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E60 Chassis Dynamics

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Subject **Page**

Model: E60

Production: Start of Production MY 2004

Chassis Dynamics

Objectives:

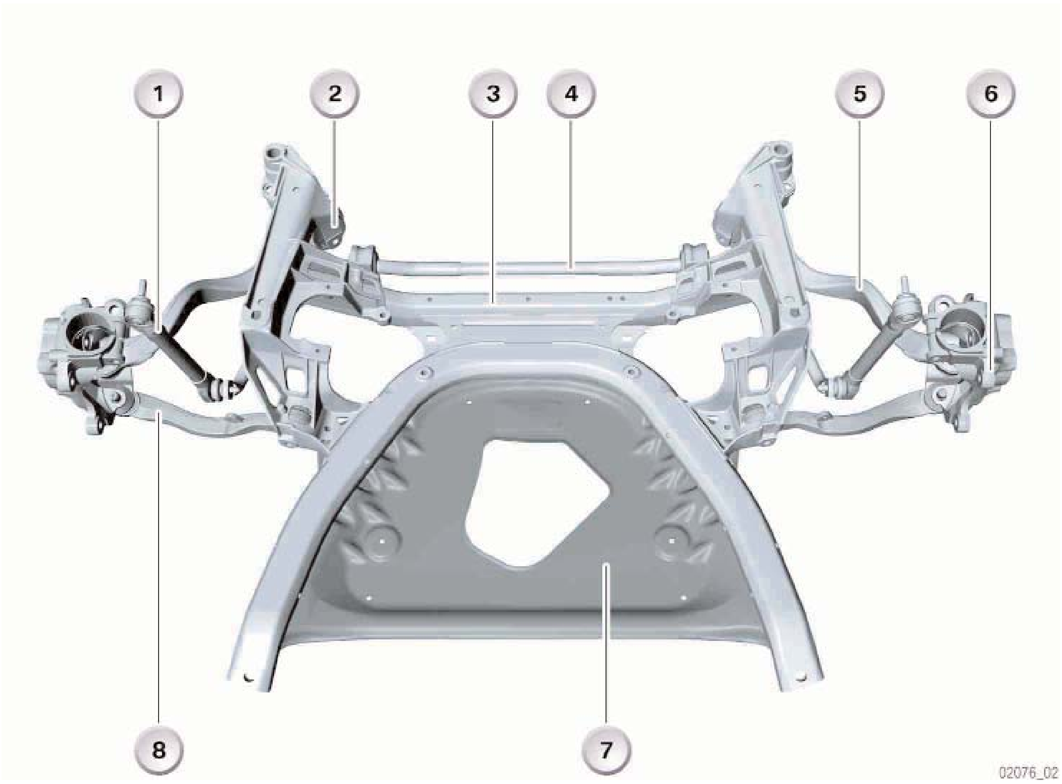
After completion of this module you will be able to:

- Understand E60 Front and Rear Suspension layout
- Understand operation of DSC 8
- Understand parking brake operation
- Understand RPA operation

E60 Chassis Dynamics

Front Axle

The double-joint spring strut axle with tension struts is essentially the same as the front axle of the E65. The complete front axle is made from aluminum. It has been possible to save on weight and space compared with the E39 thanks to the use of the reinforcement plate. The reinforcement plate ensures a high degree of transversal vehicle rigidity.



1. Stabilizer link
2. Hydro-mount
3. Front axle carrier
4. Stabilizer bar
5. Tension strut
6. Swivel bearing
7. Reinforcement plate
8. Control arm

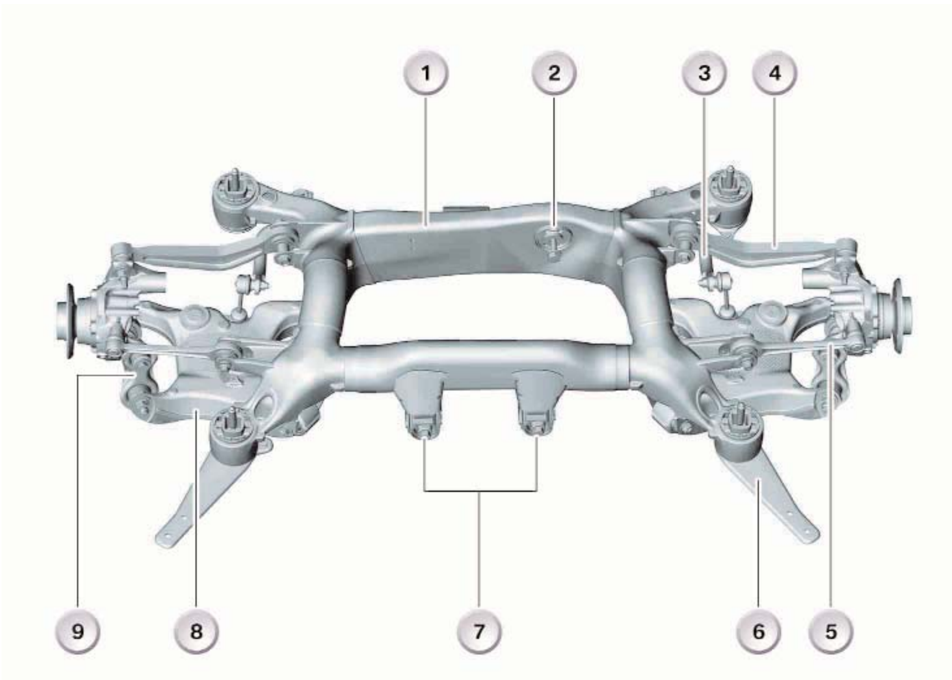
Axle alignment is performed at the tie rods. If necessary, the camber is corrected by removing the pin on the upper support bearing.

