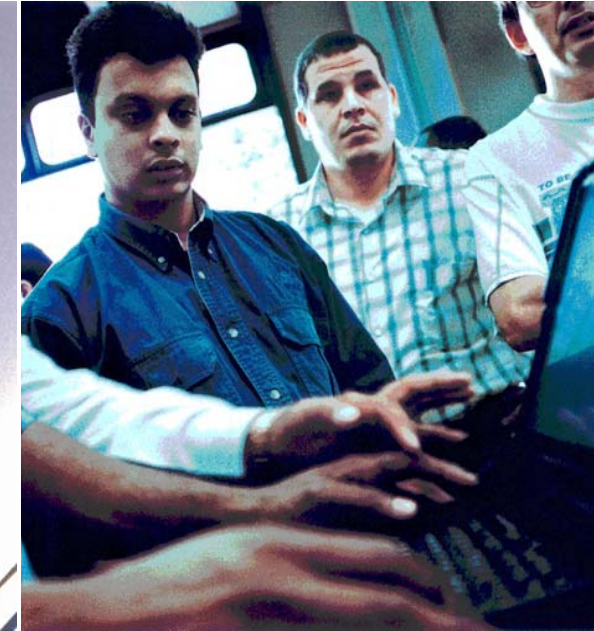


Cars • Chassis &  
active safety systems  
Suspension systems  
in model 164, 221, 251  
Specialist training

Information module



As at 12/05

## Global Training.

The finest automotive learning

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Printed in Germany

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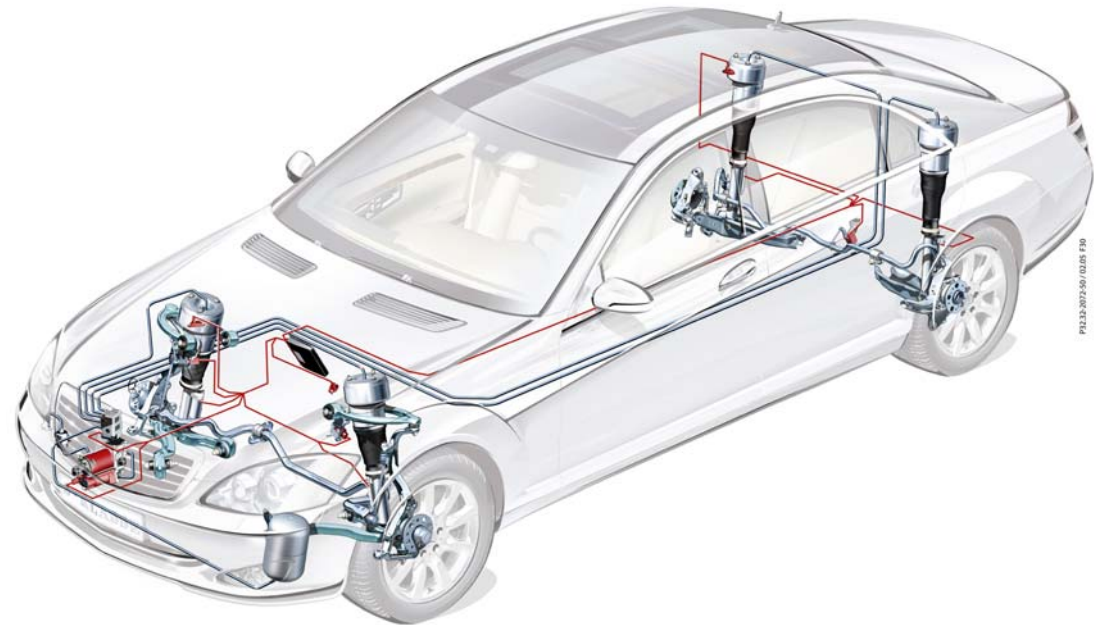
Note:

The term »employees« does not imply any preference of gender and incorporated male and refers to male and female employees alike.

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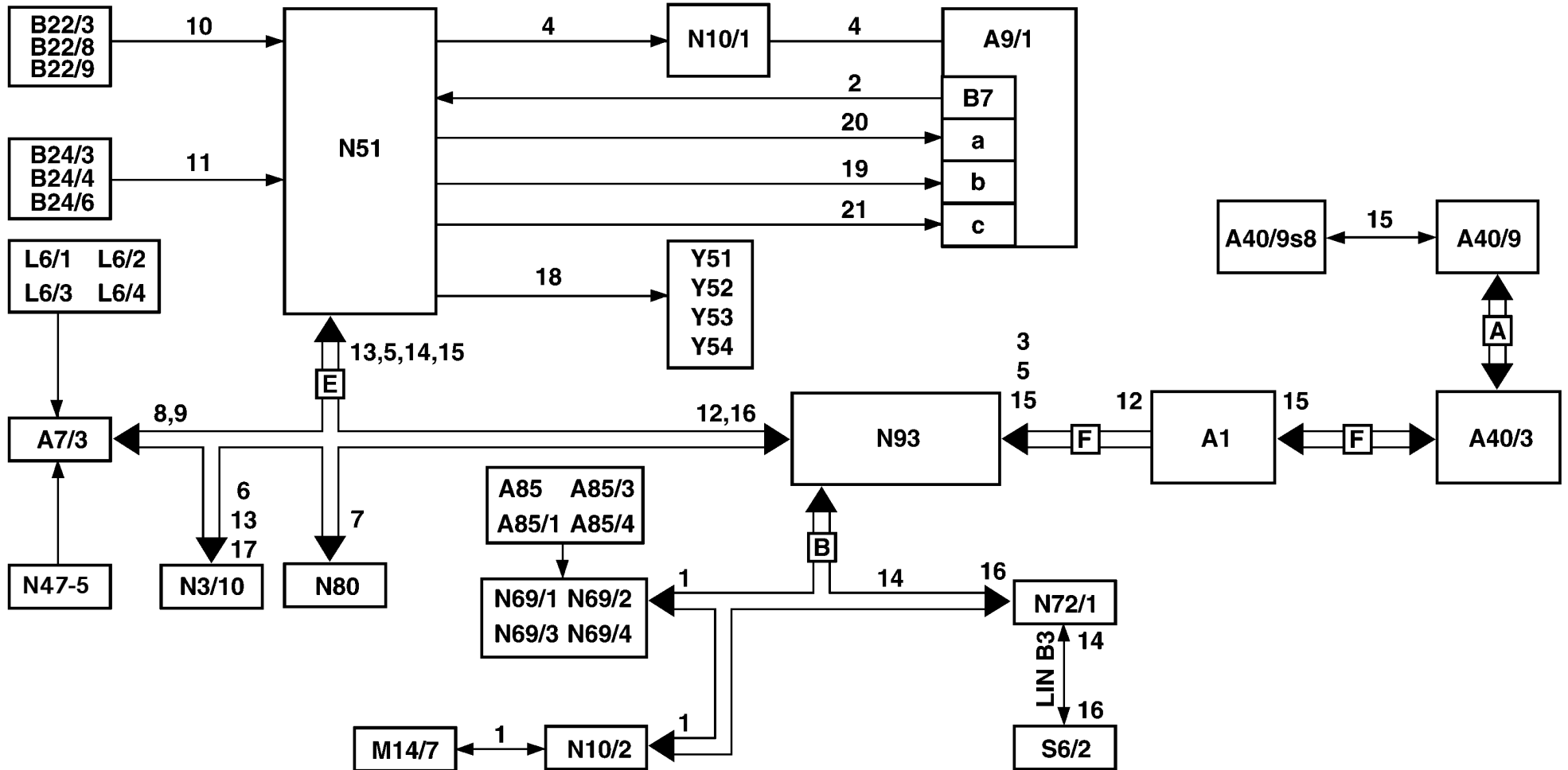
As in the predecessor models, the AIRmatic consists of 4 suspension struts, a central reservoir, a compressor unit, a valve unit and the sensor system.  
The well-known ADS II system is available for damping.



### New functions in model series 221

Manual adjustment between the “Comfort” and “Sport” damping characteristics is now done with the C/M/S program selection button (S16/12).  
In programs S and M, the sporty damping characteristic is set.

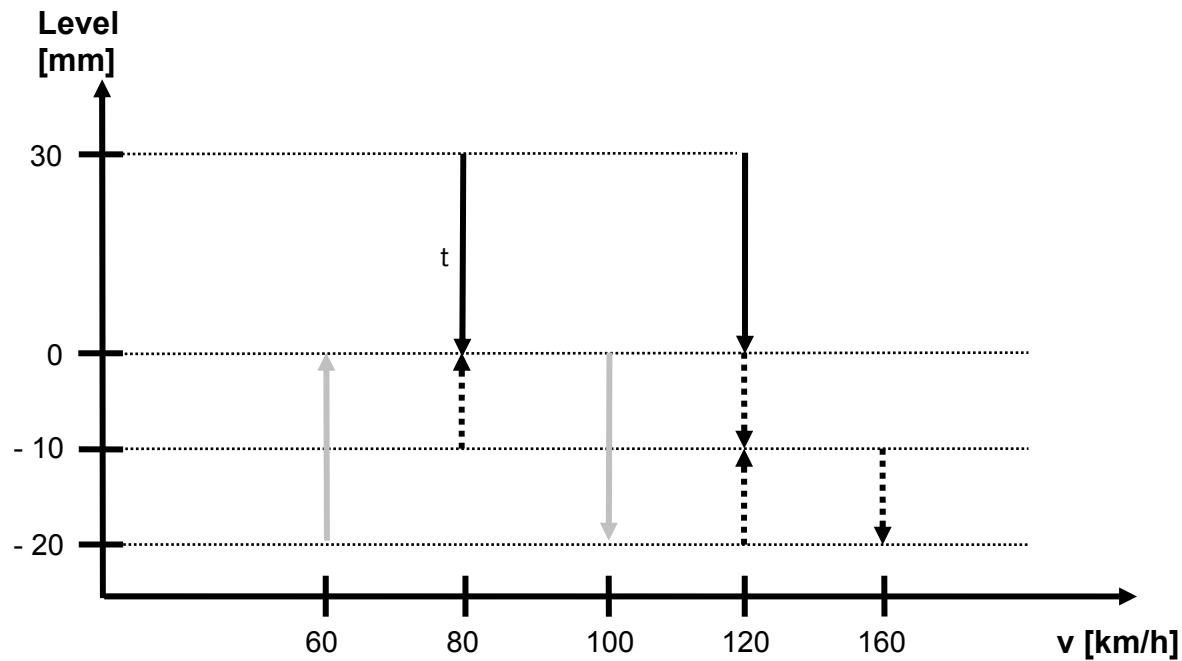




P32.22-2358-C09

1	Wake-up signal with door/trunk contact on	A40/9s8	Transmission modes button	N47-5	ESP control unit
		A85	Left front door lock unit	N51	AIRmatic with ADS control unit
2	Air spring pressure signal	A85/1	Right front door lock switch	N69/1	Left front door control unit
3	Speed display signal	A85/3	Left rear door lock unit	N69/2	Right front door control unit
4	Compressor actuation via relay	A85/4	Right rear door lock unit	N69/3	Left rear door control unit
5	Outside temperature signal	B7	AIRmatic pressure sensor	N69/4	Right rear door control unit
6	Atmospheric pressure signal	B22/3	Rear axle level sensor	N72/1	Control unit for upper control panel
7	Steering angle sensor signal	B22/8	Left front level sensor	N80	Steering column module
8	Service brake actuated signal	B22/9	Right front level sensor	N93	Central gateway control unit
9	Wheel speed signals	B24/3	Left front body lateral acceleration sensor	S6/2	Cockpit switch group
10	Level sensor signals	B24/4	Right front body lateral acceleration sensor	Y51	Left front axle damper valve unit
11	Vertical acceleration signal	B24/6	Right rear body lateral acceleration sensor	Y52	Right front axle damper valve unit
12	System/error message	L6/1	Left front rpm sensor	Y53	Left rear axle damper valve unit
13	Vehicle data	L6/2	Right front rpm sensor	Y54	Right rear axle damper valve unit
14	Change vehicle level signal	L6/3	Left rear rpm sensor		
15	Change suspension setting signal	L6/4	Right rear rpm sensor	a	AIRmatic central reservoir charge valve integrated into level control valve unit
16	Status LED signal	M14/7	Trunk lid CL motor	b	Four level valves integrated into level control valve unit
17	Intake air temperature for compressor control signal	N3/10	ME control unit	c	AIRmatic pressure reduction valve (A9/1y1) integrated into AIRmatic compressor unit (A9/1)
		N10/1	Front SAM control unit with fuse and relay module		
18	Damping valve actuation				
19	Level valve actuation	N10/2	Rear SAM control unit with fuse and relay module		
20	Level control valve unit actuation				
21	Deflating valve actuation				
A1	Instrument cluster			A	Telematics CAN
A7/7	BAS brake booster			B	Interior CAN
A9/1	AIRmatic compressor unit			E	Chassis CAN
A40/3	COMAND control unit			F	Central CAN
A40/9	Front central operating unit			LIN B3	UCP-LIN

