Automatic Transmission Basics

Automatic Transmissions/Transaxles contain 3 Major Components or Systems

1) Torque Converter

2) The Planetary Gears and holding devices

4) The Hydraulic Controls
Major Components

Torque Converter
- Transfers Power from Engine

Planetary Gear Unit
- Gear Sets
- Holding Devices

Hydraulic Control Unit
- Non-Electronically Controlled
- Electronically Controlled
**Major Components**

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Selecting the Proper ATF is CRITICAL

Mixing fluids can ruin a transmission

Always look up and use specified fluid

Transmission fluid has three major functions:
- Lubricate, clean, and cool
- Transmit torque
- Transmit pressure

Types of Toyota ATF
- WS (World Standard)
- Type T-IV
- Type T
- Dexron III
- Type F

It is vital to use the correct ATF. Fluid variations include:
- Viscosity
- Coefficient of friction
- Additives
- Compatibility with seals
Torque Converter

- Automatically transfers engine torque to the automatic transmission input shaft.
- Multiplies torque under certain operation conditions.
- Helps smooth driveline operation.
- Drives the oil pump.
**Oil Pump**

The oil pump is the “heart” of an automatic transmission.
- Driven by the torque converter.
- Supplies fluid pressure for the hydraulic control system.
Torque Converter

Components and Operation

1. Pump Impeller
2. Turbine Runner
3. Stator
4. Lock-up Clutch
Watch animation of Torque Converter at
https://www.youtube.com/watch?v=z5G2zQ_3xTc
Torque Converter

The **Impeller** is also called the Pump

Impeller turns with the engine crankshaft

The **Turbine** is driven by the centrifugal force of the A.T.F.

The Turbine is splined to the transmission input shaft

When vehicle is stopped and in gear, the impeller turns and the stator does not.
Torque Converter – Impeller or Pump

Pump Impeller
- Driven by the engine crankshaft.
- When impeller speed increases, centrifugal force causes fluid to flow to the turbine runner.
Torque Converter - Turbine

- Connected to automatic transmission input shaft.
- Vane curvature is opposite of pump impeller.
- Fluid from pump impeller causes turbine runner to rotate in the same direction as the pump impeller, transferring engine power to transmission input shaft.
Stator Operation

The Stator provides Torque Multiplication

When the engine is running and the car is stopped, the stator will lock on the One Way Clutch

The one way clutch is splined to the transmission oil pump cover or stator shaft that does not rotate

This provides maximum torque multiplication

At “Coupling Speed” the stator will spin freely on the overrunning (one way) clutch

At coupling speed, about 10% of engine RPM is lost to ATF fluid slippage
Torque Converter - Stator

- Located between the impeller and the turbine.
- Redirects fluid from the turbine runner so that it strikes the back of the impeller vanes to improve torque by as much as 50%, especially when vehicle accelerates from a standstill.
- As the impeller and turbine reach the same speed, fluid strikes the back of the stator vanes. This releases the stator one-way clutch and causes the stator to freewheel.

- Path of Fluid (If There was No Stator)

- Free
- Locked
Torque Converter - Stator

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- Located between the impeller and the turbine.
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Free

Locked
The oil pump is the “heart” of an automatic transmission.

- Driven by the torque converter.
- Supplies fluid pressure for the hydraulic control system.
Locking Torque Converter

Lock-up Clutch

- Lock-up clutch provides overdrive at cruising speeds.
- Reduces energy loss and improves fuel economy by mechanically connecting the pump impeller and turbine runner.
- When lock-up clutch is fully engaged, 100% of engine power is transferred through the torque converter to the automatic transmission input shaft.
- Later designs provide variable levels of clutch application, known as “flex lock-up.”
- Use correct bolt length to install torque converter to avoid damaging the flex plate.

Options:
- **Unlocked**
- **Lock-up**
- **Use correct bolt length**
Locking Torque Converter

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- Locked
- Use correct bolt length
Locking Torque Converter

The torque converter clutch is applied by hydraulic pressure.

The PCM will control a Torque Converter Clutch (TCC) solenoid to send ATF under pressure to the lock-up clutch.

Modern TCC solenoids are duty cycled to gradually apply.

The TCC will only lock in higher gears.

The TCC will unlock under acceleration (TPS input), high load (MAP or MAF) and when braking (Brake Switch).
Torque Converter mounting bolts are application specific. Using a substitute bolt(s) can cause damage to any torque converter.

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Use correct length bolts during installation to avoid additional damage.
Torque converters generate a large amount of heat, especially under acceleration.

Most transmissions send ATF fluid to the transmission cooler after it leaves the torque converter.

Most ATF coolers are located inside the radiator tank.

Vehicles used to tow trailers often require an additional ATF cooler mounted in front of the radiator.
Major Components

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- Holding Devices

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This link is an animation and explanation of Planetary gears
https://epxx.co/artigos/autogear.php
A Planetary gear can provide gear reduction (Underdrive) Direct Drive, Overdrive, or Reverse when you hold one part stationary, or lock two parts together.
Powerflow through the Planetary Gear Set

Mathmagically the Carrier is the largest gear in the planetary gear set.

