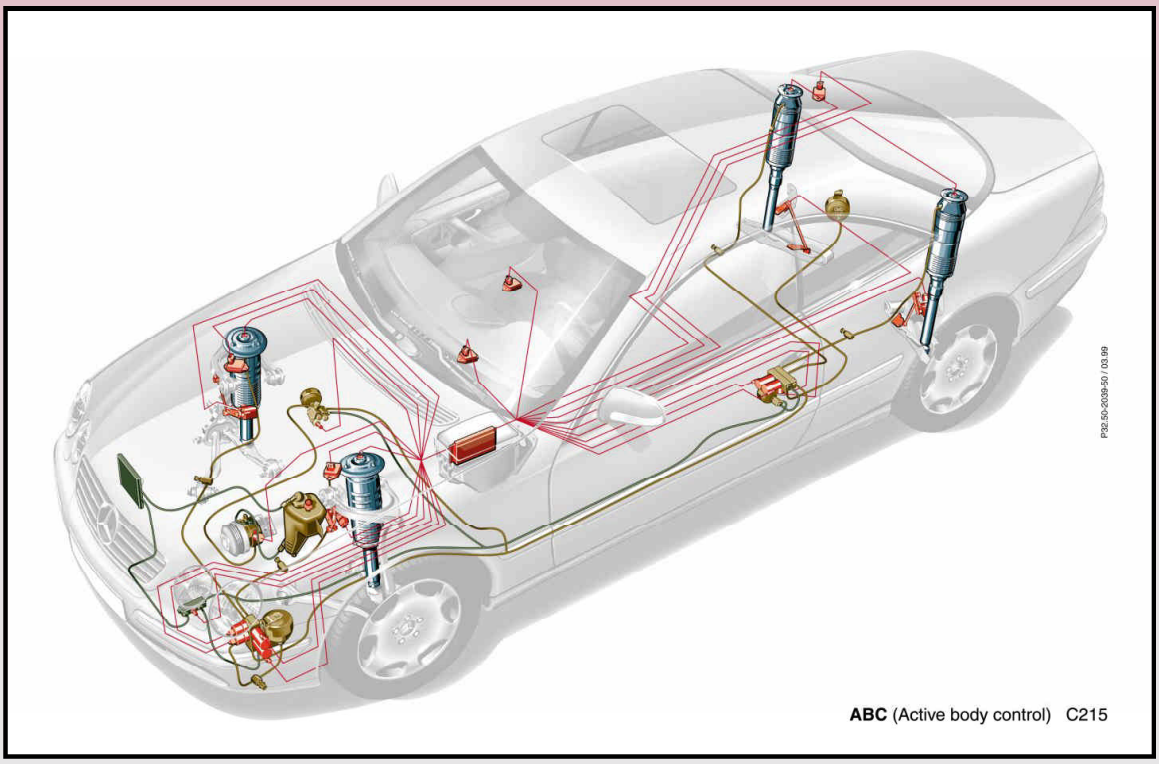
# Active Body Control (ABC) and (ABC Plus)



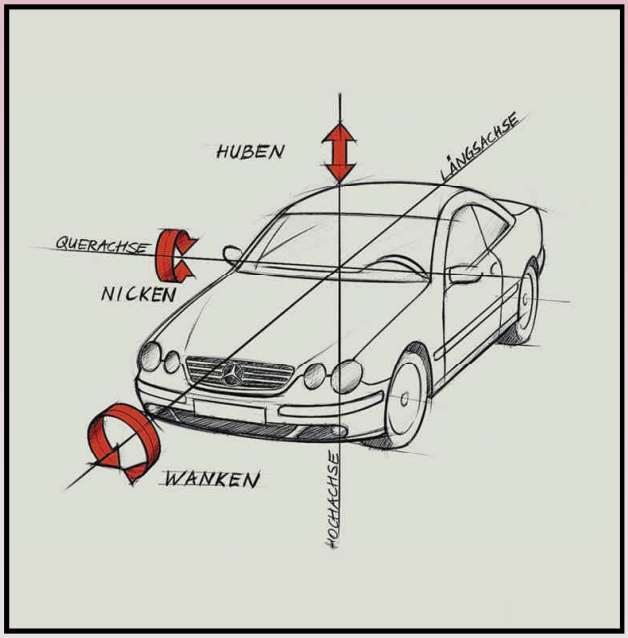

**ABC** (Active body control) C215

# Objectives

- Understand the advantages of the ABC and ABC Plus systems
- Understand the differences in the ABC and ABC Plus systems
- Understand operation of the components involved with both system
- Understand the hydraulic flow of both systems
- Understand the system algorithm for suspension control

# 220 / 215/ R230 Active Body Control (ABC) Advantages

- Full hydraulic suspension
- Both ABC and ABC Plus systems offer same basic advantages
  *(ABC Plus system differences will be covered at the end of this presentation)*
- Reduced body pitch and roll
- Elimination of sway bars and ADS II system
- Reduce body vibrations
- Automatic ride height adjustment at speed
- Driver option to adjust suspension firmness and raise ride height for road conditions

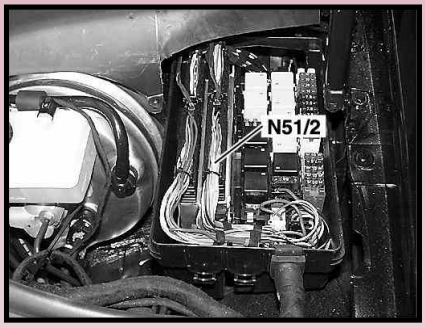


# Driver Inputs

- Driver can select between 3 ride heights using switch (N72/1s2)
  - Normal (no LED's)
  - Raise approx. 14 mm (1 LED)
  - Raised approx. 24 mm (2 LED's)
- At speed vehicle,s ride height will be lowered to  high speed level (driver selection to increase ride height will be cancelled)
- Sport switch (N72/1s3) reduces allowable body roll

# ABC Control Module (N51/2)

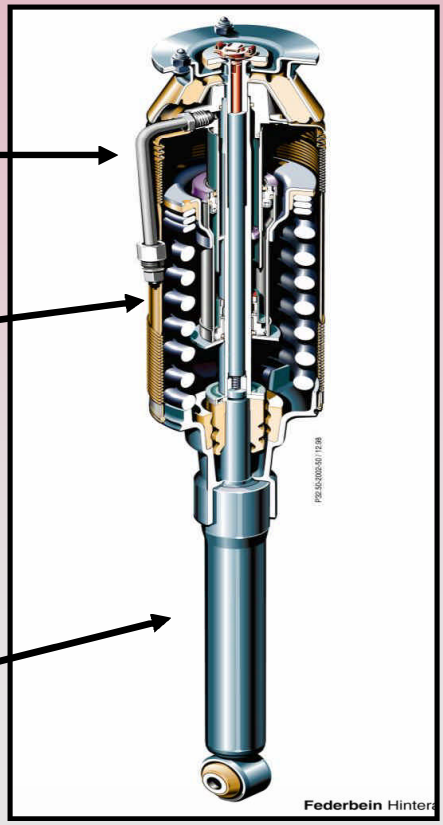
- Located next to LF SAM
- CAN C component
- Discrete wake up line from LF SAM
- Discrete inputs
  - 4 level sensors (2 opposing redundant signals from each sensor)
  - 3 body acceleration sensors
  - 4 plunger travel sensors
  - ABC pressure and temp. sensors
  - ABC lateral and longitudinal sensors
- Discrete outputs
  - ABC suction restrictor valve
  - ABC front and rear axle valve units




- CAN inputs
  - UCP (level, sport switches)
  - CGW
  - ME (RPM)
  - ETC (D/R, shift points)
  - IC (ambient temp, malfunction)
  - ESP (VS, braking)

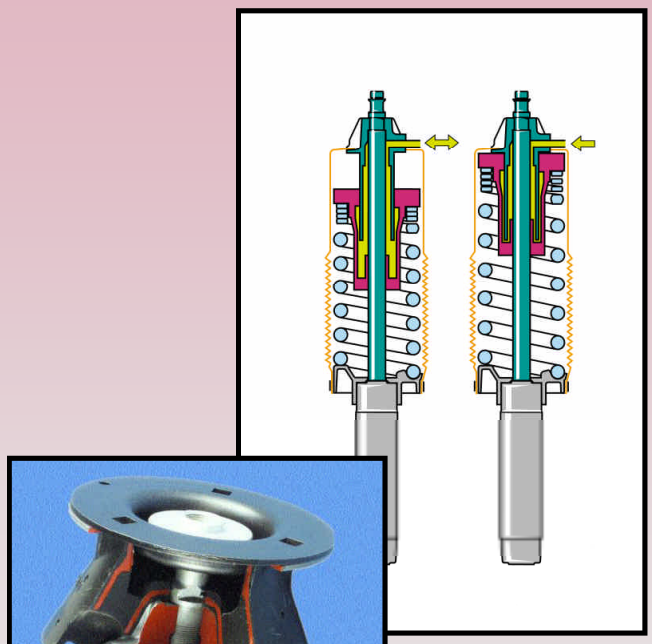
# ABC Struts

- Hydraulic fluid under pressure (approx. 200 bar) enters strut on top of spring
- Fluid compresses spring, changing effective spring rate
- Combination of hydraulic pressure and spring dampen vibrations up to 5 hertz
- Gas charged shock and spring dampen vibrations above 5 hertz



