Table of Contents

E70 Chassis Dynamics Workbook

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Table of Contents

Subject | Page

Table of Contents

Subject | Page

Table of Contents

Table of Contents

E70 Chassis Dynamics

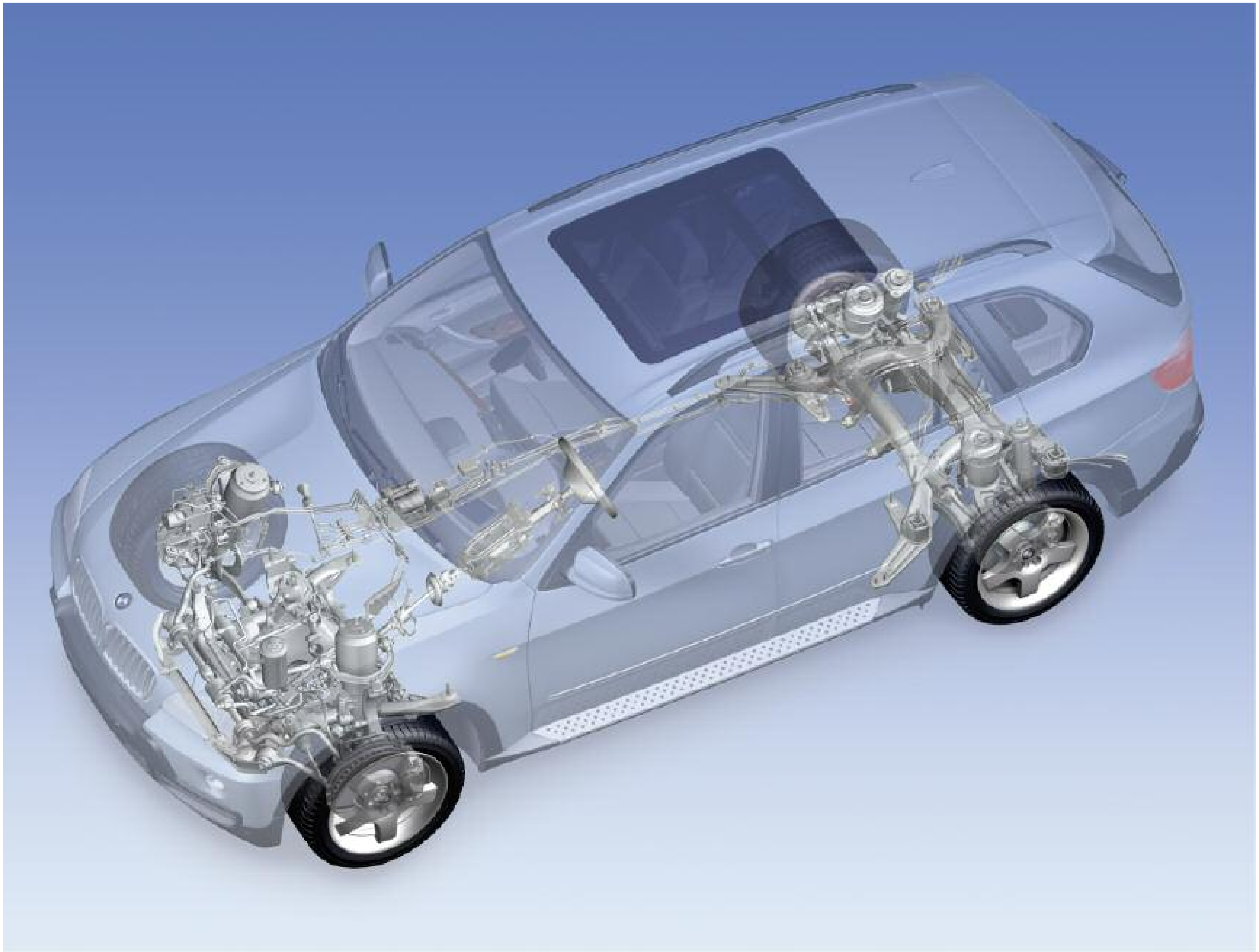
Model: E70

Production: From Start of Production

OBJECTIVES

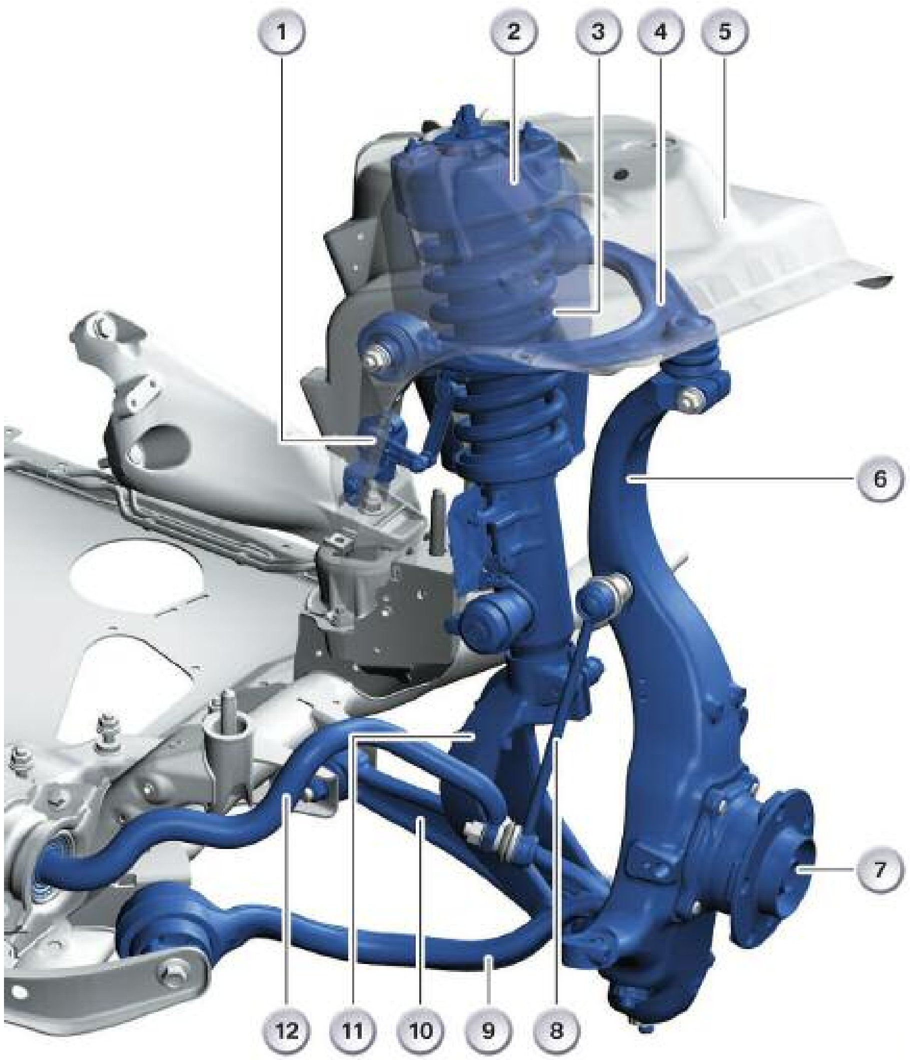
After completion of this module you will be able to:

- Identify and Adjust E70 Front Suspension
- Diagnose VDC and FlexRay Concerns
- Understand Changes to Active Steering on the E70



Front Axle

For the first time on a BMW vehicle, a double wishbone front axle is used on the E70. The outstanding driving dynamics, the excellent driving comfort as well as the stable straight-ahead running properties are factors of this design solution that contribute to a high degree of driving pleasure and safety while making the vehicle ideal for every day use and providing the most relaxing drive on long journeys.



Index	Explanation
1	Ride-height sensor
2	Mount
3	Spring strut
4	Upper control arm (upper wishbone)
5	Spring strut support
6	Swivel bearing
7	Wheel bearing
8	Stabilizer link
9	Tension strut with hydraulic mount
10	Control arm, bottom
11	Spring strut fork
12	Anti-roll bar

The addition of the upper control arm (wishbone) positively influences front wheel travel by reducing Camber changes during jounce and rebound events.

The arrangement of the suspension allows the strut assembly to be focused on dampening duties alone. The strut is no longer part of the steering, but fixed in place (no upper bearing).

The steering axis now rotates by way of the swivel bearing (6). The arrangement of the front suspension includes bearings at various swivel points. This allows for reduced friction, which in turn allows the damper (strut) to respond more sensitively to road surface irregularities.

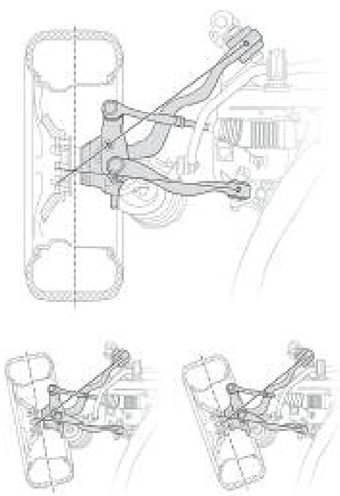
This design works well in conjunction with the Vertical Dynamics Management (VDM) system.

Components with special materials (see graphic on previous page):

- The forged aluminum swivel bearing (6) with the 3rd generation wheel bearing (7) Semi-trailing arm connected via steel bushes/tapered screw connection to the swivel bearing. Attention: Refer to special repair instructions!
- The A-arm at the top (4) is made from forged aluminum and the cylindrical joint pin is clamped in the swivel bearing (6).
- Tension strut with hydraulic mount (9) and bottom control arm (10) are forged steel components while the bottom control arm bears the spring strut (3) by means of the cast steel spring strut fork (11).
- The front axle subframe is a welded steel structure with an aluminum thrust panel for maximum lateral stiffness with service openings.

Virtual Pivot Point

The steering pivot axis of the wheel suspension is now formed by a joint at the top A-arm and the virtual pivot point of the lower arm level as known from the spring strut or McPherson axle.



Front Axle Data

Front axle data	E70
Wheel	R18 8.5J X 18 EH2 + IS46
Tires	255/55 R18
Rim offset (mm)	46
Tire radius (mm)	338
Wheelbase (mm)	2933
Track width (mm)	1644
Camber	-0° 20’ ±20’
Camber difference	0° ±30’
Total toe-in	10’ ±6’
Wheel axle angle	0° ±4’
Kingpin offset (mm)	-8.4
Toe-out difference angle	2.1° ±30’
Caster angle	7° 48’ ±30’

Front Axle Adjustments

The toe adjustment on the front axle is carried out by means of a tie rod adjustment as on past models.

The Camber adjustment, however, can only be adjusted by a replacement of the upper control arm (wishbone). The control arm is available in three possible part numbers. One of which is the standard (zero) arm, while the other two are offset to effect a small Camber change if needed.

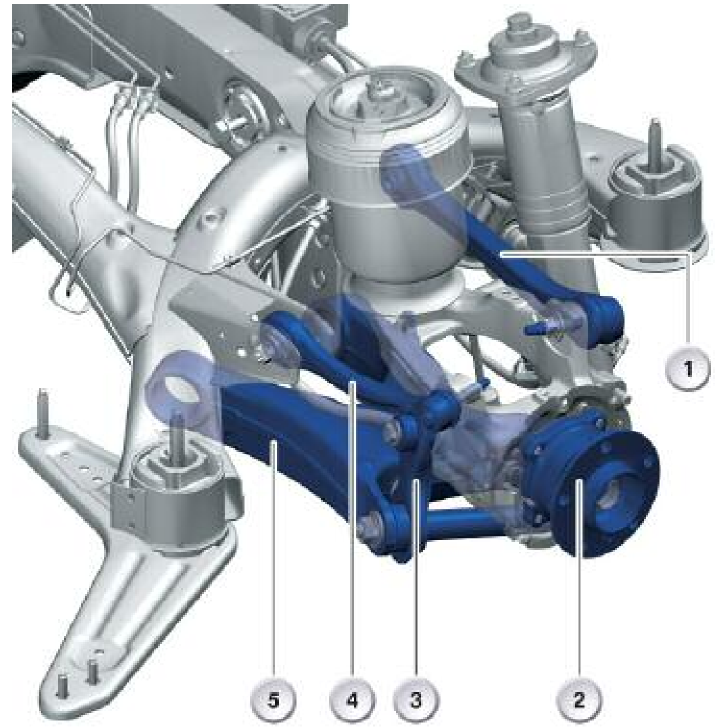
Rear Axle

The E70 utilizes the integral IV rear axle from the E53 with some further improvements. This rear axle design contributes to improved driving dynamics without compromising comfort and driving safety.

The rear axle arrangement made it possible to increase the width and depth of the load area. The result is a considerably larger and more functional load space (third row of seats) particularly through the use of the single-axle air spring (rear axle air suspension).

The resulting advantages include:

- Outstanding driving dynamics, further increased compared to the E53, without compromising comfort and driving safety.
- Distinctly larger and more functional load area by increasing the effective load width and depth.
- Level control (1-axis air suspension) ensures constant ride-height and driving characteristics irrespective of the vehicle load.



Rear axle data	E70
Wheel	R18 8.5J X 18 EH2 + IS46
Tires	255/55 R18
Rim offset (mm)	46
Tire radius (mm)	338
Wheelbase (mm)	2933
Track width (mm)	1650
Camber	-1° 30’ ±15’
Camber difference	0° ±30’
Total toe-in	10’ ±6’
Wheel axle angle	0° ±4’

Index	Explanation
1	Control arm
2	Wheel carrier
3	Integral link
4	Upper radius arm
5	Swinging arm

Chassis Comparison (E70 vs. E53)

	E53	E70
Front axle	Double pivot spring strut front axle	Double wishbone front axle
Suspension/damping, front	Steel spring or air spring	Steel spring
Anti-roll bar, front	Mechanical	Mechanical or Hydraulic
Rear axle	Integral IV	Integral IV
Suspension/damping, rear	Steel spring or air spring	Steel spring or air spring
Anti-roll bar, rear	Mechanical	Mechanical or Hydraulic
Brake, front	Brake disc diameter up to 356 mm	Brake disc diameter up to 365 mm
Brake, rear	Brake disc diameter up to 324 mm	Brake disc diameter up to 345 mm
Parking brake	Drum brake, mechanical	Drum brake, with electro-mechanical parking brake (EMF)
Wheels/tires	Standard tires	Run flat tires
Steering	Power steering or Servotronic	Power steering or active steering

Wheels and Tires

For the first time, an X-vehicle is equipped as standard with the run flat safety system. Tire damage and tire failure are among the most feared driving experiences.

The BMW run flat safety system:

- Warns the driver in good time of imminent tire pressure loss so that counter-measure can be taken.
- Allows the journey to be continued for a defined distance even in the event of complete loss of tire pressure.
- Keeps the tire safely on the rim even in the event of sudden tire pressure loss at high speed.

The entire safety package consists of three components:

- RSC tires with emergency running properties
- Extended hump rims (EH2+)
- Tire Pressure Monitoring System (TPMS).

RSC tires with emergency running properties

With its reinforced side walls, additional strip inserts and heat-resistant rubber mixtures, even when completely depressurized, the "self-supporting tire" makes it possible to continue the journey for a limited distance at a maximum speed of 80 km/h. This means each tire is also its own spare wheel.

The maximum range after complete tire pressure loss is:

- approximately 250 km at low vehicle load
- approximately 150 km at medium vehicle load
- approximately 50 km at high vehicle load

In the case of slow pressure loss, i.e. representative of approximately 80% of all tire failure cases, the remaining range as from the TPMS warning is approximately 2000 km. ABS, ASC and DSC remain fully operational even in the event of complete tire pressure loss.

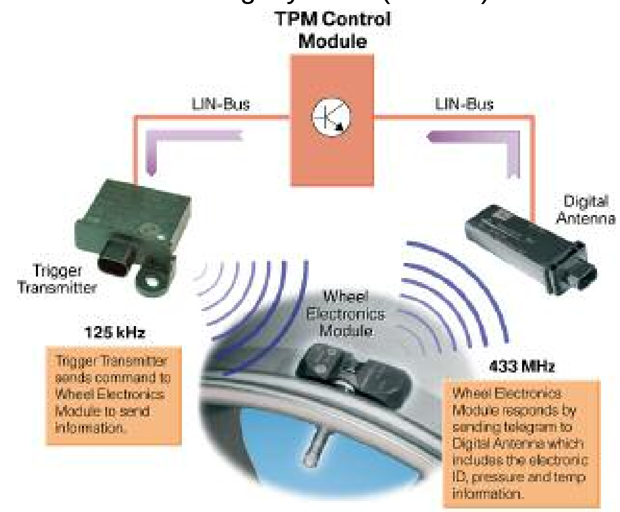
When driving with a run flat tire with no pressure, the optionally available adaptive drive system automatically distributes the vehicle weight over the remaining wheels so as to relieve the load on the depressurized tire with the aim of achieving the highest possible range for continued operation.

Extended Hump Rims (EH2+)

The specially shaped rim humps ensure that the RSC tire cannot detach from the rim even in the case of sudden tire pressure loss. This means substantially greater safety particularly when driving at high speed and on winding roads.

The system consisting of the run flat tires (RSC), rims with the extended hump (EH2+) contour and the electronic monitoring system (TPMS in USA), renders a spare wheel or space-saver wheel, breakdown kit or vehicle jack unnecessary and this creates more storage space in the luggage compartment while also saving weight.

Tire Pressure Monitoring System (TPMS)



Note: For more information on the TPMS system, refer to the reference material in the Chassis Dynamics (ST504) class which is available on TIS or ICP.

Brakes

In terms of function, an optimized high performance brake system is used on the E70. Floating brake calipers are fitted on the front and rear axle. The brake system in the E70 features the known brake wear monitoring system for the CBS indicator.

