A comprehensive system approach for future powertrain electrification

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Electrification Portfolio of Magna Powertrain
Driven by CO₂ legislation and market pull, the share of electrified Powertrains will increase strongly within the next decade.
What are the challenges?

- Cost & Value
- Peak Power & Continuous Power
- Efficiency
- Package
- Power density
- Modularity & Scalability
**7HDT300 DCT vs. HDT Value Add**

**Key Features**
- No transmission length increase
- Minimized overall hybrid package
- Same interfaces as DCT

**BUILDING BLOCKS**

**Hybrid Modes**
- El. creep/drive: limited (20 - 30km/h) vs. possible (>130 km/h)
- Boosting/Generator: possible (diff. gears) vs. possible (diff. gears)

**Cost**
- Medium vs. high (Battery)

**Fuel Efficiency**
- NEDC: up to 22% vs. up to 26% (80%, 50km EV)
- WLTP: up to 16% vs. up to 19% (68%, 50 km EV)

Possibility for charging at standstill
-> Additional cost reduction potential (starter/alternator)
What are the challenges?
eDrive Systems: Power Ranges, Applications and Motor Type

### HV low power
- 50 - 100 kW<sub>peak</sub>

### HV mid power
- 100 - 180 kW<sub>peak</sub>

### HV high power
- > 180 kW<sub>peak</sub>

#### HV low power
- Small EVs/ AWD drive/ HEV
- Primary/secondary propulsion

#### HV mid power
- Primary propulsion

#### HV high power
- Primary propulsion

### Secondary Propulsion
- 48V boost/recup

#### Small EVs/ AWD drive/ HEV
- Primary/secondary propulsion

#### Primary Propulsion EV
- C/ D / SUV Segment

#### Primary Propulsion
- Premium/ Sportscar segment

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What are the challenges?
Interaction of Electrical Motors & Transmissions
Transmission impact on attributes of an electrical motor

- Two-speed transmissions are able to deliver more wheel torque at low speeds
- Gradeability will be significantly improved with same top speed
- Increased acceleration with smaller traction motor
- eMachine running in high efficiency region (extension of efficient area)

Additional costs for two speed transmission can be compensated by smaller electric motor/inverter and reduced required battery capacity/higher range.
Future role of transmissions in different architectures
What are the challenges?

- Cost & Value
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Package Challenge for eDrive Systems

Specific Requirements

**Location** – Vehicle Electrification Architecture
- xEV vs. HEV
- FWD vs. 4WD/AWD architecture
- Front axle vs. rear axle

**Function** of eDrive System
- HV primary vs. secondary axle
- 48V Boosting / Recup / TV / Traction Aid / eCreeping

**OEM Package Requirements**
- Vehicle/ Powertrain Platform

One-fits-all eDrive Product will not meet the needs of the market ➔ A smart modularization concept is required
What are the challenges?

- Cost & Value
- Peak Power & Continuous Power
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Why is the Traction Motor not an off-the-shelf Product?

<table>
<thead>
<tr>
<th>Operating Speed (min⁻¹)</th>
<th>0 – 35000</th>
<th>0 – 16000</th>
<th>1500 / 3000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Voltage (V)</td>
<td>36 - 52V</td>
<td>280 – 420V DC</td>
<td>400V AC</td>
</tr>
<tr>
<td>Weight (act. parts) (kg)</td>
<td>7kg (18kW cont.)</td>
<td>21kg (35kW cont.)</td>
<td>260kg (45kW cont., incl. housing)</td>
</tr>
<tr>
<td>Power density (kWₚ/kg)</td>
<td>2.5</td>
<td>1.7</td>
<td>0.17</td>
</tr>
<tr>
<td>Power density (kWₑ/kg)</td>
<td>3.5</td>
<td>3.3</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operating mode</th>
<th>Variable operations, Different driving cycles</th>
<th>Permanent up to periodic operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>Key to capture most recup. potential</td>
<td>Excellent efficiency is essential, since each percent yields to more range</td>
</tr>
<tr>
<td>Modulation method</td>
<td>Space vector modulation and/or over modulation, Expansion of field weakening area</td>
<td>Standard 3-phase sinusoidal activation</td>
</tr>
<tr>
<td>Operation time</td>
<td>Typical 8.000 hours</td>
<td>up to 100.000 hours</td>
</tr>
<tr>
<td>Environmental conditions</td>
<td>-40 °C … 150 °C</td>
<td>temperature requirements not demanding</td>
</tr>
<tr>
<td>Cooling method</td>
<td>Water cooling of stator and/or rotor; oil cooling</td>
<td>Cooling by air flow or water cooling</td>
</tr>
</tbody>
</table>
Increasing Power Density will also be a demand for electrical traction motors

Continuous increase of volumetric and gravimetric power density considering the efficiency needs is key.
What are the challenges?

