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Subject **Page**

SUSPENSION and STEERING

Model: E65 - 745i

Production Date: 11/2001

Objectives of The Module

After Completing this module, you will be able to:

- Identify the correct installation of the twin tube gas pressurized shock absorbers.
- Describe the alignment adjustments that can be performed.
- Understand the correct installation procedure for the “quick couplings” on the steering gear.
- Explain the Crash Element function.
- Locate the steering angle sensor.
- List the functions controlled by the CIM module.
- Install the wheel weights in the correct position.
- List the correct wheel bolt torque value.

Suspension and Steering

Purpose of The System

The E65 front suspension uses the double pivot spring strut axle design with tension rods (based on the E39 528i). The multi-link rear suspension with the integral axle is also used in the E65 to allow each wheel to move and flex individually without transmitting loads and forces through the sub-frame to the other wheel.

The suspension is equipped with coil springs on the front and rear (standard equipment) providing the best comfort possible.This suspension systems keep the vehicle level during hard acceleration, braking and cornering.

One of the factors that influenced the E65 suspension design was weight reduction. This results in improved fuel economy and handling characteristics (reduction of unsprung weight). The front and rear axle carriers, front and rear control arms, tension rods and front hub carrier assemblies are all made from aluminum. The weight is reduced by approximately 30% as compared to using steel components.

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System Components

Front Axle: The traditional double pivot spring strut axle with tension rods is used. The double pivot refers to the lower mounting of the strut and hub carrier around which the wheel turns. The lower control arm and the tension rod form the two lower physical pivot points. The lower pivot point is actually an imaginary point formed by the extension of the control arm and tension rod.

This suspension system is preferred because of these excellent features:

- Constant tracking over the entire compression and extension travel of the suspension.
- Camber change (reaction) during compression.
- Straight-ahead driving with 0 mm kingpin offset (also reduces steering effort) even though wide tires are used.
- Anti-dive control (during braking).
- Fewer components (weight savings).

The double pivot front axle of the is bolted to the body sub-frame.

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Front Axle Carrier: The materials used in the front axle carrier offer high tensile strength to support extreme loads. The front axle carrier is also manufactured from aluminum. It consists of cast alloy preformed sections which are welded into the extruded sections.

The front axle carrier accommodates the steering gear, control arms and tension struts, engine mounts, stabilizer bar, heat shield and the underbody panels.

An “thrust zone” panel is bolted on to increase the transverse rigidity of the front of the vehicle. This reinforcement has a positive effect on the handling, sound level and crash performance.

1. Thrust zone
2. Control arm
3. Tension rod
4. Hub carrier
5. Wheel bearing
6. Axle Carrier

42-06-03

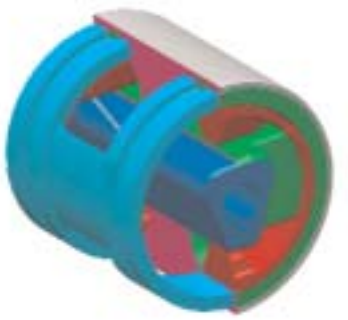
Front Axle Carrier

The benefits as a result of the improved front axle include increased agility, improved comfort by the reduction of unsprung weight, a reduction in fuel consumption by lowering the gross vehicle weight and better axle load distribution.

Control Arms: The control arm locations are similar to the E39 528i with a single control arm and tension rod per side. The layout of the arms combined with the tensioning rods located in front of the wheel center provides balanced steering during cornering.

The hydro mounts in the front of the tension rods contain hydraulic fluid in internal channeling to dampen wheel vibrations.

Small vibrations are cushioned by these mounts and isolated from the steering wheel.



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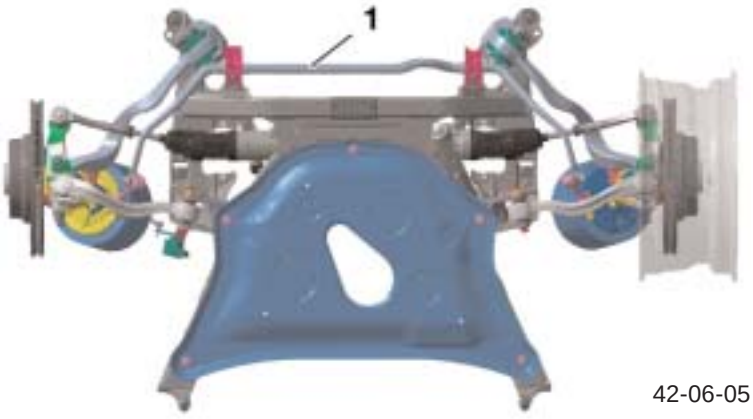
Stabilizer Bar: The standard stabilizer bar (1) is designed as a tubular stabilizer bar, which minimizes body “roll” during cornering. It is connected to the spring struts by links (rods) to provide the best performance leverage.

