

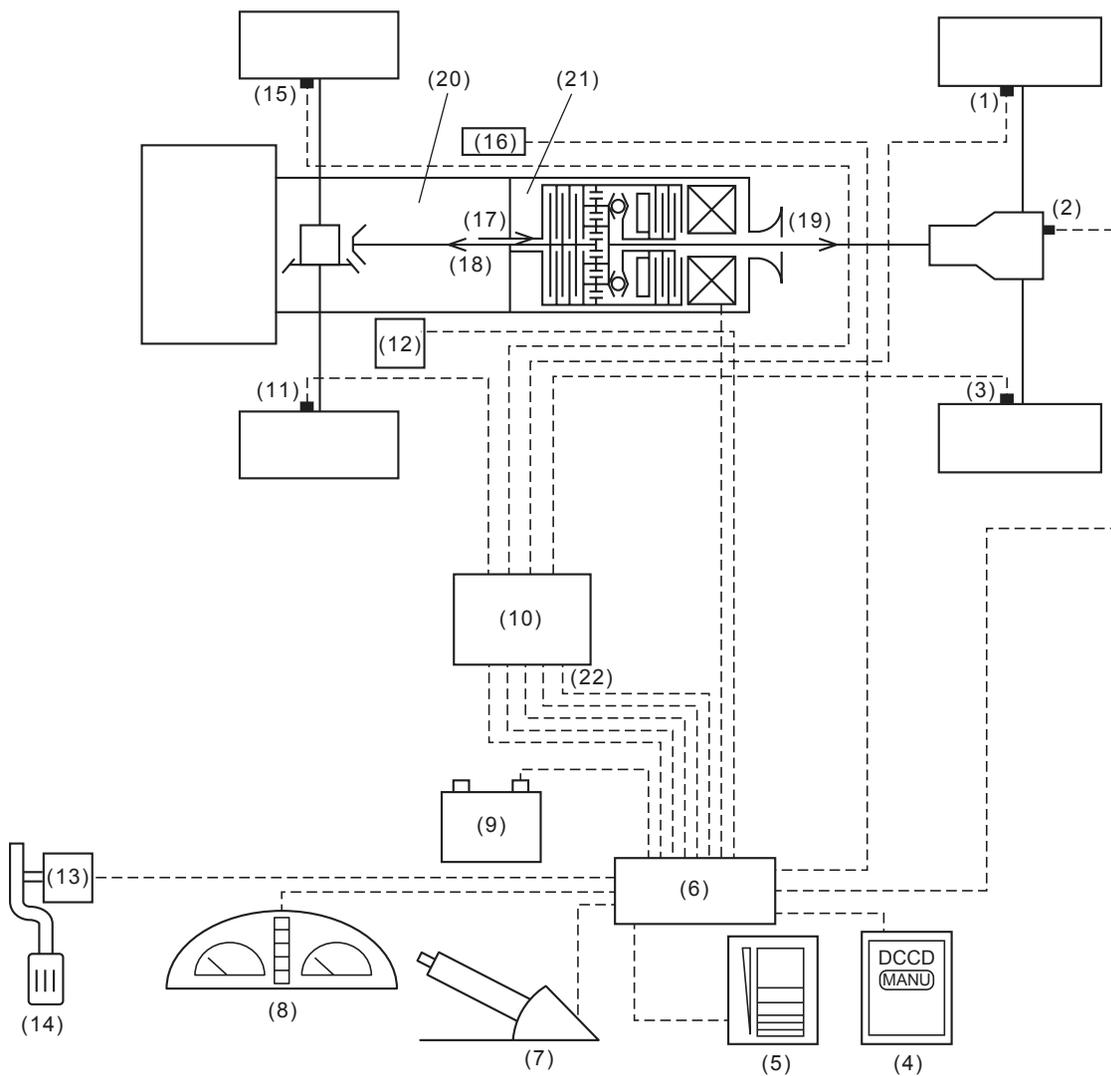
DRIVER-CONTROLLABLE CENTER DIFFERENTIAL SYSTEM

MANUAL TRANSMISSION AND DIFFERENTIAL

7. Driver-controllable Center Differential System

A: FEATURES

- The driver-controllable center differential system consists of a planetary gear set and electromagnetically engaged variably controlled multi plate clutches, distributing the drive torque to the front and rear wheels at a ratio of 35 : 65. The driver can optionally change the locking rate of the center differential.
- The system optimally controls the restricting action of the center differential using a computer and works together with the ABS control.



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DRIVER-CONTROLLABLE CENTER DIFFERENTIAL SYSTEM

MANUAL TRANSMISSION AND DIFFERENTIAL

- | | |
|---|-------------------------------------|
| (1) Wheel speed sensor (RR) | (12) Brake light switch |
| (2) Rear differential oil temperature switch | (13) Throttle position sensor |
| (3) Wheel speed sensor (RL) | (14) Accelerator pedal |
| (4) Manual mode switch | (15) Wheel speed sensor (FR) |
| (5) Control dial | (16) Lateral G sensor |
| (6) Driver-controllable center differential unit | (17) Input from main reduction gear |
| (7) Parking brake switch | (18) Front output |
| (8) Driver-controllable center differential indicator light | (19) Rear output |
| (9) Battery | (20) Transmission assembly |
| (10) ABSCU & H/U | (21) Center differential |
| (11) Wheel speed sensor (FL) | (22) ABS monitor signal |

Control	Auto mode	Manual mode
Hand brake control	yes	yes
Brake control	yes	yes
Center differential control	yes	yes
Fail-safe control	yes	yes
ABS control	yes	yes
Throttle respondent torque control	yes	yes
Slip control	yes	no
Tight cornering control	yes	yes
Volume control	no	yes
Cornering control	yes	no
Rear differential oil control	yes	yes

- **Hand brake control**

When the hand brake is operated, the current to the coil is lowered to forcibly free the center differential.

