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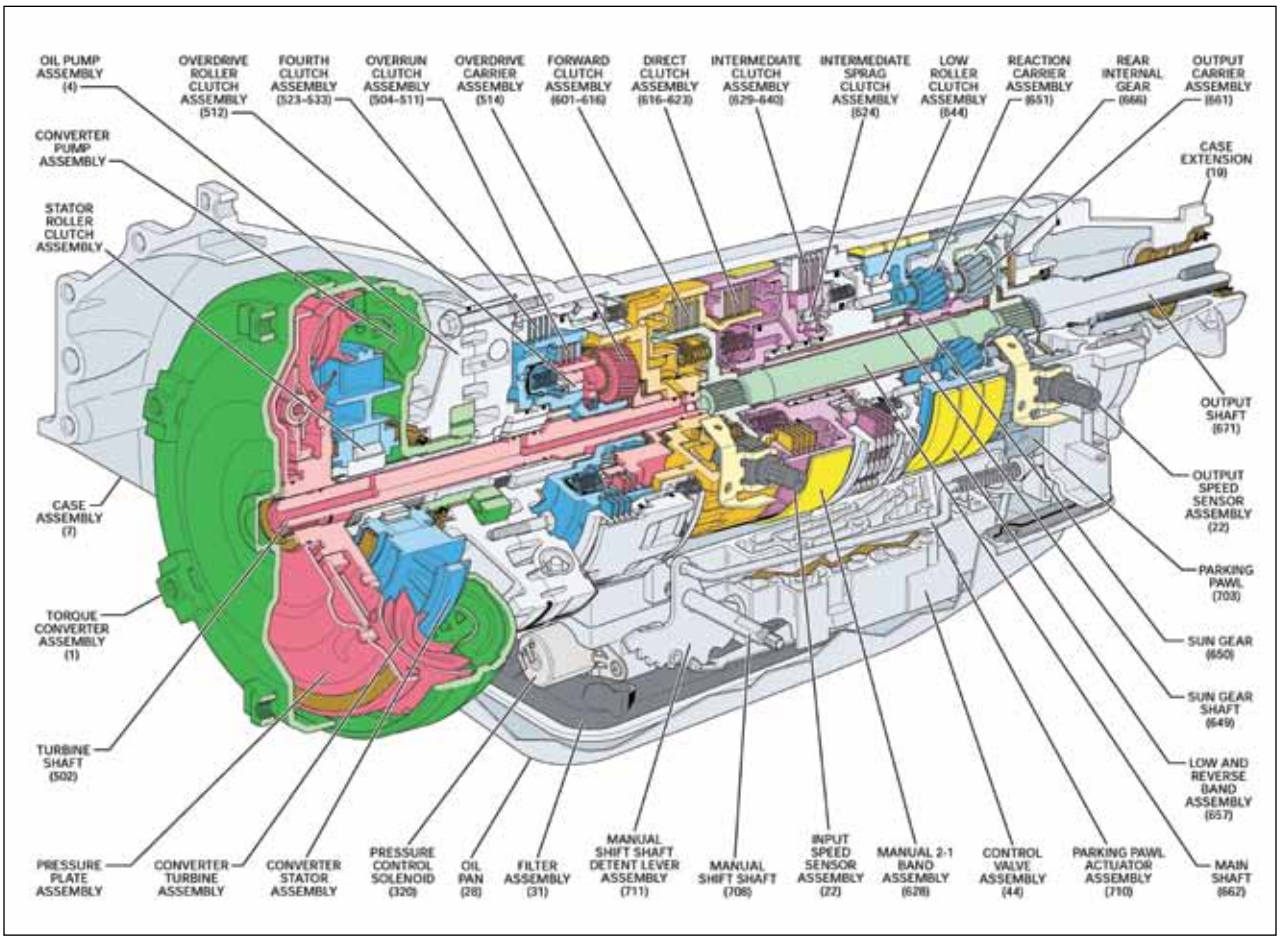


SHIFTLESS **PLEASURE**

GM Automatic Overdrive Basics and Exploring the Virtues of the THM 4L85-E SuperMatic Transmission

BY RAY T. BOHACZ
PHOTOGRAPHY AND ILLUSTRATIONS COURTESY OF GENERAL MOTORS

Those of us who have long been around cars, especially Pontiacs, can remember when converting from three-on-the-tree to a floor shifter meant we were serious about performance. Then the four-speed manual transmission came into play, known as "four-on-the-floor." Every true hot rodder rowed a four-speed through a Hurst shifter.

As time went on, a sacrilege occurred within Detroit—more and more slush boxes were being factory-installed in musclecars. To many, an automatic transmission didn't belong in a performance car. It was thought to be the domain of a grocery getter, luxury car, or station wagon that moms used to drive the kids to school.