## ECE levels



- Raised level at 80 km/h with time prerequisite (3 minutes over 80 km/h) lowering to 0
- Sport mode at 120 km/h immediate lowering to 0
- Sport mode at 100 km/h lowering to -20 mm
- Sport mode at 60 km/h raising to 0
- ..... Comfort mode at 120 km/h lowering to -10 mm
- ..... Comfort mode at 160 km/h lowering to -20 mm
- ..... Comfort mode at 120 km/h raising to -10 mm
- ..... Comfort mode at 80 km/h raising to 0



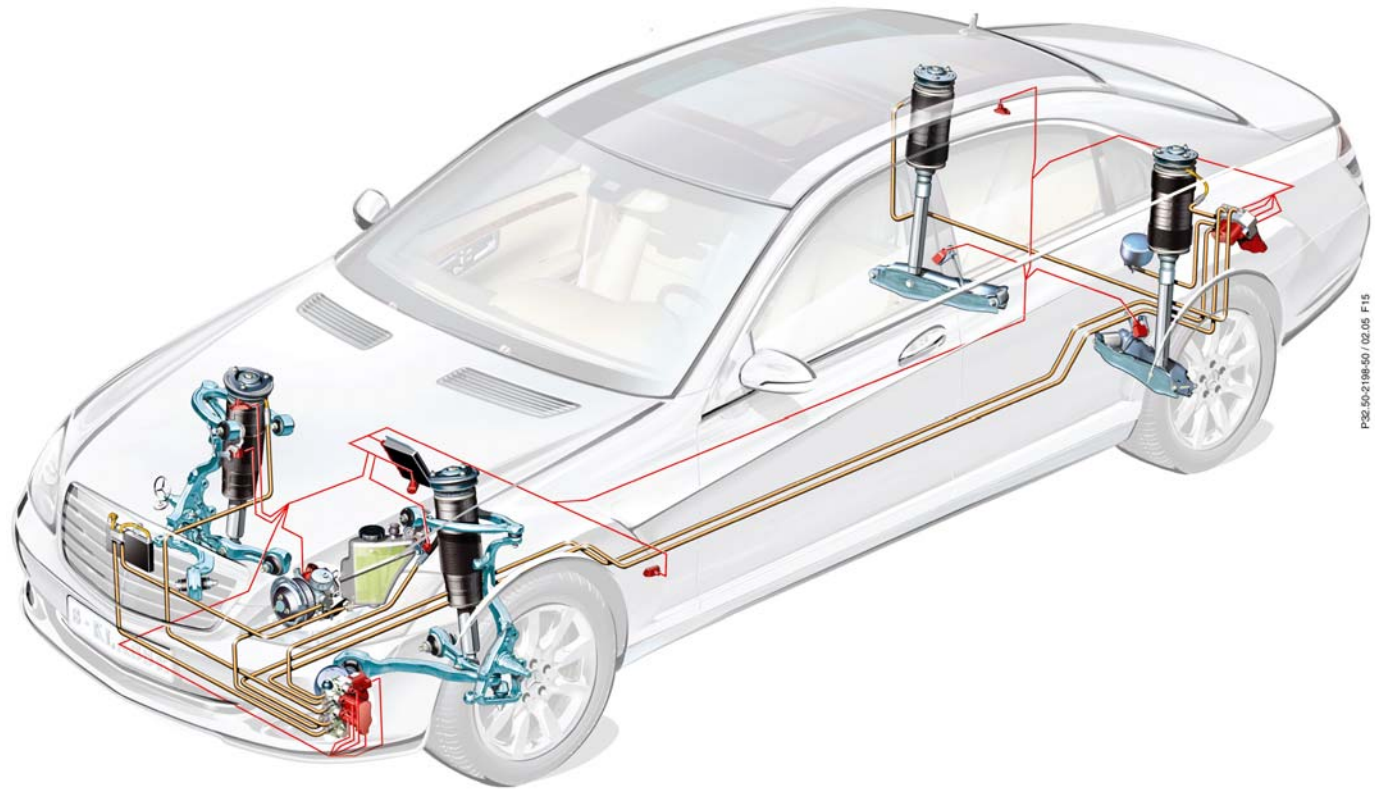
For the 12-cylinder top-of-the-line version of model series 221 (market launch January 2006), the active suspension system (ABC) is used as standard.

The system is available as special equipment only with the 8-cylinder variants.

The function of this active suspension is almost identical to the familiar ABC system in the predecessor model series.

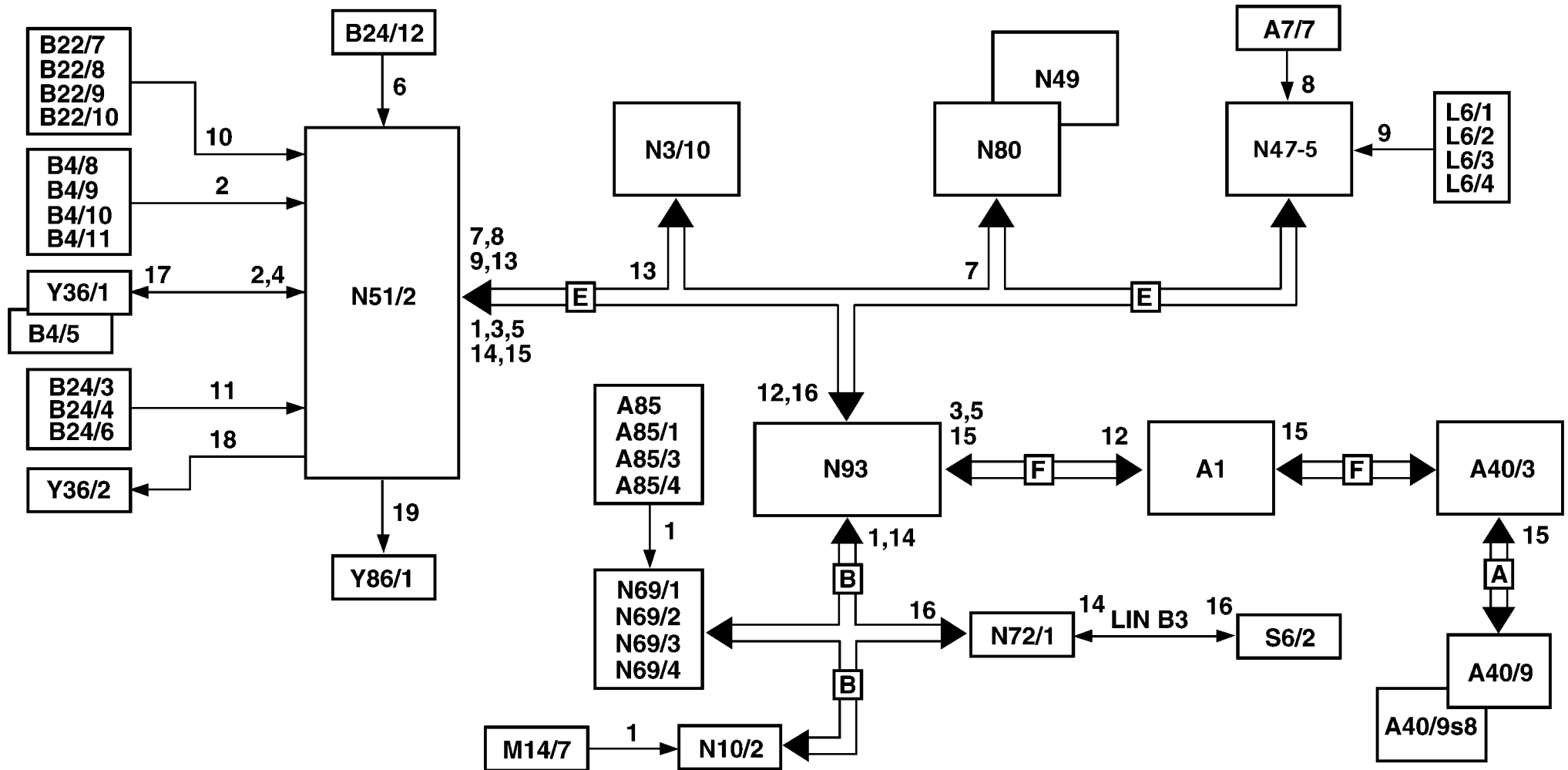
### Modifications:

- \* Omission of plunger travel sensor
- \* Omission of longitudinal acceleration sensor
- \* Pressure sensors in the valve unit
- \* High pressure pump with integral pulsation damper
- \* Switching between Sport/Comfort performance map through program selection button (S/C/M)
- \* Possible level stages
  - NN Normal level
  - EN Raised level
  - AN Lowered level
 (not randomly selectable by driver)



**Federungssystem ABC (Active Body Control)**  
S-Klasse (BR221)

P32.50-2198-50



P32.50-2243-C09

1	Wake-up signal from door lock or from trunk lid CL [ZV] motor	B4/5	ABC pressure sensor	N3/10	ME control unit
2	System pressure signal	B4/8	Left front ABC pressure sensor	N10/2	Rear SAM control unit with fuse and relay module
3	Speed display signal	B4/9	Right front ABC pressure sensor	N47-5	ESP control unit
4	Cylinder travel signal	B4/10	Left rear ABC pressure sensor	N49	Steering angle sensor
5	Outside temperature	B4/11	Right rear ABC pressure sensor	N51/2	ABC control unit
6	Lateral acceleration signal	B22/7	Rear left level sensor	N69/1	Left front door control unit
7	Steering angle sensor signal	B22/8	Left front level sensor	N69/2	Right front door control unit
8	Service brake actuated signal	B22/9	Right front level sensor	N69/3	Left rear door control unit
9	Wheel speed signals	B22/10	Rear right level sensor	N69/4	Right rear door control unit
10	Level sensor signals	B24/3	Left front body lateral acceleration sensor	N72/1	Control unit for upper control panel
11	Vertical acceleration signal	B24/4	Right front body acceleration sensor	N80	Steering column module
12	System and error message signals	B24/6	Right rear body lateral acceleration sensor	N93	Central gateway control unit
13	Vehicle data signal	B24/12	ABC lateral acceleration sensor	S6/2	Cockpit switch group
14	Change vehicle level signal			Y36/1	ABC front axle valve unit
15	Suspension setting signal	L6/1	Left front rpm sensor	Y36/2	ABC rear axle valve unit
16	Status LED actuation signal	L6/2	Right front rpm sensor	Y86/1	ABC suction restrictor valve
17	Plunger valve (front) actuation signal	L6/3	Left rear rpm sensor		
18	Plunger valve (rear) actuation signal	L6/4	Right rear rpm sensor	A	Telematics CAN
19	Suction restrictor valve actuation signal			B	Interior CAN
		M14/7	Trunk lid CL motor	E	Chassis CAN
A1	Instrument cluster			F	Central CAN
A7/7	BAS brake booster			LIN B3	UCP-LIN
A40/3	COMAND control unit				
A40/9	Front central operating unit				
A40/9s8	Transmission modes button				
A85	Left front door lock unit				
A85/1	Right front door lock switch				
A85/3	Left rear door lock unit				
A85/4	Right rear door lock unit				

- \* The ABC control unit (N51/2) is located in the front passenger footwell behind the foot rest.
- \* The new emergency mode rubber elements are used in the front axle (W221 589 00 31 00).
- \* If the vehicle level falls below the critical level (-60 mm), an optical and acoustic driver warning will appear in the driver display.
- \* The procedure for vehicle level calibration is same as that in the predecessor.

