13.Transmission Control Module (TCM)

The TCM receives various sensor signals and determines the running conditions of the vehicle. It then sends control signals to each solenoid according to the preset gearshift characteristic data, lockup operation data, and transfer clutch torque data (duty ratios).

A: CONTROL SYSTEM

1. MPT MODELS

Control items		Input signals
Shifting control	Ordinary shift control	Throttle position sensor Rear vehicle speed sensor Front vehicle speed sensor Engine speed rpm Inhibitor switch
	ABS-in-operation control	ABS signal Throttle position sensor Rear vehicle speed sensor Front vehicle speed sensor Brake switch
	Hydraulic oil temperature control	ATF temperature sensor
	Reverse inhibition control	Throttle position sensor Rear vehicle speed sensor Front vehicle speed sensor Inhibitor switch
	Shift pattern (Base/Power) select control	Throttle position sensor Rear vehicle speed sensor Front vehicle speed sensor Inhibitor switch
	Hold control	Inhibitor switch
	Grade control	Throttle position sensor Rear vehicle speed sensor Front vehicle speed sensor Brake switch Inhibitor switch Engine speed Intake manifold pressure
Lockup control	Ordinary lockup control	Throttle position sensor Rear vehicle speed sensor Front vehicle speed sensor Engine speed Inhibitor switch
	Smooth control	Throttle position sensor
	Hydraulic oil temperature control	ATF temperature sensor

Control items		Input signals
Oil pressure control	Ordinary pressure control	Throttle position sensor Rear vehicle speed sensor Front vehicle speed sensor Engine speed Inhibitor switch ATF temperature sensor
	Shifting control	Throttle position sensor Rear vehicle speed sensor Front vehicle speed sensor Engine speed Torque converter turbine speed sensor Inhibitor switch ATF temperature sensor
	Starting control	Engine speed ATF temperature sensor Inhibitor switch
	Learning control	Shift solenoid 1 Shift solenoid 2 Rear vehicle speed sensor Front vehicle speed sensor Throttle position sensor Torque converter turbine speed sensor ATF temperature sensor
AWD transfer clutch control	Ordinary transfer control	Throttle position sensor Rear vehicle speed sensor Front vehicle speed sensor Inhibitor switch ATF temperature sensor FWD switch
	1 range control	Throttle position sensor Rear vehicle speed sensor Front vehicle speed sensor Inhibitor switch
	Slip detection control	Throttle position sensor Rear vehicle speed sensor Front vehicle speed sensor
	Steering control	Throttle position sensor Rear vehicle speed sensor Front vehicle speed sensor
	ABS-in-operation control	ABS signal Rear vehicle speed sensor Front vehicle speed sensor Brake switch

2. VTD MODELS

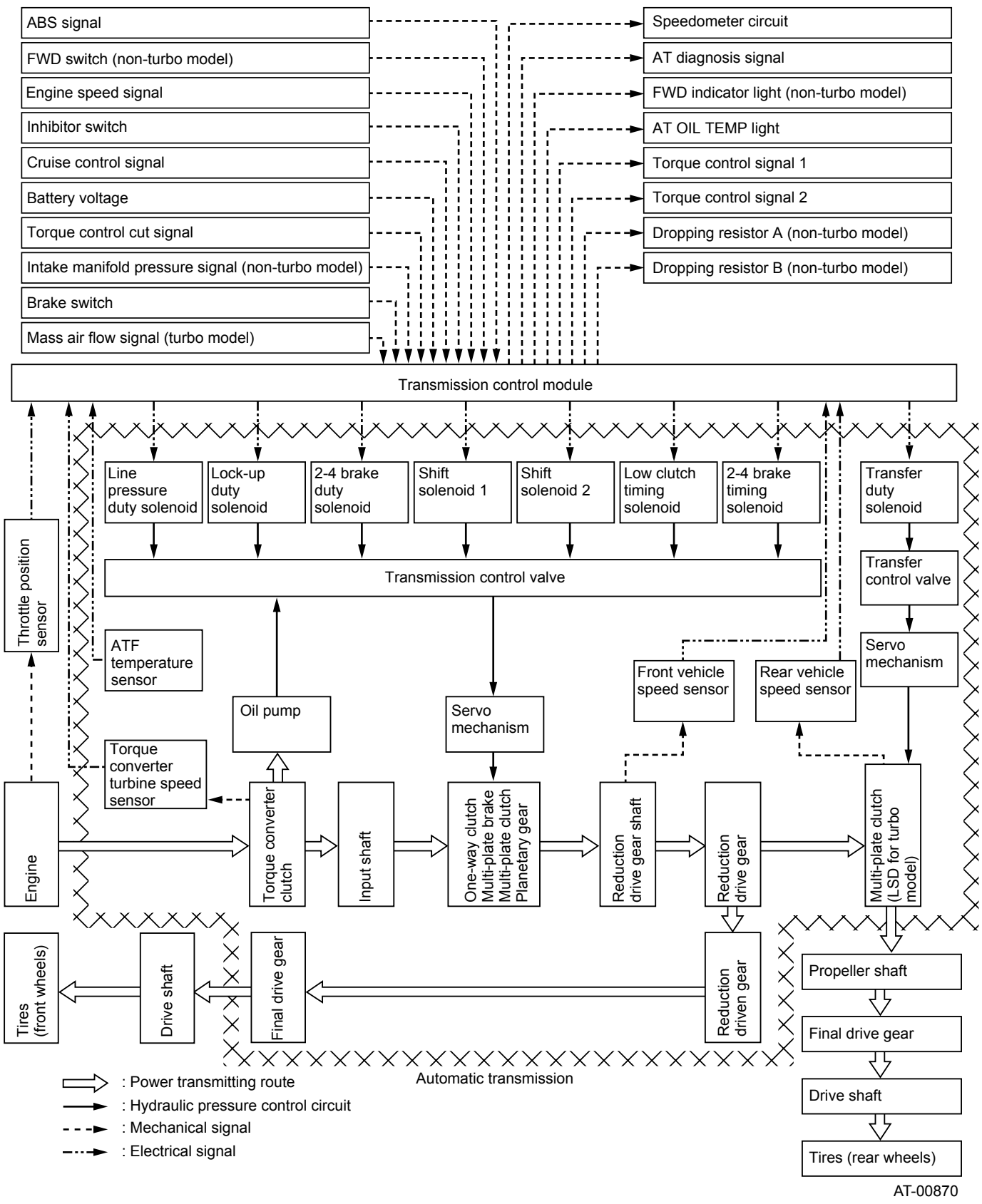
Control items		Input signals
Shifting control	Ordinary shift control	Throttle position sensor Rear vehicle speed sensor Front vehicle speed sensor Engine speed Inhibitor switch
	ABS-in-operation control	ABS signal Throttle position sensor Rear vehicle speed sensor Front vehicle speed sensor Brake switch
	Hydraulic oil temperature control	ATF temperature sensor
	Reverse inhibition control	Throttle position sensor Rear vehicle speed sensor Front vehicle speed sensor Inhibitor switch
	Shift pattern (Base/Power) select control	Throttle position sensor Rear vehicle speed sensor Front vehicle speed sensor Inhibitor switch
	Grade control	Throttle position sensor Rear vehicle speed sensor Front vehicle speed sensor Brake switch Inhibitor switch Engine speed Mass air flow
Lockup control	Ordinary lockup control	Throttle position sensor Rear vehicle speed sensor Front vehicle speed sensor Engine speed Inhibitor switch
	Smooth control	Throttle position sensor
	Hydraulic oil temperature control	ATF temperature sensor

