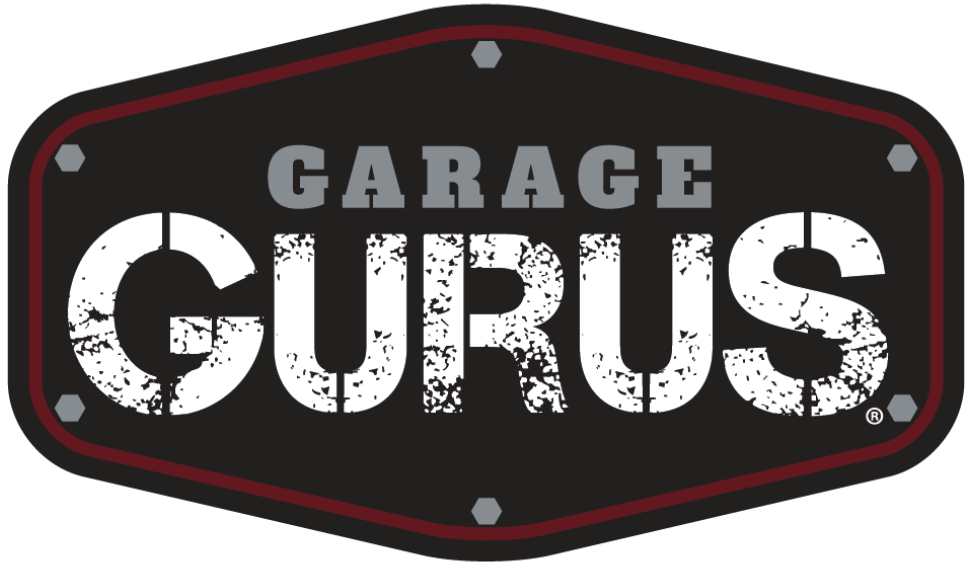
Diagnosing Steering and Suspension Systems from A to Z

SS.1021.3.FC

GARAGE GURUS®

Objectives

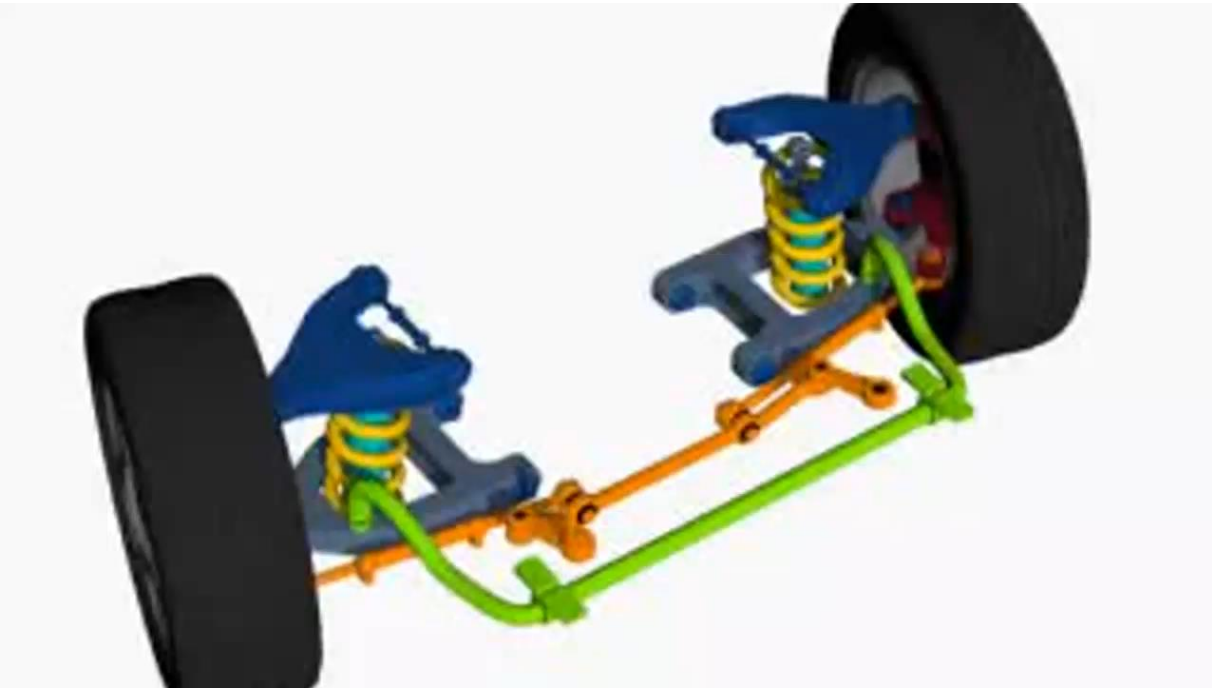
- Identify vehicle steering and suspension system types
- Discuss various types of vehicle steering systems and their operations
- Review proper methods for performing steering and suspension inspections
- Acknowledge ride control components and their effect on vehicle performance
- Discuss how worn chassis components relate to tire wear, handling, and ride quality concerns



Suspension Systems Overview

SLA (Short / Long Arm)

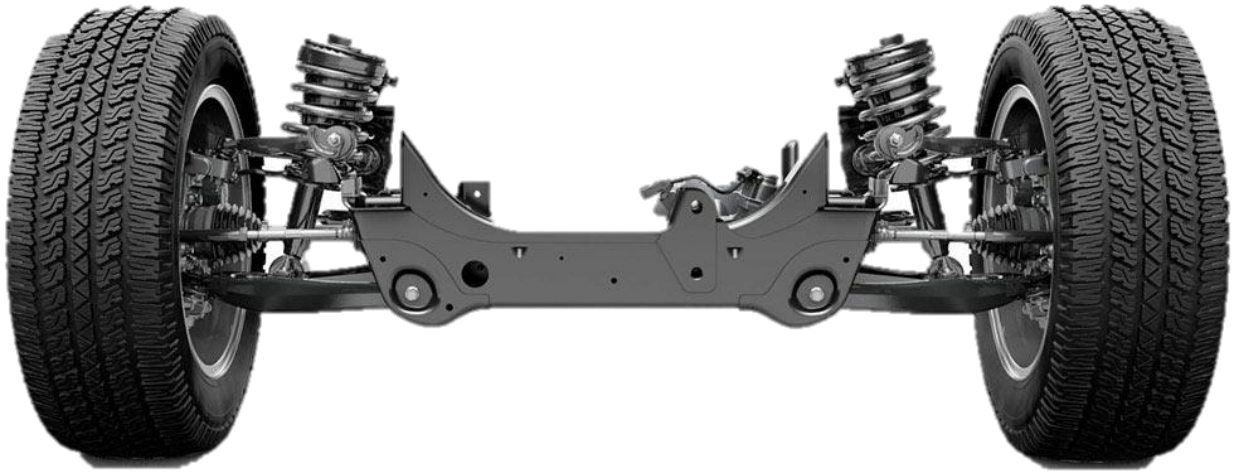
- Also known as Type 1 or double wishbone suspension.
- Has upper and lower control arms.
- Spring located between frame and lower control arm. May also use a strut / spring assembly between the body and lower arm.
- Most modern versions will include a sway bar and links.



SLA (Short / Long Arm)

- Extremely versatile- can be installed along with many different spring, shock, strut designs (including air suspensions) to accomplish different handling and load carrying characteristics.
- Typically used for good handling and road feel
- Started out in use for RWD applications. Modern versions include FWD and AWD as well.

2015 Chevrolet Tahoe AWD
Type 1 - SLA with struts

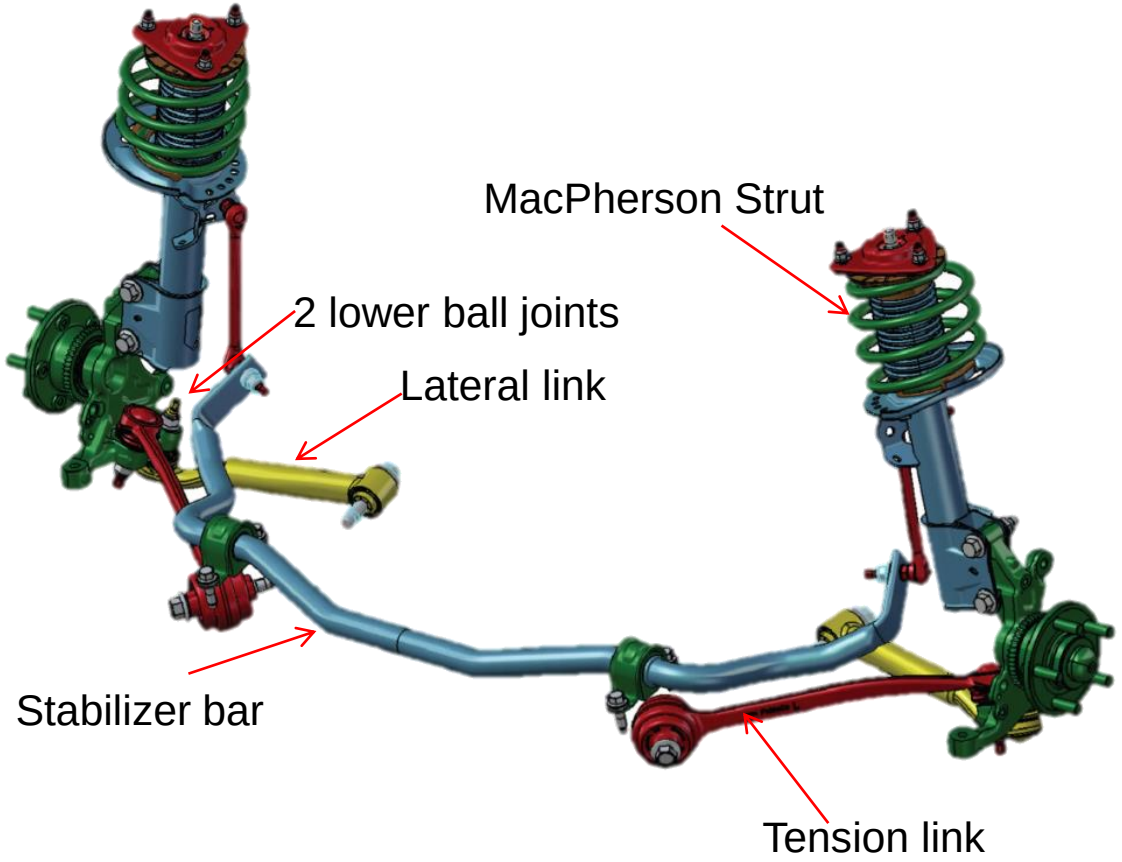


MacPherson Strut

- Has lower control arm, upper is replaced by the strut assembly
- Strut bearing plate replaces upper ball joint
- Bearing plate is load carrier

MacPherson Strut

- Commonly found on FWD applications.
- Economical: Less wear parts (no upper control arm).
- Has less unsprung weight due to less suspension members.
- Handling has improved with better spring and strut technology, but is still a cost-based compromise compared to SLA or Multi-Link

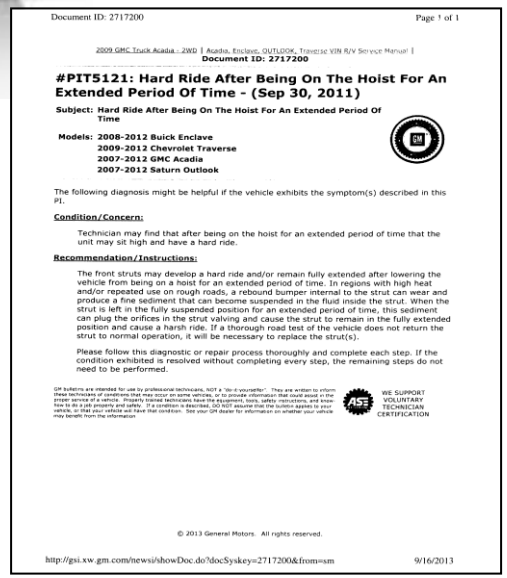


2015 Ford Mustang

GM Crossovers

- Harsh Suspension After Free Hang Overnight

TSB 2717200



Document ID: 2717200 Page 1 of 1

2009 GMC Truck Acadia - 2WD | Acadia, Enclave, OUTLOOK, Traverse VIN R/V Service Manual |
Document ID: 2717200

#PIT5121: Hard Ride After Being On The Hoist For An Extended Period Of Time - (Sep 30, 2011)

Subject: Hard Ride After Being On The Hoist For An Extended Period Of Time

Models: 2008-2012 Buick Enclave
2009-2012 Chevrolet Traverse
2007-2012 GMC Acadia
2007-2012 Saturn Outlook

The following diagnosis might be helpful if the vehicle exhibits the symptom(s) described in this PI.

Condition/Concern:

Technician may find that after being on the hoist for an extended period of time that the unit may sit high and have a hard ride.

Recommendation/Instructions:

The front struts may develop a hard ride and/or remain fully extended after lowering the vehicle from being on a hoist for an extended period of time. In regions with high heat and/or repeated use on rough roads, a rebound bumper internal to the strut can wear and produce a fine sediment that can become suspended in the fluid inside the strut. When the strut is left in the fully suspended position for an extended period of time, this sediment can plug the orifices in the strut valving and cause the strut to remain in the fully extended position and cause a harsh ride. If a thorough road test of the vehicle does not return the strut to normal operation, it will be necessary to replace the strut(s).

Please follow this diagnostic or repair process thoroughly and complete each step. If the condition exhibited is resolved without completing every step, the remaining steps do not need to be performed.

GM bulletins are intended for use by professional technicians, NOT a "do-it-yourselfer". They are written to inform these technicians of conditions that may occur on some vehicles, or to provide information that could assist in the proper service of a vehicle. Properly trained technicians have the equipment, tools, safety instructions, and know-how to do a job properly and safely. If a condition is described, DO NOT assume that the bulletin applies to your vehicle, or that your vehicle will have that condition. See your GM dealer for information on whether your vehicle may benefit from the information.

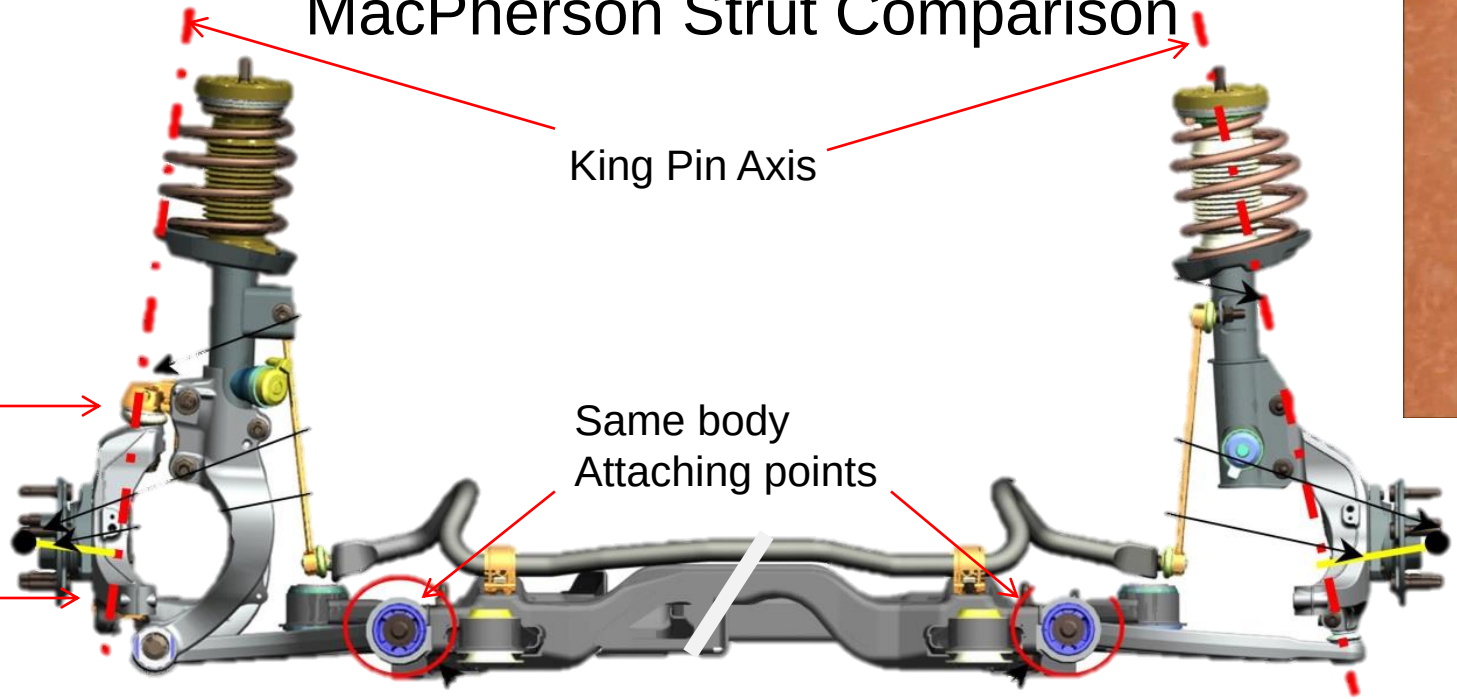
WE SUPPORT VOLUNTARY TECHNICIAN CERTIFICATION

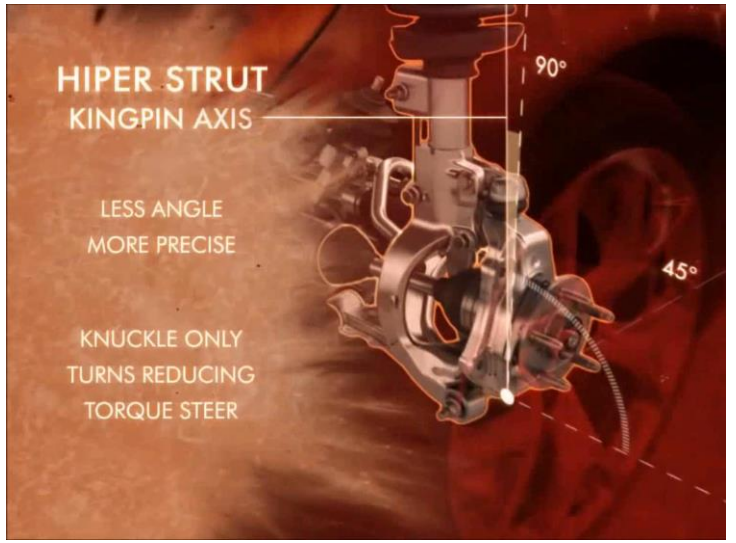
http://gsi.xw.gm.com/news/showDoc.do?docSyskey=2717200&from=sm 9/16/2013

"In regions of high heat and/or repeated use on rough roads, a rebound bumper internal to the strut can wear and produce a fine sediment that can become suspended in the fluid inside the strut. When the strut is left in the fully extended position for an extended period of time, this sediment can plug orifices in the strut valving and cause the strut to remain in the fully extended position and cause a harsh ride. If a thorough road test of the vehicles does not return the strut to normal operation, it will be necessary to replace the strut(s)."

Buick Hi-Per Strut

2010 LaCrosse HiPer Strut
Vs
MacPherson Strut Comparison





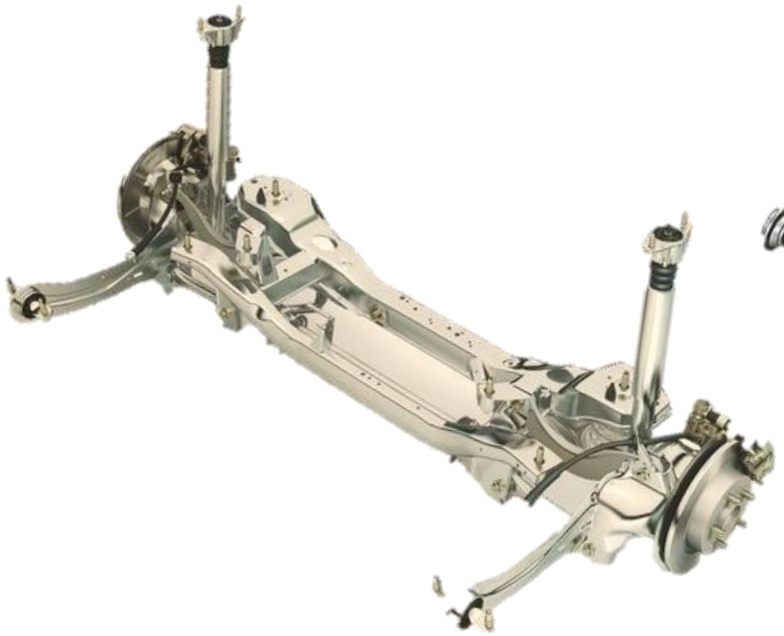
Multi Link Suspension

- Used on many Front and Rear Drive axles FWD and AWD.
- Individual links as opposed to conjoined A-arms.
- Arms may have bushings at both ends or a bushing and a ball joint.

2006 Audi A6

Rear Suspension

’09 Honda Fit
H Beam Straight axle



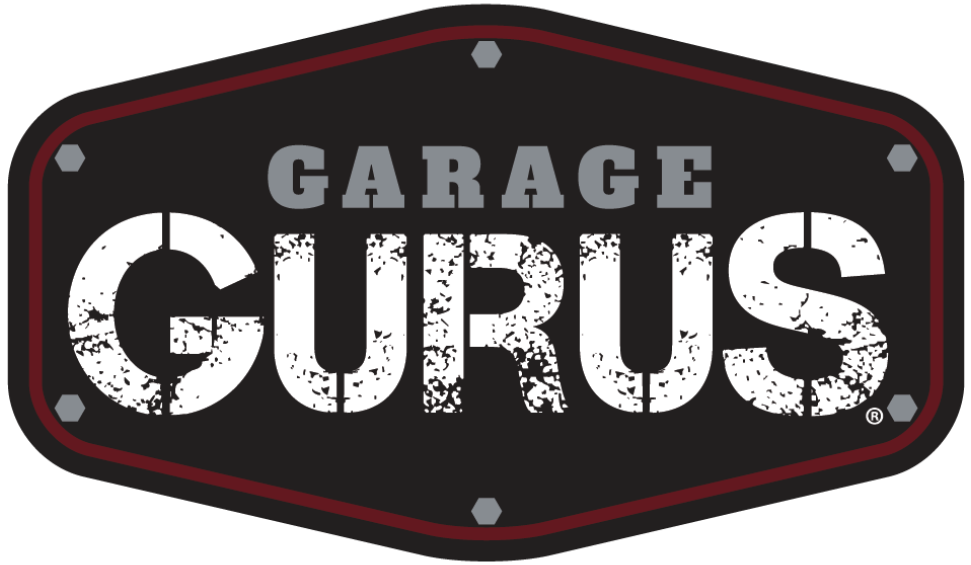
’07 Ford Focus
Independent suspension

’10 PT Cruiser
H Beam Straight axle
w/ Watts Link

Solid Axle Rear Suspension

2014 Ram 2500

- 5 Link coil spring design.
- Better articulation over obstacles than leaf spring suspension.
- Ride quality and handling are improved.
- Coil spring design can tow up to 17,940 pounds.



Advanced/Active Suspension

CVSA – Continuously Variable Semi-Active

Active Suspension

Who uses it?

Post 2000

2002: Mazda6 Wagon 4wd

2002 - 2020: Cadillac Seville STS, first MagneRide

2002 - 2020: Audi A8 and Volkswagen Phaeton: Adaptive Air Suspension with Continuous Damping Control (CDC)

2003 - 2021: Chevrolet Corvette, some Cadillacs and other GM vehicles with MagneRide

2004 – 2007: Volvo S60R/ V70R "Four-C Active Chassis"

2008: Audi TT Magnetic Ride

2010 – 2020: Acura MDX (optional Advance package version)

2010 - 2020: Volkswagen Passat with Adaptive Chassis Control (DCC)

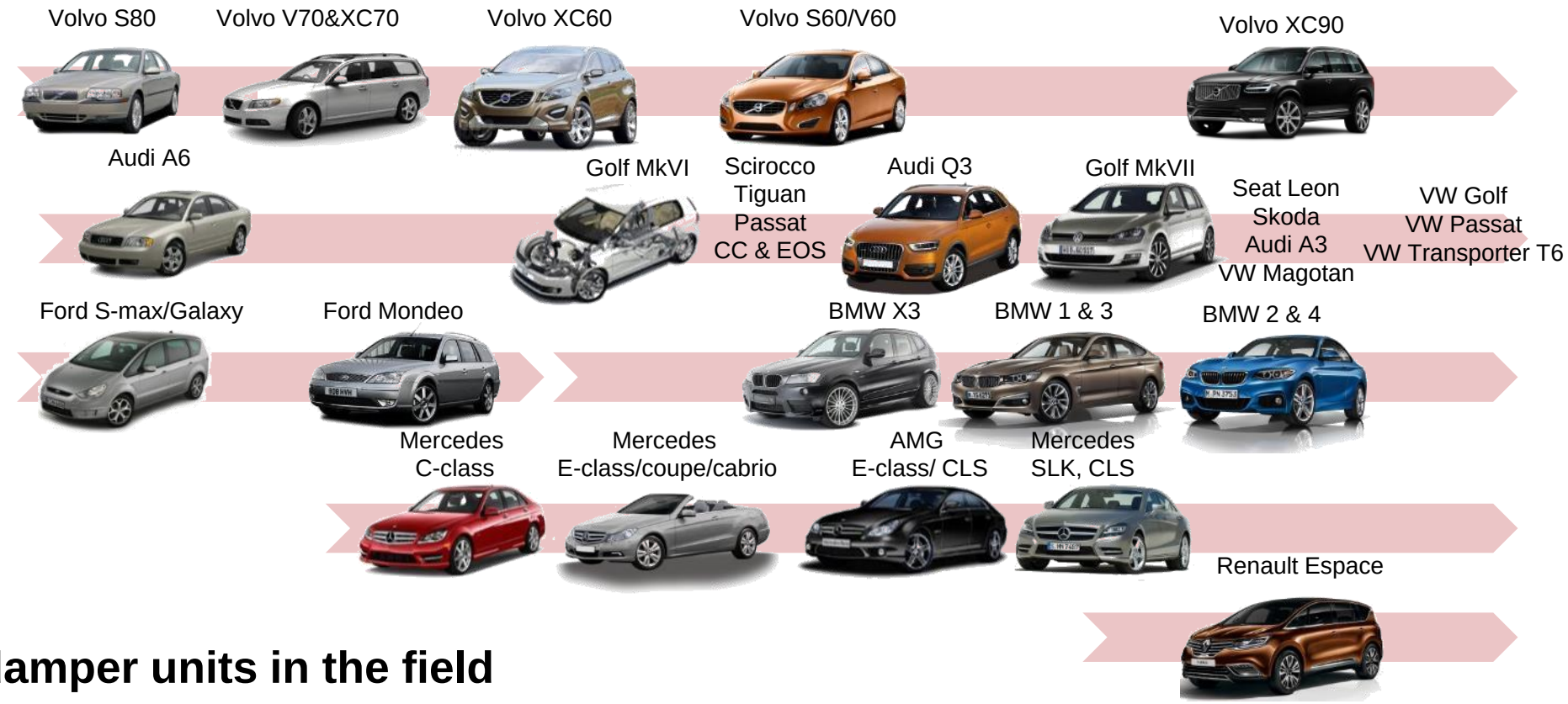
2010 -2020: Volkswagen Touareg with Adaptive Body Roll Compensation

2012 -2020: Range Rover Evoque - MagneRide

2013 -2020: Range Rover Sport - Adaptive Dynamics w/ Magnetorheological dampers&Dynamic Response w/ active anti-roll bars

2014 - 2020: Mercedes S Class (Magic Body Control)

CVSAe (Active) Suspension Vehicles



5 million damper units in the field

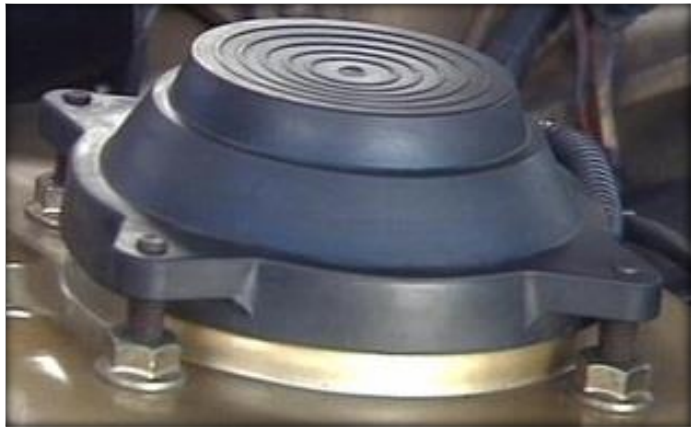
Launched on 37 models, 9 new models in development

2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020

Variable Orifice

Electrically Adjusted Type I

- Ride Adjustment accomplished using electric motor and module
- Motor will rotate mechanical selector to the desired ride
- Early designs of Automatic Variable Ride Control only determined stiffness of shock by restricting flow
- Available in aftermarket but also available as an OE application on some models



Variable Orifice

Electrically Adjusted Type II

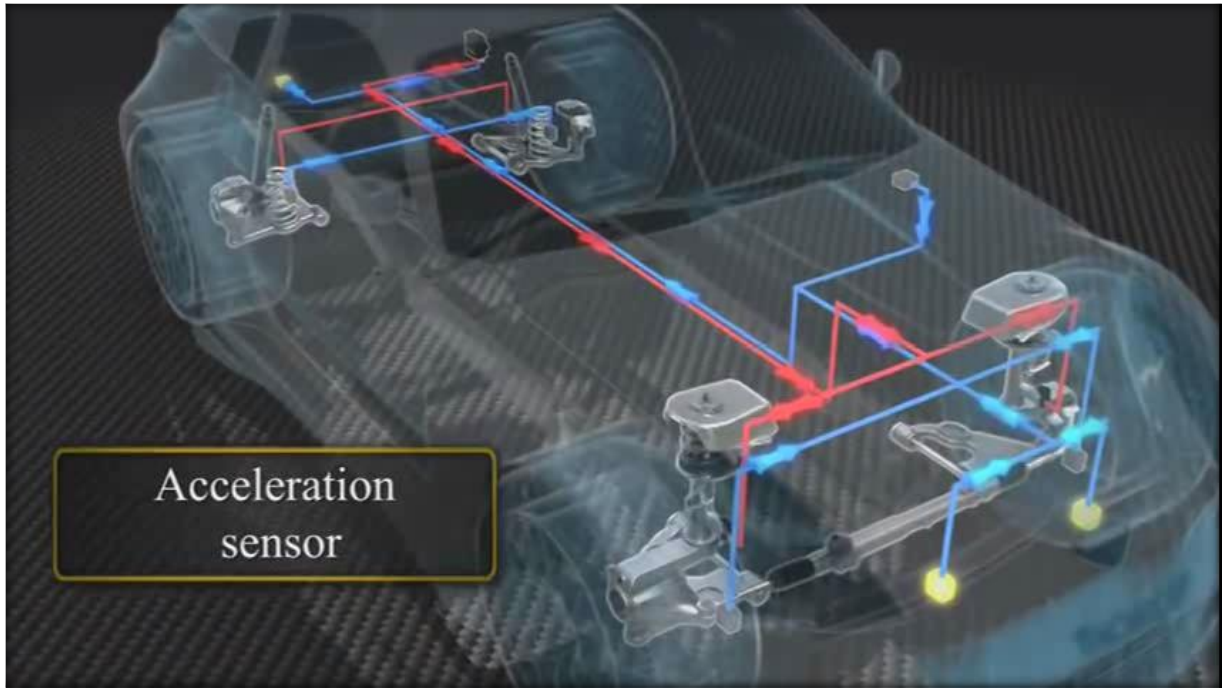
- Ride Adjustment accomplished using electric solenoid and module
- Solenoid will control hydraulic flow depending on coil energizing
- This system can be paired with stability control programs due to the speed of command and reaction

Electronic Variable Orifice

Inputs

- Accelerometers
- Body Height Sensor
- Steering Angle Sensor/Steering Rate
- Wheel Speed Sensor

Suspension Module & ABS Module transfer data continuously



Outputs

- Solenoids
- Brakes

Electronic Variable Orifice

Solenoid Control

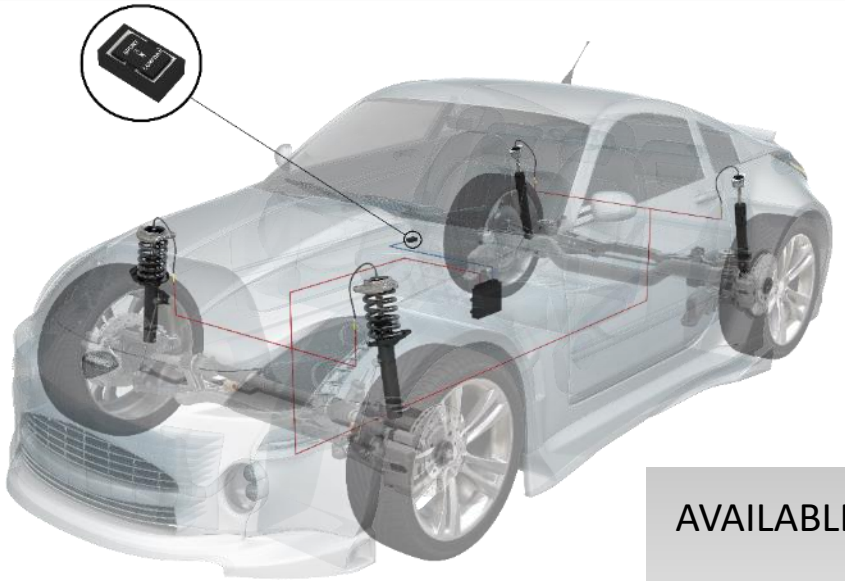
- Valve will control both Compression & Extension
- Suspension Module is in full immediate control of all 4 corners
- Shock Dampening is Controlled using:

<u>Current</u>

- Sport ride = 1.6 Amps
- Comfort = 0.29 Amps

Dual Mode Selective Damping

- Dual Mode selective damping offers compact car drivers a default comfort drive or a more sporty ride at the touch of a button.
- Four electronically controlled dampers connect to a simple control unit which adjusts the position of the valve in each damper.
- A motor inside the damper cylinder aligns two different sets of orifices on the piston to allow for more/less hydraulic fluid flow.



AVAILABLE MODELS

Ford Focus RS
Mazda 626

Continuously Variable Semi-Active
CVSA**e** – external valve
CVSA**i** – internal valve
CVSA**2** – two independent valves

CVSAe

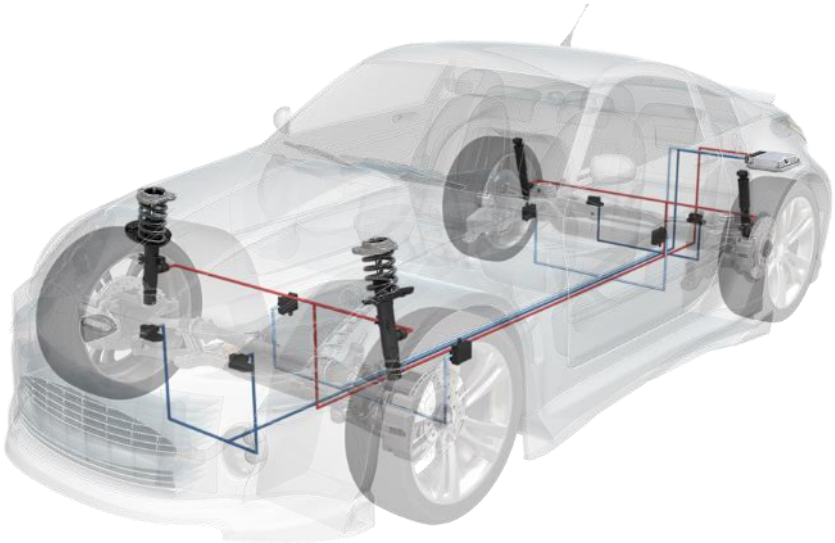
- Continuously Variable Semi-Active Suspension (CVSA) with external valve technology senses the road and driving conditions to independently adjust four dampers in real time for a more comfortable and controlled ride.

- An externally mounted electronic valve is linked to the vehicle's driving mode control, so the system can perfectly match the driver's needs.

- The externally mounted electronic valve controls the amount of hydraulic fluid flowing through the cylinder by restricting flow based on electrical current.

