AUTOMATIC TRANSMISSION (From '08M) (5AT)

1. General

A: GENERAL

In purpose of improving shifting quality, driving performance and fuel efficiency, we have developed 5-speed automatic transmission mainly with new hydraulic control and electronic control systems. This automatic transmission features the following:

B: NEW STRUCTURE

- Low coast brake and forward one-way clutch are eliminated to reduce friction torque.
- Torque converter structure is modified to improve acceleration performance for more linearity.
- Control valve structure is modified to reduce drive torque and weight.

C: MODIFICATIONS FOR DRIVING PERFORMANCE IMPROVEMENT

1. SHIFTING PERFORMANCE IMPROVEMENT

- Structure change of control valve has realized highly accurate and responsive control system.
- Blipping control is employed to provide automatic switching of shift schedule and active shifting control in manual mode.
- A new control system is applied so that operating the paddle switch up ⇔ down while driving in D range enables manual shifting and automatically returns to normal automatic shifting under certain conditions. (models with paddle switch)

D: MODIFICATIONS FOR FUEL EFFICIENCY IMPROVEMENT

1. EFFICIENCY IMPROVEMENT

- Low coast brake and forward one-way clutch are eliminated to reduce friction on gear train.
- Slip lock-up range is expanded.

2. WEIGHT SAVING

- Low coast brake and forward one-way clutch are eliminated.
- Control valve is changed to two-layer type.

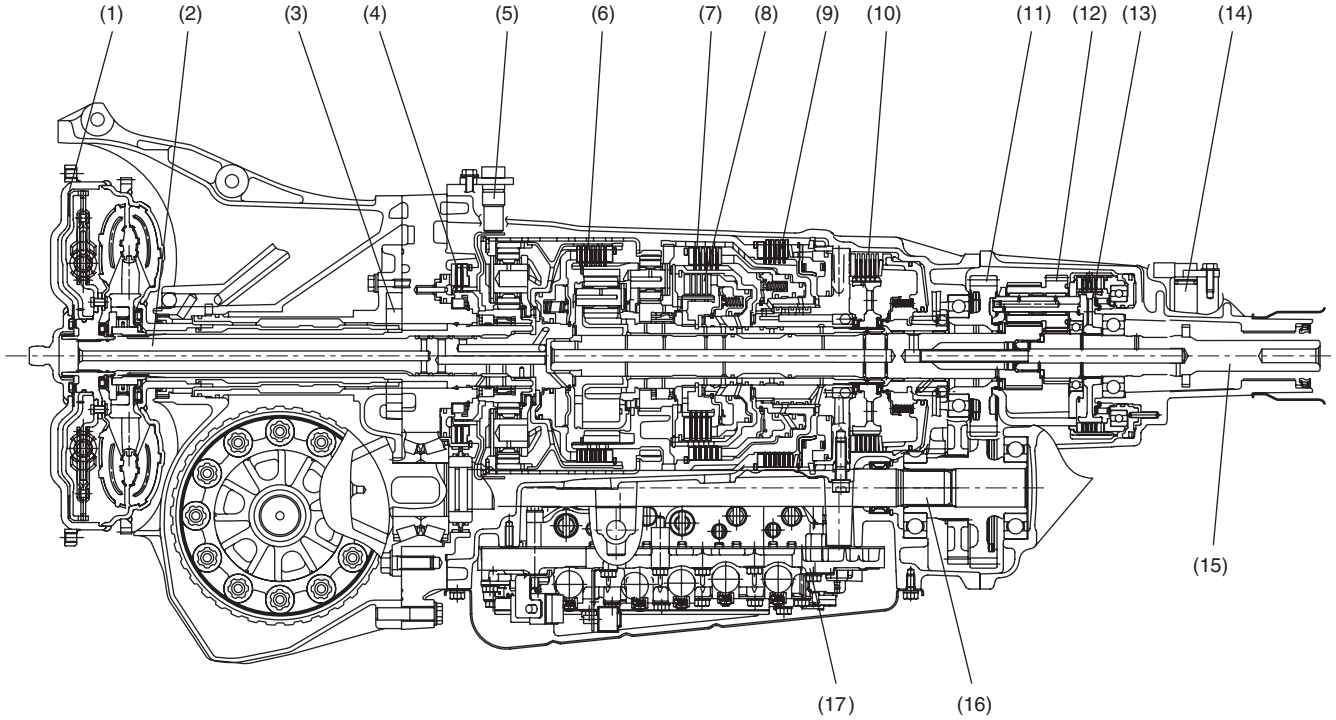
E: UNCHANGED MECHANISM

The following mechanisms are unchanged from the former systems:

- Oil pump
- Front brake
- Input clutch
- Direct clutch
- High & low reverse clutch
- Reverse brake
- AWD transfer system
- Transmission mount
- Transfer

2. Cross-section

A: CROSS-SECTION



(1)	Torque converter ASSY	(7)	Direct clutch	(13)	Transfer clutch
(2)	Input shaft	(8)	High & low reverse clutch	(14)	Rear vehicle speed sensor
(3)	Oil pump	(9)	Reverse brake	(15)	Rear drive shaft
(4)	Front brake	(10)	Forward brake	(16)	Drive pinion shaft
(5)	Turbine speed sensor 1	(11)	Reduction gear	(17)	Control valve
(6)	Input clutch	(12)	Variable torque distribution (VTD)		

3. Oil Pump

A: GENERAL

Same mechanism as the existing model.

4. Front Brake

A: GENERAL

Same mechanism as the existing model.

5. Input Clutch

A: GENERAL

Same mechanism as the existing model.

6. Direct Clutch

A: GENERAL

Same mechanism as the existing model.

7. High & Low Reverse Clutch

A: GENERAL

Same mechanism as the existing model.

8. Reverse Brake

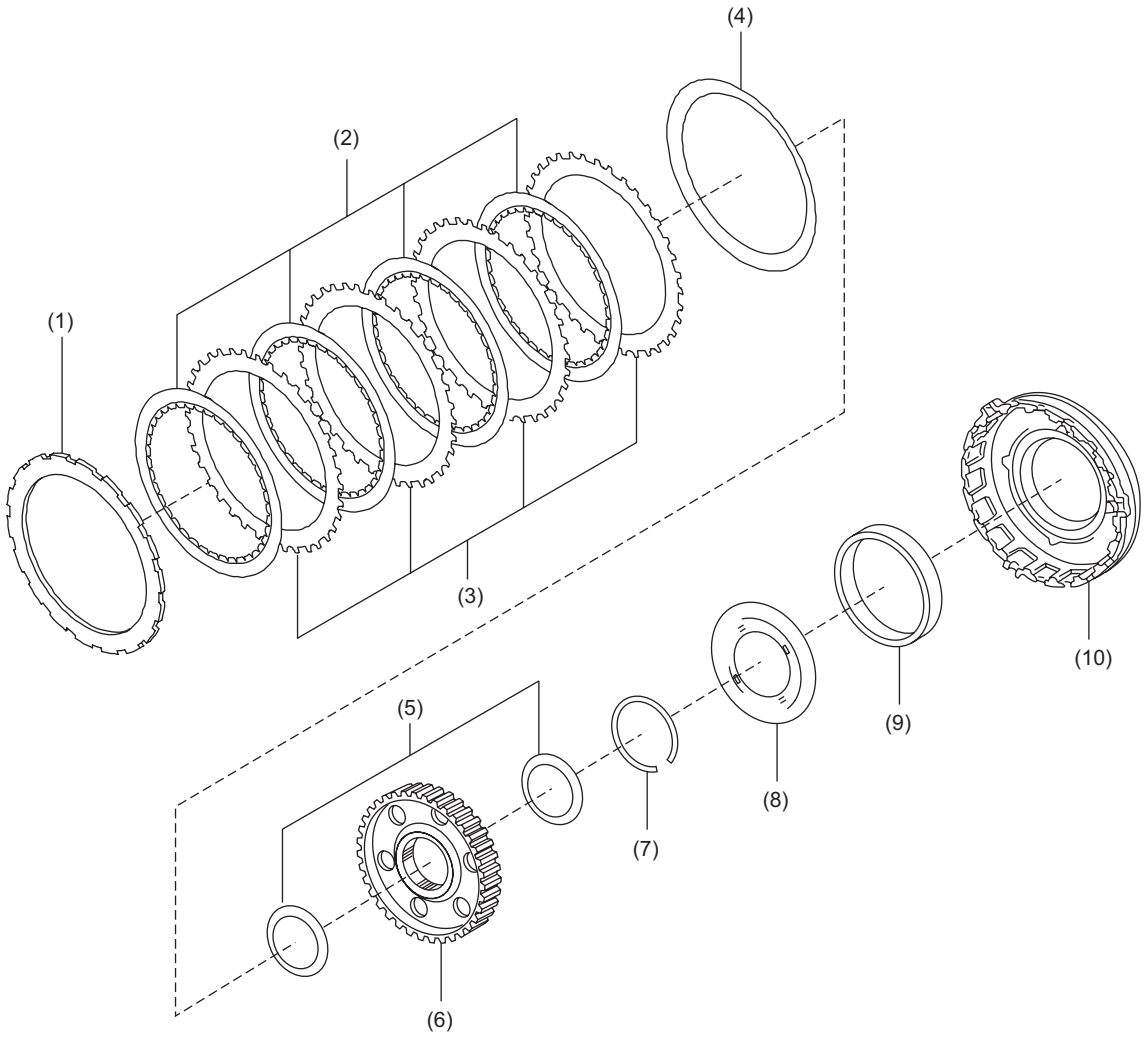
A: GENERAL

Same mechanism as the existing model.

9. Forward Brake

A: COMPONENT

The forward brake consists of forward brake hub, forward brake piston, return spring, dish plate, drive plates, driven plates and retaining plate.
The forward brake restrains reverse rotation of mid sun gear at 1st and 2nd speed.
(Forward brake cannot be disassembled.)



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(1) Retaining plate
(2) Drive plate
(3) Driven plate
(4) Dish plate
(5) Thrust bearing
(6) Forward brake hub
(7) Snap ring
(8) Retainer
(9) Return spring
(10) Forward brake piston

10.Control Valve

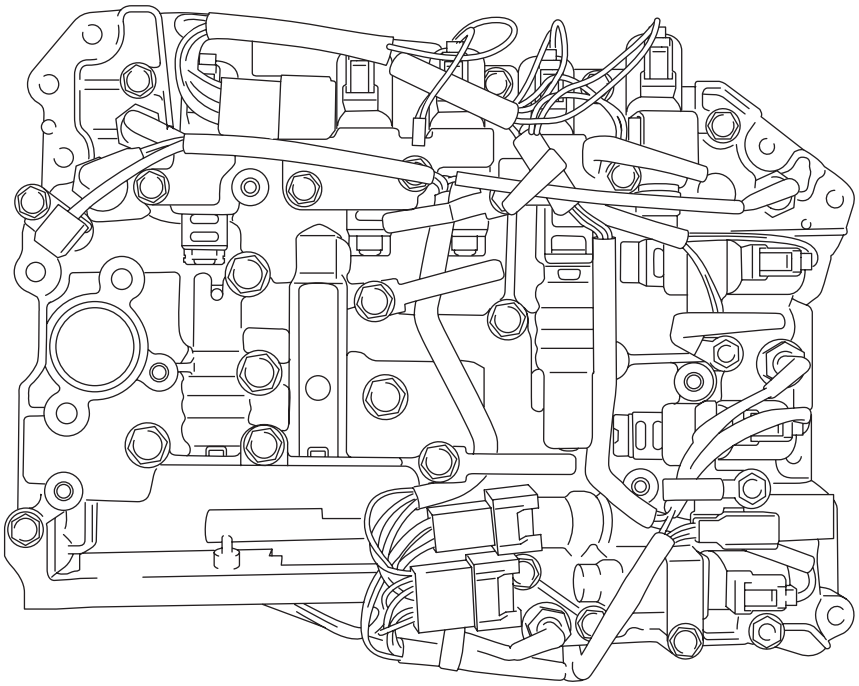
A: GENERAL

The control system of automatic transmission consists of oil pump, valve body containing valves, clutches and fluid passages. The system is operated by both driver's input and electrical input from TCM.

