1.4 TRANSMISSION OUTPUTS CONTROLLED BY THE PCM

PRESSURE CONTROL SOLENOID

The transmission Pressure Control Solenoid (PCS) is an electronic pressure regulator that controls pressure based on current flow through its coil winding. The magnetic field produced by the coil moves the solenoid's internal valve which varies pressure to the pressure regulator valve.

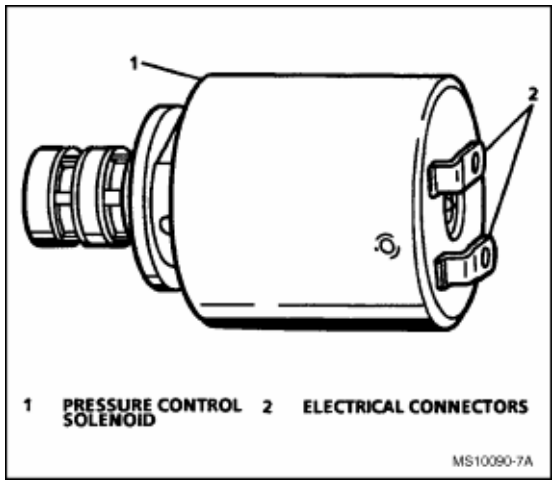

Figure 6C2-1-69 Pressure Control Solenoid

The pressure control solenoid takes the place of the throttle valve used on past model 4L60 transmissions. The PCM varies line pressure based on engine load. Engine load is calculated from various inputs, including the TP and MAP sensors. The transmission line pressure is actually varied by the PCM's control of the pressure control solenoid and its ability to change the amperage applied to the pressure control solenoid from 0 amps (high line pressure) to 1.1 amps (low line pressure). This changes the duty cycle of the solenoid, which can range between 0% and 100%.

There is one diagnostic trouble code associated with the pressure control solenoid Diagnostic Trouble Code (DTC) 73. Diagnostic Trouble Code 73 will set when the PCM detects a difference of 0.16 amp or more between the amperage commanded and actual amperage. While the diagnostic trouble code 73 is set, the pressure control solenoid will be turned "OFF" creating maximum line pressure. Recovery can occur after the next ignition cycle. Diagnostic Trouble Code 73 will not sense a stuck valve.

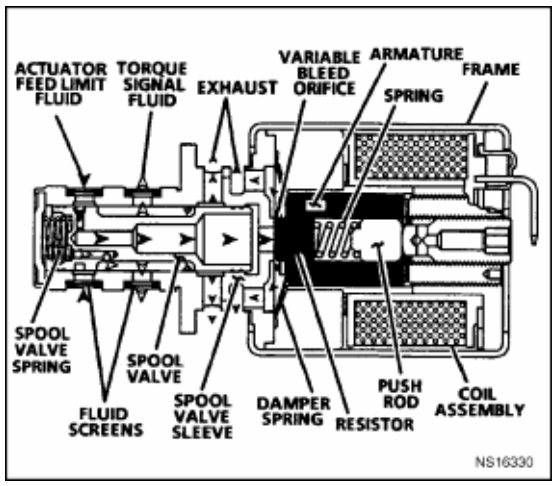

Figure 6C2-1-70 Pressure Control Solenoid Cutaway View

SHIFT SOLENOIDS

The 1-2 shift solenoid "A" and 2-3 shift solenoid "B" are identical solenoids that control the movement of the 1-2 and 2-3 shift valves (the 3-4 shift valve is not directly controlled by a shift solenoid). The solenoids are normally open exhaust valves that work in four combinations to shift the transmission into different gears. PCM controlled shift solenoids eliminate the need for Throttle Valve (TV) and governor pressures to control shift valve operation.