Front axle	N52B30 US+LA	N62B48 US+LA
Brake caliper housing	GGG (Cast iron)	GGG (Cast iron)
Brake caliper/piston diameter [mm]	60	60
Brake disc thickness [mm]	30	30
Brake disc diameter [mm]	332	348
Size	17’’	18’’
Rear axle	N52B30 US+LA	N62B48 US+LA
Brake caliper housing	Aluminum	Aluminum
Brake caliper/piston diameter [mm]	44	44
Brake disc thickness [mm]	20	24
Brake disc diameter [mm]	320	345
Size	17’’	18’’
Parking brake	Duo-Servo 185x30 (EMF)	

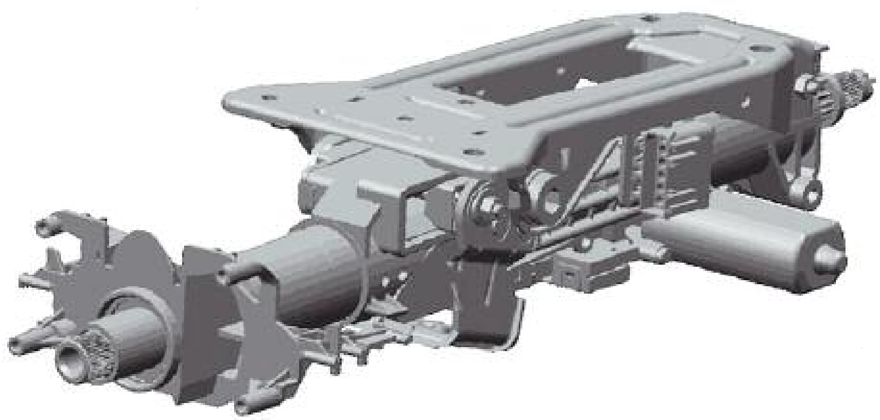
Steering Column

The E70 is available with an electrically adjustable steering column as standard equipment.

Adjustment range of electrical steering column:

- Vertical +/-25 mm
- Horizontal +/-20 mm

A special feature of the electrically adjustable column is that only one electric motor is required for the height and tilt adjustment and this motor is connected to a special gear mechanism for both adjustment axes.



Lateral Dynamics

Active Steering on the E70 is part of the lateral dynamics systems. Nowadays, dynamic driving systems are subdivided according to their mode of operation. For example, lateral dynamics systems are those systems which influence the vehicle laterally (in a turn).

In the E70, there are two systems which are considered part of the lateral dynamics systems.

- Servotronic - Speed-dependent hydraulic steering torque assistance
- AS - Active Steering (previously AFS, Active Front Steering)

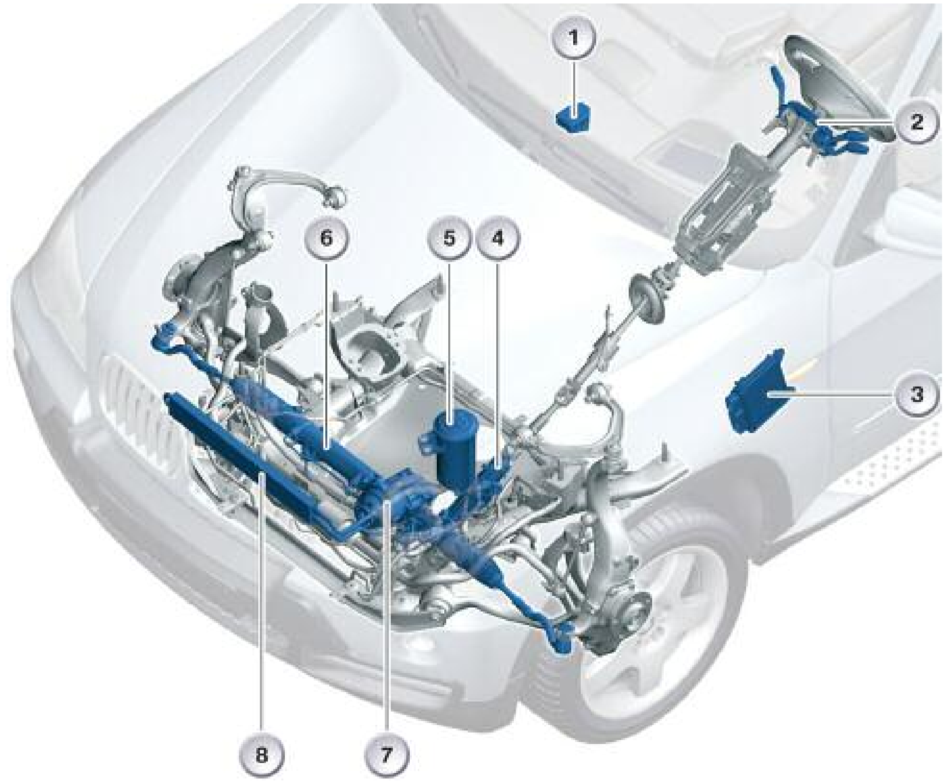
The E70 is the first all-wheel-drive vehicle to be offered with Active Steering (AS) Servotronic is only offered in conjunction with the Active Steering.

Active Steering (AS)

Active Steering was initially offered in the E60 (5 Series). Since then, a large proportion of BMW's in the 3 and 6 Series now have Active Steering. It is only the X models and other all-wheel-drive vehicles that have not yet been provided with this for reasons of space.

This innovative steering system is now being offered, as an option, in an all-wheel-drive vehicle for the first time at BMW, namely in the E70.

For the most part, the active steering system on the E70 is much the same as on previous models. There are some minor changes which will be discussed in this section.



Index	Explanation	Index	Explanation
1	DSC Sensor	5	Fluid reservoir
2	Steering Column Switch Cluster	6	Steering gear
3	AS control unit	7	Hydraulic pump
4	AS actuating unit	8	Power steering cooler

Changes to Active Steering

On the E70, certain changes have been made to the Active Steering system on the E70. They are as follows:

- The cumulative (total) steering angle sensor has been omitted.
- The ECO valve has been replaced by the Electronically Controlled Bypass Valve (EVV).
- Yaw moment compensation is now enhanced with the addition of GRR+.

Cumulative (total) Steering Angle (virtual)

With the addition of Active Steering on the E70, the total steering angle sensor has been omitted from the system. The value for the total steering angle is now a “virtual” value which is calculated from the driver’s steering angle and the motor position sensor value.

The virtual (total) steering angle value provides the same information as the the total steering angle sensor. The initialization procedure still needs to be carried out when there are any changes to the system.

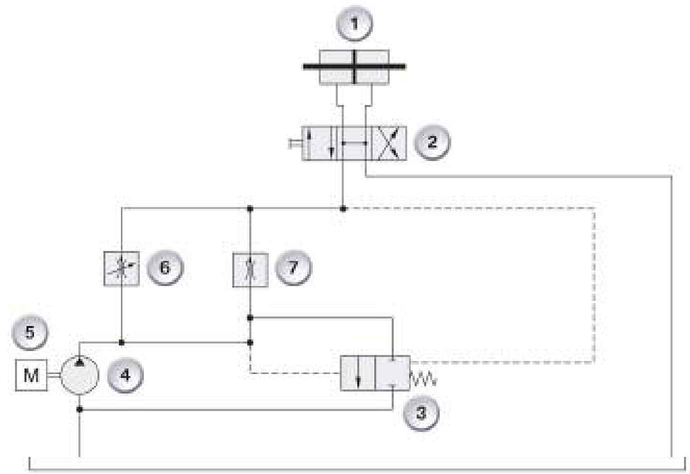
The initialization process has changed and differs slightly from the procedure on previous vehicles with Active Steering.

Electronically Controlled Bypass Valve (EVV)

The EVV regulates the volumetric flow of hydraulic fluid in the hydraulic pump to ensure that only the volumetric flow currently required to provide power assistance is made available.

Example:

When the vehicle is being driven straight ahead without power assistance, the circulation pressure in the steering hydraulic circuit drops, thus reducing the circulation pressure and the power consumption. If a steering movement is required, the volumetric flow is immediately raised again and the usual steering angle speed is ensured.



Index	Explanation	Index	Explanation
1	Rack and pinion unit	5	Engine
2	Steering valve	6	EVV
3	Flow regulating piston (in pump)	7	Throttle (restrictor)
4	Vane-cell pump		

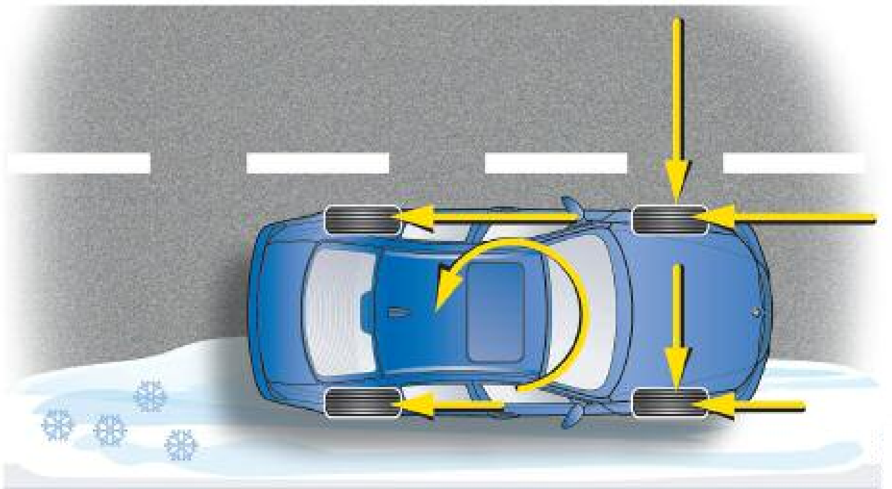
The EVV (1) therefore controls the power consumption of the hydraulic pump, thus reducing the fuel consumption and the CO_2 emissions of the combustion engine.

Yaw-rate Control Plus (GRR+)

The "yaw-rate control plus" function assists the driver when he is braking on roads with varying friction coefficients, in a similar way to the yaw moment compensation. This function represents a significant safety feature.

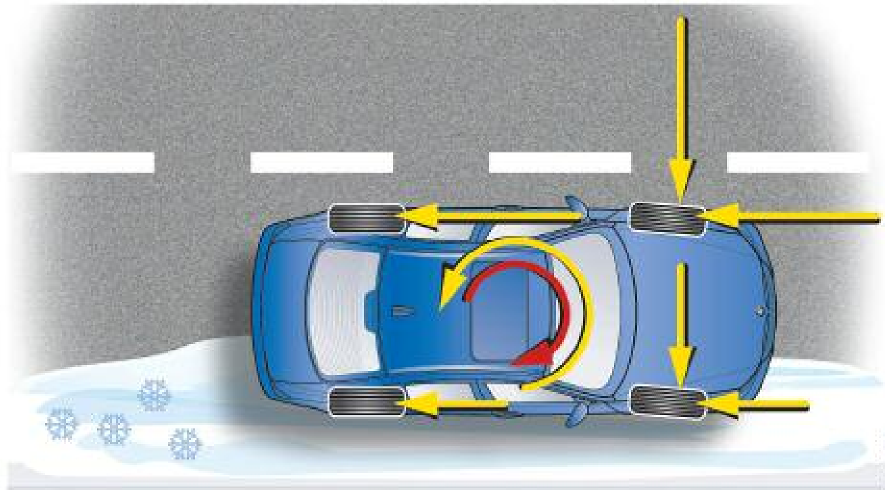
In the case of braking on different surface friction coefficients (asphalt/ice or snow), a moment builds up about the z or vertical axis (yaw moment) rendering the vehicle unstable.

In this special case, the Active Steering control unit calculates the steering angle (maximum ±4°) required for the front wheels to keep the vehicle stable using the actual yaw rate and the longitudinal and lateral acceleration.



This active counter-steering creates counter-torque about the z or vertical axis (red arrow) which compensates for the earlier acting yawing force (yellow arrow).

In this way, the vehicle is stabilized by clever interaction between the DSC braking and the AS function, resulting in a new safety aspect, unique in this class.



Special Feature

This function shortens the braking distance because the yaw-rate control plus allows higher braking pressure on the high friction coefficient side.

Difference to Yaw Moment Compensation

With yaw moment compensation, an important calculation principle for automatic early counter-steering was the difference between the front wheel braking pressures that were detected by the DSC and based on which the DSC calculated the angle for attack of the front wheels and transmitted to the AS control unit.

This shared functionality of the DSC and AS control unit is now fully integrated into the AS control unit with yaw-rate control plus and, due to the high communication rate, precise interaction between the two units has now been achieved.

Workshop Exercise - Active Steering

Using an instructor designated E70, connect the diagnostic equipment and perform a short test. Proceed to test module for Active Steering initialization.

Are there any special tools required for this process?

When does this procedure need to be carried out?

How is total steering angle value calculated?

Is there a “physical” sensor for the total steering angle?

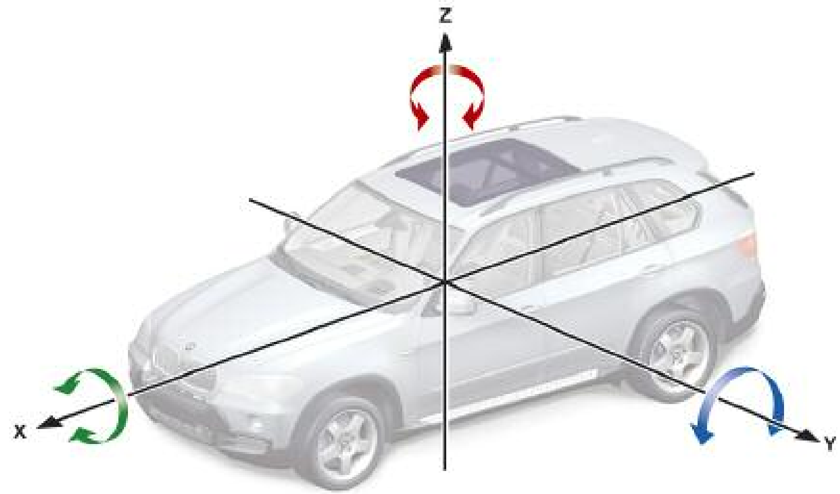
Where can the “startup/adjustment” test module be found in diagnosis?

Vertical Dynamics

The vertical dynamics systems are those systems which affect vehicle motion along the vertical (or z-axis). In other words, the up and down movement of the chassis and or body.

On the E70, these systems include:

- Vertical Dynamics Control (VDC -previously EDC)
- Electronic Height Control (EHC)
- Active Roll Stabilization (ARS)



Adaptive Drive

Adaptive Drive is an optional system on the E70 which includes the combination of ARS and VDC. For the first time, these systems are functionally linked which provides maximum safety, comfort and agility beyond compare for an SAV.

Adaptive Drive reduces lateral roll of the body, which normally occurs during high-speed cornering or in the event of rapid swerving.

Adaptive Drive also reduces the required steering angle and improves ride comfort coupled with increased driving dynamics.

The customer can choose between a normal and a sporty basic setting via a switch on the center console (near GWS).

Unpleasant pitching and lateral rolling of the body are diminished or eliminated entirely. The self-steering and load transfer characteristics of the vehicle are significantly improved.

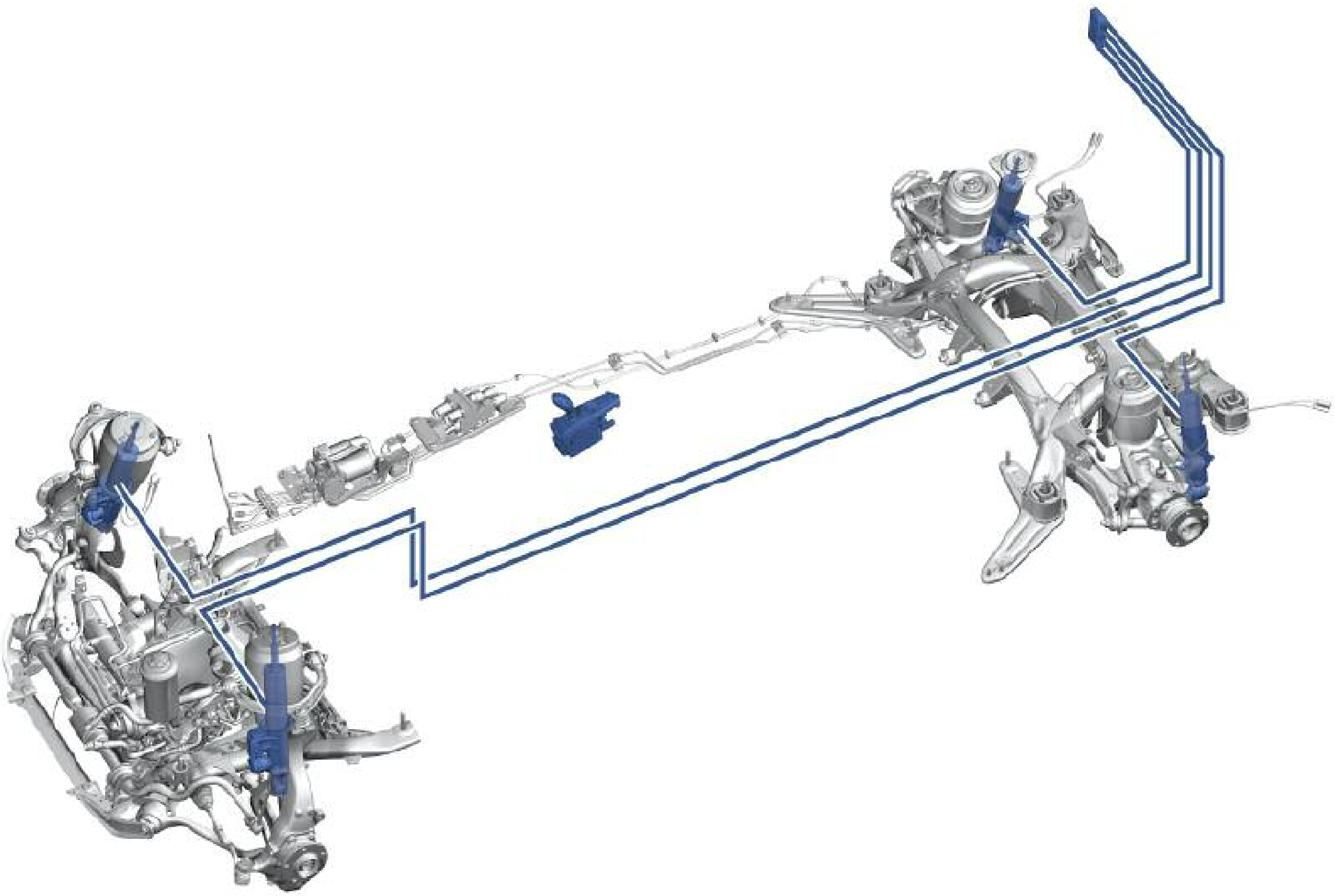
The reciprocal movements in the upper part of the body, which are inherent in the design of SAV vehicles, are considerably reduced. The vehicle can be driven with higher levels of precision and agility. The system also contributes to shorter braking distances.