B: FUNCTION

Name	Function
Primary regulator valve	Regulates the pressure of oil discharged from the oil pump to the optimum pressure (line pressure) depending on the driving condition.
Front brake control valve	During front brake engagement, regulates the line pressure to the optimum level (front brake pressure) and supplies to front brake. (Regulates the clutch pressure at 1st, 2nd, 3rd and 5th speed)
Modulator valve 1	Regulates the line pressure to create a certain pressure (pilot pressure) required for line pressure control, shifting control and lock-up control.
Modulator valve 2	Regulates the line pressure to create a certain pressure (pilot pressure) required for shifting control.
Forward brake control valve	During forward brake engagement, regulates the line pressure to the optimum level (forward brake pressure) and supplies to forward brake.
High & low reverse clutch control valve	During high & low reverse clutch engagement, regulates the line pressure to the optimum level (high & low reverse clutch) and supplies to high & low reverse clutch. (Regulates the clutch pressure at 1st, 3rd, 4th and 5th speed)
Input clutch control valve	During input clutch engagement, regulates the line pressure to the optimum level (input clutch pressure) and supplies to input clutch. (Regulates the clutch pressure at 4th and 5th speed)
Direct clutch control valve	During direct clutch engagement, regulates the line pressure to the optimum level (direct clutch pressure) and supplies to direct clutch. (Regulates the clutch pressure at 2nd, 3rd and 4th speed)
Transfer clutch control valve	Regulates the line pressure to the optimum level (transfer clutch pressure) and supplies to transfer clutch.
Lock-up control valve	Switches lock-up function between operation and release. Also provides smooth lock-up by continuously performing the lock-up operation.
Oil cooler bypass valve	Bypasses redundant oil of the cooler circuit without sending it.
Line pressure relief valve	Discharges redundant oil of the line pressure circuit.
Manual valve	Distributes the line pressure to each circuit in accordance with each selector position. For the circuits where no line pressure is distributed, drain occurs.
Front brake oil pressure switch	Detects problems in front brake oil pressure and switches to the fail safe mode if a problem is detected.
Forward brake oil pressure switch	Detects problems in forward brake oil pressure and switches to the fail safe mode if a problem is detected.
Input clutch oil pressure switch	Detects problems in input clutch oil pressure and switches to the fail safe mode if a problem is detected.
Direct clutch oil pressure switch	Detects problems in direct clutch oil pressure and switches to the fail safe mode if a problem is detected.
High & low reverse clutch oil pressure switch	Detects problems in high & low reverse clutch oil pressure and switches to the fail safe mode if a problem is detected.

C: ARRANGEMENT



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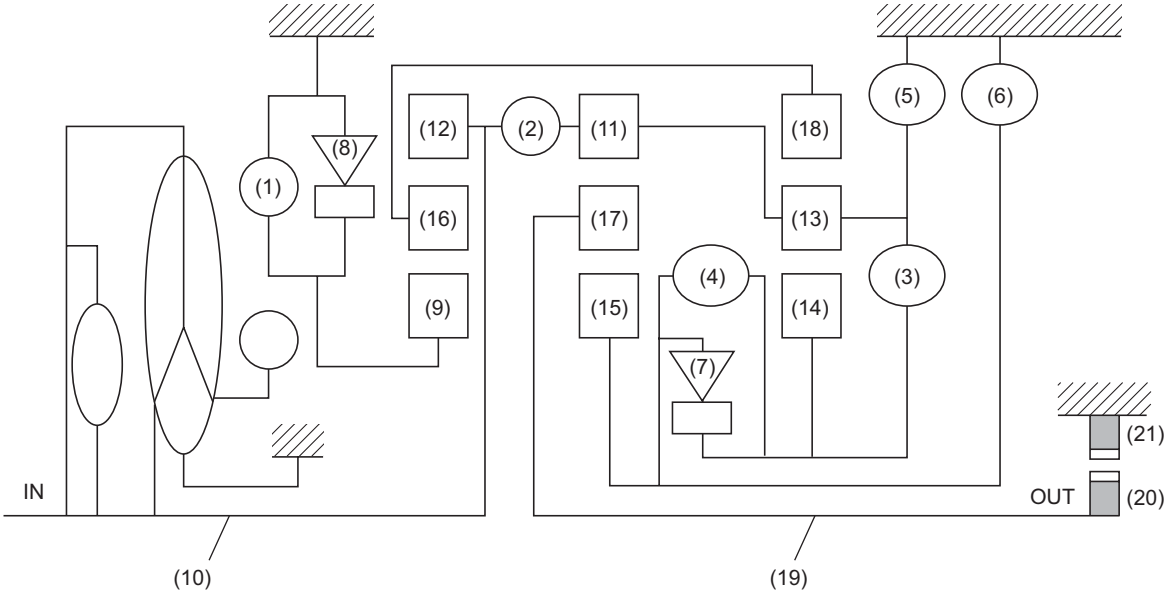
11.Gear Train

A: STRUCTURE

The gear train consists of three sets of planetary gears, three sets of multi-plate clutches, three sets of multi-plate brakes and two sets of one-way clutches.



(1)	Front brake	(8)	3rd one-way clutch	(15)	Mid sun gear
(2)	Input clutch	(9)	Front sun gear	(16)	Front carrier
(3)	Direct clutch	(10)	Input shaft	(17)	Mid carrier
(4)	High & low reverse clutch	(11)	Mid internal gear	(18)	Rear internal gear
(5)	Reverse brake	(12)	Front internal gear	(19)	Output shaft
(6)	Forward brake	(13)	Rear carrier	(20)	Parking gear
(7)	1st one-way clutch	(14)	Rear sun gear	(21)	Parking pawl

B: OPERATION

1. OPERATION TABLE

Selector lever selection		Input clutch	High & low reverse clutch	Direct clutch	Reverse brake	Front brake	Forward brake	1st one-way clutch	3rd one-way clutch
P			△			△			
R			◇		○	◇		◎	◎
N			△			△			
D	1st		◇*			◇	○	◎	◎
	2nd			○		◇	○		◎
	3rd		○	○		◇		◇	◎
	4th	○	○	○				◇	
	5th	○	○			○		◇	◇

○ : Engaged
◎ : Torque is transmitted only when vehicle is driven
◇ : Torque is transmitted only when vehicle is coasting
◇* : When SPORT mode is engaged
△ : Engaged but no influence for output

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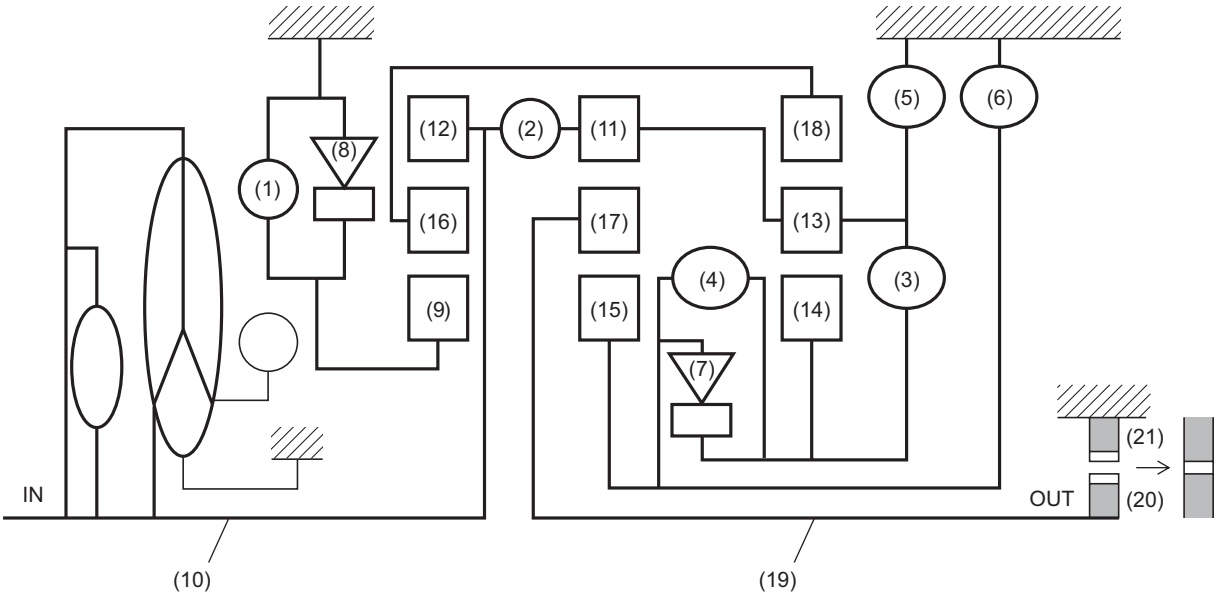
2. N RANGE

Since both forward brake and reverse brake are in the release status, driving force of input shaft is not transmitted to output shaft.

3. P RANGE

- As with N range, since both forward brake and reverse brake are in the release status, driving force of input shaft is not transmitted to output shaft.
- The parking pawl that operates in conjunction with the select lever engages with the parking gear and mechanically fixes the output shaft.



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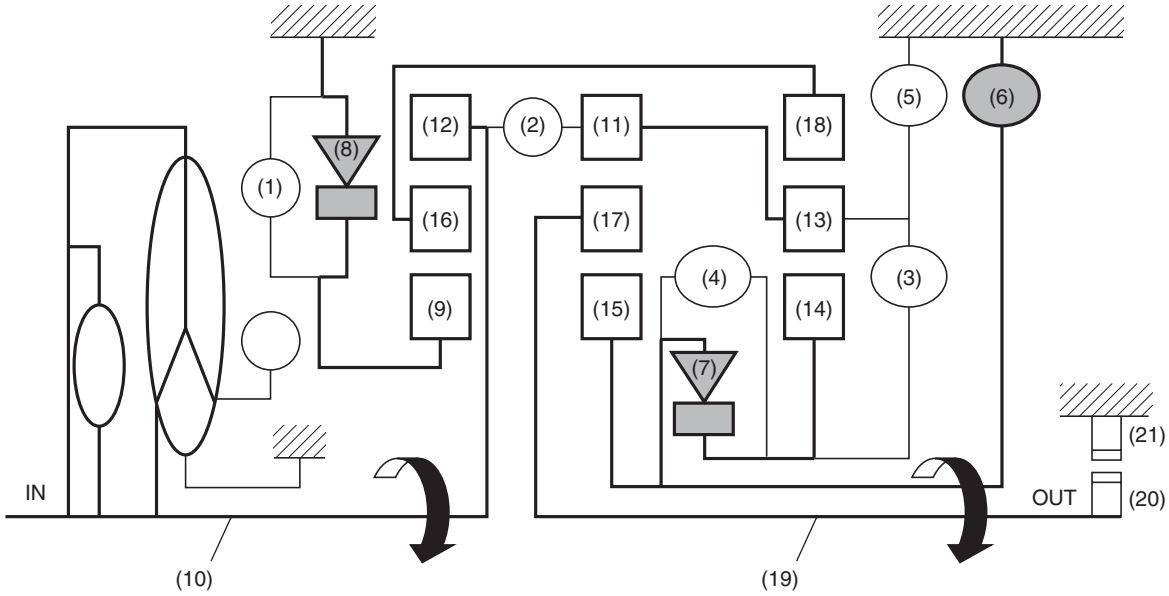
(1)	Front brake	(8)	3rd one-way clutch	(15)	Mid sun gear
(2)	Input clutch	(9)	Front sun gear	(16)	Front carrier
(3)	Direct clutch	(10)	Input shaft	(17)	Mid carrier
(4)	High & low reverse clutch	(11)	Mid internal gear	(18)	Rear internal gear
(5)	Reverse brake	(12)	Front internal gear	(19)	Output shaft
(6)	Forward brake	(13)	Rear carrier	(20)	Parking gear
(7)	1st one-way clutch	(14)	Rear sun gear	(21)	Parking pawl

4. 1st GEAR IN D RANGE

- Forward brake operates to fix the mid sun gear.
- 1st one-way clutch operates to restrain reverse rotation of rear sun gear.
- 3rd one-way clutch operates to restrain reverse rotation of front sun gear.
- During deceleration, because the rear sun gear rotates in normal direction, 1st one-way clutch slips and engine brake does not work.



