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E60 Dynamic Drive

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Model: E60

Production: Start of Production MY 2004

Dynamic Drive

Objectives:

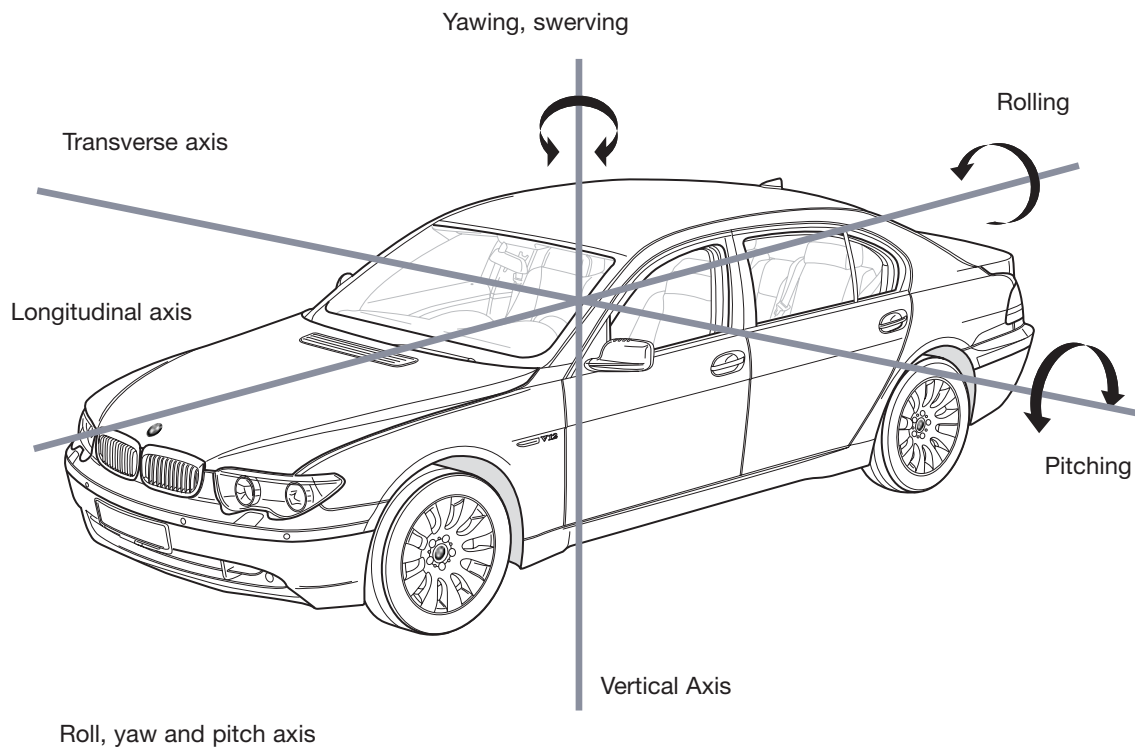
After completion of this module you will be able to:

- Identify and locate components of the Dynamic Drive System
- Understand Operation of the Dynamic Drive System
- Understand diagnosis and service operation of Dynamic Drive

Purpose of the System

Dynamic Drive

The design of the Dynamic Drive is the same as the system fitted in the E65. The function of the Dynamic Drive in the E60 is identical to the function of the Dynamic Drive in the E65. The disadvantage of a passive stabilizer bar is that the basic suspension hardens in the case of straight-ahead driving and one sided jouncing. This reduces comfort.



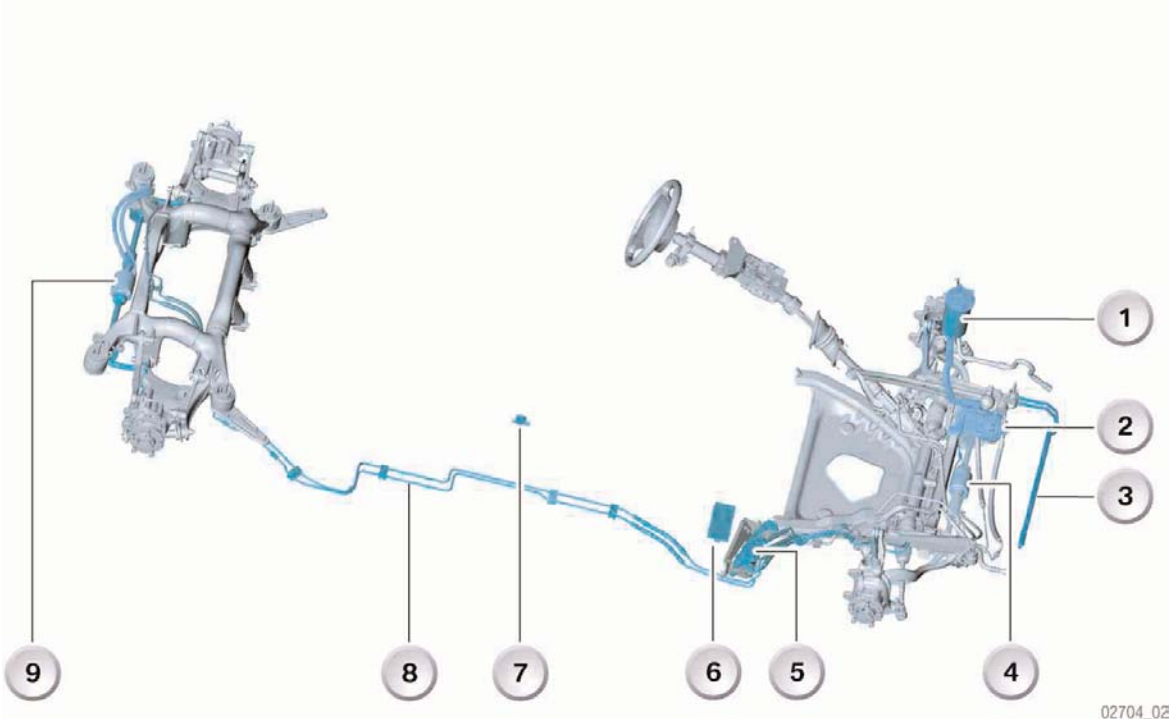
Dynamic Drive has two active stabilizer bars which have a positive effect on the roll tilt angle and handling.

Split stabilizer bars on the axles act as the basis of the Dynamic Drive. The halves of the stabilizer bars are joined by way of a hydraulic oscillating motor. One half of the stabilizer bar is connected to the oscillating motor shaft while the other is connected to the oscillating motor housing.

When you are driving straight ahead, the system improves suspension comfort because the stabilizer bar halves are non-interacting and therefore do not harden the basic suspension when suspension is used on one side.