Control items		Input signals
Oil pressure control	Ordinary pressure control	Throttle position sensor Rear vehicle speed sensor Front vehicle speed sensor Engine speed Inhibitor switch ATF temperature sensor
	Shifting control	Throttle position sensor Rear vehicle speed sensor Front vehicle speed sensor Engine speed Torque converter turbine speed sensor Inhibitor switch ATF temperature sensor
	Starting control	Engine speed ATF temperature sensor Inhibitor switch
	Learning control	Shift solenoid 1 Shift solenoid 2 Rear vehicle speed sensor Front vehicle speed sensor Throttle position sensor Torque converter turbine speed sensor ATF temperature sensor
AWD multi-plate clutch (LSD) control	Ordinary transfer control	Throttle position sensor Rear vehicle speed sensor Front vehicle speed sensor Inhibitor switch ATF temperature sensor
	1 range control	Throttle position sensor Rear vehicle speed sensor Front vehicle speed sensor Inhibitor switch
	Slip detection control	Throttle position sensor Rear vehicle speed sensor Front vehicle speed sensor
	Steering control	Throttle position sensor Rear vehicle speed sensor Front vehicle speed sensor
	ABS-in-operation control	ABS signal Rear vehicle speed sensor Front vehicle speed sensor Brake switch
	Base brake control	Throttle position sensor Front vehicle speed sensor Brake switch

B: SCHEMATIC DIAGRAMS

1. SOHC MODELS

TRANSMISSION CONTROL MODULE (TCM)



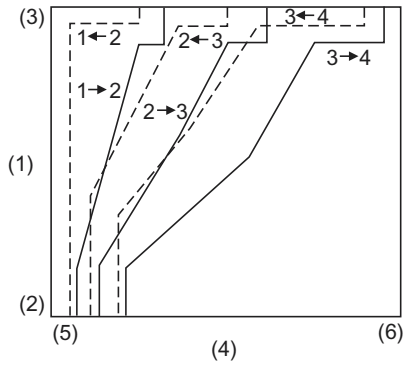
AT-00870

C: SHIFTING CONTROL

The TCM performs gear shifting control according to driving conditions by using the shift point characteristic data stored in its memory. Appropriate solenoids are operated at the proper timing corresponding to the shift pattern, throttle position, and vehicle speed for smooth shifting.

NOTE:
When the ATF temperature is below approximately 10 °C (50 °F), the gear cannot be shifted to the 4th speed.

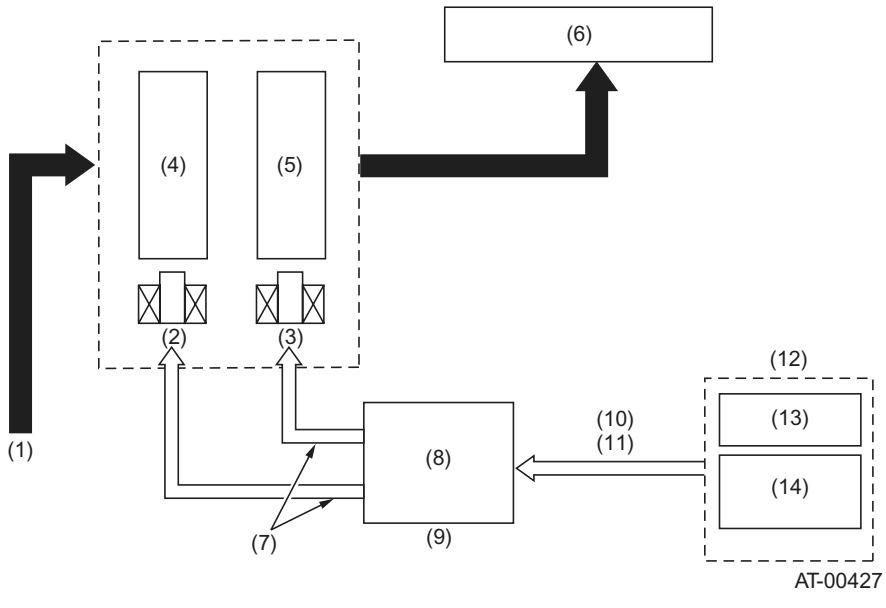
	Solenoid 1	Solenoid 2
1st speed	ON	ON
2nd speed	OFF	ON
3rd speed	OFF	OFF
4th speed	ON	OFF



AT-00426

(1) Throttle opening
(2) Small
(3) Large
(4) Vehicle speed
(5) Low
(6) High

- The TCM activates both solenoids 1 and 2 in response to throttle and vehicle speed signals.
- Shift valves move in response to operation of the solenoids, supplying or interrupting the line pressure to each clutch.
- A shift to each gear takes place according to ON-OFF operation of both the solenoids as indicated in the table above.



(1) ATF
(2) Solenoid 1
(3) Solenoid 2
(4) Shift valve A
(5) Shift valve B
(6) Shift clutch
(7) Shift command signal
(8) TCM
(9) Determination of optimum gear position (including selection of shift pattern)
(10) Throttle opening
(11) Vehicle speed
(12) Sensor
(13) Vehicle speed sensor
(14) Throttle position sensor

D: LOCKUP CONTROL

● The TCM has pre-programmed lockup clutch engagement and disengagement conditions for each gear and shift pattern. The engagement and disengagement conditions are defined in terms of the throttle valve position and vehicle speed.

