Reference Manual

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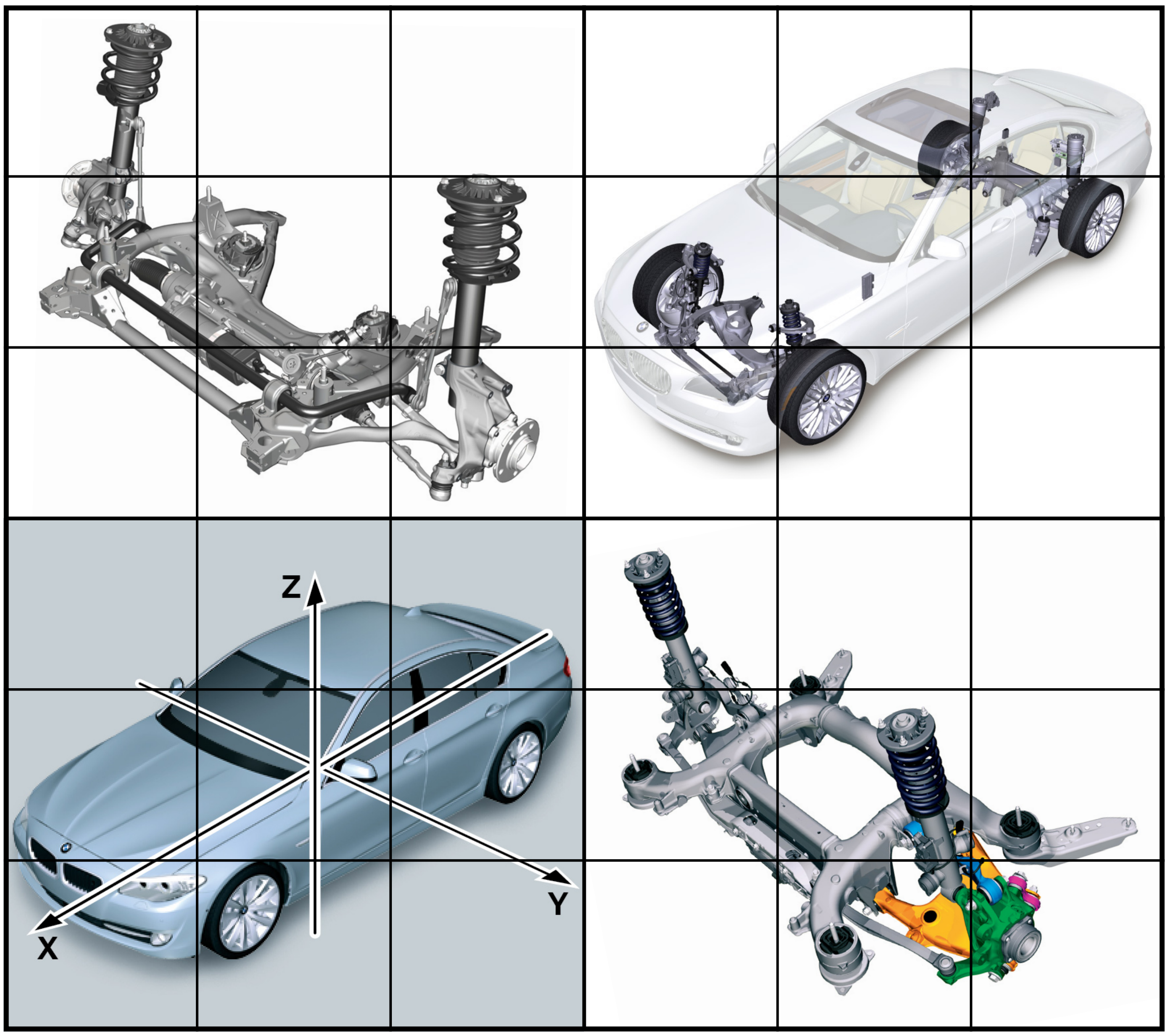
Chassis Dynamics



BMW of North America, LLC
Technical Training
ST1115
8/1/12

Information Status: August 01, 2012

Course Code: ST1115 Chassis Dynamics

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Vertical Dynamics (Z Axis)

Model: All

Production: Start of Production

OBJECTIVES

After completion of this module you will be able to:

- Understand the operation of the Electronic Damper Control system.
- Describe the operation of the Vertical Dynamics System.
- Describe the differences between the two Vertical Dynamics systems used in BMW
- Diagnose the FlexRay communication network.

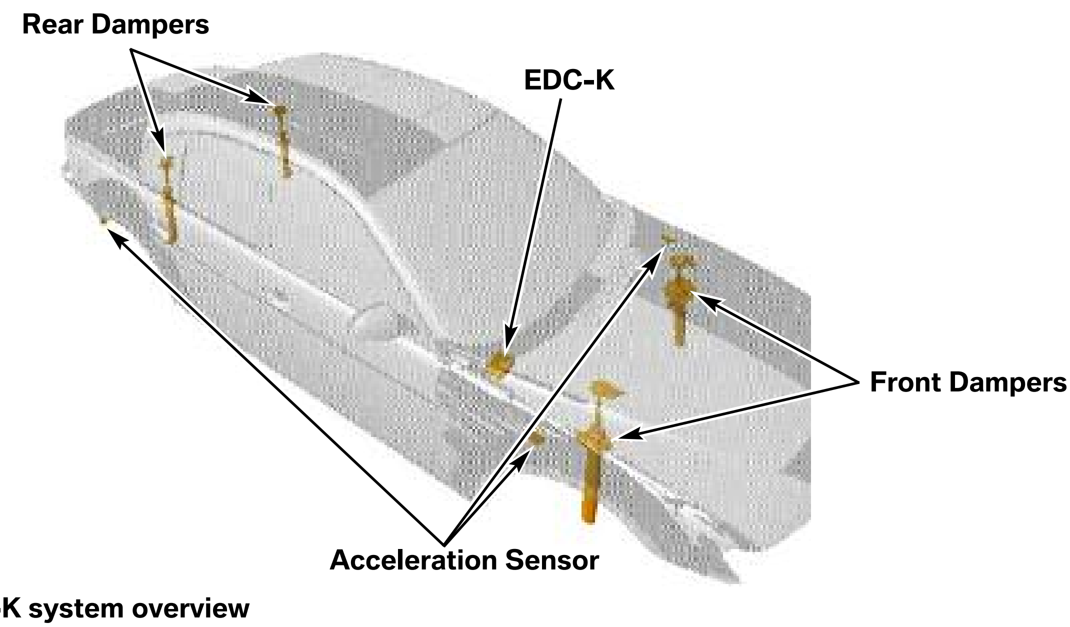
Electronic Damper Control (EDC-K)

History

With EDC I in the 1987 E32, BMW AG was the first European manufacturer to introduce a fully automatic electronically adjustable damper system. EDC I provided manual selection during driving between hard, sport and soft damping. EDC II was then introduced in the E24 (6 Series) and the system was continuously enhanced and evolved into EDC III. It set the standard (in 1990) for adjustable damper systems in the 5 and 7 Series.

EDC III was fitted in the series production of the E31, E38 and E39. It evaluates the status of the road surface, vehicle load, driving speed and driver's request to automatically activate one of three damper programs: soft, medium or hard. The driver also has the option of selecting a comfort or sports program.

EDC-K is a further development of EDC III and was introduced to the US market in 2001 with the launch of the E65 (745i). The German abbreviation "K" stands for continuous damping force adjustment. The major change from EDC III is the damper valves and the activation control.

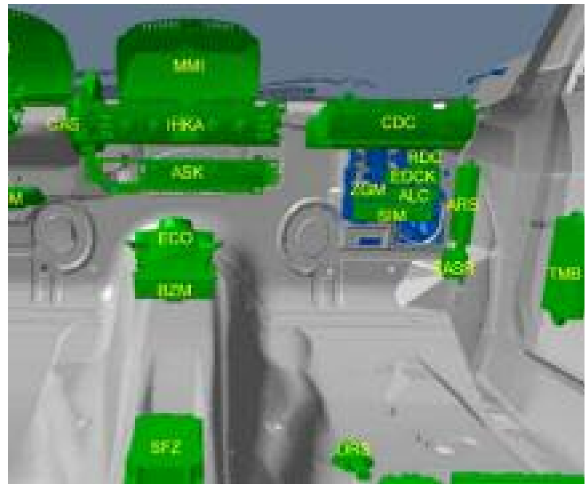


E65 EDC-K system overview

EDC-K operates with a continuously adjustable valve in each damper. The damping force is adjusted for individual piston speed. The damping force adapts continuously to the low frequency movement of the vehicle body, resulting in a significant increase in driving comfort. The driver has the option to select a comfort or sports setting by using the Controller in the Control Display menu.

The EDC-K system was offered as an option under the Adaptive Ride Package.

System Components



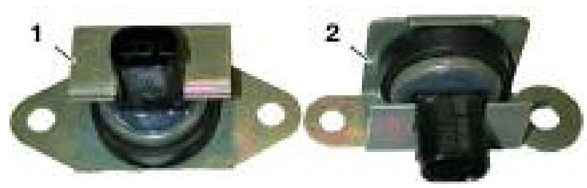
EDC-K Control Module

The control module is located in front of the glovebox and is powered by B+, operating within a voltage range of 9 to 16V. In the event of undervoltage, the EDC-K system shuts down to prevent excessive battery draw.

The control module incorporates various control functions that determines the current applied to the damper valves.

Vertical Acceleration Sensors

The three vertical acceleration sensors provide a varying voltage signal (0.2 - 4.5V) to the control module indicating the speed of body movement. The three sensors are identical and have a measuring range of ± 2.5 g.



The front sensors (1) are mounted on the inside top of the wheel archs and the rear sensor (2) is mounted on the side of the rear wheel arch.

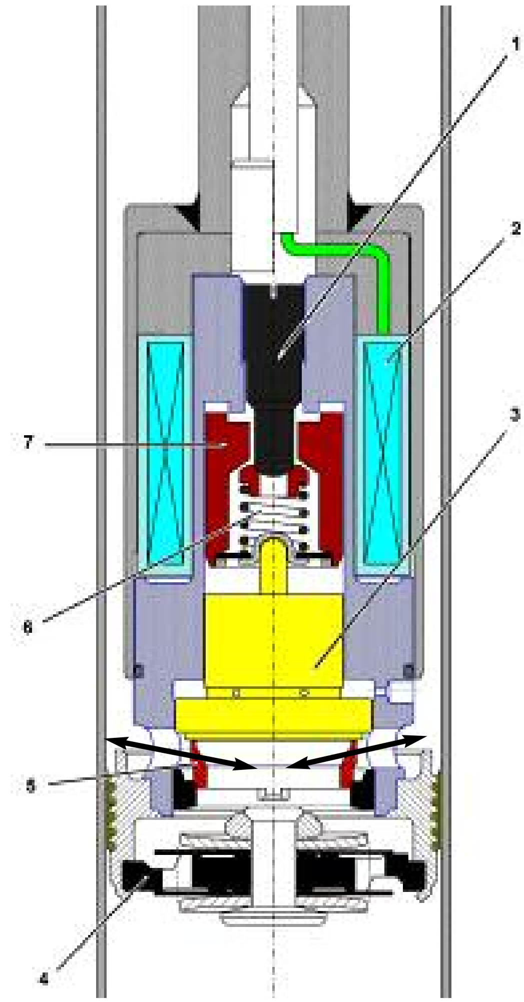
Electronically Adjustable Dampers

The front and rear axles are equipped with twin tube gas pressurized dampers supplied by Mannesmann Sachs Boge. The fully variable dampers are map controlled and do not have fixed stages.

Each damper incorporates an adjustable proportioning control valve on the piston. The wiring harness for this valve is routed through the hollow piston rod. Damper oil flows through this valve during compression and rebound. The control valve generates a pressure drop between the lower and upper chambers depending on the oil flow volume.

The front and rear axles are separately activated to achieve an optimum response for vibrations in all driving conditions. The valves are deactivated in the event of a control module failure or when the ignition is switched "OFF". The dampers automatically rest in the hardest setting (without power). On vehicles equipped with Dynamic Drive, the spring struts have different valve configurations on the front and rear axles. The dampers are de-energized when the vehicle is stationary. They are energized initially from 5 km/h.

Index	Explanation
1	Pre-tensioning screw
2	Solenoid coil
3	EDC-K Damper valve
4	Primary valve
5	Floating seat ring
6	Valve spring
7	Armature



EDC-K Damper Valve - Detail

Infinitely Variable Control Valve

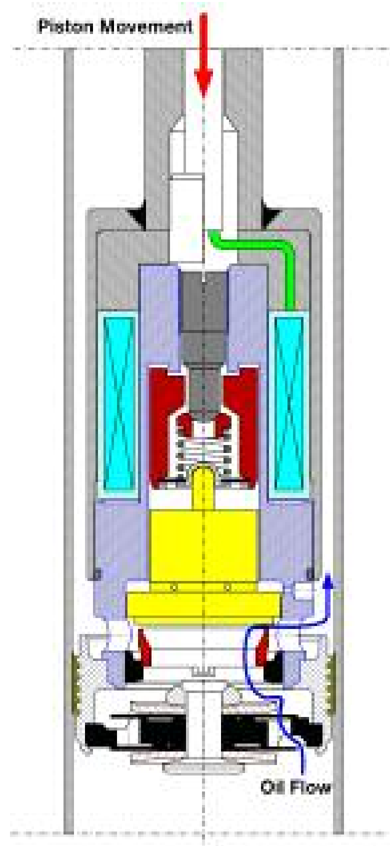
Without power, the maximum hydraulic resistance is set by the screw (1), which pre-tensions the valve spring (6). This is the hardest damper setting, also known as the failsafe (rest) setting.

The valve spring provides maximum tension on the armature (7), which presses down on the EDC-K Damper valve (3). This in turn presses down on the floating seat ring (5) which offers resistance to the oil flow by restricting the orifices (indicated by arrows).

When the solenoid coil (2) is energized by the EDC-K control module, the armature is magnetically pulled upwards against the valve spring tension. The armature will exert less pressure on the EDC-K Damper valve. The tension is decreased on the floating seat ring decreasing the orifice restriction. The oil flow will increase, resulting in softer damping.

When the solenoid coil receives maximum power, the effect will be the lightest tension on the floating seat ring. The orifices are unrestricted, providing the softest damping.

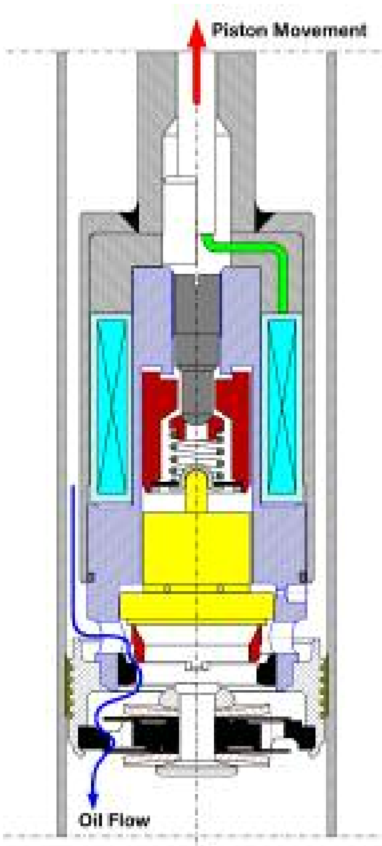
Damper Valve - Hydraulic Details



Compression Stage

The rod and attached piston is forced downwards in the damper cylinder. The oil in the cylinder provides lubrication and resistance to the piston movement (shown to the right).

