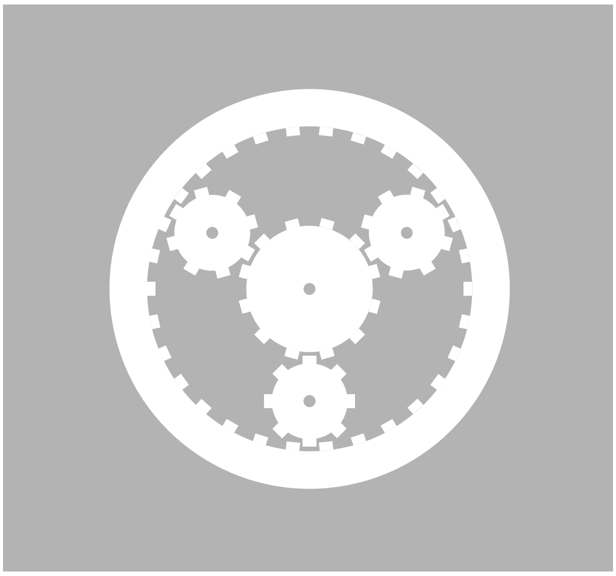
Curriculum Training

Automatic Transmission



JAGUAR

Technical Training

T201.1 en 12/2004

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Please remember that our training literature has been prepared for TRAINING PURPOSES only. Repairs and adjustments MUST always be carried out according to the instructions and specifications in the workshop literature. Please make full use of the training offered by Technical Training to gain extensive knowledge of both theory and practice.

PAGE

Lesson 9 – Manual Transmission — Vehicles With: Getrag 221

Lesson 10 – Manual Transmission — Vehicles With: MTX-75

Lesson 11 – Transfer Case — AWD

Workshop safety

This page highlights the general observations expected whilst attending this training programme, and its continuation upon returning to your place of work.

General

Whilst working on all vehicles, the following items where available should always be used:

- Wing covers
- Seat covers
- Floor protection

Optional items:

- Steering wheel cover
- Park brake lever cover
- Door grab handle protection

Safety

All precautions must be taken and observed at all times, to prevent injury or damage to the following:

- Yourself
- Customer's property
- Workshop equipment
- Work place colleagues

Operating guidelines

Whilst using any piece of workshop equipment:

The manufacturer's guidelines and warning labels must be followed.

This will ensure correct use and application at all times.

Seek the necessary advice or training where equipment usage is unclear.

Chemicals, Oils and Solvents

Follow all manufacturer's warnings and labels, also take into account local disposal regulations when working with chemicals, oils or solvents.

Ensure that all risks are completely minimised.

Make sure that all protective items of clothing are worn where required e.g.

- Eye protection
- Gloves
- Overalls
- Footwear

System capping

Upon disconnecting components from a system, take all precautions necessary to prevent system contamination or environmental leakage.

Fit relevant plugs or caps i.e. to pipes, unions and component orifices etc.

Updates

Keep abreast of all relevant changes that effect your role within the dealership, by monitoring all factory issued documentation.

Driving

Operating vehicle features, such as ICE, mobile phones and CD player equipment etc., can cause a momentary distraction whilst driving.

Follow all road traffic regulations as written in the Highway Code, when operating vehicle systems or using diagnostic equipment whilst on the move.

Mobile diagnostic equipment operation, may require the use of an assistant.

This instructor-led course is intended to provide Jaguar dealer service personnel with the knowledge and understanding of Jaguar Transmission operation. Upon completion, the service personnel will be able to:

- Explain the operation of Jaguar Transmissions
- Evaluate transmission condition based on published testing procedures
- Locate and identify all control components of Jaguar transmissions
- Perform all required transmission adjustments and service checks
- Perform the replacement of transmission gaskets, seals, and serviceable components
- Diagnose electronic control system faults by using all available Jaguar tools and service literature

MODEL DESIGNATIONS

Jaguar Training publications use the following internal designations when referring to vehicle models.

Jaguar Internal Designation	Model	Model Year(s)
X100	XK	1997 – 2002
X103	XK	2003 – 2004
X105	XK	2005 – 2006
X200	S-TYPE	2000 – 2002
X202	S-TYPE	2003 – 2004
X204	S-TYPE	2005
X206	S-TYPE	2006 Onward
X308	XJ	1998 – 2003
X350	XJ	2004 – 2005
X356	XJ	2006 Onward
X400	X-TYPE	2002 – 2003
X404	X-TYPE	2004 Onward

Acronyms

NOTE: A large majority of the following acronyms conform to SAE J1930 standards.

Acronym	Definition
ABS	Anti-Lock Braking System
A/C	Air Conditioning
APP	Accelerator Pedal Position
ASIS	Adaptive Shift Strategy
ATF	Automatic Transmission Fluid
AWD	All-Wheel Drive
B+	Battery Positive Voltage
BPM	Body Processor Module
CAN	Controller Area Network
CHT	Cylinder Head Temperature
CKP	Crankshaft Position
CM	Control Module
CMP	Camshaft Position
DLC	Data Link Connector
DSC	Dynamic Stability Control
DTC	Diagnostic Trouble Code
ECM	Engine Control Module
ECT	Engine Coolant Temperature
EOT	Engine Oil Temperature
EEPROM	Electrically Erasable Programmable Read Only Memory
EPROM	Erasable Programmable Read Only Memory
GEM	Generic Electronic Module
GTR	Global Technical Reference
IAT	Intake Air Temperature

Acronym	Definition
IDS	Integrated Diagnostic System
ISS	Intermediate Shaft Speed
LED	Light Emitting Diode
LEV	Low Emissions Vehicle
LH	Left Hand
MAF	Mass Air Flow
MY	Model Year
N/A	Normally Aspirated
NAS	North American Specification
NTC	Negative Temperature Coefficient
OBD	On-Board Diagnostics
O/C	Open Circuit
OEM	Original Equipment Manufacturer
OSS	Output Shaft Speed
PCM	Powertrain Control Module
PTC	Positive Temperature Coefficient
PTEC	Powertrain Electronic Control
PWM	Pulse Width Modulation
RH	Right Hand
SAE	Society of Automotive Engineers
SCP	Standard Corporate Protocol
S/C	Short Circuit
SC	Supercharged
TCC	Torque Converter Clutch
TCM	Transmission Control Module
TFT	Transmission Fluid Temperature
TOT	Transmission Oil Temperature
TP	Throttle Position

Acronym	Definition
TSS	Turbine Shaft Speed
WDS	Worldwide Diagnostic System
WOT	Wide Open Throttle

Transmission Application 1997 – 2005 MY

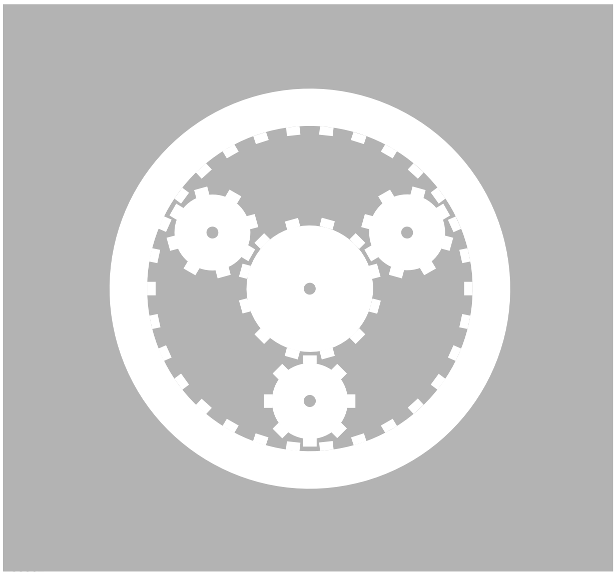
Automatic Transmission Application

Model	Transmission Type				
	ZF 5HP24	**W5A580**	**5R55N**	**JF506E**	**ZF 6HP26**
XJ	1998 – 2003 MY	—	—	—	2004 – 2006 MY
XJR	—	1998 – 2003 MY	—	—	2004 – 2006 MY
XK	1997 – 2002 MY	—	—	—	2003 – 2006 MY
XKR	—	2000 – 2002 MY	—	—	2003 – 2006 MY
S-TYPE	—	—	2000 – 2002 MY	—	2003 – 2006 MY
S-TYPE R	—	—	—	—	2003 – 2006 MY
X-TYPE	—	—	—	2002 – 2005 MY	—

Manual Transmission Application

Model	Transmission Type	
	Getrag 221	**MTX-75 with AWD Transfer Case**
S-TYPE V6	2003 – 2004 MY	—
X-TYPE	—	2002 – 2005 MY

Automatic Transmission
Lesson 2 - Fundamentals



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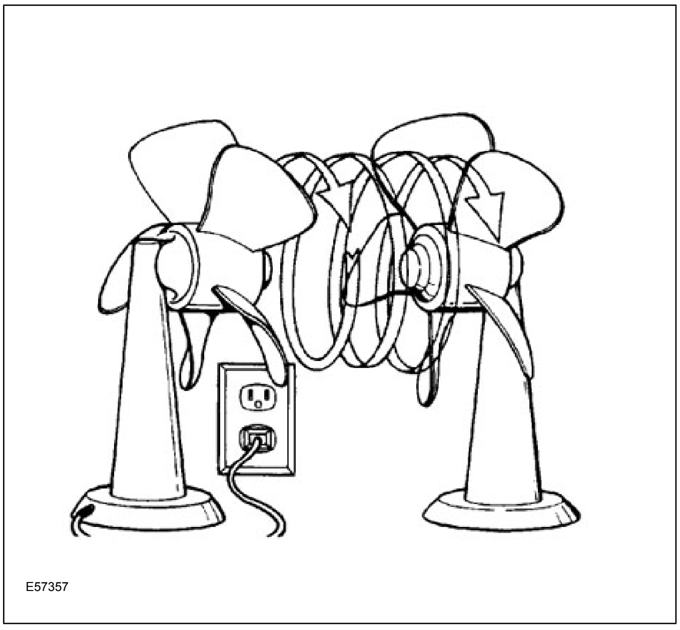
TORQUE CONVERTER

The torque converter is the linking component that transmits the power from the engine to the transmission. There is no direct mechanical connection via the torque converter between the engine and the transmission until the torque converter locking clutch is actuated at highway speeds.

Fluid Coupling

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

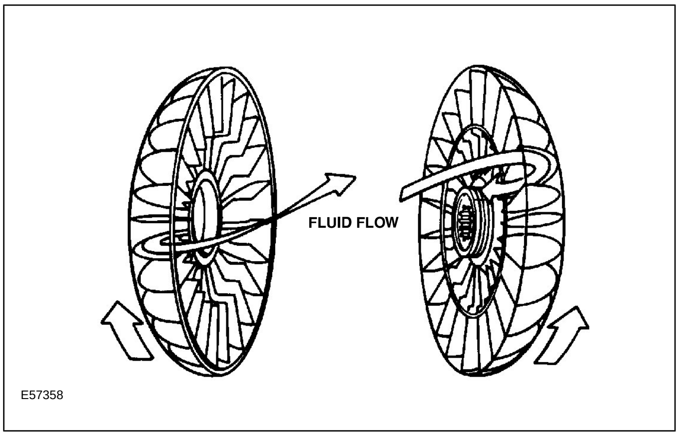
Fluid Coupling Principle



Fluid Flow

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

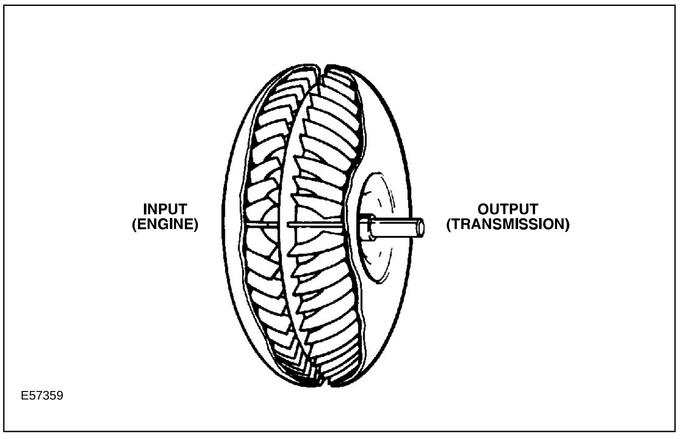
Fluid Flow in a Torque Converter



Power Flow

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

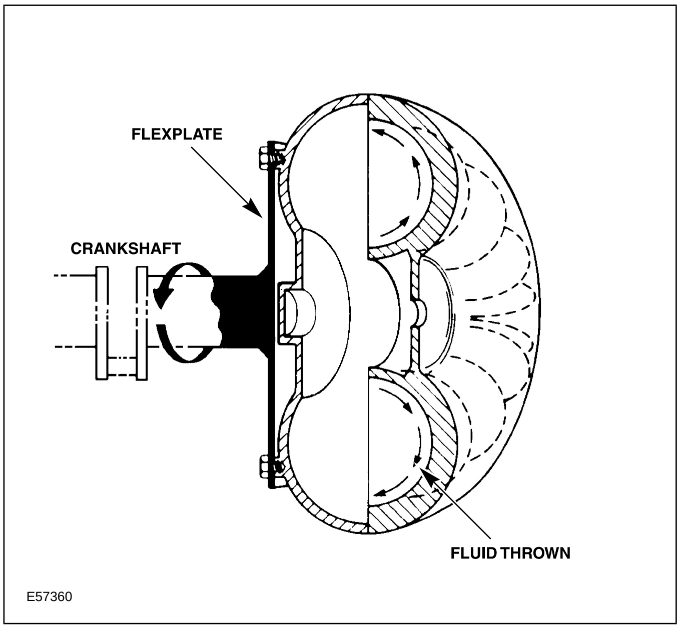
Power Input/Output



Pump Impeller

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

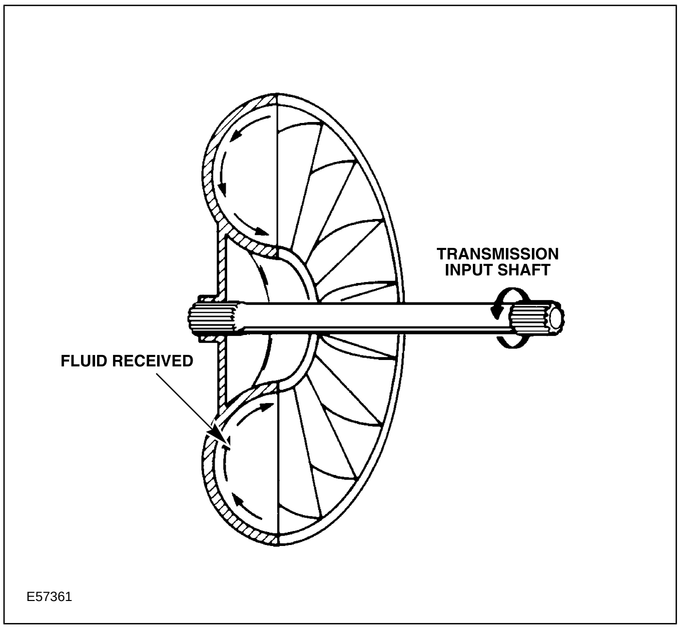
Pump Impeller



Turbine

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

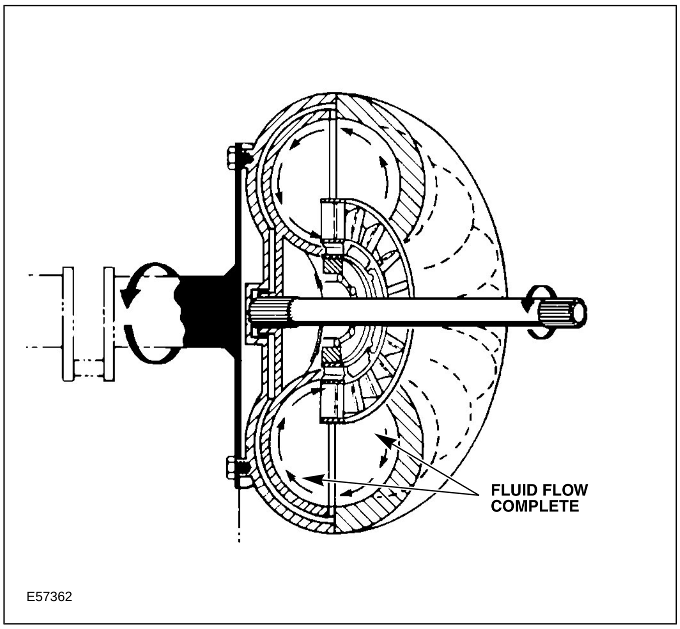
Turbine



Stator

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

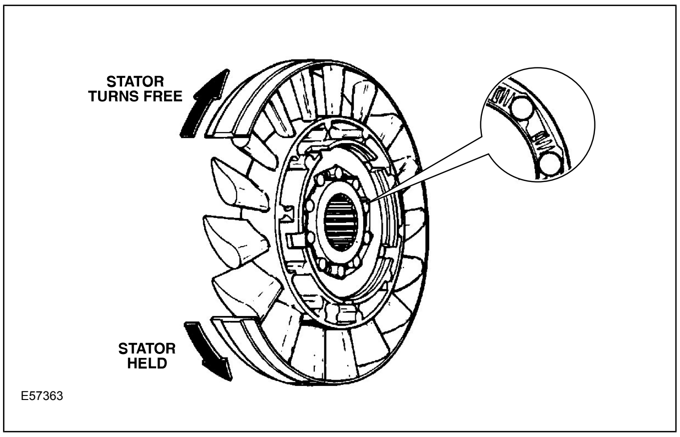
Stator



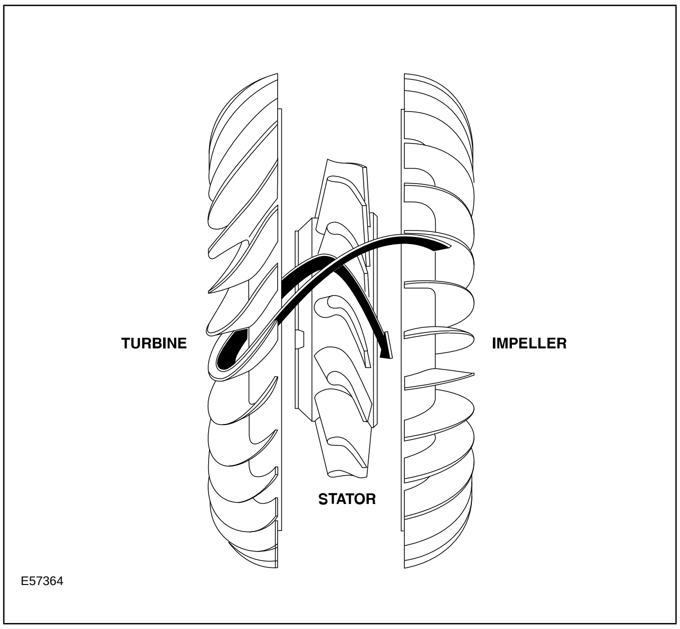
Stator Assembly

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

Stator Assembly



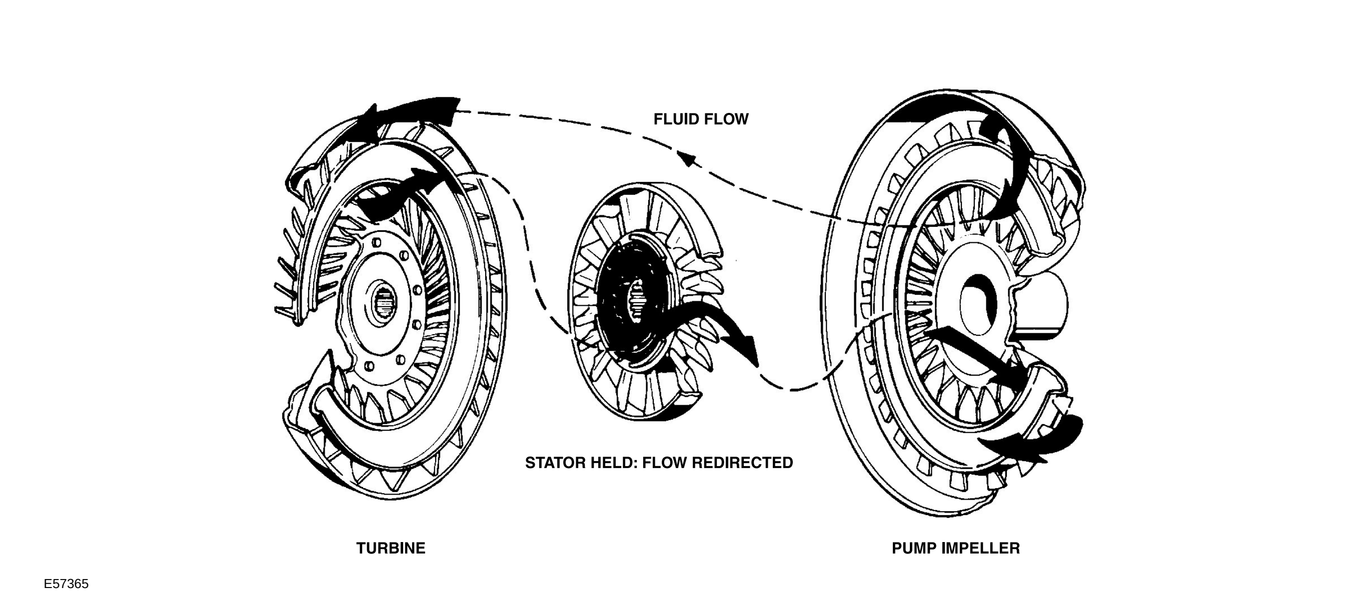
Fluid Flow from Impeller Through Turbine and Stator



Torque Multiplication

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

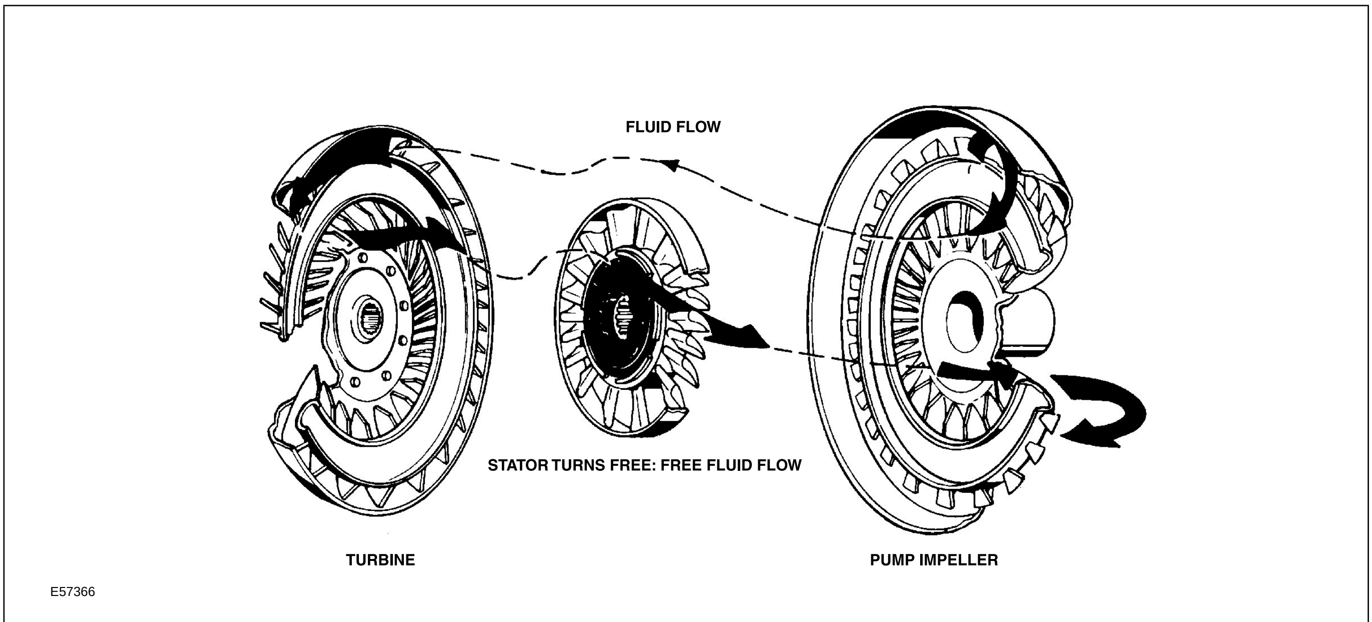
Torque Multiplication



Fluid Coupling

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

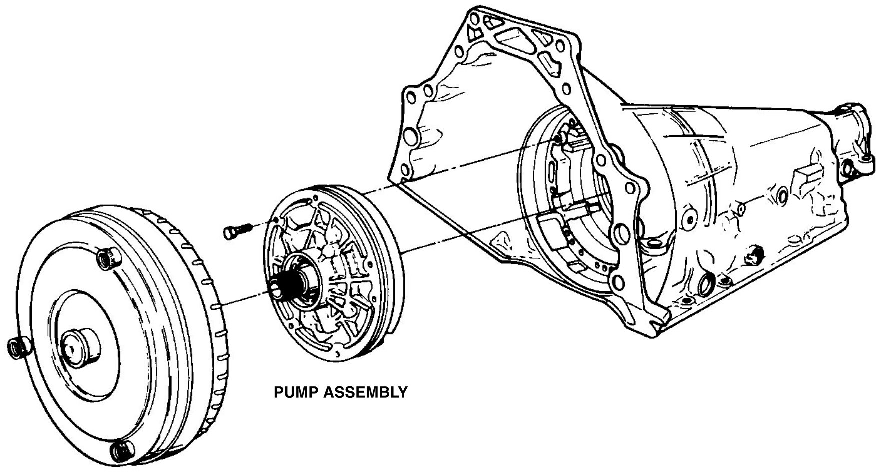
Fluid Coupling



Torque Converter and Oil Pump

The torque converter housing mechanically drives the transmission oil pump.

Torque Converter and Transmission Oil Pump

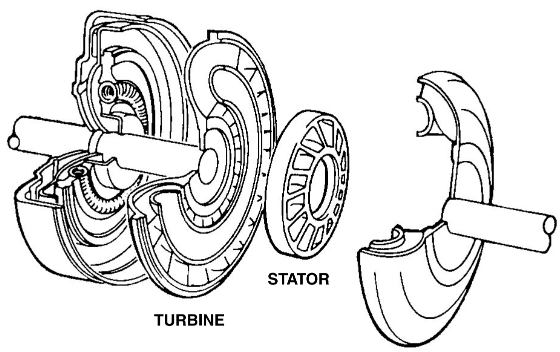


Torque Converter Lockup Clutch

The torque converter lockup clutch provides a direct mechanical coupling between the engine and the transmission at highway speed. The direct coupling eliminates the slight amount of slippage present when the torque converter is acting as a fluid coupling, thereby improving efficiency, reducing fuel consumption and fluid thermal loads. The lockup clutch is connected to the pump impeller and can be either a single plate or two plate design.

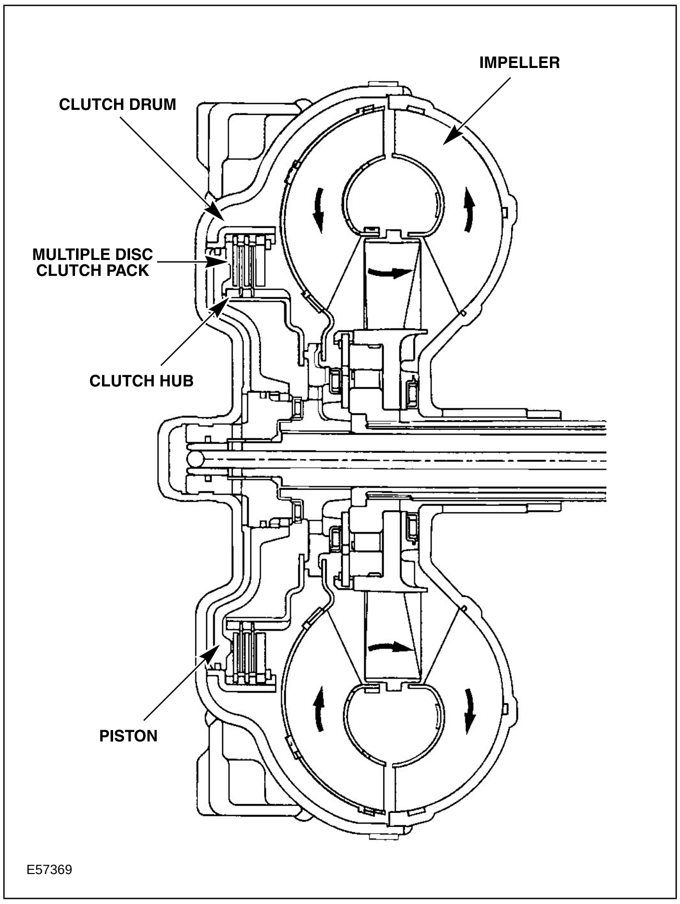
The single plate clutch is engaged by the force of the fluid acting on the pump impeller and released by hydraulic force directed from the valve body.

Single Plate Lockup Clutch



The two plate clutch operates opposite in that it is engaged by hydraulic force directed from the valve body and released by the force of the fluid acting on the pump impeller. The clutch connects the converter housing and the pump impeller assembly.

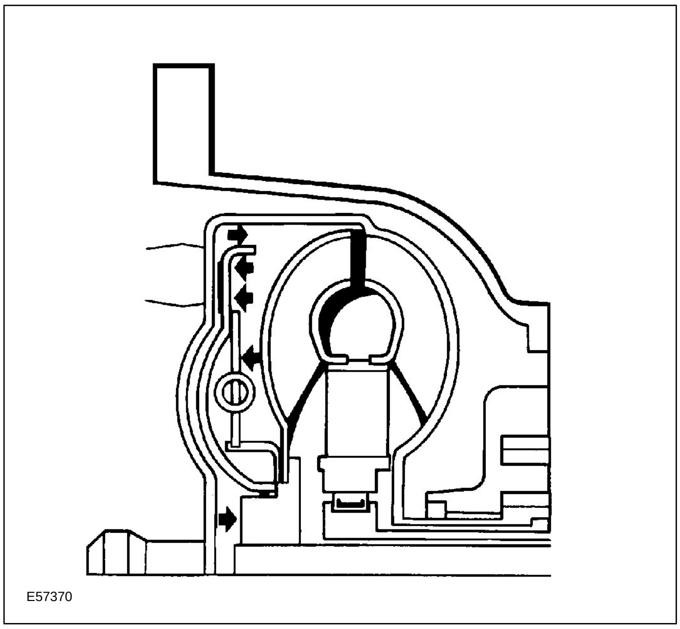
Two-Plate Lockup Clutch



Lock Up Clutch Operation: Clutch Released

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

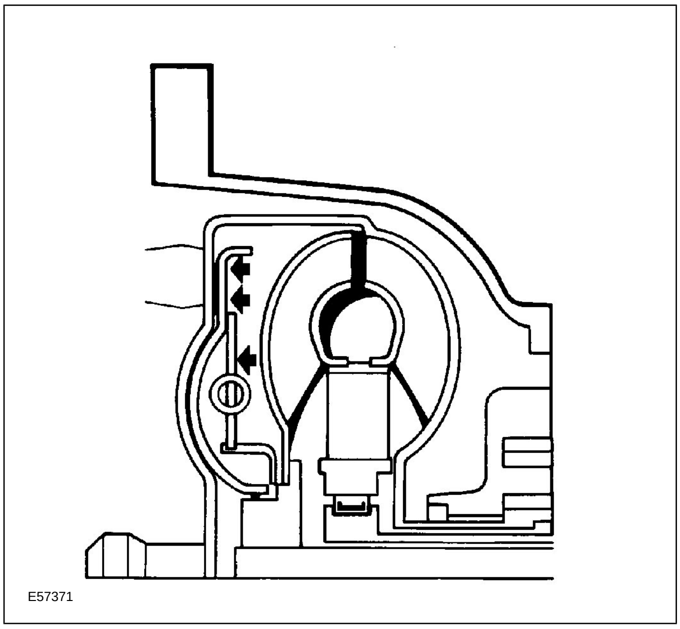
Single Plate Lockup Clutch Released by Hydraulic Force



Lockup Clutch Operation: Clutch Engaged

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

Single Plate Lockup Clutch Engaged by Impeller Force



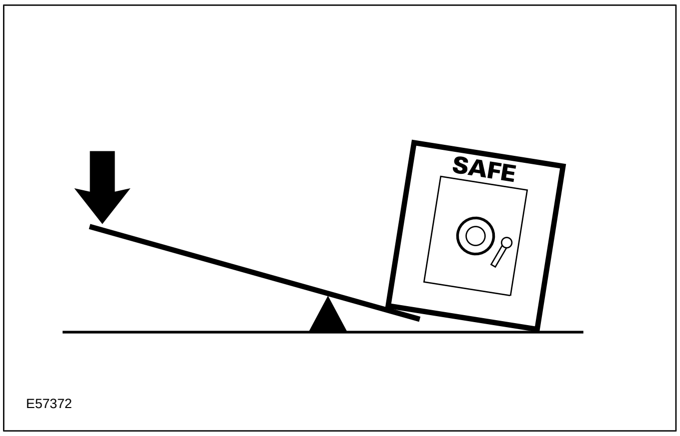
GEARS AND TORQUE

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

Leverage

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

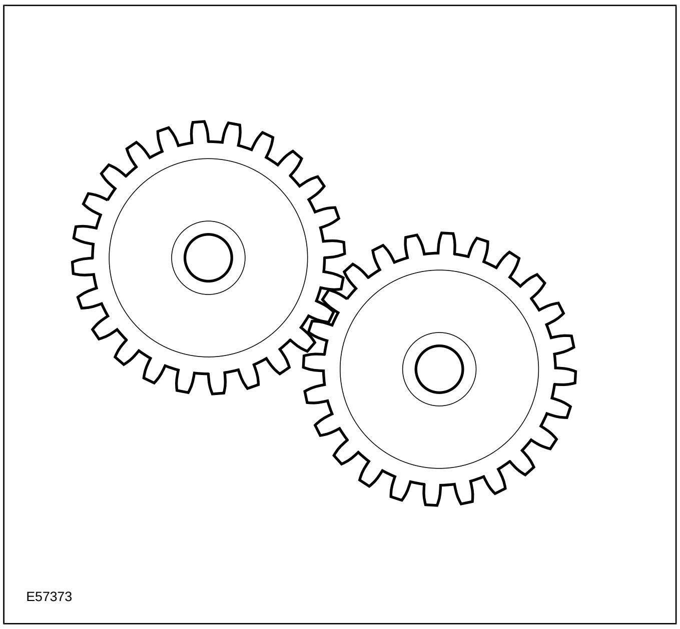
Lever Arm Increases Applied Force



Torque Transmission

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

Transmission of Torque with a Ratio of 1:1

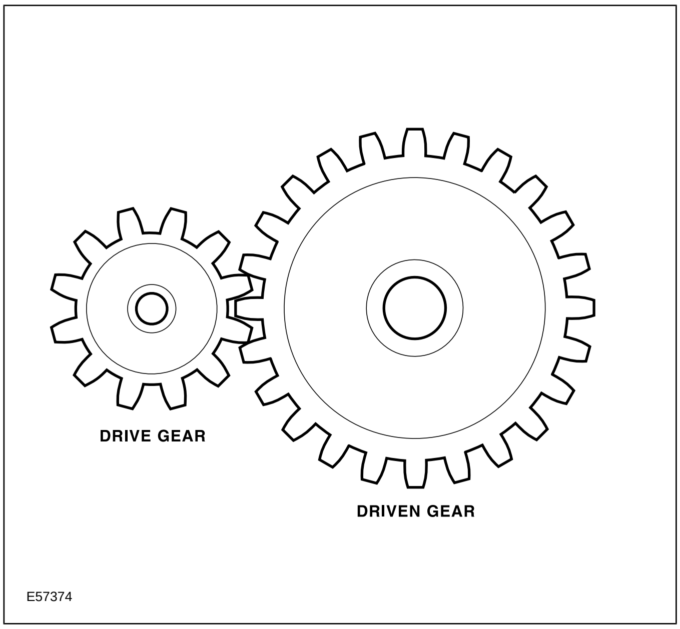


The input and output torque will be the same; therefore, the torque ratio is also 1:1.

Torque Multiplication

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

Torque Multiplication



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

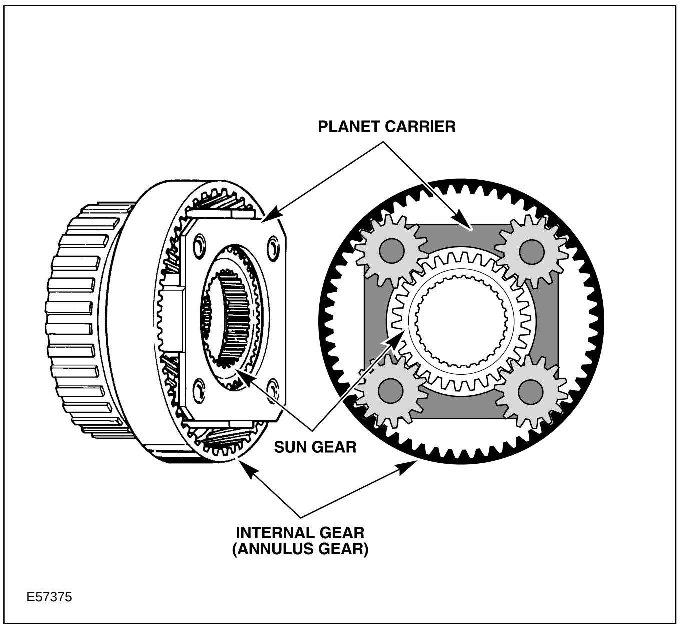
PLANETARY GEAR SETS

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

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

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

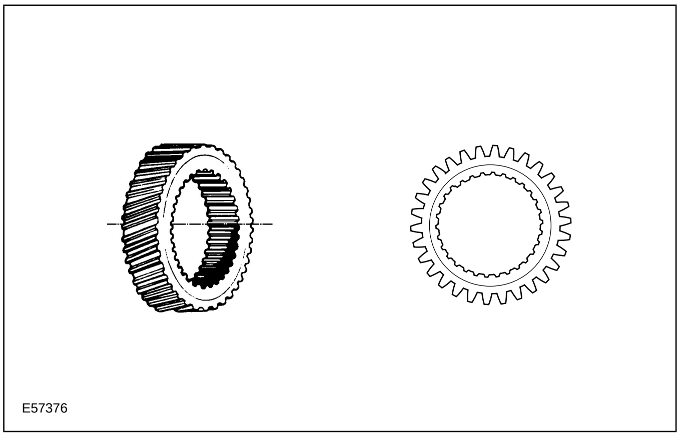
Single Planetary Gear Set



Sun Gear

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

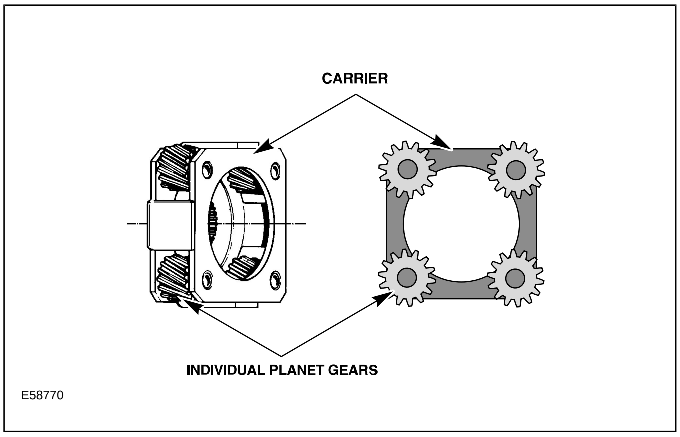
Sun Gear



Planet Carrier and Planet Gears

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

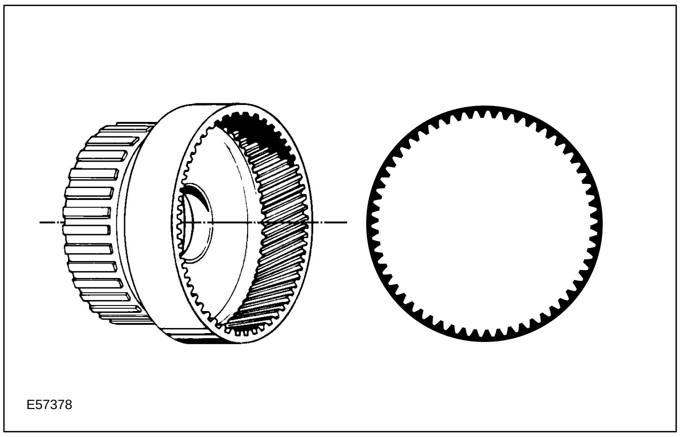
Planet Carrier and Gears



Internal Gear (Annulus Gear)

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

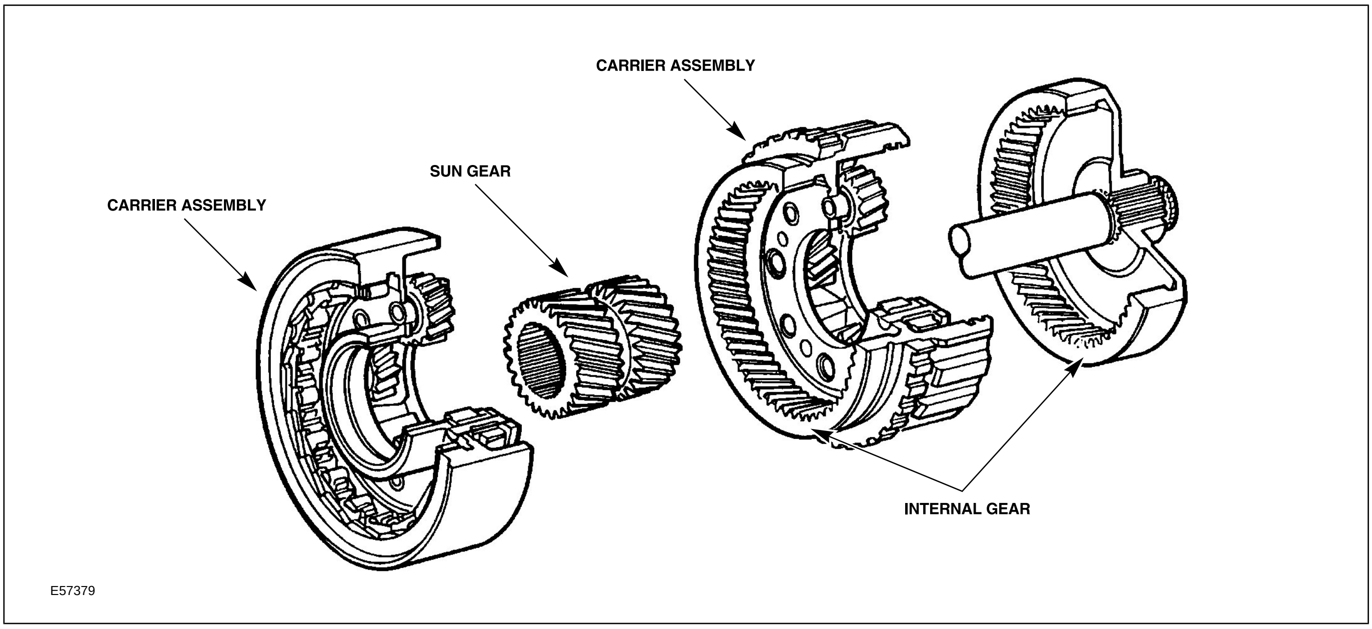
Internal Gear



Compound Planetary Gear Sets

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

Compound Planetary Gear Set



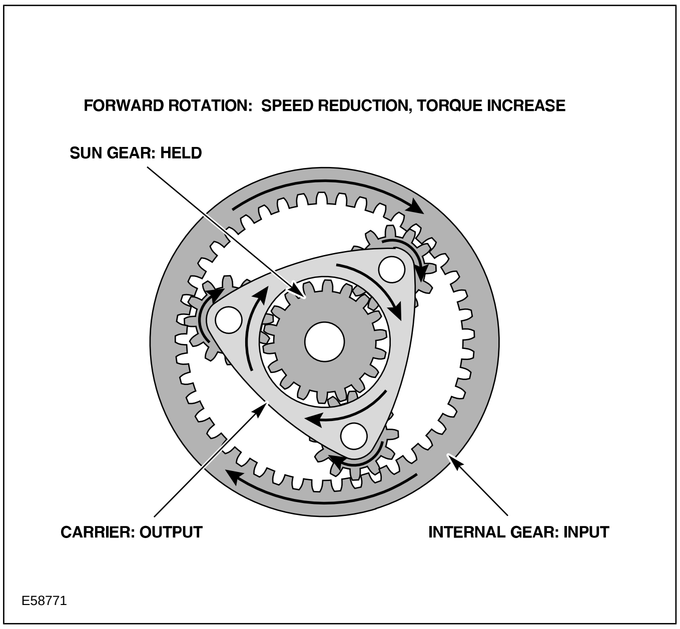
Uses for Planetary Gear Sets

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

Reduction

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

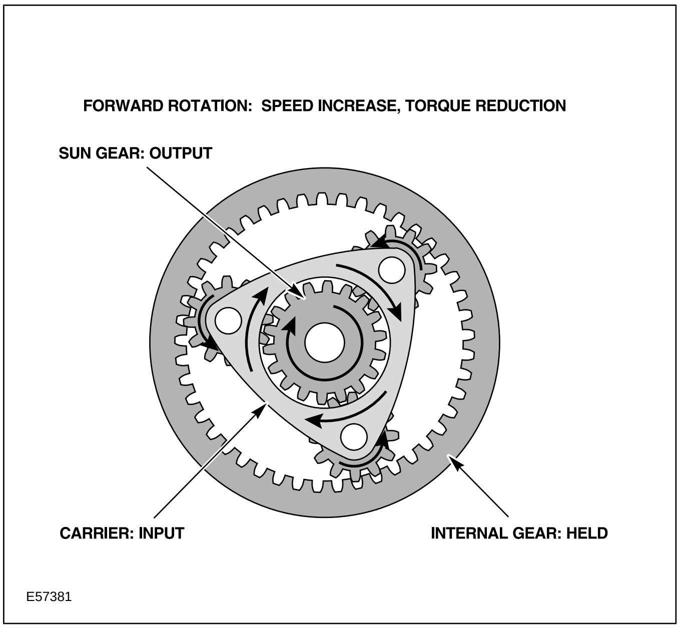
Reduction



Overdrive (increase speed)

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

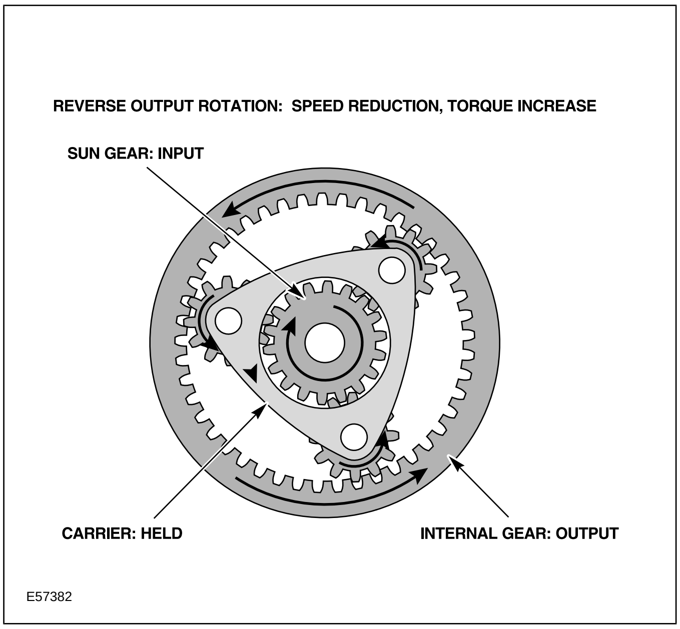
Overdrive



Reverse Direction

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

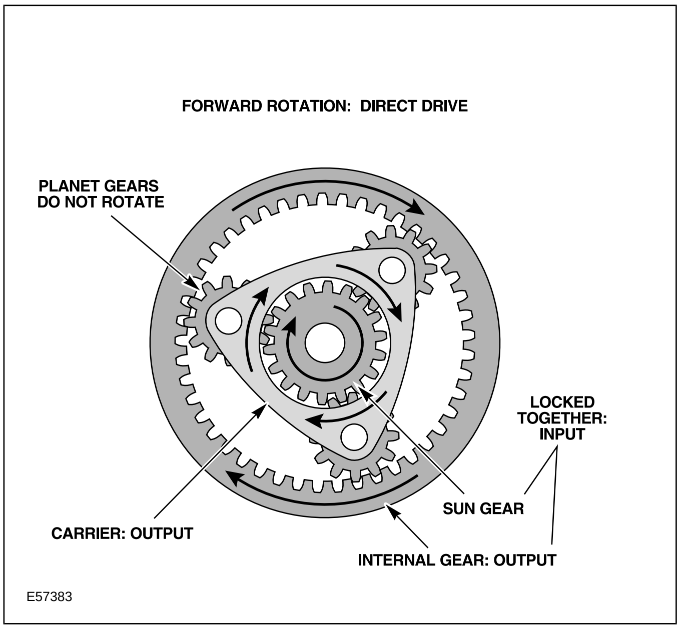
Reverse



Direct Drive

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

Direct Drive



Planetary Gear Set Drive Summary

	INPUT			OUTPUT	
	Drive Gear	**Direction**	**Held**	**Driven Gear**	**Speed Ratio**
1	sun	forward	ring	carrier	low forward
2	ring	forward	sun	carrier	intermediate forward
3	any 2	forward	any 2	unit locked	direct forward
4	carrier	forward	sun	ring	1st overdrive forward
5	carrier	forward	ring	sun	2nd overdrive forward
6	sun	forward	carrier	ring	low reverse
7	ring	forward	carrier	sun	overdrive reverse

BASIC HYDRAULICS

Pascal's Law

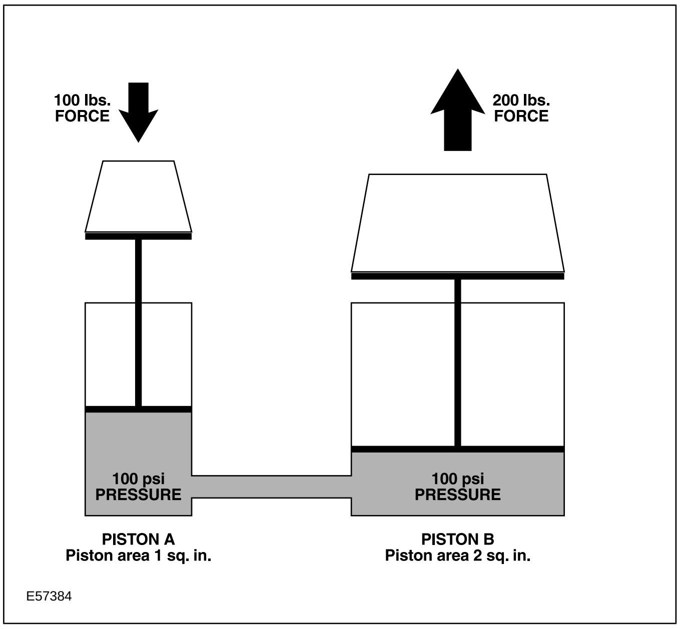
Pascal's Law states that, for all practical purposes, a fluid cannot be compressed. Therefore, pressure applied to a confined fluid is transmitted equally in all directions and acts with equal force in all directions.