● The TCM controls the operation of the lockup clutch by means of the duty solenoid which in turn controls the lockup control valve as described below:

1. NON-LOCKUP OPERATION

The duty solenoid allows the pilot pressure (supplied from the pilot valve) to be applied to the “disengaging” end of the lockup control valve spool.The lockup control valve then opens the clutch disengaging circuit port to allow the lockup operating pressure (torque converter clutch regular pressure) to build up in the circuit. On the other hand, the valve opens the clutch engaging circuit’s port and allows the fluid in the circuit to flow to the ATF cooler, thus lowering the pressure in the circuit. As a result, the lockup clutch is disengaged due to difference in pressure between both circuits.

This operation is performed for all the speed gears except the 4th gear of the D range.

2. LOCKUP OPERATION

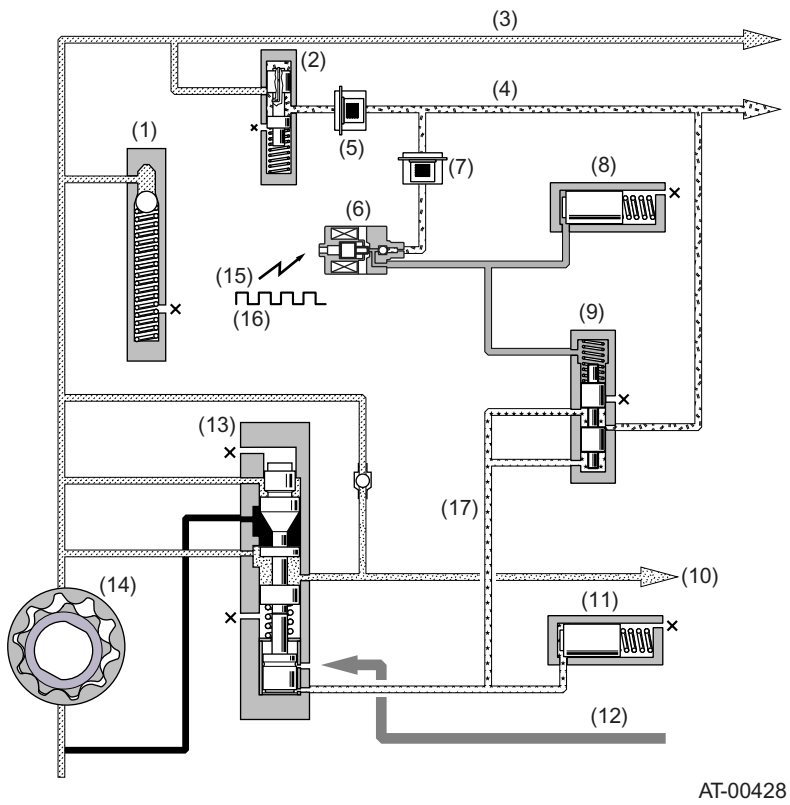
The duty solenoid allows the pilot pressure to be applied to the “engaging” end of the lockup control valve spool.The lockup control valve then opens the clutch engaging circuit’s port that communicates to the torque converter’s impeller chamber, allowing high pressure fluid to flow to the lockup clutch. The clutch then engages.

● The TCM controls the current to the duty solenoid by gradually changing the current. As a result, the lockup control valve also moves gradually, so the clutch engagement pressure increases smoothly. This causes the lockup clutch to become initially in a half-engaged state and then in a fully engaged state, thus preventing shock during engagement.

This operation is performed for all the speed gears.

E: LINE-PRESSURE CONTROL

- The oil pump delivery pressure (line pressure) is regulated to a constant pressure by the pilot valve. This pressure is used as the pilot pressure for controlling spool valves.
- The pilot pressure applied to the pressure modifier valve is modulated into pressure modifier pressure at the line pressure duty solenoid by activating the pressure modifier valve.
- The pressure modifier valve is an auxiliary valve for the pressure regulator valve, and it creates a signal pressure (pressure modifier pressure). The pressure modifier pressure is used to regulate the line pressure to a level optimum for a particular driving condition.
- This pressure modifier pressure is applied to the pressure regulator valve which controls the oil pump delivery pressure.
- The pressure modifier pressure from the pressure modifier valve is cushioned by the pressure modifier accumulator to remove pulsation of the pressure.



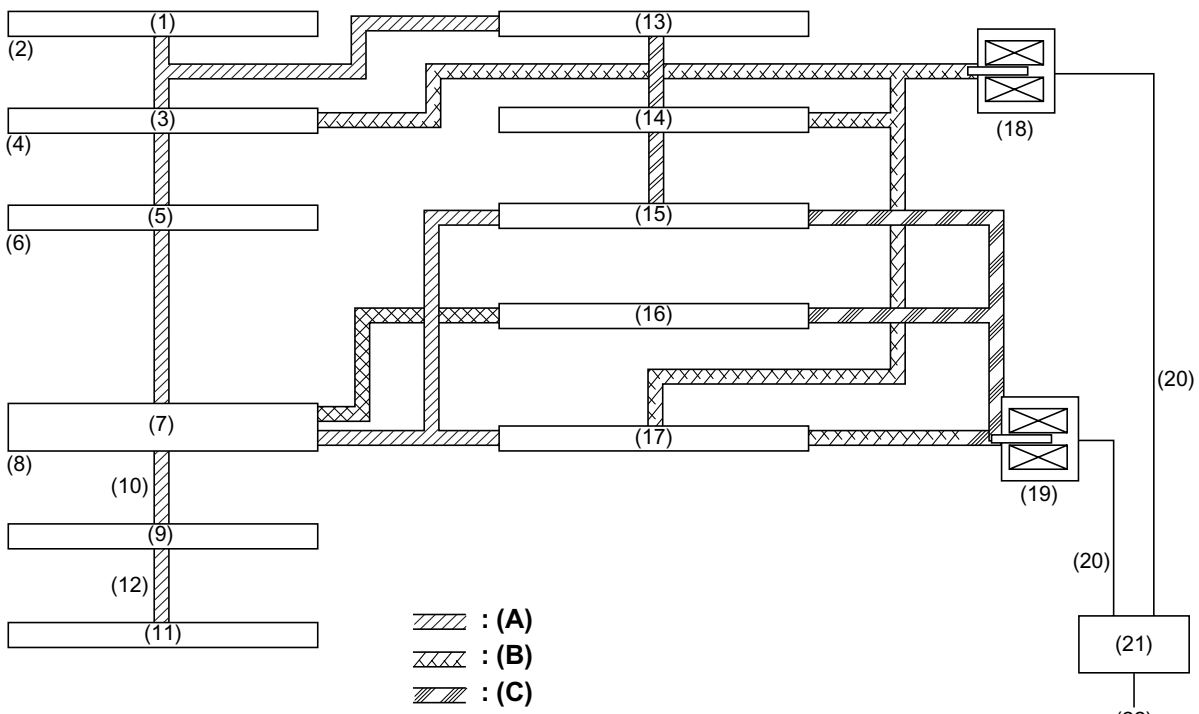
AT-00428

(1) Relief valve
(2) Pilot valve
(3) Line pressure
(4) Pilot pressure
(5) Filter
(6) Line pressure duty solenoid
(7) Filter
(8) Accumulator
(9) Pressure modifier valve
(10) To ATF cooler circuit
(11) Pressure modifier accumulator
(12) From R range pressure circuit
(13) Pressure regulator valve
(14) Oil pump
(15) ON
(16) OFF
(17) Pressure modifier pressure