It was quickly realized that with some internal tweaking of the Turbo Hydra-matic (THM) and torque converter, quicker acceleration could be realized with automatic shifting, and it eliminated any human error. A proficient driver with a good manual transmission would most likely be a little faster down the track, but there was always the risk of "blowing" a shift and losing a race. The automatic transmission did have one undeniable downfall, however—it had only three speeds, while the manual gearbox had four forward gears.

THE MORE THE MERRIER

The number of gears in a transmission is paramount to its performance. With most transmissions, regardless if they are a three- or four-speed, the top gear is a direct or 1:1 ratio. The lower gears are a higher numerical ratio and act as a multiplier of the engine's torque

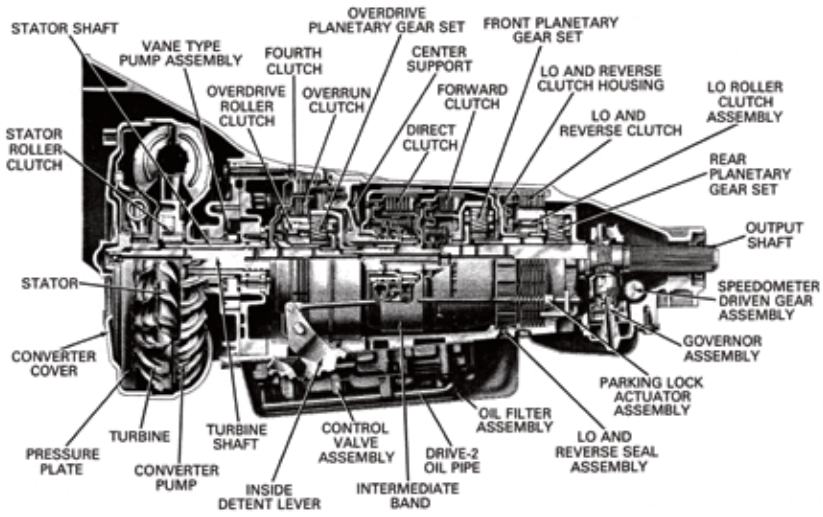
This cutaway highlights the basic components found in the 4L80-E, 4L85-E, and the 4L85-E SuperMatic transmissions.

output. That's why a truck designed to pull a heavy load has such high numerical gear ratios in the transmission and differential.

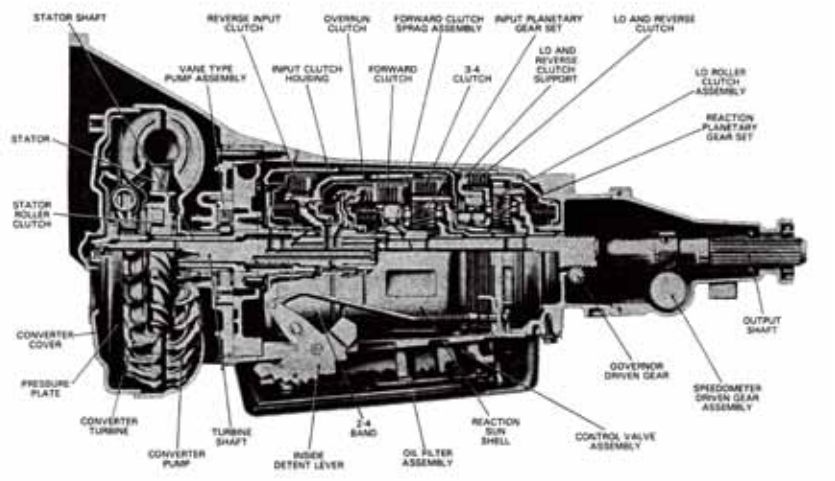
The downside of steep gearing is that the engine runs out of rpm quickly, and the vehicle's top speed is the direct result of how fast the tires can turn in the least-aggressive transmission gear. Here is where an overdrive trans can help, as it allows for a more aggressive rear gear, while lowering highway rpm by way of the less than 1:1 ratio Overdrive gear.

In addition, the spacing between the gear ratios in the transmission impacts the acceleration of the vehicle. Transmissions with fewer gear ratios, such as a three-speed, need a large drop in the multiplicative advantage when going from Second to Third so that 1:1 can be accomplished. This often makes less torquey engines bog and feel very lazy while diving, especially when trying to accelerate. The Pontiac V-8, however, is known for its extremely high torque output, and this would often mask the severe drop in gear multiplication when shifting either manually or automatically to the direct-drive range.

During the '60s, the Hydra-matic Division of General Motors designed and built what many consider the best automatic transmissions in the world—the THM 350 and THM 400. The 350



The THM 200-4R was the first GM overdrive. It added a third planetary gear set in the front of the unit to create the overdrive reduction.



The THM 700-R4, which was used in Third-Gen Firebirds, was designed as an overdrive. It wasn't modified from an existing three-speed design and was later renamed 4L60.