Vertical Dynamics Control

The Vertical Dynamics Control (VDC) system being introduced on the E70 from SOP. VDC is a component of the Adaptive Drive equipment package and is an advancement of the EDC-K already fitted on the E65.

Like EDC-K, VDC is notable for its continually adjustable dampers whereby, within certain limits, as many damping characteristic curves (damping force - piston speed) as desired can be plotted.

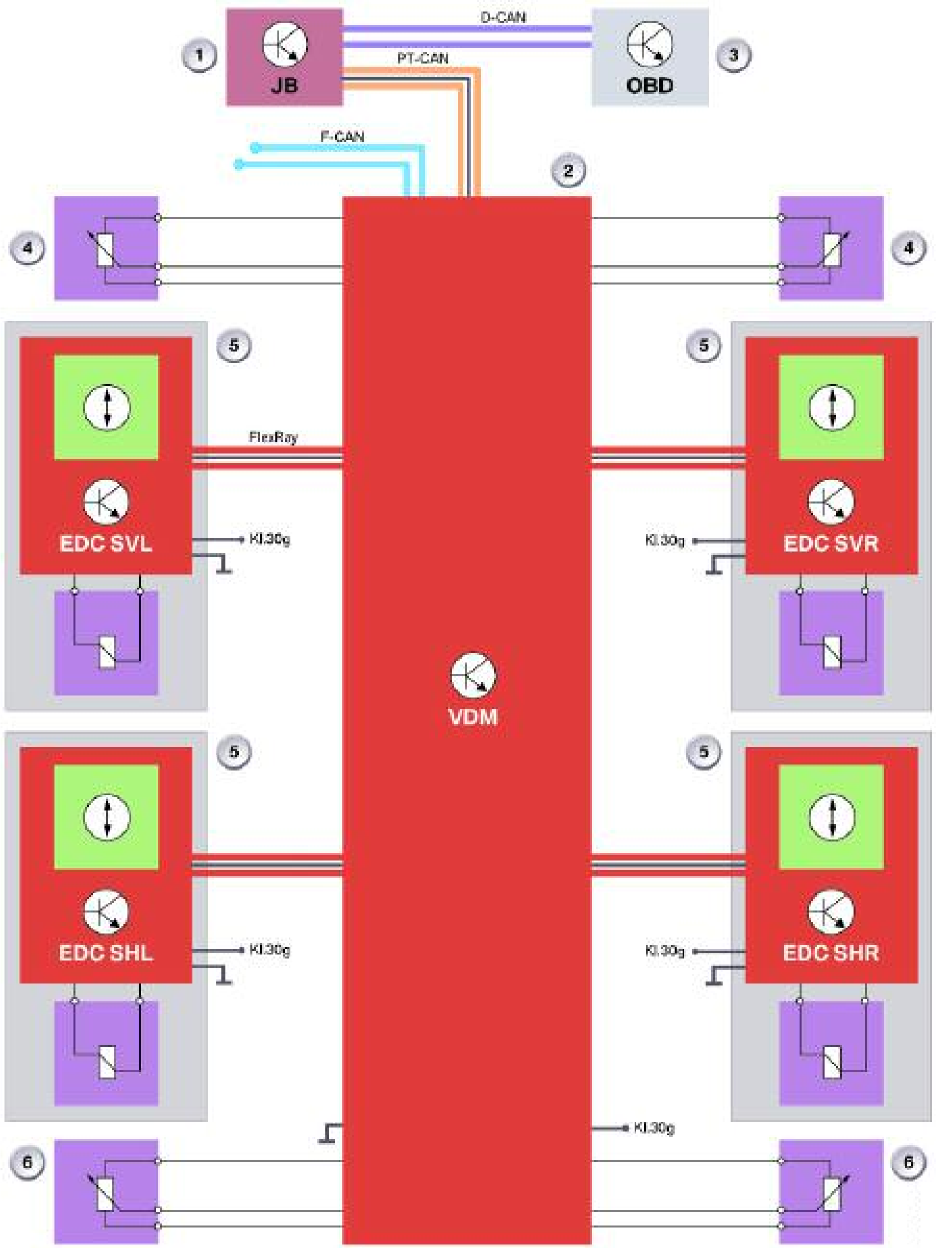
The characteristic curve used depends on the driving situation, in other words, the variables that describe the dynamic driving state of the vehicle and which are selected automatically at the driver's command.



Comparison between EDC-K in the E65 and VDC in the E70

	EDC-K	VDC
Model	E65 from introduction into series production from 7/2001	E70 from SOP 10/06 in the Adaptive Drive equipment package
Program Selection	via Control Display and controller	“SPORT” button next to gear selector switch
Control unit	EDC-K control unit on the device holder behind glove compartment	VDM control unit: rear left of luggage compartment Four EDC satellite control units directly on the damper
Sensors	Vertical: vertical acceleration sensor, front left, front right, rear right Longitudinal: wheel speed sensors, front left, front right Lateral: steering angle sensor (LWS) from the steering column switch cluster	Vertical: four vertical acceleration sensors integrated in the EDC satellite-control units, four ride-height sensors connected directly to the VDM control unit Longitudinal: wheel speed sensors or vehicle speed from the DSC control unit Lateral: steering angle sensor (LWS) from the steering column switch cluster, Rotor position sensor (if Active Steering fitted), lateral acceleration (DSC sensor) as redundant signal to the steering angle
Damper	Twin-tube gas-pressure dampers	Twin-tube gas-pressure dampers
Diagnostics	fully compatible	VDM and EDC satellite control units flash-programmable
Programming	EDC-K control unit is flash programmable	VDM and EDC satellite control units are flash programmable
Coding		VDM and EDC satellite control units are codable
Malfunction display	Messages in the Control Display or instrument cluster	Messages in the Control Display or instrument cluster
Testing	Diagnostic tester	Diagnostic tester

VDC System Overview



Index	Explanation	Index	Explanation
1	Junction Box Control Module	4	Ride height sensors, front
2	Vertical Dynamics Management	5	EDC Satellites
3	Diagnostic connector	6	Ride height sensors, rear

VDC Overview Explanation

The VDM control module is connected to F-CAN, PT-CAN and the FlexRay bus systems. The four EDC satellites are connected to the VDM through FlexRay. The satellites contain the vertical acceleration sensors and the solenoid valves for dampening.

Each satellite has its own power and ground supply. Power (B+) is supplied by the KL30g circuit.

The ride height sensors are "hardwired" to the VDM and send analog signals to report vehicle ride height.

Objectives of the VDC System

The primary objective of the VDC system to improve ride comfort while maintaining driving safety at an invariably high level. High levels of ride comfort are achieved when the vehicle body hardly moves along the vertical axis in spite of excitations of the vehicle induced by cornering or by the road surface itself (bumps, gaps).

For this reason, the adjustable dampers are operated in line with a soft, comfortable damping characteristic curve in as many situations as possible.

High levels of driving safety are achieved if the wheels never lose contact with the road surface and a high support force is available if required. A harder damping characteristic is therefore set if the driving situation or driver's intervention (e.g. steering, braking) demands it.

As with EDC-K, the dampers have an infinite number of damping characteristic curves at their disposal; unlike EDC-K, however, the dampers are controlled not only axle by axle but also at each individual wheel.

In its regulation, the system uses the complete characteristic map of the rebound and compression stages between the comfort (1) and stability (2) threshold curves.

In the event of a fault, the control range is minimized to safety characteristic curve (3).

System Network

The VDC system is a mechatronic system consisting of electronic, hydraulic and mechanical subsystems. These can be subdivided by function as follows:

- Detection of input signals
  - Sensors for ride heights and rates of vertical acceleration to permit detection of the driving state and the prevailing road conditions
  - Control element to enable the driver to set the damping program (comfort, sport). This is located on, and electrically integrated in, the gear selector switch.
  - Steering angle (output by the SZL control unit via F-CAN) for preemptive detection of cornering
  - Lateral acceleration (out by the DSC sensor via F-CAN) for detection of cornering
  - Vehicle speed or wheel speeds (output by the DSC control unit via F-CAN)
- Processing unit
  - VDM control unit - This checks the plausibility of the incoming signals and uses control algorithms that deliver damping forces at individual wheels as a set point value
  - EDC satellite control units - These process the signals from the vertical acceleration sensors on the one hand and output the processed signal. On the other hand, they convert into a valve current the target force from the VDM control unit by means of a stored characteristic curve
- Actuators
  The electrically controllable valve in the adjusting damper makes it possible to realize the different damping force characteristic curves
- Communications media
  The VDM control unit is connected to the PT-CAN, F-CAN and FlexRay; the EDC satellite control units are only connected to the FlexRay

VDC Components

VDM Control Unit

Index	Explanation	Index	Explanation
1	Comfort Access	4	Vertical Dynamics Management
2	Not for US Market	5	Electronic Height Control
3	Park Distance Control		

Control Strategy

The underlying control strategy is known as the "Skyhook regulator"; the name reflects the highest of control objectives: to keep the vehicle body at the same height irrespective of the driving situation (as if the vehicle were suspended from the sky).

To achieve this highest of all comfort objectives, the movements of the entire body have to be evaluated. To this end, there is a comprehensive analysis of ride heights and accelerations along the z-axis within the frequency range of between approximately 1 and 3 Hz.

The necessary (total) damping force for this control component will turn out to be comparatively low. To simultaneously ensure that the wheels do not lose contact with the road surface and that optimum contact force is transferred according to the situation, the movement of each individual wheel is evaluated and not just the movement of the entire body.

The movements, or excitations, relevant here take place within a frequency range of between approximately 11 and 13 Hz and can therefore be distinguished from the movements of the body.
This control component will therefore calculate high damping forces dependent on the vertical movement of the individual wheel.

As a matter of principal, these forces may be different at each individual wheel and, for the first time with VDC, can be implemented as such. Furthermore, VDC regulation takes into consideration steering inputs (e.g. transition from straight-ahead travel to cornering) based on the steering angle curve.

If VDC detects a rapid increase in the steering angle, the controller infers that the vehicle is entering a bend and can preventively adjust the dampers on the outside of the bend to a harder setting in advance. In this way, VDC is able to support ARS regulation and contributes to a reduction in vehicle rolling movements (of course, this applies also during steady-state circular driving).

Moreover, VDC is able to detect the braking applications of the driver based on the brake pressure information supplied by DSC. A high brake pressure normally results in a pitching of the vehicle; VDC counteracts this by adjusting the front dampers to higher damping forces.

This also results in an improvement in the front/rear brake force distribution, which in turn reduces the braking distance (by comparison with a vehicle without VDC).

The VDC controller adjusts the basic damping force level in accordance with the damping program selected by the driver (comfort/sport).

Nevertheless, high damping forces are always applied at individual wheels in critical driving situations, e.g. despite the fact that the comfort program is selected.

Once the individual control components have been prioritized, a target damping force is output on the FlexRay for each wheel or damper. In addition, the dampers are prescribed a current value for the steady-state operating point.

Display Control

The VDM control unit is responsible for evaluating the button on the gear selector lever that the driver uses to select the damping program. Depending on the damping program selected, the VDM control unit issues a request on the PT-CAN to switch the LED in the button on or off (off = comfort, on = sport).

Degradation Behavior in the Event of a Fault

Depending on the type of fault present, the VDM control unit decides which of three degradation levels must come into effect.

- Level 1: Substitute values If, for example, the steering angle signal is unavailable, different variables will be used as a substitute value for cornering detection. The driver receives no failure message. No fault code memory entry is stored.
- Level 2: Constant supply of current. The VDM control unit specifies a constant damping force, which is the same for all four wheels ("medium-hard damping"). This leads to a constant supply of current to the valve in the adjusting dampers. A triggering factor for this degradation level may be a faulty ride-height sensor, for example. The driver receives a failure message. A fault code memory entry is stored.
- Level 3: Zero supply of current. If a fault is present in the load circuit, e.g. in the control of a valve, the VDM control unit will select the third degradation level: it tells the dampers that the valve is no longer permitted to be supplied with current. The valve therefore moves into a position that corresponds to a rather hard suspension setting. The driver receives a failure message. A fault code memory entry is stored.

From the damping force selected in the degradation levels, it can be seen that it is always the safe condition (harder tuning) that is adopted in the event of a fault (failsafe behavior).

Diagnostic Functions

The VDM control unit only stores its own faults in its fault memory. Faults with the EDC satellite control units are stored in their own fault memory. In the event of a VDC fault, therefore, it is necessary to check not only the fault memory of the VDM control unit, but of the satellites too. The VDM control unit also functions as a diagnostics gateway between the PT-CAN and VD-FlexRay so that the EDC satellite control units are accessible to the tester).

Note: The fault memories of the VDM control unit and the EDC satellite control units must be checked in the event of a VDC system failure. Unlike the EDC-K in the E65, it is not necessary to perform straight-ahead calibration of the VDC system following replacement of the steering angle sensor.

EDC Satellite Control (with damper)

This new generation EDC on the E70 is located externally, unlike the EDC system in the E65. The twin-tube gas-pressure damper, EDC satellite control unit and the EDC control valve with wiring as far as the first plug connection form one complete component and can only be replaced in this combination.

Index	Explanation	Index	Explanation
1	Strut damper (shock)	3	EDC solenoid (control valve)
2	EDC Satellite (with sensor)		

EDC Satellite Control Unit

The following functions are implemented in the EDC satellite control unit:

- Signal processing: The EDC satellite control units each have one single-axis acceleration sensor on the control unit board. It is a micro mechanical structural element, which converts accelerations into capacitance changes first and then into an analog voltage signal.

  This is processed accordingly by the EDC satellite control unit and made available to the VDM control unit via FlexRay.

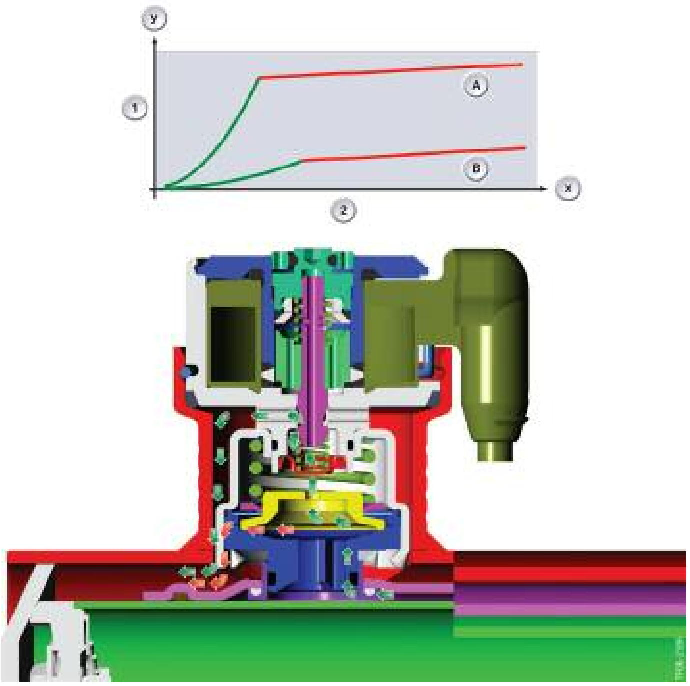
- Actuating functions: Each EDC satellite control unit has a damping characteristic map valid for this type of damper that is electronically stored in the form of support points. It is therefore possible to compensate for unavoidable tolerances (variations) arising from manufacture and achieve a higher degree of actuating precision (damping force).

Note: The EDC satellite control unit with twin tube gas-pressure damper and EDC control valve can only be replaced as one unit. The vehicle model and installation location (e.g. front left) must be stated when a replacement part is being ordered.

- Diagnostic functions
  Each EDC satellite control unit is compatible with diagnostics and has its own fault memory.

Note: The fault memories of the VDM control unit and the EDC satellite control units must be checked in the event of a VDC system failure. If the EDC satellite control units do not respond to diagnostics, there may be a fault in the VDM control unit (diagnostic gateway) or FlexRay. A calibration of the ride-height sensors and acceleration sensors must be carried out in the VDM control unit following replacement of an EDC satellite control unit.

Twin-Tube Gas Pressure Damper



Index	Explanation	Index	Explanation
1	Damping Force (N)	A	Control current = 2 A
2	Piston Speed (m/s)	B	Control current = 0.65 A

Ride-height Sensor

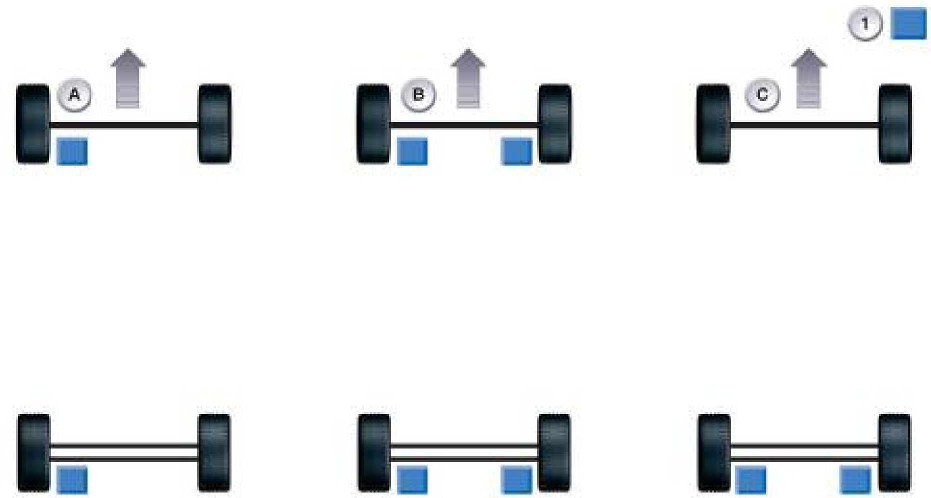
The ride-height sensors are electrically connected (hardwired) directly to the VDM control unit. The ride height is sent from the sensor to the VDM via an analog circuit.