The car must not be driven without the reinforcement plate in place! The reinforcement plate ensures the transversal rigidity of the car and contributes in conjunction with the front axle carrier to the strength of the front axle.

Rear Axle

The rear axle carrier, the control arms and the swinging arms are made of aluminum. The concept is that of the Integral 4 rear axle. All the bearings used on the rear axle are rubber bearings. Tension struts serve to increase body rigidity.

The stabilizer bar is fitted behind the rear axle carrier. The ride level sensors have been moved forward.



1. Axle carrier
2. Rear axle differential bearing, rear
3. Stabilizer bar
4. Control arm
5. Traction strut
6. Thrust rod
7. Rear axle differential bearing, front
8. Swinging arm
9. Integral link

Technical Data for Alignment

Wheels	7x16; 7.5x17; 8x17; 8x18
Caster angle	7°51'
Caster offset (mm)	28
Camber	-0.2°
Total toe-in	10' +/- 8'
Toe difference angle	1.66° at 20° steer angle
Kingpin inclination	14°32'
Rim offset (mm)	20
Kingpin offset (mm)	+2
Track width (mm)	1558
Maximum steering angle inner	inner 43°22' outer 34°1'

Suspension and Damping

Spring struts with coil springs and twin-tube gas-pressure dampers are used on the front and rear axles. The sports suspension available as an option is 15 mm lower at the front and rear axles compared with the standard suspension. The sports suspension has been equipped with harder springs, sportier damper tuning and stiffer stabilizer bars.

Brakes

The E60 has a hydraulic dual-circuit brake system with "front/rear split". The electric precharging pump for the DSC function has been omitted. The 525i is fitted with conventional floating calipers on the front and rear axles. The 530i is fitted with floating calipers with frames on the front axle and conventional floating calipers on the rear axle. With the exception of the floating calipers on the 545i all caliper housing are made of aluminum.

The new lightweight brake rotors are used on the E60. The braking surface is made from grey cast iron, while the hubs are made from aluminum. The hubs are mated to the rotor using a series of rivets. The following configuration is used:

Model	Front Rotor (mm)	Rear Rotor (mm)
525i	310 X 24	320 X 20
530i	324 X 30	320 X 20
545i	348 X 30	345 X 24

All brake discs are coated with geomet. M12 studs are used to bolt the wheel.

Pedals

The pedal bracket is a glass-fibre-reinforced molded plastic part. The brake and clutch pedals are mounted on axle shafts, which are also made of glass-fibre-reinforced plastic. These axle shafts are secured by retaining lugs in the axial direction in the bracket.

Notes for Service:

Because it is not always possible to remove axle shafts without damaging them, they must not be reused once they have been removed.

Because the pedal bracket/brake pedal connection is particularly critical to safety, the brake pedal is not to be removed on its own. The entire component must be replaced instead.

Dynamic Stability Control DSC8

Dynamic Stability Control DSC8 manufactured by Bosch is used for the first time in the E60.

New system features:

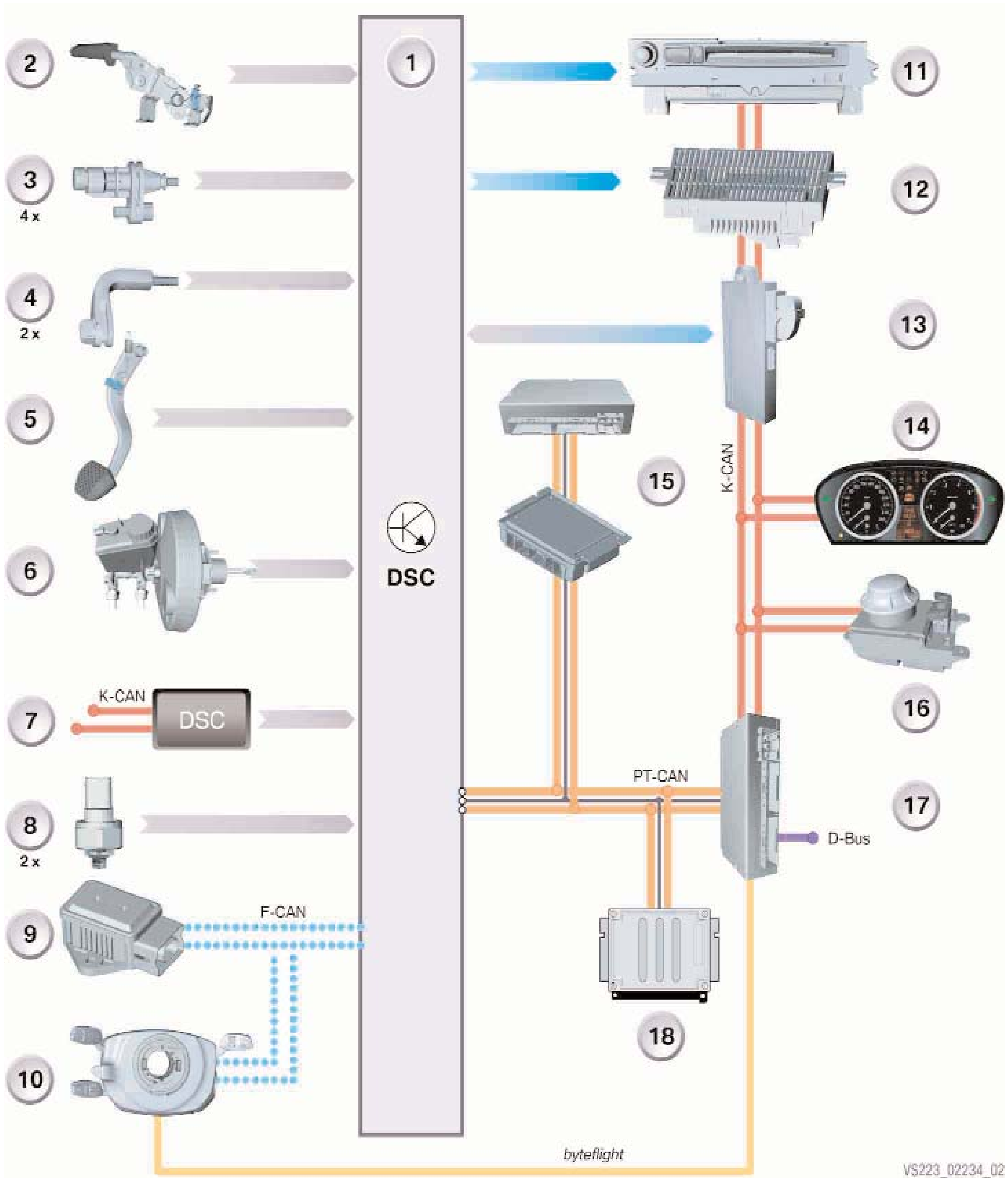
- The hardware component of DSC8 is a newly developed component.
- The electric precharging pump (eVLP) has now been omitted.
- The DSC module is connected to the Powertrain CAN (PT-CAN) and to the Chassis CAN (F-CAN).
- 2 new pressure sensors are incorporated in the brake lines in the ACC optional extra.

