

VEHICLE SPEED SENSORS

11/30/03

Before Stealth Conversions began offering aftermarket vehicle speed sensors for engine swaps (in 1991), the biggest obstacle for most people who installed the TPI/TBI engines into their vehicles was the VSS (Vehicle Speed Sensor). Some aftermarket wiring harnesses don't use a VSS—they simply ground the P/N (Park/Neutral) wire so that the ECM always thinks the vehicle is in park. If they didn't ground the P/N wire, the "Check Engine" light would always be turned on. Because of the importance of the vehicle speed sensor, we cannot recommend these harnesses. If you have a harness which does not use a VSS, you can add the VSS and properly connect the P/N wire on automatic transmission vehicles, or remove the P/N wire on cars with manual transmissions.

Basically, the VSS tells the ECM how fast the vehicle is going. Most people think the VSS is only used for the lock-up torque converter. The VSS is also used to control the EGR valve, the charcoal canister purge valve, the electric cooling fans, idle speed, and air/fuel ratio. This is all explained in the Chevrolet shop manual (available from Helm at (800)782-4356), which is required reading for installing the TPI/TBI engine into your vehicle.

It must be emphasized that the VSS is used to control the idle speed when the vehicle is moving. Without the VSS, a vehicle may have stalling problems under certain conditions. The reason an engine not equipped with a VSS may stall is because when the ECM has the signals that indicate the engine should be idling (foot off the gas pedal, vehicle moving less than 2 mph), *idle speed is closed loop* (which is not the same as the O₂ sensor running closed loop) and the ECM will try to maintain a *programmed* idle speed. If the vehicle is moving (with a VSS), the ECM opens the IAC (idle air control) a programmed amount, regardless of engine speed, which is usually a position that will make the engine idle about 50-100 rpm above the stationary *programmed* idle speed. Stalling can occur when the vehicle is in the over-run condition (foot off the gas pedal, engine speed above the programmed idle speed) because the ECM will close the IAC to try to lower the idle speed to the stationary *programmed* speed. During some overrun conditions, the fully closed IAC may not be able to open rapidly enough to prevent the engine from stalling.

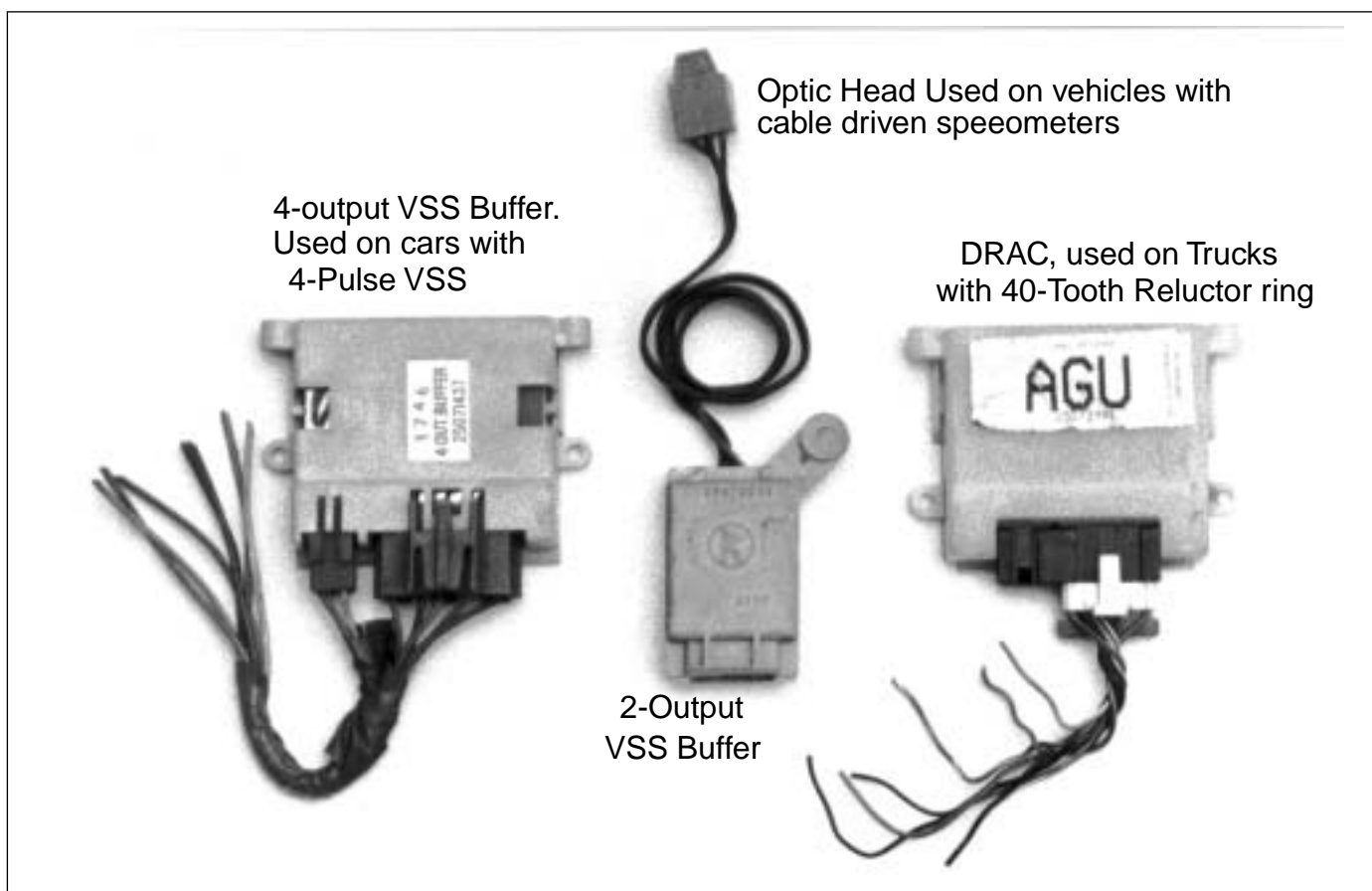
Raising the minimum idle speed with the adjusting screw can eliminate stalling, but the engine will still not run optimally without a VSS.

A lot of people think that running "closed loop" is best for fuel mileage. Closed loop simply means that the oxygen sensor is being used to monitor the fuel/air ratio. Some of the Chevrolet fuel-injected engines are programmed to run lean under certain conditions (called "highway mode") to improve fuel mileage during steady cruise conditions. Without a VSS, the ECM will not get the correct signals to run the engine for best fuel mileage. There are a lot of programs in the ECM which depend on the VSS. For best operation, the Chevrolet fuel-injected engines require *all* sensors to be connected and functioning.

There are 4 types of VSS signals required by the ECM:

1. The two-pulse (2000 pulses per mile) square wave (D.C current or direct current) used on all TBI engines thru 1992, all computer-controlled-carbureted engines, and on 1985-1989 TPI engines.
2. A four-pulse (4000 pulses per mile) sine-wave (A.C. current or alternating current) signal is required by the 1990-1993 TPI, 1992-1993 LT1 engines, and 1990-1993 Camaro 3.1/3.4 V6 engines.
3. A 40 pulse per driveshaft revolution speed sensor used on 1993 and newer trucks with automatic transmission, 1994 and newer rear drive cars with the automatic transmission
4. A 17 tooth per driveshaft revolution speed sensor used on 1993-1997 LT1 engines with the Borg-Warner 6-speed transmission. An 11 tooth reluctor ring is used on 1993 LT1 engines with the Borg-Warner wide ratio (3.35 First gear) 6-speed transmission.

VEHICLE SPEED SENSORS



VSS, BUFFERS, AND DRACS

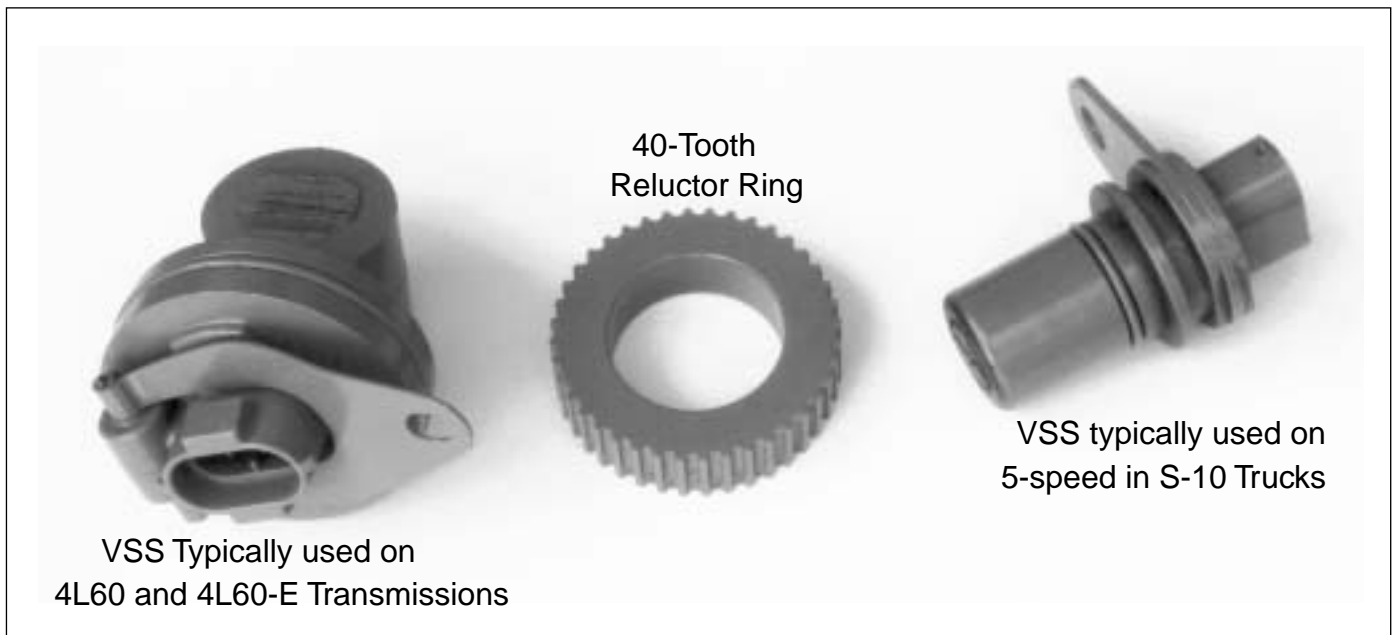
With American cars, speedometer cables turn 1000 revolutions in one mile. If a speed sensor is called a "2-pulse speed sensor", it means the speed sensor puts out 2-pulses per cable revolution. A 2-pulse speed sensor puts out 2000 pulses per mile. Likewise, a 4-pulse speed sensor puts out 4000 pulses per mile.

