VADEN® ORIGINAL

TECHNİCAL GUİDE

ABS Wheel Speed Sensor & ECU: Faults, Replacement & Care

Diagnose, replace and maintain the ABS wheel speed sensor, tone ring and ECU on heavy commercial vehicles: symptoms, air gap, testing and fault codes.

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When the amber ABS light comes on in the dash of a tractor unit, most drivers say "the brakes still bite, I'll keep going." But with ABS disabled, the wheels lock under hard braking, the trailer can jackknife and the stopping distance grows noticeably. On a heavy commercial vehicle, the name for that difference is the gap between a crash and a controlled stop. This guide explains the trio of the ABS wheel speed sensor, the tone ring and the ECU/module in language that comes straight from the workshop floor; it walks through failure symptoms, air gap setting, measurement methods and replacement steps in order.

E-E-A-T note: This document was prepared by the VADEN technical team, which works on heavy commercial vehicle braking and electronic systems. The values here are for general reference; for exact figures such as air gap, resistance and torque, always rely on the current OE service manual of the vehicle/axle manufacturer. **Last updated: September 2026.**

Heavy commercial vehicle air brake systems are designed within the framework of ECE R13 (UN/EU braking regulation) and ISO 611.

What Are the ABS Wheel Speed Sensor and ECU? Function and Working Principle

The ABS wheel speed sensor is an electronic measurement and control system that converts the rotational speed of each wheel into an electrical signal and passes it to the ABS/EBS module (ECU); the ECU then uses this information to adjust brake pressure wheel by wheel, preventing lock-up.

The heart of the system is three parts: the **speed sensor** positioned close to the wheel hub, the toothed ring that turns with the wheel (**tone ring / tone wheel / pulse wheel**) and the **ECU/ABS module** that processes the signals from all wheels. As the teeth of the tone ring pass in front of the sensor, the sensor produces hundreds of pulses per second. As the pulse frequency rises the ECU understands the wheel is accelerating, and when it drops suddenly it understands that wheel is starting to lock; it then releases and reapplies the pressure to the relevant brake chamber via the modulator valves within fractions of a second.

On a heavy commercial vehicle this system is often intertwined with EBS (Electronic Braking System). Modules of the Knorr-Bremse, Wabco (ZF) or Bendix type manage not only ABS but also ASR (traction control), hill-start assist and retarder integration. When the sensor data is corrupted, not only ABS but also these auxiliary functions can be disabled.

- **Speed sensor:** A probe that converts changes in the magnetic field into an electrical signal, usually fixed to the hub with a clamping bush.
- **Tone ring (toothed ring):** A toothed metal ring pressed onto the axle hub or spindle; it determines the pulse count.
- **Sensor cable and connector:** The point most exposed to vibration and water; most corrosion and chafing failures occur here.
- **ECU / ABS-EBS module:** The brain that processes the signals, generates fault codes and drives the modulator valves.

How Does a Passive (Inductive) Sensor Work?

A passive sensor is a simple structure containing a permanent magnet and a coil; it needs no external supply. As the tone ring teeth pass, the magnetic field changes and an alternating (AC) voltage is generated in the coil. The signal amplitude depends on wheel speed: at low speed the voltage is weak, which is why a passive sensor can go "blind" at very low speeds. It is still widespread on the majority of heavy commercial vehicles because of its durability.

How Does an Active Sensor Work?

An active sensor (Hall effect or magneto-resistive) draws a supply from the ECU and its output is a square wave (digital) signal of constant amplitude that does not depend on speed. It can take a reading even at very low speed, indeed at speeds close to zero; this is why it is preferred in hill-start and precise ASR applications. Active sensors generally work with a magnetically coded ring (encoder ring) and can be more sensitive to contamination than the inductive type.

Processing the Signal in the ECU

The ECU continuously compares the signals from four (or more, in a 6x2/6x4 configuration) wheels. If one wheel's speed deviates abnormally from the others, it interprets this as a cable break, a disturbed air gap or tone ring damage; it writes the relevant fault code (DTC) to memory and, if necessary, partially or fully disables ABS.

Feature	Passive / Inductive Sensor	Active Sensor (Hall/MR)
Supply	Not required (self-generating)	Supply from ECU required
Signal type	Analog AC (sine)	Digital square wave
Low-speed reading	Weak / limited	Very good (close to zero)
Measurement	Resistance (ohm) + AC voltage	Resistance measurement mostly meaningless; check signal/current
Typical use	Classic heavy commercial ABS	Modern EBS, ASR, hill-start
Sensitivity to contamination	Medium	Can be high on the coded ring

Part-number verification: The front and rear axles of the same tractor unit may use different sensor lengths, connector types and signal architectures (passive/active). Do not fit a sensor just because it looks like the old one removed from the hub; confirm it with the vehicle chassis number and the OE part reference. The wrong type of sensor causes ABS to never engage at all.

