CITROËN

TECHNICAL TRAINING

CONSULTANT TECHNICIAN

MODULE B7

- **Hydractive I XM**
- **Hydractive II XM Xantia**

DOCUMENT REF Nº: **6.2.304** June 2001

DEALER QUALITY
DEVELOPMENT DIVISION

HYDRACTIVE II SUSPENSION

INTRODUCTION

The choice of spring and damping settings of a vehicle's suspension is based on two main **criteria.**

I - COMFORT

The flexibility and the damping rate are defined so as to isolate the occupants of the vehicle from **impacts** and vibrations by using an oscillating frequency btween 0.9 and 1.2 Hertz and by limiting vertical accelerations to 0.25 g (2.45 mls^2).

II - ROAD HOLDING

Like competition can, **hard suspension** and anti-roll adjustments are required to limit the movement of the body and to make the tyres work in a precise manner.

The aim of this system is to obtain comfortable suspension whilst having the ability to modify the suspension and anti-roll adjustments automatically when the vehicle is in a limit situation which requires hard **adjustments(quick** steering, tight bend, heavy braking), which corresponds to approximately fifteen per cent of the time.

Therefore, there are two suspensions in one allowing "comfort" and "sport" behaviours to be set automatically depending on the driving conditions.

I - PRINCIPLE OF HYDRACTIVE SUSPENSION

For a vehicle to be comfortable, its suspension must be set to be supple in flexibility, damping and anti-roll.

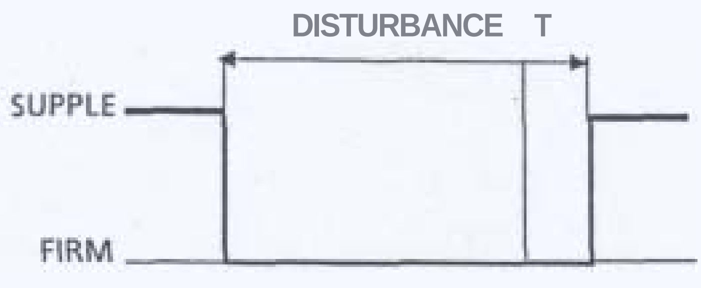
These settings do not allow the movement of the vehicle to be controlled properly when disturbed. In this case, firm suspension is needed which reduces comfort.

Standard suspension is a compromise defined as a function of the type of vehicle (family or sports). The role of hydractive is to offer these two types of settings and to select the ideal solution automatically as a function of the driving conditions:

No disturbance : supple suspension promoting comfort,

Disturbance : firm suspension to control the movements of the vehicle.

Switching from one state to another is controlled by a computer which, as it is informed of the driving conditions by sensors, acts on the suspension settings.



By default the suspension is supple. When disturbed, the suspension switches to firm. When the disturbance passes, the suspension switches back to supple after a short time delay "T" (variable from one to three seconds).

Switching to firm by anticipation

The computer will switch to the firm position as a function of the events which risk compromising the stability of the vehicle. The suspension will therefore become harder before the vehicle has moved.

EVENT	VALUE MEASURED	SENSOR
Bend	Angle of rotation	Steering wheel
Steering wheel turned	Rotational speed	Steering wheel
Request for power Engine brake	Development speed of the accelerator pedal	Accelerator pedal
Braking	Front brake pressure	Brake

Switching to firm by reaction :

The computer switches to the firm position as a function of the reactions of the vehicle.

EVENT	VALUE MEASURED	SENSOR
Height variations	Compression - extension	Body movement
Acceleration Deceleration	Speed variation per second	Speed (or Distance)

III - IMPROVEMENTS MADE TO HYDRACTIVE II

- a front electrovalve and a rear electrovalve : each of these is directly integrated into one of the stiffness regulator.
- a computer programmed with new laws:
- for switching to the "soft" and "firm" states:

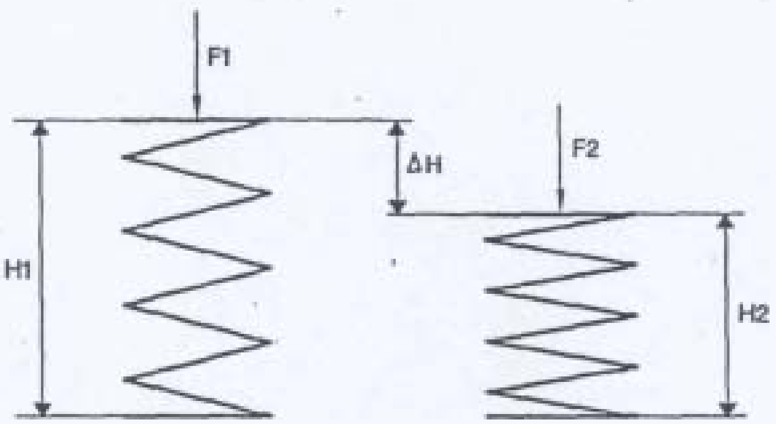
in the "sport" position, the "firm" state is no longer permanent and in the "comfort" position, the thresholds for switching from the "supple" state to the "firm" state are more lower*, this strategy prevents a sudden change in behaviour when switching from one state to the other, the overall response time of the system is extremely short (less than 51100th of a second).

* Example of the new laws for switching from the supple state to the "firm" state.

On the motorway at 120 km/h (75 mph), in the "auto" position, switching to "firm" occurs for a steering wheel angle greater than 33 degrees, this state is maintained for 1.2 seconds when the steering wheel returns to an angle less than 33 degrees. In the same configuration, in the "sport" position, switching to "firm" occurs for an angle of 22 degrees and this state is then maintained for 1.6 seconds.
On country roads or in town, at 50 km/h (31 mph), switching to "firm" occurs for a steering wheel angle of 120 degrees (a third of a turn of the steering wheel) when in the "auto" position and the time delay is 1.2 seconds. In the same conditions, in the "sport" position, switching from supple to "firm" occurs for an angle of 80 degrees and this time the time delay is 1.6 seconds.

I - VARYING THE SPRING SETTING

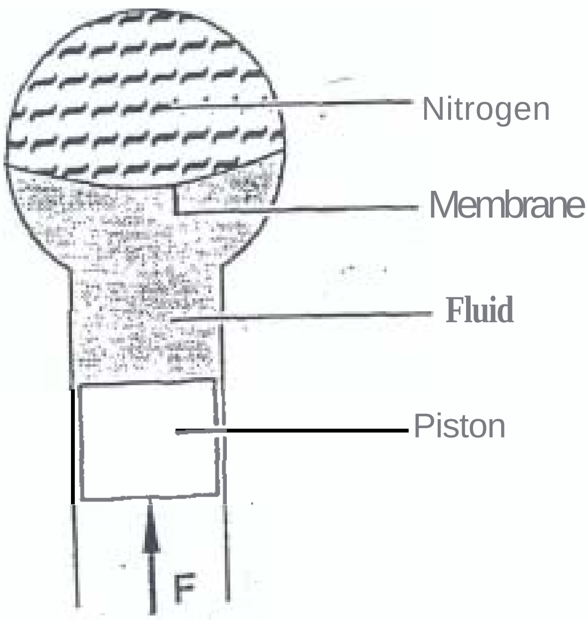
A - REMINDER



A mechanical spring (helical, torsion bar...) is characterised by its spring constant which is defined as its material deformation as a function of the force applied to it.

$$\lambda = \frac{H1 - H2}{F2 - F1} = \frac{\Delta H}{\Delta F}$$

B - THE HYDROPNEUMATIC SPRING



The elastic element consists of a mass of nitrogen of which the pressure and volume vary as a function of the force F applied to the piston

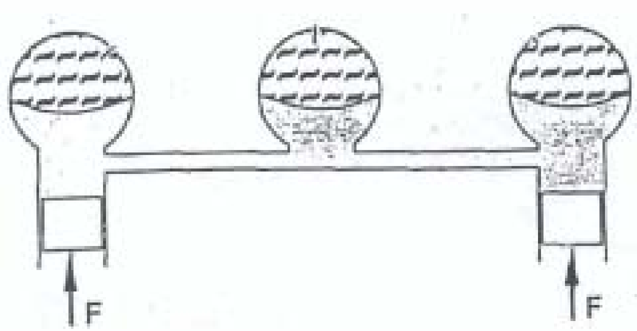
Therefore, to alter the setting of a hydropneumatic suspension system for a given load, the volume of nitrogen V has to be altered.

This is the solution used to obtain the "Soft" and "Firm" states.

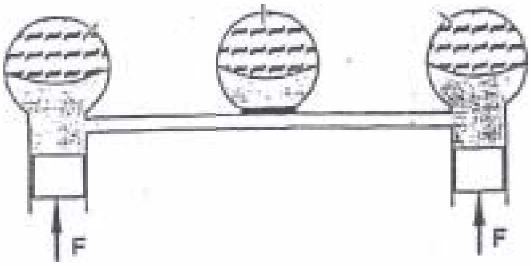
Application

By adding an additional sphere or not to the main circuit, the volume of nitrogen is modified.

SOFT



FIRM



Comments:

When the vehicle is loaded, the volume of nitrogen in the spheres is reduced and therefore the suspension is harder. Likewise, when the suspension is compressed the volume is reduced thus reducing the flexibility. This is the reason why the hydropneumatic spring has a variable spring constant due to its constitution when the load changes or during vibrations.

Hydractive suspension allows the flexibility to be varied for a given load.

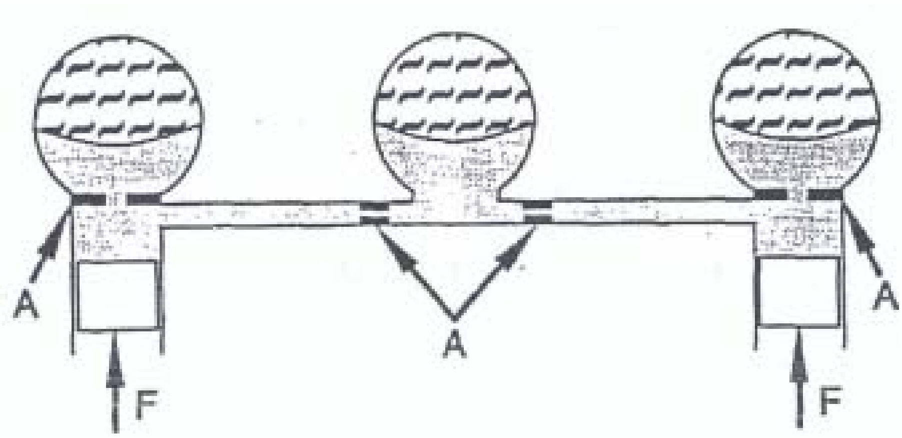
- The inlet or outlet of the fluid in the cylinder does not modify the flexibility only the height by modifying the distance between the membrane and the piston (provided that the suspension is not at its limit).

II - VARIABLE DAMPING

This consists of putting two shock absorbers in parallel and isolating, or not, one of them to vary the damping.

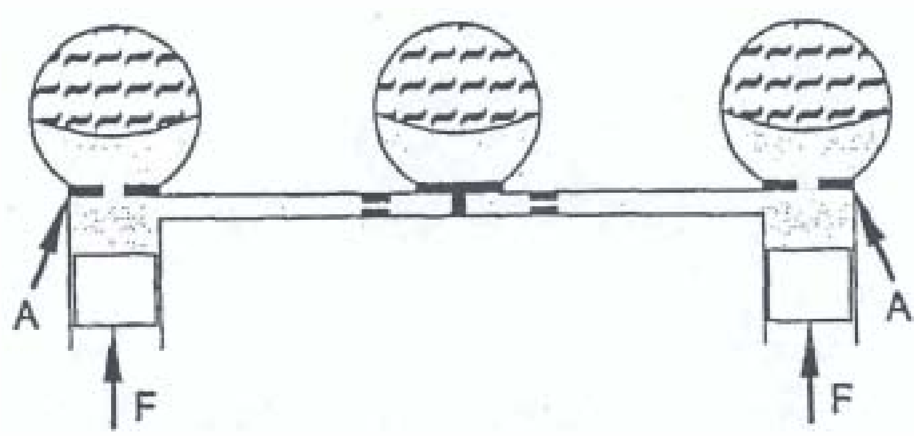
A - "SOFT" POSITION

The fluid passes through A towards the main sphere and through A' towards the additional sphere. Fluid braking is low since the fluid can flow in two ways +damping is low.



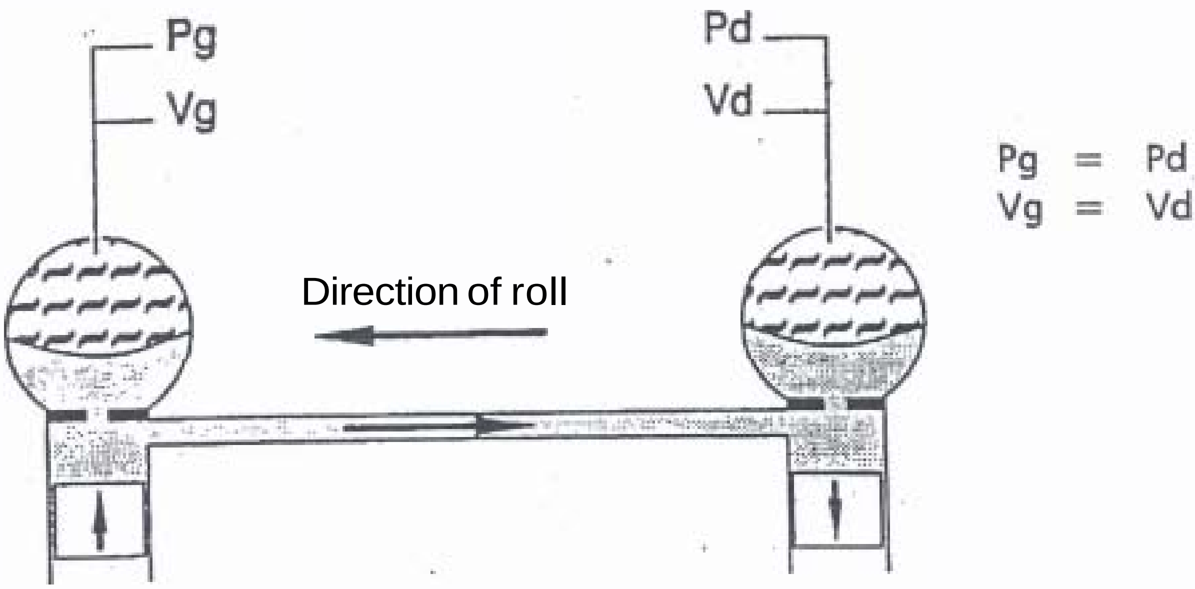
B - "FIRM" POSITION

The fluid only flows through **A.** There is increased damping.



III - ANTI-ROLL

A - REMINDER OF HOW STANDARD HYDROPNEUMATIC SUSPENSION WORKS

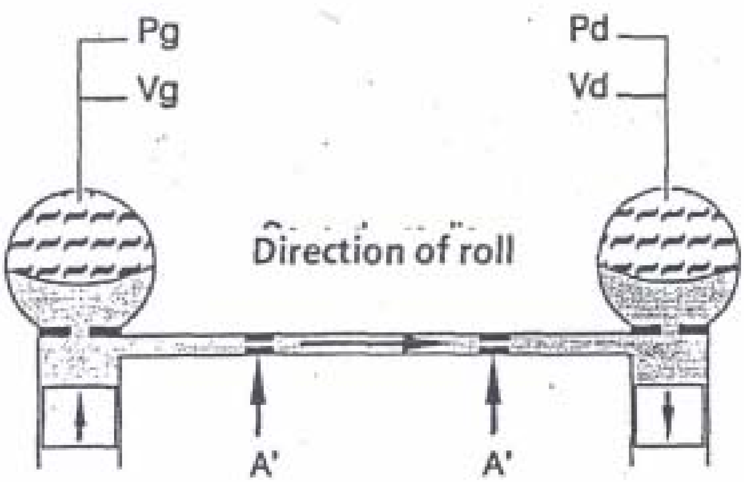


With metallic or pneumatic spring suspension, when a force is exerted when cornering, the outer wheel compresses its suspension which limits the roll. With hydropneumatic suspension, as the two elements on the same axle are linked together hydraulically, the fluid from the compressed element is discharged to the extended element and therefore neither the volume nor the pressure vary in the compressed element, and do not oppose the roll. The anti-roll effect is only performed by the anti-roll bars, which explains their rigid mountings (trunnions).

B - ACTIVE ANTI-ROLL OF HYDRACTIVE SUSPENSION

The circuit is modified with respect to the standard system in the both states.

1 - "Soft" state

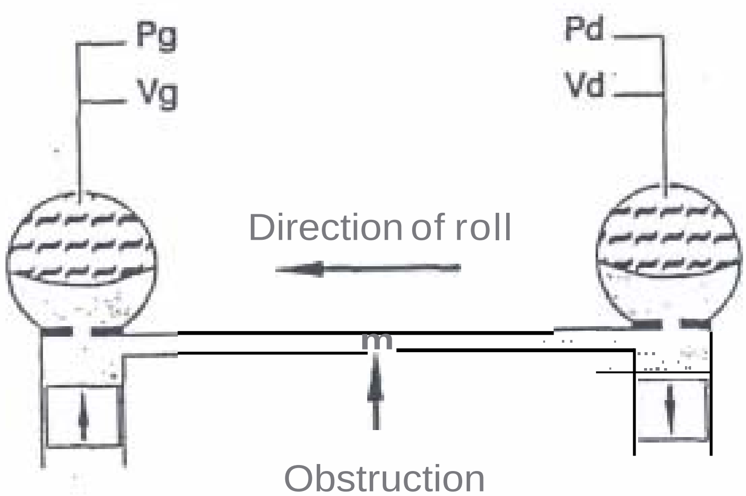


Pg = Pd

Vg = Vd

A' = Shock absorber

Dynamic anti-roll is improved by the two additional shock absorbers A' which brake the fluid movement between the two elements, which means that the force is applied progressively and the pressures Pg and Pd are balanced more slowly.

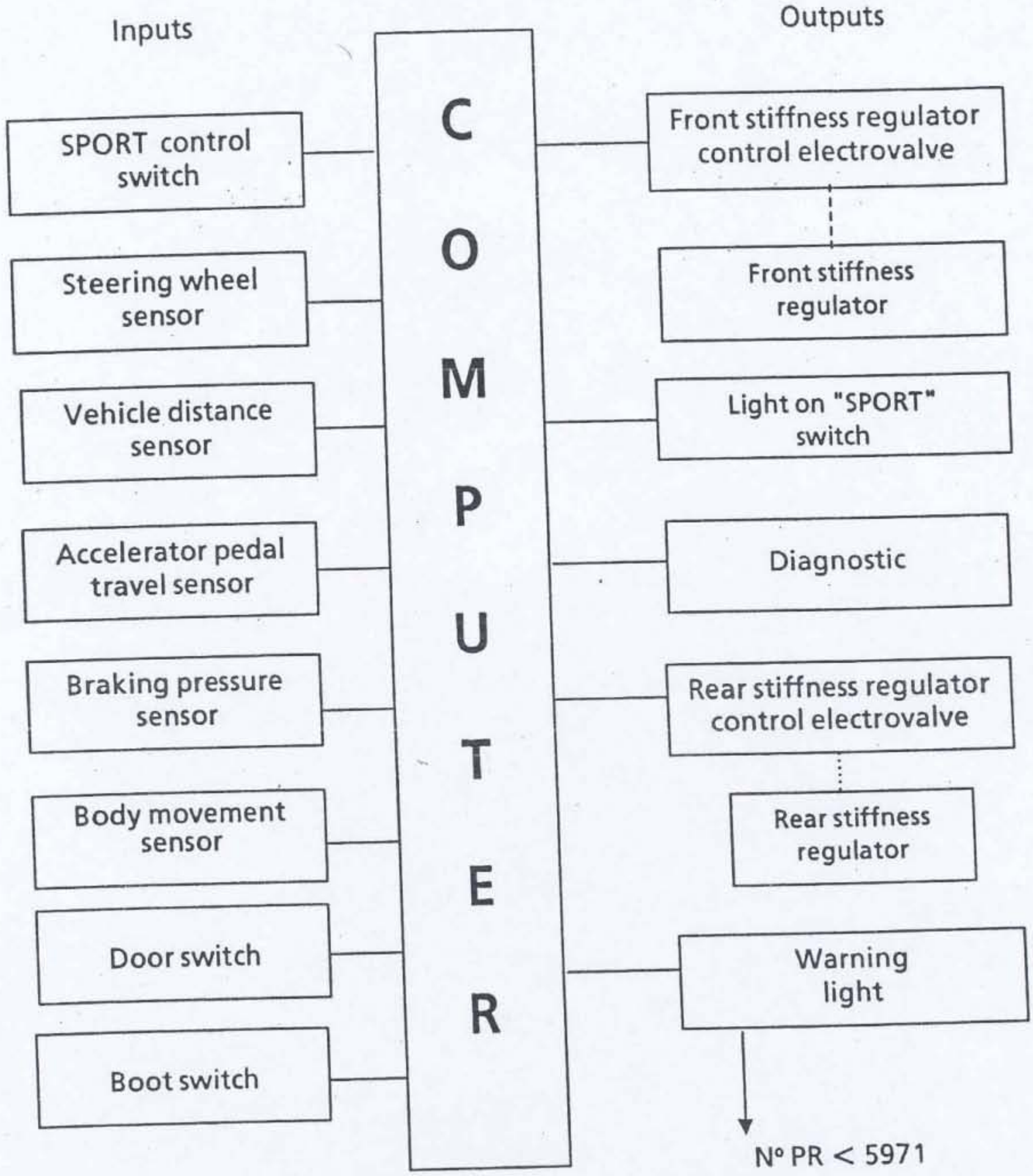


The two elements are isolated since the fluid flow is obstructed. The anti-roll function of the suspension element is at a maximum.

