ELECTRONIC CONTROL SUSPENSION (ECS)

The electronic control suspension (ECS) is a system that automatically switches the damping force characteristics of the four shock absorbers, front and rear, in three steps (SOFT, MEDIUM and HARD) in response to driving conditions and the conditions of the road surface. It is also possible to select two modes (TOUR and SPORT) according to driver preference. The damping force is changed by commands from the ECS control unit; the actuator built into the shock absorbers is activated and the flow of oil inside the absorbers is varied.
This system also has a diagnostic function and a failsafe function for improved serviceability and safety.

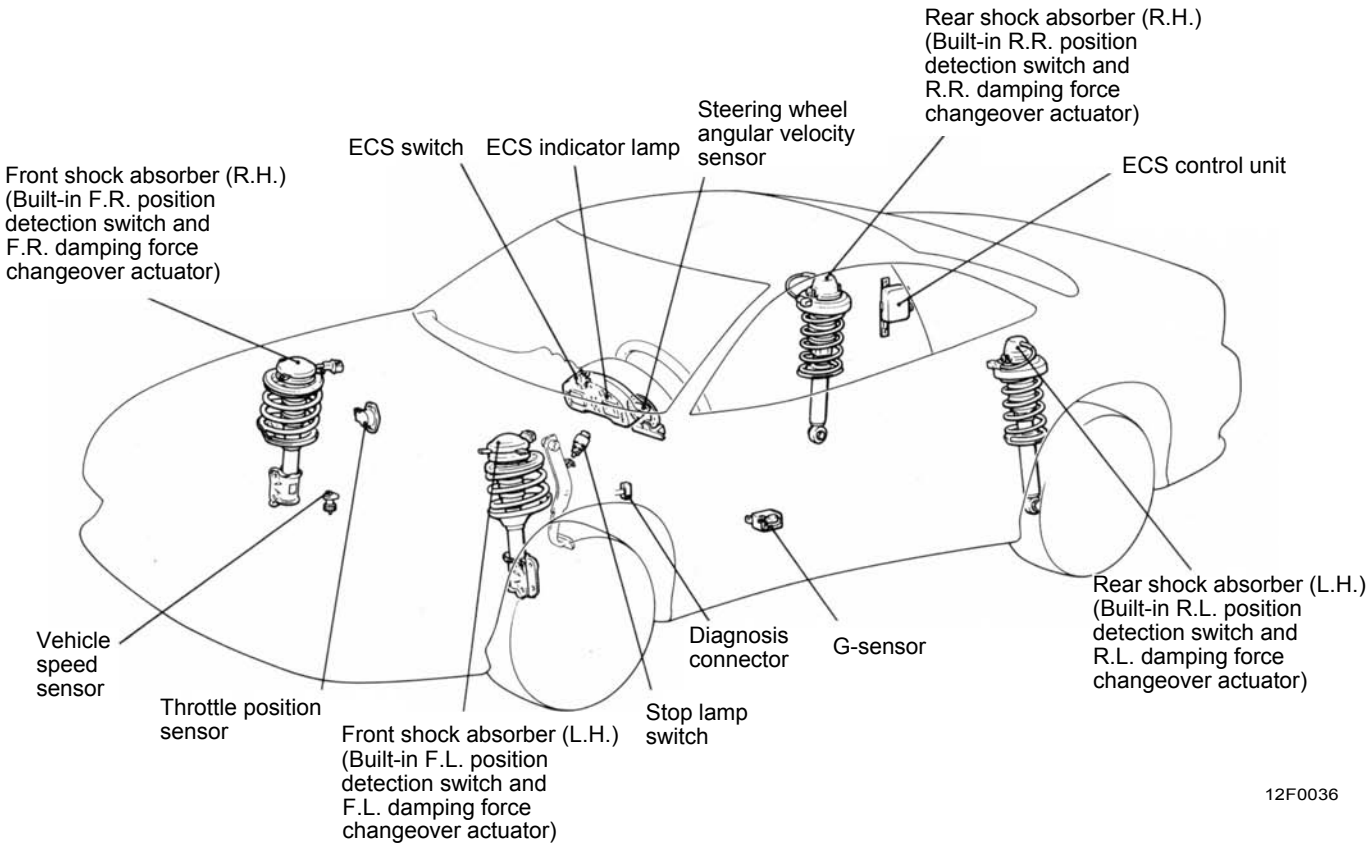
SPECIFICATIONS

FRONT SUSPENSION

Items	Specifications
Suspension system	MacPherson strut with coil spring and compression rod type
Camber	0° ± 30'
Caster	3°55' ± 30'
Toe-i n mm (in.)	$0 \pm 3\ (0 \pm 0.12)$
Coil spring	
Wire dia. x 0.D. x free length mm (in.)	
Vehicles for Europe	15.4 x 185.4 x 293 (0.61 x 7.30 x 11.54)
Vehicles for General Export, GCC and Australia	15.7 x 185.7 x 301.5 (0.62 x 7.31 x 11.87)
Coil spring identification colour	
Vehicles for Europe	Pink x 2
Vehicles for General Export, GCC and Australia	Blue x 1
Spring constant N/mm (kg/mm, lbs./in.)	39 (3.9, 218)
Shock absorber	
Type	Hydraulic, cylindrical double acting type
Stroke mm (in.)	150 (5.91)
Damping force [at 0.3 m/sec. (0.984 ft./sec.)]	
Expansion N (kg, lbs.)	Hard: 2,650 (265, 584) Medium: 1,650 (165, 363) Soft: 650 (65, 143)
Contraction N (kg, lbs.)	Hard: 1,200 (120, 265) Medium: 1,150 (115, 253) Soft: 1,000 (100, 220)
Stabilizer bar	
Mounting method	Pillow ball type
0.D. mm (in.)	23 (0.91)

