Wheel speed sensors in motor vehicles

Function, diagnosis, troubleshooting.

Ideas today for the cars of tomorrow

Contents

Importance of wheel speed sensors

The increasing complexity of road traffic makes great demands on drivers. Driver assistance systems relieve drivers and optimise safety on the road. Therefore, modern driver assistance systems are part of the standard equipment in almost all new cars in Europe and pose new challenges for garages.

Vehicle electronics today play a key role in all comfort and safety features. The optimal interaction of complex electronic systems ensures fault-free function of the vehicle and thus improves traffic safety.

The intelligent data communication of the electronic vehicle systems is supported by sensors. In relation to driving safety, wheel speed sensors are of particular importance and are used in numerous applications in various vehicle systems.

In driver assistance systems such as ABS, TCS, ESP or ACC, motor control units use these sensors to determine the wheel speed.

Via data lines, the wheel speed information from the Anti-Lock Brake System (ABS) is also provided to other systems (engine management, gearbox and chassis control systems and navigation systems).

Due to this variety of applications, wheel speed sensors make a direct contribution to driving dynamics, driving safety, driving comfort and reduced fuel consumption and emissions.

Design and function of wheel speed sensors

Based on their mode of functioning, wheel speed sensors are classified into active and passive sensors. A clear assignment is not defined.
In the garage, the following definition has established itself:

- If a sensor becomes "active" only when a power supply is connected to it and if it then generates an output signal, it is called **"active"**.
- If a sensor works without an additional power supply, then it is called **"passive"**.

Inductive passive sensors

Signal processing

Wheel speed sensors are installed directly above the pulse wheel, which is connected to the wheel hub or the drive shaft. The pole pin inside a coil is connected to a permanent magnet and the magnetic field extends to the pulse wheel. The rotational movement of the pulse wheel and the associated alternation of teeth and gaps effects a change in the magnetic flux through the pulse wheel and the coil. The changing magnetic field induces an alternating voltage in the coil that can be measured.
The frequencies and amplitudes of the alternating voltage are related to the wheel speed **(Fig. 1)**. Passive inductive sensors do not need a separate power supply from the control unit.

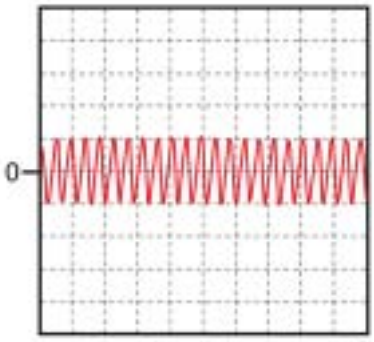


Fig. 1

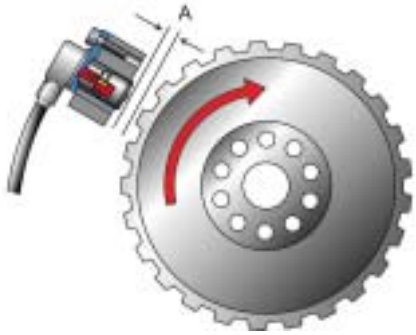


Fig. 2

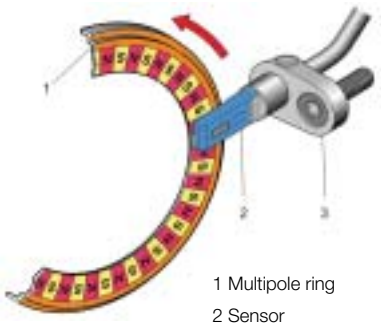
As the signal range for signal detection is defined by the control unit, the amplitudes must be within a voltage range. The distance (A) between sensor and pulse wheel is determined by the axle design **(Fig. 2)**.

Active sensors

Method of operation

The active sensor is a proximity sensor with integrated electronics supplied with a voltage defined by the ABS control unit. For the pulse wheel, a multipolar ring may be used and may be positioned in a sealing ring of the wheel bearing. Magnets with alternating poles are installed in the sealing ring **(Fig. 3)**. The magneto-resistors integrated in the sensor electronics detect a rotating magnetic field when the multipolar ring rotates. The electronics in the sensor convert the resulting sinoidal signal into a digital signal **(Fig. 4)**. The signal is transmitted to the control unit in the form of a current signal using pulse width modulation. The sensor is connected to the control unit via a two-wire electric cable. The sensor signal is transmitted via the power supply wire. The other wire is used as an earth for the sensor. In addition to magneto-resistor sensor elements, Hall sensors are also used today that permit wider air gaps and react to the smallest changes in the magnetic field.

