Hybrid DCTs are ready to support future modular platform strategies

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Agenda

- Motivation
- DCT Transmission Family
- Hybrid Transmission Kit
- 48 V Comparison
- Plug-In Hybrid Solutions
- Summary and Outlook
## Requirements

### CO₂ Improvements
- High efficient powertrain
- Power-on-demand actuation
- Extended sailing functionality
- Pure electric driving
- Downsized engines

### Customer/OEM Needs
- Hybrid as must-have option
- New driving functionalities
- Easy scalability
- Easy adaptation
- No serviceability
- Real-world fuel savings
- Autonomous driving

### Costs
- Transmission kit
- Volume of scale
- Reduce rare earth materials

### Fun 2 Drive
- Increased launch performance
-Boosting
-Immediate reaction

### Functionality
- Shift-by-wire
-Park-by-wire
-In-a-box solution
-Integrated hybridization
Situation Today – Near Future:
- Various concepts (minor to medium volumes)
- Various hybrid power levels:
  - Mild hybrid (48 V with 15 kW) with significant volume demand
  - Full hybrid (220 V with 50 kW)
  - Plug-in hybrid (>360 V with 80 kW)
- Very high diversity on OEM requirements
- High cost (for piece price and development) due to low overall volumes

Target: One hybrid transmission kit, that can cover most of the needs
DCT Transmission Family
DCT Transmission Family

- **7DCT300**
  - Input torque up to 320 Nm
  - 7-speed + R with a gear ratio span of up to 8.5
  - Center distance of 188 mm and 197 mm
  - Dry weight of 67 kg

- **6DCT200**
  - Input torque up to 230 Nm
  - 6-speed + R with a gear ratio span of up to 8.0
  - Center distance of 183 mm
  - Dry weight of 61 kg
Common Hardware

• Wet nested double clutch
• TCU mounted to housing
• Electronics
  – Sensors
  – BLDC motors
• Clutch actuation and clutch cooling

Others

• Global manufacturing footprint
• Common software architecture
Hybrid Transmission Kit
Key Features

- Torquesplit architecture
- Scalable power level:
  - 48V hybrid up to 16 kW
  - Plug-in hybrid more than 80 kW
- E-machine:
  - Integrated and high-speed
  - Oil-cooled
  - Pre-assembled as tested unit
- Adjustable cooling flow (using the same electric cooling pump as the clutch cooling)
- Assembly of e-machine and inverter at GETRAG
Hybrid Modes

- Pure electric driving
- Extended sailing
- Recuperation
- Boosting
- Generator-mode / load-shift
- Charge@standstill
- Restart of internal combustion engine with torquesplit effect

Remark: Hybrid modes identical for 48 V Mild and Plug-in version
Hybrid Transmission Family 1/2

7HDT300 - 48V
• Based on 7DCT300
• E-machine connected to sub-transmission 2
• Additional weight of 21 kg
• Up to 1800 Nm pure electric output torque

6HDT200 – 48V
• Based on 6DCT200
• E-machine connected to sub-transmission 2
• Additional weight of 22 kg
• Up to 1500 Nm pure electric output torque
8HDT500 - 48V

- Based on 8DCT500
- E-machine connected to sub-transmission 1
- Additional weight of 22 kg
- Reinforced e-machine (more than 20 kW possible)
- Up to 2500 Nm pure electric output torque
Key Features

- No transmission length increase
- Minimized overall hybrid package
- Same interfaces as DCT
7HDT300 – Latest Design for 48 V

- Shift drum 2 motor
- E-machine
- 48 V inverter
- Shift drum 1 motor
- Clutch 1/2 actuation motor
48 V Comparison
48 V Comparison: Belt vs. Flanged vs. Integrated Solution

Belt Solution
- Air-cooled claw pole EM
- Belt connection to ICE
- Integrated inverter

Flanged Solution
- Water-cooled EM
- Flanged to transmission
- Stand-alone inverter

Integrated Solution
- Oil-cooled EM
- Integrated in gearbox
- Stand-alone inverter

Remark:
For simplicity reasons, only these three main-stream examples have been chosen
# 48 V Comparison: Belt vs. Flanged vs. Integrated Solution

