CITROËN TECHNICAL TRAINING

ZF 4HP20 AUTOMATIC TRANSMISSION

CITROËN UK LTD
221 BATH ROAD
SLOUGH SL1 4BA

DEALER PERSONNEL
DEVELOPMENT AND
TRAINING

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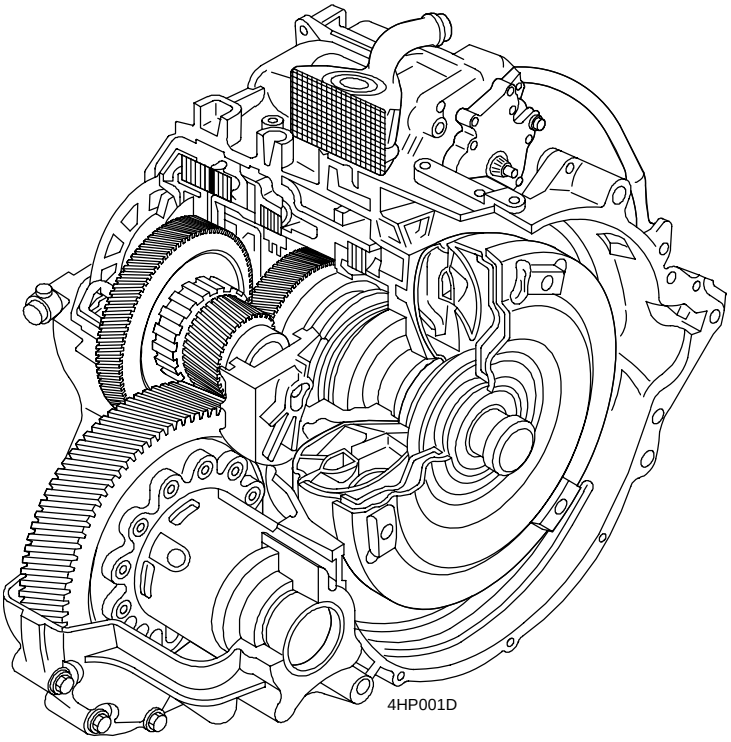
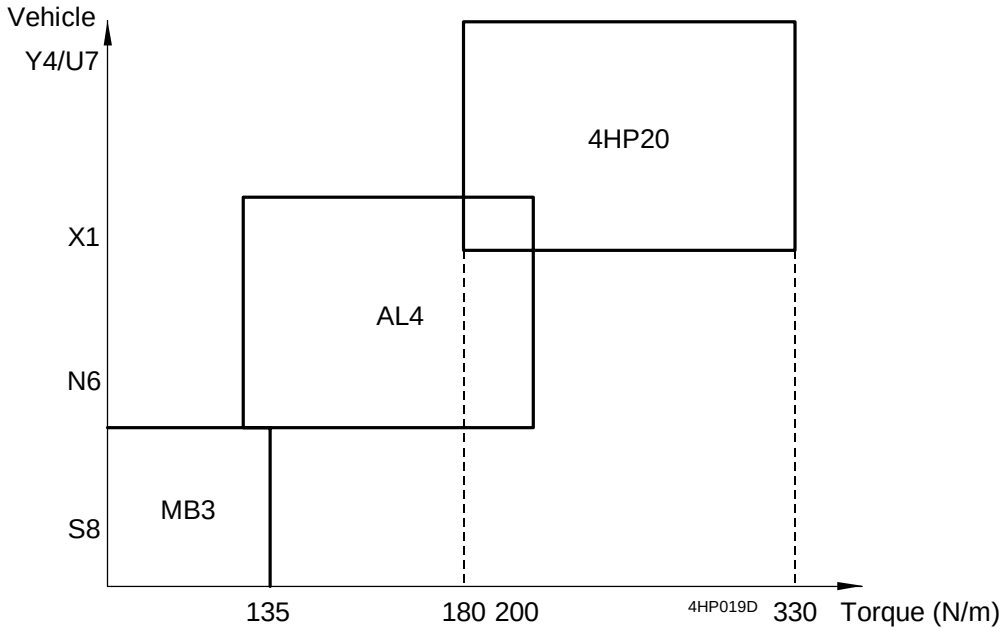
PRESENTATION - GENERAL

I - INTRODUCTION



- Totally electronically managed transverse automatic transmission.
- Four forward gears and one reverse gear.
- Auto-adaptive ECU used for managing the converter, gear changes and specific programs.
- The maximum torque capacity is 330 mN.
- Sealed transmission with reduced maintenance.
- This transmission is aimed at the powerful engines fitted to the top of the range CITROËN vehicles: mono volume, H and M2 segments.

Note: This document only deals with the ES9 J4 L3 engine.



II - PRESENTATION

Transmission architecture

- Hydraulic torque converter with lock-up device.
- Primary shaft.
- Two "Simpson 2" type epicyclic gear trains.
- Multidisc clutches / brakes (no belt brakes).
- Step down torque in central position.
- Differential with sealed outputs.

Control

This is provided by:

- the hydraulic unit,
- the ECU,
- the control cable.

Points of note

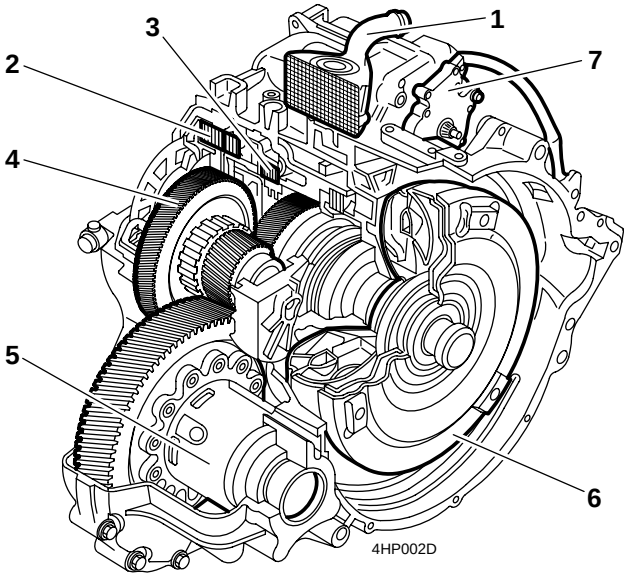
- Lock-up of 2nd, 3rd and 4th gears with controlled slip.
- Electronic management of all regulation and gear changing functions.
- Multiple programs: auto-adaptive (DSP) - Sport-Snow.
- Gears and programs displayed on dashboard.
- Possibility of manually selecting one of the first three gears: 1 - 2 - 3.
- Cannot change up a gear when in no load position (foot off accelerator).
- ECU with auto-adaptive "Flash EPROM".
- Downgraded mode operation in the event of a fault.
- Closed loop operation.
- Autodiagnostic and downgraded mode.
- SHIFT LOCK* and KEY LOCK** functions

* Shift lock: impossible to leave position P without having pressed brake beforehand.

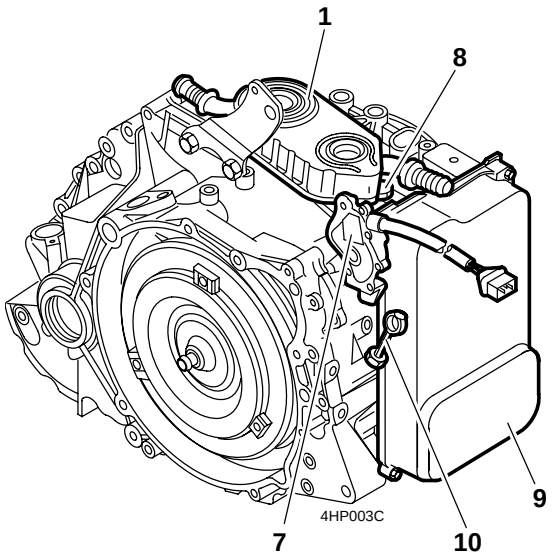
** KEY LOCK: impossible to remove key from ignition if the selector lever is not in P. On CITROËN vehicles, the KEY LOCK device has not been chosen and may be replaced by a buzzer (same as the lights on reminder buzzer).

This will appear on the restyled CITROËN XANTIA.

III - DESCRIPTION



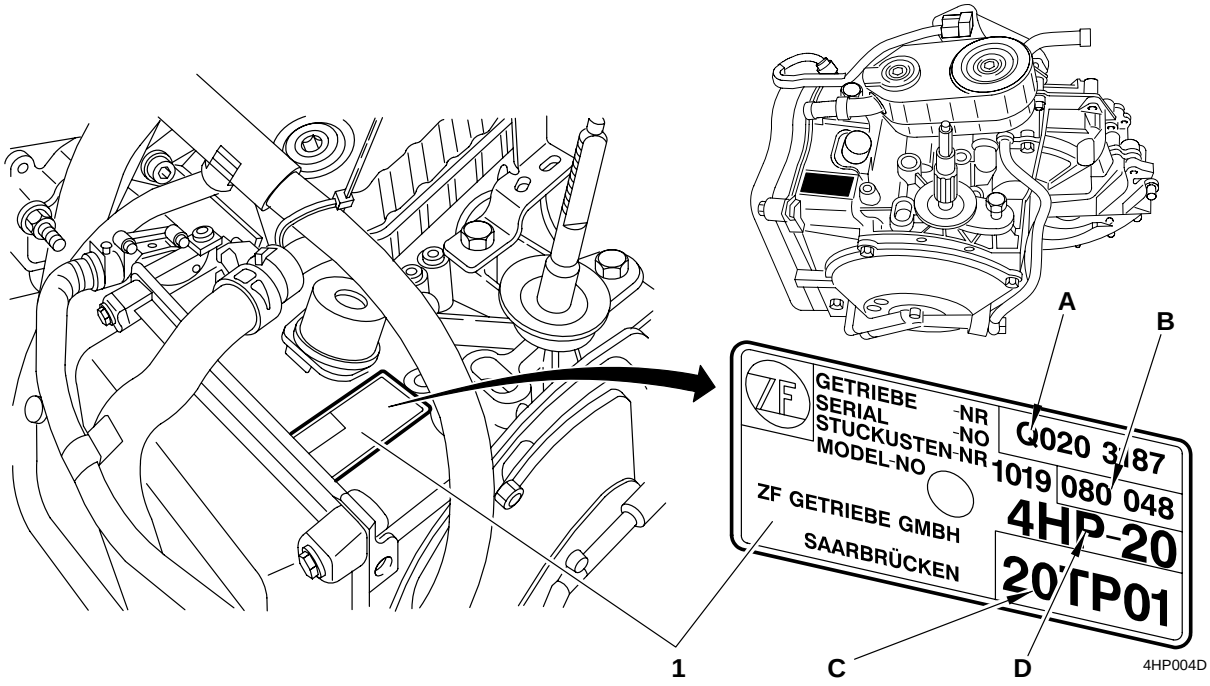
1 - Heat exchanger
2 - Clutch
3 - Brake
4 - Step-down torque
5 - Differential
6 - Torque converter
7 - Multifunction switch



8 - Breather
9 - Hydraulic unit cover
10 - Oil dipstick

IV - IDENTIFICATION OF THE COMPONENTS OF THE AUTOMATIC TRANSMISSION

A - AUTOMATIC TRANSMISSION



1 - Identification plate

The transmission is identified by means of a plate riveted to the housing:

A - Serial number.

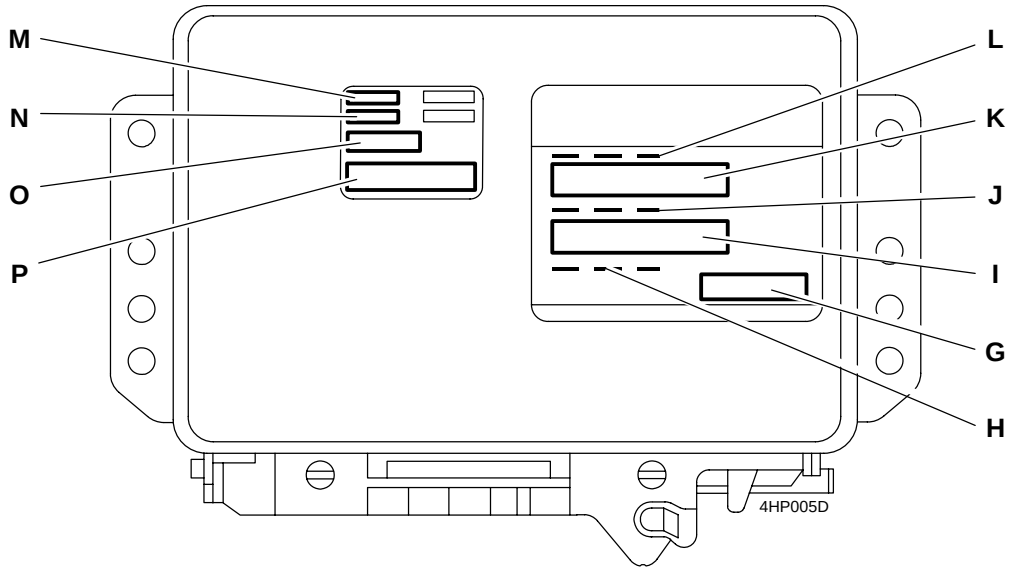
B - Parts list number (last 3 figures taken into account).

C - Component reference.

D - Automatic transmission type.

ZF PARTS LIST NUMBER (B)	COMPONENT REFERENCE (C)	HYDRAULIC UNIT NUMBER (D)
1019000010	20HZ07	1019198306

B - ECU



G - Reference.

H - Customer number.

I - Customer number bar code.

J - ZF parts list number.

K - ZF number bar code (software identification).

L - Order number.

M - Hardware version.

N - Program data version (software version).

O - Date of manufacture.

P - Serial number.

Identification (with an ELIT type diagnostic device)

- The ECU identification is found in the Identification menu.

V - SPECIFICATIONS - MAINTENANCE

A - INTERVALS - CAPACITIES

	XANTIA
Engine	ES9J4L3
Transmission capacity	7.7 - 8.3 litres
Draining capacity	between 2.7 and 3 litres
Exclusive oil	ESSO LT 71141
Draining interval	lubricated for life
Top-up interval	60 000 km
Transmission lubrication	pressurised
Final drive lubrication	oil splash
Weight	88 kg with oil and electronics
Torque capacity	330 mN at 3500 rpm

B - GEARS

	XANTIA	XM
Engine	ES9J4L3	ES9J4L3
Tyres - circumference	205/60R15MXV3 A	205/65R15 index V
1st	2.718 - 11.35 km/h*	2.718 - 11.65 km/h*
2nd	1.481 - 21 km/h*	1.481 - 21.4 km/h*
3rd	1 - 31 km/h*	1 - 31.66 km/h*
4th	0.720 - 43 km/h*	0.720 - 44 km/h*
Reverse	2.568 - 12 km/h*	2.568 - 12.33 km/h*
Step-down torque	61x66	59x68
Cylindrical torque	20x69	20x69
Tachometric torque	20x16	20x16

* Speeds in km/h are given at 1000 rpm.

Internal gear change safety thresholds:

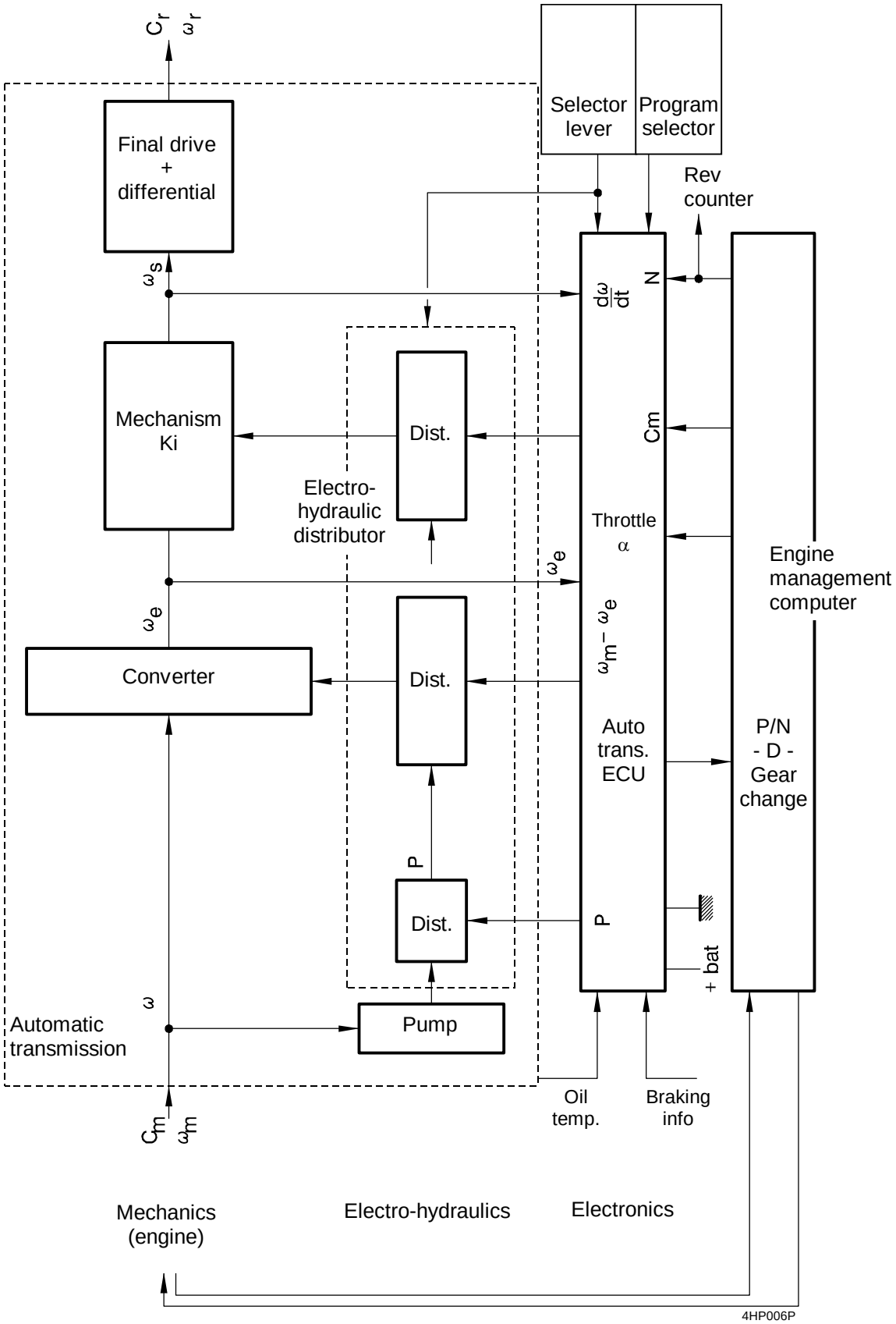
LEVER POSITION	SAFETY THRESHOLD
D $\rightarrow$ R	10 km/h
D $\rightarrow$ 3	165 km/h
3 $\rightarrow$ 2	110 km/h
2 $\rightarrow$ 1	60 km/h

VI - TIGHTENING TORQUES

TRANSMISSION COMPONENT	DESCRIPTION	N° BOLTS	HEX HEAD	BOLT DIMENSIONS	TIGHTENING TORQUE(S)
Auto trans housing	Exchanger output connector tube mounting to auto. trans	1	Hex head - 13 mm spanner	M8	23 Nm
Side cover	Cover mountings	5	Hex head - 13 mm spanner	M8 L = 28	23 Nm
Side cover	Banjo connect. Transmission input	1	Hex head - 19 mm spanner	M14 x 1.5	25 Nm
Converter housing	External mountings on auto trans + strap bracket (2 bolts)	18	Hex head - 13 mm spanner	M8 L = 40	23 Nm
Converter housing	auto trans mountings behind converter	5	Hex head - 13 mm spanner	M8 L = 50	23 Nm
Converter housing	Drain plug	1	6 point socket bolt, 8 spanner	M16 x 1.5	45 Nm
Exchanger	Mounting(s) on auto trans (socket bolts)	2	6 point socket bolt, 6 spanner	M12 x 1.5	35 Nm
Position switch	Switch mountings on support plate	2	Hex head - 10 mm spanner	M6 L = 16	10 Nm
Selector control	Selector mounting on shaft	1	Hex nut (13)	M8	21 Nm
Selector control	Sleeve stop lug mounting on converter housing	2	Hex head - 13 mm spanner	M8	15 Nm
Hydraulic unit cover	Bridge mountings on auto trans housing	4	-	M6 L = 37	6 Nm
Hydraulic unit cover	Angle mountings on auto trans housing	2	Hex head - 10 mm spanner	M6 L = 20	6 Nm
Hydraulic unit	Mounting(s) on auto trans housing	7	TORX	M6 L = 55	8 Nm
Engine speed sensor	Mounting on hydraulic unit (output speed)	1	TORX	M6 L = 20	10 Nm
Engine speed sensor	Mounting(s) on auto trans housing (input speed)	1	TORX	M6 L = 35	8 Nm
Speedo sensor	Mounting(s) on auto trans housing	1	Hex head - 11 mm spanner	M7 X1 L = 16	8 Nm

ASSEMBLY	N° BOLTS	BOLT HEAD	BOLT DIMENSIONS	TIGHTENING TORQUE(S)
Drive plate converter	3	Hex head - 16 mm spanner	M8 x 1.25 L = 14	65 Nm (± 20%)
Engine block converter housing	4	Hex head - 17 mm spanner	M10 x 1.5 L = 75	65 Nm (± 20%)
Engine block converter housing	2	6 point socket bolt - 8 spanner (thread on AT side)	M10 x 1.5 L = 80	65 Nm (± 20%)
Crankshaft/carrier - ring	8	Hex head - 17 mm spanner	M9 x 1 L = 18	90 Nm (± 10%)
Closure plate	3	Hex head - 10 mm spanner	M6 x 1 L = 16	17.6 Nm (± 10%)
Auto trans. suspension	1	Stud(s)	M14 x 1.5 L = 29	50 Nm (± 10%)
Auto trans. suspension	1	Hex head - 13 mm spanner	M12 x 1.5 L = 35	60 Nm

VII - LAYOUT OF THE 4HP20 AUTOMATIC TRANSMISSION



ZF 4HP20 AUTOMATIC TRANSMISSION

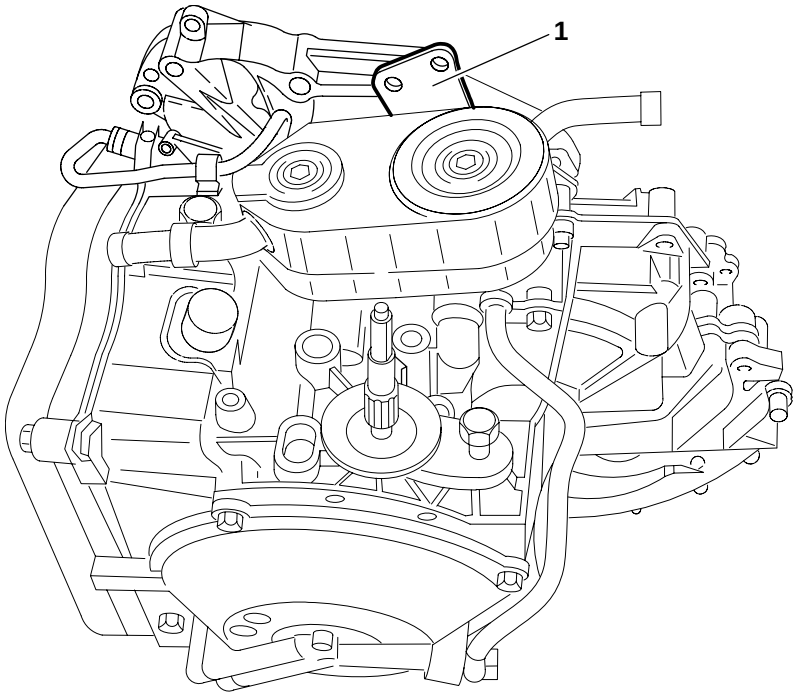
VIII - MISCELLANEOUS NOTES

A - TOWING

The transmission is lubricated when the engine is running since the engine drives the transmission oil pump; therefore, when towing, the drive wheels must be raised off the ground. The vehicle can however be towed with the drive wheels on the ground under exceptional circumstances as long as the following conditions are complied with:

- travel a distance of no more than 100 km,
- drive at less than 70 km/h,
- put lever in position N,
- the vehicle must be horizontal or else be inclined by a maximum of 5° if the rear wheels have to be raised.

B - LIFTING



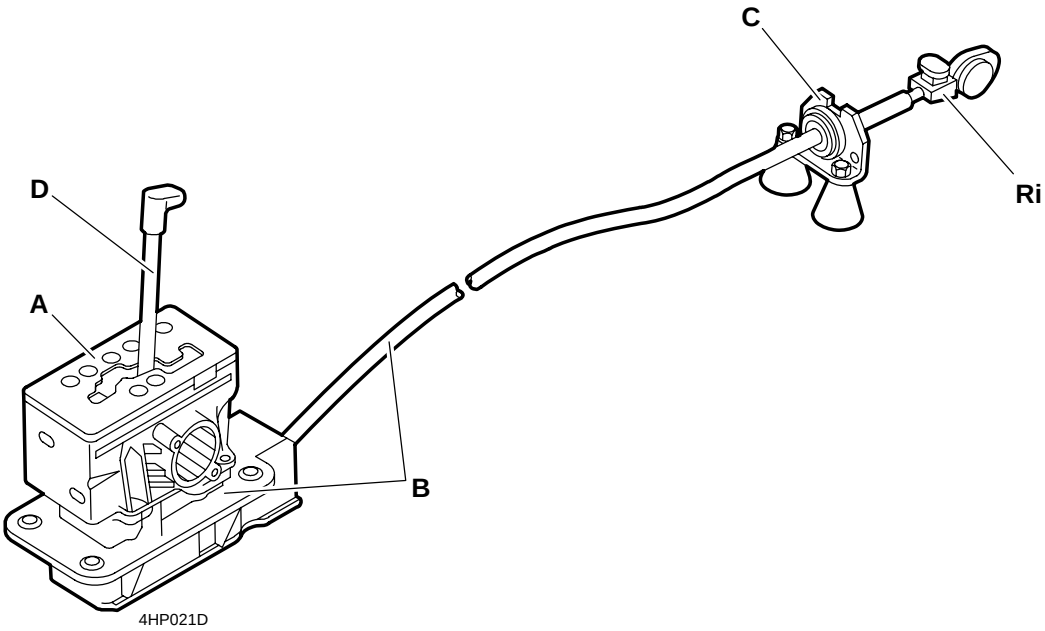
The 4HP20 transmission is fitted with a sling bracket (1) for easy lifting.

Never place the transmission on the floor unprotected.

SELECTOR CONTROL

XANTIA

I - SELECTOR LEVER



A - Upper part

B - Lower part

C - Sleeve stop

D - Control lever

Ri - Initial adjustment

The selector lever, located on the central console, has 7 positions using an offset grid.

The lever has a mechanical safety device which locks by means of a radial action on the lever.

Different positions:

- P - park: the transmission is mechanically locked, the starter motor may be operated.
- R - reverse: corresponds to reverse gear with illumination of reversing lights.
- N - neutral: corresponds to the neutral position; the starter motor may be operated.
- D - drive: the 4 gears are changed automatically; 1-2, 2-3, 3-4, 4-3, 3-2, 2-1
- 3-3rd hold: the first 3 gears can be used
- 2-2nd hold: the first 2 gears can be used
- 1-1st hold: only first gear can be used

Except in "snow" program

The 3rd, 2nd and 1st hold positions are totally controlled by the ECU.

Mechanical safety

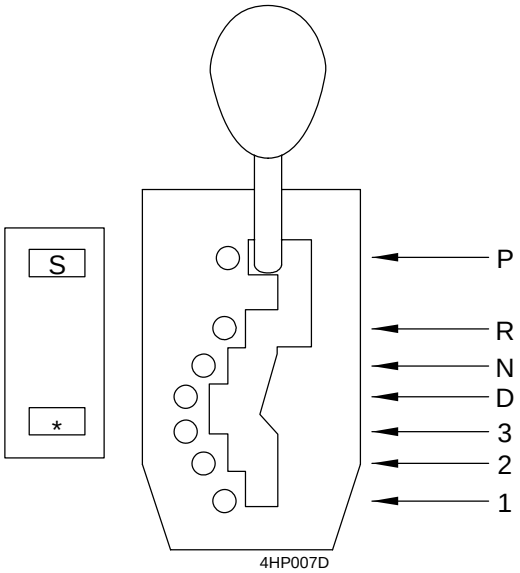
The lever has to be moved radially in the following cases:

- from position P to position R,
- from position R to position P,
- from position N to position R,
- from position D to position N,
- from position 3 to position 2,
- from position 2 to position 1.

II - PROGRAM SELECTOR

Gears change automatically depending on the vehicle speed and engine load, in accordance with different gear changing strategies. The gear changing strategies are chosen by the ECU as a function of one of three programs offered to the driver.

The driver selects a program by pressing a "double push" switch located on the central console.



The following three programs exist:

- Auto-adaptive or "normal" (no action on switch):

  This is the basic program; the ECU adjusts the operation of the automatic transmission to the style of driving, to the road and to the vehicle load; it promotes economical fuel consumption.

- "Sport" (press S switch):

  This program promotes sporty driving to the detriment of consumption. Gears are still changed automatically.

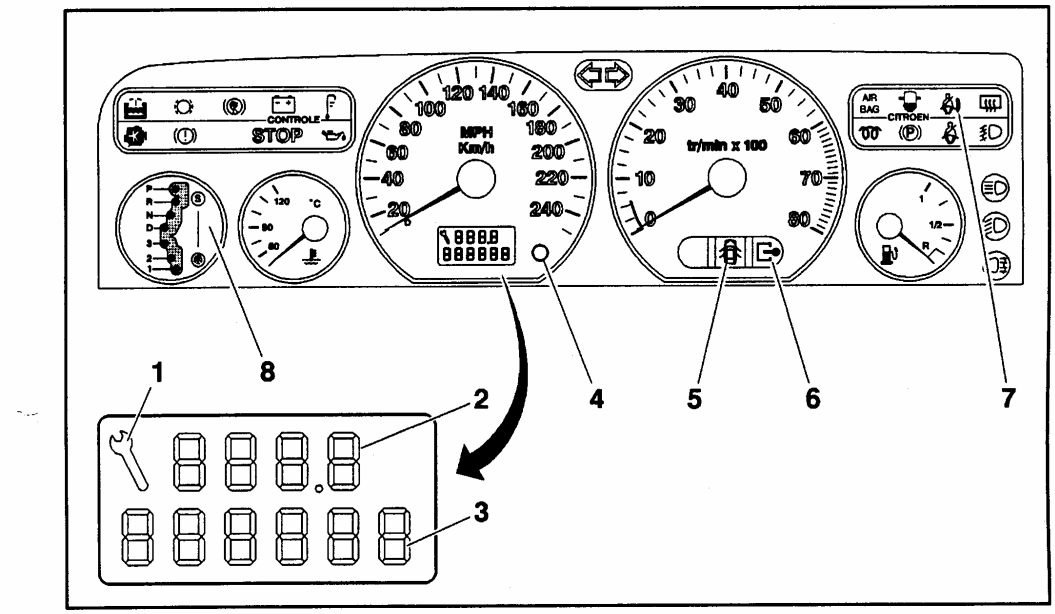
- "Snow" (press * switch):

  This program is suited to driving on ground with low adherence. In drive, it is characterised by the removal of the first two forward gears and by less frequent change downs.

  Furthermore, in the 1st, 2nd and 3rd hold positions, the transmission will change to the gear shown by the lever (3rd in position 3, 2nd in position 2 and 1st in position 1).

III - DISPLAY ON CONTROL PANEL

This function only appears on the restyled CITROËN XANTIA.



1 - maintenance symbol

2 - tripometers (I and II)

3 - dual function:

- maintenance indicator counter
- mileometer

4 - button for resetting maintenance indicator or selecting and resetting tripometers

5 - door open warning light

6 - transponder warning light

7 - lateral airbag warning light

8 - automatic transmission selector position display.

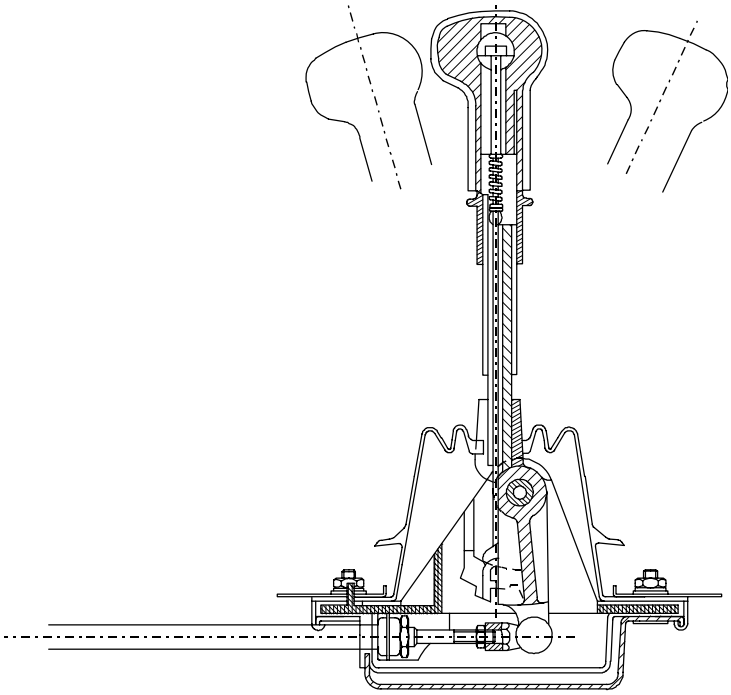
The LED display on the control panels informs the driver:

- of the position of the selector lever,
- of the program used,
- that the transmission is in emergency mode.

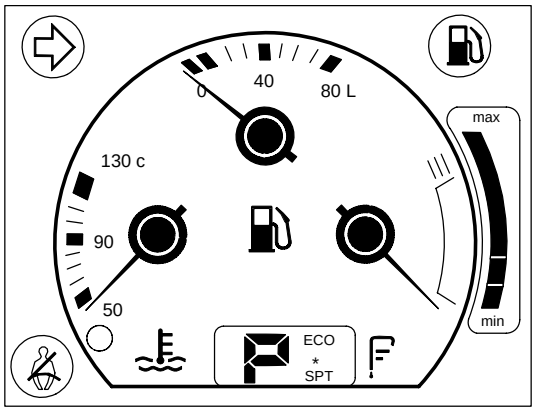
XM

The selector lever and control as well as the gear selection display on the control panel are unchanged.
However, the following have been added:

- a indicator showing the program selected on the control panel,
- a program selector switch.