If a steel pulse wheel is installed in the vehicle instead of a multipolar ring, then a magnet is additionally installed on the sensor element. When the pulse wheel rotates, the constant magnetic field in the sensor changes. Signal processing and the IC are the same as in the case of magneto-resistive sensors.



1 Multipole ring
2 Sensor
3 Sensor housing

Fig. 3

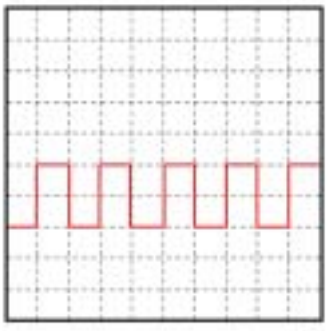


Fig. 4

Advantages of the active sensors (over passive sensors):

- Wheel speed detection from standstill. This allows speeds of just 0.1 km/h to be measured which is of importance in the case of traction control systems (TCS) right from the moment of starting.
- The Hall sensors are able to detect forward and backward movement.
- The sensor design is smaller and lighter.
- Pulse wheels are not used, so that the power transmission joints are simpler.
- Sensitivity to electromagnetic interference is lower.
- Changes of the air gap between sensor and magnetic ring have no direct effect on the signal.
- Good insensitivity to vibration and temperature fluctuation.

Effects in case of failure

The following system characteristics appear if wheel speed sensors fail:

- Lighting of the ABS control lamp, storing of an error code, locking of the wheels during braking, pseudo control, failure of other systems

Failure causes

- Disruption of cable connections
- Internal short circuit
- External damage
- Heavy soiling
- Increased wheel bearing play
- Mechanical damage to the pickup wheel

Troubleshooting

- Reading of the error memory
- Check of the supply voltages and signals with multimeter and oscilloscope
- Visual inspection of the wiring and the mechanical components

Due to their advantageous technical characteristics such as accuracy and low structural size, the vehicle manufacturers have installed mainly active wheel speed sensors since 1998.

Therefore, troubleshooting is dealt with only for active wheel speed sensors in this leaflet.

Usually, a check of the wheel speed sensors is preceded by a malfunction of an ABS, TCR, ESP braking system. The following options for troubleshooting and diagnosis exist when the warning lamp is lit:

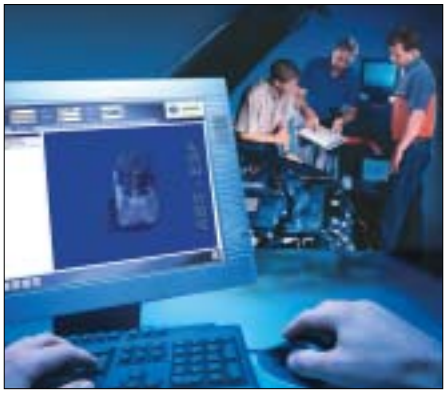
Diagnostic device
- Read error memory
- Evaluate parameter
- Comparison of the wheel speeds on the brake test stand

Multimeter
- Voltmeter
  Check voltage supply (plus and earth)
- Ohmmeter
  Cannot be used because the resistance measurement may destroy the sensor electronics.

Oscilloscope
- Evaluation of the signal curve

Pre-requisites for a reliable diagnosis are:
- Sufficient documentation in the form of technical data
- A suitable diagnostic device, multimeter or oscilloscope
- The technical know-how of the technician, training of the employees

When diagnosing complex systems, the best technology alone cannot help repair the vehicle. The random replacement of system components usually result in malfunctions in the garage processes and can put strains on the trusting relationship with the customer.



Example from practice of diagnosis in the garage

We will use the following example of a "defective speed wheel sensor on the rear left side" to explain the diagnosis of an **active** wheel speed sensor.

Customer complaint

- Your customer reports a malfunction of the anti-lock brake system.
- The ABS warning lamp goes on during driving.

▶ **Also see diagram on page 10-11 (guided troubleshooting).**

The ABS warning lamp is lit.