The connection on the spring strut is high mounted so that when driving straight ahead and hitting a bump on one side, the spring strut will not be turned (bump steer).

The active roll stabilizer bar (ARS) will be covered in Dynamic Drive.



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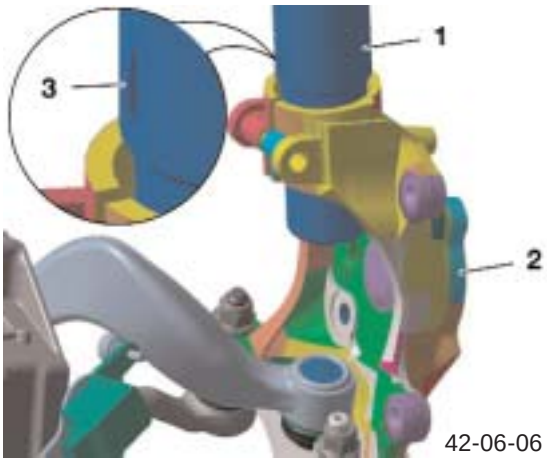
View from Bottom

Spring Strut, Hub Carrier and Wheel Bearing: The twin tube gas pressurized shock absorbers and the hub carrier are bolted together. The tube is made of aluminum and has a locating tab on the side which is used to align it into the hub carrier in the correct position.

The tube and hub carrier are produced in left and right versions and are identified by a label. The wheel bearing assembly is bolted onto the hub carrier.

1. Support tube
2. Hub carrier
3. Locating tab



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Spring Strut, Hub Carrier, and Wheel Bearing

Upper Mount: The upper mount contains the spring strut support bearing and a centering pin (1) inserted to retain the factory preset camber.

The centering pin can be removed for minor camber adjustments (+/-18’) provided by slots in the strut tower under the upper mount securing nuts .

The cable shown in the diagram is the connection for the EDC-K which will be covered in Dynamic Drive.

42-06-07

Technical Data

The following shows the alignment data in relation to the wheel sizes.

Wheels	**8 J x 18**
Caster angle (20º wheel lock)	**7º 56' ±30'**
Caster offset (mm)	**30’**
Camber	**-6' ±25'**
Total toe	**0º 10' ±8'**
Track differential angle (20º lock - inside wheel)	**-1º 27' ±30'**
Rim offset (mm)	**24**
Track (mm)	**1578**

Workshop Hints

Refer to the Repair Instructions for the following adjustments.

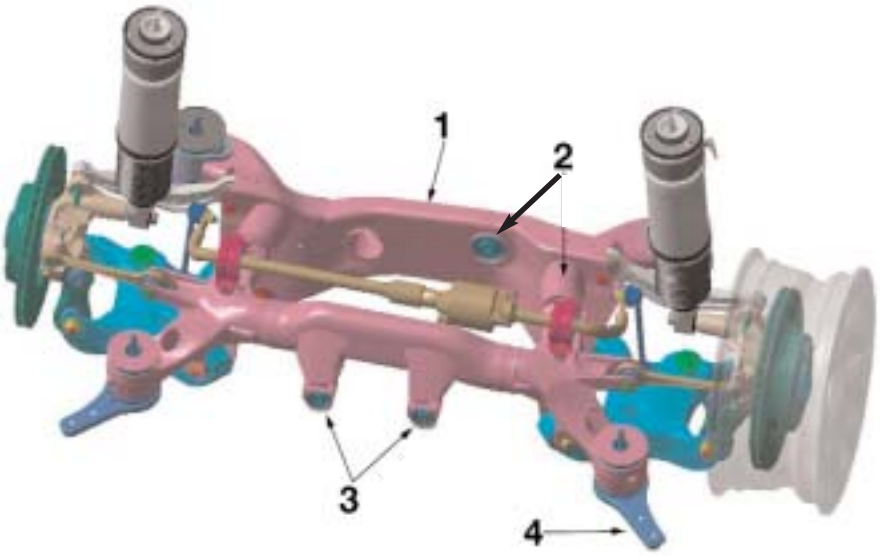
Toe Setting: The toe is set by loosening the external securing nuts and turning the inner track rods (left and right). Consult TIS for proper tightening torque on the securing nuts.

Camber Setting: The camber is set on the spring-strut support bearing. If it is necessary to adjust this in the workshop, the centering pin is removed and the camber correction is provided using the slots in the strut tower (adjustments of ±30' are possible).

Notes:

Rear Axle: The rear axle is designed with kinematics, aerodynamic features and also houses the differential. This suspension system incorporates anti-dive (when braking) and anti-squat (when accelerating) geometry which keeps the vehicle level.

Kinematics relates to the suspension system design type. The term implies flex, which in fact the system does. Under load (acceleration, turning, braking), the suspension changes its geometry to counteract changes induced by the increased loads. The suspension changes are pre-determined and built into the system.



