

Transmissions

This publication is intended for instructional purposes only. Always refer to the appropriate Jaguar Service publication for specific details and procedures.

 **WARNING: WHILE SERVICING AND TESTING VEHICLES AND VEHICLE SYSTEMS, TAKE ALL NECESSARY SAFETY PRECAUTIONS TO PREVENT THE POSSIBILITY OF BODILY INJURY OR DEATH.**

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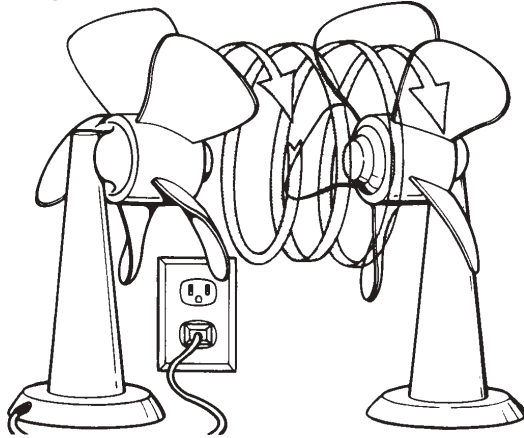
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Torque Converter

The torque converter is the linking component that transmits the power from the engine to the transmission. Except for the locking clutch in some applications, there is no direct mechanical connection via the torque converter between the engine and the transmission.

FLUID COUPLING



T200/1.01

Fluid coupling

The operating principle of the torque converter can be demonstrated with two fans facing each other. One fan is operating under power; the other fan is at rest. When the air flow from the first fan strikes the blades of the second fan, the second fan will turn. Thus, power has been transferred from the first fan to the second fan. Torque converters use this same process with fluid flow replacing the air flow.

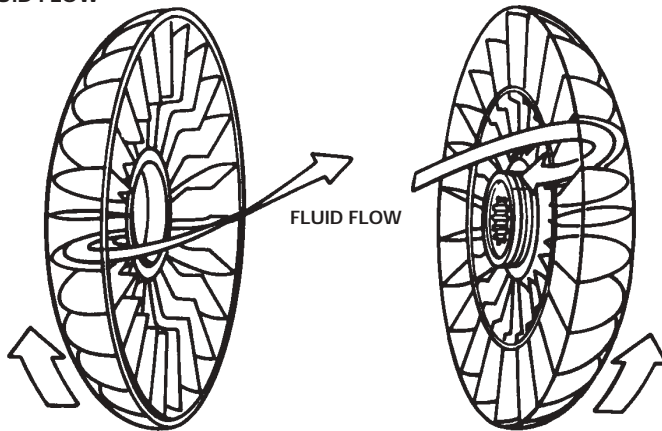
Fluid flow

The inner shape of the torque converter resembles two doughnut halves with their inner surfaces lined with vanes and filled with automatic transmission fluid. The drive member is called the pump impeller and is in turn driven by the engine. The driven member is called the turbine and in turn drives the transmission input shaft. As the torque converter rotates, its shape gives acceleration to the fluid.

Power flow

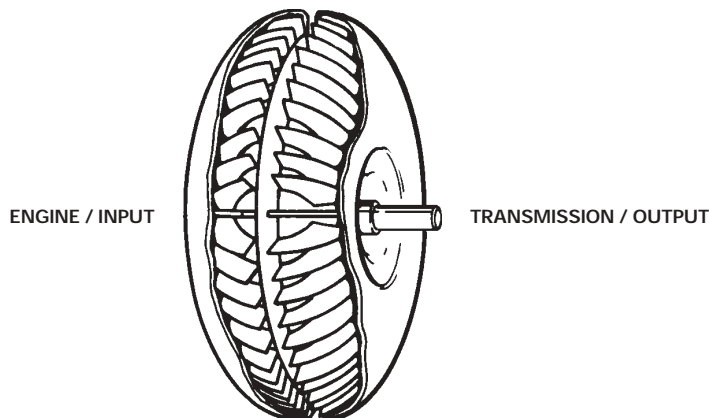
The rotating unit transmits power from the engine to the transmission as the whirling fluid flows continuously from the pump impeller to the turbine and back to the pump.

FLUID FLOW



T200/1.02

INPUT / OUTPUT



T200/1.03

Pump impeller

The torque converter cover is bolted to the engine flex plate and is welded to the converter pump impeller to form the outer housing. When turned by the engine, the pump impeller causes the fluid to flow toward the turbine.

Turbine

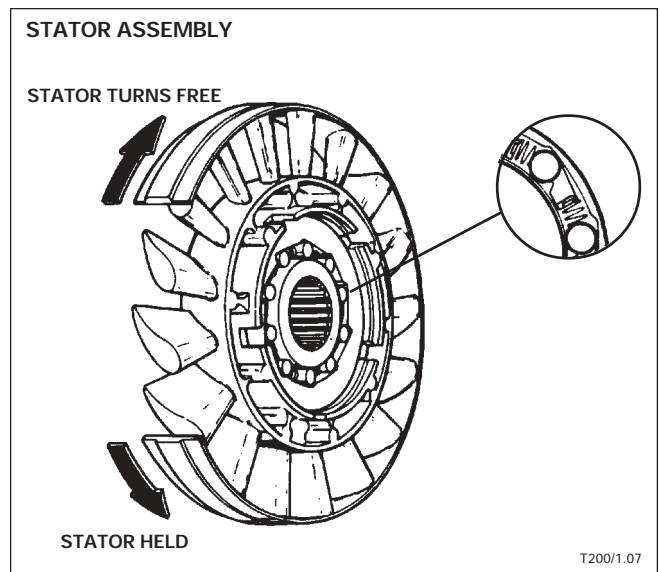
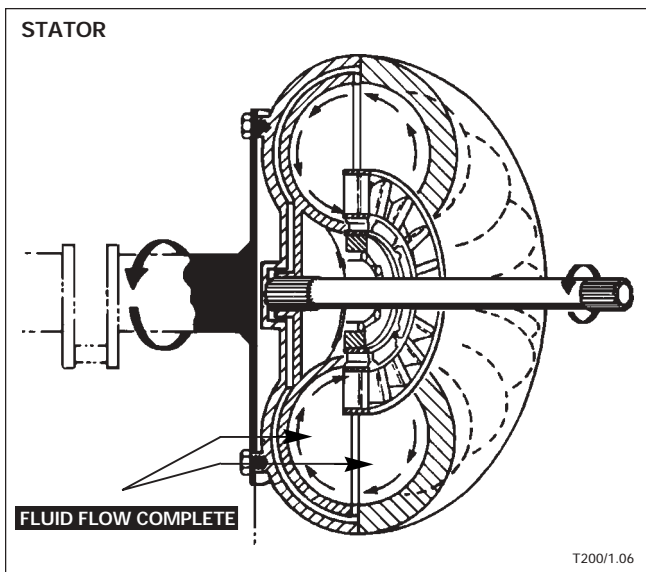
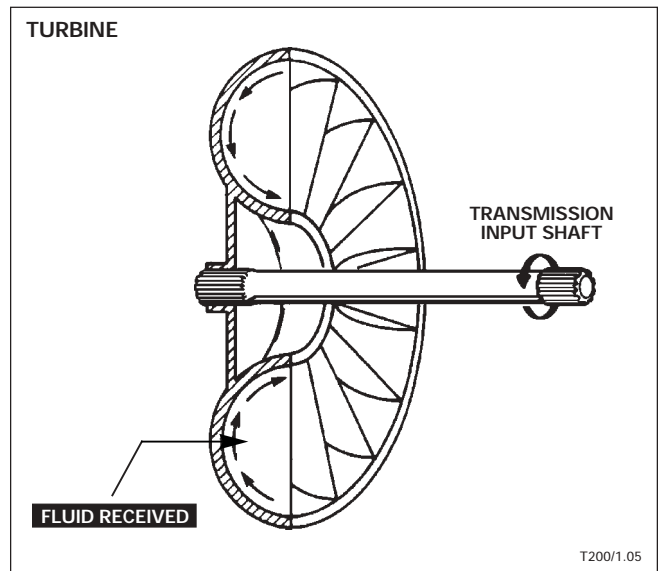
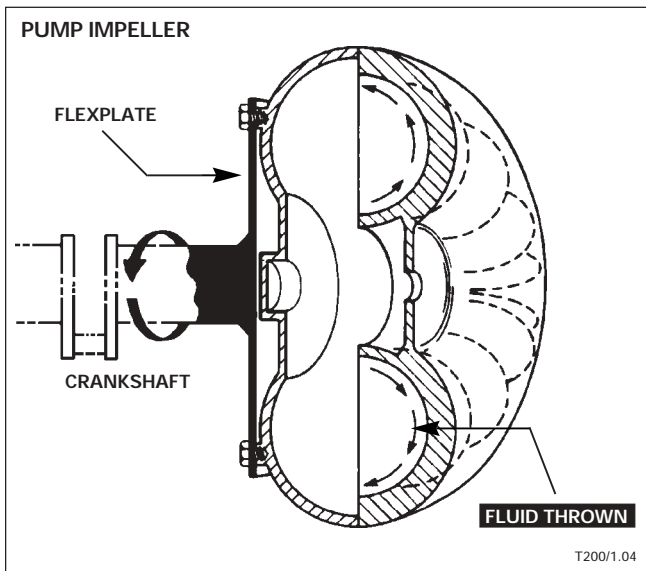
The turbine is connected to the transmission input shaft. When fluid flowing from the pump impeller enters the turbine, the turbine rotates and drives the transmission input shaft.

Stator

A stator is placed between the pump impeller and the turbine to redirect the oil to the pump impeller during torque multiplication.

Stator assembly

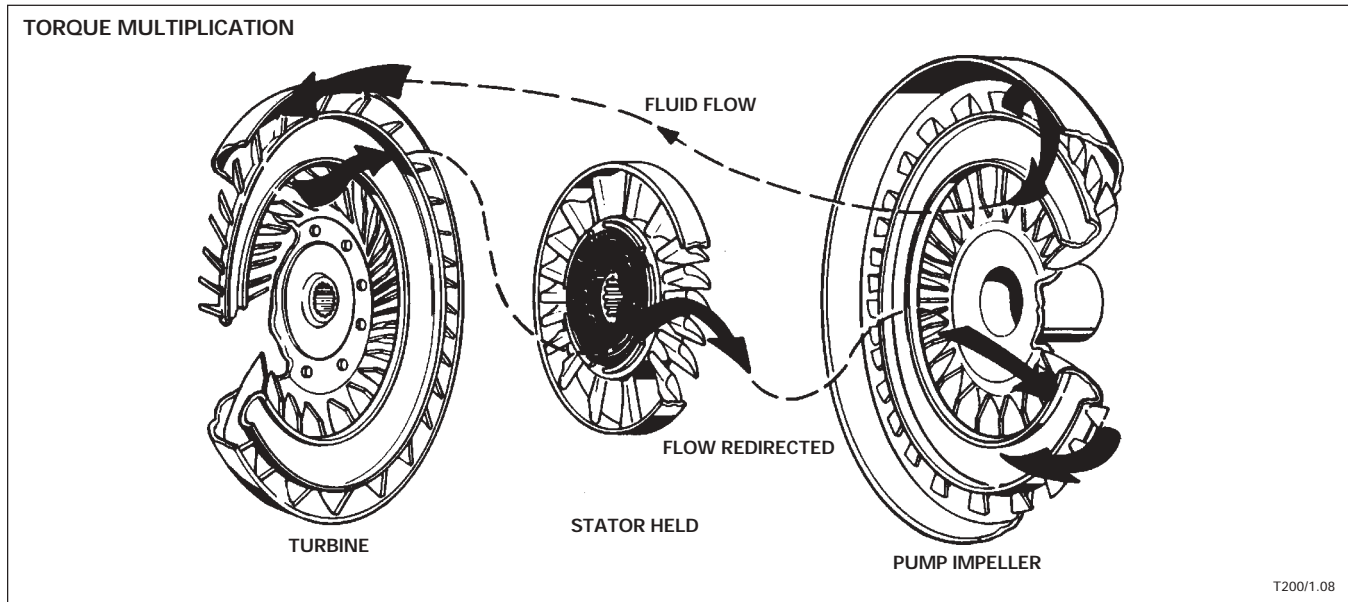
The stator assembly incorporates directing vanes and a one-way roller clutch.



Torque Converter (continued)

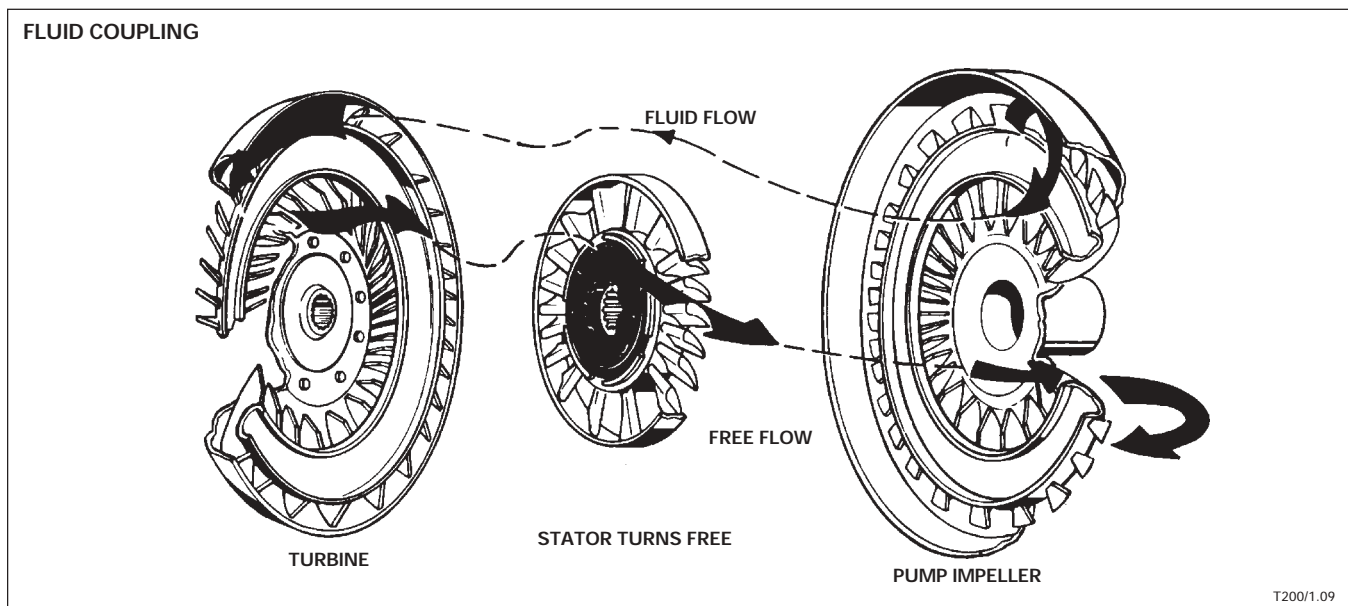
Torque multiplication

As the vehicle starts off and accelerates, the stator is held by the one-way clutch and redirects the fluid from the turbine to the pump impeller. By redirecting the oil, the stator increases the force of the fluid driving the turbine thereby multiplying the engine output torque. While the stator is held, the engine torque can be multiplied by two times or more. The stator holds as long as the vehicle accelerates.



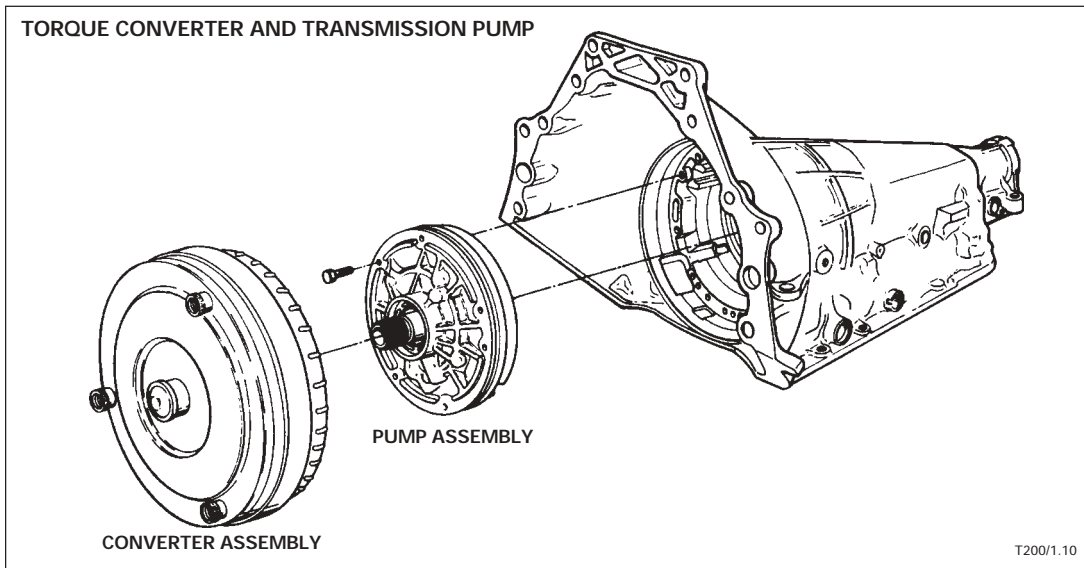
Fluid coupling

As acceleration ends and cruise speed is maintained, the pump impeller and turbine speeds equal, the stator releases and rotates freely with the pump impeller and the turbine. The speed of the stator is about the same as the other components. If the accelerator is applied to the point where the pump impeller speed is significantly greater than the turbine speed, the stator clutch will hold to increase torque.



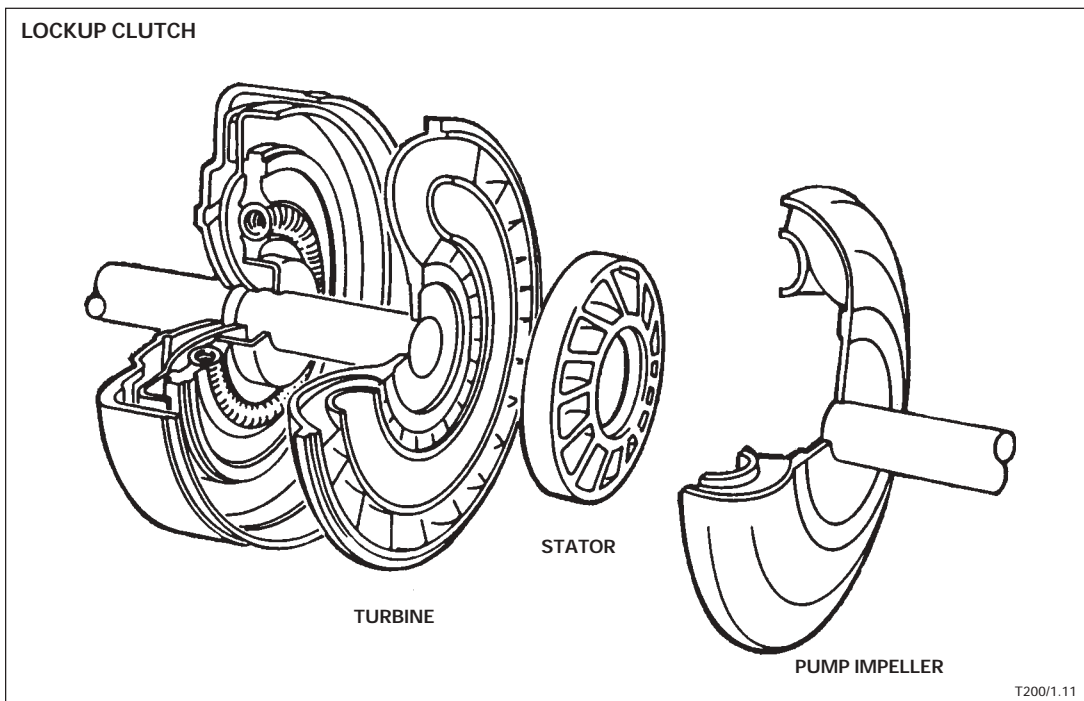
Torque converter and transmission pump

The torque converter drives the transmission oil pump. Refer to OIL PUMP, page 18.



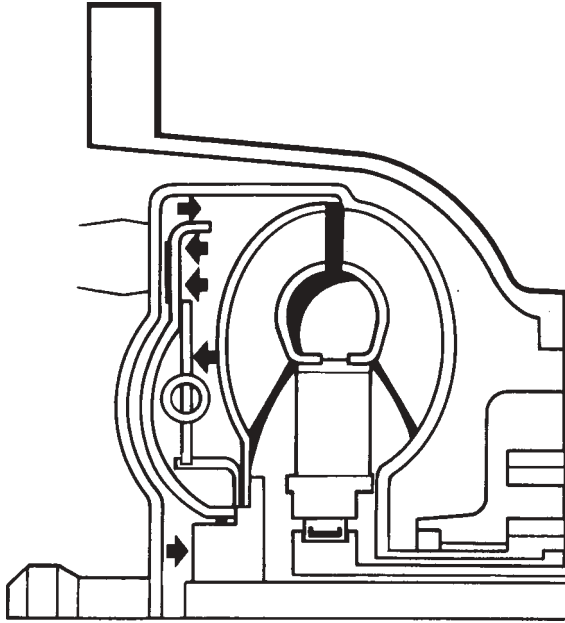
Torque converter lockup clutch

The torque converter lockup clutch provides a direct mechanical coupling between the engine and the transmission at highway speed. The direct coupling eliminates the slight amount of slippage present when the torque converter is acting as a fluid coupling, thereby improving efficiency, reducing fuel consumption, and cooling the fluid. The lockup clutch is incorporated with the pump impeller and is applied by the force of the fluid acting on the pump impeller. The clutch is released by hydraulic force directed from the transmission valve body. The clutch connects the converter housing and pump impeller assembly to the output shaft.



Torque Converter (continued)

LOCKUP CLUTCH RELEASED



T200/1.12

Lockup Clutch Operation

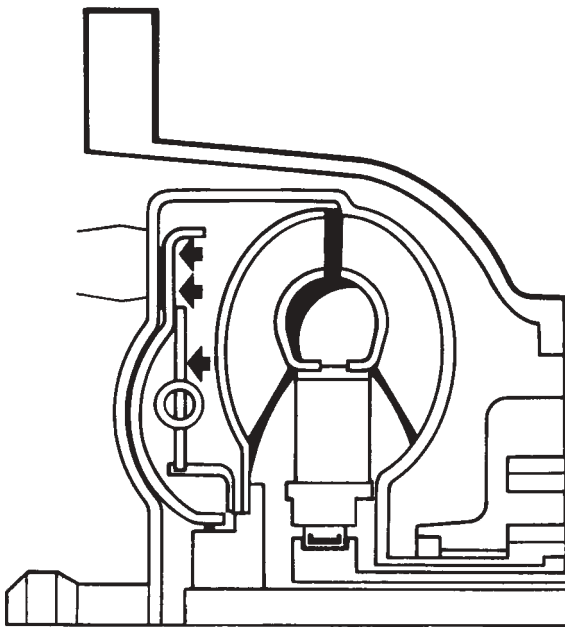
Clutch released

Hydraulic pressure is applied to the front face of the clutch, preventing contact between the clutch and the converter housing.

Clutch engaged

Hydraulic pressure is removed from the front face of the clutch, allowing the force of the fluid acting on the pump impeller to force the clutch in contact with the converter housing.

LOCKUP CLUTCH ENGAGED



T200/1.13

Gears and Torque

Torque is a twisting or turning effort and is measured in pound-feet (lb-ft). The torque produced by the engine is delivered to the transmission at a high rotating speed. In order to utilize this torque to drive the rear wheels, the drive train, including the transmission, reduces the rotational speed while increasing the turning effort at the rear wheels. This reduction is accomplished in part by the use of gears of different sizes.

Leverage

Gears multiply torque in the same manner as levers multiply force.

Torque transmission

When two meshing gears have the same number of teeth, they will both turn at the same speed. The gear ratio is 1:1.

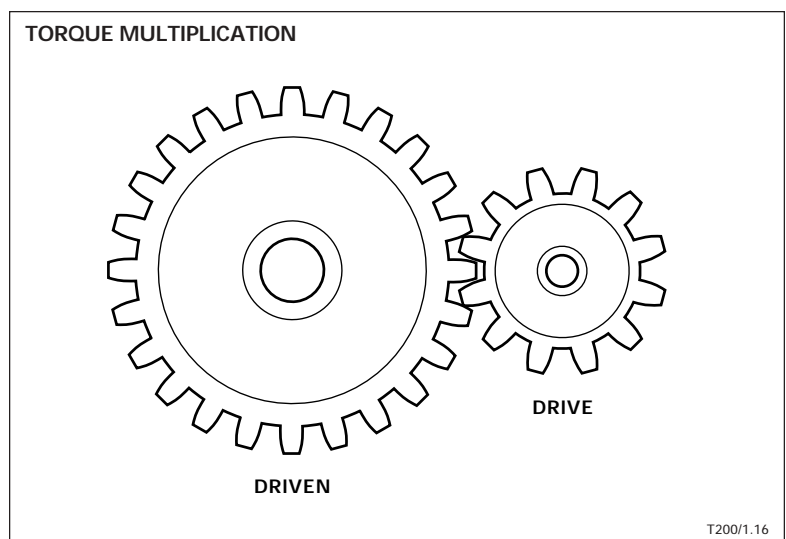
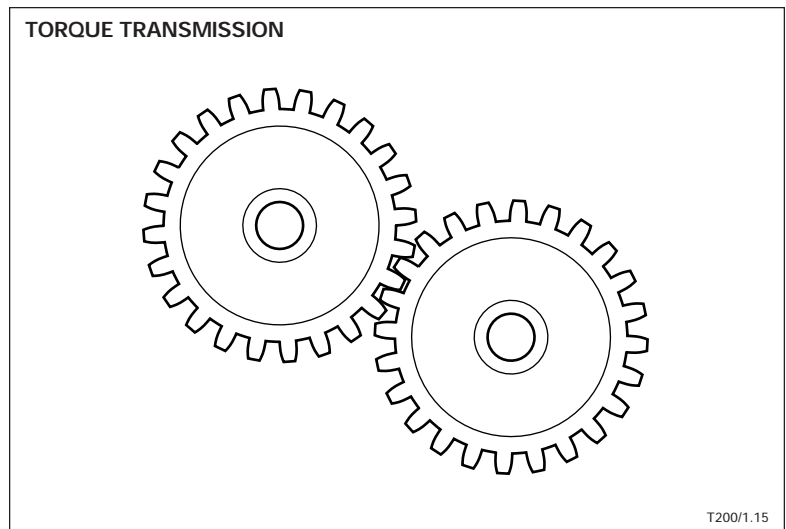
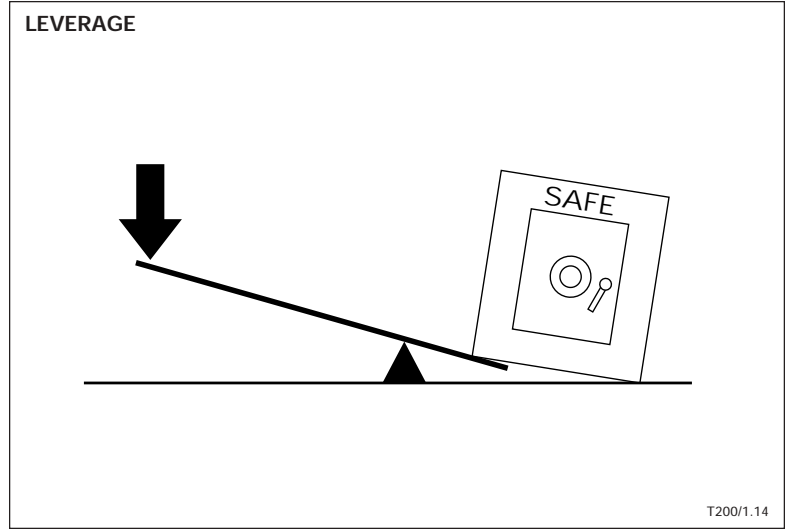
The input and output torque will be the same; therefore, the torque ratio is also 1:1.

Torque multiplication

If one gear has more teeth than the other, the smaller gear will turn more rapidly than the larger one. In the example, the drive gear has 12 teeth and the driven gear has 24 teeth. The gear ratio is 2:1. The drive gear will turn at two times the speed of the driven gear.

Torque is multiplied or reduced in the opposite of the gear ratio.

In this example, the torque ratio is 1:2. The driven gear will turn at 1/2 the drive gear speed, however, the driven gear will have twice the torque of the drive gear. Torque is multiplied by two.

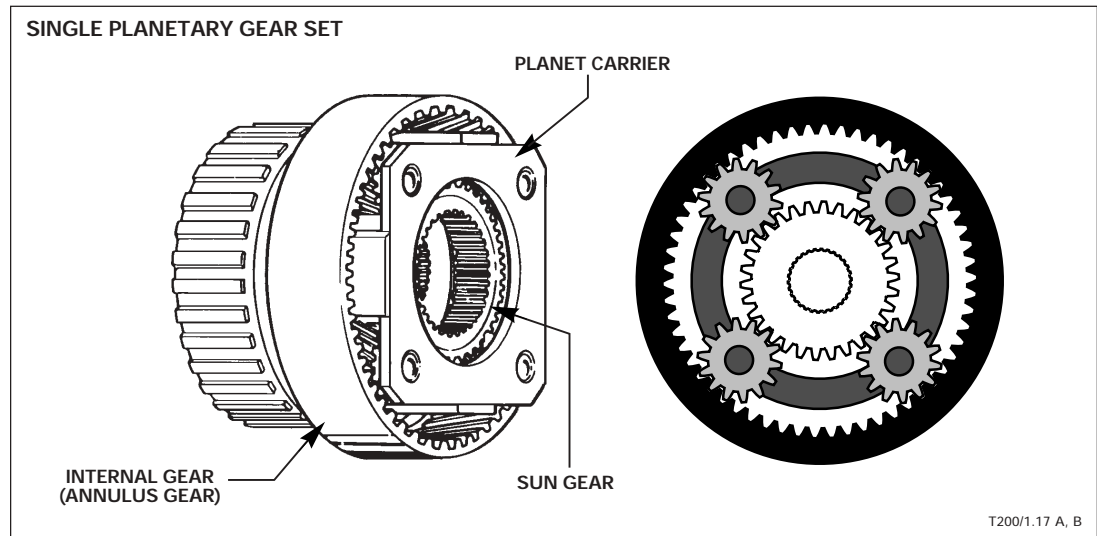


Planetary Gear Sets

Planetary gears are used in automatic transmissions as a means of multiplying the torque produced by the engine. Planetary gears are so named because their physical arrangement resembles planetary orbits. Planetary gears have several advantages that make them well suited for use in automatic transmissions:

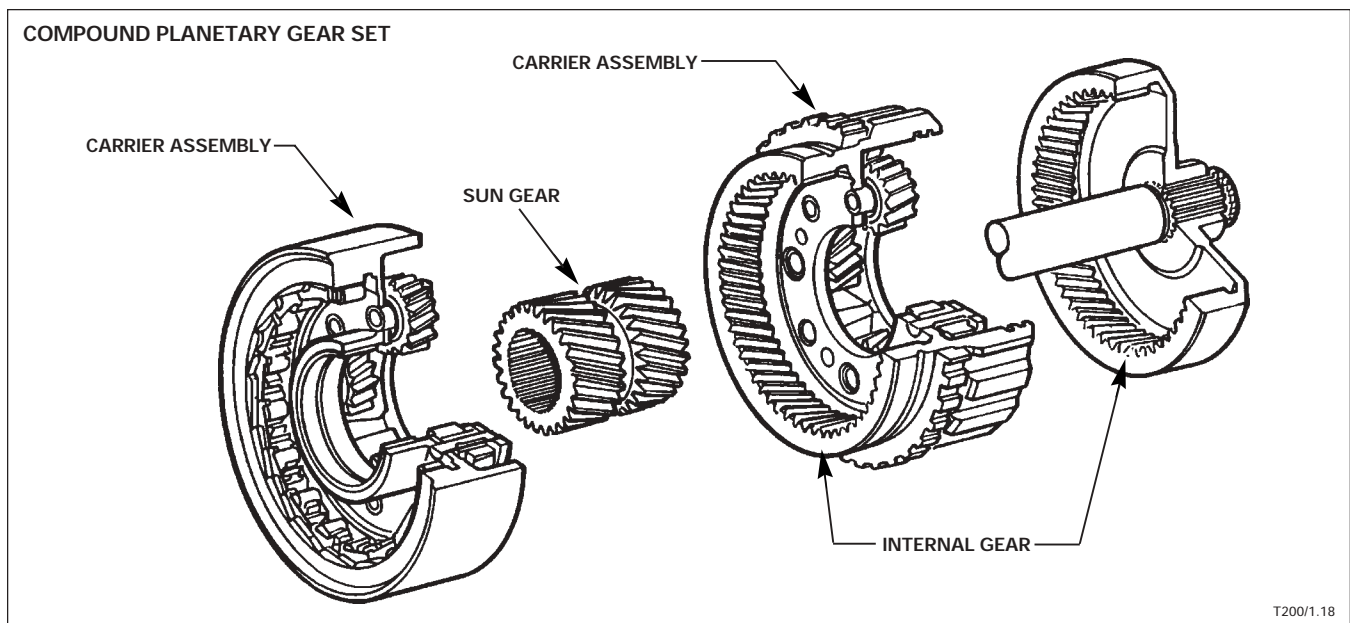
- The gears are always in mesh and cannot clash
- Several gear teeth are in contact at one time distributing the force over a larger area
- The arrangement of the gear sets on the same centerline allows for a compact unit

The gear set consists of a center or sun gear, an internal gear (or annulus gear), and a planetary carrier assembly that includes and supports the smaller planet gears (also called pinions).



Compound Planetary Gear Sets

In many applications, a compound planetary gear set is used. A compound planetary gear set consists of two sets of planet gears and internal gears on a common sun gear.



Sun gear

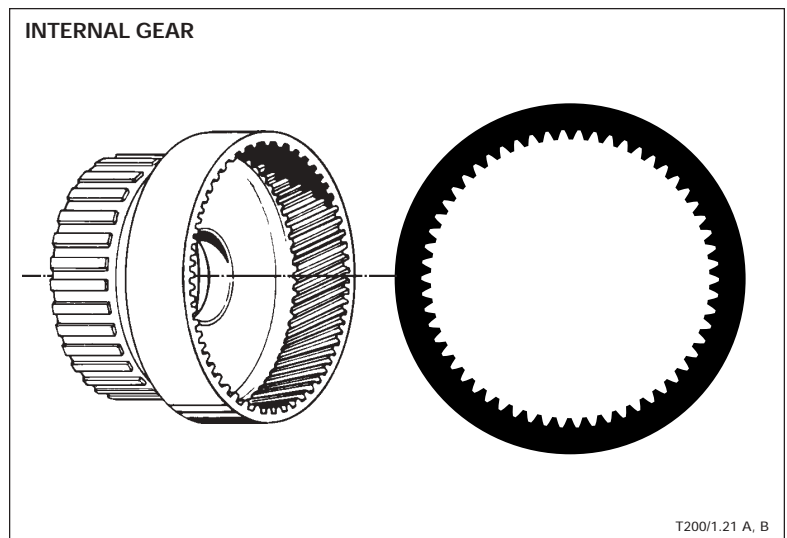
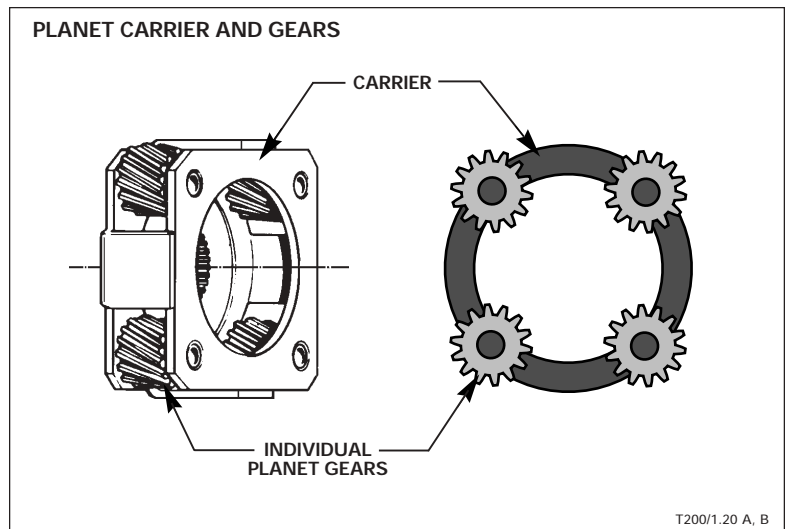
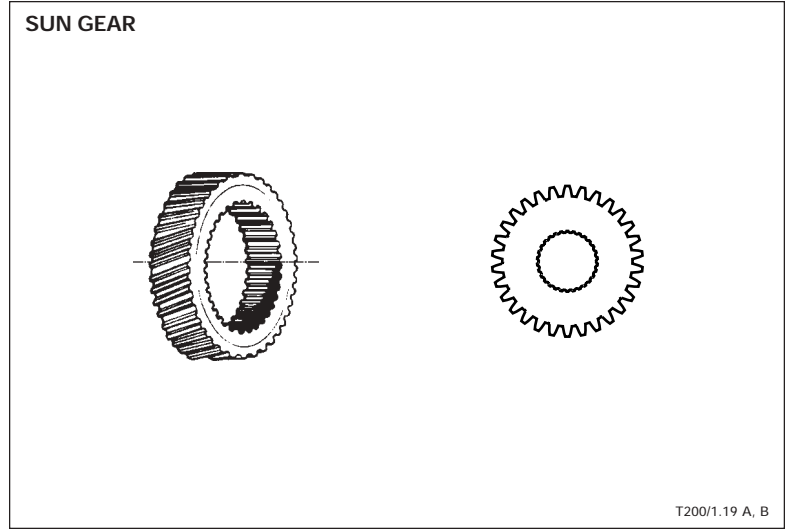
The sun gear is the center gear of the planetary gears. The other gears rotate around it, hence the name sun gear.

Planet carrier and planet gears

The planet gears are mounted in a carrier that rotates around the sun gear. The planet carrier and the planet gears act as a single unit.

Internal gear (annulus gear)

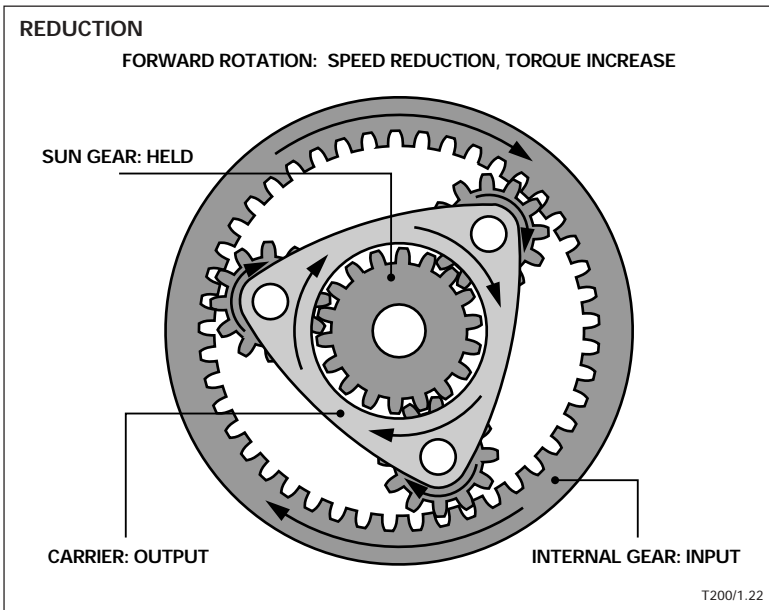
The internal gear is the outermost member of the planetary gear set. The name is derived from the fact that the gear teeth are cut on the inside surface.



Planetary Gear Sets (continued)

Uses for Planetary Gear Sets

Planetary gear sets can be used for the following purposes: to increase torque, increase speed, reverse direction and to act as a direct drive coupling. Increasing torque is generally known as operating in reduction because there is always a decrease in output member speed that is proportional to the increase in output torque. The various uses are achieved by holding or releasing the various members of the planetary gear set.

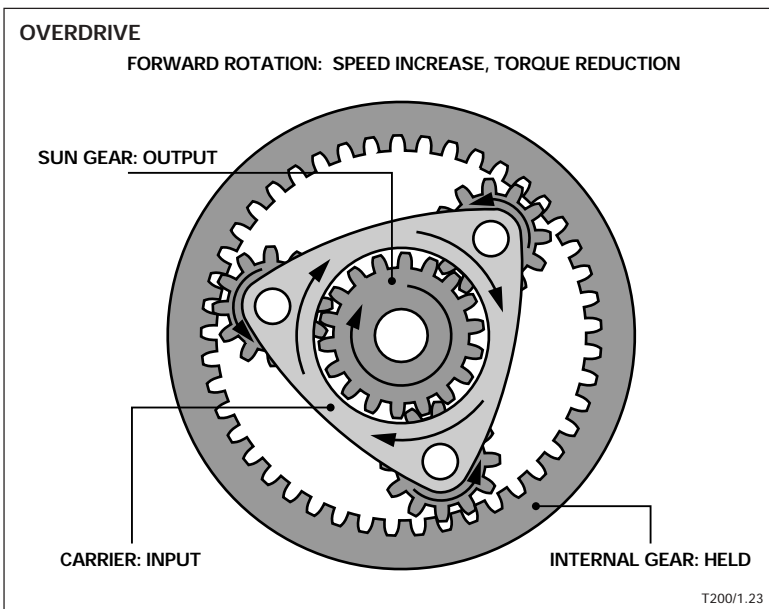


Reduction

By holding the sun gear and turning the internal gear, the planet carrier assembly will turn slower in the same direction as the internal gear. The internal gear is the input member; the planet carrier is the output member.

Overdrive (increase speed)

By turning the planet carrier and holding the internal gear, the sun gear turns faster in the same direction as the planet carrier. The planet carrier is the input member; the sun gear is the output member.

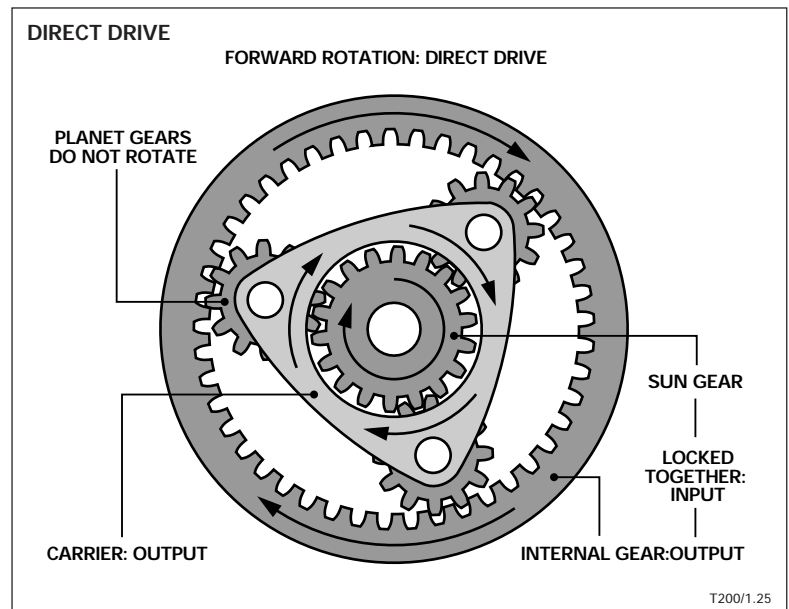
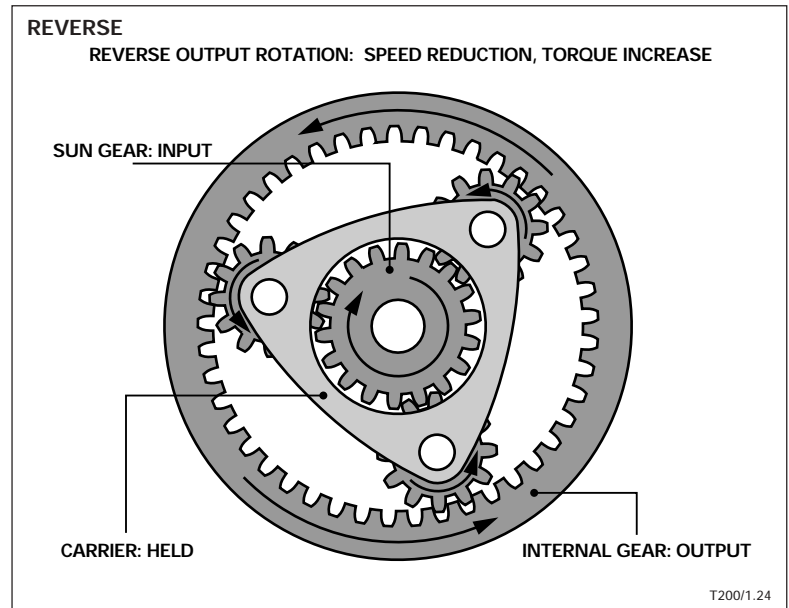


Reverse Direction

By holding the planet carrier, the other gears will rotate in the opposite direction to one another. Either the sun gear or the internal gear can act as the input member.

Direct Drive

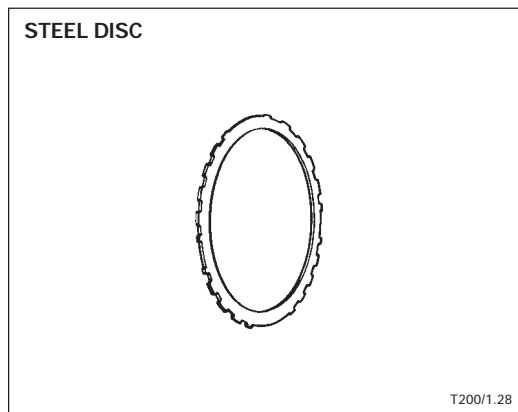
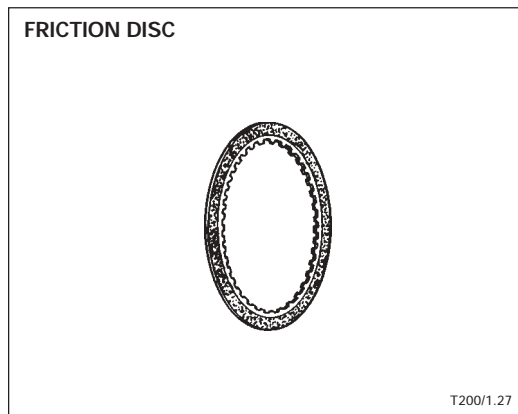
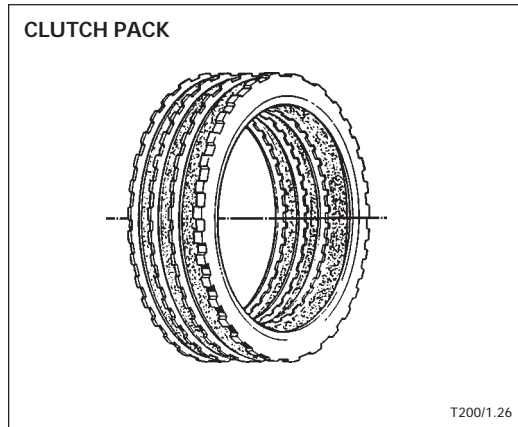
By turning any two gear members at the same time, the third gear will turn at the same speed in the same direction and the gear set will act as a direct drive.



Apply Devices

As detailed during the description of planetary gear sets, different gear ratios and different output directions were achieved by driving and/or holding the various planetary components. The action of selectively turning or holding different members of the planetary gear set is achieved through the use of apply devices. Apply devices used in automatic transmissions include:

- Multiple-disc clutches
- One-way clutches
- Bands and servos



Multiple-Disc Clutches

Clutch pack

Multiple-disc clutches consist of a series of two different types of clutch discs, friction discs and steel discs. The discs are stacked in a clutch pack assembly in alternating friction and steel discs.

Friction disc

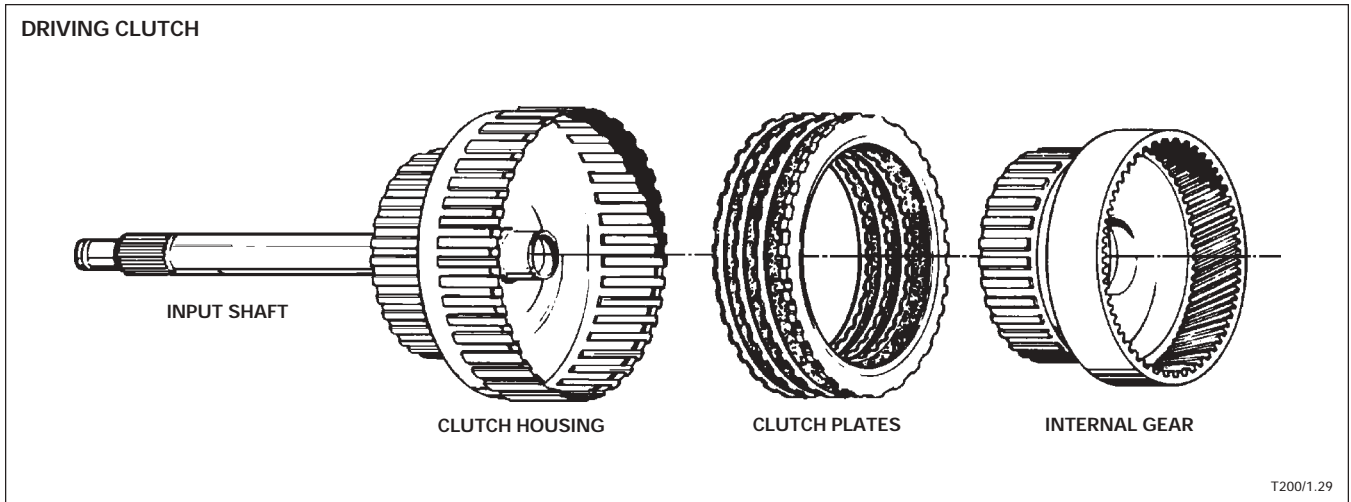
The friction discs have friction material bonded to their surfaces. In Jaguar transmissions, teeth are cut around the inside diameter of the disc.

Steel disc

The steel discs are flat and very smooth so that uniform contact is made with the friction discs. In Jaguar transmissions, teeth are cut around the outside diameter of the disc.

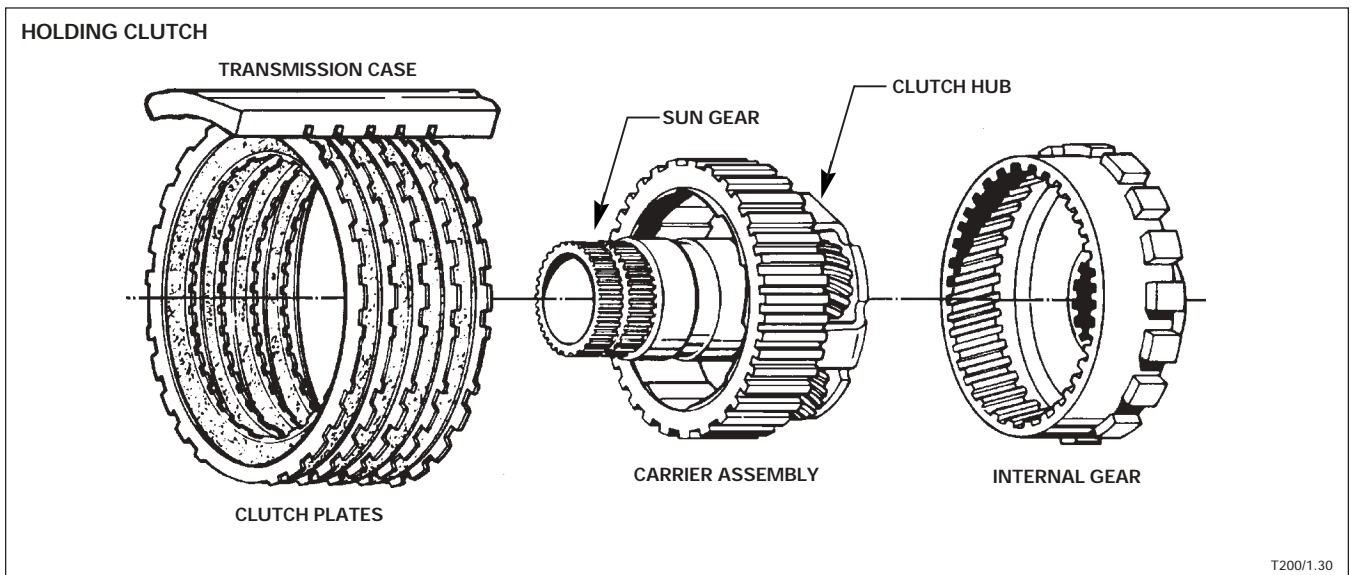
Multiple-Disc Driving Clutches

A multiple-disc clutch can be used as a driving clutch by splining one set of discs to an input source and the other set of alternating discs to an output member. In this example, the steel discs are splined to a clutch housing that is part of an input shaft; the friction discs are splined to an internal gear (planetary gear set). The clutch housing and the internal gear rotate freely when the clutches are not applied. When the clutches are applied by hydraulic pressure, they rotate together and the input shaft drives the internal gear.