Thus, low anti-roll can be obtained to optimise comfort (when one wheel passes over a hump. the fluid flows from the disturbed element to the other without alfering the transversal height of the body) and high anti-roll for violent forces (stability of the transversal height).

PRESENTATION OF THE ASSEMBLY

I- SUMMARY DIAGRAM



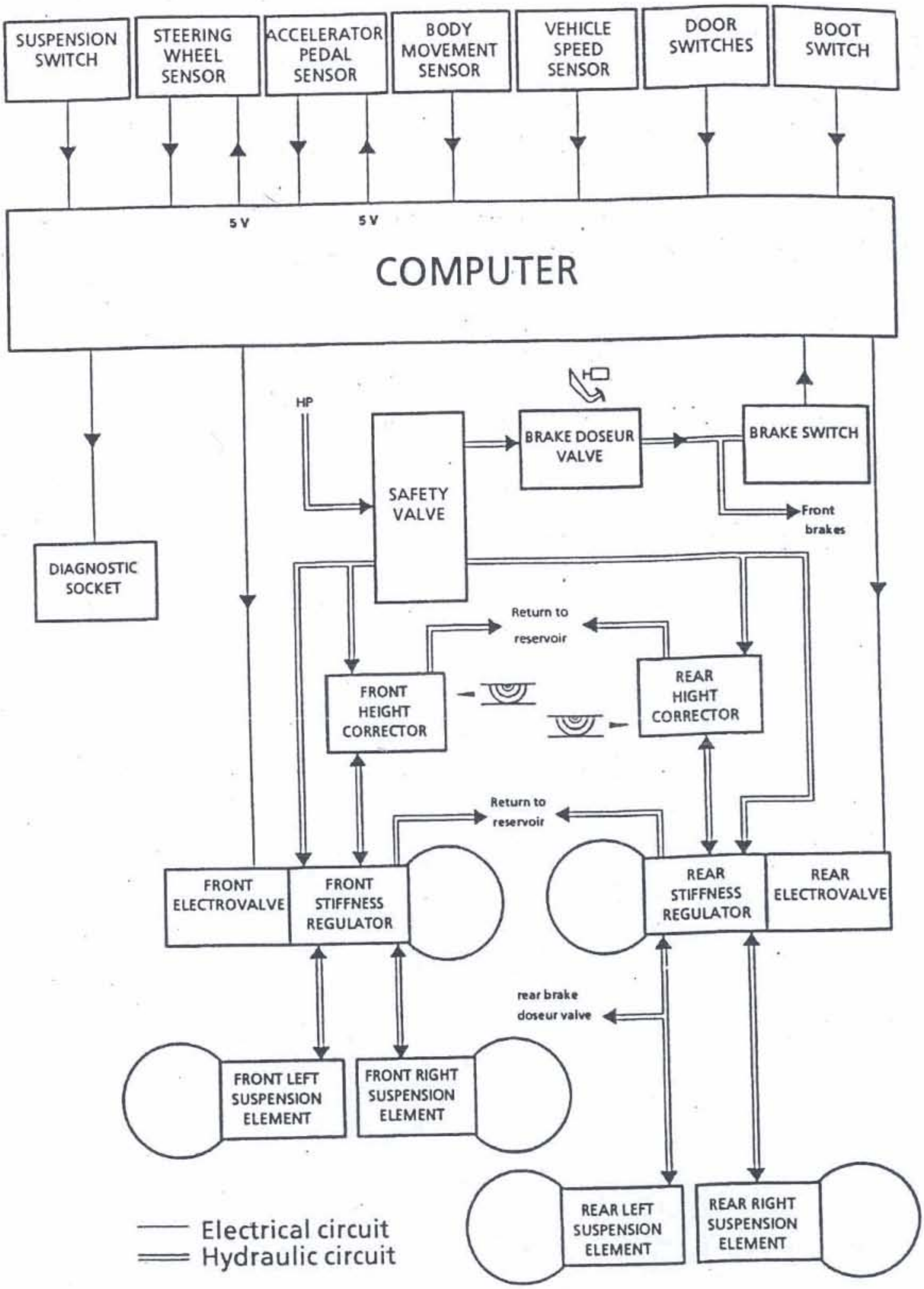
———— : Electrical connections

--------- : Hydraulic connections

II - POSITION

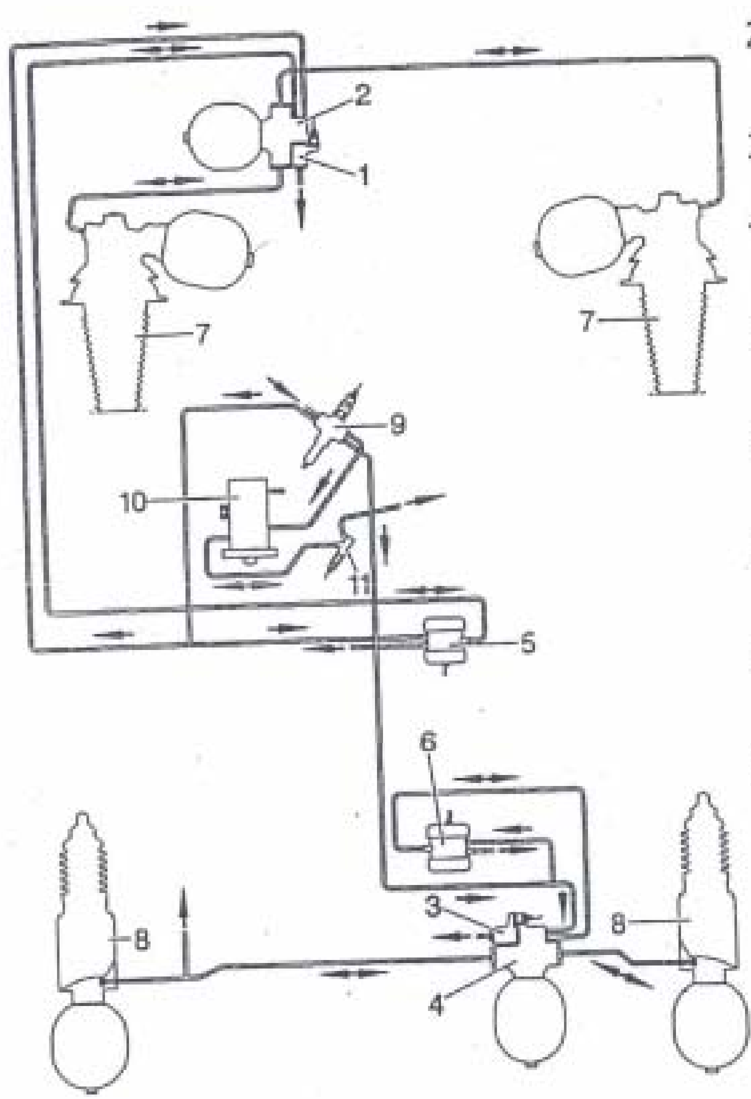
ELEMENT	POSITION
Computer	Ventilated housing on the front right wheel arch under the bonnet
Control switch	Central console behind the height control lever
Steering wheel sensor	On the steering column behind the steering wheel
Vehicle speed sensor	On the gearbox (tachometric socket)
Accelerator pedal travel sensor	On the pedal arm
Braking pressure sensor	On the front left of the engine sub-frame
Body movement sensor	Right of the front sub-frame
Front stiffness regulator + electrovalve	Behind the cooling radiator at the front left
Rear stiffness regulator + electrovalve	Rear axle pipe
Dashboard warning light	At the top on the right
Auto-diagnostic socket	Under the dashboard on the front left (with fuse box)

DIAGRAM OF OPERATING PRINCIPLE



OPERATION OF THE HYDRAULIC PART

I - PRESENTATION



Parts list

1 - Front electrovalve

2 - Front stiffness regulator

3 - Rear electrovalve

4 - Rear stiffness regulator

5 - Front height corrector

6 - Rear height corrector

7 - Front suspension elements

8 - Rear suspension elements

9 - Priority valve

10 - Brake doseur valve

11 - Pressure switch

The system differs from standard suspension due to the addition of two stiffness regulators 2 and 4 (one per axle) each incorporating an electrovalve.

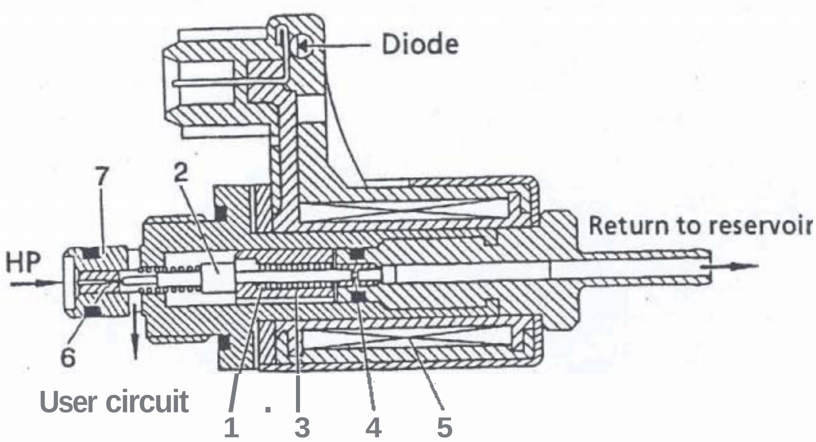
Note that the pipes connecting the suspension elements to the regulators have a large diameter (8 x 10) in order to reduce load losses and therefore the response time. Sealing is provided by ISO tapered connectors without gaskets. The tightening torque is 3 to 3.5 mdaN.

II - THE ELECTROVALVE

A - ROLE

This allows the stiffness regulator to be controlled hydraulically according to the electrical information it receives from the computer.

B - CONSTITUTION

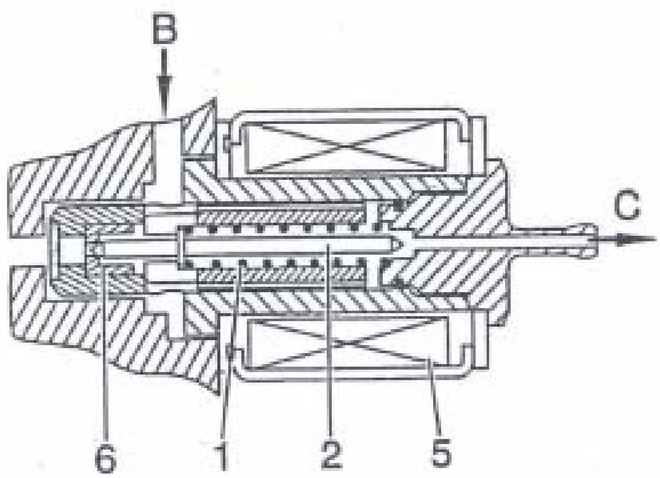


Parts list

1 - Spring
2 - Needle
3 - Core
4 - Seat
5 - Coil
6 - Seat
7 - Filter

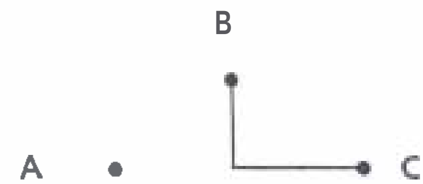
C - OPERATION

I - At rest



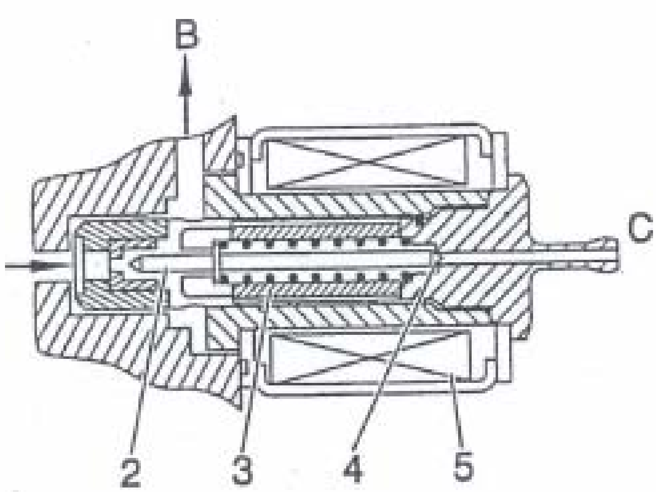
As the coil (5) is not energised, the spring (1) presses the needle (2) onto the seat (6).

The following are connected



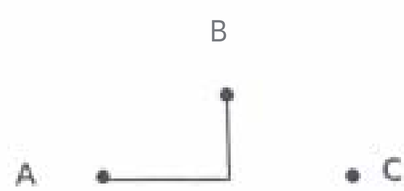
The user circuit output **B** is therefore connected to the reservoir C.

2 - Activated postion



As the coil (5) is energised, it creates a magnetic force in the core (3). This causes the needle (2) to move which comes into contact with the seat (4).

Therefore, we have :



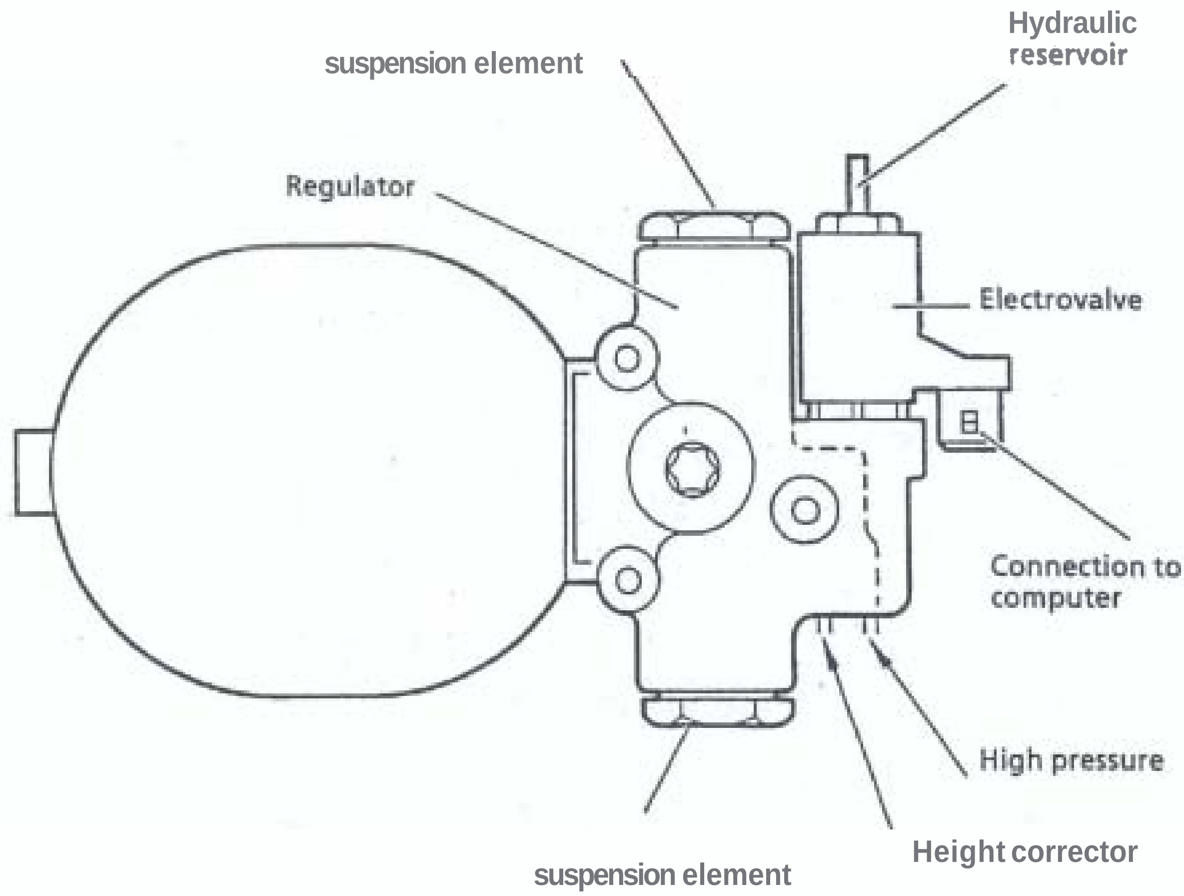
The user circuit output **B** is at the supply pressure A.

Conclusion:

Electrovalve	User circuit pressure
not activated	reservoir
activated	supply (HP)

D - CHARACTERISTICS

Nominal voltage	:	13.5 V
Nominal intensity	:	3 A when powering up for 0.5 seconds with the maximum voltage. 0.5 A when holding by disconnecting the supply voltage Maximum cut-out time < 1.8 ms
Resistance	:	4.8 Ω
Control frequency	:	1000 Hz

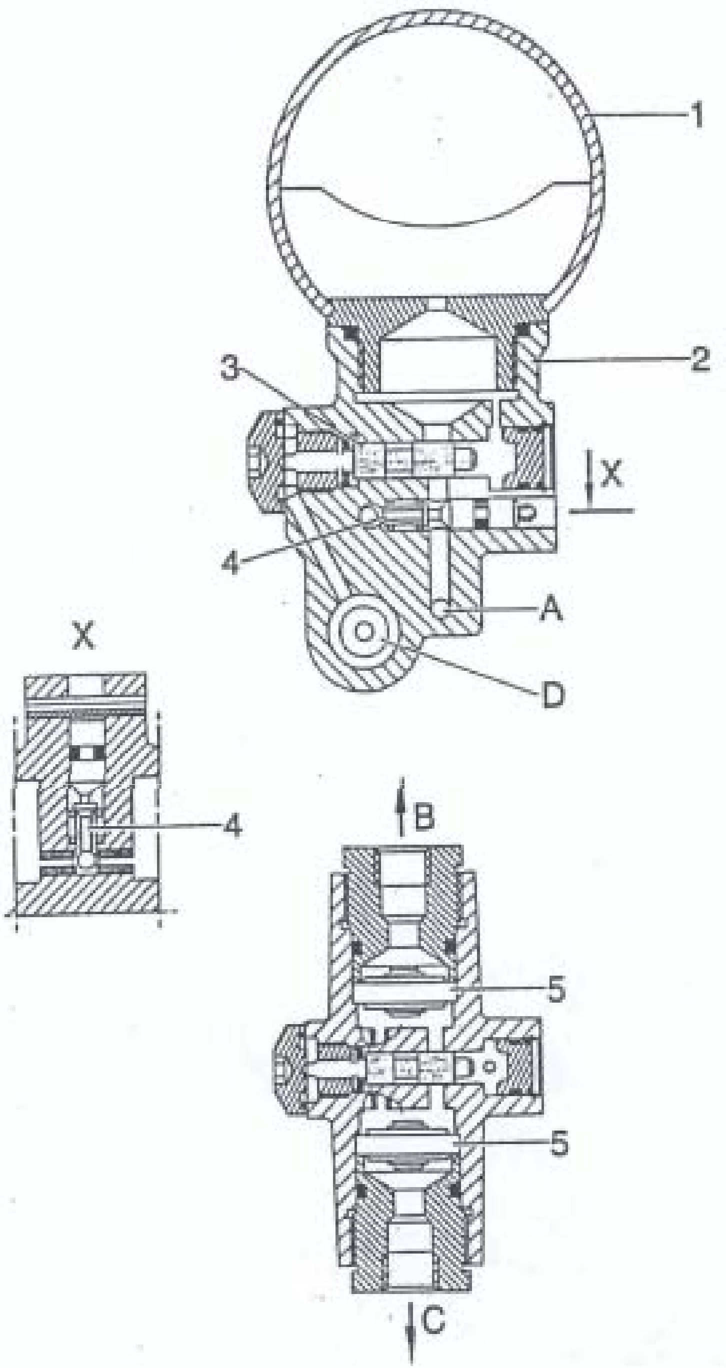


III - THE STIFFNESS REGULATOR

A - ROLE

Two stiffness regulators are fitted (one front and one rear) which modify the physical state of the suspension as a function of the status of the electrovalve.