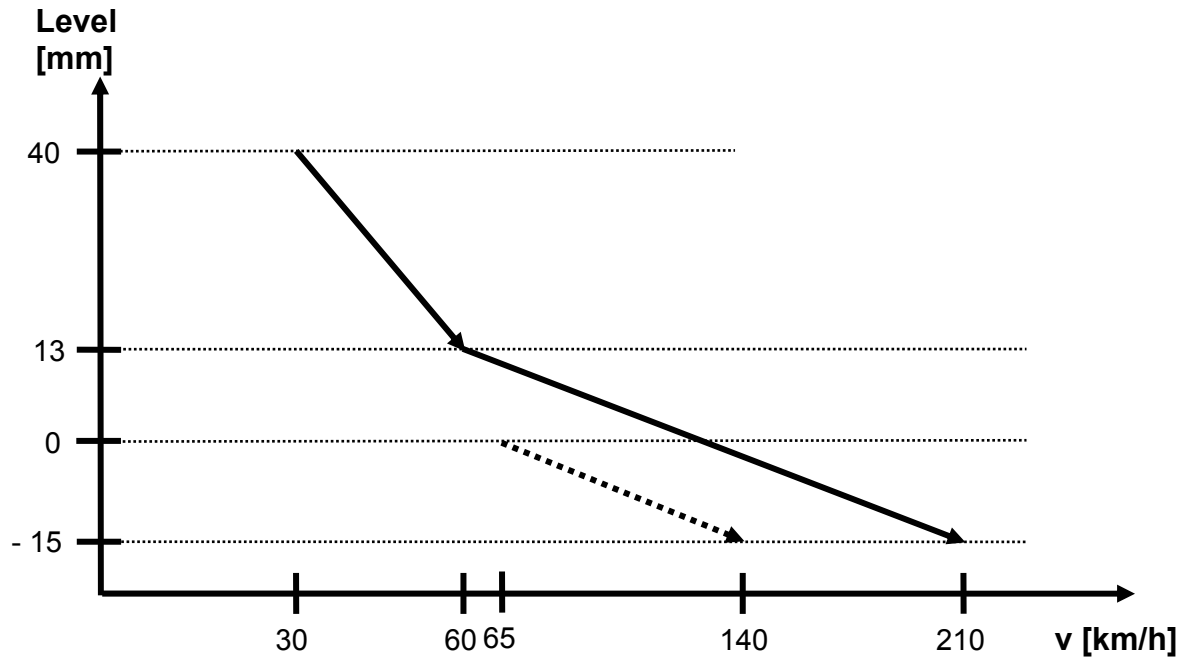
### Special tool for loosening the suspension strut connections

W221 589 01 33 00 VA  
W230 589 01 33 00 HA

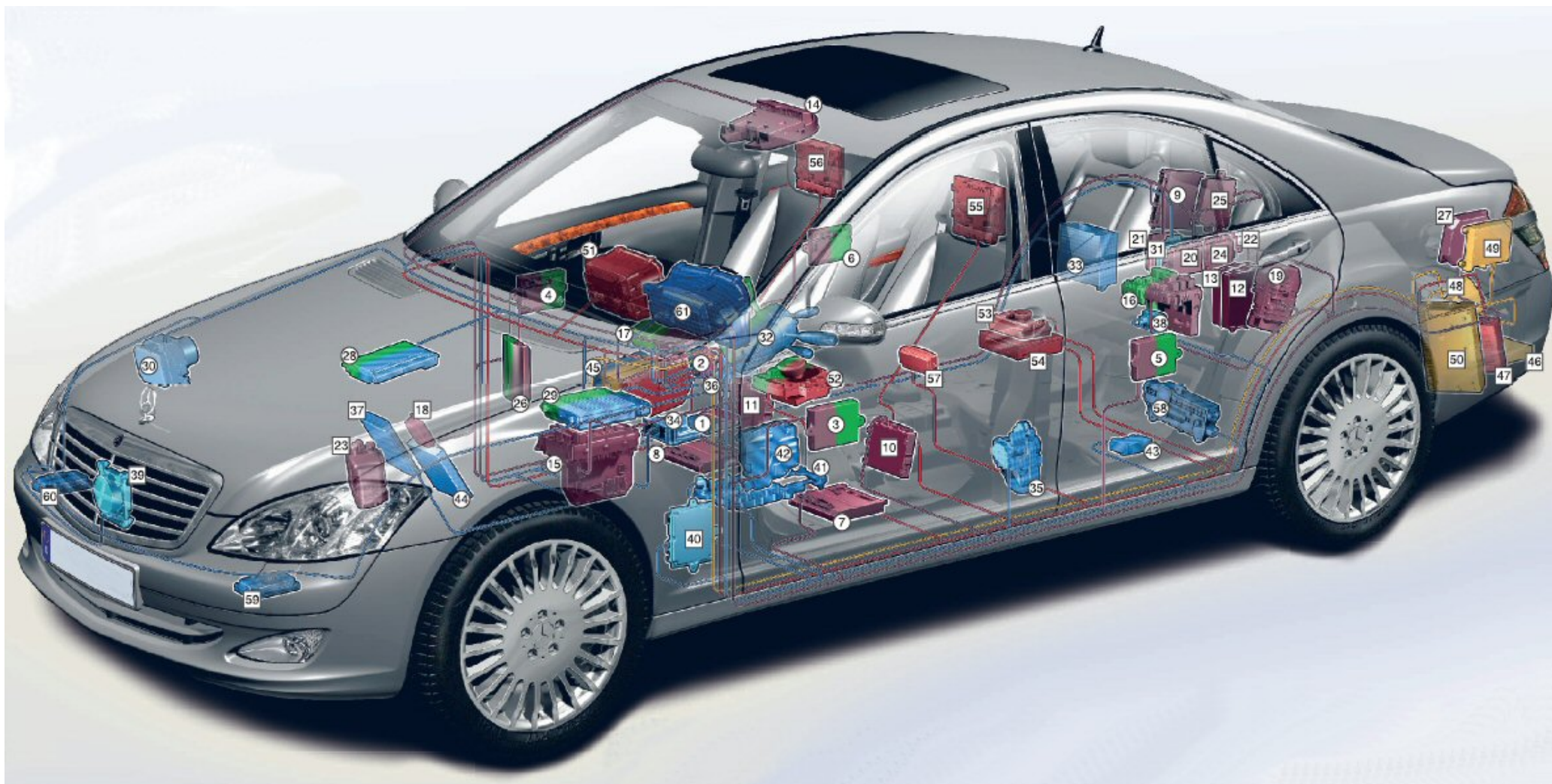


GT32\_50\_0021\_C71

ECE levels

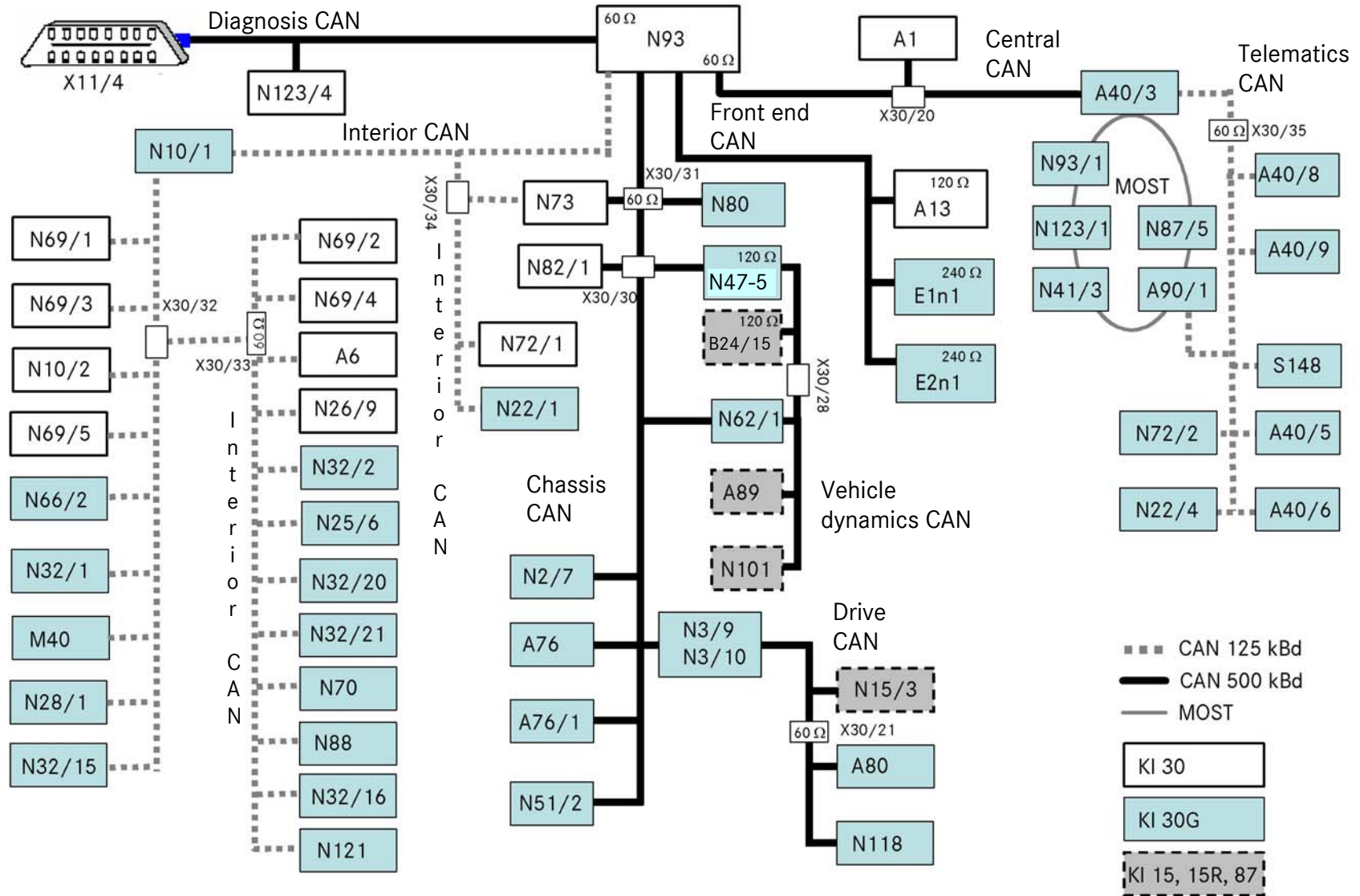


- Raised level (switch position C) at 30 km/h to 60 km/h lowering to +13 mm
- at 60 km/h to 210 km/h lowering to -15 mm
- ..... Sport mode (switch position S, M) at 65 km/h to 140 km/h lowering to -15 mm



