■4-WHEEL ACTIVE HEIGHT CONTROL SUSPENSION AND ADAPTIVE VARIABLE SUSPENSION

1. General

The suspension system, which consists of 4-wheel active height control suspension and adaptive variable suspension, offers both comfort and convenience to achieve high driving performance for on-road and off-road driving.

- The front suspension uses spring rate control to improve driving performance during on-road driving.
- 4-wheel related control is used to improve driving performance during on-road and off-road driving.
- The vehicle height control is provided with an easy access control function for improved convenience.
- The damping force control uses non-linear H∞ control.

Control	Outline	LX 570	LX 470
Vehicle Height Control	The amount of fluid to be sent through the height control valve into the shock absorbers for each of the wheels is regulated in accordance with the manual switch operation and driving conditions.	○	○
Damping Force Control	The optimum damping force can be obtained by controlling the damping force control actuators arranged on each of the wheels in accordance with the manual switch operation and driving conditions.	○	○
Spring Rate Control (for Front Suspension)	The spring rate can be controlled by switching the fluid passage to the gas chambers arranged on both the left and right front shock absorbers.	○	—
4-wheel Related Control	The hydraulic tubes for the shock absorbers are channeled through the center suspension control cylinder, therefore, the amount of hydraulic pressure for each of the shock absorbers can be individually adjusted via the center suspension control cylinder in accordance with the driving conditions.	○	—

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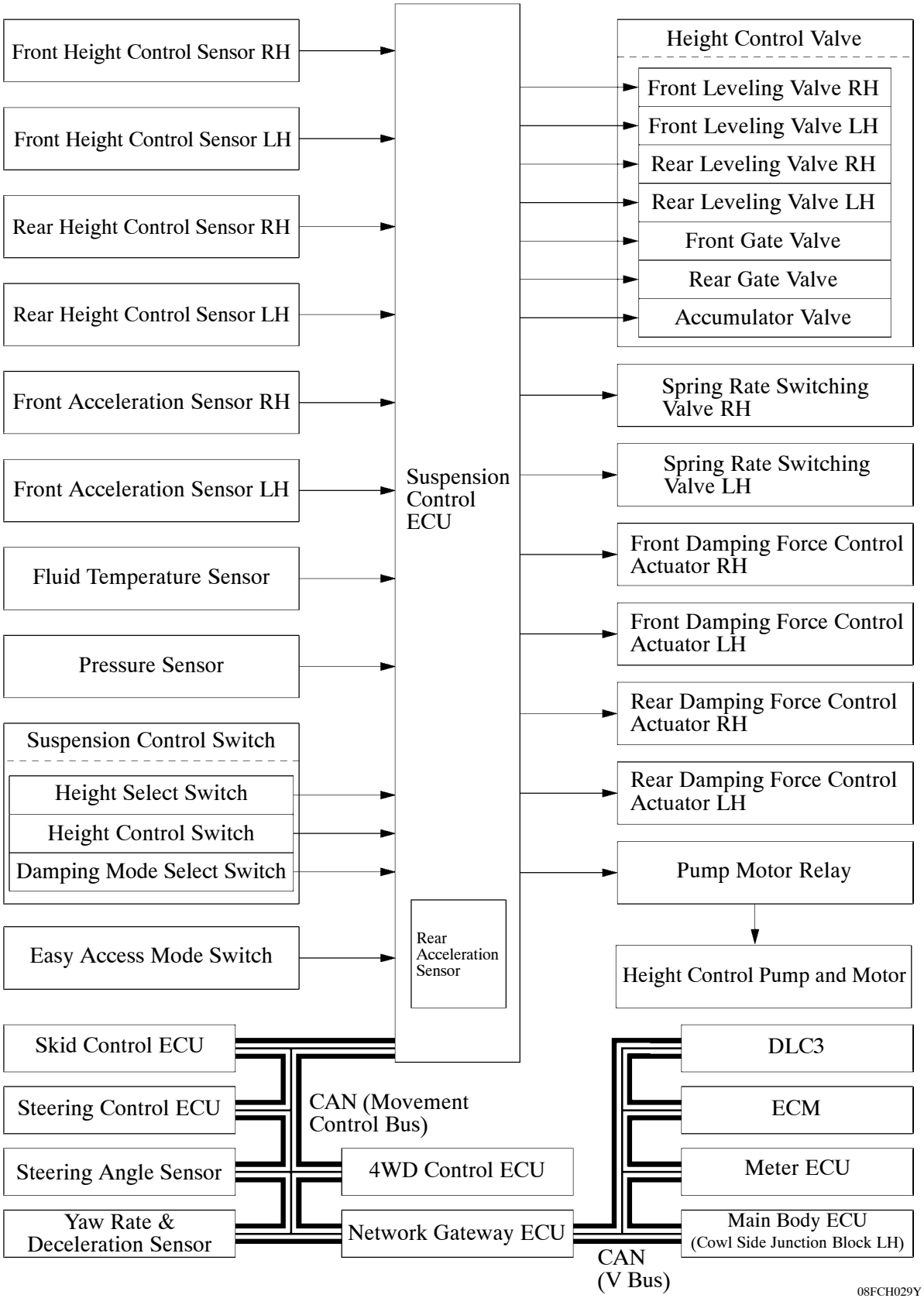
— REFERENCE —

- *To summarize, H^{∞} control is a theory for designing a controller that meets the control specifications that are represented by the H^{∞} norm (a unit of measurement of the transfer function of the system). When this is expanded into a non-linear system, it is called "non-linear H^{∞} control".*
- *The "H" is the initial letter of the mathematician named Hardy (who studied the stability of control systems) who advocated the mathematical space that is handled by this control logic. The "∞" represents the ∞ norm, which is one of the mathematical units used for measuring the size of the signals.*

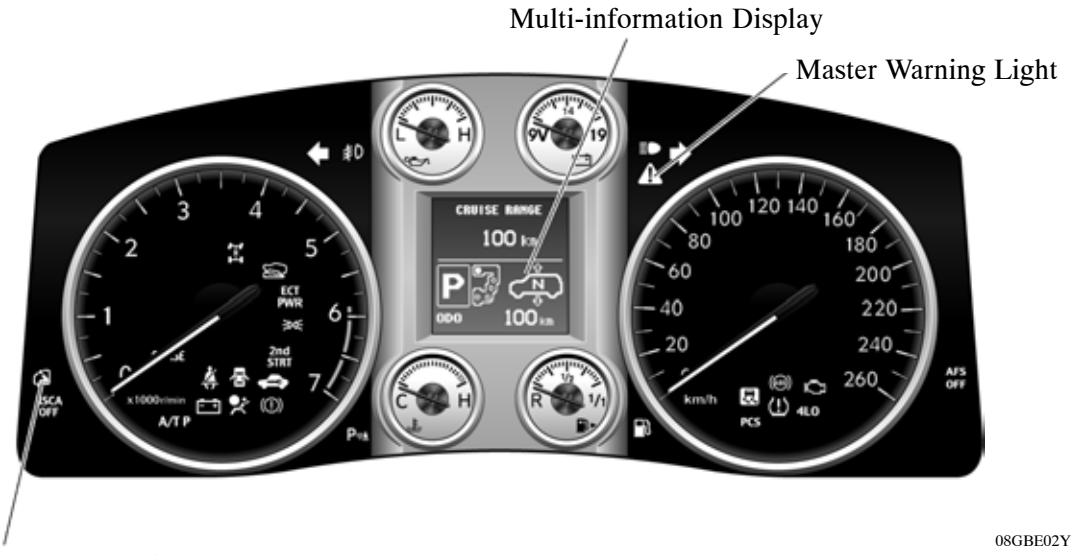
Service Tip

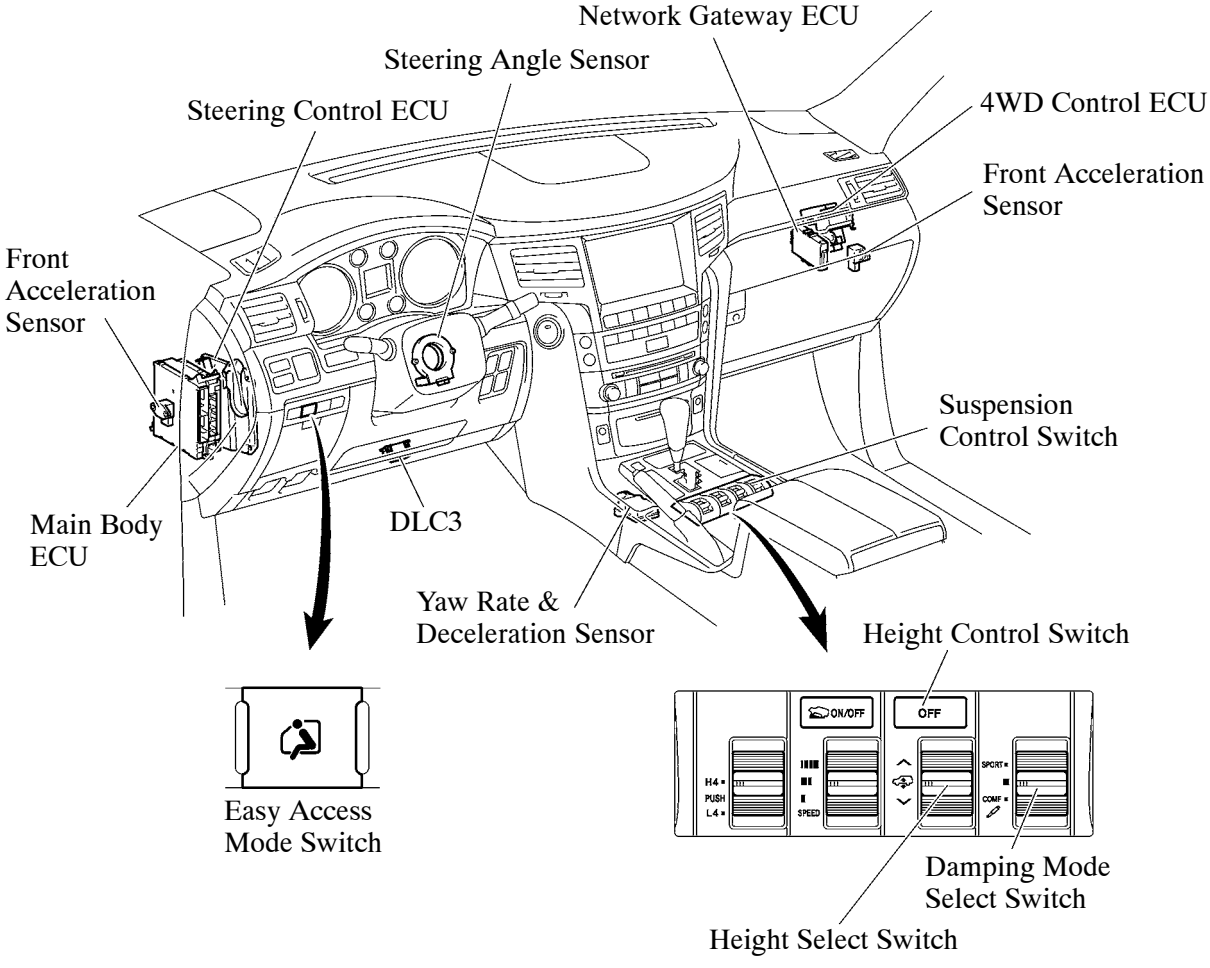
Before jacking the vehicle or raising it on a hoist, make sure that the engine switch is OFF.
If the vehicle must be lifted up when the engine switch is ON (IG), turn the height control OFF switch OFF and connect the OPA and CG terminals of the DLC3 using SST (09843-18040) to suspend vehicle height control operations in the suspension control ECU.
For derails, see the LEXUS LX 570 Repair Manual (Pub. No. RM08G0E).