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Rear Axle

1. Rear cross member
2. Differential mounting, rear
3. Differential mounting, front
4. Thrust plate

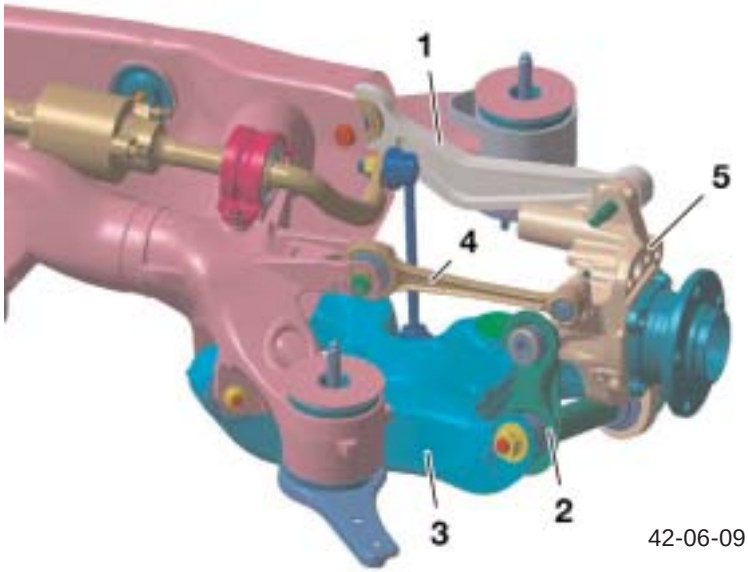
Rear Axle Carrier: The rear axle carrier is a welded structure made of formed aluminum sections and cast aluminum joints. The differential is mounted in the rear axle carrier, with two mount points at the front and one at the rear.

This offers advantages regarding sound and vibration characteristics. The rear rubber mount features kidney-shaped recesses allowing for vibrations in horizontal or vertical direction.

Note: The differential mounts must be installed in the correct position (direction indicated). Refer to the Repair Instructions for correct removal and installation.

Control Arms and Links: The control arms and links are aluminum and are geometrically adapted to the E65.

When the rear suspension is in the normal position, it is aligned parallel to the road and creates the desired air flow to the rear of the vehicle.



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1. Upper control arm
2. Integral link
3. Lower traction strut
4. Upper traction strut
5. Hub carrier

Control Arms & Links

Stabilizer Bar: The stabilizer bar is designed as a tubular stabilizer bar, which minimizes body “roll” during cornering. It is connected by links between the rear axle carrier and the control arms. The connection at the control arm is an axial ball joint which is secured by a taper seat and Torx bolt. The active roll stabilizer bar (ARS) will be covered in Dynamic Drive.

Technical Data

	Steel Spring
Wheel	**8J x 18**
Tires	**245/55 R18**
Track width (mm)	**1582**
Total toe-in	**0º 18' ±10'**
Geometric axis deviation	**0º ±12'**
Camber	**-1º 30' ±20'**

Workshop Hints

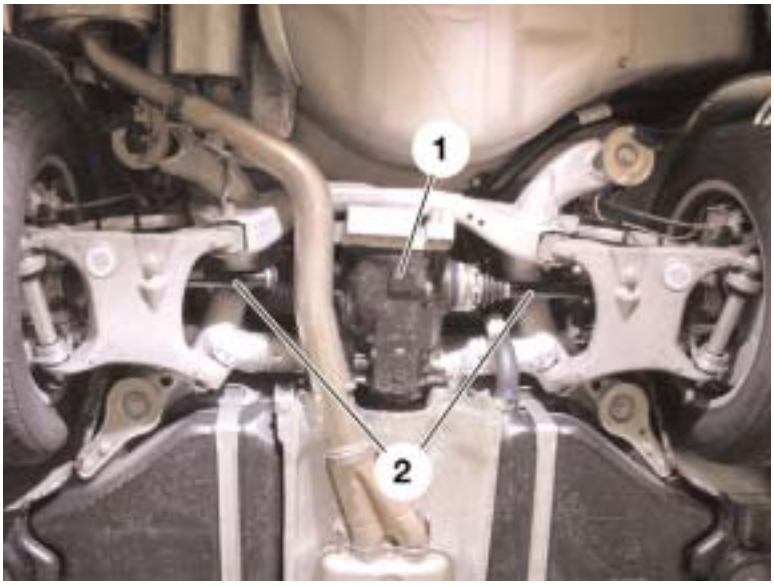
Refer to the Repair Instructions for the following adjustments.

Toe Adjustment: The toe is adjusted by an eccentric bolt at the front upper traction strut.

Camber Adjustment: The camber is adjusted by an eccentric bolt on the lower control arm at the connection to the axle carrier.

Differential and Axle Shafts: The compact final drive is an “open” differential (traction controlled by DSC) with a ratio of 3.38 : 1. The axle mounting bolts feature a special surface paint coating for corrosion resistance.