GT00\_19\_0114\_C79

- |  |  |
|--|--|
| <ul style="list-style-type: none"> <li><b>1</b> Central gateway control unit (N93)</li> <li><b>2</b> Electronic ignition switch (EIS) control unit (N73)</li> <li><b>3</b> Left front door control unit (N69/1)</li> <li><b>4</b> Right front door control unit (N69/2)</li> <li><b>5</b> Left rear door control unit (N69/3)</li> <li><b>6</b> Right rear door control unit (N69/4)</li> <li><b>7</b> Left front seat control unit (N32/1)</li> <li><b>8</b> Right front seat control unit (N32/2)</li> <li><b>9</b> Rear seats control unit (N25/6)</li> <li><b>10</b> Left front multicontour backrest (OSB-LF) control unit (N32/15)</li> <li><b>11</b> Right front multicontour backrest (OSB-RF) control unit (N32/16)</li> <li><b>12</b> Left rear multicontour backrest (OSB-LR) control unit (N32/20)</li> <li><b>13</b> Right rear multicontour backrest control unit OSB-RR (N32/21)</li> <li><b>14</b> Overhead control panel (OCP) control unit (N70)</li> <li><b>15</b> Front SAM control unit with fuse and relay module (1)</li> <li><b>16</b> Rear SAM control unit with fuse and relay module (2)</li> <li><b>17</b> Upper control panel (UCP) control unit (N72/1)</li> <li><b>18</b> Tire pressure monitor (TPM) control unit (N88)</li> <li><b>19</b> Multicontour seat pneumatic pump (M40)</li> <li><b>20</b> AAG trailer recognition control unit (N28/1)</li> <li><b>21</b> Parktronic system (PTS) control unit (N62)</li> <li><b>22</b> Special vehicle multifunction (SVMCU [MSS]) control unit (N26/9)</li> <li><b>23</b> Stationary heater STH (A6)</li> <li><b>24</b> Remote trunk closing (RTC [HDFS]) control unit (N121)</li> <li><b>25</b> Keyless Go (KG) control unit (N69/5)</li> <li><b>26</b> Automatic air conditioning (AAC) control unit (N22/1)</li> <li><b>27</b> Backup camera (RFK) control unit (N66/2)</li> <li><b>28</b> ME control unit (N3/10) for gasoline engines</li> <li><b>29</b> CDI control unit (N3/9) for diesel engines</li> <li><b>30</b> ESP control unit (N47-5)</li> <li><b>31</b> Radar sensors control unit (N62/1)</li> </ul> | <ul style="list-style-type: none"> <li><b>32</b> Steering column module control unit (N80)</li> <li><b>33</b> Vehicle power supply control unit (N82/1)</li> <li><b>34</b> Restraint systems control unit (N2/7)</li> <li><b>35</b> Left front reversible emergency tensioning retractor (A76)</li> <li><b>36</b> Right front reversible emergency tensioning retractor (A76/1)</li> <li><b>37</b> ABC control unit (N51/2)</li> <li><b>38</b> Yaw rate, lateral and longitudinal acceleration sensor B24/15</li> <li><b>39</b> Distronic control unit (A89)</li> <li><b>40</b> Night vision assist (N101)</li> <li><b>41</b> Fully integrated transmission control (VGS) control unit (Y3/8n4)</li> <li><b>42</b> Intelligent servo module ISM (A80)</li> <li><b>43</b> Tank control unit (N118/3) (only M275)</li> <li><b>44</b> Electronic transmission control (ETC [EGS]) control unit (N15/3)</li> <li><b>45</b> COMAND control unit (A40/3)</li> <li><b>46</b> SDAR satellite radio control unit (N87/5) (only USA)</li> <li><b>47</b> TV combination tuner (analog/digital) (A90/1)</li> <li><b>48</b> VCS voice control system control unit (N41/3)</li> <li><b>49</b> Cellular mobile phone preinstallation with universal interface (N123/1)</li> <li><b>50</b> Audio tuner control unit (N93/1)</li> <li><b>51</b> Cockpit central display (A40/8)</li> <li><b>52</b> Front central operating unit (A40/9)</li> <li><b>53</b> Rear control panel (RCP) control unit (N72/2)</li> <li><b>54</b> Audio/video controller control unit (N66/3)</li> <li><b>55</b> Left rear display (A40/5)</li> <li><b>56</b> Right rear display (A40/6)</li> <li><b>57</b> FKLA rear air conditioning control unit (N22/4)</li> <li><b>58</b> Electric parking brake (A13)</li> <li><b>59</b> Xenon headlamp control unit (E1n1)</li> <li><b>60</b> Xenon headlamp control unit (E2n1)</li> <li><b>61</b> Instrument cluster (A1)</li> </ul> |
|--|--|





<b>A1</b>	Instrument cluster	<b>N32/2</b>	Right front seat control unit
<b>A6</b>	Stationary heater (STH)	<b>N32/15</b>	Left front multicontour backrest (OSB-LF) control unit
<b>A13</b>	Electric parking brake	<b>N32/16</b>	Right front multicontour backrest (OSB-RF) control unit
<b>A40/3</b>	COMAND control unit	<b>N32/20</b>	Left rear multicontour backrest (OSB-LR) control unit
<b>A40/5</b>	Left rear display	<b>N32/21</b>	Right rear multicontour backrest control unit OSB-RR
<b>A40/6</b>	Right rear display	<b>N41/3</b>	Voice control system (VCS) control unit
<b>A40/8</b>	Cockpit central display	<b>N51/2</b>	ABC control unit
<b>A40/9</b>	Front central operating unit	<b>N62/1</b>	Radar sensor control unit
<b>A76</b>	Left front reversible emergency tensioning retractor	<b>N66/2</b>	Backup camera control unit
<b>A76/1</b>	Right front reversible emergency tensioning retractor	<b>N66/3</b>	Audio/video controller control unit
<b>A80</b>	Intelligent servo module (ISM)	<b>N69/1</b>	Front left door control unit
<b>A89</b>	Distronic control unit	<b>N69/2</b>	Front right door control unit
<b>A90/1</b>	TV combination tuner (analog/digital)	<b>N69/3</b>	Rear left door control unit
<b>B24/15</b>	Yaw rate, lateral and longitudinal acceleration sensor	<b>N69/4</b>	Rear right door control unit
<b>E1n1</b>	Xenon headlamp control unit	<b>N69/5</b>	Keyless Go (KG) control unit
<b>E2n1</b>	Xenon headlamp control unit	<b>N70</b>	Overhead control panel (OCP) control unit
<b>M40</b>	Multicontour seat pneumatic pump	<b>N72/1</b>	Upper control panel (UCP) control unit
<b>N2/7</b>	Restraint systems control unit	<b>N72/2</b>	Rear control panel (RCP) control unit
<b>N3/9</b>	Diesel (CDI) control unit	<b>N73</b>	Electronic ignition switch (EIS) control unit
<b>N3/10</b>	Gasoline engine (ME) control unit	<b>N80</b>	Steering column module control unit
<b>N10/1</b>	Front SAM control unit	<b>N82/1</b>	Vehicle power supply control unit
<b>N10/2</b>	Rear SAM control unit	<b>N87/5</b>	Satellite radio (SDAR) control unit (USA only)
<b>N15/3</b>	Electronic transmission control (ETC) control unit	<b>N88</b>	Tire pressure monitor (TPM) control unit
<b>N22/1</b>	Automatic air conditioning (AAC) control unit	<b>N93</b>	Central gateway control unit (CGW)
<b>N22/4</b>	Rear air conditioning (FKLA)	<b>N93/1</b>	Audio tuner control unit
<b>N25/6</b>	Rear seats control unit	<b>N101</b>	Night vision assist
<b>N26/9</b>	Special vehicle multifunction (SVMCU) control unit	<b>N118/3</b>	Tank control unit (M275 only)
<b>N28/1</b>	Trailer recognition (AAG) control unit	<b>N121</b>	Remote trunk closing (RTC [HDFS]) control unit
<b>N32/1</b>	Left front seat control unit	<b>N123/1</b>	Cellular mobile phone preinstallation with universal interface
<b>N47-5</b>	ESP control unit	<b>N123/4</b>	Low cost Teleaid (USA only)
		<b>Y3/8n4</b>	Fully integrated transmission control (VGS) control unit

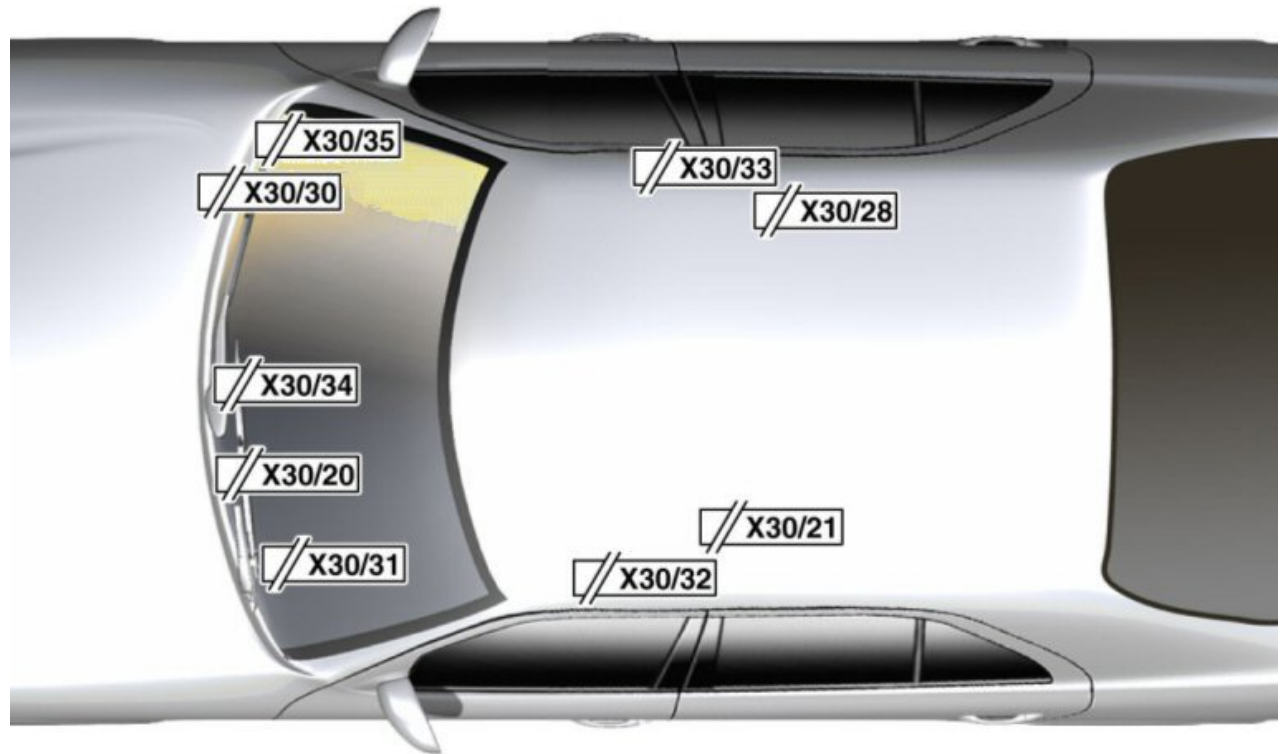
### Voltage distributor:

<b>X30/20</b>	Central CAN voltage distributor	<b>X30/32</b>	Interior CAN/left FFS* voltage distributor
<b>X30/21</b>	Drive train CAN voltage distributor	<b>X30/33</b>	Interior CAN/right FFS* voltage distributor
<b>X30/28</b>	Vehicle dynamics CAN voltage distributor	<b>X30/34</b>	Interior CAN/COC** voltage distributor
<b>X30/30</b>	Suspension CAN/FFS* voltage distributor	<b>X30/35</b>	Telematics CAN voltage distributor
<b>X30/31</b>	Chassis CAN/COC** voltage distributor		

\* FFS= frame floor system / \*\* COC= Cockpit

## Overview of CAN distributors

X30/20	Central CAN voltage distributor H Yellow/white L Yellow
X30/21	Drive train CAN voltage distributor H Blue/white L Blue
X30/28	Vehicle dynamics CAN voltage distributor H Purple/white L Purple
X30/30	Chassis CAN/FFS* voltage distributor H Green/white L Green
X30/31	Chassis CAN/COC** voltage distributor H Green/white L Green
X30/32	Interior CAN/left FFS* voltage distributor H Brown/red L Brown
X30/33	Interior CAN/right FFS* voltage distributor H Brown/red L Brown
X30/34	Interior CAN/COC** voltage distributor H Brown/red L Brown
X30/35	Telematics CAN voltage distributor H Black/white L Black