2. System Diagram

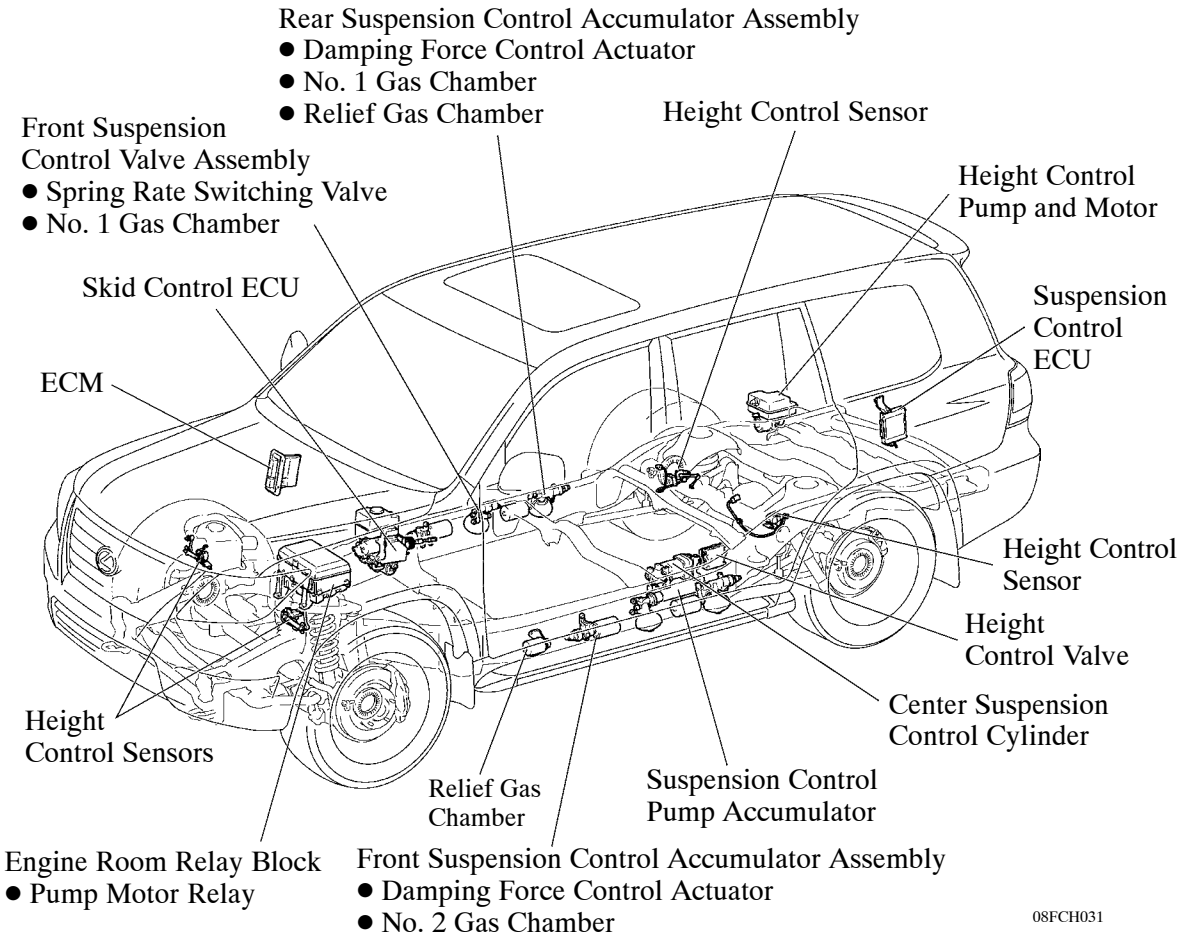


3. Layout of Main Components

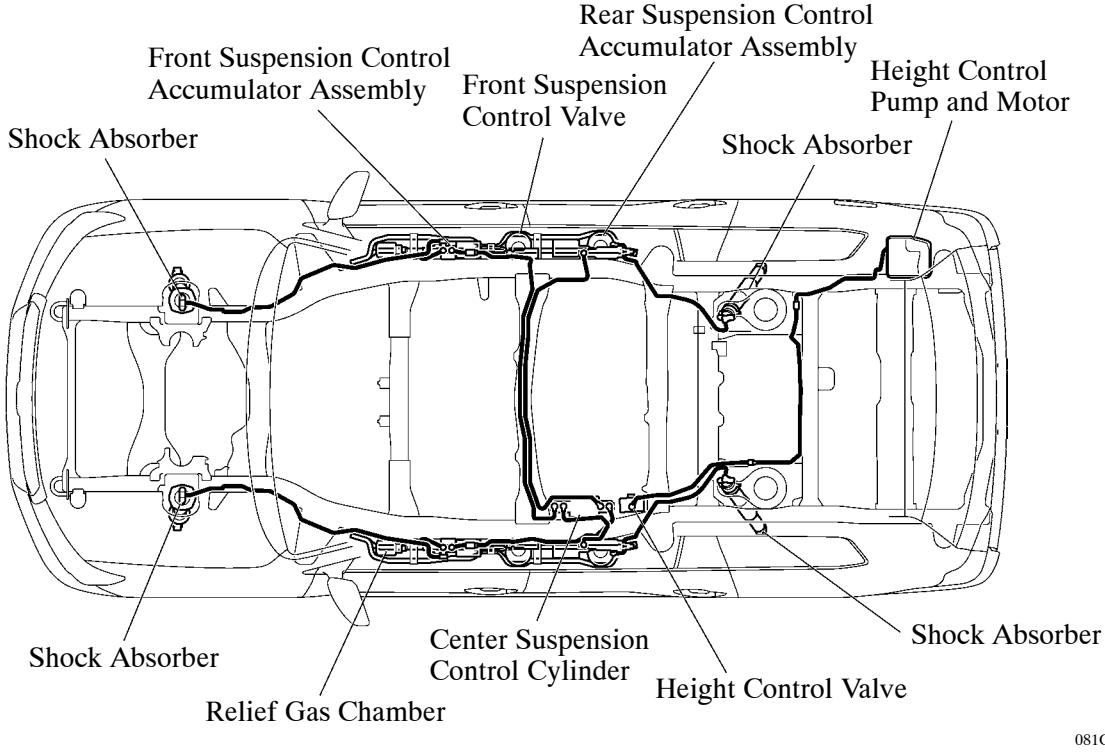




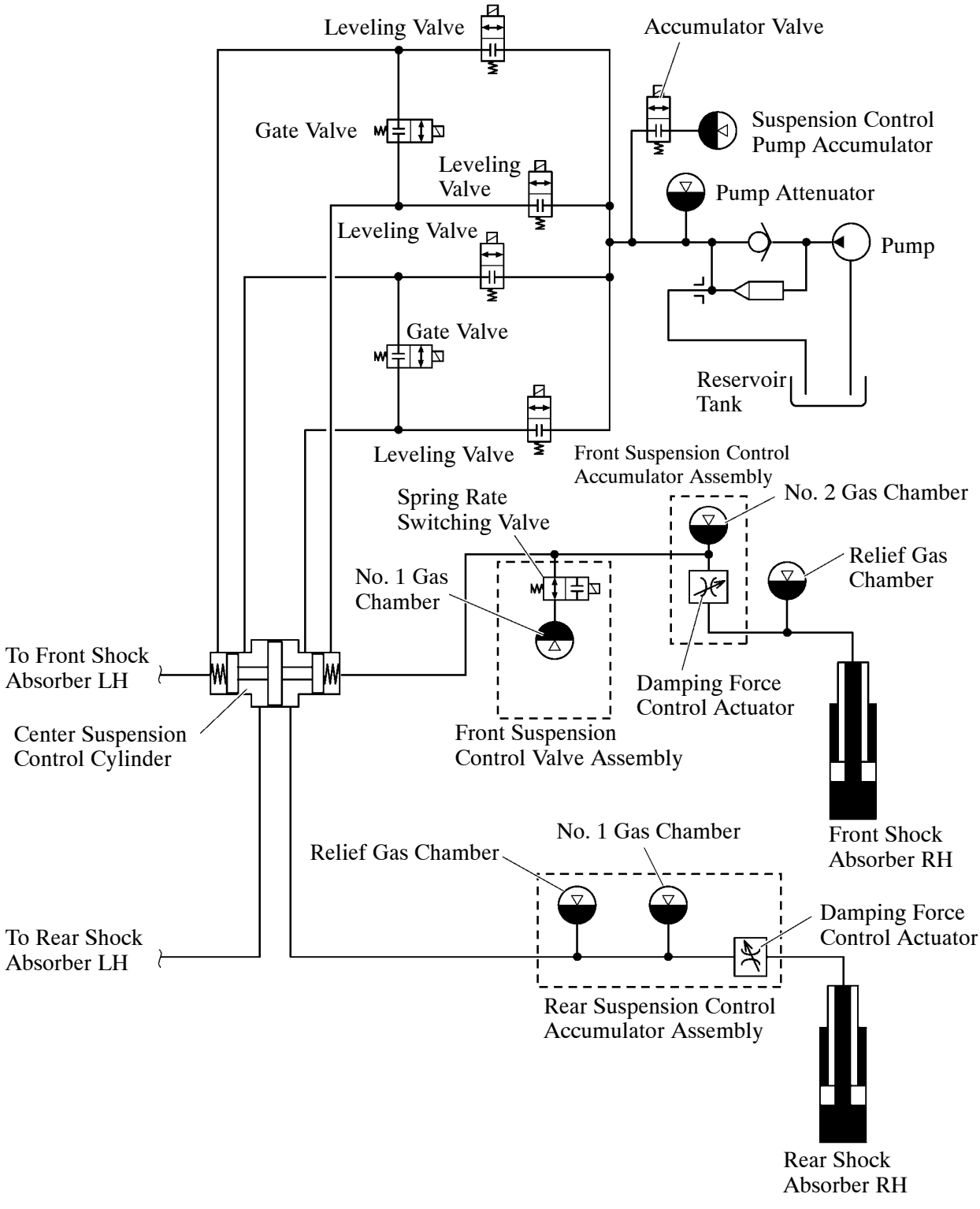
LHD Model



4. Suspension Tubing Diagram



5. Hydraulic Circuit



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6. Function of Main Components

Component		Function
Height Control Pump and Motor		Generates the high hydraulic pressure that is necessary for raising the vehicle height.
	Reservoir Tank	Maintains the amount of fluid that is returned during the LO position and the amount of fluid that is discharged during the HI position.
	Return Valve	Opens and closes the fluid passage between the height control valve and the reservoir tank.
	Pressure Sensor	Detects the pump's discharge pressure.
	Fluid Temperature Sensor	Detects the fluid temperature.
	Pump Attenuator	Dampens the hydraulic pulsation of the fluid that is discharged by the pump.
Suspension Control Pump Accumulator		Stores the hydraulic pressure to accelerate the speed in which the vehicle height is raised.
Height Control Valve	Leveling Valve	Opens and closes the fluid passage between the pump and the gas chamber on the wheel.
	Gate Valve	Opens and closes the fluid passage between the right and left shock absorbers.
	Accumulator Valve	Opens and closes the fluid passage to the suspension control pump accumulator.
Center Suspension Control Cylinder		Mechanically operates in accordance with the pressure applied to the shock absorbers and optimally distributes the hydraulic pressure to each of the wheels.
Front Suspension Control Valve Assembly	Spring Rate Switching Valve	Opens and closes the fluid passage to the No. 1 gas chamber.
	No. 1 Gas Chamber (Low spring rate)	Acts like a gas spring by partially utilizing coil spring force. This is provided on the front wheels.
Front Suspension Control Accumulator Assembly	No. 2 Gas Chamber (High spring rate)	Acts like a gas spring by partially utilizing coil spring force. This is provided on the front wheels.
	Damping Force Control Actuato	Switches the damping force.
Relief Gas Chamber (for Front Suspension)		Protects hydraulic systems by restricting increase in the hydraulic pressure inside the hydraulic tubes.
Rear Suspension Control Accumulator Assembly	No. 1 Gas Chamber	Acts like a gas spring by partially utilizing coil spring force. This is provided on the rear wheels.
	Relief Gas Chamber	Protects hydraulic systems by restricting increase in the hydraulic pressure inside the hydraulic tubes.
	Damping Force Control Actuator	Switches the damping force.
Shock Absorber		● Generates a damping force similar to the conventional shock absorber. ● Includes a high-pressure main seal and high-pressure oil seal for friction reduction and further improvement of the sealing performance.

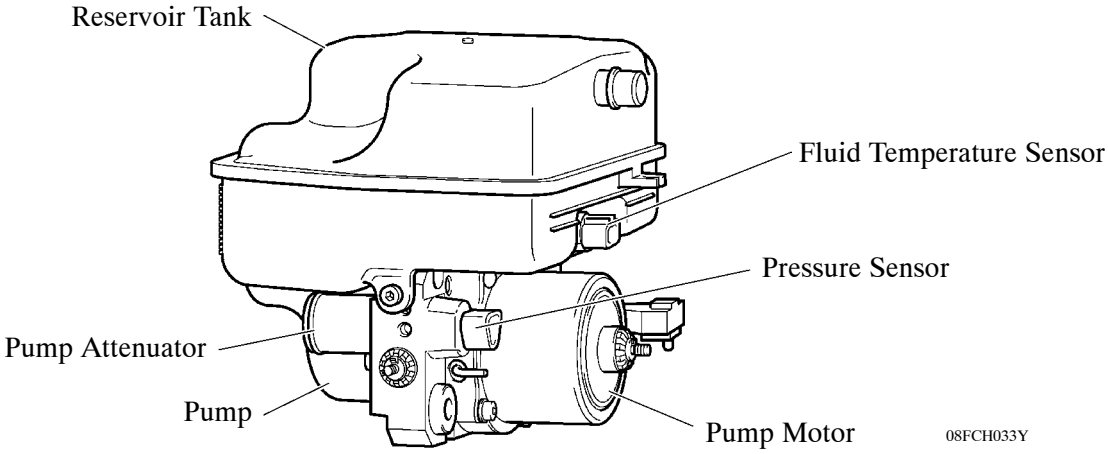
(Continued)

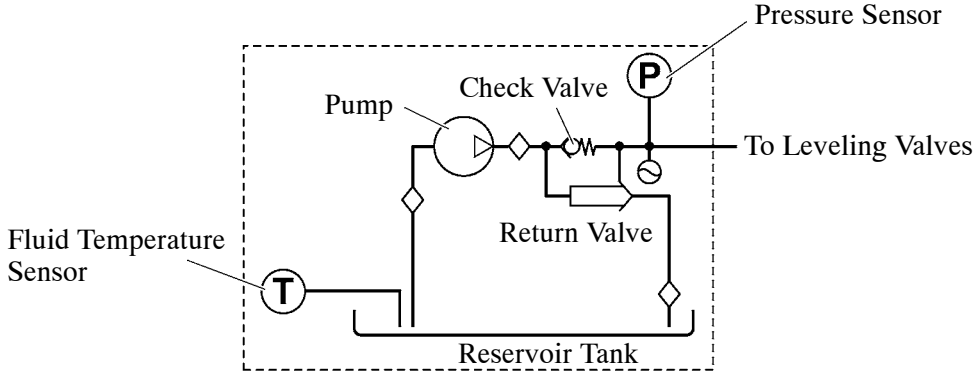
Component		Function
Combination Meter	Multi-information Display	● Displays the vehicle height and control conditions. ● Displays a warning message when a system malfunction occurs.
	Master Warning Light	Illuminates when the warning message is displayed.
	Buzzer	Sounds when the warning message is displayed.
	Easy Access Mode Indicator Light	● Illuminates when the easy access mode switch is turned ON. ● Blinks while the easy access control is operating.
Suspension Control Switch	Height Select Switch	Selects the target vehicle height.
	Height Control Switch	Prohibits the vehicle height control.
	Damping Mode Select Switch	Selects a damping force control mode.
Easy Access Mode Switch		Switches the easy access control between ON and OFF.
Height Control Sensor		Detects the vehicle height.
Steering Angle Sensor		Detects the steering direction and angle of the steering wheel.
Yaw Rate & Deceleration Sensor		● Detects the vehicle's yaw rate. ● Detects the vehicle's longitudinal and lateral acceleration and deceleration.
Acceleration Sensor		3 acceleration sensors are provided in total. The two of them are provided in the front of the vehicle and one is built into the suspension control ECU located in the rear of the vehicle. Thus, the acceleration sensors independently detect the vertical acceleration rate of the vehicle.
Pump Motor Relay		Controls the pump motor operation.
Suspension Control ECU		Controls the entire system by performing the calculations for height control, damping force control and spring rate control based on the signals received from the sensors and switches.
Steering Control ECU		Sends the VGRS control status signal to the suspension control ECU.
Skid Control ECU		Sends the speed sensor signal and brake control status signal to the suspension control ECU.
4WD Control ECU		Sends the 4WD control status signal to the suspension control ECU.
ECM		Sends the engine speed signal to the suspension control ECU.
Main Body ECU (Cowl Side Junction Block LH)		Sends the engine switch status signal, door courtesy switch signal and suspension control switch signal to the suspension control ECU.

7. Construction and Operation of Main Components

Height Control Pump and Motor

A system in which the pump, pump motor, reservoir tank, return valve, pump attenuator, pressure sensor, and fluid temperature sensor are integrated is used.

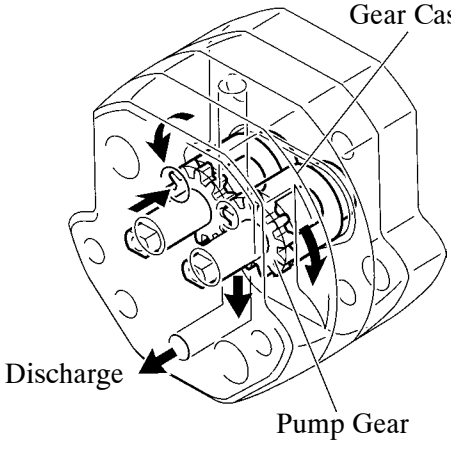


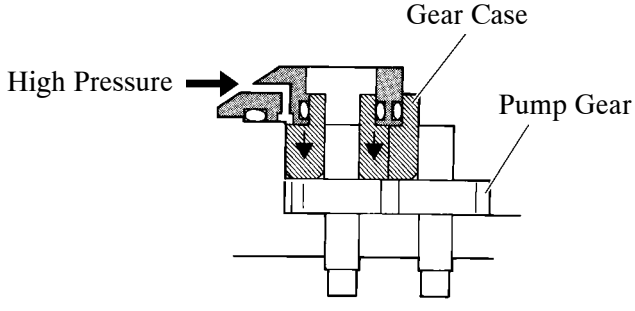


Pump and Motor Hydraulic Diagram 081CH68Y

1) Pump

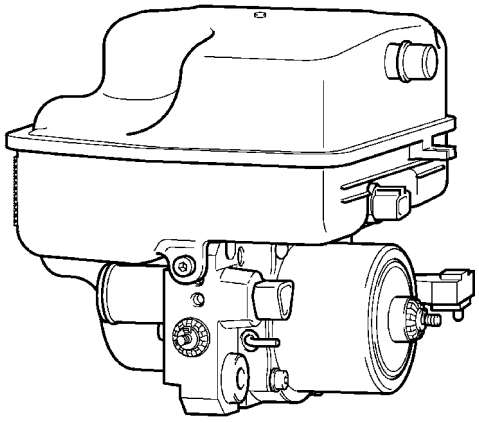
An external gear pump that contains less parts and excels in durability is used. Also, the pump is a pressure-loading type in which the discharge pressure of the pump itself is utilized and routed via the gear case to push on the side of the pump gear in order to reduce the internal leakage, thus making high-pressure discharge possible.





