Magna Powertrain eDrive System: One-Stop-Shop for Hybrids and Electric vehicles

Drivetrain Forum 2016, Untergruppenbach
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Advanced Engineering
Objectives

Powertrain Electrification – global Market trends
Significance for supplier
Magna Powertrain Solutions
GLOBAL MEGATRENDS
Market Trends and Drivers
Powertrain Electrification

Legislation & Public Framework
- CO₂ requirements
- Local emission free requirements
- Fundings, promotions (monetary and non-monetary)
- Public charging infrastructure

Customer Expectations
- Affordable mobility
- Safety/reliability/freedom for long range trips
  - Quiet operation
  - Increasing demand of vehicle dynamic
- Awareness and sensitivity on clean environment and carbon footprint

Natural Resources
- Price of raw oil/fossil fuels and synthetic fuels
- Rare Earth price and availability
- Lithium
- Efficient use of resources

Technology
- Battery chemistry -> power density and price
- Charging technology
- Diversification in powertrain architecture

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Market Trends and Drivers
Increasing demand of vehicle dynamic

Increasing Vehicle Dynamic Demand (Torque, Power), Time Lag Less Responds and Increasing Power Density is met by Electrified Powertrains

Power density [kW/kg] vs. average acceleration [m/s²] for 0-100 km/h (all segments), trend / prediction 2002 – 2015 – 2025 (C-segment median values)
Market Enabler – Decreasing Battery Costs

When is the tipping point?

Estimates of costs of lithium-ion batteries for use in electric vehicles

- Future battery costs, estimated in studies
- Projection of cost development

Conventional ICE
- Battery cost decrease
- High Volume Production
- CO2 legislation
- Customer expectations

E-Mobility
- Low Oil Price
- Charging infrastructure

Source: Stockholm Environment Institute, SEI, Björn Nykvist and Mans Nilsson, 2015, complemented by Magna Powertrain
Market for Electric Vehicles
Disunity in Forecasts

Source: IHS, ICCT, Fraunhofer, TSR, Bloomberg, Just-auto, Goldman Sachs, LMC, Schäffler, Mahle, Bosch 2016
Significance

For Supplier

• New opportunities for entire drivetrain business
• High volatility in volume forecasts, SOP and requirements
• Need for flexibility in development and production
• Short time-to-market
• High capital expenditure requirements
Magna Powertrain Electrification Solutions

**Mild Hybrid**
- 48 Volt Mild Hybrid HDT
- Flex4™ AWD Disconnect or
- 48 Volt eAxle

**HV Hybrids / Plug-in**
- HV Hybrid HDT
- Highly integrated eDrive

**Electric Vehicles (Battery / Fuel Cell)**
- Highly integrated eDrive
Powertrain Electrification
High Voltage Electrification Platform Elements and Target Products

Standard platform elements
- Inverter
- Power Mechanics (Shafts, Differentials, Bearings, Sealings)
- Park Lock & Actuator

Scalable e-machine
- ASM Asynchronous Machine
- PSM Permanent Magnet Synchronous Machine

Opportunity for custom tailoring
- Housing
- Gears
- Connectors

Target Product Portfolio
- Highly Integrated eDrive System
- E-Motor and Gearbox
- eDrive Gearboxes
- Hybrid Transmission (GETRAG)

Software
- Motor Control
- Universal Complex Drivers, Base SW, Operating System, Comm. SW, Diagnosis
# Highly Integrated eDrive Platform (HV)

## E-Motor

<table>
<thead>
<tr>
<th>Scalable ASM</th>
<th>Scalable PSM</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 50 - 150 kW</td>
<td>• 120 – 250 kW</td>
</tr>
<tr>
<td>• Up to 18,000 rpm</td>
<td>• 16.500 rpm</td>
</tr>
<tr>
<td>• 3 or 6 phases</td>
<td>• 3 or 6 phases</td>
</tr>
</tbody>
</table>

## Gearbox eDrive/HDCT

- Modular gearboxes, differential, park lock, cooling, lubrication concepts

## System Integration & Validation

- Software Integration
- Vehicle Integration

## Platform Software

- Base Software: Complex Motor Management and Safety functions
- SW Sharing (Autosar)

## Inverter

- Modular concept with standardized components
- HV DC nominal operation voltage 350 - 420V
- with one power stage: Output Current 500A<sub>rms</sub>
- with two power stages: Output Current 2 x 480 A<sub>rms</sub>

## Applications

<table>
<thead>
<tr>
<th>Application</th>
<th>#1 50kW</th>
<th>#2 70kW</th>
<th>#3 100kW</th>
<th>#4 140kW</th>
<th>#5 140kW</th>
<th>#6 180kW</th>
<th>#7 260kW</th>
<th>HDT 68 - 80kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASM</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>PSM</td>
<td></td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inverter with one Power Stage</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inverter with two Power Stages</td>
<td></td>
<td></td>
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<td>●</td>
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</tbody>
</table>
Full System approach for NVH, thermal management and EMAG design
Vehicle dynamic experience (4WD), system know-how and vehicle integration capabilities
eDrive Platform Design & Validation
One-Source System Capabilities

NVH Simulation

Increment: 0.02, Frequency: 9610 Hz

Contour acceleration

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### Highly Integrated eDrive Platform

#### Power- / Power Density Matrix

<table>
<thead>
<tr>
<th>Low Power Density (2.5 – 3kW*/l)</th>
<th>Medium Power Density (3-4kW*/l)</th>
<th>High Power Density (5-6 kW*/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Platform low 50 – 100 kW*, ASM</td>
<td></td>
<td>B-Sample planned 2017</td>
</tr>
<tr>
<td>Platform mid 100 – 180 kW*, ASM/ PSM</td>
<td></td>
<td>A-Sample available</td>
</tr>
<tr>
<td>Platform high 180-260 kW*, PSM 6 phases</td>
<td></td>
<td>A-Sample ready by 1.Q/2017</td>
</tr>
</tbody>
</table>

* Peak Power for 20s @ nominal Voltage (360V), max. current 500A and Platform high 2x 480A
Objectives:
- Demonstrate eDrive product capabilities
- Proof system and vehicle Integration capabilities
- Vehicle controls: improved stability and handling
- Electronic Torque Vectoring (eTV)

Technical Data:

Front Axle: Highly Integrated eDrive System, with ASM
Peak power 140kW (for 20s)
Inverter (integrated) 500A_{rms}

Rear Axle: Highly Integrated eDrive System, 2 x ASM with summation gearbox, with axle lock clutch (eTV)
Peak power 280kW (for 20s)
Inverter (integrated) 2x480A_{rms}

Both drives: Liquid cooled Inverter, e-Motor stator and rotor
Enhanced thermal management
Rare Earth free
THANK YOU
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