Failure Symptoms and Diagnosis

ABS sensor failures rarely arrive suddenly as "everything stopped"; most often they begin as signals that appear under certain conditions and then disappear. The table below summarizes the symptoms most frequently encountered in the field, their possible causes and the verification method.

Symptom	Possible Cause	Check / Verification
ABS warning light on continuously	Sensor open circuit, broken cable, damaged tone ring	Read DTC with a diagnostic tool; identify the relevant wheel, measure resistance/signal
ABS light on only while moving	Excessive air gap, broken tone ring tooth, loose sensor	Check sensor seating and air gap; turn the wheel and watch live data
Single wheel locks / vibrates at a certain speed	Intermittent signal, contaminated sensor tip, occasional loss of contact	Watch the waveform with an oscilloscope; look for signal loss while moving the cable
ASR/traction control or hill-start not working	One axle sensor giving a weak signal	Compare all wheel speeds in live data; find the deviating wheel
Vehicle pulls, does not track straight during braking	ABS disabled on one wheel, active on the others	Test drive + DTC; identify the disabled wheel
Intermittent ABS fault, returns after clearing	Connector corrosion, cable crack, hub play (bearing)	Open and clean the connector; rock the wheel to check bearing play
Fault appearing in cold/rain, disappearing when dry	Water ingress into the connector, crack in cable insulation	Inspect connector sealing and cable routing visually + test by measuring

Reading Diagnostics (DTC)

The first step is always to read the fault code. Modern EBS modules report separately which wheel (e.g. "front left", "rear right") and what kind of fault (open circuit, short circuit, no signal, implausible signal) is present. An "implausible signal" code is usually a sign not of the sensor but of the air gap or tone ring; replacing the sensor without making this distinction is a common waste.

Comparing Wheels with Live Data

Lift the vehicle and rotate the wheels by hand or at idle, then compare the speed values of the four wheels on the diagnostic tool's live data screen. In a healthy system the values rise and fall close to one another. If one wheel's value jumps, resets or lags behind the others, the problem is on that line.

Waveform Analysis with an Oscilloscope

The most precise method is the oscilloscope. On a passive sensor, a smooth, symmetrical sine wave is expected while the wheel is turned; sudden drops in amplitude indicate damage to a tone ring tooth or a variable air gap. On an active sensor, a clean square wave with clear low-high transitions should be seen. Distortion of the wave while moving the cable by hand is definitive proof of a broken/intermittent contact fault.

Standards and further reading

This subject is governed by the equipment rules for air-braked commercial vehicles. In the United States the federal air brake standard, FMVSS 121 (49 CFR 571.121) defines the reservoirs, protection and timing a compliant system must provide, and Europe applies the equivalent limits of UNECE Regulation No. 13. For further detail, see the illustrated reference guide at airbrakecompressor.com. Always confirm specific figures against the current regulation and the vehicle manufacturer service data.

Outside the United States the equivalent duties sit in national law. In the United Kingdom, regulation 18 of the Road Vehicles (Construction and Use) Regulations 1986 requires every part of the braking system to be maintained in good working order. In Canada, air brake systems fall under the Motor Vehicle Safety Regulations, which contain CMVSS 121.

Replacement / Installation Steps

Personal protective equipment and safety (PPE): Before starting, secure the vehicle on level ground, chock it and bring the air pressure down to a safe level. Switch off the ABS/EBS supply contact during lifting; disconnecting a connector on a live circuit can cause a fault entry in the module. Use gloves and safety goggles; when working around the brake system, watch out for residual pressure in the chambers and valves.

1. **Verify the fault:** Before removing the sensor, read the DTC and confirm which wheel is responsible; avoid unnecessary disassembly.
2. **Cut the contact and supply:** Switch off the system to protect the ABS module from a false entry, and chock the vehicle.
3. **Lift the wheel and gain access:** Raise the relevant wheel off the ground, remove the rim if needed; reach the sensor and cable route.
4. **Disconnect the connector:** Carefully release the sensor connector from its lock; do not force and break the clip, and note any corrosion.
5. **Remove the old sensor:** On the clamping-bush type, the sensor is pulled out with a slight twist; if it is seized, turn it free with pliers, do not force the bore.
6. **Clean the seat and tone ring:** Clean the rust and dirt in the sensor seat; visually inspect the tone ring teeth, and if there is a broken/packed tooth, renew the ring as well.
7. **Fit a new clamping bush:** In most applications a new clamping bush is used together with the sensor; this ensures the sensor seats tightly at the correct distance from the tone ring.
8. **Prepare the sensor tip:** A thin grease/paste recommended by the manufacturer may be applied to the sensor head (refer to the OE manual); do not scratch the tip and keep it clean.

9. **Push the sensor fully home:** Push the sensor into the seat until it touches the tone ring. In many designs the air gap sets itself automatically on the first wheel rotation; on types that require a separate measurement, check the air gap.
10. **Route the cable correctly:** Run the cable through its original clamps; keep it away from rotating/moving parts, the exhaust and sharp edges. Lock the connector fully.
11. **Clear, test and road-test:** Clear the fault memory with the diagnostic tool, verify wheel speed in live data; with a controlled test drive at low speed, confirm that the ABS light stays off.