AVAILABLE MODELS

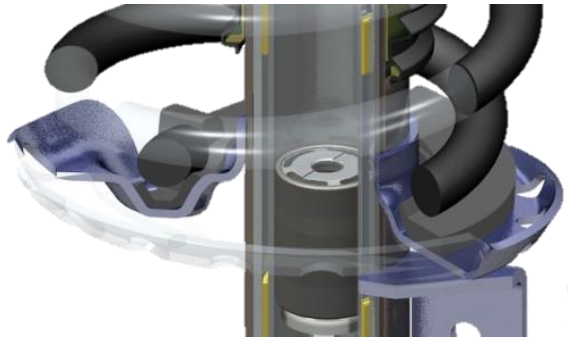
Audi Q2,Q3
BMW 1 series, 2 series Cabrio, 2 series coupe, 3 series, 4 series, X3, X4
Infiniti Q50
Mercedes-Benz CLS, SLC
Volkswagen Golf, Passat, Sharan, Tiguan, Touran, Transporter
And More

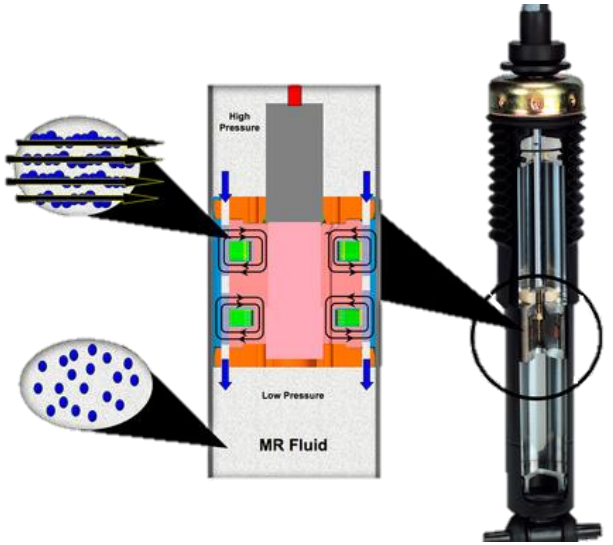


Magnetorheological

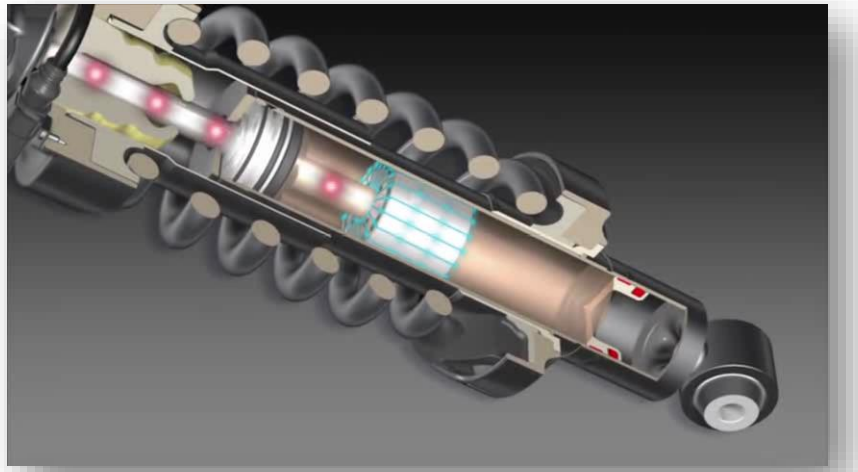
Commonly known as:
MagneRide

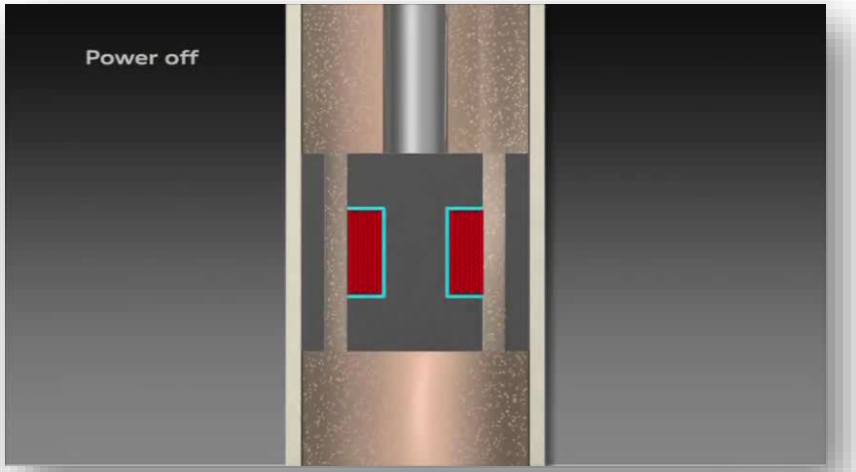
- Ride Adjustment accomplished using electromagnetism
- Electromagnet will change fluid viscosity
- Pulse width modulated
- This system can be commonly paired with stability control programs due to the speed of command and reaction

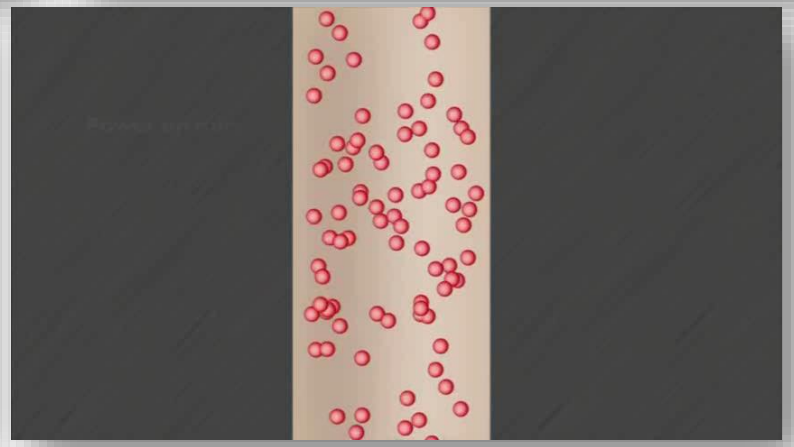


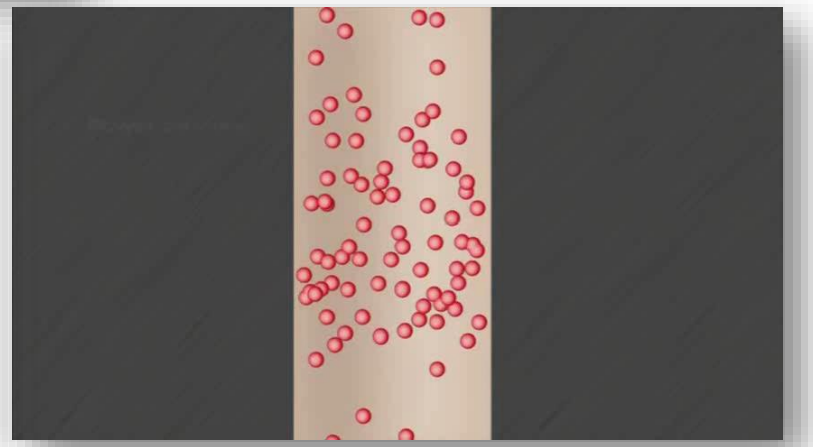


Magnetorheological









Magnetorheological

Inputs

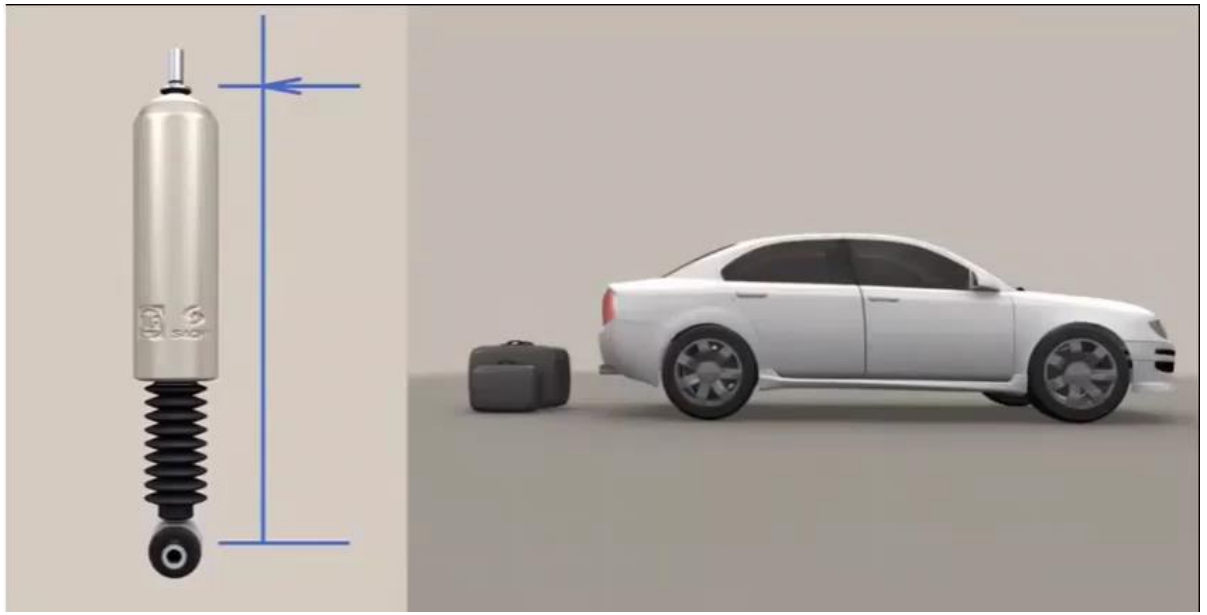
- Ride Height Sensors
- Yaw Rate, Lateral & Longitudinal Sensor
- Throttle Position Sensor
- Steering Angle Sensor

Outputs

- Shock Actuator
  - Actuator controls shock using duty cycle control via Suspension Module
    - System “OFF” = 5%
    - System “ON” = 80%

Self Leveling Hydraulic Damper

- This is a self-contained and self energized unit, which automatically optimizes front-to-rear ride height, which is generated by the relative movements between the axle and vehicle body.



- Each unit is a self-contained leveling system complete with internal pump, reservoir, sensor, regulating mechanism and damper.

Nivomat

Active Ride Control – High Speed Hydraulic

High Speed Hydraulic

- Ride Adjustment accomplished using electric solenoid and module
- Solenoid will restrict hydraulic flow pending on coil energizing
- This may be a linear feed based on electrical potential or accomplished through pulse width modulation
- This system can be commonly paired with stability control programs due to the speed of command and reaction

Active Body Control

Height & Strut Position Sensors, & Accelerometers:

- Side to Side
- Front to Rear
- Vertical

The Strut is composed of:

- Spring
- Shock Absorber
- **Active** hydraulic cylinder

The system is controlled by:

- Two micro-computers
- High pressure hydraulic pump

Active Ride

(Mercedes Active “Magic” Body Control)

Accuracy

- Measures up to 45ft ahead of the vehicle
- Accuracy of up to 1/8” ground deviation
- Functional up to speeds of 80MPH

Specs

Pressures

Oil Pump Delivery @ Idle = >120 Bar (1740 Psi)

< 120 Bar = Possible Oil Pump Failure

>140 Bar (model 210)

>153 Bar (model 140) = Possible Level Controller Failure

Active Ride

Diagnostics, Calibration & Bleed

“Rodeo Mode”

“Calibration Mode”

“Shock Rate Diagnostic”

Air Suspension

System Overview

- Air ride control uses a form of air bag or air strut assembly as the primary spring (some systems may have a combination of both airbags and coil springs as helpers and fault control)

- The system will generally utilize an electric compressor typically located in the rear of the vehicle to compress air drawn from the atmosphere and stored in an accumulator/reservoir

Air Suspension

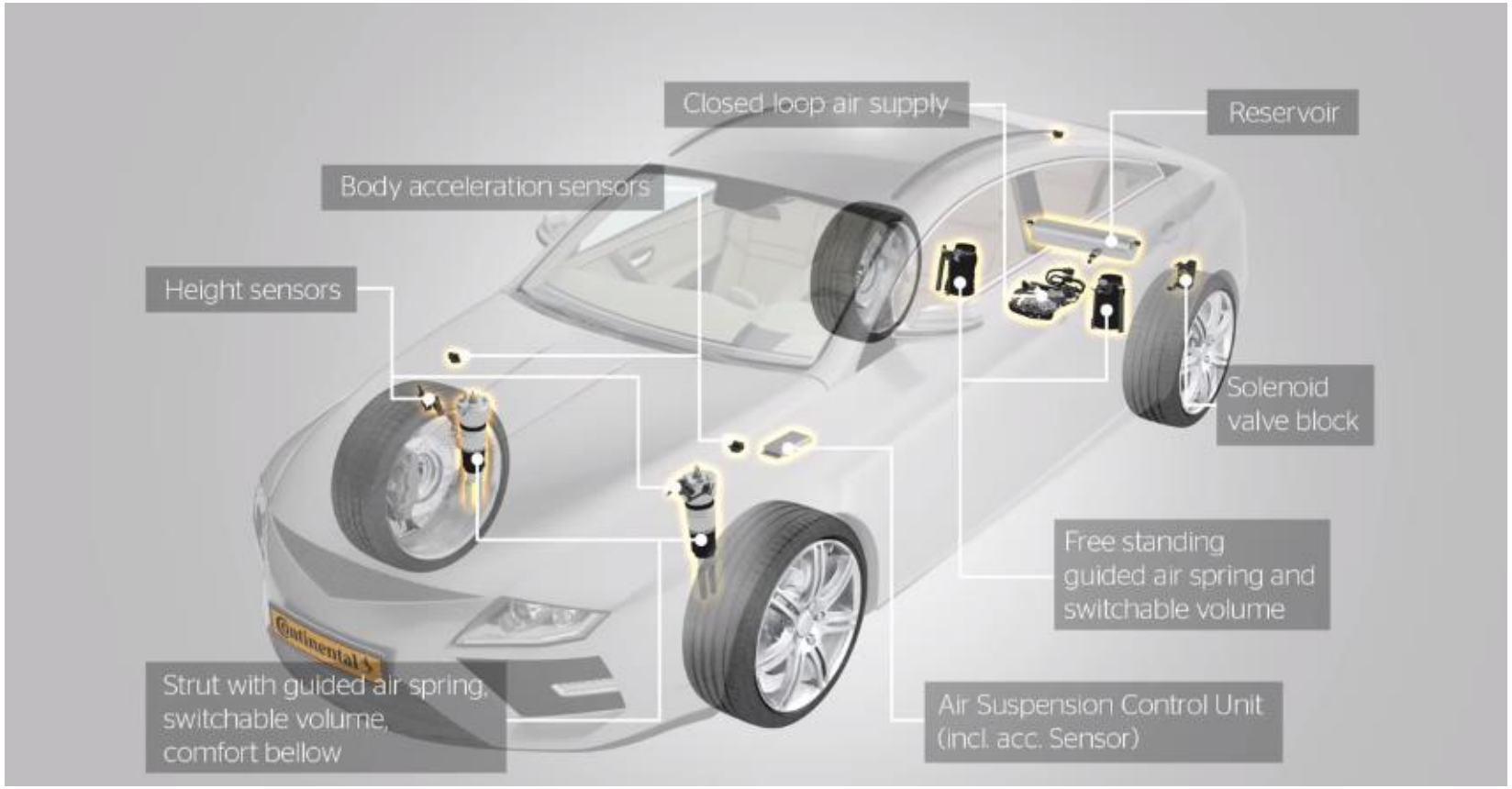
System Overview

Inputs

- Height sensors
- Accelerometers
- Pressure sensors
- Valve position input
- Ride Control Switch

Outputs

- Air compressor
- Solenoids/ Valves
- Suspension Module



Air Suspension

Service

- Some vehicles will require you as a technician to de-activate the suspension system for basic services, lift or alignments
- Also review and research the manufacturers specifications for service and locations
- Newer vehicles may require you to use scan tools or special tools to accomplish this task

Lincoln Navigator

Conversion Option

- Convert electronic or air suspension to passive suspension
  - Reasons:
    - Cost of replacing damper
    - Cost of replacing air compressor
    - Cost of replacing air spring
    - Cost of replacing ECU

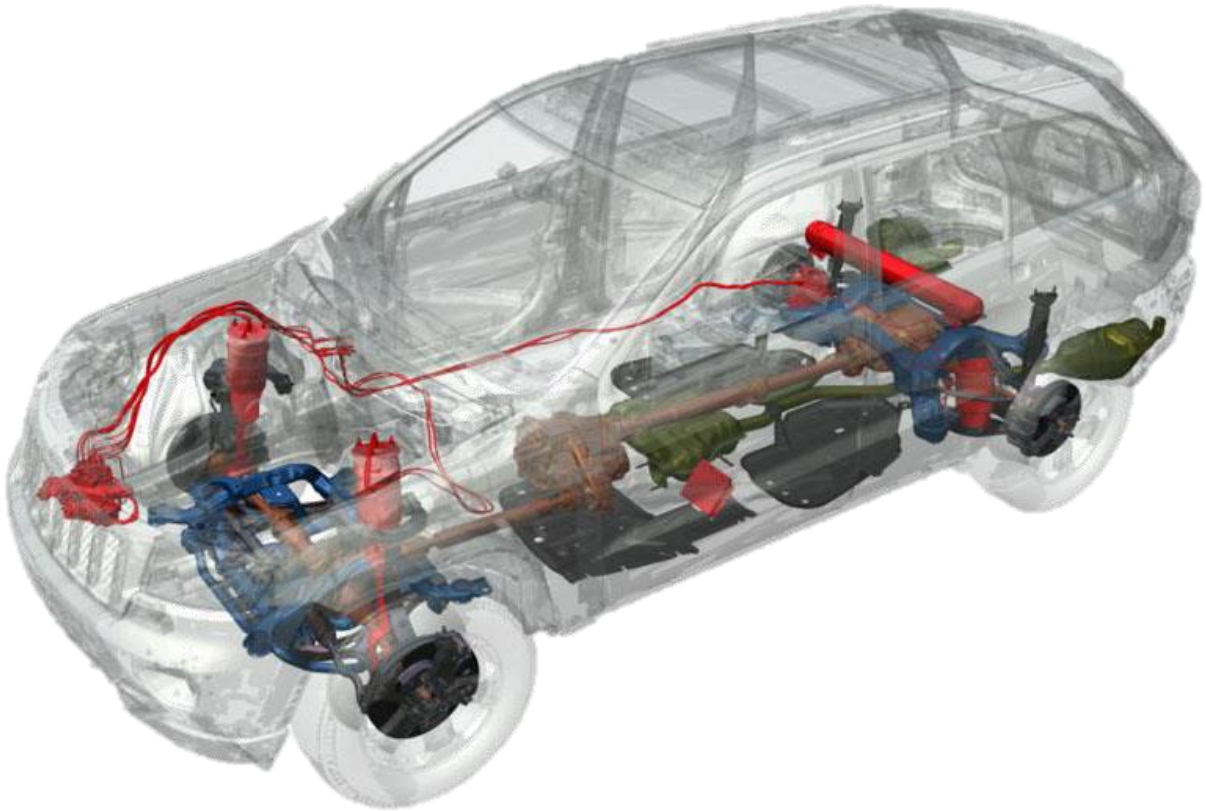
Removal and replacement tips

- Verify type of OE system before replacement
  - Conversion kits are designed specifically for the type of electronic suspension they are replacing
    - Standard Electronic
    - Magnetorheological
    - Air Suspension

Standard Electronic Conversion

Air Suspension Conversion

Nitrogen Suspension



- Chrysler has introduced this closed variable height system substituting compressed air with Nitrogen.

- **Benefits**:
- Inert - Less vulnerable to temperature changes
- Dry - Does not suffer of condensation build-up
- True closed - Atmospheric air does not influence the system keeping system free of corrosion

Nitrogen Suspension

- Ride height changes with changes in drive mode selected from Selec-Terrain switch
- Ability to change ride height by the push of a button
- Improved fuel economy at highway speeds
- Improved off-road capability
- Full time, four-corner, load leveling

Nitrogen Suspension

Park Mode

- 1.5” lower from normal ride height
- Allows easier entry & exit
- Improved roof access
- Accommodates for loading & unloading

Nitrogen Suspension

Aero Mode

- 0.5” lower from normal ride height automatically
- Reduces Drag at Hwy Speeds
- Improves fuel economy
- Improves ride comfort

Nitrogen Suspension

Off-Road 1 Mode

- 1.3” higher from normal ride height
- Increased ground clearance for weather & Off-Road conditions
- Increased:
  - Approach
  - Departure
  - Break-over Angles

Nitrogen Suspension

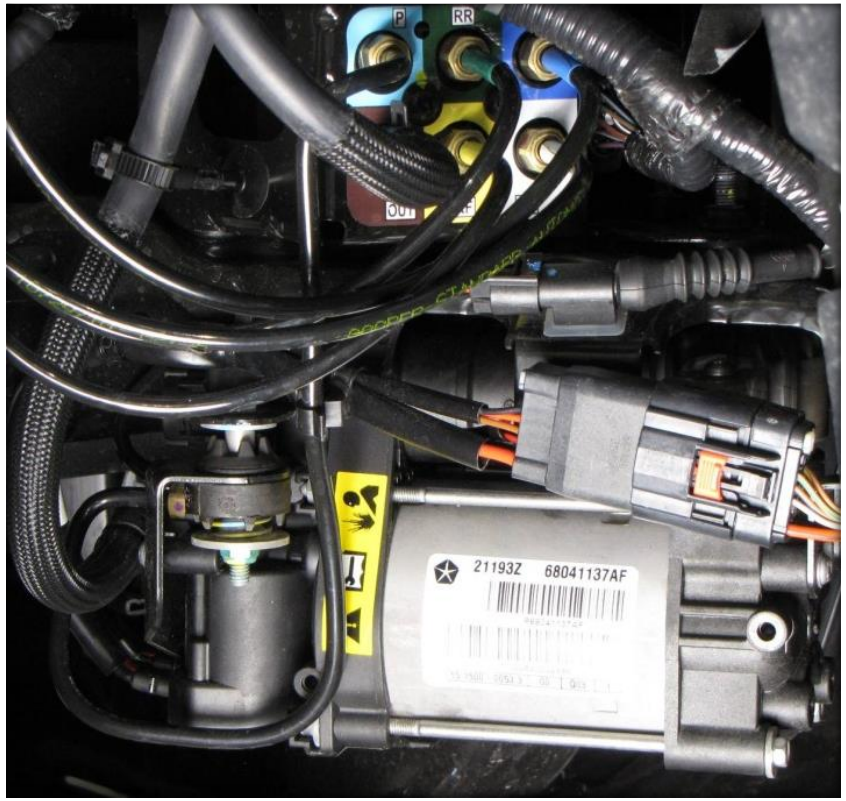
Off-Road 2 Mode

- 2.6” higher from normal ride height
- Operates only at low speeds
- Total of 10.6” of ground clearance

Nitrogen Suspension

Service Mode

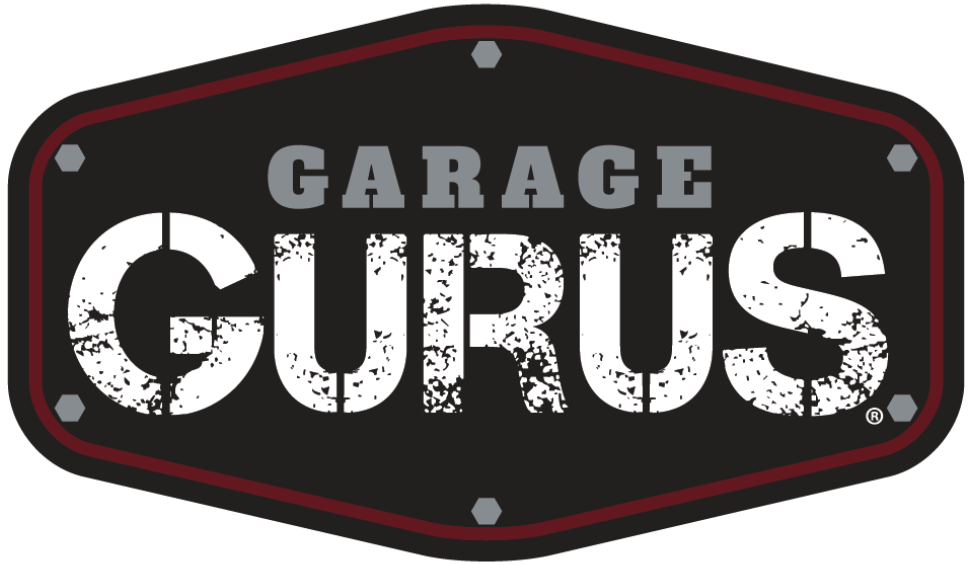
- To service or raise the vehicle it will not be necessary to put into a “Service Mode”
- “Service Mode” will be necessary to service the actual system and replace “Air” lines. This insures the closed system is not contaminated allowing proper functions



System is “conveniently” located under the passenger headlight

Mercedes Airmatic Suspension

Modern Suspension Technology



Road Sensing Suspension Case Study

Cadillac DeVille DTS

Cadillac DeVille DTS

- Operation:
- The Electronic Suspension Control system with rear Automatic Level Control (ALC) controls damping forces in the front struts and rear shocks in response to various road and driving conditions.

Cadillac DeVille DTS

- Operation:
  - The ALC system automatically adjusts the rear height in response to changes in vehicle loading.
  - Height is measured by 2 rear position sensors. The analog voltage is read by the ESC module.
  - The ESC module then determines what action to take. Raise, lower, or no action at all.

Cadillac DeVille DTS

- Operation:
  - The Road Sensing Suspension system receives the following inputs:
    - Wheel-to-body position
    - Vehicle speed
    - Lift/dive
  - The module evaluates these inputs and controls actuators in each of the dampers independently to provide varied levels of suspension control.

Road Sensing Suspension Case Study

Cadillac Deville DTS

Owner complaint:

- "**Service Suspension System**" message upon startup.
- Poor ride quality.

Road Sensing Suspension Case Study

- Service Suspension System message on every start
- 118k miles, original shocks and struts
- Test drove the car to confirm condition
- Graphed suspension data during test drive
- Both rear shocks stayed at zero percent

ShopStream™ Scanner Data Viewer - 2002 Cadillac DeVille DTS 2015-11-03 15.09.pids

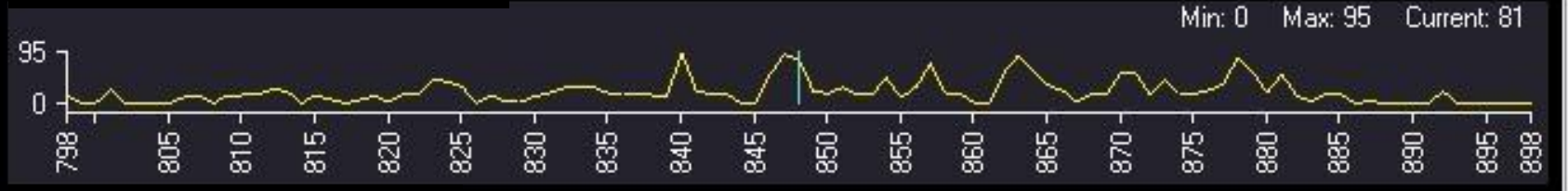
File View Tools Help

Exit | Hide PID List | 1 | 2 | 4 | 4 | 6 | 6 | 8 | 12 | 16 | Scale | Sweep

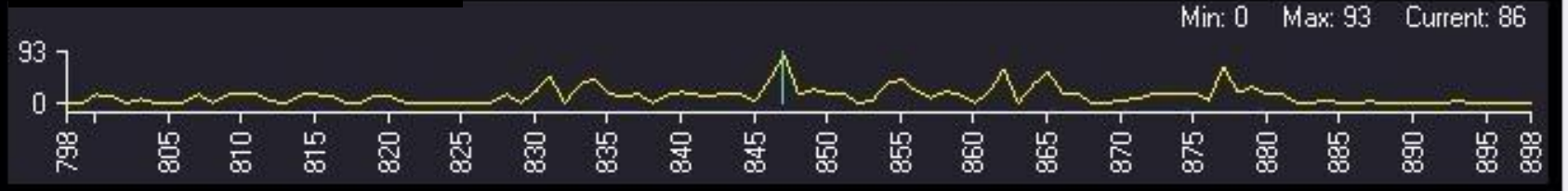
Complete List | Custom List

Name	Value
RF Damper Actuator Command (%)	90
LF Damper Actuator Command (%)	86
RR Damper Actuator Command (%)	0
LR Damper Actuator Command (%)	0
RF Position Sensor (V)	2.33
LF Position Sensor (V)	2.51
RR Position Sensor (V)	3
LR Position Sensor (V)	3.49
Vehicle Speed (mph)	14 MPH
Steering Position PWM	10.04
Battery Voltage Signal	14.47
Lift/Dive Status	Active
Lift/Dive Changed	No
ALC Compressor	No
ALC Exhaust Solenoid	No
LF Normal Force	40%
RF Normal Force	60%

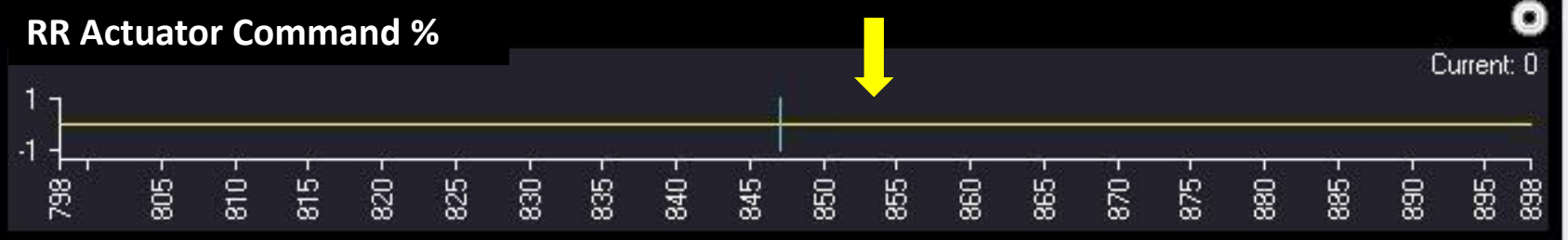
RF Actuator Command %



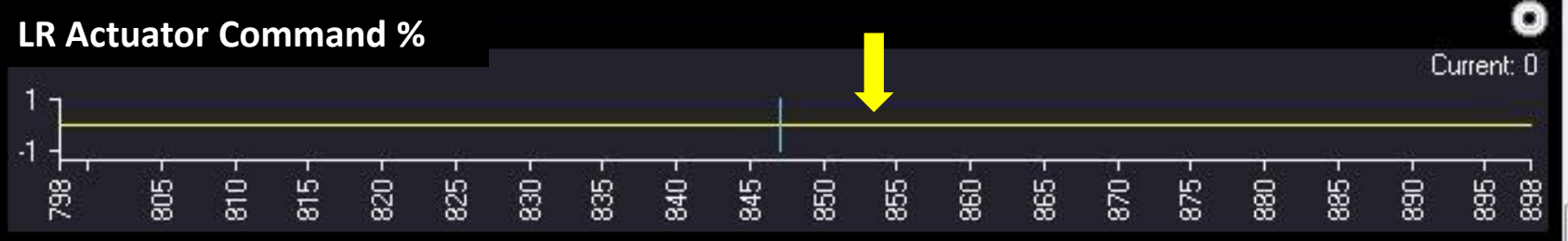
LF Actuator Command %



RR Actuator Command %



LR Actuator Command %



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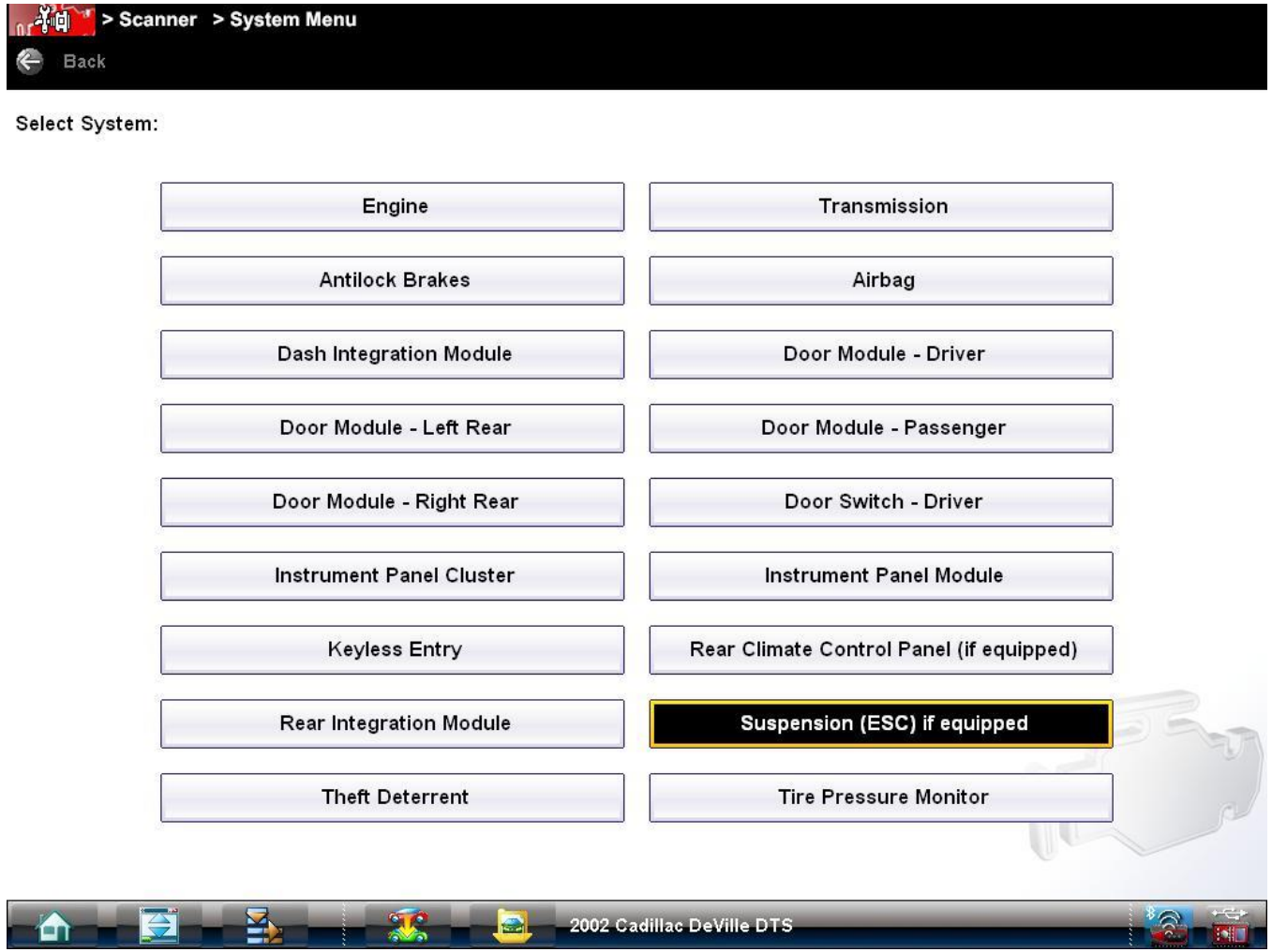
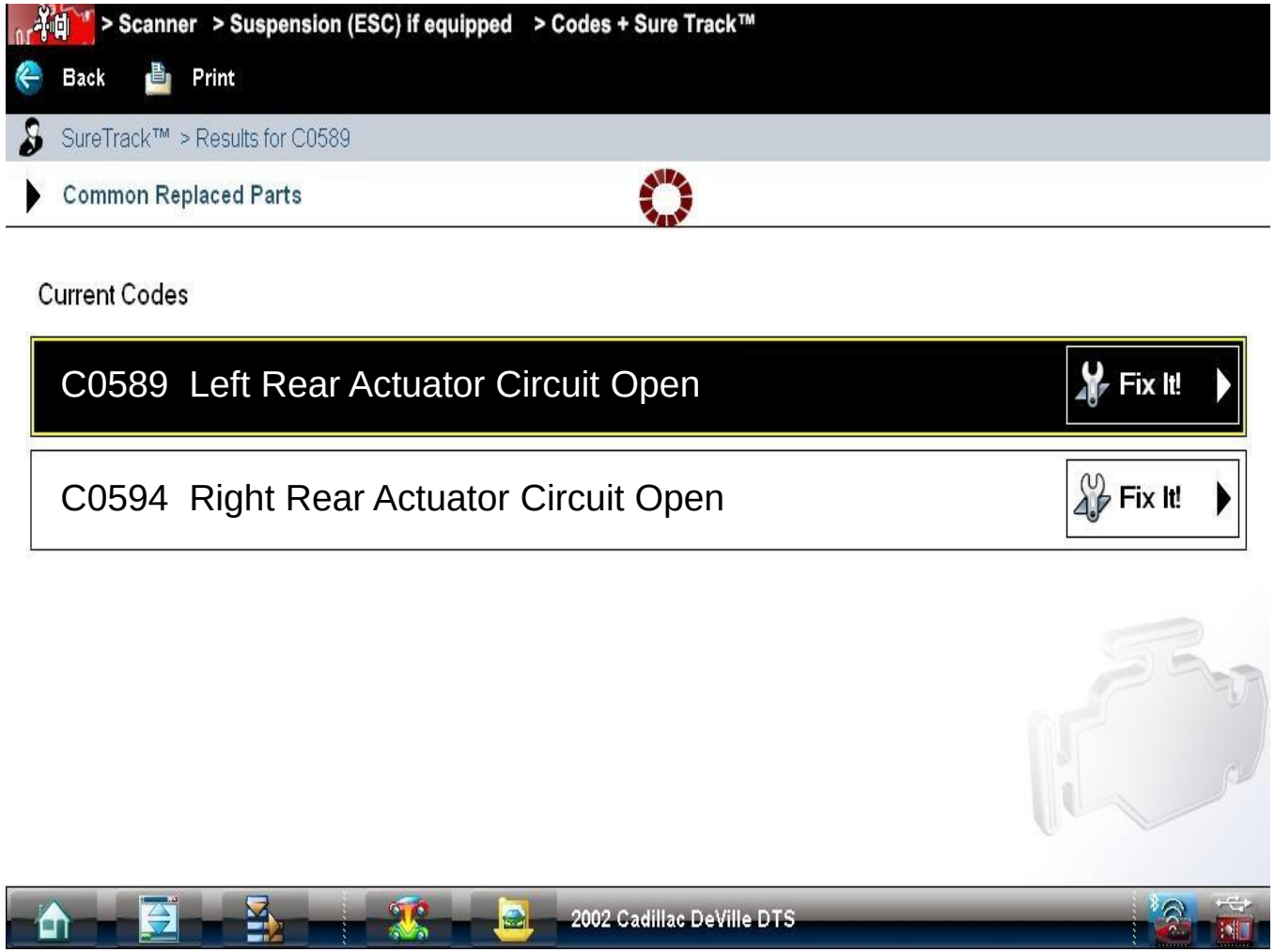
Road Sensing Suspension Case Study



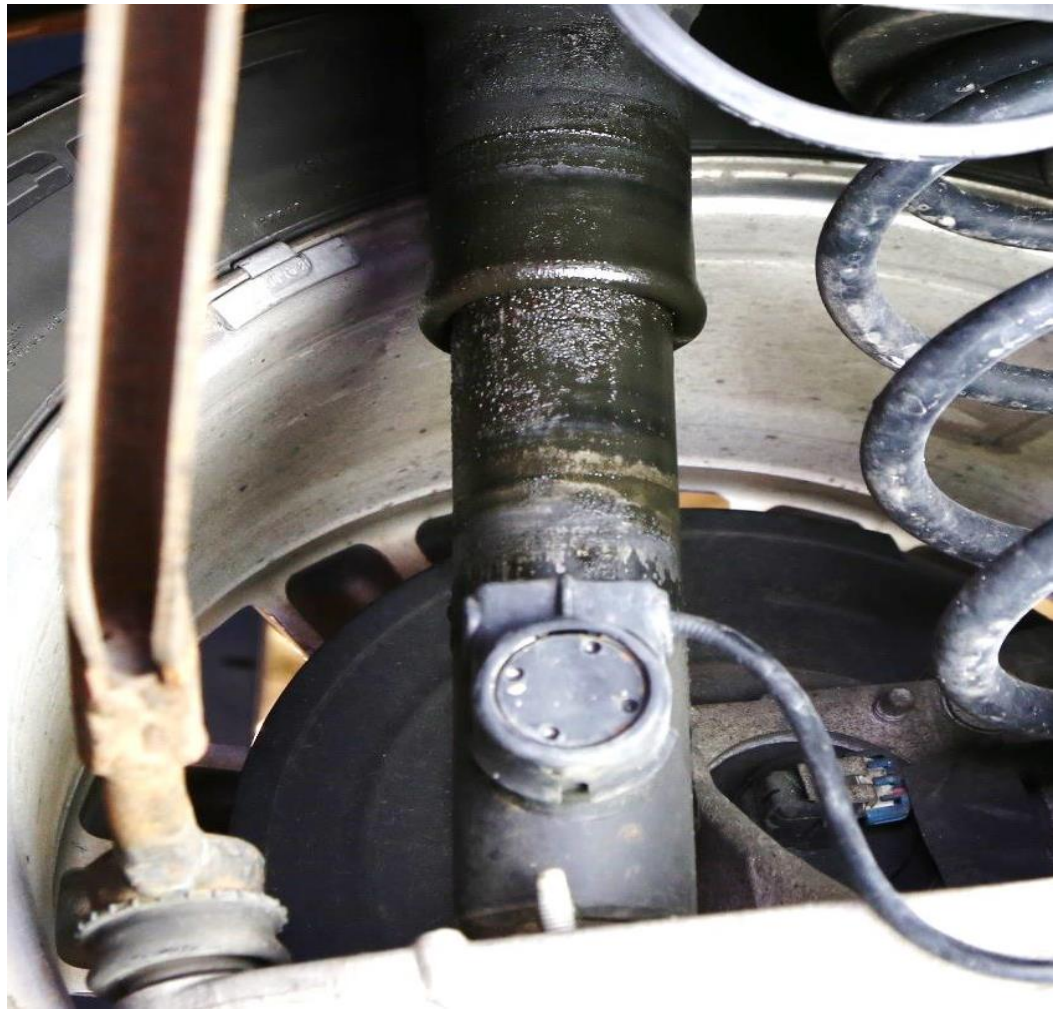
- Checked for codes in Electronic Suspension Control module

