Magnetic Field Distribution in a WPT System for Electric Vehicle Charging

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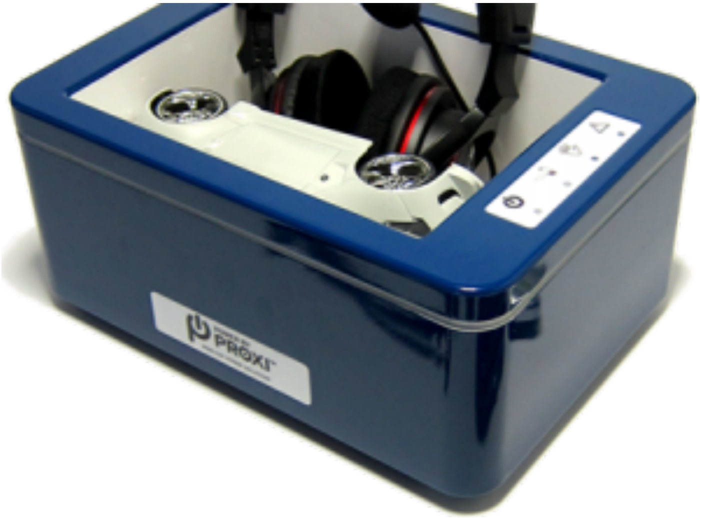
Introduction

➢ Wireless power transfer technology has various applications.

Smart phones & Tablets

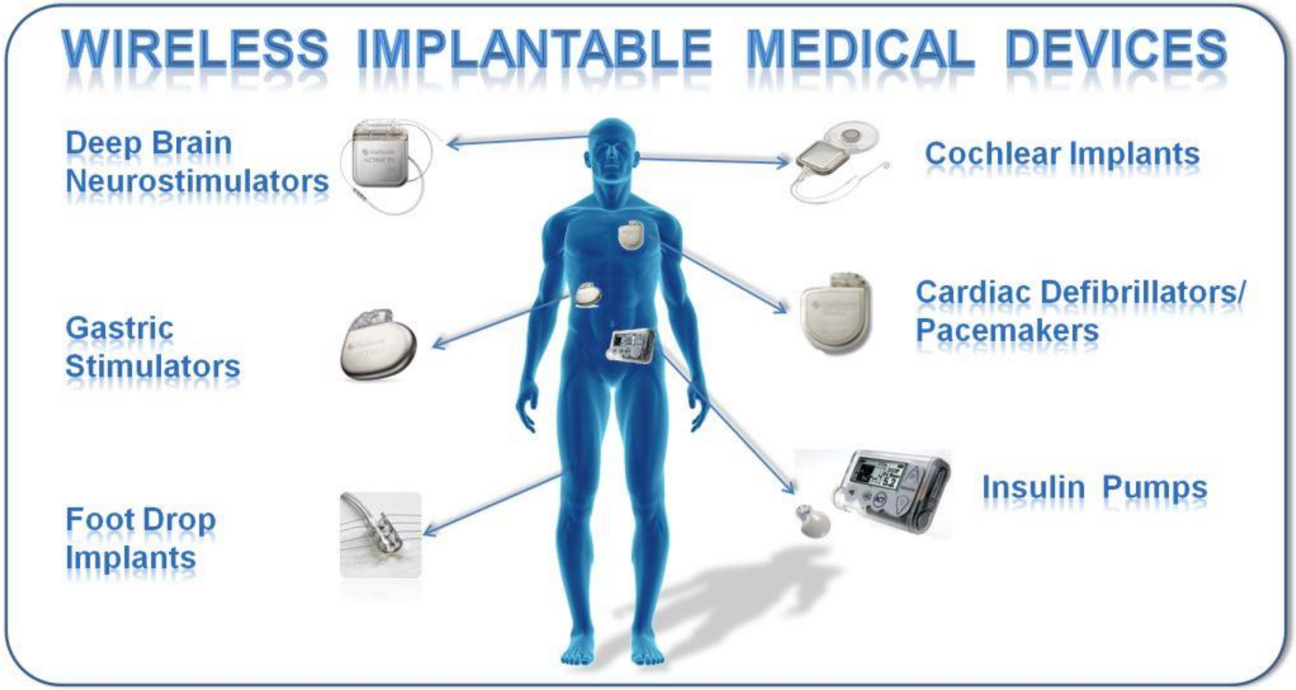
Source: www.iectechnology.com

AA Battery Powered Devices



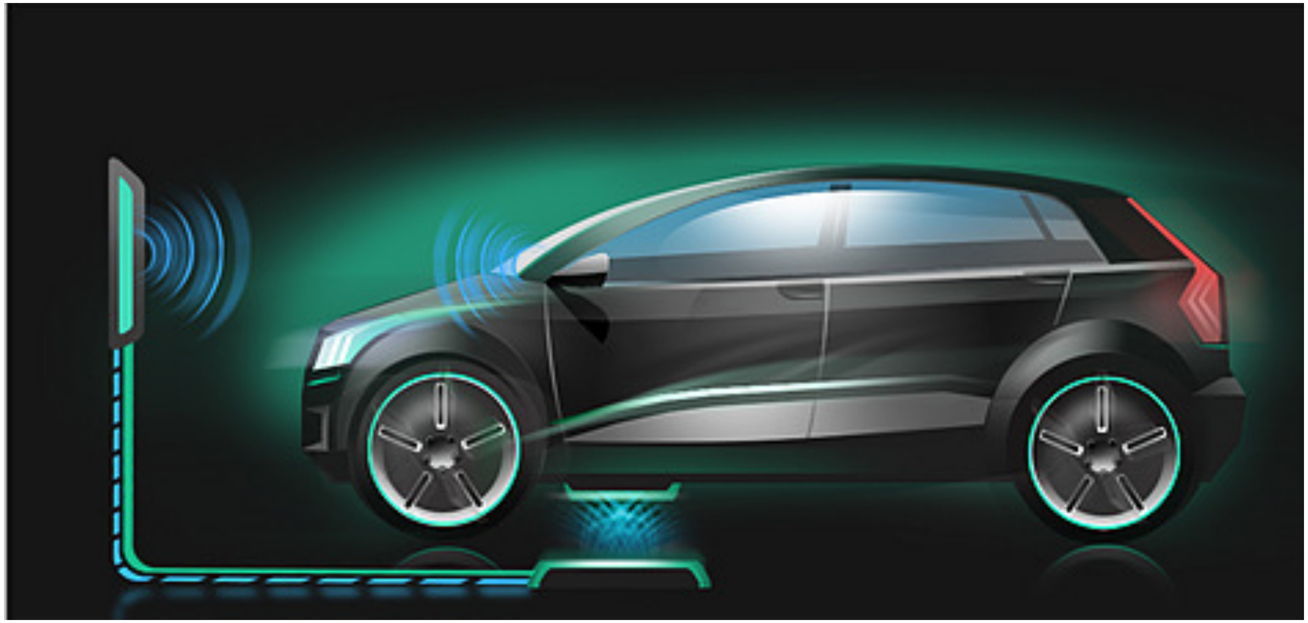
Source: http://powerbyproxi.com/wireless-charging/