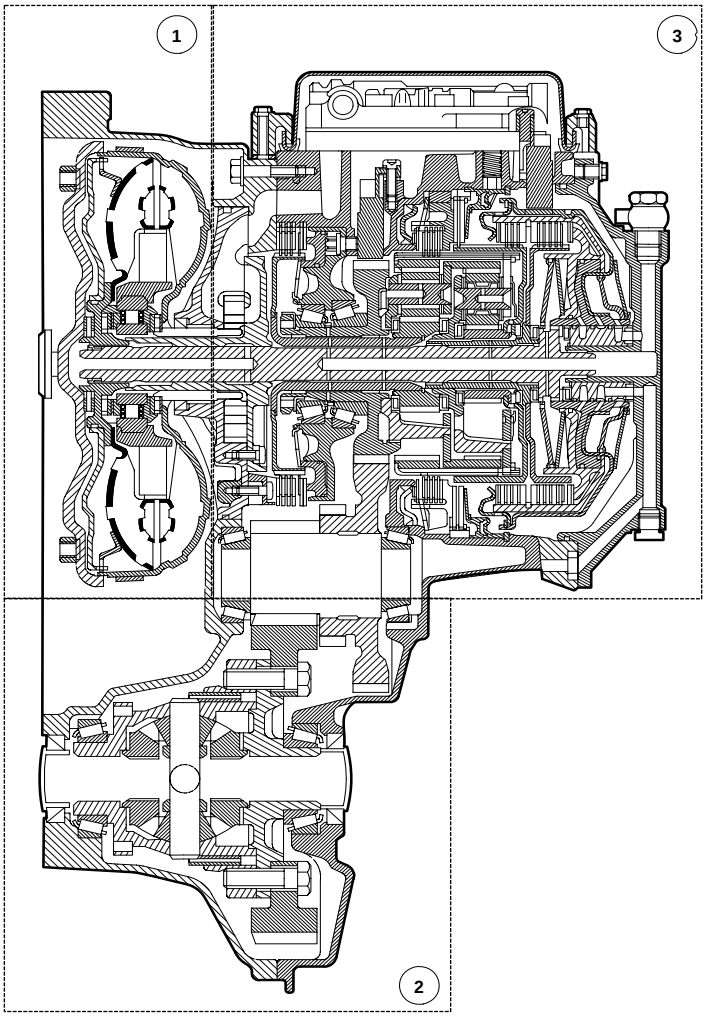
4HP023D



4HP024C

LUBRICATION

I - LUBRICATION CIRCUIT



The same oil is used to lubricate the 3 parts of the transmission:

- 1 - Converter (pressurised lubrication),
- 2 - Final drive (oil splash lubrication),
- 3 - Mechanism (pressurised lubrication),

The oil is cooled by a heat exchanger linked to the engine's cooling circuit.

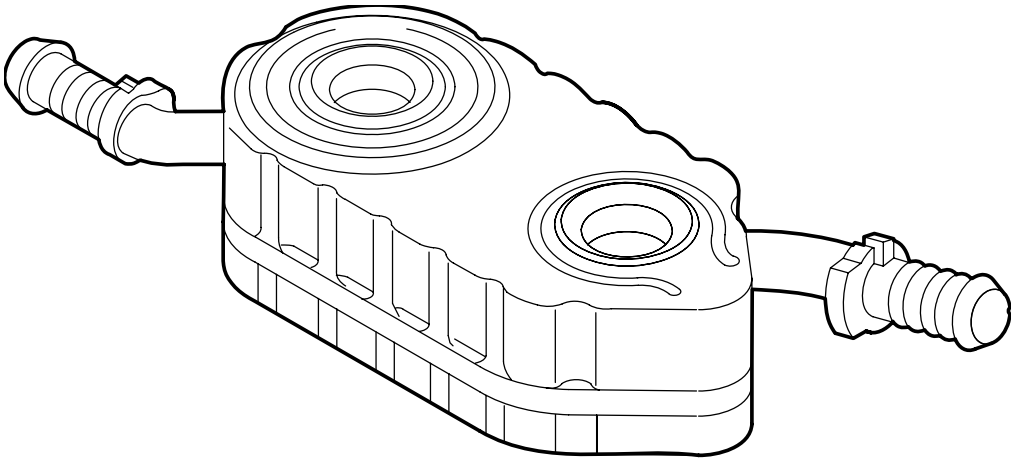
The transmission is lubricated for life and the level should be checked every 60 000 km.

II - OIL GRADE

Exclusively: ESSO LT 71 141

III - PERIPHERAL COMPONENTS

A - WATER/OIL HEAT EXCHANGER



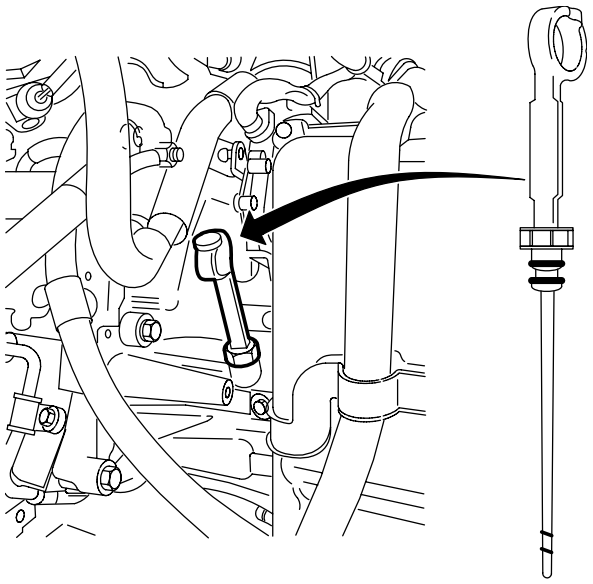
4HP026D

This is an 8 plate cooler connected to the engine's cooling circuit allowing the transmission temperature to be regulated.

Transmission operating temperature: approximately 100°C.

Note: Ensure it is mounted the correct way round: point of the exchanger towards the front of the vehicle.

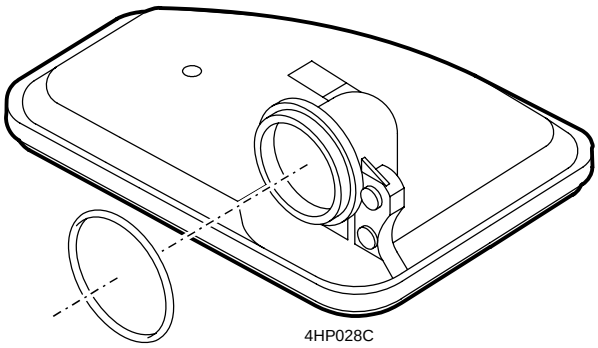
B - DIPSTICK



4HP027C

The dipstick is used to check the oil level in the transmission.

C - FILTER

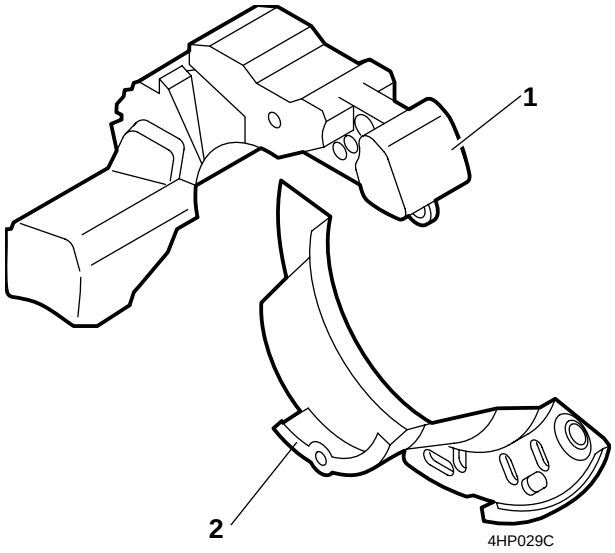


4HP028C

The filter is used to filter impurities contained in the oil before it is drawn in by the pump.

D - SUMP

1 - Description



1 - Sump

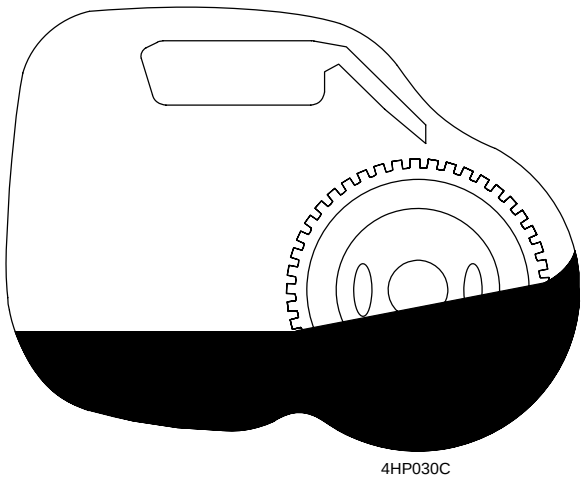
2 - Protective plate

The sump is used to maintain a constant oil level regardless of the temperature of the transmission.

It is located in the upper part of the transmission and has calibrated leaks.

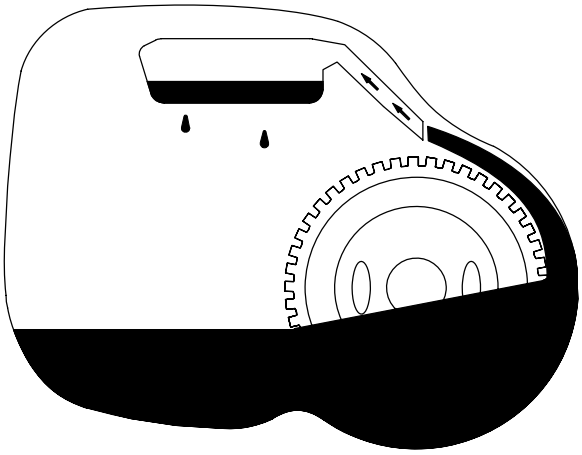
2 - Operating principle

a - Cold transmission



The oil, which is too viscous, cannot be projected into the sump which therefore remains empty.

b - Warm transmission



4HP031C

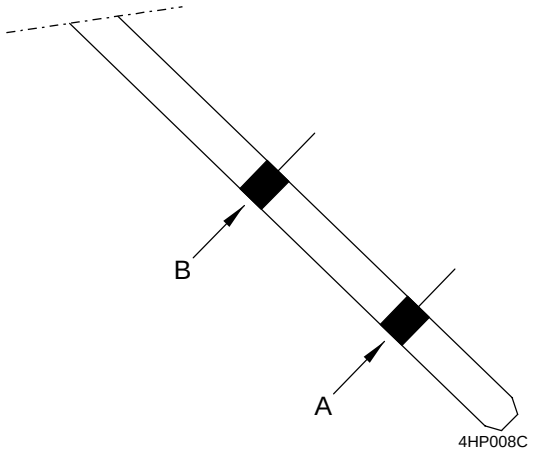
The oil is fluid enough to be projected through the differential ring which acts as an oil pump.

The sump therefore fills up but empties progressively through the two calibrated leaks, thus reducing the active quantity of oil in the transmission.

IV - CHECKING THE OIL LEVEL

Check the oil level every 60000 km.
Prior conditions:

- engine warm (transmission temperature: approximately 80° C),
- foot on brake, change through all the gears,
- vehicle on horizontal ground,
- selector lever in position P/N,
- engine idling, check the oil level.



The oil level on the dipstick should between the min (A) and max (B) marks.
Difference between min and max on the dipstick: 0.5 litre (s).

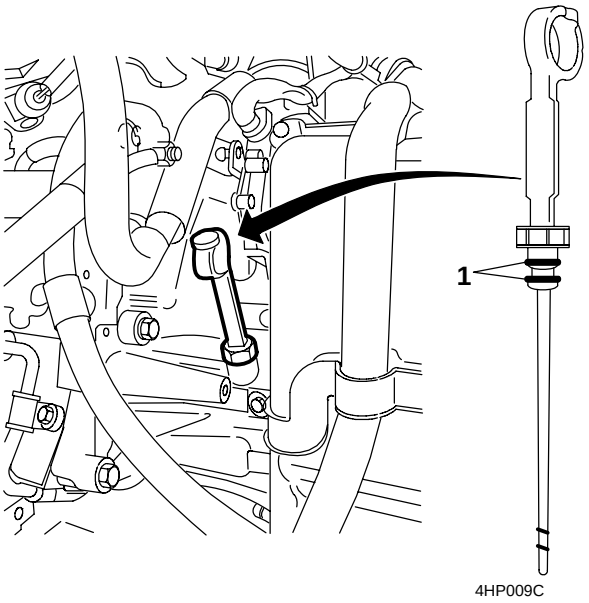
Important:	The oil level should not under any circumstances be above the max mark (B).

Too much oil may cause the following consequences:

- abnormal heating of the oil
- oil leaks

Not enough oil may damage the transmission.

Warning:	As dirt may collect around the dipstick, blow using compressed air before removing it.



If a leak develops around the dipstick, replace the 2 O-rings (1).

V - DRAINING - REFILLING THE TRANSMISSION

A - DRAINING DURING SERVICING

Prerequisites:

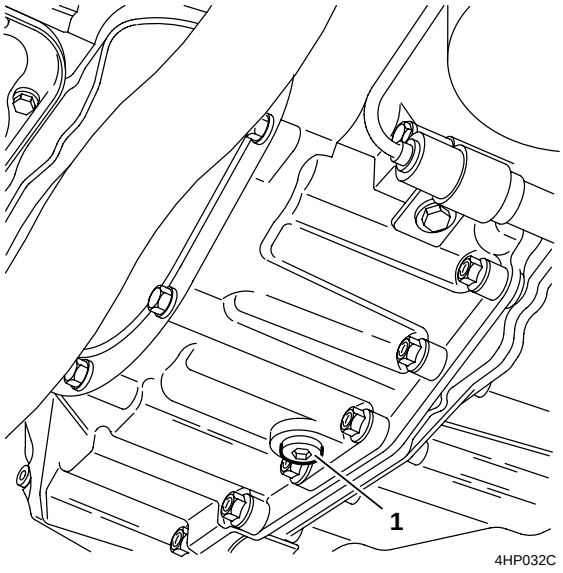
- transmission to be drained when warm to remove the impurities in suspension in the oil.

Draining is only partial since the converter cannot be totally drained.

Total capacity of the transmission:

- minimum: 7.7 litres,
- maximum: 8.3 litres.

When draining, approximately 3 litres are removed.



Drain plug (1).

B - FILLING

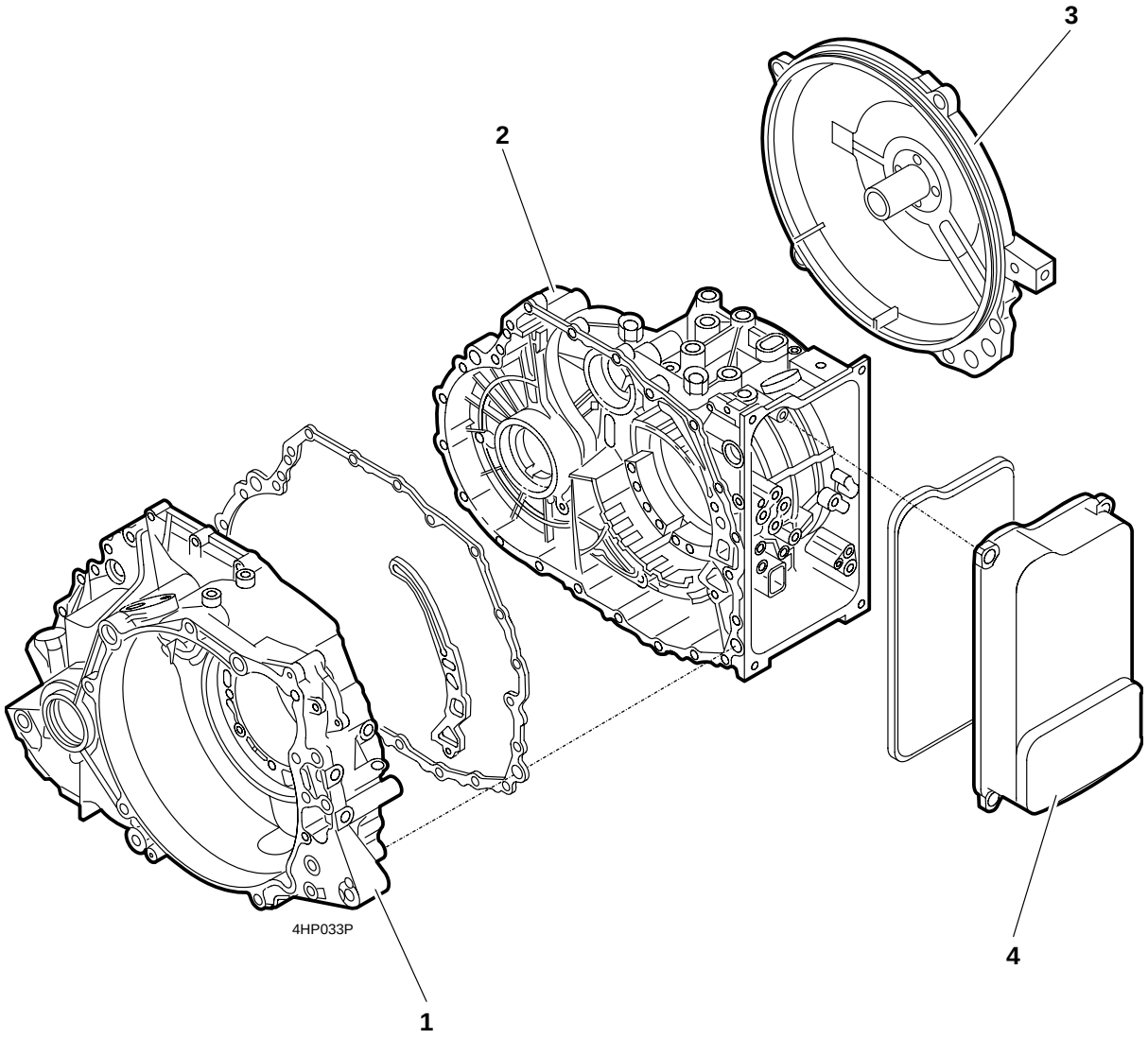
Oil is filled through the filler plug.

Use a funnel with a very fine strainer (mesh 0.15 mm).

Amount of oil to be added after draining (approximately) 3 litres.

Complete the operation by checking the dipstick with the engine running (idling).

THE HOUSINGS



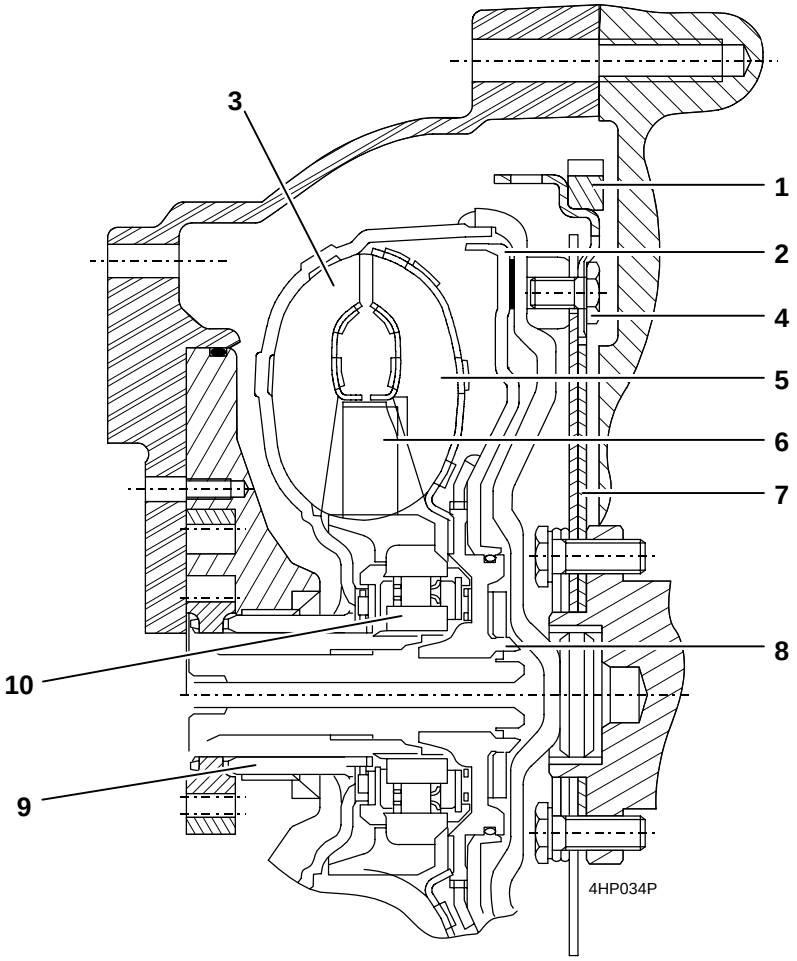
1 - Converter housing
2 - Transmission housing
3 - Rear housing
4 - Hydraulic unit cover

ZF 4HP20 AUTOMATIC TRANSMISSION

THE TORQUE CONVERTER

The 4HP20 automatic transmission is fitted with a standard torque converter to which is combined a lock-up device with controlled slip (controlled lock-up).

I - DESCRIPTION

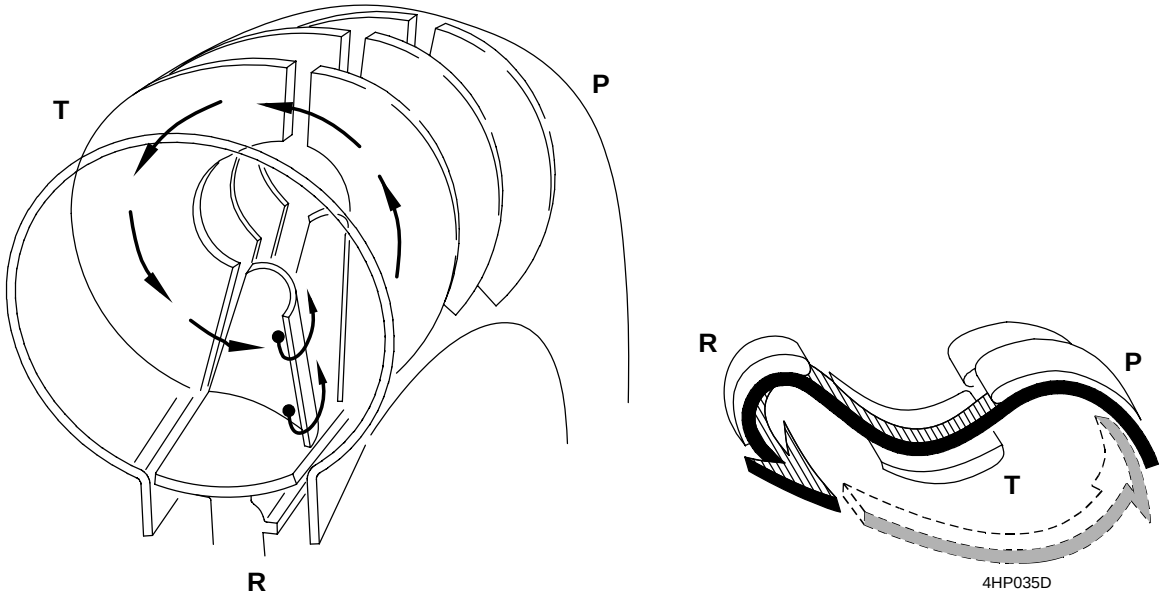


1 - Starter motor ring
2 - Lock - up piston
3 - Pump or impeller
4 - Assembly bolt
5 - Turbine
6 - Stator
7 - Flange
8 - Turbine shaft
9 - Pump shaft
10 - Stator free wheel

The body of the converter consists of two half-shells which are welded together. It is connected to the engine's crankshaft by a drive flange (7). It is supplied with oil. As the connection between the engine and transmission is not rigid, the converter allows the vehicle to move off progressively and prevents the engine from stalling when the vehicle is stationary.

- The pump or impeller (3) is connected to the engine.
- The turbine (5) is connected to the transmission by the turbine shaft (8).
- The stator (6) fitted on a free wheel (10) is located between the pump and the turbine.
- The lock - up (2) is a clutch which rigidly and directly connects the pump shaft to the turbine shaft.

Note: The converter of the 4HP20 automatic transmission has an oval cross section thus giving a more compact transmission without affecting the hydraulics.



P - Impeller
T - Turbine
R - Stator

II - SPECIFICATIONS

Diameter: 254 mm - Type: X18

Converter phase (when starting):

The engine torque is multiplied by 1.96

Setting torque: 170 mN at 2000 rpm (turbine locked)

III - LOCK-UP DEVICE

A - PRESENTATION

The lock-up device is electronically controlled and can have three different states:

- Open state → normal operation of the converter with slip (there may be a difference of 100 - 200 rpm between N pump and N turbine at stabilised speed).
- Closed state → "Lock - up"; all the engine torque is transmitted.

Advantages:

- availability of engine brake,
- reduction in fuel consumption,
- cooling of automatic transmission oil,
- cooling of the lock-up track.

Disadvantages:

No filtering (acyclic/hesitation)

- Controlled state → slip is obtained such that N pump - N turbine = 50 rpm in most cases.

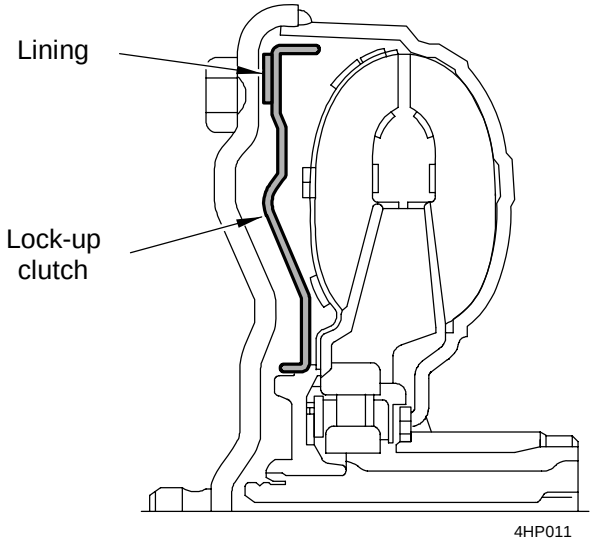
Advantages:

- filtering of engine acyclisms (oscillations),
- filtering of hesitation during variations in engine load, without losing the first three advantages given above (closed state).

The lock-up system is in the form of a clutch located between the converter cover and the turbine.

The converter can either be locked up or not by inverting the direction of oil circulation.

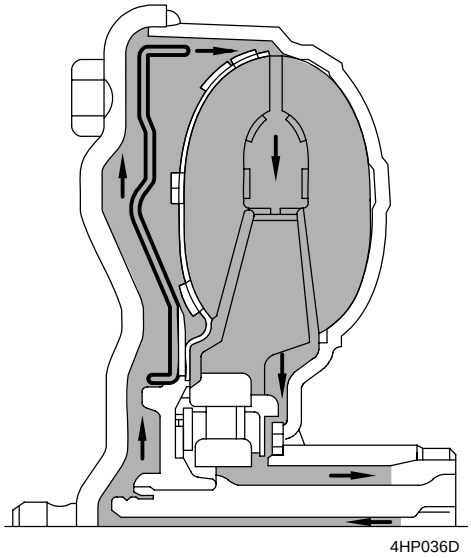
The various states are managed by the ECU using a network of strategy curves specific to each program and each gear in question (2nd, 3rd or 4th), depending on how much the throttle is open and the transmission output speed.



Note: It is essential that the original bolts which mount the converter onto the drive plate are used otherwise the friction track of the lock-up may be damaged.

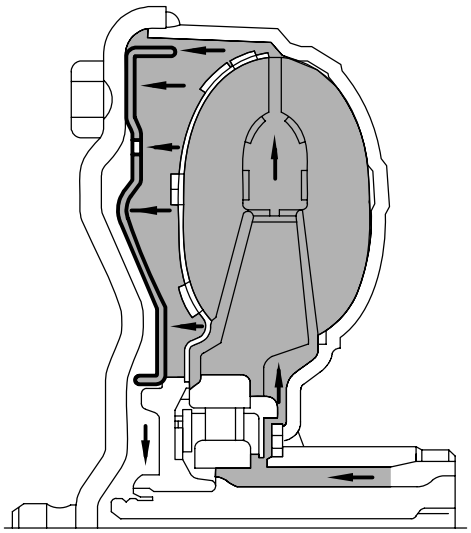
B - OPERATING PRINCIPLE

→ **Open state:**



The direction of oil circulation allows the converter to operate normally. The oil pressure is the same in all places.

→ Closed state:

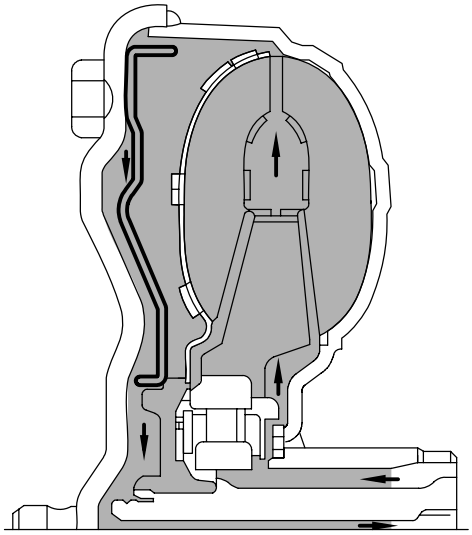


The direction of oil circulation is inverted and at the same time, the space behind the clutch is bled. The oil presses the lock-up clutch (integral with the turbine) against the body of the converter (integral with the pump). There is no longer any slip between the pump and the turbine.

The pressure acting on the lock-up clutch on the turbine side is then 5 - 8 bar. On the lining side, there is a residual pressure of 0.2 bar.

Note: A pilot hole located on the lock-up clutch allows the residual oil to circulate in the converter so as to renew the oil between the converter housing and lock-up.

→ Controlled state (or controlled slip):

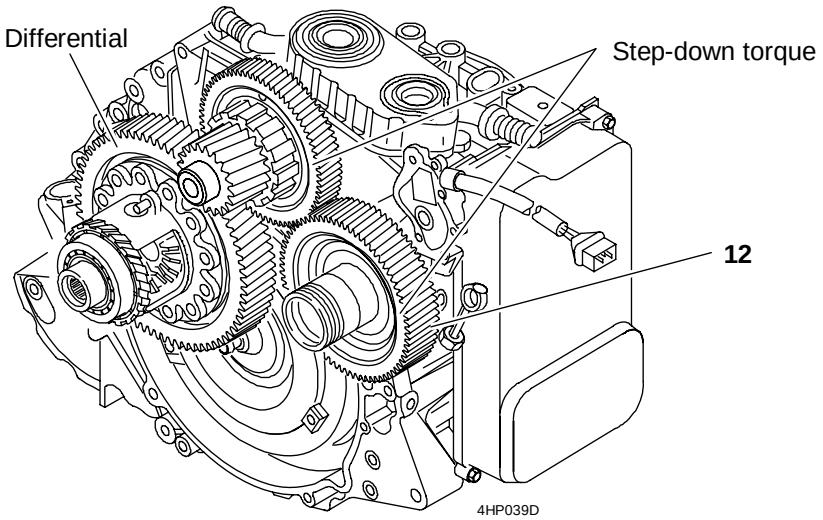


4HP038D

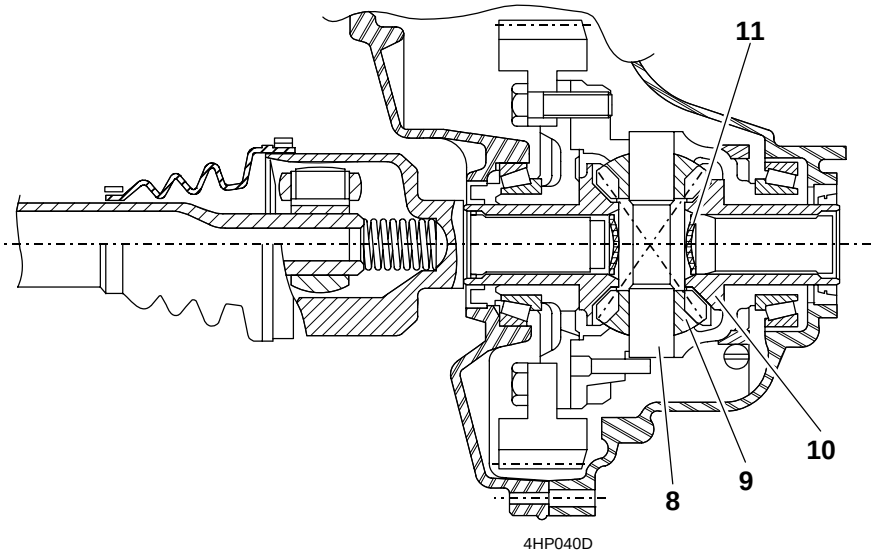
The reduction in oil flow, when circulating in the converter, is used to maintain a slight slip between the pump and the turbine. This slip is wholly controlled by the ECU.

THE FINAL DRIVE

I - DESCRIPTION

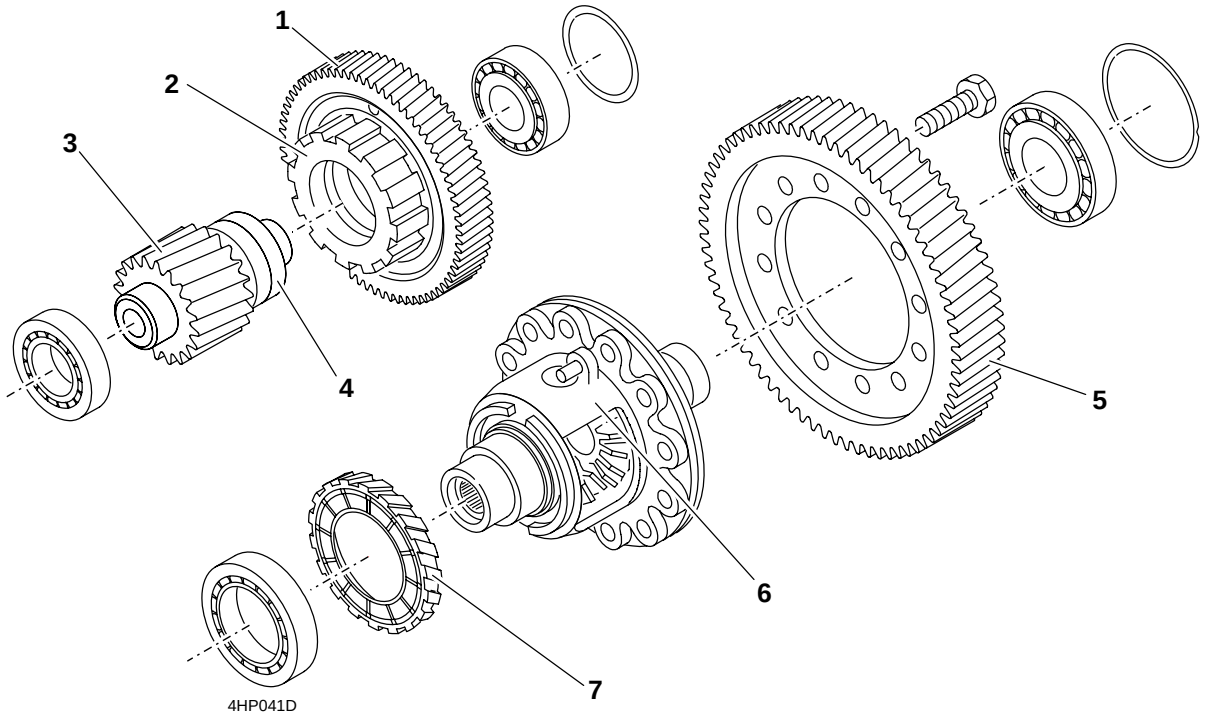


4HP039D



4HP040D

8 - Planet wheel shaft
9 - Planet wheels
10 - Sunwheels
11 - Seals
12 - Step-down gear input pinion



1 - Step-down gear output pinion
2 - Park wheel
3 - Drive pinion
4 - Secondary shaft
5 - Crown wheel
6 - Differential unit
7 - Speedo drive gear

II - FUNCTION

To transmit the movement supplied by the planet wheel carrier of gear train N° 1 to the drive wheels.

