BMW Driver Assistance Systems &
Active Safety Systems

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BMW Group
# Driver Assistance Systems & Active Safety

## Content

<table>
<thead>
<tr>
<th>Overview</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMW xDrive</td>
</tr>
<tr>
<td>Torque Vectoring: Dynamic Performance Control (DPC)</td>
</tr>
<tr>
<td>BMW Active Steering</td>
</tr>
<tr>
<td>System Integration: BMW Integrated Chassis Management (ICM)</td>
</tr>
<tr>
<td>Predictive Active Safety: Adaptive Brake Assistant</td>
</tr>
<tr>
<td>Further Driver Assistant Systems to</td>
</tr>
<tr>
<td>– improve perception &amp; interaction</td>
</tr>
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</tr>
<tr>
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</tr>
</tbody>
</table>
Driver Assistance Systems
Level of Safety and Comfort Functions

Active Safety
(Collision Avoidance)

Passive Safety
(Collision Mitigation)

Environment: weather, traffic guidance, traffic density
Driver: condition, perception, operation
Vehicle: handling characteristics

Safety
Comfort

Driver Instruction/-Information/-Warning

active
passive

RFT
DPC
DSC
DXC
AFS
LDW
ACC
ACC S&G
PMA
NiVi
LDW
ACN
Coll.-Mit. Braking
Coll.-Mit. Warning
Chassis Control and Driver Assistance Systems
Enhancement of Driver and Car

- Vehicle Traction
- Deceleration
- Driver Enhancement
- Agility
- Vehicle Guidance
- Vehicle Potential
- Driver Potential
- Vehicle Stability
- Acceleration
- Steer-ability
Chassis Design.

Additonal important parameters:
- Weight
- Unsprung Masses
- Body Stiffness
- Drivetrain Concept
- Engine Characteristic
- Axle Kinematics/Steering
- Seat
- MMI
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Stability Control: xDrive
Innovative Transfer Gear Box
Stability Control: xDrive

xDrive Drive Train Concept
Forces at the Wheel:
Kamm‘s Circle.
Situation Oversteer:
Torque Distribution Front-Rear
Situation Understeer: Torque Distribution Front-Rear
Handling Course with Low-Friction (Snow track)

- Stability Control: xDrive
- Reduced Steering Effort

- Permanent 4WD
  - Vehicle Stability Control System not active

- xDrive aktive
  - Vehicle Stability Control System not active
xDrive vs. 4WD-DSC:
Comparison System Dynamics

- Torque Front Axle = 100% for DSC 4x4 BA
- Torque Front Axle = 38% for xDrive
- 4x4 with Brake Actuation:
  - 62% and 38%

**Timings:**
- t = ca. 0.1 s
- t = ca. 0.5 s
Vehicle Stability Control and All-Wheel Drive: BMW Application Philosophy

DSC Actuation Threshold

Engine Control
Brake Control

xDrive Control

xDrive + DSC in 3 Series Coupé

DSC Actuation Threshold

Engine Control
Brake Control
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**Further Driver Assistant Systems to**
- improve perception & interaction
- facilitate driving tasks
- optimal driver information
Torque Vectoring:
BMW Dynamic Performance Control.

Separation of oil chambers
Planetary gear (3 planetary gears)
Ball ramp (Two-stage pitch)
Breather
Multi-disc brake
Asynchronous motor
BMW Dynamic Performance Control.
Layout of Final Drive Unit.

- Torque vectoring unit “left”
- Basic gearbox
- Torque vectoring unit “right”

Planetary gear

Multi-disc brake
BMW Dynamic Performance Control.

Torque Flow (I).

WITHOUT torque transfer

\[ M_{\text{left}} = M_{\text{right}} \]
BMW Dynamic Performance Control.
Torque Flow (II).

WITH torque transfer
WITH drive torque
\( M_{\text{left}} < M_{\text{right}} \)
BMW Dynamic Performance Control.
Torque Flow without Engine Torque.

WITH torque transfer
WITHOUT drive torque
$M_{\text{left}} < M_{\text{right}}$

500 Nm
500
500

1000

900 100

400 Nm
BMW Dynamic Performance Control.
Summary Torque Flow.

**WITHOUT torque transfer**

- $M_{left} = M_{right}$
- Same behaviour as with conventional final drive
- Driving straight-ahead: Planetary gear circulates “in a block“
- In a bend: Planetary gear rolls without load

**WITH torque transfer**

- $M_{left} < M_{right}$
- Force transfer independent of drive torque
- Planetary gear opens second load path
BMV Dynamic Performance Control:
Mode of Operation

**Benefits:**
- improved responsiveness
- optimized traction in bends and from standstill
- increased yaw damping
- reduced understeer

conventional rear axle differential

Rear axle differential with torque vectoring

Driver Assistance &
Active Safety Systems
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Seite 22
BMW Dynamic Performance Control.
Function: Avoiding Understeer.
BMW Dynamic Performance Control.
Function: Avoiding Understeer.

Understeering **without** BMW Dynamic Performance Control.

Steering precision and stability in bends **without** BMW Dynamic Performance Control.

Stable driving in a bend with turn in yaw moment through BMW Dynamic Performance Control.