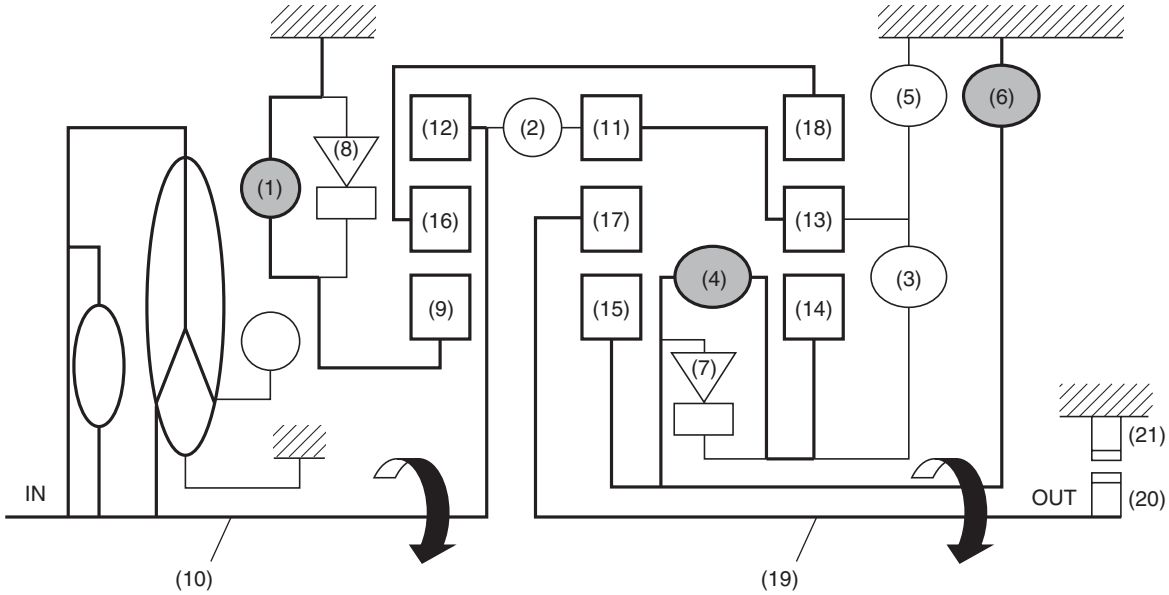
Power flow
Input shaft ⇨ Front internal gear ⇨ Front carrier ⇨ Rear internal gear ⇨ Rear carrier ⇨ Mid internal gear ⇨ Mid carrier ⇨ Output shaft

AT-04719

(1)	Front brake	(8)	3rd one-way clutch	(15)	Mid sun gear
(2)	Input clutch	(9)	Front sun gear	(16)	Front carrier
(3)	Direct clutch	(10)	Input shaft	(17)	Mid carrier
(4)	High & low reverse clutch	(11)	Mid internal gear	(18)	Rear internal gear
(5)	Reverse brake	(12)	Front internal gear	(19)	Output shaft
(6)	Forward brake	(13)	Rear carrier	(20)	Parking gear
(7)	1st one-way clutch	(14)	Rear sun gear	(21)	Parking pawl

5. 1st GEAR IN MANUAL MODE

- Front brake operates to fix the front sun gear.
- Forward brake operates to fix the mid sun gear.
- High & low reverse clutch operates to engage rear sun gear and mid sun gear.
- Forward brake operates to fix the mid sun gear.
- During deceleration, high & low reverse clutch restrains normal rotation of rear sun gear and engine brake works.



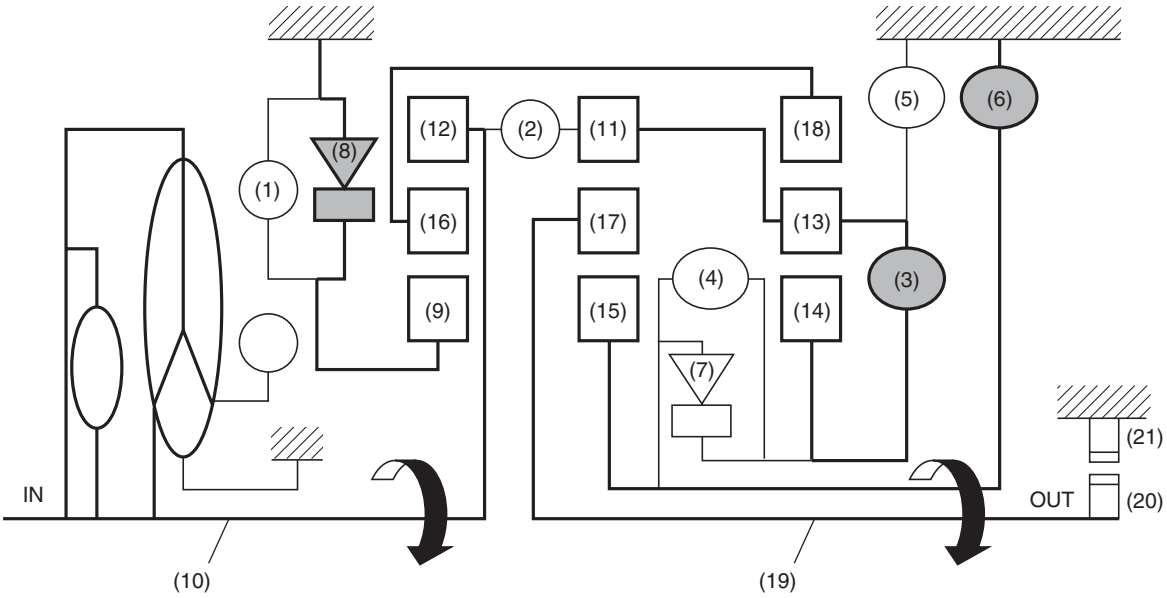
Power flow
Input shaft ⇨ Front internal gear ⇨ Front carrier ⇨ Rear internal gear ⇨ Rear carrier ⇨ Mid internal gear ⇨ Mid carrier ⇨ Output shaft

AT-04720

(1)	Front brake	(8)	3rd one-way clutch	(15)	Mid sun gear
(2)	Input clutch	(9)	Front sun gear	(16)	Front carrier
(3)	Direct clutch	(10)	Input shaft	(17)	Mid carrier
(4)	High & low reverse clutch	(11)	Mid internal gear	(18)	Rear internal gear
(5)	Reverse brake	(12)	Front internal gear	(19)	Output shaft
(6)	Forward brake	(13)	Rear carrier	(20)	Parking gear
(7)	1st one-way clutch	(14)	Rear sun gear	(21)	Parking pawl

6. 2nd GEAR IN D RANGE

- Forward brake operates to fix the mid sun gear.
- 3rd one-way clutch operates to restrain reverse rotation of front sun gear.
- Direct clutch engages and connects rear carrier and rear sun gear.
- Engine brake works during deceleration.



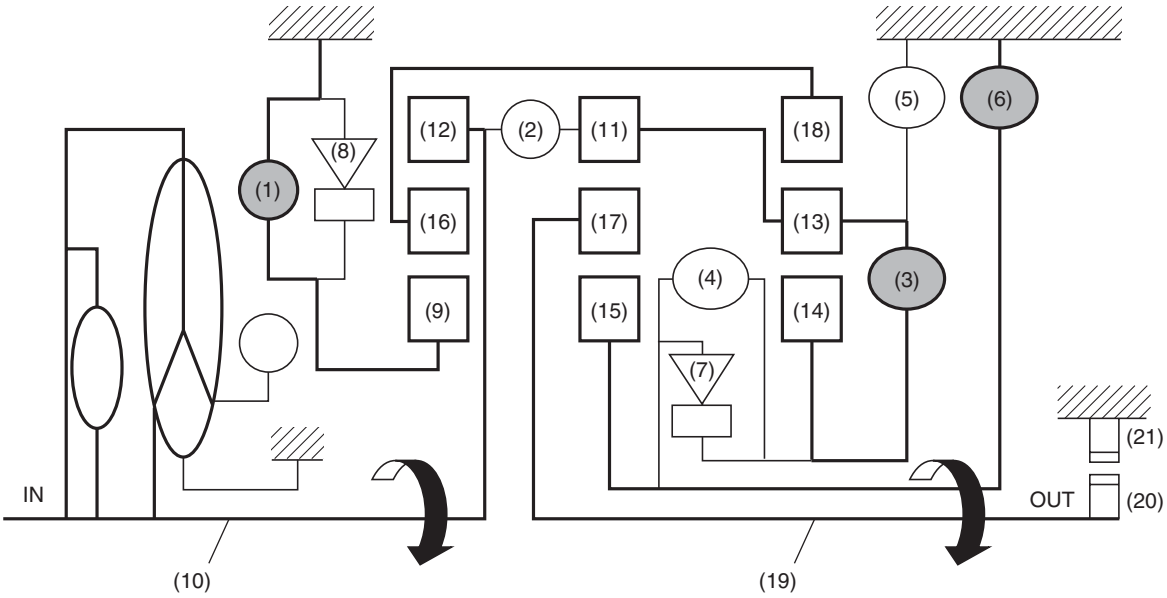
Power flow
Input shaft ⇨ Front internal gear ⇨ Front carrier ⇨
Rear internal gear ⇨ Rear carrier ⇨ Mid internal gear ⇨
Mid carrier ⇨ Output shaft

AT-04721

(1)	Front brake	(8)	3rd one-way clutch	(15)	Mid sun gear
(2)	Input clutch	(9)	Front sun gear	(16)	Front carrier
(3)	Direct clutch	(10)	Input shaft	(17)	Mid carrier
(4)	High & low reverse clutch	(11)	Mid internal gear	(18)	Rear internal gear
(5)	Reverse brake	(12)	Front internal gear	(19)	Output shaft
(6)	Forward brake	(13)	Rear carrier	(20)	Parking gear
(7)	1st one-way clutch	(14)	Rear sun gear	(21)	Parking pawl

7. 2nd GEAR IN MANUAL MODE

- Forward brake engages and fixes the mid sun gear.
- Front brake operates to fix the front sun gear.
- Direct clutch engages and connects rear carrier and rear sun gear.
- Engine brake works during deceleration.



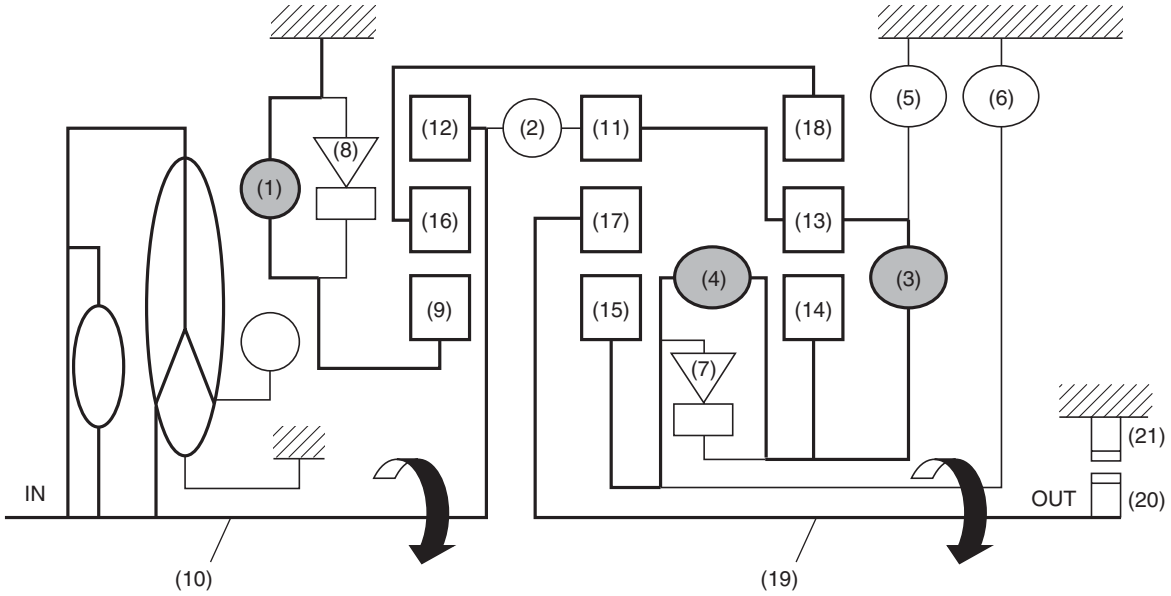
Power flow
Input shaft ⇨ Front internal gear ⇨ Front carrier ⇨
Rear internal gear ⇨ Rear carrier ⇨ Mid internal gear ⇨
Mid carrier ⇨ Output shaft

AT-04722

(1)	Front brake	(8)	3rd one-way clutch	(15)	Mid sun gear
(2)	Input clutch	(9)	Front sun gear	(16)	Front carrier
(3)	Direct clutch	(10)	Input shaft	(17)	Mid carrier
(4)	High & low reverse clutch	(11)	Mid internal gear	(18)	Rear internal gear
(5)	Reverse brake	(12)	Front internal gear	(19)	Output shaft
(6)	Forward brake	(13)	Rear carrier	(20)	Parking gear
(7)	1st one-way clutch	(14)	Rear sun gear	(21)	Parking pawl

8. 3rd GEAR IN D RANGE OR MANUAL MODE

- Front brake operates to fix the front sun gear.
- Direct clutch engages and connects rear carrier and rear sun gear.
- High & low reverse clutch engages and connects mid sun gear and rear sun gear.