System Overview

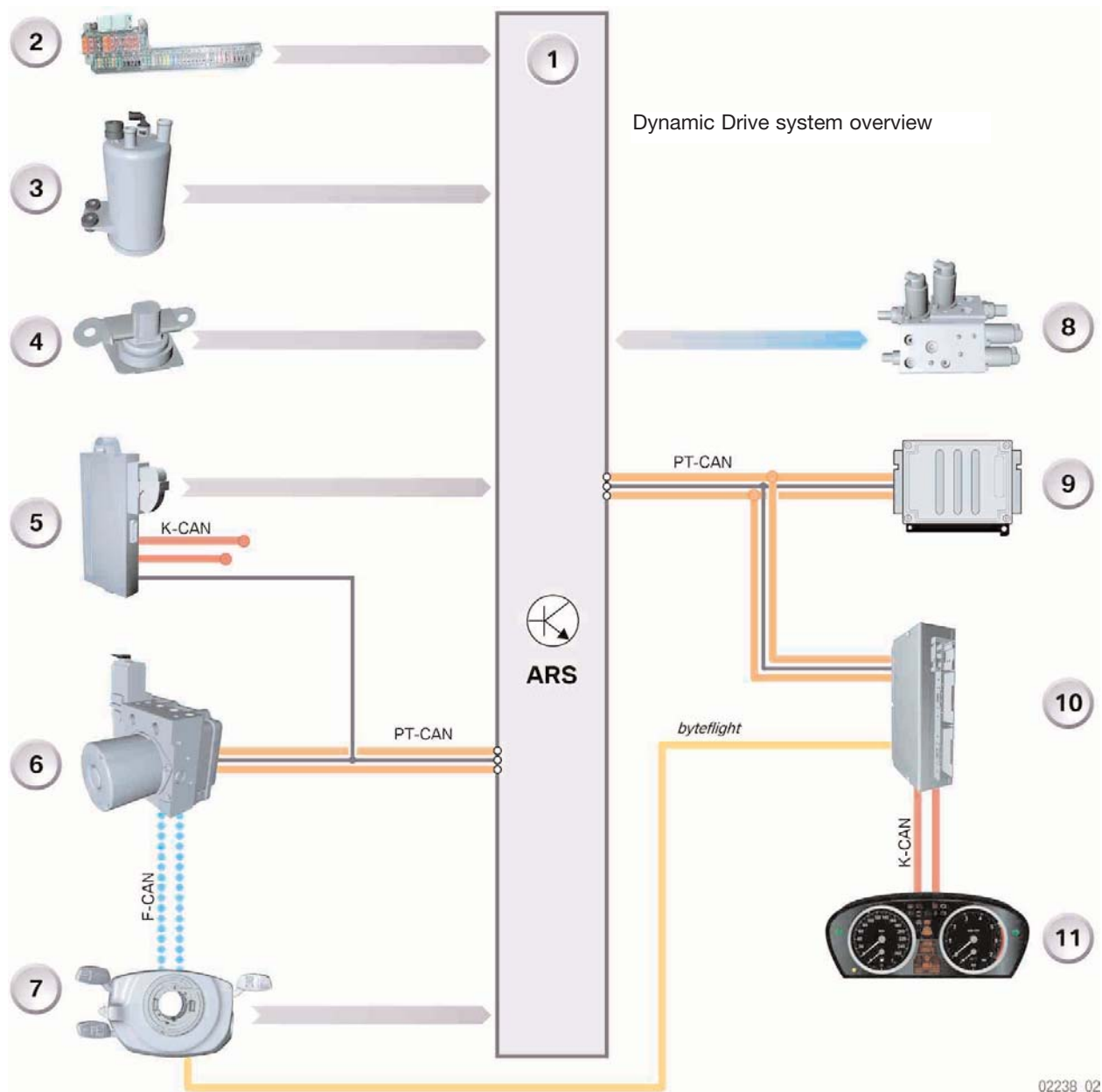
Mechanical Components



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- 1. Hydraulic-fluid reservoir
- 2. Tandem pump
- 3. Hydraulic-fluid cooler
- 4. Front oscillating motor
- 5. Valve block
- 6. Control unit
- 7. Lateral-acceleration sensor
- 8. Hydraulic lines
- 9. Rear oscillating motor

