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Human Exposure Analysis to EMFs from Ground Assembly of a WPT System during the Vehicle's Non-attendance

Authors

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Outlines

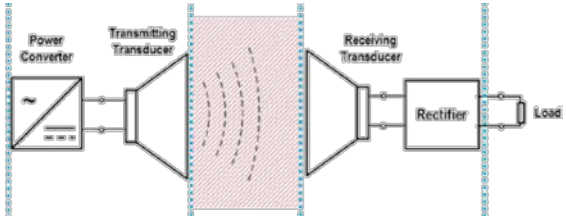
- **Introduction**
- Description of in-vehicle WPT system.
- Vehicle Alignment for wireless charging
- Assessment of EMF based on FEA and Measurements
- Results and discussion
- Conclusion

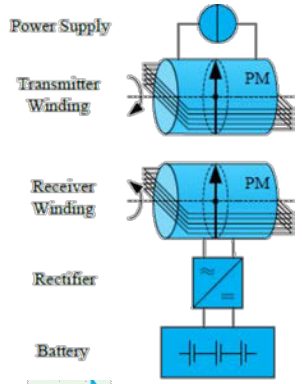
Introduction

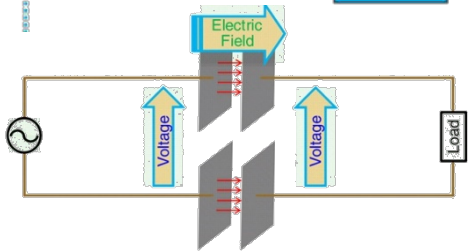
- ✓ Wireless power transfer (WPT) is a technology that could set human free from the annoying wires.

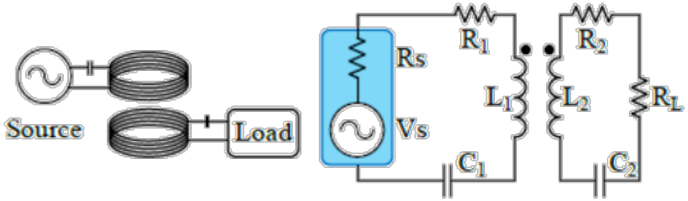
- ✓ WPT technologies:
  1. Magnetic gear (MGWPT).
  2. Acoustic (AWPT).
  3. Capacitive (CWPT).
  4. Inductive (IWPT).

- ✓ IWPT is the most attractive for EV applications. Why?
  1. High power transfer capability.
  2. Large air-gap (10-25 cm).
  3. Maintenance and noise free.









Visions of WPT for EV

Quasi-dynamic WPT

Stationary WPT

Dynamic WPT

https://www.nbcnews.com/mach/mach/futuristic-roads-may-make-recharging-electric-cars-thing-past-ncna766456

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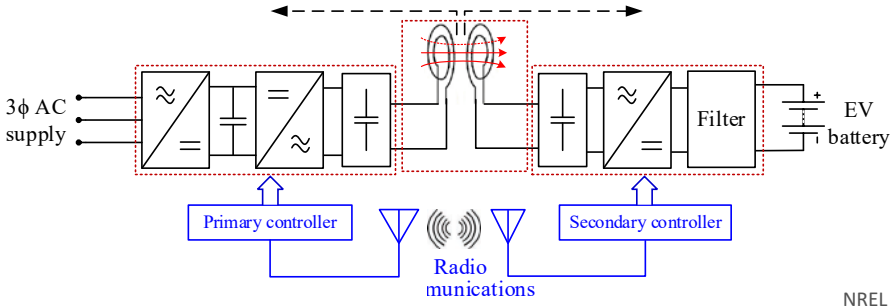
System Description

- ✓ Wirelessly Charged NREL's Shuttle
  - Full electric on-demand
  - 16 passenger
  - 62.1 kWh battery capacity
  - 100 miles range
  - 7600 kg curb weight, including VA
  - 6.6 kW on-board charger
- ✓ Momentum Dynamics WPT system
  - 36"x36" symmetrical square pads
  - 25 kW maximum power transfer
  - 20 (19-21) kHz nominal operating frequency



