INTRODUCTION

The purpose of the transmission is to provide neutral, forward gear speeds or ranges, and reverse. It must be able to provide a gear ratio that is low enough, when multiplied by the final drive ratio, to increase the engine's torque sufficiently to accelerate the vehicle at the desired rate.

A manual transmission, also called a standard transmission, is constructed with a group of paths through which power can flow with each path used being a different gear ratio. Synchronizer assemblies or sliding gears and the shift linkage are used to control or engage the power paths.

A transmission has several different paths through which power can flow. These paths provide the required forward gear ranges and a reverse. In a rear-wheel-drive (RWD) transmission, power enters the input shaft and passes through at least two gear sets before transferring to the main shaft. Figure 1.

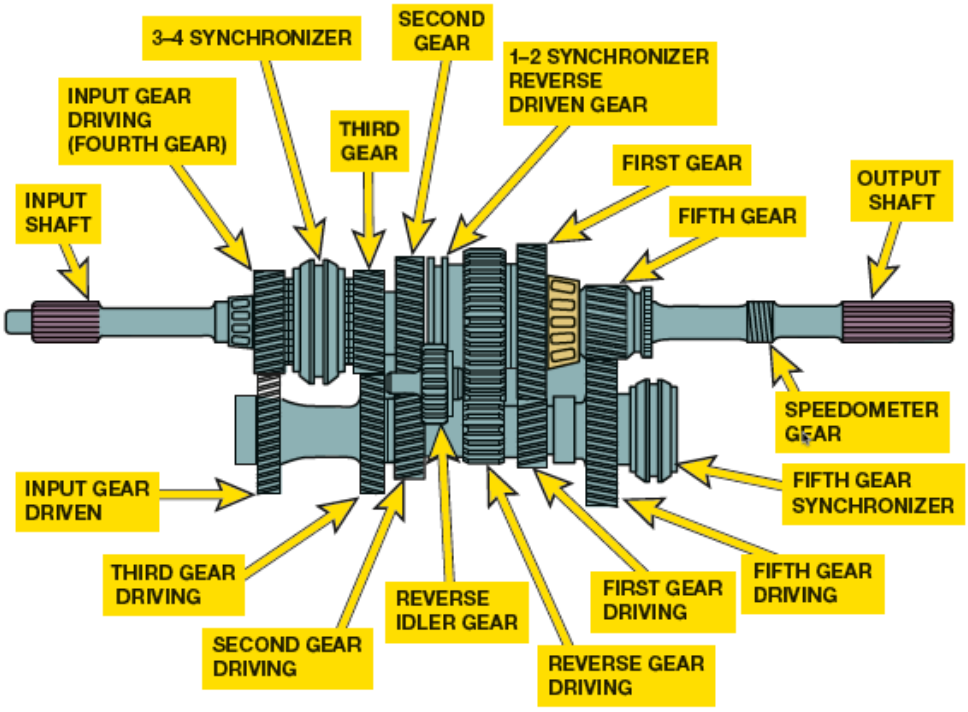

Figure 1. Five-speed transmission.

A rear-wheel-drive (RWD) manual transmission includes the following four shafts:

1. A cluster gear, countershaft gear or layshaft (a British term).
2. The input shaft , also called a main drive gear or clutch shaft.
3. The output shaft , also called a main shaft.
4. The reverse idler shaft.

In all gear speeds but one, the power flows from the main drive gear (input) to the cluster gear and then from the cluster gear to the main shaft (output). The power passes through two gear sets. The exception is a 1:1 ratio, where the power flows directly from the main drive gear to the main shaft.

Constant mesh gears are always engaged with their mating gear and are mounted so that one of them, called a speed gear, can freewheel on its shaft. The gears are shifted by connecting the freewheeling gear to its shaft. This is done through a synchronizer assembly.

The real “shifting” in a synchromesh transmission takes place in the synchronizer assemblies, not the gears. Most synchronizer assemblies ride on the output shaft between two gears. A synchronizer assembly is named for the gears on either side of it, which are the two speeds that it engages. For example, a five-speed transmission with constant-mesh reverse uses a 1–2 synchronizer, a 3–4 synchronizer, and a 5-reverse synchronizer. Figure 2.