2) Motor

A DC motor with 4-pole brushes is used to realize excellent durability and high torque.



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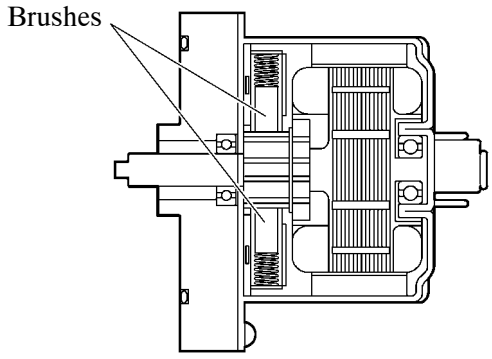

Cross Section

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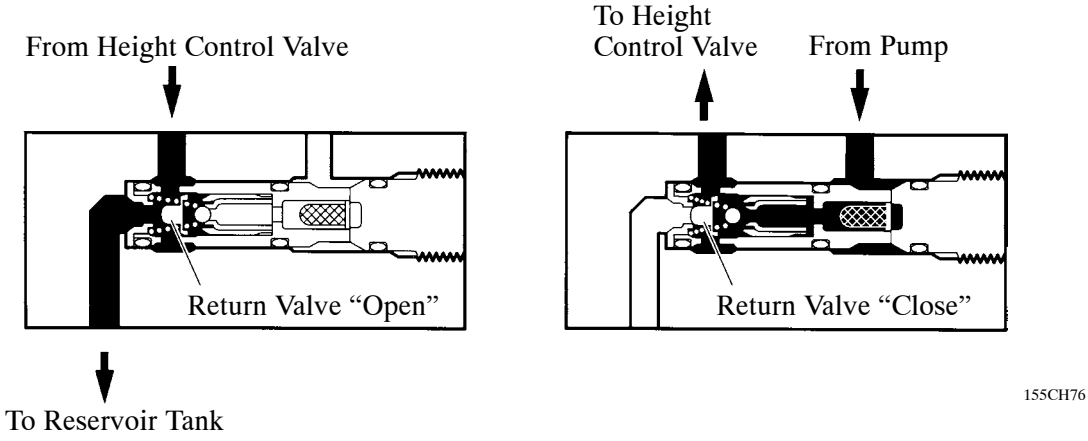
3) Return Valve

The return valve opens and closes the fluid passage between the height control valve and the reservoir tank. The return valve has been simplified by adopting a construction in which the valve is closed by the flow of the discharged fluid.
Normally, a spring force is applied to the return valve to maintain the fluid passage between the height control valve and the reservoir tank open.
When the pump operates in order to raise the vehicle height, the pressure of the fluid that is discharged by the pump causes the return valve to move to the left of the diagram as illustrated.
Accordingly, the fluid passage between the height control valve and the reservoir tank closes, and the fluid that is discharged from the pump flows towards the height control valve.



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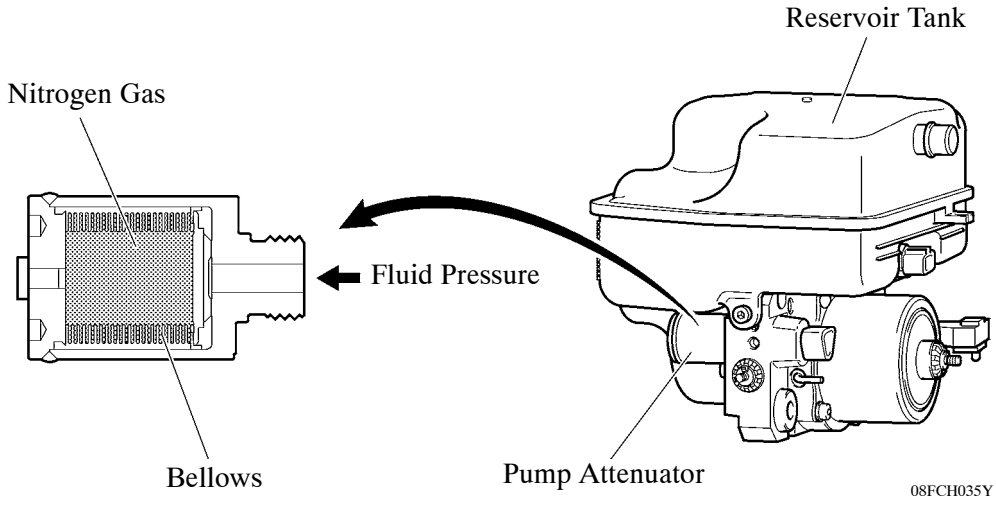
Normal Condition **Pump in Operation**

4) Pump Attenuator

The pump attenuator dampens the hydraulic pulsation of the fluid that is discharged by the pump. A bellows type accumulator that is made of stainless steel, which offers excellent gas penetration resistance and good pulsation absorption performance, is used.

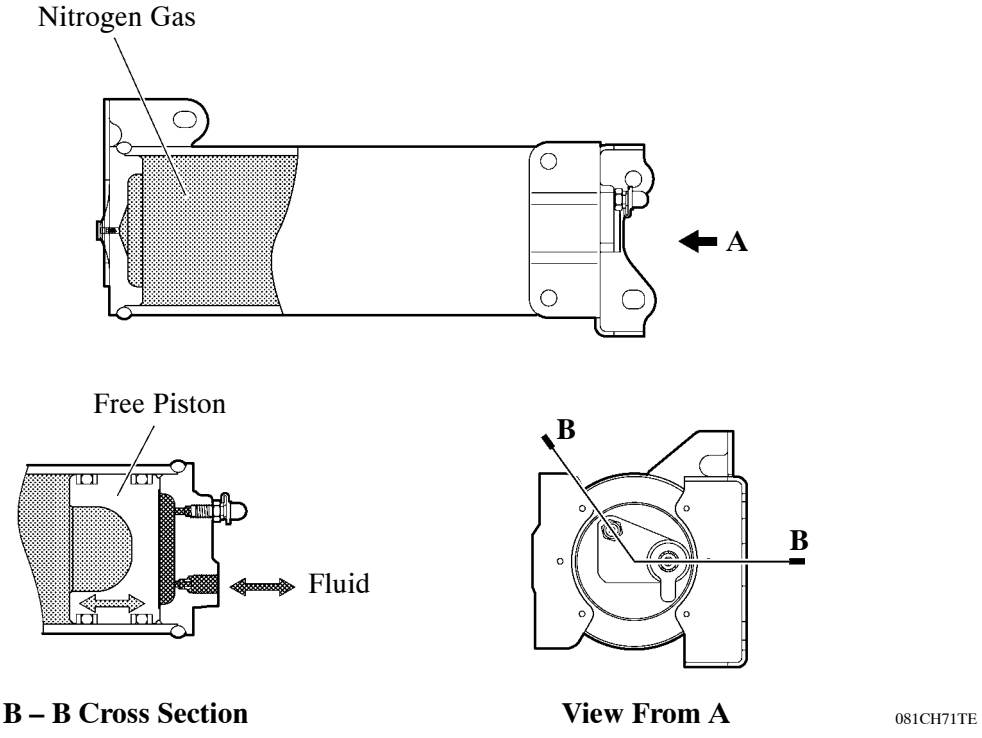


▶ Specifications ◀

Sealed Gas		Nitrogen Gas
Gas Chamber Volume	cc (cu in.)	1.75 (0.11)
Sealed Gas Pressure	MPa (kgf/cm^2, psi)	2.0 (20.4, 290.1)

Suspension Control Pump Accumulator

A free piston type accumulator, which provides a large gas chamber capacity, is used for the suspension control pump accumulator.
When the vehicle height is being raised, the accumulator discharges the stored fluid to accelerate the raising speed.



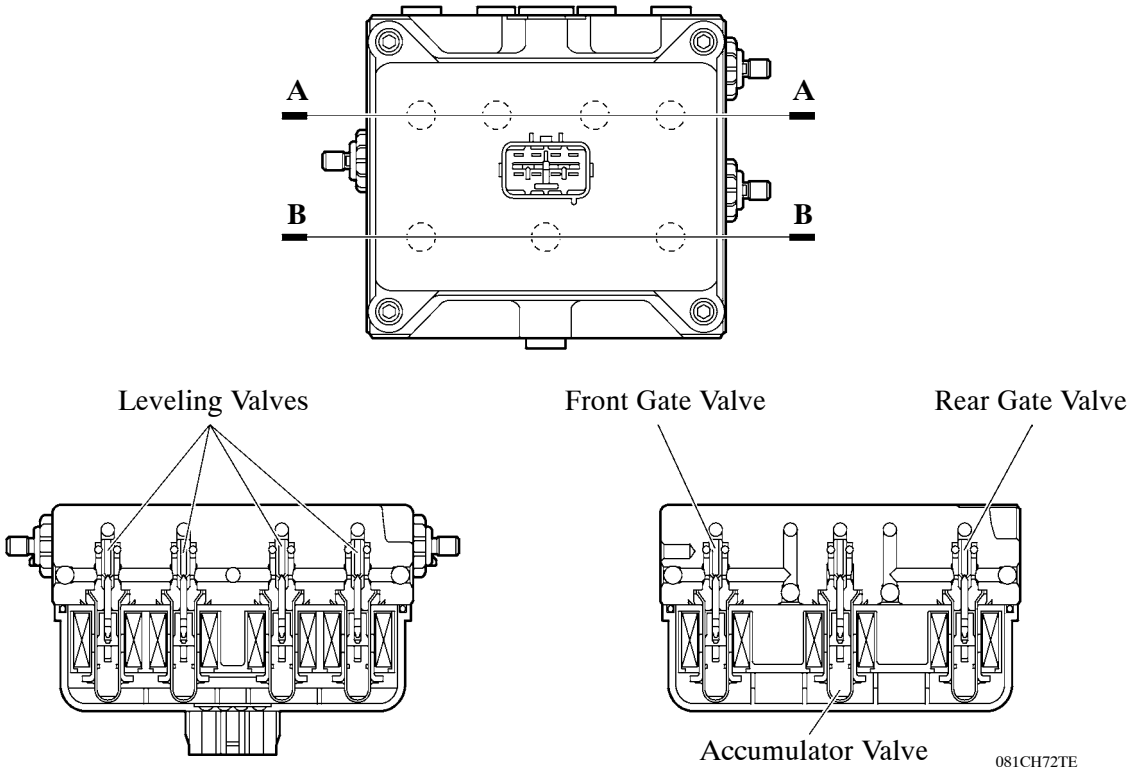
B – B Cross Section **View From A** 081CH71TE

▶ Specifications ◀

Sealed Gas		Nitrogen Gas
Gas Chamber Volume	cc (cu in.)	945 (57.7)
Sealed Gas Pressure	MPa (kgf/cm^2, psi)	5.9 (60, 856)

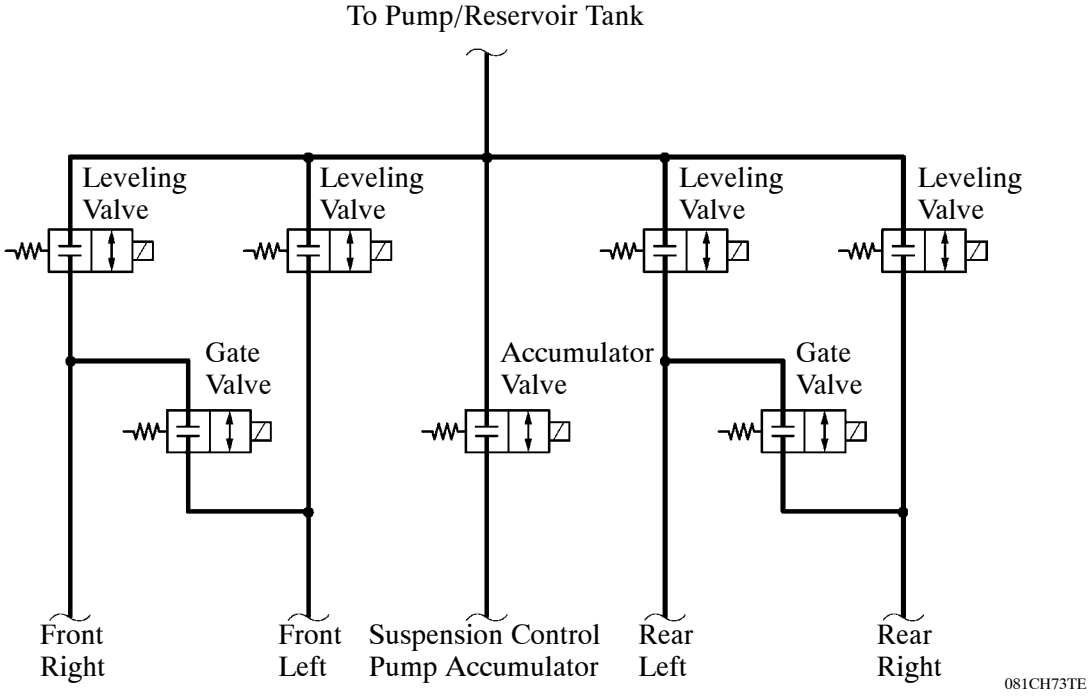
Height Control Valve

The height control valve is comprised of four leveling valves, two gate valves and an accumulator valve.



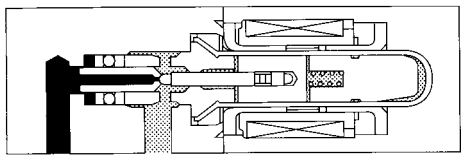
A – A Cross Section **B – B Cross Section**

▶ Arrangement Layout of Hydraulic Tubes ◀

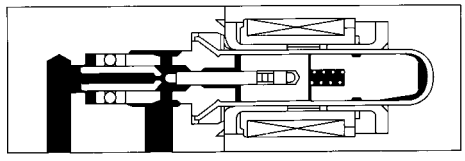


1) Leveling Valve

This valve opens and closes the fluid passage between the pump and the gas chamber located at each wheel. Normally, the fluid passage remains closed. During vehicle height control, the fluid passage opens in accordance with the signal received from the suspension control ECU.



Close



Open

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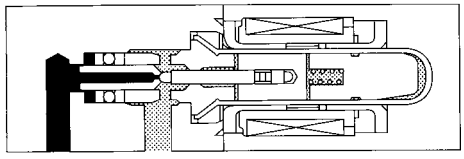
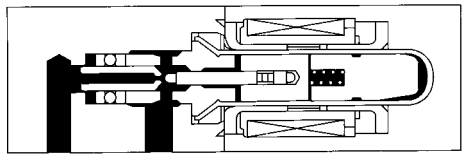
2) Gate Valve

This valve is provided for both the front and rear sides. This valve opens and closes the fluid passage to both the left and right leveling valves. Normally, the fluid passage is closed. The fluid passage opens in accordance with signals from the suspension control ECU, thereby balancing the fluid pressure for both the left and right gas chambers.



Close



Open

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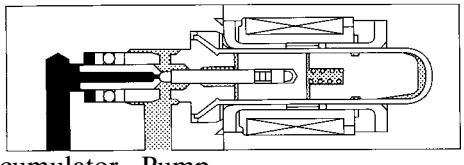
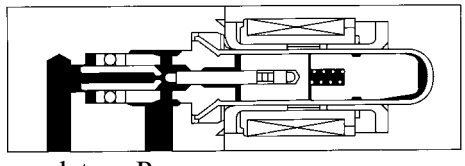
3) Accumulator Valve

This valve opens and closes the fluid passage between the pump and the suspension control pump accumulator. Normally, the fluid passage remains closed. When the vehicle height is being raised or the fluid is being stored in the suspension control pump accumulator, the solenoid valve opens in accordance with the signal received from the suspension control ECU.