Advantages of System Over DSC5.7

DSC8 has the following advantages over DSC5.7:

- 25% lower structural volume
- 30% lighter (saving 700 g in the module, saving of 1.8 kg through omission of the electric precharging pump)
- Control-unit memory 768 kB ROM (previously 256 kB ROM)
- Processor computing cycle time 5 to 10 ms (previously 20 ms)

DSC System Overview

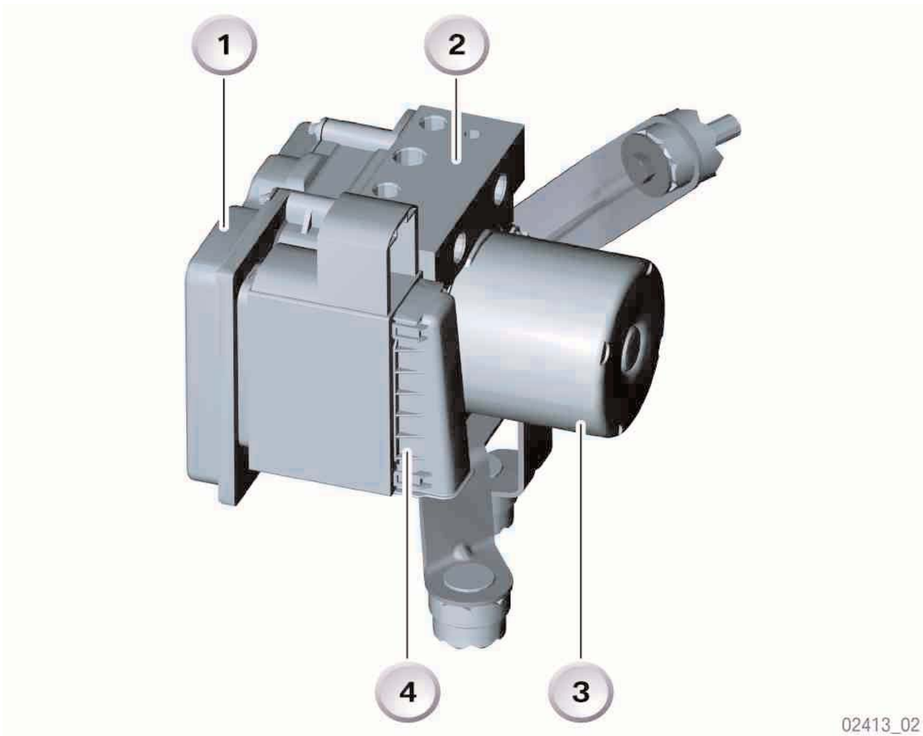


1. DSC Module
2. Parking brake input
3. Wheel speed sensor
4. Brake pad wear sensors
5. Brake light switch
6. Brake fluid level switch
7. DSC Switch
8. Brake pressure sensor
9. DSC sensor
10. Steering angle sensor (SZL)
11. M-ASK
12. Light switch module
13. Car access system
14. Instrument cluster
15. EGS or SMG
16. Controller
17. Safety and Gateway module (SGM)
18. DME

Components

DSC Module

The DSC module is located on the right side of the engine compartment between the coolant expansion tank and the cooling module.



1. DSC control unit
2. Valve block
3. Electric motor/pump
4. Plug connector

In a DSC control operation, the braking pressure is built up with the aid of an electric motor. A pressure sensor integrated in the valve block senses the braking pressure established when the driver applies the brake.

Brake Pressure Sensors

If the car is equipped with ACC, the left front-axle and rear-axle brake lines each incorporate a brake pressure sensor.

The brake pressure sensor for the front-axle brake circuit is located on the front right wheel arch.

The brake pressure sensor for the rear-axle brake circuit is located on the left side of the engine compartment at the rear.