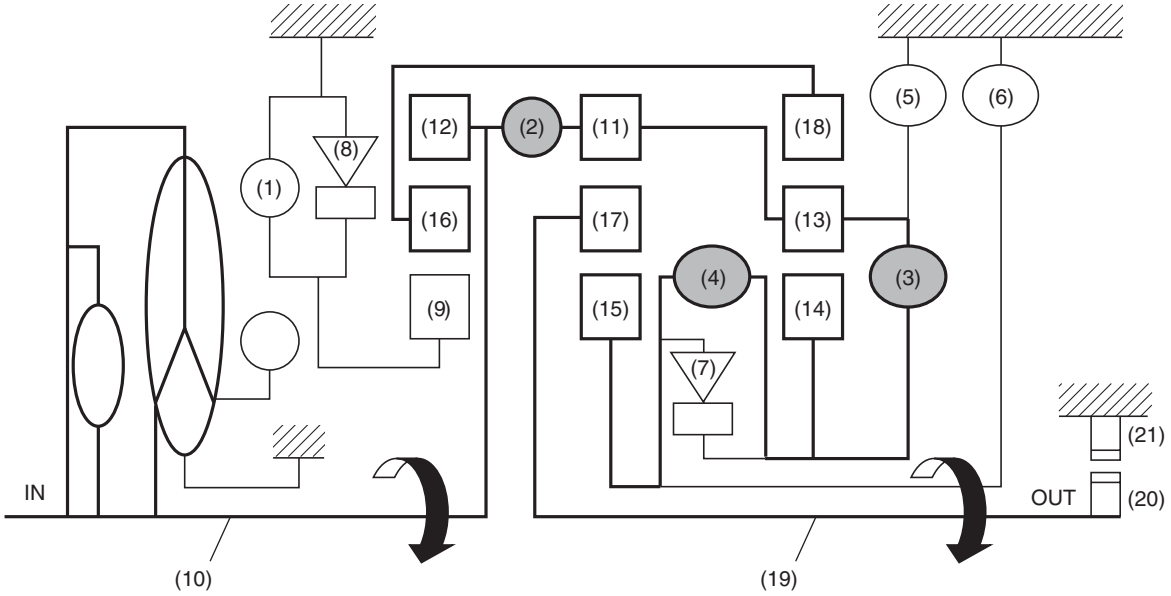
Power flow
Input shaft ⇨ Front internal gear ⇨ Front carrier ⇨
Rear internal gear ⇨ Rear carrier ⇨ Mid internal gear ⇨
Mid carrier ⇨ Output shaft

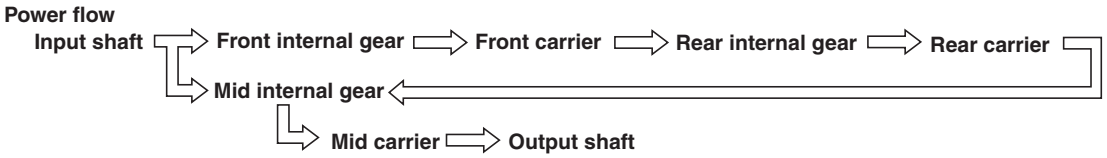
AT-04723

(1)	Front brake	(8)	3rd one-way clutch	(15)	Mid sun gear
(2)	Input clutch	(9)	Front sun gear	(16)	Front carrier
(3)	Direct clutch	(10)	Input shaft	(17)	Mid carrier
(4)	High & low reverse clutch	(11)	Mid internal gear	(18)	Rear internal gear
(5)	Reverse brake	(12)	Front internal gear	(19)	Output shaft
(6)	Forward brake	(13)	Rear carrier	(20)	Parking gear
(7)	1st one-way clutch	(14)	Rear sun gear	(21)	Parking pawl

9. 4th GEAR IN D RANGE OR MANUAL MODE

- Direct clutch engages and connects rear carrier and rear sun gear.
- High & low reverse clutch engages and connects mid sun gear and rear sun gear.
- Input clutch engages and connects front internal gear and mid internal gear.
- Driving force is transmitted to front internal gear, mid internal gear and rear carrier, and the three planetary gears rotate in normal direction as a unit.





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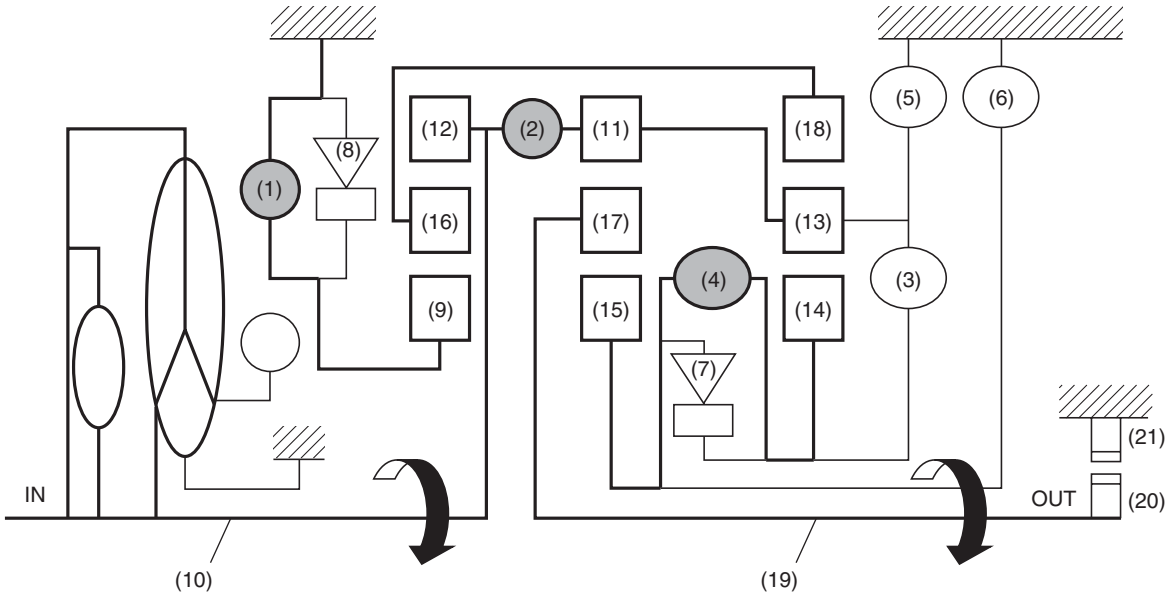
(1)	Front brake	(8)	3rd one-way clutch	(15)	Mid sun gear
(2)	Input clutch	(9)	Front sun gear	(16)	Front carrier
(3)	Direct clutch	(10)	Input shaft	(17)	Mid carrier
(4)	High & low reverse clutch	(11)	Mid internal gear	(18)	Rear internal gear
(5)	Reverse brake	(12)	Front internal gear	(19)	Output shaft
(6)	Forward brake	(13)	Rear carrier	(20)	Parking gear
(7)	1st one-way clutch	(14)	Rear sun gear	(21)	Parking pawl

10.5th GEAR IN D RANGE OR MANUAL MODE

- Front brake operates to fix the front sun gear.
- Input clutch engages and connects front internal gear and mid internal gear.
- High & low reverse clutch engages and connects mid sun gear and rear sun gear.



Power flow

Input shaft ⇨ Front internal gear ⇨ Front carrier ⇨ Rear internal gear

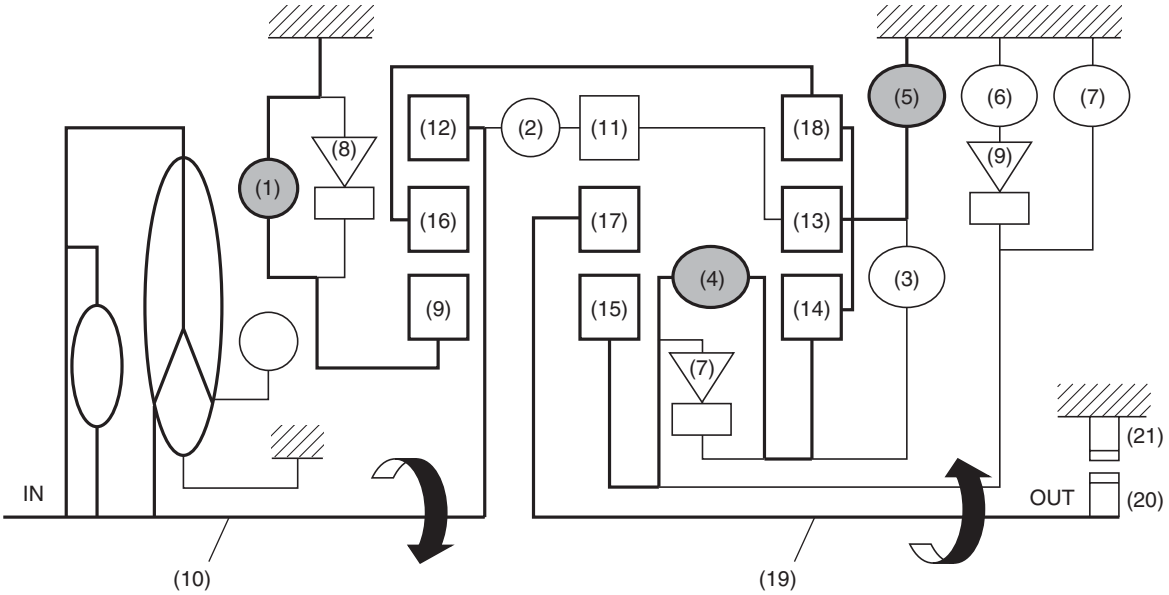
Input shaft ⇨ Mid internal gear ⇨ Rear carrier ⇨ Rear sun gear ⇨
Mid sun gear ⇨ Mid carrier ⇨ Output shaft

AT-04725

(1)	Front brake	(8)	3rd one-way clutch	(15)	Mid sun gear
(2)	Input clutch	(9)	Front sun gear	(16)	Front carrier
(3)	Direct clutch	(10)	Input shaft	(17)	Mid carrier
(4)	High & low reverse clutch	(11)	Mid internal gear	(18)	Rear internal gear
(5)	Reverse brake	(12)	Front internal gear	(19)	Output shaft
(6)	Forward brake	(13)	Rear carrier	(20)	Parking gear
(7)	1st one-way clutch	(14)	Rear sun gear	(21)	Parking pawl

11.R RANGE

- Front brake operates to fix the front sun gear.
- High & low reverse clutch engages and connects mid sun gear and rear sun gear.
- Reverse brake operates to fix the rear carrier.



Power flow

Input shaft ⇨ Front internal gear ⇨ Front carrier ⇨ Rear internal gear ⇨
Rear sun gear ⇨ Mid sun gear ⇨ Mid carrier ⇨ Output shaft

AT-04726

(1)	Front brake	(8)	3rd one-way clutch	(15)	Mid sun gear
(2)	Input clutch	(9)	Front sun gear	(16)	Front carrier
(3)	Direct clutch	(10)	Input shaft	(17)	Mid carrier
(4)	High & low reverse clutch	(11)	Mid internal gear	(18)	Rear internal gear
(5)	Reverse brake	(12)	Front internal gear	(19)	Output shaft
(6)	Forward brake	(13)	Rear carrier	(20)	Parking gear
(7)	1st one-way clutch	(14)	Rear sun gear	(21)	Parking pawl

12.AWD Transfer System

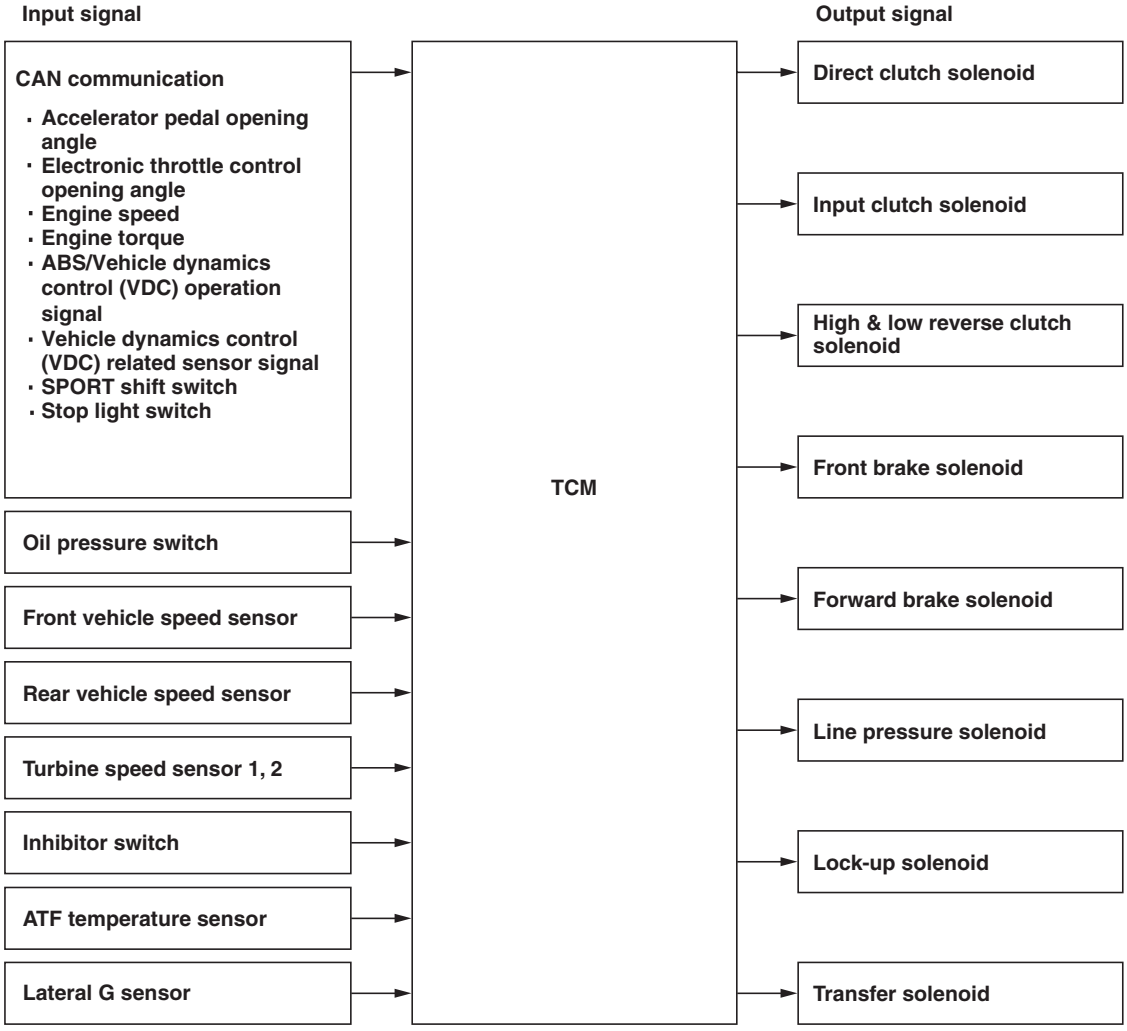
A: GENERAL

Same mechanism as the existing model.