F: LINE-PRESSURE CONTROL DURING SHIFTING

The line pressure which engages shift clutches to create 1st to 4th speeds is controlled by the TCM to meet varying operating conditions.

During gear shifting, the TCM decreases the line pressure to a level that matches the selected gear in order to minimize shifting shock loads.



(1) Shift clutch
(2) Transient oil pressure to operate clutches
(3) Shift valve
(4) Shift select valve
(5) Manual valve
(6) Manual shift valve operated through selector lever
(7) Pressure regulator valve
(8) Line pressure optimally regulated for clutch operation
(9) Oil pump
(10) Line pressure built up by oil pump
(11) Oil pan
(12) Suction
(13) Low clutch accumulator
(14) Low clutch timing valve A
(15) Accumulator control valve A
(16) Pressure modifier valve
(17) Pilot valve
(18) Shift solenoids 1 and 2
(19) Line pressure duty solenoid
(20) Output signals
(21) TCM
(22) Throttle position, accelerator pedal depressing speed, etc.

(A) Line pressure
(B) Pilot pressure
(C) Line pressure duty pressure
(D) Modifier pressure
(E) Accumulator control

During gear shifting, the TCM controls the line pressure as follows:

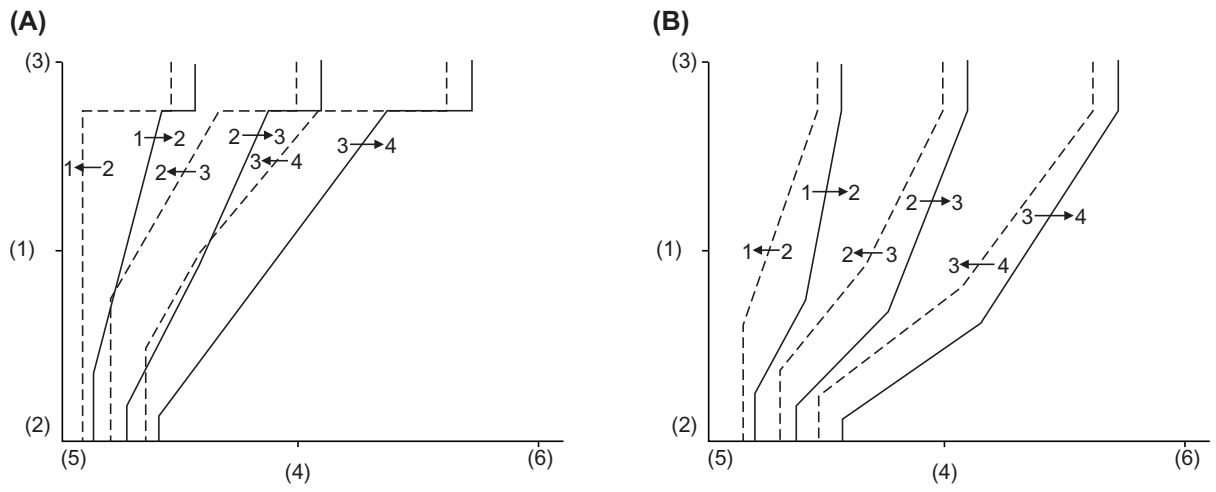
- The TCM receives signals such as throttle position signal and accelerator pedal speed signal. Based on these input signals, it issues a control signal to the line pressure duty solenoid.
- The pressure from the line pressure duty solenoid (line pressure duty pressure) is converted by the pressure modifier valve into a modifier pressure, and the modifier pressure is applied to the pressure regulator valve.
- The pressure regulator valve adjusts the oil-pump-generated line pressure according to the modifier pressure to make the line pressure matched to the driving condition.

G: SHIFT PATTERN SELECTION CONTROL

The TCM changes its gear shift control pattern automatically between the Base pattern suitable for ordinary economy driving and the Power pattern suitable for climbing uphill or rapid acceleration.

In the Power pattern, the downshift point and upshift point are set higher than those of the Base pattern.

Selector lever position	Changeover from Base to Power pattern
D and 3 ranges	Performed automatically according to accelerator pedal depression speed.



