FORD/LINCOLN/MERCURY 6R60

PRELIMINARY INFORMATION

Beginning at the start of production for the model year 2005 for Lincoln Navigator and 2006 for Explorer and Mountaineer (4.6LV-8), and 2007 for Expedition, Ford/Lincoln/Mercury introduced a new 6 speed Rear Wheel Drive transmission designated as the 6R60, shown in Figure 1.This transmission is based on the ZF6HP26 that has been in existence since 2002, although there are numerous differences and similarities.

This Transmission features, a four element Torque Converter with Lock-up Clutch, 3 driving clutches referred to as clutch A, B and E, 2 brake clutches referred to as clutch C and D, a Lepelletier Planetary Gear Train, and a Mechatronics Module.

Mechanically, the six forward speeds and reverse are accomplished through the use of what is known as a Lepelletier planetary gear train, 3 driving clutches and 2 holding clutches as seen in the application chart displayed in Figure 2.

Electrically and hydraulically, this gear box is controlled by what is known as "The Mechatronic Module." This is a combination of a transmission control module and valve body configured as one unit. In other words, the computer for the transmission is mounted onto the valve body and is submerged in transmission fluid. As a result of this Mechatronic Module technology, the pass through case connector from the module to the vehicle harness will basically contain only power, ground and CAN Bus network wiring.

In addition to six forward speeds, there is a ***torque converter clutch*** strategy to further enhance fuel economy. The Torque Converter uses a three plate lockup clutch design which is slip- controlled in all forward gears (1 through 6).

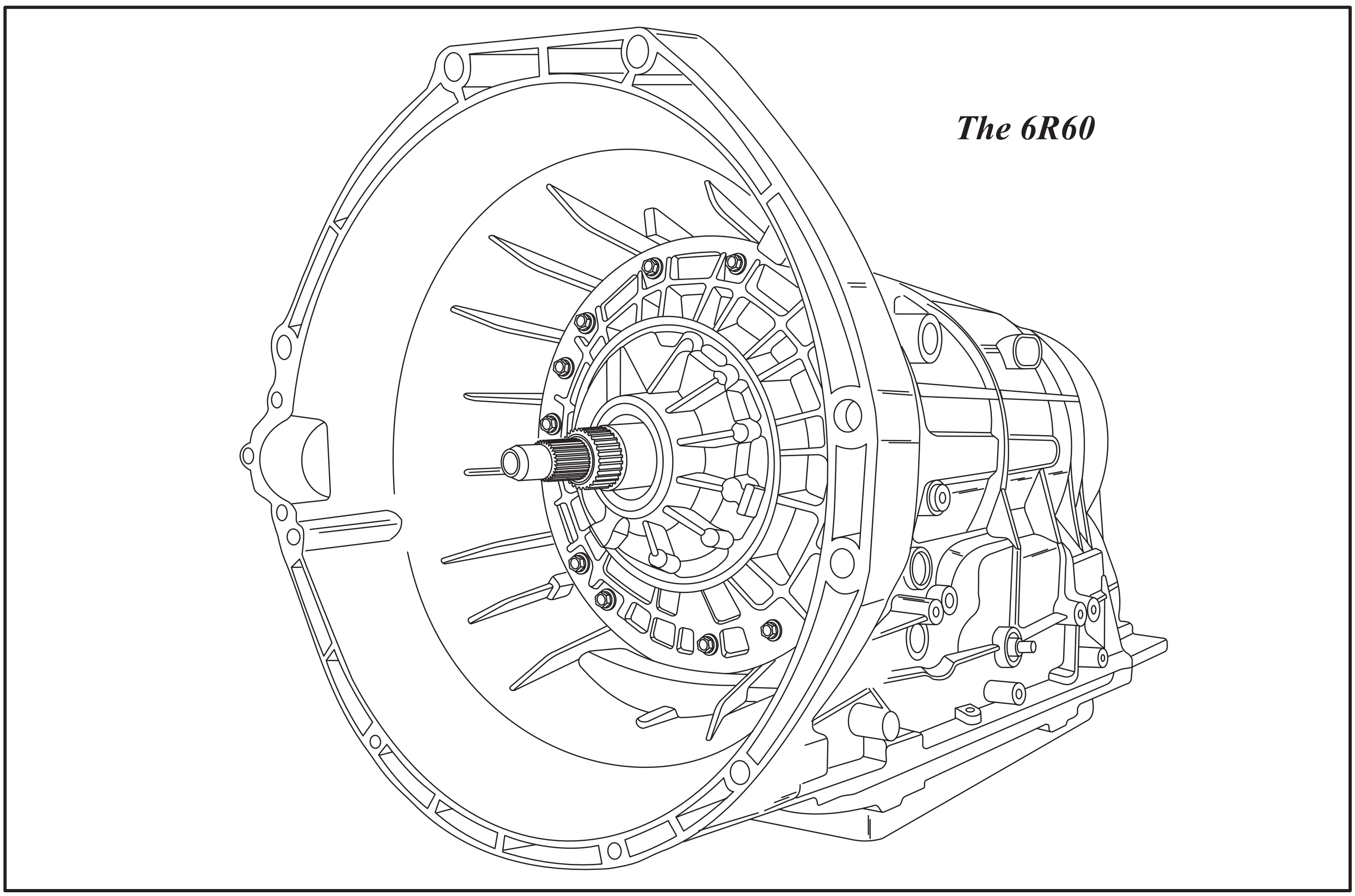
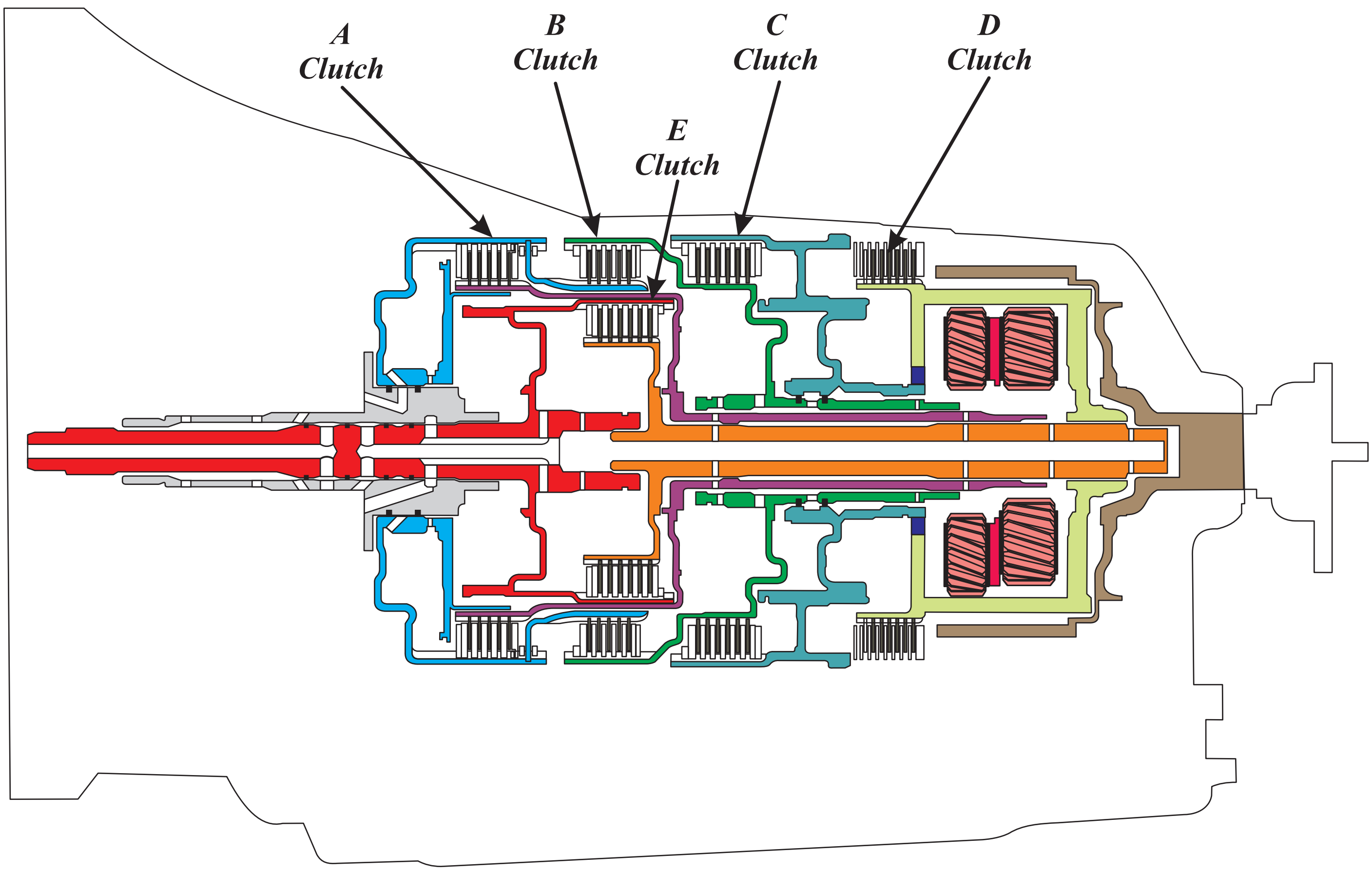


Figure 1

6R60
INTERNAL COMPONENT IDENTIFICATION AND LOCATION



COMPONENT APPLICATION CHART

RANGE	A Clutch	B Clutch	E Clutch	C Clutch	D Clutch	Torq Conv Clutch	GEAR RATIO	
Park					*Applied*			
Reverse		*Applied*			*Applied*		*3.40*	
Neutral					*Applied*			
"D"-1st	*Applied*				*Applied*		*4.17*	
"D"-2nd	*Applied*			*Applied*		*Applied**	*2.34*	
"D"-3rd	*Applied*	*Applied*				*Applied**	*1.52*	
"D"-4th	*Applied*		*Applied*			*Applied**	*1.14*	
"D"-5th		*Applied*	*Applied*			*Applied**	*0.87*	
"D"-6th			*Applied*	*Applied*		*Applied**	*0.69*	

*** TCC IS AVAILABLE IN 2ND THRU 6TH GEAR, BASED ON THROTTLE POSITION, FLUID TEMP AND VEHICLE SPEED.***

Figure 2

Operational Strategy

The converter clutch will not engage until transmission fluid and engine temperature are at operating temp. Slip control is dependent upon various factors such as engine load, vehicle speed, the selected gear shift program and transmission fluid temperature.