Movement is transmitted as follows:

- The movement leaves the planet wheel carrier n° 1 and is received by the input gear (12) of the step-down gear,
- This transmits the movement to a secondary shaft (4) through the output gear (1) of the step-down gear,
- The secondary shaft transmits the movement to the crown wheel (5) of the differential through its drive pinion (3).

Final drive composition:

Step-down gear: This transmits the output torque from the epicyclic gear train to the return shaft (secondary line) and increases the movement (61 x 66 ratio). It is positioned in the middle of the transmission so as to reduce gearing noises. Its secondary shaft is guided by two tapered bearings with adjusting shims.

Final drive gear: This provides the link between the secondary return shaft and the differential. In addition, it increases movement (20 x 69 ratio).

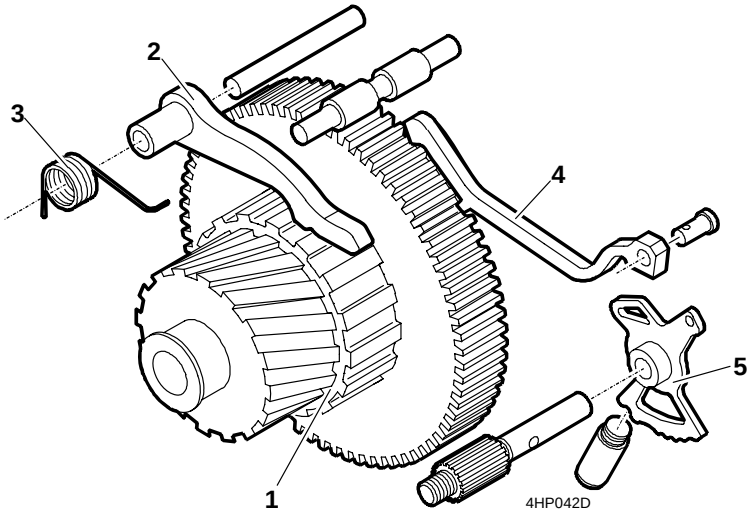
Differential: This is of standard design and has two planet wheels. It transmits the transmission movement to the wheels.
The differential unit is guided by two X layout tapered bearings with adjustments on the mechanism housing side.
The sunwheels are used to seal the transmission on their outer diameter and provide a seal inside by means of a plug.

Assembly of the driveshafts

Right hand driveshaft → mounted on a bearing

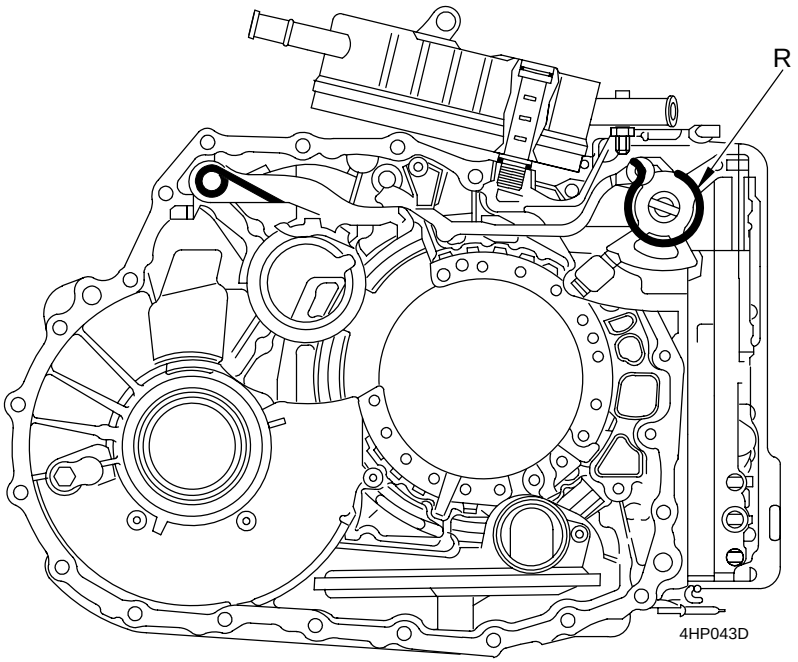
Left hand driveshaft → locked by a spring

III - PARK LOCK SYSTEM

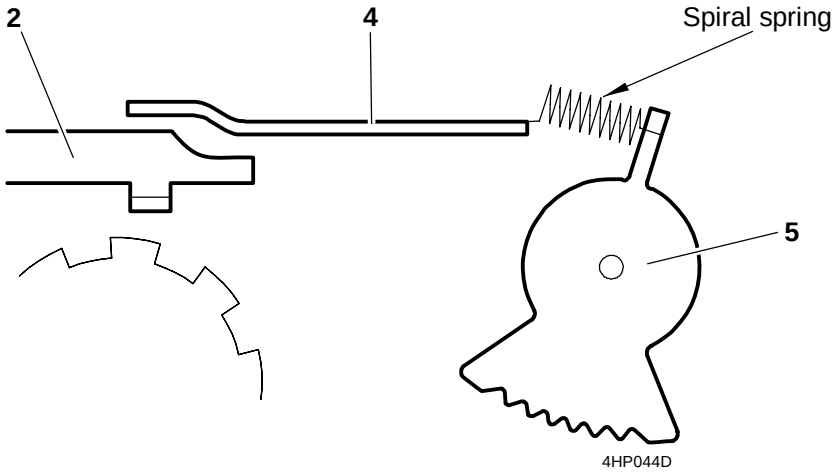


1 - Castellated gear or park wheel
2 - Park plunger
3 - Spring
4 - Lever
5 - Segment

This is a mechanical system which locks the transmission output when the selector lever is in position P by acting on the castellated gear (1) fitted on the secondary shaft:
When the selector lever is moved to position P, a lever (4) is operated by means of the segment (5); the plunger (2) tilts and then engages into the castellation of the park wheel.
The spring (3) keeps the plunger away from the wheel when the lever is not in position P.
The shape of the teeth of the park wheel and a spiral spring R prevent the plunger from accidentally being engaged when driving (above 4 km/h).



Note:



The role of the spiral spring (shown as a normal spring on the diagram above) is essential. In effect, if the segment (5) tries to engage the park plunger (2) by pushing on the lever (4) on the one side and if on the other the park plunger (2), since it cannot engage, resists the action of the lever (4), the lever risks being broken. The role of the spiral spring, by compressing, is therefore to absorb the force transmitted by the segment (5) to the lever (4) when the park plunger (2) cannot be engaged. When the plunger (2) can finally be engaged into the park wheel, the spiral spring extends so that the lever (4) can operate the plunger (2).

THE MECHANISM

I - INTRODUCTION

The transmission mechanism has two roles:

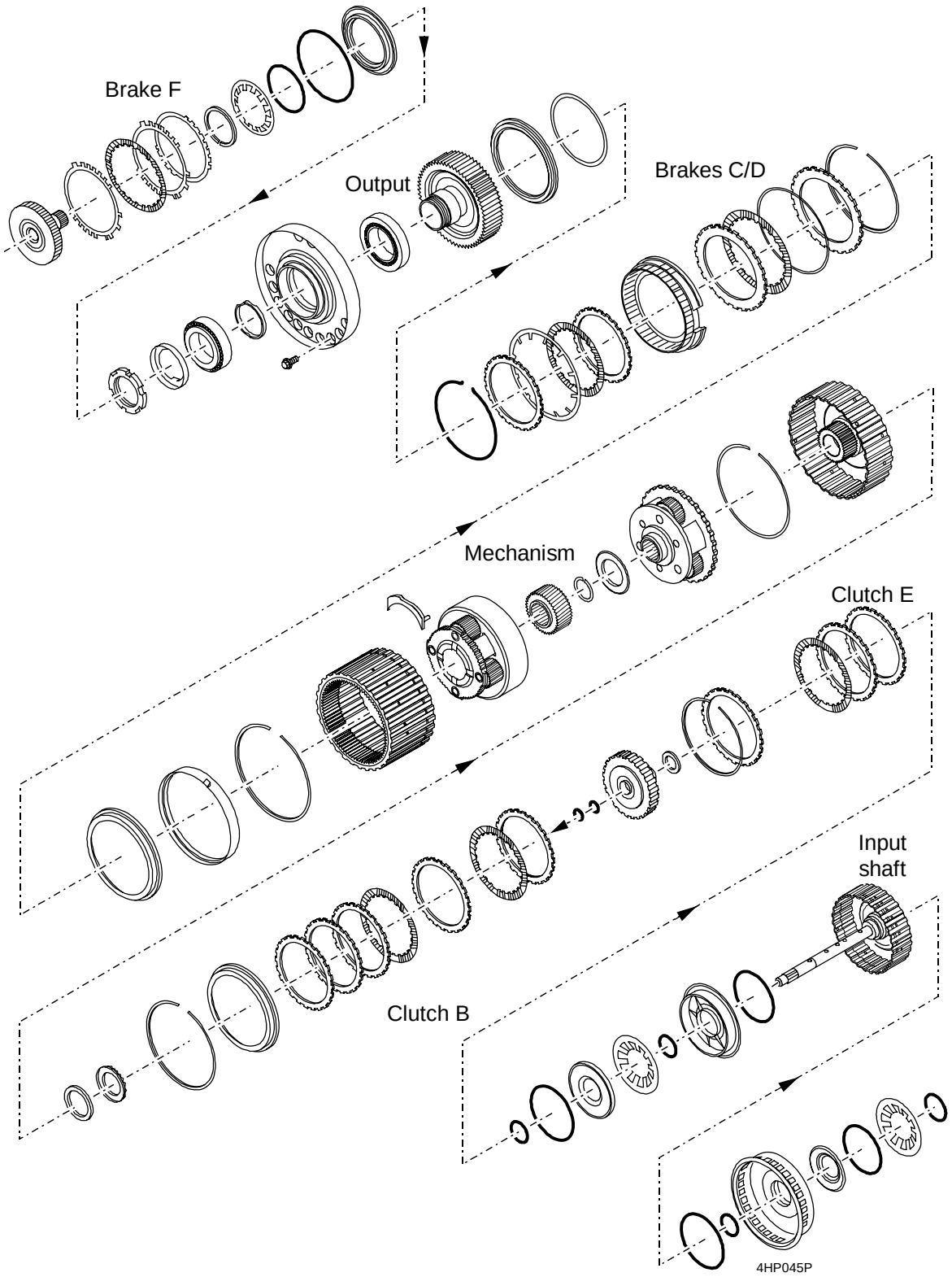
- it provides 4 forward gears and 1 reverse gear,
- it automatically changes the forward gears.

The first function is provided by two epicyclic gear trains which receive the movement from the turbine shaft, perform the demultiplications and transmit the movement to the step-down gear.
Automatic changes are performed by hydraulic, electric and electronic components.

Note: The mechanism of the 4HP20 automatic transmission does not have a free wheel since gear changes are performed in a very precise manner and under the best possible conditions due to the hydraulic unit and the ECU strategies.

Reminder of free wheels: in previous automatic transmissions, free wheels allowed gears to be changed without any interruption in the traction force.
Removing the free wheels has the following advantages:

- compact and lighter transmission,
- less mechanical coupling components,
- better efficiency by reducing friction losses,
- lower torque peaks on the components and the moving items.



ZF 4HP20 AUTOMATIC TRANSMISSION

II - THE EPICYCLIC GEAR TRAIN

A - PRESENTATION

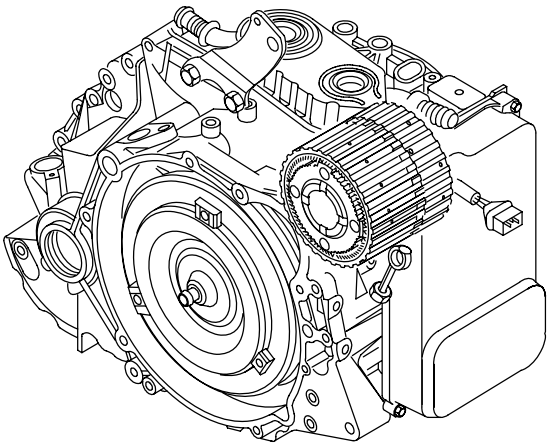
To provide four forward gears and one reverse gear, the 4HP20 transmission consists of a SIMPSON type epicyclic gear train. This consists of two simple epicyclic gear trains which are connected together.

There are:

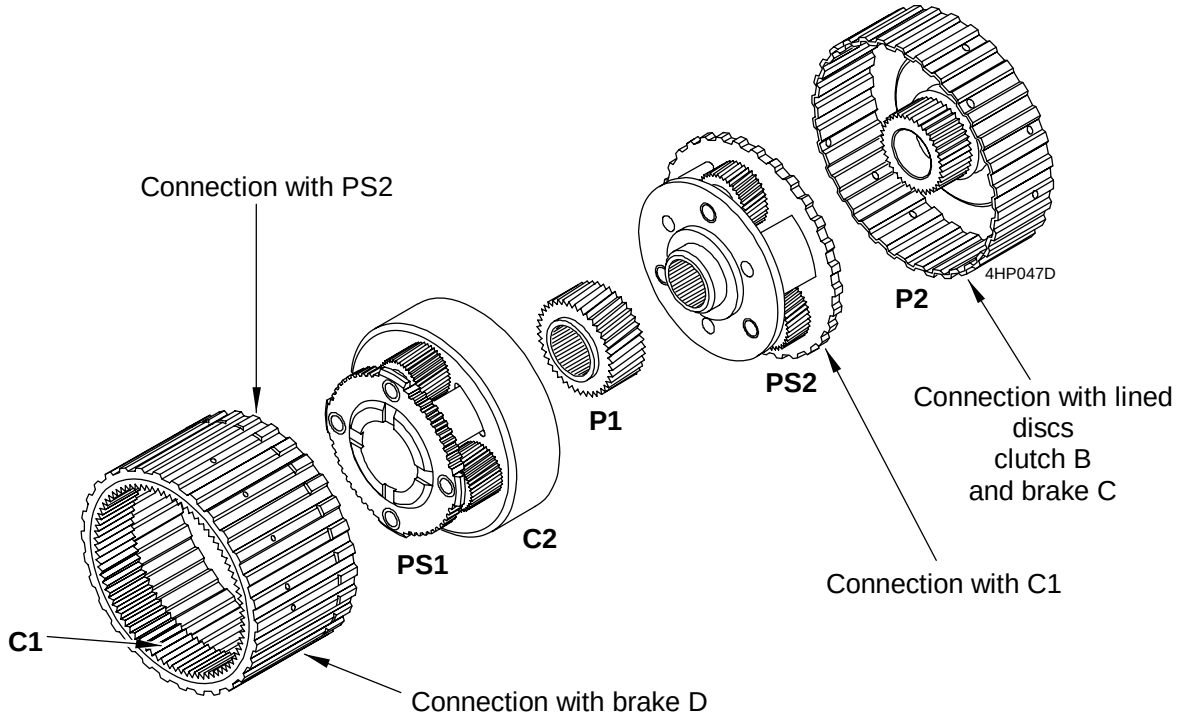
- two sunwheels P1 and P2,
- two sets of planet wheels S1 and S2,
- two planet wheel carriers PS1 and PS2,
- two rings C1 and C2.

The two gear trains are connected in the following way:

- the planet wheel carrier PS1 and the ring C2 are joined together,
- the planet wheel carrier PS2 and the ring C1 are joined together.



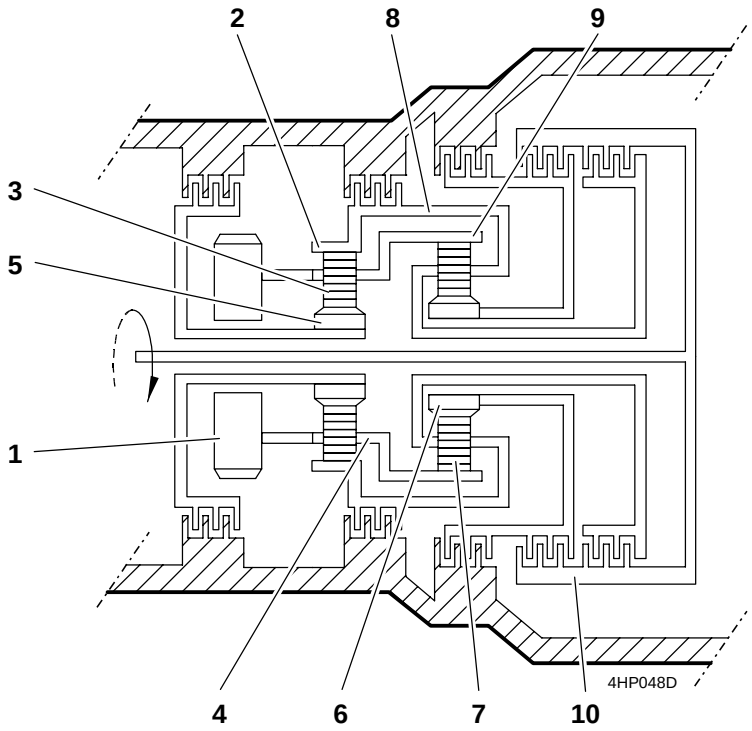
4HP046C



Specifications of gear train:

Sunwheel **P1**	39 teeth
Sunwheel **P2**	37 teeth
Planet wheel **S1**	21 teeth
Planet wheel **S2**	29 teeth
Ring **C1**	81 teeth
Ring **C2**	95 teeth

B - DESCRIPTION



1 - Step-down gear output gear
2 - Ring C1 of gear train n°1
3 - Planet wheel S1 of gear train n°1
4 - Planet wheel carrier PS1 of gear train n°1
5 - Sunwheel P1 of gear train n°1
6 - Sunwheel P2 of gear train n°2
7 - Planet wheel S2 of gear train n°2
8 - Planet wheel carrier PS2 of gear train n°2
9 - Ring C2 of gear train n°2
10 - Movement input housing

III - BRAKES AND CLUTCHES

To obtain the various gear ratios:

- PS2 - C1 must be a driving, free or reaction component
- P2 must be a driving, free or reaction component
- P1 must be a free or reaction component

In practice, the various shafts are locked or driven by "oil pressure multiplate" type receivers which are either operated or not by the hydraulic control components.
These receivers are divided into two families:

- Clutches B and E which are used to couple the driving element to the turbine shaft of the converter.
- Brakes F, D, and C which are used to lock the reaction element by coupling it to the housing.

C1 - PS2 can be: - driven by E
- locked by D

P2 can be: - driven by B
- locked by C

P1 can be locked by F
The clutches and brakes use the same technology and have:

- A succession of smooth steel discs and lined discs
  - the lined discs are connected to the receiver through a disc carrier plate,
  - the smooth discs are coupled to: - the housing → brakes
    - the input housing → clutches

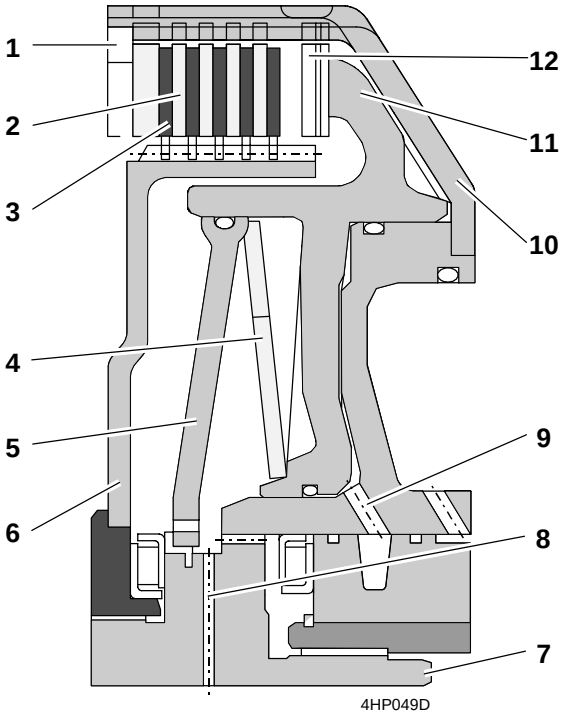
Contact of the discs between each other provides a driving action (clutch) or locking action (brake).
The number of these discs depends on the engine torque to be transmitted.

- A piston is moved by the oil pressure and returned by a diaphragm spring. The piston comes into contact with all the smooth and lined discs of the clutch or the brake.

Seals are used to seal the unit.

The clutches or brakes are supplied with oil through channels located in the shafts or in the transmission housing.

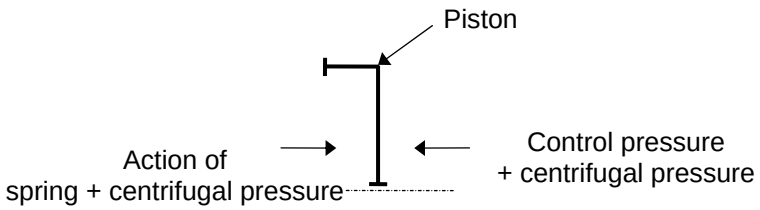
Example: Description of a clutch



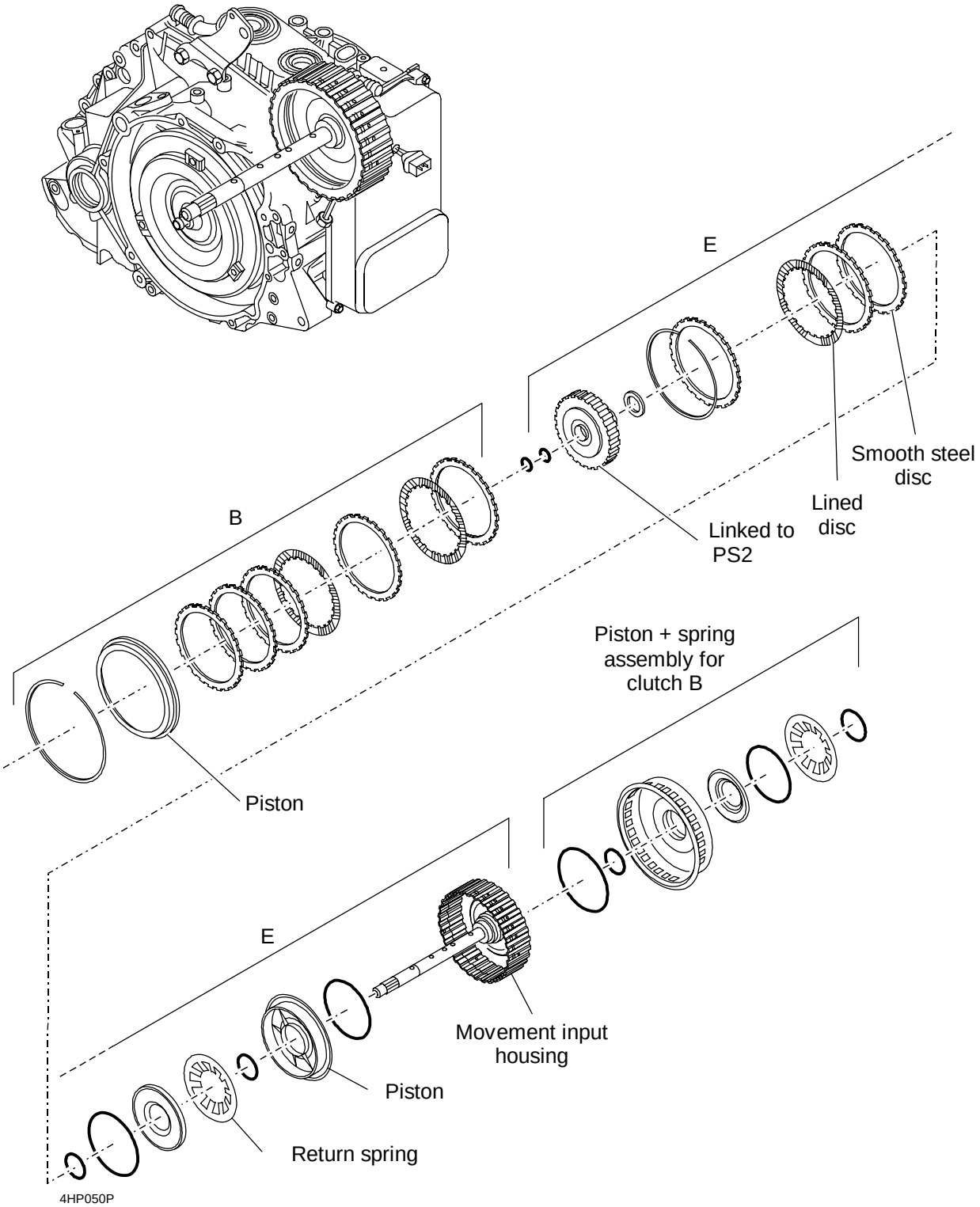
1 - Spring ring
2 - Steel disc
3 - Lined disc
4 - Spring - washer
5 - Stop washer
6 - Disc carrier plate
7 - Input shaft
8 - Oil supply for dynamic pressure balance
9 - Clutch oil supply
10 - Cylinder
11 - Piston
12 - Spring - disc

Feature: Dynamic pressure balance.
Clutches B and E are balanced in dynamic pressure since this pressure is the same on either side of the piston.
Process: The gap between the stop washer and the piston is filled with non pressurised oil. A dynamic pressure which depends on the engine speed is then step up. The gap between the piston and the cylinder is filled with pressurised oil by the control valve. A dynamic pressure is also set up but the static pressure controlling the clutch also exists at the same time. When the static pressure falls, the piston returns to its initial position under the action of the spring-washer.
The advantages of the dynamic pressure balance are the following:

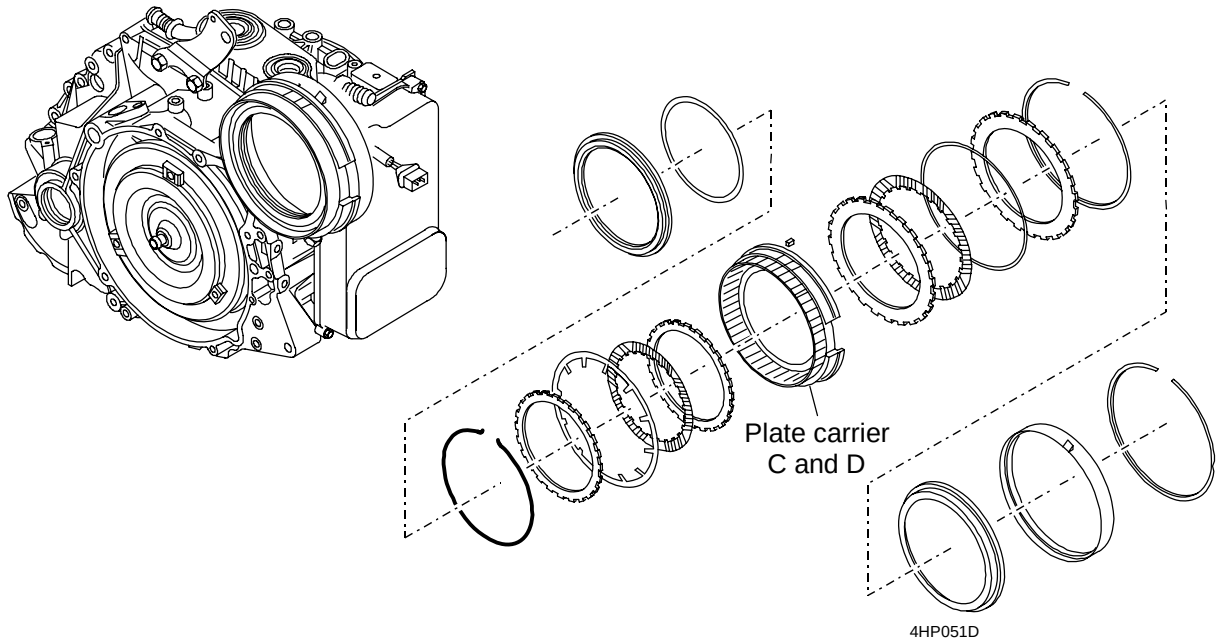
- Certain opening of the clutch in all engine speed ranges.
- Greatly improved gear changing quality.



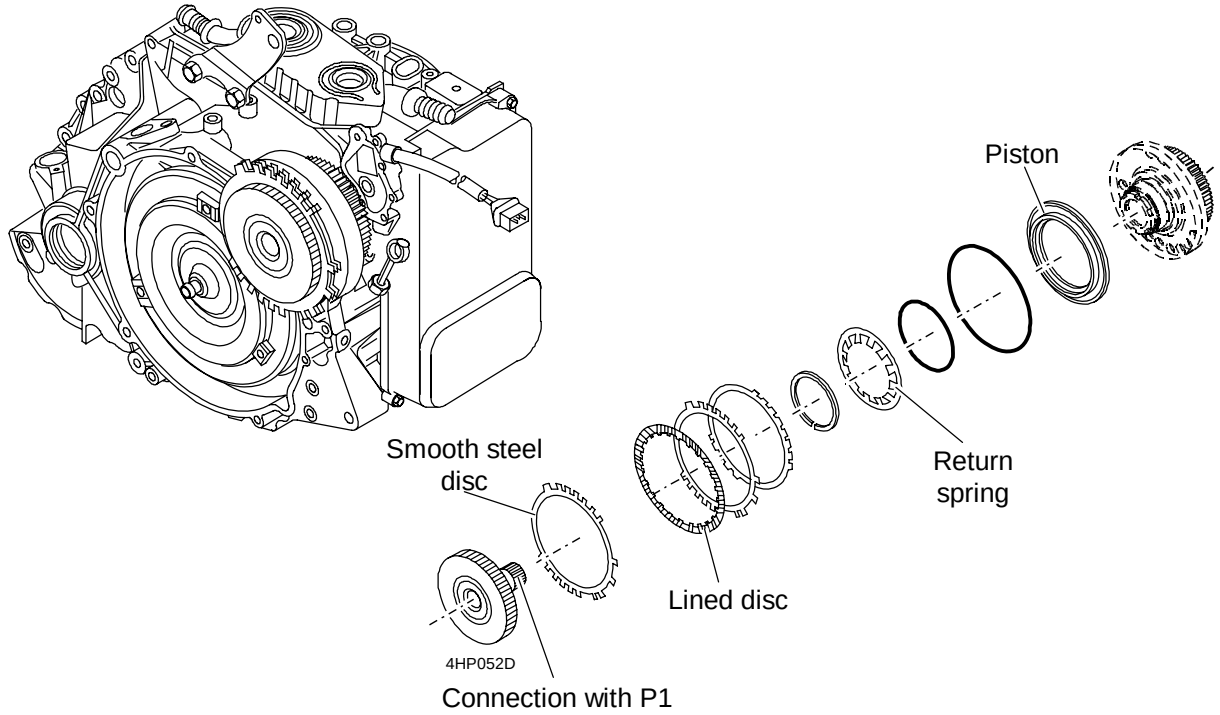
Clutches B and E



Brakes C and D

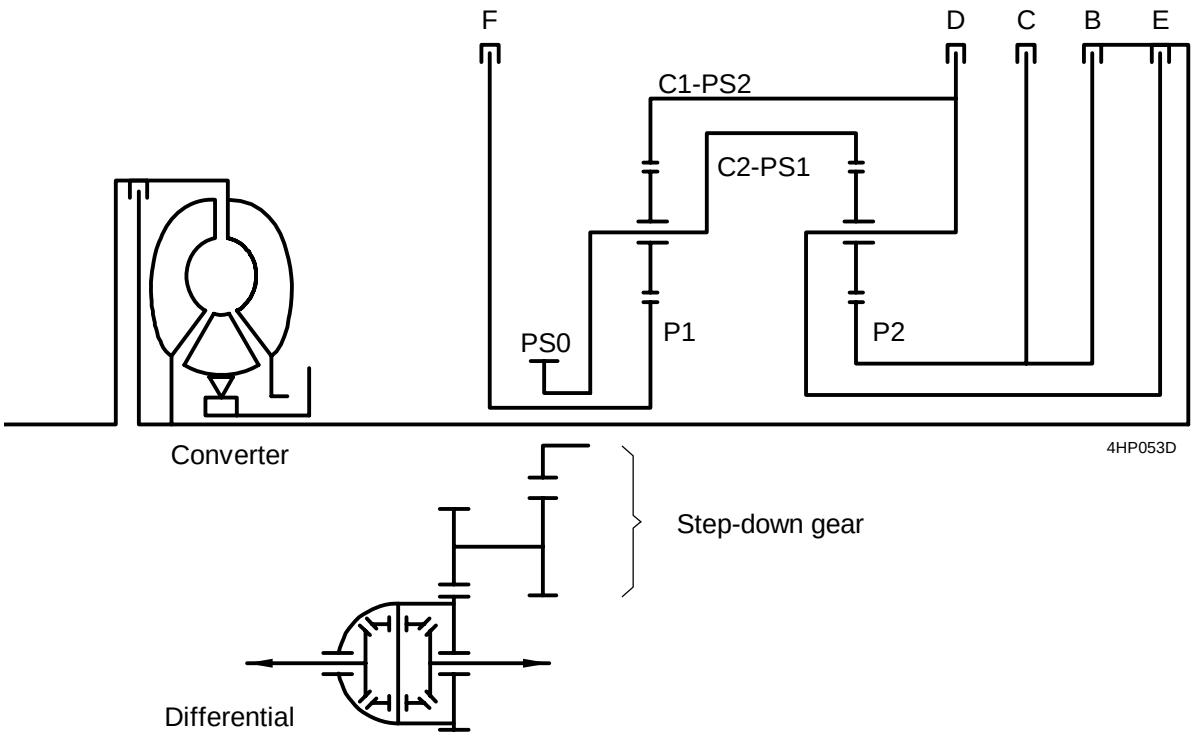


Brake F



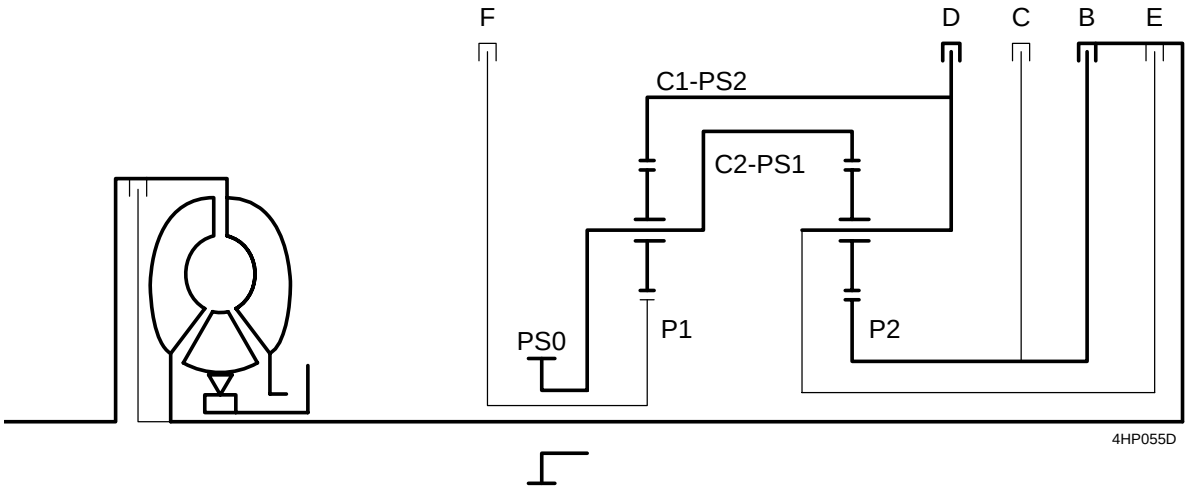
IV - OBTAINING THE GEARS

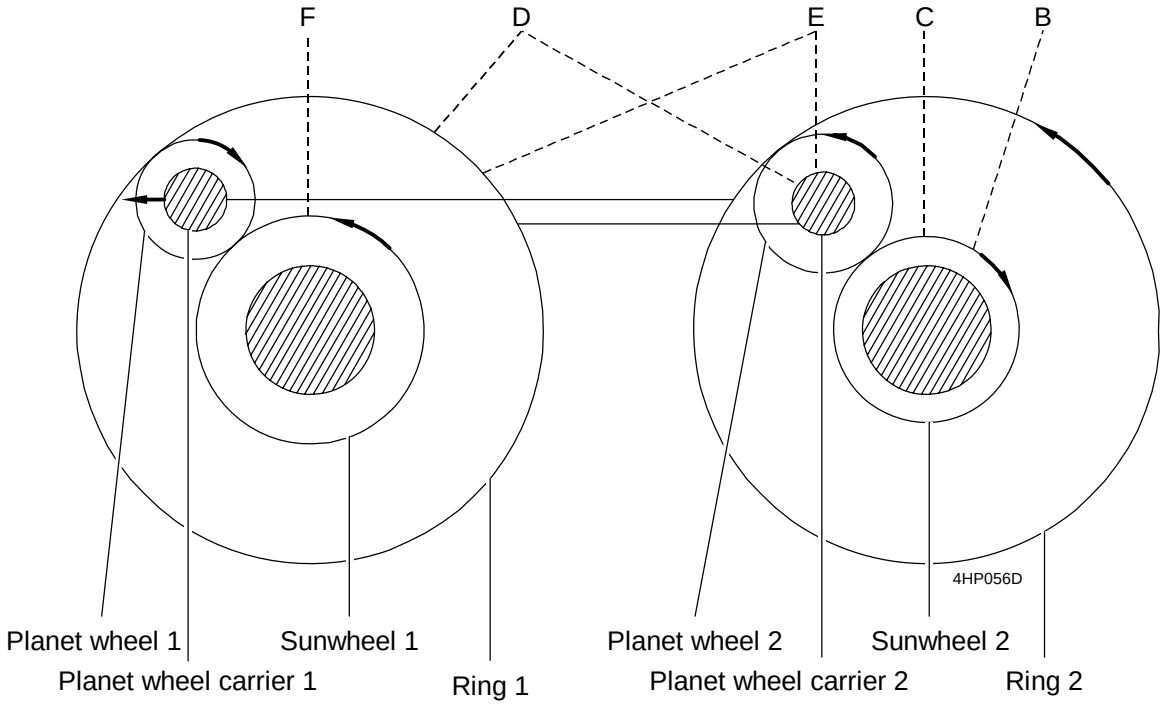
A - OPERATING DIAGRAM OF THE AUTOMATIC TRANSMISSION