On the left is a "4-output vehicle speed buffer" used on vehicles with electric speedometers. It gets the vehicle speed signal from a 4-pulse sine-wave generator mounted at the transmission, and converts the sine-wave into a square wave signal for the ECM, speedometer, cruise control, and on some models, the radio (to control volume with vehicle speed). 1990 and newer TPI engines have the buffer incorporated into the ECM, and the ECM outputs the square wave to the speedometer, cruise control and radio.

In the center is a two-output vehicle speed buffer used on vehicles with cable-driven speedometers. The piece on top is called the "optic head" and it mounts to the speedometer and senses vehicle speed through a light beam and reflector on the speedometer (it is more fully explained in the Camaro and Firebird shop manuals, available from Helm). The buffer (the lower part) converts the reflected light signal into a 2-pulse square wave signal for the ECM and cruise control.

On the right is a "DRAC" (Digital Ratio Adapter Controller) from a 1989-1994 S-10 truck. It is also called a buffer. These are used on the Astro Vans and 1990-1995 full-size trucks. Earlier (1987-1989) Full-size trucks use a programmable DRAC that is incorporated into the instrument panel. All Chevrolet trucks with rear wheel anti-lock brakes (1989 and newer) use electric speedometers. The rear wheel speed is monitored by a sensor mounted on the output shaft of the transmission, where a speedometer cable would normally be installed (see next page). The signal (40 pulses per driveshaft revolution) goes to the DRAC which divides and conditions the signal for the electric speedometer, ECM, cruise control and anti-lock brakes. There are different DRAC modules for different gear ratios and tire sizes.

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40 PULSE PER DRIVESHAFT REVOLUTION VEHICLE SPEED SENSORS

The part that looks like a gear (in the center) is a 40 tooth reluctor ring that is used on the trucks with electric speedometers, and newer Camaros, Corvettes, and Caprices with the automatic transmission. It puts out 40 pulses per *driveshaft* revolution. With 4.11 gears and 25 inch diameter tires (an S-10 truck for example), this will put out about 133,000 pulses per mile. With 2.73 gears and 27 inch tires, this will put out about 82,000 pulses per mile.

With a 2000 pulse per mile signal (as used on earlier vehicles), a pulse is generated every 2.64 feet (31.7 inches), with 82,000 pulses per mile, a pulse is generated every 0.77 inches. This greater accuracy is required for the anti-lock brakes, and to control the shifting of the electronic transmissions.

On the left of the reluctor ring is the VSS used on trucks and cars with the 700-R4 transmission.

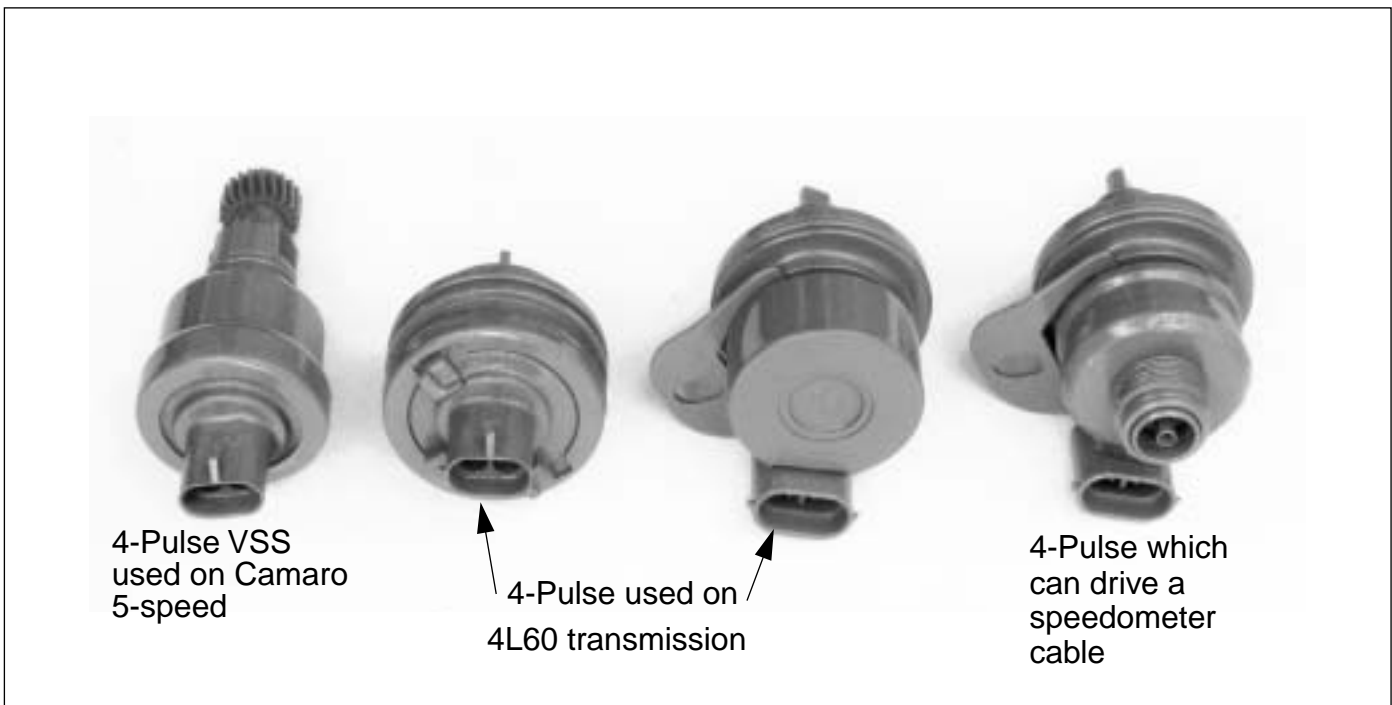
On the far right is the VSS used on the 2-wheel-drive S-10 Trucks with the Borg-Warner 5-speed transmissions.

The Vehicle Speed Sensors supply an AC (alternating current) to the DRAC module or Buffer on trucks. The DRAC or Buffer then converts the signal for the speedometer, anti-lock brakes, cruise control, and engine.

If you are installing a TPI engine and transmission into your late-model truck, the VSS and reluctor ring must be installed onto the TPI transmission. If you have a 1990 or newer TPI engine, you will also need Stealth Conversions vehicle speed sensor module (part #4PT) to condition the signal for the 1990-1992 TPI and the 1992-1993 LT1 ECM.

The reluctor ring is pressed onto the output shaft with a .002 interference fit and is difficult to install without the proper equipment due to the force required. Stealth Conversions has a reluctor ring assembly (part #4L60-005) designed for running speedometer cables with the electronic transmissions, but it can be used to install the reluctor ring onto the output shaft.

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PASSENGER CAR VEHICLE SPEED SENSORS

