Anti-lock braking system

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Introduction
The anti-lock braking system consists of a speed sensor fitted to each wheel, an electronic control unit (ECU), and a three channel hydraulic modulator.

The speed signals from the sensors are continually processed by the ECU. When the brakes are applied, the wheel deceleration and slip is determined by the ECU. Signals from the ECU are fed to the 3-way solenoid valves in the modulator. The modulator then either holds pressure, decreases pressure, or allows pressure to increase to the brake calipers.

The rear wheels are controlled jointly, using the 'select low' control principle.

Failure of the anti-lock braking system is indicated by a warning lamp on the facia, and does not affect normal braking performance. A check for transient malfunctions of the system can be carried out by switching off the ignition and then restarting the engine. Continued illumination will need to be checked as described later in this Section.

Whenever any work is carried out which disturbs the anti-lock braking system components, the complete system must be checked with the ABS test box **before** the car is driven (see Anti-lock braking system – To test).

Wheel sensors
If any of the wheel speed sensors are found to be defective and need to be replaced, refer to either Chapter H (front hub) or Chapter J (rear hub) for the removal procedure.

Electronic control unit (ECU)
The electronic control unit situated in the luggage compartment, is mounted on the left-hand side rear wheel arch. Access to the ECU is gained by removing the left-hand side trim panel.

Hydraulic modulator
The hydraulic modulator is located in the engine compartment forward of the left-hand side suspension spring cover (see fig. G6-1).

The modulator consists of three solenoid valves (one for each front wheel, and one for the rear axle). These valves are actuated by the electronic control unit (ECU).

Whenever any work is carried out on the modulator, it is important to note the pipe connections and return them to the same positions (see fig. G6-2 and Section G2).

The modulator is a non-serviceable assembly, therefore if a fault is found, the complete assembly should be removed and a new one fitted.

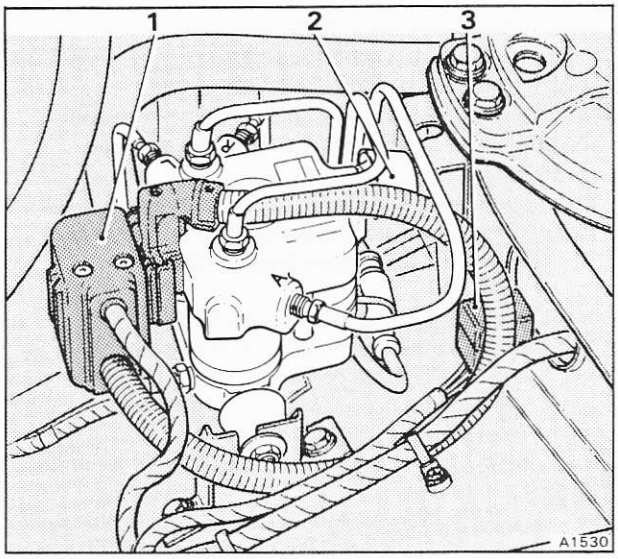


Fig. G6-1 Hydraulic modulator
1 Electrical plug
2 Flexible mount
3 Modulator relay – 1987 model year cars. From 1988 model year the modulator relay is repositioned in the luggage compartment

Precautions
If any work is carried out on a car equipped with an anti-lock braking system, the following points should be observed.

1. Before any welding is carried out on the car, the electrical connection to the ECU should be disconnected.
2. If force drying is to be used after spraying the car, remove the ECU.
3. Always ensure the battery connections are secure.
4. In the event of accident damage or failure of any part in the system, the only serviceable items are.

a. ECU
b. Relays (ABS and modulator)
c. Hydraulic modulator
d. Wheel speed sensors.

Hydraulic modulator – To remove
1. Depressurize the hydraulic systems as described in Section G3.
2. Disconnect the battery.
3. Ensure the modulator and surrounding area is thoroughly clean.
4. Disconnect the hydraulic pipes from the modulator and blank the open ports and pipes.
5. Slide the electrical plug upwards from the modulator. Disconnect the main loom connections

from the plug, noting the cable colours and positions.
6. Slacken the nuts securing the modulator to the mounting bracket. Lift the modulator clear of the bracket, taking care to avoid damaging the hydraulic pipes.