B - CONSTITUTION



Parts list

1 - Additional Sphere

2 - Body

3 - Slide valve

4 - Valve

5 - Shock absorbers

Hydraulic connections

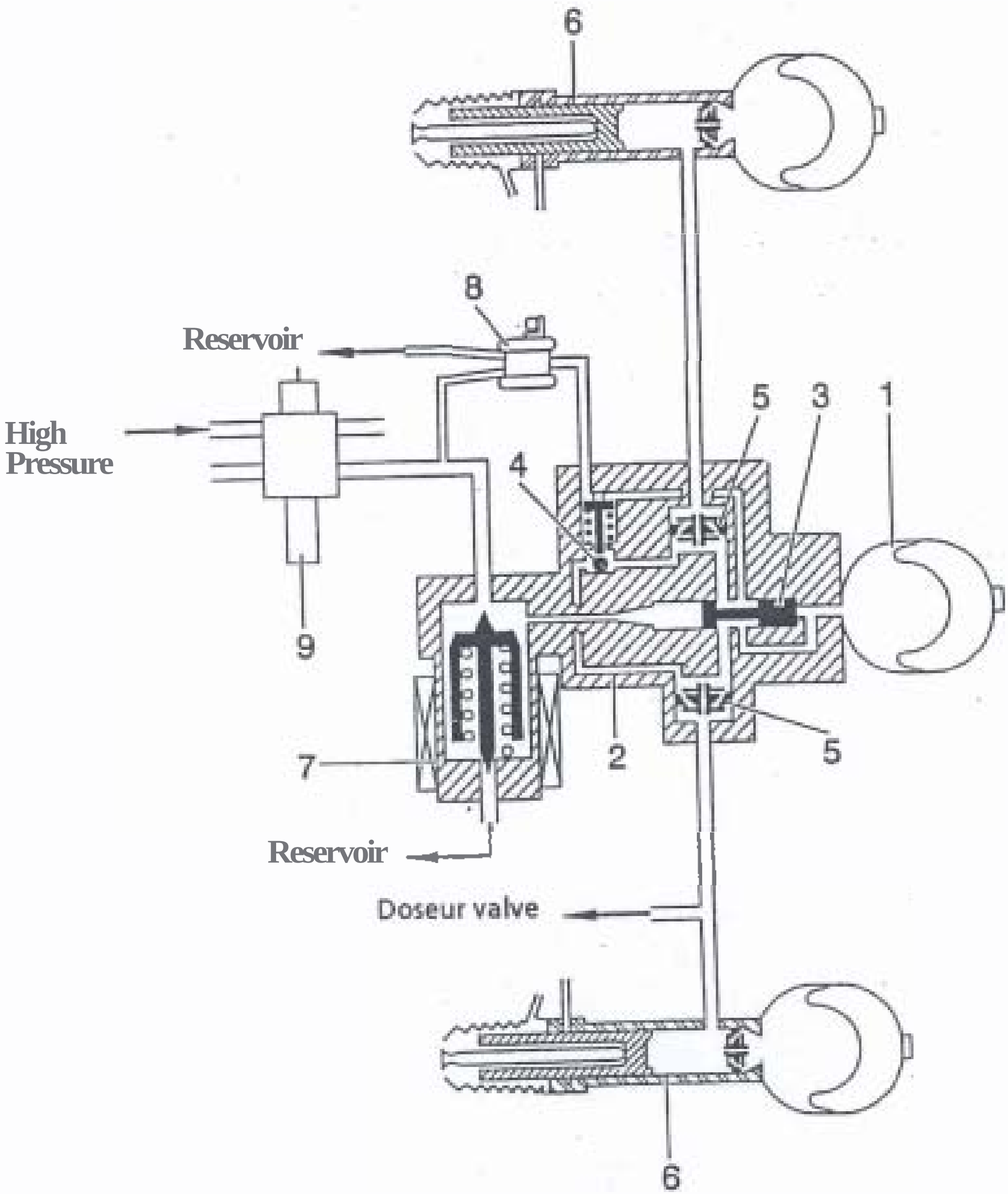
A - Height corrector

B - C-Suspension elements

D - Electrovalve

C - OPERATING PRINCIPLE

I - "Soft" state



Parts list

I - Additional sphere

2 - Body

3 - Slide valve

4 - Valve

5 - Shock absorbers

6 - Rear suspension elements

7 - Electrovalve

8 - Height corrector

9 - Priority valve

When the electrovalve is energised, the slide valve (3) is subjected to the high pressure HP on one side and to the suspension pressure Ps on the other.

Since HP > Ps, the slide valve is locked in the "Soft" position.

There is therefore a link between the two suspension elements and the additional sphere.

This gives:

- Large volume of gas (suspension spheres + additional sphere)

  → soft suspension.

- Fluid passes through four shock absorbers (to reach the additional sphere, the fluid passes through the shock absorbers (5))

  → soft damping

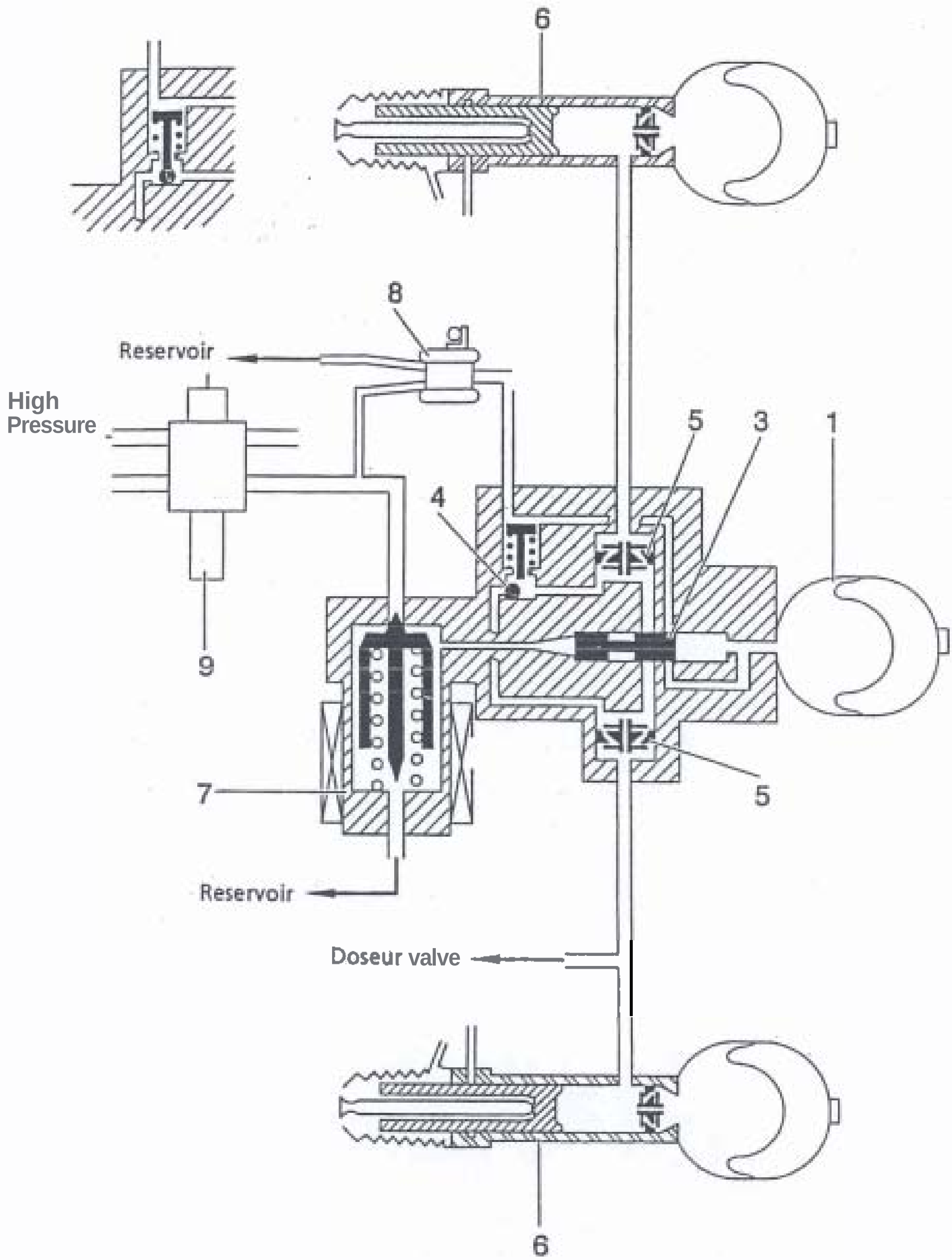
- Fluid passes from one suspension element to the other

  → soft anti-roll

When the height correction is in the "Soft" position, the fluid passes directly through the shock absorbers (5) and supplies the cylinders (6).

Note: The operation of the valve (4) will be discussed later.

2 - "Firm" state



6
8
9
Reservoir
High
Pressure
5
3
1
4
9
7
5
Reservoir
Doseur valve
6

As the electrovalve is not energised, the slide valve (3) is subjected to the suspension pressure Ps on one side and to the reservoir pressure Pr on the other. Since Ps > Pr, the slide valve is locked in the "Firm" position.

The additional sphere is therefore completely isolated and the main link between the two suspension elements is broken.

Therefore, there is :

- Small volume of gas (additional sphere isolated)

  → Firm suspension

- Fluid no longer passes through the shock absorbers (5) since the additional sphere is isolated.

  → Firm damping

- Fluid does not flow between the two suspension elements

  → Firm anti-roll

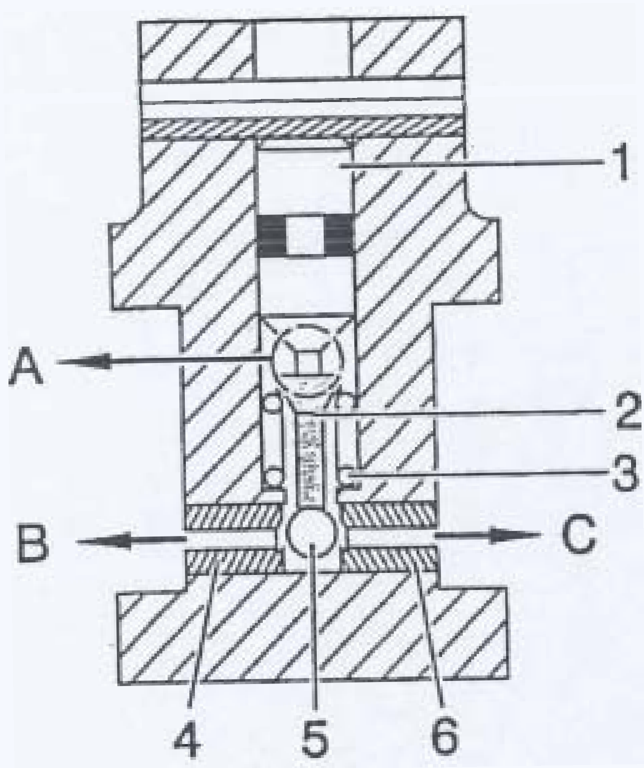
III - STIFFNESS REGULATOR BALL VALVE

A - ROLE

This allows:

- In the "Firm" state, the suspension elements to be connected to the height corrector during correction or,
- The suspension elements to be isolated for roll, therefore preventing fluid flowing between the two spheres.

B - CONSTITUTION



Parts list

1 - End Stop

2 - Thrust Rod

3 - Spring

4 - Seat

5 - Ball

6 - Seat

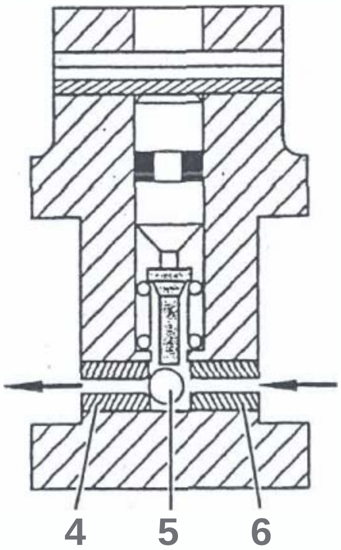
Hydraulic connections

A - Height corrector

B - C-Suspension element

3 - OPERATION

1 - Anti roll

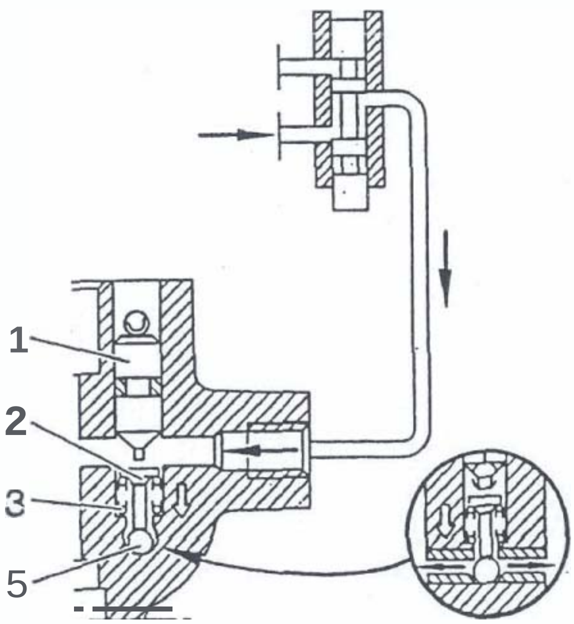


When rolling, fluid tends to flow from one suspension element to the other. It moves the ball (5) which presses against the seat (4), thus closing the connection.

As the pressure of the compressed suspension element is greater than that of the extended suspension element, the ball is locked whilst the vehicle is rolling. When the roll stops, there is no longer any transverse strain on the vehicle and the ball is released.

When turning in the opposite direction, the ball is pressed against the seat (6).

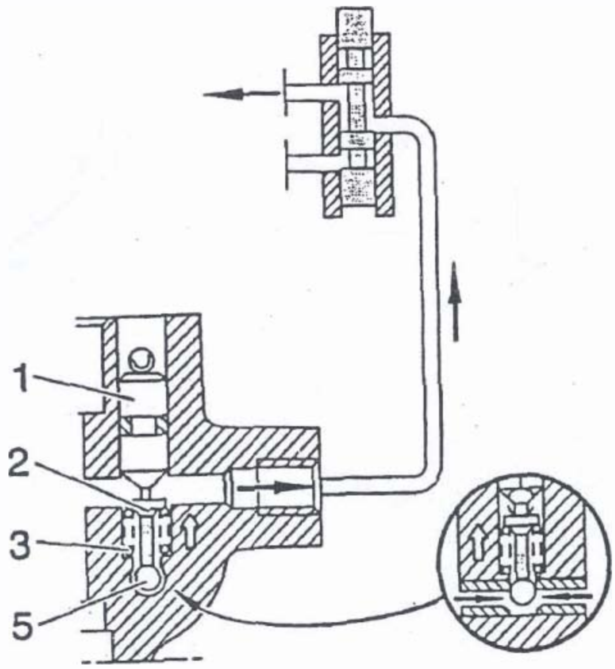
2 - Inlet admission



Since the area around the thrust rod (2) where fluid can pass is small, the upstream pressure is greater than the downstream pressure. The rod (2) compresses the spring (3) and presses on the ball (5), locking this at the base of the valve.

When the height corrector returns to the neutral position, since there is no flow, the thrust rod (2), under the action of spring (3), presses against the end stop (1) and releases the ball.

3 - Outlet correction



Under the effect of the fluid discharged by the suspension elements, the ball presses against the thrust rod (2). This then presses against the end stop (1). It is therefore locked in this position and does not prevent the fluid flowing.

At the end of the correction, the flow is zero and the ball is released.

ELECTRONIC OPERATION

I - PRINCIPLE

The suspension has two stiffness states and two damping states. Changes in state are controlled by anticipation by one of the four parameters of steering wheel angle, steering wheel speed, braking and the amount the pedal is pressed down as well as by analysing the vertical movement of the body (amplitude of the movement).

The parameters from the sensors are compared with variable thresholds as a function of the vehicle speed. The state changes to firm when the threshold is exceeded; returning to the supple (or soft) state occurs when the value of the parameter is once again lower that the threshold and after a time delay has elapsed.

II - COMPUTER

A - ROLE

- Controls the stiffness regulator electrovalves so as to switch the suspension from one state to another (supple or firm), as a function of the information from the various sensors.

- Monitors all the system components:

- Sensors, actuators, electrical links, unit itself, power supply.

- Monitors the operating software

- Should a hardware or software fault occur:

  - Ensures maximum possible safety

  - Switches to a downgraded operating mode (emergency strategy)

  - Warns the drivers by illuminating a warning light

  - Carries out an auto-diagnostic of the essential elements and functions

B - CONSTITUTION

This is a sealed unit into which are fitted the various electronic components.

The link to the outside is provided by two connectors each with fifteen channels (one white and one black), which can be disconnected in any order.

The heart af the computer consists of two TEXAS INSTRUMENTS 16 kB and 4 kB microprocessors.

The control transistors of the electrovalves (called "intelligent") are capable of detecting open circuit and closed circuits.

Integrated circuits monitor the supply voltage and protect the computer.

C - CHARACTERISTICS

• Operating temperature	- 30 °C to + 85 °C
• Storage temperature	- 40 °C to + 110 °C

- Operating voltage:
- 0 to 7.5 V → no functions work
- 7.5 to 11 V → no functions work except element protection and auto-diagnostic
- 11 to 16 V → all functions work
- 16 to 24 V → no functions work except element protection and auto-diagnostic
    - 16 to 18 V → 2 hours before destruction
    - 18 to 24 V → 1 minute before destruction
- Above 24 V → no functions work

- Consumption:
    - When operating, without electrovalve consumption → < 500 mA
    - When not operating (ignition off and after self-levelling timer), doors and boot closed → < 2 mA
    - When not operating, doors and/or boot open → < 100 mA

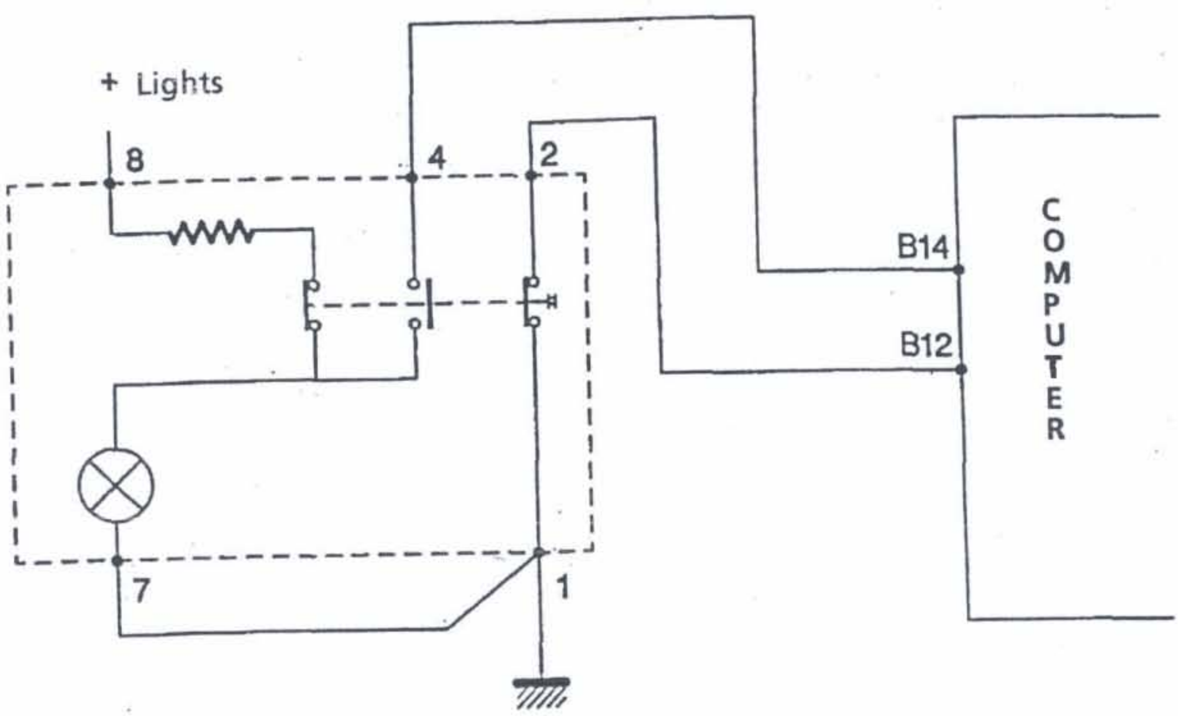
III - SENSORS

A - "SPORT" CONTROL SWITCH

1 - Role

This allows the driver to impose the "SPORT" rule.

