THM 4T65-E/EV-GT
PRELIMINARY INFORMATION

Refer to Figure 1 for gear shift position information.

Refer to Figure 2 for clutch and band application.

Refer to Figure 3 for Geartronic gear shift information.

Refer to Figure 4 for channel plate differences and channel plate check ball locations.

Refer to Figure 5 for channel plate gasket and spacer plate differences.

Refer to Figure 6 for valve body gasket differences and valve body check ball locations.

Refer to Figure 7 for the Volvo TCM wiring diagram.

Refer to Figure 8 for transmission case connector and vehicle harness connector terminal function.

Refer to Figure 9 for check ball function.

Refer to Figures 10 to 16 for input speed sensor differences.

Refer to Figure 17 for fourth clutch pack differences.

THM 4T65-E/EV-GT
PRELIMINARY INFORMATION

GENERAL DESCRIPTION

The Hydra-matic 4T65-E is a fully automatic, four speed front wheel drive electronically controlled transaxle. It consists primarily of a four element torque converter, two planetary gear sets, a hydraulic pressurization and control system, friction and mechanical clutches and a final drive gear set with a differential assembly.

The four element torque converter contains a pump, a turbine, a pressure plate splined to the turbine, and a stator assembly. The torque converter acts as a fluid coupling to smoothly transmit power from the engine to the transaxle. It also hydraulically provides additional torque multiplication when required. The pressure plate, when applied, provides a mechanical "direct drive" coupling of the engine to the transmission.

The two planetary gear sets provide the four forward gear ratios and reverse. Changing gear ratios is fully automatic and is accomplished through the use of a Transmission Control Module (TCM-Volvo).

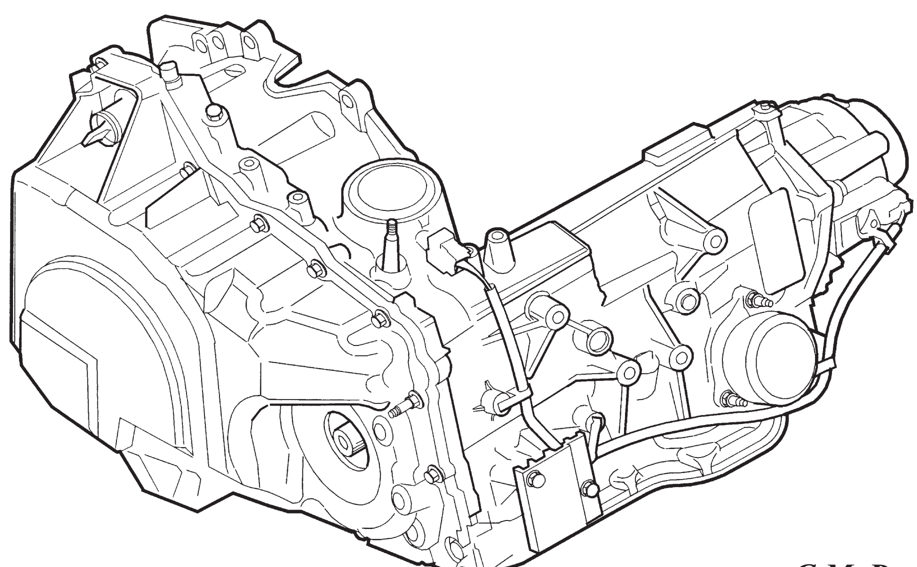
The TCM receives and monitors various electronic sensor inputs and uses this information to shift the transaxle at the optimum time.

The TCM commands shift solenoids, within the transaxle, on and off to control shift timing. The TCM controls the apply and release of the torque converter clutch which allows the engine to deliver the maximum fuel efficiency without sacrificing vehicle performance.

The hydraulic system consists of a vane type pump, control valve body and case cover. The pump maintains the working pressure needed to stroke the servos and clutch pistons that apply and release the friction components.

The friction components used in this transaxle consist of four multiple disc clutches and three bands. The multiple disc clutches combine with one roller clutch and two sprag clutches, to deliver four forward gear ratios and reverse, through the gear sets. The gear sets then transfer torque through the final

Volvo Designation 4T65-E/EV-GT
1999-2002 80 Series 2.5L Engine



G.M. Designation 4T65-E
1997 and up various applications

GENERAL DESCRIPTION (Cont'd)

drive differential assembly and out to the drive axles.

A Component Application chart and solenoid application chart have been provided for you in Figure 2.

GEAR RANGE DESCRIPTION

The transaxle can be operated in any one of the seven different positions on the shift quadrant, that is shown in Figure 1 (Non-Geartronic applications).

P - Park position enables the engine to be started while preventing the vehicle from rolling either forward or backward. For safety reasons the vehicle's parking brake should be used in addition to the "Park" position. Since the final drive differential and output shaft are mechanically locked to the case through the parking pawl and final drive internal gear, Park position should not be selected until the vehicle has come to a complete stop.

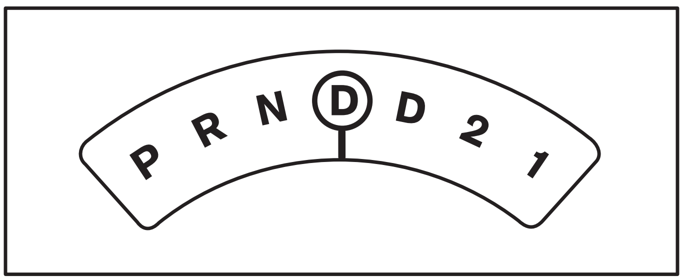


Figure 1

R - Reverse position enables the vehicle to be operated in a rearward direction.

N - Neutral position enables the engine to start and operate without driving the vehicle. If necessary, this position should be selected to restart the engine while the vehicle is moving.

D - Overdrive range should be used for all normal driving conditions for maximum efficiency and fuel economy. Overdrive range allows the transaxle to operate in each of the four forward gear ratios. Downshifts to a lower gear, or a higher gear ratio are available for safe passing by depressing the accelerator or by manually selecting a lower gear range with the selector lever.

D - Manual third can be used for conditions where it may be desirable to use only three gear ratios. These conditions include towing a trailer or driving on hilly terrain. This range is also helpful for engine braking when decending slight grades. Upshifts and downshifts are the same as Overdrive range first, second and third gears except that the transaxle will not upshift to fourth.

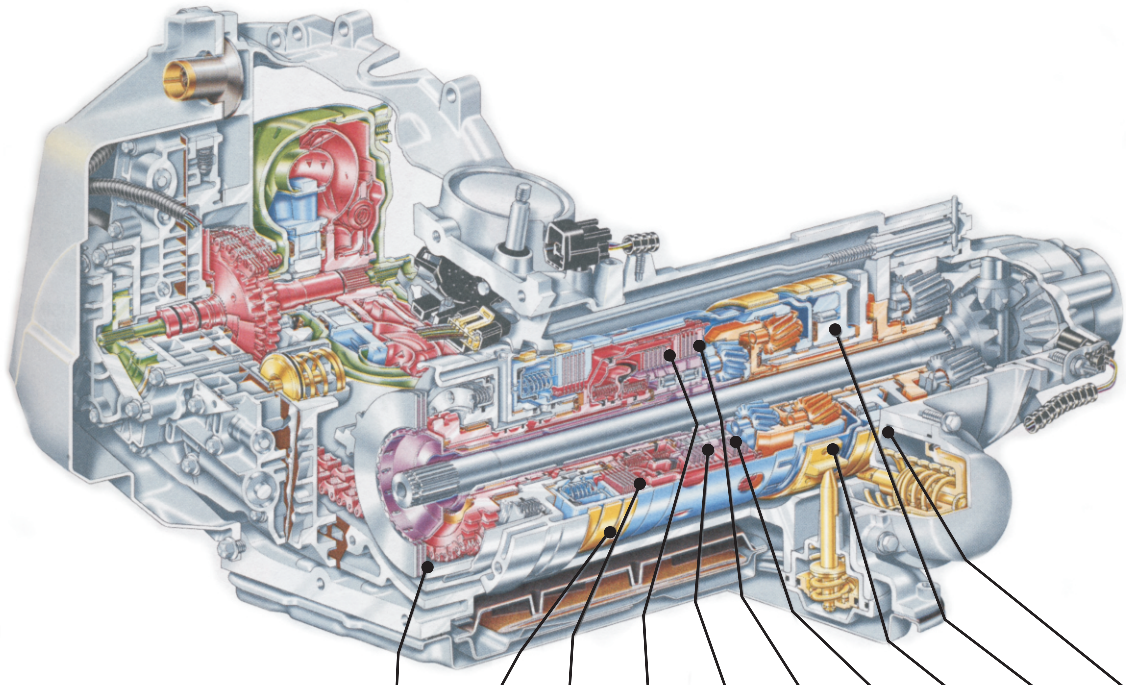
2 - Manual second adds more performance for congested traffic and hilly terrain. It has the same starting ratio (first gear) as Manual third but prevents the transaxle from shifting above second. Thus manual second can be used to retain second gear for accelerations and engine braking as desired. Manual second can be selected at any vehicle speed but will not downshift into second gear until the vehicle speed drops below 100 Km/h (62 mph).

1 - Manual first can be selected at any vehicle speed. If the transaxle is in third or fourth gear it will immediately shift into second gear. When the vehicle speed slows to below approximately 60 Km/h (37 mph) the transaxle will then shift into first gear. This is particularly beneficial for maintaining maximum engine braking when descending steep grades.

Triptronic/Geartronic

As an alternative to the conventional automatic transmission, this transmission is available with Triptronic (Geartronic - GM), a manual shifting position.