The oil is forced through the primary valve which pushes the EDC-K Damper valve upwards. The floating seat ring rests at the bottom and the oil will flow through the orifices which control the rate (direction indicated by the arrow).



Rebound Stage

The rod and attached piston is forced upwards in the damper cylinder. The oil in the cylinder provides resistance to the piston movement (shown to the left).

The oil will flow through the orifices forcing the floating seat ring up against the EDC-K Damper valve. The oil continues to flow through the primary valve to control the rate (direction indicated by the arrow).

The armature is controlled (electronically) by the EDC-K control module to regulate the EDC-K Damper valve and floating seat ring positions which varies the resistance to oil flow by restricting the orifices.

Principle of Operation

EDC-K is a microprocessor controlled damper adjusting system. The system consists of mechanical, hydraulic and electrical/electronic subsystems. Acceleration sensors record the driving/road surface conditions and the control module receives the sensor frequency signals for evaluation. The sensor signals are compared with each other for plausibility. The control module logic activates the damper valves according to internal programmed maps to dampen body and wheel movement as needed.

The driver can use the Controller and Control Display menu to select between comfort and sports programs. The system is diagnosable with ISTA. In the event of sensor faults, the system is switched to a "safe state" by supplying fixed power to the damper valves. In the event of a system failure (no power), the dampers are mechanically sprung to the firmest setting.

The EDC-K function is divided into 3 blocks:

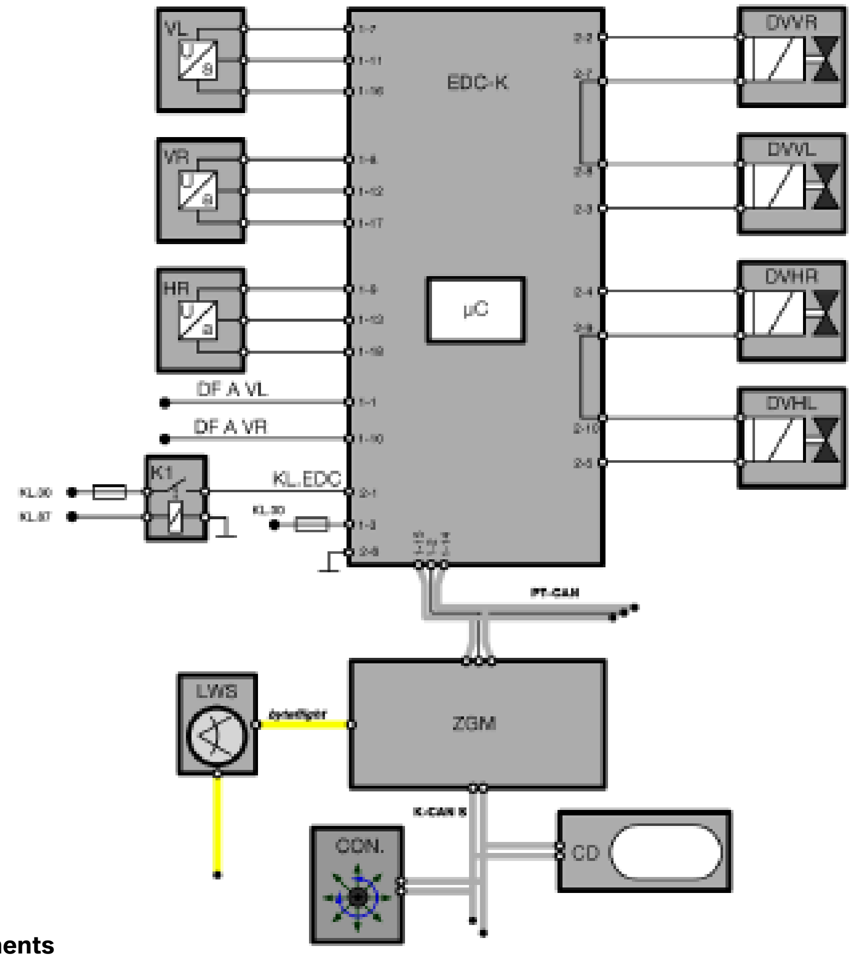
- Control Module
- Sensors and program selection option
- Actuators - 4 electronically adjustable dampers

The input signals for the system are explained in the following table.

Sensor/Switch	Signal	Calculated Variable	Location
Acceleration sensors front axle, rear axle	Vertical acceleration front, rear	Vertical velocity, Compression/rebound travel	Sprint-strut dome FR, FL, RR
Steering angle sensor	Steering angle	Steering angle velocity	SZL
Wheel speed sensors FL/FR	Wheel speed	Driving speed, acceleration/braking	Wheel hubs FL/FR
Program selection	Comfort/sports program		Controller FL/FR Wheel hubs

In addition to the forces calculated in each measured movement, there are vertical, longitudinal, transversal, copy and tolerance control logic.

EDC-K Electronic System Overview



EDC-K Components

Index	Explanation	Index	Explanation
VL	Front left acceleration sensor	CD	Control Display
VR	Front right acceleration sensor	DVVR	Damper valve, front right
HR	Rear right accelerator sensor	DVVL	Damper valve, front left
DF A	Front left wheel speed sensor	DVHR	Damper valve, rear right
Con	Controller	DVHL	Damper valve, rear left
LWS	Steering angle sensor	ZGM	Central gateway module

Vertical Dynamics Control

Vertical Dynamics Control responds to vertical (up/down) body movements based on wheel/body acceleration and speed. A distinction is made between a low frequency body vibration (approx. 1 Hz) and a high frequency wheel vibration (approx. 10 to 15 Hz). Because the body speed cannot be measured, a characteristic value is calculated from the acceleration signals. This value is adapted based on the vehicle speed, frequency ranges and road surfaces.

The higher frequency vibrations of the axle are calculated as the wheel dynamics value based on the wheel speed signal inputs. The value is determined from the irregularities of the wheel rotation when driving over bumps. This control operation takes place separately for both axles.

Longitudinal Dynamics Control

The Longitudinal Dynamics Control responds to acceleration and braking body movements (forward/backward). The vehicle speed signals are monitored by the control module: two direct wheel speed inputs from the DSC control module and three digital inputs from the PT-CAN Bus. Two of the signals on the PT-CAN Bus correspond to the 2 wheel speed signals from DSC and the third signal is the averaged vehicle speed.

The EDC-K control module assesses the plausibility of these signals. A Longitudinal Dynamics value is calculated from the wheel speed signal, which represents the level of acceleration or deceleration. The dampers are adjusted (on both axles) to the harder setting to counter act the longitudinal movement.

Transversal Dynamics Control

The Transversal Dynamics Control responds to transversal movement (dive and squat - front to back roll). This value is calculated from the steering angle sensor and the vehicle speed signals. The onset of "yaw" movement is detected very early from the steering angle sensor signal. A harder damper setting to support the vehicle as it enters a curve is activated at an early stage. The front and rear axles are separately controlled.

Copy Control

The Copy Control function responds to the compression and rebound of the body (encountering bounces on one side of the vehicle) while driving straight ahead. Through comfortable damper tuning, EDC-K responds to one sided unevenness due to the road surface. This prevents a side to side rolling motion while driving straight ahead.

Once vehicle "copying" is detected, a harder damping combination is applied to the front and rear axles. Detection is based on the evaluation of the right and left vertical acceleration signals from the front axle.

Tolerance Adaptation
The damper force is diminished as part of the operating time function. Diminishing damper forces are compensated by current (amperage) reductions which are calculated by the tolerance control. This also individually compensates for mechanical damper wear on each axle.

Control Strategy
All of the dampers are controlled simultaneously until a single damper control in particular is required. For stability reasons, the smallest desired output current of the four damper controls (hardest damper setting) is set.

Plausibility Monitoring and Safety Concept
The EDC-K inputs and outputs are checked for plausibility. Depending on the type of fault, restricted operation of the damper control system will occur while a high degree of safety and comfort is maintained.

The control display informs the driver when an EDC-K system fault has occurred. There are two different shutdown options in the event of faults.

- In partial operation, medium damping is set by a fixed current at the front and rear axle valves.
- When the entire system is shut down, the de-energized valves instantly switch (spring loaded) and remain in the "hard damping" setting.

In the event of system faults, the chassis and suspension is set to a safe condition that is acceptable to the driver. The valves, sensors, electric circuits and EDC-K control module are fault monitored.

System Faults and Reactions

Malfunction	Fault Response
CAN steering angle signal correction Deviation > 10^{o} Acceleration sensor (front, left, right, rear)	Fixed current, fault in memory, gong at end of trip Fixed current output for front axel, rear axle Fault in memory, gong at end of trip
Wheel speed front left/right	1) Control operation with replacement sensor 2) Fixed current output for front and rear axles
External voltage supply fault fluctuation (normal should be 5 V +/- 10%)	Fixed current output for front axle, rear axle Fault in memory, gong at end of trip
Voltage supply to EDC control module between 2 V and 8 V	Calves de-energized, fault in memory, gong during trip
Valve Failure	Valves de-energized, fault in memory, gong during trip
Voltage wake up, < 2 V standing & wake up > 7 V	Valves de-energized, fault in memory, gong during trip
No vehicle speed via CAN Bus	Fixed current, fault in memory, gong at end of trip
Control module EEPROM faulty	Fixed current, fault in memory
Control module - no alive message from EDC-K	Valves de-energized, fault in memory, gong during trip

CAN Interface
The steering angle value is prepared and is transmitted by the SZL over the CAN Bus. Both of the front wheel speed signals (including the direct DSC wheel speed signal), the vehicle speed reference value and the mileage reading are provided by the DSC control module over the CAN Bus to the EDC-K control module.

Power Supply
Low current supply to the damper valves results in hard damping and a high current results in soft damping. The EDC-K control module determines the setpoints and outputs pulse-width modulated (PWM) signals to the damper valves to regulate the current flow. Current flow limitation is ensured by an overcurrent detection and deactivation. All of the analog inputs are protected by diodes against positive and negative overvoltage.

The following analog signals are processed by the EDC-K control module:

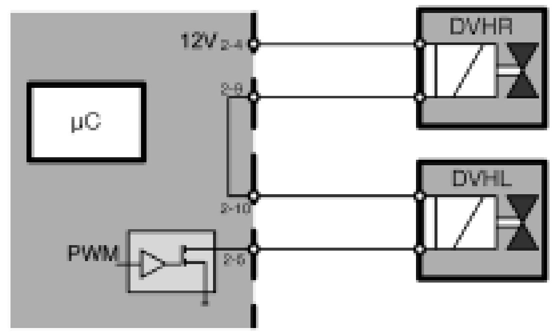
- Vehicle supply voltage
- EDC-K switched output voltage
- Damper valve voltage and current

Valve Activation / Output Stage Circuit

The solenoid valves have low resistance, approximately 2.2 ohms per valve at room temperature because high current is needed at a low voltage. The current is set in the 0 to 2 Amps range depending on the desired damping force. The setpoint value will not exceed 2 Amps to avoid valve damage. The solenoid valves are connected in series for each axle and are supplied with a ground (PWM for continuous adjustment) from the EDC-K control module

Rear Axle EDC-K Valves Series Connection

uC = Microcontroller (EDC-K control module)
PWM = Pulse width modulation (output signal)
DVHR = Right rear damper valve
DVHL = Left rear damper valve



Controller and Control Display Operation

Sports Program

The driver can activate/deactivate the sports program by the Controller in the Control Display menu.

A firmer damping is set when the EDC-K request is set to "SPORT". EDC-K always reverts back to the comfort program each time the engine is restarted.

Notes:

Service Information

Diagnosis

System Monitoring and Plausibility
For safety reasons, faults with one damper valve will result in deactivation of all damper valves. Fault detection takes place on each axle. To pinpoint which valve is faulty, use the diagnostic equipment to measure the resistance of the individual valves (per axle). The resistance of a good valve is 2.2 ohms ±10% at room temperature (20 °C).

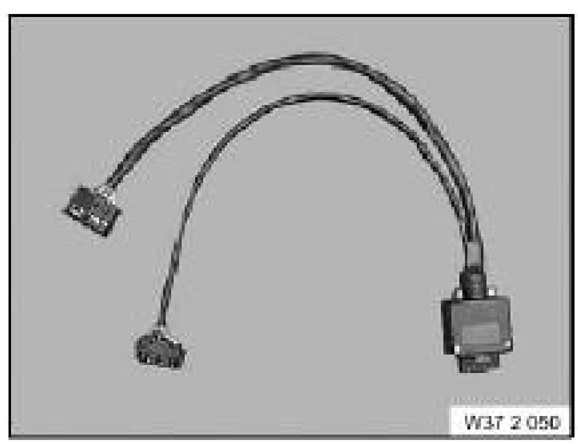
Acceleration Sensors
The EDC-K control module does not distinguish individual malfunctions between the sensors. The power supply to the three sensors is connected in parallel in the control module (without isolation). A short circuit in the supply voltage to one of the sensors will also affect the supply to the other sensors.

A maximum of seven different faults can be stored for the acceleration sensors. The coding data will indicate the functions of the control module (vehicle and country specific).

Notes on Service
When the steering angle sensor is removed, the steering wheel must be manually positioned to the straight ahead position and this position re-initialized in the SZL. The steering wheel straight ahead position is permanently monitored while driving.

EDC-K diagnosis detects electronic damper faults on the complete axle only. Mechanical testing of individual dampers can be carried out in the damper test. Mechanical wear causes the dampers to weaken over the service life, therefore a running time memory adapts the damper curves towards a harder setting (over time). Faulty dampers must be replaced together (in pairs) on a single axle. After a replacement, the running time memory for the front or rear axle must be reset with the BMW diagnostic equipment

A 10 Pin Adapter Cable is available to adapt the MFK cables to the EDC-K control module when using the diagnostic equipment (Test Plan).



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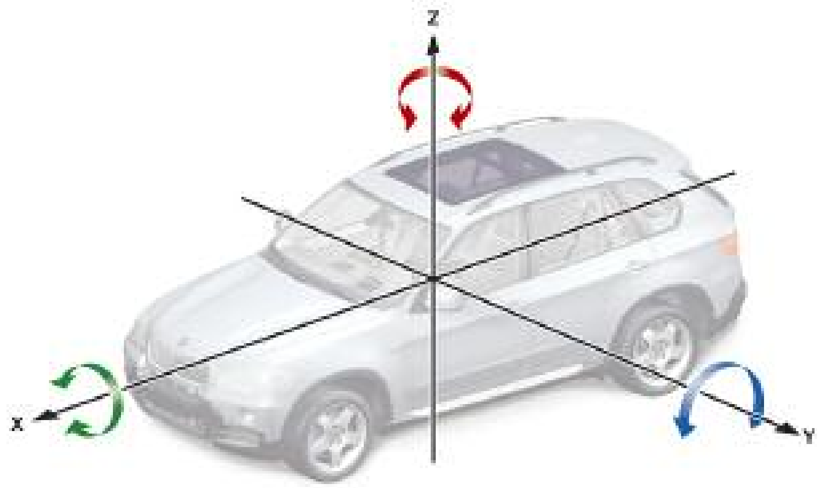
NOTES PAGE

Vertical Dynamics I (E70 / E71)

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 (first introduced on the E70) which includes the combination of ARS and VDC. These two systems are functionally linked to provide 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. It also reduces the required steering angle, improves ride comfort and enhances 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.