Force and Pressure

- Pressure = force x area
- Force = pressure x area
- Piston travel = output travel = input travel x (output area ÷ input area)

In the illustration below, 100 lbs. of force acts on Piston A, producing hydraulic pressure of 100 psi throughout the system. The piston area of Piston B is double that of Piston A, so that the force acting on Piston B would be 200 lbs. (double that of Piston A). If Piston A were to move 1 inch, then Piston B would move 0.5 in.

Basic Hydraulics



APPLY DEVICES

Detailed during the description of planetary gear sets, different gear ratios and different output directions were achieved by driving and/or holding the various planetary components. The action of selectively turning or holding different members of the planetary gear set is achieved through the use of apply devices.

Apply devices used in automatic transmissions include:

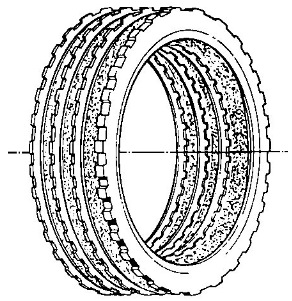
- Multiple-disc clutches
- One-way clutches
- Bands and servos

Multiple-Disc Clutches

Clutch Pack

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

Clutch Pack



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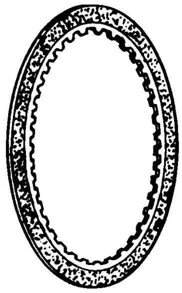
Friction Disc

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

Friction Disc



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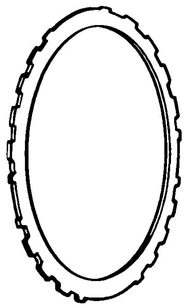
Steel Disc

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

Steel Disc



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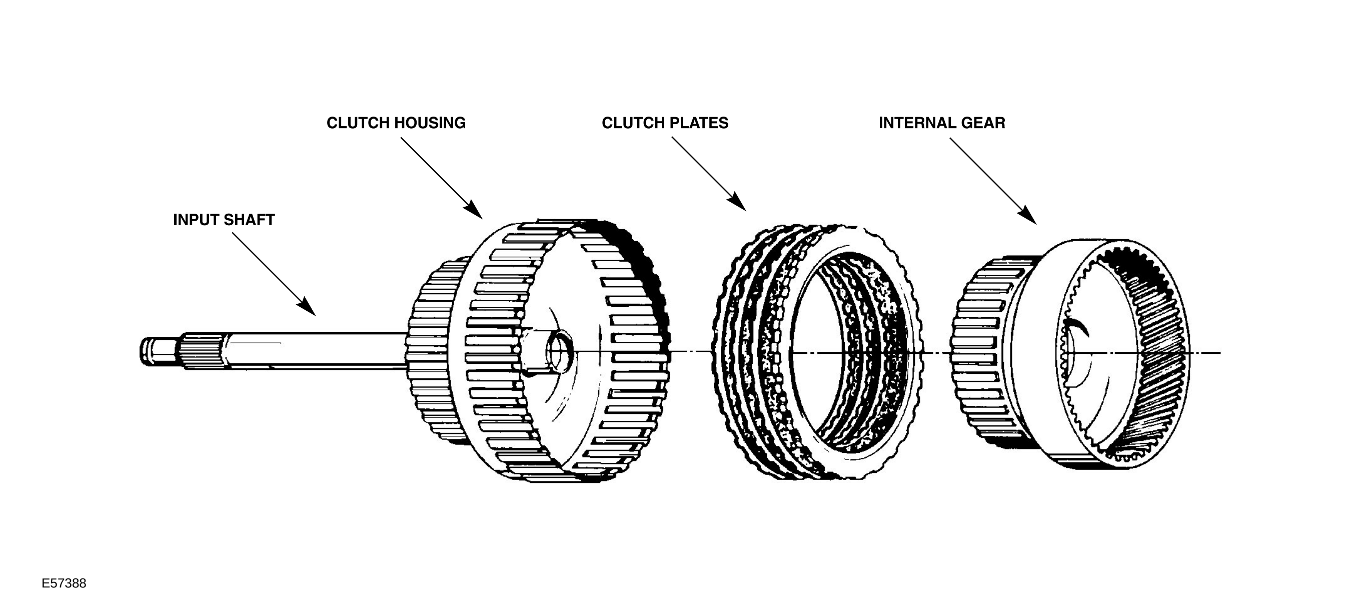
Multiple-Disc Driving Clutches

A multiple-disc clutch can be used as a driving clutch by splining one set of discs to an input source and the other set of alternating discs to an output member.

In this example, the steel discs are splined to a clutch housing that is part of an input shaft; the friction discs are splined to an internal gear (planetary gear set). The clutch housing and the internal gear rotate freely when the clutches are not applied. When the clutches are applied by hydraulic pressure, they rotate together and the input shaft drives the internal gear.

Driving Clutch

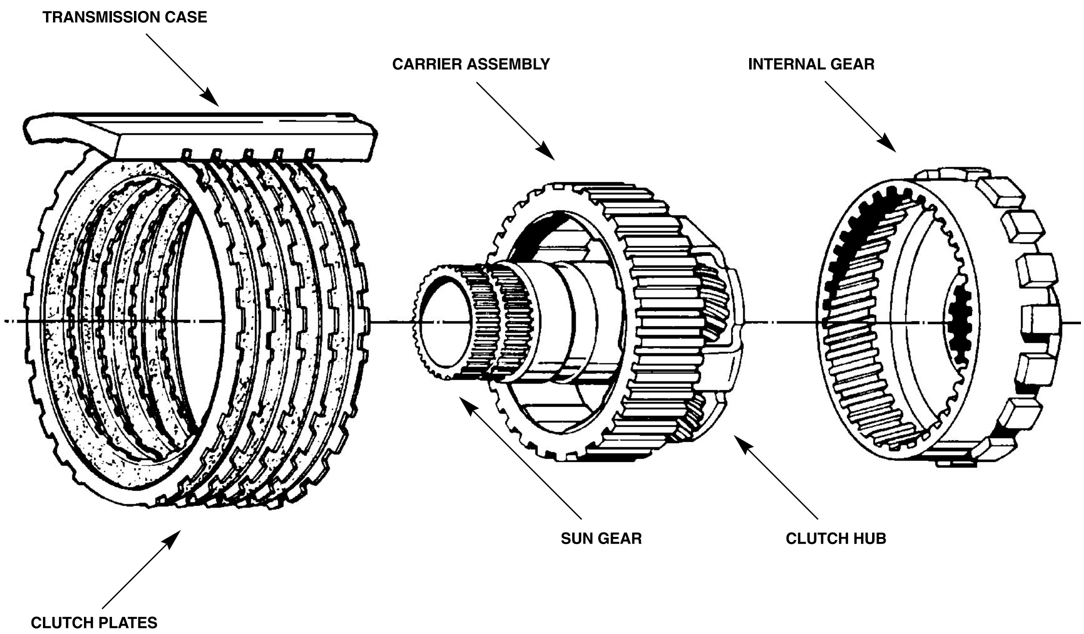


Multiple-Disc Brake Clutches

A multiple-disc clutch can also be used to act as a brake for a member of a gear set.

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

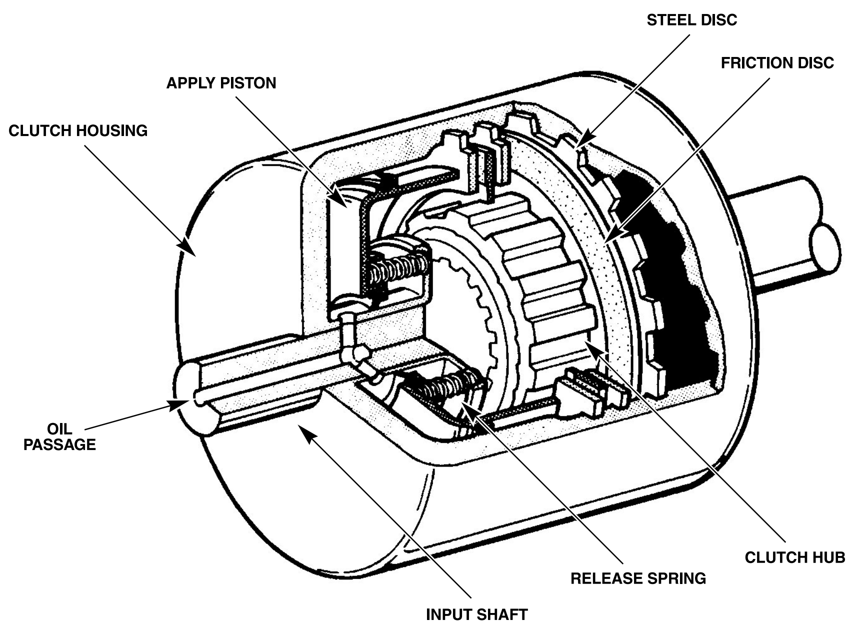
Brake Clutch



Applying Multiple-Disc Clutches

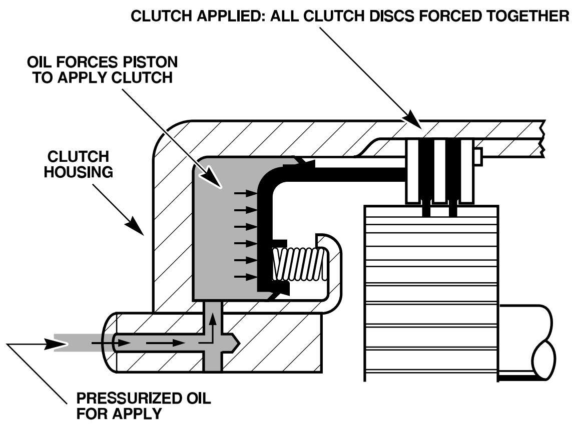
The clutch assemblies (as well as all transmission internal components) are bathed in automatic transmission fluid that coats the components and allows them to turn freely and independently. The clutch assembly is applied by hydraulic pressure.

Clutch Assembly

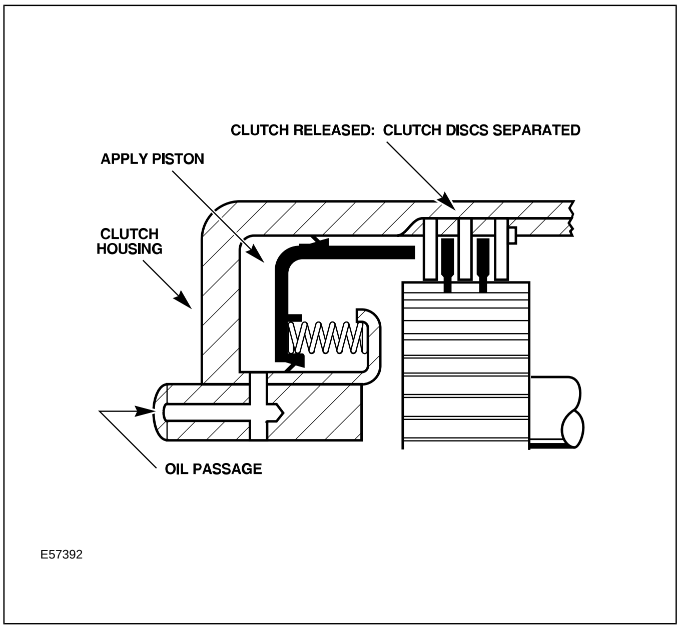


Pressurized oil acts on the apply piston moving the piston in contact with the clutch pack. The hydraulic pressure forces the discs together and the resulting friction connects the discs causing the housing and hub to rotate (or hold) together as one unit. When the hydraulic pressure is released, the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

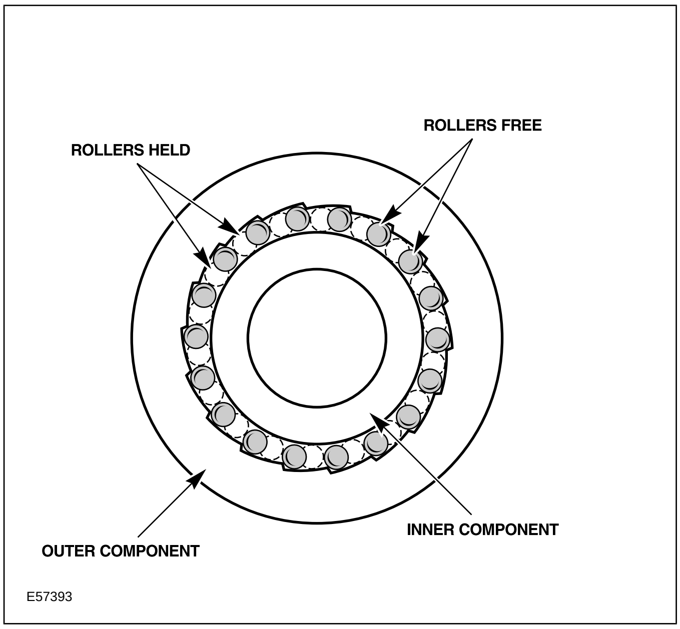
Clutch Applied



Clutch Released



Roller Clutch



One-Way Clutches

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

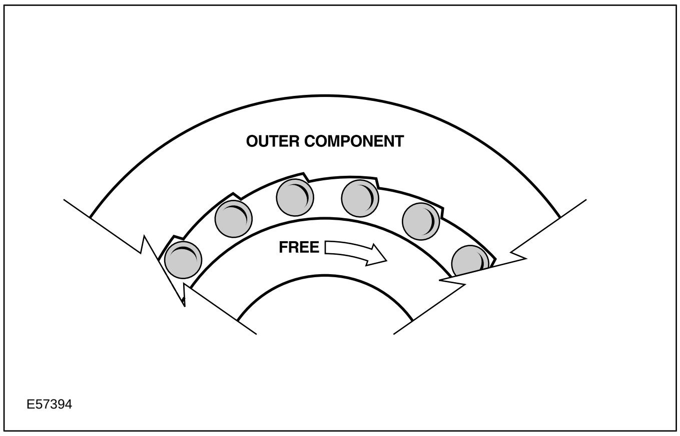
Roller Clutch

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

Roller Clutch: Free Rotation

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

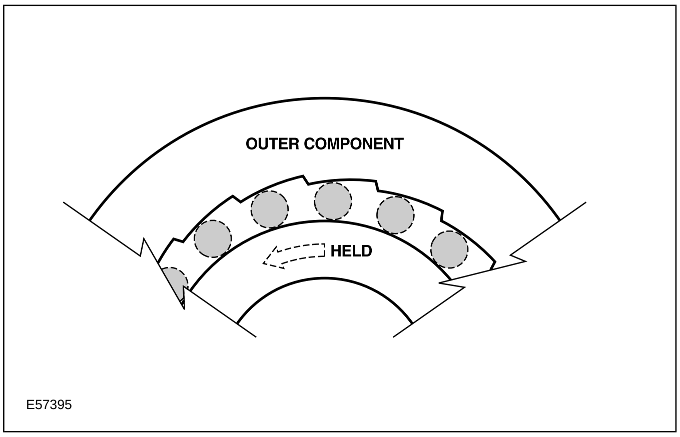
Free Rotation



Roller Clutch: Components Held

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

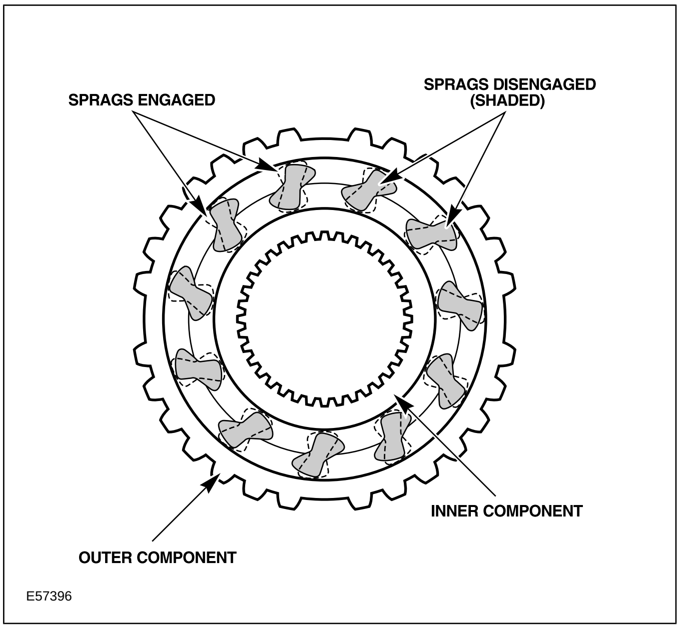
Components Held



Sprag Clutch

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

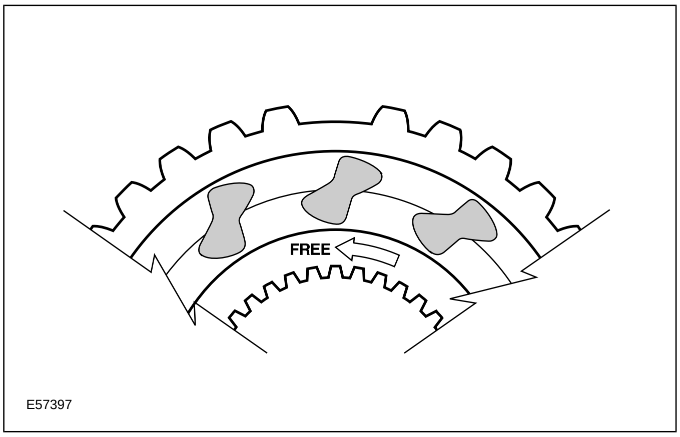
Sprag Clutch



Sprag Clutch: Free Rotation

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

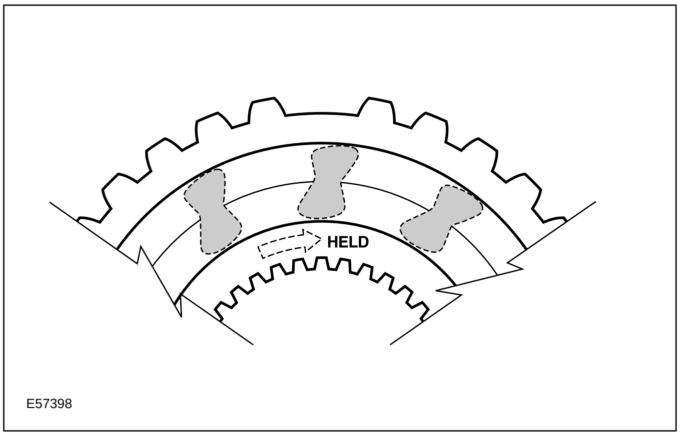
Free Rotation



Sprag Clutch: Components Held

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

Components Held



Relative Advantages of One-Way Clutches

Sprag clutch advantages over a roller clutch:

- Less rotation before lockup
- Typically a higher torque capacity for an equivalent size

Roller clutch advantages over a sprag clutch:

- Less friction during free rotation
- Less expensive

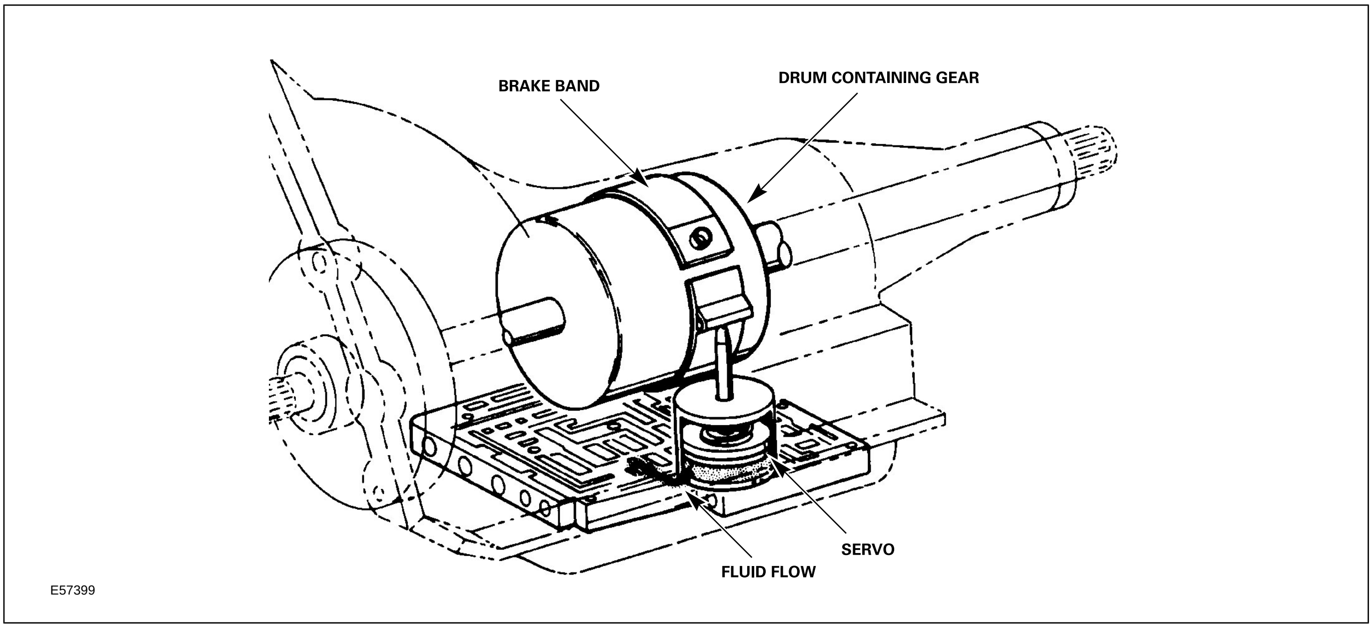
Transmission Brakes and Servos

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

Brake Band and Servo

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

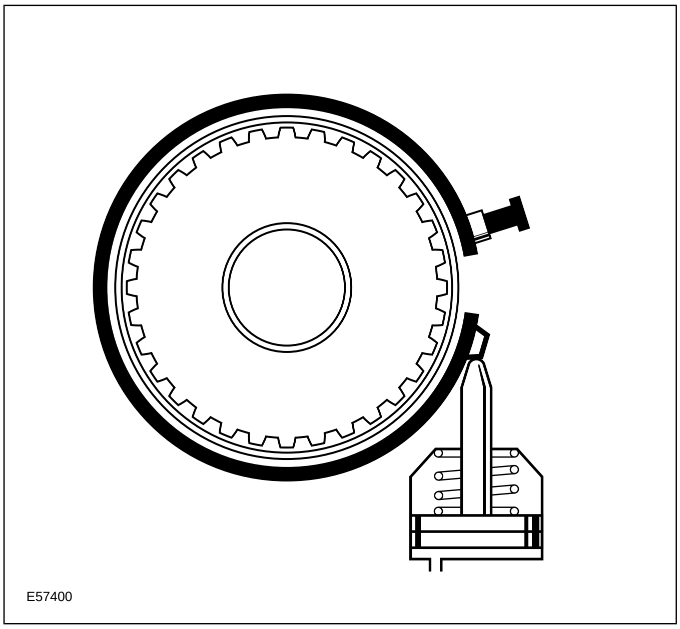
Brake Band and Servo



Brake Band Released

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

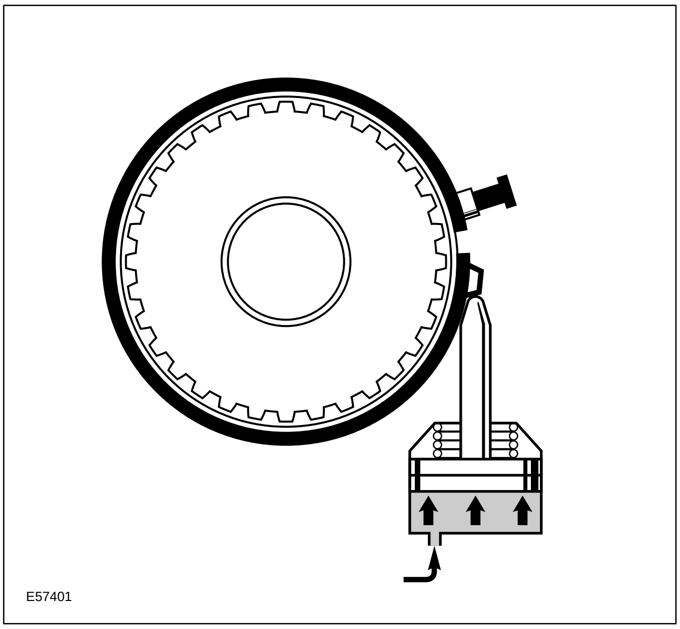
Brake Band Released



Brake Band Applied

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

Brake Band Applied



OIL PUMP AND COOLER

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

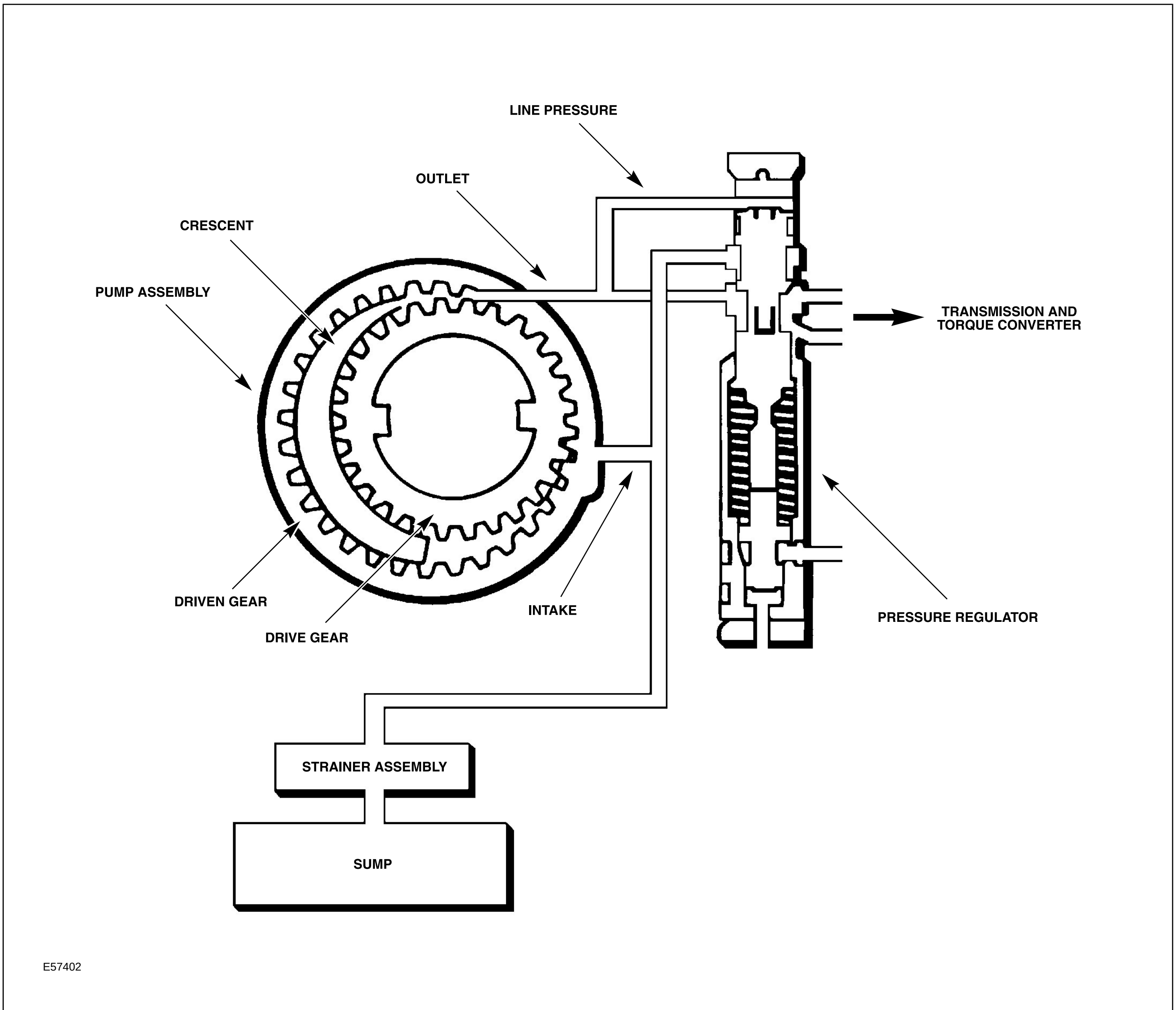
Crescent-Type Pump

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

Pump Operation

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

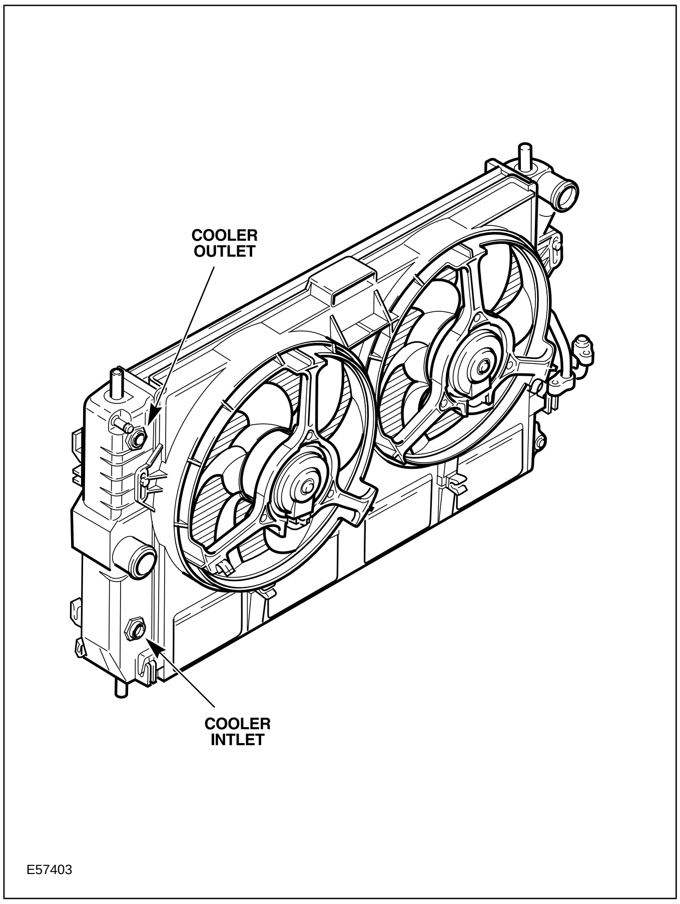
Crescent Oil Pump and Pressure Regulator



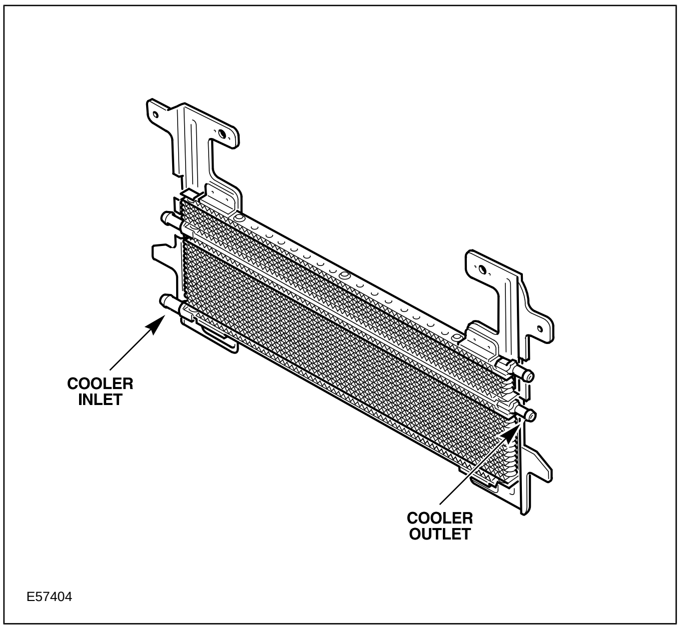
Oil Cooler

An oil cooler is necessary to maintain transmission oil temperature. The external cooler can be incorporated into the side tank of the engine coolant radiator as a liquid-to-liquid cooler or can be incorporated into a separate oil cooler as an air-to-liquid cooler.

Cooling Pack with Integral Oil Cooler (Liquid to Liquid)



Separate Oil Cooler (Air to Liquid)



TRANSMISSION VALVES

Valves are used in the transmission hydraulic circuits to actuate and release apply devices, and to control or limit hydraulic pressure.

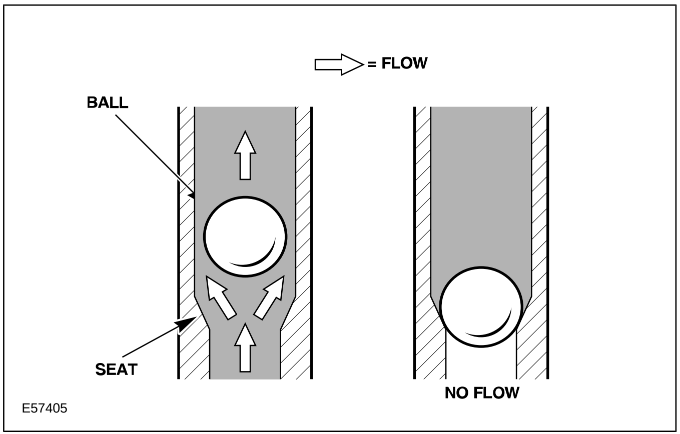
Two basic types of valves are used: the ball valve and the spool valve. All or most of the valves are contained in the control valve assembly (valve body).

Ball Valves

One-Way Ball Check Valve

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

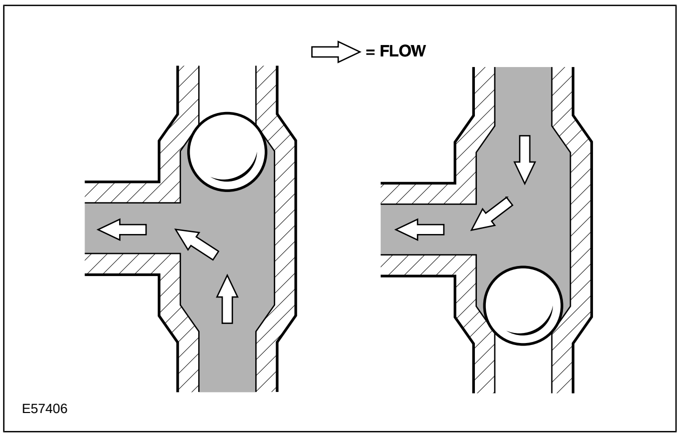
One-Way Ball Check Valve



Two-Way Ball Check Valve

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

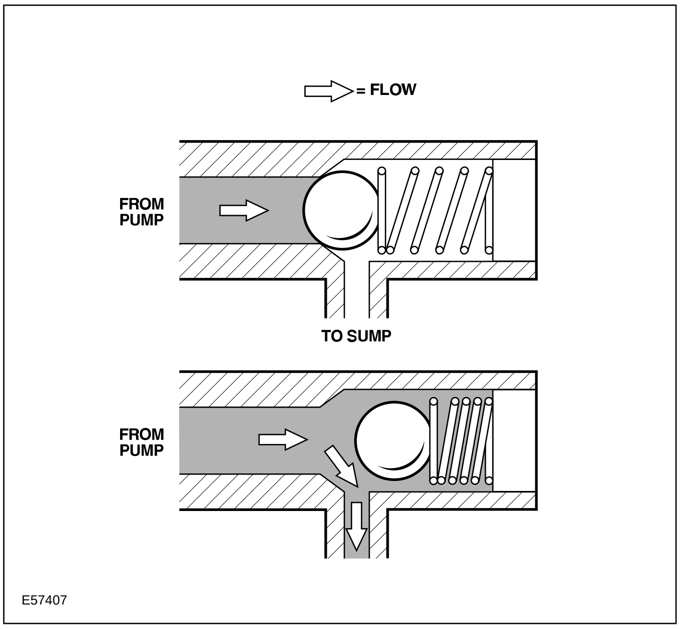
Two-Way Ball Check Valve



Ball Pressure Relief Valve

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

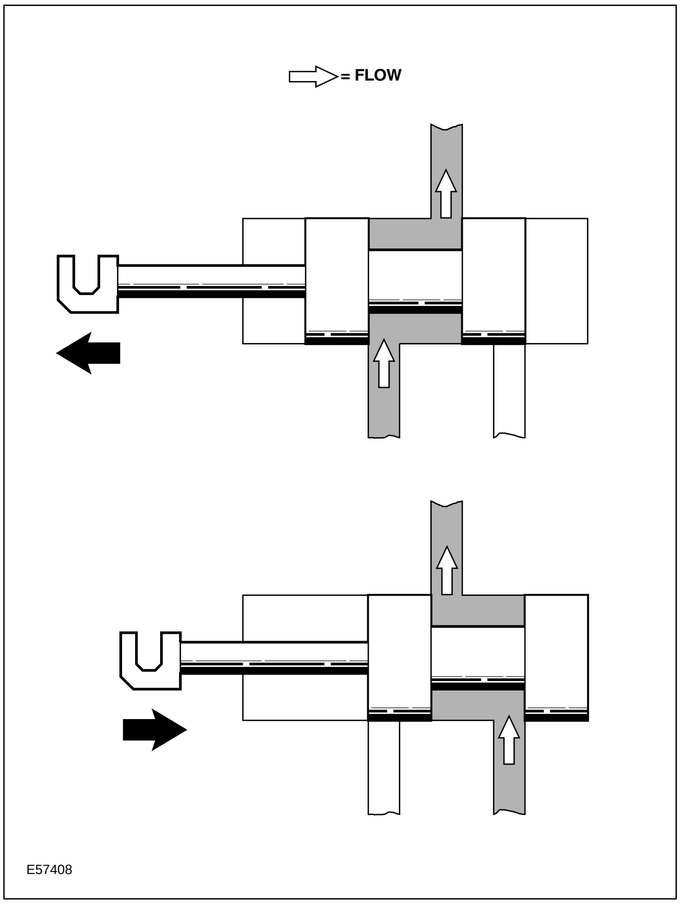
Ball Pressure Relief Valve



Spool Valves

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

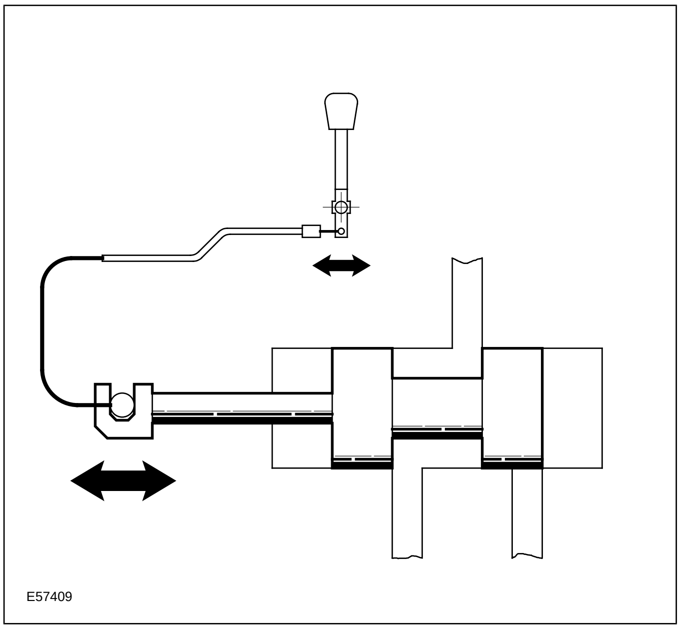
Basic Spool Valve



Manually Operated Spool Valve

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

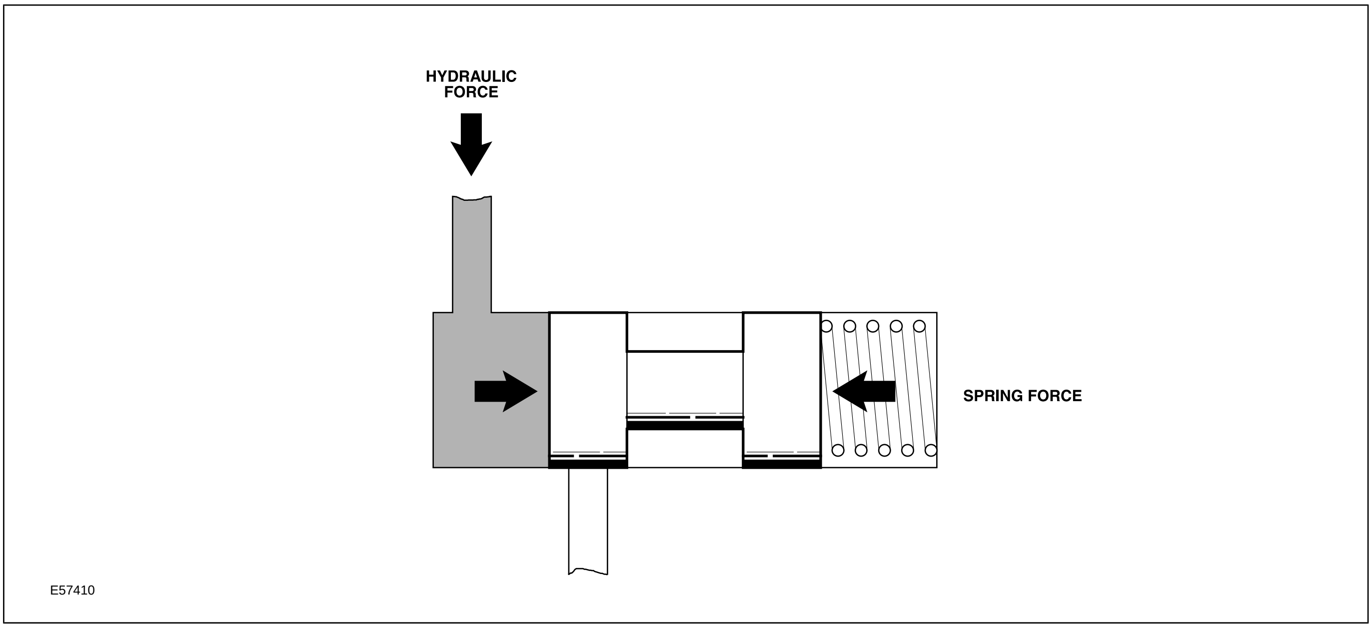
Manually Operated Spool Valve



Balanced Spool Valve

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

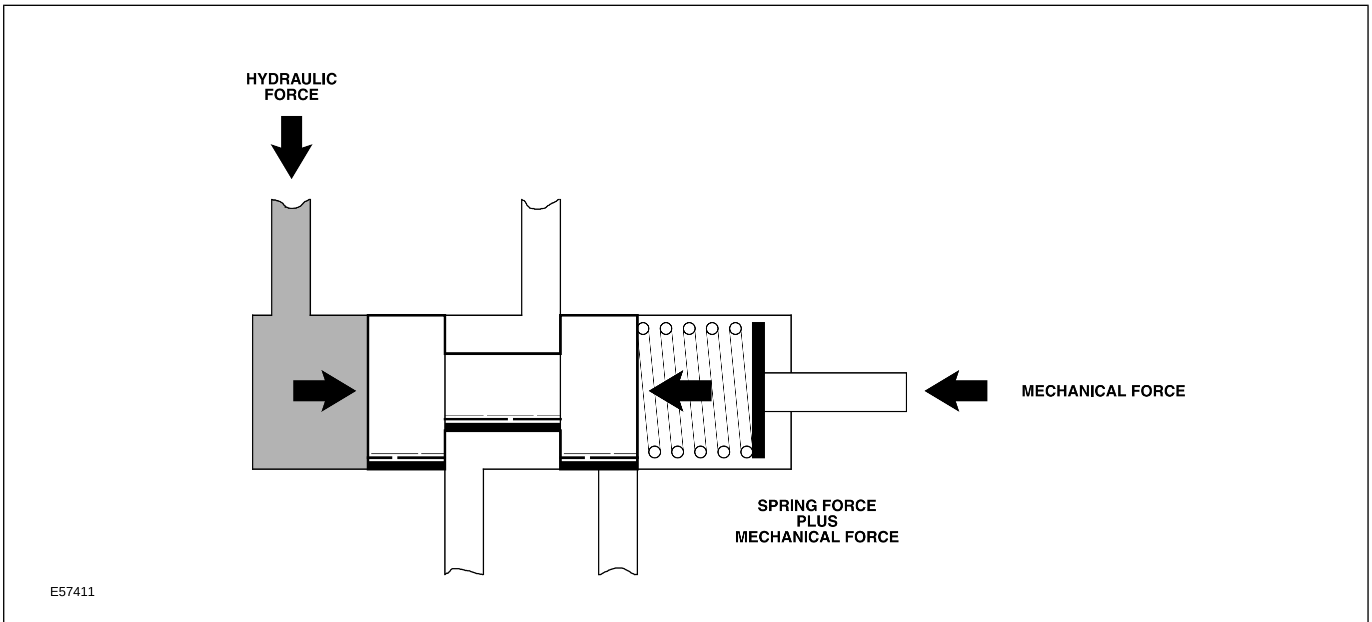
Balanced Spool Valve



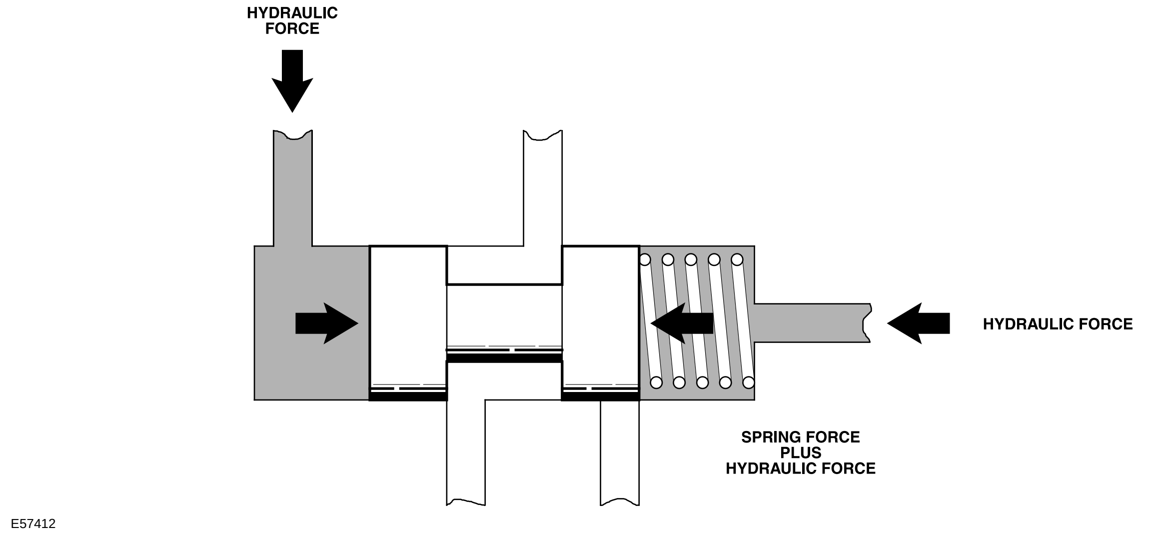
Variable Spring Pressure

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

Balanced Spool Valve: Mechanical Force



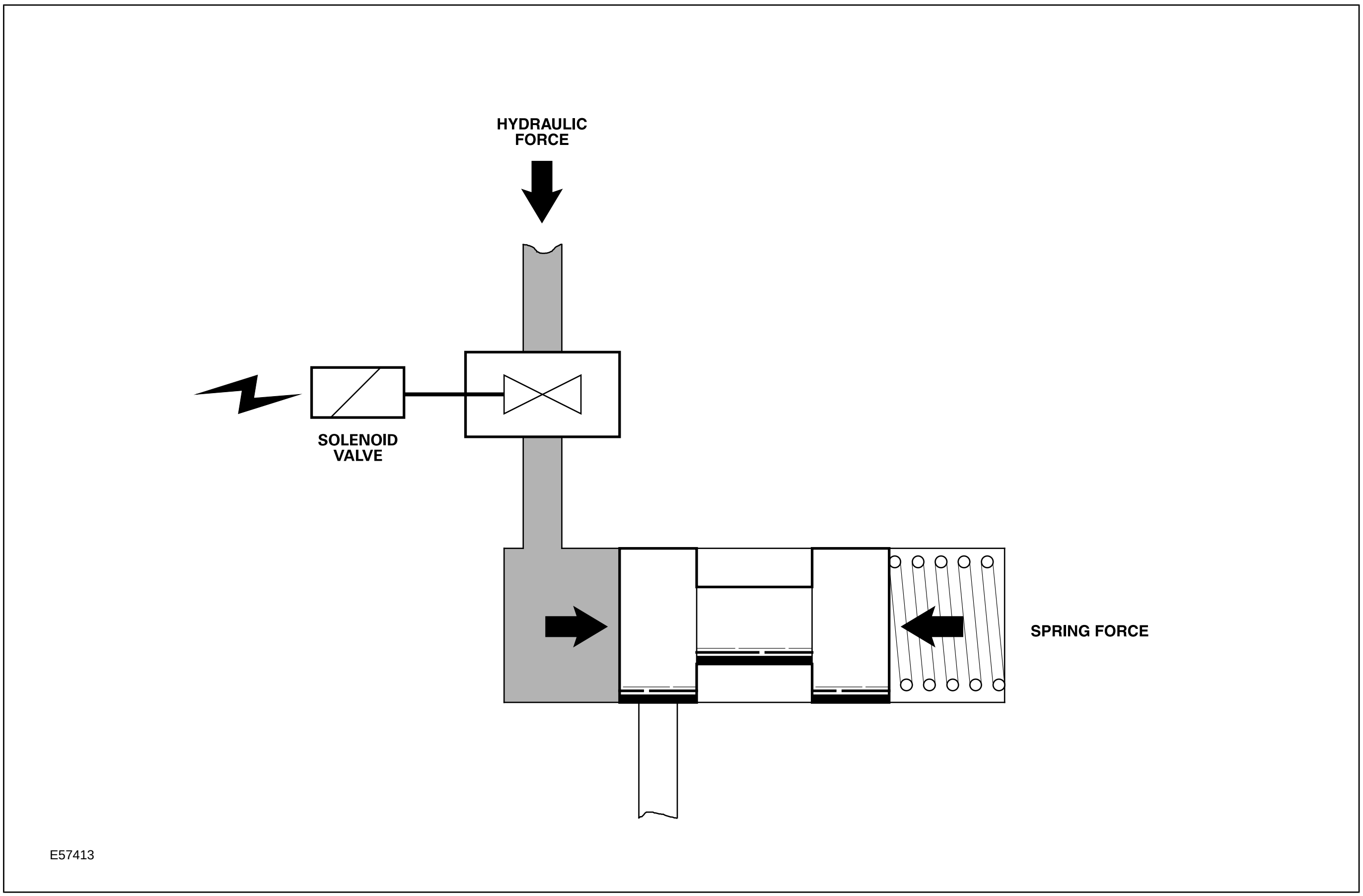
Balanced Spool Valve: Hydraulic Force



Solenoid Operated Spool Valve

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

Solenoid Operated Spool Valve



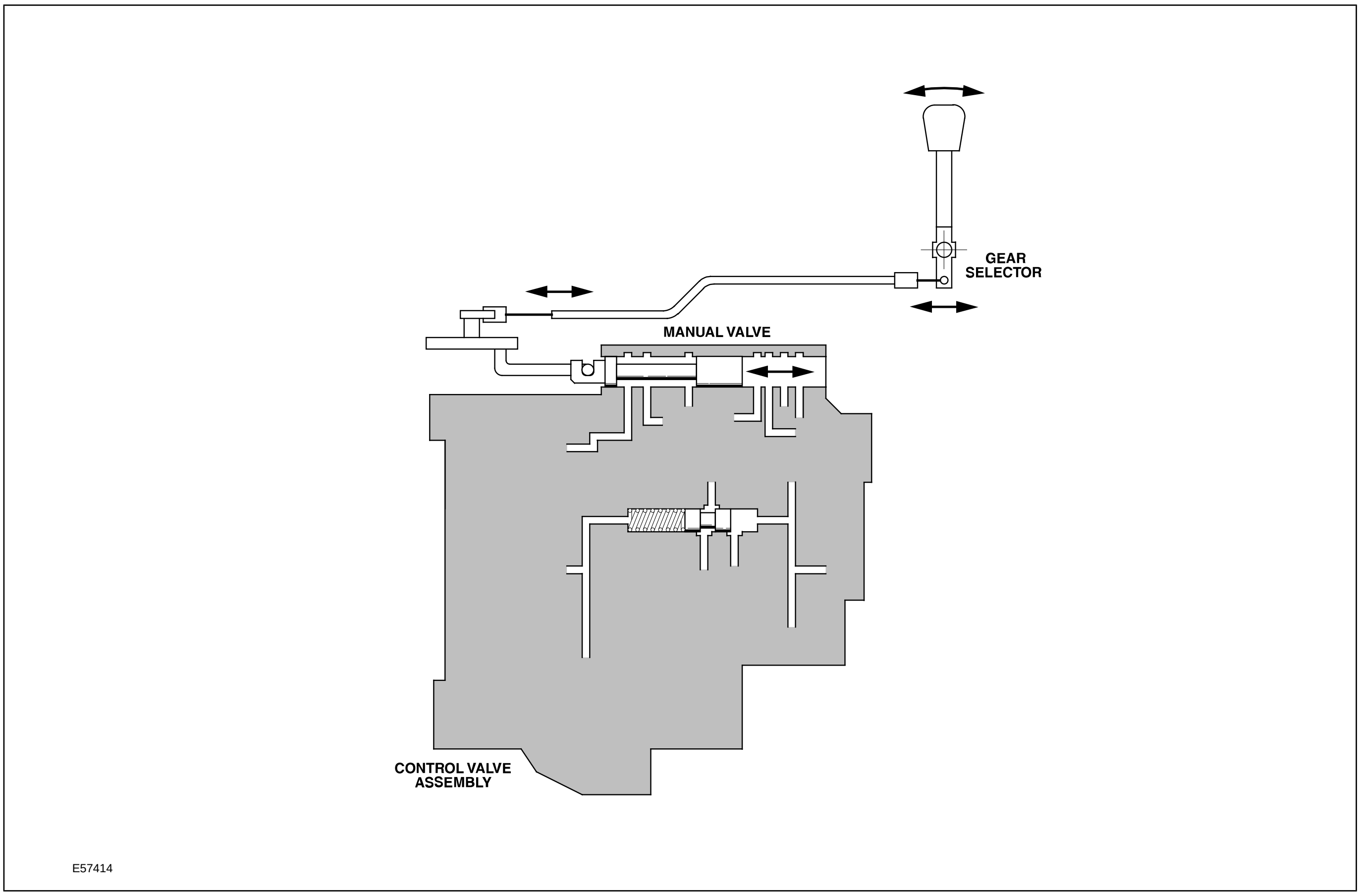
CONTROL VALVES (VALVE BODIES)

The control valve assembly, located at the bottom of the transmission, incorporates the transmission hydraulic apply and control circuits. It also contains the apply valves, pressure regulators, electronic components and some of the transmission sensors.

