DESCRIPTION AND OPERATION

TRANSMISSION DESCRIPTION

This transmission uses planetary gears with hydraulic electronic controls. The transmission control module (TCM) and the main control valve body units form a composite element that is installed as a single unit inside the automatic transmission.

This transmission has the following features:

- Six forward speeds
- Torque converter with an integral converter clutch
- Electronic shift and pressure controls
- Single planetary gear set
- Double planetary gear set
- Two fixed multi-disc clutches
- Three multi-plate clutches

All hydraulic functions are directed by electronic solenoids to control:

- engagement feel.
- shift feel.
- shift scheduling.
- modulated torque converter clutch (TCC) applications.

This transmission has a mechatronic unit also referred to as a transmission control module (TCM) which contains:

- Turbine shaft speed (TSS) sensor
- Output shaft speed (OSS) sensor
- An internal P, R, N, D selector shaft position sensor
- Transmission fluid temperature (TFT) sensor

Engine power reaches the transmission by a torque converter with an integral converter clutch. The 6 forward gears and one reverse gear are obtained from single planetary sets.

This automatic transmission is a 6-speed electronically controlled transmission comprising the basic elements of a TCM, main control valve body unit, torque converter, one solenoid valve and 6 pressure regulators. Gear selection is achieved by the control of automatic transmission fluid flow to operate various internal clutches. The TCM operates the electrical components and provides for the control of gear selection shift pressure which increases refinement and torque converter slip.

In the event of a system fault, the TCM also provides for failure mode effect management (FMEM) to maintain maximum functional operation of the transmission with a minimum reduction in driver, passenger or vehicle safety. In the event of a total loss of control or electrical power, the basic transmission functions PARK, REVERSE, NEUTRAL and DRIVE are retained. Also 3rd or 5th gear is retained by the hydraulic system. The gear retained is dependent upon the gear selected at the time of the failure.

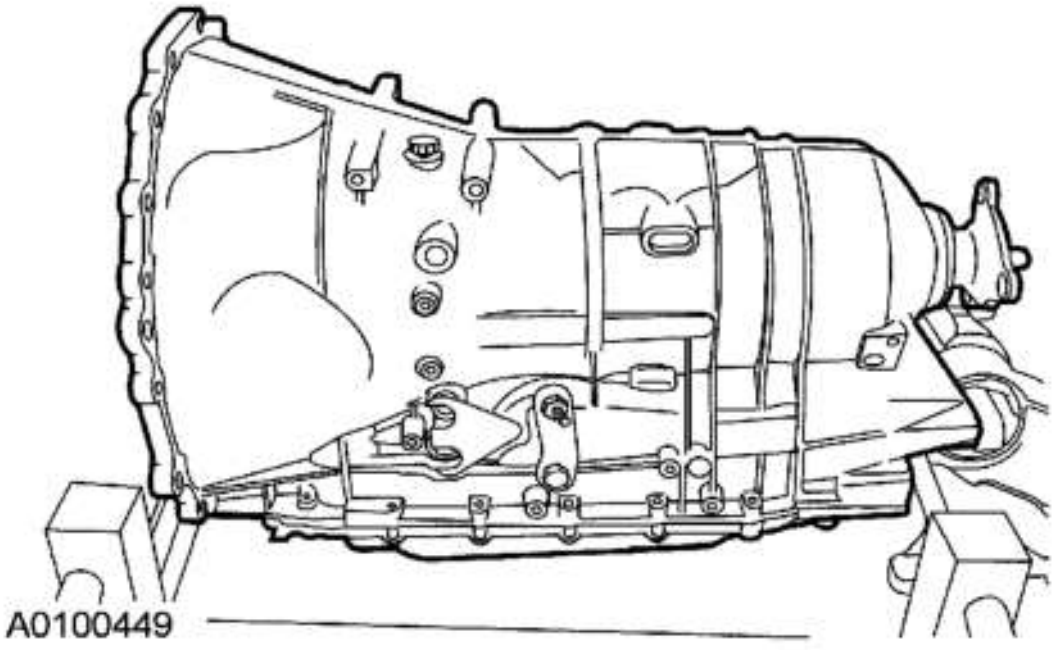
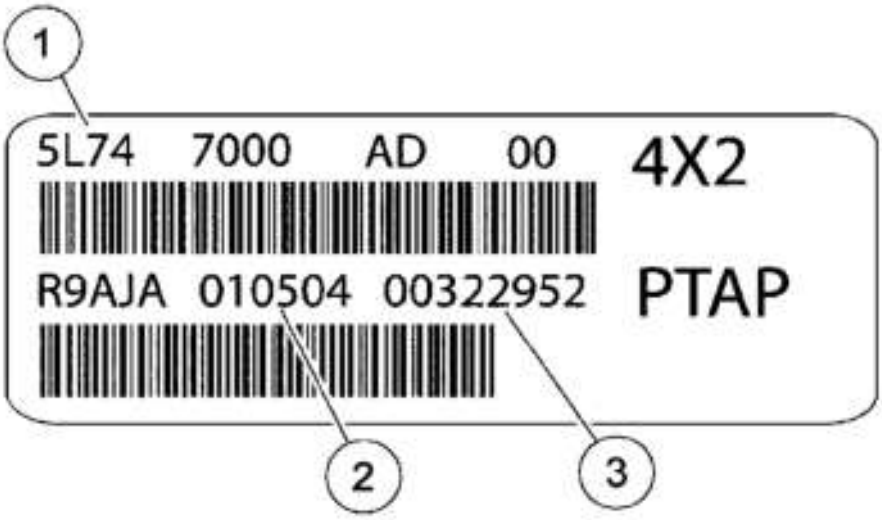