The 4L85-E SuperMatic is a 4L85-E was based on the 4L80-E, but it enjoys internal modifications for improved torque capacity.

was less stout than the 400 and was meant to be placed behind a smaller engine with less torque, while the 400 could handle more than any production engine could put through it.

Both of these units were known for excellent shift quality, long life, quiet operation, and an extreme level of tunability that allowed the aftermarket to create a true race automatic. The Hydra-matic line was so good that even Rolls-Royce used them in their motorcars. Many drag racers with non-GM vehicles would retrofit a Turbo 400 into their cars. That practice is still going on today.

Despite their great performance, the need for better fuel economy ushered in the era of the automatic overdrive transmission in the early '80s. It allowed for a high numerical rear-gear ratio for quick acceleration, without the penalty of high-engine rpm, as well as the inherent drop in fuel mileage and increase in engine noise and wear when cruising on the highway. The often-desired 3.90:1 rearend could be tamed to a ratio equivalent to 2.92:1 when shifting into Overdrive with a ratio of 0.75:1 (3.90 X 0.75 = 2.925). With this theory, you could drive your Pontiac to the track and not have to sacrifice quarter-mile acceleration for an enjoyable, high-speed ride.

Lower engine rpm at highway speeds produces gains in fuel economy beyond the obvious slower turning of the crankshaft and less firing events. In any engine, there are three areas of loss that don't allow the complete transfer of energy from the fuel to the crankshaft. (Energy is measured in British thermal units [BTU] and is considered a caloric value.) The internal combustion engine suffers from thermal, frictional, and pumping losses: the heat from combustion that goes into the exhaust port, the internal friction to run the engine and move the parts, and the work required to pump the air in and out of the cylinder bores.

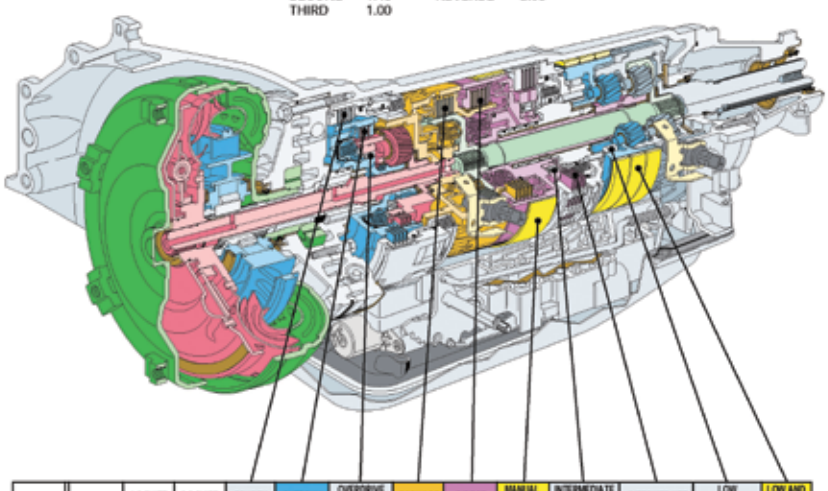
At minimal throttle-plate opening (either with a carburetor or a throttle body), the pumping losses are increased, since the engine is trying to breathe through a severe restriction. To put this in practical terms, think of how difficult it is to breathe when you have a stuffy nose. The throttle restriction makes the engine work harder to try and fill the cylinders, which is defined as volumetric efficiency (VE).

When an engine is running through an overdrive gear set, even though the crankshaft speed is lower, the throttle plate is open more. This is due to the higher load than at the same road speed when in a direct-drive gear. The additional throttle-plate opening reduces the pumping losses and allows more of the gasoline's chemical energy to be converted to work, thus providing better fuel economy.