COMPONENT APPLICATION AND SOLENOID CHART



RANGE	GEAR	1-2, 3-4 SHIFT SOLENOID	2-3 SHIFT SOLENOID	4TH CLUTCH	REV. BAND	2ND CLUTCH	3RD CLUTCH	3RD CLUTCH SPRAG	INPUT CLUTCH	INPUT CLUTCH SPRAG	2/1 BAND	1-2 ROLLER CLUTCH	FORW. BAND
P-N		ON	ON						*	*			
OD	1ST	ON	ON						APPLIED	HOLDING		HOLDING	APPLIED
	2ND	OFF	ON			APPLIED			*	OVERRUN		HOLDING	APPLIED
	3RD	OFF	OFF			APPLIED	APPLIED	HOLDING				OVERRUN	*
	4TH	ON	OFF	APPLIED		APPLIED	*	OVERRUN				OVERRUN	*
D	3RD	OFF	OFF			APPLIED	APPLIED	HOLDING	APPLIED	HOLDING		OVERRUN	*
	2ND	OFF	ON			APPLIED			*	OVERRUN		HOLDING	APPLIED
	1ST	ON	ON						APPLIED	HOLDING		HOLDING	APPLIED
2	2ND	OFF	ON			APPLIED			*	OVERRUN	APPLIED	HOLDING	APPLIED
	1ST	ON	ON						APPLIED	HOLDING	APPLIED	HOLDING	APPLIED
1	1ST	ON	ON				APPLIED	HOLDING	APPLIED	HOLDING	APPLIED	HOLDING	APPLIED
REV	REVERSE	ON	ON		APPLIED				APPLIED	HOLDING			

(Shaded) The Geartronic version of the 4T65-E uses only these forward gears, plus Park, Neutral and Reverse

* Applied and holding with no load (Not Transmitting Torque)

Figure 2

GEAR SELECTOR WITH GEARTRONIC CONTROL

Shifting Using Geartronic

When the gear selector is moved to the Geartronic position (MAN) the automatic transmission remains in hydraulic position D, but when the gear selector is moved upwards (+) the gear selector module (GSM) transmits a signal to the transmission control module (TCM) to shift up. When the gear selector is moved downwards (-) a signal is transmitted to the transmission control module (TCM) to shift down. The driver information module (DIM) switches the symbol in the combined instrument panel from D to the current gear, for example 3, when the gear selector is in the MAN position. A signal is sent to the gear selector module (GSM) to light the M LED and switches off the other LEDs. The transmission control module (TCM) determines if shifting can be carried out and the driver information module (DIM) indicates the current gear. If shifting is permitted the solenoids are activated according to each specific gear pattern. However, in certain situations the transmission control module (TCM) assumes the shifting decision. The following applies:

1. When stationary only 1st, 2nd and 3rd gears can be selected. 4th gear can be selected at speeds exceeding 30 km/h

2. Automatic down shifting occurs for all gears below a certain speed. Example: 2nd gear is selected.

3. Automatic down shifting occurs when shifting from 2nd gear to 1st at 2 km/h if the speed, before this has exceeded 25 km/h. in other cases 2nd gear is retained. For example, when 3rd gear is engaged despite the car being stationary.

4. Manual up shifting is required after automatic down shifting. Kick-down is not available in the Geartronic position (MAN).

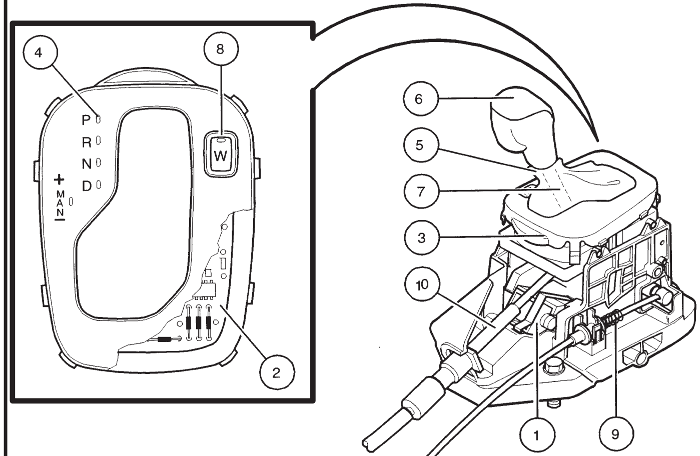
5. The permitted speed for manual down shifting corresponds to those for kick-down up shifting, i.e. engine speed at approximately 6,000 rpm.

6. If the transmission temperature becomes too high the transmission control module (TCM) determines the shift position. The purpose is to maintain a gear where lock-up is possible at the current speed.

7. Lock-up command is possible in 3rd and 4th gears. (1st and 2nd gears do not have commanded lock-up although hydraulically it is possible to have TCC in second.).

Other

In the MAN position a signal about the lever position is generated for the gear selector module (GSM) as follows: For each of the three gear selector positions a hall sensor is mounted on the printed circuit board for the gear selector control module (GSM). A permanent magnet on the lever affects the output signals from the sensors to the control module. The control module can read off the position of the lever through the differences in the signal characteristics.



1 Solenoid
2 Printed Circuit Board - This is the Gear Select Module (GSM)
3 Top Panel
4 Gear Shift Position
5 Boot
6 Gear Selector Lever Knob
7 Push Rod
8 Winter Button
9 Ignition Switch
10 Transmission Cable

Figure 3

Gear Selector Assembly Construction

The housing, shiftlock solenoid (1) and mounting lever for the ignition switch interlock cable is common to both gear selector assemblies.

In the 4T65EV / EV-GT the solenoid in the gear selector assembly has a reverse inhibitor function. The reverse inhibitor makes it impossible to engage R and P when the car is traveling faster than 12 km/h. The gear selector assembly (and therefore the solenoid) is supplied with current and signals via the connector on the rear side.

A printed circuit board (2) is located under the top panel (3). The circuit board has the WINTER button (8) and 14 LEDs (13 LEDs with Geartronic) which light up the gear position (4). The LEDs also indicate the selected gear.

Gear Selector Module

The gear selector assembly, solenoid and printed circuit board together constitute the gear selector module and it is a slave module to the TCM.

Information between the gear selector module and the transmission module is transferred using serial communication, which requires a micro processor located on the printed circuit board.

The TCM gives instructions to the GSM about which LEDs should be lit up and to what strength of illumination. In addition, the TCM controls the solenoid connection at the reverse inhibitor.

The gear selector module informs the TCM about the position of the WINTER button and controls the connection of the solenoid for the reverse inhibitor function. In Geartronic, information is sent about the gear shift position in MAN and if the gear selector lever is moved backwards or forwards.

The gear selector module is connected to the transmission diagnostic system.

The transmission is electronically controlled using the Transmission Control Module (TCM) which controls it based on signals from the network and sensor in the transmission.

The TCM has built-in diagnostics which are read via the Data Link Connector (DLC) using VADIS.

Shifting Program

Economy Mode

When driving at normal acceleration, the transmission control module (TCM) uses a pre-set shifting program, optimized to shift for economy driving. This shifting program is suitable for “normal” driving which provides earlier up shifts and lock-up. In addition the transmission oil pressure is adjusted to provide smooth gear engagement.

Sport mode

In the sport mode shifting program the shifting points are adjusted to provide the best possible performance. Downshifts occur earlier. The transmission control module (TCM) selects the shifting and lock-up points which provide the best possible performance. The transmission switches from economy mode to sport mode in step 1 or step 2 if the accelerator pedal (AP) is pressed down quickly. The conditions are that the throttle opens and the vehicle speed exceeds 50 km/h. As soon as the accelerator pedal (AP) is released to a certain level economy mode is resumed.

Kick-down program

At wide open throttle (WOT) the kick-down function is engaged which provides quick downshifts for maximum performance. In this way a boost of power is achieved when overtaking for example.

Winter mode

Winter mode is selected using the (W) button on the top panel of the gear selector assembly. Winter mode enables starting off in a high gear to prevent the wheels from spinning on a slippery surface. This mode can also be used in other difficult situations in which the driver needs more direct control over gear selection. Lock-up can be engaged in 2nd gear. The shifting pattern is optimized to minimize the number of shifts. Depending on the gear position, the following combinations can be obtained:

D - The car starts in 2nd gear. Automatic shifting between 2nd and 3rd gears occurs earlier than in Economy mode, D position.

3 - The car starts in 2nd gear. 4th gear is locked out

2 - The car starts in 2nd gear. There is no up shifting or downshifting.

1 - The car starts in 1st gear. There is no up shifting or downshifting.

The W lamp on the dashboard lights when winter mode is selected.

If kick-down is activated in Winter mode, the transmission uses all gears for maximum performance.

Emergency programs in the event of a fault

An emergency program is activated to deal with the fault when the transmission control module (TCM) detects a transmission fault (permanent fault). The control system then implements corrective action to protect the transmission, while leaving the car in the best possible drive-able condition. Minor malfunctions do not activate an emergency program. There are different programs depending on the type of fault:
Emergency mode I
Emergency mode II
Emergency mode III
Limp-home mode
Emergency mode I is activated in the event of minor faults and the Limp-home mode is activated for the most serious faults. If the malfunction is intermittent, the transmission control module (TCM) returns to normal operation the next time the ignition is switched on.

Emergency mode I

1. The warning lamp in the combined instrument panel lights (S80), flashes (S/V/C70) for certain diagnostic trouble codes (DTCs).
2. The transmission shifts in all gears but transmits no signal to the lock-up solenoid. This means that lockup is not available.

Emergency mode II

1. Remedy as for Emergency mode I.
2. No reduction of line pressure when moving the gear selector between positions P-R, N-R and N-D. This results in harsh shifting.
3. No torque limiting request from the engine control module (ECM) during gear shifting.
4. The warning lamp in the combined instrument panel lights / flashes.

Emergency mode III

1. Remedy as for Emergency modes I and II.
2. No control of line pressure solenoid STH. Constant maximum system pressure. This results in harsh shifting and harsher gear engagement in positions P-R, N-R and N-D.

Limp -home mode

1. The transmission control module (TCM) interrupts the activation of all solenoids. This results in the transmission not shifting at all. The transmission operates only in 3rd gear in positions 3 and L, 4th gear in position D and reverse in position R. Shifting can only be carried out manually between 3rd and 4th gear and reverse gear.
2. No control of line pressure solenoid STH. Constant maximum system pressure. This results in harsh shifting and harsher gear engagement in positions P-R, N-R and N-D.
3. The warning lamp in the combined instrument panel flashes.

Note! When starting and driving, the gear selector should first be moved to position L to minimize stress on the transmission.

Emergency mode in the event of a fault

If the transmission control module (TCM) detects a permanent fault, an emergency mode is activated. The transmission control module (TCM) then implements corrective action to protect the transmission. Minor malfunctions do not activate an emergency program. There are different programs depending on the type of fault:

1. Emergency mode
2. Limp home mode.

Emergency mode is activated for minor faults and the Limp home mode for the most serious faults. If the malfunction is intermittent, the transmission control module (TCM) returns to normal operation the next time the ignition is switched on.

Emergency mode

A text message is displayed in the combined instrument panel for diagnostic trouble codes (DTCs) stored in the transmission control module (TCM). The transmission shifts in all gears but transmits no signal to the lock-up solenoid. This means that lock-up is not available.

Limp home mode

A text message is displayed in the combined instrument panel for diagnostic trouble codes (DTCs) stored in the transmission control module (TCM).

The transmission control module (TCM) interrupts the activation of all solenoids. This means that no shifting is possible. The transmission only functions in 3rd gear and back-up (reverse) gear. No regulation of line pressure solenoid STH. Maximum system pressure constantly which results in harsh P-R, N-R and N-D engagements. This can also result in a whining noise from the transmission pump.

Additional Information

Gear ratios:
1st 2.921:1
2nd 1.568:1
3rd 1.000:1
4th 0.706:1
Reverse: 2.385:1

Weight including fluid: 97.0 kg (214 lbs)

Approximate oil capacity:7.0L (7.4 US quarts)

If the oil pan and the cooling circuit are removed: 7.5L (8 US quarts)

If the oil pan and the torque converter are removed: 9.5L (10 US quarts)

Completely dry with cooling circuit (theoretical value):12.4L (13 US quarts)

Transmission fluid: Dexron III with G-license number (G-32xxx).