Close



Open

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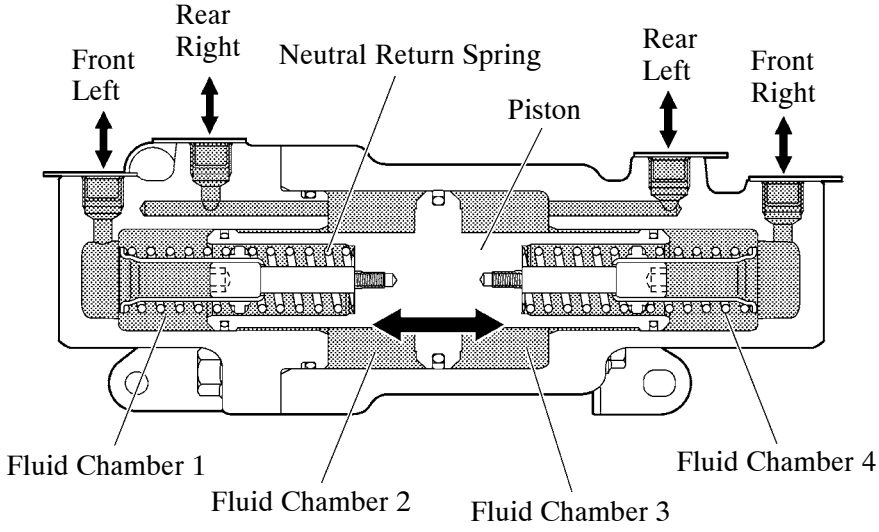
Center Suspension Control Cylinder

- The center suspension control cylinder is comprised of four fluid chambers and a piston.
- The fluid chambers are connected to each other via the hydraulic tubes from each of the shock absorbers. The center suspension control cylinder optimally distributes the hydraulic pressure for each of the wheels through the piston which operates in accordance with the input hydraulic pressure.



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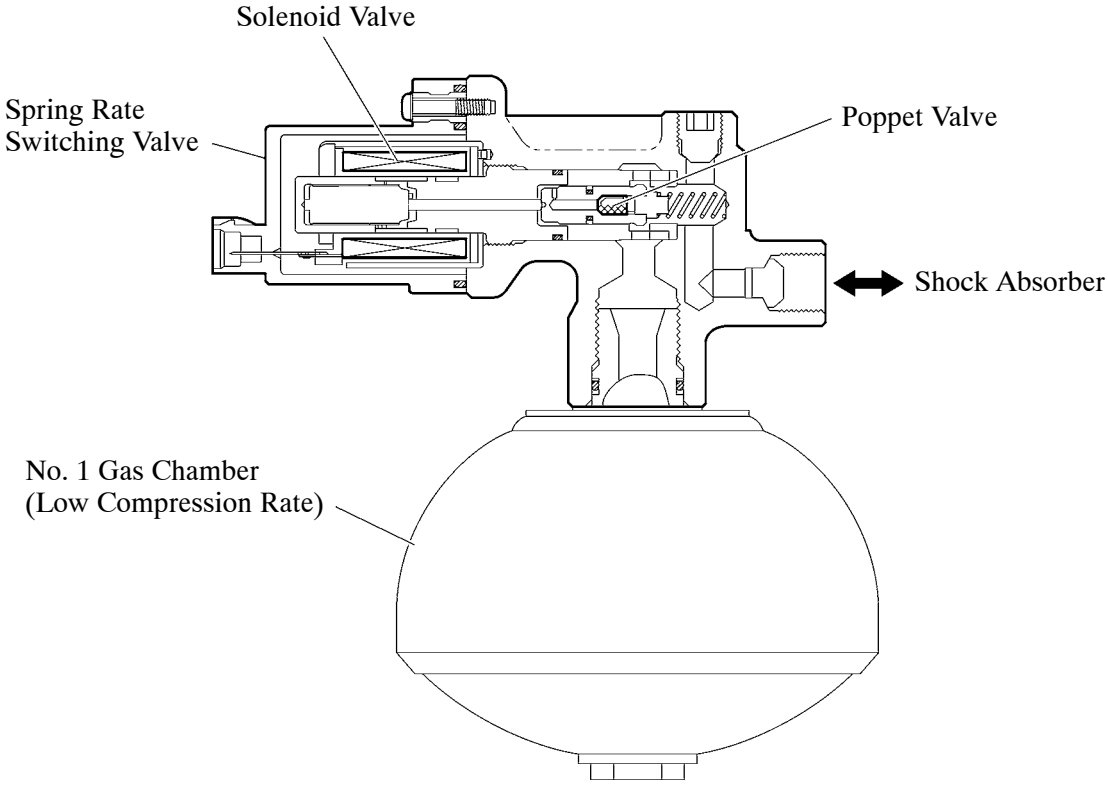
Spring Rate Switching Valve

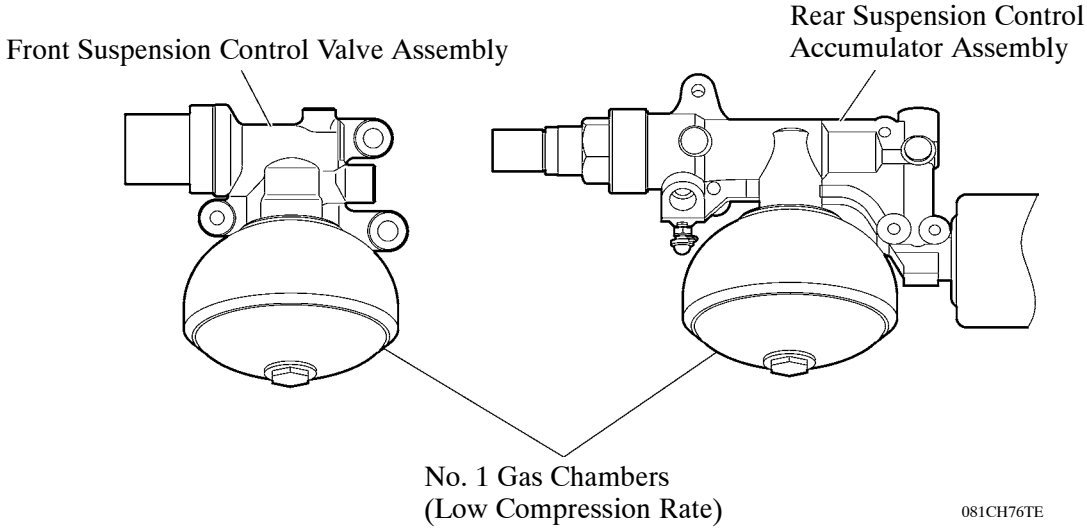
- This valve is provided in the front suspension control valve assembly, and it opens and closes the fluid passage to the No. 1 gas chamber to perform spring rate control.
- Normally, the fluid passage remains opened. During spring rate control, the fluid passage closes is accordance with the signal received from the suspension control ECU.

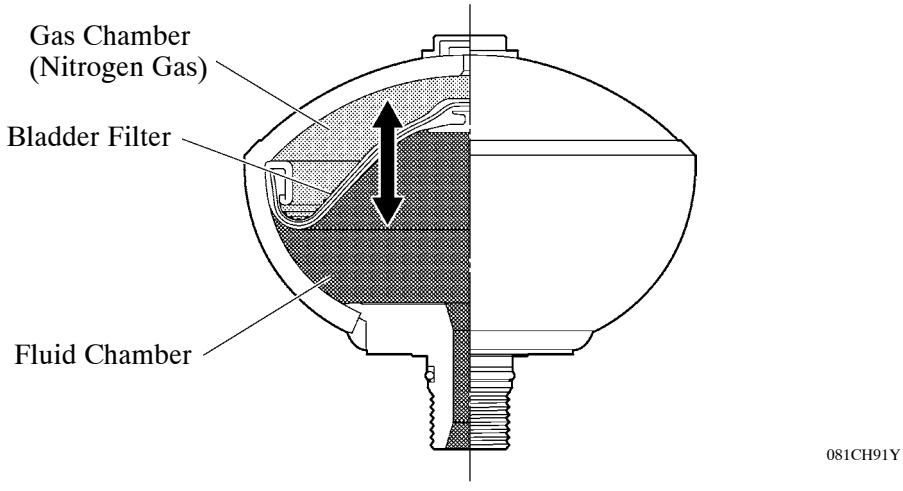


Front Suspension Control Valve Assembly 081CH75TI

No. 1 Gas Chamber

- The No. 1 gas chamber is provided for each of the wheels. This gas chamber is designed with a low compression rate utilizing a large-volume gas chamber.
- The front No. 1 gas chamber is provided for the front suspension control valve assembly.
- The rear No. 1 gas chamber is provided for the rear suspension control accumulator assembly.
- The No. 1 gas chamber uses the bladder filter type hydro-pneumatic accumulator. A resin membrane is sandwiched between rubber layers to realize excellent gas penetration resistance.
- The internal pressure of the gas chamber is varied by allowing the fluid to flow in and out of this gas chamber in order to raise or lower the vehicle height.





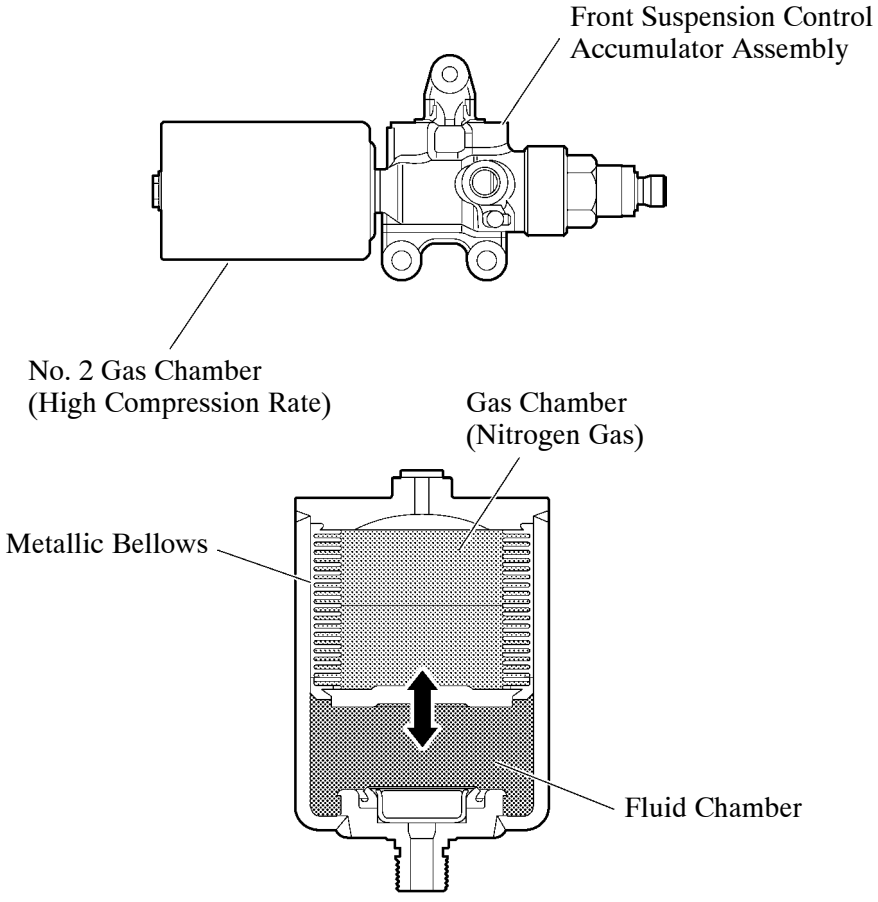
No. 1 Gas Chamber

▶ Specifications ◀

No. 1 Gas Chamber		Front	Rear
Sealed Gas		Nitrogen Gas	←
Gas Chamber Volume	cc (cu in.)	400 (24.4)	←
Sealed Gas Pressure	MPa (kgf/cm^2, psi)	2.26 (23, 328)	1.90 (19, 276)

No. 2 Gas Chamber

- A No. 2 gas chamber is provided for the front suspension control accumulator assembly. This gas chamber is designed with a high compression rate utilizing a small-volume gas chamber.
- The No. 2 gas chamber uses a metallic bellows type hydro-pneumatic accumulator, to prevent gas leakage.
- The internal pressure of the gas chamber is varied by allowing the fluid to flow in and out of this gas chamber in order to raise or lower the vehicle height.



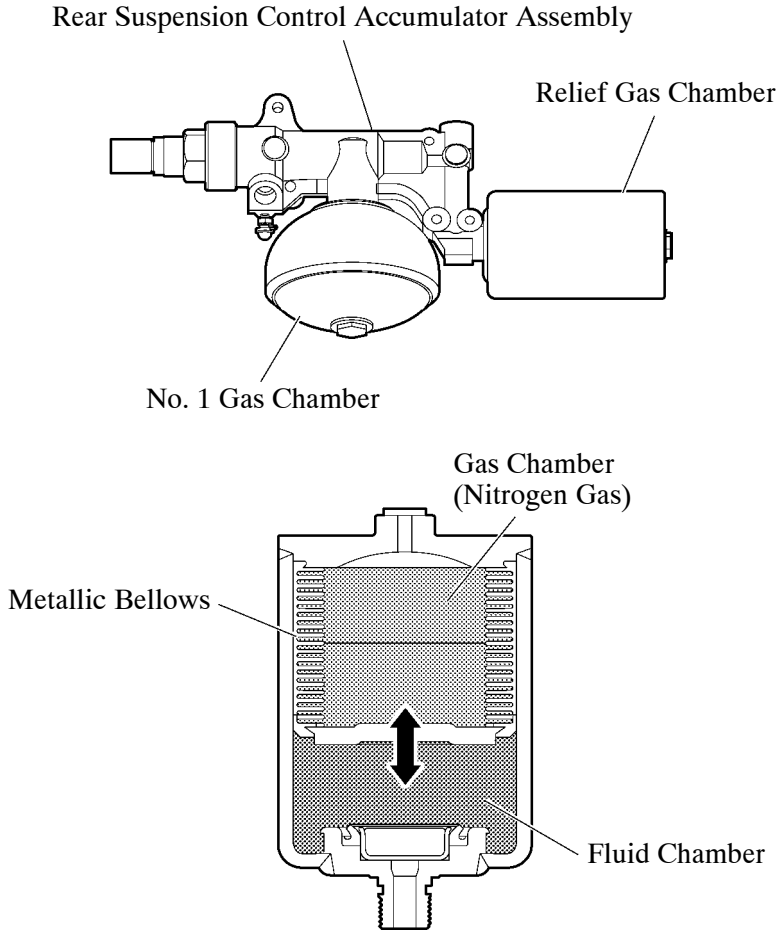
No. 2 Gas Chamber 08FCH036Y

▶ Specifications ◀

Sealed Gas		Nitrogen Gas
Gas Chamber Volume	cc (cu in.)	120 (7.3)
Sealed Gas Pressure	MPa (kgf/cm^2, psi)	1.8 (18, 261)

Relief Gas Chamber

- A relief gas chamber is provided for each of the wheels. This protects the hydraulic system by reducing increases in the fluid pressure inside the hydraulic tubes for the 4-wheel active height control suspension.
- The front relief gas chamber is placed directly over the front hydraulic tubes.
- The rear relief gas chamber is provided for the rear suspension control accumulator assembly.
- The relief gas chamber uses a metallic bellows type hydro-pneumatic accumulator likewise with the No. 2 gas chamber.
- The fluid inside the hydraulic tubes is allowed to flow into the relief gas chamber when the fluid pressure inside the hydraulic tubes exceeds the pressure of the nitrogen gas sealed in the relief gas chamber. Thus, fluid pressure increases inside the hydraulic tubes can be reduced.