RANGE REFERENCE CHART

HYDRAMATIC 4L80-E - GEAR RATIOS

FIRST	2.48	FOURTH	.75
SECOND	1.48	REVERSE	2.08
THIRD	1.00		



RANGE	GEAR	1-2 SHIFT SOLENOID	2-3 SHIFT SOLENOID	FOURTH CLUTCH	OVERRUN CLUTCH	OVERDRIVE ROLLER CLUTCH	FORWARD CLUTCH	DIRECT CLUTCH	MANUAL 2-4 BAND	INTERMEDIATE SPRAG CLUTCH	INTERMEDIATE CLUTCH	LOW ROLLER CLUTCH	LOW AND REVERSE BAND
P-N		ON	OFF			HOLDING							
R	REVERSE	ON	OFF			HOLDING		APPLIED					APPLIED
D	1st	ON	OFF			HOLDING	APPLIED			*		HOLDING	
	2nd	OFF	OFF			HOLDING	APPLIED			HOLDING	APPLIED	OVERRUNNING	
	3rd	OFF	ON			HOLDING	APPLIED	APPLIED		OVERRUNNING	APPLIED	OVERRUNNING	
	4th	ON	ON	APPLIED		OVERRUNNING	APPLIED	APPLIED		OVERRUNNING	APPLIED	OVERRUNNING	
D	1st	ON	OFF		APPLIED	HOLDING	APPLIED			*		HOLDING	
	2nd	OFF	OFF		APPLIED	HOLDING	APPLIED			HOLDING	APPLIED	OVERRUNNING	
	3rd	OFF	ON		APPLIED	HOLDING	APPLIED	APPLIED		OVERRUNNING	APPLIED	OVERRUNNING	
2	1st	ON	OFF		APPLIED	HOLDING	APPLIED			*		HOLDING	
	2nd	OFF	OFF		APPLIED	HOLDING	APPLIED		APPLIED	HOLDING	APPLIED	OVERRUNNING	
1	1st	ON	OFF		APPLIED	HOLDING	APPLIED			*		HOLDING	APPLIED
	2nd	OFF	OFF		APPLIED	HOLDING	APPLIED		APPLIED	HOLDING	APPLIED	OVERRUNNING	

*HOLDING BUT NOT EFFECTIVE

@ THE SOLENOID'S STATE FOLLOWS A SHIFT PATTERN WHICH DEPENDS UPON VEHICLE SPEED AND THROTTLE POSTION. IT DOES NOT DEPEND UPON THE SELECTED GEAR.

ON = SOLENOID ENERGIZED
OFF = SOLENOID DE-ENERGIZED

NOTE: DESCRIPTIONS ABOVE EXPLAIN COMPONENT FUNCTION DURING ACCELERATION.

For the 4L80-E, 4L85-E, and SuperMatic, electronic solenoids control fluid flow instead of a mechanical valvebody. This chart demonstrates the transmission's actions during acceleration.

OLD MEETS NEW

A while back, *HPP* documented the buildup of an SD-455 in a '74 Trans-Am owned by Melvin Benzaquen. The Pontiac mill was tweaked to the tune of over 500 hp, and was run with both a four-barrel carburetor and the Mass-Flo EFI sys-

PHOTO BY TOM READ

One of the upgraded components that make the 4L85-E and SuperMatic stronger is the five-pinion planetary gear set, which replaces the four-pinion units of the 4L80-E.

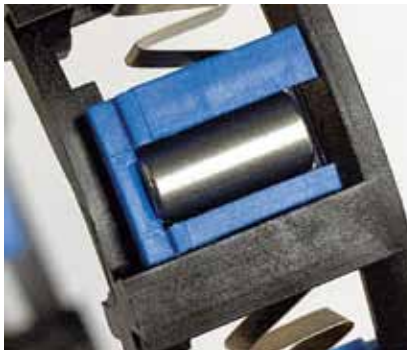


PHOTO BY TOM READ

Another is the heavier-duty roller clutch.

tem. The engine provided stunning performance and driveability, even though the rearend gearing wasn't dragstrip-friendly and the torque converter was on the tight side for the cammed mill. Since this Pontiac already was a melding of old and new engine technology, when the opportunity arose to upgrade the transmission to a modern overdrive, it was taken.

GM Performance Parts (www.gmperformanceparts.com) offers a complete THM 4L85-E SuperMatic unit with all the controls that allow installation in an older Pontiac, gaining the referenced attributes in driveability and performance. The installation of this transmission, along with the tuning of the electronic controller, will be covered in an upcoming issue of *HPP*. The task at hand now is to provide an overview of the THM 4L85-E SuperMatic and a brief history of GM's other automatic overdrive transmissions.

A NUMBERS GAME

THM 200-4R

When GM introduced its first overdrive transmission for '81 models, it was identified as the THM 200-4R and had gear ratios of 2.74 First, 1.57 Second, 1.00 Third, and 0.067 Fourth. This unit was basically a modified TMH 200 three-speed, which was one of the first lightweight designs produced in response to the downsized vehicle models and government-mandated fuel-economy standards of the late '70s.

The THM 200-4R was created by adding a third planetary unit (gear set) in the front of the geartrain. This created the fourth (overdrive) ratio. It was a fully automatic transmission with a three-element lock-up torque converter and a compound planetary unit (due to the added third member). Five multiple-disc clutches, two roller clutches, and a band provided the friction elements required to obtain the desired function of the compound planetary gear set and the overdrive unit. This trans was used through the '90 model year in various Big-Cars.