Counter for transmission fluid data

A counter for transmission oil quality is built into the software for the transmission control module (TCM). The counter counts up the amount of time the oil is above a certain temperature. When the counter has reached the maximum value, the diagnostic trouble code (DTC) for an oil change is stored in the control module. When replacing transmission fluid, the counter must be reset to prevent a diagnostic trouble code (DTC) being stored incorrectly. This applies when the transmission fluid is changed and when the fluid is changed during a repair.

The reset function is activated via the VIDA vehicle communication socket.

GM and Volvo Differences

As previously stated, this transmission is available with Geartronic, a manual shift strategy package. This means it is also available with GM's typical 7 position gear select of PRND321. It is when a Geartronic shift package is used that there are significantly more differences between GM and Volvo applications. Here are most of the changes to be aware of:

1.Volvo uses the Geartronic shift strategy which allows for engine braking in 1st, 2nd and 3rd gears manually. To accommodate this shift strategy, hydraulic changes were made to the valve body, valve body spacer plate, gaskets and channel plate (See Figures 4-6). Additionally, manual valve position signals from the Pressure Switch manifold are no longer needed with Volvo vehicles as it reads signals from the Internal Mode Switch (IMS) and the Gear Select Module (GSM). The only pressure switch used from the Pressure Switch Manifold (PSM) is the TCC On/Off switch (Figure 7).

Vehicles which use the seven position gear select assembly will make full use of the PSM.

Although the TCM does not use all the signals from the PSM with the Geartronic package, the internal wiring harness is the same. It is the external wiring plugging into the transmission that eliminates the wiring for the switches not being used.

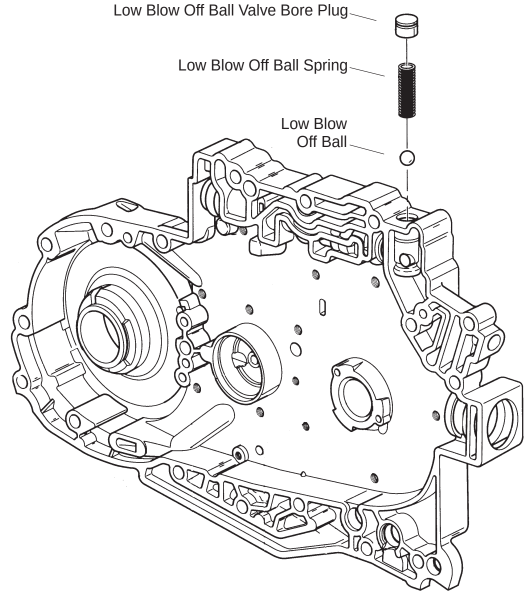
2. Volvo uses an Asian Warner style TCM. As a result of this style TCM, the shift solenoids are power driven rather than ground driven (Figure 7 & 8).

Other significant differences is GM uses an AC pulse generator for the Turbine and Output shaft speed sensor while Volvo uses internally grounded Hall Effect Sensors (Figure 7).

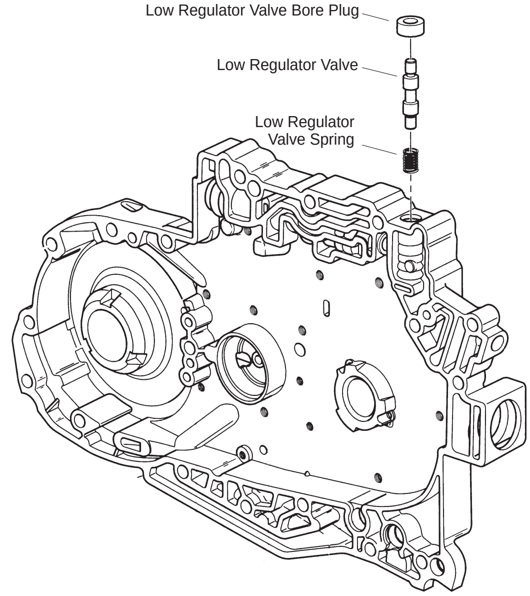
GM uses a typical steel plate and friction plate stack up for the fourth clutch while Volvo uses single sided friction plates (Figure 17).

These are some of the more significant differences that can be found between GM and Volvo applications. Different size right side axle seals would be another, as well as Volvo uses a Viscous clutch in the differential in some applications.

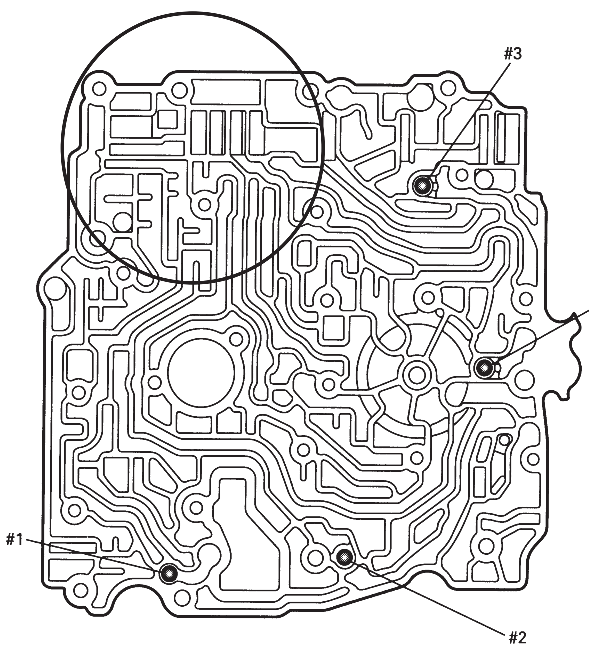
General Motors Application	*Volvo Application*



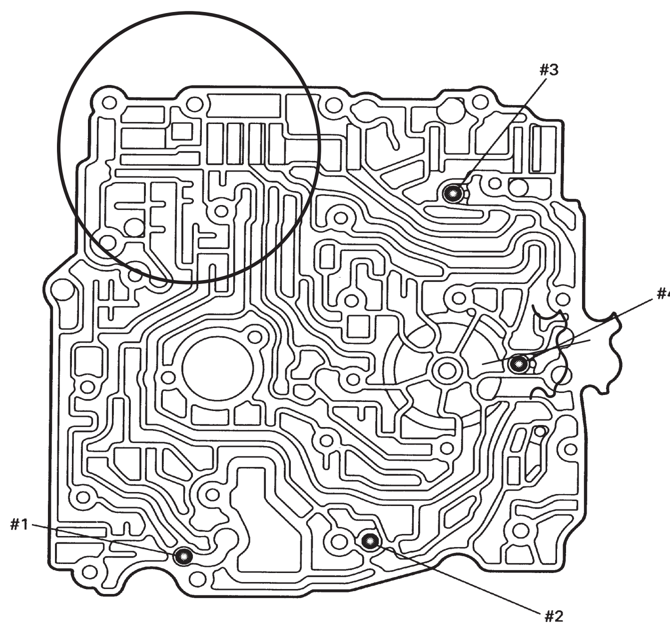
Channel Plate



Channel Plate



Check ball function and location in the channel plate are the same for GM and Volvo

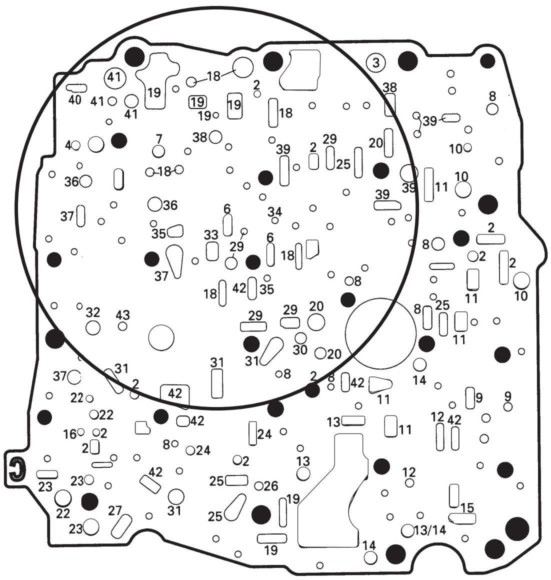


Check ball function and location in the channel plate are the same for GM and Volvo

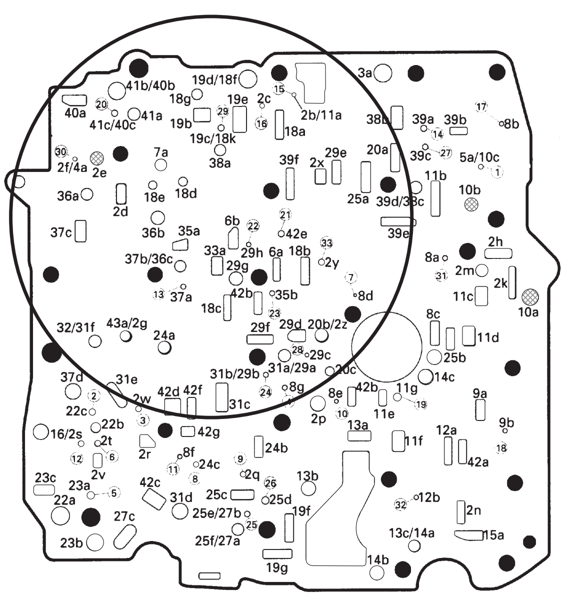
Figure 4

General Motors Application	*Volvo Application*

General Motors Application

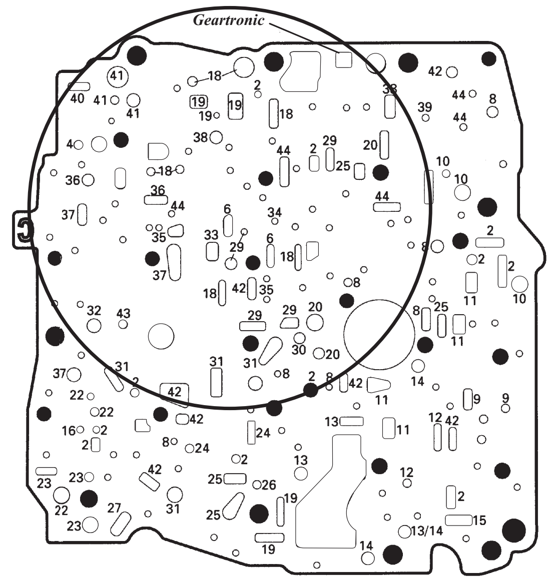


Gasket (Channel Plate to Spacer Plate)