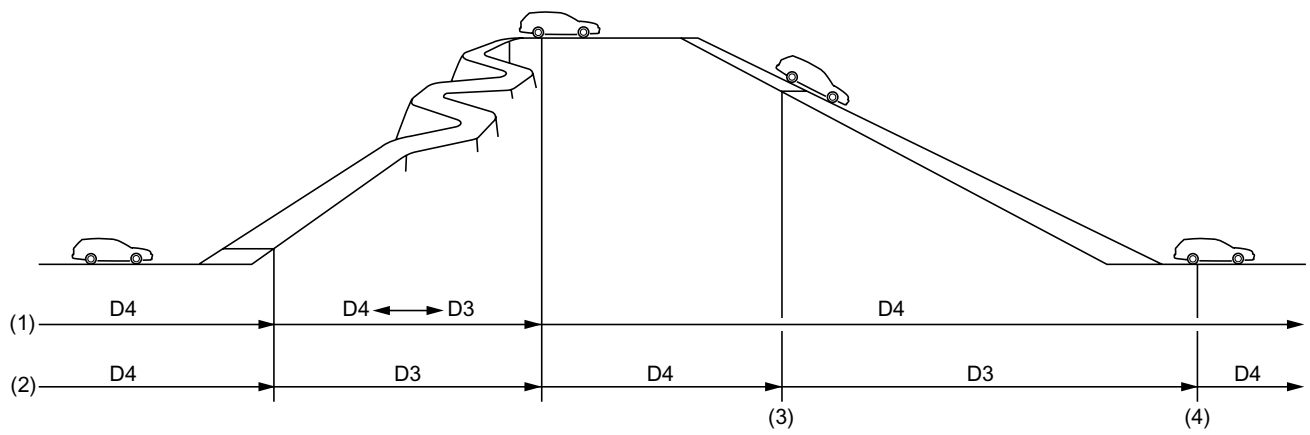
AT-00430

(A) D range (Base pattern)
(1) Throttle opening
(2) Small
(3) Large

(B) D range (Power pattern)
(4) Vehicle speed
(5) Low
(6) High

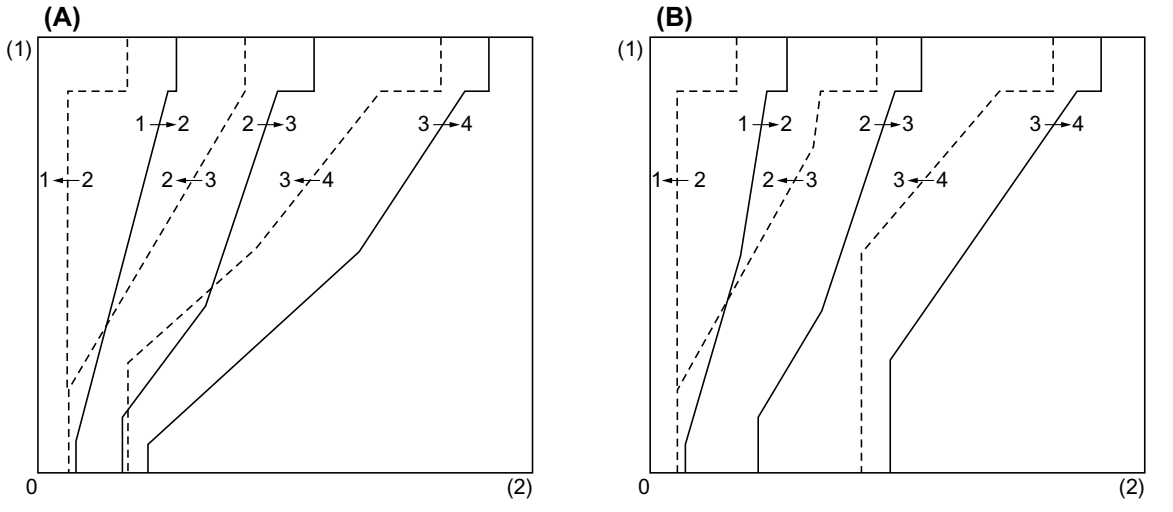
H: GRADE CONTROL

While the vehicle is driving up a hill, the gear is fixed to the 3rd to avoid repeated gear shift between the 3rd and 4th gears.
When the vehicle is descending a steep slope at a speed of approximately 80 km/h (50 MPH), a 4th to 3rd downshift occurs automatically when the brake pedal is depressed. This gearshift control is cancelled when the accelerator pedal is depressed.
The TCM performs these controls based mainly on the throttle opening, engine speed and vehicle speed.



AT-00431

(1) Without grade control
(2) With grade control
(3) Brake pedal ON
(4) Re-acceleration



AT-00432

(A) D range (Base pattern)
(1) Throttle opening

(B) D range (grade control pattern)
(2) Vehicle speed

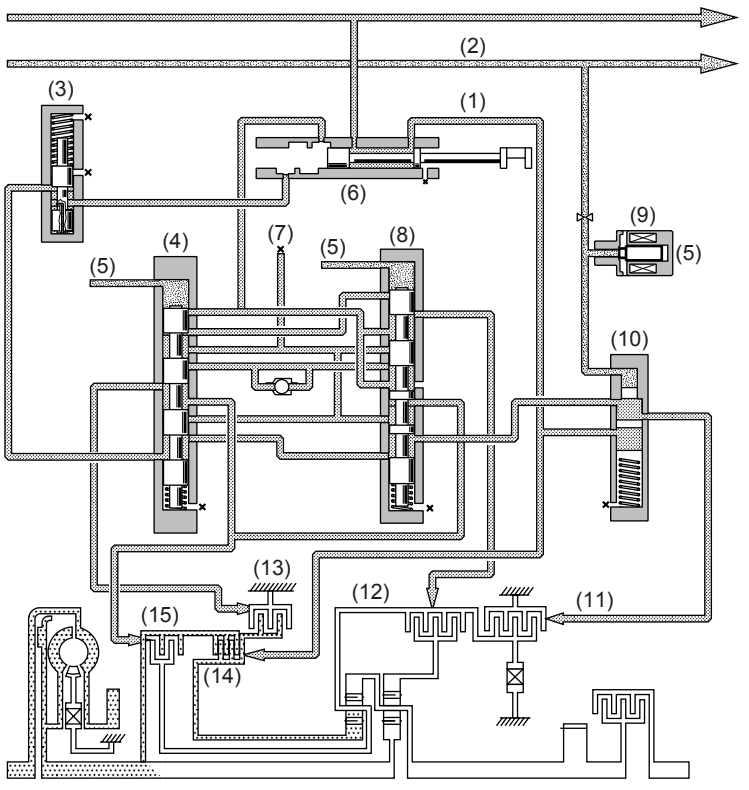
I: LEARNING CONTROL

The TCM has a learning control function with which it can adapt gear shift timing optimally to the current vehicle conditions by updating correction factors in the memory.
For this reason, gear shift shock may become larger after the power supply is interrupted (disconnection of battery, flat battery, etc.) or immediately after the ATF is replaced.
Larger gear shift shock after power supply interruption occurs because the correction data is reset to those for the new vehicle condition.
The TCM starts learning function again as soon as the power supply is restored. After driving for a while, therefore, the transmission will become able to make gear shifts at the optimum timing. Larger shift shock immediately after ATF change is caused by change in friction characteristics of the transmission internal parts. Also in this case, the transmission recovers shock-less gear shifting after driving for a while.

J: REVERSE INHIBITION CONTROL

This control prevents the transmission from shifting into the reverse gear when the select lever is accidentally placed in the R position, thus protecting the components such as reverse clutch from being damaged.