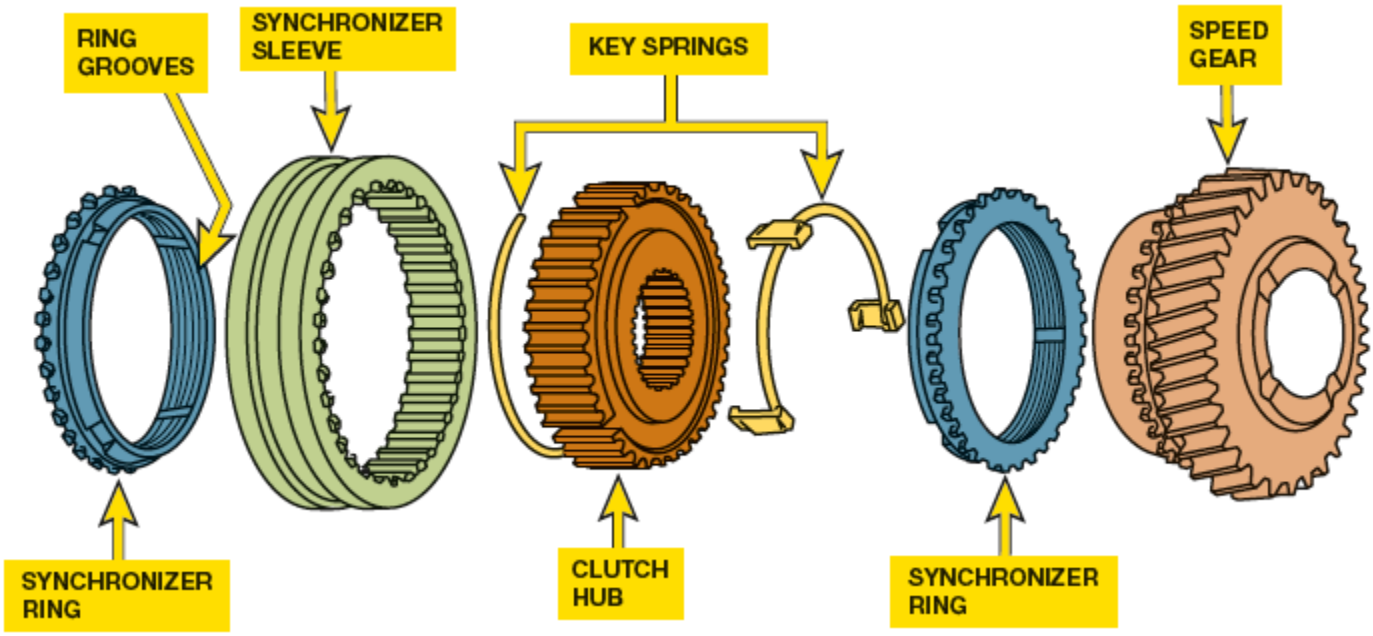

Figure 2. The synchronizer sleeve slides on the hub toward the speed gear. The synchronizer ring slows the speed gear to match the speed of the hub. Then, the sleeve slides onto the gear tangs, locking the speed gear to the hub.

As the gearshift lever moves, the shifter mechanism moves one or two synchronizer sleeves or gears to engage the desired gear speed. During upshift or downshift, one synchronizer sleeve is moved to neutral before the sleeve of the desired gear is moved to engage the desired gear. Figure 3.

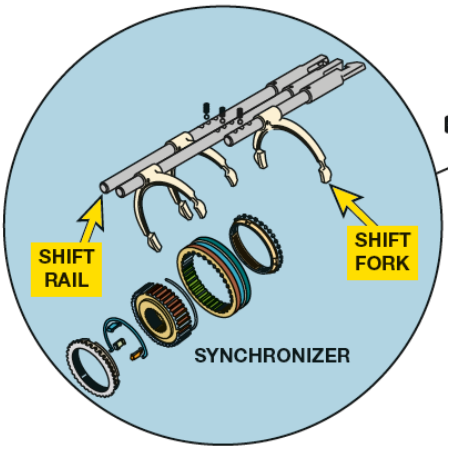

Figure 3. The synchronizer sleeves are moved by the shift forks.

ASE TEST TOPICS

1. Diagnose transmission noise, difficult shifting, gear clash, jumping out of gear, fluid condition and type, and fluid leakage problems; determine needed repairs.

In-vehicle service, also called on-vehicle service , in most cases is a normal maintenance operation and includes the following:

- Periodic check of the lubricant level
- Linkage/shifter adjustment
- Mount inspection or replacement as needed
- Visual inspection for leaks and other abnormal conditions

The engine-off shift test, also called a static shift test or a shift effort test, measures the effort required to move the synchronizer sleeve or gear, fork, and shift rail past the neutral detent and into mesh. Compare the effort to shift into one gear with the effort to shift into the gears on a similar transmission.

The engine-running shift test, also called a dynamic shift test, is almost a repeat of the engine-off check except that it checks for clutch drag as well as transmission problems.

Incorrect fluid can cause shifting problems. Many transmissions and transaxles do not use SAE 80W-90 gear oil. If the wrong lubricant is used, it can soak into the composite blocker ring linings. Even if drained immediately and refilled with the correct fluid, noise or erratic shifts can result.

Figure 4 lists possible transmission faults and possible causes.

TRANSMISSION/ TRANSAXLE FAULT	DESCRIPTION OF FAULT	POSSIBLE CAUSE(S)
Leaks	Fluid escapes from the transaxle/ transmission	Leaking gaskets or seals
Hard shifts	Requires an abnormally high amount of force to shift into gear	Possible incorrect lubricant in the transmission and/or shifter/linkage/shift fork problems
Shift block-out	Will not shift into one or more gears	Possible shift linkage and/or interlock concerns. Can be caused by the "shift skip" system which forces a shift to 4th instead of 2nd at lower vehicle speeds to improve fuel economy
Locked into gear	Transmission/transaxle will not shift out of a gear	Shifter/linkage/shift fork problems
Jumps out of gear	Will shift into neutral on its own	Often caused by worn synchronizer assemblies
Clash/grinding during a shift	Gear clash/grinding noise occurs as shift is made	Often caused by worn synchronizer assemblies
Noisy	A grinding, growling noise while in neutral	Worn or defective bearings
No gear at all	Sometimes the teeth are sheared and there is no gear at all (usually second gear)	Usually caused by driver abuse

Figure 4. Faults and possible causes.

2. Inspect, adjust, lubricate and replace transmission external shift assemblies, linkages, brackets, bushings/grommets, cables, pivots, and levers.

The exact method of adjusting transmission shift linkages varies. Some have no adjustment, whereas others provide adjustments with gauging methods. Always follow the procedures found in service information for the vehicle being serviced. An internal shifter has no external adjustments, but the remote shifter may use brackets and/or rubber mounts that need inspection. Figure 5.

