INTELLIGENT ACTIVE ROLL CONTROL

SHAUN TATE
Production Experience & Awards

Series Production – 12V

- BMW 7 Series 2015
- BMW 5 Series 2017
- RR Phantom 2018

Series Production – 48V

- Bentley Bentayga 2015
- Audi SQ7 2016
- Porsche Panamera 2017
- Porsche Cayenne 2017
- Bentley Continental 2018

Award-Winning System

- German Innovation Award 2016
- Vehicle Dynamics International Award 2016
- Auto Test Sieger 2016
- PACE Award 2017

Feature to Product Mapping

- Feature to Product Mapping

- Products
  - iARC

- Feature
  - Easy Loading
  - Easy Entry
  - Easy Parking

- Stationary Conditions
  - Reduce Ground Clearance
  - Reduce Wheel Load
  - Reduce Articulation
  - Reduce Load Leveling

- Adaptive Suspension Setup
  - Reduce Vertical Acceleration
  - Reduce Jitter Acceleration
  - ReduceYaw Acceleration
  - Reduce Steering Response

- Ride Comfort Improvement
  - Increase Articulation

- Agility & Stability
  - Easy Parking
  - Easy Entry
  - Easy Loading
  - Reduce Jitter Acceleration
  - Reduce Yaw Acceleration
  - Dynamic Body Roll Control
  - Traction Stability
### Market Trends & Features

1. **Trend 1:** SUV for improved comfort and agility
2. **Trend 2:** HEV/EV for improved comfort and system availability
3. **Trend 3:** Large Trucks/SUVs/Vans for improved comfort and more safety

### Selling Features Using Schaeffler iARC System

<table>
<thead>
<tr>
<th>Feature</th>
<th>Driving Dynamics</th>
<th>Comfort Features</th>
<th>ADAS Support L3 / Active Safety</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Active Body Roll Control</td>
<td>Dynamic Steering Ratio Control</td>
<td>Lane Change Assist</td>
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<tr>
<td>Sports Car</td>
<td>Off-Road Mode</td>
<td>Smooth Ride Control</td>
<td>Lane Departure Warning</td>
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<tr>
<td>Luxury Sedan / Coupe</td>
<td>Dynamic Yaw Stabilization</td>
<td>Low Speed Maneuverability</td>
<td>Emergency Braking</td>
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<tr>
<td>SUV</td>
<td>Dynamic Steering Ratio Control</td>
<td>Maneuverability</td>
<td>Lane Keeping Assist</td>
</tr>
<tr>
<td>Trucks / Off-Road Vehicle</td>
<td>Trailer Stability Control</td>
<td>Smooth Ride Control</td>
<td>Trail Quality Control</td>
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</tbody>
</table>
Dynamic Body-Roll Control

Control body-roll-angle relative to lateral acceleration, steering angle input and vehicle speed
Enhancing body-roll-control performance using roll acceleration, strut acceleration or suspension displacement signals
Supporting different tuning modes

Adaptive Self-Steering Behavior

Adaptation of roll-moment distribution through look-up tables (e.g. relative to vehicle speed)
Support of different tunes through mode selections
Enhanced performance opportunities through integration with ESC by adaptation of roll-moment-to-road-conditions or stability rating relative to dynamic vehicle reference model
Improved Ride Comfort & Off-Road Capabilities

- Reduction of copying behavior through wheel-force decoupling between left and right
- Increased suspension articulation through reduced-static-roll stiffness
- Enhanced dynamic comfort control using wheel acceleration and displacement sensors

System Evolution

<table>
<thead>
<tr>
<th>Generation 1</th>
<th>Generation 2</th>
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<tbody>
<tr>
<td><strong>Design 1</strong></td>
<td><strong>Design 2</strong></td>
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<tr>
<td>July 2015</td>
<td>November 2015</td>
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<tr>
<td>Launch BMW 7 Series 1st Generation</td>
<td>Launch Bentley Bentayga 1st Generation</td>
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<tr>
<td>12V</td>
<td>48V</td>
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<tr>
<td>900 Nm Torque Sensor Elastic Decoupling Unit Fully Integrated</td>
<td>1200 Nm 48V Torque Sensor Elastic Decoupling Unit External ECU</td>
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<tr>
<th><strong>Design 3</strong></th>
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</thead>
<tbody>
<tr>
<td>June 2020</td>
</tr>
<tr>
<td>Launch Generation 2 48V</td>
</tr>
<tr>
<td>1400 Nm Torque Sensor Elastic Decoupling Unit External ECU</td>
</tr>
</tbody>
</table>
Gen 2 Attributes

- Nominal voltage 48V
- CAN, CAN FD or FlexRay Communication
- Integrated torque sensor (optional)
- Integrated decoupling device (optional)
- Ø 91 x 311 mm (without bars)
- Total weight 12 kg + roll bars

Top Level Control Strategy

Body Roll
- Lateral Acceleration
- Steering Angle
- Vehicle Speed

Agility & Handling
- Torque Distribution
- iARC Front
- iARC Rear
- Front Speed & Angle
- Rear Speed & Angle

Comfort
- Wheel Motion
- Wheel Acceleration

- Roll Torque
- Front Torque
- Rear Torque
- Disturbance Observer
- iARC Front
- iARC Rear
Simulation Environment

Vehicle Level

- Vehicle / Chassis
  - Linear, non-linear
- Driving Maneuver
  - Constant Radius, Double Lane Change, ...
- Tire
  - Pacejka, F-Tire, ...
- Driver Type
  - economic, sport, ...

Subsystem Level

- Chassis Systems
  - iARC, iRHA, iRWS...

Teamwork

Chassis Controller for Simulation
- Low & High Level Controller

Simulation Vehicle Data

- Test Rig
  - Kinematic & Compliance (K&C)
- Converter
  - Conversion of K&C Data for Model
- Verification
  - K&C analysis in CarMaker™
Simulation Example

Simulation Example