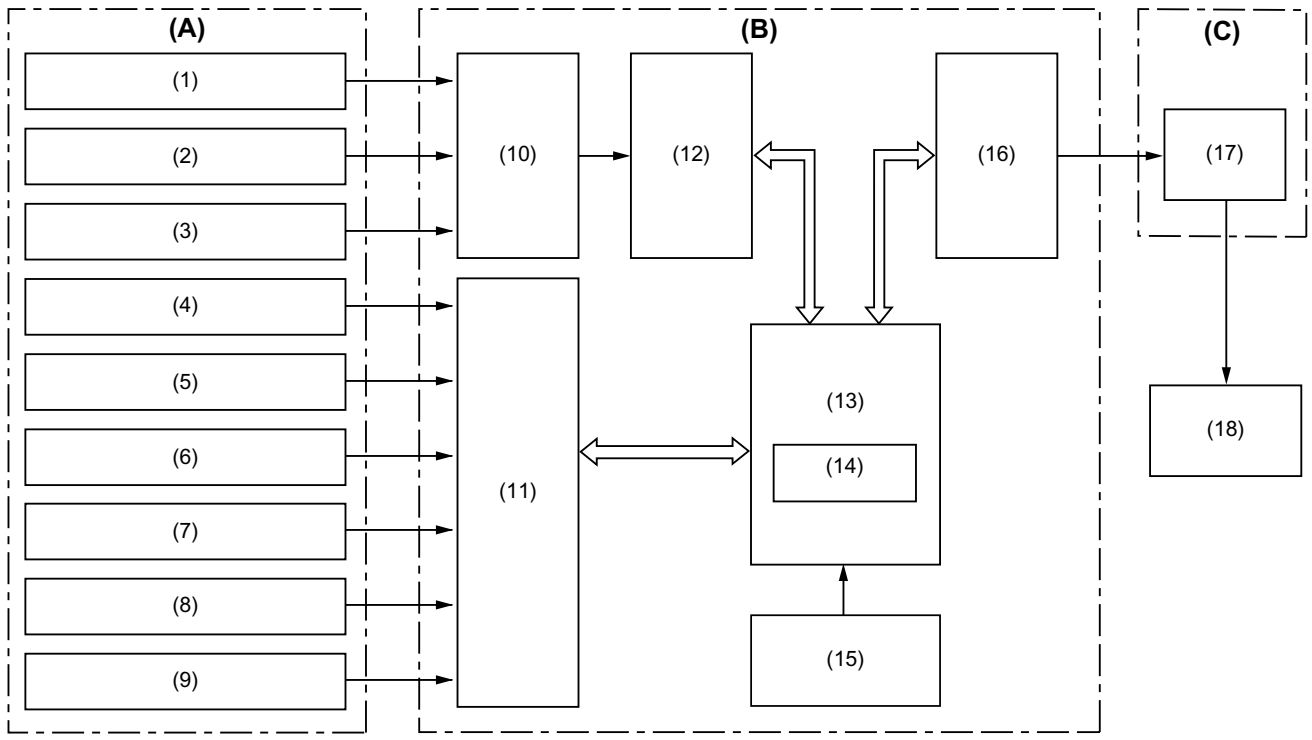
If the selector lever is moved to the R position during driving at a speed faster than the predetermined speed, the low clutch timing solenoid is energized. Then, the pilot pressure is supplied to the reverse inhibitor valve. This causes the reverse inhibitor valve to move downward, closing the low & reverse brake port.
In this condition, the low & reverse brake does not engage since the ATF flowing from the manual valve is blocked by the reverse inhibitor valve.
As a result, the transmission is put into the neutral state, and the shifting into the reverse gear is inhibited.



AT-00433

(1) Line pressure
(2) Pilot pressure
(3) 1st reducing valve
(4) Shift valve A
(5) ON
(6) Manual valve (P range)
(7) Drain
(8) Shift valve B
(9) Low-clutch timing solenoid
(10) Reverse inhibitor valve
(11) Low & reverse brake (released)
(12) Low clutch
(13) 2-4 brake
(14) Reverse clutch
(15) High clutch

K: AWD TRANSFER CLUTCH CONTROL (MPT MODELS)



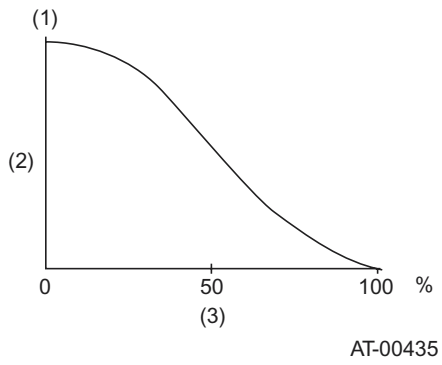
AT-00434

(A) Sensor
(1) Battery voltage
(2) Throttle position sensor
(3) ATF temperature sensor
(4) Rear vehicle speed sensor (rear wheel rpm)
(5) Front vehicle speed sensor (front wheel rpm)
(6) Inhibitor switch

(B) TCM
(7) FWD switch
(8) Brake switch
(9) ABS signal
(10) Input interface circuit
(11) Input interface circuit
(12) A/D converter

(C) Actuator
(13) CPU
(14) Memory
(15) Constant voltage power source
(16) Output interface circuit
(17) Transfer duty solenoid
(18) Transfer clutch

1. BASIC CONTROL

Type of control	Regulates transfer clutch pressure in response to throttle position and vehicle speed.
Gear position	1st thru 4th and reverse
Remarks	 AT-00435 (1) Ordinary control (2) Transfer clutch capacity (3) Duty-ratio

2. 1 RANGE CONTROL

Type of control	Increases transfer clutch pressure above basic control pressure
Gear position	1st speed
Remarks	—

3. SLIP CONTROL

Type of control	Increases transfer clutch pressure to the same level as in the 1 range immediately after a slip is detected.
Gear position	1st thru 4th and reverse
Remarks	Release: The transfer clutch pressure is lowered when a turn under turning control is detected while running faster than the set vehicle speed with fully closed throttle.

4. TURNING CONTROL

Type of control	Decreases transfer clutch pressure upon detection of a turn.
Gear position	1st thru 4th and reverse
Remarks	—

5. ABS CONTROL

Type of control	Regulates to the specified transfer clutch pressure quickly when the ABS signal is input.
Gear position	1st thru 4th and reverse
Remarks	—

6. P AND N RANGE CONTROL

Type of control	Regulates to the specified transfer clutch pressure immediately after a P or N range signal is input.
Gear position	P and N
Remarks	—

L: AWD CENTER DIFFERENTIAL CONTROL (VTD MODELS)

1. CONTROL DESCRIPTION

The TCM controls the engagement of the center differential's multi-plate clutch (LSD) using maps that are pre-programmed based on the throttle opening and torque converter turbine speed. It selects a map according to driving conditions and use it as the control basis.

2. FLOW CONTROL

The torque input to the multi-plate clutch is calculated according to various factors such as intake manifold pressure, torque converter turbine speed and selected speed gear. Based on the calculation result, the basic coupling force of the clutch is determined.