Steering precision and stability in bends with BMW Dynamic Performance Control.
**BMW Dynamic Performance Control.**

**ISO Lane Change.**

**Steering angle**

- Mean difference in steering angle effort: 20.6 °

**Vehicle speed**

- Mean difference in speed of car: 3.3 [km/h]

### Improvement by BMW Dynamic Performance Control

- No counter-steering in the second lane
- Less counter-steering in the third lane
- Lower steering forces

### Additional Features

- Higher speed at entry
- Higher average speed
## Overview

### BMW xDrive

### Torque Vectoring: Dynamic Performance Control (DPC)

### BMW Active Steering

### System Integration: BMW Integrated Chassis Management (ICM)

### Predictive Active Safety: Adaptive Brake Assistant

### Further Driver Assistant Systems to
- improve perception & interaction
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Components of a Mechatronic System:

- one or several electrical / mechanical energy converters, (i.e. electric motors or generators),
- electronic control unit,
- additional mechanical equipment, e.g. gears, connecting rods.
Superposition Gearing

Basic Function

- complete form-fit mechanical connection
- Steering angle superposition
- real feedback torque
- inherent fail-safe

Diagram with labeled components:
- \( z_1 \) from steering wheel
- \( z_4 \) to power steering
- \( Z \) worm gear
BMW Active Steering: Variable Steering Ratio

System Function: Variable Steering Ratio

- Optimal control at high vehicle speed
- Improved controllability in dynamic manoeuvres
- Improved comfort in parking and taxiing
- Improved handling and agility at low and medium vehicle speeds
System Function: Vehicle Stabilization

- Maximum vehicle stability via combined steering and braking control
- Support of the driver for vehicle stabilization
- Less dominant braking activities, improved driving dynamics
BMW Active Steering.

Yaw Rate Control.

Conventional Steering + DSC

Active Steering + DSC

- Stabilising Brake Control (DSC)
- Engine Torque Control
- Stabilising Steering Control (Active Steering)
BMW Active Steering.
Yaw Moment Compensation.

High $\mu$

Lane change w/o steering control

Low $\mu$

- Wheel Brake Force
- Vehicle Speed
- Yaw Moment
- Stabilising Steering Control
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High level control software of DSC, xDrive, and parking brake implemented in DSC ECU, interface to Active Steering ECU via CAN bus.
Integrated Chassis Management.
New Potentials for Active Safety.

ICM
Integrated Chassis Management

Assistance Control Systems
Ride Control Systems
Supervision Control Systems
Steering Control Systems
Brake Control Systems
### Overview

- BMW xDrive
- Torque Vectoring: Dynamic Performance Control (DPC)
- BMW Active Steering
- System Integration: BMW Integrated Chassis Management (ICM)
- Predictive Active Safety: Adaptive Brake Assistant

Further Driver Assistant Systems to
- improve perception & interaction
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Predictive Active Safety: Adaptive Brake Assist
Reduction of Stopping Distance

- Reaction time
- Pressure rise
- Maximum pedal force
- Stop

Potential for reduction of stopping distance
Adaptive Brake Assist.
In Case of Inattention ...

Reduces stopping distance in case of
- unexpected braking of leading vehicle or
- closing up on slow vehicles

Hesitating driver recognizes unexpected obstacle on the street

Without Assistance

100km/h  40m  30m
2m due to prefill time

Prefill

100km/h  40m  30m

Prefill and Brake Assist

100km/h  40m

Reduced stopping distance due to maximum deceleration
Collision Warning.
In Case of Inattention ...

Reduces **overall stopping distance** using an additional driver warning

<table>
<thead>
<tr>
<th>Warning</th>
<th>Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Assistance</td>
<td>40m</td>
</tr>
<tr>
<td>Prefill</td>
<td>40m</td>
</tr>
<tr>
<td>Prefill and Brake Assist</td>
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</tbody>
</table>

2m due to prefill time

Reduced overall stopping distance because of faster reaction due to collision warning
Overview

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Predictive Active Safety: Adaptive Brake Assistant

Further Driver Assistant Systems to
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Comfortable and fast input of e.g.:
- **destinations** into navigation system
- telephone calls by **number or by name**
- **radio stations** or CD-Titles through extremely reliable **whole-word voice recognition**.
Head-Up Display:
Driver has all the important information while still paying attention to traffic
Aktive Cruise Control with Stop&Go Function
Automated speed and distance control in exhausting traffic situations

Distance control in flowing traffic and when driving dead slow.

60 km/h ➔ 0 km/h ➔ 60 km/h
Lane Departure Warning
Always safe on course

Intuitive warning: Steering wheel vibrates lightly on unintentional lane deviations.
High-Beam Assistant
Unique feature for automated headlamp dimming

Automatic switching off of headlights in the event of oncoming traffic, vehicle ahead and in lit built-up areas.
**BMW Night Vision:**

Highest degree of safety when driving at night

Thermal image camera identifies persons, animals and objects at the roadside up to a distance of 300 meters.
**Vision:**
Enhanced Network/Integration of all Systems

**Active Safety**
- to keep the vehicle safely on track

**Driver Assistance**

**Stability Control**
Active Safety is real teamwork:

A precisely designed layout of

- chassis components and
- premium stability control systems plus an
- array of predictive active safety systems

keep the vehicle safely on track - even in the most demanding situations.
Thank you for your attention!

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