PSO: Transmission output gear

B - REVERSE GEAR

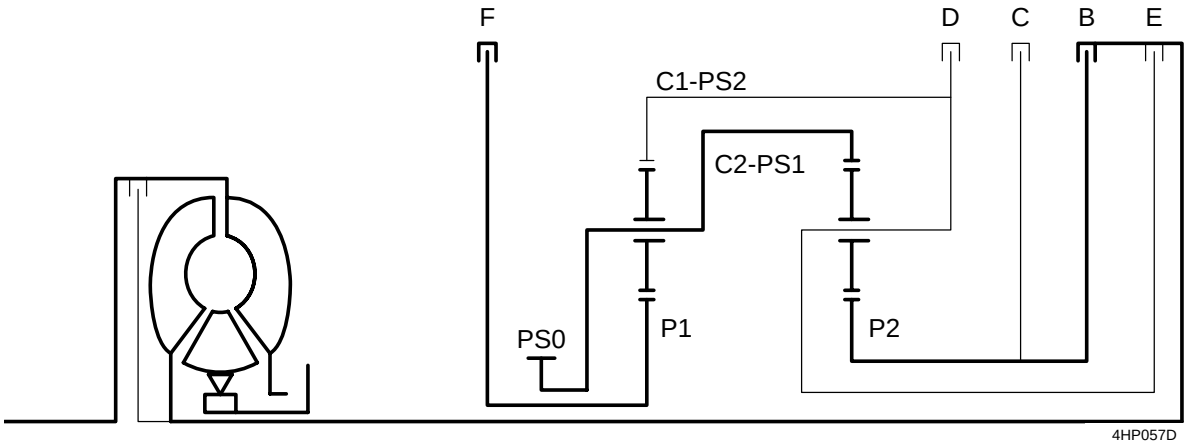


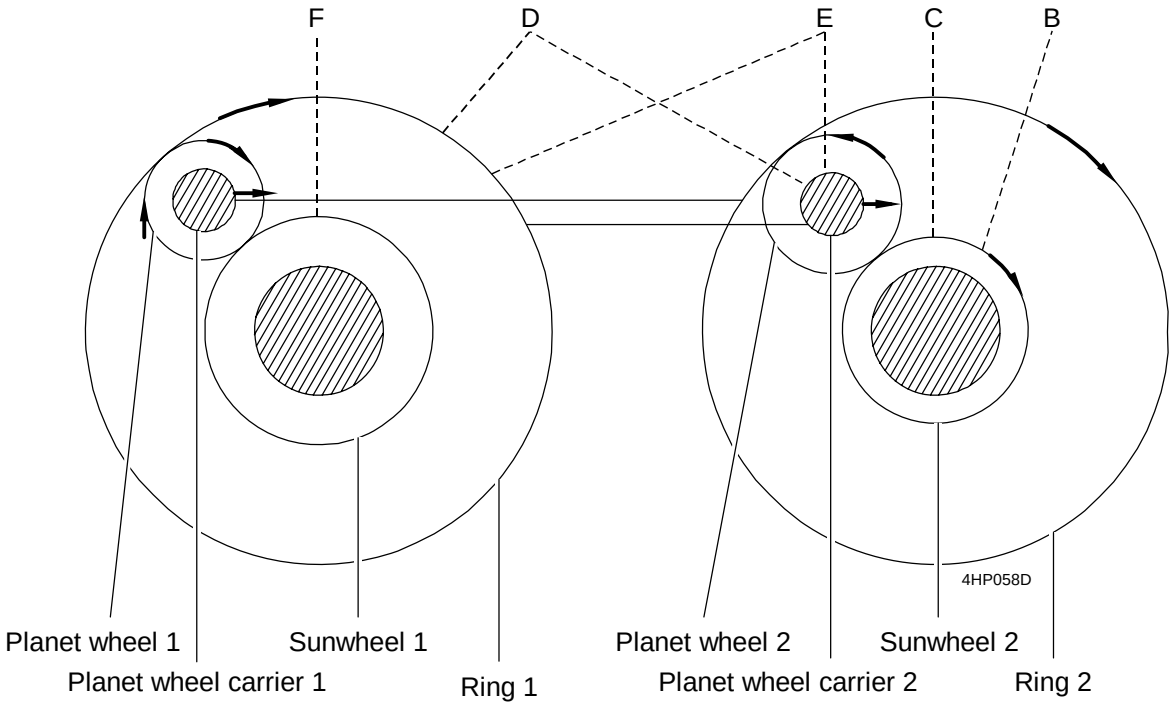


- Drive element P2
- Reaction element PS2 -C1
- P2 → S2
- S2 → C2 - PS1. The planet wheels S1 rotate inside C1
- PS1 → PS0
- PS0/PS1 -C2 turns in the opposite direction to P2
- Demultiplication ratio: - 2.568

Note: The lock-up is systematically open.

C - 1ST GEAR

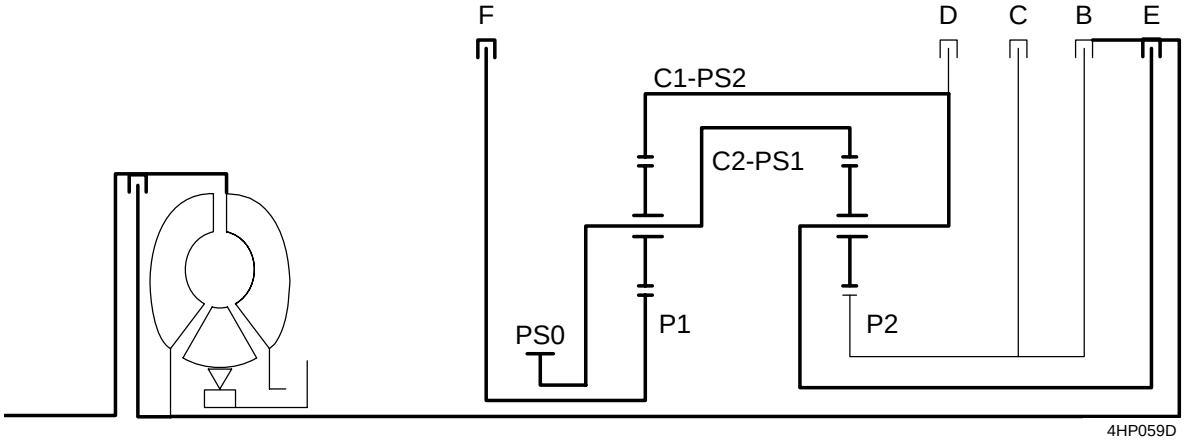


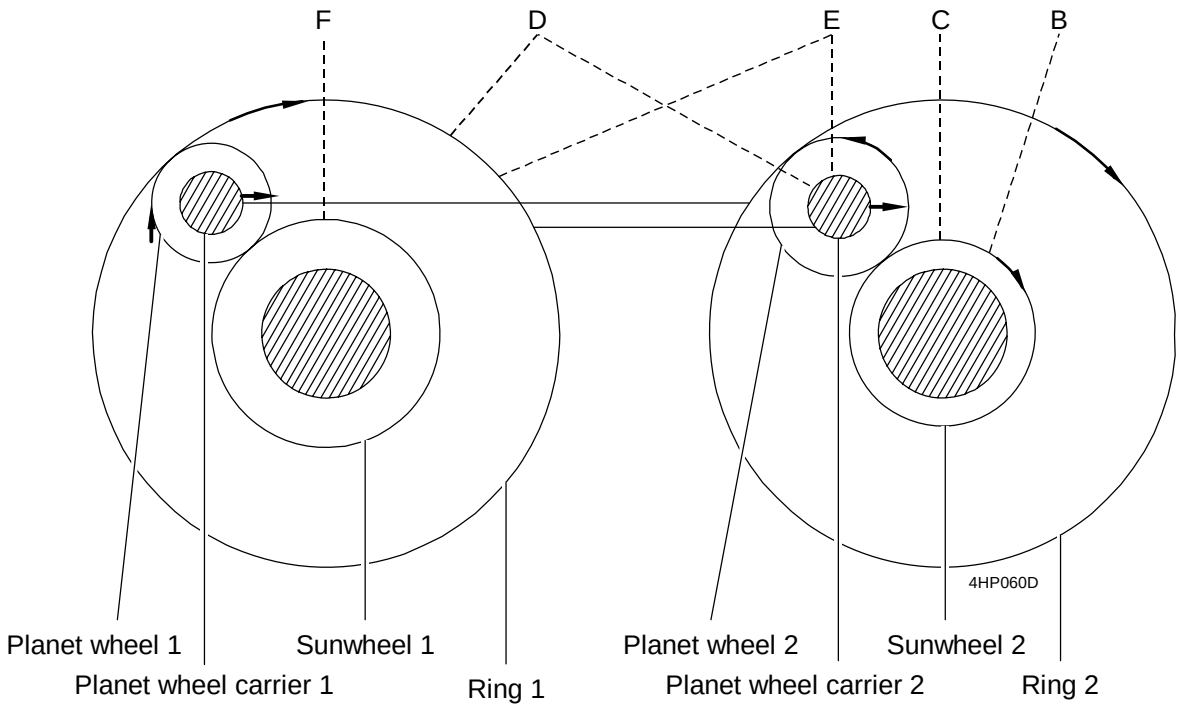


- Drive element P2
- Reaction element P1
- P2 → S2
- S2 → C2 - PS1
- PS1 wants to drive the planet wheels S1
- The teeth of the planet wheels S1 butt up against the teeth of locked P1; the planet wheels S1 therefore rotate around P1
- PS1 → PS0
- PS0/PS1 -C2 turns in the same direction as P2
- Demultiplication ratio: 2.718

Note: The lock-up is systematically open

D - 2ND GEAR

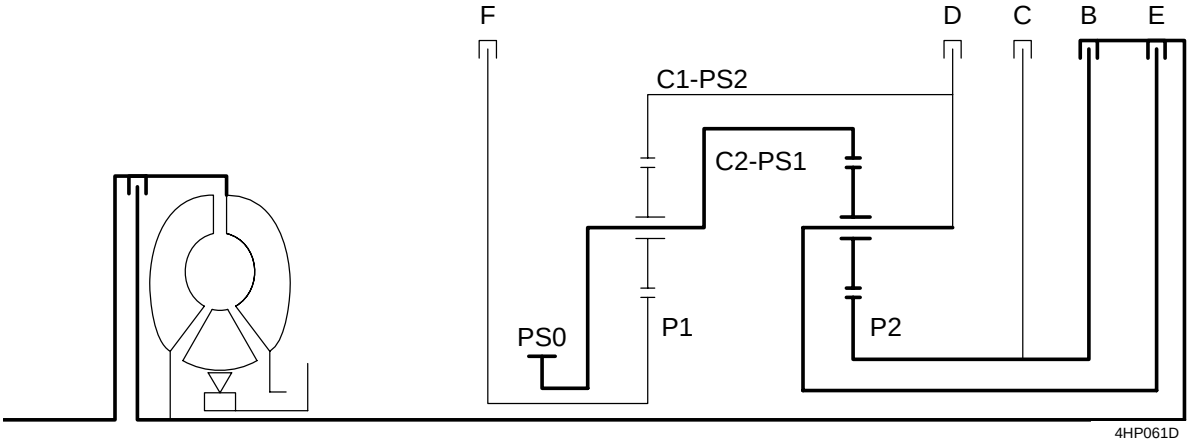


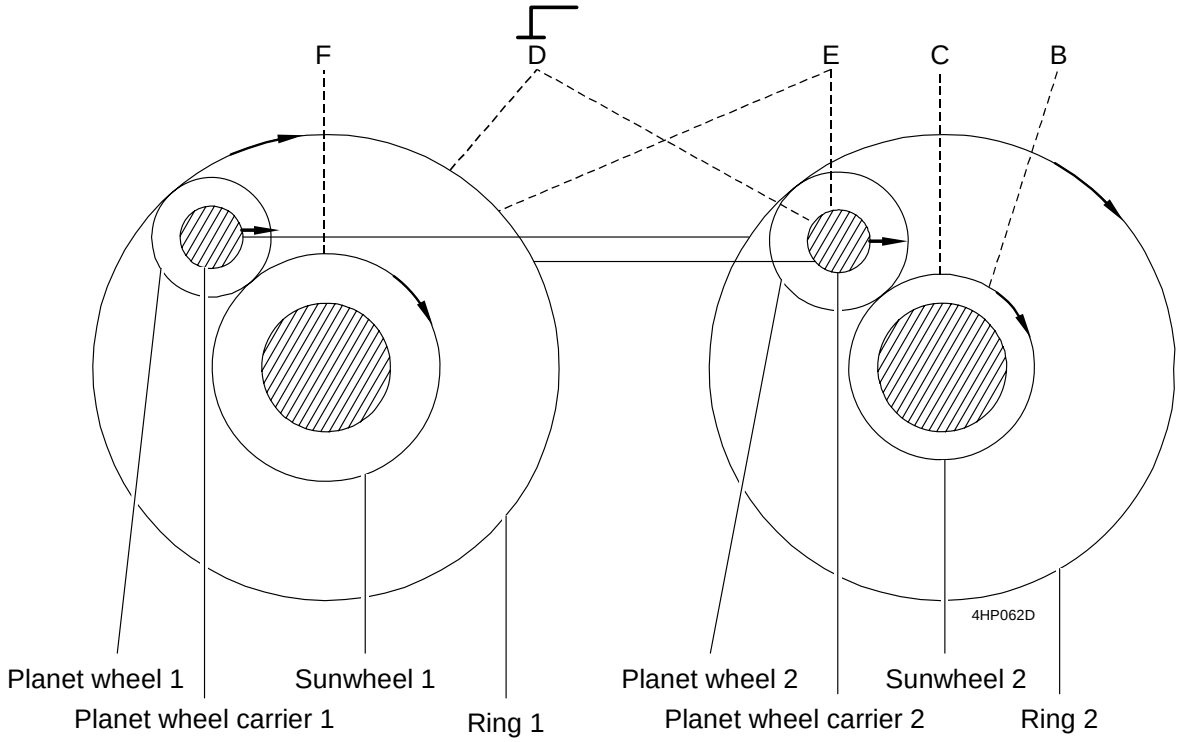


- Drive element C1 - PS2
- Reaction element P1
- PS2 - C1 → S1
- The teeth of the planet wheels S1 butt up against the teeth of locked P1; the planet wheels S1 therefore rotate around P1
- S1 → PS1
- PS1 → PS0
- PS0/PS1 - C2 turns in the same direction as PS2
- Demultiplication ratio: 1.481

Note: The lock-up can either be open, controlled or closed.

E - 3RD GEAR

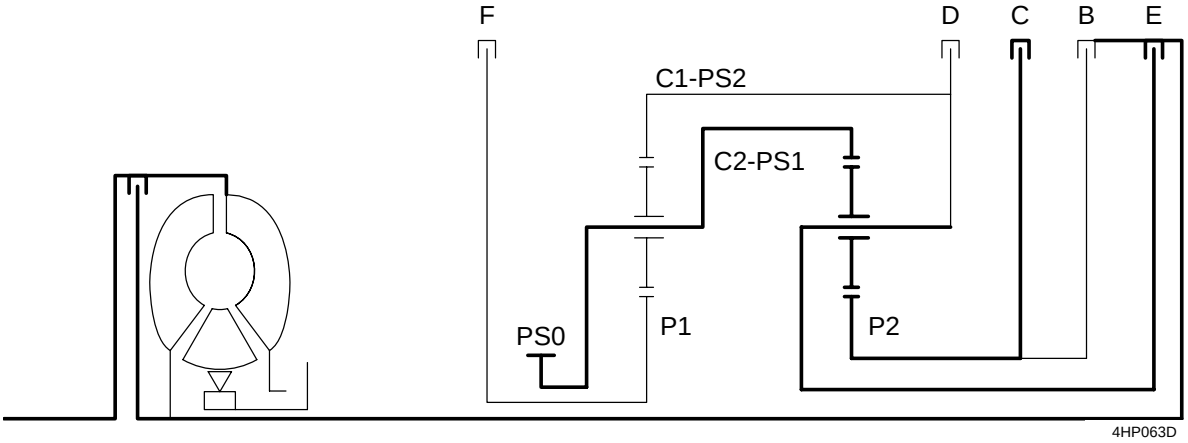


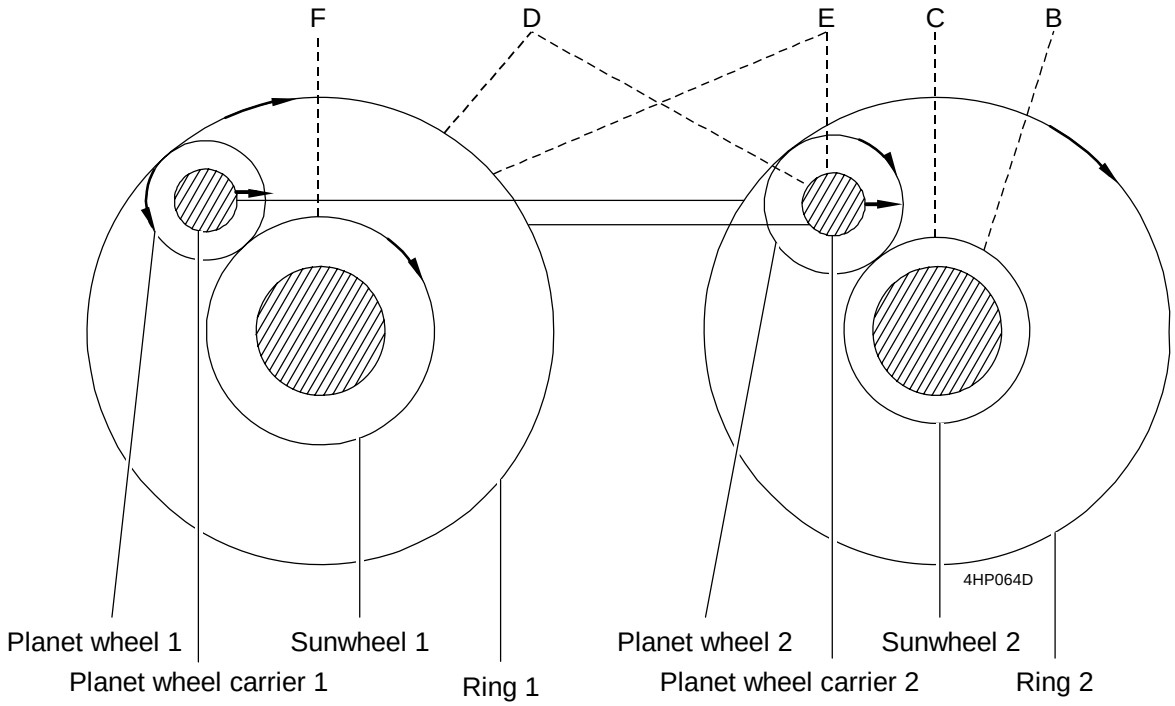


- Drive elements PS2 - C1 and P2
- The planet wheels S2 are driven by PS2 and P2; they therefore cannot rotate about themselves.
- S2 → C2 - PS1. PS1 and PS2 turn together.
- PS1 → PS0
- PS0/PS1 turns in the same direction and PS2. This is therefore direct drive.
- Demultiplication ratio: 1

Note: The lock-up can either be open, controlled or closed.

F - 4TH GEAR





- Drive element PS2 - C1
- Reaction element P2
- PS2 wants to drive the planet wheels S2
- The teeth of the planet wheels S2 butt up against the teeth of locked P2; the planet wheels S2 therefore rotate around P2
- S2 $\rightarrow$ C2 - PS1
- PS1 $\rightarrow$ PS0
- PS0/PS1 -C2 turns in the same direction as PS2
- Demultiplication ratio: 0.720

G - DEMONSTRATION

1st GEAR

For gear train 2

$$\frac{\omega C2 - \omega PS2}{\omega P2 - \omega PS2} = -\frac{37}{95}$$

For gear train 1

$$\frac{\omega C1 - \omega C2}{\cancel{\omega P1} - \omega C2} = -\frac{39}{81} \quad (\omega C2 = \omega PS1)$$

$$\Rightarrow \omega C1 - \omega C2 = \frac{39}{81}\ \omega C2$$

$$\Rightarrow \omega C1 = \frac{120}{81}\ \omega C2 \Rightarrow \omega C2 = \frac{81}{120}\ \omega C1$$

$$\frac{\frac{81}{120}\omega C1 - \omega PS2}{\omega P2 - \omega PS2} = -\frac{37}{95}$$

$$\Rightarrow \frac{81}{120}\ \omega C1 - \omega PS2 = -\frac{37}{95}\ \omega P2 + \frac{37}{95}\ \omega PS2$$

$$\Rightarrow \frac{81}{120}\ \omega C1 = -\frac{37}{95}\ \omega P2 + \frac{132}{95}\ \omega PS2$$

$$\Rightarrow \omega C1 = -\frac{37 \times 120}{95 \times 81}\ \omega P2 + \frac{132 \times 120}{95 \times 81}\ \omega PS2 \text{ however } \omega PS2 = \omega C1$$

$$\Rightarrow \omega C1 - \frac{15840}{7695}\ \omega C1 = -\frac{4440}{7695}\ \omega P2$$

$$\Rightarrow -\frac{8145}{7695}\ \omega C1 = -\frac{4440}{7695}\ \omega P2$$

$$\Rightarrow \omega C1 = \frac{4440 \times 7695}{7695 \times 8145}\ \omega P2$$

$$\Rightarrow \boxed{\omega C1 = \frac{4440}{8145}\ \omega P2}$$

Therefore, for gear train 1:

$$\frac{\omega C1 - \omega PS1}{\cancel{\omega P1} - \omega PS1} = -\frac{39}{81}$$

$$\Rightarrow \omega C1 - \omega PS1 = \frac{39}{81}\ \omega PS1$$

$$\Rightarrow \omega C1 = \frac{120}{81}\ \omega PS1$$

$$\Rightarrow \underset{\omega C1}{\underset{||}{\frac{4440}{8145}}}\ \omega P2 = \frac{120}{81}\ \omega PS1$$

$$\Rightarrow \omega P2 = \frac{120 \times 8145}{81 \times 4440}\ \omega PS1$$

$$\Rightarrow \omega P2 = \frac{977400}{359640}\ \omega PS1$$

$$\hookrightarrow \approx 2.718$$

2nd GEAR

$$\frac{\omega C1 - \omega PS1}{\cancel{\omega P1} - \omega PS1} = -\frac{39}{81}$$

$$\Rightarrow \omega C1 - \omega PS1 = \frac{39}{81}\ \omega PS1$$

$$\Rightarrow \omega C1 = \frac{120}{81}\ \omega PS1$$

$$\hookrightarrow = 1.481$$

3rd GEAR

$$\frac{\omega C2 - \omega PS2}{\omega P2 - \omega PS2} = -\frac{37}{95}$$

$$\Rightarrow \omega C2 - \omega PS2 = \frac{37}{95}\ \omega PS2 - \frac{37}{95}\ \omega P2$$

$$\Rightarrow \omega C2 = \frac{132}{95}\ \omega PS2 - \frac{37}{95}\ \omega P2 \text{ however, } \omega P2 = \omega PS2$$

$$\Rightarrow \omega C2 = \frac{132}{95}\ \omega PS2 - \frac{37}{95}\ \omega PS2$$

$$\Rightarrow \omega C2 = \frac{95}{95}\ \omega PS2 \Rightarrow \omega C2 = \omega PS2 = 1 \Rightarrow \text{Direct drive}$$

4th GEAR

$$\frac{\omega C2 - \omega PS2}{\cancel{\omega P2} - \omega PS2} = -\frac{37}{95}$$

$$\Rightarrow \omega C2 - \omega PS2 = \frac{37}{95}\ \omega PS2$$

$$\Rightarrow \omega C2 = \frac{132}{95}\ \omega PS2$$

$$\Rightarrow \omega PS2 = \frac{95}{132}\ \omega C2$$

$$\hookrightarrow \approx 0.720$$

Reverse gear

$$\frac{\omega C2 - \cancel{\omega PS2}}{\omega P2 - \cancel{\omega PS2}} = -\frac{37}{95}$$

$$\Rightarrow \omega C2 = -\frac{37}{95}\ \omega P2$$

$$\Rightarrow \omega P2 = -\frac{95}{37}\ \omega P2$$

$$\hookrightarrow \approx 2.568$$

H - SUMMARY

Table of operated components

GEAR	DRIVE ELEMENT	REACTION ELEMENT	RATIOS
1	**P2**	**P1**	2.718
2	**C1-PS2**	**P1**	1.481
3	**P2** and **C1-PS2**	none	1
4	**C1-PS2**	**P2**	0.720
Reverse	**P2**	**C1-PS2**	2.568

The assembly **C2-PS1** forms the output element.

Table of operated clutches and brakes:

		CLUTCHES		BRAKES		
GEAR		**B**	**E**	**C**	**D**	**F**
P		**X**				
R		**X**			**X**	
N		**X***				
D	1st	**X**				**X**
	2nd		**X**			**X**
	3rd	**X**	**X**			
	4th		**X**	**X**		
3	1st	**X**				**X**
	2nd		**X**			**X**
	3rd	**X**	**X**			
2	1st	**X**				**X**
	2nd		**X**			**X**
1	1st	**X**				**X**

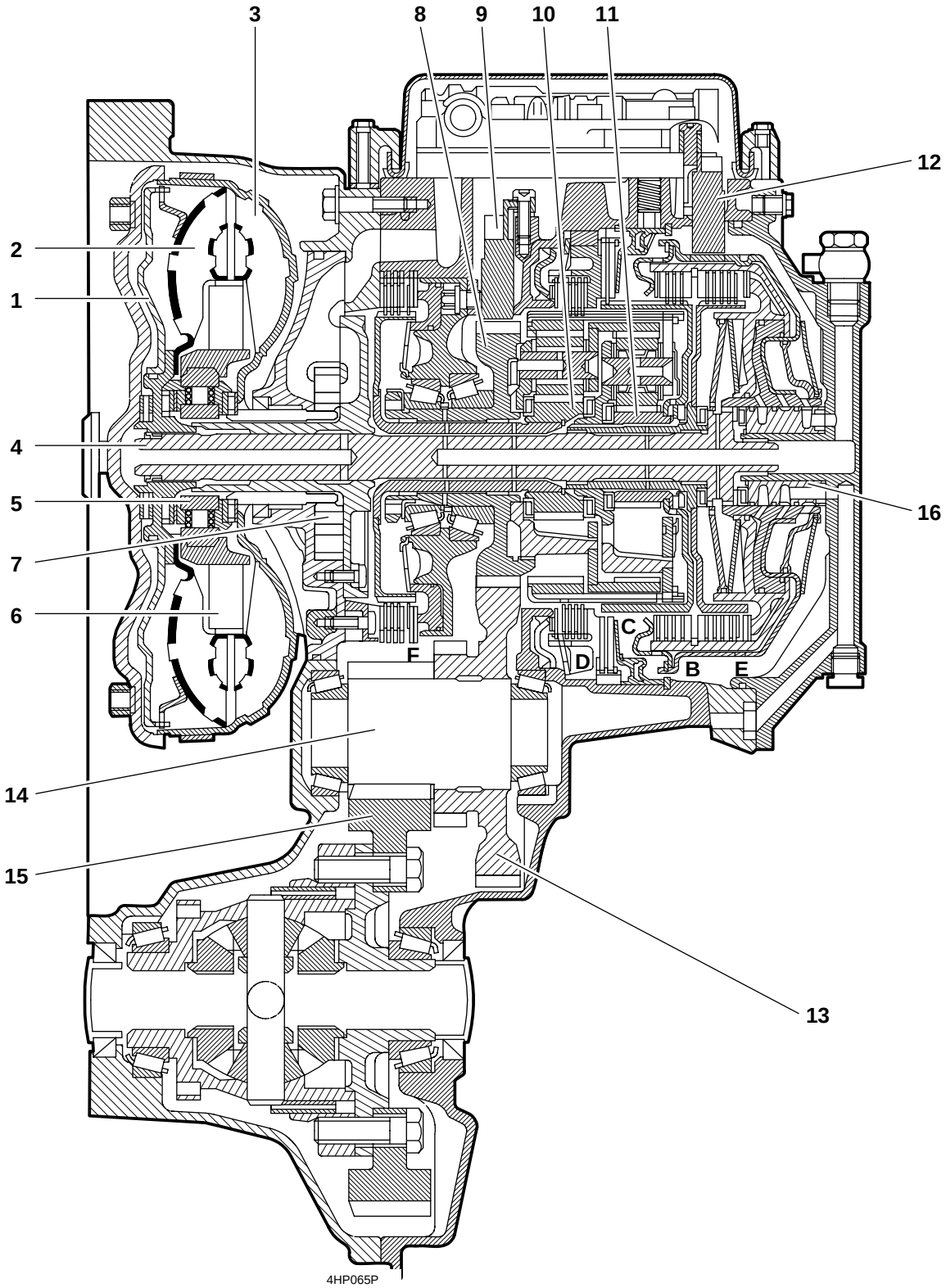
* Except in Snow program

Note: In 1st automatic, there is an engine brake.

Note: The architecture of the epicyclic gear train means that a 5th gear can be obtained by adding a clutch.

Note: In P and N*, clutch B is supplied in order to anticipate the next gear being engaged (R or 1).

V - COMPLETE OVERVIEW OF THE AUTOMATIC TRANSMISSION



A - PARTS LIST

1 - Lock-up piston
2 - Turbine
3 - Pump
4 - Movement input shaft
5 - Free wheel
6 - Stator
7 - Oil pump
8 - Step-down gear output gear
9 - Transmission output speed sensor
10 - Epicyclic gear train n°1
11 - Epicyclic gear train n°2
12 - Transmission input or turbine speed sensor
13 - Step-down gear intermediate gear
14 - Drive pinion
15 - Differential ring
16 - Clutch supply ring

ZF 4HP20 AUTOMATIC TRANSMISSION

THE HYDRAULIC CIRCUIT

I - FUNCTIONS

The essential elements of the hydraulic circuit are:

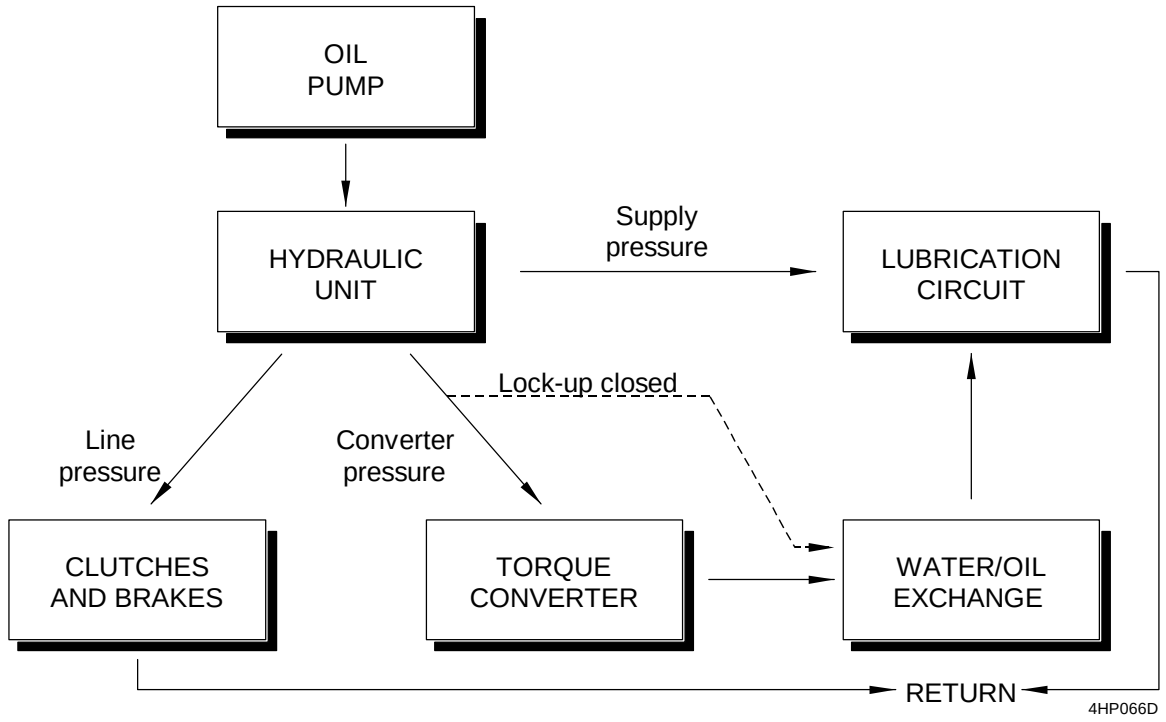
- the oil pump,
- the hydraulic distributor (or unit).