2 - Constitution - Operation



Note: In "SPORT", 5 V is measured at terminal B12 of the computer.

The switch is closed in the "Normal" position, open in the "Sport" position. If terminal 12 of the computer is earthed (link 2 → 1 made), this applies the "Comfort" suspension rule.

If terminal 12 of the computer is "open" (link 2 → 1 cut), this applies the "Sport" suspension rule. The illuminating light of the switch unit is dimly lit by the light + due to the resistor integrated into the unit. When the switch is in the "Sport" position, the light is brightly lit due to a + from terminal 14 of the computer.

B - EATON SPEED SENSOR

a) Role

This sensor supplies an electrical signal which is proportional to the rotational speed of the secondary gearbox shaft, and therefore to the vehicle speed.

b) Position

It is mounted onto the tachometric socket of the gearbox.

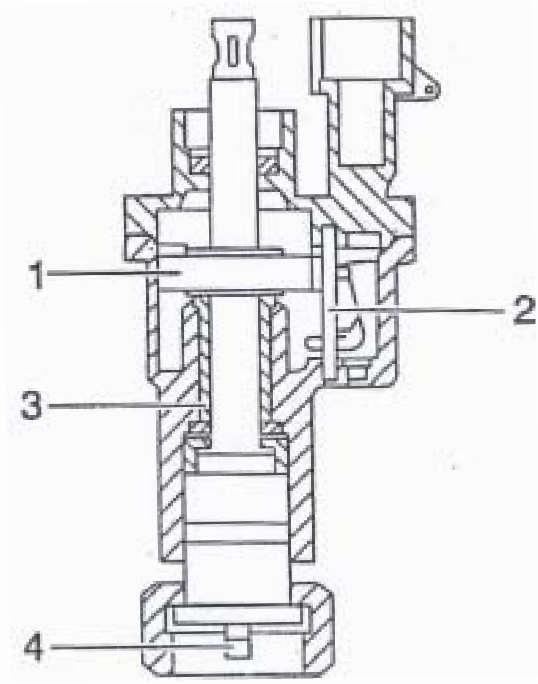
c) Operation

1 - Polar wheel

2 - Hall sensor

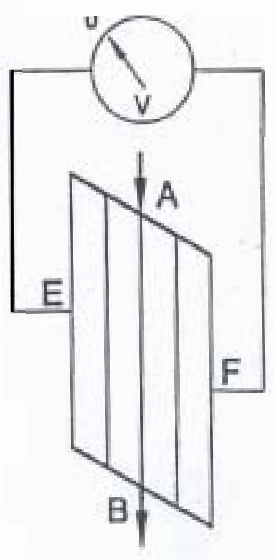
3 - Bearing

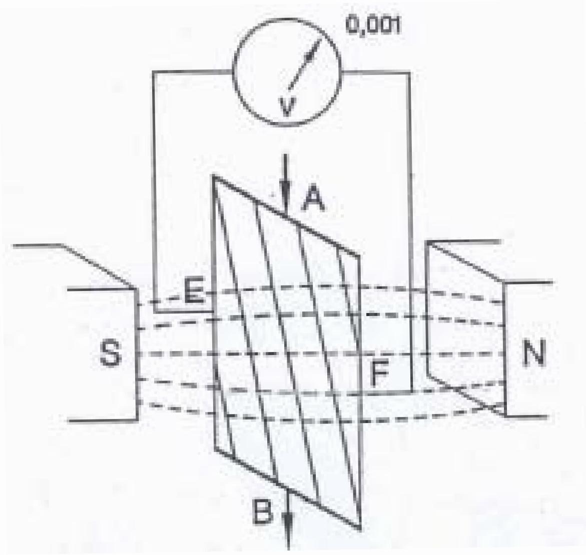
4 - Drive



This sensor is a Hall effect pulse generator.

<u>Principle of Hall effect</u>





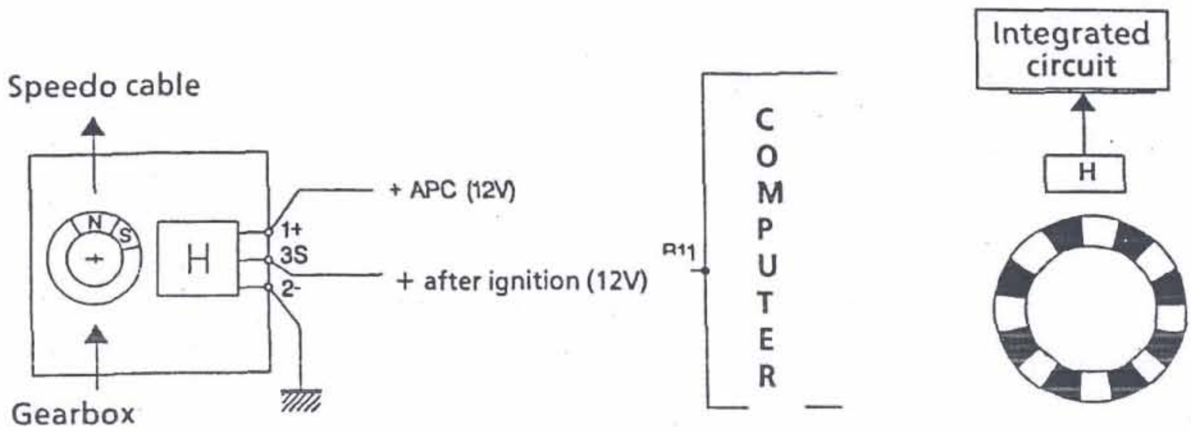
The essential element of this system is a plate of 1.2mm length.

- A current passes over this plate between points A and B. If there is no magnetic field, no voltage is obtained between the equidistant points E and F.

- When a S-N magnetic field is applied at right angles to the plate, a very low Hall voltage of 0.001 volts is obtained between points E and F.

(This comes from the deflection of the A-B current lines by the magnetic field, provided that the two simultaneous conditions of electric current and magnetic field are satisfied).

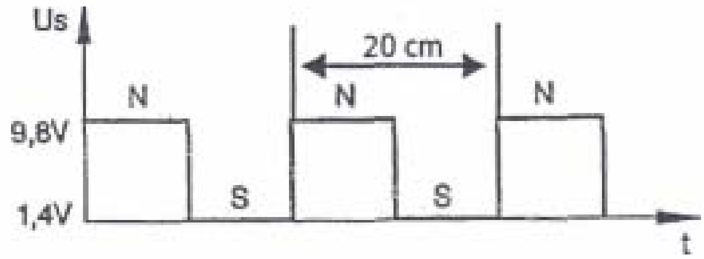
Operation



The polar wheel, when rotating, causes a north pole, south pole, north pole, etc.. to pass successively in front of the Hall plate. The current supplied by the slice therefore changes direction alternately. The integrated circuit, which is used for amplifying the signal, supplies a square signal to the computer of which the upper limit corresponds to the direction of the plate current and the lower limit corresponds to the inverse direction of the plate current as a function of the pole passed in front of it.

d) Calculating the speed

The sensor supplies square signals, of which the frequency is proportional to the speed



We know that the sensor supplies:

- **Eight pulses per revolution** of **the polarwheel**

(eight pairs of **poles)** **- Five pulses per metre travelled.**

Therefore, one pulse corresponds to 0.2 m travelled → 20 cm (1 m15 pulses). Each time the vehicle travels 20 cm, the voltage reaches its maximum value (pulse). All that is required now is to count the number of pulses per second to determine the vehicle speed.

Example

The sensor supplies 50 pulses per second.

- 50 pulses → 50 x 20 cm = 1000 cm = 10 metres

The vehicle is therefore travelling at 10 m/s

- 10 m/s = 10 x 3600 = 36 000 m/h = 36 km/h

Therefore, if the sensor supplies 50 pulses per second, the vehicle is travelling at 36 km/h.

- 50 pulses → 36 km/h
- 100 pulses → 72 **kmlh**
- 10 pulses → 7.2 km/h

Note: the sensor output signal is measured with a voltmeter in the "direct current" position.

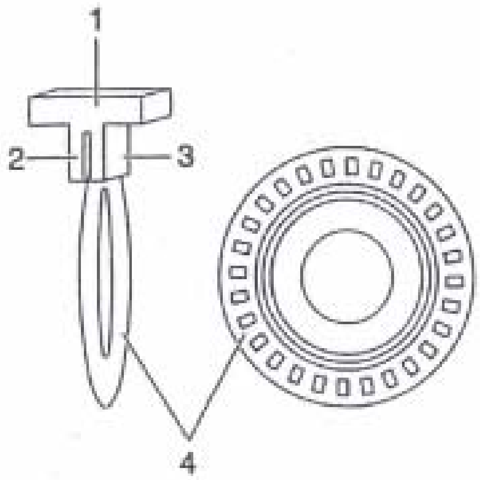
C - STEERING WHEEL SENSOR

1 - Role

This generates signals which enable the computer to define the angle and the speed of the steering wheel.

2 - Constitution

It is a double optoelectronic sensor. It consists of two light emitters, two receivers and a phonic wheel with windows. The sensor is fixed and the phonic wheel turns with the steering wheel. The phonic wheel and the sensor form a compact Valeo make unit, indexed in rotation.



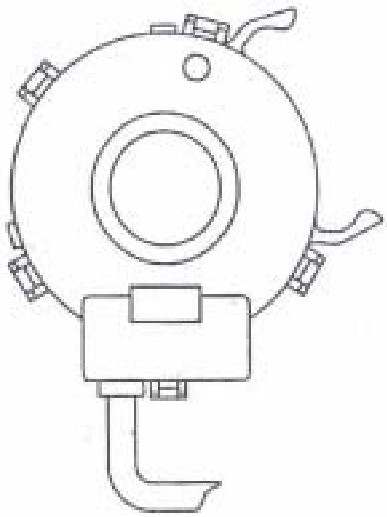
Partslist

1 - Optoelectronic sensor

2 - Double emitting part

3 - Double receiving part

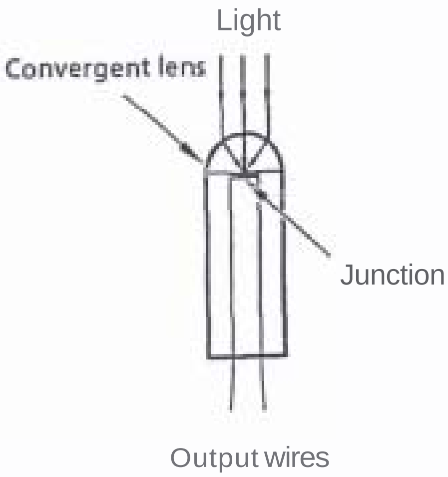
4 - Phonic wheel

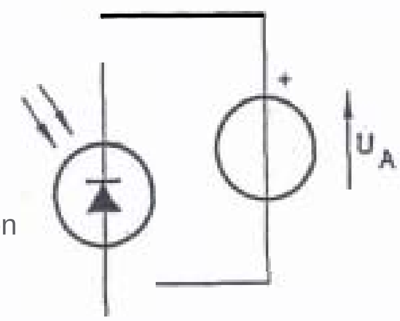


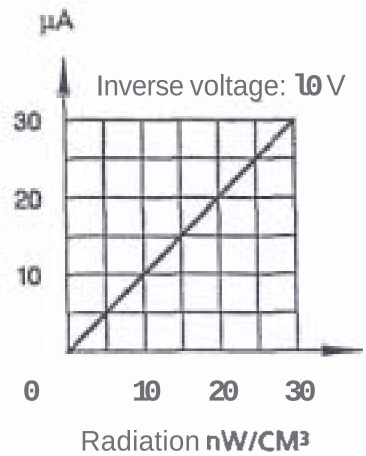
3 - Operation

a) Reminder of a photodiode

A photodiode is made from a PN junction which can be illuminated externally. Its reverse conductivity is proportional to the illumination.



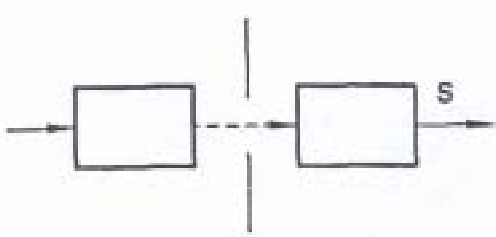


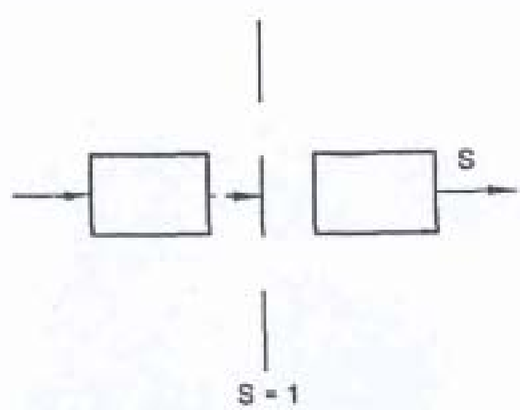


Therefore, by simplifying, it can be seen that the diode conducts when it is illuminated and does not conduct when there is no illumination.

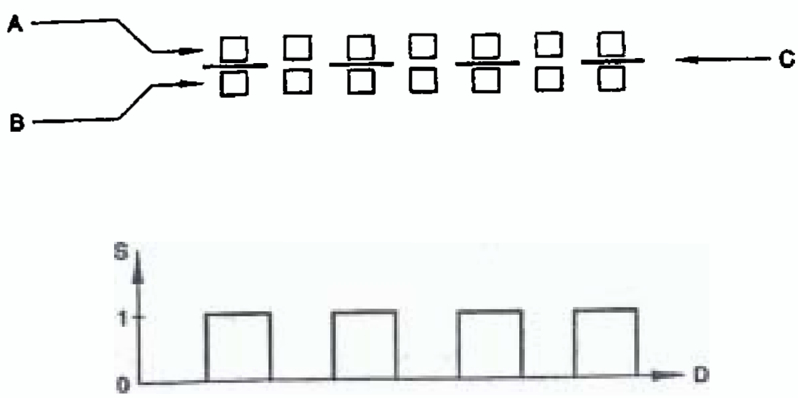
b) Application of the optoelectronic sensor

If a photodiode is fitted opposite a light source and if a phonic wheel with windows is passed between these two items, the displacement of the phonic wheel can be turned into signals depending on whether there is a window or not.





We therefore have:



A - Emitter

B - Receiver

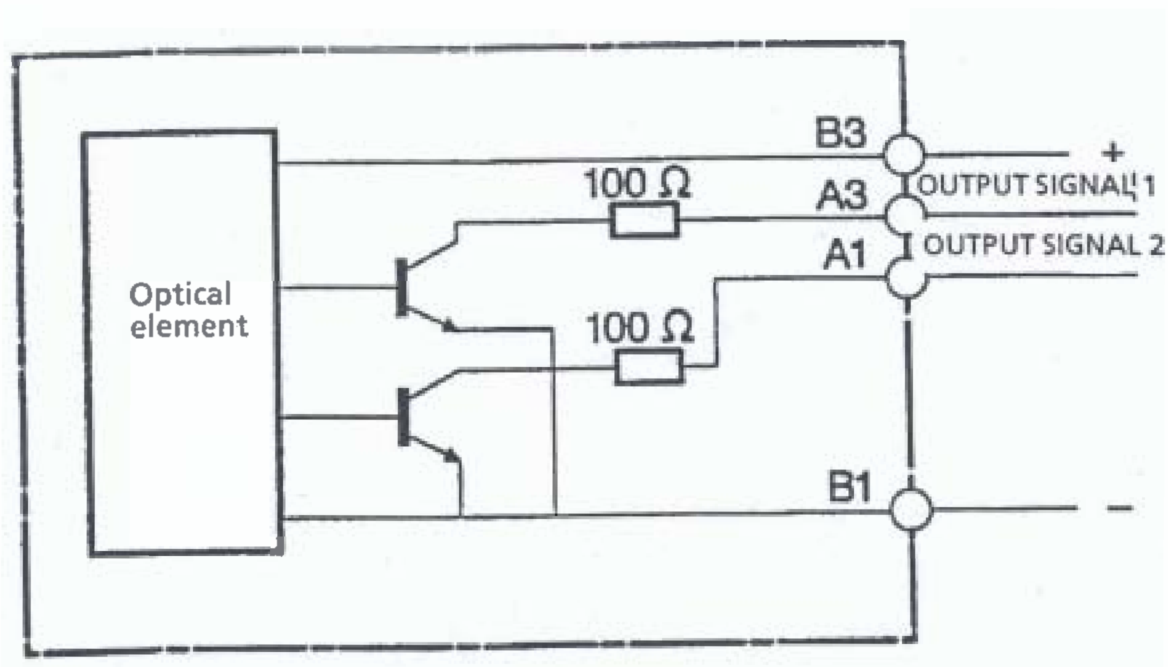
C - Phonic wheel

D - Displacement

S - Output

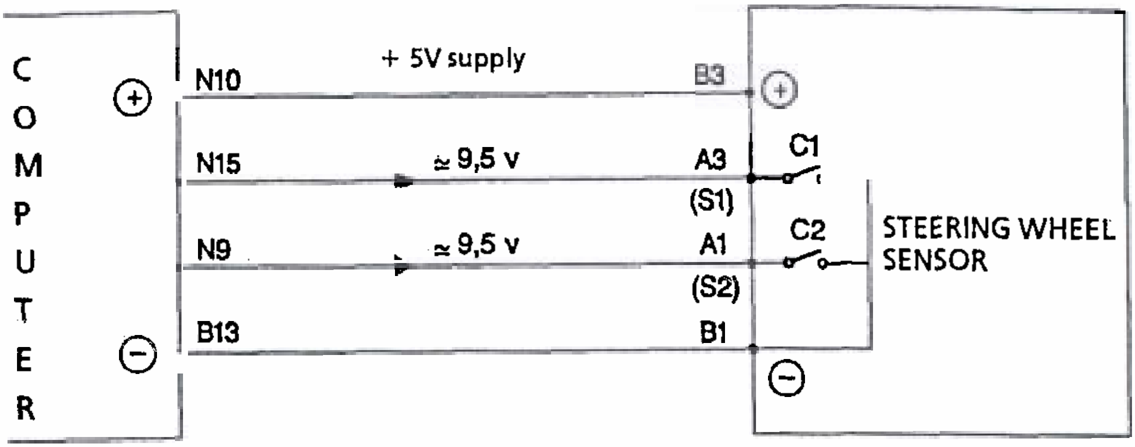
One complete steering wheel revolution = 28 pulses

C) Electrical diagram



The sensor is a double one so as to obtain better precision and to allow the computer to determine the direction of rotation of the phonic wheel.

d) Operating principle



The computer supplies the sensor with + 5 volts.

The two output transistors of the sensor are like two switches C1 and C2.

When the phonic wheel breaks the light beam pointing at a photodiode, the corresponding transistor (C) is blocked switch → open. The corresponding output (S) is therefore "open" → there is a voltage of 9.5 V from the computer.

When the window lets the light beam hit the photodiode, this conducts and unblocks the corresponding transistor (C) → contact made. The corresponding output (S) is therefore connected to the negative → the voltage is practically zero.

4 - Note

The two sensors are offset by 1/4 step (phase quadrature) so that the direction of rotation can be determined and so as to give better precision.