There are three modes of TCC application. Full release, Controlled modulation and Full apply. The converter clutch will fully apply in any gear during speeds of 50 mph (80 km/h) or greater and will disengage at speeds below 12 mph (20 km/h) or at full load or kick-down conditions.

The converter clutch is designed with small channels in the lining to allow the fluid to quickly reduce temperatures after the clutch fully engages.

SHIFT QUADRANTS

P= Parking pawl engaged
R= Reverse
N= Neutral
D= 1st thru 6th gear automatic up and downshifts
3= 3rd gear hold- with coast braking
2= 2nd gear hold- with coast braking
1= 1st gear hold- with coast braking

As seen in Figure 2 of the clutch application chart, this gearbox requires only 5 clutch packs with which 6 gears and reverse are obtained. Clutch packs A, B and E are the driving clutches while Clutch packs C and D are holding or brake clutches. Since clutch packs A, B and D are rotational, there is a tendency to have centrifugal force creep the clutch on when it is not in use which could cause premature damage to the pack. As a preventive measure, a balance area is provided in each of these clutch packs in front of the piston. A slight amount of fluid pressure is supplied to this area which is used to balance centrifugal head oil behind the apply piston neutralizing its affect. This feature is referred to as "***dynamic pressure balance.***" This feature also assists in greater engagement and disengagement control of the clutch pack which ultimately improves gear shift comfort.

Operational Strategy Contd.

G M's 6L80 operates in a similar manner regarding both the clutch application and dynamic pressure balance they call the ***Compensator Feed Fluid***. One deviation is that the 6L80 uses a low sprag while the 6R60 does not use any free wheel devices. All shifting scheduling is executed with an overlap strategy. So each shift is controlled by the computer via the solenoids and regulating valves to release one clutch while applying the oncoming clutch overlapping them with various pressures and time to accommodate the amount of torque at the time of the shift.

Mechanical Components

These clutches drive and hold different parts of the planetary gear sets known as the ***Lepelletier Planetary Gear Train.*** This set up consists of a single planetary carrier and a double planetary carrier.

The single planetary (input) carrier is located behind the front pump (Figure 3). Its sun gear (#1) splines to the pump stator support holding it stationary at all times (Figure 4). The internal ring gear is being driven by the turbine (input) shaft through the E clutch drum as the drum has the internal ring gear on the back side of it (Figure 5).

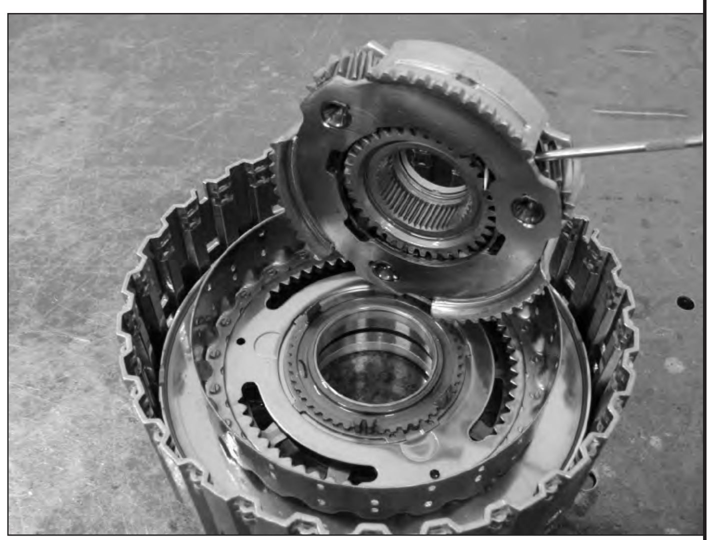


Figure 3

Mechanical Components

Figure 4

Figure 5

The carrier is then linked to the A clutch drum as seen in Figure 3. So the front powerflow begins with the turbine shaft being driven by the converter which drives the internal ring gear that is integral to the turbine shaft. The internal ring gear then drives the pinions around the stationary sun gear causing the carrier to drive the A clutch drum in a reduction. When the A clutch applies, it will then drive a rear sun gear (#3) in the rear planetary in that reductive rotation. When the B clutch applies, it locks onto the A clutch drum which then drives a front (or middle #2) sun gear in the rear planetary in the same reductive speed.

Mechanical Components Contd.

The double planetary (output) carrier is located in the back of the transmission where its' internal ring gear drives the output shaft (Figure 6). The rear sun gear (#3) in this double planetary assembly is driven by the A clutch and meshes with three short pinions. The front sun gear (#2) which meshes with three long pinions in this double planetary assembly is driven by the B clutch (Figure 7) while the C clutch is used to hold the # 2 sun gear stationary.

Figure 6

The E clutch drum drives the carrier assembly (Figure 7) while the D clutch is used to hold it stationary.

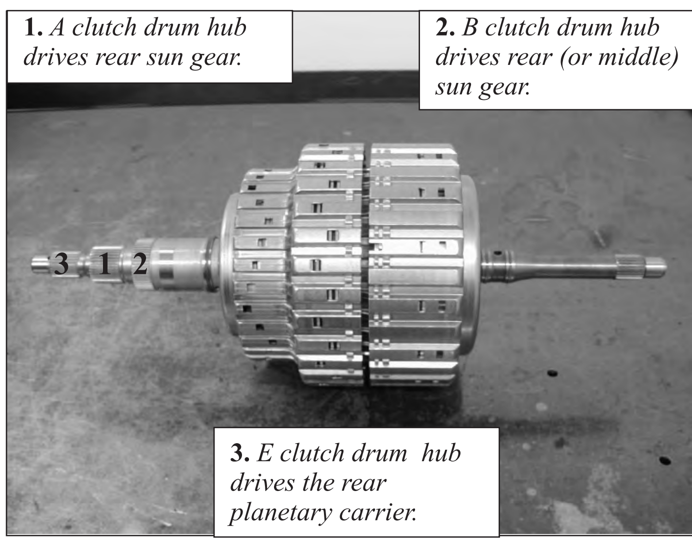


Figure 7

Planetary Powerflow

Powerflow in first gear: The A clutch is applied and is driven in a reduction through the front planetary assembly via the turbine shaft. The A clutch in turn inputs torque to the small rear (#3) sun gear. The D clutch is also applied holding the double planetary output carrier stationary. This causes the small rear (#3) sun gear to drive the short pinions, the short pinions drive the long pinions and the long pinions drive the internal ring gear and output shaft in an approximate reduction ratio of 4.17:1 (Figure 8).

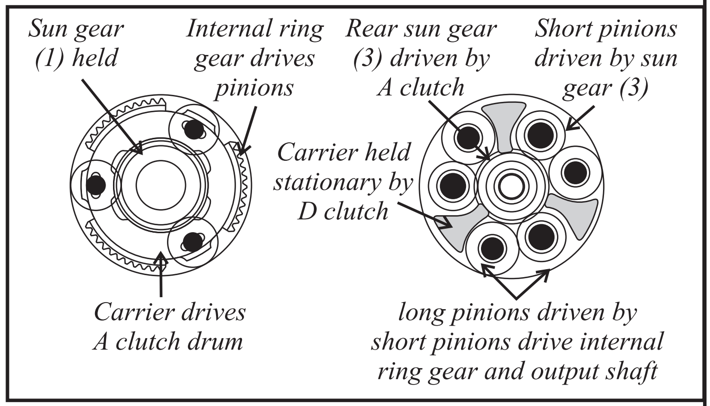


Figure 8

Powerflow in 2nd gear: With the A clutch still applied, the turbine shaft is driving the A clutch drum in a reduction. The A clutch drum continues to drive the small rear (#3) sun gear in the double planetary output carrier. The D clutch is released and the C clutch is applied which holds the larger front (#2) sun gear in the double planetary output carrier stationary. The reaction of the short pinions being driven by the A clutch and the long pinions being forced to walk around the stationary sun gear, causes the internal ring gear and output shaft to rotate in an approximate reduction ratio of 2.34:1 (Figure 9).