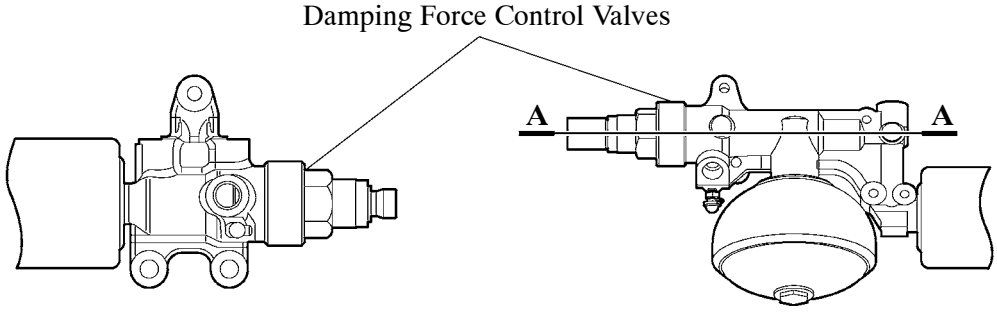
Relief Gas Chamber 08FCH037Y

▶ Specifications ◀

Relief Gas Chamber		Front	Rear
Sealed Gas		Nitrogen Gas	←
Gas Chamber Volume	cc (cu in.)	120 (7.3)	150 (9.2)
Sealed Gas Pressure	MPa (kgf/cm^2, psi)	13.5 (138, 1958)	10 (102, 1450)

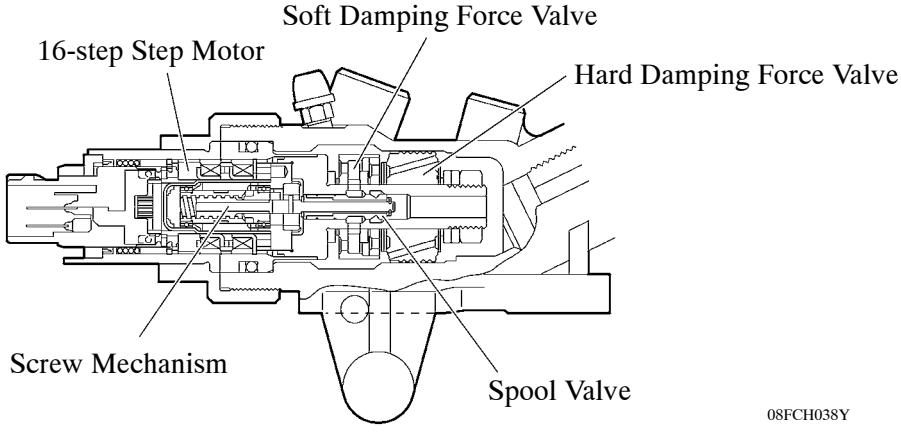
Damping Force Control Actuator

- The damping force control actuator is provided for each of the suspension control accumulator assemblies.
- This actuator consists of the 16-step step motor, a screw mechanism (which converts the rotational movement to a linear movement), a spool valve, a soft damping force valve and a hard damping force valve.
- Signals from the suspension control ECU activate the actuator, causing the spool valve to switch the fluid passage. Thus, the volume of fluid that passes through each valve is varied in order to control the damping force in 16 steps.

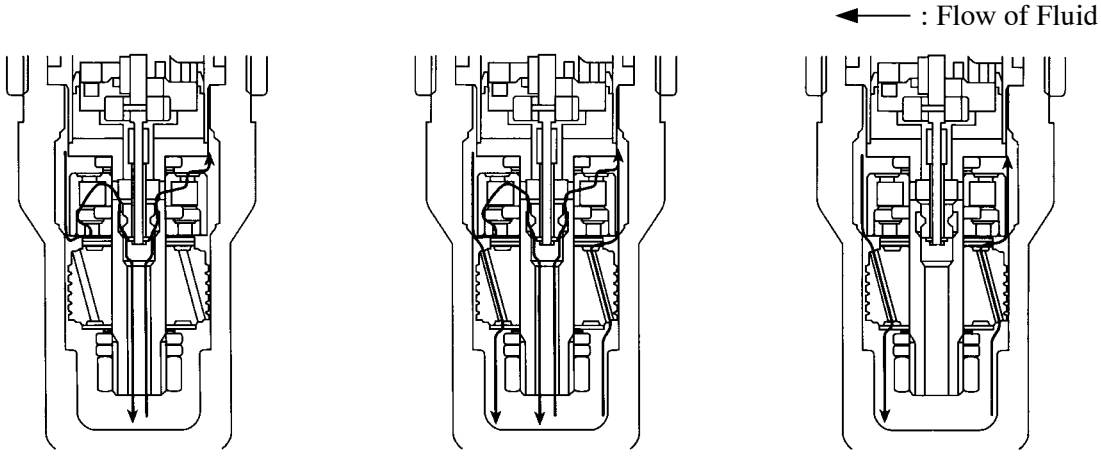


Front Suspension Control Accumulator Assembly

Rear Suspension Control Accumulator Assembly



A – A Cross Section



Damping Force (Soft)

Damping Force (Medium)

Damping Force (Hard)

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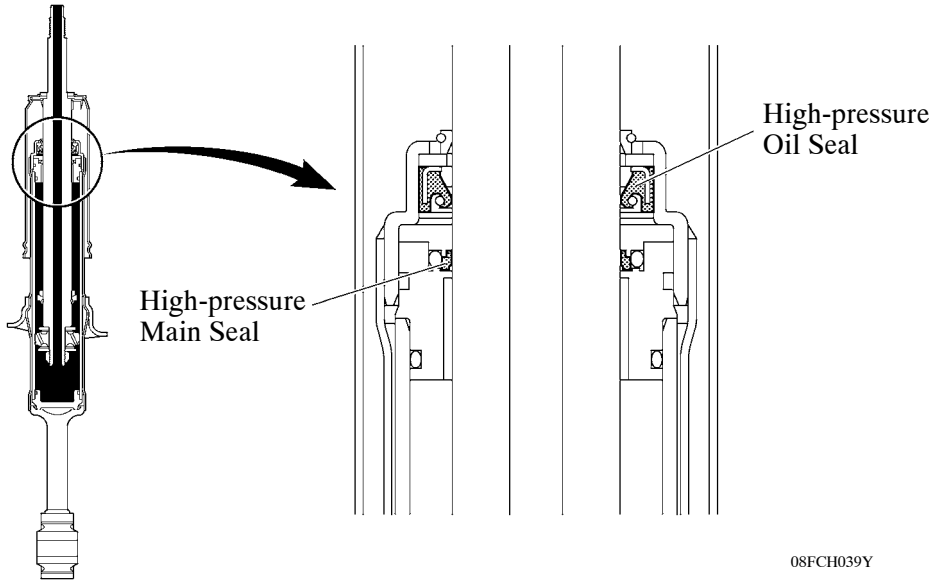
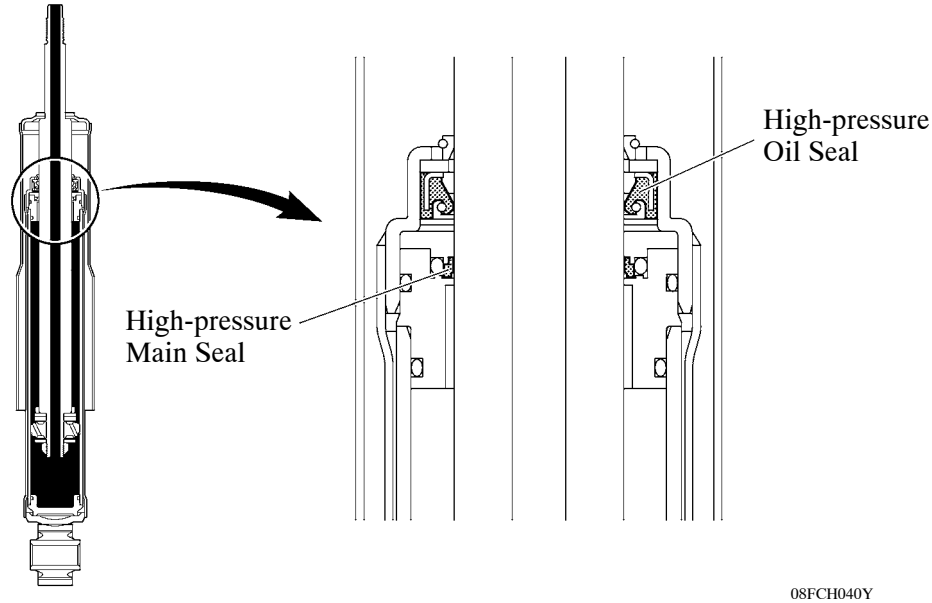
Shock Absorber

- The shock absorber has a dual construction using a high-pressure main seal made of fluoroethylene resin and a high-pressure oil seal made of nitrile rubber and provided with a backup ring in order to ensure sealing performance and reduce friction.
- The piston size has been increased to improve response, drivability, and ride comfort.



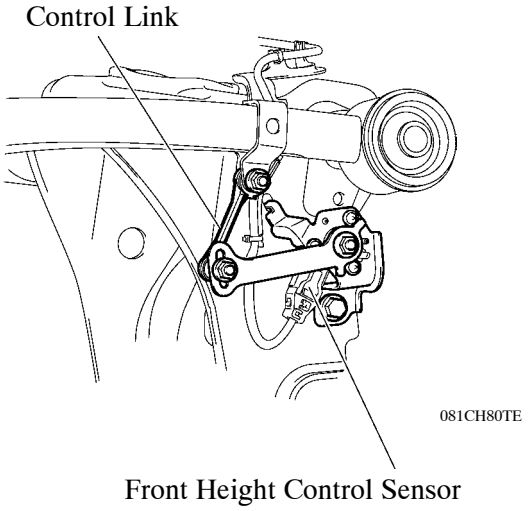
Front Shock Absorber

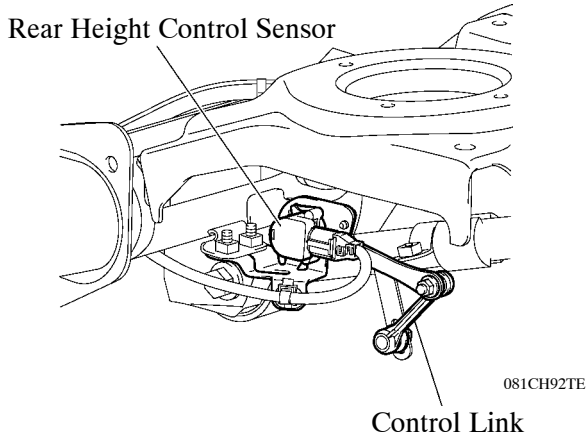


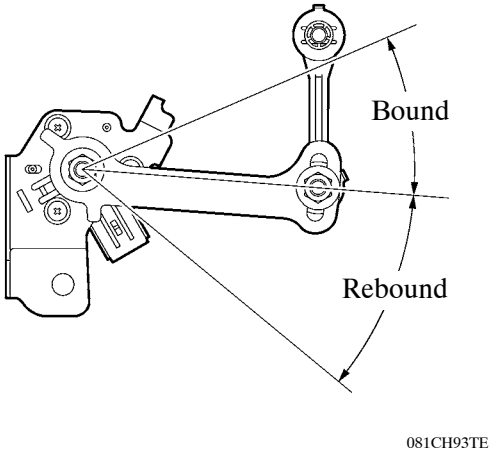
Rear Shock Absorber

Height Control Sensor

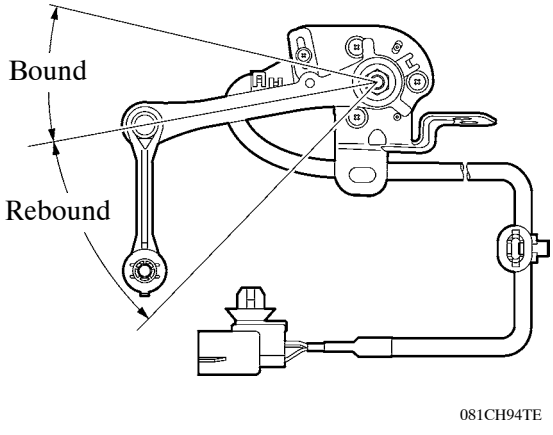
- Hall IC type height control sensors have been provided. The Hall IC converts the changes in the magnetic flux that occur at that time into electrical signals, and outputs them in the form of height control sensor effort to the suspension control ECU.
- There are two front height control sensors, one for the right, and the other for the left. They are mounted via the control links to the upper arms of the front suspension and to the body.
- There are also two rear height control sensors, one for the right, and the other for the left. They are mounted via the control links to the upper control arms of the rear suspension and to the body.
- Through the use of a height control sensor link and shaft, each height control sensor converts the rectilinear movement of the control link into a rotational movement, and the result is detected in the form of a rotational angle.







Front Height Control Sensor

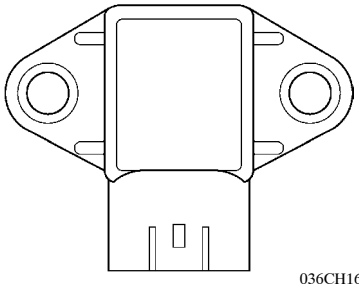


Rear Height Control Sensor

Acceleration Sensor

- The acceleration sensors detect the vertical movement above the body.
- The front acceleration sensors are placed on the right and left sides of the instrument panel and the rear acceleration sensor is placed inside the suspension control ECU. Thus, the acceleration sensors independently detect the vertical acceleration rate of the vehicle.

▶ Method for Detecting Vertical Acceleration ◀



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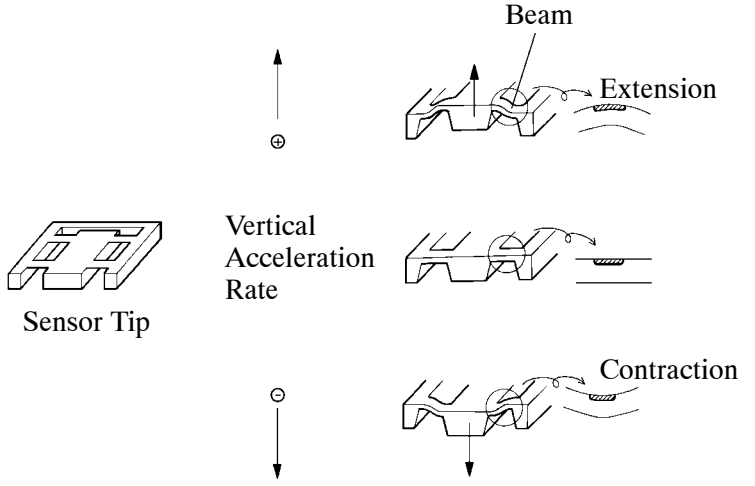
Front Acceleration Sensor



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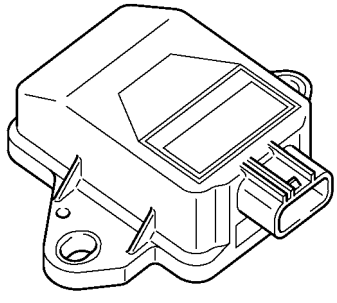
Yaw Rate and Deceleration Sensor

- A deceleration sensor is built into the yaw rate sensor.
- This sensor detects the yaw rate and lateral and longitudinal acceleration and deceleration, and sends this signal to the suspension control ECU.