Medical Devices & Equipment



Source: rahulmittal.wordpress.com/2014/03/31/wireless-charging-do-we-need-this-technology-in-its-current-form/

Vehicles & Transport



Source: http://articles.sae.org/12647/

Introduction

- Wireless power transfer technology has various applications.
- Wireless power transfer technology has many benefits.

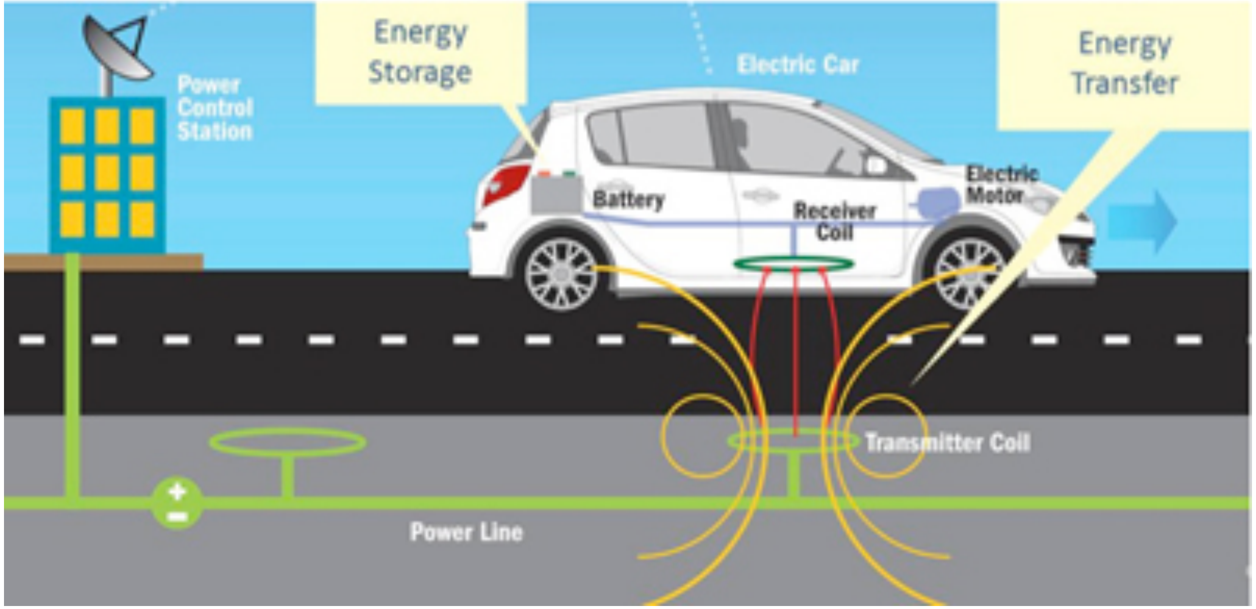
  - Convenience;
  - Compatibility;
  - Safety;
  - Durability;

Motivations

- Efficient design of WPT for electric vehicles;
- Safety consideration of WPT system.

System Overview

➢ Wireless charging electric vehicle;



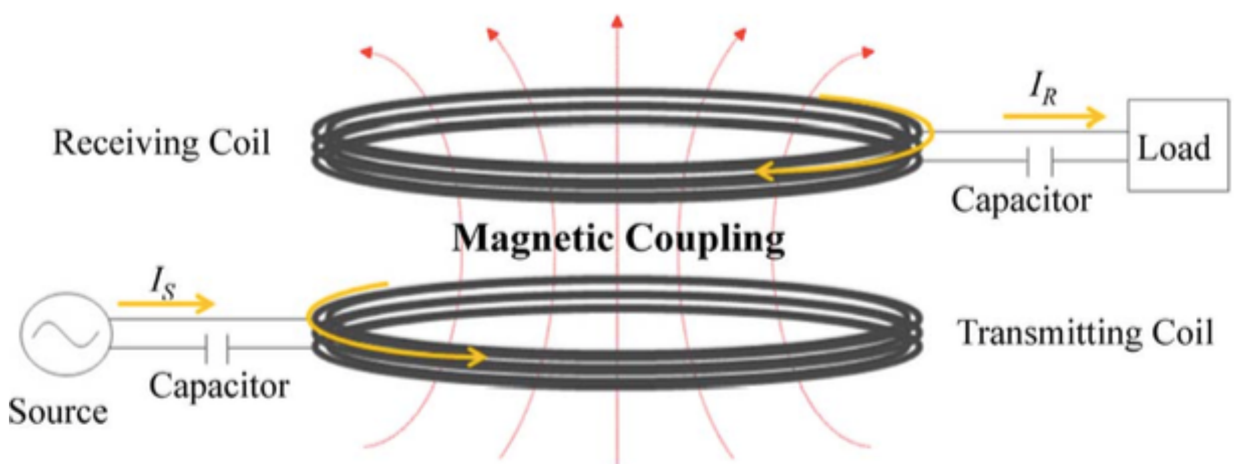
Source:http://gcep.stanford.edu/images/news/wireless_car_charging_400px.jpg