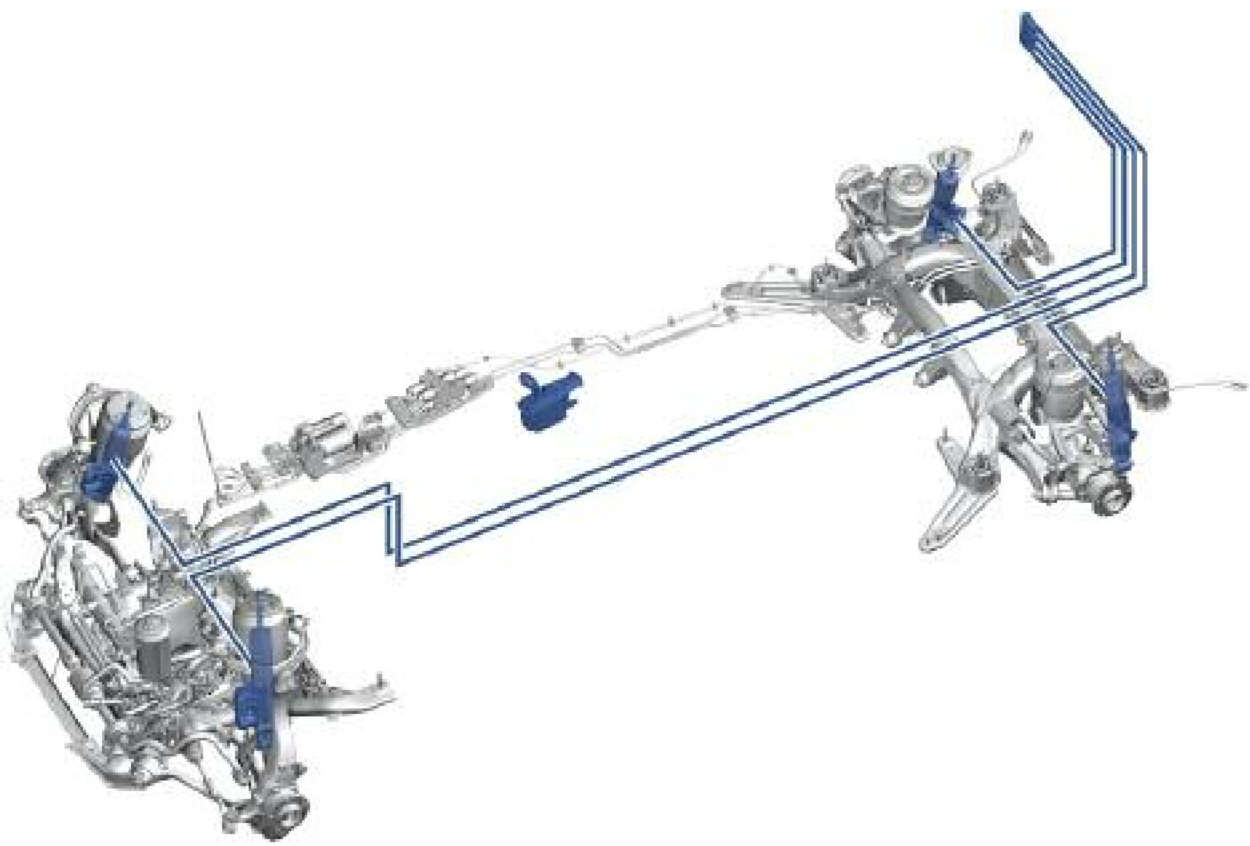
The reciprocal movements in the upper part of the body, which are inherent in the design of SAV vehicles, are considerably reduced. The vehicle can be driven with higher levels of precision and agility. The system also contributes to shorter braking distances.

Vertical Dynamics Control

The Vertical Dynamics Control (VDC) system was 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.

As with 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.

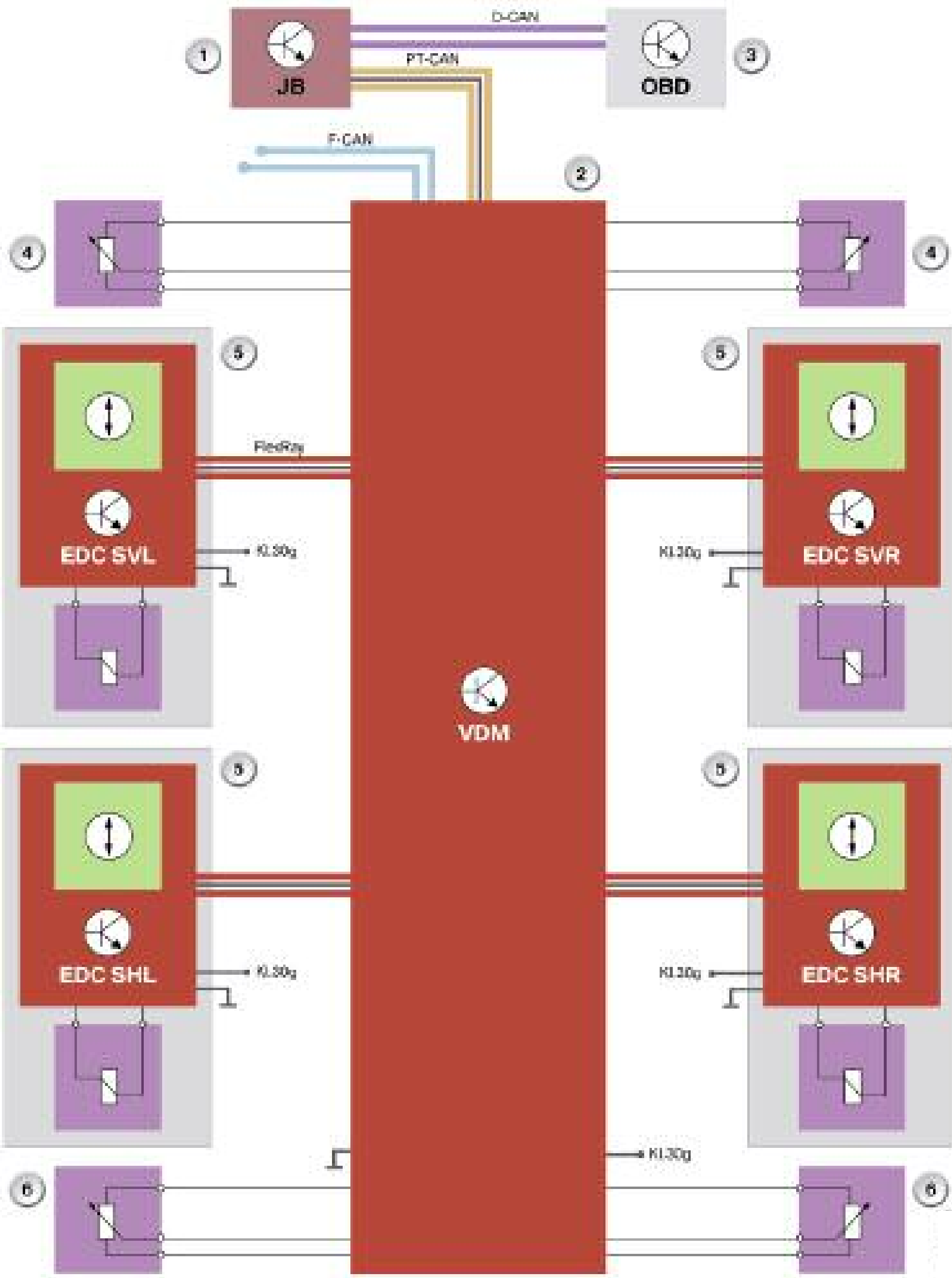
The characteristic curve used depends on the driving situation, in other words, the variables that describe the dynamic driving state of the vehicle and which are selected automatically at the driver's command.



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. 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 stiffer 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 dampening 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).

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)

On the E70/E71, the EDC is located externally, unlike the EDC-K 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.

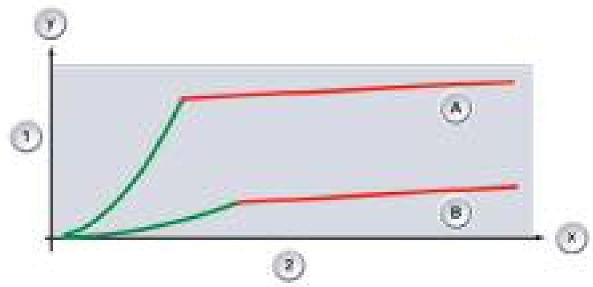
- Actuating functions: Each EDC satellite control unit has a damping characteristic map valid for this type of damper that is electronically stored in the form of support points. It is therefore possible to compensate for unavoidable tolerances (variations) arising from manufacture and achieve a higher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

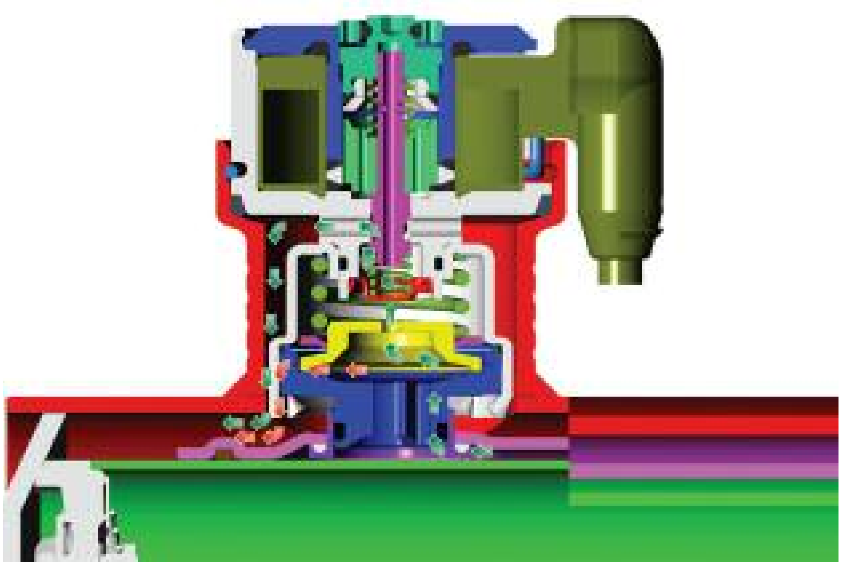
> **The EDC satellite control unit with twin tube gas-pressure damper and EDC control valve can only be replaced as one unit. The vehicle model and installation location (e.g. front left) must be stated when a replacement part is being ordered.**

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

> **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

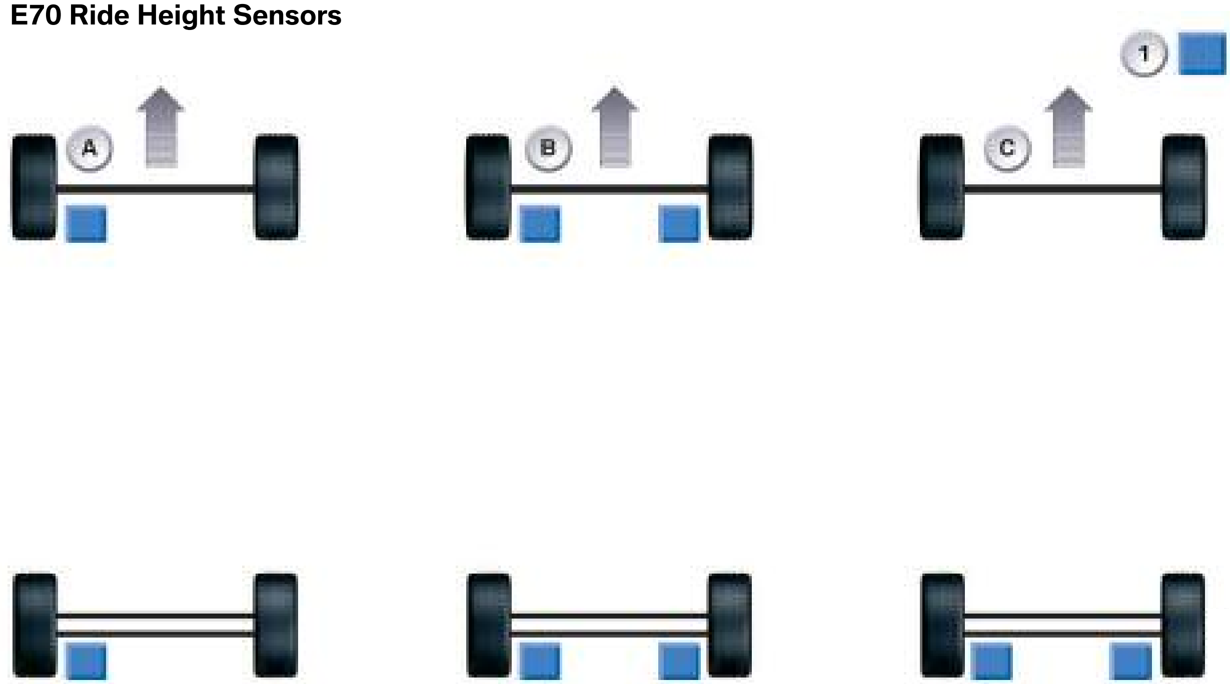
The ride-height sensors are electrically connected (hardwired) directly to the VDM control unit. The ride height is sent from the sensor to the VDM via an analog circuit.

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.

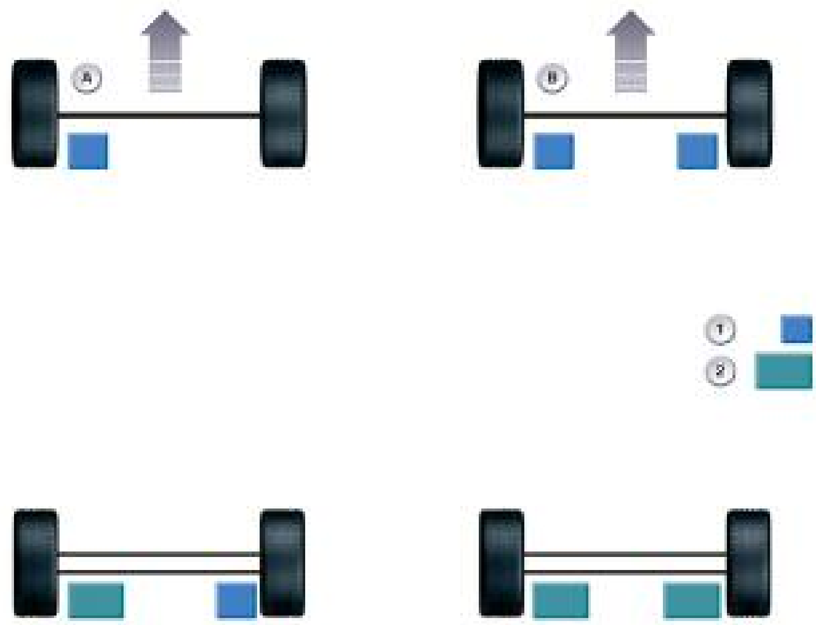
If a new ride-height sensor is being fitted, it must be ensured that only parts with matching part numbers are fitted. In particular, care must be taken not to confuse one-way and two-way sensors (one-way/two-way depends on the equipment level of the vehicle). Two-way sensors bear the marking "doppelt"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

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.)