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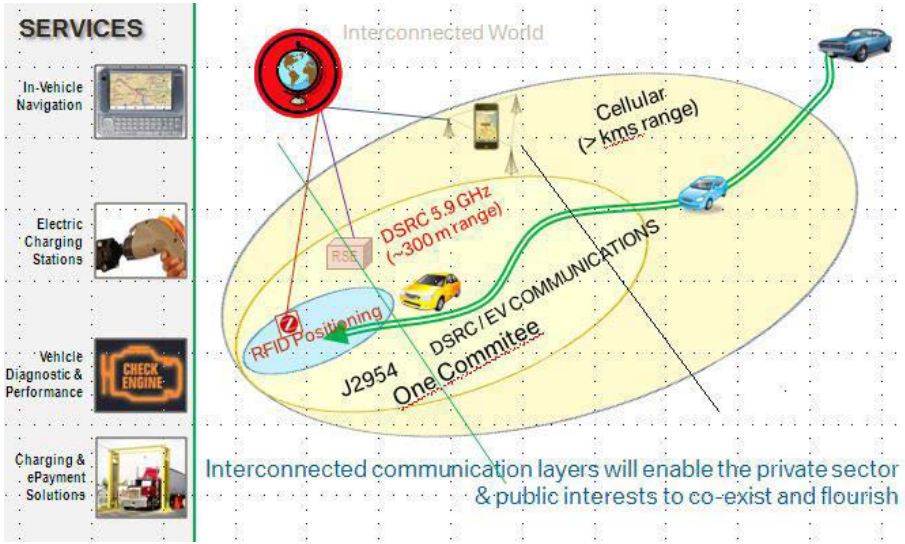
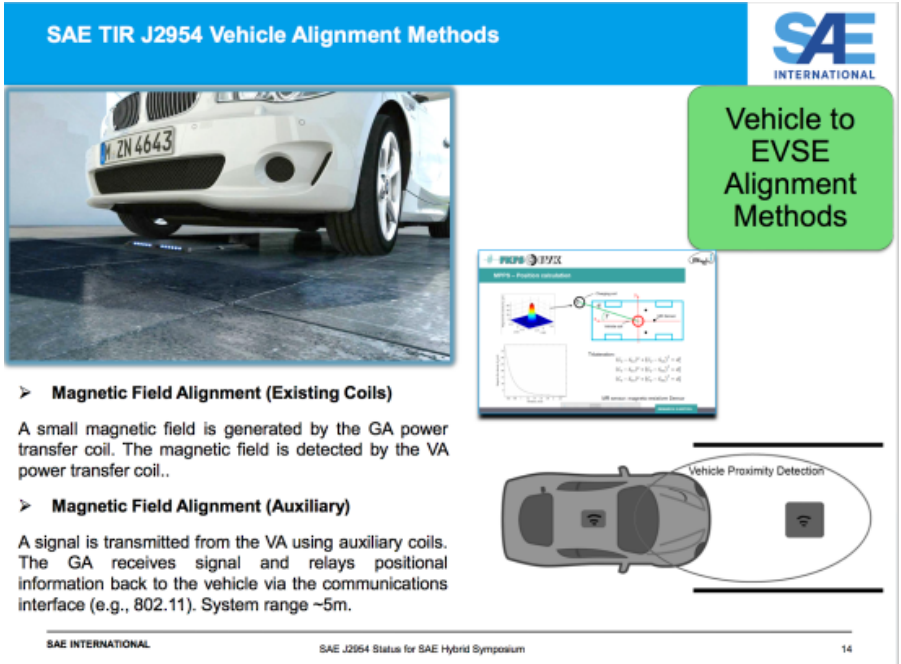
Vehicle Alignment for wireless charging