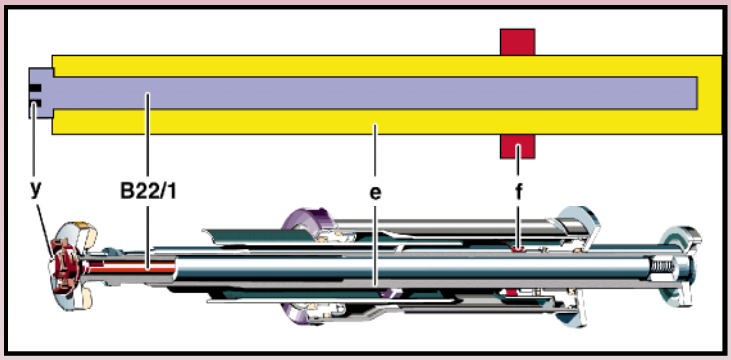
# ABC Struts

- Hydraulic fluid under high pressure used to compress spring and change spring rate, enters into a relatively small chamber
- Combination of the spring and hydraulic fluid under pressure supports the vehicle weight.
- Increasing and decreasing volume of fluid in strut regulates the ride height and controls suspension firmness
- Effective changes can be made up to 8 times per second

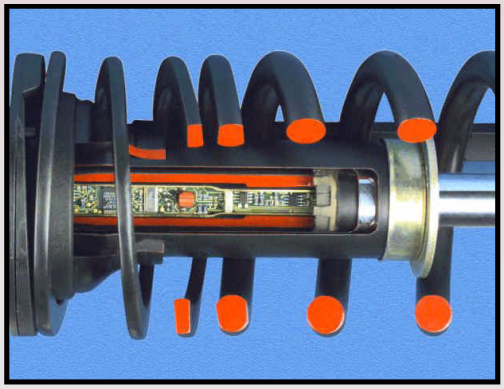


# Plunger Travel Sensors (B22/1,4,5,6)

- Magnetostrictive sensor
  - Integrated in strut
  - Can not be replaced separately
- Strut rods made of “austentenitic high grade steel” which can not be magnetized
- As strut rod passes through center of fixed magnet it alters length and width of the magnetic field creating small current pulses
- Changes in magnet field and current pulses used to determine position of strut rod



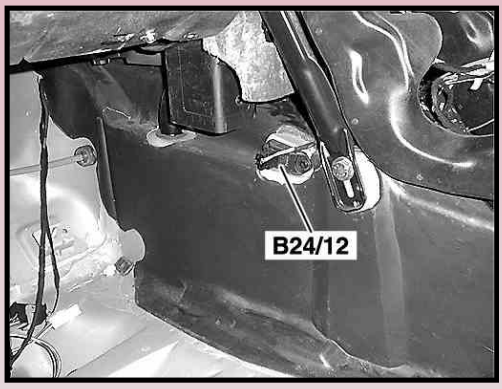

f = magnet
e = strut rod
y = electrical connector



Sensor electronics

# Acceleration Sensors

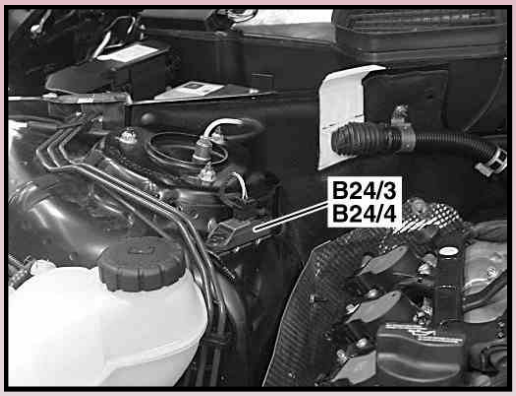
- Lateral acceleration sensor (B24/12) used to determine side to side movement of body
  - Separate from ESP combination sensor
  - Located left side of transmission tunnel
- Longitudinal acceleration sensor (B24/14) used to determine fore and aft movement of body
  - Separate from ESP combination sensor
  - Located under right front seat

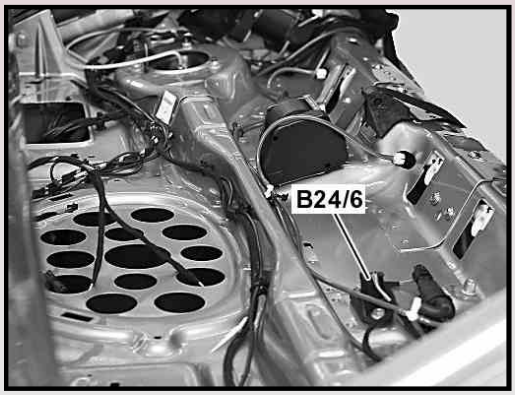



# Acceleration Sensors

- 3 body acceleration sensors used to determine vertical movement of body
  - Left front (B24/3)
  - Right front (B24/4)
  - Rear hat shelf (B24/6)

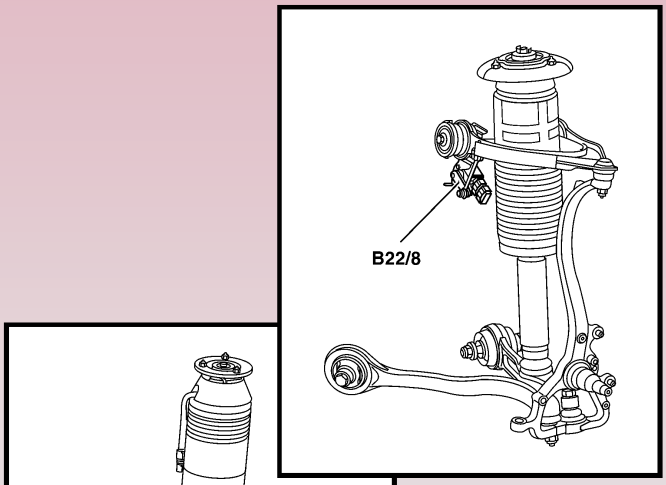
- Function is same as per ADS II presentation

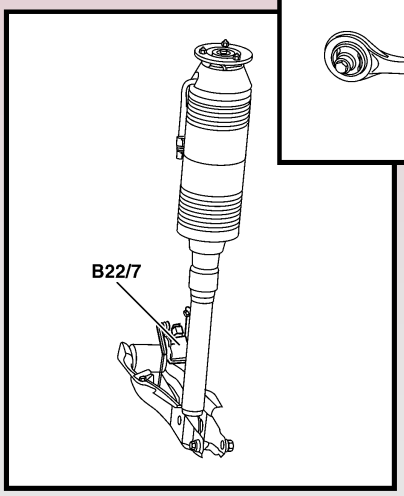


# Level Sensors (B22/7 – B22/10)

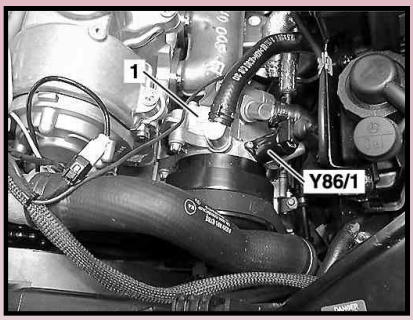
- 4 level sensors used
  - LF (B22/8)
  - RF (B22/9)
  - LR (B22/7)
  - RR (B22/10)
- Each contains 2 hall effect sensors
  - Transmits opposing / redundant signals
- Level must be recalibrated if any level sensor is replaced

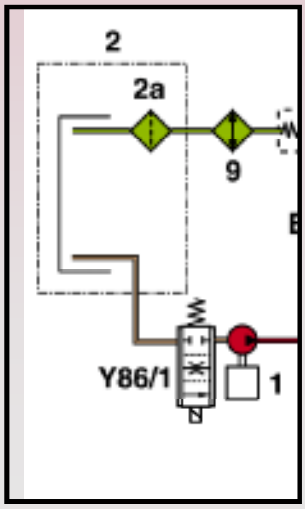


# High Pressure Pump

- Tandem 7-piston radial pump used for both ABC and power steering
  - Separate reservoirs
  - Same fluid (do not share)
- Suction restrictor valve (Y86/1) attached to pump
  - Adjust intake volume of pump to demand
  - Acts as a proportioning valve
  - Normally closed valve, however due to its proportioning function does not completely close

