page

ANTI-LOCK BRAKES (A.B.S. LUCAS VARITY EBC 430)

ANTI-LOCK BRAKES (LUCAS Varity EBC 430)

COMPOSITION

The Varity EBC 430 system is extremely compact (easy to fit), light and reliable.
The use of new microhybrid electronic components, the improvement of the mangetic flows achieved thanks to the design of new compact shapes for the valve bodies and the reduction in the number of hydraulic components achieved through the direct pressing of the jets in the valve seat, have made it possible to improve the modular features of the solenoid valves.
In addition to the anti-locking function, the system controls the distributing of the braking force between the front and rear axles through the EBA function (Electronic Brake Apportioning) thereby eliminating the need for the conventional load proportioning valve in hydraulic braking systems.

The main system components are:
- electronic control unit;
- electro-hydraulic control unit which modulates the braking pressure at the brake calipers by means of eight solenoid valves, two for each wheel;
- four active sensors, one for each wheel, which measure the angular rotation speed of the actual wheels.

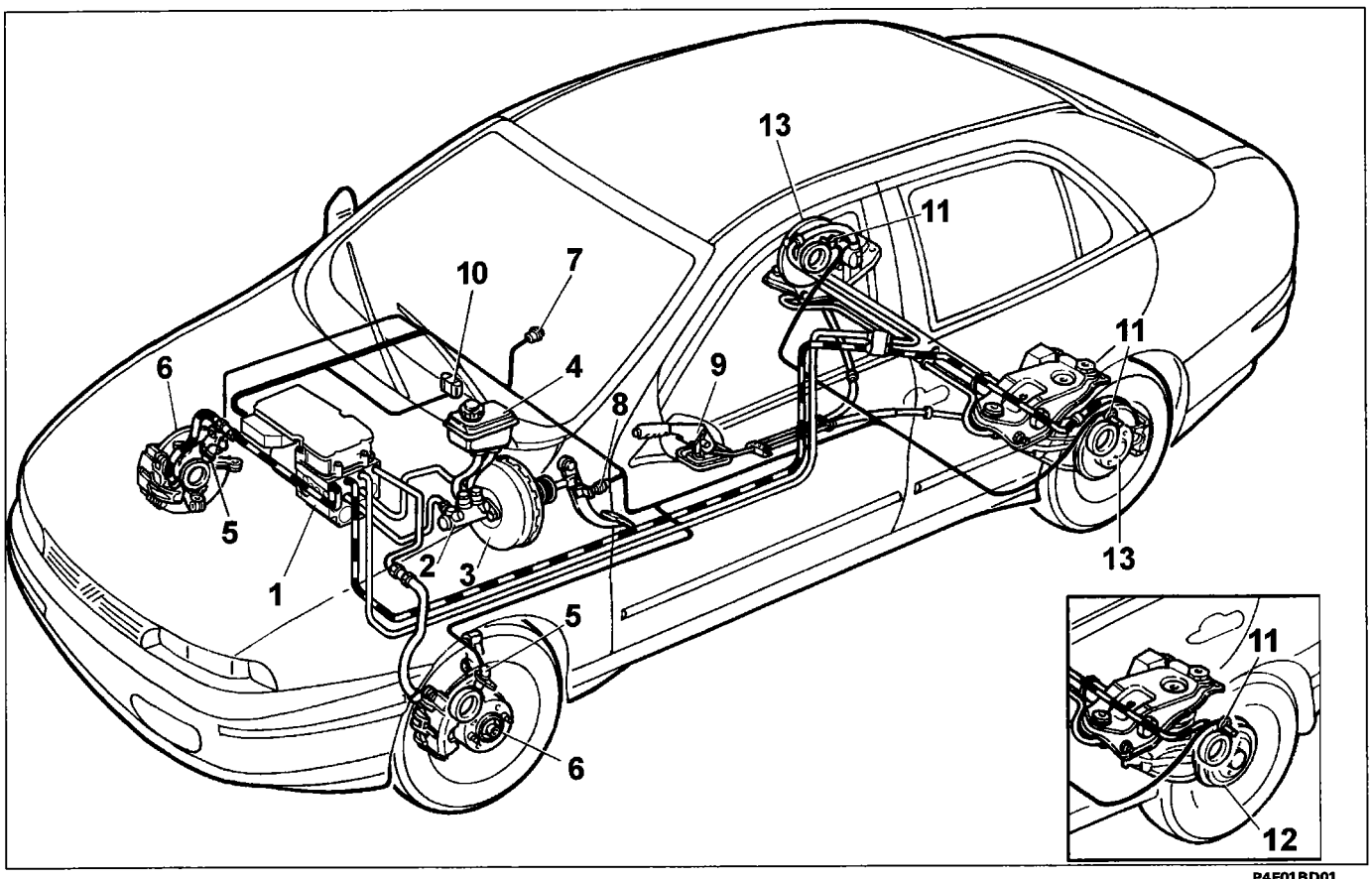


Diagram showing Lucas Varity EBC 430 anti-lock braking system

1. Electro-hydraulic control unit with electronic control unit incorporated
2. Master cylinder for front and rear brake circuit
3. Vacuum servo brake
4. Brake fluid reservoir
5. Front wheel rpm sensor
6. Front disc brakes
7. Instrument panel (ABS and braking system failure warning light)
8. Brake lights switch
9. Handbrake switch
10. Diagnostic socket
11. Rear wheel rpm sensor
12. Rear drum brakes
13. Rear disc brakes

The system is completed by:
- the hydraulic system pipes;
- specific electric wiring;
- a switch on the brake pedal for detecting the braking condition;
- an ABS warning light and a braking system failure warning light, in the instrument panel.

ELECTRO-HYDRAULIC CONTROL UNIT

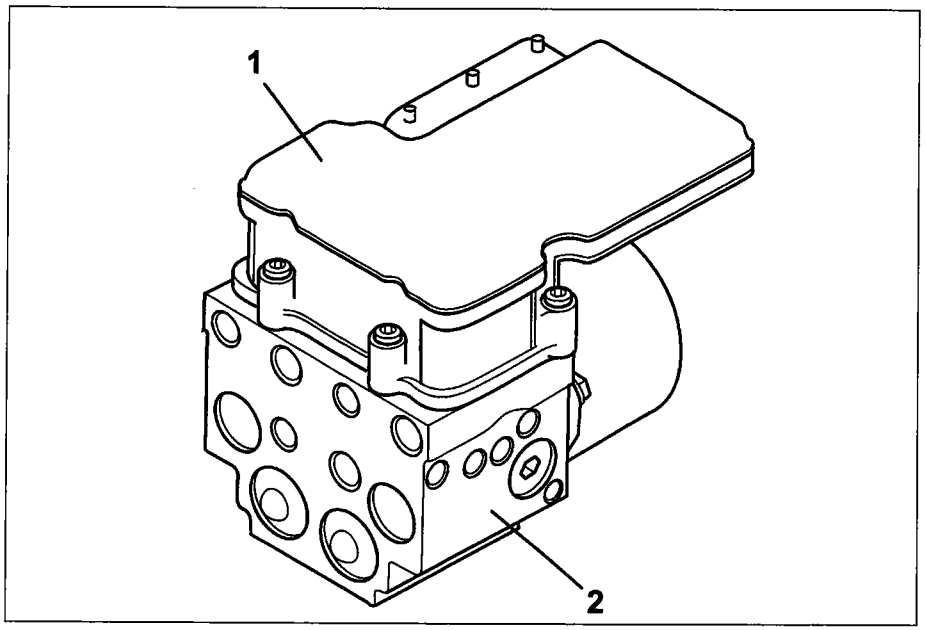
The electro-hydraulic control unit is composed of two sections fixed to one another: an electronic control unit and an electro-hydraulic control unit.
The electronic control unit is connected to the A.B.S. wiring by means of a multiple connector.
On the basis of the signals coming from the sensors and with the aid of programmes stored in its memories, the electronic control unit operates the electro-hydraulic control unit.
The electro-hydraulic control unit is connected to the brake pump and the A.B.S. components through the braking system pipes.

Electronic control unit

The electronic control unit is made up of hybrid circuits with resistances, diodes, transistors and integrated logic circuits. The core of the system comprises two CMOS microprocessors with 24 K of ROM. The main 16 bit processor calculates the ABS responses and constantly controls the operation of the system, ensuring the safety (fail-safe), whilst the 8 bit (secondary) processor independently checks the wheel speed signals; when the results obtained correspond, the electronic control unit issues the operating command to the electro-hydraulic control unit.

If this is not the case, if, for example, there is a fault in the anti-lock braking system, the device excludes itself and braking takes place conventionally; at the same time, the failure warning light in the instrument panel comes on.

The information relating to the fault is recorded in a non volatile memory; in effect, one of the two microprocessors has a CMOS EEPROM memory whose contents are presevered even if the battery voltage is cut off. This memory also has the task of preserving the fault codes to be read later using the diagnostic equipment.