IMPORTANT: The PCM does NOT have total control of shifting the transmission. The manual valve can hydraulically override the shift solenoids. Only in "D" are the PCM and shift solenoids totally determining what gear the transmission is in. In the manual positions "3", "2", and "1", the transmission manual valve position will change fluid direction in the valve body. The transmission will shift on its own hydraulically, the PCM will have limited control and will respond to the hydraulic changes to the manual valve. The PCM will change the shift solenoids when the pressure switch assembly switches change position and throttle position and vehicle speeds fall into the correct ranges for PCM control. In other words the PCM "catches up" to what

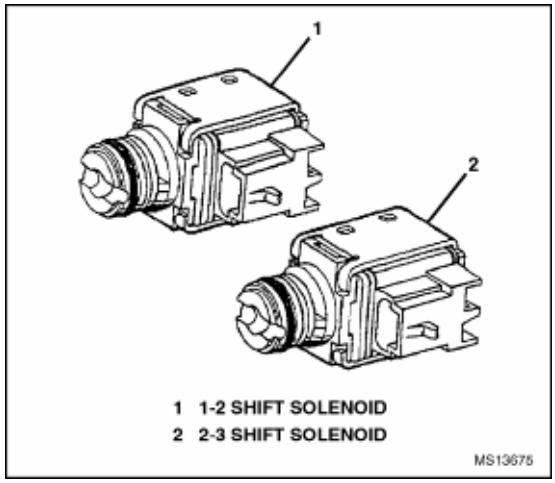

Figure 6C2-1-71 Shift Solenoids

control. In other words the PCM "catches up" to what happened hydraulically. This is important to remember, as the Tech 1 scan tool will only display the commanded state of the shift solenoids not the actual gear the transmission is in.

1-2 Shift Solenoid "A"

The 1-2 shift solenoid "A" is attached to the valve body and is a normally open exhaust valve. The PCM activates the solenoid by earthing it through an internal quad driver. The 1-2 shift solenoid "A" is "ON" in 1st and 4th gear, and "OFF" in 2nd and 3rd gears.

When "ON," the shift solenoid redirects fluid to act on the shift valves.

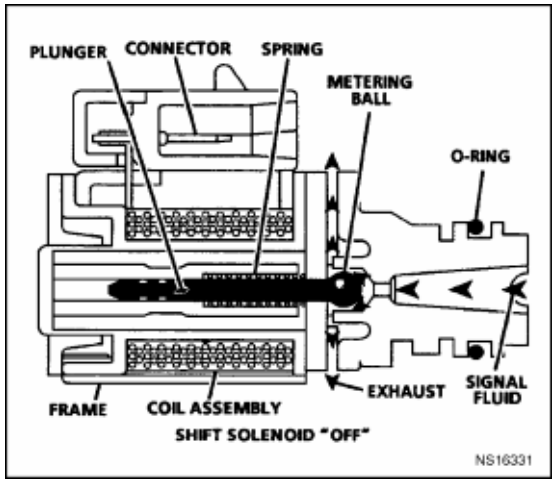

Figure 6C2-1-72 Shift Solenoid Cutaway View

There is one diagnostic trouble code associated with the 1-2 shift solenoid "A", Diagnostic Trouble Code 82 1-2 shift solenoid "A" circuit fault. The PCM continually monitors the 1-2 shift solenoid "A" circuit for expected voltage ("OFF" high "ON" low). If the voltage reading is not what is expected on the circuit, Diagnostic Trouble Code 82 will set. While Diagnostic Trouble Code 82 is present, line pressure will be set to high and the vehicle will have 2nd or 3rd gear only. When the fault is removed, recovery will occur on the next ignition cycle.

2-3 Shift Solenoid "B"

The 2-3 shift solenoid "B" is attached to the valve body and is a normally open exhaust valve. The PCM activates the solenoid by earthing it through an internal quad driver. The 2-3 shift solenoid "B" is "ON" in 1st and 2nd gear and "OFF" in 3rd and 4th gear. When "ON," the shift solenoid redirects fluid to act on the shift valves.

There is one diagnostic trouble code (DTC) associated with the 2-3 shift solenoid "B", DTC 81. The PCM continually monitors the 2-3 shift solenoid "B" circuit for expected voltage ("OFF" high "ON" low). If the voltage reading is not what is expected, Diagnostic Trouble Code 81 will set. While Diagnostic Trouble Code 81 is present, TCC operation will be inhibited, line pressure will be set to high and the transmission will have 2nd or 3rd gear only. When the fault is removed, recovery will occur at the next ignition cycle.