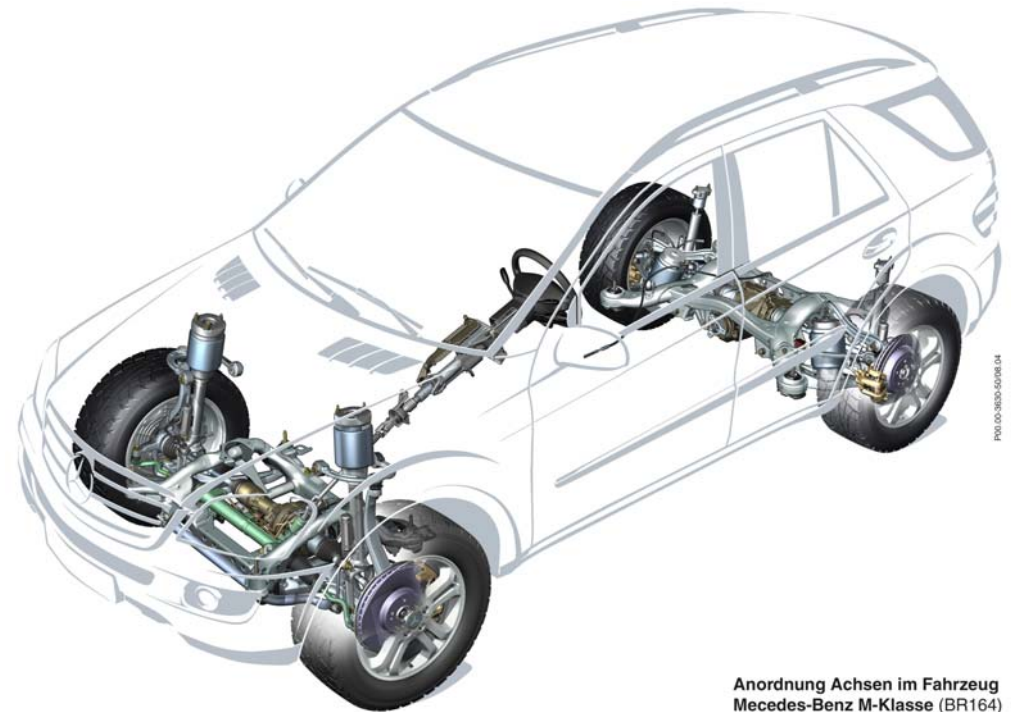
GT00\_19\_0113\_C78

\* FFS = frame floor system

\*\* COC = cockpit

3 suspension systems are available for M-Class:

- \* Steel suspension (standard)  
The standard system consists of traditional cylindrical coil springs with single-tube gas pressure shock absorbers and a large-displacement head bearing.
- \* Air suspension (code 489)  
The AIRMATIC air suspension system features greater driving comfort, particularly during on-road operation. An adaptive damping system (ADS) is part of the package. There are also three vehicle levels to choose from.
- \* Air suspension with Off-road-Pro Technology package (Code 430)  
The expanded Off-road Pro Technology package) offers additional increases in performance. Five vehicle levels are now available. This increases vehicle ground clearance by up to 110 mm.

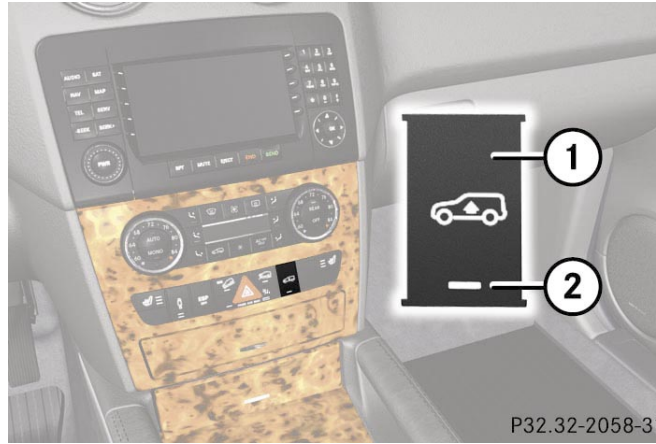


## AIRmatic M-Class



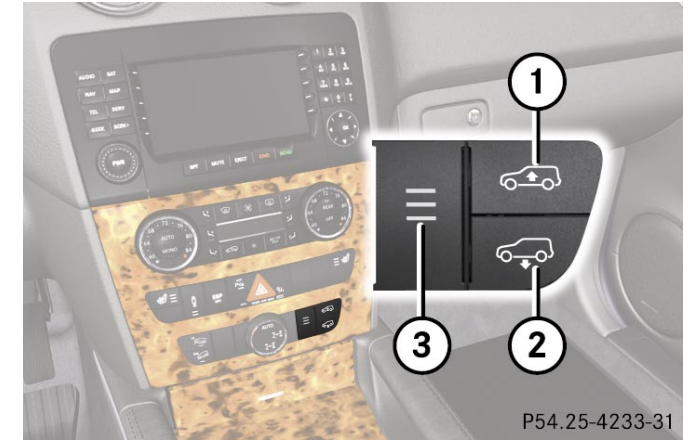
The customer can select three damping system maps using the button (N72/1s3). The switching sequence is predefined.

AUTO	LED's off
SPORT	Upper LED on
COMFORT/COMF	Lower LED on



The vehicle level can be changed (air spring code 489) by using the button (N72/1s2)

Normal level	LED off
Offroad level	LED on



The vehicle level can be changed in four steps (code 430) using the button (N72/ )

Normal level	LED off
Offroad levels 1-3	LED's on for the corresponding level

The customer can activate the Highspeed level using a defined vehicle speed or by selecting the "Sport" damping performance map.

## Components

The AIRmatic system consists of the following components:

- \* Four air springs support the vehicle
- \* Compressed air reservoir
- \* Air pump
- \* Valve block/valve unit
- \* Level sensor and body acceleration sensor
- \* Level control with selectable levels
- \* Adaptive damping system (ADS) with 3 damping performance maps
- \* The ADS system controls the setting of the vehicle damping dependent on:
  - the driver's selection/desired setting
  - the vehicle body acceleration

## Struts

The basic design of the suspension struts is familiar from the 220 model series. Thicker rubber bellows have been installed to reduce possible damage in case of air leakage. The shock absorbers and bellows are physically separated in the rear axle.

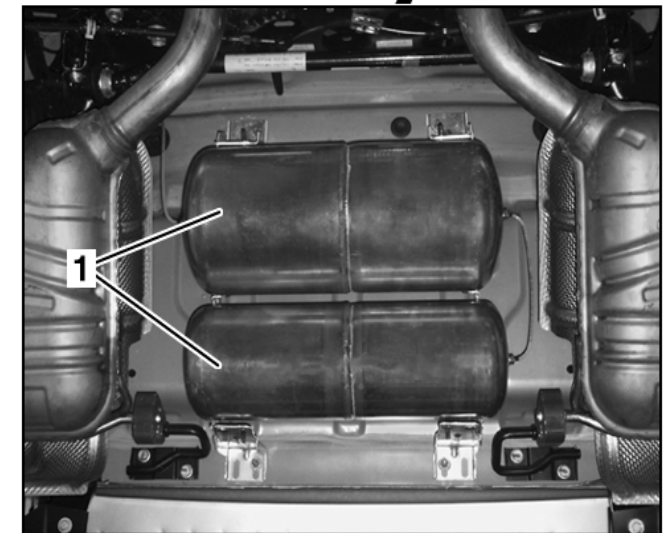
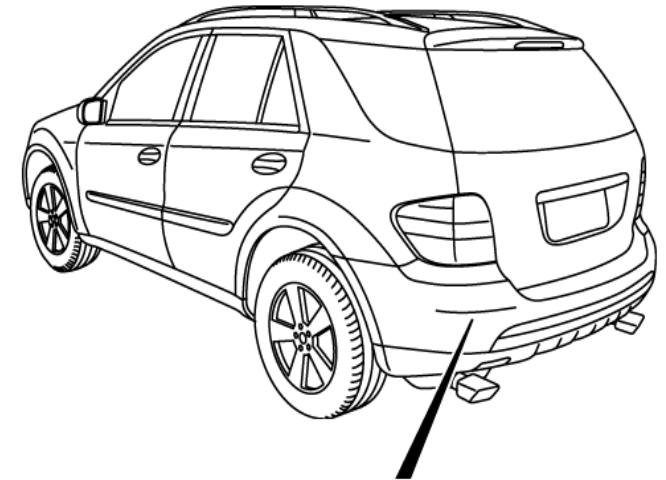
## Compressed air reservoir

### Task

Storage of compressed air for level adjustment. To guarantee fast adjustment times of vehicle level independent of compressor operation. To enable level adjustment without actuation of the AIRmatic compressor unit (A9/1) when stopped or at low speeds.

Normal air bellows pressure: 6-11 bar

Volume of 12.6 liters (system pressure 16 bar) broken down into 8.1 liters in a larger reservoir and 4.5 liters in a smaller one



P32.22-2337-03

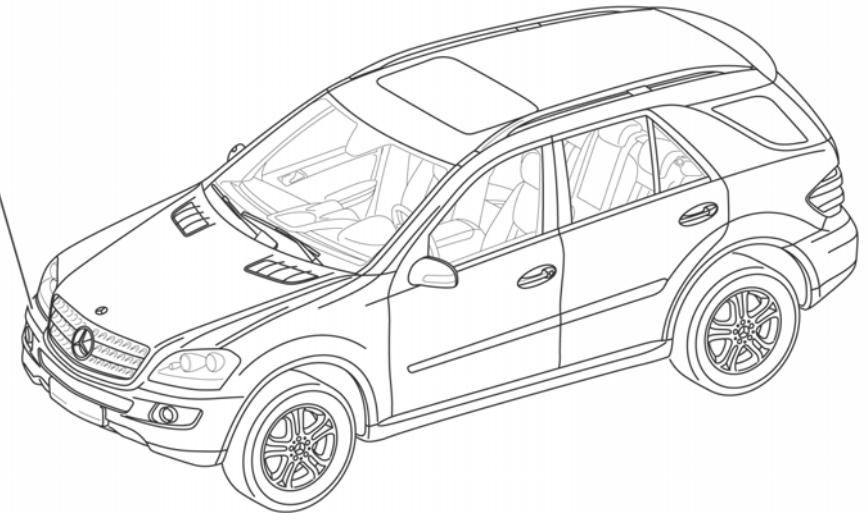
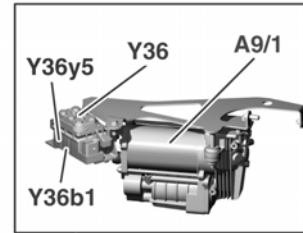
## Compressor

The AIRmatic compressor unit (A9/1) is located on a bracket behind the right side of the bumper. The AIRmatic compressor unit generates the air pressure required to raise the vehicle.

### Function

Compressor motor actuation does not take place directly via the AIRmatic control unit with ADS (N51), rather the load current is switched via the AIRmatic relay. A drain valve has also been integrated into the AIRmatic compressor unit to assist in lowering the vehicle level.

If an excessively high pressure is generated in the AIRmatic compressor unit by mistake, it is reduced automatically by an integrated mechanical pressure relief valve.



P32.22-2339-06

### Function

The electronic rear axle level control compensates for load influences acting on the rear axle. To this end the system is equipped with two air spring bellows on the rear axle, which take up the entire static and dynamic contact area.

If the AIRmatic compressor unit pumps air over the valve for the electrical rear-axle level control into the left air spring bellows or the right air spring bellows, the vehicle level is raised.

Inversely, the vehicle level is lowered, when air is vented over the AIRmatic pressure reduction valve (A9/1y1) in the AIRmatic compressor unit.

Under normal driving conditions the AIRmatic compressor unit operates - depending on the load - at a pressure between 6 and 10 bar or 87 psi and 145 psi.