P4F02BD01

1. Electronic control unit
2. Electro-hydraulic control unit

The wheel speed signals are sent by the active sensors to the electronic control unit.
The frequency of these signals provides the controlunit with the corresponding speed, acceleration or deceleration values for the individual wheels.
A reference speed is processed from the combination of the individual peripheral wheel speeds which, being constantly updated, indicates the speed of the vehicle at any moment.
When the driver presses the brake pedal the wheels may decelerate in differing degrees: by comparing the peripheral speed of the individual wheels with the reference speed it is possible to constantly control the creeping of each individual wheel.
If the braking force causes one wheel to creep in relation to the others (known in English as *split*), the electronic control unit gives the command to the electro-hydraulic control unit solenoid valves to reduce the braking force at the wheel where there is a loss of grip. The wheel concerned then regains speed.

NOTE *The peripheral speed of a braking wheel decreases to a greater extent than that of the vehicle, with the wheels completely locked through the braking action (peripheral speed of the wheel = 0) and the vehicle still moving the difference between these two speeds is at the maximum value.*
This difference is known as creeping or the slipping coefficient when expressed as a percentage.
Creeping 0% = free wheel
Creeping 100% = wheel locked and vehicle moving
During braking the friction coefficient tends to increase when the braking takes place with limited creeping (rolling) and decrease when the sliding of the tyre is accentuated until it locks.
By means of a considerable number of practical tests and experiments it has been proven that, generally, it is possible to reach the maximum braking force with creeping values of between 10% and 20%. This defines an optimum area within which the anti-lock brakes operate for all types of vehicles.

The electronic control unit also contains deceleration and acceleration threshold figures in its memory which each individual wheel should never exceed.
Therefore, by means of a systematic, continuous and extremely rapid comparison of the wheel slipping, deceleration and acceleration values the rolling of the tyre during braking is kept in check.

As soon as the acceleration/deceleration and combined *split* threshold values are exceeded, the electronic control unit intervenes, operating the electro-hydraulic control unit solenoid valves in the three regulation stages to decrease, maintain or restore the pressure created by the driver on the brake pedal to the brake calipers, restoring the braking conditions to the optimum values for the system.

These stages determine an intermittent, but extremely fast adjustment cycle which is repeated until the vehicle stops. The electronic control unit controls the various stages, supplying the solenoid valves with impulses of variable lengths. It is also ensures that both the rear wheels receive the same braking force applied to the rear wheel most likely to lock, i.e. the one with less adhesion (to ensure optimum trajectory stability).

The A.B.S. system is also activated when braking in reverse gear.
Usually, the intervention of the device ceases at speeds below 5 kph to allow the wheels to lock completely with the vehicle stationary.
Since the parameters which the control unit controls (wheel speed and acceleration) are affected by the inertia of the wheel/tyre assembly, vehicles equipped with anti-lock brakes **should only be fitted with the wheel rims, tyres and brake pads recommended by the Manufacturer.**

If snow chains are fitted, the rolling condition gives rise to signals which are suitably filtered in the control unit and the anti-lock brakes are not excluded if driving over hard, compact snow.

In conditions where the grip conditions are poor and/or the engine torque is incorrect distributed (aquaplaning), the electronic control unit is informed through the rpm sensors on each wheel of an irregular condition whereby the driving wheels tend to rotate at a different speed from the driven wheels.

This condition involves switching the operation of the control unit in order to prevent the sensation of hardness during the operation of the brake pedal.

The electronic control unit has a safety circuit which has the task of safeguarding the efficiency of the system before every departure and whilst driving.
The safety circuit carries out the following self-checks:

1. after the ignition is switched on, for about 4 seconds it controls the operation of the control unit and the relays which operate the solenoid valves and the connection of the sensors;
2. after the engine is started up, as soon as 5 kph is exceeded, it activates the solenoid valves and the recovery pump for an operating check; it also checks the 4 wheel speed signals;
3. whilst driving it constantly compares the peripheral speed of the wheels with the reference speed calculated, it checks the memory conditions and constantly checks the battery voltage.

If one of these faults is detected, the anti-lock brakes, whilst still ensuring the normal operation of the conventional braking system, switch off and signal this condition to the driver through the failure warning light in the instrument panel coming on.

The electronic control unit is informed that the driver is braking by the signal arriving from the switch on the brake pedal. This information is useful in the case of strong deceleration, which causes the wheels to slip, followed by strong braking or in the case of uneven road surfaces (undulating, cobblestones) which could cause variations in the speed of the wheels for reasons not connected with the braking in progress.
Under these circumstances the microprocessors process a strategy linked to the variations in the speed of the wheels at these particular moments, restoring the braking in progress to within the correct parameters. Since these are particular braking conditions, a faulty connection of the switch on the brake pedal with the control unit will not adeversely affect the operation of the system. For this reason it is not signalled by the warning light coming on, neither is the A.B.S. system disabled.

Electro-hydraulic control unit

The electro-hydraulic control unit is connected to the brake pump and to the brake caliper cylinders by means of the braking system pipes.

Its task is to vary the pressure of the brake fluid in the brake caliper cylinders corresponding to the signals coming from the electronic control unit.

It is made up of eight two-way solenoid valves (two for each hydraulic circuit) and a twin circuit electric recovery pump.

The eight solenoid valves and the electric recovery pump are operated by the electronic control unit according to the signals from the four rpm sensors. In particular, the pump allows the recovery of brake fluid during the pressure reduction stage making it available once again upstream of the solenoid valves for the subsequent pressure increase stage.
The low pressure accumulators make it possible to absorb brake fluid during the pressure reduction stage.

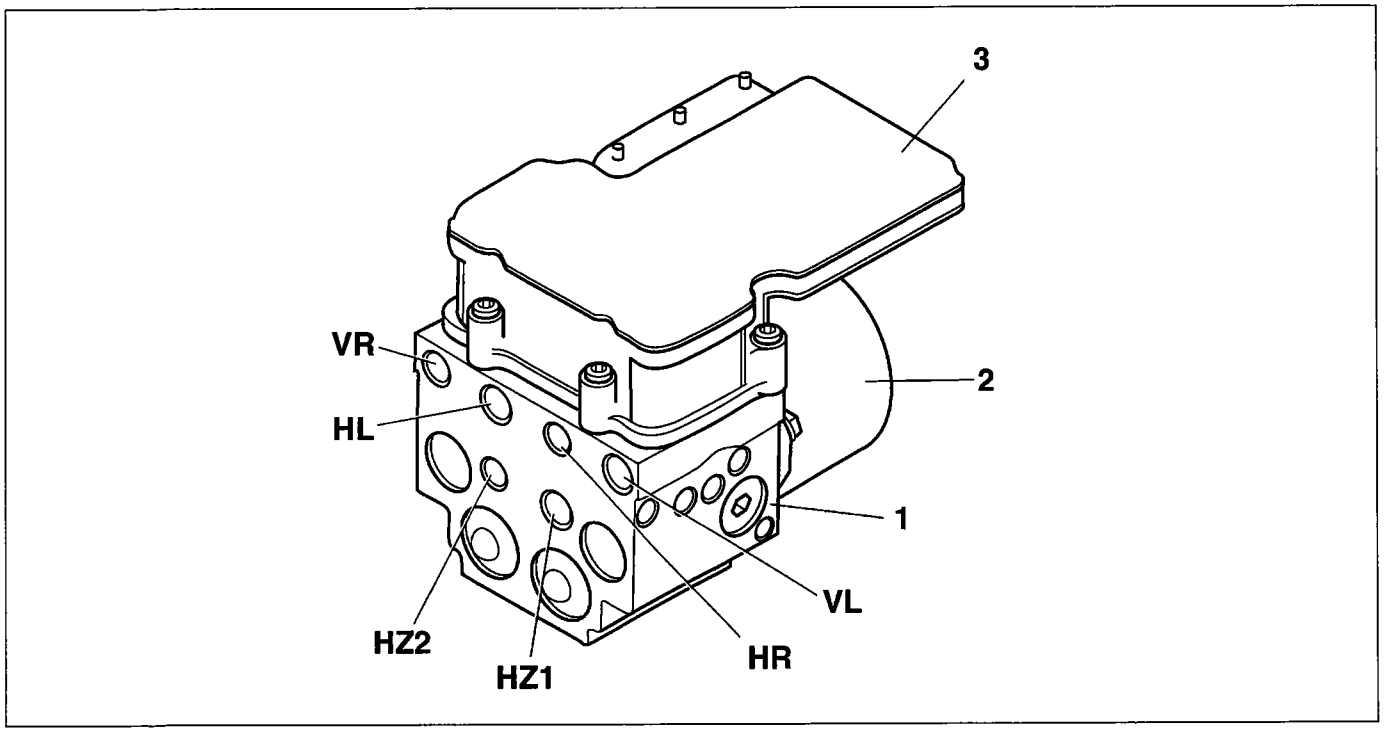
The unit is connected to the braking system by means of connectors which can be identified by the codes stamped on them as illustrated in the diagrams.

The electro-hydraulic control unit cannot be overhauled and should not be tampered with.
If a fault is confirmed, it should be replaced.

It is available as spares filled with brake fluid and with the solenoid valves not supplied.

The operation of bleeding and refilling the braking system is the same as for conventional systems.