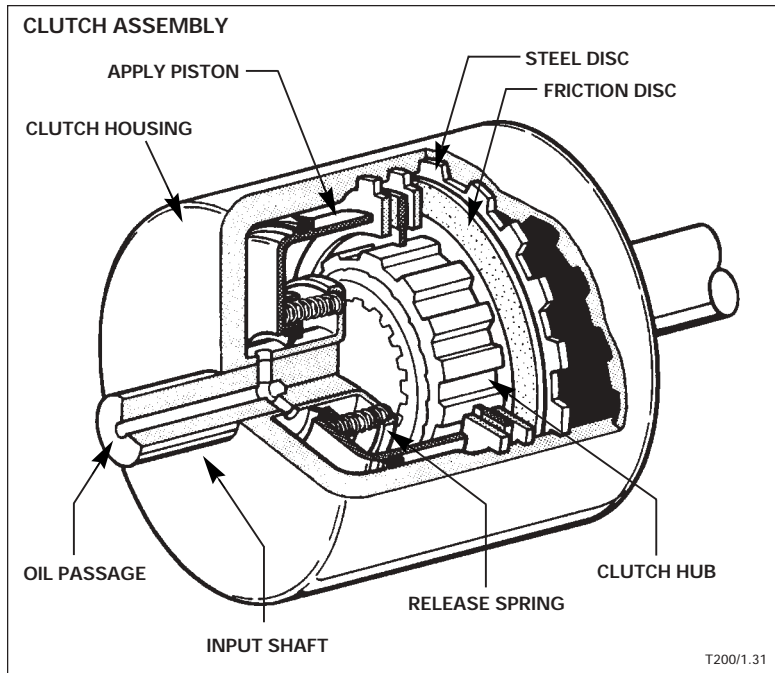


Multiple-Disc Holding Clutches

A multiple-disc clutch can also be used to hold a member of a gear set. In this example, friction discs are splined to the outside of a clutch hub and alternated between steel discs splined to the inside of a transmission case. The clutch hub is part of a planetary carrier assembly. When the clutches are not applied, the clutch hub turns freely in either direction. When the clutches are applied by hydraulic pressure, the friction between the two sets of discs stops the rotation of the clutch hub. The hub is held to the case until the clutch discs are released.



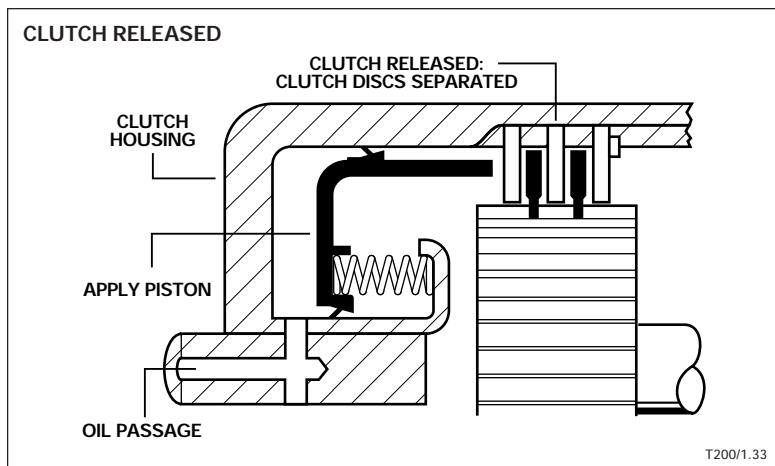
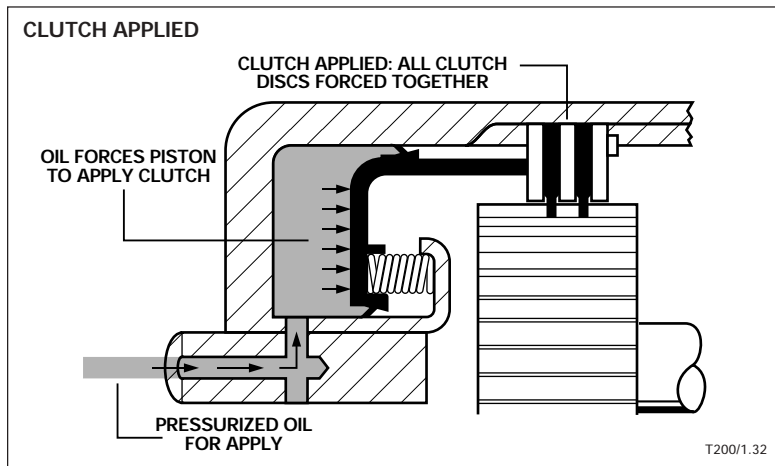
Apply Devices (continued)



Applying Multiple-Disc Clutches

The clutch assemblies (as well as all transmission internal components) are bathed in automatic transmission fluid that coats the components and allows them to turn freely and independently. The clutch assembly is applied by hydraulic pressure.

Pressurized oil acts on the apply piston moving the piston in contact with the clutch pack. The hydraulic pressure forces the discs together and the resulting friction connects the discs causing the the housing and hub to rotate (or hold) together as one unit. When the hydraulic pressure is released, the clutch return springs move the apply piston away from the clutch discs, allowing them to once again rotate freely.



One-Way Clutches

One-way clutches allow components to rotate in one direction only and can be used to drive or hold rotating members. Their simple mechanical design gives them certain advantages over hydraulic apply devices. One-way clutches can be designed to hold in either direction. For automatic transmissions, the roller clutch and the sprag clutch are commonly used.

Roller clutch

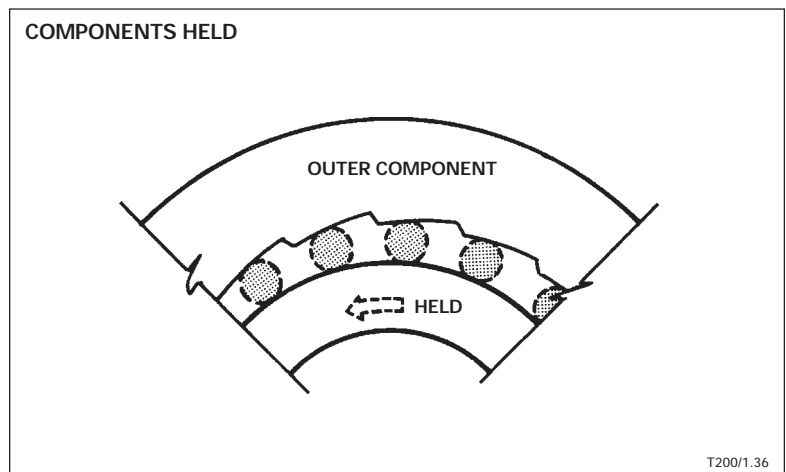
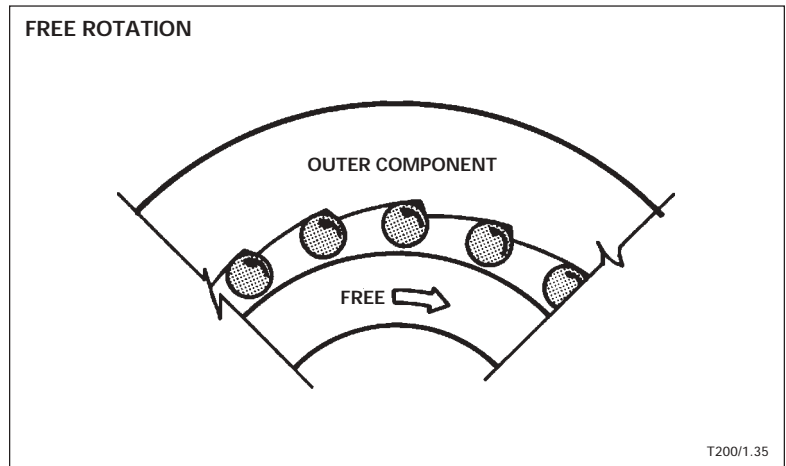
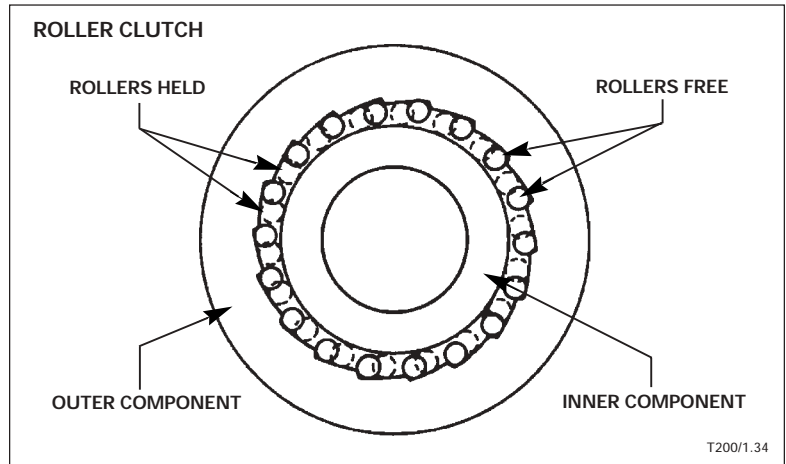
Rollers are positioned between an outer and inner component. The outer component is machined with ramps that hold the rollers. The example shows a roller clutch that allows the inner component to rotate freely in a clockwise direction.

Roller clutch: Free rotation

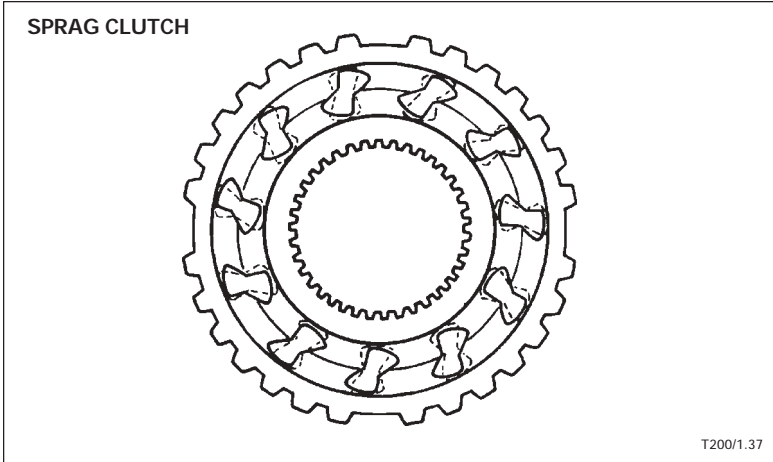
Clockwise rotation of the inner component moves the rollers to the wide space of the ramps, freeing the two components.

Roller clutch: Components held

Counterclockwise rotation of the inner component forces the rollers to the narrow area of the ramps, holding the two components together.



Apply Devices (continued)



Sprag clutch

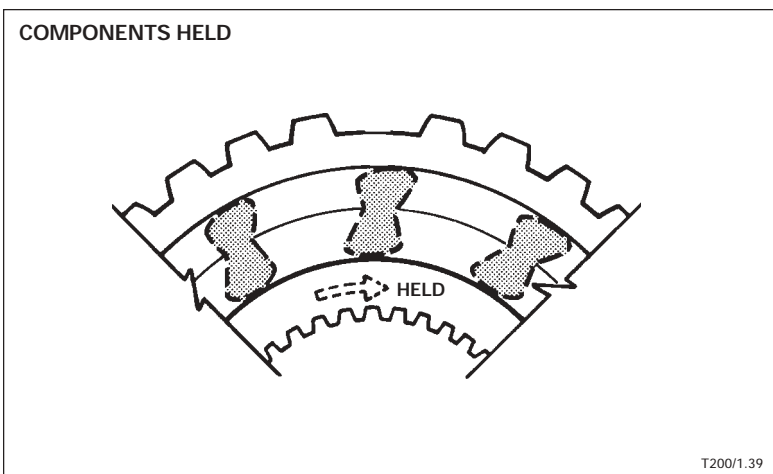
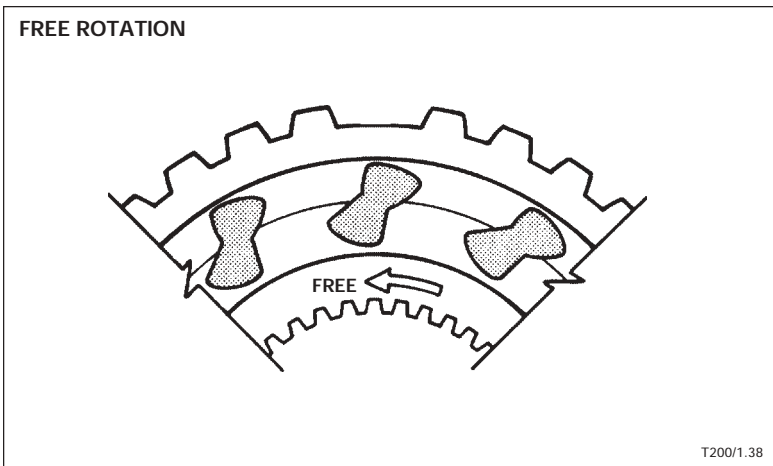
Sprags are positioned between an outer and inner component. The sprags are retained and positioned between the inner and outer components. The example shows a sprag clutch that allows the inner component to rotate freely in a counterclockwise direction.

Sprag clutch: Free rotation

Counterclockwise rotation of the inner component disengages the sprags, freeing the two components.

Sprag clutch: Components held

Clockwise rotation of the inner component engages the sprags, holding the two components together.

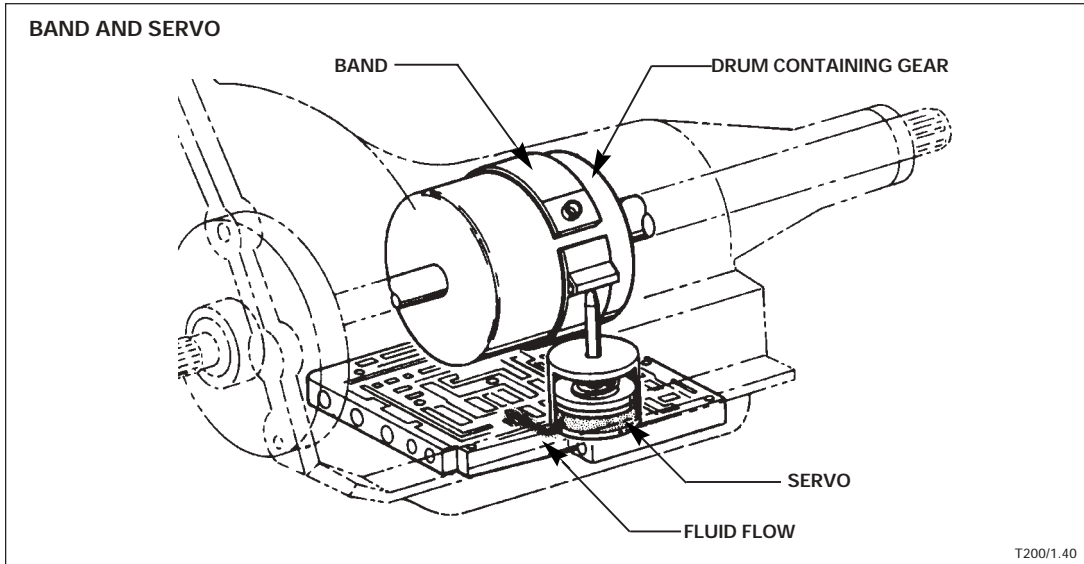


Transmission Bands and Servos

Transmission bands and servos are used to stop and hold a rotating member of a planetary gear set.

Band and servo

The band surrounds a drum and is anchored at one end to the transmission case. Hydraulic force is applied to the other end of the band by a servo. The band is made of steel and lined with a friction material.

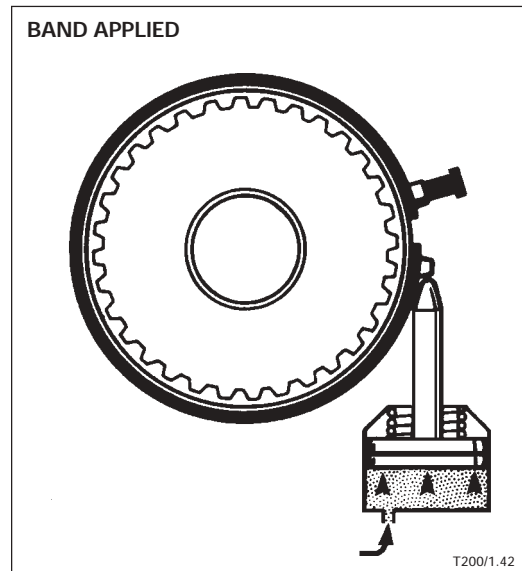
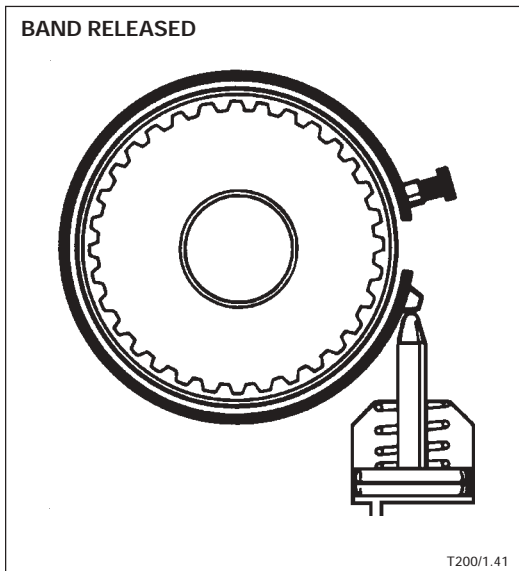


Band released

With no hydraulic force acting on the servo, the band is relaxed and the drum turns freely.

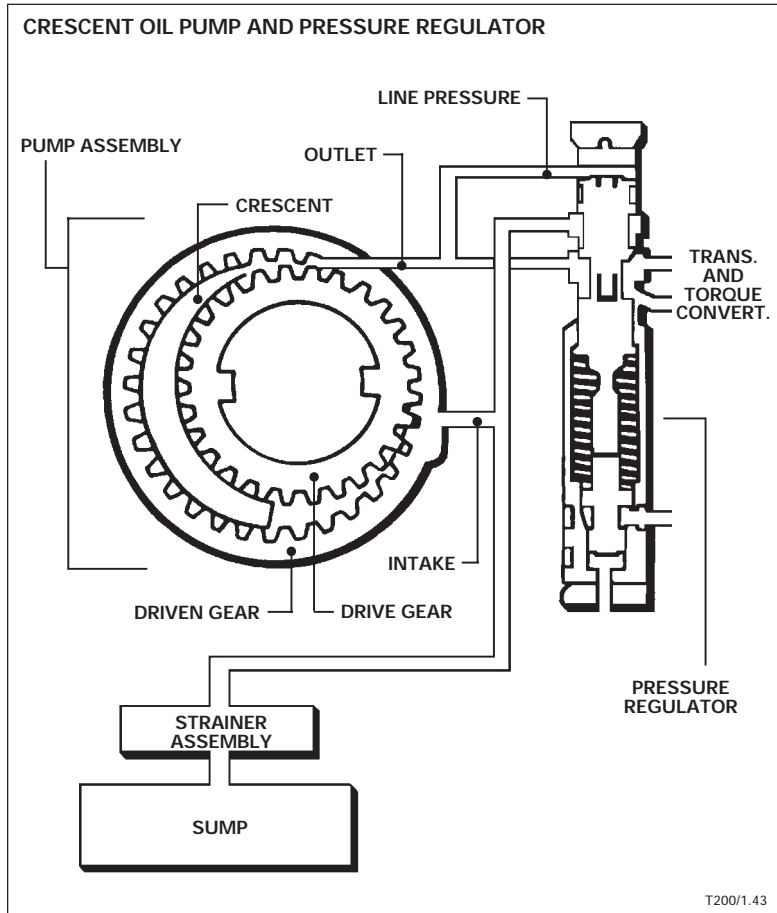
Band applied

When hydraulic force acts on the servo, the servo applies the band to tighten on the drum, stopping and holding the drum.



Oil Pump and Cooler

A hydraulic pressure system, such as an automatic transmission, requires a pump to pressurize and flow the hydraulic fluid. The most common type of pump used in automatic transmissions is the crescent-type positive displacement pump. A cooler is used to maintain control over transmission operating temperature.



Crescent-Type Pump

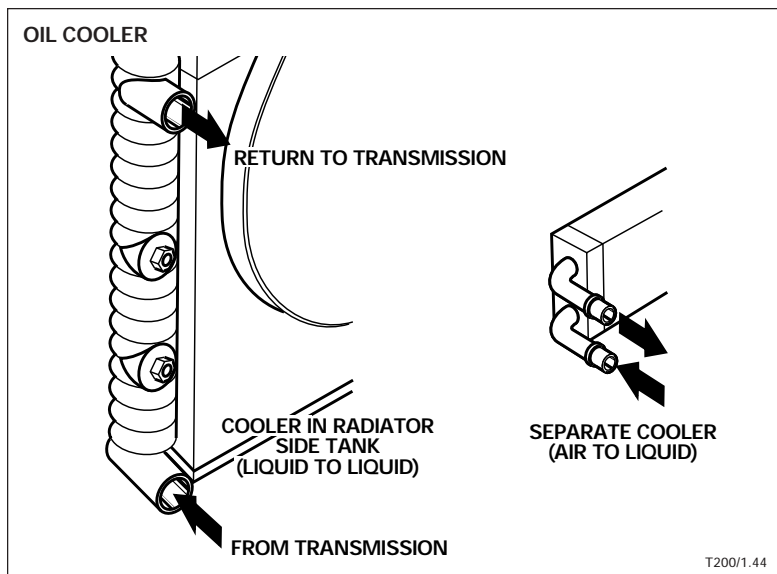
The pump has an intake and an outlet port. Between these, a drive gear turns a driven gear of a larger diameter. The area between the two gears is maintained by a stationary crescent-shaped casting. Because this type of pump delivers the same amount of fluid on each revolution, it is referred to as a positive displacement pump.

Pump operation

The pump drive gear is driven at engine speed by the torque converter and is configured so that the pump turns whenever the engine is operating. When the drive gear turns, it also turns the driven gear, causing a void on the intake side. Oil is lifted from the transmission sump to fill the void. As the gears continue to turn, the oil is carried past the crescent section of the pump. Once past the crescent, the oil is pressurized as the gears close and squeeze the oil. At this point pressurized oil is delivered through the pump outlet to the pressure system where the pressure is regulated before distribution.

Oil Cooler

An oil cooler is necessary to maintain transmission oil temperature. The external cooler can be incorporated into the side tank of the engine coolant radiator as a liquid-to-liquid cooler or can be incorporated into a separate engine oil cooler as a air-to-liquid cooler. Some installations may incorporate both arrangements as a series circuit.



Transmission Valves

Valves are used in the transmission hydraulic circuits to actuate and release apply devices, and to control or limit hydraulic pressure. Two basic types of valves are used: the ball valve and the spool valve. All or most of the valves are contained in the control valve assembly (valve body).

Ball Valves

One-way ball check valve

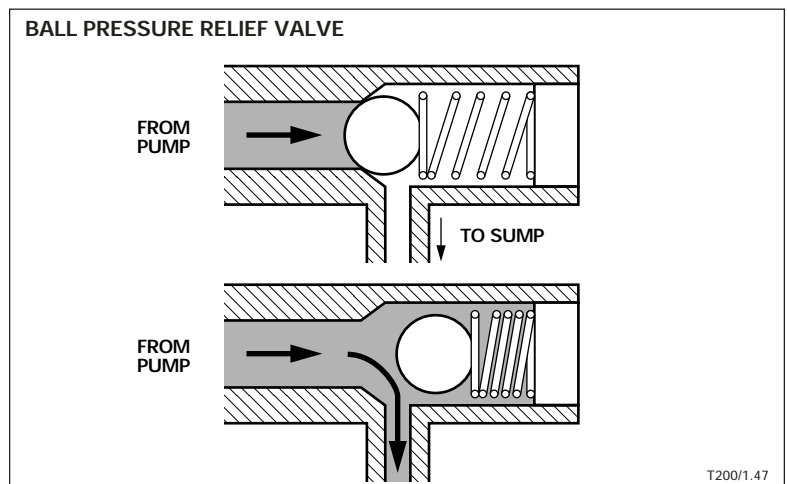
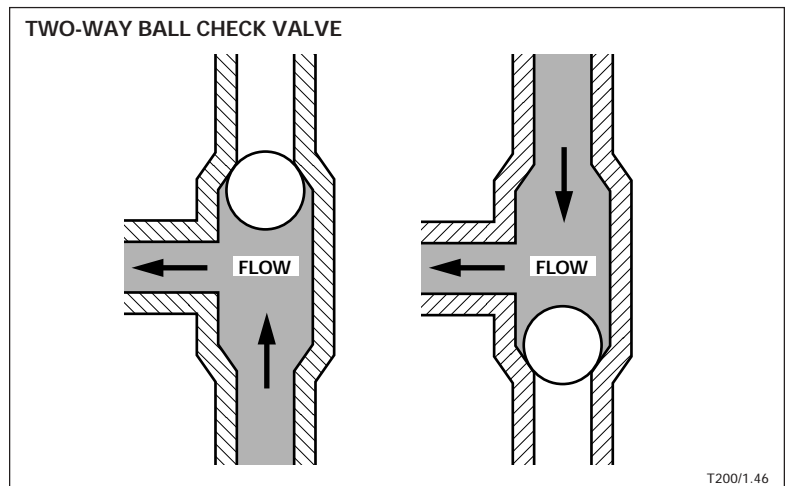
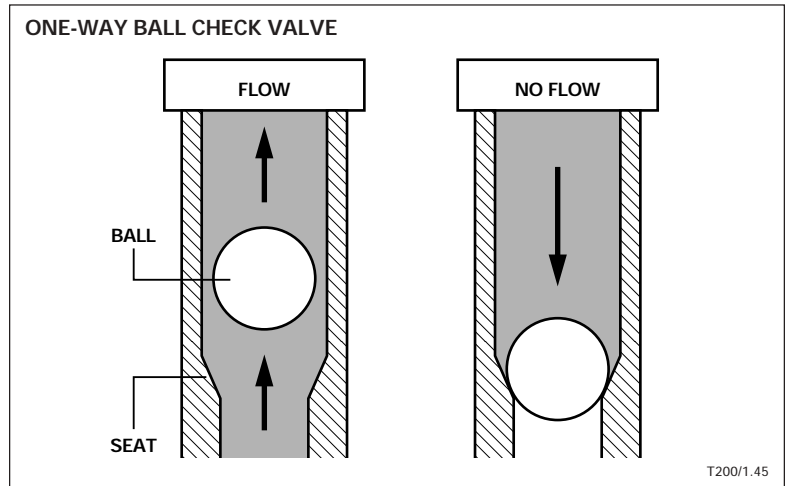
A one-way check valve allows fluid to flow in one direction only.

Two-way ball check valve

A two-way check valve allows fluid to flow only from the inlet side under pressure.

Ball pressure relief valves

A ball pressure relief valve uses spring loading to limit pressure. When the hydraulic pressure is less than the spring pressure, the ball remains seated and no fluid returns to the sump. When the hydraulic pressure exceeds the spring pressure, the ball is forced off its seat, allowing fluid to return to the sump. The strength of the spring determines the maximum hydraulic pressure in the circuit.

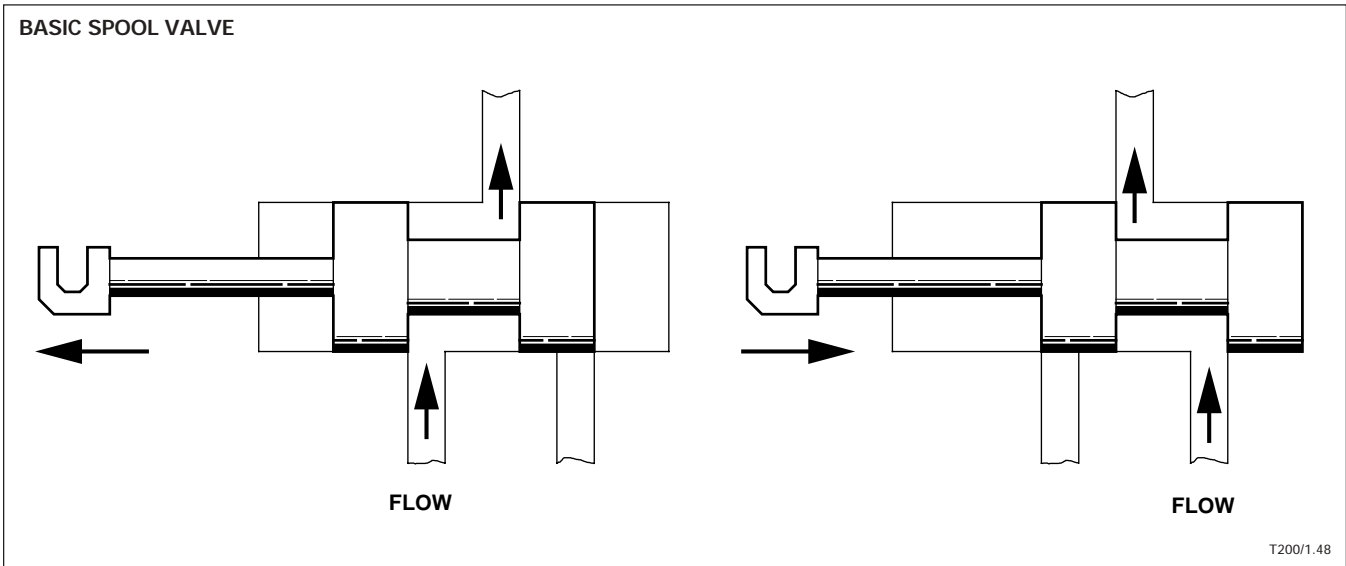


Transmission Valves (continued)

Spool Valves

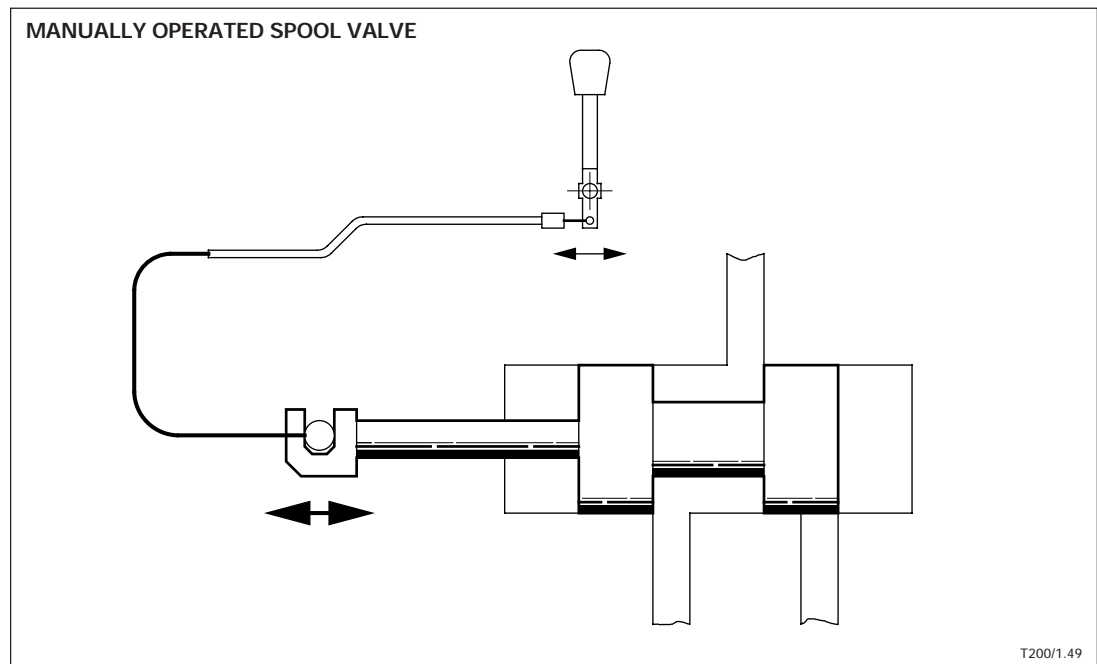
Basic spool valve

The other type of valve used in the transmission control valve assembly is the spool valve. The spool valve is a cylindrical valve with one or more steps cut into it. The valve is moved in a bore that interconnects fluid passages. As the spool valve moves in the bore, passages are opened and/or closed, allowing fluid to be directed. Each passage connects to circuits that direct pressurized fluid to a specific component or another hydraulic valve.



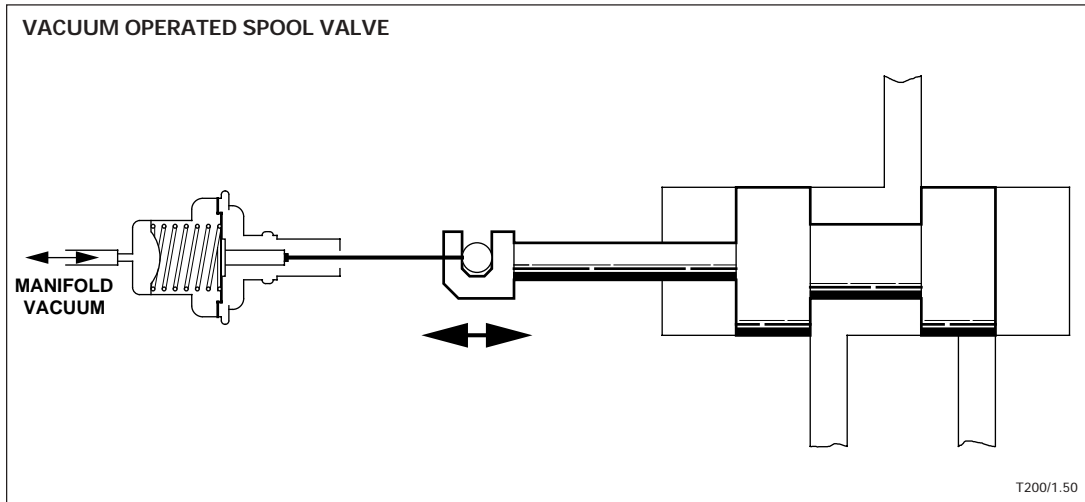
Manually operated spool valve

Manual operation of spool valves is normally accomplished via a control cable. An example would be the gear select cable from the shift lever.



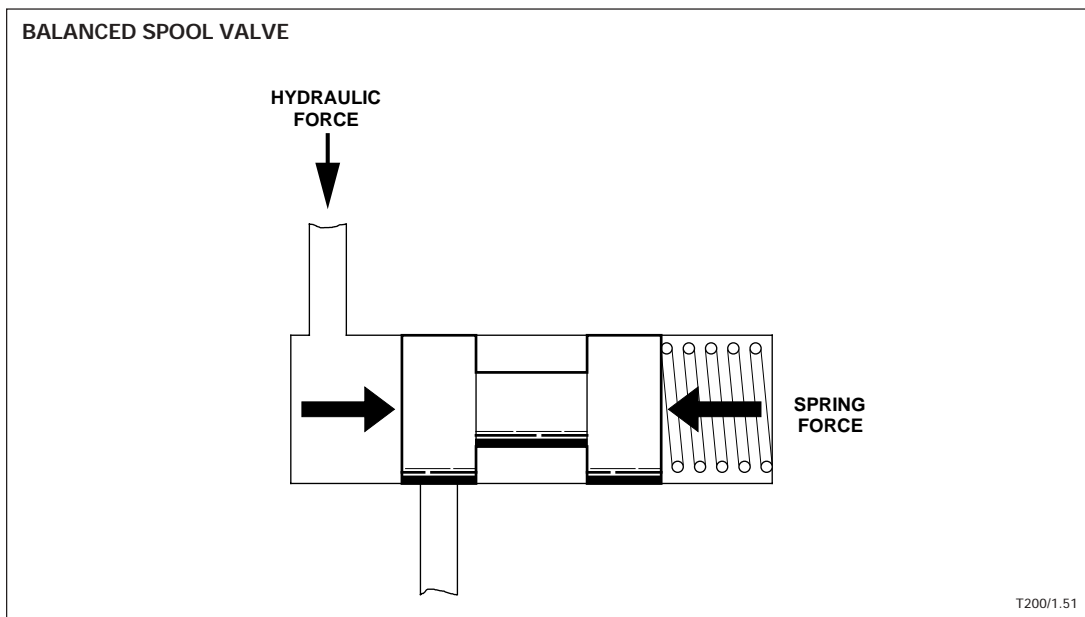
Vacuum operated spool valve

Vacuum operation of spool valves is accomplished via a vacuum servo. They are commonly used in vacuum modulator circuits.



Balanced spool valve

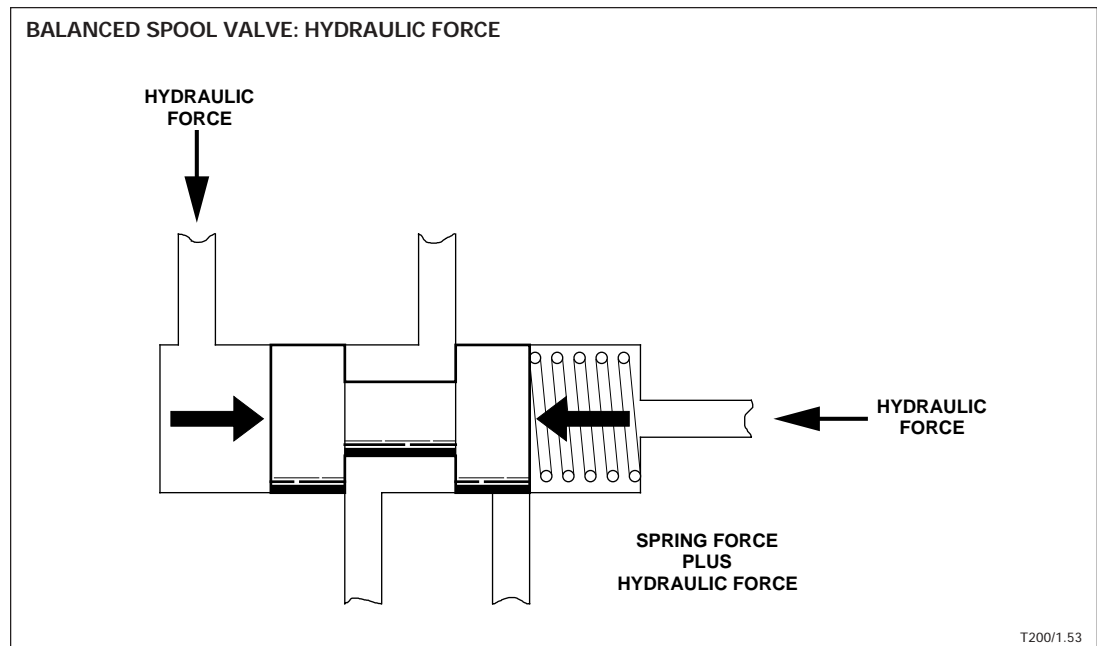
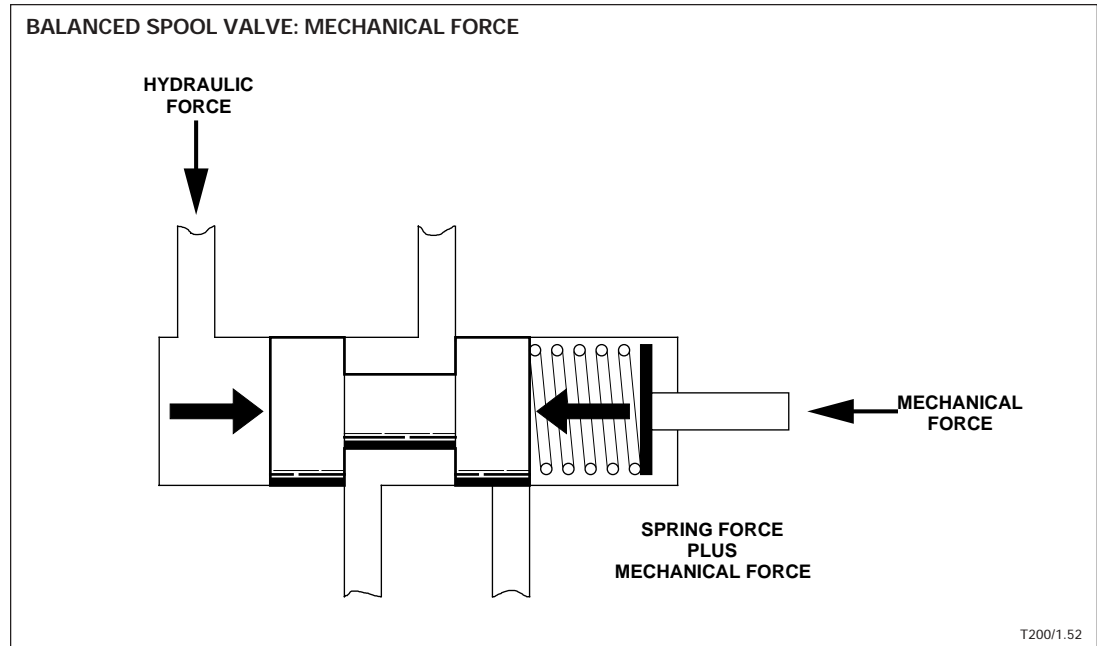
A balanced spool valve is one in which hydraulic force is balanced against spring force. The spring pressure can be fixed or variable.



Transmission Valves (continued)

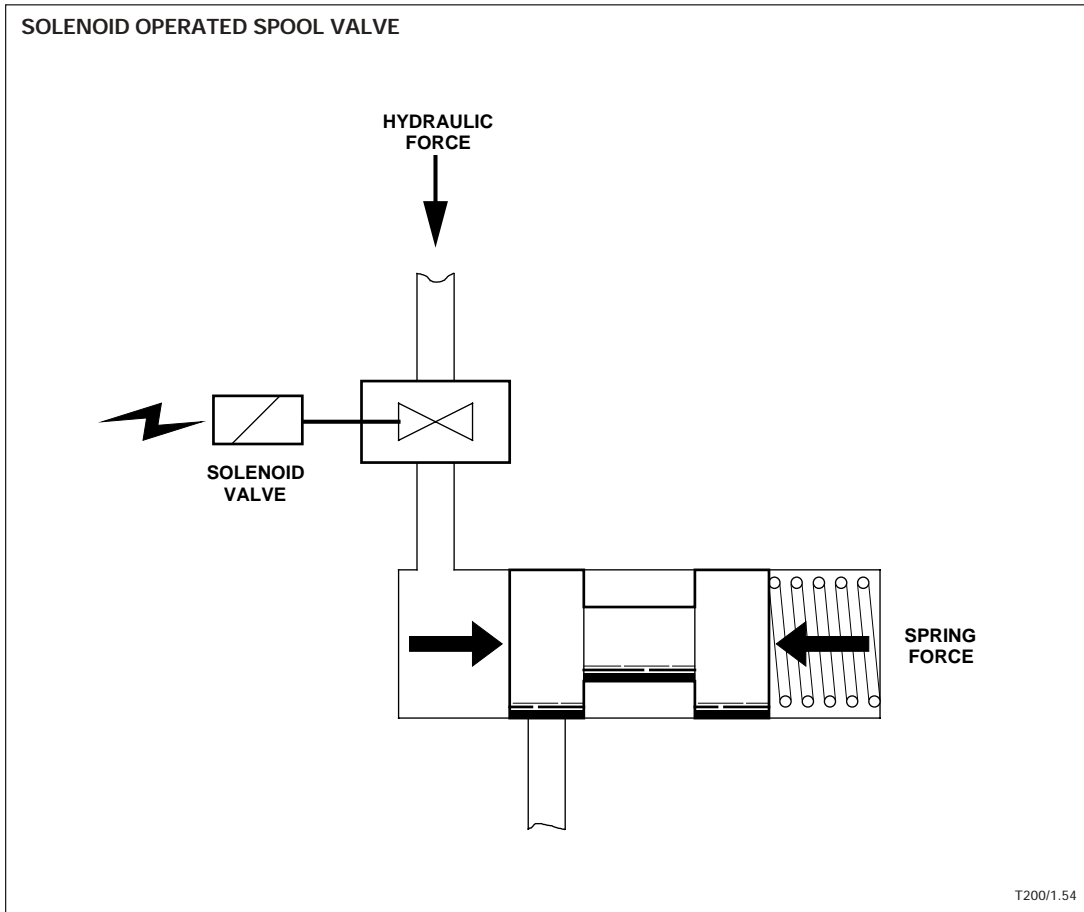
Balanced spool valve: Variable spring pressure

The amount of force acting on the spring side of the spool valve can be varied by mechanical or hydraulic means.



Solenoid operated spool valve

Electrical solenoids can be used to operate spool valves. The solenoid valve switches a hydraulic circuit, which in turn operates the spool valve. The spring is used to return the spool to the static position when the hydraulic force is released.



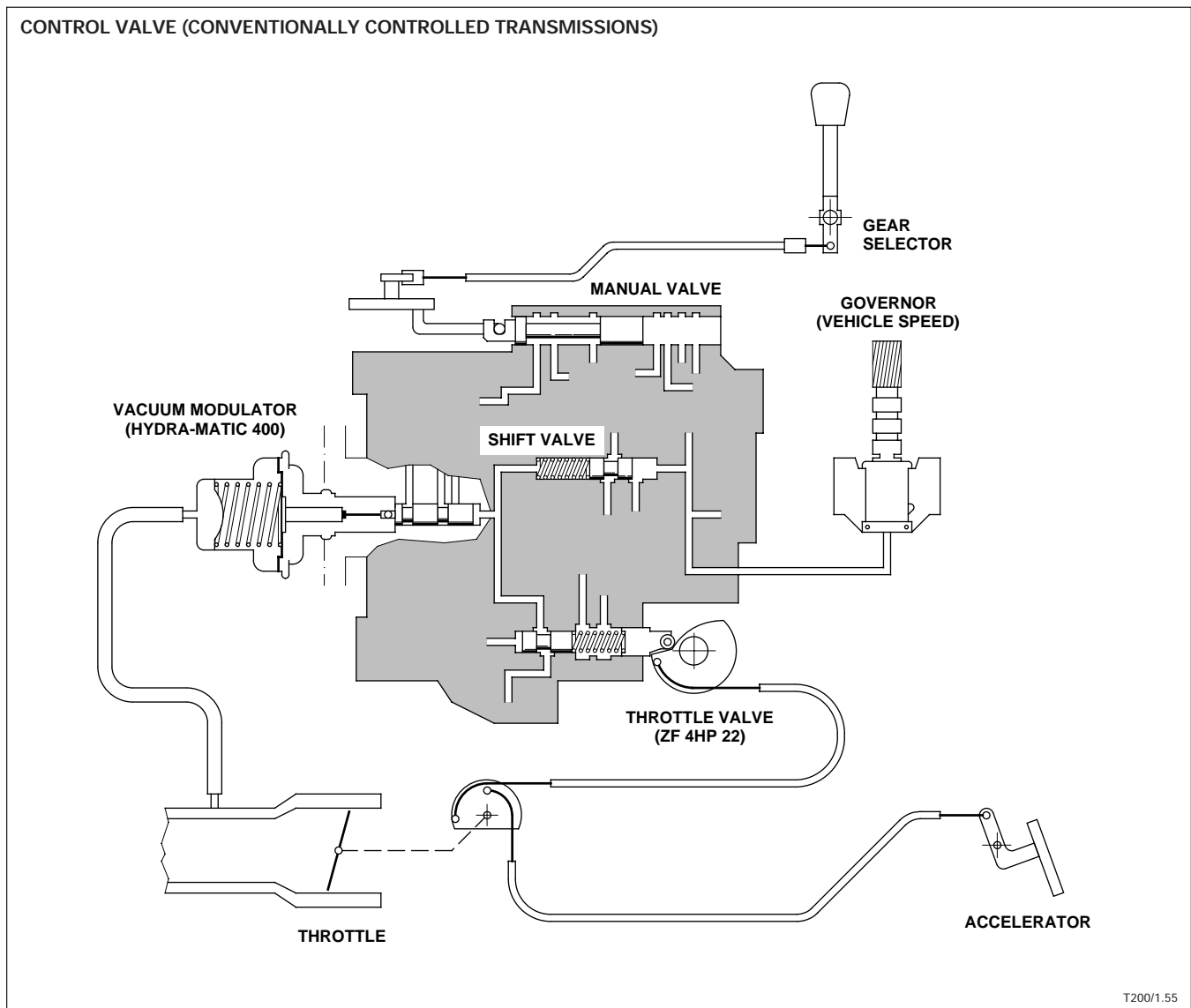
Control Valves (Valve Bodies): Conventionally Controlled Transmissions

Vehicles without electronic transmission control use a conventional control valve that receives inputs from mechanical and hydraulic components. The control valve assembly located at the bottom of the transmission contains most of the controlling valves as well as interconnection hydraulic circuits. The control valve accomplishes specific types of control and application functions to manually and automatically change gears. Inputs to the control valve include:

- Gear selection
- Engine load and speed
- Acceleration

Control Valve Assembly

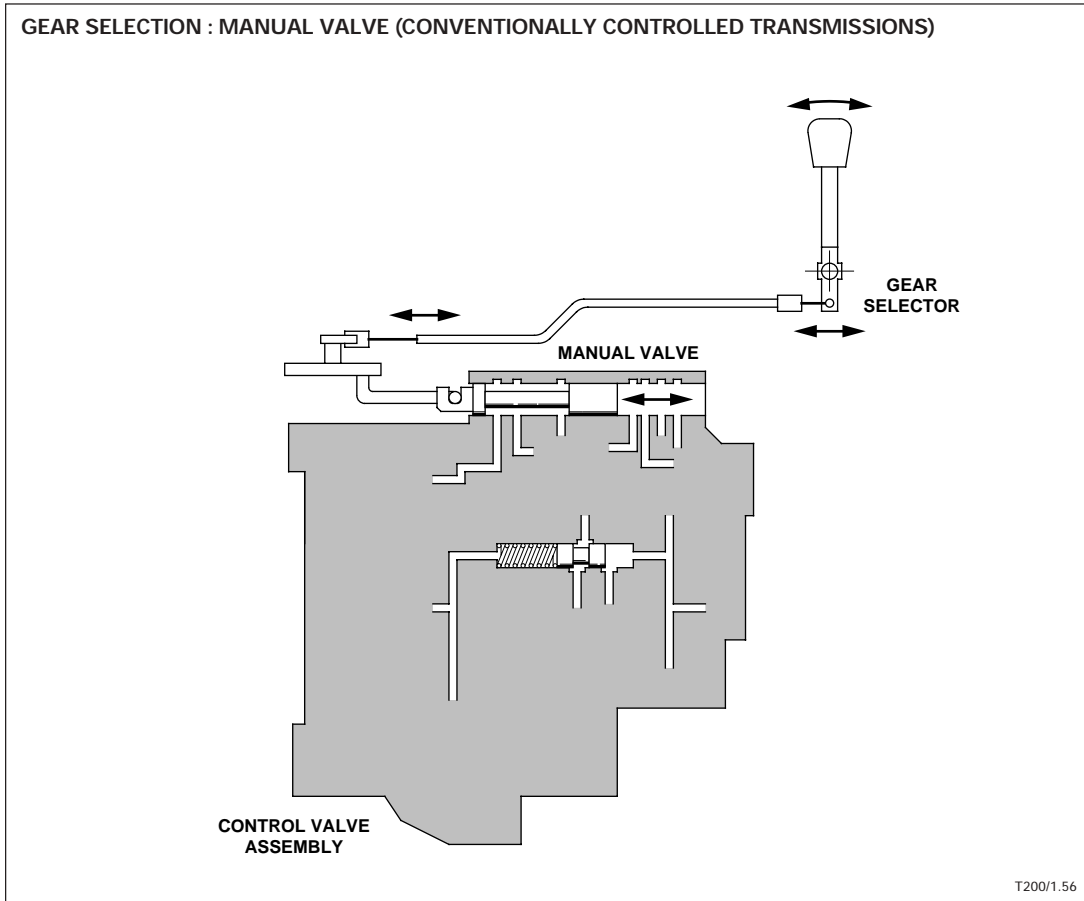
The main control components and arrangement of a conventional automatic transmission control valve are shown in the illustration. The system would use either a throttle valve (ZF 4HP 22) or a modulator (Hydra-Matic 400) arrangement, not both.