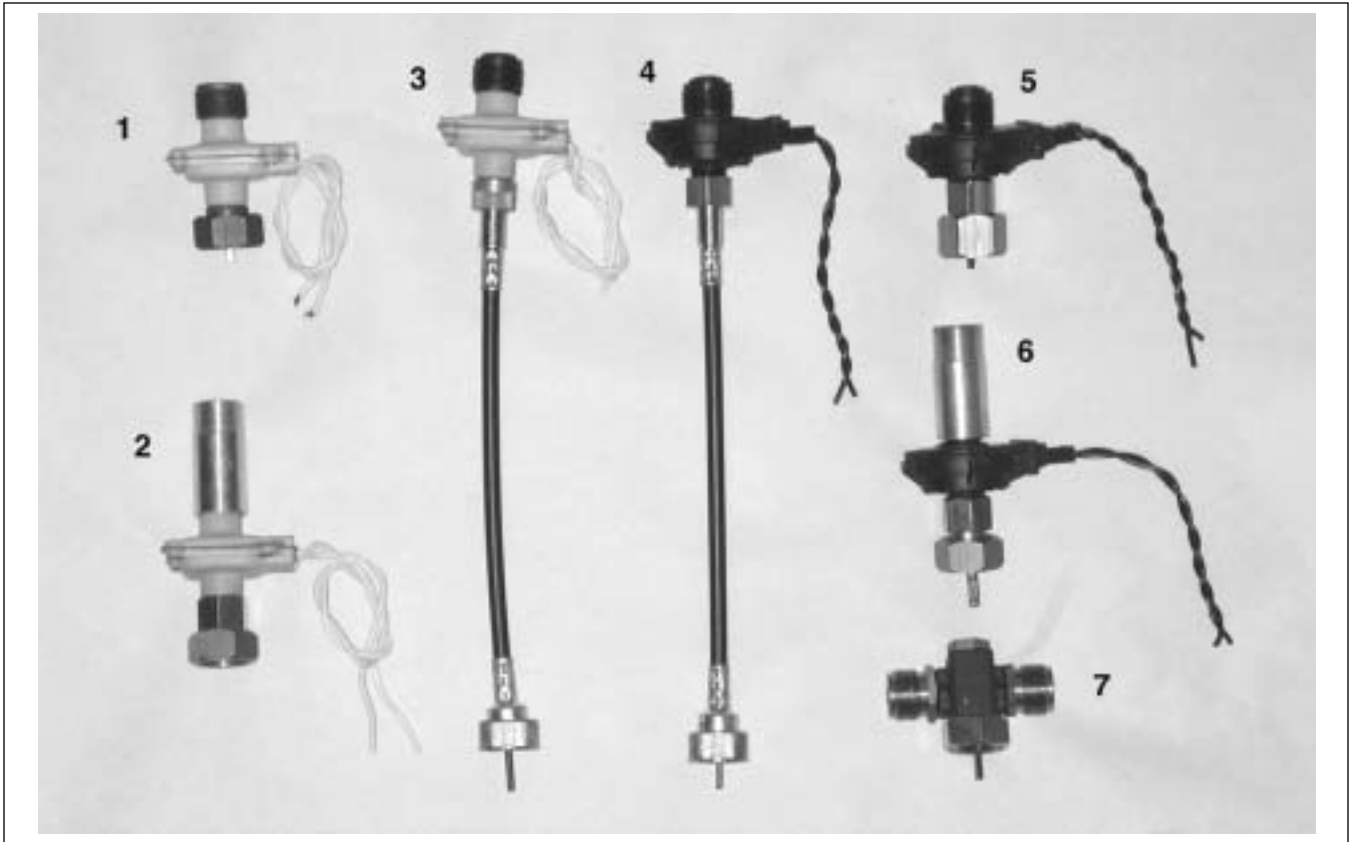
On the left is the 4-pulse VSS used on manual transmission Camaros with electric speedometers.

Second from the left is the 4-pulse VSS used on 1984 and newer Corvettes.

Third from the left is the 4-pulse VSS used on Camaros with automatic transmissions and electric speedometers.

On the far right is a 4-pulse integral VSS/speedometer sleeve. This VSS has provisions for using a standard speedometer cable and was used on 1990-1992 Police cars which had cable driven radar units. The unit is no longer available from Chevrolet, but Stealth Conversions has a large inventory of the remaining units. This will work for a 1990-1992 TPI (or 1990-1992 Camaro V6) and 1992-1993 LT1 engine with a 700-R4 transmission or ZF six-speed into a vehicle which requires a mechanical speedometer. This unit comes in two styles: one for 34-39 tooth driven gears, and one for 40-45 tooth driven gears. They use the same speedometer gears as the Corvettes and Camaros. This unit will also trigger the 4-output vehicle speed buffer shown on page 12-2. This unit is made of plastic, and will not support an angle drive unit.

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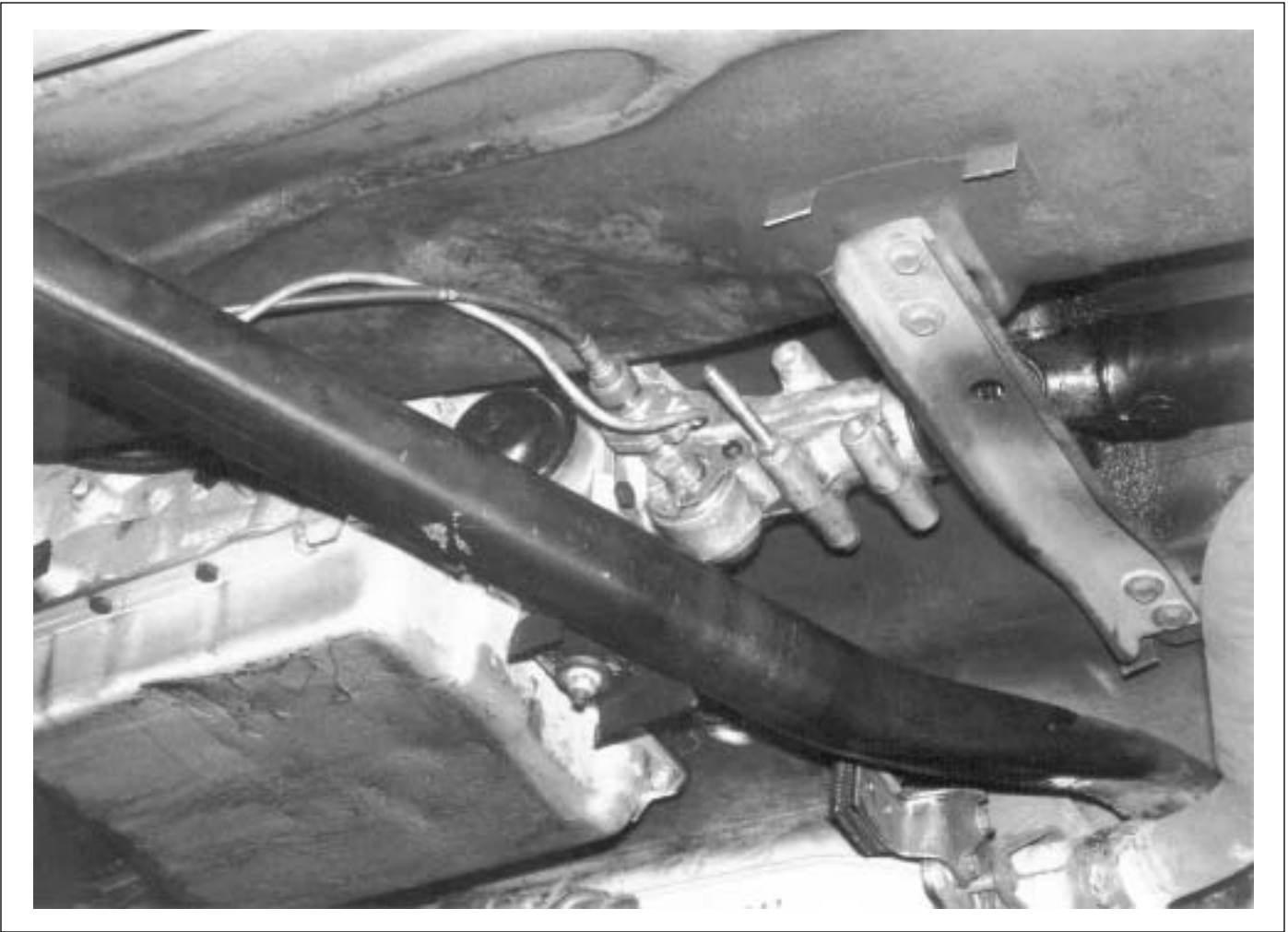
STEALTH CONVERSIONS VEHICLE SPEED SENSORS

Stealth Conversions has several types of vehicle speed sensors designed for easy installation. They wire up directly to the ECM—they do not require a buffer or DRAC module. All Stealth Conversions VSS units have CARB EO numbers (#D-371)—they are smog legal for engine swaps.

Shown above are:

1. Part #2PRS. The two-pulse square wave unit for all passenger car TBI installations, all computer controlled carbureted engines, and 1985-1989 TPI engines. 7/8-18 thread, .104" square drive.
2. Part # 2PRS-TOY. Two-pulse for Toyota. Same as above, except for 22 mm metric threads, and .187 tang drive which fits Toyota transmissions and transfer cases.
3. Part # 2PRS-EXT. Two-pulse square wave with extension cable, 10" long, 7/8-18 male to 7/8-18 female with .104" square drive.
4. Part # 4PAC-EXT. Four-pulse sine wave with 10" extension. Use for 1990-1993 TPI V8, 3.1 V6, and 3.4 V6.
5. Part # 4PAC. Four-pulse sine wave. Same as above, except without extension cable.
6. Part # 4PAC-TOY. Four-pulse sine wave for Toyota with 22 mm metric thread and .187 tang drive.
7. Part # 2X90. Dual output 90° angle drive. Use on Jaguars with electric speedometers. Allows connecting Jaguar XJ-S transducer on one end to operate Jaguar speedometer, and connecting two-pulse or four-pulse unit on other end for Chevrolet ECM. XJ-6 Jaguars must use transducer from XJ-S