Road Sensing Suspension Case Study



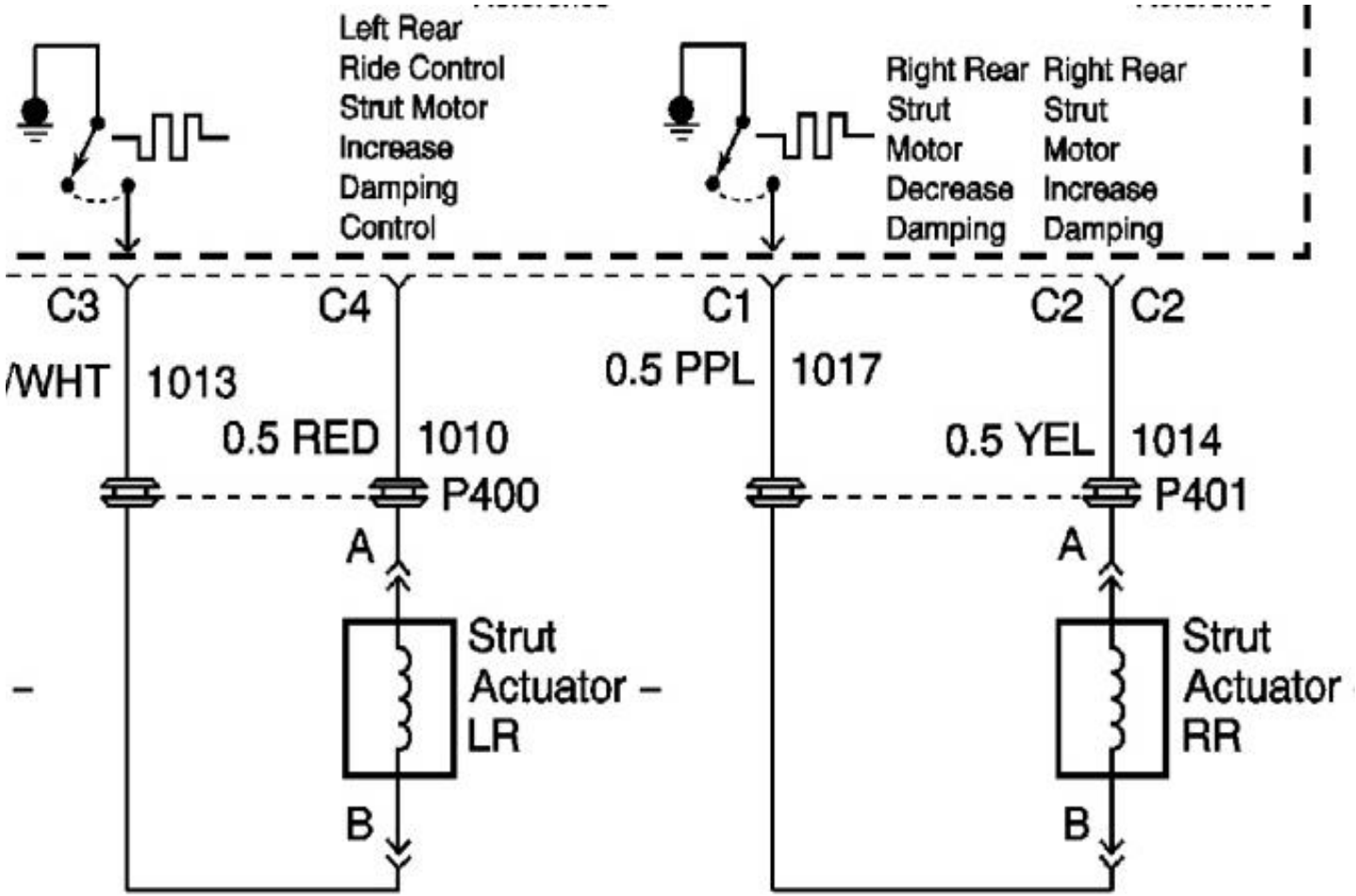
- Both rear actuator (shocks) circuits open C0589, C0594
- System strategy will command a zero percent pulse width to each affected actuator
- Perform circuit tests and visual inspection

Road Sensing Suspension Case Study



- Found both rear shocks leaking oil

Road Sensing Suspension Case Study



- With key off and actuators disconnected, measure resistance
- Specification is 9.5-15.5 ohms
- Strut motors controlled by PWM on the ground side

Road Sensing Suspension Case Study

- Both rear strut actuator circuits were open

Road Sensing Suspension Case Study

- Closer inspection revealed wire damage at each connector

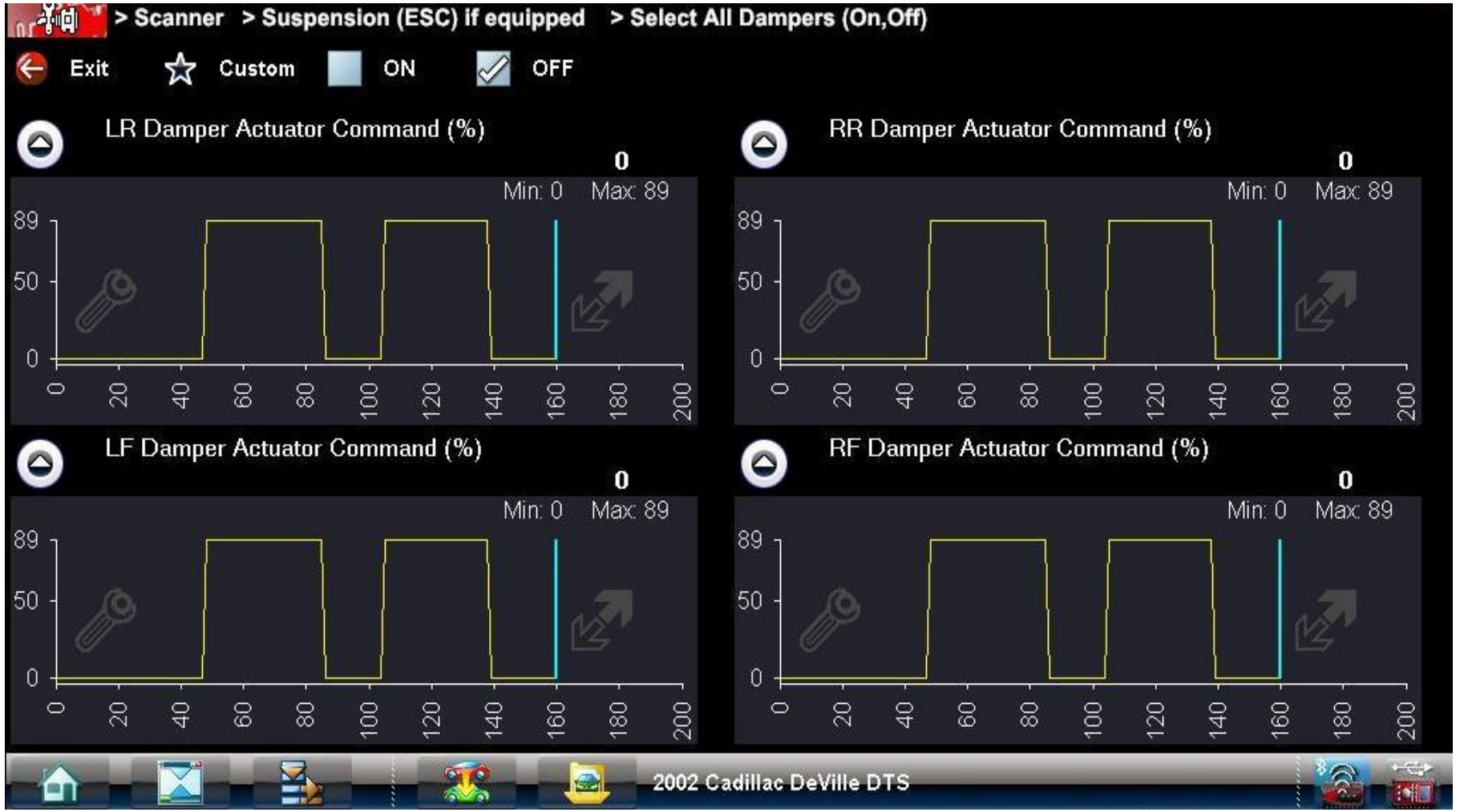
Road Sensing Suspension Case Study

- Tooth marks from an animal were found on both harnesses

Road Sensing Suspension Case Study

- New rear shocks were installed
- DTC’s erased and problem repaired

Road Sensing Suspension Case Study



- Notice all four commands after the repair

Case Study - Ride and Handling

Cadillac SRX With MagneRide Suspension

- Right front suspension seems very loose (bounces)
- When cornering on dips, vehicle feels like it may go out of control
- No warning lamps on dash
- 100K plus on odometer
- What would be the next step?

Visual Inspection

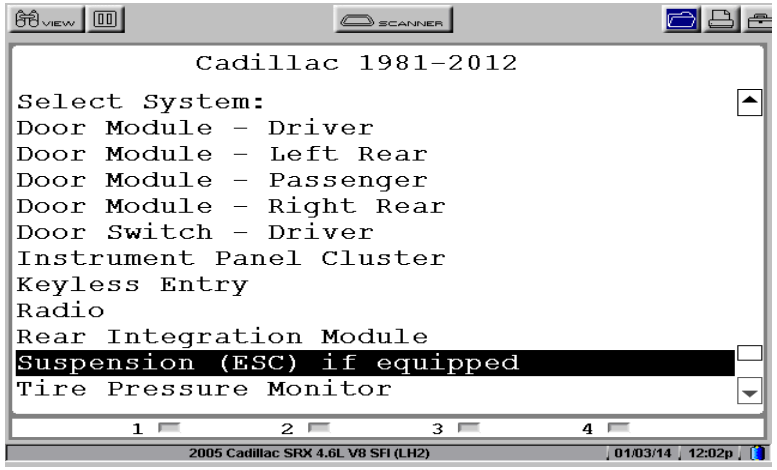
MagneRide™ suspension

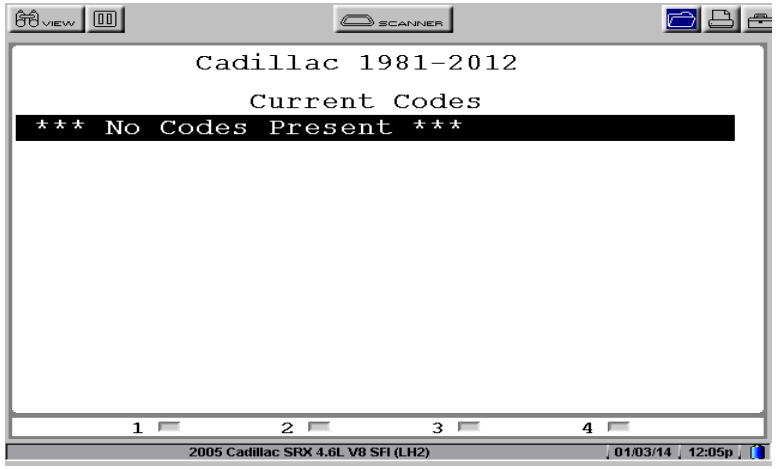
- Visual inspection revealed severe damper leakage front and rear (fairly common) and rear air bag empty
- We know at this point that costly mechanical repair is needed but can we verify that the electrical system is OK before calling the customer?

Diagnostic Steps Taken Using Snap-on scanner

If we had a circuit issue, wouldn't we normally have a code?

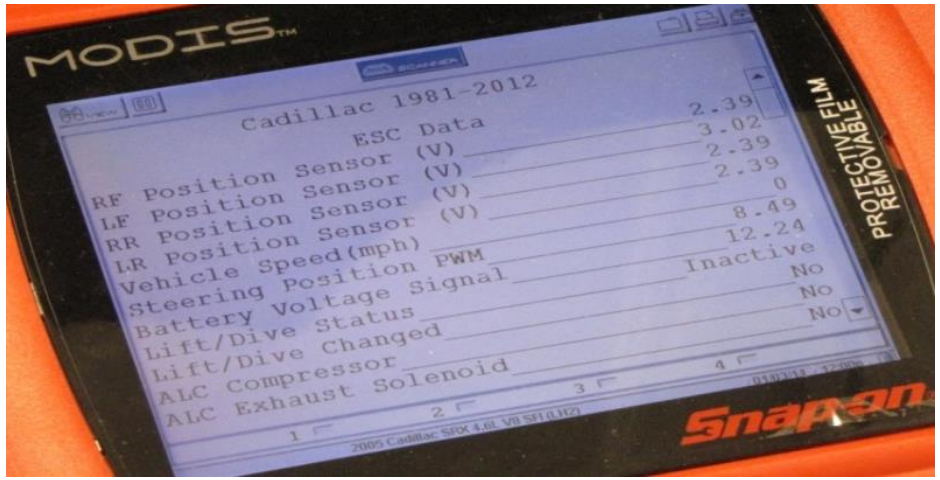
Select Suspension module



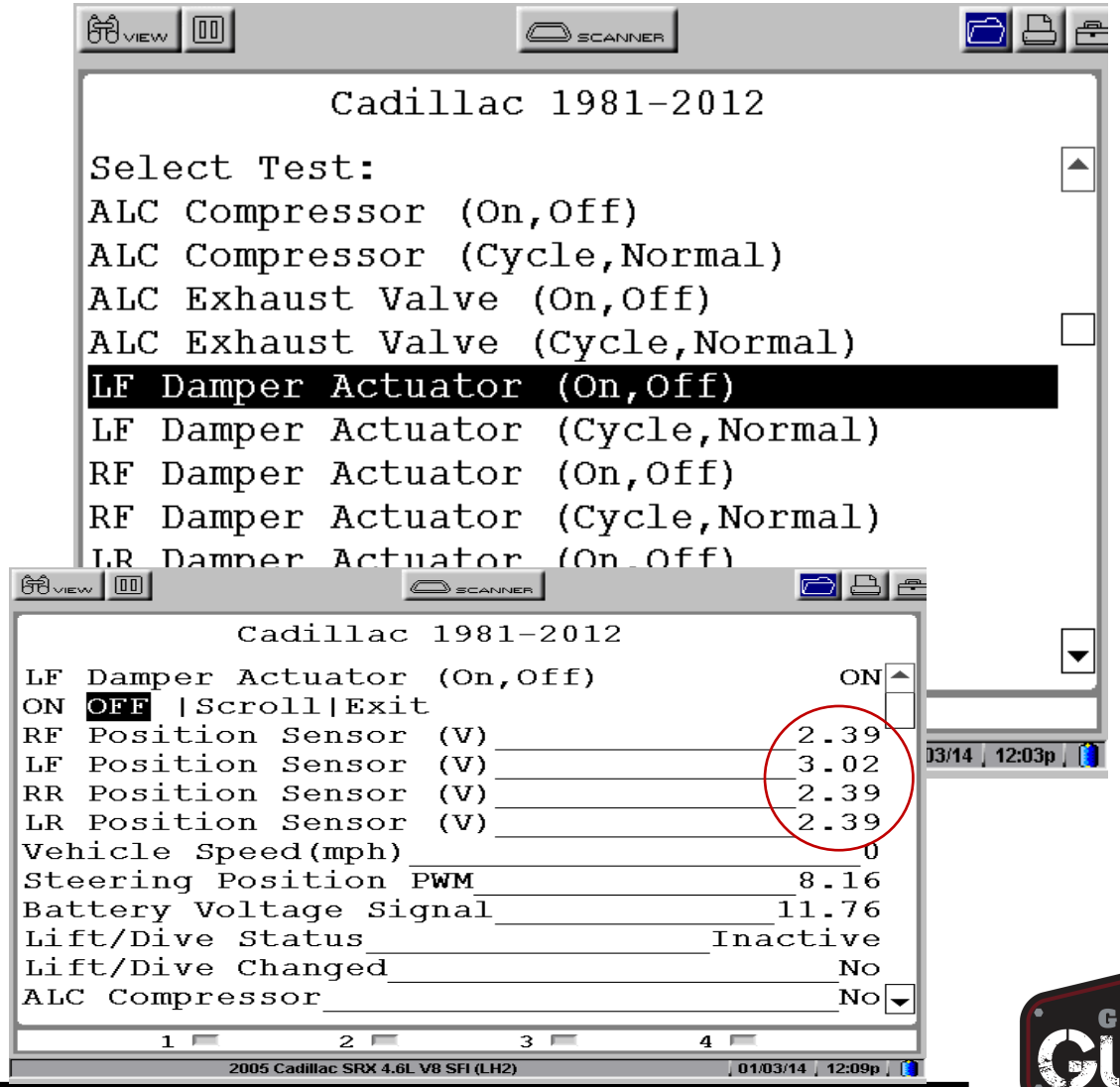


No current or history codes

Bi-Directional Control



- Bouncing the SRX at all four corners caused voltage change in the PIDs- you can also graph the data with the MODIS/VERUS for more clarity
- Many PIDS are displayed and bi-directional control is possible with Tech II and MODIS/VERUS



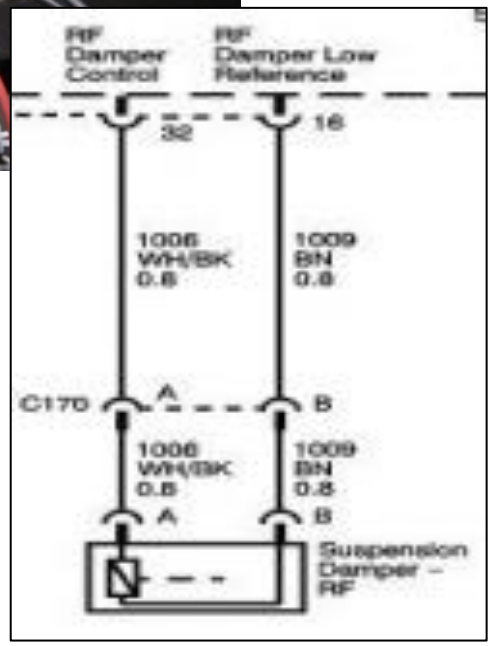
Bi-Directional Control with Snap On Scan Tool

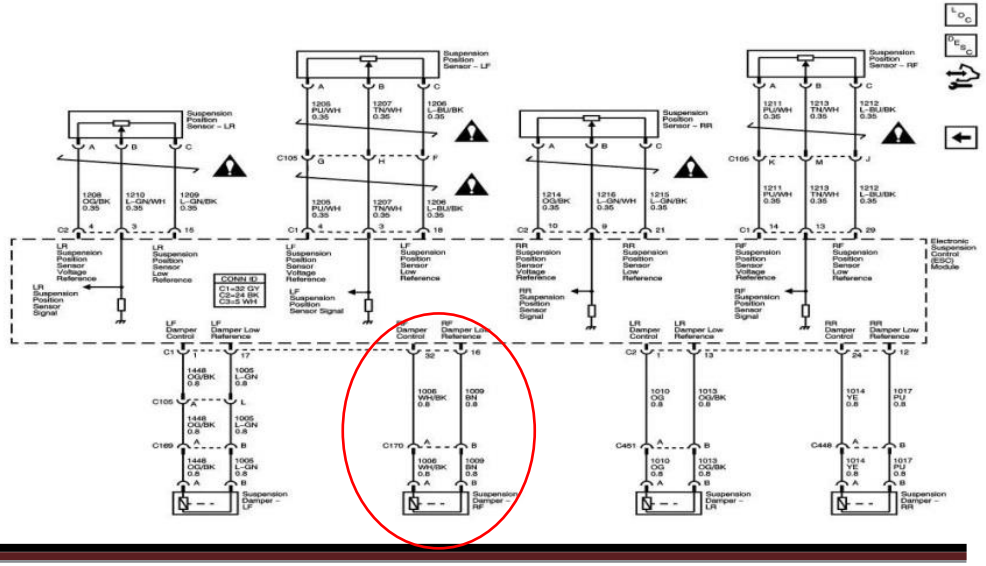
Normal Operation

Abnormal Operation

Is the ECM Sending a Signal to the Actuator?

- One scope channel has the red lead on the input side of the actuator (WH/BK), black lead to ground
- Second channel is the low amp probe around the wire
- DVOM-red to input side of actuator, black to ground

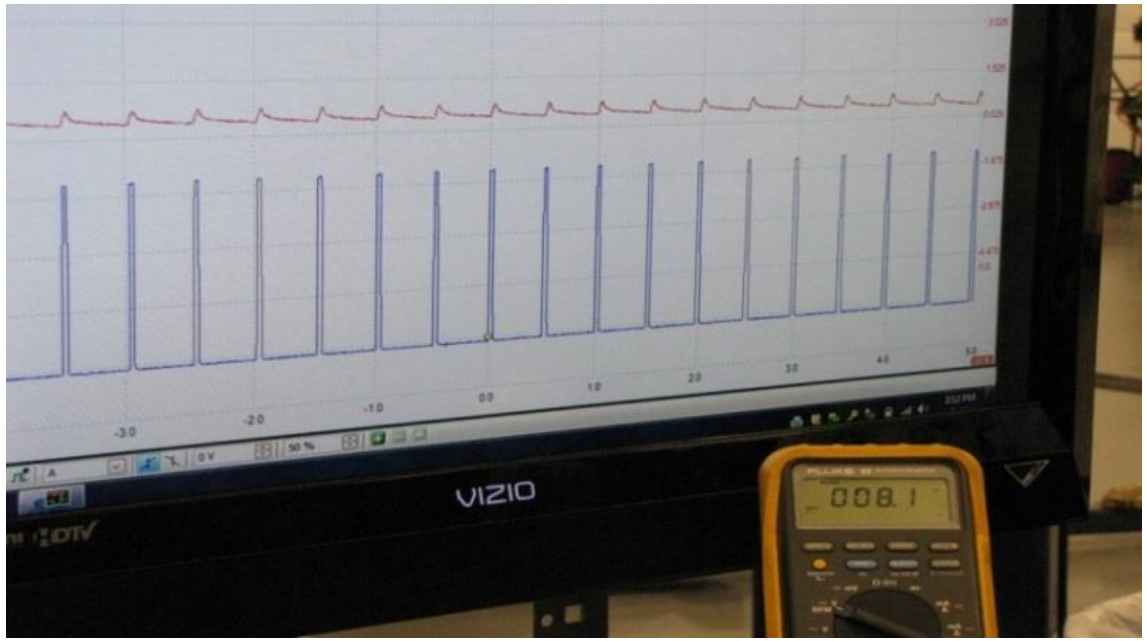




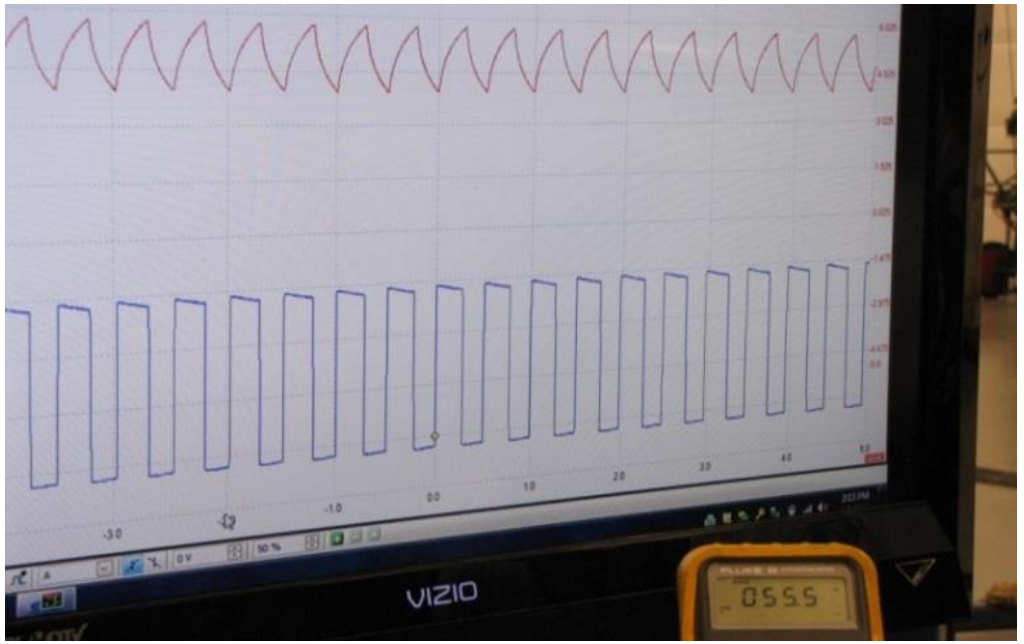
Actuator Turned On and Off by Scan Tool

- The computer is duty cycling a 12v signal
- A DVOM can be used to see a change as the actuator is turned on and off, but it is not telling the whole story

What is Really Happening?

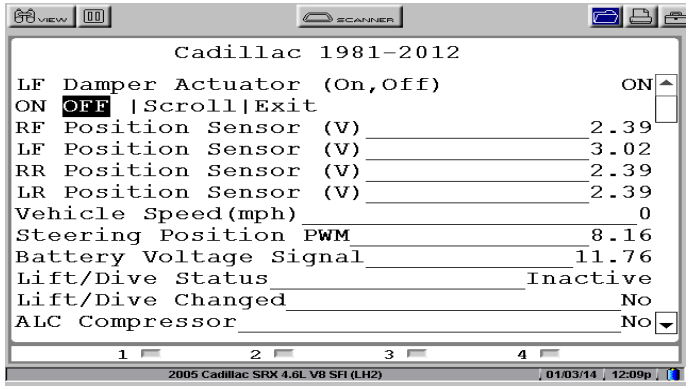


Commanded Off

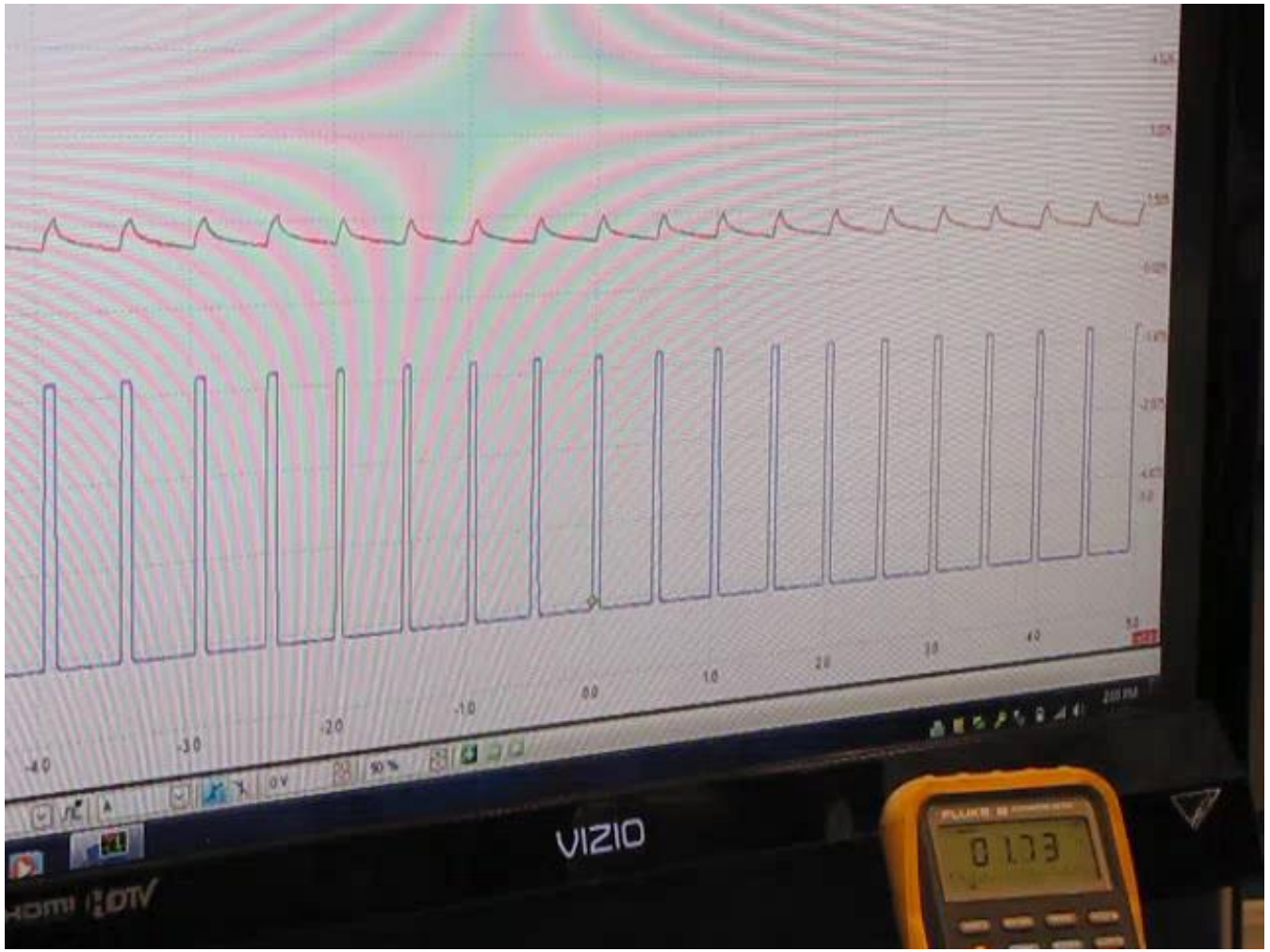


Commanded On

DVOM is now displaying % of duty cycle

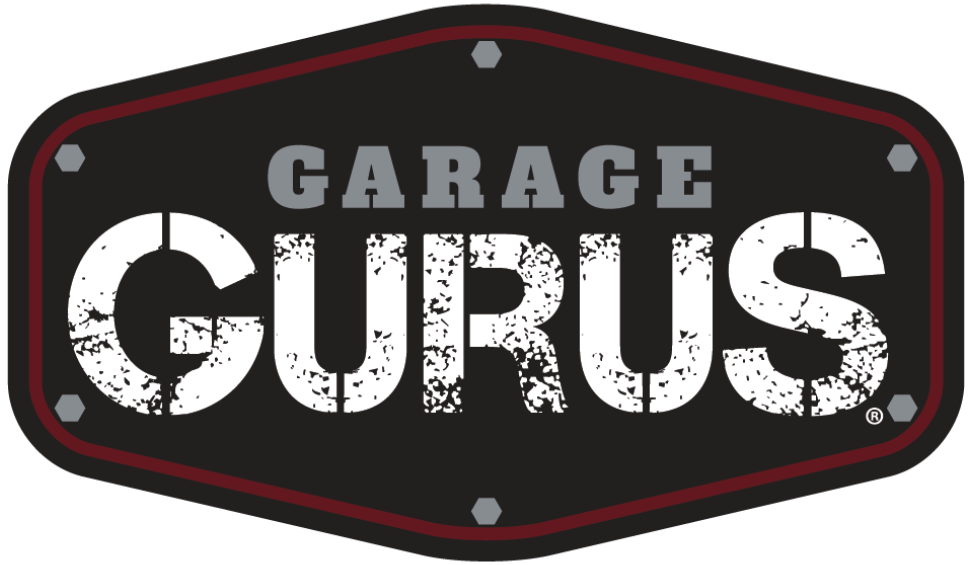


Cycling Actuator with Scan Tool



- Red channel is low amp probe around wire at R/F actuator
- Blue channel is connected to input wire from computer at R/F actuator
- This verifies that the computer is sending the signal and the strut is at fault

Gen 3 MagneRide



Chassis Inspection

Checking Ball Joint Wear

- Ball joint wear can be verified and measured using a dial indicator.
- Specifications vary widely between manufacturers, so be sure to consult service information for the application.
- In some states, the measurement must be recorded on safety inspection forms.

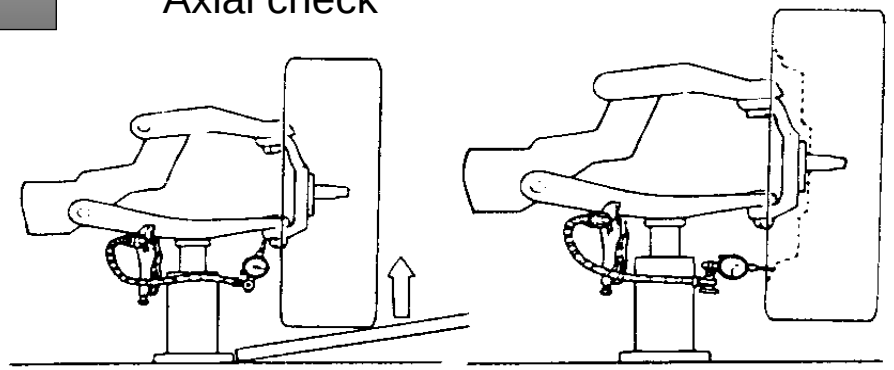
Pre-Alignment Inspection Procedure

Typical RWD

Typical FWD

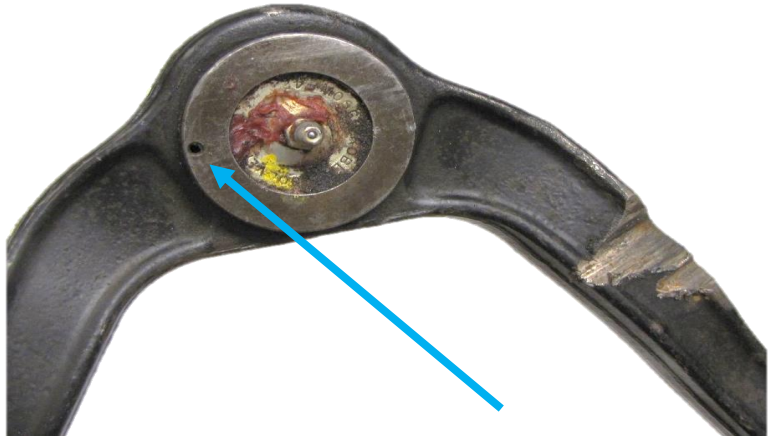
Axial check

Radial check

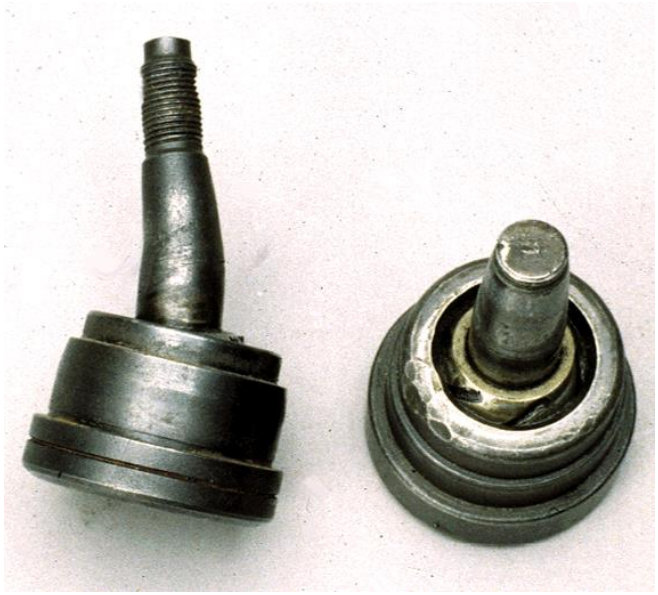


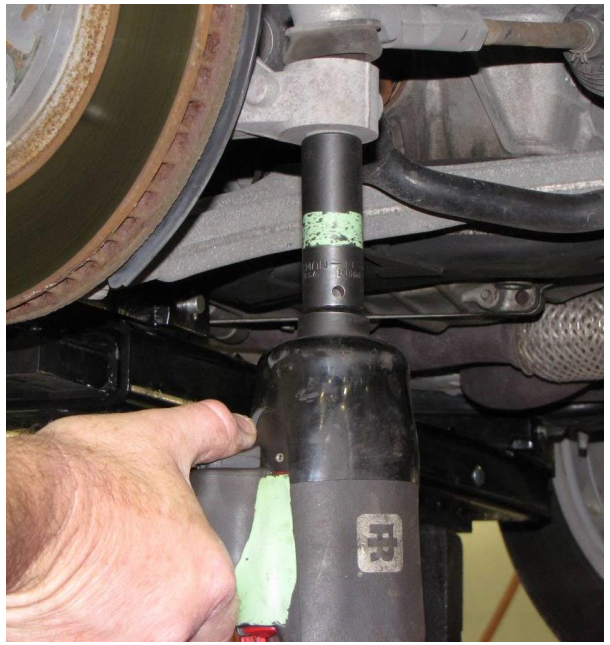
Remember, you can’t align looseness!

Elliptical Ball Joint Precautions



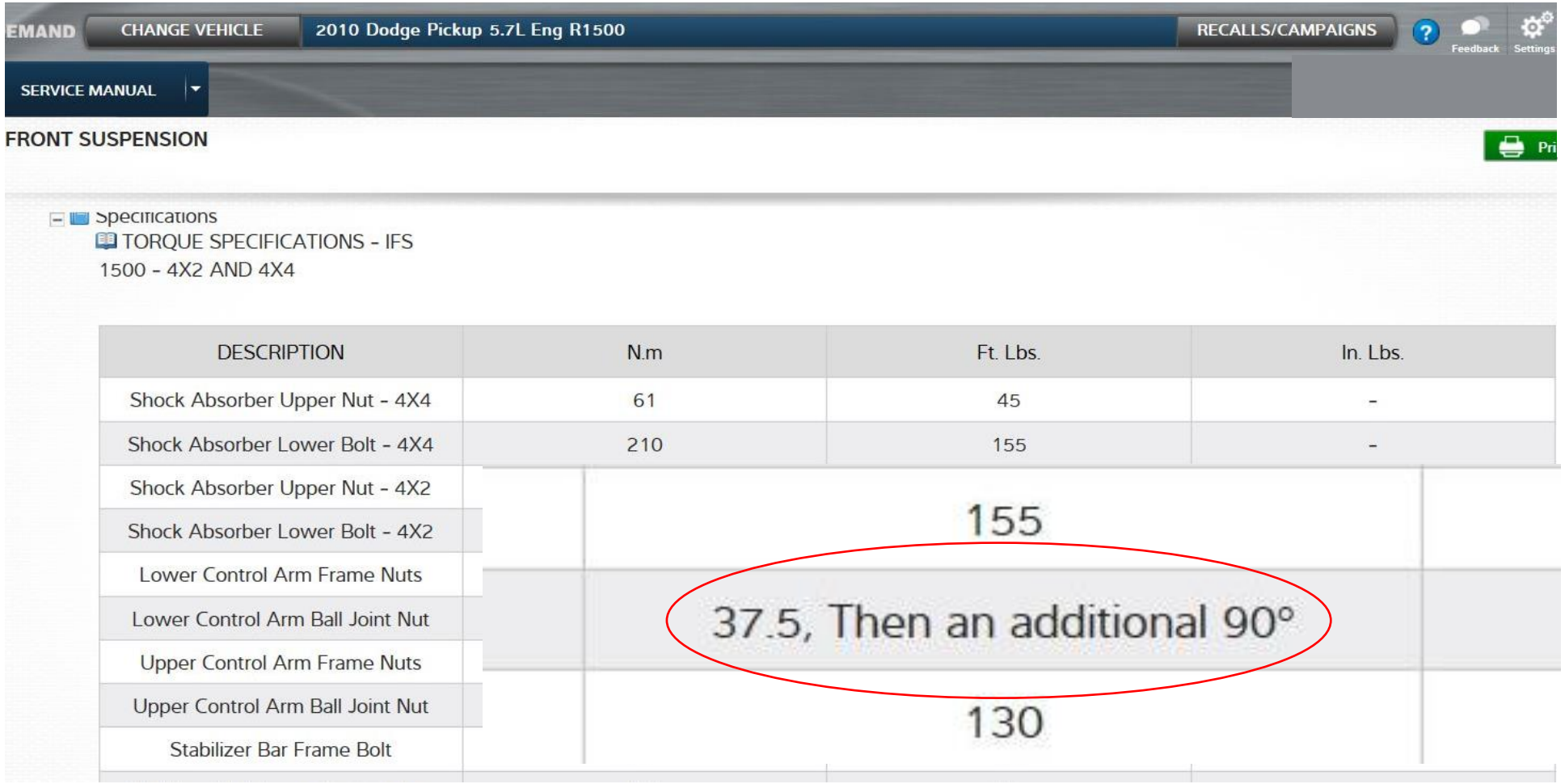
Ball Joint Precautions





- Bent studs can lead to damaged taper holes
- Use the new stud to check the knuckle taper
- Do not re-use components with damaged taper holes

Ball Joint Torque Specifications



Some steering and suspensions components require torque to angle procedure

Honda Acura Ball Joint Service

- SP TOOLS 68600
- Honda/Acura Ball Joint R&R Tool
- Service lower ball joint with knuckle on the car

Bolt Removal

- CP 717 uses large shank bits .498”
- Reducer allows .401” shank bits to be used in the CP 717
- SR498401

Tie Rod Service Tip

- Air hammer can be used to loosen frozen nuts and sleeves

Bushing inspection

- To use the tool, a tire is raised off the ground to allow clearance, then lowered until some of the vehicles weight rests on the tool.