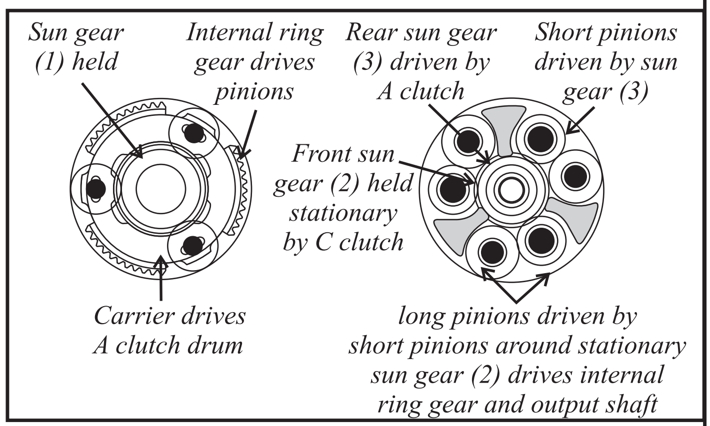


Figure 9

Powerflow in 3rd gear: Once again the A clutch is applied as it is in 1st and 2nd. The C clutch is released and the B clutch is applied. This now drives both sun gears in the same direction and at the same speed inside the double planetary output carrier. This causes the pinons, the carrier and internal ring gear to rotate as 1 complete assembly driving the output shaft in an approximate reduction ratio of 1.52:1 (Figure 10).

The reason for the overall ratio continuing to be in a reduction rather than a 1:1 ratio is that both the A and B clutch drums are rotating in a reduction when compared to turbine shaft speed. *(See explanation on the previous page under the single planetary (input) carrier heading on page 4).*

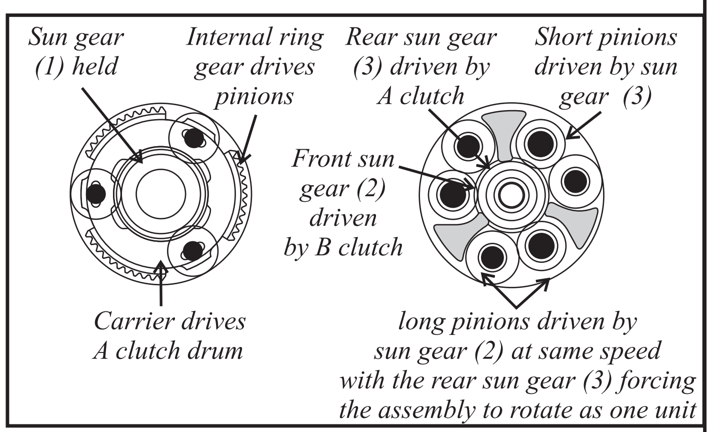


Figure 10

Planetary Powerflow Contd.

Powerflow in 4th gear: The A clutch still applied drives the small rear (#3) sun gear. The B clutch is released and the E clutch applies driving the double planetary output carrier at turbine shaft speed. The action of the carrier forcing the pinions to rotate around a reductive spinning sun gear causes the internal ring gear and output shaft to rotate in an approximate reduction ratio of 1.14:1 (Figure 11).

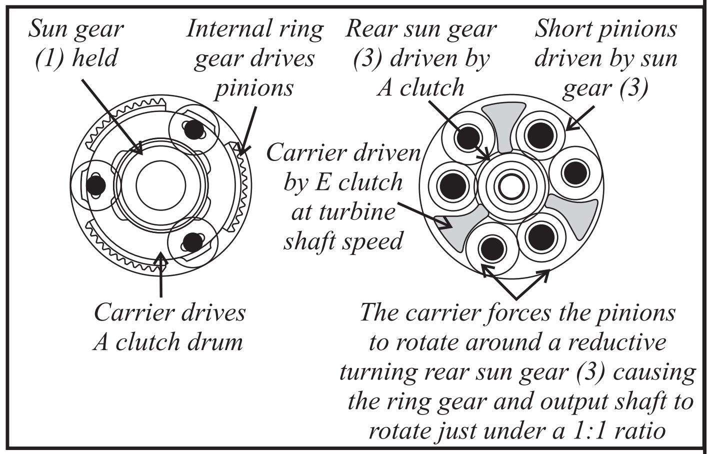


Figure 11

Powerflow in 5th gear: The A clutch is released and the B clutch is applied which drives the larger front (#2) sun gear in the double planetary output carrier. The E clutch is still applied driving the double planetary output carrier at turbine shaft speed. The reaction of the long pinions being forced to rotate around a reductive spinning sun gear (#2) causes the internal ring gear and output shaft to rotate in an approximate overdrive ratio of 0.87:1 (Figure 12).

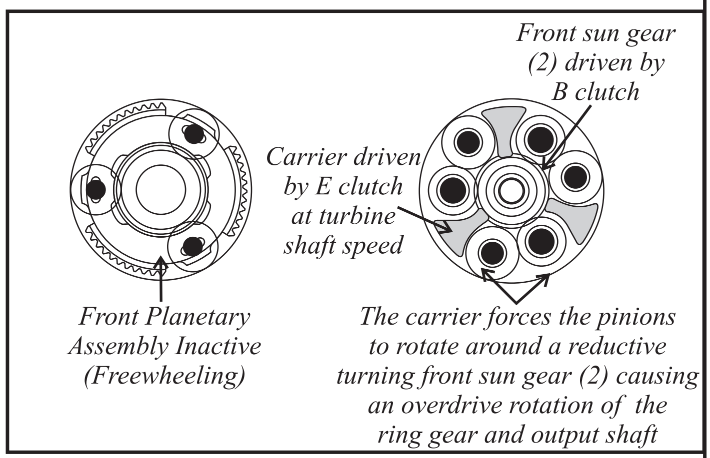


Figure 12

Powerflow in 6th gear: The B clutch is released while the E clutch is still applied driving the double planetary output carrier at turbine shaft speed. The C clutch applies which now holds the larger (#2) sun gear in the double planetary output carrier. The reaction of the double planetary output carrier spinning at turbine shaft speed forcing the long pinions to rotate around a stationary larger (# 2) sun gear, causes the rear internal ring gear and output shaft to rotate in an approximate overdrive ratio of 0.69:1 (Figure 13).

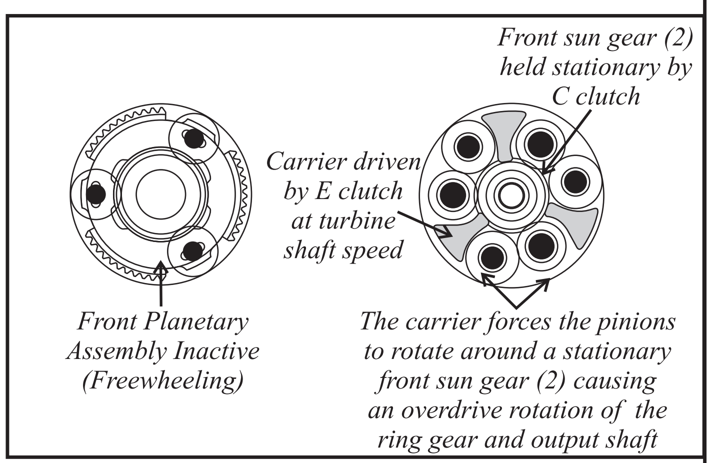


Figure 13

Planetary Powerflow Contd.

Powerflow in reverse: The B clutch is applied driving the larger front (#2) sun gear in the double planetary output carrier. The D clutch is also applied which holds the double planetary output carrier. This causes the sun gear to drive the long pinions in an opposite rotation of the turbine shaft. The long pinions then drives the internal ring gear and output shaft in a reverse reduction ratio of approximately 3.40:1 (Figure 14).