- **Brake control**

Controls the center differential restriction torque toward the free state in response to brake switch input.

- **Center differential control**

Based on throttle respondent torque control and slip control as basic controls, the differential restriction torque of the center differential is controlled between the free state and locked state through PWM control. Also, information received from other various switches and sensors are used in correcting the instruction torque for center differential control.

- **Fail-safe control**

If a failure such as breakage of the coil drive element is detected, the coil driving power is turned off and warning indication is given on the meter cluster at a 1 Hz cycle to call attention of the driver. If a failure occurs in any of the sensors, a fixed value is substituted for the value from the failed sensor to maintain control as usual, while activating a warning indication on the meter at a 1 Hz cycle to call attention of the driver.

- **ABS control**

When the ABS operates, the ABSCU & H/U outputs an activating signal to the center differential control unit to decrease the differential restriction torque of the driver-controllable center differential.

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- Throttle respondent torque control

Controls the restriction torque of the center differential in response to the throttle opening. The restriction torque of the center differential calculated for each mode is corrected using particular values, however, basically toward the locked state when the throttle is wide open or toward the free state when the throttle is fully closed.

- Slip control

Controls the restriction torque of the center differential based on the amount of slip derived from the speed of four wheels.

- Tight cornering control

A correction value is calculated from the left and right wheel speed ratio and applied to the restriction torque of center differential, which is derived from the throttle respondent, slip control, etc.

- Volume control

By operating the control dial, the driver can optionally control the restriction torque of the center differential.

- Cornering control

The restriction torque of center differential is controlled based on a value derived from the throttle opening, lateral G sensor, four wheel speeds, etc.

- Rear differential oil control

When the rear differential oil temperature rises and the oil temperature switch activates, the center differential restriction torque is controlled toward the free state.

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B: INPUT AND OUTPUT SIGNALS

Name	Function
Driver-controllable center differential	In response to the signal from the driver-controllable center differential control unit, the current is varied to change the transmitting torque of the multi-plate clutch and control the differential torque.
Driver-controllable center differential control unit	Processes the signals from various sensors and switches and controls the current to the driver-controllable center differential.
Lateral G sensor	Sends information on acceleration of the vehicle in lateral directions to the driver-controllable center differential control unit.
Driver-controllable center differential indicator light	Indicates the locking rate of the center differential in a range from 0% to 100%.
Manual mode switch	Switches the driver-controllable center differential control mode between auto and manual.
Control dial	Enables to manually select the locking rate of the center differential in a range from 0% to 100%.
Rear differential oil temperature switch	Sends a signal to the driver-controllable center differential control unit if the rear differential oil temperature rises abnormally.
Parking brake switch	Sends information on the parking brake operational status to the driver-controllable center differential control unit.
Stop light switch	Sends information on the brakes' operational status to the driver-controllable center differential control unit.
Throttle position sensor	Sends information on the throttle valve opening to the driver-controllable center differential control unit.
ABSCU & H/U	Sends ABS monitor signals to the driver-controllable center differential control unit.

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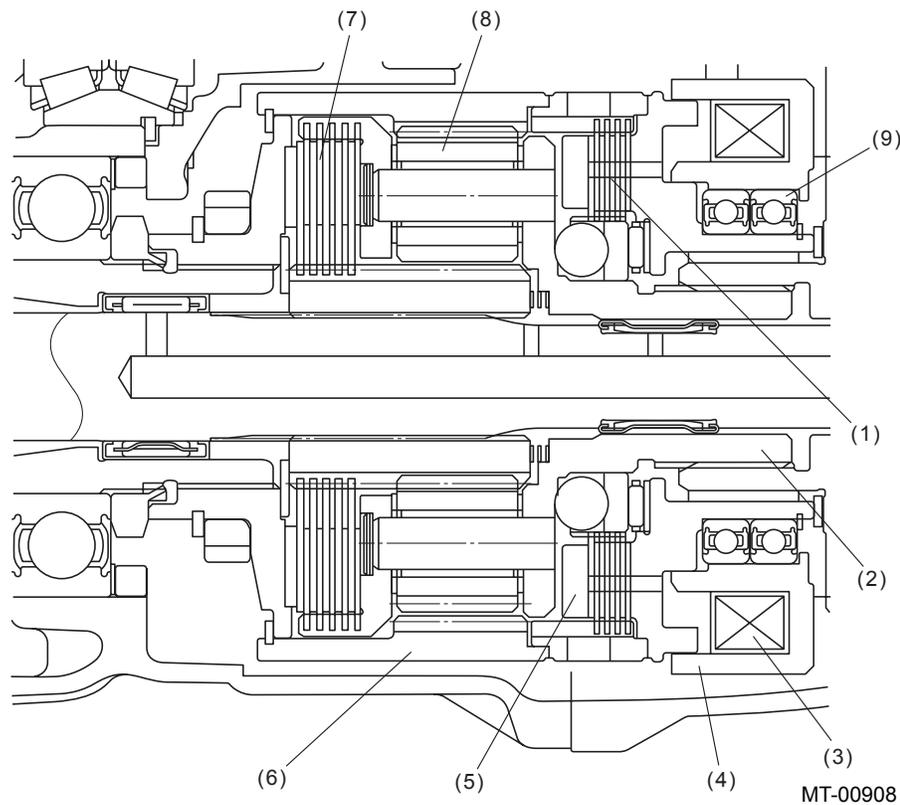
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|--|---|
| (1) Battery | (12) Indicator light |
| (2) Ignition relay | (13) ABSCU & HU |
| (3) Stop light switch | (14) Throttle position sensor |
| (4) Driver-controllable center differential relay | (15) Engine control unit |
| (5) Combination meter | (16) Driver-controllable center differential |
| (6) Driver-controllable center differential indicator light (0% locked) | (17) Parking brake switch |
| (7) Driver-controllable center differential indicator light (15% locked) | (18) Manual mode switch |
| (8) Driver-controllable center differential indicator light (35% locked) | (19) Rear differential oil temperature switch |
| (9) Driver-controllable center differential indicator light (65% locked) | (20) Control dial |
| (10) Driver-controllable center differential indicator light (85% locked) | (21) Lateral G sensor |
| (11) Driver-controllable center differential indicator light (100% locked) | (22) Driver-controllable center differential control unit |

