# LESSON 3 RACK & PINION POWER STEERING SYSTEMS

## INTEGRATED CURRICULUM STANDARDS (ICS)ICS

Successful completion of this Units enabling objectives (technical competencies) will allow you to meet the Integrated Curriculum Standards (ICS) listed in the right margin.

007 Chemical and Physical Properties

042 Math Formulas

101 Basic Physics

102 Mechanics and Forces

155 Steering & Suspension Systems

## LEARNING OBJECTIVES

- Identify the components of a rack and pinion steering gear and explain its operation.
- Identify the components of a non-hydraulic electric-power assist steering system and explain system operation.
- Identify the components of an electronically controlled four-wheel power steering system and explain the system operation.

## KEY TERMS

- **Electric Power Steering (EPS)**
- **EPS ECU**
- **EPS Motor**
- **MagnaSteerII®**
- **Electromagnetic actuator**
- **Power Steering Control Module**
- **Rear wheel position sensor**
- **Rear wheel steering control module**
- **Rear Wheel Steering mode switch**
- **Reduction Mechanism**
- **Quadrasteer™**
- **Rear wheel steering motor**
- **Steering Wheel Position Sensor (SWPS)**
- **Torque-sensor**
- **Variable Assist**
- **Variable Effort Steering (VES)**

## Rack-and-Pinion Steering Gear

Today most vehicles use a rack-and-pinion steering system. Rack and pinion is lighter in weight and has fewer components than parallelogram integral non-rack & pinion steering (Figure 1-33). Tie-rods are used in the same fashion on both systems, but the resemblance stops there. Steering input is received from a pinion gear attached to the steering column. This gear moves a toothed rack that is attached to the tie-rods. In the rack and pinion steering arrangement, there is no pitman arm, idler arm assembly, or center link. The rack performs the task of the center link. Its movement pushes and pulls the tie-rods to change the wheels direction. The tie-rods are the only steering linkage parts used in a rack and pinion system

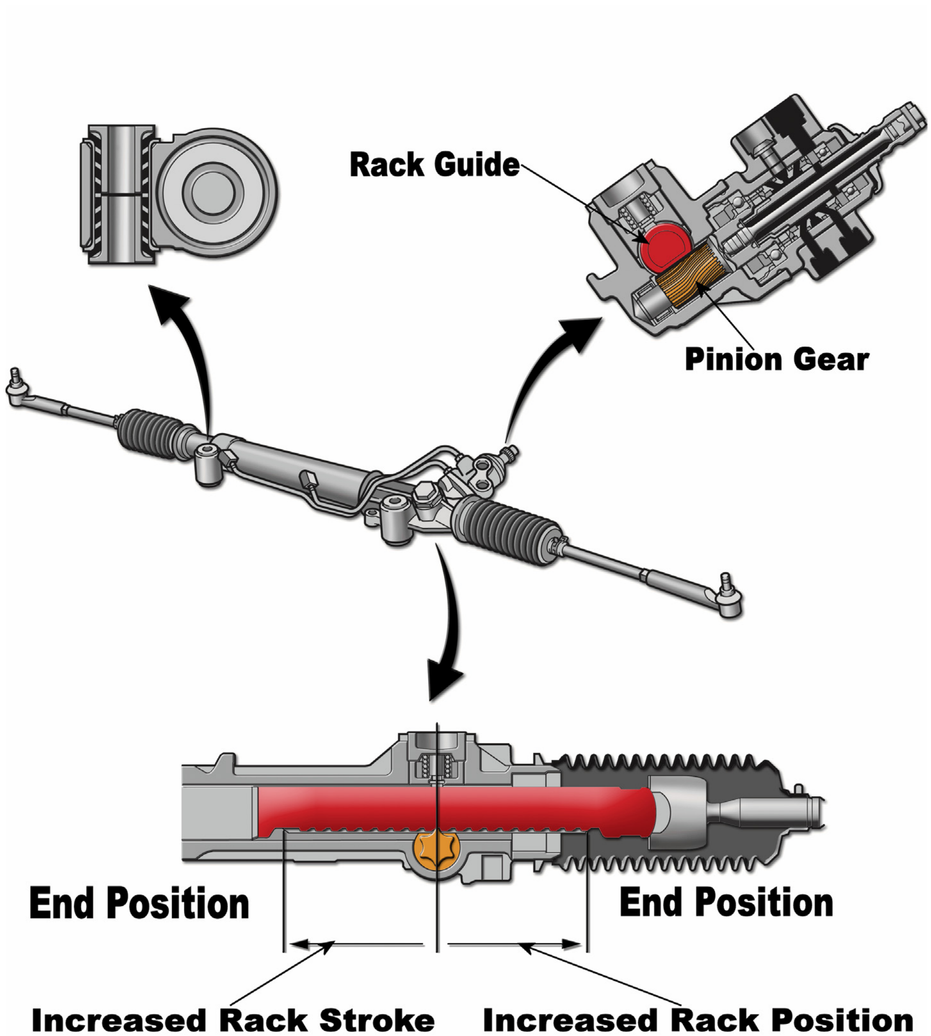


Figure 1-33 Rack & Pinion Steering Gear

Most rack and pinion constructions are composed of a tube in which the steering rack can slide. The rack is a rod with gear teeth cut along one endspur and helical. The other end is fitted with two balls to which the ends of the divided track rods are attached. The rack meshes with the teeth of a small pinion at the end of the steering column.

The rack preload (yoke lash) is adjusted by a screw, plug, or shim pack. column. The two inner tie-rod ends, which are attached to the rack, are covered by rubber bellows boots that protect the rack from contamination. The inner tie-rods connect to outer tie-rod ends, which connect to the steering arms. The rack and pinion housing is fastened to the vehicle at two or three points. In some cases, the rack and pinion steering gear on unibody cars is bolted directly to a body panel, like a cowl. When this is done, the body panel must hold the steering gear in its correct location. The unibody structure must maintain the proper relationship of the steering and suspension parts to each other. Along with other advantages, the rack and pinion steering system combined with the MacPherson strut suspension system is found in most front-wheel-drive unibody vehicles because of their weight- and space-saving feature. The driver gets a greater feeling of the road with rack and pinion because there are less friction points. This means a higher probability of car owners with steering complaints. Fewer friction points can reduce the system's total ability to isolate and dampen vibrations.

Rack-and-pinion systems offer several advantages over parallelogram systems:

- Saves space
- Weighs, costs less
- Provides responsive steering

## Speed Proportional Variable Assist

A **variable assist** speed proportional power steering system is available on some front-wheel drive cars (Figure 1-34). The system increases low vehicle speed power steering assist during parking and low speed turns. During faster vehicle speeds the system pressure (assist) is reduced based on vehicle speed sensor input. A Solenoid Control Module (SCM) and solenoid control valve reduce the assist to provide a firmer and more stable ride.

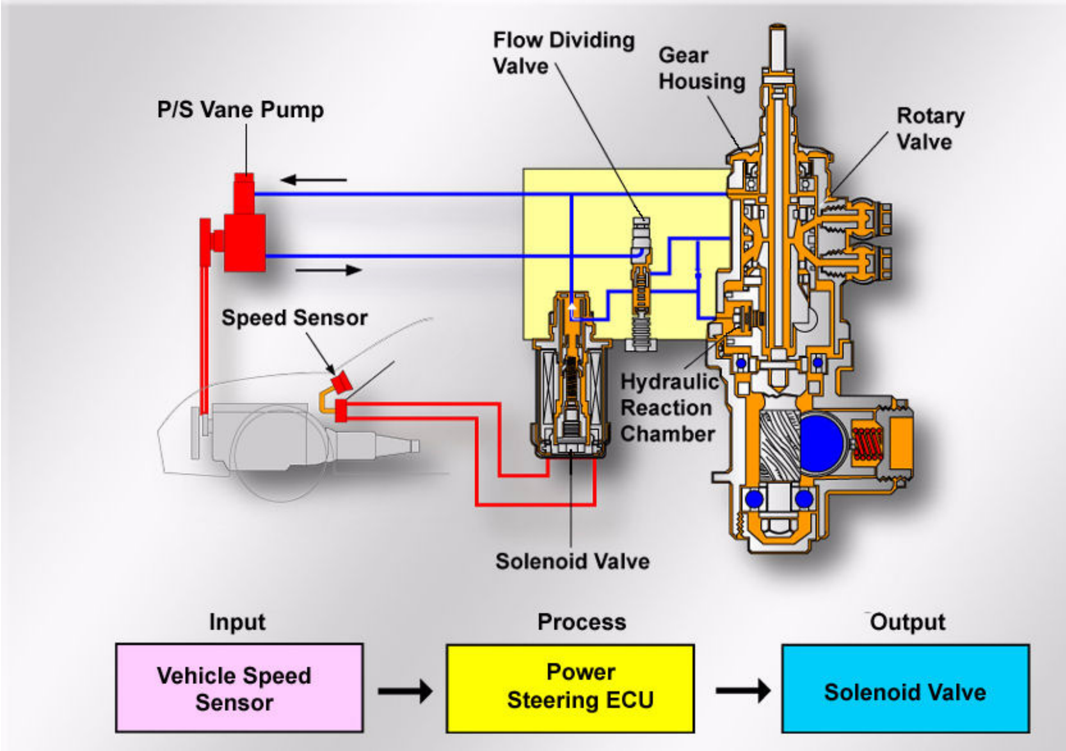


Figure 1-34 Speed controlled variable power steering

Pressure is regulated by a torsion bar much like a recirculating ball steering gear. The SCM provides less return pressure against the reaction disk at low speeds causing the reaction disk to move up; this reduces the torsion load (steering effort). By modulating return pressure with the solenoid, the system decreases assist as vehicle speed increases.

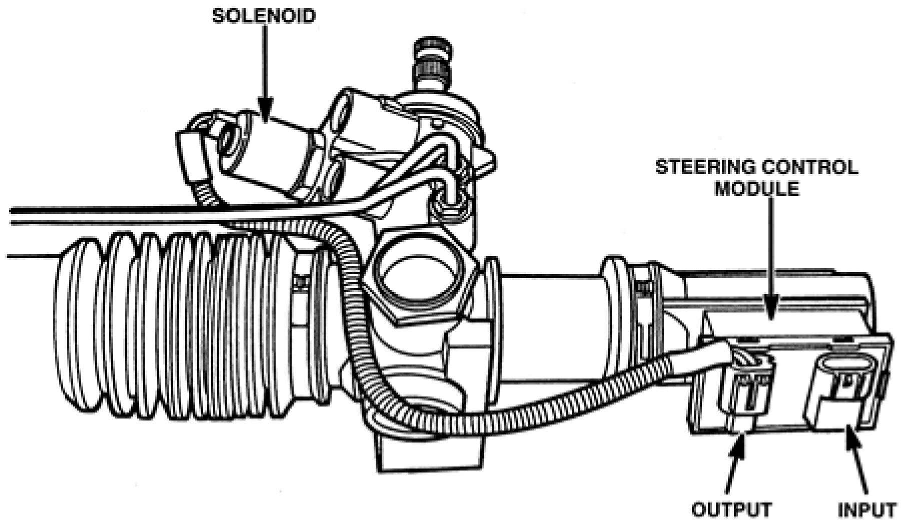


**Figure 1-35 Speed controlled variable power steering gear**

The system provides full assist for "evasive maneuvers" at higher speeds. To test the system, you can test drive the vehicle or use a Scan Tool to enter false vehicle speed inputs to check if the system is changing the amount of assist (Figure 1-35).