System Overview

➢ Wireless charging electric vehicles;

➢ Inductive coupled power transfer (ICPT) system;

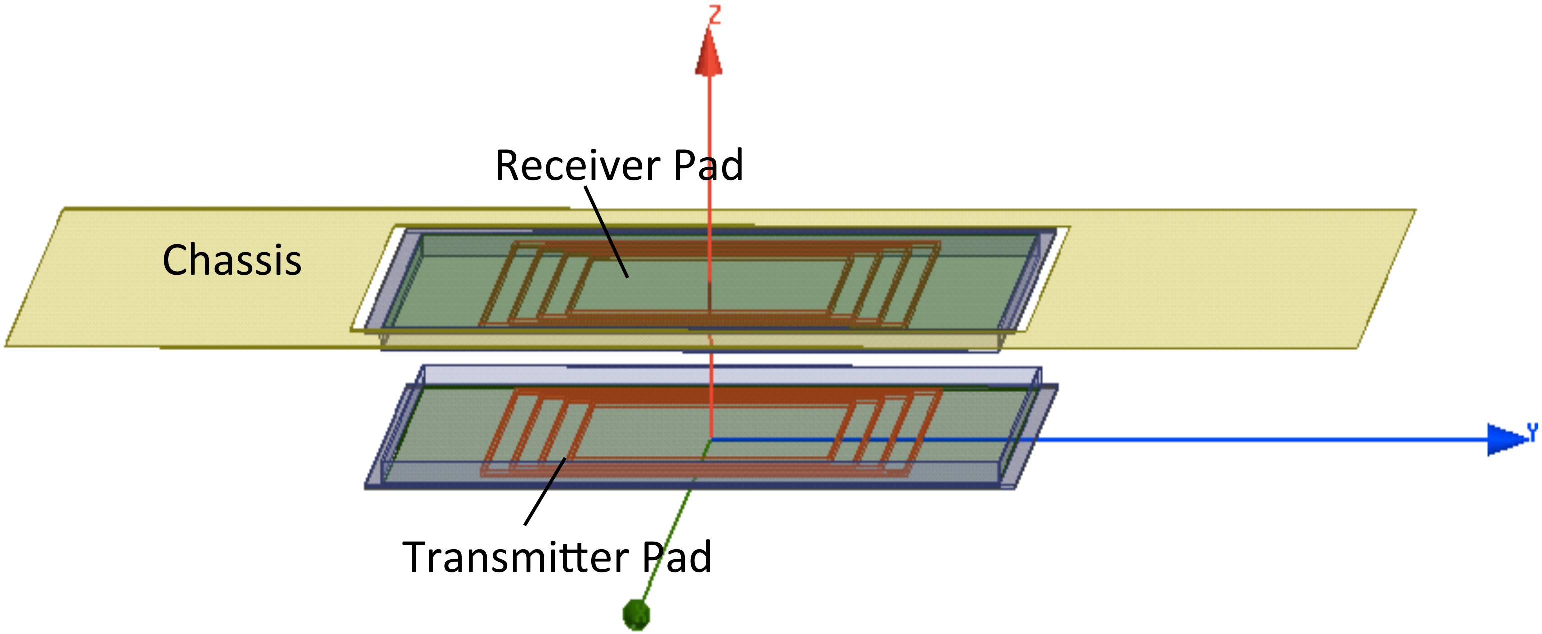
- Near range
- High power efficiency
- Low frequency



Ref. J. Kim, 2013

System Overview

- Wireless charging electric vehicles;
- Inductive coupled power transfer system;
- 3-D finite-element analysis in system design;