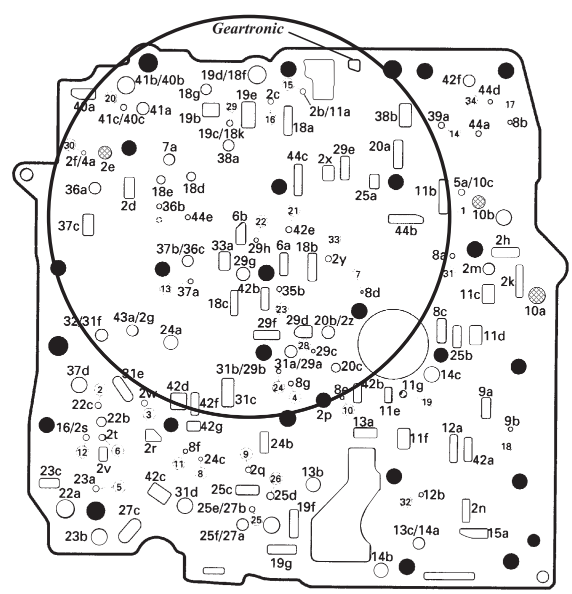


Spacer Plate

Volvo Application



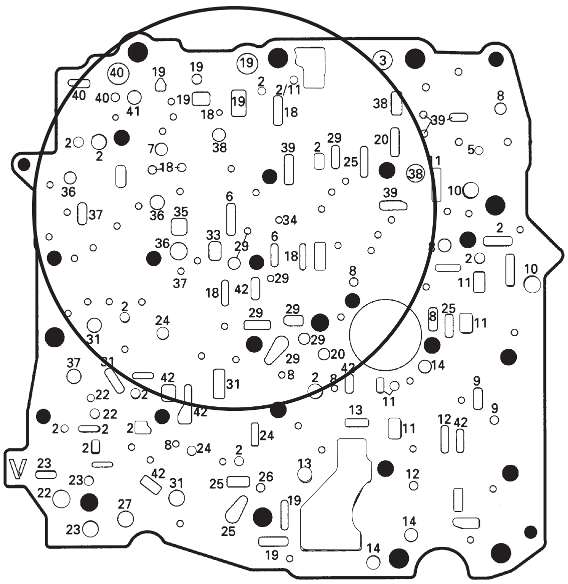
Gasket (Channel Plate to Spacer Plate)



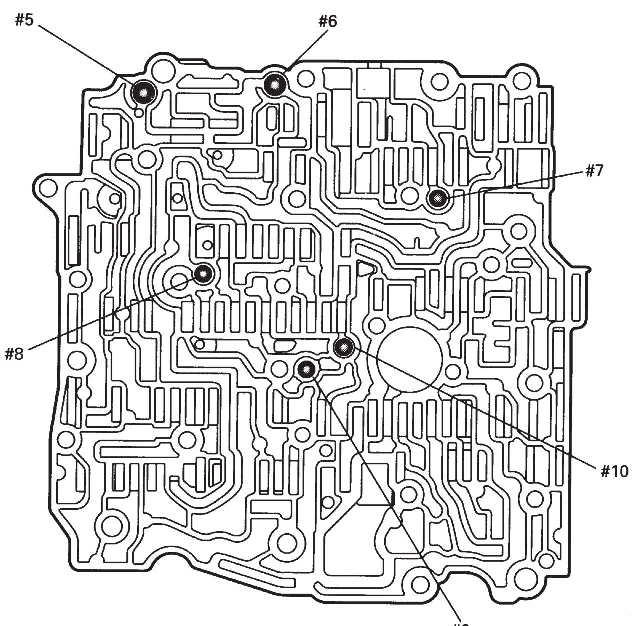
Spacer Plate

Figure 5

General Motors Application



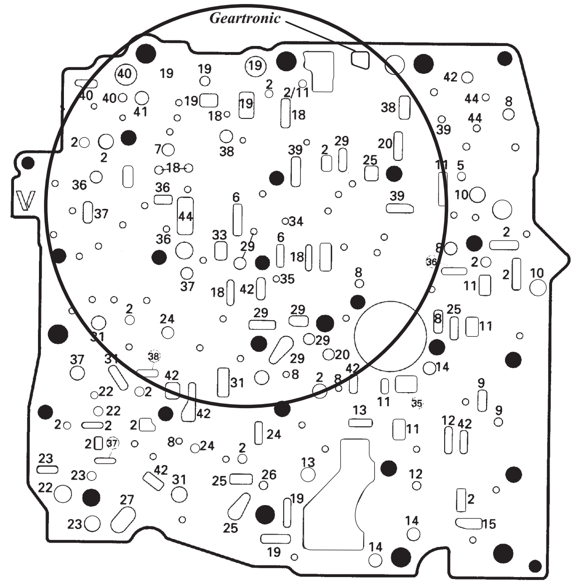
Gasket (Spacer Plate to VB)



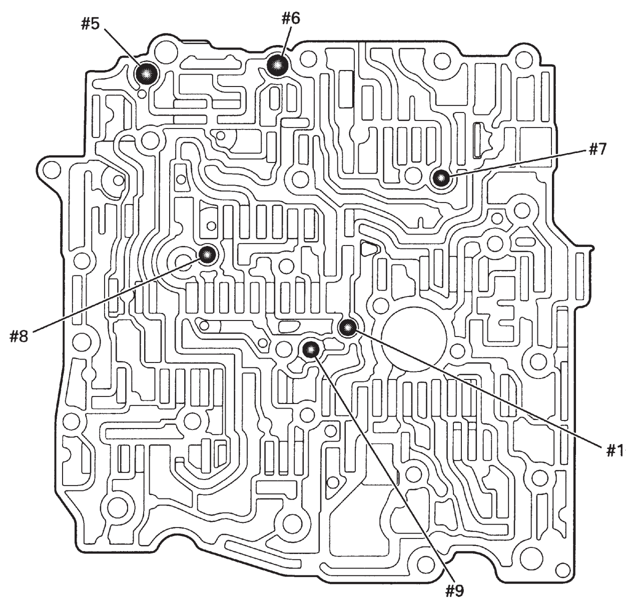
Valve Body

Check ball location in the VB is same for GM and Volvo. The # 7 and # 8 ball have different functions

Volvo Application



Gasket (Spacer Plate to VB)



Valve Body

Check ball location in the VB is same for GM and Volvo. The # 7 and # 8 ball have different functions

Figure 6

Typical Volvo Wiring

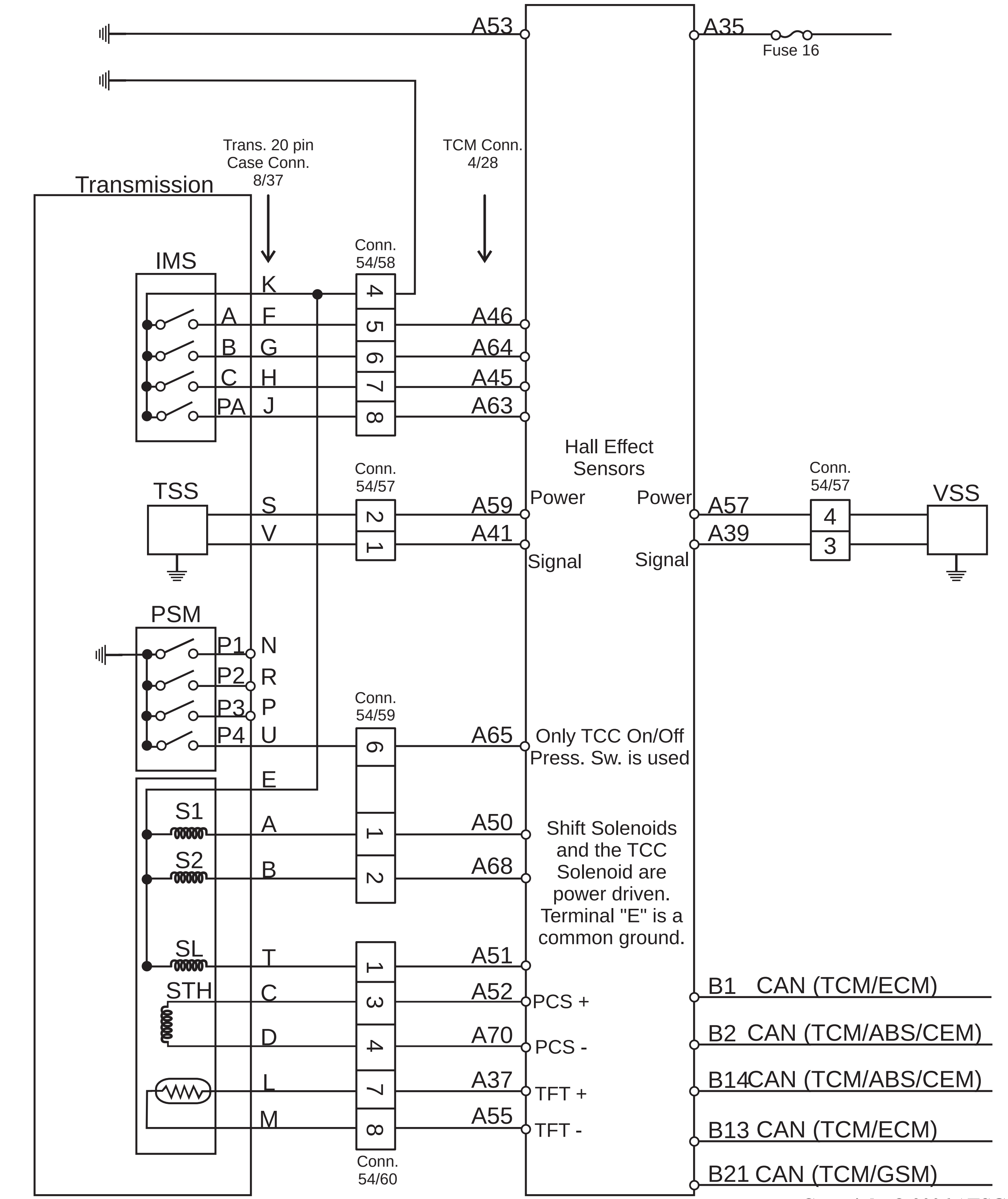
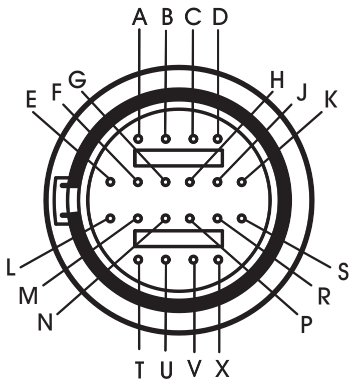


