Module 5: Automatic Transmissions and Torque Converters

- TERMS AND DEFINITIONS
- MAJOR MECHANICAL PARTS OF A FOUR SPEED AUTO TRANSMISSION
- PARTS OF A PLANETARY GEAR SYSTEM
- PLANETARY GEAR SYSTEM OPERATION
- SPEED, TORQUE, AND DIRECTIONAL FUNCTION
- FLUID PUMP AND PRESSURE REGULATING VALVE OPERATION
- CLUTCH APPLICATION IN AN AUTOMATIC TRANSMISSION FOR VARIOUS GEARS
- PARTS OF A TORQUE CONVERTER
- TORQUE CONVERTER PARTS AND THEIR FUNCTIONS
- TYPES OF FLUID FLOW IN TORQUE CONVERTERS AND THEIR CHARACTERISTICS
- PHASES IN TORQUE CONVERTER OPERATION
- CHARACTERISTICS OF AUTOMATIC TRANSMISSION FLUID
- IN-VEHICLE TRANSMISSION TESTS AND THEIR FUNCTIONS

Terms and Definitions

READY FOR REVIEW

- ATEC system is one type of an electronic system that includes an electronic control system, torque converter, lockup clutch, and planetary gear train.
- Auto shift finger corresponds to the tab on the end of the gearshift lever in manual systems and engages the shift blocks on the yoke bars.
- Clutch pack consists of clutch plates, friction discs, and a pressure plate.
- Flex plate, which is sometimes called a flex disc, is positioned between, and used to mount, the engine crankshaft to the torque converter, and transfers the crankshaft rotation to the shell of the torque converter.
- Impeller/pump is positioned with its back facing the transmission and is part of a torque converter that acts like a pump to circulate oil through the torque converter shell and is the input (drive) member that receives power from the engine.
- Input retarder is an auxiliary braking system used on downgrades and applied by the driver and is located between the torque converter housing and the main housing. Oil flowing into the retarder housing causes resistance that is transferred through the transmission to the driveline.
- Lockup torque converter eliminates the 10% slip that takes place between the impeller and turbine at the coupling stage of operation.
- Multiple disc clutches is located in a drum housing that can be separate or part of the main transmission housing, and they are an integral part of an automatic transmission.
- Power synchronizer is mounted to the back of the auxiliary section of the transmission and allows for smoother downshifts and upshifts by speeding up or slowing down the rotation of the main section gearing.
- Ring gear (annulus) is the largest part of the simple gear set.
- Stator is the torque multiplier part of a torque converter.
- Torque converter is a fluid clutch that transfers and multiplies torque from the engine to the transmission.
- Turbine is connected to the forward clutch of the transmission and turbine shaft, and it is the output (driven) part of a torque converter.
- Variable pitch stator is a design used in torque converters for off-highway applications.

Major Mechanical Parts of a Four Speed Auto Transmission

READY FOR REVIEW

- Torque converter module consists of the turbine, impeller or pump, stator, and the damper.
- Front support/oil pump module is comprised of the front support and the oil pump.
- Main housing module consists of the main housing, C3 clutch, C4 clutch, and C5 clutch.
- Retarder module or the retarder housing assembly is made up of the rotor and stator.
- Main shaft module consists of the main shaft, P2 sun gear, and P3 sun gear.
- P3 module is comprised of the P3 planetary assembly.
- P2 module is made up of the P2 planetary assembly.
- P1 module consists of the P1 planetary assembly.
- Control module is made up of the hydroelectric controls.
- Rotating clutch module consists of the C2 clutch, C1 clutch, and the turbine shaft.
- Converter housing module.

Parts of a Planetary Gear System

READY FOR REVIEW

- Sun gear.
- Planet pinion (gears).
- Ring gear (internal).
- Planetary carrier.
- Sun gear shaft.

Planetary Gear System Operation

READY FOR REVIEW

- A planetary gear system can act as a speed increaser and torque reducer.
- The planetary gear system can also act as a speed reducer and a torque increaser.
- The planetary gear system can also act as a means to reverse flow of power.
- Different speeds and torques, and reverse operations are achieved by applying the input rotation to different gears and holding one of the other two gears stationary.

  Note: When two external gears are in mesh, rotation of the output gear will be opposite of the rotation of the input gear, and when an external gear is in mesh with an internal gear, the rotation of the output gear will be the same as the rotation of the input gear.

