Bendix® SAS-60™, SAS-70™, and SAS-80™ Steering Angle Sensors

INTRODUCTION

The Bendix® Steering Angle Sensor (SAS) is a 12V electronic sensor that senses the position of the steering wheel and communicates the information to either the brake control Electronic Control Unit (ECU) or a vehicle ECU. This sensor data is critical to the Bendix® Electronic Stability Program (ESP) functionality of the brake controller, and may also be used by other advanced systems on the vehicle.

The SAS has been available for multiple generations (SAS-60™, SAS-70™, SAS-80™) with minor updates made between the different generations. The sensors are compatible across generations as long as the same hardware and software configuration is chosen. Contact your local Bendix sales representative or use B2Bendix.com to find replacement service parts.

The sensors are available with two different orientation styles of the same harness connector: a "90-degree" connector where the electrical connector comes out of the face of the sensor, and a "straight" connector where the electrical connector comes out the end of the sensor. *See Figure 1.*

The sensors are available with a variety of CAN communication protocols and bitrates. Each individual SAS part number has a specific communications protocol assigned at the point of manufacturing. This protocol cannot be change or altered in the field. These different protocols are not compatible. Always use the assigned replacement part number when ordering service parts.

For vehicles equipped with the Bendix® EC-80™ or EC-60™ brake control ECUs, the sensor is directly connected to the brake control ECU and receives power and ground directly from the brake controller. It is also directly connected to the brake controller by a private "Sensor CAN" link which is shared only with the Yaw Rate Sensor (YAS).

For vehicles equipped with Bendix® GSBC® (Global Scalable Brake Control), depending on the vehicle Original Equipment Manufacturer (OEM), the SAS may or may not be connected to the GSBC Central ECU. Refer to the vehicle OEM wiring diagram for more information.

⚠ WARNING

The SAS must be calibrated if a steering wheel has been removed or replaced, the vehicle has received an alignment, or if the SAS has been replaced. If the SAS is not calibrated correctly, ESP functions may not operate properly, which may result in loss of vehicle control, potential collisions, property damage, serious injuries, and/or death. *Refer to the SAS Calibration section on page 5 for more information.*

Special care should be taken if aftermarket steering wheels are installed on a vehicle. Aftermarket steering wheels may interfere with the mounting or proper operation of the SAS. Only use steering wheels that have been approved by the vehicle OEM.

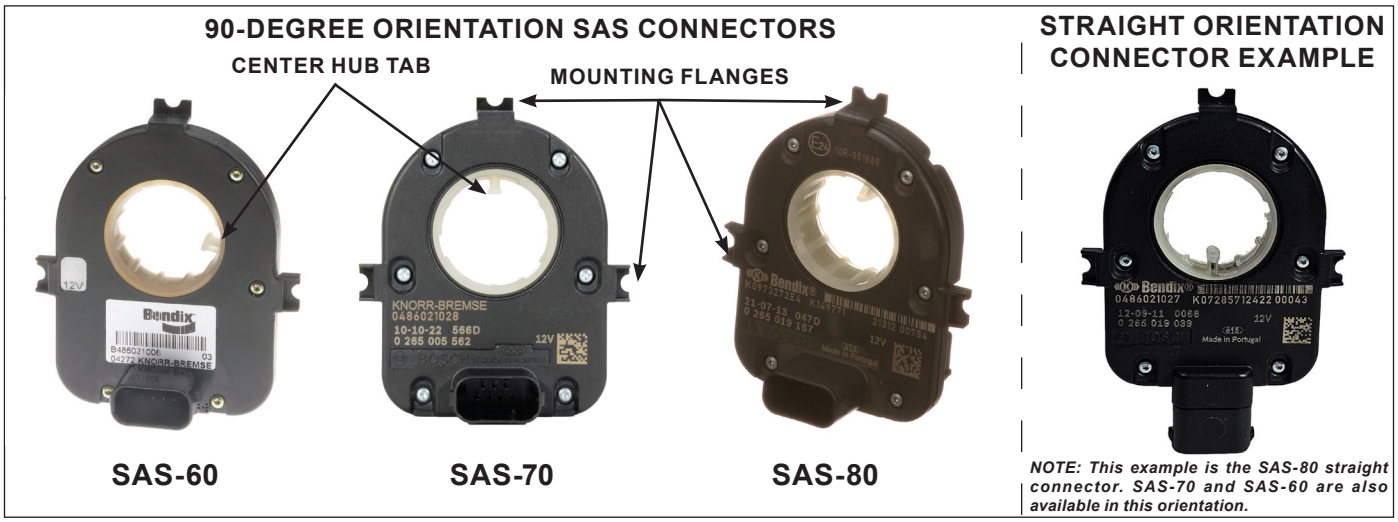


Figure 1 – Bendix SAS-60, SAS-70, and SAS-80 Steering Angle Sensors

GENERAL SAFETY GUIDELINES

WARNING! PLEASE READ AND FOLLOW THESE INSTRUCTIONS TO AVOID PERSONAL INJURY OR DEATH:

When working on or around a vehicle, the following guidelines should be observed AT ALL TIMES:

- ▲ Park the vehicle on a level surface, apply the parking brakes, and always block the wheels. Always wear personal protection equipment.
- ▲ Stop the engine and remove the ignition key when working under or around the vehicle. When working in the engine compartment, the engine should be shut off and the ignition key should be removed. Where circumstances require that the engine be in operation, EXTREME CAUTION should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated, or electrically charged components.
- ▲ Do not attempt to install, remove, disassemble, or assemble a component until you have read, and thoroughly understand, the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.
- ▲ If the work is being performed on the vehicle's air brake system, or any auxiliary pressurized air systems, make certain to drain the air pressure from all reservoirs before beginning ANY work on the vehicle. If the vehicle is equipped with a Bendix® AD-IS® air dryer system, a Bendix® DRM™ dryer reservoir module, a Bendix® AD-9si®, AD-HF®, or AD-HFi® air dryer, be sure to drain the purge reservoir.
- ▲ Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that safely removes all electrical power from the vehicle.
- ▲ Never exceed manufacturer's recommended pressures.
- ▲ Never connect or disconnect a hose or line containing pressure; it may whip and/or cause hazardous airborne dust and dirt particles. Wear eye protection. Slowly open connections with care, and verify that no pressure is present. Never remove a component or plug unless you are certain all system pressure has been depleted.
- ▲ Use only genuine Bendix® brand replacement parts, components, and kits. Replacement hardware, tubing, hose, fittings, wiring, etc. must be of equivalent size, type, and strength as original equipment and be designed specifically for such applications and systems.
- ▲ Components with stripped threads or damaged parts should be replaced rather than repaired. Do not attempt repairs requiring machining or welding unless specifically stated and approved by the vehicle and component manufacturer.
- ▲ Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.
- ▲ For vehicles with Automatic Traction Control (ATC), the ATC function must be disabled (ATC indicator lamp should be ON) prior to performing any vehicle maintenance where one or more wheels on a drive axle are lifted off the ground and moving.
- ▲ The power MUST be temporarily disconnected from the radar sensor whenever any tests USING A DYNAMOMETER are conducted on a vehicle equipped with a Bendix® Wingman® system.
- ▲ You should consult the vehicle manufacturer's operating and service manuals, and any related literature, in conjunction with the Guidelines above.

IMPORTANT

Bendix®-brand Electronic Control Units (ECUs) are not designed to store data for purposes of accident reconstruction and Bendix® ACom® Diagnostic Software is not intended to retrieve data for purposes of accident reconstruction. Bendix makes no representations as to the accuracy of data or video retrieved and interpreted from ECUs for purposes of accident reconstruction. Bendix does not offer accident reconstruction services or interpretation of stored data. Bendix ECUs are not protected from fire, loss of power, impact damage, or other conditions that may be sustained in a crash situation and may cause data to be unavailable or irretrievable.

WARNING

Only technicians who have had specific training for diagnosing or repairing steering systems should attempt to make the repairs outlined in these instructions. This service procedure does not replace your manuals; use both these instructions and your vehicle/steering column manufacturer's manual(s) together as your guide in carrying out the diagnosis and/or replacement. Use of the correct equipment, tools, etc. is necessary to perform the work correctly and safely. If in doubt, contact the vehicle and/or steering column manufacturer(s) for further information.

REPLACEMENT INSTRUCTIONS

The sensors are compatible across generations as long as the same hardware and software configuration is chosen. Contact your local Bendix sales representative or use B2Bendix.com to find replacement service parts.

NOTE: Do not change the hardware configuration of an SAS as each steering column and wiring harness is designed to accept a specific hardware variant. When replacing an SAS, replace with a like-for-like component with the same orientation.