GEAR	1-2 SHIFT SOLENOID	2-3 SHIFT SOLENOID
PARK, REVERSE, NEUTRAL	"ON"	"ON"
FIRST	"ON"	"ON"
SECOND	"OFF"	"ON"
THIRD	"OFF"	"OFF"
FOURTH	"ON"	"OFF"

NS14709

Figure 6C2-1-73 Solenoid Status

3-2 CONTROL SOLENOID

The 3-2 control solenoid is a pulse width modulated (PWM) solenoid used to improve the 3-2 downshift. The 3-2 control solenoid uses pulse width modulation to control pressure so that the release of the 3-4 clutch and the apply of the 2-4 band are smooth. The duty cycle is normally about 0% in first gear and about 90% in all other drive gears, except during a 3-2 downshift when the duty cycle drops. The duty cycle is determined by throttle position, vehicle speed, and the commanded gear.

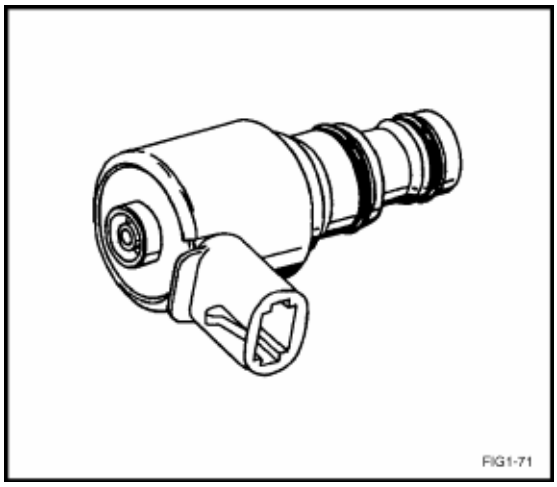

Figure 6C2-1-74 3-2 Control Solenoid

There is one Diagnostic Trouble Code (DTC) associated with the 3-2 control solenoid, DTC 66. DTC 66 will set when the PCM detects either high voltage when the 3-2 control solenoid is commanded high duty cycle or if low voltage exists on the feed back line when the solenoid is commanded low duty cycle. While the 3-2 control solenoid DTC 66 is set, the solenoid will be at a low duty cycle, creating a soft landing into 3rd gear. The vehicle will only have 3rd gear unless second gear is manually selected. TCC will be "ON" in third gear only and line pressure will be high. When the fault is removed recovery can occur after the next ignition cycle.

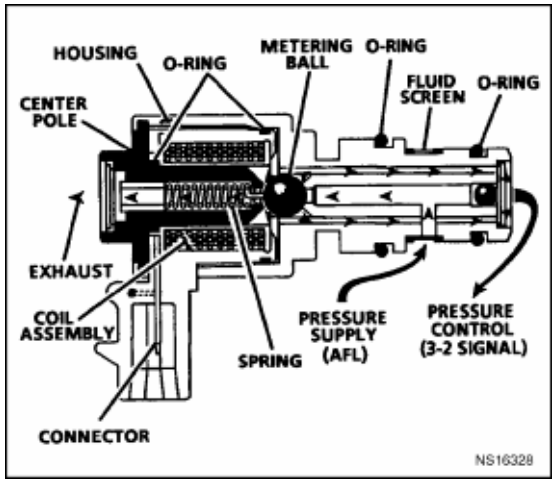

Figure 6C2-1-75 3-2 Control Solenoid Cutaway View

TORQUE CONVERTER CLUTCH (TCC) SOLENOIDS

This transmission uses two Torque Converter Clutch (TCC) solenoids. that are used to control torque converter clutch apply and release. The TCC "ON-OFF" solenoid has priority in applying and releasing the torque converter clutch.