NOTE *To avoid errors when connecting the various braking system circuits during repair operations, the electro-hydraulic unit connections are different sizes (M10x1 and M12x1) and also the connectors can be identified by the codes on them as illustrated in the diagram.*



P4F05BD01

Identification of electro-hydraulic control unit outlets

HZ1. Supply connector from brake pump M12x1 (primary circuit)
HZ2. Supply connector from brake pump M10x1 (secondary circuit)
VL. Supply connector to the left front brake caliper M12x1
HL. Supply connector to left rear brake caliper M12x1
VR. Supply connector to the right front brake caliper M10x1
HR. Supply connector to right rear brake caliper M10x1

1. Electro-hydraulic control unit
2. Electric recovery pump
3. Electronic control unit

WHEEL RPM SENSORS (ACTIVE)

The operation of the "active sensors" is based on the variation of the internal electrical resistance depending on the intensity and the direction of the lines of force of an external magnetic field producing a square wave signal whose frequency varies according to the rotation speed of the wheel, but whose amplitude is constant.

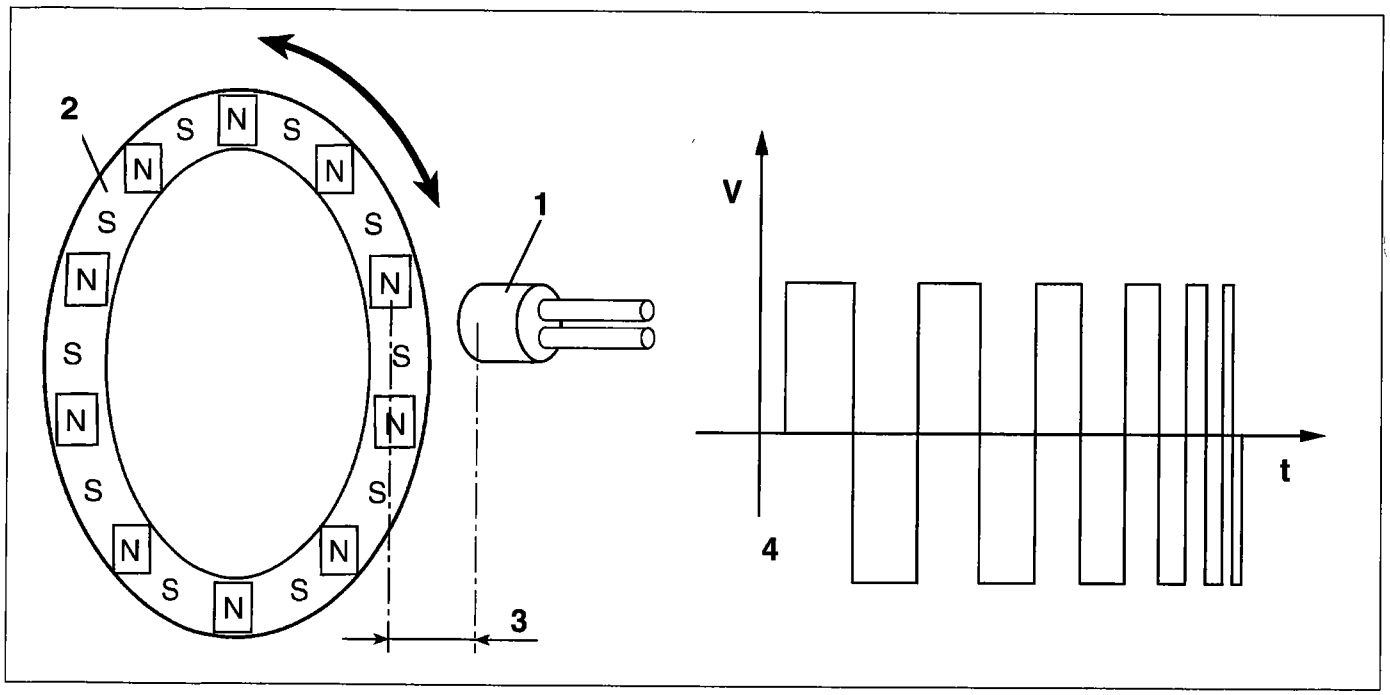
The external magnetic field is produced by a so-called "multi-polar ring" made up of an elastomer with a certain quantity of magnetic particles which, through a particular magnetization technique, are directed to create different magents with alternating North - South polarities around the circumference.

The multi-polar ring can be fitted on the wheel bearing seal or on the hub (rear wheels).

The sensor is supplied by the ABS electronic control unit and produces a square wave signal with an almost constant amplitude and a frequency proportional to the wheel rotation speed.

The use of this new type of sensor offers the following advantages compared with traditional magnetic induction sensors:

- less sensitivity to the distance between the sensor and the magnetic ring;
- improved immunity to electro-magnetic fields;
- the capacity of the sensor to measure the speed of the wheel up to zero (rather than 2.5 kph for the passive sensor);
- the reduction in weight and size in the vehicle.



P4F06BD01

1. Active sensor casing
2. Multi-polar ring
3. Gap
4. Exampleof wheel rpm sensor output signal

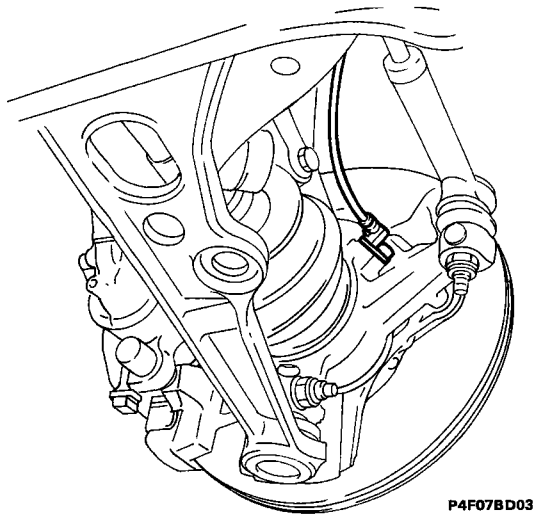
The recommended distance (gap), to obtain the correct signals, between the end of the sensor and the multi-polar ring should be between:

0,17 ÷ 2,02 mm for the front wheels
0,57 ÷ 1,53 mm for the rear wheels

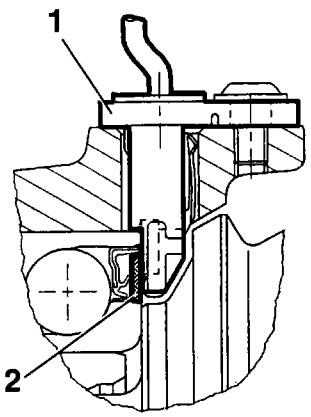
This distance cannot be adjusted, therefore if the gap is outside of the tolerance, check the condition of the sensor and the multi-polar ring.

NOTE *Each time an rpm sensor is fitted, it should be lubricated with water-repellant grease to prevent the effects of thermal variations making it difficult to remove over a period of time.*

Positioning of front wheel sensor



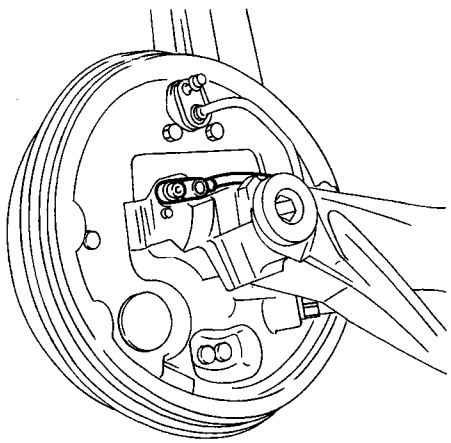
P4F07BD03



P4F07BD01

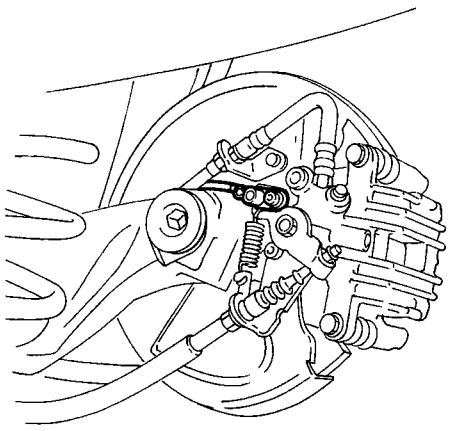
Positioning of rear wheel sensor

Version with drum

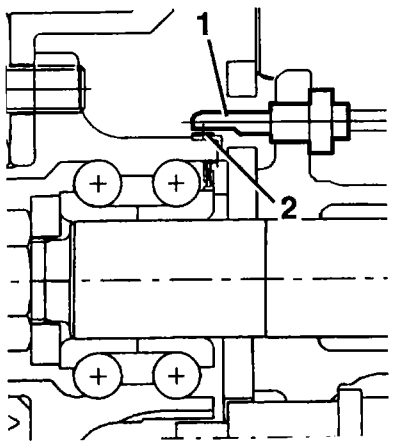


P4F07BD04

Version with disc



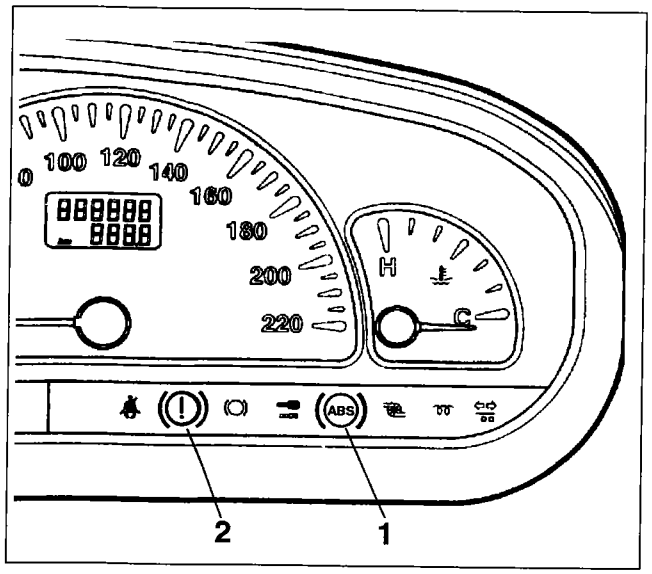
P4F07BD05



P4F07BD02

1. Active sensor
2. Multi-polar ring

Warning light signalling A.B.S. failure



P4F08BD01

1. ABS warning light
2. Braking system failure warning light

With the ignition switch in the ON position, the control unit carries out a static self-control cycle during which the warning lights (1 and 2) come on.