THM 700-R4

The next GM overdrive unit, which came out for '82 models, was the THM 700-R4 (3.06 First, 1.63 Second, 1.00 Third, and 0.070 Fourth) and was loosely based on the THM 350, with most of the design work done by the Chevrolet Division. Its original intended use was in light-duty trucks. Unlike the THM 200-4R, this model was designed from scratch as an overdrive transmission and didn't require the installation of a third planetary unit. The major components of the THM 700-R4 were a vane-type oil pump, a 2-4 band assembly, five multiple-disc clutches, two planetary-gear sets, a sprag clutch, a roller clutch, and the traditional valvebody assembly.

4L60/4L60-E/4L65-E/4L70-E

For the '90 model year, the 700-R4 was renamed 4L60 and it was used until '92. The new GM transmission identification code is deciphered as:

4—four-speed;

L—longitudinal installation (RWD);

(**T**—transverse installation (FWD));

XX—torque rating as assigned by GM Powertrain;

E—electronic controls instead of a conventional valvebody, beginning in '93.

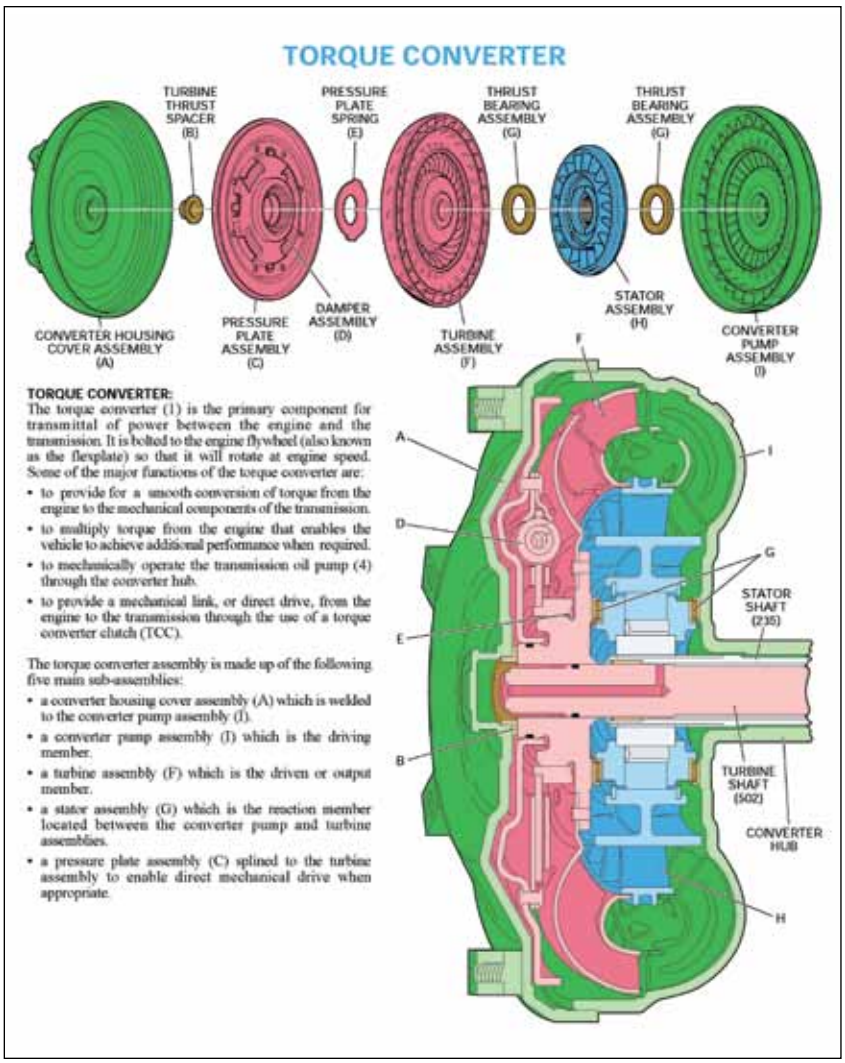
With advancements in electronics, it wasn't long until the transmission was integrated into the engine controller. It was realized that many functions controlled through the valvebody could be better tuned via solenoids. Thus, the traditional valves that gave the valvebody its name were replaced by fast-acting electric solenoids. Hydraulic pressure was still at work, but instead of overcoming spring pressure in mechanical valves, the solenoids directed fluid flow when commanded by the ECM/PCM. The integration of electronic controls changed the name of the 4L60 (which was known internally in GM as the MD8), to the 4L60-E, for '93.

A variation called the 4L65-E featured a five-pinion planetary-gear set in place of the 4L60-E's four-pinion, and a stronger output shaft, making it heavier duty. It was introduced for the '01. The 4L70-E followed and was stronger yet.