The Torque Converter Clutch (TCC) "ON-OFF" solenoid is commanded either "ON" or "OFF" by the PCM. When earthed (energised "ON"), by the PCM, the TCC solenoid stops converter feed from exhausting. This causes converter feed pressure to increase and shift the TCC valve into the apply position. This pressure allows the TCC to couple the transmission with the engine for a near 100% engagement.

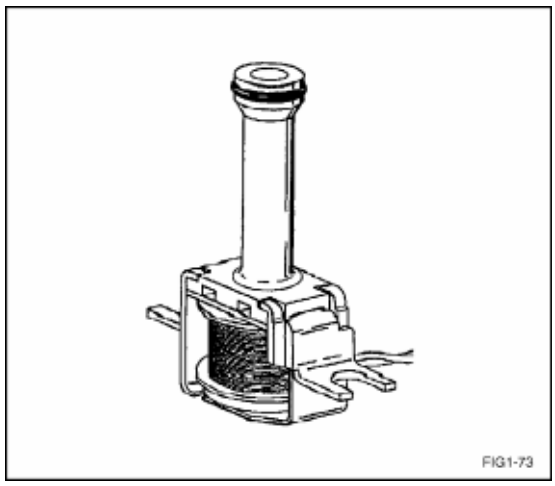

Figure 6C2-1-76 Torque Converter Clutch (TCC) "ON-OFF" Solenoid

There are two Diagnostic Trouble Codes (DTC) associated with the TCC "ON-OFF" solenoid. The first diagnostic trouble code is DTC 67, TCC "ON-OFF" Solenoid Circuit Fault. Diagnostic Trouble Code 67 is designed to detect a fault in the TCC electrical circuit. While Diagnostic Trouble Code 67 is set the PCM will inhibit 4th gear if the transmission is in the hot mode, and no TCC operation.

The second diagnostic trouble code associated with the TCC "ON-OFF" solenoid is DTC 69 TCC Stuck "ON". Diagnostic Trouble Code 69 is designed to detect a TCC that does not disengage. It does this by monitoring engine RPM when the TCC solenoid is commanded "ON." If the engine speed does not rise when the TCC solenoid is disengaged, the DTC 69 is set. While DTC 69 is set the TCC will be "ON" in all gears or second, third and fourth gears depending upon the failure and the transmission will have an early shift pattern. When the fault is removed, recovery will occur on the next ignition cycle.

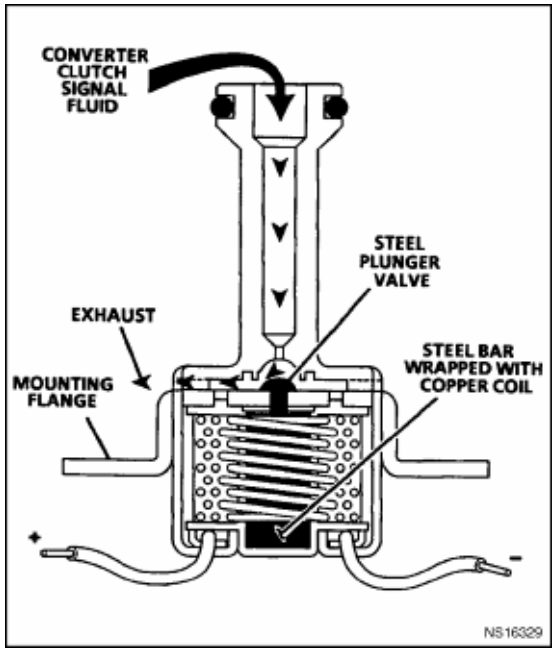

Figure 6C2-1-77 TCC Solenoid Cutaway View

The Torque Converter Clutch "PWM" Solenoid is used to control fluid acting on the converter clutch valve, which then controls TCC apply and release. This solenoid is attached to the control valve body assembly within the transmission. The TCC "PWM" Solenoid does not have total control over TCC engagement. The TCC Solenoid is used as a supplement to the TCC "ON-OFF" Solenoid. The TCC "PWM" Solenoid is used to provide smooth engagement of the torque converter clutch by operating on a negative duty cycle percent of "ON" time, which means that the earth (negative or low) side of the solenoid circuit is controlled by the PCM.