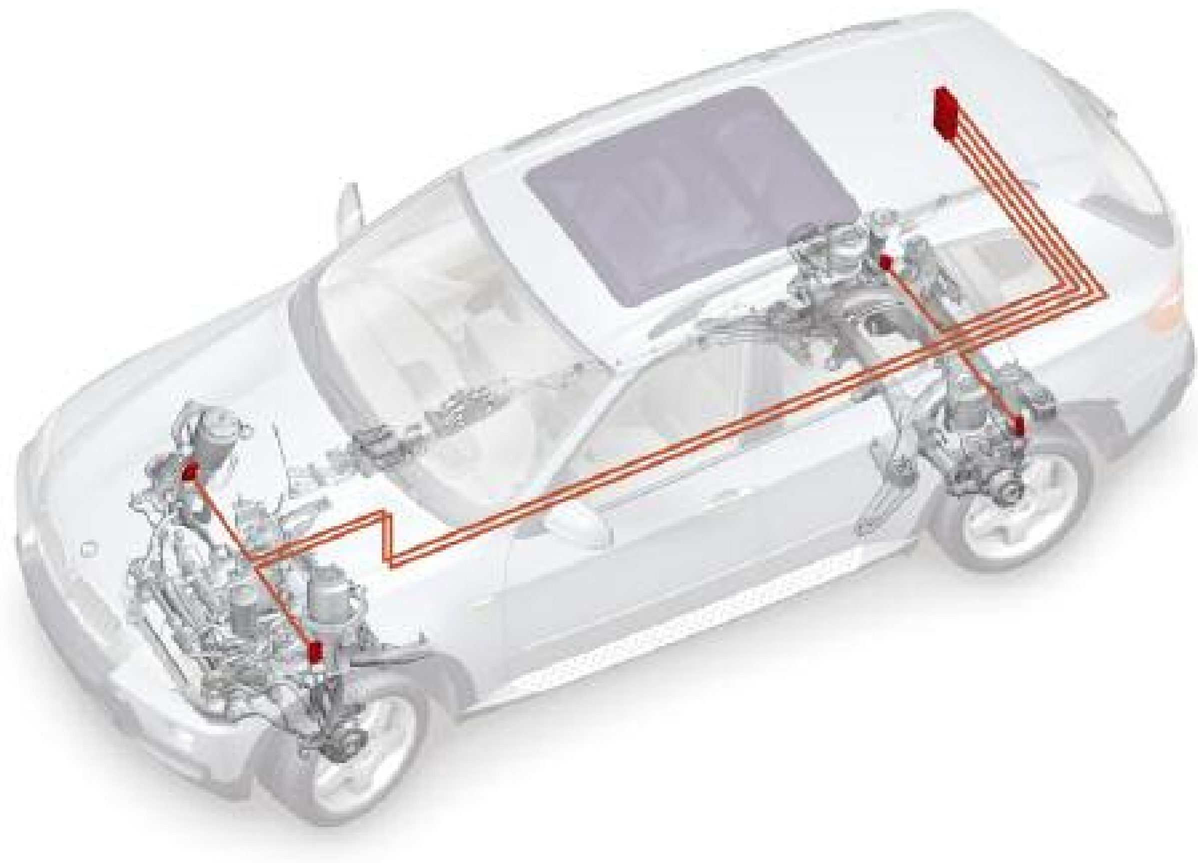


Index	Explanation	Index	Explanation
1	One-way ride height sensor with one output	A	Adaptive drive and EHC w or w/o Xenon
2	Two-way ride height sensor with two outputs	B	Option - EHC and Xenon

E70 Ride Height Sensor Variants

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

FlexRay in the E70



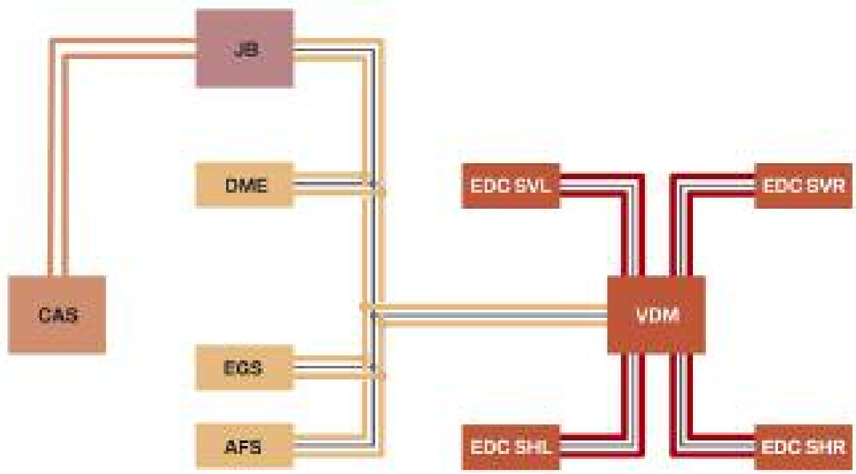
The FlexRay bus system was introduced with the launch of the E70, and used for the first time worldwide in a standard production vehicle.

The E70 and E71 use the FlexRay bus only 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.

Current BMW modules have expand the use of FlexRay due to the need for increased network speed and reliability. (See Vertical Dynamics II section of this training material)

The FlexRay bus system 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.

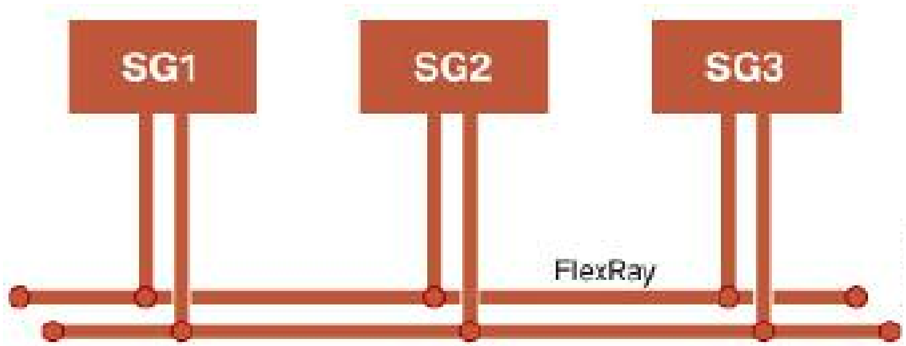
The following topologies can be used:

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

Line-based Bus Topology

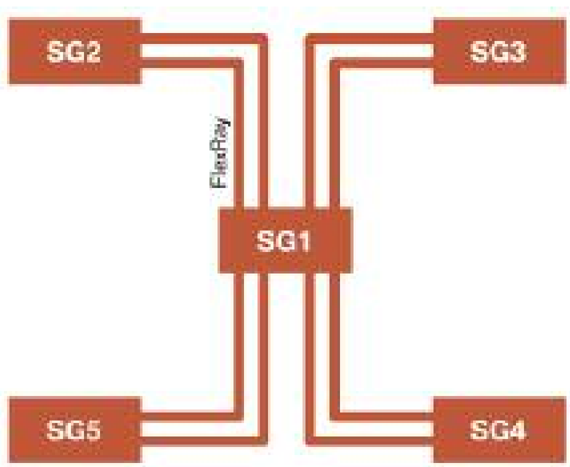
All control units (SG1...SG3) in line-based topology are connected by means of a two-wire bus, consisting of two twisted copper cores. This type of connection is also used on the CAN-bus.
The same information but with different voltage level is sent on both lines.

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.

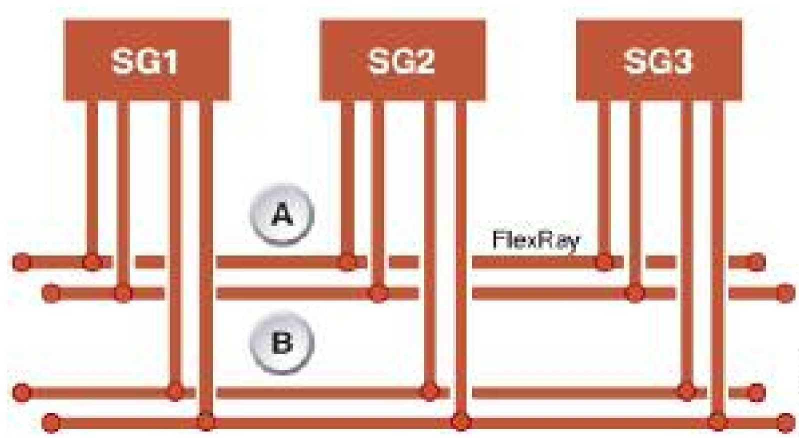
A bus system with redundant data transmission uses two independent channels. Each channel consists of a two-wire connection. In the event of one channel failing, the information of the defective channel can be transmitted on the intact channel.

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.



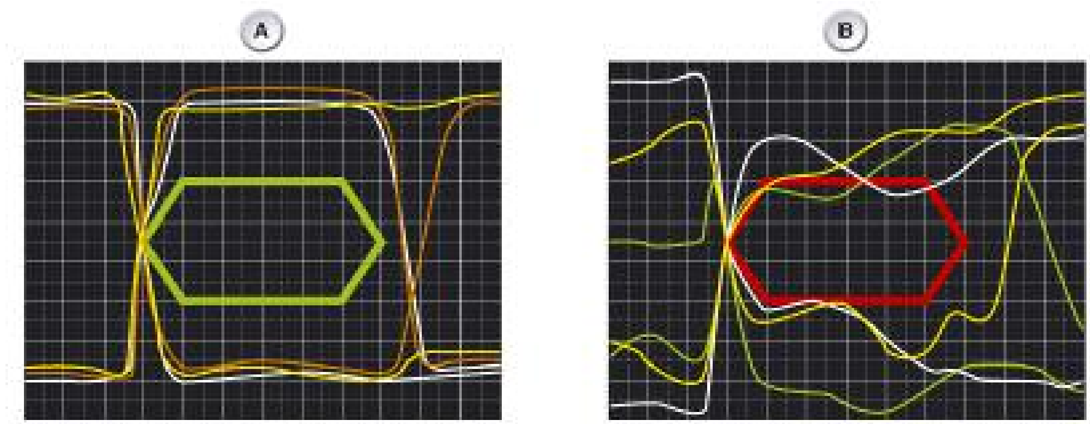
Index	Explanation
A	Channel 1
B	Channel 2

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.

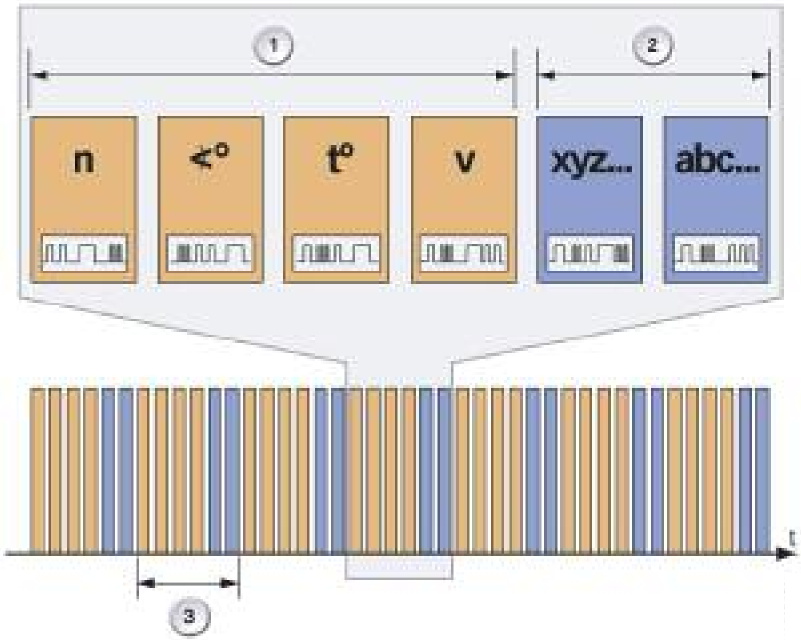
The voltage ranges of the FlexRay bus system are:

- 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^o	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**

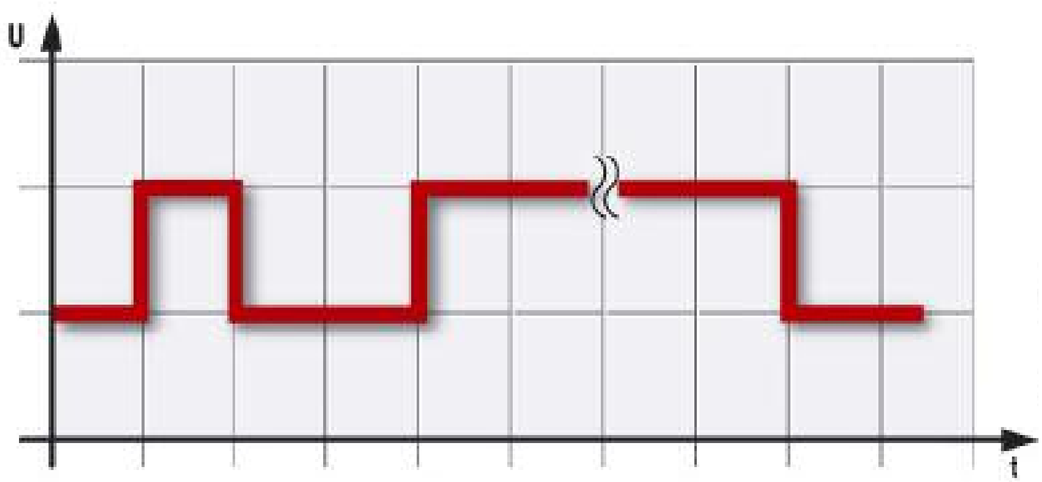
A common time base is necessary in order to ensure synchronous execution of individual functions in interconnected control units. Time matching must take place via the bus system as all control units operate with their own clock generator.

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:

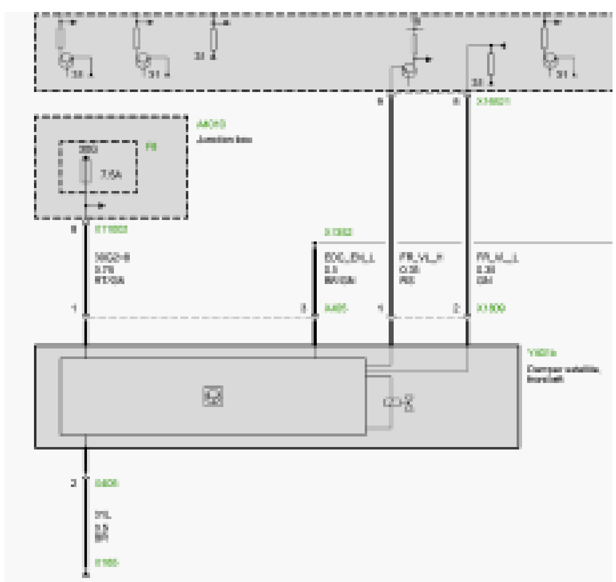
The complete vehicle network must assume sleep mode at terminal R OFF in order to avoid unnecessary power consumption. Each control unit in the network signs off to ensure that all control units "are sleeping".