After about 2 seconds (if the control system does not detect any faults), the warning lights go out.

If the warning light (1) remains on, this means that there is a fault in one or more of the A.B.S. system components. Under these circumstances, the A.B.S. system is disabled but the EBA system continues to operate, therefore the braking force continues to be distributed like on a conventional braking system.

If the warning light (1) does not come on, (with the ignition switched on) then the cause of the problem should be sought in the LED of the actual warning light or in the electrical connection.

At around 6 kph the A.B.S. system is switched on.

When driving at a speed of about 6 kph, the system test cycle starts to operate. If the system component responses are positive, then the warning light remains switched off. If the response is negative, then the warning light comes on and the A.B.S. system is automatically deactivated. Braking takes place conventionally.

When the battery is not fully charged, the warning light may come on and the A.B.S. is excluded such as, for example, in town when driving at very low speeds with all the consumers switched on.

EBA function failure signal

A failure of the EBA function is signalled by the ABS warning light coming on at the same time as the braking system failure warning light (2) in the instrument panel.

The warning light (2) in the instrument panel coming on not accompanied by the ABS warning light (1) coming on does not indicate a malfunction of the EBA, but one of the other faults signalled (low brake fluid level, handbrake applied).

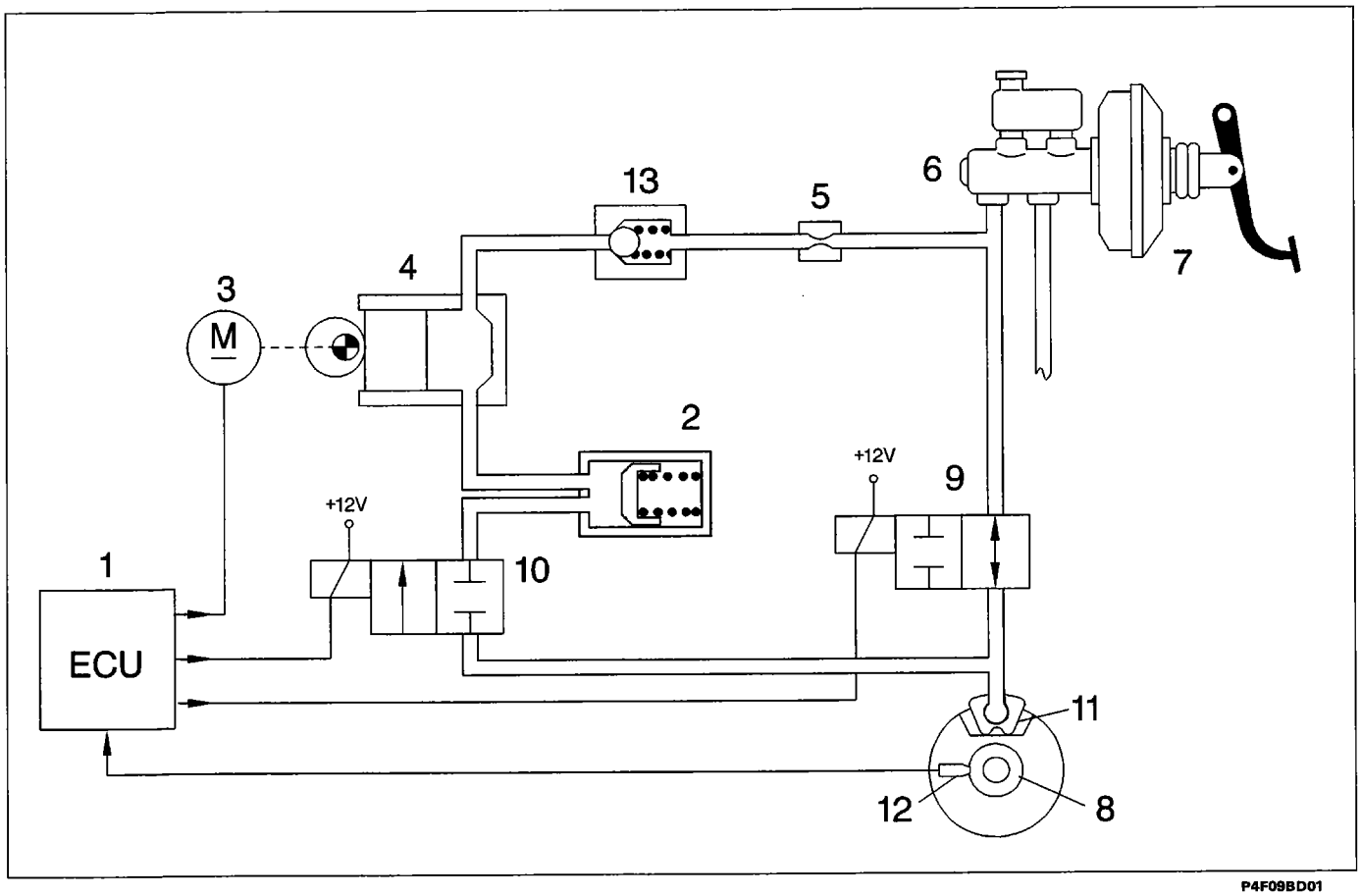
If there is a fault in the EBA, the distribution of the brake force between the front and rear axles tends to fail with the consequent risk of the rear wheels locking during braking in certain conditions.

DESCRIPTION OF THE OPERATION OF THE ANTI-LOCK BRAKES

Rest position

Each branch of the ABS EBC 430 system hydraulic circuit is equipped with two two-way solenoid valves; all the solenoid valves are managed by the control unit (1).
When the pressurizing solenoid valve (9) is deactivated (not connected to earth by the control unit) it is in an open position, allowing the flow of fluid to the brake caliper.

The pressure maintenance is achieved by closing this valve, i.e. supplying it electrically.



1. Electronic control unit
2. Low pressure accumulator (reservoir)
3. Recovery pump motor
4. Recovery pump
5. Restricter
6. Brake pump
7. Brake servo
8. Multi-polar ring
9. Pressurizing solenoid valve
10. Discharging solenoid valve
11. Brake caliper
12. Rpm sensor
13. Single-acting valve

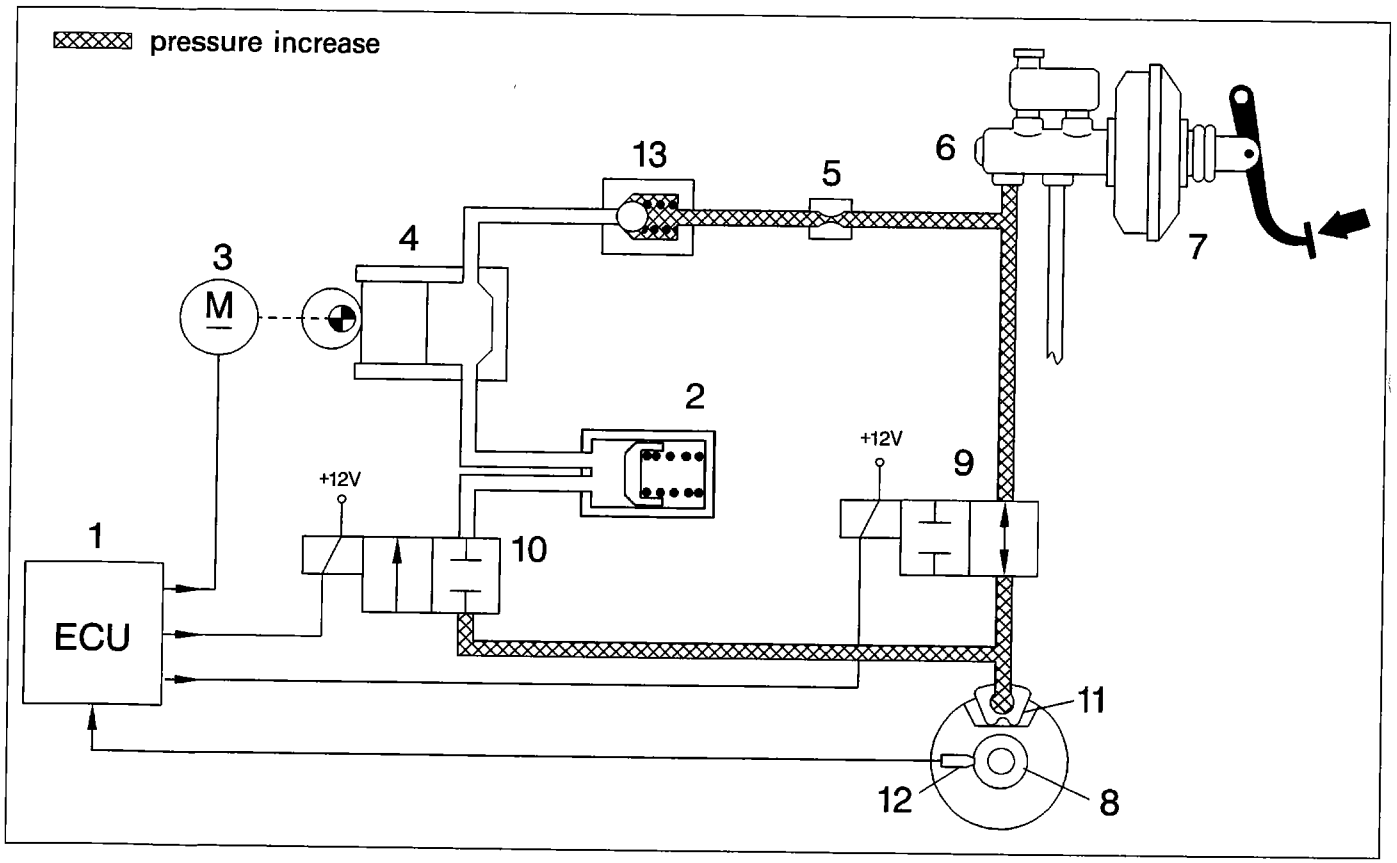
When it is deactivated, the discharging solenoid valve (10) (not connected to earth by the control unit) is in the closed position and does not allow the fluid to be discharged at the low pressure accumulator (2).