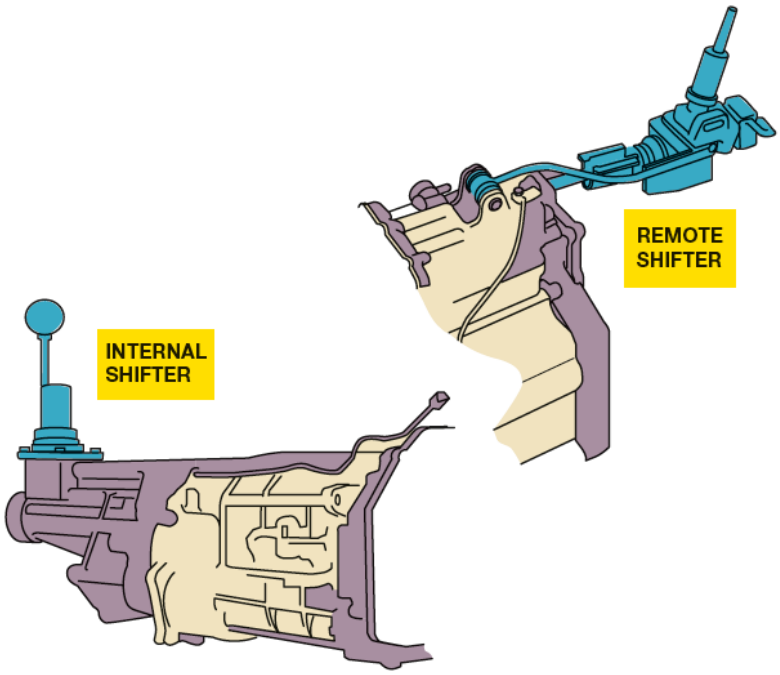

Figure 5. Internal and remote shifters.

3. Inspect and replace transmission gaskets, sealants, seals, and fasteners; inspect sealing surfaces.

Most cases include one or more seals, which are normally replaced during a rebuild. These seals include one or two output shaft seals and an input shaft seal. To make a good seal sealants require surfaces that are clean and oil-free when they are applied. Figure 6.

Figure 6. Sealant take the place of a gasket.

4. Remove and replace transmission; inspect transmission mounts.

TRANSMISSION REMOVAL. The procedure usually includes the following steps:

STEP 1 Disconnect the negative – ( ) battery cable.

STEP 2 Raise and securely support the vehicle.

STEP 3 Drain the fluid, noting the amount and condition of fluid that comes out.

STEP 4 Remove the backup light wires, speed sensor connections. It is usually necessary to remove the boot and shift lever from inside the vehicle before it is lifted. On some vehicles it is necessary to remove part of the exhaust system.

STEP 5 Position a transmission jack to support the transmission. Remove the transmission support bolts, raise the transmission slightly, and remove the transmission support. In some cases, it may also be necessary to remove the cross-member and rear transmission mount.

STEP 6 Remove the transmission-to-engine bolts. In many vehicles, the transmission can be lowered enough to gain access to the upper mounting bolts.

STEP 7 Move the transmission and jack to the rear to clear the clutch shaft and lower the unit out of the vehicle.

TRANSMISSION INSTALLATION. Transmission replacement usually follows the procedure just described, only in reverse.

5. Disassemble and clean transmission components; reassemble transmission.

The overhaul operations for most transmissions are very similar. The steps involved are as follows:

- Disassembly of the unit
- Clean and identify the unit so that the correct parts and specifications can be found
- Gear inspection
- Bearing inspection
- Reconditioning of the subassemblies
- Checking gear end float and adjusting bearing clearances as the unit is reassembled

The exact procedure for carrying out each of these steps will vary depending on the make and model. It is highly recommended that the procedure specified in service information be followed along with the clearances and torque specifications. The procedure given here is general and intended to familiarize the service procedures and how they are performed.

1. Remove the case cover or case cover with shift mechanism.

2. On units that use tapered roller bearings, remove the shims and bearing cup. The input shaft/main drive gear can now be removed.

3. Remove the extension housing. The countershaft extension with the fifth and sixth drive gears and the synchronizer assembly along with the shift fork can now be removed.

4. Remove the rear bearing and then remove the main shaft assembly. This usually involves using a puller to remove the bearings. Figure 7.

5. Remove the cluster gear and countershaft.

6. Locate and remove the reverse idler gear shaft locking device, and remove the shaft, gear, and any thrust washers or O-rings.

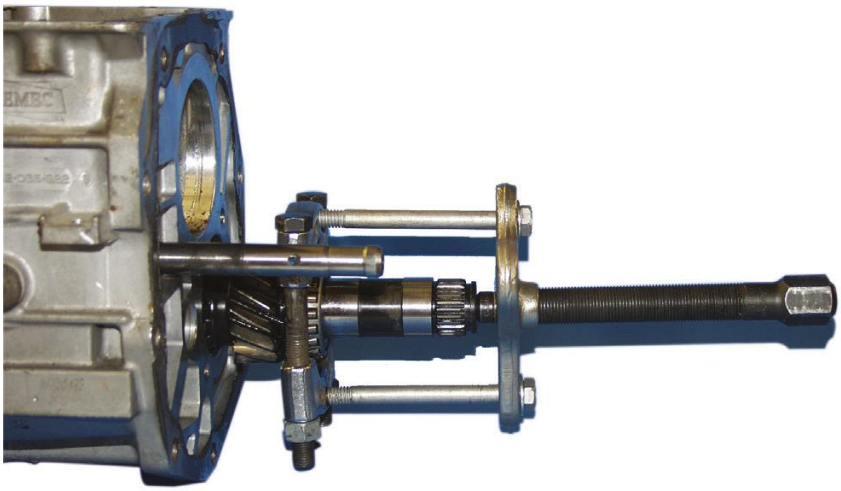

Figure 7. A rear bearing being removed using a gear/bearing puller.