http://www.greencarcongress.com/2017/02/20170213-j2954.html

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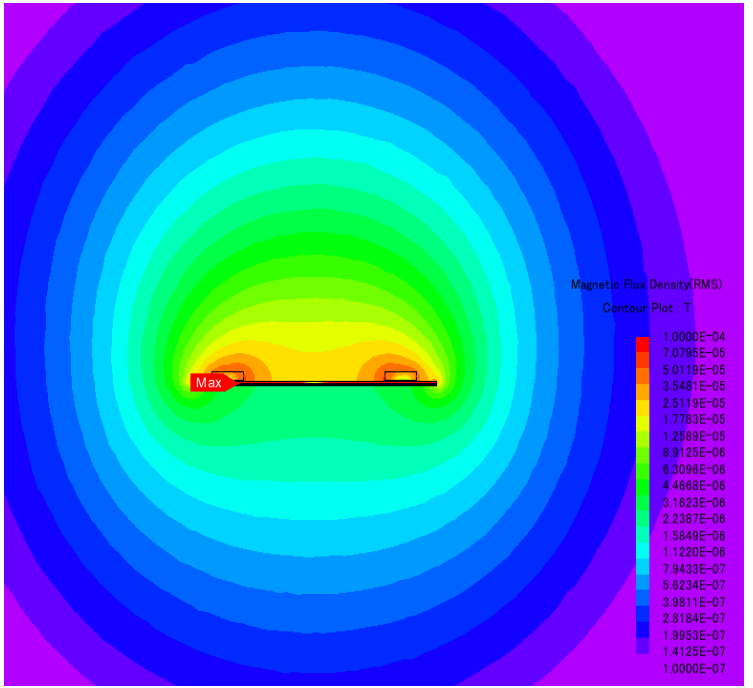
Assessment of EMF based on FEA

✓ 3D-FEM for Ground Coil

- Includes material properties (e.g. permeability and conductivity).
- Current sources were used for providing the coil currents.
- Eddy currents induced in nearby conductors are modeled and contribute to the total calculated magnetic fields.
- The finite element mesh maximum dimension varies from 10 mm to 100 mm.
- Dirichlet (Flux Tangential) boundary conditions are applied to the surrounding area around the model



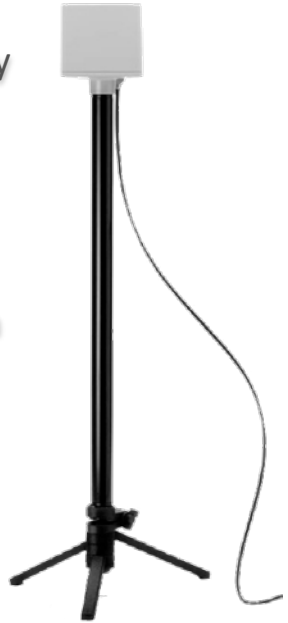
Assessment of EMF based on Near Field Measurement

✓ Test Device

Low frequency isotropic field probe-analyzer EHP-50D, Narda, Germany

- 5 Hz – 100 kHz
- XYZ field measurements
- Built-in spectrum analyzer
- connected to a PC by a fiber optic cable
- dedicated software manages the probe setting, data acquisition and storage

Parameter	Value
Span	3-100 kHz
Measurement mode	Max RMS over 30 sec.
Hold Maximum	Enable
Showing XYZ measurements	Enable
Measuring Range	Small range
Units	B (μT) & E (V/m)