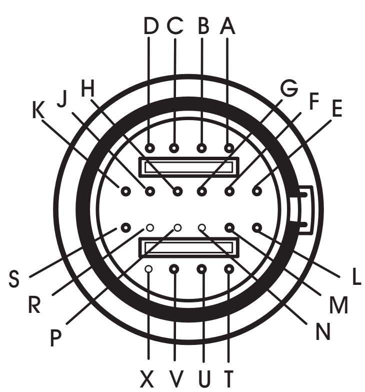
Figure 7



View Looking Into
Transaxle Case Connector

Ohms Resistance Chart			
Cavities	**Component**	**Resistance @ 68°F**	**Resistance @ 190°F**
A-E	**1-2 Shift Solenoid**	**19-24W**	**24-31W**
B-E	**2-3 Shift Solenoid**	**19-24W**	**24-31W**
T-E	**TCC/PWM Solenoid**	**10-12W**	**13-15W**
C-D	**EPC Solenoid**	**3-5W**	**5-6W**
S-V	**Input Speed Sensor**	**Hall Effect**	**Hall Effect**
M-L	**TFT Sensor**	**3164-3867W**	**225-285W**
	Output Speed Sensor	**Hall Effect**	**Hall Effect**

A - 1-2/3-4 Shift Solenoid 1 power signal wire
B - 2-3 Shift Solenoid 2 power signal wire
C - Pressure Control Solenoid power signal wire
D - Pressure Control Solenoid ground wire
E - Ground for the shift and lock up solenoid
F - IMS "A" Signal
G - IMS "B" Signal
H - IMS "C" Signal
J - IMS "PA" Signal
K - IMS Ground (Shared with terminal "E")
L - Transmission Fluid Temperature Sensor Signal
M -Transmission Fluid Temperature Sensor Ground
N - PSM PS1 Signal
P - PSM PS3 Signal
R - PSM PS2 Signal
S - Turbine Shaft Speed Sensor Power
T - Lock Up Solenoid Power Signal Wire
U - PSM PS4 Signal
V - Turbine Shaft Speed Sensor Signal Wire
X - Not Used



View Looking Into
Vehicle Harness Connector

A - Shift Solenoid 1 power signal wire
B - Shift Solenoid 2 power signal wire
C - Pressure Control Solenoid power signal wire
D - Pressure Control Solenoid ground wire
E - Ground for the shift and lock up solenoid
F - IMS "A" Signal
G - IMS "B" Signal
H - IMS "C" Signal
J - IMS "PA" Signal
K - IMS Ground (Shared with terminal "E")
L - Transmission Fluid Temperature Sensor Signal
M -Transmission Fluid Temperature Sensor Ground
N - Not Used
P - Not Used
R - Not Used
S - Turbine Shaft Speed Sensor Power
T - Lock Up Solenoid Power Signal Wire
U - PSM PS4 Signal (TCC On/Off Signal)
V - Turbine Shaft Speed Sensor Signal Wire
X - Not Used

Figure 8

Channel Plate Valve Description

Manual Valve

The manual valve is fed by line pressure from the pressure regulator valve and is mechanically linked to the gear selector lever. When a gear range is selected, the manual valve directs line pressure into the various circuits by opening and closing feed passages. The circuits that are fed by the manual valve are: Reverse. PRN, D4, D3, D2 and Lo.

Stuck, misaligned or damaged valve and linkage could cause:

No reverse or slips in reverse
No first gear or slips in first gear
No fourth gear or slips in fourth gear
No Park
No engine compression braking in all manual ranges
Drives in neutral
No gear selections
Shift indicator indicates wrong gear selection

Low Regulator Valve Lineup (442, 443 & 444)

The low regulator valve (443) is a spool type regulating valve that regulates braking 1st gear fluid into the low regulator fluid circuit. Low regulator fluid is used to apply the third clutch in manual first.

Damaged/missing valve, spring or bore plug can cause slipping in manual first.

Cooler Blow Off Ball Check Valve Lineup (407, 417 & 420C)

The cooler blow off ball check valve (420C) is held closed by spring force from the cooler blow off spring (407). If cooler fluid pressure exceeds 1103 kPa (160 psi), the ball check valve moves against spring force to exhaust the excess pressure.

Actuator Feed Limit Valve Train (414-416)

The actuator feed limit valve is a spool type regulating valve that regulates line fluid pressure into actuator feed fluid pressure. Actuator feed fluid then feeds the pressure control solenoid and the shift solenoids after passing through a filter (screen assembly 382)

Accumulators

In the Hydra-matic 4T65-E, accumulators are used in the 2nd, 3rd and 4th clutch apply circuits to control shift feel. An accumulator is a spring loaded device that absorbs a certain amount of fluid pressure in a circuit to cushion clutch engagement according to engine torque. The clutch apply fluid pressure acts against spring force and torque signal fluid biased accumulator pressure to act like a shock absorber.

During the apply of the 2nd, 3rd and 4th clutch packs, apply fluid overcomes the clutch piston return springs and begins to compress the clutch plates. When the clearance between the clutch plates is taken up by piston travel and the clutch begins to apply. Pressure in the circuit builds up rapidly. Without an accumulator in the circuit, this rapid build up of fluid pressure would cause the clutch to grab very quickly and create a harsh shift. However, accumulator spring force and accumulator fluid pressure is designed to absorb some of the clutch apply fluid pressure allowing for a more gradual apply of the clutch.

The force of the accumulator spring and accumulator fluid pressure together control the rate at which a clutch applies. In the Hydra-matic 4T65-E, accumulator pressure varies in proportion to the torque signal pressure acting on the accumulator valves. Therefore, when torque signal pressure is high, accumulator pressure will he high. Likewise, when torque signal pressure is low, accumulator pressure will be low. Since torque signal pressure is regulated by the pressure control solenoid, (which is controlled by throttle position through the PCM), the accumulator valves regulate accumulator fluid pressure in proportion to throttle position to control shift feel.

3-4 Accumulator Assembly (421-428)

Shift feel for a 3-4 shift and durability of the 4th clutch is largely dependent upon 4th clutch fluid pressure used to apply the clutch. To control 4th clutch apply pressure and shift feel, a 3-4 accumulator assembly (421-428) and 3-4 accumulator pressure is used.

Fluid pressure in the 3-4 accumulator passage occurs when Line fluid pressure is regulated at the 3-4 accumulator valve (350) by torque signal fluid pressure and spring force. Regulated Line fluid pressure is then directed into the 3-4 accumulator circuit, through the hollow 3-4 accumulator pin (426) to the spring side of the 3-4 accumulator piston (428). When the 4th clutch applies during a 3-4 shift, 4th clutch pressure is fed to the 3-4 accumulator piston.

(428) and compresses the 3-4 accumulator springs (423-424). When this occurs, 3-4 accumulator fluid is forced out of the 3-4 accumulator cannister (421) back to the 3-4 accumulator valve (341) where it exhausts. Again, torque signal fluid pressure and spring force at the 3-4 accumulator valve (341) regulates exhausting 3-4 accumulator fluid to control the 4th clutch apply.

Accumulator Related Diagnostic Tips
A leak at the accumulator piston seal or porosity in the case, case cover or accumulator housing could cause no fourth gear/slips in fourth gear.

Valve Body Valve Description

1-2 Accumulator Assembly (135A-137A, 139 & 142)
Shift feel for a 1-2 shift and durability of the 2nd clutch is largely dependent upon 2nd clutch fluid pressure used to apply the clutch. To control 2nd clutch apply pressure and shift feel, a 1-2 accumulator assembly and 1-2 accumulator fluid pressure is used in addition to the 2nd clutch wave plate (623).

Fluid pressure in the 1-2 accumulator passage occurs when Line fluid pressure is regulated at the (primary) 1-2 accumulator valve (350) by torque signal fluid pressure and spring force. Regulated Line fluid pressure is then directed into the 1-2 accumulator fluid passage where it is routed through orifice #2 to the other end of the accumulator valve where it will oppose torque signal fluid pressure and spring force to regulate 1-2 accumulator fluid pressure. 1-2 accumulator pressure is also routed to the spring side of the 1-2 accumulator piston (136).

When the 2nd clutch applies during a 1-2 shift, 2nd clutch pressure is fed to the 1-2 accumulator piston (136A) and compresses the 1-2 accumulator spring (139). When this occurs, 1-2 accumulator fluid is forced out of the accumulator housing (140) hack to the 1-2 accumulator valve (350) where it exhausts. Torque signal fluid pressure and spring force at the 1-2 accumulator valve regulate exhausting 1-2 accumulator fluid to control 2nd clutch apply.

A leak at the accumulator piston seal or porosity in the case, case cover or accumulator housing could cause no 2nd gear/slips in 2nd gear

A stuck accumulator piston would cause harsh shifts

2-3 Accumulator Assembly (135B-138 & 143)
The 2-3 accumulator assembly functions basically the same as the 1-2 accumulator assembly. To control 3rd clutch apply pressure and shift feel, a 2-3 accumulator assembly and 2-3 accumulator pressure is used in addition to the 3rd clutch waved plate (645).

Fluid pressure in the 2-3 accumulator passage occurs when Line fluid pressure is regulated at the 2-3 accumulator valve (344) by torque signal fluid pressure. Regulated Line fluid pressure is then directed into the 2-3 accumulator fluid passage to the spring side of the 2-3 accumulator piston (136B).

When the 3rd clutch applies during a 2-3 shift, 3rd clutch pressure is fed to the 2-3 accumulator piston (136B) and compresses the 2-3 accumulator spring (143). When this occurs. 2-3 accumulator fluid is forced out of the accumulator housing (140) back to the 2-3 accumulator valve (344) where it exhausts. 'Torque signal fluid pressure and spring force at the 2-3 accumulator valve (344) regulate exhausting 2-3 accumulator fluid to control 3rd clutch apply.

A leak at the accumulator piston seal or porosity in the case, case cover or accumulator housing could cause no 3rd gear/slips in 3rd gear

A stuck accumulator piston would cause harsh shifts

Pressure Regulator Valve Train (302-313)
Pressure Regulator Valve (313)
The pressure regulator valve (313) directs line pressure to the manual valve, the converter feed circuit to control hydraulic apply and release of the converter clutch and the decrease passage to regulate pump output.

If stuck, missing or binding pressure regulator valve or spring could cause incorrect line pressure

Reverse Boost Valve (310)
Acted on by PRN fluid from the manual valve (404) , it moves against pressure regulator valve spring (311 & 312) pressure. This increases line pressure in Park, Reverse and Neutral in response to a high percentage of throttle travel.

Line Boost Valve (304)
Acted on by torque signal fluid pressure, it moves against the reverse boost valve (310) and pressure regulator spring force (311, 312) to increase line pressure. Its function is in response to changes in throttle position (through pressure control solenoid valve response to PCM signals).

1-2 Shift Valve Train (314-318)
1-2,3-4 Shift Solenoid Valve Assembly (315A)
The 1-2 Shift Solenoid Valve assembly (315) is an ON/OFF type. The PCM controls the solenoid by providing a ground (GM) or power (Volvo) to energize it in: Park, Reverse, Neutral, Overdrive Range First and Fourth Gear, and also Manual First Gear. When energized (ON), its exhaust port closes, moves the 1-2 shift valve and allows filtered line pressure to enter the 1-2, 3-4 signal fluid passage. When the PCM removes the ground (GM) or power (Volvo), the solenoid is OFF allowing line pressure to exhaust through the solenoid.

