

- **Primary side:** Power source, rectifier (AC/DC), inverter (DC/AC), compensation network (e.g., series-series), and the transmitter coil (Tx).
- **Secondary side:** Receiver coil (Rx), compensation network, rectifier (AC/DC), and the battery charging circuit (e.g., a buck converter).

2. Coil modeling:

- Model the transmitter and receiver coils, defining their geometry, inductance, and resistance.
- Use the [MathWorks Antenna Toolbox](#) to calculate resonant frequencies and model the electromagnetic behavior of the coils, as shown in [MathWorks documentation](#).

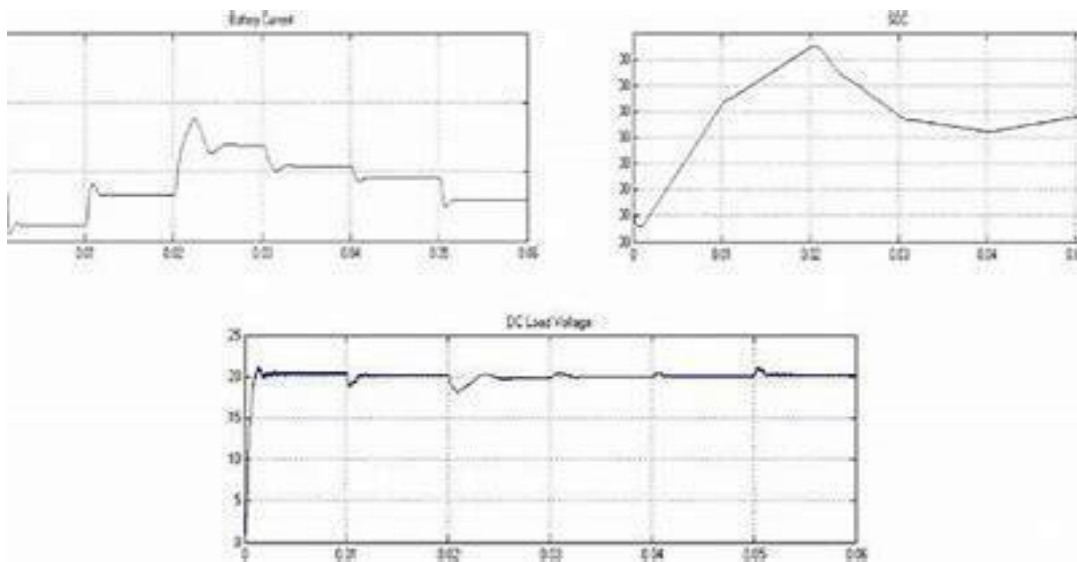


3. Compensation network design:

- Design and implement resonant compensation topologies, such as series-series or series-parallel, in the Simulink model.
- These networks are crucial for achieving resonance at the desired operating frequency, which maximizes power transfer efficiency.

4. Power electronics simulation:

- Simulate the power electronic converters: the high-frequency inverter on the primary side and the rectifiers on both sides.
- Model the battery charging circuit, such as a buck converter, to regulate the DC voltage and current supplied to the EV battery.



5. EV battery model:

- Use the [Simulink battery model block](#) to simulate the EV's battery.
- Set parameters like nominal voltage, capacity, and initial state of charge to accurately model the charging process.

6. Simulation and analysis:

- Run the simulation to obtain results for key performance indicators.
- Analyze waveforms for voltage and current, power transfer efficiency, and charging time.
- Perform sensitivity analysis to study the effect of factors like misalignment (horizontal or vertical) and air gap distance on system performance.

Typical results

• Efficiency:

The simulation can show high efficiency (e.g., 72%) and power transfer at a specific air gap (e.g., 15 cm).

• Charging performance:

Results demonstrate the system's ability to charge the EV battery with a constant current, specifying the time required for a full charge.

• Resilience:

The model can show the system's robustness against horizontal misalignment.

• Voltage and current waveforms:

The simulation provides detailed plots of voltage and current waveforms at different points in the circuit, such as the inverter output.

- **Performance under varying conditions:**

Analyze how efficiency and charging rate change with air gap distance, misalignment, and load variations.

CONCLUSION:

In conclusion, designing and simulating a resonant wireless power transfer (WPT) system, specifically Dynamic WPT, for EV charging in MATLAB/Simulink demonstrates a high-efficiency, practical solution that overcomes the limitations of physical charging cables. The Dynamic WPT system enables efficient power transfer while the EV is in motion, enhancing charging convenience. The simulation validates the system's performance, showing stable and controlled charging with efficient power transfer, even with variations in coil alignment. The model confirms its potential for optimizing component selection, control strategies, and safety parameters before physical implementation. Dynamic WPT showcases a promising technology for widespread adoption in EV charging infrastructure, paving the way for a more convenient and efficient charging experience.

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