HIGH PERFORMANCE 800V E-MOTOR
FOR AUTOMOTIVE APPLICATION

Katrin Wand
AVL Trimerics GmbH
Public
800 V DRIVES FOR HIGH PERFORMANCE ELECTRIC POWERTRAINS

AVL SOLUTION FOR ALL CUSTOMER SEGMENTS

AVL E-Drive Core Competences

E-motor

EMC

Control

Power Electronics

Passenger Cars  2-Wheelers  Racing

Construction  Agriculture  Commercial Vehicle

Locomotive  Marine  Power Plants
800 V DRIVES FOR HIGH PERFORMANCE ELECTRIC POWERTRAINS

Target Specification

**AVL Coupe-e 800**
- 0-100 km/h in 5.7 s
- Maximum speed 185 km/h
- Rear Wheel Drive no transmission
- Charging AC 10 kW, DC 62 kW
- High performance 200 kW

**KAMAZ Delivery Truck 12 tons**
- 90 km/h
- 20% grade ability at full load
- Zero emission range 60 km
- No reduction of pay load
- Continuous power ≥ 140 kW

Drive Faster

Work Harder
**800 V DRIVES FOR HIGH PERFORMANCE ELECTRIC POWERTRAINS**

**VOLTAGE LEVEL VERSUS ELECTRIFICATION LEVEL AND POWER**

**Peak power of E-Motor**

- **~250 kW**
  - 250A
  - $U_{\text{max}} < 890 \text{ V}$
  - 1200 V IGBT

- **~120 kW**
  - 250A
  - $U_{\text{max}} < 475 \text{ V}$
  - 600 V IGBT

- **30 kW**
  - 250A
  - $U_{\text{max}} < 120 \text{ V}$
  - MOSFET

- **10 kW**
  - 250A
  - 48 V

**System Modules**

- **800 Volt System Modules**
800 V DRIVES FOR HIGH PERFORMANCE ELECTRIC POWERTRAINs

SYSTEM WEIGHT, PACKAGING AND COSTS FOR SAME POWER

WEIGHT & PACKAGING

- Connectors, power cables

Reduction of 10 – 12 kg possible
Advantage in packaging due to reduced cable bending radius

COSTS

- Semiconductors, connectors, power cables

Outlook: Cost per kW-Power @ 800 V < Cost per kW-Power @ 400 V

AVAILABILITY

- Electronics, traction drives, auxiliaries

Less available for 800 V
→ new business opportunity!
800 V DRIVES FOR HIGH PERFORMANCE ELECTRIC POWERTRAINS

CHARGING SPEED AS A DECISIVE FACTOR

More important than charging power (kW) is the range profit per minute (km/min):

- **Gasoline**: 500 km/min
- **400V-Tesla-System**:
  - Power: 120 kW
  - Limitation: 300 A Connector
  - Speed: 9 km/min
- **800V-System**:
  - Power: 220 kW
  - Limitation: 3.0 C-Rate
  - Battery: 91 Ah
  - Speed: 27 km/min
800 V DRIVES FOR HIGH PERFORMANCE ELECTRIC POWERTRAINS

HM132-250-090: 800 V PERMANENT MAGNET SYNCHRONOUS MOTOR

Designed for 750 V DC, therefore a high power of 250 kW can be provided

Direct oil cooled stator

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power @ 750 VDC (cont./short time 15 s) kW</td>
<td>160 / 250</td>
<td></td>
</tr>
<tr>
<td>Torque (cont./15 s)</td>
<td>Nm</td>
<td>500 / 770</td>
</tr>
<tr>
<td>Efficiency</td>
<td>%</td>
<td>up to 98%</td>
</tr>
<tr>
<td>Total e-motor length</td>
<td>mm</td>
<td>380</td>
</tr>
<tr>
<td>Diameter e-motor</td>
<td>mm</td>
<td>270</td>
</tr>
<tr>
<td>Total e-motor weight</td>
<td>kg</td>
<td>86.5</td>
</tr>
<tr>
<td>Rotor inertia</td>
<td>kg m²</td>
<td>0.102</td>
</tr>
<tr>
<td>Maximum speed</td>
<td>rpm</td>
<td>9,000</td>
</tr>
</tbody>
</table>
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HM132-250-090: 800 V PERMANENT MAGNET SYNCHRONOUS MOTOR

Torque-speed characteristics for continuous and short time operation
Continuous and short time operation for 15 s depends strongly on cooling system
800 V DRIVES FOR HIGH PERFORMANCE ELECTRIC POWER TRAINTS