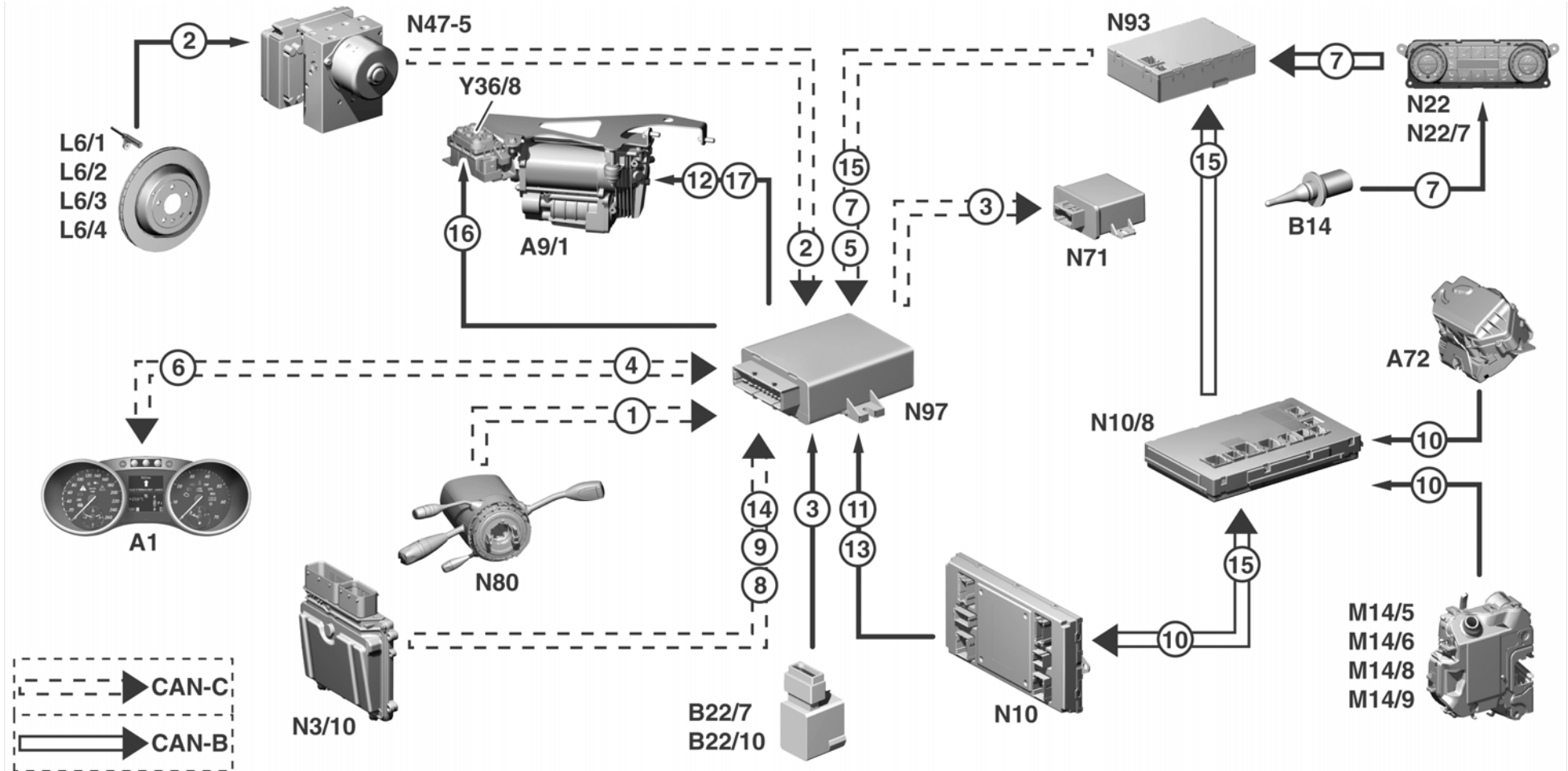
### Wake-up input

The right front door rotary tumbler microswitch (M14/5s1), left front door rotary tumbler microswitch (M14/6s1), left rear door rotary tumbler microswitch (M14/8s1), right rear door rotary tumbler microswitch (M14/9s1), the rear door locking unit and activities of the transmitter key (A8/1) the rear axle level control system control unit is woken up when the ignition is switched off (Terminal 87 OFF) by the front SAM control unit over a hardware line, to check the instantaneous vehicle level, and correct it if necessary.

The status of the rotary tumbler microswitch and the rear door locking unit is evaluated by the rear SAM control unit and forwarded to the front SAM control unit over CAN-B.

With the ignition switched on the front SAM control unit sends a wake-up signal to the rear axle level control system control unit, as long as at least one door or the load compartment is open or an opening and closing process is underway using the transmitter key.

Because actuation of the AIRmatic compressor unit with the combustion engine at a standstill would place excessive strain on the on-board electrical system, the AIRmatic compressor unit is generally not actuated when in the wake-up mode.



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1	Steering angle sensor signal	A1	Instrument cluster	M14/9	Right rear door CL [ZV] motor
2	Wheel speed signals	A9/1	AIRmatic compressor unit	N3/10	ME-SFI [ME] control unit
3	Level sensor signals	A72	Rear door locking unit	N10	Front SAM control unit
4	Driven distance	B14	Outside temperature display temperature sensor	N10/8	Rear SAM control unit
5	National code			N22	AAC [KLA] control and operating unit
6	System/error messages	B22/7	Left rear level sensor	N22/7	Comfort AAC control and operating unit
7	Outside temperature	B22/10	Right rear level sensor	N47-5	ESP control unit
8	Atmospheric pressure	L6/1	Left front rpm sensor	N71	Headlamp range adjustment control unit
9	Vehicle data	L6/2	Right front rpm sensor	N80	Steering column module
10	Door/rear door contact status	L6/3	Left rear rpm sensor	N93	Central gateway control unit
11	Wake-up signal for door/rear door contact	L6/4	Right rear rpm sensor	N97	Rear axle level control system control unit
12	AIRmatic compressor unit motor load current	M14/5	Right front door CL [ZV] motor	Y36/8	Electronic rear axle level control valve unit
13	Terminal 87	M14/6	Left front door CL [ZV] motor		
14	Intake air temperature for AIRmatic compressor unit control	M14/8	Left rear door CL [ZV] motor	CAN-B	CAN-Class B
				CAN-C	CAN-Class C
15	Terminal 61 signal				
16	Level valve actuation				
17	AIRmatic pressure reduction valve actuation				

## 1 Air suspension

For its new S-Class, DaimlerChrysler in close cooperation with the development partner Thyssen-Krupp-Bilstein has realized a fully bearing air spring system with the aim of clearly outperforming the properties familiar from the current S-Class. In combination with a fully automatic damper adjustment this air suspension provides top quality ride comfort and vehicle dynamics. The outside air springs are equipped with inset bellows optimized in terms of harshness with a wall thickness of 1.6 mm. The adaptive damping system II (ADS II) comes with four damper characteristics, two of which are switched to a skyhook mode if defined thresholds in sprung mass vibrations are exceeded. Through application of declining characteristics it was possible to further improve the vehicle dynamics and ride comfort properties. In contrast to other skyhook systems, ADS II dispenses with the need for sensing of wheel movement. The ride control is electronically regulated, the control unit is part of the CAN Class C-data bus network.

### 1.1 Introduction

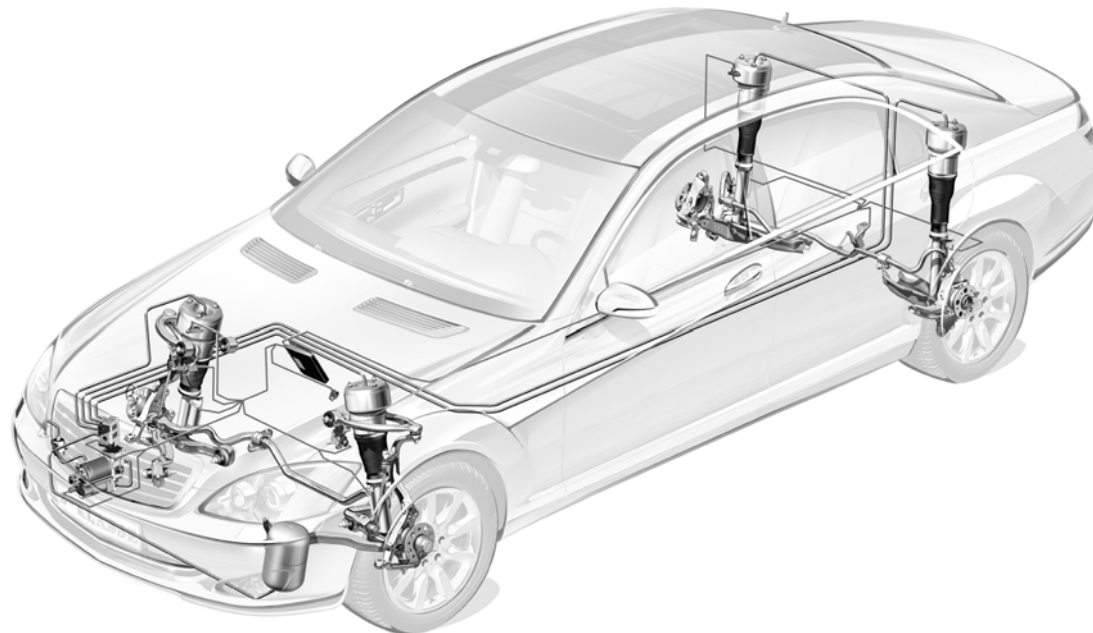
The primary goal in development of the air suspension system for the new S-Class was the realization of outstanding ride comfort. The intention here was to outperform the current S-Class. At the same time however, allowances also had to be made for an increase in vehicle dynamics, something which normally for a vehicle in this class is only possible by compromising comfort. To solve this conflict of objectives, one decided to opt for an air suspension system with a damper adjustment system with declining characteristics and an extremely effective skyhook control. This system enables ride comfort and vehicle dynamics to be combined at the highest level.

## 1.2 System features

### 1.2.1 Air suspension

The advantages of 4-corner air suspension in detail are:

- Comfortable vibration response with almost constant natural body frequency across the vehicle's entire weight range (load)
- Outstanding tire comfort even during activation with small amplitudes, through application of harshness-optimized inset bellows on outside of front and rear axles
- Soft base suspension realizable, because the automatic all-round level and control makes it independent of the load status and thus the full spring travel is always available
- Design advantages, because the vehicle level is always constant
- Manual raising of vehicle to increase ground clearance on rough roads or on unfavorable entrances
- Automatic lowering of vehicle, depending on speed, to enhance directional stability and road adhesion and to reduce aerodynamic drag
- Environmentally-compatible operating medium (air).



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### 1.2.3 Damper adjustment

To be able to fully utilize the advantages of air suspension, it is advisable to combine them with an automatic damper adjustment:

- Optimum ride comfort through extremely soft base damping under a normal, low-dynamics journey
- Immediate adaptation of damper characteristics to vehicle dynamics. Thus for example in the event of an evasive maneuver, the damping force is adapted within 50 ms to match requirements
- Through the use of the skyhook control, each wheel is assigned its own damper adjustment to enable it to retain directional stability and road adhesion and simultaneously to settle the vehicle body.

## 1.3 Description of overall system

### 1.3.1 System design

The system consists individually of:

- Air suspension struts on the front and rear axle with ADS II adjustment dampers
- Pressure supply unit with electrically driven dry-running, dual-stage compressor with regenerative air drier, drain valve, residual and pressure relief valves, three-point suspension over steel springs, vibration limiting over rubber buffers
- Distributor block mounted on same bracket with integrated reservoir charge valve and Pressure sensor for reservoir control
- Aluminum central reservoir
- Electronic control unit with CAN bus networking
- Three turning angle sensors for level sensing
- Steering angle sensor and three body acceleration sensors for damper control
- C/S button for damper control program selection
- Level select button for selection of raised level
- Display option for system notification messages in instrument cluster display
- Stabilizer bars with scorched torsion bushings and transfer linkages with ball joints to the front axle and rubber mounts to the rear axle.