5 - Processing of the signal by the computer

a) Work done by the computer

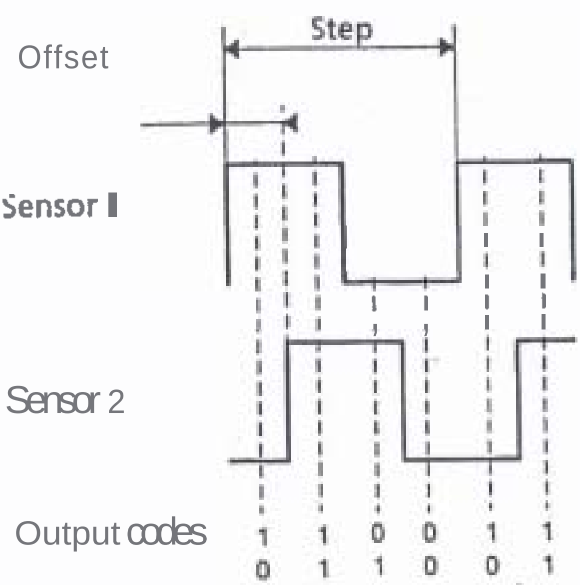
- Interprets the signals from the sensor (number of steps)
- Determines the direction of rotation
- Determines the straight line position
- Calculates the angle of the steering wheel with respect to the calculated straight line
- Calculates the rotational speed of the steering wheel
- Compares the values of the rotational speed and the angle found with the switching to firm thresholds of the computer.

Controls, or not, switching of the suspension to the "firm" state.

b) Determining the number of steps P

We have seen that the sensor is double, the two elements being offset by a 1/4 of a step (phase quadrature).

Therefore, we have:



Note that for one step of the phonic wheel, there are four output codes.

The precision is therefore multiplied by two due to the double sensor.

The steps read by the computer are therefore the output codes. As the wheel has twenty eight windows, the precision is one code step for :

$$3.21° \left(\frac{360}{28 \times 4} \right)$$

c) Deterining the direction of rotation

As the computer knows the logical order of the codes, it just has to compare the new code with the old code to work out the direction of rotation.

E.g. :	0 New 1	0 Old 0 → Left
	0 New 1	1 Old 1 → Right

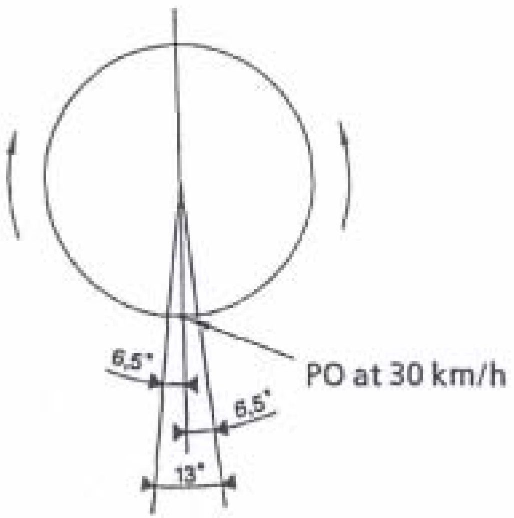
d) Determining the straight line

Definition of the "calm steering wheel" notion

The steering wheel is said to be "Calm" when its movements remain within a sector of + 6.5" with respect to a zero point for at least one second.

Definition of the zero point Po

The first point Po corresponds to the position of the steering wheel when the speed of the vehicle reaches 30 km/h. A sector of + 6.5" with respect to this point is therefore created.



If the steering wheel is "calm", the computer starts measuring the distance travelled, and calculates the average of the steering wheel positions sampled every 1.6 metres.

As soon as the steering wheel leaves this sector, it is said to be "not calm". The computer then memorises the distance travelled in this sector and the calculated average. (The conditions in which the computer updates the straight line position will be discussed later).

The new position of the steering wheel becomes the new point Po, a new sector of 13° centred about Po is created and therefore the steering wheel becomes calm, the distance travelled counter returns to zero and the computer calculates the average of the steering wheel positions in this sector.

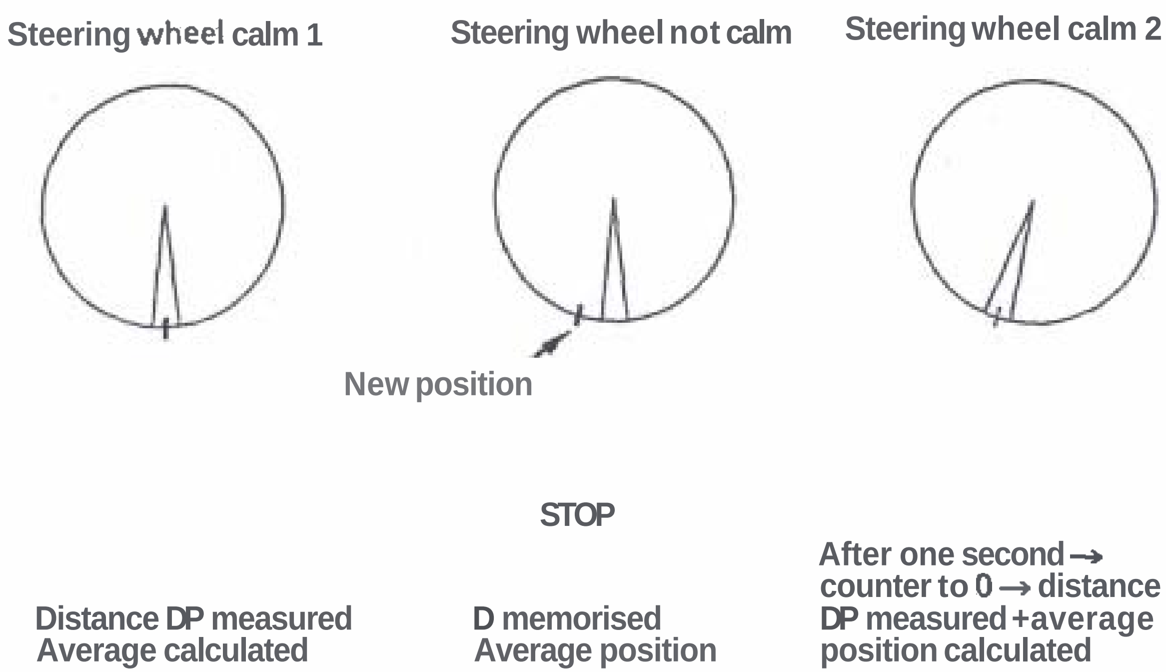
Definition of distances

The following are known as:

D → distance over which the computer has calculated the straight line,

DP → distance travelled with the steering wheel calm

Application:



Updating the straight line

The computer memorises the straight line position LD (average of the positions in the sector: $\frac{\text{Sum of the number of steering wheel positions}}{\text{number of acquisitions}}$
and the distance D over which it has been calculated.

The first straight line memorised LDo is the position of the steering wheel when Vveh = 30 km/h (Po), therefore the distance memorised is D = 0.

A new straight line LD will be memorised (average of the positions in the sector) as well as the distance D over which it was calculated if one of these two events arises:

- Distance travelled with steering wheel calm DP more than 50 metres than that memorised D: DP = D + 50. Therefore, for as long as the steering wheel is calm, updating will occur every 50 metres, the memorised distance D increasing by 50 m.

  Example : distance memorised D = 500 metres. After travelling a distance DP = 550 metres with steering wheel calm → steering wheel position updated and D becomes equal to 550 metres. Then, at DP = 600 m → and D = 600 m etc...

- The steering wheel leaves the current 13° sector → steering wheel not calm. The computer compares the distance travelled DP in this sector with the memorised distance D. If DP > D → LD updated, if not (DP < D) → LD not updated.

  Example : the last update occurred at D = 510 m. The straight line will be updated if :

  - Steering wheel calm for DP = 560 m (D + 50), or
  - Steering wheel not calm after 511 m (DP > D)

  Therefore, when the distance travelled with the steering wheel calm DP is greater that the memorised distance D at the time of the last update, an update will have to be done in this sector.

  Note: The *maximum* distance D = 3000 m; above 3000 metres, the straight line position will be updated every 3000 m, only when the steering wheel is calm,

  Therefore, the computer determines its straight line when the steering wheel is calm for the longest distance.

e) **Measuring the angle**

The computer counts the code changes emitted by the sensor with respect to the straight line it has defined.

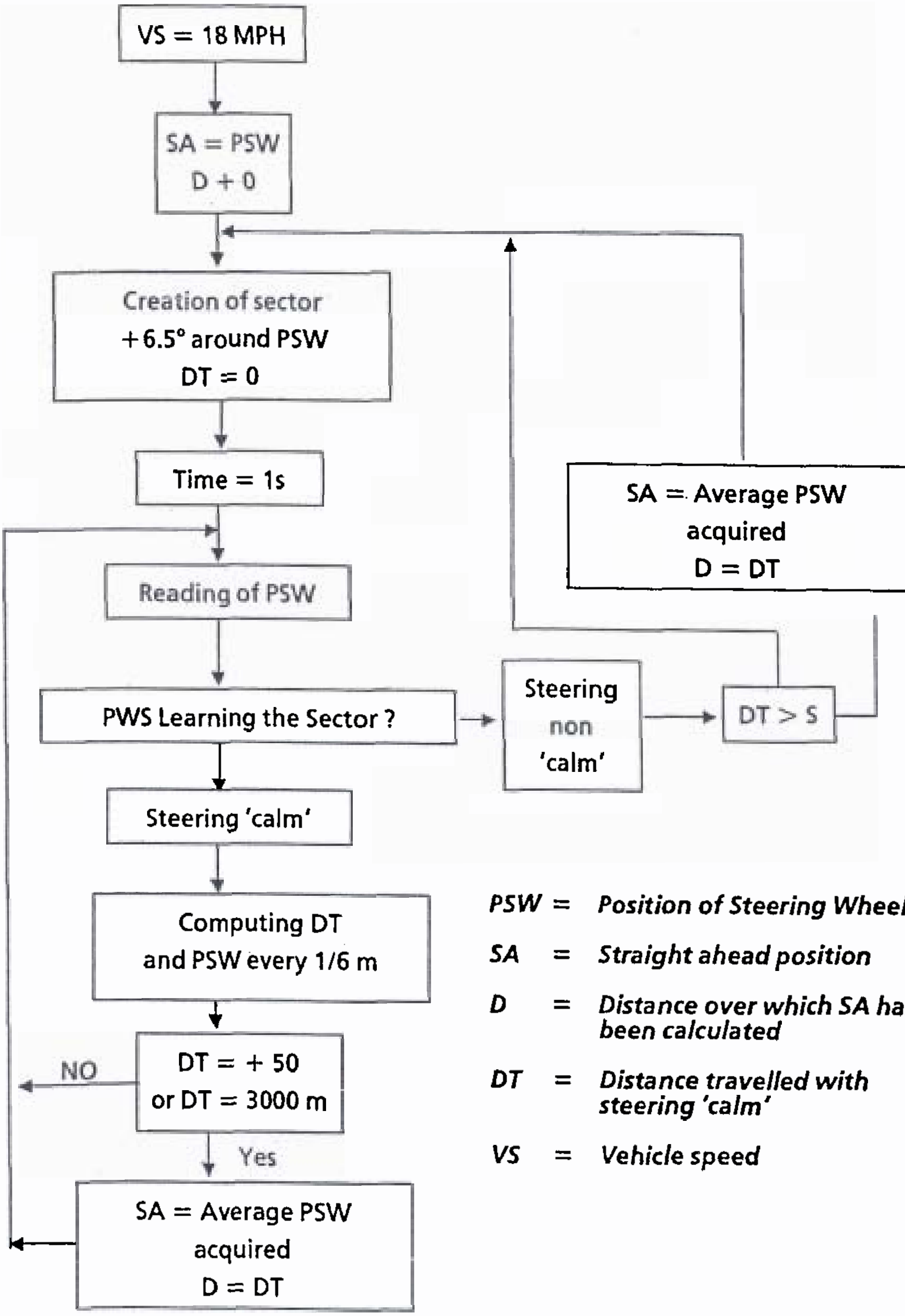
f) **Measuring the speed of rotation**

The computer counts the code changes emitted by the sensor in one second.

NOTE:

The ECU accepts rotational speed signals of up to 2.5" per milli-second from the steering wheel sensor. Any value above this threshold has the same effect.

SYNOPTIC FOR DETERMINING STRAIGHT AHEAD POSITION



PSW = *Position of Steering Wheel*

SA = *Straight ahead position*

D = *Distance over which SA has been calculated*

DT = *Distance travelled with steering 'calm'*

VS = *Vehicle speed*

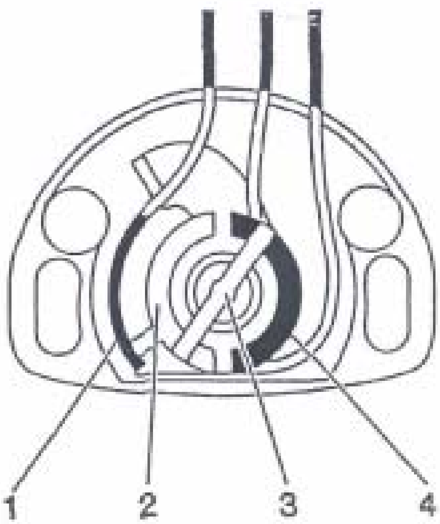
D - ACCELERATOR PEDAL TRAVEL SENSOR

1 - Role

This enables the computer to know the position of the accelerator pedal.

2 - Constitution - Operation

It consists of a variable resistor, of which the cursor is controlled by the pedal.



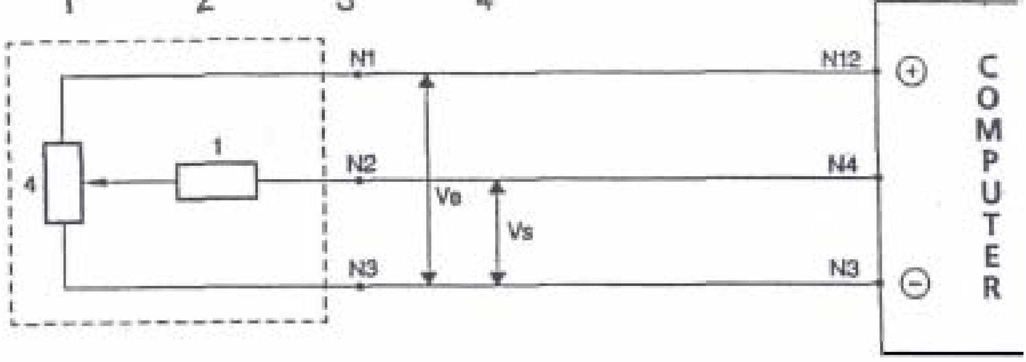
Parts list

1 - Protective resistor

2 - Receiving track

3 -Cursor

4 - Resistor



ACCELERATOR SENSOR

The output voltage Vs depends on the position of the cursor

- Cursor up → Vs ≈ Ve with Ve = + 3.8 V supplied by the computer (pedal fully down)

- Cursor down → Vs ≈ 0 (pedal up)

- Cursor in any position → Vs = Ve x % travel

  The protective resistor (1) limits the intensity when faulty connections are made (E.g. inversion of the wires on N1 and N2 → if the cursor is down, there would be a short circuit).

3 - Characteristics

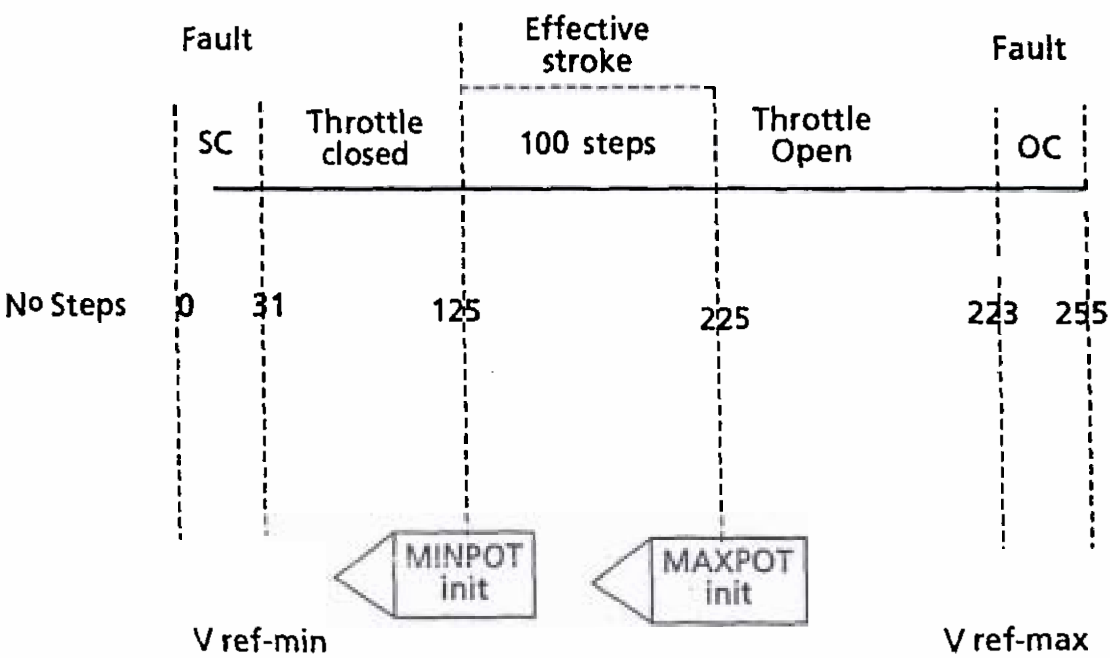
- Main resistor : 4.7 kΩ
- Protective resistor : 2.05 kΩ

4 - Computer processing of the signal

a) Work performed by the computer

- Reads the sensor voltage with the accelerator pedal in the 'throttle closed' position and the sensor voltage with the pedal in the 'throttle open' position.
- Deduce the actual electrical stroke of the sensor from this information.
- Divide this actual stroke into a certain number of steps.
- Check how many steps are covered in 32 ms (speed at which throttle is closed or opened) when the driver operates the accelerator pedal.
- Compare the speed at which the throttle is opened or closed with the limits for switching the suspension to firms.
- Give the order to swtich the suspension to firm or not.

b) Dividing the sensor stoke into a number of steps



Previously, the throttle closed position should have been between 10 and 30% of the total theoretical electrical stroke; this was too restrictive and from now on the computer will use a minimum effective electrical stroke of 100 steps for analysing the development of the accelerator pedal.

The computer has the total electrical stroke stored in its memory (0 to 5V, divided into 255 steps which gives a value of 0.0196 V per step. It is considered that, with the sensor fitted, the throttle closed' should be a maximum of 125 steps, thus giving a minimum effective stroke of 100 steps.

In reality, the computer knows how to adapt to all situations.

The process is as follows:

When the ignition is switched on, the computer reads the voltage from the potentiometer slider and considers it to represent the throttle closed position. From this value, it adds 100 steps for the minimum compulsory effective stroke which gives a voltage value for the 'throttle open' position. When the driver accelerates for the first time, if the voltage is of a higher value than that corresponding to 100 steps of minimum effective stroke, it takes this as the real 'throttle open' value.

Likewise, if the driver presses the accelerator pedal slightly when he switches on the ignition, the computer will correct the 'throttle closed' position when it receives a voltage value which is lower than that read when the ignition was switched on.

When the computer has read the two values of 'throttle closed' (pedal up) and 'throttle open' (pedal down), if the 'electrical distance' is greater than 100 steps, it has a greater effective stoke which it then divides into a certain number of steps directly as a function of the electrical value of one step.

Example:

255 steps divided by 5 V gives a value of 0.0196 V for one step.

In theory:

- throttle closed = 125 steps ⇒ 2.45 V
- throttle open = 255 steps ⇒ 2.45 + 1.96 = 4.41 A step = 100 steps = 1.09V
- 35 steps ⇒ 0.6V - 0 to 0.6V =Short circuit fault zone
- 233 steps ⇒ 4.5V - 4.5 to 5 V = Open circuit fault zone

The driver swtiches the ignition on:

- The computer reads 1.96 V; 1.96 < 2.54 V (throttle closed at 125 steps) The computer takes these values of 1.96V, thus 1.96 + 1.96 = 3.92 V. It therefore has a minimum effective stroke of 100 steps between 1.96V (throttle closed) and 3,92 V (throttle open).

- The driver presses the accelerator pedal and the computer receives a voltage of 4.47 V; 4.47V > 4.41 V (throttle open at 255 steps);

  The computer takes the value of 4.47 V as being that of the actual 'throttle open' position. The effective stroke is therefore now between 1.96 V (throttle closed) and 4.47 V (throttle open). Now, 4.47 - 1.96 = 2.51 V, which gives 128 steps at 0.0196 V per step. The computer therefore has available a usable effective stroke of 128 steps instead of 100 steps.