13.Electronic Hydraulic Control System

A: GENERAL

The electronic hydraulic control system for transmission and transfer consists of various sensors, switches, TCM and control valve containing solenoid valves. This system controls shifting, lock-up clutch operation, line pressure and automatic transmission operation including shift timing. This also controls transfer clutch operation. TCM judges vehicle driving status based on various types of input signals and controls a total of eight solenoids (front brake solenoid, forward brake solenoid, input clutch solenoid, high & low reverse clutch solenoid, direct clutch solenoid, lock-up solenoid, line pressure solenoid and transfer solenoid) by sending appropriate signals.



AT-04727

B: CONTROL ITEMS

Control items			Control details
Transmission hydraulic control	Shifting control	Shift pattern selection	Based on the shift pattern selected by input from switches in each range, upshift and downshift points are set according to accelerator pedal opening angle and vehicle speed. (Refer to "Transmission Control Module (TCM)" in <Ref. to 5AT-33, Transmission Control Module (TCM).>.)
		Linear solenoid control for each shift clutch	Directly controls the linear solenoid for each shift clutch according to target gear range. The control values are constantly corrected by learning control and real-time feedback, contributing shifting quality improvement and prevention of quality aging.
		Engine brake control	In manual mode, controls high & low reverse clutch solenoid so that engine brake is applied at 1st speed.
	Lock-up control	Basic lock-up control	Based on the shift pattern selected by input from switches in each range, lock-up engagement and release points are set according to accelerator pedal opening angle and vehicle speed. In accordance with these points, the lock-up solenoid is controlled to engage and release the lock-up clutch in torque converter.
		Smooth control	In lock-up clutch engagement, gradually changes pressure to provide smooth engagement.
	Line pressure control		Controls the line pressure in accordance with the input torque, front vehicle speed signal, rear vehicle speed signal and gear range.
AWD center differential control	Normal transfer control	Torque sensitive control	Adjusts the multi-plate clutch (LSD) pressure according to torque input to the transfer.
		Control for turning	Adjusts the LSD pressure based on the steering angle and vehicle speed.
		Slip control	LSD pressure increases if front or rear wheels start to slip.
	Cooperation control	Control during ABS operation	LSD pressure is adjusted to the set value during ABS operation.
		Control during braking	LSD pressure is adjusted to the set value while the brake switch is ON with the throttle valve fully closed.
		Control during VDC and TCS operation	LSD pressure is adjusted to the set value during VDC and TCS operation.

C: TRANSMISSION SHIFTING HYDRAULIC CONTROL

- Linear solenoid control for each shift clutch

Directly controls the linear solenoid for each shift clutch with electric current according to target gear range. The control current values are constantly corrected by learning control and real-time feedback control, contributing shifting quality improvement and prevention of quality aging.

- Engine brake control

In manual mode, controls high & low reverse clutch solenoid so that engine brake is applied at 1st speed.

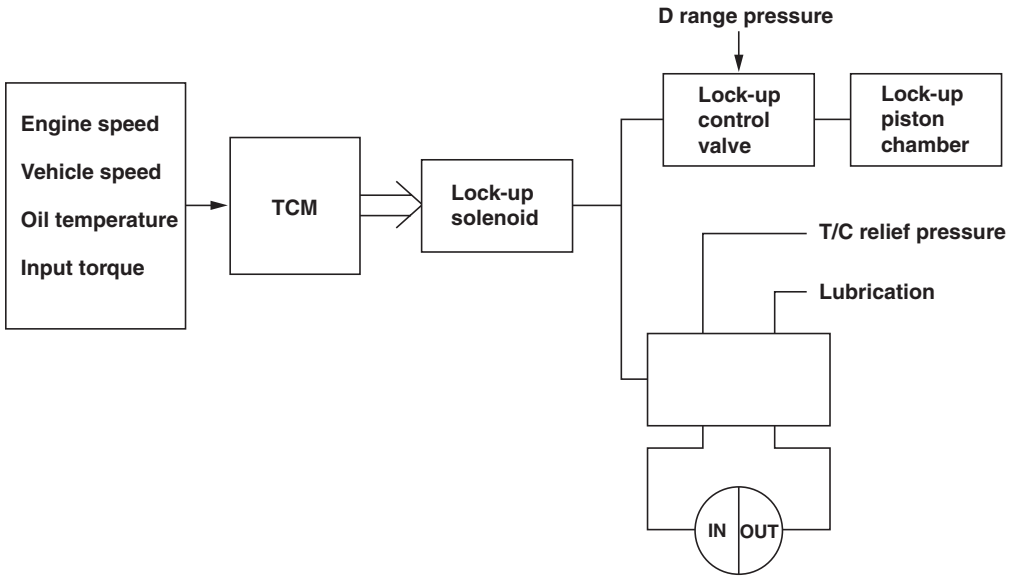
D: LOCK-UP CONTROL

- Engages lock-up clutch in torque converter to prevent torque converter slippage and improve transmission efficiency.
- Upon receipt of signals from TCM, controls lock-up solenoid to operate lock-up control valve, adjusts the application pressure and release pressure, and changes the engaging force of lock-up clutch.

Lock-up operation conditions

Select lever	Gear position	Slip lock-up	Full lock-up
D range Manual mode	2	○	△
	3	○	△
	4	○	○
	5	○	○

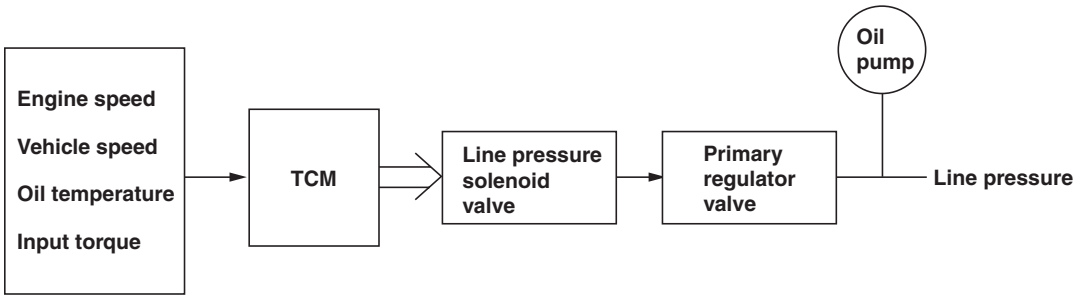
△: Full lock-up occurs when high ATF oil temperature is determined.



AT-01623

E: LINE PRESSURE CONTROL

When torque signal equivalent to engine driving force is sent from ECM to TCM, TCM controls the line pressure solenoid. By using the line pressure solenoid pressure as the signal pressure, controls the primary regulator valve and adjusts the pressure of ATF discharged from oil pump to the optimum level depending on the driving condition.



AT-01624

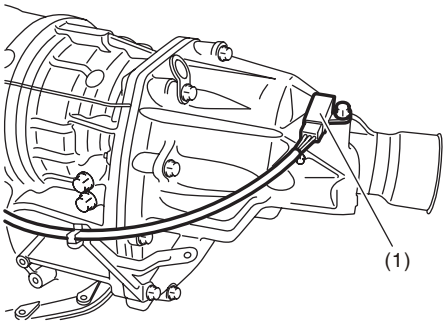
Maximum value of the calculated four values of required line pressure is set as the line pressure.

No.	Control details
1. Required line pressure for lubrication	The line pressure is calculated based on the input torque and gear range.
2. Required line pressure for shift clutch	The line pressure is calculated based on the input torque, front vehicle speed signal, rear vehicle speed signal and gear range.
3. Required line pressure for multi-plate clutch controlled by AWD	The line pressure required for the multi-plate clutch (LSD) is calculated.
4. Required line pressure for lock-up clutch	The line pressure required for the lock-up clutch is calculated.

14.Sensors

A: REAR VEHICLE SPEED SENSOR

This vehicle speed sensor uses the hall element type sensor and is installed on the outside of extension case. This sensor detects the rear wheel speed based on the circumferential speed of rear drive shaft and sends pulse signal (22 pulses per one turn) to TCM.

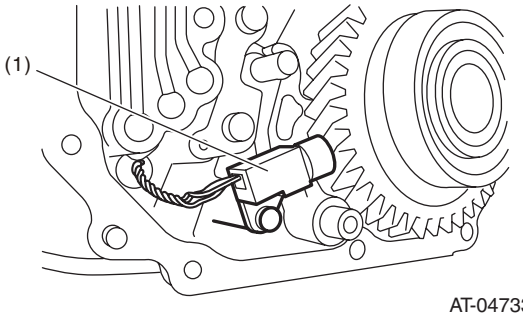


AT-04734

(1) Rear vehicle speed sensor

B: FRONT VEHICLE SPEED SENSOR

This vehicle speed sensor uses the hall element type sensor and is installed on the inside of transmission case. This sensor detects the drive pinion shaft speed and sends pulse signal (41 pulses per one turn) to TCM.
The vehicle speed for control is calculated from the signals of front vehicle speed sensor and rear speed vehicle sensor and is used for shifting control.

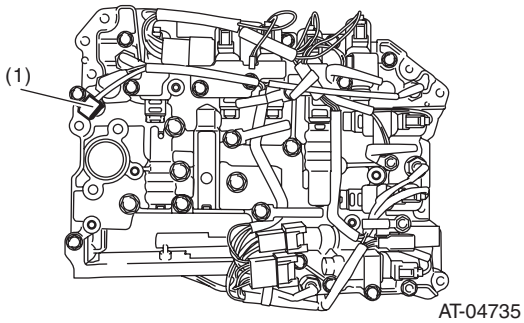


AT-04733

(1) Front vehicle speed sensor

C: ATF TEMPERATURE SENSOR

This temperature sensor uses thermistor and is installed on the control valve body. The ATF temperature sensor detects the ATF temperature and outputs it as electrical resistance signal.

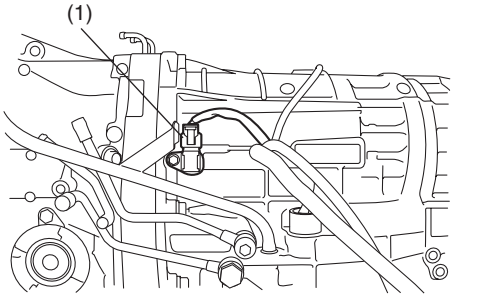


AT-04735

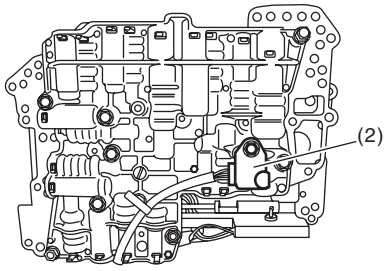
(1) ATF temperature sensor

D: TURBINE SPEED SENSOR 1 AND 2

This speed sensor uses the hall element type sensor. The turbine speed sensor 1 detects the front sun gear speed, the turbine speed sensor 2 detects the front carrier speed, and then both send pulse signal (60 pulses per one turn) to TCM. From these two speed values, turbine speed is calculated and is used for shifting control.



AT-01559



AT-04736

(1) Turbine speed sensor 1
(2) Turbine speed sensor 2

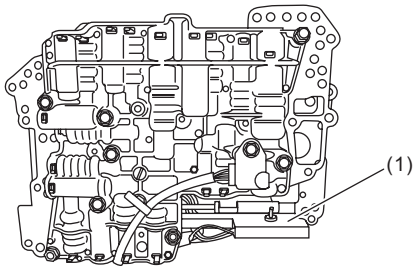
E: INHIBITOR SWITCH

The inhibitor switch is installed in the control valve. TCM detects the range position based on the ON/OFF signal of each range output by the inhibitor switch, and performs various controls. The following list shows the inhibitor switch signal (INH1 — 4) and range position patterns.