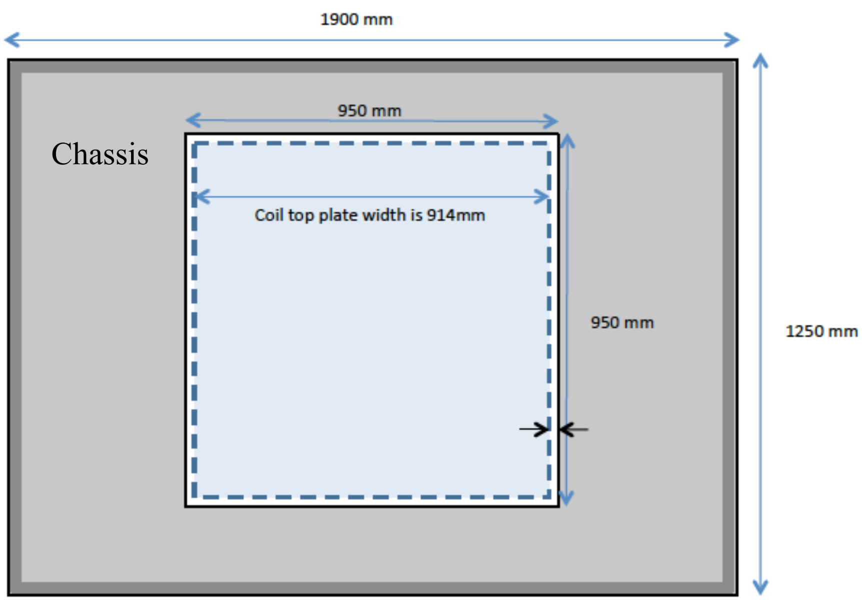


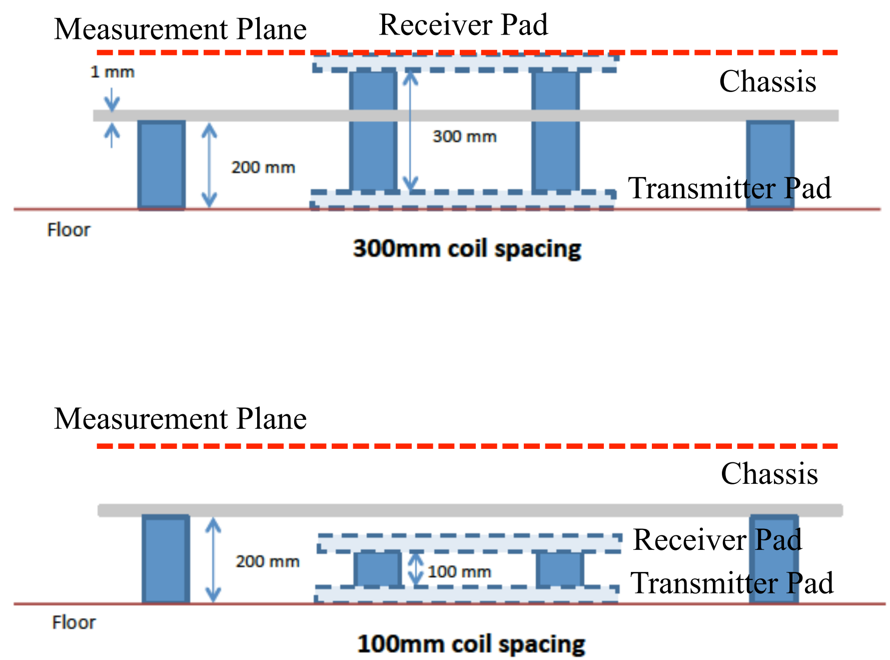
Chassis: steel sheet (1250mm x 1900mm).

Transmitter/Receiver Pad
- Copper coils (4 turns);
- Ferrite Core (840mm x 680mm);
- Aluminum shield (914mm x 914mm).

System Overview

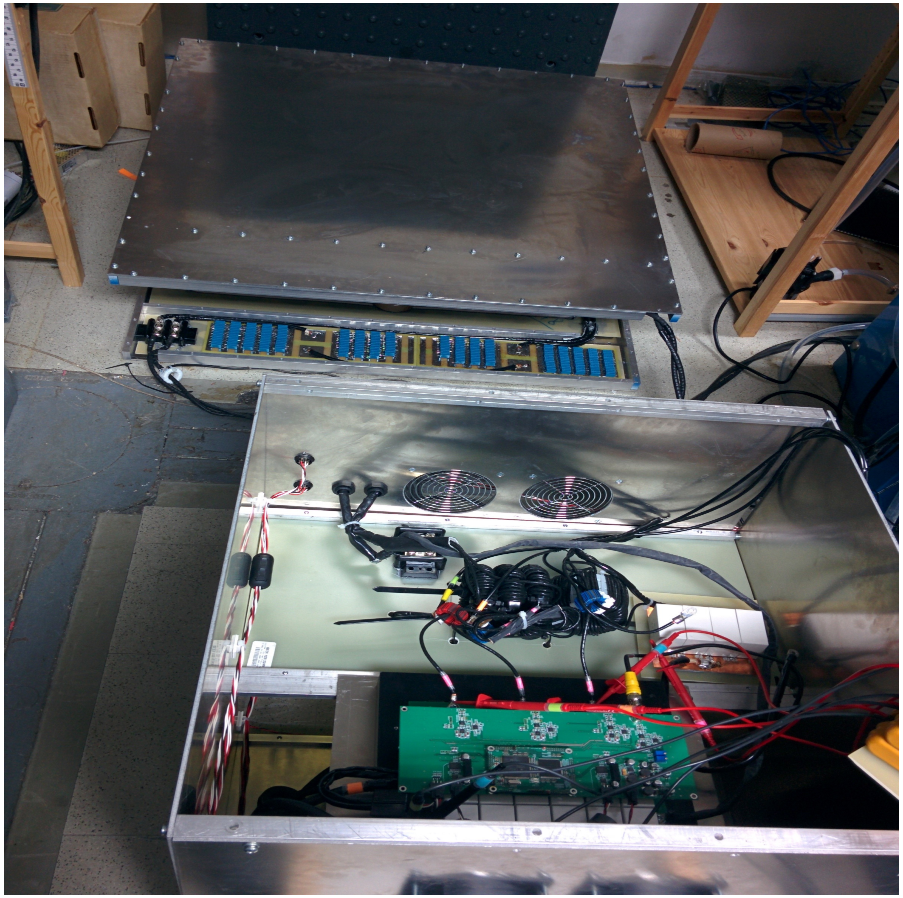
- Wireless charging electric vehicles;
- Inductive coupled power transfer system;
- 3-D finite-element analysis in system design;





System Overview

- Wireless charging electric vehicles;
- Inductive coupled power transfer system;
- 3-D finite-element analysis in system design;
- Experimental system.



Results Outline

1) Effect of **output power** on magnetic field distribution (MFD)
2) Effect of **coil spacing** on MFD
3) Effect of **chassis** on MFD
4) Effect of **misalignment** on MFD

Effect of Output Power

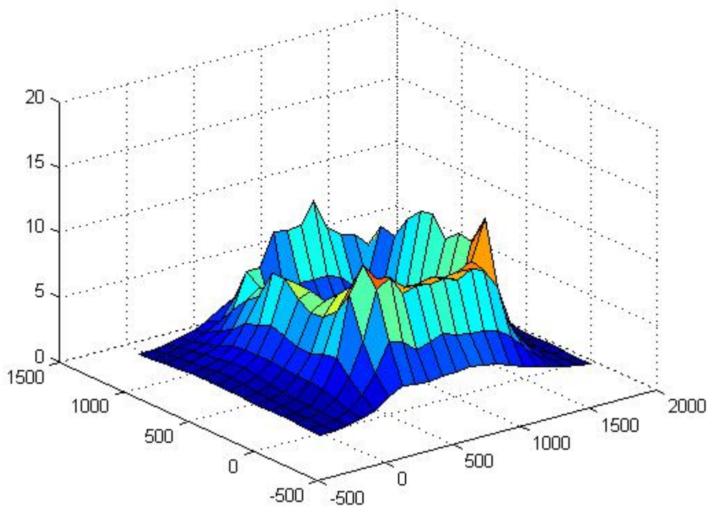
- The transmitter pad and the receiver pad are perfectly aligned.
- Coil spacing is 200mm.
- Chassis is in position.
- Load resistance is 5.54Ω.
- MFD is measured 300mm above ground.