Speed, Torque, and Directional Function

READY FOR REVIEW

- Speed, torque, and directional function of an automatic transmission.
  - Maximum forward reduction is when the sun gear is input, the carrier is the output, and the ring gear is held, and the result is that the speed will be the maximum reduction, the torque will increase, and the direction is the same as the input gear.
  - Minimum forward reduction is when the sun gear is held, the carrier is the output, and the ring gear is the input, and the result is that the speed is minimum reduction, the torque will increase, and the direction is the same as the input gear.
  - Maximum overdrive is when the sun gear is output, the carrier is the input, and the ring gear is held, and the result is that the speed is maximum increase, the torque is maximum decrease, and the direction is the same as the input gear.
  - Minimum overdrive is when the sun gear is held, the carrier is the input, and the ring gear is the output, and the result is that the speed will be minimum increase, the torque is minimum decrease, and the direction is the same as the input gear.
  - Direct drive is when the ring and sun gear are the input, then the speed and direction are the same as the input gear.
  - Slow reverse is when the sun gear is input, the carrier is held, and the ring gear is the output, then the result is that the speed is reduced, torque is increased, and the direction is the reverse of the input gear.
  - Fast reverse is when the sun gear is output, the carrier is held, and the ring gear is the input, and the result is that the speed will increase, torque will decrease, and the direction is the reverse of the input gear.
  - Neutral is when no member is held stationary or locked, there will be input into the gear set, but no output.
- Speed, torque, and directional function of an automatic transmission.
  - The effect of the carrier can be summarized in the following ways:
    - When the carrier is the output, speed decreases.
    - When the carrier is the input, speed increases.
    - When the carrier is held, the output direction is reversed.

Fluid Pump and Pressure Regulating Valve Operation

READY FOR REVIEW

- The fluid pump is located between the torque converter and the gearing and clutches.
- The following describes the general principles of operation:
  - The fluid pump is of the gear type, and the crescent is part of the pump housing.
  - When the inner gear is turned by the converter hub, the outer gear also turns.
  - As the teeth of the gears move apart, it creates increased volume and suction that causes fluid to be drawn in from the oil sump.
  - As the fluid in the teeth of the gears is carried around to the other side of the crescent, the teeth come together causing decreased volume and outlet flow, and oil is forced out into the supply cavity.
  - The fluid pump can create low flow at low speed and high flow at high speed, so a pressure regulating valve is used to keep the pump from building to high flow.

    Note: On some transmissions the pressure regulator controls pressure in the system by controlling pump flow and this is accomplished by using a variable displacement pump. Other systems use a fixed displacement pump that controls pressure through resistance to oil flow, and when resistance exceeds the spring force of the spool, the spool moves letting excess pump flow to return to the sump.
  - The valve is usually of the spool type, and when there is no pressure on the valve, the spring pushes the valve to the bottom of its bore.
  - While the engine is running, the pump directs the fluid to the pressure regulator valve, and then the fluid comes in around the lands of the spool.
  - As the fluid flows through the pressure line, a small amount flows through an orifice under the valve.
  - As pressure is built up, the valve rises, and one band will uncover the passage leading to the return line preventing pressure from getting too high.

Clutch Application in an Automatic Transmission for Various Gears

READY FOR REVIEW

- The power flow (clutch arrangement) for each gear range varies slightly depending on the make, model, and series of vehicle.
- The basic arrangement of most transmissions follows the same building block approach shown below.
  - First gear—C1 and C5.
  - Second gear—C1 and C4.
  - Third gear—C1 and C3.
  - Fourth gear—C1 and C2.
  - Fifth gear—C2 and C3.
  - Sixth gear—C2 and C4.
  - Reverse—C3 and C5.
  - Neutral—C5.

    Note: The number of gears present in an automatic transmission will vary, and if, for instance, a vehicle only has four gears, then the clutch application shown above for fifth and sixth gears will not apply.

Parts of a Torque Converter

READY FOR REVIEW

- Impeller (pump).
- Turbine.
- Stator (overrunning clutch).
- Lockup clutch.

Torque Converter Parts and Their Functions

READY FOR REVIEW

- Impeller (pump).
  - The impeller rotates at engine speed.
  - As the pump rotates, fluid enters from around the pump hub.
  - When the engine is running, the impeller is spinning; therefore it acts as a centrifugal pump.
  - Centrifugal force causes fluid to be thrown outward and upward to the converter turbine.
  - Once the force reaches a certain point, the fluid begins to spin the turbine.
- Turbine.
  - Turbine is splined to the transmission turbine shaft.
  - When oil from the impeller strikes the turbine blades, it transfers a force to the turbine, causing it to turn.
  - Since the turbine is splined to the turbine shaft, the turbine shaft rotates and supplies input to the transmission's gearing.
  - Fluid exits the turbine near its hub and flows to the stator.
- Stator (overrunning clutch).
  - Mounted on a one-way roller clutch, which allows it to rotate one way but not the other.
  - Fluid leaving the turbine locks the stator and is directed back to the pump at an accelerated rate, thereby increasing torque.
  - As the turbine gains speed, it directs oil to the back side of the stator blades, causing the stator to freewheel.
  - Fluid flowing through the freewheeling stator is no longer accelerated and does not increase torque.
  - As turbine speed increases, flow through the stator becomes smoother and eventually stops.
- Lockup clutch.
  - Once rotary flow has been achieved and certain speed and range requirements are met, the torque converter attains lockup.
  - When the lockup clutch is applied, the converter elements (impeller, turbine, and stator) rotate as a unit at engine speed.
  - This provides a direct drive from the engine to the turbine shaft.
  - When the lockup clutch is applied, slippage is eliminated.