## MAGNASTEER II® VARIABLE EFFORT STEERING (VES)

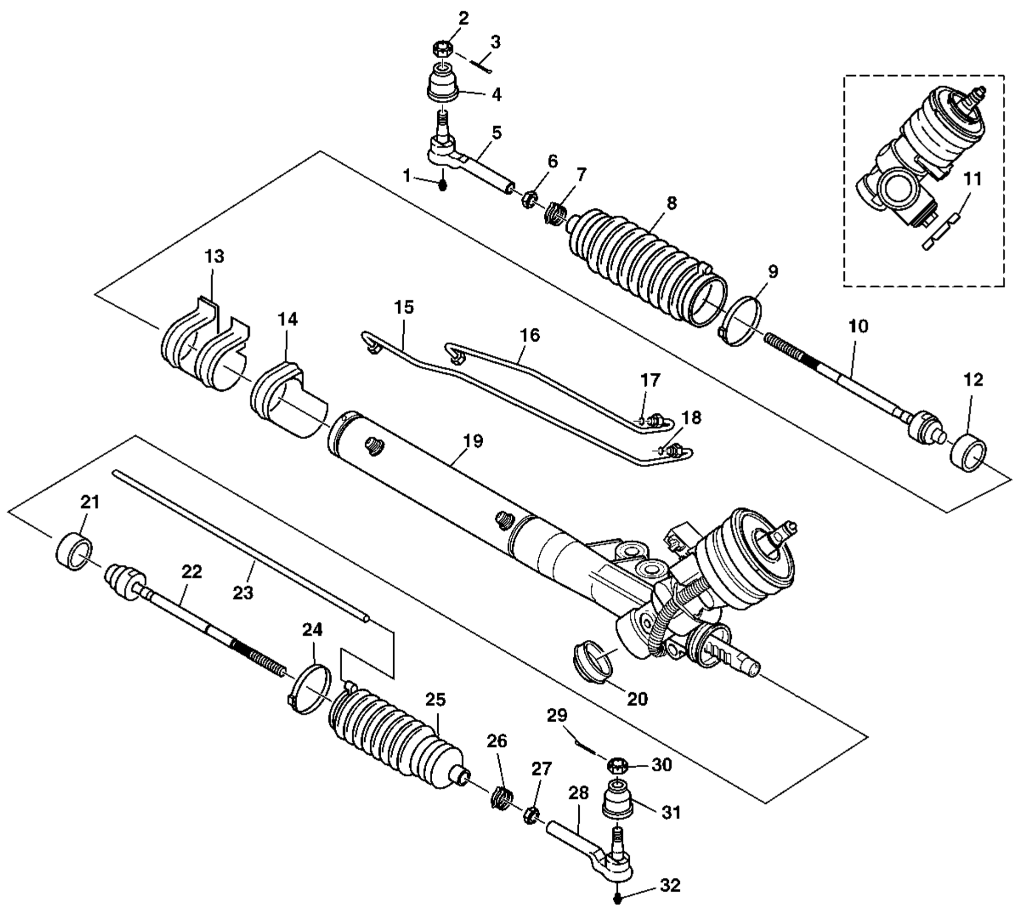


Figure 1-36 Magnasteer II® Steering Gear Exploded View

| | | | |
|---|---|---|---|
| (1) | Lubrication Fitting | (17) | O-ring Seal |
| (2) | Hexagon Slotted Nut | (18) | O-ring Seal |
| (3) | Cotter Pin | (19) | Rack and Pinion Gear Assembly (Partial) |
| (4) | Tie Rod Seal | (20) | Dust Cover |
| (5) | Outer Tie Rod | (21) | Shock Dampener Ring |
| (6) | Hexagon Jam Nut | (22) | Inner Tie Rod |
| (7) | Tie Rod End Clamp | (23) | Breather Tube |
| (8) | Rack and Pinion Boot | (24) | Large Boot Retaining Clamp |
| (9) | Large Boot Retaining Clamp | (25) | Rack and Pinion Boot |
| (10) | Inner Tie Rod | (26) | Tie Rod End Clamp |
| (11) | Adjuster Plug Lock Nut | (27) | Hexagon Jam Nut |
| (12) | Shock Dampener Ring | (28) | Outer Tie Rod |
| (13) | Mounting Bracket Assembly | (29) | Cotter Pin |
| (14) | Mounting Grommet | (30) | Hexagon Slotted Nut |
| (15) | Cylinder Line (LH) | (31) | Tie Rod Seal |
| (16) | Cylinder Line (RH) | (32) | Lubrication Fitting |

The **Variable Effort Steering (VES)** system, or **MagnaSteerII®** (Figure 1-36) varies the amount of effort required to steer the vehicle as vehicle speed changes or lateral acceleration occurs. At low speeds, the system provides minimal steering effort for easy turning and parking maneuvers. At high speeds, the system provides firmer steering (road feel) and directional stability. When the system senses lateral acceleration, steering becomes firmer to reduce oversteering.

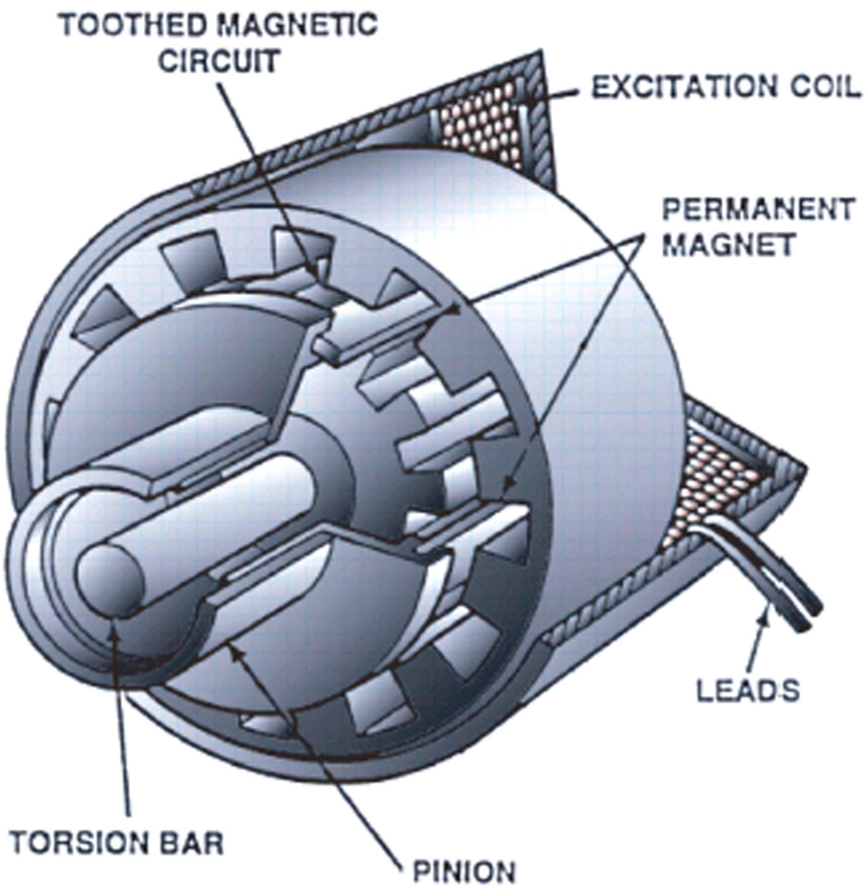


Figure 1-37 MagnasteerII® Actuator

Integrated with the pinion shaft is a spool valve that senses the level of torque in the shaft and applies hydraulic pressure to the steering rack whenever assistance is needed. The electromagnet acts in parallel with the input shaft from the steering wheel to open or close the spool valve. The main component of the system is an **electromagnetic actuator** (Figure 1-37), which consists of a multiple-pole ring-style permanent magnet, a pole piece, and an electromagnetic coil assembly.

The electromagnet in the actuator generates variable torque, which can either increase or diminish the amount of steering torque that is needed to open the spool valve.  To vary the amount of steering assist, the EBCM uses the signal from the wheel speed sensor to calculate the required amperage and direction of current flow to the electromagnetic actuator (Figure 1-37).

The amperage and direction of current flow has a direct effect on the steering effort and flow rate to the rack piston. When the vehicle is stationary, there is approximately 1.6 amps of current flow through the electromagnetic coil.

As the vehicle speed increases to approximately 45 mph, the current decreases to 0 amps .The EBCM then switches the direction of current flow. Current flow through the electromagnetic coil causes either a magnetic attraction or repelling in the MAGNASTEER actuator.

At low vehicle speeds below 45 mph, the direction of current flow creates a magnetic field, which opposes the permanent magnet.  The repelling force of the magnetic fields assists the spool valve in moving out of alignment with the valve body, and this increases the power assist.

With vehicle speeds below 45 mph, increased current provides increased steering assist. At vehicle speeds above 45 mph, the direction of current through the electromagnetic coil creates a magnetic field, which attracts the permanent magnet.

- The magnet helps keep the spool valve aligned with the valve body, and this reduces the power assist and provides a greater road feel.
- As the vehicle speed increases, the amount of effort required to overcome the attracting force of the magnetic fields increases.
- With vehicle speeds above 45 mph, increased current flow provides decreased steering assist.