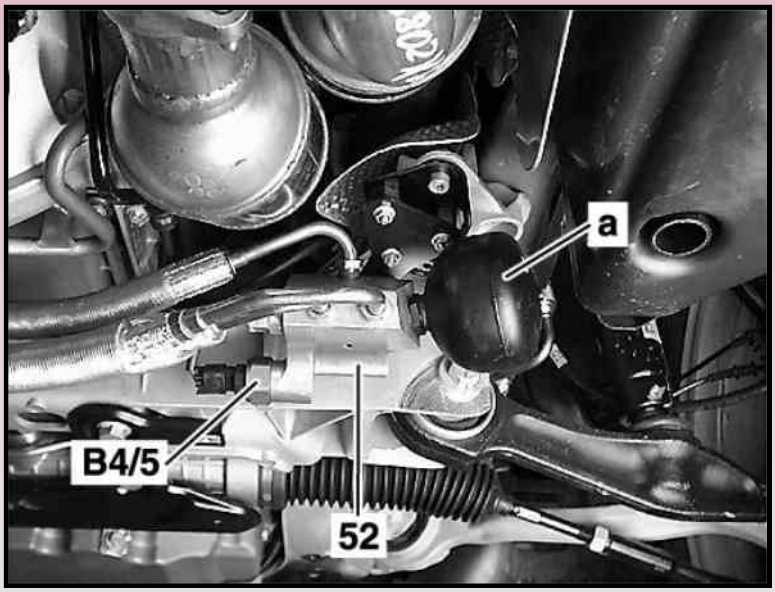


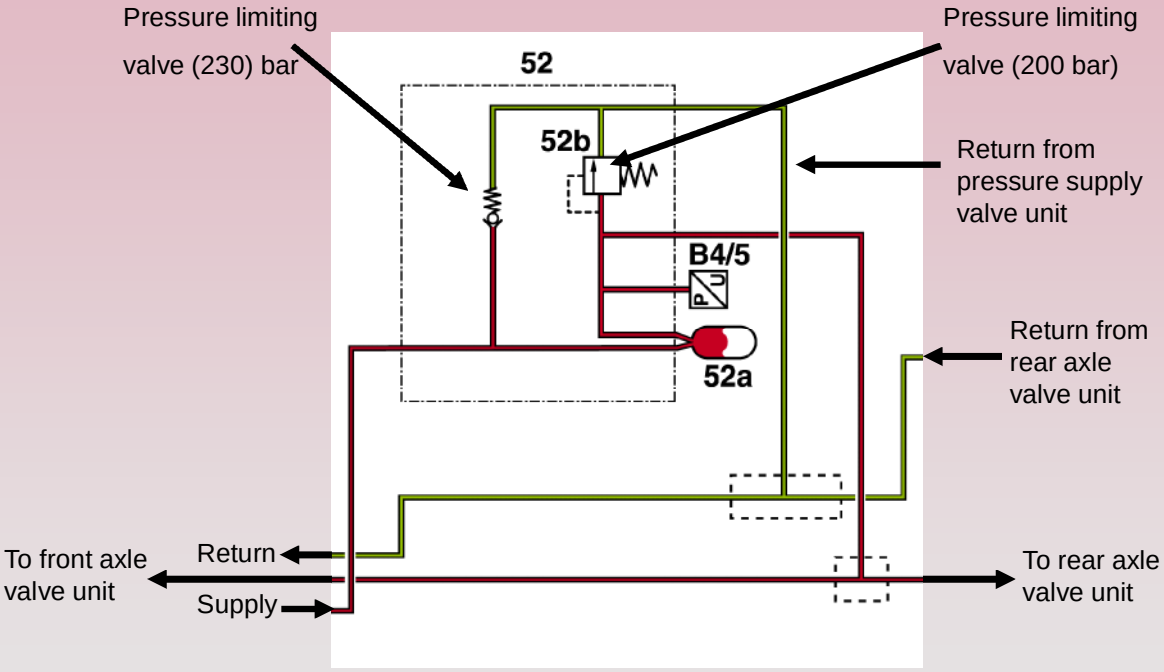

2 - reservoir
2a - filter
9 - cooler
1 - pump
Y86/1 - suction restrictor valve

# Pressure Supply Valve Unit

- Oil from pump is first routed to pressure supply valve unit
- Located behind right front wheel
- Components include:
  - pressure sensor (B4/5), used to measure system supply pressure
  - Pulsation damper (a)
  - 2 pressure limiting valves
    - First @ 200 bar
    - Second @ 230 bar



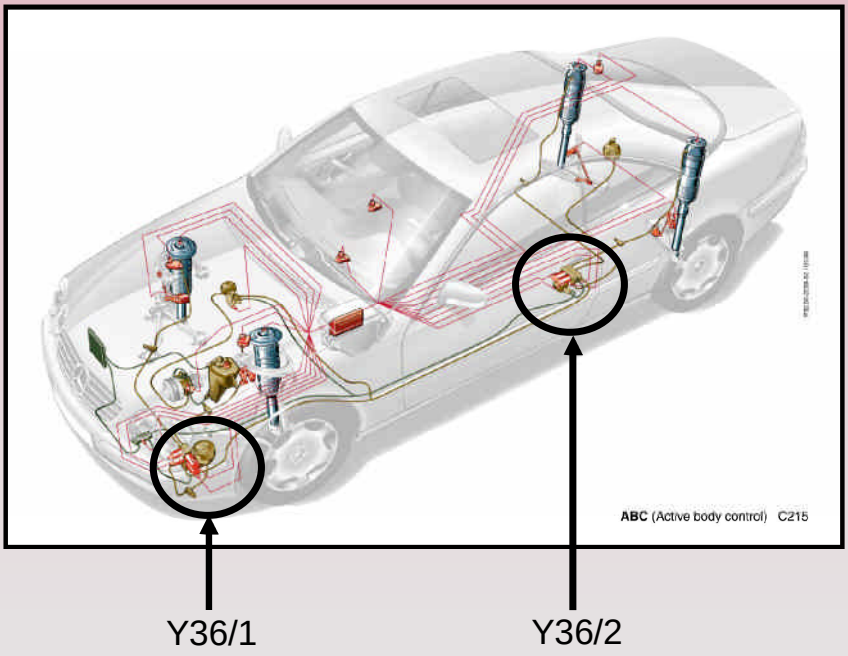
# Pressure Supply Valve Unit




Regulates and supplies pressure to both front and rear axle valve units

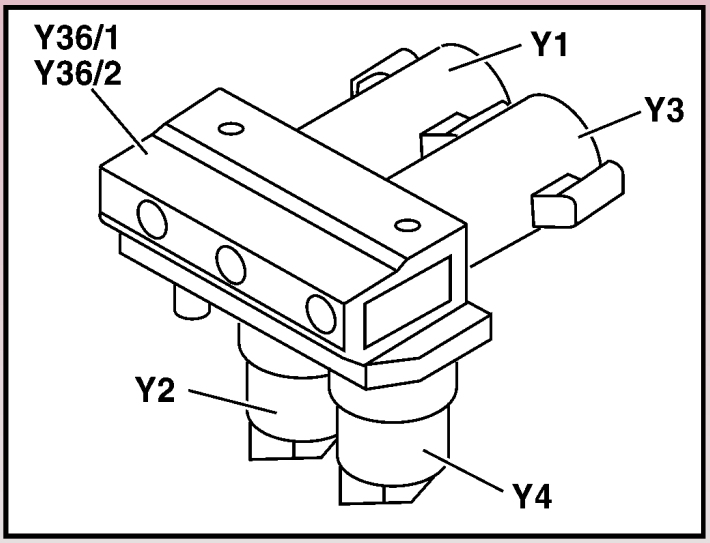
# Front (Y36/1) and Rear (Y36/2) Axle Valve Units

- Used to regulate oil supply into individual struts
- Each valve unit includes:
  - 2 regulating solenoids (1 for each wheel)
  - 2 shut-off valves (1 for each wheel)
  - Pressure reservoir (directly mounted on front or remotely mounted on rear)



# Front (Y36/1) and Rear (Y36/2) Axle Valve Units

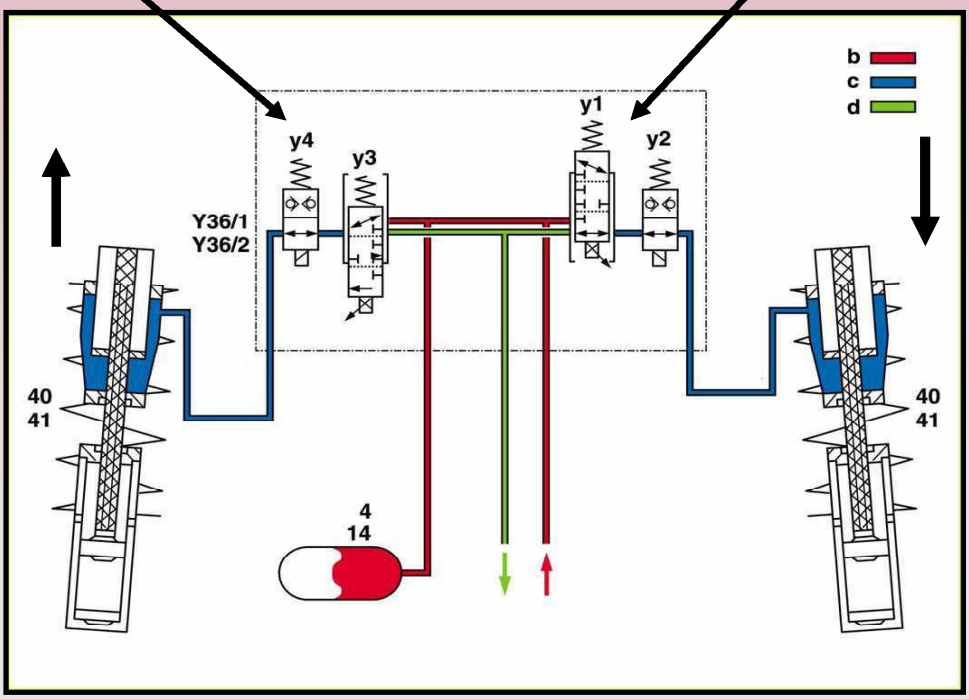
- Regulating valves (y1 and y3) are 3 position valves
  - Center position: closed
  - One direction: allows oil into strut
  - Opposite direction: allows oil to exit strut
  - Controlled by a PWM signal
- Shut off valves (y2 and y4) are normally closed
  - Energized to allow oil into or out of strut
  - Prevents oil from leaking out of strut in the event of regulating valve leakage