System Functions

DSC calculates the current driving status using sensor signals. DSC corrects identified instances of driving instability through active brake interventions. For example, in the event of vehicle oversteering, a stabilizing torque is effected by means of brake intervention at the outer cornering front wheel which counteracts the unstable torque. In the event of vehicle understeering, active interventions at the inner cornering wheels provide a stabilizing counter-torque.

Drive stabilization by DSC is performed in all driving situations, i.e. free rolling, accelerating and (ABS) braking.

The system comprises the following functions:

- ABS Anti-lock Braking System
- ASC Automatic Stability Control
- MSR Engine drag-torque control
- DSC Dynamic Stability Control
- DBC Dynamic Brake Control
- CBC Cornering Brake Control
- ECD Electronically Controlled Deceleration (with ACC only)
- EBV Electronic brake-force distribution
- FLR Driving-performance reduction
- DTC Dynamic Traction Control
- BTM Brake Temperature Model
- RPA Tyre defect indicator
- BBV Brake-pad wear indication

Anti-Lock Braking System (ABS)

ABS distinguishes between a full system and a fallback level.

Full ABS System:

- Full ABS system with intact system: The vehicle controller achieves through active braking-pressure increase at the individual wheels a stabilizing effect beyond the driver's choice.
- The formation of the speed reference is supported, in addition to the information of all the wheel speeds, by the information of the yaw rate and the steering angle.
- Especially in speed ranges < 60 km/h it is possible through individual control that meets requirements (control in relation to the wheel with the greater slip) to achieve shortening of the braking distance for different friction coefficients.

ABS Fallback Level:

- In the event of a drop-out of the yaw-rate, lateral-acceleration or steering-angle signal or a CAN fault, ABS adopts the so-called fallback level. In this case, the vehicle speed is only determined by way of the wheel-speed sensors.

Differences from the Full System:

- No supporting active interventions on brake application.
- On account of the lack of information from the additional sensors, there is a con vergence with the Select Low control at the rear axle for the purpose of increasing stability.
- No ASC function.
- No MSR function.

Automatic Stability Control (ASC)

ASC prevents wheelspin during acceleration on all types of road surface.

Control is effected at a control threshold stored in the control unit. Brake interventions are performed as well as intervention in engine management for the purpose of reducing the tractive force.

The ASC function can be deactivated by pressing the DSC button for a longer period (3 s).

Engine Drag-Torque Control (MSR)

The MSR function prevents the rear of the vehicle from swerving in the event of sudden throttle closure or unadapted downshifting to a lower gear by lessening heavy load changes through brief engine-torque increases.

The MSR function is only activated from a driving speed of 15 km/h.

Dynamic Stability Control (DSC)

The control unit uses the vehicle speed, steering angle and lateral acceleration signals to calculate the setpoint yaw angle of the vehicle while cornering. The DSC sensor supplies the actual value. A comparison is made in the control unit between the calculated yaw value and the actual yaw value. A DSC control operation is performed if a deviation is detected which is above the control threshold stored in the control unit.

A DSC control operation is performed depending on whether the vehicle is oversteering or understeering. The control operation consists of an intervention in engine management in order to reduce the tractive forces. Braking pressures are built up at the wheels which serve to stabilize the vehicle again.

The DSC function can be deactivated by means of the DSC button.

Dynamic Brake Control (DBC)

The DBC (Dynamic Brake Control) function is divided into 3 subfunctions:

- Dynamic Brake Support (DBS)
- Maximum Brake Support (MBS)
- Fading Brake Support (FBS)

Dynamic Brake Support (DBS):

DBS assists the driver in emergency-braking situations.

The DBS function is triggered by a sufficiently quick actuation of the brake pedal (6 bar per 1/1000 s). The braking pressure generated by the driver is increased by the hydraulic system to such an extent that the front and rear axle go into ABS control mode. The driver can thus achieve full deceleration with low pedal force.

Maximum Brake Support (MBS):

MBS assists the driver in normal, non-emergency braking situations. When the ABS control range is reached at the front axle, MBS increases the pressure at the rear axle until the ABS control limit is reached here as well. Optimum braking deceleration is thus achieved here as well as normally the driver stops pressing the brake in this situation.

Fading Brake Support (FBS):

If the driver is unable to make use himself of full vehicle deceleration on account of poor brake-pad friction coefficients, e.g. due to high thermal loads, he is supported by the FBS function. The requirement is a high braking pressure with a simultaneously low vehicle deceleration and high brake-disc temperature.

The FBS function compensates for the brake-force loss through an increase in temperature.

The diminishing braking effect when brakes are hot requires the driver to press the brake pedal more firmly. This increase in pressure is now assumed by an activation of the hydraulic pump.

The brake-disc temperature is not measured but rather calculated by means of the following input variables:

- Wheel speed
- Individual wheel brake pressure
- Ambient temperature
- Number of brake applications over time

Cornering Brake Control (CBC)

CBC is a subfunction of DSC.

The CBC function is activated at medium to high lateral acceleration.

If a vehicle goes into a curve as it is being braked and threatens to oversteer, an increase in stability is achieved through partial release of the inner cornering rear-wheel brake.

In the case of braking on bends, the pressure in the rear-axle wheelbrake cylinders is individually controlled. Essentially this prevents the vehicle from oversteering.

When decelerating on bends, CBC ensures the best possible directional stability by means of optimum brake-force distribution.

CBC:

- performs its control function ahead of ABS or DSC
- also functions when DSC is deactivated
- is deactivated only in the event of an ABS failure

Electronically Controlled Deceleration (ECD)

ECD responds to the requests of the ACC (Active Cruise Control) signals.