The oil fill and drain plugs contain integral seals and are also treated with the corrosion protection coating. The drive shaft is aluminum for weight reduction. The compact output shafts are also weight-optimized.



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Differential & Output shafts

1. Differential Unit
2. Output (half) shafts

If the differential is damaged, internal repairs are not permitted. The differential is replaced as a complete unit. The only repair that can be performed is external seal replacement (output shaft seals and pinion seal). The differential does not require an oil change because it has a lifetime oil fill.

Steering

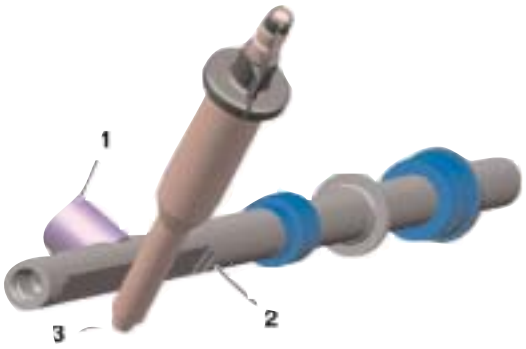
The E65 is equipped with a rack and pinion power assisted steering system with Servotronic. The adjustable steering column is all electric with the adjustment control located on the left on the steering column. The steering column is designed without a steering wheel lock, the anti-theft requirement is fulfilled by the parking lock in the automatic transmission.

As a driver protection feature, a newly designed telescopic crash element is mounted in the upper section of the steering column.

System Components

Steering Gear: The steering gear is bolted at 4 points to the front axle carrier. The gear ratio is variable from 47.0 to 59.0 mm rack movement per steering wheel revolution. This keeps the number of total steering wheel revolutions as low as possible when turning to full lock.

1. Thrust piece
2. Variable pitch gear tooth rack
3. Steering shaft



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Steering Gear

With larger dimensioning, the rack and pinion steering system is used in the E65. The thrust piece required for automatic play compensation is lengthened and equipped with a stronger spring. The thrust piece contains integral lubrication pockets where it contacts the rack for longevity and noise reduction.

The gearing is pressed on the rack to increase resistance to stress. The rack is hollowed which saves weight (reduction of 280 g) and allows air equalization between the right and left bellows eliminating the external plastic tube.

Threadless plug “quick couplings” are used at the supply (1) and return (2) connections on the steering gear.

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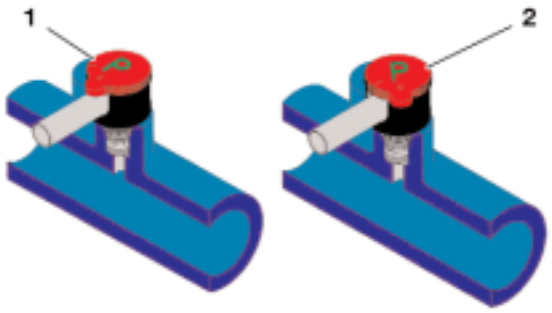
To release the quick coupling, turn the cap to position 2. The connection is then released by pressing with the thumb while at the same time pulling the quick coupling.

1. Operating position
2. Release position



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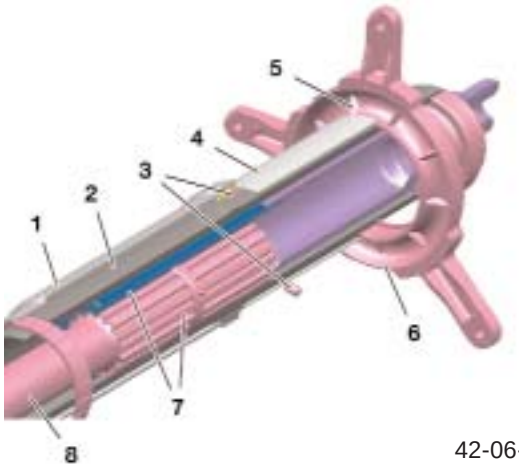
Prior to reconnection, the cap must be reset to the locked operating position (1) and should be plugged into the connection only in this position.

Power Steering Pump: Different power steering pumps are used depending on the vehicle equipment. Vehicles without dynamic drive are equipped with a vane type pump and standard oil reservoir.

A tandem pump is used when the vehicle is equipped with dynamic drive. This pump consists of a radial piston pump with a maximum output of 180 bar and a vane pump section with a maximum output of 135 bar. These vehicles are also equipped with large oil reservoir with oil level monitoring.

Steering Column: The upper steering column with crash element can be compressed telescopically by 70 mm when the steering column is subject to load in the event of a crash. This telescopic action is controlled by a crash element made of fiber glass reinforced plastic.