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:

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

RBP **Resistance Bus Plus**
BM **Bus Minus**

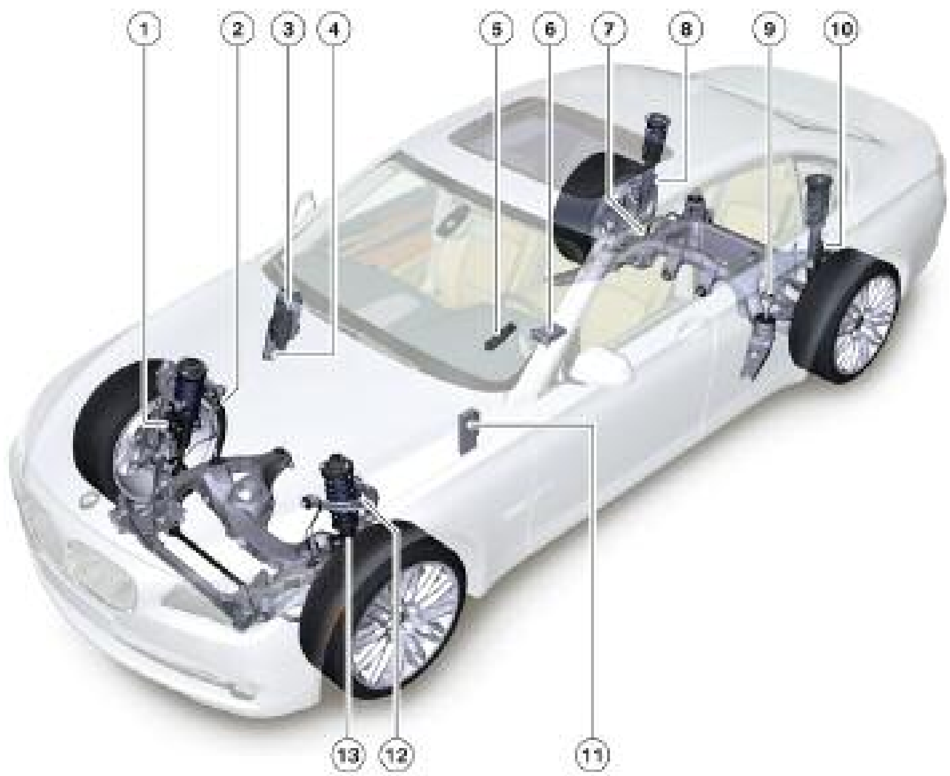
Vertical Dynamics II (F0x / F1x)

The following systems are available on LG (F0x/F1x) vehicles:

- Vertical Dynamics Control 2 (VDC II)
- Active Roll Stabilization (ARS)
- Electronic ride-height control (EHC)

Although not the case with all LG (F0x/F1x) vehicles, VDC II is fitted as standard on the F01/F02, F06 and F07 with ARS available as an option, whereas EHC is standard on the F02 and F06.

Vertical Dynamics Control



Index	Explanation	Index	Explanation
1	EDC, SVR	8	EDC, SHR
2	Ride-height sensor, front right	9	Ride height sensor, rear left
3	Front power distribution box	10	EDC, SHL
4	VDM	11	ZGM
5	Driving Dynamics switch	12	Ride height sensor, front left
6	ICM	13	EDC, SVL
7	Ride height sensor, rear right		

When driven vigorously or on an uneven road surface, a vehicle tends to respond with undesirable body movements. BMW first developed Vertical Dynamics Control for the E70 and was able to effectively reduce such body motion as a result.

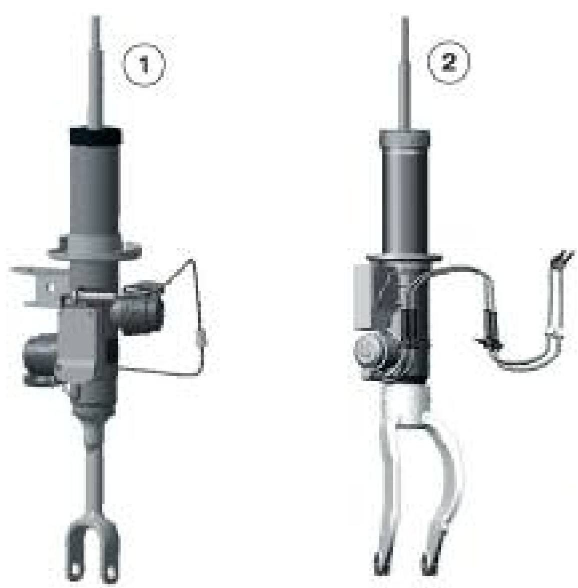
VDC improves the following driver-perception related vehicle characteristics according to road surface conditions:

- Body-related ride comfort (primary ride comfort).
- Road wheel-related ride comfort (secondary ride comfort).
- Dynamic handling (transitional response, agility) even with more comfortable suspension setting.

BMW is the first manufacturer to offer a damper adjustment system that is continuously controllable independently of damper compression/extension as is the case with the VDC (2) on the F01/F02.

The essential improvements compared with VDC I are:

- 2 EDC control valves per damper, 1 for damper extension control and 1 for damper compression control.
- "Pre-opening adjustment" for improved body stabilization (has adjustment effect even at low damper rates).
- Driver-perceptible broad spread in conjunction with the driving dynamics switch (difference between soft and hard characteristics.)
- Separately adjustable characteristic for road wheel-related ride comfort (extension characteristic independent of compression characteristic).



Index	Explanation	Index	Explanation
1	Front damper, VDC 2	2	Front damper, VDC 1

	VDC 1	VDC 2
Model	On E70/E71 included in Adaptive Drive Equipment package	Standard equipment in F01/F02
Program selection	Sport button next to gear selector	Handling setting switch next to gear selector
Program type	Sport/Comfort	Coordinated integration in all dynamic handling control functions
Control unit	VDM control module, right rear of luggage compartment 4 EDC satellite control modules directly on damper units	VDM control module, front right A-pillar 4 EDC satellite control modules directly on damper units
Damper	Twin tube, gas filled shock absorbers	Twin tube, gas filled shock absorbers
Fault diagnosis	VDM and EDC satellite control modules fully diagnosable	VDM and EDC satellite control modules fully diagnosable
Programming	VDM and EDC satellite control modules flash programmable	VDM and EDC satellite control modules flash programmable
Coding	VDM and EDC satellite control modules codable	VDM and EDC satellite control modules codable
Malfunction display	Messages in the Control Display or instrument cluster	Messages in the Control Display or instrument cluster
Testing	BMW diagnostic systems	BMW diagnostic systems

Signal Processing

- The vertical movement of the wheels is detected by the wheel-acceleration sensors integrated in the EDC satellite control modules.
- From the wheel acceleration rates and the ride height signals (FlexRay bus) the vehicle body motion is calculated.
- In addition, signals such as the vehicle road speed are read from the FlexRay bus for the purpose of determining required damping forces.

Signal Processing / VDC (2) Controller

Individual damping forces are calculated for each individual wheel according to the vehicle body motion, the wheel motion and the additional signals read from the FlexRay bus, and are sent every 2.5 ms to the EDC satellite control units.

Damping Force Adjustment

- Stored on each EDC satellite control unit is the actual individual damper characteristic, making it possible to minimize differences from the specified characteristic arising from manufacturing tolerances.
- From the specified damping force and the damper characteristic data-map, the EDC satellite control units calculate the required current to be applied to the damper extension valve and compression valve.

VDC System Components

VDM Control Module

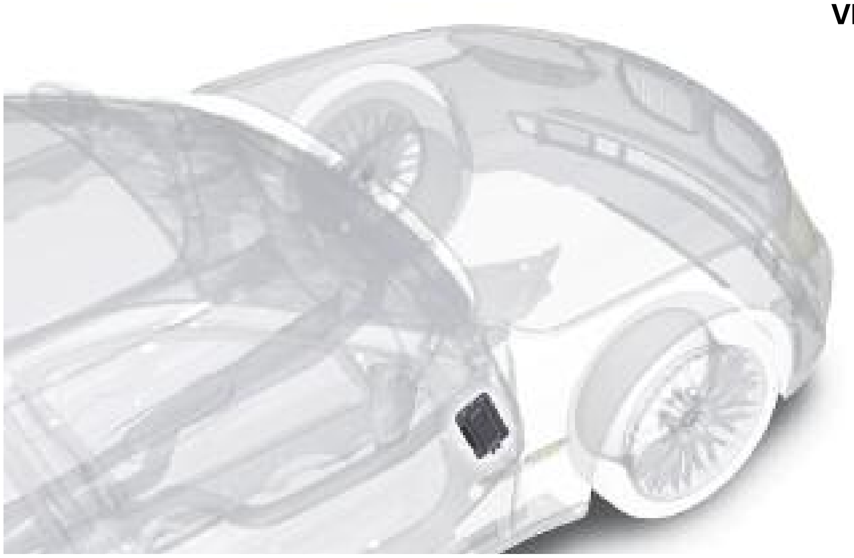
The VDM control unit is located near the right hand A-pillar.

There are two different versions of the VDM control unit according to the equipment options fitted on the vehicle:

- The basic version of the VDM control unit is used if the vehicle has only the standard VDC equipment.
- The “high” version of the VDM control unit is used if, as well as the standard VDC system, the vehicle also has ARS Active Roll Stabilization (Dynamic Drive).

In that case, the output stages for controlling the ARS valve manifold are also integrated in the VDM control unit.

VDM Control Unit Location F01



Ride Height Sensors

On the E70/E71 with VDC I, the “Sport” button for switching between comfort and sports setting only affected the VDC characteristics.

The ride height sensors on VDC II are a direct hardwired input to the ICM. Thus with the introduction of the handling setting switch, the VDC setting is incorporated in a number of modes which bring about a coordinated overall setting across all systems.

The angle of a pivoting lever is converted into a voltage signal by the ride height sensor. The greater the angle (relative to a defined starting or zero position), the greater is the output voltage. It is generated by a Hall-effect sensor element.

Designs

There are always four ride-height sensors fitted. They all operate according to the same principle but there are different designs (different part numbers). The reason for the differences are the available space and the starting position (zero position) of the individual ride-height sensors.

Depending on whether or not the vehicle is fitted with Electronic Height Control (EHC), double or single ride-height sensors are fitted on the rear suspension.

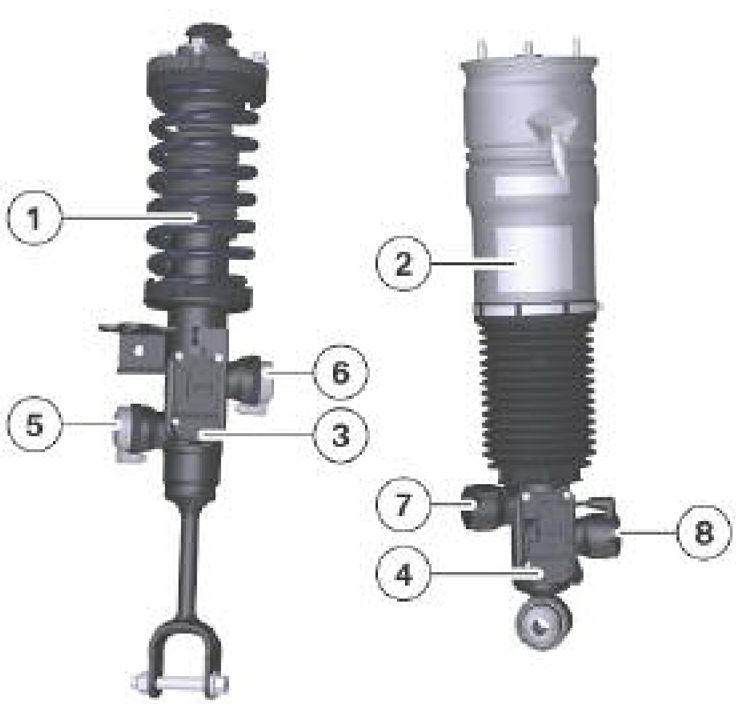
On the front suspension, single ride-height sensors are always used.

Index	Front suspension	Rear suspension
EHC, not fitted	Single RHS	Single
EHC, fitted	Single RHS	Double

RHS = Ride-height sensor

EDC Satellite with Damper

The VDC dampers on the rear suspension are either steel-spring or air-spring versions depending on the optional equipment fitted.

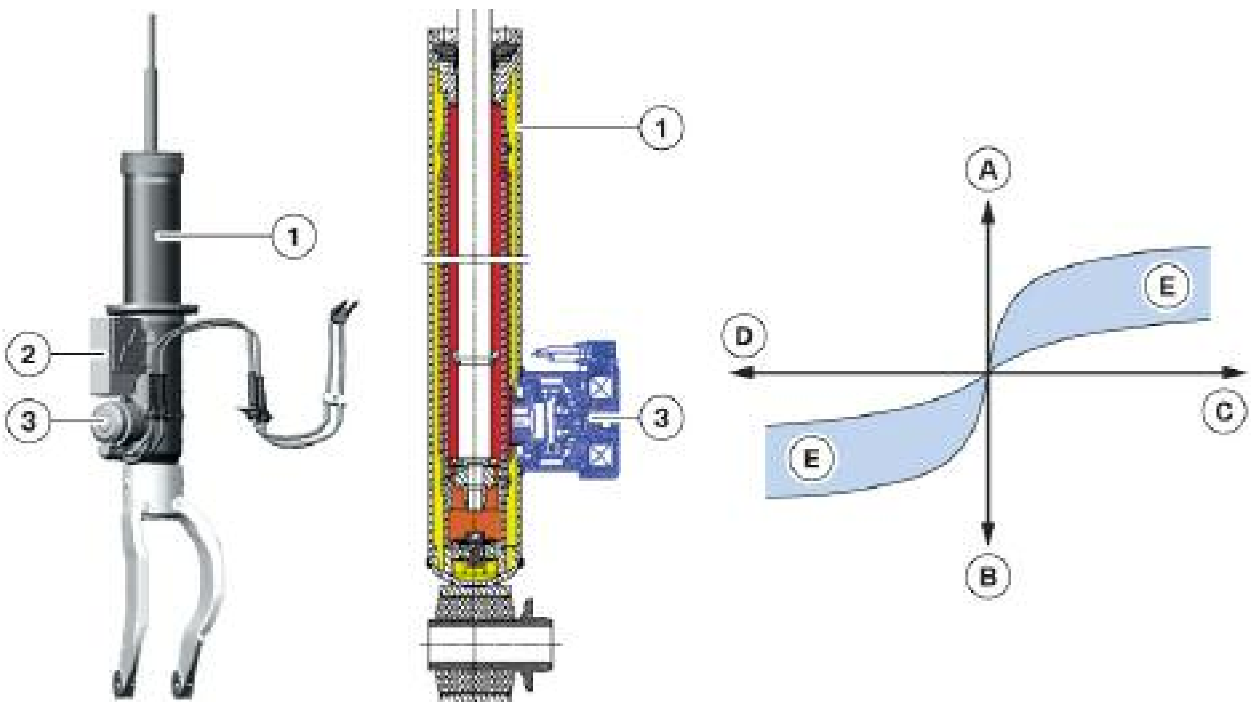


Index	Explanation
1	VDC Damper with steel spring
2	VDC damper with air spring
3	Front EDC satellite module
4	Rear EDC satellite module
5	EDC data-map valve for compression control
6	EDC data-map valve for extension control
7	EDC data-map valve for extension control
8	EDC data-map valve for compression control

VDC II Damper Operation

Comparison of VDC I to VDC II Damper
A VDC I damper with only one EDC data-map valve uses combined extension/compression adjustment which has to be cycled extremely rapidly.