3. START CONTROL

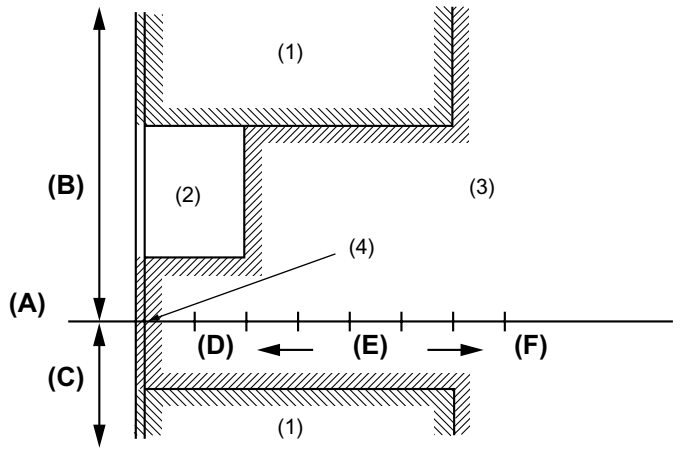
When the vehicle speed is 0 km/h (0 MPH), the TCM makes control to generate differential action limiting torque that is proportional to the throttle angle.
This enables the vehicle to start smoothly without swerving even on a slippery road.

4. TURNING CONTROL

The TCM makes a correction such that the engaging force of the multi-plate clutch is reduced as the steering angle increases.
This function is performed to improves turning performance at certain vehicle speed range.

5. SLIP CONTROL

When front or rear wheels start slipping with the vehicle running slower than the predetermined speed, the TCM makes control to increase the differential action limiting torque.
This function maintains traction and improves driving stability.



AT-00737

(A) Front and rear wheel speed ratio
(B) Front wheel slip
(C) Rear wheel slip
(D) Low
(E) Vehicle speed
(F) High

(1) Slip control
(2) Turning control
(3) Flow control
(4) Start control

6. ABS CONTROL

When the TCM receives an ABS operation signal from the ABS unit, it adjusts the differential action limiting torque to the predetermined level and selects the gear appropriate for the vehicle speed in which the one-way clutch freewheels.
This function improves ABS control.

7. BASE BRAKE CONTROL

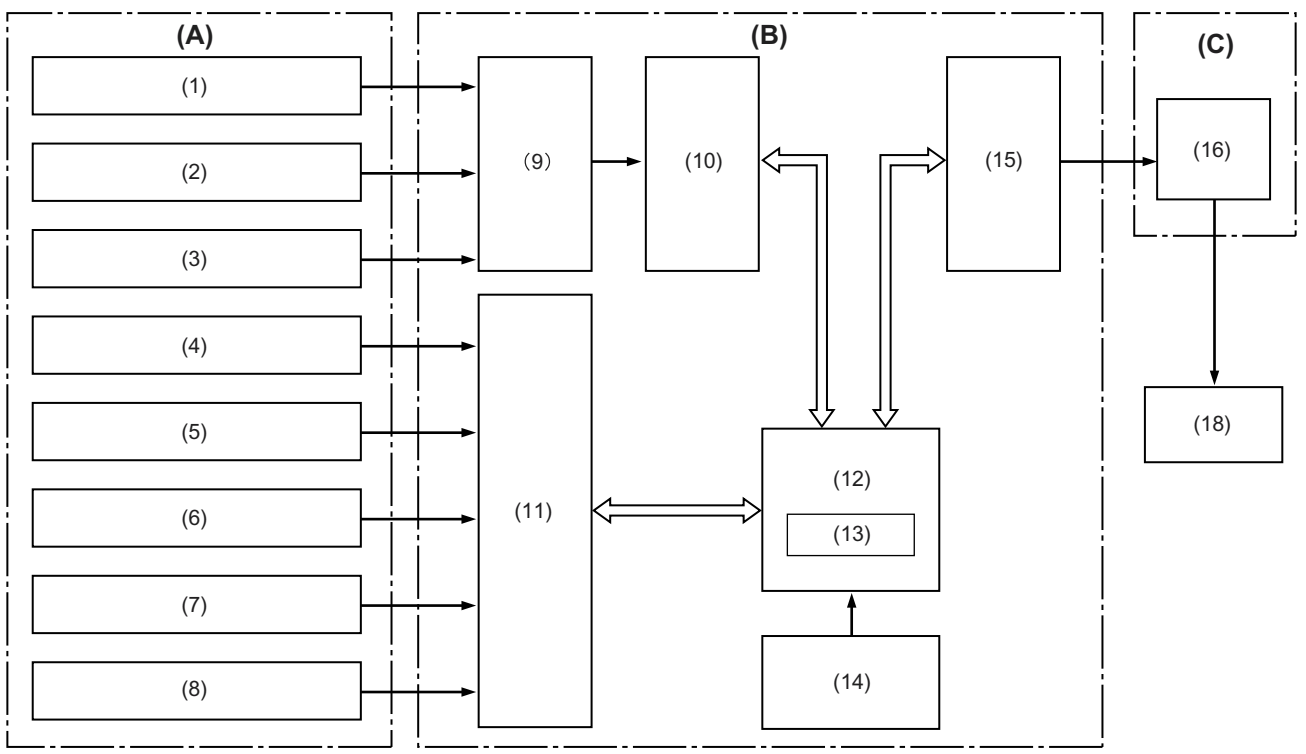
When the brake switch is ON and the throttle valve is fully closed, the TCM makes control to decrease the differential action limiting torque. The ABS control has priority over this control.
This function improves stability during braking.

8. 1 RANGE CONTROL

When the 1 range is selected, the TCM makes control to increase the differential action limiting torque.
This function improves driving performance and traction.

9. CONTROL SYSTEM

The TCM constantly monitors the driving conditions of the vehicle using the eight input signals. Based on the conditions it has determined, the TCM adjusts the duty ratio of current to the transfer duty solenoid thus changing the engagement of the multi-plate clutch. The input signals are used also for automatic transmission control.