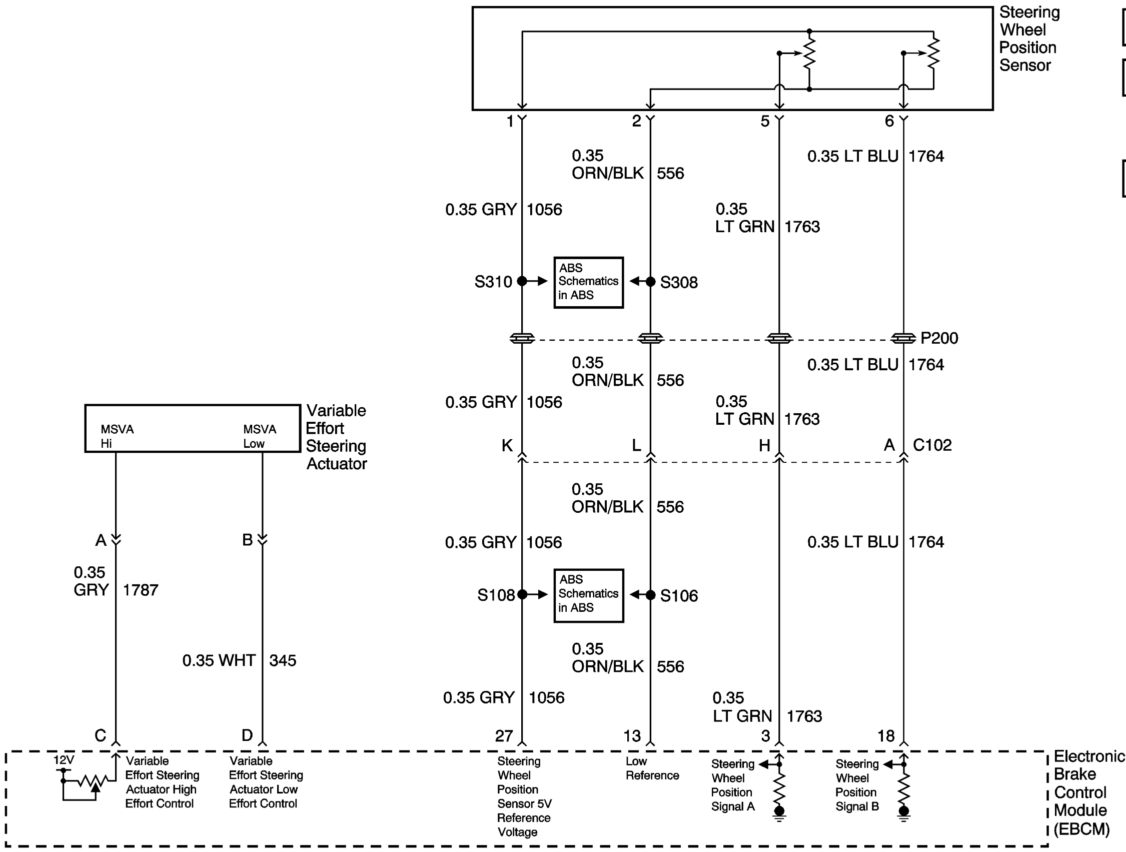


Figure 1-38 MagnasteerII® Electrical Schematic

The Electronic Brake Control Module (EBCM) as shown in Figure 1-38 controls the bidirectional *magnetic rotary actuator* located in the steering rack and pinion shown in Figure 1-37 and also on the schematic in Figure 1-38. The EBCM varies the steering assist by adjusting the current flow through the magnetic rotary actuator. The actuator adjusts the amount of power steering assist to achieve a given level of effort to steer the vehicle. The VES system accomplishes this by adding or subtracting torque on the input shaft to the rack and pinion. The VES system uses the Antilock Brake System (ABS) wheel speed sensor inputs to determine vehicle speed (Figure 1-39). When the EBCM senses vehicle speed, it commands a current to the actuator that is most appropriate for each speed.

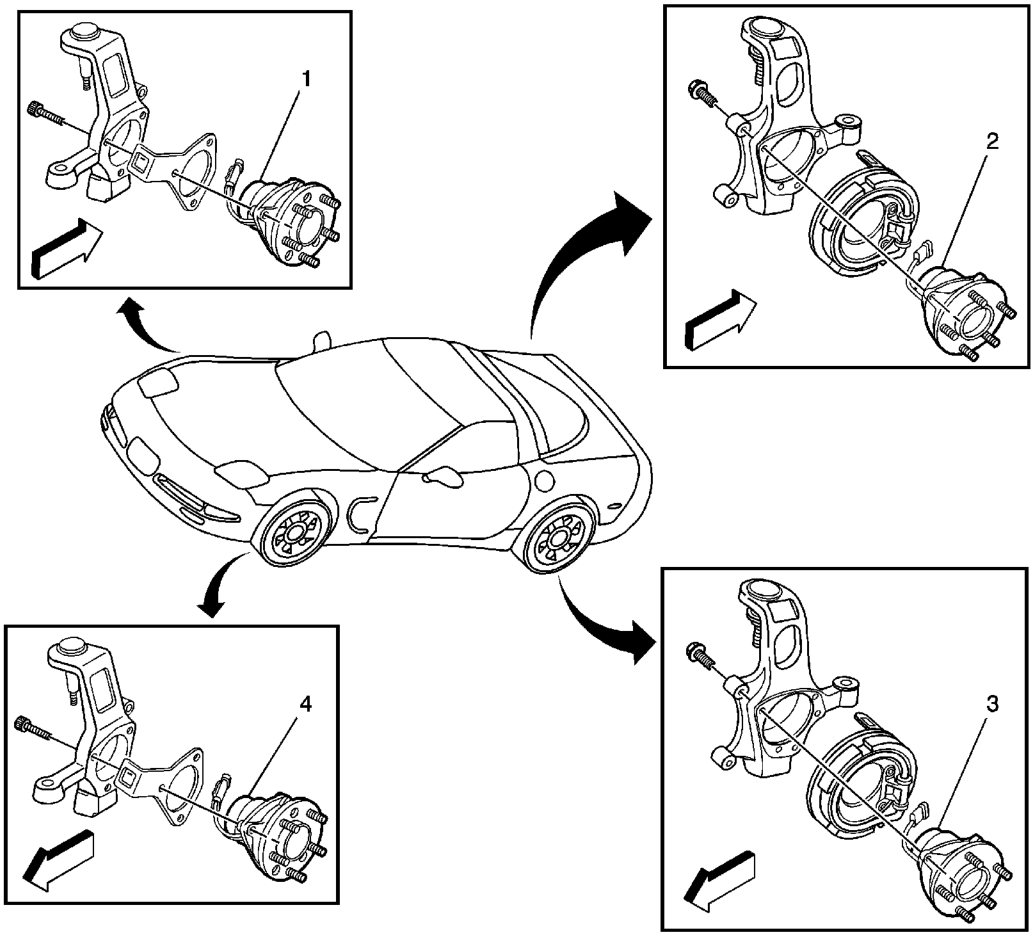


Figure 1-39 Corvette ABS Wheel Sensors

(1) Wheel Speed Sensor (WSS) - RF
(2) Wheel Speed Sensor (WSS) - RR
(3) Wheel Speed Sensor (WSS) - LR
(4) Wheel Speed Sensor (WSS) - LF

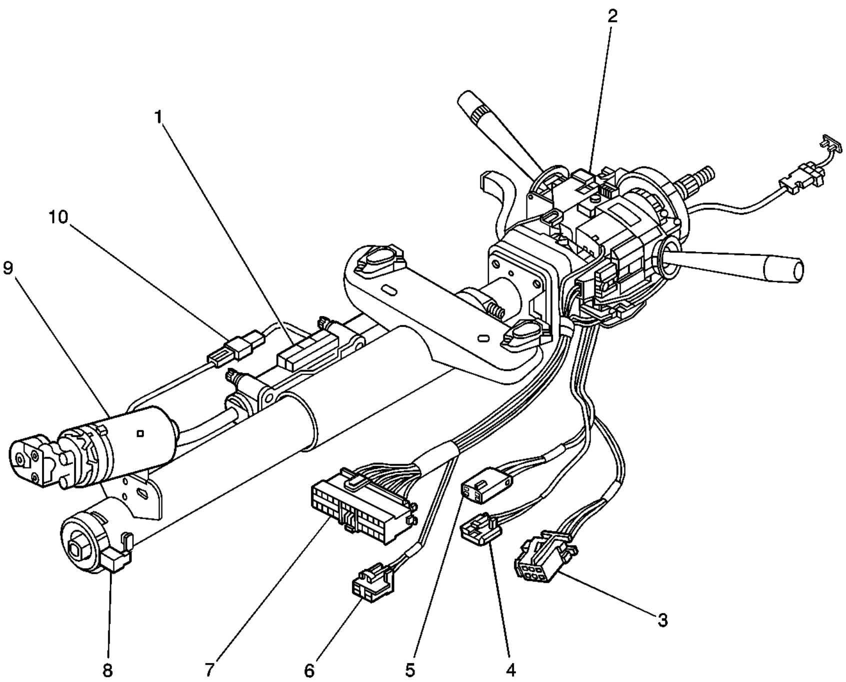


**Figure 1-40 MagnaSteer Steering Column Steering Wheel Position Sensor**

**(1) Telescoping Sensor**
**(2) Steering Column Lock**
**(8) Steering Wheel Position Sensor**
**(9) Telescoping Drive Motor**

The system also uses inputs such as Handwheel position from the **steering wheel position sensor** shown in Figure 1-40, wheelbase, understeer coefficient and steering ratio to calculate lateral acceleration. The EBCM commands current from negative two amps to positive three amps to the actuator, which is polarized. At low speeds, a negative current is commanded, which assists steering. At medium speeds, no current is commanded and steering is assisted by hydraulics only. At high speeds, a positive current is commanded, which creates steering resistance. Ignition voltage and ground are provided through the EBCM. The EBCM has the ability to detect malfunctions in the actuator or the circuitry to the actuator. Any malfunctions detected will cause the system to ramp to zero amps and steering will be assisted by hydraulics only.

## Saturn Vue Electric Power Steering (EPS)

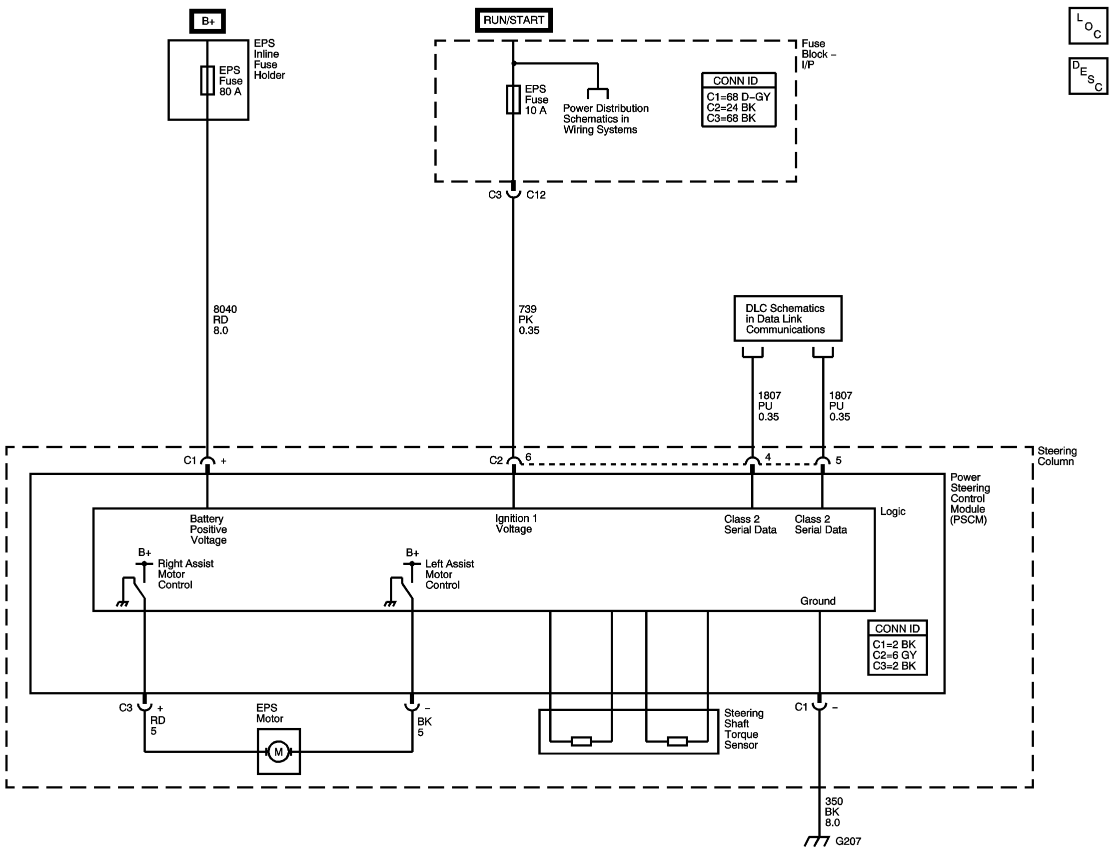


Figure 1-41 Power Steering Control Module (PSCM)

The **Electric Power Steering (EPS)** system (Figure 1-41) on the GM Saturn Vue reduces the amount of effort needed to steer the vehicle. The system uses the Under Hood Fuse Block (UHFB), Instrument Panel Fuse Block (IPFB), **Power Steering Control Module (PSCM)** shown in Figure 1-41, torque sensor, discrete battery voltage supply circuit, EPS motor, class 2 serial data circuit, and the Instrument Panel Cluster (IPC) to perform the system functions.  The PSCM, torque sensor, EPS motor are serviced as an assembly and part of the steering column. Any EPS components diagnosed to be malfunctioning requires replacement of the complete steering column assembly, also known as the EPS assembly, shown as number “6” in Figure 1-42.