The role of these elements is to:

- supply the clutches and the brakes,
- supply and control the converter,
- supply the transmission lubrication circuit,
- cool the transmission by circulating oil through a heat exchanger.

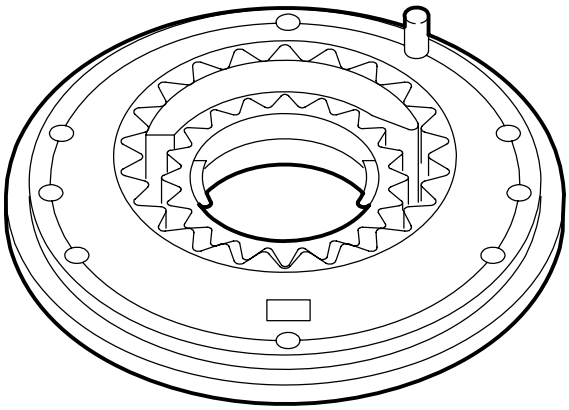
There are therefore three types of pressure in the hydraulic circuit:

- the supply pressure for the lubrication circuit,
- the converter pressure for supplying and controlling it,
- the line pressure, in other words, the pressure set up on the pistons of the operated brakes and clutches.



II - OIL PUMP

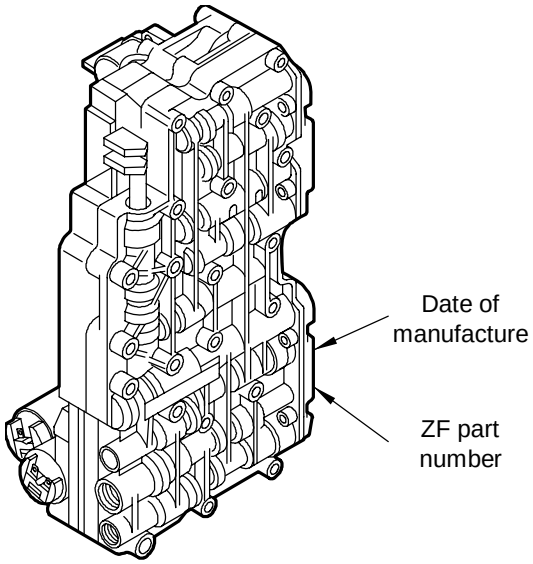
Crescent shaped internal gear oil pump, driven by the converter impeller and therefore operates as soon as the engine is running.
Its flow is proportional to the speed of rotation. The oil is drawn into the lower part of the mechanism housing through a strainer. This is designed not to be replaced throughout the vehicle's life.
The pressure generated by the oil pump has to be limited by regulating slide valves.
A SPIE seal is used to seal the primary shaft. A paper seal is used to seal the housing.



4HP068C

III - THE HYDRAULIC UNIT

A - ROLE



The hydraulic unit performs the following functions:

- regulates the control line pressure of the brakes and clutches,
- controls the brakes and clutches in order to obtain the various gears by using electrovalves and slide valves,
- provides a reduced emergency function (purely hydraulic) of the transmission in the event of problems,
- controls the converter lock-up clutch,
- generates the lubrication pressure for the transmission.

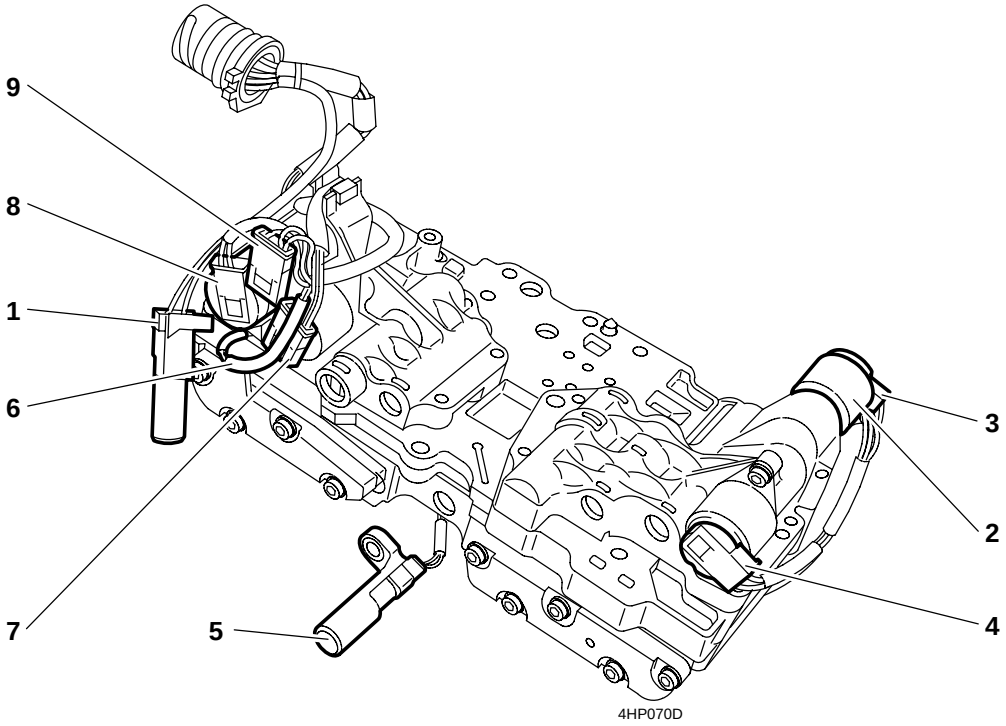
B - COMPOSITION

The hydraulic unit consists of:

- a selector slide valve (WS),
- a main pressure valve (SYS.DR - V),
- a pressure reducing valve (DR.RED - V),
- a safety valve (SIV),
- a gear control valve (SV),
- a converter pressure valve (WD -V),
- a converter control valve (WD - SV),
- a converter clutch valve (WK -V),
- a lubrication valve (SCHM - V),
- five clutch valves KV - B/C/D/E/F,
- five holding valves HV - B/C/D/E/F,
- four dampers,
- four proportional electrovalves or regulators (EDS3/4/5/6),
- two all or nothing electrovalves (MV 1/2).

C - DESCRIPTION

1 - External appearance



1 - Automatic transmission output speed sensor connector

2 - Regulator number 6 (EDS6)

3 - Electrovalve MV1

4 - Regulator number 4 (EDS4)

5 - Automatic transmission input speed sensor

6 - Oil temperature probe

7 - Regulator number 3 (EDS3)

8 - Electrovalve MV2

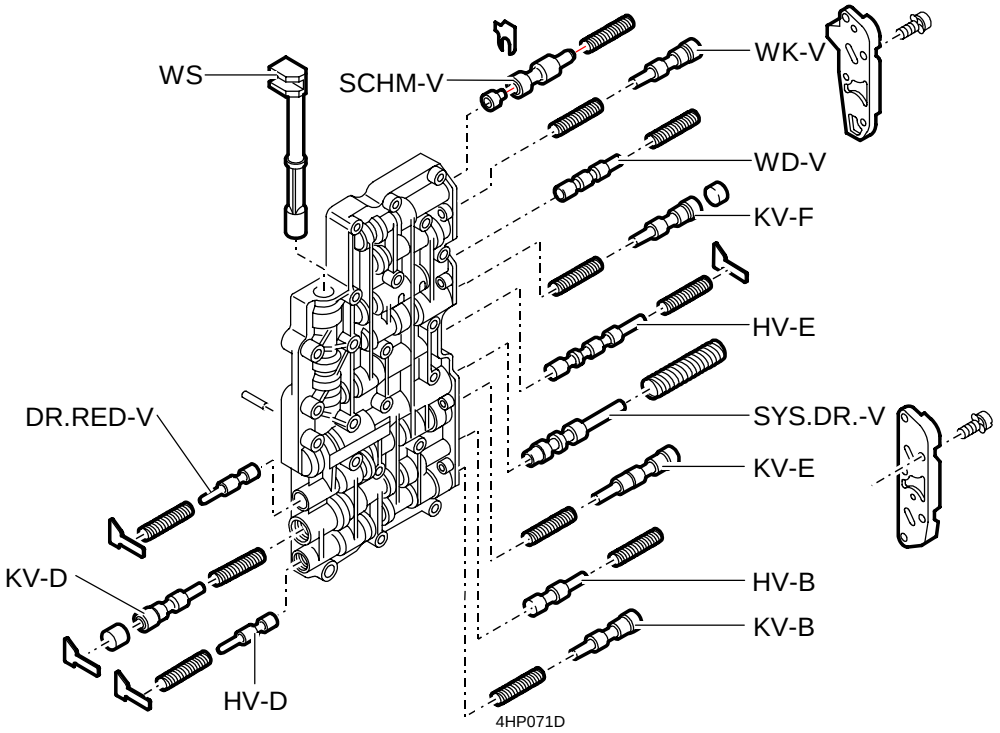
9 - Regulator number 5 (EDS5)

Note: - Regulators 3, 5 and 6 are the same; regulator 4 operates in the opposite manner with respect to the three others.

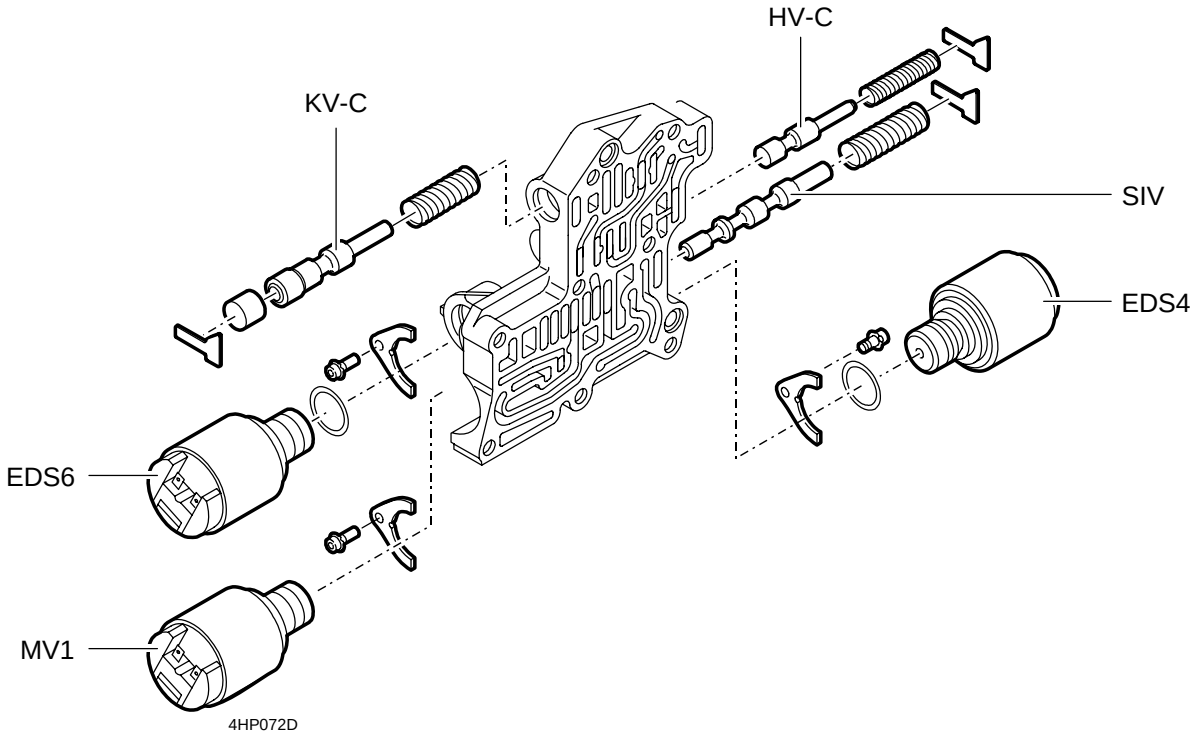
- The 2 electrovalves are the same.

- The black rings identify the regulators; the green rings identify the electrovalves.

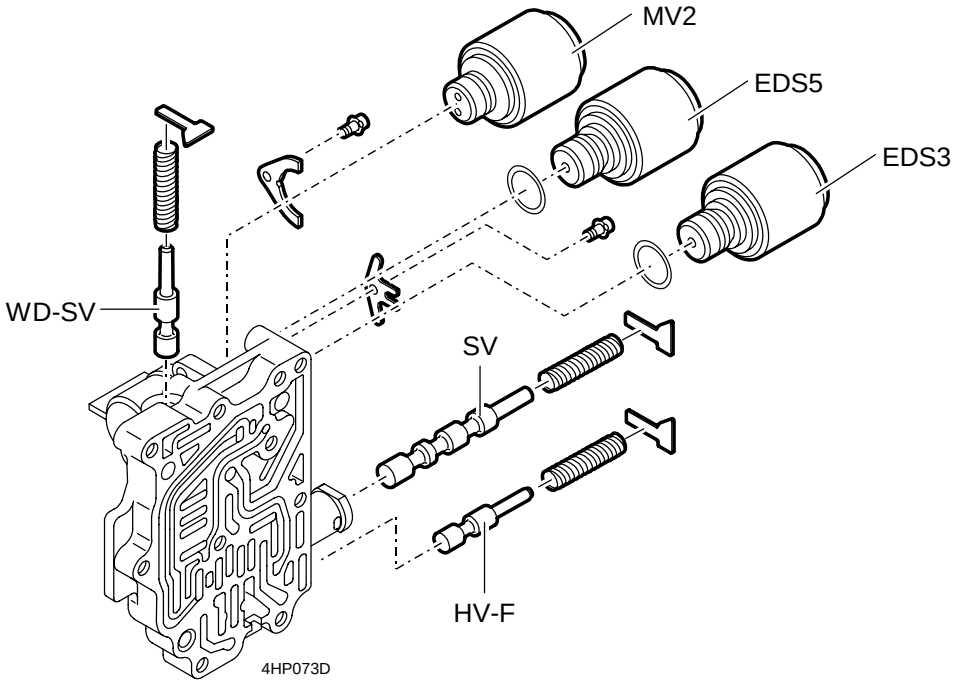
2 - Internal components



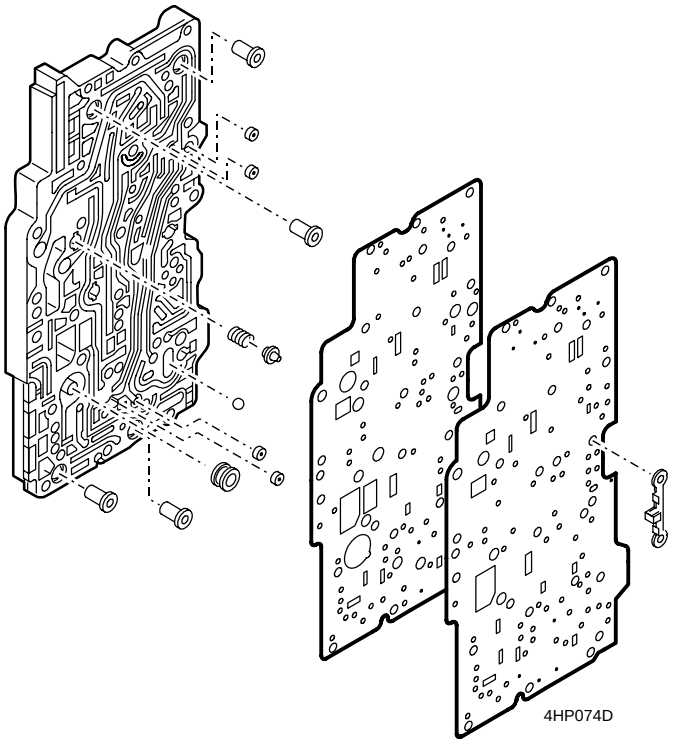
In the upper part of the hydraulic unit there is the selector valve WS and the various slide valves along with their springs.



Housing along with its electrovalve MV1 and its pressure regulators EDS4 - EDS6.

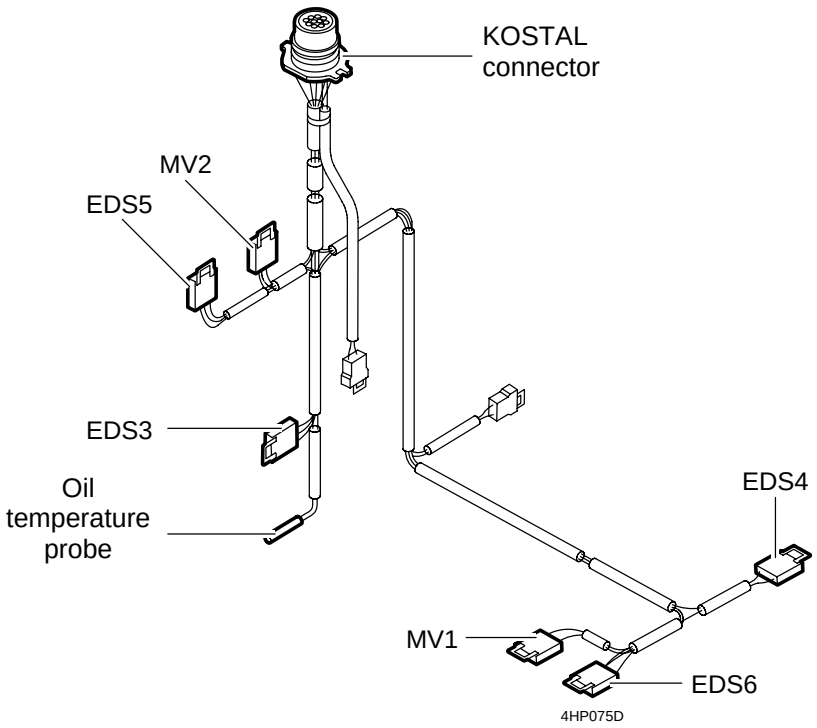


Housing along with its electrovalve MV2 and its pressure regulators EDS5 - EDS3.



Rear valve housing along with its dampers and its adjusters.

3 - Harness



Electrical harness of the hydraulic unit consisting of various connectors for the electrovalves, pressure regulators, input and output speed sensors as well as the oil temperature probe.

It is connected to the ECU harness by means of a KOSTAL type connector.

D - FUNCTION OF THE VARIOUS ELEMENTS

1 - Selector slide valve WS

This "informs" the hydraulic unit of the position of the selector lever. It only affects the hydraulics in the followings positions:
- P
- R
- N
- D

Everything occurs electrically for positions 1, 2 and 3.

2 - Main pressure valve SYS.DR - V

This determines the maximum level of the main operating pressure. When not changing gear, the main pressure may have two maximum levels depending on the turbine torque. The main pressure valve firstly supplies (before the maximum value is reached) the clutches and the brakes. Then, the oil for cooling and lubrication reaches the converter.

3 - Pressure reduction valve DR.RED - V

This reduces the main pressure designed to supply the all or nothing electrovalves and the pressure regulators. This allows small electrovalves to be used. Furthermore, the EDS require a constant supply pressure.

4 - Clutch slide valves KV

These provide the necessary oil flow for the clutch from a multiplate element (brake or clutch). They also allow the pressure corresponding to the gear ratio to be transmitted.

Case of slide valve KV -E

Its role is the same as the other slide valves KV but it differs in the following way. When the clutch pressure has been set up, the pressure limiting function is added to a maximum authorised valve (11 bar). This pressure, which is lower than the upper maximum allowable value of the main pressure, allows a smaller clutch to be used.

5 - Holding slide valves HV

These check that, for a fixed value of pressure in the proportional electrovalve EDS, the corresponding clutch valves allow gears to be changed and that the clutch pressure then increases up to the maximum value of main pressure.

Case of holding slide valve HV - E

These checks that, for a certain value of pressure defined by the proportional electrovalve EDS, the clutch valve E switches the pressure to the maximum allowable value.

Furthermore, the regulation range of the brake F is reduced in 2nd gear. The clutch valve C is supplied by the operating pressure.

6 - Gear control valve SV

Using this, the proportional electrovalve EDS 3 is used when changing from 1st to 2nd gear or for the converter lock-up clutch.

7 - Safety valve SIV

If an electrical fault occurs when driving, the brake C is engaged or else held by the safety valve if it was already engaged. Therefore, 4th gear is obtained in conjunction with the clutch E;

When restarting and in ECU emergency mode, the clutch B is pressurised by the safety valve. 3rd gear is therefore obtained in conjunction with the clutch E.

The safety valve has a holding function which is removed when restarting and is once again made active by the ECU.

8 - Converter pressure valve WD - V

This supplies the lubrication circuit with oil when the converter lock-up clutch is open. When the clutch is closed, it allows the oil to be drained from the gap between the clutch and the converter housing.

9 - Converter clutch valve WK - V

This is the valve which follows the proportional electrovalve EDS3 when the electrovalve MV2 is no longer energised.

The converter clutch valve is required to provide the flow necessary for the converter clutch. Furthermore, the pressure demultiplication which is required occurs through the converter clutch valve.

10 - Converter pressure control valve WD -SV

This is used to invert the direction of circulation of the oil supplying the converter, depending on whether the lock-up clutch is closed or not.

11 - Lubrication valve SCHM - V

This checks that, when the pump flow is low, the converter is supplied with cooled oil first. Furthermore, it provides, through a by-pass channel, the quantity of oil necessary for cooling and lubricating the transmission.

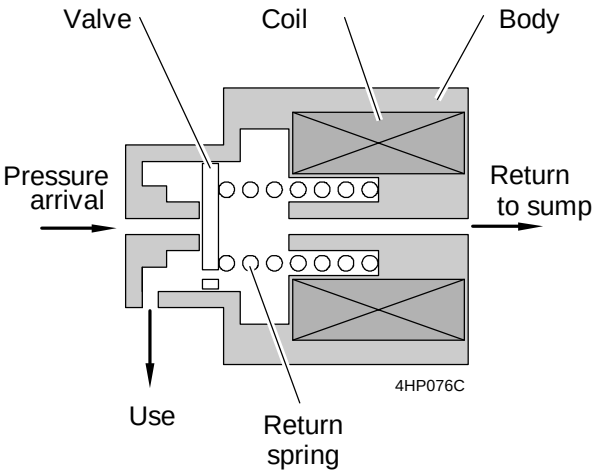
12 - All or nothing electrovalves MV1 - MV2

These are supplied with 12 volts and are controlled by being earthed by the ECU. These electrovalves are of 3/2 type, in other words, they have three connections but only two positions: open or closed.

At rest (not energised), they are closed $\rightarrow$ the main pressure is blocked. The operating channel is connected to the oil sump return. When energised (earthed), the coil creates a magnetic field. The valve is then attracted, its return spring compresses $\rightarrow$ the return channel is then blocked whilst the operating channel is connected to the main pressure.

During normal operation, MV1 is always energised and is so as soon as the ECU is powered up.

Diagram



- MV1 is used to obtain the two main pressure levels:
  - energised → low pressure level (7 bar),
  - not energised → high pressure level (16 bar).
- MV2 is used to lock clutch E in 2nd, 3rd and 4th gears as well as in 3rd hydraulic in emergency mode.

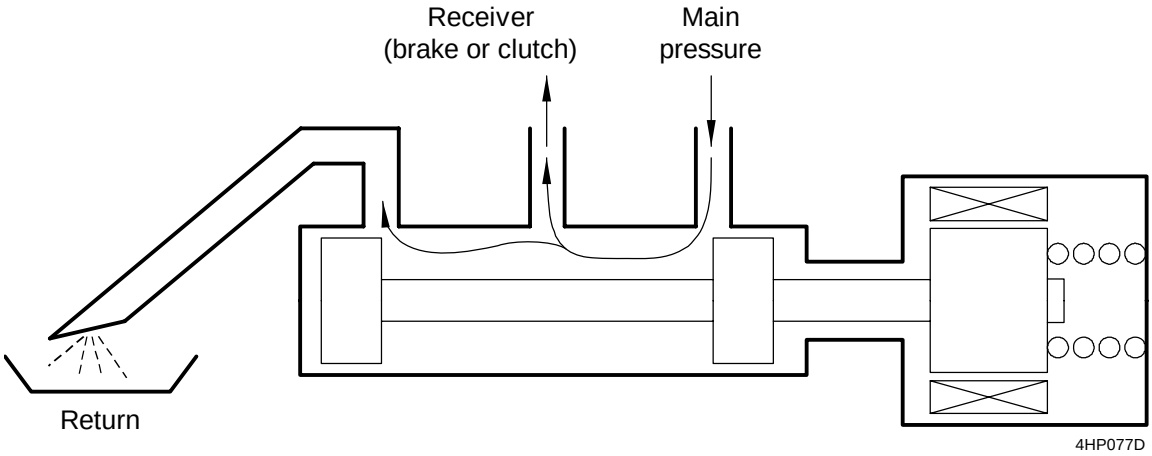
13 - Proportional electrovalves or pressure regulators EDS3-4-5-6

a - Introduction

These are supplied with 12 Volts and are controlled by being earthed by the ECU. Their role is to fill or empty a brake or a clutch when changing gear and to keep the receivers closed during a stable gear.

For good driving pleasure and uninterrupted torque transmission when changing gear, the pressure must rise or fall gradually. The main pressure must therefore be modulated and to do this, the proportional electrovalve must cause a variable leak to the sump return.

b - Operation



The electrovalves EDS mainly consist of a slide valve linked to an electromagnetic core which is held at rest by a return spring. The EDS are energised by the ECU with a variable cyclic opening ratio (COR). A slide valve opening position and therefore a certain leak and consequently a certain pressure acting on the receiver piston of a brake or a clutch correspond to a set COR.

EDS3 -EDS5 - EDS6:

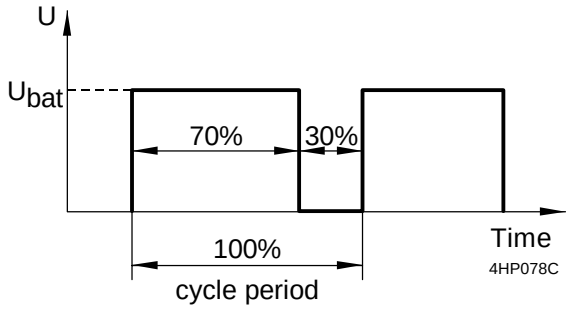
100% energised → operating pressure = main pressure

Not energised (at rest) → operating pressure = atmospheric pressure

EDS4: Its operation is inverted, in other words when at rest (not energised), operating pressure = main pressure.

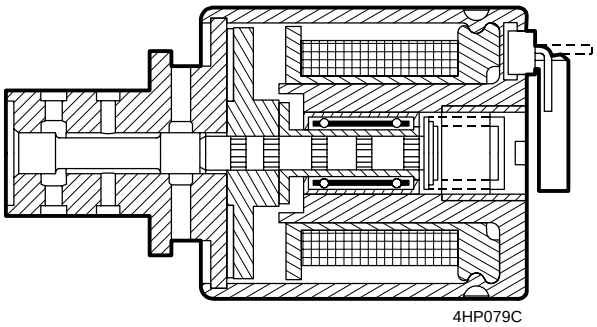
Principle of the COR

The ECU alternately causes the electrovalve coil to be energised then non energised. Over one cycle (period), the energised coil attracts the magnetic core in the direction of pressure increase, if EDS 3, 5 and 6 are used as an example. When the coil is not energised, the core is driven in the direction of pressure reduction under the action of the return spring. The position obtained, and therefore the pressure, depends on the cyclic opening ratio, in other words, the ratio between the percentage of time for which the coil is energised and the percentage of time for which it is not.



Note: In order to permanently check the proportional electrovalves, the ECU permanently supplies them. The current therefore varies from 159 mA to 768 mA; for EDS3, 5 and 6, 159 mA corresponds to the idle position and 768 mA to the fully open position.

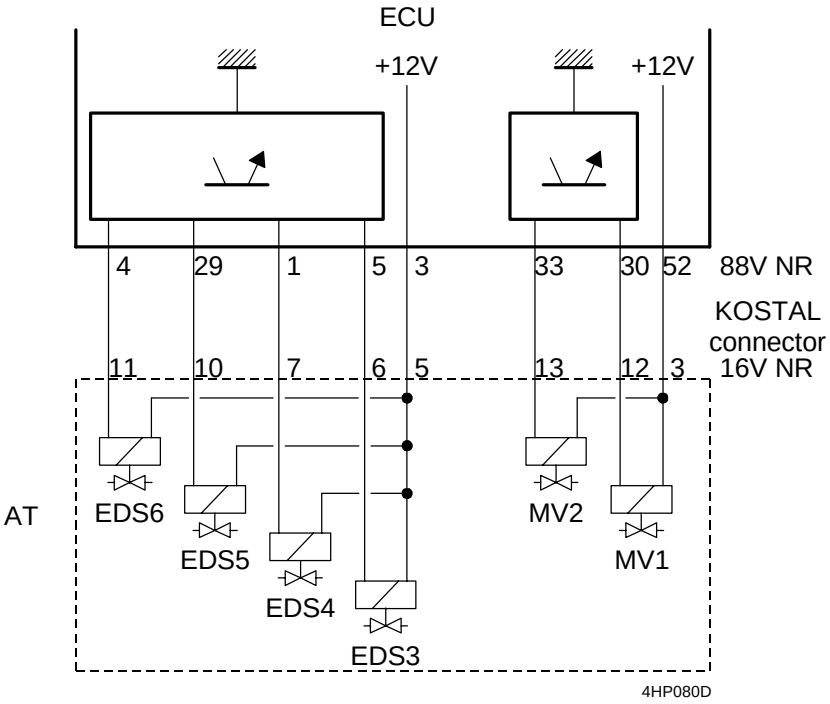
Cross section of EDS3, or 5 or 6



c - Functions of the EDS

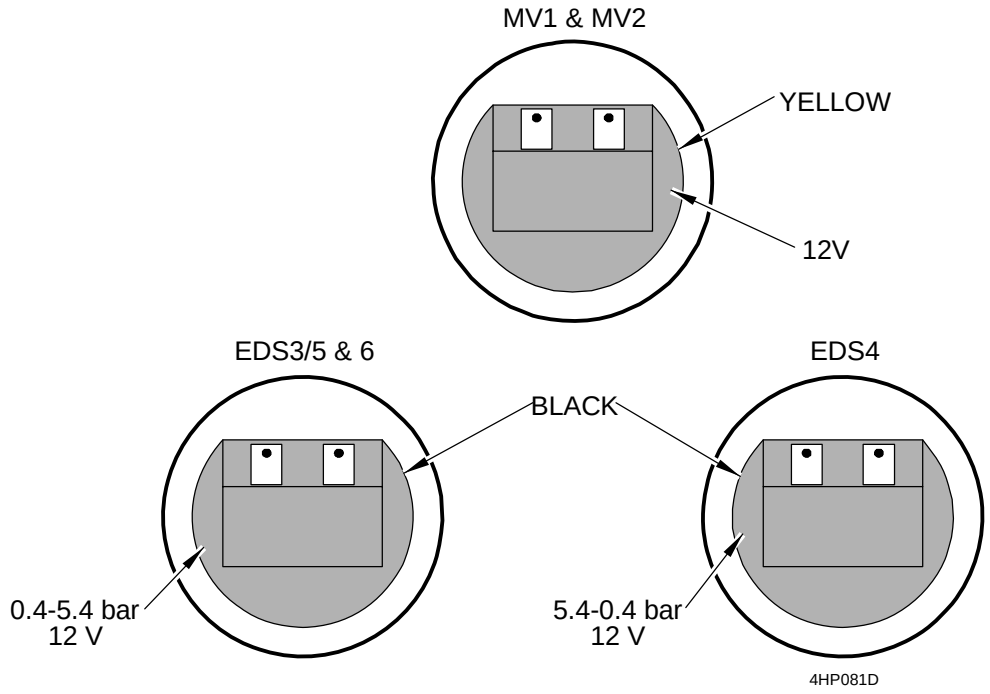
- EDS3 → neutral position and 1st, then lock-up control
- EDS4 → Reverse, 4th
- EDS5 → 1st and 2nd
- EDS6 → N/1st and 3rd

d - Actuator connections



Note: The feed wires of the electrovalves are doubled up for safety (violet wires).

e - Actuator identification

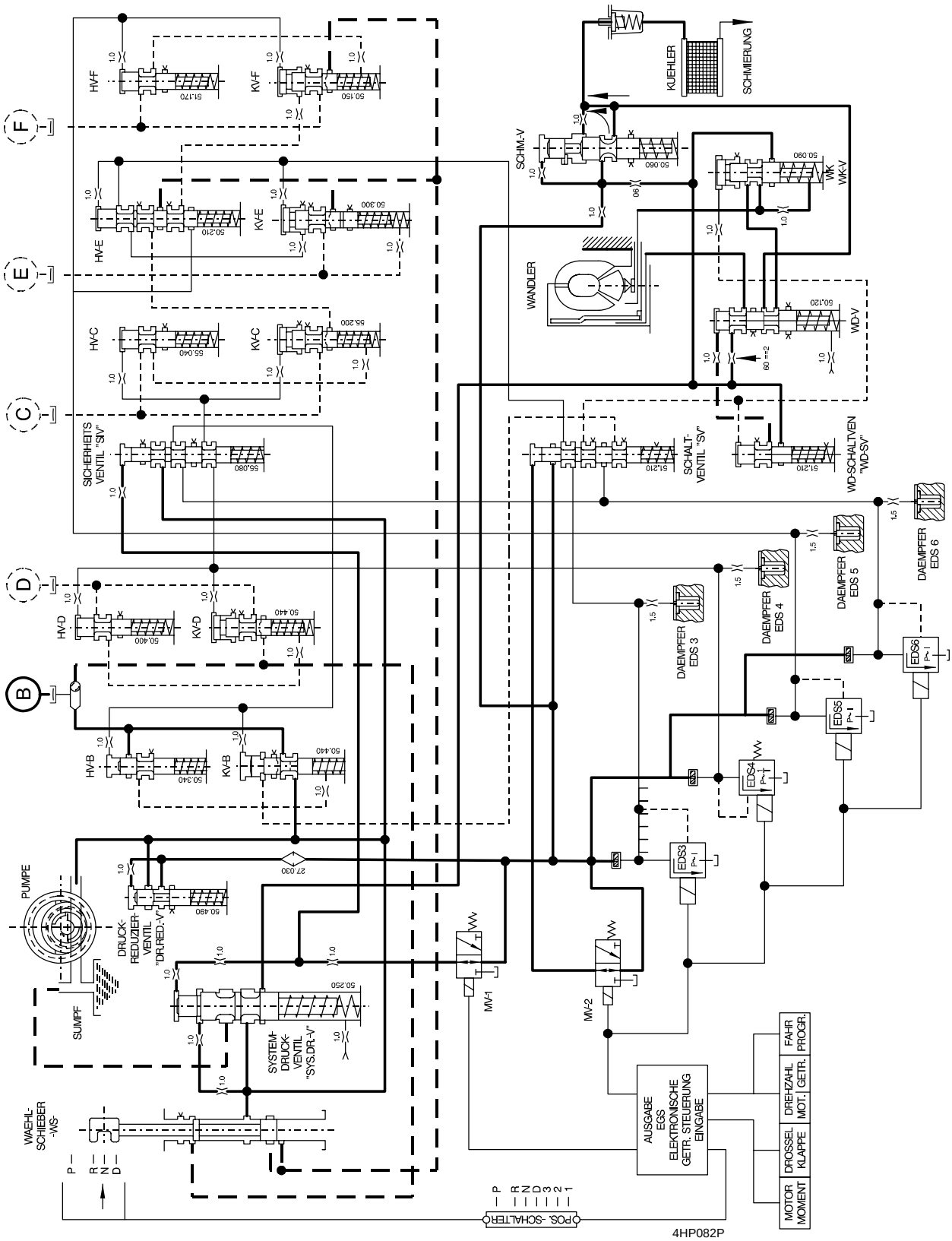


E - SUMMARY OF OPERATED ELEMENTS

	Clutches		**Brakes**			**Electrovalves - Pressure regulators**						**Lock-up**
gear	**B**	**E**	**C**	**D**	**F**	**MV1**	**MV2**	**EDS3**	**EDS4**	**EDS5**	**EDS6**	
P	X	-	-	-	-	X	X	-	X	-	X	/
R	X	-	-	X	-	X -	X	-	-	-	-	/
N	X (1)	-	-	-	-	X	X	-	X	-	X (1)	/
D 1st	X	-	-	-	X	X -	X	-	X	X	X	/
D 2nd	-	X	-	-	X	X -	-	- X	X	X	-	X
D 3rd	X	X	-	-	-	X -	-	- X	X	-	X	X
D 4th	-	X	X	-	-	X -	-	- X	-	-	-	X
3 1st	X	-	-	-	X	X -	X	-	X	X	X	/
3 2nd	-	X	-	-	X	X -	-	X	X	X	-	X
3 3rd	X	X	-	-	-	X -	-	- X	X	-	X	X
2 1st	X	-	-	-	X	X -	X	-	X	X	X	/
2 2nd	-	X	-	-	X	X -	-	X	X	X	-	X
1 1st	X	-	-	-	X	X -	X	-	X	X	X	/
3rd emer-gency	X	X	-	-	-	-	-	-	-	-	-	/
R emer-gency	X	-	-	X	-	-	-	-	-	-	-	/