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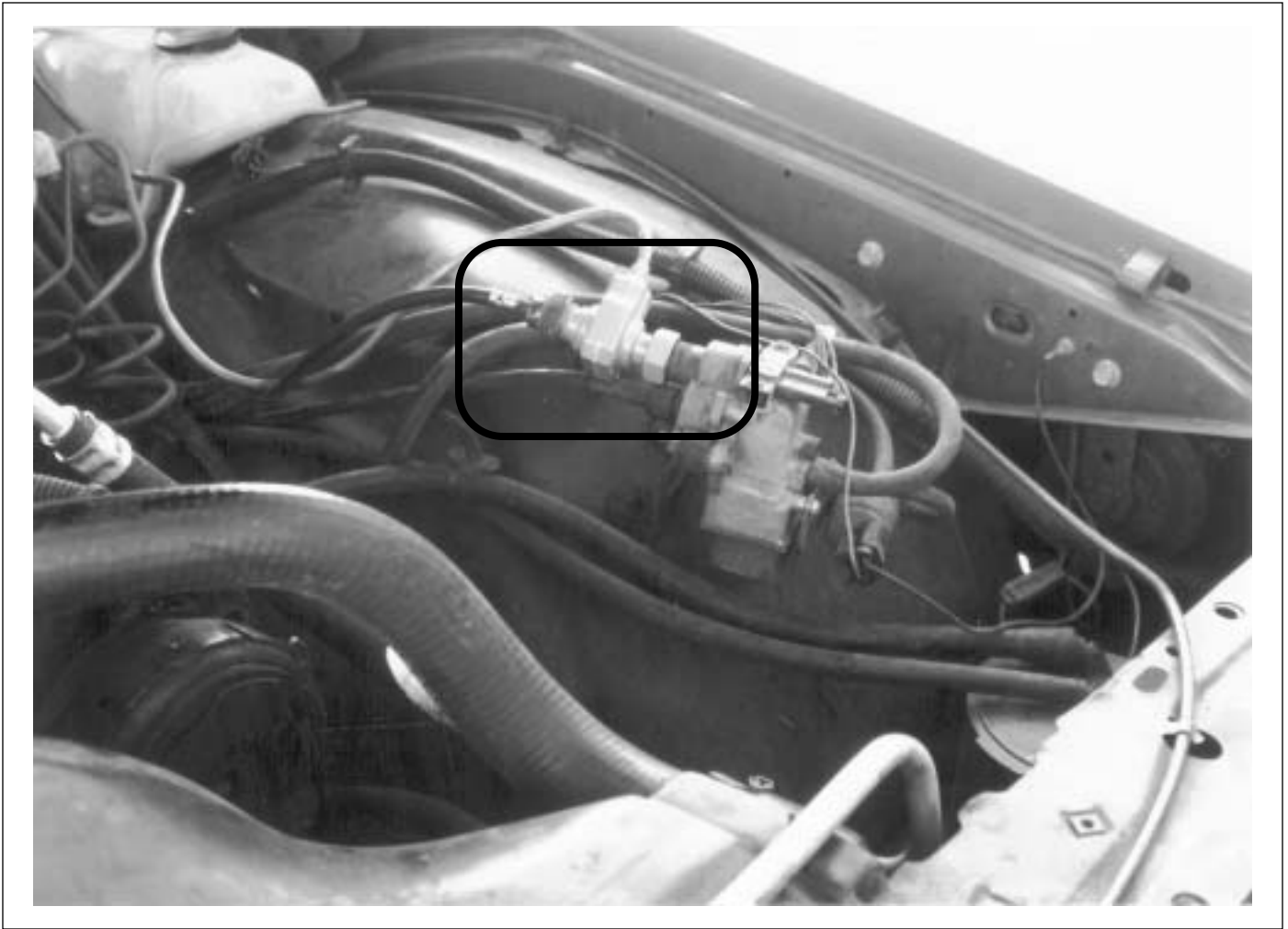
TRANSMISSION TUNNEL CLEARANCE PROBLEMS

This is Stealth Conversions' 2-pulse vehicle speed sensor installed on a G-Body (1981 Malibu equipped with 700-R4 transmission). The length of the VSS required substantial floor pan modifications (we used a big hammer). Many vehicles (especially trucks) require no such modification.

There are several alternatives to this problem. One solution would be to run a 90° angle drive to angle the VSS away from the floor pan. Another solution would be to use a two-piece speedometer cable and install the VSS away from the transmission. Another solution would be to run the Stealth Conversions' VSS/speedometer sleeve (shown on page 12-4, and use it to trigger the 4-output VSS (shown on page 12-2) for ECMs requiring a 2-pulse signal. Still another solution is to install the VSS on the cruise control module (if equipped) as shown on the next page.

When using a 1990-1992 TPI and 1992-1993 LT1 engine, use the Stealth Conversions' VSS/speedometer sleeve shown on page 12-4 (which only fits the 700-R4 transmission and Corvette six-speed ZF transmission). It installs in place of the normal speedometer sleeve, the speedometer cable screws onto it, and the factory 1990-1992 TPI and 1992-1993 LT1 wiring plugs into it.

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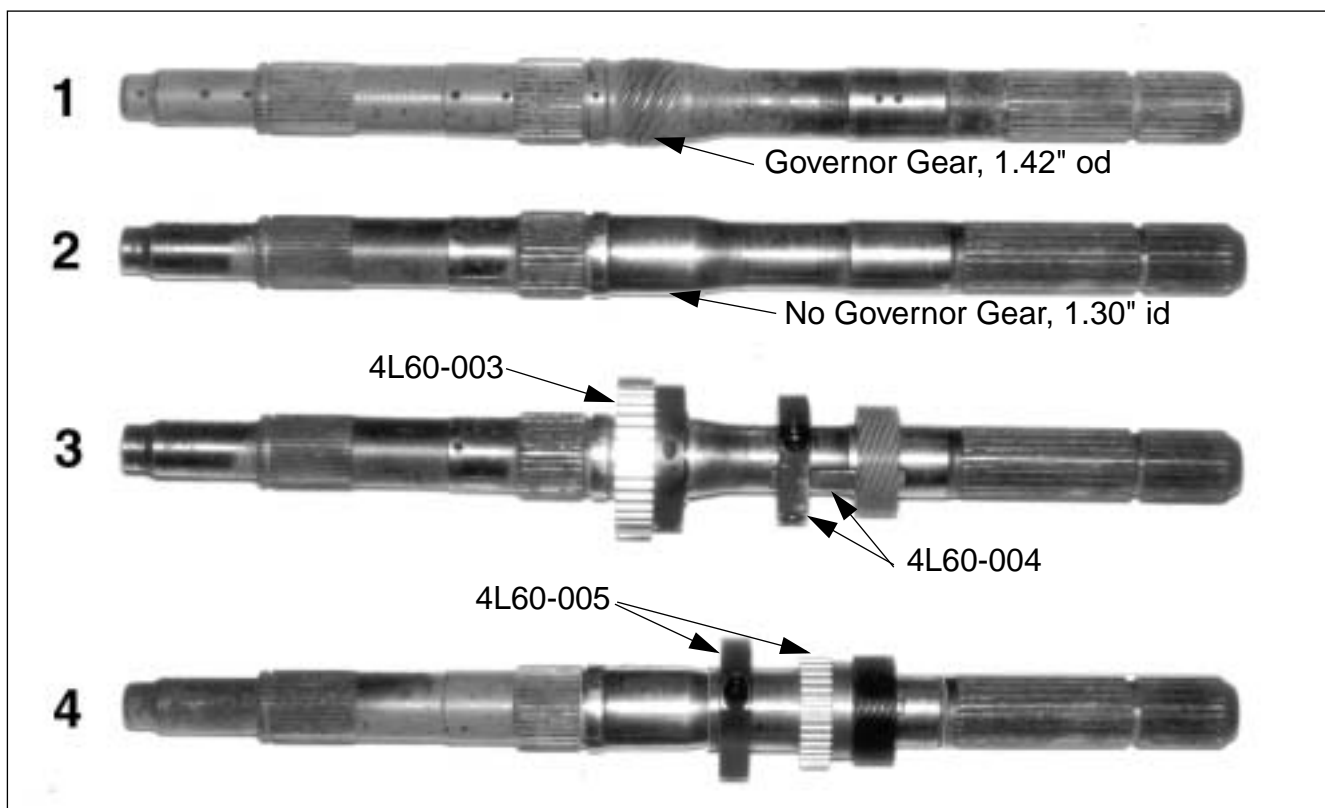


VSS MOUNTING OPTIONS

This is a variation of the short extension cable idea explained on the previous page. Here, the VSS is attached to the cruise control module to avoid transmission tunnel modifications.

The only problem with this type of VSS installation is if the speedometer cable is old and not lubricated properly. We have seen instances where the speedometer needle bounces at low vehicle speeds, and the computer reads the “bounces” and constantly locks and unlocks the torque converter. A lot of people think the transmission is damaged, but it is just a speedometer cable that needs lubrication or replacement. In more extreme cases, the “bouncing” speedometer cable will trigger the speed limiter (used in many new vehicles) which will temporarily cut fuel delivery to the engine resulting in a harsh jerking response.

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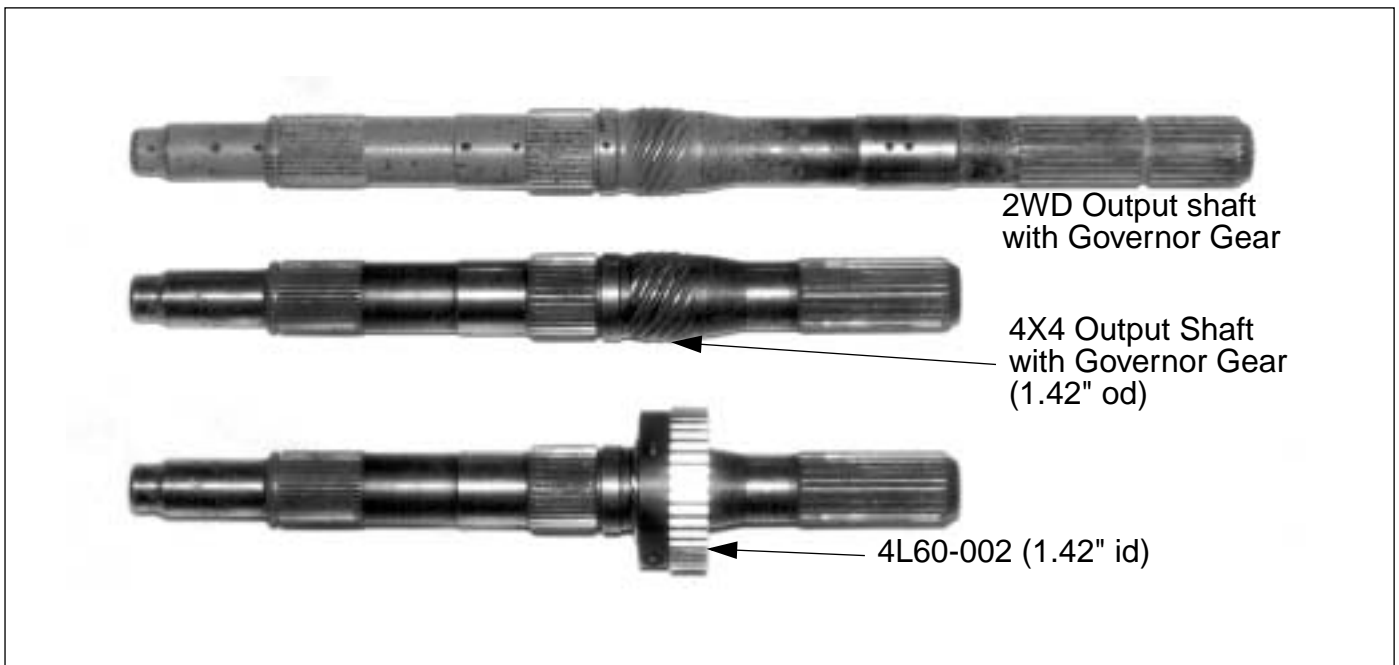


4L60-E RELUCTOR RING RELOCATION

The 4L60-E transmission is used in 1993 and newer trucks, and it in 1994 and newer rear-wheel drive cars. This transmission has no provisions for a speedometer cable, but Stealth Conversions has developed parts to run a speedometer cable.

