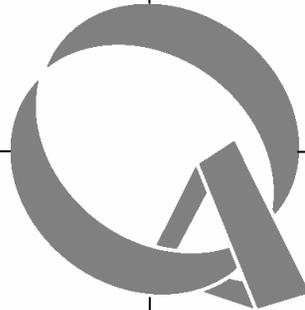
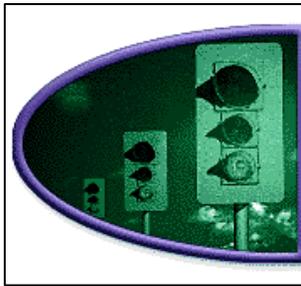


115 VAC Battery Charging for Electric Drive Vehicles

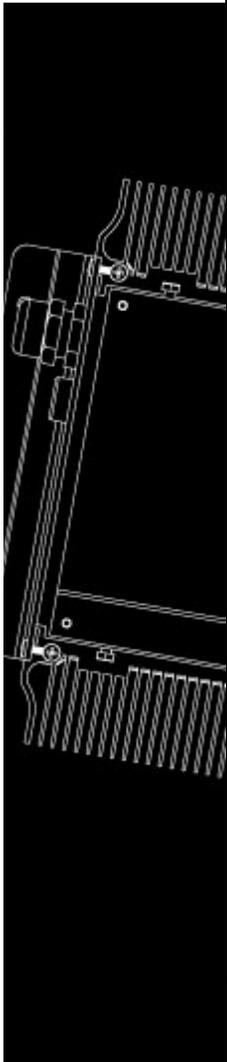
Presented to
ZEV Technologies Conference
25-27 September 2006

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Introduction

Electric Drive Charge Requirements

Early Chargers

Present-day Chargers

Future chargers

Presentation Overview

Electric Drive Charge Requirements

Early/Traditional Chargers

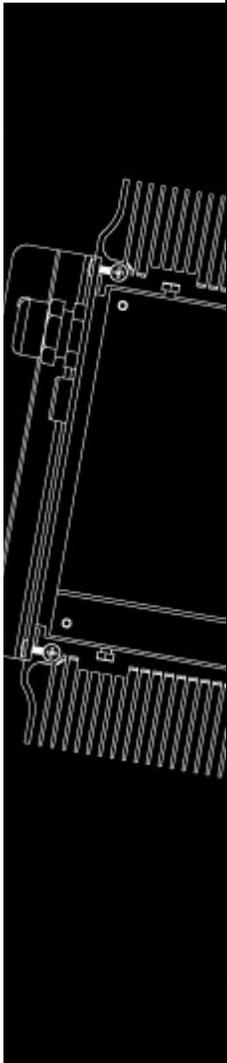
Present-day Chargers

Chargers for the Near Future





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Typical Electric Drive Charger

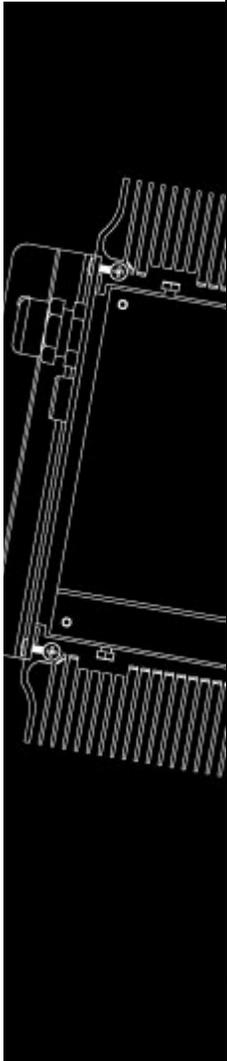
- Majority of applications (>300,000/year) are battery operated industrial equipment and electric utility vehicles not on-road battery electric vehicles (BEV)
- ~1kW power level plugged into 115VAC (Typical domestic power outlet) Intelligence to work within Time of Use requirements
- Typically 24-72V, ~10kWh lead-acid battery pack to be charged overnight
- Trend from off-board to on-board charging enabled by high frequency (HF) Technology