REAR SUSPENSION

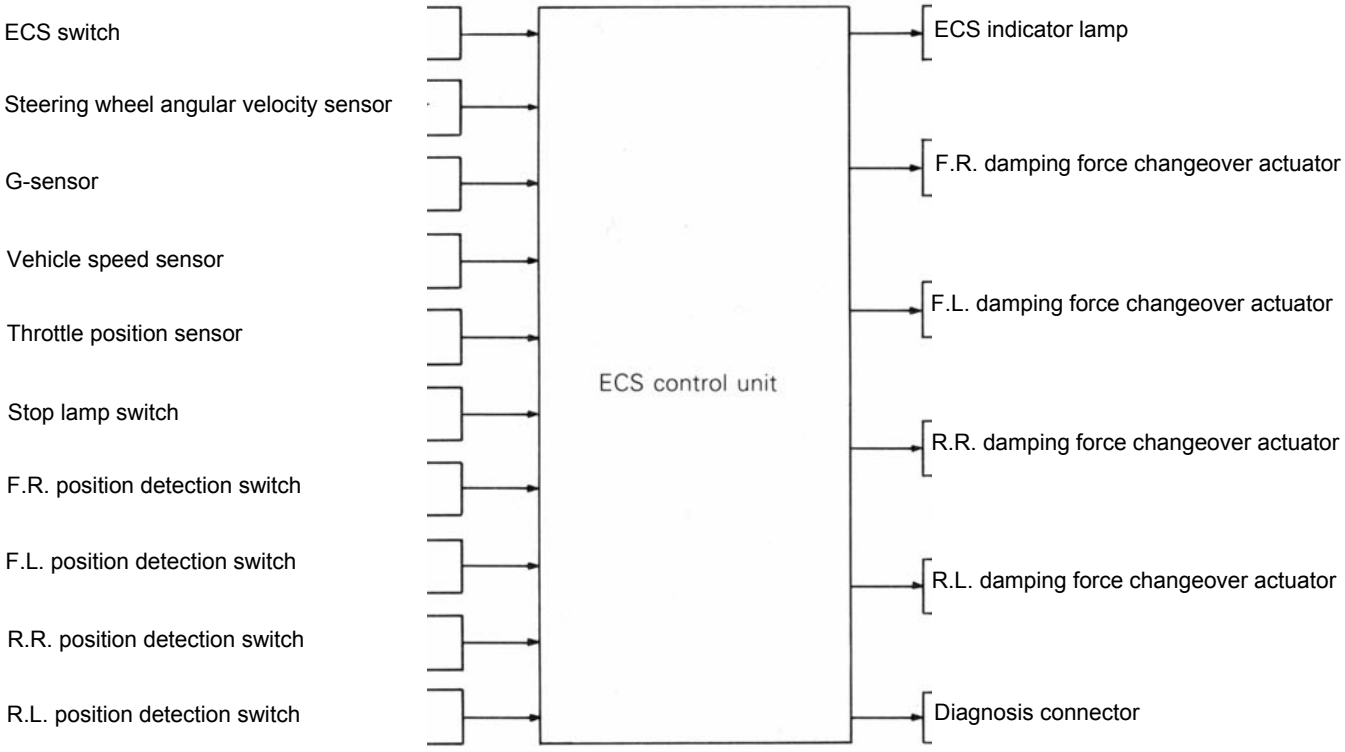
Items		Specifications
Suspension system		Double-wishbone type
Camber		-0°10' ± 30'
Toe-in	mm (in.)	0.5 ± 2.5 (0.02 ± 0.10)
Coil spring		
Wire dia. x 0.D. x free length	mm (in.).	12.2 x 117.2 x 379.3 (0.48 x 4.61 x 14.93)
Coil spring identification colour		Blue x 2
Spring constant	N/mm (kg/mm, lbs./in.)	28.0 (2.8, 157)
Shock absorber		
Type		Hydraulic, cylindrical double-acting type
Stroke	mm (in.)	203 (8.0)
Damping force [at 0.3 m/sec. (0.984 ft./sec.)]		
Expansion	N (kg, lbs.)	Hard: 1,710 (171, 377)
		Medium: 1,160 (116, 256)
		Soft: 560 (56, 123)
Contraction	N (kg, lbs.)	Hard: 1,010 (101, 223)
		Medium: 880 (88, 194)
		Soft: 670 (67, 148)
Stabilizer bar		
Mounting method		Pillow ball type
0.D.	mm (in.)	22 (0.86)



MAIN PARTS AND THEIR FUNCTIONS

Parts	Function	Mounting position
Sensor		
ECS switch	Control mode selection switch	Meter bezel
Steering wheel angular velocity sensor	Detects turning direction and angular velocity of steering wheel	Column switch
G-sensor	Detects up/down vibration of vehicle	Under front seat (LH)
Vehicle speed sensor	Detects speed of vehicle	Transmission case
		Throttle body
Throttle position sensor	Detects throttle opening	Brake pedal bracket
Stop lamp switch	Detects condition of brake pedal	Built in shock absorber (x 4)
Position detection switch	Detects damping conditions of shock absorbers	
Actuator		
ECS indicator lamp	Indicates control mode	Inside combination meter
Damping force changeover actuator	Orifice changeover of inside of shock absorber	Built in shock absorber (x 4)
ECS control unit	System control	Right side of luggage compartment
Diagnosis connector	Output of safe diagnosis code	Side of junction block

SYSTEM BLOCK DIAGRAM

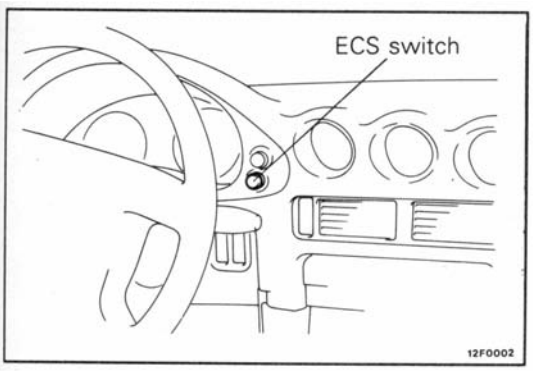


FEATURES OF EACH MODE

Mode	ECS indicator light	Damping force	Features
TOUR		Automatic selection depending on driving conditions SOFT MEDIUM- HARD	• Normal damping force with emphasis on a comfortable ride (SOFT) • Safe operation control when making sudden turns or during high speed. • Vehicle position control when starting and braking • Comfortable riding control when there is up/down vibration of the vehicle and when driving on bad roads is detected
SPORT		Normally fixed in high damping force (HARD)	• Ideal mode for sporty driving • Normally high damping force with emphasis on safe operation and stability (HARD)