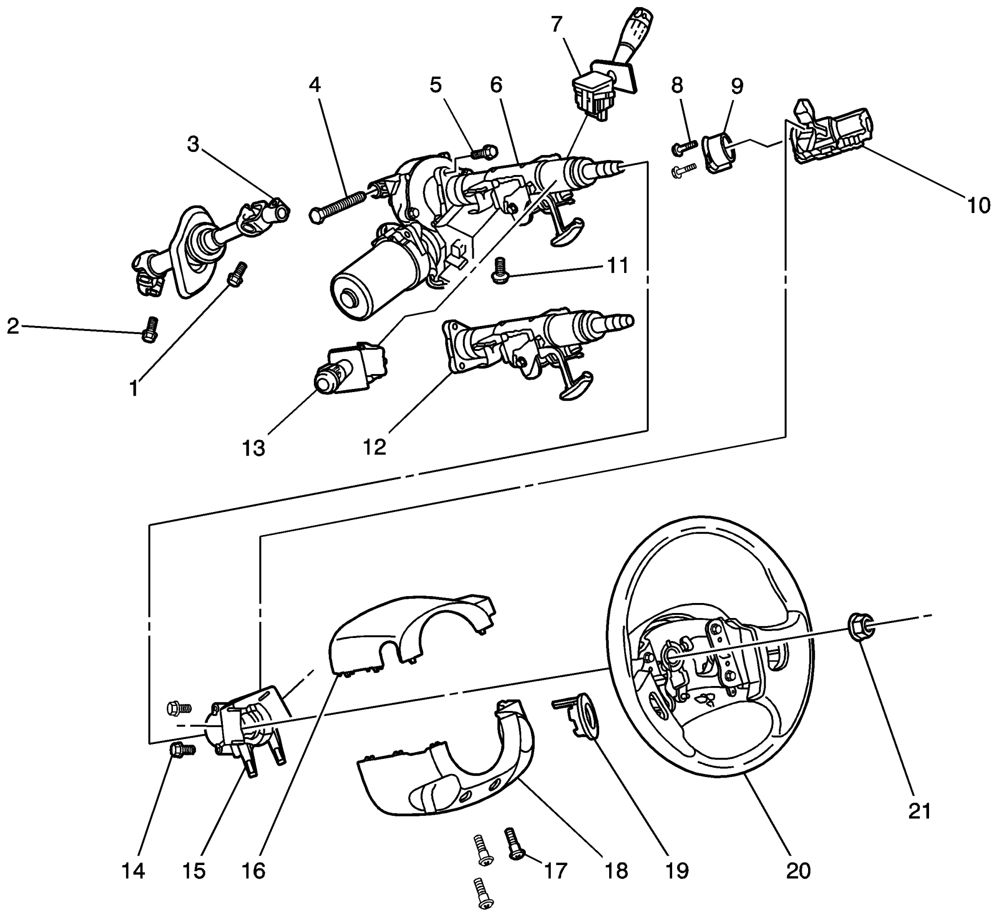


Figure 1-42 Saturn Vue Steering Column with EPS

(1) Upper Intermediate Shaft Bolt
(2) Lower Intermediate Shaft Bolt
(3) Intermediate Shaft Assembly
(4) Lower Steering Column Support Bracket Bolt
(5) Lower Steering Column Jacket Bolt
(6) Steering Column Assembly
(7) Wiper/Washer Switch Assembly
(8) Ignition Start Switch Screw
(9) Ignition Start Switch Assembly
(10) Ignition Start Switch Housing Assembly
(11) Upper Steering Column Support Bracket Bolt
(12) Steering Column Jacket Assembly
(13) Headlamp/Dimmer/Park/Turn Signal Switch Assembly
(14) Ignition Start Switch Bracket Bolt
(15) Wiper/Washer Switch and Headlamp/Dimmer/Park/Turn Signal Switch Bracket
(16) Steering Column Shroud Assembly
(17) Lower Steering Column Shroud Screw
(18) Steering Column Shroud
(19) Ignition Start Switch Bezel
(20) Steering Wheel Assembly

## Torque Sensor

The PSCM uses a **torque-sensor** (Figure 1-41 schematic), as it's main input for determining the amount of steering assists. It is part of the EPS assembly and not serviced separately. The steering column has an input shaft, from the steering wheel to the torque sensor, and an output shaft, from the torque sensor to the steering shaft coupler. The input and output shafts are separated by a torsion bar, where the torque sensor is located. The sensor consists of a compensation coil, detecting coil, and 3 detecting rings. These detecting rings have toothed edges that face each other. Detecting ring 1 is fixed to the output shaft, detecting rings 2 and 3 are fixed to the input shaft. The detecting coil is positioned around the toothed edges of detecting rings 1 and 2. As torque is applied to the steering column shaft the alignment of the teeth between detecting rings 1 and 2 changes, which causes the detecting coil signal voltage to change. The PSCM recognizes this change in signal voltage as steering column shaft torque. The compensation coil is used to compensate for changes in electrical circuit impedance due to circuit temperature changes from electrical current and voltage levels as well as ambient temperatures for accurate torque detection.

## EPS Motor

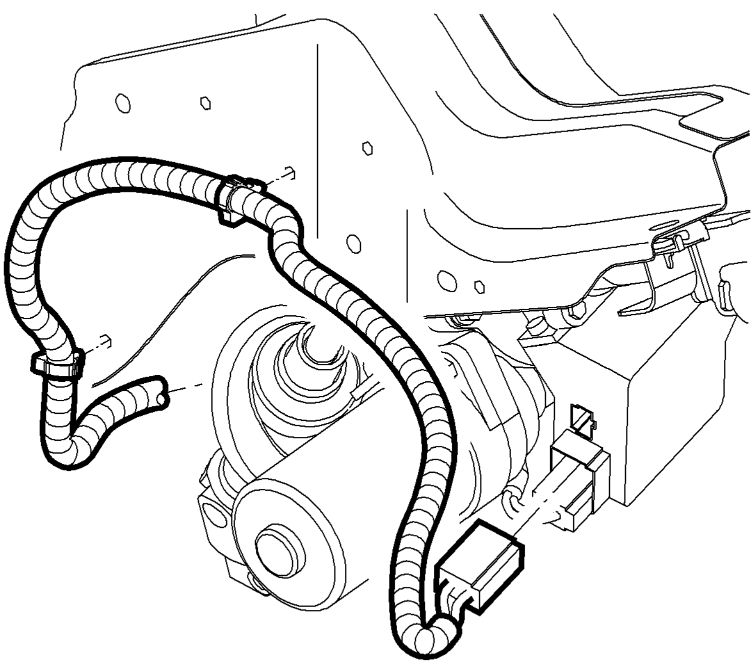

Figure 1-43 Saturn Vue EPS Motor and EPS Controller Connector

The **EPS motor** (Figure 1-43) is a 12-volt brushed DC reversible motor with a 58 amp rating. The motor assists steering through a worm shaft and reduction gear located in the steering column housing.

### Power Steering Control Module (PSCM)

The **Power Steering Control Module (PSCM)** that is part of the EPS assembly (Figure 1-041 Schematic) uses a combination of torque sensor inputs; vehicle speed, calculated system temperature and the tuning profile to determine the amount of steering assist. When the steering wheel is turned, the PSCM uses signal voltage from the torque sensor to detect the amount of torque being applied to the steering column shaft and the amount of current to command to the EPS motor. The PSCM receives a class 2-vehicle speed message from the Engine Control Module (ECM) to determine vehicle speed. At low speeds more assist is provided for easy turning during parking maneuvers. At high speeds, less assist is provided for improved road feel and directional stability. Neither the PSCM nor the EPS motor is designed to handle 65 amps continuously. The PSCM will go into overload protection mode to avoid system thermal damage. In this mode the PSCM will limit the amount of current commanded to the EPS motor, which reduces steering assist levels. The PSCM must be programmed with the proper tuning profile using the Saturn Service Stall when ever its replaced. The tuning profiles are different in relation to the vehicle configuration, FWD, AWD, and V6 etc. The PSCM has the ability to detect malfunctions within the EPS system. Any malfunction detected will cause the IPC to display the SERVICE VEHICLE SOON warning message.

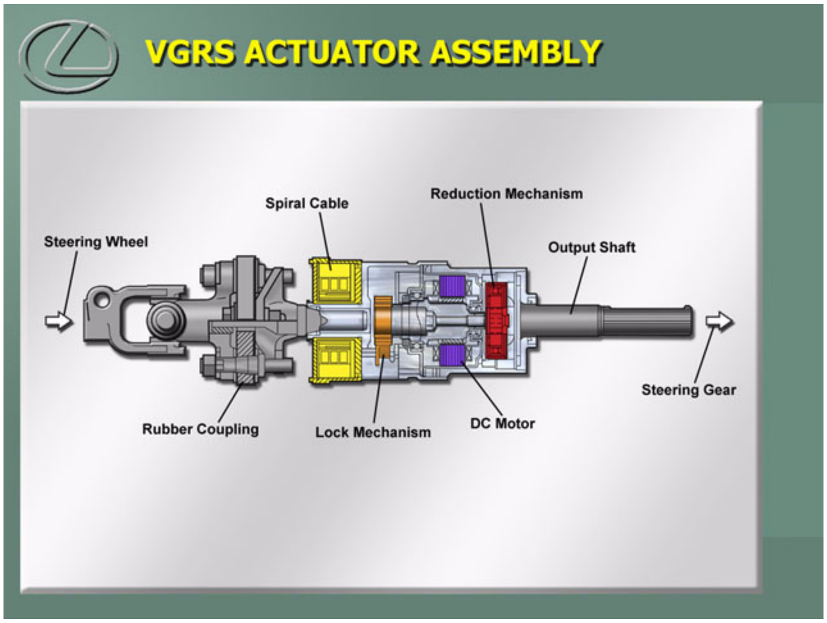


Figure 1-44 Lexus Variable Gear Ratio Steering

## Lexus Variable Gear Ratio Steering (VGRS) System

Figure 1-44 Shows a Lexus electronic variable power steering system. The electronically controlled steering column uses an electric motor to provide steering power assist. It does not use a hydraulic system. In addition to the steering assist the Lexus Variable Gear Ratio Steering (VGRS) system uses a lock mechanism to engage a gear reduction transmission to vary the steering ratio.