1. Steering column
2. Slide tube
3. Shear pins (3)
4. Crash element
5. Support webs for SZL
6. SZL carrier
7. Telescopic adjustable splines
8. Steering shaft



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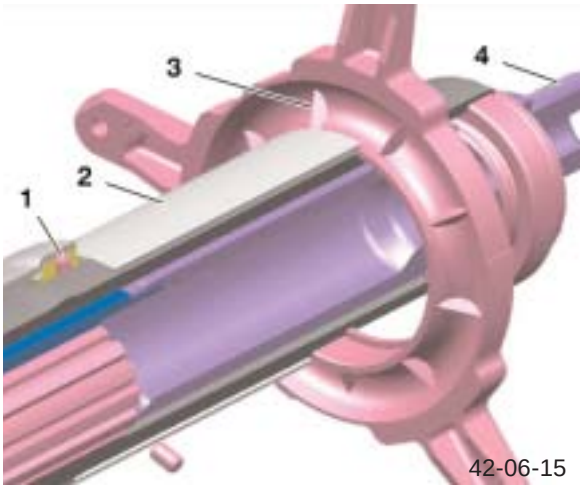
Steering column

The compression movement begins when the three plastic pins shear under an axial force of approximately 3 kN.

The telescopic adjustment splines inter-slide allowing compression when the crash element is deformed over a defined length (at a force of 3 to 7 kN).

1. Shear pins (3)
2. Crash element
3. Support webs for SZL
4. Splined shaft (steering wheel mount)



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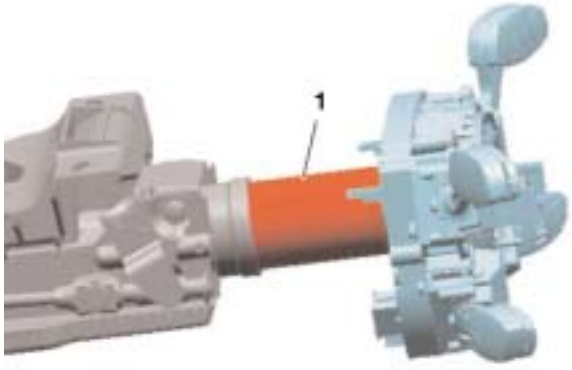
Crash Element Components

Crash Element (before and after compression):



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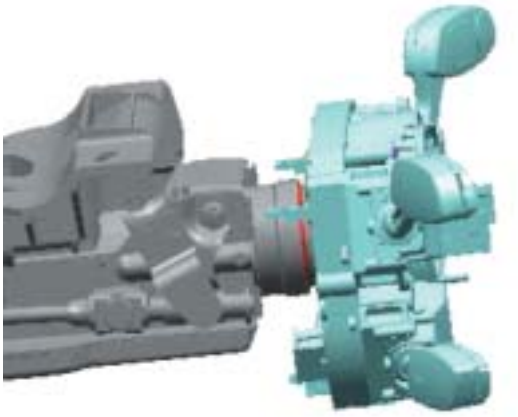

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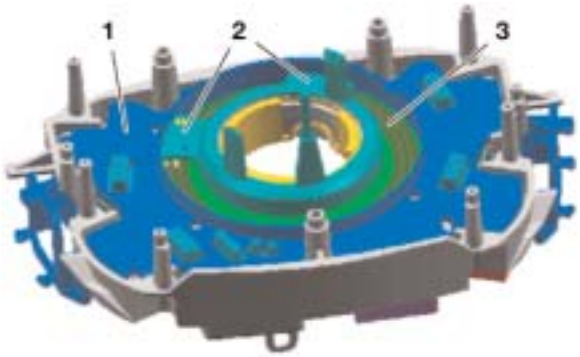
1 Crash element before **after**

Note: Never disassemble the steering column to perform repairs on the crash element! In the event of a defect (particularly a crash), replace the entire steering column.

Always set the steering wheel in the straight ahead position before removal/installation. Remove/install the steering column switch center (SZL) in the straight ahead position, also observe the marking on the locking tooth when installing the steering wheel.

Steering Angle Sensor: The steering angle sensor is integrated in the Steering Column Switch Center (SZL) module. The steering angle positions are transferred by Bus signals to other control modules.

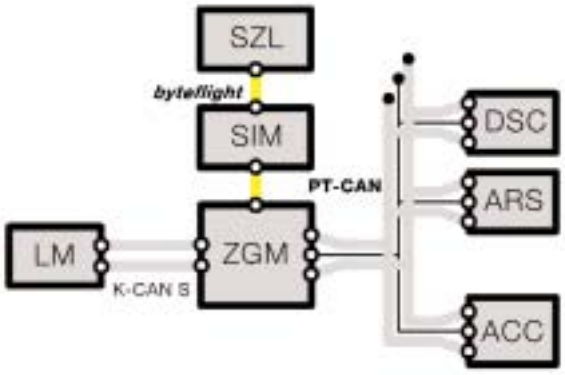
1. SZL - Steering column switch center module
2. Steering angle wiper contact
3. Steering angle wiper tracks



Steering Angle Sensor

The steering angle sensor is a 3.4 kOhm potentiometer with two wipers offset by 90 degrees. From the two wiper signals and a reference signal, the SZL calculates the steering angle sensor position and transfers it over the Byteflight and CAN Bus to other control modules. Shorts to B+ or ground are detected as faults.