Practical tip

Preparation for diagnosis

- To be able to correctly assign the vehicle, it is important that the vehicle documents are provided with the order (vehicle registration document).
- Check the battery voltage. Insufficient voltage supply may cause system failure or result in incorrect measurements or voltage drops.
- Check the fuses related to the system. A look into the fuse-box may already rule out the first source of the defect.

Troubleshooting

1. Check of the driving brake

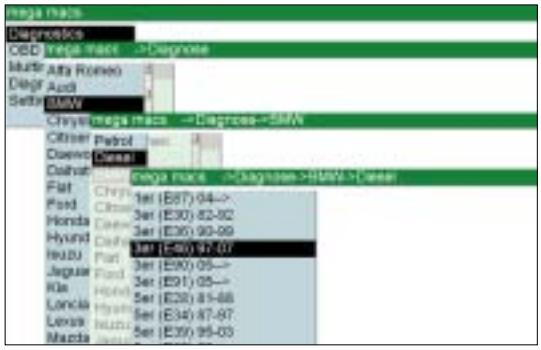
- Check the brakes on the brake test stand. It is advisable to use a roller-type test stand. Even slight braking may reveal defects at the braking mechanism. Imbalance of the brake disc results in different wheel speeds during braking and thus changes the wheel speed information sent to the control unit.
- Determine braking effect.

2. Visual inspection

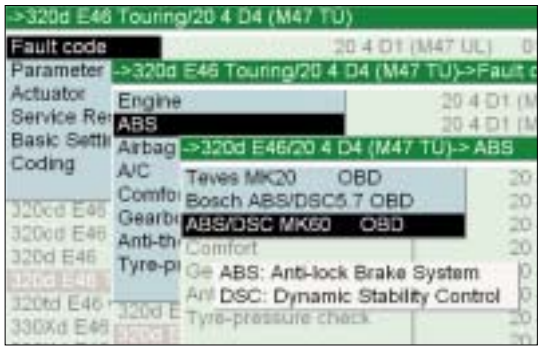
- Move the vehicle to the car lift.
- Check correct size of the wheels and correct tyres.
- Check tyre pressure and tread.
- Check the wheel bearing play and the axle suspension.
- Check the brake fluid level.
- Check wear of the brake linings.
- Check position and fastening of and any clear damage to connectors and wiring of the sensors.

3. Application of the diagnostic device

- Connect the diagnostic device to the 16-pin OBD connector. Depending on manufacturer and time of registration of the vehicle it may be necessary to use a different socket and an additional adapter.



- Select program.
- Select vehicle.
- Select fuel type.
- Select model.

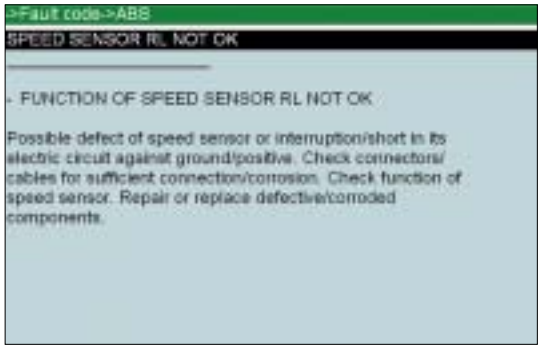


- Select desired function.
- Select system.
  Depending on the diagnostic device used, additional hints to the system variants installed in the vehicle may be displayed. If no clear assignment to the system can be made, then diagnosis can be attempted with the control units specified, checking them one after the other without damaging them. Only the control unit clearly identified by the diagnostic device will establish communication.

- Start error diagnosis.
  Reliable communication with the control unit requires correct connection and sufficient battery voltage. In this case, the battery voltage checked by the control unit is 12.69 V. Insufficient supply voltage of the control unit might be a hint to a defect in the wiring or of the vehicle battery.

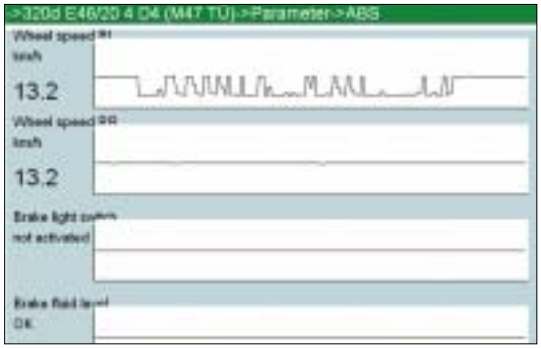
4. Reading the error memory

- In this example, the error code stored was "Wheel speed sensor rear left side".
  In addition to the number code, some diagnostic devices also provide a definition of the error code. This makes further steps for diagnosis easier.