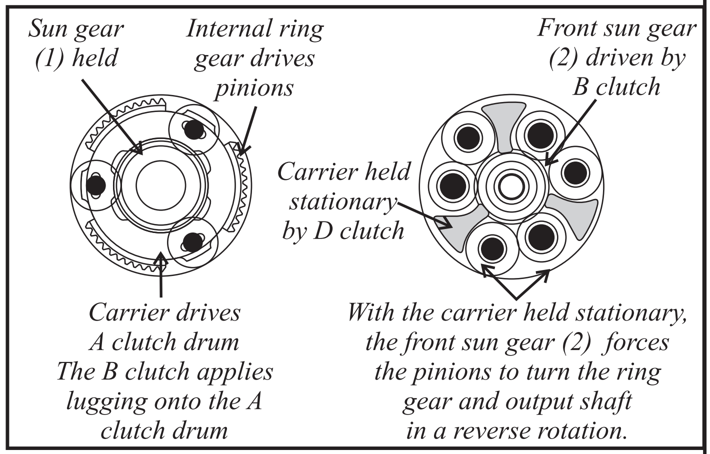


Figure 14

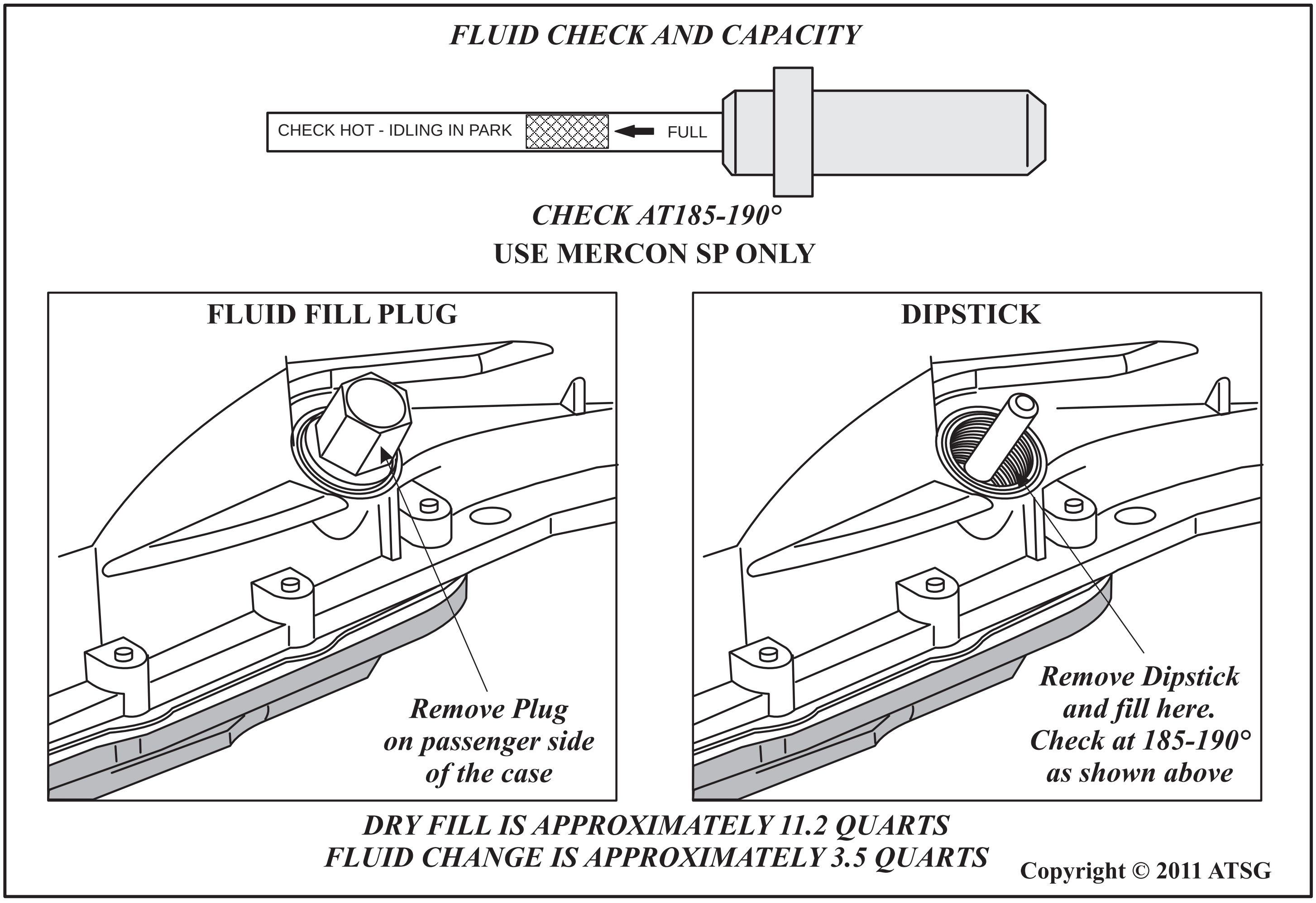


Figure 15

Mechatronic Module and Solenoid I.D..

The *Mechatronic Module* is located in the oil sump on top of the Valve Body. The electronic module is completely sealed and oil tight, and is designed to withstand temperatures up to 284ºF (140° C). It manages the complete electronic control of the transmission and is considered to be an integral part of the valve body making it not replaceable separately. Refer to Figure 18 for a connector view and pin-out of the Mechatronic Module.

The electronic control module contains a Micro-Position Switch which monitors the position of the Manual Valve via the Transmission Range Sensor. It also contains the Turbine and Output Speed Sensors, the Temperature Sensor and the Transmission Control Module (Figure 16).

The valve body contains all the valves, springs, dampers and solenoids. The 6R60 has 6 Variable Force Solenoids and 1 On/Off solenoid (Figure 17).

The SSE (SS1) solenoid is identified by a ***white*** cap and contains an inlet, outlet and exhaust port. When the solenoid is energized, the inlet is open to the outlet port and the exhaust is blocked. When the solenoid turns off, the inlet is blocked and the outlet is opened to exhaust (Figure 19).

The Variable Force Solenoids convert electrical current into a proportional hydraulic pressure. They are designed in two different ways:

SSA, SSC and the TCC (VFS 1, 3 and 6) are designed using a rising curve. In other words, at 0 mA it produces an output pressure of 0 psi (0 bars). At 850 mA output pressure rises as high as 67 psi (4.6 bar). See Figure 20.

At 68ºF (20°C) they measure approximately 5 ohms. They are supplied with system voltage and are ground side controlled.

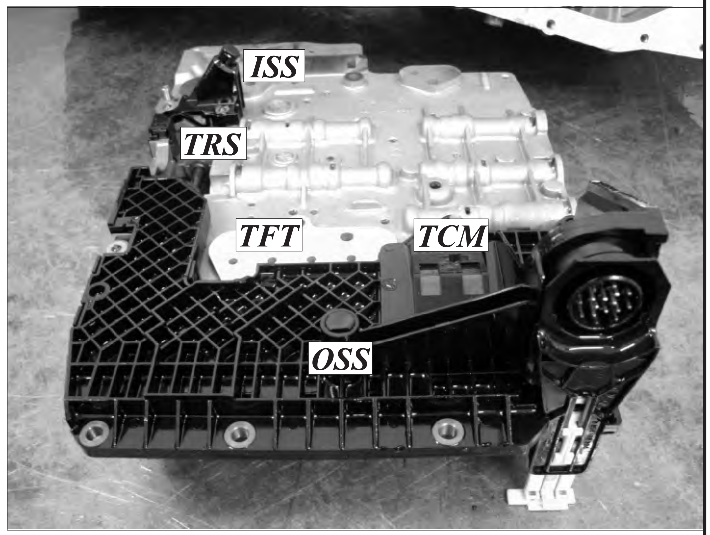


Figure 16

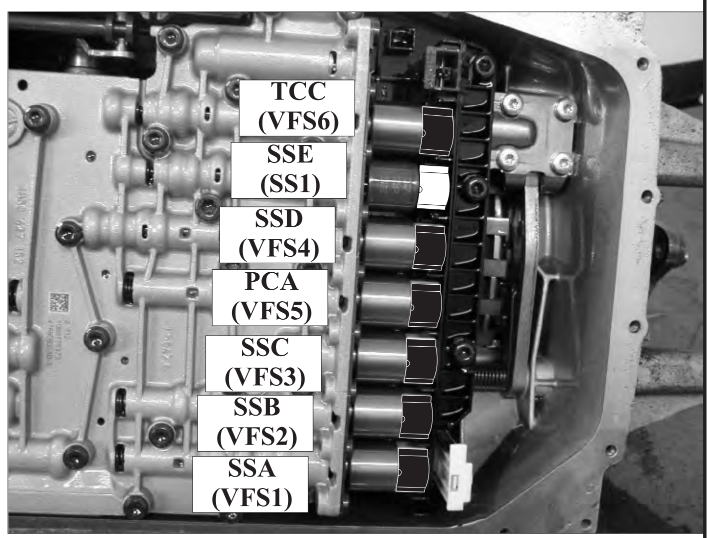
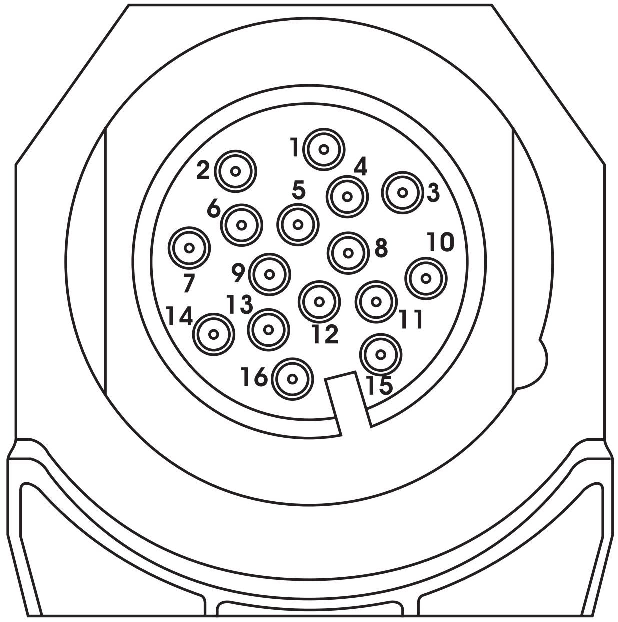


Figure 17

EDS solenoids 2, 4 and 5 are identified by a ***blue*** cap and are designed using a falling curve. In other words, at 0 mA it produces an output pressure of 67 psi (4.6 bars). At 850 mA output pressure rises as low as 0 psi (0 bars). See Figure 21.