The accumulators (2) have the task of temporarily storing the brake fluid which is available during the pressure reduction stage.

The recovery pump (4) sends the brake fluid which flows from the brake calipers, during the pressure reduction stage, to the brake pump through the restricter (5), which has the task of damping the pressure and the impulses generated by the pump perceived by the driver.

On the basis of the signals received from the rpm sensors on the front and rear wheels, the electronic control unit operates the electro-hydraulic control unit which, in turn, varies the pressure of the brake fluid sent to the calipers in accordance with three stages: pressure increase, maintenance or decrease.

Pressure increase stage



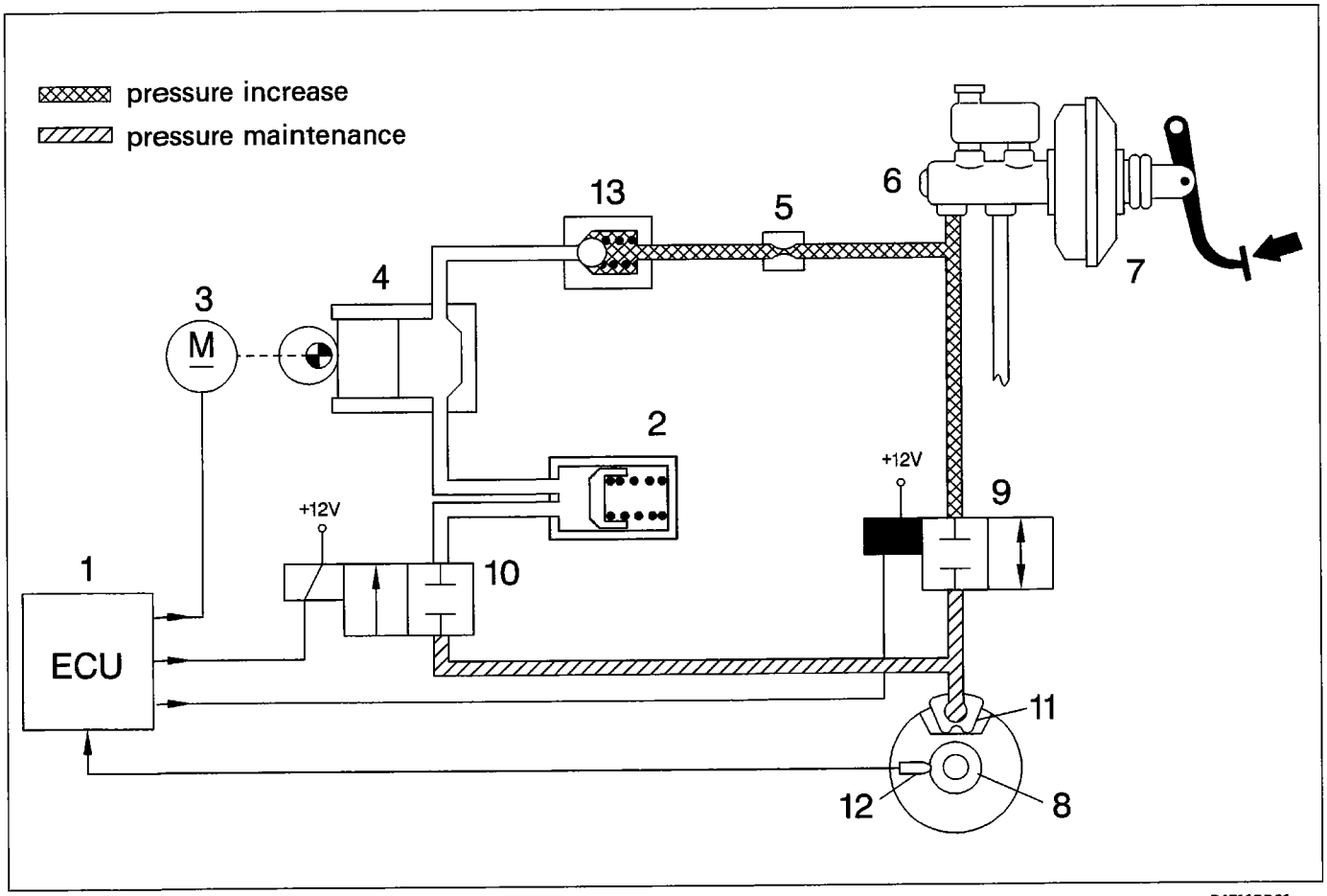
1. Electronic control unit
2. Low pressure accumulator (reservoir)
3. Recovery pump motor
4. Recovery pump
5. Restricter
6. Brake pump
7. Brake servo
8. Multi-polar ring
9. Pressurizing solenoid valve
10. Discharging solenoid valve
11. Brake caliper
12. Rpm sensor
13. Single-acting valve

When the driver presses the brake pedal, the pressure produced by the brake pump (6) reaches the brake caliper without undergoing variations, because the solenoid valves (9) and (10) for the hydraulic unit are not connected to earth by the electronic control unit.

When the braking force increases, the deceleration of the wheel consequently increases: this causes a faster deceleration of the vehicle (i.e. the slipping of the wheel increases).
The value of the creeping should not exceed a given figure beyond which the wheel loses its grip with the ground and starts to slip, losing direction and increasing the braking distances.

The rpm sensor (12) signals that the deceleration values reached could adversely affect the adhesion of the wheel to the ground: at this point the electronic control unit (1) commands the electro-hydraulic unit solenoid valves, reducing the braking force and allowing the speed of the wheel to increase to recover its grip.