DSC executes braking retardation when deceleration is requested by ACC.

This is performed by way of an automatic brake intervention at the four disc brakes, dependent on the vehicle speed, the distance and the speed of the vehicle travelling in front, with max. 3 m/s2 deceleration.

On downhill gradients at a preselected driving speed, ECD maintains the driving speed continuously at the preset value by way of automatic brake intervention.

The new brake pressure sensors can guarantee more uniform braking at the front and rear axles. This allows longer activation without compromising on comfort or overheating of the brakes on one axle.

In the case of automatic braking, the brake lights are activated in line with legal requirements.

Only from a deceleration > 1 m/s2 will a brake-light activation be performed by the light module (LM). This prevents the brake lights from coming on frequently and for brief periods.

Electronic Brake-Force Distribution (EBV)

Electronic brake-force distribution prevents overbraking of the rear axle when the system is intact (rear-axle influencing function, HAB) and in the event of an ABS failure (EBV emergency operation). The HAB function prevents the rear wheels from going into ABS control mode before the front wheels when the vehicle is braked both in straight ahead driving and with sufficiently high deceleration and also when cornering. This ensures a high level of vehicle stability.

The EBV emergency operation function prevents overbraking in the event of ABS failure under the following combinations:

- Effective until the failure of 2 wheel-speed sensors. The failure can occur in any order.
- Effective with intact pump-motor activation (pressure-holding function or pressure decrease meeting requirements at the rear axle).
- Effective even if the admission-pressure sensor fails.

In the event of system malfunctions or additional sensor faults, the driver is alerted by the red brake warning lamp in the instrument cluster.

Driving-Performance Reduction (FLR)

The FLR function protects the brakes against overloading in the event of misuse.

If a temperature in excess of 600 ºC is determined, the engine power is reduced to a defined value (dependent on the type of vehicle) in order to limit the vehicle's accelerating performance. When the temperature drops below a lower limit (typically 500 ºC), the reduced engine torque is increased as a function of time on a ramp basis to the maximum torque again. Driving-performance reduction should only be active from a speed of 60 km/h.

This reduction of the engine torque is stored as a fault (driving performance reduction active). Should the customer find fault with the lack of engine power, this can be established by the garage/workshop and explained as brake overloading.

Dynamic Traction Control (DTC)

The DTC function can be activated by means of the DSC button. The active DTC function increases the ASC slip thresholds for improving propulsion up to a speed of 70 km/h. Basically the permissible slip is doubled but there is a program map in the background. This function offers advantages when driving on poor roads and thick fresh snow.

Driving is not safety- but rather traction-orientated. With increasing transversal dynamics, measured by the yaw-rate sensor, the slip thresholds are reduced back to the normal mode for stability reasons.

When the DTC traction mode is activated, the letters DTC are displayed in the cluster.

Brake Temperature Model (BTM)

The BTM function determines by way of a calculation model integrated on a software basis in the DSC control unit the temperatures of all four brake discs as a function of the input variables:

- Wheel speed
- Individual wheel brake pressure
- Ambient temperature

If the critical brake-disc temperature is exceeded (t > 600 ºC) at a wheel, DSC functions are limited as a function of the prevailing driving conditions:

- Locking interventions are reduced to zero for each individual wheel.
- Symmetrical braking torques on the corresponding axle are prohibited.
- The engine torque is limited temporarily via an algorithm for driving performance reduction.

The restrictions are lifted again when the temperature drops below a further threshold (t < 500 ºC).

Tire Defect Indicator (RPA)

The RPA function is integrated in the DSC control unit. The system uses the wheel speeds to compare the deviations in the rolling circumferences of the wheels.

In the event of the same pressure loss in a diagonal tire pair, the wheel speeds change to the same extent and the pressure loss is not detected.

The RPA system does not monitor the uniform diffusion loss over all 4 tires.

Customers must monitor tyre inflation pressures themselves on a regular basis.

Brake-Pad Wear Indication (BBV)

The evaluation of the 2-stage brake-pad wear sensors is integrated in the DSC control unit.

Operation

The DTC and DSC functions can be activated and deactivated by means of the DSC button in the centre-console switch centre (SZM). Briefly pressing the button activates the DTC function. Press the button for a longer period (approx. 3 s) deactivates the DSC function. The ABS function remains active however. The activated DTC function and the deactivated DSC function are indicated by means of warning and telltale lamps in the instrument cluster.

If the DSC button is pressed for longer than 10 s, the DSC function is activated and cannot be deactivated until the next ignition ON. This is a safety function for such a scenario where an object placed on the centre console (e.g. a handbag) presses down on the DSC button.

Notes for Service

Service Information

An open circuit to the rotation-rate sensor is not detected.

After the battery has been disconnected, the steering-angle sensor must re-learn its offset. The steering angle is only learned by the DSC control unit when the vehicle is driven off. If the DSC control unit does not receive the steering-angle offset before the vehicle reaches 25 km/h, the DSC telltale in the instrument cluster lights up.

A different DSC control unit is used in vehicles equipped with active steering. The control units for vehicles with active steering and without active steering differ in the matching resistors they use.

Diagnosis

Diagnosis is performed by means of the PT-CAN.

Programming

Flash programming of the control unit is possible by means of the PT-CAN.

Coding

The DSC control unit detects automatically whether the relevant vehicle is fitted with ACC, Dynamic Drive or Active Front Steering.

The RPA function must be coded.

Tire Defect Indicator (RPA)

The RPA function is integrated in the DSC control unit. The system compares by way of the wheel speeds the tire-tread circumferences of the 4 wheels.