SZL - Steering column switch center
DSC - Dynamic stability control
SIM - Safety integration module
ARS - Dynamic Drive
ZGM - Central gateway module



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Steering Angle Sensor Communication Link

Note: When replacing the SZL with the integrated steering angle sensor, the coil spring cassette must be installed in the center position with the wheels set in the straight ahead position. The wiper does not have an electrical reference point and steering angle matching must be performed with the DISplus after repairs.

After performing the steering angle matching, self-learning with the front wheel speed signals is necessary to determine the number of steering wheel turns. The number of steering wheel turns is necessary for determining the exact steering angle.

Chassis Integration Module (CIM): The CIM is located on the underside of the steering column.

The CIM controls the following functions:

- Servotronic
- Electric steering column adjustment

1. Crash element
2. CIM module

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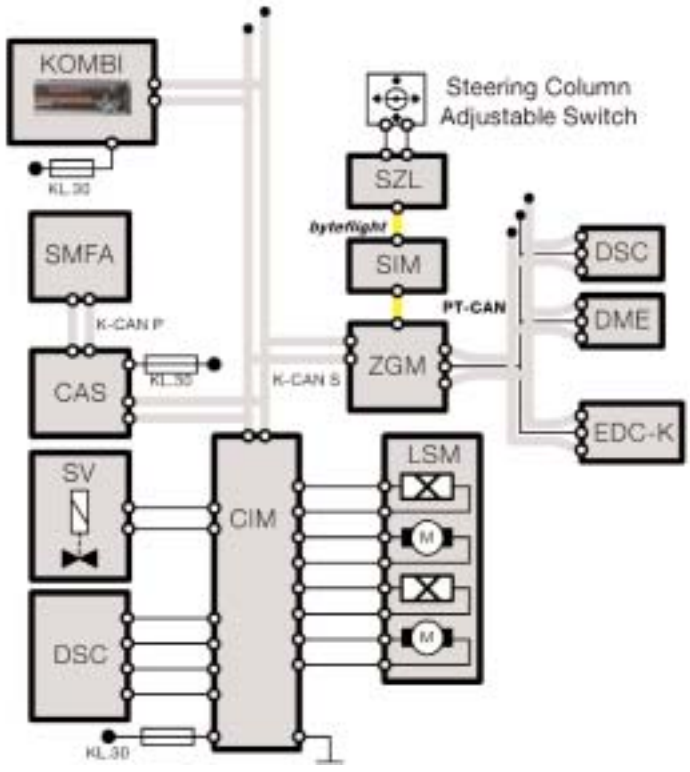
CIM Location

The CIM is linked to the K-CAN S Bus for communication with other control modules. The ZGM provides the gateway for diagnostic communication.



CIM Communication Link

SMFA	Seat memory, driver	SZL	Steering column switch center
CAS	Car access system	ZGM	Central gateway module
SV	Servotronic valve	LSM	Steering column motors
DSC	Dynamic stability control	CIM	Control module
DME	Digital motor electronics	EDC-K	Control module
SIM	Safety integration module		

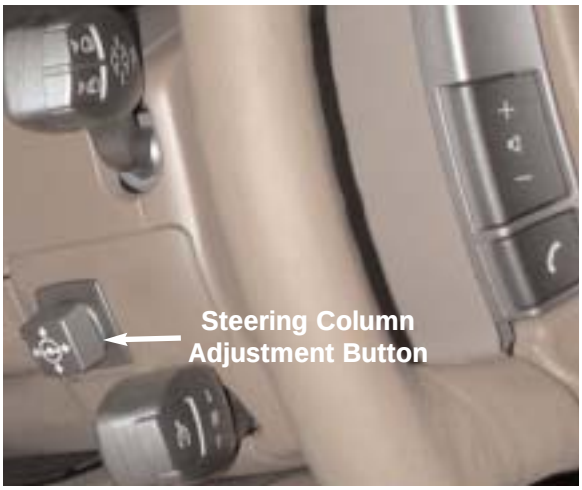
Systems in the CIM Module - Steering Column Adjustment

The electric steering column adjustment system consist of the following components:

- CIM module
- 2 adjustment drive motors for forward/backward and up/down adjustment
- Hall sensors for position recognition

Principle of Operation

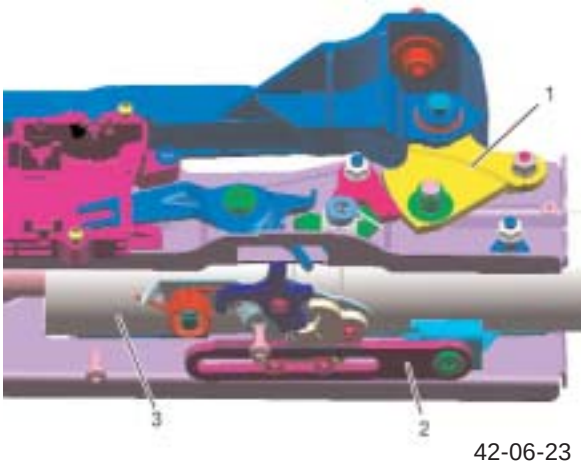
The steering column adjustment is electrically controlled by a button located on the left side of the steering column.