Gear Selection

Manual valve

The gear change valve in the valve body is positioned directly by the action of the driver, and is transmitted via the selector cable. This arrangement is called a manual valve.



Control Valves (Valve Bodies): Conventionally Controlled Transmissions (continued)

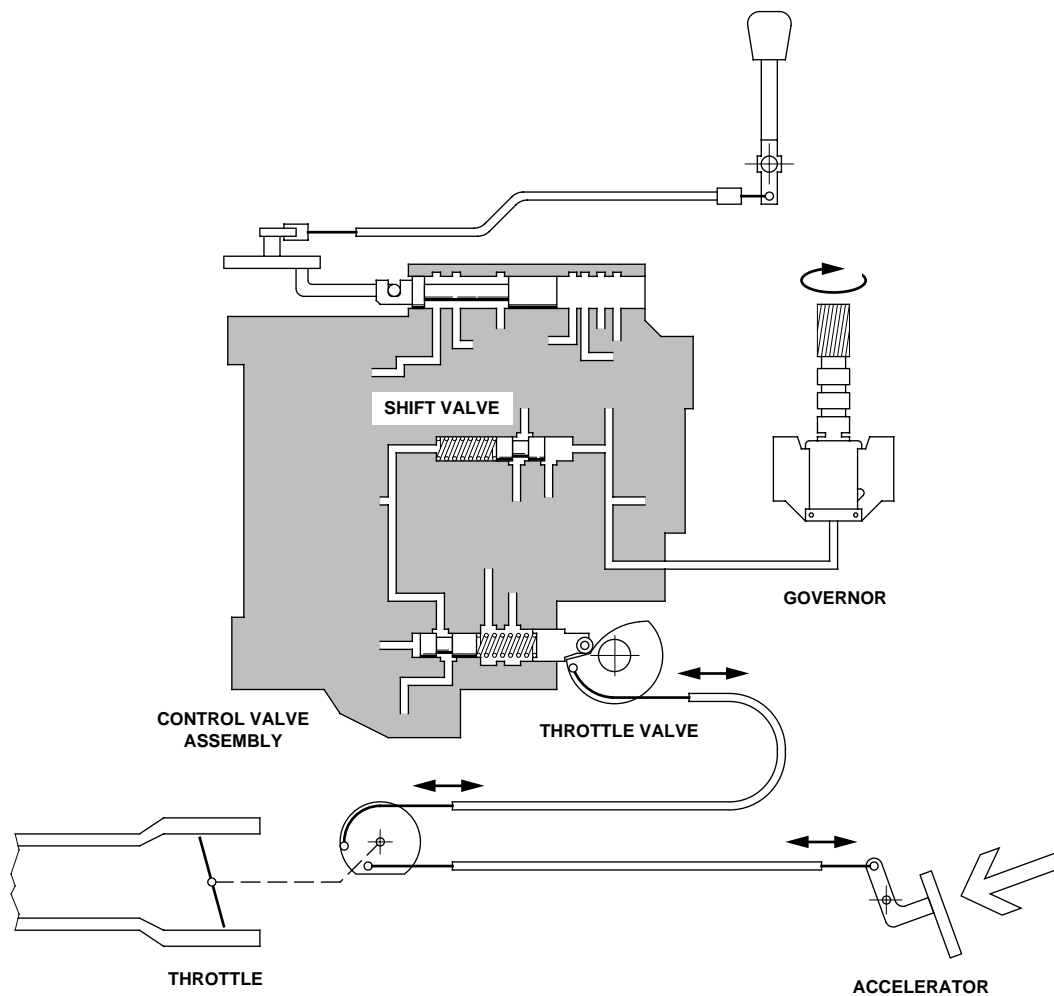
Engine Load and Road Speed

Engine load and road speed information is used by the transmission to vary the automatic shift points. Two types of systems are used in conventionally controlled transmissions: a throttle valve and governor system and a modulator valve and governor system.

Throttle valve and governor

Engine load is interpreted as the position of the throttle plate; road speed is interpreted as the governor hydraulic pressure. A cable is used to transmit the throttle position to the throttle valve. The position of the throttle acts on the spring of the balanced spool valve in addition to moving the valve. The change in fluid flow created by moving the valve signals the control valve (valve body) to shift the transmission. The hydraulic line pressure acting against the spring pressure of the balanced valve is controlled by the governor. The governor is driven by the transmission output shaft and varies the hydraulic pressure acting against the throttle valve depending on shaft speed. This process matches the transmission shift points to the engine load and road speed.

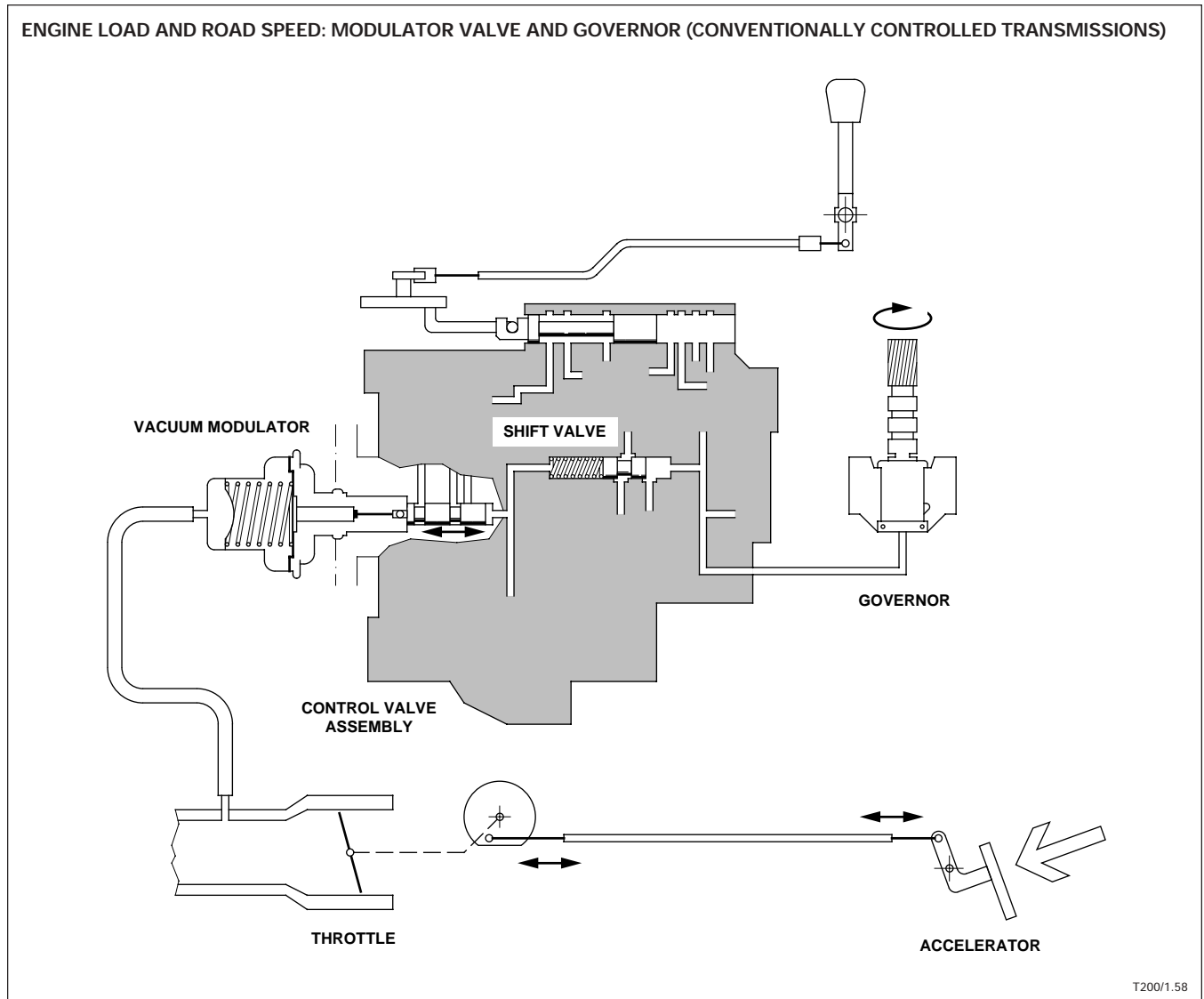
ENGINE LOAD AND ROAD SPEED: THROTTLE VALVE AND GOVERNOR (CONVENTIONALLY CONTROLLED TRANSMISSIONS)



T200/1.57

Modulator valve and governor

In this configuration, engine load is interpreted as manifold absolute pressure (vacuum). A vacuum line connects to a vacuum servo that in turn actuates the modulator valve depending on manifold vacuum. A spring within the servo acts against the valve to produce a balanced spool valve (high vacuum – less spring pressure; low vacuum – greater spring pressure). The governor pressure acts against the modulator valve to adjust hydraulic line pressure and achieve shift points matched to the engine load and road speed.



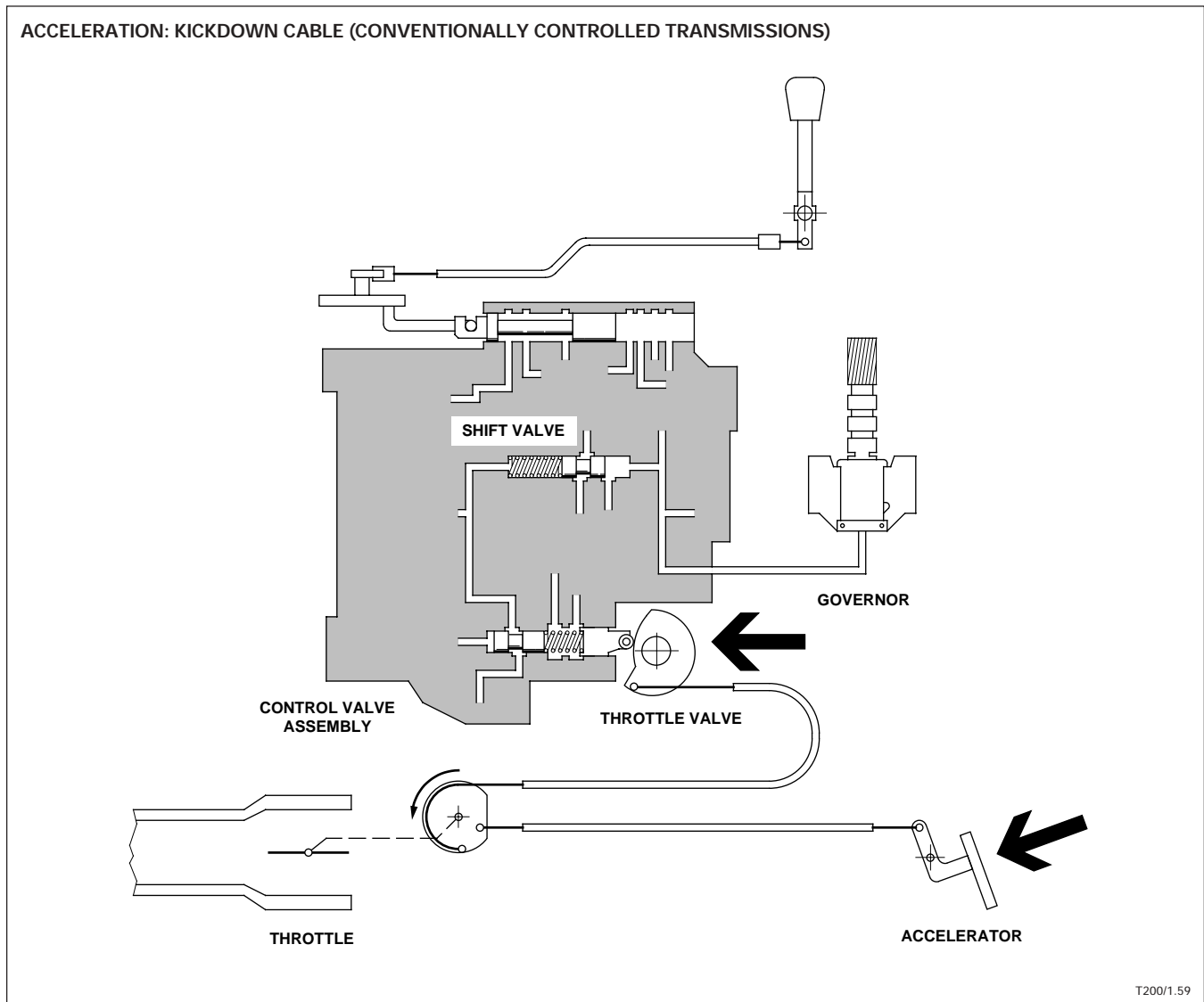
Control Valves (Valve Bodies): Conventionally Controlled Transmissions (continued)

Acceleration

When immediate acceleration is required, the transmission must downshift to achieve increased torque output. This type of downshift is called "kickdown". Two methods of sensing the need for kickdown are used: mechanical cable and electrical switch.

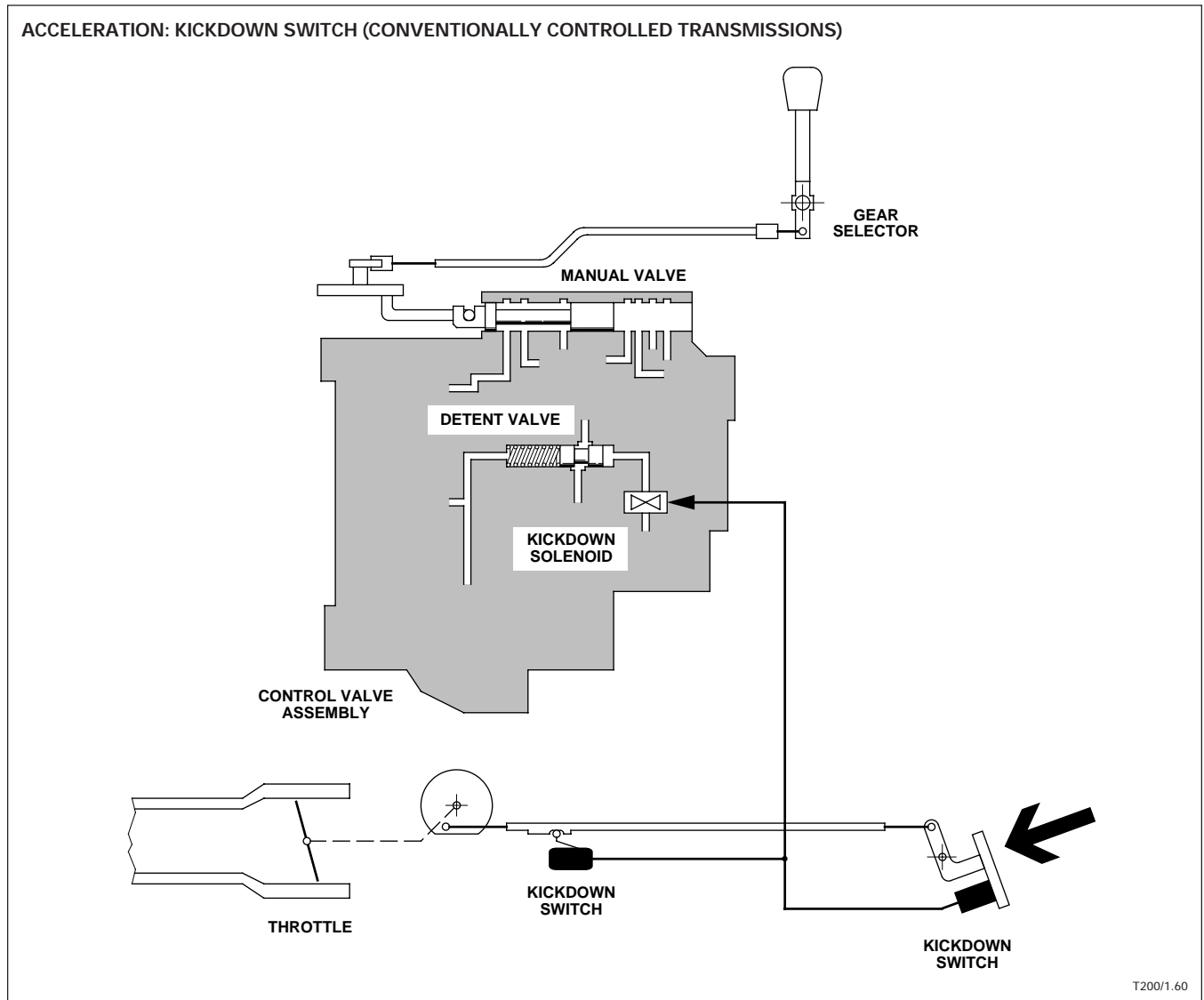
Kickdown (cable)

Transmissions using a throttle valve positioned by a cable will kickdown when the throttle opens rapidly. Kickdown occurs because the spring pressure in the balanced valve suddenly changes.



Kickdown (switch)

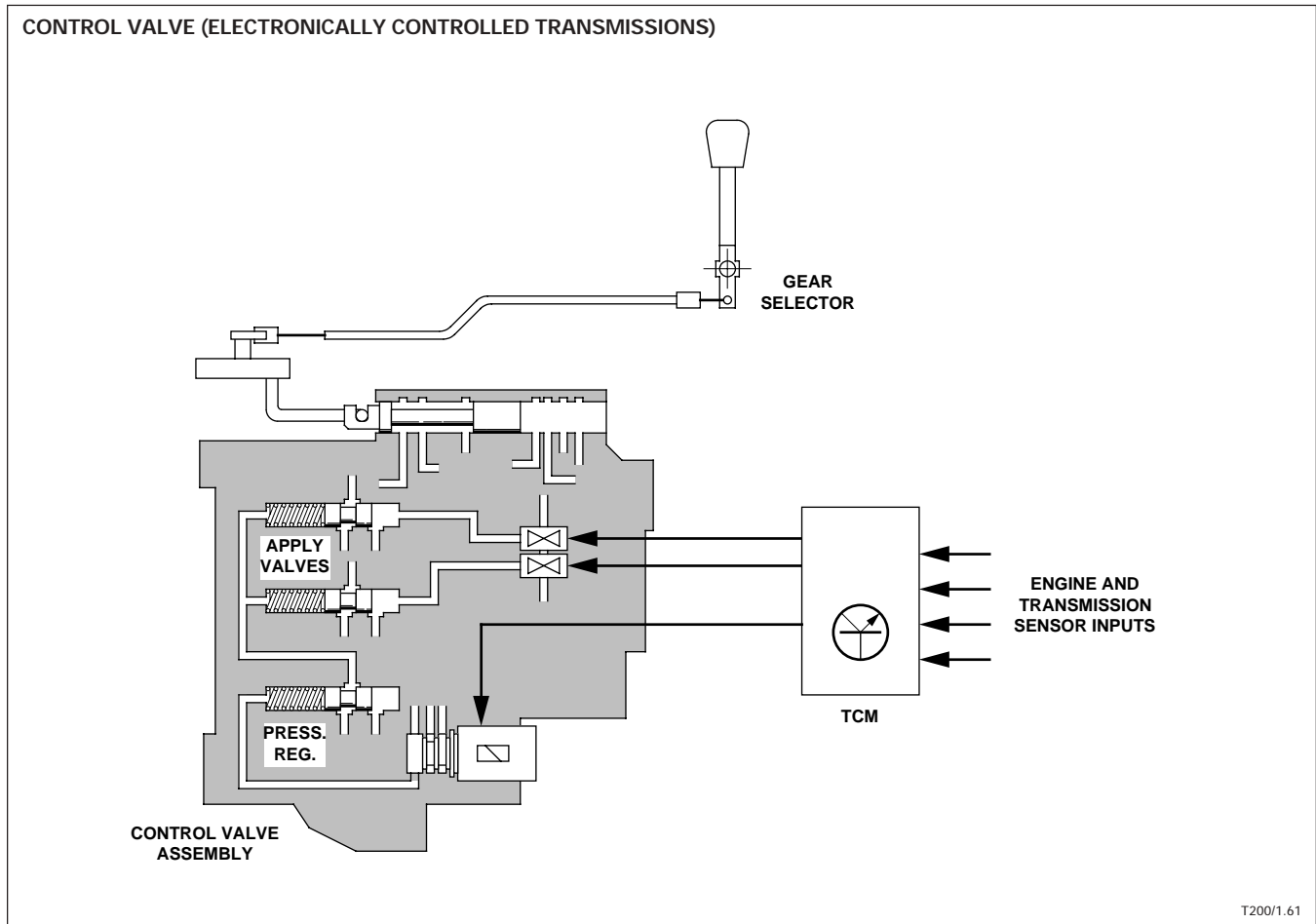
Transmissions using a modulator valve arrangement use a kickdown switch to activate a kickdown solenoid, which in turn switches the modulator function to the detent valve, causing kickdown to occur.



Control Valves (Valve Bodies): Electronically Controlled Transmissions

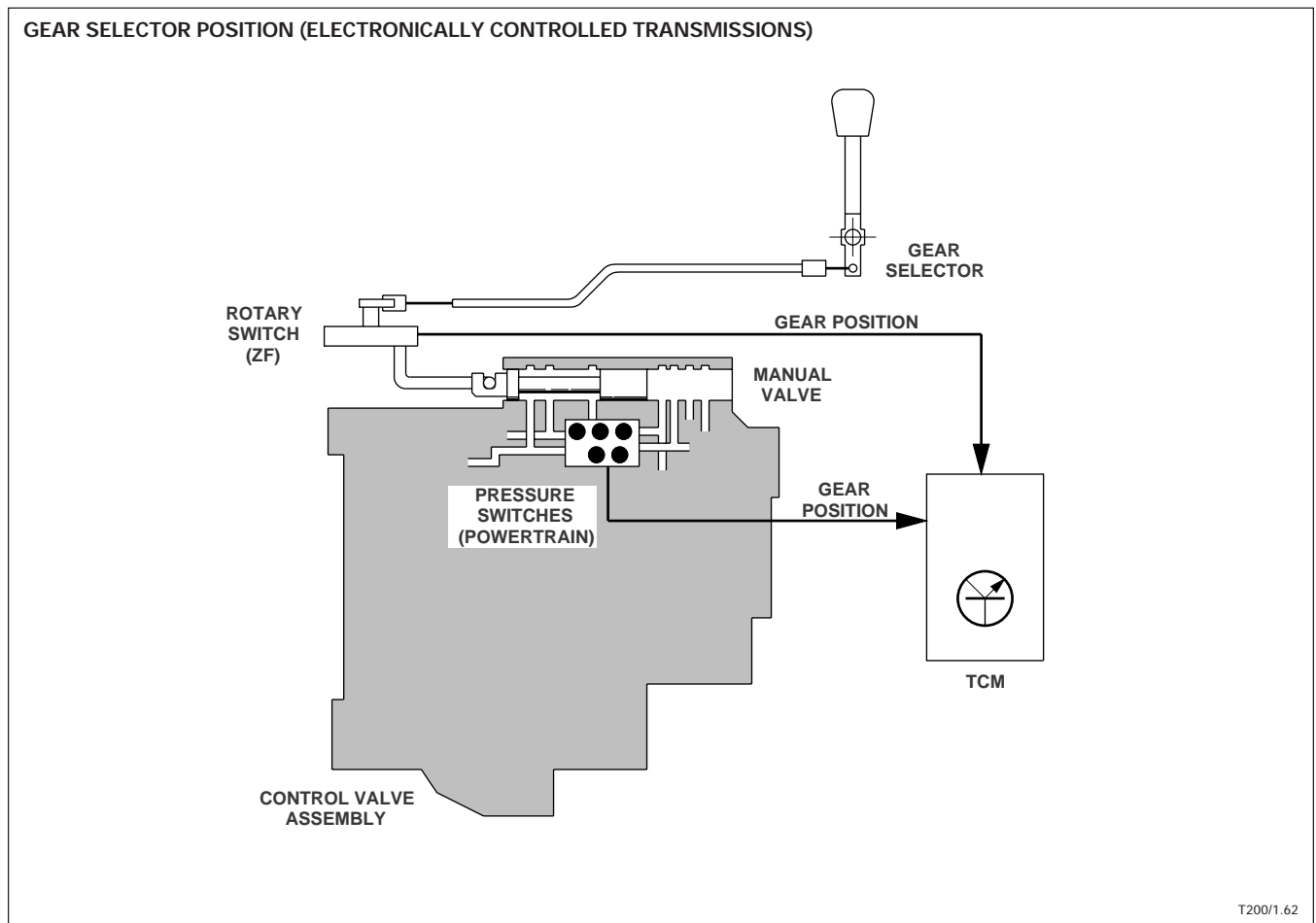
Control Valve Assembly

The electronically controlled transmission uses a manual valve for driver selected gears. All apply functions and hydraulic line pressure are controlled by the transmission control module (TCM). The TCM determines the necessary control outputs based on sensor inputs. The TCM matches the transmission shift points to the combined sensor inputs and positions the solenoid and line pressure control valves, which in turn control the apply functions.



Gear selector position input to the TCM

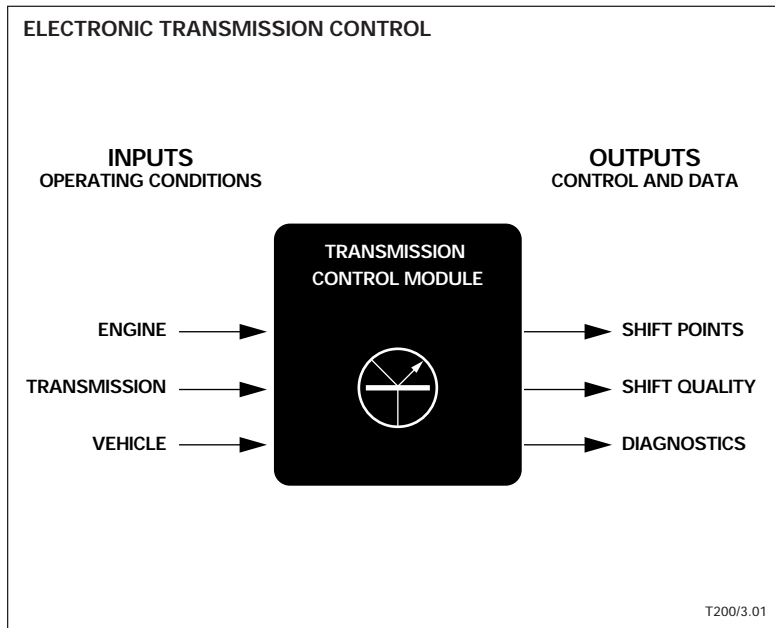
The position of the manual valve is input to the TCM in one of two ways, depending on the type of transmission. The PowerTrain transmission uses a pressure switch manifold containing switches that are closed (activated) by hydraulic pressure supplied from the various manual valve ports. The combined switch positions are output to the TCM as an indication of the selected gear. The ZF transmission uses a mechanical rotary switch, mounted outside the transmission, to signal the selected gear to the TCM.



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Transmission Control Components	25 – 35

Overview



The ZF 4 HP 24 E9 is an electronic four-speed automatic transmission that utilizes a transmission control module (TCM) to control shift points, torque converter clutch apply and release, and line pressure. Inputs from sensors and switches provide engine, transmission, and vehicle operating information to the TCM. The TCM uses this information to determine the precise moment to operate the three transmission solenoid valves and pressure control regulator, which cause the transmission to upshift or down shift, apply or release the torque converter clutch, and provide the correct line pressure for component operation. The TCM also incorporates an on-board diagnostic facility that monitors transmission component operation and signal conditions. This type of transmission control, based on vehicle operating conditions, results in precise shift points and shift quality.

The transmission interfaces with the engine control module (ECM). The engine management system (EMS) and transmission control systems operate jointly to provide smooth effortless control of the vehicle power train.

Seven multi-plate disc clutches and three one-way clutches make up the application devices required to obtain the gears and gear ratios. Two planetary gear sets (one compound, one single) provide four forward gears and reverse.

Power loss through the torque converter at cruising speeds is minimized with a lockup feature. When locked-up, the torque converter forms a fixed mechanical connection between the engine and the transmission gearbox.

NORMAL, SPORT and DELETE FIRST Modes

Depending on the model year, up to three operating strategies are available to the driver.

NORMAL

This strategy is designed for everyday use. With DRIVE selected, torque converter lockup occurs in fourth gear only; with "3" selected, lockup will not occur. High speed performance is available as required.

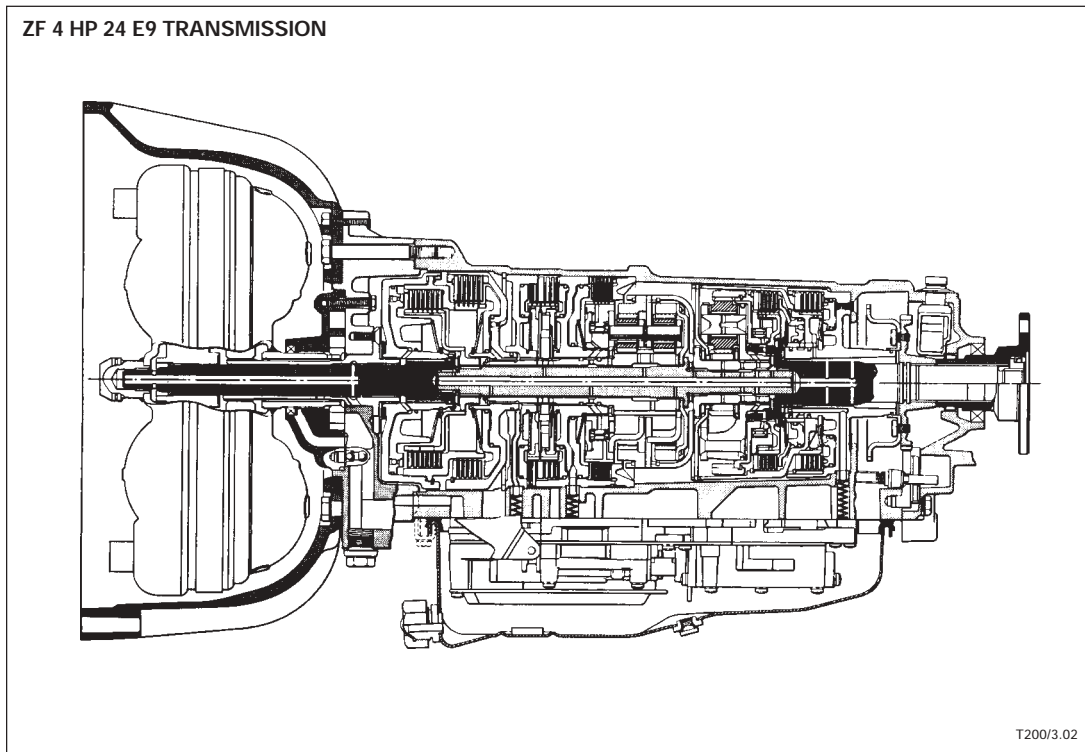
SPORT

This strategy makes the transmission more sensitive to throttle position. Kickdown occurs more readily at higher engine speeds. During acceleration, gears are held longer. Part throttle downshift to first speed is possible. Torque converter lockup occurs only in fourth gear.

DELETE FIRST

DELETE FIRST mode provides a second gear start-off to help prevent wheel spin on road surfaces with poor traction. If delete first is selected with the gear selector in DRIVE, the transmission will momentarily engage first gear before engaging second gear.

PLEASE NOTE: TO AID IN THE UNDERSTANDING OF THE AUTOMATIC TRANSMISSION CONTROL SYSTEM, REFER TO THE APPLICABLE JAGUAR ELECTRICAL GUIDE FOR ELECTRICAL CIRCUIT DETAILS, COMPONENT INFORMATION, AND PIN-OUT DATA.



Specifications

	First	Second	Third	Fourth	Reverse
Gear Ratios	2.48 : 1	1.48 : 1	1.00 : 1	0.73 : 1	2.09 : 1

Converter lockup occurs:

Fourth gear

At approx. 52 mph (normal highway speed)

Torque converter Stall speed 1900 rpm + 150 rpm

Oil cooler Integral with radiator, left side

Transmission fluid Dexron II 'D'; check at normal operating temperature:
176° F (80° C)

Approximate capacity from dry 8.5 qt. (8 liters)

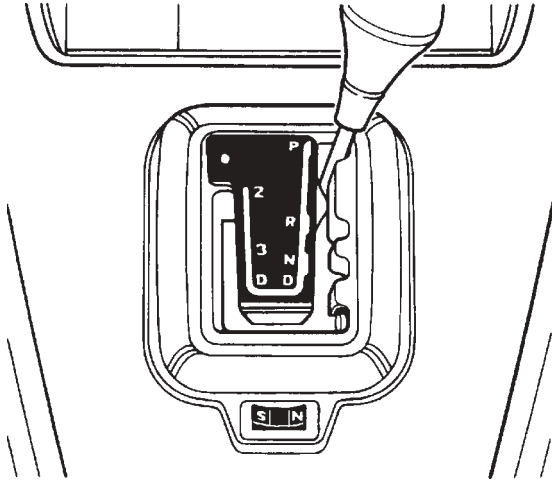
Drain and refill 3.2 qt. (3 liters)

NOTES

Gear Selectors

Both the Sedan and XJS Range gear selectors provide fully automatic or manual control of transmission shifting. Refer to the Gear Shift Interlock section for descriptions of the selector assemblies and the interlock system.

SEDAN RANGE GEAR SELECTOR



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Sedan Range

The unique 'J' gate selector gives the driver a choice between the fully automatic modes on the right – P, R, N, D – and manually selected gears on the left – D, 3, 2.

XJS Range

The XJS gear selector provides the driver with fully automatic operation in D or the choice of selecting position 3 or 2.

Gear Positions

Position "D"

All four gear ratios are selected automatically. Torque converter lockup occurs in fourth gear only.

Position "3"

Only the three lowest gear ratios are available. These are selected automatically.

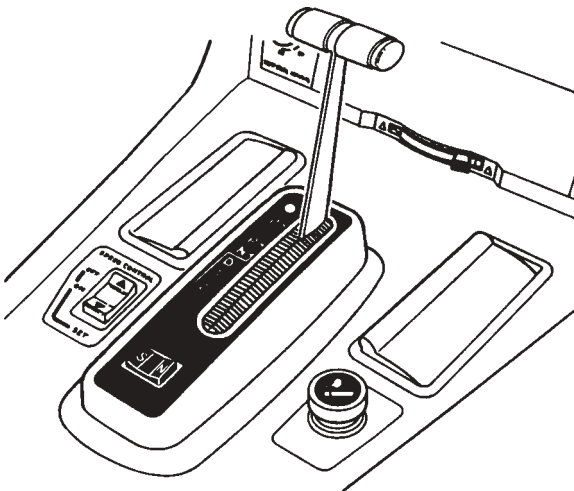
Position "2"

Only the two lowest gear ratios are available. These are selected automatically. Position "2" can be selected at any road speed; however the TCM (transmission control module) will prevent the transmission from down shifting until the road speed reaches a point where the engine will not over-speed.

Kickdown

Kickdown is mechanically activated via the kickdown switch located under the accelerator pedal.

XJS RANGE GEAR SELECTOR



T200/3.04

NOTES

Hydraulic System

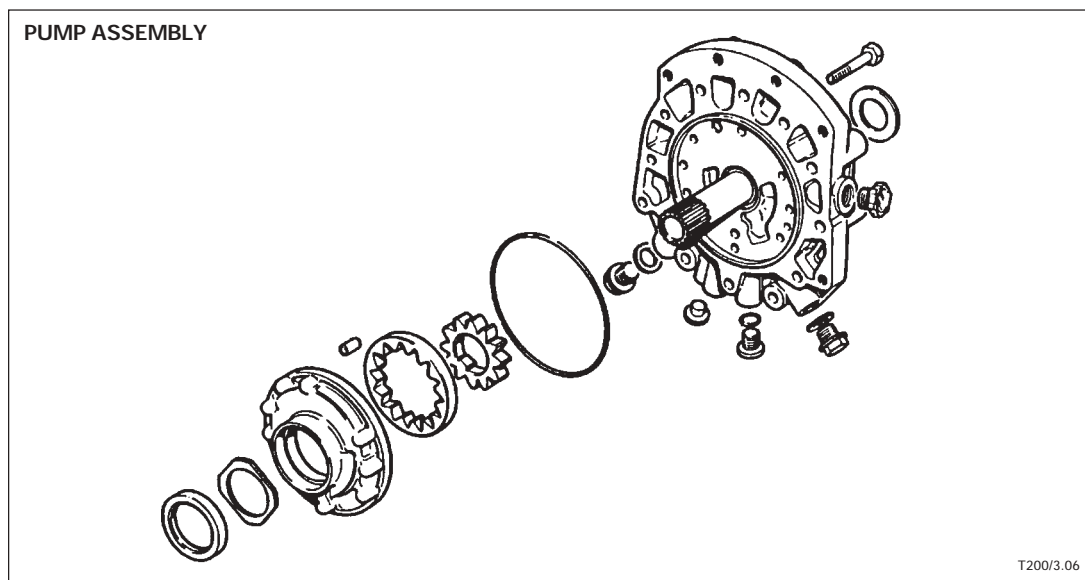
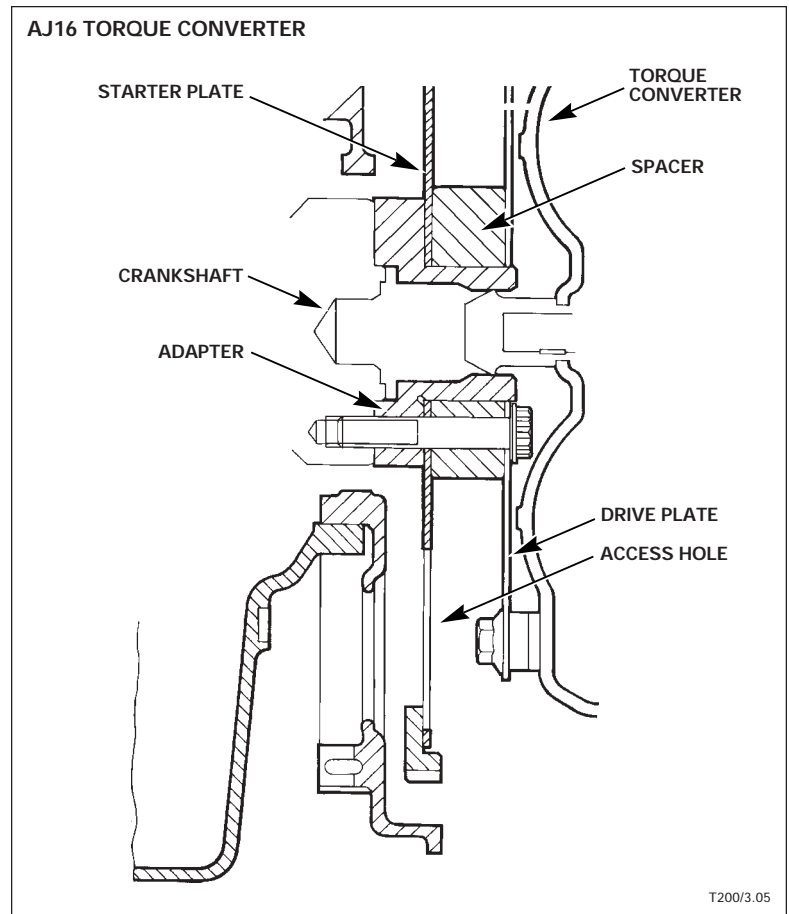
Torque Converter

The power train in AJ16 engine vehicles utilizes a reduced mass torque converter that improves engine response. The depth of the torque converter is reduced 1.18 in (30 mm) from the converter used in AJ6 vehicles. In order to allow the use of the same torque converter housing (bell housing), a spacer and drive plate are added between the crankshaft and the torque converter.

NOTE: The AJ6 torque converter is attached to the drive plate with 6 bolts. The AJ16 torque converter attaches to the drive plate with 3 bolts.

Pump Assembly

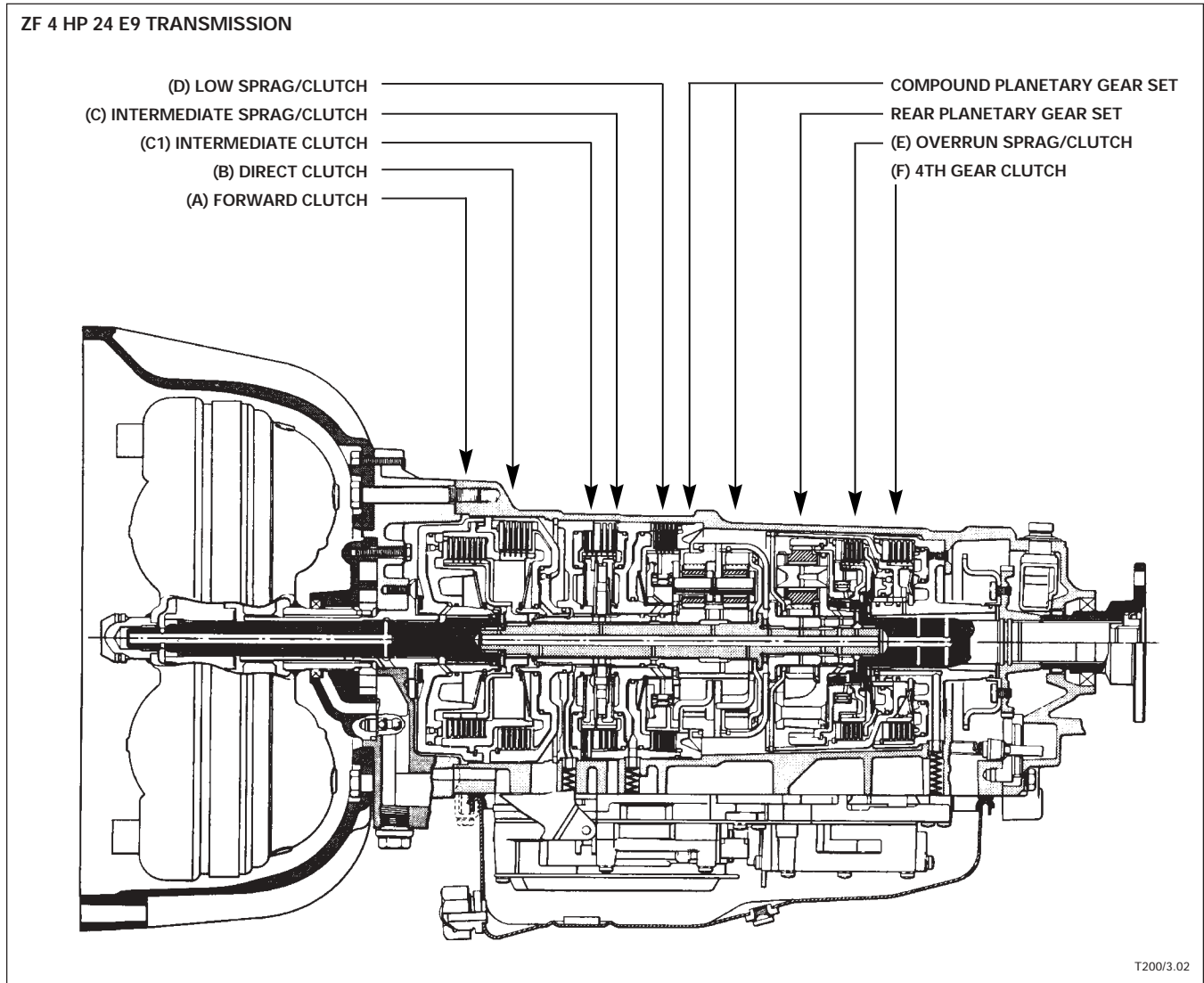
The pump assembly is a conventional "crescent type" pump that is driven by the torque converter hub. The pump rotates at engine speed. The pump housing is fastened from the rear of the transmission intermediate plate. The bell housing / intermediate plate assembly must be removed to access the pump retaining bolts.



NOTES

ZF 4 HP 24 E9 Automatic Transmission

Power Transmission



NOTES

APPLICATION SUMMARY: ALL RANGES AND GEARS

RANGE	FORWARD CLUTCH (A)	DIRECT CLUTCH (B)	INTERMEDIATE CLUTCH BRAKE (C1)	INTERMEDIATE CLUTCH & O.W.C (C)	LOW CLUTCH (D)	LOW CLUTCH & O.W.C. (D)	OVERRUN CLUTCH & O.W.C. (E)	4th GEAR CLUTCH (F)
DRIVE 1	Drives Annulus C/W					Holds F/Carrier against A/C/W	Drives Output Shaft C/W	
DRIVE 2	Drives Annulus C/W		Holds Sun gear against A/C/W	Holds Sun gear against A/C/W			Drives Output Shaft C/W	
DRIVE 3	Drives Annulus C/W	Drives Sun gear C/W		Holds Sun gear against A/C/W			Drives Output Shaft C/W	
DRIVE 4	Drives Annulus C/W	Drives Sun gear C/W		Holds Sun gear against A/C/W			Drives Output Shaft C/W	Holds Sun gear (4th Gear set)
REVERSE		Drives Sun gear C/W			Holds Carrier against C/W		Drives Output Shaft A/C/W	
PARK, NEUTRAL							Applied (Hydraulics)	

T200/3.08

NOTE: Power flow descriptions and exploded views of the clutches and planetary gear sets are shown on the following pages.

NOTES

Power Transmission (continued)

First Gear

The FORWARD (A) CLUTCH and the OVERRUN (E) CLUTCHES are applied. When the engine is pulling, the front planetary gear carrier of the COMPOUND PLANETARY GEAR SET is locked against the transmission case through the one way clutch. When the engine is coasting, the planet carrier overruns. The REAR PLANETARY GEAR SET rotates as a unit with the front planet carrier. When the gear selector is in position 1 and the transmission is in speed range 1, the LOW CLUTCH is applied to permit engine braking.

Second Gear

The FORWARD (A), INTERMEDIATE (C), and OVERRUN (E) CLUTCHES, as well as the INTERMEDIATE CLUTCH BRAKE (C1) are applied. The one way clutch under the LOW (D) CLUTCH overruns. The hollow shaft with the REAR PLANETARY GEAR SET rotates as a unit.

Third Gear

The FORWARD (A), DIRECT (B), INTERMEDIATE (C), and OVERRUN (E) CLUTCHES are applied. The one way clutches under the INTERMEDIATE (C) and LOW (D) CLUTCHES overrun. The rear unit of the COMPOUND PLANETARY and REAR PLANETARY GEAR SETS rotate as a unit at a ratio of 1 : 1.

Fourth Gear

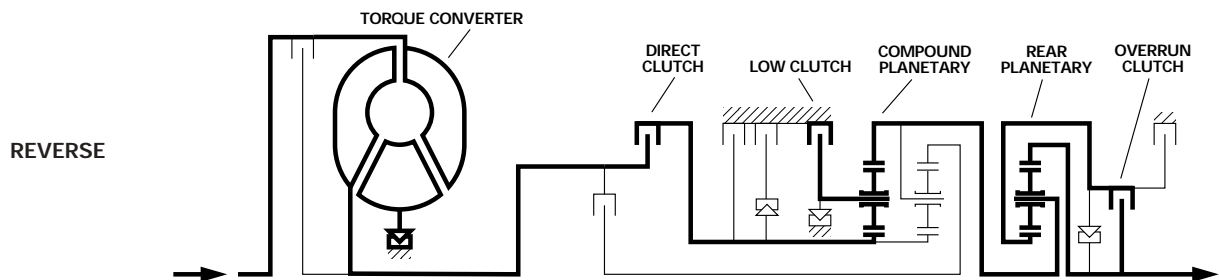
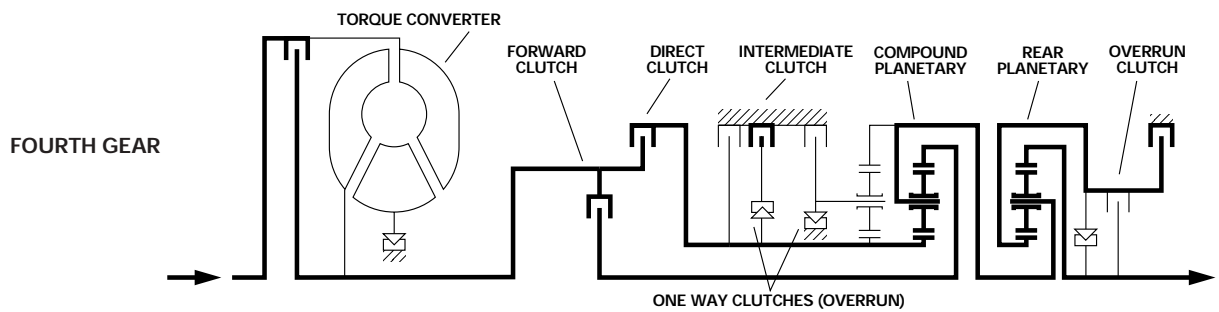
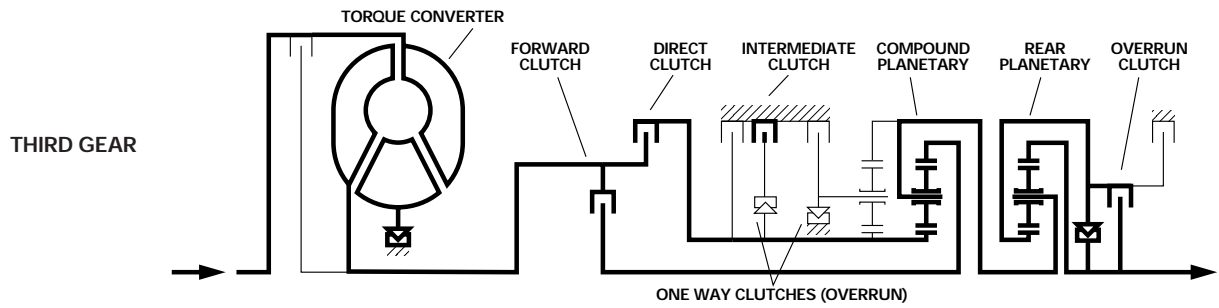
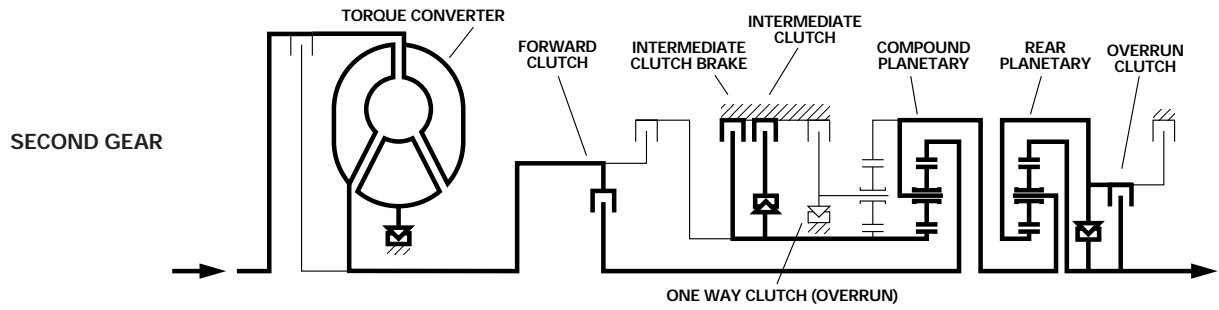
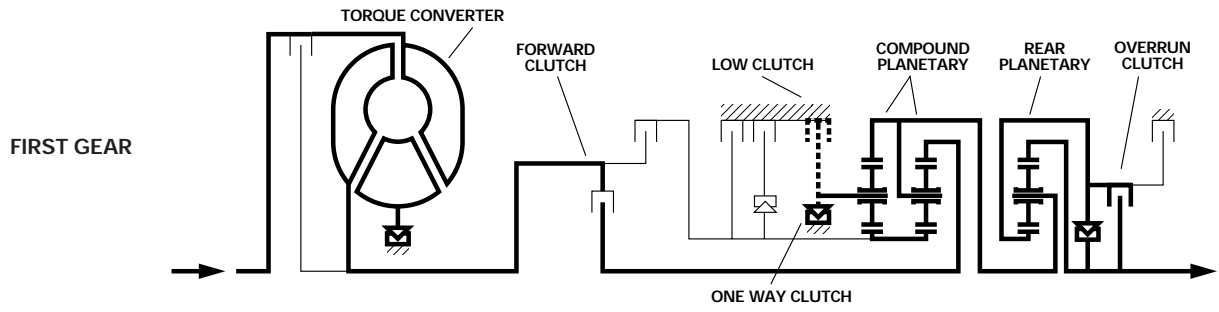
The FORWARD (A), DIRECT (B), INTERMEDIATE (C) and 4th GEAR (F) CLUTCHES are applied. All one way clutches overrun. The rear unit of the COMPOUND PLANETARY GEAR SET is locked. Above a predetermined road speed, the lockup clutch is applied to couple the engine directly to the transmission.