A faulty (stuck on) 1-2, 3-4 Shift Solenoid Valve assembly can cause I st and 4th gear only.
A faulty (stuck off) 1-2, 3-4 Shift Solenoid Valve assembly can cause 2nd and 3rd gear only.

1-2 Shift Valve (318)
The 1-2 shift valve responds to 1-2, 3-4 signal fluid pressure, force from the 1-2 shift valve spring (317) and 2-3 off signal fluid pressure. Depending on the position of the valve, it will route D4 fluid into the 2nd fluid passage or lo fluid into the braking 1st gear fluid passage.

A stuck or binding 1-2 shift valve can cause 1st or 2nd gear only, or slipping/ no 1st or 2nd gear.

Line Pressure Relief Valve (324)
Prevents line pressure from exceeding 1,690-2,480 kPa (245-360 psi). Excess line pressure unseats the ball check valve allowing it to exhaust.

Torque Signal Regulator Valve Train (320-322)
Pressure Control Solenoid Valve Assembly (322)
An electronically controlled pressure regulator that regulates the torque signal regulator valve against torque signal fluid and spring force.

A leaking/damaged o-ring or had electrical connection can cause high or low line pressure.

Torque Signal Regulator Valve (321)
Regulates torque signal fluid, fed by line fluid pressure. The pressure control solenoid, a variable bleed solenoid, acts on one end of the valve (relative to throttle position) against torque signal fluid and spring pressure on the other end.

A stuck torque signal regulator valve can cause high or low line pressure.

TCC Control (PWM) Solenoid Valve (334)
An electronically controlled pressure regulator that regulates 2nd clutch fluid pressure into the TCC signal fluid circuit to shuttle the TCC control valve to the apply position. Regulated TCC signal fluid pressure also shuttles the TCC regulator apply valve to allow line pressure into the TCC regulated apply circuit for a controlled apply and release of the torque converter clutch.

Stuck on, exhaust plugged, would cause no TCC release.
Stuck off, leaking o-ring, no voltage, would cause no TCC/slip or soft apply.

TCC Control Valve (335)
When the TCC PWM solenoid is OFF, the TCC control valve (335) is held in the released position by the TCC spring (336). In this position, converter feed pressure enters the torque converter clutch release circuit and apply fluid flows around the valve into the cooler circuit. When the TCC PWM solenoid (334) is ON, TCC signal fluid moves the valve against spring force. When shifted, it directs regulated line fluid (TCC regulated apply) into the apply passage; converter feed fluid into the cooler passage, and, allows converter release fluid to exhaust.

If stuck, missing or binding the TCC control valve or spring could cause:

TCC stuck on in all gears
No TCC apply

TCC Regulator Apply Valve Train (326-328)
The TCC regulator apply valve (327) is biased by TCC signal and TCC regulated apply fluid pressures in order to regulate line pressure passing through the valve. TCC regulated apply fluid pressure acting on the end of the valve combines with the spring force from the TCC regulator apply valve spring (326). In this manner, line pressure is regulated before it is routed to the converter TCC valve (335).

If stuck. missing or binding the TCC regulator apply valve or spring could cause:

Harsh TCC apply or release, slip, shudder, rough apply or no apply

Forward Servo Boost Valve (367B)
Held by spring force, it opens during hard acceleration to allow D4 fluid to enter the drive servo apply passage, bypassing the feed orifice. This provides for a quick fill of the forward servo apply passage and quick apply of the forward band assembly to prevent slippage during abusive shifts from Park or Neutral to Drive.

Reverse Servo Boost Valve (367A)
Held by spring force, it opens during hard acceleration to allow reverse fluid to enter the reverse servo passage, bypassing the feed orifice. This provides for a quick fill of the reverse servo passage and quick apply of the reverse band to prevent hand slippage during abusive shifts from Park or Neutral to Reverse.

2-3 Shift Solenoid Valve (315B):
The 2-3 Shift Solenoid Valve is an ON/ OFF type. The PCM controls the solenoid by providing a ground (GM) or power (Volvo) to energize it in: Park. Reverse. Neutral, Overdrive Range First and Second Gear; and also Manual Second and Manual First Gear Ranges. When energized (ON), its exhaust port closes, allowing filtered line pressure into the 2-3 signal fluid passage. When the PCM removes the ground (GM) or power (Volvo), the solenoid is OFF allowing line pressure to exhaust through the solenoid.

A faulty (stuck on) 2-3 Shift Solenoid Valve assembly can cause 1st and 2nd gear only.
A faulty (stuck oft) 2-3 Shift Solenoid Valve assembly can cause 3rd and 4th gear only.

3-4 / 4-3 Shift Valve Train (359-362)
3-4 Shift Valve (362)
The 3-4 shift valve is controlled by 1-2, 3-4 signal fluid pressure on one end of the valve and the 4-3 manual downshift valve (360) at the other. When downshifted, input clutch feed pressure can apply or release the input clutch depending on the gear range. When up shifted by 2-3 signal fluid pressure, 3rd fluid is allowed to enter the 4th clutch circuit to apply the 4th clutch.

A stuck or binding 3-4 Shift Valve can cause slipping or no 4th gear.

4-3 Manual Downshift Valve (360)
The 4-3 manual downshift valve is controlled by 2-3 signal fluid pressure acting on one side of the valve and spring force from the 4-3 manual downshift valve spring (361) on the other side. When the 2-3 solenoid is ON, 2-3 signal fluid pressure moves the valve against spring force to hold the 3-4 shift valve (362) in the downshift position.

2-3 / 3-2 Shift Valve Trains (353-357)
3-2 Manual Downshift Valve (356)
The 3-2 manual downshift valve is controlled by 2-3 signal fluid pressure and spring force from the 3-2 downshift valve spring (355). When the 2-3 solenoid is ON, 2-3 signal fluid pressure moves the valve against the 2-3 shift valve (357) to prevent a 2-3 upshift.

2-3 Shift Valve (357)
The 2-3 shift valve (357) is controlled by line pressure acting on one end of the valve and the 3-2 downshift valve (356) at the other end. Depending on the position of the manual valve, 1-2, 3-4 solenoid (315A)and the 2-3 solenoid (315B) state (ON or OFF), the 2-3 shift valve (357) directs: line pressure into the input clutch feed passage, D4 pressure into the auxiliary input clutch feed passage, D3 into the input clutch feed passage, D2 into the into the manual 2-1 servo passage, and 3rd fluid to exhaust at the valve.
A stuck or binding 2-3 Shift Valve can cause slipping or no 3rd gear.

1-2 Accumulator Valve Train (350-351)
1-2 Accumulator Valve (350)

The 1-2 accumulator valve is biased by torque signal fluid pressure and spring force acting on one end of the valve and 1-2 accumulator fluid pressure at the other end. It regulates the amount of line fluid passing through the valve and entering the 1-2 accumulator circuit.

3-4 Accumulator and 2-3 Accumulator Valve Trains (340-346)
3-4 Accumulator Valve (341)

The 3-4 accumulator valve is biased by torque signal fluid pressure and spring force from the 3-4 accumulator spring (351) on one end of the valve and 3-4 accumulator fluid on the other end. It regulates the amount of line pressure passing through the valve and entering the 3-4 accumulator circuit.

2-3 Accumulator Valve (344)

The 2-3 accumulator valve regulates 2-3 accumulator pressure in proportion to torque signal fluid pressure and spring force from the 2-3 accumulator spring (346). It regulates the amount of line pressure entering into the 2-3 accumulator circuit.

Check Ball Function and Location

#1 Converter Clutch Release/Apply

Located in the case cover (400), it directs either release or apply fluid pressures to the TCC blow off ball check valve in the case cover.

#2 2nd Clutch

Located in the case cover (400), it directs 2nd (apply) fluid through orifice 25 on the spacer plate into the 2nd clutch passage. When the 2nd clutch releases, it seats in the case cover (400) forcing 2nd clutch fluid through orifice 26 and into the 2nd fluid passage.

#3 Input Clutch/PRN

Located in the case cover (400), it blocks the PRN passage to direct input clutch fluid to the input clutch during the appropriate gear range. In Park, Reverse or Neutral gear ranges, PRN fluid unseats the ball check valve and also feeds the input clutch.

#4 3rd Clutch/Low Reg

Located in the case cover (400), during Overdrive Range Third Gear, it seats against the low reg passage allowing 3rd clutch fluid into the 3rd clutch/low reg passage to apply the 3rd clutch. During a 3-2 shift, it allows 3rd clutch/low reg fluid to exhaust into the 3rd clutch fluid passage. In Drive Range - Manual First, it seats against 3rd clutch fluid allowing low reg fluid to enter the 3rd clutch/low reg fluid passage to apply the 3rd clutch.

#5 Reverse/Reverse Servo Feed

Located in the valve body (300), it blocks the reverse servo feed passage forcing reverse fluid through an orifice before entering the reverse servo feed passage. When the manual valve is moved out of Reverse gear range, the ball check valve unseats allowing reverse servo fluid to exhaust through the reverse fluid passage.

#6 D4 /Servo Apply

Located in the valve body (300), it blocks the forward servo apply passage and forces D4 fluid pressure to the forward servo feed orifice on the spacer plate (370). When the manual valve is moved from Drive Range to Park or Neutral or Reverse, the ball check valve unseats to allow for a quick exhaust of the servo apply fluid and release of the forward band assembly.

#7 LO (Volvo Geartronic)

Located in the valve body (300), it is part of the Lo fluid circuit but has no function as the fluid is blocked at the spacer plate.

#8 D2 / Manual 2-1 Servo Feed **(Volvo Geartronic)**

Located in the valve body (300), it is fed by D-3 and D-2 fluid from the manual valve and seated against orificed manual 2-1 servo feed fluid at the spacer plate. D-2 fluid is then directed to the 3-2 Manual Downshift valve (356) where it enters the 2-1 manual servo feed passage and is forced through orifice 13. When the 2-1 manual band servo releases the ball check valve unseats and fluid exhausts without going through orifice 13.

#9 3rd / 3rd Clutch
Located in the valve body, it forces 3rd fluid through feed orifice 24 into the 3rd clutch passage during apply of the 3rd clutch. When the 3rd clutch releases, 3rd clutch fluid seats the ball check valve against the 3rd passage, forcing fluid through orifice 28 and into the 3rd fluid passage to the 2-3 shift valve (357) where it exhausts.

#10 Line / 4th Clutch
Located in the valve body, it is seated against the 1st gear fluid passage during all forward ranges, except first, and directs line fluid through orifice 33. In drive range first gear or manual first lst gear fluid pressure unseats the ball check valve and bypasses orifice 33 to send fluid to the input clutch apply passage.