Two way or one-way sensors may be fitted to the rear axle, depending on the vehicle's equipment level.

Two-way sensors deliver the signal not only to the VDM control unit but also to the EHC control unit.

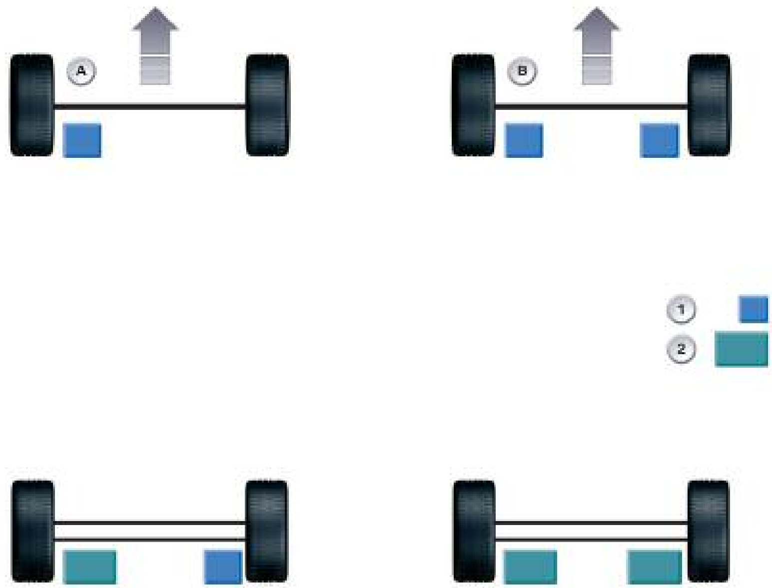
Note: If a new ride-height sensor is being fitted, it must be ensured that only parts with matching part numbers are fitted. In particular, care must be taken not to confuse one-way and two-way sensors (one-way/two-way depends on the equipment level of the vehicle). Two-way sensors bear the marking "dop-pelt" on the housing.

E70 Ride Height Sensors



Index	Explanation	Index	Explanation
1	One-way ride height sensor with one output	B	Adaptive drive w or w/o Xenon
A	Option- Xenon only	C	Option - EHC only

E70 Ride Height Sensors (cont.)



Index	Explanation	Index	Explanation
1	Two-way ride height sensor with two outputs	2	One-way ride height sensor with one output

E70 Ride Height Sensor Variants

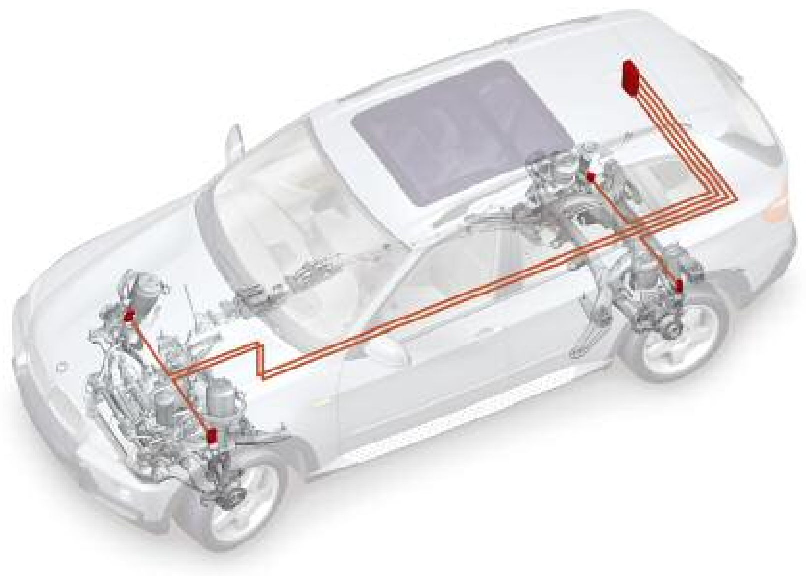
Index	Explanation	Index	Explanation
1	One-way ride height sensor with one output	B	Option -EHC and Xenon
2	Two-way ride height sensor with two outputs	C	Adaptive drive and EHC w or w/o Xenon

FlexRay in the E70

With the launch of the E70, the FlexRay bus system will be used for the first time worldwide in a standard production vehicle.

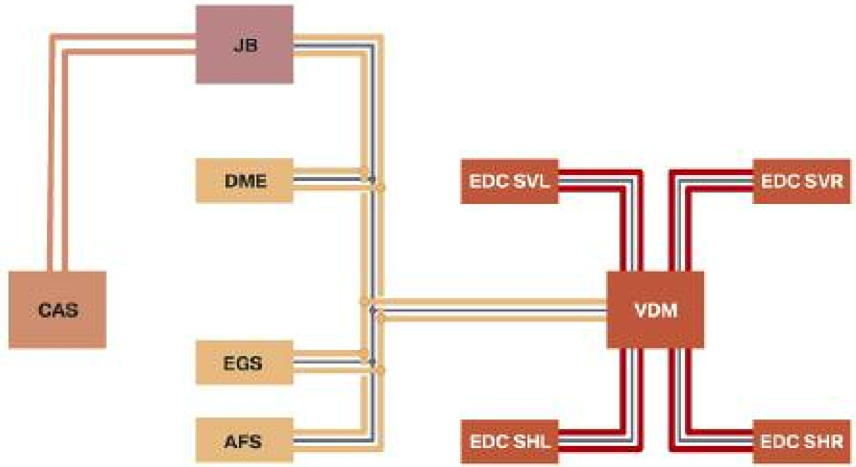
Currently, the E70 only uses the FlexRay bus in the Vertical Dynamics Management (VDM) system. The FlexRay bus system establishes the connection between the VDM control unit (vertical dynamics management) and the EDC satellites at the shock absorbers.

Future BMW modules will expand the use of FlexRay due to the need for increased network speed and reliability.



The FlexRay bus system in the E70 is designed as a two-wire, single-channel bus system. Acting as the gateway, the VDM control unit establishes the connection between the PT-CAN and FlexRay bus systems.

Data communication between the EDC satellites on the FlexRay and the other control units installed in the E70 takes place via the VDM control unit.



Index	Explanation
EDC SVL	EDC Satellite, Front Left
EDC SVR	EDC Satellite, Front Right
EDC SHL	EDC Satellite, Rear Left
EDC SHR	EDC Satellite, Rear Right
VDM	Vertical Dynamics Management

The most important properties of the FlexRay bus system are outlined in the following:

- Bus topology
- Transmission medium - signal properties
- Deterministic data transmission
- Bus protocol

Bus Topology

The FlexRay bus system can be integrated in various topologies and versions in the vehicle.

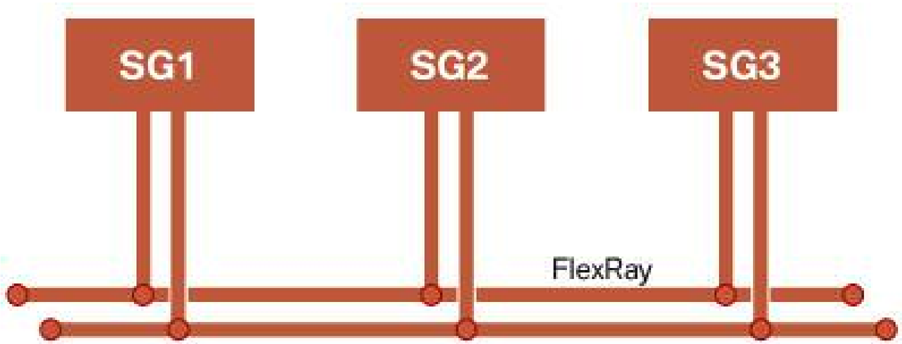
The following topologies can be used:

- Line-based bus topology
- Point-to-point bus topology
- Mixed bus topology

Line-based Bus Topology

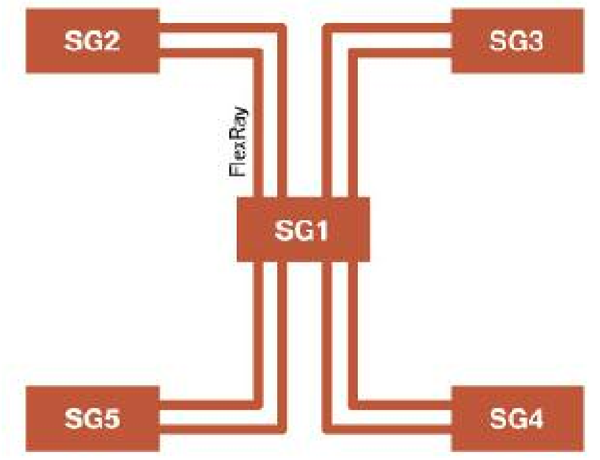
All control units (SG1...SG3) in line-based topology are connected by means of a two-wire bus, consisting of two twisted copper cores. This type of connection is also used on the CAN-bus. The same information but with different voltage level is sent on both lines.

The transmitted differential signal is immune to interference. The line-based topology is suitable only for electrical data transmission.



Point-to-point Bus Topology

The satellites (control units SG2...SG5) in point-to-point bus topology are each connected by a separate line to the central master control unit (SG1). Point-to-point topology is suitable for both electrical as well as optical data transmission.



Mixed Bus Topology

Mixed bus topology caters for the use of different topologies in one bus system. Parts of the bus system are line-based while other parts are point-to-point.

Redundant Data Transmission

Fault-tolerant systems must ensure continued reliable data transmission even after failure of a bus line. This requirement is realized by way of redundant data transmission on a second data channel.

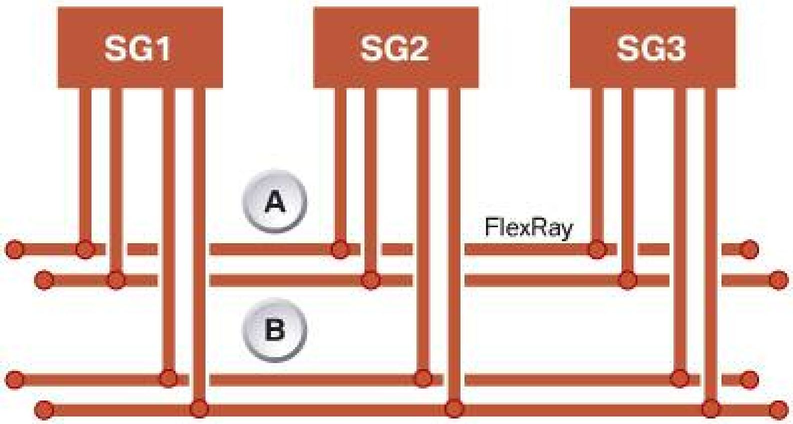
A bus system with redundant data transmission uses two independent channels. Each channel consists of a two-wire connection. In the event of one channel failing, the information of the defective channel can be transmitted on the intact channel.

FlexRay enables the use of mixed topologies also in connection with redundant data transmission.

Bus Topology of FlexRay in the E70

The physical configuration of the FlexRay bus system in the E70 is point-to-point. All EDC satellites are individually connected via plug connections to the VDM control unit.

Internally, however, the left and right EDC satellites are connected to form a line-based topology. The two lines are connected by means of a double point-to-point connection consisting of two bus drivers. Every item of information that is sent from one of the EDC satellites or from the central VDM control unit reaches all connected control units.



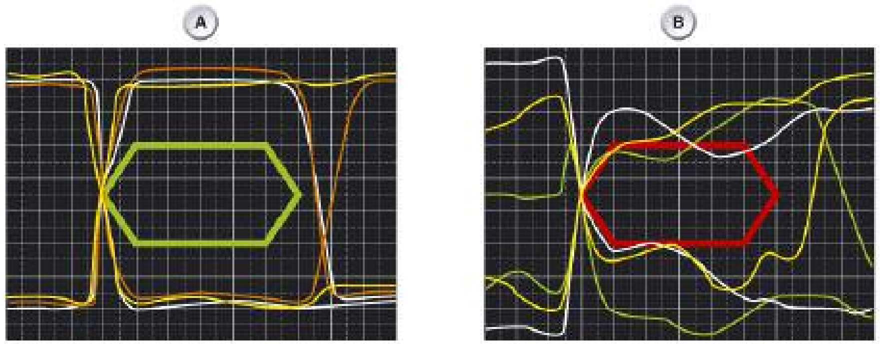
Index	Explanation
A	Channel 1
B	Channel 2

Transmission Medium - Signal Properties

The bus signal of the FlexRay must be within defined limits. A good and bad image of the bus signal is depicted below. The electrical signal must not enter the inner area neither on the time axis nor on the voltage axis.

The FlexRay bus system is a bus system with a high data transmission rate and therefore with rapid changes in the voltage level.

The voltage level as well as the rise and drop of the voltage (edge steepness) are precisely defined and must be within certain values. There must be no infringements of the marked "fields" (green and red hexagon).



Electrical faults resulting from incorrect cable installation, contact resistance etc. can cause data transmission problems.

The images shown above can be depicted only with very fast oscilloscopes. The oscilloscope in the current BMW diagnostic system is not suitable for representing such images.

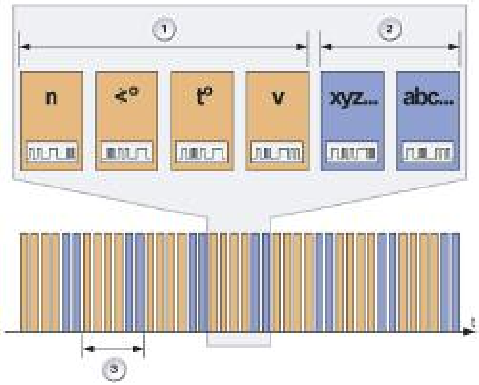
The voltage ranges of the FlexRay bus system are:

- System ON - no bus communication 2.5 V
- High signal - 3.1 V (voltage signal rises by 600 mV)
- Low signal - 1.9 V (voltage signal falls by 600 mV)

The voltage values are measured with respect to ground.

Deterministic Data Transmission

The CAN-bus system is an event-controlled bus system. Data are transmitted when an event occurs. In the event of an accumulation of events, delays may occur before further information can be sent.



Index	Explanation
1	Time-controlled part of cyclic data transmission
2	Event-controlled part of cyclic data transmission
3	Cycle (5 ms total cycle length of which 3 ms static (= time-controlled) and 2 ms dynamic (= event-controlled)
n	Engine speed
<	Angle
t°	Temperature
v	Road speed
xyz.. abc..	Event-controlled information
t	Time

If an item of information cannot be sent successfully and free of errors, this information is continually sent until the communication partner confirms its receipt.

If faults occur in the bus system, this “event controlled” information can back up causing the bus system to overload, i.e. there is a significant delay in the transmission of individual signals. This can result in poor control characteristics of individual systems.

The FlexRay bus system is a time-controlled bus system that additionally provides the option of transmitting sections of the data transmission event-controlled. In the time controlled part, time slots are assigned to certain items of information. One time slot is a defined period of time that is kept free for a specific item of information (e.g. engine speed).

Consequently, important periodic information is transmitted at a fixed time interval in the FlexRay bus system so that the system cannot be overloaded. Other less time-critical messages are transmitted in the event-controlled part.

Bus Protocol

Deterministic data transmission ensures that each message in the time-controlled part is transmitted in real time. Real time means that the transmission takes place within a defined time.

Therefore, important bus messages are not sent too late due to overloading of the bus system. If lost due to a temporary problem in the bus system (e.g. EMC problem) a message cannot be sent again. A current value is sent in the next assigned time slot.

High Bandwidth

The FlexRay bus system operates with a data transmission rate of 10 Mbits/s. This speed corresponds to 20 times the data transmission rate of the PT-CAN.

Synchronization

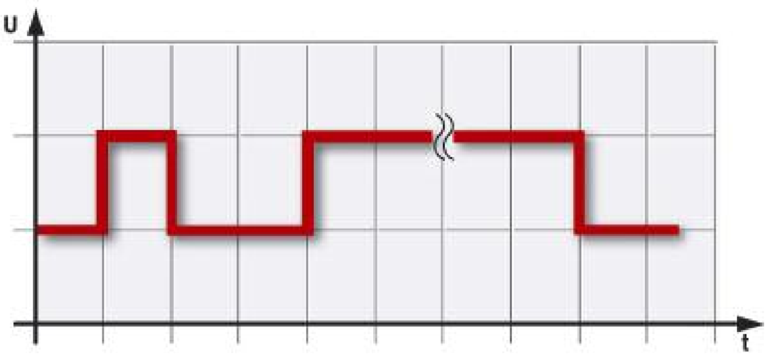
A common time base is necessary in order to ensure synchronous execution of individual functions in interconnected control units. Time matching must take place via the bus system as all control units operate with their own clock generator.

The control units measure the time of certain synchronization bits, calculate the mean value and adapt their bus clock to this value. This system ensures that even minimal time differences do not cause transmission errors in the long term.

Wake-up and Sleep Characteristics

The control units are activated by means of an additional wake-up line. The wake-up line has the same function as the previous wake-up line (15WUP) in the PT-CAN. The signal curve corresponds to the signal curve of the PT-CAN.

As soon as the bus system is woken, the VDM receives a High level on the PT-CAN and transfers this signal to the wake-up line of the FlexRay, thus also waking the satellites.