### 1.3.2 System behavior in vehicle

The full-bearing air suspension is designed as an open system, i.e. vehicle position and control operations are achieved by adding or reducing the amount of compressed air. The suspension struts are designed for a maximum static pressure of 10 bar. The vehicle position is regulated by means of the wheel specific assignment of the solenoid valves. Actuation is conducted using pulses for specific wheels, to enable the vehicle to be horizontally aligned. The control process is electronic. The control unit is part of the CAN data bus system. The primary control variables are recorded by the system's own sensors. A central pressure sensor for system pressure. Three body acceleration sensors lf, rf, rr for recording sprung mass vibrations. Supplemental data from the CAN data bus are driver request (specification of normal or raised level or the comfort/sport characteristic map), vehicle speed, steering wheel angle, door and load compartment contacts, braking torque, engine torque, engine manifold air temperature, atmospheric pressure and ignition ON/OFF. The electronic control unit also contains an automatic locking function, in other words in certain situations such as "Changing wheel using jack" or "Vehicle on lifting platform" each control such as, for example draining air from suspension struts or compressor operation are suppressed. This situation is detected by the software. The air suspension system is supplied by air by means of an electrically-driven dual-stage compressor unit, which is installed in the right front end. It encompasses an electric motor with approximately 400 W power absorption capacity, an electronically-driven drain valve as well as a pressure relief valve and a residual pressure valve. An integrated, maintenance free silicate gel air drier, stores the humidity of the aspirated air and regenerates itself during draining operations. The dual-stage loading principle of the compressor enables the system's control performance to be yet further enhanced. The system is equipped with a central reservoir with 3.9 l volume (filling pressure 16 bar), to be able to silently regulate the vehicle load when at a standstill. Also attached to the compressor bracket is the valve unit with the reservoir charge valve and a central pressure sensor. The pressure sensor is not only for regulating the centralreservoir pressure, but also for monitoring each pressure applied to the suspension strutsduring control operations, so that faults in the system can be detected, for example through a filling operation during a specific period not resulting in a corresponding change in level.

### 1.3.2.1 ADS II damping system

The ADS II adaptive damping system is a fully automatic electronically operated system, which adapts the damping force at each individual wheel to the momentary requirement. In comparison to a passive system with constant damper adjustment the vehicle is stabilized equally for all driving conditions, which ultimately enhances directional stability and road adhesion while tangibly stabilizing the body. Both the primary working piston in the damper, and the bypass piston in the ADS-valve are designed as declining pistons. This enables an additional spread of the damping forces between the compression and rebound stages and thus a more comfortable and similarly sporty setup. With the aid of two shift valves in the ADS modules, which are flange-mounted to the single-tube gas pressuredampers, a bypass for rebound stage damping and a bypass for compression stage damping can each be activated. Up to 4 damper characteristics can be realized.

Characteristic 1: bypass rebound open, bypass compression open, soft rebound stages and soft compression stage damping

Characteristic 2: bypass rebound closed, bypass compression open, firm rebound stage and soft compression stage damping

Characteristic 3: bypass rebound open, bypass compression closed, soft rebound stage and firm compression stage damping

Characteristic 4: bypass rebound closed, bypass compression closed, firm rebound stage and firm compression stage damping.

Where only a low vertical and horizontal dynamic is applied, characteristic 1 is activated. The vehicle should provide maximum comfort. Characteristic 1 realizes the default operating mode for the ADS II system. The system uses its own sensors (body acceleration  $l_f$ ,  $r_f$  and  $rr$ ) and the data from the CAN bus (vehicle speed, steering wheel angle, braking torque, engine torque) to permanently determine the applied instantaneous vertical and horizontal dynamics. If the vertical or horizontal dynamics exceed the specified threshold value, the default operating mode (= characteristic 1) is exited. If the vertical dynamic threshold value is exceeded the skyhook operating mode is activated. The system's own body acceleration sensors  $l_f$ ,  $r_f$  and  $rr$  are used to determine the body speed through integration over each wheel. For the skyhook operating mode the damping force per wheel is set such that maximum body stabilization is achieved:

The permanently installed “crosswise plating” in the dampers of characteristics 2 and 3 means that in contrast to other skyhook system the wheel movement does not need to be sensed, which in turn means that the shift valves need only be designed for the body frequency range, as they do not respond to directional changes in wheel movement. The vertical dynamic threshold values of the skyhook operating mode are dependent on the driver request (comfort/sport), road condition, vehicle speed and lateral acceleration. The dependency on the road condition should serve to ensure that the skyhook operating mode is primarily deployed on smooth roads with low-frequency excitation. As soon as the road condition worsens and the high-frequency road percentages increase, the thresholds for the skyhook operating mode are raised. When on poor roads it is advantageous to activate characteristic 1 for a longer period in favor of achieving a better sensing characteristic. The road condition is determined for each wheel by evaluating the high-pass filtered body acceleration. Apart from this the body speed  $l_f$  and  $r_f$  is used to permanently determine the roll velocity. If this roll velocity exceeds a threshold value which is dependent on vehicle speed, then, for all the wheels, exclusive firm shifting of the rebound stage in accordance with the skyhook logic stabilizes the body under road-surface induced rolling. If horizontal dynamics are present then a dual-stage strategy is activated. In the event that any medium strength horizontal dynamics should be exceeded then, starting with characteristic 1, only the rebound or compression stage is shifted firmly per wheel. If the horizontal dynamics continue to increase then when a second threshold limit is exceeded at all four wheels the rebound and compression stage are firmly shifted (characteristic 4). Activating the firm damping characteristics relative to the horizontal dynamics serves to guarantee driving safety in critical situations. With medium horizontal dynamics the body may be slightly stabilized in favor of driving safety, without compromising comfort to any significant degree. If a vehicle speed drops below 160 km/h (sport driver request: 40 km/h) then the compression stage is set to firm for all four wheels. This in turn means that the vehicle body is better connected at high vehicle speeds. The above-mentioned operating modes may overlay without any problem (for example in the event of simultaneous occurrence of vertical and lateral dynamics). The bypass valves in the damping modules are designed such that in a de-energized state they are closed. This serves to ensure in the event of any system malfunction that the greatest possible damping force is pending and thus driving safety assured.

### 1.3.3 Control concept for level selection

A load-independent all-round level and control enables the vehicle to be regulated to a required level, picture 14. This influences the visual overall impression positively. The following level adjustments are possible:

Raise level driver request: Level raised to +30 mm to increase the ground clearance on rough roads  
Comfort driver request: Automatic, speed-dependent level lowering to -10 mm on both axles for reduction of aerodynamic drag and for lowering of vehicle center of gravity when exceeding 120 km/h.  
Resetting of level to 0 mm  
when dropping below 80 km/h. Further level lowering to -20 mm on both axles when exceeding 160 km/h. Resetting of level to -10 mm when dropping below 120 km/h  
Sport driver request: Automatic, speed-dependent level lowering to -20 mm on both axles for reduction of aerodynamic drag and for lowering of vehicle center of gravity when exceeding 100 km/h. Resetting of level to 0 mm when dropping below 60 km/h.

The system is activated by means of a wake-up function, which when the doors or luggage compartment flap are open or it starts up when the remote control is operated. If the vehicle level is deemed to be too low, the vehicle is raised before starting by means of the central reservoir and/or compressor.

The driver has the option to influence the damping using the Comfort/Sport switch, in order to select his/her required suspension characteristics. The Comfort/Sport switch enables both a comfort and sporty suspension to be experienced in the vehicle. Assignment of the damper settings is available in Table 5.



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## **1.4 Major assembly design**

### **1.4.1 Suspension struts**

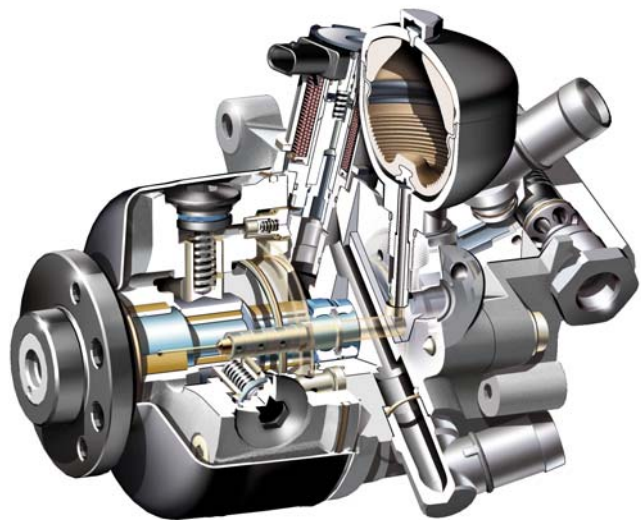
#### **1.4.1.1 Front-axle suspension strut**

The suspension struts, have been redesigned and further developed, based on the tried-and-tested model series 220 design. In doing so the force path of the spring, damper and compression buffer are separated. Thus the damper head bearing for transmission of damping forces could be specifically adapted to the requirement profile. The buffer forces are introduced directly over massive metal components into the vehicle shell. The damper head bearing is designed on very soft cardanic suspension to enable the kinematic motion of the front axle to be followed across the entire spring travel, without introducing greater lateral forces into the suspension strut and thus into the guide elements of the damper. These lateral forces would result otherwise in increased friction and thus lead to a reduction in comfort. The dampers used here are single-tube gasfilled spring struts. The ADS module is mounted externally to the damper. The dampers contain diverse comfort-relevant measures, such as, for example a sintered bottom valve to lower the gas pressure and thus minimize the preload on the sealing unit. In combination with the air suspension internal pressure this results in an extremely low pressure differential on the piston rod gasket. A piston rod with diameter 14 mm, combined with a step-seal based single-lip seal also contribute to a friction reduction. Optimization of the step-seal-contour, and the special type of fastening for the sealing serve to guarantee refrigeration leaktightness. The piston-rod guide is located directly underneath, on the oil side. A low-friction, bronze-armored Teflon tape is inserted onto the operating piston. The total sum of measures resulted in a friction value of approximately 40 N. The base bearing of the suspension strut is designed as a “stationary” ball joint. This design enabled the breakaway torques that occur otherwise on a base bearing to be minimized. The actual air spring consists of a steelbody, which bears the upper clamping of the air spring bellows, serves as a limiting element for the stop buffer and simultaneously realizes the head bearing connection. Pressed and caulked onto this steel body is the external guide made of aluminum for the air spring bellows.

The external guide is cylindrical to match the space available and design of the air spring characteristics. The air spring plunger, also made of aluminum, is contoured for spring tuning. To be able to follow the kinematics, the air spring plunger has been pulled far down and mounted on soft cardanic suspension with thrust-absorbing rubber mounts on the damper, which at the same time brings about an acoustic decoupling. Because of the low-mounted point of force application on the damper the lateral forces on it, and thus the guide friction in the damper, are held low even under deflections. The cap contains the mounting for the redesigned residual-pressure pressure-maintaining valve.

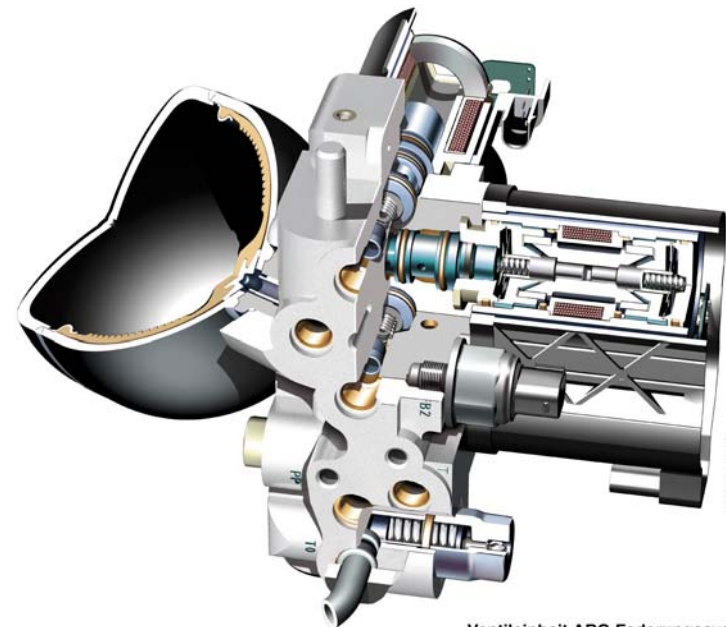
#### 1.4.1.2 Rear-axle suspension struts

The rear-axle air suspension strut with the exception of adaptations regarding axle load and spring travel, is identical both in concept and design terms with the suspension strut of the front axle. The basic components were able to be standardized. Both suspension struts have an equal amount of aluminum components. For weight reduction purposes this material was systematically used. Similarly in both suspension struts thin-walled inset bellows were used.