Manual Valve

The gear change valve in the valve body is positioned directly by the action of the driver, and is transmitted via the selector cable. This arrangement is called a manual valve. In electronically controlled transmission systems the manual valve is used to select only Drive (forward), Reverse and Neutral.

Manual Valve



CONTROL VALVES: CONVENTIONALLY CONTROLLED TRANSMISSIONS

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

Inputs to the control valve include:

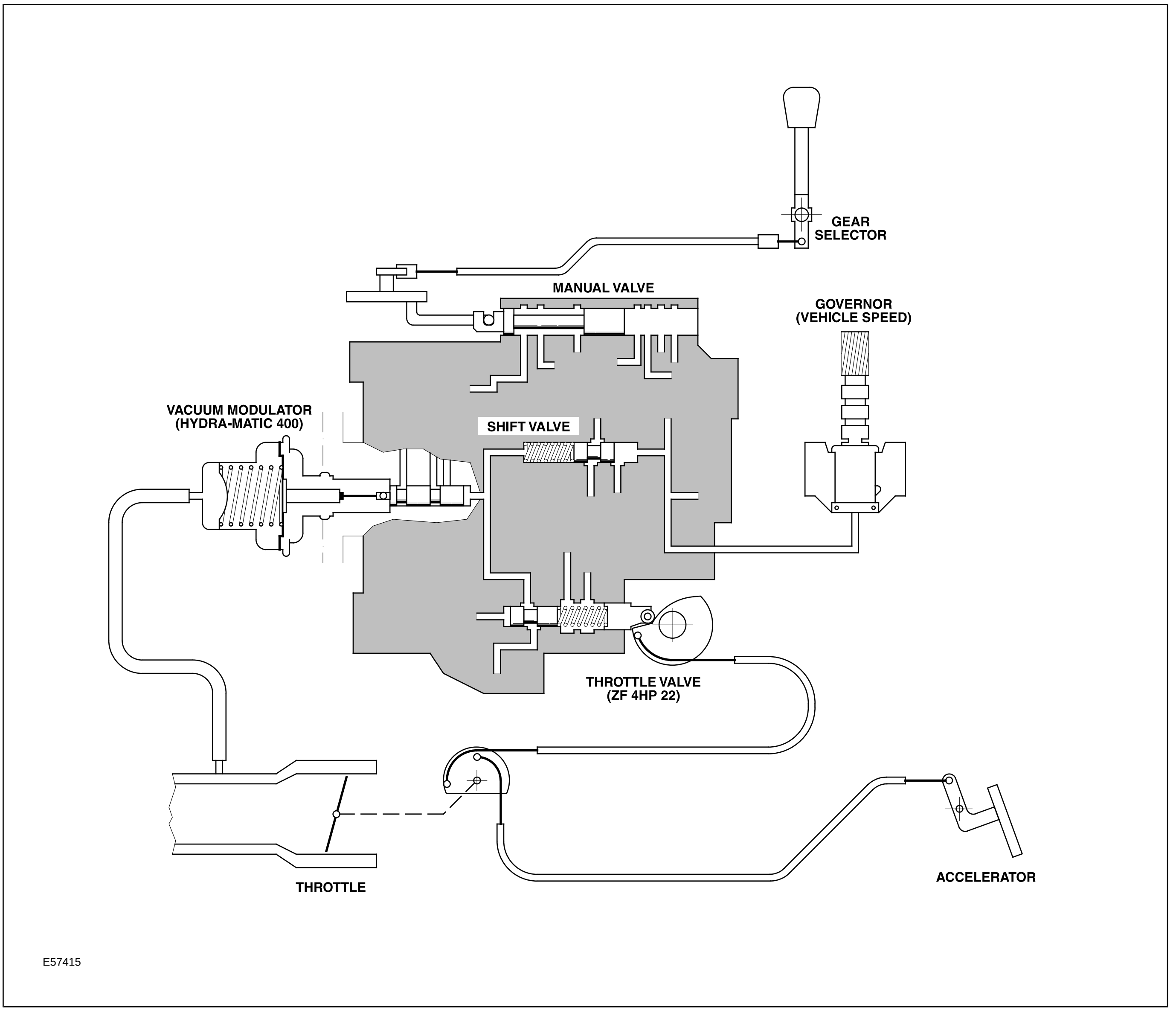
- Gear selection
- Engine load
- Vehicle speed

Control Valve Assembly

The main control components and arrangement of a conventional automatic transmission control valve are shown in the illustration. The system would use either a throttle valve (ZF 4HP22) or a modulator (Hydra-Matic 400) arrangement, not both.

NOTE: Both the ZF 4HP22 and the Hydra-Matic 400 transmission were used on earlier Jaguar models.

Control Valve (Conventionally Controlled Transmissions)



Engine Load and Road Speed

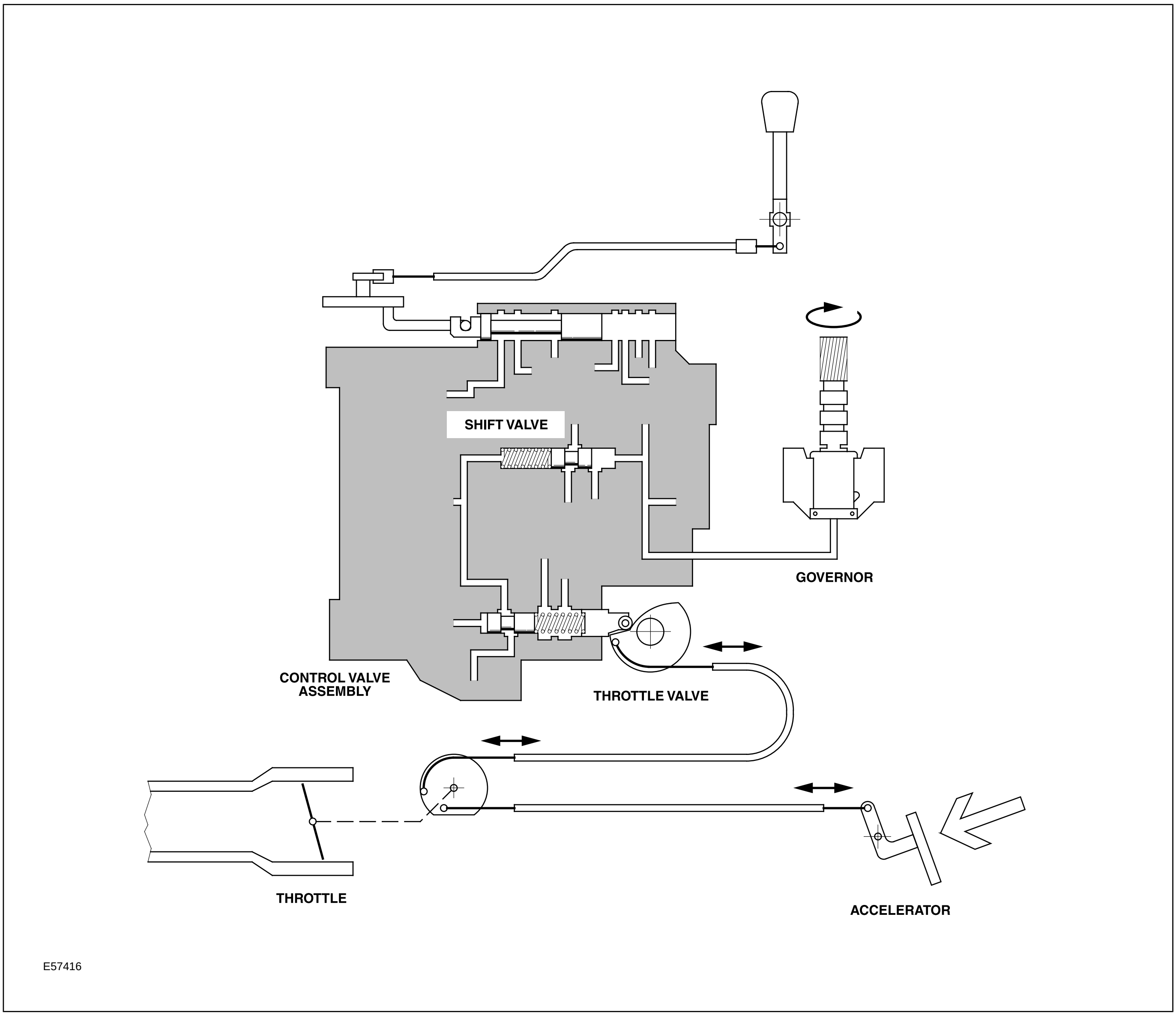
Engine load and road speed information is used by the transmission to vary the automatic shift points. Two types of systems are used in conventionally controlled transmissions: a throttle valve and governor system and a modulator valve and governor system.

Throttle Valve and Governor

Engine load is interpreted as the position of the throttle plate; road speed is interpreted as the governor hydraulic pressure. A cable is used to transmit the throttle position to the throttle valve. The position of the throttle acts on the spring of the balanced spool valve in addition to moving the valve. The change in fluid flow created by moving the valve signals the control valve (valve body) to shift the transmission. The hydraulic pressure acting against the spring pressure of the balanced valve is controlled by the governor.

The governor is driven by the transmission output shaft and varies the hydraulic pressure acting against the throttle valve depending on shaft speed. This process matches the transmission shift points to the engine load and road speed.

Throttle Valve and Governor (Conventionally Controlled Transmissions)

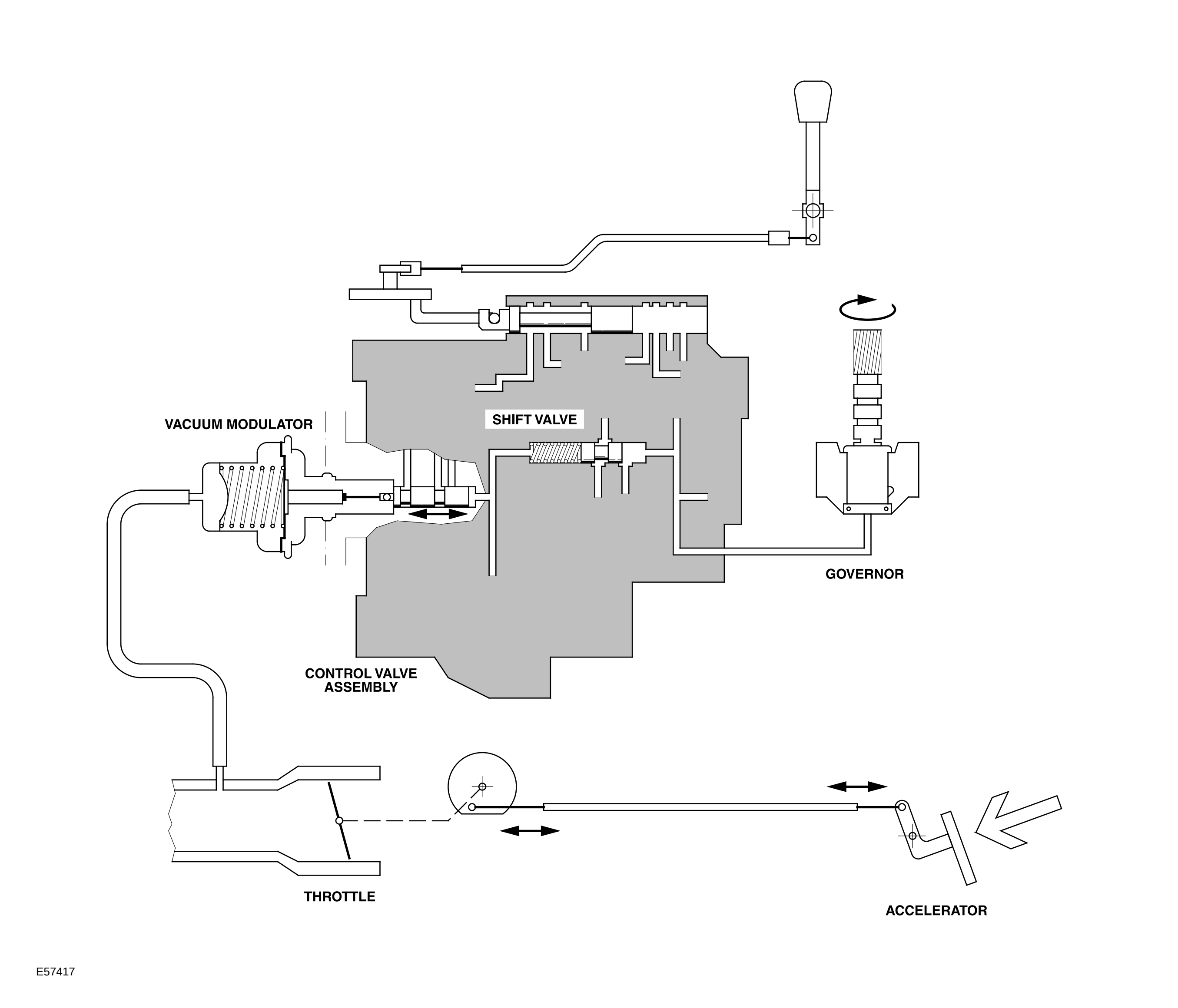


Modulator Valve and Governor

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

The governor pressure acts against the modulator valve to adjust hydraulic line pressure and achieve shift points matched to the engine load and road speed.

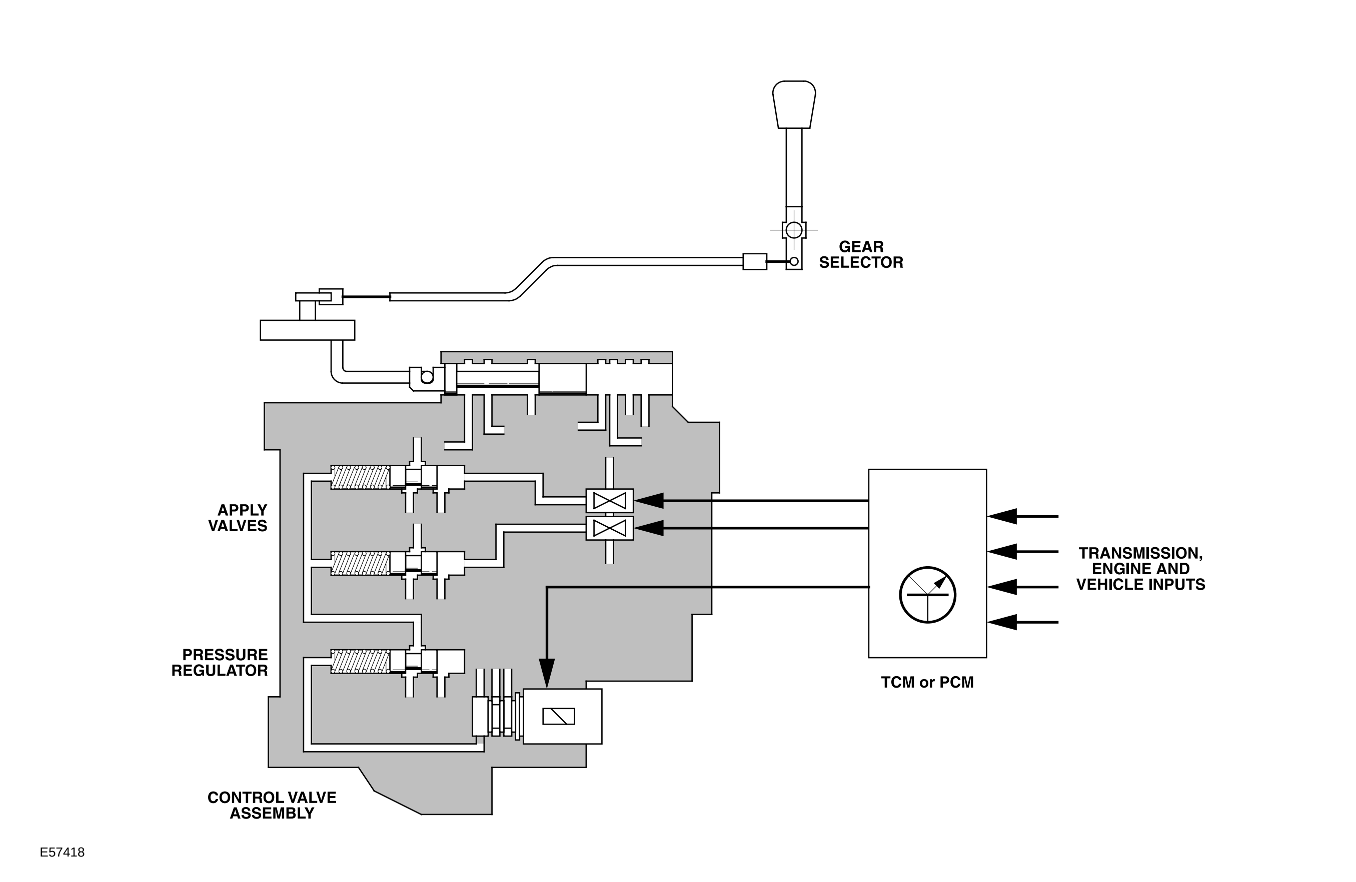
Modulator Valve and Governor (Conventionally Controlled Transmissions)



Electromechanical Control of Hydraulic Pressure

All apply functions and hydraulic line pressure are controlled by the transmission control module (TCM) or Powertrain Control Module (PCM). The TCM / PCM determines the necessary control outputs based on sensor inputs. The TCM / PCM matches the transmission shift points to the combined sensor inputs and positions the shift solenoids and pressure solenoids, which in turn control apply functions and transmission pressures.

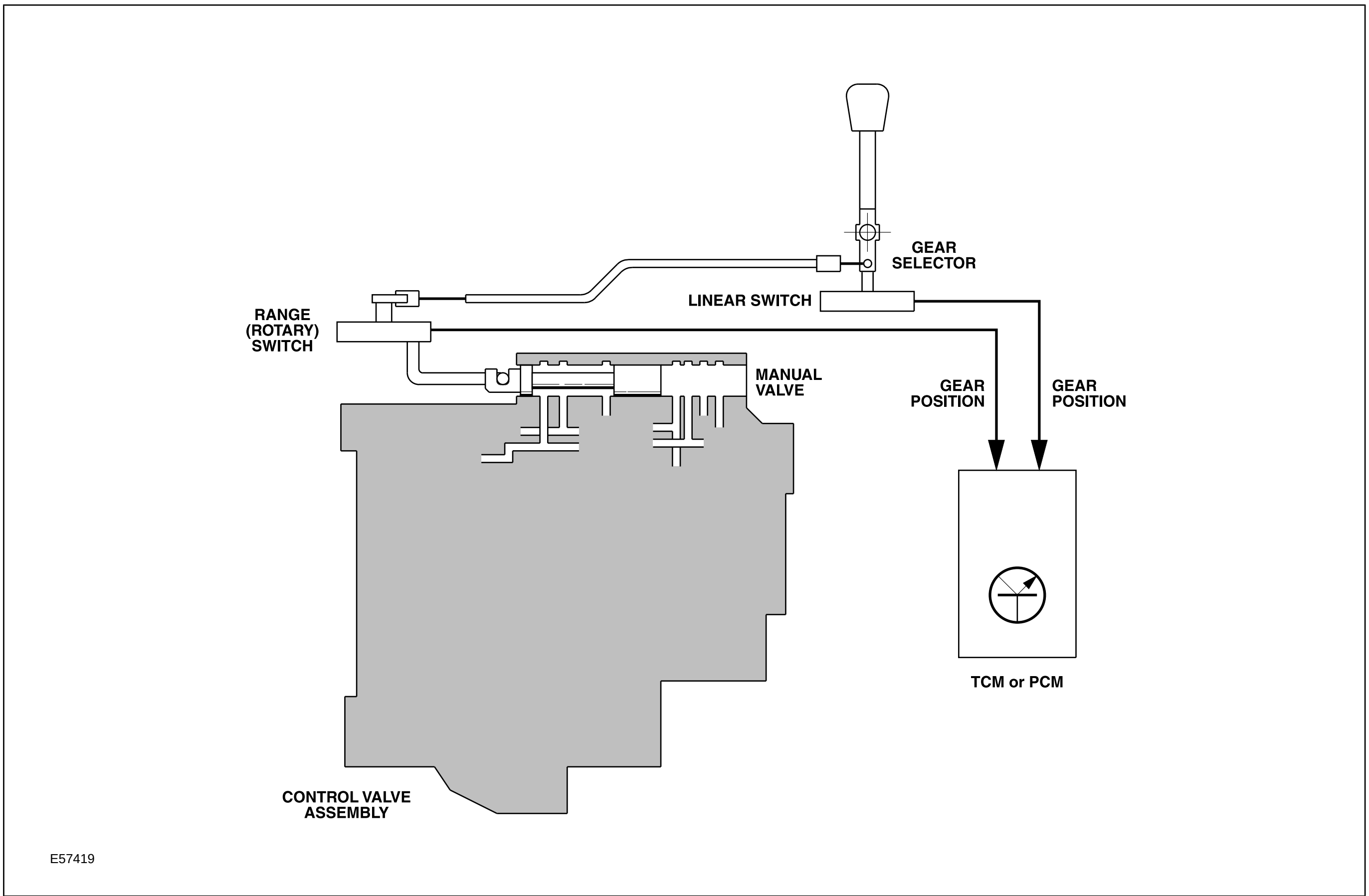
Control Valve



Gear Selector Position Input to the TCM / PCM

The position of the manual valve is input to the TCM / PCM differs depending on the type of transmission. The most common arrangement is the transmission range (rotary) switch, mounted outside the transmission over the selector shaft. When the selector shaft rotates, the driver selected gear is signaled to the TCM / PCM. A second arrangement is a linear gear position switch mounted at the base of the selector lever. As the selector is moved by the driver, the linear switch signals the selected gear lever position to the TCM.

Range / Linear Switch

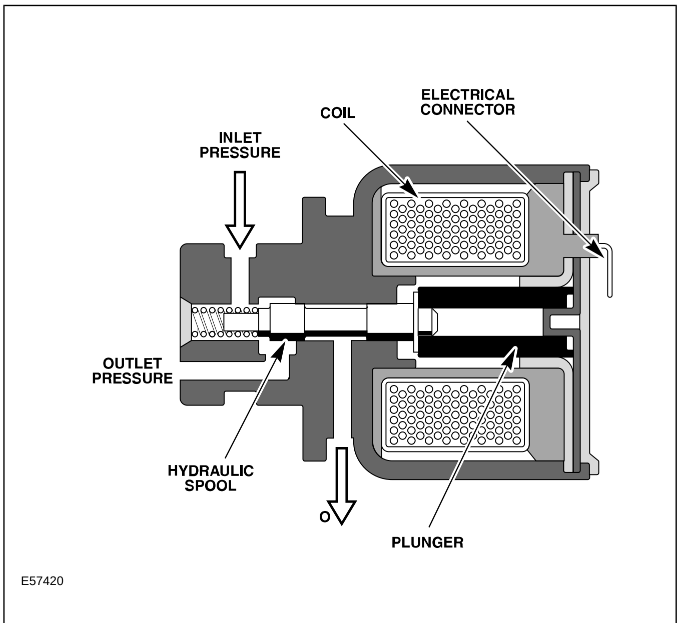


SHIFT AND PRESSURE SOLENOIDS

Shift Solenoids

Shift solenoids are located on the valve body and are used to apply upshifts and downshifts, as well as torque converter clutch lockup. The solenoid valves work in combination to direct hydraulic pressure to the various apply valves. The solenoid operating state is ‘0’ with the solenoid inactive and ‘1’ when the solenoid is energized.

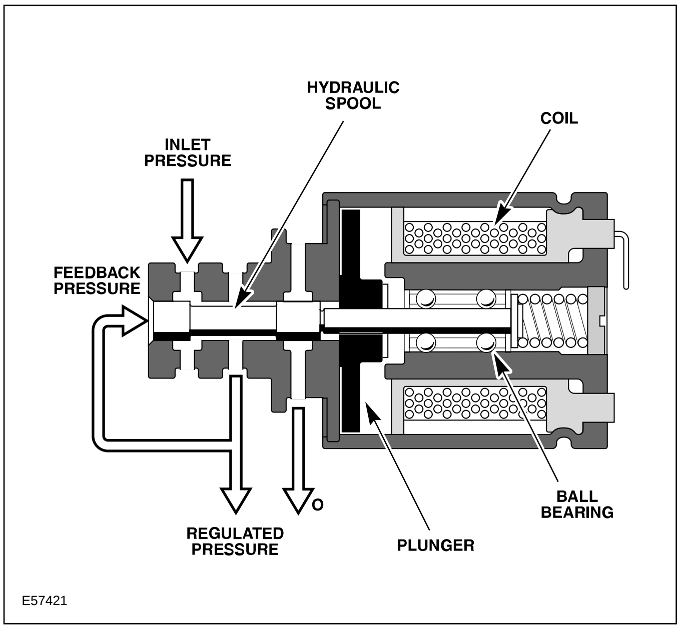
Typical Shift Solenoid



Pressure Control Solenoids

Transmission pressures are controlled by pressure control solenoids located on the valve body. The hydraulic spool is positioned to vary pressure based on Pulse Width Modulated (PWM) control.

Pressure Control Solenoid



PULSE WIDTH MODULATED (PWM) CONTROL

Pulse Width Modulated (PWM) control is an electronic means of switching a control signal ON / OFF to a control device such as a hydraulic pressure control solenoid so that it can be positioned as necessary to achieve a required hydraulic pressure.

In order for the solenoid to be positioned somewhere between fully closed and fully open to achieve the required hydraulic pressure, the control signal to the solenoid must be controlled in a way that allows infinite positioning between closed / open.

Frequency

With pulse width modulation, the control signal to the solenoid is switched ON and OFF very quickly at a frequency (cycles per second) normally expressed in Hertz (Hz). An average frequency for automotive application is approximately 300 Hz.

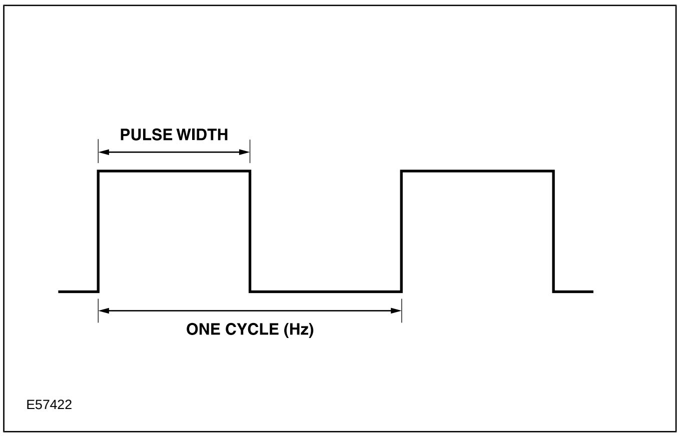
Duty Cycle

The length of time the control signal is switched ON during each cycle (pulse width) is varied by the control module and referred to as the duty cycle, normally expressed as a ratio percentage between 0 and 100. The duty cycle will determine the position of the solenoid because the solenoid cannot follow the rapid on / off control signal and assumes a position between the limits of travel proportional to the duty cycle.

Pulse Width

Only the pulse width is varied by the control module. The frequency usually remains fixed with PWM controlled devices.

Duty Cycle

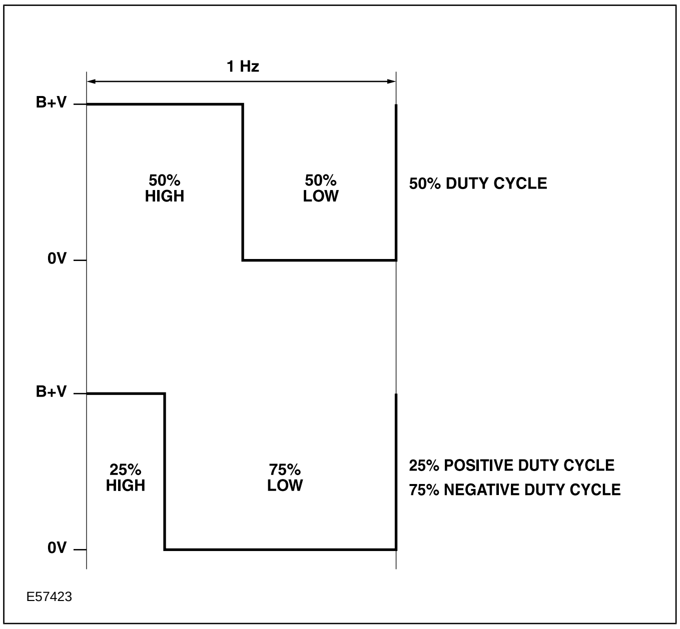


Positive / Negative Duty Cycle

The control signal can be either a power supply or ground. If the control signal is a power supply, the duty cycle is determined as the high voltage pulse (duty cycle high). If the control signal is a ground, the duty cycle is determined as the zero voltage pulse (duty cycle low).

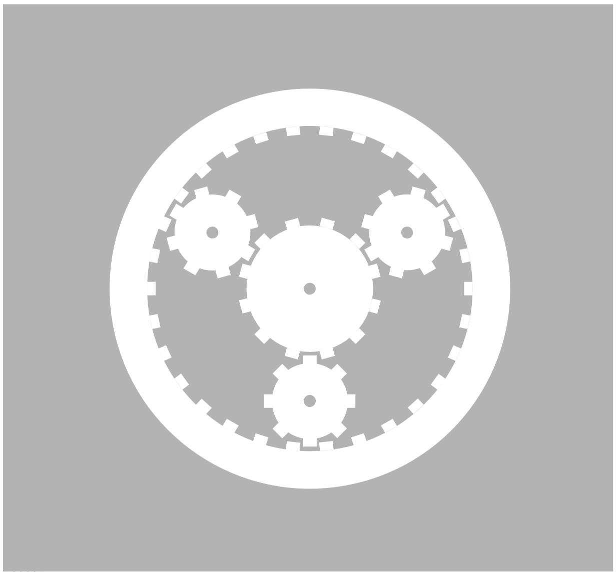
Before measuring or monitoring a PWM signal, first determine if the signal is a positive or negative duty cycle.

Positive/Negative Duty Cycle



Automatic Transmission

Lesson 3 - Transmission Control



Technical Training

T201.1 en 12/2004

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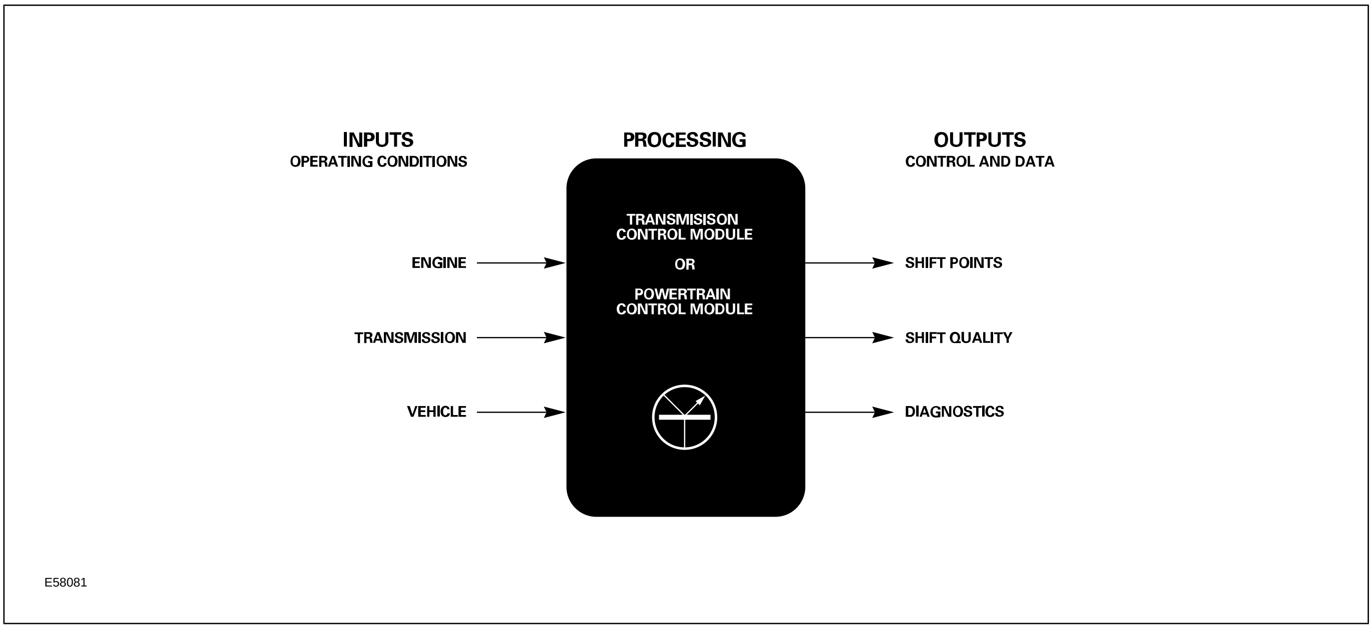
CONTROL MODULE

Electronically controlled automatic transmissions are power transmission systems that are centered around an electronic control module. The control module is able to communicate with sensors to evaluate transmission operating conditions, process the sensor information via programmed software and issue drive signals to the transmission electro-hydraulic apply and pressure regulation solenoids. In addition, the control module is able to communicate with engine and vehicle electronically controlled systems. This additional information, allows the control module to refine its transmission drive signals by accessing software strategies that correspond to the engine and vehicle operating modes. At its very basic level of control, the control module takes input signals from the transmission, engine, and the vehicle, processes the signals to access pre-programmed software strategies, and outputs drive signals to the transmission electronic components. During this process, the control module employs diagnostic test to monitor and report transmission system faults.

CONTROL MODULE COMMUNICATION

Basic Transmission Electronic Control



The transmission control module communicates with other vehicle systems, including:

- Engine management
- Anti-Lock Braking / Traction Control
- Instrument cluster (driver information)
- Diagnostic Connector

The control module can communicate with other vehicle systems in three ways:

- Hard-wire
- Network
- Combined control module and network

Hard-wire

Early transmission systems used hard-wired circuits to connect the transmission system with other vehicle systems.

Network: CAN / SCP

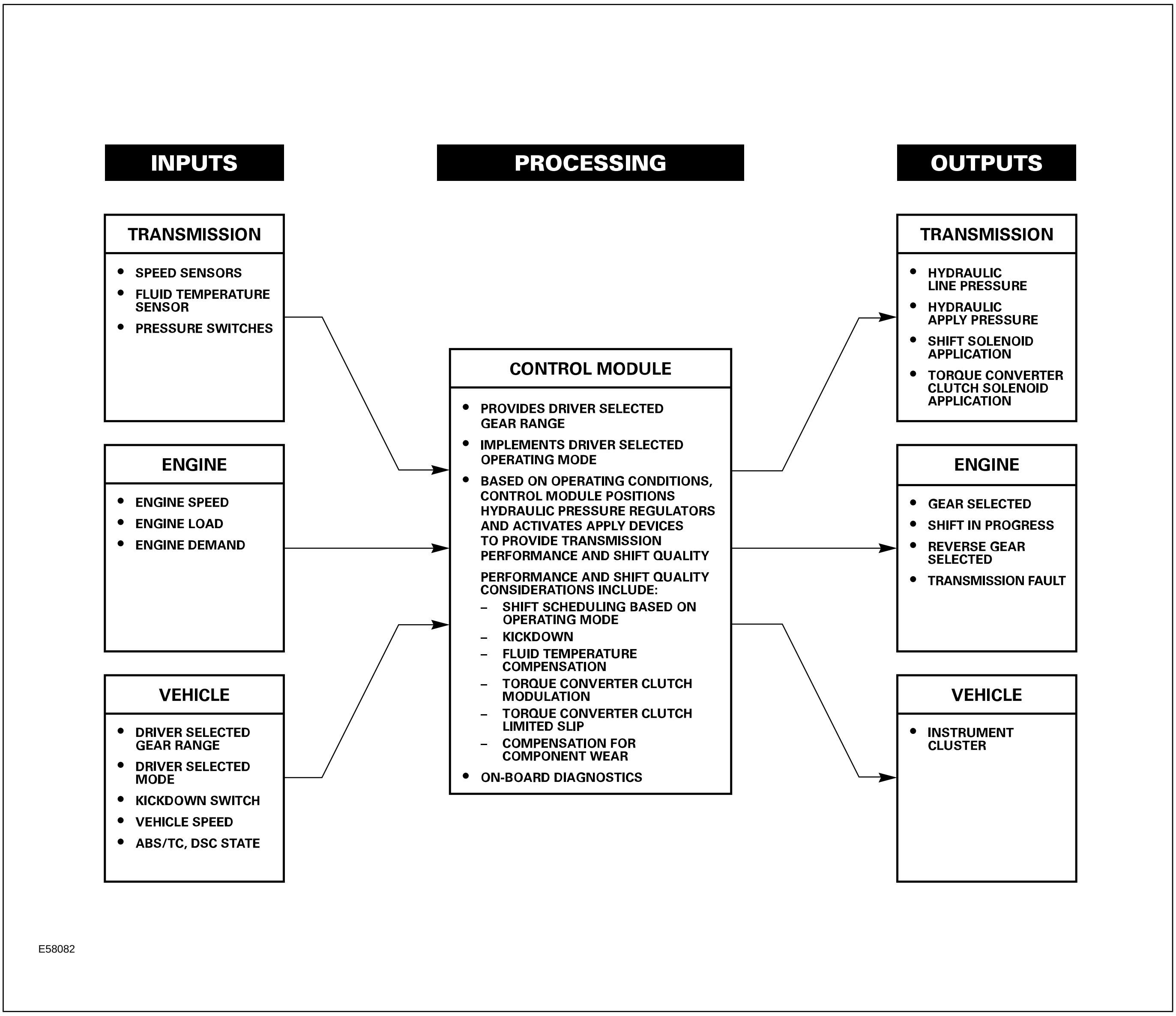
A controller area network (CAN) provides high speed communication between the transmission system and the other modules on the network. This network interfaces with the slower standard corporate protocol (SCP) “body systems” network at the instrument cluster.

PCM / SCP

A combined engine management and transmission controller (powertrain control module – PCM) eliminates the need for a CAN network. Additionally, the PCM is part of the SCP network, eliminating the need for a CAN / SCP interface.

CONTROL MODULE INPUTS

Control Module Inputs, Processing and Outputs



Control Module Inputs: Transmission

Transmission sensor inputs include speed, fluid temperature and in certain cases, pressure switches.

Speed Sensors

Depending on the transmission system design, speed sensors are located on or within the transmission case and provide an alternating voltage signal generated by reluctor teeth on internal rotating components. Speed sensors are use to signal torque converter turbine speed, intermediate transmission component speed(s), and transmission output speed.

Fluid Temperature Sensor

A temperature sensitive resistor (thermistor), located with the valve body electronic components and submerged in fluid, is used to supply a transmission fluid temperature voltage signal.

Pressure Switches

Hydraulic pressure switches (open / close) monitor hydraulic circuit(s) pressure and provide an ON / OFF signal.

Control Module Inputs: Engine

The main engine operating mode inputs to the control module include speed, load and demand. Most engine inputs are supplied from the engine control module (ECM).

Engine Speed

The engine speed signal, provided to the control module, is a calibrated input derived from the engine crankshaft position (CKP) sensor or the camshaft position (CMP) sensor.

Engine Load

The engine load signal, provided to the control module, is a calibrated input derived from the mass air flow (MAF) sensor.

Engine Demand

Throttle angle and rate of movement is calibrated and provided to the control module. This input is derived from the throttle position (TP) sensor and the accelerator pedal position (APP) sensor.

Control Module Inputs: Vehicle

Driver Selected Gear Range

The driver selected gear range (P, R, N, D, 4, 3, 2) is signaled to the control module as a “W – X – Y – Z” logic code. 0 = logic low voltage; 1 = logic high voltage. The signal is supplied either from a range sensor (rotary switch) mounted over the transmission selector shaft or a linear switch connected to the gear selector lever at the J gate.

Driver Selected Mode

The driver selected NORMAL or SPORT mode is signaled to the control module.

Kickdown Switch

Certain systems require a kickdown switch input to the control module. When activated by the position of the accelerator pedal, the switch closes to complete a circuit to ground.

Vehicle Speed

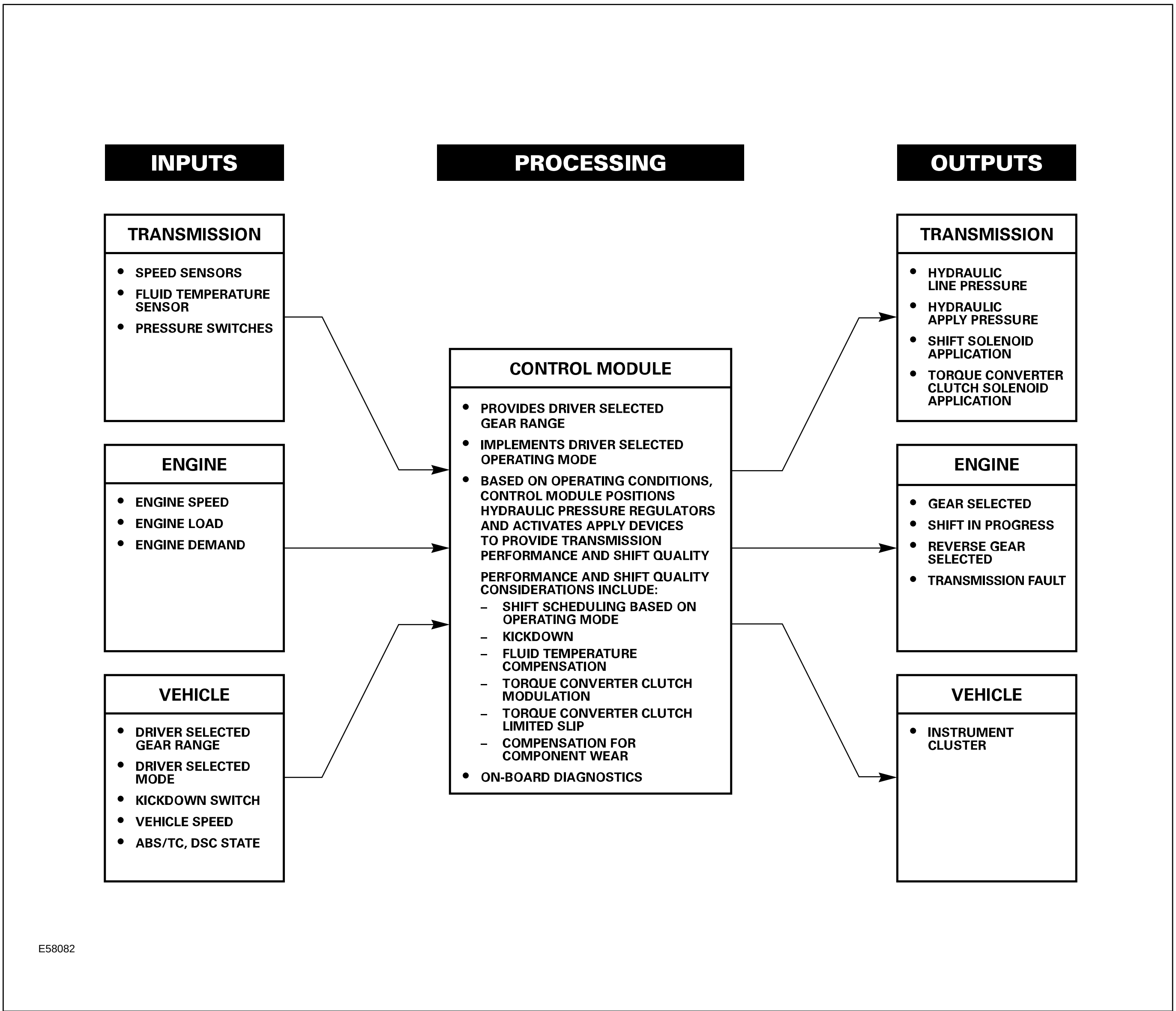
The vehicle speed input is supplied from the ABS/TC or DSC system and is derived from a designated wheel speed sensor.

ABS/TC, DSC State

The state of the ABS/TC or DSC system (ON / OFF) is input to the control module.

CONTROL MODULE INPUT PROCESSING

Control Module Inputs, Processing and Outputs



The control module processes the transmission input signals and inputs (signals / data messages) from other systems to perform the following control functions:

- It implements the driver selected operating mode.
- It provides the driver selected gear range.
- It positions hydraulic pressure regulators and activates apply devices via solenoids from programmed strategies based on current transmission, engine and vehicle operating conditions, to provide the required transmission performance while maintaining the desired shift quality.