The "wake-up voltage curve" graphic shows the typical behavior of the voltage curve in response to unlocking and starting the vehicle.

Phase 1:

Driver unlocks the car, the CAS control unit activates the K-CAN and the PT-CAN, the voltage level in the PT-CAN briefly goes to High, the VDM copies the signal and transfers it to the wake-up line on the FlexRay.

Phase 2:

Car is opened, terminal R is still OFF, the voltage levels in the bus systems drop again.

Phase 3:

Car is started, terminal 15 is ON, the voltages remain at the set levels until terminal 15 is turned off again.

Phase 4:

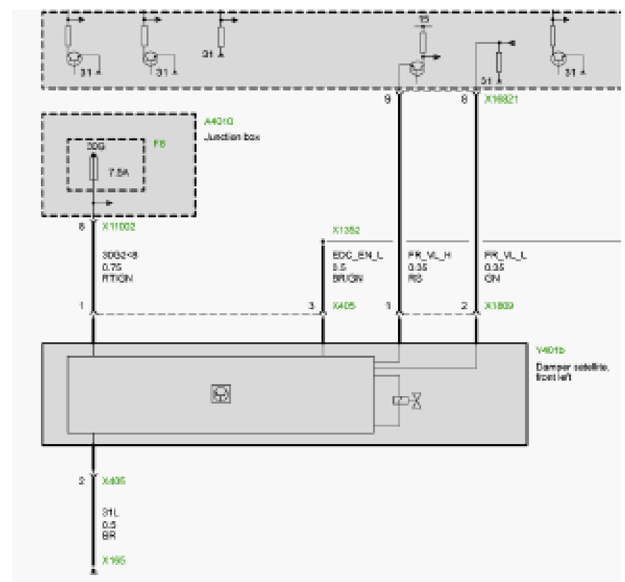
The complete vehicle network must assume sleep mode at terminal R OFF in order to avoid unnecessary power consumption. Each control unit in the network signs off to ensure that all control units "are sleeping".

Only when all EDC satellites have signed off at the VDM control unit can this control unit pass on this information to the PT-CAN and therefore to the complete network. An error message is stored if this is not the case.

This error message is then evaluated as part of the energy diagnosis procedure.

Wiring

The wiring of the FlexRay bus in the E70 is executed as a sheathed, two-core, twisted cable. The sheathing protects the wires from mechanical damage. The terminating resistors are located in the EDC satellites. Each satellite has one terminating resistor.



Since the surge impedance (impedance of high-frequency lines) of the lines depends on external influencing factors, the terminating resistors are precisely matched to the required resistance.

The four sections of line to the satellites can be checked relatively easily by means of a resistance measuring instrument (ohmmeter, multimeter). The resistance should be measured from the VDM control unit. See BMW diagnostic system for pin assignments.

The following conclusions can be made about the resistance between the VMD module and EDC satellite:

- < or = 10 Ohms – There is a short circuit in this section of line.
- 10-90 Ohms – This section of line is damaged (e.g. moisture in connector, line pinched)
- 90-110 Ohms – This section of line is OK and the satellite is connected (Note: Impedance errors are not recognized)
- > 110 Ohms – There is a break in the line or the satellite is not connected or there is a break in the connection to the satellites.

Workshop Exercise - FlexRay and VDM

Using the instructor designated E70, connect diagnostic equipment and perform short test. Note any faults to VDC or EDC systems.

List any faults present:

Using the test module and or ETM, locate the VDM connector. Unplug the VDM and test resistance to each EDC satellite. Record results below:

EDC Satellite	Resistance Value
Front Left	
Front Right	
Rear Left	
Rear Right	

What should the resistance values be on a normal (non-faulted) circuit?

Are any of the above values out of specification?

While investigating the above fault, note the power supply (B+) to each of the EDC satellites and record in the chart below:

EDC Satellite	Power Supply/Fuse #
Front Left	
Front Right	
Rear Left	
Rear Right	

What relay/circuit supplies power supply for each of the above satellites?

Besides wiring concerns and terminating resistors, what other issues can affect the FlexRay bus system?

What is the operating voltage of the FlexRay bus?

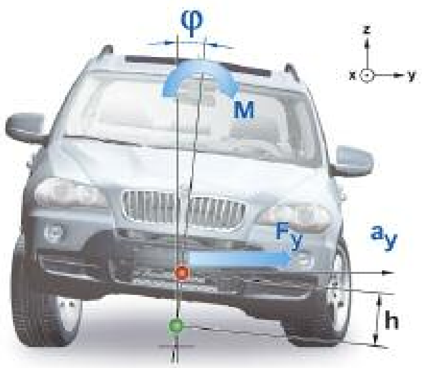
Can the oscilloscope from the DISplus/GT-1 be used to check the FlexRay bus? Explain answer.

NOTES PAGE

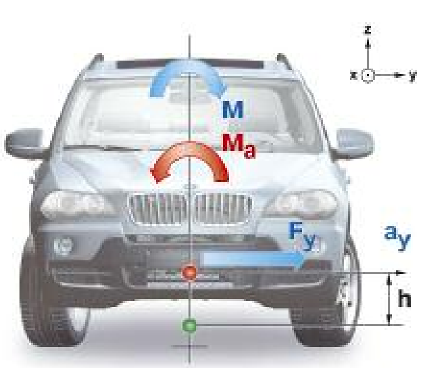
Active Roll Stabilization

The customer-friendly name for the option is "Dynamic Drive" and was first available in the 7 Series with the E65. Since then, the ARS system has been used in the 5 and 6 series and now for the first time in an SAV - the E70.

ARS is one of the two “functionally linked” systems which make up the “Adaptive Drive” feature in the E70.



E70 without ARS (when turning)



E70 with ARS (when turning)

As the vehicle drives through a bend, forces act on the vehicle causing it to rotate about the vehicles roll axis (X-axis). This force causes the body to tilt towards the outside of the bend. Ultimately, this causes the vehicle to rapidly approach its dynamic limits.

The ARS system, through the use of active anti-roll bars, is capable of counteracting this force. By preventing this situation, ARS can greatly contribute to vehicle stability especially on turns and during evasive maneuvers.

Passive vs. Active Roll Bar

The following is a comparison of passive and active roll bars:

- Conventional (passive) anti-roll bar - During cornering, the wheel suspension on the outside of the bend is compressed and the wheel suspension on the inside of the bend rebounds. This has a twisting effect on the anti-roll bar (torsion). The forces arising in the bearing points of the anti-roll bar produce a moment that counteracts the tilting of the body. The effect is to improve the distribution of loads acting on both wheels on the same axle.

  A disadvantage of a passive anti-roll bar is that the basic suspension tuning hardens when the suspension is compressed on one side of the vehicle during straight ahead travel. This results in a reduction in comfort.

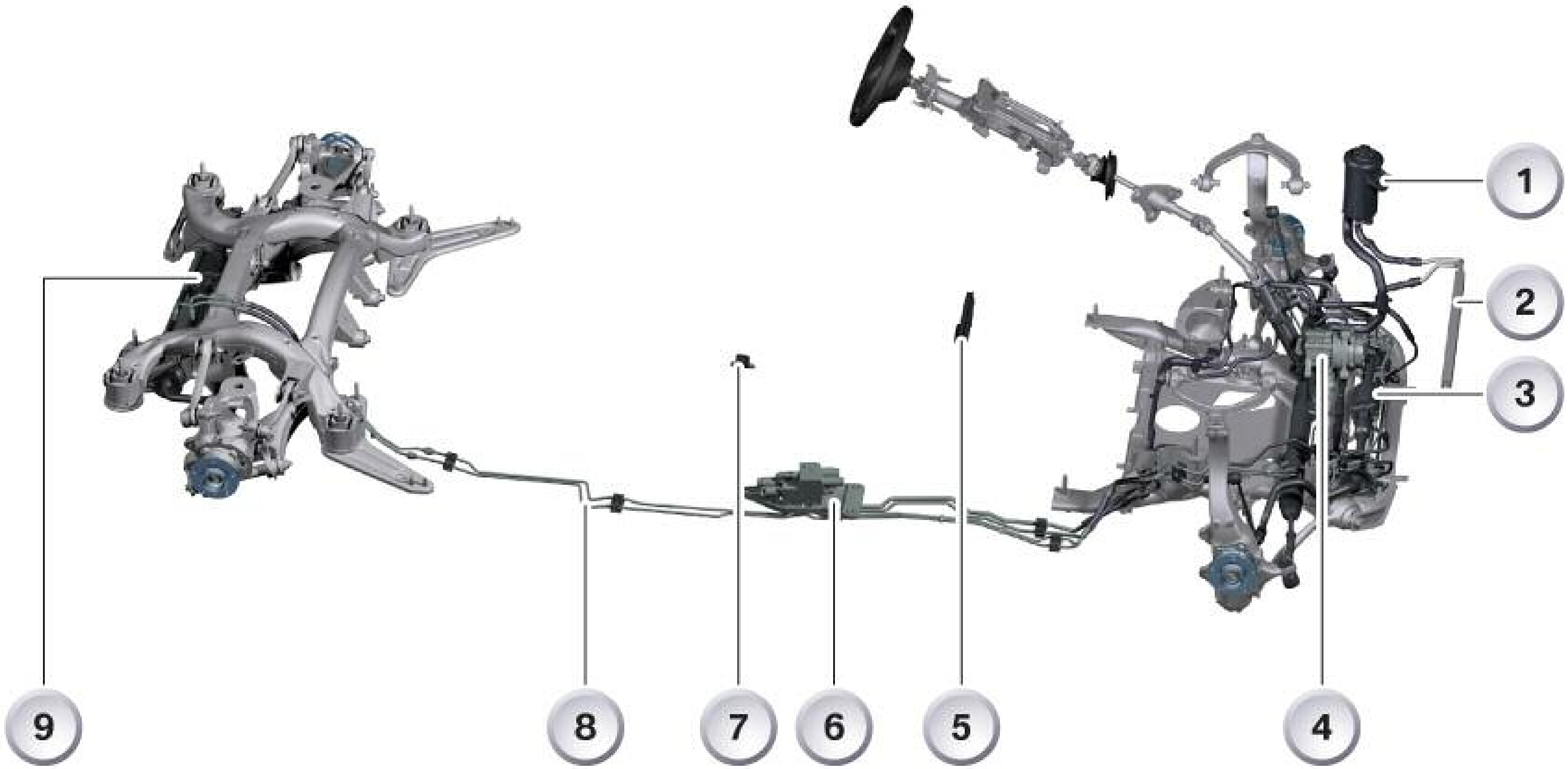
- Active anti-roll bar - The Dynamic Drive active chassis system also known as Active Roll Stabilization (ARS) - is a revolutionary step in chassis and suspension engineering. For the first time, the trade-off between handling/agility and comfort is largely eliminated. This results in a new type of "driving pleasure" typical of BMW.

  Dynamic Drive has two active anti-roll bars, which have a positive influence on body roll and handling characteristics. The fundamental feature of Dynamic Drive is the divided anti-roll bars on each axle. The two halves of the anti-roll bars are connected by a hydraulic oscillating motor.

  One half of the anti-roll bar is connected to the shaft of the oscillating motor, the other to the housing of the oscillating motor. These active anti-roll bars control stabilizing moments:

  - which reduce the reciprocal movement of the vehicle body,
  - which make it possible to achieve high levels of agility and target precision over the entire road speed range,
  - and produce optimum self-steering characteristics.

During straight-ahead travel, the system improves suspension comfort because the anti-roll bar halves are de-coupled, with the effect that the basic suspension tuning does not additionally harden when the suspension on one side is compressed.



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

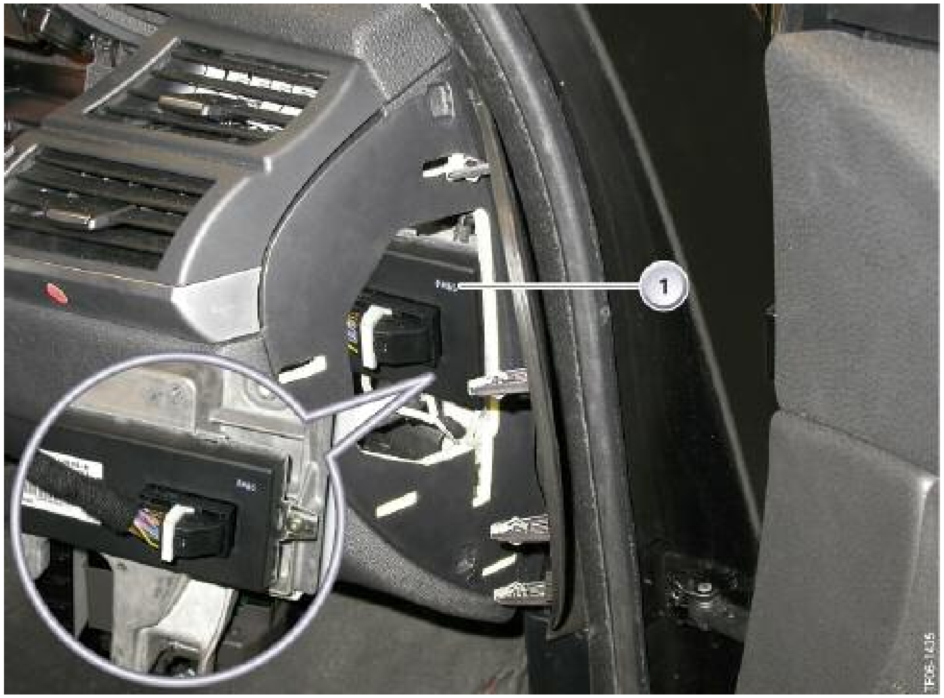
ARS System Components

The ARS system components are outlined in the following:

ARS Control Module

The ARS control module (1) is located in the vehicle interior near the right-hand A-pillar. The module is supplied with power via terminal 30 and is protected by a 10 A fuse.

The ARS control module is activated exclusively by the Car Access System (CAS) on a CAN wake-up line after "ignition ON".



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 ARS control unit.

Then the ARS control unit's hardware and software are checked.

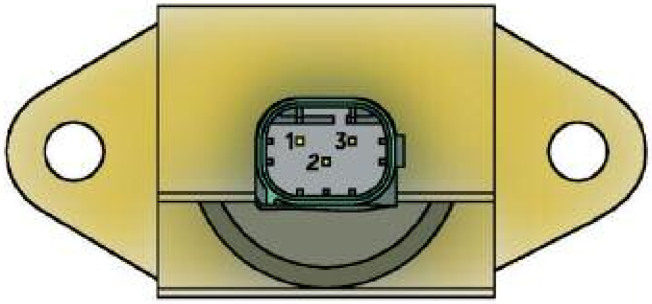
All the outputs (valve magnets) are subjected to a complex check for short circuits and breaks. If there is a fault, the system switches the actuators into a safe driving condition.

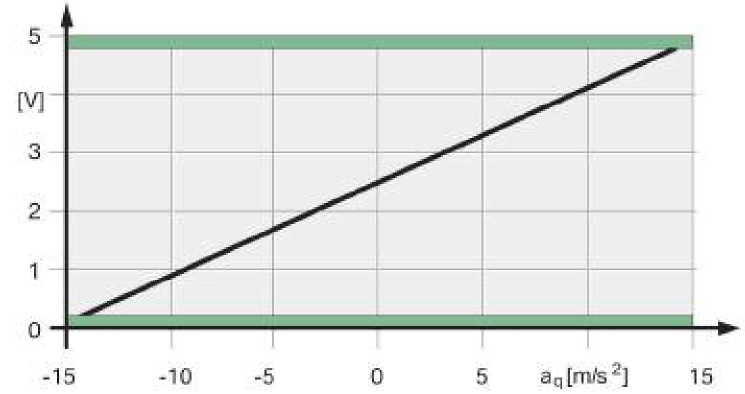
The ARS control unit switches off if there is undervoltage or over-voltage.

The ARS control unit learns the offset for the steering angle and the lateral acceleration during start-up and during driving.

Lateral Acceleration Sensor

The lateral acceleration sensor supplies the main sensor signal. It measures the lateral acceleration of the vehicle during cornering up to a measurement range of 1.1 g. It is installed on the base plate under the right front seat. The ARS control unit can learn an offset during start-up and when the vehicle is in motion.

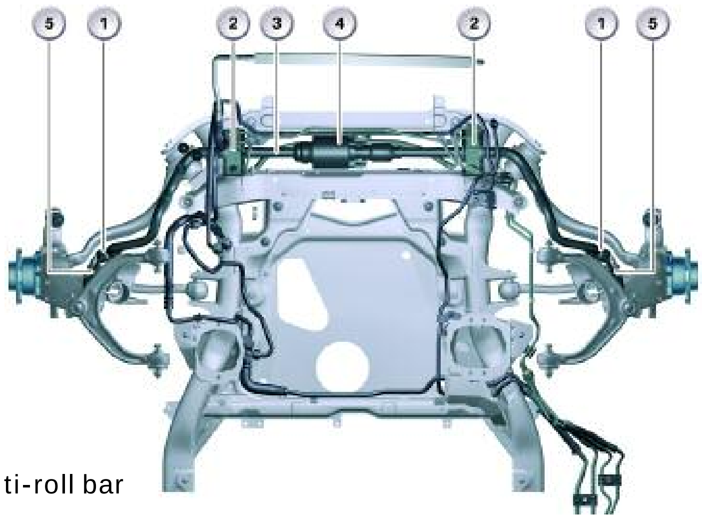




Active Anti-roll Bar

The oscillating motor and the oscillating motor housing are joined by one half of the anti-roll bar.

The active anti-roll bar consists of the oscillating motor and the anti-roll bar halves fitted to the oscillating motor, with press-fitted roller bearings for their connection to the axle carriers. The use of roller bearings ensures optimum comfort thanks to better response and reduced control forces.