Hydraulic modulator – To fit
To fit the hydraulic modulator, reverse the procedure given for removal noting the following.
1. If a new modulator is to be fitted, the rubber mounts must be transposed from the modulator removed.
2. All nuts and setscrews must be torque tightened to the figures quoted in Section G22 and Chapter P.
3. Bleed the system (see Section G5).

Anti-lock braking system – To test

The anti-lock braking system electronic control unit (ECU) has a self-check programme which is activated whenever the car is operating. Any fault detected will cause the system to switch itself off, indicated by illumination of the ANTILOCK warning panel on the facia.

Before the system is checked with the test box (see fig. G6-3), switch off the ignition and then restart the engine. If the warning panel is still illuminated, proceed as follows, referring also to the Electrical Manual TSD 4701, Section 9.

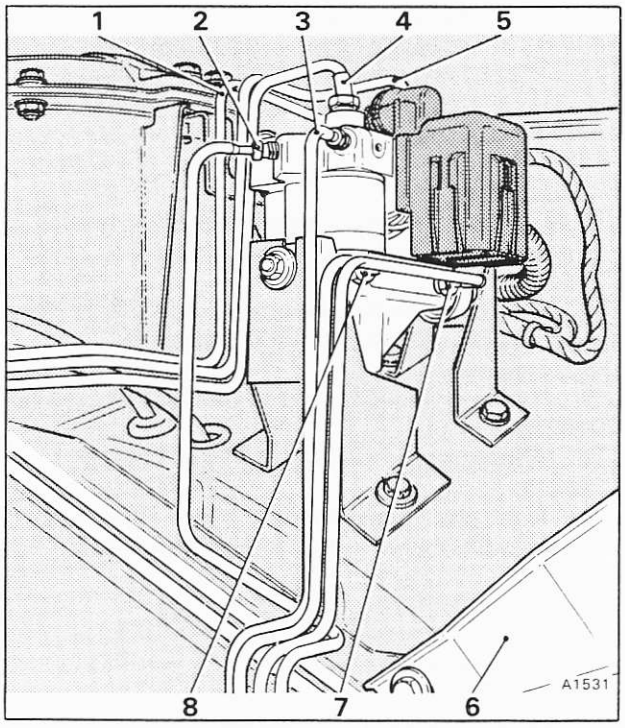


Fig. G6-2 Hydraulic modulator connections
1 Blue pipe to rear brakes
2 Mauve pipe to right-hand front calipers
3 Mauve pipe to left-hand front calipers
4 White pipe to outboard reservoir
5 Black pipe to inboard reservoir
6 Bonnet support bracket
7 Blue pipe to upper distribution valve
8 Mauve pipe to lower distribution valve

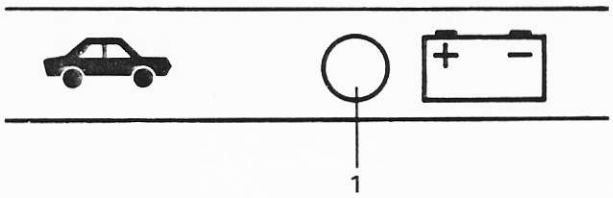
1. **Ensure the ignition is switched off** and then disconnect the electrical harness plug from the electronic control unit in the luggage compartment.
2. Connect the 35-way connector lead from the test box (Bosch ABS2 LED KDAS 0003), to the harness plug removed.

All tests are carried out with the ignition switch ON. The ignition must be switched off before removing or replacing the multi-pin plug to the ECU. **The car must not be driven with the test box connected.**

Note The electronic control unit is not checked. The test box checks the following system components.
a. Hydraulic modulator
b. Valve relay
c. Wheel speed sensors
d. Warning lamp
e. Cable harness
f. Connectors
g. Earth connections
h. Brake lamp switch signal
i. Alternator signal.

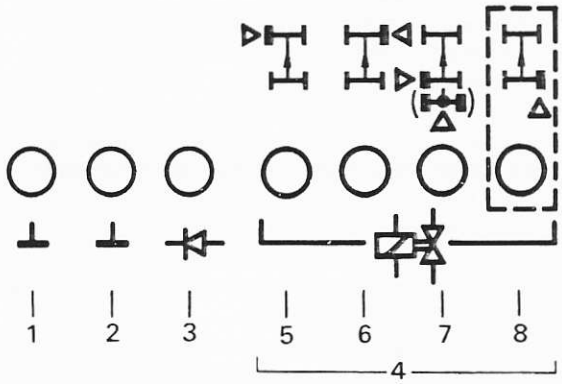
Description of test box symbols
The test box obtains supply voltage from the car's battery.