1. This output shaft is from a 1983-1992 Camaro or Caprice with the 700-R4 transmission. Near the middle of the shaft is the gear that drives the governor on the non-electronically controlled transmissions. The overall diameter of the governor gear is 1.42"
2. This output shaft is from a 4L60-E transmission which has no gear to drive the governor because the transmission is electronically controlled. The diameter of the shaft at the governor gear location is about 1.30 inches. The output shaft does not have locating holes for the speedometer gear because they don't use speedometer gears. Instead, a 40-tooth reluctor ring is pressed onto the shaft which provides the signal for the engine computer and the electric speedometer.
3. This output shaft has a 40-tooth reluctor ring (Stealth Conversions part # 4L60-003) that installs in the governor gear location so that a speed sensor can be mounted in the governor gear area (see page 12-11). The inside diameter of the reluctor ring is about 1.30 inches. The outside diameter is about 2.62 inches. This reluctor ring location requires drilling and tapping a 3/4-16 UNF threaded hole into the transmission case. The speedometer gear is held in place with a clamp assembly (Stealth Conversions part # 4L60-004). See page 12-10 for a close-up.
4. This output shaft has a reluctor ring sleeve assembly (Stealth Conversions part # 4L60-005) that has a 40-tooth reluctor ring and a clamp to hold the speedometer drive gear. This requires a modified tailhousing (see page 12-12 thru 12-15), but the transmission case does not have to be drilled.

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4L60-E 4X4 APPLICATIONS

A two-wheel-drive output shaft is shown on top. With 4X4 applications, a short output shaft is used, which connects to the transfer case. With 4X4 applications, the speedometer cable or speed sensor normally attaches to the back of the transfer case.

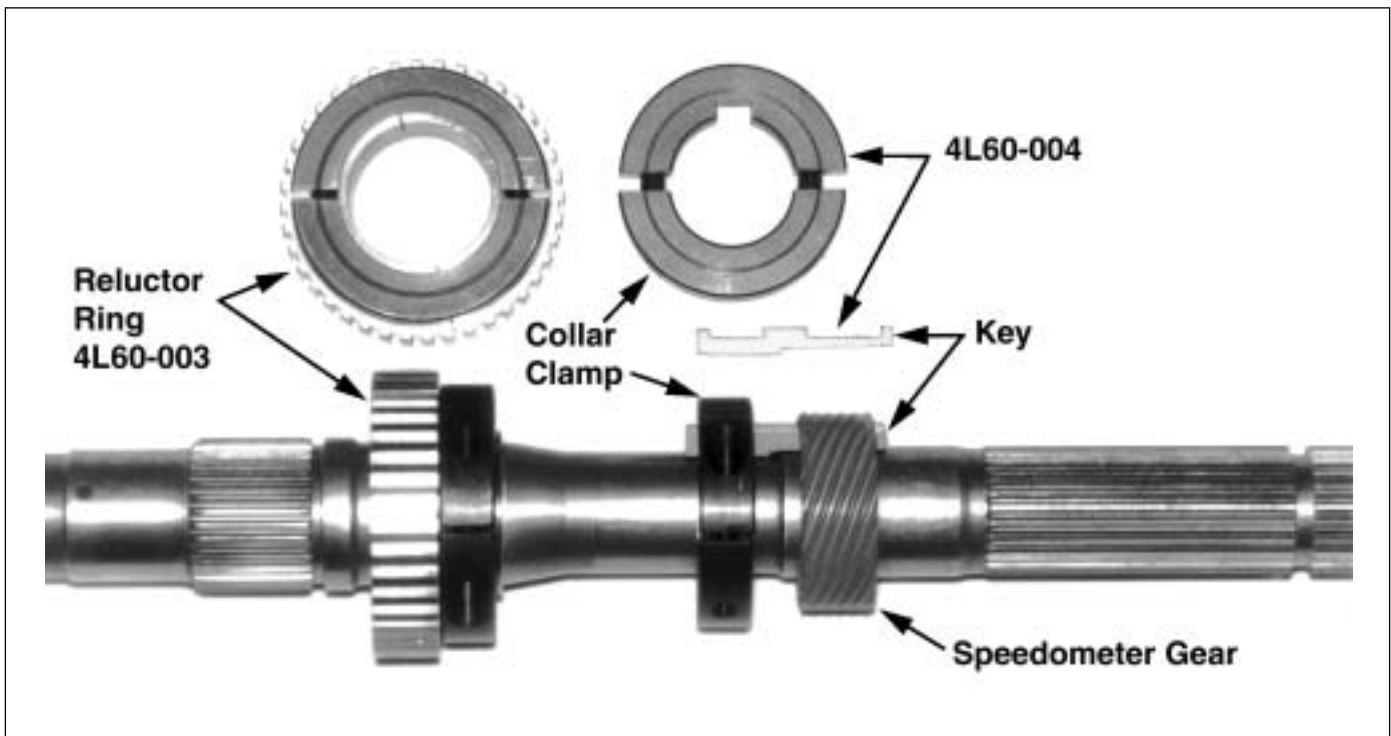
The reluctor ring must be installed in the governor area because the ECM would get an erroneous speed signal if the reluctor ring was located on the output shaft of the transfer case when the transfer case is in low-range.

Installing the speed sensor in the governor gear area requires drilling and tapping a 3/4"-16 UNF thread into the transmission case.

If you are using an aftermarket transfer case adapter and output shaft, the output shaft probably has the governor gear as shown above. This requires Stealth Conversions part # 4L60-002 which has an inside diameter of about 1.42 inches to fit over the governor gear.

The governor gear has a slight crown which requires that the reluctor ring must be installed as shown with the clamp towards the front so that the clamp is directly over the crown of the governor gear so that it does not slip off.

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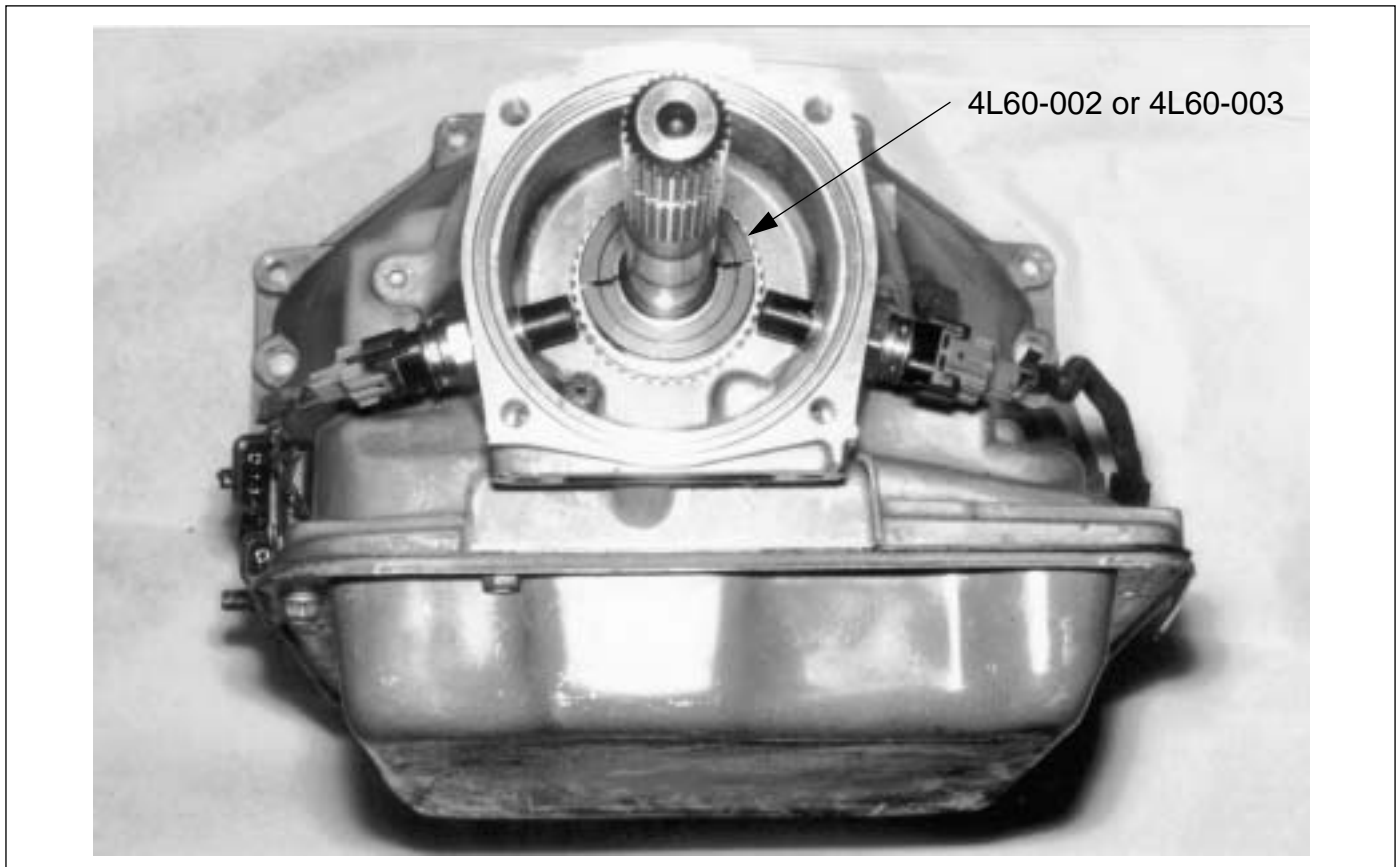
RELUCTOR RING AND SPEEDOMETER CLAMP FOR 4L60-E TRANSMISSIONS