How is the magnetic field distribution for——

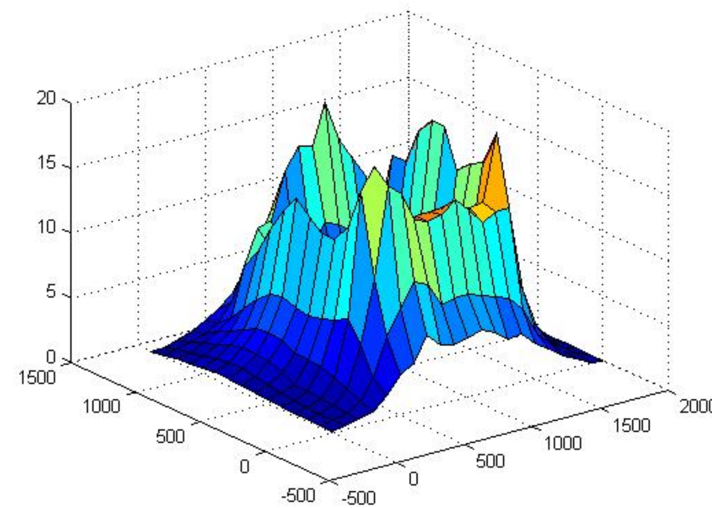
5kW, 15kW and 20kW output power?