Fig. 1: Identifying Automatic Transmission Gear Box
Courtesy of FORD MOTOR CO.

IDENTIFICATION TAGS

The identification tag is located on the left side of the case just rearward of the manual control lever.



Item	Part Number	Description
1	—	Part number
2	—	Build date
3	—	Serial number

Fig. 2: Identifying Identification Tags
Courtesy of FORD MOTOR CO.

RANGE SELECTION

The transmission has 8 range positions: P, R, N, D6, D4, 3, 2 and 1.

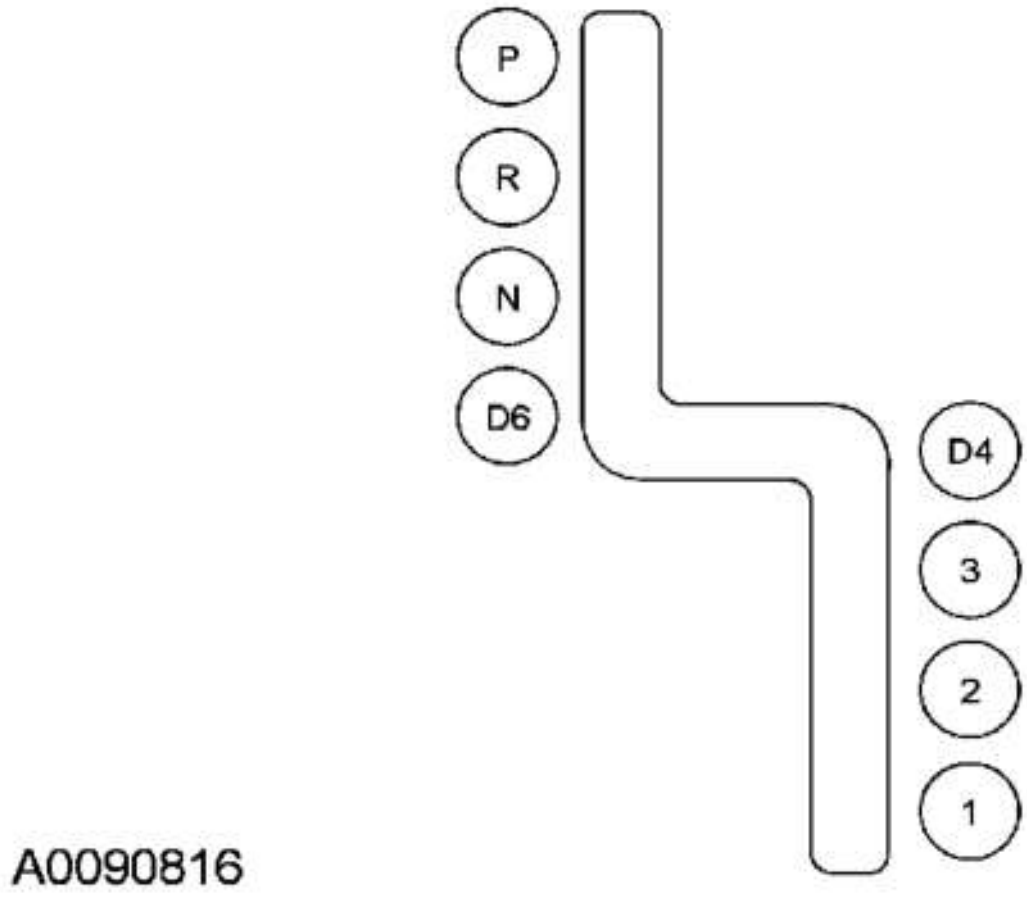


Fig. 3: Identifying Transmission Range Selection
Courtesy of FORD MOTOR CO.