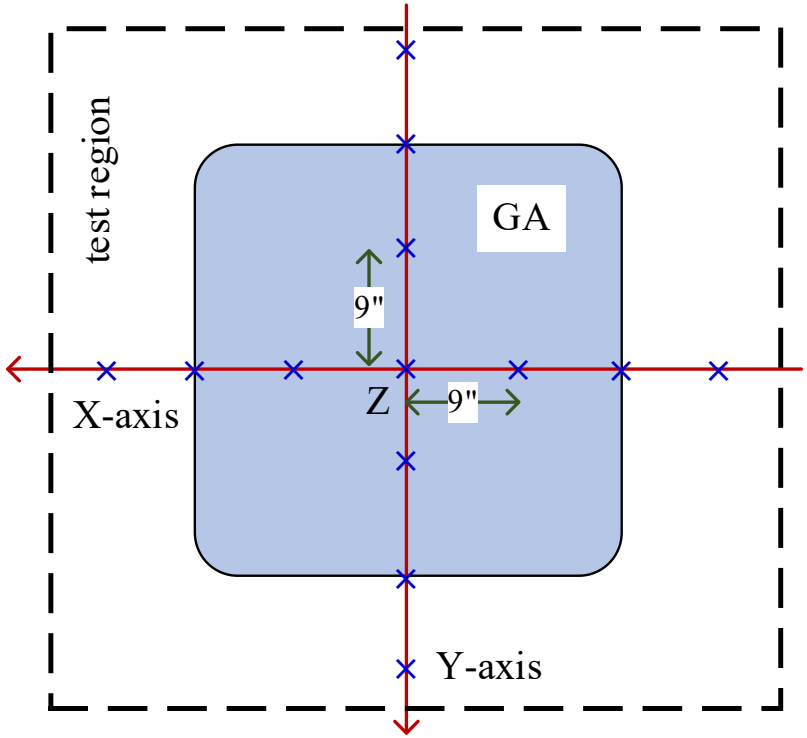


https://www.narda-sts.com/en/
http://www.eenewsautomotive.com/news/one-test-system-analysing-electromagnetic-fields-5-hz-60-ghz

Assessment of EMF based on Near Field Measurement

✓ Test Set-Up

- Defining coordinates
- Defining a marked safety perimeter
- Conducting EMF measurements in X, Y, and Z directions over and around the GA coil.



Assessment of EMF

✓ J2954 Standard Exposure Limits (2010 ICNIRP guidelines)

- **Human Exposure**
  - General public
  - Occupational

✓ EMF Standard Limits

- **Basic Restrictions**
- **Reference Levels**

Ref. Limits for General Exposure

Magnetic Field Limit	Electric Field Limit
B_{peak} (μT)	E_{peak} (V/m)
38.2 (27 RMS)	117 (83 RMS)
38.2 (27 RMS)	117 (83 RMS)

Ref. Limits for Occupational

Magnetic Field Limit	Electric Field Limit
B_{peak} (μT)	E_{peak} (V/m)
141.5 (100 RMS)	240.5 (170 RMS)
141.5 (100 RMS)	240.5 (170 RMS)

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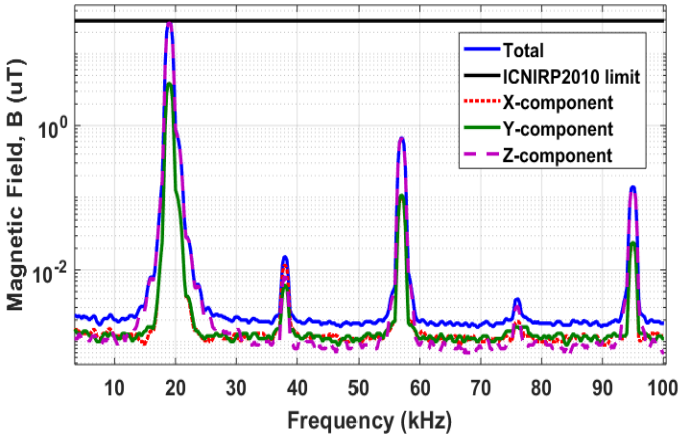
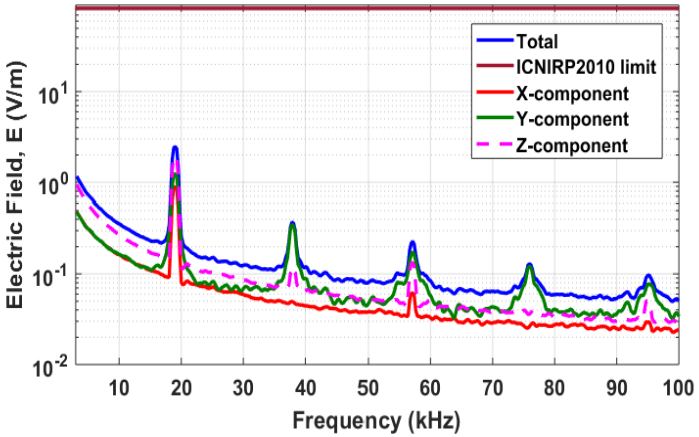
Results and discussion