Performance and shift quality considerations include:

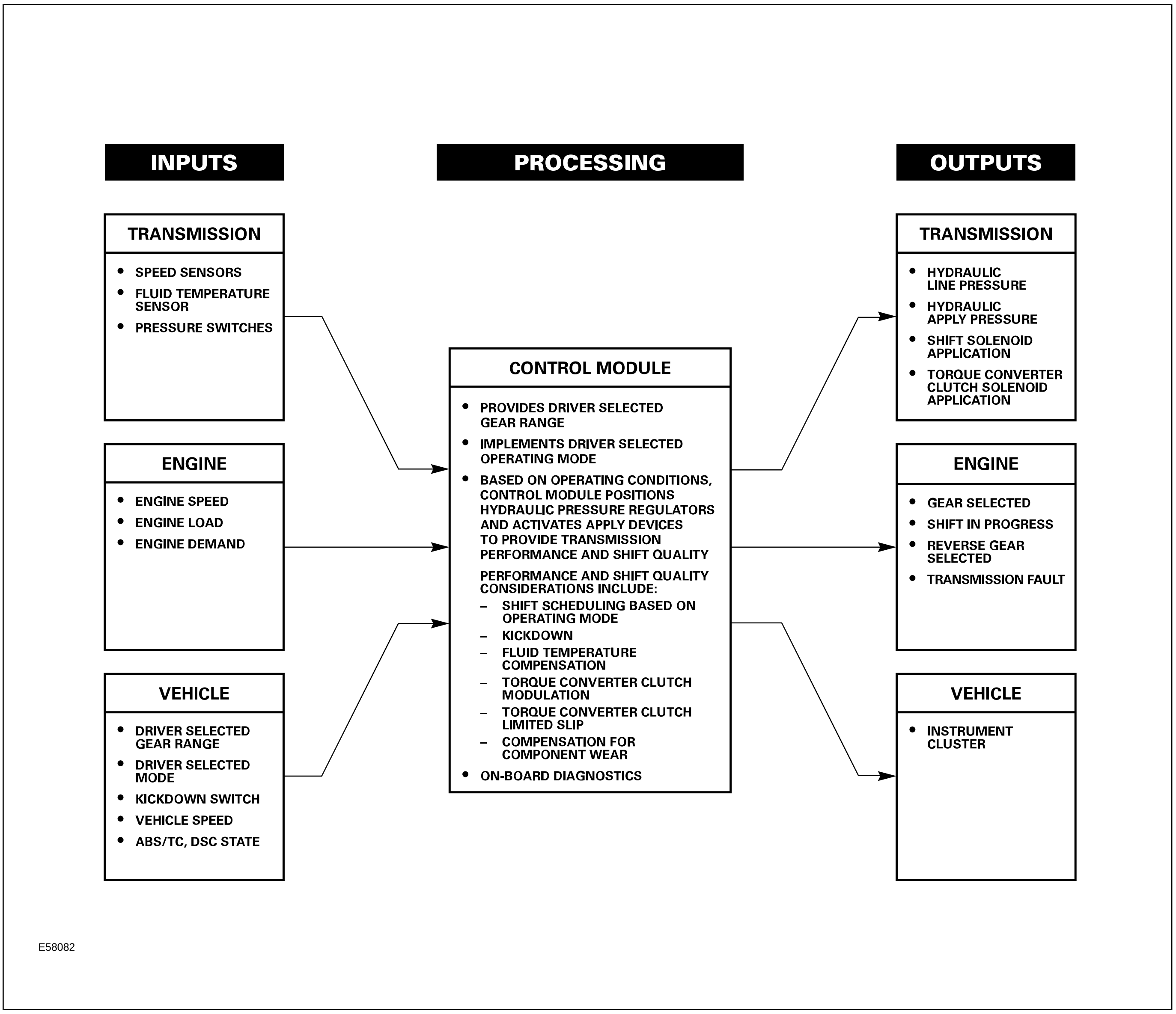
- Shift scheduling based on vehicle operating mode – acceleration, rapid acceleration, cruise, coast, idle, vehicle speed, ABS/TC or DSC active
- Downshift for rapid acceleration (kickdown)
- Fluid temperature compensation
- Torque converter clutch modulation

- Torque converter clutch limited slip
- Pressure and application adjustment to compensate for component aging (wear)

In addition, the inputs are processed for diagnostic checks on transmission components and circuits.

CONTROL MODULE OUTPUTS

Control Module Inputs, Processing and Outputs



Control Module Outputs: Transmission

The control module directs the transmission electronic pressure regulators and shift solenoids as necessary to achieve the required performance and shift quality.

Hydraulic Line Pressure

The control module “drives” a pressure regulator solenoid to adjust hydraulic “line” pressure (the maximum available transmission pressure).

Hydraulic Apply Pressure

The control module “drives” additional pressure regulator solenoids to vary component apply pressure.

Shift Solenoid Application

The control module positions the shift solenoid valves in combinations to achieve component applications that result in the desired gear. Shift solenoids can be either ON / OFF or momentary ON / OFF depending on the transmission system.

Torque Converter Clutch Solenoid Application

The control module positions the torque converter clutch solenoid with a PWM signal to achieve engage / disengage quality and in certain systems, allow clutch limited slip.

Control Module Outputs: Engine

The control module supplies signals / data messages to the engine management system so that engine control can be refined to accommodate the transmission system state. Examples include:

Gear Selected

The engine management system uses “gear selected” (P / N – D 4, 3, 2) for idle speed control refinement.

Shift In Progress

The engine management system uses “shift in progress” for momentary torque reduction to refine transmission shift quality.

Reverse Gear Selected

The engine management system uses “reverse gear selected” to reduce torque and limit power during reverse gear operation.

Transmission Fault

The engine management system uses “transmission fault” to limit power and prevent transmission damage (limp home).

Control Module Outputs: Vehicle

Control module outputs to the vehicle consist mainly of driver information messages.

Instrument Cluster

Driver transmission information examples include: selected transmission range / gear, CHECK ENGINE warning (transmission warning via engine management control module).

CONTROL MODULE ON-BOARD DIAGNOSTICS

The control module monitors the transmission system components and circuits for OBD II and non-OBD II faults.

Diagnostic Checks / DTCs

The control module conducts continuous diagnostic checks on transmission components and circuits. Detected faults are transmitted to the engine control module, which acts as an OBD II “host”, where they are logged and flagged as diagnostic trouble codes (DTC).

For example: The engine speed is compared to the transmission turbine speed to monitor and diagnose torque converter slippage / failure.

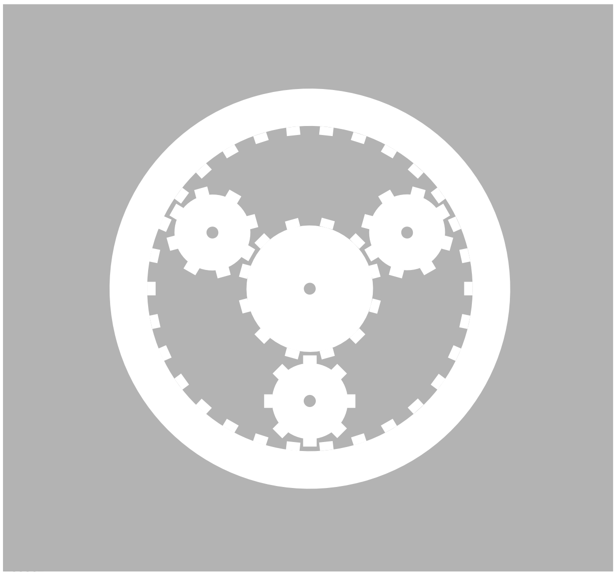
Default Actions

Many detected faults initiate default action by the control module. The default action usually involves other powertrain systems. This involvement may or may not be noticeable by the driver.

For example: If the transmission fluid temperature signal is lost, the control module will substitute the engine coolant temperature. This default substitution would not be noticed by the driver.

For example: In the case of a detected transmission mechanical, shift solenoid or pressure regulator solenoid fault, the control module will communicate the fault condition to the engine control module, which in turn will limit engine power to prevent transmission damage. This default action will be noticed by the driver.

Automatic Transmission
Lesson 4 - ZF 5HP24



Technical Training

T201.1 en 12/2004

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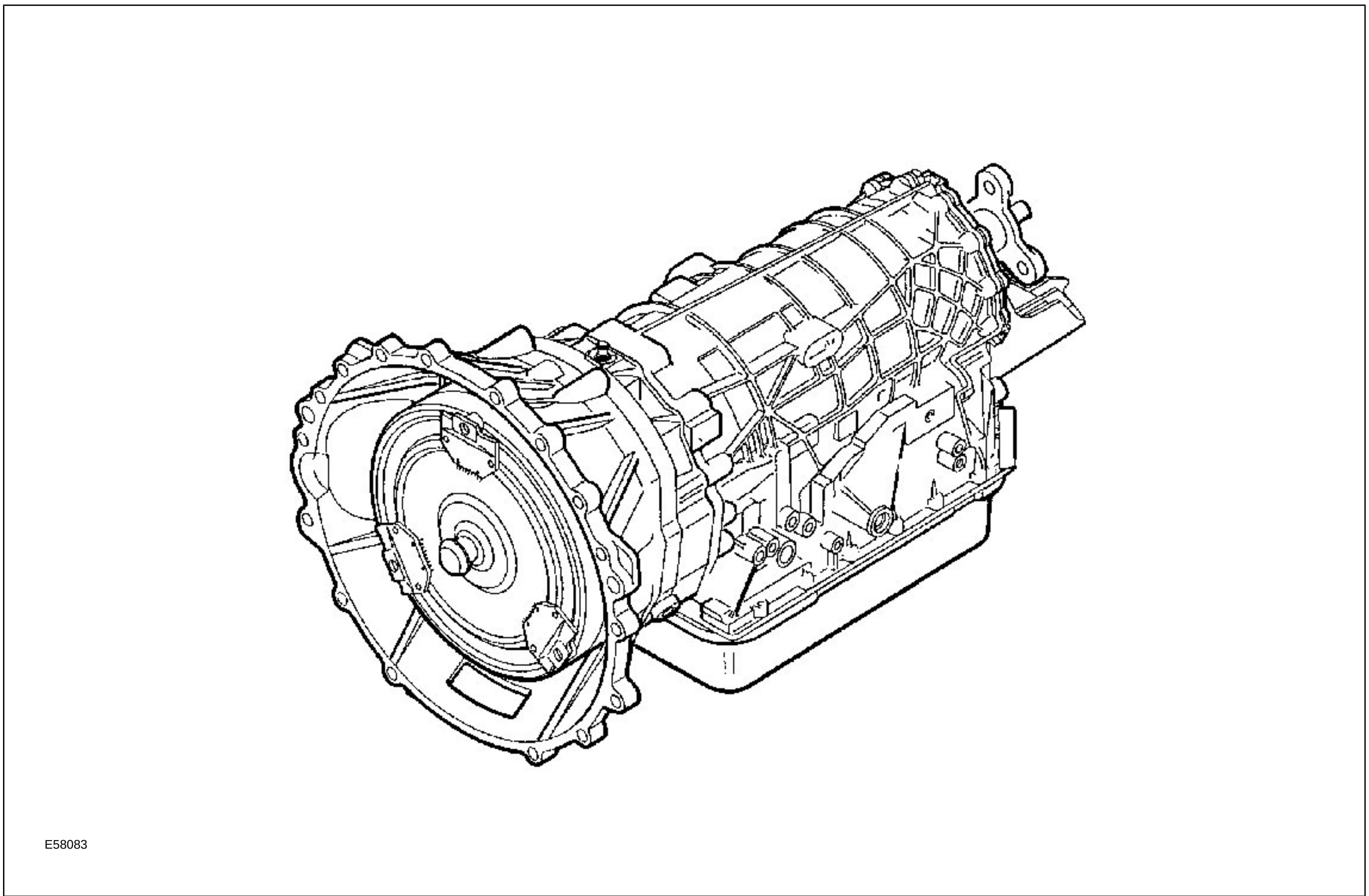
OVERVIEW

Normally aspirated XJ8 1998 – 2003 MY and XK8 1997 – 2002 MY Jaguar vehicles are equipped with the ZF 5HP24 five-speed automatic transmission system. The transmission and most of the vehicle interface components are mechanically identical for both vehicles.

The transmission is TCM (transmission control module) controlled. The TCM communicates with the engine management system, ABS/TC system and the instrument cluster via the high speed Controller Area Network (CAN). Gear selection occurs via the Jaguar style J-gate gear selector assembly that features fully automatic shifting (Drive) on the right hand side and driver controlled semi-manual shifting on the left hand side (4th, 3rd, 2nd). Normal and Sport transmission operating modes are selected by the driver via the mode switch located near the J-gate.

ZF 5HP24 Transmission

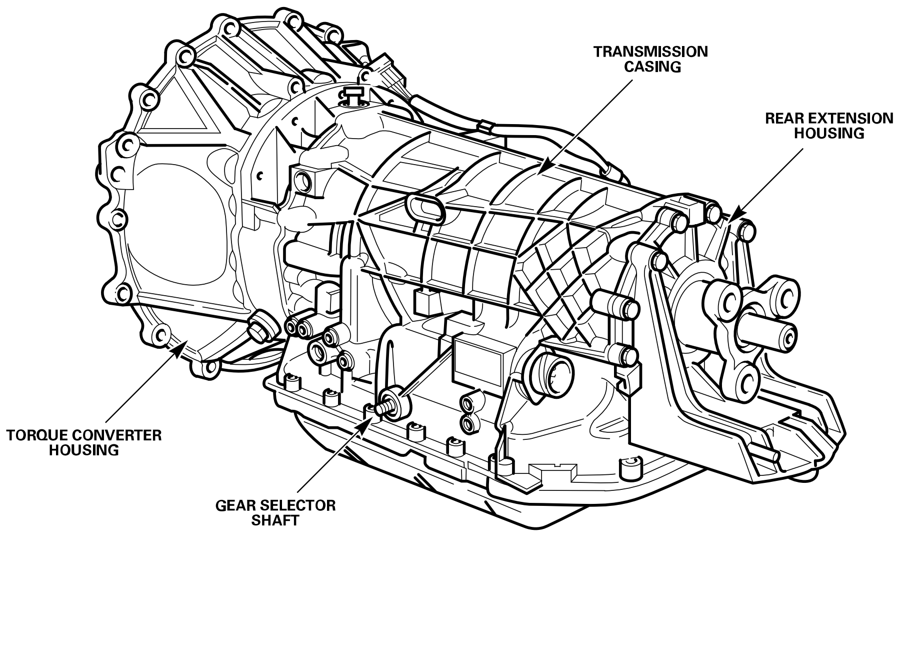


ZF 5HP24 is interpreted as follows:

- **ZF** – Transmission manufacturer
- **5** – 5 forward gears
- **HP** – Hydraulic Planetary type transmission
- **24** – Maximum torque designation (no units; higher number = greater torque)

ZF 5HP24 Specifications						
Transmission weight	95 kg (210 lb.) with torque converter and fluid					
Mechanical features	Transmission case in three sections – torque converter housing, main case and rear extension housing Torque converter with single-plate controlled slip lock-up clutch Planetary gear train (no brake bands)					
Transmission fluid	Capacity – 10 liters (10.6 quarts); filled for life Type – Esso ATF LT7114					
Transmission fluid cooler	External liquid-to-liquid cooler integral with the left hand side radiator tank					
Stall Test	There is no stall test specification for the 5HP24 transmission					
Gear ratios	**1st**	**2nd**	**3rd**	**4th**	**5th**	**Reverse**
	3.57	2.20	1.51	1.00	0.80	4.10

ZF 5HP24 Transmission



SYSTEM COMPONENTS

Torque Converter

The torque converter incorporates a single plate lock-up clutch, which is controlled by the TCM. The torque converter clutch (TCC) is applied by impeller hydraulic pressure and released by hydraulic pressure from a TCM controlled pressure control solenoid located on the valve body. The TCC is controlled on / off / controlled slip as determined by the TCM.

Gear Train

All forward gears and reverse gear are obtained from a planetary gear train consisting of:

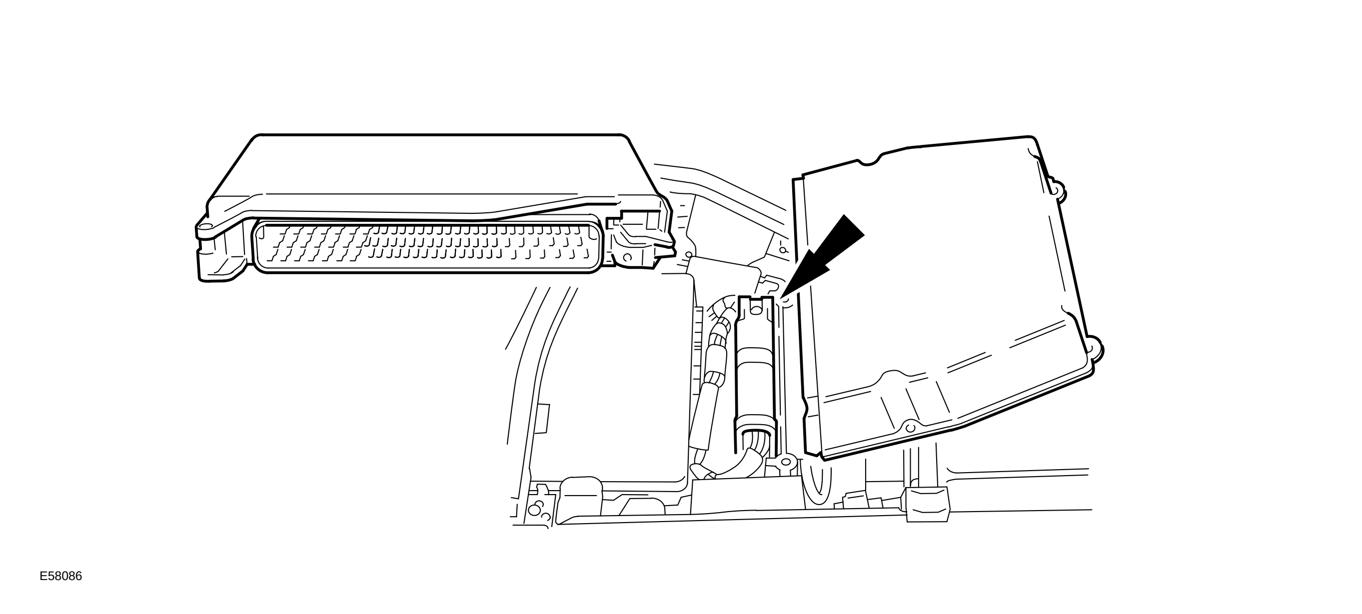
- Three single planet gear sets connected in series
- Three clutch packs – A, B, C
- Three brakes (lock to transmission case) – D, E, F
- One free wheel (sprag clutch) – 1.G

The individual gear ratios are obtained by driving certain planetary gear train elements while others are braked. Power is always transmitted to the output shaft via the last series connected planetary gear set.

TRANSMISSION CONTROL

The 5HP24 automatic transmission system is fully controlled by the transmission control module (TCM) located in the engine compartment “cool box” along with the engine control module (ECM). A high speed controller area network (CAN) allows communication between the TCM, ECM, ABS/TC CM, Gear Selector Illumination Module and the Instrument Cluster.

Transmission Control Module



ZF 5HP24 TCM control incorporates the following control features:

- Normal / Sport operational modes
- Shift scheduling / shift feel strategy
- Closed loop shift control
- Controlled overlap shifting
- Adaptive pressure control to account for component aging and operating conditions
- Specific driving conditions shift strategies:
  - Traction control
  - Gradient
  - Cruise control
  - Hot mode
  - Manual shift (M 2, 3, 4)
- Torque converter clutch on, off and controlled slip
- Shift energy management (engine torque modulation during shift)
- Engine torque reduction during “transmission failure”, Reverse
- On-board diagnostics (OBD II and non OBD II)
- Component failure default modes (mechanical and electronic “limp home”)

TCM Volatile Memory

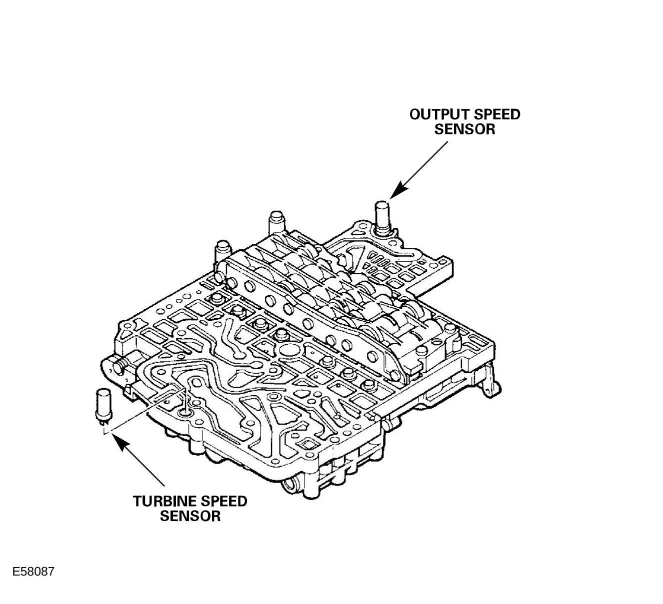
Adaptive values and DTCs are stored in TCM volatile memory. If the vehicle battery is disconnected, all TCM stored adaptive values DTCs will be lost. The TCM will relearn the adaptive values during the next driving cycle.

TCM Inputs – Transmission

Transmission Speed Sensors

The 5HP24 transmission has two speed sensors: the turbine shaft speed (TSS) sensor and the output shaft speed (OSS) sensor.

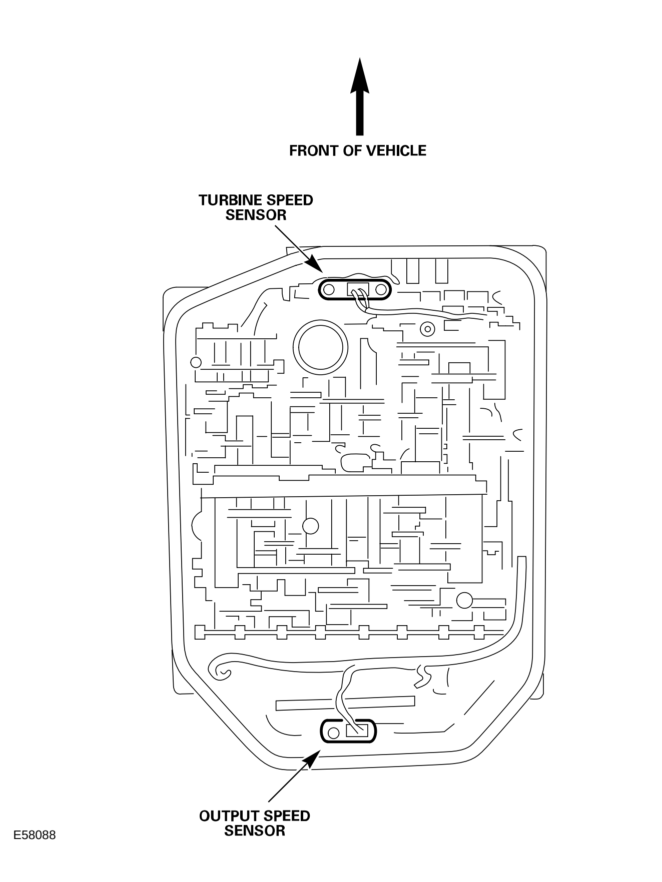
Transmission Speed Sensors



Both speed sensors are inductive pulse generators, which provide the TCM with a transmission speed alternating voltage signal. The pickup (coil) portion of the sensors are mounted to the valve body; the reluctors are integrated with transmission rotating components. The TSS sensor reluctor has 30 teeth; the OSS sensor reluctor has 36 teeth.

If the TSS signal is lost, the TCM defaults transmission operation to “mechanical limp home” mode (4th gear). If the OSS signal is lost, the TCM substitutes rear wheel speed (CAN message – ABS/TC).

Transmission Speed Sensor Location

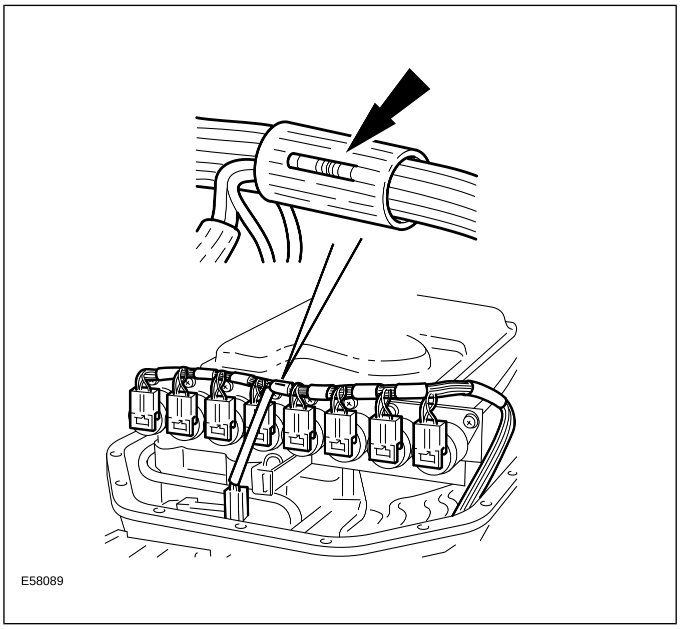


Transmission Fluid Temperature (TFT) Sensor

The TFT sensor, located within the valve body wiring harness, is a thermistor which has a positive temperature coefficient (PTC). Transmission fluid temperature is determined by the TCM by the change in the sensor resistance. The TCM applies 5 volts (nominal) to the sensor and monitors the voltage across the pins to detect the varying resistance.

If the TFT sensor signal is lost, the TCM will substitute engine coolant temperature (CAN message).

TFT Sensor



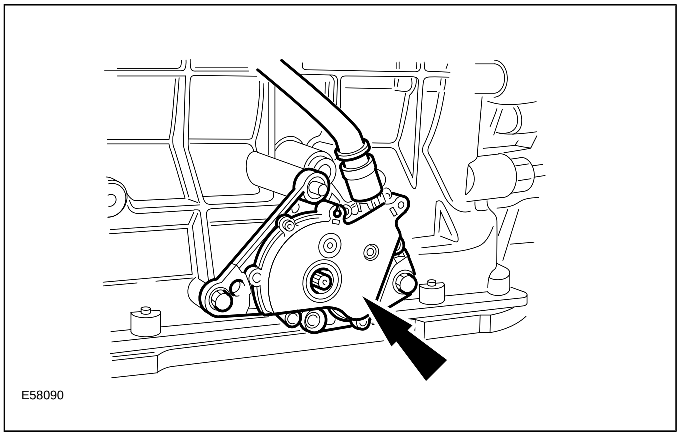
TFT Characteristics	
Temperature °C (°F)	**Resistance (Ohms)**
-20 (-04)	685
0 (32)	812
20 (68)	953
40 (104)	1107
60 (140)	1256
80 (176)	1458
100 (212)	1653

Transmission Rotary Switch

The digital rotary switch is mounted on the right hand side of the transmission and is operated by transmission gear selector shaft. Selection of a particular gear generates a 4-bit binary coded signal which is transmitted directly to the TCM over a four-wire parallel interface. In addition to the gear selector positions, the rotary switch incorporates a separate Park/Neutral open/close switch used for engine start inhibit.

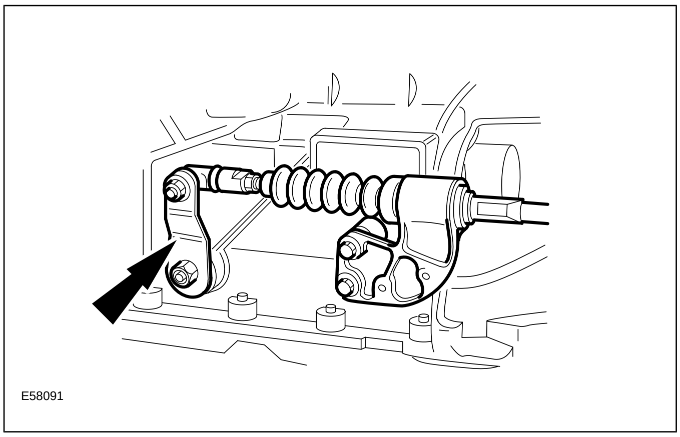
The rotary switch bolts directly to the transmission case and does not require a service tool for installation.

Rotary Switch



NOTE: If the selector cable is incorrectly adjusted, the range selector may transmit an invalid code, which would cause a DTC to be flagged.

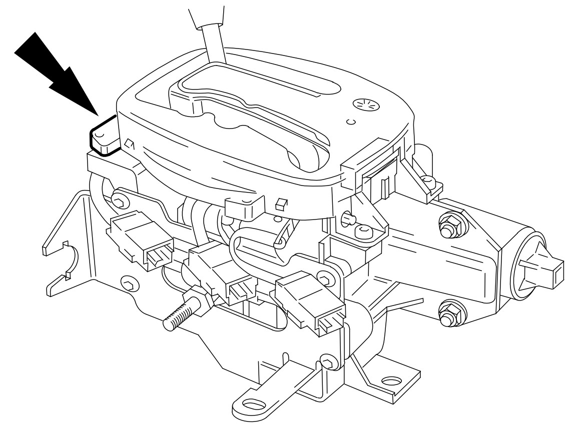
Gear Selector Lever



D – 4 Switch

The normally open D – 4 (Drive range) switch, located at the J-gate selector, provides the TCM with a voltage input when the gear selector is moved from one side to the other. This input is required as no selector cable or range sensor movement occurs during the sideways movement.

D – 4 Switch



WDS Datalogger Readings

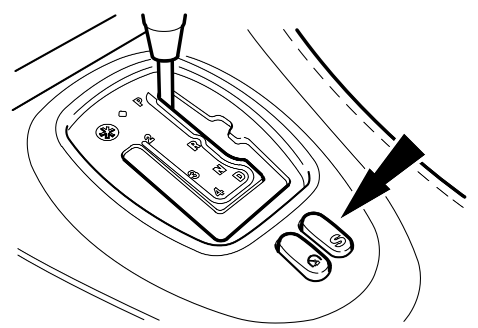
WDS Datalogger readings for the range sensor and the D – 4 switch will show as follows:

Range Sensor / D–4 Switch Output Status					
RANGE	**SWL1**	**SWL2**	**SWL3**	**SWL4**	**D4SW**
Park	1	0	0	0	0
Reverse	0	1	0	0	0
Neutral	1	1	1	0	0
Drive	1	0	1	1	0
Manual 4th	1	0	1	1	1
Manual 3rd	0	1	1	1	1
Manual 2nd	0	0	0	1	1
SWL 0 = closed / low voltage; 1 = open / high voltage **D4SW** 0 = open / low voltage; 1 = closed / high voltage (B+)					

Mode Switch

The mode switch allows the driver to select between Normal and Sport modes (transmission operating strategies). Sport mode strategy moves the transmission shift characteristics so that upshifts occur at higher engine speeds.

Mode Switch



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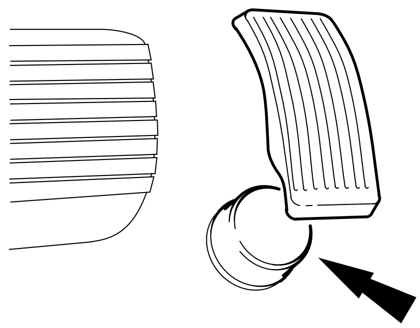
Kickdown Switch / Accelerator Pedal Stop

The normally open kickdown switch (fitted to early vehicles only), provides the TCM with a voltage input when the accelerator is fully depressed (full throttle). This input signals the transmission to provide maximum acceleration. An adjustable stop limits accelerator pedal travel. 1999 MY onwards vehicles are equipped with a pedal stop incorporating a simplified adjustment method. Both the kickdown switch and the pedal stop must be adjusted using WDS.

NOTE: Current production vehicles do not incorporate a kickdown switch as the TCM is able to determine “kickdown” from the CAN Accelerator Pedal Position message.

Kickdown Switch/Pedal Stop Location



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TCM Inputs – Engine (CAN)

Several engine management derived inputs are used by the TCM for transmission control processing. All of the inputs are received from the engine control module (ECM) as data messages via the controller area network (CAN). The inputs are used by the TCM to determine the required transmission control.

NOTE: The examples of TCM input usage may be incomplete.

Engine Torque

The ECM calculates engine torque from the engine speed and engine load (MAF) signals and continuously communicates the calculated value on the CAN network. Engine torque is used by the TCM as one of the factors for determining transmission hydraulic pressures and for torque converter clutch control.

Throttle Position / Accelerator Pedal Position

The ECM communicates the actual throttle and accelerator pedal position. These inputs are used by the TCM as factors for determining shift scheduling and torque converter clutch control.

Engine Coolant Temperature / Engine Oil Temperature

These inputs are used by the TCM as factors for determining shift scheduling, torque converter clutch control and the initiation of Hot Mode.

Cruise Control

When cruise control is active, the TCM uses a cruise control strategy for transmission control. The strategy is canceled when the driver switches off cruise control or activates the brake cancel switch.

TCM Inputs – ABS / TC (CAN)

Inputs from the anti-lock braking / traction control module include:

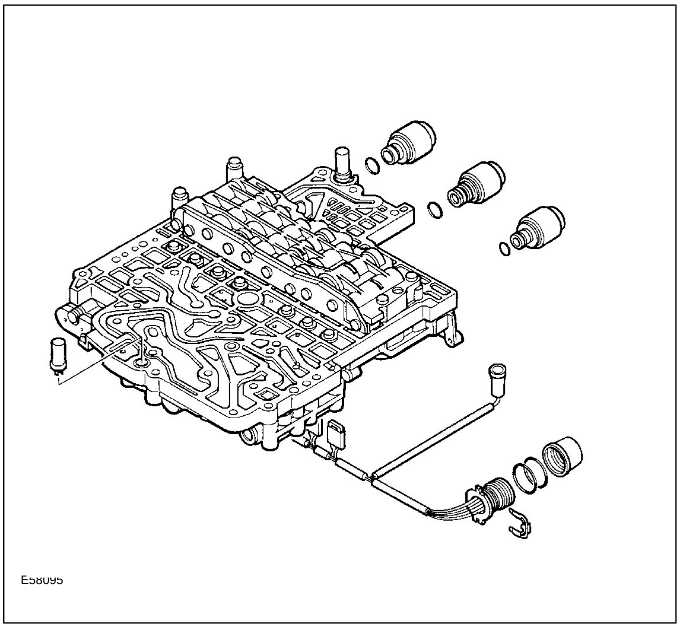
- Vehicle speed (front wheel speed)
- Rear wheel speed
- Anti-lock braking / traction control status

The ABS/TC inputs allow the TCM to refine shift scheduling and react to ABS/TC events. In addition, the TCM will substitute the rear wheel speed if the output speed sensor signal is lost.

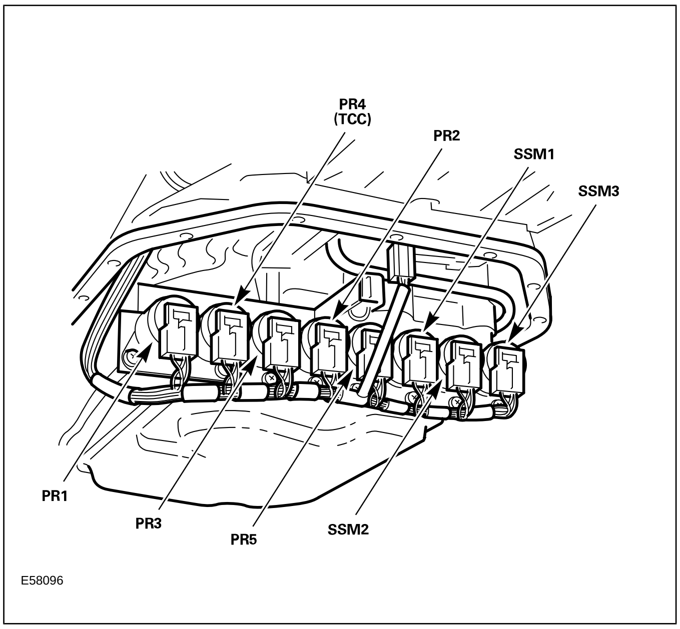
TCM Transmission Control Outputs

The TCM controlled transmission actuators are incorporated into the transmission valve body assembly. The ZF 5HP24 uses three shift solenoids and five pressure control solenoids

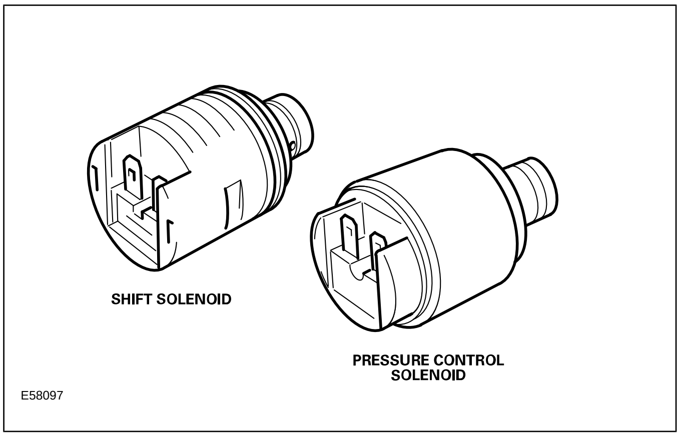
Valve Body



Solenoid Locations



Shift and Pressure Control Solenoids



Shift solenoids SSM1, 2 and 3 are used to shift the transmission through all forward gears and reverse. They are two-way on / off normally closed solenoids. The TCM controls the solenoids by switching the ground side of the circuit.

Pressure control solenoid PR4 is PWM driven by the TCM to apply and release the torque converter clutch (TCC). By using pressure control, the TCM is able to allow controlled slip of the TCC.

Pressure control solenoids PR1, 2, 3 and 5 are PWM driven by the TCM to control transmission line, apply and modulation pressures. Solenoids PR2, 3 and 5 are driven either on, off or modulated (controlled). Solenoid PR1 (line pressure) is always modulated.

The TCM PWM drive to the pressure control solenoids switches the ground side of the circuits.

Application Chart								
Solenoid Logic								
RANGE	**SSM1**	**SSM2**	**SSM3**	**PR1**	**PR2**	**PR3**	**PR4 (TCC)**	**PR5**
R	ON	OFF	OFF	C	(O)	ON	OFF	(O)
P, N	ON	OFF	ON	C	(O)	ON	OFF	(O)
D 1	ON	OFF	OFF	C	(O)	ON	OFF	(O)
D 2	ON	ON	OFF	C	OFF	ON	(O)	ON
D 3	OFF	ON	OFF	C	ON	ON	(O)	ON
D 4	OFF	ON	OFF	C	OFF	OFF	(O)	OFF
D 5	OFF	OFF	OFF	C	ON	OFF	(O)	OFF
Clutch Logic								
	Clutch			**Brake**			**Freewheel** (Sprag Clutch)	
RANGE	**A**	**B**	**C**	**D**	**E**	**F**	**1.G**	
R	OFF	OFF	ON	OFF	OFF	ON	OFF	
P, N	OFF	OFF	OFF	OFF	OFF	ON	OFF	
D 1	ON	OFF	OFF	OFF	OFF	(O)	ON	
D 2	ON	OFF	OFF	OFF	ON	OFF	OFF	
D 3	ON	OFF	OFF	ON	OFF	OFF	OFF	
D 4	ON	ON	OFF	OFF	OFF	OFF	OFF	
D 5	OFF	ON	OFF	ON	OFF	OFF	OFF	

ON Activated
OFF Deactivated
C Controlled
(O) Depending on shift strategy and speed: ON, OFF or controlled

Solenoid and Sensor Characteristics				
Actuator / Sensor	**Wire Color**	**TCM Connector (EM46) pin numbers**	**Approximate Resistance (Ohms)**	**Actual Reading**
SSM1	White	12/8	25 – 35	
SSM2	Green	12/9	25 – 35	
SSM3	Slate	12/4	25 – 35	
PR1	Slate	16/2	4.8 – 6.8	
PR2	Orange	16/3	4.8 – 6.8	
PR3	Yellow	16/7	4.8 – 6.8	
PR4	Red	16/11	4.8 – 6.8	
PR5	Blue	16/15	4.8 – 6.8	
TFT	Black/Green Blue/Yellow	13/14	950 – 955 (@70°F)	
TSS	Brown/Green	6/5	330	
OSS	Black/Orange	1/10	340	

TCM CONTROL STRATEGIES

The TCM directly controls the transmission actuators as a response to driver demand, engine and vehicle requirements and according to the driver selected transmission operating mode (strategy).

Normal

The normal strategy optimizes fuel consumption by:

- Upshifting at low vehicle speeds
- Downshifting at high throttle angles

Sport

The sport strategy optimizes vehicle acceleration by:

- Upshifting at high vehicle speeds
- Downshifting at low throttle angles

In addition to the Normal and Sport “base” transmission operating strategies, the TCM chooses between five additional programmed strategies as dictated by operating conditions (TCM inputs). The five strategies are as follows:

Traction Control

During traction control events, the TCM will implement the traction strategy to maximize control of wheel slip. The traction strategy:

- Immediately upshifts (depending on vehicle speed)
- Immediately downshifts (depending on vehicle speed)
- Reduces throttle angle influence on shift scheduling
- Inhibits fifth gear

Gradient

When increased driving resistance is detected, the TCM implements the gradient strategy to minimize gear shift “hunting”, increase vehicle performance, and improve cooling performance. The gradient strategy:

- Upshifts at higher vehicle speeds
- Downshifts at higher throttle angles
- Increases the time before the next gear shift (up or down)
- Operates the torque converter clutch (lock-up or controlled slip) in second through fifth gears

Cruise Control

When cruise control is active, the TCM implements the cruise strategy to minimize gear shift “hunting”. The cruise strategy:

- Increases the time before the next gear shift (up or down)
- Will not downshift below third gear
- Prefers third and fourth gear

Hot Mode

If either the engine oil temperature (EOT) or the transmission fluid temperature (TFT) exceed a specified temperature, the TCM implements the hot mode strategy. The hot mode strategy is canceled when the temperature(s) drop below a specified level. The hot mode strategy:

- Operates the torque converter clutch (lock-up or controlled slip) in second through fifth gears
- Upshifts at higher vehicle speeds
- Increases the time before the next upshift

Hot Mode entry: EOT > 120°C (248°F) or TFT > 135°C (275°F)

Hot Mode exit: EOT < 112°C (234°F) or TFT < 127°C (261°F)

Manual

When the driver moves the gear selector to the left hand side of the J-gate (manual mode), the TCM implements the manual strategy, allowing semi-manual shifting to occur.

Engine Warm-Up Period

During the engine warm-up period, the TCM modifies the shift pattern to aid in reducing engine emission (catalyst warm-up) and maximize fuel economy. The warm-up shift pattern is implemented below a specified engine coolant temperature.

Torque Converter Clutch

Except in Gradient and Hot modes, the TCM activates the torque converter clutch (TCC) in fourth and fifth gear. The use of a pressure control solenoid allows the TCM to activate OFF / ON or CONTROLLED SLIP. Controlled TCC slip is used to prevent engine torsional vibration from being passed on to the transmission, thereby improving drive line refinement.

The amount of TCC slip is calculated by the TCM from the engine speed input (CAN) and the turbine speed sensor input signal. In addition to TCC control, the TCM uses this comparison for TCC fault monitoring.

Shift Energy Managemen

Transmission shift quality is enhanced by “shift energy management”. The ECM communicates engine torque data via the CAN network. Before implementing a shift, the TCM determines the amount of torque reduction required. As the gear shifts occur, the TCM communicates a CAN torque reduction request message. The ECM responds by retarding the ignition to momentarily reduce engine torque.

Reverse Gear

In order to prevent transmission damage during vehicle reverse direction, the ECM limits engine power when Reverse gear is engaged.

ON-BOARD DIAGNOSTICS

The TCM continuously monitors the transmission control system and the transmission mechanical components for fault conditions. Transmission mechanical components are monitored for faults by comparison of the CAN engine speed message to the turbine speed sensor signal to the output speed sensor signal. As the TCM knows the correct sensor signal values for any given gear and operating condition, component slip can be recognized.

Many flagged faults are accompanied by TCM and ECM default actions. Two transmission “limp home” modes are available. Depending on the failed component, one of these can be implemented by the TCM.

Mechanical Limp Home

If the TCM adopts mechanical limp home, the transmission defaults to fourth gear only operation. The TCM communicates a CAN transmission overload message. ECM responds by limiting engine power.

Electronic Limp Home

If the TCM adopts electronic limp home, the transmission makes controlled shifts to fifth gear, then remains in fifth gear. The TCM communicates a CAN transmission overload message. ECM responds by limiting engine power.

Faults can either be OBD II specific or non OBD II. OBD II DTCs are communicated as CAN messages to the ECM, which acts as the OBD II “host” with connection to the Data Link Connector (DLC).

TCM Volatile Memory

All flagged DTCs are stored in TCM volatile memory. If the vehicle battery is disconnected, all TCM stored DTCs will be lost.

AJ26 ECM Volatile Memory

The AJ26 ECM stores OBD II DTC data in volatile memory. If the vehicle battery is disconnected, all stored ECM OBD II DTC data will be lost.

AJ27 ECM Non-Volatile Memory

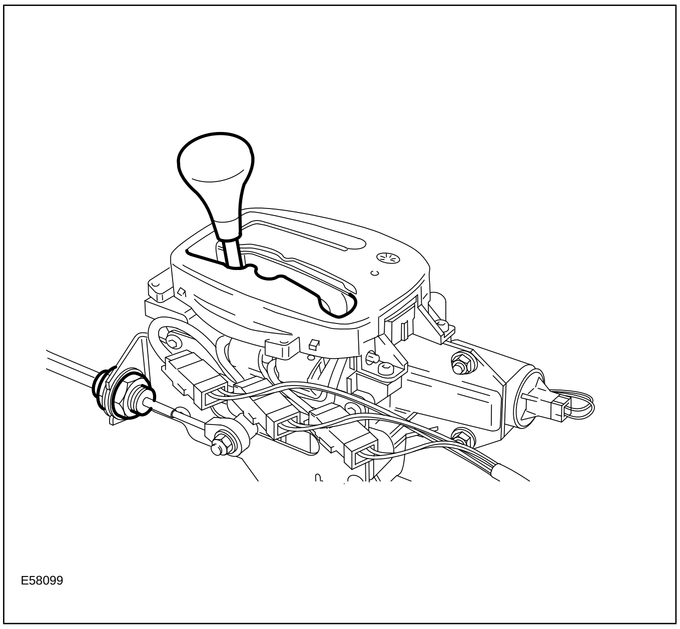
The AJ27 ECM stores OBD II DTC data in non-volatile memory. If the vehicle battery is disconnected, all stored ECM OBD II DTC data will be retained.

Complete DTC / fault information is contained in the Jaguar publication DTC Summaries. Drive cycles for each individual DTC are included in the DTC Summaries.

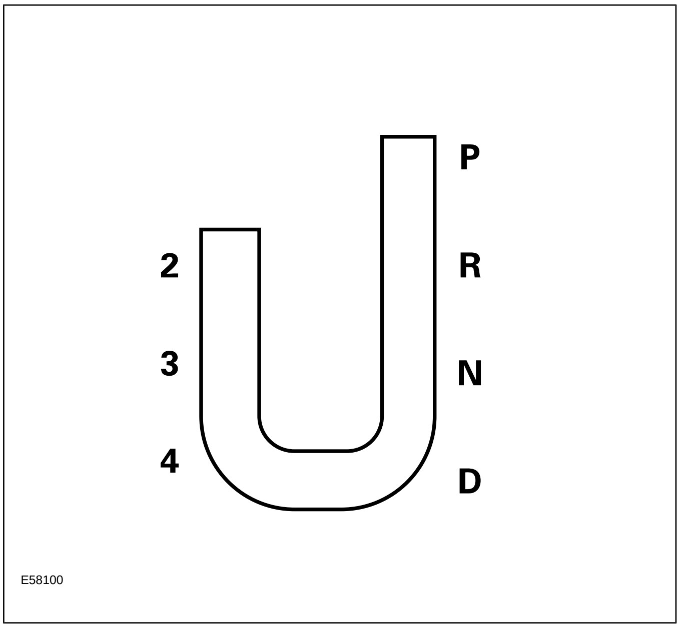
GEAR SELECTION

The J-gate gear selector allows driver selection of the normal Jaguar transmission functions: P, R, N, D on the right hand side and manual selection of 4th, 3rd, and 2nd gear ranges on the left hand side.

Gear Selector



J-Gate Pattern

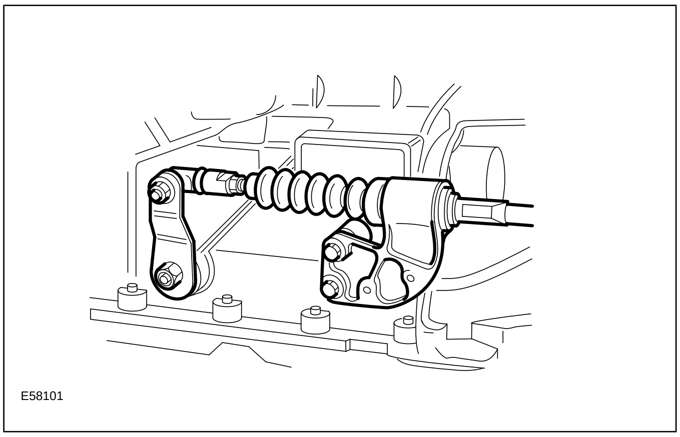


The gear selector positions are:

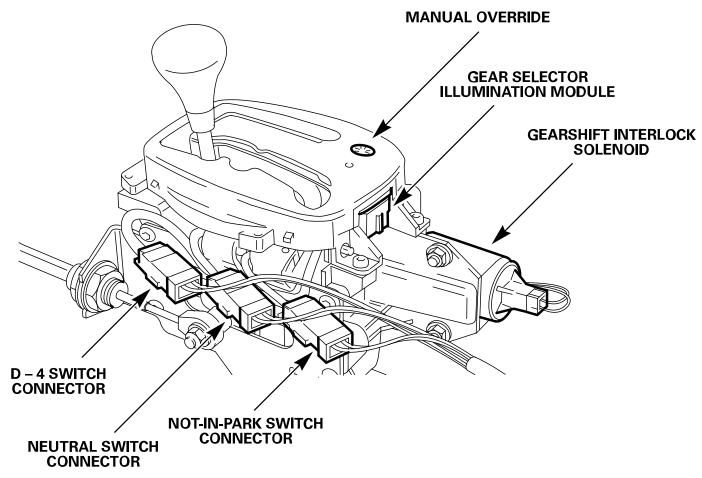
- **P** – The transmission is mechanically locked (starting available)
- **R** – Reverse gear
- **N** – No power to the rear wheels (starting available)
- **D** – All five forward gears available
- **4** – Upshift to 4th gear only
- **3** – Upshift to 3rd gear only
- **2** – Upshift to 2nd gear only

The gear selector lever is mechanically connected to the selector lever in the transmission with an adjustable cable.

Transmission Selector Lever



J-Gate Assembly



The J-gate assembly incorporates three micro switches:

D – 4 Switch

The D – 4 switch provides a TCM input when the selector is moved from the Drive range to the Manual range.

Neutral Switch

The neutral switch provides an input to the body processor module (BPM) for engine starter control (Neutral safety switch).

Not-in-Park Switch

The not-in-park switch provides an input to the BPM for Gearshift Interlock control.