On the left is reluctor ring, Stealth Conversions part # 4L60-003, which has a 1.30" i.d. (part # 4L60-002 is similar but has a 1.42" i.d.). Price is \$90. It is shown both on and off the transmission output shaft. It can be installed without removing the output shaft from the transmission.

This reluctor ring requires relocating the VSS onto the transmission case, which requires drilling and tapping a 3/4-16 UNF hole into the transmission case, but it allows using a stock tail housing on 2wd applications, and costs about \$200 less than part # 4L60-005 and the associated tailhousing. On four-wheel-drive applications with a transfer case that uses a speedometer cable, this is the only way to get the proper speed signal to the ECM.

On the right is the collar clamp and key (Stealth Conversions part # 4L60-004, price is \$35) to hold the speedometer gear in place on transmission output shafts that were not drilled for the speedometer clip. It is shown both on and off the transmission output shaft. The collar clamp is machined so that the key is on the lighter side. When assembled, the collar clamp and key assembly are balanced.

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4L60-E RELUCTOR RING RELOCATION

Installing the reluctor ring (Stealth Conversions Part # 4L60-002 for 1.42" i.d. or 4L60-003 for 1.30" i.d.) in the governor area is a requirement on the 4X4 applications, but on the 2-wheel-drive applications, this is the lowest cost way to run the speed sensor and speedometer cable because it doesn't require a modified tailhousing (see page 12-12 thru 12-15).

When relocating the reluctor ring to the governor gear location, the speed sensor (GM part # 15547452, retail price \$72), can be mounted on the driver's side or the passenger's side (shown on both sides in this photo).

On 4X4 applications, the shift linkage to the transfer case may interfere with the sensor if it is installed on the driver's side, so mounting the sensor on the passenger's side is the obvious solution.

Installing the sensor requires drilling and tapping a 3/4"-16 UNF thread hole into the transmission case. The wall thickness of the case is 5/16" in the areas shown, which gives five full threads of engagement. When installing the sensor, coat the threads with epoxy, then screw the sensor into the case until it just touches the reluctor ring, then back it off 1/2 turn. This gives a .030" gap, which is ideal. Epoxy putty should be built up around the sensor on the outside of the case to hold the sensor securely in place.

Many people fear drilling and tapping a hole into the transmission case—the case is aluminum, and it is an easy job to drill and tap. The positioning of the hole is not that critical, and the drilling can be done with a hand-held electric drill. To keep aluminum chips from getting into the transmission, put a piece of tape over the oil return hole (about 1/2" diameter), and put a piece of tape over the oil spray hole (see page 12-13). After drilling and tapping the hole, wipe the area clean with a paper towel and remove the two pieces of tape.

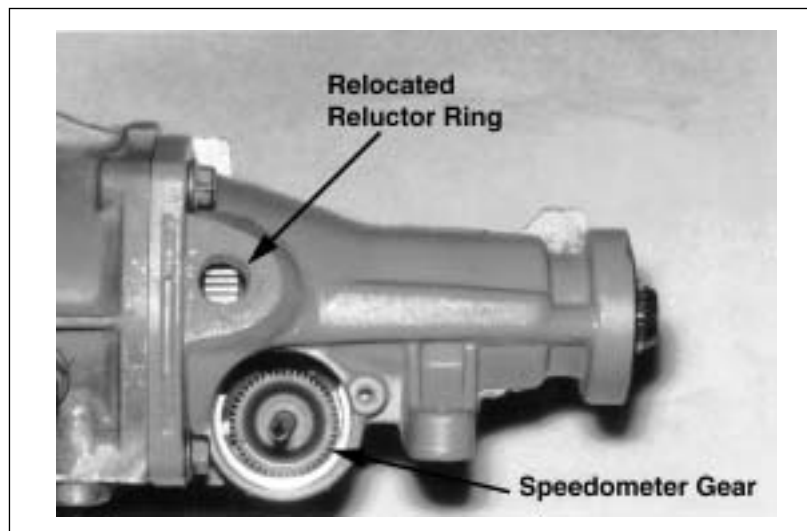
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RELUCTOR RING SLEEVE ASSEMBLY

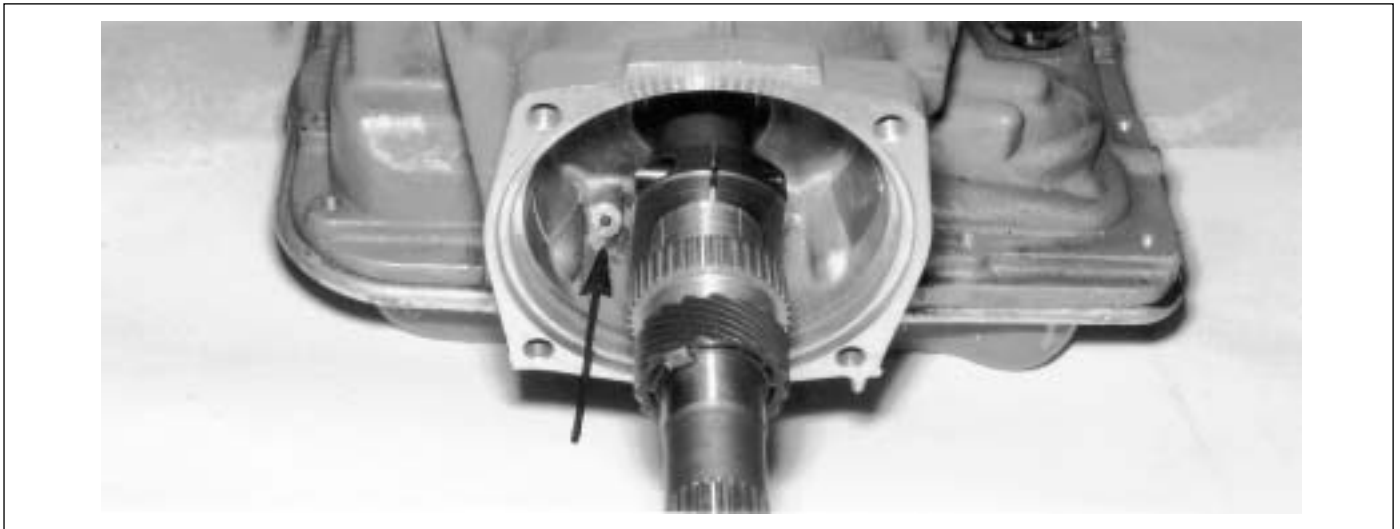
This shows the reluctor ring sleeve assembly (Stealth Conversions part# 4L60-005) both on and off the output shaft. It can be installed without removing the output shaft from the transmission, and it does not require drilling a hole into the transmission case. This unit holds the speedometer drive gear onto the output shaft, and it has a reluctor ring which is positioned about 7/8" forward of the original location which requires a tailhousing modified to accept the relocated sensor (see photo below, and next page). This assembly simply slides onto the output shaft and the collar clamp securely holds the unit in place. Alignment holes (not visible in the photo) ease the positioning, and also balance the assembly.

The collar clamp has the outside portion machined flat to allow proper oil spray to the rear bushing in the tailhousing (see next page).



The modified tailhousing above, shows the relocated reluctor ring. A GM speed sensor (part #15547452) simply screws into the modified tailhousing to give the appropriate signal to the engine computer, and the speedometer cable is driven with stock Chevrolet truck speedometer gears, which are also available from Stealth Conversions.

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4L60-E RELUCTOR RING RELOCATION

This is a reluctor ring sleeve assembly (Stealth Conversions part # 4L60-005) installed on the transmission. This unit doesn't require drilling a hole into the transmission case, but it does require a modified tailhousing.

The sleeve assembly has a tang (or key) to hold the speedometer gear in place.