With this type of control, the damper adjustment is based on wheel frequency. The wheel frequency is the frequency at which the wheel oscillates along the z-axis (vertically)



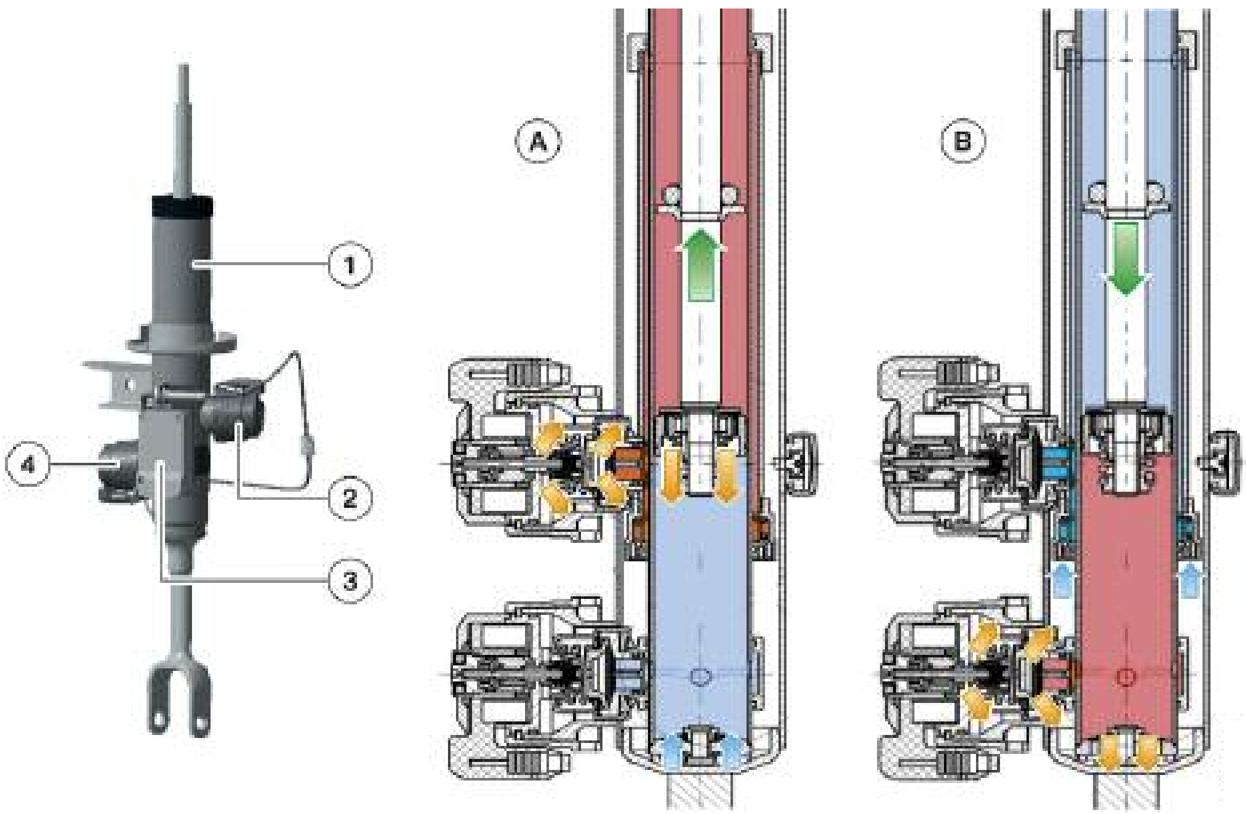
VDC I

Index	Explanation	Index	Explanation
1	Damper tube	B	FC = Compression force
2	EDC satellite control unit	C	VE = Extension velocity
3	EDC data-map valve for extension and compression control	D	VC = Compression velocity
A	FE = Extension force	E	Extension and compression characteristic data-map

A VDC II damper with two EDC data-map valves uses independent extension/compression adjustment which does not demand such a high cycling rate.

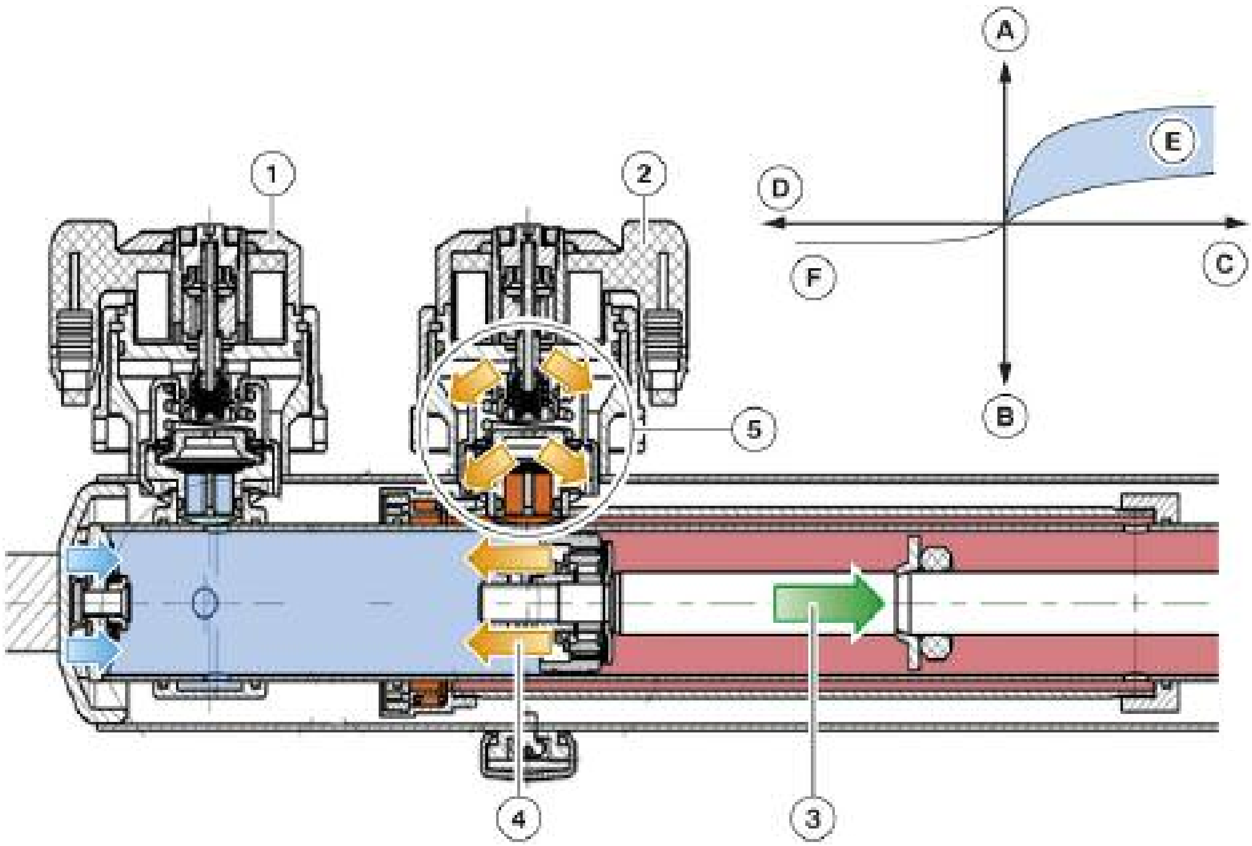
With this type of control, the damper adjustment can be based on body frequency. The body frequency is the frequency at which the body oscillates along the z-axis (vertically).

The two EDC data-map valves firstly enable independent extension control and, therefore, data-map compatible design, and secondly independent compression control and, therefore, data-map compatible design.



VDC II

Index	Explanation	Index	Explanation
A	Extension progression	2	EDC data-map valve for extension
B	Compression progression	3	EDC satellite control unit
1	Damper tube	4	EDC data-map valve for compression

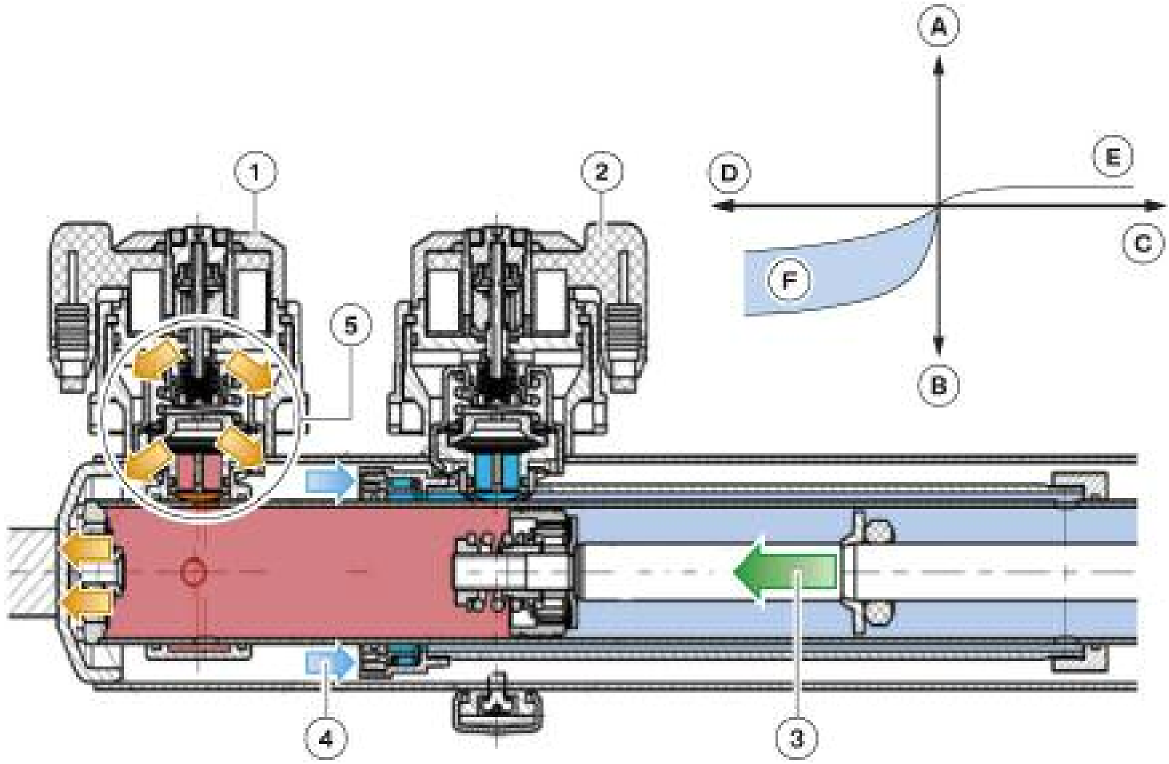


Index	Explanation	Index	Explanation
1	EDC data-map valve for compression	B	FC = Compression force
2	EDC data-map valve for extension	C	VE = Extension velocity
3	Force/direction of piston rod movement	D	VC = Compression velocity
4	Fluid medium	E	Extension data-map
5	Data-map control	F	Compression data-map
A	FE = Extension force		

Control Strategy

The fundamental control principle is known as the "Skyhook system", which means, in theory, primary control objective of holding the vehicle stationary in a vertical direction regardless of driving situation as if suspended from a "hook in the sky".

To achieve this highest of all comfort objectives, the movements of the entire body have to be evaluated. Thus an overall analysis is performed of the ride height data and z-axis acceleration rates.



Index	Explanation	Index	Explanation
1	EDC data-map valve for compression	B	FC = Compression force
2	EDC data-map valve for extension	C	VE = Extension velocity
3	Force/direction of piston rod movement	D	VC = Compression velocity
4	Fluid medium	E	Extension data-map
5	Data-map control	F	Compression data-map
A	FE = Extension force		

Furthermore, VDC regulation takes into consideration steering inputs based on the steering angle curve. If VDC II detects a rapid increase in the steering angle, the driving dynamics control function 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. Thus VDC assists the ARS system, if fitted, and contributes to reducing vehicle roll (roll tendency).

Moreover, VDC is able to detect the braking operations (by the driver) based on the brake pressure information supplied by DSC.

A high brake pressure normally results in pitching of the vehicle body; VDC counteracts that effect by setting 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).

With the introduction of the handling setting switch, the VDC setting is incorporated in a number of modes which bring about a coordinated overall setting across all systems.

Active Roll Stabilization (ARS)

Active Roll Stabilization was first fitted on the 7 Series predecessor, the E65/E66, and has been used in similar form since on the E6x and E7x models.

As Vertical Dynamics Control (VDC) is fitted as standard on the F01/F02, the ARS is now an option.

In customer communications, ARS continues to be marketed under the name "Dynamic Drive" on the F01/F02.

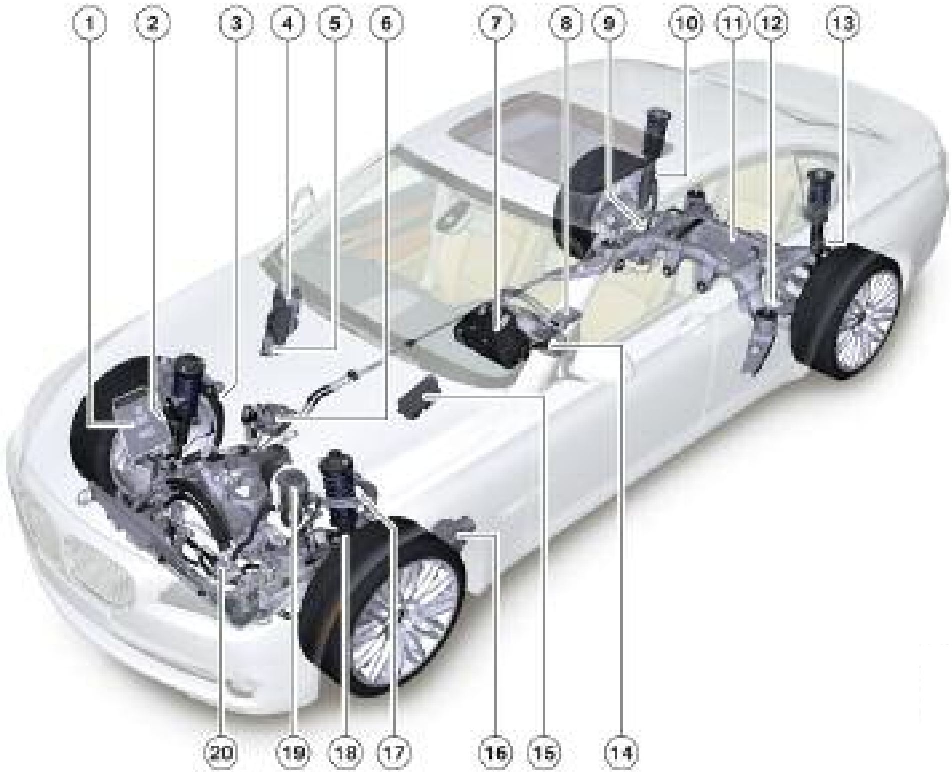
Vertical Dynamics Control
VDC and ARS have to respond with the appropriate speed in the event of rapid lane changes, rapid cornering or rapid changes of direction on winding country roads.

Overview of ARS Components
The components of the ARS system of the F01 are much the same as on past ARS systems.

The ARS control module is no longer used, the control of the ARS system (via ARS valve block) has been assumed by the VDM module.

VDM Module
The VDM module contains the appropriate output stages for controlling the ARS valve block. The system architecture on the F01/F02 features two different versions of the VDM control module:

- If ARS is **not** fitted, the VDM has **no** output stages for ARS valve manifold control.
- If ARS is fitted, the VDM has output stages for ARS valve manifold control.