⚠ WARNING

If a vehicle was involved in an incident that may have led to damage of the SAS or assembly, or any steering or front suspension-related component, Bendix recommends that the SAS is visually inspected, tested, and replaced if necessary. If the SAS is installed incorrectly, ESP functions may not operate properly, which can result in loss of vehicle control, potential collisions, property damage, serious injuries, and/or death.

REMOVAL

To remove an SAS from a vehicle, complete the following steps:

1. Ensure the vehicle is safe to work on before beginning. Refer to the *General Safety Guidelines* on page 2 for more information.
2. Remove any interior trim required to gain access to the steering column. Refer to the vehicle OEM's maintenance instructions for the specific procedure required to remove the steering column shroud and associated trim.
3. Depending upon the vehicle manufacturer, the SAS may be located either near the steering wheel, necessitating the removal of the steering wheel, or near the joint to the vehicle steering mechanism, requiring that this linkage be disconnected.

⚠ WARNING

Follow all vehicle OEM and/or steering column manufacturer instructions for disassembly of the steering column. Improper removal or assembly of the steering column can result in loss of steering, loss of vehicle control, potential collisions, property damage, serious injuries, and/or death.

4. Once the SAS is accessible, unplug the sensor cable assembly from the sensor body by squeezing the mounting tabs and pulling gently on the connector until it disengages.

   NOTE: It may be necessary to cut cable ties to remove the sensor plug. Be sure to note the position of the cable ties for replacement during installation.
5. Take a photo of the sensor or mark the sensor orientation prior to removing it from the steering column. Make a note whether the sensor label is facing upward or downward since the replacement sensor needs to be installed with the same orientation.

⚠ WARNING

On some vehicles, it is possible to reverse the installation, resulting in incorrect readings to the brake controller and/or damage to the SAS. If the SAS is installed incorrectly, ESP functions may not operate properly, which can result in loss of vehicle control, potential collisions, property damage, serious injuries, and/or death.

6. Unscrew the two (2) or three (3) mounting screws that hold the body of the sensor to the steering column body. Retain the screws for installation.

   NOTE: In certain vehicles, one of the mounting flanges fits into a slot instead of being held in position by a screw.
7. Remove the sensor by sliding it off the steering column.

   NOTE: The sensor is not repairable in the field.
8. If applicable, if the SAS is mounted to a vehicle component made of plastic, it is recommended that the plastic piece be replaced by a new original equipment part. Contact the vehicle OEM and/or steering column manufacturer for replacement parts.

INSTALLATION

To install an SAS to a vehicle, complete the following steps:

1. Slide the new sensor over the column with the center hub tab of the sensor aligned with the corresponding notch in the column. *See Figure 1*.

   NOTE: Different column manufacturers may implement the center hub tab alignment in different ways. The sensor label should be facing in the same direction as the removed sensor.

2. Refer to photo taken or the marks made in *Step 5* of the *Removal* process for confirmation of proper sensor orientation and mounting.

⚠ WARNING

The location and orientation of the SAS must not be altered from its factory-installed location and orientation. When servicing, an identical component must be used in the same orientation (using OEM brackets and torque requirements). Failure to do so can result in loss of vehicle control, potential collisions, property damage, serious injuries, and/or death.

Reference the OEM and/or steering column manufacturer's documentation for instructions and replacement parts.

3. Reinstall the two (2) or three (3) mounting screws that were previously removed from the old SAS to secure the new SAS in position.
4. Tighten screws to the steering column manufacturer's recommended torque specification.
5. Reconnect the electrical connector making sure that connector locking tabs are fully seated. Be sure to route the electrical harness carefully per the vehicle OEM and/or steering column manufacturer's instructions to prevent the harness from pulling on the body of the sensor.
6. Reinstall any cable ties that were removed during the disassembly process.
7. If the wire harness leading to the sensor is being replaced and/or the cable ties were removed, ensure that the harness is adequately tie wrapped and secured so that the full motion of the steering column can be achieved without pulling apart the connectors.

   NOTE: If the steering column offers "tilt/tele" functionality, move the column through the full range of motion to ensure that the harness and sensor are properly installed, do not restrict the movement of the column, and are not able to be pinched or stretched by moving parts.

8. Reinstall the interior trim.

   NOTE: The sensor is not protected against dirt or water intrusion, so care must be taken not to introduce these elements during installation.

9. After the SAS has been reinstalled, perform an SAS calibration using the appropriate diagnostic software. Do not drive or operate the vehicle until the calibration has been performed successfully.

⚠ WARNING

If the SAS is not calibrated correctly, ESP functions may not operate properly, which can result in loss of vehicle control, potential collisions, property damage, serious injuries, and/or death.