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C: DRIVER-CONTROLLABLE CENTER DIFFERENTIAL

- The driver-controllable center differential consists of a differential case, planetary carrier, planetary gears, electro-magnetic coils, armature, main clutch (multi-plate clutch), pilot clutch, and ball bearings.
- The engine torque enters the differential case from the transmission's driven shaft. The torque from the differential case is divided into front and rear directions at the planetary carrier; the torque to the front is transferred from the planetary carrier through the planetary gears to the sun gear, while the torque to the rear is transferred from the transfer drive gear (integrated with the planetary carrier) through the driven gear to the propeller shaft.
- If either of the front or rear wheels spins, the driver-controllable center differential controls the differential action between the front and rear wheels.

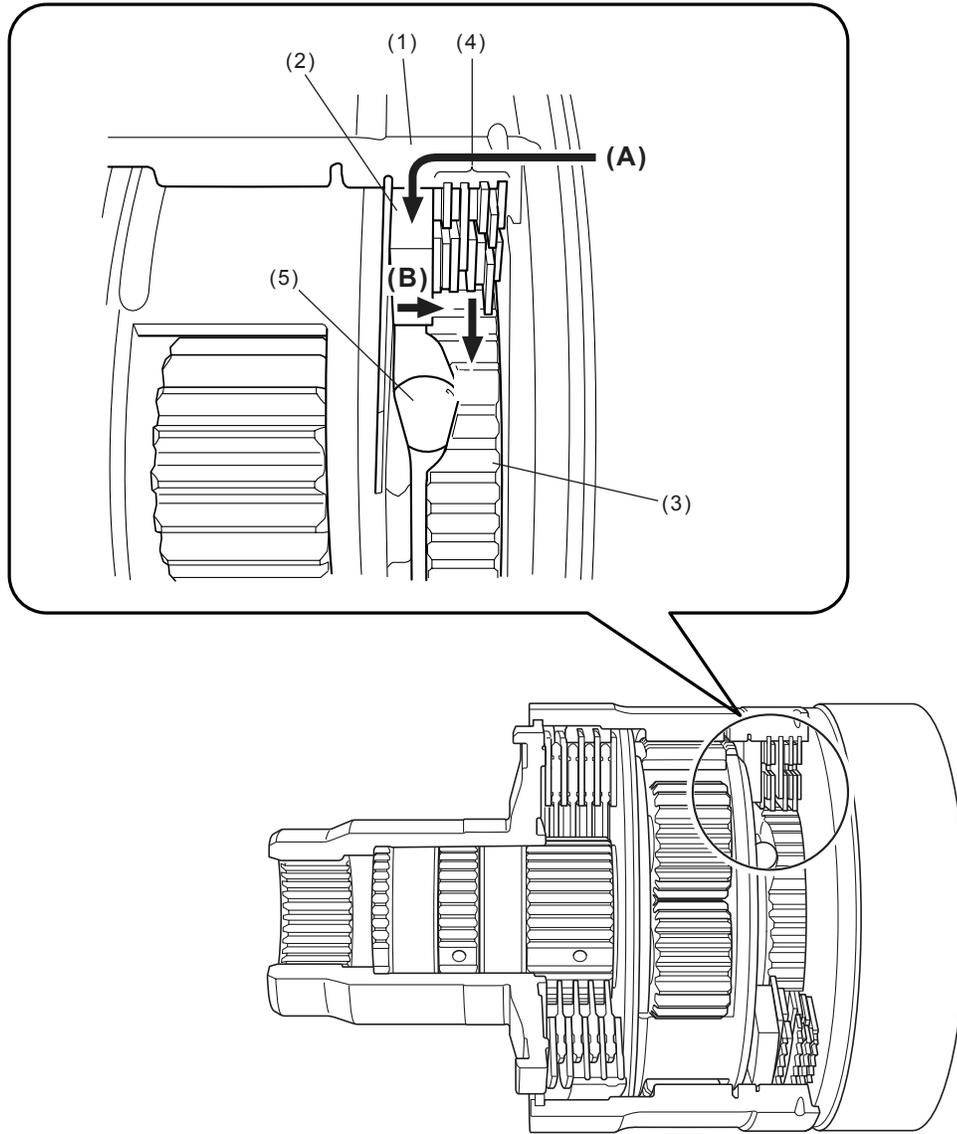


- | | |
|---------------------------|-----------------------|
| (1) Pilot clutch | (6) Differential case |
| (2) Planetary carrier | (7) Main clutch |
| (3) Electro-magnetic coil | (8) Planetary gear |
| (4) Electro-magnet | (9) Ball bearing |
| (5) Armature | |