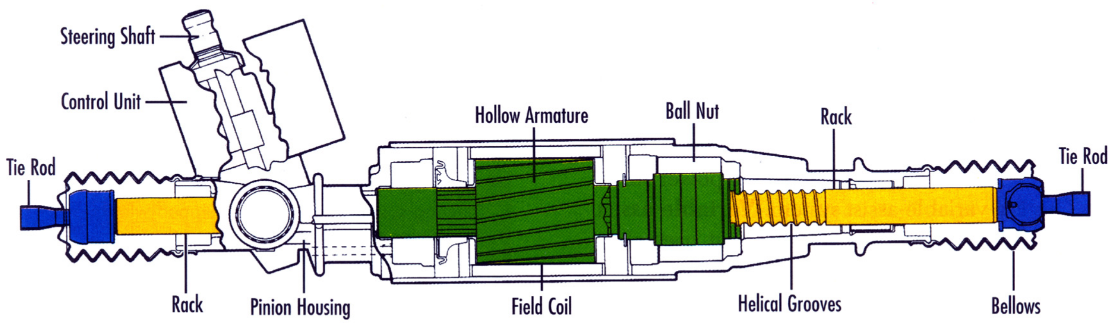


**Figure 1-45 TRW Electronic Rack & Pinion Steering Gear**

Electronic rack and pinion steering uses an electric motor to provide steering power assist. It does not use a hydraulic system (Figure 1-45). In the case of the TRW system, instead of using a flat rack with straight teeth as in a standard rack, this type of system uses a helical-gear rack driven by a fast acting electric motor. A torque sensor mounted on the pinion shaft measures input steering torque. As torque is applied a signal is sent to the powertrain control module (PCM). The PCM sends a signal to the electric motor, which provides the power assist.

# UNIT ONE STEERING SYSTEM DESIGN

## HEV Electric Power Steering (EPS)

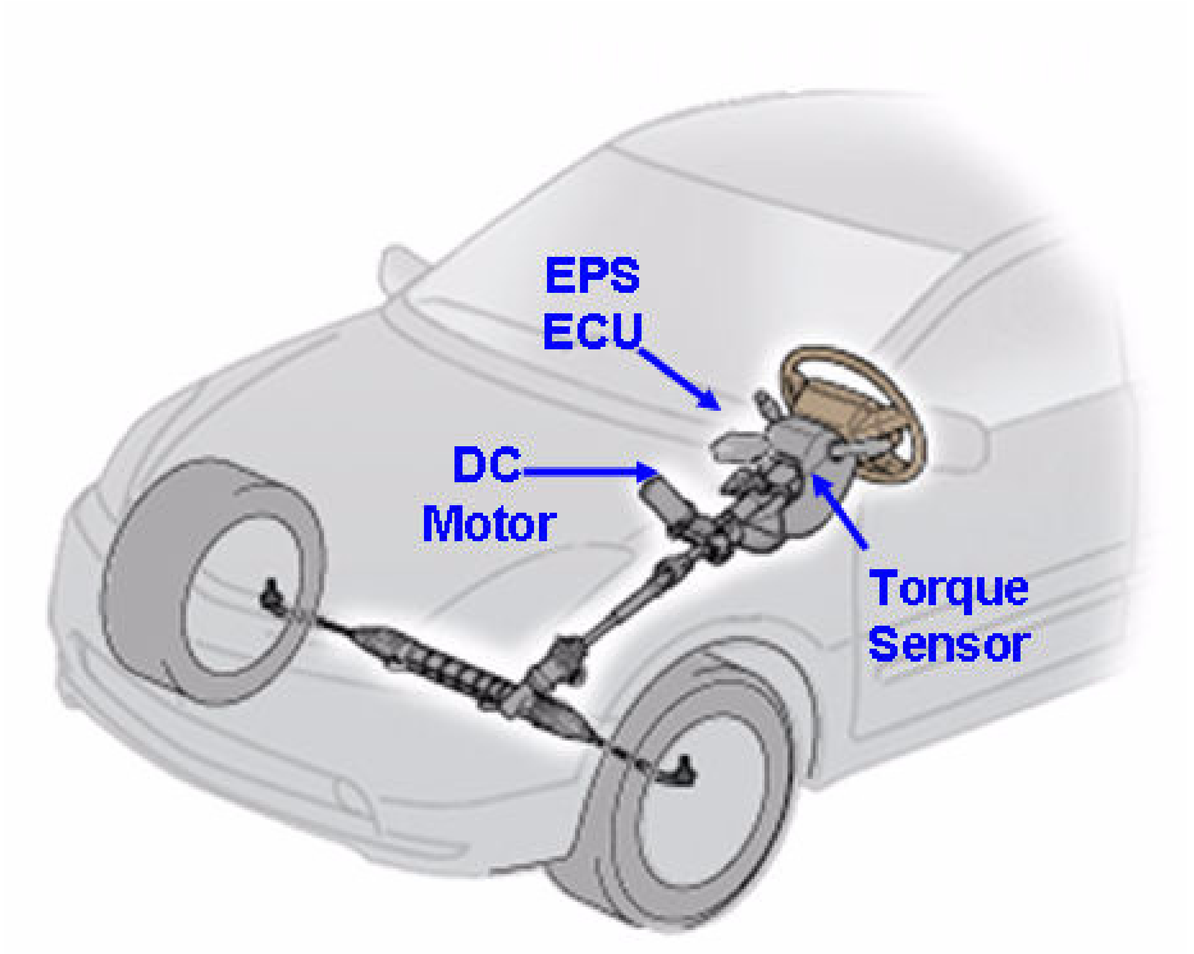


Figure 1-46 Toyota Prius HEV EPS Components

A 12 volt DC electric motor (Figure 1-46) powers the EPS system so that steering feel is not affected when the engine shuts off. The EPS ECU uses torque sensor output along with information from the Skid Control ECU about vehicle speed and torque assist demand to determine the direction and force of the power assist. It then actuates the DC motor accordingly.

### EPS Electronic Control Unit (ECU)

The **EPS ECU** (Figure 1-46) uses signals from the torque sensor to interpret the diver’s steering intentions. It combines this information with data from other sensors regarding current vehicle conditions to determine the amount of steering assist that will be required. It can then control the current to the DC motor that provides steering assist current to the DC motor that provides steering assist.

## Power Steering System

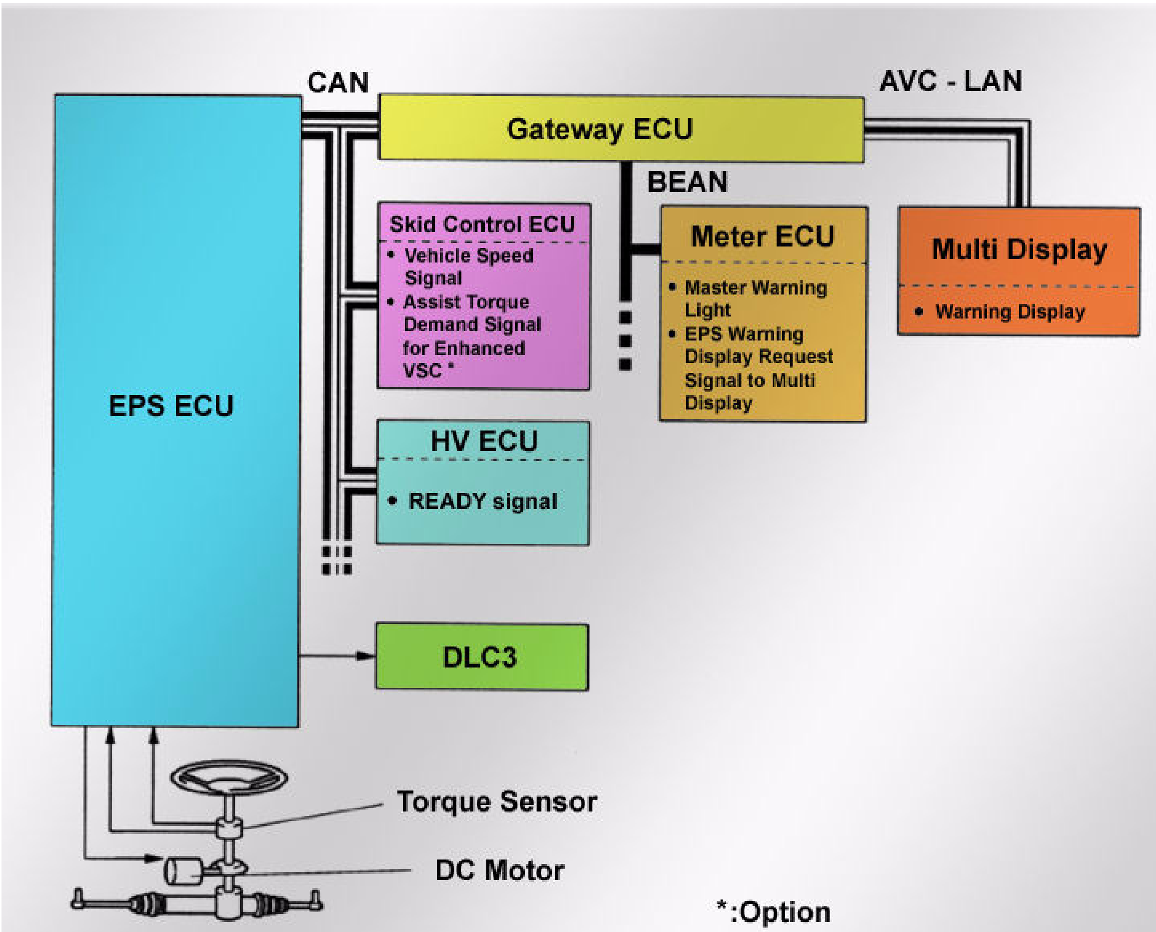


Figure 1-47 Toyota Prius HEV Power Steering System

When the steering wheel is turned, torque is transmitted to the pinion causing the input shaft to rotate (Figure 1-47). The torsion bar that links the input shaft and the pinion twists until the torque and the reaction force equalize. The torque sensor detects the twist of the torsion bar and generates an electrical signal that is proportional to the amount of torque applied to the torsion bar. The EPS ECU uses that signal to calculate the amount of power assist the DC motor should provide.

### DC Motor

The DC motor uses a worm gear to transmit the motor's torque to the column shaft.

## Early Torque Sensor, Motor, & Reduction Mechanism

Figure 1-48 Early HEV EPS Torque Sensor, Motor, & Reduction

The 2001-2003 Prius torque sensor is a surface-contact resistor. The early 2001-2003 reduction mechanism transmits power assist from the motor to the pinion shaft. The reduction mechanism consists of a pinion gear integrated with the motor shaft and a ring gear that is secured to the pinion shaft (Figure 1-48).