The following are normally checked during disassembly:

- The internal shift linkages for rough operation and wear
- Clearance between all shift forks and sleeves
- All shafts for excessive end play and rough operation
- All floating gears for excess end float or rough rotation
- All blocker rings for free motion and excessive or insufficient clearance or damaged lining
- All gears for chipped or broken teeth

The cleanup of most of the internal parts is done using safety solvent while scrubbing them with a cleaning brush or by running them through a hot-water washer.

To reassemble the transmission, reverse the order of instructions, checking components and assemblies along the way.

6. Inspect, repair, and/or replace transmission shift cover and internal shift forks, bushings, bearings, levers, shafts, sleeves, detent mechanisms, interlocks, and springs.

The shift mechanism contains a fork for each synchronizer sleeve or gear to be shifted, and each fork is mounted on a rail or lever that moves it through its travel. Figure 8.

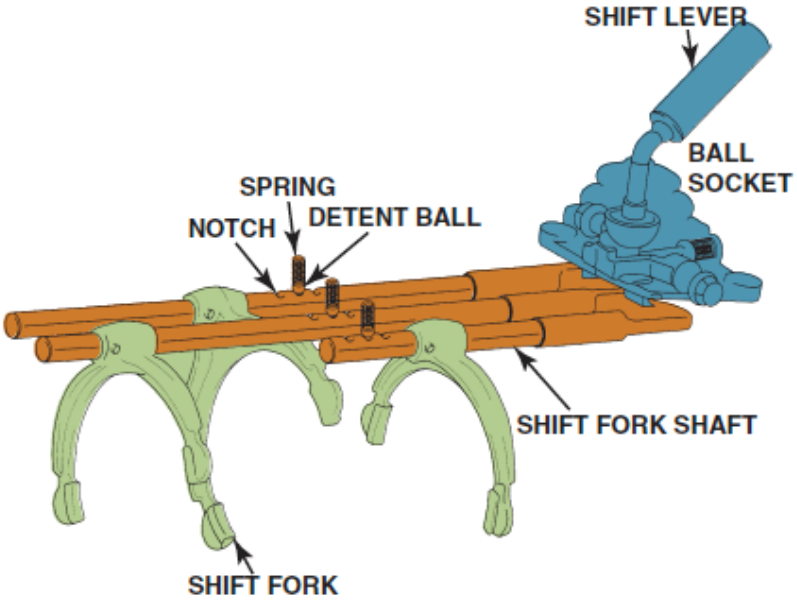

Figure 8. Shift rails and forks. Detent balls and springs are shown.

Each shifter includes one or more spring loaded detent balls or cams and some form of interlock that allows only one shift fork to move at a time. Figure 9.

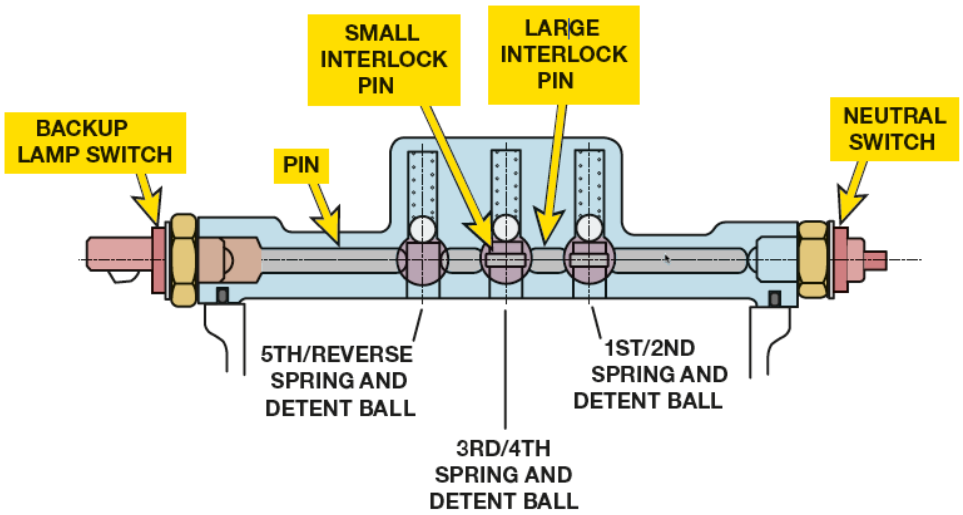

Figure 9. Looking at the shift rails from the end, showing the detents and interlick pins.

Shift forks should be inspected for distortion, bends, cracks, broken or worn inserts, and step wear at both the sleeve and fork contact areas. Figure 10.