Effect of Output Power

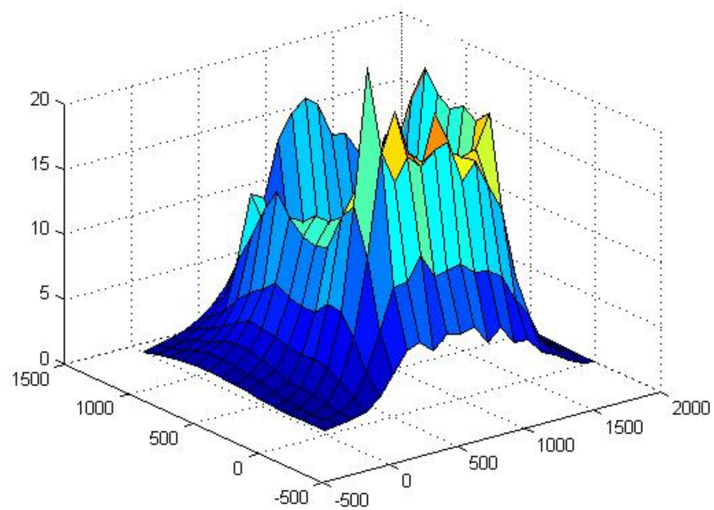
Experimental Results



5kW



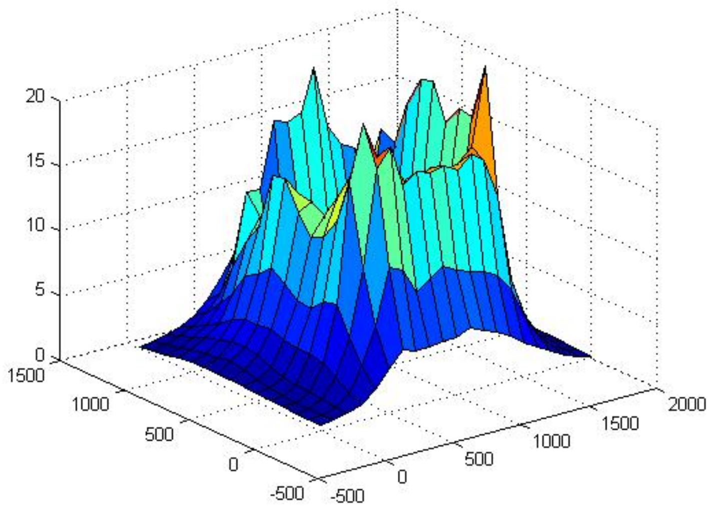
15kW



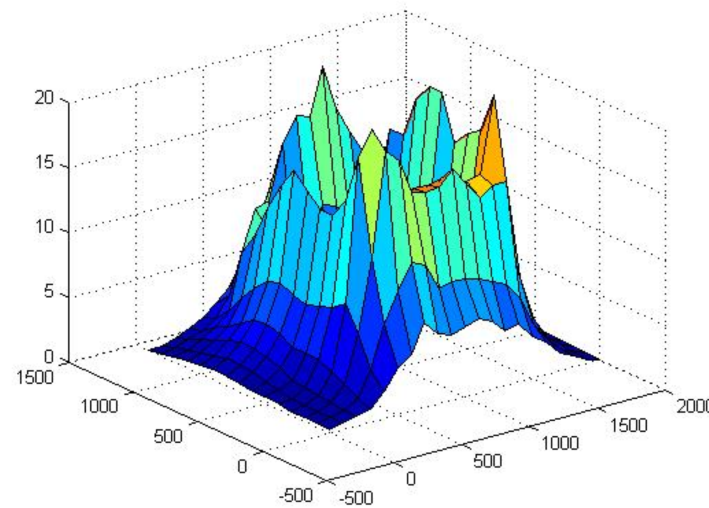
20kW

Effect of Output Power

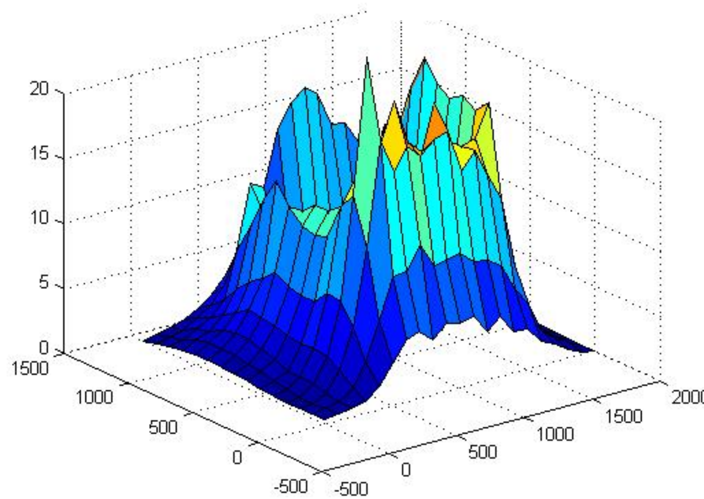
Experimental Results (Scaled to 20kW)



5kW



15kW



20kW

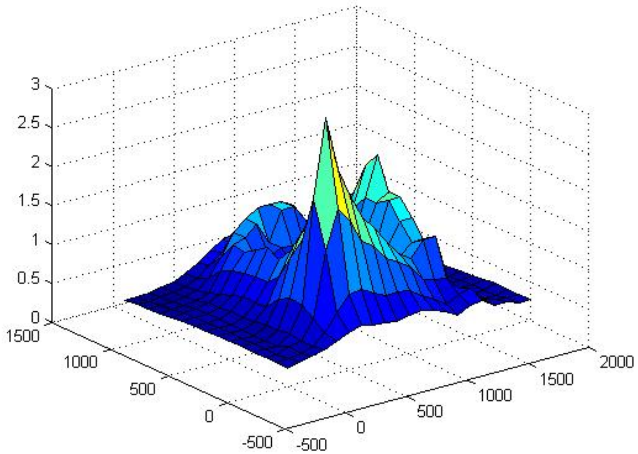
Effect of Coil Spacing

- The transmitter pad and the receiver pad are perfectly aligned.
- Chassis is in position.
- MFD is measured 300mm above ground.

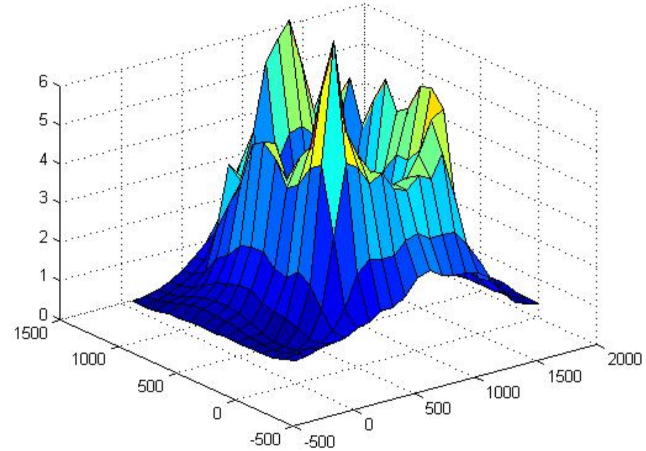
How is the magnetic field distribution for——

100mm, 150mm, 200mm and 250mm coil spacing?