Index	Explanation	Index	Explanation
1	DME	11	Rear hydraulic motor
2	EDC, SVR	12	Ride height sensor
3	Ride height sensor	13	EDC, SHL
4	Front power distribution box	14	SZL
5	VDM	15	ZGM
6	ARS valve manifold	16	DSC
7	Instrument cluster	17	Ride height sensor
8	ICM	18	EDC, SVL
9	Ride height sensor	19	Hydraulic fluid reservoir
10	EDC, SHR	20	Front hydraulic motor

The VDM control module is located in the passenger compartment near the right hand A-pillar. It receives its power supply via KL15N and is protected by a 5A fuse.

The VDM control unit is activated exclusively by the Car Access System (CAS) via a Terminal 15N lead as of status "Ignition ON".

A vehicle authentication process takes place when the system is started.

All outputs (valve solenoids and sensors) are subjected to a comprehensive check for short circuits and circuit breaks. If there is a fault, the system switches the actuators to a safe-driving mode.

The VDM control unit switches off if the voltage is too low/too high.

VDM Control Unit Inputs

From the input signals, the VDM control unit calculates the control signals to the actuators. The input signals are also checked for plausibility and used for system monitoring.

The VDM control unit receives the following input signals:

- FlexRay bus
- Front-suspension circuit pressure (analog)
- Rear-suspension circuit pressure (analog)
- Switch position detector reading (analog)
- Fluid level sensor signal (analog)

The most important control signal for the ARS function is the lateral acceleration measured by the ICM control unit, which is sent to the VDM via the FlexRay bus. Additional lateral dynamics information from the FlexRay bus which is also provided by the ICM comprises the road speed signal and the steering angle.

From that, the stabilization requirement is calculated and the relevant active forces are applied. The road speed and steering angle information is also used to improve the reaction time of the system.

VDM Control Unit Outputs

All outputs are compatible with diagnostics and protected against short-circuit. The outputs include controls for:

- Pressure regulating valves for front and rear axle
- Failsafe valve
- Directional valve
- Intake restrictor valve
- 5 V power supply for the sensors:
  - Pressure sensors at the front and rear axle
  - Switch-position detector (SSE)

The valves are controlled by the supply of current regulated by pulse-width modulation (PWM).

The valve currents are mutually checked for plausibility on a continuous basis. Therefore, the pressure can be set more precisely and the switch valves can be monitored electronically.

Fault symptoms of the output signals are:

- Short circuit to Terminal 30 and Terminal
- Open circuit and
- Valve short circuits
- Sensor power supply faults

A message is sent to the DME via the FlexRay bus from the central dynamic handling controller on the ICM. The message contains information on how much power the tandem pump currently requires to supply the active anti-roll bars.

In this way, output at the engine can be increased to satisfy the additional power requirement. A regular data signal (alive signal) is broadcast and read by other VDM control units to identify whether the system is still active. In addition, a function status signal is broadcast which communicates the status of the ARS function.

The VDM control unit transmits an additional status message via the FlexRay to the instrument cluster in order to actively initiate display messages. That status message is assigned a priority among all suspension/steering messages by the message coordinator on the ICM control unit and passed to the instrument cluster.

All signal faults are recorded and permanently stored in the fault memory. If the alive signal fails, the ICM control unit automatically sends a message to the instrument cluster to activate the ARS warning lamp.

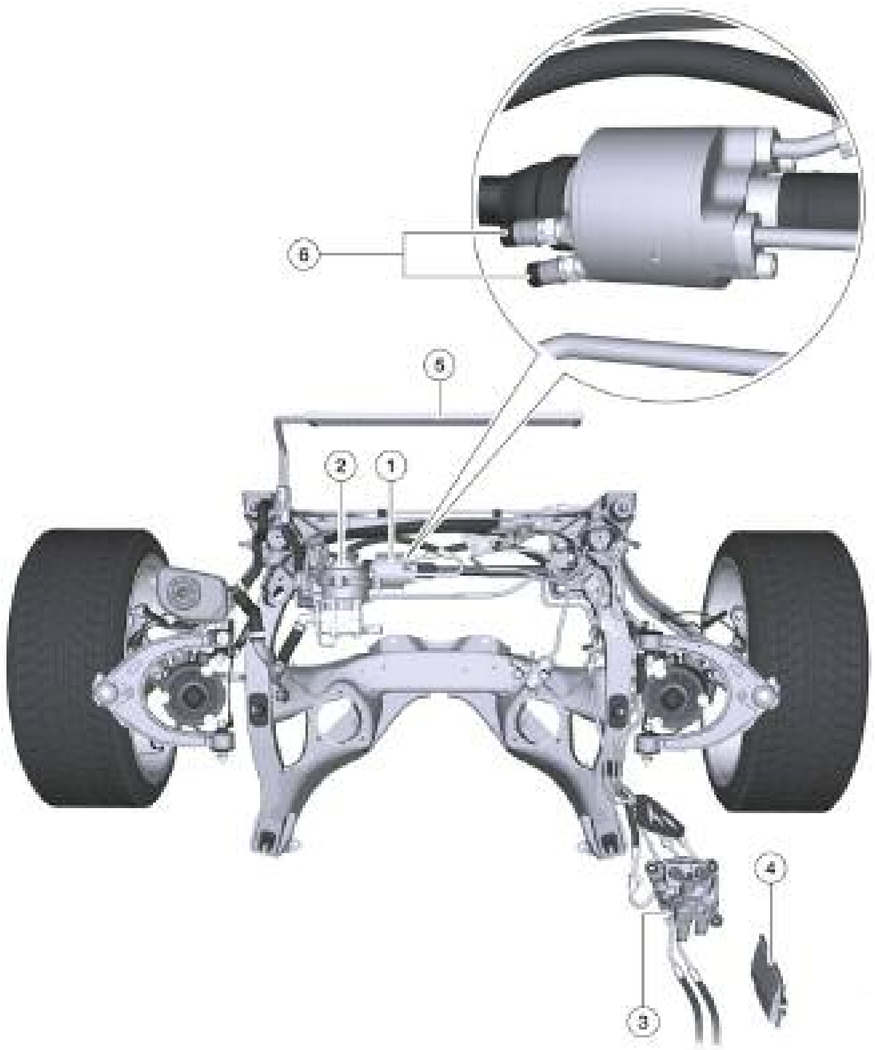
Oscillating Motor

The hydraulic motor and the hydraulic motor body are each attached to 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. A thin coating of grease on the roller bearing does not impair the function of the active anti-roll bar.

Active Anti-roll Bar, Front

The anti-roll bar is mounted on the front suspension subframe. The anti-roll bar links are attached to the pivot bearing. There are two pressure relief valves on the hydraulic motor of the front suspension anti-roll bar.

On the pressure relief valves there are air filter elements (black plastic caps) attached. Those black air filter caps with Goretex inserts must not be removed.

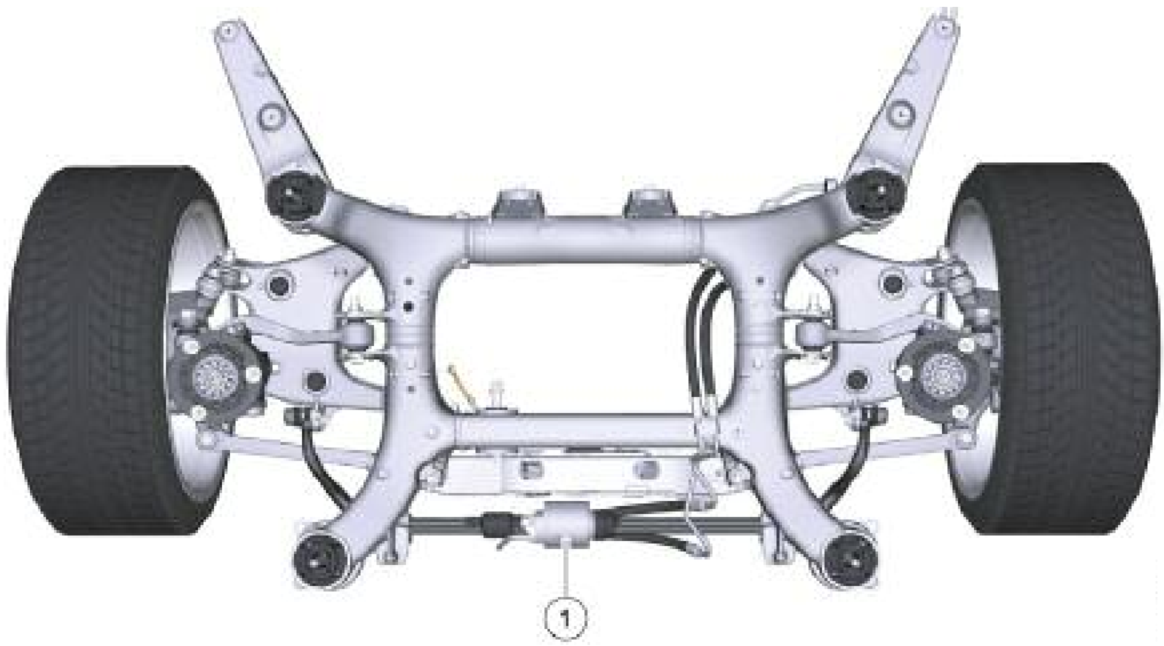


Index	Explanation	Index	Explanation
1	Oscillating motor	4	VDM
2	Tandem pump	5	Power steering cooler
3	ARS valve manifold	6	Air filter element

Rear Suspension Active Anti-roll Bar

The anti-roll bar is mounted behind the rear suspension subframe. The anti-roll bar links are attached to the rear suspension swing arms.

On the hydraulic motor for the rear suspension anti-roll bar, blanking plugs are fitted in place of the pressure relief valves.



Index	Explanation
1	Rear suspension, oscillating motor (hydraulic)

ARS Hydraulic Valve Manifold

The hydraulic valve block is located on the floor plate of the vehicle behind the front right hand wheel housing level with the front righthand door.

The hydraulic valve block is connected to a carrier plate bolted to the body. The hydraulic valve block houses the following valves and sensors:

- 2 pressure valves; 1 for the front suspension and 1 for the rear suspension [these are proportional pressure limiting valves]
- 1 directional control valve
- 1 failsafe valve
- 2 pressure sensors; 1 sensor for the front suspension, 1 sensor for the rear suspension
- Switch-position detector

Tandem Pump

The hydraulic pumps fitted in this model series were based on a modular design principle. Depending on the engine and equipment specification, a suitably dimensioned hydraulic pump is flange-mounted to the engine in the same installation space.

Decisive equipment features for these tandem pumps:

- Basic steering
- Integrated Active Steering (IAL)
- CO2 reduction measures
- Dynamic Drive (ARS)
- Dynamic Drive (ARS) and Integrated Active Steering (IAL)
- Intake restrictor valve

Index	Explanation
1	Radial piston pump
2	Intake restrictor valve
3	Electronic volumetric flow control valve
4	Vane pump, power steering

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

Radial Piston Pump

This radial piston pump has 8 pistons in a single row and is designed for a maximum pressure of 210 bar.

When the engine is idling, the pump speed is approximately 750 rpm. At that speed, the radial piston pump section delivers a minimum fluid flow rate of approximately 5.5 liters per minute at a pressure of approximately 3 bar. Consequently an adequate fluid flow rate is guaranteed even at idling speed.

At a pump speed of 1450 rpm, the maximum fluid flow rate is limited to approximately 9 liters per minute.

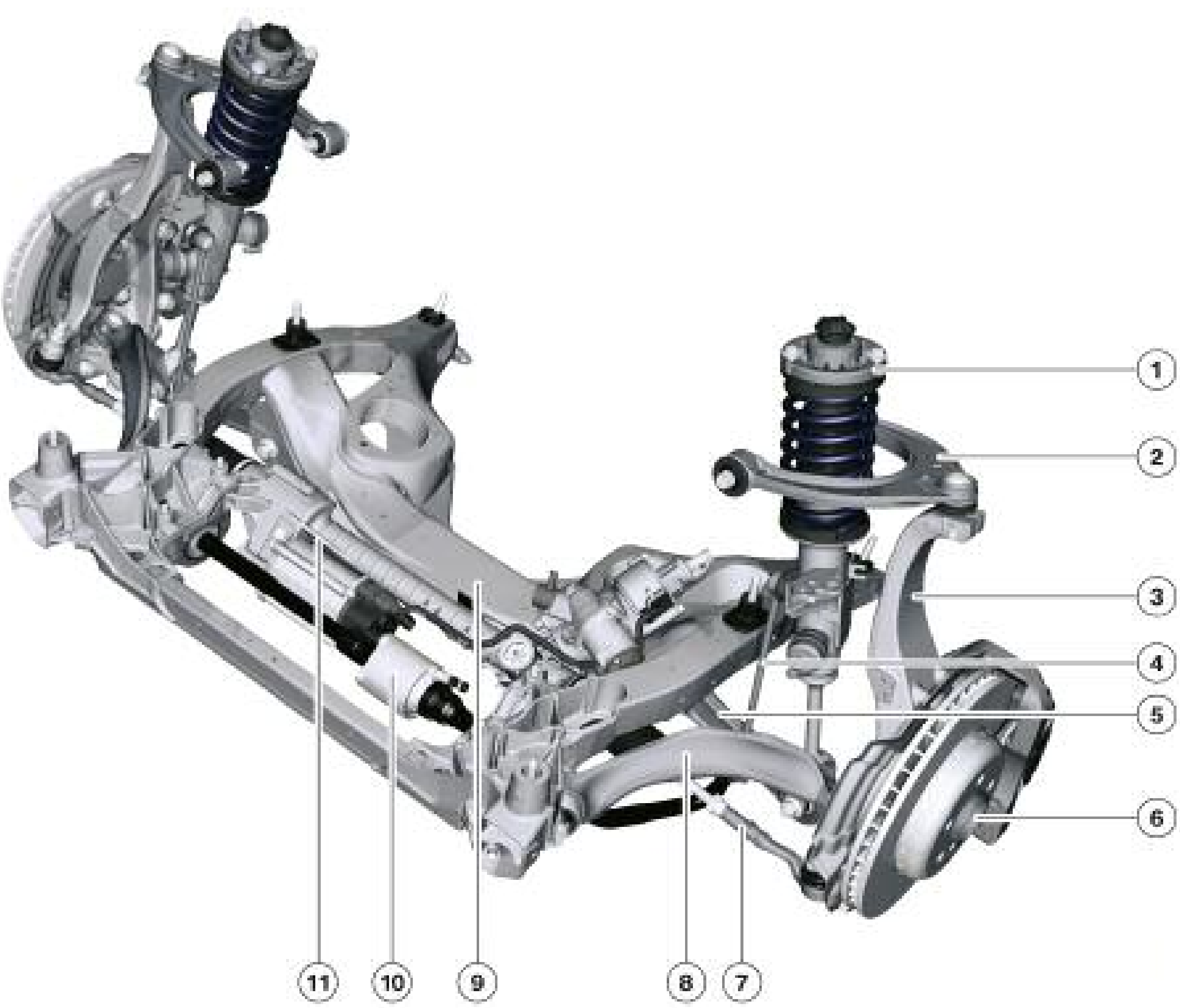
New CO2 Reduction Measures

As a CO2 reduction measure when driving in a straight line, the fluid flow rate of the radial piston pump is restricted by a restrictor valve on the intake side, thereby substantially reducing the circulation pressure and, therefore, the engine power used to drive the pump. As a result, active control of the intake restrictor valve makes a positive contribution to the CO2 equation. The Dynamic Drive and hydraulic power steering share a common fluid reservoir and fluid cooler.