Reverse

The DIRECT (B), LOW (D) and OVERRUN (E) CLUTCHES are applied. The front planet carrier of the COMPOUND PLANETARY GEAR SET is locked reversing the direction of the output shaft rotation. The REAR PLANETARY GEAR SET rotates as a unit.

NOTES

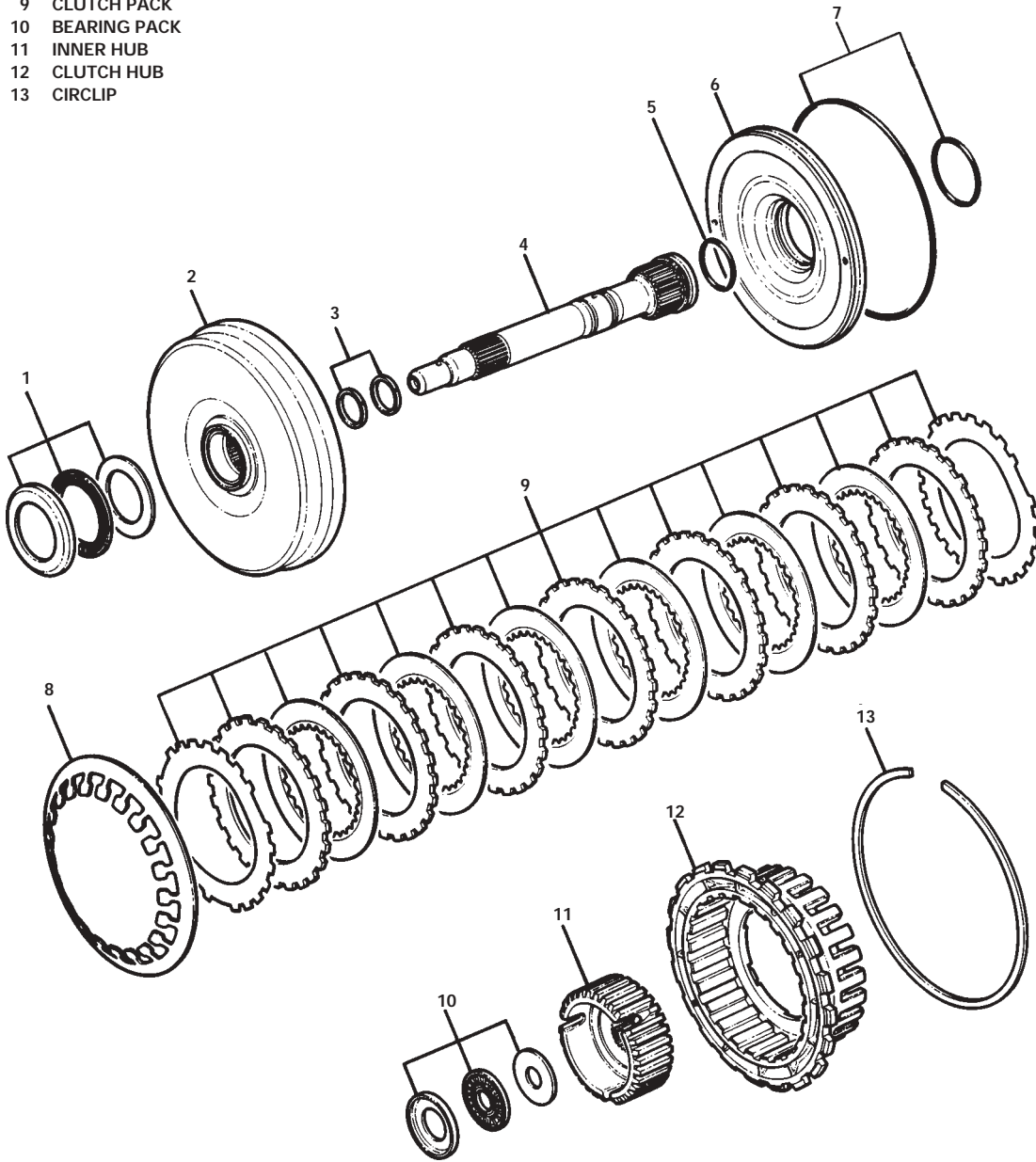
CUTCH AND PLANETARY GEAR POWER FLOW



Power Transmission (continued)

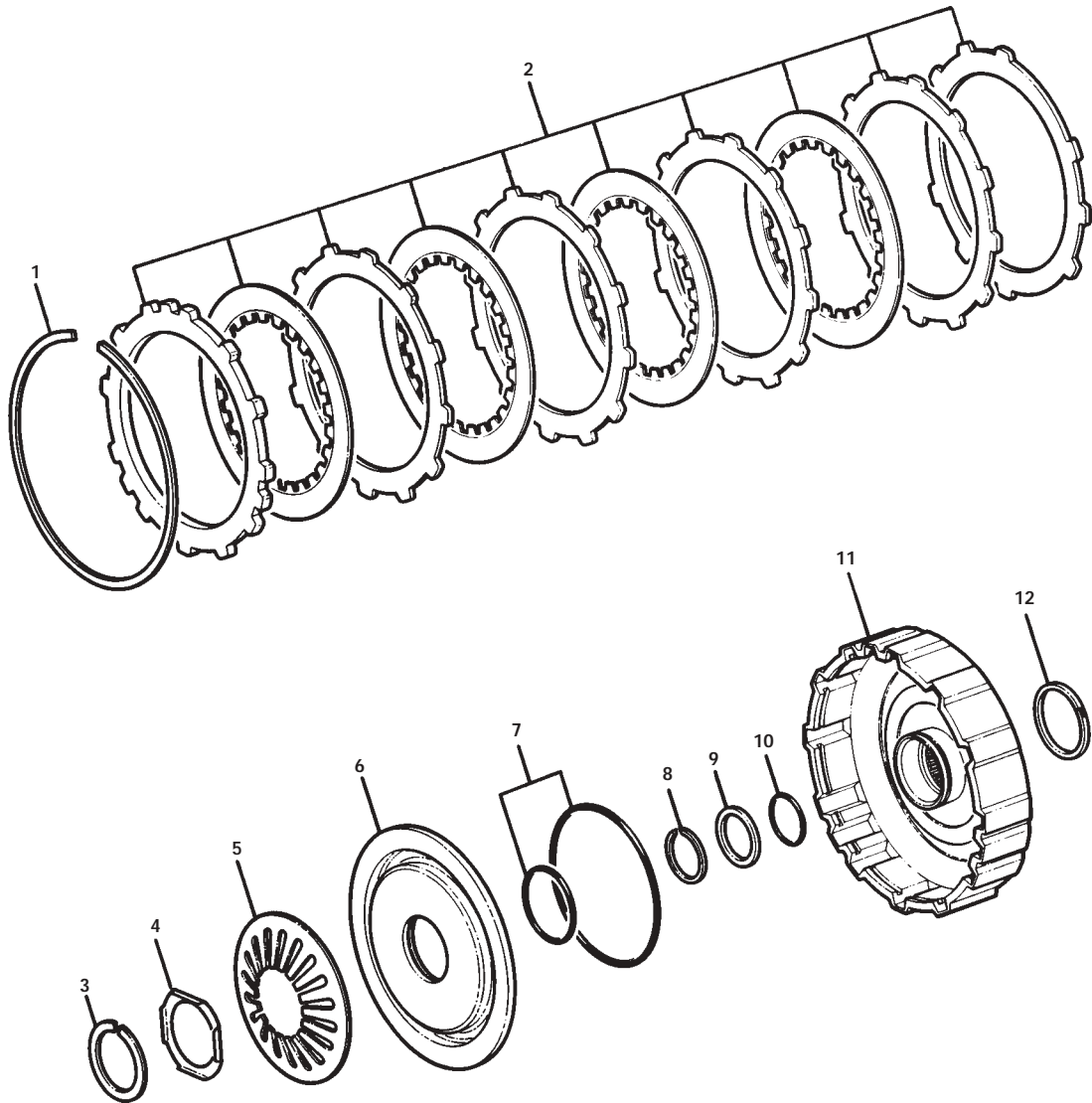
FORWARD (A) CLUTCH

- 1 BEARING PACK
- 2 CLUTCH DRUM
- 3 SEALING RINGS
- 4 TURBINE SHAFT
- 5 'O' RING
- 6 PISTON
- 7 'O' RING SEALS
- 8 DIAPHRAGM
- 9 CLUTCH PACK
- 10 BEARING PACK
- 11 INNER HUB
- 12 CLUTCH HUB
- 13 CIRCLIP



DIRECT (B) CLUTCH

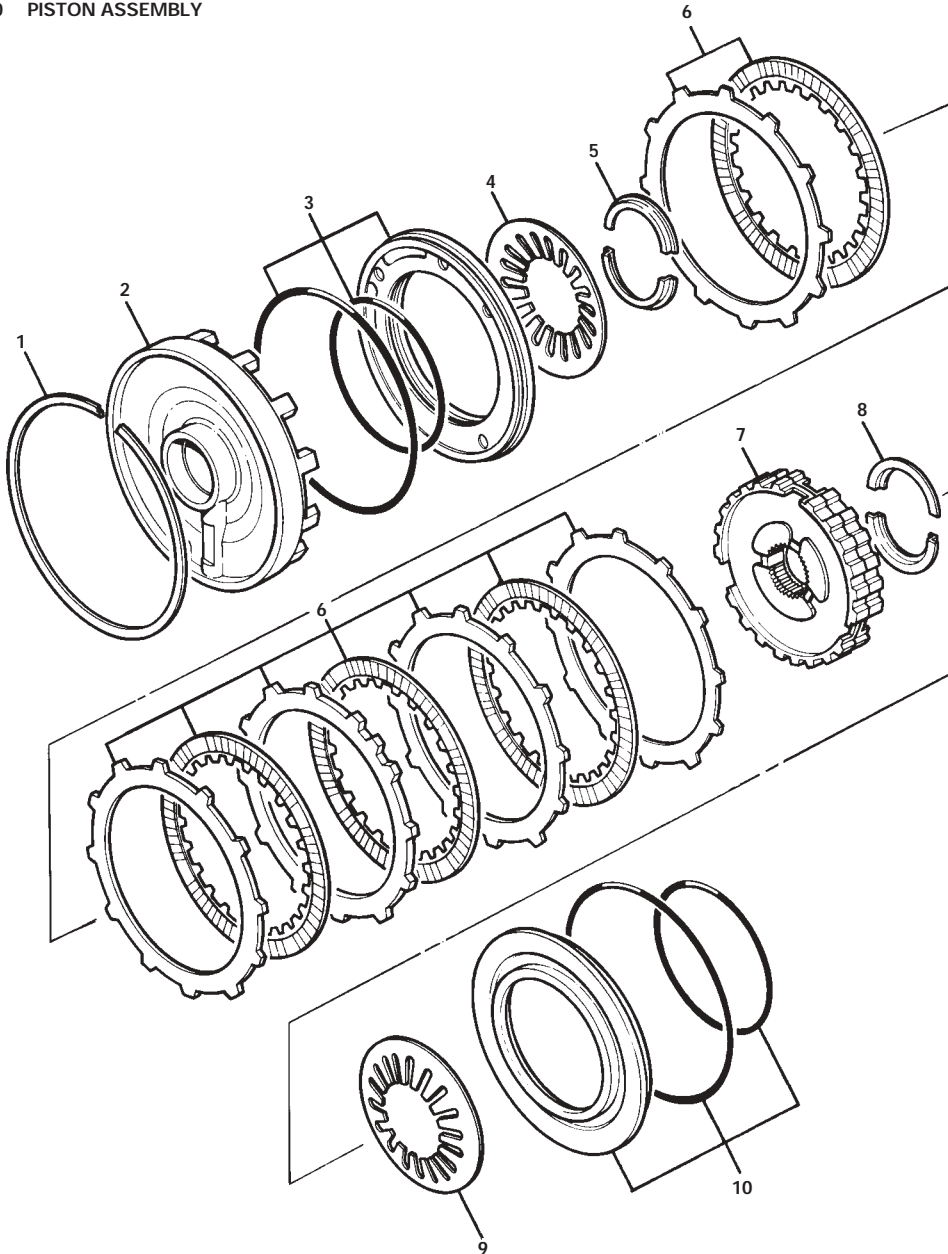
- 1 CIRCLIP
- 2 STEEL AND COMPOSITION-FACED CLUTCH PLATES
- 3 CIRCLIP
- 4 RETAINER
- 5 DIAPHRAGM
- 6 PISTON
- 7 'O' RING SEALS
- 8 CIRCLIP
- 9 RETAINER
- 10 'O' RING
- 11 B CLUTCH DRUM
- 12 SEALING RING



Power Transmission (continued)

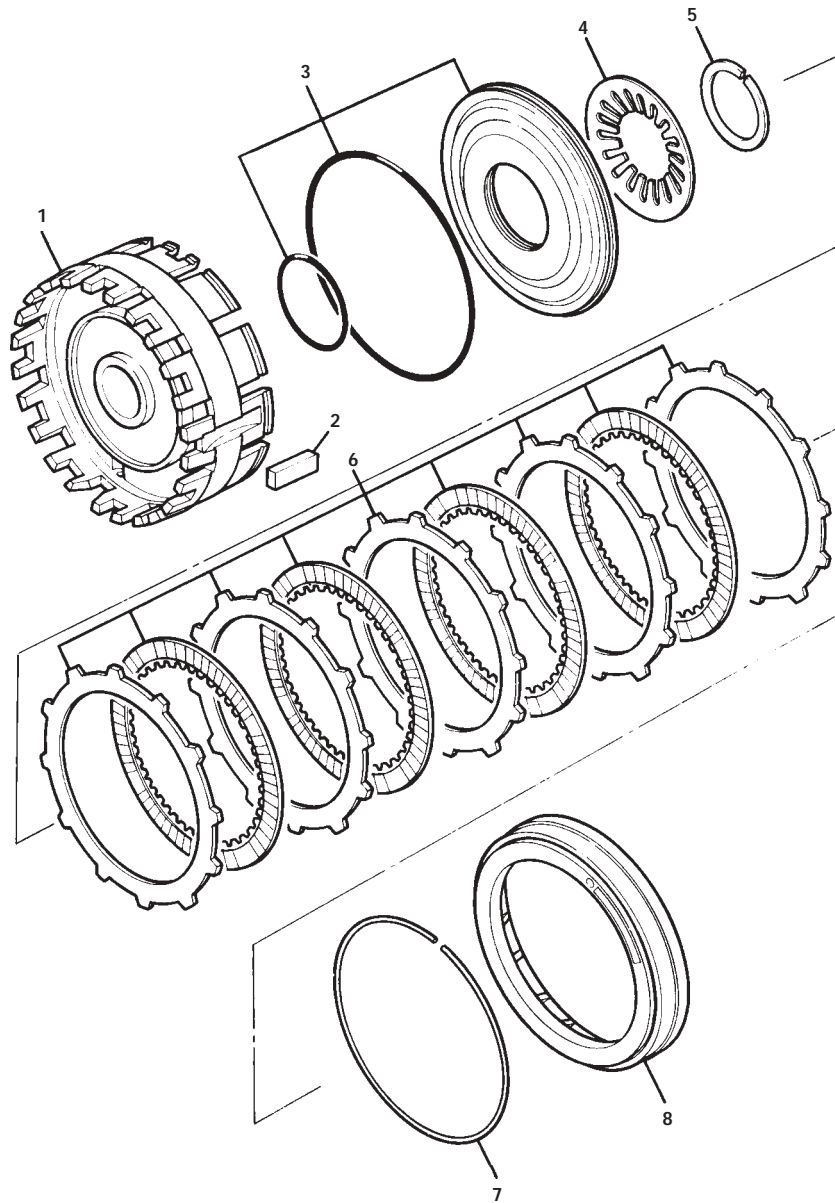
INTERMEDIATE (C) CLUTCH AND ONE-WAY CLUTCH (O.W.C.)

- 1 CIRCLIP
- 2 C1 CLUTCH HOUSING
- 3 PISTON ASSEMBLY
- 4 DIAPHRAGM
- 5 RETAINING CLIPS
- 6 STEEL AND COMPOSITION-FACED CLUTCH PLATES
- 7 INNER HUB AND O.W.C. ASSEMBLY
- 8 RETAINING CLIPS
- 9 DIAPHRAGM
- 10 PISTON ASSEMBLY



LOW (D) CLUTCH

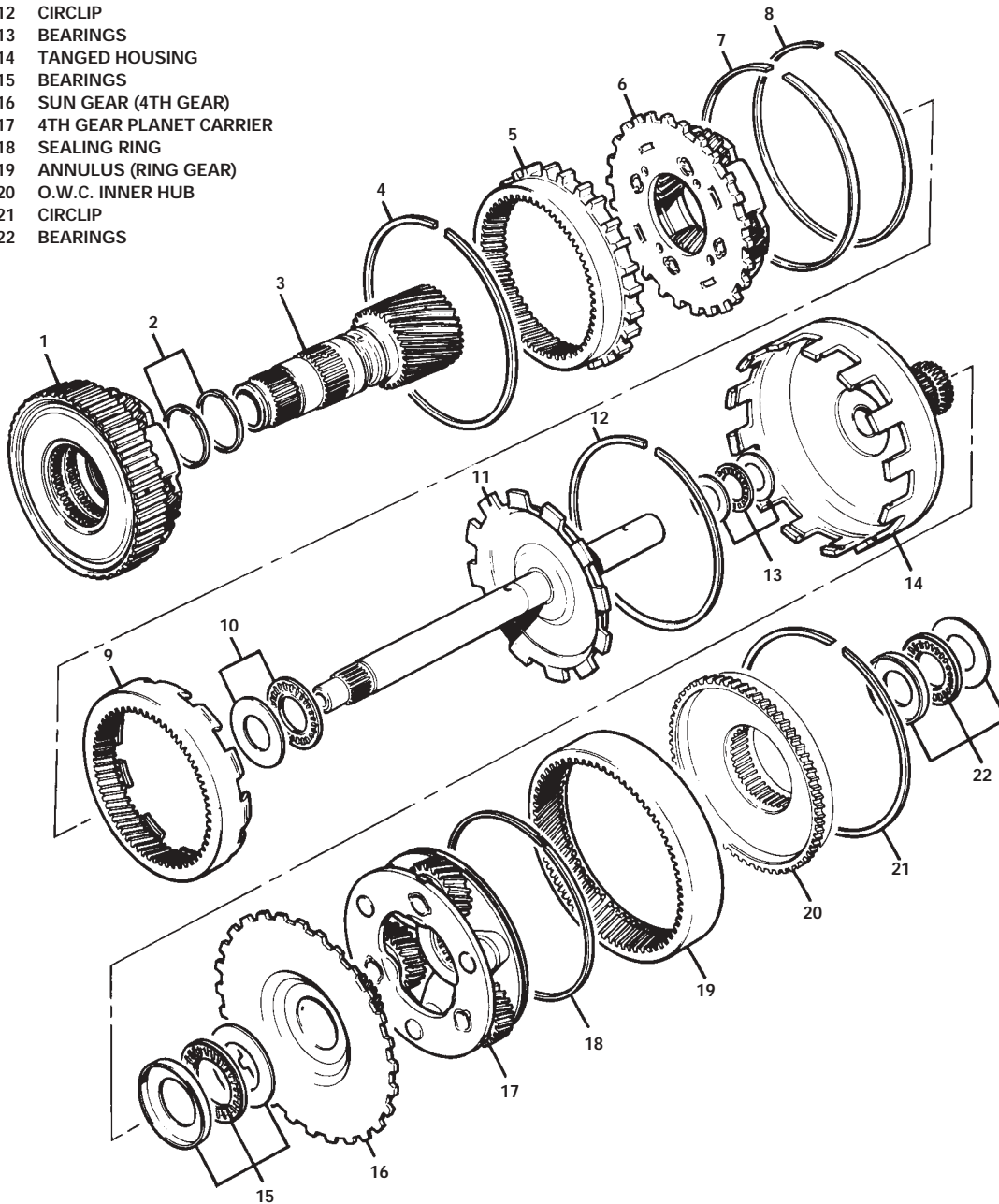
- 1 C & D CLUTCH HOUSING
- 2 C & D CLUTCH HOUSING LOCATION KEYS
- 3 PISTON ASSEMBLY AND 'O' RING SEALS
- 4 DIAPHRAGM
- 5 CIRCLIP
- 6 STEEL AND COMPOSITION-FACED CLUTCH PLATES
- 7 RETAINING CLIP
- 8 SPACER HUB



Power Transmission (continued)

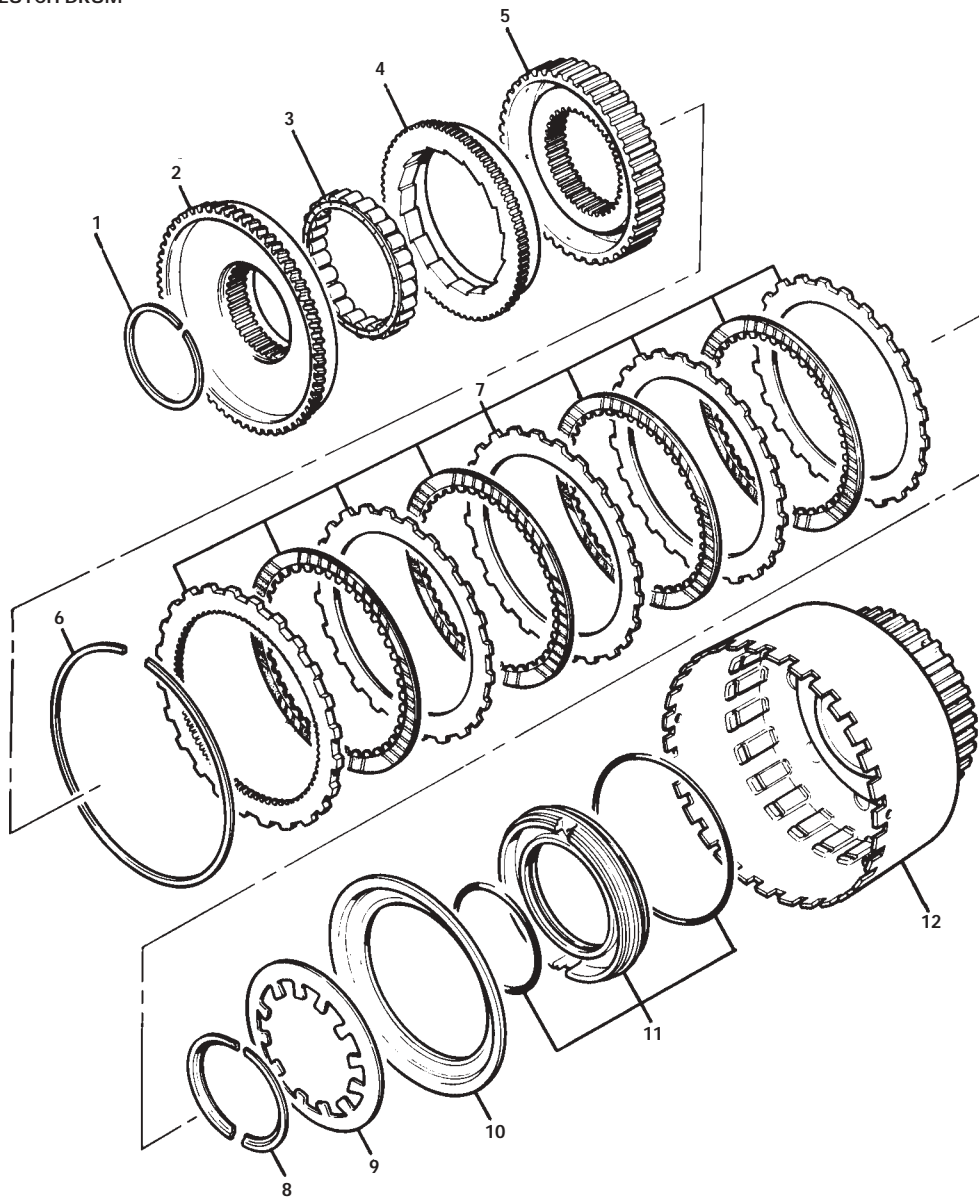
PLANETARY GEAR SETS

- 1 FRONT PLANET CARRIER AND D CLUTCH O.W.C.
- 2 SEALING RINGS
- 3 SUN GEAR
- 4 CIRCLIP
- 5 FRONT ANNULUS (RING GEAR)
- 6 REAR PLANET CARRIER
- 7 SPACER RING
- 8 CIRCLIP
- 9 REAR ANNULUS (RING GEAR)
- 10 BEARING
- 11 TANGED SHAFT
- 12 CIRCLIP
- 13 BEARINGS
- 14 TANGED HOUSING
- 15 BEARINGS
- 16 SUN GEAR (4TH GEAR)
- 17 4TH GEAR PLANET CARRIER
- 18 SEALING RING
- 19 ANNULUS (RING GEAR)
- 20 O.W.C. INNER HUB
- 21 CIRCLIP
- 22 BEARINGS



OVERRUN (E) CLUTCH

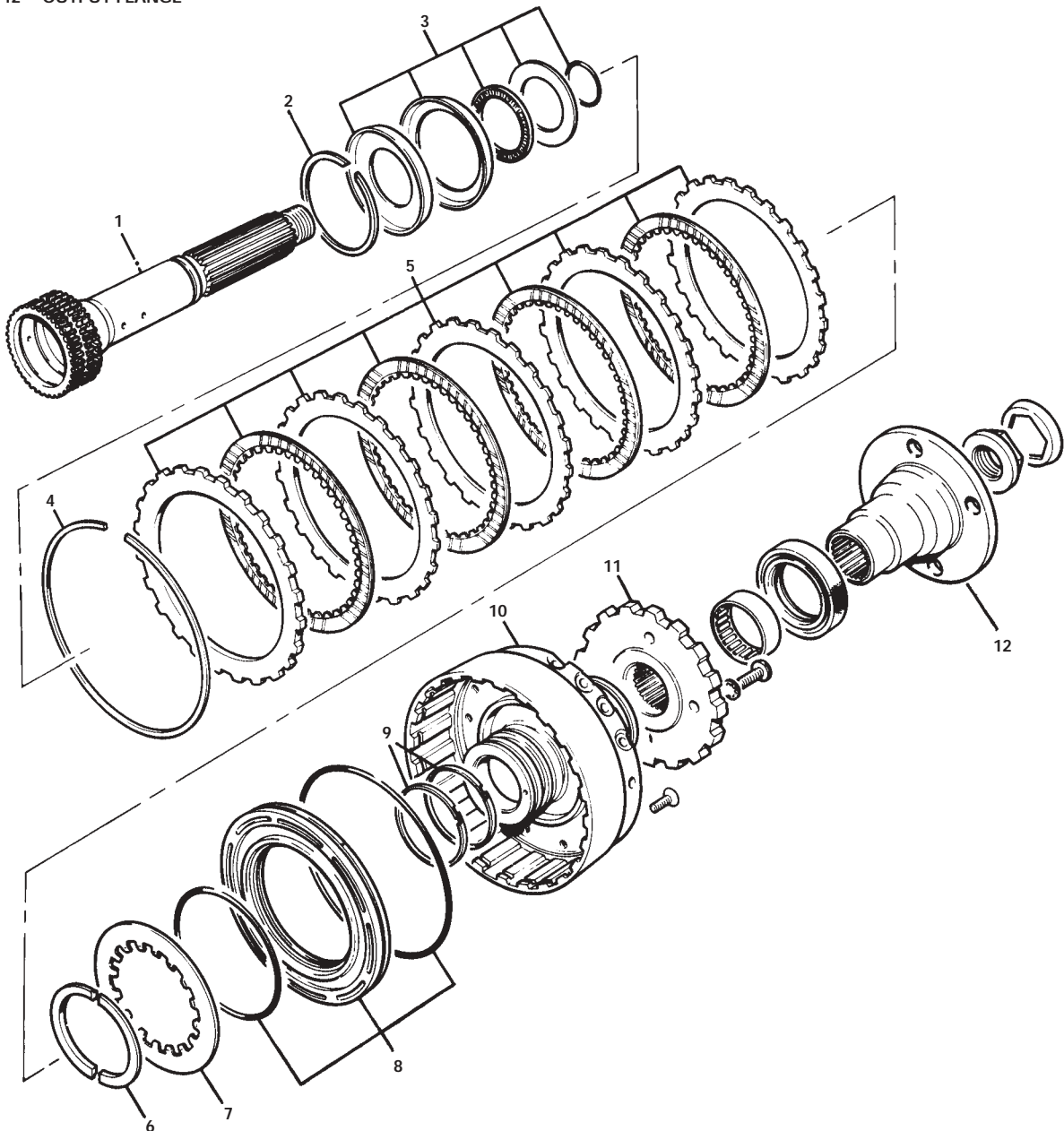
- 1 CIRCLIP
- 2 O.W.C. INNER HUB
- 3 O.W.C. ASSEMBLY
- 4 O.W.C. OUTER HUB
- 5 E CLUTCH INNER HUB
- 6 CIRCLIP
- 7 STEEL AND COMPOSITION-FACED CLUTCH PLATES
- 8 RETAINING CLIPS
- 9 DIAPHRAGM
- 10 DIAPHRAGM SPACER
- 11 PISTON ASSEMBLY
- 12 E CLUTCH DRUM



Power Transmission (continued)

4TH GEAR (F) CLUTCH AND GOVERNOR

- 1 OUTPUT SHAFT
- 2 CIRCLIP
- 3 BEARING ASSEMBLY
- 4 CIRCLIP
- 5 STEEL AND COMPOSITION-FACED CLUTCH PLATES
- 6 RETAINING CLIPS
- 7 DIAPHRAGM
- 8 PISTON ASSEMBLY AND 'O' RINGS
- 9 SEALING RINGS
- 10 F CLUTCH DRUM
- 11 PARKING RING
- 12 OUTPUT FLANGE



On-Board Diagnostics (OBD)

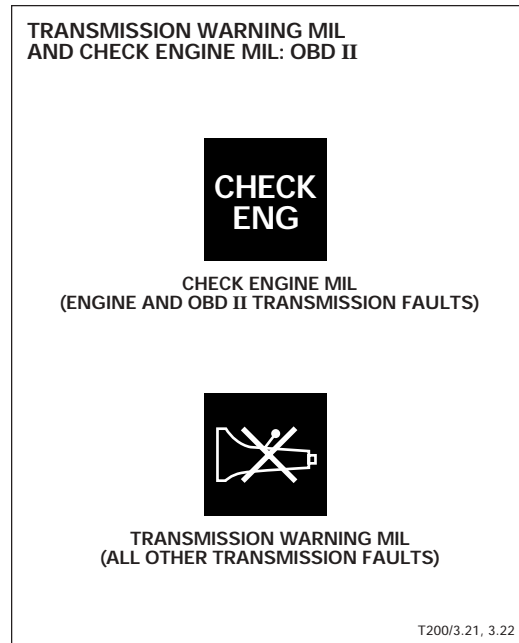
The transmission on-board diagnostic facility (OBD) monitors the transmission system for operating errors and faults. If a fault is detected by OBD monitoring or testing, it is registered in the TCM internal software. The TCM decides whether to flag a diagnostic trouble code (DTC) and whether to activate the TRANSMISSION MIL (Malfunction Indicator Light). If the fault is not critical, the TCM substitutes a default value for the faulty signal and continues normal operation. The vehicle can be operated normally, but shift quality may be effected. If the fault is critical, the TCM may substitute a default value for the faulty signal and revert to a "limp home" strategy. The vehicle can be driven but no automatic shifting will occur.

The OBD systems and diagnostic trouble codes (DTCs) vary depending on the engine management system (EMS) and model year of the vehicle.

OBD II: AJ16 Vehicles

The transmission OBD facility for AJ16 vehicles is expanded to comply with OBD II legislation. OBD II legislation requires monitoring and diagnosis of any power train system fault that will likely cause emissions to exceed 1.5 times the standard level. The TCM (transmission control module) and the ECM (engine control module) communicate with each other via serial communication. The TRANSMISSION MIL is activated by the TCM according to the transmission on-board diagnostic strategy. The CHECK ENGINE MIL is activated by the ECM (engine control module) if the transmission fault is classified as an OBD II fault. Therefore, either the TRANSMISSION MIL and / or the CHECK ENGINE MIL may be activated depending on the nature and classification of the fault.

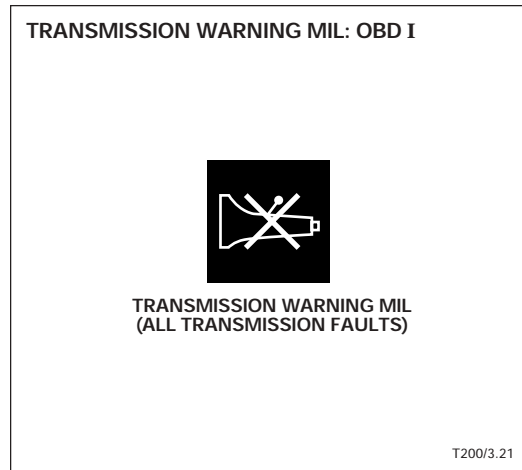
Each DTC is a five place industry standardized code that describes the subsystem and specific fault. DTCs are stored in a nonvolatile electronically erasable programmable read only memory (EEPROM), and can be accessed or erased only by Jaguar diagnostic equipment (PDU) or a generic (after market) scan tool. PDU allows advanced fault diagnostics by providing engine and transmission operating information and circuit information related to the fault. DTC access is via the vehicle data link connector.



NOTES

On-Board Diagnostics (OBD) (continued)

OBD I: AJ6 Vehicles



The AJ6 transmission on-board diagnostic facility is independent of the ECM and complies with OBD I legislation. The TRANSMISSION MIL is activated by the TCM according to the transmission on-board diagnostic strategy. The on-board diagnostic facility also provides diagnostic trouble codes and default strategies for the transmission. DTCs are expressed as two-digit codes by PDU and can be retrieved via serial communications. PDU provides additional diagnostic information, including the ambient temperature and gear position indicated at the time of failure. DTCs are stored in a volatile memory and will be lost if battery power is disconnected from the TCM.

Refer to the specific component and systems descriptions for explanations of fault parameters and DTCs. Refer to the Service Manual and DTC Summary information in this publication for a listing of DTCs.

Limp Home Facility

In case of certain critical faults, the OBD I and OBD II TCMs revert to a "limp home" mode by disabling the shift and torque converter clutch solenoids. This allows the vehicle to be operated but no shifting will occur in forward gears.

The limp home mode operates as follows:

If a failure occurs while the transmission is in fourth gear, fourth will remain engaged until the vehicle is stopped and the ignition key is cycled OFF then ON, or the vehicle is stopped, NEUTRAL is selected and DRIVE is reselected. Then, third gear will be engaged as long as the gear selector remains in drive and the fault is still present.

If a failure occurs while the transmission is in first, second or third gear, third will immediately be engaged and / or held.

Limp home is canceled when the ignition switch is cycled. Normal transmission operation will resume if the fault has been corrected or is intermittent and not present.

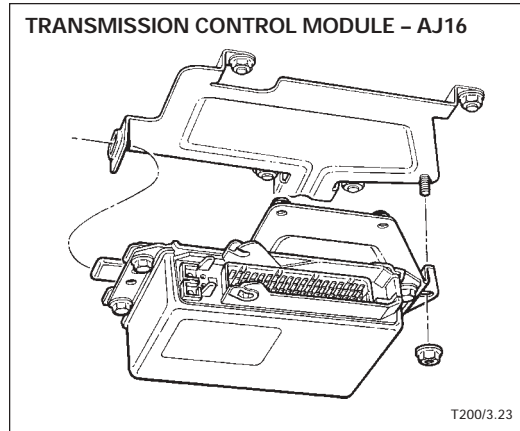
Refer to the DTC Summary on pages 37 – 43 to determine which faults will cause limp home.

NOTES

Transmission Control

Transmission Control Module (TCM)

The transmission is controlled by a microprocessor based TCM (transmission control module) that receives inputs from the transmission, ECM (engine control module) and other vehicle systems and components. The TCM supplies the input sensors with a five volt reference signal. The return input sensor information is applied to the transmission operating strategy programmed into the TCM memory. From the strategy, the TCM controls the shift solenoids and the pressure regulator solenoid. An on-board diagnostic facility (OBD) allows the TCM to diagnose transmission and related component problems. If the TCM detects a fault, it signals the ECM, stores a diagnostic trouble code (DTC) in memory and may activate the TRANSMISSION MIL depending on the nature of the fault. If the fault is classified as an OBD II fault, the ECM will activate the CHECK ENGINE MIL. In some cases the TCM substitutes a default value for the faulty signal. For critical faults, the TCM enters the "limp home" mode and disables the shift and converter clutch solenoids.



The TCM used in AJ16 (OBD II compliant vehicles) utilizes a nonvolatile memory for the storage of DTCs. DTCs will be retained in TCM memory with battery power disconnected. In addition, the TCM is PECUS (programmable electronic control system) programmed at the factory for specific markets.

The TCM used in AJ6 (OBD I complaint vehicles) has a volatile memory. DTCs will be lost if battery power is disconnected.

AJ16 transmission control module diagnostic monitoring

The TCM monitors itself and will flag a DTC under the following conditions:

- If the TCM supply voltage is below 10.5V and engine speed is above 1600 rpm, DTC P1794 will flag.
- When the vehicle is started or the TCM is reset, the TCM internal relay circuit controlling the voltage supply for the transmission control valve solenoids is tested. A fault will trigger DTC P0702.
- The TCM logs internal memory errors. After 100 "read" errors, the TCM will flag DTC P0603.
- The TCM tests the integrity of its data. After two consecutive "checksum errors" DTC P0605 will flag.
- A diagnostic facility within the TCM monitors the state of the TCM internal timing. If no timing pulse is detected within 10 ms, DTC P1608 will be flagged.

DTC	Component / signal	Trans MIL	Check Engine MIL (95 MY ON)	Limp home
P0603	TCM internal memory error	–	YES	–
P0605	TCM data corrupted	YES	YES	YES
P0702	TCM internal solenoid control relay malfunction	YES	YES	YES
P1608	TCM internal timing error	YES	YES	YES
P1794	TCM voltage supply low	YES	YES	YES

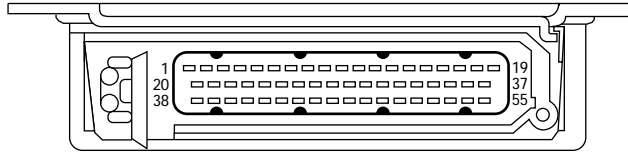
Refer to the DTC Summary, pages 37 – 43.

Transmission Control (continued)

Transmission control module pin-out information

NOTE: For more detailed pin-out information, refer to the Electrical Guide.

TYPICAL TRANSMISSION CONTROL MODULE PIN-OUT INFORMATION

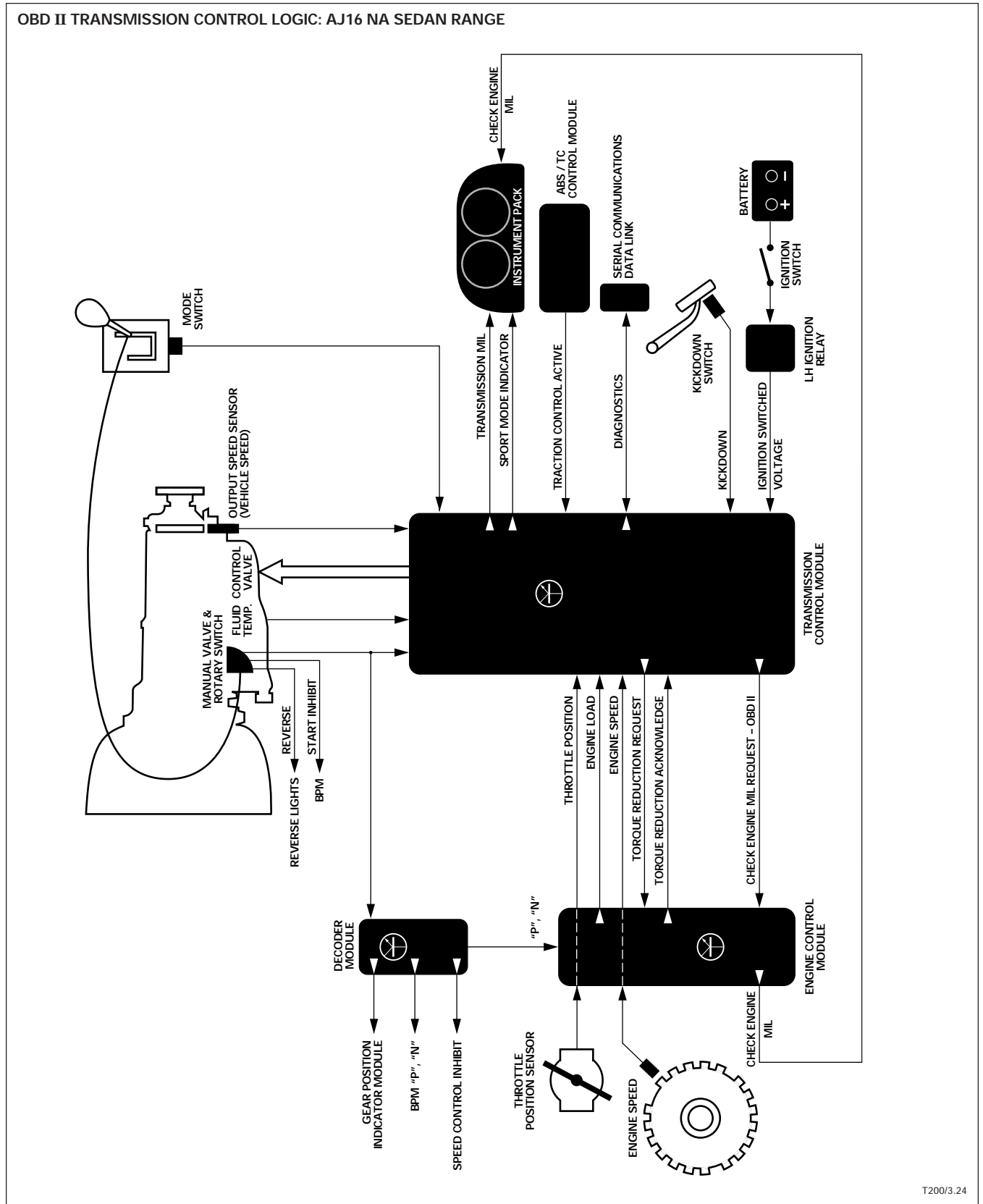


1	POWER SUPPLY	20	NOT USED	38	ROAD SPEED (-)
2	ROAD SPEED (+)	21	ENGINE TORQUE SIGNAL	39	NOT USED
3	ENGINE SPEED	22	NOT USED	40	NOT USED
4	MODE SELECTOR INPUT B	23	NOT USED	41	KICKDOWN SWITCH
5	SOLENOID VALVE MV1 CONTROL	24	SOLENOID VALVE MV2 CONTROL	42	SOLENOID VALVE MV3 CONTROL
6	FLUID PRESSURE REGULATOR CONTROL	25	NOT USED	43	NOT USED
7	DIGITAL GROUND	26	POWER GROUND	44	FLUID TEMPERATURE GROUND
8	NOT USED	27	NOT USED	45	NOT USED
12	NOT USED	28	NOT USED	46	FLUID TEMPERATURE SENSOR
13	FIRST GEAR INHIBIT MODE INDICATOR	29	MODE SELECTOR INPUT A	47	THROTTLE POSITION
14	GEAR SELECTOR POSITION CODE Y	30	NOT USED	48	NOT USED
15	SERIAL COMMUNICATIONS INPUT	31	NOT USED	49	SPORT MODE INDICATOR
16	TRANSMISSION WARNING	32	ENGINE TORQUE REDUCTION	50	GEAR SELECTOR POSITION CODE X
17	NOT USED	33	GEAR SELECTOR POSITION CODE Z	51	SERIAL COMMUNICATIONS OUTPUT
18	NOT USED	34	NOT USED	52	NOT USED
19	SOLENOIDS SUPPLY	35	NOT USED	53	NOT USED
		36	NOT USED	54	NOT USED
		37	NOT USED	55	NOT USED

T200/3.26

NOTES

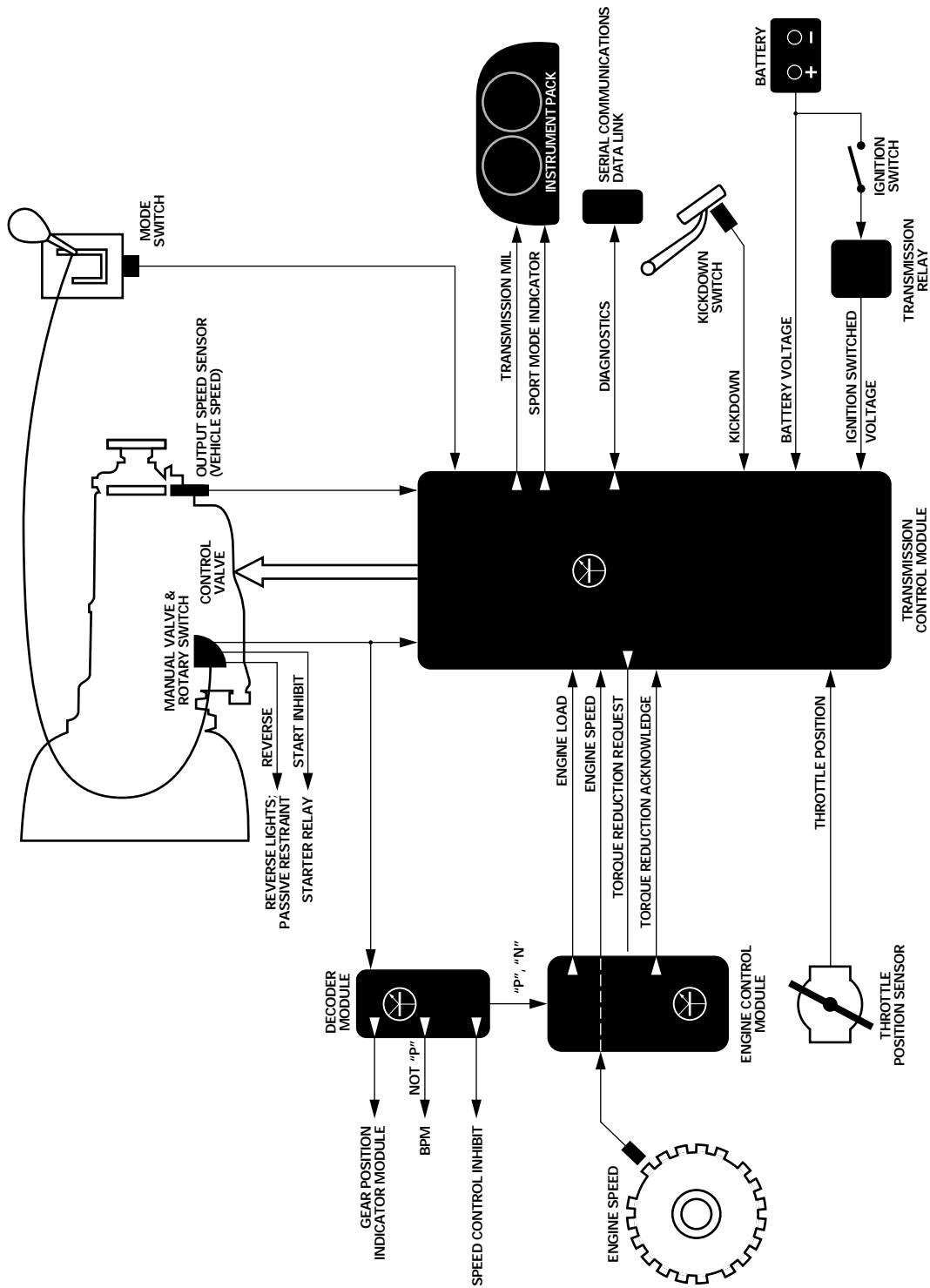
Transmission Control Module Inputs and Outputs



Transmission Control (continued)

Transmission Control Module Inputs and Outputs

TYPICAL OBD I TRANSMISSION CONTROL LOGIC: AJ6 SEDAN RANGE



Transmission Control Module Inputs

Mode Switch

The mode switch inputs the driver's choice of operating strategy, NORMAL, SPORT or DELETE FIRST (as equipped).

Rotary switch

The rotary switch logic signal is used by the TCM and decoder module to determine what gear range (PRND32) is selected. The rotary switch also contains contacts for starter inhibit and reverse lights.

Output shaft speed sensor

The TCM uses the signal from the transmission output speed sensor (vehicle speed) to determine line pressure, shift patterns, and torque converter lockup clutch timing and apply pressure.

Kickdown

A ground signal is supplied to the TCM when the driver activates the kickdown switch by fully depressing the accelerator pedal.

Engine throttle position

A signal input from the ECM (AJ16) or twin track TPS (throttle position sensor) (AJ6) allows the TCM to sense throttle position. Throttle position and other inputs are used to determine shift patterns and torque converter lockup clutch apply and release. In general, the greater the throttle opening, the higher the upshift speed and the greater the transmission line pressure.

Engine speed

The ECM supplies an engine speed input to the TCM. Engine speed is one of the inputs used to determine shift patterns and torque converter lockup clutch apply and release.

Engine load

The ECM supplies fuel injection pulse duration information to the TCM. The TCM uses this signal as a measure of engine torque.

Fluid temperature (AJ16)

Transmission fluid temperature is supplied to the TCM from a positive temperature coefficient sensor in the transmission. The TCM uses this signal to modify line pressure and optimize shift quality at low fluid temperatures.

Traction control active (AJ16 vehicles equipped with traction control)

A "traction control active" signal is supplied to the TCM from the ABS / traction control control module. The signal allows the TCM to select a shift strategy to increase the effectiveness of traction control.

NOTES

Transmission Control (continued)

Transmission Control Module Outputs

Pressure regulator (line pressure)

The TCM varies the current to the pressure control regulator to control the modulation pressure valve, which in turn controls the line pressure. Higher line pressure results in firmer shift quality.

Shift solenoid valves MV1, MV2, and MV3

The TCM controls the shift solenoid valves from the operating strategy by switching the solenoid coil ground circuits. The following table shows the solenoid state combination for each gear range:

Range / Gear	MV1	MV2	MV3
P	—	ON	—
R	—	—	—
N	—	ON	—
D / 4 and TCC	—	—	ON
D / 3	ON	—	—
D / 2	ON	ON	—
D / 1	—	ON	—
3 / 3	ON	—	—
3 / 2	ON	ON	—
3 / 1	—	ON	—
2 / 2	ON	ON	—
2 / 1	—	ON	—

Engine torque reduction

The TCM supplies a two part ignition timing retard output to the ECM; a transmission shift “up / down” signal (IGNITION SELECT), and a transmission “shift in progress” signal (IGNITION RETARD). When the ignition is momentarily retarded by the ECM, engine torque is reduced and a smoother, softer shift occurs.

Mode indication

The TCM provides a ground to illuminate the instrument pack mode indicator light.

TRANSMISSION MIL

The TCM provides a ground to activate the TRANSMISSION MIL.

CHECK ENGINE MIL

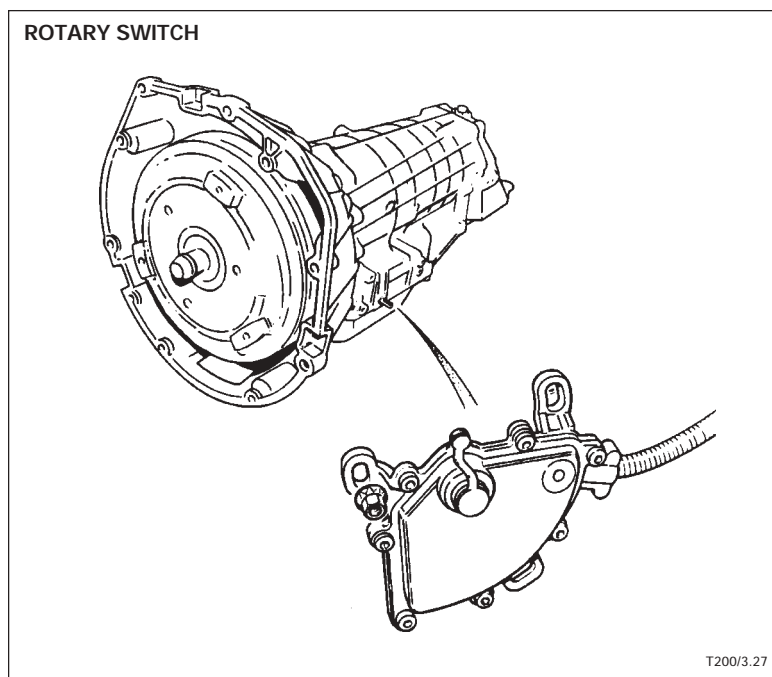
From the 1995 MY ON, the TCM communicates with the ECM to request the CHECK ENGINE MIL and the DTC for faults classified as emission related.