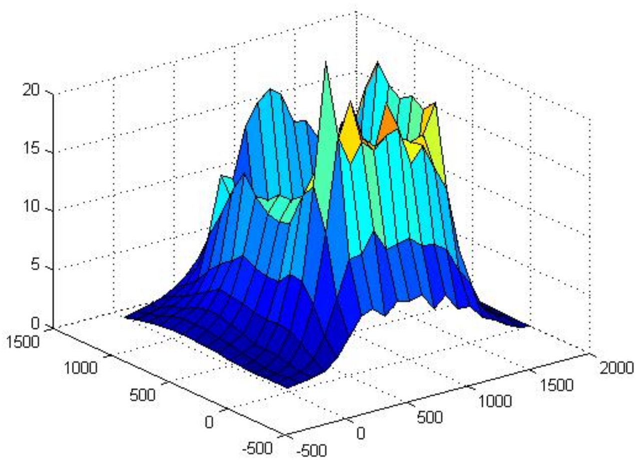
Effect of Coil Spacing



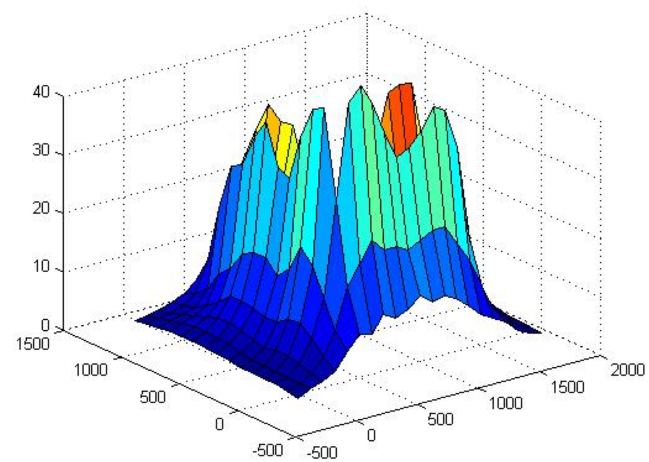
100mm



150mm



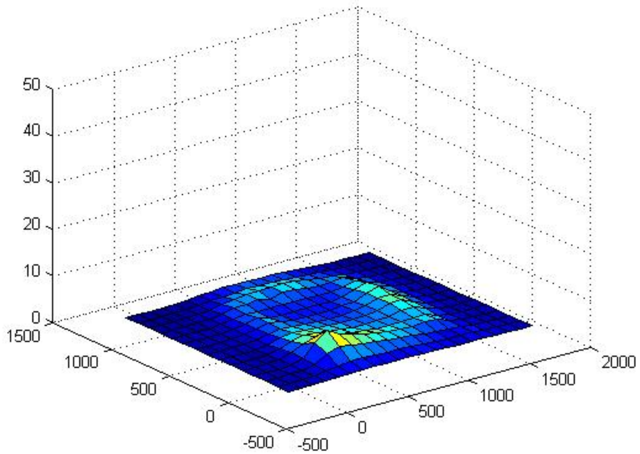
200mm



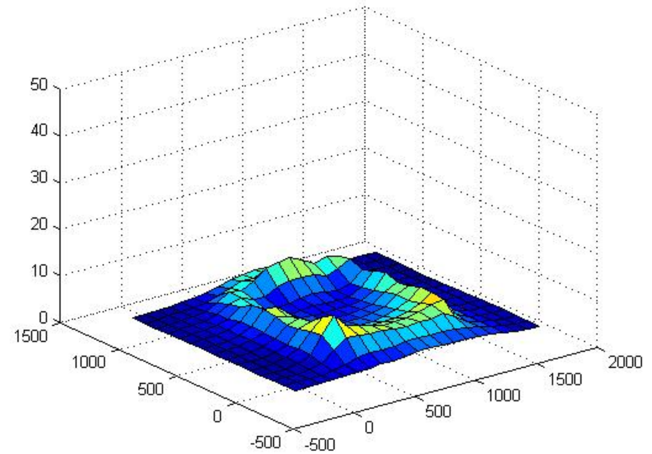
250mm

Effect of Coil Spacing

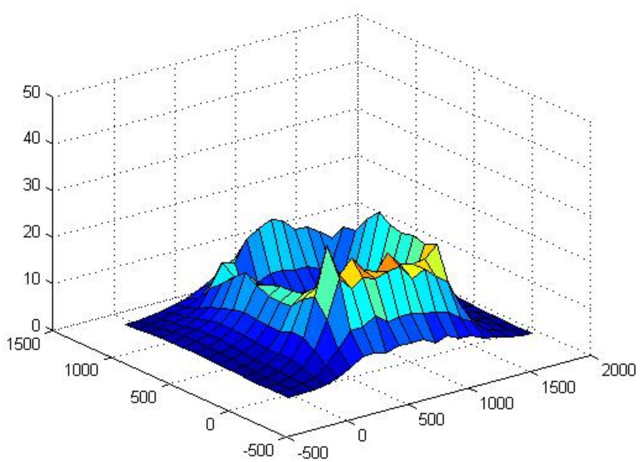
Put all results in the same-size window. All results are scaled to 20kW.



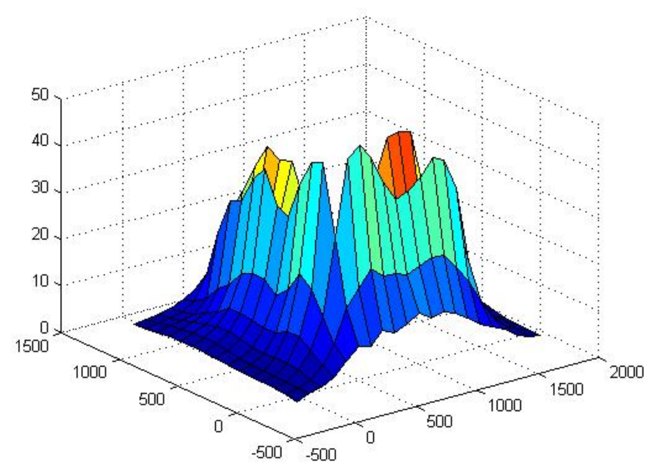
100mm



150mm



200mm



250mm

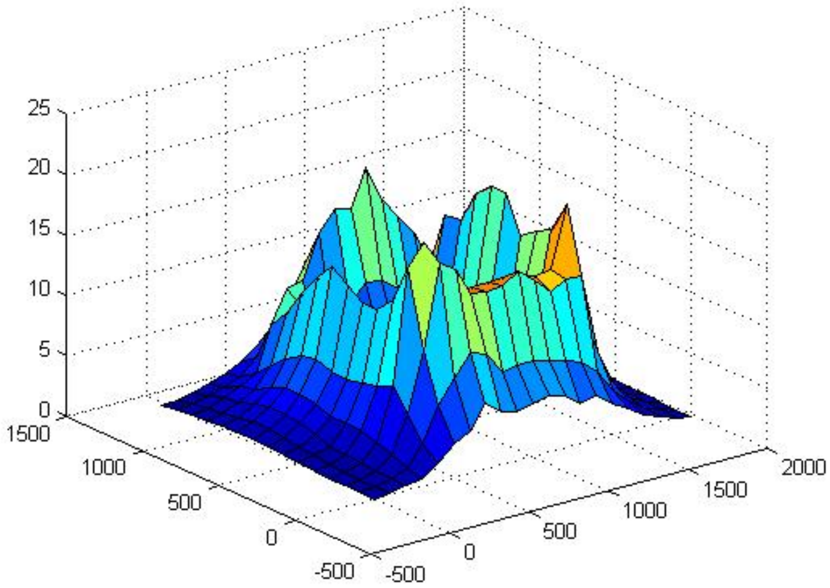
Effect of Chassis

- The transmitter pad and the receiver pad are perfectly aligned.
- Coil spacing is 200mm.
- Output power is 15kW.
- MFD is measured 300mm above ground.