# Axle Valve Units

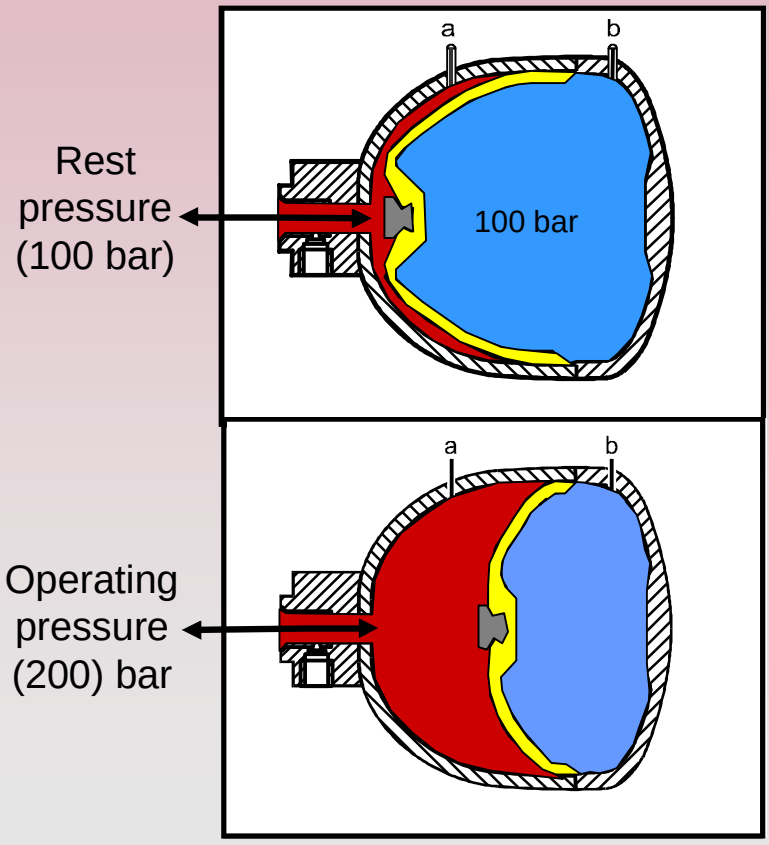
y3 and y4 energized to allow oil into strut

y1 and y2 energized to exhaust oil from strut

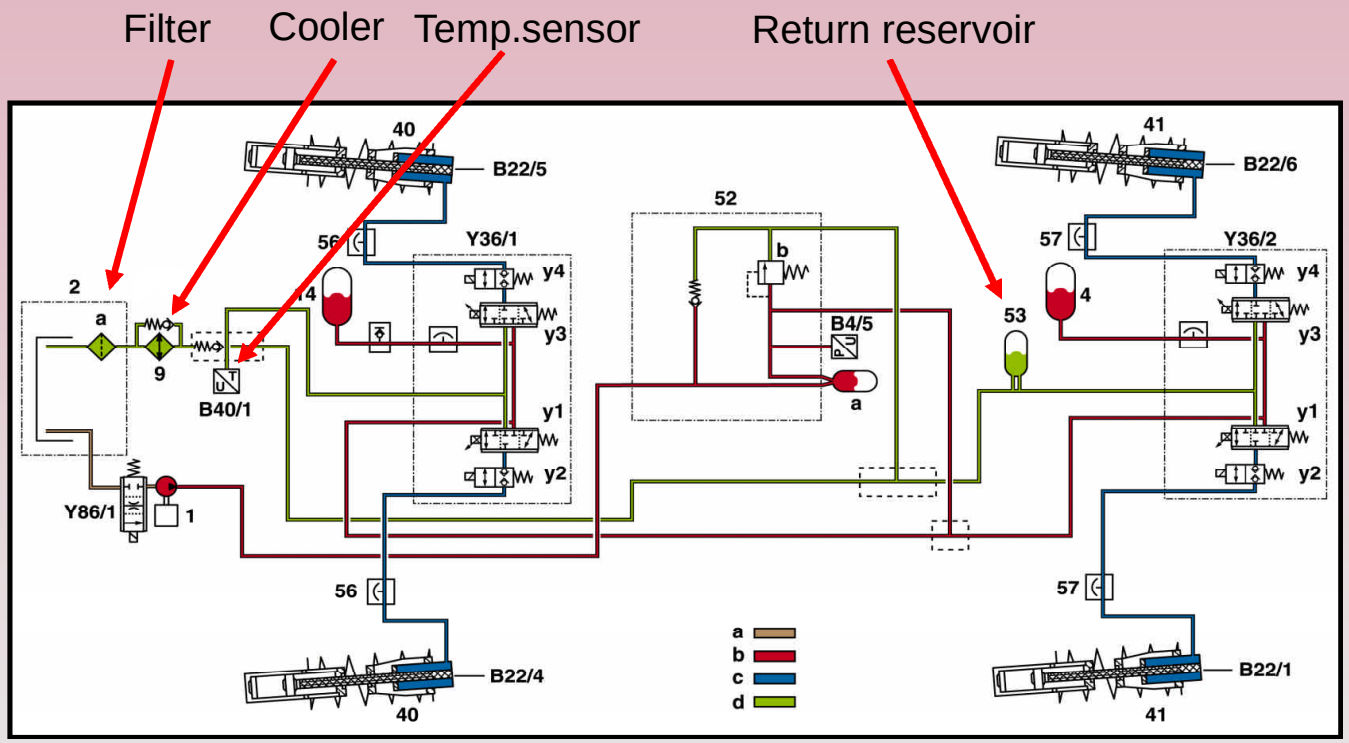


# Pressure Reservoirs

- Provides for high pressure fluid storage
- Primarily consist of 3 parts
  - Spherical steel container with oil chamber (a)
  - Gas chamber filled with 100 bar of nitrogen (b)
  - Separation membrane
- Even though reservoirs are positioned with axle valve units, their placement is before the regulator valves (volume stored available to both axle valves)



# Return Circuit




**Return path of oil back to reservoir consist of:**

Return flow pressure reservoir (53)

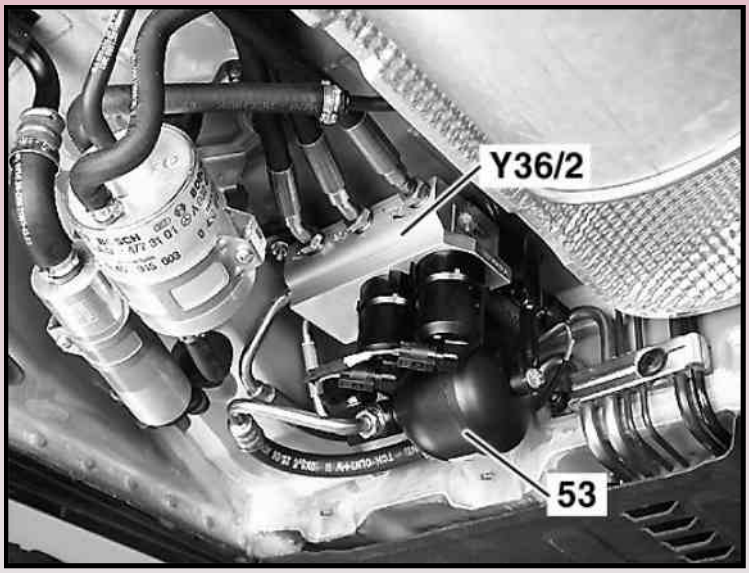
Oil temp. sensor (B40/1)

Oil cooler w/ bypass valve (9)

Oil filter (2)

# Return Flow Pressure Reservoir

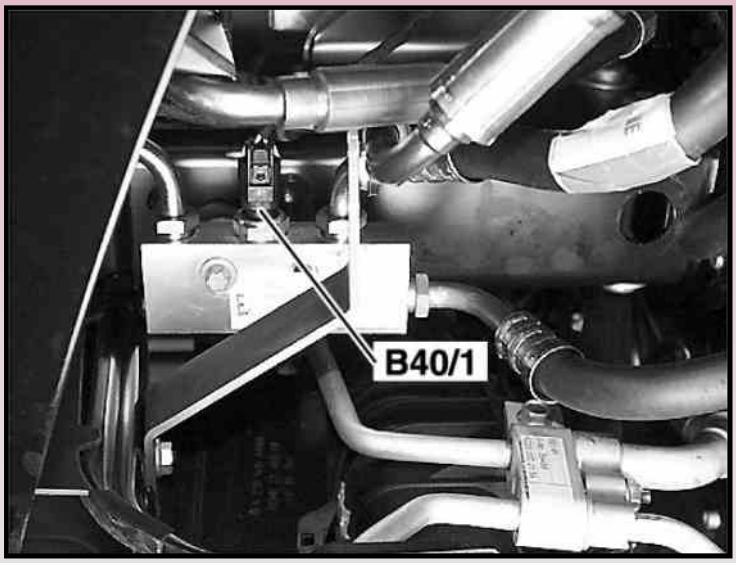
- Located with the rear axle valve block
- Reduces pressure spikes in return circuit