    Note: The engagement of a clutch between the engine crankshaft and the turbine assembly has the advantage of improving vehicle fuel economy, reducing torque converter operational heat, and reducing engine speed.

Types of Fluid Flow in Torque Converters and Their Characteristics

READY FOR REVIEW

- Vortex flow.
  - Occurs when the stator is in the locked position.
  - Fluid is directed from the impeller to the turbine.
  - Fluid exiting the turbine strikes the front face of the stator blades, locking the stator.
- Rotary flow.
  - Occurs when the stator is in the freewheeling position.
  - Achieved when the direction of oil flow in the stator is the same as that of the impeller and turbine.
  - As the turbine begins to rotate and its speed increases, the fluid exiting the turbine strikes the back of the stator blades.
  - This frees the one-way clutch and allows the stator to rotate.
  - Rotary flow is minimum at stall and maximum during the coupling phase.

Phases in Torque Converter Operation

READY FOR REVIEW

- Torque multiplication phase.
  - Stator reverses the direction of the impeller causing vortex oil flow.
  - Oil flow locks the stator one-way clutch causing rotary flow to be at a minimum.
  - Vortex oil flow causes more torque on the turbine shaft than the engine is putting out because the fluid is accelerated more than once.
  - Multiplication phase decreases when turbine speed increases to match impeller rotation.
  - When turbine speed approaches to within 90% of impeller speed, the converter enters the coupling phase.
- Coupling phase.
  - In this phase, turbine revolutions per minute (RPM) are within 10% of impeller RPM.
  - Rotary flow causes the stator one-way clutch to unlock, enabling the impeller, turbine, and stator to turn together.
  - Due to slippage, the turbine will always rotate at a slightly lower speed than the impeller.
  - Converter now transfers engine torque directly to the drive train.
  - If equipped, the lockup clutch will apply during this phase.
- Lockup phase.
  - The lockup clutch locks the turbine to the front cover.
  - Lockup phase causes the impeller and turbine to rotate at the same speed.
  - Eliminates the 10% slippage between the turbine and impeller.

Characteristics of Automatic Transmission Fluid

READY FOR REVIEW

- Automatic transmission fluid has several additives, such as:
  - Viscosity-index improver.
  - Oxidation and corrosion inhibitors.
  - Extreme pressure and antifoam agents.
  - Detergents.
  - Dispersants.
  - Friction modifiers.
  - Pour point depressants.
  - Fluidity modifiers.
  - Red dye is added to the fluid so it will not be confused with any other lubricants.
- Do not use a fluid that is not recommended by the manufacturer, because it could cause serious damage to the transmission.
- Some manufacturers may require the use of synthetic transmission fluid, which can be better than conventional fluids, because they:
  - Degrade at a lower rate.
  - Provide better fuel economy.
  - Reduce wear on certain components.
  - Provide better protection at extreme temperatures.

In-Vehicle Transmission Tests and Their Functions

READY FOR REVIEW

- Road test warms up transmission fluid to operating temperature and indicates overall characteristics of transmission operation.
- Stall test indicates the condition of torque converter operation and strength of hydraulic system and can also indicate whether it is a transmission- or engine-related problem.
- Fluid pressure test tests each hydraulic circuit and compares it with manufacturer's specifications to detect general problems in hydraulic components.
- Electronic diagnostic test refers to the fact that all electronically controlled automatic transmissions offer some form of self-diagnostic system, and most, like the ATEC system, constantly monitors transmission operations and stores a record of the problem in the electronic control unit (ECU).
- Shift point adjustment refers to the fact that automatic transmissions are designed to shift within predetermined RPM and speed ranges, and adjusting the shift signal valve spring pressure rate and/or the modulator spring force will adjust the shift points. There are three methods of checking a vehicle's shift points:
  - Calibration using speedometer readings.
  - Calibration using engine RPM.
  - Calibration using a test stand.