- With the tool positioned parallel to the tire tread, slowly rocking the handle allows the user to check for side-to side suspension wear.

Suspension Wear Indicator
Muller-Werkzeug 432910

Control Arm Assemblies

- Assemblies available with ball joints and bushings
- Some applications have non-replaceable ball joints

Vertical Control Arm Bushing

- Vertical control arm bushings are a high failure rate item
- Orient the slots in the bushing to the arm

Nissan Quest

- 102,000 miles
- Owner complaint:
- Loud clicking noise while braking

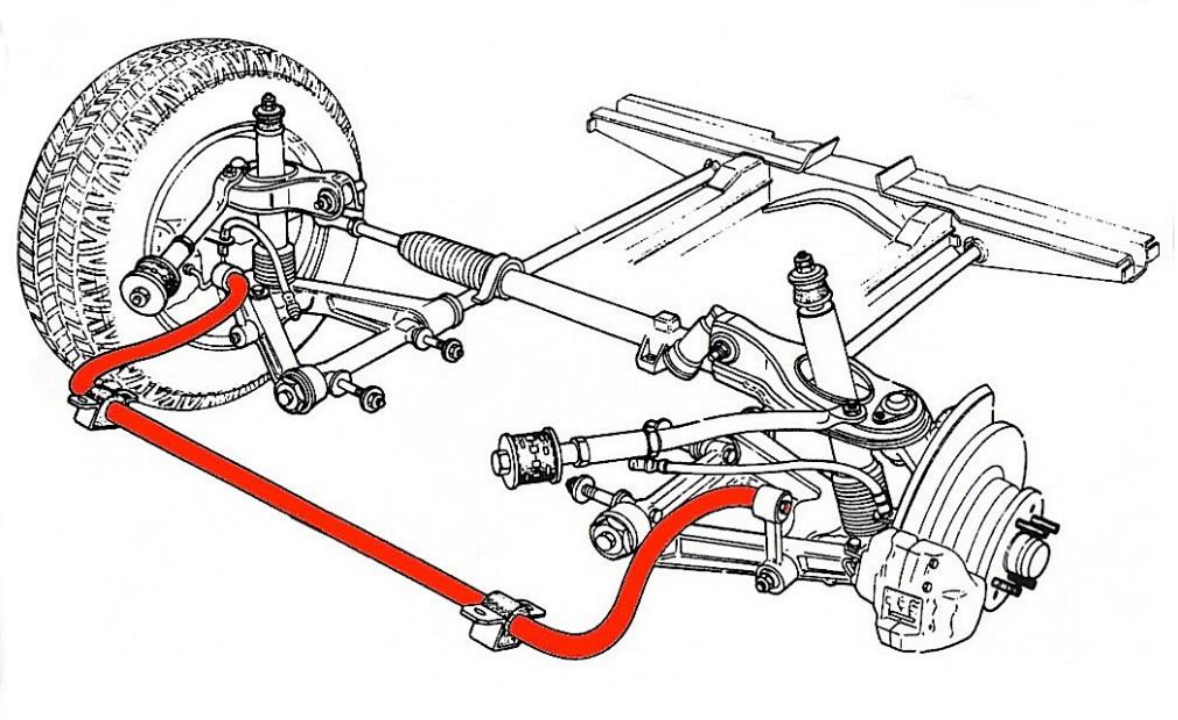
Nissan Quest

Nissan Quest

- What we found:
- Worn lower control arm bushing
- Replaced both control arms

Sway Bars

- Mounted to frame with bushings
- Links connect end of sway bar to control arm or strut.
- Reduces body roll while cornering.
- Only flexes if there is a difference in height / load side to side.
- Usually found on front and rear axles.
- Links can be metal or plastic and may have grease fittings.
- Hollow sway bars can break



Sway Bar Failure

- Hollow sway bars are prone to rust out and break

Sway Bar Links

- Traditional sway bar links use rubber or polyurethane bushings
- Check for looseness, split bushings and broken bolts

Sway Bar Links

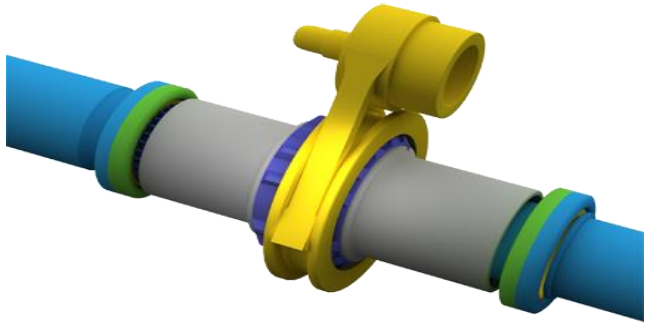
- Ball and socket type sway bar links should be checked for looseness
- Some will have grease fittings and should be lubed regularly

Sway Bar Frame Bushings

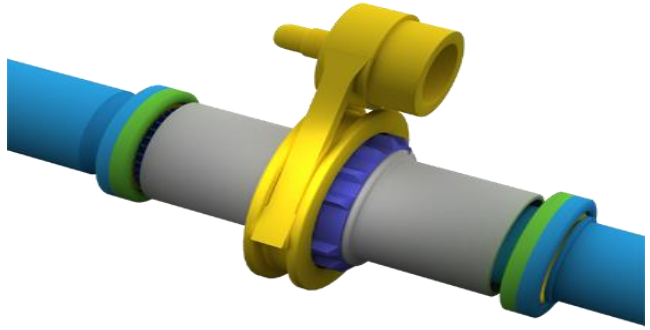
- Bushings must be checked for wear, dry-rotting, and cracking.
- Inspect for wear and gaps around the sway bar
- Worn bushings may cause the bar to rattle or vibrate.

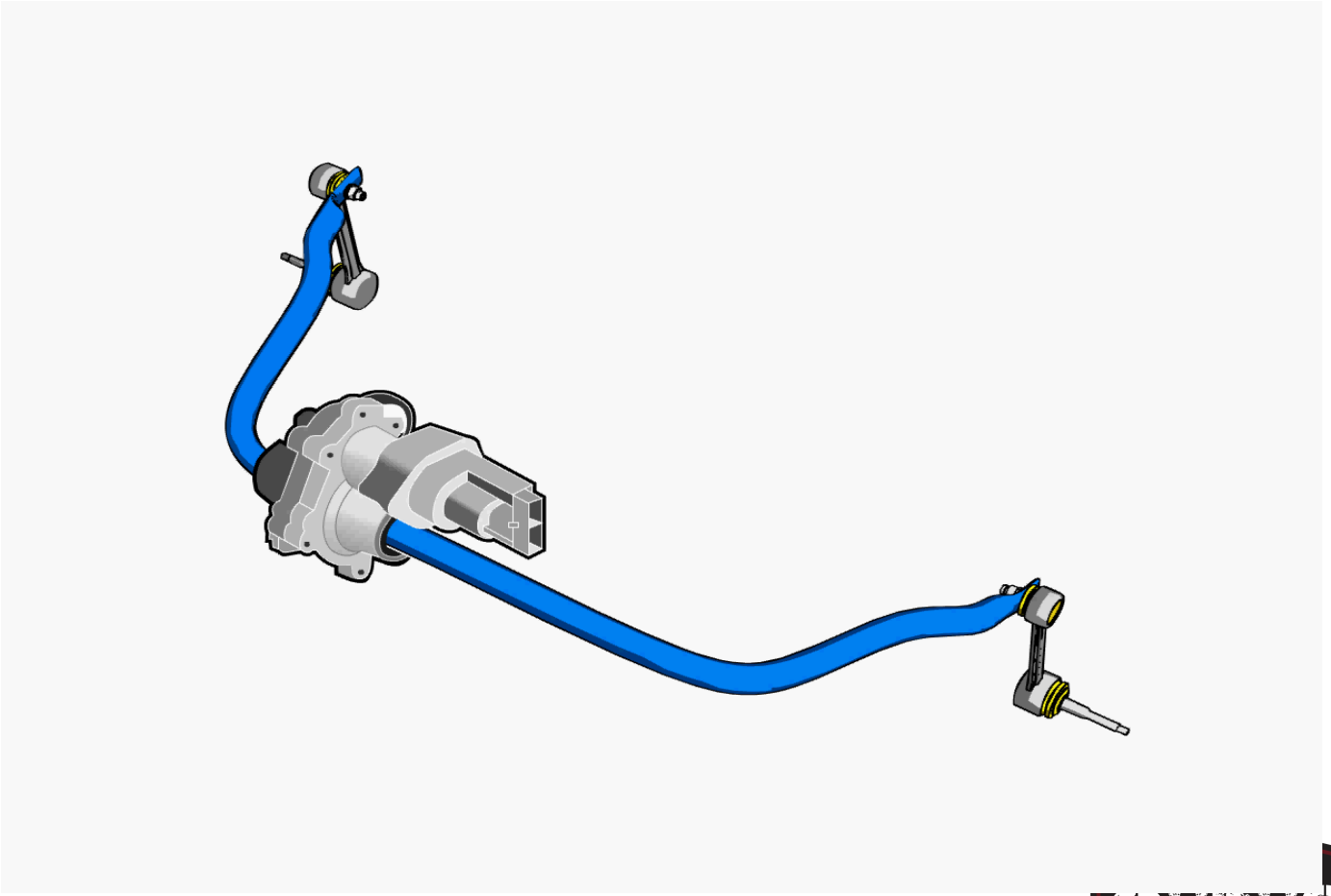
Jeep-Dodge
ASBS - Automatic Sway Bar System

Engage



Dis-engage





Jeep-Dodge
ASBS - Automatic Sway Bar System

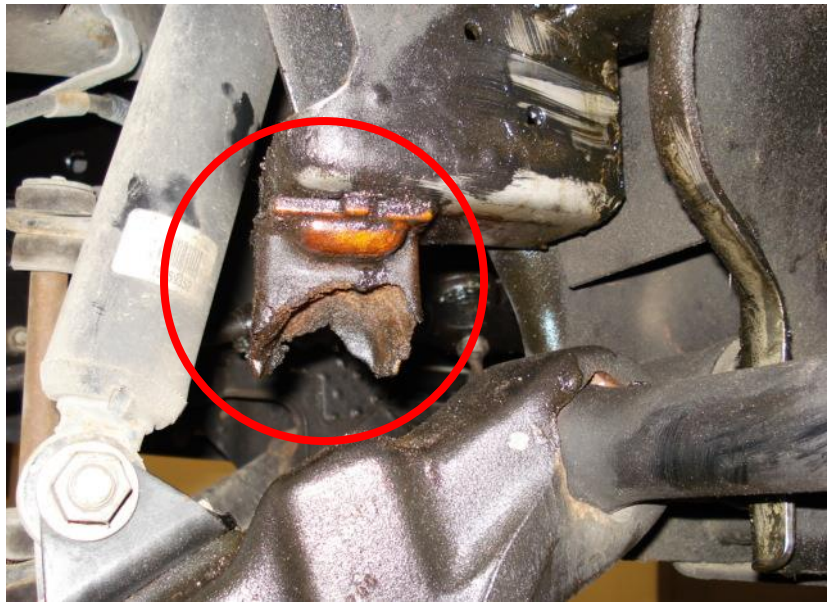
Indicator Light

- ON when disengaged
- ON and blinking w/transitioning from one state to the next
- ON and blinking w/request to disconnect, but conditions NOT met
- OFF when engaged
- ON and fast blinking w/fault detected
- OFF in diagnostic mode

Bump Stops

- Bump stops and control arm dampers should be replaced as needed

GM Bump Stop Damage



- GM trucks and SUVs with damaged bump stops may exhibit tendency to wobble during turns
- Bump Stops reduce spring whip and oscillation

Severe Shimmy

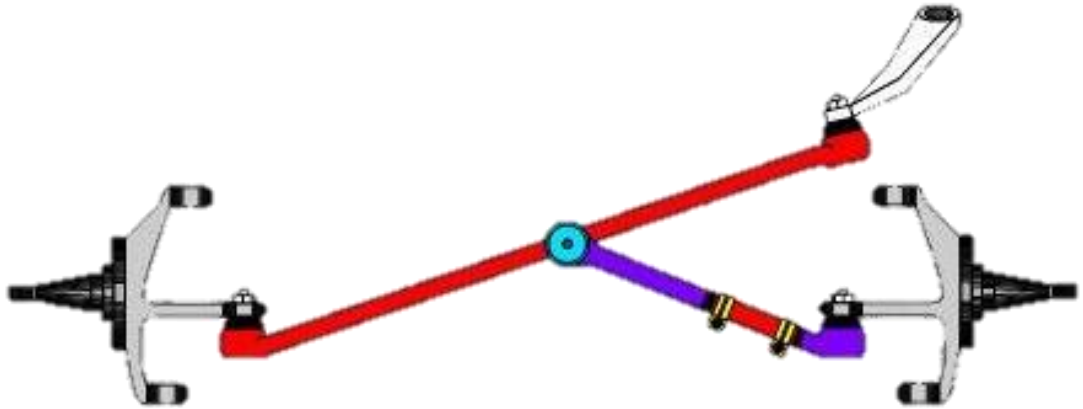
- Typically seen on front solid axle vehicles
- Oversize tires amplify the problem

Severe Shimmy

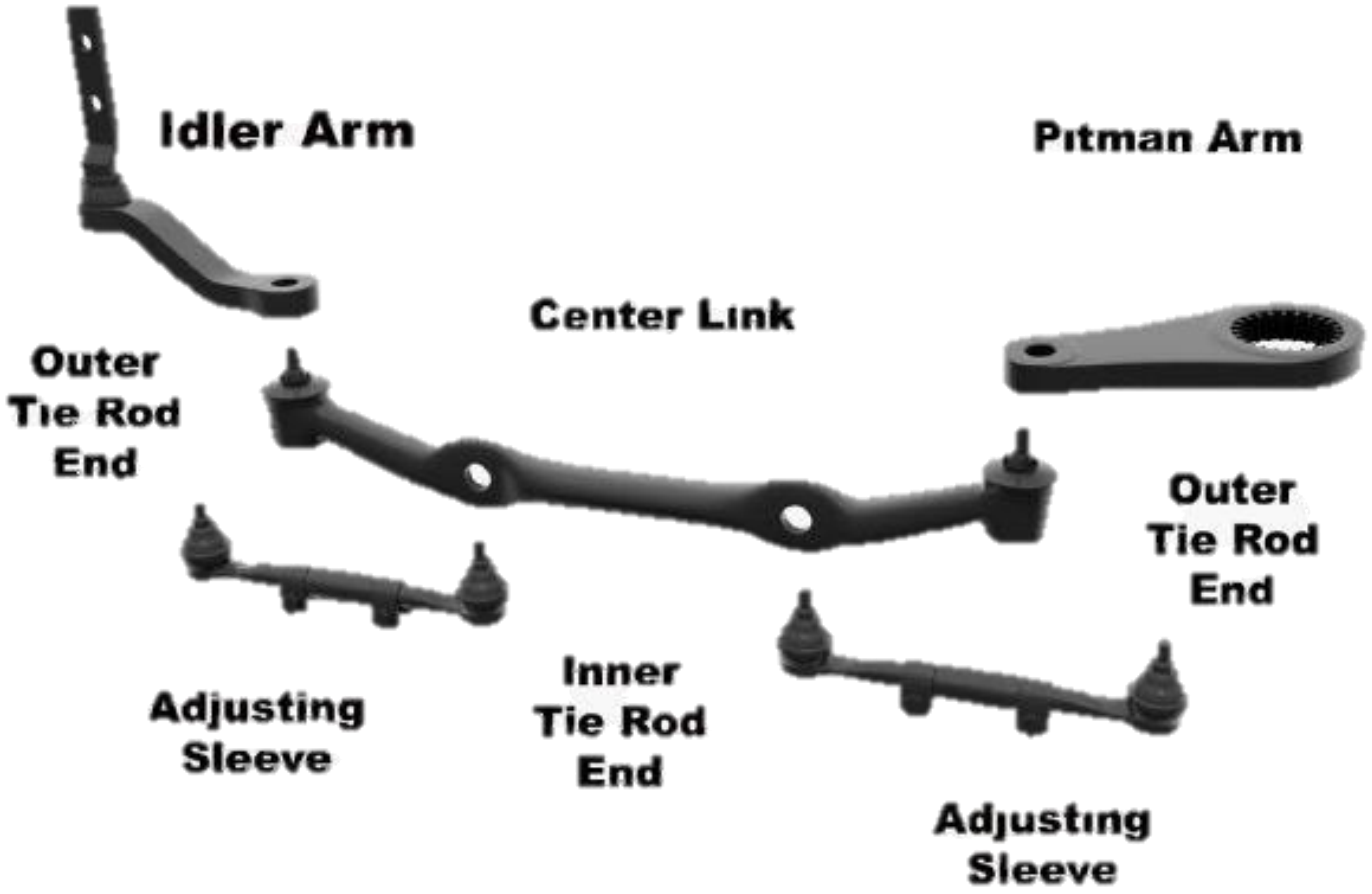
- Inspect all Ball Joints, Control Arm/Radius Arms, Bushings, Track Bar, and Steering Components.
- Look for Elongated Holes in Bushings and Components.
- Inspect Tires
- Inspect Steering Gear.
- Increase Caster Setting

Steering System Types

- Parallelogram
- Haltenberger
- Rack & Pinion



Parallelogram



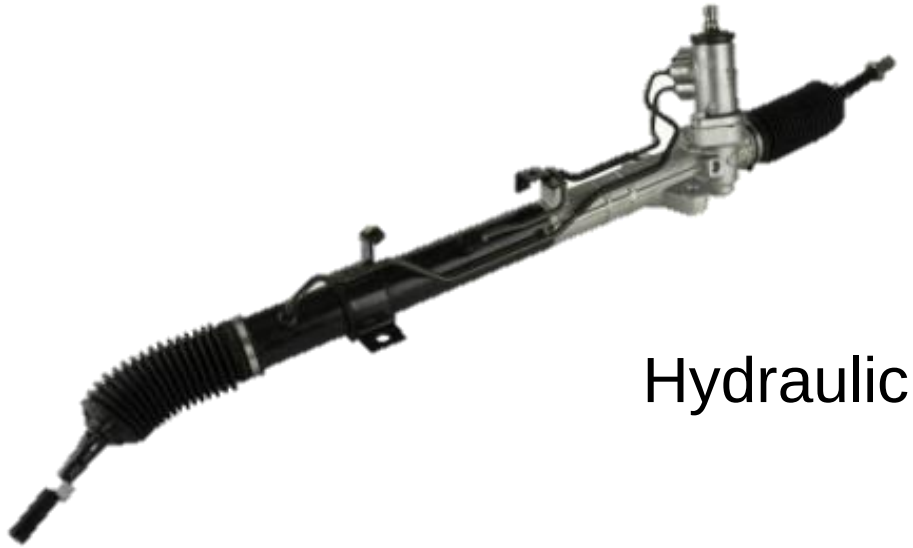
- Heavier components
- Typically found on trucks and older vehicles
- Many wear points, thorough inspection needed

Haltenberger

Haltenberger linkage found on Ford Twin I Beam

Rack & Pinion

Electric



Hydraulic

Manual

Steering Linkage Inspection

Dry Park Test

- Done prior to lubing.
- Wheels are on a flat surface.
- Rock the steering wheel slightly side to side while inspecting EVERY steering component.
- This includes rack mounts, steering gear box bolts, sector shaft, and steering shaft.

Steering Linkage Inspection

- All steering systems use linkage which must be inspected for looseness.

- Toe change is a major cause of premature tire wear and handling problems.

Inner Tie Rod Inspection

- Squeeze bellow boot to feel for looseness
- Inspect for leaking rack

Speedy Inner Tie Rod Tool

- Universal
- Fits 35 to 45 MM
- Fits 99% of inner tie rods
- Mayhew 29910

Case Study: Silverado K1500

- K1500
- Severe steering wheel jerking on tight turns
- Recent alignment after installation
  of new idler and pitman arm
- Several other shops have installed many parts (control arms, tie rods, gearbox)

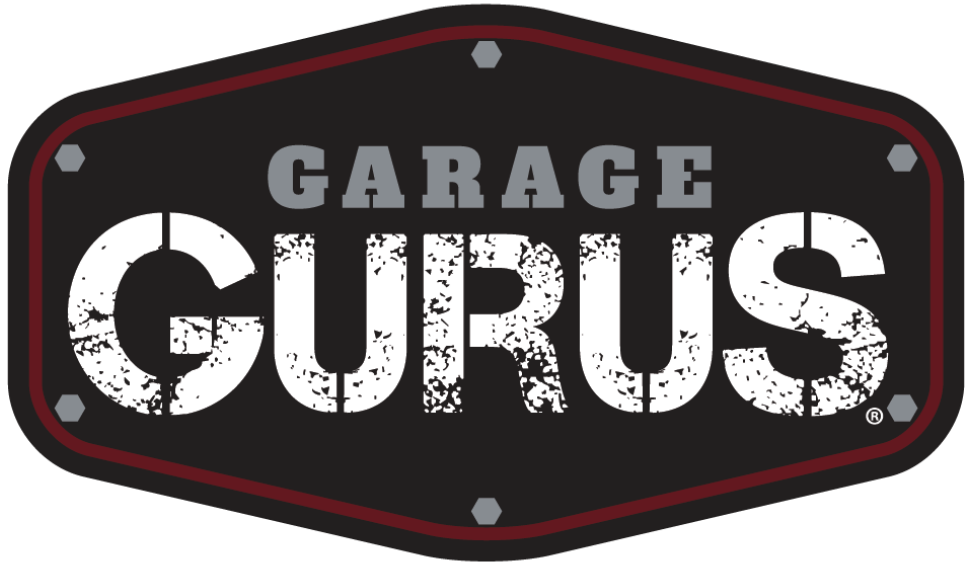
Case Study: Silverado K1500

- Center link issue

Mark It Before Removal

Late GM K Series Truck/SUV

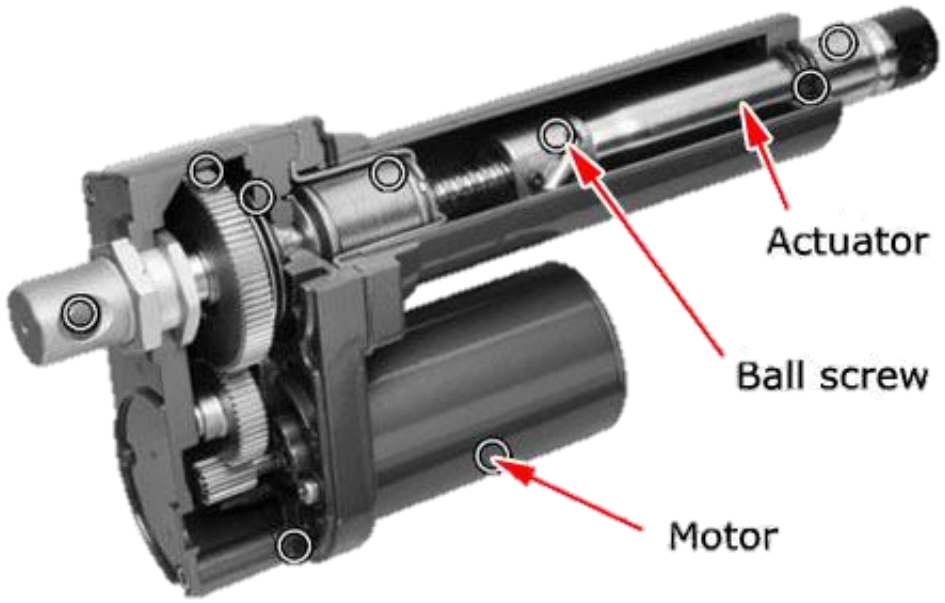
This centerlink can easily be installed backward, which causes the toe out on turns to invert



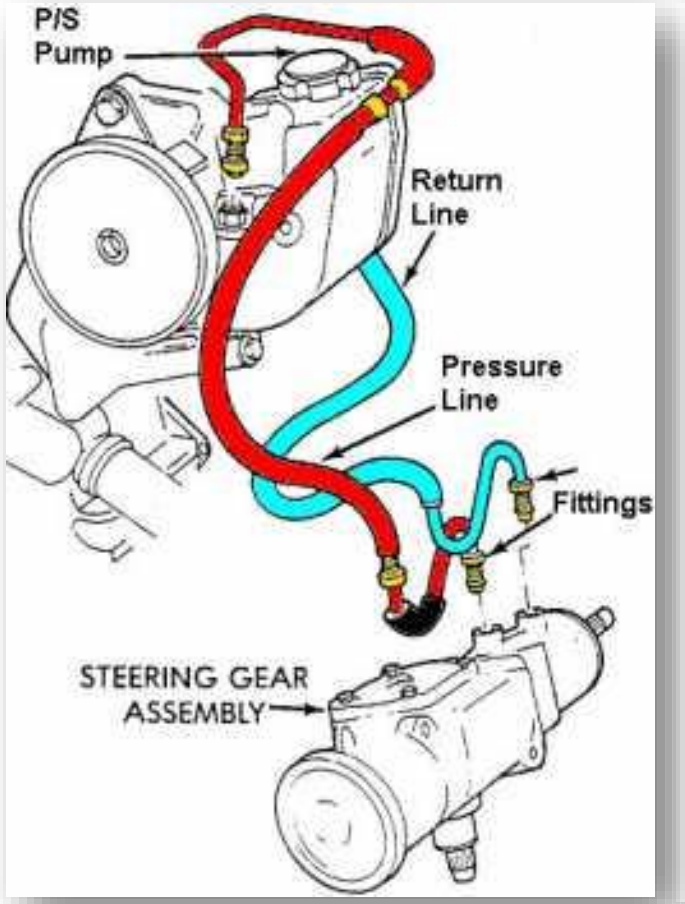
Power Assist

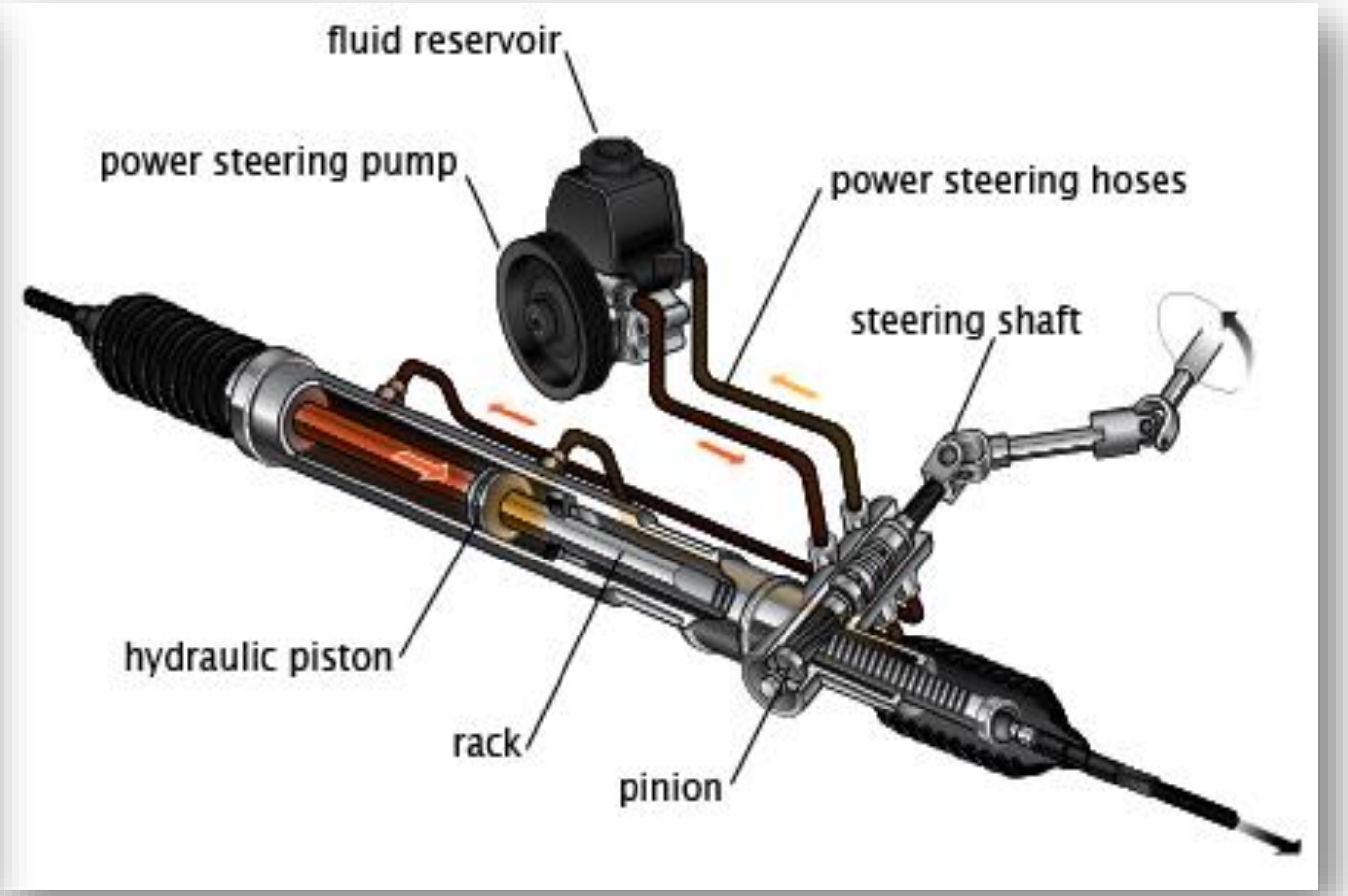
Power Assist

- Hydraulic Assist
- Electric Assist



Hydraulic Power Assist





Inspection:

- System hoses- check for leaks and cracks.
- Belts and pulleys- check for cracks or glazing on belts. Check pulleys for damage, alignment, and rust.

Hydraulic Power Assist

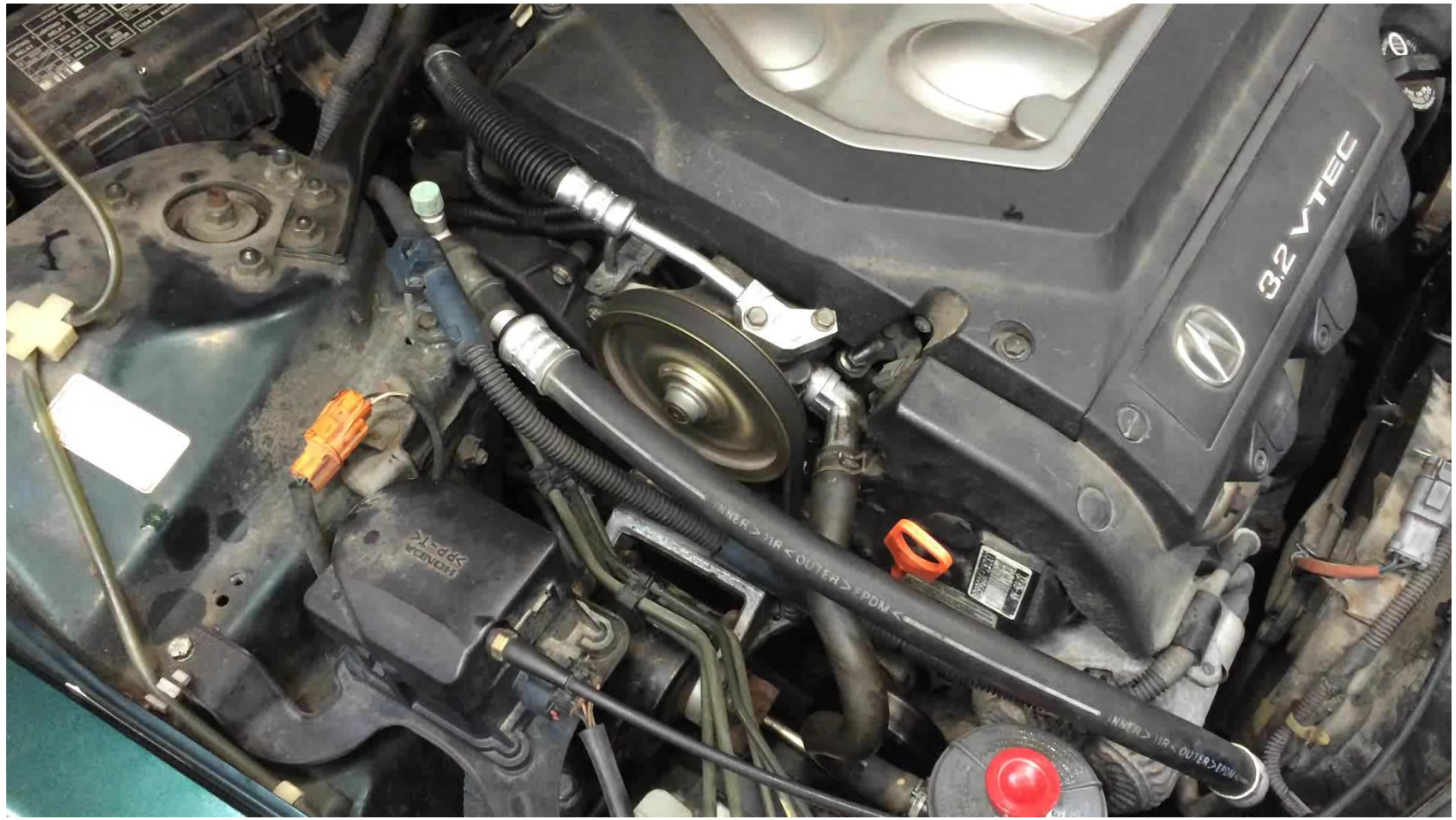
Inspection

- Check for leaks
- Fluid level and condition
- Use the correct, quality power steering fluid.

ACURA

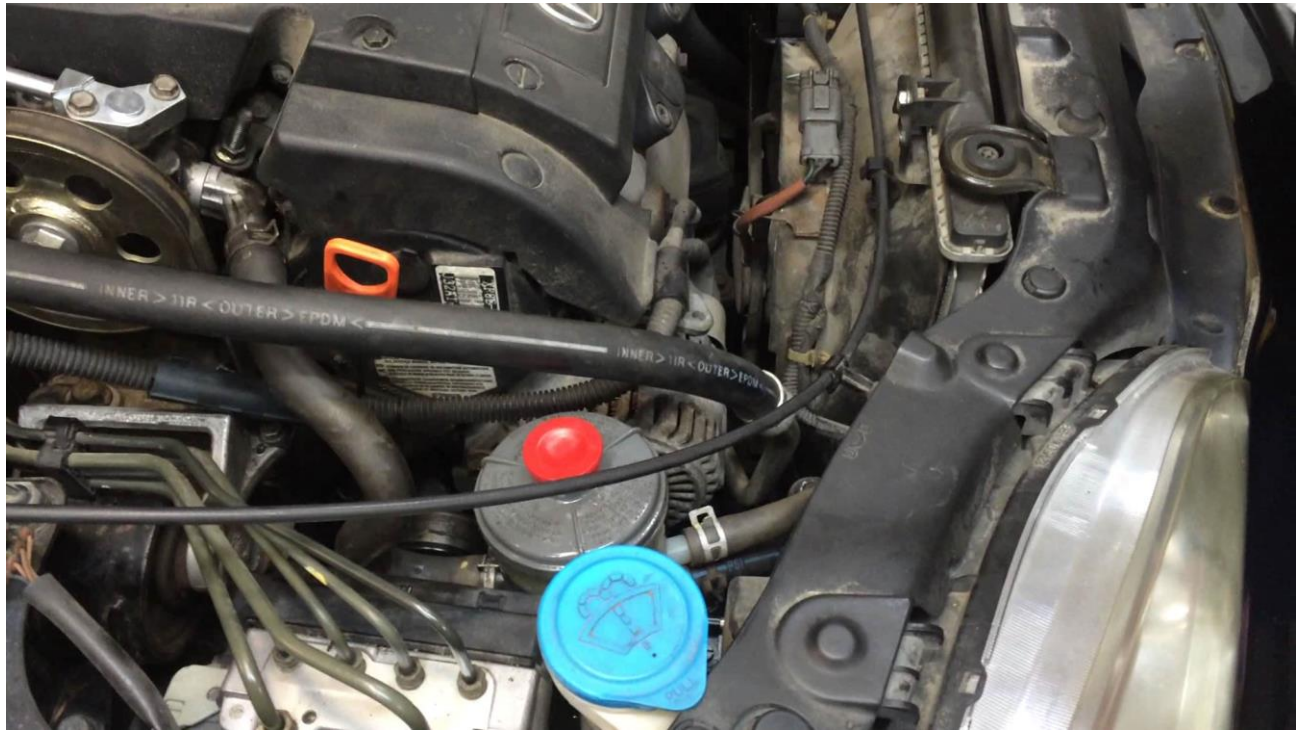
HONDA

Power Steering Noise



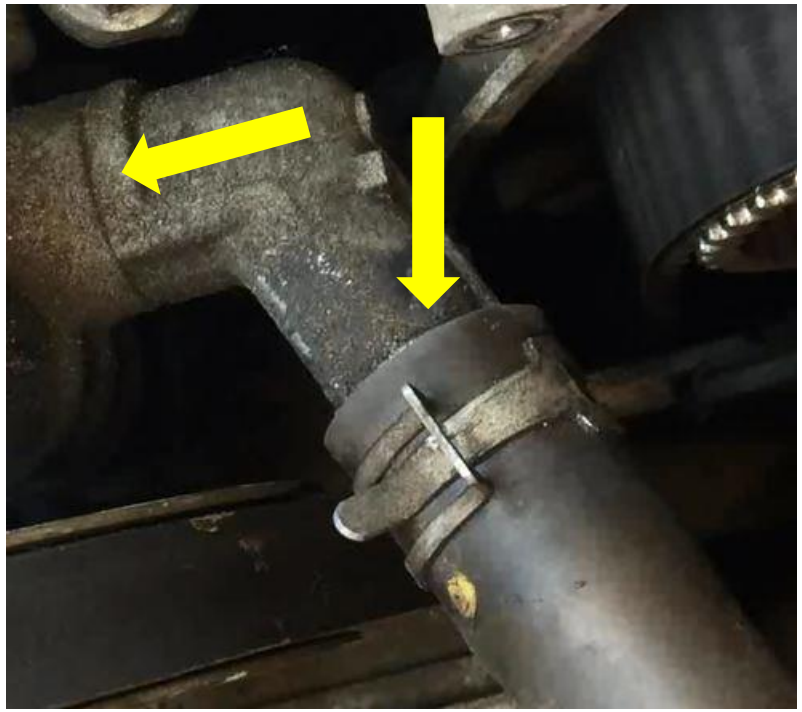
- Severe power steering whine when turning the wheel.
- Fluid in the reservoir would foam and overflow

Power Steering System Leak



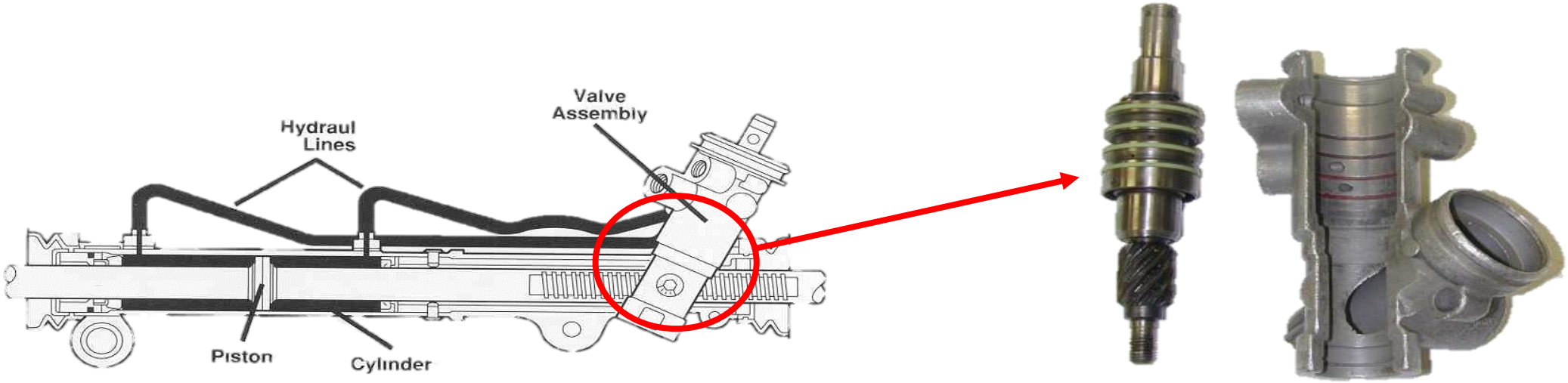
- The fluid level was not low enough to cause aeration
- No major leaks found in pump, lines or rack and pinion
- The leak is in the suction side of the system
- The leak allowed air to be drawn into the system without fluid leaking out

Problem Fixed

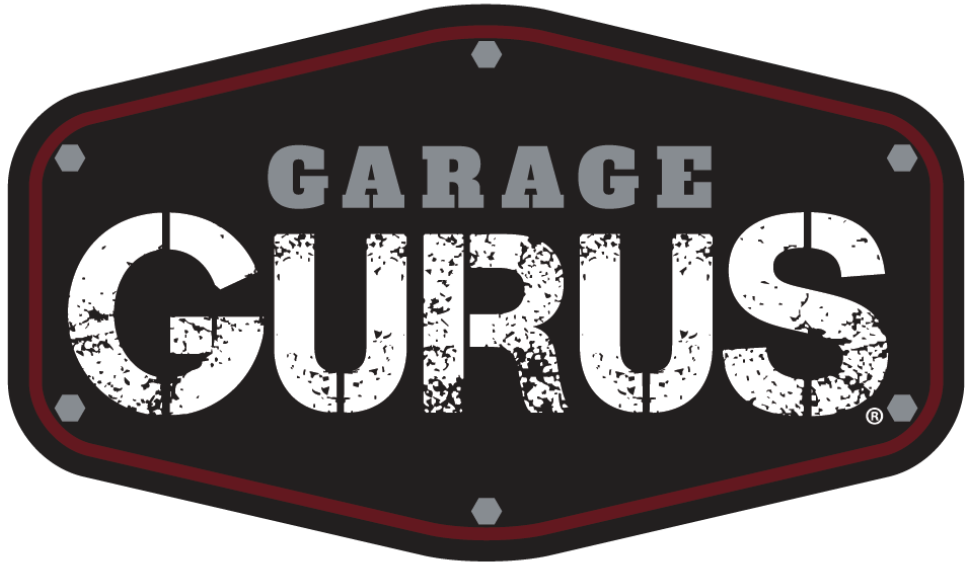


- “O” ring at pipe junction was brittle
- Allowed air to be drawn in but no fluid to leak out
- Replaced “O” ring and bled the air from the system
- Be sure to check other places in the suction side of the steering system for leaks
- Return hoses and reservoir supply hoses can become brittle

Diagnosing



- Leaking control valve seals can cause pulls.
- Can cause hard steering in one or both directions.
- Raise vehicle and straighten wheels. Start vehicle and notice steering wheel. If tendency to turn, possible leaking seals.