- Cost & Value
- Peak Power & Continuous Power
- Efficiency
- Package
- Power density
- Modularity & Scalability
Full System approach for EMAG, inverter, gearbox, NVH, thermal design and management. Vehicle dynamic experience (4WD), system know-how and vehicle integration capabilities.
Integrating Modularity with Scalability to enable Economies of Scales and Flexibility
What are the challenges?

- Cost & Value
- Continuous Power
- Peak Power & Continuous Power
- Package
- Power density
- Efficiency
- Modularity & Scalability
Creating Solutions in the solution room

- **Cost & Value**
- **Peak Power**
- **Continuous Power**
- **Efficiency**

- **Package**
- **Weight**

- **HV Main Propulsion**
- **HDT**
- **HV Secondary eDrive**
- **48V Traction assist system**
How to set up Modules in an effective Way

### Inverter

<table>
<thead>
<tr>
<th>Component</th>
<th>Scalable and Modular?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Design</td>
<td>Yes, with fixed architecture and 75% of functions</td>
</tr>
<tr>
<td>Mechanical Design</td>
<td>Yes, within package restrictions</td>
</tr>
<tr>
<td>eDrive Control SW</td>
<td>Yes, architecture and 100% of functions</td>
</tr>
<tr>
<td>Vehicle Interface SW</td>
<td>No, must be customer specific</td>
</tr>
<tr>
<td>Safety Concept</td>
<td>Yes, overall concept for all products</td>
</tr>
<tr>
<td>IGBT modules</td>
<td>Yes</td>
</tr>
<tr>
<td>Cooling Concept</td>
<td>Yes, with restriction to concept and thermal protection functions</td>
</tr>
<tr>
<td>EMC Filters</td>
<td>Yes, scalable overall Concept</td>
</tr>
</tbody>
</table>

### Motor

<table>
<thead>
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<th>Component</th>
<th>Scalable and Modular?</th>
</tr>
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<tbody>
<tr>
<td>Electromagnetic design</td>
<td>Yes, with restrictions to efficiency, package and voltage</td>
</tr>
<tr>
<td>Cooling Concept</td>
<td>Yes, scaling depending on required continuous power</td>
</tr>
<tr>
<td>Isolation Concept</td>
<td>Yes, material selected depending on voltage and temperature</td>
</tr>
<tr>
<td>Sheet Material</td>
<td>Yes, standardized, cut is design specific</td>
</tr>
<tr>
<td>Magnet Material</td>
<td>Yes, with design specific shape</td>
</tr>
<tr>
<td>Copper Wire</td>
<td>Yes, when form and winding technology is fixed</td>
</tr>
</tbody>
</table>

### Gearbox and Housing

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<th>Scalable and Modular?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gearbox Architecture</td>
<td>Yes</td>
</tr>
<tr>
<td>Gear Ratio</td>
<td>No, dependent on customer requirements e.g. max speed</td>
</tr>
<tr>
<td>Gear Width</td>
<td>No, dependent on customer requirements</td>
</tr>
<tr>
<td>Differential</td>
<td>Yes, MPT Portfolio</td>
</tr>
<tr>
<td>Bearings</td>
<td>Yes, MPT Portfolio</td>
</tr>
<tr>
<td>Housing</td>
<td>Yes, with package restrictions</td>
</tr>
</tbody>
</table>

**Legend:**
- Fully modularized/standardized
- Partly re-use, with adoptions
- New design according the project specific requirements
Magna Demo Vehicle e1 Shows the possibilities for future eMobility

- Demonstrate different eDrive concepts for vehicle positioning
  - Various control strategies
  - Electronic Torque Vectoring
    - Improved longitudinal and lateral dynamics
    - Better vehicle stability for more safety
  - New AWD concepts
- Advanced Thermal Management system

**Front Drive System:**
Highly Integrated eDrive System,
1 x ASM
Peak power 160kW (20s)
Torque 3300Nm
Inverter 500A_{rms}

**Rear Drive System:**
Highly Integrated eDrive System,
Electronic Torque Vectoring (eTV) with axle lock clutch
2 x ASM
Peak power 320kW (20s)
Torque 6600Nm
Inverter 2x 500A_{rms}

Enables FUN TO DRIVE
THANK YOU FOR YOUR ATTENTION
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