NOTES

Transmission Control Components

Rotary Switch

The rotary switch, mounted to the transmission and connected to the gear selector cable, is used to signal gear selection to the TCM. Additionally, the switch signals the gear position to various systems and circuits in the vehicle. When the driver selects a gear, a selector bar moves across the switch quadrant to contact the copper switch segments. The switch segments are set in bands across the quadrant with each band an output to the TCM and the decoder module (described on page 26). Gear selector position outputs are in the form of a three-character XYZ position code. Three switch segments are used for the three-character code. The remaining switch segments are used for the reverse lights, column / mirror movement control module, starter inhibit (SI), and a common (ground).



Gear Selector Position	Position Code XYZ
P	0 1 1
R	0 0 1
N	1 0 1
D	1 0 0
3	0 0 0
2	0 1 0
1	1 1 0

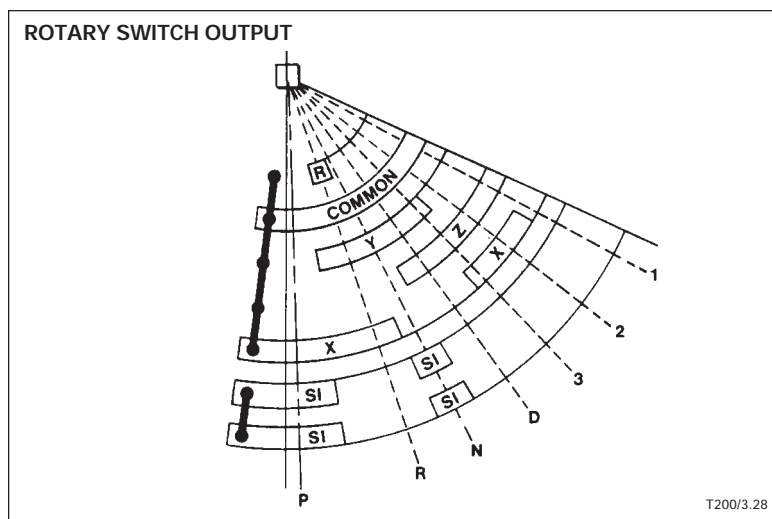
O = contacts closed, ground 0V

1 = contacts open, 12V

Rotary switch diagnostic monitoring

With the engine running at a speed greater than 448 rpm and the gear selector switch not in "P" or "N", the TCM continuously monitors the rotary switch signal for invalid XYZ signals. If an invalid signal is detected, DTC P0705 will be flagged.

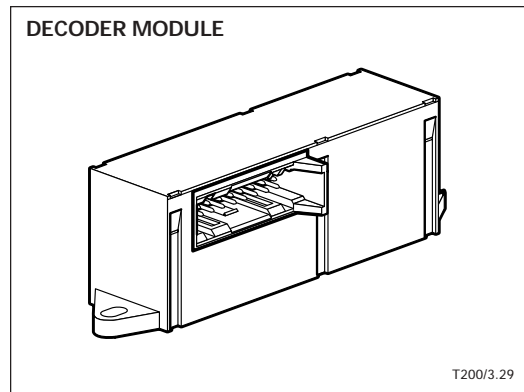
The TCM monitors the rotary switch XYZ codes for selector position during cranking when engine speed rises above 448 rpm. DTC P0706 will flag if the rotary switch indicates a position other than "P" or "N".



DTC	Component / signal	Trans MIL	Check Engine MIL (95 MY ON)	Limp home
P0705	Rotary switch invalid position signal	YES	YES	YES
P0706	Rotary switch not in "P" or "N" signal	YES	YES	YES

Refer to the DTC Summary, pages 37 – 43.

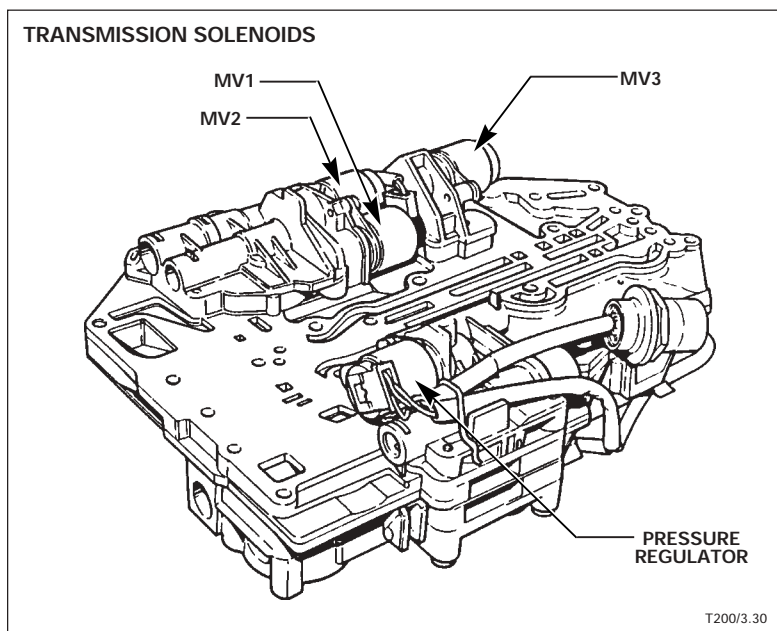
Transmission Control Components (continued)



Decoder Module

Sedan Range vehicles use a decoder module to “translate” the rotary switch three-character XYZ code into a single line signal. The single line signals are fed to the speed control module, body processor module (BPM), ECM, and the gear selector indicator module. XJS Range vehicles do not require a decoder module.

The TCM does not monitor the decoder module for diagnostics.



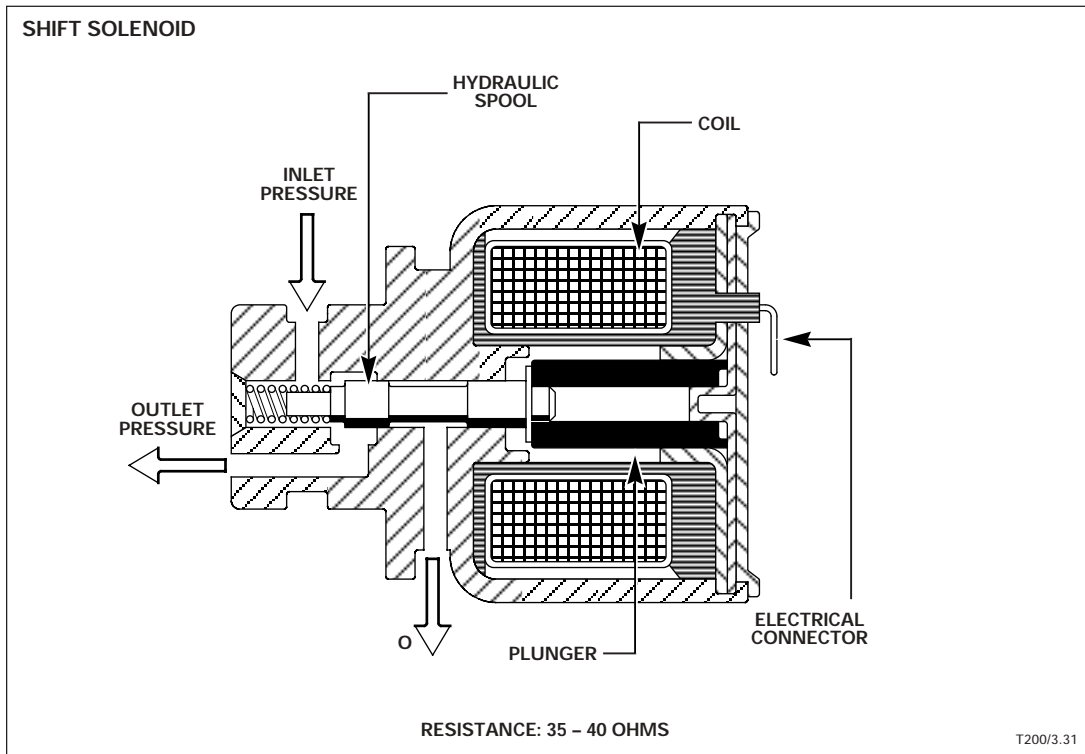
Shift Solenoid Valves

Three shift solenoids – MV1, MV2, and MV3 – are located on the valve body and are used to apply upshifts and down shifts in all forward gear ranges as well as torque converter clutch lockup. The solenoid valves (MV1, MV2, MV3) work in combination to direct hydraulic pressure to the various apply valves. PDU monitoring will show the solenoid operating state ‘0’ (12V) with the solenoid inactive and ‘1’ (0V [ground]) when the solenoid is energized.

The following table shows the solenoid state combination required for each gear (1 = energized):

Gear	MV1	MV2	MV3
1	0	1	0
2	1	1	0
3	1	0	0
4 and TCC lockup	0	0	1
Park	0	1	0
Reverse	0	0	0
Neutral	0	1	0

NOTE: Manual selection of D, 3 and 2 will activate the solenoids as shown above.



Shift solenoid diagnostic monitoring

The shift solenoids are provided with a common 12V signal through a relay in the TCM. The TCM operates each solenoid separately by controlling its ground. The OBD facility continuously monitors the solenoid drive signal vs. the feedback signal for errors. A voltage greater than 3.5V with the solenoid activated or less than 2.5V OFF will flag a DTC and cause the TCM to remove the 12V solenoid supply by opening the relay and the transmission will revert to the limp home default described on page 18.

DTC	Component / signal	Trans MIL	Check Engine MIL (95 MY ON)	Limp home
P0743	Shift solenoid 3 (MV3) (TCC) voltage incorrect	YES	YES	YES
P0753	Shift solenoid 1 (MV1) voltage incorrect	YES	YES	YES
P0758	Shift solenoid 2 (MV2) voltage incorrect	YES	YES	YES

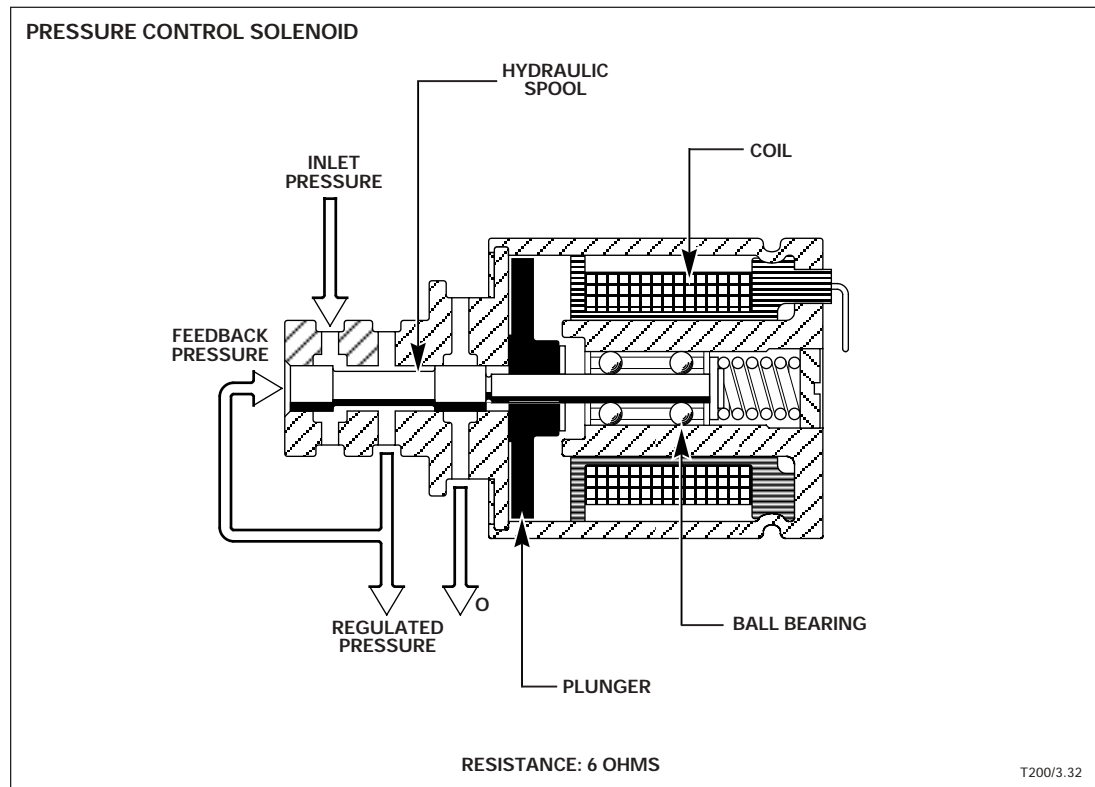
Refer to the DTC Summary, pages 37 - 43.

NOTES

Transmission Control Components (continued)

Pressure Control Solenoid

Transmission line pressure is controlled by the pressure control solenoid to produce hydraulic line pressure consistent with engine torque and to compensate for transmission component wear. The solenoid is located on the valve body. The TCM controls this solenoid similarly to the shift solenoids; 12V inactive and 0V (ground) with the solenoid active (energized). The pressure control solenoid applies a "correction" hydraulic pressure signal from 0 – 4.8 psi (0 – 0.33 bar) that acts on the modulation pressure valve, which in turn controls the line pressure supplied to the various supply components. The duty cycle (percent time energized) of the pressure control solenoid (force motor) is regulated by the TCM.



Pressure control solenoid diagnostic monitoring

The TCM continuously monitors the pressure control solenoid drive and feedback signals for errors. A voltage greater than 3.5V activated or less than 2.5V OFF will flag DTC P0748 and cause the TCM to open the 12V solenoid feed control relay in the TCM.

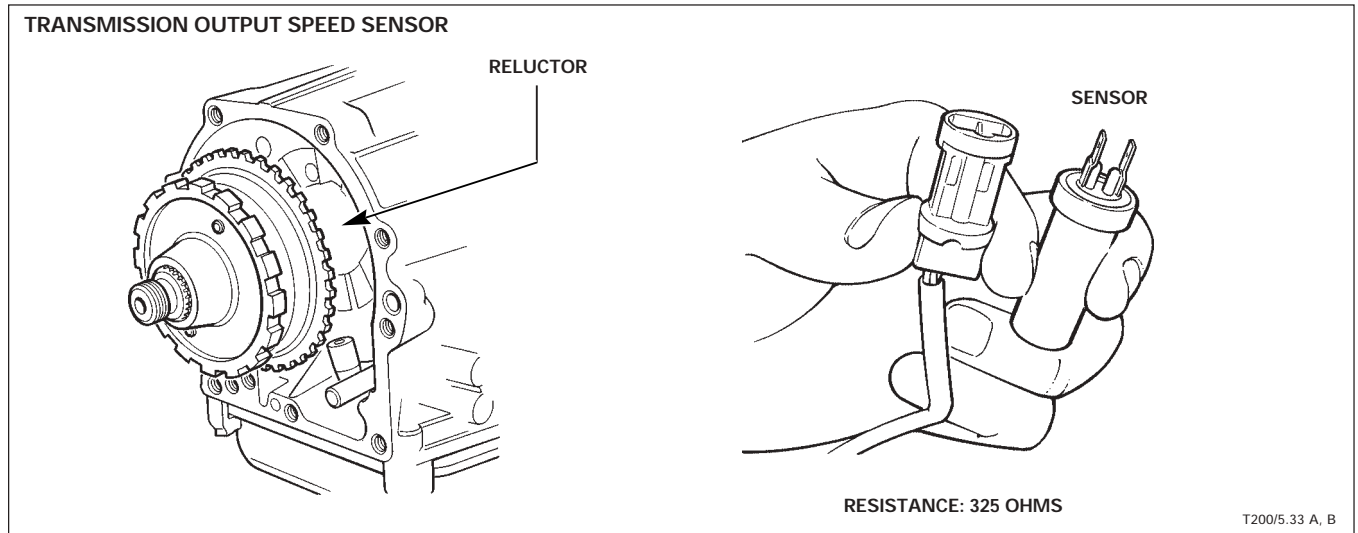
DTC	Component / signal	Trans MIL	Check Engine MIL (95 MY ON)	Limp home
P0748	Pressure control regulator solenoid voltage incorrect	YES	YES	YES

Refer to the DTC Summary, pages 37 – 43.

NOTES

Transmission Output Speed Sensor

The output speed sensor is a variable reluctance magnetic pickup located at the rear of the valve block assembly. A toothed rotor, fixed to the output shaft, generates a pulsed wave form speed signal. The TCM calculates the vehicle road speed from this signal using the final drive ratio and tire rolling radius data in memory. The road speed signal range is from 0 – 158 mph (0 – 255 km/h).



Transmission output speed sensor diagnostic monitoring

The TCM continuously monitors the speed sensor output when the transmission is in a forward gear.

During down shifts, the TCM will flag DTC P0721 if the engine speed is above a value specified for the down shift taking place and the state of the torque converter clutch. If the speed sensor signal is zero and engine speed is above 2000 rpm, the TCM flags DTC P0722.

DTC	Component / signal	Trans MIL	Check Engine MIL (95 MY ON)	Limp home
P0721	Output speed sensor signal out of range (high)	YES	YES	YES
P0722	Output speed sensor, no signal	YES	YES	YES

Refer to the DTC Summary, pages 37 – 43.

NOTES

Transmission Control Components (continued)

Engine Speed Input

The ECM provides an engine speed signal to the TCM. The square wave signal consists of 3 pulses per crankshaft revolution (each pulse signal consists of 50° ON and 70° OFF).

Engine speed input diagnostic monitoring

DTC P0726 will be flagged if the engine speed signal is above 6800 rpm.

If the engine speed signal indicates less than 95 rpm in any gear but “P” or N, and the transmission output speed is above 300 rpm, DTC P0727 will be flagged.

DTC	Component / signal	Trans MIL	Check Engine MIL (95 MY ON)	Limp home
P0726	Engine speed signal out of range (high)	YES	YES	YES
P0727	Engine speed, no signal	YES	YES	YES

Refer to the DTC Summary, pages 37 – 43.

Engine Torque Signal

The ECM continuously provides the TCM with an engine torque (load) signal based on fuel injection pulse duration. The pulse width modulated (PWM) signal represents the actual engine torque developed between 0 – 376 lb ft (0 – 510 Nm). The engine torque signal is used by the TCM to determine transmission line pressure and the amount of ignition retard to be applied to the ignition advance angle during shifting. The signal is also used to communicate a torque reduction signal fault to the TCM.

Engine torque signal diagnostic monitoring

The engine torque signal is continuously monitored. The 91 Hz PWM signal duty cycle should be between 10% and 90%. If the frequency or duty cycle is out of range and the engine speed is above 448 rpm, DTC P1781 will be flagged and the TCM will substitute a default value for the incorrect signal.

DTC	Component / signal	Trans MIL	Check Engine MIL (95 MY ON)	Limp home
P1781	Torque signal out of range (frequency or pulse width)	YES	YES	—

Refer to the DTC Summary, pages 37 – 43.

NOTES

Throttle Position Sensor (TPS)

The TCM receives a throttle position signal from the engine management system. Generally, larger throttle openings result in higher line pressure and delayed upshifts.

The AJ16 engine management system ECM processes the signal from the single track TPS (throttle position sensor) and provides a pulse width modulated (PWM) signal to the TCM to indicate throttle position. The throttle position signal line on AJ16 engine vehicles also transmits coolant temperature information to the TCM during engine cranking. This coolant temperature information is used to determine the completion of warm-up cycles for OBD II code management.

AJ6 engine management systems provide a throttle position signal from the twin track TPS directly to the TCM.

Throttle position sensor diagnostic monitoring (AJ16)

When the engine is running, the TCM receives a PWM 5% – 94% duty cycle signal from the ECM, depending on the throttle opening angle. If the PWM signal is out of range (less than 5% or greater than 94%) or the signal frequency is out of range (183 ± 1 Hz) the TCM substitutes a default value of 47% and flags DTC P1790. During cranking, if the TCM does not recognize a valid TPS signal 700 ms after the engine speed reaches 580 rpm, DTC P1790 will be flagged and the 47% default value will be used.

During cranking, the TPS signal is used to carry engine coolant temperature information. If during cranking, an invalid coolant temperature signal is recognized, a default coolant temperature value of 170° F (77°C) will be substituted but no DTC will be stored.

If the TCM receives no TPS signal from the engine management system, with engine speed greater than 580 rpm, the 47% duty cycle default is substituted and DTC P1791 is flagged. The transmission remains in normal mode but no kickdown is available.

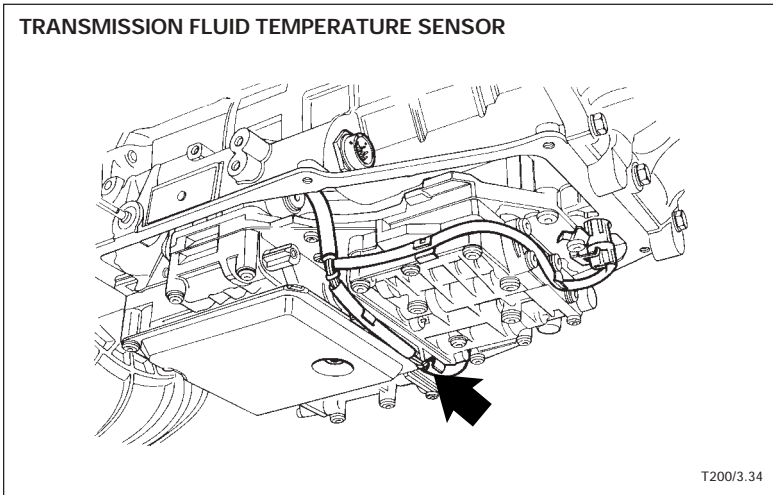
DTC	Component / signal	Trans MIL	Check Engine MIL (95 MY ON)	Limp home
P1790	TPS signal out of range	YES	YES	—
P1791	TPS, no signal	YES	YES	—

Refer to the DTC Summary, pages 37 – 43.

NOTES

Transmission Control Components (continued)

Transmission Fluid Temperature Sensor



The positive temperature coefficient (PTC) fluid temperature sensor is located in the transmission internal wiring harness and exposed to transmission fluid. As the fluid temperature increases, the sensor resistance also increases, this decreases the sensor voltage. The sensor provides the TCM with a fluid temperature signal used to calculate and adjust line pressure to refine gear shift quality at low fluid temperature.

Transmission fluid temperature sensor diagnostic monitoring

The transmission fluid temperature signal is continuously monitored by the TCM. A fluid temperature below -58° F (-50° C) will flag DTC P0712. A fluid temperature above 365° F (185° C) will flag P0713. The TCM will substitute a default temperature signal but no MIL will be activated.

DTC	Component / signal	Trans MIL	Check Engine MIL (95 MY ON)	Limp home
P0712	Fluid temperature sensor circuit low voltage	—	—	—
P0713	Fluid temperature sensor circuit high voltage	—	—	—

Refer to the DTC Summary, pages 37 – 43.

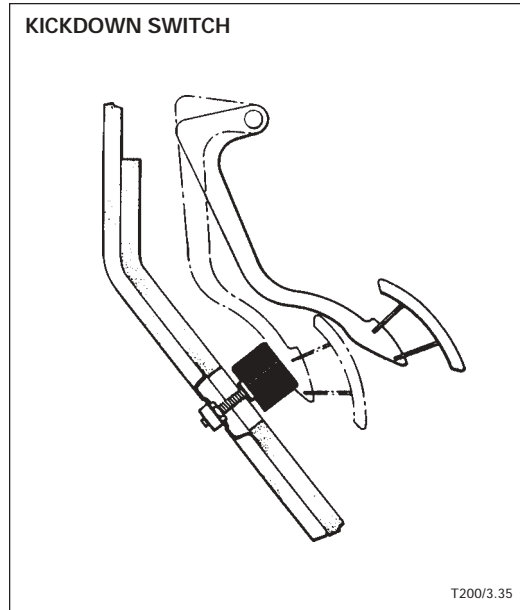
NOTES

Kickdown Switch

The normally open, adjustable kickdown switch is mechanically operated by pressure from the accelerator pedal. When the throttle is fully (90%) depressed, the switch provides a ground signal to the TCM. The TCM applies this signal and other inputs to the shifting strategy to determine when the transmission should down shift or if upshifts should be extended.

Kickdown switch diagnostic monitoring

The TCM continuously monitors the kickdown switch circuit when the engine speed is above 256 rpm. If a kickdown signal is detected and the throttle angle, as determined by the TPS, is less than 50%, DTC P1796 will be flagged and no kickdown will be available. The DTC will be ignored if a TPS DTC is already flagged.



DTC	Component / signal	Trans MIL	Check Engine MIL (95 MY ON)	Limp home
P1796	Kickdown switch signal error	—	—	—

Refer to the DTC Summary, pages 37 – 43.

Traction Control Input

The anti-lock braking / traction-control control module (ABS / TC CM) provides the TCM with a square wave 2.5 Hz signal when traction control is active. The TCM selects a shift strategy that increases the effectiveness of the traction control function.

Traction control input diagnostic monitoring

When traction control is inactive, the signal to the TCM is at battery voltage. When traction control is active, the signal from the ABS / TC CM is a pulsed ground. The TCM will flag DTC P1782 if the signal voltage is less than 1.8V for more than 200 ms. No MIL will be activated but the TCM will not adopt the traction control shift strategy.

DTC	Component / signal	Trans MIL	Check Engine MIL (95 MY ON)	Limp home
P1782	Traction control signal voltage low	—	—	—

Refer to the DTC Summary, pages 37 – 43.

NOTES

Transmission Control Components (continued)

Torque Based Shifting

The TCM controls shift quality by the precise combination of clutch apply and release timing and pressure required for the operating conditions. In addition, the TCM outputs a pulse width modulated torque reduction signal requesting the ECM to retard the ignition timing during the shift. The ignition retard reduces engine torque providing for a smoother shift.

Torque Reduction Signal

The TCM provides the ECM with a two-part torque reduction signal; IGNITION SELECT, which indicates whether the transmission shift is "up" or "down" and IGNITION RETARD, which identifies a "shift in progress." The normal torque reduction signal pulse width is 17%.

The torque reduction signal pulse width is increased to 20% to indicate the start of a shift. If the shift requires ignition retard, the TCM increases the signal pulse width to between 20% and 90% and the ECM retards the ignition timing. A 20% pulse width indicates 0° retard and 90% indicates maximum retard. The signal returns to 20% at the end of the shift and then returns to the normal 17% pulse width.

On OBD II systems, the torque reduction signal is also used by the TCM to request the ECM to activate the CHECK ENGINE MIL for emission related transmission faults. If the torque reduction signal pulse width is less than 12%, the CHECK ENGINE MIL will activate and EMS DTC P1775 will be stored in the ECM.

Torque reduction signal diagnostic monitoring

If the torque reduction signal is active for more than 2 seconds, the ECM starts a 10 second "clock." If the signal is still active after the 10 seconds, the TCM flags DTC P1780.

The ten second "clock" is also started if the torque reduction signal is high or low for longer than 125 ms. If the signal is still high or low after the 10 seconds, DTC P1780 is flagged.

In both cases the ECM will transmit a 93% pulse width modulated signal to the TCM on the engine torque signal line. The 93% signal informs the TCM of a fault with its transmission torque reduction signal.

DTC	Component / signal	Trans MIL	Check Engine MIL (95 MY ON)	Limp home
P1780	Torque reduction signal out of range	YES		

Refer to the DTC Summary, pages 37 – 43.

NOTES

Transmission Warning Light (TRANSMISSION MIL)

The transmission warning light (TRANSMISSION MIL) is located in the instrument pack and warns the driver of transmission faults. The TCM provides a signal to activate the TRANSMISSION MIL when most DTCs are present. In addition, OBD II classified transmission faults will also activate the CHECK ENGINE MIL.

Transmission warning light (TRANSMISSION MIL) diagnostic monitoring

The TRANSMISSION MIL is driven OFF by an active low voltage signal from the TCM. If the TCM is disconnected, the MIL will be ON. A short circuit to ground or to battery voltage will flag DTC P1785.

DTC	Component / signal	Trans MIL	Check Engine MIL (95 MY ON)	Limp home
P1785	TRANSMISSION MIL	—	—	—

Refer to the DTC Summary, pages 37 – 43.

CHECK ENGINE MIL

For OBD II emission related transmission faults, the TCM requests the ECM to activate the CHECK ENGINE MIL. The request signal is a pulse width modulated signal of 12% or less on the torque reduction signal line.

TCM on board diagnostics do not monitor the CHECK ENGINE MIL request signal.

Sport Mode Indicator

The sport mode indicator light in the instrument pack alerts the driver when sport mode is selected by the transmission mode switch.

Sport mode indicator diagnostic monitoring

The sport mode indicator is activated by a ground signal provided by the TCM. If the TCM detects a circuit fault it will flag DTC P1792. The sport mode indicator will be permanently on or off.

DTC	Component / signal	Trans MIL	Check Engine MIL (95 MY ON)	Limp home
P1792	Sport mode indicator circuit failure	—	—	—

Refer to the DTC Summary, pages 37 – 43.

NOTES

DTC Summary

ZF 4 HP 24 E9 / AJ16 Transmission Control System – OBD II

OBD II MONITORING CONDITIONS

DTCs can be accessed only through the DLC (diagnostic link connector).
Using PDU, select ToolBox, Engine / Transmission DTC, and Bosch / ZF 4 HP 24 E9.

MIL Activation

CHECK ENGINE MIL: A number in the CHECK ENG. MIL column indicates the consecutive trips required to activate the MIL. The CHECK ENGINE MIL activates for OBD II related transmission faults. Activation will store engine management DTC P1775 in the ECM memory.

TRANSMISSION MIL: A check mark in the TRANS. MIL column indicates MIL activation. The number of trips required to activate the TRANSMISSION MIL may vary depending on other fault parameters.

PDU Datalogger Acronyms

CL	Calculated load value	SSMV1	Shift solenoid valve state MV1
DTCS	Number of DTCs logged	SSMV2	Shift solenoid valve state MV2
FAV	TRANSMISSION MIL - volt	TCCS	Torque converter clutch solenoid valve state MV3 (MVWK)
IGN+	Ignition supplied power feed	TCSA	Mode switch state (signal A)
KDSW	Kickdown switch	TCSB	Mode switch state (signal B)
MV1V	Shift solenoid MV1 volts	TOST	Transmission output speed
MV2V	Shift solenoid MV2 volts	TOT	Transmission fluid temperature
MVWKV	Torque converter clutch solenoid volts (MV3)	TP	Throttle position sensor (TPS) position
PC	Pressure correction valve	TR	Torque reduction
PCV	Pressure control valve	TRX	Rotary switch position code " X"
PMOD	Modulating pressure	TRY	Rotary switch position code " Y"
RPM	Engine speed	TRZ	Rotary switch position code " Z"
SP V	Sport mode signal volts		

DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS	CHECK ENG. MIL	TRANS. MIL	LIMP HOME	POSSIBLE CAUSES
P0603	TCM internal memory error	Start engine.	2	—	—	TCM failure
P0605	TCM data corrupted	Start engine.	2	✓	✓	TCM failure
P0702	TCM internal shift solenoid control relay malfunction	Switch ignition ON.	2	✓	✓	TCM failure
P0705	Rotary switch position signal invalid	Start engine. Operate gear selector through all ranges.	2	✓	✓	Rotary switch to TCM * position code XYZ* circuit: open circuit or short circuit to ground Rotary switch failure
P0706	Rotary switch * not in P or N* signal during starting	Start engine.	2	✓	✓	Rotary switch incorrect adjustment Gear selector / rotary switch not in P or N Rotary switch to TCM * position code Z* circuit: short circuit to ground Rotary switch failure
P0712	Fluid temperature sensor circuit low voltage or fluid temperature < -58° F (-50° C)	Run engine from cold to normal operating temperature.	—	—	—	Transmission internal harness temp. sensor signal circuit: short circuit to ground Transmission to TCM harness temp. sensor signal circuit: short circuit to ground Temperature sensor failure
P0713	Fluid temperature sensor circuit high voltage or fluid temperature > 365° F (185° C)	Run engine from cold to normal operating temperature.	—	—	—	High transmission operating temperature. (Look for burned transmission fluid) Transmission internal harness temp. sensor signal circuit: open circuit or short circuit to B+ voltage Transmission to TCM harness temp. sensor signal circuit: open circuit or short circuit to B+ voltage Temperature sensor failure
P0721	Output speed sensor signal out of range (high)	Drive vehicle and accelerate to force downshifting.	2	✓	✓	Transmission internal harness output speed sensor circuit: intermittent open circuit or short circuit to ground or B+ voltage Transmission to TCM harness output speed sensor circuit: intermittent open circuit or short circuit to ground or B+ voltage Intermittent speed sensor failure
P0722	Output speed sensor, no signal	Drive vehicle in a forward gear at an engine speed greater than 2000 rpm.	2	✓	✓	Transmission internal harness speed sensor circuit: open circuit or short circuit to ground or B+ voltage Transmission to TCM harness speed sensor circuit: open circuit or short circuit to ground or B+ voltage Output speed sensor failure Transmission mechanical failure (no drive)
P0726	Engine speed signal high, out of range	Start engine.	2	✓	✓	ECM to TCM engine speed signal circuit intermittent open circuit, intermittent short circuit to ground or B+ voltage ECM engine speed signal error
P0727	Engine speed, no signal	Drive vehicle above 10 mph (16 km/h).	2	✓	✓	Engine stalled at a road speed above 10 mph (16 km/h) ECM to TCM engine speed signal circuit open circuit or short circuit to ground ECM engine speed signal error (TCM failure)
P0743	Shift solenoid 3 (MV3) (TCC) voltage incorrect	Drive vehicle at a steady speed of 55 mph (88.5 km/h) or above.	2	✓	✓	Transmission internal harness torque converter clutch solenoid circuit: open circuit, short circuit to ground or B+ voltage Transmission to TCM harness torque converter clutch solenoid circuit: open circuit, short circuit to ground or B+ voltage Torque converter clutch solenoid failure

DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS	CHECK ENG. MIL	TRANS. MIL	LIMP HOME	POSSIBLE CAUSES
P0748	Pressure control regulator solenoid voltage incorrect	Drive vehicle through all gear ranges.	2	√	√	Transmission internal harness pressure control solenoid circuit: open circuit, short circuit to ground or B+ voltage Transmission to TCM harness pressure control solenoid circuit: open circuit, short circuit to ground or B+ voltage Pressure control solenoid failure
P0753	Shift solenoid 1 (MV1) voltage incorrect	Drive vehicle through all gear ranges.	2	√	√	Transmission internal harness shift solenoid circuit: open circuit, short circuit to ground or B+ voltage Transmission to TCM harness shift solenoid circuit: open circuit, short circuit to ground or B+ voltage Shift solenoid failure
P0758	Shift solenoid 2 (MV2) voltage incorrect	Drive vehicle through all gear ranges.	2	√	√	Transmission internal harness shift solenoid circuit: open circuit, short circuit to ground or B+ voltage Transmission to TCM harness shift solenoid circuit: open circuit, short circuit to ground or B+ voltage Shift solenoid failure
P1608	TCM internal timing error	Switch ignition ON.	2	√	√	TCM failure
P1780	Torque reduction signal out of range	Run engine for more than 12 seconds.	2*	√	—	TCM to ECM torque reduction signal circuit: open circuit, short circuit to ground or B+ voltage ECM torque reduction signal error
P1781	Torque signal out of range (frequency or pulse width)	Run engine above 500 rpm.	2*	√	—	ECM to TCM torque signal circuit: open circuit, short circuit to ground or B+ voltage ECM torque signal error
P1782	Traction control signal voltage low	Switch ignition ON. Operate traction control switch.	—	—	—	ABS / TC CM to TCM signal circuit: short circuit to ground ABS / TC CM failure
P1785	TRANSMISSION MIL	Switch ignition ON.	—	—	—	TCM to instrument pack TRANSMISSION MIL circuit: open circuit, short circuit to ground or B+ voltage Instrument pack failure
P1790	TPS signal out of range	Run engine above 580 rpm.	2	√	—	ECM to TCM TPS signal circuit: open circuit, short circuit to ground or B+ voltage ECM TPS signal output error
P1791	TPS, no signal	Run engine above 580 rpm.	2	√	—	ECM to TCM TPS signal circuit: open circuit, short circuit to ground or B+ voltage ECM TPS signal output error
P1792	Sport mode indicator circuit failure	Switch ignition ON. Operate mode switch.	—	—	—	Sport mode indicator bulb failure TCM to instrument pack sport mode indicator circuit: open circuit, short circuit to ground or B+ voltage Instrument pack failure
P1794	TCM voltage supply less than 10.5V (ignition supply must be 8V for TCM to store DTC)	Start engine. Run above 1600 rpm.	2	√	√	Ignition switched TCM power fuse defective LH heelboard fuse box to TCM ignition switched power circuit: high resistance
P1796	Kickdown switch signal error	Drive vehicle, depress accelerator pedal fully	—	—	—	Kickdown switch adjustment Kickdown switch to TCM circuit: short circuit to ground Kickdown switch failure

* Depending on other fault parameters, CHECK ENGINE MIL may not activate

DTC Summary
ZF 4 HP 24 E9 / AJ6 Transmission Control System – OBD I

DTCs can be accessed with JDS or PDU. PDU displays the DTCs as 2 digit numbers. JDS displays DTCs as a fault table. Refer to the appropriate JDS Software Reference Guide: pages 4.57 – 4.62 for release 4040, pages 12 – 19 for release 4050.

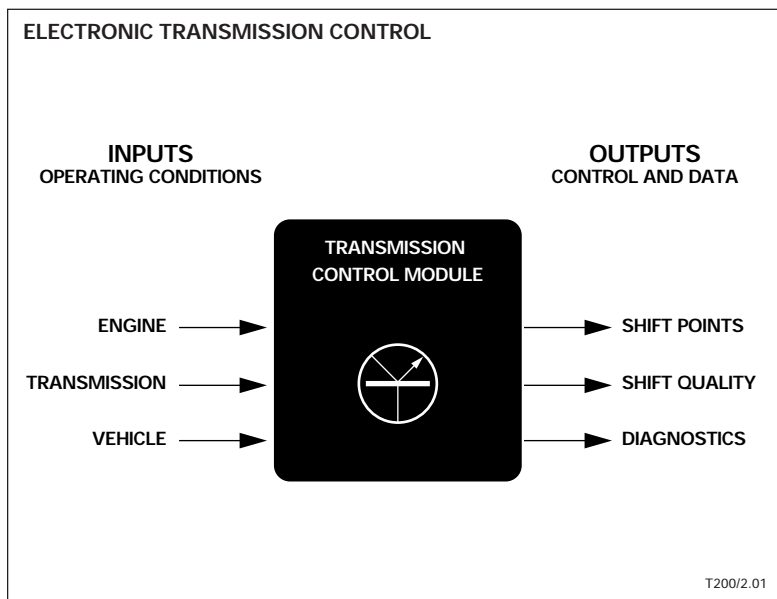
DTC	FAULT DESCRIPTION	MONITORING CONDITIONS	TRANS. MIL ACTIVATED	LIMP HOME	POSSIBLE CAUSES
01	TCM internal timing error	Switch ignition ON.	YES	YES	TCM failure
02	TCM data corrupted	Switch ignition ON.	YES	YES	TCM failure
03	Kickdown switch signal error	Drive vehicle, depress accelerator pedal fully.	—	—	Kickdown switch adjustment Kickdown switch to TCM circuit; short circuit to ground Kickdown switch failure
04	Mode switch circuit failure	Run engine, operate mode switch.	—	—	Mode switch circuit; short circuit to B+ voltage
05	TPS signal out of range	Switch ignition ON.	YES	—	Twin track TPS incorrect adjustment TPS signal circuit; open circuit, short circuit to ground or B+ voltage ECM TPS signal output error TPS failure
06	Shift solenoid 1 (MV1)	Drive vehicle through all gear ranges.	YES	YES	Transmission internal harness shift solenoid circuit; open circuit, voltage incorrect short circuit to ground or B+ voltage Transmission to TCM harness shift solenoid circuit; open circuit, short circuit to ground or B+ voltage Shift solenoid failure
07	Shift solenoid 2 (MV2)	Drive vehicle through all gear ranges.	YES	YES	Transmission internal harness shift solenoid circuit; open circuit, voltage incorrect short circuit to ground or B+ voltage Transmission to TCM harness shift solenoid circuit; open circuit, short circuit to ground or B+ voltage Shift solenoid failure
08	TCM internal shift solenoid supply relay malfunction	Switch ignition ON.	YES	YES	TCM failure
09	Sport mode indicator circuit failure	Switch ignition ON. Operate mode switch.	—	—	Sport mode indicator bulb failure TCM to instrument pack sport mode indicator circuit; open circuit, short circuit to ground or B+ voltage Instrument pack failure
10	TRANSMISSION MIL circuit failure	Switch ignition ON.	—	—	TRANSMISSION MIL bulb failure TCM to instrument pack TRANSMISSION MIL circuit; open circuit, short circuit to ground or B+ voltage Instrument pack failure
11	DELETE FIRST warning light circuit	Switch ignition ON. Operate mode switch.	—	—	DELETE FIRST bulb failure TCM to instrument pack DELETE FIRST circuit; open circuit, short circuit to ground or B+ voltage Instrument pack failure
13	Torque converter clutch solenoid (MV3) voltage incorrect	Drive vehicle at a steady speed of 55 mph (88.5 km/h) or above.	YES	—	Transmission internal harness torque converter clutch solenoid circuit; open circuit, short circuit to ground or B+ voltage Transmission to TCM harness torque converter clutch solenoid circuit; open circuit, short circuit to ground or B+ voltage Torque converter clutch solenoid failure
20	Solenoid electrical supply voltage incorrect	Switch ignition ON.	YES	YES	TCM to transmission harness solenoid voltage supply circuit; high resistance or short circuit to ground TCM failure
21	Engine speed signal out of range	Drive vehicle above 10 mph (16 km/h).	YES	YES	Engine stalled at a road speed above 10 mph (16 km/h) ECM to TCM engine speed signal circuit; open circuit, short circuit to ground or B+ voltage ECM engine speed signal error (ECM failure)
22	Pressure control regulator solenoid voltage incorrect	Drive vehicle through all gear ranges.	YES	YES	Transmission internal harness pressure control solenoid circuit; open circuit, short circuit to ground or B+ voltage Transmission to TCM harness pressure control solenoid circuit; open circuit, short circuit to ground or B+ voltage Pressure control solenoid failure

DTC	FAULT DESCRIPTION	MONITORING CONDITIONS	TRANS. MIL ACTIVATED	LIMP HOME	POSSIBLE CAUSES
23	Torque reduction signal out of range	Start engine. Run for more than 12 seconds.	YES	YES	TCM to ECM torque reduction signal circuit; open circuit, short circuit to ground or B+ voltage ECM torque reduction signal error
24	Output speed signal out of range	Drive vehicle and accelerate to force down shifting.	YES	YES	Transmission internal harness output speed sensor circuit; intermittent open circuit or short circuit to ground or B+ voltage Transmission to TCM harness output speed sensor circuit; intermittent open circuit or short circuit to ground or B+ voltage Intermittent speed sensor failure
26	Engine torque signal out of range	Start engine. Run above 500 rpm.	YES	YES	ECM to TCM torque signal circuit; open circuit, short circuit to ground or B+ voltage ECM torque signal error
27	Output speed sensor, no signal	Drive vehicle in a forward gear at an engine speed greater than 2000 rpm.	YES	YES	Transmission internal harness speed sensor circuit; open circuit or short circuit to ground or B+ voltage Transmission to TCM harness speed sensor circuit; open circuit or short circuit to ground or B+ voltage Output speed sensor failure Transmission mechanical failure, no drive
28	TCM internal memory error	Switch ignition ON.	YES	YES	TCM failure
29	TCM voltage supply less than 10.5V (ignition supply must be 8V for TCM to store DTC)	Start engine. Run above 1600 rpm.	YES	YES	Ignition switched power fuse defective LH heelboard fuse box to TCM ignition switched power circuit; high resistance or short circuit to ground
30	Rotary switch invalid position signal	Start engine. Operate gear selector through all ranges.	YES	YES	Rotary switch incorrect adjustment Gear selector / rotary switch not in P or N Rotary switch to TCM "position code Z" circuit; short circuit to ground Rotary switch failure
31	Rotary switch not in P or N signal during starting	Start engine.	YES	YES	Rotary switch incorrect adjustment Rotary switch to TCM "position code XYZ" circuit; open circuit or short circuit to ground Rotary switch failure

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Overview



The PowerTrain (formerly Hydra-matic) 4L80-E electronic four-speed transmission incorporates electronic controls that utilize the transmission control module (TCM) to control shift points, torque converter clutch apply and release, and line pressure. Inputs from sensors and switches provide engine, transmission and vehicle operating information to the TCM. The TCM uses this information to determine the precise moment to upshift or down shift, apply or release the torque converter clutch, and what line pressure is required to apply the clutches or bands. The TCM also incorporates an on-board diagnostic facility that monitors transmission component operation and signal conditions. This type of control, based on the operating conditions of the vehicle, results in consistent and precise shift points and shift quality.

NORMAL and SPORT modes

Two operating strategies are available to the driver.

NORMAL

Normal mode provides economy operation by causing the transmission to upshift at lower engine speeds and throttle openings. Start-off occurs in second gear unless the accelerator is depressed to the kickdown position. High speed performance is available as required.

SPORT

Sport mode allows the engine power to be used to its full potential at all times. Start-off occurs in first gear and upshifts and kickdown are tailored to performance requirements.

Torque Converter Lockup Clutch

Power loss through the torque converter at cruise speeds is minimized with a lockup feature. When locked-up, the torque converter forms a fixed mechanical connection between the engine and the transmission gearbox. Torque converter lockup is possible in second, third and fourth gears.

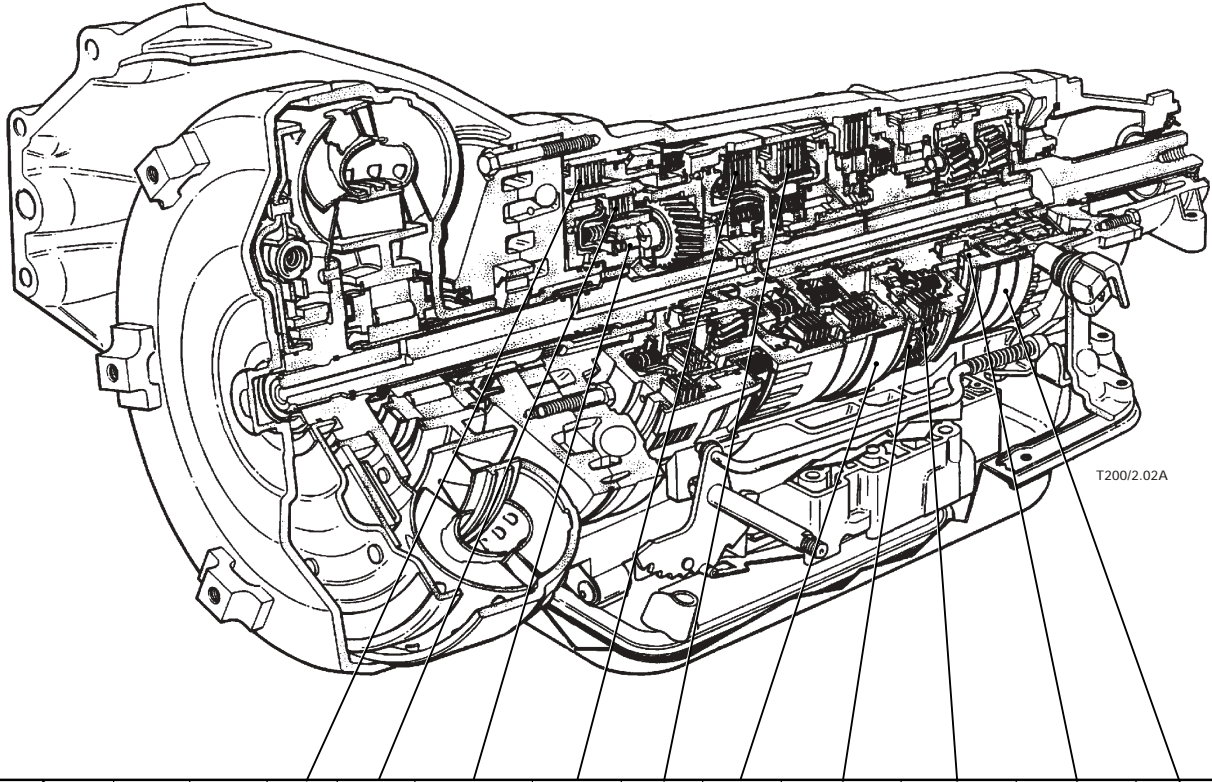
Specifications

	First	Second	Third	Fourth	Reverse
Gear ratios	2.48 : 1	1.48 : 1	1 : 1	0.75 : 1	2.07 : 1
Max. engine speed	6000 rpm	6000 rpm	6000 rpm		
Transmission fluid	Dexron II 'E'				
Approximate capacity from dry	13.5 quarts (US) (12.8 liters)				
Drain and refill	7.7 quarts (US) (7.3 liters)				
Min. – Max. difference	0.3 quart (US) (0.3 liter)				

PLEASE NOTE: TO AID IN THE UNDERSTANDING OF THE AUTOMATIC TRANSMISSION CONTROL SYSTEM, REFER TO THE APPLICABLE JAGUAR ELECTRICAL GUIDE FOR ELECTRICAL CIRCUIT DETAILS, COMPONENT INFORMATION, AND PIN-OUT DATA.

Range Reference Chart

4L80-E RANGE REFERENCE



RANGE	GEAR	SOLENOID @ A	SOLENOID @ B	FOURTH CLUTCH	OVERRUN CLUTCH	OVERDRIVE ROLLER CLUTCH	FORWARD CLUTCH	DIRECT CLUTCH	FRONT BAND INT.	INTERMEDIATE SPRAG CLUTCH	INTERMEDIATE CLUTCH	LO ROLLER CLUTCH	REAR BAND LO/REV
P, N		ON	OFF			HOLDING							
R	REVERSE	ON	OFF			HOLDING		APPLIED					APPLIED
D	1st	ON	OFF			HOLDING	APPLIED			*		HOLDING	
	2nd	OFF	OFF			HOLDING	APPLIED			HOLDING	APPLIED	OVERRUNNING	
	3rd	OFF	ON			HOLDING	APPLIED	APPLIED		OVERRUNNING	APPLIED	OVERRUNNING	
	4th	ON	ON	APPLIED		OVERRUNNING	APPLIED	APPLIED		OVERRUNNING	APPLIED	OVERRUNNING	
3	1st	ON	OFF		APPLIED	HOLDING	APPLIED			*		HOLDING	
	2nd	OFF	OFF		APPLIED	HOLDING	APPLIED			HOLDING	APPLIED	OVERRUNNING	
	3rd	OFF	ON		APPLIED	HOLDING	APPLIED	APPLIED		OVERRUNNING	APPLIED	OVERRUNNING	
2	1st	ON	OFF		APPLIED	HOLDING	APPLIED			*		HOLDING	
	2nd	OFF	OFF		APPLIED	HOLDING	APPLIED		APPLIED	HOLDING	APPLIED	OVERRUNNING	

DESCRIPTIONS ABOVE EXPLAIN COMPONENT FUNCTION DURING ACCELERATION

* HOLDING BUT NOT EFFECTIVE
 ON = SOLENOID ENERGIZED
 OFF = SOLENOID DE-ENERGIZED

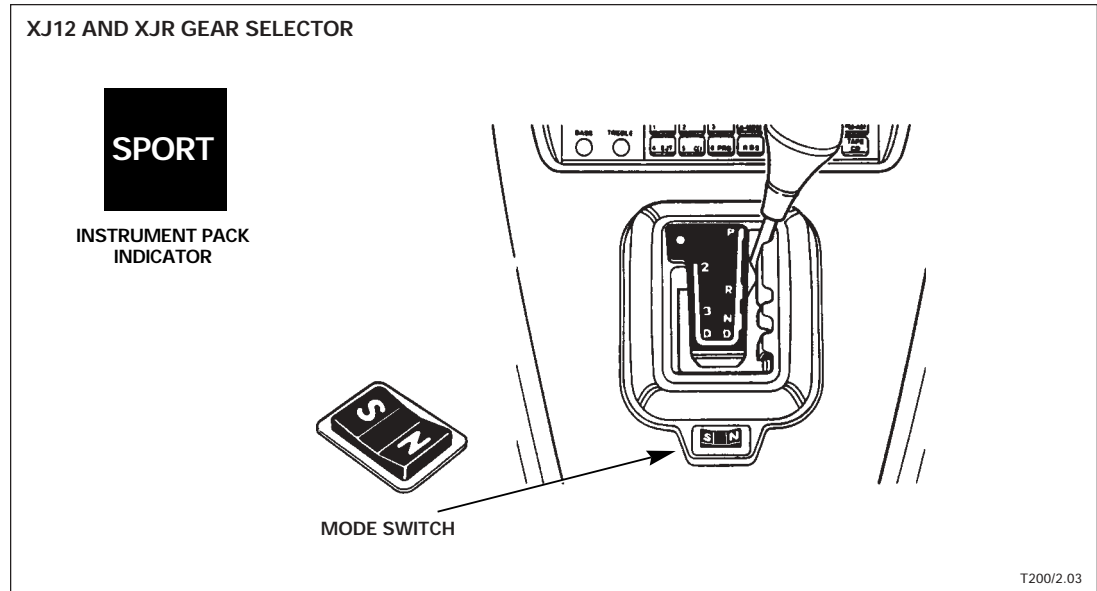
@ THE SOLENOID'S STATE FOLLOWS A SHIFT PATTERN WHICH DEPENDS UPON VEHICLE SPEED AND THROTTLE POSITION. IT DOES NOT DEPEND UPON THE SELECTED GEAR.