	INH1	INH2	INH3	INH4
P	○			○
R		○		
N			○	○
D	○	○	○	

○: Inhibitor switch ON

If the range position is judged as P or N, TCM outputs the signal (PN signal) to permit starter drive. In R or D range, starter drive is inhibited to ensure safety.
In addition, if the position is judged as R range, TCM turns back lamp relay output to ON and turns the back lamp on.

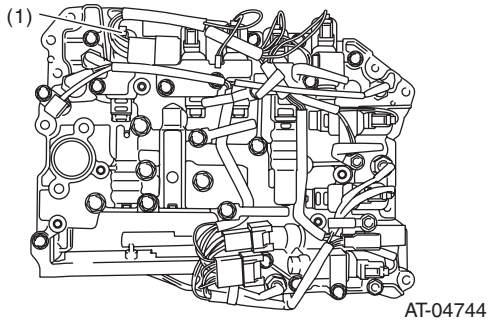


AT-04737

(1) Inhibitor switch

F: LINE PRESSURE SOLENOID

The line pressure solenoid is installed on the control valve and is directly controlled by indicator current from TCM. This controls the pressure modifier valve and accumulator control valve A and adjusts the line pressure to the optimum level in accordance with the driving condition.

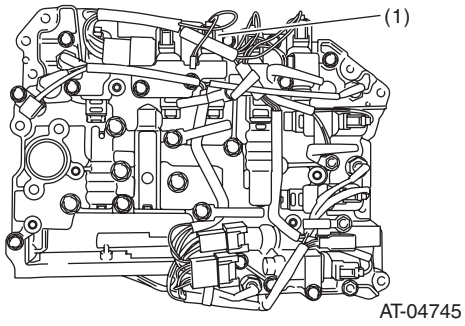


AT-04744

(1) Line pressure solenoid

G: LOCK-UP SOLENOID

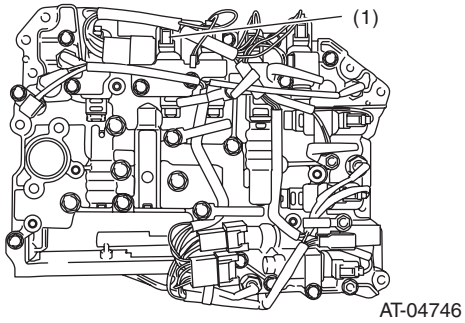
The lock-up solenoid is installed on the control valve and is directly controlled by indicator current from TCM. This controls lock-up control valve, enabling smooth engagement and release. Real-time feedback enables stable control of slip lock-up.



(1) Lock-up solenoid

H: FRONT BRAKE SOLENOID

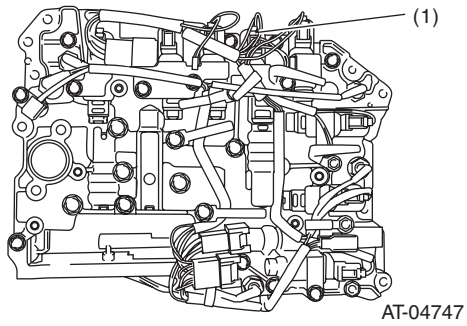
The front brake solenoid is installed on the control valve and is directly controlled by indicator current from TCM. This solenoid is driven when the front brake is operated. The indicator current values are constantly corrected by learning control and real-time feedback, contributing shifting quality improvement and prevention of quality aging.



(1) Front brake solenoid

I: INPUT CLUTCH SOLENOID

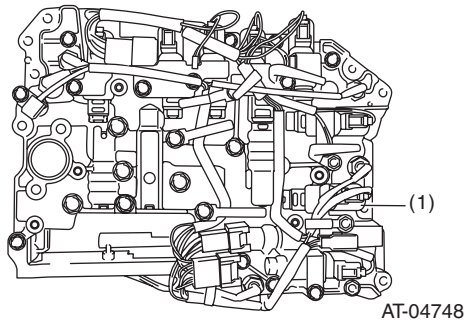
The input clutch solenoid is installed on the control valve and is directly controlled by indicator current from TCM. This solenoid is driven when the input clutch is operated. The indicator current values are constantly corrected by learning control and real-time feedback, contributing shifting quality improvement and prevention of quality aging.



(1) Input clutch solenoid

J: DIRECT CLUTCH SOLENOID

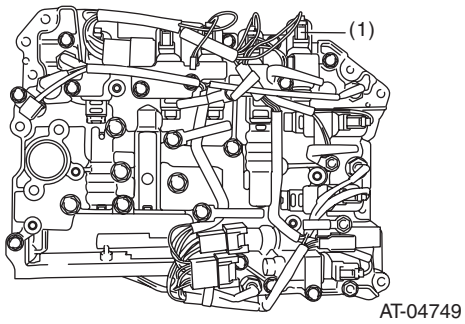
The direct clutch solenoid is installed on the control valve and is directly controlled by indicator current from TCM. This solenoid is driven when the direct clutch is operated. The indicator current values are constantly corrected by learning control and real-time feedback, contributing shifting quality improvement and prevention of quality aging.
Direct clutch pressure can be switched between two types of range pressure with the direct clutch piston switch valve.



(1) Direct clutch solenoid

K: HIGH & LOW REVERSE CLUTCH SOLENOID

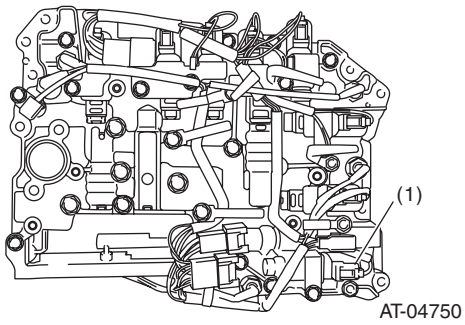
The high & low reverse clutch solenoid is installed on the control valve and is directly controlled by indicator current from TCM. This solenoid is driven when the high & low reverse clutch is operated. The indicator current values are constantly corrected by learning control and real-time feedback, contributing shifting quality improvement and prevention of quality aging.



(1) High & low reverse clutch solenoid

L: FORWARD BRAKE SOLENOID

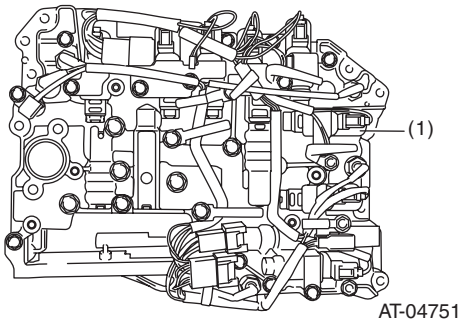
The forward brake solenoid is installed on the control valve and is operated by ON/OFF instructions from TCM. This solenoid is driven when the forward brake is engaged during engine brake operation at 1st or 2nd speed in manual mode.



(1) Forward brake solenoid

M: TRANSFER SOLENOID

The transfer solenoid is installed on the control valve and is directly controlled by indicator current from TCM. This engages/releases the transfer clutch, enabling optimum AWD control depending on changes in road surface.



(1) Transfer solenoid

15.Transmission Control Module (TCM)

A: GENERAL

TCM receives signal from various sensors and judges the vehicle driving status. TCM then sends control signal to each solenoid according to preset shifting characteristics data, lock-up operation data and transfer clutch torque data.

B: CONTROL ITEMS

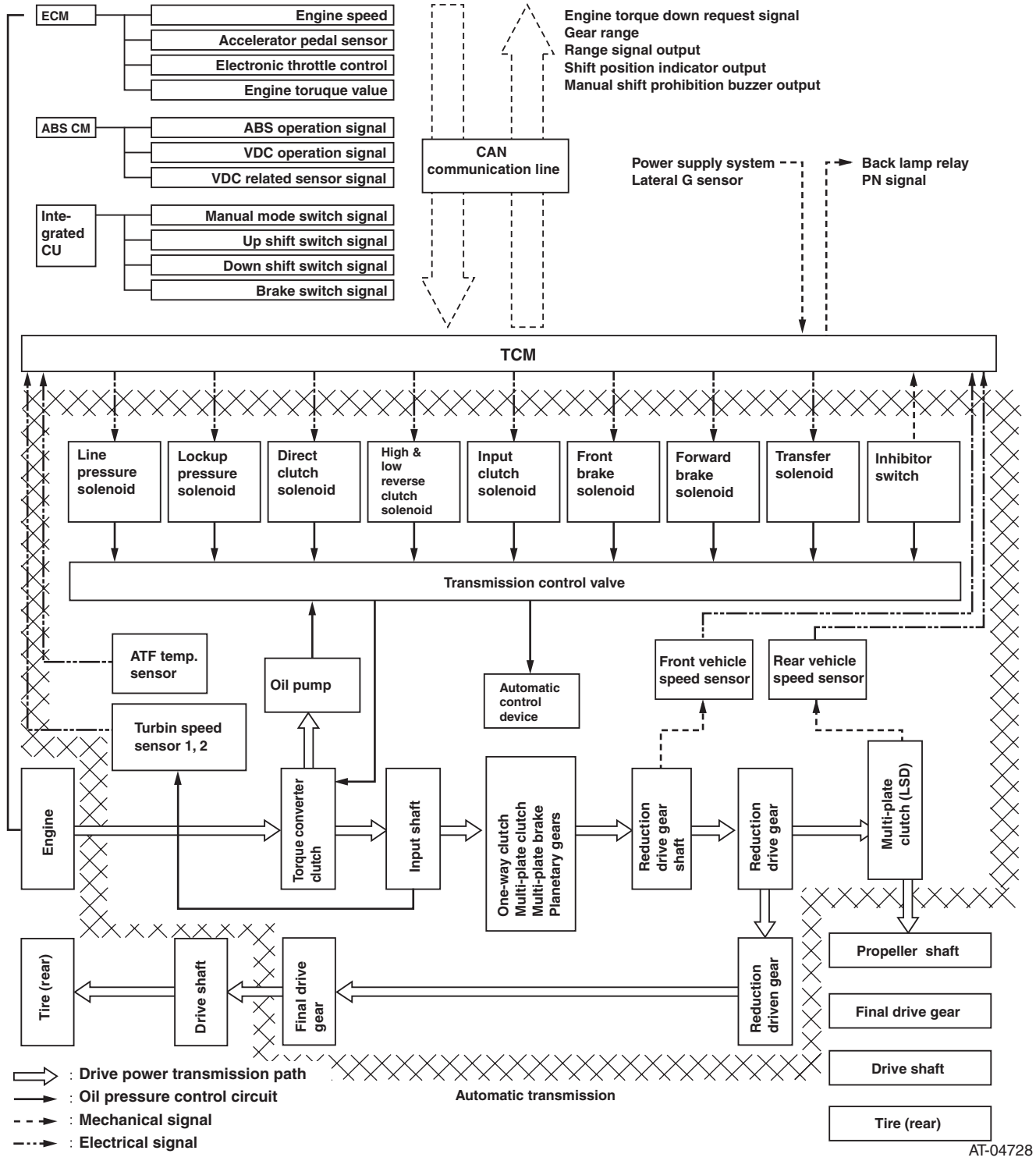
Control items		Control details
Shifting control	Normal shifting control	Accelerator position signal Engine torque signal Front vehicle speed signal Rear vehicle speed signal Turbine sensor 1 and 2 signal Range signal SI-DRIVE switch signal (models with SI-DRIVE) Manual mode switch signal (models with manual mode)
	Engine cooperation control	Front vehicle speed signal Rear vehicle speed signal Various engine information
	Control at high oil temperature	ATF oil temperature sensor signal
	Control at low ATF oil temperature or low water temperature	ATF oil temperature sensor signal Engine coolant temperature information
	Control during cruise control operation	Cruise control switch signal Cruise control SET signal

Control items			Control details
Shift pattern selection control	Adaptive control	Uphill control	Accelerator position signal Engine torque signal Front vehicle speed signal Rear vehicle speed signal Range signal Turbine sensor 1 and 2 signal SI-DRIVE switch signal (models with SI-DRIVE) Manual mode switch signal (models with manual mode)
		Control during sudden depression of accelerator pedal	Accelerator position signal Front vehicle speed signal Rear vehicle speed signal Range signal
		Control during sudden release of accelerator pedal	Accelerator position signal Front vehicle speed signal Rear vehicle speed signal Turbine sensor 1 and 2 signal Range signal SI-DRIVE switch signal (models with SI-DRIVE) Manual mode switch signal (models with manual mode)
		Control during braking	Accelerator position signal Front vehicle speed signal Rear vehicle speed signal Range signal Turbine sensor 1 and 2 signal Lateral G sensor signal Brake switch signal SI-DRIVE switch signal (models with SI-DRIVE) Manual mode switch signal (models with manual mode)
		Control during cornering	Accelerator position signal Front vehicle speed signal Rear vehicle speed signal Range signal Turbine sensor 1 and 2 signal Lateral G sensor signal SI-DRIVE switch signal (models with SI-DRIVE) Manual mode switch signal (models with manual mode)
	Manual mode control		Engine speed Front vehicle speed signal Rear vehicle speed signal Range signal Up shift switch signal Down shift switch signal SI-DRIVE switch signal (models with SI-DRIVE) Manual mode switch signal (models with manual mode)
	SI-DRIVE control (models with SI-DRIVE)		SI-DRIVE switch signal Accelerator position signal Engine speed Engine torque signal Front vehicle speed signal Rear vehicle speed signal Range signal

