Wireless Power Charging: Stationary & Dynamic Applications
Oak Ridge National Laboratory (ORNL)

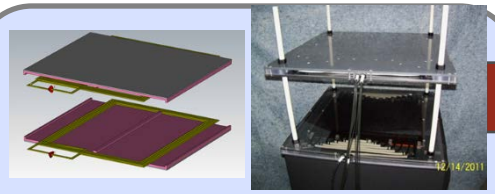
STATUS QUO

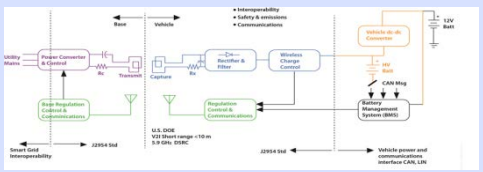
Graphic: Nissan Leaf Connector

SAE J1772 level 2 (3.3 kW – 19.2 kW) plug and 25 feet cable per NEC

- *240V_{ac}, 1j, 14A_{rms} → 80 A_{rms}*
- *Vehicle charging port, left: dc fast charge and right: ac level 2 power conn.*
- *Ac limited by on-board-charger (OBC) rating*
- *Dc direct to battery charging, EVSE limited*

NEW INSIGHTS



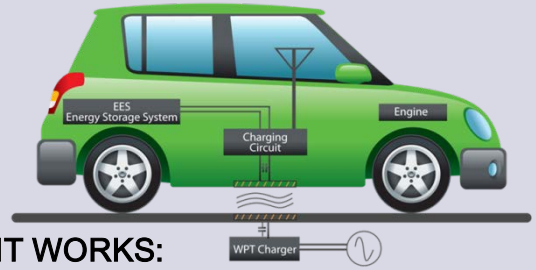


- **ORNL Coupling Coil Design** based on first principles electro-magnetic design. System design tailored to minimize vehicle complexity, cost and packaging.

WIRELESS POWER TRANSFER ACHIEVEMENT

MAIN ACHIEVEMENT:

- Non-contacting power transfer at SAE level 2 (3.3kW) over 250mm gap at >90% wall to load efficiency



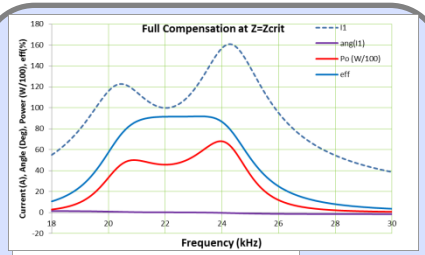
HOW IT WORKS:

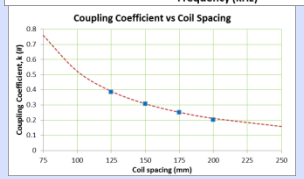
- A grid-tied high frequency (~20 kHz) power inverter energizes the primary coupling coil and establishes magnetic field that links the vehicle mounted coil.
- Capacitive tuning elements facilitate "magnetic resonance" power transfer to secondary coil.
- Rectified and filtered dc current is fed directly to the vehicle regenerative energy storage system, ESS
- Regulation of power flow to vehicle battery performed over the DSRC (IEEE 802.11p) wireless channel.

ASSUMPTIONS AND LIMITATIONS:

- ORNL advocates primary side regulation of WPT and DOT compliant dedicated short range communications (DSRC, 5.9 GHz) in the regulation loop.
- Loosely coupled tuned circuits introduce bifurcated response at light load and low coefficient of coupling that control algorithm for inverter (U_{d0}, ω, d) compensates.
- The vehicle WPT secondary coil aides alignment prior to power transfer phase.

QUANTITATIVE IMPACT





Broad efficiency plateau across wide frequency spectrum at high power

Controller dynamically adjusts for k-factor variation due to vehicle ground clearance and loading

END-OF-PROGRAM GOAL

Primary side regulation of WPT charging to SAE level 2, 6.6 kW

Maintains high transfer efficiency regardless of loading and gap

Scalable to high power for dynamic on-road charging (60 kW to >100 kW)

Budget: DOE VTP for stationary and ORNL LDRD funded dynamic charging

Transition Partners: are being solicited

Wireless power charging of electric vehicles is flexible, safe, convenient, and fully autonomous.