FEATURES OF EACH CONTROL

Control function		Feature
Safe operation control	Anti-rolling control	Rolling when going into a curve is controlled and safe operation is improved by increasing the shock absorber damping force according to the steering wheel angular velocity and vehicle speed.
	High speed control	Operation safety is improved by increasing the shock absorber damping force when driving at high speed.
Position control	Anti-diving control	Nose diving is controlled by increasing the shock absorber damping force depending on deceleration when braking.
	Anti-squatting control	Squatting when starting, accelerating quickly, etc. is controlled by increasing the shock absorber damping force according to how far the accelerator pedal is pressed and according to the vehicle speed.
Comfortable ride control	Pitching and bouncing control	A comfortable ride with little car pitching or bouncing is made possible by increasing the shock absorber damping force according to the up/down vibration of the vehicle.
	Bad road detection control	A bad road is detected by the up/down vibration of the vehicle, and a comfortable ride and bad road driving is improved by intensionally maintaining the shock absorber damping force soft or medium.

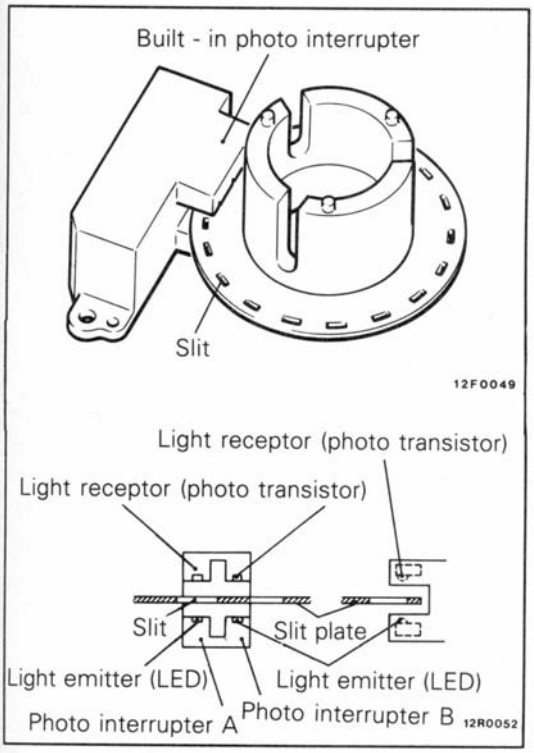


STRUCTURE AND OPERATION

SENSOR

ECS Switch

The ECS switch is a return type switch mounted on the meter bezel.
When the battery is connected and the ignition switch turned ON, it starts in the TOUR mode. Then, it changes between the TOUR and SPORT mode each time the mode changeover switch is pressed.



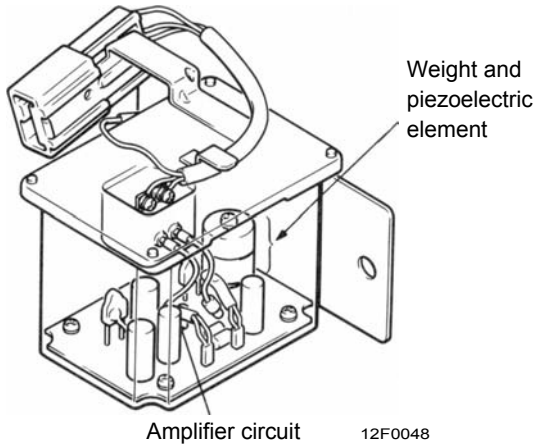
Steering Wheel Angular Velocity Sensor

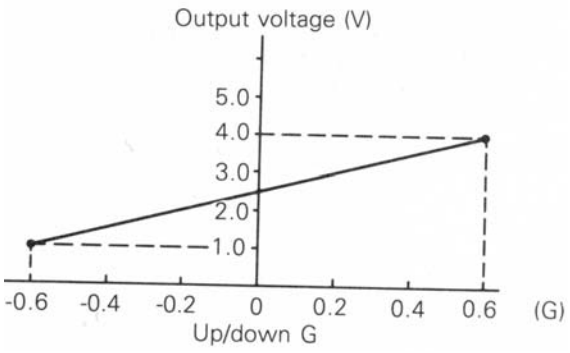
The steering wheel angular velocity sensor is made up of 2 photo interrupters and a slit plate. The photo interrupters are mounted on the column switch and the slit plate is mounted on the steering shaft. The slit plate rotates between the photo interrupters so the light from the LED of photo interrupter is interrupted and passed through and that is changed by the photo diode to an electric signal according to the steering wheel angular velocity.
Furthermore, the steering turning direction can also be detected by the divergence in each 1/4 cycle of the output wave of the photo interrupters.

G-Sensor

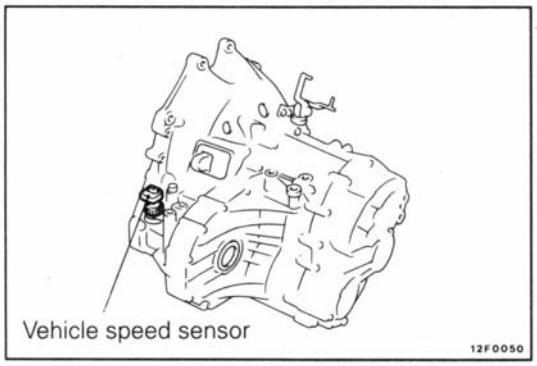
The G-sensor detects the up/down vibration of the vehicle and outputs an electric signal. This sensor is used for controlling a comfortable ride, and it is mounted under the front seat (LH) where it can accurately detect the up/down vibration felt by the driver.

The inside of the G-sensor are made up of a piezoelectric ceramic and a weight. The weight adds extra force on the piezoelectric ceramic depending on the up/down vibration and the G-sensor outputs an electric signal according to the vibration due to the piezoelectric effect.