At 68ºF (20°C) they measure approximately 5 ohms. They are supplied with system voltage and are ground side controlled.

CASE CONNECTOR TERMINAL FUNCTION



PIN #	FUNCTION	NOTES
1	NOT IN USE	
2	CAN L	CAN LOW
3	NOT IN USE	
4	NOT IN USE	
5	NOT IN USE	
6	CAN H	CAN HIGH
7	NOT IN USE	
8	NOT IN USE	
9	TCM TERMINAL 15	IGNITION SWITCH
10	TERMINAL 19	P ARK NEUTRAL SIGNAL-PN
11	NOT IN USE	
12	NOT IN USE	
13	TCM TERMINAL 31	GROUND
14	TCM TERMINAL 30	PERMANENT POSITIVE (BATTERY VOLTAGE)
15	INTERLOCK	
16	TCM TERMINAL31	GROUND

Figure 18

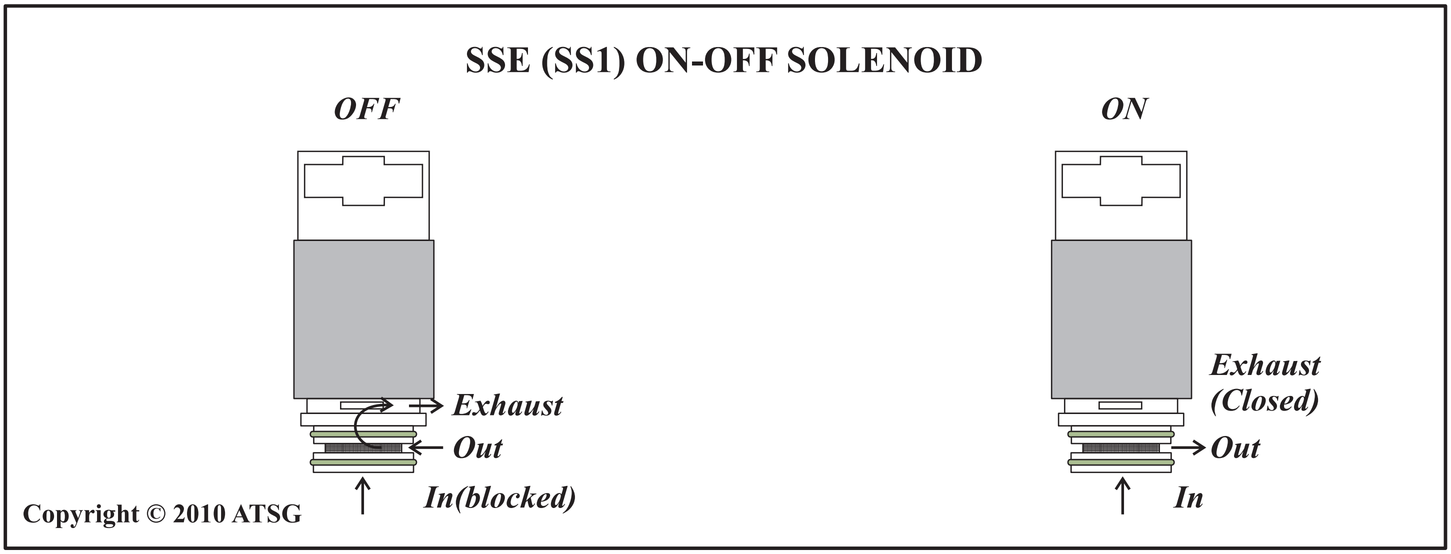


Figure 19

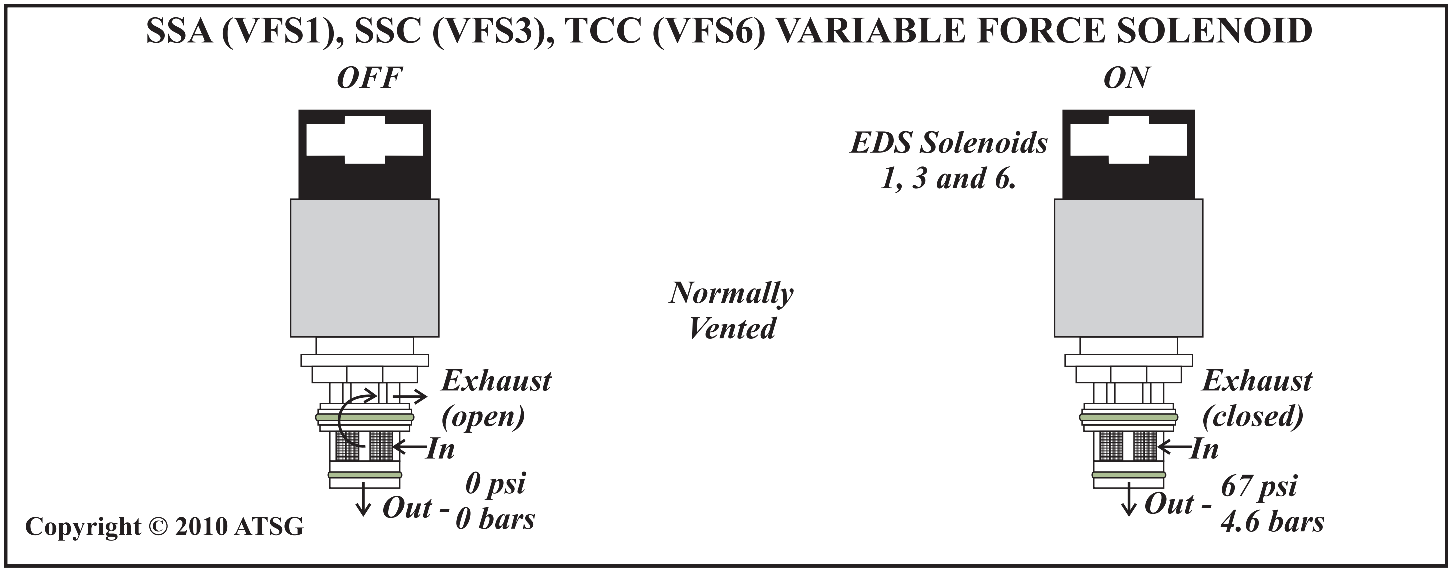


Figure 20

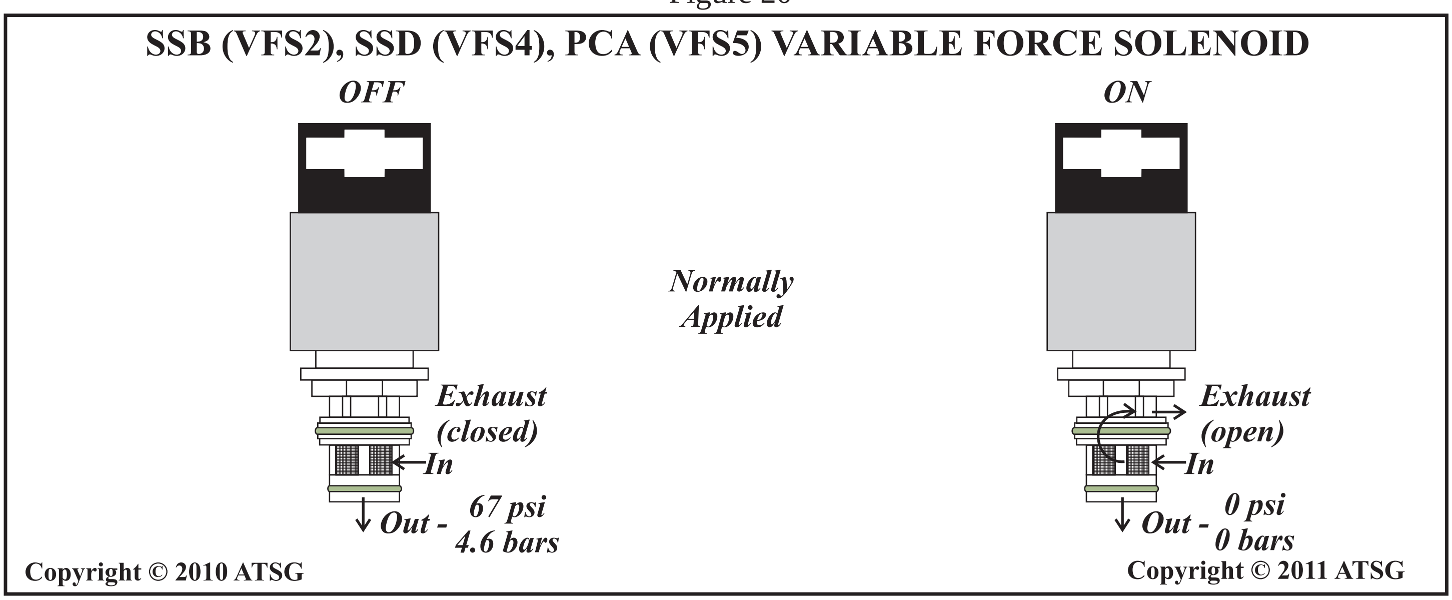


Figure 21

SOLENOID APPLICATION CHART