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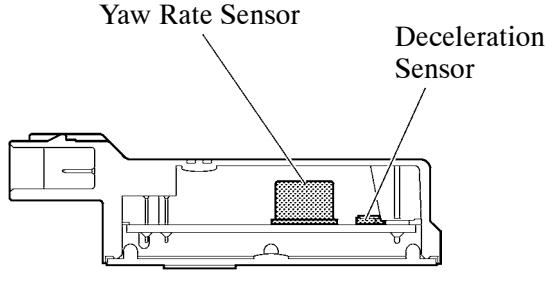
Yaw Rate and Deceleration Sensor



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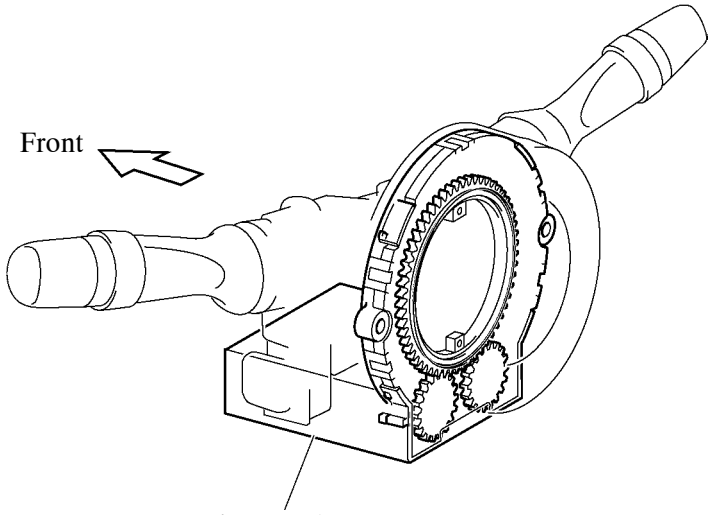
Cross Section

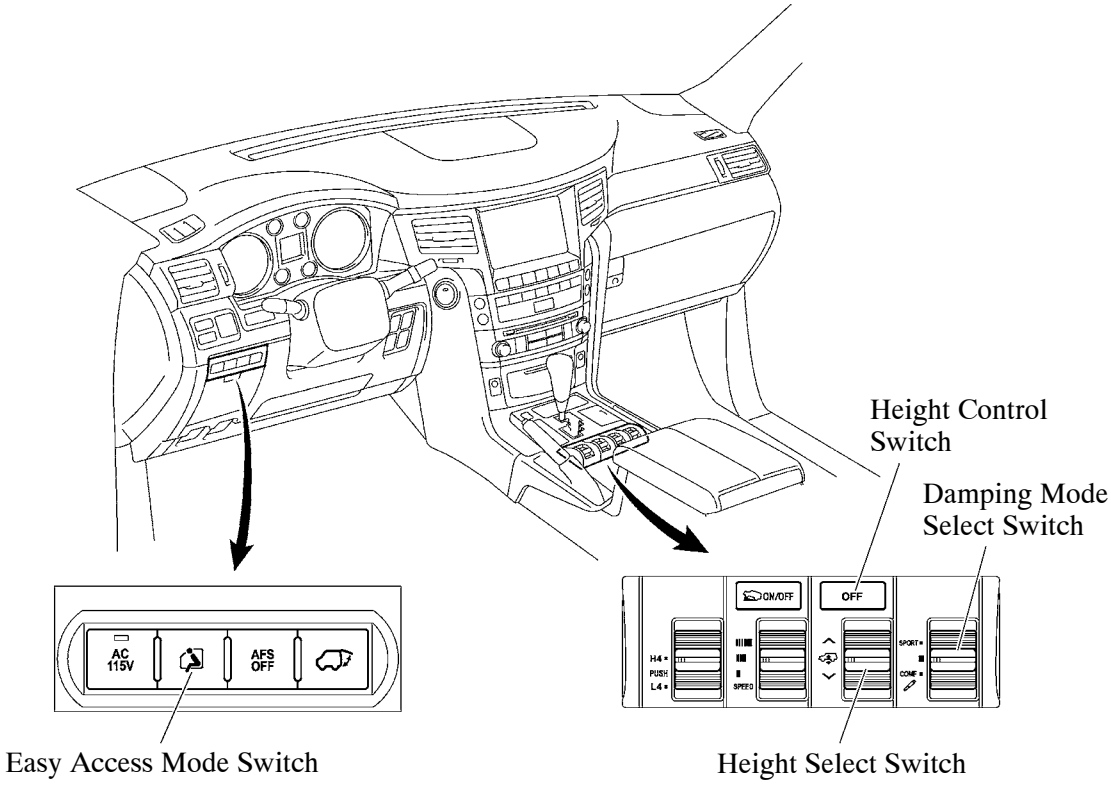
Steering Angle Sensor

- A steering angle sensor is provided in the combination switch area. This sensor detects the amount of steering effort and the direction of steering wheel.
- The sensor assembly contains two sets of magnetic reluctance elements that detect the rotational movement of a magnet that is built into the detection gear. Thus, the sensor detects the changes that occur in the magnetic reluctance elements along with the rotational movement of the detection gear, in order to detect the rotational movement of the steering wheel.



Suspension Control Switch and Easy Access Mode Switch

- The suspension control switch (the height select switch, height control switch, and damping mode select switch) is placed on the center console.
- The easy access mode switch is placed on the left side of the instrument panel (for LHD models).
- The easy access mode switch is placed on the right side of the instrument panel (for RHD models).



LHD Model

Switch		Function
Suspension Control Switch	Height Select Switch	Selects vehicle height between three levels by operating this switch. When the height control switch is ON, vehicle height cannot be changed.
	Height Control Switch	Prohibits the vehicle height control by operating this switch.
	Damping Mode Select Switch	Selects damping force between three levels by operating this switch.
Easy Access Mode Switch		Switches the easy access control between ON and OFF by operating this switch.

8. System Operation

Vehicle Height Control

- The vehicle height control controls the vehicle height over 5 levels in accordance with the manual switch operation or the driving conditions.
- The vehicle height control has the following functions:

Function	Outline
Vehicle Height Selection Function (See Page CH-100)	Enables the selection of 3 levels of vehicle height by operating a switch.
Automatic Leveling Function	This function maintains the vehicle height constant regardless of the load conditions such as the number of occupants or the weight of the cargo under the prescribed loading condition. It effects constant control so that the vehicle height is maintained at a prescribed value when the Normal position is selected.
Extra HI Mode	● While driving on an unpaved road with the transfer shifted in the L4 range and the vehicle height set to the HI position, if one of the wheels freewheels, the vehicle is raised up to the Extra HI position, 20 mm (0.8 in.) higher than the HI position. ● When the CRAWL function of the brake control system is in operation and the vehicle height adjustment request signal for switching to the Extra HI position is input from the skid control ECU to the suspension control ECU, the vehicle is raised up to the Extra HI position.
Vehicle Speed Sensing Function (See Page CH-104)	The vehicle height will be automatically adjusted in accordance with the vehicle speed and selected vehicle height.
Easy Access Control (See Page CH-106)	For convenient in-and-out access, this function effects vehicle height control in conjunction with the engine switch when the easy access mode is set to ON.
Vehicle Height Adjustment Prohibition Control	When the vehicle is raised on a jack or is being towed, the vehicle adjustment can be prohibited by operating the height control switch*. However, the prohibition control cancels automatically when the vehicle speed becomes higher than approximately 80 km/h (50 mph) at the Normal position, or higher than approximately 30 km/h (19 mph) at the HI or LO position.

*: This control is available only when the vehicle is stopped [the vehicle speed is 5 km/h (3.1 mph) or less].

1) Vehicle Height Selection Function

The following three types of vehicle heights can be selected by operating the switch: normal vehicle height (Normal), low vehicle height (LO), and high vehicle height (HI).

Selected Height Position		LO	Normal	HI
Vehicle Height	Front	Approximately –60 mm (–2.4 in.)	Standard Vehicle Height	Approximately +50 mm (+2.0 in.)
	Rear	Approximately –40 mm (–1.6 in.)	Standard Vehicle Height	Approximately +60 mm (+2.4 in.)
Vehicle Height Adjustment Speed*1	Up	LO to Normal Approximately 11 to 16 seconds		
	Down	Normal to LO Approximately 2 seconds*2		

*1: Vehicle height control speed differs depending on the loaded condition.
*2: Approximately 5 seconds when the shift lever is in N.

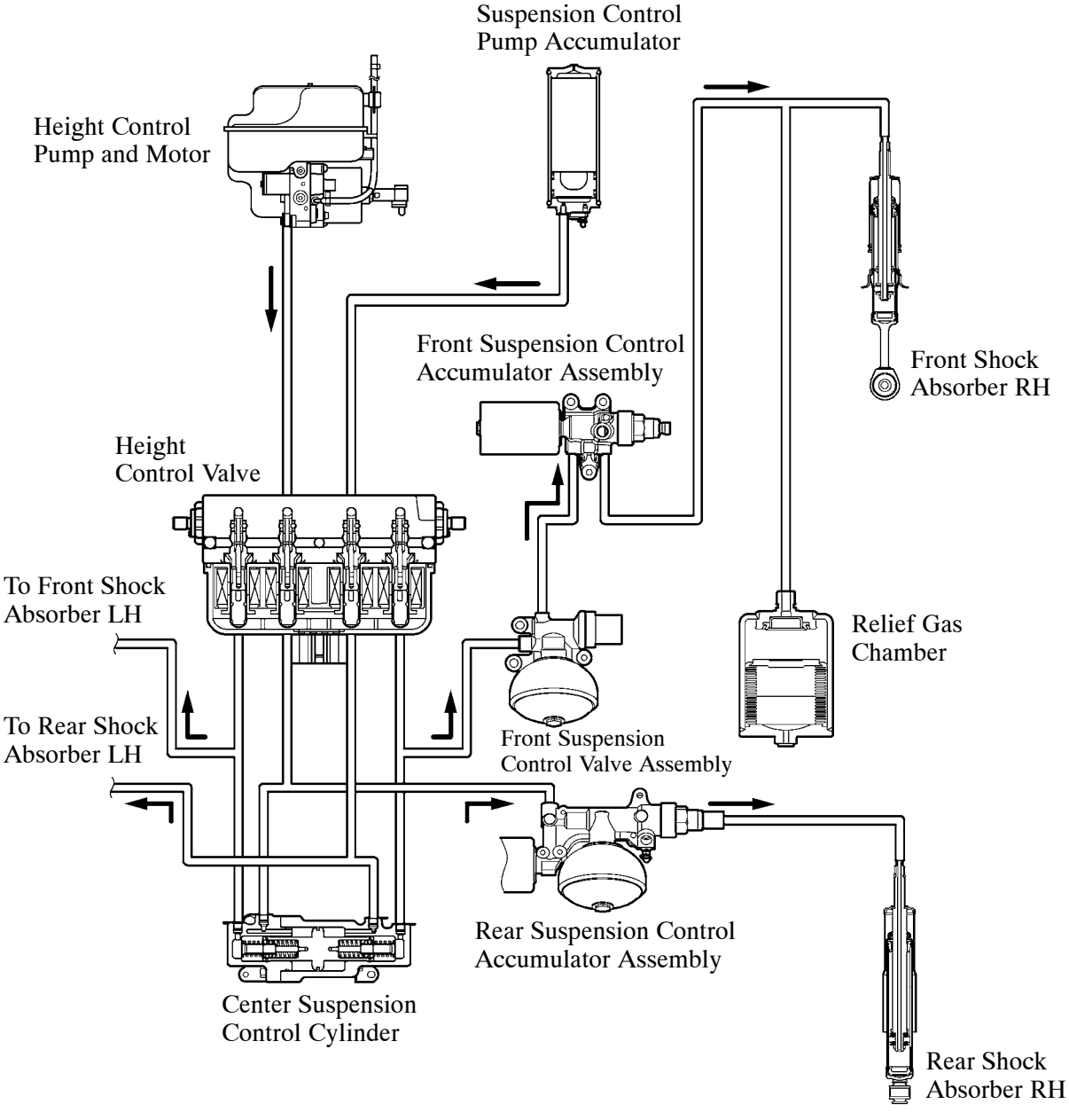
NOTE

When a load exceeding the following axle weight limitations is applied to the vehicle, it causes the vehicle not to stay at the Normal height. At times like this, it might not be possible to raise the vehicle height even by operating the switch.

- In Normal mode: Front axle weight: 1460 kg (3212 lb)/Rear axle weight: 1800 kg (3960 lb)

a. Raising Vehicle Height (Manual Operation)

When the height select switch is operated to raise the vehicle height, the suspension control ECU opens the leveling valves for each of the wheels arranged inside the height control valve. This allows the fluid to flow from the pump into the shock absorber and gas chamber and results in an increase in the vehicle height. Simultaneously, the accumulator valve opens, guiding the fluid into them from the suspension control pump accumulator, thereby raising the vehicle height.



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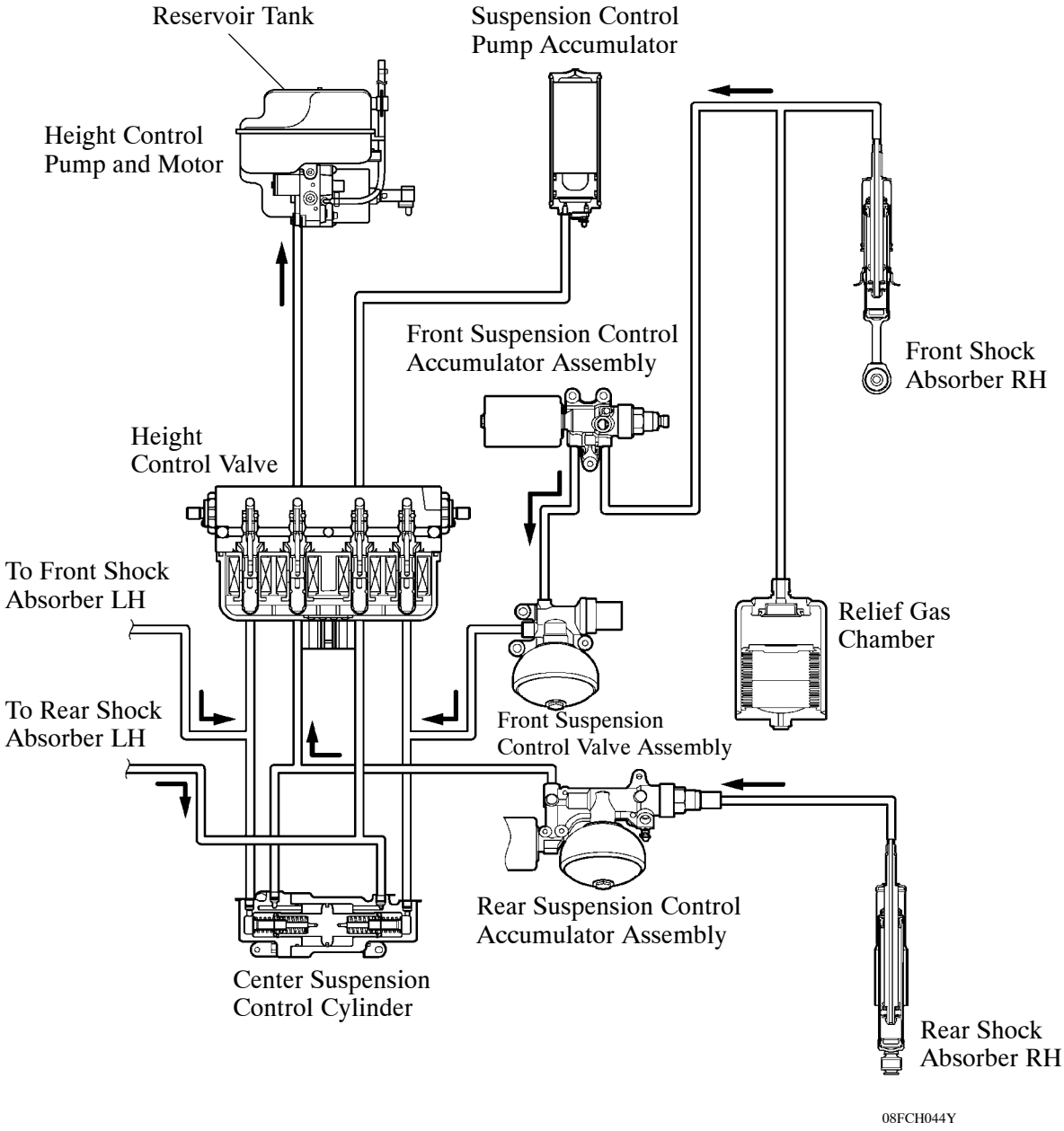
b. Lowering Vehicle Height (Manual Operation)

When the height select switch is operated to lower the vehicle height from the HI to the Normal position, or from the Normal to the LO position, the suspension control ECU opens the front and rear leveling valves. As a result, the fluid in the gas chambers and the shock absorbers arranged for each of the wheels returns into the reservoir tank, thereby lowering the height of the suspension. However, if the rear side is expected to become lower more quickly due to the load condition, and the difference between the lowering of the front side and the rear side becomes greater than a prescribed value, the rear leveling valve closes once, allowing only the vehicle height to become lowered at the front side. This feature prevents the headlights from being aimed upward.