Front axle anti-roll bar

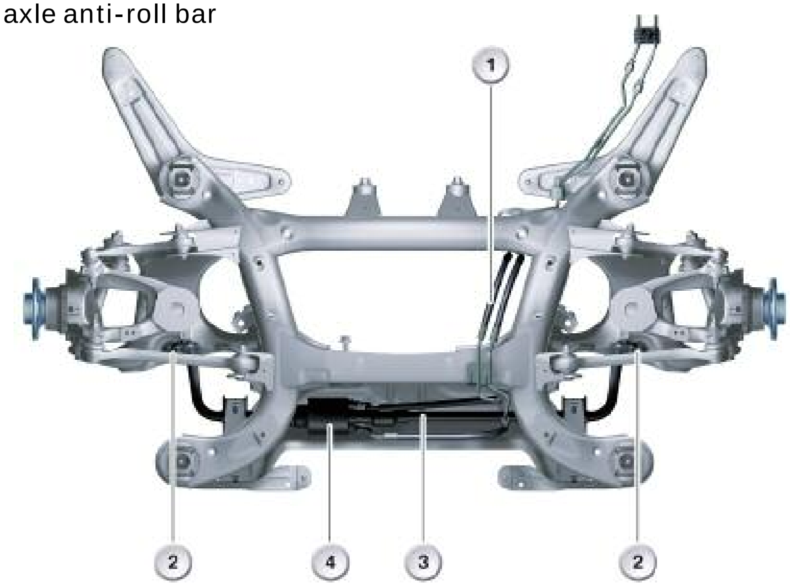
Index	Explanation
1	Anti-roll bar link connection to swivel bearing
2	Anti-roll bar bracket
3	Anti-roll bar
4	Oscillating motor (hydraulic)
5	Anti-roll bar links

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

Air filter elements are fitted to the pressure relief valves. These air filter caps with Goretex inserts must not be removed.

There are screw plugs in the area of the pressure relief valves on the oscillating motor of the rear-axle anti-roll bar.

Rear axle anti-roll bar

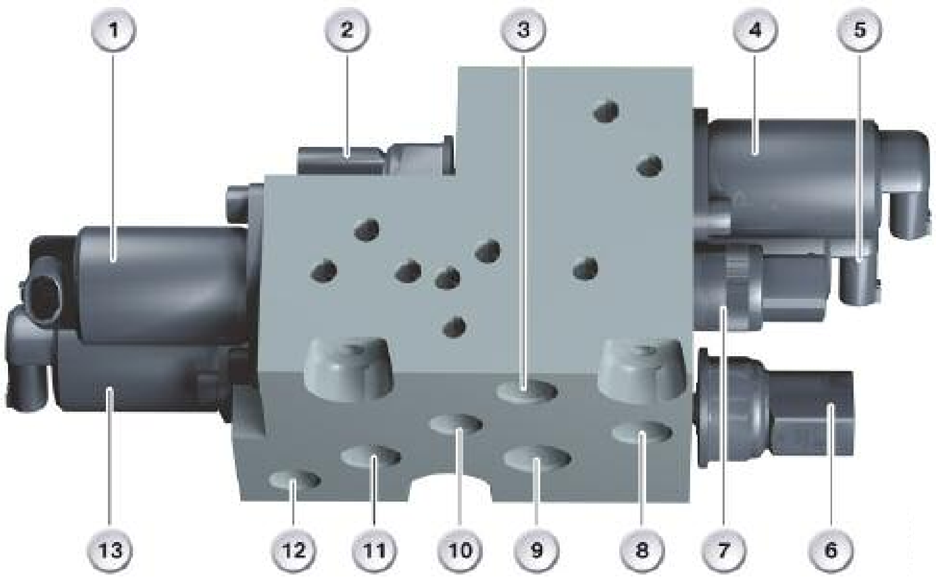


Index	Explanation
1	Lines from hydraulic valve block
2	Anti-roll bar links
3	Anti-roll bar
4	Oscillating motor (hydraulic)

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

Hydraulic Valve Block

The hydraulic valve block is located on the floor plate of the vehicle behind the front right hand wheel housing level with the front right hand door. The hydraulic valve block is connected to a carrier plate bolted to the body.



Index	Explanation	Index	Explanation
1	Directional valve	8	Tandem pump line
2	Rear-axle pressure sensor	9	Hydraulic fluid reservoir line
3	Line 2, front axle oscillating motor	10	Line 1, rear axle oscillating motor
4	Proportional pressure limiting valve, front axle	11	Line 2, front axle oscillating motor
5	Proportional pressure limiting valve, rear axle	12	Line 1, front axle oscillating motor
6	Front axle pressure sensor	13	Failsafe valve
7	Switch position recognition sensor		

The hydraulic valve block houses the following valves and sensors:

- 2 pressure regulating valves; one for the front axle and one for the rear axle
- one direction valve
- one failsafe valve
- 2 pressure sensors; one sensor for the front axle, one sensor for the rear axle
- one switch-position recognition sensor.

The hydraulic valve block has the following connections:

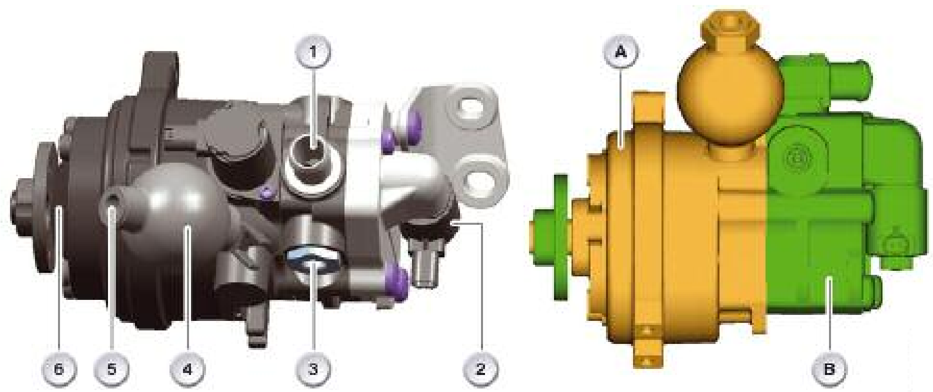
- 2 lines to the oscillating motor at the front
- 2 lines to the oscillating motor at the rear
- one connection for the line to the tandem pump
- one connection for the line to the hydraulic fluid reservoir.

Tandem Pump

The hydraulic pumps fitted in the E70 were developed with a modular design. Depending on the engine and equipment specification, a suitably dimensioned hydraulic pump is flange-mounted to the engine in the same installation space.

The exact pump design installed is dependent upon the optional equipment, such as:

- Basic steering
- Active Steering (AS)
- CO2 measures
- Adaptive Drive
- Adaptive Drive and Active Steering.



Index	Explanation	Index	Explanation
A	Radial piston pump	3	Steering pressure connection
B	Vane-cell pump	4	ARS pressure connection
1	Intake connection	5	Input flange
2	Proportional valve		

The hydraulic pump driven by the engine's poly-V-belt is, on vehicles with Adaptive Drive, invariably a tandem pump, which consists of a radial piston part for ARS and a vane-cell part for the power steering.

Radial Piston Pump (part of tandem pump)

This radial piston pump has 10 pistons set out in two rows and designed for a maximum pressure of 210 bar.

When the engine is idling, the pump speed is approximately 750 rpm. At this idling speed, the radial piston part delivers a minimum fluid flow rate of approximately 6.75 liters/minute at a pressure of approximately 5 bar. This means that sufficient system dynamics are also guaranteed when the engine is idling.

At a pump speed of 1,450 rpm, the maximum fluid flow rate is limited to 13.3 rpm.

Vane-cell Pump (part of the tandem pump)

This part comprises 10 vane cells and designed for a maximum pressure of 135 bar. The vane-cell part has a characteristic map controlled fluid flow rate of 7-15 liters/minute.

The decisive parameters for the characteristic map are the vehicle's road speed and the steering angle speed.

Adaptive Drive and the power steering share the same fluid reservoir and radiator.

Fluid Reservoir

In the fluid reservoir is a fluid filter and fluid level sensor. The fluid filter cannot be replaced. The screw cap is fitted with a dipstick, which makes it possible to check the fluid level. A "MAX" mark indicates the maximum permissible fluid level, measured at room temperature (20°C).

If a dipstick check at room temperature reveals the fluid reservoir to be dry, the reservoir must be topped up with the specified hydraulic fluid. If the lowest edge of the dipstick is still only just wet with hydraulic fluid (3), this is to be construed as the "MIN" mark.

Fluid Level Sensor

The fluid level sensor detects the fluid level in the fluid reservoir. The fluid level sensor determines whether the fluid level has dropped below a critical minimum level and activates a warning message. Normal movements of the fluid in the reservoir are not cause for a message.

A mobile float contains a reed contact that converts float movements into an electric signal.

The fluid level sensor (1) is fitted to the fluid reservoir. Short/open circuits cannot be detected by the fluid level sensor. A line break is interpreted as a loss of fluid.

Hydraulic-fluid Cooler

The hydraulic-fluid cooler serves to maintain a fluid temperature of < 120°C in all hydro-mechanical components under all conditions, although temperatures of < 135°C are acceptable for brief periods.

Service Notes

If 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 disturbing transmission of noise into the vehicle interior occurs due mainly to the assembly and line connections. The lines must not make contact; they must be routed correctly through the brackets without slack or tension. They are covered by the underbody paneling.

Steering Angle Calibration

After work on the front axle, it is necessary to carry out a steering angle calibration with the Dynamic Drive control unit.

The Dynamic Drive system is dependent on the exact zero balance of the steering angle. The maximum deviation tolerance is 1. Precise chassis alignment is a prerequisite.

The steering angle calibration must always be carried out on the measuring stand and in accordance with BMW axle alignment guidelines.

The zero position is lost each time the Dynamic Drive control unit is flash programmed. A steering angle calibration is required whenever the control unit is flash programmed.

ARS Initialization

The initialization 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 calibration of the offset values of the lateral acceleration sensor and the two pressure sensors:

- 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 initialization (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.

ARS Bleeding Procedure

A bleeding procedure must be carried out using the diagnostic tester if the ARS system was opened hydraulically. The bleeding procedure is performed exclusively by way of the initialization 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 initialization routine must then be repeated after the short trip.

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

Programming

It is possible to program the Dynamic Drive control unit.

Coding

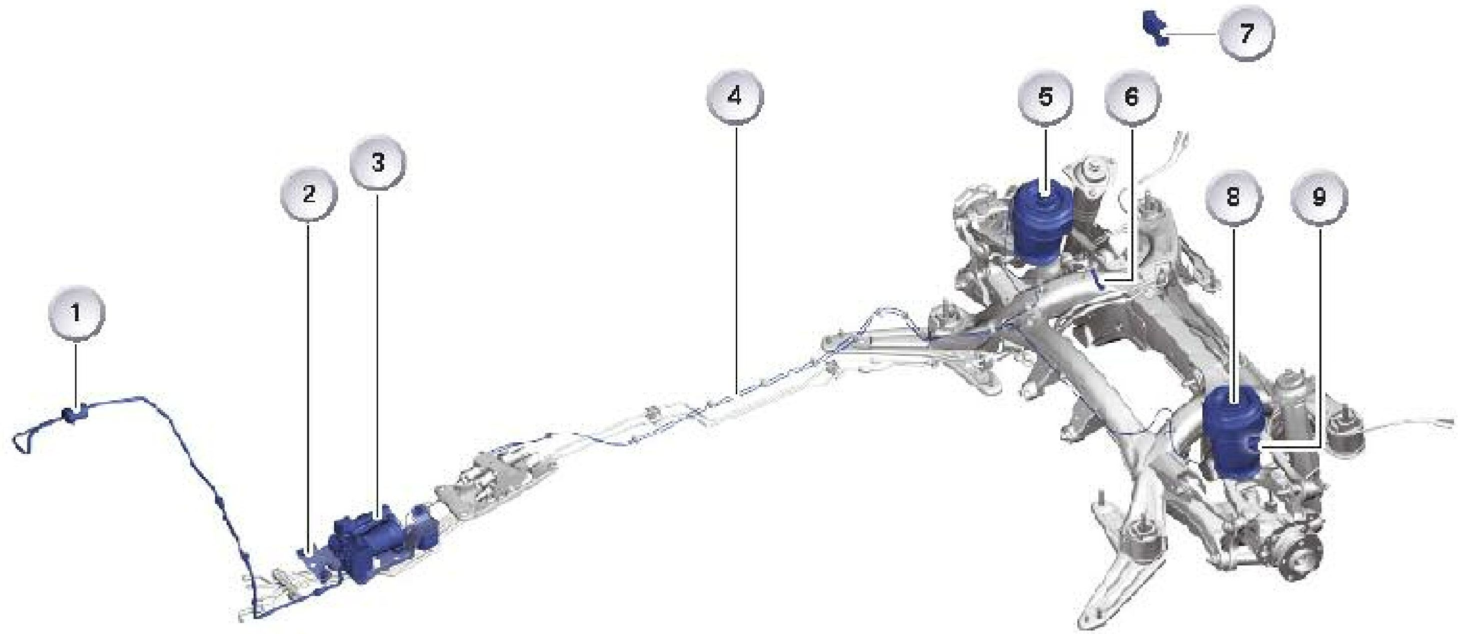
It is possible to code the Dynamic Drive control unit.

Note: For more detailed information on ARS in the E70, refer to the reference material on TIS and ICP.

Electronic Height Control (EHC)

As with the previous SAV, the E53, the new X5 has an available single-axle air suspension system. The EHC system is standard on the 4.8is and only available on the 3.0 version as part of the 3rd row seat option. This system operates in a similar manner to previous EHC systems.

The purpose of a level control system is to maintain the height of the vehicle body as close as possible to a predefined level under all load conditions. Through a constant level of the body mainly the driving quality (e.g. camber, toe-in) will remain unaltered in the event of changes in payload.



Index	Explanation	Index	Explanation
1	Air cleaner (filter)	6	Ride height sensor, right
2	Retaining plate	7	EHC control unit
3	Air Supply Unit (LVA)	8	Air spring, rear left
4	Pneumatic lines	9	Ride height sensor, left
5	Air spring, rear right		

EHC Control Unit

The EHC control unit is located in a module carrier in the rear of the luggage compartment on the right-hand side.

The EHC control unit receives the following signal information:

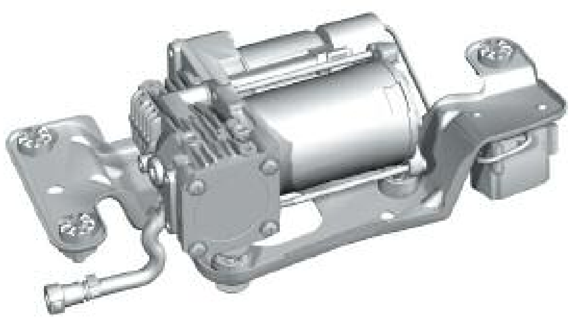
- Vehicle ride height
- Load cutout signals
- Terminal 15 ON/OFF
- Vehicle speed
- Lateral acceleration
- "Engine running" signal
- Hatch status.

The EHC control unit decides on a case-by-case basis whether a control operation is required in order to compensate for changes in load. It is thus possible to optimally adapt the frequency, specified heights, tolerance thresholds and battery load to the relevant situation by means of the control operation.

The EHC control unit is fully compatible with diagnostics.

Air Supply Unit (LVA)

The air supply unit is fitted to the underbody of vehicle by a component carrier level with the front right door.



Air Suspension

The E70 with EHC uses air spring fitted at the rear axle. Take note of the following cautions:

Note: When a new air spring is being fitted, care must be taken to ensure that it is not over-stretched. Otherwise, the retaining ring for the inner pipe could snap off the rubber gaiter, which could result in damage to the suspension air bag.

For this reason, the top of the air spring should be secured to the body first, and only then should it be connected to the axle carrier.

Ride-height Sensor

The ride-height sensors are electrically connected directly to the EHC control unit. The mode of signal transfer is analog. Two-way or one-way sensors may be fitted to the rear axle, depending on the vehicle's equipment level. Two-way sensors deliver the signal not only to the VDM control unit but also to the EHC control unit.

Note: If a new ride-height sensor is being fitted, it must be ensured that only parts with matching part numbers are fitted. In particular, care must be taken not to confuse one-way and two-way sensors (one-way/two-way depends on the equipment level of the vehicle). Two-way sensors bear the marking "doppelt" on the housing.

For more information on ride height sensor configuration, refer to the VDC section of this workbook or the reference material on TIS or ICP.

Longitudinal Dynamics

Systems which affect the forward or rearward dynamics along the "X-axis" is referred to as longitudinal dynamics systems. These systems include various types of braking systems.

In the E70, these systems include:

- Dynamic Stability Control (DSC)
- Anti-lock Braking System (ABS)
- Electro-mechanical Parking Brake (EMF)
- Dynamic Cruise Control (DCC)

Dynamic Stability Control

The DSC system utilized on the E70 is referred to as DSC E7x. The system is supplied by Bosch. With its optimized control functions, the new system design makes a significant contribution to increased driving dynamics.