AT-01250

(A) Sensor
(1) Power supply
(2) Throttle sensor
(3) ATF temperature sensor
(4) Rear vehicle speed sensor (rear wheel rpm)
(5) Front vehicle speed sensor (front wheel rpm)
(6) Inhibitor switch
(7) Brake switch
(8) ABS signal

(B) TCM
(9) Input interface circuit
(10) A/D converter
(11) CPU
(12) Memory
(13) Constant voltage power source
(15) Output interface circuit

(C) Actuator
(16) Transfer duty solenoid
(17) Multi-plate clutch (LSD)

M: TRANSFER CONTROL

1. MPT MODELS

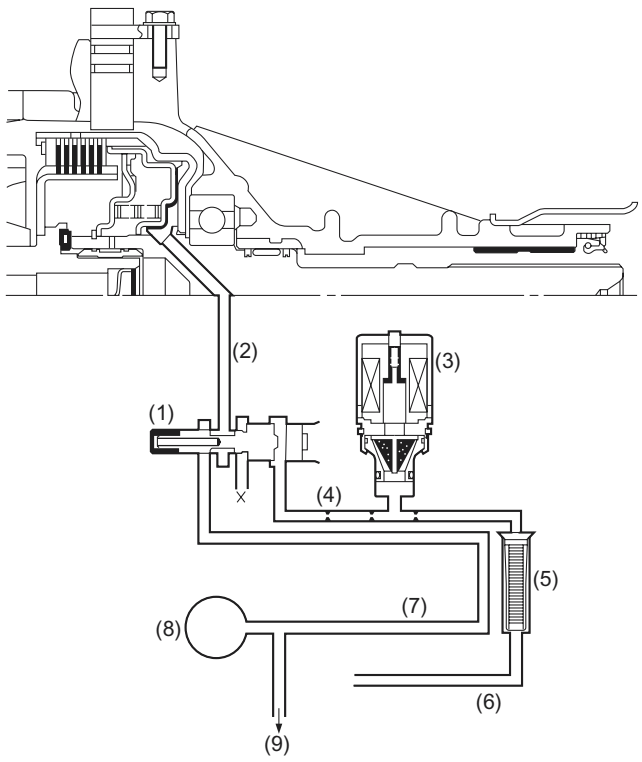
The transfer hydraulic pressure control unit includes a valve body attached to the side of the extension case through a gasket and separator plate.

The pressurized fluids for the transfer hydraulic pressure control (line pressure and pilot pressure) are supplied from the oil pump by way of the passages formed in the transmission case and then the passages in the extension case that lead to the hydraulic circuit in the transfer valve body.

The line pressure is regulated by the transfer control valve whose opening is controlled by the transfer pressure created by the transfer duty solenoid.

- The transfer duty solenoid is controlled by the TCM. The TCM changes the solenoid controlling duty ratio according to driving conditions.
- The transfer duty solenoid creates the transfer pressure from the pilot pressure. The transfer pressure is applied to the transfer control valve and adjusts the valve's opening.
- The line pressure directly led to the transfer control valve, on the other hand, is regulated by the transfer control valve and becomes the transfer clutch pressure.
- The transfer clutch pressure is applied to the transfer clutch and engages the clutch to a controlled degree.

In this way, the degree of transfer clutch engagement is varied so that optimum torque is distributed to the rear wheels according to vehicle driving conditions.



AT-00436

(1) Transfer control valve
(2) Transfer clutch pressure
(3) Transfer duty solenoid
(4) Transfer pressure
(5) Filter
(6) Pilot pressure
(7) Line pressure
(8) Oil pump
(9) Control valve

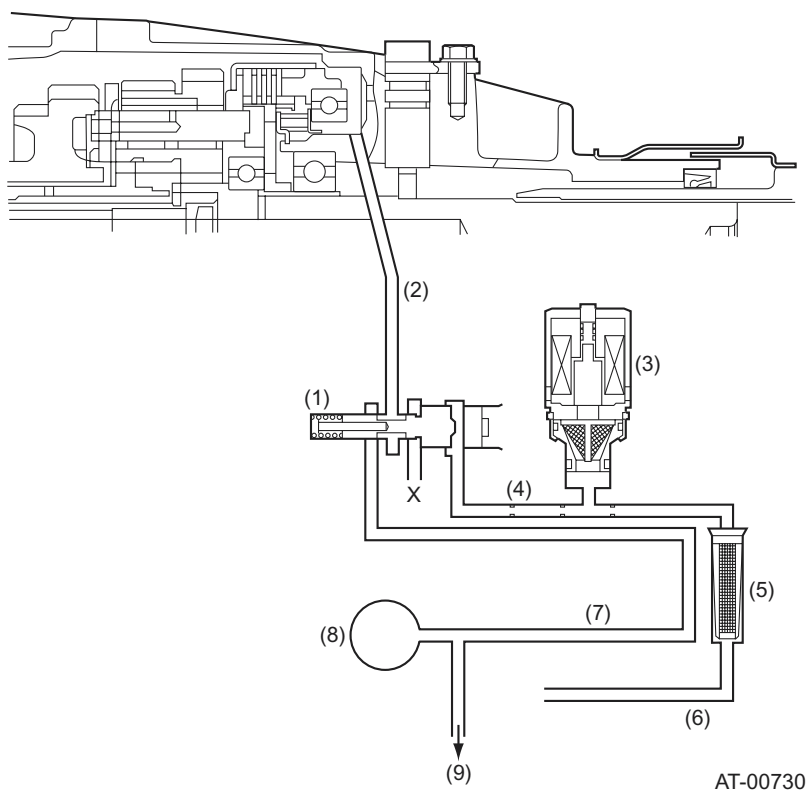
2. VTD MODELS

The drive power distribution system includes a valve body attached to the side of the extension case through a gasket and separator plate.
The pressurized fluids for the drive power distribution system (line pressure and pilot pressure) are supplied from the oil pump by way of the passages formed in the transmission case and then the passages in the extension case that lead to the hydraulic circuit in the transfer valve body.

The line pressure is regulated by the transfer control valve whose opening is controlled by the transfer pressure created by the transfer duty solenoid.

- The pilot pressure created by passing through the pilot valve in the transmission's hydraulic control assembly is further regulated into the transfer pressure by the transfer duty solenoid.
- The transfer duty solenoid is controlled by the TCM. The TCM changes the solenoid controlling duty ratio according to driving conditions.
- The transfer pressure thus created is applied to the transfer control valve and adjusts the valve's opening.
- The line pressure directly led to the transfer control valve, on the other hand, is regulated by the transfer control valve and becomes the transfer clutch pressure.
- The transfer clutch pressure is applied to the multi-plate clutch (LSD) and engages the clutch to a controlled degree.

In this way, the degree of multi-plate clutch engagement is varied so that optimum torque is distributed to the rear wheels.



(1) Transfer control valve
(2) Transfer clutch pressure
(3) Transfer duty solenoid
(4) Transfer pressure
(5) Filter
(6) Pilot pressure
(7) Line pressure
(8) Oil pump
(9) Control valve