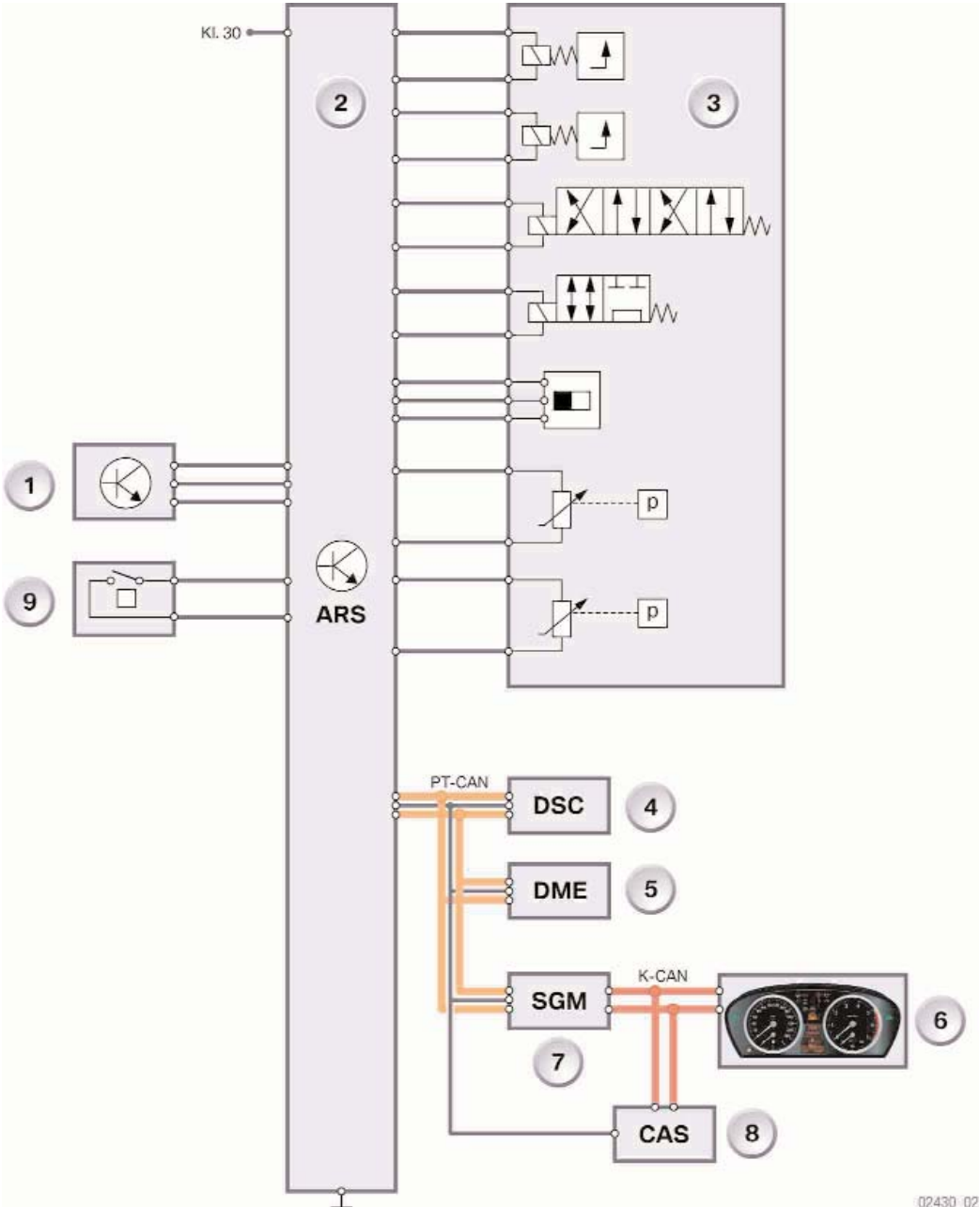
Inputs/Outputs



- | | |
|---|-------------------------------|
| 1. Dynamic Drive control unit | 7. Steering-angle sensor |
| 2. Current distributor, front, power supply | 8. Dynamic Drive valve block |
| 3. Hydraulic reservoir, fluid level | 9. Digital Motor Electronics |
| 4. Lateral-acceleration sensor | 10. Safety and Gateway Module |
| 5. Car Access System control unit | 11. Instrument cluster |
| 6. DSC module | |

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System Schematic



- 1. Lateral-acceleration sensor
- 2. Dynamic Drive control unit
- 3. Dynamic Drive valve block
- 4. DSC control unit
- 5. Digital Motor Electronics
- 6. Instrument cluster

- 7. Safety and Gateway Module
- 8. Car Access System control unit
- 9. Hydraulic-fluid level sensor
- PT-CAN Powertrain CAN
- K-CAN Body CAN

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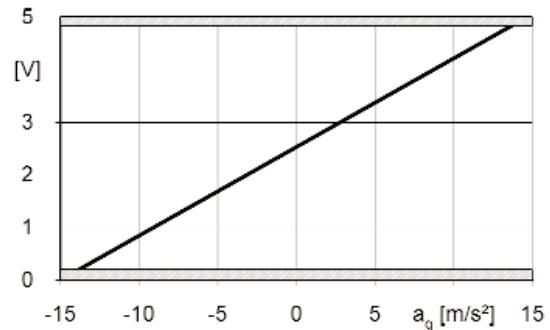
Components

Lateral-Acceleration Sensor

The lateral-acceleration sensor supplies the main sensor signal. When cornering, it measures the vehicle's lateral acceleration up to a measuring range of ± 1.1 g. It is mounted beneath the right-hand front seat on the floor plate.



Lateral-acceleration sensor;natural color connector, individual connector coding



Lateral-acceleration sensor,characteristic curve

Fluid Level Sensor

The fluid level sensor detects the fluid supply in the fluid reservoir. The fluid level sensor is mounted on the fluid reservoir. Short circuits/open circuits cannot be detected by the fluid level sensor. A line break is interpreted as a loss of fluid.

Dynamic Drive Control Unit

The Dynamic Drive control unit is located on the right side of the passenger compartment in the A-pillar area.

The control unit is supplied with power via terminal 30 and is protected by a 10 A fuse.

A vehicle authentication process takes place when the system is started. This compares the vehicle identification number from CAS with the vehicle identification number which is encoded in the Dynamic Drive control unit.

Then the control unit's hardware and software is checked.

All the outputs (valve magnets) are subjected to a complex check for short circuits and breaks. If there is a fault, the system switches the actuators into a safe driving condition.

The control unit switches off if there is undervoltage or overvoltage.

The control unit learns the offset for the steering angle and the lateral acceleration during startup and during driving.

Active Stabilizer Bar

The active stabilizer bar consists of the oscillating motor and the halves of the stabilizer bar with press-fitted roller bearings which are mounted on the oscillating motor for connection to the axle carriers. The use of roller bearings ensures optimum comfort thanks to better response and reduced control forces.

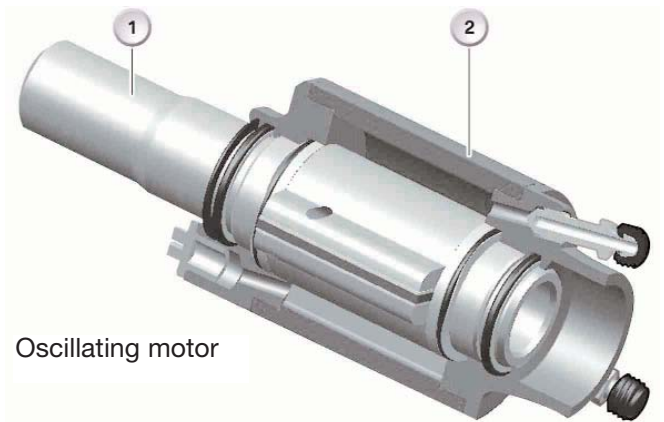
The oscillating motor and the oscillating motor housing are joined by one half of the stabilizer bar.

The oscillating motor of the front-axle stabilizer bar is fitted with 2 pressure relief valves.

Pneumatic lines are connected to the pressure relief valves. These pneumatic lines end in a filter element (conventional fuel filter) which is inserted in the diagonal strut on the left wheel arch.

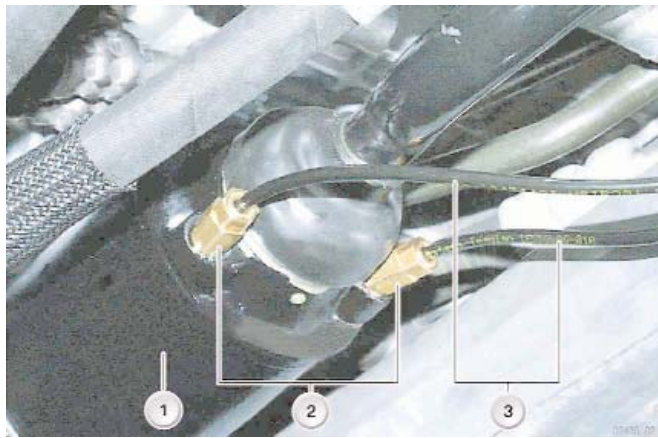
The filter element is located in different positions in the engine compartment depending on the mounting position of the various engines.