# UNIT ONE STEERING SYSTEM DESIGN

## Late Model Torque Sensor

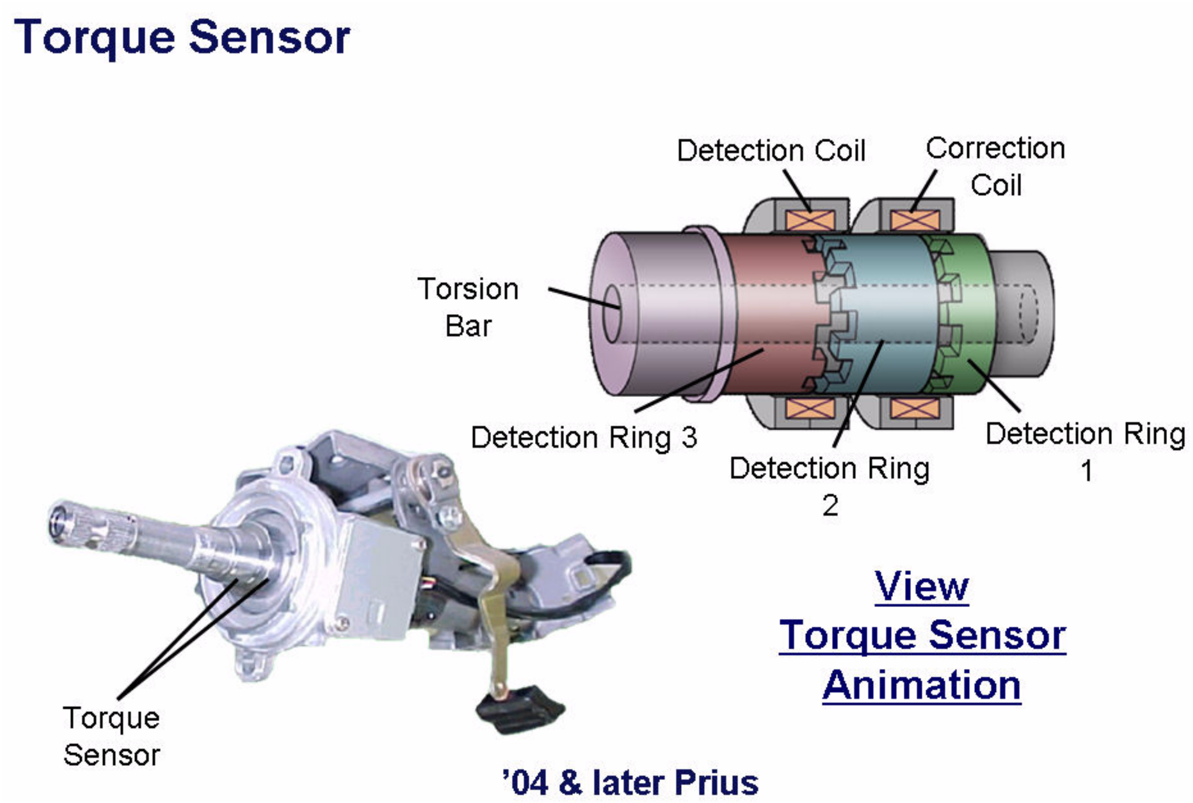


**Figure 1-49 Late model HEV EPS Torque Sensor**

The 2004 & later Prius uses an induction-type torque sensor (Figure 1-49). Detection ring 1 and 2 are mounted on the input shaft and detection ring 3 is mounted on the output shaft. When torqu is applied to the torsion bar the detection rings move in relationship to each other. The detection coil senses a change in inductance that is proportional to the amount of torque applied.

## Reduction Mechanism

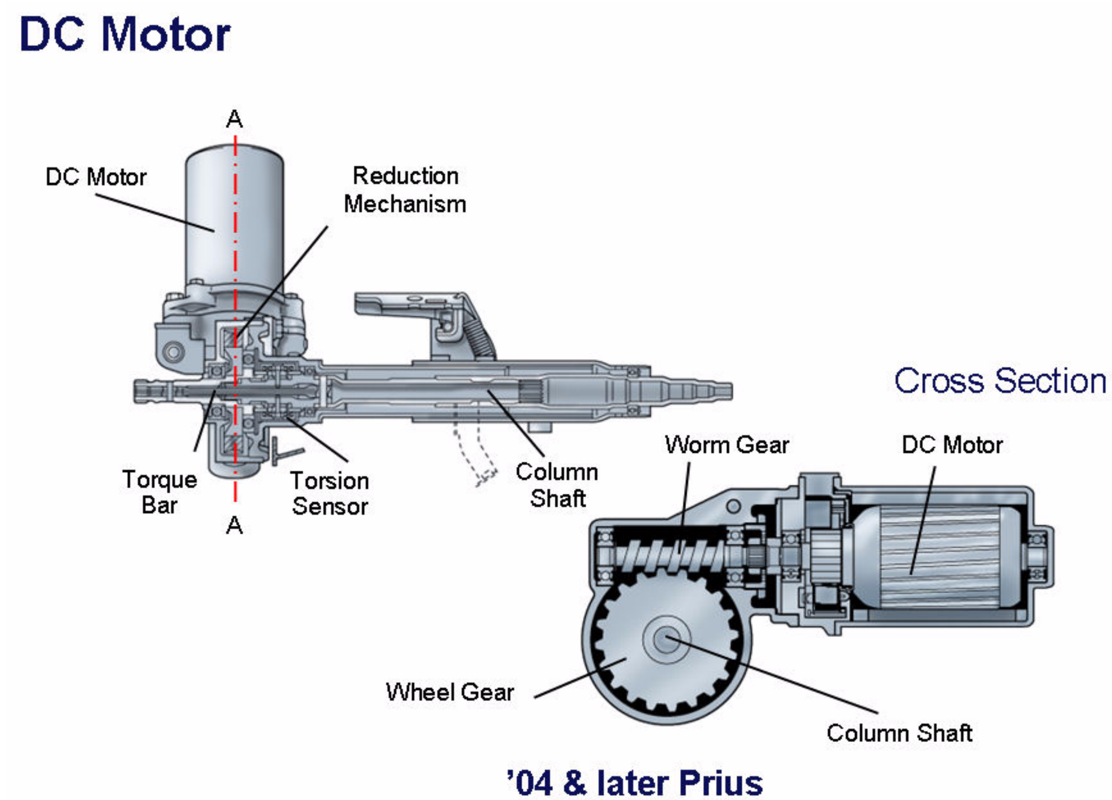


Figure 1-50 Late model HEV EPS reduction mechanism

For 2004 & later, the **reduction mechanism** (Figure 1-50) transmits power assist from the motor to the column shaft. The reduction mechanism consists of a worm gear integrated with the motor shaft and wheel gear that is connected to the column shaft.

## EPS ECU Malfunction

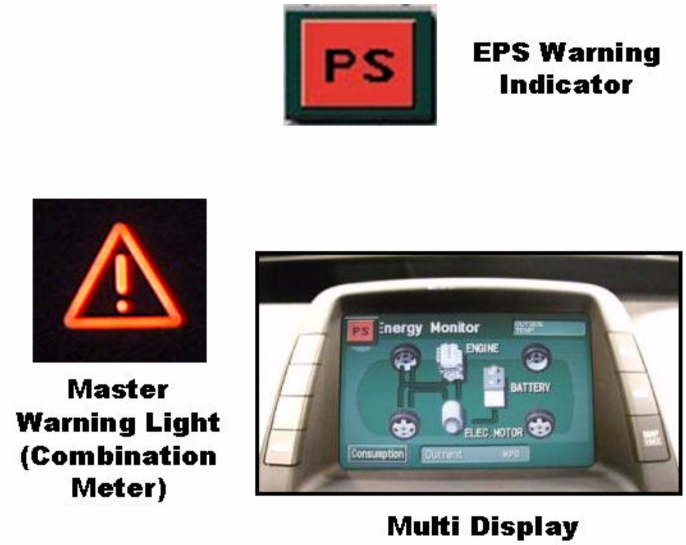


Figure 1-51 HEV EPS Warning Light

If the EPS ECU detects a malfunction in the EPS system, a warning light illuminates to alert the driver. The EPS ECU will store the DTC(s) and the system will power down, however the system still provides the ability to steer manually.

# REAR WHEEL STEERING

## PASSIVE REAR STEERING (MULTI-LINK)

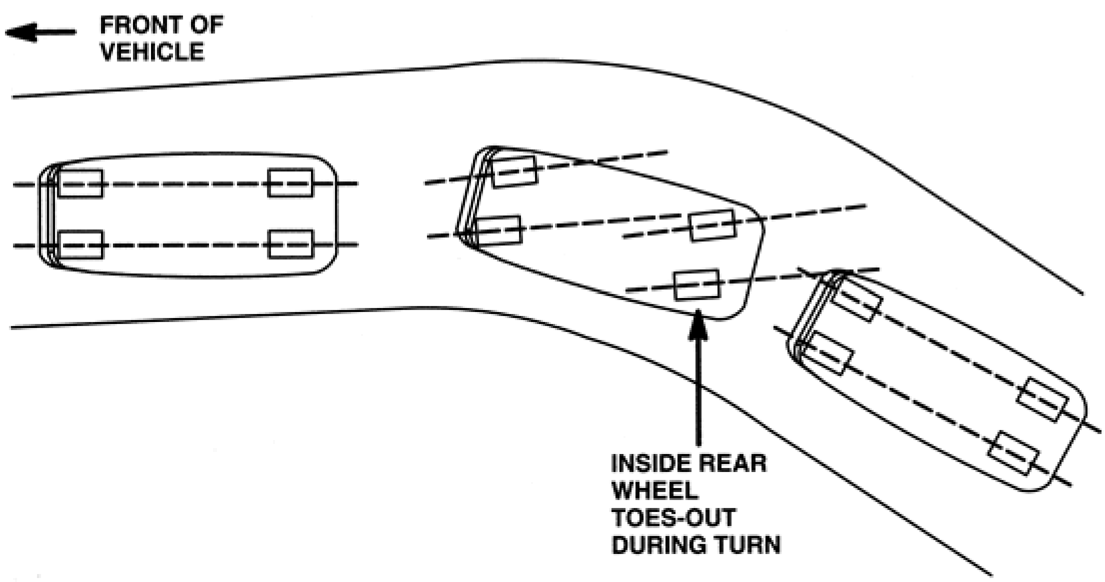


Figure 1-52 rear wheel steering pattern

In the passive rear steering system, the suspension uses the vehicle's weight and the forces induced on the suspension components to slightly change rear toe angles during turns (Figure 1-52). The configuration of the toe control arm, the lower lateral arm, and the trailing arm force the inside rear wheel into a toe-out condition during a turn. The outside wheel toes-in. This provides passive rear steering and, therefore, improved cornering without a large number of additional components like mechanical or hydraulic rear steering systems.

## Passive Rear Steering (Toe Link)

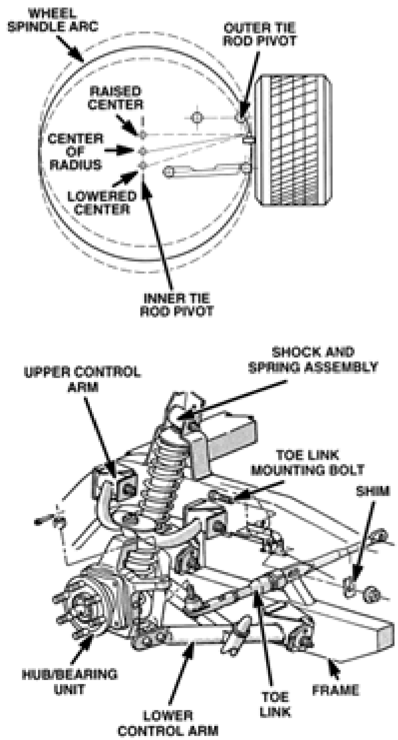


**Figure 1-53 rear wheel steering linkage**

Some vehicles use a toe link rear suspension as shown in Figure 1-53. The suspension is actually an SLA suspension using upper and lower arms, with the knuckle mounted on ball joints. The knuckles remain stationary when the vehicle is turned, but the toe links (tie rods) adjust rear toe as the suspension goes through jounce and rebound.