Control items		Control details
Shift pattern selection control	2nd hold control (in manual mode)	Front vehicle speed signal Rear vehicle speed signal Range signal SI-DRIVE switch signal (models with SI-DRIVE) Manual mode switch signal (models with manual mode)
	Semi SPORT shift control (models with paddle shift)	Engine speed Front vehicle speed signal Rear vehicle speed signal Range signal Up shift switch signal Down shift switch signal ATF oil temperature sensor signal Lateral G sensor signal SI-DRIVE switch signal (models with SI-DRIVE) Manual mode switch signal (models with manual mode)
Lock-up control	Lock-up control	Turbine sensor 1 and 2 signal Rear vehicle speed signal Front vehicle speed signal Engine speed Range signal ATF temperature signal SI-DRIVE switch signal (models with SI-DRIVE) Manual mode switch signal (models with manual mode)
	Slip lock-up control	Front vehicle speed signal Rear vehicle speed signal Range signal Engine speed Turbine sensor 1 and 2 signal ATF temperature signal SI-DRIVE switch signal (models with SI-DRIVE) Manual mode switch signal (models with manual mode)
Hydraulic control	Normal hydraulic control	Accelerator position signal Rear vehicle speed signal Front vehicle speed signal Engine speed Range signal ATF temperature signal
	Transmission shifting hydraulic control	Accelerator position signal Rear vehicle speed signal Front vehicle speed signal Engine speed Range signal ATF temperature signal

Control items			Control details
AWD center differential control	Normal transfer control	Torque sensitive control	Engine torque signal Front vehicle speed signal Rear vehicle speed signal ATF temperature signal Inhibitor switch signal
		Control for turning	Steering angle signal Front vehicle speed signal Rear vehicle speed signal
		Control for slip	Brake switch signal 4-wheel speed signal
	Cooperation control	Control during ABS operation	ABS operation signal
		Control during braking	Brake switch signal Front vehicle speed signal Rear vehicle speed signal
		Control during VDC and TCS operation	VDC and TCS operation signal Brake switch signal

C: SCHEMATIC DIAGRAM



AT-04728

D: SHIFTING CONTROL

1. NORMAL SHIFTING CONTROL

Based on the input signal information such as inhibitor switch, vehicle speed and accelerator pedal opening angle, TCM controls each solenoid and automatically shifts to an appropriate gear position according to the shift schedule.

2. ENGINE COOPERATION CONTROL

When shifting, TCM outputs torque down request signal. Receiving the signal, ECM retards the ignition timing of each cylinder to temporarily reduce the torque developed by the engine. In synchronization with this control, TCM constantly monitors the shifting status using the vehicle speed sensor and turbine sensor, and performs feedback control to obtain optimum shifting. This control enables smooth and comfortable shifting under any conditions.

3. CONTROL AT HIGH OIL TEMPERATURE

When ATF oil temperature is extremely high, the shift schedule is automatically changed so that temperature rise is minimized.

4. CONTROL AT LOW ATF OIL TEMPERATURE OR LOW ENGINE COOLANT TEMPERATURE

When ATF oil temperature or engine coolant temperature is extremely low, at engine start for example, the shift schedule is automatically changed to actively raise the oil temperature.

E: SHIFT PATTERN SELECTION

1. SI-DRIVE CONTROL

By changing the SI-DRIVE mode switch while driving in D range, shift control can be switched among three types according to each engine characteristics.

1. I mode

When I mode engine characteristics is employed, shifting is performed at the optimum point to realize low fuel consumption. Compared to S and S# mode, slip lock-up range and full lock-up range are expanded.

2. S mode

When S mode engine characteristics is employed, shifting characteristics is applied so that linear acceleration can be obtained and the acceleration is even in any vehicle speed range.

3. S# mode

When S# mode engine characteristics is employed, shift timing is intended for higher speed than that of S mode and is set so that full engine performance can be obtained to provide driving with great response. In addition, adaptive control is operated more actively compared to I mode or S mode to realize sportier driving performance.

2. MANUAL MODE CONTROL

By operating the manual mode switch to ON (tilting the shift lever to the left) in D range, the mode shifts to the manual mode and the combination meter indicates the current gear range and permission for upshift and downshift.

[+] operation of shift lever or paddle causes upshift and [–] operation causes downshift; and the shift is held in the selected gear range while driving.

- Upshift prohibition and auto downshift control

"▲" mark next to the SPORT indicator indicates permission for upshift, with which upshift occurs by each [+] operation. However, when the current vehicle speed is too low for higher gear range, "▲" mark lights off, prohibiting further upshift.

If the vehicle speed level becomes too low for the current gear range, the gear automatically shifts down to prevent engine stall. When the vehicle stops, the gear always downshifts to 1st except when the vehicle is in the 2nd hold control mode.

- Downshift prohibition control

"▼" mark next to the SPORT indicator indicates permission for downshift, with which downshift occurs by each [–] operation. However, when the current vehicle speed is too high for lower gear range, "▼" mark lights off, prohibiting further downshift. In this case, if downshift operation occurs, the alarm beeps to warn the driver.

When ATF oil temperature is extremely low, for instance, immediately after engine start in winter, upshift to 5th is prohibited to promote warm-up.

- Engine over speed preventive control

If the engine speed exceeds the specified level during acceleration in manual mode, the gear automatically shifts up to prevent engine over speed.

3. 2nd HOLD CONTROL (IN MANUAL MODE)

Starting vehicle with 2nd gear on slippery road surface has been enabled.

This condition continues unless

1) the manual mode is off,

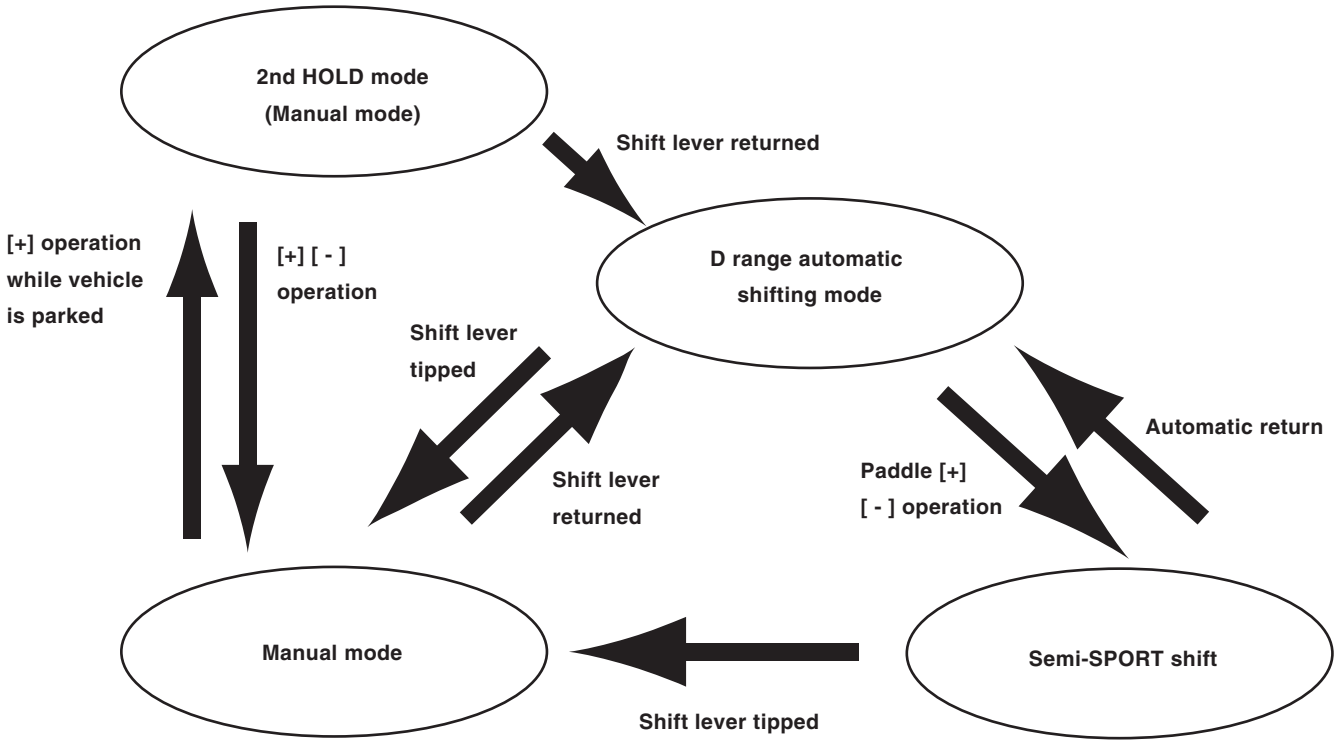
2) [+] or [–] switch is operated again, or

3) engine over speed preventive control is operated,

and 2nd gear is maintained while vehicle is stopped.

4. SEMI SPORT SHIFT CONTROL (MODELS WITH PADDLE SHIFT)

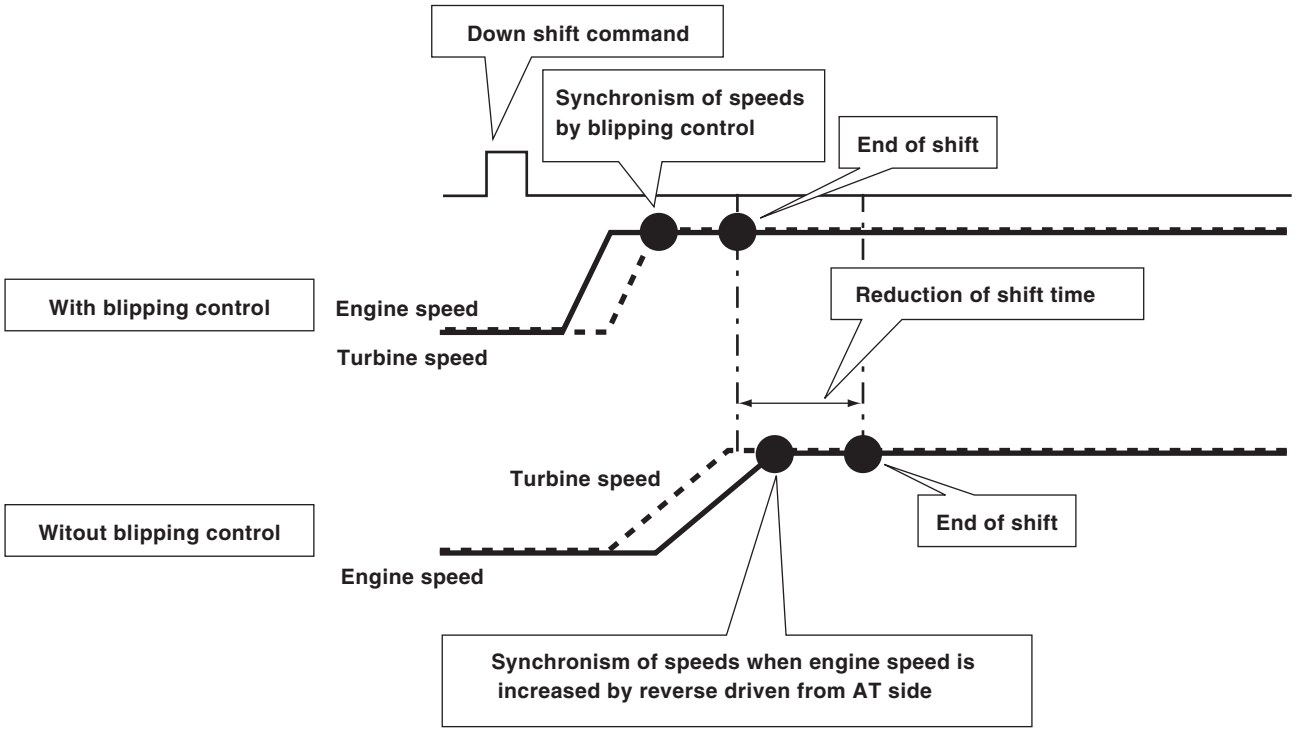
Operation of [+] and [–] switches on the paddle in D range can temporarily shift the mode to manual mode, enabling gear shifting with manual operation using paddles. This mode is cancelled under the specified conditions such as linear acceleration status, and the vehicle is automatically returns to D range automatic shifting mode. When ATF oil temperature is extremely high, the semi manual mode is prohibited.