5. Evaluating details

- First hints to the possible cause of the fault are stored here.
  The error code displayed is not necessarily indicative of an actual defect of the component. Before you start replacing individual components, this information should be read carefully to define the further diagnostic procedure after that.



6. Reading parameters/block of measured values

- The actual values are displayed here for further assessment. In this case, you can clearly see the faulty signal curve in relation to sensor HR (rear left). The visible irregularity of the signal curve enables you to narrow down the cause of the defect.

Note

If the signal curve is not irregular, you should delete the error. After that, make a test drive with the diagnostic device connected. It is advisable to evaluate the parameters at the same time to be able to narrow down the cause if the error occurs again.

7. Checking the voltage supply

- It is advisable to measure directly at the sensor connector to check the complete line between the sensor and the control unit.

Practical tip

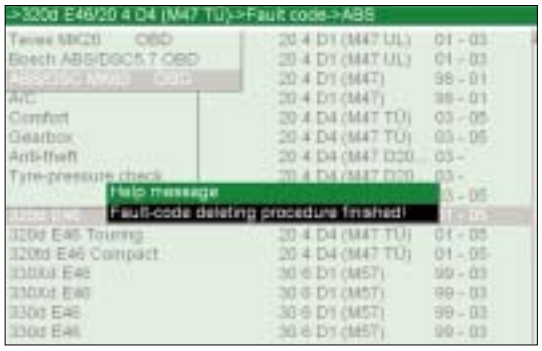
The design of the connector makes reliable measurement at the contact pins very difficult. It may be helpful to make an adapter from an old, identical sensor

8. Checking sensor holder and pulse ring

- Remove the sensor.
- Check the sensor and the pulse ring.
  In this example, a defective sensor cable was found. Disruption of the cable caused by mechanical damage resulted in intermittent contact at the connector housing.

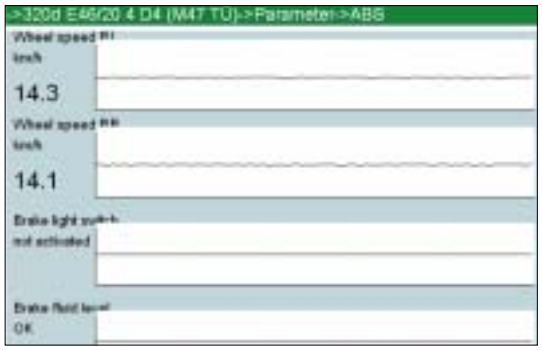
9. Replacing a wheel speed sensor

- Clean the sensor holder.
  Clean the supporting surface with a wire brush or if necessary with sandpaper.
- Replace the wheel speed sensor.
  Please ensure correct installation and fastening of the sensor cable.
- Observe the tightening torque.
  If the vehicle manufacturer specifies a tightening torque, observe it.



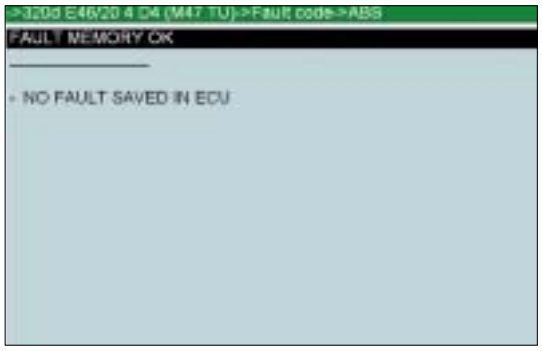
10. Reading the error memory

- Delete the error entry.
- The diagnostic work carried out on the vehicle enables the control unit to detect additional faults. They have to be deleted prior to the test drive.



11. Test drive

- To check the wheel speed sensor after replacement, you should go for a test drive with the diagnostic device connected and simultaneously evaluate the parameters.