The RPA system does not monitor the uniform diffusion loss over all 4 tires. If the same pressure loss occurs in the 4 tires, the wheel speeds change to the same extent and the pressure loss is not detected. The customers must regularly monitor inflation pressures themselves.

The system must be re-initialized when tire inflation pressures are changed or when the tires are changed. The RPA is initialized by means of the controller at terminal 15 ON. The system switches to the "Learning phase" status. This status is shown in a status line in the Central Information Display (CID). After a brief driving time, the system learns the new wheel speeds as reference values.

For the RPA there are 2 variable warning lamps with 2 associated Check Control messages (CC messages) which are displayed in the instrument cluster:

- "Tire puncture!" signals a loss of pressure of more than 30% in a tire. This is accompanied by a gong sound.
- "Run Flat Indicator failure!" signals that the system is inactive due to a fault and can not detect any tire failures.

Explanatory notes pertaining to the relevant CC messages appear in the CID.

Variable warning lamp	Notes in CID
 Red	Stop vehicle carefully and change wheel, see owners handbook. Safety tires: Possible to continue at max speed of 80km/h (50 mph). Distance limit, see Owners Handbook. Have the problem checked at the nearest BMW service.
 Yellow	Tire punctures are not identified. Have fault checked by BMW service as soon as possible.

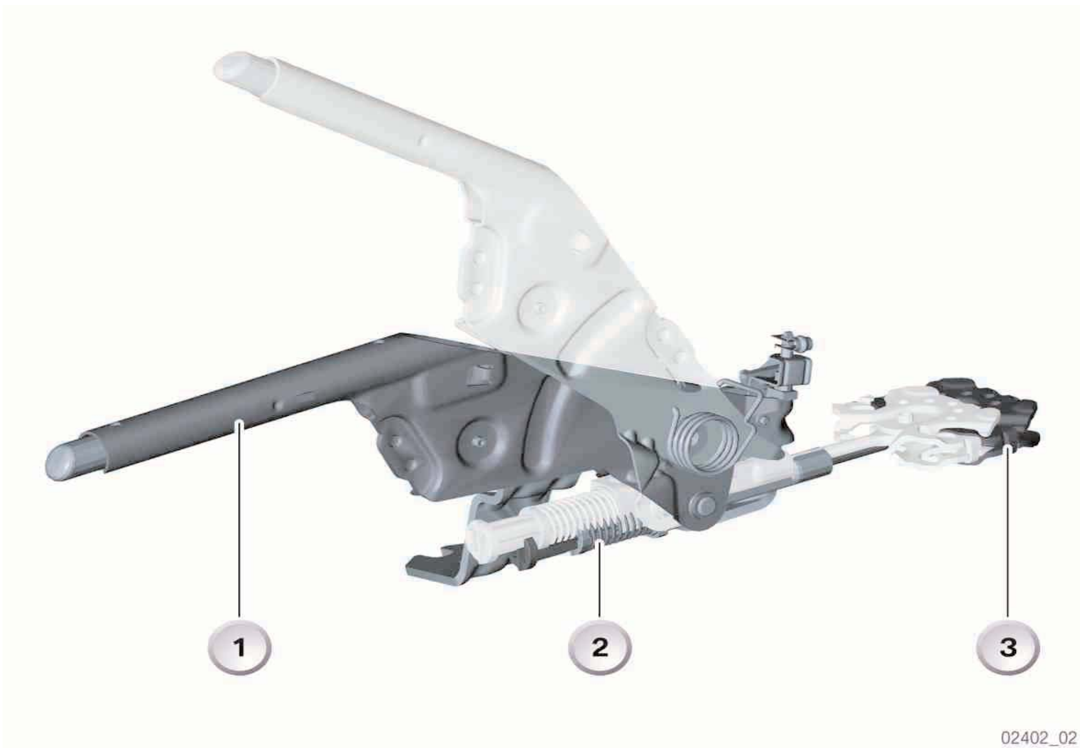
The RPA submenu in the CID also features a status line which indicates the current RPA status.

- "Learning phase," i.e. the system is standardized. The learning phase is indicated until RPA is ready for operation the first time after the start of standardization.
- "Inactive" because there is a fault in the system and thus no tire failure can be detected.
- "Active" when the system can detect a tire failure.

Parking Brake

The parking brake is actuated by means of a conventional handbrake lever. The handbrake lever is located on the centre console and bolted to the floor pan.