Electro-Hydraulic Steering

Electrically Driven Hydraulic Pumps

- Electrically driven hydraulic steering pumps can be found on Ford Focus, Chrysler/Dodge vehicles, Mazda 3, Mini-Cooper, Volvo, and GM PHT hybrid truck.
- These may be used to reduce engine load or supply pressure in hybrid applications when the gas engine is shut down.

Electro-Hydraulic Power Steering

2013 Dodge Charger

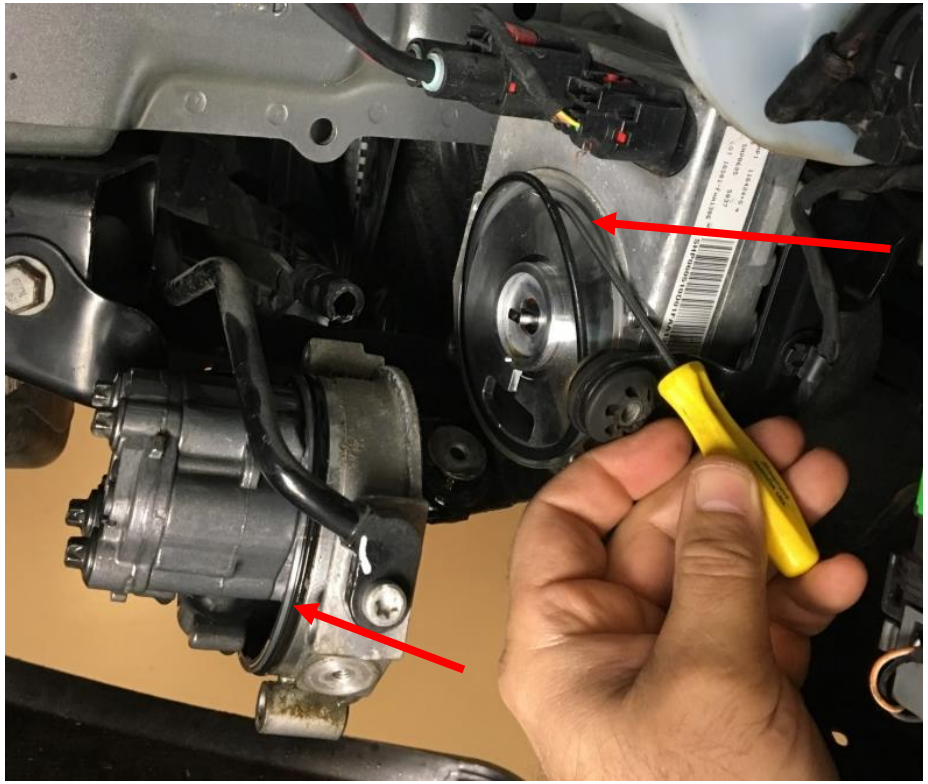
Chrysler EHPS Pump Location

- Hydraulic pressure for operation of the power steering gear is provided by an Electro Hydraulic Power Steering (EHPS) pump

- The EHPS pump is located in front of the right side tire and can be accessed by loosening and positioning aside the front wheelhouse splash shield.

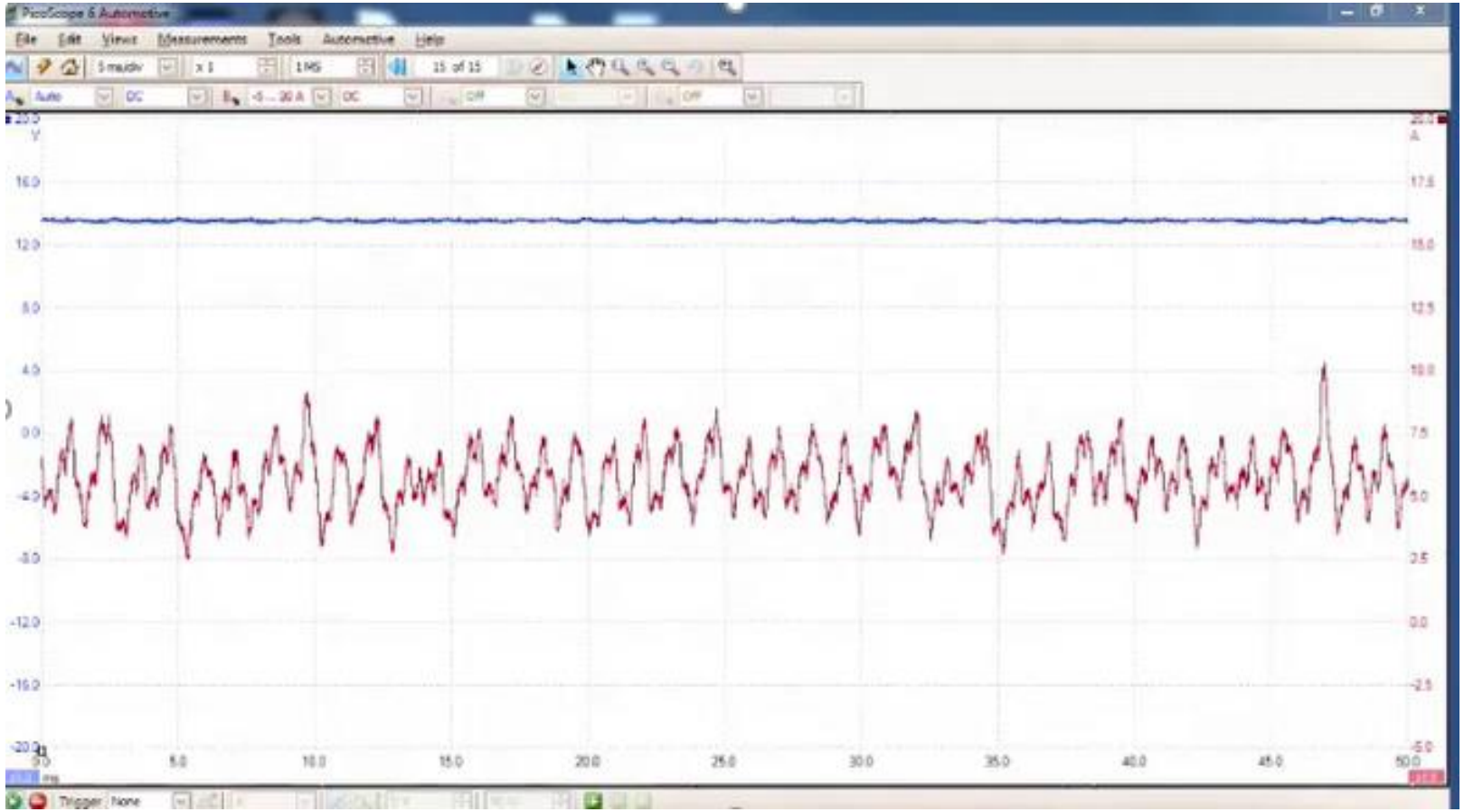
- Inspect for leaks around reservoir housing

Leak Repair



- Common leak area
- Reservoir kit comes with 2 O-rings

Chrysler Pump Motor Current



- Channel A is measuring Voltage
- Channel B is measuring Current

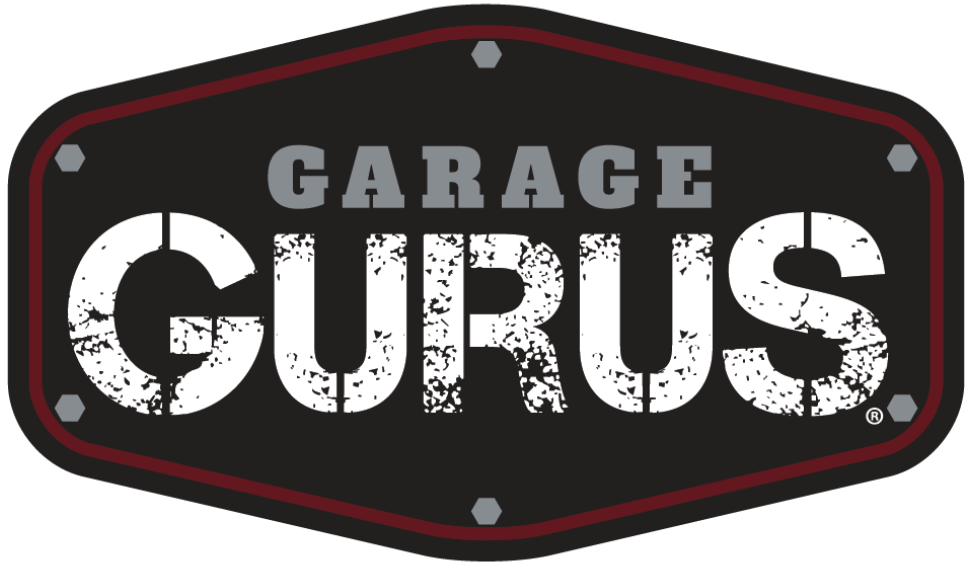
- In this capture we are monitoring current flow through the pump.
- When the steering wheel is at rest the current remains steady.
- When steering wheel is rotated current flow fluctuates.

- Notice that when the steering is locked out the pump will draw high amperage. When this occurs, the EHPS will duty cycle the voltage to the pump to prevent overheat damage.

Mopar Power Steering Fluid

CAUTION:

- Electro Hydraulic Power Steering (EHPS) pump vehicles which requires a different power steering fluid.
- Do not mix power steering fluid types. Damage may result to the power steering pump and system if any other fluid is used.
- The EHPS system uses fluid which meets material specification MS-11655or equivalent. Do not overfill.



Electric Steer

Electric Power Steering Systems

- Electric motor on rack unit
- Electric motor on column

Electric Power Steering Systems

Powered column, manual rack

- In this layout, the motor and torque sensors will be mounted in the passenger compartment under the dash.
- The steering rack is a manual unit

Electric Steering System Operation

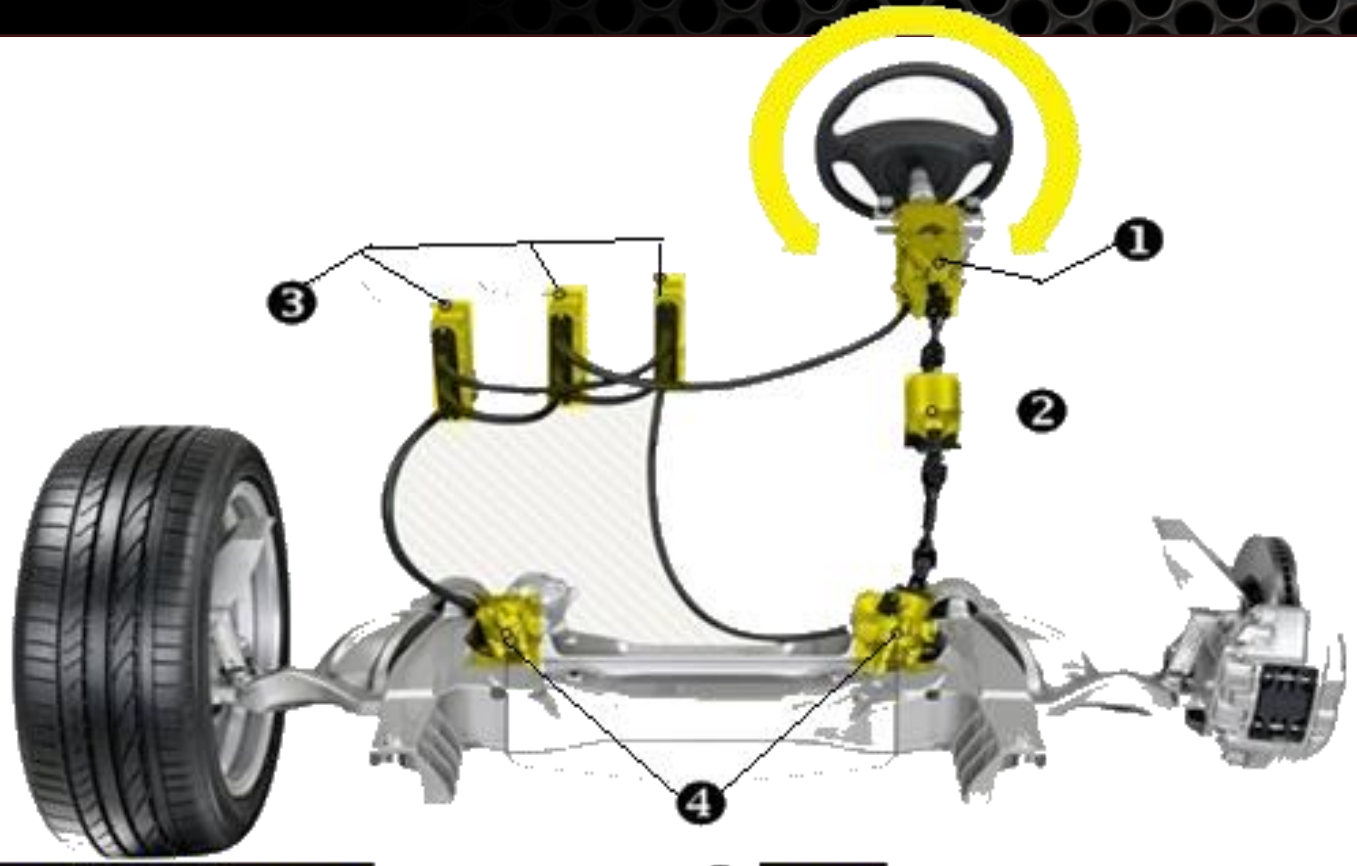
Manual column, powered rack

- Many larger SUVs and trucks will use this layout.
- A motor is mounted to the steering rack to provide assist.
- A belt housing or gear reduction setup may be included.

Infiniti Q50 Drive by Wire

- First offered in 2014
- No flex or lash in the steering feel
- Complete isolation from steering “kickback” or steering impact
- Infinite steering ratio adjustment
- Steering “pull” compensation, such as from road crown

Infiniti Q50



1 STEERING-FORCE SENSOR

Playing two roles, this unit sends commands to the control modules and acts as the driver's feedback source by varying resistance to the wheel

2 CLUTCH

Most of the time it's open. Faults in the electronics force it closed, creating a solid mechanical connection between the steering wheel and the rack.

3 CONTROL MODULES

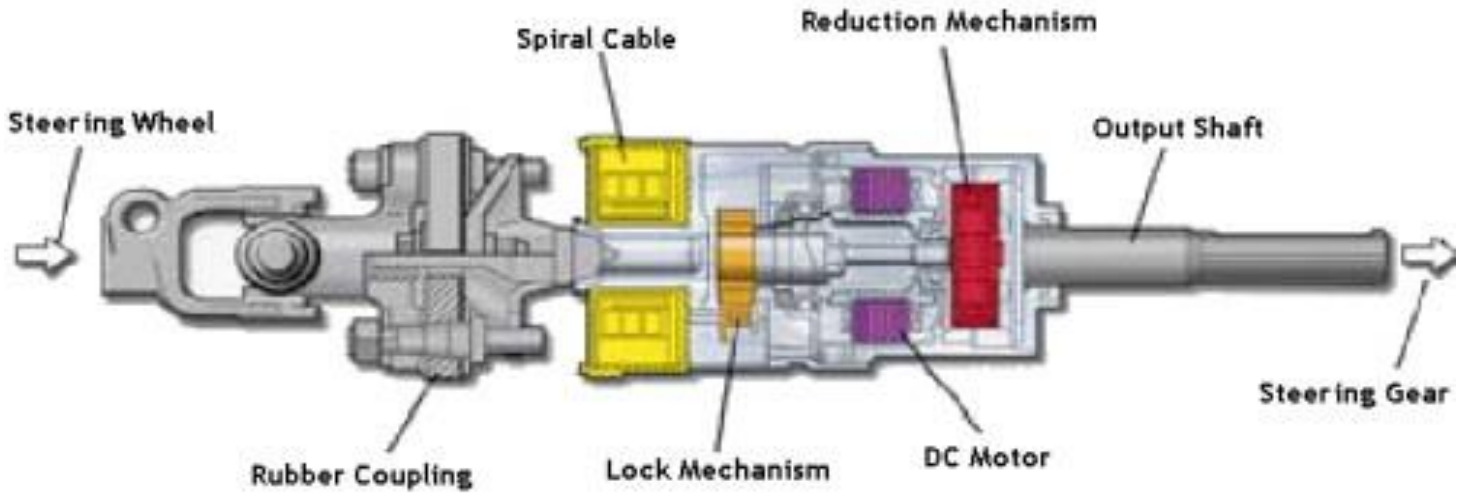
This trio controls the electric-assist motors and the steering-force sensor. They also act as redundancies, you know, for safety

4 STEERING-ASSIST MOTORS

Two of these smaller motors are cheaper than one large one. Plus, this arrangement frees some space for a low-slung longitudinal engine

BMW Variable Ratio Steering

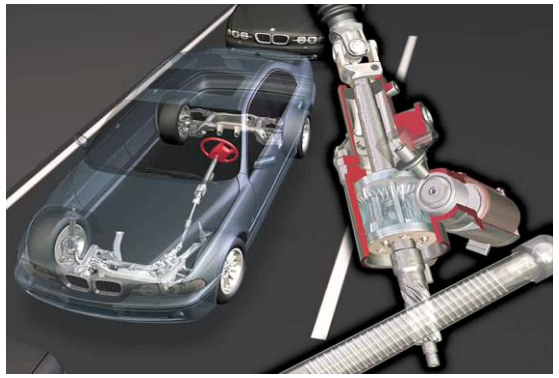
- A motor controlled planetary gear set between the steering column and steering box can alter “lock to lock” ratios. On the highway, movements have less impact (about 5 turns lock to lock) and more impact at low speed (about 1.5 turns lock to lock) Use caution during parking!



Active Front Steering

Which OEMs use AFS?

Audi	Infiniti
BMW	Lexus
Cadillac	



Low-speed steering maneuver

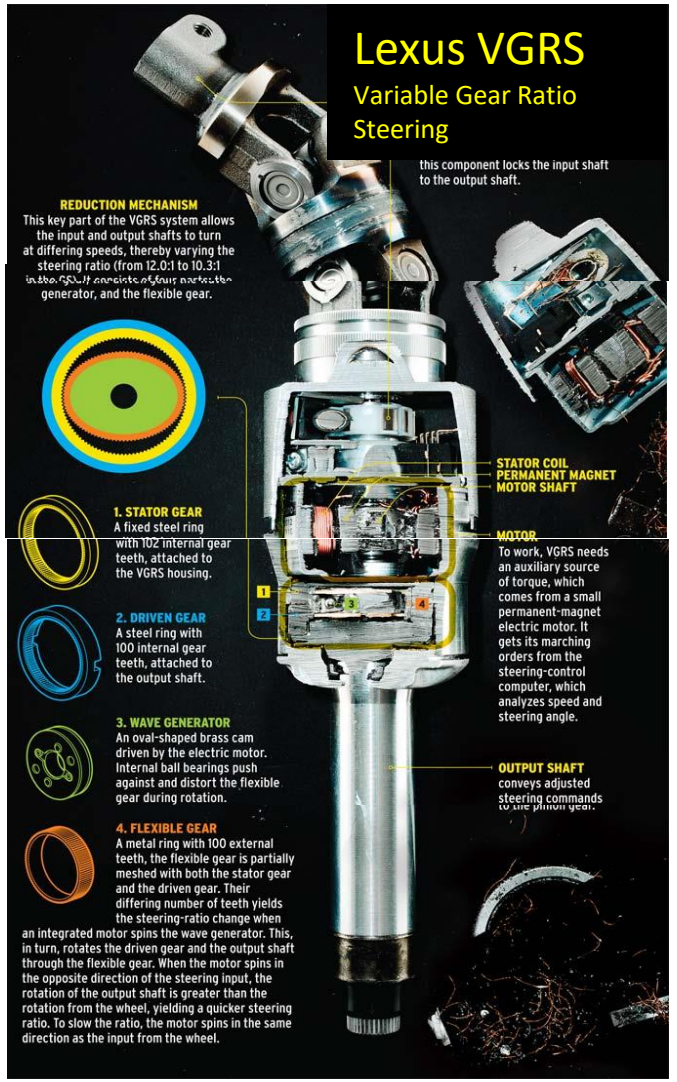
At low speeds, AFS increases the steering ratio to enable the driver to turn the wheels sharply with only a slight turn of the steering wheel.

High-speed steering maneuver

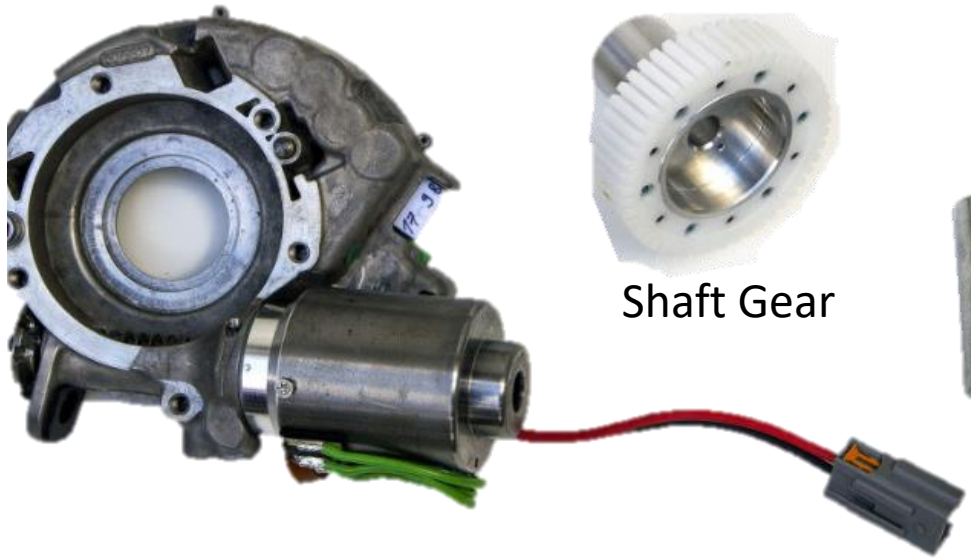
At high speeds, AFS decreases the steering ratio to prevent the driver from oversteering in a potentially dangerous situation.

Lexus VGRS

Variable Gear Ratio Steering



Ford Adaptive Steering

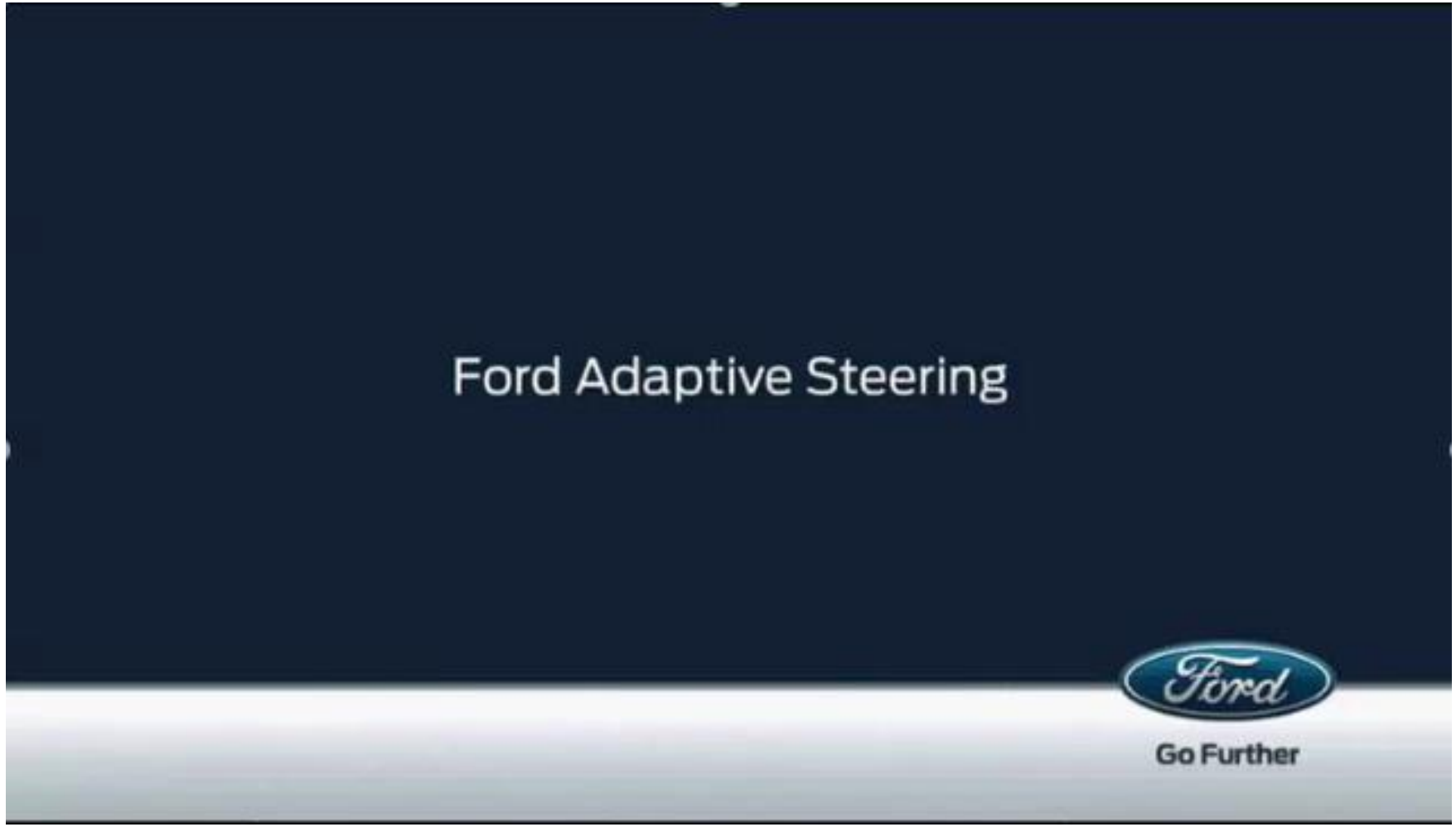


Shaft Gear

Worm Gear

Motor

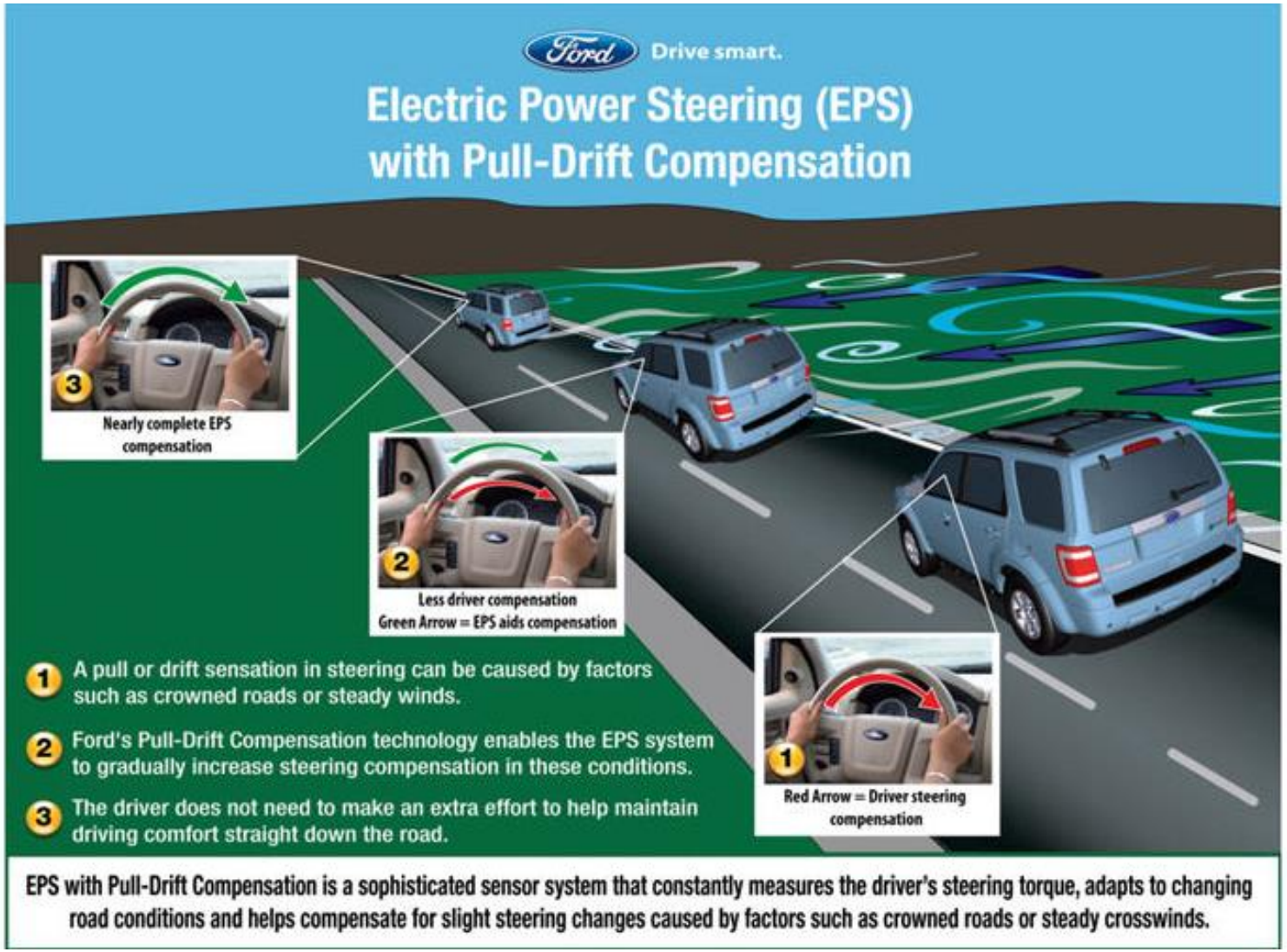
Ford Advance Steering Control



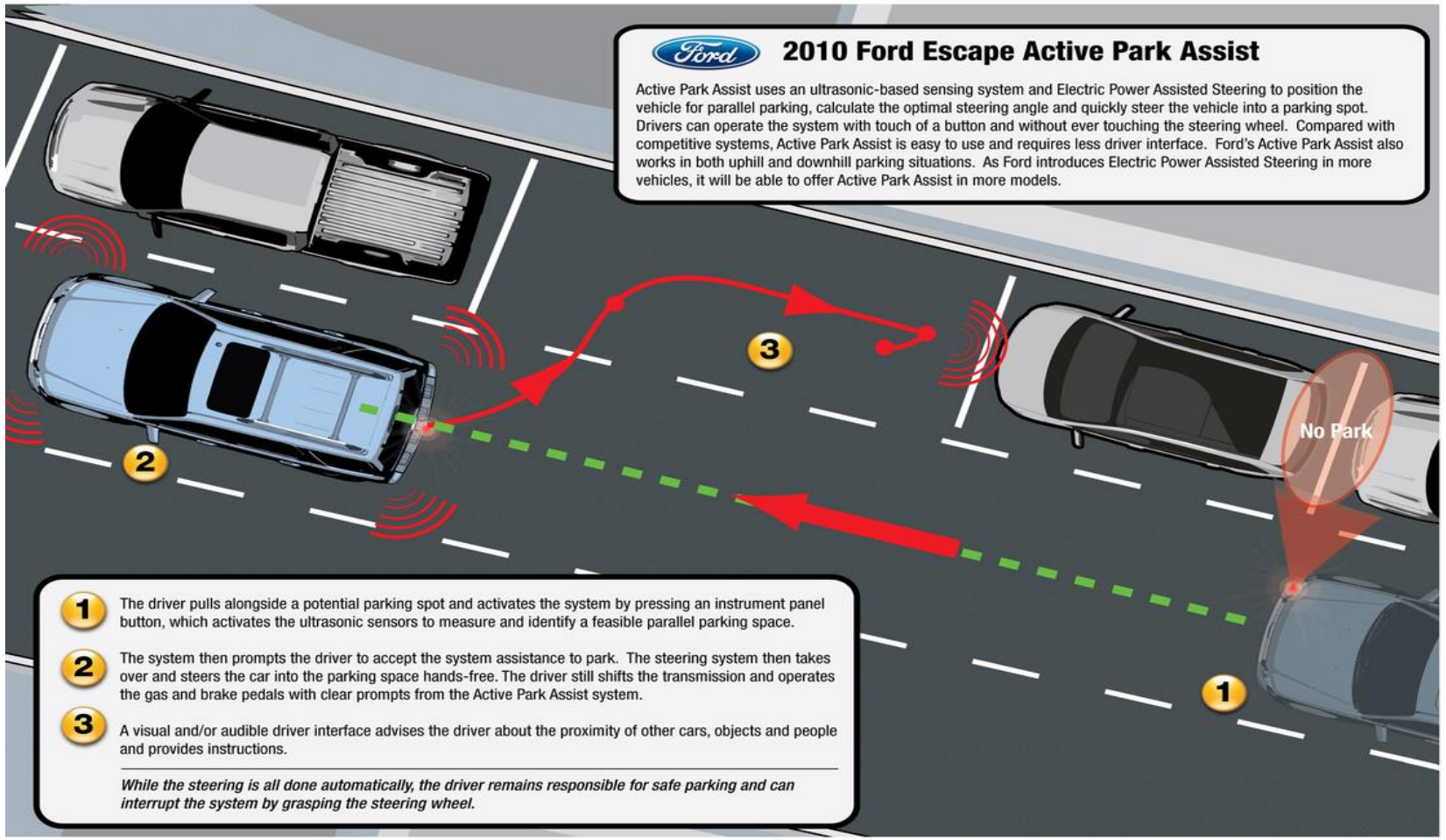
Ford's system uses a precision-controlled actuator placed inside the steering wheel, and requires no change to a vehicle's traditional steering system.

At highway speeds, the system further optimizes steering response, enabling the vehicle to react more smoothly and precisely to driver input

Pull-Drift Compensation

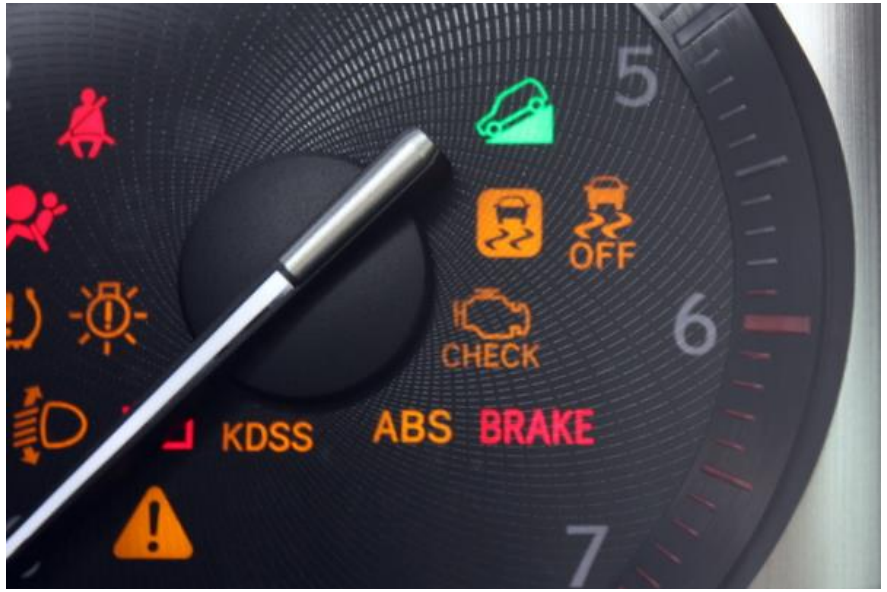


Active Park Assist Systems



- SAS sensor input and proper calibration is critical to these systems

Scan Tool Diagnostics



- Check for warning lights on dash
- Use scanner to look at data and retrieve codes
- Recalibration procedures

Hyundai/Kia Steering Noise

- 2011 Sonata
- Steering knock occurs only with engine running (EPS active)
- Other Hyundai and Kia models are affected

Hyundai/Kia Steering Noise

- Noise evident only with engine running (EPS active)

Hyundai TSB 14-ST-002 May 2014

- TSB search revealed an issue with a rubber insulator between the EPS motor drive and column input gear
- Inexpensive part but high labor time to remove column
- Some motors can be serviced in the car

PRODEMAND 2011 Hyundai Sonata 2.4L Eng Limited

MOTOR DRIVEN POWER STEERING (MDPS) COUPLING REPLACEMENT

TECHNICAL SERVICE BULLETIN

Reference Number(s): 14-ST-002-1, Date of Issue: May, 2014
HYUNDAI: 2011-2014 Sonata (YFa); 2011-2014 Sonata Hybrid (YF HEV); 2007-2014 Elantra (HD, MD/UD); 2009-2012 Elantra Touring (FD); 2013-2014 Elantra GT (GD); 2013-2014 Elantra Coupe (JK); 2013-2014 Santa Fe (NC); 2012-2014 Azera (HG); 2012-2014 Veloster (FS)
GROUP: STEERING
Superceded Bulletin(s): 14-ST-002, Date of Issue: May, 2014

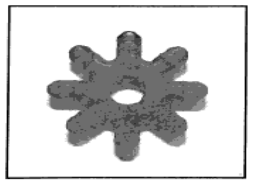
REVISION HISTORY

THIS TSB SUPERSEDES TSB TO ADD VELOSTER (FS) TO THE APPLICABLE VEHICLES LIST.

