FIND YOURS.

Wireless Battery Charging: From your electric toothbrush to your lift truck – wireless charging will soon revolutionize your DC

Presented by:
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Cutting the Cord!

- Higher level of convenience
- More reliable charging
- No moisture concern
- No movable parts
Today This is Becoming Commonplace
Wireless Fundamentals

“I am becoming daily more convinced of the practicability of the scheme.”
– Nikola Tesla (1893)

Tesla Tower (1904)
Wireless Fundamentals

(a) Inductive Coupling

(b) Magnetic Resonance Coupling
Wireless Fundamentals

- Primary Coil
- Secondary Coil
- Power Controller
Primary Assembly:
- Battery management system
- Power Controller:
  - Wireless communication
  - Inverter
  - PFC
  - Control
- Secondary Assembly:
  - Positioning system
  - Wireless communication
  - Resonant receiver
  - Resonant transmitter
  - Wireless Communication
  - Foreign object detection
  - Living object detection

Vehicle Interfaces:
Benefits of Wireless

No cables and plugs
Easy to use

Drop in Solution
New or used vehicles

One charger
multiple trucks
Cost competitive

Easy opportunity
charge
Hands free automated charging

Agnostic
Works with all chemistries

Li or Pb
Benefits of Wireless

- **Drop in Solution**
  - New or existing vehicles

- **No cables and plugs**
  - Easy to use

- **One charger**
  - Multiple trucks
  - Cost competitive

- **Easy opportunity charge**
  - Hands free automated charging

- **Agnostic**
  - Works with all chemistries

- **Li or Pb**
Benefits of Wireless

- No cables and plugs
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- New or used vehicles
- One charger, multiple trucks
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- Easy opportunity charge
- Hands free automated charging
- Agnostic
- Works with all chemistries
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- Agnostic
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- No cables and plugs
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- One charger
  - Multiple trucks
  - Cost competitive
- Easy opportunity charge
  - Hands free automated charging

Agnostic
Works with all chemistries
Metal Object Detection

- Varying magnetic fields create currents
- These currents cause heat
- This is how induction cooking works!

Need to determine if metal exists in the magnetic field
Foreign Object Detection

• Under normal operation, the magnetic field is produced by the primary

Power received = Power sent − Inefficiencies

• If an object is present, energy will be absorbed by the object

Power received = Power sent − Inefficiencies − Attenuation
Speed

Primary

Secondary
Speed

Primary
Speed

Primary
Speed

- Use multiple coils
- Tolerance on field strength
- Automatic guidance
- Assisted guidance
Safety

• Magnetic fields will dissipate $1/R^2$
• Currents from induced fields are minimal
• Effects on biology are minimal outside of field
Safety

- Optimized coil design
- Higher coupling factor
- Modeling magnetic fields to minimize leakage
Regulations

- **SAE J2954: Wireless Charging Standards Electric Vehicles**
  - TIR SAE J2954/2 establishes an industry-wide specification guideline that defines acceptable criteria for the interoperability, electromagnetic compatibility, minimum performance, safety and testing for wireless power transfer (WPT) of electric and plug-in electric heavy-duty vehicles.

- **IEC 61980: Electric vehicle wireless power transfer systems (WPT)**
  - Part 1: General requirements Draft IEC/TS 61980-2 Ed. 1.0
  - Part 2: Communication between EV and infrastructure with respect to wireless power transfer (WPT) systems, will be published 2017
  - Part 3: Specific requirements for the magnetic field power transfer systems

- **Field exposure:**
  - **ICNIRP**: Electric and magnetic field limiting exposure
  - **EN62311**: Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields.
Putting it all together

- 3 x 400/480Vac

- Convert incoming AC 60hz to high frequency 80-100khz
- Wall mount
- Adaptive control for maximize efficiency
- Zero Voltage Commutation (SiC semiconductors)
- Efficiency > 98%

Battery
Putting it all together

3 x 400/480Vac

Primary converter

Ground Coil

Vehicle Coil

Secondary converter

- Size: 15.7 x 15.7 inch (400 x 400mm)
- Flush mount grounded
- Compatible with smaller truck
- Magnetic resonance coupling
- FOD with infrared camera
Putting it all together

3 x 400/480Vac

Primary converter

Ground Coil

Vehicle Coil

Secondary converter

• Size adapted to the truck and ground clearance
  - Z = 100 to 150mm = 350 x 350 x 20mm
  - Z = 50 to 100mm = 200 x 200 x 20mm

• Embedded ultra sonic sensor for position assistance
Putting it all together

3 x 400/480Vac

Primary converter → Ground Coil → Vehicle Coil → Secondary converter → Battery

- Embedded in the battery
- Flat and robust design
- CANOPEN communication with the truck and battery
- High speed wireless communication with primary converter
For more information

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