(1) except in snow program

F - LAYOUT OF THE HYDRAULIC UNIT



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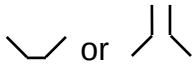
G - OPERATION

Key

: Oil pump

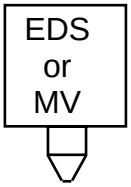


: Oil return to sump

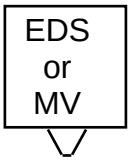
: Empty pipe

: Main pipe used for the gear

: Pipe full of oil but not used for changing gear



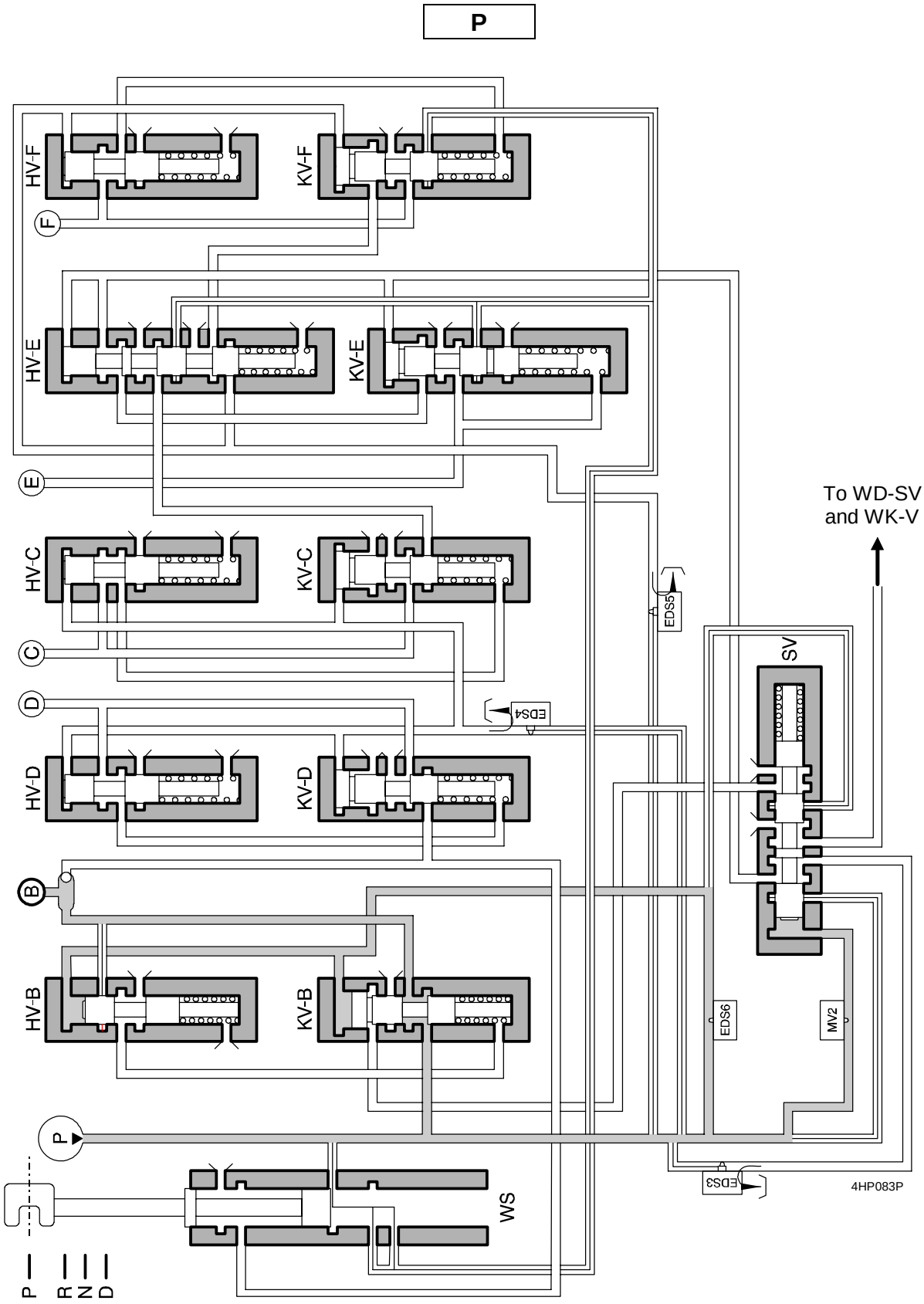
: Electrovalve closed



: Electrovalve open

Warning: Only the elements involved in the subject being dealt with (gear changes, lock-up control, etc…) are shown with the aim of simplifying the highly complicated hydraulic circuit!

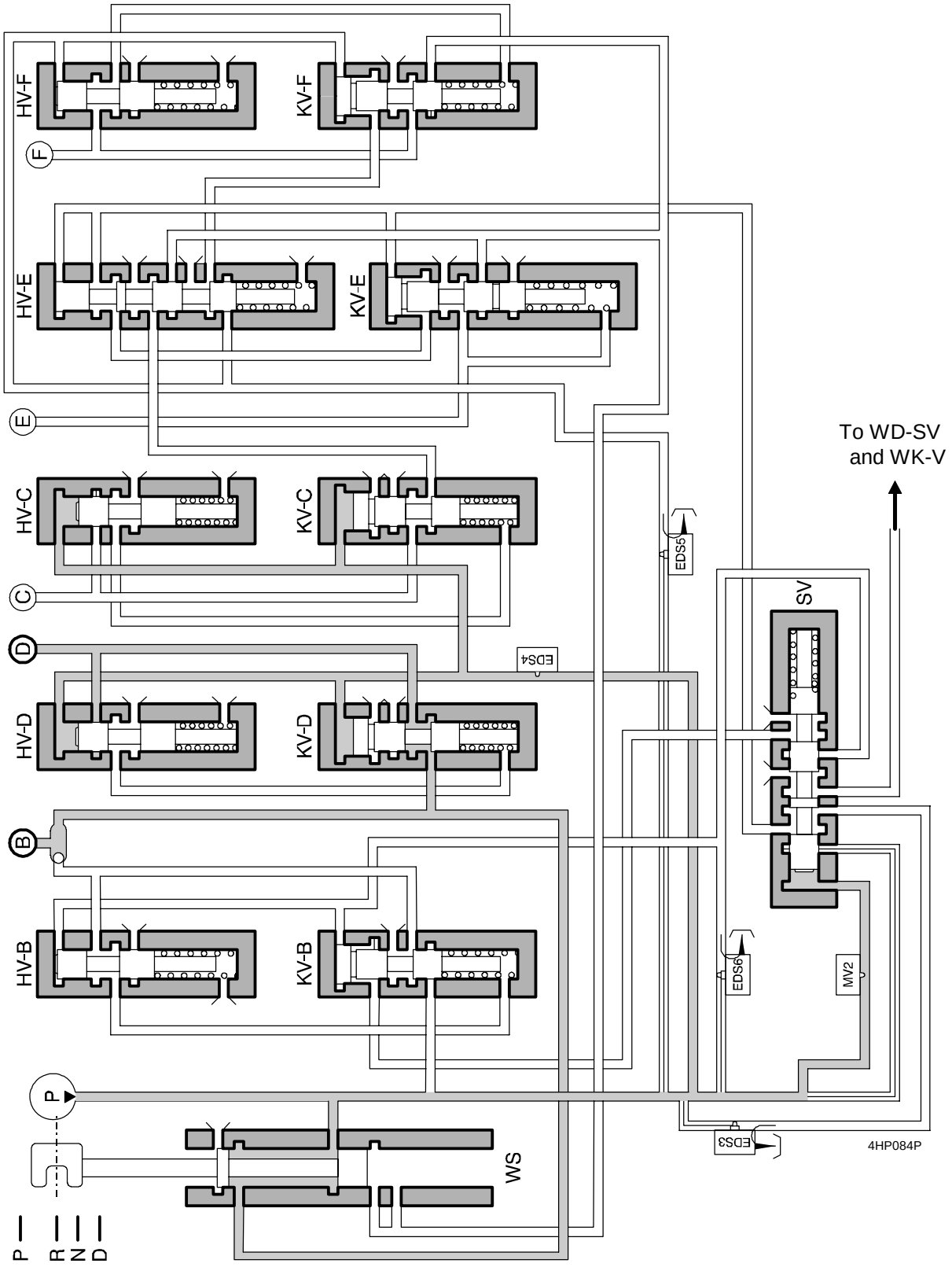
1 - Gear changes



a - Parking position

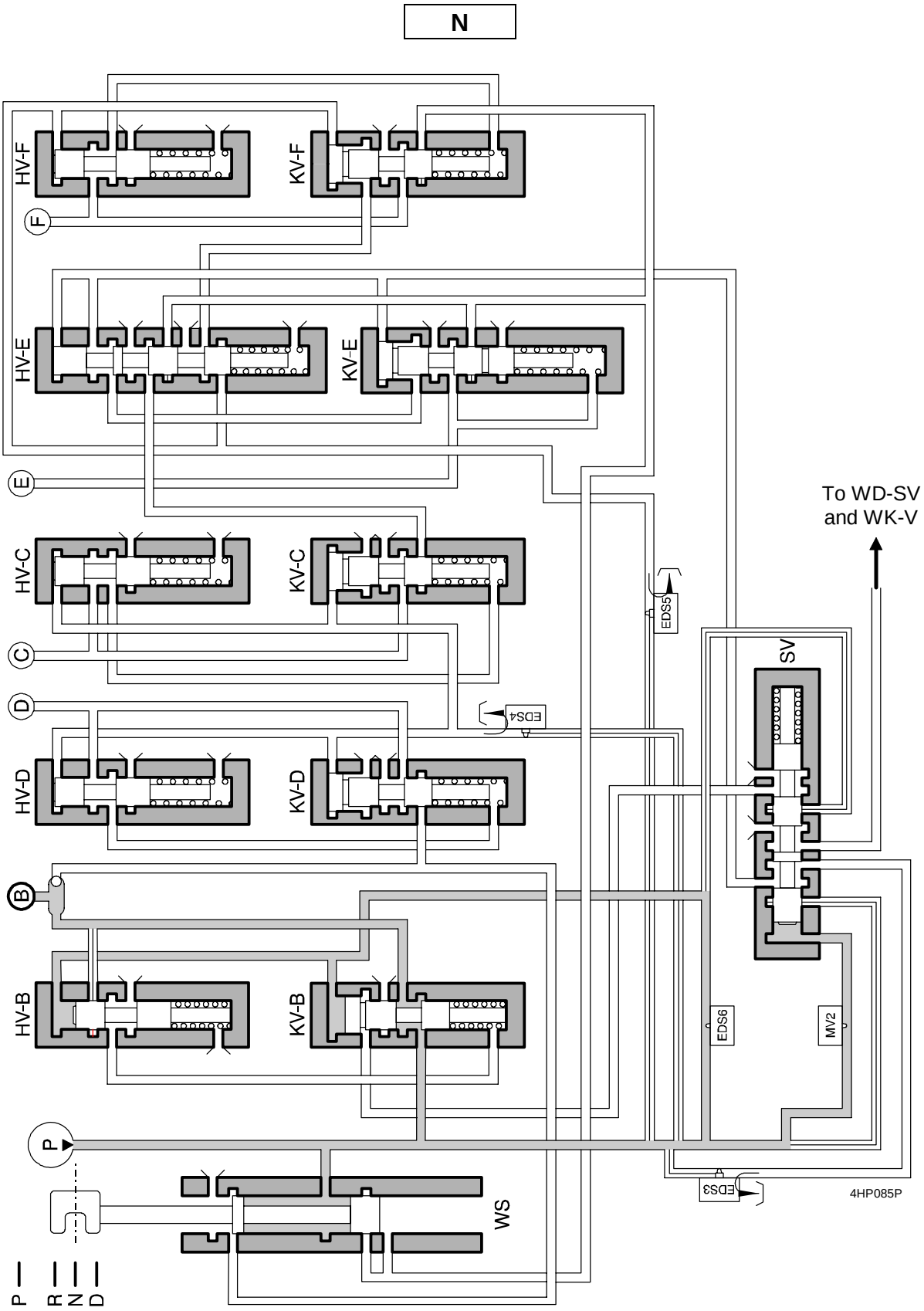
- B must be engaged in order to anticipate 1st or reverse gear
- Elements controlled: MV2, EDS4, EDS6 ⇒ The slide valve of HV-B lowers → the slide valve of KV-B lowers in turn ⇒ B is supplied

Reverse gear



b - Reverse gear

- Clutch B and brake D must be engaged.
- Elements controlled: MV2 → no effect.
- As the manual valve is in position R ⇒ clutch B is supplied directly.
- As the proportional valve EDS4 is at rest, and therefore open ⇒ the slide valve HV-D lowers → the slide valve KV-D then lowers in turn → brake D is supplied.

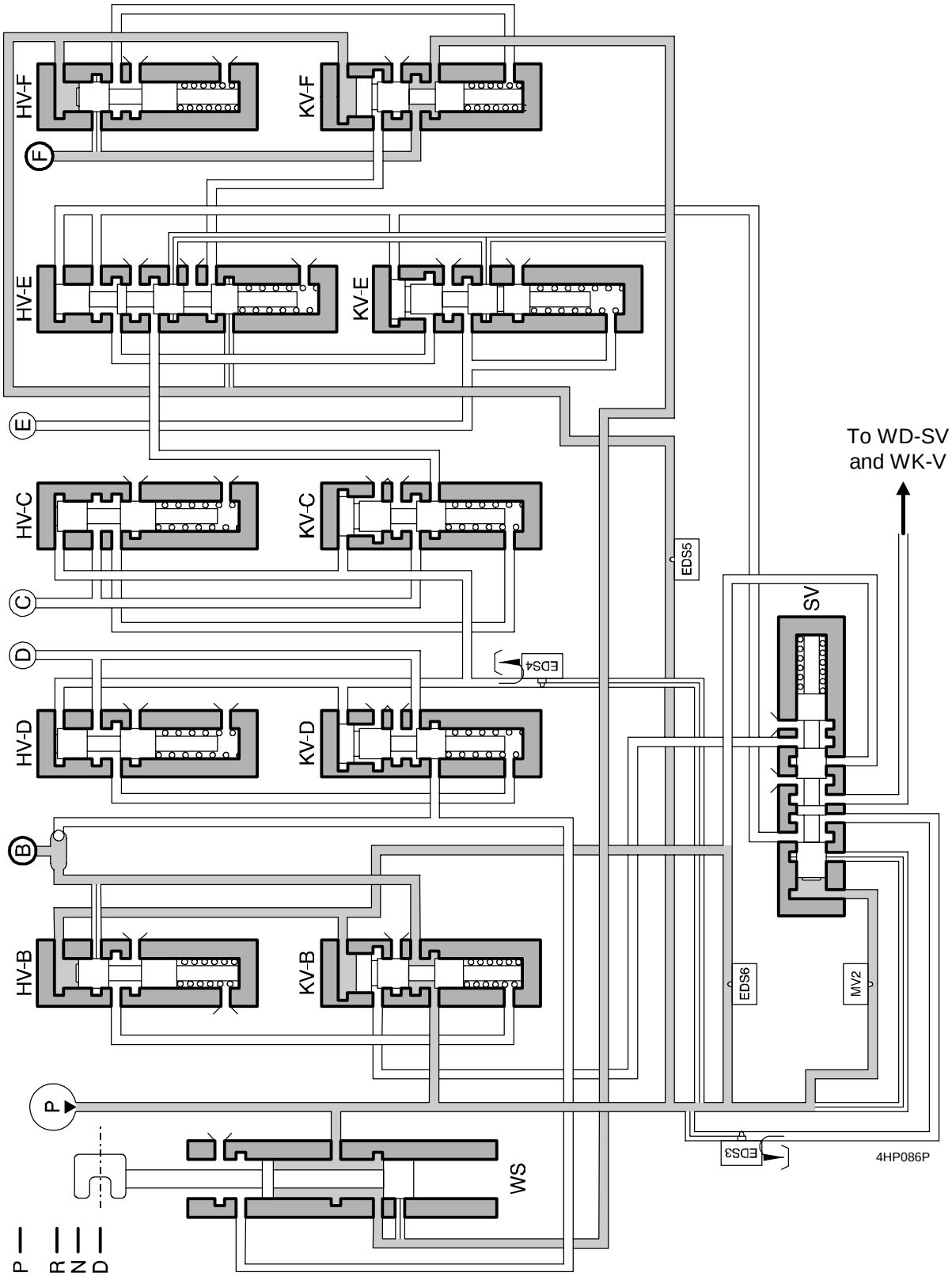


c - Neutral

Same as parking position.

Elements MV2, EDS4, EDS6 are controlled ⇒ Slide valve HV-B lowers which allows KV-B to lower in turn ⇒ clutch B is supplied.

D - 1st



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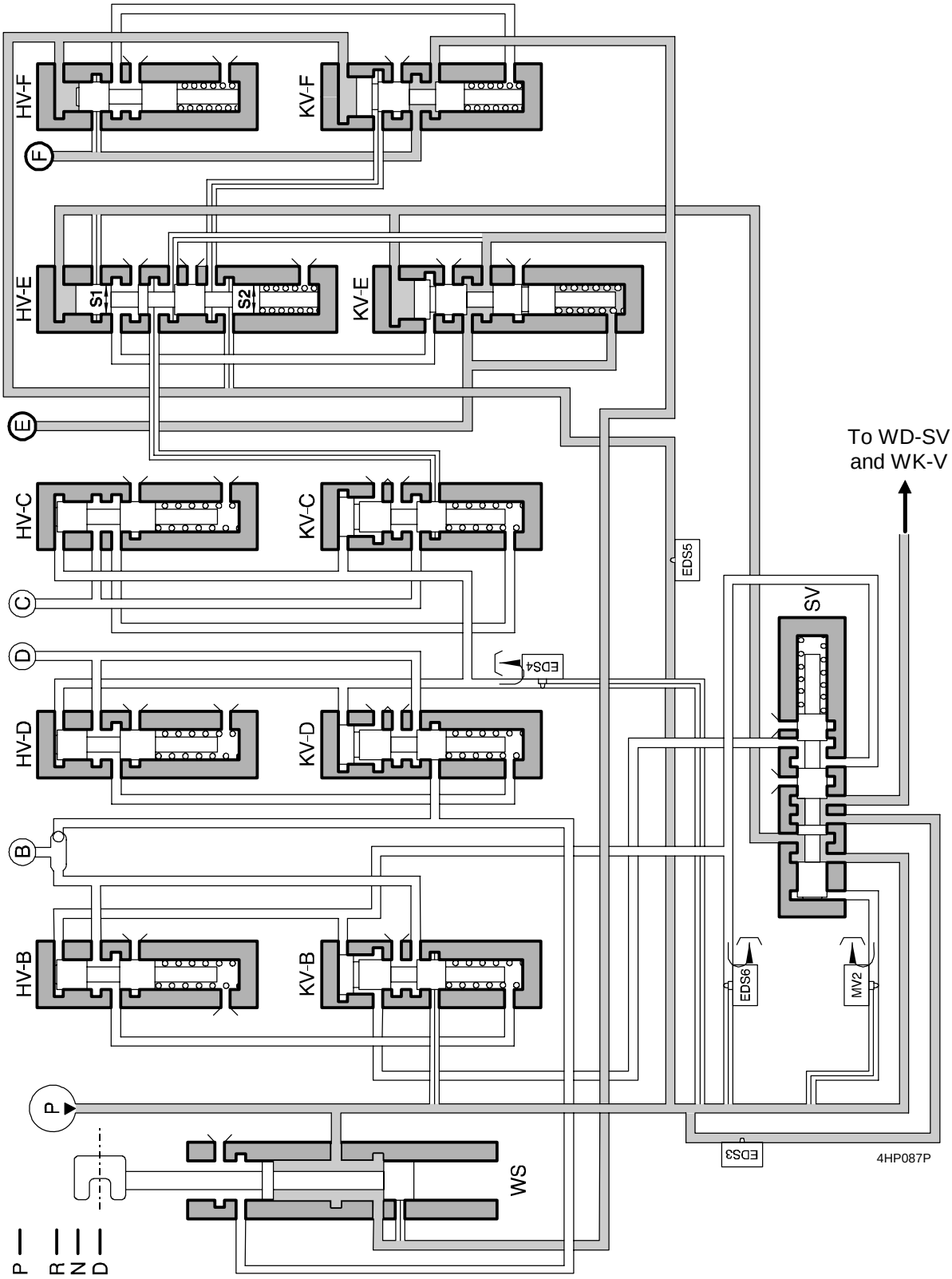
d - Position D - 1st gear

- Clutch B and brake F must be engaged.
- Elements controlled:
  - MV2
  - EDS4
  - EDS5
  - EDS6

  – Through EDS6 $\rightarrow$ slide valve HV-B lowers allowing slide valve KV-B to lower in turn $\Rightarrow$ B is supplied.

  – Through EDS5 $\rightarrow$ slide valve HV-F lowers, allowing slide valve KV-F to lower in turn $\Rightarrow$ F is supplied.

D - 2nd

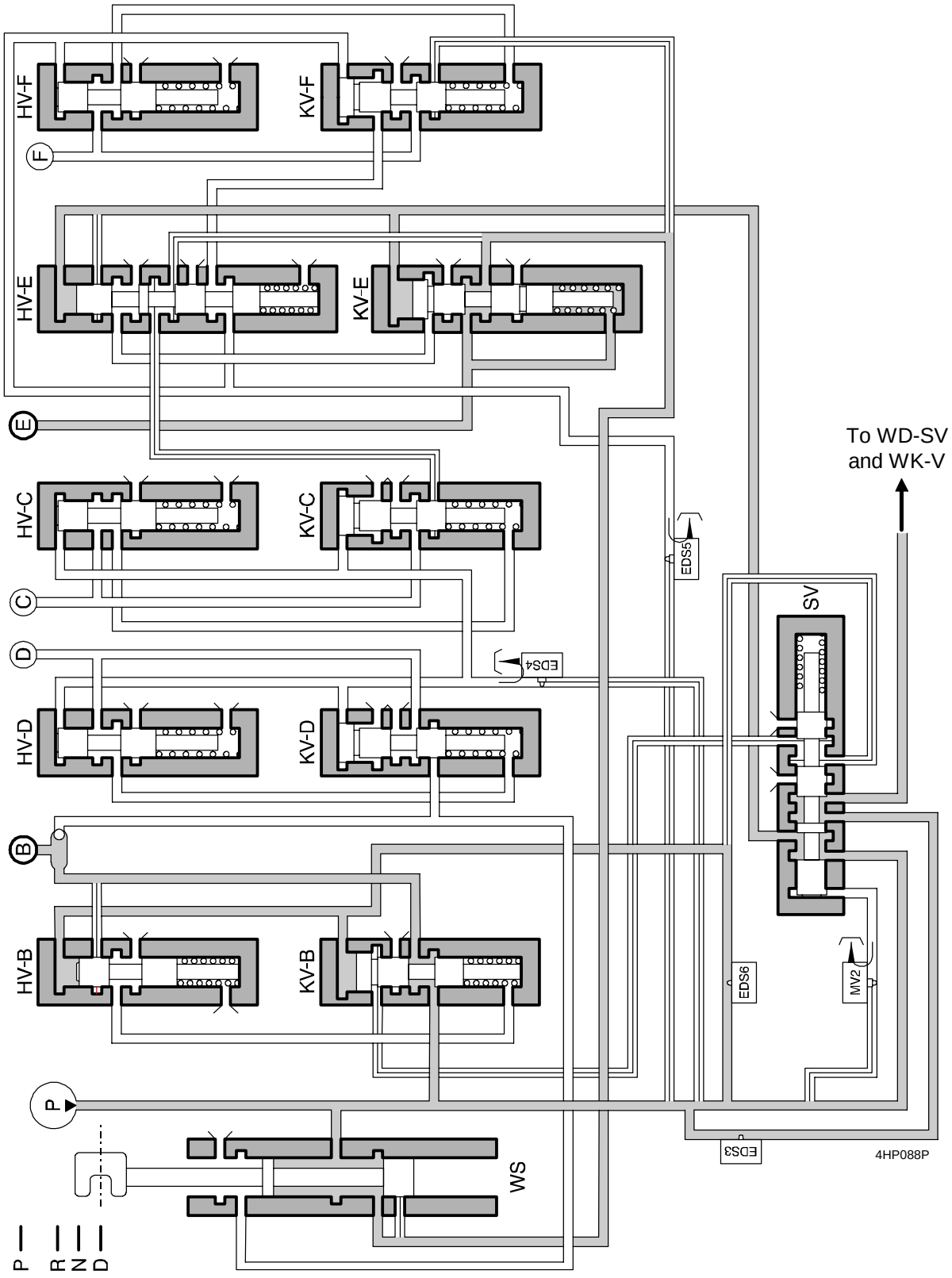


ZF 4HP20 AUTOMATIC TRANSMISSION

e - Position D - 2nd gear

- Clutch E and brake F must be engaged.
- Elements controlled:
  - EDS3
  - EDS4
  - EDS5
- As MV2 is at rest, slide valve SV returns to the idle position $\Rightarrow$ through EDS3, slide valve HV-E lowers $\rightarrow$ slide valve KV-E lowers so as to allow E to be supplied; but this same pressure supplying E comes under slide valve KV-E. When the force created by this pressure combined with the action of the return spring (P x S2 + FR) is greater than the force (P x S1) acting on the top of the slide valve, this slide valve rises $\Rightarrow$ the clutch E is therefore operated with a pressure which is slightly lower than the maximum main pressure.
- Through EDS5 $\rightarrow$ slide valve HV-F lowers, which allows slide valve KV-F to lower in turn $\rightarrow$ F is supplied.

D - 3rd



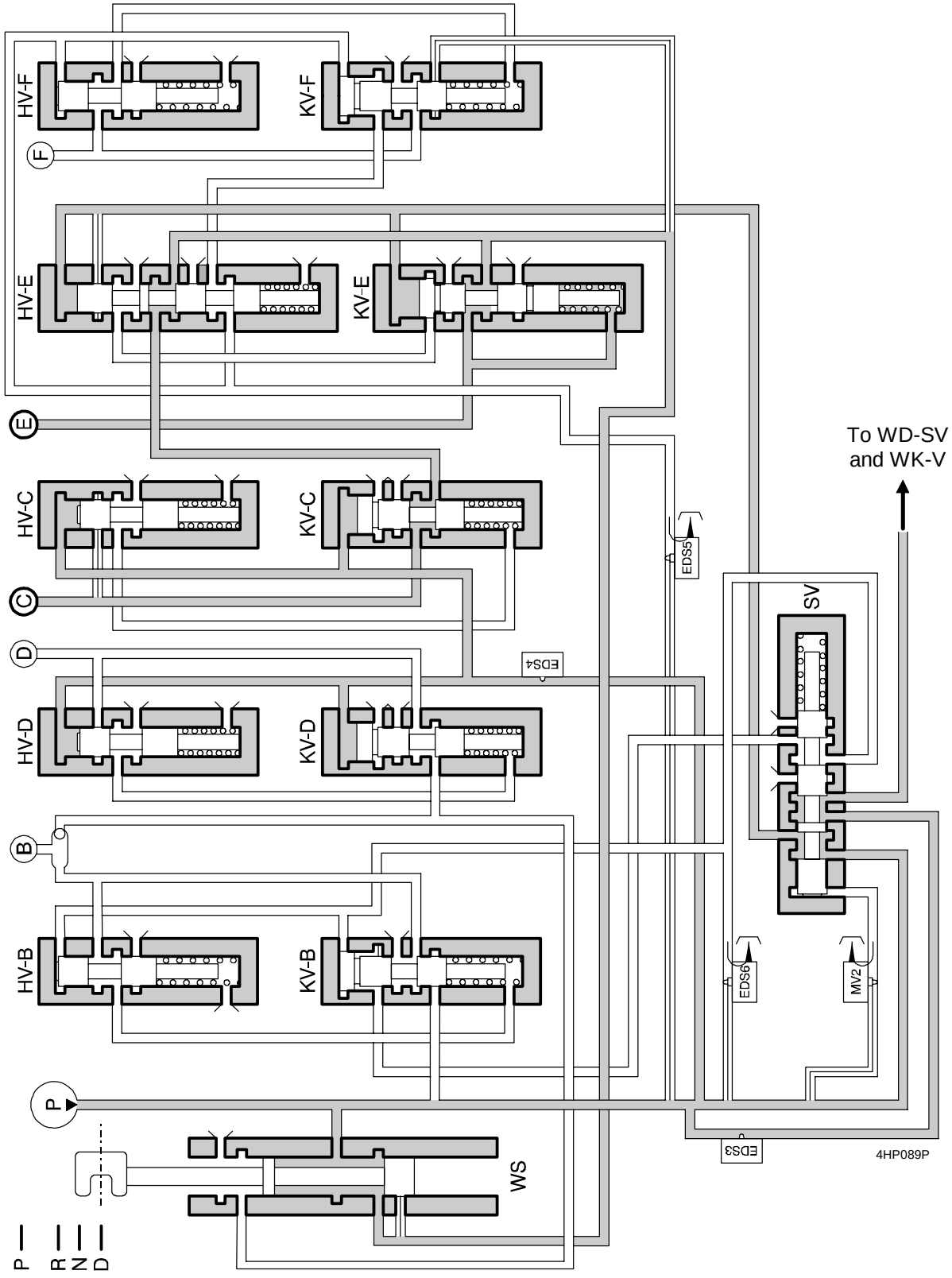
ZF 4HP20 AUTOMATIC TRANSMISSION

f - Position Drive - 3rd gear

- Clutch E and clutch B must be engaged.
- Elements controlled:
  - EDS3
  - EDS4
  - EDS6

  - E is supplied in the same way as in 2nd gear through slide valves HV-E and KV-E by controlling EDS3 and the idle position of slide valve SV (MV2 at rest).
  - Through EDS6 $\rightarrow$ slide valve HV-B lowers, allowing slide valve KV-B to lower in turn $\Rightarrow$ B is supplied.

D - 4th



ZF 4HP20 AUTOMATIC TRANSMISSION

g - Position Drive - 4th gear

- Clutch E and brake C must be engaged.
- Elements controlled: - EDS3
- Supply to E: same as 2nd and 3rd.
- When EDS4 is at rest and therefore open → slide valve HV-D lowers which allows slide valve KV-D to lower in turn → slide valve HV-C then lowers thus allowing slide valve KV-C to lower → C is then supplied through HV-E.