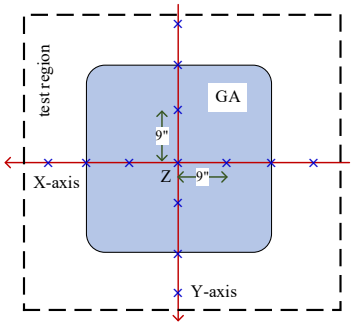
✓ Measured FFT for Magnetic and Electric Felids



(Height = 6.25” Measured FFT of magnetic fields at the center with 2 A coil current).

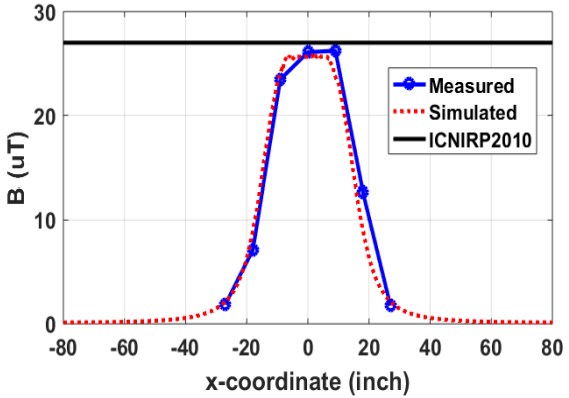


Measured FFT of electric fields at the center with 2 A coil current (Height = 6.25”).

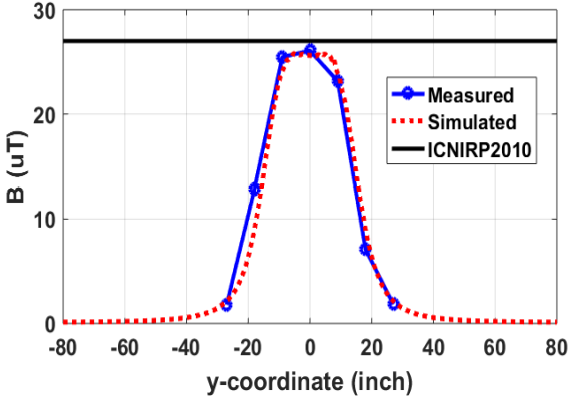


Results and discussion

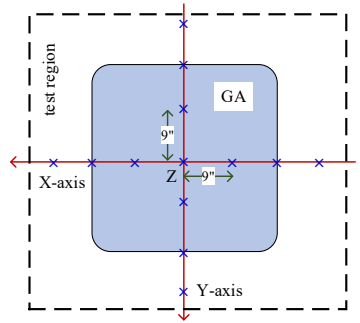
✓ Measured and Simulated Magnetic Field in XYZ Directions

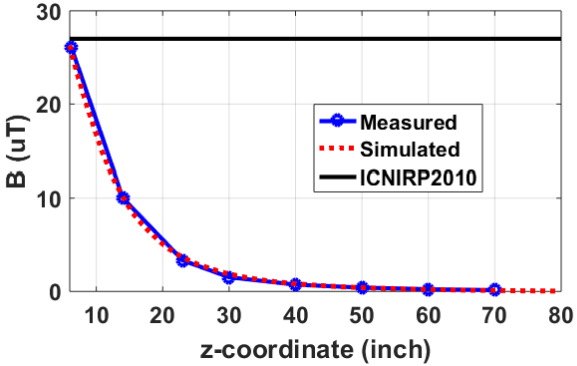


Measured and simulated maximum RMS value of magnetic field along x-axis at 6.25” height.