This supply voltage is monitored during the entire testing sequence and in all programme switch settings. One light emitting diode (LED) is constantly illuminated (1) to indicate that the voltage is sufficient.



Note When checking with the test box, the system(s) are correct when the LED indicators are illuminated (unless stated).

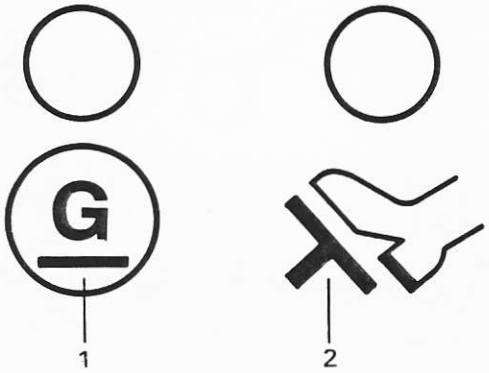
Programme switch position 1



1. LED indicator for earth connection 1.

2. LED indicator for earth connection 2.
3. LED indicator for warning lamp control diode.
4. LED indicators for internal resistances of the modulator solenoid valves and the off position of the valve relay.
5. LED indicator for front left-hand wheel.
6. LED indicator for front right-hand wheel.
7. LED indicator for rear axle (bracketed symbol).
8. Not applicable for 3-channel hydraulic modulator.

Programme switch position 2

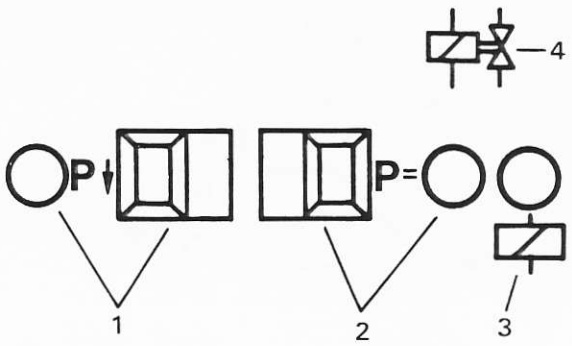


1. LED indicator for alternator connection.
2. LED indicator for stop lamp switch connection.

Programme switch positions 3 and 4

Positions 3 and 4 are not used with this type of anti-lock braking system.

Programme switch position 5



Functional tests of the solenoid valves and valve relay in the hydraulic modulator, and checking that the solenoid valves channel assignments are correct.