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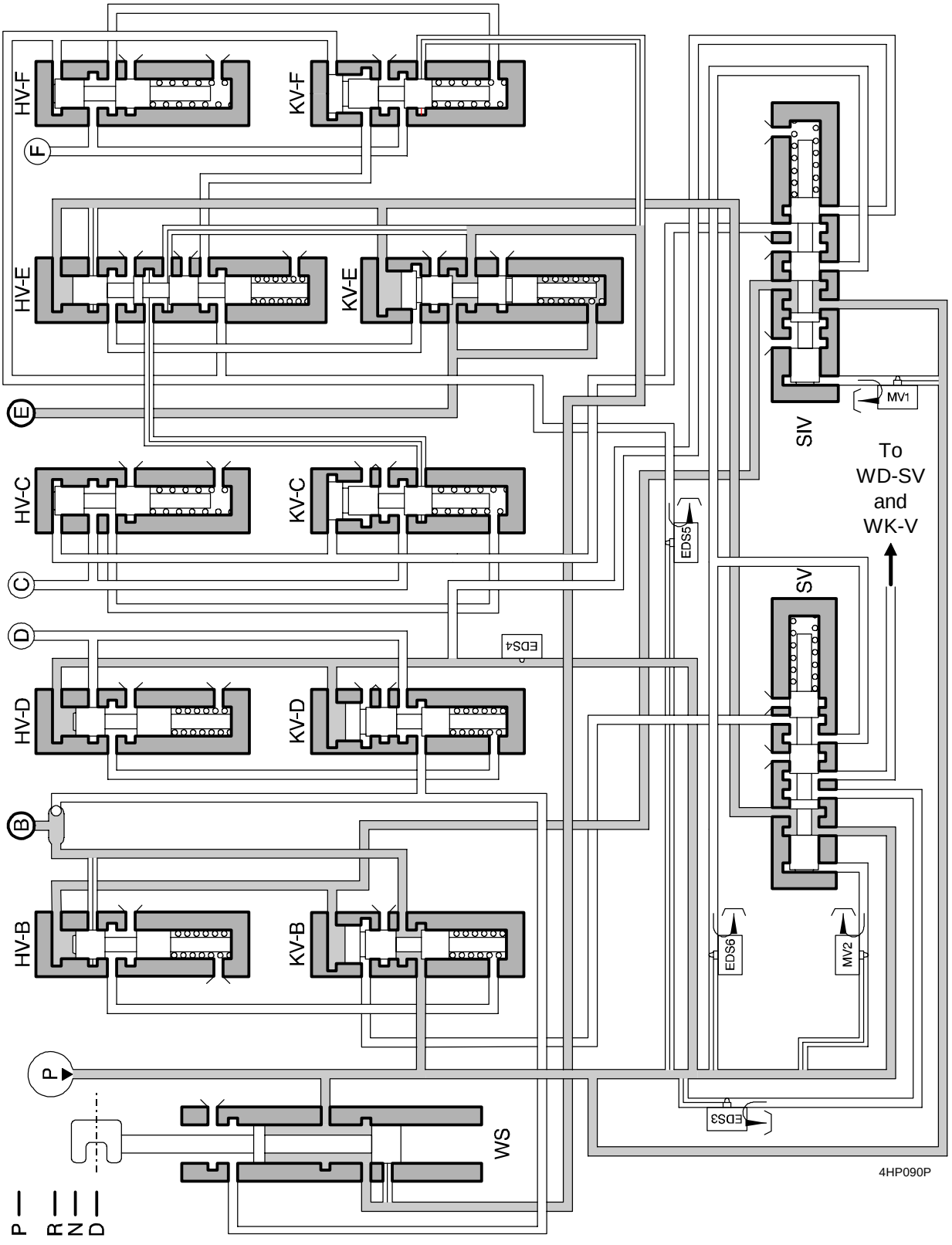
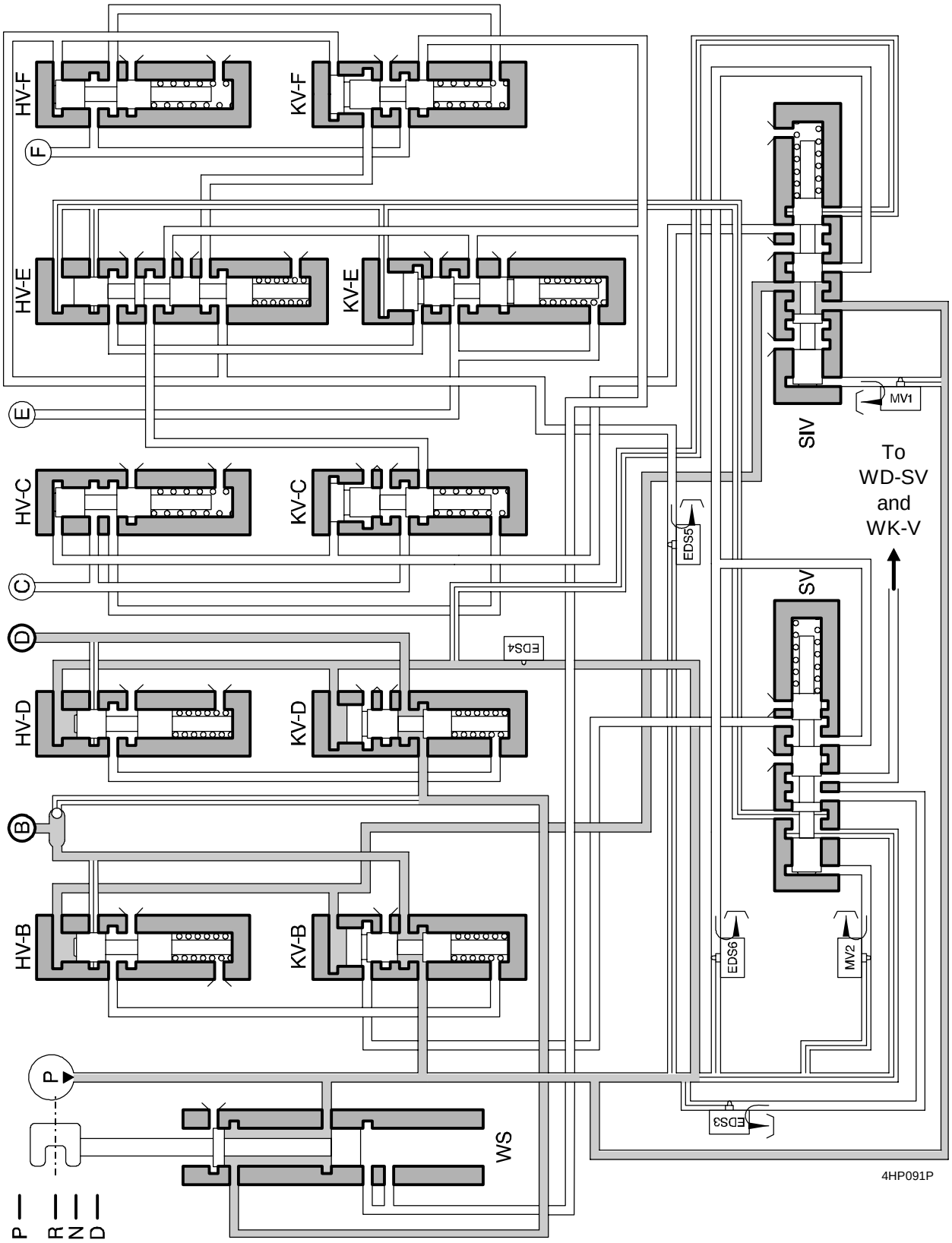
3rd emergency



ZF 4HP20 AUTOMATIC TRANSMISSION

Reverse emergency



h - Position D - 3rd emergency/Reverse emergency

If the ECU is unable to operate the hydraulic unit, the driver only has the use of two gears; 3rd and reverse.

A way must be found hydraulically of supplying the brakes and clutches corresponding to the desired gear just like during normal operation.

To do this, an additional slide valve SIV has been incorporated into the hydraulic unit. This has been positioned between:

- HV-D/KV-D and HV-C/KV-C
- HV-B/KV-B and EDS6/SV

In the event of a fault, all electrovalves are at rest, including MV1, the role of which is to select the maximum value of the main pressure.

- MV1 is at rest $\Rightarrow$ slide valve SIV is at rest $\rightarrow$ slide valve HV-B lowers, allowing slide valve KV-B to lower in turn $\rightarrow$ B is supplied.
- For third gear, as the manual valve is in position D, slide valve HV-E is directly moved downwards $\rightarrow$ KV-E is then moved in turn in order to supply E.
- For reverse gear, D is supplied directly by the manual valve which is in the reverse gear position $\rightarrow$ same as normal operation.

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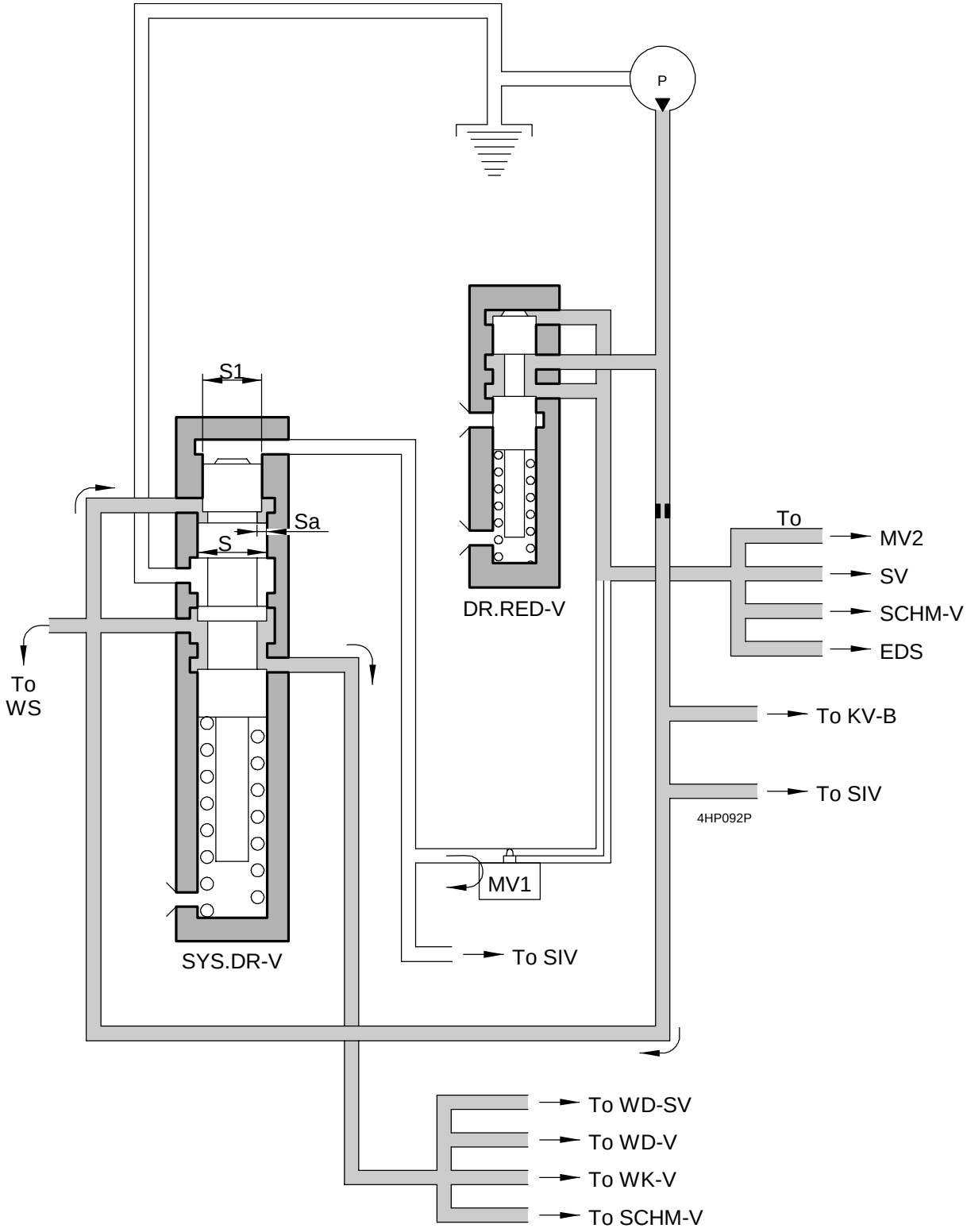
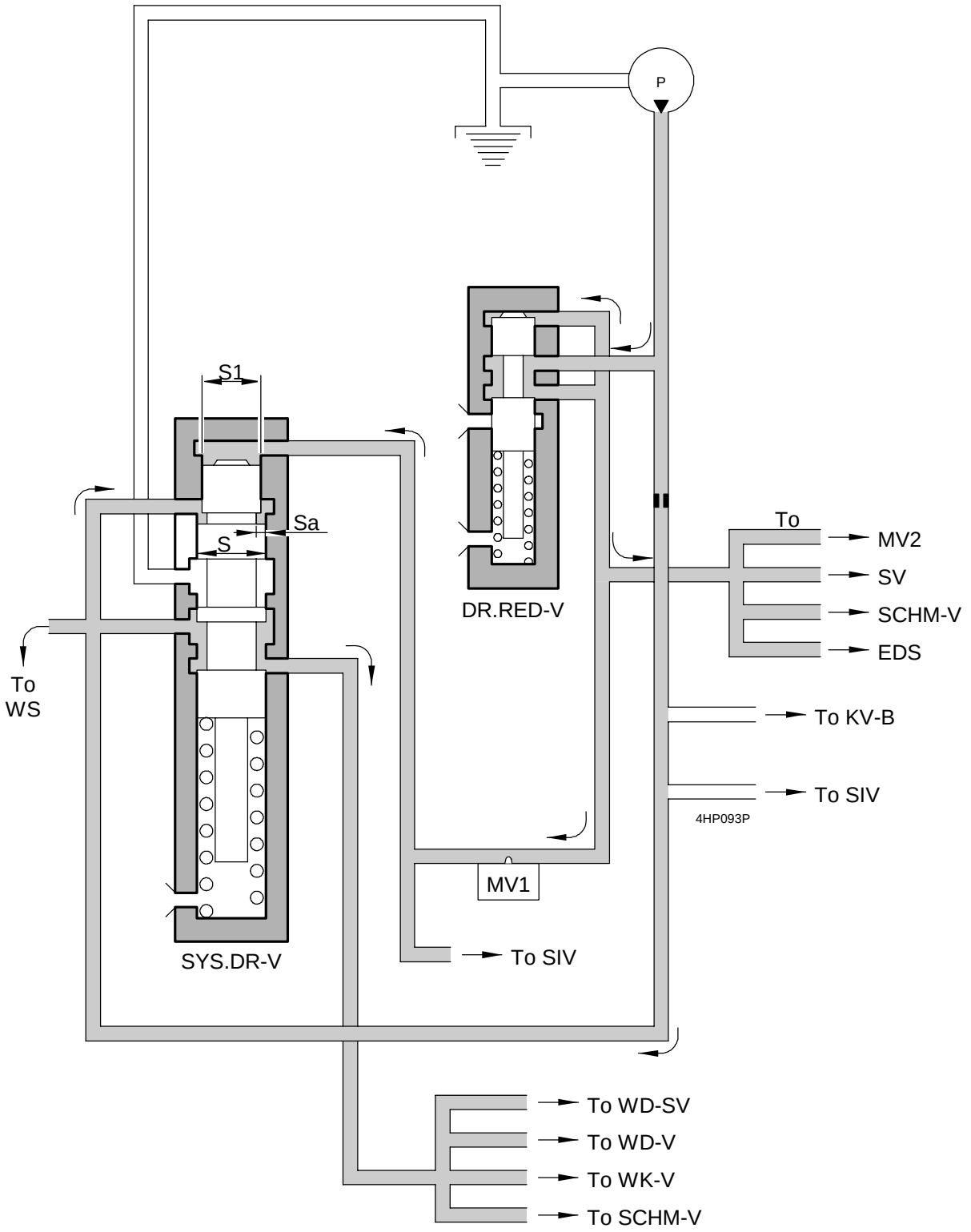
16 bar position



7 bar position



2 - Controlling the main line pressure

Valve "SYS.DR - V" regulates the main pressure. When this, multiplied by the surface area of the slide valve on which it is being applied, becomes greater than the rating of the spring FR, the slide valve lowers fully in order to uncover the return to sump channel.

a - 16 bar position

The oil provided by the pump applies a force to the annular area Sa of slide valve SYS.DR-V. When P x Sa = FR, the slide valve lowers in order to adopt the equilibrium position such that: Pmain = 16 bar; at this point, the converter and the lubrication circuit are supplied.

b - 7 bar position

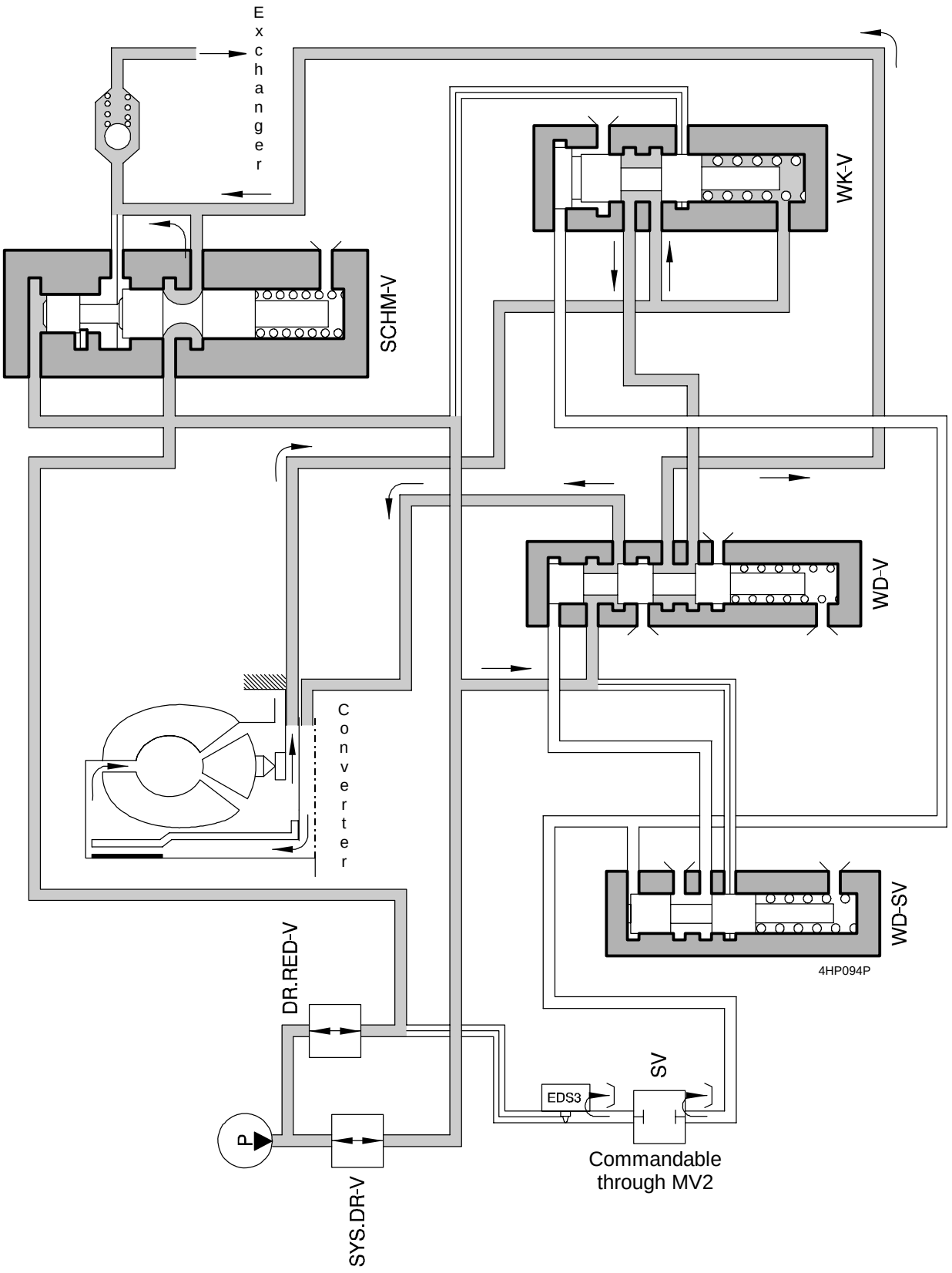
The ECU supplies the all or nothing electrovalve MV1 $\rightarrow$ MV1 opens. The oil from the pump is now applied to slide valve SYS.DR-V on an area S = Sa + S1. Slide valve equilibrium is therefore found when FR = P x (Sa + S1); as the application area is greater, the main pressure is proportionally lower: Pmain = 7 bar.

c - Role of DR.RED-V

The control pressure of the receivers can take two maximum valves: 7 or 16 bar. However, for this oil to be applied to the receivers, valves HV and KV are used. These are operated by pressure regulating electrovalves EDS. This operating pressure is regulated to a maximum value of 5 bar.

When the oil reaches a pressure greater than 5 bar, slide valve DR - RED - V moves downwards in order to uncover the return to sump channel.

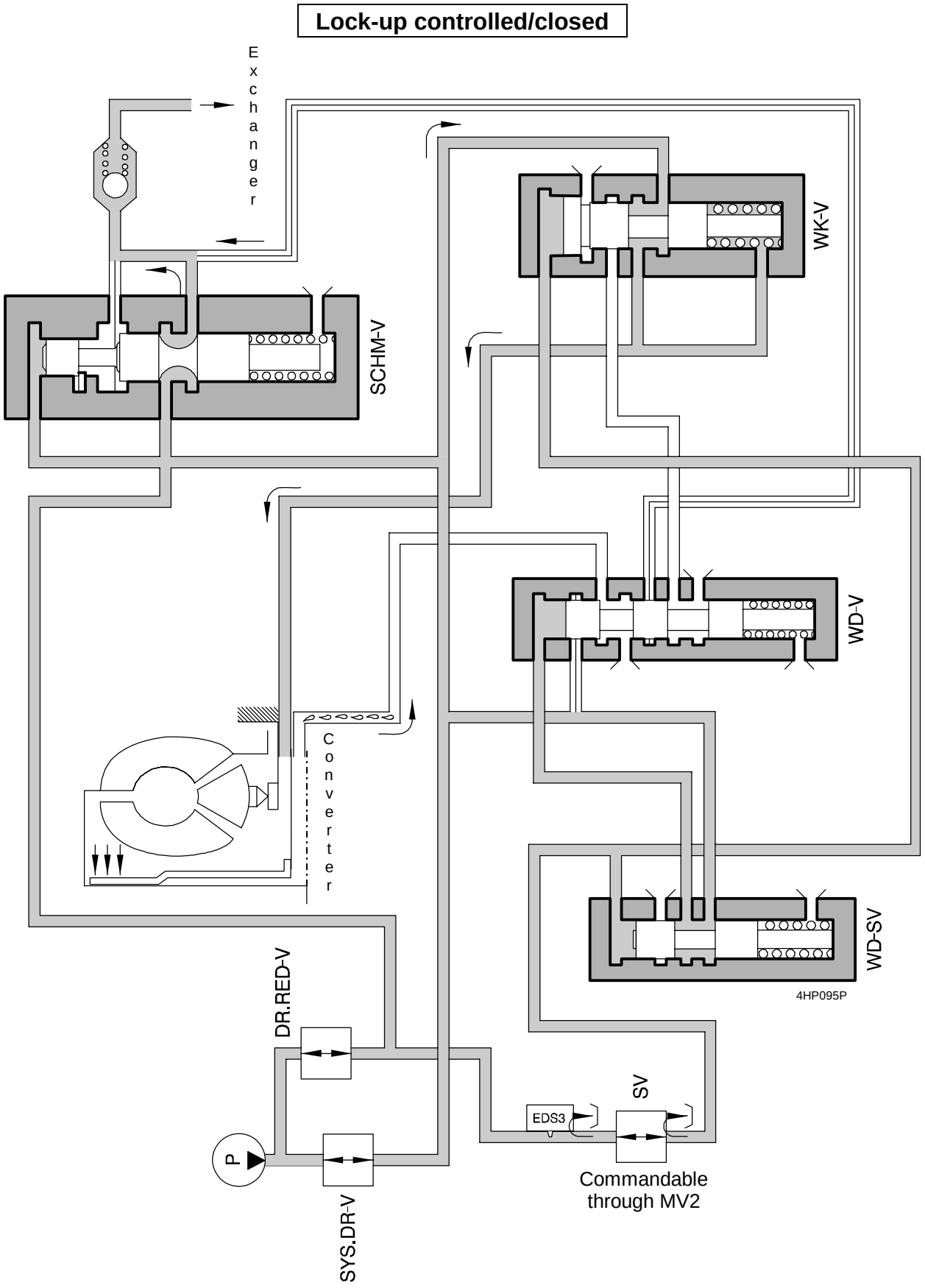
Lock-up open



3 - Controlling the lock-up

a - "Open" position

- In positions P, N, 1st and reverse, the lock-up is systematically open.
- MV2 is operated and therefore open which allows slide valve SV to be controlled → slide valve WD-SV is at rest. Slide valve WD-D is therefore also at rest.
- WD-V directs the pressurised oil to the converter on the lock-up side; the oil therefore separates the lock-up disc from the impeller housing → it is open. The oil returning from the converter via WK-V and WD-V is then directed to the water/oil exchanger in order to be cooled.



b - Controlled - closed position

In 2nd, 3rd and 4th gears, MV2 is not controlled → slide valve SV returns to the idle position.

In this case, if the lock-up is to be controlled, all that is required is to order the proportional electrovalve EDS to open.

⇒ Slide valve WD-SV lowers, in order to cause the direction of oil circulation to invert in the converter; in effect:

→ the lowering of slide valve WD-SV causes slide valve WD-V to lower ⇒ the rear of the lock-up disc is connected to the housing, in order to drain this chamber and thus allow a compulsory calibrated return of the oil from the converter.

→ furthermore, the pressurised oil from EDS3 causes slide valve WK-V to lower ⇒ the pressurised oil from SYS.DR-V is then directed towards the converter on the shaft side of the stator; the oil fills the converter and exerts a force on the lock-up disc; this then comes into contact with the impeller housing.

WK-V is hydraulically a regulator, in other words, when the desired pressure in the converter is reached, the slide valve closes again, in other words for $P_{converter} \times S_2 + F_{spring} > P_{EDS3} \times S_1$.

In effect, if the lock-up slip is to be regulated (in other words controlled), it must be possible to control the pressure acting on the lock-up disc perfectly.

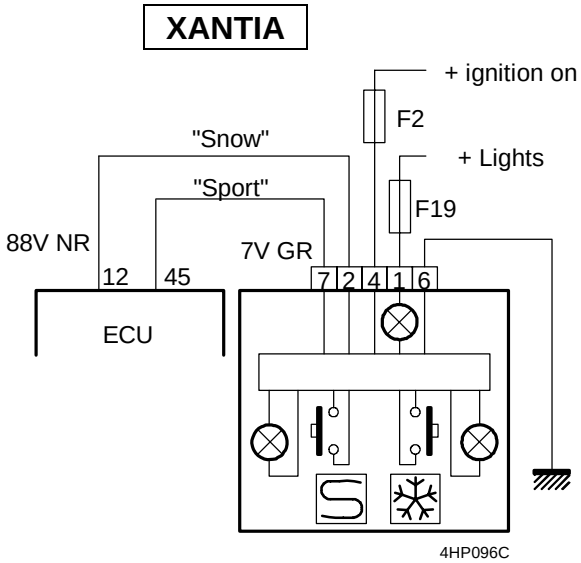
The principle therefore consists of modulating, through EDS3, the value of the pressure acting on the top of slide valve WK-V, in other words P_{EDS3}.

ZF 4HP20 AUTOMATIC TRANSMISSION

SENSORS AND INFORMATION

I - PROGRAM SELECTOR

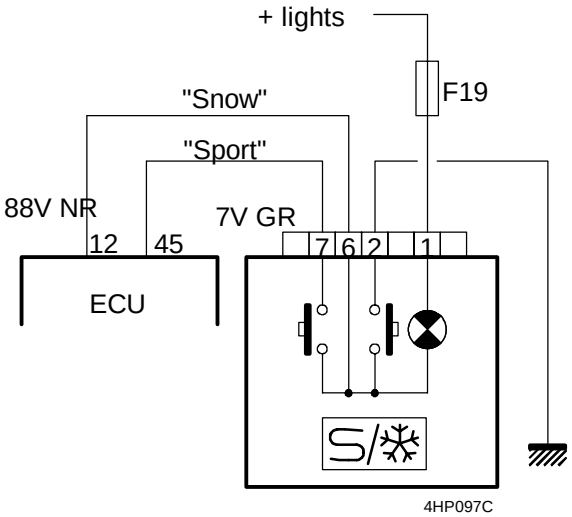
This is a double "push" switch located on the central console.



When the switch is pressed, the electronic stage connects an ECU terminal (12 or 45 depending on user's selection) to negative and supplies the corresponding operating light. A second press on the switch cancels the previous selection.
If the switch has never been moved to one of the two proposed programs, the ECU responds to the normal auto-adaptive program.
Therefore, an odd number of presses leads to a specific program being selected and an even number of presses leads to the specific program being cancelled.
Furthermore, the switch has an illumination light supplied by the + lights so that it can be located at night.

Note: After pressing the switch, the earthing is maintained by the electronic stage until a second pulse appears.

XM - restyled XANTIA

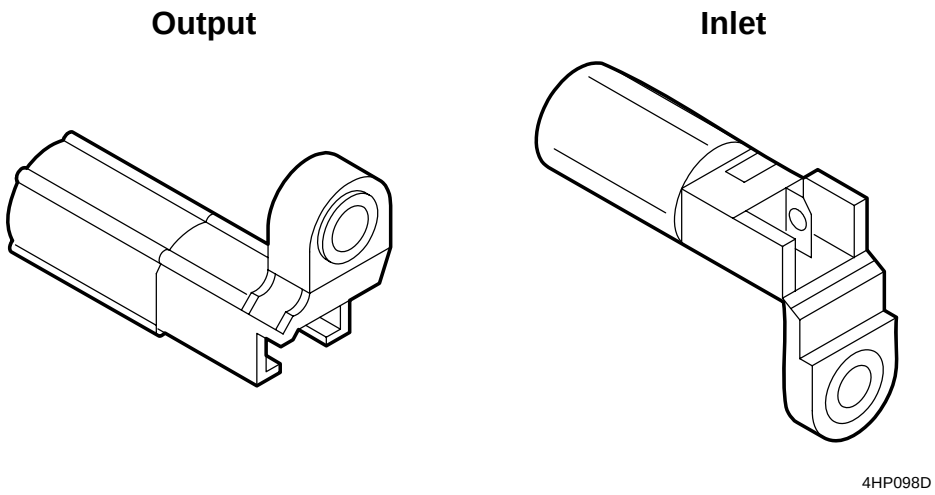


This switch is fitted to vehicles having a selected program indicator on the instrument panel; this means that the electronic stage is no longer required in the switch. The operation remains unchanged:
Pressing the switch connects an ECU terminal (12 or 45 depending on user's selection) to earth. A second press cancels the previous selection.

Note: The earthing operations caused by the switch only last for the length of the press.

II - AUTOMATIC TRANSMISSION INPUT AND OUTPUT SPEED SENSORS

A - ROLE

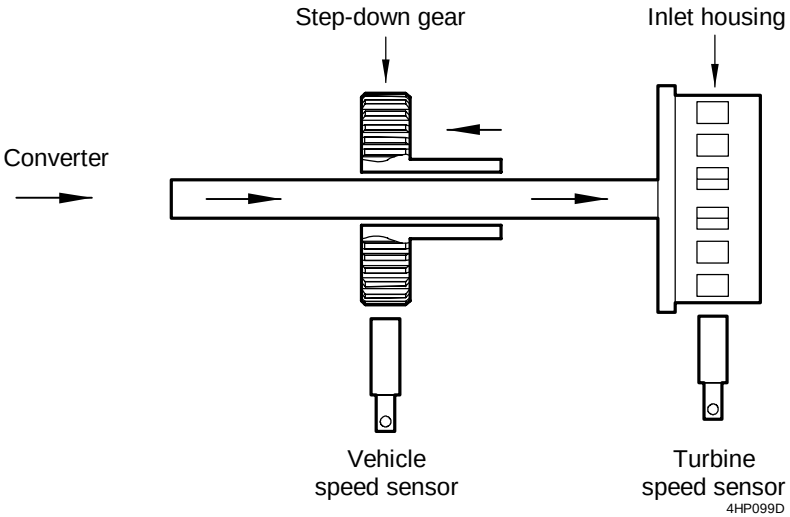


These two sensors provide the ECU with:

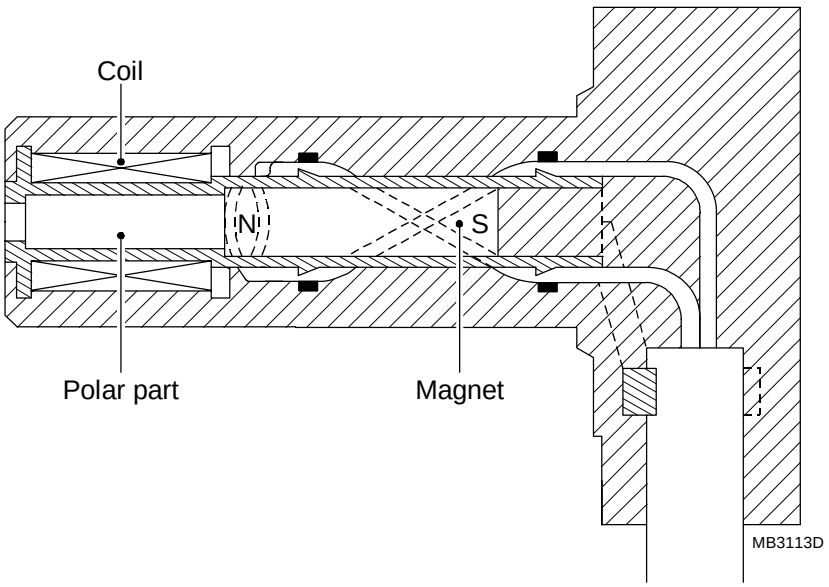
- the transmission input speed, by measuring the speed of rotation of the converter turbine,
- the transmission output speed, by measuring the speed of rotation of the mechanism output shaft from the step-down gear,

The input speed sensor is mounted on the hydraulic unit, opposite the movement inlet housing.

The output speed sensor is mounted in the mechanism housing, opposite the mechanism output gear of the step-down gear.



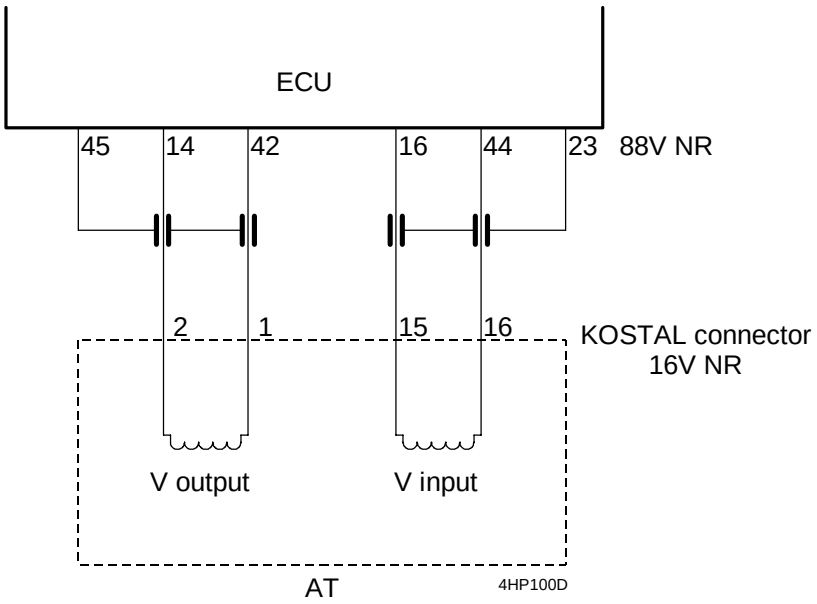
B - DESCRIPTION



They consist of:

- a permanent magnet,
- a coil,

and a polar part.



C - OPERATION

1 - Turbine speed sensor

The movement inlet housing is connected to the converter turbine by means of the input shaft; it therefore rotates at the same speed as the turbine.

This housing has slots all around its periphery at regular intervals. The material between two slots is similar to a tooth.

When one of these "tooth" sections of the inlet housing passes under the sensor, a variation in flux in the coil is created which then sets up an induced electromotive force.

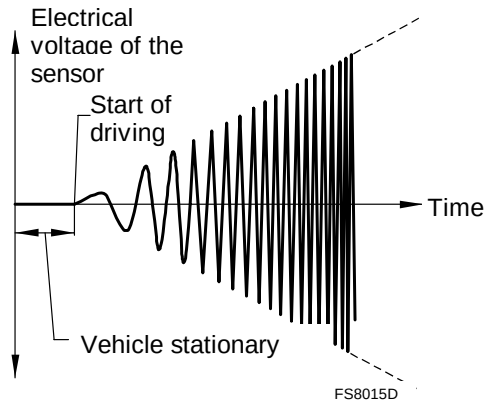
The frequency and amplitude of the sinusoidal signal generated in this way are proportional to the speed of rotation of the inlet housing, and therefore the converter turbine.

2 - Vehicle speed sensor

The input gear of the step-down gear is the mechanism output pinion since it is connected to the planet wheel carrier PS1. Its speed of rotation is therefore proportional to the speed of the vehicle.

Using the same principle as for measuring the input speed, every time one of the gear teeth passes under the sensor, an alternating signal is produced, the frequency and amplitude of which are proportional to the speed of rotation of the mechanism output gear.

Example for the output speed sensor



Note: - The input speed sensor cannot be adjusted.

- The output speed sensor can be adjusted using a shim; in effect, the input gear of the step-down gear has a variable number of teeth depending on the vehicle in question. As its diameter is therefore variable, the sensor must be adjusted to ensure the correct air gap.