Additional functions for active safety and additional comfort have been implemented in the new system. The new system in the E70 offers the following advantages:

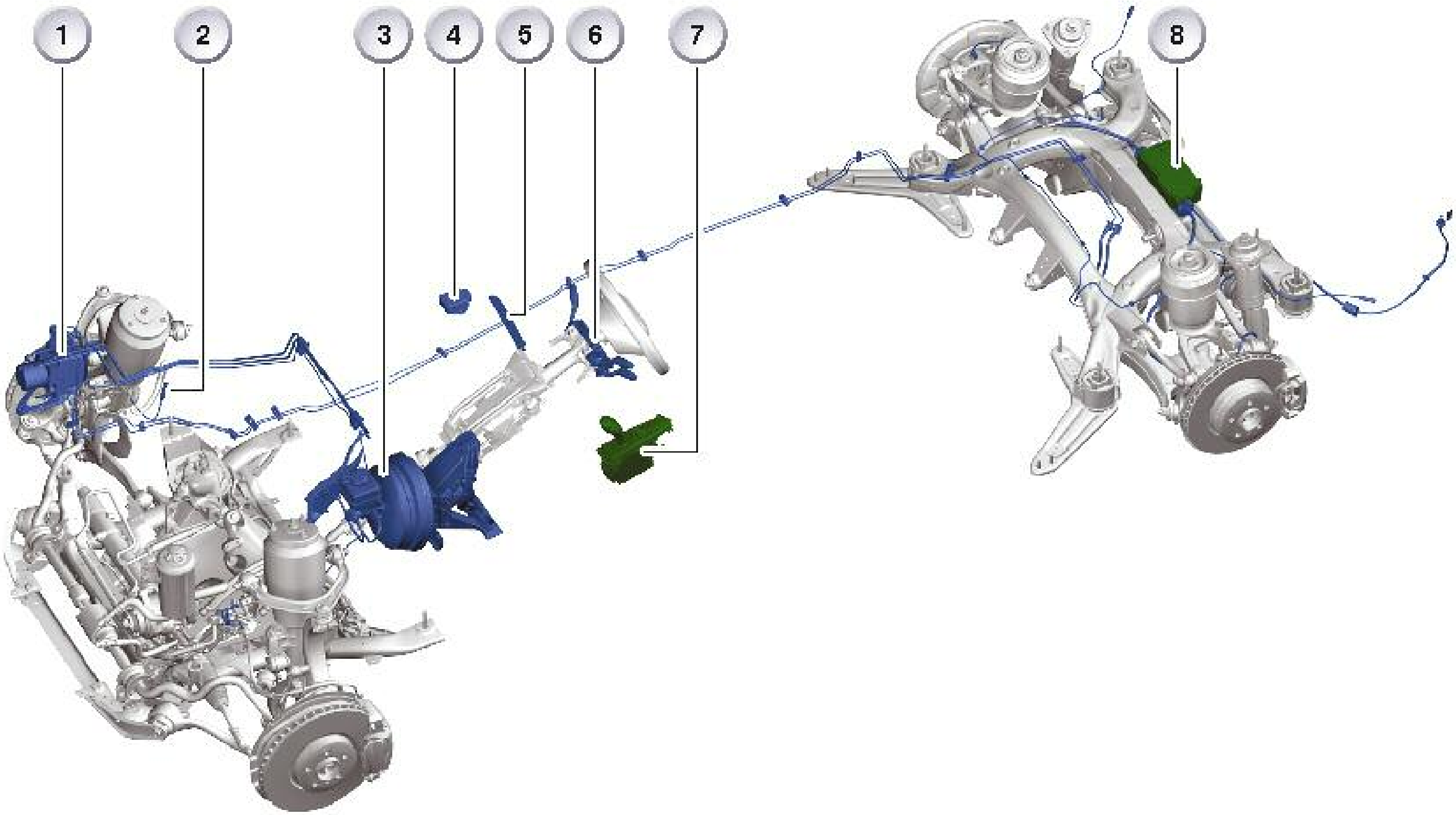
- Driving Dynamics
  - DSC mode: Increased driving dynamics and maximum traction. Thanks to more precise and faster control interventions, the driver can further extend the boundaries of driving dynamics while retaining vehicle safety.
  - DTC mode: Compared to DSC mode, Dynamic Traction Control (DTC) allows for increased slip at the drive wheels to provide maximum propulsion when driving off in snow for instance. In addition, the stabilizing interventions cut in later in DTC mode thus allowing a more sport-oriented driving profile.
- Active Safety
  - The additional functions of brake standby, dry braking and fading assistance shorten the stopping distances.
  - Increased DSC efficiency makes for more effective safety relevant functions.
- Comfort
  - Improved operating comfort (brake interventions are less audible, pedal vibration is drastically reduced) through the use of a 6-piston pump in connection with a new higher-frequency electrical actuation system.
  - Additional functions such as start-off assistant and parking brake provide increased driver assistance and comfort.

Note: To date, the DSC driving dynamics system on all-wheel drive vehicles was referred to with the abbreviation "DXC". Since this lead to confusion with the xDrive, in the future the dynamic stability control system will be known as DSC also on all-wheel drive vehicles.

ABS

ABS functions in the E70 are identical to those functions in previous models. The pedal pulsations and noise from the solenoid valves and pump are reduced in the E70. This is a result of the high-performance hydraulic unit on the DSC E7X system.

DSC System Overview



Index	Explanation	Index	Explanation
1	Hydraulic unit with DSC control unit	5	Center Console Switch Cluster (SZM)
2	Wheel speed sensors (4x)	6	Steering Column Switch Cluster (SZL)
3	Master cylinder	7	Gear Selector Lever (GWS)
4	DSC sensor	8	EMF Actuating Unit

Overview of DSC Components

DSC Hydraulic Unit

With its new pump concept, the hydraulic unit provides a significant improvement in control accuracy. 2 x 3 pump elements with a diameter of 6.5mm and intake-optimized units operate in the hydraulic unit. This pump concept ensures substantially improved pressure dynamics resulting in lower pedal feedback in ABS mode and higher control quality.

For the driver this is noticeable in as far as the pedal pulsation can now only be felt very slightly during ABS braking. There is a pressure sensor in the hydraulic unit.

DSC Control Unit

The DSC control unit can be replaced individually. The 47-pin connector connects the DSC control unit to the engine wiring harness.

Wheel Speed Sensor

4 active wheel speed sensors are installed in the E70. All 4 sensors have a direct hardwired connection to the DSC control unit.

These active wheel speed sensors facilitate recognition of the direction of rotation, air gap (clearance) and standstill. The DSC control unit receives this information in the form of a PWM signal.

DSC Sensor

The DSC sensor is located under the front passenger seat and is available in two variants in the E70:

- Vehicle without active steering, DSC sensor (designation MM3.8), containing a
  - Transverse acceleration sensor.
  - Longitudinal acceleration sensor.
  - Yaw rate sensor in a housing.
- Vehicle with active steering, DSC sensor (designation MM3.2.2), containing.
  - 2 redundant transverse acceleration sensors.
  - Longitudinal acceleration sensor.
  - 2 redundant yaw rate sensors in a housing.

Steering Column Switch Cluster (SZL)

The Steering Column Switch Cluster (SZL) is carried over from the E90 and consists of the following components:

- SZL electronics
- Steering angle sensor (optical code disc)
- Steering column stalk, cruise control
- Steering column stalk, direction indicator
- Steering column stalk, wiper
- Coil spring assembly

The steering column switch cluster can only be replaced as a complete unit. The coil spring assembly is fitted on the steering column switch cluster. The spring coil assembly can be removed and replaced individually.

Overview of DSC Functions (DSC E7X)

Function	Can be switched on/off by driver	DSC ON	DTC	DSC OFF
ABS		●	●	●
EBV		●	●	●
CBC		●	●	●
MSR		●	●	●
ASC		●	X	
ADB-X		●	●	●
DSC	⊕	●	X	
HDC	⊕	●	●	●
Dry braking		●	●	●
Start assist		●	●	●
Braking readiness		●	●	●
Fading assistance		●	●	●
DBC		●	●	●
- DBS		●	●	●
- MBS		●	●	●
EMF [parking brake]	⊕	●	●	●
GRR+ (included in active steering option)		●	●	●
RPA		●	●	●
CBS		●	●	●

Symbols:

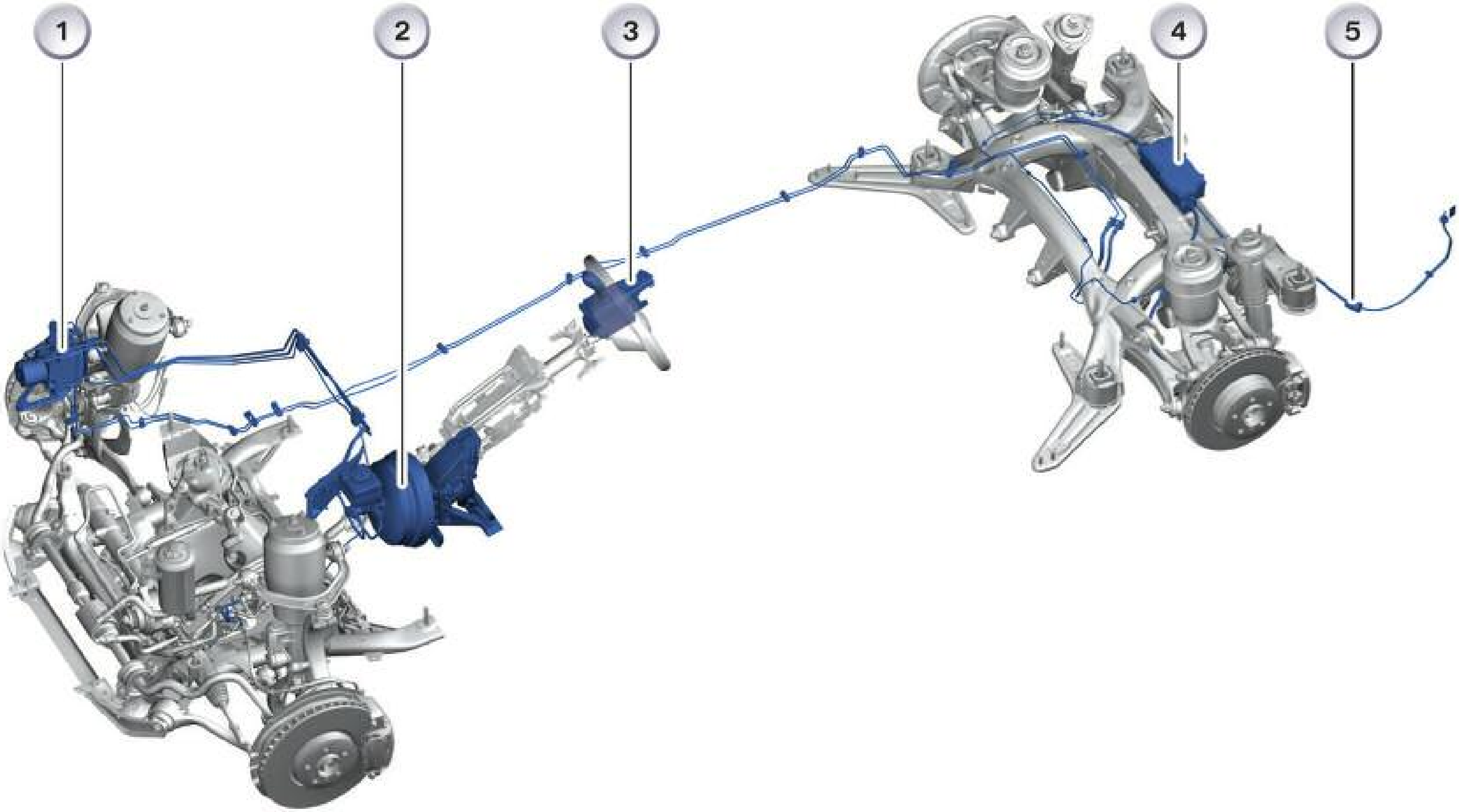
● = System active

X = System with elevated control thresholds

⊕ = Can be switched on/off

Electromechanical Parking Brake (EMF)

The concept of EMF has been carried over from the E65. The system functions in much the same way as the previous design. Most of the differences lie in component location and emergency release procedures.



Index	Explanation	Index	Explanation
1	Dynamic Stability Control	4	EMF actuating unit
2	Master Cylinder	5	Emergency release for EMF
3	Gear Selector Lever		

Basic Functions of EMF

The parking brake (EMF) has two different functions, depending on the operating status of the vehicle.

- Parking brake mode
  - When the engine is running or the vehicle is rolling, the parking brake acts on the service brake with the aid of the DSC hydraulics. This means the brake units on the front and rear axle are active.
  - If the engine is not running and the vehicle is stationary, the electromechanical actuator and its cable assembly ensure the parking brake acts on the duo-servo drum brake on the rear axle. In this case, the vehicle is braked as defined in the control unit.
- Dynamic braking

  Defined retardation is triggered via the DSC system if the parking brake button is pulled up while driving. The deceleration is monitored by the DSC control functions and takes place for as long as the parking brake button is pulled.

Emergency Release

A mechanical emergency release facility is provided in order to be able to release the parking brake in the event of the electromechanical actuating unit failing or insufficient power supply.

CAUTION!!! Secure vehicle to prevent it rolling before operating the emergency release!

The release procedure is performed manually with the emergency release cable assembly (2) and the emergency release handle (1) from the vehicle tool kit. The emergency release procedure releases the duo-servo drum brake by way of mechanical intervention in the actuator of the electromechanical control unit.

Note: After a power failure, it may still not be possible to move the vehicle even after releasing the brake with the emergency release facility. The parking lock of the automatic gearbox may still be engaged.

Once released, using the emergency release facility, the parking brake cannot be reactivated manually. The function can be restored only by way of electrical activation.

Restoring Operation After Emergency Release

After turning on the ignition, push down the EMF operating button and pull up again to activate the parking brake.

EMF Components

EMF Button

On the E70, the EMF button (1) is located in the center console next to the gear selector lever.

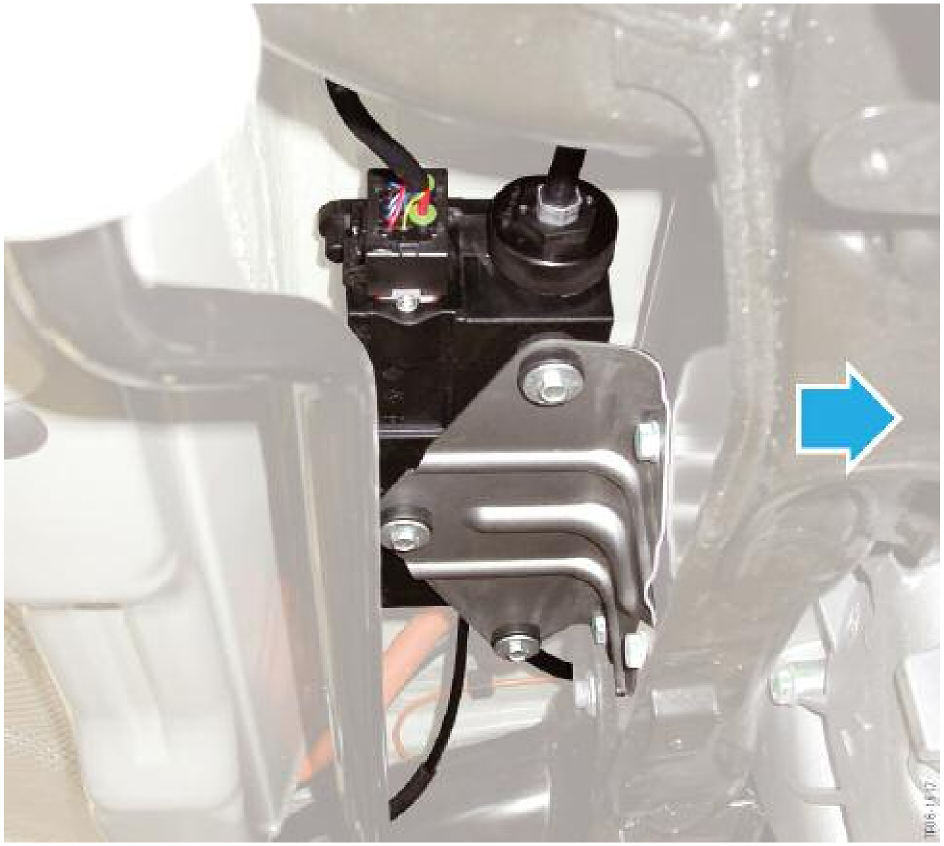
The EMF button is based on the function logic of a hand brake.

- Pull EMF button (1) up: Parking brake is activated
- Press EMF button (1) down: Parking brake is deactivated

Note: The indicator lamp in the instrument cluster shows the driver when the EMF is activated.

EMF Actuating Unit

The EMF actuating unit is located on the rear axle component carrier.

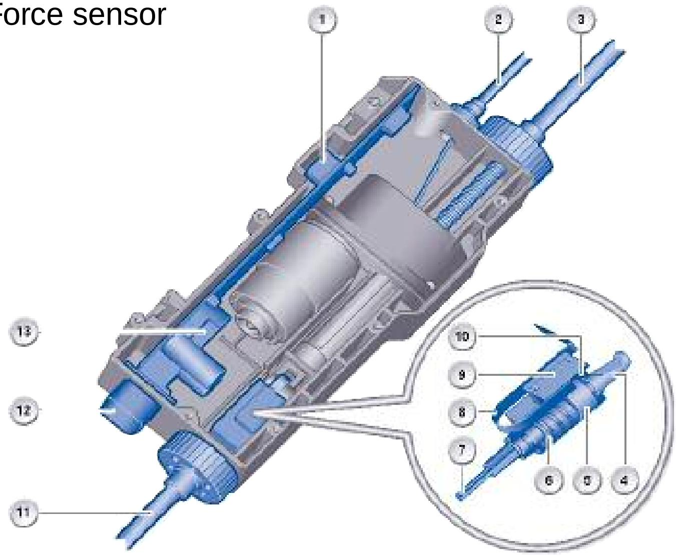


EMF Actuating Unit (Internal Components)

The EMF actuating unit is sealed watertight and the housing cannot be opened.