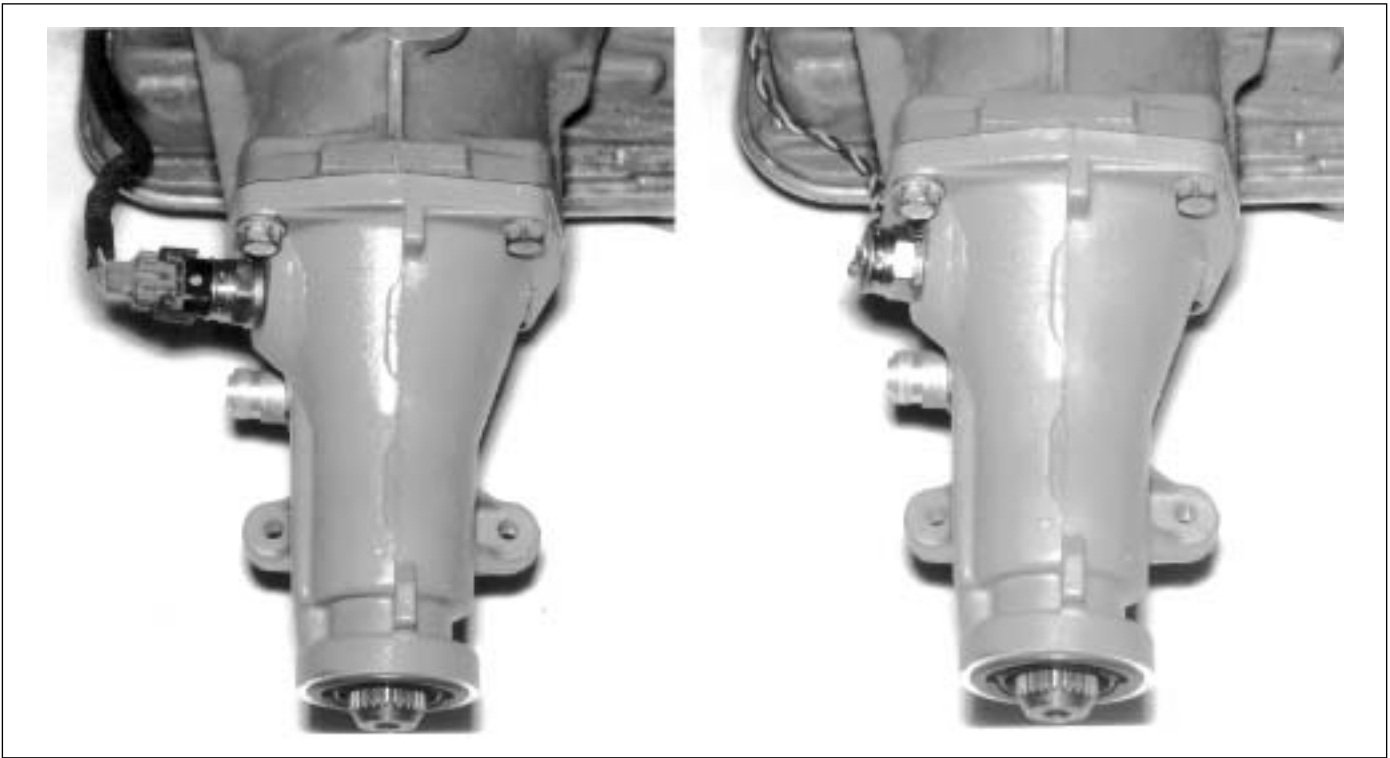
The two-piece collar clamp has the outside machined flat to assure that the oil spray nozzle shown above (arrow) is not blocked, insuring adequate oiling to the rear bushing (see below).



The location of the speed sensor is important so as not to block the rail (arrow) that is designed to allow oil to flow to the rear bushing (Prototype tailhousing shown).

The modified tail housings available from Stealth Conversions are made from new tail housings, which includes a new rear bushing and seal. To mount the speed sensor, an aluminum bung is skip-welded in place to minimize distortion. The housing is then machined on a special fixture to provide the correct clearance between the sensor and the reluctor ring. The bung is sealed with epoxy to prevent any leaks.

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4L60-E TAILHOUSING WITH SPEED SENSOR

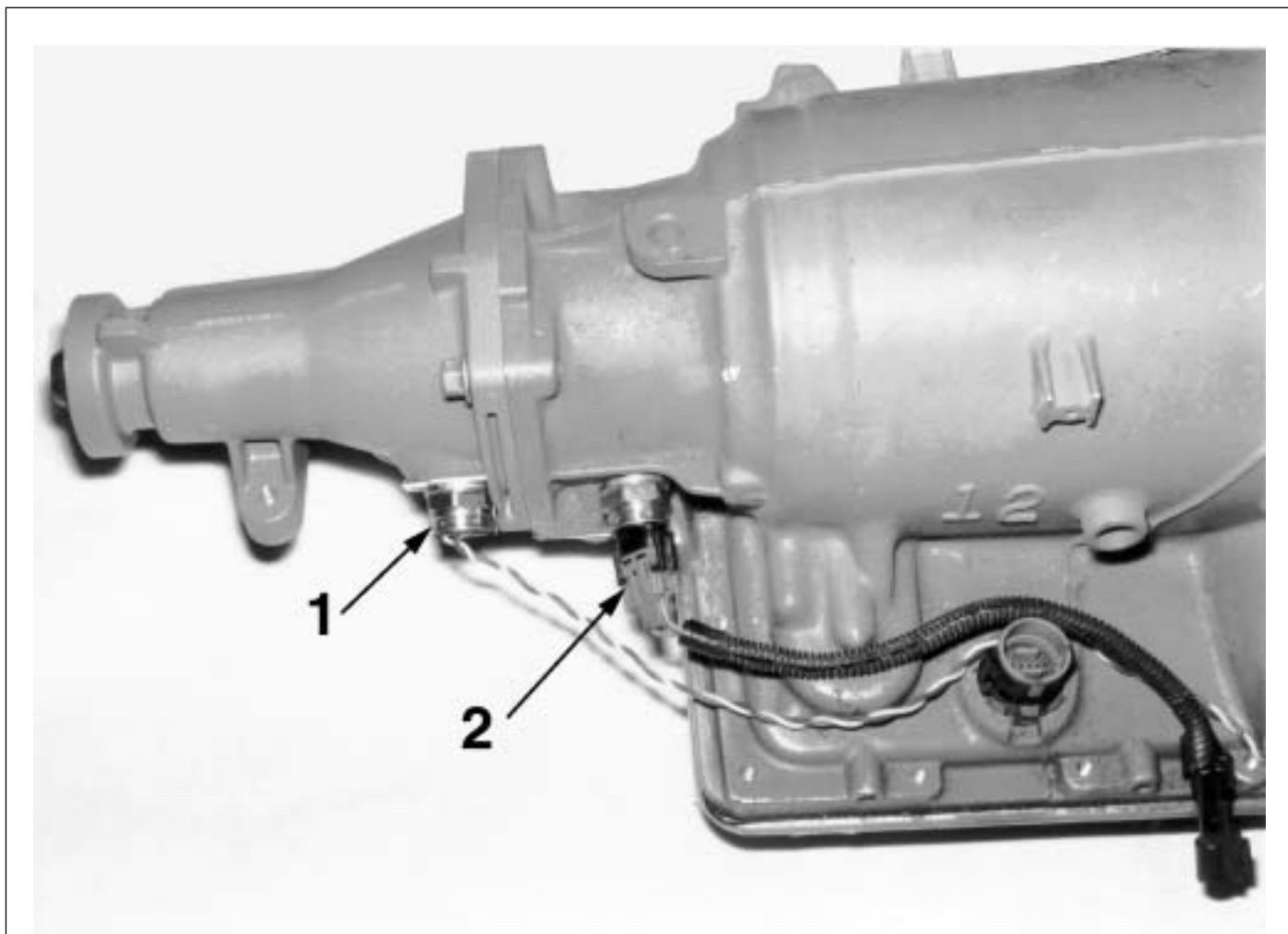
On the left is a tailhousing with the stock 4X4 speed sensor (from a 1989 and newer 4x4 truck) and electrical connector. The unit sticks out about 2-1/4" past the side of the tailhousing, which causes interference in most passenger car applications.

On the right is a modified 4X4 speed sensor which has the plastic end removed, and the wires are soldered directly to the tangs. With this modification, the speed sensor and wires stick out about 1/2" past the side of the tailhousing, greatly improving transmission tunnel clearance.



This shows a closer view of the modified speed sensor, compared to the stock sensor (GM part # 15547452, used on 1989 and newer 4X4 trucks) and wiring connector. You can modify the speed sensor yourself if you are good with a soldering iron, or the modified speed sensor (with 18" of wiring) is available from Stealth Conversions as part # 4L60-015.

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4L60-E WITH VSS MOUNTED ON PASSENGER'S SIDE

If you cannot install the 4X4 speed sensor (GM part # 15547452) on the driver's side, it can be mounted on the passenger's side.

Arrow 1 shows a shortened speed sensor (Stealth Conversions part # 4L60-015) on a modified tailhousing (Stealth Conversions part # 4L60-012).

Arrow 2 shows a stock speed sensor and connector on the transmission case in the governor gear location.

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DIFFERENTIAL MOUNTED 40-TOOTH RELUCTOR RING

The 40-tooth reluctor-ring shown above, bolts to the differential pinion flange. The reluctor ring is made of two halves, so that it can be installed without removing the pinion flange.

The vehicle-speed-sensor (GM part # 1554752) is mounted to a bracket (prototype shown) that bolts to the differential webbing. Two 1/4" holes (arrows) need to be drilled into the differential webbing to mount the bracket.

The VSS (GM part # 15547452) is used on the transfer cases of 1989 and newer S-10 4x4 trucks, AWD Astro Vans, and 1987 and newer full-size 4x4 trucks. This part is readily available at most wrecking yards.