Tandempumpe ABC-Federungssystem (Active Body Control)  
S-Klasse (BR221)

P32.50-2234-C81



Ventileinheit ABC-Federungssystem (Active Body Control)  
S-Klasse (BR221)

P32.50-2233-C81

These bellows, with a wall thickness of 1.6 mm, were optimized in terms of rubber and fabric properties such that it clearly outperformed the previous benchmark, for the current S-Class, without any incurring any compromises in its technological properties. This so-called harshness characteristic is a decisive measure for the rolling characteristics of an air-sprung vehicle and thus also a measure of perceivable ride comfort. The air suspension is designed as an open system, in other words the required vehicle position, i.e. level is achieved by adding or removing compressed air. This is pulsed, over wheel specific assignment of 2/2 solenoid valves, in order to raise the vehicle as uniformly as possible. The level valves are combined in the valve block mounted in the compressor. The reservoir charge valve and pressure sensor, which monitors the filling pressure of the central reservoir and the suspension strut pressures when the valves are correspondingly switched, are also integrated into this valve block. The electrically driven, dual-stage compressor unit, picture 17, and the valve block are mounted on a common bracket in the right front end. The compressor contains an electric motor (400 W), an electronically driven drain valve and a pressure relief/residual pressure valve. An air drier stores the humidity in the aspirated air and is regenerated when venting the system's dry air. A paper air filter is integrated into the air suction-tract length. The compressed air is routed over the valve block to the spring elements and the central reservoir. To ensure that a suitably short level control time is given, the system is equipped with a pressure reservoir (filling pressure 16 bar), which enables silent raising at a standstill and which is installed in the left front end below the lamp units. The pressure lines between the air pump, reservoir and spring elements are made of PA 6.6. Special connectors serve to ensure simple assembly and disassembly as well as optimum refrigeration leaktightness.

#### **1.4.2 Control unit and sensor system**

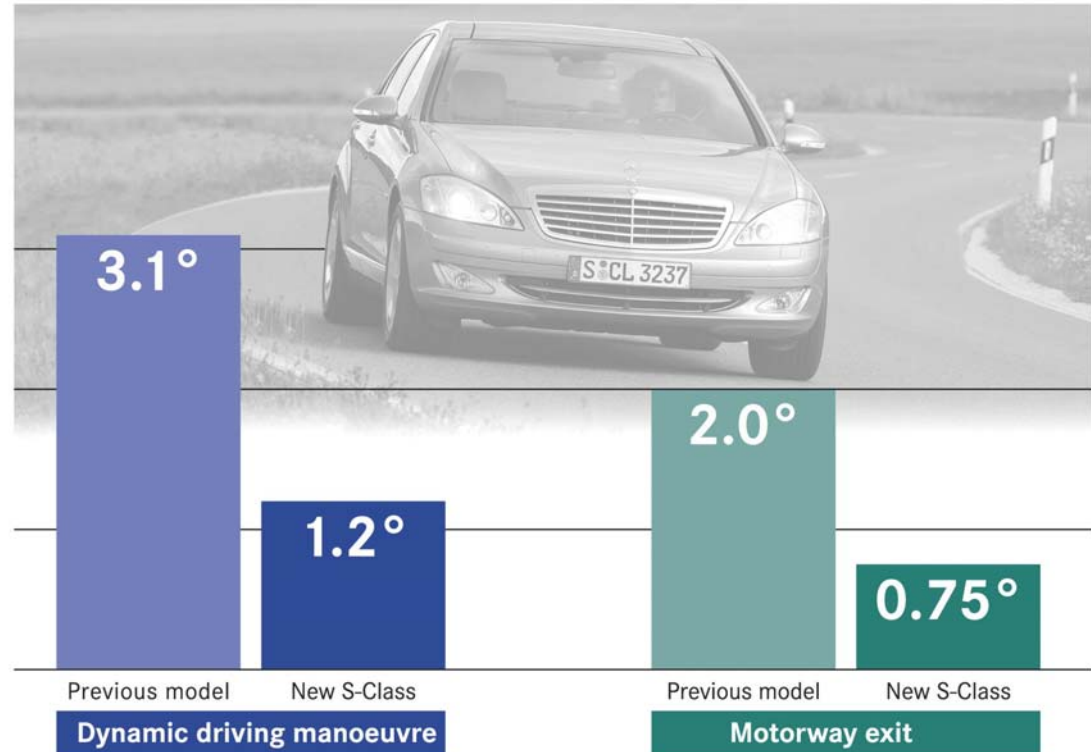
The control process is electronic. The control unit is part of the data bus network. Important controlled variables for the level control are the current vehicle level (load status, driver request), and the vehicle speed. The vehicle level is transmitted to the control unit by three level sensors, of which two are located on the front axle and one on the rear axle. In addition to this the control unit also records signals from three body-mounted acceleration sensors, from the steering angle sensor, and the data for speed and brake actuation stored in the CAN, in order to determine the current damper requirement and to switch to the corresponding damper characteristics. The control unit contains an automatic locking function, in order to suppress a control intervention in certain situations (wheel changing with jack etc.).

## 2 Active Body Control - ABC

### 2.1 Development goals for ABC active suspension

Through the use of ABC in the predecessor model series 220 it was possible to achieve a previously unattained degree of vehicle dynamics coupled with outstanding ride comfort. This active suspension combination from Mercedes-Benz is still unique today. Now the development goal for model series 221 was to further boost the vehicle dynamics of the ABC system while retaining the model series 220 ride comfort.

Active Body Control in the new S-Class: 60 percent less roll than the previous model



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## 2.2 System design

The new generation ABC system, picture 18, is geared towards the design of the predecessor system. To be able to realize the development goals, the control algorithm and the hydraulic components have been completely redesigned. Four suspension struts with plunger cylinders are controlled by the microprocessor and are capable of almost completely eliminating vertical, rolling and pitch motion. The microprocessor records each respective driving situation by evaluating the transversal, longitudinal and vertical acceleration sensor signals and the pressure sensors assigned to each individual suspension strut, the level of the body is determined with the aid of level sensors on the control arms of the front and rear axles. The computed control signals are then converted by servo-hydraulic valves into oil volume flows which adjust the plunger cylinders. The engine-side pressure supply then supplies the servo-hydraulic valves with a hydraulic pressure of up to 200 bar. The constantly available system pressure and the deployed pressure reservoirs enables the ABC system to respond within fractions of a second to the first signs of any body motion. The locking valves mounted in the valve blocks prevent the vehicle level from lowering while at a standstill. An effective cooling and oil-supply concept serves to round off the system's hydraulic design.



Federbein Vorderachse ABC-Federungssystem (Active Body Control)  
S-Klasse (BR221)

P32.50-2228-C73

## **2.3 ABC function**

As in the predecessor ABC system of model series 220, the new ABC system minimizes body motion in vertical, rolling and pitch directions as soon as the first signs appear. The ABC system of model series 221 excels on account of its greater body horizontal alignment compared with the model series 220. A “Comfort” or “Sport” driver request is executed over the central program selection button S/C/M in the center console. Selector position C selects the ABC Comfort performance map, and this setting achieves a distinctly better horizontal alignment compared with model series 220. In selector positions S and M, the ABC is operated in the sporty mode providing further improved horizontal alignment and body damping. In addition to this the dynamic driving properties of ABC vehicles are adjusted with the aid of variable ground speed rolling-moment distribution between the front axle and rear axles. The load adaptation capability of the ABC control algorithm enables the vehicle's load status to be considered accordingly. The vehicle level can be raised at the touch of a button by 40 mm to enable obstacles to be avoided when driving over them and for driving on rough roads. In driving mode the vehicle level is lowered by up to 15 mm to help reduce fuel consumption.

### **2.3.1 ABC components**

To ensure excellent overall functionality all the hydraulic components and the line technology have been completely redesigned and have undergone advance development, the long-term development work was rounded off by intensive component trials.

### **2.3.2 Control unit with ABC control algorithm**

The heart of the ABC system is the microprocessor which contains the ABC control algorithm. As in the first-generation ABC, the controller is based on three control strategies, ABC controller (active body control), the skyhook controller and the longitudinal and transversal acceleration circuit. The active body control algorithm primarily defines the level behavior. This also realizes the all-round level and control of the ABC system. The input variables for the active body control algorithm are the relative paths between the body and the wheel and the pressure sensor signals. The skyhook control algorithm evaluates the body acceleration sensors and attempts to stabilize the body as far as possible irrespective of road bumps. With the aid of the longitudinal and transversal acceleration circuit, the interruptive sprung mass vibrations induced by the vehicle dynamics can be minimized.

### **2.3.3 Oil container, pump and line technology**

The ABC system's energy supply is provided by means of an adjustable high-pressure hydraulic pump, picture 20. It sucks the hydraulic fluid out of the oil container which is equipped with a fine filter and supplies the ABC with a system pressure of 180 to 200 bar for a volumetric oil flow of 1 to 11.5 l/min. The adjustability of the required oil quantity enables the energy consumption of the ABC system to be adapted to suit the respective driving situation requirements, thus achieving an excellent overall efficiency. To reduce the principle-related pulsations of the radial piston pumps, a pulsation damper is integrated in the pump itself, and this in turn means that any external pump noise abatement measures can mainly be dispensed with. The tandem pump supplies not only the ABC system, but over an integrated vane-type pump, it also supplies the hydraulic power steering with hydraulic power. The connection for the hydraulic components is made by newly developed lines and line terminals. The line terminals provide an extremely reliable sealing capability on account of their radial sealing concept. A high integration density of the pump and valve block system components enabled the circumferences of the line and terminals to be distinctly reduced.

### **2.3.4 Valve blocks for front axle and rear axles, rear axle pressure reservoir**

The front-axle valve block which is also a new development contains the components for system protection and for axle-specific energy storage and suspension strut actuation. In a first step an integrated pressure limiting valve restricts the ABC system pressure to maximum 200 bar. After this a permanently connected pressure reservoir ensures that the control valves are constantly supplied with high-pressure oil. The proportioning valves, when actuated by the control unit, enable volumetric oil flow to be increased or reduced to each assigned suspension strut. The cutoff frequency for the valves lies at approximately 15 Hz, which is sufficiently higher than the vehicle control range, so that any restriction to the requested vehicle dynamics is excluded. The locking valves located between the control valve and suspension strut reliably prevent a parked vehicle from lowering its level. The rear-axle valve block contains the control and locking valves for both rear-axle suspension struts. A pressure reservoir which is located in the vicinity ensures that in the event of any system oil requirement called up at short notice over the pump delivery rate a sufficient amount of high-pressure oil is made available for the rear-axle control valves and for actuation of the rear-axle suspension struts.

### **2.3.5 Suspension strut**

The ABC suspension struts are used to apply the forces required for the ABC function, to this end the suspension struts must be adapted to 22 of the new boundary conditions of the model series 221. The volumetric oil flow regulated by the control valves can flow into and out of an adjustment cylinder (plunger). This in turn means that the spring base point of the integrated steel springs can be adjusted and the forces required to stabilize the body or to boost ride comfort can be generated within fractions of a second. As in the ABC system of the first generation the body frequency range is actively regulated, the damping of higher frequencies (wheel frequency range) is performed by the passive twin-tube dampers. Modifications to the suspension struts also went beyond pure adaptation to the model series 221. New head bearings provide an excellent acoustic behavior, cardanic motion and the necessary decoupling from the body. Newly developed ball joints set up the connection to the axle. By means of an intelligent choice of spring rates the number of suspension strut variants has been able to be kept very low.

## **2.4 Summary**

The ABC development for the model series 221 represents another milestone in the development of active suspensions for Mercedes-Benz vehicles. A refined, active second-generation suspension has been created based on the outstanding driving functionality of the predecessor; the excellent features have served to boost vehicle dynamics while retaining ride comfort.





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