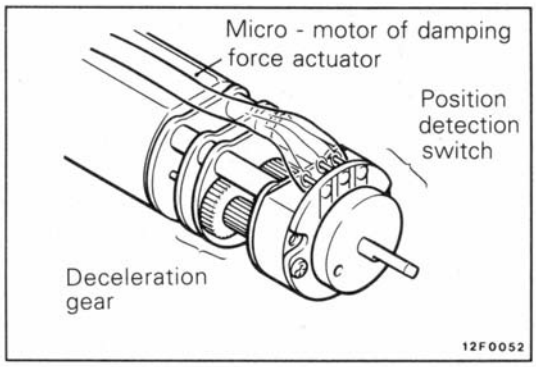


G-sensor output characteristics 12F0003



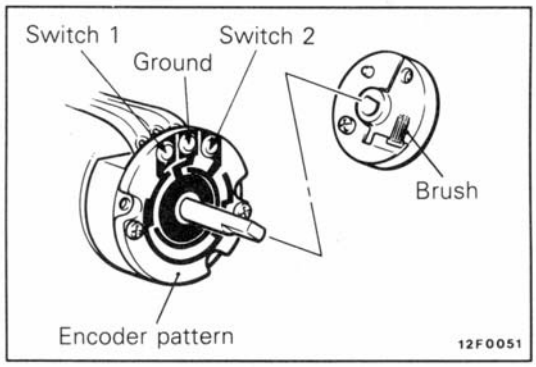
Vehicle Speed Sensor

The vehicle speed sensor is mounted directly onto the transmission. For the structure of the vehicle speed sensor, refer to GROUP 7 - Meters and Gauges.



Position Detection Switch

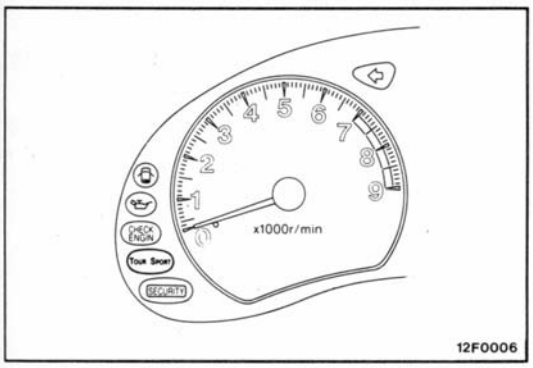
The position detection switches are combined with the damping force changeover actuator built into each shock absorber.
It detects the orifice changeover position of the damping force changeover actuator by the combination of the 2 switches (ON/OFF).
The control unit controls the stop position of the orifice changeover based on the signal from this position detection switch.



The inside structure of the position detection switch is as shown in the figure on the left and it is made up of the encoder pattern and the brush rotating above it. Switches 1 and 2 are turned ON and OFF by the rotations of the brush. The relation between the switch output and the damping force characteristics is shown in the table below.
For one revolution of the switch, the damping force changes from SOFT → HARD → MEDIUM →HARD → (unfixed)

Damping force	SOFT	HARD	MEDIUM	HARD	(unfixed)
Switch 1	ON	OFF	ON	OFF	OFF
Switch 2	OFF	ON	ON	ON	OFF

Rotation angle 0° 360^0



ACTUATOR

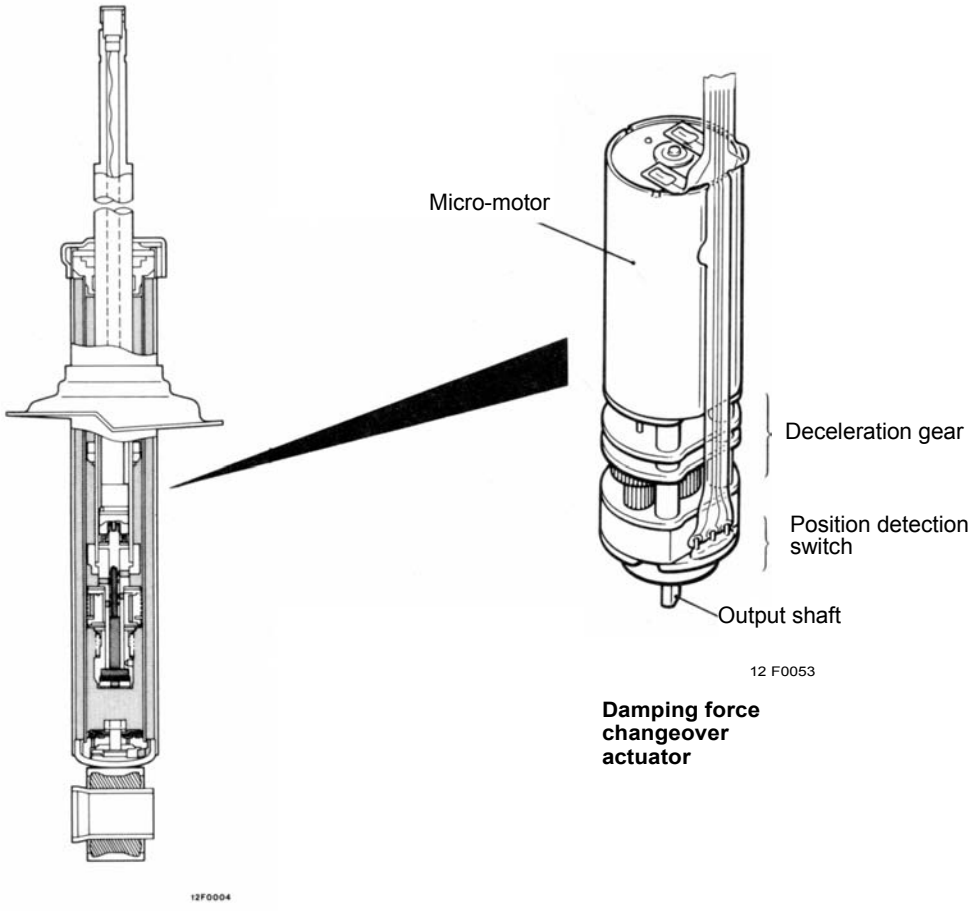
ECS Indicator Lamp

There is an indicator lamp (green) to indicate the mode in the combination meter. When a breakdown is detected, it flashes at intervals of 0.5 second to warn the driver.

Mode	TOUR	SPORT	When breakdown
TOUR lamp	ON	OFF	Flashing
SPORT lamp	OFF	ON	Flashing

Damping Force Changeover Actuator

The damping force changeover actuator is built into the front and rear shock absorbers and designed for compactness, lightweight and reduction of mounting space. It is made up of the micro-motor section, deceleration gear section, position detection switch section and output shaft. The output shaft has a high torque output because the high revolutions of the micro-motor are reduced by the deceleration gear.