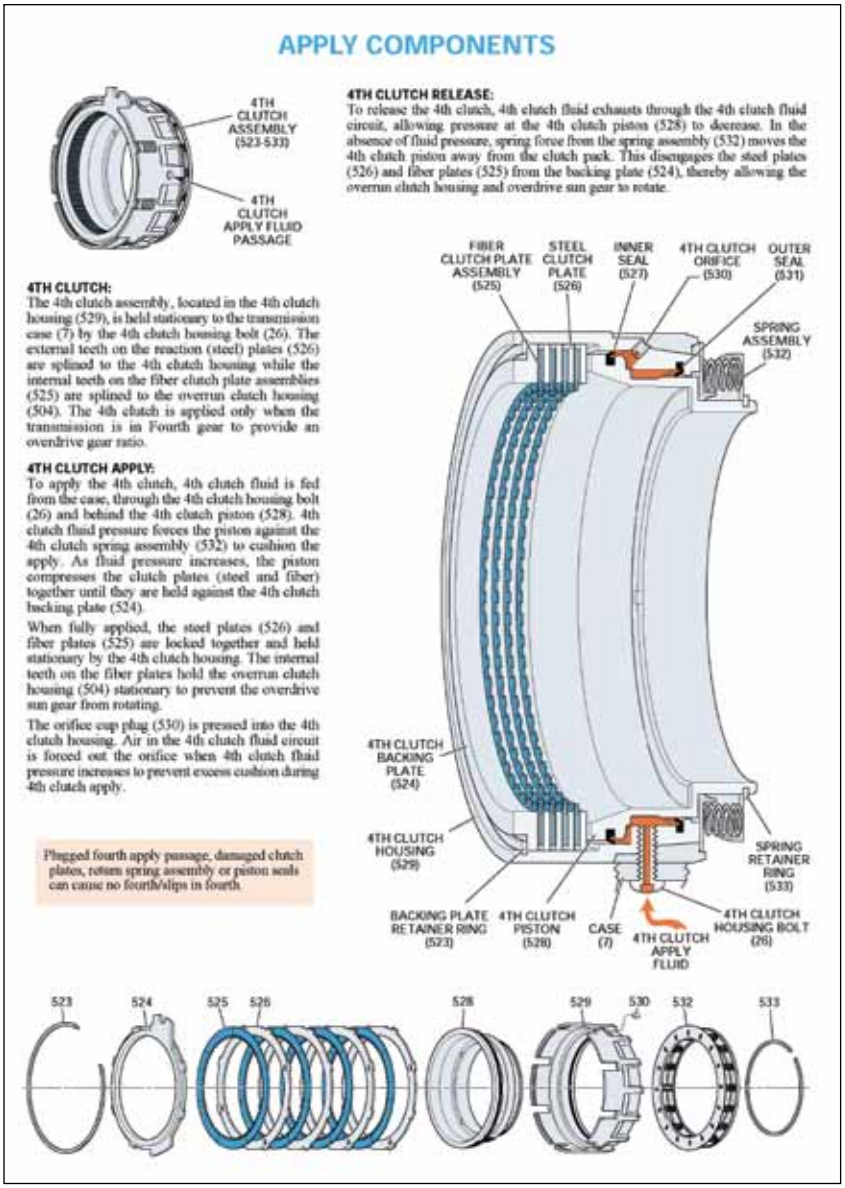
4L80-E

The 4L80-E was based on the THM 400 three-speed (later called the 3L80) and debuted for '90 or '91. It used six bolts in the bellhousing case and a four-pinion planetary gear set.

By '02, the 4L80-E had been in production for 11 years and was due for upgrades, so it received a heavier-duty overdrive roller clutch. GM states: "This modification incorporates larger-diameter rollers and a 'shuttle-car' design, which allows the high-speed 4-2 downshift maneuver without downshift-sequencing delays. This design also incorporates error-proof assembly features and maintains the roller position in the clutch assembly."

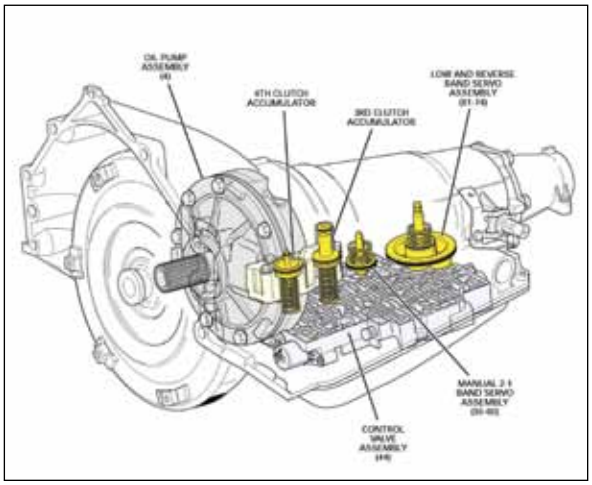


The torque converter is an advanced design that is able to better control stall speed, while mechanically locking during highway operation.



The Fourth gear clutches—a weak link in the 200, 700, and 4L60 overdrive units—are now able to hold the torque of a built V-8 Pontiac. The 4L85-E and Supermatic have even more clutch plates than the 4L80-E shown here.