As the spindle arc changes during jounce and rebound, the tie rod pivot point moves. This causes toe to be altered, much like an SLA suspension changes camber because of the different arm lengths. The toe link sets toe similar to tie rods on other front suspension systems. The system improves vehicle response and does not require a large number of additional components like mechanical or hydraulic systems.

## Mechanical Rear Steering

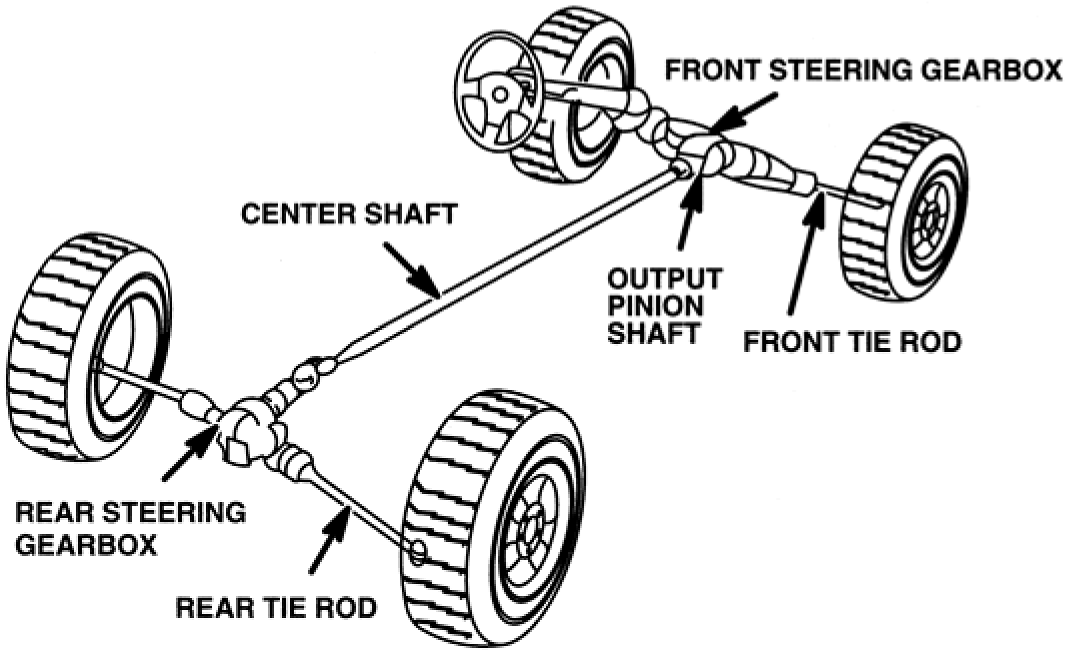


**Figure 1-54 Honda mechanical rear wheel steering**

Some manufacturers use a mechanical linkage (Figure 1-54) to help steer the rear wheels on a vehicle. The mechanical rear steering system uses a shaft turned by the front rack to control a gear box in the rear. The system is designed to steer the rear wheels in the same direction as the front wheels when the steering wheel is turned between center and about one third of a turn off center in either direction. This allows the rear wheels to help turn when maneuvering at driving speeds.

The rear steering gear turns the rear wheels in the opposite direction as the front wheels when a vehicle is performing low speed maneuvers, such as parking. The steering system alters the rear wheel direction as the steering wheel is turned from about one third of a turn and beyond.

During an alignment, this system requires the rear toe be set first, like all other four-wheel alignments. The rear toe aligns the thrust angle and centers the rear steering gear. If a steering wheel is off-center after alignment, the rear steering is affected because the front and rear steering gears are not synchronized (centered together).

## QUADRASTEER 4-WHEEL STEERING DESCRIPTION AND OPERATION


Figure 1-55 GM Quadrasteer rear wheel steering system

Quadrasteer™ is a 4-wheel steering system (Figure 1-55) that dramatically enhances low speed maneuverability, high-speed stability, and towing capability. The system is an electrically powered rear wheel steering system comprised of the following components:

- steerable, solid rear axle.
- heavy duty wiring harness and fuse.
- programmable control module.
- power relay in the control module.
- rack and pinion style steering actuator mounted on the rear differential cover.
- An electric motor assembly on top of the rear steering actuator.
- three Hall effect switches in the motor assembly.
- shorting relay in the motor assembly.
- rear wheel position sensor located under a cover on the bottom of the actuator, below the motor assembly.

- steering wheel position sensor located at the base of the steering column.
- mode select switch on the dash.

**The rear wheel steering control module has these inputs:**

- Rear wheel steering module class 2 serial data.
- Rear wheel steering motor phase a control.
- Rear wheel steering motor phase B control.
- Rear wheel steering motor phase C control.
- Rear wheel steering motor shorting relay voltage.
- Rear wheel steering mode select switch supply voltage.
- 2- Wheel Steer mode indicator control.
- 4- Wheel Steer mode indicator control.
- 4- Wheel Steer Tow mode indicator control.
- Rear wheel position sensor 5-volt reference.
- Rear wheel steering motor hall sensor 12-volt reference.
- Steering wheel position sensor Phase A, Phase B, and marker pulse 12-volt reference.

**Separate connectors to the rear wheel steering control module are provided for the following 4 capacities:**

- Battery voltage.
- Switched battery voltage.
- Class 2 serial data.
- vehicle class 2, steering wheel position, mode select switch, speed sensor
- The motor phase power leads.
- The motor hall sensors, shorting relay, and rear wheel position sensor signals.

**NOTE: Beginning with the 2003 model year, the rear wheel steering control module supports flash programming. Beginning with the 2004 model year, the combination yaw rate/lateral accelerometer sensor has been removed.**

## Steering Modes

The system operates in 3 principal modes, as follows:

### 2-Wheel Steer Mode:

Normal steering operation; the rear wheels held in a centered position and rear wheel steering is disabled while in this mode.

**4-Wheel Steer Mode:**

The 4-wheel steering mode provides 3 principal phases of steering: negative phase, neutral phase, and positive phase. Negative phase occurs at low speeds and the rear wheels turn opposite of the front wheels. In the neutral phase the rear wheels are centered and do not turn. Positive phase occurs at higher speeds and the rear wheels turn in the same direction as the front wheels.

**NOTE: There is a crossover speed. This is the speed at which the control module transitions from negative phase steering to positive phase steering. In 4-Wheel Steer mode, this transition occurs when the vehicle obtains a speed of 65 km/h (40 mph).**

**4-Wheel Steer Tow Mode:**

The 4-wheel steer tow mode provides more positive phase steering than the normal 4-wheel steering at high speed. During low speed driving, the 4-wheel steer tow mode provides similar negative phase steering as it does in the normal 4-wheel steering mode. The cross over speed in the 4-Wheel Steer tow mode occurs at 40 km/h (25 mph).

## Rear Wheel Steering Control Module

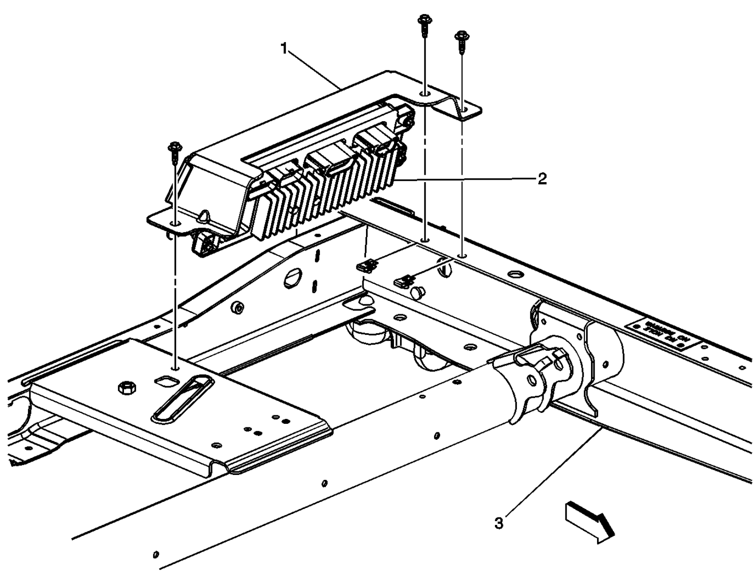


Figure 1-56 Rear Wheel Steering Control Module

**(1) Mounting Bracket**

**(2) Rear Wheel Steering Control Module**

**(3) Frame**

# UNIT ONE STEERING SYSTEM DESIGN

The **rear wheel steering control module** (Figure 1-56) controls all functions of the rear wheel steering system. The module has a dedicated power feed line from an under hood fuse holder, via a 125-amp mega fuse. The module is located in the rear of the vehicle on the underbody. The module uses the inputs listed above to determine when and how far to turn the rear wheels. The module uses the hall switches in the motor assembly, a shorting relay and a motor control relay to monitor and control the direction and speed of the motor. The module also controls the duty cycle of the phase leads to the motor. The motor control relay is part of the rear wheel steering control module and is not serviceable.

The module uses both a class 2 and a discrete vehicle speed signal. The two vehicle speed signals are used for comparison purposes. The system will not function without a discrete vehicle speed sensor signal. The module uses digital inputs from the steering wheel position sensor to determine steering wheel position and rate of change. The BCM sends a class 2 message for the analog portion of the signal from the steering wheel position sensor. The rear wheel position sensor signals provide the module with rear wheel position data. The module will send out a class 2 message to the IPC to turn on and off the Service 4 Wheel Steering message. The rear wheel steering control module also controls the ground circuits for the mode indicator lamps in the mode select switch.

The control module allows the vehicle's rear wheels to turn a maximum of 12 degrees left or right. When the vehicle is operated in reverse, the maximum rear wheel steering angle is 5 degrees left or right. When the vehicle is sitting still in the test mode the system will move a maximum of 5 degrees left or right.

**NOTE: Rear wheel steering control module may shut down if the system is operated under very extreme conditions and becomes overheated. The Service 4 Wheel Steering message will not be displayed. Once the temperature decreases back to operating range, the rear wheel steering system will resume normal operation upon the next ignition cycle.**

## Rear Wheel Steering Mode Switch

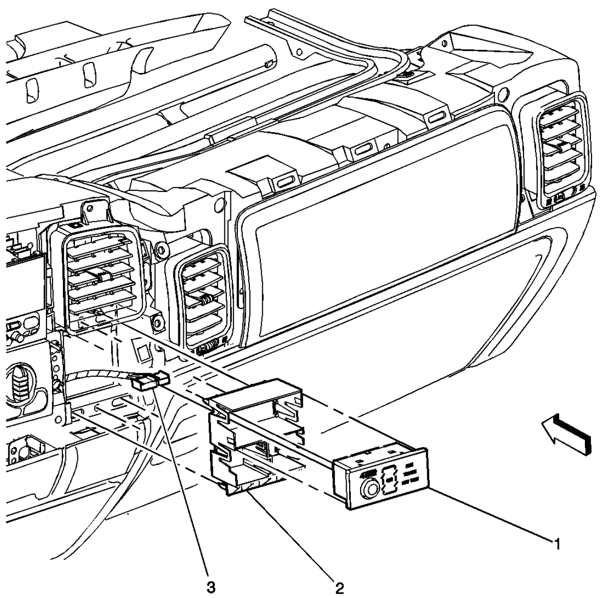


Figure 1-57 Rear Wheel Steering Mode Switch

**(1) Rear Wheel Steering Mode Select Switch**
**(2) Switch Housing**
**(3) Switch Electrical Connector**

The **Rear Wheel Steering mode switch** (Figure 1-57) located in the instrument panel allows the driver the option of selecting 2-wheel steering, 4-wheel steering, or 4-wheel steering tow modes of operation. The mode switch has indicators that show which mode the rear wheel steering system is in. When all indicators are lit the rear wheel steering control module has lost its memory settings and the scan tool must be used to re-calibrate the rear wheel steering control module. During a mode change, the indicator for the selected mode will flash until the mode change is complete. The rear wheel steering control module will wait for the steering wheel to pass the center position before entering the selected mode. The indicators on the mode switch are LED's, the switch is also backlit.