Pressure maintenance stage



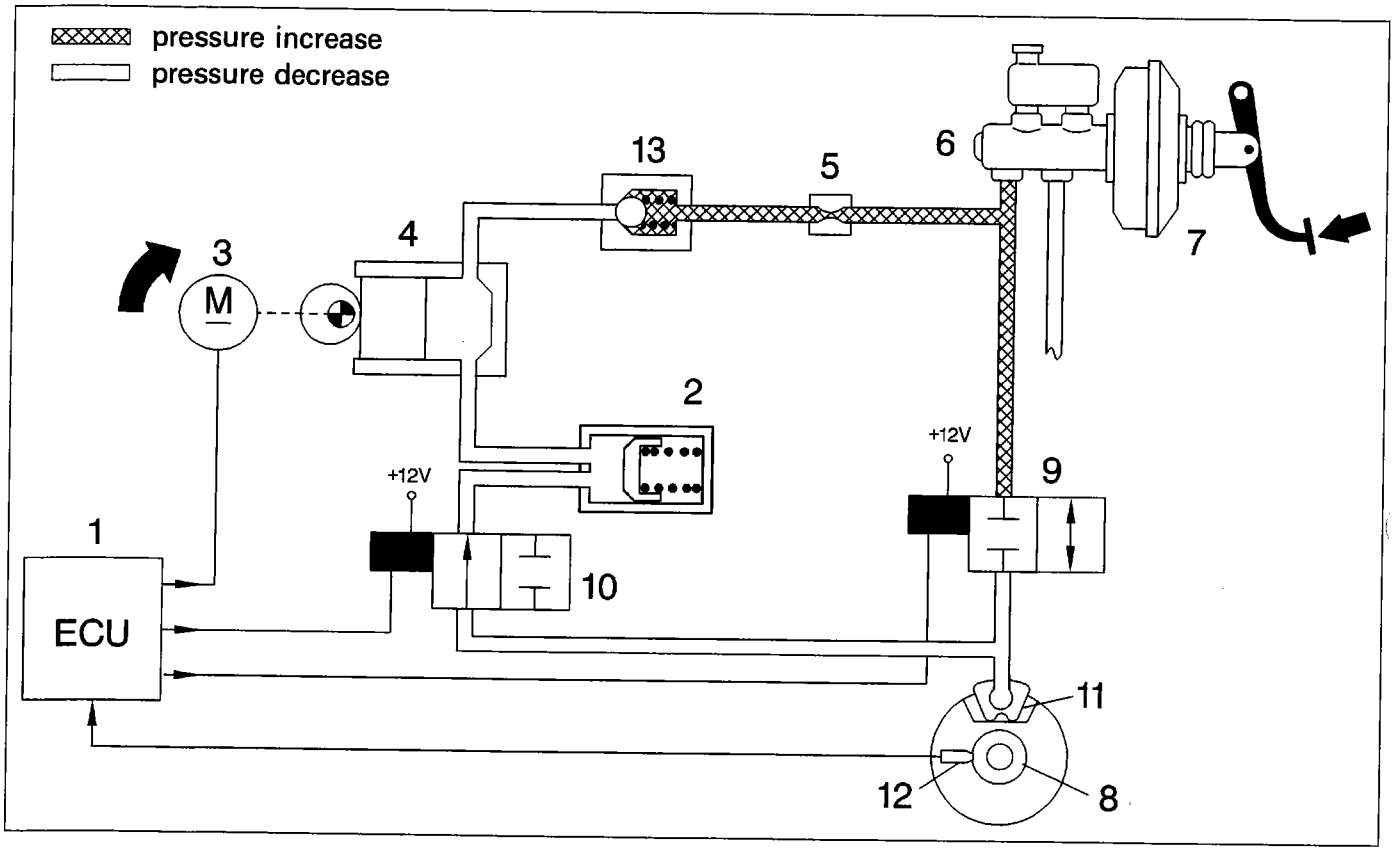
1. Electronic control unit
2. Low pressure accumulator (reservoir)
3. Recovery pump motor
4. Recovery pump
5. Restricter
6. Brake pump
7. Brake servo
8. Multi-polar ring
9. Pressurizing solenoid valve
10. Discharging solenoid valve
11. Brake caliper
12. Rpm sensor

During this stage the electronic control unit (1) connects the pressurizing solenoid valve (9) to earth which closes, whilst the discharing solenoid valve (10) is already closed as it is not connected to earth.

The hydraulic connection between the brake pump (6) and the brake caliper (11) in interrupted (waiting position).
The pressure in the brake caliper (11) is kept constant at the value reached previously, even if the pressure on the brake pedal is increased.

In spite of this the braking force maintains a constant slowing down action, the speed of the wheel varies, according to the adhesion on the ground, until the rpm sensor (12) signal detects a value which is comparable to the reference speed calculated by the electronic control unit (1).
At this point the control unit moves on from the pressure maintenance stage to the increase stage (if the wheel is accelerating) or to the decrease stage (if the wheel tends to lock).

Pressure reduction stage



P4F128D01

1. Electronic control unit
2. Low pressure accumulator (reservoir)
3. Recovery pump motor
4. Recovery pump
5. Restricter
6. Brake pump
7. Brake servo
8. Multi-polar ring
9. Pressurizing solenoid valve
10. Discharging solenoid valve
11. Brake caliper
12. Rpm sensor
13. Single-acting valve

The electronic control unit (1) detects the tendency of the wheel to lock and alerts the electro-hydraulic unit to contain the deceleration of the wheel within the permissible limits.

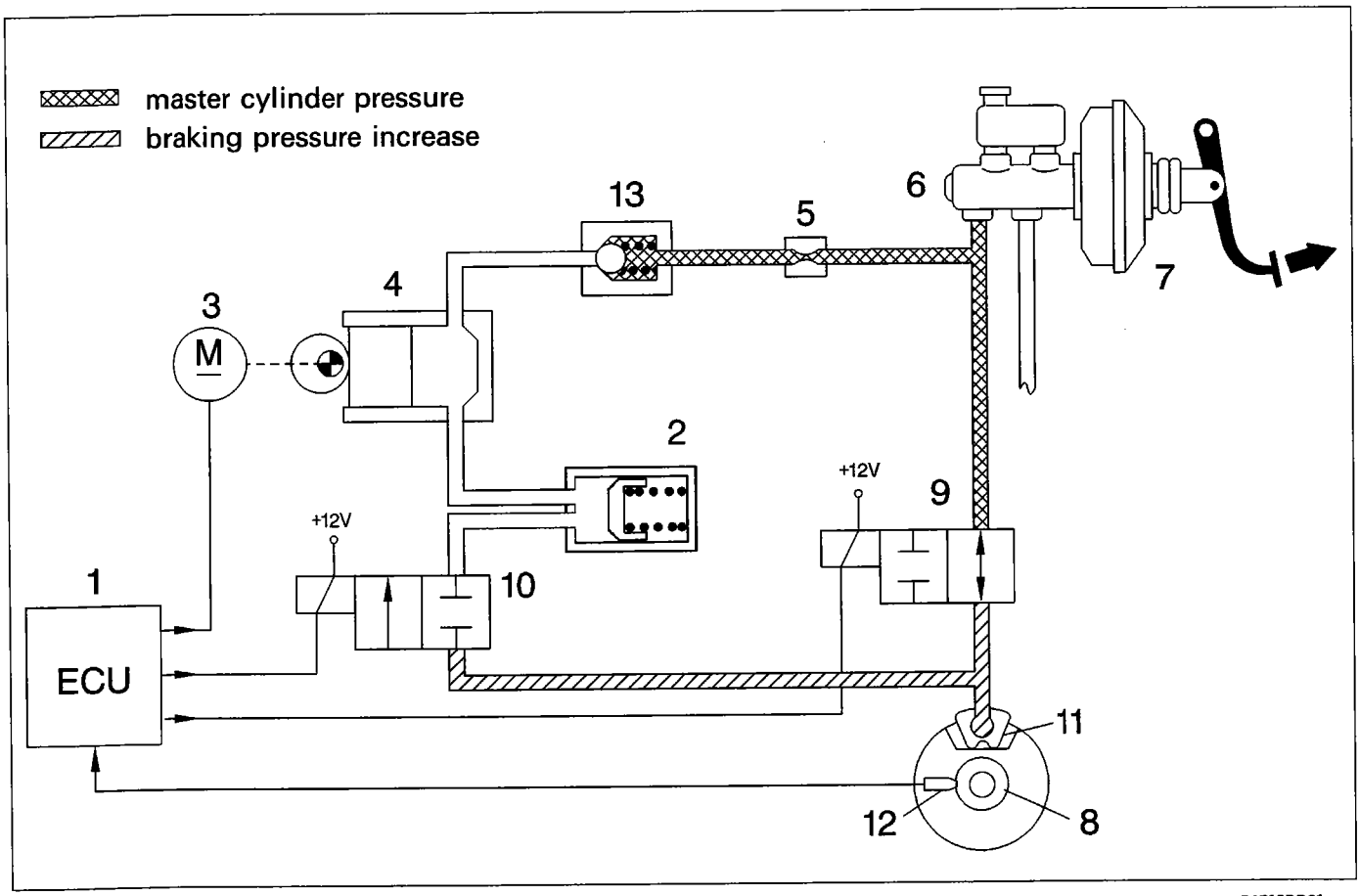
The electronic control unit (1) connects the pressurizing (9) and discharging (10) solenoid valves to earth.
The pressurizing solenoid valve (9) remains closed keeping the connection between the brake pump (6) and the brake caliper (11) interrupted; the discharging solenoid valve (10) opens making a hydraulic connection between the brake caliper (11) and the low pressure accumulator (2) and the recovery pump (4), in such a way as to remove some of the fluid from the brake caliper (11) and decrease the pressure at the actual caliper.
At the same time, the electronic control unit (1) supplies the recover pump (4) motor (3) which allows the fluid removed from the brake caliper (11) to be reintroduced into the main circuit.
The low pressure reservoir or accumulator (2) in the circuit has the task of storing part of the brake fluid removed from the calipers. The fluid is drawn in through the recovery pump (4) circuit and sent, by means of the restricter (5), into the brake pump (6) main circuit.
During this stage a series of pressure waves (or hydraulic thrusts) are produced which notify the driver that the ABS device has started to work.

During braking, slight force on the brake pedal should be considered normal during the intervention of the A.B.S. system, During this stage, as a result of the decreased braking force, the wheel tends to return to the reference speed calculated by the electronic control unit (1).

The ABS stops working at speeds below 5 kph to allow the wheels to lock completely with the vehicle stationary.