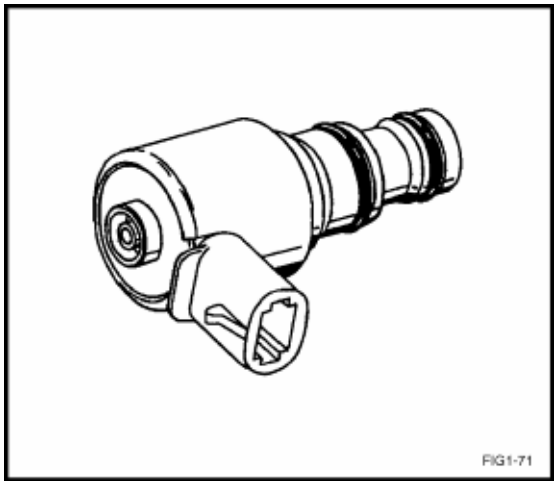

Figure 6C2-1-78 Torque Converter Clutch (TCC) "PWM" Solenoid

Therefore, the TCC "PWM" solenoid is constantly fed approximately 12 volts to the high (positive) side and the PCM controls the length of time the electrical circuit path to earth is closed (ie. duty cycle).

When the PCM closes the solenoid earth circuit, current flows through the TCC "PWM" solenoid, and the earth circuit (or negative side) is at low voltage state (0 volts and solenoid energised).

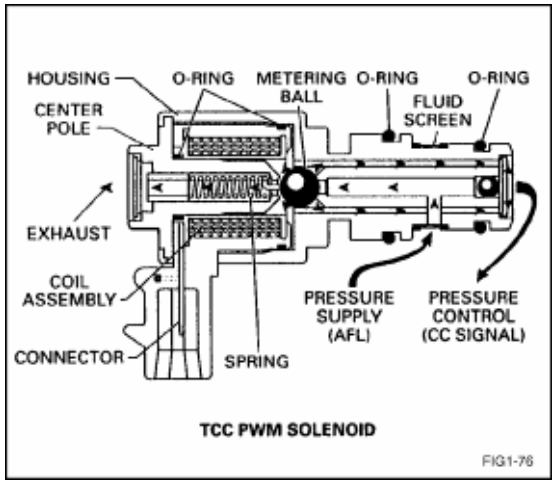

Figure 6C2-1-79 Torque Converter Clutch (TCC) "PWM" Solenoid Cutaway View

Fig. 6C2-1-80 illustrates an example of the TCC "PWM" solenoid operating with a 90% negative duty cycle at a constant operating frequency of 32 Hz (cycles per second). The frequency means that the solenoid is pulsed (energised) with current from the PCM 32 times per second. The 90% negative duty cycle means that during each of these 32 cycles the solenoid is energised (ON) and 0 volts is measured on the low (negative) side

(ON) and 0 volts is measured on the low (negative) side of the circuit, 90 % of the time.

At road speeds below approximately 13 km/h, the negative duty cycle will be 0%, which means that no current will flow through the TCC "PWM" solenoid, deactivating it. When in this condition, spring force will move the plunger (refer Fig. 6C2-1-79), seating the metering ball and blocking the filtered Actuator Feed Limit (AFL) fluid from entering the Converter Clutch Signal (CC SIGNAL) circuit. This action opens the Converter Clutch Signal fluid circuit to exhaust through the solenoid.

Above road speed of approximately 13 km/h, the TCC "PWM" solenoid will be operating at about a 90% duty cycle. This action will cause the metering ball to close off the path to exhaust, most of the time and allow AFL fluid to flow past the metering ball and into the CC SIGNAL circuit, in readiness for the apply of the torque converter clutch.