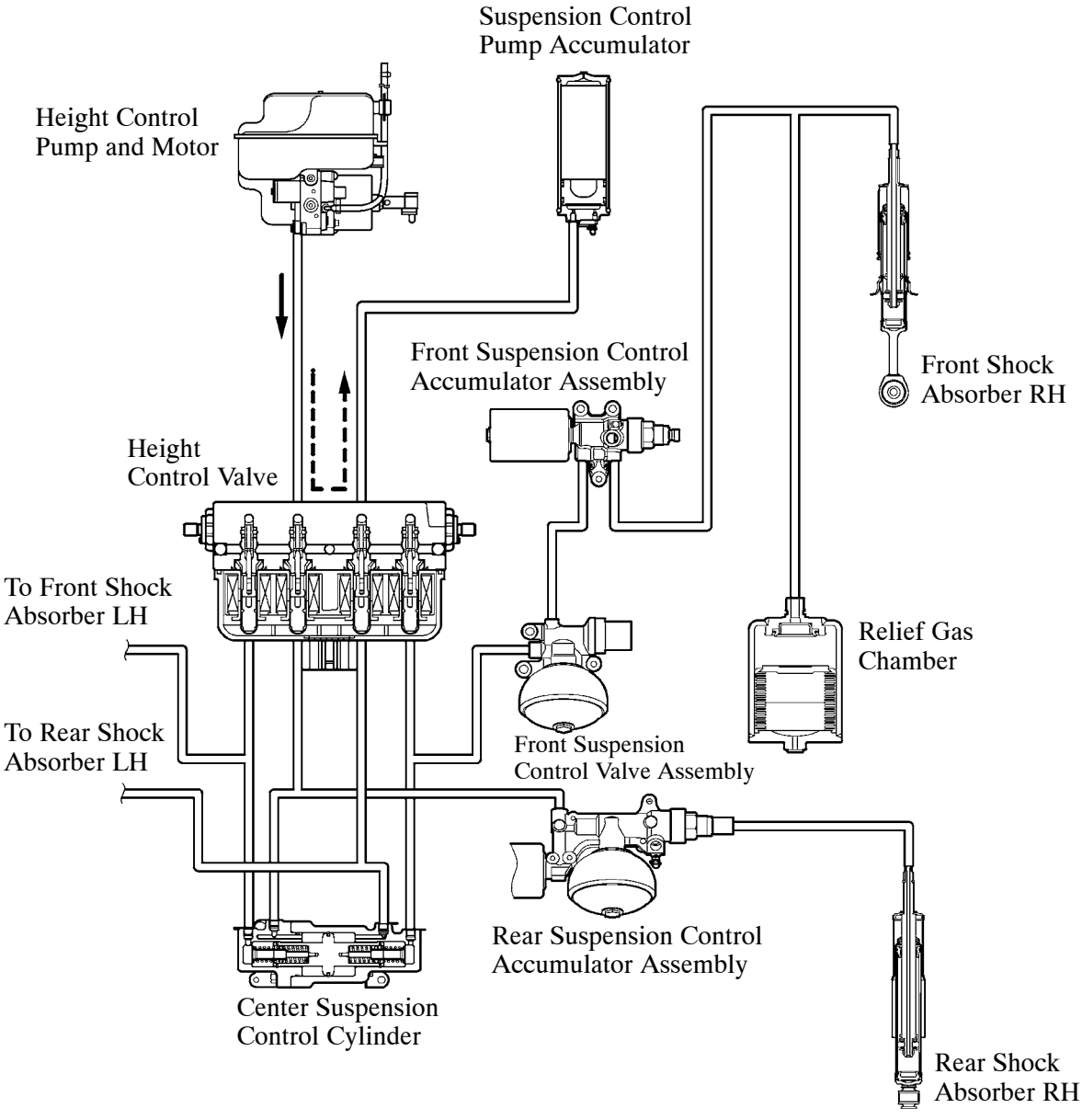


c. Fluid Stored in Height Control Accumulator

Normally, the suspension control pump accumulator stores only the amount of fluid that is equivalent that used in raising the vehicle height once. Therefore, after the vehicle has been raised from the LO position to the Normal position, or from the Normal position to the HI position, it is necessary to replenish the fluid in the suspension control pump accumulator.

At this time, the pump motor is operated to rotate the pump, the leveling valves are closed, the accumulator valve of the height control valve is opened, and the fluid is stored in the suspension control pump accumulator.

When the vehicle height is raised while the fluid that is stored in the suspension control pump accumulator has not reached a prescribed pressure, only the fluid that is discharged by the pump is used for raising the vehicle height, without using the fluid in the suspension control pump accumulator.



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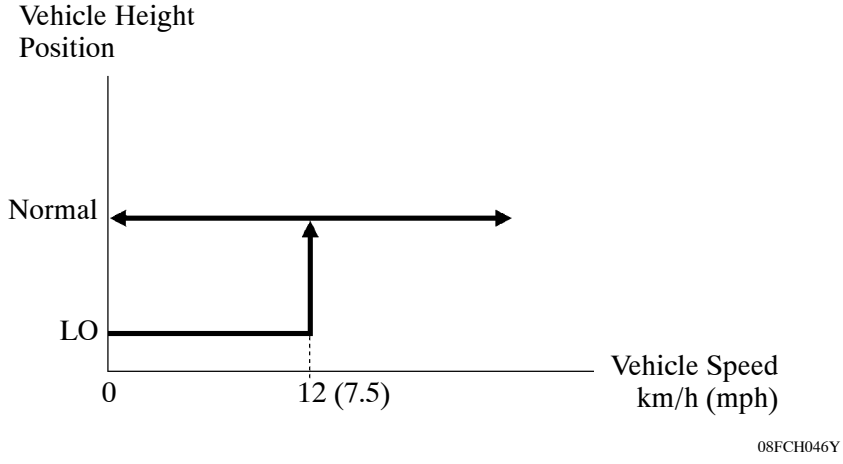
2) Vehicle Speed Sensing Function

This function automatically adjusts the vehicle to any of the six levels of the height positions depending on vehicle speeds and vehicle conditions. The values of each height position are as follows:

Height Position	Front Suspension Adjustment Value	Rear Suspension Adjustment Value
Extra HI	70 mm (2.8 in.)	80 mm (3.1 in.)
HI	50 mm (2.0 in.)	60 mm (2.4 in.)
L4 Range HI	25 mm (1.0 in.)	25 mm (1.0 in.)
Normal	0 mm (0 in.)	0 mm (0 in.)
High Speed LO	–20 mm (–0.8 in.)	–15 mm (–0.6 in.)
LO	–60 mm (–2.4 in.)	–40 mm (–1.6 in.)

- If the vehicle speed exceeds approximately 12 km/h (7.5 mph) when the vehicle height is set to the LO position, the vehicle height will be automatically adjusted to the Normal position.



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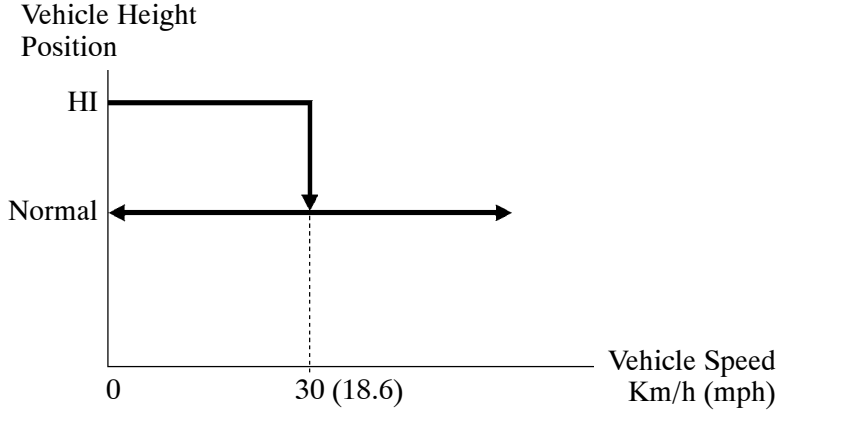
- If the vehicle speed exceeds approximately 30 km/h (18.6 mph) when the vehicle height is set to the HI position, the vehicle height will be automatically adjusted to the Normal position.



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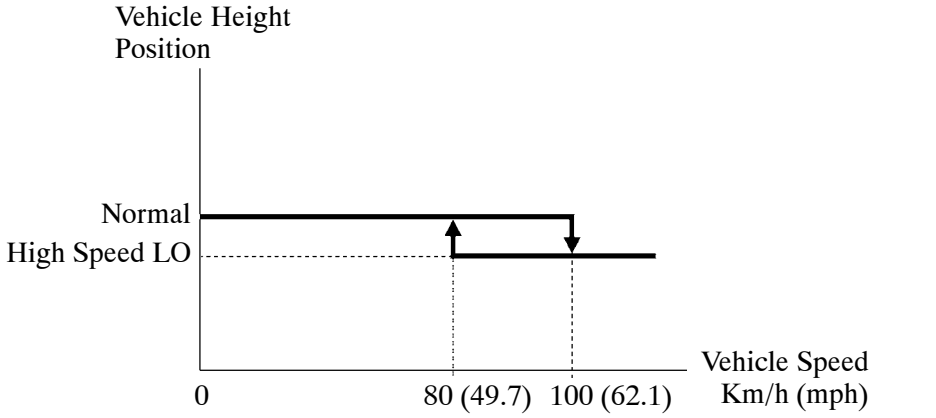
- If the vehicle speed exceeds approximately 100 km/h (62.1 mph) when the vehicle height is set to the Normal position, the vehicle height will be adjusted to the High Speed LO position. If the vehicle speed is decreased to approximately 80 km/h (49.7 mph) or less while this is in effect, the vehicle height will be automatically adjusted to the Normal position.



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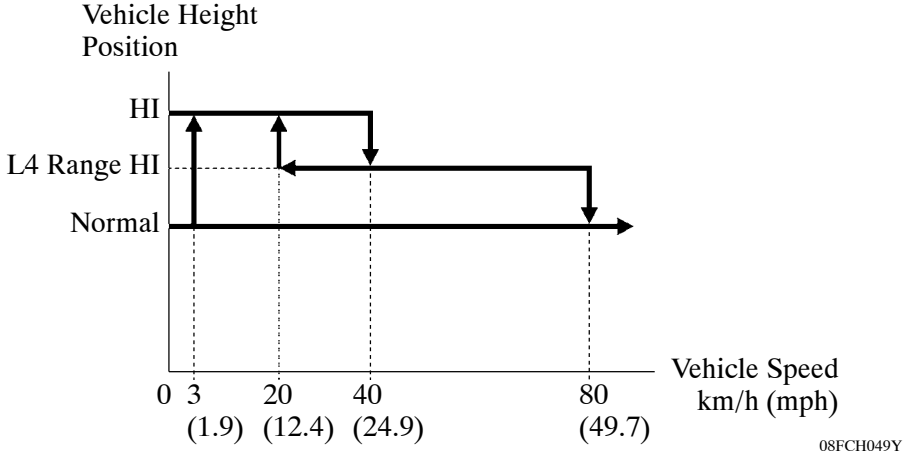
- When the transfer is set in the L4 range, the following control is performed.
  - If the vehicle speed exceeds approximately 3 km/h (1.9 mph) when the vehicle height is set to the Normal or LO position and a rough road condition is detected, the vehicle height will be automatically adjusted to the HI position.
  - When the vehicle speed exceeds 40 km/h (24.9 mph), the vehicle height will be adjusted to the L4 Range HI position. If the vehicle further accelerates in this condition and the vehicle speed exceeds 80 km/h (49.7 mph), the vehicle height will be automatically adjusted to the Normal position. On the other hand, if the vehicle decelerates and the vehicle speed is decreased to 20 km/h (12.4 mph) or less, the vehicle height will be automatically adjusted to the HI position.



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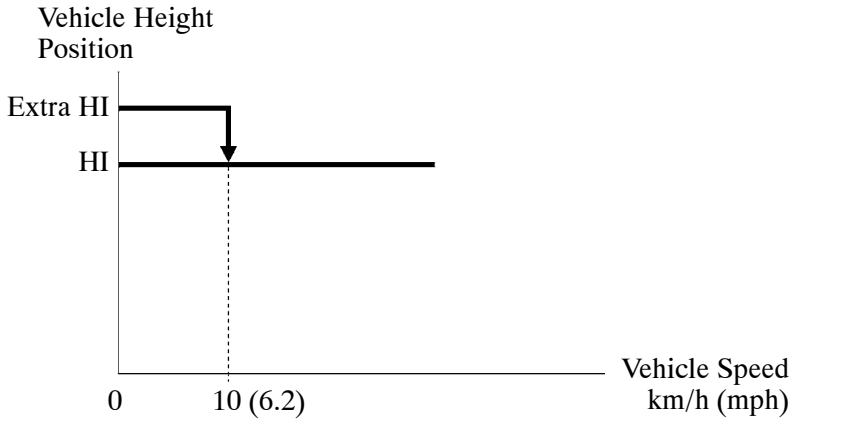
- If the vehicle speed exceeds approximately 10 km/h (6.2 mph) when the vehicle height is set to Extra HI position, the vehicle height will be automatically adjusted to the HI position.



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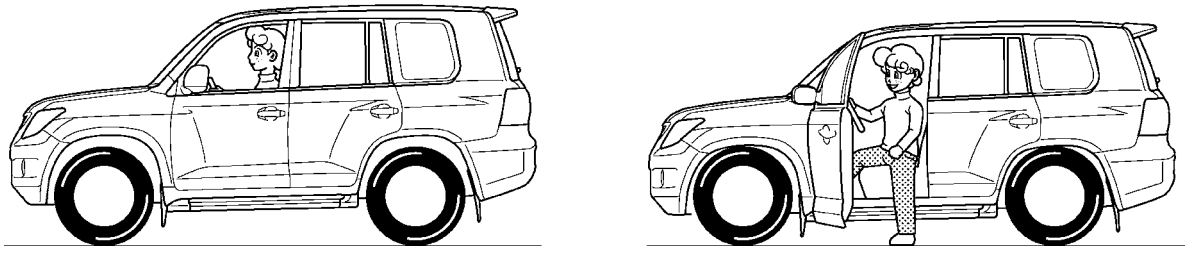
3) Easy Access Control

This function effects vehicle height control in conjunction with the engine switch when all of the following conditions have been met.

Condition	Function
● Easy access mode switch is ON ● Vehicle height is Normal ● Shift lever is in P position ● Vehicle speed is 0 km/h (0 mph) ● Engine switch is turned OFF ● Vehicle is on flat road	● The vehicle height is changed from the Normal position to the LO position. ● The wireless door lock buzzer sounds*1. ● The hazard light flashes*2. ● The easy access mode indicator light is changed from illuminating condition to blinking condition.
● Easy access mode switch is ON ● Engine switch is turned ON (IG) ● Vehicle speed is 12 km/h (7.5 mph) or more	● The vehicle height is changed from the LO position to the Normal position.