## Rear Wheel Steering Motor Assembly

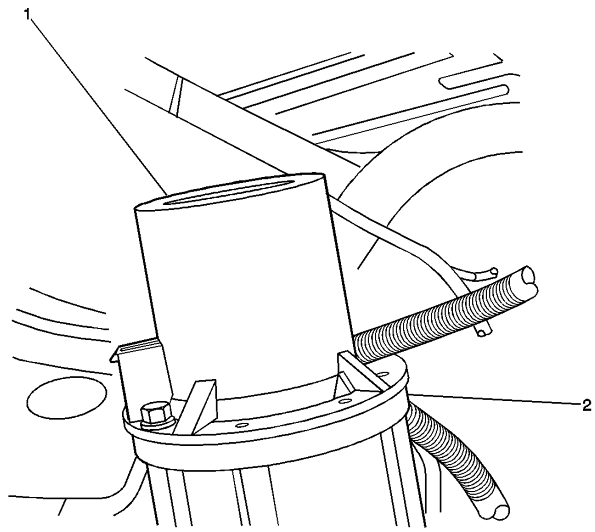


Figure 1-58 Rear Wheel Steering Motor Assembly

(1) Rear Steering Gear Motor

(2) Steering Gear Assembly

The **rear wheel steering motor** (Figure 1-58) assembly is a 3 phase, 6 pole, and brushless DC motor. The motor assembly is located on the top of the rear steering actuator, and transmits its power through a planetary gear set inside the actuator. There are 3 hall switches inside the assembly: Hall "A," Hall "B," and Hall "C." The rear wheel steering control modules uses the hall switch inputs to monitor the position, speed and direction of the motor. There is a motor phase shorting relay located inside the motor assembly. The hall switches and shorting relay are part of the motor assembly and cannot be serviced separately. The motor leads are not to be repaired or spliced in any fashion. If there is damage to the motor wiring, the motor assembly must be replaced, as any damage to the wiring could permit water intrusion into the actuator. The motor assembly can be serviced separately from the actuator.

## Steering Wheel Position Sensor

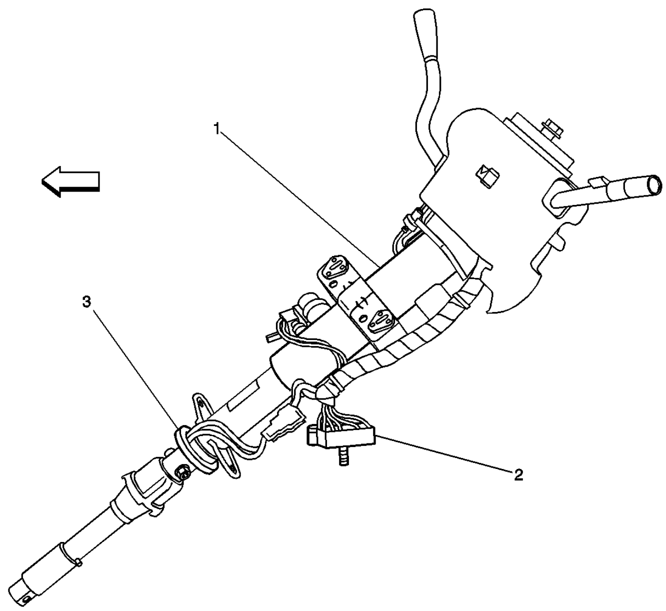


Figure 1-59 Steering Wheel Position Sensor

(1) Steering Column

(2) C201

(3) Steering Wheel Speed/Position Sensor

The **Steering Wheel Position Sensor (SWPS)** as shown in Figure 1-59 provides one analog signal and 3 digital signals. The digital signals, Phase A, Phase B and marker pulse, are direct inputs to the rear wheel steering control module. The analog signal is input to the BCM and is sent via a class 2 message to the rear wheel steering control module. Battery voltage is supplied to the sensor from the cruise fuse to operate the digital portion of the sensor. A 12 volt reference is provided by the rear wheel steering control module to the Phase A, Phase B, and marker pulse circuits of the SWPS. The module monitors each circuit as it is either remains high or is pulled low by the SWPS.

The scan tool displays the Phase A and Phase B data parameters as either HIGH or LOW when the steering wheel is being rotated. Each change from HIGH to LOW, or LOW to HIGH, represents one degree of steering wheel rotation. When observing the Phase A and Phase B data with the scan tool, the parameters will not always display the same value at the same time. The marker pulse is a digital pulse signal that is displayed as HIGH by the scan tool with the steering wheel angle between +10° and -10°. At greater than 10° steering wheel angle in either direction, the marker pulse data will be displayed as LOW.  The BCM (body computer module) provides the 5-volt reference and low reference for the analog portion of the SWPS. The BCM reads the SWPS analog signal in voltage, which is typically 2.5 volts with the steering wheel on center.

The voltage ranges from .25 volts at approximately 1 full turn left to 4.75 volts at approximately 1 full turn right. The voltage will then remain at that level for the remainder of steering wheel travel. This voltage can be monitored in BCM data display. The rear wheel steering control module receives the analog signal via a class 2 message from the BCM. When monitoring the rear wheel steering data, this information is displayed in the Steering Wheel Angle (TBC) data parameter, and is shown in degrees. The range of the display is +/- 225 °, with negative numbers representing steering input to the left, and positive numbers representing input to the right.  The sensor may also be utilized by other optional systems.

## Rear Wheel Position Sensor

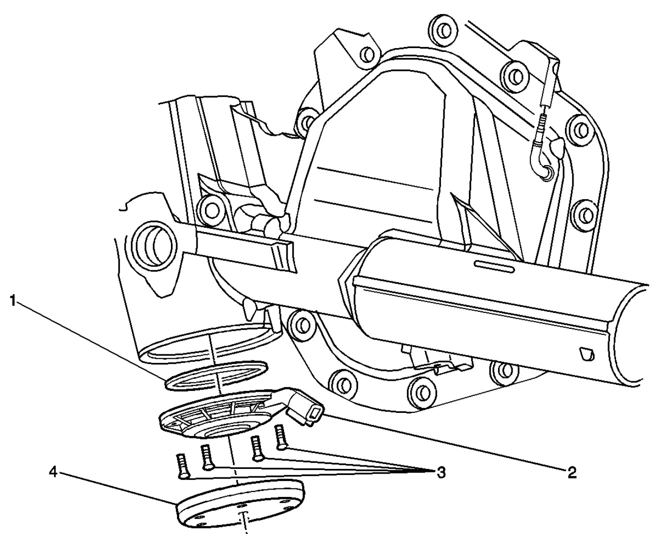


Figure 1-60 Rear Wheel Position Sensor

(1) O-Ring

(2) Rear Wheel Position Sensor

(3) Retaining Bolts

(4) Sensor Cover

The **rear wheel position sensor** (Figure 1-60) has 2 signal circuits: position 1 and position 2. Position 1 is a linear measurement of voltage per degree. The voltage range for position 1 is from 0.25 to 4.75 volts, and the angular measurement range is from - 620° to + 620°. At 0.25 volts the steering wheel has been rotated - 600° past center. At 4.75 volts the steering wheel has been rotated + 600° past center. Position 2 circuit is a linear measurement of voltage per degree. The voltage for position 2 increases or decreases from 0.25 to 4.75 volts every 180°. When the steering wheel is 0° or at center, position 1 and position 2 output signals measure 2.5 volts respectively.

### Steerable Rear Axle

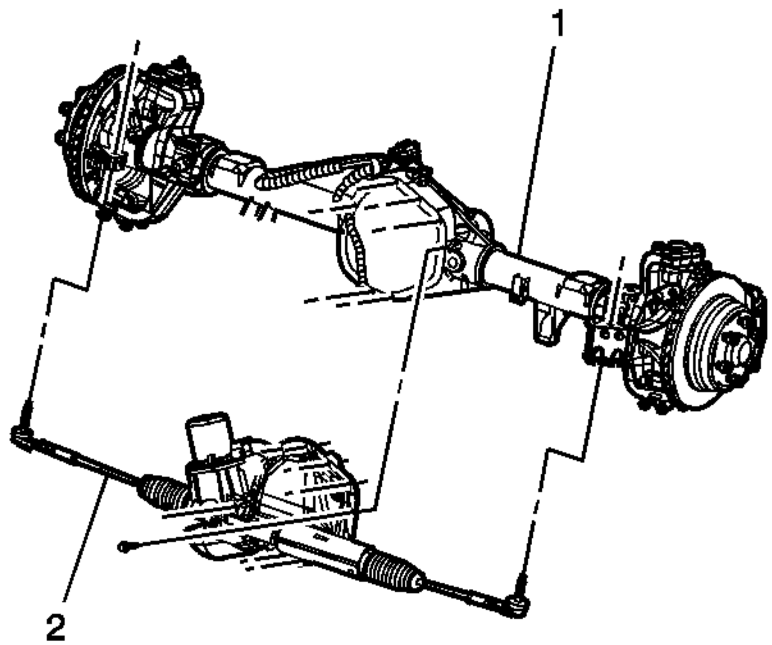


**Figure 1-61 Steerable Rear Axle**

The steerable rear axle (2) as shown in Figure 1-61 has a rack and pinion style actuator mounted to the differential cover (1), specially designed axle shafts, and movable hub and bearing assemblies mounted by upper and lower ball joints. The actuator housing is part of the differential cover. In the event of a system malfunction, the actuator returns the rear wheels to the center position through internal springs. The actuator has specially designed inner and outer tie rods ends. There are inner tie rod boots to prevent contaminants from entering the actuator. Long term exposure to moisture due to a damaged boot or components can result in an internal malfunction or damage.

The actuator has the rear wheel steering motor assembly attached to the upper housing. There are shields and a skid plate on the rear axle to protect the actuator. There are no internal adjustments to the actuator. It is mandatory to perform a four-wheel alignment if any hard parts, such as tie rods, ball joints or wheel bearings are serviced. The axle shafts are a heavy-duty design with a specially designed CV joint and boot at the wheel end of the axle to provide up to 15 ° of movement. The axle assembly is a heavier duty version of the standard rear axle used on a non-rear wheel steer truck.