53 - Return flow pressure reservoir
Y36/2 - Rear axle valve block

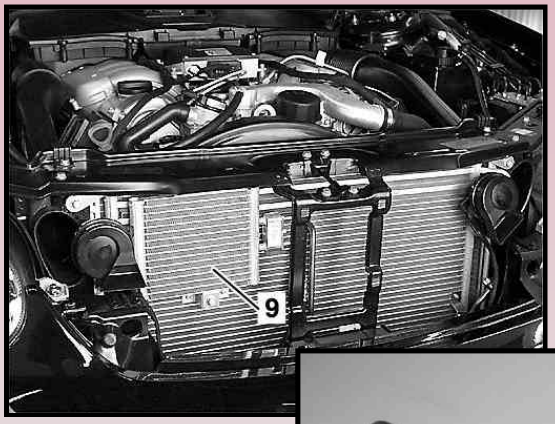
# Oil Temperature Sensor (B40/1)

- Mounted to junction point for oil return from axle valves and pressure supply valve
- Monitors oil temp. of return circuit before oil cooler
- Used to calculate oil viscosity



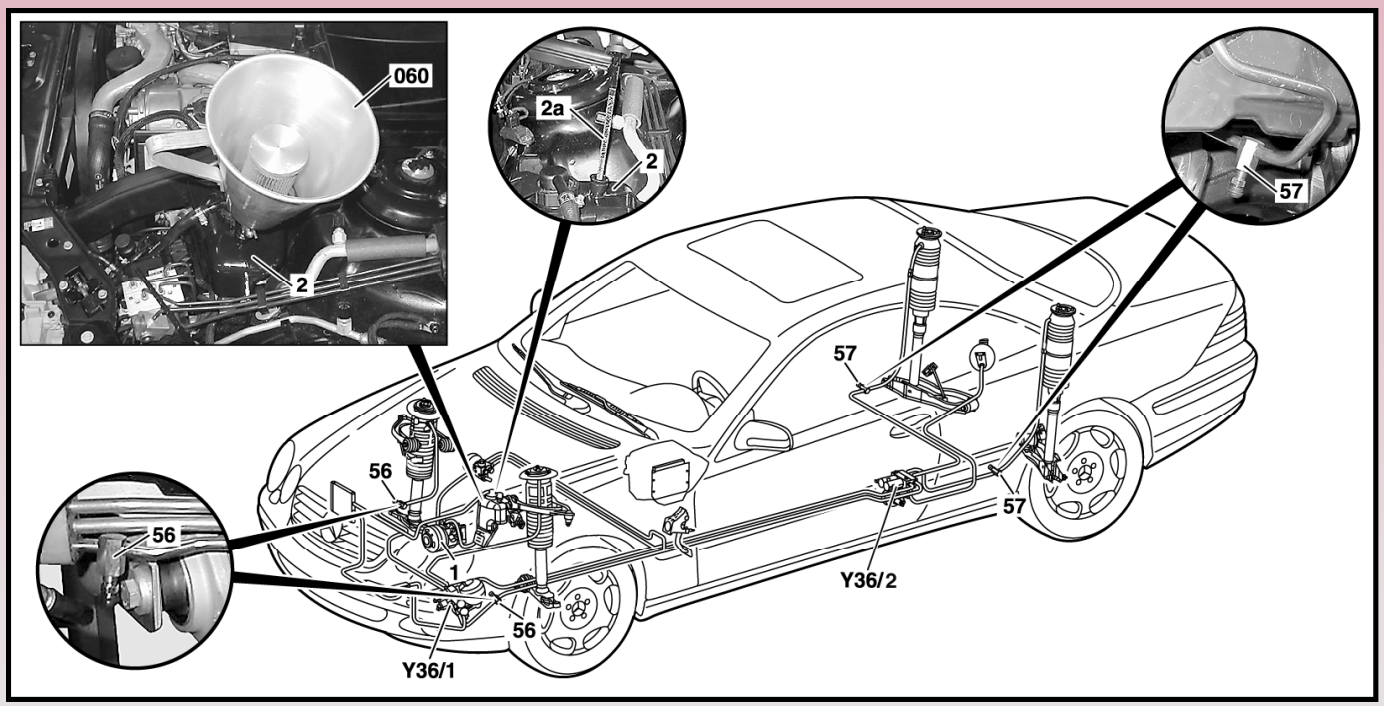
# Oil Cooler and Reservoir Filter

- Aids in maintaining oil within specified operating range
- Located after temp. sensor (B40/1)
- Oil operating temperature
  - –35°C to 100°C
  - –31°F to 212°F