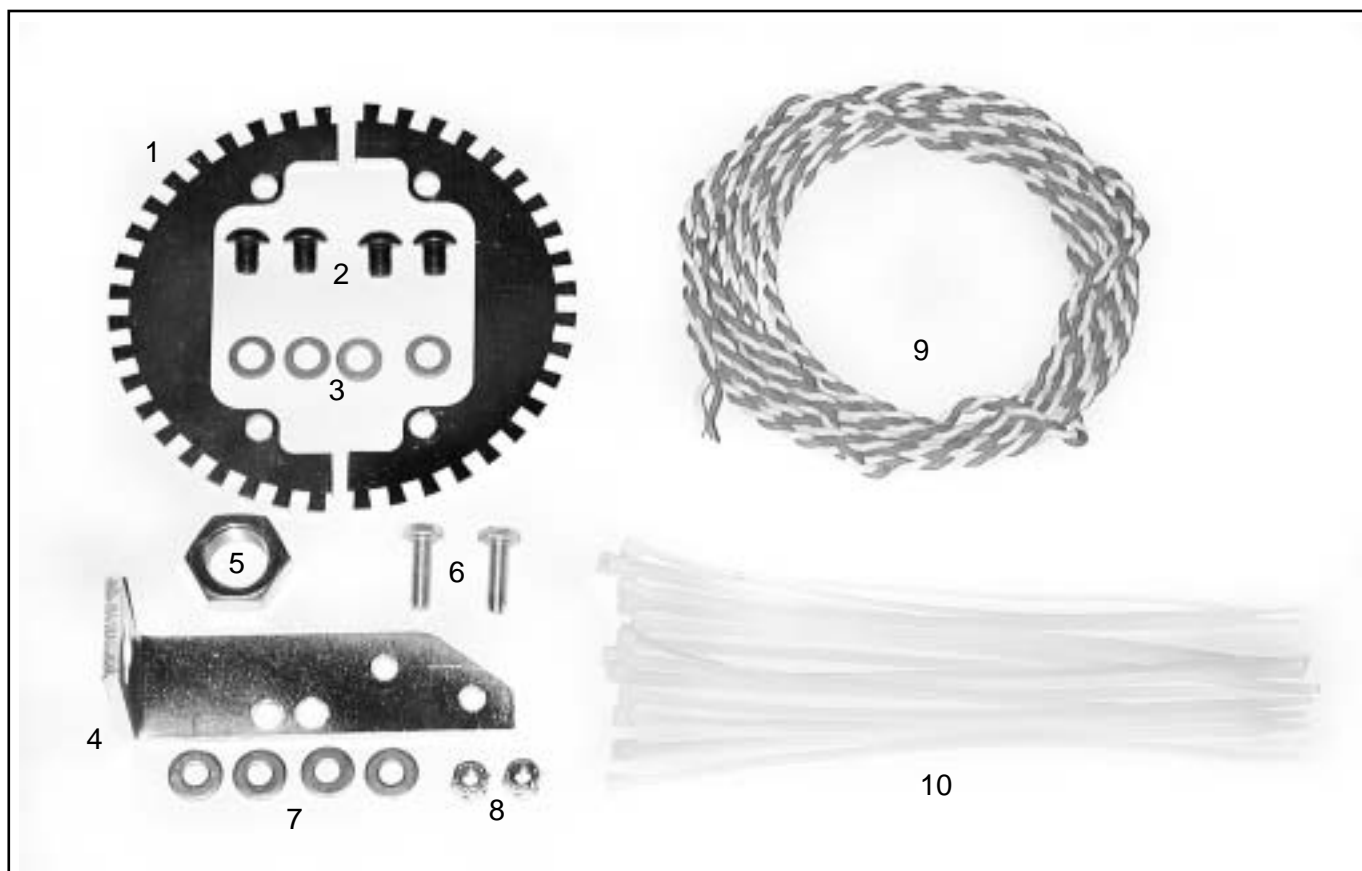
Flexible twisted-pair wiring connects the VSS to the engine wiring harness.

The differential mounted reluctor-ring is a simple way to run a 40-tooth reluctor ring, and normally takes less than an hour to install, using normal hand tools.

The complete differential-mounted reluctor-ring kit for a 7-1/2" or 7-5/8" rear-end is shown on the next page.

Another kit (Stealth Conversions part # 4L60-007), which uses a different, and more complex bracket to mount the VSS to the differential should be available for the 8-1/2" and 8.6" rear-end used on full-size 1/2 ton trucks.

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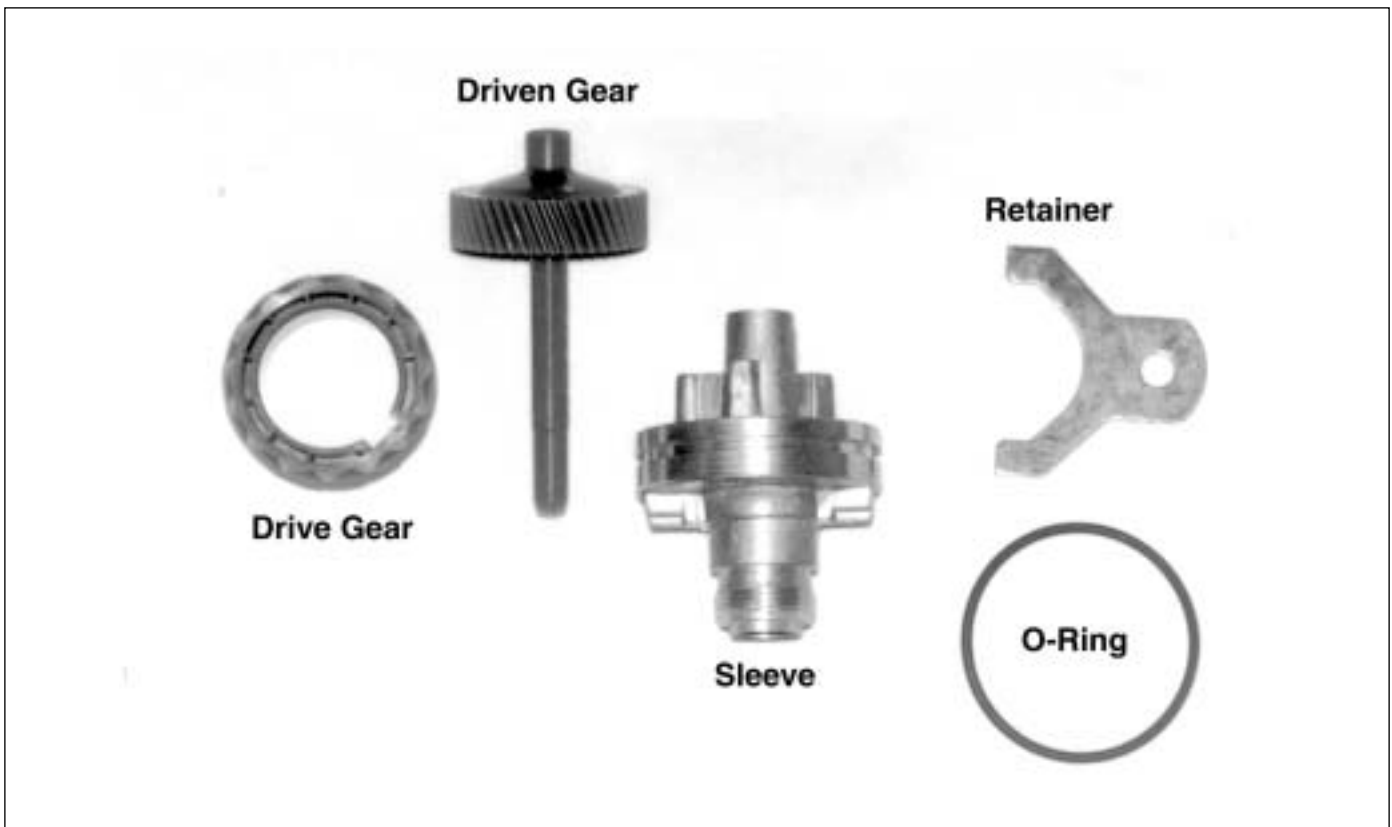


DIFFERENTIAL MOUNTED RELUCTOR-RING KIT

The kit for the 7-1/2" and 7-5/8 differential is shown above. Cost of the above kit (Stealth Conversions part # 4L60-006) is \$75. It includes the following parts:

1. reluctor ring halves
2. 5/16-24 x 3" button-head allen bolts
3. 5/16" id aluminum washers
4. VSS bracket
5. 3/4-16 jam nut
6. 1/4"-28 x 1" bolts
7. 1/4" steel washers
8. 1/4"-28 lock-nuts
9. twisted-pair wire
10. Nylon tie-wraps
11. instructions (not shown)

VEHICLE SPEED SENSORS



SPEEDOMETER CALIBRATION

Calibrating the speedometer consists of using the appropriate speedometer gears in the transmission so that the speedometer cable turns 1000 revolutions in a mile. Some foreign cars have speedometers that require a different number of revolutions per mile, but it is usually close to 1000 revolutions per mile. If you look at the bottom of the speedometer face, it will often state the cable revolutions required per mile.

The above photo shows the speedometer drive gear, driven gear, sleeve, retainer and O-ring for a 700-R4 transmission. Numerous gears are available, and your Chevrolet dealer can supply the appropriate gears for your application. Your best selection of gears and sleeves for the 700-R4 comes on the 1982-1986 1/2 ton trucks and S-10 trucks. The trucks use aluminum sleeves. Camaros often use plastic sleeves, which are easily stripped, and cost more.

Stealth Conversions carries a complete selection of speedometer gears, sleeves, and retainers for the 700-R4 (also called the 4L60) transmission and for the Borg-Warner T5 and T56 transmissions. Stealth Conversions will supply the proper gears, sleeve, O-ring and retainer for your application for \$49 if you know the tire size and the rear axle ratio.

If you are doing an engine swap into a non-Chevrolet vehicle and need a special speedometer cable, look in the Yellow Pages under "Speedometer". Many cities have speedometer shops that can make custom cables for under \$70, however, many shops are no longer in business because fewer cars use speedometer cables. Stealth Conversions can make custom speedometer cables for engine swaps.