Electric solenoids and advanced engine management actually made the internal workings of the 4L80-E, 4L85-E, and the 4L85-E SuperMatic simpler than their predecessors. Automatic shifting of the transmission is accomplished via the apply and release of the clutch packs and bands, which are directed by the hydraulic-control components shown here.



Another upgrade was an induction-hardened and shot-peened turbine shaft for increased durability. GM explains: "The turbine shaft transfers torque from the engine via the torque converter to the gear sets. The turbine shaft is now hardened by electrical heat-treating and then shot-peened to relieve internal stresses in the metal. This sequence of processes increases the strength of the shaft, for increased durability." The torque rating of the 4L80-E was 440 lb-ft, and the transmission was used through '06 in some truck applications.

4L85-E

In '02, the 4L85-E was born of the need to hold even more torque. It featured beefier internal parts, along with a five-pinion planetary design. This allowed for less stress on the gear-train during high-torque input.

The 4L85-E was also originally designed as a truck transmission, and was offered with three different bellhousing configurations and minor internal tweaks to make the unit application-specific. The latest versions use a bellhousing with seven bolt holes to further expand the installation appeal.

Torque-converter upgrades increase durability. According to GM, "The torque converter input and output pump blades, where torque is transferred via fluid, are brazed to the torque converter input and output shells."

To further the durability, the output and reaction gear sets were fitted with five pinions, instead of the four found in the 4L80-E. "Within the output and reaction gear-set carrier assemblies, the smallest gears are the pinions that revolve around the sun gears. Increasing the number of pinion gears from four to five allows the gear set to handle higher loads," according to GM. There's also a 34-element intermediate sprag, induction-hardened input shaft, and hardened forward hub. The torque rating for the 4L85-E is 460 lb-ft.

4L85-E SuperMatic

Now we have the 4L85-E SuperMatic (GMPP PN 19154550), introduced in 2009. It was designed to work behind high-torque engines like the Chevy ZZ572/720 crate package, and is advertised as a direct bolt-in for the Chevy Gen 1 small-block and all big-blocks. To bolt one into a Pontiac, we employ a bellhousing adapter.

GM Performance Parts tested the torque capacity of the 4L85-E using a 572/720R big-block Chevy crate engine. Afterward, the trans was torn down and examined for wear. Rusty Sampsel, GM Performance Parts Continuous Improvement Technical Liaison, tells *HPP*, "We took it apart and looked for areas that could be improved, and made those improvements. More clutch plates with upgraded materials were added in the intermediate, direct, and forward clutches, as was an improved overrun roller and selective-fit intermediate sprag outer race. Other

modifications were made to the direct-clutch housing to improve longevity by preventing centrifugal apply at high rpm." An increase in fluid pressure and a revised firm-shift valvebody round out the upgrades.

Following the improvements, the transmission was back on the dyno (with the big-block ahead of it) for durability testing. Subsequent teardown verified that the new design was able to handle to at least 720 hp and 685 lb-ft of torque reliably.

The gear ratios are the same as the 4L80-E and 4L85-E: 2.48 First, 1.48 Second, 1.00 Third, and 0.75 Fourth. Most Pontiac hobbyists who are into vintage models will quickly note that the first three forward gears are the same as the famed Turbo 400, from which these transmissions were originally derived. To use this electronically-controlled transmissions in a vintage Pontiac, electronic controller GMPP P/N 12497316 is required.