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- When current flows through the electromagnetic coils, magnetism is generated at components in the following sequence: electromagnet, differential case, armature (A). The armature is moved to the right (B) by this magnetism causing the pilot clutch to engage, and a magnetic field is formed in the area from the electromagnet, differential case, armature, and to the pilot clutch. The pilot clutch locks the differential case side and cam 1 side together, thus the rotational speed of the cam 1 and differential case are synchronized. The engagement of the pilot clutch is controlled by adjusting the current flowing through the electromagnetic coils.



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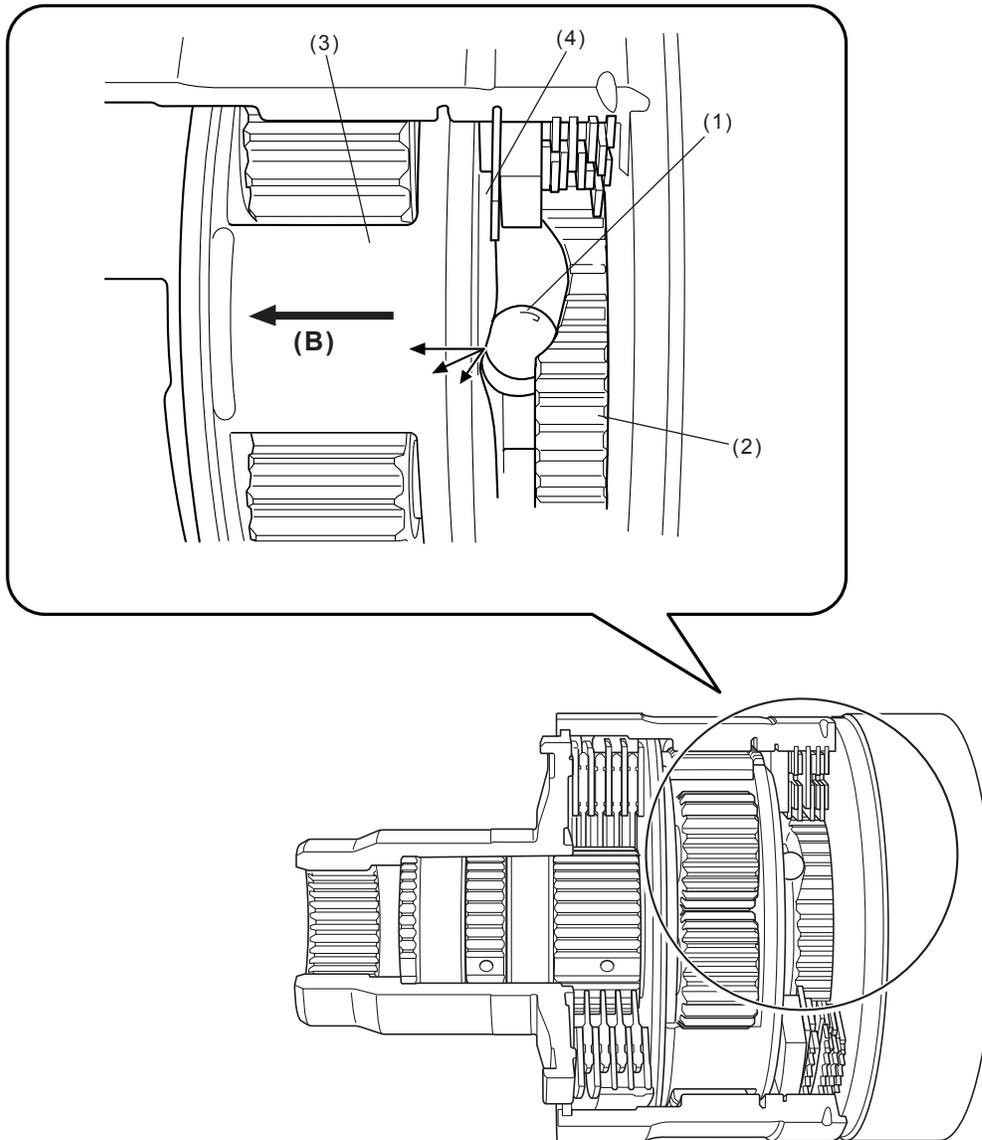
- (1) Differential case
- (2) Armature
- (3) Cam 1

- (4) Pilot clutch
- (5) Steel ball

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- When a speed difference occurs, a force (B) pushing the cam 2 to the left is generated at the steel balls sandwiched between cam 1 and cam 2, pushing the planetary carrier to the left.