Electric Drive Applications

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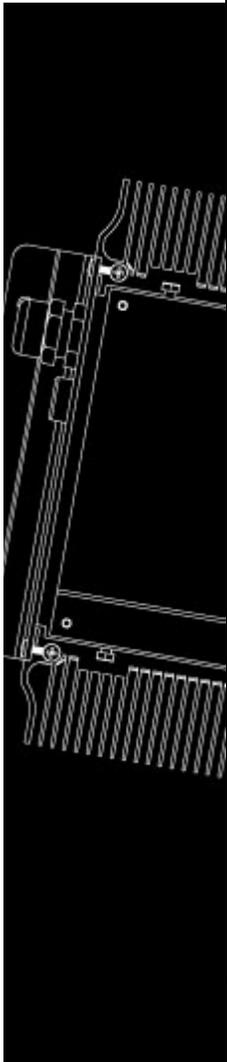


Battery Charging Solutions

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Off-board chargers in fleet application



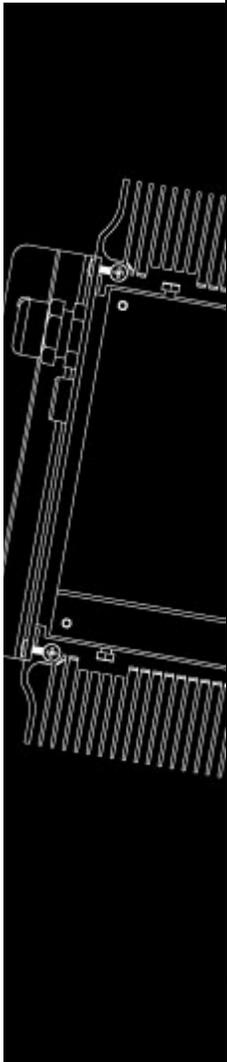


Battery Charging Solutions

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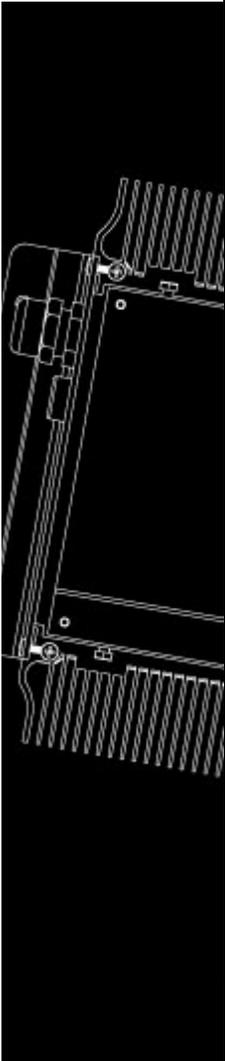


Early onboard application





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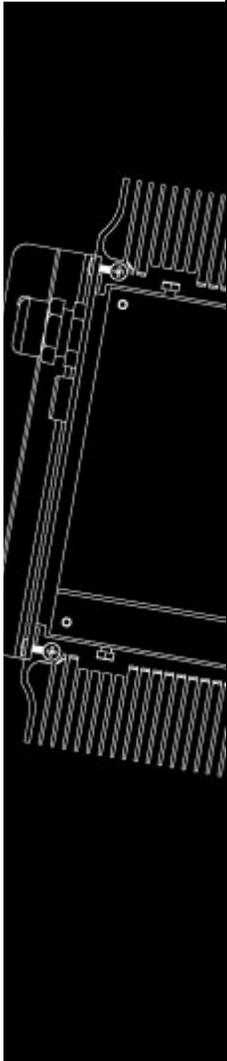