<table>
<thead>
<tr>
<th></th>
<th>Belt Solution</th>
<th>Flanged Solution</th>
<th>Integrated Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EM-Performance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. torque</td>
<td>up to 50 Nm</td>
<td>up to 50 Nm</td>
<td>up to 50 Nm</td>
</tr>
<tr>
<td>Max. power</td>
<td>12 - 14 kW</td>
<td>up to 18 kW</td>
<td>more than 20 kW</td>
</tr>
<tr>
<td>Cont. power</td>
<td>2,5 - 3,5 kW</td>
<td>up to 8 kW*</td>
<td>up to 13 kW*</td>
</tr>
<tr>
<td>Efficiency</td>
<td>up to 85%</td>
<td>up to 94%</td>
<td>up to 95%</td>
</tr>
<tr>
<td><strong>Fuel Efficiency</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEDC</td>
<td>10 - 12%</td>
<td>17 - 20%</td>
<td>19 - 22%</td>
</tr>
<tr>
<td>WLTP</td>
<td>7 - 9%</td>
<td>12 - 14%</td>
<td>14 - 16%</td>
</tr>
</tbody>
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### 48 V Comparison: Belt vs. Flanged vs. Integrated Solution

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<th>Integrated Solution</th>
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</thead>
<tbody>
<tr>
<td>El. creep/drive</td>
<td>☐ not possible</td>
<td>☑ possible*</td>
<td>☑ possible*</td>
</tr>
<tr>
<td>Boosting</td>
<td>☑ limited</td>
<td>☑ possible</td>
<td>☑ possible</td>
</tr>
<tr>
<td>Generator</td>
<td>☑ possible</td>
<td>☑ diff. gears</td>
<td>☑ diff. gears</td>
</tr>
<tr>
<td>Drivability</td>
<td>☑ limited improvement</td>
<td>☑ strong improvement</td>
<td>☑ strong improvement</td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Package</td>
<td>☑ “easy”</td>
<td>☐ challenging</td>
<td>☑ possible</td>
</tr>
<tr>
<td>Efficiency</td>
<td>☑ belt-drive</td>
<td>☑ efficient</td>
<td>☑ very high</td>
</tr>
</tbody>
</table>
Integrated Solution Offers Much Better el. Driving Performance

Remark: The Flanged Solution is close to the Integrated Solution

Continuous Power of Belt vs. Integrated Solution

Drag torque range of typical combustion engines
Easy Scalability
Easy Scalability: From 48 V Mild up to 360 V Plug-In Hybrid

<table>
<thead>
<tr>
<th>EM-Performance</th>
<th>48 V System</th>
<th>360 V System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. torque</td>
<td>up to 50 Nm</td>
<td>&gt; 150 Nm</td>
</tr>
<tr>
<td>Max. power</td>
<td>more than 20 kW</td>
<td>&gt; 80 kW</td>
</tr>
<tr>
<td>Cont. power</td>
<td>up to 13 kW*</td>
<td>up to 35 kW*</td>
</tr>
<tr>
<td>Efficiency</td>
<td>up to 95%</td>
<td>up to 96%</td>
</tr>
<tr>
<td>Max. speed</td>
<td>18.000 rpm</td>
<td>18.000 rpm</td>
</tr>
<tr>
<td>Max. phase current</td>
<td>350 A</td>
<td>450 A</td>
</tr>
</tbody>
</table>

Changed stator windings and power connectors ensure easy scalability.
### Easy Scalability: From 48 V Mild up to 360 V Plug-In Hybrid

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<th>Hybrid Modes</th>
<th>48 V System</th>
<th>360 V System</th>
</tr>
</thead>
<tbody>
<tr>
<td>El. creep/drive</td>
<td>limited (20 - 30km/h)</td>
<td>possible (&gt;130 km/h)</td>
</tr>
<tr>
<td>Boosting/Generator</td>
<td>possible (diff. gears)</td>
<td>possible (diff. gears)</td>
</tr>
<tr>
<td>Cost</td>
<td>medium</td>
<td>high (battery!)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fuel Efficiency</th>
<th>48 V System</th>
<th>360 V System</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEDC</td>
<td>19 - 22%</td>
<td>26 - 80%</td>
</tr>
<tr>
<td>WLTP</td>
<td>14 - 16%</td>
<td>19 - 68%</td>
</tr>
</tbody>
</table>
Summary

- Hybrid transmission kit established for new DCT transmission family
- Easy scalability from 48 V up to Plug-In Hybrid
Modular Hybrid Transmission Kit also usable for MTs

Outlook

• The same hybrid transmission kit can also be used for MT
• Hybrid set-up:
  – MT gearbox with e-clutch
  – Integrated high-speed e-machine
THANK YOU FOR YOUR ATTENTION
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