DESCRIPTION

This bulletin describes the procedure to replace the flexible rubber coupling in the MDPS (motor driven power steering) assembly to address a minor "clicking" or "thud" type noise when turning the steering wheel in some models.

NOTE: There are no steering performance issues associated with this condition.



Applicable Vehicles:

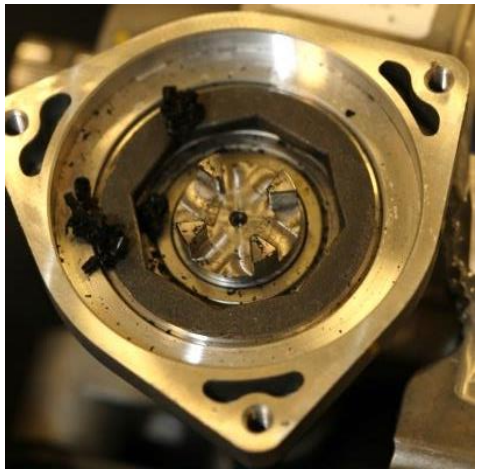
- 2011~2014 Sonata (YFa), 2011~2014 Sonata Hybrid (YF HEV)
- 2007~2014 Elantra (HD, MD/UD), 2009~2012 Elantra Touring (FD), 2013~2014 Elantra GT (GD), 2013~2014 Elantra Coupe (JK)
- 2013~2014 Santa Fe (NC)

http://www1.prodemand.com/Print/Index?content=article&module=false&tab=false&term... 1/20/2016

Affects several Hyundai and Kia models

Isolator Inspection

- Isolator was damaged
- Do not turn motor or input shaft on column

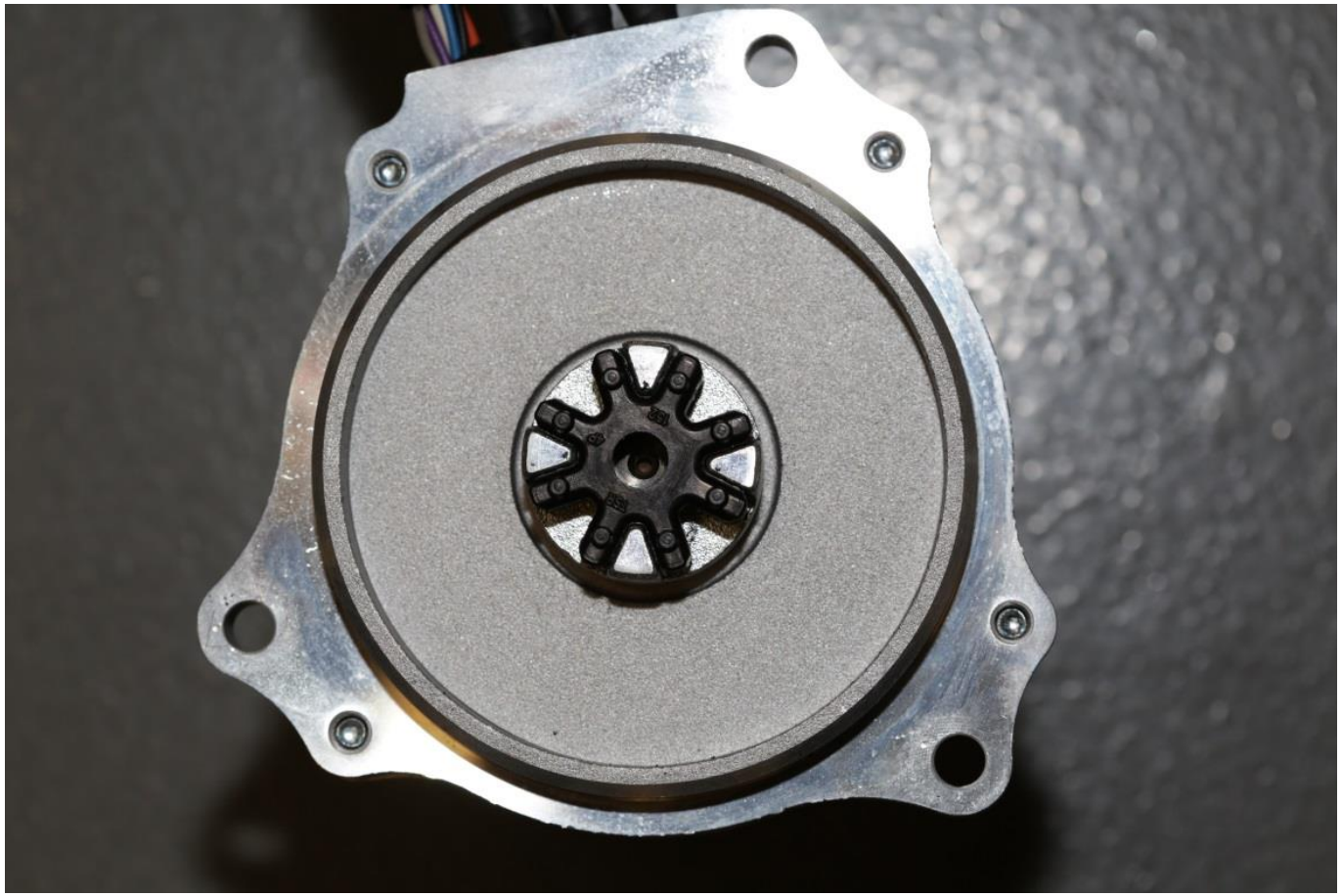


Removing damaged insulator

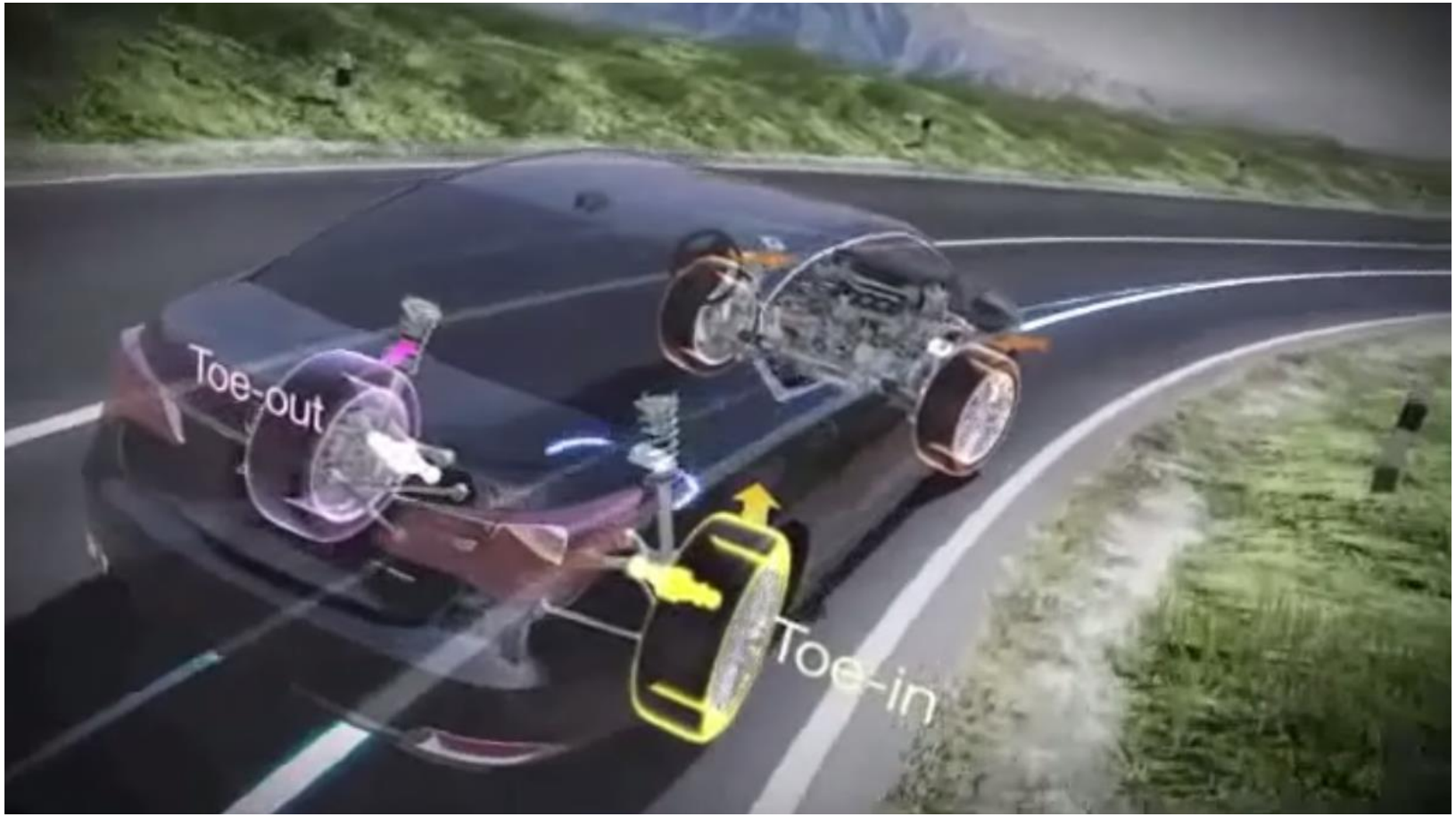
- Use low pressure shop air
- Heavier deposits may require a soft bristle brush to remove

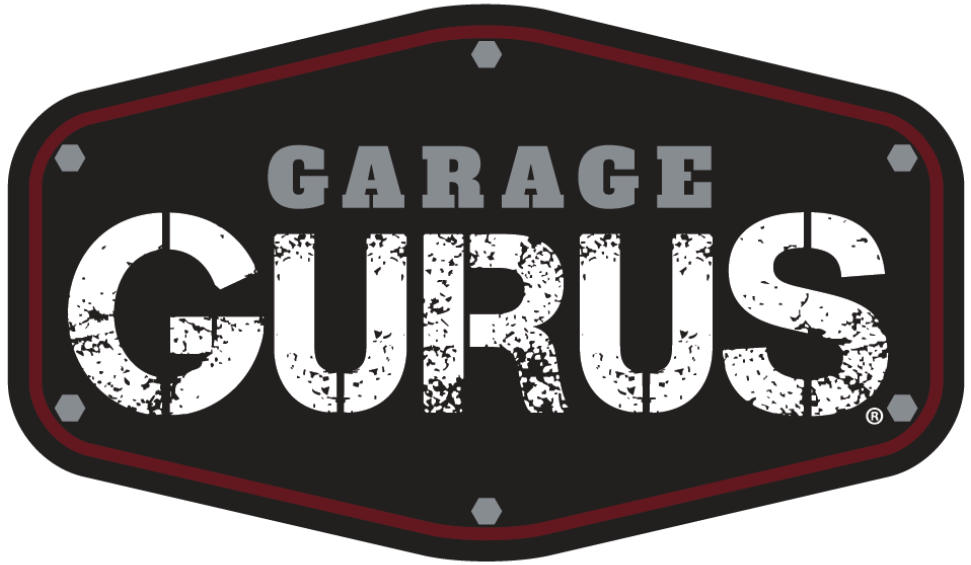
New insulator installed

- Replacement unit is improved for longer life
- OE Part #56315 2KK000FFF



Acura All Wheel Steer

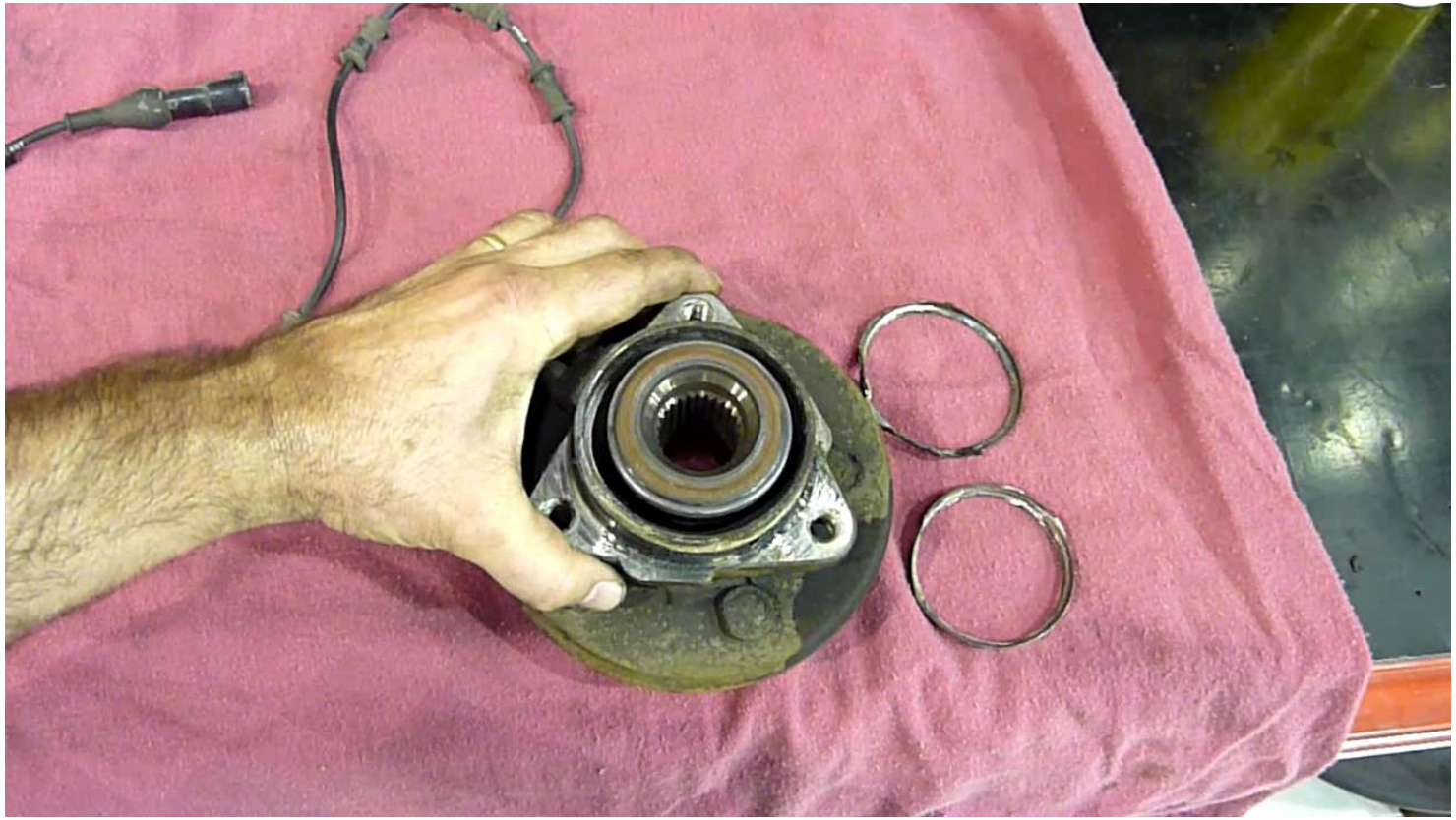




Hub Bearings

Hub Bearings

Symptoms that typically develop because of a worn / failing hub



- Humming or growling noise increases on acceleration or on turns.
- Vibration, felt in steering wheel
- Pulling to one side during braking
- Excessive brake pedal travel
- ABS system issues

Wheel Bearing Noise

- 2009 Toyota Corolla
- Noise from front of vehicle on when braking at low speed and when turning in one direction

Hub Bearing Inspection

- Raise vehicle
- Grasp tire to shake to check for looseness

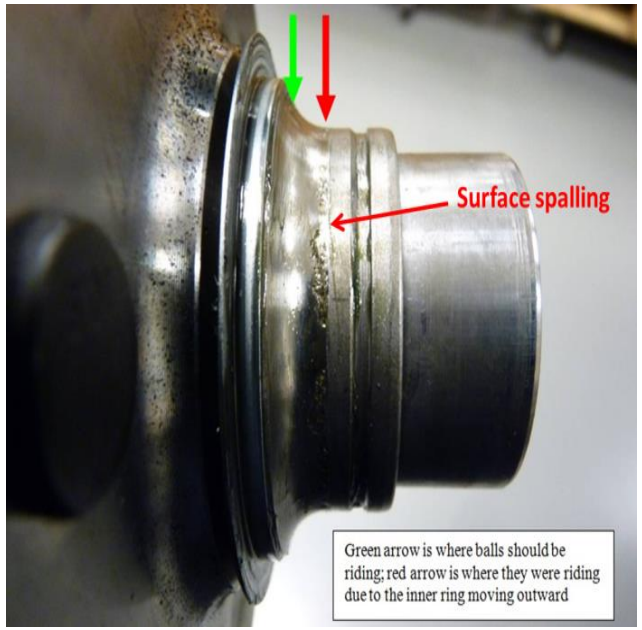
Tip for Locating a Noisy Wheel Bearing

- Raise the vehicle
- Hold the coil spring while rotating the tire
- Vibration can be felt in the spring

Loss of bearing Pre-Load

- Here is the most common mistake seen when installing hub assemblies; **the inner rings separating because the axle shaft nut had become loose in service**.
- The splines of the axle shaft must be extremely clean of dirt, debris, and rust.

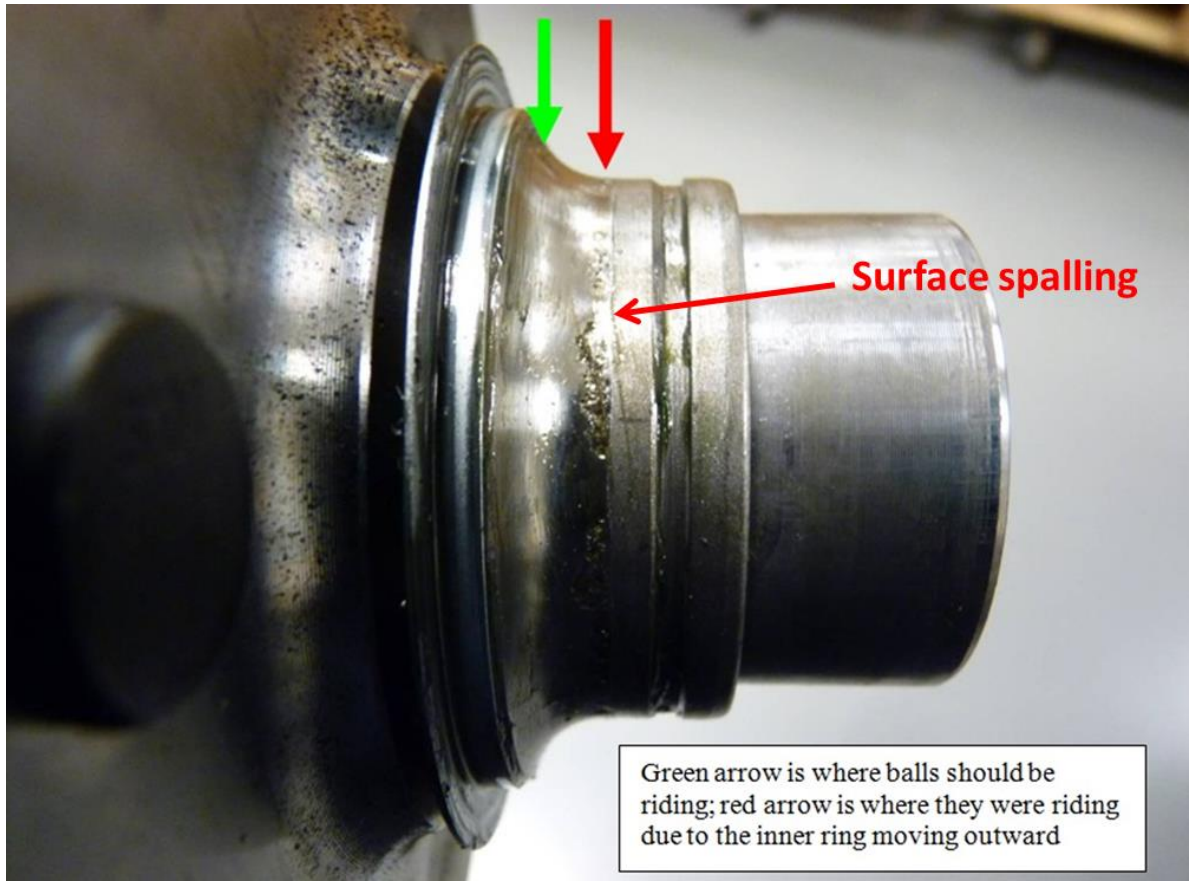
- Separated Bearing races allow the bearings to ride outside of designated area, causing flaking and wear.



Axle Nut Installation Do's and Dont's

- This is another example of what happens to a bearing internally when the axle nut comes loose and the raceways separate.

- The balls are not longer riding in the center of the raceway as intended. You can see surface spalling (metallic flaking) where the balls were riding off-center.



Improper Tools of Hub Service

- Torch damage. This hub assembly was actually submitted as a warranty return.

- Any part's warranty is void when the part is received with this kind of damage.

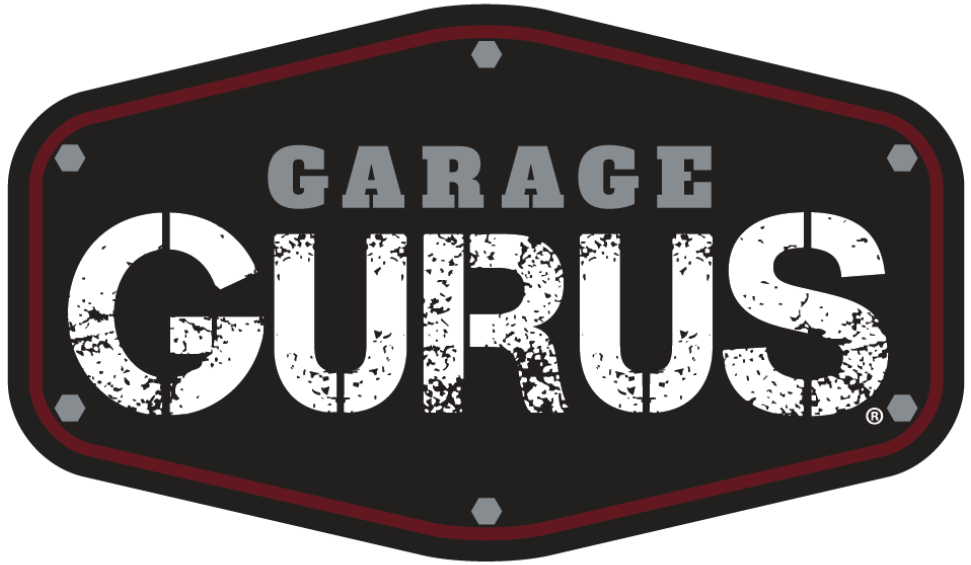
- Impact wrenches can cause hub bearing damage.

Proper Axle Nut Installation

- ALWAYS replace old axle nuts with NEW.
- It is good practice to apply a thread-locker to the threads to prevent the nut from backing off.
- Axle nut torque specs found in driv.cat

ABS reluctor ring contamination

- This hub was removed due to an ABS code, but the problem was not caused by the hub, it was caused by heavy contamination around the magnetic ABS encoder.
- Use caution not to press on the encoder ring

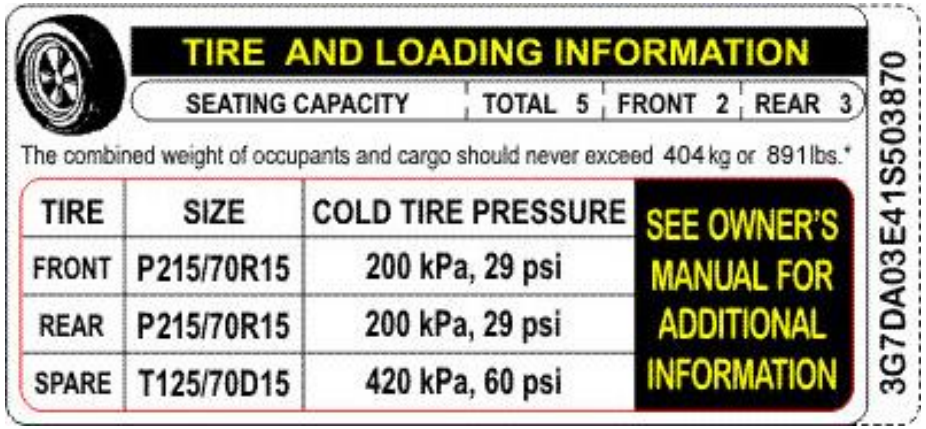


Tire Wear Patterns

Inspect tires for wear before discarding

Alignment techs can learn a lot from the old tires

Tire Wear Patterns



Subject: Steering Wheel Shimmy at low speeds

Vehicle Involved: 2001- 2005 Hyundai Santa Fe vehicles.

Condition: Low and uneven tire pressure will cause vehicle to battle with Rack and Pinion centering, causing steering wheel to shimmy at lower speeds.

Repair Procedure: Properly inflate tires to manufacture specification. Two common methods are referring to door jam sticker or follow tire manufacturer specification on tire.

Tire Wear Patterns

Under inflated tire wear - Wear on inner and outer edges of tire

Tire Wear Patterns

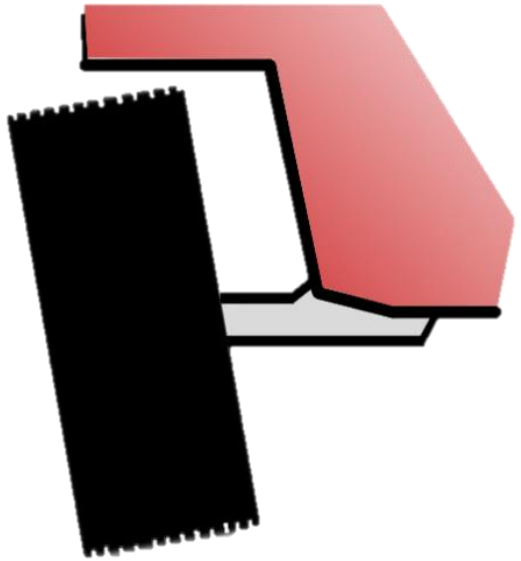
Over inflated tire wear

- Tire wear on center of tire
- Tread separation

Tire Wear Patterns

Excessive Positive Camber tire wear

- Will wear on the outer edge of tire tread

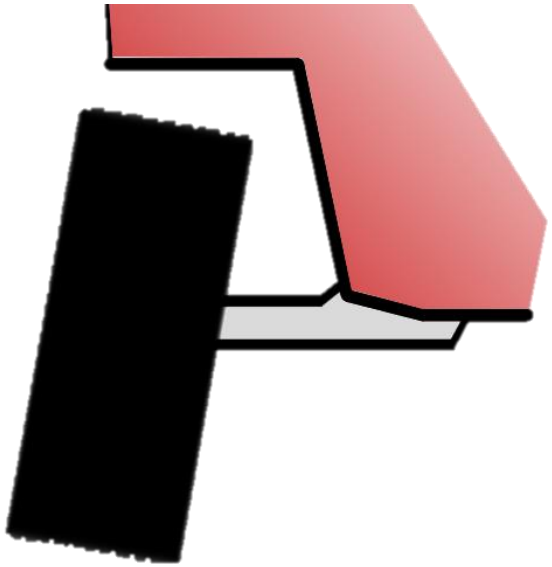


Positive Camber

Tire Wear Patterns

Excessive Negative Camber tire wear

- Will wear tire on inner edge of tire tread



Negative Camber

Tire Wear Patterns

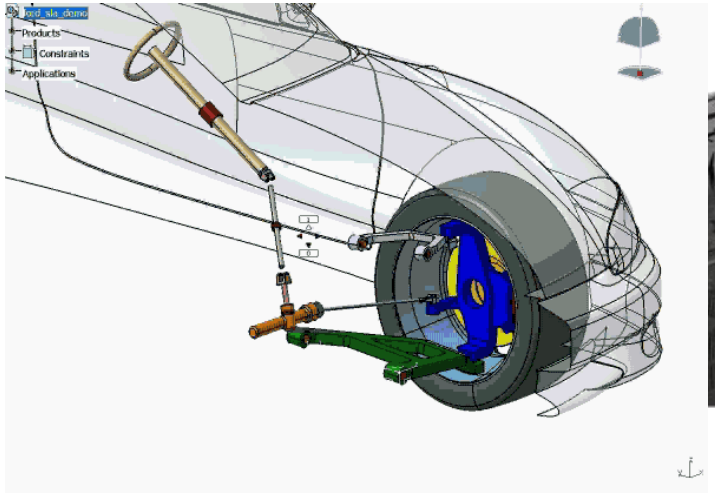
Toe in / Toe out tire wear

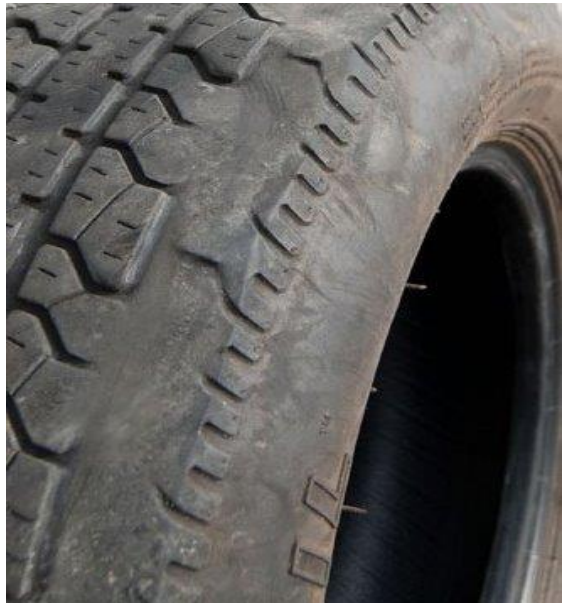
- Feathering tread wear

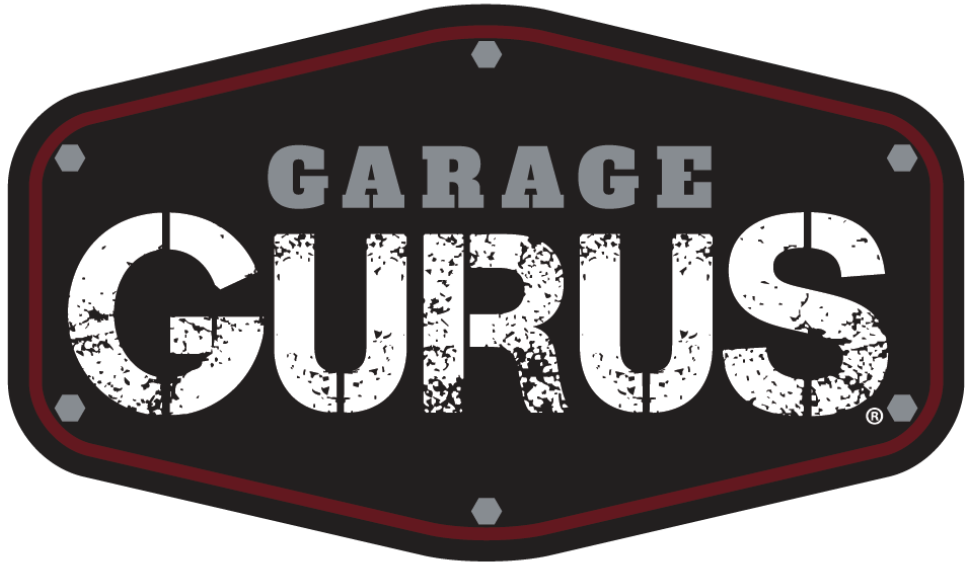
Tire Wear Patterns

Worn Steering & Suspension tire wear

- Uneven tire wear
- Cupping wear







SAS

Steering Angle Sensor

SAS in Electronic Steering

Newer vehicles may provide modern technology to assist in vehicle steering correction. These calculations are made using various inputs such as Steering Angle & Yaw rate. These systems can control current to EPS motor, brake application to correct direction, and some may control the suspension to achieve it's driving pattern.

Steering Angle Sensor

Integration to vehicle systems

- **Electronic Stability Control System**:
  - The SAS tells the ABS control module where the driver is steering the vehicle, while the body motion sensors tell it how the body is responding. At the same time, the ABS wheel-speed sensors are monitoring tire traction and slippage. The control module takes all of this data into account and compares the sensor inputs to its programming to determine overall vehicle dynamics.

Actual vs Desired

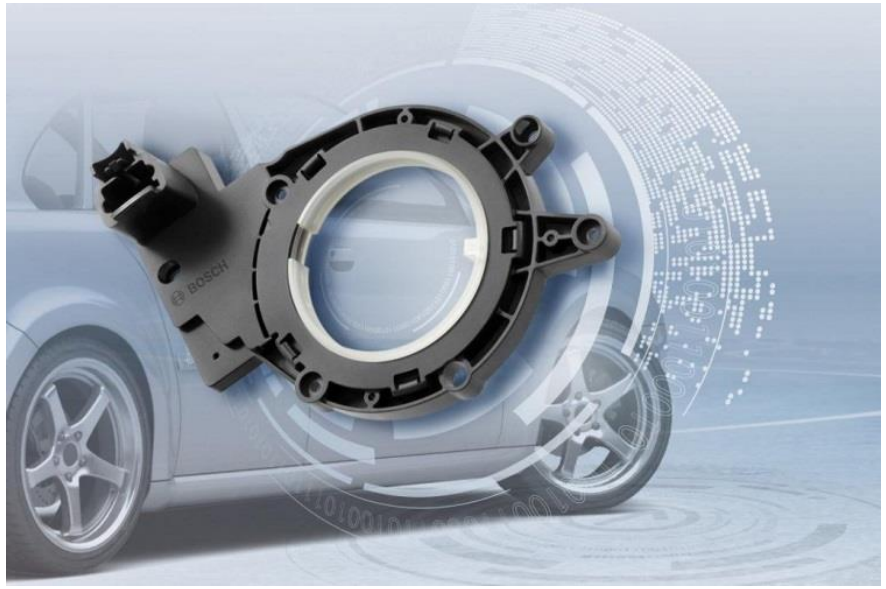
SAS input could be related to the ‘desired’ vehicle direction (driver input). SAS will feed an output signal to the EBCM in analog, digital or CAN data. Calibration is critical.

YAW represents the ‘actual movement’ of the vehicle in regards to all the forces acting on the car. YAW will feed an output signal to the EBCM via CAN data according to the vehicle’s true movements. Calibration is critical

Steering Rate / Speed

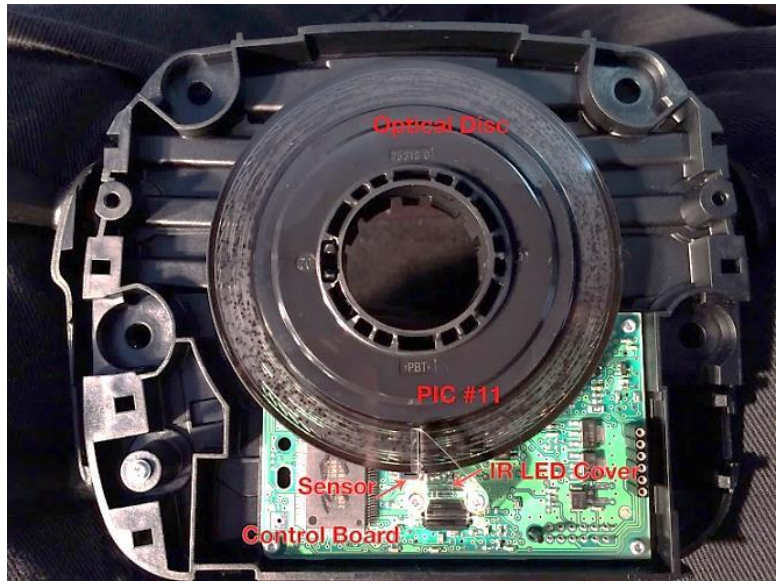
- Steering rate or speed was originally performed using SWPS (steering wheel position sensors). Its only task was to measure the rate of speed through driver input to control power steering assist.