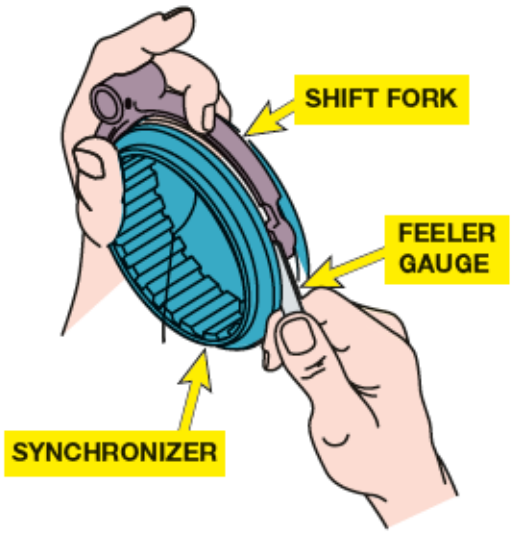

Figure 10. There should be a specified clearance, usually about 0.030 inch (0.8 mm), between the fork and the groove in the sleeve.

7. Inspect and replace input (clutch) shaft, bearings, and retainers.

After removing the retainer and input shaft, inspect the gear and bearing. Figure 11.

Figure11. Input shaft gear and bearing.

In some cases, gear damage is quite obvious and easy to locate. With other gears, however, a close inspection is necessary to determine if there is a problem with the teeth or thrust or bearing surfaces.

If one gear of a set has a broken tooth, be aware that a tooth on the mating gear encountered the same load and is probably damaged. The broken gear and its mate are replaced as a set.

Inspection of a bearing is normally done by sight, feel, and sound. Visual inspection of a worn bearing can reveal a broken cage or pitted races.

The release bearing is supported by and rides on the front bearing retainer (release bearing support shaft), also called a quill, or candlestick. Inspect for damage and wear. Figure 12.

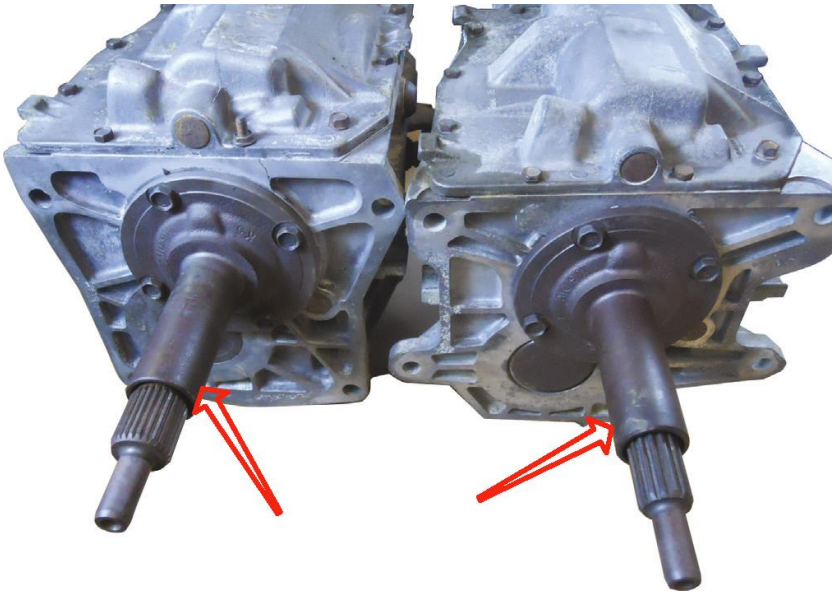

Figure 12. Inspect the front bearing retainer wear surfaces.

8. Inspect and replace output (main) shaft, gears, thrust washers, bearings, and retainers/snap rings; measure clearance and endplay.

Transmission main shafts are disassembled to allow a thorough inspection of the journals and bearings where the gears are mounted and for access to the synchronizer assemblies. In some cases, this is simply a matter of removing snap rings and sliding the various parts off the shaft but in most cases, the parts must be removed using a press or puller. Clearance between the gear and thrust washer should be measured. Figure 13.

Figure 13. After the bearing is pressed off measure the thrust washer clearance.

9. Inspect and replace synchronizer hub, sleeve, keys (inserts), springs, and blocking (synchronizing) rings/mechanisms; measure blocking ring clearance.

Synchronizer assemblies are disassembled for cleaning, inspection, and occasionally for deburring the ends of the splines in the sleeve. The sleeve and hub are matched at the factory and should be marked before it is disassembled. To disassemble a synchronizer assembly, remove the energizer springs and slide the sleeve off the hub. The inserts will either fall or slide out of their grooves.

Paper-lined and composite blocker rings should be checked for glazing of the friction surface and discoloration, which often indicates glazing.

The thread-like grooves of a new blocker ring are sharp so that they cut through the lubrication film. They become flattened as they wear, and the flat edges will reflect light. Figure 14.

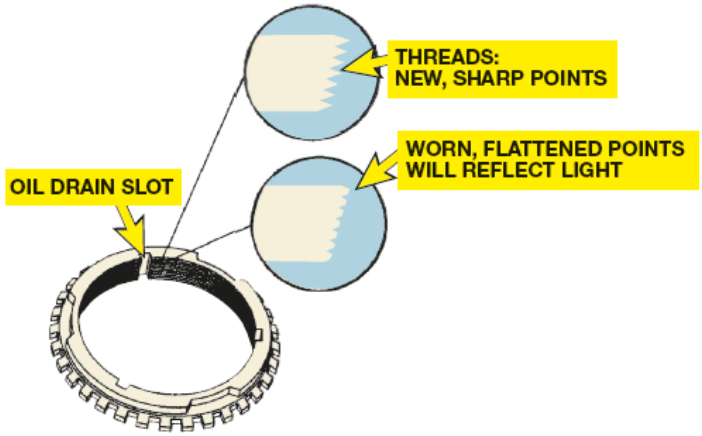

Figure 14. Blocker ring inspection.