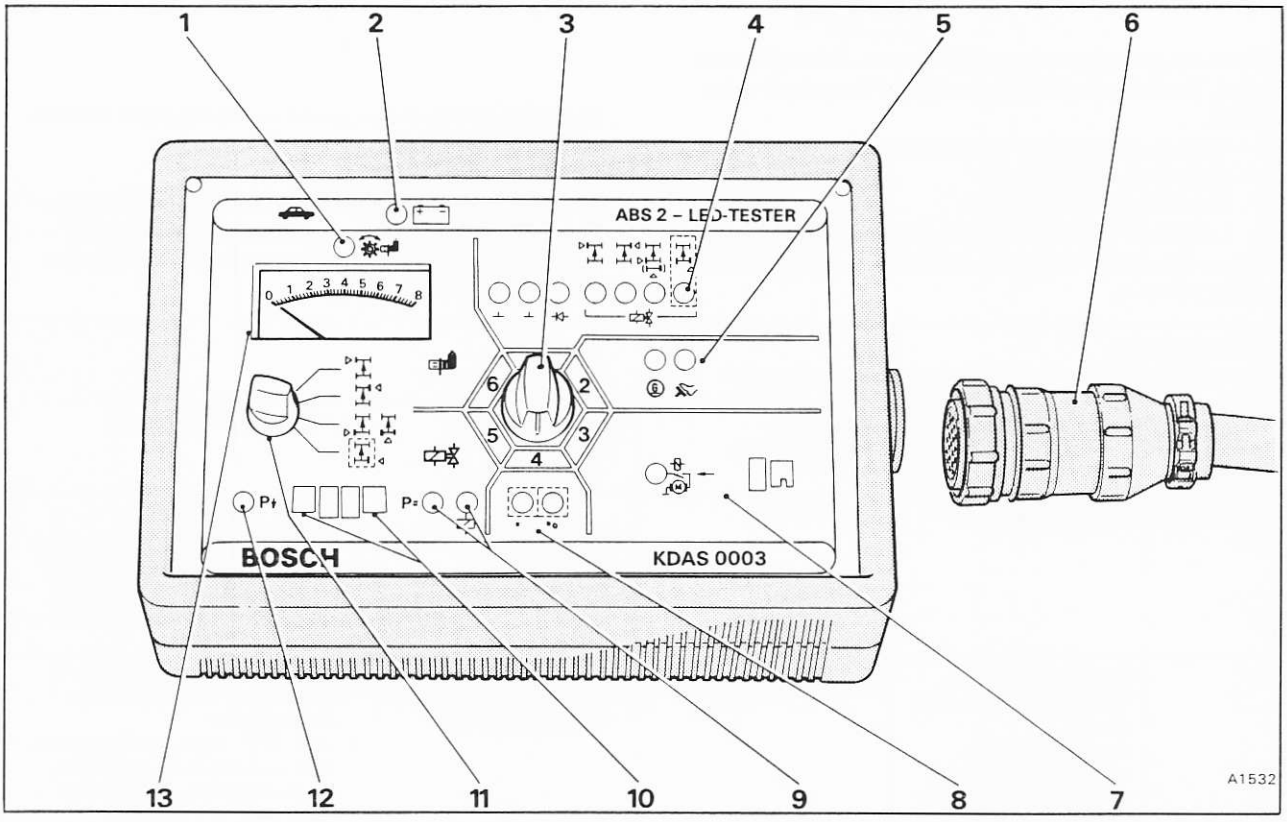
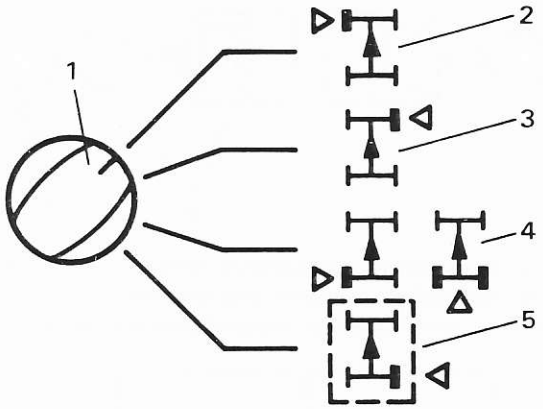


Fig. G6-3 Anti-lock braking system test box (Bosch ABS2 LED KDAS 0003)

1 LED indicator for wheel speed
2 LED indicator for battery voltage
3 Programme selection switch
4 LED indicators for switch position 1
5 LED indicators for switch position 2
6 Adapter lead to ABS wiring harness
7 Switch position 3 (not used)
8 Switch position 4 (not used)
9 LED indicators for switch position 5
10 Push buttons for 'Reduce pressure' and 'Maintain pressure' (switch position 5)
11 Wheel selection switch
12 LED indicator for switch position 5
13 Indicator gauge for switch position 6

1. Push button and LED indicator for the 'Reduce pressure' function. The LED must illuminate **after** operating the push button.
2. Push button and LED indicator for the 'Maintain pressure' function. The LED must illuminate **after** operating the push button.
3. LED indicator for correct functioning of the valve relay. This LED must illuminate continuously when the programme switch is set to position 5.
4. Solenoid valve symbol.

Wheel selection switch

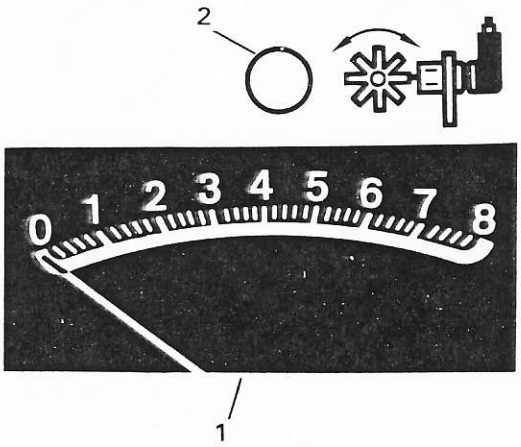


When the programme switch is set to either position 5 or 6, the switch can be adjusted to the wheel to be tested.
1. Rotary switch for wheel selection.
2. Front left-hand wheel.
3. Front right-hand wheel.
4. Left-hand symbol – Rear left-hand wheel for use with programme switch position 6 (i.e. rear left-hand wheel sensor).