Design Factors for Onboard Charging

- Space
- Weight
- Reliability
- Cost
- Thermal Efficiency
- Cabling
- Maintenance
- Ease of Use
- Charge time



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HF Switchmode Technology

Space – typically $\frac{1}{4}$ volume of low or line frequency (LF)

Weight – typically $<\frac{1}{4}$ weight of LF

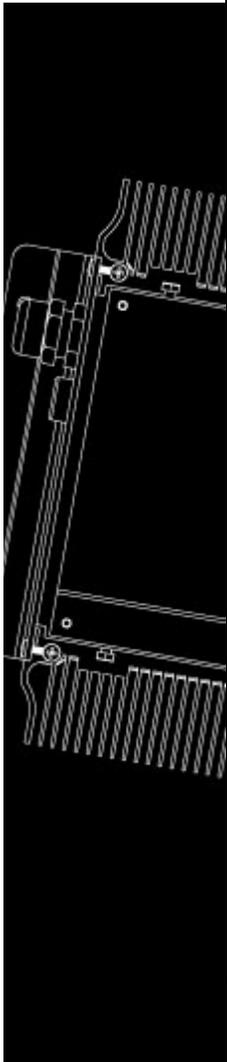
Reliability – HF technology is maturing, $>50,000$ hours MTBF

Cost – Silicon/microprocessor dominant design vs. line frequency transformer copper and iron

Thermal Efficiency – HF allows for sealed convection cooling or active cooling



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HF Switchmode Technology

Cabling – HF capability can include interlock, battery temp monitoring, communications, drivers for SOC and SOH display

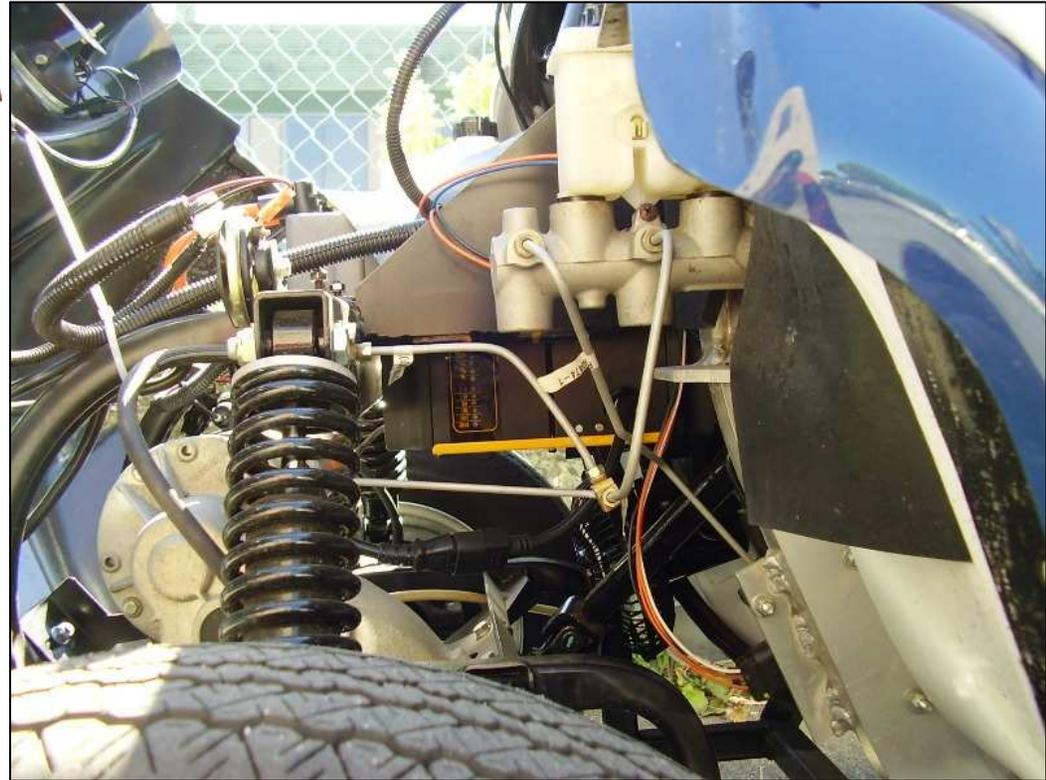
Maintenance – sophisticated charge algorithms optimized for battery type and minimum charge times