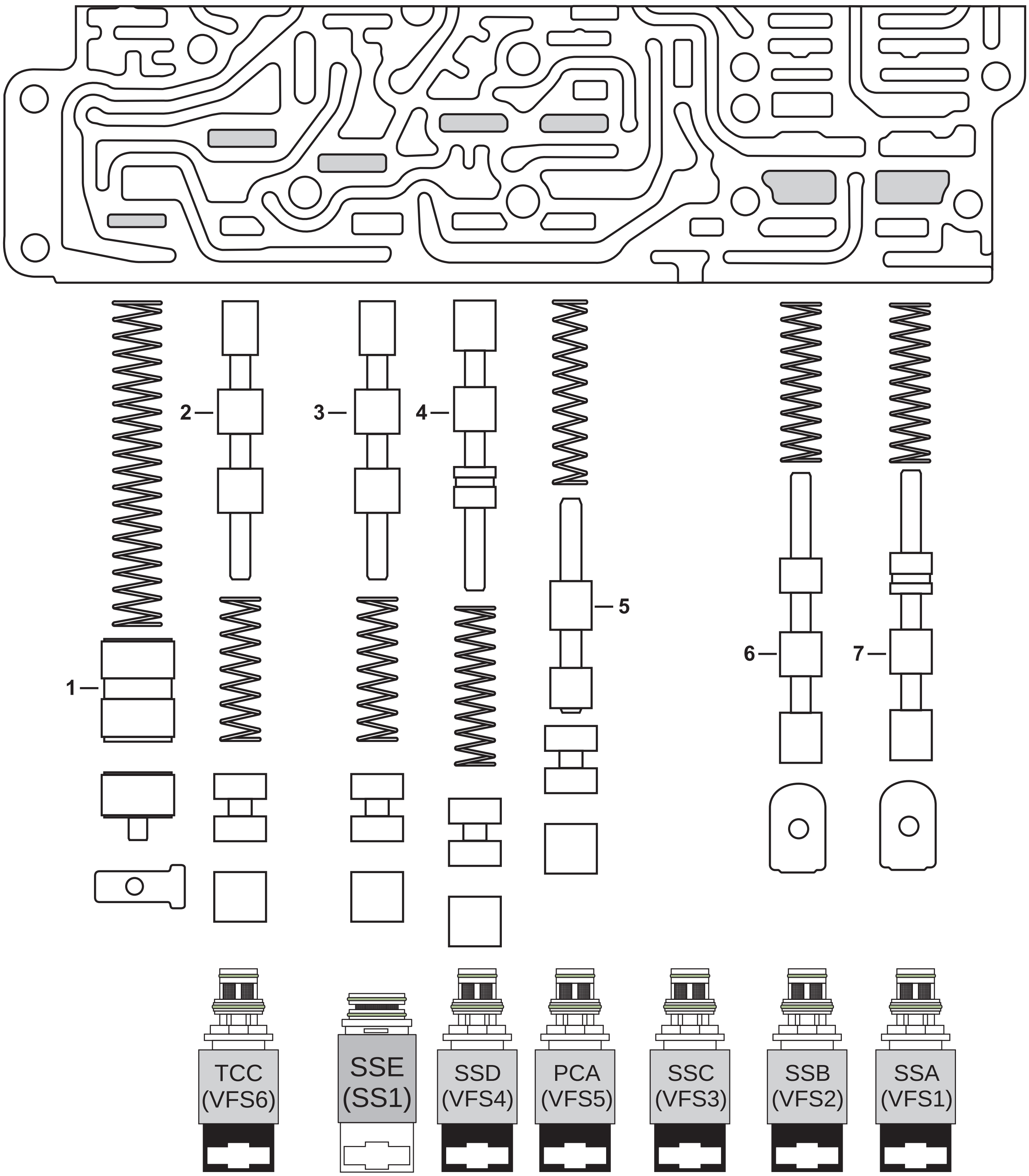
RANGE	SSE (SS1)	SSA (VFS1)	SSB (VFS2)	SSC (VFS3)	SSD (VFS4)	PCA (VFS5)	TCC (VFS6)
Park					X	X*	
Reverse						X*	
Neutral					X	X*	
D 1st gear		X	X			X*	X*
D 2nd gear		X	X	X	X	X*	X*
D 3rd gear		X			X	X*	X*
D 4th gear	ON	X	X			X*	X*
D 5th gear	ON					X*	X*
D 6th gear	ON		X	X		X*	X*

X = Solenoid at high duty cycle approximately 850 mA
No "X"= Solenoid at low duty cycle is approximately 50mA

X* = Modulated by the TCM based on engine load and driving conditions

Figure 22

6R60 LOWER VALVE BODY

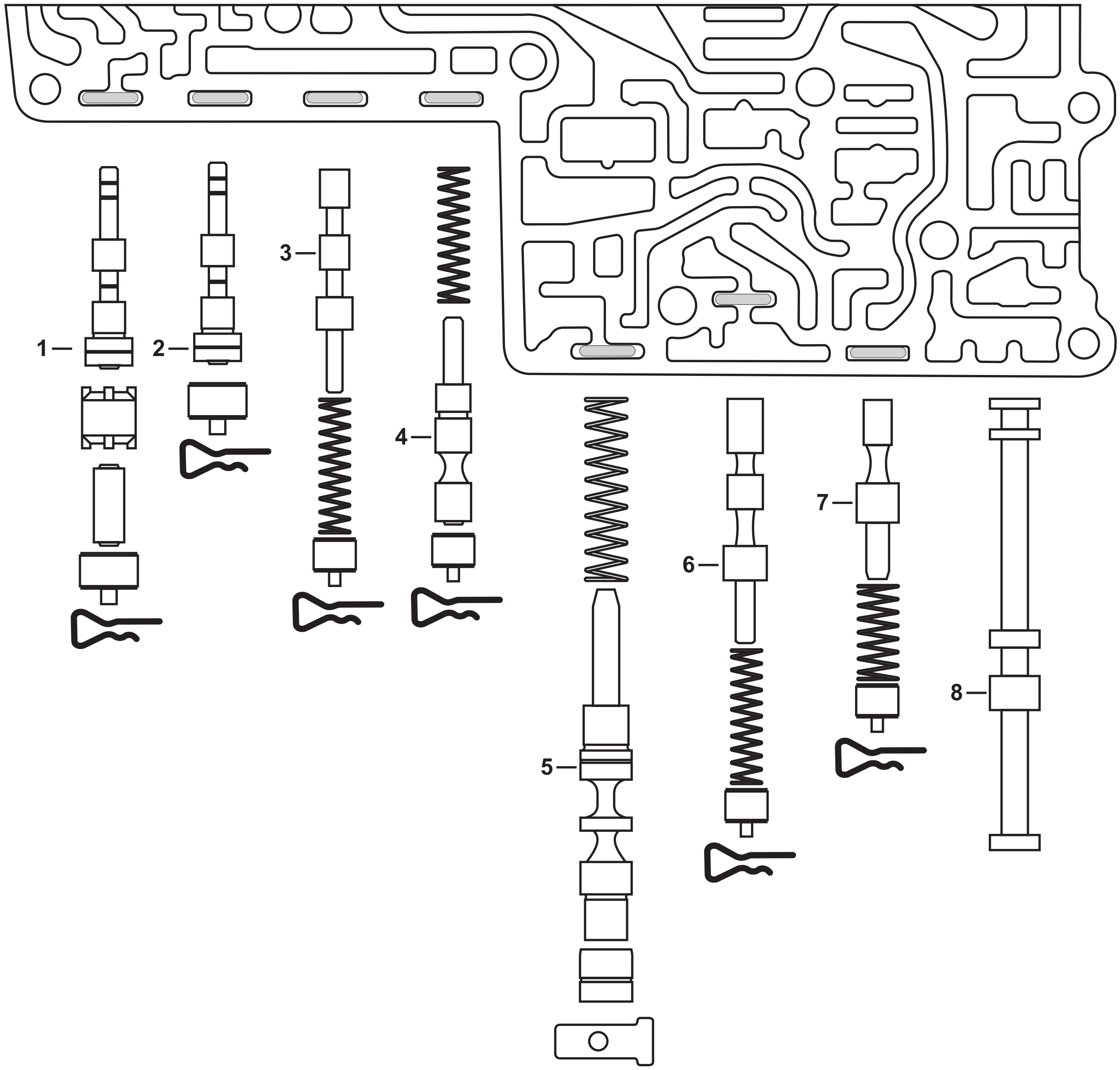


1. SSE Solenoid Damper
2. Solenoid Multiplex
3. Drive Enable
4. Clutch D1 Latch
5. Solenoid Pressure Regulator Valve
6. Clutch B Latch
7. Clutch A Latch