Right-hand symbol – Rear axle for use with programme switch position 5 (i.e. rear axle modulator solenoid).
5. Rear right-hand wheel for use with programme switch position 6 (i.e. rear right-hand wheel sensor).

Not applicable for 3-channel hydraulic modulator when at programme switch position 5.

Programme switch position 6



Checking of the wheel speed sensor signals and for correct connections.
1. Instrument scale.
2. LED indicator for rotary motion of the wheels. This LED illuminates continuously when the test speed is adequate. Only then must the instrument indication be read.

Test procedure
Do not drive the car with the test box connected.

Programme switch position	Items to be tested	Additional requirements	Correct test box indication	Possible cause if incorrect
All settings	Power supply	Ignition on	LED [+ −] illuminates continuously	1. Battery voltage low. 2. Excessive voltage drops. 3. Fuse blown; check fuse on ABS relay, fuse B2 on fuseboard F1. In addition from 1988 model year, fuse in luggage compartment. 4. ABS relay defective.
1	Earth connections. Warning lamp control diode. Solenoid valves internal resistances. Off position and earth connection of valve relay.	Ignition on	All 6 LED indicators illuminate to the same extent	1. LED ⊥ does not illuminate. Check earth connections for discontinuity. 2. LED ⊣◁⊢ does not illuminate. ABS warning lamp defective, diode defective, check valve relay earth connections. 3. LED ⇦ does not illuminate. Check corresponding connectors of solenoid valve and leads. 4. All LED indicators ⇦ and ⊣◁⊢ do not illuminate. Check valve relay earth connection, valve relay defective. 5. Weaker illumination of the LED indicates a contact resistance in the corresponding current path.

Programme switch position	Items to be tested	Additional requirements	Correct test box indication	Possible cause if incorrect
2	Alternator voltage	Ignition on	LED (G) illuminates	1. LED may not extinguish until after engine speed increase (test thus passed). 2. Check lead to alternator terminal. 3. Alternator defective.
		Start engine	LED (G) is extinguished when engine running	
	Stop lamp switch	Ignition on	LED illuminates	1. Check lead to stop lamp switch. 2. Stop lamp switch defective. 3. Lead incorrectly connected to stop lamp switch.
		Operate brake pedal	LED is extinguished	
5	Solenoid valve relay operation (modulator)	Ignition on	LED illuminates	1. Modulator relay defective.
	Solenoid valves in hydraulic modulator functioning and correct connections. **Note** Test each wheel consecutively, keeping to operating sequence.	Jack up the vehicle. Ignition on. Wheel to be tested must be free to rotate by hand. Set the selection switch to the wheel to be tested.		1. Repeat the test with the engine running. 2. Modulator control leads transposed, short or open circuit. 3. Current value not reached (LED P↓ or P= extinguished) because battery voltage is low. Repeat the test with the engine running. 4. Hydraulic modulator defective. 5. Hydraulic modulator pipes transposed.
	'Maintain pressure' function	1. Operate push button P=	LED P= illuminates	
		2. Depress brake pedal	Wheel rotates by hand	
		3. Release push button P=	LED P= is extinguished, wheel locked	
	'Reduce pressure' function	4. Operate push button P↓	LED P↓ illuminates, wheel rotates by hand	
		5. Release push button P↓	LED P↓ is extinguished, wheel locked	
		6. Release brake pedal		
		It is only necessary to check one rear wheel, 'chock' the other wheel when testing		
6	Wheel speed sensors operating correctly and correct connections. **Note** Test each wheel consecutively.	Jack up the vehicle. Ignition on. Wheel to be tested must be free to rotate by hand. When testing the rear axle, the wheel not being tested must be held. Set the wheel selection switch to the wheel to be tested.		1. Wheel speed sensor lead incorrectly connected. 2. Wheel speed sensor lead open circuit. 3. Excessive air gap between wheel speed sensor and toothed wheel. 4. Toothed wheel defective or loose. 5. Excessive wheel bearing play.
		Turn the wheel by hand until the LED above the instrument illuminates without flickering (speed approx. 1 rev/second). Then read the instrument indication.		
			Minimum indication must be greater than 4 divisions. Permissible fluctuation; 4% of the maximum indication.	