AZD Power Electronics for Hybrid Vehicles

June 13, 2011
Agenda

> Azure Dynamics Background
> P/HEV and EV Products
  > P/HEV Balance
  > Transit Connect Electric
  > LEEP Lift
> Power Electronics
> V2G considerations
Who is Azure Dynamics?

> Azure Dynamics is an industry leader in hybrid electric and electric powertrain solutions in the commercial vehicle segment
> ~ 20 years in this industry
> Locations in Detroit, Boston, Vancouver & UK (total employees ~ 160)
Broad Range of Applications

We drive a world of difference
PHEV Balance Hybrid

- 14 kWh Li-Ion battery (nominal = 346 V)
- Electric drive motor cont. power ~ 50 kW
- >20 mile electric range (blended)
- Acceleration rates within ~ 10% of stock veh.
- Level 1 & 2 Smart charging capability
- Charge time (240V) ~ 4 hours

Azure’s PHEV product offer the following features:

- Engine Idle Off
- Urban Electric drive Performance
- Electric launch assist (PHEV and HEV mode)
- Regenerative braking
- Electric A/C – chassis cab and body
- Automatic conventional mode redundancy
- Electric power steering and brake assist
2011 MY Balance Hybrid Technology

Advancements to AZD Industry Leading V8 Belt Starter Generator - integrated electric Clutch - motor can spin auxiliaries with Engine off - Approx 6 kw continuous

JCS Li Ion PHEV battery Pack
14 kwh
HEV Pack 2.4 kwh

65,000 BTU Electric A/C compressor – AZD Force Drive inverter controlled (for Shuttle bus)

AZD Force Drive inverters:
- Traction – (600 amp)
- FEAD – (400 amp)
+ 3.3 kw charger

Traction Motor:
- 50 kw continuous; 625 nm peak torque

We drive a world of difference
PHEV Balance

We drive a world of difference
Transit Connect Electric

Transit Connect electric
Driving a world of difference in a light-duty electric vehicle.

- 28 kWh Li-Ion battery (nominal = 346 V)
- Electric drive motor cont. power ~ 57 kW
- 80 mile electric range UDDS
- Level 1 & 2 Smart charging capability
- Charge time (240V/30A) ~ 8 hours
Lessons Learned – Ideal Platform for an EV

UDDS Energy Distribution

US06 Energy Distribution

We drive a world of difference
LEEP Lift

System Benefits are:

- Significant fuel and emissions savings
- Anti-idle compliance
- Engine-off boom operation
- Engine-off 12V DC Supply
- Reduced overall engine maintenance
- Excellent fault tolerance
- No-little impact to normal packaging space
- Modest impact on payload

Options

- Plug-in recharging capable
- 2 kVA 115 VAC export Power
- 750 Watt 12V Blocks of power
PHEV Balance Hybrid Pack

- Liquid Cooled, 14 kWh system
- 346 V nominal
- 96 x VL41M cells
- Unique housing utilizing carry-over components:
  - Core Electronics (BMU, CSC and Trace Board)
  - EM12B Module; Coolant Manifolds
  - HV / LV Connectors; Service Disconnect
  - Contactors; Pre-charge Resistor

"We drive a world of difference"
Transit Connect Electric Pack

- Liquid Cooled, 28 kWh system
- 192 x VL41M cells
- 2 parallel strings of 96 cells
- 346 V nominal
- Unique housing utilizing carry-over components:
  - Core Electronics (BMU, CSC and Trace Board)
  - EM12B Module; Coolant Manifolds
  - HV / LV Connectors; Service Disconnect
  - Contactors; Pre-charge Resistor

- DESIGN LIFE – 10 Years; 120,000 Miles
Flagship Components
Our components are based on over 15 years of development and field experience

Digital Motor Controllers (DMOC)
- Ground-up design
- Three power levels (120 kVA, 80 kVA, 20 kVA)
- All digital field oriented control
- Space-vector PWM
- Thermal management (air and liquid cooled)
- Over and under-voltage protection
- Three level over-current protection

DC-DC Converters
- Voltage source and battery charging
- Isolated power transfer
Power Electronics

Our latest generation components are designed to meet the stringent requirements of commercial fleets.

- Life: 20,000 hours
- EMC:
  - EU specifications 2004/104/EC
  - Ford ES-XW7T-1A278-AC
  - GM3097
- IP65/IP67
- Chemical: SAE J1455
- Vibration: ISO 16750-3
Gen-II Characteristics

- Max AC current: 420 Arms
- Max DC voltage: 400 VDC
- Coolant: 55C @ 10l/min
- Weight: 21 kg
- Volume: 25 L
- AC Motor Control Algorithms
- Derivability Algorithms
- CAN Interface
- UDS for Diagnostics

DMOC645-LC
**Gen-III Drive Characteristics**

- Nominal peak power: 150 kW
- Max voltage (non-operating): 550 V – up from 450V
- Max operating voltage: 450V – up from 400 V
- Max output current: 420 Arms - unchanged
- Rated current: 200 Arms, at 10l, 65C coolant – up from 55C
- Weight: 15 kg – down from 21 kg (DOE: 12 kW/kg)
- Volume: 10 L – down from 25 L (DOE: 12 kW/L)
- Cost: 40% reduction
- ISO 26262 compliant (Functional Safety)
- Complete Ford EMC compliance
V2G Considerations

> V2G components must be robust to meet on vehicle environmental; EMC; Safety; performance requirements
> P/HEV and EV’s are already cost challenged – V2G must provide economic return
> What is the best way to integrate – standalone or with drive inverter & motor? Some level of integration is preferred for lower cost, weight and robustness
> What is the new design life requirements for all affected components – already a 20,000 hr requirement without considering V2G?
> Vehicle availability for EV’s – when to charge/discharge?
> Standardized communications and smart grid readiness
> How will battery life be affected?
Lessons Learned – Opportunities to Support Wider EV Adoption

EV range and infrastructure continue to limit widespread adoption

> There is no single answer => focus on all of the following areas will improve EV adoption:
  > Battery advancements
  > Vehicle and electric drive efficiency gains
  > Fast charging infrastructure - mitigate need of on-board energy
  > V2G and Smart charging - improve Cost of ownership
  > Range extender and PHEV options