BASIC OPERATION

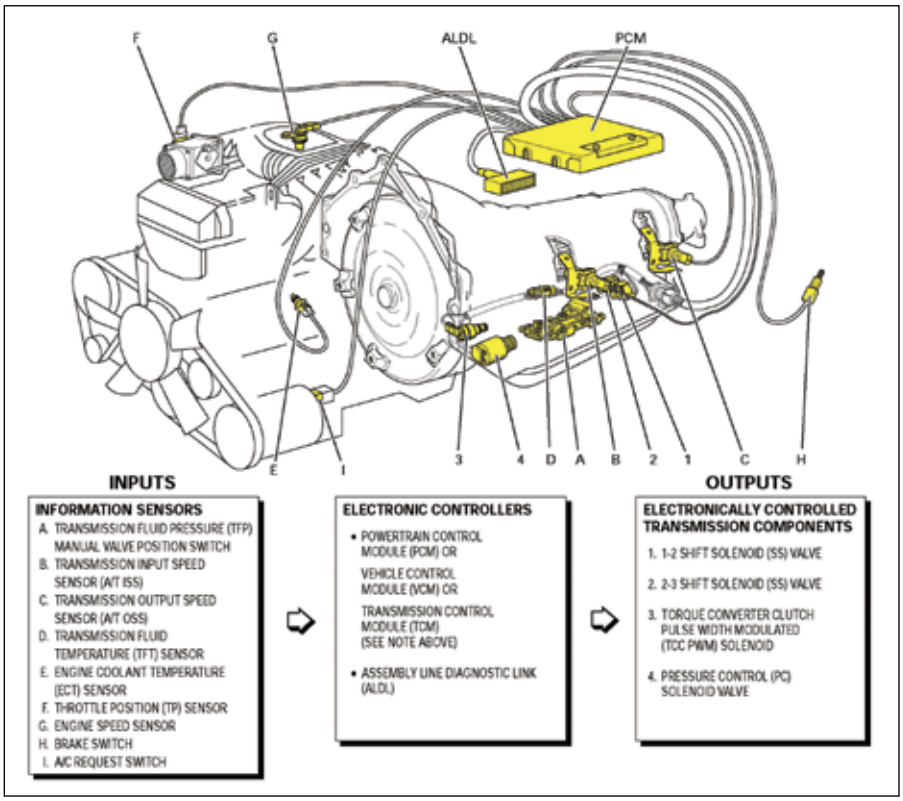
The 4L85-E SuperMatic is a fully automatic four-forward-speed transmission with electronic controls. It is designed with a four-element torque converter, three planetary gear sets, a hydraulic pressurization and control system, along with both friction and mechanical clutches. Its four-element torque converter contains a pump, a turbine, a pressure-plate splined to the turbine, and a stator assembly. The torque converter acts as a fluid coupling and is able to multiply engine output when required. The pressure plate, when applied, provides a mechanical direct-drive coupling of the engine to the transmission (lock-up), which eliminates any inherent slipping.

Three planetary gear sets provide the four forward speeds and reverse. Changing gear ratios is fully automatic and is accomplished through the use of a powertrain-control module (PCM). The PCM receives and monitors various electronic-sensor inputs and uses this information to shift the transmission at the optimum time with the required line pressure. It commands shift-solenoid valves within the transmission on and off to control shift timing, and it also controls the apply and release of the torque-converter clutch, which allows the engine to deliver maximum fuel efficiency without sacrificing vehicle performance.

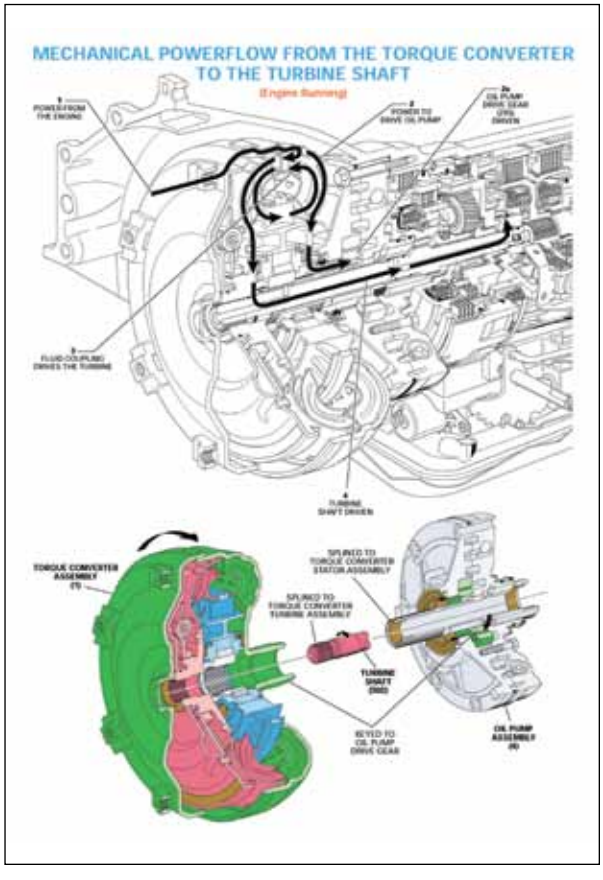
Its hydraulic system primarily consists of a gear-type pump and control valvebody. The pump maintains the working pressures needed to stroke the servos and clutch pistons that apply or release the friction components. These friction components (when applied or released) support the automatic shifting qualities of the transmission. Friction components in the 4L85-E Supermatic consist of five multiple-disc clutches and two bands. These combine with three mechanical components, two roller clutches, and a sprag clutch to deliver four different gear ratios through gear sets, which then transfer torque through the output shaft and out to the drive axles.

Look for a complete install of a 4L85-E SuperMatic in an upcoming issue.

HPP *would like to thank Tom Read, GM Advanced Technology Communications, Powertrain; and Patrick "Zak" Walczak of GearStar Performance Transmissions in Akron, Obio, [(800) 633-2353] for their technical assistance.*



The PCM monitors both engine and transmission signals through sensors to determine the shift points and line pressure required.



With the engine running, the fluid flow begins at the torque converter.