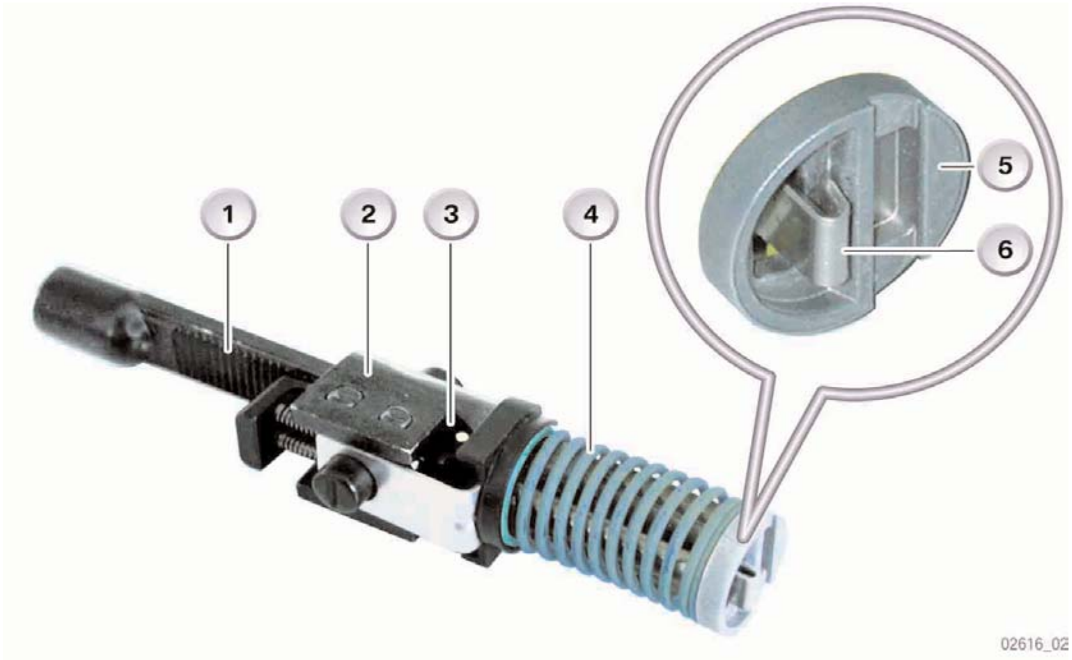
The parking brake is equipped with an automatic cable adjuster (ASZE) and a compensating element.



1. Parking-brake lever
2. Automatic cable adjuster
3. Compensating element with mounting clip

The mounting clip locks the cables in the compensating element. The duo-servo brakes correspond to the duo-servo brakes of the E65 (dia. 185 x 30 mm).

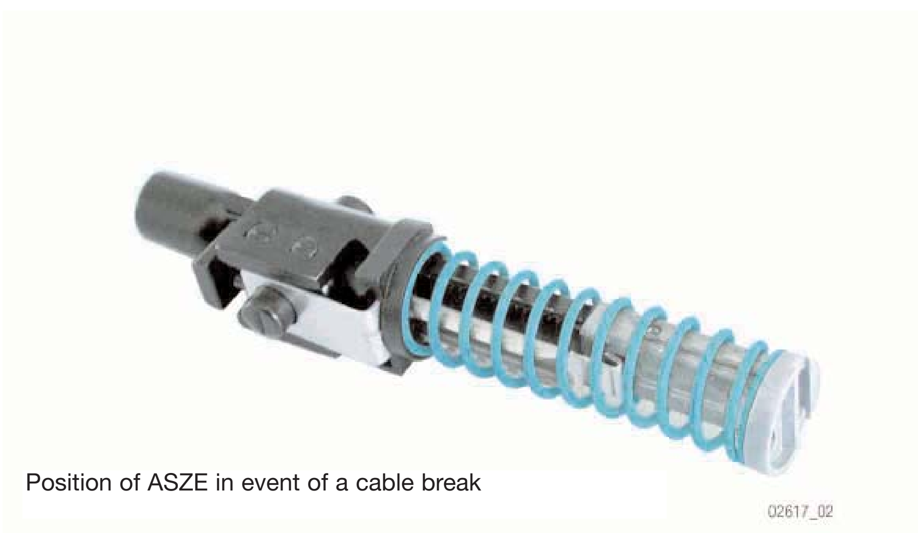
The function of the ASZE is to adjust the handbrake cables and compensate longitudinal variations and settling. It does not however adjust the wear on the duo-servo brake. This must, as before, be adjusted at the expander lock in the brake. The function of the compensating element is to distribute the actuating force uniformly to both handbrake cables.



1. Rack
2. ASZE housing
3. Clamping jaw
4. Tensioning spring
5. Locking clip
6. Locking hook

Notes for Service:

If there is a cable break, the automatic cable adjuster is in the most untensioned position.



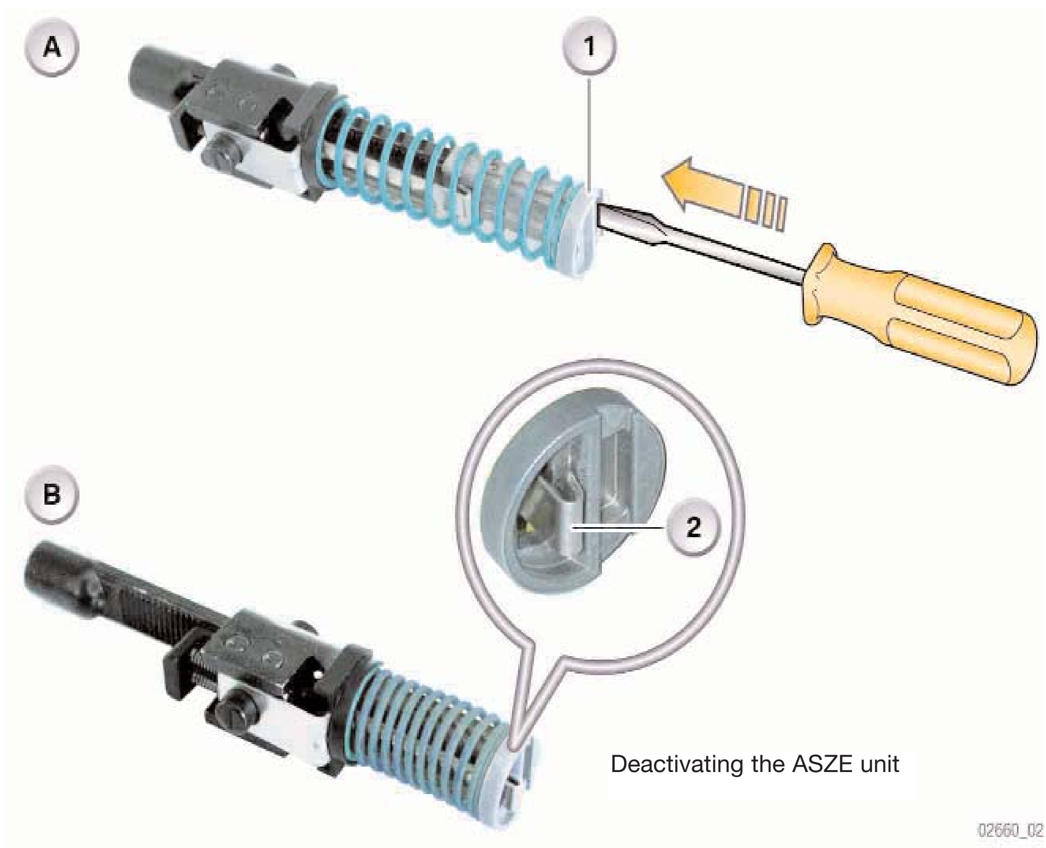
Position of ASZE in event of a cable break