Gear Selectors

Both the Sedan and XJS Range gear selectors provide fully automatic or manual control of transmission shifting. Refer to the Gear Shift Interlock section for descriptions of the selector assemblies and the interlock system.

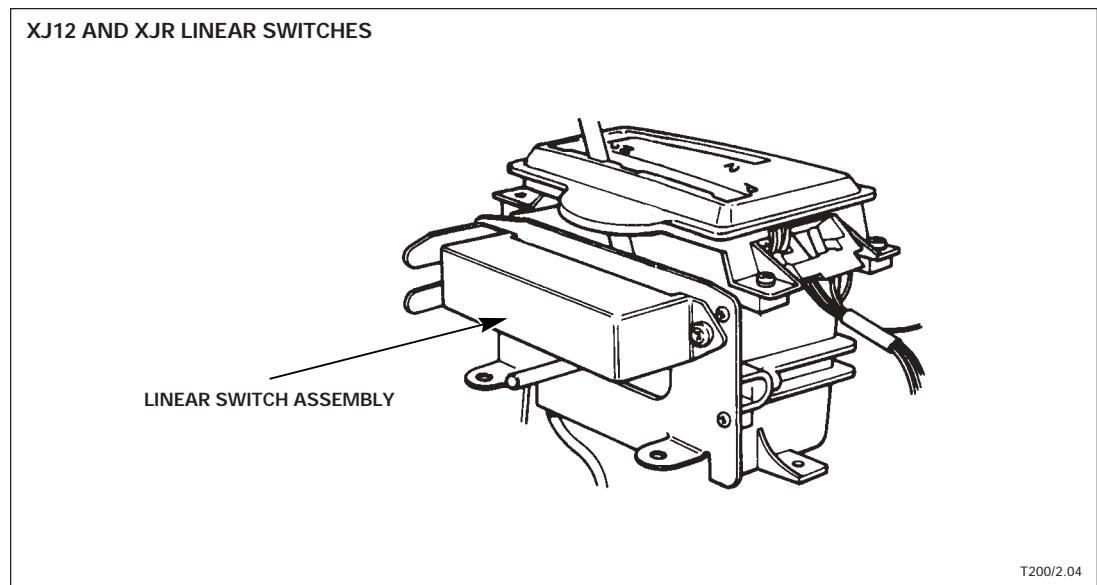
XJ12 and XJR Sedan Gear Selector

The "J" gate gear selector assembly incorporates linear gear position switches and the two-way rocker switch use for selecting NORMAL or SPORT mode.



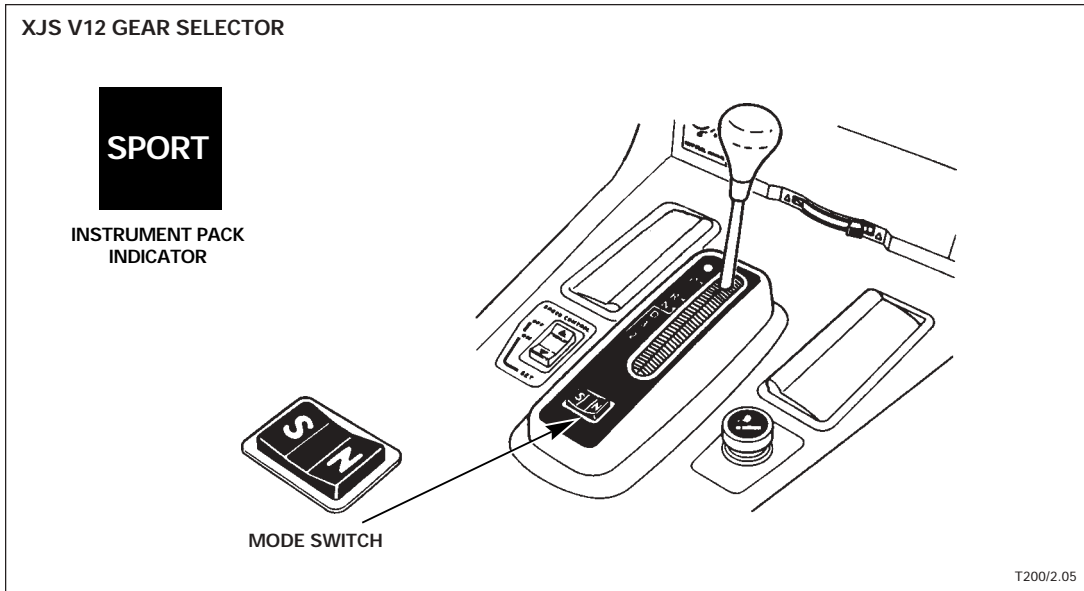
Linear gear position switches

The linear switches are used for switching the gear range state illumination and providing input to the body processor module (BPM) for starter inhibit.



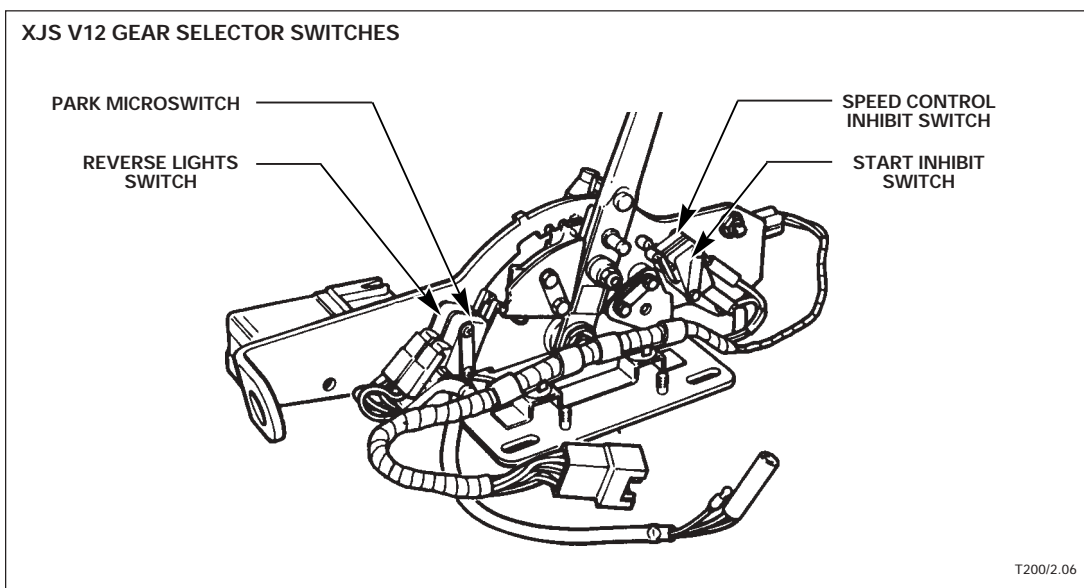
XJS V12 Gear Selector

The gear selector assembly incorporates micro switches and the two-way rocker switch used for selecting NORMAL or SPORT mode.



Gear selector switches

The gear selector assembly incorporates four micro switches that provide signals for the gear shift interlock system (park micro switch), reverse lights, speed control inhibit and starter inhibit.

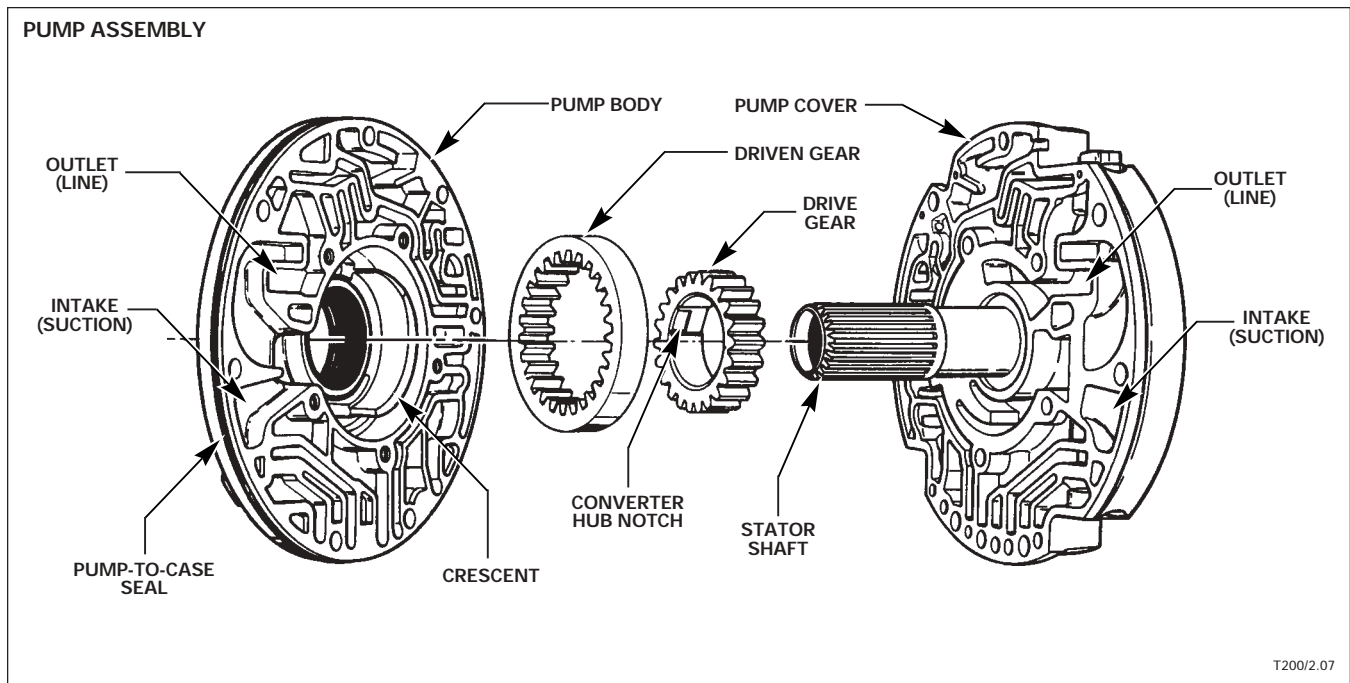


Hydraulic Control

Pump Assembly

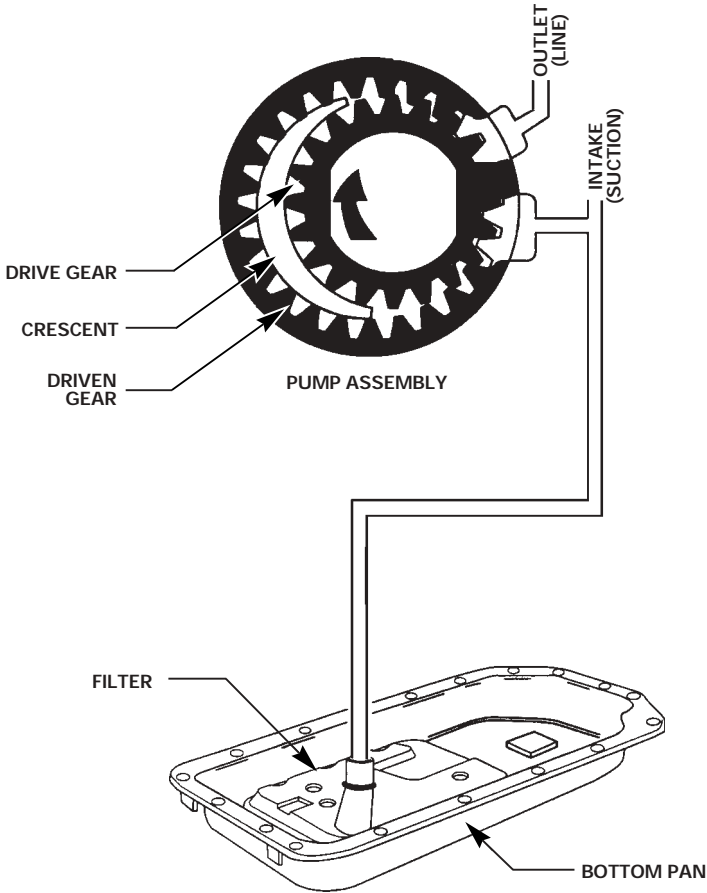
The pump assembly is a conventional "crescent type" pump that is driven by the torque converter hub. The pump rotates at engine speed and pump delivery rate is controlled by a pressure regulating valve. Five valves are located in the pump assembly.

The pump is fastened to the front of the transmission case behind the torque converter.



NOTES

PUMP OPERATION



T200/2.08

Hydraulic Control (continued)

Valves Located in the Pump Assembly

Five hydraulically actuated valves are located in the pump assembly.

TCC (torque converter clutch) enable valve

TCC RELEASED: When the TCC is released, regulated fluid passes through the valve to keep the TCC shift valve in the released position.

TCC APPLIED: When the TCC is applied, TCC signal fluid moves the enable valve against spring force to block regulated fluid flow and allow TCC enable fluid to exhaust at the valve.

TCC shift valve

TCC RELEASED: To keep the TCC released, the TCC shift valve is held in the released position by spring force and TCC enable pressure. Regulated fluid passes through the shift valve and enters the TCC release circuit. Apply / return fluid from the torque converter also passes through the valve and enters the cooler circuit.

TCC APPLIED: TCC enable fluid exhausts and the shift valve is shifted by TCC signal fluid pressure, allowing regulated apply fluid to enter the apply / return circuit. Regulated converter feed fluid passes through the shift valve to enter the cooler passage. Release fluid from the torque converter passes through the shift valve and enters the TCC enable circuit to exhaust at the enable valve.

Torque converter limit valve

The torque converter limit valve allows converter feed pressure to enter the regulated converter feed circuit. It also limits converter feed pressure to 93 – 107 psi (6.4 – 7.4 bar).

Pressure regulator valve

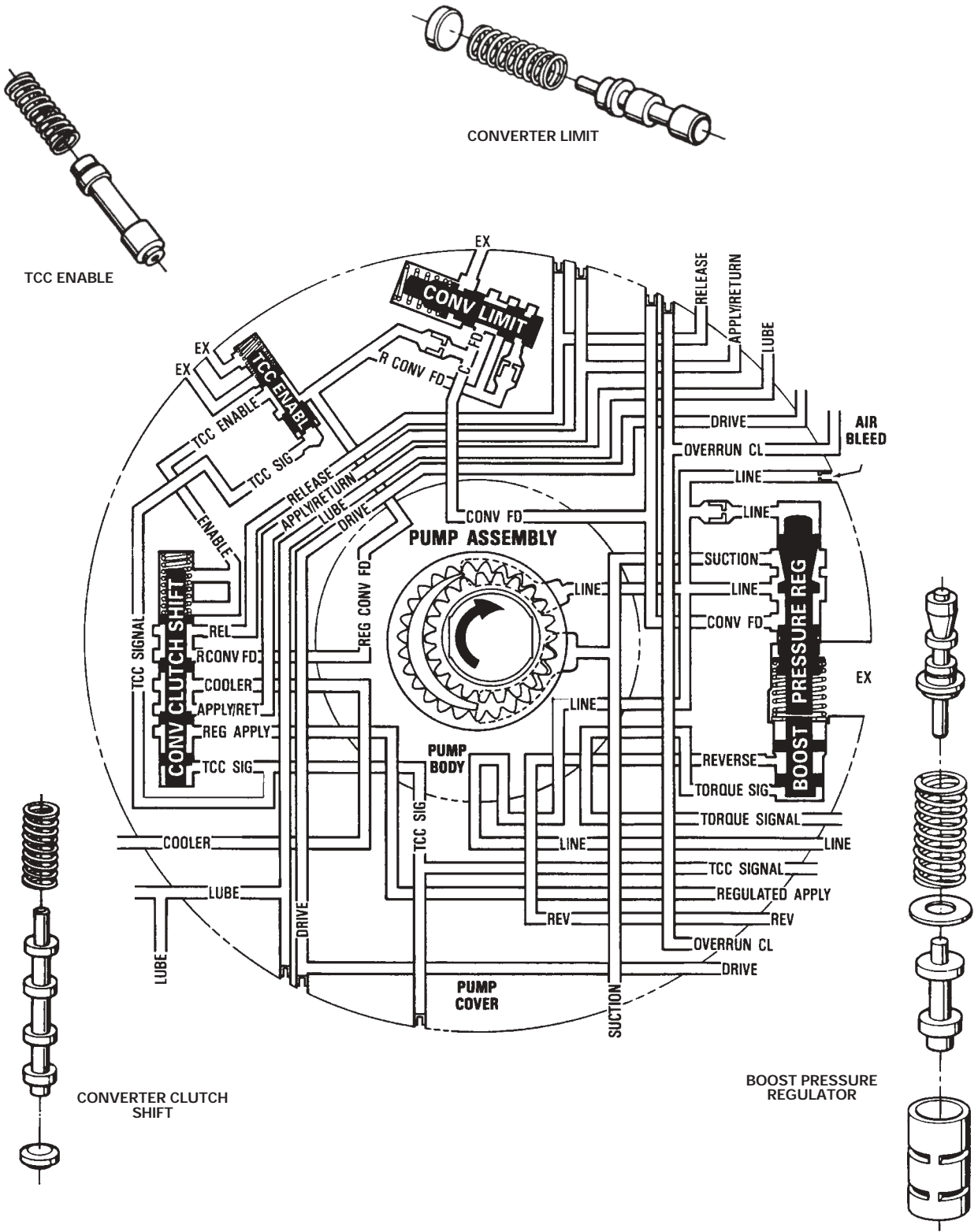
The pressure regulator valve regulates line pressure and directs it to the converter feed circuit and the pump suction circuit. The feed to the pump suction circuit regulates pump output.

Reverse boost valve

When activated by torque signal pressure (see Force Motor, page 32), the boost valve moves against the pressure regulator valve spring. The pressure regulator valve moves against the supply fluid, thereby boosting line pressure in relation to engine torque. When reverse gear is selected, reverse fluid pressure is also applied to the boost valve to boost the line pressure.

NOTES

PUMP ASSEMBLY VALVES



Hydraulic Control (continued)

Valves Located in the Control Valve Assembly

Six hydraulically actuated valves, four electrically operated valves and the manual valve are located in the control valve assembly:

Accumulator valve (hydraulically actuated)

The accumulator valve is biased by three forces: torque signal fluid, orificed accumulator fluid, and spring force from the accumulator valve spring. The accumulator valve regulates drive fluid pressure to the accumulator fluid circuit. In addition, the valve regulates accumulator fluid pressure exhaust as the second, third and fourth accumulator pistons are stroked during their respective shifts.

Actuator feed limit valve (hydraulically actuated)

The actuator feed limit valve is controlled by its force spring and limits the line pressure to 105 – 125 psi (7.2 – 8.6 bar) as it passes through the valve and enters the actuator feed circuit.

TCC solenoid (electrically actuated)

The TCC solenoid regulates 2 – 3 drive fluid pressure to the TCC signal fluid circuit. Refer to TCC Solenoid, page 30.

TCC regulator apply valve (hydraulically actuated)

The TCC regulator apply valve is controlled by the TCC signal fluid pressure on one end and spring force plus regulated apply pressure on the other end. When TCC signal fluid pressure is present, the valve regulates line pressure to the regulated apply fluid passage.

Force motor (electrically actuated)

The force motor controls torque signal fluid pressure to the reverse boost valve, the accumulator valve, and the torque signal compensator valve. Refer to Force Motor, page 32.

Manual valve

When a gear range is selected, the manual valve directs line pressure to the various circuits by opening and closing feed passages.

3 – 4 Shift valve (hydraulically actuated)

The 3 – 4 shift valve responds to signal “A” line pressure, PRN fluid pressure, actuator fluid pressure, and return spring pressure. Depending on the transmission gear range operation and solenoid “A” state, the 3 – 4 shift valve directs feed fluid to apply the fourth clutch. When down shifted, the valve opens the fourth clutch fluid to an orificed exhaust.

2 – 3 Shift valve (hydraulically actuated)

The 2 – 3 shift valve responds to signal “B” fluid pressure, actuator feed fluid pressure, D21 fluid pressure, and return spring force. Depending on the transmission gear range operation and solenoid “B” state, the 2 – 3 shift valve directs PRND4 fluid into the fourth clutch feed circuit. In addition, it directs 2 – 3 drive fluid to either apply the front band or feed the third clutch feed circuit. When downshifted, the valve opens the front band apply and third clutch fluids to exhaust.

1 – 2 Shift valve (hydraulically actuated)

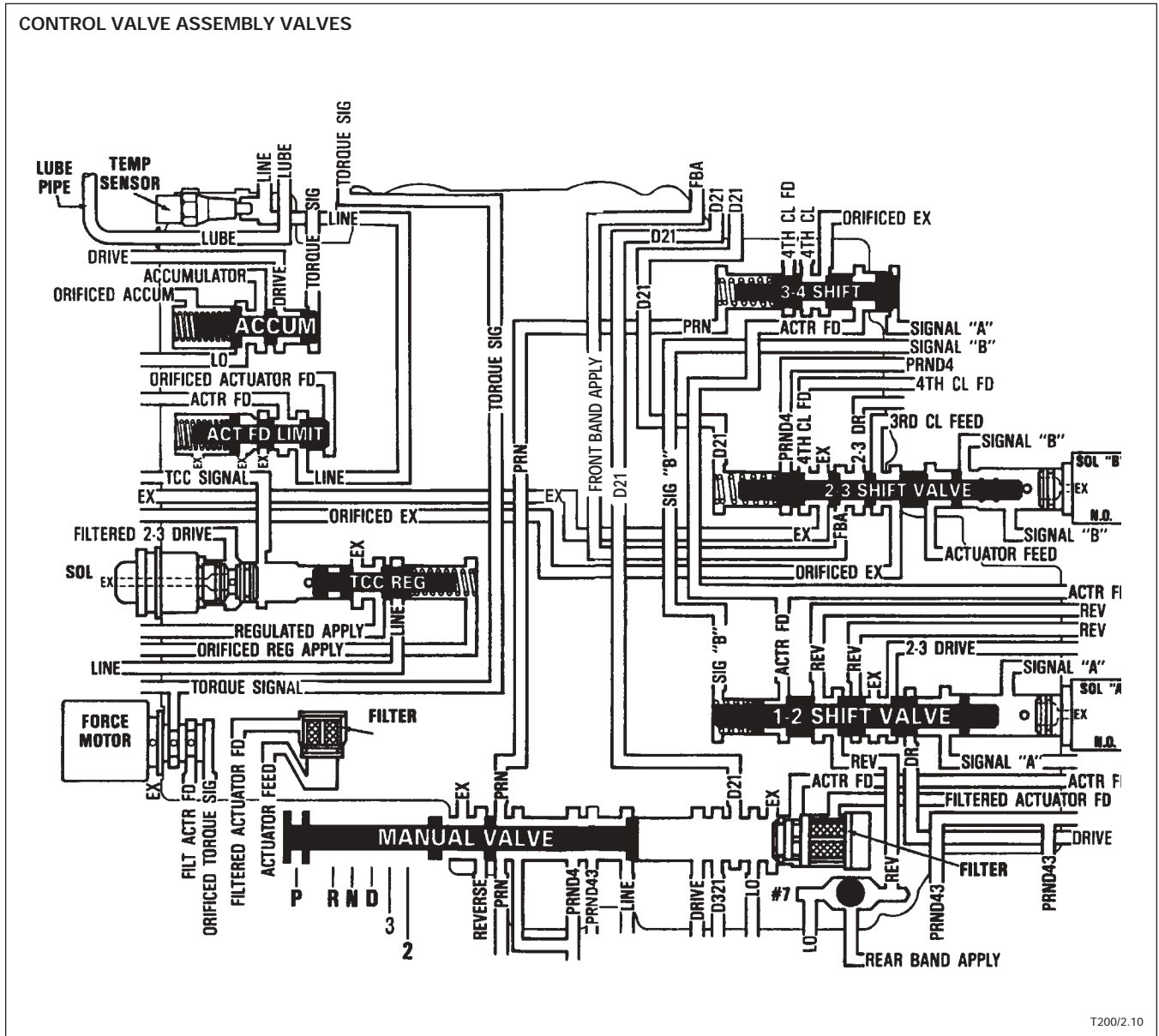
The 1 – 2 shift valve responds to signals “A” and “B” fluid pressures and return spring force. Depending on the transmission gear range operation and solenoids “A” and “B” states, the 1 – 2 shift valve directs reverse fluid through the valve and drive fluid into the 2 – 3 drive fluid circuit. When down shifted, the valve opens 2 – 3 drive fluid to exhaust.

Shift solenoid “A” (electrically actuated)

When energized, the exhaust port is closed and signal “A” fluid pressure increases. Signal “A” fluid pressure acts on both the 1 – 2 and 3 – 4 shift valves to help control the shift valve position for the appropriate gear range. When de-energized, signal “A” fluid exhausts through the solenoid to create low pressure in the signal “A” fluid circuit. Refer to Shift Solenoids, page 28.

Shift Solenoid "B" (electrically actuated)

When energized, the exhaust port is closed and signal "B" fluid pressure increases. Signal "B" fluid pressure acts both on the 1 - 2 and 2 - 3 shift valves to help control the shift valve position for the appropriate gear range. When de-energized, signal "B" fluid exhausts through the solenoid to create low pressure in the signal "B" circuit. Refer to Shift Solenoids, page 28.

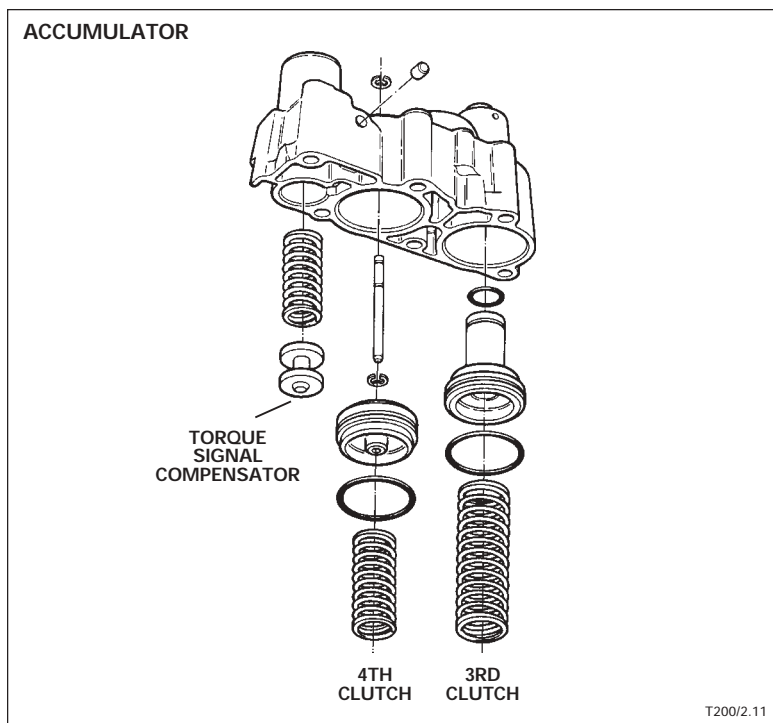


Hydraulic Control (continued)

Accumulators

An accumulator is a spring-loaded device that absorbs a certain amount of fluid pressure in the clutch engagement circuit to cushion clutch apply according to engine torque. The clutch apply fluid pressure on one side of the accumulator piston strokes against spring force and accumulator fluid pressure on the opposite side of the piston. When this action occurs, the accumulator acts like a shock absorber by controlling the rate of accumulator fluid exhaust.

The 4L80-E transmission uses accumulators in the second, third and fourth clutch apply circuits. During the apply of a clutch, apply fluid overcomes the clutch piston return spring force and begins to compress the clutch plates. When the clutch starts to hold, fluid pressure in the circuit builds up rapidly. The accumulator assembly absorbs some of the clutch apply fluid pressure and allows a more gradual apply of the clutch, producing a smoother shift.

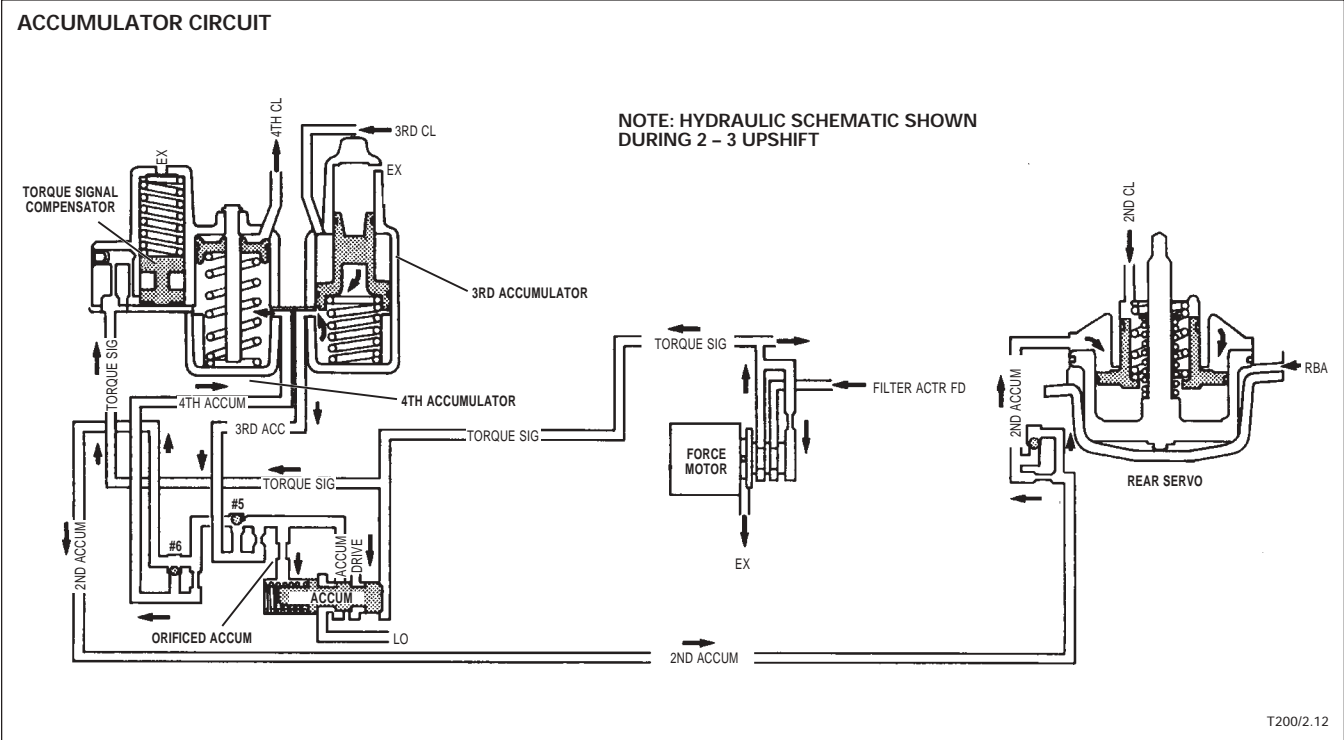


The force of the accumulator spring and the accumulator fluid controls the rate at which the clutch is applied. At minimum or light throttle, engine torque is at a minimum and the clutches require less apply force. At full throttle, the engine develops a large amount of torque that requires a greater apply pressure to hold the clutches. To accommodate these varying conditions, the accumulator valve (page 10) regulates accumulator fluid pressure proportional to throttle position in order to control shift "feel." At wider throttle openings, accumulator fluid pressure increases, providing less cushion for the clutch apply during an upshift. Note that torque signal fluid acting on the accumulator valve is regulated by the force motor according to engine torque. Refer to Force Motor, page 32.

NOTES

Torque signal compensating valve

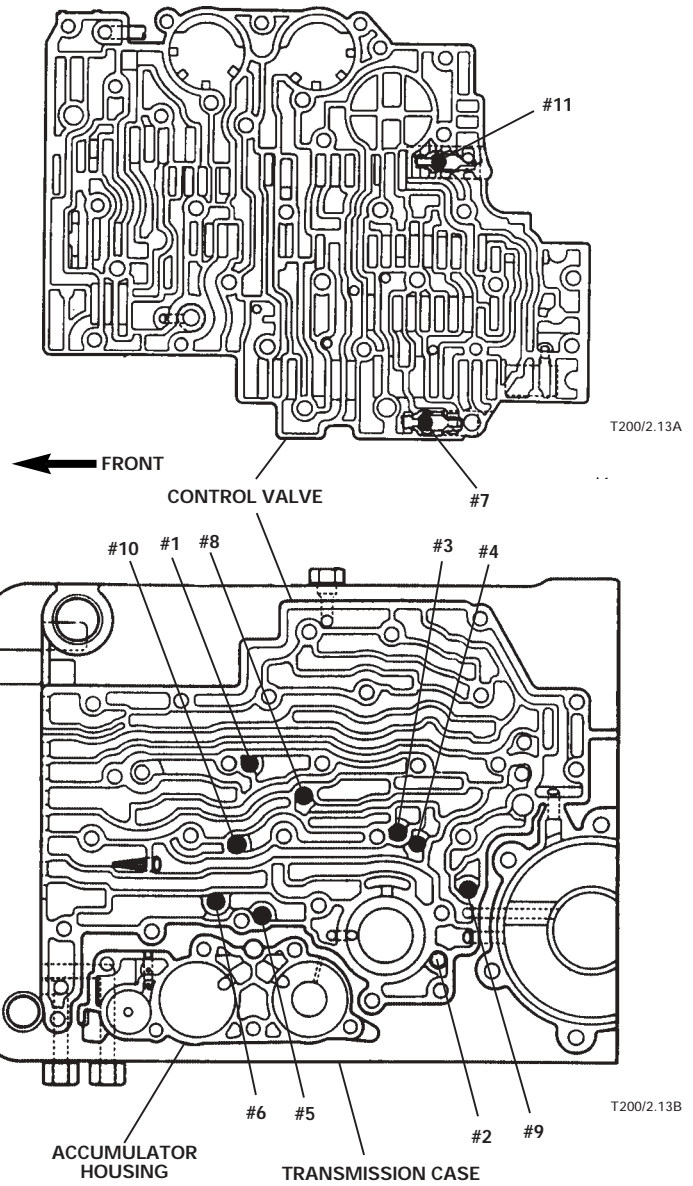
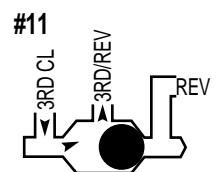
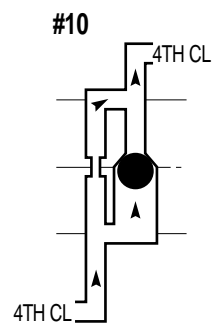
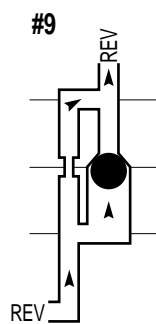
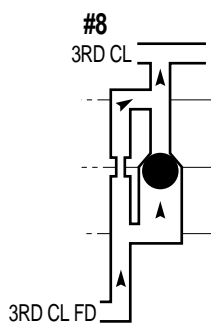
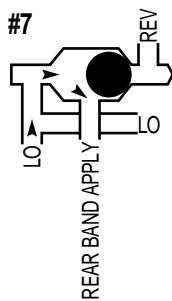
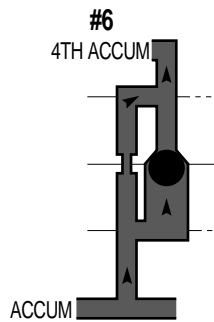
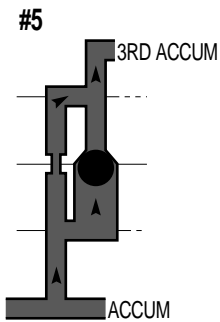
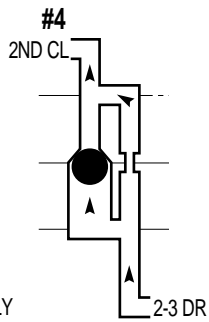
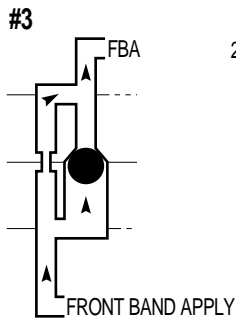
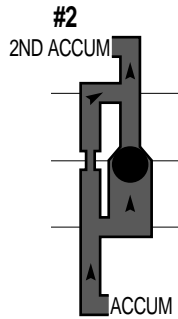
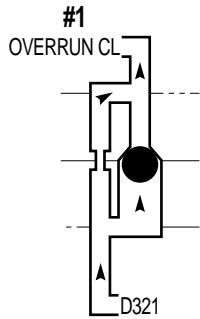
The torque signal compensating valve dampens the pressure irregularities in the torque signal fluid circuit. These irregularities are caused by the action of the force motor.



NOTES

Hydraulic Control (continued)

BALL CHECK VALVE FUNCTION AND LOCATION



T200/2.13C

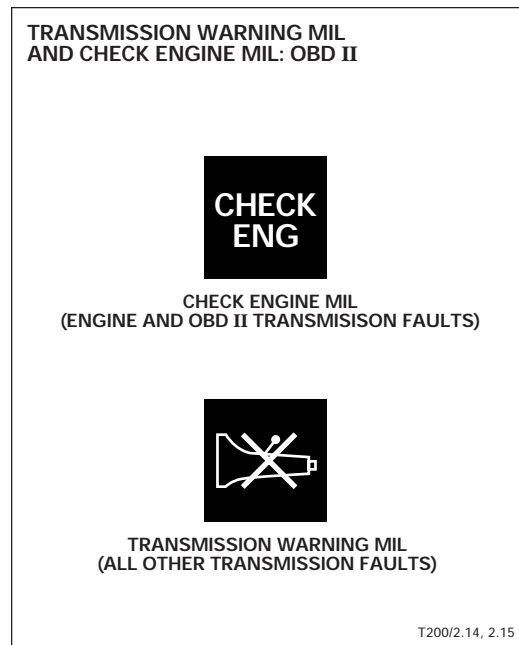
On-Board Diagnostics (OBD)

The transmission on-board diagnostic facility (OBD) monitors the transmission system for operating errors and faults. If a fault is detected by OBD monitoring or testing, it is registered in the TCM internal software. The TCM decides whether to flag a diagnostic trouble code (DTC) and whether to activate the TRANSMISSION MIL (Malfunction Indicator Light). If the fault is not critical, the TCM substitutes a default value for the faulty signal and continues normal operation. The vehicle can be operated normally, but shift quality may be effected. If the fault is critical, the TCM may substitute a default value for the faulty signal and revert to a "limp home" strategy. The vehicle can be driven but no automatic shifting will occur.

The OBD systems and diagnostic trouble codes (DTCs) vary depending on the engine management system (EMS) and model year of the vehicle.

OBD II: XJ12 1995 MY ON and XJR

The transmission OBD facility for XJ12 1995 MY ON and XJR vehicles is expanded to comply with OBD II legislation. OBD II legislation requires monitoring and diagnosis of any power train system fault that will likely cause emissions to exceed 1.5 times the standard level. The TCM (transmission control module) and the ECM (engine control module) communicate with each other via serial communications. The TRANSMISSION MIL is activated by the TCM according to the transmission on-board diagnostic strategy. The CHECK ENGINE MIL is activated by the ECM (engine control module) if the transmission fault is classified as an OBD II fault. Therefore, either the TRANSMISSION MIL or the both TRANSMISSION MIL and CHECK ENGINE MIL may be activated depending on the nature and classification of the fault.

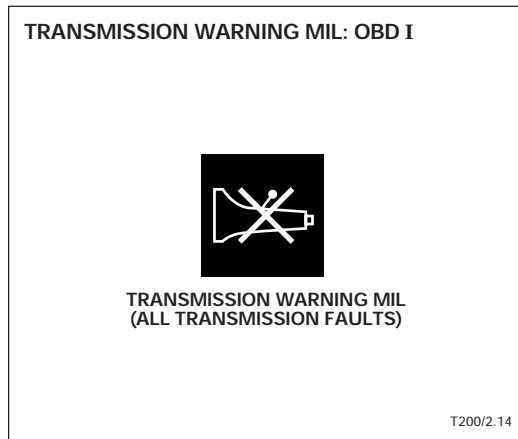


Each DTC is a five place industry standardized code that describes the subsystem and specific fault. Transmission DTCs are stored in a volatile electronically erasable programmable read only memory (EEPROM), and can be accessed only by Jaguar diagnostic equipment (PDU) or a generic (after market) scan tool. PDU allows advanced fault diagnostics by providing engine and transmission operating information and circuit information related to the fault. DTC access is via the vehicle data link connector.

NOTES

On-Board Diagnostics (OBD) (continued)

OBD I: XJ12 through 1994 MY and All XJS V12



The OBD facility for XJ12 Sedans through the 1994 MY and all XJS (V12) Range vehicles is independent of the engine management system and complies with OBD I legislation. The TRANSMISSION MIL is activated by the TCM according to the transmission OBD strategy. This OBD system also provides diagnostic trouble codes and diagnosis facilities for the transmission. The two-digit DTCs can be retrieved via serial communications with PDU. Depending on the model year, DTCs are accessed via the serial communications data link or the engine / transmission diagnostic link.

Refer to the specific component and systems descriptions for explanations of fault parameters. Refer to the Service Manual and DTC Summary information in this publication for a listing of DTCs.

NOTES

Fail Safe Mode

If the entire transmission electronic control system becomes disabled, the following occurs:

- both of the shift solenoids will be de-energized forcing the transmission to operate in second gear when the gear selector is in a forward drive range
- the force motor is switched off, increasing line pressure to maximum
- the torque converter clutch solenoid cannot apply the torque converter lockup clutch

Adaptive Learning

The TCM programming allows for adjustment in line pressure based on the changing characteristics of the transmission components as sensed from the various TCM inputs. Line pressure is adjusted to maintain the originally calibrated shift timing as apply components wear.

If the TCM detects certain faults, it will attempt to rectify the fault by adjusting line pressure. If the fault is rectified, the line pressure increase becomes the normal line pressure for that portion of the operating strategy. If the TCM cannot rectify the fault, a diagnostic trouble code (DTC) is flagged.

Default and Limp Home Facilities

For certain component or signal failures, the TCM substitutes a "default" value for the failed signal. The vehicle can be driven, but shift quality may be impaired. The default will be canceled when the ignition switch is cycled. Normal operation will resume if the fault has been corrected or is intermittent and not present.

For critical faults, the TCM reverts to a "limp home" mode by disabling the shift and torque converter clutch solenoids. In limp home mode, the transmission will only operate in second gear when the gear selector is in a forward drive range.

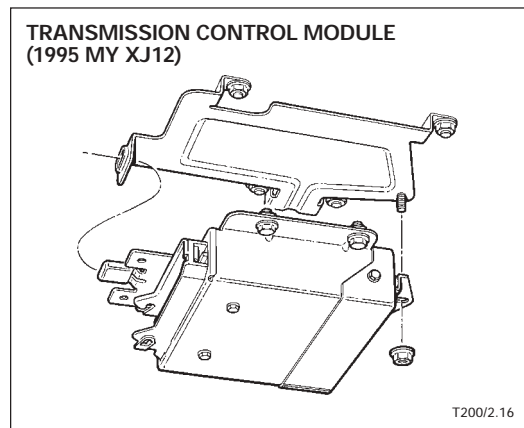
Refer to the DTC Summary on pages 43 – 46 to determine which faults will cause limp home.

NOTES

Transmission Control

The transmission is controlled by a microprocessor based transmission control module (TCM) that receives inputs from the transmission, engine control module (ECM) and other vehicle systems and components. The TCM supplies the input sensors with a five volt reference signal. The return input sensor information is applied by the TCM to the transmission operating strategy programmed into its memory. From the strategy, the TCM controls the shift solenoids and the force motor (pressure regulator).

An on-board diagnostic facility (OBD) allows the TCM to diagnose transmission and related component problems. If the TCM detects a fault, it will store the fault code (DTC) in memory and may activate the TRANSMISSION MIL or both the TRANSMISSION MIL and CHECK ENGINE MIL depending on the nature of the fault and the vehicle Model Year. In some cases a default value may be substituted for a faulty signal.



Transmission Control Module (TCM)

The TCM used in 4L80-E transmission equipped Jaguars utilizes a volatile memory. DTCs will be lost if battery power is disconnected. However, on XJ12 1995 MY ON and XJR (OBD II compliant vehicles), OBD II related transmission DTCs are also stored in the memory of the ECM. The XJR utilizes an ECM with nonvolatile memory, DTCs will be maintained if the battery is disconnected. The XJ12 utilizes an ECM with volatile memory, all DTCs will be lost if the battery is disconnected.

XJ12 1995 MY ON and XJR transmission control module diagnostic monitoring

The TCM monitors itself and will flag a DTC under the following conditions:

An error in the TCM programmable read only memory (PROM) will be detected during TCM initialization, when the ignition is switched on. An error will flag DTC P0605.

Out of range TCM supply voltage is monitored while the ignition is in position II. Supply voltage below 8V at a fluid temperature of -40° F (-40° C) or below 10.5V at a fluid temperature of 302° F (151° C) for 4 seconds with engine speed above 1250 rpm, or TCM supply voltage above 19.5V for more than 2 seconds will flag DTC P1794. The CHECK ENGINE MIL and TRANSMISSION MIL will activate. If the fault is high voltage, the transmission immediately defaults to limp home. If the fault is low voltage, and the transmission is in fourth gear lockup, the system will revert to limp home at the first down shift.

The limp home default is described on page 17.

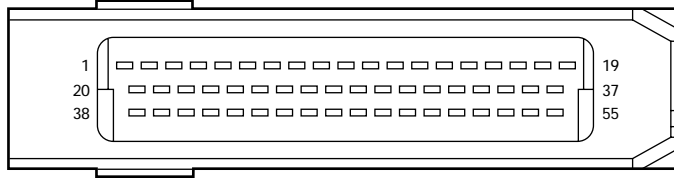
DTC	Component / signal	Trans MIL	Check Engine MIL (OBD II)	Limp home
P0605	TCM data corrupted	YES	YES	YES
P1794	TCM voltage supply out of range	YES	YES	YES

Refer to the DTC Summary, pages 43 – 46.

Transmission control module pin-out information

NOTE: For more detailed pin-out information, refer to the Electrical Guide.

TRANSMISSION CONTROL MODULE PIN-OUT INFORMATION (1995 MY XJ12)



1	NOT USED	20	NOT USED	38	NOT USED
2	NOT USED	21	NOT USED	39	SHIFT SOLENOID A
3	PRESSURE SWITCH MANIFOLD	22	PRESSURE SWITCH MANIFOLD	40	TRANSMISSION MIL
4	PRESSURE SWITCH MANIFOLD	23	TRACTION ACTIVE	41	SPORT MODE INDICATOR LAMP
5	MODE SWITCH	24	KICKDOWN SWITCH	42	TORQUE CONVERTER CLUTCH SOLENOID
6	CALIBRATION SELECT LINK (DEALER FIT)	25	BRAKE SWITCH	43	SHIFT SOLENOID B
7	TORQUE REDUCTION REQUEST	26	TRANSMISSION TEMPERATURE SENSOR	44	NOT USED
8	NOT USED	27	NOT USED	45	SERIAL COMMUNICATION OUTPUT
9	NOT USED	28	NOT USED	46	NOT USED
10	NOT USED	29	NOT USED	47	NOT USED
11	THROTTLE POSITION	30	ENGINE SPEED SIGNAL	48	NOT USED
12	ENGINE TORQUE	31	NOT USED	49	FORCE MOTOR
13	NOT USED	32	NOT USED	50	INPUT SPEED SENSOR
14	TEMPERATURE SENSOR GROUND	33	NOT USED	51	OUTPUT SPEED SENSOR
15	NOT USED	34	VEHICLE SPEED SENSOR	52	VARIABLE FORCE MOTOR
16	SERIAL COMMUNICATION OUTPUT	35	NOT USED	53	IGNITION SUPPLY
17	NOT USED	36	OUTPUT SPEED SENSOR	54	POWER GROUND
18	NOT USED	37	INPUT SPEED SENSOR	55	BATTERY POWER
19	NOT USED				

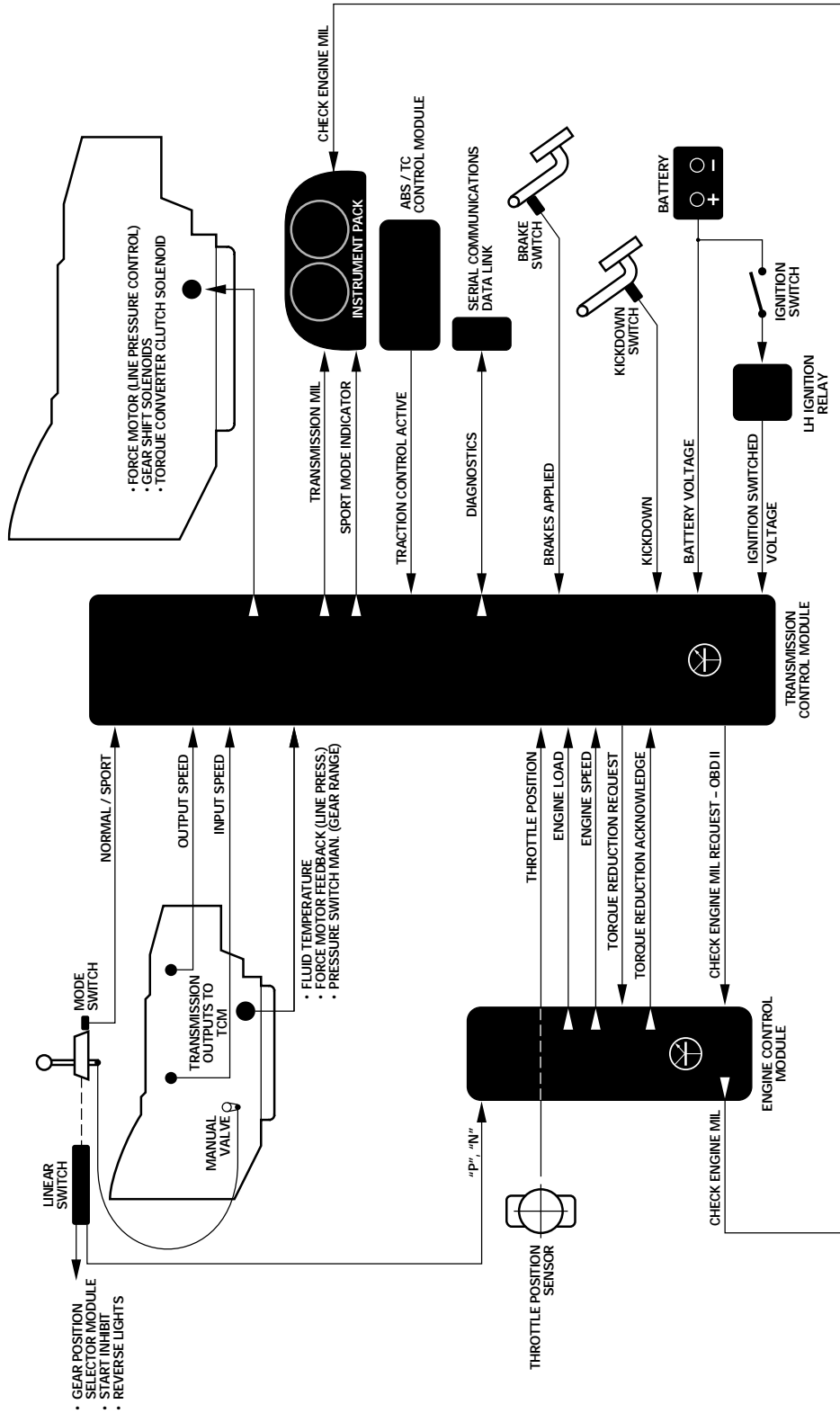
T200/2.17

NOTES

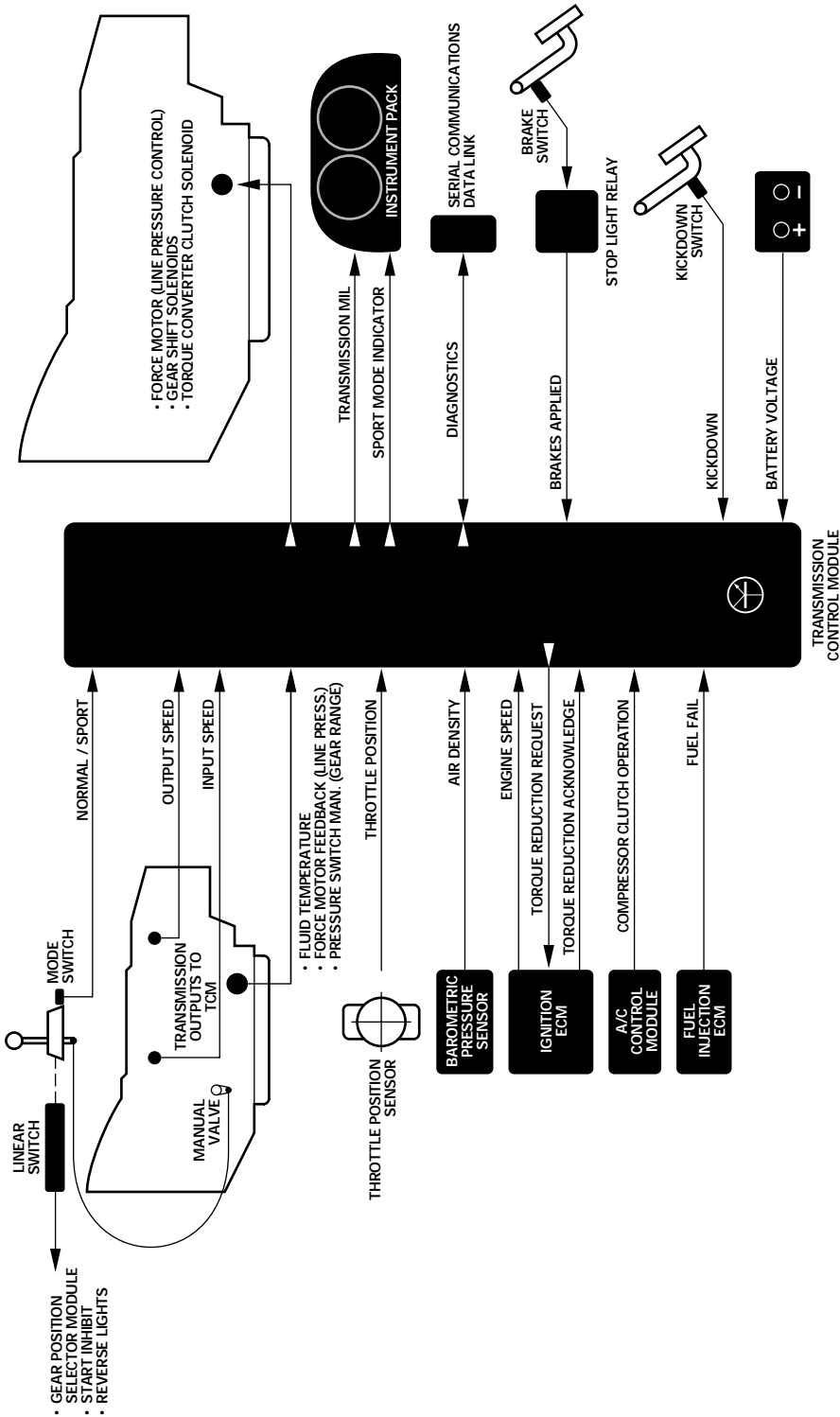
Transmission Control (continued)

Transmission Control Module Inputs and Outputs

OBD II TRANSMISSION CONTROL LOGIC: XJ12 AND XJR 1995 MY ON



TYPICAL OBD I TRANSMISSION CONTROL LOGIC: XJ12 THROUGH 1994 MY AND XJS 1994-95 MY



T200/2.19

Transmission Control (continued)

Transmission Control Module Inputs

Mode switch

The mode switch inputs the driver's choice of operating strategy, NORMAL or SPORT.