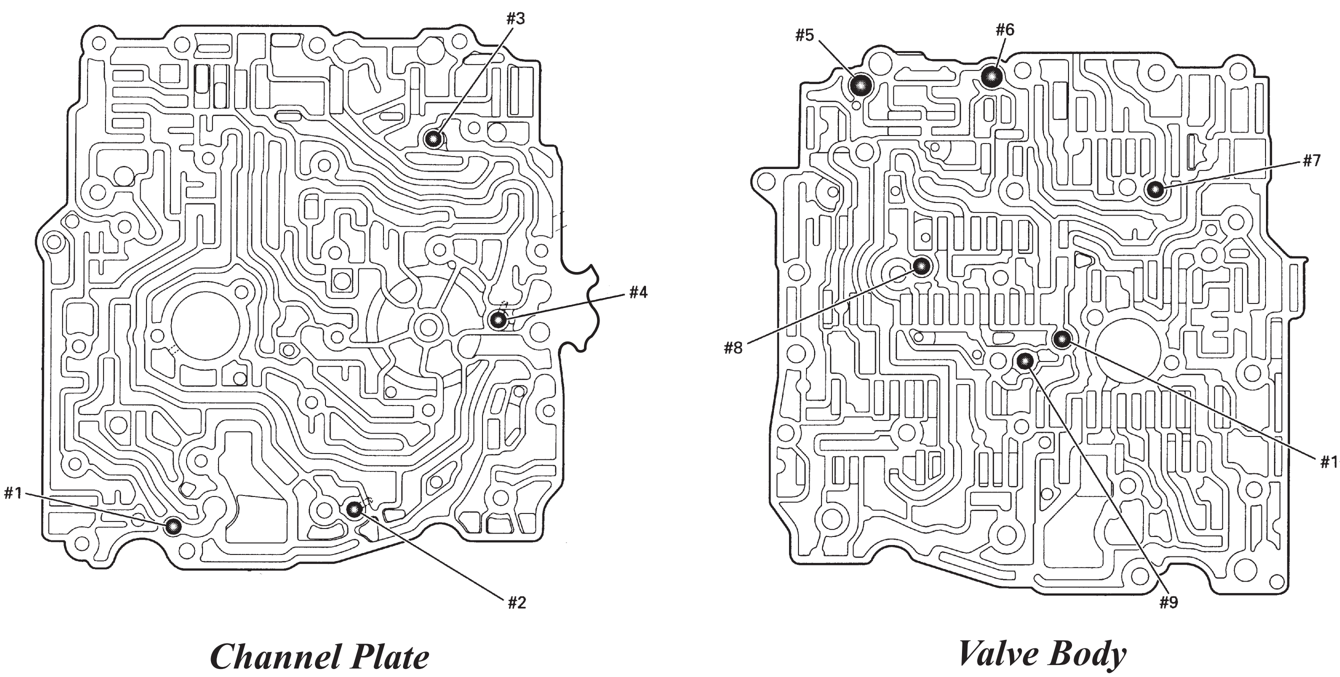


Figure 9

GM Application

Valve:
Low Blow Off Ball Lineup (405, 406 & 420A)
The low blow off valve (420A) located in the channel plate is a pressure relief valve that exhausts excess Lo-1st fluid pressures above 448 kPa (65 psi) in the 3rd clutch apply circuit.

Check Balls:
#7 LO/LO-1st
Located in the valve body (300), it blocks the lo-1st passage when Drive Range Manual First gear is selected and sends Lo fluid pressure to the 1-2 shift valve where it passes through the valve and is forced through orifice 27 into the Lo-1st circuit.

#8 D2 / Manual 2-1 Servo Feed
Located in the valve body (300), it is fed by D-2 fluid from the manual valve and seated against orificed manual 2-1 servo feed fluid at the spacer plate. D-2 fluid is then directed to the 3-2 Manual Downshift valve (356) where it enters the 2-1 manual servo feed passage and is forced through orifice 13. When the 2-1 manual band servo releases the ball check valve unseats and fluid exhausts without going through orifice 13.

Input Speed Sensor

Located in the channel plate, and excited by a tone ring on the drive sprocket, the North American version is a Permanent Magnet type, while the Volvo version is a Hall Effect type.

In Figure 10, the top illustration shows the Permanent Magnet type and has a small metal tip protruding from the sensor, while the bottom illustration shows the Hall Effect type which has no metal tip.

Although a typical Hall Effect Speed Sensor has three wires, the Volvo version is a two wire Hall Effect Speed Sensor. The third wire could be considered as contained inside the sensor. It is easy to put the wrong sensor in either version transmission, which will cause an incorrect signal and transmission gear ratio problems.

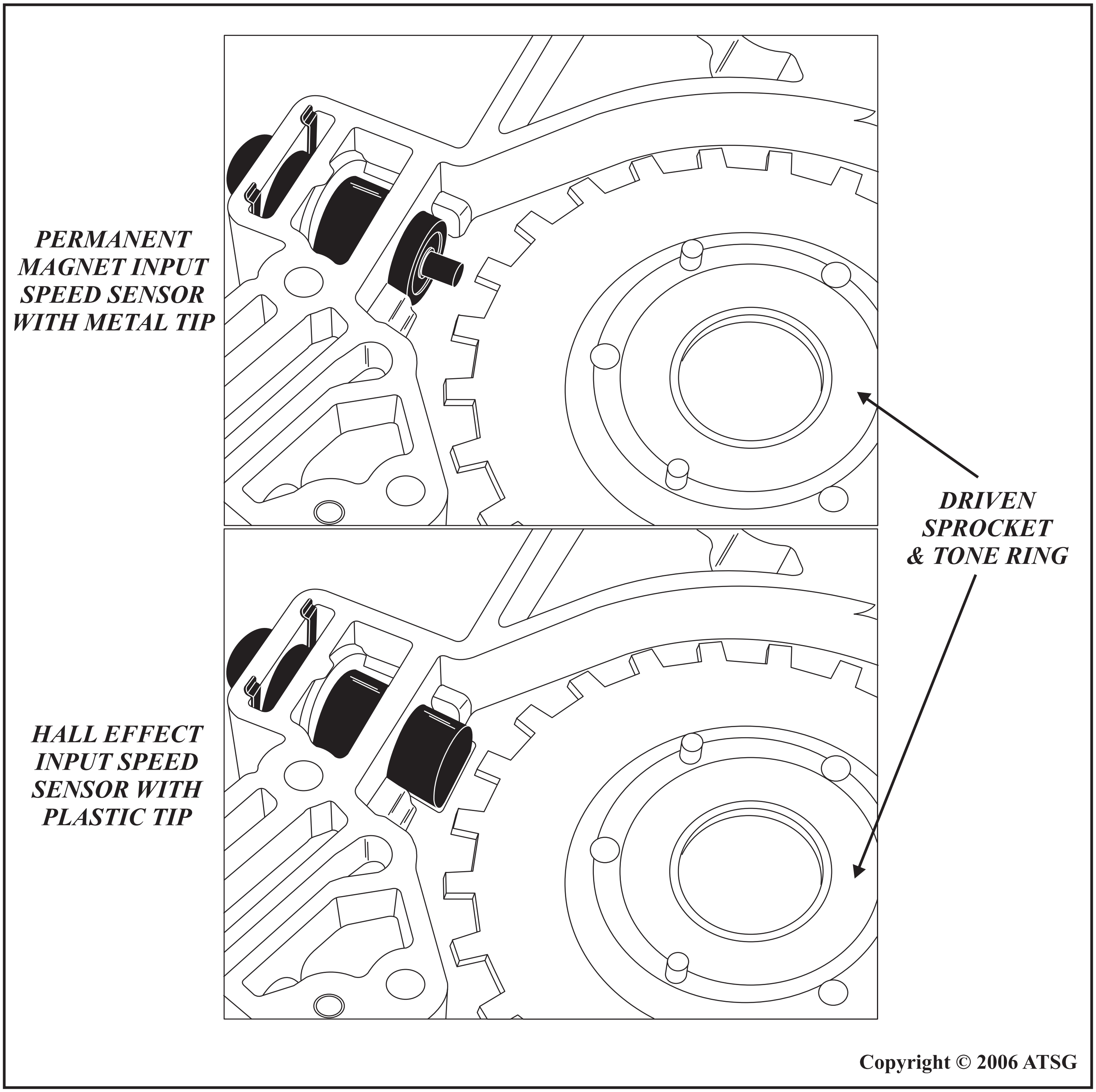


Figure 10

Input Speed Sensor...continued

The diagram in Figure 11 is the Input Speed Sensor circuit found in the North American version of the 4T65E. The input speed sensor is the AC Voltage Generator type. It sends AC voltage sine wave to the PCM where it is buffered internally in order to convert the AC voltage to a DC voltage signal that is pulsed to ground by the buffer. This is done because automotive computers do not understand AC voltage as a language. This signal can also be measured in Hertz which is the frequency of the signal. For example, the specs on the input speed sensor is at least 0.1 volt AC @ 3 mph and approximately 33 Hz @ 30 mph. This signal is best tested with a scope.

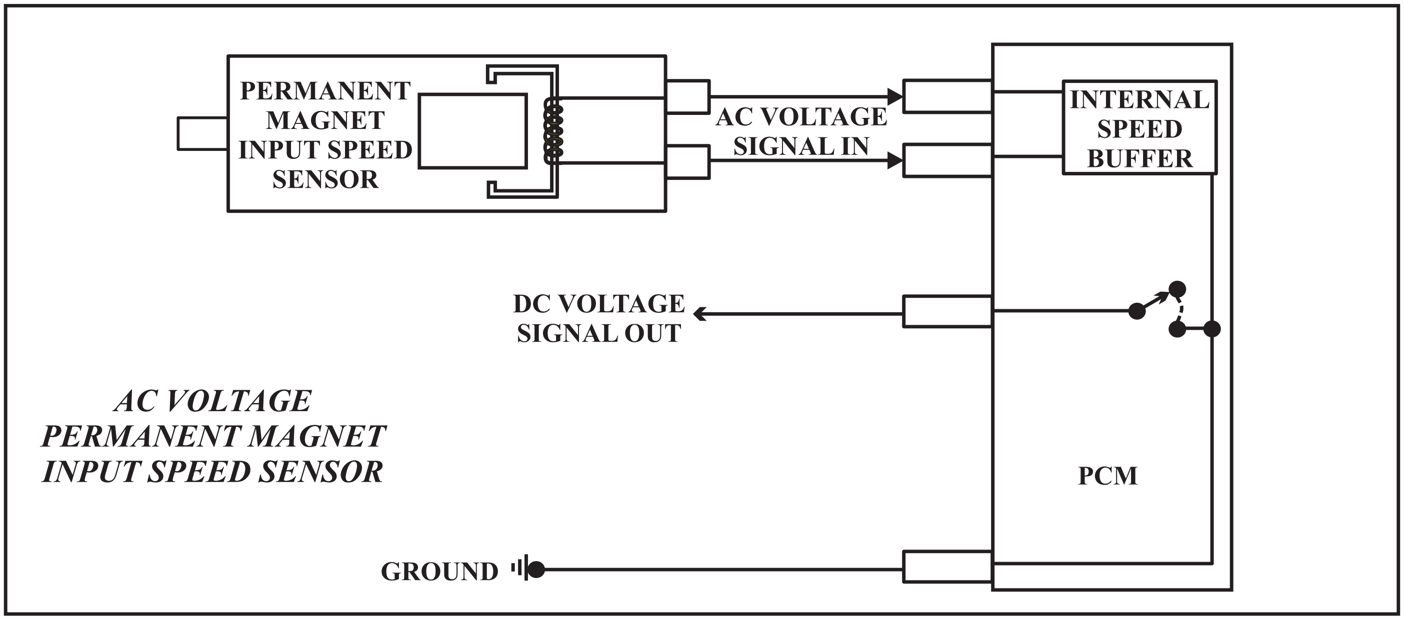


Figure 11

The diagram in Figure 12 is the Input Speed Sensor Circuit found in the Volvo S80 with 4T65E-V. The input speed sensor is a Hall Effect type. What makes this sensor different is instead of the typical 3 wire arrangement, it only has two (2) wires. The third wire is basically a part of and controlled by a capacitor inside the speed sensor.