The positions for the pressure relief valves are fitted with screw plugs on the oscillating motor of the rear-axle stabilizer bar.



Oscillating motor

1. Oscillating motor shaft
2. Oscillating motor housing



1. Oscillating motor
2. Pressure relief valves
3. Pneumatic lines



1. Filter element

Function of Pressure Relief Valves

When the vehicle is driven on poor road surfaces, the stabilizer-bar movements give rise to brief vacuum pressures (cavitation) in the oscillating motors which in turn cause rattling noises.

Pressure relief valves have been fitted on the front oscillating motor in order to eliminate these noises. These pressure relief valves allow filtered air to flow into the oscillating motor through the connected pneumatic lines. This prevents cavitation.

This small quantity of air is absorbed by the hydraulic fluid (Pentosin) to form an emulsion, which is discharged during the next activations of the oscillating motor. The air is separated in the expansion tank.

Because no noises can be heard at the rear axle, the pressure relief valves have been omitted from the rear oscillating motor.

Operating Principle of Oscillating Motors

The oscillating motor has three functions to perform:

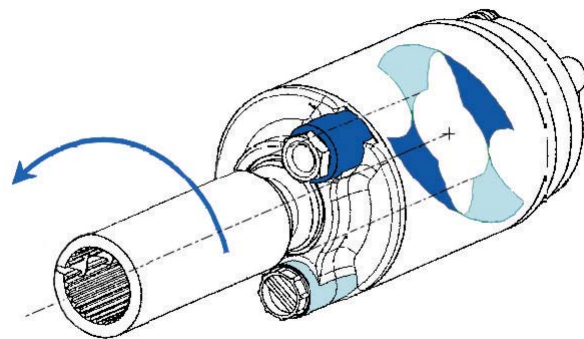
- It guides the torque into the two halves of the stabilizer bar.
- It decouples the two halves of the stabilizer bar.
- In the event of system failure (failsafe mode), the front axle stabilizer bar creates sufficient damping via the oscillating motor hydraulic fluid (hydraulic locking). It now works like a conventional stabilizer bar.

Exception: If the oscillating motor chambers no longer contain any fluid as a result of a leak, the front axle stabilizer bar can no longer create damping.

Since one half of the stabilizer bar is connected to the shaft, and the other with the housing, the two halves turn in opposite directions.

The shell is forced upwards on the outside of a curve, and dragged down on the inside of a curve.

The maximum body torque on the front and rear axle occurs when there is a high degree of lateral acceleration. The system pressure is then 180 bar at the front axle and 170 bar at the rear axle.



Front-Axle Stabilizer Bar

The stabilizer bar is mounted on the front-axle carrier. The stabilizer links are connected to the "goose-necks" of the swivel bearings.

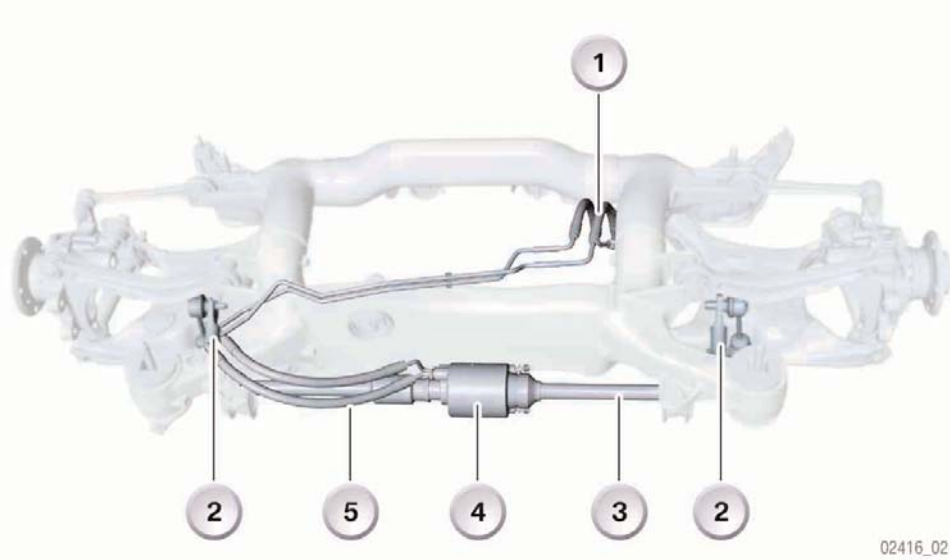


- 1. Stabilizer-link connection to swivel bearing
- 2. Stabilizer-bar bracket
- 3. Stabilizer bar
- 4. Oscillating motor
- 5. Stabilizer links

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Rear-Axle Stabilizer Bar

The stabilizer bar is mounted behind the rear-axle carrier. The stabilizer links are connected to the rear-axle swinging arms.

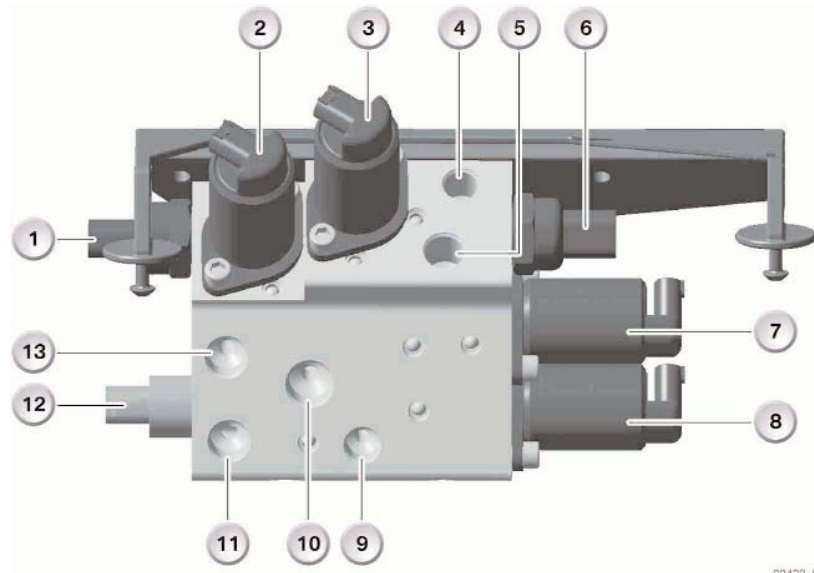


- 1. Hydraulic lines from valve block
- 2. Stabilizer links
- 3. Stabilizer bar
- 4. Oscillating motor
- 5. Hydraulic lines

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Valve Block

The valve block is located on the floor plate behind the front right wheel-arch trim.