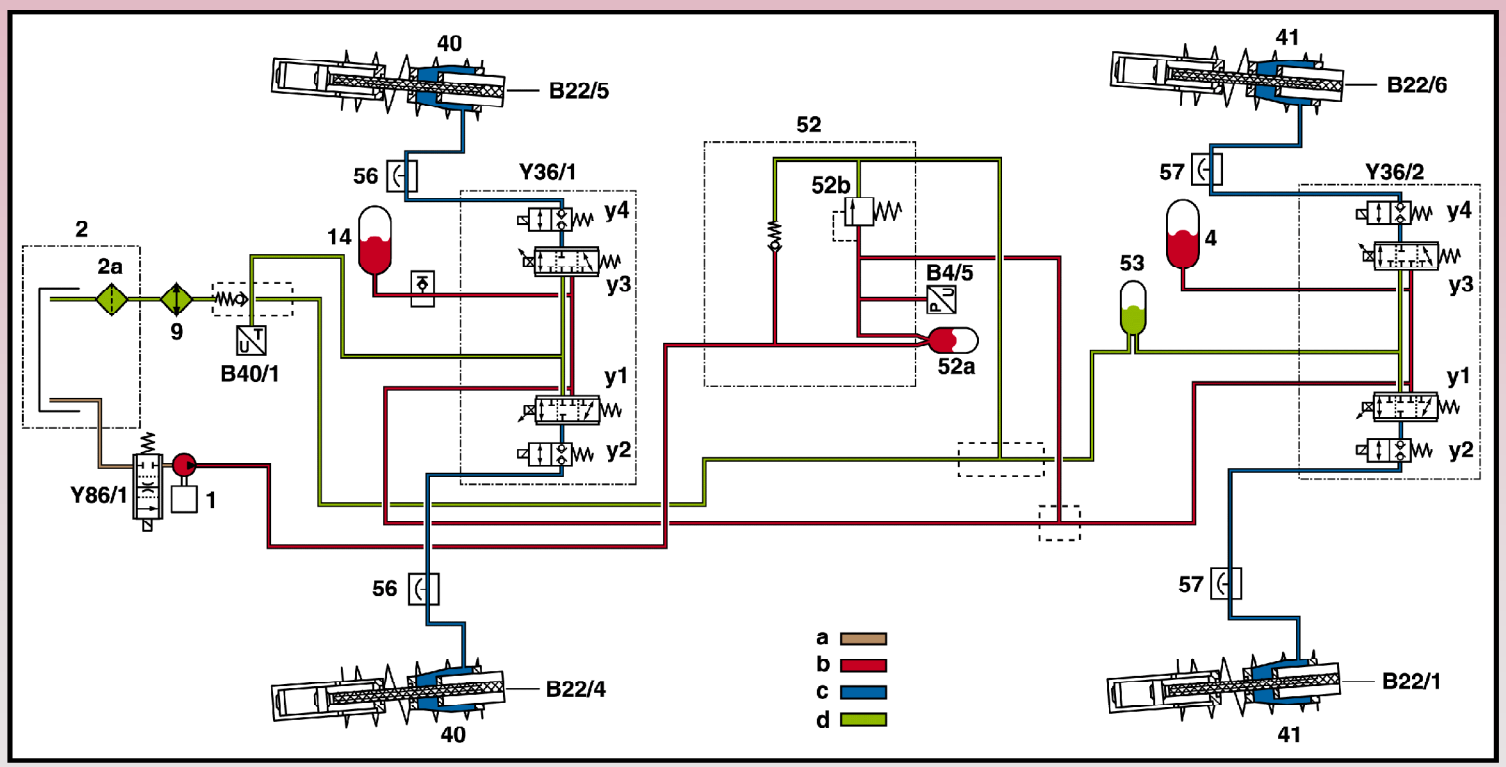

- Filter located on inside of reservoir cap from return line

# Bleeder Fittings




4 bleeder fittings used for reducing pressure in system prior to service

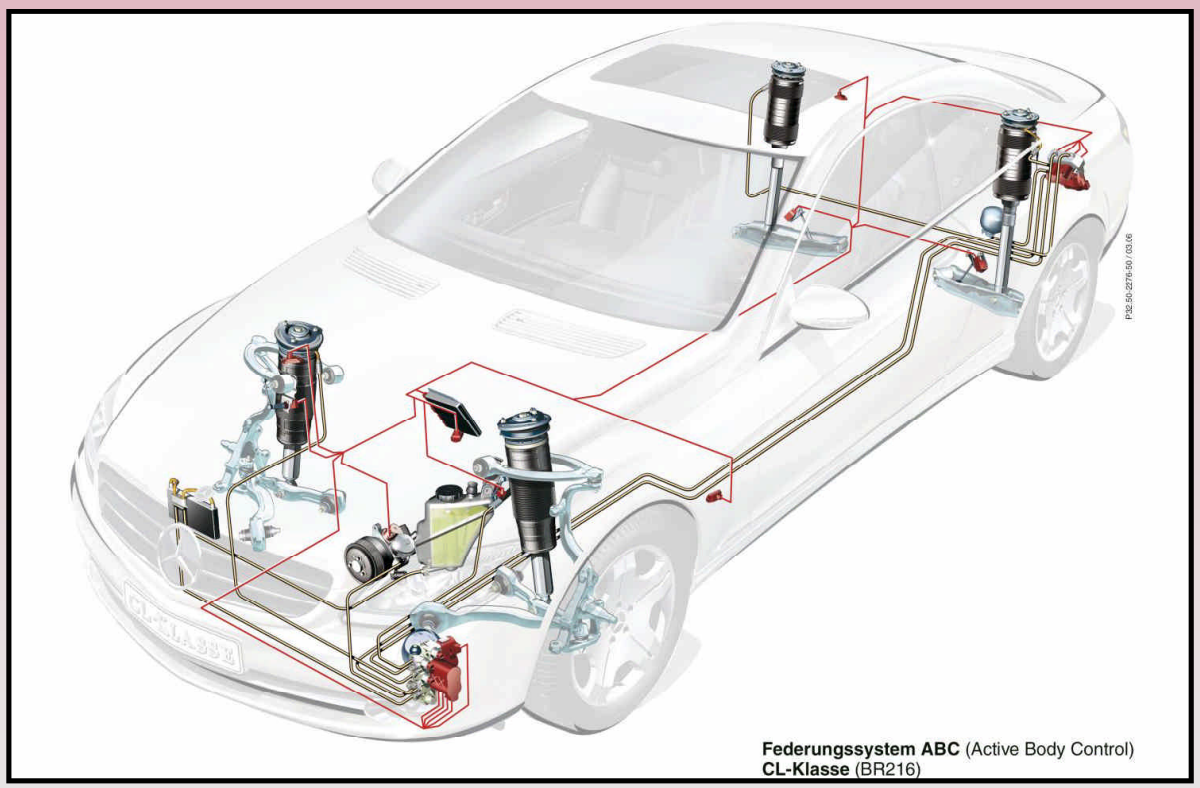
# Hydraulic Schematic



# System Algorithm

- ABC system can make adjustments to vehicle level and suspension firmness every 120 ms.
- Wake-up and after-run function criteria is same as AIRmatic, except the system is unable to increase ride height until engine is started
- Locking position – when vehicle is being raised on a hoist or a tire is being changed with key “on” or the engine running, the ABC control module will recognize the situation and de-energize (close) all 4 shut off valves.

# ABC Plus
# 221 / 216 / R230 (as of MY 07)



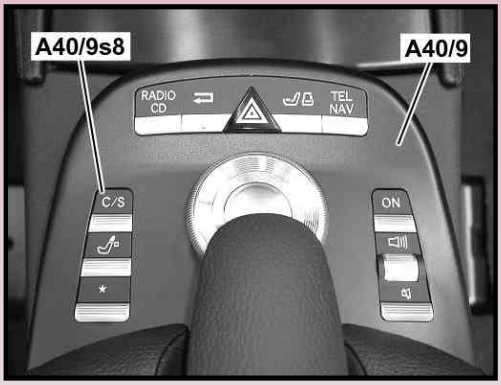

Concept from preceding ABC system with
improved functionality and reduced complexity

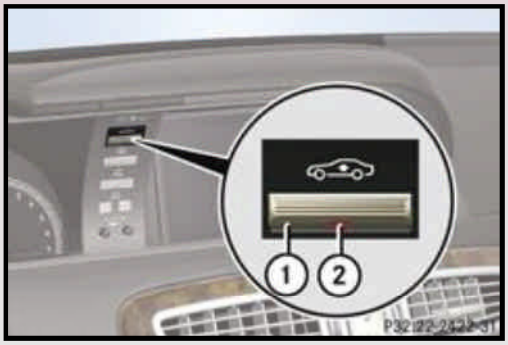
# ABC Plus
# Driver Inputs

221 / 216

- C/S mode switch (A40/9s8) used for selection of ABC “Sport” mode as well as trans. mode
- Single selection of increased ride height
- Ride height modes:
  - Raised level
  - Normal level
  - High speed level

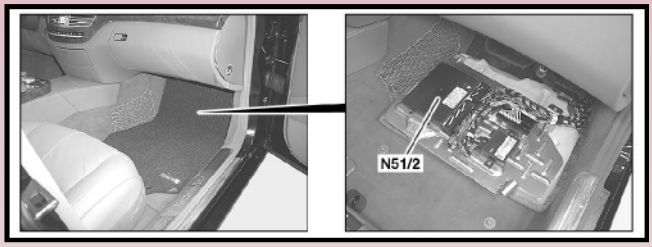
R230 (as of MY 07) driver input operation as per ABC

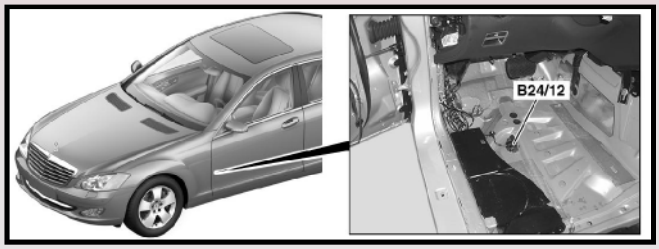


# ABC Plus
# Technical Changes

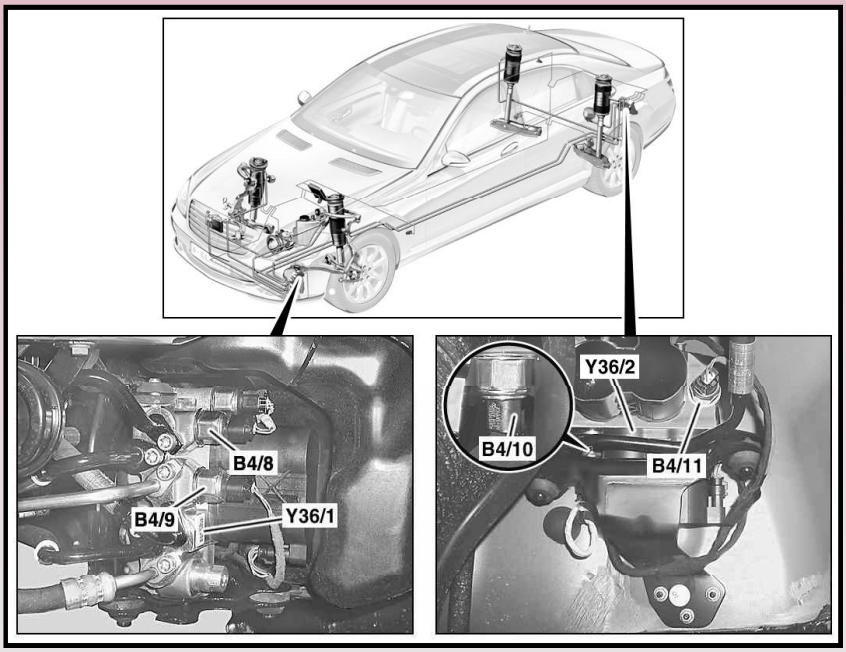
- Control module located under passenger floor board
- 221 / 216 wake up signal no longer discrete wired from LF SAM (CAN signal)
- R230 wake up discrete wire from LF SAM
- Lateral acceleration sensor located under drivers floor board
- Longitudinal acceleration sensor eliminated, information now calculated from:
  - ME
  - ETC
  - ESP