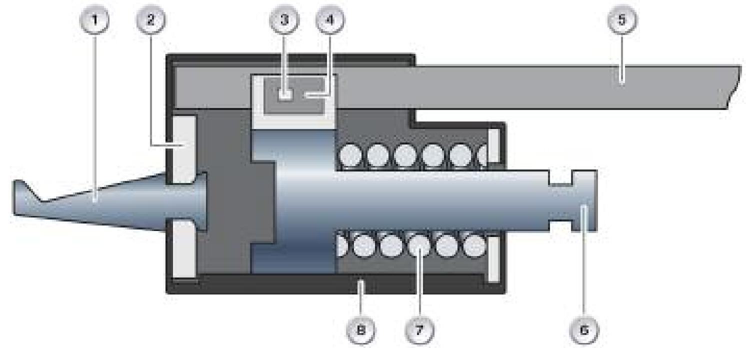
The EMF actuating unit contains the following main components:

- EMF control unit
- Electric motor
- Spindle gear mechanism
- Force sensor



Index	Explanation	Index	Explanation
1	EMF Control unit	8	Flexible band
2	Bowden cable, emergency release	9	Force sensor, pc board
3	Bowden cable, rear left	10	Force sensor magnet
4	Lock pin	11	Bowden cable, rear right
5	Actuating piston	12	Electrical connection
6	Spring	13	EMF Control unit
7	Emergency release cable		

The force sensor in the EMF actuating unit is a very important component for operation of the parking brake. With its signals, the force sensor makes it possible for the EMF control unit to determine the actuating force. The actuating force is essential for securing the required braking pressure.



Index	Explanation	Index	Explanation
1	Hook	5	Force sensor pc-board
2	Retaining plate	6	Piston
3	Hall-IC	7	Spring
4	Magnet	8	Lower section of housing

The housing of the force sensor consists of two halves. The lower section of the housing (8) is made from pressure diecast aluminum so that it can take up the exerted forces.

The upper section of the housing is made of plastic, to which the force sensor pc-board (5) with the Hall-IC (3) is secured.

The magnet (4) is fixed to the piston (6). The sensor is located between the left and right bowden cable assembly. During actuation, the piston (6) moves with the magnet against the spring (7).

The travel range of spring compression is measured in accordance with the familiar Hall principle. Since the spring data are defined, the EMF control unit can calculate the applied force from the travel range and the spring data. The force sensor is calibrated at the end of the assembly line.

Service Information for EMF

Adjusting the Brake Shoes

The procedure for adjusting the parking brake shoes is the same as before:

Turn the adjusting screw using a screwdriver through the threaded hole in the wheel hub (10 teeth).

Removing the Bowden Cable Assemblies

Note: The EMF must be set to service mode with the diagnostic tester before performing any maintenance or service procedures (the parking brake cannot be applied, EMF assumes the outermost position). The EMF will not respond to an operating signal until service mode has been deactivated again.

Necessary preparation:

- To remove emergency release bowden cable assembly in luggage compartment (see Emergency Release). Use pointed pliers to press together the white clip while pressing in the direction of the floor plate.

  Remove the wheels, brake calipers and brake discs (according to repair instructions) to expose the duo-servo brake shoes.

  The heat shield must be removed on vehicles with Active Roll Stabilization (ARS) and the ARS anti-roll bar lowered. (It is sufficient to release the ARS anti-roll bar at the mounting points and to lower it.)

  Unplug the electrical connector from the EMF actuating unit.

- To detach and expose the emergency release bowden cable assembly (Note: Clip fastening behind wheel arch panel). Release spring clip on wheel carrier. Detach nipple of cable assembly from brake show expander and pull the cable out of the wheel carrier. Release the cable assembly from the clip on the rear axle carrier and pull in the direction of the EMF actuating unit.

- Detach the carrier for the EMF actuating unit from the rear axle carrier and from the EMF actuating unit and pull out.

- Screw the union nut on the rear left wheel cable assembly by 5-7 turns (left-hand thread) into the spline shaft of the actuator. Then fit the twist lock (square) of the threaded spindle in the guide in the actuator housing. The sleeve of the cable assembly must lie flat on the actuator housing before fitting the union nut. Tighten the union nut to 6 Nm. Attach the rear right wheel cable assembly to the mounting point on the actuator and secure with the clip. Make sure that the cable is firmly fitted.

  The cable assembly must lie flat on the actuator housing before fitting the union nut. Tighten to 6 Nm.

- Reinstallation takes place in the reverse order of removal. Fit the new EMF actuating unit, cable assemblies first, in the package space. If it was necessary to slack off the carrier from the EMF actuating unit, it must be resecured to the EMF actuating unit and tightened to a torque of 4 ± 0.5 Nm. The component carrier must be secured to the rear axle carrier to a torque of 19Nm±15 %. Before securing the cable assemblies to the wheel carrier (tightening torque 8 Nm), check that the brake cables are securely attached in the brake shoe expander otherwise the EMF actuating unit may be damaged as soon as it is operated.

Start-up

A new EMF actuating unit is always set to "service mode". This mode can be actively reset with the diagnostic tester or it resets itself automatically on exceeding a defined vehicle speed. The actuating unit is now in "standby mode". The EMF actuating unit must then be encoded to the vehicle.

Initializing the Parking Brake

Note: The EMF must be initialized with the diagnostic tester after replacing the drum brake linings.

Bedding in the Duo-servo Brake

If the brake shoes of the duo-servo brake are replaced as part of repair or maintenance work, it is necessary to bed in the brake shoes before a sufficient holding effect may be achieved. Also in this case, the special routine must be activated in the EMF with the diagnostic tester.

The flashing indicator lamp in the instrument cluster signals that the bedding-in program is ready.

The bedding-in program will be aborted and the normal parking brake function resumed if the bedding-in is not started within 30 minutes of program activation or if the ignition is switched off.

The bedding-in procedure can also be performed on the roller dynamometer.

Function on Brake Rolling Dynamometer

The Operation of the E70 parking brake can be tested on the brake rolling dynamometer. As part of the road inspection, the rear axle brake can be tested with the engine running by pulling the EMF button.

As part of the road inspection, the rear axle brake can be tested with the engine running by pulling the EMF button. As a result, the EMF actuating unit is applied, the duo-servo brake is applied and the vehicle normally jumps out of the roller of the test rig.

Example Scenarios

Basic function of the parking brake controlled by the actuating unit
Scenario: "Ignition ON", the engine is not yet running and the foot brake is pressed.

With the vehicle stationary, the parking brake is released or applied by pulling or pressing the EMF button. The indicator lamp in the instrument cluster either goes out or lights up red.

Note: The parking brake can be released only with the foot brake pressed when the engine is running or turned off.

The dynamic braking function is triggered if the EMF operating button is pulled while the vehicle is rolling.

Transition from EMF Actuating Unit to DSC

The system switches over from mechanical to hydraulic mode when the engine is started. If the EMF actuating unit was applied at the time, the DSC hydraulics will assume control of the braking force.

The EMF actuating unit is not released until the hydraulics are holding the vehicle secure. The indicator lamp remains lit red throughout this process, and the driver is unaware of the transition (the lamp does not even flash).

Transition from DSC to EMF Actuating Unit

The transition to the EMF actuating unit always takes place on exiting the hydraulic function at "ignition OFF". If the parking brake was applied, the hydraulics are not released until the EMF actuating unit is applied. The indicator lamp remains red throughout this transition.

Function of the Parking Brake Controlled by the DSC Hydraulics

Scenario: "Engine running"

The parking brake is applied or released completely by hydraulic means when the EMF operating button is pulled or pressed.

Dynamic braking (hydraulic) is triggered with the vehicle rolling and the button operated at v >3 km/h. The basic functions mainly correspond to the functional scope of a conventional mechanical parking brake.

The system switches between "brake applied" and "brake released" with pressure buildup and pressure reduction every time the EMF button is pulled or pressed.

The parking brake must be released by pressing the EMF button before starting off. Pulling away against the applied brake pressure results in an increase in pressure and a warning to the driver.

Scenario: "At rest"

Remove control removed The parking brake enters rest status when the remote control is removed. If the parking brake is applied, the time-delayed red indicator lamp signals this status to the driver.

If the EMF actuating unit is released in rest mode, the EMF actuating unit is applied when the EMF button is pulled with the vehicle stationary. If the vehicle is in motion, pressing the button will initiate dynamic braking.

Note: Always take the remote control with you when leaving the vehicle otherwise children could release the parking brake.

Dynamic Braking

Two braking units for brake operation are required by law (previously: foot brake and hand brake) In the E70, the second operating point besides the foot brake is the EMF button on the gear selector lever.

The vehicle is braked by the drum brakes at the rear axle if the EMF button is pressed and held at speeds below v = 3 km/h and with the engine switched off.

The vehicle is braked at a rate of 3 m/s^2 for 0.8 seconds if the EMF button is pressed when the vehicle is in motion. Braking power is then ramped up to 5 m/s^2 for the next 2 seconds. This braking action is retained for as long as the EMF button is pulled.

For stability reasons (over-braking - rear axle) the dynamic braking function is also triggered in the rest state in response to the vehicle rolling (engine turned off, ignition OFF) by means of active pressure build-up by the DSC hydraulics together with the DSC function.

The brake pressure required is made available as rapidly as possible. The braking action is always monitored by the DSC control function. This ensures vehicle stability while braking. Since all four wheels are braked hydraulically, there is considerably greater deceleration with a minimum of operating effort (EMF button) by comparison with conventional parking brakes. The controlled brakes are therefore able to contribute to improving vehicle safety.

For traffic safety reasons, operation of dynamic braking is indicated to the road users behind by the brake lights coming on.

To avoid accidental operation and misuse, the driver is notified of dynamic braking operation by a display message and gong.

This function is intended only for use in an emergency and must never be used as a substitute for normal operation of the service brake.

The more effective braking solution is used if the parking brake deceleration request is overlapped by the brake pedal being depressed. The DSC control unit decides which deceleration request is to be carried out.

Exiting Dynamic Emergency Braking

The vehicle will remain hydraulically braked even after the EMF button has been released if the vehicle is braked to a halt by dynamic braking. There is a transition to the normal DSC hydraulics function. The hydraulic brake is only released when the EMF button is pressed once more.

If the EMF button is pressed while the vehicle is still in motion, the system level prevailing before the emergency dynamic braking was activated is resumed. If the parking brake is released and the vehicle is coasting, it is possible to activate emergency dynamic braking in any situation (terminal 30, 15, R) by pressing the EMF button.

Error Messages

All fault statuses are detected by the monitoring system and displayed to the driver. The main aim is to avoid safety-critical conditions for vehicle occupants, the vehicle and its surroundings.

A fault can be assigned different priorities depending on the driving situation (vehicle stationary/ in motion, starting/stopping) and the system availability. In addition to the indicator lamp, supplementary instructions may be shown in the control display.

To avoid additional damage, faults in the parking brake mechanism, particularly a broken cable in the operating cable assembly and excess load are detected by the force sensor and indicated accordingly. (See shutdown strategy table).

Error messages can no longer be output actively in the event of the EMF control unit failing.

In this case, the instrument cluster assumes the control of the correct error message on recognizing the absence of the regular EMF telegram via the PT-CAN (alive signal).

Shut-down Strategy			
Fault	Availability		Back-up System
	Parking brake (mechanical) v = 0	Dynamic braking (hydraulic) v > 0	
CAN signal	OK	OK	
DSC hydraulics	OK	NA	Service brake + hand brake
Actuating mechanism	NA	OK	Park position automatic gearbox
EMF control unit	NA	NA	Park position automatic gearbox and service brake and auxiliary brake if necessary

General Parking Brake Fault Concept

Fault Distribution Between DSC and EMF Control Unit

Only DSC faults that actually affect operation of the parking brake result in shut-down of the hydraulic function. These are mainly faults that result in shut-down of the ABS functionality.

They trigger the transition to manual emergency mode. Dynamic braking is no longer possible unless only CAN faults occur affecting this functionality.

- Shut-down level "electromechanical mode" (only EMF actuating unit) initiated by following DSC faults
  - – DSC control unit fault
  - – Electrical fault (e.g. wiring harness)
  - – Sensor fault (brake light switch/wheel speed)
  - – actuator fault/hydraulic unit
  - – Bus communication fault
- Shut-down level "electrohydraulic mode" (failure of EMF actuating unit)
  - – Force sensor fault
  - – Actuator fault of EMF actuating unit
  - – Error in actuation electronics
  - – Fault in actuating mechanism
  - – Electrical fault
- Shut-down level "total shut-down"
  - – EMF control unit or controller fault
  - – EMF button fault
  - – Electrical fault, power supply

Note: All fault codes are stored in the control unit in which the monitoring routine was performed. The EMF control unit is informed of the fault status of the DSC control unit and vice versa.

Fault Regeneration

When a fault is detected, the system remains in a safe mode until the end of the "ignition ON" cycle, once reached, a shut-down level is not cancelled during the cycle.

Dynamic Cruise Control (DCC)

The operating and display philosophy on the DCC steering column stalk and in the instrument cluster in the E70 is the same as that in other model series.

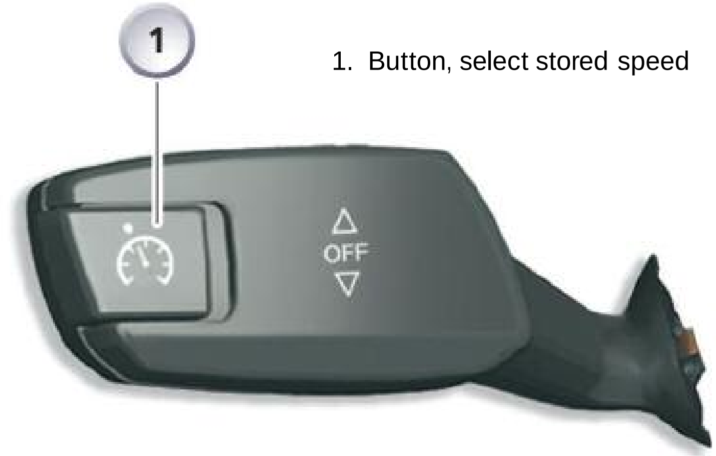
Functionally, the DCC is integrated in the DSC control unit.
The DCC functionality is realized by way of communication with the partner control units of the DSC control unit in the system network such as DME/DDE, EGS, SZL and instrument cluster.

The DCC function can be activated from 30 km/h/19 mph (up to max. 250km/h/155mph) and is deactivated by similar factors as for cruise control:

- Brake pedal actuation
- Deactivation of DSC
- Activation of DTC
- Active DSC intervention
- Deactivation by the driver
- Speed is reduced below 22 km/h
- "N" engaged
- EMF function activated

DCC achieves a deceleration of max. 2.1 m/s^2 and an acceleration of about. 1.7 m/s^2. The transverse acceleration is variably limited by the Curve Speed Limiter (CLS). The primary emphasis has been placed on comfortable performance in this system configuration.

When cruise control with brake intervention is activated, the brake lights are also activated in accordance with legal requirements in connection with a system related braking operation DCC.



1. Button, select stored speed

Extended functions of the DCC compared to a conventional cruise control system:

- Active brake intervention to realize the set speed also when driving downhill
- Curve Speed Limiter (CLS) - adaptation of driving speed when cornering (transverse acceleration).

This function limits the maximum transverse acceleration dependent on vehicle speed with the aim of achieving the greatest possible agility in DCC mode. Driving on winding country roads in a speed range from > 50 km/h/31mph to < 120 km/h/74mph is controlled with a value of 3.3 - 3.7 m/s^2.

The value can increase up to 4.5 m/s for fast highway bends and slow lane changes at speeds between < 50 km/h/31mph and > 120 km/h/74mph.

- Comfort Dynamic System (CDS) - this enables a type of "manual throttle mode" on the steering column stalk.
- Adapted downhill mode - the overrun fuel cutout and gear down shift are correspondingly adapted.

Classroom Exercise - Review Questions

1. Circle the bus systems below which are directly connected to the VDM?

D-CAN	PT-CAN	K-CAN	FlexRay
F-CAN	MOST	LIN	BSD

2. Which of the following diagnostic procedures is NOT recommended (or possible) when investigating faults in the FlexRay system? (cross out the procedure which is NOT useful in diagnosis)

   ETM and Ohm meter

   Fault codes and test modules

   Oscilloscope in DISplus or GT-1

   Physical inspection of connectors and wiring

3. During an alignment on an E70, a Camber change is needed, which procedure represents the proper method to change *front* Camber? (circle the correct answer)

   An eccentric must be adjusted

   A special tool is used to move the strut assembly

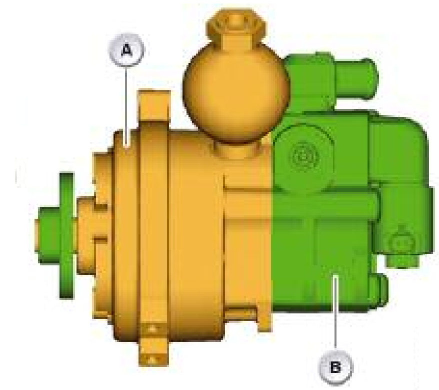
   The upper wishbone must be replaced

   The swivel bearing must be replaced

   The front Camber cannot be corrected in service

4. On previous vehicles equipped with Active Steering (AS), the ECO valve was responsible for controlling the flow of power steering fluid. Which component replaces the ECO valve in the E70? (circle the correct answer)

EWS	VDM	EVV	GRR+
GWS	SHL	ARS	RFK



5. On an E70 equipped with the Adaptive Drive package and Active Steering a tandem power steering pump is installed. Which part of the power steering pump is responsible for the hydraulic pressure in the ARS system? (circle one)

   Part A   Part B

6. On the Active Steering system on the E70, which of the following components has been omitted as compared to previous models with AS? (circle one)

Actuator Motor Sensor

Cumulative (total) steering angle sensor

Steering Angle Sensor (SZL)

Electromagnetic Safety Lock

7. On vehicles equipped with VDC, how do the ride height sensors communicate with the VMD control module? (circle one)

The sensors are hardwired to the VDM

The sensors communicate to VDM via FlexRay

The sensors are hardwired to the EDC Satellites

The sensors communicate to the VDM via PT-CAN

8. The resistance of the terminating resistors on the FlexRay bus is between: (circle one)

200 and 240 Ohms	90 and 110 Ohms
10 and 60 Ohms	80 to 100 Ohms

9. What is the communication speed of the FlexRay bus? (circle one)

500Kbit/second	10Mbits/second
22.5 Mbits/second	10Kbits/second

10. Which of the following systems/components on the E70 is directly connected to the FlexRay bus system?

GWS	SZL	EDC Satellites	ARS
EHC	VDM	EMF	DME