Measured and simulated maximum RMS value of magnetic field along y-axis at 6.25” height.

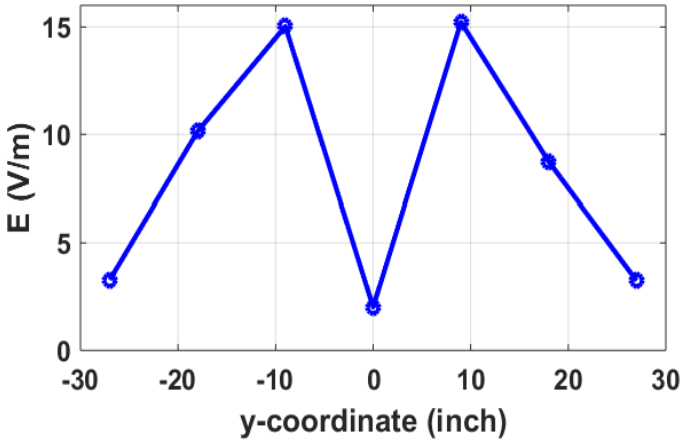




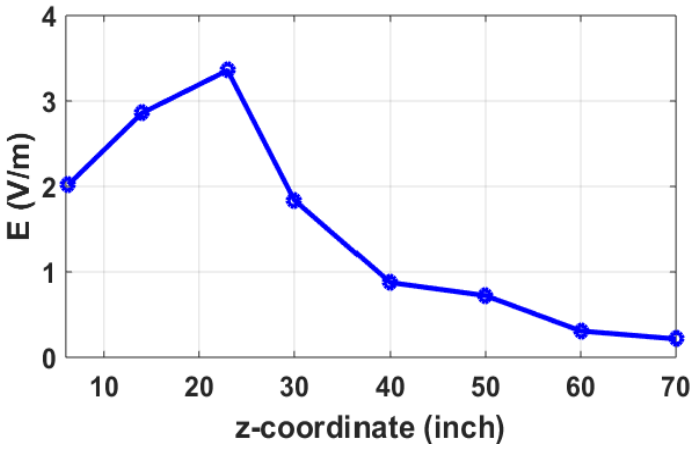
Measured and simulated maximum RMS value of magnetic field along z-axis at 6.25” height.

Results and discussion

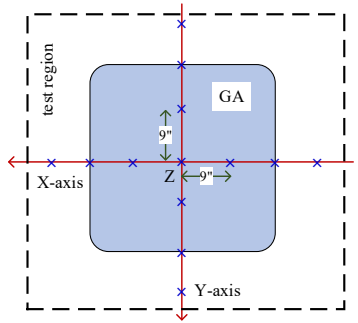
✓ Measured Electric Field in XYZ Directions



Measured maximum RMS value of electric field along y-axis at 6.25” height.



Measured maximum RMS value of electric field along z-axis at 6.25” height.



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Conclusion

- ✓ The paper presents a methodology to assess the human exposure to EMFs from GA during and before alignment.
- ✓ Magnetic and electric fields are evaluated while the system is working at low power excitation and the vehicle is not present.
- ✓ The EMFs are assessed based on both numerical analysis and measurements.
- ✓ The results show good correlation between experimental and simulated results.
- ✓ The magnetic field near the surface of the pad is significant and it is necessary to be evaluated.
- ✓ For the system under test, both the magnetic and electric fields are within the standards limits for human exposure

Thank you

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NREL/PR-5400-72242

This work was authored in part by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Vehicles Technologies Office. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

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