  The effective stroke will be increased once again if:

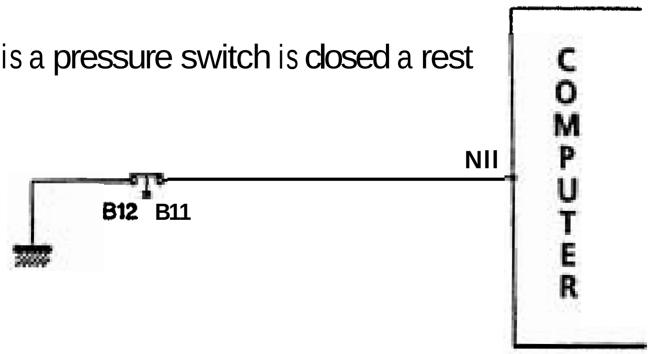
- The computer receives a voltage of 4.47 < U < 4.5 (the driver had not opened the throttle completely [pedal fully down] the first time).

- The computer receives a voltage 0.6 < U < 1.96 (the driver had opened the throttle slightly by pressing the accelerator pedal when he switched the ignition on).

It can be concluded that the number of steps of the effective stroke can be greater than 100 every time the slider voltage approached 0.6 V in one direction or the other. However, if the voltage exceeds the 0.6 V threshold or the 4.5 V threshold, the fualt zones are entered.

E - BRAKING PRESSURE SENSOR

This is a pressure switch is closed a rest



It is closed for a braking pressure ≤ 35 bar and open for a braking pressure > 35 bar.

The computer reads the electrical signal at its terminal N 11 :

If P < 35 bar > earth signal,

If P > 35 bar > "Open"-- 5 V.

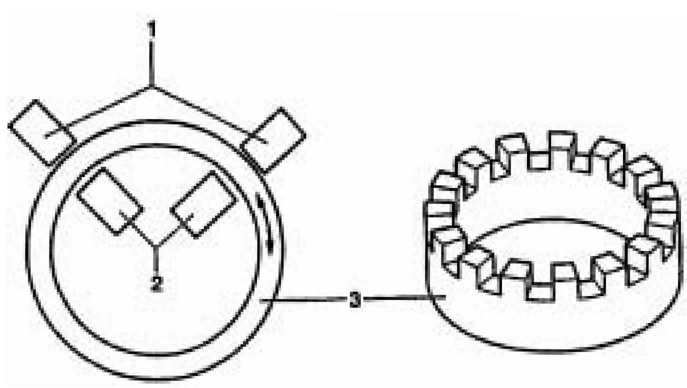
F - BODY MOVEMENT SENSOR

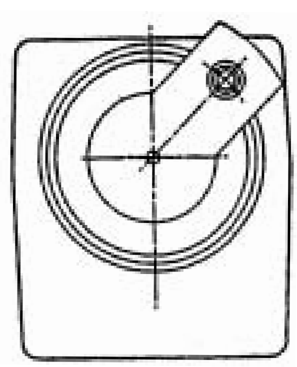
1 - Role

Allows the computer to define the average height of the body and the movements of the suspension.

2 - Constitution

It consists of a double optoelectronic sensor of the same design as the steering wheel sensor; however, the phonic wheel is replaced by a phonic ring with 45 teeth. The two optical elements are offset by a 1/4 of a step (phase quadrature).





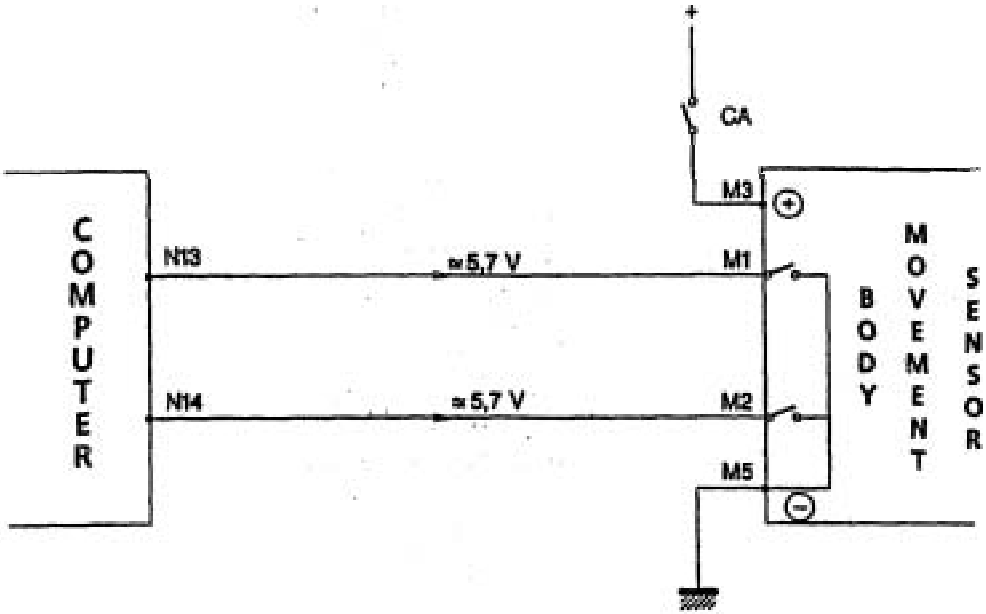
Parts list

1 - Emitters

2 - Receivers

3 - Phonic ring

3 - Operation



The operating principle is the same as that of the steering wheel sensor. In the case of the body movement sensor, when a tooth of the ring breaks the light beam, the corresponding transistor is blocked. At the corresponding terminal on the computer, 5.7 V is measured since it is "open". When a gap of the ring allows the light beam past, the corresponding transistor is unblocked and connects the corresponding computer terminal to earth → a voltage of approximately 0 V is measured.

In this case, the sensor is supplied with + 12 V after ignition.

The ring is connected by system of small connecting rods to the front anti-roll bar. The rotation of the anti-roll bar causes the rina to turn and the rotation is detected by the optical element.

4 - Characteristics

Maximum movement: 180 mm → 30 steps

Therefore 1 step → 6 mm

1 step = 2° → 180 mm = 60°

5 - Processing of the signal by the computer

a) Work performed by the computer

- Interprets the signals from the sensor (number of steps)
- Determines the direction of rotation of the ring (leading or trailing)
- Calculates the displacement speed
- Determines the average height (Have) and updates it
- Calculates the movement by the difference with the average height
- Compares the movement values found with the switching to firm thresholds of the suspension
- Controls, or not, switching of the suspension to the "firm" state

b) Determining the number of steps P

The body movement sensor operates in the same way as the steering wheel sensor, therefore it determines the coded steps and the direction of rotation in the same manner.

The phonic ring has 45 teeth, the precision is 2° per step $\left(\frac{360}{45 \times 4}\right)$

c) Determining the average position

The average height is the average of the signals from the sensor in both directions.

It is updated every 120 ms.

The updating formula is as follows :

$$H_{ave} = \frac{1}{32}(H_{instantaneous}) + \frac{31}{32}(H_{ave}\text{ already calculated} = H_{ave-1})$$

Putting Δ = Have - 1 - Hinst = difference between average height already calculated and the current height (instantaneous) → Hinst = Have - 1 + Δ.

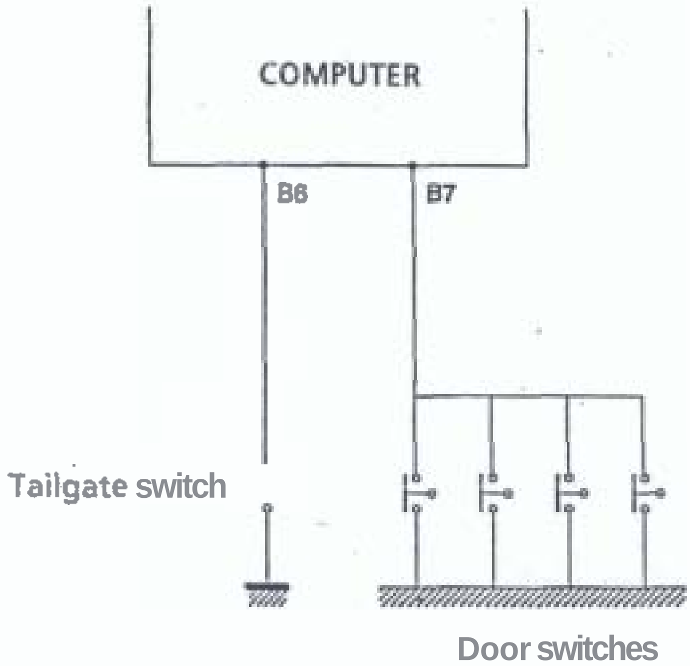
Therefore, it can be deduced that : Have = $\boxed{H_{ave-1} + \frac{\Delta}{32}}$

G - THE DOORS AND TAILGATE

The aim of the door or tailgate switches is to provide an earth signal to the computer or not.

They are used for the anti-jolt function which will be discussed later. The earth signal is present when one of the doors or the tailgate is opened.

Contacts open, a voltage of 12 V is measured at terminals B6 and B7.



IV - STRATEGIES FOR SWITCHING TO FIRM

A - PRINCIPLE - ELECTROVALVE CONTROL

Normally, the suspension is "supple" (three spheres per axle) ; the computer switches to "firm" (two spheres per axle) via one of the following parameters :

- Steering wheel angle } steering wheel sensor
- Steering wheel speed }
- Amplitude of vertical movement in both directions → body movement sensor
- Braking → brake sensor
- Speed the accelerator pedal is being pressed or lifted → pedal sensor

All these parameters are a function of the vehicle speed, and allow the transversal, longitudinal or vertical accelerations of the vehicle to be determined by anticipation or reaction.

<u>Control logic of electrovalves</u>

The two electrovalves are always controlled at the same time :

Supple suspension → they are energised

Firm suspension → they are not energised

Note: The rear electrovalve must be controlled 10 ms max after the front electrovalve.

B - SWITCHING TO FIRM IN ANTICIPATION

1- Steering wheel

a) Using the angle of rotation

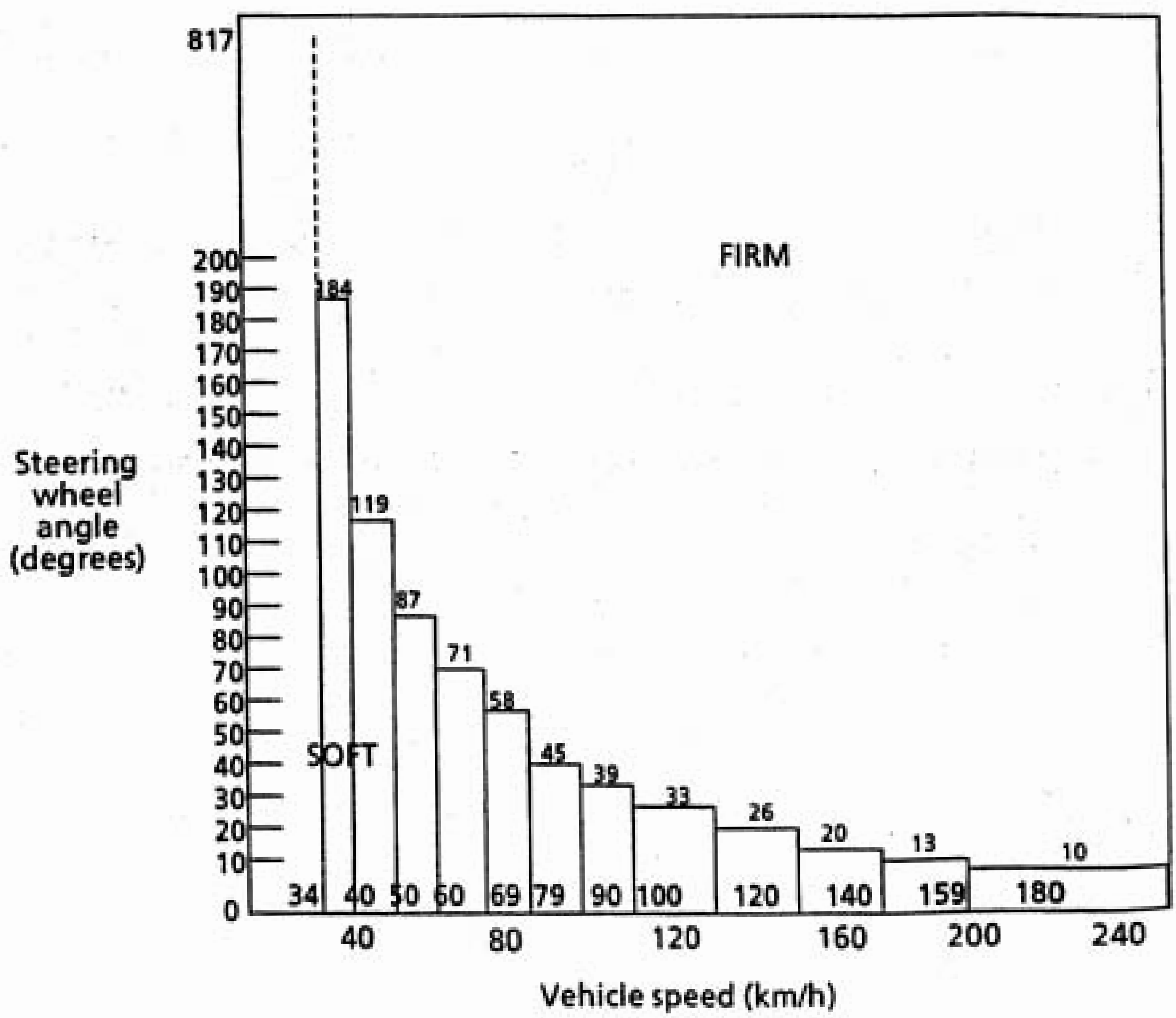
The vehicle speed must have exceeded 30 km/h once and the angle must be greater then a limit which is a function of the vehicle speed.

The suspension will return to soft when the steering wheel angle becomes less than a limit value and after a 1.2 s timer.

Note:

In the sport position, each limit for switching to firm is divided by 1.5 and the timer for returning to soft is multiplied by 1.3.

STEERING WHEEL ANGLE LIMITS
(Normal position)



It should be noted that the higher the speed, the lower the limit for switching to firm (inverse relationship).

Speed	Normal	Sport
0 → 33	817	545
34 → 39	184	123
40 → 49	119	79
50 → 59	87	58
60 → 68	71	47
69 → 78	58	39
79 → 89	45	30
90 → 99	39	26
100 → 119	33	22
120 → 139	26	17
140 → 158	20	13
159 → 179	13	9
180 → 255	10	7

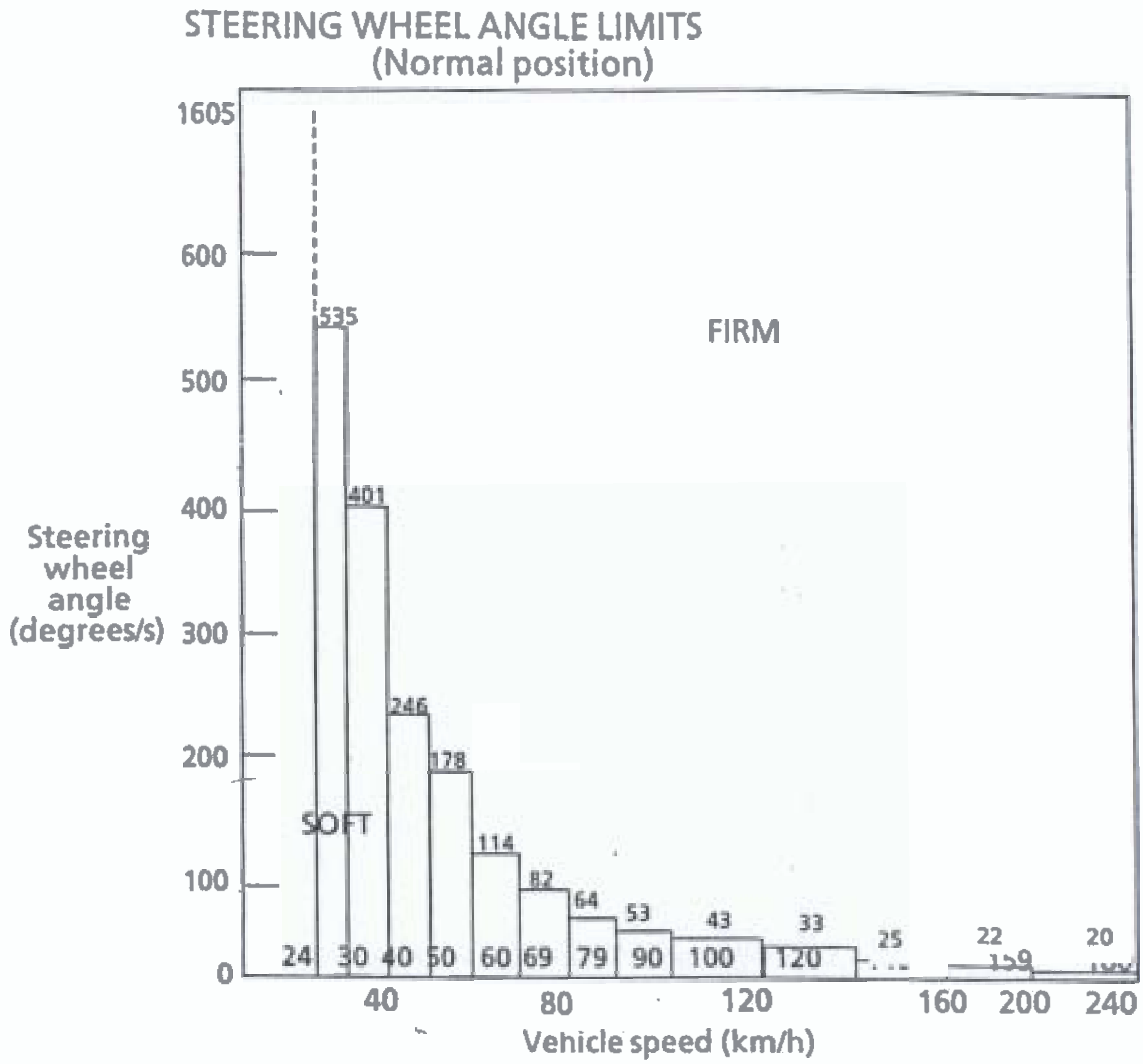
b) Using the angular speed of the steering wheel

The turning speed must be greater than a limit which is a function of the vehicle speed.

The suspension will return to soft when the steering wheel speed becomes less than a limit value and after a 1.4 s timer.

Note:

In the sport position, each limit for switching to firm is divided by 1.5 and the timer for returning to soft is multiplied by 1.3.



It should be noted that the higher the speed, the lower the limit for switching to firm (inverse relationship).

Vitesse	Normal	Sport
0 → 23	1605	1070
24 → 29	535	357
30 → 39	401	267
40 → 49	246	164
50 → 59	178	119
60 → 68	114	76
69 → 78	82	55
79 → 89	64	43
90 → 99	53	35
100 → 119	43	29
120 → 139	33	22
140 → 158	25	17
159 → 179	22	17
180 → 255	20	13

Specific case of steering wheel centring

Through experience, it has been realised that the steering wheel always returns to the straight line position quicker than when it moves to the turning position, without it being necessary to switch to firm to stabilise the vehicle. Thus, the limits for switching to firm on the steering wheel return are higher than when turning, and overshooting the straight line position, which always happens, is also filtered.

The limits for switching to firm based on speed are multiplied by two during the phase when the steering wheel is returning to the straight line position and for a possible maximum overshoot of 17º. The straight line position is said to have been overshot when the steerng wheel passes through this point at a speed greater than 13º per second. If, when returning the steering wheel to the straight line position, a limit for switching to firm is exceeded, the soft state will be reinstated when the value becomes less than this limit and after a one second timer.

c) - Note:

If the time for switching to firm using the steering wheel angle is greater than 120 s, the computer returns to the soft state and will reinitialise the straight line position.

The straight line position will not be reinitialised if a speed sensor fault is validated.

2- Accelerator pedal

After the ignition has been switched on, the vehicle speed must have exceeded S kmlh once in order to switch to the firm state.