Small gear driving large gear = Under Drive
Under Drive happens when Carrier is the Output

Under drive increases Torque – decreases Speed

Large Gear driving Smaller gear = Overdrive
Overdrive happens when the Carrier is the Input

If the Carrier is HELD, the Gear set goes to REVERSE
If you do not hold or lock any part, all gears will “Freewheel” and no power is transferred (neutral).
Underdrive is when Carrier is the Output. Hold Ring for maximum reduction
Hold Sun for minimum reduction

Gear reduction or Underdrive will INCREASE TORQUE
Direct Drive happens when ANY TWO components are locked together. This is done with multiple disc clutch packs.

**Planetary Gear Set**

![Planetary Gear Set Diagram](image)

- **Carrier (Input)**
- **Ring Gear (Output/Held to Sun Gear)**
- **Sun Gear (Held to Ring Gear)**

1:1 Input Output Direct Drive
Overdrive is when Carrier is the Input. Hold Ring for maximum overdrive. Hold Sun for minimum overdrive.
Reverse is when Carrier is Held.
Input Ring for reverse overdrive
Input Sun for reverse underdrive
Automatic Transmissions use compound planetary gear sets to provide multiple gear ranges

Simpson Gear trains share a common Sun gear

Ravigneaux Gear trains share a common Ring Gear

Many combinations are used

Output of one gear set becomes Input for other gear set allowing many gear ratios
There are three types of holding devices used to hold gears and carriers in planetary gear sets:

- Multiplate Clutches
- Brakes
- One-way Clutches

Each design has specific advantages.
Automatic Transmissions use compound planetary gear sets are controlled by:

Multiple Disc Clutches
  Used to connect rotating components together

One-Way (overrunning) Clutches
  Used to connect rotating components together in one direction and freewheel in the other

Multiplate brakes
  used to stop or hold

Brake Bands  also used to stop or hold
Multiple Disc Clutches connect rotating components together.

Multiplate clutches hold two rotating planetary gear set components together so they act as an assembly.

The versatile design is easily adapted to a transmission by removing or including friction discs to accommodate engines of different power output.
One-Way Clutches

Holding Devices

One-way clutches hold planetary gear set components so they can rotate in only one direction.

Outer Race
Sprag
Inner Race

One-Way Sprag Clutch
Sprag
Outer Race
Inner Race
Retainer Spring
One-Way Clutches

Holding Devices

One-way clutches hold planetary gear set components so they can rotate in only one direction.

One-Way Sprag Clutch

- Outer Race
- Sprag
- Inner Race
- Retainer Spring

- Sprag
- Outer Race
Multi-plate Brakes

Brakes hold planetary components to the transmission case so they cannot turn in either direction.

Along with multiplate clutches, multiplate brakes are among the most common holding devices. The versatile design is easily adapted to a transmission by removing or including friction discs to accommodate engines of different power output.
Brake Bands

**Holding Devices**

Brakes hold planetary components to the transmission case so they cannot turn in either direction.

Brake bands are less common than multiplate brakes. They are used to hold one-way clutches to provide an additional state of operation.
**Major Components**

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  - Gear Sets
  - Holding Devices

- **Hydraulic Control Unit**
  - Non-Electronically Controlled
  - Electronically Controlled
The **hydraulic control unit** has passages and valves that direct fluid flow to control:

- ATF pressure
- Gear selection (application of holding devices)
- Shift timing
- Shift quality
Valve bodies control shift timing, shift pressure, gear selection, fluid pressure
Valve Body must be kept spotless clean!

Valve body needs clean ATF to stay trouble free.

DO NOT USE shop rags to clean oil pan.

DO NOT allow shop rags to contact the valve body.

Rags will deposit lint that can block or jam shift valves, check balls, and hydraulic ports.

Only use lint free paper or cloth to protect and clean around the valve body or inside any part of the transmission.
!Valve Body must be kept spotless clean!

Shift pressures and shift points are controlled electronically using solenoids
Use ATF fluid level - Scan Tool – DVOM - and Labscope to diagnose shift problems

- **Reduction Timing Solenoid** (White Wire/White Conn) 14 to 18 ohms
- **Shift A Solenoid** (Short Brn Wire/Brn Conn) 14 to 18 ohms
- **EPC Solenoid** (Green Wire/Green Connector) 2.6 to 3.2 ohms
- **High Clutch Solenoid** (Blue & Blk Wire/White Conn) 2.6 to 3.2 ohms
- **Shift B Solenoid** (Long Brn Wire/Brn Conn) 14 to 18 ohms
- **Shift C Solenoid** (long Grn Wire/Grn Conn) 14 to 18 ohms
- **TCC Solenoid** (Blk & Red Wire/White Connector) 12 to 13.2 ohms
- **2-4 Brake Solenoid** (Yellow & Black Wire/White connector) 2.6 to 3.2 ohms
- **Neutral Shift Solenoid** (Grey wire/Black Connector) 14 to 18 ohms