Park

In the PARK position:

- there is no power flow through the transmission.
- the parking pawl locks the output shaft to the case.
- the engine can be started.
- the ignition key can be removed.

Reverse

In the REVERSE position:

- the vehicle can be operated in a rearward direction, at a reduced gear ratio.
- backup lamps are illuminated.

Neutral

In the NEUTRAL position:

- there is no power flow through the transmission.
- the output shaft is not held and is free to turn.
- the engine can be started.

D6

The D6 is the normal position for most forward driving.

The D6 position provides:

- automatic shifts 1-6 and 6-1.
- apply and release of the torque converter clutch.
- maximum fuel economy during normal operation.
- engine braking in all gears.

D4

The D4 position provides:

- automatic shifts 1-4 and 4-1.
- apply and release of the torque converter clutch.
- engine braking in 1-4 gears.

Manual 3 Position

This position provides:

- manual 3rd gear.
- engine braking in 3rd gear.

Manual 2 Position

This position provides:

- manual 2nd gear.
- engine braking in 2nd gear.

Manual 1 Position

This position provides:

- first gear operation only.
- engine braking for descending steep grades.

SHIFT PATTERNS

Downshifts

Under certain conditions, the transmission will downshift automatically to a lower gear range (without moving the range selector lever). There are 3 categories of automatic downshifts:

- Coastdown
- Torque demand
- Forced or kickdown shifts

Coastdown

The coastdown 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.

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 due to tire size, engine and transmission calibration requirements.

TORQUE CONVERTER

The torque converter is a 3-element unit containing a dual-plate clutch. The clutch can be controlled and engaged in any gear 1st to 6th. Calibration parameters may be set to allow lock-up in a higher gear only. The clutch is applied by removing fluid pressure from one side of the plate. The torque converter transmits and multiplies torque. The torque converter includes the following 3 elements:

- Impeller assembly
- Turbine assembly
- Reactor assembly

The standard torque converter components operate as follows:

- Rotation of the converter housing and impeller set the fluid in motion.
- The turbine reacts to the fluid motion from the impeller, transferring rotation to the geartrain through the input shaft.
- The reactor redirects fluid going back into the impeller, allowing for torque multiplication.
- Power is transmitted from the torque converter to the planetary gearsets and other components through the input shaft.

Torque Converter Clutch

The torque converter clutch is a device that reduces slip in the torque converter and, therefore, helps to keep fuel consumption to a minimum.

The torque converter clutch is engaged and released by the control system.

Pressure at the torque converter clutch piston is determined by an electronic pressure control valve.

GEARTRAIN

Power is transmitted from the torque converter to the planetary gearsets through the input shaft. Clutches are used to hold and drive certain combinations of gearsets. This results in 6 forward ratios and 1 reverse ratio which are transmitted to the output shaft and differential. The ratios are as follows:

GEARTRAIN

Gear Ratio	
1ST	4.17 to 1
2ND	2.34 to 1
3RD	1.52 to 1
4TH	1.14 to 1
5TH	0.87 to 1
6TH	0.69 to 1
Reverse	3.40 to 1

Single Planetary Gearset

The single planetary gear overdrive carrier is driven by the input shaft. The single planetary gear set consists of the following components:

- One sun gear
- Four planetary gears meshing with the sun gear
- One planetary carrier
- One ring gear

Ravigenaux Planetary Gearset

The ravigenaux planetary gearset is splined to the output shaft and consists of the following components:

- Two sun gears of different sizes
- Three short planetary gear pinions meshing with the sun gears
- Three long planetary gear pinions meshing with the sun gears
- One planetary carrier
- One ring gear

Output Shaft

The output shaft provides torque to the driveshaft and rear axle assembly. It is driven by the ring gear of the planetary gearset.

APPLY COMPONENTS

Shift Elements

In addition to the torque converter, the other shift elements are:

- three rotating multi-plate clutches: forward, direct and overdrive.
- two fixed multi-disc brakes: intermediate and overdrive.

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

The shift elements, clutches or brakes are engaged hydraulically. The transmission fluid pressure builds up between the cylinder and the piston, pressing the clutches together.