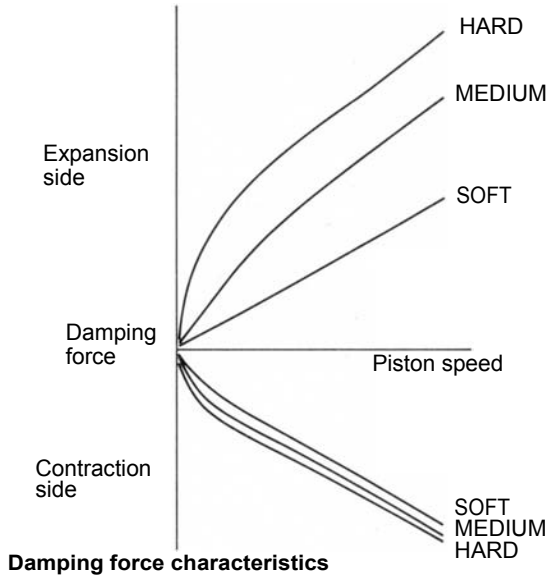


Damping force changeover actuator

SHOCK ABSORBER

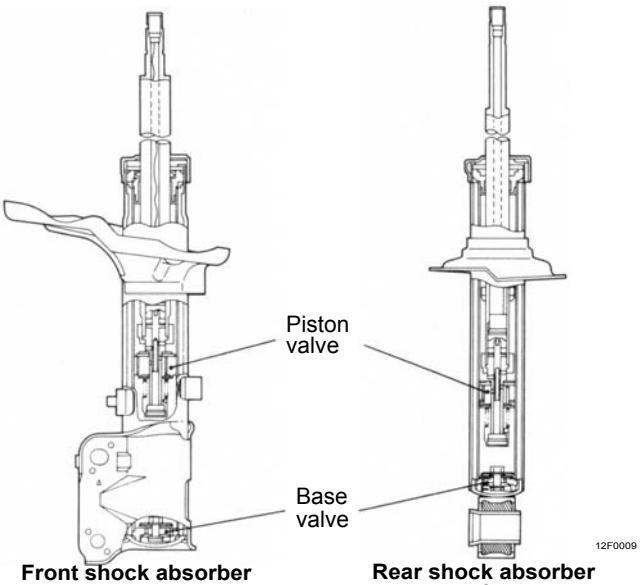
The shock absorber comes with a built in damping force changeover actuator (including a, position detection switch) and the damping force can be changed in 3 steps (SOFT, MEDIUM and HARD) with this actuator.

Furthermore, the piston valve has a double seat and the base valve is made of 2 valves; accurate control is possible at any damping force step for achieving both safe operation and comfortable riding.



Damping force characteristics

12F0008



Front shock absorber cross section

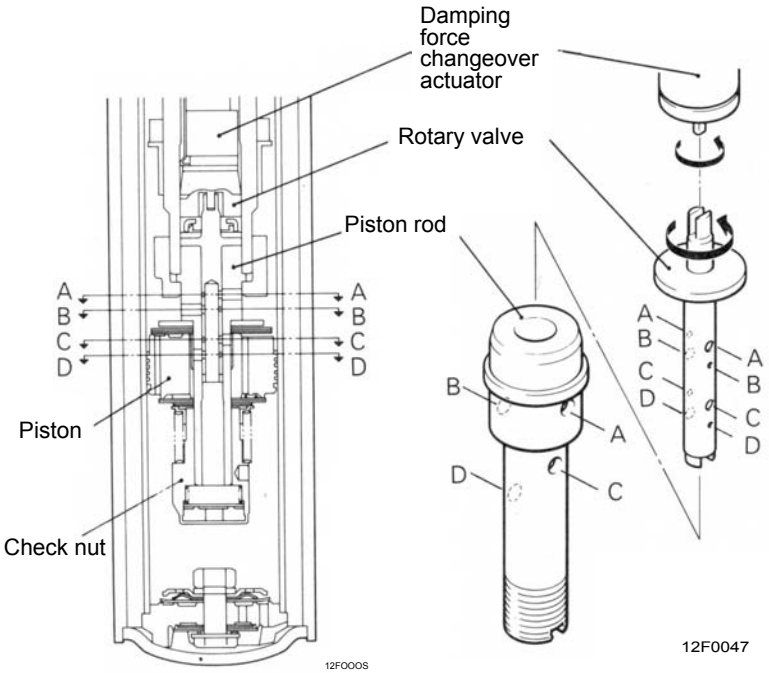
Rear shock absorber cross section

12F0009

Damping Force Changeover Mechanism

For damping force changeover, the damping force changeover actuator is operated by a signal from the control unit which causes the rotary valve built into the piston rod to rotate and changes the opening/closing of the orifice and the oil flow passage area. The rotary valve has large and small orifices (1 each for a total of 8) as shown in the cross sections A-A, B-B, C-C, and D-D in the figure below. There is also one passage (for a total of 4) for each cross section in the piston rod.

The damping force is changed in 3 steps by combining the rotary valve and piston rod passages.
When the ECS control unit confirms the change in the damping force by the command from the position detection switch, it stops the signal sent to operate the damping force changeover actuator.