The electric steering column is adjusted by two motors in the up/down and in/out directions. The various positions are stored in the driver's seat module when one of the seat memory buttons are pressed.

The steering column is automatically moved to the uppermost forward position to provide easy entry and exit from the driver's seat.

There are no Check Control messages for the steering column adjustment because the driver receives immediate feedback in the event of a fault.



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1. Up/down adjustment
2. Forward/backward adjustment
3. Steering column

Steering Column Adjustments

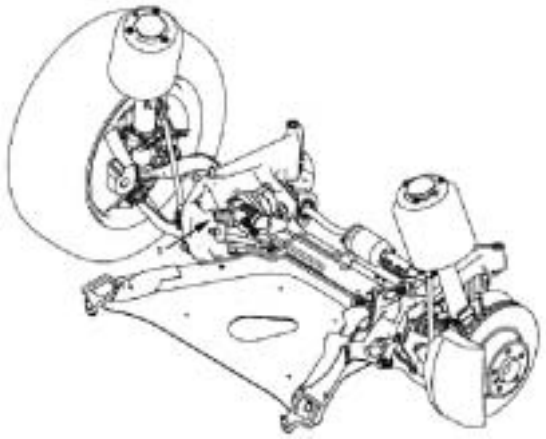
The CIM module will deactivate the steering column adjustment motors when overvoltage is detected (>16 V). The motors will be activated again when the voltage drops below 16 V for more than 2 seconds.

The motors are also protected from overheating by the CIM module. A temperature calculation is performed in the CIM based on activation time (in case of jamming) and the motors will be deactivated to allow a "cool down" time.

Systems in the CIM Module - Servotronic

The Servotronic system consist of the following components:

- CIM module
- Servotronic solenoid valve (1)



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Principle of Operation

Servotronic provides speed dependent control of the power assisted steering. The flow of hydraulic oil is reduced (variable) by an electro-hydraulic pressure converter (solenoid valve) located on the steering rack (1). The degree of oil flow reduction is varied by the current supplied to the solenoid valve from the CIM control circuit.

In connection with EDC-K, the driver can influence the power assisted steering by choosing between ***two characteristic curves, comfort or sport.*** The comfort or sport request dictates the current supplied to the solenoid valve dependent on the vehicle speed.

Start Preconditions: The ignition “ON" signal is the only requirement and the solenoid valve is activated only when the engine is running. If a speed signal or steering angle input (movement) is not present within 5 seconds after starting the engine, the Servotronic switches over to the fast drive characteristic (power assist reduced).

This is the substitute value (without power) when there is a fault present. When a speed signal is received or steering angle input, the solenoid valve is activated by current from the CIM module control circuit to increase the power steering assist (speed variable).

Servotronic Initialization: A short initialization phase (approximately 1 second) is necessary to achieve the characteristic curve as fast as possible during the starting procedure. During this phase, vehicle standstill is detected. A current flow plausibility test is conducted and concluded within the initialization phase (test for short to B+ or ground).

Speed Acquisition: The speed signal is generated by the DSC module and is transferred over the PT-CAN and K-CAN Busses to the CIM module to calculate the acceleration. If the acceleration values are greater than 1.3 g, the speed is interpreted as being implausible and the CIM formulates a “failsafe” speed.

Determining Setpoint: Depending on the measured vehicle speed value, the Servotronic is adjusted every 100 ms in the comfort or sport characteristic curve. This provides a smooth transition in power assisted steering regulation.

Characteristic Curve Changeover: The transition between the comfort and sport characteristic curves is gradual in order to avoid jolts in the power steering during changeover. The time required for the changeover is dependent on the cyclic CAN message "comfort or sport" sent by the EDC-K. The comfort characteristic curve is used if the vehicle is not equipped with EDC-K.

Actual Value Acquisition: The voltage drop generated by the solenoid valve current during operation is monitored by the CIM for plausibility, comparing the actual value in relation to the Servotronic required.

Solenoid Valve Control: The solenoid valve is activated by a pulse width modulated signal (PWM) that has a period duration of 2.5 ms at 400 Hz. The pulse duty factor can be set in 2000 steps from 0 - 99.95%, at a time of 1.25 ms per step change.

Operation at the Controller: The Controller and Control Display form the interfaces to the driver. If the vehicle is equipped with EDC-K, the driver can set the chassis to sports tuning. The Servotronic will also switch to the sport steering characteristic curve.

