ATech Educator News

November 2017

How many gears before the gear head spins?

Ok, I have to admit, my understanding of the inner workings of a modern automatic transmission is akin to a frog watching TV. I see what it does. Understand it? Not really. The sheer number of moving and rotating parts is almost incomprehensible. As they say "The journey of a thousand miles begins with a single step", so shall we try and demystify the automatic transmission/transaxle. The transaxle generally refers to front wheel drive vehicles, with the transmission and axle built into one housing, while transmission generally refers to front engine rear wheel drive vehicles. For simplicity I will use the term transmission for both.

In the modern drivetrain that pushes our vehicles down the road, the engine and transmission work together as one, but they are two very different things. Your engine connects to the transmission inside the "Bell Housing". Inside the bell housing is the **Torque Converter**. In a manual transmission the clutch is used to couple the engine to the transmission. In the modern automatic transmission, the torque converter is used to couple the engine and transmission together.

The torque converter is a type of fluid coupling that connects the two main components, the engine and the transmission. An easy way to describe this is by you placing two fans facing each other. Turn on one fan at low speed and leave the other turned off. After a few seconds the fan that is turned off will start to spin. Turn the running fan to high and the second fan will pick up speed matching the wind velocity of the first. A Torque Converter does this except with transmission fluid. As the engine runs, it turns a set of blades, or Impellers, inside the Torque Converter. A second set of blades, called the Turbine, attached to the transmission, is driven by the first without ever actually coming into contact. The system uses only liquid to drive the transmission from the engine. A Torque Converter differs from a standard fluid coupling in that it provides a **variable** amount of torque depending on driving needs and engine speeds.

Figure 1: Torque Converter inside the Bell Housing.

In my search for education on the matter I found a video on fluid coupling. It was made by the U.S. Army in 1953, and is the best video regarding fluid coupling I have ever seen. This video is for education and has a Creative Commons Attribution license, so you can show this in your classroom. Take a minute and refer the link below:
https://www.youtube.com/watch?v=leCEmJA0WsI

The Torque Converter's operation can be simplified into three stages: Stall, Acceleration, and Coupled. In the Stall mode, the transmission is in gear, but the applied torque from the torque converter is low enough that it can easily be overcome by applying the brake. During Acceleration, the engine speeds up and the torque converter follows suit slowly allowing the transmission to accelerate to the point that it almost matches the engine. As the vehicle reaches highway speeds and the engine and transmission get closer to matching speeds, the Torque Converter Clutch is applied and the two components are then coupled to work as one direct drive from the engine to the transmission. The key to the Torque Converter's ability to do this is the **Stator**. The Stator sits between the Impeller and the Turbine. Its primary function is to minimize losses due to churning and increase torque output by redirecting fluid as it is needed.

Following the Torque Converter is the main body of the transmission and it houses all of those spin-

ning gears. The gears in the automatic transmission are never disengaged from one gear to the next like in a manual transmission. They are always working in conjunction with each other. These gear sets are called **Planetary Gears**.

The modern automatic transmission will employ

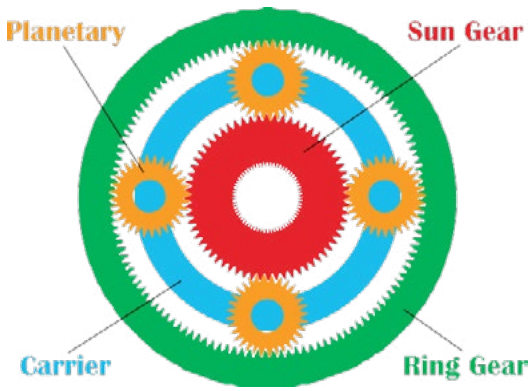
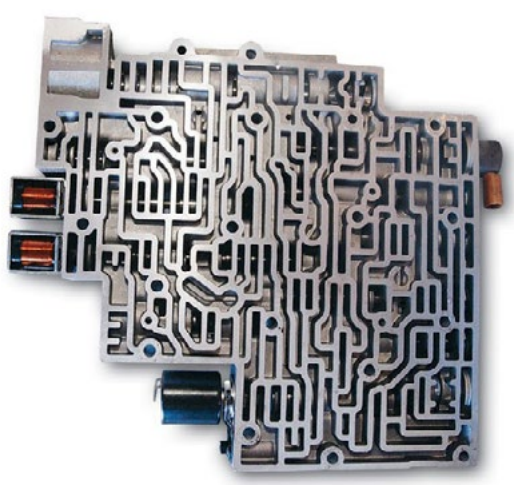


Figure 2: Planetary Gears

several sets of Planetary Gears to get all of the gear ratios that it needs. Two Planetary Gear sets will give you up to four forward gear ratios. Add another and you are talking about 6 to 8 forward gears. There are three main parts of all Planetary Gear sets. These are the Sun gear, the Planet gears and their carrier, and the Ring gear. These Planetary Gear sets are meshed together into one single housing about the size of a soccer ball. Each of these gear sets can be utilized as the input, the output, or held stationary. This is how you can get so many different gear ratios out of a single set of gears without ever having to engage or disengage any of them. How does it do that?

If you look inside a transmission you will find several sets of bands and clutches. These bands and clutches grab the individual gear sets of the Planetary Gears to make them either the input or the output. These bands and clutches are controlled by the valve body of the transmission.

Figure 3: Transmission Valve Body



The valve body and its maze of oil journals, tiny springs and valves control those bands and clutches via hydraulic solenoids. Their purpose is to either couple things together, decouple them, or hold them stationary. Bands can grab the outside Ring gears on the multiple Planetary Gear sets to let the Sun gears and Planet gears drive the vehicle, and the clutches can grab the Sun gears and Planet gears to either couple them together or hold them stationary. The solenoids are controlled by numerous inputs, including the PRNDL switch, the gas pedal, etc. A computer takes all of these inputs and activates the appropriate band and/or clutch to set the transmission into the proper gear ratio for the gear your automobile needs to do its job efficiently.

If you watch this video you will have a better understanding of how the multiple planetary gear sets work together. It too is from 1953, has the same license, and is equally informative.
https://www.youtube.com/watch?v=rQhzruw2Qh8

Now that we have a simple understanding of how the modern transmission works to give us all of those gear ratios, we can look at what is coming up around the corner. The commonality of the 8 (eight) speed transmission has become old hat, so what is new will surprise you. Both Ford and General Motors (and all of their associated companies) have joined forces to engineer a new 10 speed transmission. The first vehicle to receive this engineering marvel is the 2017 Ford Raptor. It will then trickle down into all light duty trucks in the following years. Did I just say 10 speed? Yes. This transmission will have 6 (six) forward **under drive** ratios (the input turns faster than the output), a direct drive ratio and 3 (three) **over drive** ratios (the output turns faster than the input). Inside the unit there are 4 (four) planetary gear sets and 6 (six) shift elements. Of these 6 shift elements 2 (two) are brakes (bands for the ring gears) and 4 (four) are clutches to couple and decouple Suns and Planets. All of this technological wizardry allows a big truck with 400+ horse power to get twenty plus miles per gallon. The logic behind it all is to allow the intended vehicle to always be working at the best point in its power band for the intended task at hand. Incredible acceleration and ridiculous top speed. To take things even further, Ford has applied for a patent on an even newer 11 speed transmission that should reach market by 2019. When will it end? Not really sure. Is it all worth it? Not really sure. Are they reliable? Only time will tell, but it does give us something to talk about.

Jeff Bogue, Product Representative

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