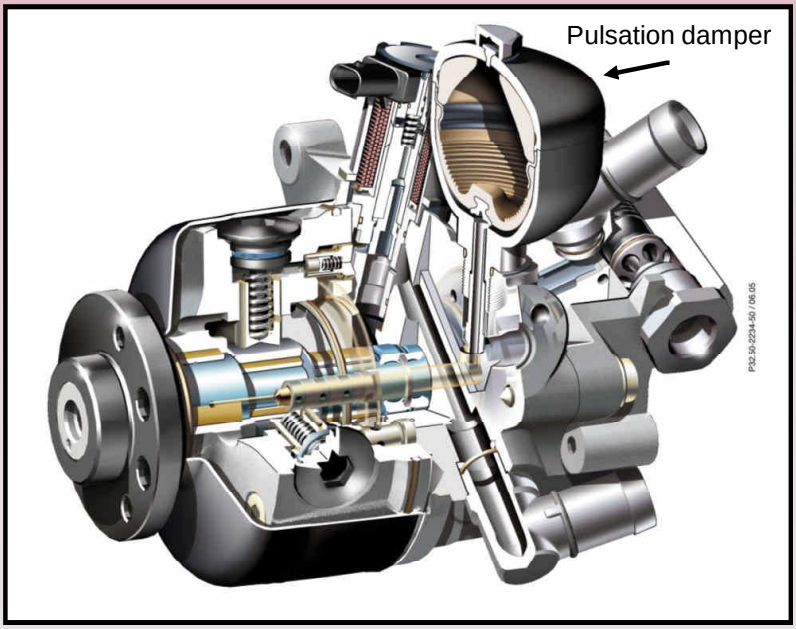
# ABC Plus
# Technical Changes

- Plunger Travel sensors in struts replaced by pressure sensors (B4/8 – B4/11) in front and rear axle valve units for each strut
- Control module logic modified to calculate strut spring rate based upon pressure at each strut



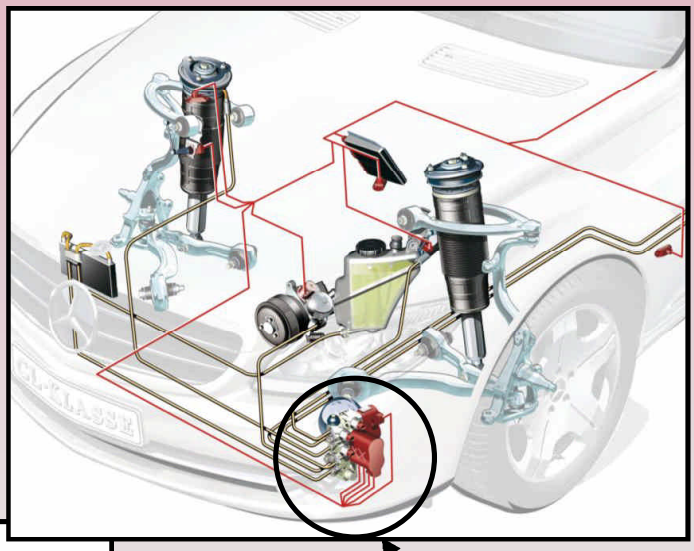
# ABC Plus
# Technical Changes

- Pressure supply valve unit eliminated and it's associated components relocated
- Pulsation damper from pressure supply valve now located on tandem pump
- Pump must be removed to replace pulsation damper

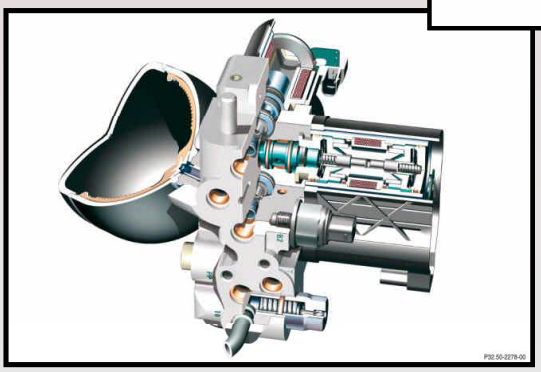


# ABC Plus
# Technical Changes

- System pressure sensor moved to front axle valve unit
- Front axle valve unit (Y36/1) now functions as hydraulic distributor for pressure distribution and return circuits
- Front axle valve incorporates 250 bar pressure limiting valve
- Oil temperature sensor removed



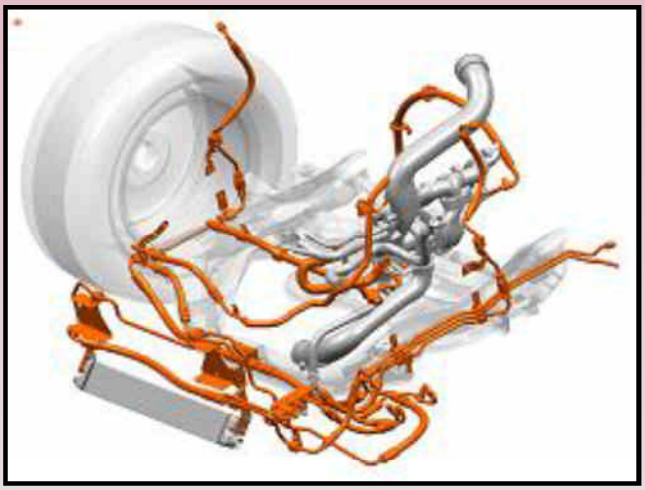
Y36/1



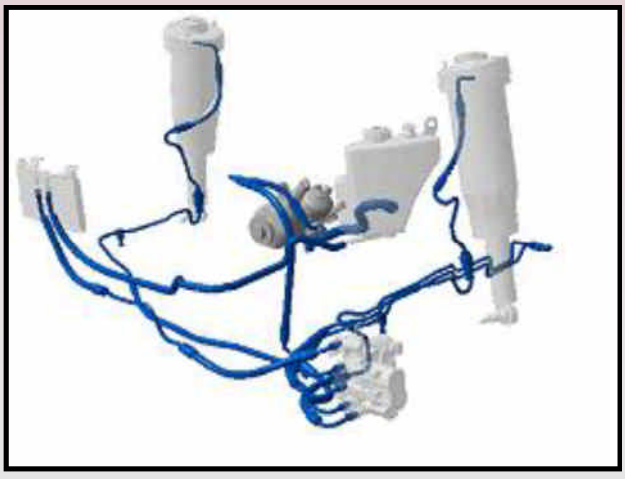
# ABC Plus
# Technical Changes

- Reduced system complexity by:
  - Component integration
  - Optimizing existing components