SAS CALIBRATION

The SAS calibration can only be achieved when the sensor is connected to the vehicle's Bendix brake control ECU. No stand-alone sensor calibration is possible. Use Bendix® ACom® Diagnostic Software to calibrate the SAS on vehicles with Bendix brake control system ECUs.

NOTE: Depending on the vehicle OEM and brake control ECU family, it may also be possible to calibrate the SAS using the OEM service tool.

The sensor must be recalibrated after any of these situations:

- Any time the steering angle sensor is removed or replaced;
- If the SAS wiring harness is repaired or replaced;
- Any maintenance or repair work on the steering linkage, steering column, steering gear, or other related mechanism; or
- Adjustment of the wheel alignment or wheel track.

⚠ WARNING

If the SAS is not calibrated correctly, ESP functions may not operate properly, which can result in loss of vehicle control, potential collisions, property damage, serious injuries, and/or death.

DIAGNOSTICS

Bendix SASs can only report diagnostic information, including Diagnostic Trouble Codes (DTCs), when connected to a Bendix brake control system ECU. Stand-alone diagnostics are not possible.

DTCs can be read using Bendix ACom Diagnostic Software. Depending on the vehicle OEM and brake control ECU family, it may also be possible to read SAS DTCs using the OEM service tool. Contact the vehicle OEM for more information.

SAS WIRING INFORMATION

If it is necessary to troubleshoot, repair, or replace any part of the wiring harness that connects to the Bendix SAS-60, SAS-70, or SAS-80 to the brake control ECU, contact the vehicle OEM for the appropriate troubleshooting procedure, harnessing, and repair procedures.

NOTE: If the harness is replaced, calibrate the SAS once the new harness has been installed.

⚠ CAUTION

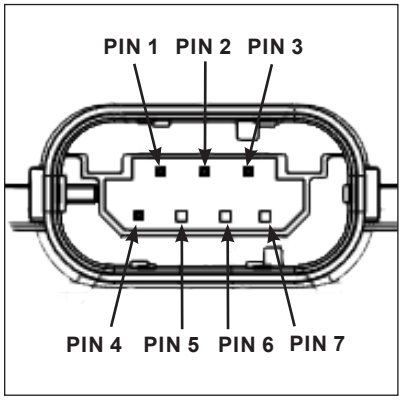
All wires must be carefully routed to avoid contact with rotating elements. Only use OEM components to repair or replace the SAS harness. Install any replacement parts according to the vehicle OEM's published maintenance procedures.

SAS TROUBLESHOOTING

To troubleshoot an SAS and the SAS vehicle harness, complete the following steps:

1. Make the vehicle safe for maintenance by following the *General Safety Guidelines on page 2*.
2. Turn the vehicle off and remove the key from the ignition.
3. Remove the steering column shroud/sheathing. Refer to the vehicle OEM's maintenance instructions for the specific procedure required to remove the steering column shroud and trim.
4. Unplug the SAS from the wiring harness.
5. Using a multimeter, measure the resistance between pins 3 and 4 at the electrical connector of the SAS. This resistance should read 120 ohms. If the resistance is not 120 ohms, replace the SAS.
6. Using a multimeter, measure continuity between pin 3 and pins 1 and 2 on the SAS electrical connector. There should be no continuity between pin 3 and either pins 1 or 2. If continuity is present, replace the SAS.
7. Using a multimeter, measure continuity between pin 4 and pins 1 and 2 on the SAS electrical connector. There should be no continuity between pin 4 and either pins 1 or 2. If continuity is present, replace the SAS.
8. With the harness still disconnected from the SAS, measure continuity between the power (pin 2) and ground (pin 1) pins on the vehicle harness with a multimeter. If resistance measures 0 ohms (continuity), inspect for a short in the harness per the vehicle OEM troubleshooting procedure to diagnose and repair the short.
9. With the harness still disconnected from the SAS and the vehicle ignition off, measure the voltage between the power (pin 2) and ground (pin 1) pins on the vehicle harness with a multimeter. There should be no voltage present if the key is off. If voltage is detected, refer to the OEM procedure for troubleshooting a short to battery in the wiring harness.