* Shaded area in the valve body indicate retainer location

Figure 23

6R60 LOWER VALVE BODY

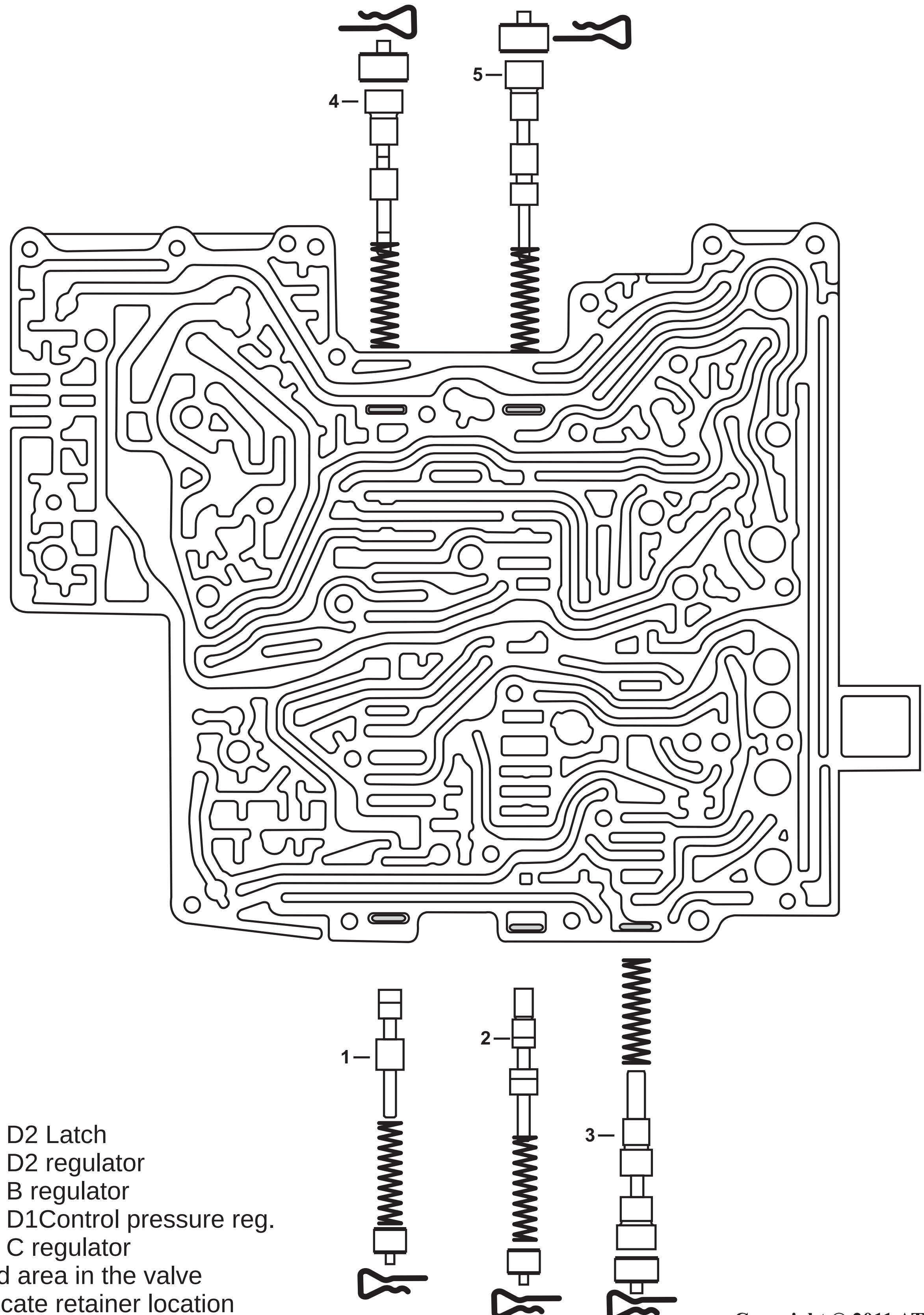


1. Clutch A Control Pressure Reg.
2. Clutch E Control Pressure Reg.
3. Clutch E Latch
4. Bypass Clutch Control Regulator Valve
5. Main Pressure Regulator Valve
6. Torque Converter Release Regulator Valve
7. Lubrication/Cooler Control Valve
8. Manual Valve

* Shaded area in the valve body indicate retainer location

Figure 24

6R60 UPPER (CHANNEL PLATE) VALVE BODY



1. Clutch D2 Latch
2. Clutch D2 regulator
3. Clutch B regulator
4. Clutch D1Control pressure reg.
5. Clutch C regulator
* Shaded area in the valve body indicate retainer location

Figure 25

6R60 UPPER (CHANNEL PLATE) VALVE BODY CHECK BALL LOCATIONS

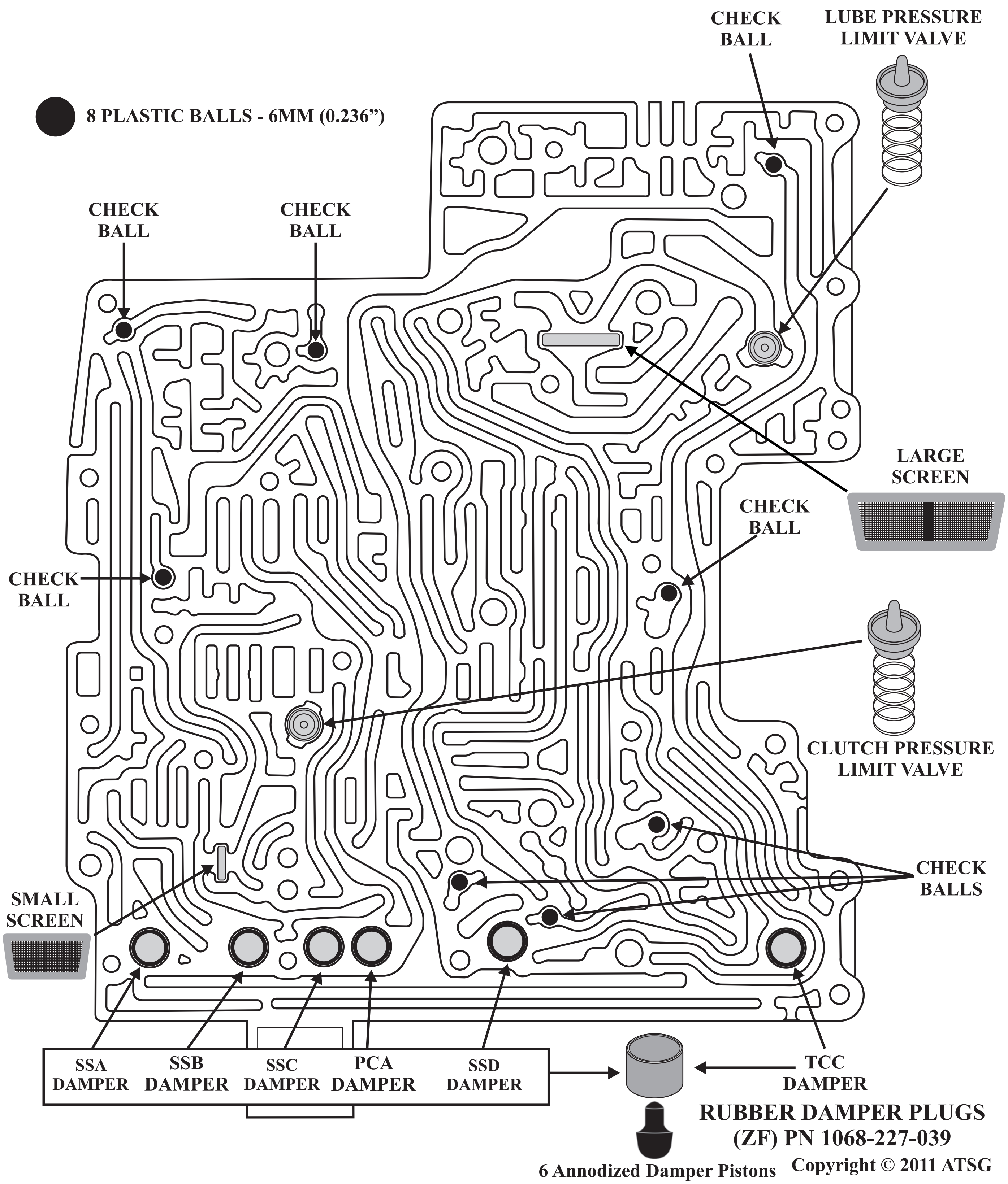
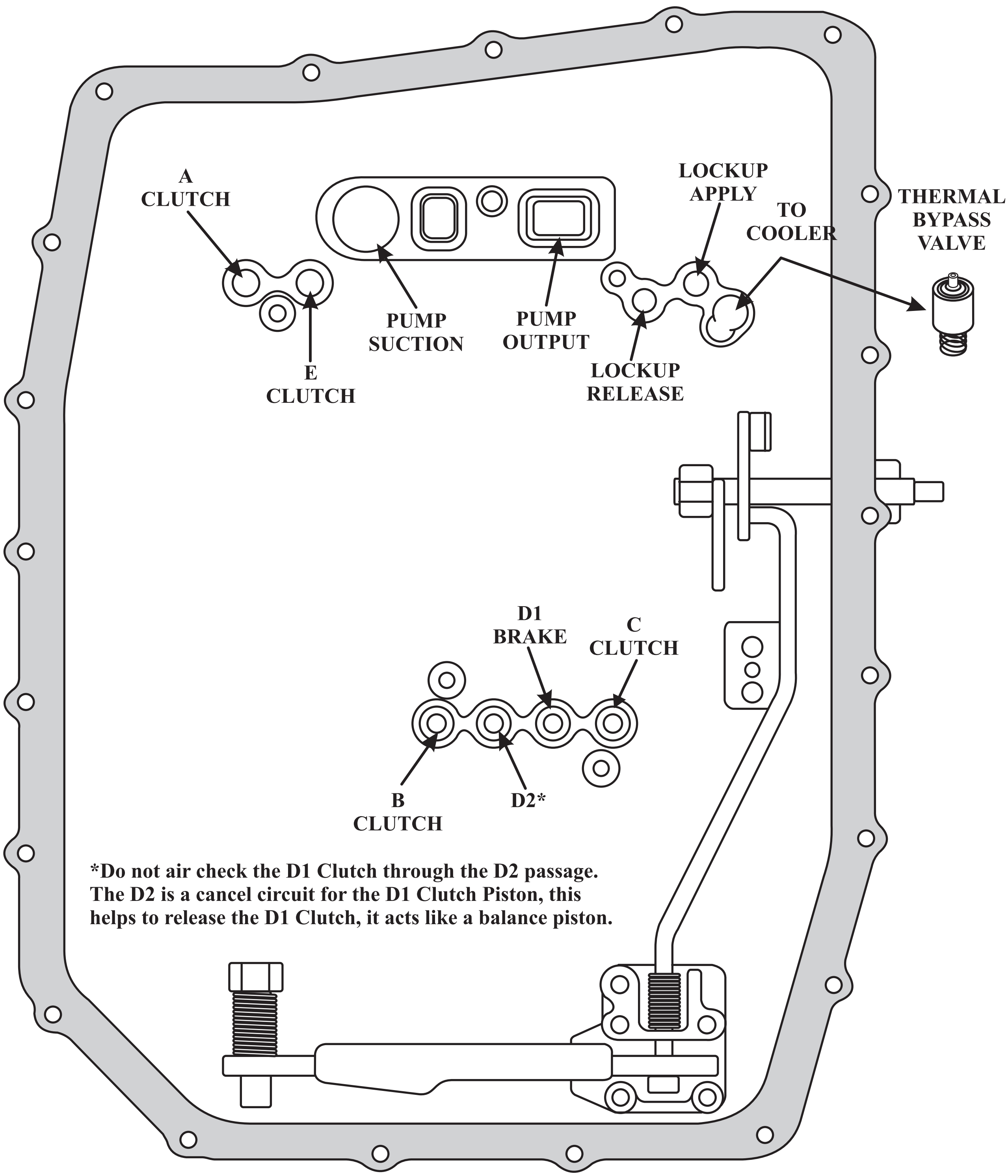