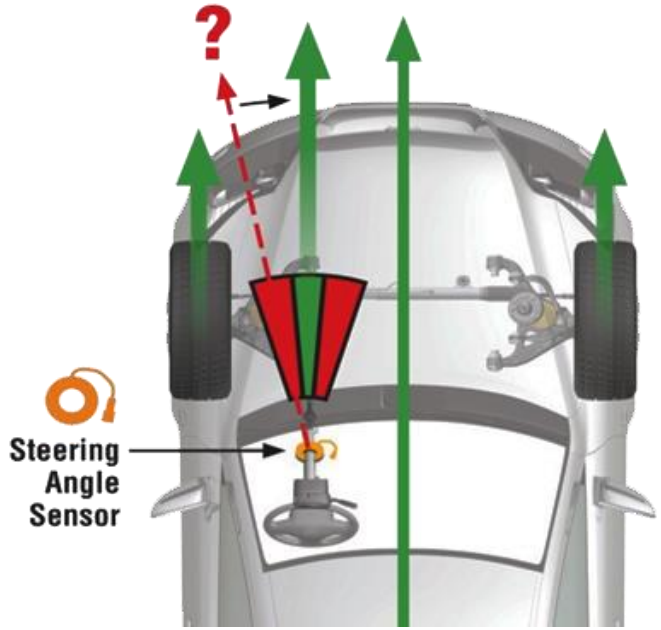
- Today we use the steering angle for this, but also many other functions such as:
  - Active steering control
  - Active suspension
  - Stability control



High Resolution SAS

- These sensors will generally be either a **Hall Effect Type** or an **Optical Type**
- They produce **DIGITAL** outputs and can be tested with a Digital Storage Oscilloscope
- SAS center must correspond to the new Steer Ahead position after a wheel alignment or parts are replaced

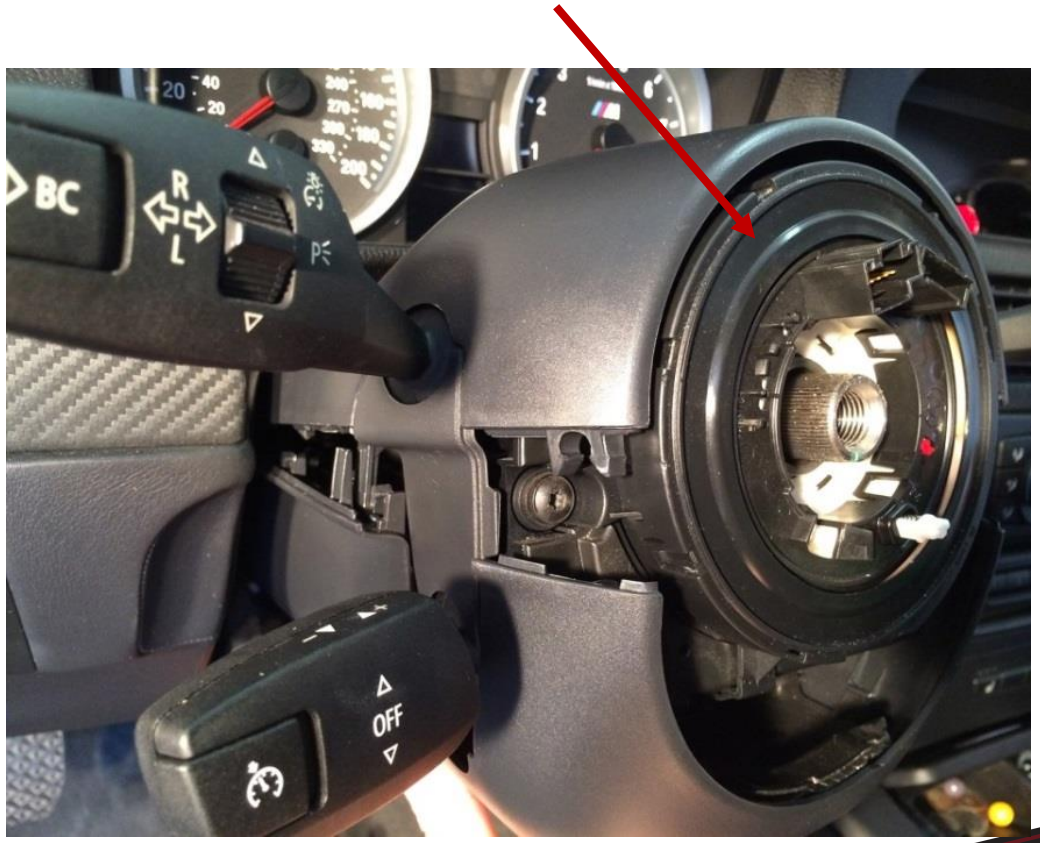




Steering Angle Sensor

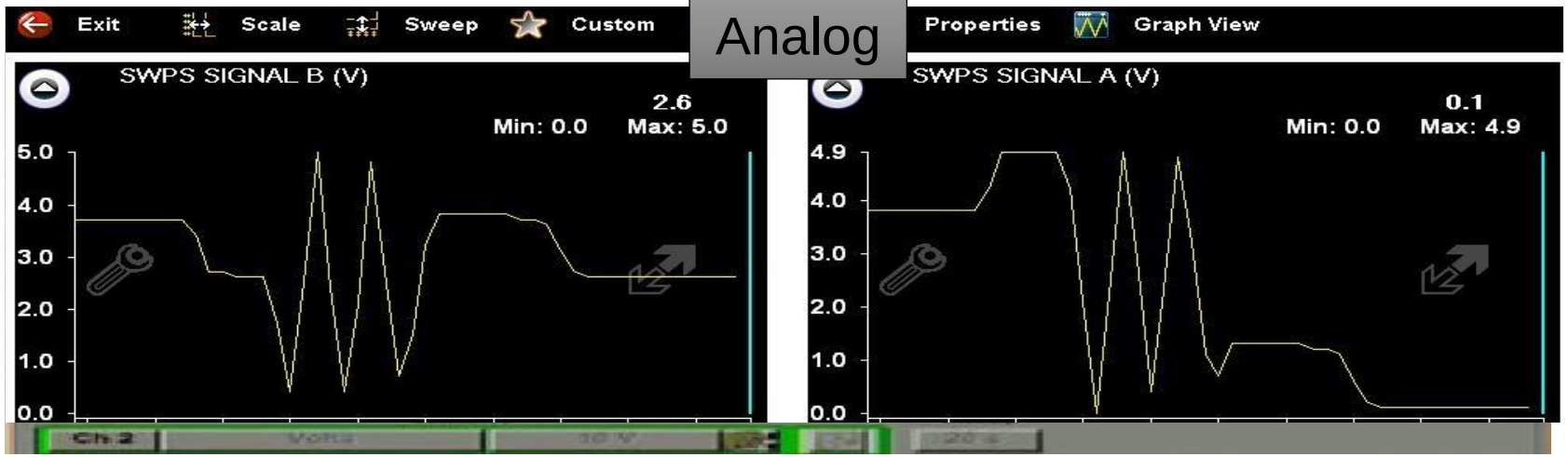
- **Location**:

  Usually integrated into a harness that contain various controls as well as the air bag clock spring

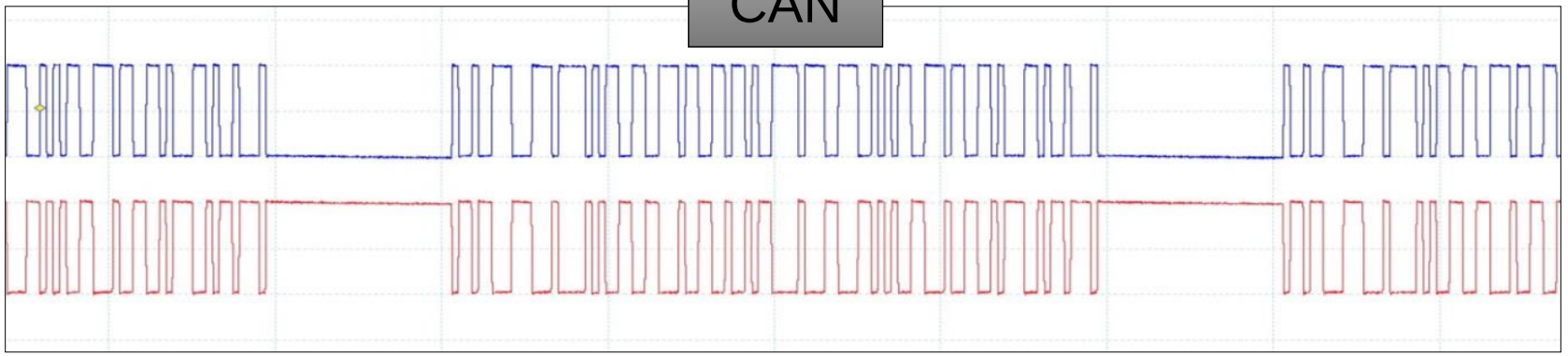


Testing the SAS

Analog

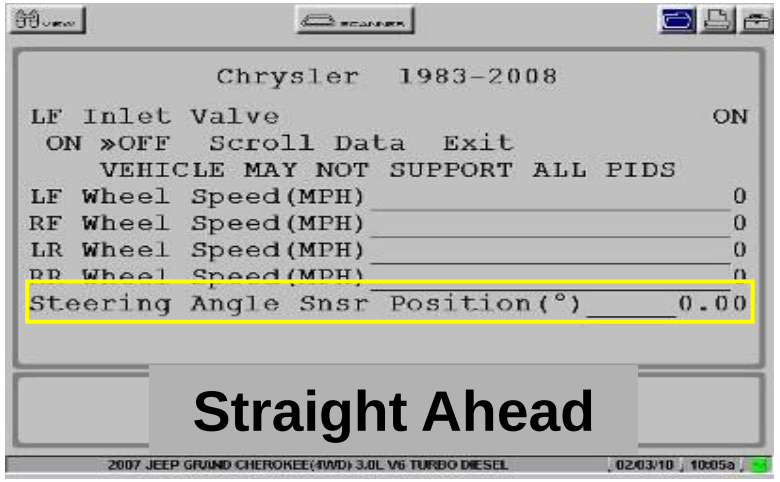


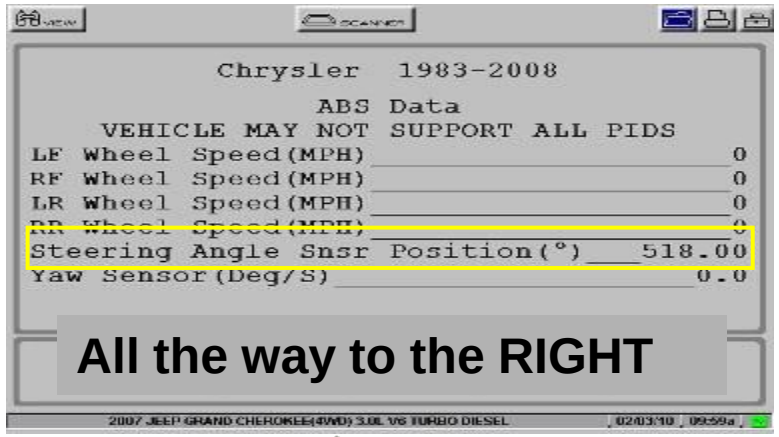
CAN

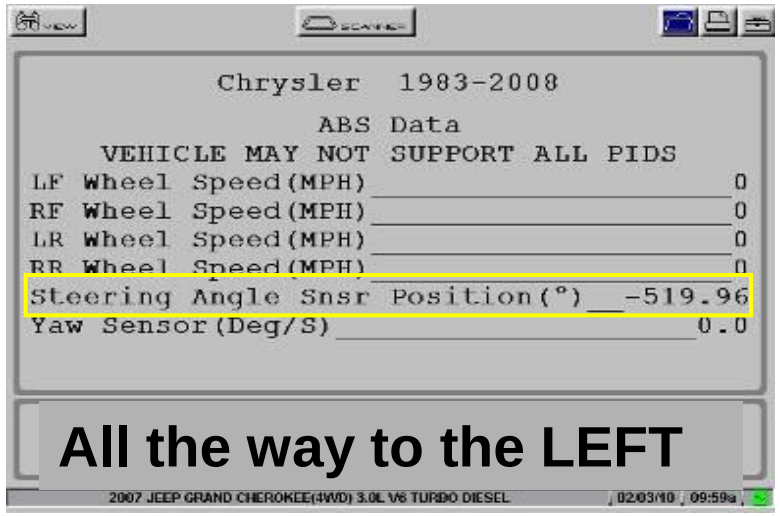


- The SAS works with voltage signals, so they can be graphed with a scan tool and/or a scope

Testing the SAS with a Scan Tool







Often, the SAS PID is in the ABS data list

When & Why

When do you need to potentially perform a Steering Angle Calibration?

- Loss of B+ or Battery replacement
- Alignments
- Sensor replacement
- Steering component replacements
- Module replacement or reprogram

When & Why

Toyota : Corolla : 2009-13 : 1.8L USA/Canada assembled : with 195/65R15 Tire

Steer Ahead

-292.5°

Steering Angle Sensor

1. Steer the vehicle straight ahead.
2. Disconnect the CodeLink® tool from the vehicle's diagnostic connector.
3. Switch the ignition off.
4. Disconnect the cable from the negative (–) terminal of the 12 Volt battery for five (5) to ten (10) seconds (this will set the Steering Angle Sensor to zero).

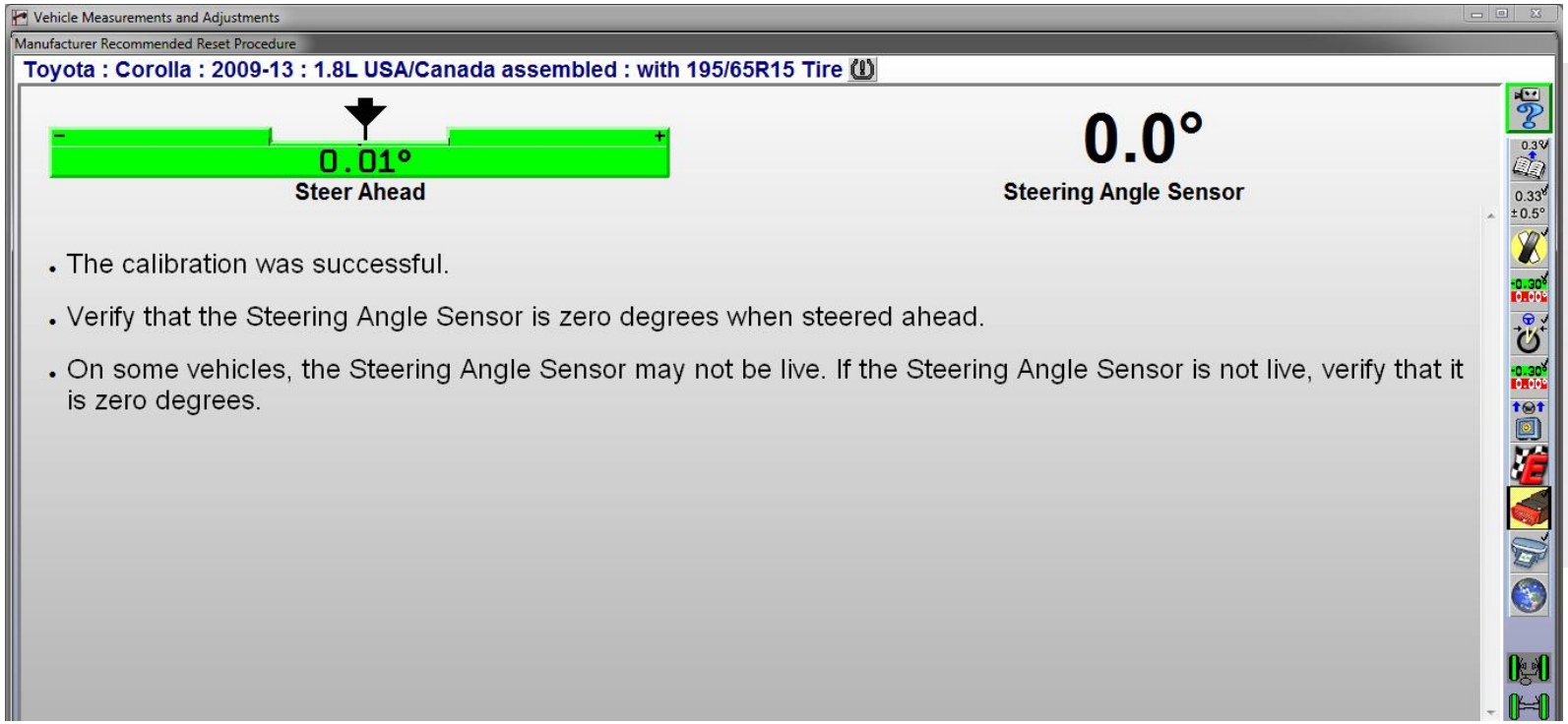
   Do not use a "memory saver" or other device to power the vehicle while the battery is disconnected!

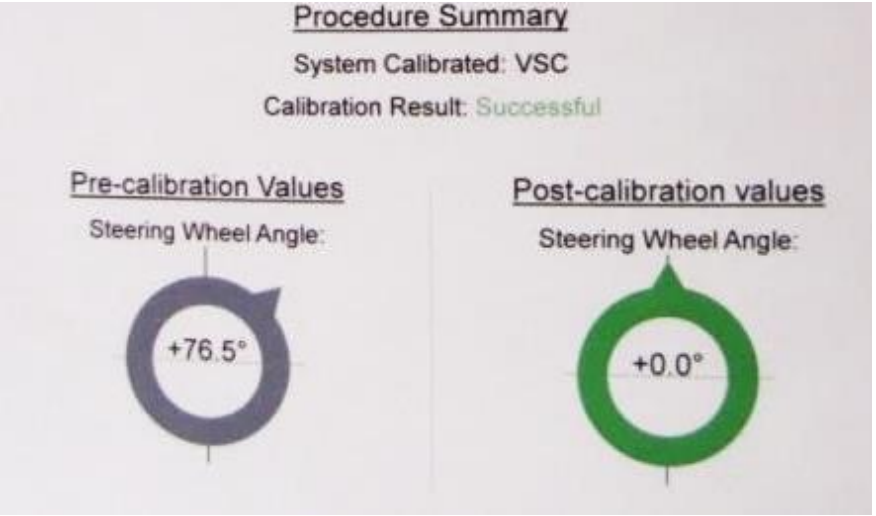
   (For more information regarding battery disconnect, refer to applicable service bulletin;
   Lexus L-SB-0015-08, Scion S-SB-0002-08, or Toyota T-SB-0020-08
   Titled "Disconnect Battery & Perform Zero Point Calibration After Wheel Alignment Adjustment")
5. Reconnect the cable to the negative (–) battery terminal.
6. Turn the ignition switch to the ON position.

Just because your vehicle is at a good steer-ahead does not necessarily mean your angle sensor is reading correct values. Some vehicles could lose or learn calibration by simply replacing a battery.

When & Why

Ensure a professional & (most importantly) a safe completely job.
It is your responsibility!





Hyundai Tucson

Customer Complaint: Dash lights were on but have turned off on it's own

Conditions: Vehicle was recently aligned but steering feels loose & hard to drive in a straight line

Codes: No Codes

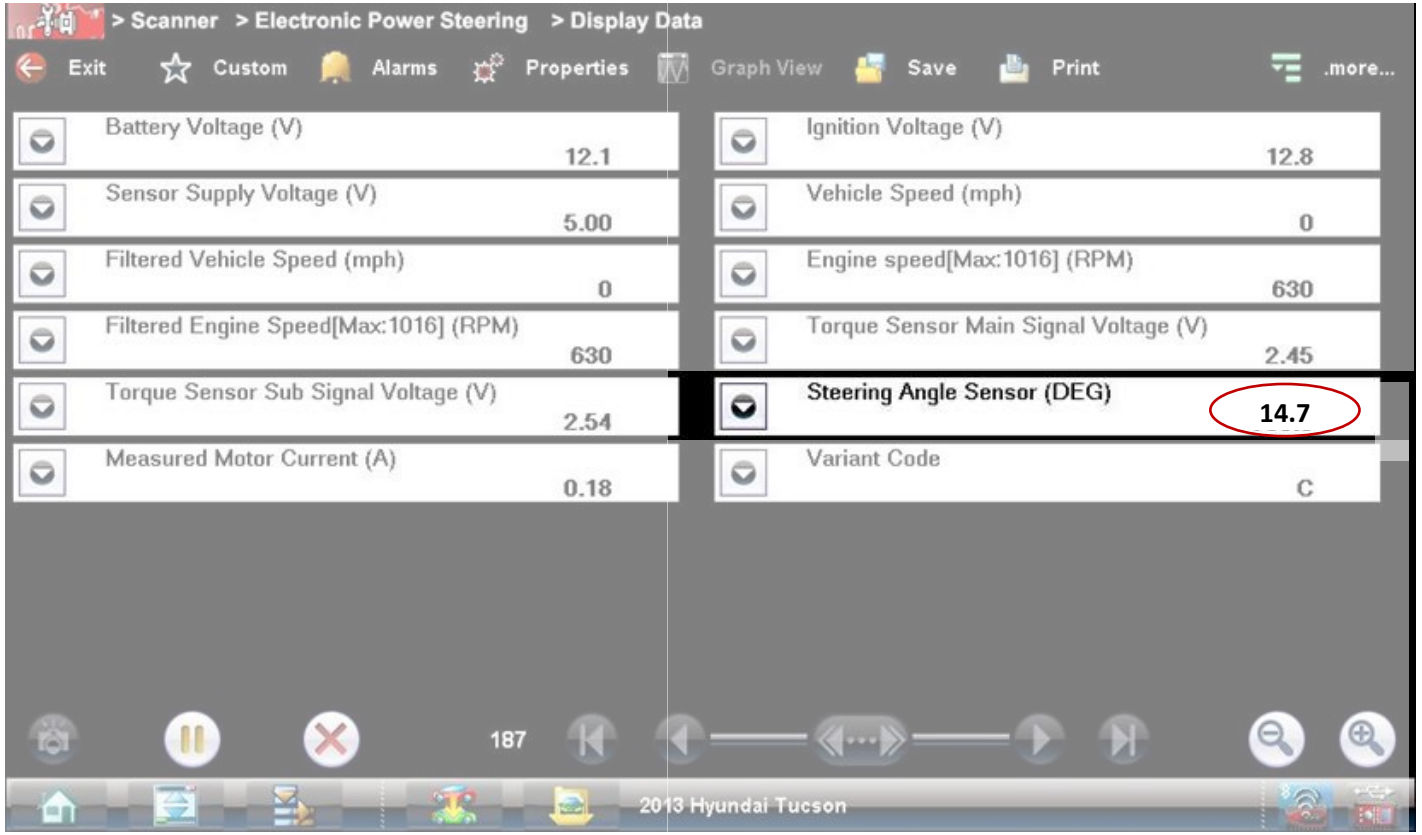
Possible Cause: Unknown

Test Drive

Test Drive:

- Steering feels it has max assist all of the time
- “Hill Descent Control” & “TC Warning” lamps turn on at a stop & turns off when moving
- Steering wheel does not return to center after turns
- Steering wheel off center while driving straight
- Steering wheel position must be correct to track

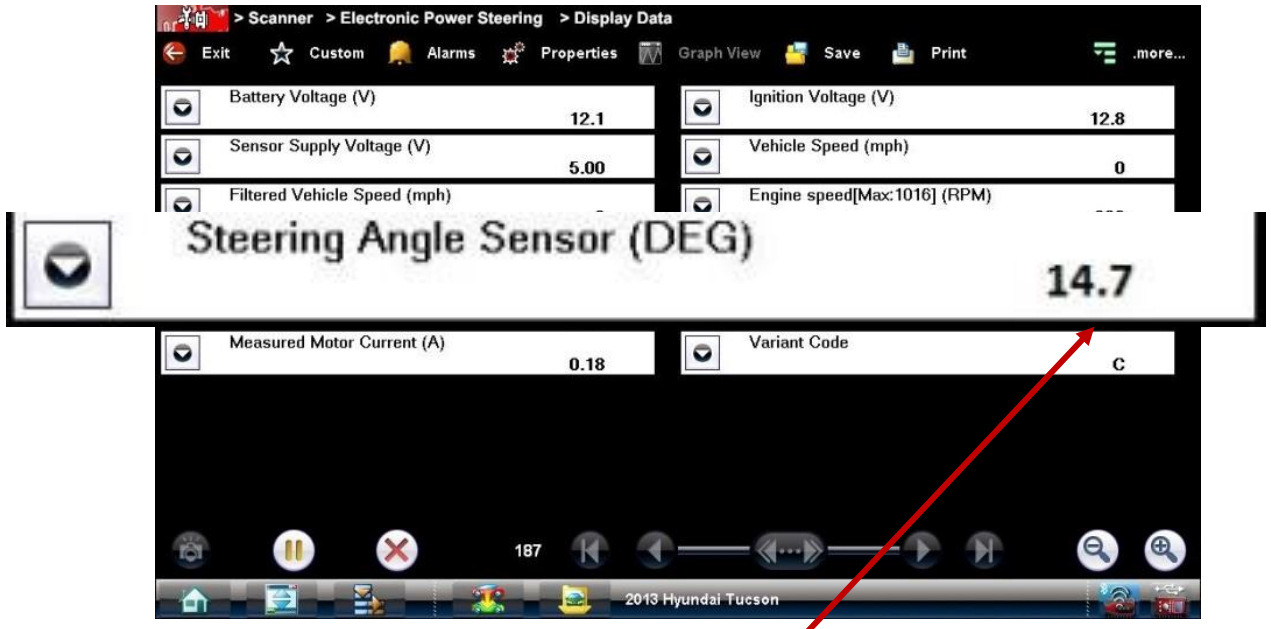
Zero Calibrated



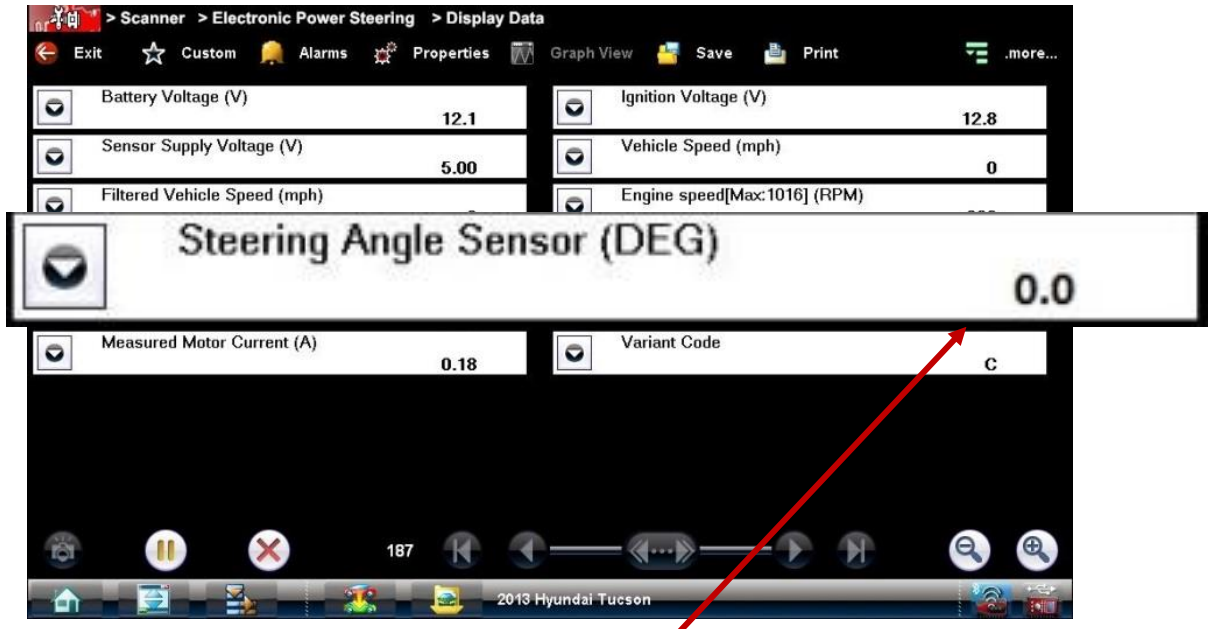
Wheels are straight ahead, hands off steering wheel

Steering Angle (DEG) = 14.7°

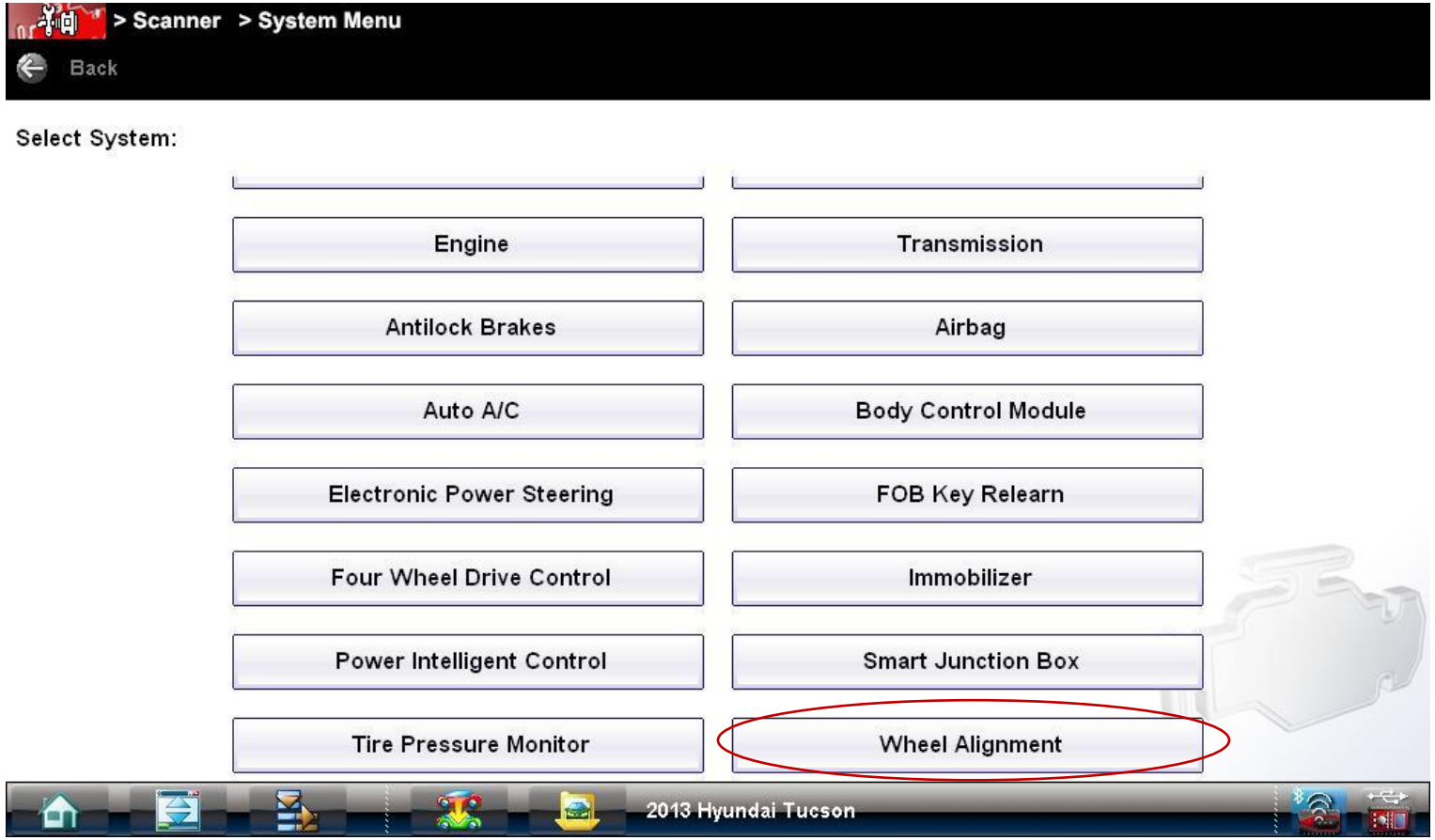
Steering Center vs Zero Point



The SAS is out of Calibration



SAS Calibration

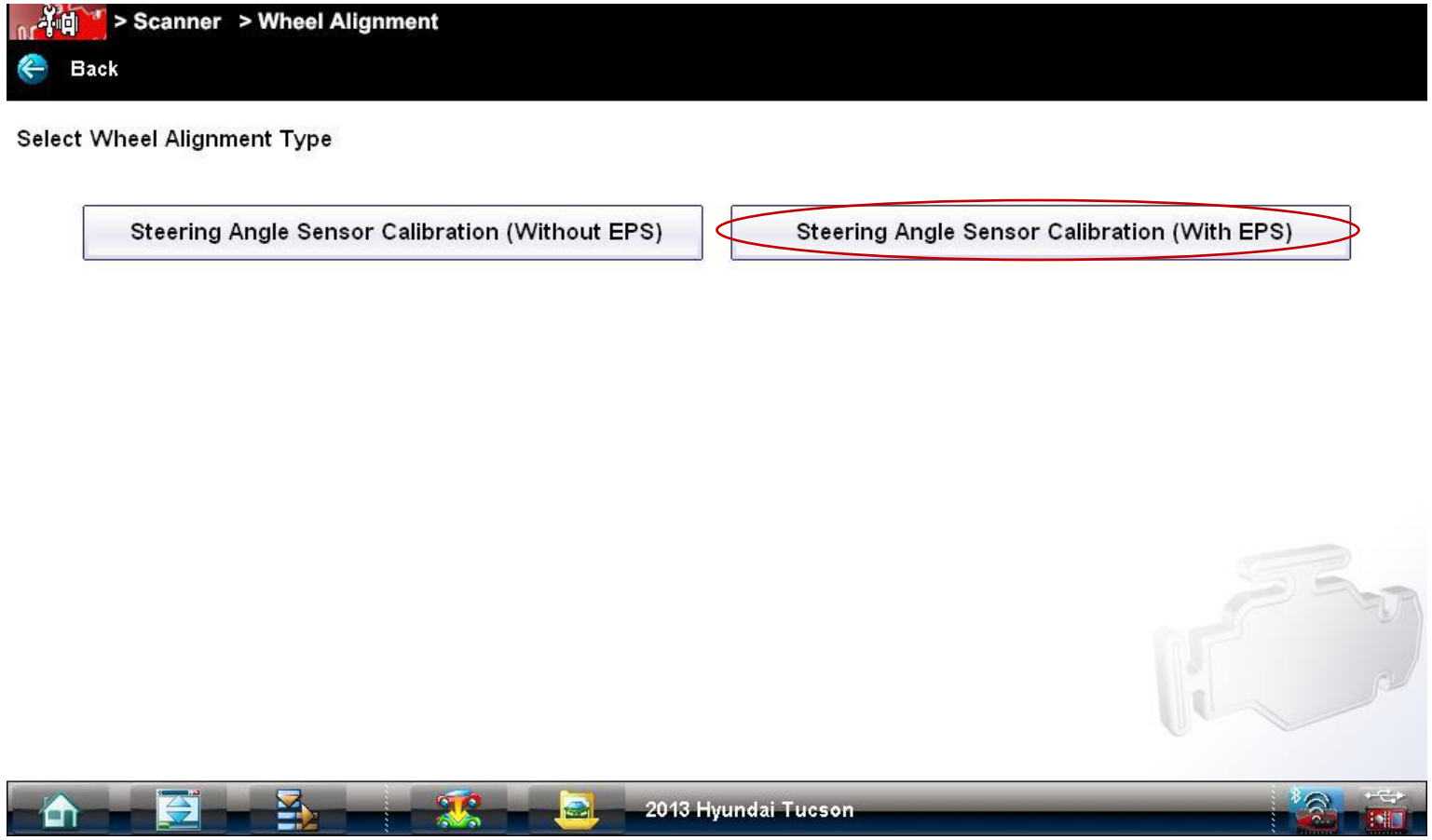


Test Requirements:

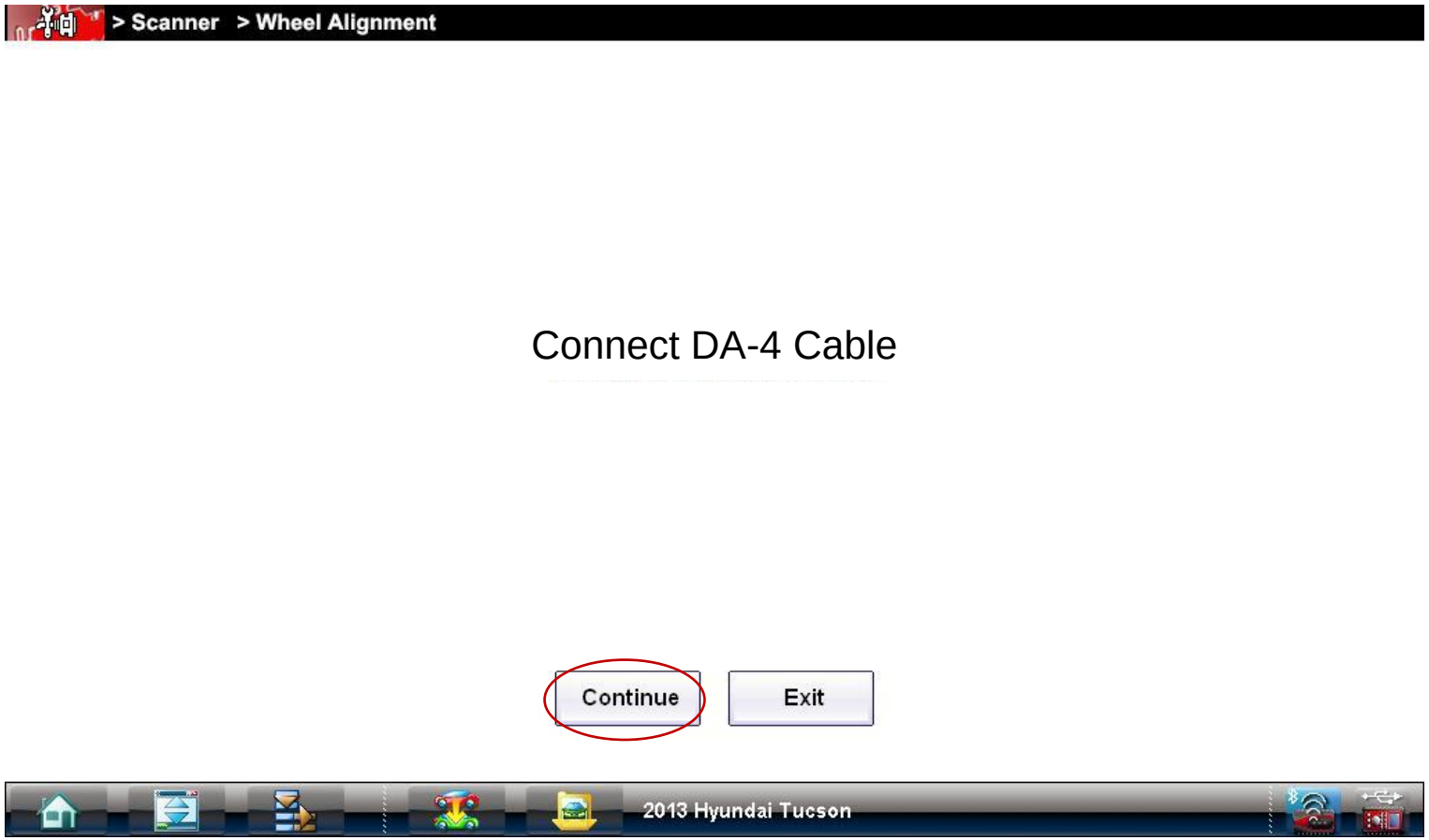
- Key On
- Engine On
- Wheels Straight
- Steering Wheel Centered