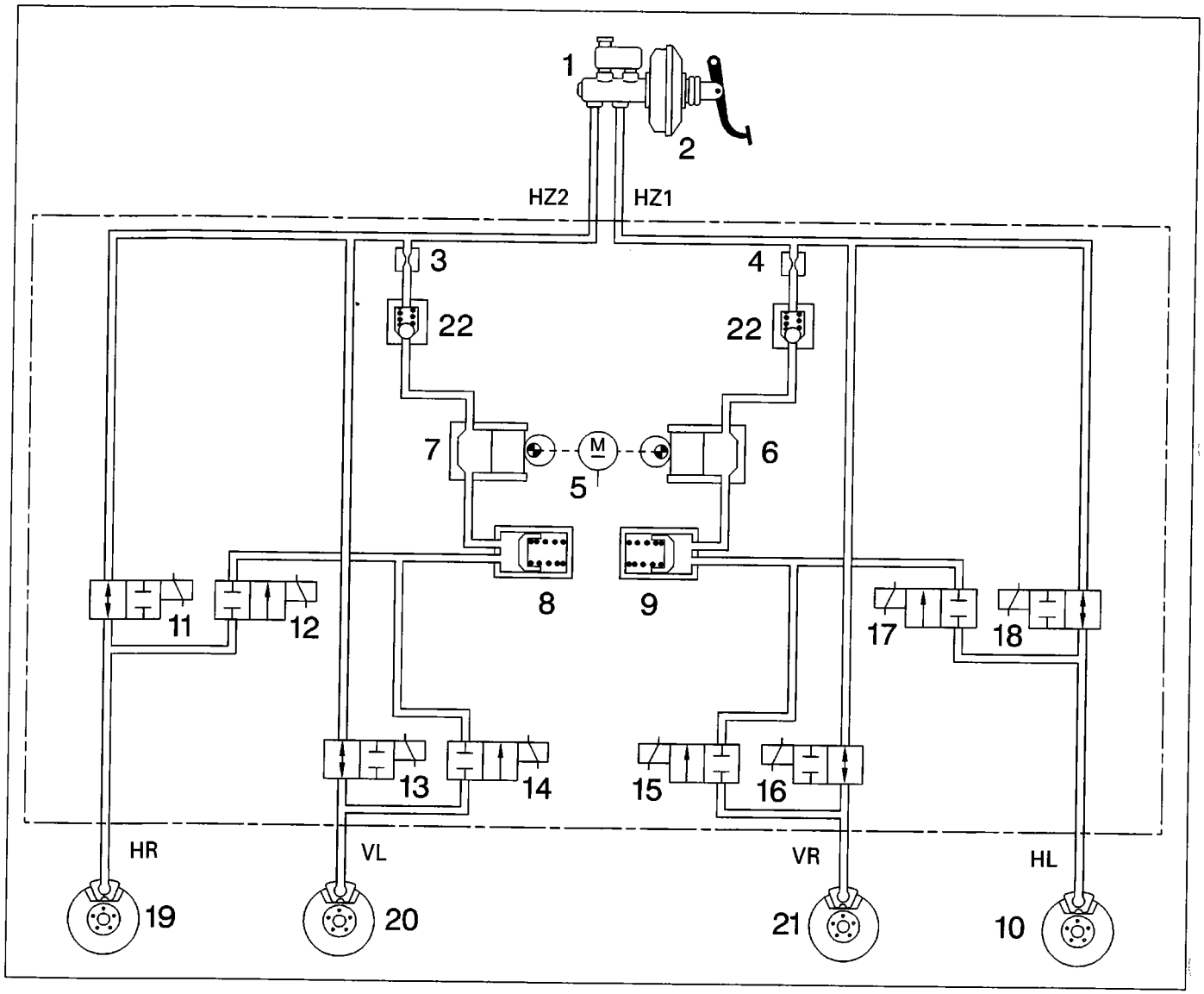
Pressure increase stage

When the tendency to slip is over, the discharging solenoid valve (10) closes. The system enters the pressure increase stage for the brake caliper (11); this is achieved through a rapid opening and closing sequence of the pressurizing valve (9). When the electronic control unit (1) once again detects creeping conditions, it activates the strategy described in the "Pressure reduction stage" paragraph.



1. Electronic control unit
2. Low pressure accumulator (reservoir)
3. Recovery pump motor
4. Recovery pump
5. Restricter
6. Brake pump
7. Brake servo
8. Multi-polar ring
9. Pressurizing solenoid valve
10. Discharging solenoid valve
11. Brake caliper
12. Rpm sensor
13. Single-acting valve

DIAGRAM SHOWING A.B.S. HYDRAULIC SYSTEM



Twin circuit cross-over braking system

1. Brake pump
2. Brake servo
3. Restricter
4. Restricter
5. Recovery pump motors
6. Recovery pump
7. Recovery pump
8. Low pressure accumulator (reservoir)
9. Low pressure accumulator (reservoir)
10. Left rear disc (or drum) brake
11. Right rear pressurizing solenoid valve
12. Right rear discharging solenoid valve
13. Left front pressurizing solenoid valve
14. Left front discharging solenoid valve
15. Right front pressurizing solenoid valve
16. Right front discharging solenoid valve
17. Left rear pressurizing solenoid valve
18. Left rear discharging solenoid valve
19. Right rear disc (or drum) brake
20. Left front disc brake
21. Right front disc brake
22. Single-acting valve

HZ1. Supply connector 1st stage for brake pump
HZ2. Supply connector 2nd stage for brake pump

HR. Supply connector to the right rear caliper
VL. Supply connector to the left front caliper
VR. Supply connector to the right front caliper
HL. Supply connector to the left rear caliper

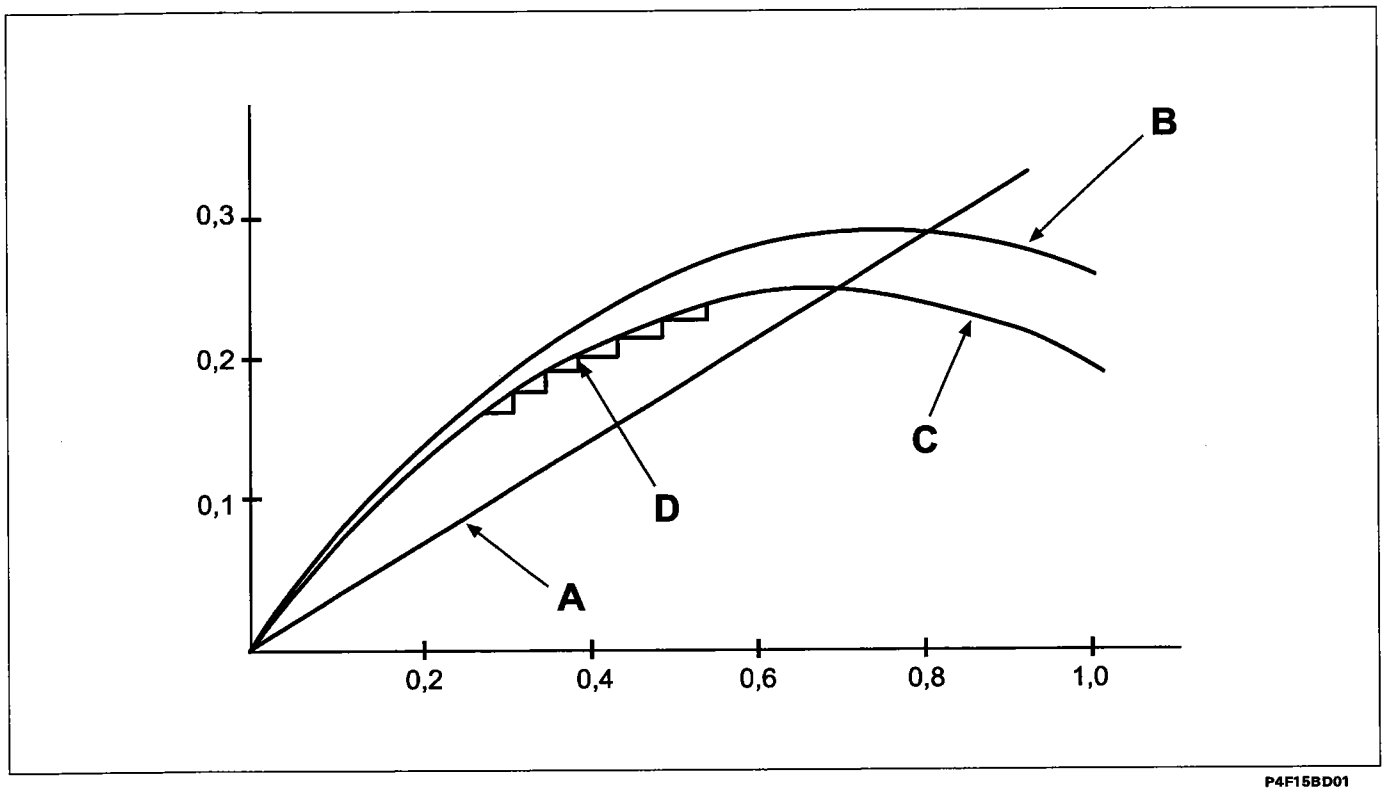
EBA function (Electronic Brake Apportioning)

The introduction of the EBC 430 makes it possible to distribute the brake force between the front and rear axles using a special function of the electronic control unit.

With this in mind, the electronic control unit continuously compares the speed of the front and rear wheels using the speed sensors and operates the electro-hydraulic unit in order to prevent the rear wheels from locking, always taking maximum advantage of the adhesion to the ground in all load conditions.

The EBA function makes the need for the hydraulic load proportioning valve acting according to the load on the rear axle superfluous which is why it has been eliminated from the vehicle braking circuit.

The graph below illustrates the intervention of the EBA device (curve D) in relation to the pressure in the braking system (curva A), the ideal pressure at the rear axle brakes (curve C), on the assumption that the vehicle is empty.