ARS with EPS

Another CO2 reduction measure in most current BMW vehicles is the use of electronic power steering (EPS). Thus rear wheel drive versions of F1x vehicles starting with the launch of F10 (and including F12 and F13) use EPS in combination with the optional ARS system.

F10 Front Suspension with ARS Combined with Electronic Power Steering (EPS)



Index	Explanation	Index	Explanation
1	Spring strut	7	Tension strut with hydraulic mount
2	Upper wishbone	8	Track rod
3	Swivel bearing	9	Front axle subframe
4	Stabilizer link	10	Anti-roll bar with **ARS** hydraulic swivel motor
5	Lower wishbone	11	**EPS** steering rack
6	Wheel hub		

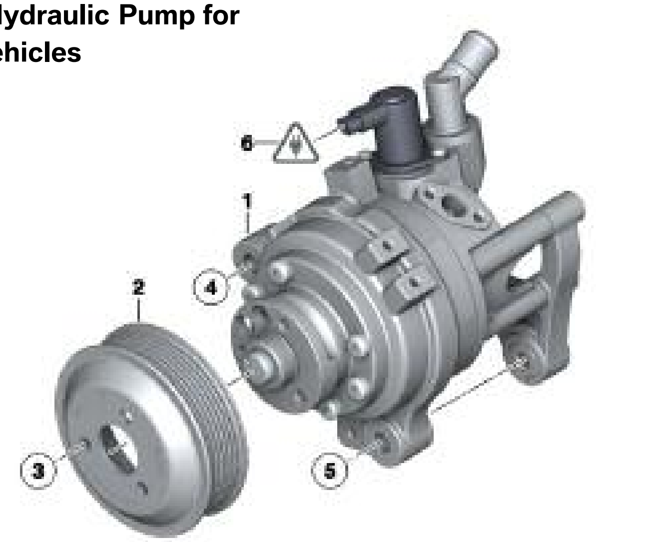
The system is available individually as Dynamic Handling (option). As is the also case with the EDC (VDC), the ARS function is calculated by the VDM control unit.

Due to the use of EPS there is no hydraulic **power steering pump** installed.

Instead an engine driven radial-piston type hydraulic pump is installed in its place to provide the necessary oil pressure to operate the front and rear (ARS) anti-roll hydraulic swivel motors.

In this case the ARS system has its own (dedicated) hydraulic reservoir filled with BMW power steering fluid.

Radial-piston Type Hydraulic Pump for ARS Used on EPS Vehicles



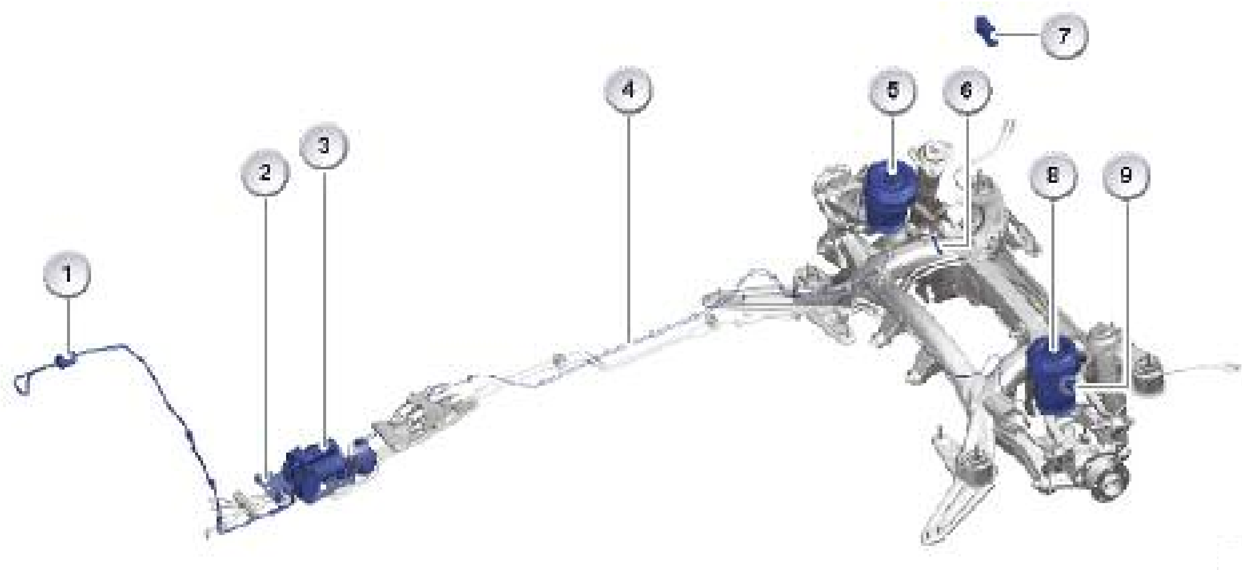
All current F10, F06, F12 and F13 xDrive models still use hydraulic power steering instead of EPS and thus have a tandem pump installed when equipped with the optional ARS system.

Electronic Height Control (EHC)

The self-leveling air suspension system (EHC I) was first introduced to the US market with the launch of the E39 sport wagon and later was available on the E53 X5 SAV. The single axle air suspension system later used on the E66 was a further enhancement of the E39 and X5 system.

As with the E53, the E70 X5 has an available single-axle air suspension system. The EHC system is available as standard or an option depending on the model and in combination with 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:

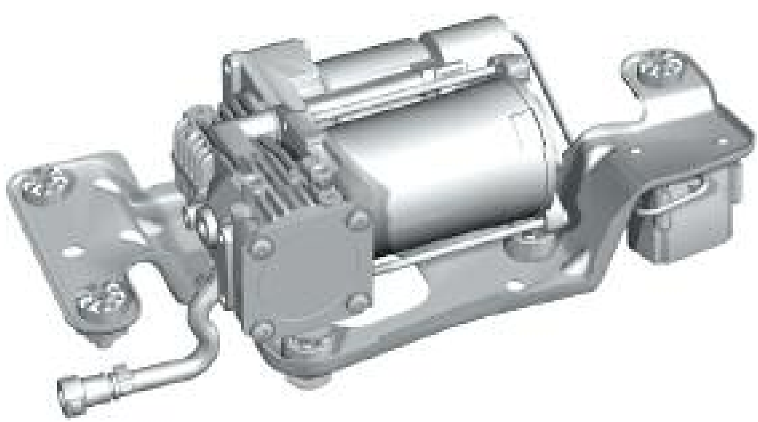
- Vehicle ride height
- Load cutout signals
- Terminal 15 ON/OFF
- Vehicle speed
- Lateral acceleration
- "Engine running" signal
- Hatch status.

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.



Electronic Ride Height Control (EHC)

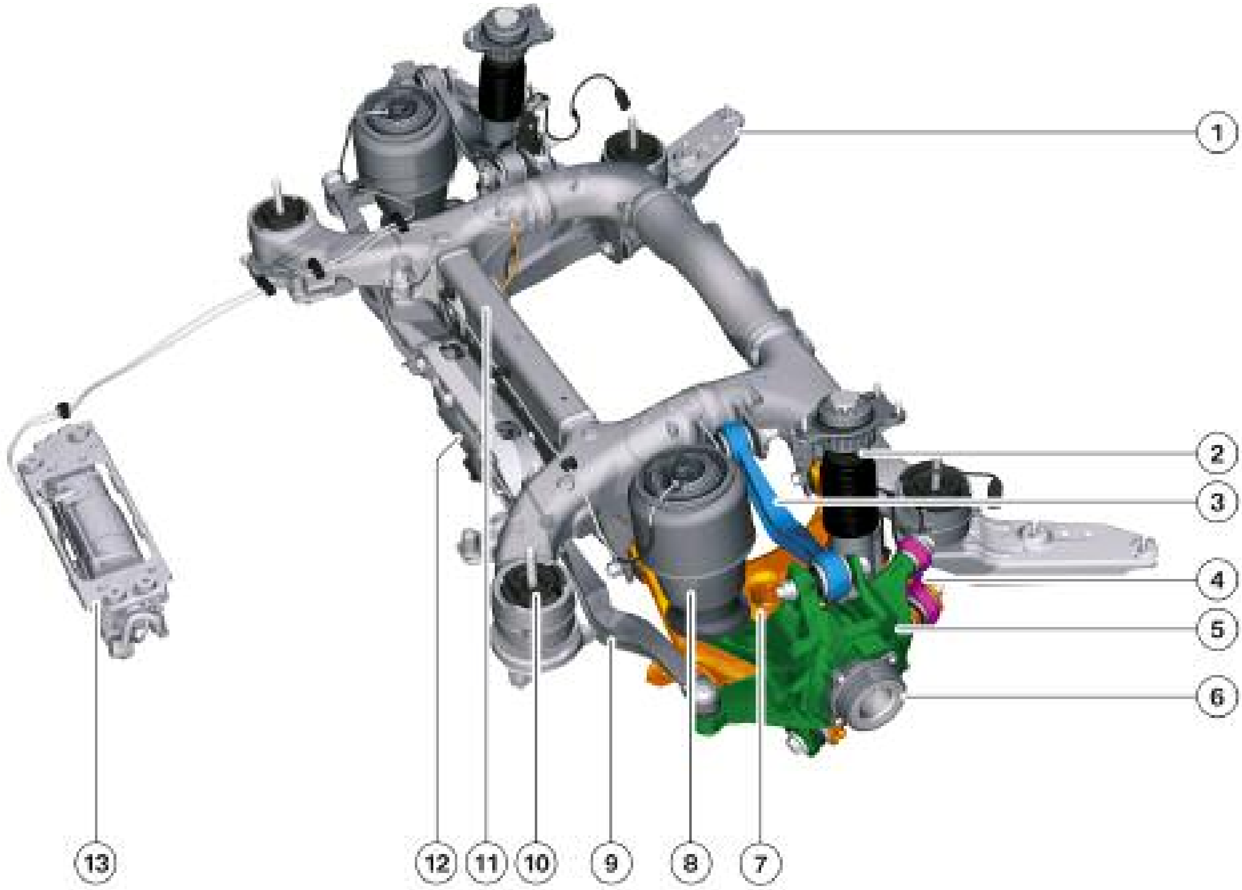
The EHC system of the F01 is based on the previous used “single-axle” air spring systems. And (as of the start of production) was only available as standard equipment on the F02. The same system is also standard equipment on the F07. EHC is not currently available on the F01, F06, F10, F12, F13.

The EHC system operates much the same as previous EHC systems. The control unit for the EHC system is located in the right rear luggage compartment area in the control module carrier near the rear power distribution box.

F02 with Electronic Ride Height Control

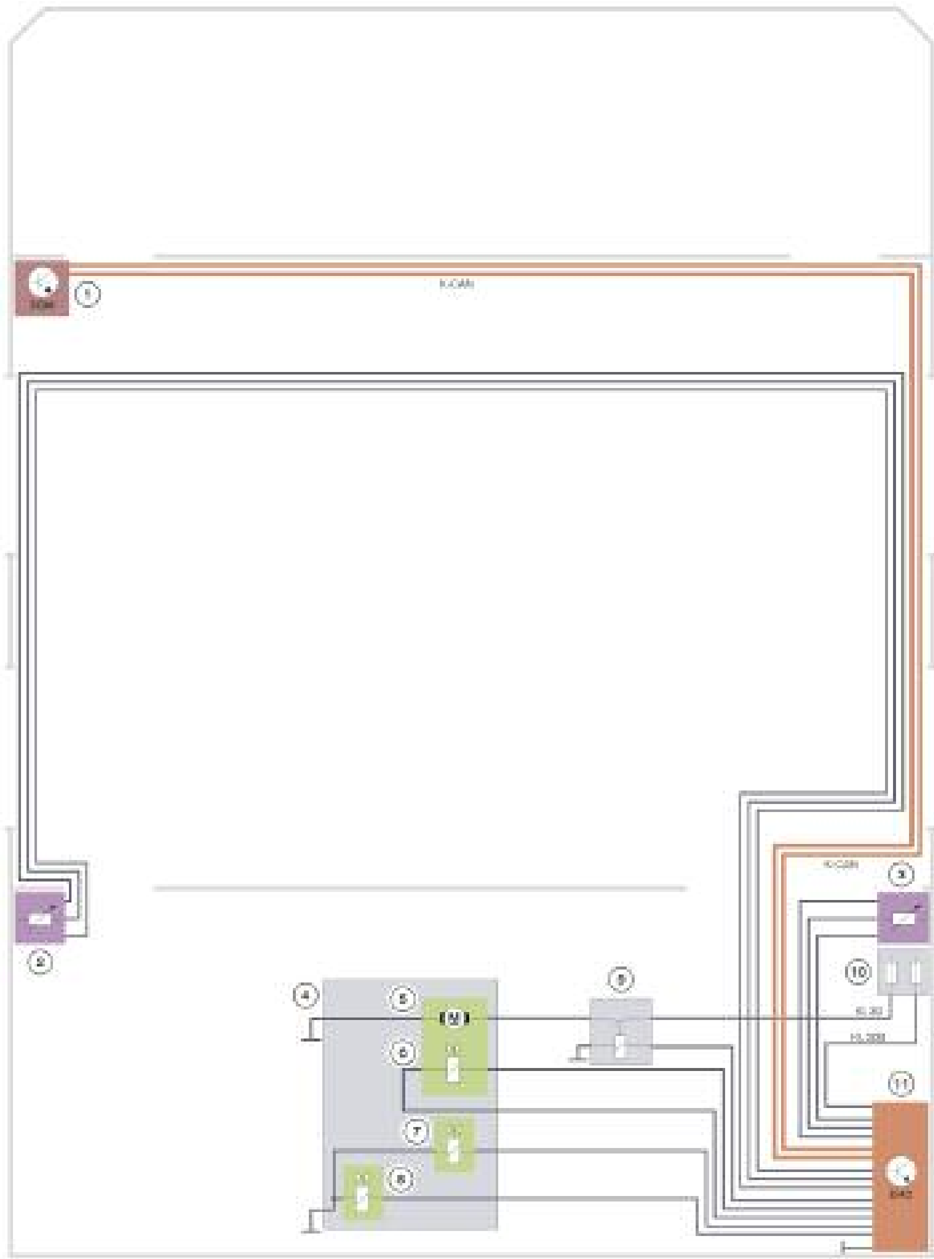
Index	Explanation	Index	Explanation
1	ZGM	6	Air supply relay
2	Ride height sensor, rear right	7	Air Supply Unit (LVA)
3	EDC_SHR	8	EDC_SHL
4	Rear power distribution box	9	Ride height sensor, rear left
5	EHC control module		

F07 Electronic Ride Height Control



Index	Explanation	Index	Explanation
1	Compression strut	8	Air spring
2	Shock absorber	9	Track link
3	Wishbone top	10	Rear axle support mount
4	Integral link	11	Rear axle support
5	Wheel carrier	12	Rear axle slip angle control actuator
6	Retaining Plate	13	Air supply system (LVA)
7	Swinging arm		

EHC Circuit Diagram



Index	Explanation	Index	Explanation
1	ZGM	7	Solenoid valve, right side
2	Ride height sensor, rear left	8	Air exhaust valve
3	Ride height sensor, rear right	9	Air supply relay
4	Air Supply Unit (LVA)	10	Rear power distribution box
5	Compressor unit	11	EHC control module
6	Solenoid valve, left side		