Figure 26

6R60 AIR CHECK AND CASE PASSAGE IDENTIFICATION



***Do not air check the D1 Clutch through the D2 passage. The D2 is a cancel circuit for the D1 Clutch Piston, this helps to release the D1 Clutch, it acts like a balance piston.**

Figure 27

DTC	DTC DESCRIPTION	COMMENTS
P0218	Transmission Fluid Temperature "Overtemp"	Fluid overheat- agressive lock-up schedule
P0562	Battery- System Voltage Low (Below 9 volts)	May cause Limp mode 3rd or 5th gear
P0563	Battery- System Voltage High (Above 16 volts)	May cause Limp mode 3rd or 5th gear
P0605	TCM Read Only Memory corrupted	Reflash or replace Mechatronic unit (Limp mode)
P0613	TCM Internal Processor fault (software fault)	Reflash or replace Mechatronic unit (Limp mode)
P0634	TCM Module temperature too high	Verify Trans temp. Replace Mechatronic unit
P0641	TCM Module sensor voltage failed	Verify System voltage. Replace Mechatronic unit
P0657	Actuator Supply Voltage A open	Replace Mechatronic unit
P0658	Actuator Supply Voltage A low (short to ground)	Replace Mechatronic unit
P0659	Actuator Supply Voltage A high (short to power before ignition ON)	Replace Mechatronic unit
P0667	PCM,ECM,TCM internal temp range operation	
P0701	TCM control system range operation	May be caused by multiple DTC's- clear and see if it resets the code
P0705	Transmission Range Sensor	TCM has detected a TR signal that is out of Normal range. (Part of Mecatronic unit)
P0711	Transmission Fluid Temp Sensor	TCM has detected no change in the TFT during operation. (Part of Mecatronic unit)
P0712	Transmission Fluid Temp Sensor grounded	Part of Mecatronic unit
P0713	Transmission Fluid Temp Sensor (short to power)	Part of Mecatronic unit
P0714	Transmission Fluid Temp Sensor intermittent fault	Part of Mecatronic unit
P0715	Turbine Shaft Speed Sensor (short to power)	Part of Mecatronic unit
P0716	Turbine Shaft Speed Sensor (insufficient input)	Part of Mecatronic unit may be caused by material build up on the sensor
P0717	Turbine Shaft Speed Sensor (no input when OSS is operating)	Part of Mecatronic unit may be caused by material build up on the sensor
P0720	Output Shaft Speed Sensor (short to power)	Part of Mecatronic unit
P0721	Output Shaft Speed Sensor (insufficient Output)	Part of Mecatronic unit may be caused by material build up on the sensor
P0722	Output Shaft Speed Sensor (no Output when TSS is operating)	Part of Mecatronic unit may be caused by material build up on the sensor
P0723	Output Shaft Speed Sensor (intermittent signal)	Part of Mecatronic unit may be caused by material build up on the sensor
P0729	Sixth Gear ratio Error	Mechanical Fault
P0731	First Gear ratio Error	Mechanical Fault
P0781	1-2 or 2-1 Shift ratio Error	Mechanical Fault
P0782	2-3 or 3-2 Shift ratio Error	Mechanical Fault
P0783	3-4 or 4-3 Shift ratio Error	Mechanical Fault
P0784	4-5 or 5-4 Shift ratio Error	Mechanical Fault
P0732	Second Gear ratio Error	Mechanical Fault
P0733	Third Gear ratio Error	Mechanical Fault
P0734	Fourth Gear ratio Error	Mechanical Fault
P0735	Fifth Gear ratio Error	Mechanical Fault
P0736	Reverse Gear ratio Error	Mechanical Fault

Figure 28

DTC	DTC DESCRIPTION	COMMENTS
P0829	5-6 or 6-5 Shift ratio Error	Mechanical Fault
P0960	PCA (Variable Force Solenoid 5) failed or open ckt.	Check resistance and replace as necessary
P0962	PCA (Variable Force Solenoid 5) signal or ground open circuit.	Check resistance and replace as necessary
P0963	PCA (Variable Force Solenoid 5) short to power.	Check resistance and replace as necessary
P0972	SSA (VFS1) circuit shorted to ground or open	Check resistance and replace as necessary
P0973	SSA (VFS1) circuit shorted to ground or open (may be out of tolerance).	Check resistance and replace as necessary
P0974	SSA (VFS1) circuit shorted to power or open (may be out of tolerance).	Check resistance and replace as necessary
P0975	SSB (VFS2) circuit shorted to ground or open	Check resistance and replace as necessary
P0976	SSB (VFS2) circuit shorted to ground or open (may be out of tolerance).	Check resistance and replace as necessary
P0977	SSB (VFS2) circuit shorted to power or open (may be out of tolerance).	Check resistance and replace as necessary
P0978	SSC (VFS3) circuit shorted to ground or open	Check resistance and replace as necessary
P0979	SSC (VFS3) circuit shorted to ground or open (may be out of tolerance).	Check resistance and replace as necessary
P0980	SSC (VFS3) circuit shorted to power or open (may be out of tolerance).	Check resistance and replace as necessary
P0981	SSD (VFS4) circuit shorted to ground or open	Check resistance and replace as necessary
P0982	SSD (VFS4) circuit shorted to ground or open (may be out of tolerance).	Check resistance and replace as necessary
P0983	SSD (VFS4) circuit shorted to power or open (may be out of tolerance).	Check resistance and replace as necessary
P0770	SSE (SS1) circuit or solenoid failure	Check resistance and replace as necessary
P0985	SSE (SS1)circuit shorted to ground or open (may be out of tolerance).	Check resistance and replace as necessary
P0986	SSE (SS1)circuit shorted to power or open (may be out of tolerance).	Check resistance and replace as necessary
P1707	P/N switch circuit fault (no engine crank)	Part of Mecatronic unit
P1910	Reverse lamp circuit fault	Reverse solenoid ckt./ Lamps may be on at all times
P1911	Reverse lamp circuit fault (short to ground)	Reverse circuit or sensor fault
P1912	Reverse lamp circuit fault (short to power)	Reverse circuit or sensor fault
P0740	TCC (VFS6) circuit open	Check resistance and replace as necessary
P2763	TCC (VFS6) circuit fault (shorted to power)	Check resistance and replace as necessary
P2764	TCC (VFS6) circuit fault (shorted to ground)	Check resistance and replace as necessary
P0741	TCC slip or TCC solenoid stuck open	Mechanical fault- Torque Converter mechanical slip
P0155	Control Area Network fault TCM and IP	Communication error
U0073	Control Area Network short from high to low	Communication error
U0100	Control Area Network between TCM and ECM	Communication error
U0121	CAN PCM/TCM error from ABS wheel speed.	Communication error
P062F	TCM EPROM error	TCM detects internal software concern with KAM

Figure 29