Pressure switch manifold

The pressure switch manifold logic signal is used by the TCM to determine what gear range the driver has selected.

Input and output shaft speed sensors

The TCM uses the transmission input and output speed to determine the line pressure, shift patterns and torque converter lockup clutch apply pressure and timing. The speed inputs are also used to calculate converter turbine speed, gear ratios and lockup clutch slippage for diagnostic purposes.

Force motor feedback

The TCM senses the force motor duty cycle (percent time energized) to determine the prevailing transmission line pressure.

Transmission fluid temperature

The TCM monitors the transmission fluid temperature to help determine torque converter lockup clutch operation and line pressure. The TCM inhibits lockup clutch operation until the fluid temperature reaches approximately 68° F (20° C).

If the fluid temperature becomes too high (approximately 250° F [122° C]), the TCM will apply the lockup clutch whenever the transmission is in second, third, or fourth gears. Applying the lockup clutch serves to reduce the fluid temperature because the torque converter fluid coupling is bypassed.

Above approximately 310° F (154° C), the TCM will flag a temperature diagnostic trouble code (DTC). Once the DTC is flagged, the TCM assumes a fixed temperature input of 266° F (130° C) and applies the lockup clutch in second, third, and fourth gears.

Kickdown

A ground signal is supplied to the TCM when the driver activates the kickdown switch by fully depressing the accelerator pedal.

Engine throttle position

XJ12 1995 MY ON and XJR The variable voltage throttle position signal is input directly from the ECM to the TCM.

XJ12 through 1994 MY and XJS A variable voltage signal from the twin track TPS (throttle position sensor) directly to the TCM allows the TCM to sense throttle position.

The TCM uses throttle position and other inputs to determine shift patterns and torque converter lockup clutch apply and release. In general, the greater the throttle opening, the higher the up-shift speed and the greater the transmission line pressure. The TCM releases the lockup clutch at minimum throttle opening and during open-throttle heavy acceleration.

NOTES

Engine load

XJ12 1995 MY ON and XJR The ECM supplies fuel injection pulse duration information to the TCM. The TCM uses this signal to determine engine torque.

XJ12 through 1994 MY and XJS The ECM calculates engine torque using engine throttle position, barometric pressure, A/C compressor clutch operation and other signals.

Barometric pressure sensor (XJ12 through 1994 MY and XJS)

The barometric pressure sensor input allows the TCM to adjust the line pressure for changes in air density that effect engine power.

Engine speed

The ECM (XJ12 1995 MY ON and XJR) or the Ignition ECM (XJ12 through 1994 MY and XJS) supplies an engine speed input to the TCM. Engine speed is one of the inputs used to determine shift patterns and torque converter lockup clutch apply and release.

Brake operation

The TCM receives a brake applied input via the brake switch (XJ12 1995 MY ON and XJR) or the stop light relay (XJ12 through 1994 MY and XJS). When the brakes are applied, the TCM releases the torque converter lockup clutch.

A/C compressor clutch operation

The TCM receives a compressor clutch operating input from the Air Conditioning Control Module (XJS and L / M EMS only). When the compressor is operating, the TCM adjusts the line pressure and shift timing to compensate for the added engine load.

CHECK ENGINE MIL

If a fuel fail input is received from the Fuel Injection ECM (XJ12 through 1994 MY and XJS), the TCM defaults to a higher line pressure to compensate for the loss of engine power.

Battery voltage

The TCM monitors battery voltage to detect a high or low voltage condition.

Traction control active (XJ12 1995 MY ON and XJR only)

A "traction control active" signal is supplied to the TCM from the ABS / Traction Control Control Module. The signal allows the TCM to select a shift strategy to increase the effectiveness of traction control.

NOTES

Transmission Control (continued)

Transmission Control Module Outputs

Force motor

The TCM varies the current to the force motor to control "torque signal" pressure, which in turn, controls line pressure. The lower the "torque signal" pressure, the lower the line pressure; the higher the "torque signal" pressure, the higher the line pressure. At idle (throttle closed), current flow is close to maximum, positioning the force motor so that the minimum "torque signal" pressure is applied to the line pressure regulator. At full throttle, current flow is close to minimum, positioning the force motor so that maximum "torque signal" pressure is applied to the line pressure regulator.

If the electrical system becomes disabled, current flow to the force motor will stop and maximum line pressure will result, thus preventing component slippage until the condition can be corrected.

Shift solenoids A and B

The TCM controls the shift solenoids from the operating strategy by switching the solenoid coil ground circuits. The following table shows the solenoid state combination for each gear range:

Range	Solenoid A	Solenoid B
P,R,N	1	0
First	1	0
Second	0	0
Third	0	1
Fourth	1	1

1 = energized, valve closed

0 = not energized, valve open

Torque converter clutch (TCC) solenoid

The application rate of the torque converter lockup clutch depends on the torque converter clutch pressure as controlled by the duty cycle of the TCC solenoid. The TCM varies the TCC solenoid duty cycle by controlling the ground circuit. The normally open TCC solenoid valve varies the torque converter clutch signal pressure acting on the lockup clutch shift valve. By controlling the duty cycle of the TCC solenoid, lockup clutch apply and release occurs smoothly.

NOTES

Engine torque reduction

Ignition timing retard (XJ12 1995 MY ON and XJR) The TCM supplies a two part ignition timing retard output to the ECM; a transmission shift “up / down” signal (IGNITION SELECT), and a transmission “shift in progress” signal (IGNITION RETARD). When the ignition is momentarily retarded by the ECM, engine torque is reduced and a smoother, softer shift occurs.

Ignition retard request and acknowledge (XJ12 through 1994 MY and XJS) When the TCM senses that a reduction in engine torque is required to allow a “quality shift”, a request for ignition retard is output to the ignition. After the ignition has been retarded, the ignition ECM signals the TCM to acknowledge ignition retard.

Road speed (XJ12 1995 MY ON only) The TCM generates a road speed signal that is output to the ECM.

Mode indication

The TCM provides a ground to activate the instrument pack mode indicator light.

TRANSMISSION MIL

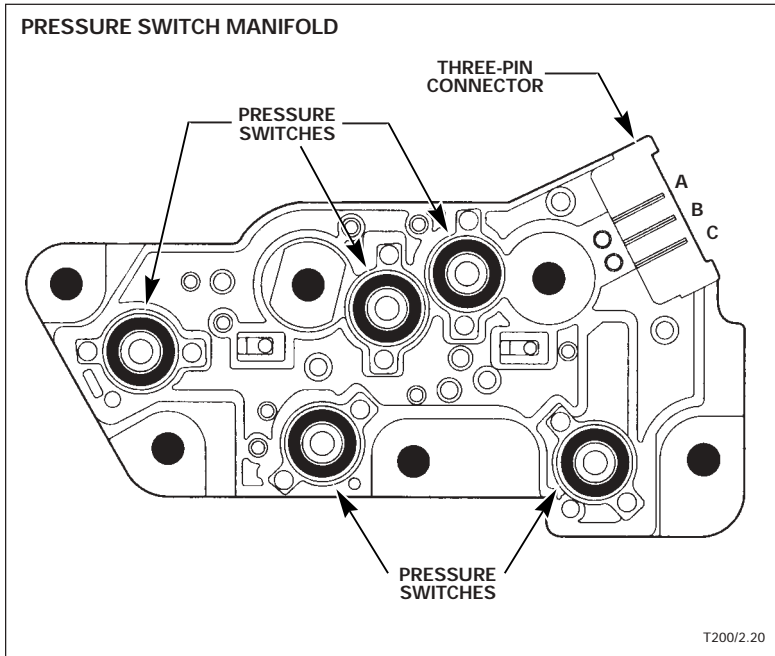
The TCM provides a ground to activate the TRANSMISSION MIL.

CHECK ENGINE MIL

On 1995 MY and later OBD II compliant vehicles, the TCM communicates with the ECM to request the CHECK ENGINE MIL and the DTC for emission related failures.

NOTES

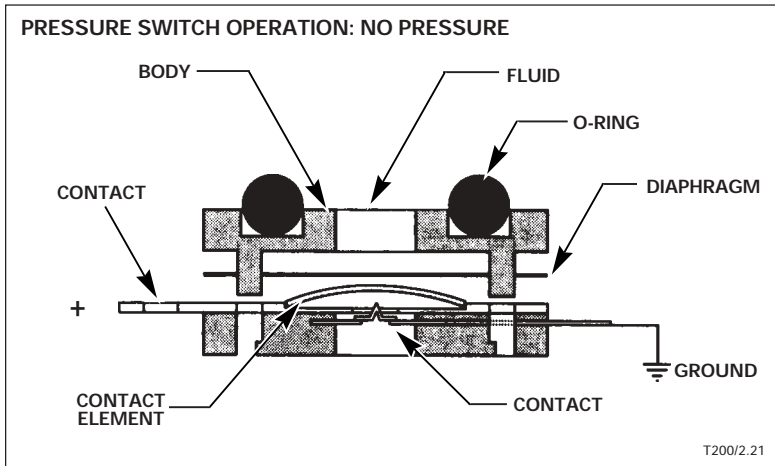
Transmission Control Components



Pressure Switch Manifold

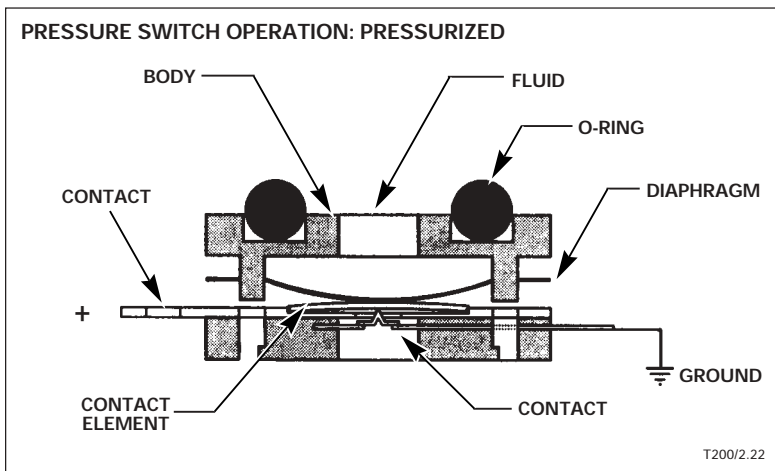
The pressure switch manifold is a multiple switch assembly to provide gear position logic input to the TCM. It is made up of 5 normally open pressure switches. Various fluid pressures are fed from the manual valve to the switches depending on gear selector and manual valve positioning. Fluid pressure acting on the switches determine the digital logic at the connector pins A, B, and C.

When no fluid pressure is present, the pressure switches are open. When fluid pressure is applied, the switch diaphragm causes the upper switch contact to close against the lower switch contact. Switches REV, LO and PRND43 complete the circuit to ground. Switches PRND4 and DRIVE complete their circuits to the PRND43 switch.

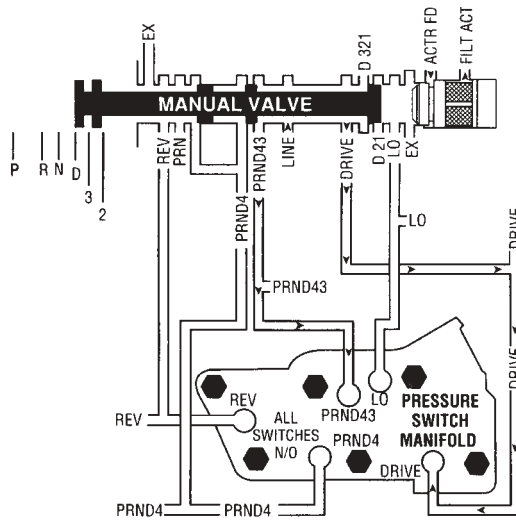


In the example shown for MANUAL THIRD, the DRIVE and PRND43 switches are pressurized and closed, allowing circuit C to be completed to ground. The digital logic at connector pin C is "0" (circuit completed to ground). The digital logic at pins A and B remains "1" (circuits open). The TCM interprets this signal as MANUAL THIRD range.

NOTES



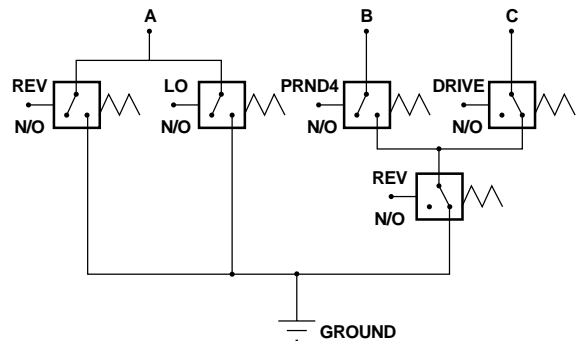
PRESSURE SWITCH HYDRAULIC AND ELECTRICAL CIRCUITS (THIRD GEAR)



RANGE INDICATOR	FLUIDS					CIRCUIT		
	REV	LO	PRND4	PRND43	DRIVE	A	B	C
PARK						0	1	0
REVERSE						1	1	0
NEUTRAL						0	1	0
D						0	1	1
3						0	0	1
2						0	0	0
(1)						1	0	0

■ PRESSURIZED

1- GROUNDED: 0V LOW
0- OPEN: 12V HIGH
(as read by PDU)



T200/2.23A & B

Pressure switch manifold diagnostic monitoring

The TCM monitors the gear range output signals from the pressure switch manifold and compares them to other inputs to determine if a malfunction has occurred.

Any of the following conditions will cause DTC P0706 to flag:

- A "not in P or N" signal during cranking.
- A "P" or "N" signal for more than 0.1 second with road speed above 7 mph (11 km/h).
- The pressure switch manifold output signal does not match the calculated gear ratio.
- An invalid in gear range position code. The two invalid gear range position codes are:

CIRCUIT:	A	B	C
	0	0	0
	0	1	0

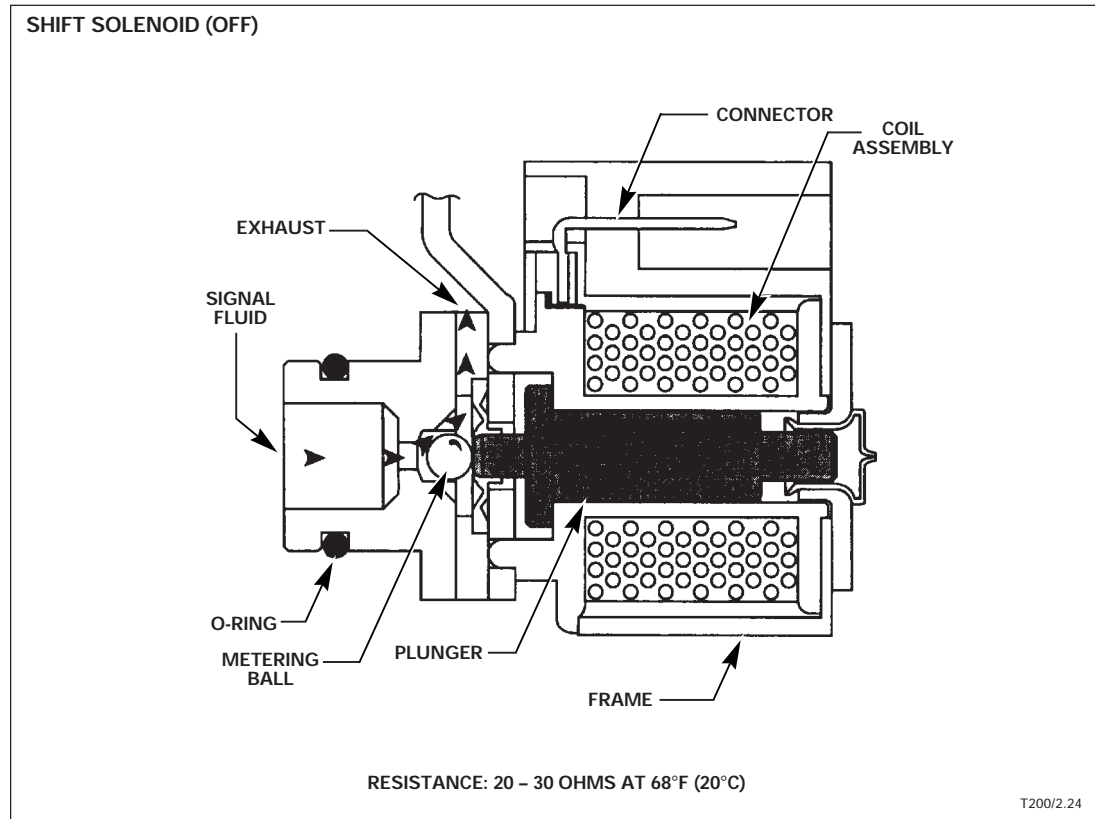
DTC	Component / signal	Trans MIL	Check Engine MIL (OBD II)	Limp home
P0706	Pressure switch manifold range / performance	YES	YES	—

Refer to the DTC Summary, pages 43 – 46.

Transmission Control Components (continued)

Shift Solenoid Valves

Two normally open shift solenoid valves – A and B – are used to apply upshifts and down shifts in all forward gear ranges. The solenoid valves work in combination to direct hydraulic pressure to the various apply valves.



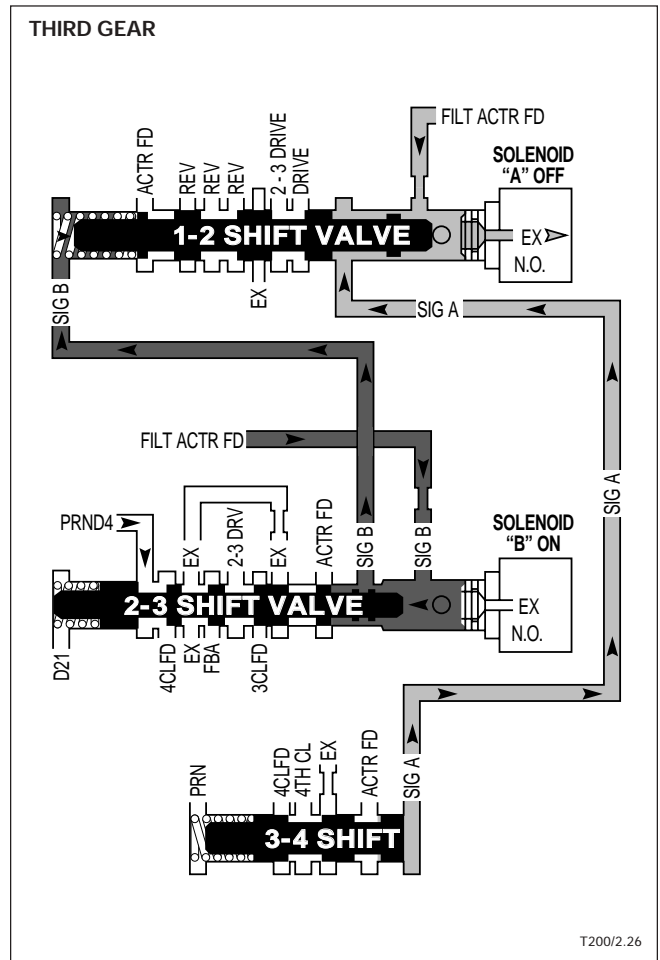
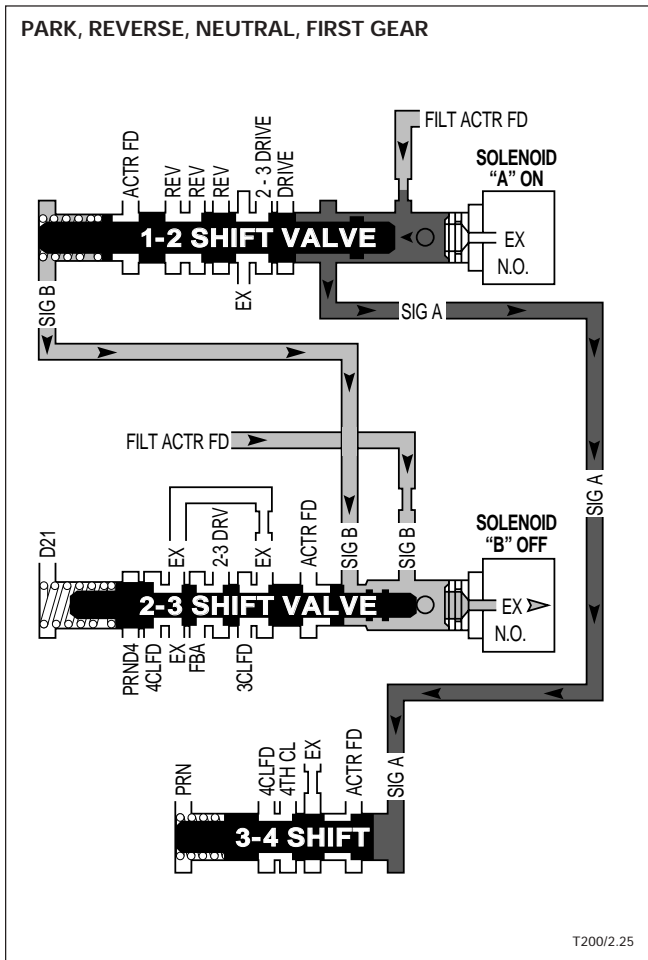
The following table shows the shift solenoid state combination required for each gear range:

Range	Solenoid A	Solenoid B
P,R,N	1	0
First	1	0
Second	0	0
Third	0	1
Fourth	1	1

1 = energized, valve closed

0 = not energized, valve open

NOTES



Shift solenoid diagnostic monitoring

The shift solenoids are provided with a fused ignition switched power feed. The TCM energizes each solenoid by controlling its ground. The electrical state of each solenoid is continuously monitored by the TCM, which compares the solenoid drive signal voltage to the solenoid feedback voltage.

If an open or short circuit is detected, the TCM will flag DTC P0753 for a solenoid A fault and DTC P0758 for a solenoid B fault.

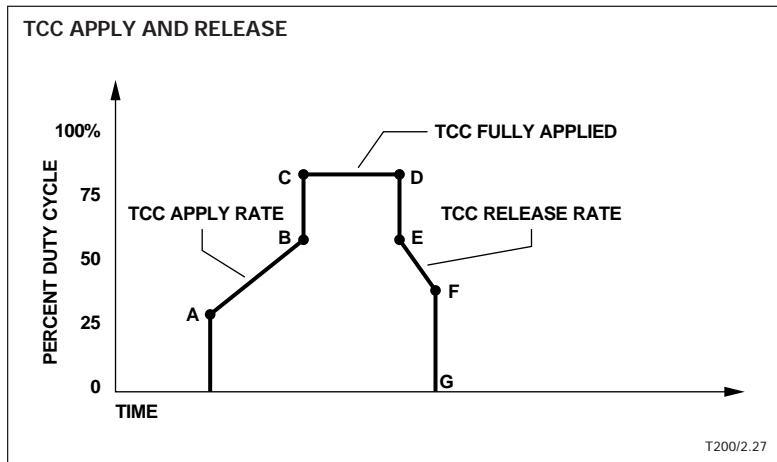
If the TCM detects an invalid gear ratio (refer to Transmission mechanical / hydraulic gear selection diagnostic monitoring on page 40) for more than 2 seconds after the solenoid is commanded on, the TCM assumes a stuck solenoid and immediately flags DTC P0751 for solenoid A or DTC P0756 for solenoid B.

DTC	Component / signal	Trans MIL	Check Engine MIL (OBD II)	Limp home
P0751	Shift solenoid A stuck ON or OFF	YES	YES	YES
P0753	Shift solenoid A state does not match commanded state	YES	YES	YES
P0756	Shift solenoid B stuck ON or OFF	YES	YES	YES
P0758	Shift solenoid B state does not match commanded state	YES	YES	YES

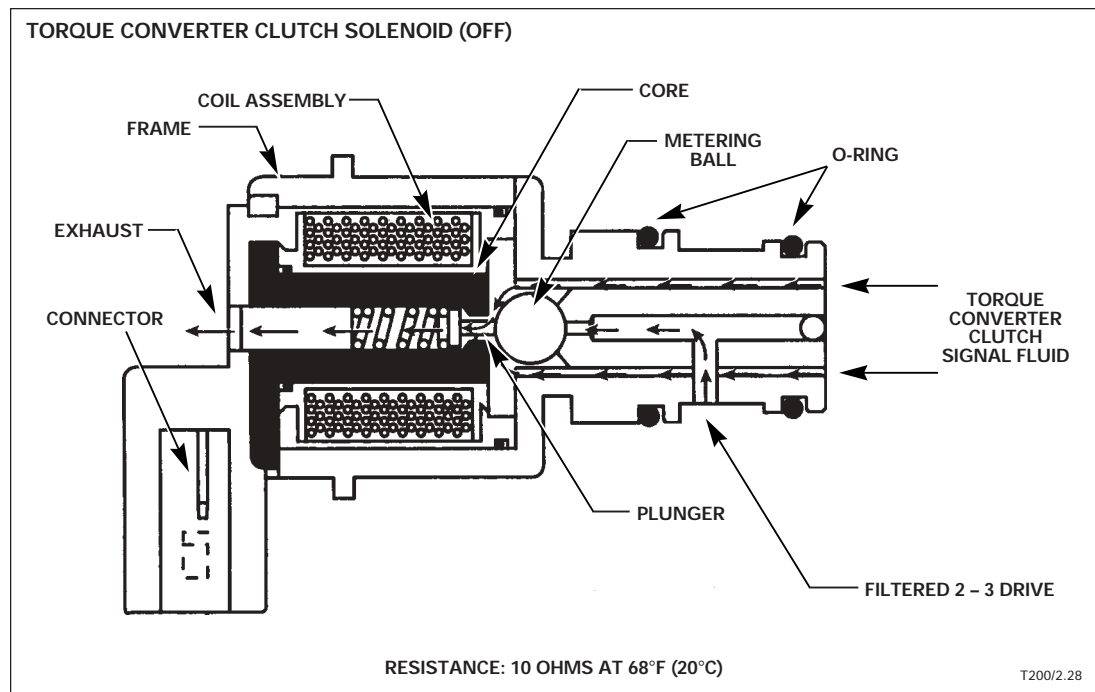
Refer to the DTC Summary, pages 43 – 46.

Transmission Control Components (continued)

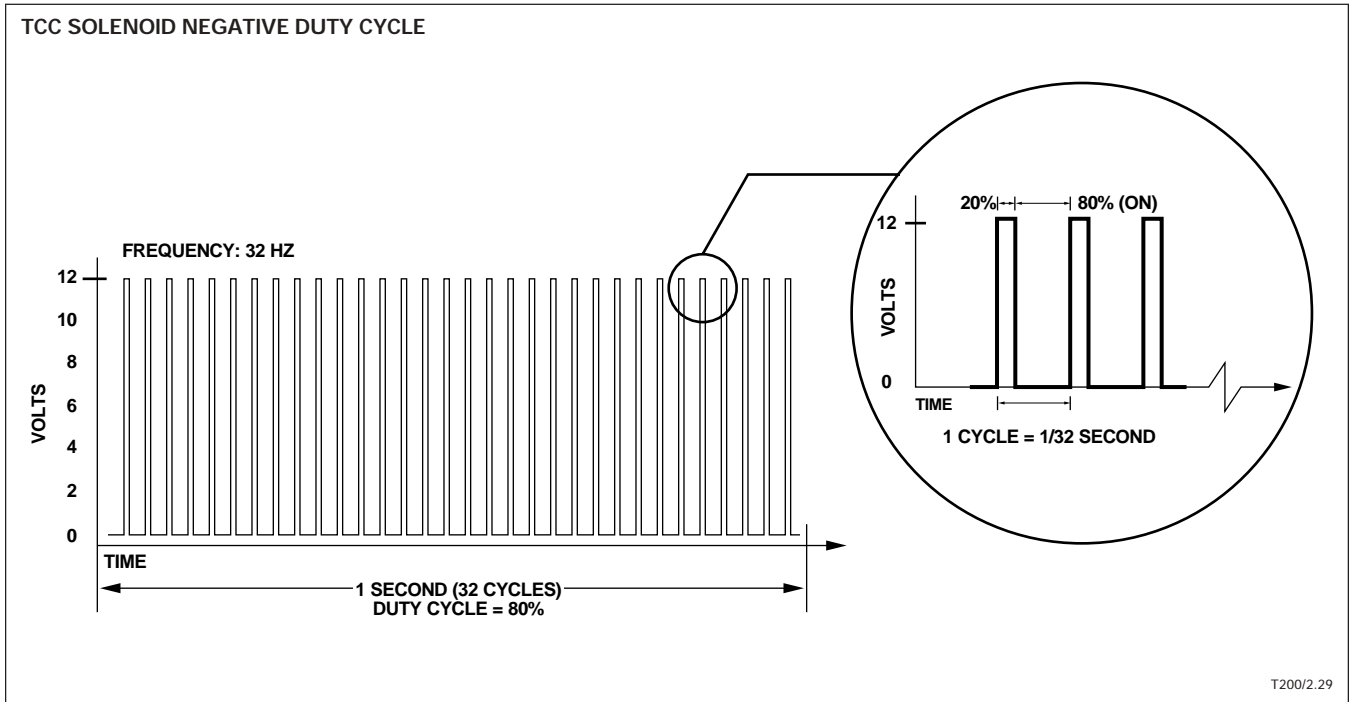
Torque Converter Clutch Solenoid Valve



The normally closed TCC solenoid valve is used to control the torque converter lockup clutch apply and release. The solenoid duty cycle (percent time energized) is varied by TCM control of the ground circuit. The variable duty cycle of the solenoid allows the clutch apply force and lockup rate to be varied to ensure smooth operation.



NOTES



Torque converter clutch solenoid diagnostic monitoring

The TCM monitors the operation of the TCC solenoid. Using engine speed and transmission input speed, the TCM calculates the amount of torque converter clutch slip.

If the TCM detects more than a 110 rpm difference between engine speed and transmission input speed in fourth gear when the TCC is commanded full ON with fluid temperature between 68° F and 286° F (20° C and 141° C) and the engine throttle angle is between 15% and 70%, DTC P0741 will flag. The TCM assumes the TCC solenoid valve is stuck OFF.

If the TCC is OFF and the calculated slip is less than 15 rpm for more than 5 seconds with a throttle angle greater than 15%, the TCM assumes a stuck ON TCC solenoid valve and flags DTC P0742.

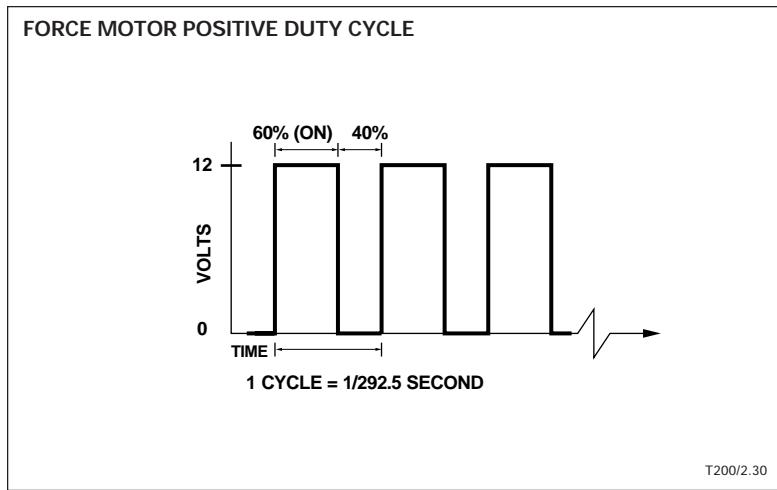
The TCM also monitors the TCC signal voltage. A signal of 0V or 12V for more than 2 seconds indicates an open or short circuit. The TCM will flag DTC P0743.

In all cases the MIL will be activated.

DTC	Component / signal	Trans MIL	Check Engine MIL (OBD II)	Limp home
P0741	TCC slipping / stuck OFF	YES	YES	—
P0742	TCC stuck ON	YES	YES	—
P0743	TCC state does not match commanded state	YES	YES	—

Refer to the DTC Summary, pages 43 – 46.

Transmission Control Components (continued)



Force Motor

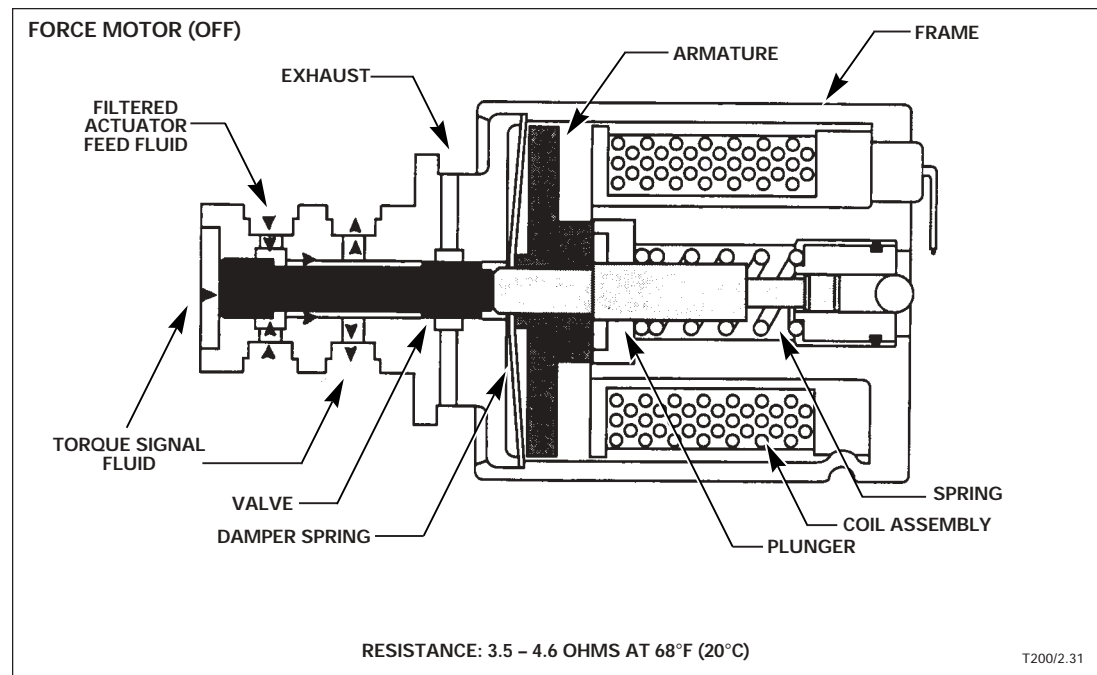
The force motor is an electronic pressure regulator controlled by the TCM to produce a hydraulic "torque signal pressure" that is primarily an indication of throttle opening. The duty cycle (percent of time energized) of the force motor is regulated by TCM control of the supply current. No current flow applies maximum torque signal pressure. Torque signal pressure controls transmission main line pressure at the pressure regulator valve.

NOTE: Two different force motors have been used in production. The force motor must match the TCM.

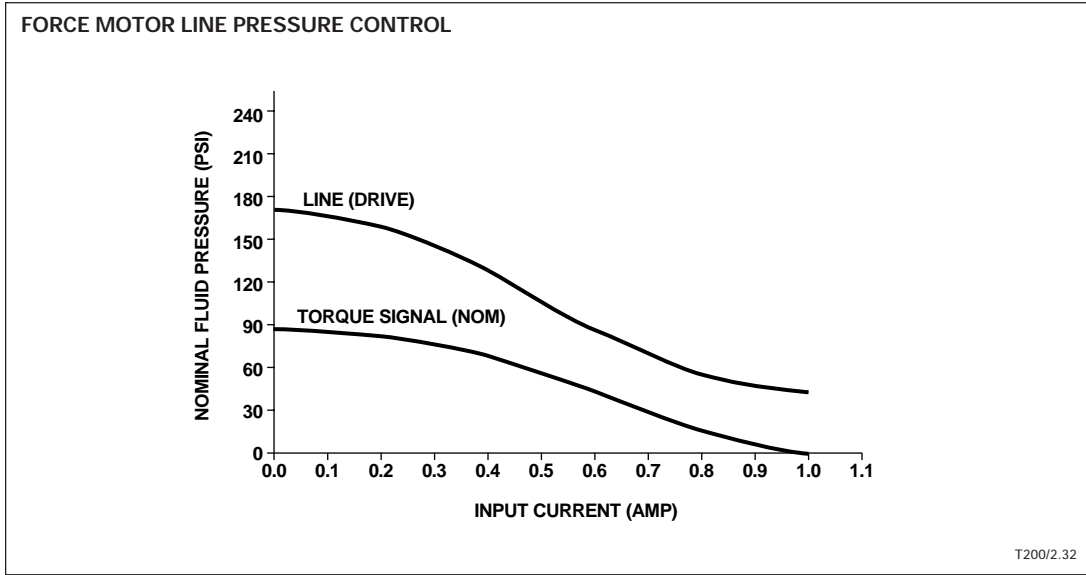
Transmissions with a yellow tag use a Bosch force motor (silver case) matched to a 4 ZDP TCM.

The Bosch force motor is pulsed full ON and OFF by the TCM once every 10 seconds to prevent contamination of the spool valve. This action will not occur during a shifting operation.

Later version transmissions use a Holley force motor (black case) matched to a 4 ZFR TCM. The Holley force motor is not pulsed by the TCM to clean the spool valve.



NOTES



Force motor diagnostic monitoring

The force motor operates in a current range of 0.1 – 1.1 Amp. average.

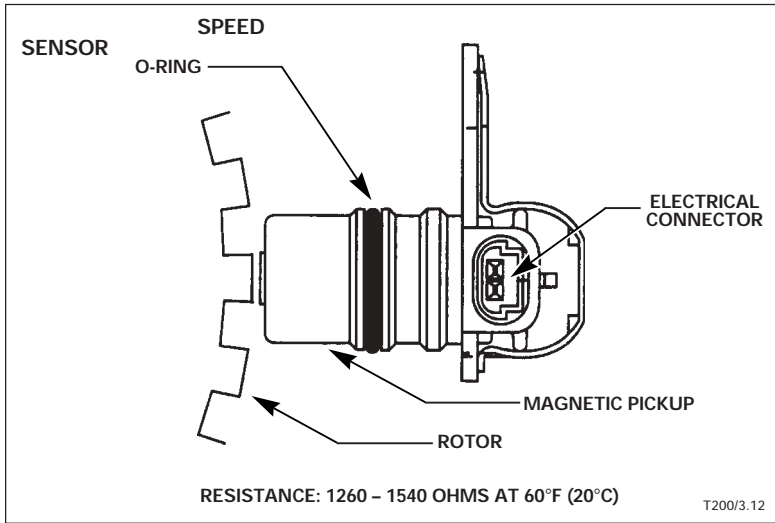
If the current constantly exceeds 1.5 Amps at 185° F (85° C), the TCM compares the commanded force motor current to the actual current. A difference 0.16 Amp for more than 2 seconds will flag DTC P0748.

DTC	Component / signal	Trans MIL	Check Engine MIL (OBD II)	Limp home
P0748	Force motor (pressure control regulator solenoid) current high	—	YES	—

Refer to the DTC Summary, pages 43 – 46.

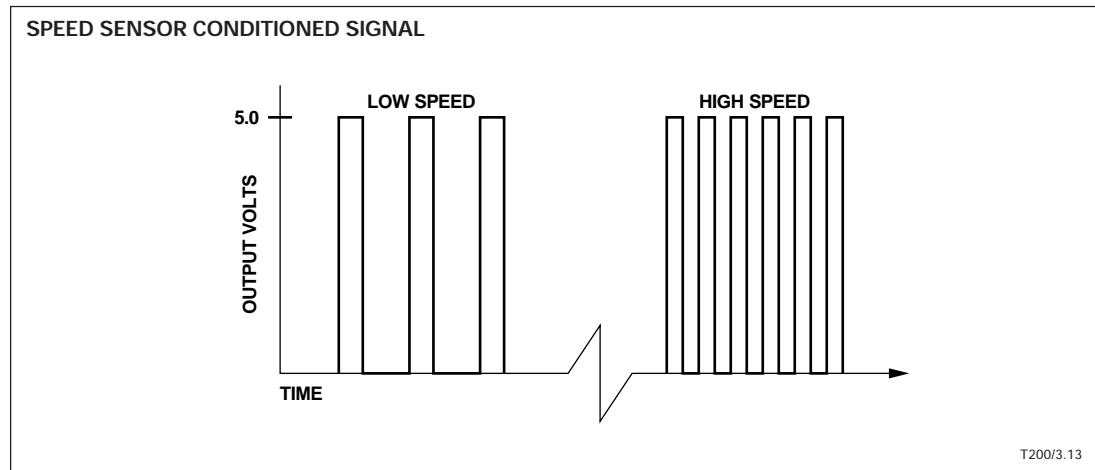
NOTES

Transmission Control Components (continued)



Transmission Output Speed Sensor

The output speed sensor is a variable reluctance magnetic pickup. The sensor is mounted in the transmission case opposite the output sensor ring that is pressed on the output carrier assembly. Whenever the vehicle is moving, the sensor produces an AC voltage input to the TCM proportional to the transmission output shaft speed. The TCM also applies this signal to the final drive ratio and tire rolling radius to calculate a road speed signal.



Transmission output speed sensor diagnostic monitoring

The TCM continuously monitors the speed sensor output when the transmission is not in "P" or "N".

If the output speed signal is less than 200 rpm with an input speed above 3000 rpm for more than 4 seconds with the throttle angle between 15% and 98%, the TCM flags DTC P0720.

DTC P0721 indicates an error in the signal range if the rate of the speed signal increase or decrease is more than 1000 rpm in less than 25 ms.

DTC	Component / signal	Trans MIL	Check Engine MIL (OBD II)	Limp home
P0720	Transmission output speed signal low	YES	YES	YES
P0721	Transmission output speed signal out of range	YES	YES	YES

Refer to the DTC Summary, pages 43 – 46.

Transmission Input Speed Sensor

The input speed sensor is identical to the output speed sensor except that it uses the machined teeth on the forward clutch housing as the rotor. The sensor produces an AC voltage input to the TCM proportional to torque converter turbine speed.

Transmission input speed sensor diagnostic monitoring

An input speed sensor signal of less than 50 rpm coupled with an output speed of more than 200 rpm with the engine running and the transmission not in "P" or "N" will set DTC P0715.

DTC P0716 indicates an error in the signal range if the rate of the input speed signal change is more than 1800 rpm within 25 ms.

DTC	Component / signal	Trans MIL	Check Engine MIL (OBD II)	Limp home
P0715	Transmission input speed, no signal	YES	YES	—
P0716	Transmission input speed signal out of range	YES	YES	—

Refer to the DTC Summary, pages 43 – 46.

Engine Speed Input

The TCM receives a speed signal input from the EMS. The signal is one of the inputs used to determine shift patterns, torque converter apply and release, and on-board diagnosis of the transmission.

Engine speed input diagnostic monitoring

If the engine speed signal increases at a rate greater than expected, DTC P0726 will be flagged.

If the engine speed signal is less than 200 rpm for more than 2 seconds when not in "P" or "N" with the transmission input speed greater than 600 rpm and the throttle angle more than 15%, DTC P0727 will be set.

DTC	Component / signal	Trans MIL	Check Engine MIL (OBD II)	Limp home
P0726	Engine speed signal out of range	YES	YES	—
P0727	Engine speed signal low	YES	YES	—

Refer to the DTC Summary, pages 43 – 46.

NOTES

Transmission Control Components (continued)

Engine Torque Signal

The ECM provides the TCM with a pulse width modulated engine torque signal based on injector pulse duration. The signal is used to calculate the line pressure and amount of torque reduction required for optimum shift quality. The engine torque signal line is also used by the ECM to communicate a torque reduction signal fault to the TCM. During cranking, the ECM also transmits a "completion of engine warm up cycle" message to the TCM for OBD II code management.

Engine torque signal diagnostic monitoring

The TCM monitors the engine torque signal frequency and pulse width.

If the frequency or duty cycle (pulse width) is out of range for more than 5 seconds with the engine speed above 450 rpm, DTC P1781 will be flagged and the TCM will substitute a default value for the incorrect signal. Depending on other fault parameters, the CHECK ENGINE MIL may not activate.

DTC	Component / signal	Trans MIL	Check Engine MIL (OBD II)	Limp home
P1781	Engine torque signal out of range	YES	YES	—

Refer to the DTC Summary, pages 43 – 46.

Throttle Position Sensor (TPS)

The throttle position signal is used in conjunction with other signals to provide the TCM with engine operating information. The signal is also used by the TCM as a monitoring factor for OBD and other functions.

TPS diagnostic monitoring

The TPS signal is monitored by the TCM except during cranking.

If the signal is greater than 91.8% or less than 8.9% with engine speed above 580 rpm, DTC P1791 is flagged and a default TPS signal of 35% is substituted.

DTC	Component / signal	Trans MIL	Check Engine MIL (OBD II)	Limp home
P1791	TPS signal out of range	YES	YES	—

Refer to the DTC Summary, pages 43 – 46.

NOTES

Transmission Fluid Temperature Sensor

The transmission fluid temperature sensor, located in the pressure switch wiring harness is an NTC (negative temperature coefficient) thermistor that provides a fluid temperature input to the TCM. As fluid temperature increases, temperature sensor resistance decreases. At a fluid temperature of 250° F (122° C), the transmission adopts a "hot mode." The TCC applies in second, third and fourth gear ranges and fluid is routed directly to the cooler, which reduces the amount of heat generated by the torque converter.

FLUID TEMPERATURE VERSUS SENSOR RESISTANCE			
°C	°F	MINIMUM RESISTANCE	NORMAL RESISTANCE
-40°	-40°	80.96 kΩ	100.54 kΩ
-30°	-20°	42.70 kΩ	52.43 kΩ
-20°	-04°	23.46 kΩ	28.90 kΩ
-10°	14°	13.37 kΩ	16.07 kΩ
0°	32°	7.87 kΩ	93.80 kΩ
10°	50°	4.77 kΩ	9.38 kΩ
20°	68°	2.98 kΩ	3.50 kΩ
30°	86°	1.92 kΩ	2.23 kΩ
40°	104°	1.26 kΩ	1.46 kΩ
50°	122°	848.80 Ω	977.10 Ω
60°	140°	584.10 Ω	668.10 Ω
70°	158°	410.30 Ω	467.20 Ω
80°	176°	293.90 Ω	332.70 Ω
90°	194°	213.90 Ω	241.00 Ω
100°	212°	158.10 Ω	177.40 Ω
110°	230°	118.80 Ω	132.60 Ω
120°	248°	90.40 Ω	100.00 Ω
130°	266°	69.48 Ω	77.29 Ω
140°	284°	53.96 Ω	60.13 Ω
150°	302°	42.43 Ω	47.31 Ω
160°	320°	32.51 Ω	36.13 Ω
170°	338°	23.13 Ω	27.92 Ω
180°	356°	19.42 Ω	21.58 Ω
190°	374°	15.01 Ω	16.68 Ω
200°	392°	11.60 Ω	12.89 Ω

NOTE: MEASURED RESISTANCE SHOULD NOT EXCEED NORMAL.

T200/2.35

Transmission fluid temperature sensor diagnostic monitoring

The TCM monitors the fluid temperature sensor output signal each time the ignition is switched ON.

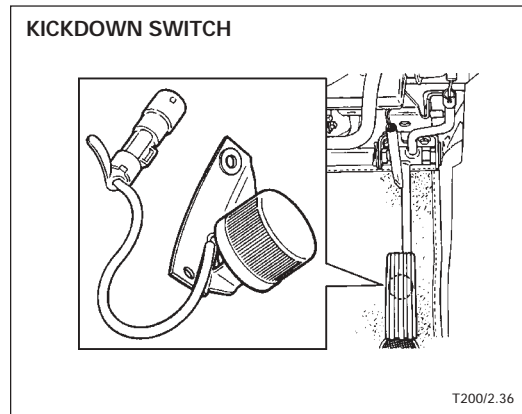
A temperature signal above 307° F (153° C) for more than 25 seconds or below -54° F (-48° C) for more than 10 seconds will trigger a DTC. The TCM will substitute a default temperature signal of 278° F (135° C).

If the temperature rises above 250° F (122° C), The TCC will be applied in second, third and fourth gears. DTC P1783 will flag but no MIL is illuminated.

DTC	Component / signal	Trans MIL	Check Engine MIL (OBD II)	Limp home
P0712	Fluid temperature sensor low voltage (high temp.)	—	YES	—
P0713	Fluid temperature high voltage (low temp.)	—	YES	—
P1783	Transmission hot mode	—	—	—

Refer to the DTC Summary, pages 43 – 46.