- | | |
|---|--|
| 1. Rear-axle pressure sensor | 8. Directional valve |
| 2. Rear-axle pressure-limiting valve | 9. Line 1, rear-axle oscillating motor |
| 3. Front-axle pressure-limiting valve | 10. Hydraulic reservoir |
| 4. Line 1, front-axle oscillating motor | 11. Line 2, rear-axle oscillating motor |
| 5. Front-axle pressure sensor | 12. Selector-position recognition sensor |
| 6. Line 2, front-axle oscillating motor | 13. Tandem pump connection |
| 7. Failsafe valve | |

Pressure Control Valves

There is a pressure control valve on both the front and rear axles. They both adjust the actuation pressures for the front- and rear-axle stabilizer bars.

Directional Valve

The directional valve is electrically actuated. It specifies the direction of the high-pressure fluid (active pressures) and the reservoir fluid for right-hand and left-hand bends.

Failsafe Valve

The failsafe valve (safety valve) is electrically actuated. The failsafe valve responds in the event of a power-supply failure or an identified fault in the system. The failsafe valve shuts off the front-axle oscillating motor when de-energized. Thus the active stabilizer bar behaves like a normal mechanical stabilizer bar and brings about understeering.

Selector-Position Recognition Sensor

The task of this sensor is to detect the specific position of the directional valve.

2 positions can be detected:

- Left-hand control
- Right-hand control

Front-Axle/Rear-Axle Pressure Sensors

The pressure sensors are responsible for detecting the front and rear axle stabilizer bar hydraulic pressures. The sensors are mounted on the valve block. The pressure sensor offset values are taught-in by the control unit once, during commissioning.

Tandem Pump

The tandem pump, which is driven by the engine via a ribbed V-belt, consists of a radial-piston part for the Dynamic Drive and a vane part for the power steering.

When the engine is idling, the pump speed is approximately 750 rpm.

The pump's minimum fluid flow rate is 4.5 l/min at approximately 5 bar and 3.3 l/min at 200 bar. This means that sufficient system dynamics are also guaranteed when the engine is idling.

From a pumping speed of approximately 1165 rpm, the maximum fluid flow rate is limited to 7 l/min.

Dynamic Drive and power steering have a joint fluid reservoir and fluid cooler.

Fluid Reservoir

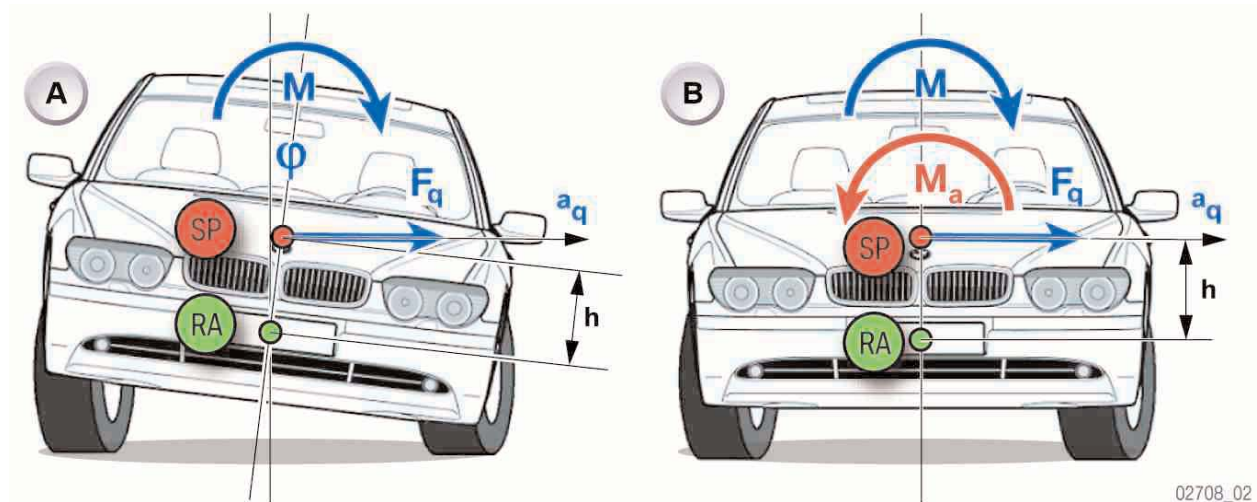
The fluid reservoir is identical on all vehicles, whether they have the Dynamic Drive function or not. The reservoir incorporates a fluid filter. A fluid level sensor is provided for the minimum quantity.

Cooler

The cooler ensures a long-term fluid temperature of < 120 °C and a short-term fluid temperature of < 135 °C in all hydromechanical components under all conditions.

System Functions

The car sets lateral acceleration while cornering (a_q) which affects the vehicle body at the centre of gravity (SP). The body rolls around the roll axis (RA) which is predefined by the front and rear axle kinematics. This sets the roll angle (max. 5°). This produces a maximum change in level on the wheel arch of ± 10 cm.



A. Car without Dynamic Drive
 B. Car with Dynamic Drive
 M. Rolling moment
 a_q . Lateral acceleration
 ϕ Roll angle

M_a . Body torque
 SP. Centre of gravity
 RA. Roll axis
 F_q . Lateral force
 h. Lever arm centre of gravity height

In the vehicle with Dynamic Drive, the rolling moment M can be compensated for by the active stabilizer bars up to a lateral acceleration a_q of approximately 3 m/s^2 (0.3 g).

Note: The tire suspension created by the rolling moment (M) is not compensated for.

The distribution of the active body torque between the front and rear axle depends on the road speed.

Affect of the Self-Steering Behavior

The self-steering behavior can be decisively influenced by the distribution of the stabilizing torque on the axles. The greater the stabilizing torque on an axle, the lower the lateral forces transmitted on this axle.

Two cases are described below with different distribution of stabilizing torque on the axles:

1. Identical stabilizing torque on both axles

Handling is "NEUTRAL."

The front wheels can apply about the same amount of lateral force on the road as the rear wheels without drive torque. The handling conditions are neutral.

A vehicle which is tuned to neutral handling conditions provides very agile handling, the steering reacts very quickly. The driver experiences precise handling.

Even an inexperienced driver can control a vehicle which is tuned to neutral handling very well at low speeds.

2. Larger stabilizing torque on the front axle

Handling is "UNDERSTEERING."