This sensor receives voltage from the PCM and the sensor toggles this reference voltage between zero and five volts. Internally the PCM reads this signal as 0-5-0-5-0-5 which it uses to calculate turbine speed. This signal can be tested with a volt meter using the MIN/MAX feature or a scope.

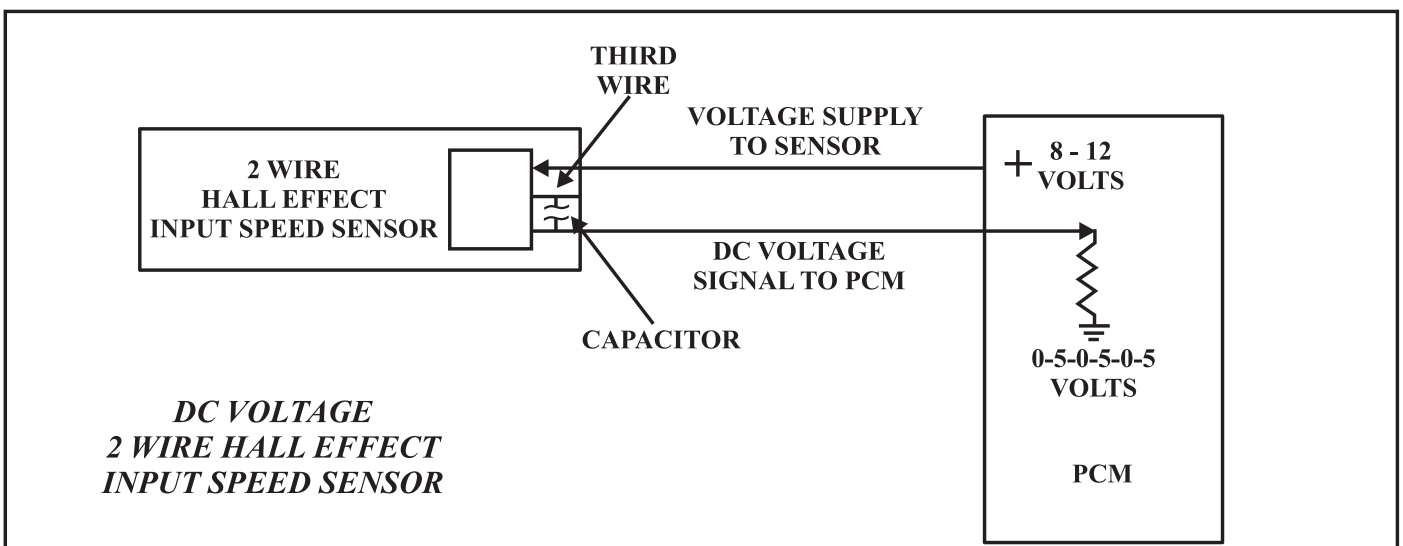


Figure 12

Input Speed Sensor...continued

The biggest problem is how to be sure of which sensor you have when the transmission is out of the vehicle. The test that can resolve this is a “Diode Test”. With a “Diode Test”, the Permanent Magnet type speed sensor will have the same voltage reading when the meter leads are switched as seen in Figures 13 and 14..

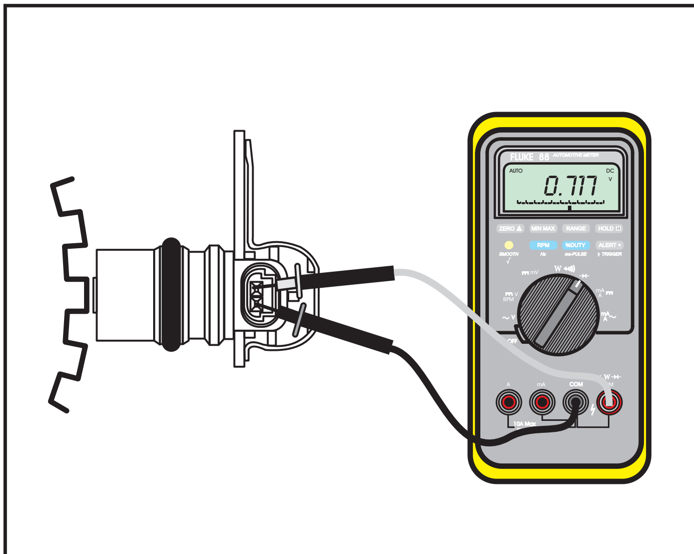


Figure 13

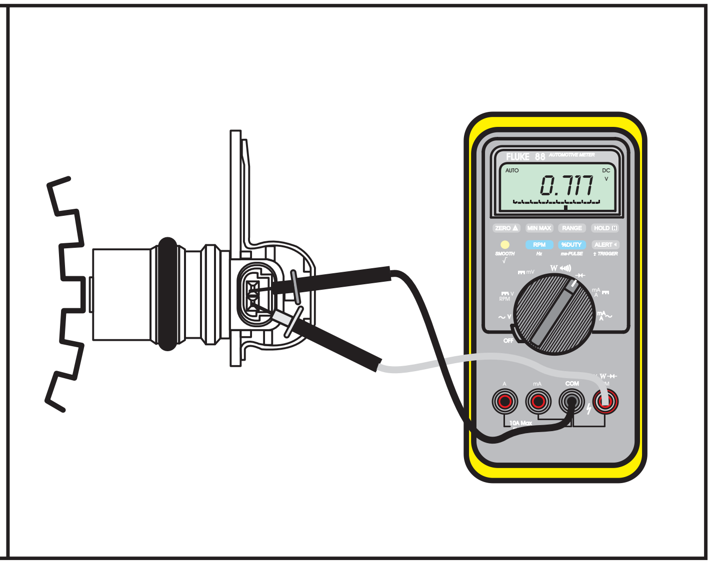


Figure 14

In Figures 15 and 16 there is a significant difference in the voltage that is seen when the meter leads are switched during the “Diode Test” on the two wire Hall Effect Sensor.

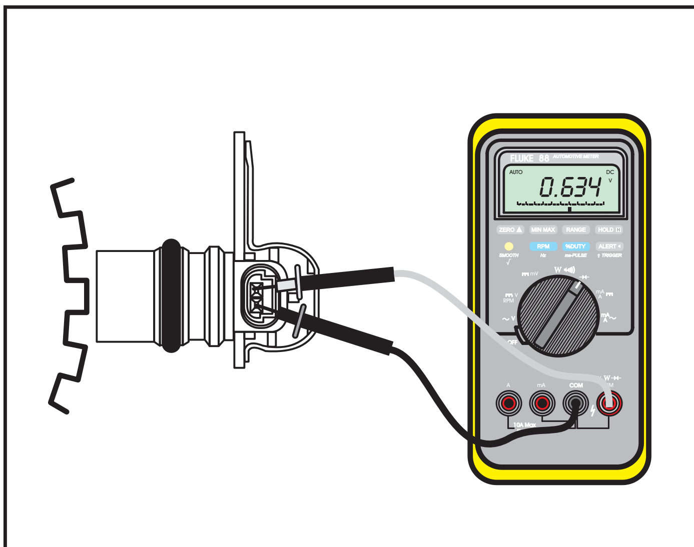


Figure 15

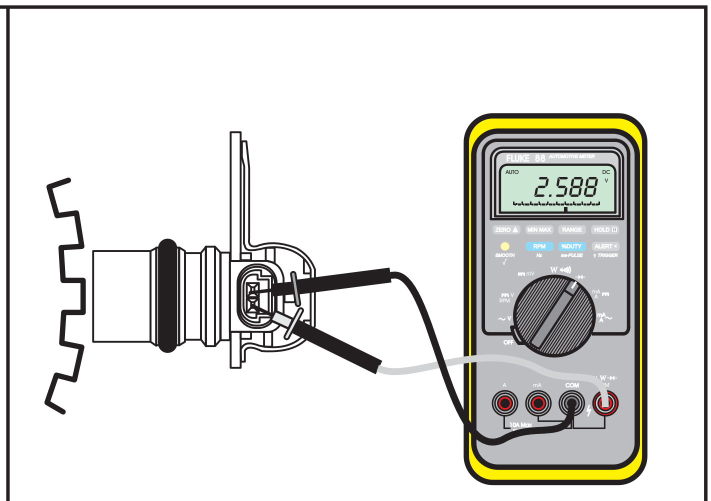


Figure 16

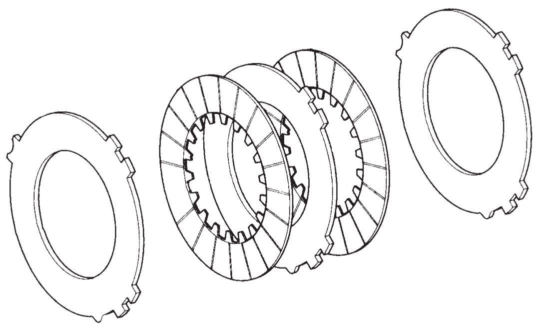
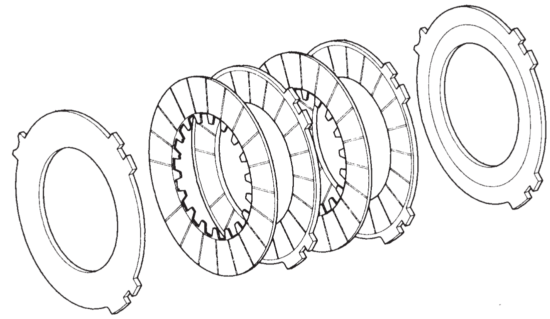
General Motors Application	*Volvo Application*
	
Typical 4th clutch stack up using friction and steel plates	***Single sided internally and externally toothed 4th clutch friction plates***

Figure 17