Transmission Control Components (continued)



Kickdown Switch

The adjustable kickdown switch is activated by fully depressing the accelerator pedal. When the pedal is depressed to approximately 95%, the normally open switch contacts close, providing a ground signal to the TCM requesting increased performance.

Kickdown switch diagnostic monitoring

The TCM monitors the kickdown switch signal and compares it to throttle position. If it detects an error – kickdown signal active with the throttle position less than 65% at more than 256 rpm, or kickdown signal inactive with the throttle position less than 82% at more than 256 rpm – it will flag DTC P1796 and ignore the kickdown switch signal command. The TCM will default to operating the kickdown function using the signal from the TPS.

DTC	Component / signal	Trans MIL	Check Engine MIL (OBD II)	Limp home
P1796	Kickdown signal active	—	—	—

Refer to the DTC Summary, pages 43 – 46.

Traction Control Active Signal

The ABS / TC CM provides a signal to the TCM indicating if the traction control function is active or inactive. The TCM adapts a shift strategy that enhances traction control operation.

Traction control active signal diagnostic monitoring

The TCM monitors the traction control signal from the ABS / TC CM. The signal should be at battery voltage when traction control is inactive or ground when traction control is active

If the signal is more than 1.8V with traction control active, DTC P1782 will flag.

DTC	Component / signal	Trans MIL	Check Engine MIL (OBD II)	Limp home
P1782	Traction control signal voltage low	—	—	—

Refer to the DTC Summary, pages 43 – 46.

NOTES

Torque Based Shifting

The TCM controls shift quality by the precise combination of clutch apply and release timing and pressure required for the operating conditions. In addition, the TCM outputs a pulse width modulated torque reduction signal requesting the ECM to retard the ignition timing during the shift. The ignition retard reduces engine torque providing for a smoother shift.

Torque Reduction Signal

The TCM provides the ECM with a two-part torque reduction signal; IGNITION SELECT, which indicates whether the transmission shift is "up" or "down" and IGNITION RETARD, which identifies a "shift in progress." The normal torque reduction signal pulse width is 17%.

The signal pulse width is increased to 20% to indicate the start of a shift. If the shift requires ignition retard, the TCM increases the signal pulse width to between 20% and 90% and the ECM retards the ignition timing. A 20% pulse width indicates 0° retard and 90% indicates maximum retard. The signal returns to 20% at the end of the shift and then returns to the normal 17% pulse width.

On OBD II systems, the torque reduction signal is also used by the TCM to request the ECM to activate the CHECK ENGINE MIL for emission related transmission faults. If the torque reduction signal pulse width is less than 12%, the CHECK ENGINE MIL will activate and EMS DTC P1775 will be stored in the ECM.

Torque reduction signal diagnostic monitoring

If the torque reduction signal is active for more than 2 seconds, the ECM starts a 10 second "clock." If the signal is still active after the 10 seconds, the ECM flags DTC P1780.

The ten second "clock" is also started if the torque reduction signal is high or low for longer than 125 ms. If the signal is still high or low after the 10 seconds, DTC P1780 is flagged.

In both cases the ECM will transmit a 93% pulse width modulated signal to the TCM on the engine torque signal line. The 93% signal informs the TCM of a fault with its transmission torque reduction signal. Depending on other fault parameters, the CHECK ENGINE MIL may not activate.

DTC	Component / signal	Trans MIL	Check Engine MIL (OBD II)	Limp home
P1780	Torque reduction signal error	YES	YES	—

Refer to the DTC Summary, pages 43 – 46.

NOTES

Transmission Control Components (continued)

Transmission Mechanical / Hydraulic Gear Selection

Transmission gear changes occur as a result of electronic control and transmission mechanical / hydraulic actions.

Transmission mechanical / hydraulic gear selection diagnostic monitoring

The TCM monitors the gear selected when the transmission is not in "P" or "N" with the vehicle speed greater than 7 mph (11 km/h) and the throttle angle greater than 11 – 15%. The actual transmission ratio is calculated by the TCM using data from the input and output speed sensors and compared to a "standard" gear ratio for each speed.

If the ratios do not match within 10 seconds, with the torque converter clutch not engaged, DTC P0730 is flagged and the MIL is activated.

DTC	Component / signal	Trans MIL	Check Engine MIL (OBD II)	Limp home
P0730	Transmission gear ratio incorrect	YES	YES	—

Refer to the DTC Summary, pages 43 – 46.

Transmission Slippage

Transmission slippage can be caused by incorrect hydraulic pressures or worn mechanical components (one way and mechanical clutches, brakes) as well as electrical / electronic faults.

Transmission slippage diagnostic monitoring

The TCM compares engine speed to transmission output speed.

If transmission output speed is more than 200 rpm above engine speed for 7 seconds when fourth gear is engaged with the torque converter clutch applied, fluid temperature between approximately 68° F – 286° F (20° C – 141° C), and the throttle open, the TCM will flag DTC P1739 and activate the MIL.

DTC	Component / signal	Trans MIL	Check Engine MIL (OBD II)	Limp home
P1739	Transmission slippage	YES	YES	—

Refer to the DTC Summary, pages 43 – 46.

NOTES

Brake Switch

The brake switch signals the TCM to disengage the TCC.

Brake switch diagnostic monitoring

The TCM monitors the brake switch signal.

If the brake switch is determined to be ON (signaling brakes applied) for more than 10 periods of acceleration to more than 20 mph (32 km/h) or the brake switch is determined to be OFF (signaling brakes released) for more than 6 periods of deceleration to less than 5 mph (8 km/h), DTC P0703 will be flagged.

DTC	Component / signal	Trans MIL	Check Engine MIL (OBD II)	Limp home
P0703	Brake switch input error	YES	—	—

Refer to the DTC Summary, pages 43 – 46.

Transmission Warning Light (TRANSMISSION MIL)

The transmission warning light (TRANSMISSION MIL) is located in the instrument pack and warns the driver of transmission faults. The TCM provides a signal to activate the TRANSMISSION MIL when most DTCs are present. In addition, OBD II classified transmission faults will also activate the CHECK ENGINE MIL.

Transmission warning light (TRANSMISSION MIL) diagnostic monitoring

The TRANSMISSION MIL is driven OFF by an active low voltage signal from the TCM. If the TCM is disconnected, the MIL will be ON. A short circuit to ground or to battery voltage will flag DTC P1785.

DTC	Component / signal	Trans MIL	Check Engine MIL (OBD II)	Limp home
P1785	TRANSMISSION MIL	—	—	—

Refer to the DTC Summary, pages 43 – 46.

CHECK ENGINE MIL

For OBD II emission related transmission faults, the TCM requests the ECM to activate the CHECK ENGINE MIL. The request signal is a pulse width modulated signal of 12% or less on the torque reduction signal line.

TCM on-board diagnostics do not monitor the CHECK ENGINE MIL request signal.

NOTES

4L80-E Automatic Transmission

Transmission Control Components (continued)

Sport Mode Indicator

The sport mode indicator light in the instrument pack alerts the driver when sport mode is selected by the transmission mode switch.

TCM on-board diagnostics do not monitor the sport mode indicator signal.

Adaptive Learning

As the transmission clutches and bands wear, the TCM corrects line pressure to maintain shift timing and apply pressures.

Adaptive learning diagnostic monitoring.

If the TCM determines that shift timing cannot be corrected because line pressure has reached the limit of adjustment, DTC P0780 is flagged. No MIL is activated, however shift quality will be harsh.

DTC	Component / signal	Trans MIL	Check Engine MIL (OBD II)	Limp home
P0780	Shift malfunction (max. adapt.)	—	—	—

Refer to the DTC Summary, pages 43 – 46.

NOTES

DTC Summary

PowerTrain 4L80-E Transmission Control System: XJ12 and XJR (AJ16 SC) – OBD II

OBD II MONITORING CONDITIONS

DTCs can be accessed only through the DLC (diagnostic link connector). Using PDU, select ToolBox, DTC, and 4L80-E.

MIL Activation

CHECK ENGINE MIL: A number in the CHECK ENG. MIL column indicates the consecutive trips required to activate the MIL. The CHECK ENGINE MIL activates for OBD II related transmission faults. Activation will store engine management DTC P1775 in the ECM memory.

TRANSMISSION MIL: A number in the TRANS. MIL column indicates the consecutive trips required to activate the MIL.

PDU Datalogger Acronyms

CLV	Calculated load value (engine torque)	SSB	Shift solenoid B state
DTC5	Number of DTCs logged	TA	Traction control active
F BRAKE	Foot brake switch	TCC	Torque converter clutch
FMA	Actual force motor current	TCCS	Torque converter clutch switch
HOT	Transmission fluid temp. above 261°F (122° C)	TCS	Torque converter slip
IGN+	Ignition power supplied feed	TCSA	Mode switch state
KDSW	Kickdown switch	TISSA	Transmission (turbine) input speed
MD	Force motor current desired	TOST	Transmission output speed
M PROVE	Manifold pressure switch	TOT	Transmission fluid temperature
RATIO	Calculated gear ratio	TP	Throttle position sensor (TPS) position
RPM	Engine speed	VS	Vehicle speed
SSA	Shift solenoid A state		

DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS	CHECK ENG. MIL	TRANS. MIL	LIMP HOME	POSSIBLE CAUSES
P0605	TCM data corrupted	Start engine	1	1	√	TCM failure
P0703	Brake switch input error	More than 10 accelerations to more than 20 mph (32 km/h), no brake during acceleration. More than 6 decelerations to less than 5 mph (8 km/h), brake applied. Each acceleration or deceleration within 25 seconds.	—	1	—	Brake switch incorrect adjustment Brake switch to TCM wire: open circuit, short circuit to ground or B+ voltage Brake switch ground circuit: open circuit Brake switch failure
P0706	Pressure switch manifold range / performance	Crank engine for 8 seconds. Start engine. Operate gear selector through all ranges. Drive vehicle above 10 mph (16 km/h) for more than 25 seconds.	2	1	—	Gear selector cable incorrect adjustment Pressure manifold switch to TCM harness open circuit, short circuit to ground or B+ voltage Linear switch to TCM signal circuit: open circuit, short circuit to ground or B+ voltage Linear switch failure Pressure switch manifold failure
P0712	Fluid temperature sensor circuit low voltage or fluid temperature above 307° F (153° C)	Switch ignition ON for more than 25 seconds.	2	—	—	Transmission internal harness temp. sensor circuit: short circuit to ground Transmission to TCM harness temp. sensor circuit: short circuit to ground Temperature sensor failure
P0713	Fluid temperature sensor circuit high voltage or fluid temperature below -54° F (-48° C)	Switch ignition ON for more than 10 seconds.	2	—	—	Transmission internal harness temp. sensor circuit: open circuit or short circuit to B+ voltage Transmission to TCM harness temp. sensor circuit: open circuit or short circuit to B+ voltage Temperature sensor failure
P0715	Transmission input speed, no signal	Drive vehicle above 15 mph (24 km/h).	2	1	—	Input speed sensor to TCM circuit: open circuit or short circuit to ground Speed sensor failure
P0716	Transmission input speed signal out of range	Drive vehicle above 15 mph (24 km/h).	2	1	—	Input speed sensor to TCM circuit: short circuit to B+ voltage Speed sensor failure
P0720	Transmission output speed signal low	Drive vehicle with engine speed above 3000 rpm, but not at full throttle, for more than 4 seconds.	2	1	√	Output speed sensor to TCM circuit: open circuit or short circuit to ground Speed sensor failure Transmission failure, no drive
P0721	Transmission output speed signal out of range	Drive vehicle.	2	1	√	Output speed sensor to TCM circuit: short circuit to B+ voltage Speed sensor failure
P0726	Engine speed signal out of range	Run engine above 1000 rpm.	2	1	—	ECM to TCM engine speed signal circuit: intermittent short circuit to ground or B+ voltage ECM engine speed signal error
P0727	Engine speed signal low	Drive vehicle. Accelerate up hill to more than 30 mph.	2	1	—	Engine stalled while driving ECM to TCM engine speed signal circuit: open circuit or short circuit to ground or B+ voltage ECM engine speed signal error
P0730	Transmission gear ratio incorrect	Drive vehicle above 7 mph (11 km/h) with TCC applied and throttle angle greater than 11%. Fluid temperature must be above 32° F (0° C).	2	1	—	Low transmission fluid level Refer to P0706 Transmission mechanical / hydraulic failure
P0741	TCC slipping / stuck OFF	Drive vehicle in fourth gear for 25 seconds with TCC applied and throttle angle between 15% and 50%. Fluid temperature must be between 68° F (20° C)	2	1	—	Transmission internal harness TCC solenoid circuit: open circuit, short circuit to ground or B+ voltage Transmission to TCM harness TCC solenoid circuit: open circuit, short circuit to ground or B+ voltage TCC solenoid failure

DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS	CHECK ENG. MIL	TRANS. MIL	LIMP HOME	POSSIBLE CAUSES
P0742	TCC stuck ON	Drive vehicle longer than 5 seconds in 2nd, 3rd or 4th gear with TCC OFF, throttle angle greater than 15%.	2	1	—	Transmission internal harness TCC solenoid circuit: open circuit, short circuit to ground or B+ voltage Transmission to TCM harness TCC solenoid circuit: open circuit, short circuit to ground or B+ voltage TCC solenoid failure
P0743	TCC circuit output state does not match command state	Drive vehicle in fourth gear with TCC applied.	2	1	—	Ignition switched power circuit to TCC solenoid open circuit or short circuit to ground Transmission internal harness TCC solenoid circuit: open circuit, short circuit to ground or B+ voltage Transmission to TCM harness TCC solenoid circuit: open circuit, short circuit to ground or B+ voltage TCC solenoid failure
P0748	Force motor (pressure control regulator solenoid) current high	Run engine. Move gear selector through all ranges.	—	1	—	Force motor to TCM circuit high resistance or short circuit to ground Force motor failure
P0751	Shift solenoid A stuck ON or OFF	Drive vehicle. Accelerate up hill with gear selector in D.	2	1	✓	Ignition switched power circuit to solenoid: open circuit or short circuit to ground Transmission internal harness shift solenoid circuit: open circuit, short circuit to ground or B+ voltage Transmission to TCM harness shift solenoid circuit: open circuit, short circuit to ground or B+ voltage Shift solenoid failure
P0753	Shift solenoid A output state does not match command state	Drive vehicle through all forward gears with gear selector in D.	2	1	✓	Transmission internal harness shift solenoid circuit: open circuit, short circuit to ground or B+ voltage Transmission to TCM harness shift solenoid circuit: open circuit, short circuit to ground or B+ voltage Shift solenoid failure
P0756	Shift solenoid B stuck ON or OFF	Drive vehicle above 10 mph (16 km/h) for more than 10 seconds.	2	1	✓	Ignition switched power circuit to solenoid: open circuit or short circuit to ground Transmission internal harness shift solenoid circuit: open circuit, short circuit to ground or B+ voltage Transmission to TCM harness shift solenoid circuit: open circuit, short circuit to ground or B+ voltage Shift solenoid failure
P0758	Shift solenoid B output state does not match command state	Drive vehicle through all forward gears with gear selector in D.	2	1	✓	Transmission internal harness shift solenoid circuit: open circuit, short circuit to ground or B+ voltage Transmission to TCM harness shift solenoid circuit: open circuit, short circuit to ground or B+ voltage Shift solenoid failure
P1739	Transmission slipping	Drive vehicle in fourth gear for 25 seconds with TCC applied and throttle angle between 15% and 50%. Fluid temperature must be between 68° F (20° C) and 285° F (141° C).	2	1	—	Low transmission fluid level Transmission mechanical / hydraulic failure
P1780	Torque reduction signal error	Start engine. Allow to run more than 12 seconds.	2*	1	—	ECM internal torque signal error
P1781	Engine torque signal out of range	Start engine. Allow to run more than 12 seconds.	2*	1	—	ECM to TCM torque signal circuit: open circuit, short circuit to ground or B+ voltage ECM torque signal error
P1782	Traction control signal	Switch ignition ON.	—	—	—	ABS / TC CM to TCM signal circuit: short circuit to ground ABS / TC CM signal error
P1783	Transmission hot mode, fluid temperature above 250° F (122° C)	Switch ignition ON.	—	—	—	High transmission fluid temperature; severe operating conditions Blocked transmission cooler Restricted fluid flow to cooler

DTC	FAULT DESCRIPTION	OBD II MONITORING CONDITIONS	CHECK ENG. MIL	TRANS. MIL	LIMP HOME	POSSIBLE CAUSES
P1785	TRANSMISSION MIL	Switch ignition ON.	—	—	—	TCM to instrument pack TRANSMISSION MIL circuit: open circuit, short circuit to ground or B+ voltage Instrument pack failure
P1791	TPS signal	Switch ignition ON.	2	1	—	ECM to TCM TPS signal circuit: open circuit, short circuit to ground or B+ voltage ECM TPS signal output error
P1794	TCM voltage supply out of range	Run engine above 1500 rpm for five seconds.	2	1	√	Ignition switched TCM power fuse defective LH heelboard fuse box to TCM ignition switched power circuit: open circuit, high resistance or short circuit to ground Charging circuit failure
P1796	Kickdown switch signal active	Switch ignition ON. Operate accelerator through full range of travel.	—	—	—	Kickdown switch adjustment Kickdown switch to TCM circuit: short circuit to ground Kickdown switch failure

* Depending on other fault parameters, CHECK ENGINE MIL may not activate.

DTC Summary
PowerTrain 4L80-E Transmission Control System:
XJ12 up to 1995 MY and XJS 6.0L – OBD I

DTCs can be accessed only through the DLC (diagnostic link connector) using PDU or JDS.
PDU displays the DTCs as 2 digit numbers.

DTC	FAULT DESCRIPTION	MONITORING CONDITIONS	TRANS. MIL ACTIVATED	LIMP HOME	POSSIBLE CAUSES
21	TPS signal high, greater than 4.5V	Start engine. Allow to run more than 5 seconds.	YES	YES	TPS adjustment ECM to TPS, TPS to TCM circuit; short circuit to B+ voltage TPS failure
22	TPS signal low, less than 0.2V	Start engine. Allow to run more than 5 seconds.	YES	YES	TPS adjustment ECM to TPS, TPS to TCM circuit; short circuit to ground, open circuit TPS failure
24	Transmission output speed signal low	Drive vehicle with engine speed above 3000 rpm (but not at full throttle) for more than 4 seconds.	YES	YES	Output speed sensor to TCM circuit; open circuit or short circuit to ground Speed sensor failure Transmission mechanical failure, no drive
28	Pressure switch manifold position signal invalid	Start engine. Operate gear selector through all ranges.	YES	—	Gear selector cable incorrect adjustment Pressure manifold switch to TCM harness circuit; open circuit, short circuit to ground or B+ voltage Linear switch to TCM signal circuit; open circuit, short circuit to ground or B+ voltage Linear switch failure Pressure switch manifold failure
33	Baro pressure signal high (Sedan up to 1994 MY and XJS)	Switch ignition ON.	—	—	Baro sensor ground circuit; open circuit Baro sensor to TCM signal circuit; short circuit Baro sensor failure
34	Baro pressure signal low (Sedan up to 1994 MY and XJS)	Switch ignition ON.	—	—	Baro sensor to TCM signal circuit; open circuit, high resistance or short circuit to ground TCM to Baro sensor voltage circuit; open circuit, high resistance or short circuit to ground TCM to Baro sensor ground circuit; high resistance or open circuit Baro sensor failure
37	Brake switch stuck ON	Accelerations of more than 6 seconds to more than 20 mph (32 km/h), with no braking during acceleration.	—	—	Brake switch incorrect adjustment Brake switch to TCM circuit; short circuit to ground Brake switch failure
38	Brake switch stuck OFF	Decelerations of more than 6 seconds to less than 5 mph (8 km/h), brake applied during deceleration.	—	—	Brake switch incorrect adjustment Brake switch to TCM wire; open circuit, short circuit to B+ voltage Brake switch ground circuit; open circuit Brake switch failure
39	TCC stuck OFF	Drive vehicle at a steady speed of 55 mph (88.5 km/h) with the TCC applied longer than 2 seconds.	YES	YES	Ignition switched power circuit to TCC solenoid; open circuit or short circuit to ground TCC to ECM circuit; open circuit or short circuit to B+ voltage TCC solenoid failure Slipping TCC
53	System voltage high, greater than 19.5V	Start engine. Run over 1600 rpm for longer than 2 seconds.	YES	YES	Charging system failure
58	Fluid temperature sensor voltage high or fluid temperature above 307° F (153° C)	Switch ignition ON.	YES	—	Very high transmission fluid temperature; severe operating conditions, fluid temperature above 307° F (153° C) Transmission internal harness temperature sensor circuit; open circuit or short circuit to B+ voltage Transmission to TCM harness temperature sensor circuit; open circuit or short circuit to B+ voltage Temperature sensor failure
59	Fluid temperature sensor voltage low or fluid temperature below -54° F (-48° C)	Switch ignition ON.	YES	—	Transmission internal harness temperature sensor circuit; open circuit or short circuit to ground Transmission to TCM harness temperature sensor circuit; open circuit or short circuit to ground Temperature sensor failure

DTC	FAULT DESCRIPTION	MONITORING CONDITIONS	TRANS. MIL ACTIVATED	LIMP HOME	POSSIBLE CAUSES
61	Torque reduction request signal error	Start engine.	YES	—	ECM internal torque signal error
62	Torque reduction acknowledge signal fault	Start engine.	YES	—	ECM to TCM torque signal circuit; open circuit, short circuit to ground or B+ voltage ECM torque signal error
68	Overdrive (4th) ratio incorrect	Drive vehicle at a steady speed of 55 mph (88.5 km/h) with the TCC applied longer than 2 seconds.	YES	—	Refer to DTC 74 Engine speed signal error
69	TCC stuck ON	Drive vehicle in D2 or D3. Maintain a steady 25% throttle opening.	YES	YES	Transmission internal harness TCC solenoid circuit: open circuit, short circuit to ground or B+ voltage Transmission to TCM harness TCC solenoid circuit: open circuit, short circuit to ground or B+ voltage TCC solenoid failure
71	Engine speed signal out of range	Drive vehicle above 20 mph (32 km/h) at a throttle angle greater than 15% for more than 2 seconds.	YES	—	Engine stalled while driving ECM to TCM engine speed signal circuit: open circuit, short circuit to ground or B+ voltage ECM engine speed signal error
72	Loss of output speed signal	Drive vehicle above 20 mph (32 km/h).	YES	YES	Output speed sensor circuit: open circuit, short circuit to ground or B+ voltage Output speed sensor failure
73	Force motor current error	Run engine. Move gear selector through all ranges.	YES	—	Force motor coil circuit: open circuit, high resistance, short circuit to ground or B+ voltage Force motor failure
74	Input speed sensor, loss of signal	Drive vehicle above 20 mph (32 km/h).	YES	—	Input speed sensor to TCM circuit: open circuit, short circuit to ground or B+ voltage Speed sensor failure
75	TCM supply voltage low, less than 8V	Start engine. Run above 1300 rpm for longer than 4 seconds.	YES	YES	Ignition switched TCM power fuse defective Fuse box to TCM ignition switched power circuit: open circuit, high resistance or short circuit to ground Charging circuit failure
77	Mode select switch	Switch ignition on. Operate mode switch.	—	—	Mode switch to TCM circuit: open circuit, short circuit to ground or B+ voltage Mode switch failure
78	Kickdown switch stuck OFF	Drive vehicle. Apply full throttle acceleration.	—	—	Kickdown switch adjustment Kickdown switch to TCM circuit: short circuit to B+ voltage Kickdown switch failure
79	Transmission fluid temperature above 250° F (122° C)	Switch ignition ON.	YES	—	Hot transmission fluid: severe operating conditions Blocked transmission cooler Restricted fluid flow to cooler
81	Shift solenoid B electrical error	Drive vehicle. Operate through all gear ranges.	YES	YES	Solenoid to TCM harness shift solenoid circuit: open circuit, short circuit to ground or B+ voltage Shift solenoid failure
82	Shift solenoid A range / performance	Drive vehicle. Operate through all gear ranges.	YES	YES	Ignition switched power circuit to solenoid: open circuit or short circuit to ground Solenoid to TCM harness shift solenoid circuit: open circuit, short circuit to ground or B+ voltage Transmission internal harness shift solenoid circuit: circuit, short circuit to ground or B+ voltage Shift solenoid failure

DTC	FAULT DESCRIPTION	MONITORING CONDITIONS	TRANS. MIL ACTIVATED	LIMP HOME	POSSIBLE CAUSES
83	TCC solenoid circuit error	Drive vehicle at a steady speed of 55 mph 88.5 km/h) with the TCC applied longer than 2 seconds.	YES	YES	Ignition switched power circuit to TCC solenoid open circuit or short circuit to ground Transmission internal harness TCC solenoid circuit: open circuit, short circuit to ground or B+ voltage Transmission to TCM harness TCC solenoid circuit: open circuit, short circuit to ground or B+ voltage TCC solenoid failure
84	Kickdown switch stuck ON	Start engine. Allow to idle.	—	—	Kickdown switch adjustment Kickdown switch to TCM circuit; open circuit or short circuit to ground Kickdown switch failure
85	Pressure switch manifold signal, undefined ratio	Drive vehicle. Operate through all gear ranges.	YES	—	Low transmission fluid level Refer to DTC 28 Transmission mechanical / hydraulic failure
86	Shift solenoid B stuck ON	Drive vehicle in D2.	YES	YES	Shift solenoid failure
87	Shift solenoid B stuck OFF	Drive vehicle in D4.	YES	YES	Shift solenoid failure
89	Maximum line pressure adaption and long shift	Drive vehicle. Operate through all gear ranges and gear selector positions.	YES	YES	Low transmission fluid level Refer to DTC 28 / 85 Transmission mechanical / hydraulic failure

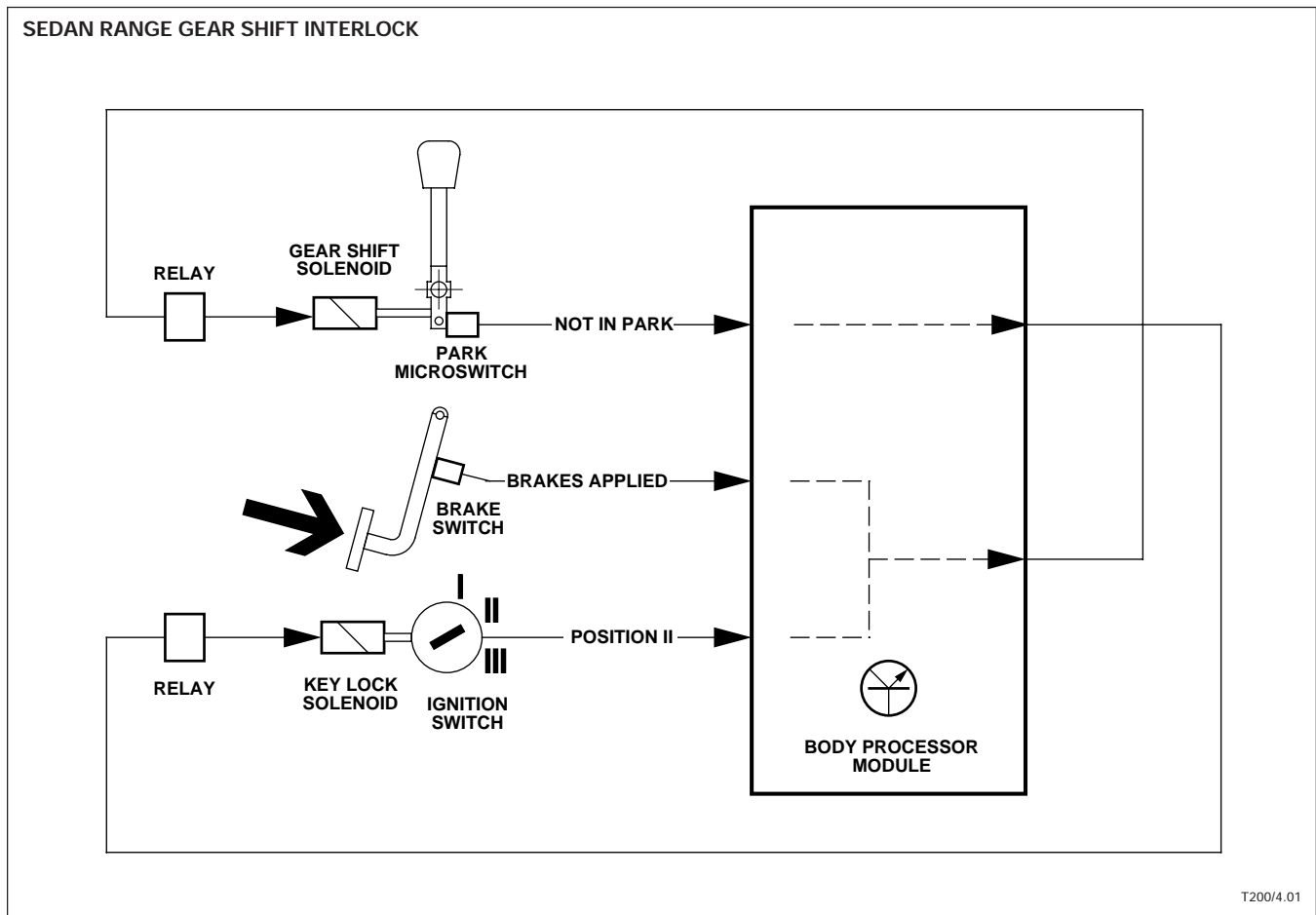
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Gear Shift Interlock

XJ6 and XJ12 Sedan Range

The gear shift interlock system prevents movement of the gear selector from PARK unless the ignition switch is in position II and the brake pedal is applied. In addition, the ignition key cannot be removed from the ignition switch unless the gear selector is in PARK. Once the key is removed, the selector is locked in PARK.



System Operation

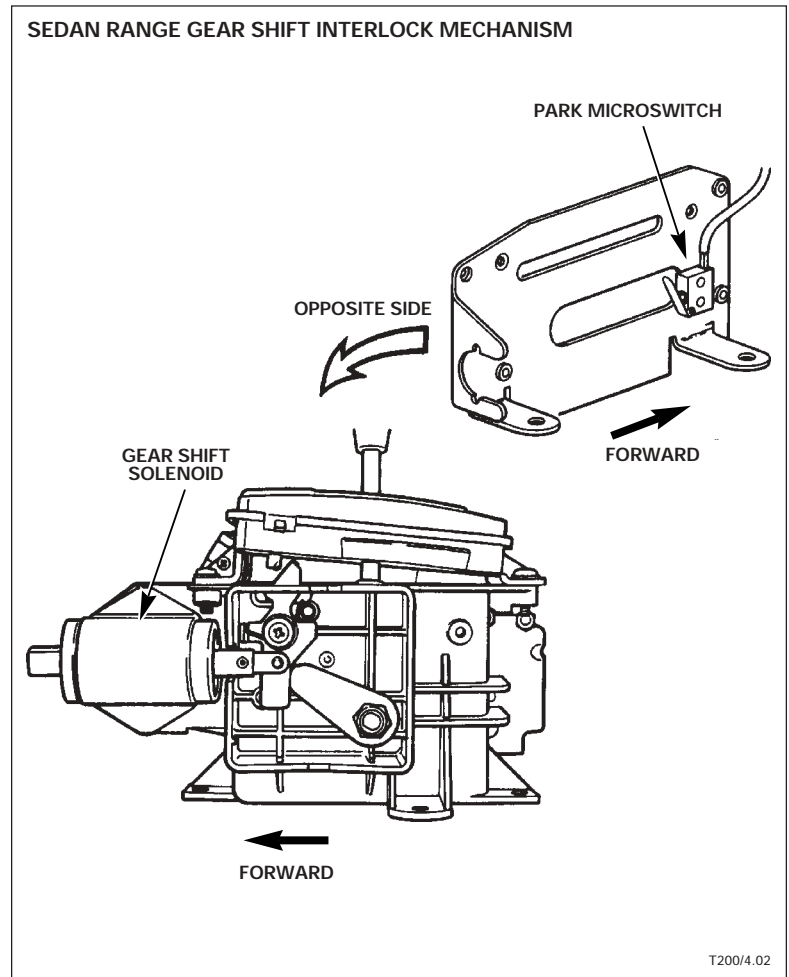
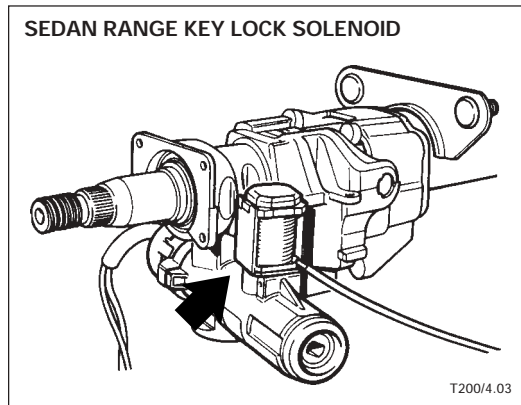
The system is controlled through the BPM (body processor module) with inputs for brake pedal applied, PARK position and ignition key in position II. The brake pedal applied input is sourced from the brake switch; the PARK position input is sourced from the PARK microswitch on the 'J' gate assembly and the ignition switch position II input is sourced from the ignition power supply circuit.

The BPM energizes the gear shift solenoid in response to the input signals that the brakes are applied and the ignition is in position II. The energized solenoid moves the locking mechanism allowing the gear selector to be moved out of PARK. When the gear selector is moved out of PARK, the BPM energizes the key lock solenoid to prevent ignition key removal. The BPM de-energizes the key lock solenoid in response to the input signal that the gear selector is in PARK thus allowing ignition key removal.

System Components

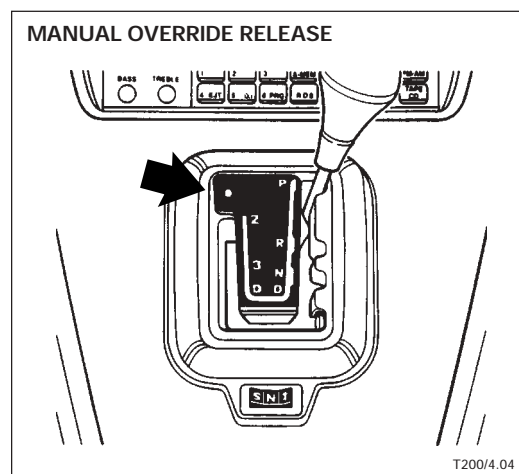
The system components are as follows:

- Body processor module located under the passenger's side dash panel
- Gear shift solenoid and key lock solenoid relays (1993-94 MY: relay module M located under the front passenger seat; 1995 MY ON: two micro-relays located under the 'J' gate / center console)
- Gear shift solenoid and locking mechanism located on the 'J' gate assembly
- PARK microswitch located on the 'J' gate assembly
- Key lock solenoid located on the steering column



Manual Override

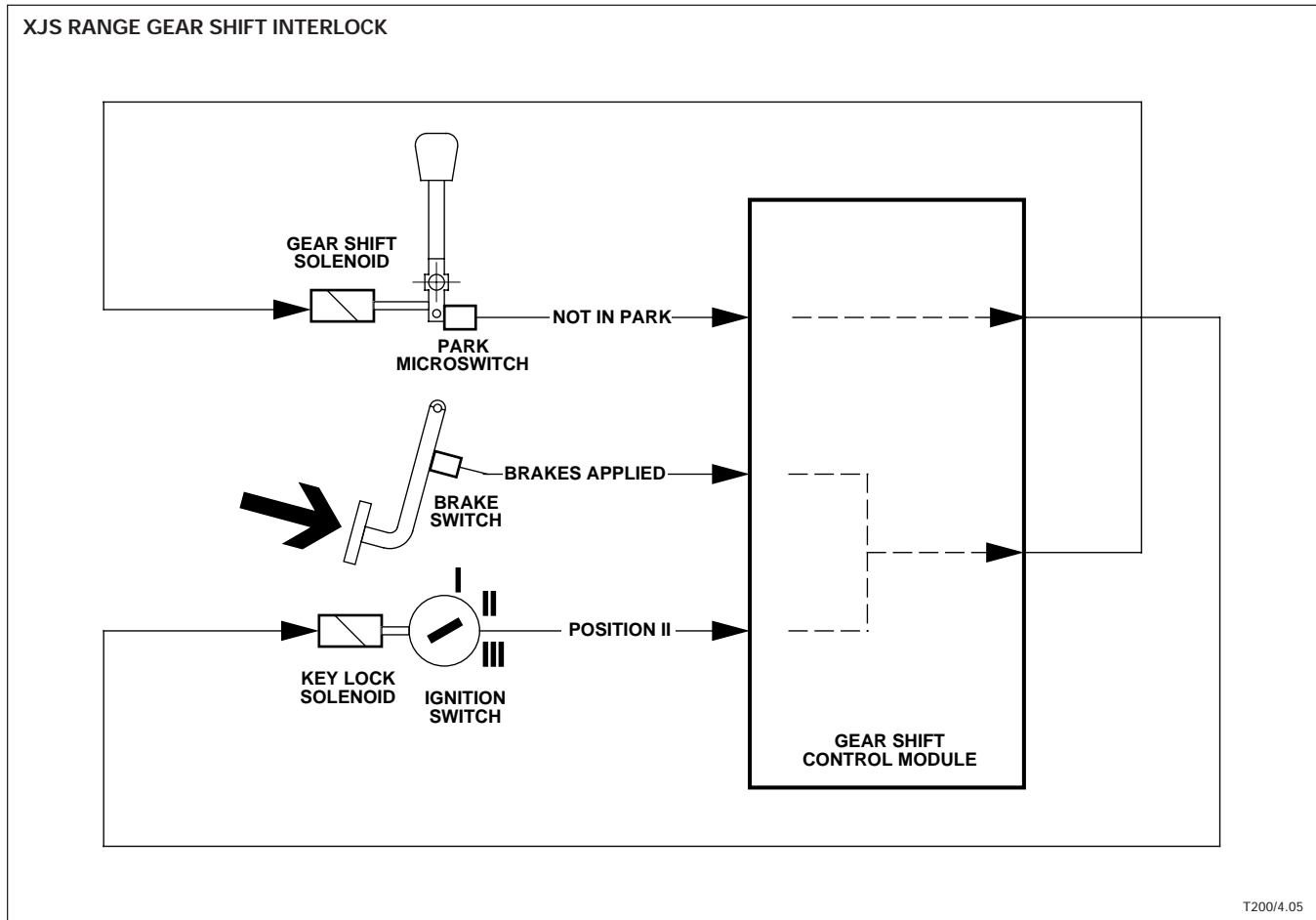
If the vehicle must be moved without power, the gearshift locking mechanism can be disengaged. To prevent inadvertent use, the release requires a two-handed operation. Remove the TORX screw, then depress the button at the top of the 'J' gate with an implement such as the ignition key and move the lever out of PARK. An audible warning sounds for 10 seconds if the ignition key is not in position II when the gear selector is moved from PARK.



Gear Shift Interlock

XJS Range

The gear shift interlock system prevents movement of the gear selector from PARK unless the ignition switch is in position II and the brake pedal is applied. In addition, the ignition key cannot be removed from the ignition switch unless the gear selector is in PARK.



System Operation

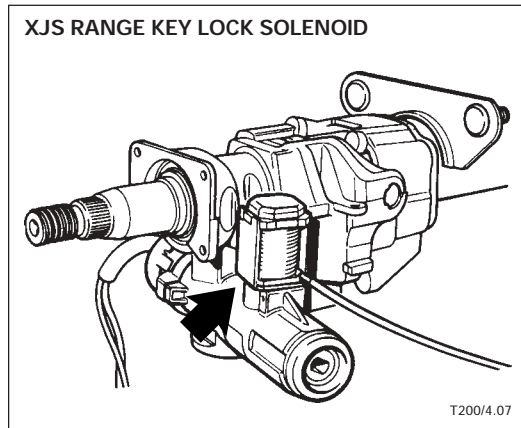
The system is controlled through the gear shift control module with inputs for brake pedal applied, PARK position and ignition key in position II. The brake pedal applied input is sourced from the brake switch; the PARK position input is sourced from the PARK microswitch on the selector assembly and the ignition switch position II input is sourced from the ignition power supply circuit.

The gear shift control module energizes the gear shift solenoid when the ignition is in position II and the brakes are applied. The energized solenoid releases the locking mechanism allowing the gear selector to be moved out of PARK. When the gear selector is moved out of PARK, the gear shift control module energizes the key lock solenoid to prevent ignition key removal. The gear shift control module de-energizes the key lock solenoid when the gear selector is in PARK thus allowing ignition key removal.

System Components

The system components are as follows:

- Gear shift control module mounted on the gear selector assembly
- Gear shift solenoid located on the gear selector assembly
- PARK microswitch located on the gear selector assembly
- Key lock solenoid located on the steering column

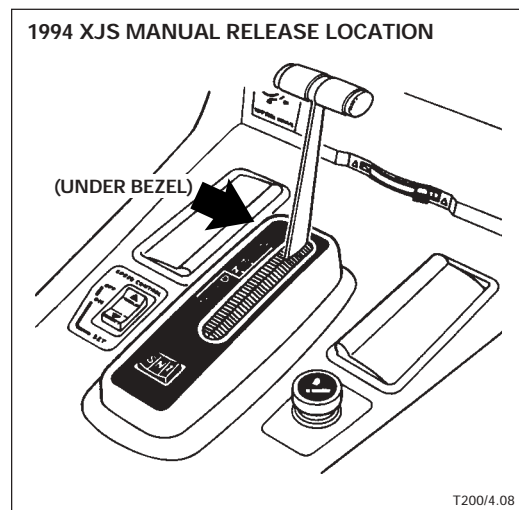
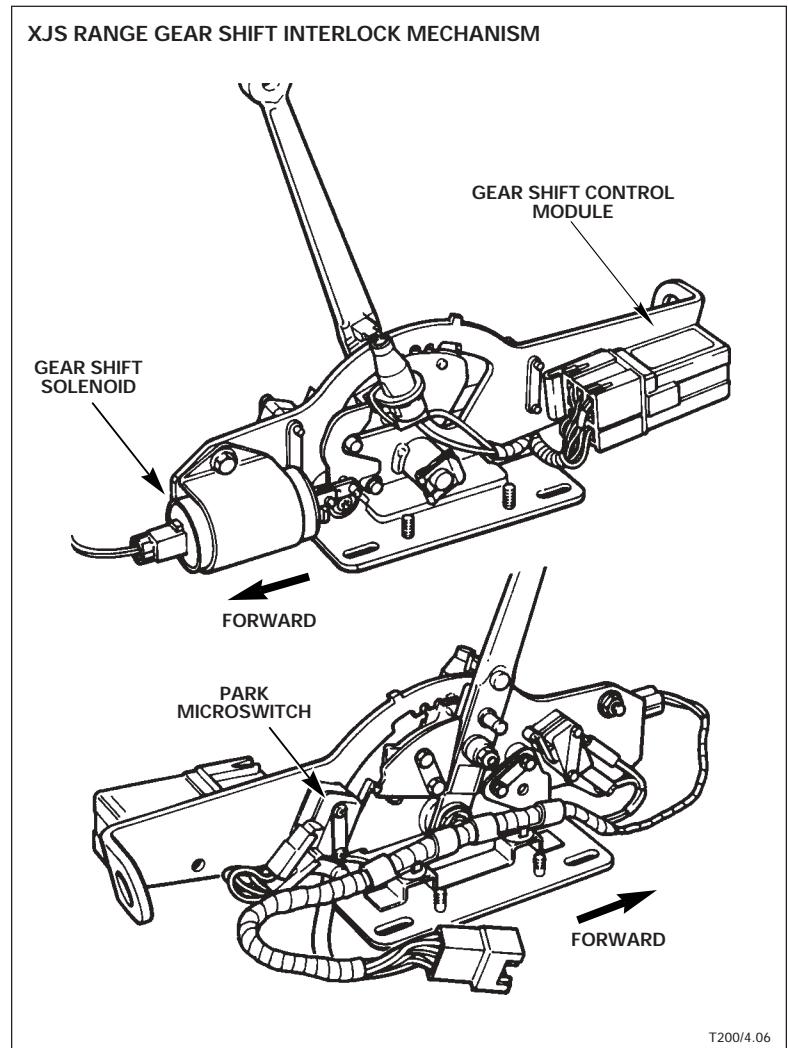


Manual Override (1993 MY)

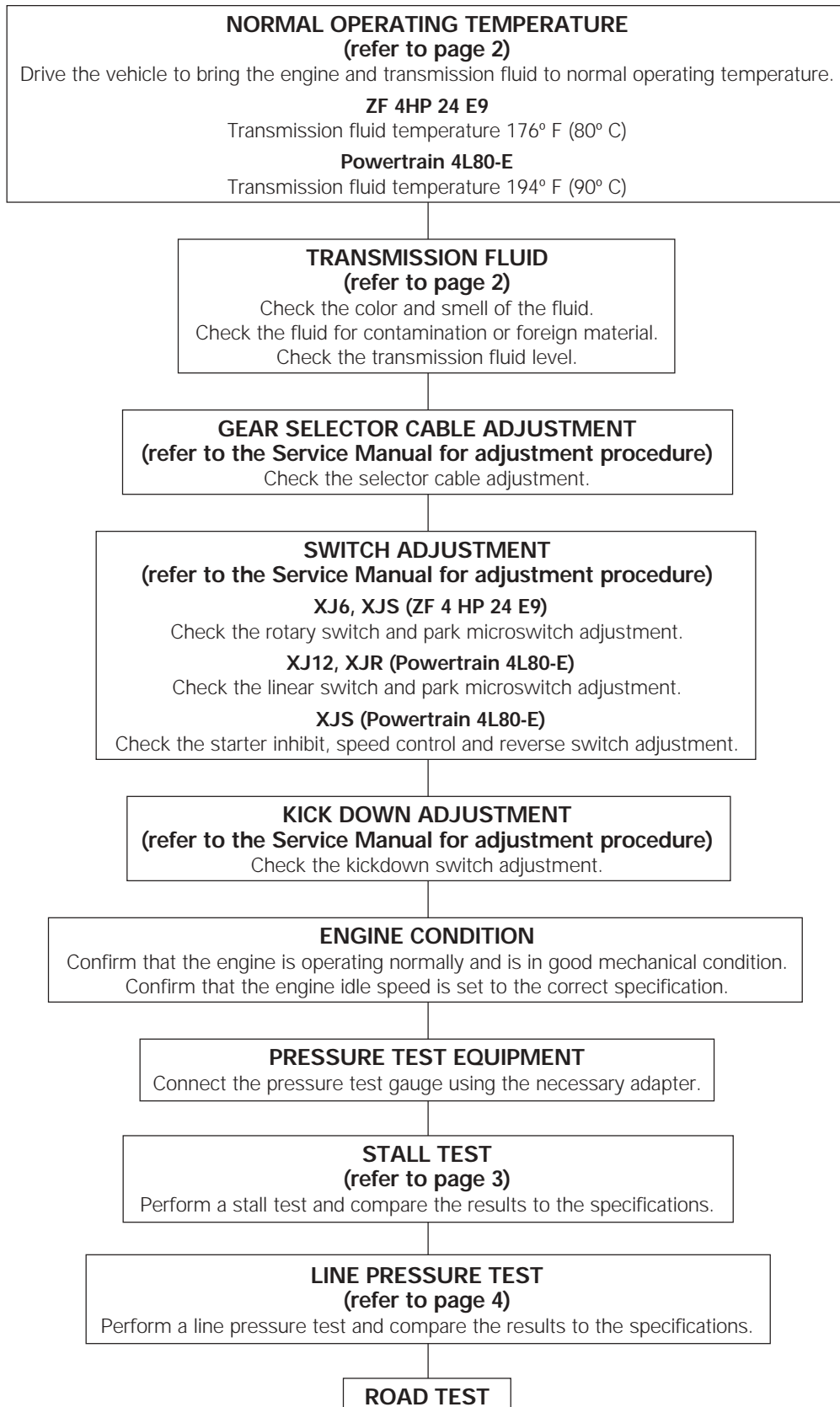
If the vehicle must be moved without power, the gearshift locking mechanism can be disengaged. The release requires removal of the center console top finisher (the slotted side mount fasteners have been deleted). Reach under the gear selector assembly from the left front and manually release the lock by moving the cam forward while moving the selector lever out of PARK.

Manual Override (1994 MY ON)

A manual override access located under the gear selector bezel has been added. To override the interlock, remove the gearshift lever bezel. Then, gently press down on the interlock release with a screwdriver through the access hole. Move the shift lever to neutral.



Automatic Transmission Diagnostic Process



Normal Operating Temperature

Before driving the vehicle conduct a visual inspection of the transmission for leaks and check the COLD transmission fluid level.

- Set the parking brake, start the vehicle and allow it to idle in PARK for 3 to 5 minutes.
- Firmly depress the brake pedal, move the gear selector through each gear range, pausing 3 seconds in each range.
- With the vehicle level, accessories turned off, and the engine idling in PARK, check the fluid level.

The level should be between the tip of the dip stick and the hot mark.

Transmission Fluid

- Check the smell and color of the transmission fluid

RED – OK

FOAM – High fluid level or contamination

MILKY – Contamination

NON-TRANSPARENT PINK – Fluid overheated

LIGHT BROWN – Contamination of oxidation

Note: Fluid will darken in normal use and does not always indicate contamination or oxidation

BURNED SMELL – Slipping / worn transmission components

If the transmission fluid shows signs of contamination drain the fluid and inspect the pan, filter and drained fluid for foreign material.

Large amounts of material or metal in the pan indicates internal transmission damage.

Very small amounts of foreign material may be caused by normal use. Change the fluid and filter and road test.

Transmission fluid level

- Drive the vehicle for a minimum of 10 – 15 miles (16 – 24 km) or until the transmission is at normal operating temperature.
- With the vehicle level, set the parking brake and firmly depress the brake pedal.
- With the engine idling in PARK, move the gear selector through each gear range, pausing 3 seconds in each range.
- With the engine still running, select PARK and check the fluid level with the dipstick.

Transmission fluid level is critical to transmission operation. Level must be checked at the fluid temperatures listed below. PDU can be used to verify transmission fluid temperature.

DO NOT STALL TEST THE TRANSMISSION TO HEAT THE TRANSMISSION FLUID.

ZF 4HP 24 E9 Transmission fluid normal operating temperature – 176° F (80° C)

Powertrain 4L80-E Transmission fluid normal operating temperature – 194° F (90° C)

NOTES

Automatic Transmission Stall Test

The procedure for conducting a stall test is the same for all models:

- **Safety** Block both sides of the drive wheels
- **DRIVE and REVERSE** Perform the test in both DRIVE and REVERSE
- **Full Throttle** Apply firm pressure to the brake pedal and select the gear. Momentarily operate the engine at full throttle while observing the pressure gauge and tachometer.
- **Test Limits** Test no longer than five seconds with a two minute cool down between tests. Do not perform more than three tests within 30 minutes.

ZF 4 HP 24 E9 Stall Test

Stall test specifications

Stall speed	1900 +150 rpm
Stall pressure DRIVE	181 – 208 psi
Stall pressure REVERSE	325 – 352 psi

Stall test diagnostic information

Engine speed at stall	Condition indicated
under 1300 rpm	torque converter stator slip
1300 – 1900 rpm	poor engine tune / condition
1900 – 2050 rpm	normal
over 2050 rpm	transmission slip

Powertrain 4L80-E Stall Test

Stall test specifications

Stall speed	2200 – 2300 rpm
Stall pressure DRIVE	154 – 175 psi
Stall pressure REVERSE	292 – 366 psi

Stall test diagnostic information

Engine speed at stall	Condition indicated
under 1800 rpm	torque converter stator slip
1800 – 2200 rpm	poor engine tune / condition
2200 – 2300 rpm	normal
over 2300 rpm	transmission slip

NOTES

Automatic Transmission Line Pressure Test

The procedure for performing a line pressure test is the same for all models:

- **Safety** Block both sides of the drive wheels
- **Range, Engine Speed and Pressure** Apply firm pressure to the brake pedal. Select the gear as directed by the chart and observe the line pressure.
- **Test Limits** Test no longer than two minutes with a two-minute idle cool-down between tests.

ZF 4 HP 24 E9 Line Pressure Test

Gear Range		Pressure
DRIVE	brakes applied; engine idle	90 – 110 psi
DRIVE	brakes applied; engine 1000 rpm	105 – 130 psi
REVERSE	brakes applied; engine idle	160 – 181 psi

ZF 4 HP 24 E9 Line Pressure Test

Gear Range		Pressure
DRIVE	brakes applied; engine idle	35 psi
REVERSE	brakes applied; engine idle	67 psi

NOTES