If the rate of change of the accelerator pedal is greater than a limit which is a function of thevehicle speed, the suspension will switch to the 'firm' sate for:

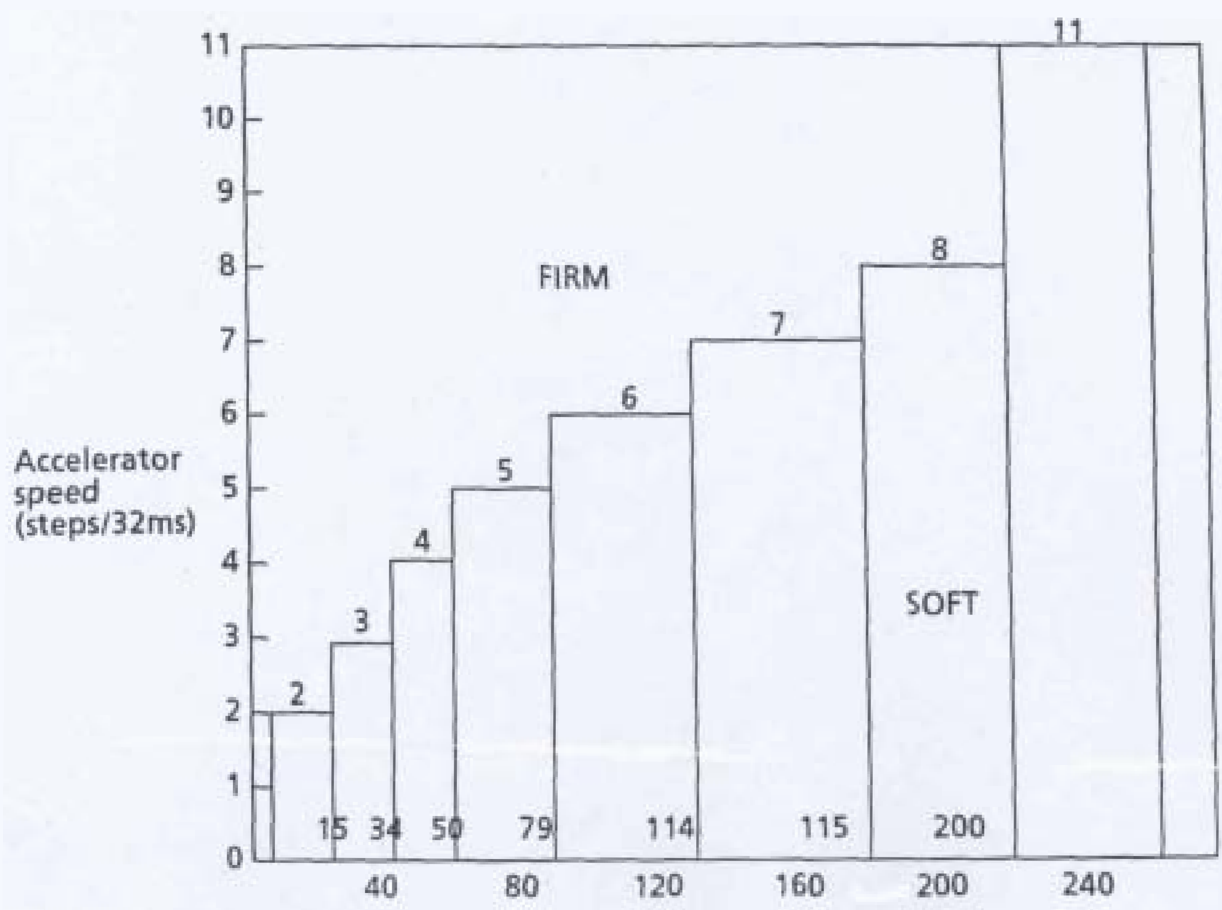
- **1.2 s if** the vehicle speed < 140 **km/h**) pedal released or
- **1 s** if the vehicle speed > 140 **km/h**) pressed down

The limits for switching to firm are different depending on whether the accelerator pedal is being pressed down or released.

Note: In the sport position, each limit for switching to firm is divided by 1.5 and the timer for returning to soft is multiplied by 1.3.

It should be noted that the higher the speed, the higher the limit for switching to firm (parallel relationship).

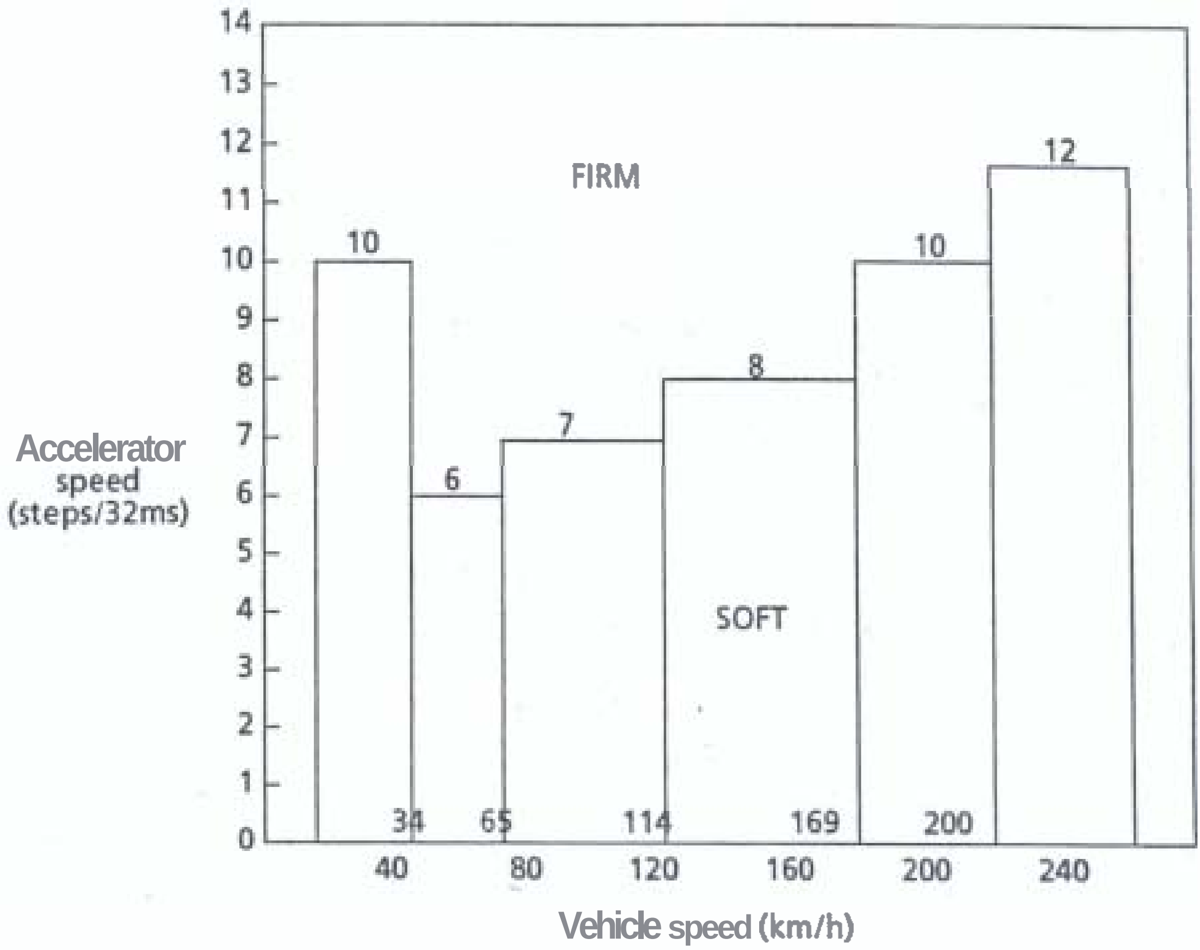
ACCELERATOR LIMITS (PRESSING DOWN)
(Normal position)



Vehicle speed *(kmlh)*

Vitesse	Normal	Sport
0 → 14	2	1, 3
15 → 33	3	2
34 → 49	4	2, 6
50 → 78	5	3, 3
79 → 113	6	4
114 → 149	7	4, 6
150 → 199	8	5, 3
200 → 255	11	7, 3

ACCELERATOR LIMITS (RELEASING)
(Normal position)



It should be noted that, above 34 km/h, the higher the speed, the higher the limit for switching to firm (parallel realtionship)

Speed	Normal	Sport
0 → 33	10	6.6
34 → 64	6	4
65 → 113	7	4.6
114 → 168	8	5.3
169 → 199	10	6.6
200 → 255	12	8

Considering the vehicle acceleration

If, after a switch to firm caused by the accelerator, the acceleration or deceleration of the vehicle is greater than four pulses in 512 ms **(≈ 1/2** per **second),** the firm position is maintained for the whole time during which the limit is exceeded (3 pulses in 512 ms) with a minimum duration of ***0.8*** seconds.

Example:

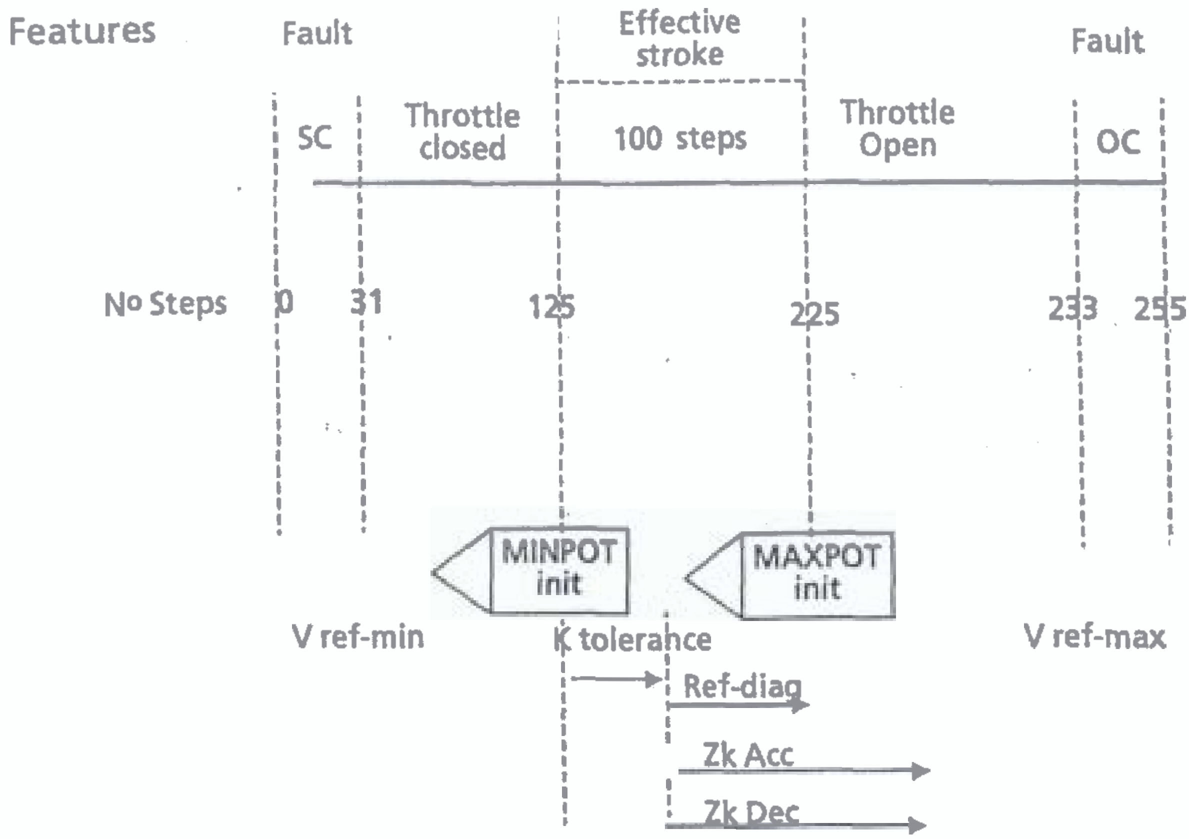
The vehicle is travelling at ***36* km/h,** which corresponds to 50 pulses per second and 25 pulses1500 ms. **If,**during the next 500 ms, the speed sensor sends ***28*** pulses (3 additional pulses), the vehicle is ten travelling at:

$$\frac{36 \times 28}{25} \text{ km/h } 40.32 \text{ km}$$

in other words, 4.3 **km/h** more than before. Therefore, in one second, the vehicle has accelerated **by4.3 x** 2 = ***8.6* km/h.** This is not sufficient to maintain the firm position; the computer would have had to receive more than 28 pulses in the next 500 ms.

Reminder:

One pulse per second ⇒ 0.72 **km/h** therefore **1/2** pulse in 500 ms. Therefore one pulse in 500 ms ⇒ 2 x 0.72 = 1.44 **km/h.**



- The suspension is not switched to firm if the amount the pedal is pressed down (throttle opened) is in the minimum pedal position zone - minimum pedal position + 15 steps so as to compensate for mechanical play.

- The limits for switching to firm are multipled by 17 when pressing down or releasing the pedal from the moment when the rate of change of the pedal is in the 10% zone of the mechanical stroke (15 steps + 10% from the pedal minimum position).

  Dynamic body anti-jump

  When a switch to firm is triggered by the accelerator being pressed down whilst the vehicle speed is zero, the firm state if maintained for a time of 3.5s, which can be reset. If, whilst this timer is decrementing the vehicle speed becomes non-zero, a 1.2s timer which maintians the firm state replaces the 3.5s timer.

3 - Braking

If the vehicle speed is greater than 24 km/h, the suspension will switch to the 'firm' state for a braking pressure greater then 35 bar.

The suspension will return to the soft state when the pressure becomes less than 35 bar and after a one second timer.

Note: In the sport position, the timer for teturning to soft is multiplied by 1.3.

C - SWITCHING TO FIRM BY REACTION

Body movement

The vehicle speed must be greater than 10 km/h and the movement (attach or release) must be greater than a limit as a function of the vehicle speed.

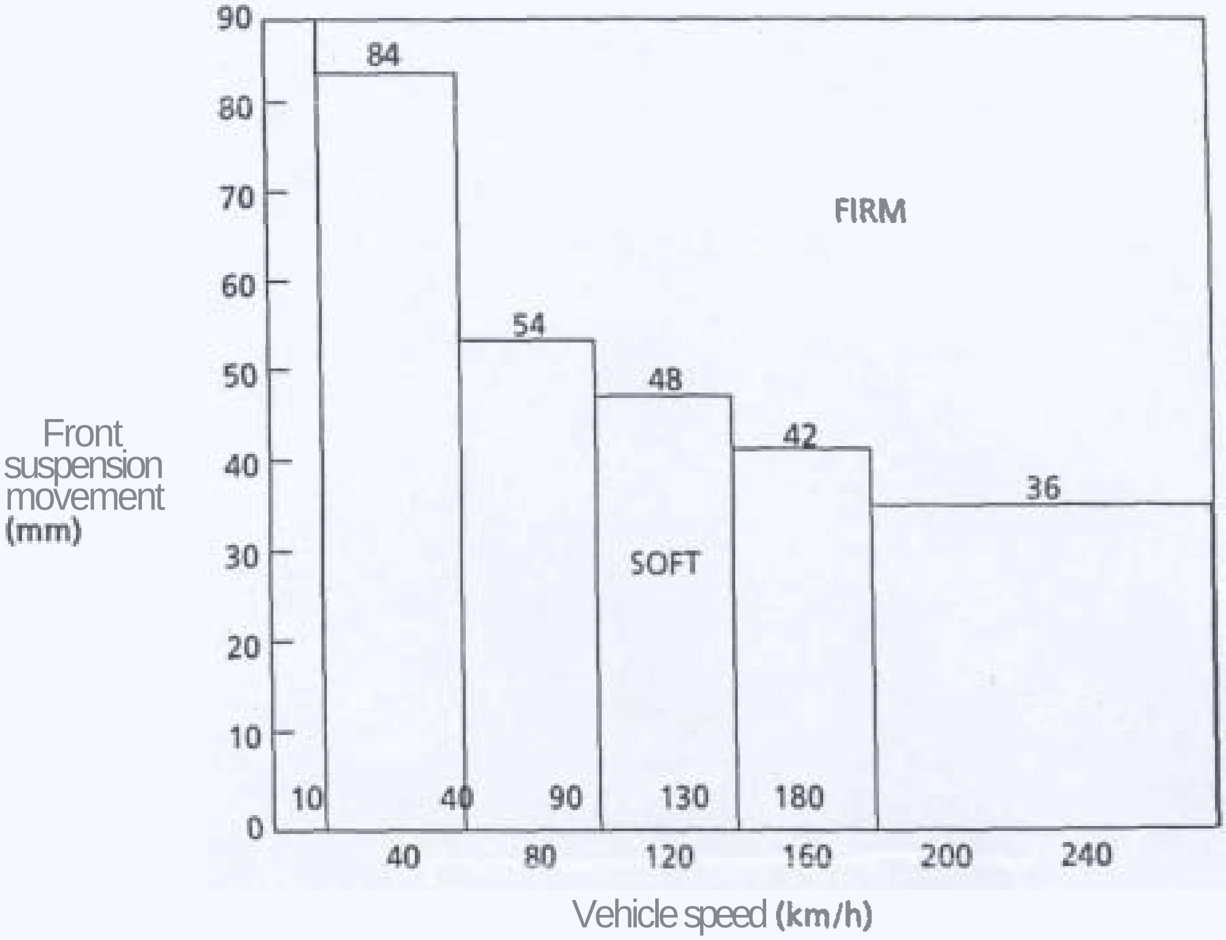
The limits are different depending on whether the movement is in the 'attach'direction or the release' direction.

The suspension will return to the soft state when the amplitude of the movement is less than a limit value and after a 0.8s timer.

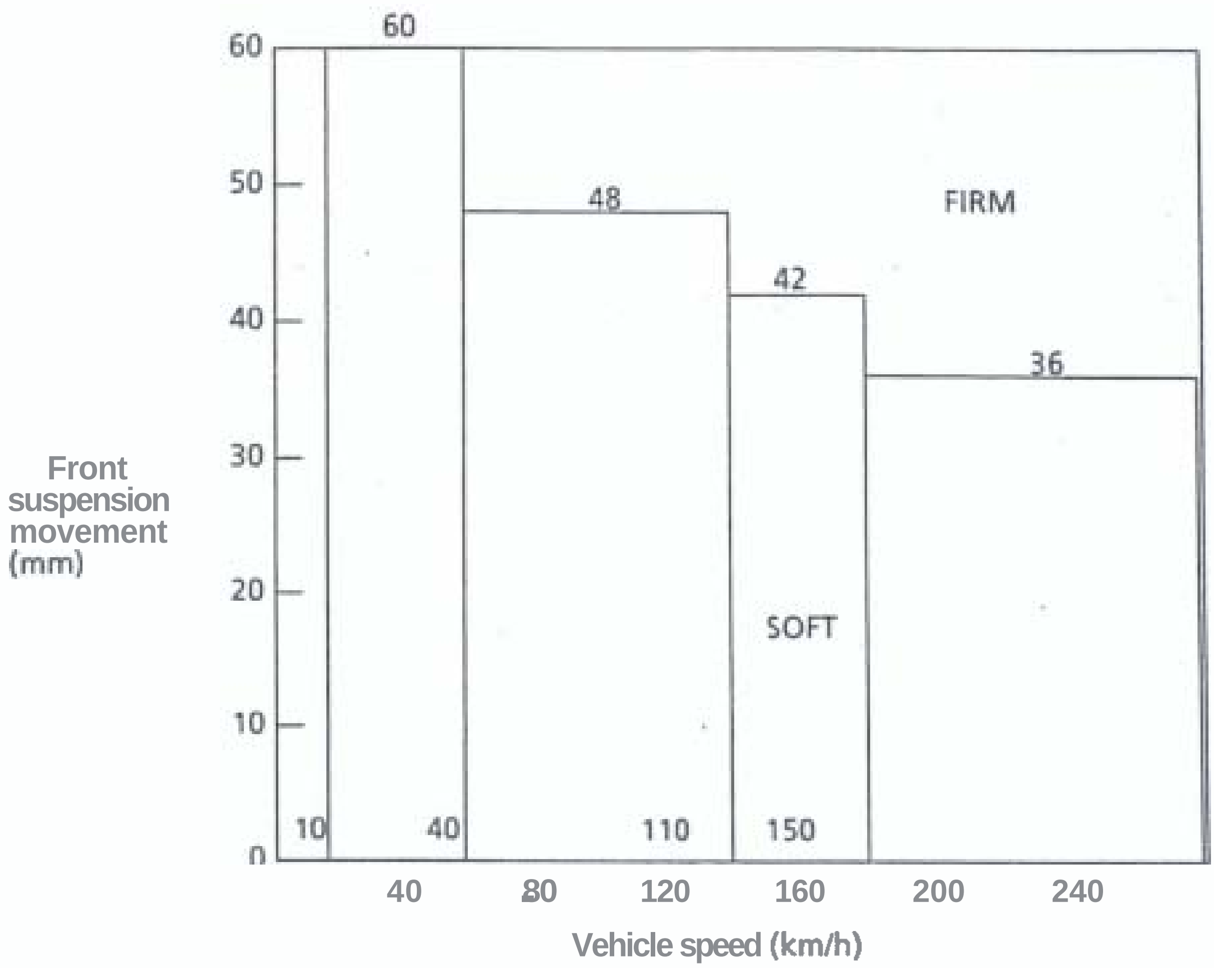
Note:

In the sport position, the limits for switching to firm as well as the timer remain unchanged.