AT-04729

5. BLIPPING CONTROL

Under the manual mode or semi SPORT shift mode control, if the gear is shifted down manually at a certain vehicle speed or higher with fully closed accelerator, engine speed automatically increases to be close to the level after shifting, which improves shifting response and shifting quality.

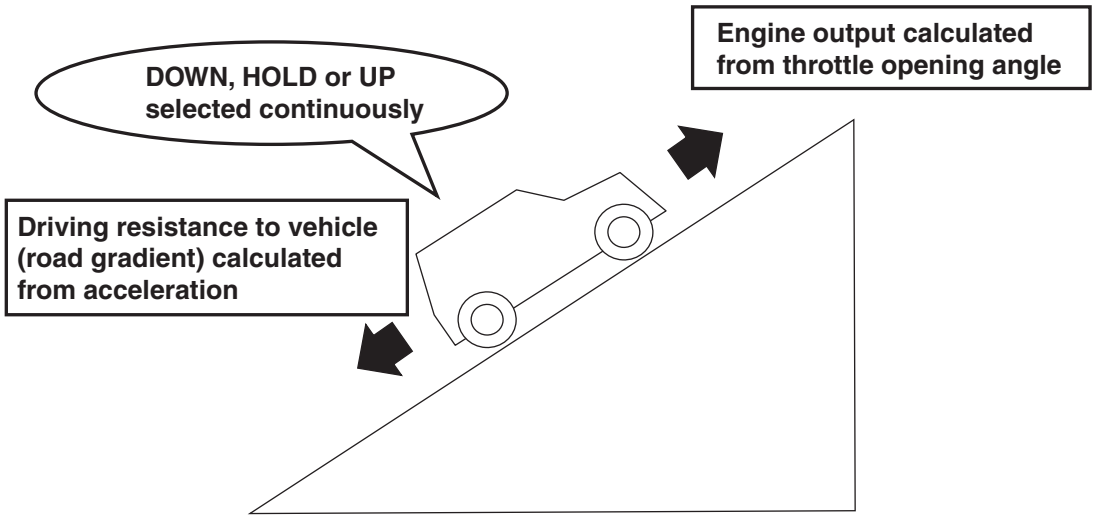


AT-04731

6. ADAPTIVE CONTROL

• Uphill/downhill control

Based on the vehicle speed and accelerator opening angle, excess driving force is judged from engine output and acceleration while the road gradient is estimated, in order to select optimum gear range as needed and reduce unnecessary shifting.



AT-04850

• Control during sudden release of accelerator pedal

When accelerator pedal is suddenly released, TCM judges the driver's intention for deceleration and temporarily prohibits shift-up to hold the current gear position in order to ensure engine brake operation.

• Control during braking

Operation frequency of this function in S# mode is higher than that in S mode.

The gear range is held (restraining upshift) or shifted down depending on the driving condition and braking force (deceleration), in order to ensure engine brake operation and driving force for re-acceleration.

• Control during cornering

Operation frequency of this function is as follows: S# > S > I.

Based on the cornering driving judgement from the driving condition and vehicle acceleration (longitudinal and lateral acceleration), unnecessary shift-up is restrained to ensure stable driving force and turning performance.

Control items	Mode	Supporting model
Control during sudden release of accelerator pedal	SI-DRIVE S# mode	Models with SI-DRIVE
	Normal mode	Models with manual mode
	Manual mode	Models with manual mode
Control during braking	SI-DRIVE S# mode	Models with SI-DRIVE
	Normal mode	Models with manual mode
	Manual mode	Models with manual mode
Control during cornering	All modes	Models with SI-DRIVE
		Models with manual mode

7. VARIOUS INDICATORS ILLUMINATION CONTROL

Illumination of indicators on the combination meter are controlled as shown below according to shift pattern change.

Condition	Display	
	Arrow mark	7-segment
P, R, N range	△ ▽	P, R, N
Normal D range	△ ▽	D
Manual mode Semi SPORT shift	▲ ▼	1 — 5
Engine oil high temperature & engine high speed key	△ ▽	—
At transmission failure	△ ▽	—

▲ and ▼ indicate illumination.
ATF high temperature is informed by illuminating "ATF TEMP".

F: LEARNING CONTROL

- Transmission shifting hydraulic learning control

Online learning control performance has been improved to absorb variation from vehicle to vehicle and quality aging and to ensure constant high shifting quality.
Learning occurs at each normal shifting under certain conditions, and learned values are saved in the flash ROM. The learned values are not deleted even if power is turned to OFF (even if the battery ground terminal is disconnected).

- Initial learning

The system in which measured data of predetermined driving operations for learning is set to TCM as the initial value is employed to assure high shifting quality from immediately after completion of vehicle. This system does not require the memory box that has been located on the control valve, contributing to cost reduction.

G: AWD CENTER DIFFERENTIAL CONTROL

Control overview
Connection of multi-plate clutch (LSD) of center differential is controlled according to torque input to the transfer.

1. NORMAL CONTROL

During normal driving, connecting force of multi-plate clutch (LSD) is determined from the calculation results of the following controls:

- Torque sensitive control

Calculates connecting force of LSD according to torque input to the transfer.

- Control for turning

Calculates reduction in connecting force of LSD based on the steering angle and vehicle speed.
This function improves turning performance within the specific vehicle speed range.

- Control for slip

When the front or rear tires begin to slip, calculates the increase in connecting force of LSD according to the amount and time of the slip.
This function maintains road contact, improving drivability.

2. COOPERATION CONTROL

In this control, connecting force of LSD is determined in prior to normal control.
A. Control during ABS operation
During ABS operation, adjusts connecting force of LSD to the specified level. This function improves ABS control.
B. Control during braking
Adjusts connecting force of LSD to the specified level while the brake switch is ON with the throttle valve fully closed. This function improves stability during braking.
C. Control during VDC and TCS operation
During VDC and TCS operation, adjusts connecting force of LSD to the specified level. This function improves VDC and TCS control.
The priority is as follows: A > B > C.

16.On-board Diagnostic System

A: FUNCTION

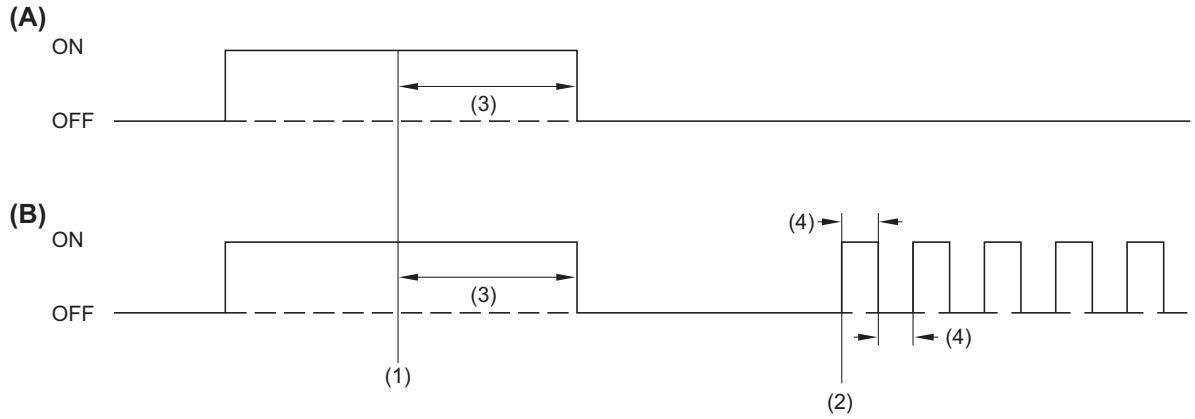
• The on-board diagnostic system detects malfunction and generates and displays the codes corresponding to the location of each malfunction. The malfunction indicator light (AT OIL TEMP light) on the combination meter blinks to indicate occurrence of a failure or error.
• If the malfunction indicator light lights up as a result of TCM detecting a malfunction, the diagnostic trouble code (DTC) corresponding to the malfunction is stored in TCM.
• When checking DTC on the models supporting OBD-II, it is required to connect Subaru Select Monitor (SSM) to data link connector.
• To facilitate each function and failure diagnosis, a diagnostic system that supports SSM is used.
• The on-board diagnostic system detects electrical failures or system errors as shown below.

Front brake oil pressure switch	Front and rear wheel speed sensor
Input clutch oil pressure switch	Turbine speed sensor 1 and 2
Forward brake oil pressure switch	Brake signal
Direct clutch oil pressure switch	ATF temperature sensor
High & low reverse clutch oil pressure switch	Lateral G sensor
Line pressure solenoid (circuit)	CAN communication system
Transfer solenoid (circuit)	SPORT shift mode switch
Lock-up solenoid (circuit, function)	Range switch system
Front brake solenoid (circuit, function)	Back lamp relay output circuit
Input clutch solenoid (circuit, function)	PN signal output circuit
Forward brake solenoid (circuit, function)	Reverse inhibitor circuit
Direct clutch solenoid (circuit, function)	1, 2, 3, 4, 5, R gear ratio
High & low reverse clutch solenoid (circuit, function)	

If a malfunction is detected, the system notifies the malfunction by blinking the AT OIL TEMP light.

B: OPERATION OF AT OIL TEMP LIGHT

At engine start, the AT OIL TEMP light illuminates to prove out and then turns off, as shown in "Normal operation" in the figure below. If some malfunction has occurred, the light keeps blinking as shown in "Abnormal operation" in the figure below.



AT-02194

(A) Normal operation
(B) Abnormal operation
(1) Engine start
(2) Malfunction detected
(3) 2 seconds
(4) 0.25 seconds

17.Fail-safe Function

A: SENSOR FAILURE

If a failure is detected on either or both of turbine speed sensor 1 and 2 installed on the transmission, the gear is fixed in 4th to ensure minimum drivability.

B: FRONT SUN GEAR OVER-SPEED FAILURE

If an over-speed failure is detected on the front sun gear in the transmission, the gear is shifted to neutral and the vehicle stops. Then the gear is fixed in 2nd from vehicle start.

C: SOLENOID ELECTRICAL FAILURE

If the solenoid status is fixed to constantly energized or de-energized status due to an electrical failure, the gear is shifted depending on the failed solenoid and its status, and then the gear range is fixed. The table below shows the relation of faulty parts and fixed gear range.

Faulty part	Failure status	Gear range at failure occurrence	Fail-safe gear range
Front brake	Constantly energized	3rd or lower	3rd
		4th	N → 3rd
		5th	Temp 5th → 3rd
	Constantly de-energized	4th or lower	4th
		5th	N → 4th
Input clutch	Constantly energized	3rd or lower	3rd
		4th or upper	N → 3rd
	Constantly de-energized	4th or lower	4th
		5th	N → 4th
High & low reverse clutch	Constantly energized	2nd or lower	2nd
		3rd or upper	N → 2nd
	Constantly de-energized	4th or lower	4th
		5th	N → 4th
Direct clutch	Constantly energized	All	5th
	Constantly de-energized	4th or lower	4th
		5th	N → 4th
Forward brake	Constantly energized	2nd or lower	2nd
		3rd or upper	N → 2nd
	Constantly de-energized	4th or lower	4th
		5th	N → 4th

NOTE:
- "→" indicates the gear range after vehicle stop.
- "Temp 5th" refers to keeping 5th until vehicle stop.

D: HYDRAULIC FUNCTIONAL FAILURE

When a hydraulic functional failure is detected, the gear is shifted depending on the relation of faulty part and gear position at failure detection in order to ensure minimum drivability. The table below shows the relation of faulty parts and fixed gear range.

		Gear position at failure detection				
		1st	2nd	3rd	4th	5th
Faulty part	Front brake	1	N → 1	N → 1	N → 1	N → 1
	Input clutch	4	4	4	N → 1	N → 1
	High & low reverse clutch	1	N → 1	N → 1	N → 1	N → 1
	Direct clutch	2	N → 1	N → 1	N → 1	N → 4
	Forward brake	4	3	N → 2	N → 2	N → 2

NOTE:
"→" indicates the gear range after vehicle stop.

E: RANGE SW ERROR

When a range SW error is detected, the gear is shifted to any of 1st, 3rd and 5th depending on the gear range before failure. If ignition is turned to OFF while a range SW error is detected, hydraulic control is electrically set to neutral after engine start until a range is selected.

F: LINE PRESSURE SOLENOID ERROR

When the line pressure solenoid has an error, the solenoid is turned to OFF to maximize the line pressure. Otherwise, normal control is performed.

G: LOCK-UP SOLENOID ERROR

When the lock-up solenoid has an error, the lock-up solenoid is constantly set to OFF (lock-up released).

H: TRANSFER CLUTCH SOLENOID ERROR

When a solenoid ON/OFF error is detected, the transfer solenoid is constantly set to OFF (LSD released).

I: CAN COMMUNICATION ERROR

When CAN communication has an error, the data received by CAN is fixed to the specified value to perform shifting control and to ensure minimum drivability.

18.Transmission Mount

A: GENERAL

Same mechanism as the existing model.