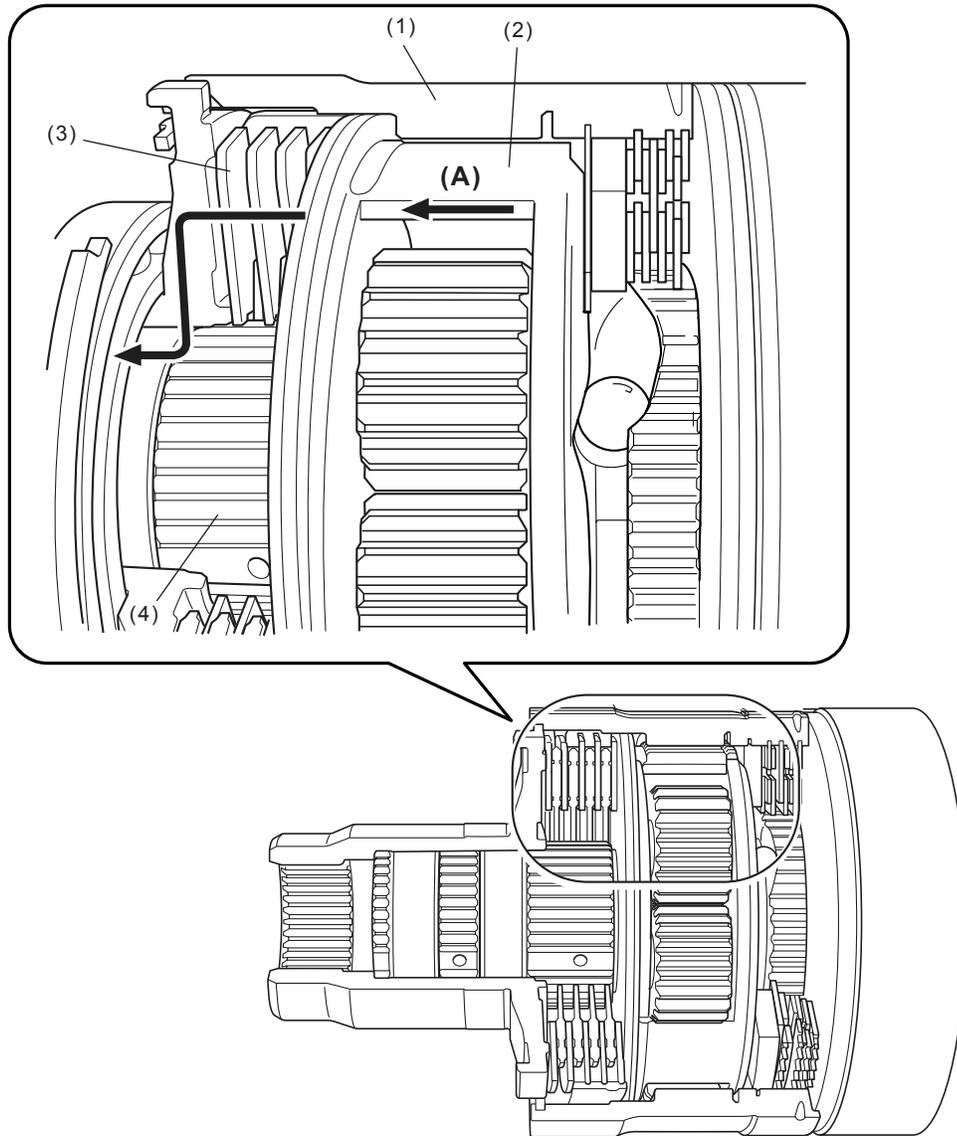
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- (1) Steel ball
- (2) Cam 1
- (3) Planetary carrier
- (4) Cam 2

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- When the planetary carrier moves to the left (A), the main clutch is engaged. The main gear locks the planetary gears and the sun gear together to generate a differential action restriction torque.



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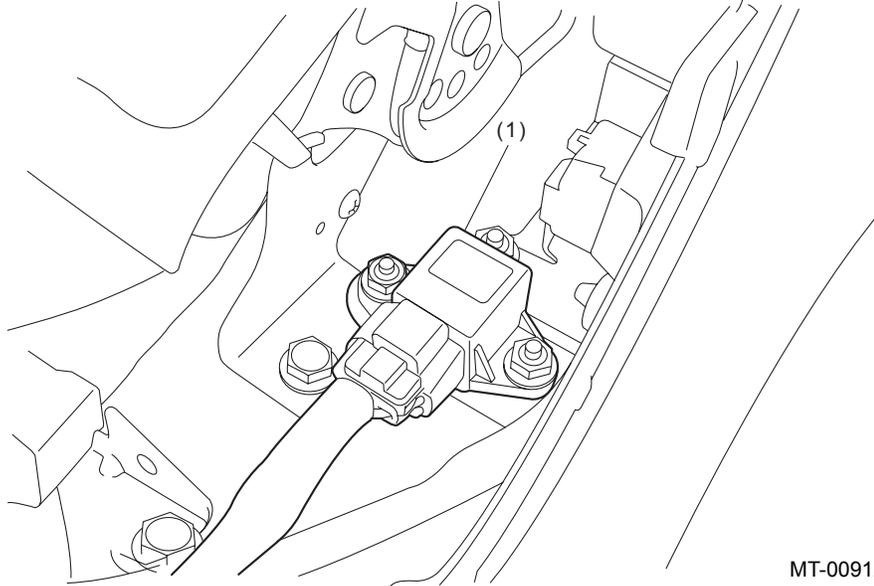
- (1) Differential case
- (2) Planetary carrier
- (3) Main clutch
- (4) Sun gear

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D: LATERAL G SENSOR

A lateral G sensor is installed to the body at inside the console. The lateral G sensor detects the acceleration of the vehicle in the lateral direction and controls the differential action restriction torque.