*1: Except China Models
*2: For China Models



Normal Position **LO Position**

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Damping Force Control

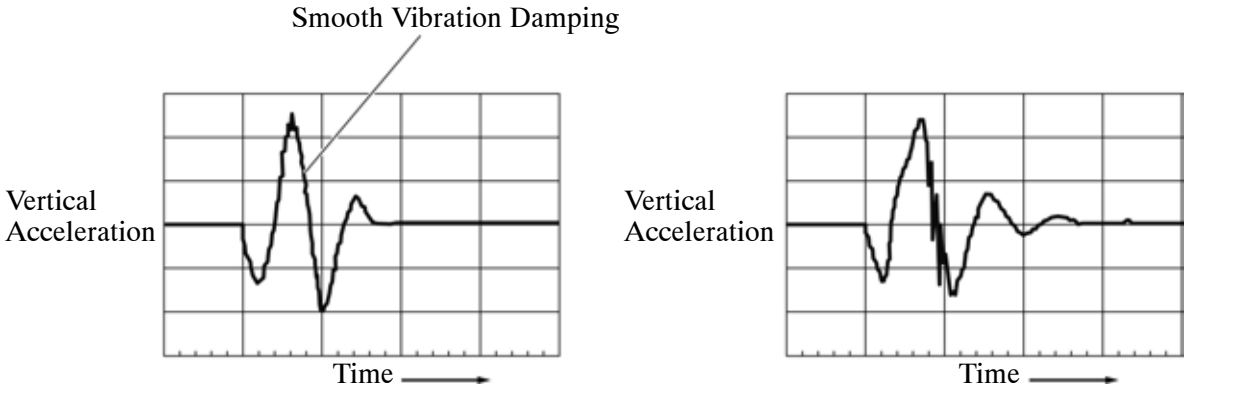
The damping force control has following functions:

Control	Function
Non-linear H^{∞} Control (See Page CH-108)	Smoothly changes the damping force to a target value in accordance with the changes in the road surface or driving conditions. Thus, excellent ride comfort has been realized while a high level of vibration damping performance is ensured.
Thumping Sensitive Control	Controls the shock absorbers so that the damping force for the shock absorbers will not increase while driving on a rough road.
Large-amplitude Control	When the suspension control ECU detects any large fluctuation in the wheel stroke when driving at low speeds, the damping force is adjusted to a firmer variable range for a predetermined time, to decrease the spring vibration.
Roll Posture Control (See Page CH-108)	Changes the damping force to control the vehicle posture during cornering. As a result, excellent stability and controllability have been realized during cornering.
Anti-dive Control	During braking, this function makes the damping force firmer to restrain the body dive, thus ensuring excellent stability and controllability.
Anti-squat Control	During acceleration, this function makes the damping force firmer to minimize the changes in the vehicle body posture.
High Speed Control	This function varies the variable range of the damping force according to vehicle speed in order to realize a soft and comfortable ride and a stable driving condition. The damping force is controlled in a softer variable range at low speeds, and in a firmer variable range at high speeds.
Absorber Control	The damping mode select switch enables the driver to select a desired damping force from the 3 modes.
L4 Range Control	The damping force is normally controlled in 16 steps. However, when the transfer is set in the L4 range, it is controlled in the intermediate 8 steps*, thereby ensuring riding comfort during off-road driving.

*: It is controlled in 3 steps when the vehicle speed is 55 km/h (34.2 mph) or less, and 8 steps when the vehicle speed is more than 55 km/h (34.2 mph).

1) Non-linear H^{∞} Control

This control uses 3 acceleration sensors to detect the vertical acceleration rate that corresponds to the bumps on the road surface and applies the non-linear H^{∞} control to calculate the target damping force. Unlike linear control which linearly changes the damping force proportional to the sprung acceleration rate, non-linear H^{∞} control achieves a higher level of vibration damping performance. As a result, superior riding comfort is ensured on any road surface or under any driving conditions.



Non-linear H^{∞} Control **Linear Control**

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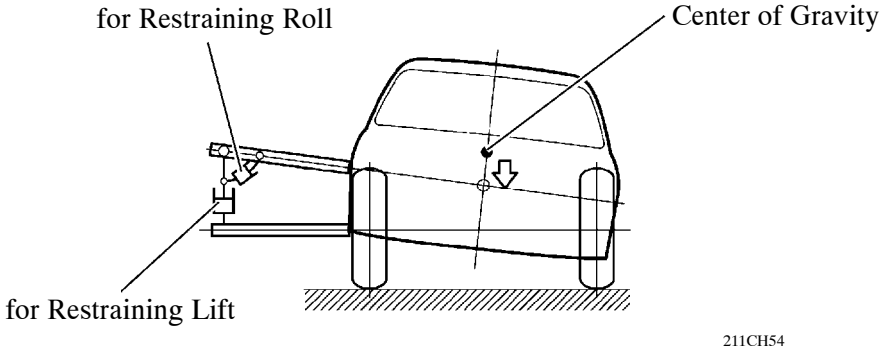
2) Roll Posture Control

- This control changes the damping force to control the vehicle posture during cornering. As a result, excellent stability and controllability have been realized during cornering. This control assumes that two types of shock absorbers (one for restraining roll and the other for restraining lift) are provided at an imaginary point on the inside of the turn of the vehicle. The function of these shock absorbers is to prevent the center of gravity of the vehicle from rising. The damping force of the front and rear shock absorbers is controlled in order to control the vehicle's posture as in this imaginary condition.
- To effect this control, the suspension stroke information is calculated based on the information from the 3 acceleration sensors and a steering angle sensor. Thus, the driving conditions of the vehicle are detected.



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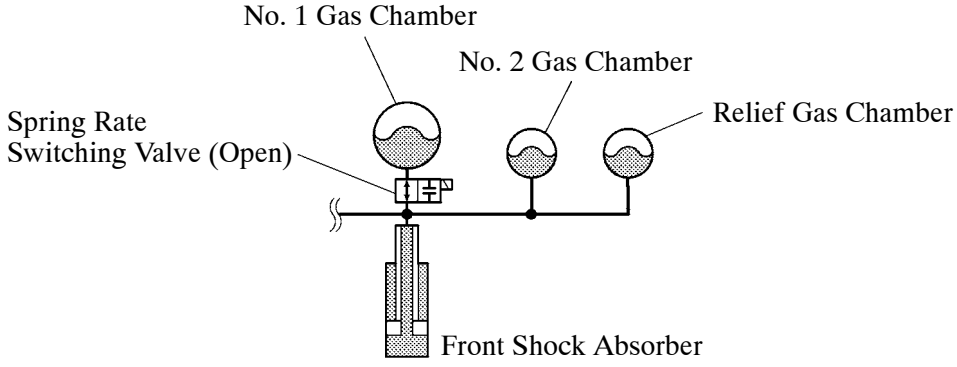
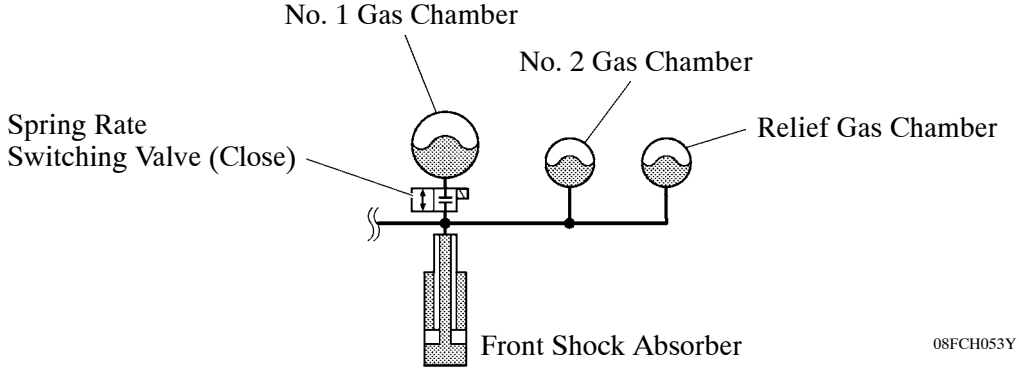
Spring Rate Control

- The front shock absorber includes No. 1 and No. 2 gas chambers. These gas chambers are automatically selected in accordance with the driving conditions, and this ensures both driving comfort and steering stability.
- Under normal driving conditions, the suspension control ECU opens the spring rate switching valve and allows the gas chambers to operate, thereby reducing the spring rate and ensuring ride comfort.
- If the vehicle speed exceeds a predetermined speed while cornering or when the brake pedal is depressed, the suspension control ECU closes the spring rate switching valve and allows only the No. 2 gas chamber to operate, thereby increasing the spring rate to control the vehicle posture and improve the steering stability.



Normal Driving Condition

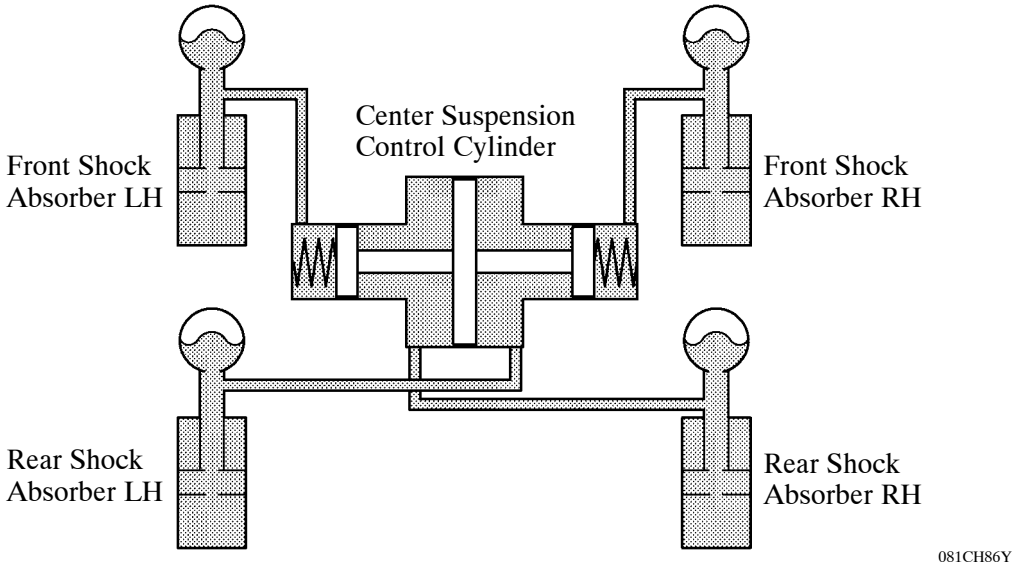


During Cornering or while Brake Pedal is being Depressed

4-wheel Related Control

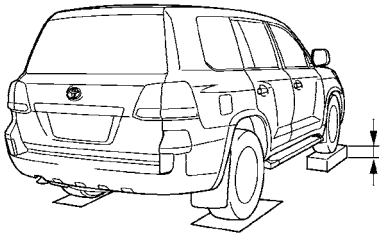
1) General

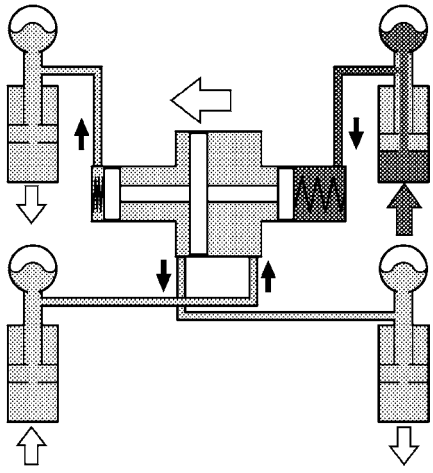
When a hydraulic pressure of one of the shock absorbers has changed because of changes in driving conditions, the 4-wheel related control adjusts the hydraulic pressure for the other shock absorbers through the center suspension control cylinder which is connected to all shock absorbers to stabilize the vehicle posture. When the vehicle is cornering, braking or driving on rough roads, the center suspension control cylinder operates differently through the center suspension control cylinder structure and shock absorber connection method, thereby achieving the optimum on-road and off-road driving performance.



2) Driving under Rough Road Conditions (When an impact force is applied to only one wheel)

When an impact is only applied to the front right wheel during on-road driving, the piston placed inside the center suspension control cylinder moves to the left in accordance with increase in the wheel pressure. This movement prompts the other shock absorbers to expand or contract as shown in the illustration, thereby improving the grounding performance.





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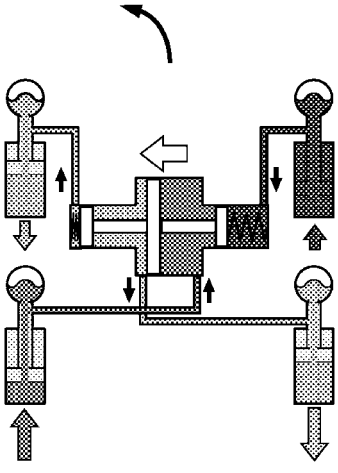
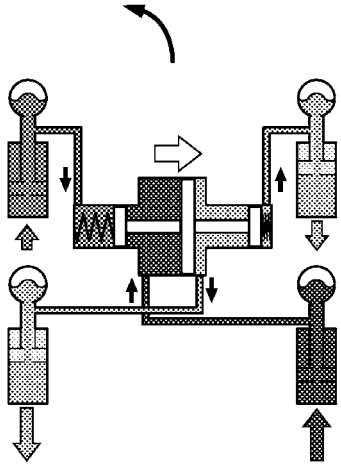
3) While Cornering

As shown in the illustration, when a small load is applied to the rear of the vehicle and the rolling stiffness of the suspension for the front wheels is high, the hydraulic pressure of the front right absorber is high. Then, the piston inside the center suspension control cylinder moves to the left in accordance with changes in the hydraulic pressure balance for each of the wheels. As a result, the pressure is applied to the rear right absorber, and the rear suspension is caused to move in the opposite direction from that of the front suspension.

On the other hand, when a large load is applied to the rear of the vehicle and the rolling stiffness of the suspension for the rear wheels is high, the hydraulic pressure of the rear right absorber is high. Then, the piston inside the center suspension control cylinder moves to the right in accordance with changes in the hydraulic pressure balance for each of the wheels. This optimizes the rolling stiffness distribution regardless of load quantity and improves the steering stability.



When Cornering Left
(Front wheel rolling stiffness is high)



When Cornering Left
(Rear wheel rolling stiffness is high)

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9. Fail-safe

- If the suspension control ECU detects a malfunction in the active height control suspension system, the ECU illuminates the master warning light, indicates the warning message “Check 4-WHEEL AHC System” on the multi-information display, and sounds the buzzer to inform the driver of the malfunction.
- When a vehicle can still be driven even if a system malfunction occurs, the vehicle height is automatically returned to the Normal position at a speed of 30 km/h or more.

10. Diagnosis

If a system malfunction occurs, DTC (Diagnostic Trouble Code) is stored in memory of the suspension control ECU. This DTC can be read by the following two methods.

- The 5-digit DTC can be read by connecting a intelligent tester II to the DLC3.
- The 2-digit DTC can be read by connecting the SST (09843-18040) between the TC and CG terminals of the DLC3.

For details, see the LEXUS LX 570 Repair Manual (Pub. No. RM08G0E).

11. Active Test

Vehicle height control and damping force control operation in the suspension system can be checked through either of the following two methods:

- Vehicle height and damping force of each wheel can be operated by connecting an intelligent tester II to the DLC3.
- Vehicle height of each wheel can be operated by connecting the terminals of the height control connector.

For details, see the LEXUS LX 570 Repair Manual (Pub. No. RM08G0E).