The front axle wheels cannot apply the same amount of lateral force on the road as the rear axle wheels. The vehicle suffers understeer.

A larger steering-wheel angle is required to be able to follow the desired course.

A vehicle with understeer can generally also be controlled well by an inexperienced driver at higher speeds and higher cornering speeds.

This very sensitive handling reduces the vehicle's agility.

Dynamic Drive sets the stabilizing torque on the front and rear axles such that a different handling characteristic is produced for low and high speeds.

The passive vehicle is configured as slightly understeering irrespective of the speed range. Dynamic Drive is neutral in the low speed range. The driver has to steer less in order to negotiate the same bend. This results in optimum handling and agility.

In the upper speed range, both vehicles behave almost identically with regard to the required steering angle on the same bend.

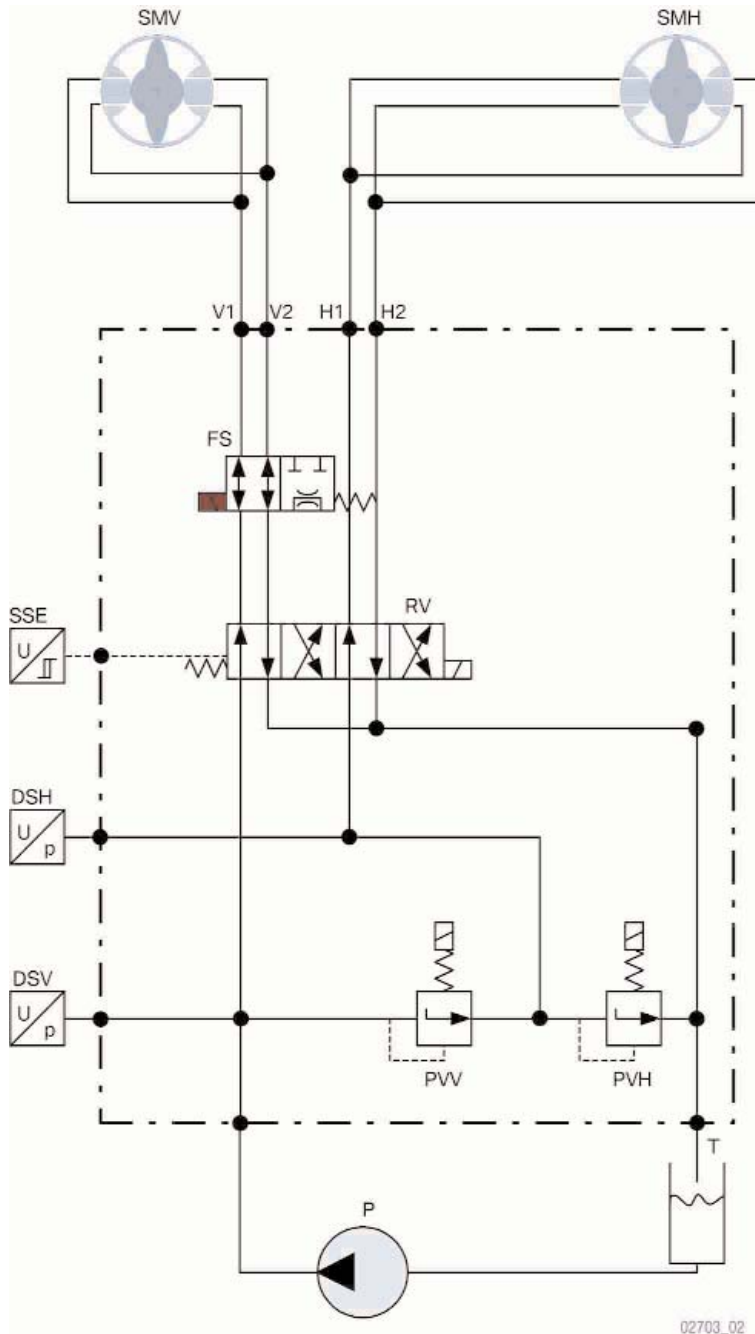
The hydromechanical concept is designed so that a larger active stabilizing torque cannot occur on the rear axle than on the front axle under any circumstances. This means that mechanically and hydraulically the vehicle with Dynamic Drive is safeguarded such that no oversteering and therefore for normal customers no critical handling characteristics can occur under any circumstances.

Comparison Between the Conventional Stabilizer Bar and the Active Stabilizer Bar

Active stabilizer bars introduce fewer comfort-reducing forces into the body than passive stabilizer bars. In this case a differentiation must be made depending on the frequency with which the forces were introduced.

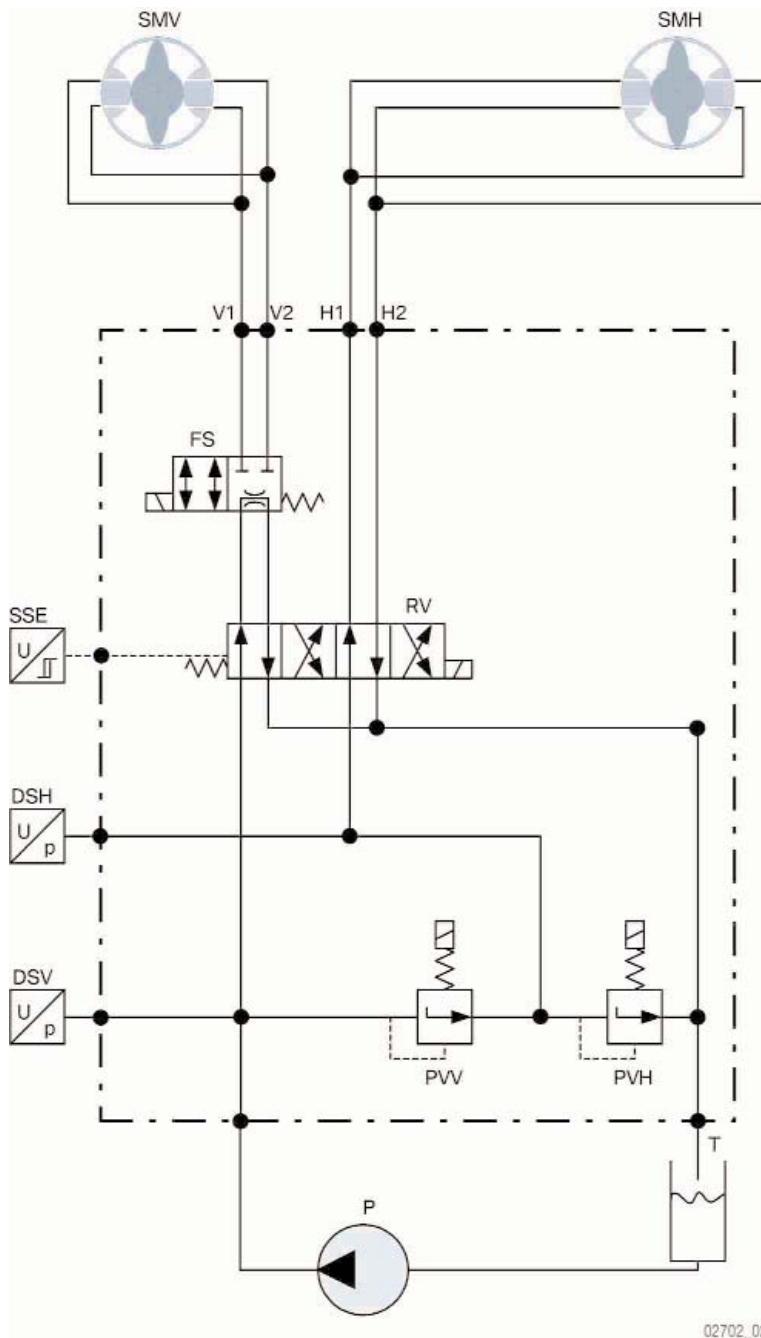
Road stimulus	Stabilizer bar behavior
At approximately 1 Hz (body natural frequency)	At smaller strokes the active stabilizer bar is easier to turn than a conventional stabilizer bar. The forces introduced into the body are fewer, the vehicle becomes more comfortable and body sound is improved
From 8 Hz (wheel natural frequency)	Both stabilizer bars behave in a similar way. On a vehicle with an active stabilizer bar this is because the fluid is not displaced so quickly.