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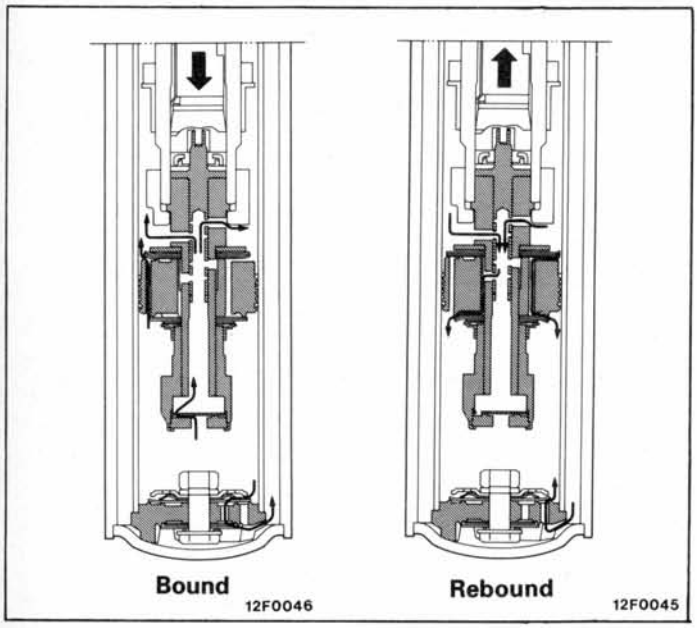
12F0005

	Damping Force		
	SOFT	MEDIUM	HARD
Cross section A-A	Orifice (large dia.)	Orifice (small dia.)	Orifice (closed)
Cross section B-B	Orifice (large dia.)	Orifice (small dia.)	Orifice (closed)
Cross section C-C	Orifice (large dia.)	Orifice (small dia.)	Orifice (closed)
Cross section D-D	Orifice (large dia.)	Orifice (small dia.)	Orifice (closed)

12F0037



Internal Operation of Shock Absorber

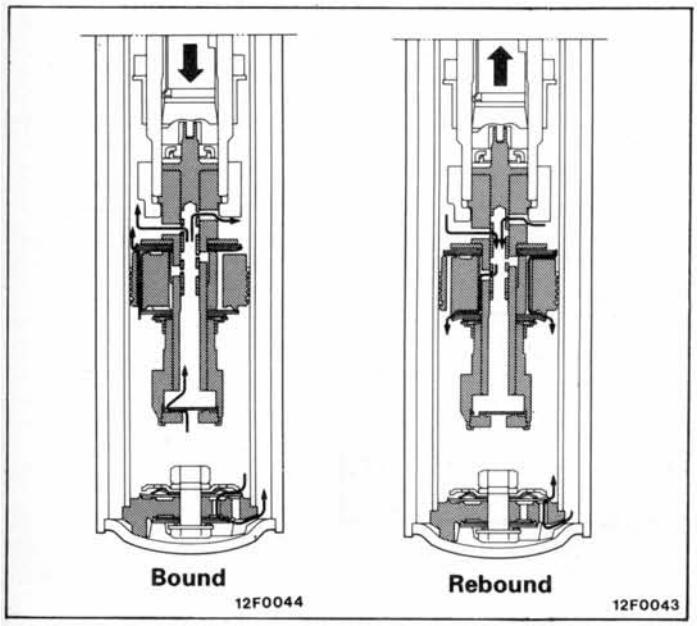
SOFT (low damping force)

When bounding

The damping force is determined mainly by the flow resistance on the base valve side and a low damping force is obtained by passing oil in the lower part of the piston through the check valve built into the check nut and the orifice (large dia.) with no resistance.

When rebounding

As the piston rod rises, oil flows as shown in the figure on the left and the damping force is determined by the flow resistance of the piston valve.



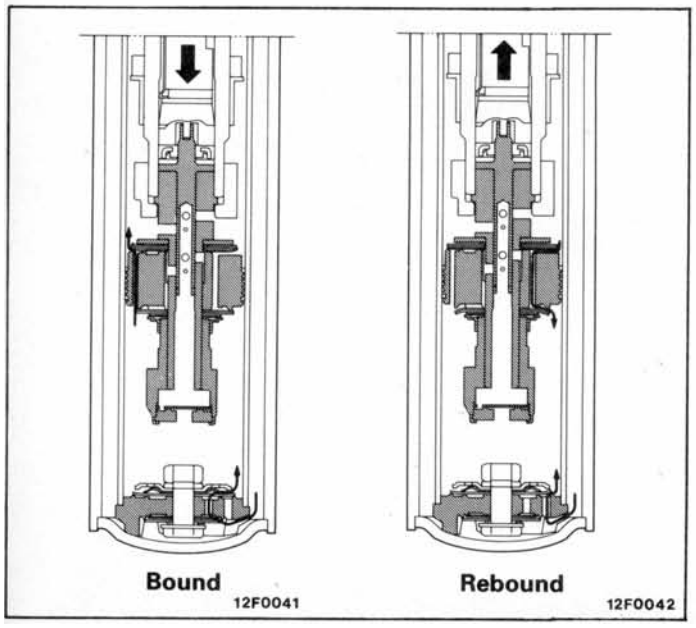
MEDIUM (medium damping force)

When bounding

Compared to SOFT damping force, the orifice diameter is smaller, piston rod flow resistance increases and the damping force is the force combined with the flow resistance on the base valve side.

When rebounding

The orifice diameter is smaller just as when bounding and a higher damping force than at SOFT is obtained.



HARD (high damping force)

When bounding

Since the orifice is closed, oil in the lower part of the piston pushes wide the valve in the upper part of the piston and flows out so flow resistance increases and a higher damping force than at MEDIUM is obtained.