Engine MUST be running

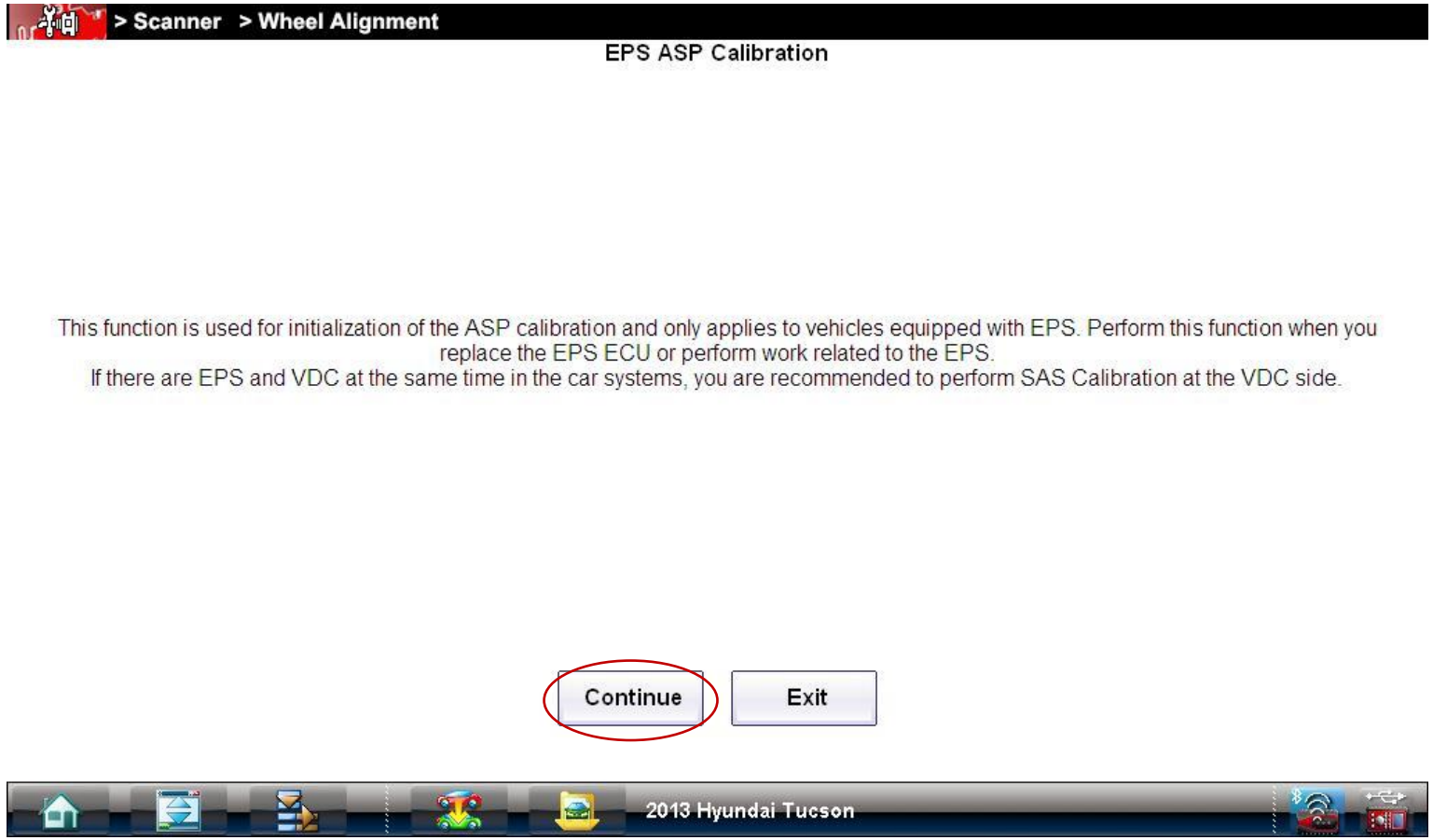
SAS Calibration



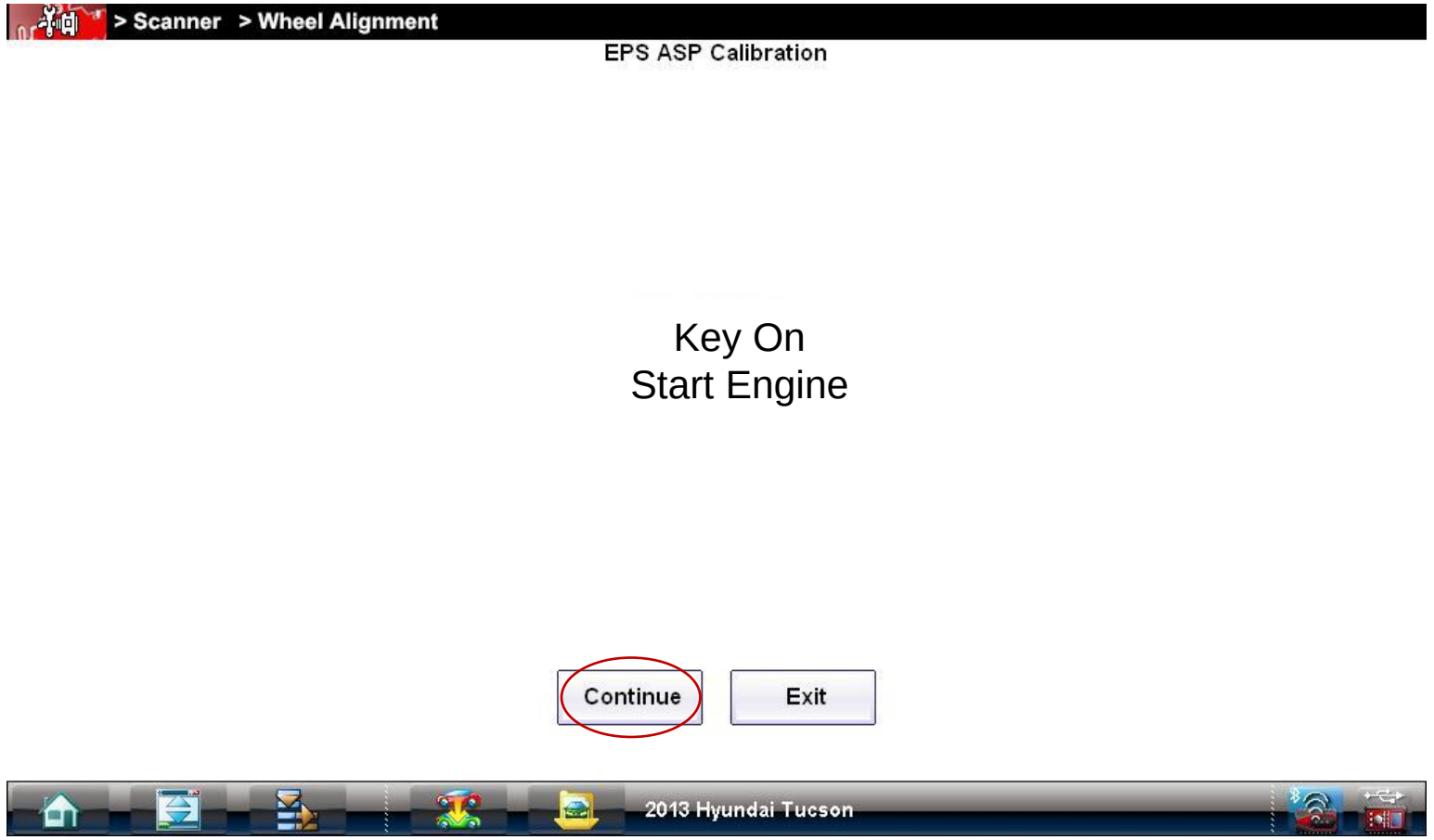
SAS Calibration



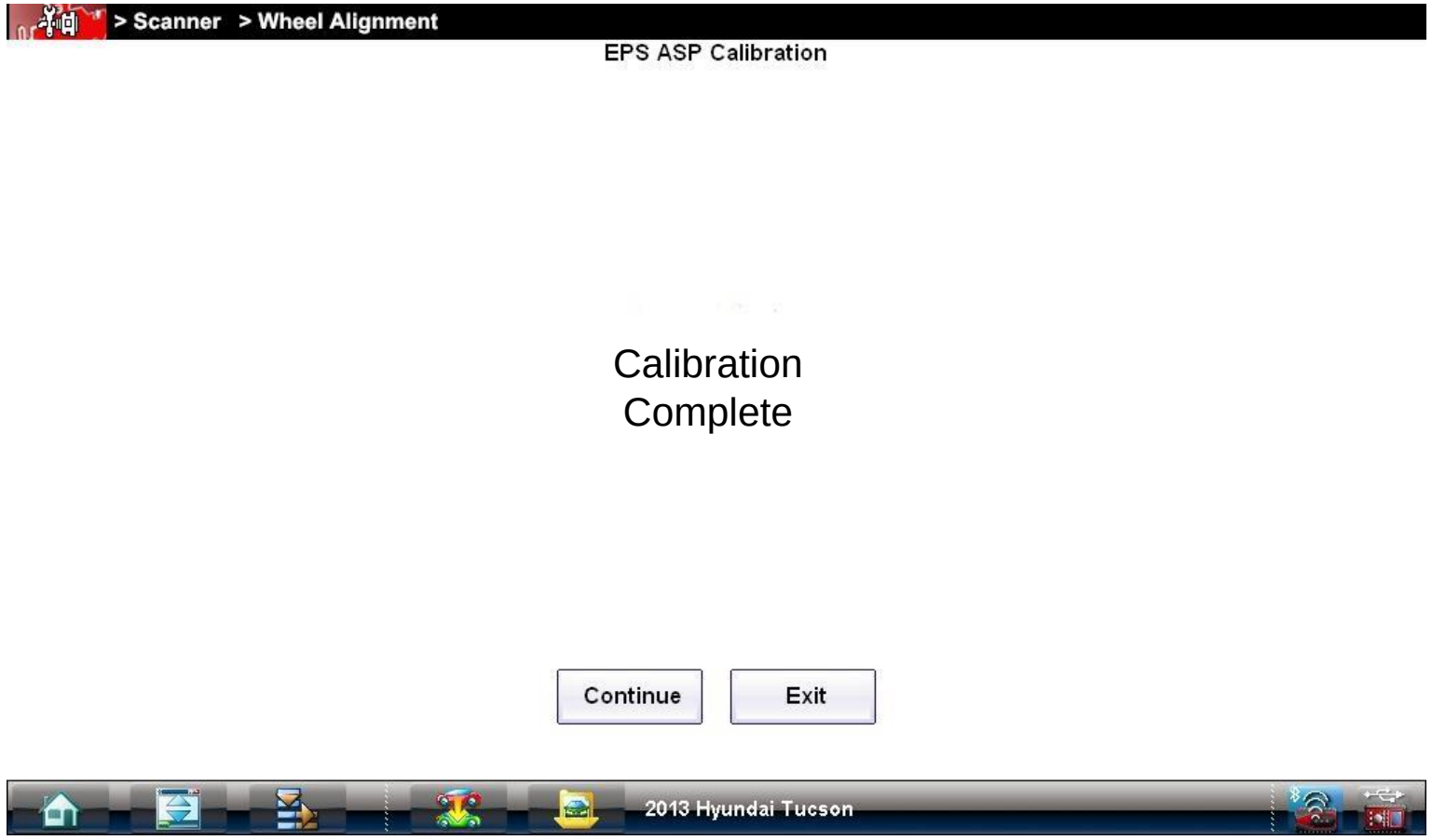
SAS Calibration



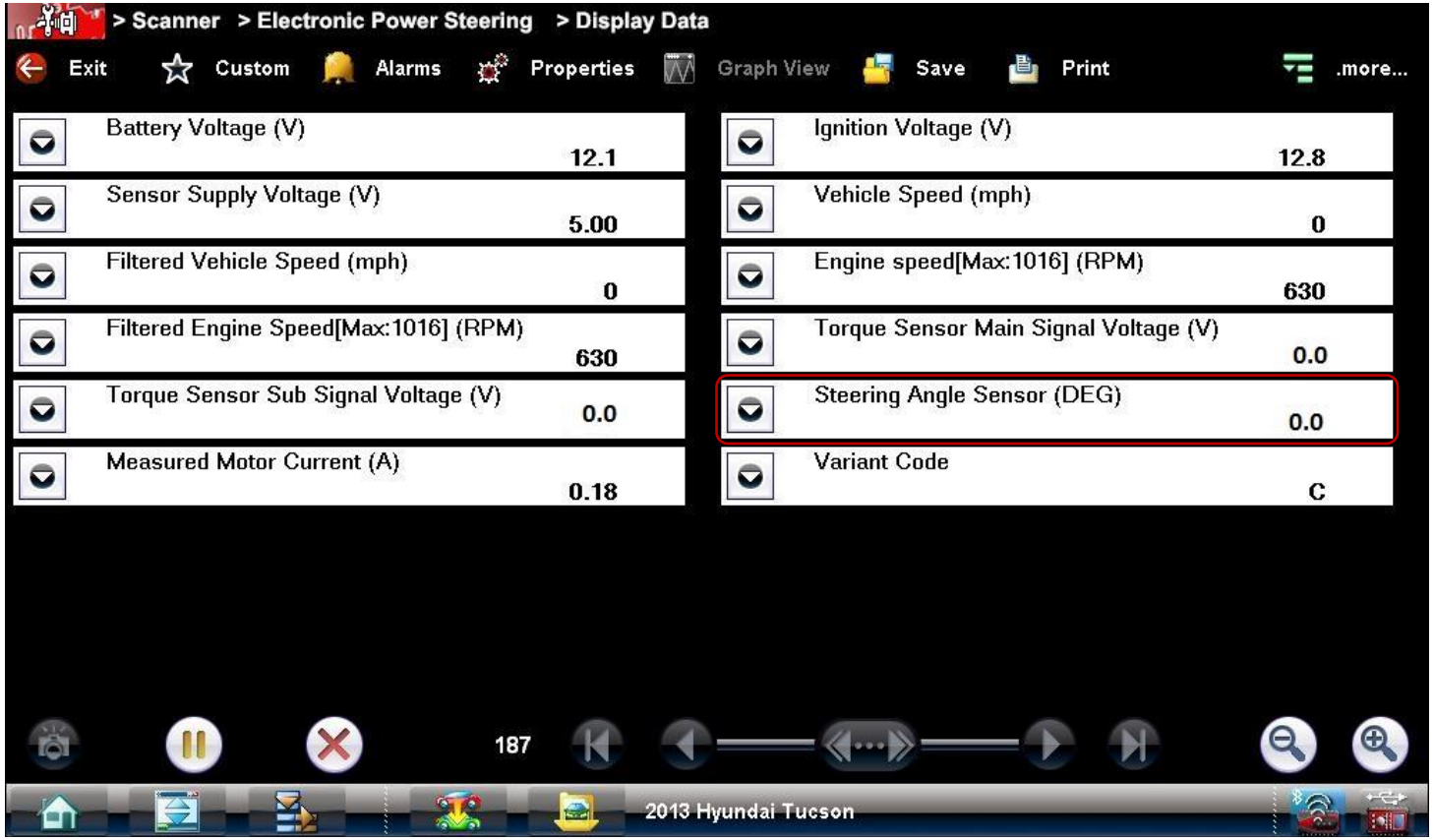
SAS Calibration



SAS Calibration

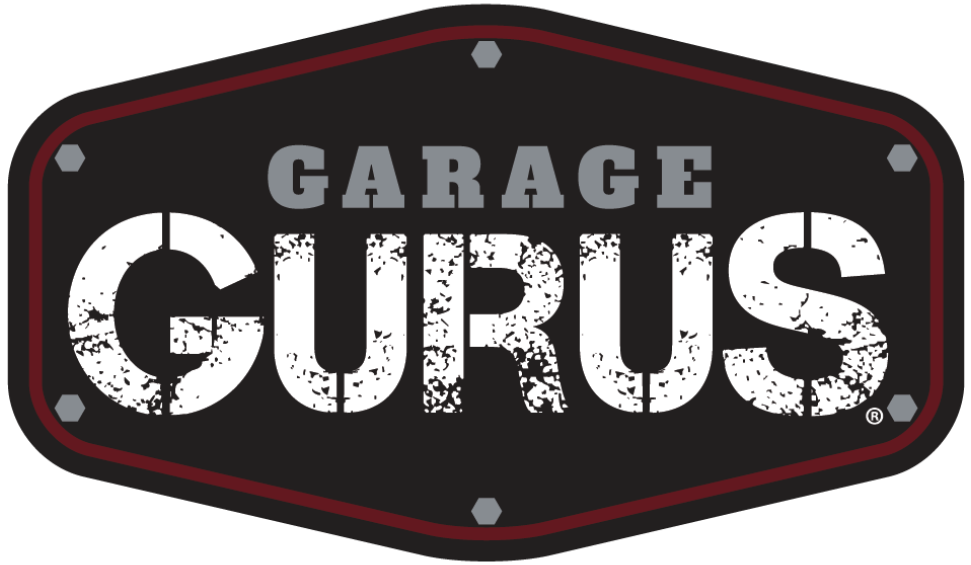


Post Calibration



After calibration review:

- SAS = 0.0°
- No warning lamps
- Steering assist returned to normal
- Steering wheel returns to center after turns
- Vehicle steers straight

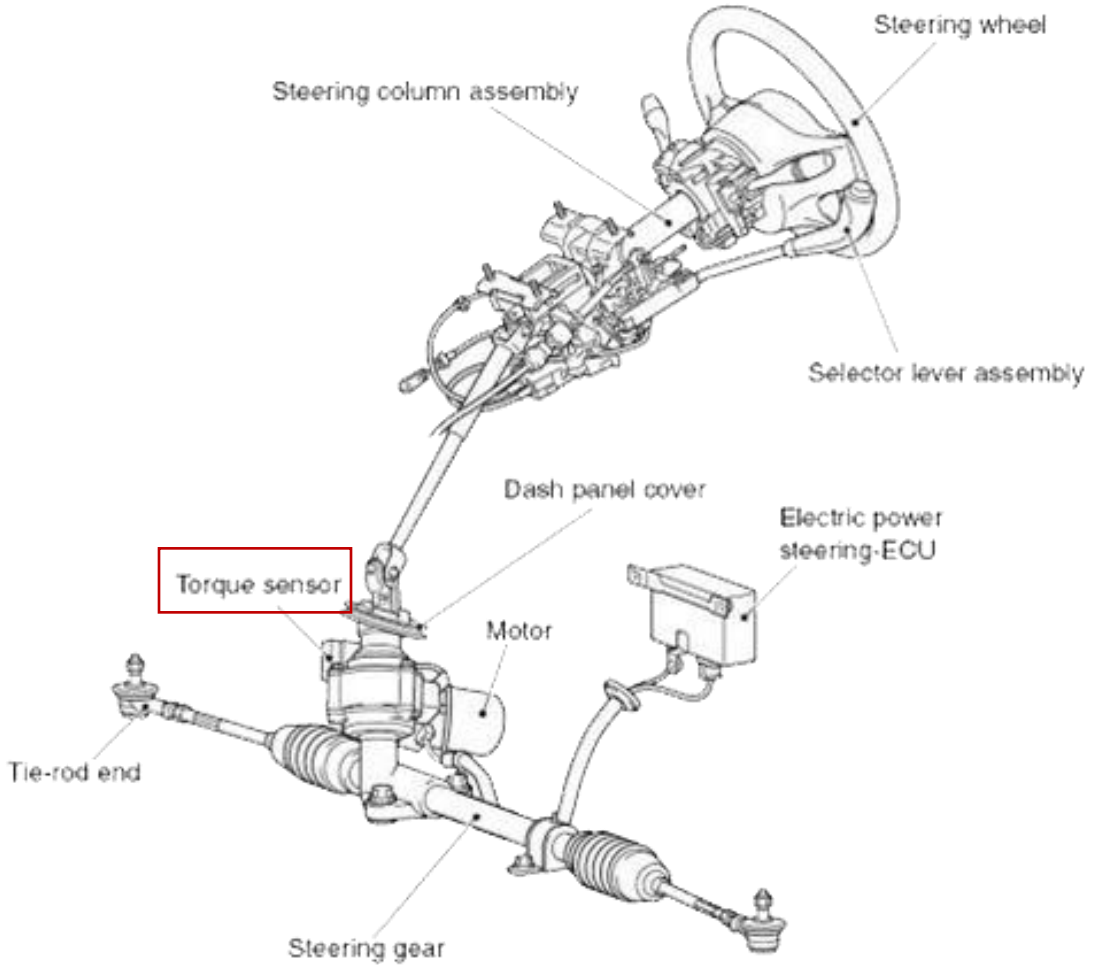


Torque Sensor

Torque Sensor

- **Description:** This device detects the steering effort generated by the driver when the steering wheel is turned and converts it into an electrical signal

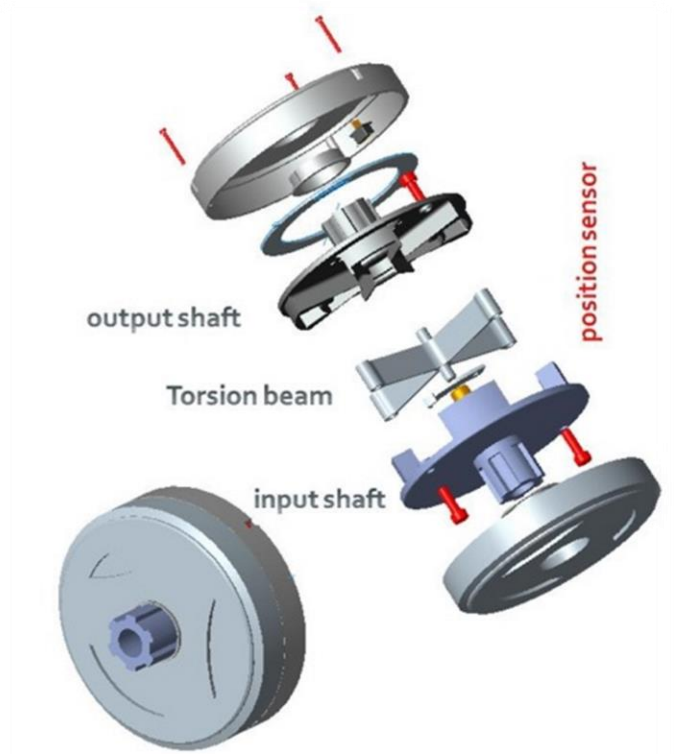
Torque Sensor

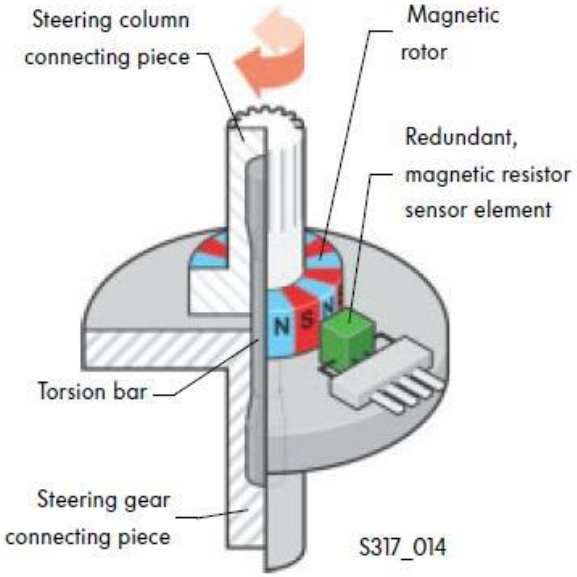


- **Location**: Most manufacturers have this sensor on the steering gear assembly, mostly on the steering shaft

Torque Sensor

- **Description**: Some designs work with a torsion bar in order to achieve the precise amount of steering effort applied by the driver on the steering wheel





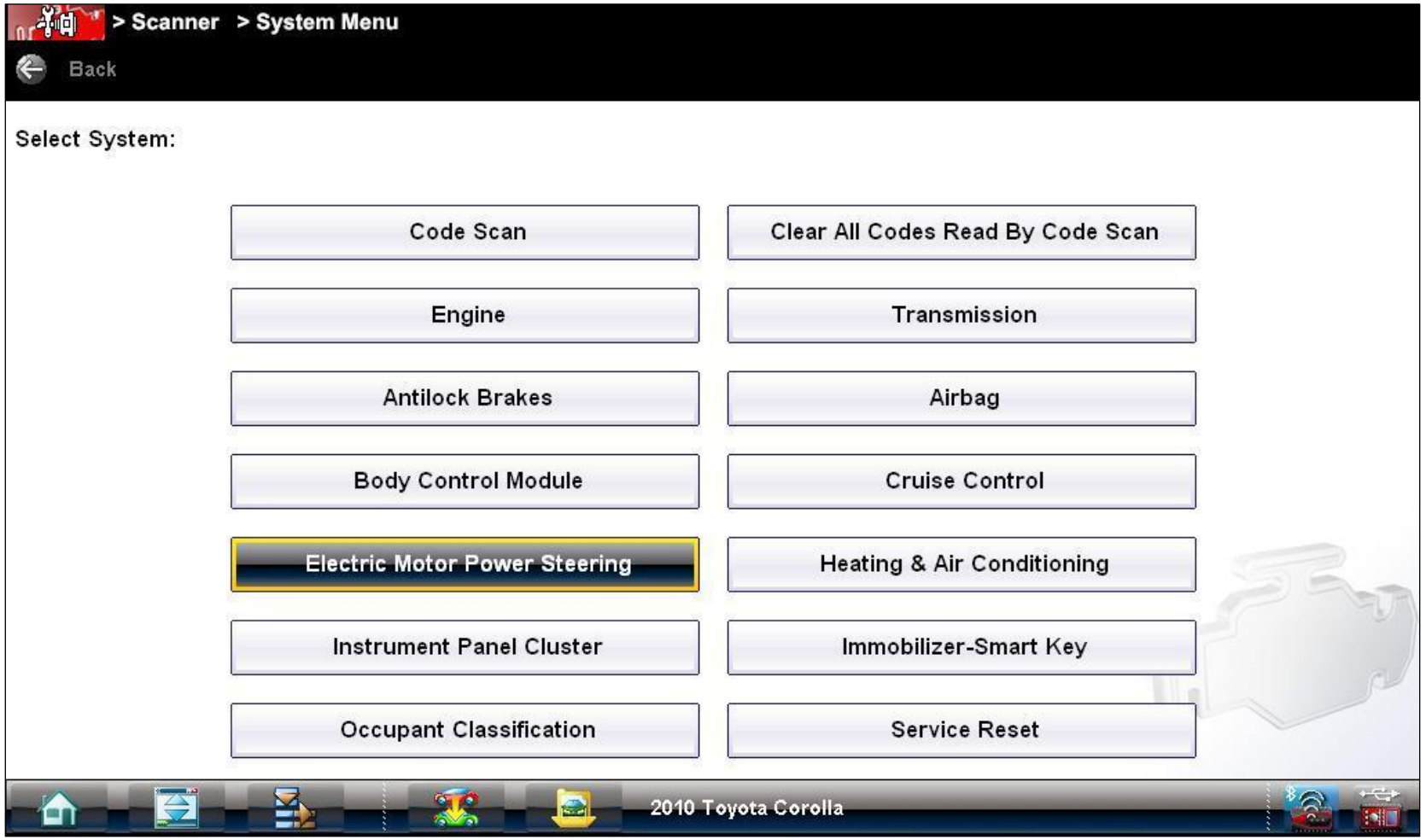
Torque Sensor

Calibration:

The sensor needs calibration if:

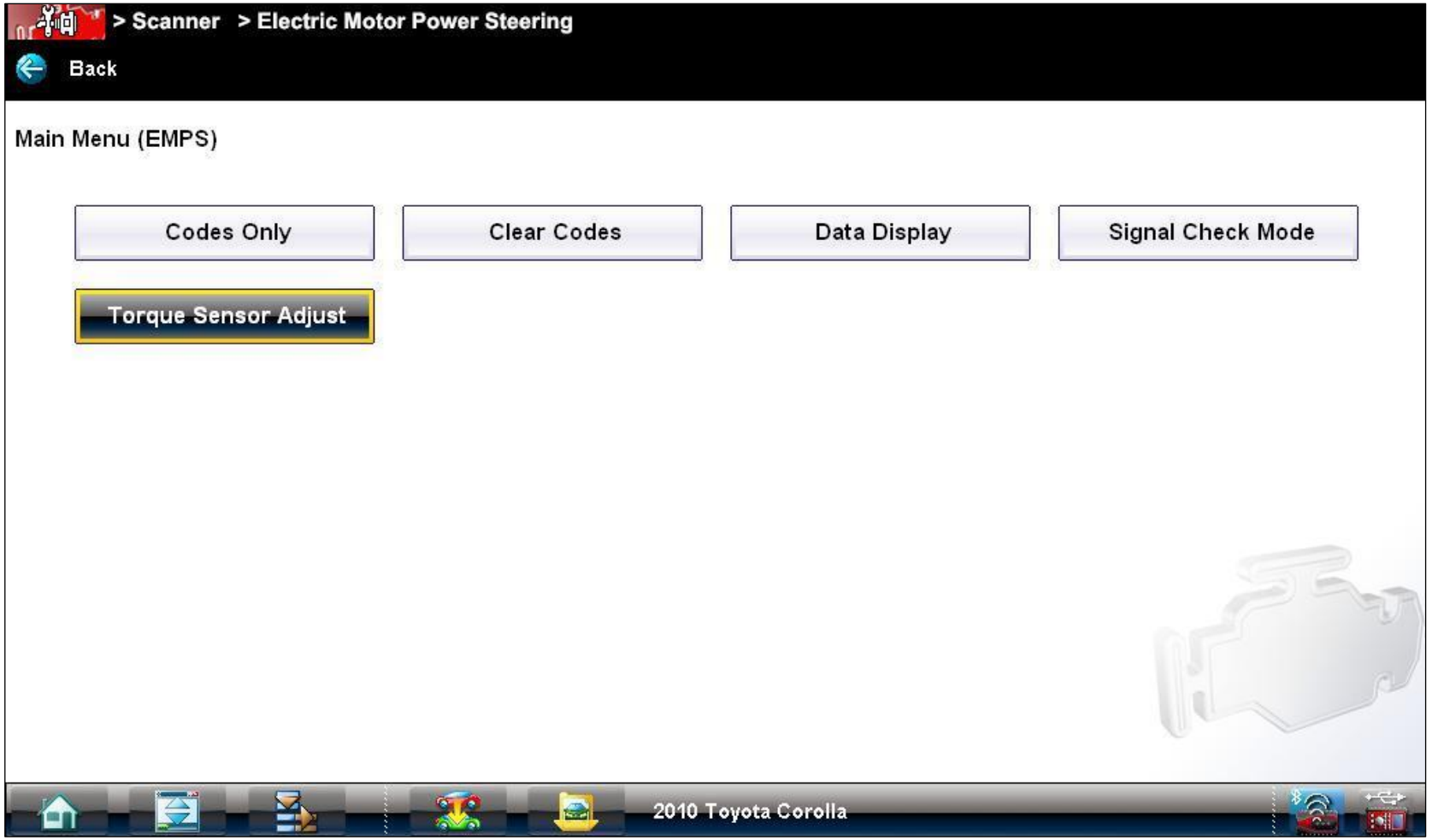
1. The steering column has been replaced
2. The power steering ECU has been replaced
3. The steering wheel has been replaced
4. The steering gear has been replaced
5. There is a difference in steering effort between right and left turning

Toyota Corolla
Torque Sensor Calibration



- Vehicle was hard to steer in one direction, and easier to steer in the opposite direction

Toyota Corolla
Torque Sensor Calibration



Toyota Corolla
Torque Sensor Calibration

TRQ SENSOR ADJUST:
This function is used for the following conditions:
-”Gear ASSY” or “EMPS ECU” was exchanged.
-Difference of steering control effort from left to right exists.

Toyota Corolla
Torque Sensor Calibration

Confirm the following:
Vehicle is stopped
Engine is running

Toyota Corolla
Torque Sensor Calibration

Turn Ignition Switch OFF for 10 seconds.

Toyota Corolla
Torque Sensor Calibration

- Step on brake pedal and start engine

Step on the brake pedal and turn
Ignition Switch on (READY) Engine Idling.

Toyota Corolla
Torque Sensor Calibration

-Check PS warning light is ON.
-Center the steering wheel.

Toyota Corolla
Torque Sensor Calibration

Now Processing
It will take 8 Seconds

Toyota Corolla
Torque Sensor Calibration

Torque Sensor Adjust Completed

SAS Calibration Procedures

- ***Codelink***®
  - Calibrating the SAS with Hunter's Codelink tool

SAS Calibration Procedures

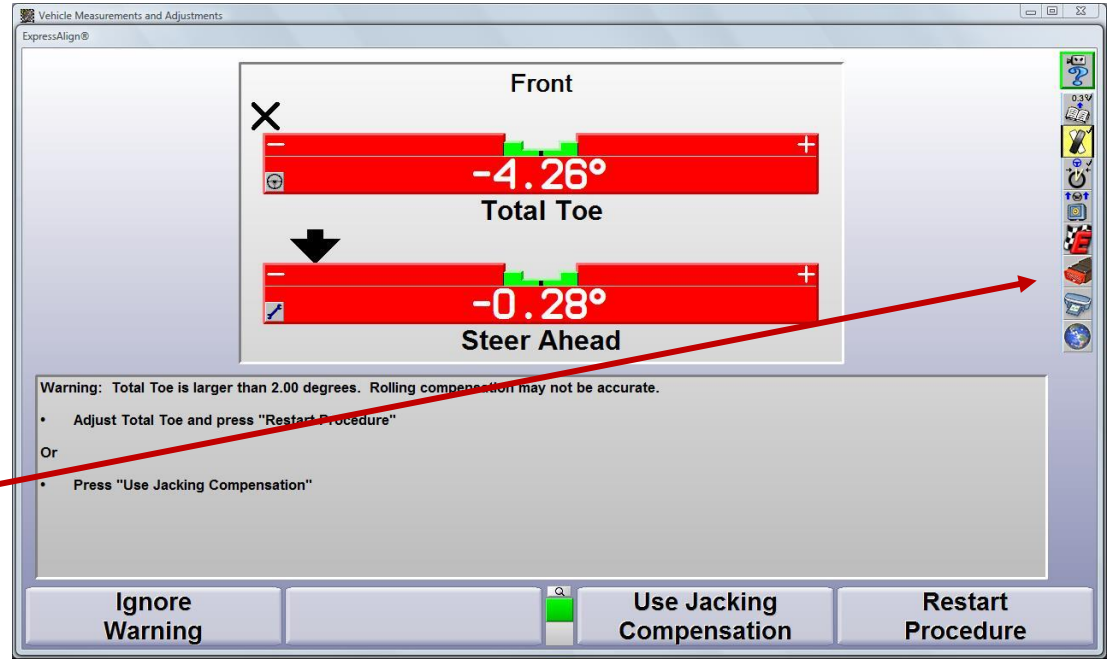
Using Hunter Aligner to recalibrate SAS

- When performing an alignment on a vehicle with Electronic Power Steering or Electronic Stability Control, connect the Hunter Codelink to the DLC
- Recalibrating the SAS is your new “last step” in your alignment procedure

SAS Calibration Procedures

Using Hunter Aligner to recalibrate SAS

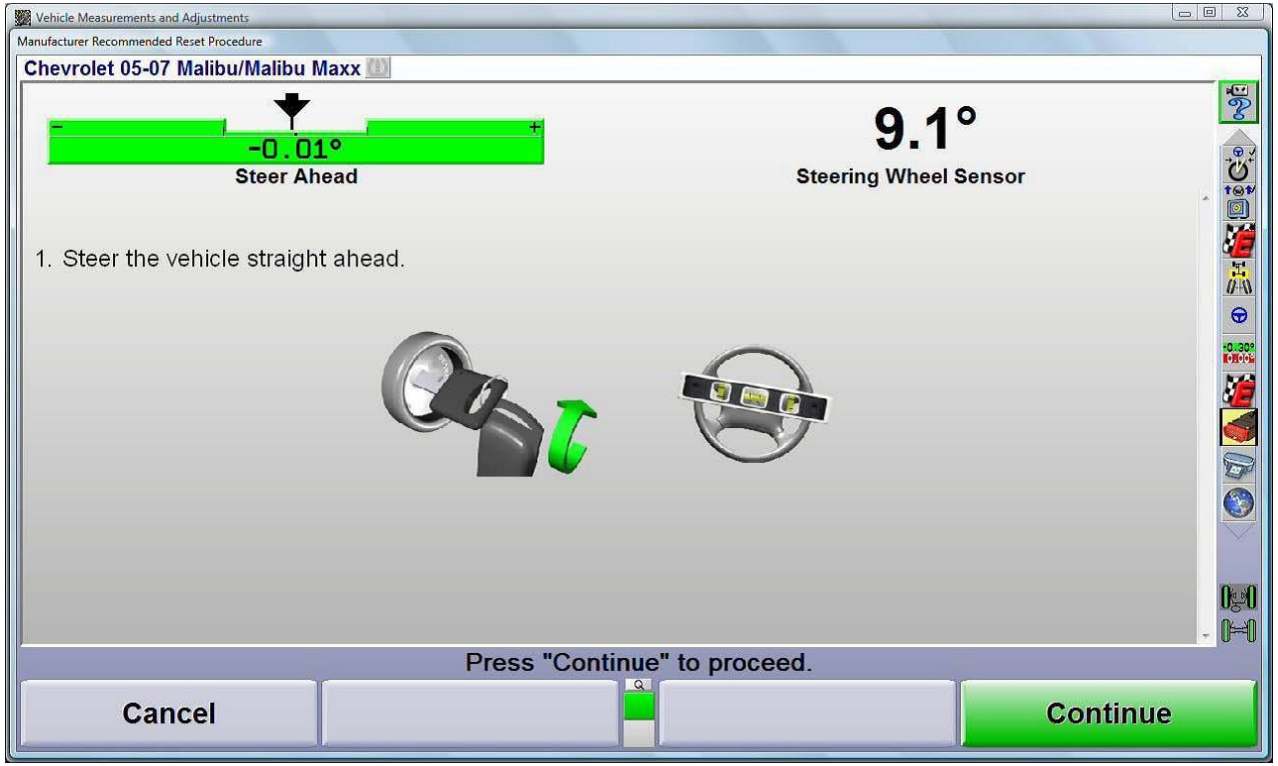
- After setting toe, you will be prompted to recalibrate the SAS
- The red DLC icon lets you know that the Codelink is available for use on the vehicle you are working on.



SAS Calibration Procedures

Using Hunter Aligner to recalibrate SAS

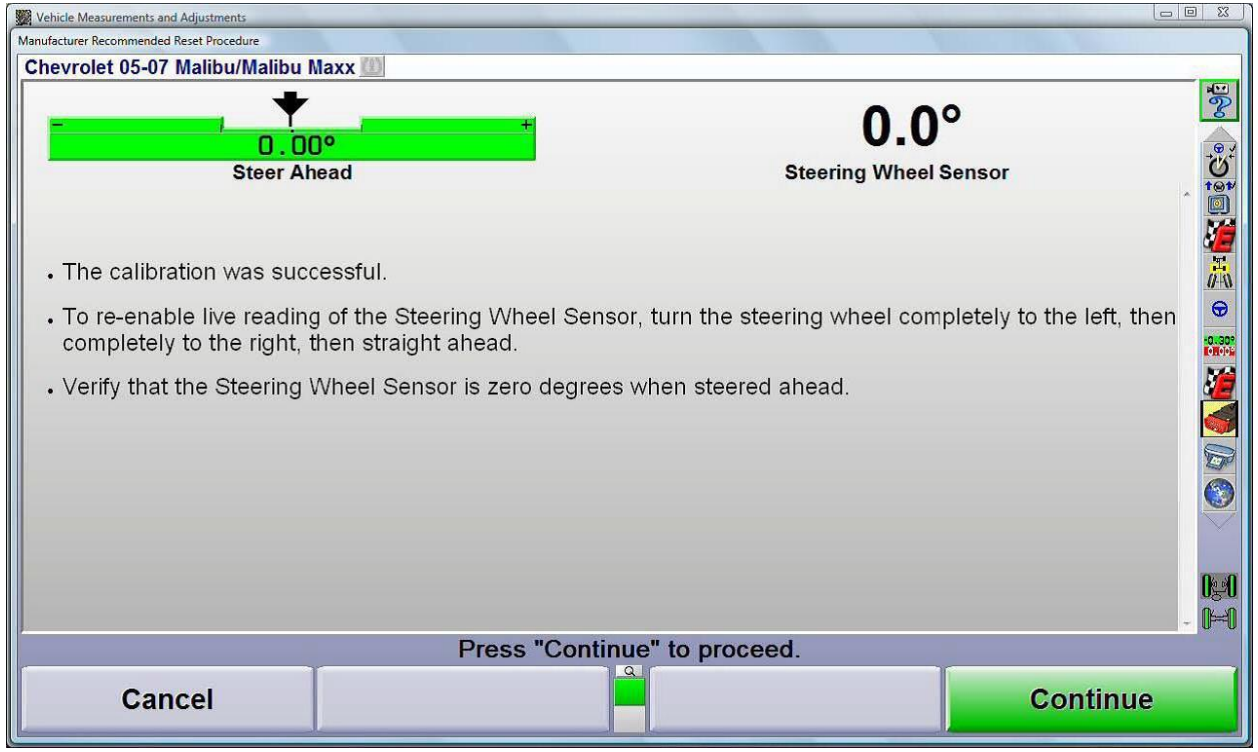
- After initiating the procedure, you will be prompted to:
  - Turn the key “on”
  - Level the steering wheel



SAS Calibration Procedures

Using Hunter Aligner to recalibrate SAS

- After clicking “Continue” the value for the SAS should be 0 degrees
- Turning the wheels lock to lock and back to center will give you a live SAS reading again
- Verify that the sensor still reads “0” with the wheels straight ahead



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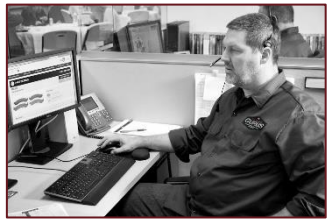

Thank You

GARAGE GURUS