J-Gate Selector State Illumination

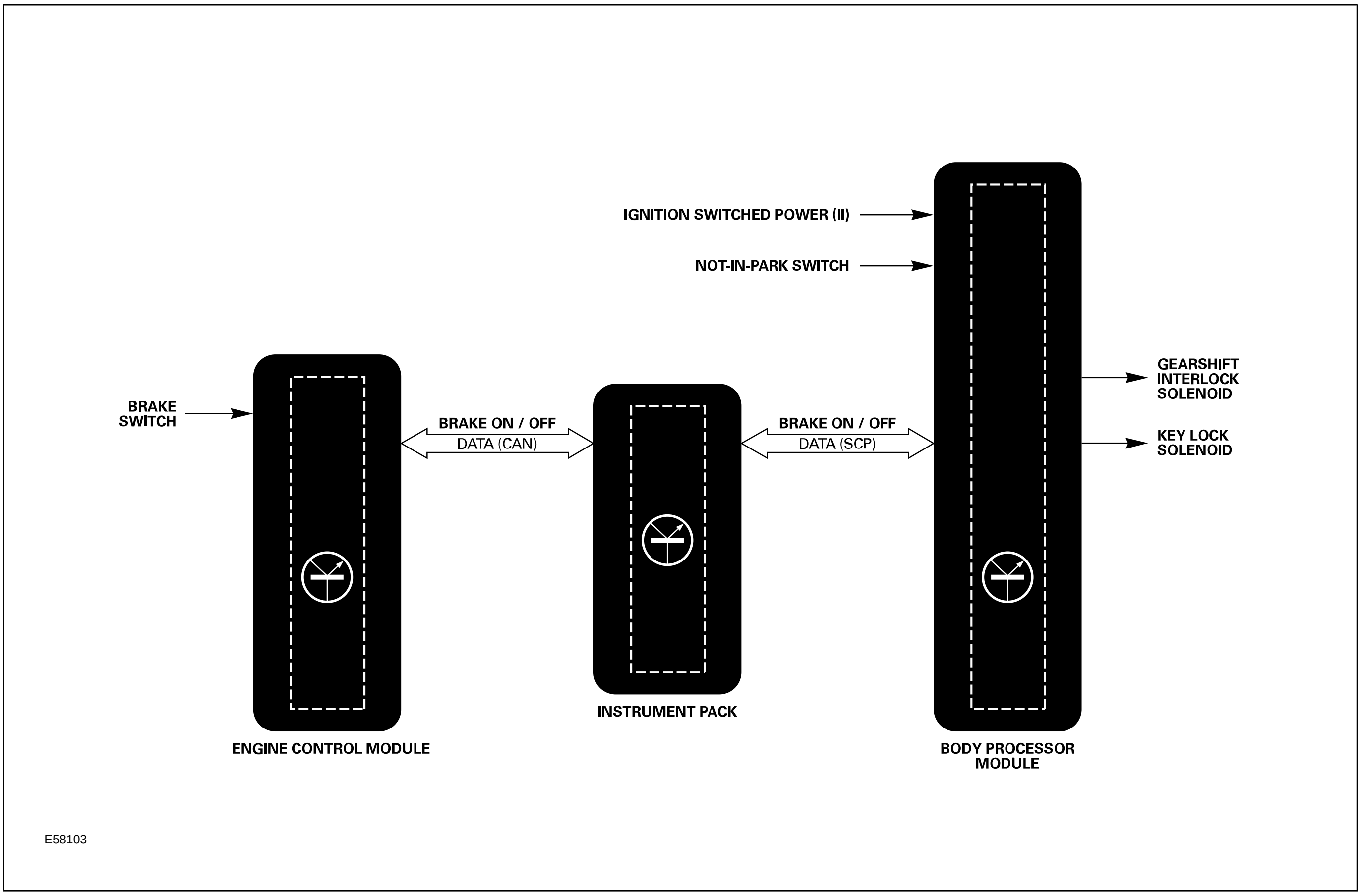
The TCM communicates a CAN gear selected message based on the rotary switch position inputs. The Gear Selector Illumination Module processes the CAN data messages and illuminates the selected gear.

Gearshift Interlock

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

The system is controlled by the BPM based on inputs for brake pedal on / off, Park position and ignition key in position II.

Gearshift Interlock



The brake pedal applied input is sourced from the brake on / off switch SCP message; the Park position input is sourced from the Not-in-Park switch; and the ignition switch position II input is sourced from the ignition power supply circuit.

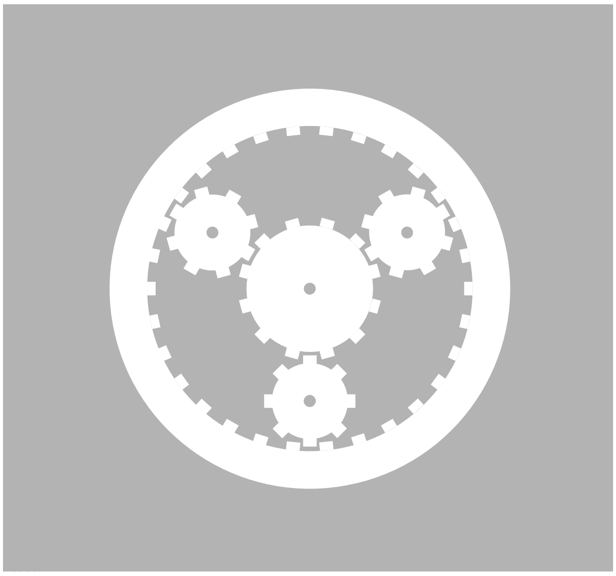
The BPM energizes the gear shift solenoid in response to the input signals that the brakes are applied and the ignition is in position II. The energized solenoid moves the locking mechanism allowing the gear selector to be moved out of PARK. When the gear selector is moved out of Park, the BPM energizes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

Manual Override

A mechanical override located under the threaded access plug allows technician gear selector movement from Park.

Automatic Transmission

Lesson 5 - W5A580



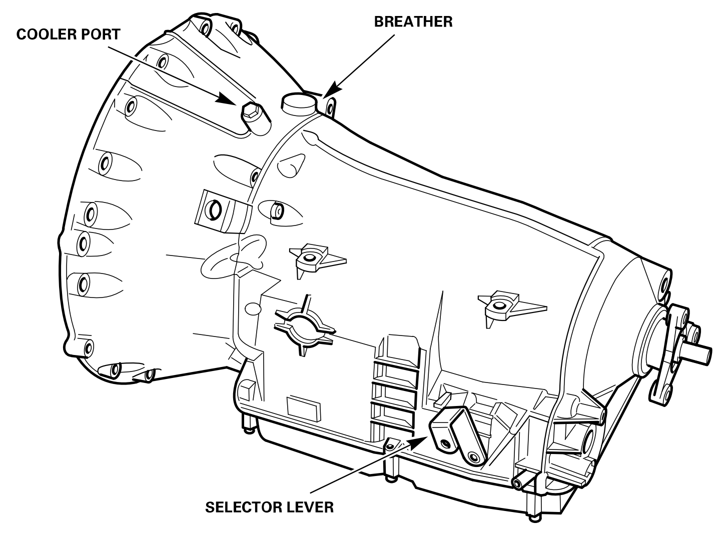
Technical Training

T201.1 en 12/2004

OVERVIEW

XJR 1998 – 2003 MY and XKR 2000 – 2002 MY Jaguar vehicles are equipped with the W5A580 5-speed automatic transmission. The transmission and most of the vehicle interface components are mechanically identical for both vehicles.

W5A580 Transmission



The transmission is TCM (transmission control module) controlled. The TCM communicates with the engine management system, ABS/TC system and the instrument cluster via the high speed Controller Area Network (CAN).

Gear selection occurs via the Jaguar style J-gate gear selector assembly that features fully automatic shifting (Drive) on the right hand side and driver controlled semi-manual shifting on the left hand side (4th, 3rd, 2nd). Normal and Sport transmission operating modes are selected by the driver via the mode switch located near the J-gate.

W5A580 is interpreted as follows:

- **W** – Wandler (German, means 'Torque Converter')
- **5** – 5 forward gears
- **A** – Version
- **580** – Maximum torque, in Nm

<table>
<tr><th colspan="7">W5A580 Specifications</th></tr>
<tr><td>Transmission weight</td><td colspan="6">81 kg (179 lb) with torque converter</td></tr>
<tr><td>Mechanical features</td><td colspan="6">Transmission case in two sections – torque converter housing and main case
Torque converter with two-plate, controlled slip lock-up clutch
Planetary gear train (no brake bands)</td></tr>
<tr><td>Transmission fluid</td><td colspan="6">Capacity – 9.4 liters (10 quarts); Filled for life
Type – Shell LA, Jaguar Part Number JLM 20292 (1 liter)</td></tr>
<tr><td>Transmission fluid cooler</td><td colspan="6">External liquid-to-liquid cooler integral with the left hand side radiator tank</td></tr>
<tr><td>Stall test</td><td colspan="6">Due to throttle limitation at low vehicle speed, a stall test cannot be performed on the W5A580 system</td></tr>
<tr><td>Towing</td><td colspan="6">Maximum 30 miles (50 km) at less than 30 mph (50 km/h)</td></tr>
<tr><td rowspan="2">Gear ratios</td><td>1st</td><td>2nd</td><td>3rd</td><td>4th</td><td>5th</td><td>Reverse</td></tr>
<tr><td>3.59</td><td>2.19</td><td>1.41</td><td>1.00</td><td>0.83</td><td>1.93 (Normal)
3.16 (Sport)</td></tr>
</table>

SYSTEM COMPONENTS

Gear Train

All forward gears and reverse gear are obtained from a planetary gear train consisting of:

- Three single planet gear sets connected in series
- Three clutch packs – K1, K2, K3
- Three brakes (lock to transmission case) – B1, B2, B3
- Two free wheels (sprag clutch) – F1, F2

The individual gear ratios are obtained by driving certain planetary gear train elements while others are braked. Power is always transmitted to the output shaft via the last series connected planetary gear set.

Application Chart

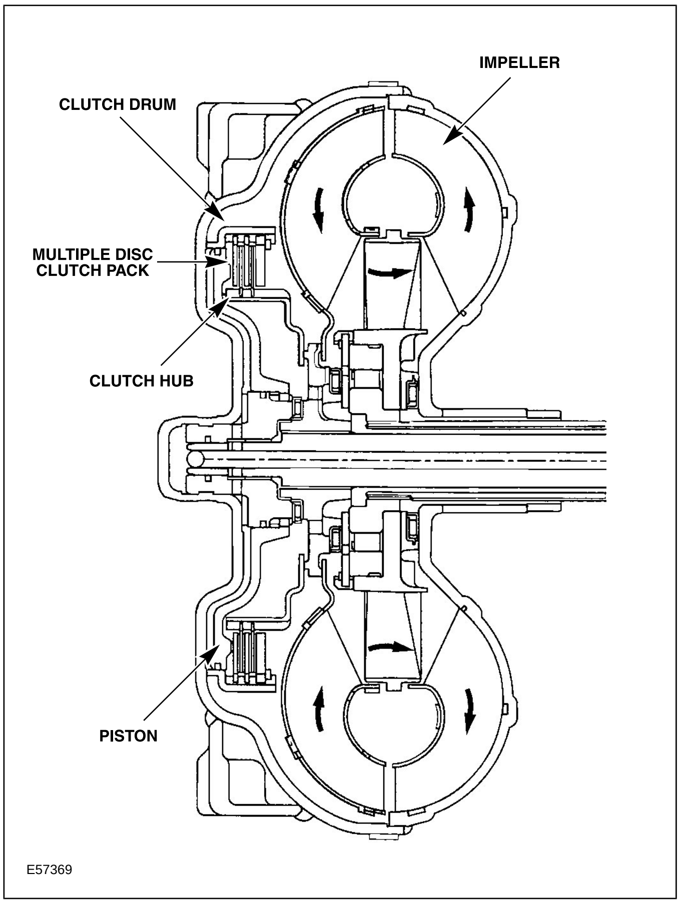
Gear	Ratio	B1	B2	B3	K1	K2	K3	F1	F2
1	3.59	X (3)	X	—	—	—	X (3)	X	X
2	2.19	—	X	X	—	—	X (3)	—	X
3	1.41	—	X	X	X	X	—	—	—
4	1	—	—	X	X	X	X	—	—
5	0.83	X	—	—	X	X	X	—	—
N	—	X	—	—	—	—	X	—	—
R (1)	-3.16	X (3)	X	—	—	—	X	—	—
R (2)	-1.93	—	X	X	—	—	X	—	—

(1) Sport Mode
(2) Normal Mode
(3) Components active during coast down

Torque Converter

The torque converter incorporates a two-plate lock-up clutch, which is controlled by the TCM. The torque converter clutch (TCC) is applied by hydraulic pressure from a TCM controlled shift solenoid located on the valve body and released by impeller hydraulic pressure. The TCC is controlled on / off / controlled slip as determined by the TCM.

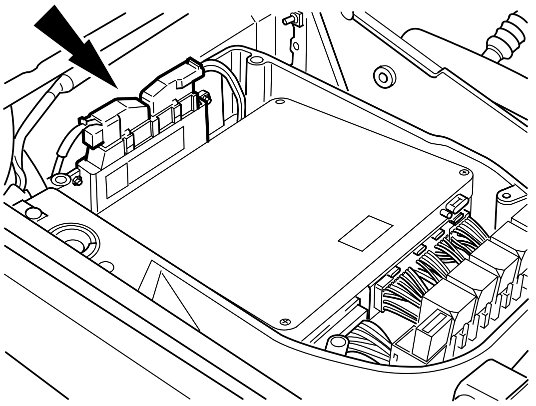
Torque Converter



TRANSMISSION CONTROL

The W5A580 automatic transmission system is fully controlled by the transmission control module (TCM), located in the engine compartment “cool box” along with the engine control module (ECM). A high speed controller area network (CAN) allows communication between the TCM, ECM, ABS/TC CM, Gear Selector Illumination Module and the Instrument Cluster.

Transmission Control Module



E58108

TCM Non-Volatile Memory

TCM adaptive values and DTCs are stored in non-volatile memory (EEPROM). If the vehicle battery is disconnected, all adaptive values and stored DTCs will be retained.

W5A580 TCM control incorporates the following control features:

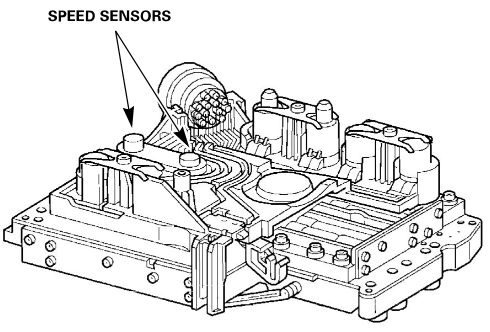
- Normal / Sport operational modes (strategies)
- Shift scheduling / shift feel
- Adaptive pressure control
- Component wear and aging adaptations – shift time, fluid filling time and pressure, TCC control
- Specific driving conditions shift strategies
- Torque converter clutch on, off and controlled slip
- Two Reverse gear ratios
- Shift energy management (engine torque modulation during shift)
- Engine torque reduction during “transmission failure”, Reverse
- On-Board Diagnostics (OBD II and non OBD II)
- Component failure default modes (mechanical and electronic “limp home”)

TCM Inputs – Transmission

Transmission Speed Sensors (n2, n3)

The W5A580 has two intermediate transmission speed sensors identified as n2 and n3. Both speed sensors are inductive pulse generators, which provide the TCM with a transmission speed alternating voltage signal.

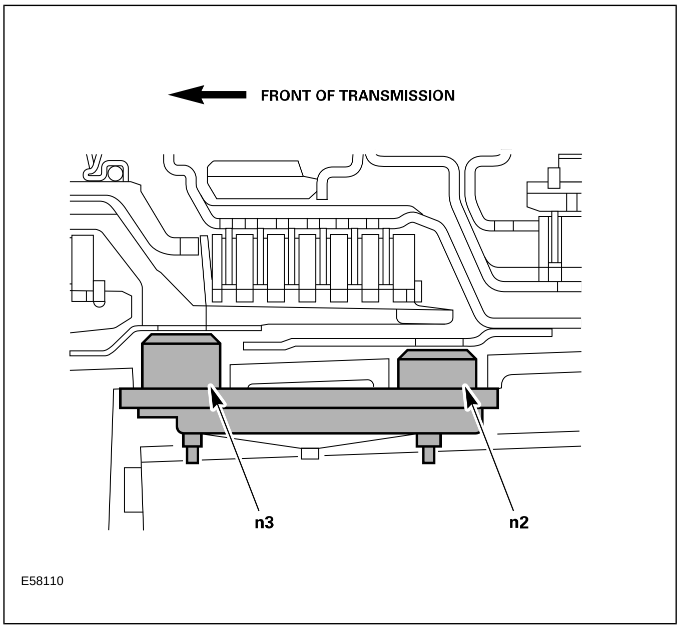
Speed Sensor Locations



E58109

The pickup (coil) portion of the sensors share a common molded platform and mount to the valve body electrical module. The reluctors are impulse rings that are attached to transmission rotating components. To ensure that the correct distance is maintained between the pickups and the impulse rings, the sensors are held in position by a leaf spring that rests against the valve body. The speed sensors are serviceable only as a unit.

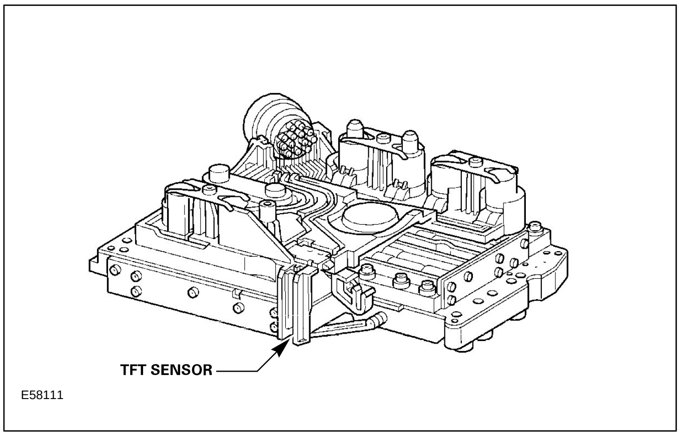
Speed Sensors



Transmission Fluid Temperature Sensor (TFT Sensor)

The TFT sensor, located on the valve body, is a thermistor which has a positive temperature coefficient (PTC).

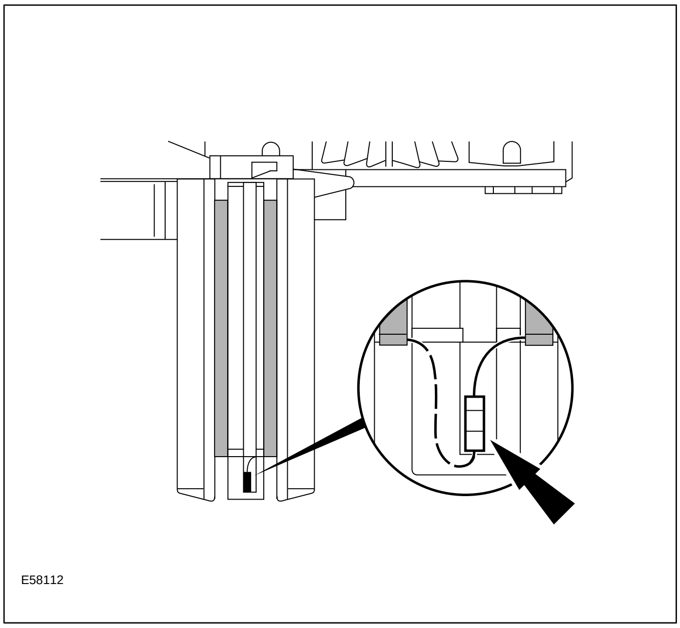
TFT Location



Transmission fluid temperature is determined by the TCM by the change in the sensor resistance. The TCM applies 5 volts (nominal) to the sensor and monitors the voltage across the pins to detect the varying resistance. TFT is one of the main factors used by the TCM to calculate shift and pressure control.

If the TFT sensor signal is lost, the TCM will substitute engine coolant temperature (CAN message).

TFT Sensor



NOTE: The TFT sensor is in a series circuit incorporating a Park and Neutral reed switch. The switch is not used for transmission control, and monitoring of transmission fluid temperature is limited to when D or R is selected only. If the selector is in P or N, engine coolant temperature is substituted.

TFT Characteristics

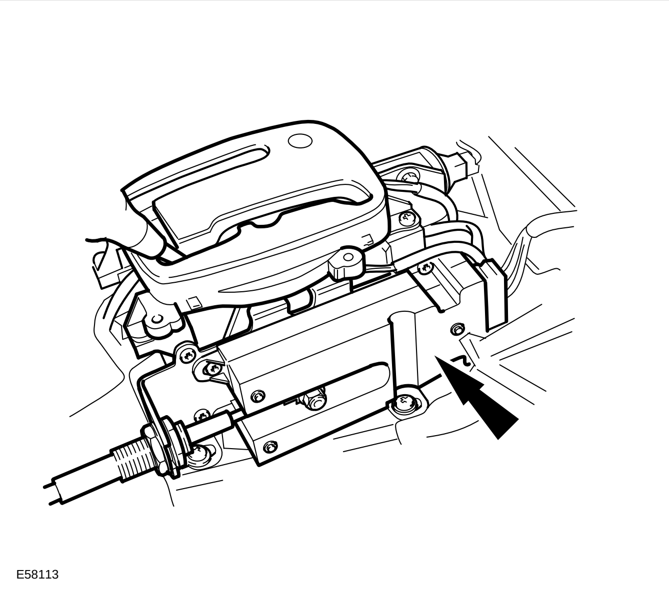
- P, N (reed switch open): nominal 20 kOhms
- R, D, 4, 3, 2: nominal range 0.5 – 2.5 kOhms

Dual Linear Switch

The digital dual linear switch, mounted on the right hand side of the J-gate assembly, is operated by the gear selector lever. Selection of a particular gear generates a 4 bit binary coded signal, which is transmitted directly to the TCM over a four wire parallel interface. The switch functions in the PRND ranges and in Manual 4, 3, 2 ranges, hence the term dual linear switch.

The dual linear switch eliminates the need for a D – 4 switch.

Dual Linear Switch



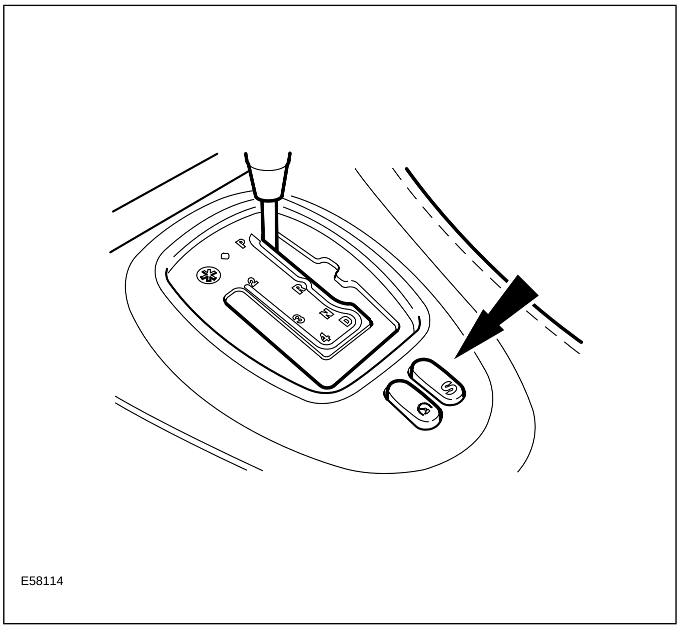
WDS Datalogger readings for the dual linear switch will show as follows: 0 = Closed / low voltage 1 = Open / high voltage

Dual Linear Switch Output States				
Gear	**SWL0**	**SWL1**	**SWL2**	**SWL3**
P	1	1	1	0
R	0	1	1	1
N	1	0	1	1
D	0	0	1	0
4	0	0	0	1
3	0	1	0	0
2	1	0	0	0
0 Closed / low voltage **1** Open / high voltage				

Mode Switch

The mode switch allows the driver to select between Normal and Sport modes (transmission operating strategies). Sport mode strategy moves the transmission shift characteristics so that upshifts occur at higher engine speeds.

Mode Switch



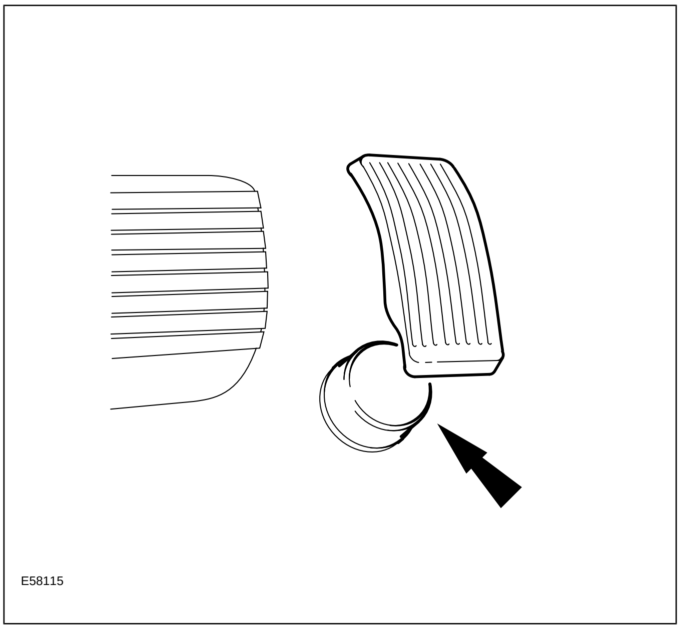
The W5A580 transmission system has two available Reverse gear ratios. When Normal is selected, the TCM implements the Reverse ratio; when Sport is selected, the TCM implements the Low Reverse ratio.

Kickdown Switch

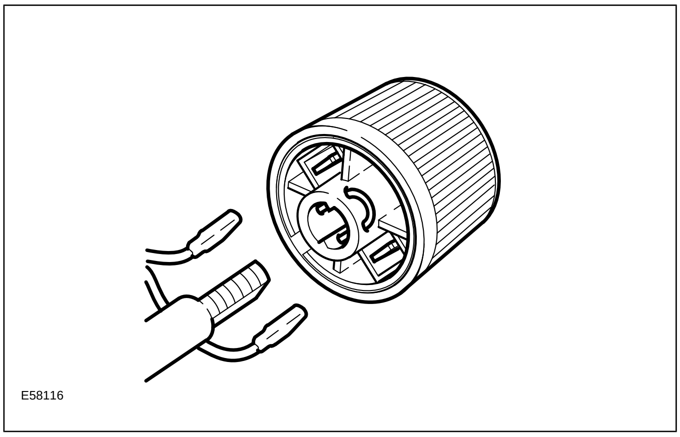
The normally open kickdown provides the TCM with a ground input when the accelerator is fully depressed (full throttle). This input signals the transmission to provide maximum acceleration.

1999 Model Year ON vehicles are equipped with a kickdown switch incorporating a simplified adjustment method. WDS must be used when adjusting the switch.

Kickdown Switch/Pedal Stop Location



Kickdown Switch



TCM Inputs – Engine (CAN)

Several engine management derived inputs are used by the TCM for transmission control processing. All of the inputs are received from the engine control module (ECM) as data messages via the controller area network (CAN). The inputs are used by the TCM to determine the required transmission control.

NOTE: The examples of TCM input usage may or may not be complete.

Engine Torque

The ECM calculates engine torque from the engine speed and engine load (MAF) signals and continuously communicates the calculated value on the CAN network. This input continuously communicates to the TCM the amount of torque to be transmitted through the transmission. Torque is used by the TCM as the basic control calculation for shift scheduling, modulation pressure and shift pressure.

Engine Speed

The TCM uses engine speed as the transmission input speed for modification to the basic control calculation and for diagnostics.

Throttle Position / Accelerator Pedal Position

The ECM communicates the actual throttle and accelerator pedal position. These inputs allow the TCM to determine engine load and driver demand.

Engine Coolant Temperature / Engine Oil Temperature

These inputs allow the TCM to know the current engine operating condition (warm-up, normal operating temperature).

Cruise Control

When cruise control is active, the TCM adjusts the transmission control strategy to enhance cruise control operation.

TCM Inputs – ABS / TC (CAN)

Inputs from the anti-lock braking / traction control module include:

Vehicle Speed (Four Wheel Speed Inputs)

The TCM uses vehicle speed as the transmission output speed for modification to the basic control calculation and for diagnostics.

Anti-Lock Braking / Traction Control Status

The ABS/TC inputs allow the TCM to refine shift scheduling and react to ABS/TC events

TCM Transmission Control Outputs

The TCM controlled transmission actuators are incorporated into the transmission valve body assembly. The W5A580 uses three shift solenoids, a TCC solenoid, and two pressure control solenoids.

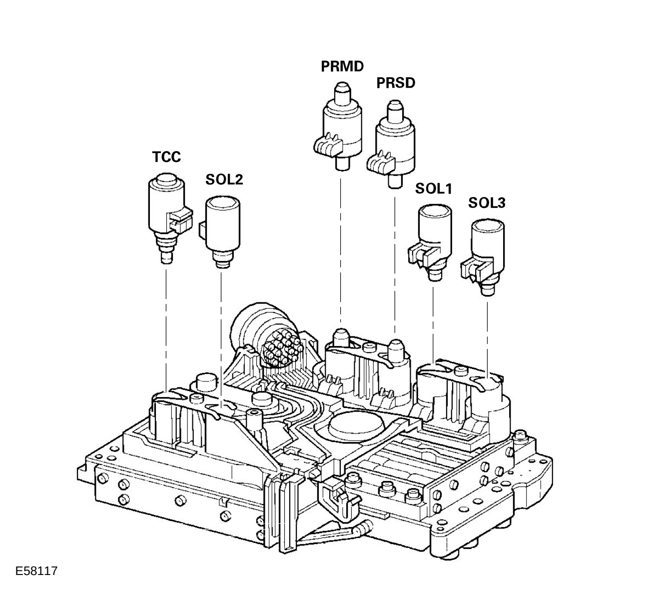
Shift solenoids SOL1, 2 and 3 are two-way on / off normally closed solenoids, used to shift the transmission through all forward gears and reverse. The TCM controls the solenoids by switching the ground side of the circuit.

- Shift solenoid 1: 1 – 2 shift; 4 – 5 shift
- Shift solenoid 2: 2 – 3 shift
- Shift solenoid 3: 3 – 4 shift

The torque converter clutch solenoid TCC is PWM driven by the PCM to apply and release the torque converter clutch (TCC). By using PWM control, the TCM is able to allow controlled slip of the TCC.

Pressure control solenoids PRMD and PRSD are PWM driven by the TCM to control transmission modulation and shift pressures. The TCM PWM drive to the pressure control solenoids switches the ground side of the circuits.

Valve Body Solenoids



Solenoid and Sensor Characteristics			
Actuator / Sensor	**Transmission Connector (GB1) pin numbers**	**Approximate Resistance (Ohms)**	**Actual Reading (Ohms)**
SOL1	6/13	4	
SOL2	6/8	4	
SOL3	6/9	4	
TCC	6/11	2.4	
PRMD	6/2	5	
PRSD	6/10	5	
TFT	12/4	980 – 985	

The following chart shows the shift solenoid and pressure control solenoid operation in P, R, N, D. The individual gear commanded states are for Drive range 1, 2, 3, 4, 5. Only D1 can be read using WDS while the vehicle is stationary.

Solenoid Operation						
Range	**SOL1**	**SOL2**	**SOL3**	**TCC**	**PRMD**	**PRSD**
P	OFF	OFF	ON	OFF	M	M
R	OFF	OFF	OFF	OFF	M	OFF
N	OFF	OFF	ON	OFF	M	M
D	OFF	OFF	OFF	OFF	M	OFF
M = Modulated pressure read as mA (WDS)						

TCM CONTROL STRATEGIES

The TCM directly controls the transmission actuators as a response to driver demand, engine and vehicle requirements and according to the driver selected transmission operating mode (strategy).

Normal Mode

The normal strategy optimizes fuel consumption by:

- TCM commands 2nd gear for launch from a stop
- Upshifting at low vehicle speeds
- Downshifting at high throttle angles
- Reverse overdrive gear ratio

Sport Mode

The sport strategy optimizes vehicle acceleration by:

- TCM commands 1st gear for launch from a stop
- Upshifting at high vehicle speeds
- Downshifting at low throttle angles
- Reverse low gear ratio

If dictated by operating conditions, the TCM will automatically select Normal or Sport mode strategy. In addition, based on input information, the TCM will modify the strategy to further to enhance vehicle operation.

Traction Control

During traction control events, the TCM will implement actions to maximize control of wheel slip.

Gradient

When increased driving resistance is detected, the TCM implements actions to minimize gear shift “hunting”, increase vehicle performance, and improve cooling performance.

Cruise Control

When cruise control is active, the TCM implements actions to minimize gear shift “hunting”.

Engine Warm-up Period

During the engine warm-up period, the TCM modifies the shift pattern to aid in reducing engine emission (catalyst warm-up) and maximize fuel economy. TCM warm-up action, is implemented below a specified engine coolant temperature.

Torque Converter Clutch

The TCM activates the torque converter lock-up clutch (TCC) in third, fourth and fifth gears. The actual operating condition (on / off / controlled slip) of the TCC is determined by many factors and is changeable depending on the selected gear range.

ON-BOARD DIAGNOSTICS

The TCM continuously monitors the transmission control system and the transmission mechanical components for fault conditions. Transmission mechanical components are monitored for faults by comparison of the CAN engine speed message to the turbine speed sensor signal to the output speed sensor signal. As the TCM knows the correct sensor signal values for any given gear and operating condition, component slip can be recognized.

Many flagged faults are accompanied by TCM and ECM default actions. Two transmission “limp home” modes are available. Depending on the failed component, one of these can be implemented by the TCM.

Electronic Limp Home

The TCM adopts electronic limp home when an electrical fault is detected. If the vehicle is being driven, electronic limp home maintains the selected gear until the ignition is switched OFF. When the vehicle is restarted (after a minimum 10 second wait), the transmission will operate in 2nd and Reverse gears only. The default will remain in effect until the fault is corrected and the DTC erased from memory.

Mechanical Limp Home

The TCM adopts mechanical limp home when a mechanical / hydraulic fault is detected. When the fault is detected, the transmission shifts into 3rd gear and remains in this gear. The default will cancel on the next ignition cycle, provided the fault is no longer present.

Faults can either be OBD II specific or non OBD II. OBD II DTCs are communicated to the ECM as CAN messages, which acts as the OBD II “host” with connection to the Data Link Connector (DLC).

TCM Non-Volatile Memory

All flagged DTCs are stored in the TCM EEPROM. If the vehicle battery is disconnected, all stored DTCs will be retained.

AJ26 ECM Volatile Memory

The AJ26 ECM stores OBD II DTC data in volatile memory. If the vehicle battery is disconnected, all stored ECM OBD II DTC data will be lost.

AJ27 ECM Non-Volatile Memory

The AJ27 ECM stores OBD II DTC data in non-volatile memory. If the vehicle battery is disconnected, all stored ECM OBD II DTC data will be retained. Complete DTC / fault information is contained in the Jaguar publication DTC Summaries. Drive cycles for each individual DTC are included in the DTC Summaries.

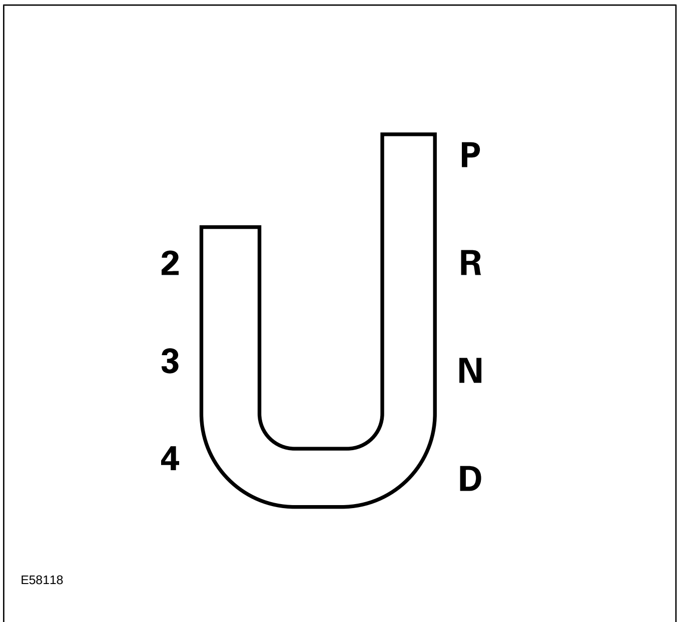
GEAR SELECTION

The J-gate gear selector allows driver selection of the normal Jaguar transmission functions: P, R, N, D on the right hand side and manual selection of 4th, 3rd, and 2nd gear ranges on the left hand side.

The gear selector positions are:

- **P** – The transmission is mechanically locked (starting available)
- **R** – Reverse gear
- **N** – No power to the rear wheels (starting available)
- **D** – All five forward gears available
- **4** – Upshift to 4th gear only (Selected by the linear switch inputs to the TCM)
- **3** – Upshift to 3rd gear only (Selected by the linear switch inputs to the TCM)
- **2** – Upshift to 2nd gear only (Selected by the linear switch inputs to the TCM)

J-Gate Pattern



The J-gate assembly incorporates two microswitches:

Neutral Switch

The neutral switch provides an input to the body processor module (BPM) for engine starter control (Neutral safety switch).

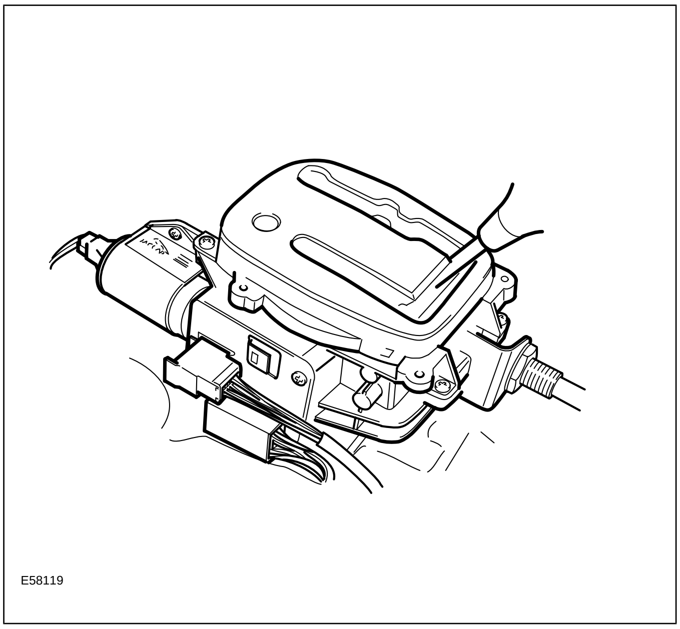
Not-in-Park Switch

The Not-in-Park switch provides an input to the BPM for Gearshift Interlock control.

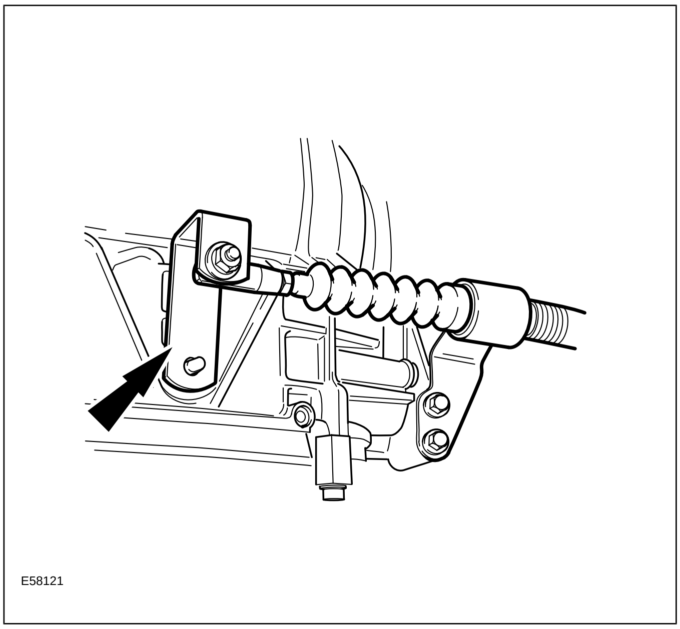
Gear Selector

The gear shift lever is mechanically connected to the selector lever in the transmission by an adjustable cable. When the shift lever is moved to the left hand side (Manual), it disconnects from the cable. All Manual gears are selected only from the dual linear switch TCM inputs.

Gear Selector



Transmission Selector Lever



J-Gate Selector State Illumination

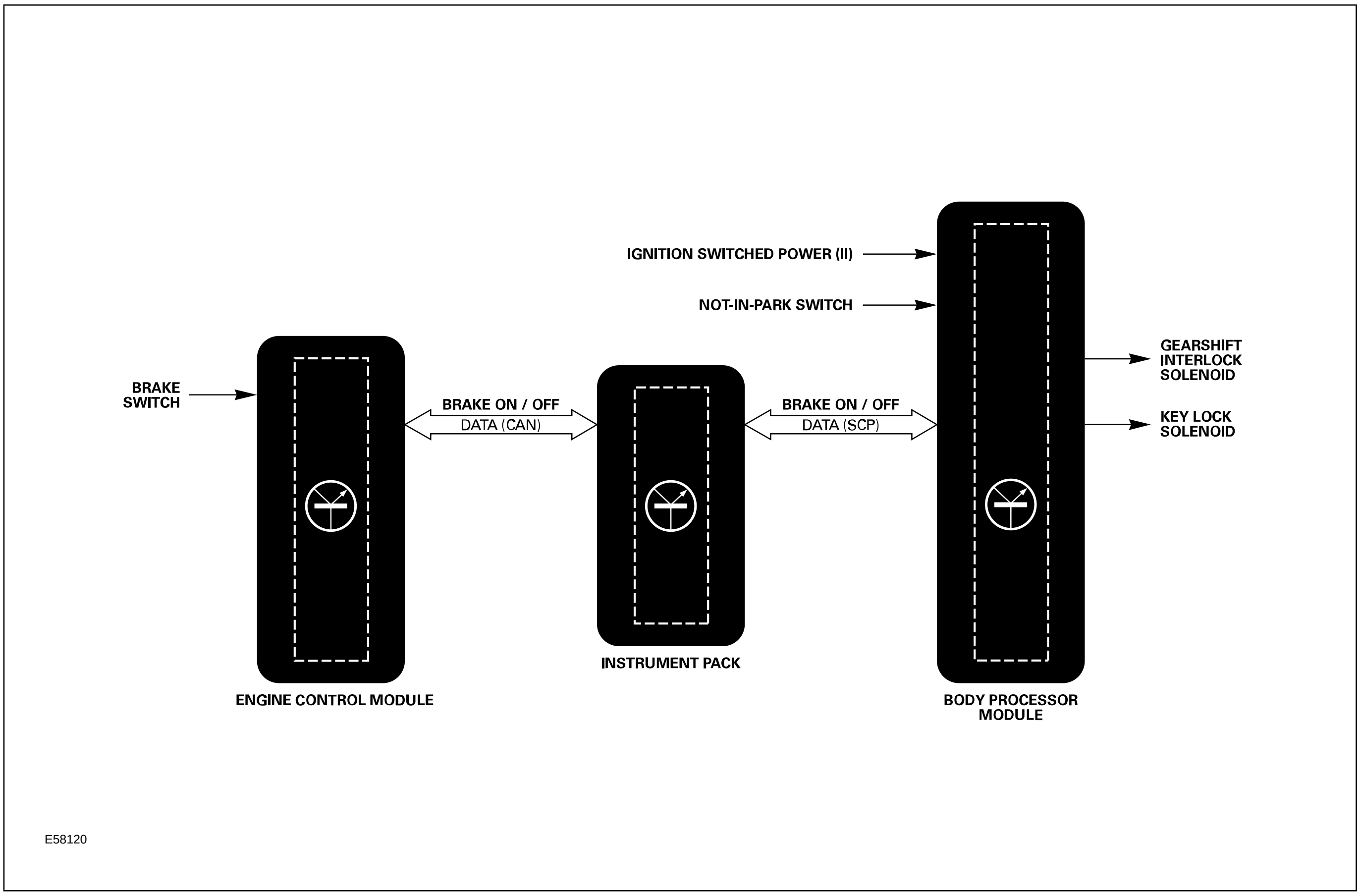
The TCM communicates a CAN gear selected message based on the dual linear switch position inputs. The Gear Selector Illumination Module processes the CAN data messages and illuminates the selected gear.

Gearshift Interlock

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

The system is controlled by the BPM based on inputs for brake pedal on / off, Park position and ignition key in position II.

Gearshift Interlock



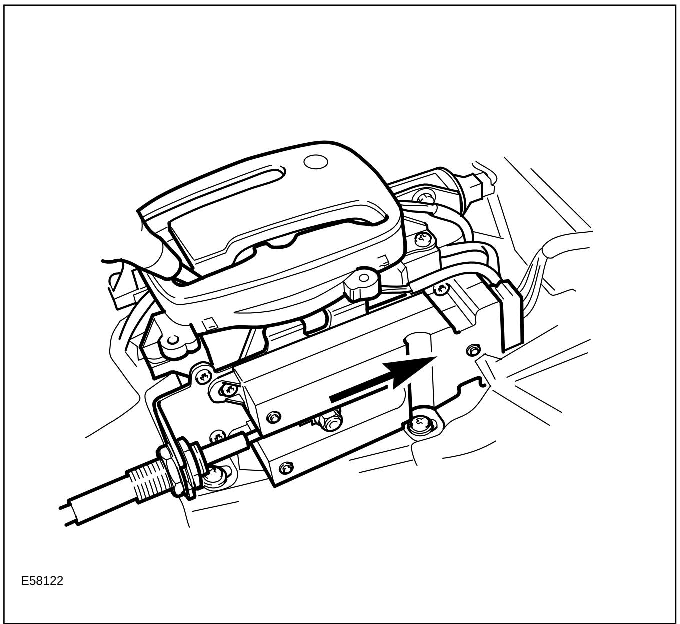
SERVICE PROCEDURES

Dual Linear Switch Adjustment

If the dual linear switch is removed, the procedure for installation is as follows:

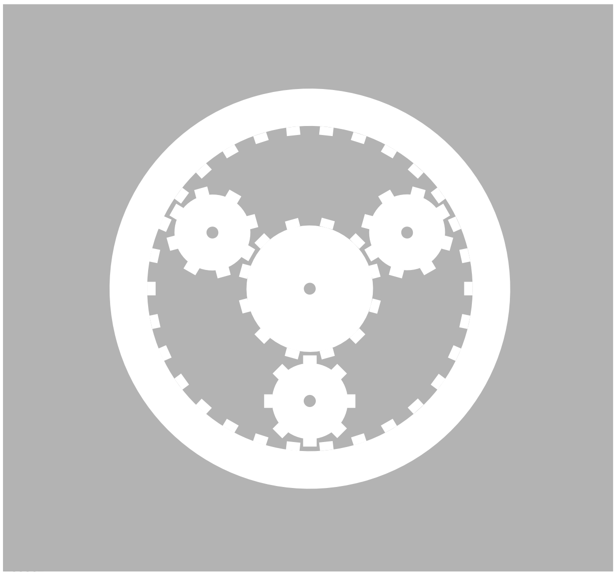
1. Loose fit the switch fixing screws
2. Push the switch fully forward (toward the front of the car), then tighten the screws
3. Check for the correct function of all gear position indicator lights at the J-gate as the shift lever is moved into each detent. If any indicators are out, loosen the screws, incrementally move the switch rearward and retighten until the J-gate indicators function correctly. There is approximately 4 mm total movement.

Dual Linear Switch Adjustment



Automatic Transmission

Lesson 6 - 5R55N



Technical Training

T201.1 en 12/2004

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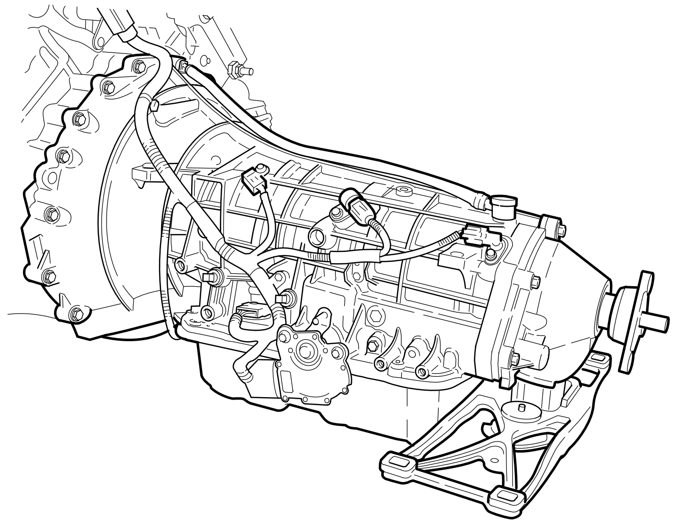
OVERVIEW

V6 and V8 Jaguar S-TYPE (X200) vehicles, 2000 – 2002 MY, are equipped with the 5R55N 5-speed automatic transmission. The transmission design for both vehicles is identical, with slight mechanical differences to account for engine power and configuration, as well as for installation in the vehicle.

The V6 requires a transmission with a longer rear extension housing and output shaft assembly to accommodate the shorter engine.

Each variant uses a unique torque converter matched to the engine torque requirement. The V8 uses an adapter plate to mate the torque converter to a large diameter drive plate.

5R55N Transmission



E58432

The transmission is electronically controlled by the Powertrain Control Module (PCM), which integrates Engine Management System control. The combined system is known as Powertrain Electronic Control (PTEC). The single control module for both engine and transmission eliminates the need for a high-speed Controller Area Network (CAN).

Normal P,R,N,D drive functions plus manual selection of 4th, 3rd and 2nd gears are provided by a Jaguar style J-gate (not the same as XJ and XK Series). Sport or Normal mode is selected by the switch located at the J-gate.

5R55N is interpreted as follows:

- **5** – Five forward gears
- **R** – Rear wheel drive
- **55** – Torque capability code number
- **N** – Type code

5R55N Specifications						
Transmission weight	90 kg (198 lb.) with fluid					
Mechanical features	Torque converter with single-plate lock-up clutch Three compound planetary gear sets Three brake bands Four multi-plate clutches Three one-way clutches					
Transmission fluid	Capacity – 9 liters (9.5 quarts); Filled for life Type – Mercon V Semi-Synthetic; Jaguar Part Number JLM 21044 (1 liter)					
Transmission fluid cooler	External, separate air-to-liquid cooler located below the air conditioning condenser					
Towing	35 m.p.h. for 50 miles					
Stall test	Test in R, D, Manual 2, 3, 4; Maximum WOT – 5 seconds V6 stall speed: 2533 – 3025 rpm; V8 stall speed: 2584 – 3009 rpm					
Gear ratios	**1st**	**2nd**	**3rd**	**4th**	**5th**	**Reverse**
	3.25	2.44	1.55	1.00	0.75	3.07

SYSTEM COMPONENTS

Gear Train and Torque Converter

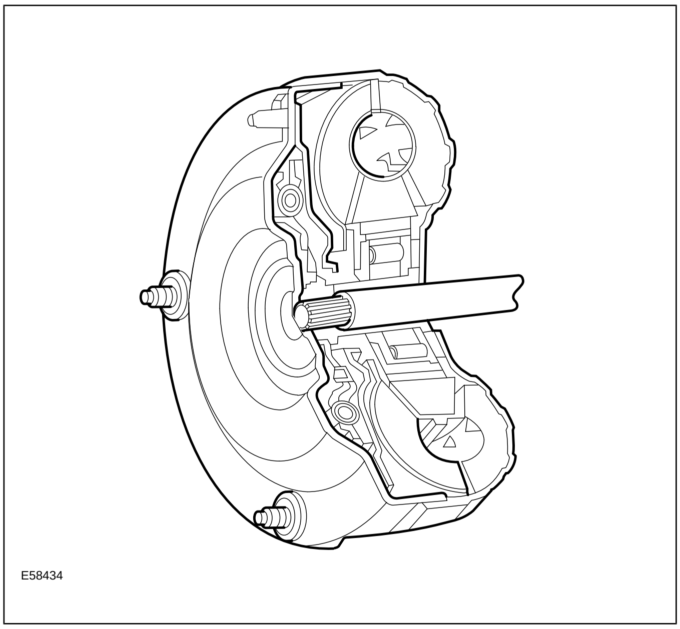
Brake bands and clutches are used to hold and drive certain combinations of gear sets to produce five forward gears and one reverse gear, which is transmitted to the output shaft and differential.