When the PCM signals TCC apply, the TCC "PWM" solenoid operates with a variable, negative duty cycle, ranging from 90% to 0%, with an operating frequency of 32 Hz. This allows the PCM to control the current flow through the solenoid coil according to the duty cycle it sets. This has the effect of creating a variable magnetic field, that magnetises the solenoid core, attracting the metering ball to seat against spring force. A high percentage duty cycle keeps the metering ball seated more often, thereby creating higher TCC signal fluid pressures.

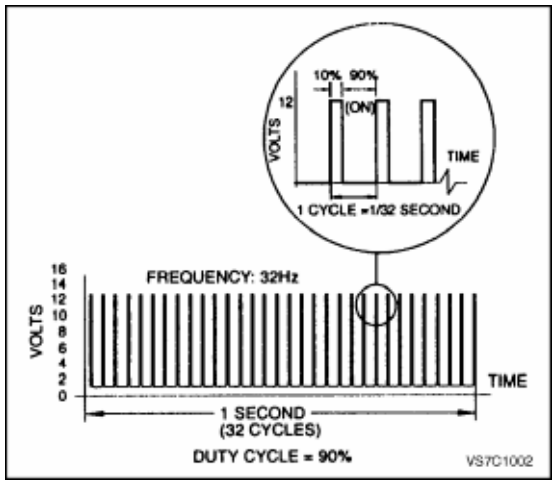

Figure 6C2-1-80 Torque Converter Clutch (TCC) "PWM" Solenoid Duty Cycle

TCC "PWM" Solenoid Operation

When vehicle road speed rises above about 13 km/h, the PCM causes the TCC "PWM" solenoid duty cycle to change from 0% to 90% (point "A"), in readiness for an apply of the torque converter.

To apply the torque converter clutch, the process the PCM adopts, is as follows;

- The duty cycle is dropped to 0% (point "B") and a measurable amount of time is allowed for the TCC "ON/OFF" solenoid to turn "ON". This is shown as the time between points "B" and "C" in Fig. 6C2-1-81. Note that, at point "B", the TCC "ON/OFF" solenoid is activated.
- The time from point "C" to "D" is used to allow converter (CONV FD) fluid to build in pressure and move the Converter Clutch Valve into the apply position.
- At this point, with the TCC "ON/OFF" solenoid applied, the PCM then increases the duty cycle to about 26% (point "E"). From this point, the duty cycle is 'ramped' to around the 82% point ("E" to "F"). The *rate* at which the duty cycle is increased over this period of time, determines how quickly the value of the regulated apply fluid increases and therefore, how quickly the torque converter clutch is applied. This rate of change also affects the converter clutch apply 'feel'.
- As soon as the duty cycle reaches the 82% value, it is then immediately increased to the maximum of 90%, to achieve full apply pressure in the regulated apply fluid circuit (point "G").

NOTE: That the duty cycle and apply pressure will continually vary, depending on vehicle specification and operating conditions.

The two TCC solenoids work together so that TCC apply or release rate can be calibrated for a variety of situations.

If a fault is detected by the PCM, in the TCC "PWM" solenoid electrical circuit, a DTC 83 will be set. When DTC 83 is set, the PCM will inhibit 4th gear and TCC operation.

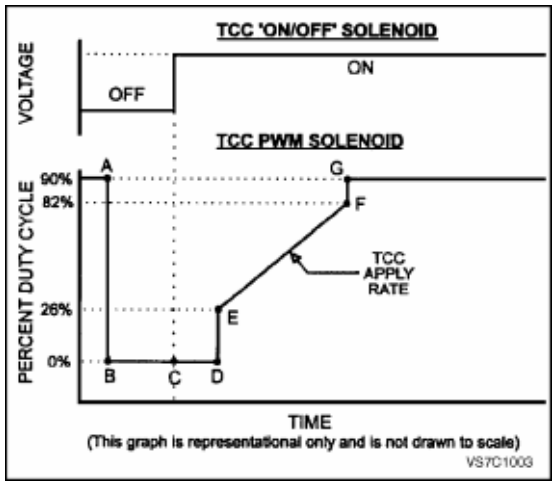

Figure 6C2-1-81 Torque Converter Clutch Solenoid Operation