HM132-250-090: 800 V PERMANENT MAGNET SYNCHRONOUS MOTOR

Oil cooling of stator while rotor stays dry

1. End windings cooling
2. Stator yoke cooling
3. Additional heat transfer at the slot openings
4. Dry rotor

Cooling Targets

- Prevention of critical thermal behavior at high load operation
- Direct heat dissipation at relevant motor locations
- Compact machine design
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AVL TOOLCHAIN – E-MOTOR ELECTRO MAGNETIC DESIGN

FEMAG

n, T, Tpp

EMAG

E-MOTOR ELECTRO MAGNETIC DESIGN
800 V DRIVES FOR HIGH PERFORMANCE ELECTRIC POWERTRAINS

AVL TOOLCHAIN – SHORT DEVELOPMENT LOOP E-MOTOR

Motor maps, $I_{ph}$

$\rightarrow L_d, L_q, P_{loss}$

$\rightarrow n, T, Forces$

$\rightarrow P_{loss}$

Temperature field

Stress, Eccentricity
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AVL TOOLCHAIN – FULL DEVELOPMENT LOOP E-MOTOR DETAIL DESIGN
800 V DRIVES FOR HIGH PERFORMANCE ELECTRIC POWERTRAIN

AVL TOOLCHAIN – SYSTEM INTEGRATION

Driving cycles & usage profile

$\Rightarrow n, T, P_{\text{loss}}$
E-drive cooling
Vehicle cooling

$\Rightarrow n, T, I_{\text{ph}}$
Drive line NVH

$\Rightarrow T_{\text{ppr}}, \text{forces}$

$\Rightarrow n, T, P_{\text{loss}}$
E-drive cooling

$\Rightarrow T_{\text{ppr}}, \text{forces}$

$\Rightarrow n, T, I_{\text{ph}}$

$\Rightarrow T_{\text{ppr}}, \text{forces}$

$\Rightarrow n, T, P_{\text{loss}}$

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$\Rightarrow T_{\text{ppr}}, \text{forces}$
800 V DRIVES FOR HIGH PERFORMANCE ELECTRIC POWERTRAIN

AVL 800 V BEV DEMONSTRATOR: COUP-E

**Coup-e 800**

**HV-Battery:**
- 180s/1p Pouch-Cells: 41 Ah
- Energy content (gross): 28 kWh

**E-Motor:**
- 210 kW (10 s) 700 Nm
- Dimensions: Ø 245 x 390 mm
- Direct fluid cooling

**System:**
- Operating Voltage: 750 V
- Continuous Power: 140 kW
- Free wheeling concept

**Coup-e 800: Powernet**
800 V DRIVES FOR HIGH PERFORMANCE ELECTRIC POWERTRAINS

KAMAZ DELIVERY TRUCK 12 TONS

Kamaz 4308 Chassis

HV-Battery:
- 180s/1p Pouch-Cells: 41 Ah
- Energy content: (gross) 28 kWh (net) 22 kWh
- Weight: 255 kg

E-Motor:
- 250 kW (10 s) 140 kW (cont.)
- 760 Nm (10 s)
- Dimensions: Ø 245 x 390 mm
- Weight: 85 kg
- Direct fluid cooling
- Gear box 3:1

Inverter:
- Operating Voltage: 750 V
- Continuous Power: 250 kVA
- Peak current: 600 A
- Dimensions: 472x280x182 mm

Powernet
SUMMARY

- **Increase of voltage level for high performance powertrains has advantages in**
  - Power density of e-motor and inverter
  - Cost and weight
  - Package
  - Reduced charging time

- **AVL has developed e-motors and inverter for 800 V which demonstrate these advantages**

- **AVL has build up and launched vehicles with 800 V power trains**

- **Challenges for 800 V power trains are**
  - Availability of e-drive components
  - Availability of auxiliaries

- **This offers new opportunities!**
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OUTLOOK

- Porsche has announced an electric sports car with 800 V

- Public granted research project in Germany HV-ModAL
  - Partners: BMW, Mercedes, Infineon, Bosch, AVL and universities
  - Modular and saleable electrified Powertrain for high Performance
  - Suitable for BEV, PHEV and truck applications
  - Evaluation of voltage levels from 100 V up to 900 V
  - Power from 50 kW to 250kW

Source: www.Porsche.com
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THANKS A LOT!
THANK YOU

www.avl.com