BODY MOVEMENT LIMITS (ATTACK)
(Normal position)



BODY MOVEMENT LIMITS (RELEASE)
(Normal position)



It can be seen that the higher the vehicle speed, the lower the limit for switching to firm (inverse relationship) where this applies to both attack and release.

Speed	Normal	Sport
0 → 9	Soft	Soft
10 → 39	84	60
40 → 89	54	48
90 → 109	48	48
110 → 129	48	42
130 → 149	42	42
150 → 179	42	36
180 →	36	36

Features

Wheel impacts

If the movement speed is greater than 0.3 m/s, the limits take the value of 60 mm for 0.4 seconds.

Uneven roads

If the limits take the value of 60 mm for 0.4 seconds, and if this occurs more than three times in three seconds, the limits takes the value of 60 mm for the next two seconds.

The wheel impact and uneven road functions are not applied:

If
- vehicle speed > 159 km/h
- the steering wheel angle is greater than half the 'firm' limit for the steering wheel angle at the considered speed.

Example: The vehicle is travelling at 120 km/h

The limit for switching to firm on steering wheel angle is $260 \rightarrow \frac{26}{2} = 130$

Therefore, if a steering wheel < 13 ⇒ wheel impact and uneven road function applied (at 120° in attack, the limit of 48 mm changes to 60 mm).

If a steering wheel > 130 ⇒ wheel impact and uneven road inhibited.

It should be noted that in the 'SPORT' position, the uneven road function does not exist.

The 60 mm limit is measured with respect to a second average height H'. This is the average of averages. It is updated every 500 ms as follows:

$H'_{ave} = H'_{ave-1} + \frac{A}{32}$ with H'_{ave-1} = average of the averages already calculated

D- SELECTED 'SPORT MODE'[a]

The 'SPORT' position does not permanently impose the firm position.

- Limits lowered by 33%. They are divided by 1.5 for the steering wheel angle, steering wheel speed and accelerator pedal speed.
- Timers extended by 30%: they are multiplied by 1.3 for the steering wheel angle, steering wheel speed, accelerator pedal speed and brake.
- The 'uneven road' strategy is cancelled for the body movement sensor.

V - VEHICLE ANTI-JOLT

A - VEHICLE LEVELLING

We have seen that when the supply to the computer is cut, the suspension is in the "Firm" position (U electrovalve = 0). Therefore the additional sphere is isolated.

If the pressure in the main spheres varies (passengers getting in or out, loading or unloading) a pressure difference with respect to the additional sphere appears.

When the ignition is switched on, as the additional sphere is connected to the circuit, the pressure difference translates as a influx (P additional > P main) or a reflux (P additional < P main) of fluid in the suspension cylinders, which suddenly alters the ride height of the vehicle, and causes the vehicle to jump.

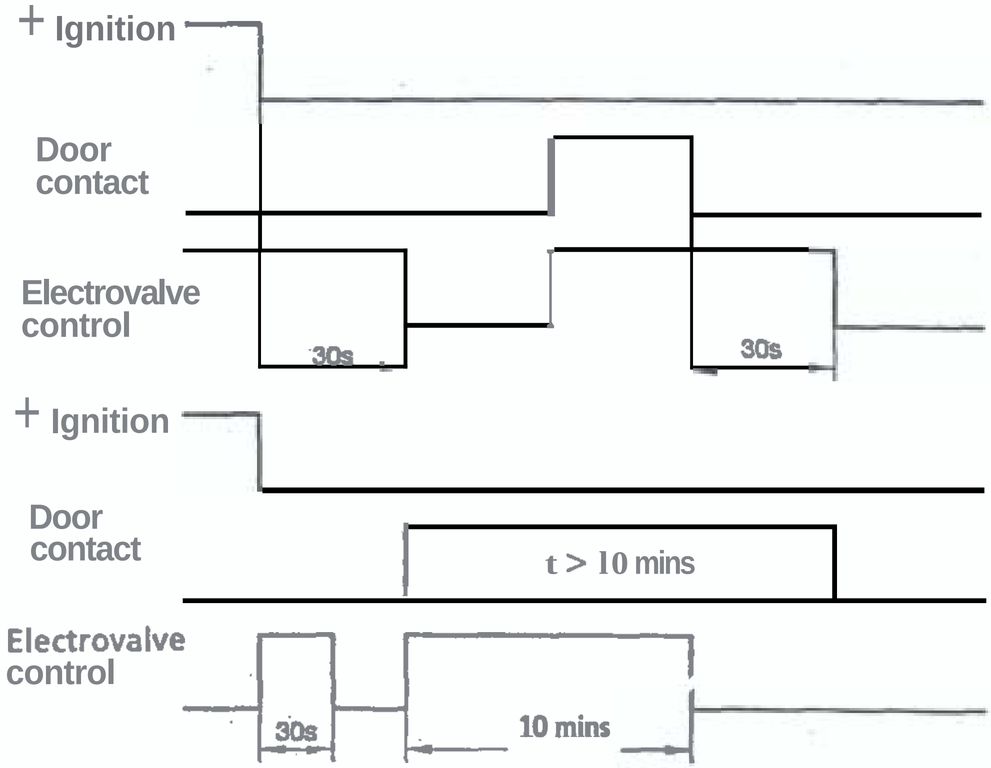
B - ROLE

The aim of this system is to balance the pressures in the circuits by energising the computer when a door or the tailgate is opened for a period limited to ten minutes and timing the supply for thirty seconds when the doors or tailgate are closed; the thirty second timer is also activated, doors and tailgate closed, when the ignition is switched off.

Note : If the hydraulic pressure is not sufficient, the additional sphere remains isolated, which, when the engine is switched on, can cause a slight jolt.

Note : The antijolt function is integrated into the computer.

C - SUMMARY OF OPERATION



VI - OPERATING SAFETY

A - SWITCHING ON THE IGNITION

When the ignition is switched on, the computer reinitialises the microprocessors. Everytime the computer is energised, all the tested elements are presumed to be in their normal operating state → all fault counters are reset to zero.

B - INITIALISING THE COMPUTER WHEN THE IGNITION IS SWITCHED ON

When the ignition is switched on, the computer checks :

- The presence of the actuators : line continuity
- Its own circuits
- The lack of abnormal development in the counters, registers, etc...

then it :

- Reinitialises the counters, registers, etc...
- Illuminates the central warning light for three seconds or causes it to flash for ten seconds at a frequency of 1 Hz if a fault is memorised.

C - SELECTING THE DATA TABLES

The computer has in its memory the tables of parameters for all the vehicles which can be fitted with hydractive suspension.

When initialised, the computer reads a code which tells it which table of parameters it should use.

If this code does not exist or is wrong, the computer systematically chooses the table of parameters of the XANTIA vehicle and switches the warning light on permanently.

D - WATCHDOG

The computer permanently checks that its internal programme is functioning correctly.

E - REINITIALISING AT A NON-ZERO SPEED

The computer will be exceptionally reinitialised if an unforeseen disturbance occurs causing the vehicle to switch to the safety mode :

Suspension in the "firm" state for as long as the straight line has not been validated over 200 metres if the speed of the vehicle is greater than 40 km/h and the warning light is illuminated for three seconds.

AUTO-DIAGNOSTIC

I - GENERAL

The auto-diagnostic has been designed with the aim of improving reliability and preserving automatic operating for as long as possible.

Where it is impossible to control the electrovalves (computer broken, electrovalve connector disconnected, supply voltage too low), the suspension is in the "firm" state hydraulically. On the other hand, for sensor faults, the suspension is maintained in the "supple" position.

A - DETECTING

1 - Steering wheel, accelerator sensors, electrovalves, computer

There are two types of diagnostic :

- By coherence of the signals between themselves.
- By electrical measurement, allowing sensor and actuator supply faults to be detected quickly especially for disconnected connectors and connectors with microscopic breaks.

2 - Body movement and vehicle speed sensors, brake pressure switch

Only diagnostic through coherence is applied.

B - DOWNGRADED MODES

1 - Steering wheel, body movement and accelerator sensors, brake pressure switch

The fault sensor is excluded from the system, but automatic operation is maintained-Therefore, comfort is maintained.

2 - Vehicle speed sensor

Emergency speed strategy = 100 km/h is used when the fault is validated.

3 - Electrovalves

The two electrovalves switch to the "firm" position.

4 - Computer

Attempts to reinitialise the computer result in the suspension switching to firm for a few seconds.

C - MEMORISING FAULT CODES

Faults are stored in a non-volatile EEPROM memory (faults are not erased when the battery is disconnected).

D - CHECKING THE SYSTEM

An after-sales test unit and the suspension computer can be connected in two different ways :

- Slow rate with coded signals with the OUT 4097 T or OUT 4120 T tools
- Fast rate by serial link to the ELIT

1 - By coded signals

This type of test allows fault codes to be read and erased. To carry out this test, the vehicle must be stationary (0 km/h) and the ignition must be on.

2 - By serial link

This test can be carried out with the ignition on at any vehicle speed.

Posssibilities available:

- Reading temporary and confirmed faults - Erasing memorised faults

  The notion of a temporary fault allows a fault to be displayed as soon as it has been detected by the computer and even before it has been confirmed. This therefore facilitates fault location.

- Dynamic analysis of the hydractive operation

  Controlling the actuators and warning lights

  Approximately every 100 ms, the computer transmits the status of its inputs and outputs: Status of the door switches, NORMAL/SPORT switch, warning lights, brake pressure switch,... as well as the operting parameters: steering wheel angle, vehicle speed, battery voltage ....

With the behicle stopped, the tester can force the computer to operate an electrovalve and a warning light.

These two functions therefore aloow a complte functional test of the suspension system to be carried outwithout having to work on the vehicle wiring loom. This test can be static or dynamic.

- Computer identification

  This gives the hardware and software versions, the computer parameters and its serial numbers.

Loading the parameter table selection code remotely

- 01/93 → XANTIA vehicle hydractive computer fitted to XM vehicles.
- The only difference between the two applications is the setting parameters (laws for switching to firm, diagnostic parameters, constructive parameters).
- For ease of uses, only one computer is used which has two tables of parameters in its memoryfor the XANTIA and XM. There is a single PSA reference in the factory and the table of paramters to be used is chosen on the assembly line by loading a code remotely using a tester connected to the computer via a serial link.
- If an error occurs (code not transmitted or wrong value), the computer chooses table No1 (XANTIA) by defaults.

  Note:

  At present, there is a specific hydractive computer for Diesel XM vehicles fitted with the DK5 ATE engine.

FUNCTION TESTED	FAULT CODE DIAG. WITH CODED SIGNALS	ANOMALY DETECTED	DETECTION STRATEGY	ELEC. TEST	TEST BY SIGNAL COHERENCE	VALIDATION	EMERGENCY STRATEGY	EMERGENCY STRATEGY ANNULLED OR VALID. COUNTER FAULT
SUPPLY + battery or earth	53	battery voltage outside range	Ub < 11 V for 2 s	X		60	suspension firm	U battery within range 11.5 V - 16 V ± 0.5 V for 2 s
			Ub > 16.5 V for 2 s			1		
		microscopic supply breakage	Electrovalve control incoherance < 10 ms during full voltage control of 500 ms	X		9	suspension firm	relaunch attempt every 30 s
ELECTROVALVE	(Front EV) 31 (Rear EV) 32		Electrovalve control incoherence for 500 ms	X		2	Suspension firm	relaunch attempt every 30 s

FUNCTION TESTED	FAULT CODE DIAG. WITH CODED SIGNALS	ANOMALY DETECTED	DETECTION STRATEGY	ELEC. TEST	TEST BY SIGNAL COHERENCE	VALIDATION	EMERGENCY STRATEGY	EMERGENCY STRATEGY ANNULLED OR VALID. COUNTER FAULT
STEERING WHEEL	23	open circuit not working short circuited	I measured > I ref max I measured < I ref min for 2 s	X		4	automatic suspension	I ref min < I measured I measured < I ref max then straight line acquistion
			if Veh Sp < 100 km/h after ignition, st. wheel angle ≦ 6.4° for 1 km or having had a st. wheel angle > 6.4° once: st. wheel angle ≦ 6.4° for 3 km if V > 100 km/h, no detection		X	3		st, wheel angle measured > 6.4° then straight line acquistion
PRESSURE SWITCH	21	open circuit	F = 1accel>15% for 10 s speed > 30 km/h accel. not at fault		X	5	automatic suspension	switch closed for 10 s (F = 0)
		short circuit	speed > 30 km/h no brake info 3 decels of 0.46g in 1.5 s		X	5		switch open and decel. of 0.1 g in 1.5 s

FUNCTION TESTED	FAULT CODE DIAG. WITH CODED SIGNALS	ANOMALY DETECTED	DETECTION STRATEGY	ELEC. TEST	TEST BY **SIGNAL** COHERENCE	VALIDATION	EMERGENCY STRATEGY	EMERGENCY STRATEGY ANNULLED OR VALID. COUNTER FAULT
VEHICLE SPEED	24	link in open circuit or short circuit	accel > 15% and no spped signal for 30 s		X	5	V = 100 km/h	signal return coherent for 20s
		sensor broken	speed drop of 30 km/h in 512 ms (V > 30 km/h). V<5 km/h for 28 s following drop and accel >15%		X	1		
BODY MOVEMENT	25	open circuit broken short circuited	speed >30 km/h and no transition in the 5 s following the brake switch signal		X	5	automatic suspension	movement angle measured >2 steps
ACCELERATOR	22	open circuit	V signal >V ref max V signal< V ref min for 2 s	X		10	automatic suspension	signal return within range for 20 s
		Short circuit						signal return within range for 20 s and speed = MPH

FUNCTION TESTED	FAULT CODE DIAG. WITH CODED SIGNALS	ANOMALY DETECTED	DETECTION STRATEGY	ELEC. TEST	TEST BY SIGNAL COHERENCE	VALIDATION	EMERGENCY STRATEGY	EMERGENCY STRATEGY ANNULLED OR VALID. COUNTER FAULT
COMPUTER	54	prog or µp fault	internal watchdog		X	10	reset µp. firm susp. if V>40 km/h	
		EEPROM memory fault	EEprom "Check sum" test + EEPROM erasure + read/write test		X	1	function normal where possible	
		diag. line	sending/receiving test when computer energised	X		1	fault codes emitted by warning light	
		Electrovalve control stage short circuited or open circuit	"Status" 1 "Input" test for 2 s Electrovalves not controlled	X		1	firm suspension	"Status" "Input" for 2 s on the 2 stages

II - COMPUTER CONNECTIONS

WHITE CONNECTOR

1 - Positive supply of front electrovalve
2 - Positive supply of rear electrovalve
5 - Diagnostic line
6 - Tailgate switch earth signal
7 - Door switches earth signal
8 - Earth
10 - Control through earth of test light
11 - Vehicle speed information
12 - Normal rule (earth)/sport rule ("open") signal
13 - Steering wheel sensor -
14 - Positive supply of illumination of switch light in sport" position
15 - Earth

BLACK CONNECTOR

1 - + direct
2 - + direct
3 - Accelerator pedal sensor + 5 V supply
4 - Accelerator pedal position information (cursor output)
5 - Computer + after ignition supply
9 - Steering wheel sensor 2 information
10 - Steering wheel sensor + 5 V supply
11 - Braking sensor signal
12 - Accelerator pedal sensor -
13 - Body movement sensor signal
14 - Body movement sensor signal
15 - Steering wheel sensor 1 information

III- DASHBOARD LIGHT OPERATION

It is supplied directly on the + after ignition side (12 V) and is controlled on the earth side by the computer.

- Ignition switched on → the light lights up for three seconds
- Presence of a fault → the light flashes for ten seconds at a frequency of 1 Hz when driving or when the ignition is switched on after a shorter initialisation than previously (≈ 1 s).
- If the microprocessor is faulty → light permanently on

FUNCTION TESTED	FAULT CODE DIAG. WITH CODED SIGNALS	ANOMALY DETECTED	DETECTION STRATEGY	ELEC. TEST	TEST BY SIGNAL COHERENCE	VALIDATION	EMERGENCY STRATEGY	EMERGENCY STRATEGY ANNULLED OR VALID. COUNTER FAULT
SUPPLY + battery or earth	53	battery voltage outside range	Ub < 11 V for 2 s	X		60	suspension firm	U battery within range 11.5 V - 16 V ± 0.5 V for 2 s
			Ub > 16.5 V for 2 s			1		
		microscopic supply *breakage*	Electrovalve control incoherance < 10 ms *during full voltage* control of 500 ms	X		9	suspension firm	relaunch attempt every 30 s
ELECTROVALVE	(Front EV) 31 (Rear EV) 32		Electrovalve control incoherence for 500 ms	X		2	Suspension firm	relaunch attempt every 30 s

FUNCTION TESTED	FAULT CODE DIAG. WITH CODED SIGNALS	ANOMALY DETECTED	DETECTION STRATEGY	ELEC. TEST	TEST BY SIGNAL COHERENCE	VALIDATION	EMERGENCY STRATEGY	EMERGENCY STRATEGY ANNULLED OR VALID. COUNTER FAULT
STEERING WHEEL	23	open circuit not working short circuited	I measured > I ref max I measured < I ref min for 2 s	X		4	automatic suspension	I ref min < I measured I measured < I ref max then straight line acquistion
			if Veh Sp < 100 km/h after ignition, st. wheel angle $\leqq$ 6.4° for 1 km or having had a st. wheel angle > 6.4° once: st. wheel angle $\leqq$ 6.4° for 3 km if V > 100 km/h, no detection		X	3		st, wheel angle measured > 6.4° then straight line acquistion
PRESSURE SWITCH	21	open circuit	F = 1accel > 15% for 10 s speed > 30 km/h accel. not at fault		X	5	automatic suspension	switch closed for 10s (F = 0)
		short circuit	speed > 30 km/h no brake info 3 decels of 0.46g in 1.5 s		X	5		switch open and decel. of 0.1 g in 1.5 s

FUNCTION TESTED	FAULT CODE DIAG. WITH CODED SIGNALS	ANOMALY DETECTED	DETECTION STRATEGY	ELEC. TEST	TEST BY SIGNAL COHERENCE	VALIDATION	EMERGENCY STRATEGY	EMERGENCY STRATEGY ANNULLED OR VALID. COUNTER FAULT
VEHICLE SPEED	24	link in open circuit or short circuit	accel > 15% and no spped signal for 30 s		X	5	V = 100 km/h	signal return coherent for 20 s
		sensor broken	speed drop of 30 km/h in 512 ms (V > 30 km/h). V<5 km/h for 28 s following drop and accel >15%		X	1		
BODY MOVEMENT	25	open circuit broken short circuited	speed>30 km/h and no transition in the 5 s following the brake switch signal		X	5	automatic suspension	movement angle measured >2 steps
ACCELERATOR	22	open circuit broken short circuited	V signal >V ref max V signal< V ref min for 2 s	X		10	automatic suspension	signal return within range for 20 s

FUNCTION TESTED	FAULT CODE DIAG. WITH CODED SIGNALS	ANOMALY DETECTED	DETECTION STRATEGY	ELEC. TEST	TEST BY SIGNAL COHERENCE	VALIDATION	EMERGENCY STRATEGY	EMERGENCY STRATEGY ANNULLED OR VALID. COUNTER FAULT
COMPUTER	54	prog or µp fault	internal watchdog		X	10	reset µp. firm susp. if V>40 km/h	
		EEPROM memory fault	EEprom "Check sum" test + EEPROM erasure + read/write test		X	1	function normal where possible	
		diag. line	sending/receiving test when computer energised	X		1	fault codes emitted by warning light	
		Electrovalve control stage short circuited or open circuit	"Status" 1 "Input" test for 2 s Electrovalves not controlled	X		1	firm suspension	"Status" "Input" for 2 s on the 2 stages