Operating States



Hydraulic schematic normal function, failsafe valve energized

SMV	Front oscillating motor	RV	Directional valve
SMH	Rear oscillating motor	DSH	Rear-axle pressure sensor
V1	Front-axle hydraulic circuit 1	DSV	Front-axle pressure sensor
V2	Front-axle hydraulic circuit 2	PVV	Front-axle pressure valve
H1	Rear-axle hydraulic circuit 1	PVH	Rear-axle pressure valve
H2	Rear-axle hydraulic circuit 2	P	Tandem pump
FS	Failsafe valve	T	Fluid reservoir
SSE	Selector-position recognition sensor		



Hydraulic schematic, failsafe function or rest position

- | | | | |
|-----|--------------------------------------|-----|----------------------------|
| SMV | Front oscillating motor | RV | Directional valve |
| SMH | Rear oscillating motor | DSH | Rear-axle pressure sensor |
| V1 | Front-axle hydraulic circuit 1 | DSV | Front-axle pressure sensor |
| V2 | Front-axle hydraulic circuit 2 | PVV | Front-axle pressure valve |
| H1 | Rear-axle hydraulic circuit 1 | PVH | Rear-axle pressure valve |
| H2 | Rear-axle hydraulic circuit 2 | P | Tandem pump |
| FS | Failsafe valve | T | Fluid reservoir |
| SSE | Selector-position recognition sensor | | |

Notes for Service

Service Information

If the Dynamic Drive fails, DSC can no longer be deactivated or if it is already deactivated it does not switch back on automatically.

The connections for all the hydraulic components are designed in different dimensions and lengths so that they cannot be transposed.

A faulty acoustic transmission in the vehicle interior predominantly occurs through the assembly and cable connections. The cables must not appear on the surface, they must lie correctly in the supports without any slack or tension. They are covered by the underbody covering.

Steering-Angle Adjustment

After working on the steering, it is necessary to carry out a steering angle adjustment with the steering-column switch cluster (SZL) control unit!

The Dynamic Drive system is dependent on the exact zero balance of the steering angle!

The maximum tolerance for a deviation is +/- 1°. Precise performance of a wheel-alignment check and adjustment is essential!

Steering-angle adjustment must always be performed on the KDS and in accordance with the BMW specifications! Each time the Dynamic Drive or SZL control unit is flashed results in a loss of the zero position! A steering-angle adjustment is necessary!

Dynamic Drive Commissioning

The commissioning procedure must always be carried out once the system has been opened or a part has been replaced. This also applies after the lateral-acceleration sensor has been replaced.

The following conditions must be guaranteed for matching the lateral acceleration sensor and the two pressure sensor offset values:

- The vehicle must be stand level on all four wheels
- The vehicle must be unladen
- The engine must be idling
- Rest status (doors closed, persons are not allowed in the vehicle)

No persons may remain within the vicinity of moving chassis parts during the commissioning (both in the works and the workshop). In addition you must ensure that the basic commissioning conditions (temperature range, constant engine speed etc.) are maintained. The ground clearance must not be limited and the doors must be closed. The arms of the hoist may no longer be situated beneath the car.

The commissioning procedure is split into five stages which follow on from each other automatically:

I: direction valve test (from 3 to 3.4 s)	First the direction valve is tested by evaluating the signal of the selector-position recognition sensor.
II: low-pressure test (from 3.4 to 4.3 s)	The failsafe and direction valves are without power during this stage. Then tests are carried out with pressure control valves with and without power on the front and rear axle. The body is then tilted. The sides of the vehicle must be clear.
III: front-axle high pressure test (from 4.3 to 9.9 s)	Pressure of 180 bar is applied to the front-axle oscillating motor. Air in the system, internal leaks and a blocked oscillating motor are detected.
IV: rear-axle high pressure test (from 9.9 to 15 s)	Pressure of 170 bar is applied to the rear-axle oscillating motor. Air in the system, internal leaks and a blocked oscillating motor are detected.
V: pressure-control valve test (from 15 to 25 s)	The characteristic curves of the front and rear axle are checked (setpoint/actual-value comparison). Faulty pressure control valves are detected.

Dynamic Drive Venting

A venting routine must be carried out using the diagnostic tester if the Dynamic Drive system was opened hydraulically.

The venting operation is performed exclusively by way of the commissioning routine of the diagnostic tester and not at the pressure relief valves or at the screw plugs of the oscillating motors!

If the test still detects air in the system, a short movement trip should be made if necessary.

The commissioning routine must then be repeated after the short trip.

In the event of an extreme leak or suspected subfunction of the pressure relief valves (noticeable by the rattling noises in the front end), the pressure relief valves and the pneumatic lines must be replaced with new components.