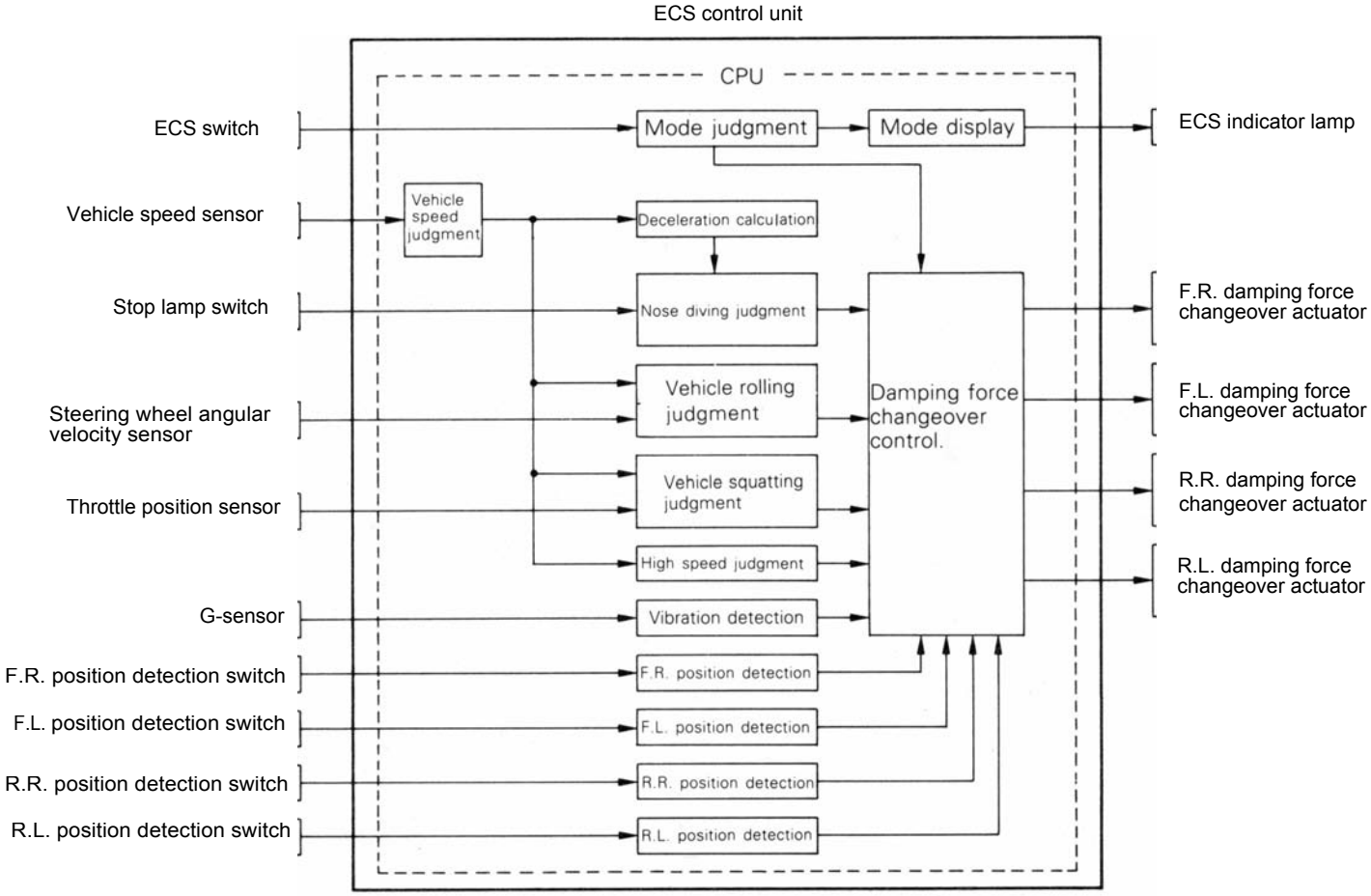
When rebounding

This is the same as when bounding. Since the orifice is closed, damping force is at its maximum.

ECS CONTROL UNIT

The ECS control unit is mounted on the inside of the rear side trim. The ECS control unit sends a signal to the damping force changeover actuator to simultaneously change the damping force of the 4 shock absorbers.

Structure



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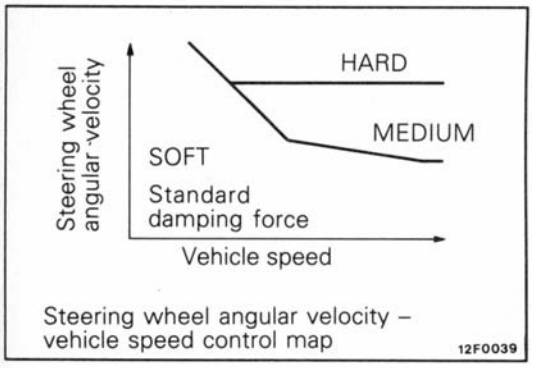
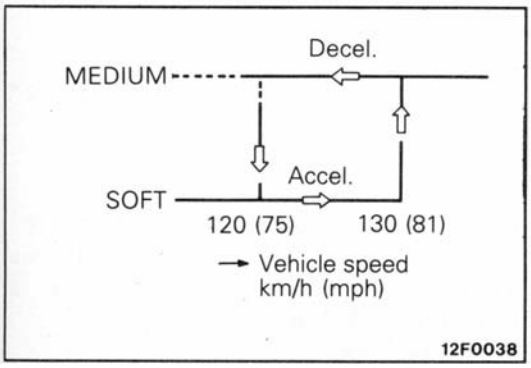
Function Chart

Control function		Control	Related sensor	Damping force mode	
				TOUR	SPORT
Selection of control mode		Selects 2 modes (TOUR and SPORT) by input from the ECS switch	ECS switch	—	—
Safe operation control	Anti-rolling control	Changes the damping force using map (steering wheel angular velocity to the vehicle speed) to control rolling when going into a corner and also to improve safe operation.	Steering wheel angular velocity sensor Vehicle speed sensor	Ⓢ Ⓜ Ⓗ	Ⓗ
	High speed response control	Changes the damping force according to speed when driving at high speed to improve operation safety.	Vehicle speed sensor	Ⓢ Ⓜ	Ⓗ
Position control	Anti-diving control	After the stop lamp switch goes ON, it calculates the deceleration from the vehicle speed and changes the damping force in accordance with that to control nose diving.	Stop lamp switch Vehicle speed sensor	Ⓢ Ⓜ Ⓗ	Ⓗ
	Anti-squatting control	Changes the damping force using map (throttle opening (closing) speed to the vehicle speed) to control squatting when starting and accelerating.	Throttle position sensor Vehicle speed sensor	Ⓢ Ⓜ Ⓗ	Ⓗ
Riding comfort control	Pitching/bouncing control	Changes the damping force according to the up/down vibration of the vehicle to control pitching and bouncing of the vehicle.	G-sensor	Ⓢ Ⓗ	Ⓗ
	Bad road detection control	Suprresses the damping force according to the up/down vibration of the vehicle to improve driving on bad roads and driving comfort.	G-sensor	Ⓢ Ⓜ	Ⓗ
Fail-safe and diagnosis		It functions on the fail-safe side when there is a breakdown and outputs a self-diagnosis code.	—	—	

S: SOFT **M**: MEDIUM **H**: HARD



Steering wheel angular velocity – vehicle speed control map



Anti-Rolling Control

CONTROL START

Change to a higher damping force according to the control map for the vehicle speed and steering wheel angular velocity which depends on the operation of the steering wheel.