  Results in reduction of hoses and connections



ABC



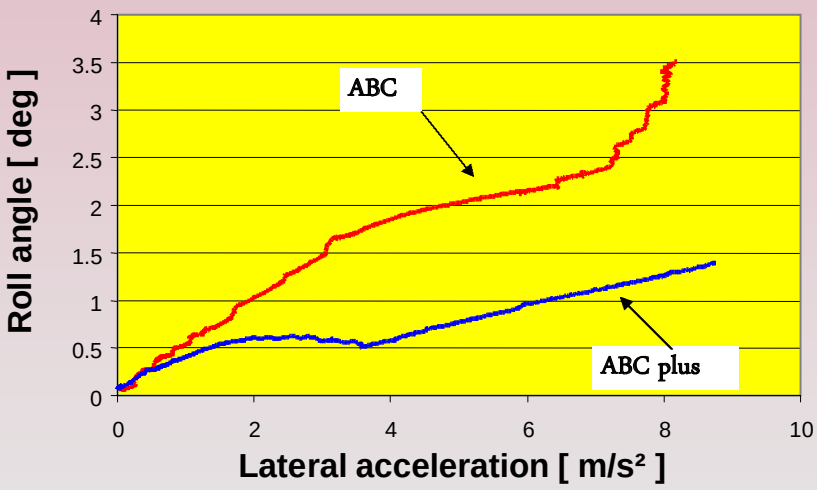
ABC Plus

**Note:** hydraulic lines and connections also improved

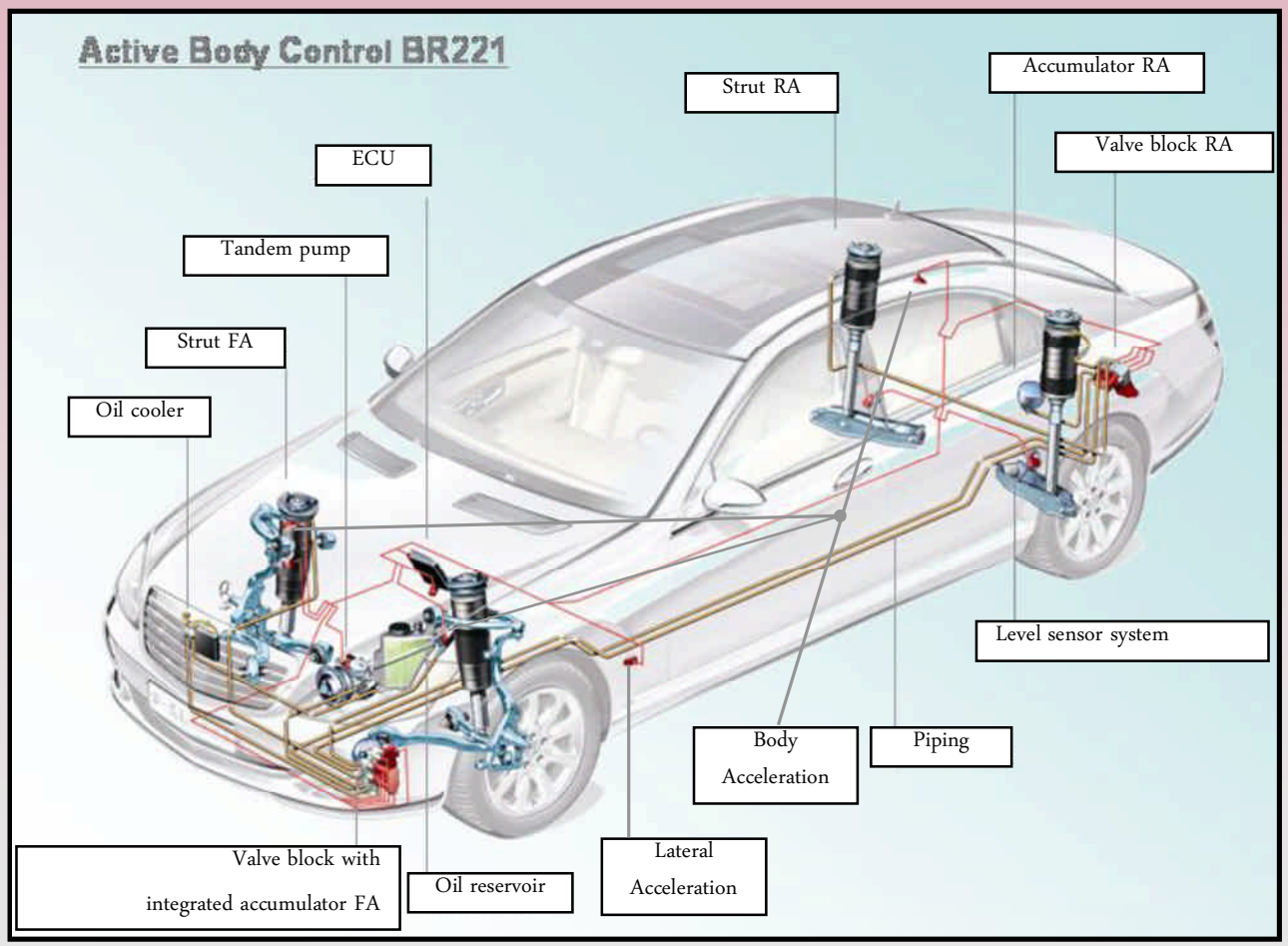
# ABC Plus
# Algorithm Changes

- Control module software modifications include:
  - Improved control of pump and strut pressures (reduced pulsations in lines)
  - Utilizing strut pressure sensors instead of plunger travel sensors for spring rate determination
  - Improved vehicle horizontal stabilization including reduced body roll by approx. 60%

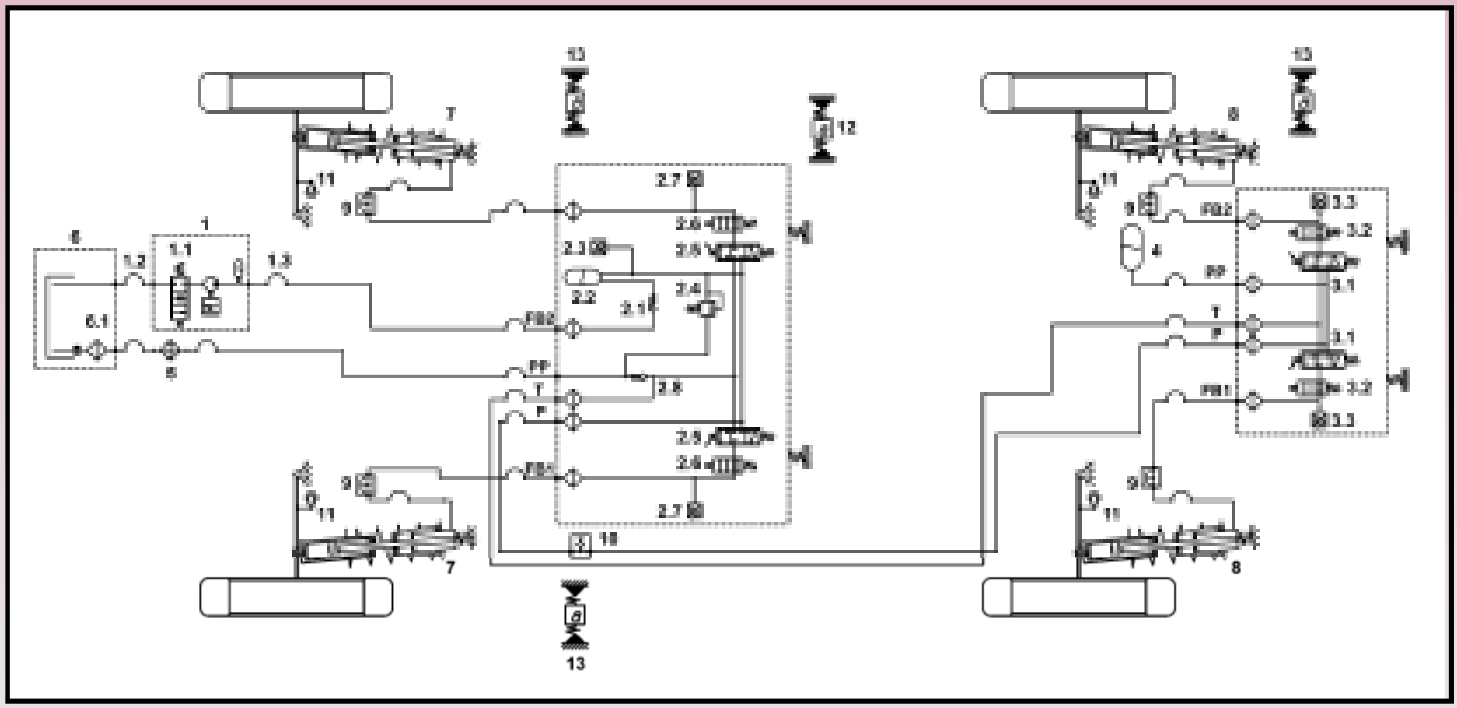
Steady-state cornering



# ABC Plus Components



# ABC Plus Hydraulic Schematic



# ABC Plus Hydraulic Schematic Legend

| | |
|---|---|
| 1 | Tandem pump with pulsation damper |
| 1.1 | Suction restrictor valve (Y88/1) |
| 1.2 | Suction hose |
| 1.3 | Pump pressure hose |
| 2 | Front axle valve unit (Y36/1) |
| 2.1 | Check valve |
| 2.2 | Front axle pressure reservoir (14) with forced flow |
| 2.3 | System pressure sensor (180 – 200 bar) (B4/5) |
| 2.4 | Pressure limiting valve (250 bar) |
| 2.5 | 3/3-way plunger valve (linear motor) to fill and empty the<br>left front axle (Y36/1y1 )<br>right front axle (Y36/1y3) |
| 2.6 | 2/2-way plunger check valve (closed de-energized)<br>left front axle (Y36/1y2 )<br>right front axle (Y36/1y4) |
| 2.7 | Suspension strut pressure sensor<br>left front axle (B4/8)<br>right front axle (B4/9) |
| 2.8 | Return line resistance valve with pressure hold of approx.10 bar |
| 3 | Rear axle valve unit (Y36/2) |
| 3.1 | 3/3-way plunger valve (linear motor) to fill and empty<br>left rear axle (Y36/2y1 )<br>right rear axle (Y36/2y3) |
| 3.2 | 2/2-way plunger check valve (closed when de-energized)<br>left rear axle (Y36/2y2)<br>right rear axle (Y36/2y4) |
| 3.3 | Suspension strut pressure sensor<br>left rear axle (B4/10)<br>right rear axle (B4/11) |
| 4 | Rear axle pressure reservoir (4) without forced flow<br>(contents 0.65 liters) |
| 5 | Oil cooler (pressure resistant up to 40 bar) |
| 6 | Oil reservoir (contents 2.0 liters) |
| 6.1 | Return filter with pressure bypass and magnet |
| 7 | Front axle suspension strut including steel spring, spring adjustment, double-tube shock absorber with support bearing (40) |
| 8 | Rear axle suspension strut including steel spring, spring adjustment, double-tube shock absorber with support bearing (41) |
| 9 | Air release valve for each suspension strut on front and rear axle |
| 10 | Initial filling valve (filling at factory) |
| 11 | Level sensors<br>Left front axle (B22/18)<br>Right front axle (B22/19)<br>Left rear axle (B22/20)<br>Right rear axle (B22/21) |
| 12 | Lateral acceleration sensor (B24/12) |
| 13 | Body lateral acceleration sensor<br>Left front body (B24/3)<br>Right front body (B24/4)<br>Right rear body (B24/6) |

Connection overview for front axle valve block (Y36/1)

| | |
|---|---|
| FB1 | Hydraulic connection/valve unit for left front axle suspension strut |
| FB2 | Hydraulic connection/valve unit for right front axle suspension strut |
| PP | Hydraulic connection/valve unit for thrust side hydraulic pump |
| T | Hydraulic connection/front axle valve unit for rear axle return line |
| TO | Hydraulic connection/valve unit for oil reservoir return line |
| P | Hydraulic connection/front axle valve unit for rear axle thrust side |

Connection overview for front axle valve block (Y36/2)

| | |
|---|---|
| FB1 | Hydraulic connection/valve unit for left rear axle suspension strut |
| FB2 | Hydraulic connection/valve unit for right rear axle suspension strut |
| T | Hydraulic connection/rear axle valve unit for front axle return line |
| P | Hydraulic connection/rear axle valve unit for front axle thrust side |
| SP | Hydraulic connection/rear axle valve unit for pressure reservoir 4 |