Removing the cables:

- To replace the cables, it is necessary to remove the centre console and the rear-compartment ventilation ducts.
- For the cables to be removed, the parking-brake lever must be in the released position.
- For the cables or the duo-servo brakes to be changed, the ASZE unit must be deactivated.

Deactivating the ASZE unit:

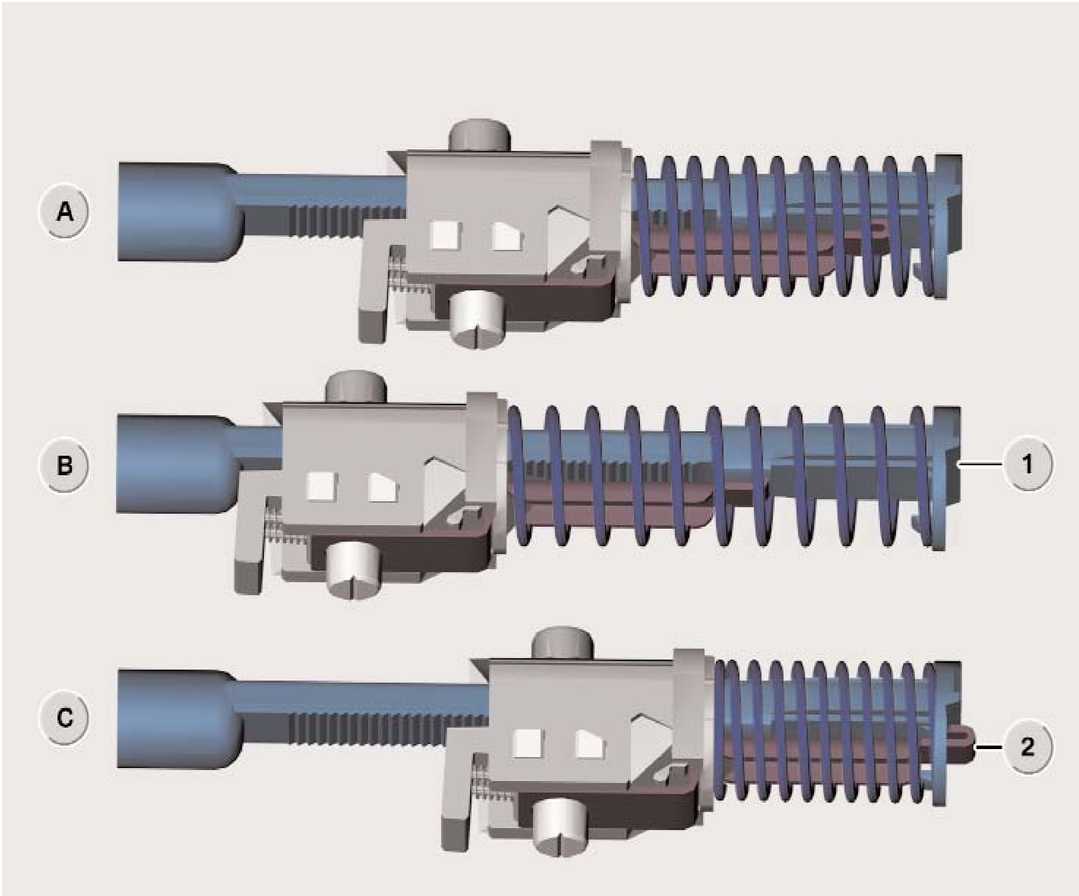
A screwdriver must be used to press back the locking clip of the tensioning spring until the locking hook engages the locking clip of the tensioning spring.



1. Locking clip
A. Cable break position

2. Locking hook
B. Assembly position

The cables can now be disconnected from the duo-servo brakes. To be able to disconnect the cables, it is necessary to remove the mounting clip.



A. Operating position
B. Position in case of a cable break
C. Assembly position

1. Locking clip
2. Locking hook

Installing the cables:

- For the cables to be installed, the parking-brake lever must be in the "released" position. The cables do not automatically feed themselves into the compensating element on insertion but rather must be guided with a screwdriver into the correct position.
- To secure the cables in the compensating element, it is necessary to attach the mounting clip.
- The cables are connected to the duo-servo brakes.
- The ASZE can be reactivated by levering the locking hook out of the locking clip.

Adjusting the duo-servo brakes:

The basic clearance of the duo-servo brake is adjusted at the adjusting screw of the duo-servo brake shoes. The parking brake is automatically adjusted when the ASZE unit is activated.