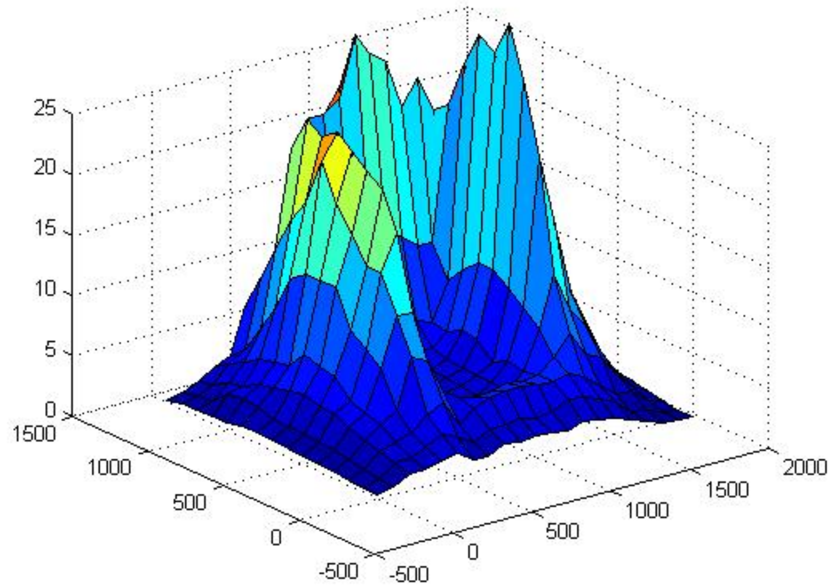
How is the magnetic field distribution for——

with chassis and without chassis case?

Effect of Chassis



With chassis



Without chassis

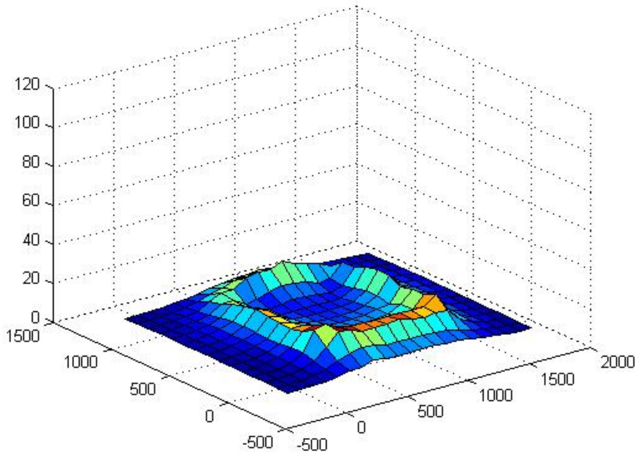
Effect of Misalignment

- Coil spacing is 200mm.
- 15kW output power;
- MFD is measured 300mm above ground.

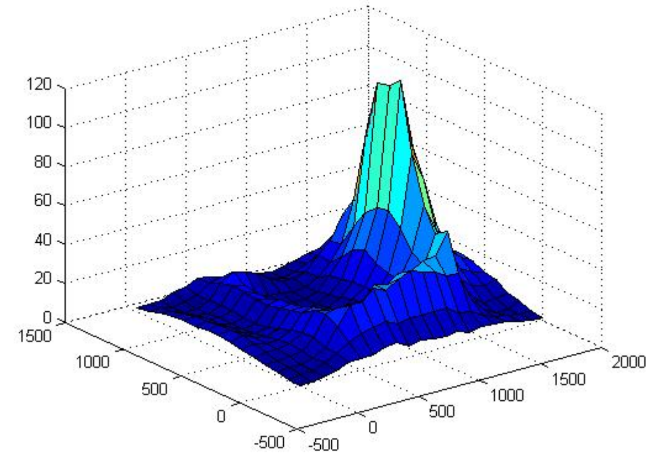
How is the magnetic field distribution for——

aligned and misaligned coils, with/without chassis?

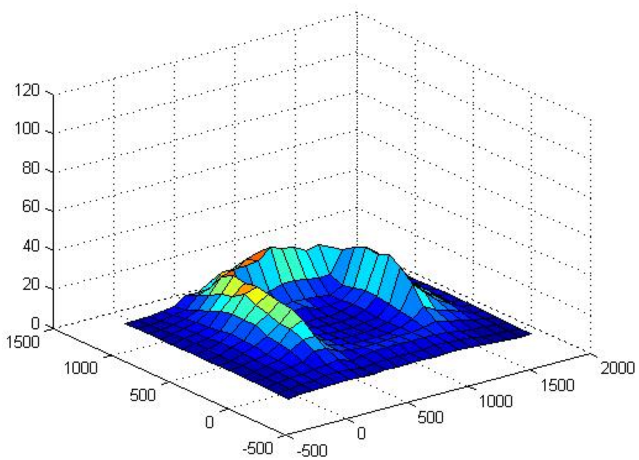
Effect of Misalignment



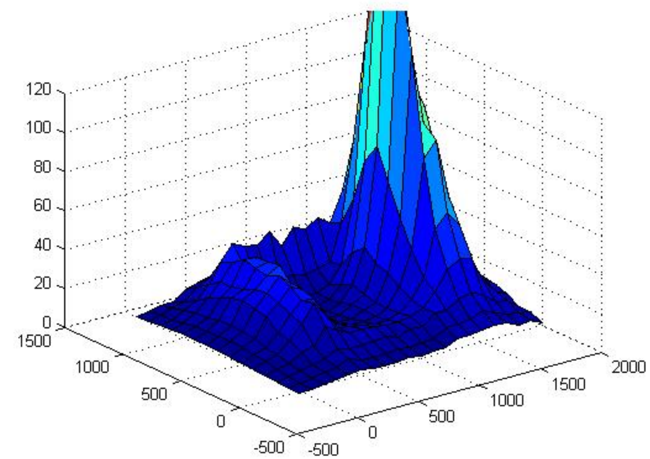
Aligned, with chassis



200mm misaligned, with chassis



Aligned, no chassis



200mm misaligned, no chassis

Conclusion

1. We have studied the impact of four parameters on the magnetic field distribution in wireless power transfer system for EVs.

2. We have verified that the magnetic field distribution is *proportional to the square root* of output power.

3. Small gap leads to *smaller fringing fields*.

4. Inclusion of chassis in the system effectively *shields* the magnetic field.

5. Misalignment between coils *increases* the magnetic field.