When the blocker ring is pushed against the gear, there should be a minimum amount of clearance between the blocker ring and gear clutching teeth. Use a feeler gauge to determine this measurement. Some manufacturers specify a minimum clearance of about 0.020 inch (0.5 mm). Figure 15.

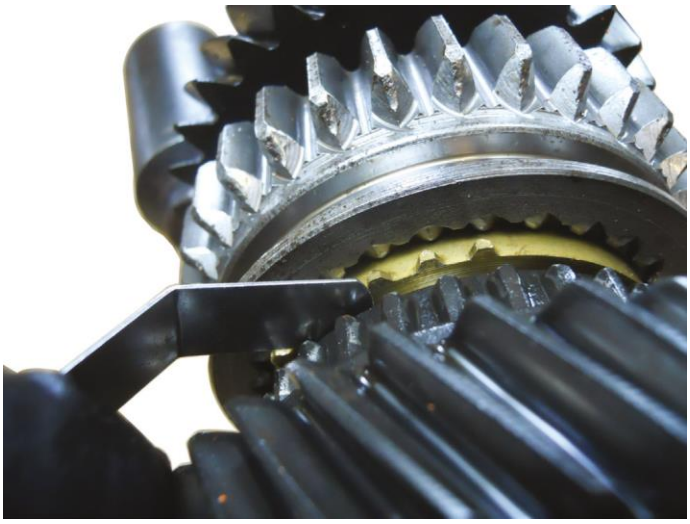

Figure 15. Measuring blocker ring clearance.

10. Inspect and replace countershaft, counter (cluster) gear, bearings, thrust washers, and retainers/snap rings.

Newer transmissions support the countershaft assembly, which includes the cluster gear, with a pair of tapered roller bearings. Tapered roller bearings are normally adjusted during installation to obtain free running with a very slight clearance.

Most cluster gears are one-piece units, and if one of the gears is damaged, the entire unit must be replaced. The cluster gear used in some transmission is a three-piece unit. Figure 16.

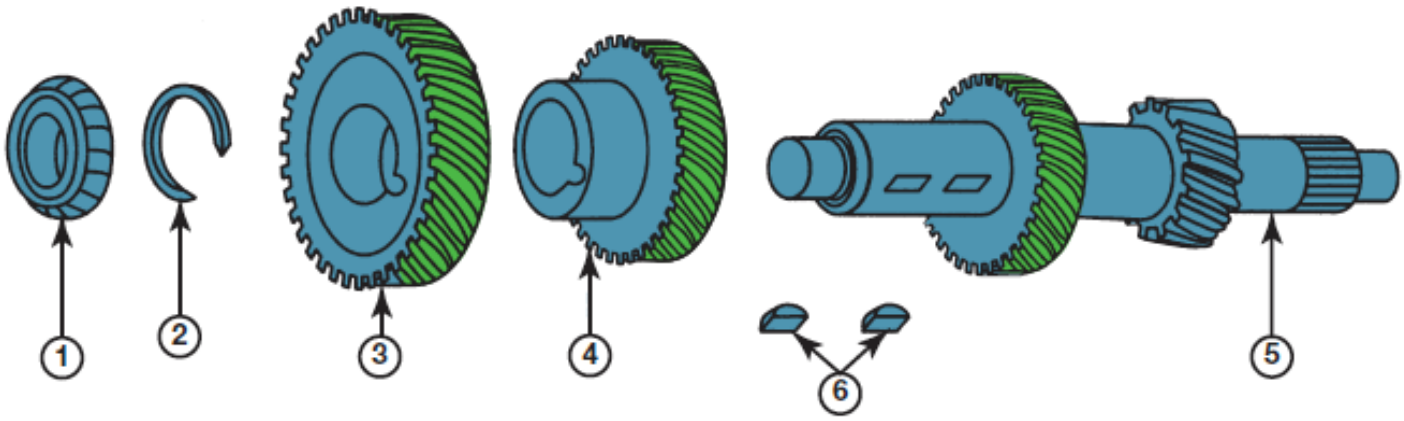

Figure 16. A three-piece cluster gear. Bearing (1), retainer ring (2), press-on gears (3 and 4), cluster gear shaft (5), and woodruff keys (6).

Carefully inspect all bearings before reassembling the unit. If one is worn or damaged, then many experts recommend that all of the bearings be replaced because they all share the same lubricating oil and any wear metal will be thrown throughout the assembly.

11. Inspect and replace reverse idler gear, shaft, bearings/bushings, thrust washers, and retainers/snap rings.

The reverse idler gear is the only gear that is actually shifted into position by sliding it into mesh with two other gears. Because of this the gear teeth are subject to chipping and wear if not shifted correctly. Inspect the idler gear and matching components for worn or broken gear teeth; replace if necessary. Figure 17.

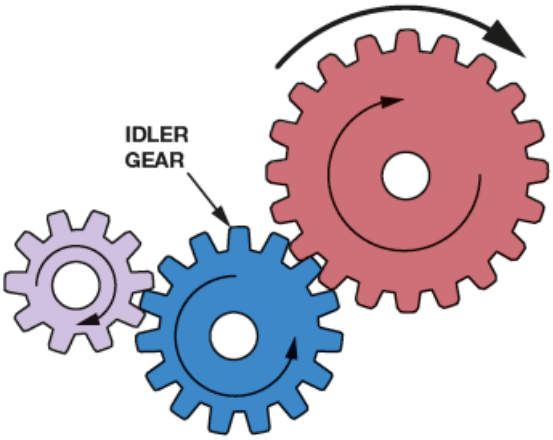

Figure 17. The reverse idler gear slides into mesh with two other gears.