   NOTE: For Bendix EC-80 or EC-60 ECUs, confirm that voltage is not present on pins 11 and 10 on the X4 connector in the same scenario. If voltage is present on those pins with the key off, refer to the appropriate Service Data sheet for additional troubleshooting information. *Refer to SD-13-4986, EC-80 ESP Service Data Sheet, or SD-13-4869, EC-60 ESP Service Data Sheet, on B2Bendix.com.*



PIN NO.	USE
1	Ground
2	Power (12V)
3	CAN High
4	CAN Low
5	Not Used
6	Not Used
7	Not Used

Table 1 – SAS Pinout

Figure 2 – Bendix SAS-60, SAS-70, and SAS-80 Wiring Pinout

10. With the harness disconnected and the multimeter still in place on the power pins of the vehicle harness, turn the ignition power from off to on. When the ignition is turned on, the multimeter should read roughly 12V.

    NOTE: Depending on the brake controller family, the voltage may only be present momentarily, as some brake controllers turn off power when it does not receive a response from the unplugged SAS.
11. Check continuity of the power wires between the SAS and the corresponding ECU it is connected to. *For vehicles equipped with EC-60 or EC-80, refer to Table 2. For vehicles equipped GSBC, refer to Table 3.*

Connector		Pin	Function
SAS		2	Power (12V)
		1	Ground
EC-60/EC-80 ECU ONLY	X4	11	Power (12V)
		10	Ground

Table 2 – EC-60/EC-80 to SAS Electrical Pin Match

Connector		Pin	Function
SAS		2	Power (12V)
		1	Ground
GSBC Central ECU ONLY	N/A	Depending on the vehicle OEM, the GSBC Central ECU to SAS electrical pin match may vary. Refer to the vehicle OEM wiring diagram for more information.	

Table 3 – GSBC Central ECU to SAS Electrical Pin Match

SAS TROUBLESHOOTING (CONT.)

12. Check the continuity of the CAN Communication wires running between the SAS and the corresponding ECU it is connected to. *For EC-60 and EC-80, refer to Table 4. For vehicles equipped with GSBC, refer to vehicle OEM wiring diagram.*

SAS Wire Harness Terminal	EC-60/EC-80 ECU Wire Harness Terminal	Measurement
4	X4-7	Verify Continuity
3	X4-8	Verify Continuity

Table 4 – EC-60/EC-80 Continuity Check Information

13. Make sure the ignition key is off. Reconnect the SAS to the electrical wiring harness.
14. **For EC-60 and EC-80 ECUs only, complete the following:**
    a. Measure the resistance at the brake control ECU harness connector between pins 7 and 8 on connector X4.
        - If both the SAS and the YAS are plugged in, the resistance between pins 7 and 8 should be 60 ohms.
        - If either the SAS or YAS are unplugged or faulty, the resistance will read 120 ohms.
        - If both devices are unplugged, or the harness is broken, the resistance will read as "open" or very high resistance.
        - If the resistance is very low, the harness is shorted.
        - If this test indicates a problem with the harness, refer to the OEM procedure for troubleshooting and repairing the electrical harness.
    b. Measure the continuity between pin 7 at the brake control ECU harness connector, and pin 4 on the SAS harness connector.
        - If these pins are not continuous, troubelshoot, repair, and replace the harness according to the vehicle OEM procedure.
    c. Measure the continutiy between pins 8 at the brake control ECU harness connector, and pin 3 on the SAS harness connector.
        - If these pins are not continuous, troubelshoot, repair, and replace the harness according to the vehicle OEM procedure.
15. **For GSBC ECUs only,** refer to the OEM wiring schematic to determine which ECU and pins the SAS is connected to. To confirm that the harness is intact and working properly, measure end to end continuity between the SAS harness connector and the connected vehicle ECU. If issues with the harness are discovered, follow the vehicle OEM troubleshooting procedure.
16. After troubleshooting is complete and the issue in the SAS or harness has been resolved, reinstall the SAS *(per Installation instructions starting on page 4)*, wiring harness, and any other components that were removed.
17. Calibrate the SAS using ACom Diagnostic Software or the appropriate vehicle OEM service tool. *Refer to the SAS Calibration section on page 5 for more information.*

WARRANTY INFORMATION

For warranty information, *refer to BW8003, Limited Warranty - Electronic Systems, on B2Bendix.com.*

BENDIX TECHNICAL SUPPORT

The Bendix Tech Team is available via email at techteam@bendix.com and by phone at 1-800-AIR-BRAKE (1-800-247-2725), option 2, Monday through Thursday, 8:00 a.m. to 6:00 p.m. and Friday, 8:00 a.m. to 5:00 p.m. ET. Follow the instructions in the recorded message.