Diagnosis

The following faults can be detected at the components:

Component	Fault type	Fault detection via:
Control unit	De-energized or faulty	Instrument cluster through absence of alive counter, VIN not recognized during authentication, watchdog
Pump	No pressure	Setpoint/actual-value comparison pressures
Directional valve	Stuck in "energized" position (spring break, swarf) Stuck in "de-energized" position (line break)	Directional-valve sensor Directional-valve sensor and current monitoring
FA pressure control valve	Open (de-energized, $p = p_{RA}$) Closed (mechanical fault) ($p_{FA} = p_{max}$)	Setpoint/actual-value comparison, pressure, front axle, current measurement Setpoint/actual-value comparison, pressure, front axle
RA pressure control valve	Open (de-energized) ($p = 0$) Closed (mechanical fault) (p_{RA} and $p_{FA} = p_{max}$)	Setpoint/actual-value comparison, pressure, rear axle, current measurement Setpoint/actual-value comparison, pressure, rear axle,
Failsafe valve	Stuck open Stuck closed(line)	Pre-drive check Current measurement
Actuator front/rear axle	Leaking (no torque) Blocked	Setpoint/actual-value comparison pressure Setpoint/actual-value comparison pressure
CAN bus	Omitted completely (line disconnected)	CAN timeout
Steering angle, vehicle speed lateral acceleration	Implausible or omitted	Plausibility monitoring and fault detection, CAN bus signals

Component	Fault type	Fault detection via:
Sensor aq (lateral acceleration)	Omitted completely (line disconnected)	Voltage monitoring
	Incorrect signal	Check plausibility via CAN signals
Fluid level sensor	No signal (line)	
Front-axle pressure sensor	No signal (line)	Voltage monitoring
	Incorrect signal	Setpoint/actual-value comparison, pressure, front axle
Rear-axle pressure sensor	No signal (line)	Voltage monitoring
	Incorrect signal	Setpoint/actual-value comparison, pressure, RA
Directional-valve sensor	No signal	Voltage monitoring
	Incorrect signal	Setpoint/actual-value comparison, direction valve and selector-position recognition sensor

System Shutdown (Failsafe Status)



Depending on the fault, the system displays one of the following responses.

The following faults result in system shutdown, i.e. all output stages are de-energized:

- Fault in the front-axle stabilizer bar
- Fault at the front-axle pressure sensor
- Fault in the pressure build-up (pump, pressure-limiting valve on the front axle)
- Fault in the control unit
- VIN is not sent via the CAS / omitted / incorrect
- Direction-valve position fault, faulty selector-position recognition sensor
- No PT-CAN signal

The de-energized failsafe valve shuts off the chambers of the active stabilizer bar. A fluid compensation is only performed by way of internal leakage of the oscillating motor and the valve block. The non-return valves in the valve block permit additional suction of fluid so that no cavitation occurs in the front-axle oscillating motor.

The chambers of the rear-axle oscillating motor must not be shut off. The handling corresponds virtually to that of a conventional vehicle. The crossover to the failsafe status can also be controlled in the event of extreme maneuvering.

Warning message	Handling instruction
<p>Cornering stability! Drive slowly around bends</p> 	<p>Driving-stability system not functioning, driving stability restricted. No high cornering speeds.</p> <p>Continued driving possible, contact BMW Service immediately</p>
<p>In the event of a fluid loss in the Dynamic Drive hydraulic system or in the steering circuit, the fluid level sensor in the fluid reservoir responds.</p> <p>The driver is alerted so that damage to the tandem pump caused by continued driving is avoided.</p>	
Warning message	Handling instruction
<p>Fluid loss! Caution Stop, engine off</p> 	<p>Fluid loss in the chassis and steering systems.</p> <p>Continued driving not possible, contact BMW Service immediately</p>

Restricted Control Comfort

A lateral acceleration is calculated from the road speed and steering wheel angle from the CAN signals. This signal is faster than the actual lateral acceleration and compensates the time delay of the hydromechanical system. In the event of a fault in these two signals, the system responds with a delayed roll compensation. This arises only in the case of extremely quick steering maneuvers and is barely noticeable in normal cornering maneuvers.

In the event of a faulty lateral-acceleration sensor, the lateral acceleration is calculated exclusively from the CAN signals. No impairment of function can be detected by the customer.

In the event of a fault in the rear-axle circuit, i.e. a stabilization at the front axle only, the customer notices that the vehicle is subject to larger rolling motions. Agility diminishes at road speeds < 120 km/h.

The system also responds if the fault "Failsafe valve stuck open" is detected in the pre-drive check.

An electrical fault in the rear-axle pressure sensor may result in minor failures in roll-angle compensation. To be on the safe side, slightly more stabilizing torque is exerted on the front axle than in normal operation. This can be felt by the driver.

Warning message	Handling instruction
Cornering stability slightly restricted	Chassis stabilization slightly restricted around bends. Continued driving possible, contact BMW Service at next opportunity

Restricted System Monitoring

Dynamic Drive receives via PT-CAN the following sensor signals from DSC and SZL:

- Lateral acceleration
- Yaw velocity
- Road speed
- Steering-wheel angle

These signals are used to check the lateral-acceleration sensor.

Drop-out of the engine-speed signal (DME) results in restricted control comfort.

In the event of a fault in the lateral acceleration and yaw velocity CAN signals, the system is lacking two items of redundant information. Since this information is used exclusively for checking the other signals, the Dynamic Drive function is preserved with full control comfort.

Although the Dynamic Drive function is not impaired, the driver receives the display "Chassis control comfort restricted." He/she is prompted to visit a garage/workshop at the next available opportunity.

Warning message	Handling instruction
Cornering stability slightly restricted	Chassis stabilization slightly restricted around bends. Continued driving possible, contact BMW Service at next opportunity

A "dynamic" driver will notice the absence of the steering-angle signal.

The warning messages must be acknowledged by the driver. Each warning message goes out only after it has been acknowledged.

Once the cause of the fault has been rectified, the control unit can be returned to full function.

There are two reset conditions depending on how fast a fault is to be detected:

- All faults which are no longer present are reset with "ignition off." It is necessary here to wait until the sleep mode has been obtained before "ignition on" is activated again.
- Sporadic faults which can mostly be traced back to communication faults in the CAN bus are then automatically reset while the vehicle is moving straight ahead or stationary provided they have only occurred briefly and rarely. In this case, the customer cannot detect the activation while the vehicle is moving or stationary.
- The associated faults with important additional information are stored in the fault memory. This additional information contains the kilometer reading/mileage at which the fault occurred, whether the fault is currently present and the frequency with which the fault in question has occurred. Thus, when the vehicle is brought into the garage/workshop, it is possible to carry out a specific analysis of the currently present fault and also an analysis of a sporadic fault.

Programming

The Dynamic Drive control unit is programmed.

Coding

The Dynamic Drive control unit is coded.