12. Measure and adjust bearing preload or endplay (shim/spacer selection procedure).

During the reassembly of a transmission that uses tapered roller bearings, the preload or end play of each shaft should be checked. A selective shim is located at a bearing at one end of each shaft, and the thickness of this shim controls the amount of preload or end play.

- Preload causes a slight drag as a shaft is rotated, and it is usually measured using a torque wrench or spring scale.
- End play is a free, lengthwise movement of the shaft and is usually measured using a dial indicator or feeler gauge.
- Place the shaft to be checked with its bearings in the case. Use an adjusting shim that is too small, so there will be end play.
- Install the bearing retainer or case cover and tighten all bolts to the correct torque.
- Move the shaft up and down through its free travel several times while reading the end play or clearance on the dial indicator. Figure 18.
- Using service information, select and install a shim of the correct size, replace the bearing retainer/case cover, tighten the bolts and check for end play. On preloaded shafts, there should not be any end play.
- Using a torque wrench or spring scale and adapter, measure the torque required to keep the shaft rotating, not the breakaway or starting torque. Compare the preload reading to the specifications.

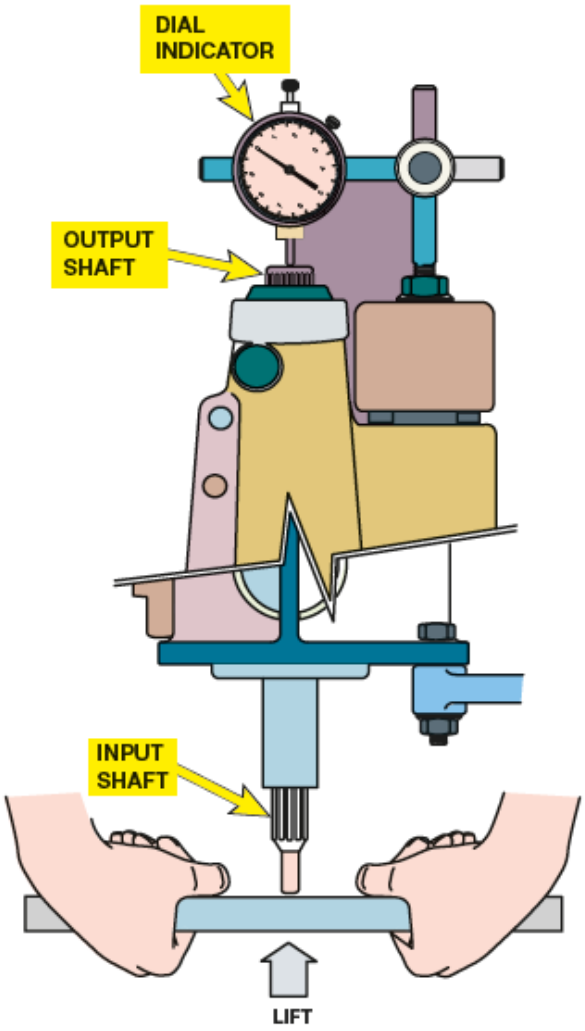

Figure 18. Measuring end play.

13. Inspect, repair, and replace extension housing and transmission case mating surfaces, bores, dowels, bushings, and vents.

The extension housing and transmission case should be thoroughly cleaned and carefully checked for cracks, distortion or wear of bearing bores, stripped bolt threads, and worn release (throwout) bearing supports. Damaged cases are normally replaced.

Each transmission includes a vent that should be checked for restriction. The vent normally located at the top of the case. This relieves internal pressure that would occur as the gears and oil warm up while operating. If not relieved, the pressure would force the oil out past the input and output shaft seals.

14. Inspect, test, replace and calibrate transmission sensors, actuators, and switches.

Vehicle speed sensors (VSS) are usually a magnetic-type sensor. A magnetic sensor consists of a notched wheel and a coil consisting of an iron core wrapped with fine wire. The notched wheel causes the magnetic strength changes enough to create a usable varying AC voltage signal. The voltage-generating speed sensor normally uses a two-wire connector and is checked using both an ohmmeter and a voltmeter. Figure 19.

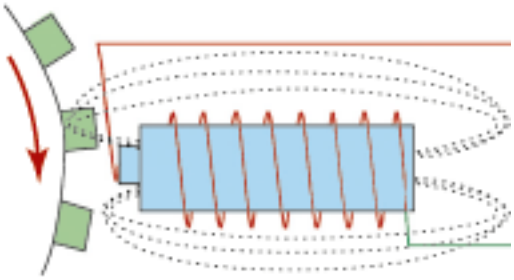

Figure 19. Magnetic speed sensor principle.

15. Inspect, test, and repair lubrication system, pumps, coolers and plumbing.

The transmission cluster gears run in a bath of lubricant, and as they spin, their motion will throw the lubricant throughout the case. The lubricant can be any of the following depending on vehicle manufacturer, model, and year:

- Gear oil such as SAE 80W-90
- Engine oil such as SAE 5W-30
- ATF such as Dexron III/VI
- Manual transmission fluid

16. Check transmission fluid level; refill with proper fluid.

A transmission usually requires the vehicle be raised to gain access to the filler/level plug. Be sure the engine is off before removing the plug. The fluid level should be even with the bottom of the opening. If the fluid is not running out, carefully insert a finger into the opening to feel the level of the fluid. Some vehicle manufacturers specify that the fluid level be 1 inch (25 mm) below the fill plug opening. Figure 20.