The comfort characteristic provides greater power assist to the steering over the entire vehicle speed range.

The sport characteristic provides less assist over the speed range, giving the driver more “road feel” and feedback required for this driving style.

42-06-02

Servotronic Safety Requirements

The CIM will output the Check Control message "Servotronic failed" to make the driver aware of a fault. In addition, a fault code will be stored in the CIM module. If the fault is still present upon the next engine start, the Check Control message will re-appear.

Overvoltage: The CIM module will not apply power to the solenoid valve if a voltage value greater than 17 V is detected (failsafe).

Undervoltage: A momentary dip in voltage will self correct, the CIM functions will resume again after a delay time. The undervoltage fault code will not set during engine starting (crank signal).

- > 7.5 V CIM module operates normally
- 6.5 V...7.5 V Reset after 200 ms; CIM will assume sleep mode, woken by CAN Bus
- < 6.5 V Reset after 20 ms; CIM will assume sleep mode, woken by CAN Bus

Speed Signal Monitoring: The CIM module evaluates the vehicle speed signal for three different reasons and will produce different fault codes when faults are detected.

Timeout Vehicle Speed: The vehicle speed (V_DSC) is read cyclically (every 100 ms) by the CIM module via the K-CAN Bus. If an update is not received within 500 ms, the solenoid valve is deactivated. The sport characteristic (power assist reduced) will be in operation.

A CAN timeout fault code will be stored in the CIM after 10 failed messages. A Check Control message will be sent if an update is not received in 5 seconds. The timeout fault code is reset with the next engine start. The fault code counter will be cleared by a correctly received message within the 5 second monitoring period. When a general CAN fault is detected, the solenoid valve is deactivated and the speed monitoring is ignored.

Fault Value of Speed Message: The CIM is informed of speed faults detected by the DSC by a fault value. A Check Control message is sent and the solenoid valve is deactivated when the fault value is received ten times in succession.

Plausibility Check by Calculating the Acceleration: The acceleration is calculated based on the vehicle speed. The Servotronic is regulated to the speed up to an acceleration of 1.3 g. If the acceleration exceeds the value of 1.3 g:

- The speed is calculated internally during braking by deducting 4 km/h per 100 ms from the last speed and storing this value as the current speed.
- The speed is calculated internally during acceleration by adding 6 km/h per 100 ms to the last speed and storing this value as the current speed. As soon as an acceleration value less than 1.3 g is observed between the stored speed and the speed supplied on the Bus, the Servotronic regulation is resumed.

Solenoid Valve Circuit Monitoring: The circuit is monitored for shorts (B+ and ground) and breaks. If a fault is detected in the control circuit for the solenoid valve, the circuit and solenoid valve will be deactivated. Only minimum power assisted steering will be provided. This check is conducted within the initialization phase of 1 second. This function will repeat each time the ignition is cycled. The Servotronic will not operate during the engine start procedure if a fault is present for longer than 1 second.

Current Plausibility Check: The solenoid valve current is monitored by the CIM module and must be within a tolerance range. This takes place within the initialization phase and the output stage for the solenoid valve is deactivated if a fault is detected.

Damper Program Signal Status Monitoring: The EDC-K status is observed by the CIM module cyclically (every 200 ms) over the K-CAN Bus. The EDC-K provides the comfort or sport request. If a message is not received within 2 seconds, the comfort characteristic will be set and the fault code "timeout EDC-K status" will be stored. A Check Control message will not be sent.

Diagnosis Information

External Faults: All inputs, actuators and mechanical functions are monitored. Open or short circuits in the wires and actuators to the CIM module are monitored.

Internal Faults: The electronic function of the CIM module and the output stages are also monitored. When a fault occurs, the entire system is shut down and a fault code is stored. The cyclic CAN signal is also monitored.

Fault Generation: When a fault is detected in a function or component, that output function is deactivated. The fault information is stored in the fault code memory. If correct function of the component cannot be determined after a fault has occurred, the function will remain deactivated. After repairs, the fault can be deleted by the DISplus.

Wheels/Tires

The E65 is equipped with light alloy wheels including the spare wheel. The alloy wheels reduce unsprung weight and also provide an attractive, stylish appearance.

The 8J x 18 cast aluminum wheels shown to the right are standard equipment. The wheels are equipped with 245/45R-18 V rated all season tires.

42-06-24

The ***optional*** cast aluminum wheels shown to the right are different sizes for the front and rear:

- Front Wheel = 9J x 19 with 245/45R -19 Performance tire
- Rear Wheel = 10J x 19 with 275/40R -19 Performance tire

42-06-25

Adhesive balance weights are used on the E65 wheels. The weights are installed on the inside of the rim on the designated precision cut areas for dynamic balancing.

1. Bonding surfaces for balance weights

42-06-26

Note: The wheel bolts are torqued to 140 Nm.