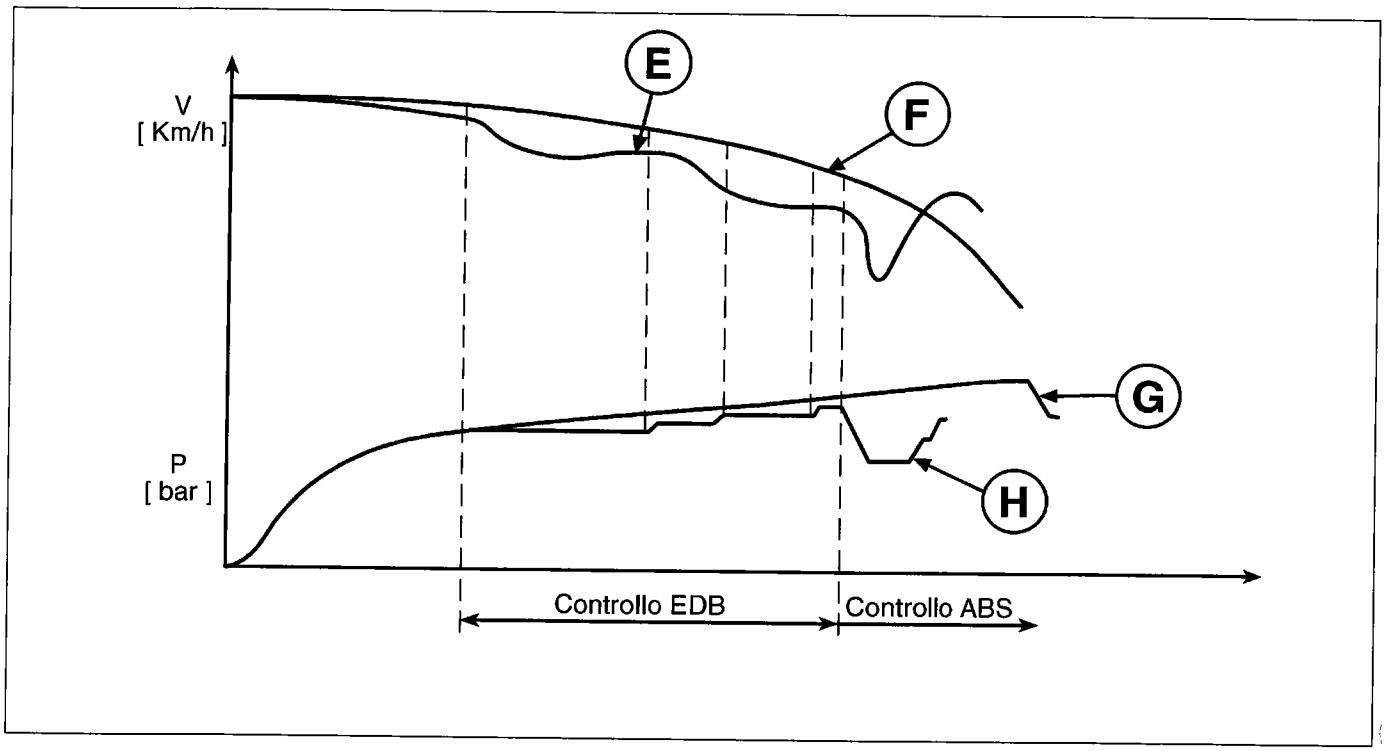


A. Distribution implemented by the braking system
B. Ideal distribution, with vehicle fully laden
C. Ideal distribution, with vehicle empty
D. EBA control

As it can be noted, the EBD function for the ABS system is capable of adapting to the ideal pressure curve, always exploiting the available adhesion in all braking conditions.

The integration of the EBA function in the regular ABS system logic gives the possibility of two simultaneous strategies; the system usually intervenes to keep the creeping of the rear wheels within values which are very close to the ideal figures, with the possibility, however, of intervening with the ABS strategy when one of the rear wheels tends to lock (for example when driving over a surface with poor adhesion).

The graph below illustrates the braking pressure implementation strategy, operated by the electronic control unit, on the basis of the input data, represented by the signal for the rotation speed of the wheels on the two axles.



E. Rear wheel speed

F. Front wheel speed

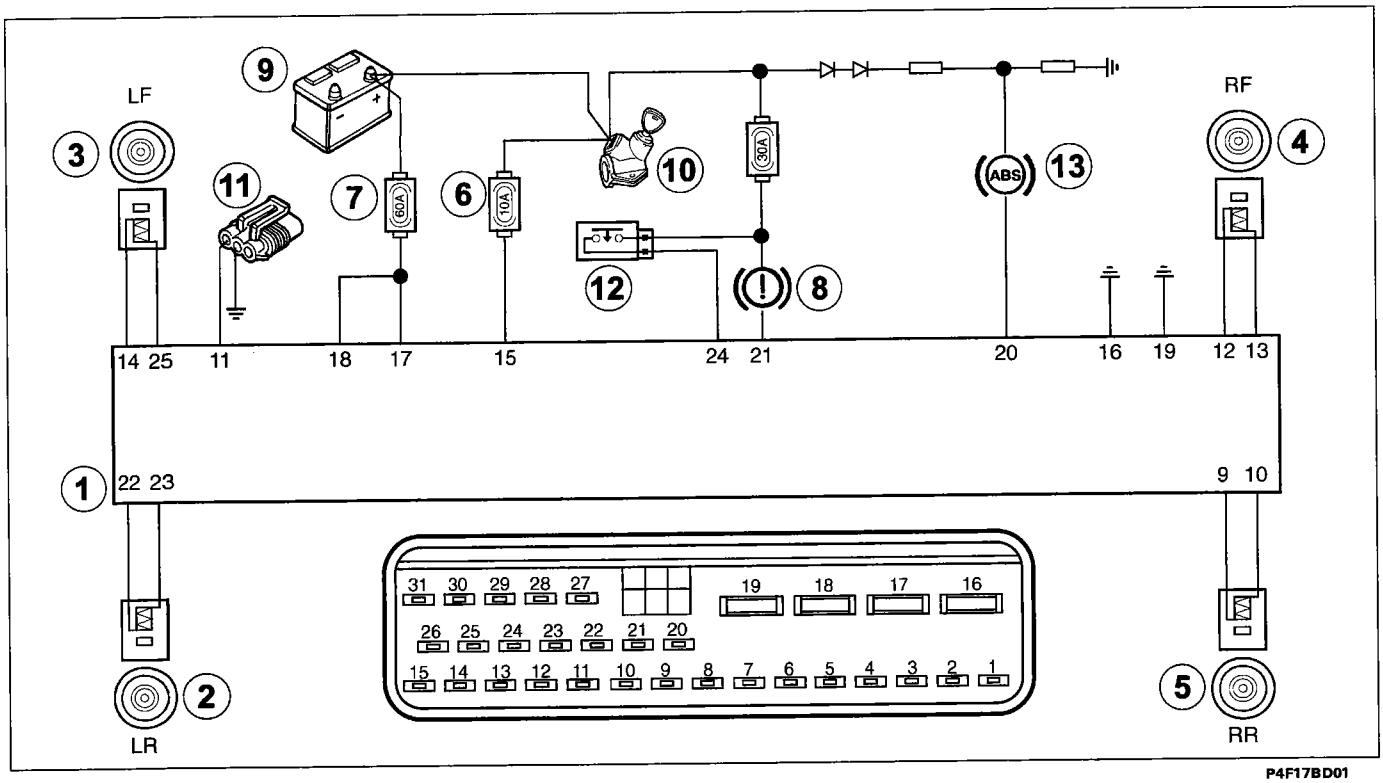
G. Front wheel pressure

H. Rear wheel pressure

EBA OPERATION

The braking pressure of the wheels on the rear axle are checked by the control unit in the same way as described for the ABS operation in the "Pressure maintenance stage" and the "Pressure reduction stage", with the difference being that the electric recovery pump is not activated and any excess hydraulic fluid is recovered in the low pressure accumulator. The fluid returns to the supply circuit when the braking is over.

WIRING DIAGRAM FOR LUCAS VARITY EBC 430 SYSTEM



1. Electronic control unit
2. Left rear rpm sensor (RL)
3. Left front rpm sensor (FL)
4. Right front rpm sensor (FR)
5. Right rear rpm sensor (RR)
6. 10A protective fuse
7. 60A protective fuse
8. Braking system failure warning light (EBA)
9. Battery
10. Ignition switch
11. Diagnostic socket
12. Brake lights switch
13. A.B.S. warning light

Identification of terminals at electronic control unit and at connector

N°	Destination	N°	Destination
1	Spare	17	60A fuse
2	Spare	18	60A fuse
3	Spare	19	Earth
4	Spare	20	ABS warning light
5	Spare	21	EBA warning light
6	Spare	22	Left rear sensor
7	Spare	23	Left rear sensor
8	Spare	24	Brake lights switch
9	Right rear sensor	25	Left front sensor
10	Right rear sensor	26	Spare
11	Diagnostic line	27	Spare
12	Right front sensor	28	Spare
13	Right front sensor	29	Spare
14	Left front sensor	30	Spare
15	10A fuse	31	Spare
16	Earth		