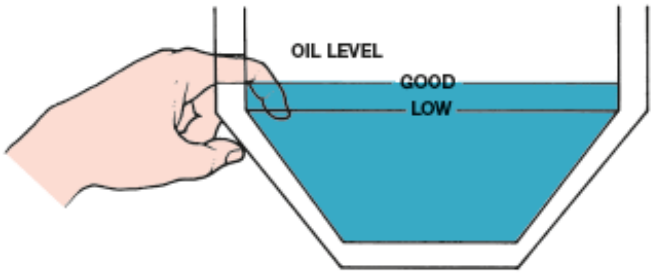

Figure 20. Checking fluid level.

Transmission fluid change.

- Check service information for the exact location of the fill and drain plugs. After lifting the vehicle, locate and loosen the fill plug to make sure that it can be removed before draining the fluid from the transmission.
- Locate the drain plug at the bottom of the transmission, place a drain pan under it, and remove the drain plug.
- Check the owner's manual or service information to determine the correct lubricant type and refill quantity.

NOTE: Many transmissions do not use SAE 80W-90 gear oil. If the wrong lubricant is used, it can soak into the composite blocker ring linings. Even if drained immediately and refilled with the correct fluid, noise or erratic shifts can result.

- Refill the transmission to the correct level.

17. Inspect, test, adjust, repair or replace electrical/electronic components and circuits including control modules, solenoids, sensors, relays, terminals, connectors, switches, and harnesses; inspect, test, and verify control module inputs, outputs, and data communications.

A digital voltmeter (DVM) measures the pressure or potential of electricity in units of volts. A voltmeter is connected to a circuit in parallel. Voltage can be measured by selecting either AC or DC volts. The DC volts (DCV) setting is the most common for automotive testing. Use this setting to measure battery voltage and voltage to all lighting and accessory circuits. Figure 21.

Figure 21. A digital voltmeter measuring battery voltage.

A terminal is a metal fastener attached to the end of a wire, which makes the electrical connection. The term connector usually refers to the plastic portion that snaps or connects together, thereby making the mechanical connection. Wire terminal ends usually snap into and are held by a connector. A small removal tool, sometimes called a pick, is used to release terminals from the connector. Figure 22.

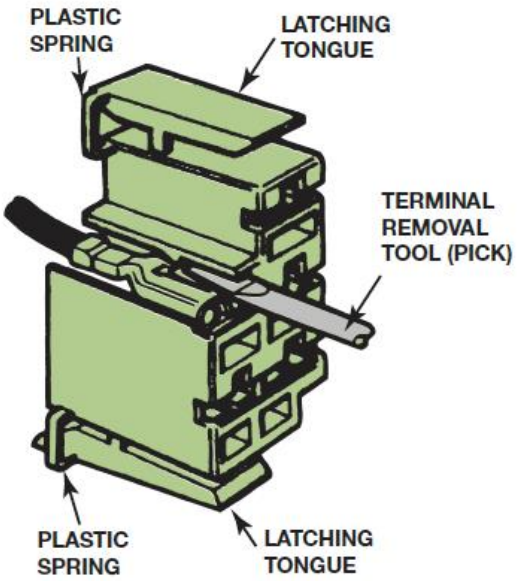

Figure 22. Removing a terminal from a connector.

Since the 1990s, vehicles have used modules to control the operation of most electrical components. A typical vehicle will have 10 or more modules, and they communicate with each other over data lines or hard wiring, depending on the application. Faults in these systems can cause transmission concerns. Figure 23.

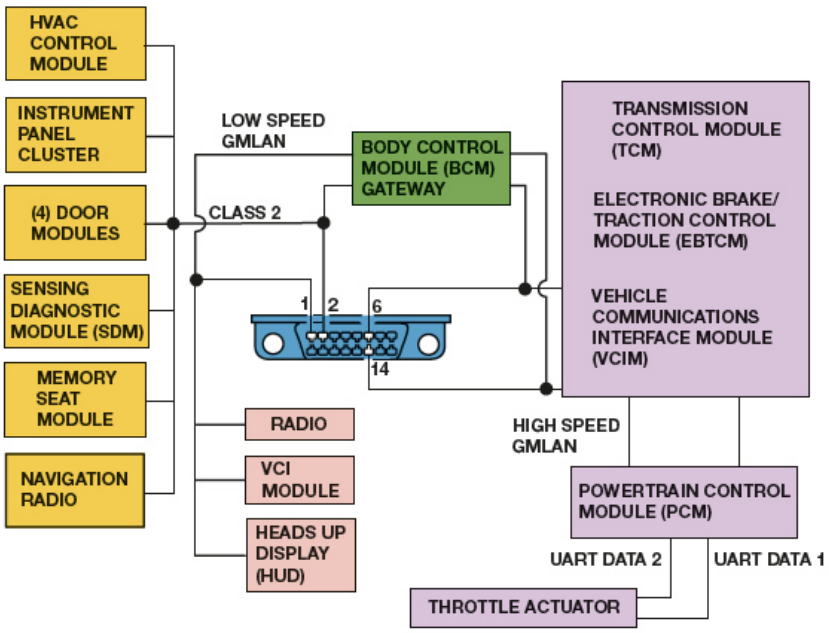

Figure 23. A typical network system shows the transmission control module (TCM)communicates with the PCM over the high speed GMLAN bus.