Points to Watch (Common Mistakes)

The most common mistake: working by the symptom rather than the code. Randomly replacing sensors because "the ABS light is on" is a widespread waste of time and money. Much of the problem is not in the sensor; it is in the air gap, the tone ring tooth, connector corrosion or hub bearing play. Read first, then remove.

Do not overlook the hub bearing: A worn wheel bearing changes the distance between the tone ring and the sensor during rotation and produces an "intermittent signal" fault. If the fault persists even though the sensor has just been fitted, check the bearing play.

- Fitting a sensor of the wrong length/type — the sensor seats but no signal ever arrives.
- Forgetting to push the sensor onto the tone ring; leaving too much air gap.
- Not locking the connector fully, or refitting a water-soaked connector without cleaning it.
- Replacing only the sensor without seeing the crack/mud packing in a tone ring tooth.
- Routing the cable near a rotating part or a hot surface — it soon chafes through and breaks.
- Trying to judge "good/faulty" by measuring resistance on an active sensor; on the active type the correct method is checking signal/supply.
- Going on a test drive without clearing the fault memory; misreading the result because of an old entry.

Technical Values and Check Points

The values below are **typical/general reference** ranges commonly encountered on heavy commercial vehicles; the exact value varies by vehicle, axle and sensor type, and the OE service manual is always authoritative.

Parameter	Typical / General Reference	Note
Passive sensor coil resistance	~ 1,000 – 2,500 ohm	Varies by type; use the OE value as the basis
Air gap	~ 0.1 – 1.5 mm	Most types self-seat; for types requiring measurement, refer to the manual

Parameter	Typical / General Reference	Note
AC output at test speed (passive)	starting at a few hundred mV when turned by hand and rising	Amplitude should rise quickly; if low/flat there is a problem
Insulation (sensor – chassis/ground)	very high (open circuit in practice)	Low value = cable/body leakage
Connector pin resistance	negligible (≈ 0 ohm)	High resistance = corrosion/looseness
Operating temperature range	approximately -40 °C to +150 °C	Must withstand the high temperature near the brake

Torque values at the sensor mounting and surrounding connections are also general reference; for the exact value the manufacturer's manual is authoritative:

Connection	Typical Torque (general reference)
Sensor holder / bracket bolt (M6)	~ 6 – 9 Nm
Sensor holder / bracket bolt (M8)	~ 15 – 25 Nm
Cable clamp/clip connections	hand-tight + clamp lock (no torque required)

Field tip: If the sensor resistance is borderline, repeat the measurement while moving the sensor and flexing the cable. If the value stays steady the sensor is probably sound; if it jumps when moved, there is a break inside the cable/connector.

- Is there a broken, dented tooth or mud/rust packing on the tone ring teeth — check by eye and by hand.
- Is the sensor tip seated enough to touch the tone ring, or is it loose?
- Is there green corrosion, a water mark or a loose pin inside the connector?
- Is there any sign of chafing, crushing or heat damage along the cable route?
- Is there any perceptible play in the wheel bearing (it disturbs the sensor distance)?
- Does the same code return after clearing, or has it cleared?

Maintenance and Service Life

The ABS wheel speed sensor is not a scheduled-replacement part; it runs until a fault appears. However, its life depends directly on the environmental conditions it is exposed to. Heavy mud, salt, road chemicals and constant vibration shorten the life of the sensor and especially the cable-connector assembly. For this reason the goal in regular maintenance is to keep the environmental conditions under control, not the sensor itself.

- At every brake service, visually inspect the sensor cable and connector; look for chafing and looseness.
- Clean the tone ring area with compressed air/a dry brush; do not direct high-pressure water straight at the sensor tip.
- Make sure the connectors are locked and dry; apply suitable sealing to a connector that has taken on water.

- During hub/bearing maintenance, verify that the sensor distance is preserved.
- If there is a recurring fault on one sensor line, evaluate the cable and connector together with the sensor as a whole.
- When working on the axle (bearing, brake, hub), protect the sensor from contamination and impact; if removed, refit it clean.

With the correct type of sensor, sound wiring and a properly seated tone ring, the ABS system runs trouble-free for years. What matters is not putting off the warning light as "I'll look at it later"; even though the vehicle seems to brake while ABS is disabled, the safety margin has narrowed seriously.

When the ABS wheel speed sensor, tone ring and ECU work soundly, your heavy commercial vehicle keeps to the road at every braking. For the front and rear axle applications of heavy commercial vehicles, VADEN ORIGINAL produces the ABS sensor ring and the ABS sensor holder to OE dimensions, together with the ABS solenoid modulator valve and repair kits for the ABS solenoid modulator valve, the ABS double relay valve and the ABS electronic control unit. With the right part choice and the diagnosis-and-replacement steps in this guide, you can switch off the ABS warning light for good.

Shop this part: ABS Sensor