**Integrated Onboard Plug-In Chargers for Next Generation Electric Vehicles**

Yichao Tang, Chuan Shi, Pedro Pena, and Alireza Khaligh

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**Level 1 & 2 On-board Chargers**
- Power: 1kW – 19.2kW
- Voltage: 120 – 240Vac
- Typical Use: Home or office

**Level 3 Off-board Chargers**
- Power: 20kW – 100kW
- Voltage: 208 – 480 Vac or 600 Vdc
- Typical Use: Commercial charging station

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**Future Work: Level 2 & Level 3 Integrated On-Board Chargers**
- Integrate/Utilize onboard power electronics
- Increase power density
- Introduce a transformative universal solution for all level 1, level 2 & level 3 charging
- Enhance charging efficiency
- Utilize benefits of wide band-gap devices

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**Charger System Diagram**

**Design Challenges**
- Wide range of battery voltages
- High efficiency especially at light load
- Power density
- Compatibility with universal Grid
- Low EMI

**System Constraints**
- Charging standards
- Charger size
- Grid impact (low THD)

**Level 2 On-board Charger**
- Power Density, Efficiency, Reliability
- Cost, Volume & Weight

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**Prototype and Results**

**Technical Methods**
- Control stage
  - DSP controller
  - Digital control system

**First stage**
- Boost active PFC topology
- Interleaved technology

**Second stage**
- CLLC resonant converter
- Electromagnetically integrated transformer

**Experimental Results: 7.6 kW Charger**
- PFC: 0.999
- THD: 3.61%
- Frequency Range: 151kHz – 195kHz
- Output Voltage Range: 200V – 420V
- Voltage Ripple: 3%
- Input Current Ripple: 2%

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