The purpose of these shift elements is to carry out in-load shifts with no interruption to traction.

Multi-plate clutches forward, direct and overdrive supply power from the engine to the planetary geartrain. Multi-disc brakes intermediate and low/reverse press against the transmission housing in order to achieve a torque reaction effect.

Multi-Plate Clutch

Clutches overdrive, forward and direct are balanced in terms of dynamic pressure. That is, its piston is exposed to the transmission fluid flow on both sides, in order to prevent pressure buildup in the clutch as speed increases. This equalization process is achieved by a baffle plate and pressure-free transmission fluid supply by a lubricating passage, through which the space between piston and baffle plate is filled with transmission fluid.

The advantages of this dynamic pressure equalization are:

- reliable clutch engagement and release in all speed ranges.
- improved shift refinement.

Shift Overlap Control

The electronic-hydraulic shift action is obtained by means of various valves in the transmission control module (TCM) and main control valve body, actuated by pressure regulators. They engage or disengage the relevant clutches or brakes at the correct moments.

Hydraulic Systems

Fluid Pump

The torque converter is supported in the fluid pump by a needle roller bearing. The fluid pump is driven directly from the engine by the torque converter shell and supplies transmission fluid to the transmission and the hydraulic control unit.

The fluid pump draws in transmission fluid through a filter and delivers it at high pressure to the main pressure valve in the main control valve body unit. The valve adjusts the pressure and returns excess transmission fluid to the fluid pan.

Fluid Pan, Gasket and Filter

The transmission fluid pan, gasket and filter is a one-piece assembly. All transmission fluid is drawn from the transmission fluid pan by the fluid pump and passes through the filter.

TRANSMISSION ELECTRONIC CONTROL SYSTEM

Transmission Electronic System

The transmission control module (TCM) and its input/output network control the following operations:

- Shift timing
- Clutch pressure (shift feel)
- Line pressure (shift feel)
- Torque converter clutch

In addition, the TCM receives input signals from certain transmission-related sensors. The TCM also uses these signals when determining transmission operating strategy.

Using all of these input signals, the TCM can determine when the time and conditions are right for a shift, or when to apply or release the torque converter clutch. It will also determine the pressure needed to optimize shift feel. To accomplish this, the TCM uses 6 pressure control solenoids and 1 shift solenoid to control transmission operation.

The following provides a brief description of each of the sensors and actuators used to control transmission operation.

Transmission Control Module (TCM) and Main Control Valve Body

The TCM and main control valve body are a combination of hydraulic and electronic control units. Both of these modules are installed in the transmission inside the transmission fluid pan.

Transmission Control Module (TCM)

The TCM for the transmission is mounted on top of the main control valve body. The control module for the transmission has been designed to operate correctly in the environment in which the TCM is located.

The TCM is activated and deactivated by the ignition supply and is connected to the transmission link harness by a 16-pin connector.

The TCM controls the operation of the transmission. The TCM processes information in both analog and digital forms, such as:

transmission input speed.

- transmission output speed.
- throttle position.
- gear selection.
- engine torque.
- engine speed.
- transmission fluid temperature.
- brake pedal position.
- engine oil temperature.
- engine coolant temperature.

- ABS wheel speed.

The information is then used by the TCM to decide which shift pattern to select and for shift energy management. Electro-hydraulic solenoid valves and pressure regulators control the transmission gear changes.

Five pressure regulators and one solenoid valve are used to control direct transmission fluid flow to select internal clutches and control the fluid pressure at the clutch. A separate pressure regulator is used exclusively for torque converter clutch control.

The TCM monitors all TCM inputs and outputs to confirm correct system operation. If a fault occurs, the TCM is able to carry out default action. It informs the driver of the problem through the instrument cluster diagnostic MIL light.

The TCM will shut down if the TCM hardware temperature rises above a predetermined temperature. Prior to shutting down, the TCM will log a fault code and enter a mechanical limp home mode.

Solenoids

The hydraulic module contains 1 solenoid valve. The solenoid valve is activated by the TCM and is either open or closed. It is used to switch the position valve.

There are 6 electronic pressure control valves, which convert an electronic current into a proportional hydraulic pressure. They are energized by the TCM and actuate the valves belonging to the relevant switching elements.

Controller Area Network (CAN) Interface

For the transmission control module (TCM) to carry out shift point and shift quality management, a number of external signals are required. For shift point management alone, the TCM requires output speed sensor, throttle pedal position, brake pedal status, gear selection position, transmission fluid temperature, 4x4 position, traction control, engine speed and engine torque. The controller area network (CAN) bus is used to share information between control modules.