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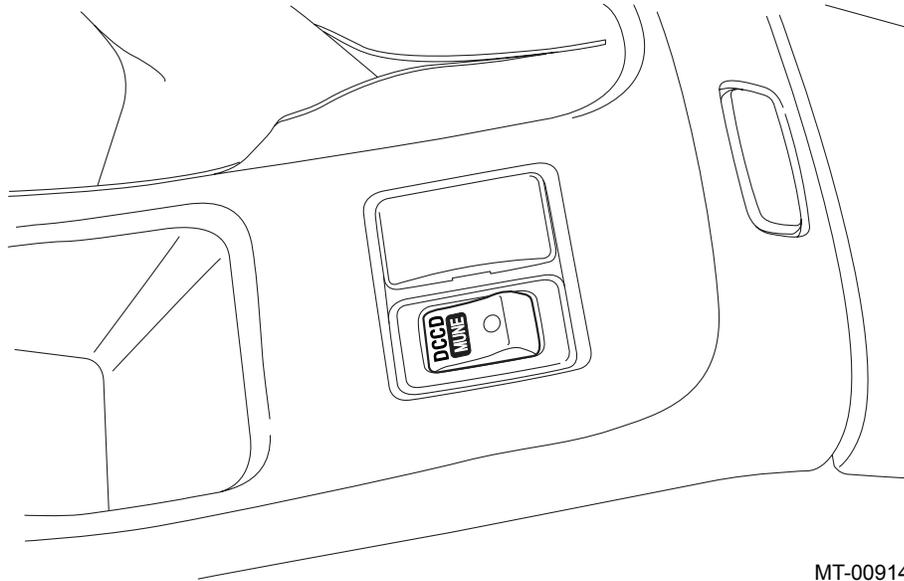
(1) Lateral G sensor

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E: MANUAL MODE SWITCH

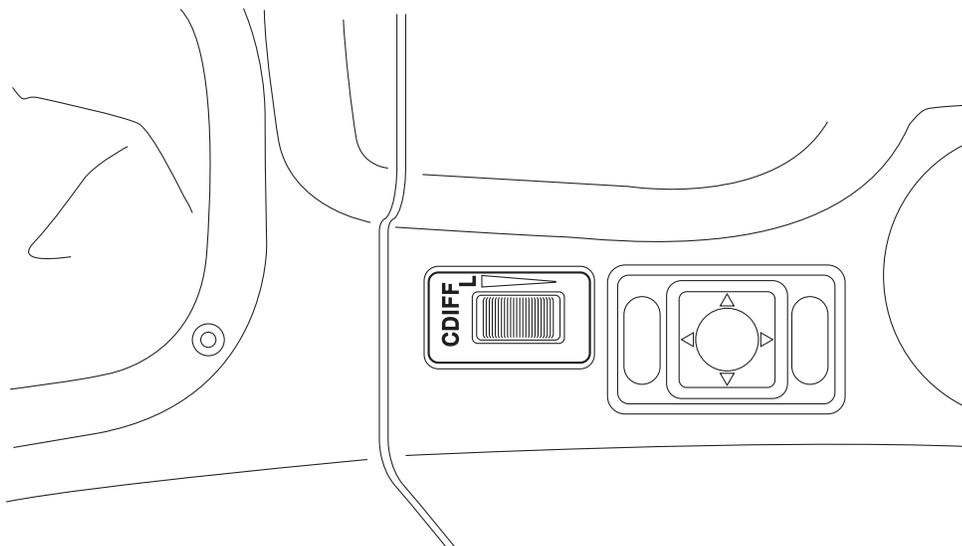
The manual mode switch enables the driver to select the mode (auto mode or manual mode) by pressing the switch each time.



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F: CONTROL DIAL

A rotary type switch is provided on the center console enabling the driver to optionally set the front-rear differential action restricting torque in the range between locking rate 0% (free) to 100% (locked). Also, detents are provided between free and locked positions.



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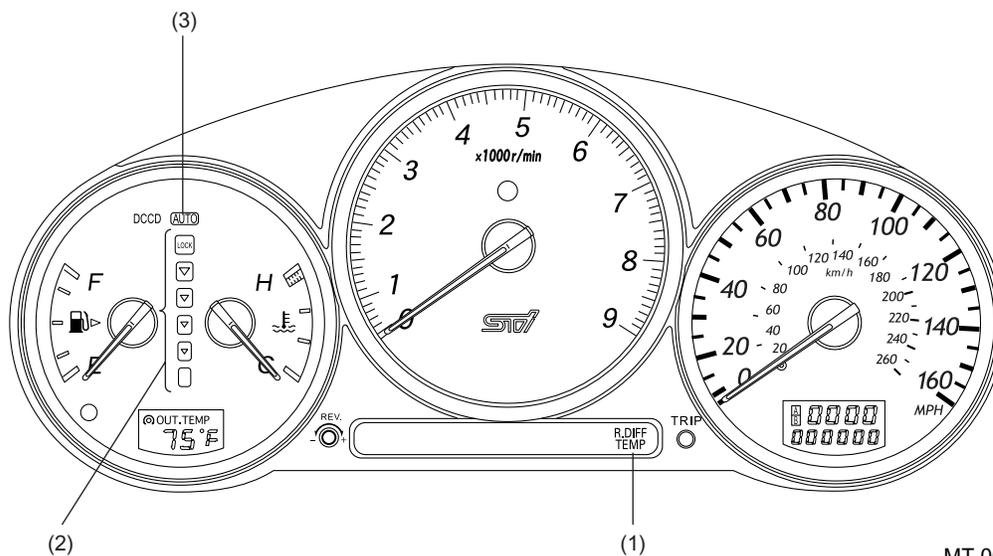
G: DRIVER-CONTROLLABLE CENTER DIFFERENTIAL INDICATOR LIGHT

Driver-controllable indicator lights which indicate the locking rate of the center differential are provided in the meter cluster.