Ease of Use – plug and play, active PFC, universal AC input

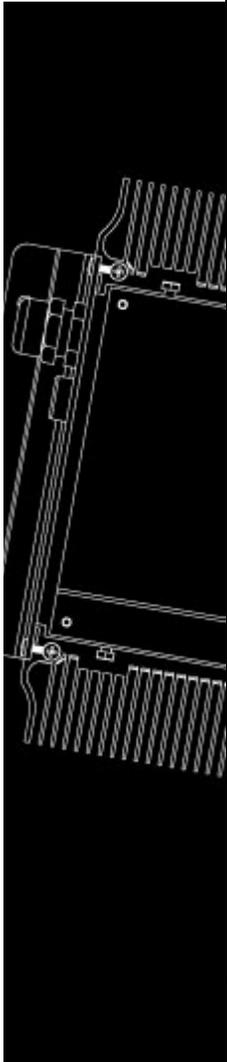


Battery EV Charger

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Onboard application using HF charger





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Introduction

Electric Drive Charge Requirements

Early Chargers

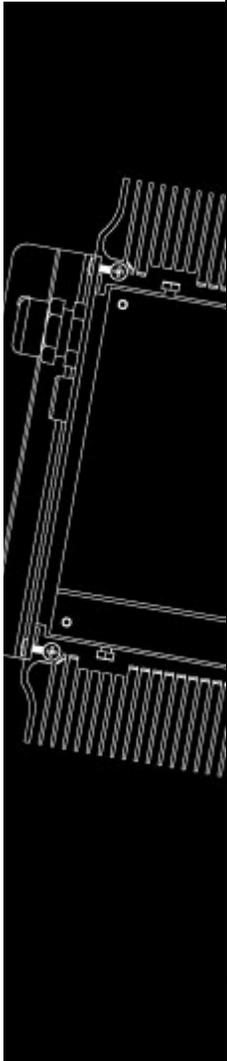
Present-day Chargers

Future chargers

Plug-in HEV Charger

EnergyCS™ Prius Conversion

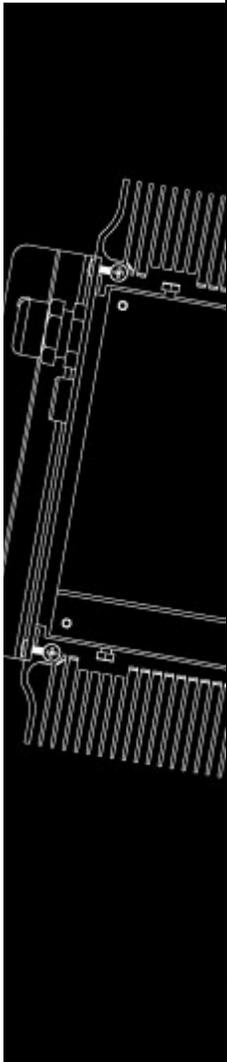
- ~1000W, 250V
- Universal I/P, .99 PF
- Sealed construction, high efficiency
- Li (Valence) batteries





HF Charger Solutions – Near Future

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- Integrated packaging solutions for mutual cooling/heating of charger and battery pack
- Integrated electrical solutions: 12V DC-DC for either auxiliary supply (BEV) or to power 12V systems when charging/key-off (PHEV)
- Intelligence to work within Time of Use requirements
- Integrated control or PLC communications to accommodate load shedding by utility
- Communications and ID systems to enable single subscriber billing for charging away from home



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