Brake Pedal Position (BPP) Switch

The brake pedal position (BPP) switch tells the TCM when the brakes are applied. The torque converter clutch disengages when the brakes are applied. The BPP switch closes when the brakes are applied and opens when they are released.

Engine Coolant Temperature (ECT) Sensor

The engine coolant temperature (ECT) sensor detects the temperature of the engine coolant and supplies the information to the TCM. The ECT is installed in the heater outlet fitting or cooling passage on the engine. For engine control applications, the ECT signal is used to modify ignition timing, EGR flow and air-to-fuel ratio as a function of engine coolant temperature.

Accelerator Pedal Position (APP) Sensor

The accelerator pedal position (APP) sensor is mounted on the accelerator pedal. The APP sensor detects the position of the accelerator pedal and inputs this information as a voltage to the powertrain control module (PCM). The PCM broadcasts the APP on the CAN bus. The transmission control module (TCM) reads APP

off the CAN message. The PCM uses the APP sensor information to aid in determining shift scheduling and torque converter (TCC) control.

Turbine Shaft Speed (TSS) Sensor

The turbine shaft speed (TSS) sensor is a Hall-effect type sensor.

The sensor is mounted internally and is located on the transmission control module.

Output Shaft Speed (OSS) Sensor

The output shaft speed (OSS) sensor is a Hall-effect type sensor.

The sensor is mounted internally and is located on the transmission control module.

Transmission Fluid Temperature (TFT) Sensor

The transmission fluid temperature sensor is located on the TCM. The TCM uses the sensor input to activate various shift strategies. The sensor is in the form of a temperature-dependent resistor.

The resistance value of the transmission fluid temperature (TFT) sensor varies with temperature change. The TCM monitors the voltage across the TFT to determine the temperature of the transmission fluid.

The TCM uses this initial signal to determine whether a cold start shift schedule is necessary. The TCM also inhibits torque converter clutch operation at low transmission fluid temperatures.

Transmission Range (TR) Sensor

The TCM uses the position of this switch, housed in the TCM, to determine the selected gear range from the range selector lever.

The sensor completes the start circuit in PARK and NEUTRAL, and the back-up lamp circuit in REVERSE. The sensor also opens/closes a set of switches that are monitored by the TCM to determine the position of the manual lever (P, R, N, D6, D4, 3, 2 and 1).

Transmission Operational Strategies

Adaptive Shift Strategy

Adaptive shift strategy is comprised of:

- Shift Energy Management - this function involves reducing or increasing engine output torque during shifting.
    - Reduces excessive energy of the friction packs
    - Increases transmission service life
    - Improves shift quality
    - Unique shift schedules are selected based on vehicle operation conditions and environmental conditions
    - Trailer towing mode
- Pressure Modulation - this function monitors the hydraulic pressure in a shift. This pressure must be

matched accurately to the transmission input torque to better provide shift comfort.

- Shift Quality Adapts - is used to provide a higher quality and consistent shift feel. Monitoring and adapting shift pressures and shift energy to overcome hardware variability over time achieve this.
- The TCM has the ability to control the engine output torque during the shift, synchronized with the operation of the transmission clutches.
- Trailer towing mode uses a different shift and converter map. This new map reduces the number of gearshifts when towing, climbing steep hills and while driving at higher altitudes.

TCM Monitoring Functions

The TCM monitors all transmission input and output to identify possible transmission failures. If a fault is detected, the TCM takes the appropriate action to make sure that the transmission enters a safe mode of operation.

- Voltage Supply - this function monitors the vehicle battery voltage.
- Watchdog Monitoring - the watchdog monitoring has 2 functions:
    - Checks for faults in the driver circuits by activating each driver.
    - Checks to see if the safety circuit is functioning correctly.
- TCM Temperature - If the TCM temperature rises above a predetermined temperature, the TCM will shut down. Prior to shutting down, the TCM will log a fault code during shutdown. The transmission will enter a mechanical limp home mode.
- Pressure Regulator/Solenoid - Each pressure regulator and solenoid is monitored for open and short circuits. The TCM also checks that the current being delivered to each solenoid valve or pressure regulator is within limits.
- Torque Converter Control - The TCM checks and verifies that the torque converter has been engaged correctly. If the torque converter has not engaged correctly, the TCM will carry out the fail-safe action of opening the converter clutch.