Current status and outlook of stationary and dynamic wireless electric vehicle charging

Qualcomm Halo™ WEVC technology is licensed by Qualcomm Incorporated. Prototype charging systems are products of Qualcomm Technologies, Inc.
1. Vision for EV Charging
2. Complete System Solution
3. Interoperability Key Factors
4. Conclusions
A Vision for EV Charging - WEVC
Overview of Societal Trends

Global urbanisation
- 70% of world’s population will live in cities by 2050
  (World Health Organization 2014)

Infrastructure strain
- Total global vehicles increasing from 1.1bn today to 2.5bn by 2050
  (OECD Report 2012)

Air pollution
- Legislation and fines for pollution
  (Environmental Protection Agency – European Commissions)

Health costs
- Urban outdoor air pollution is estimated to cause 1.3 million deaths worldwide per year
  (World Health Organization)
EVs a Solution but with Barriers to Mass Adoption

**Benefits**
- Better energy economy
- Non-polluting
- Less noise
- Clean Streets

**Challenges**
- Lack of Standards
- Limited Range
- Time to Charge
- Ease of Charging

**Charging Ubiquity**
- Infrastructure Lag
- Charging Posts
- Trailing Cables
- Vandalism
Charging impact on battery size or/and range

- Smaller battery
- Less weight
- Less cost

Driving range = Battery's available energy / Vehicle's energy consumption

More driving range = More charging instances

Effortless wireless charging
• **Wireless EV Charging for a better driver experience**
  - Simple, effortless & convenient
  - Automatic hands-free charging
  - No cord to unplug, or steal
  - Unaffected by Water, Ice & Snow
  - Simple to package on EVs

• **Multiplicity of charging opportunities**
  - Charge little, often and everywhere
  - Simple to Deploy, no street clutter
  - Encourages intensive charging infrastructure
  - Reduce battery size and EV cost

**Interoperability is Key to Adoption and EV growth**
Complete System Solution
Our Complete Solution – All in one

IPT Magnetics & Power Electronics

Auxiliary: FOD, LOP, Positioning

Application - System integration

Standard

Regulatory Compliance

Communication
### Power Range

Each system is fully integrated into the vehicle

<table>
<thead>
<tr>
<th>Output Power</th>
<th>3.7 kW</th>
<th>7.4 kW</th>
<th>20+ kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Input</td>
<td>Single Phase</td>
<td>Single / Three Phase</td>
<td>Three Phase</td>
</tr>
<tr>
<td>Base Pad Size</td>
<td>Small - Medium</td>
<td>Medium - Large</td>
<td>Large</td>
</tr>
<tr>
<td>Vehicle Pad Size</td>
<td>Small</td>
<td>Small-Medium</td>
<td>Large</td>
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</table>
Standardization
Qualcomm are involved in ISO and IEC to cover both the infrastructure and the vehicle standardization.
Interoperability – Key Factors
Standardization Areas and Constraints

SAFETY CONSTRAINTS – Thermal and RF
- Foreign Object Detection
- Living Object Protection
- Circuit protection layers
- System control

INTEROPERABILITY REQUIREMENTS–
- Common Operating Frequency
- Magnetic interoperability between vehicle assembly (VA) and ground assembly (GA)
- Vehicle to charger communications
- Default alignment mechanism
- Agreement on VA and GA positioning in parking bay

COEXISTENCE –
- RF and EMC regulations
  - Vehicle Systems
  - Implantable Medical Devices
  - Communication Services

PERFORMANCE
- Power Levels (3.7, 7.4, 22kW)
- Efficiency
- Air gap (absolute and range) \([Z_1, Z_2, Z_3]\)
- Alignment tolerance
  Stationary, Semi-dynamic, Dynamic
Magnetic Designs
Comparison of Pad Magnetic Architecture

- **Circular**
  - + Low field emissions
  - − Large diameter for z-gap
  - − Low x/y tolerance

- **Solenoid**
  - − High emissions
  - − Shielding required

- **Solenoid**
  - + Good coupling
  - − High emissions
  - − Shielding required

- **Double D / DDQ**
  - + Low field emissions
  - + High Coupling
  - + Superior z-gap
  - + Superior x/y tolerance
Universal Base Pad
Bi-polar Base Pad - Qualcomm Halo™ WEVC Magnetics

Interoperable with circular/square coil, solenoid and Double D secondary pads

- Low field emissions
- Good coupling
- High coupling
- Superior z-gap range
- Superior x/y tolerance
- Interoperability with single coil pads
Different Magnetic Pad Designs Must be Supported

- Circular/Square Coil Secondary Vehicle Pad
- Double D & DD Quadrature Secondary Vehicle Pads
- Bi-Polar Primary Base Pad
- Single Coil Solenoid Secondary Vehicle Pad
Test Conditions – 3.7 and 7.4 kW Pad Topologies

**Circular (CR)**
- Vehicle Pad: 3.7kW@250x250mm
- Base Pad: 7.4kW@400x400mm

**Solenoid (Sol)**
- Vehicle Pad: 3.7kW@250x250mm
- Base Pad: 7.4kW@400x400mm

**Double D (DD)**
- Vehicle Pad: 3.7kW@250x250mm
- Base Pad: 7.4kW@400x400mm
- Base Pad: 7.4kW@340x270mm

**Bi-Polar**
- Vehicle Pad: 3.7kW@250x250mm
- Base Pad: 7.4kW@400x400mm

765x575mm
Test Result Summary

40% smaller 7.4 kW Double D Vehicle Pad performs as well as larger Circular Vehicle Pad

3.7kW@Z1max=160mm

7.4kW@Z2min=160mm

3.7kW@Z1max=160mm

7.4kW@Z2min=160mm
3.7 & 7.4 kW Magnetic Pad Options

About 40% reduction in DD pad size for same performance as Circular pad

3.7 kW: 250mm x 190mm

7.4 kW: 340mm x 270mm
Semi dynamic and dynamic
## Evolution from Stationary to Semi and Dynamic

<table>
<thead>
<tr>
<th></th>
<th>Stationary (*)</th>
<th>Semi&amp;Dynamic (**)</th>
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<tbody>
<tr>
<td><strong>Frequency</strong></td>
<td>85 kHz</td>
<td>85 kHz</td>
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<tr>
<td><strong>Power Classes</strong></td>
<td>3.7 / 7.4 / 22 kW</td>
<td>10 / 20 / 40 / 200 kW</td>
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<tr>
<td><strong>Offset Tolerance (x/y)</strong></td>
<td>±75 / ±100 mm</td>
<td>Not relevant / ±200 mm</td>
</tr>
<tr>
<td><strong>Magnetics (vehicle side)</strong></td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
</tbody>
</table>

(*): Based on worldwide standardization  
(**): Proposal for FABRIC project (currently, there are no standards specifying requirements for dynamic charging)
Conclusions
Conclusions

- Bipolar base pad can fulfill requirements as interoperable solution for infrastructure

- Future semi dynamic and dynamic systems should be interoperable with stationary solutions

- The testing demonstrated that a single universal primary base pad could effectively transfer power to different kinds of secondary vehicle pads, different power levels and different Z heights.

- It was possible to reduce the Double D Vehicle Pad size by more than 40% and still reach better performance than the Circular VP
Driving adoption of new technologies for EVs: Qualcomm HALO WEVC

Enhancing the connected fan experience
Thank you

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