When the driver-controllable center differential is in the auto mode the “AUTO” at the upper part of the meter cluster illuminates, and when in manual mode and the differential restriction torque is varied manually the driver-controllable center differential indicator lights illuminate.

If the control unit detects a fault in a component or unit during self diagnosis, the driver-controllable center differential indicator lights flash until the ignition switch is turned OFF.

Faulty components or units can be identified by reading diagnostic trouble codes (DTC), and faults which occurred in the past can be retrieved from the memory.



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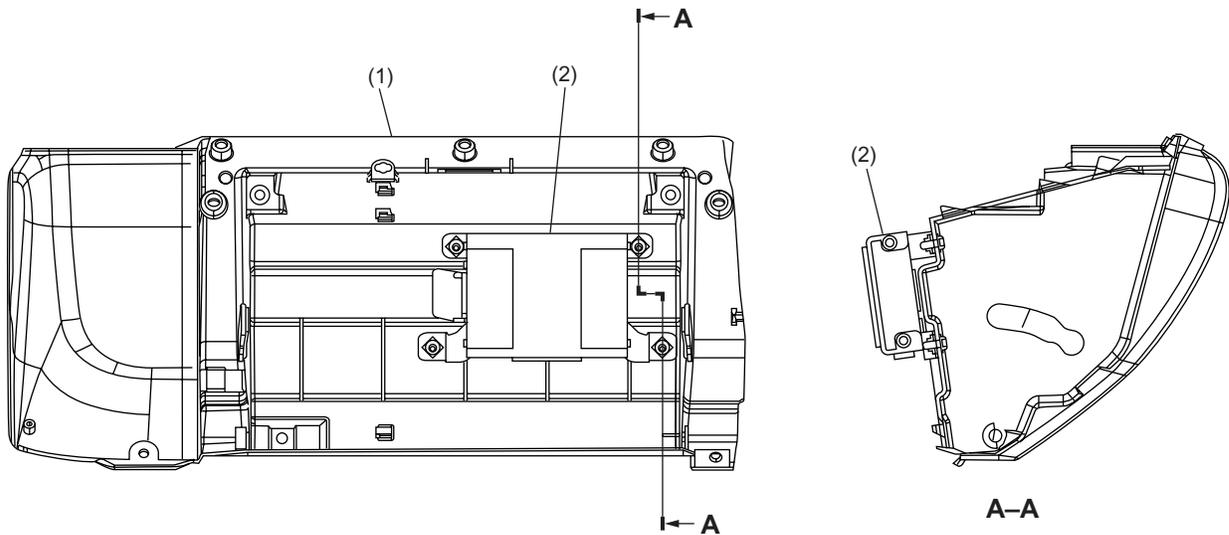
- (1) Rear differential oil temperature warning light
- (2) Driver-controllable center differential indicator light
- (3) Driver-controllable differential auto mode indicator light

H: DRIVER-CONTROLLABLE CENTER DIFFERENTIAL CONTROL UNIT

The control unit is located behind the glove box at the front passenger's side.

If the control unit detects a fault in a component or unit during self diagnosis, the driver-controllable center differential indicator light (FREE light at the bottom) flashes until the ignition switch is turned OFF.

Faulty components or units can be identified by reading diagnostic trouble codes (DTC), and faults which occurred in the past can be retrieved from the memory. The differential restriction torque of the driver-controllable center differential is controlled based on signals from various sensors and switches, ABS monitor signals and ABS wheel speed signals (from four wheels) from the ABSCU & H/U, and by taking into account the conditions of the road surface and the vehicle.



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- (1) Glove box
- (2) Driver-controllable center differential control unit

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I: OPERATION

- When the vehicle is braked (A) while running:

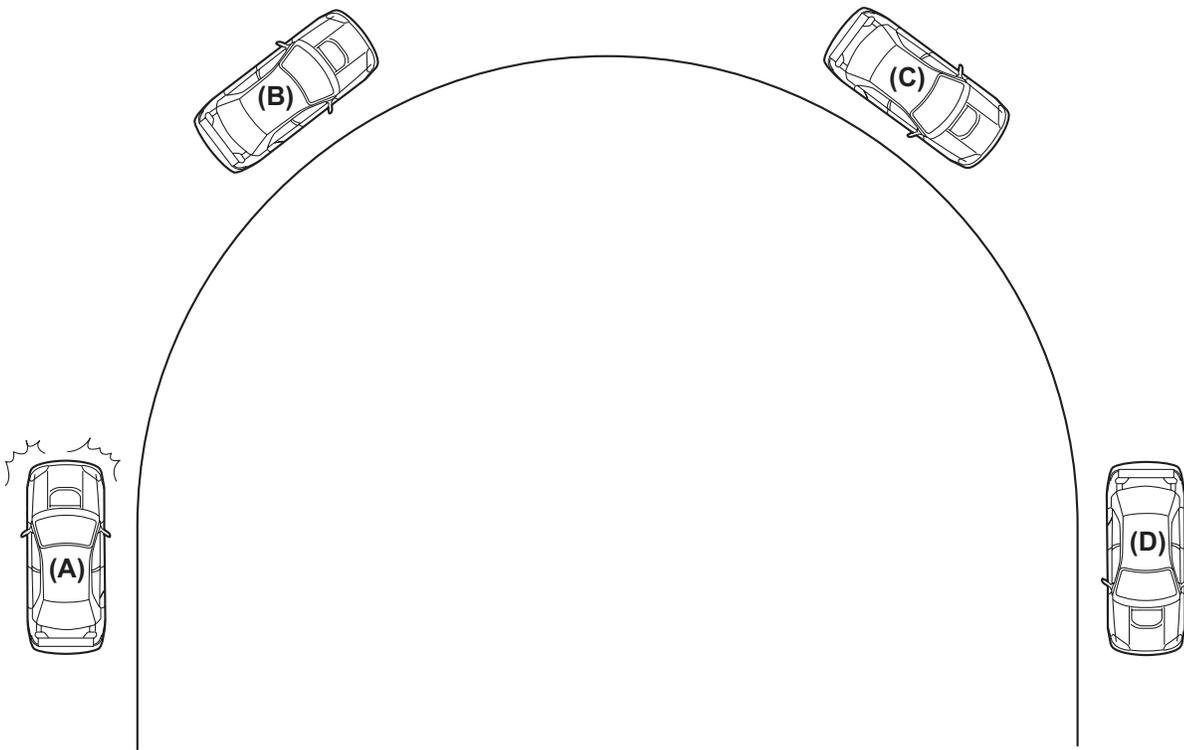
To enhance safety of the vehicle during braking the restriction force of the center differential is controlled toward the free state.

- When the vehicle is in between the turn-in point (B) and clipping point (C):

When the vehicle is running from the turn-in point toward the clipping point, the throttle opening increases (vehicle accelerates) and a signal from the lateral G sensor is input. Accordingly the center differential restriction torque is gradually increased to improve the cornering ability.

- When the vehicle is in between the clipping point (C) and exit point (D):

When the vehicle is running past the clipping point toward the exit point, the input from the lateral G sensor decreases. Accordingly the control interprets this as the vehicle is tracking out from the corner and increases the restricting force of the center differential toward the locked state to maintain traction.

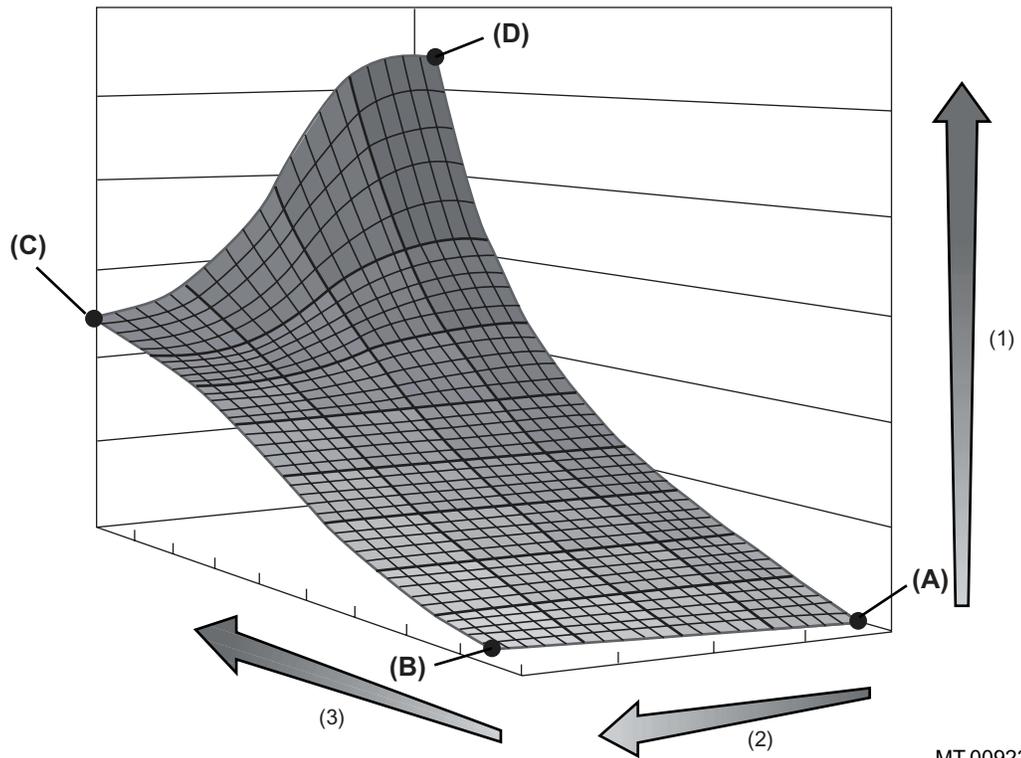


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- (A) Braking
- (B) Turn-in point
- (C) Clipping point
- (D) Exit point

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- (A) Braking
- (B) Turn-in point
- (C) Clipping point
- (D) Exit point

- (1) Center differential restriction torque
- (2) Lateral G
- (3) Throttle opening