Application Chart										
	RANGE									
		Manual 2, 3, 4				Drive				
DEVICE	**Rev**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**5**
Forward Clutch	—	X	X	X	X	X	X	X	X	X
High Clutch	X	—	—	—	X	—	—	—	X	X
Coast Clutch	C	C	—	C	C	—	—	—	—	—
Intermediate Clutch	—	—	—	X	N	—	—	X	N	N
Rev/Low Brake Band	X	C	C	—	—	—	—	—	—	—
Coast Brake Band	—	—	—	C	—	—	—	—	—	—
Overdrive Brake Band	—	—	X	—	—	—	X	—	—	X
Direct One-Way Clutch	X	X	—	X	X	X	—	X	X	—
Low One-Way Clutch	X	X	—	—	X	X	—	—	—	—
Intermediate One-Way Clutch	—	—	—	X	—	—	—	X	—	—
X – Applied **N** – Applied, no torque **C** – Coast torque										

The torque converter incorporates a single plate lockup clutch, which is controlled by the PCM. The torque converter clutch (TCC) is applied by impeller hydraulic pressure and released by hydraulic pressure from a PCM-controlled solenoid located on the valve body.

The TCC is controlled on or off as determined by the PCM. Power is transmitted from the torque converter to the planetary gear sets through the input shaft.

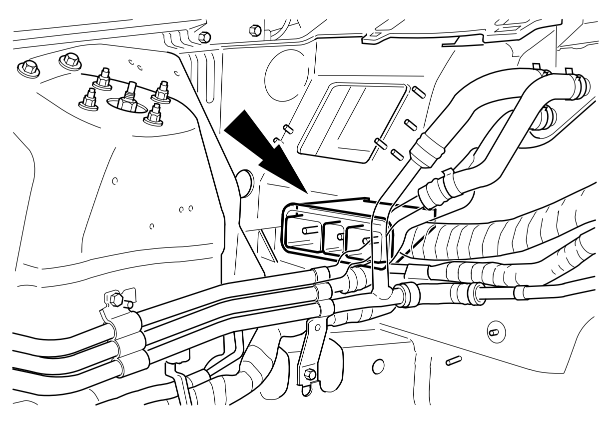
Torque Converter



TRANSMISSION CONTROL

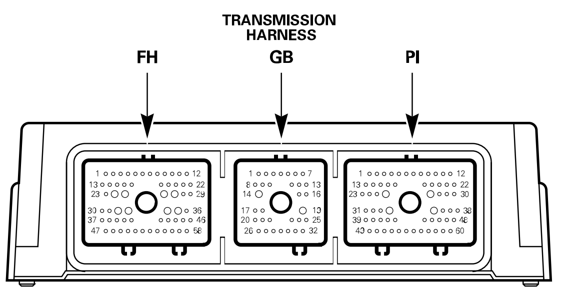
The 5R55N automatic transmission system is fully controlled by the powertrain control module (PCM), located on the passenger side of the cabin below the climate control blower unit. The PCM has a 150-way three-pocket connector housing which protrudes through the bulkhead to accept the matching connectors from the engine bay side harnesses. The 32-way center socket connects to the transmission harness (GB).

Powertrain Control Module



E58435

Powertrain Control Module Connector Faces



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The 5R55N PCM incorporates the following transmission control features:

- Closed loop shift control – the PCM controls the pressure solenoids to increase or decrease the clutch pressure relative to variations in speed (clutch engagement pressure control).
- Adaptive shift pressure control – the PCM adjusts the starting pressure of clutch application according to a calculated change ratio (maintains consistent shift quality as components wear).
- Skip shift scheduling – under normal driving conditions, the PCM will schedule a shift from 1st to 3rd gear directly, skipping the 2nd gear ratio. The PCM will only shift to 2nd gear during heavy throttle applications in 1st gear, and during certain downshift events.
- Reactive shift scheduling (shift application reacts to throttle position and rate of throttle change) – several factors will affect and influence shift scheduling:
  - Hot or cold transmission
  - Gradients
  - Sports mode
  - Dynamic Stability Control
  - Cruise Control
- Engine torque modulation during shifting
- Torque converter clutch modulation
- Manual shift capability (2, 3, 4)

The PCM activates / controls the three hydraulic pressure control solenoids, the four shift solenoids, and the torque converter clutch solenoid from strategies determined on transmission sensor / data inputs, sensor / data inputs to the engine management system, and other vehicle system sensor / data inputs.

PCM Volatile Memory

Adaptive values and DTCs are stored in PCM volatile memory. If the vehicle battery is disconnected, all stored adaptive values and DTCs will be lost. Several driving cycles are required for the PCM to relearn adaptive values.

PCM Inputs – Transmission

Transmission Speed Sensors

The 5R55N transmission has three speed sensors: Turbine speed sensor, Intermediate speed sensor and Output speed sensor. All three speed sensors are inductive pulse generators, which provide the PCM with a transmission speed alternating voltage signal. The pickup portion of the sensors are mounted to the exterior of the transmission case; the reluctors are integrated with transmission rotating components.

Speed Sensor Characteristic

21 °C (70 °F): 32 – 485 Ohms

Turbine Shaft Speed (TSS) Sensor

The PCM uses the TSS signal for: monitoring torque converter clutch (TCC) operation, as a factor in determining operating pressures, transmission diagnostics.

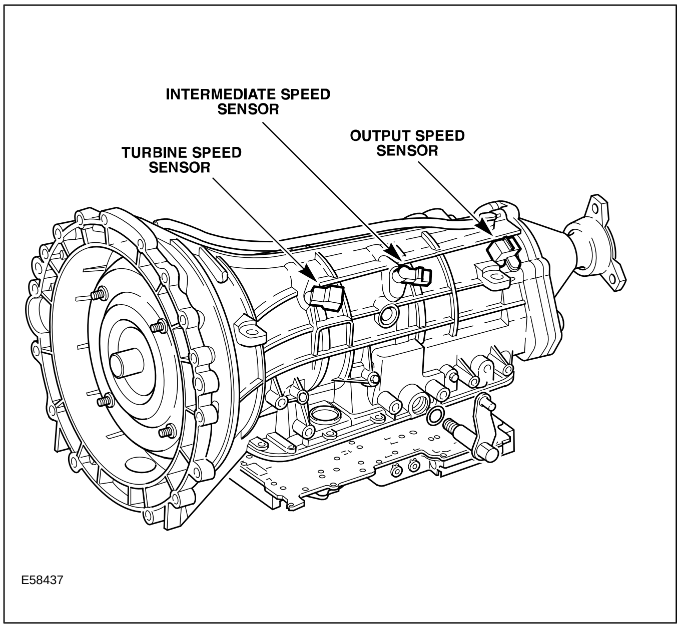
Intermediate Shaft Speed (ISS) Sensor

The PCM uses the ISS signal for: as a factor in determining operating pressures, transmission diagnostics.

Output Shaft Speed (OSS) Sensor

The PCM uses the OSS signal for: to determine torque converter clutch (TCC) control, as a factor in determining operating pressures, shift scheduling transmission diagnostics.

Transmission Speed Sensors



Transmission Fluid Temperature (TFT) Sensor

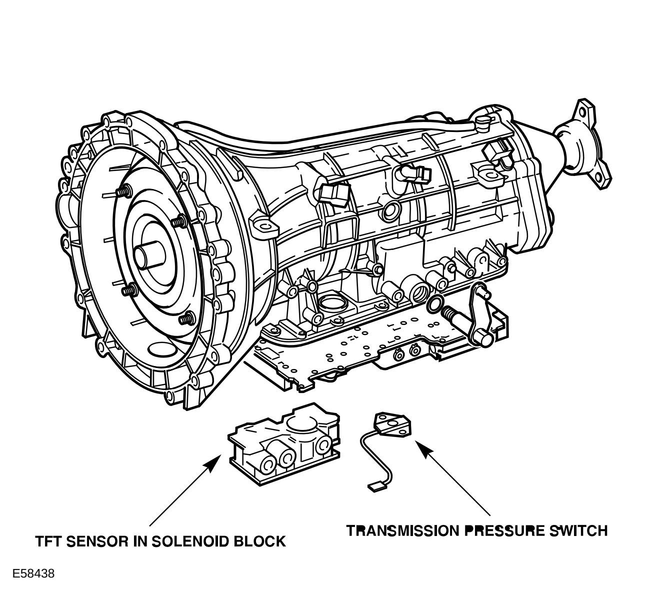
The TFT sensor, incorporated into the solenoid block, is a negative temperature coefficient (NTC) thermistor. Transmission fluid temperature is determined by the PCM by the change in the sensor resistance. The PCM applies 5 volts (nominal) to the sensor and monitors the voltage across the pins to detect the varying resistance.

The PCM uses the TFT signal for:

- TCC operation
- implementation of a cold transmission shift schedule
- as a factor in determining shift scheduling
- as a factor in determining operating pressures
- implementation of Hot Mode

TFT Sensor Characteristics		
Temperature °C (°F)	Approximate Resistance (kOhms)	Nominal Voltage at PCM (V)
0 (32)	95.851	3.88
20 (68)	37.352	3.09
40 (104)	16.092	2.15
60 (140)	7.556	1.34
80 (176)	3.837	0.79
100 (212)	2.080	0.47
120 (248)	1.191	0.28

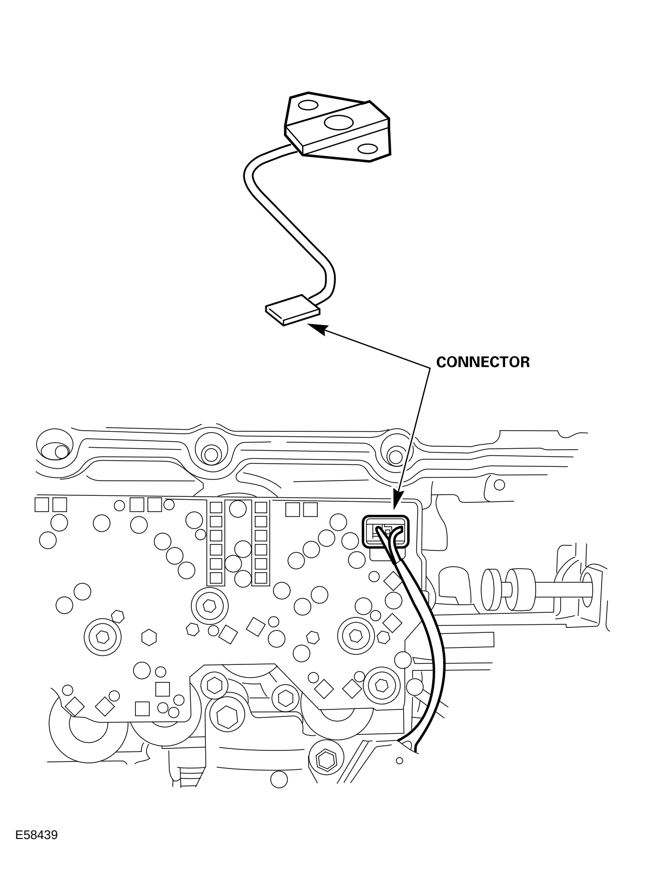
Transmission Solenoid Block



Transmission Pressure Switch

The pressure switch, mounted on the valve body, is a normally open switch that is moved to the closed position at a predetermined line pressure.

Transmission Pressure Switch

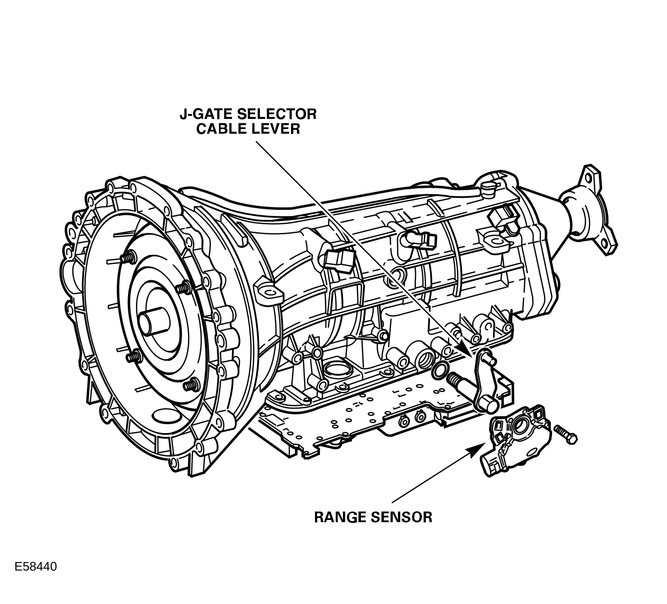


The pressure switch acts a safety switch to prevent simultaneous application of apply elements. For example, if a valve in the valve body gets stuck, it is possible that two elements could apply together causing transmission damage. The switch signals this fault to the PCM, which takes action to prevent the lock up from occurring.

Transmission Range Sensor

The transmission range sensor, which functions as a digital rotary switch, slides over the square end of the transmission gear selector shaft and is bolted to the transmission case. Selection of a particular gear generates a 4-bit binary coded signal which is transmitted directly to the PCM over a four-wire parallel interface.

Transmission Range Sensor



The gear selector lever must be in Neutral during range switch alignment and installation.

NOTE: If the selector cable is incorrectly adjusted, the range sensor may transmit an invalid code, which would cause a DTC to be flagged. Refer to the Jaguar Powertrain DTC Summaries – P0705.

D – 4 Switch

The D – 4 switch provides the PCM with an open / close input when the J-gate gear selector is moved from one side to the other. This input is required as no selector cable and range sensor movement occurs during the sideways movement.

WDS Datalogger readings for the range sensor and the D – 4 switch will show as follows:

Range Sensor and D – 4 Switch Output States					
RANGE	**TRS1**	**TRS2**	**TRS3**	**TRS4**	**TCS**
Park	0	0	0	0	0
Reverse	0	0	1	1	0
Neutral	0	1	1	0	0
Drive	1	1	1	1	0
Manual 4th	1	1	1	1	1
Manual 3rd	0	1	0	1	1
Manual 2nd	1	0	0	1	1
TRS 0 = closed / low voltage; 1 = open / high voltage **TCS (D – 4 Switch)** 0 = open / low voltage; 1 = closed / high voltage (B+)					

Mode Switch

The mode switch allows the driver to select between Normal and Sport modes. This input to the PCM is communicated from the GEM via the SCP network.

PCM Inputs – Engine Management

Several engine management sensor inputs are used by the PCM for transmission control processing.

Mass Air Flow (MAF)

Mass air flow is used as a factor for operating pressure control, shift scheduling and torque converter clutch application.

Crankshaft Speed (CKP)

Engine speed is used for wide-open throttle shift control, and as a factor for operating pressure control, and torque converter clutch application.

Engine Coolant / Cylinder Head Temperature (ECT / CHT)

Engine coolant / cylinder head temperature is used as a factor for torque converter clutch application.

Intake Air Temperature (IAT)

Intake air temperature is uses as a factor for operating pressure control.

Throttle Position (TP) 1, 2, 3

Throttle position is used as a factor for operating pressure control, shift scheduling and torque converter clutch application.

A/C Clutch Activated

When the A/C clutch is engaged, the PCM adjusts the operating pressures to compensate for the increased load.

Brake On / Off

The PCM disengages the torque converter clutch when the brakes are applied. The brake on / off input is received directly from the brake switch on ABS / TC equipped vehicles.

Cruise Control

When cruise control is active, the PCM uses a cruise control strategy for transmission control. The strategy is canceled when the driver switches off cruise control or activates the brake cancel switch

PCM Inputs – ABS / TC; DSC

Vehicle Speed

The PCM accesses the vehicle speed message communicated on the SCP network by the ABS/TC or DSC control module. Vehicle speed is used by the PCM for shift scheduling and torque converter clutch application.

ABS / TC / DSC Status

The ABS/TC or DSC inputs allow the TCM to refine shift scheduling and react to ABS/TC or DSC events.

Brake On / Off

The PCM disengages the torque converter clutch when the brakes are applied. The brake on / off input is received from the DSC control module on DSC equipped vehicles.

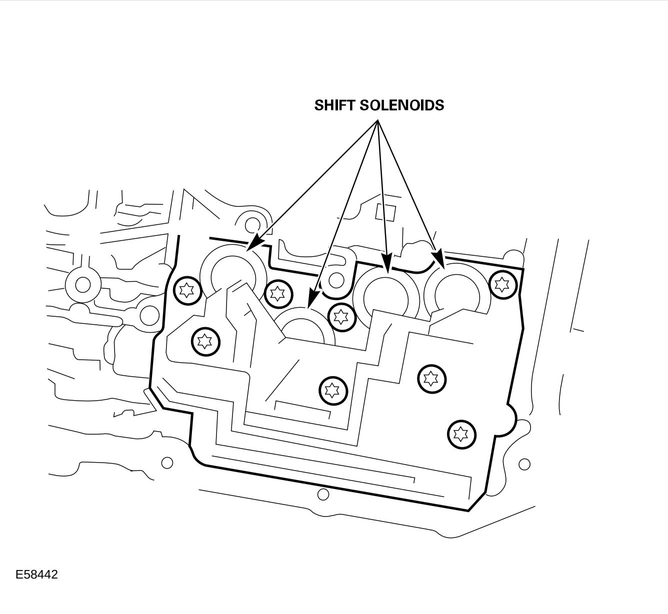
PCM Transmission Control Outputs

The PCM transmission control actuators are mounted on an integral, solenoid block module attached to the transmission control valve (valve body).

NOTE: The solenoid block is non-serviceable. If a fault occurs in any of the solenoids, the entire assembly must be replaced as a unit.

The four ON / OFF shift solenoids (SSD1, SSD2, SSD3, SSD4) are two-way normally open solenoids.

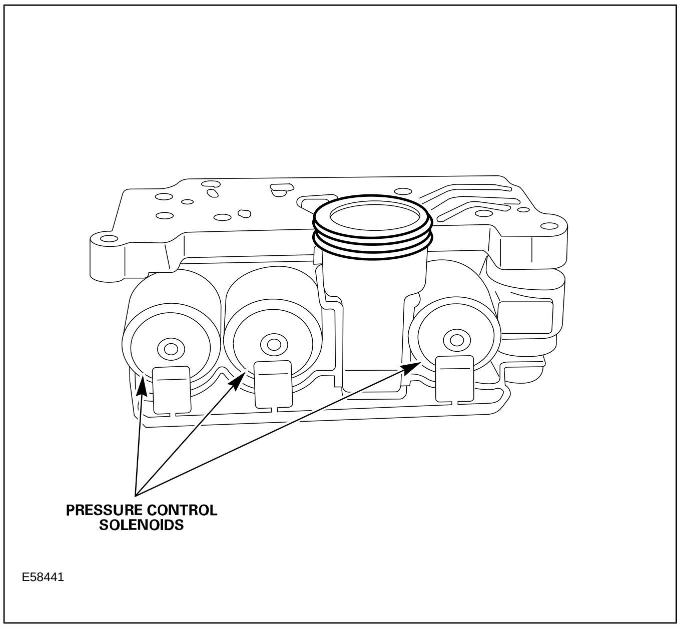
Shift Solenoids



The TCC solenoid is PWM driven by the PCM to apply and release the torque converter clutch. The TCC can be applied gradually until it is engaged 100%. There is no controlled TCC slip. Except during hot mode, the TCC operates only in 4th and 5th gears.

The three pressure control solenoids (EPCS1, EPCS2, EPCS3) are electro-hydraulic variable force actuators combining a solenoid and a regulating valve. The pressure regulators are used to control line pressure, as well as brake band and clutch application pressures. The PCM applies a PWM signal to the solenoids to vary hydraulic pressures.

Pressure Control Solenoids



Solenoid Characteristics			
Actuator	**Transmission Connector (GB5) pin numbers**	**Nominal Resistance (Ohms)**	**Actual Reading (Ohms)**
SSD1	3/16	16 – 45	
SSD2	3/15	16 – 45	
SSD3	3/6	16 – 45	
SSD4	3/5	16 – 45	
TCC	3/14	9 – 16	
EPCS1	3/1	5	
EPCS2	3/4	5	
EPCS4	3/11	5	

The following chart shows the solenoid operation in P, R, N, D. With the selector in Drive, the commanded state will be 1st gear.

Solenoid Operation							
RANGE	**SSD1**	**SSD2**	**SSD3**	**SSD4**	**EPCS1**	**EPCS2**	**EPCS3**
Park	ON	OFF	OFF	ON	L	C	L
Reverse	ON	OFF	OFF	ON	L	C	H
Neutral	ON	OFF	OFF	ON	L	C	L
Drive	ON	OFF	OFF	ON	C	L	L

ON 1
OFF 0
C Control pressure expressed as current (approx. 630 mA with engine running, vehicle stopped)
H High pressure expressed as current (0 mA). High pressure is the default pressure.
L Low pressure expressed as current (approx. 920 mA with engine running, vehicle stopped)

PCM CONTROL STRATEGIES

The PCM directly controls the transmission actuators as a response to driver demand, engine requirements and according to the selected shift mode. Gear selection is controlled by commands to the four shift solenoids. If, during gear selection, the relative speeds monitored by the speed sensors are not as expected, the PCM varies the analog signal to the pressure solenoids to increase / decrease the clutch pressure (closed loop control). Increased engagement times due to aging are also controlled by adaptive shift pressure.

Upshifts

The PCM uses engine management signals, and transmission sensor inputs to control shift scheduling, shift feel and torque converter operation.

Downshifts

Under certain conditions the transmission will downshift automatically to a lower gear range (without moving the gearshift lever). There are three categories of automatic downshifts; coast down, torque demand and forced or kickdown shifts.

Coast Down – The coast down downshift occurs when the vehicle is coasting down to a stop.

Torque Demand – The torque demand downshift occurs (automatically) during part throttle acceleration, when the demand for torque is greater than the engine can provide at that gear ratio. If applied the transmission will disengage the torque converter clutch to provide added acceleration.

Kickdown – For maximum acceleration the driver can force a downshift by pressing the accelerator pedal to the floor. A forced downshift into a lower gear is possible below calibrated speeds. Specifications for downshift speeds are subject to variations in engine and transmission calibration requirements.

Apart form the Normal, Sport, and Dynamic Stability Control / Traction Control modes (strategies) selected by the driver, there are strategies selected by the PCM in response to sensed driving conditions:

Gradient

If the PCM senses increased driving resistance, it implements a gradient strategy to produce increased vehicle performance.

Cruise Control

When the driver engages cruise control, the PCM implements a cruise strategy to reduce gear change “hunting”.

Hot Mode

If the transmission fluid temperature exceeds 116°C (240°F) the PCM will apply the torque converter lock-up clutch in all five forward gears to help reduce temperature.

Hot Mode entry: TFT > 116°C (240°F)

Hot Mode exit: TFT < 111°C (230°F)

ON-BOARD DIAGNOSTICS

The 5R55N system uses diagnostics similar to other Jaguar transmission systems. One difference of note is the PCM default strategy. If a component is diagnosed as “failed”, the system will attempt to maintain as much of its functionality as possible. There are no standard default modes for “limp home”.

Drive Cycle

All transmission components are checked by the PTEC Comprehensive Component Monitor (programmed software). After a fault has been flagged and repaired, it may be necessary to complete a drive cycle to check for a reoccurrence of the fault (as directed in the DTC Summaries). The Comprehensive Component Monitor transmission drive cycle is included in the DTC Summaries.

PCM Volatile Memory

DTCs are stored in PCM volatile memory. If the vehicle battery is disconnected, all stored DTCs will be lost.

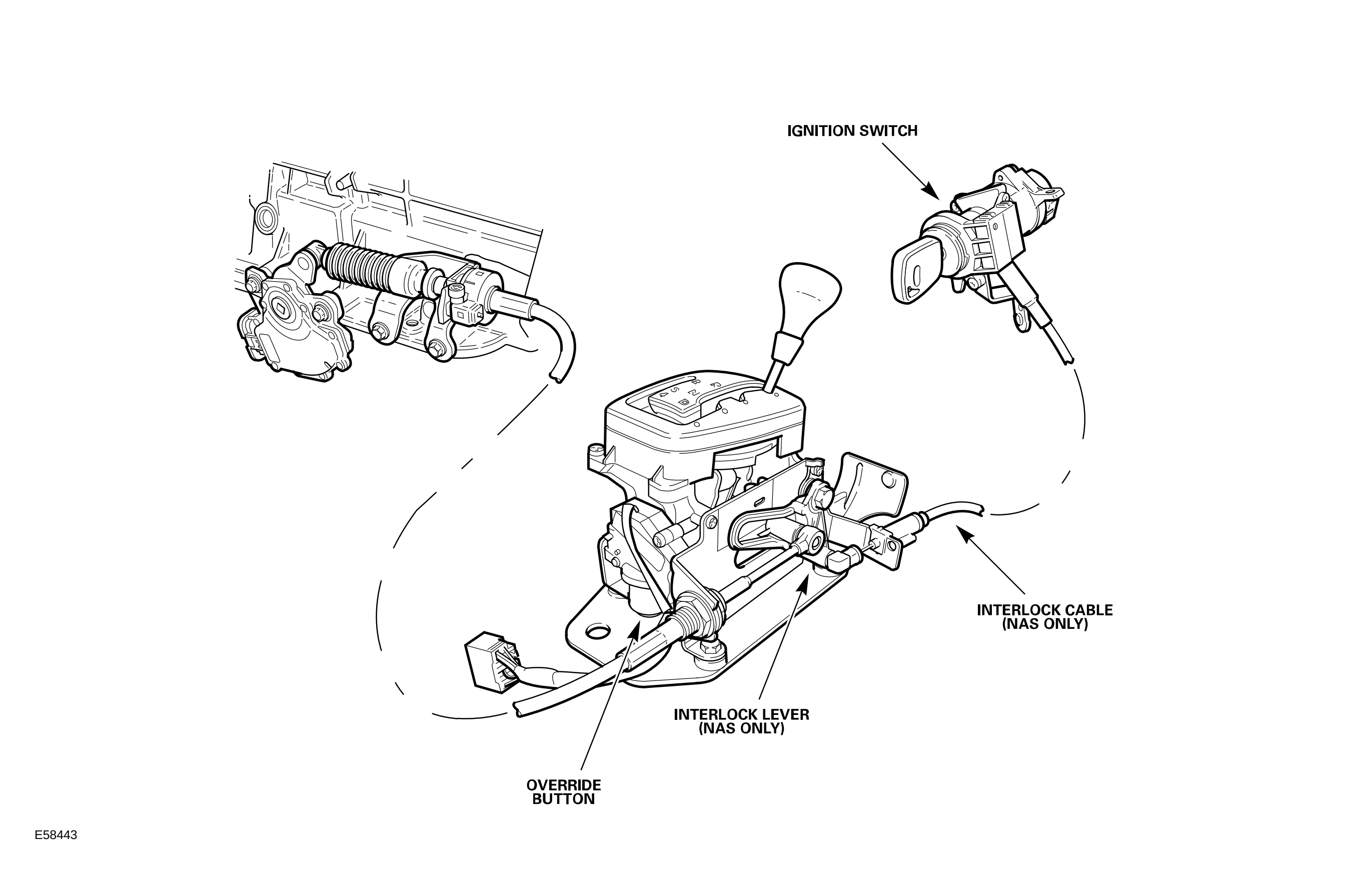
GEAR SELECTION

The J-gate gear selector allows driver selection of the normal Jaguar transmission functions: P, R, N, D, and manual selection of 4th, 3rd, and 2nd gear ranges. The D – 4 switch, located in the J-gate assembly, allows 5-speed shifts in D range or 4 -speed shifts in the 4th gear range. The gear selector lever is mechanically connected to the selector lever in the transmission with a cable.

The gear selector positions are:

- **P** – The transmission is mechanically locked (starting available)
- **R** – Reverse gear
- **N** – No power to the rear wheels (starting available)
- **D** – All 5 forward gears available
- **4** – Upshift to 4th gear only
- **3** – Upshift to 3rd gear only
- **2** – Upshift to 2nd gear only

J-Gate



Gearshift Interlock

In the P position with the ignition off, the gear selector lever is locked by a solenoid plunger which inhibits a lock plate fixed to the selector mechanism. When the ignition is switched on, pressing the brake pedal energizes the solenoid and releases the lock plate, allowing the selector lever to be moved from the P position.

Manual Override

An override button located on the interlock mechanism allows technician gear selector movement from Park.

Key Interlock

For NAS markets, the J-gate slider actuator is linked to the ignition switch barrel to provide a mechanical interlock. The interlock lever and cable are driven by the J-gate slider to operate a locking plunger in the ignition barrel. If the gear selector lever is in any position other than P, the ignition key cannot be removed.

NOTE: When servicing, the interlock cable adjustment is critical and GTR service instructions must be followed.

SERVICE PROCEDURES

Selector Cable Adjustment

Using the following procedure, adjust the gear selector cable. This procedure was extracted from GTR. Always refer to GTR and Service Bulletins for the most up-to-date specifications and procedures.

1. Unclip the parking brake boot.
2. Disconnect the electrical connectors under the center console upper section and remove.
3. Loosen the selector cable lock nuts and detach the selector cable.
4. Raise the vehicle.
5. Move the transmission selector lever to the N position. The transmission selector lever has its own detent mechanism. There is no need to hold it after engaging gear.
6. Lower the vehicle.
7. Connect the selector cable.
8. Adjust the selector cable from inside the vehicle.
9. Install the center console upper section and connect the electrical connectors.
10. Clip together the parking brake boot.

Adaptation Cycle

All 5R55N adapted values will be lost any time power to the PCM is interrupted. In such cases, the transmission adaptive strategy for pressure control on engagements must be updated.

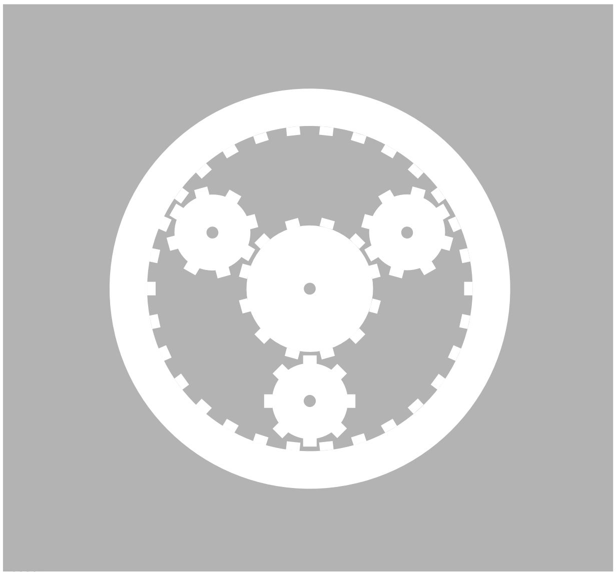
Make sure that the PCM has the latest calibration.

The transmission oil temperature must be warmer than 60°C (140°F). The vehicle should be warmed up by driving with various speeds and loads in normal mode. The cycle needs to be done at least five times.

- Perform five (5) engagements from Park to Reverse. Each engagement must be 5 seconds apart.
- Perform five (5) engagements from Drive to Reverse. Each engagement must be 5 seconds apart.
- Perform five (5) engagements from Reverse to Drive. Each engagement must be 5 seconds apart.
- Perform five (5) engagements from Neutral to Drive. Each engagement must be 5 seconds apart.

NOTE: All of these engagements must be performed in order for the engagement pressures to properly adapt.

Automatic Transmission
Lesson 7 - JF506E



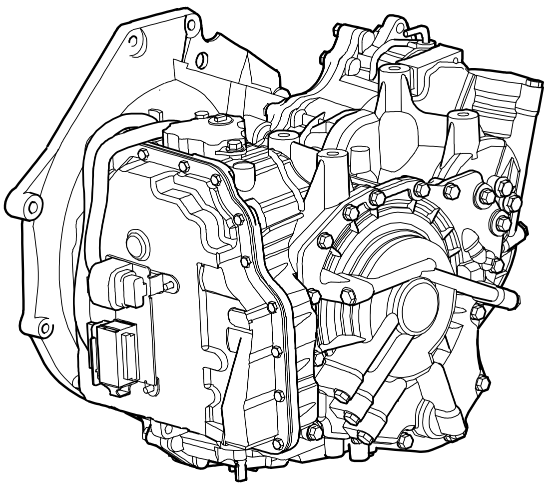
Technical Training

T201.1 en 12/2004

OVERVIEW

The JF506E automatic transmission was launched on the 2002 model year X-TYPE (X400). Made in Japan by JATCO, the transmission employs a transmission control module (TCM), three rotational speed sensors, and nine shift / pressure solenoids to achieve refined shift control with excellent response to changing driving conditions.

JF506E Transmission



JF506E is interpreted as follows:

- **J** – Japan Automatic Transmission Company
- **F** – Front wheel drive
- **5** – 5 forward gears
- **06** – Version
- **E** – Electronic control

The transmission ID is stamped on the transmission; PL 000 = 3.0 liter or PL 001 = 2.5 liter. This description is followed by the production year and month and a 5-digit serial number; for example: 08 12345.

JF506E Specifications	
Transmission weight	101 kg (223 lb.)
Mechanical features	Torque converter with single plate lock-up clutch and torsional damper
Transmission fluid	Capacity – 8.8 liters (9.3 qt.); Filled for life Type – IDEMITSU, Jaguar spec WSS-M2C922 – A1 (not compatible with other transmission oils)
Transmission fluid cooler	Air cooler with thermostat
Stall speeds	2.5 liter – 2610 rpm; 3.0 liter – 2610 rpm
Towing	0.5 miles @ 30 mph

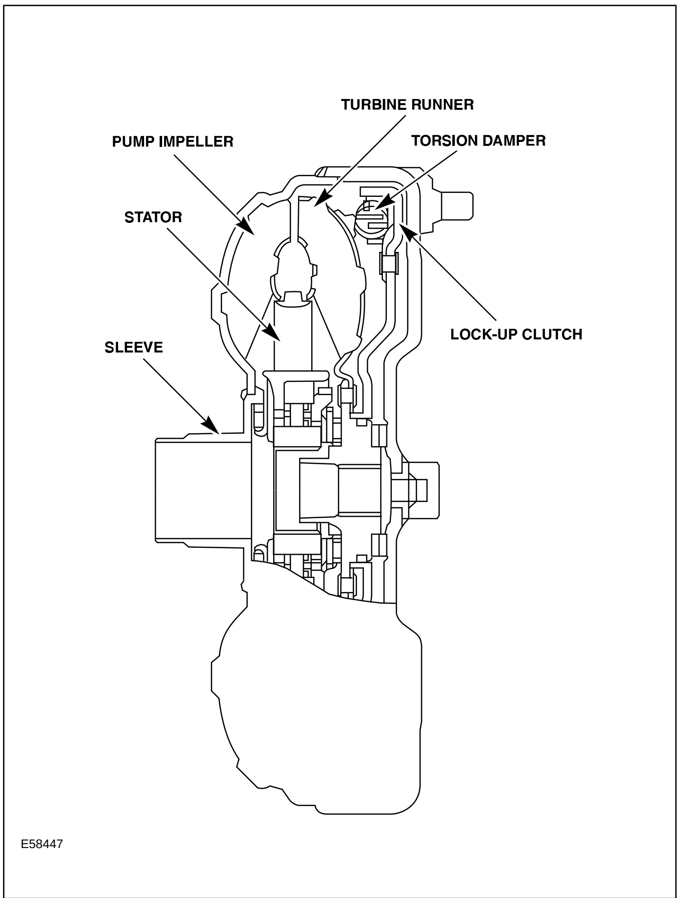
JF506E Specifications						
Gear ratios	**1st**	**2nd**	**3rd**	**4th**	**5th**	**Reverse**
	3.80	2.13	1.36	0.93	0.68	2.97
Final drive	3.8 : 1					

SYSTEM COMPONENTS

Torque Converter (with Lock-up Clutch)

The torque converter delivers the engine drive power to the transmission through to its 3 main components (impeller, turbine, and stator). The single plate lock-up clutch is controlled electronically and operates in fourth and fifth gears.

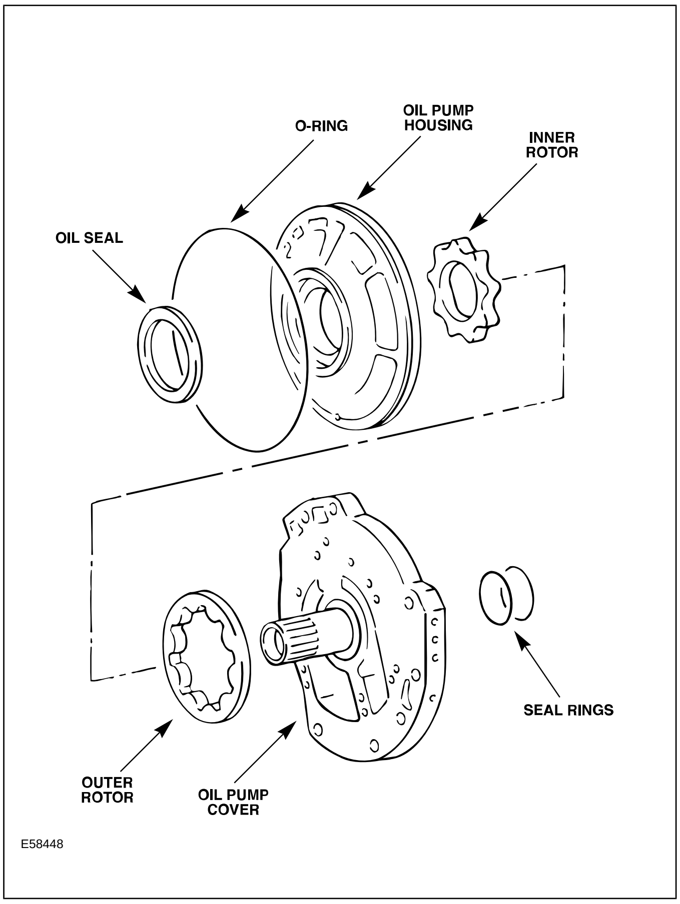
Torque Converter



Oil Pump

A trochoid oil pump is driven by the engine; the inner rotor connects to the torque converter sleeve.

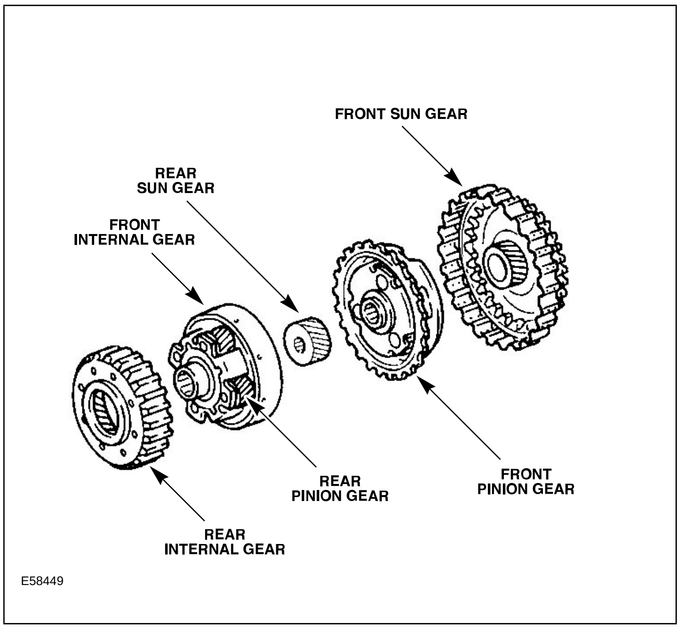
Oil Pump



Planetary Gears

There are 3 planetary gear sets – front, rear and reduction.

Planetary Gears



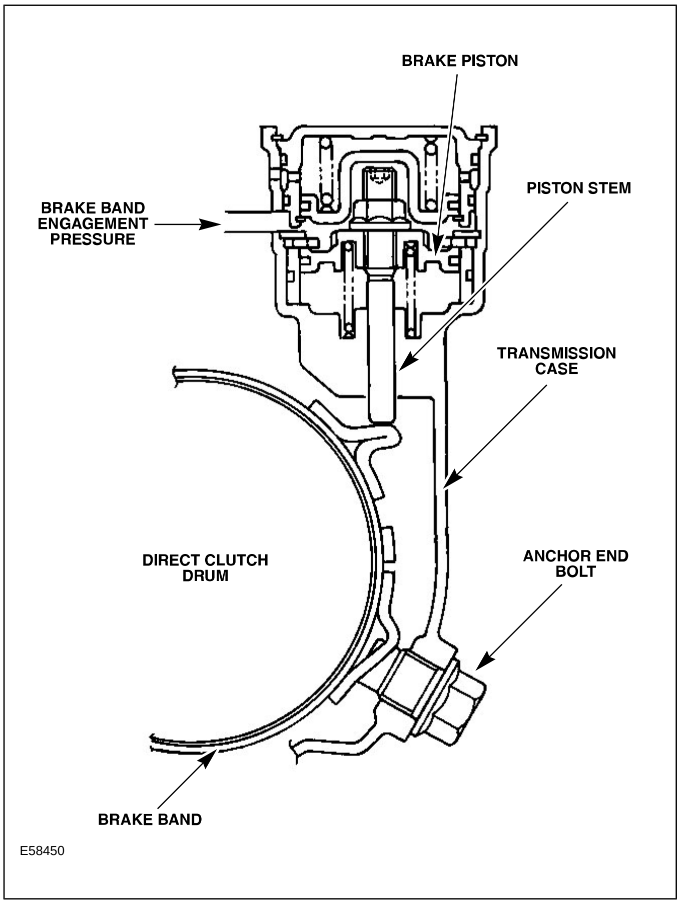
Clutches

There are 4 wet-type multidisc clutches – low clutch, high clutch, reverse clutch, and direct clutch.

Brakes

There are 3 brakes in the transmission. The low / reverse brake and the 2/4 brake are multidisc type brakes. There is one reduction brake band and servo that holds the direct clutch drum.

Reduction Brake Band and Servo



One-Way Clutches

The transmission uses two one-way clutches.

Low One-Way Clutch

The front planetary carrier is fixed by the inner race, which runs free during first gear operation.

Reduction One-Way Clutch

The reduction sun gear is fixed by the inner race, which runs free during first, second, third, and fourth gear operations.

Solenoids

There are 9 total solenoids, of both shift (on/off, in JATCO terms) and pressure control (duty, in JATCO terms), pulse width modulated (PWM) type solenoids. Three of them are duty solenoids; the other six are on/off solenoids.

On/Off Solenoids

The on/off solenoids are the shift solenoids A, B, C; low clutch solenoid; reduction timing solenoid; and the 2/4 brake timing solenoid. The on/off solenoids close the pressure circuit in response to current flow.

Duty Solenoids

The duty solenoids are the line pressure solenoid, lockup solenoid, and the 2/4 brake duty solenoid. The duty solenoids repeatedly turn on/off in 50 Hz cycles. This activity opens and closes the fluid pressure circuits.

Fluid Temperature Sensor

Installed in the transmission case, the fluid temperature sensor constantly monitors the fluid temperature. Resistance varies with fluid temperature (NTC). The fluid temperature sensor is not a serviceable component.

Transmission Rotary Switch

The rotary switch is located on top of the transmission, below the battery tray.

Speed Sensors

There are 3 sensors installed in the transmission casing. They are all of the inductive type. The speed sensors are not serviceable components.

Turbine Sensor

Detects the reverse drum speed, which is connected to the input shaft, and rotates at the same speed.

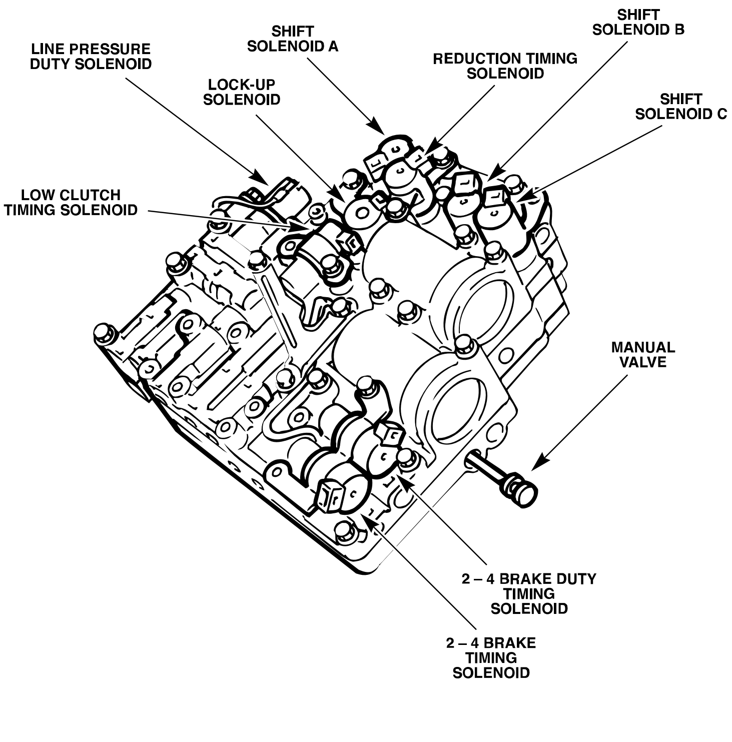
Vehicle Speed Sensor

Detects parking gear rotational speed.

Intermediate Sensor

Detects the intermediate (output) gear rotational speed.

Valve Body Components

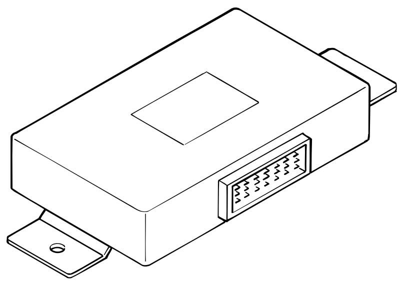


TRANSMISSION CONTROL

The transmission gear changes, oil pressure, and lockup operation are all electronically controlled.

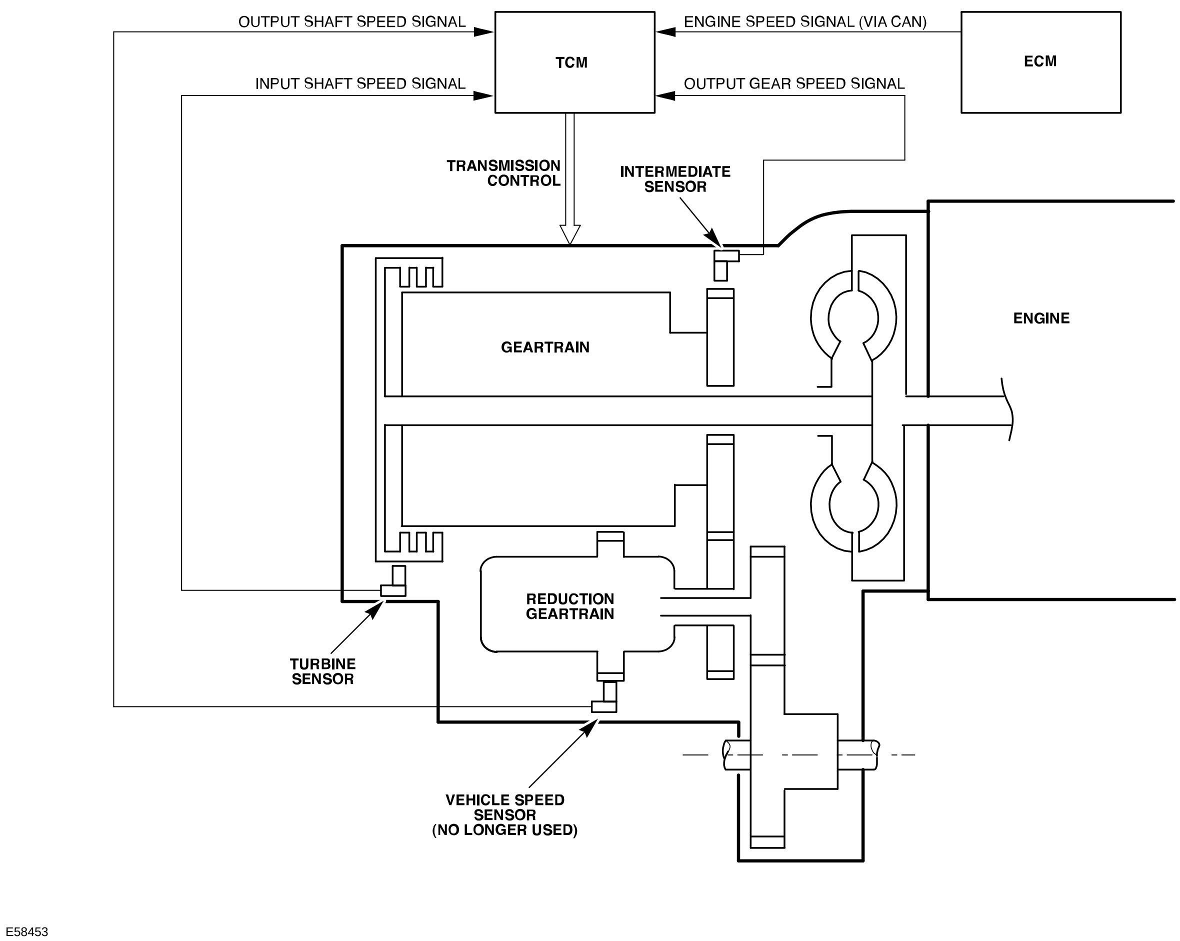
The transmission control module (TCM), located in the left-hand ‘A’ pillar, receives electrical signals from the CAN, indirectly relaying data from sensors indicating vehicle speed and throttle opening. In response to these signals, the TCM selects the appropriate gear and regulates other related conditions.

Transmission Control Module



Actual transmission control changes are made by actuators (solenoids) that respond to driver outputs provided by the TCM. These solenoids operate in response to electrical signals; they regulate the control valve operation. The control valves cause changes in the fluid flow passages. These changes result in pressure changes within the transmission.