CONTROL HOLD

After switching to a high damping force and holding that condition for 1 second, return to normal damping force (SOFT).

High Speed Response Control

CONTROL START

When vehicle speed exceeds 130km/h (81 mph) in the TOUR mode, the damping force changes from SOFT to MEDIUM to improve high speed stability.

CONTROL HOLD

Damping force which is changed to MEDIUM is held while the vehicle speed is over 120km/h (75 mph) but when it falls to 120km/h (75 mph), the damping force returns to SOFT.

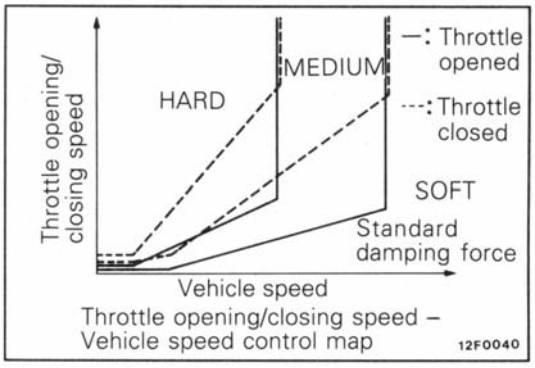
Anti-Diving Control

CONTROL START

When the stop light switch goes ON, the ECS control unit calculates deceleration from the change in vehicle speed. As a result, after the stop light goes ON, if deceleration calculated within 0.4 sec. exceeds 0.15G, the shock absorber damping force is changed to MEDIUM.
If the stop light switch is ON and the computed degree of deceleration exceeds 0.4G, there will be a change to HARD.

CONTROL HOLD

The damping force after changeover is held while calculated deceleration is over 0.15G and when it falls below 0.15G, the damping force returns to normal (SOFT).



Anti-Squatting Control

CONTROL START

When the accelerator pedal is pressed (returned), it changes to a higher damping force through map control of the vehicle speed and speed change in throttle opening (closing).
There are 2 control maps - when the accelerator pedal is pressed and when it is returned (throttle opened and closed). Furthermore, when the throttle position sensor output voltage stays over 4.0V for more than 1 second at vehicle speed of 3 - 100km/h (2 - 62 mph), it is judged that there is full throttle acceleration and the damping force is switched to MEDIUM.

CONTROL HOLD

After changing from a high damping force, there is first a 1 second hold in that condition and then the suspension reverts to the normal damping force (SOFT).
When full throttle acceleration is judged, the suspension reverts to the normal damping force (SOFT) in one second after the control conditions are not satisfied.

Pitching/Bouncing Control

CONTROL START

When the ECS control unit judges that there is serious pitching and bouncing of the vehicle (washboard road driving) via the output of the G-sensor, the damping force is changed to HARD for a flat and comfortable ride with no vehicle pitching and bouncing.

CONTROL HOLD

When the ECS control unit judges that there is no more pitching and bouncing of the vehicle via the output of the G-sensor, normal damping force (SOFT) takes over at the same time.

Bad Road Response Control

When the ECS control unit judges that there is fine pitching and bouncing of the vehicle (bad road such as gravel road, etc.) via the output of the G-sensor, the suspension is changed to MEDIUM for improved riding comfort and bad road driving even if the damping force should be set to HARD by some other control.

Warning Display Function

When a breakdown is detected, the TOUR and SPORT ECS indicator light in the meter blinks at 0.5 sec. intervals to warn the driver of an abnormality.

Fail-safe and Diagnosis Function

When the ECS control unit detects a breakdown, control related with that breakdown phenomenon stops and the damping force is fixed on the fail safe side. At the same time, the self-diagnosis code related to the breakdown phenomenon is output to the diagnosis connector.

FAIL-SAFE AND DIAGNOSIS CODE TABLE

Diagnosis code No.	Diagnosis item	Fail-safe function						
		Anti-rolling control	Anti-diving control	Anti-squatting control	High speed response control	Pitching/bouncing control	Bad road detection control	Damping force condition of shock absorber
–	Normal	X	X	X	X	X	X	———
11	G-sensor abnormal*	X	X	X	X	—	—	———
21	Steering wheel angular velocity sensor, broken wire*	—	X	X	X	X	X	———
24	Vehicle speed sensor, broke wire*	—	—	—	—	—	—	Shock absorber is fixed at MEDIUM
61	F.R. damping force changeover actuator, abnormal	—	—	—	—	—	—	Normal shock absorber is fixed HARD
62	F.L. damping force changeover actuator, abnormal	—	—	—	—	—	—	
63	R.R. damping force changeover actuator abnormal	—	—	—	—	—	—	
64	F.L. damping force changeover actuator, abnormal	—	—	—	—	—	—	

NOTE

1. An "X" indicates normal operation and a "---" indicates stop of control.
2. Control stop, warning display and fixing of damping force return to normal operation when the ignition switch is turned OFF. However, in the case of breakdowns marked with an asterisk (*), normal operation is resumed if normal output is generated even when the ignition switch is in ON (e.g. transient breakdown). In this case, the self-diagnosis code is in memory in the ECS control unit even while normal operation resumes.

Service data output function

The ECS control unit receives the data input for control and outputs it to the diagnosis connector as a serial signal.

SERVICE DATA CHART

Item No.	Service data items
11	G-sensor output
14	Throttle position sensor output
21	Steering wheel angular velocity sensor output
24	Vehicle speed sensor output
26	Stop lamp switch
61	F.R. actuator condition
62	F.L. actuator condition
63	R.R. actuator condition
64	R.L. actuator condition

Actuator test function

By using the multi-use tester to send an order to the ECS control unit, it is possible to force-drive the actuator.

ACTUATOR TEST CHART

Item No.	Actuator test items	Shock absorber damping condition
01	Damping force SOFT	Damping force for 4 shock absorbers set to SOFT
03	Damping force MEDIUM	Damping force for 4 shock absorbers set to MEDIUM
04	Damping force HARD	Damping force for 4 shock absorbers set to HARD

NOTE
The damping force set is released under the following 3 conditions

- Ignition switch is turned OFF
- Vehicle speed becomes 3km/h (1.9 mph) or more
- Multi-use tester is disconnected