All-Wheel Drive Mercedes-Benz SUV

Ralf Koesling, Daimler AG, Stuttgart

Co-Authors:
Volker Marx, Daimler AG, Stuttgart
Sven Stöhr, Daimler AG, Stuttgart
What drives us?
All-Wheel Drive
Mercedes-Benz SUV

1. 40 years SUV All-Wheel-Drive System
2. Technical Targets
3. All-Wheel-Drive Powertrain
4. GLE-Class Torque-on-Demand Transfer Cases
5. G-Class Transfer Case
6. Development Process and Validation
All-wheel drive system development in Mercedes-Benz SUVs of the last 40 years

- **Manually selectable AWD with open diff. (1979 to 2001)**
  - VG 080
  - VG 150
  - VG 2Sp

- **Permanent AWD with open diff. (1989 to present)**
  - VG 150E
  - ITC 2Sp
  - ITC+ 2Sp
  - ITC 1Sp
  - ITC+ 1Sp

**Torque-on-Demand AWD systems**
- TD116
- TD228
- FT46

<table>
<thead>
<tr>
<th>Year</th>
<th>Engine(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979</td>
<td>VG 080</td>
</tr>
<tr>
<td>1989</td>
<td>VG 150</td>
</tr>
<tr>
<td>1997</td>
<td>VG 2Sp</td>
</tr>
<tr>
<td>2005</td>
<td>ML (W164)</td>
</tr>
<tr>
<td>2015</td>
<td>ML/GLE (W166)</td>
</tr>
<tr>
<td>2018</td>
<td>GLE Coupé (C292)</td>
</tr>
<tr>
<td>2019</td>
<td>G (W463 new)</td>
</tr>
<tr>
<td></td>
<td>GLS (X167)</td>
</tr>
<tr>
<td></td>
<td>X (BR470)</td>
</tr>
<tr>
<td></td>
<td>GLE (V167)</td>
</tr>
</tbody>
</table>
All-wheel drive system development in Mercedes-Benz SUVs of the last 40 years

FT46
TD116
TD228
G (W463 new)
X (BR470)
GLE (V167)
GLS (X167)
Development goals of the new all-wheel drive systems

BR167 COMP. WITH BR166

- Longitudinal agility
- Rock climbing
- Sand
- Slippery surface
- Lateral dynamics
- Backlash effect
- Driving safety

BR166
BR167
Further objectives with regard to the vehicle integration of the transfer cases:

- Efficient operation with low drag torque
- Mercedes-Benz corrosion standards
- Damage-free endurance of the resulting peak torques
- Unobtrusive operation of the transfer cases
Further objectives with regard to the vehicle integration of the transfer cases:

- Efficient operation with low drag torque
- Mercedes-Benz corrosion standards
- Damage-free endurance of the resulting peak torques
- Unobtrusive operation of the transfer cases

- Improved comfort: reduced NVH in interior, damping of backlash effect
- On-road performance & off-road performance
The Mercedes-Benz SUV Drivetrain

- Rear prop shaft
- Automatic transmission
- Front axle differential
- Rear side-shafts
- Rear axle differential
- Transfer case
- Front prop shaft
- Front side-shafts
The Mercedes-Benz SUV powertrain modular strategy
The Mercedes-Benz SUV powertrain modular strategy
Torque-on-Demand transfer case

- Torque distribution: variable
- Clutch torque: 1,600 Nm nominal value
- Weight: 23.7 kg
- Lubrication concept: passive lubrication
- Oil capacity: 750 ml
- Maximum input torque: 2,800 Nm
- Maximum input shaft speed: 7,000 rpm
Torque-on-Demand transfer case
Torque-on-Demand transfer case

Specific drive torque distribution using various sensor signals, e.g.:

- Longitudinal acceleration
- Lateral acceleration
- Steering wheel angle
- Engine torque
- Vehicle speed
Torque-on-Demand transfer case
Torque-on-Demand transfer case with off-road gear
Torque-on-Demand transfer case with off-road gear

- Torque distribution: variable
- Clutch torque: 2,800 Nm nominal value
- Low range gear ratio: $i = 2.93$ by planetary gear set with 4 planets
- Synchronization: low-high shifting, synchronized
- Weight: 41.4 kg
- Lubrication concept: active lubrication by oil pump as well as passive lubrication
- Oil capacity: 1,500 ml
- Maximum input torque: 2,800 Nm
- Maximum input shaft speed: 7,000 rpm
Torque-on-Demand transfer case with off-road gear
Torque-on-Demand transfer case with off-road gear
Torque-on-Demand transfer case with off-road gear
Torque-on-Demand transfer case with off-road gear
Effect of TonD Load Collectives on Drivetrain

Damage comparison of similar vehicles of the 166 and 167 model series
Effect of TonD Load Collectives on Drivetrain

Comparison of revolutions at the front axle
Effect of TonD Load Collectives on Drivetrain

Comparison of revolutions at the rear axle

- BR166
- BR167
Effect of TonD Load Collectives on Drivetrain

Damage comparison of similar vehicles of the 166 and 167 model series

Comparison of revolutions at the front axle

Comparison of revolutions at the rear axle

Change of Damage

Rear Axle

Front Axle
40:60 transfer case with off-road gear

- Torque distribution: 40% / 60% by planetary gear set
- Clutch torque: 1600 Nm nominal value (longitudinal lock)
- Low range gear ratio: $i = 2.93$ by planetary gear set with 4 planets
- Synchronization: low-high and high-low shifting synchronized
- Weight: 50.8 kg
- Lubrication concept: active lubrication by oil pump as well as passive lubrication
- Oil capacity: 1,500 ml
- Maximum input torque: 2,800 Nm
- Maximum input shaft speed: 7,000 rpm
40:60 transfer case with off-road gear
40:60 transfer case with off-road gear
40:60 transfer case with off-road gear
40:60 transfer case with off-road gear
Development process and validation

Supplier

Concept & digital validation

Prototype generation

Off-tool parts

Off-process parts

Component Validation

Design

NVH simulations

CAx component validation

Component test rigs

Manufacturing

System Validation

Requirement specification

Design

NVH simulations

CAx vehicle validation

3M test rigs

VKM test rigs

Vehicle test drive

Vehicle endurance tests

Total test rig km around:
14 million km

Total vehicle km around:
13.25 million km

Total test rig km around:
7 million km
Thank you.