Transmission Input/Output Signals



TCM Inputs – CAN Messages

- Indicated engine torque
- Indicated transmission input torque
- Estimated engine torque
- Throttle position
- Throttle pedal position
- Engine speed
- Cruise control status
- OBD II
- Brake pedal on/off
- Engine cranking status
- Engine coolant temperature
- Engine oil temperature
- Traction control status

TCM Inputs from Other Sources

- Battery power
- Ignition switch
- Transmission vehicle speed sensor

- Turbine speed sensor
- Intermediate speed sensor
- Transmission fluid temperature
- Sports mode switch
- D – 4 switch
- Selected gear position
- Transmission malfunction
- TCM configuration flag
- Torque converter status
- Gear selection faults
- Performance mode selection
- OBD II
- Transmission fault codes

TCM Outputs – CAN Messages

- Engine torque reduction request
- Transmission torque limit
- Torque converter slip percentage
- Transmission input speed
- Transmission output speed
- Gear position actual
- Gear position selected
- Gear position target
- Transmission oil temperature

TCM Controlled Components

- Shift solenoids A, B, and C
- Low clutch timing solenoid
- Torque converter lock-up solenoid
- Reduction timing solenoid
- Line pressure solenoid
- 2/4 brake timing solenoid
- 2/4 brake duty solenoid

Application Chart								
	RANGE							
DEVICE	**P**	**R**	**N**	**1**	**2**	**3**	**4**	**5**
Reverse Clutch	—	X	—	—	—	—	—	—
High Clutch	—	—	—	—	—	X	X	X
Low Clutch	—	—	—	X	X	X	—	—
Direct Clutch	—	—	—	—	—	—	—	X
Low & Reverse Brake (multidisc)	—	X	—	—	—	—	—	—
2/4 Brake (multidisc)	—	—	—	—	X	—	X	X
Reduction Brake (Band)	X	X	X	X	X	X	X	—
Low One-Way Clutch	—	—	—	X	—	—	—	—
Reduction One-Way Clutch	—	—	—	X	X	X	X	—
Shift Solenoid A	N/A	N/A	N/A	X	X	O	O	X

Application Chart								
	RANGE							
DEVICE	**P**	**R**	**N**	**1**	**2**	**3**	**4**	**5**
Shift Solenoid B	N/A	N/A	N/A	X	X	X	O	O
Shift Solenoid C	N/A	N/A	N/A	X	O	O	X	X
X Clutch/Brake Applied or Solenoid Energized **O** Solenoid De-energized								

TRANSMISSION CONTROL STRATEGIES

The transmission features the following control modes:

Normal

The normal strategy epitomizes fuel consumption by:

- Upshifting at low vehicle speeds.
- Downshifting at high throttle angles.

Sport

The sport strategy epitomizes vehicle performance by:

- Upshifting at high vehicle speeds.
- Downshifting at low throttle angles.

Cruise Control

When Cruise Control is active, the TCM will implement a cruise shift map. This map has a unique shift and lockup line for fourth and fifth gears.

Gradient Mode

By comparing the following parameters, the TCM will determine if the vehicle is going uphill:

- Vehicle speed
- Vehicle acceleration
- Throttle angle
- Gear position

It will then apply one of three Gradient mode shift maps, which will inhibit upshifts to reduce transmission hunting between gears.

Hot Mode

If the engine coolant, engine oil, or automatic transmission fluid (ATF) temperatures exceed preset limits, the TCM will go into Hot mode and operate on special shift maps that will allow torque converter lock-up to take place in all gears to aid cooling.

Traction Control

During traction control events, the TCM will implement a traction shift map.

Torque Converter Clutch

The TCM activates the torque converter lock-up clutch in fourth and fifth gears in normal operation. Depending on various conditions, the actual operating condition may be one of the following:

- Off
- Controlled slip
- On

Reverse Gear

If the vehicle speed exceeds 10 km/h, the TCM will inhibit reverse gear selection.

Downshift Strategy

The TCM will prevent any driver downshift that may lead to damage of the drive train.

Fail-safe Mode

If a failure occurs within the transmission, or if one of the more important input signals from the CAN is corrupted, the transmission can go into various fail-safe modes; the two main limp-home modes are:

- The line pressure duty solenoid will deliver maximum pressure to all clutch packs, resulting in harsh shifting, thus protecting all of the friction components.
- Fourth gear only.

See GTR for details.

DIAGNOSTICS AND SERVICE PROCEDURES

Diagnostics

Diagnostics are available with WDS to read fault codes and run diagnostic routines. System components can be analyzed using Datalogger.

Battery Disconnection

No data or settings are lost following battery disconnection. However, if the battery is disconnected with the ignition on or shortly after the ignition is switched off, an error code will be flagged (P1603) and stored by the TCM; TCM adaptations could be lost.

If a new TCM is fitted, it will require configuration with WDS.

Service Procedures

TCM Drive Cycle Monitor

TCM Drive Cycle Monitor is a WDS feature that allows the technician to monitor the status of all the transmission attributes during a road test. As each attribute is achieved, such as a particular up shift, downshift or a solenoid operation, the WDS screen will indicate the occurrence by changing from a cross to a tick along side that particular attribute.

The appearance of a tick does not necessarily indicate that a particular attribute has been achieved successfully. It does however indicate that the appropriate driving conditions have been met to attempt to achieve the attribute. The technician can use this information along with DTC Monitor to confirm whether a road test has been sufficient to reproduce a fault and its associated DTC.

TCM Drive Cycle Monitor is accessed from the WDS Special Applications menu.

TCM Drive Cycle

The following drive cycle explains all of the steps covered by the WDS TCM Drive Cycle Monitor. The Comprehensive Component Monitor transmission drive cycle will “check” all transmission system components.

A Engine and transmission at normal operating temperature. Ignition OFF.

B. With gear selector in P and the ignition ON, check gearshift interlock by attempting to move selector without pressing the brake pedal. Verify P state illumination.

C. Press and hold the brake pedal. Move the gear selector to R. Verify R state illumination.

D. Set the parking brake. Press and hold the brake pedal. Attempt to start the engine. The engine should not start.

E. Move the gear selector to N. Verify N state illumination. Start the engine.

F. With the handbrake set and the brake pedal pressed, move the gear selector to the remaining positions in the J Gate (D, 4, 3, 2) for five (5) seconds each. Verify the state illumination in each position.

G Move the gear selector back to 4. Verify 4 state illumination.

H Move the gear selector to D. Verify D state illumination.

I. Move the gear selector to N. Verify N state illumination.

J. Select R, release the brakes and drive the vehicle in Reverse for a short distance.

K Stop the vehicle.

L. Select 2 and drive the vehicle up to 65 km/h (40 mph). Hold 65 km/h (40 mph) for a minimum of five (5) seconds.

M Select 3 and hold 65 km/h (40 mph) for a minimum of five (5) seconds.

N Select 4 and hold 65 km/h (40 mph) for a minimum of five (5) seconds.

Q Select D and accelerate to a minimum speed of 80 km/h (50 mph). Hold 80 – 129 km/h (50 – 80 mph) for a minimum of 1.7 kilometers (1 mile).

P. Stop the vehicle; do not switch OFF the engine.

Q Use WDS Datalogger “TOTAL NUMBER OF DTCs SET” to ensure that transmission DTC monitoring is complete.

Selector Cable Adjustment

The cable has a sliding clamp at the transmission end; the bolt needs to be slackened.

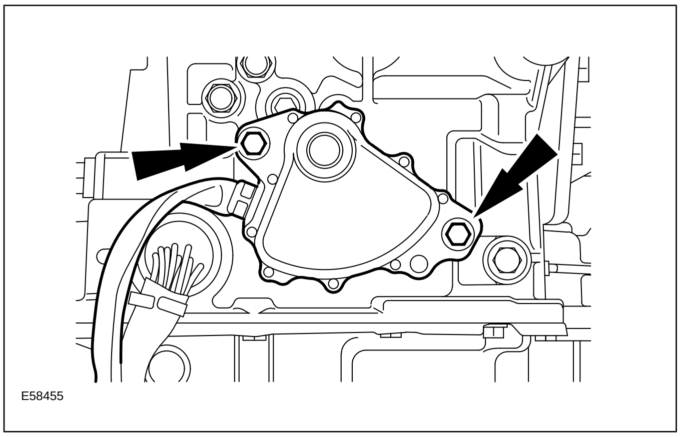
1. Position the transmission in neutral.
2. Position the selector lever in neutral.
3. Fit the cable at both ends (if they have been removed).
4. Ensure that the selector and transmission linkage are not moved.
5. Lock the bolt on the clamp.
6. Try the selector around the J-gate – ensure that it selects each position smoothly and that each LED illuminates in each position.
7. If the LED does not illuminate in one of the positions, or if the engine will not start in P or N, recheck the adjustment.

NOTE: If there is difficulty selecting manual fourth, try adjusting the cable with the lever positioned 2 mm towards the D position.

Rotary Switch Adjustment

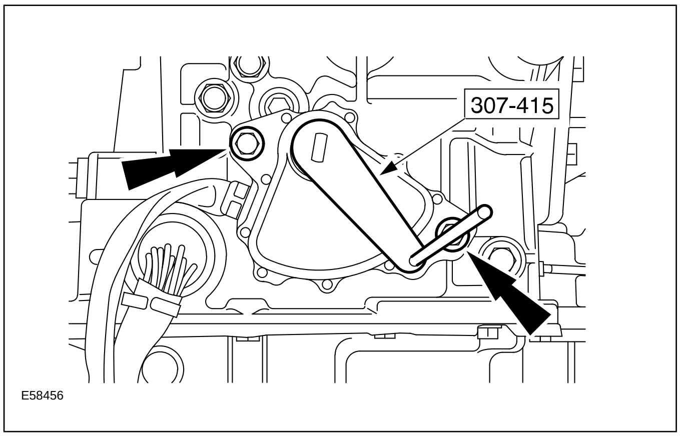
Prior to adjustment, ensure that the selector cable is correctly adjusted.

Rotary Switch Bolts



1. Fit the rotary switch to the transmission and loosely fit the 2 bolts.
2. Refit the electrical connector.
3. Position the transmission in neutral and fit the alignment plate.
4. Use Special Tool 307-415 to adjust the TR sensor as follows:
5. Position the 4 mm pin through the locating hole (there are 2 marks on the switch that should be in line when the transmission is in neutral and the switch is correctly adjusted).
6. Tighten the 2 bolts to 10 Nm.
7. Ensure that the vehicle starts in P and N and that the LED illuminates in each position.

Range Sensor Adjustment



Serviceable Items

The following components are serviceable:

- Transmission
- TCM
- Torque converter
- Output seal
- Pump seal
- Oil pan
- Valve body
- Solenoids
- Rotary switch
- Drain bolt
- Oil cooler

⚠ **CAUTION: The oil cooler supply and return line connections at the transmission must not be reversed.**

Remanufacturing service is available from JATCO.

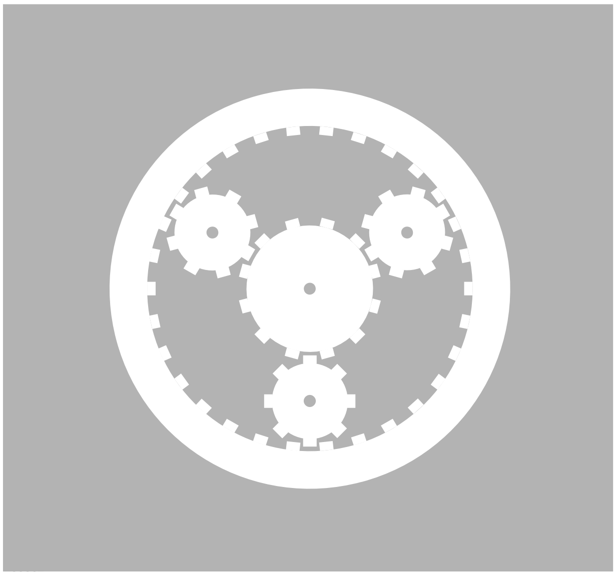
2004 Model Year Changes

Transmission Control Module

A new 32-bit TCM was introduced as a running change on 2004 MY X-TYPE models. The new processor has more available processing power and memory to allow for an increased number of shift strategies. The 32-bit TCM differs from the 16-bit TCM in the case and connector; the new TCM is not backwards compatible.

The 32-bit TCM will not be fitted to early 2004 MY X-TYPE models.

Automatic Transmission
Lesson 8 - ZF 6HP26



Technical Training

T201.1 en 12/2004

201

OVERVIEW

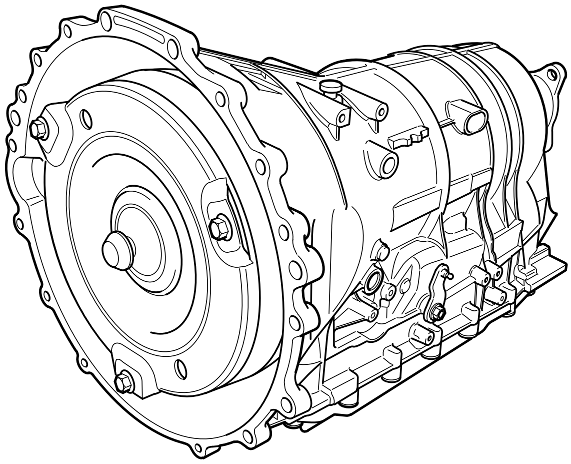
The ZF 6HP26 six-speed automatic transmission has been developed for vehicles with an engine torque of up to 600 Nm and is used on the following Jaguar models:

- S-TYPE (X202): 2003 MY onwards
- XK (X103): 2003 MY onwards
- XJ (X350): 2004 MY onwards

The ZF 6HP26 transmission uses an innovative Lepelletier planetary gear arrangement – with a double planetary gear set following the single planetary gear – to achieve 6 forward gears and one reverse.

The transmission is electronically controlled by the TCM, which is integrated into the combined hydraulic/electronic Mechatronic valve block. Transmission control is improved by the introduction of an Adaptive Shift Strategy (ASIS) and increased control module communication, via the CAN network, with other vehicle systems.

ZF 6HP26 Automatic Transmission



Compared to the previous five-speed transmission, the ZF 6HP26 provides:

- Higher torque capacity
- 5 cm reduction in length
- 13% reduction in weight
- Fewer assembly components – 470 vs. 660
- Improved fuel efficiency
- Improved vehicle performance

ZF 6HP26 is interpreted as follows:

- **ZF** – Transmission manufacturer
- **6** – 6 forward gears
- **HP** – Hydraulic Planetary type transmission
- **26** – Maximum torque designation (no units)

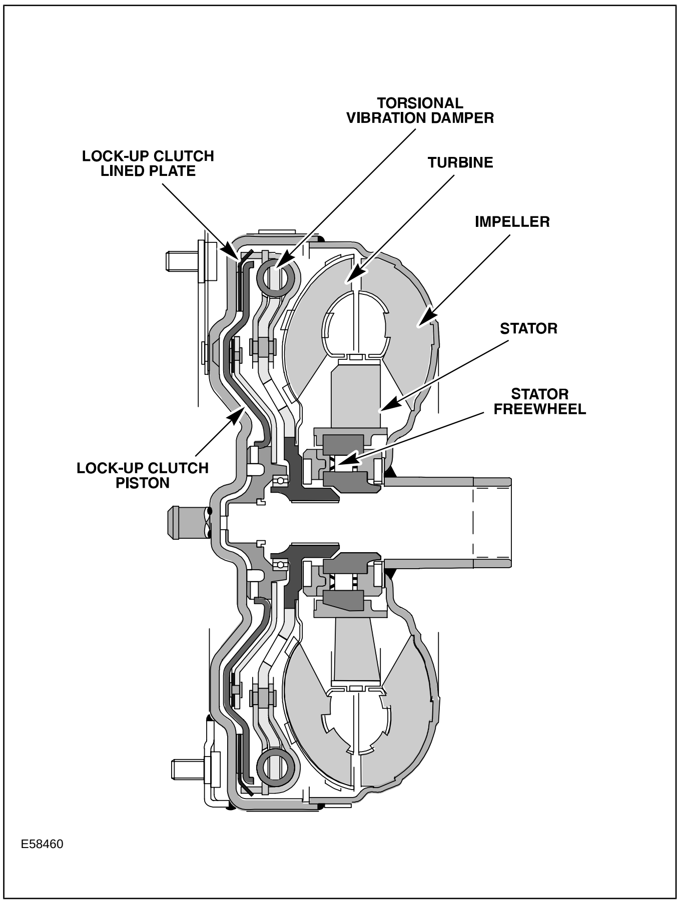
ZF 6HP26 Specifications							
Transmission weight	NA – 83 kg (184 lbs) with torque converter and fluid SC – 88.0 kg (194 lbs) with torque converter and fluid						
Mechanical features	Die cast aluminum transmission case in two sections – torque converter housing and main case Torque converter with single-plate, controlled slip lock-up clutch Mechatronic valve body with integral TCM Lepelletier double planetary gear set						
Transmission fluid	Capacity – 10 liters (10.6 quarts); Filled for life Type – Shell 1375.4, part # C2C8432						
Transmission fluid cooler	External liquid-to-liquid cooler integral with the left hand side radiator tank.						
Towing	Maximum 0.5 miles @ 30 m.p.h. (advise flatbed recovery)						
Stall Test	There is no stall test specification for the 6HP26 transmission.						
Gear ratios	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**Reverse**
	4.17	2.34	1.52	1.14	0.87	0.69	3.40

SYSTEM COMPONENTS AND OPERATION

Torque Converter

The torque converter is a three-element unit containing a single-plate lock-up clutch and torsional vibration damper. The lock-up clutch eliminates slip in the torque converter, helping to reduce fuel consumption. The lock-up clutch can be controlled and engaged in any of the six forward gears.

Torque Converter

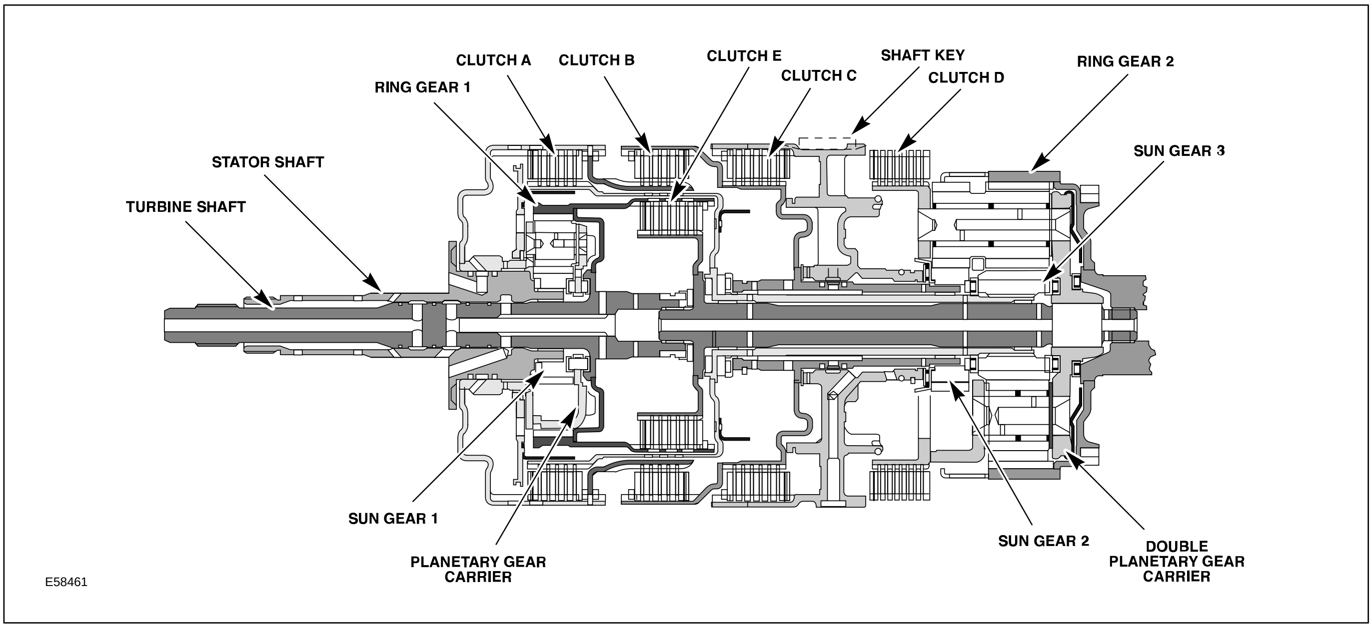


Gear Train

The gear train consists of:

- A single planetary gear set followed by a double planetary gear set
- Three rotating multi-plate clutches – A, B and E
- Two fixed multi-disc brakes – C and D

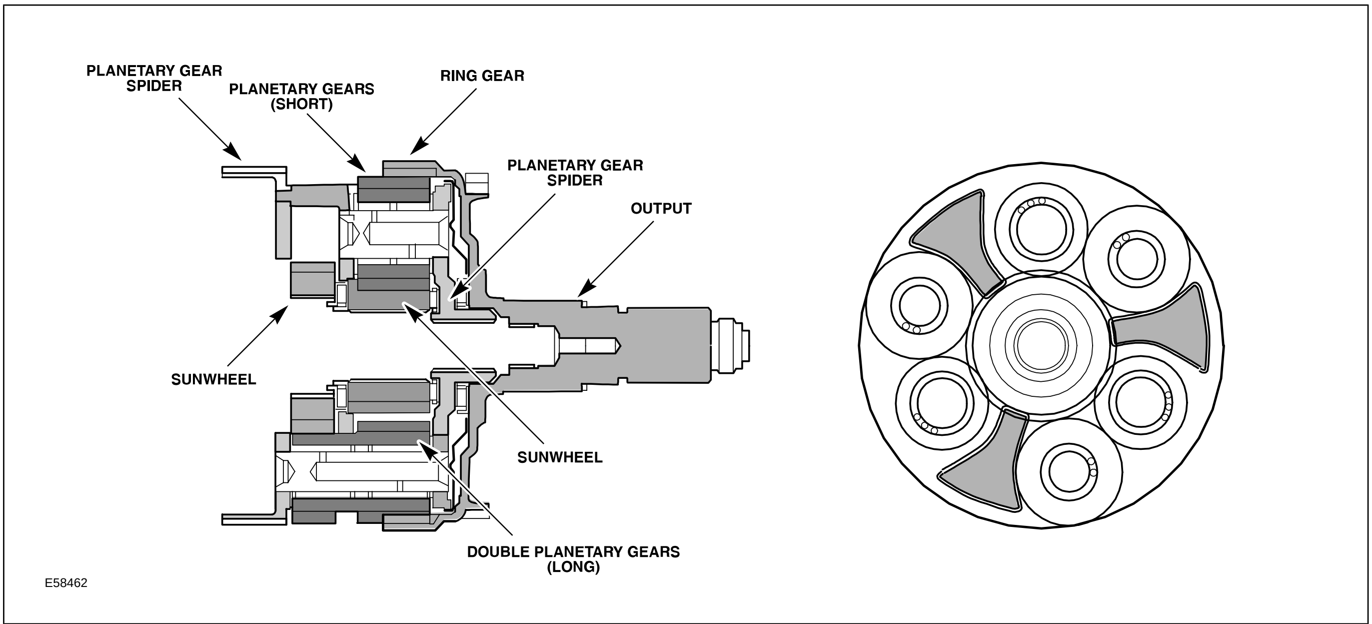
Gear Train



The following table shows clutch application for the selected gear.

Gear	Clutch A	Clutch B	Brake C	Brake D	Clutch E	TCC
P	—	—	—	X	—	—
R	—	—	—	X	—	—
N	—	—	—	X	—	—
D1	X	—	—	X	—	X
D2	X	—	X	—	—	X
D3	X	X	—	—	—	X
D4	X	—	—	—	X	X
D5	—	X	—	—	X	X
D6	—	—	X	—	X	X

Double Planetary Gear Set



All gear shifts 1st to 6th or from 6th to 1st are power-on overlapping shifts. During the shift, one of the clutches must continue to transmit the drive at lower than main pressure until the other clutch is able to accept the input torque.

Multi-plate clutches A, B and E supply power from the engine to the planetary gear train. Multi-disc brakes C and D bear against the transmission housing in order to achieve a torque reaction effect. Output is always via the ring gear of the second, downstream planetary gear set.

Shift Overlap Control

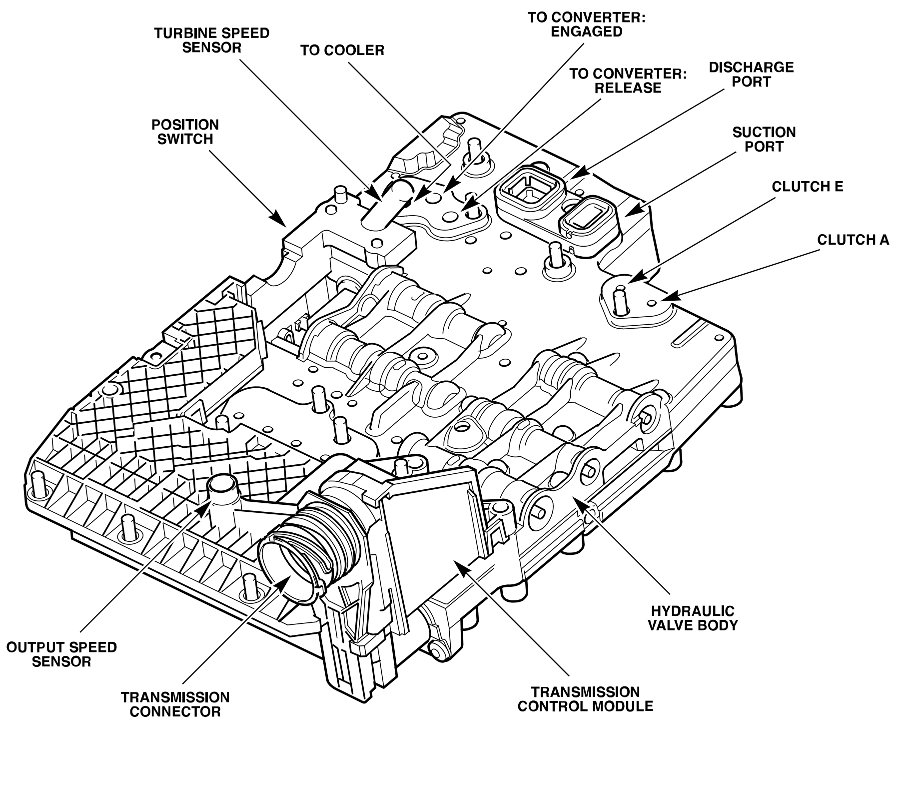
Overlap gearshifts are controlled by the TCM to limit slip. Freewheels (one-way clutches) are not used and are replaced by TCM-controlled actuation of the relevant clutches. This enables a reduction in transmission weight and size.

TRANSMISSION CONTROL

Valve Body

Transmission control is achieved through the combined hydraulic / electronic Mechatronic valve body with integral TCM. No part of the assembly is indepdently serviceable. The unit is installed immediately above the transmission fluid pan.

Transmission Control Module / Valve Body



This setup has the following advantages:

- Minimum tolerances (TCM directly mated to solenoids)
- Better coordination of gear shifts
- Increased refinement
- Optimized shift quality
- Good reliability, since the number of electrical connections are reduced

⚠ **CAUTION: When handling the TCM / Valve Body, precautions must be taken to avoid damage to the component through electrostatic discharge.**

Transmission Control Module (TCM)

The TCM controls the operation of the ZF 6HP26 transmission system. Using received signal inputs and pre-programmed data, the module calculates the correct gear, torque converter clutch setting and optimum pressure settings for gear shift and lock-up clutch control.

The TCM receives the following inputs via the CAN network:

- Transmission input speed
- Output speed
- Pedal position
- Gear selector position
- Engine torque
- Engine speed
- Transmission oil temperature
- Brake pedal status
- Engine oil temperature
- Coolant temperature
- ABS wheel speed

Using pre-programmed shift strategies, the TCM outputs signals to the shift control solenoid and the pressure regulator solenoids to control the hydraulic operation of the transmission. The TCM monitors all TCM inputs and outputs to confirm correct system operation. If a fault occurs, the TCM is able to adopt a default mode.

TCM Flash Programming and Adaptation Cycle

If a replacement Mechatronic unit is fitted, the TCM must be reprogrammed using WDS. After programming, it is advisable to perform an adaptation drive cycle. Refer to Service Procedures at the end of this Lesson.

TCM Inputs

Speed Sensors

Two Hall-effect speed sensors are located in the valve block – the input shaft (turbine) speed sensor and the output shaft speed sensor. The TCM monitors the turbine speed signal to accurately control the slip timing during shifts and adjust clutch application or release pressure for overlap shift control. Output shaft speed is monitored and compared to engine speed signals received on the CAN bus from the ECM.

By comparing the two signals, the TCM calculates the transmission slip ratio for plausibility and maintains adaptive pressure control.

Transmission Fluid Temperature (TFT) Sensor

The TFT sensor is a thermistor, or temperature-dependent resistor, located in the valve block. The sensor provides a transmission fluid temperature signal to the TCM for use in activating various shift strategies. If the sensor fails, the TCM will use a stored default value.

Gear Position Switch

The gear position switch is located on the valve body. The TCM uses a signal from the switch to determine the gear range (selected on the automatic side of the J-gate) in order to calculate shift control. The gear position signal is also used to inhibit or energize the starter relay to ensure that the engine can only be started in the park ‘P’ or neutral ‘N’ position.

TCM Outputs

The TCM-controlled transmission actuating solenoids are located in the valve body. There are 7 solenoids – one shift control solenoid (SV1) and six electronic pressure regulator solenoids (PRS1 – 6).

The shift control solenoid is used to switch the position valve located on the valve body.

The six pressure regulators convert a PWM signal from the TCM into a proportional hydraulic pressure to actuate the valves for the relevant switching elements. Two types of electronic pressure regulator are used:

Pressure Regulator Characteristics	
Regulator	**Characteristic**
PRS1, 3, 6 (green cap)	Rising characteristic: 0 mA = 0 bar; 700 mA = 4.6 bar
PRS2, 4, 5 (black cap)	Falling characteristic: 0 mA = 4.6 bar; 700 mA = 0 bar

Solenoid valve control is as follows:

- **SV1** – Clutch E engagement for 4th, 5th and 6th gears
- **PRS1** – Clutch A
- **PRS2** – Clutch B
- **PRS3** – Clutch C
- **PRS4** – Clutches D and E
- **PRS5** – System pressure
- **PRS6** – TCC lock-up

The following table shows solenoid valve status for the selected gears.

Gear	SV1	PRS1	PRS2	PRS3	PRS4	PRS5	PRS6
P	OFF	OFF	OFF	OFF	ON	- ON -	OFF
R	OFF	OFF	ON	OFF	ON	- ON -	OFF
N	OFF	OFF	OFF	OFF	ON	- ON -	OFF
D1	OFF	ON	OFF	OFF	ON	- ON -	- ON -
D2	OFF	ON	OFF	ON	OFF	- ON -	- ON -
D3	OFF	ON	ON	OFF	OFF	- ON -	- ON -
D4	ON	ON	OFF	OFF	ON	- ON -	- ON -
D5	ON	OFF	ON	OFF	ON	- ON -	- ON -
D6	ON	OFF	OFF	ON	ON	- ON -	- ON -

ON Active (pressure buildup)
- ON - Inactive (pressure drain)
OFF Inactive

ON-BOARD DIAGNOSTICS

The TCM continuously monitors the transmission control system and mechanical components for fault conditions. If a fault is detected, the TCM takes appropriate action to ensure driver safety and safe operation of the vehicle. Where necessary, DTCs may be stored and/or a “limp-home” mode may be adopted. The TCM can be interrogated for faults using WDS.

“Limp-Home” Mode

If a severe fault occurs or if electrical power supply to the electro-hydraulic actuators is lost, the transmission engages a reliable emergency gear ratio to facilitate a basic limp-home mode. 1st – 3rd gear limp home will be 3rd gear; 4th – 6th gear limp home will be 5th gear.

TRANSMISSION CONTROL STRATEGIES

The TCM uses a number of driver-selected and automatic adaptive strategies (modes) to control transmission operation. Based on gear selection, driver demand, driving conditions and vehicle status, the following strategies may be used.

Driver Selected Modes

Normal Mode

Normal is automatically selected by the TCM on power-up. In this mode, all automatic and adaptive modes are active. Normal mode remains engaged unless Sport mode is selected or Cruise Control is engaged. Normal mode is resumed when Cruise Control is disengaged. Various adaptive strategies can override Normal mode.

Sport Mode

Sport mode is selected with the Mode Switch on the J-gate. The Sport mode strategy allows upshifts to occur at higher engine speeds and downshifts at lower pedal angles. Sport mode remains engaged until Normal mode is selected or Cruise Control is engaged. If Cruise Control is engaged while Sport mode is selected, Sport mode is resumed when Cruise Control is disengaged. Various adaptive strategies can override Sport mode.

NOTE: In Sport mode, 6th gear will be inhibited when the vehicle is driven aggressively (N/A engines > 20% throttle opening; SC engines > 35%). Furthermore, consistent aggressive driving may prompt the adoption of a shift strategy in which 6th gear is unavailable. This is not a fault.

Cruise Control

When Cruise Control is activated, the TCM receives a CAN message from the ECM. The TCM adopts a shift and torque converter clutch locking strategy that minimizes upshifts and downshifts.

“Fast Off”

If the throttle pedal is released rapidly following hard acceleration, one or more upshifts are inhibited to improve subsequent response. This may be perceived by the customer as hanging on to gears. This feature has been included to reduce gear hunting and improve response; it is not a fault.

Adaptive Shift Strategy (ASIS)

The ZF 6HP26 transmission control system employs the newly developed Adaptive Shift Strategy (ASIS).

The TCM is in constant communication with other vehicle systems, and receives data regarding vehicle status, operating and driving conditions, and driver demand. Signals received by the TCM from other systems include:

- Engine speed and torque
- Engine oil temperature
- Accelerator pedal position
- Wheel speed
- Longitudinal and lateral acceleration

Comprehensive evaluation of these signals permits refined adaptive control of the transmission system. The TCM can respond to spontaneous driver action, sudden topographical changes or extremes of temperature, and immediately transmit the optimized shift strategy to the hydraulic unit. In this way, the control system can quickly adapt to innumerable variations of driving style and conditions.

ASIS includes the following adaptive modes:

Hot Mode

If transmission temperatures exceed critical thresholds, the TCM adopts a Hot mode shift strategy designed to reduce heat generated within the transmission. The Hot mode strategy allows torque converter lock-up and forces upshift at lower vehicle speeds. Hot mode is cancelled when transmission temperature falls back into normal range.

NOTE: With Hot mode implemented, the driver may experience unexpected upshifts when driving at high vehicle speeds and loads.

Traction Control Mode

On slippery road surfaces, it is possible that a driven wheel will spin (that its rotational speed will accelerate out of proportion with vehicle speed and acceleration). When the TCM senses such a “traction event” (based on a CAN message from the ABS module), it will upshift to a higher gear to reduce wheel slip; the higher gear is held until traction is regained.

Hill and Trailer Towing Mode

When the TCM senses reduced vehicle acceleration at a given throttle angle (due to the increased effort of ascending a hill or towing a trailer) it will adopt a shift strategy that will hold lower gears for a longer period, thus increasing acceleration and reducing the number of shifts. This strategy may also be used at high altitudes, where engine torque is reduced by the effects of reduced ambient pressure and, hence, reduced maximum air flow.

Safety Features

The safety functions are designed to safeguard against operation by the driver that could damage the transmission. The system:

- Prevents reverse gear from being engaged at high forward speeds (above 3 mph)
- Prevents manual downshifting at excessive engine speeds

Shift Energy Management

By reducing engine torque during synchronization without interrupting the tractive drive, the control system reduces the energy that is dissipated in the friction elements of the transmission during upshifts. This has the benefit of:

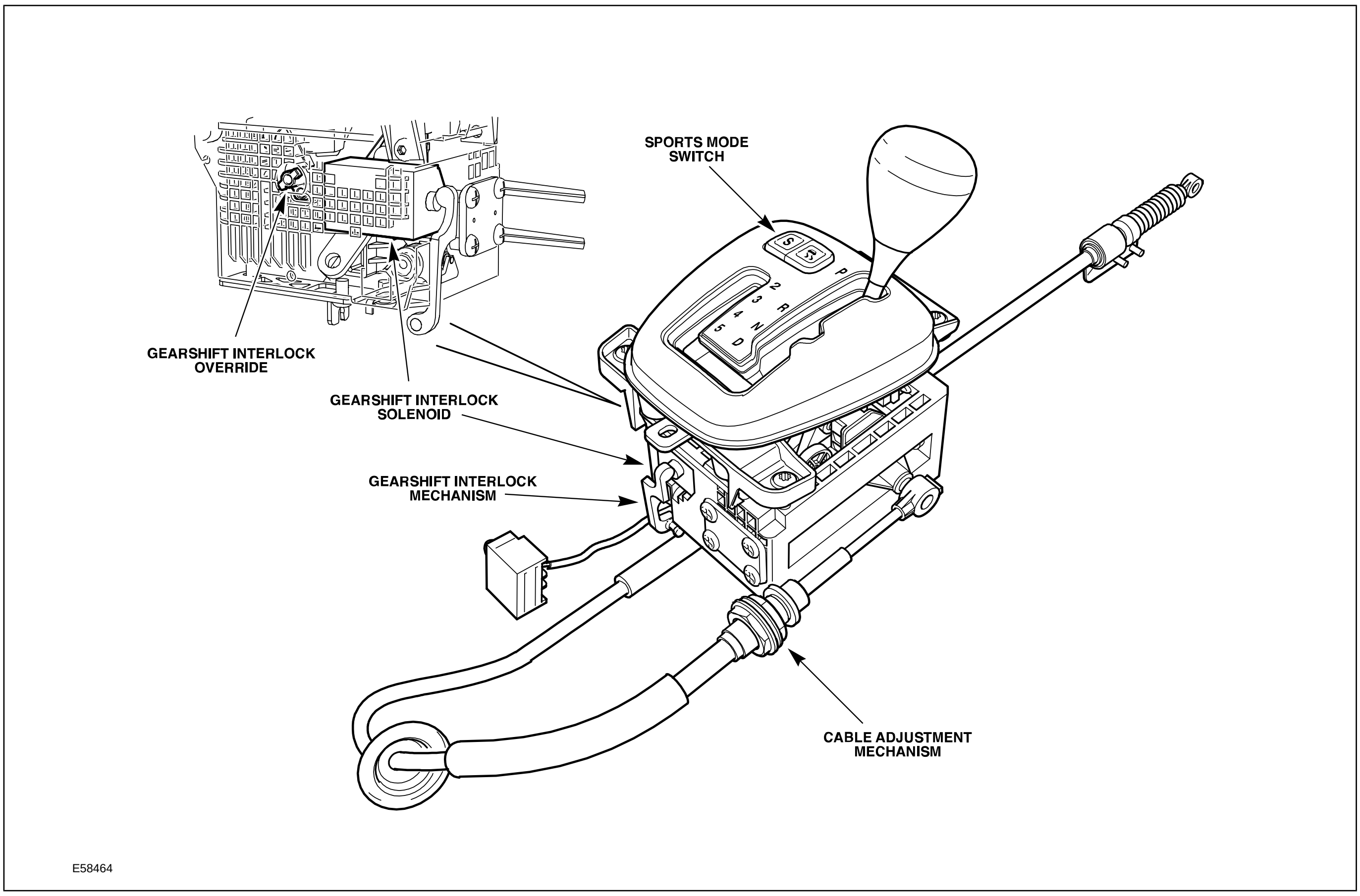
- Increasing the transmission service life by shortening the slipping time
- Improving the shift comfort by reducing the step change in torque caused by the gearshift
- Transferring reduced engine power up to the maximum allowed by the mechanical in-gear strength of the transmission

GEAR SELECTION

The XJ incorporates a new design of transmission selector mechanism with:

- Improved setting procedure
- New design of gearshift interlock mechanism
- New design of key interlock mechanism
- Reduction in component weight

2004 MY XJ Transmission Selector Mechanism

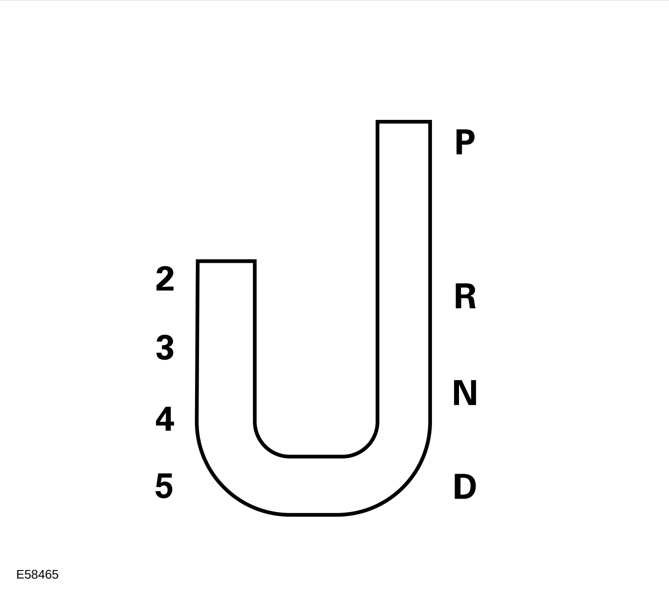


J-Gate

The J-gate is designed to allow both automatic and manual forward gear selection. On the right side of the J-gate, the gearshift lever position is sensed by the Gear Position Switch, which is linked to the lever by the shift cable. The TCM interprets the Gear Position Switch and transmits the selected gear position via CAN to illuminate the appropriate gear position LED on the J-gate.

The manual gear selection mode is activated by moving the gearshift lever to the left side of the J-gate. The shift cable does not change in manual mode. Manual gearshift lever position is sensed by Hall-effect switches within the J-gate and transmitted by the J-vate via CAN to the TCM.

J-Gate Pattern



Gearshift Interlock

The solenoid-operated gearshift interlock prevents movement of the selector lever out of park ‘P’ until the ignition is switched ON and the brake pedal is depressed. The solenoid remains de-energized until the brake pedal is depressed.

If the brake pedal is depressed simultaneously while the ignition is being switched ON or while the selector lever is being moved into ‘P’, the solenoid will remain de-energized (and the selector will remain “locked” in park). The ‘P’ LED on the J-gate will flash, indicating that the brake pedal must be released and re-depressed in order to “unlock” the selector lever.

Gearshift Interlock Override

In the event of a loss of battery power, the gearshift interlock solenoid has a manual override function. The override is accessed by removing the J-gate cover.

Key Interlock

A cable-operated mechanism prevents removal of the ignition key when the selector lever is not in the ‘P’ position.

DIAGNOSIS AND SERVICE PROCEDURES

Diagnosis

NOTE: It is important that the engine management system is checked first before any transmission concerns are diagnosed for gear load or ratio codes.

Certain transmission issues may not have an associated DTC, and therefore can't be diagnosed using WDS. In this case, technician testing must be thorough and logical.

Transmission Noise

If the customer complains of noise (such as a whine) from the transmission, perform the following checks:

- Ensure that the J-gate cable does not ground out with any other part; check the full length of the cable
- Ensure that the rubber grommet attached to the J-gate cable has a perfect seal to the body
- Ensure that the underbody heatshields do not ground out to the transmission casing
- Ensure that the driveshaft (propshaft) is aligned correctly; check that the center bearing bracket is not twisted, putting a pre-load on the rubber

Transmission Fluid Issues

Transmission fluid quality and low level will not log any fault codes, but the driver will be able to detect poor shift quality.

Transmission hot mode (excessive engine oil or transmission fluid temperature) will not log any fault codes, but the driver will be able to detect poor shift quality.

Residual fluid may remain from the assembly process in the cavity between the oil pan and the casing flange. Wipe away, clean and dry. Do not remove the oil pan.

Service Procedures

Adaptive Drive Cycle

After TCM reprogramming, it is advisable to perform an adaptive drive cycle.

General Conditions:

- Make sure that the A/C is switched off and that Sport mode is not selected.
- The transmission oil temperature must be warmer than 60°C (140°F). The vehicle should be warmed up by driving with various speeds and loads in normal mode.
- The cycle must be performed at least five times.

Normally Aspirated Vehicles

1. Light throttle upshifts up to 80 km/h (50 mph) with all shifts occurring between 1300 and 1800 rpm
2. Coast down with light brake to standstill
3. Wait at standstill in drive with the footbrake applied for at least 15 seconds

Supercharged Vehicles

1. Light throttle upshifts up to 80 km/h (50 mph) with all shifts occurring between 1000 and 1500 rpm
2. Coast down with light brake to standstill
3. Wait at standstill in drive with the footbrake applied for at least 15 seconds

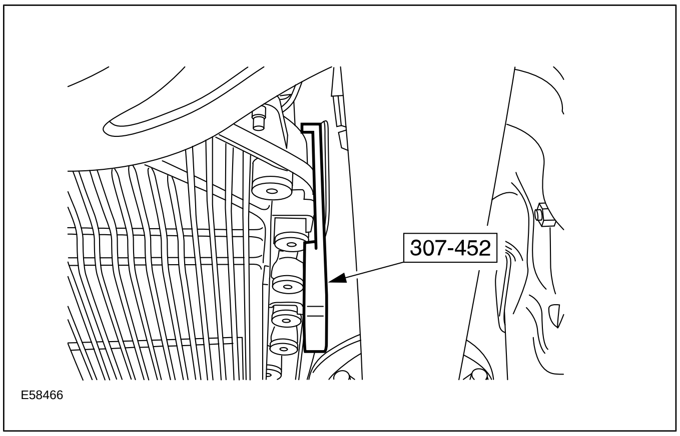
Transmission Fluid Level Checks

Before carrying out any diagnostic checks on the transmission fluid level, ensure that:

- The vehicle is level (preferably on a lift)
- The vehicle has been stationary for a minimum of two minutes prior to checking the level (ensure the park brake is applied and the transmission selector is in park 'P')
- The transmission fluid temperature is below 30°C (85°F)

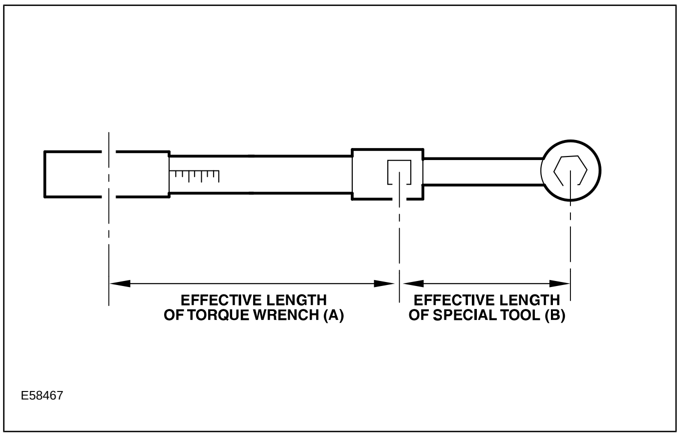
- Engage all gear positions for a minimum of three seconds with the engine running and all brakes applied
- When starting the fluid level check, make sure that the engine idles between 600 and 750 rpm with the transmission in park

Transmission Filler Plug Tool 307-452



1. Loosen the oil fill plug immediately after starting the engine using special tool 307-452
2. If transmission fluid does not come out of the filler plug hole, top up the fluid level with the correct transmission oil (See GTR) until oil drains out of the bore, then stop adding fluid.
3. Wait until the temperature is between 30°C (85°F) and 50°C (120°F)
4. Wait until fluid has been dripping for at least one minute or the temperature has reached 50°C (120°F). Do not let fluid temperature exceed 50°C (120°F). Do not switch off the engine until the fluid plug has been replaced.
5. The fluid plug should be tightened to a calculated torque of 35 Nm. Calculate torque as follows. (A) and (B) refer to the illustration below.
   a. Multiply the effective length of the torque wrench (A) by 35 Nm.
   b. Add the effective length of the special tool (B) to the effective length of the torque wrench (A).
   c. Divide the total from step 5a by the total from step 5b.
   d. Set the torque wrench to the figure arrived at in step 5c.
6. Fit the plug with new sealing washer and tighten plug to the torque calculated in step 5. Refer to GTR for more information

Torque Wrench with Special Tool 307-452



Selector Cable Adjustment

The selector cable adjustment is carried out with the selector lever in reverse (see GTR for full description). After adjustment, ensure that each gear position engages smoothly and the LEDs illuminate correctly.

Serviceable Items

The following components are serviceable:

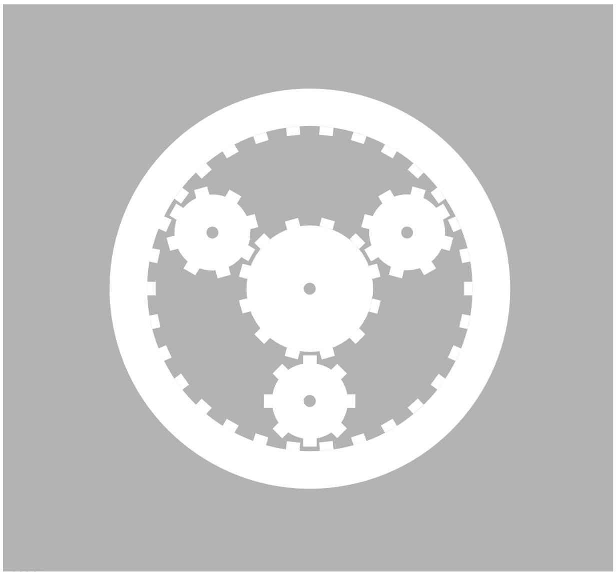
- Transmission assembly
- Transmission oil
- Fill level plug
- TCM / Valve body unit
- Oil pan, gasket and drain plug
- Selector shaft seals
- Output shaft seal
- Oil cooler pipes

- Pump seal
- Torque converter

Refer to GTR for service information.

Manual Transmission

Lesson 9 - Getrag 221



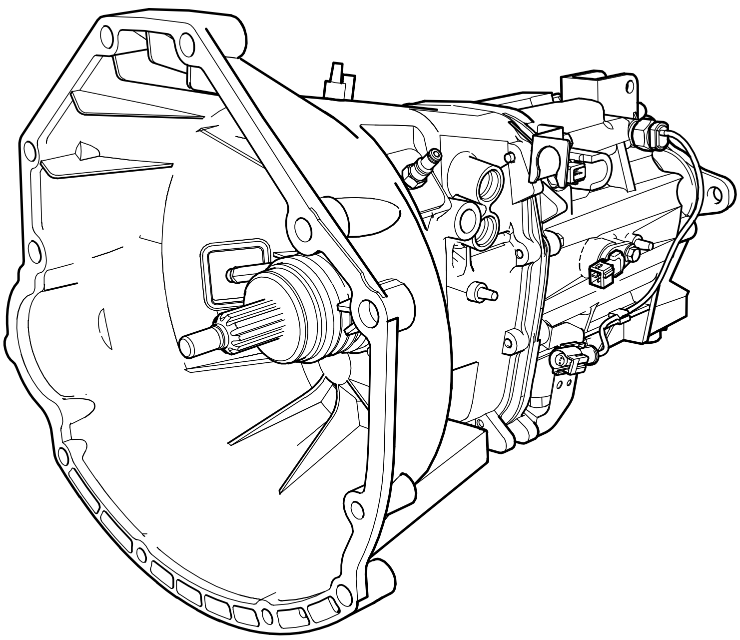
OVERVIEW

The Getrag 221 five-speed manual transmission is fitted as an option on S-TYPE 3.0L V6 models, 2003 – 2004 MY only. The manual transmission is not available for the V8 models.