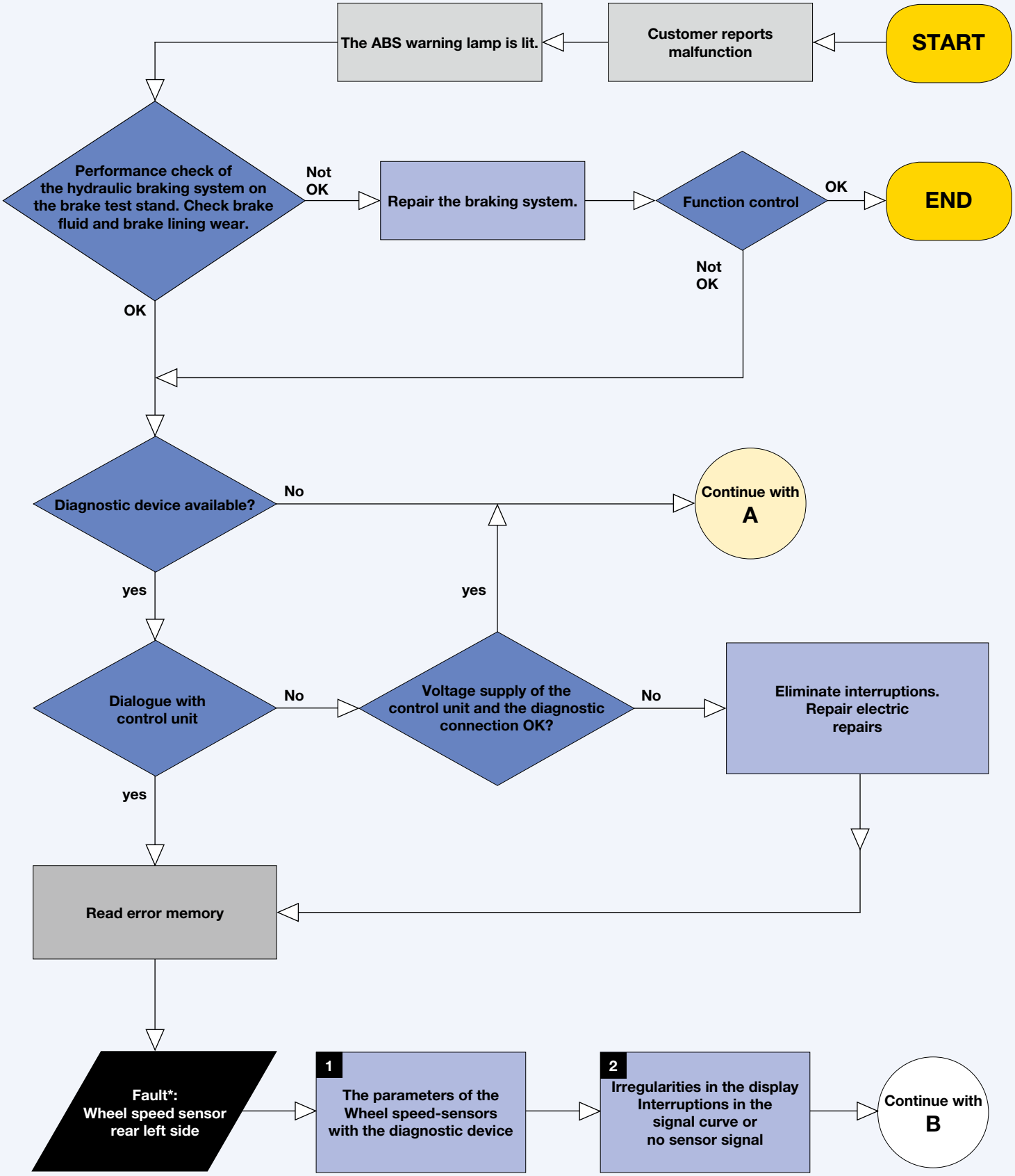
12. Final inspection

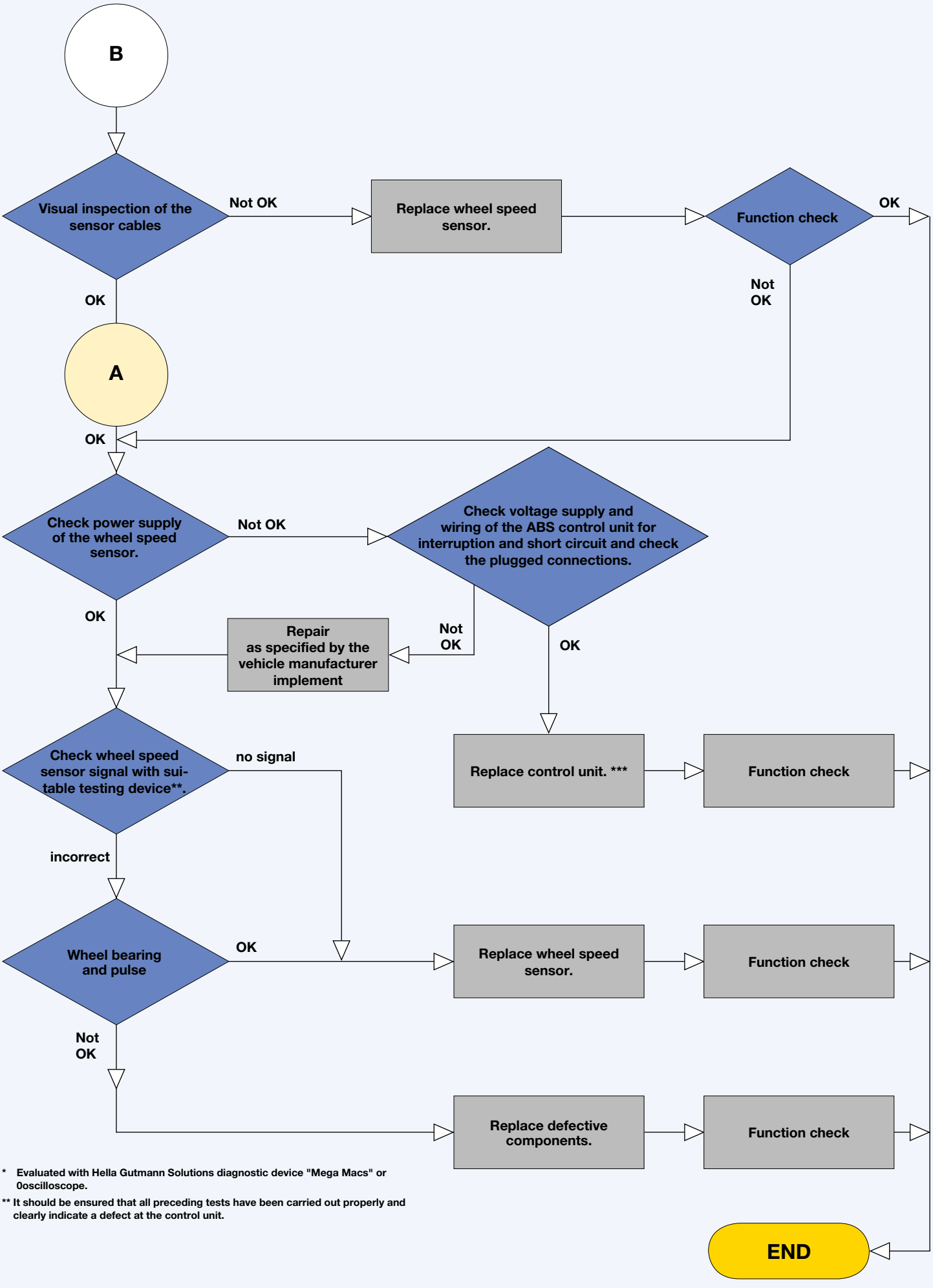
- Read the error memory again after the test drive.
  Due to the networking of the systems in the vehicle, a defect at the ABS is also stored in other control units. It is advisable to make an overall inquiry of all control units and to delete error entries.

Note:
Please note the vehicle manufacturer‘s information when carrying out any testing and diagnostic work. There may be additional vehicle-specific testing methods that need to be observed. The optimal interplay of the factors of man and technology is more important than ever. Only competent garage technicians with up-to-date knowledge of how to optimally use their technical equipment are fit for the challenges of the future.

Wheel speed sensor error search tree

Example: ABS warning lamp is lit, wheel speed sensor (active) at the rear left side is defective.
Diagnostic precondition: Tyre pressure and thread depth are OK.





* Evaluated with Hella Gutmann Solutions diagnostic device "Mega Macs" or 0oscilloscope.

** It should be ensured that all preceding tests have been carried out properly and clearly indicate a defect at the control unit.

Hella KGaA Hueck & Co.
Rixbecker Straße 75
59552 Lippstadt, Germany

Phone: +49 (0) 29 41-38-0
Fax: +49 (0) 29 41-38-71 33
Internet: www.hella.com

Ideas today for the cars of tomorrow