The Getrag 221 offers the following features:

- Direct gearing (1:1) on 5th gear (rather than 4th) for minimal highway losses
- Double synchronizing cones on 1st and 2nd gears provide smoother shifts
- Four-plane shift gate (R-1-3-5) with ‘knock-over’ protection on the Reverse position

Getrag 221 5-Speed Transmission



Getrag 221 Specifications						
Transmission weight	33kg (72 lbs)					
Mechanical features	Dual mass flywheel Self adjusting clutch Concentric slave cylinder					
Transmission fluid	ESSO Dexron III; Filled for life					
Clutch fluid	ITT Super DOT 4 (brake fluid)					
Gear ratios	**1st**	**2nd**	**3rd**	**4th**	**5th**	**Reverse**
	4.23	2.51	1.66	1.22	1.00	4.18

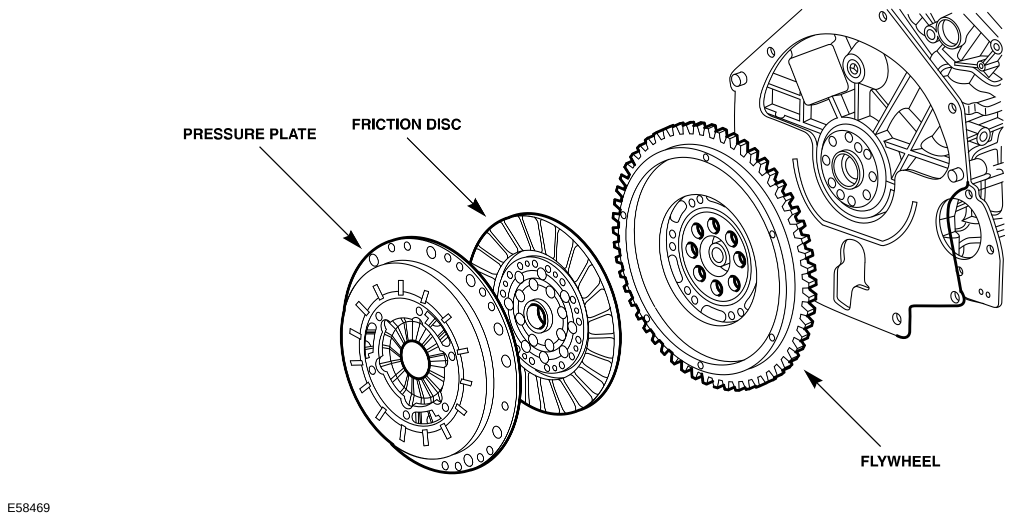
SYSTEM COMPONENTS

Flywheel

The flywheel and clutch system is based on the established principle of a single driven plate and diaphragm spring hydraulically actuated from the clutch pedal.

The flywheel incorporates the latest refinements in the technology, providing further improvements in torsional vibration isolation and reducing stresses on the crankshaft and drivetrain.

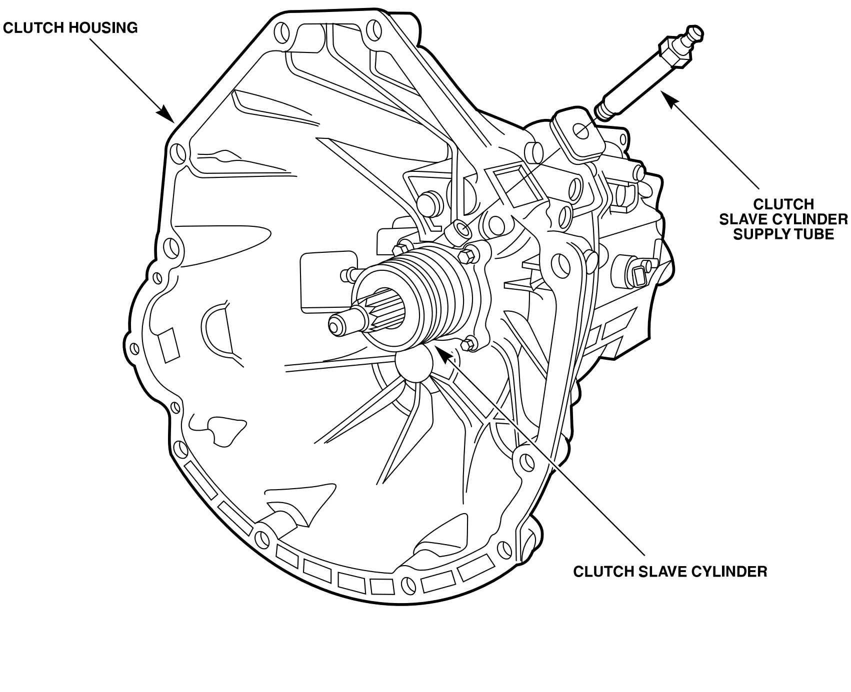
Flywheel and Clutch



Clutch

The self adjusting clutch improves operation and driver comfort by enabling a constant pedal pressure to be applied as the friction faces wear. The clutch diaphragm spring is operated directly by a slave hydraulic cylinder located concentrically about the transmission input shaft. The hydraulic clutch system is supplied with fluid from a separate chamber in the brake master cylinder reservoir.

Clutch Components



The central slave cylinder is fixed to the clutch housing with four bolts, together with an integrated release bearing press-fit on the clutch slave cylinder.

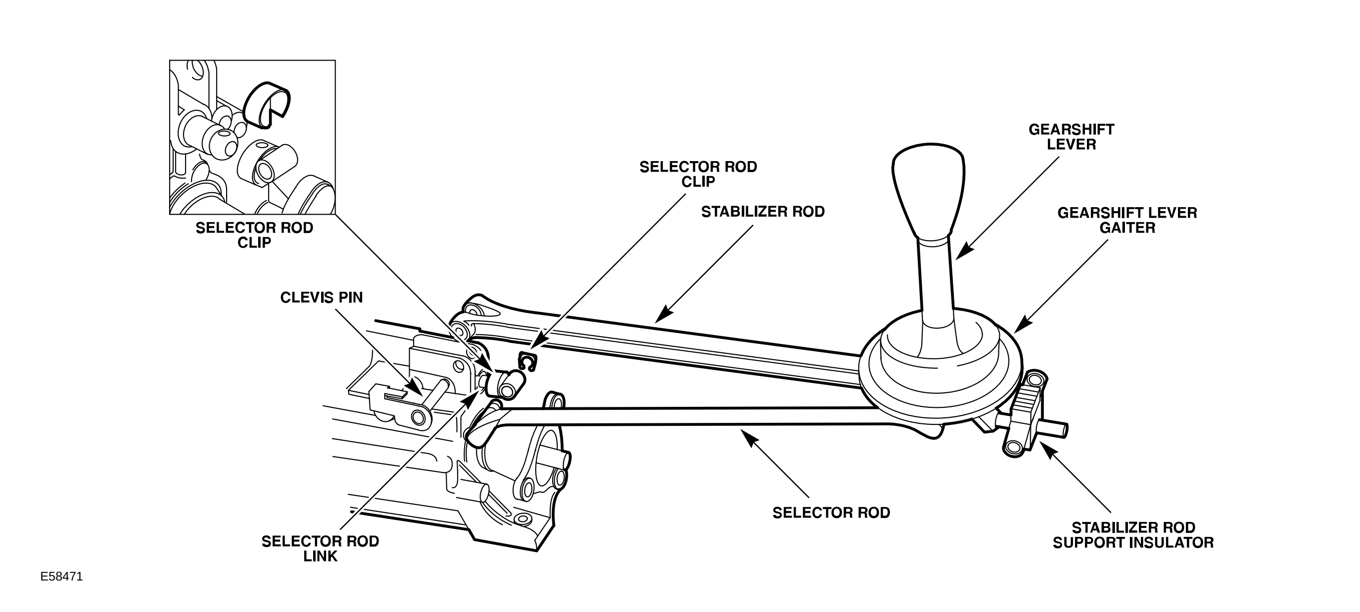
The hydraulic fluid which is displaced by the master cylinder piston moves the piston in the clutch slave cylinder, which in turn moves the release bearing in an axial direction. The release bearing presses against the tongues of the diaphragm spring with the inner bearing ring, breaking the friction contact between the clutch disc and the flywheel.

When the clutch pedal is released, the diaphragm spring returns the piston in the clutch slave cylinder to its original position. This restores the friction contact between the clutch disc and the flywheel.

Gearshift Mechanism

The manual transmission is equipped with a selector rod gearshift mechanism.

Gearshift Mechanism



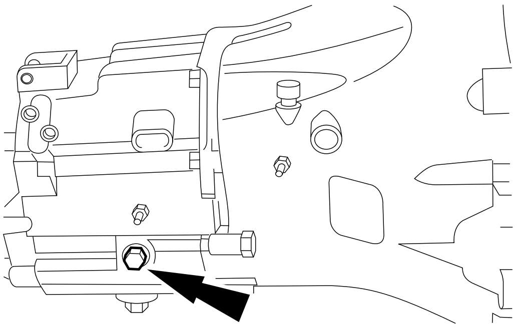
In order to isolate the outer gearshift mechanism from the bodywork, the gearshift housing is located in a remote gearshift mounting that is rigidly joined to the transmission by the gearshift stabilizer. This mounting can move lengthways to balance the rotational movements of the engine/transmission.

SERVICE PROCEDURES

Drain/Fill Fluid Procedure

To check the fluid level, remove the transmission fill/level plug.

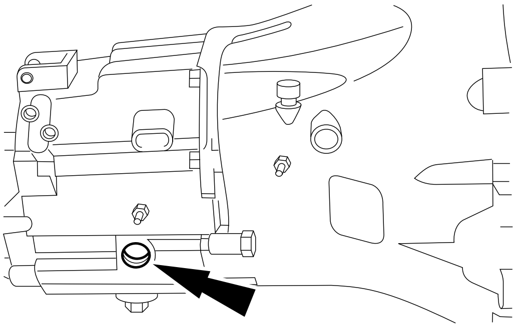
Transmission Fill/Level Plug



E58472

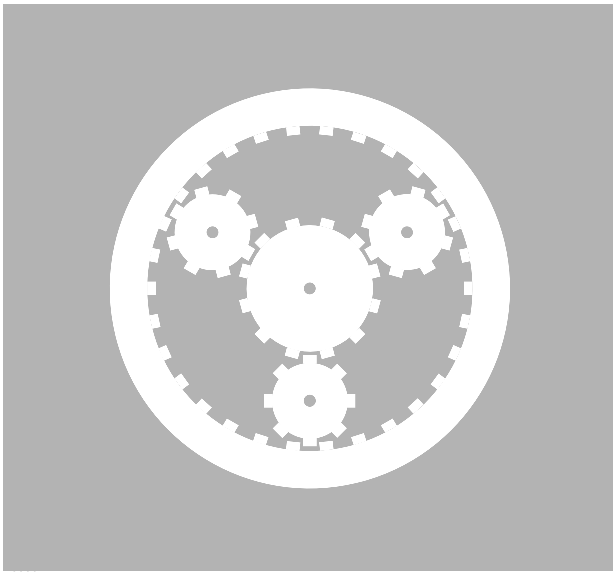
Fill the transmission to 0.5 mm (0.02 in) below the lower edge of the fill plug bore.

Fill Plug Bore



E58473

Manual Transmission
Lesson 10 - MTX-75

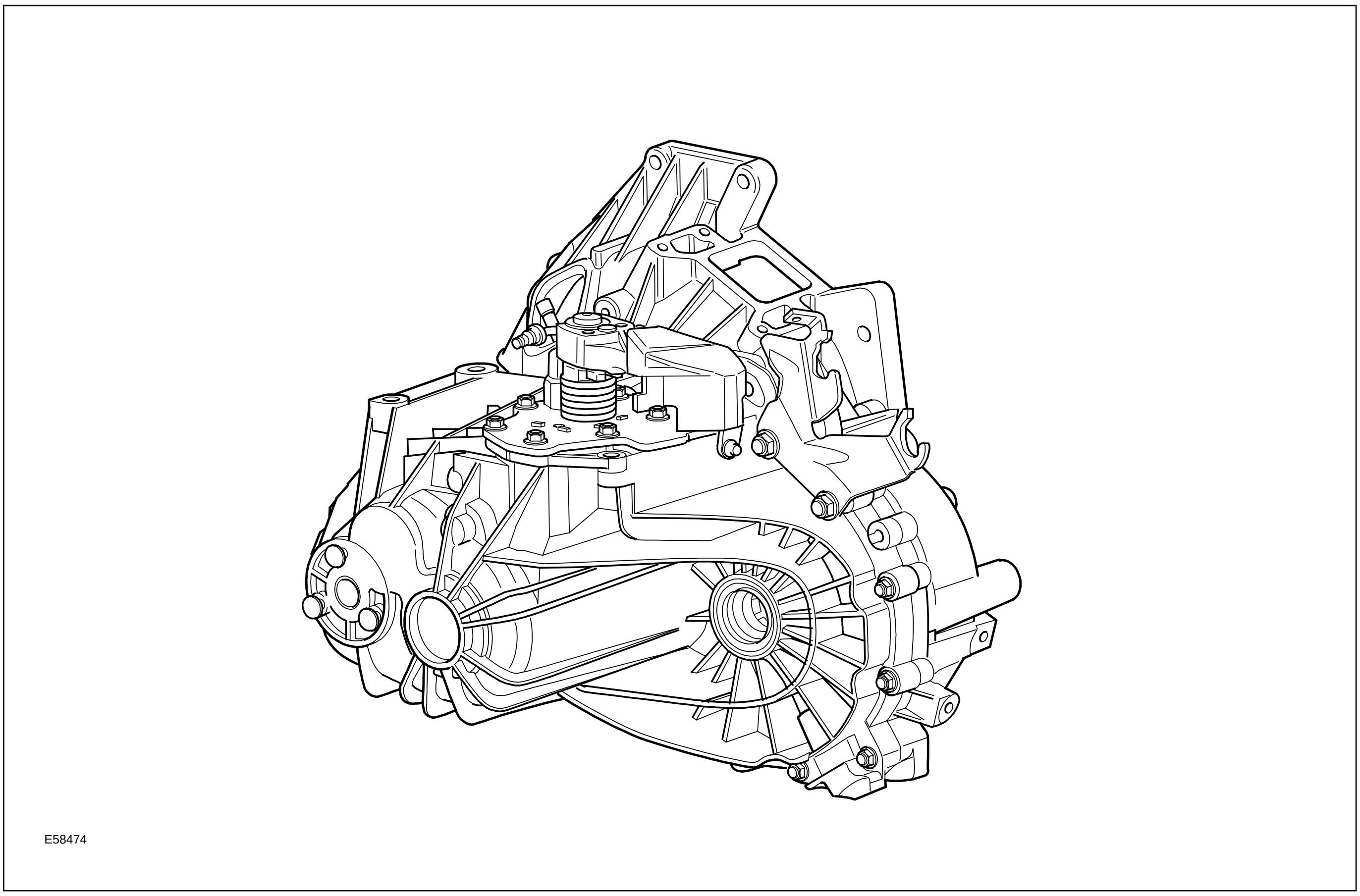


JAGUAR

OVERVIEW

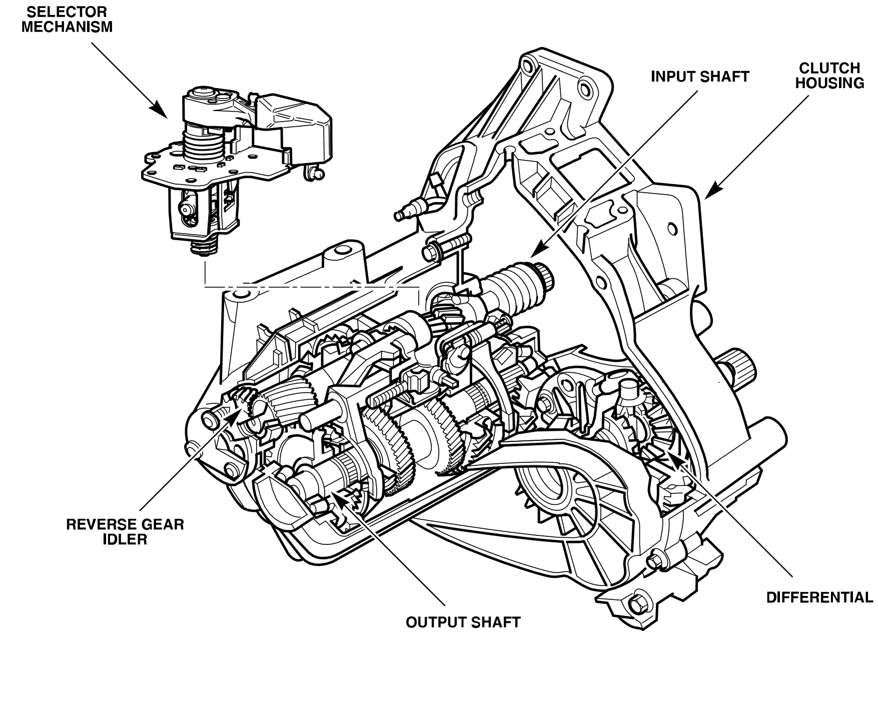
The MTX-75 5-speed manual transmission is used on both the 2.5 and 3.0-liter X-TYPE All Wheel Drive (AWD) models, 2002 - 2005 MY only. The unit is a transversely-mounted “transaxle” which combines the manual transmission and differential in one unit.

MTX-75 Transmission



The MTX-75 is a two-shaft design, with all pairs of gears in continuous mesh. Each forward gear ratio is produced through a single pair of dedicated gears, with the direction of power flow reversed in the transaxle. Rotation of the output shaft is reversed by an idler gear when reverse gear is selected.

MTX-75 Transmission Internal Components



To further improve stability and gear shifting, a maintenance-free cable operating mechanism is used. All the gear wheels, including reverse gear, are helical cut, synchronized, and run on needle roller bearings. First, second, and third gear have double synchronization. The advantages of double synchronization are that the transmission runs quietly, gearshifts are smooth, and the assembly is compact and light in weight.

Torque is transmitted from the output shaft to the differential, which then transmits the torque to the transfer case to provide All-Wheel Drive. Refer to the Transfer Case section for details.

The aluminum housing of the manual transmission consists of two closed sections. Reinforcing ribs on the transmission housing reduce noise and vibration and contribute to powertrain torsional rigidity.

MTX-75 is interpreted as follows:

- **MT** – Manual transmission
- **X** – Transaxle (front-wheel drive)
- **75** – the distance, in millimeters, between input and output shafts

MTX-75 Specifications						
Transmission weight	48.6 kg (107.1 lb)					
Mechanical features	Transversely-mounted unit with combined transmission / differential Two-part aluminum housing with reinforcing ribs					
Transmission fluid	Capacity – 1.75 liters (1.85 qt) Type – ESD-M2C186-A					
Clutch fluid	ITT Super DOT 4 (brake fluid)					
Towing	30 miles @ 30 mph (flatbed)					
Gear ratios	**1st**	**2nd**	**3rd**	**4th**	**5th**	**Reverse**
	3.42	2.14	1.45	1.03	0.77	3.47
Final drive	3.8 : 1					

SYSTEM COMPONENTS

Clutch

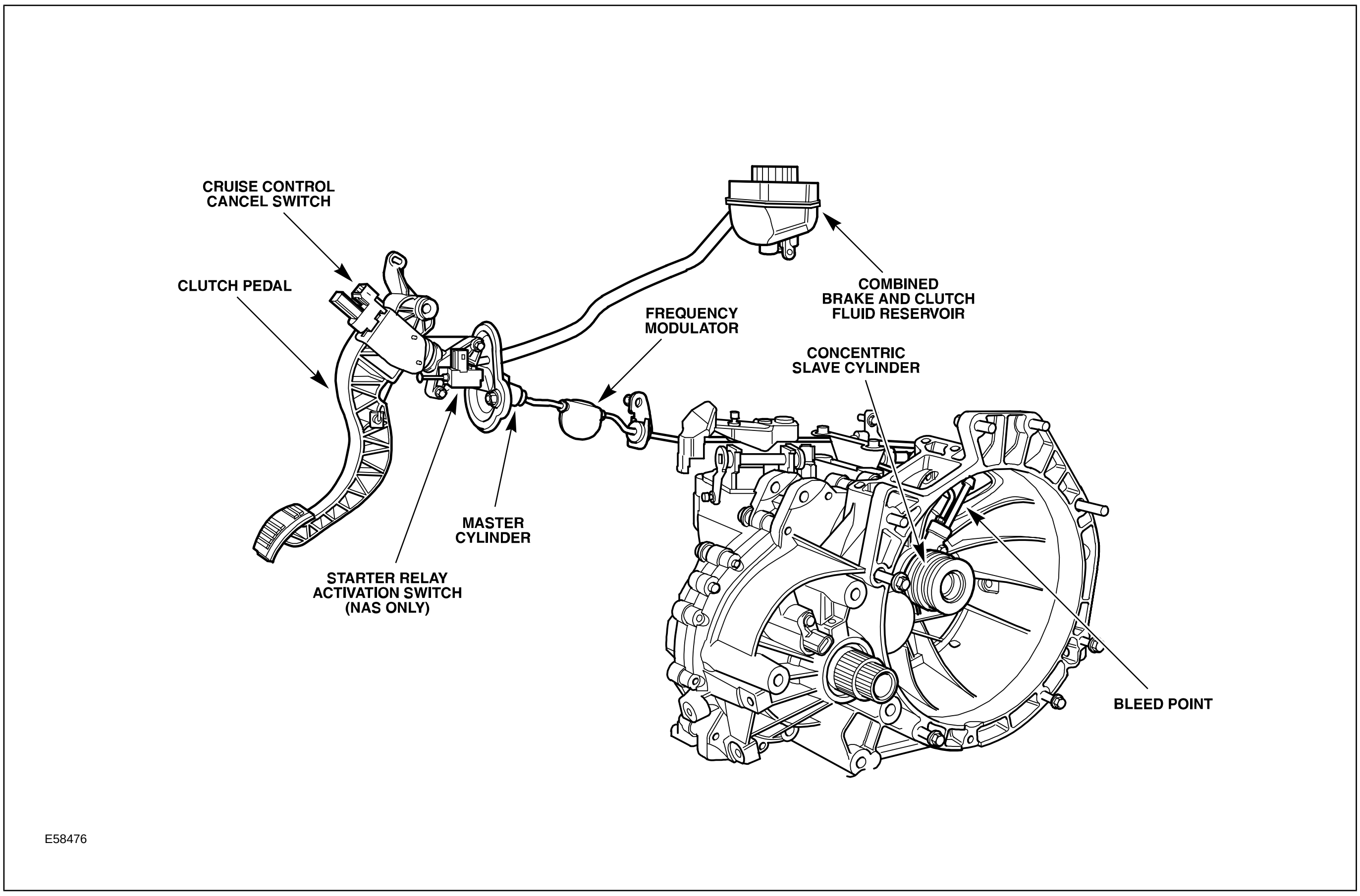
The clutch is a hydraulicly operated self-adjusting system which improves operation and driver comfort by enabling a constant pedal pressure to be applied as the friction faces of the clutch late wear. The system employs a concentric slave cylinder, located on the transaxle input shaft behind the pressure plate. The concentric slave cylinder eliminates the need for a release lever mechanism and improves operating efficiency.

The clutch pedal, which is mounted on a combined assembly with the brake pedal, employs an assister spring to reduce pedal load. The clutch master cylinder is directly actuated by the clutch pedal and shares a common fluid reservoir with the brake system.

Operation of the clutch pedal when the vehicle is in Cruise Control mode activates a switch which supplies a signal to the ECM to deactivate Cruise Control.

To enable engine starting, the clutch pedal must be fully depressed. This activates a switch which sends a signal to the ECM, providing one of the requirements for energizing the starter relay.

Clutch Assembly



Flywheel

A dual-mass flywheel is employed to isolate torsional vibration and reduce stresses on the crankshaft and drivetrain.

Gearshift Mechanism

The external shift mechanism consists of the gear lever housing with the gear shift lever. Reverse gear is selected by pulling up on the reverse gear release ring – located below the gear knob on the shift lever shaft – and moving the lever to the reverse position.

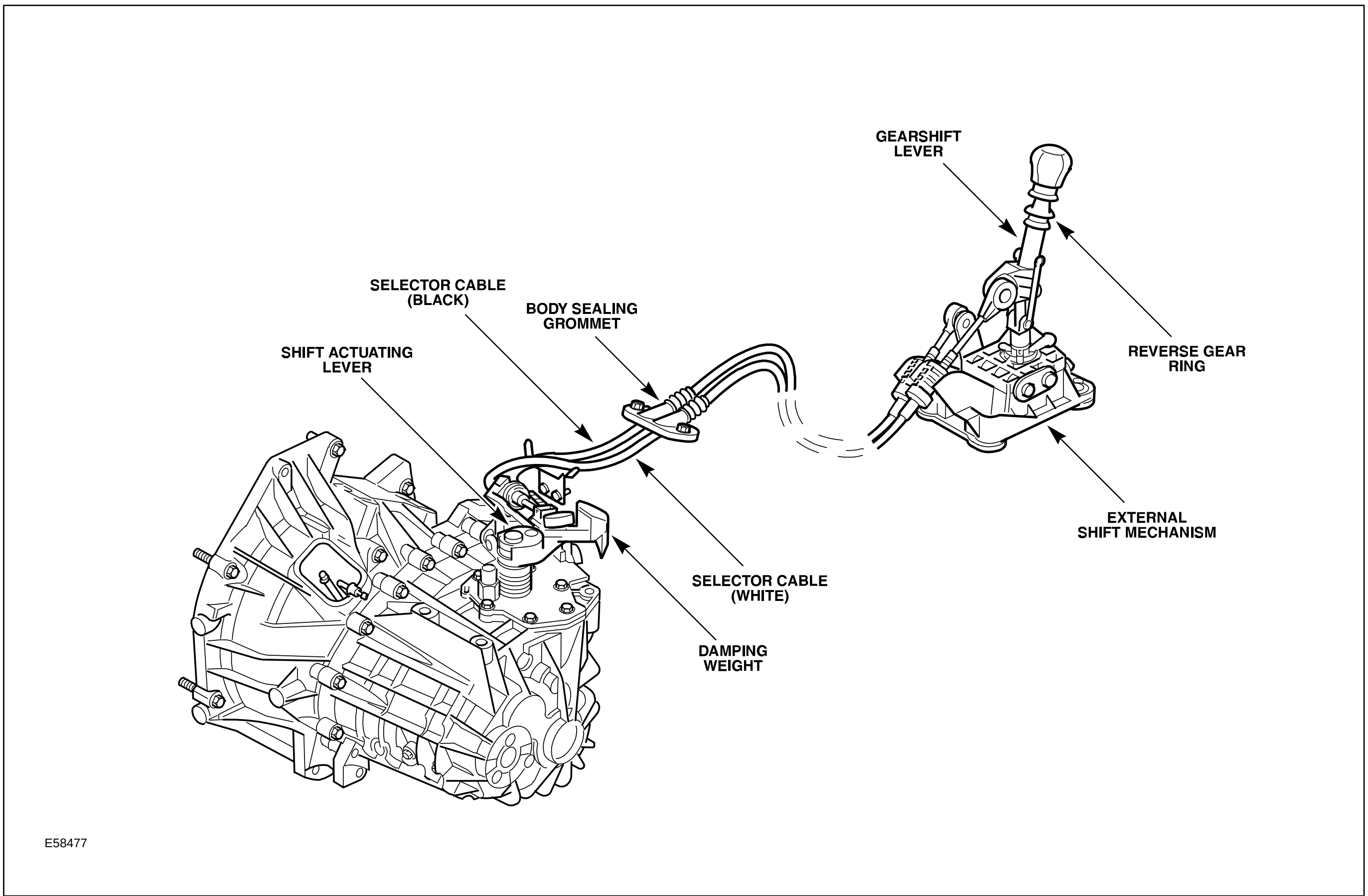
Gear selection is achieved through cable connection from the gear lever to the internal shift actuating lever.

There are two cables – the selector cable, which is black, and the shift cable, which is white. The cables are attached at both ends with ball connections incorporating a button release. A damping weight is located on the shift cable lever to prevent vibration.

Cable adjustment is achieved at the transaxle end by means of sliding plastic blocks in the abutment bracket.

NOTE: Because the cables share a common body seal grommet, they must be replaced as a pair.

Gearshift Mechanism

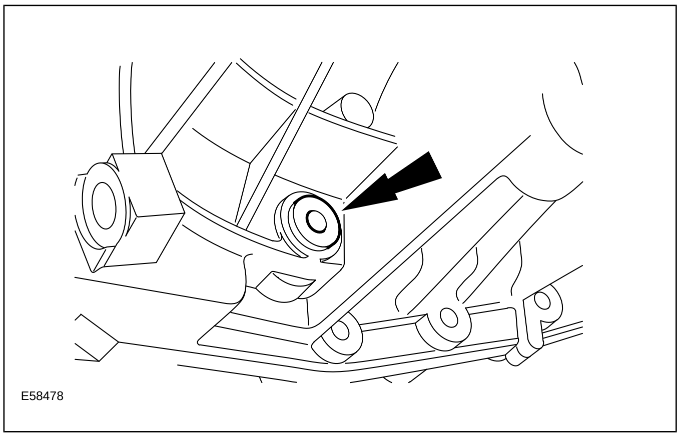


SERVICE PROCEDURES

Transmission Fluid

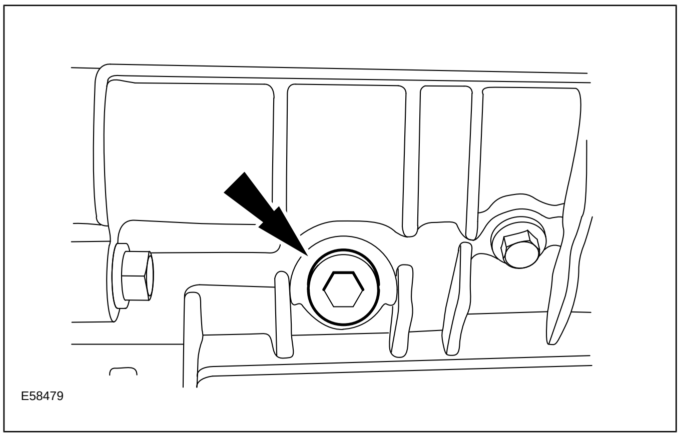
Only the specified transmission fluid should be used when topping up or filling. Refer to GTR for the latest information.

Drain Plug



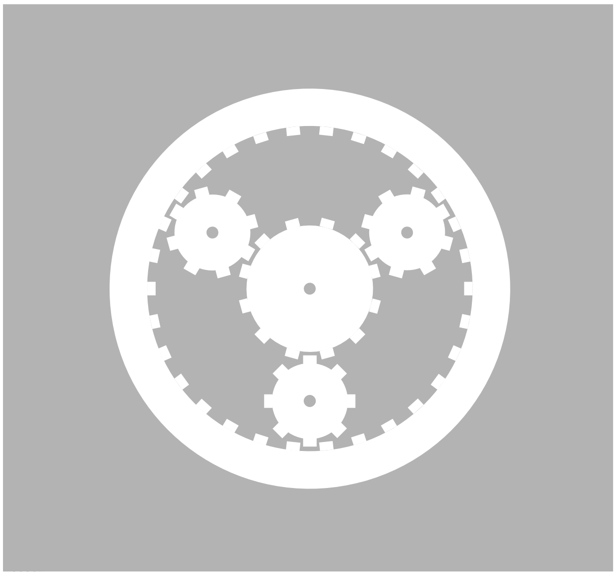
When the transmission is filled, the fluid should come up to the lower edge of the check bore. If fluid is required, fill the transaxle to 0.5 mm (0.02 in) below the lower edge of the fill plug bore.

Fill Plug



Transfer Case

Lesson 11 - AWD



Technical Training

T201.1 en 12/2004

OVERVIEW

A new feature and a first for Jaguar is the Visteon All Wheel Drive (AWD) system fitted on all X-TYPE models. This AWD system is also known as the Traction4 System.

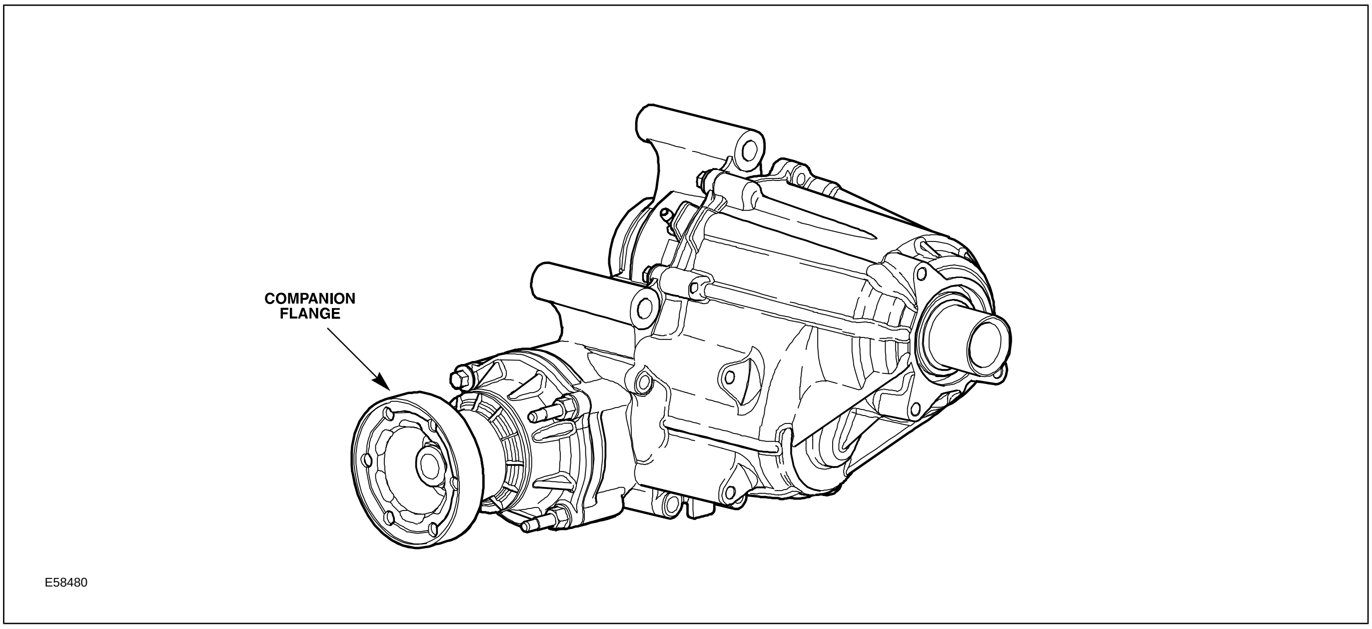
The transfer case system consists of a power transfer unit, rear driveshaft, coupling device and rear axle. The power transfer unit is a gearbox that attaches to the transaxle. The right hand halfshaft engages to the transfer case link shaft which engages to the differential side gears as in a normal 4x2 application.

The transfer case provides power to the driveshaft through a helical gear spline coupled to the transaxle differential case, a helical gear drop (idler gear) and hypoid/helical ring gear assembly and pinion set. Repair of the transfer case is limited to seals and gaskets. If any of the geared components, tapered roller bearings, case cover or internal shafts fail, a new transfer case must be installed.

The transfer case is sealed from the transaxle and has its own sump. The fill plug is located on the top of the transfer case, under the engine anti roll restrictor mounting bracket.

Special tools are required to remove the transfer case from the vehicle.

AWD Transfer Case



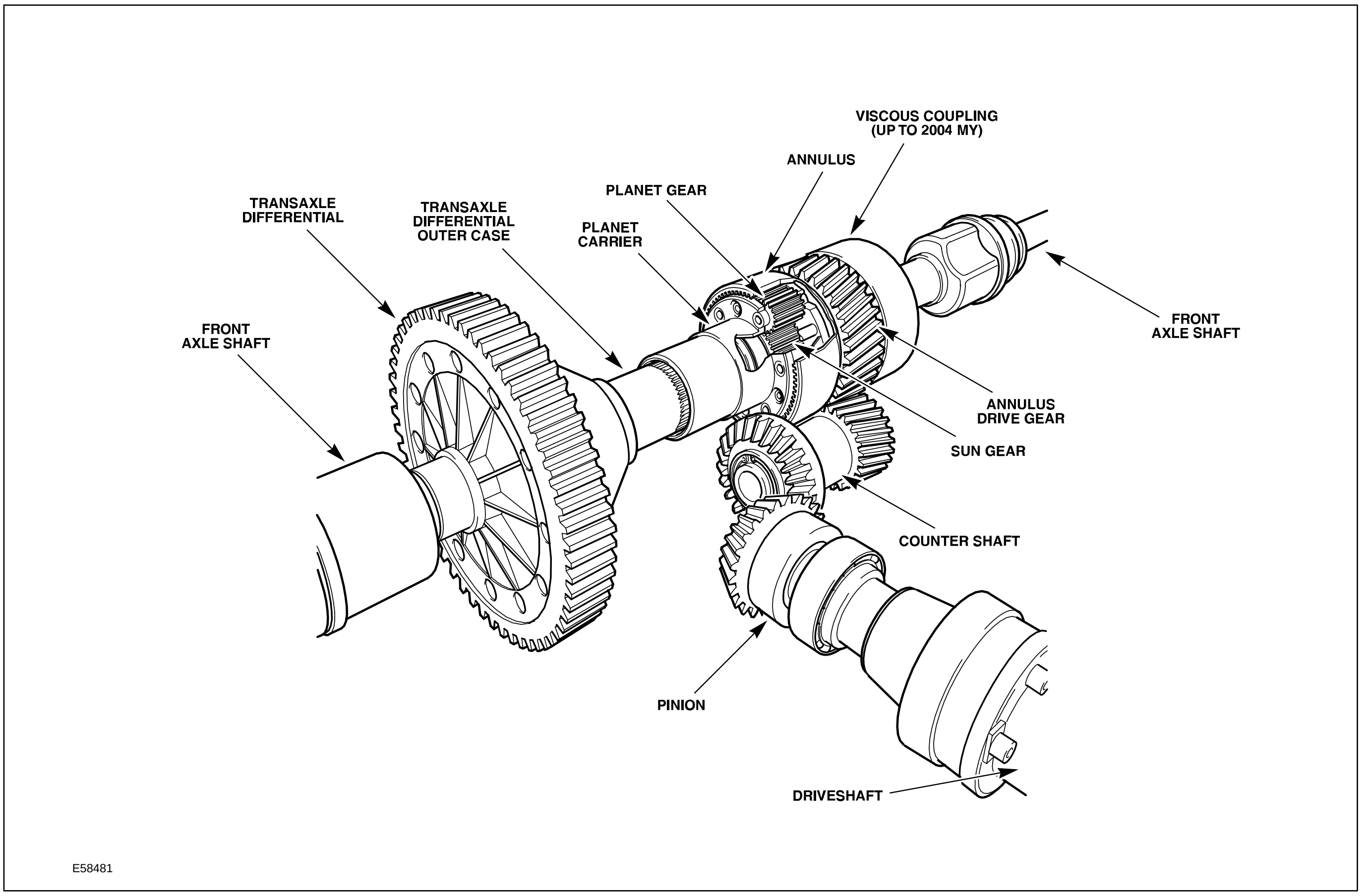
Transfer Case Specifications	
Transmission fluid	Capacity – 0.60 liters (0.63 qt), initial fill; 0.55 liters (0.58 qt), drain and refill Type – SAE 75W140 synthetic gear lubricant

AWD OPERATION

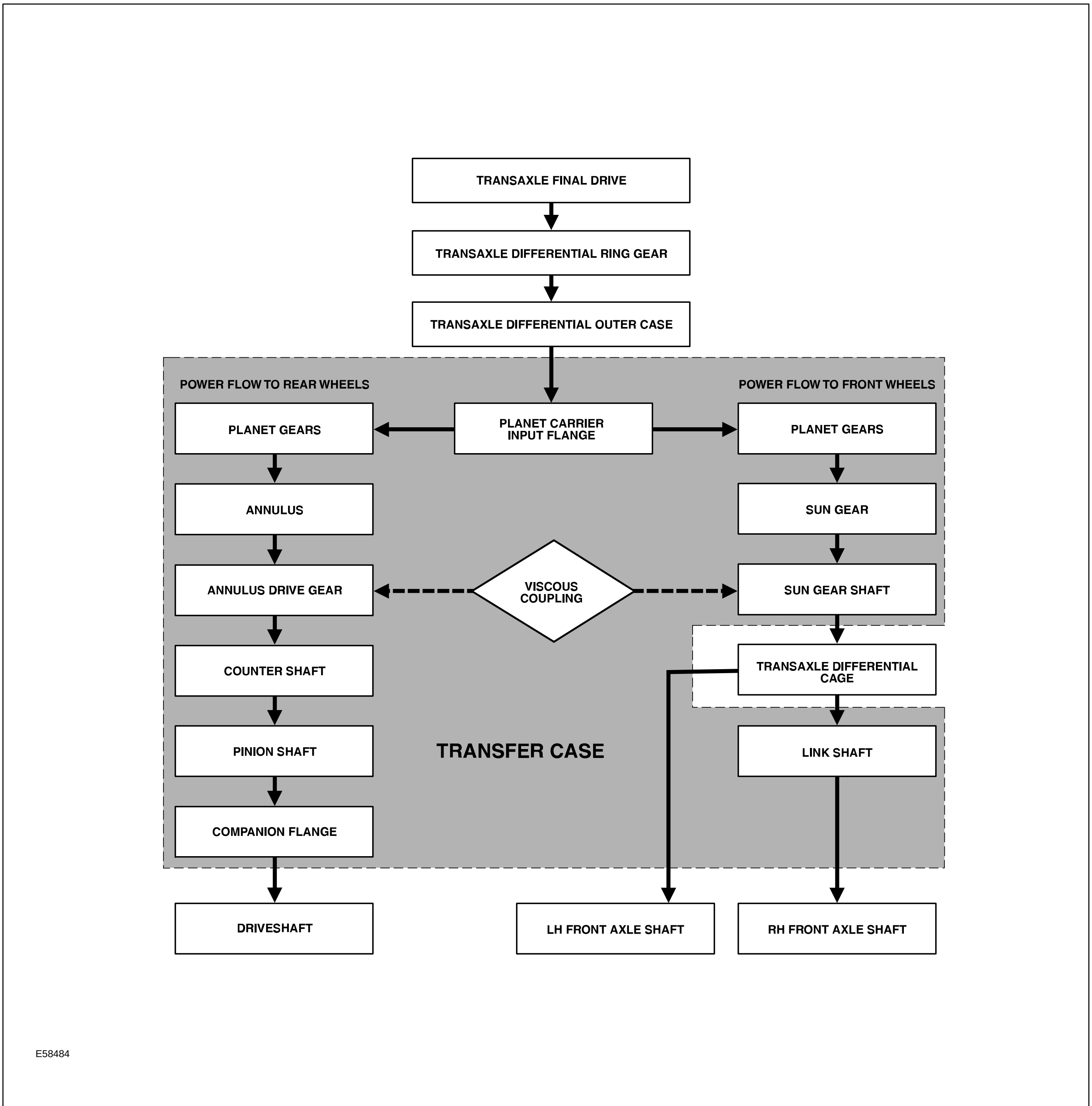
The transmission differential case is splined into the AWD epicyclic gear set planet carrier, which results in the AWD planet carrier turning in a clockwise direction; thus, the planet gears are also driven clockwise.

The AWD epicyclic annulus and sun gear are driven by the planet carrier at the same speed and in the same direction. The sun gear has splines that link back to the transmission; it drives the front differential cage. The differential cage in turn drives the differential pinion gears, resulting in an output transmitted to the front wheels via the link shaft for the RH side and pinion wheel for the LH side.

Transfer Case Internal Components

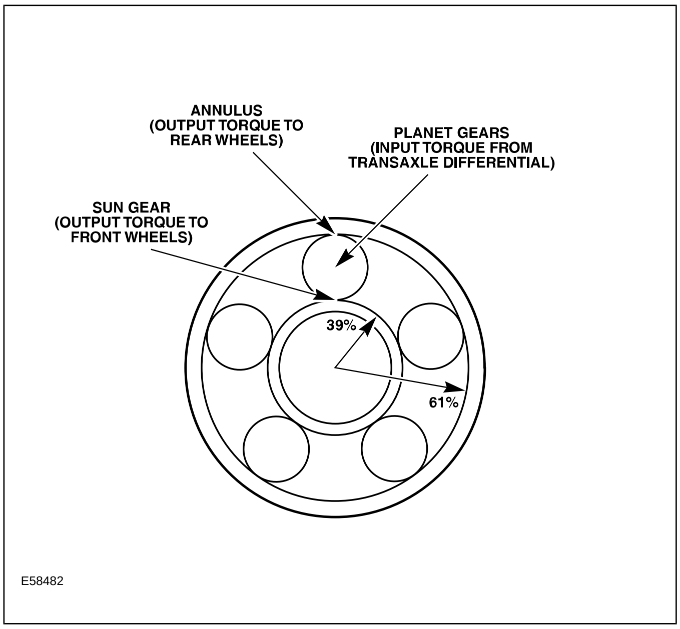


AWD Power Flow



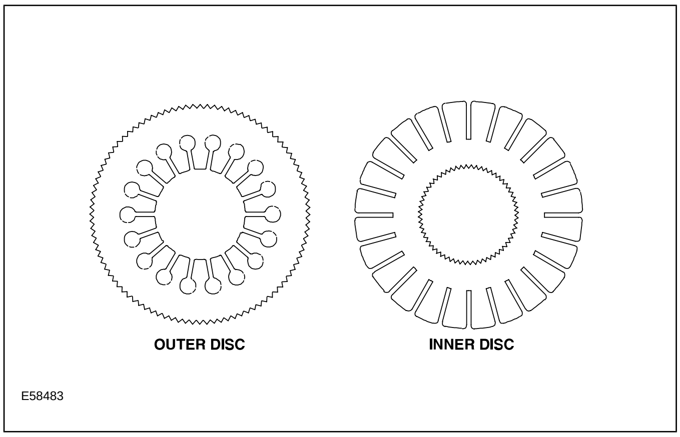
The 40% / 60% torque split is achieved by the ratio of radius to gear tooth contact on the annulus and sun gears, where they contact the planet gears, as indicated by the arrows shown in the diagram.

Epicyclic Differential Torque Split



Under normal driving conditions, all the components of the center differential rotate at the same speed, with front and rear torque split determined by the lever ratio of the tooth contacts.

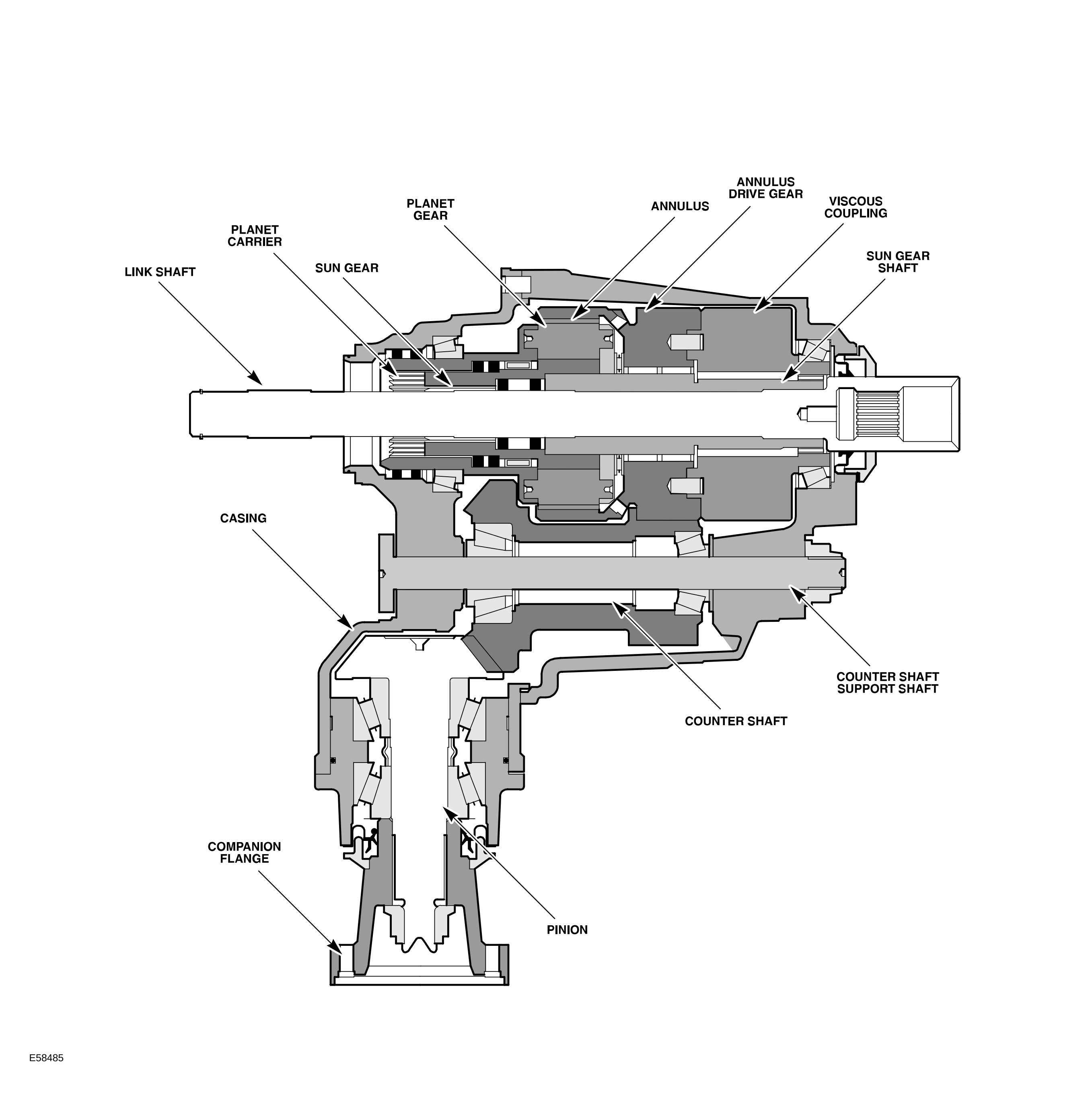
Viscous Coupling Discs



The sun shaft has male splines that connect to the viscous coupling inner hub; the outer viscous coupling is driven by the annulus via four drive pegs. The viscous action only occurs when there is a relative speed difference at the front and rear drive wheels due to reduced traction on either axle.

Drive from the annulus is via a helical gear that connects directly to a counter shaft. The counter shaft has a bevel pinion gear linked to the pinion bevel gear and out to the companion flange.

Transfer Case Cutaway View



2004 MY (X404) RUNNING CHANGES

The only change to the AWD system is the deletion of the viscous coupling. Any difference in traction between the front and rear wheels is now handled by the DSC system.