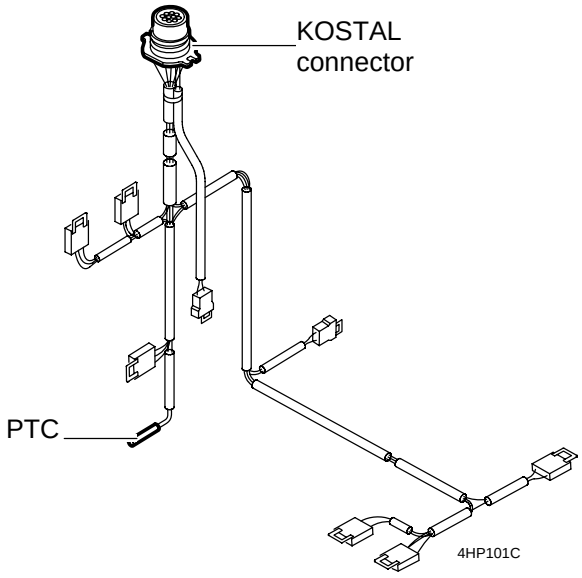
III - OIL TEMPERATURE PROBE

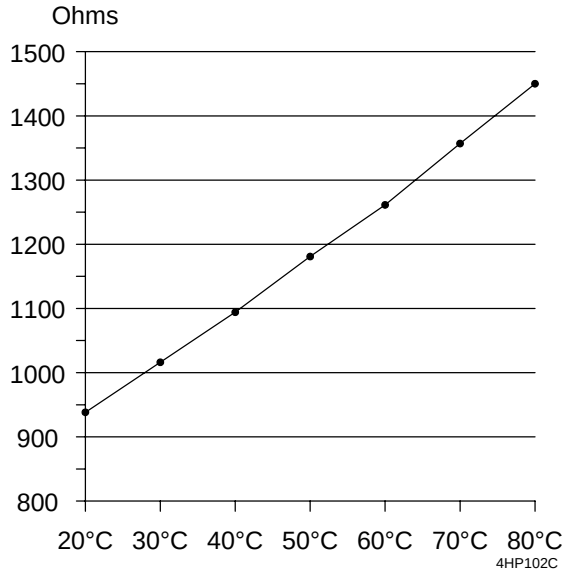
A - ROLE

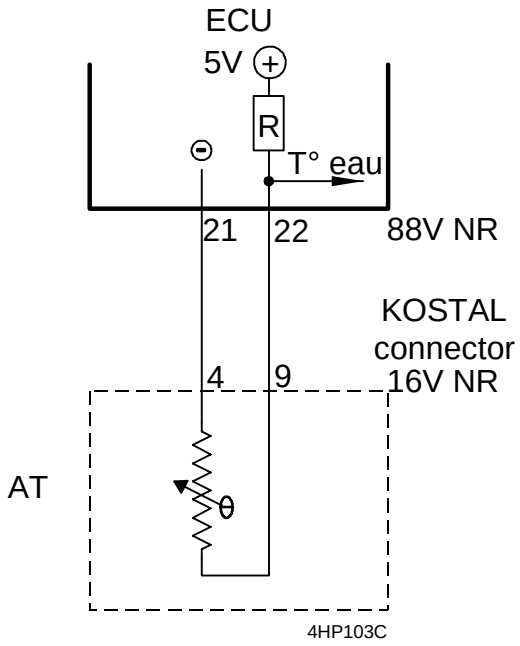
This informs the ECU of the temperature of the transmission oil. It allows it to adopt gear changing strategies and a lock-up control mode preventing the oil from overheating and consequently from damaging the transmission. It also has an effect on the control pressure calculation used within the scope of the management of gear changes.

B - OPERATION

The value of resistance increases as the temperature rises. This is a PTC type thermistor (positive temperature coefficient resistor). It is located in the hydraulic unit.







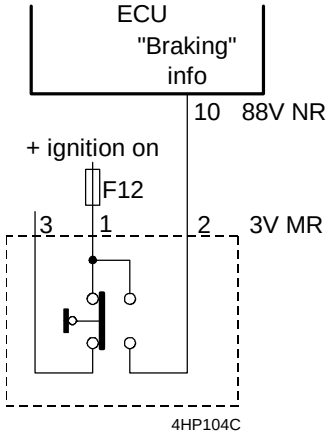
The probe circuit is supplied with five volts direct current. Between tracks 22 and 21, the ECU measures the voltage at the probe terminals which varies as a function of the probe's resistance.

IV - BRAKING INFORMATION

This is supplied to the ECU through the stop switch which is operated by the brake pedal.

This logical information (0 or 1) is used for special strategies:

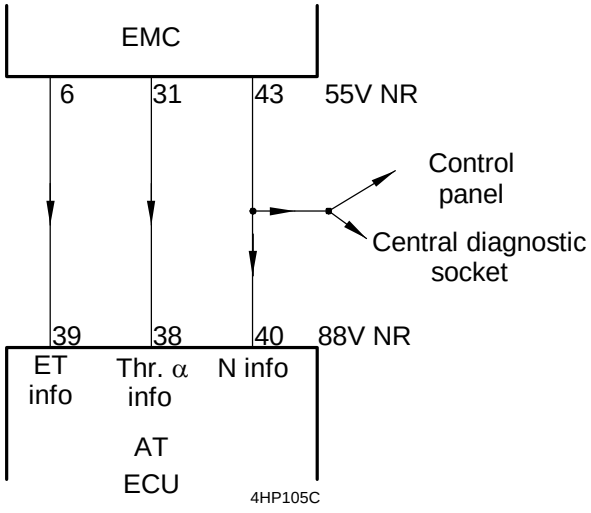
- to force a change down when the brake pedal is used,
- to perform the shift-lock function.



V - LOGICAL INFORMATION SUPPLIED BY THE EMC

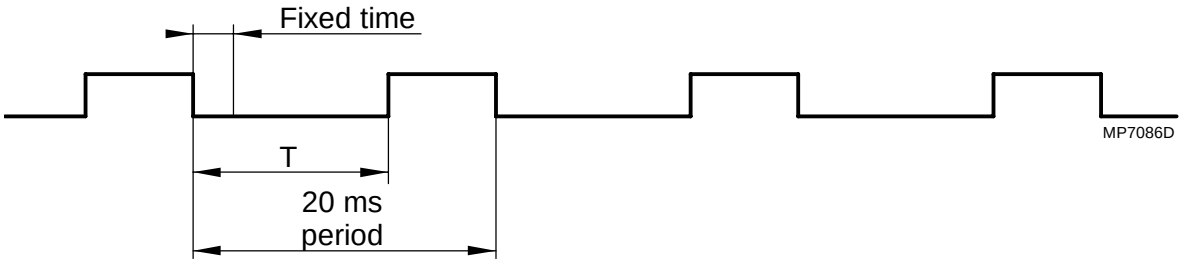
The engine management ECU provides the automatic transmission ECU with three items of information in the form of logical signals:

- throttle position (as a percentage)
  - 0% → no load
  - 100% → full load
- engine torque (in Nm),
- engine speed (in rpm).



A - THROTTLE POTENTIOMETER SIGNAL FOR AUTOMATIC TRANSMISSION

The MP7.0 ECU provides the automatic transmission ECU with throttle position information, in the form of a 0/1 logical signal, the COR of which represents the instantaneous throttle α.



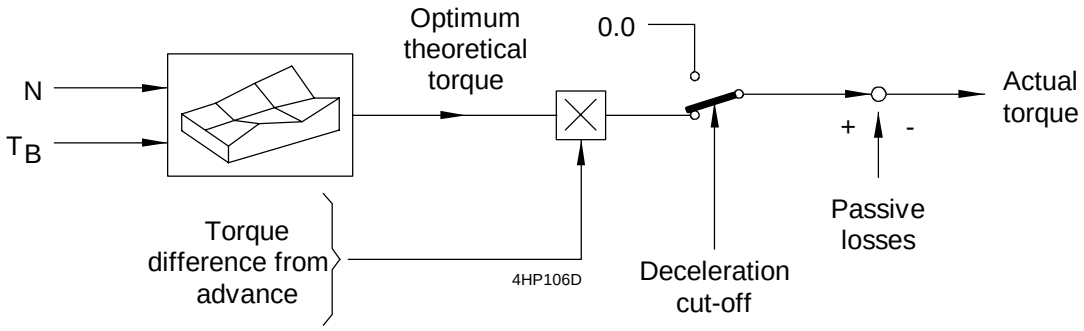
The period, which is constant, is set at 20 ms. It is the time T during which the signal is 0 which represents the throttle position.

T = t0 + t1:
- t0 calibrated time giving the automatic transmission ECU time to react,
- t1 time which is a direct function of α/idle.

B - ENGINE TORQUE SIGNAL FOR AUTOMATIC TRANSMISSION

1 - Calculating the engine torque

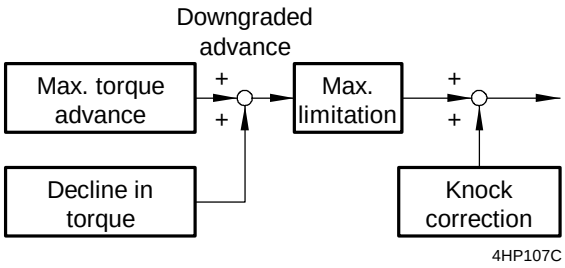
a - General method



Torque difference from advance from the shape

$$0,\ xx = \frac{100 - \text{decline in torque from advance in \%}}{100}$$

b - Reminder of simplified advance calculation



c - Calculating the decline in torque due to the advance

Value in % of decline = [Stationary torque correction + catalytic converter priming correction] limited in variation +

[corrections "depending on driving pleasure"] + [decline due to knock].

Decline due to knock = from cartographic map the inputs of which are:

- engine speed,
- sum of advance retards from all cylinders linked to knock correction and preventative correction +:

[Max. allowable advance - Downgraded advance] x 6 cylinders]

provided calculated "downgraded advance" > calculated "max allowable advance"

d - Calculating passive losses

The sum of the losses due to friction and the losses due to the absorption of power by an engaged air conditioning compressor are added.

- Losses due to friction

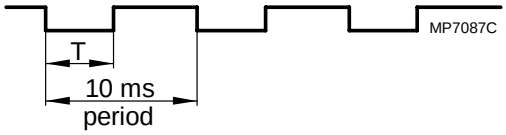
  These are evaluated using an engine speed/time cartographic map; a table f (coolant T°) is used to add a correction representing the effect of engine temperature on friction.

- Torque absorbed by air conditioning compressor

  The fixed value of torque absorbed by the compressor is used to which is added the torque absorbed due to the engaging. This comes from an engine speed/air temperature cartographic map (variable displacement pump) or from a table f (N) only (fixed displacement compressor), and is then filtered so that it decreases down to zero as a function of a calibrated time constant.

Note: It can be seen that logically, the torque reduction requested by the automatic transmission is not taken into account.

2 - Engine torque signal



The period, which is constant, is set at 10 ms.

The time T represents the engine torque.

If N < 500 rpm → T is a function of coolant temperature.

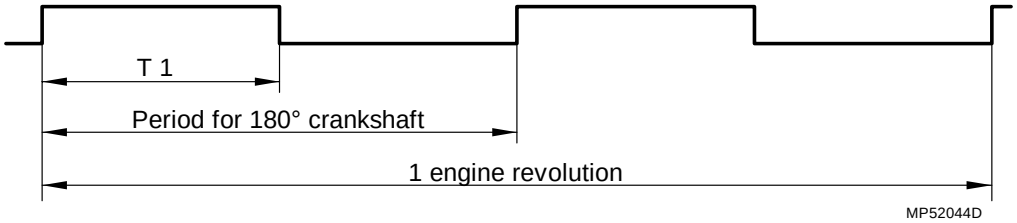
If N > 500 rpm → T = calibrated time to + time t1 f(calculated engine torque).

Note: The engine torque is updated every 20 ms.

C - REV COUNTER SIGNAL GENERATED BY THE MP7.0 EMC

The MP7.0 ECU measures the frequency at which the tooth signals pass under the engine speed/position sensor and from this deduces the engine speed.

Engine speed signal



$$T1 \text{ (in ms)} = \frac{\text{Period}}{2} = \frac{1}{4} \text{x} \frac{60 \text{x} 1000}{N} \text{ms}$$

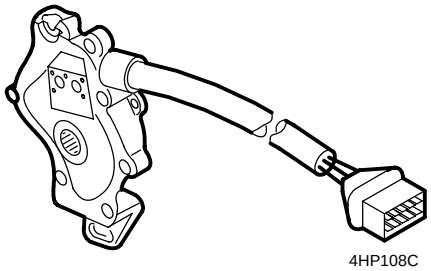
When stationary: the signal is at state 1.

Engine running: The signal switches every 15 teeth (90° crankshaft).

The lower level is less than 1.5 V.

VI - SELECTOR LEVER POSITION INFORMATION

This information is supplied to the ECU by the multifunction switch located on the transmission. It is fitted on the selector shaft which operates the manual valve of the hydraulic unit.



4HP108C

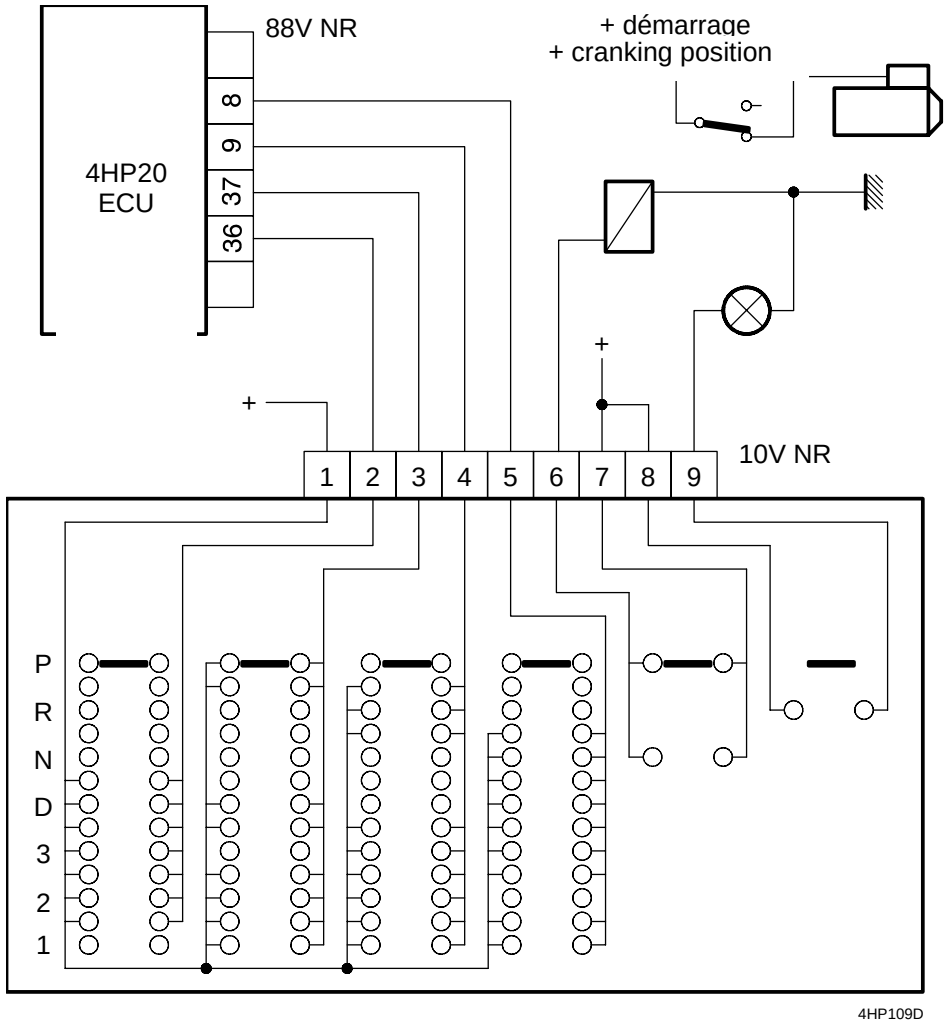
It is used for:

- managing imposed gears,
- displaying the lever position on the control panel,
- preventing the engine from being started in a position other than P and N,
- illuminating the reversing lights in position R.

Note: The multifunction switch cannot be adjusted.

Operating principle:

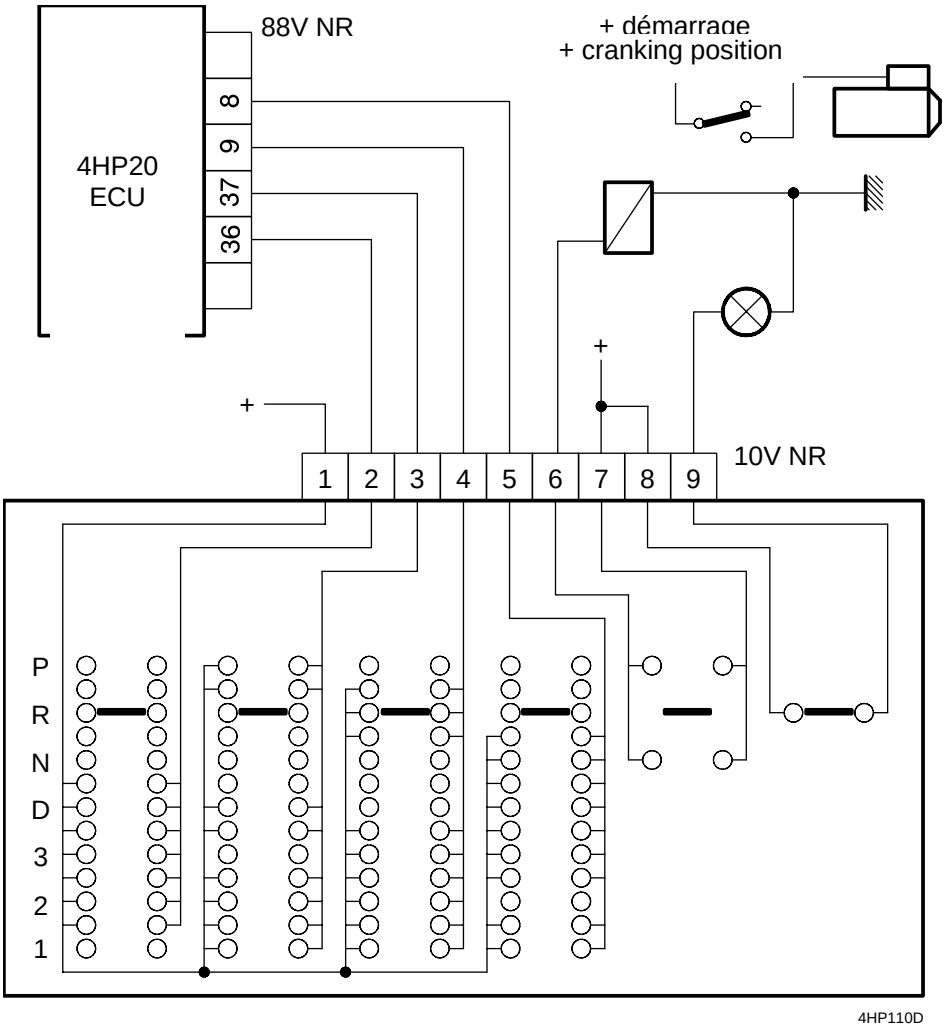
- Position P:



In this position, the multifunction switch allows the engine to be started via terminal 6 by operating the starting safety relay.

It informs the automatic transmission ECU of its position via terminal 3 for the display on the control panel.

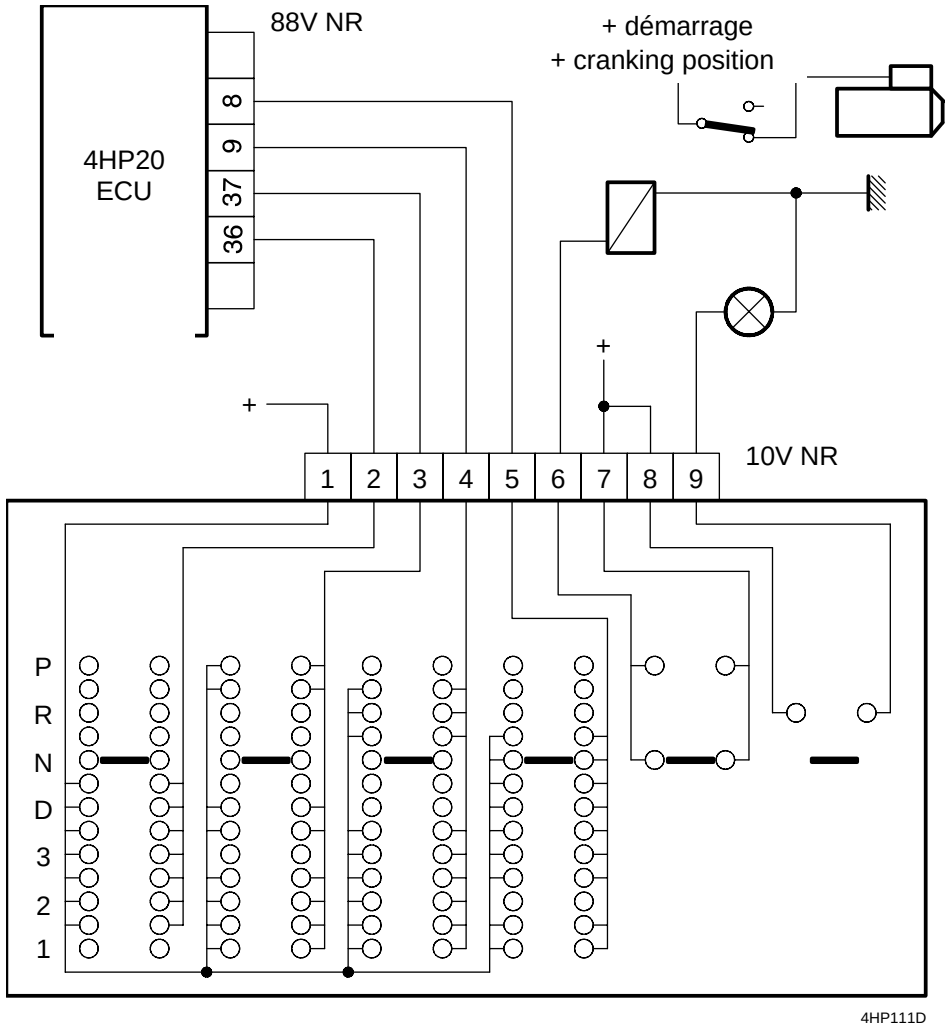
- Position R:



In this position, the multifunction switch causes the reversing lights to be illuminated via terminal 9.

It informs the automatic transmission ECU of its position via terminal 4 for the display on the control panel.

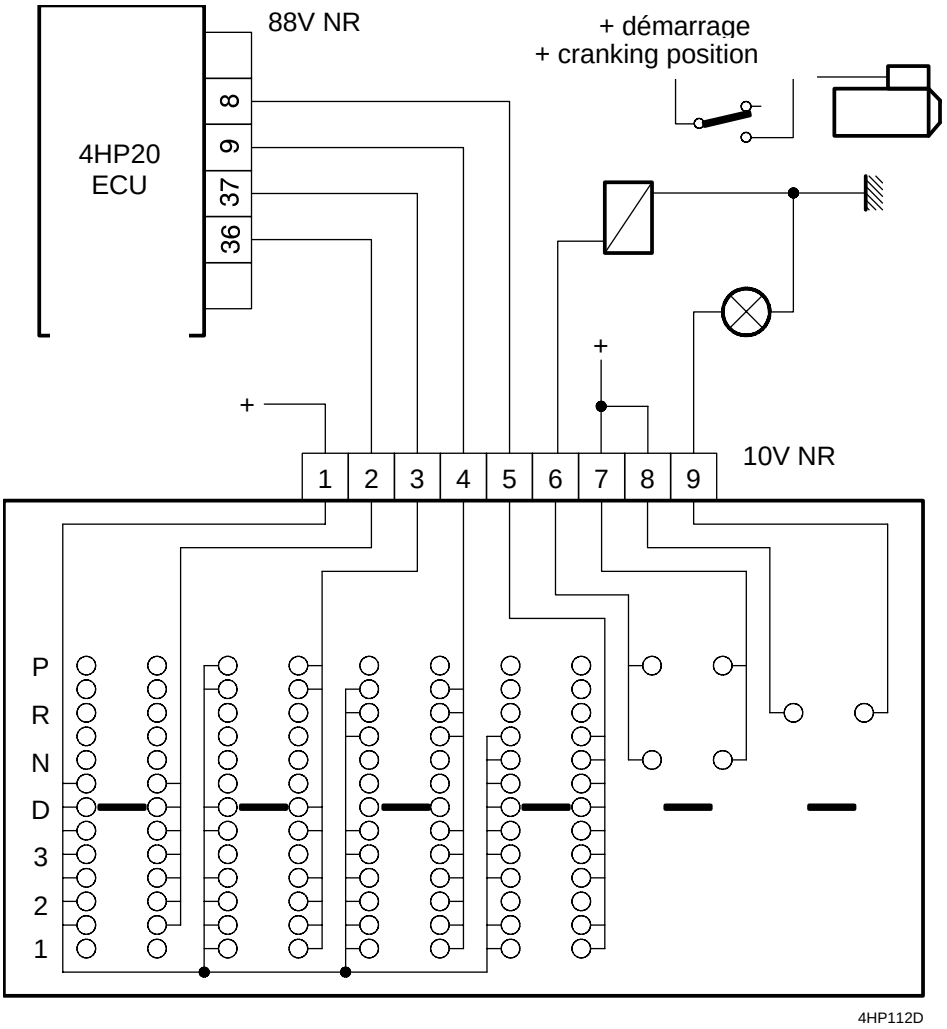
- Position N:



In this position, the multifunction switch allows the engine to be started via terminal 6 by operating the starting safety relay.

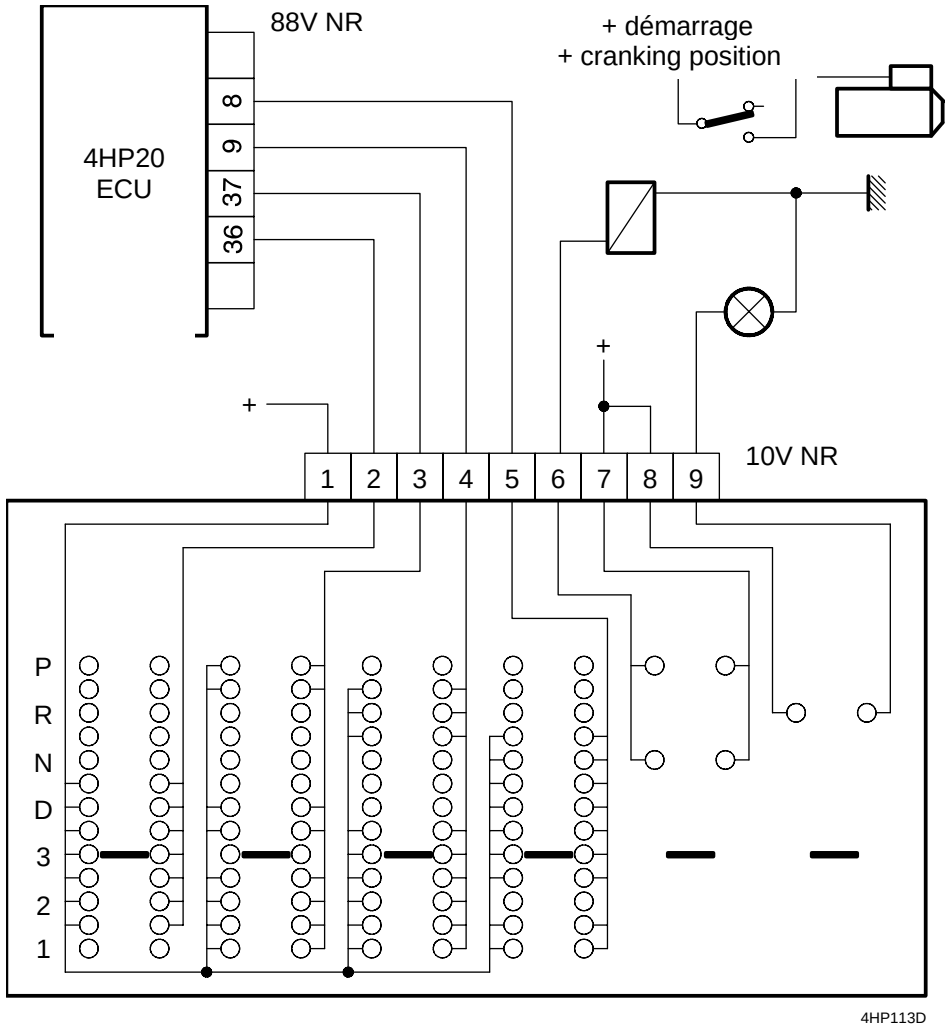
It informs the automatic transmission ECU of its position via terminal 5 for the display on the control panel.

- Position D:



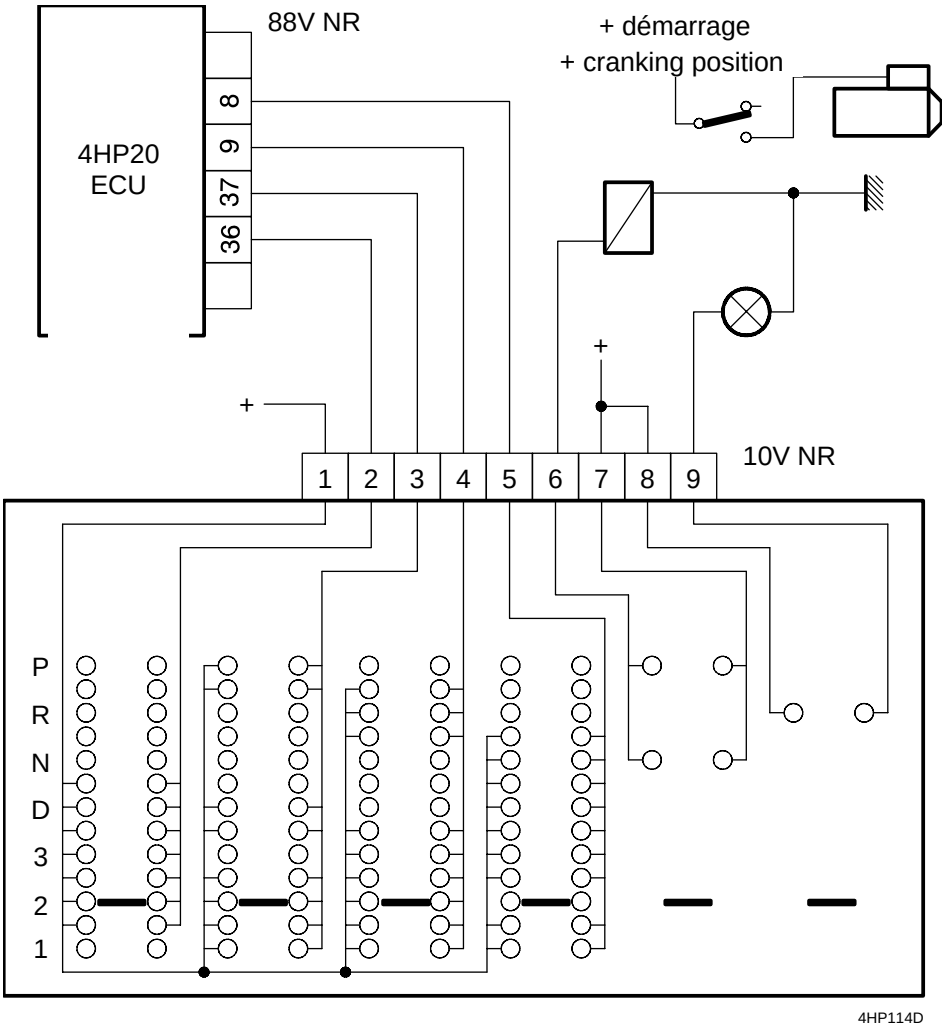
The multifunction switch informs the automatic transmission ECU of its position via terminals 2, 3 and 5 for the display on the control panel.

- Position 3:



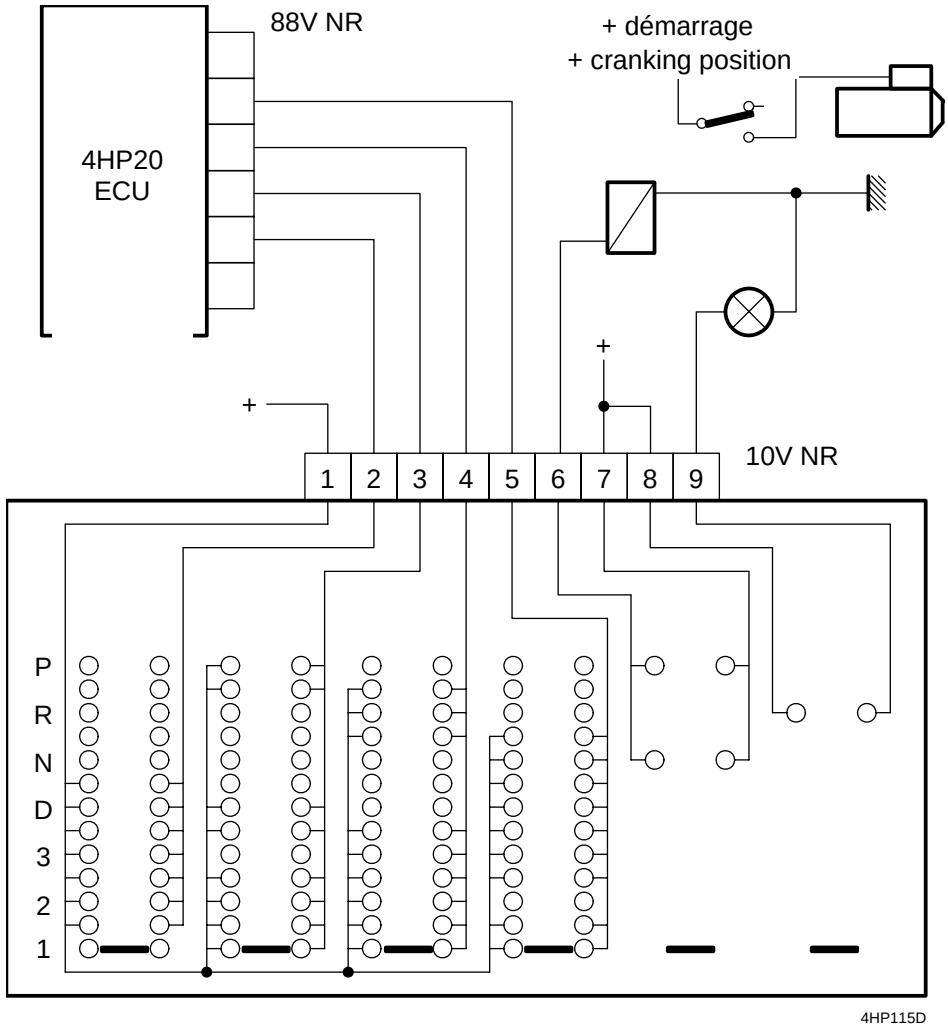
The multifunction switch informs the automatic transmission ECU of its position via terminals 2, 4 and 5 for the display on the control panel.

- Position 2:



The multifunction switch informs the automatic transmission ECU of its position via terminals 2, 3 and 4 for the display on the control panel.

- Position 1:



The multifunction switch informs the automatic transmission ECU of its position via terminals 3, 4 and 5 for the display on the control panel.

Note: The multifunction switch contains intermediate tracks allowing the warning light on the control panel to flash in the intermediate lever positions (especially between position P and D).

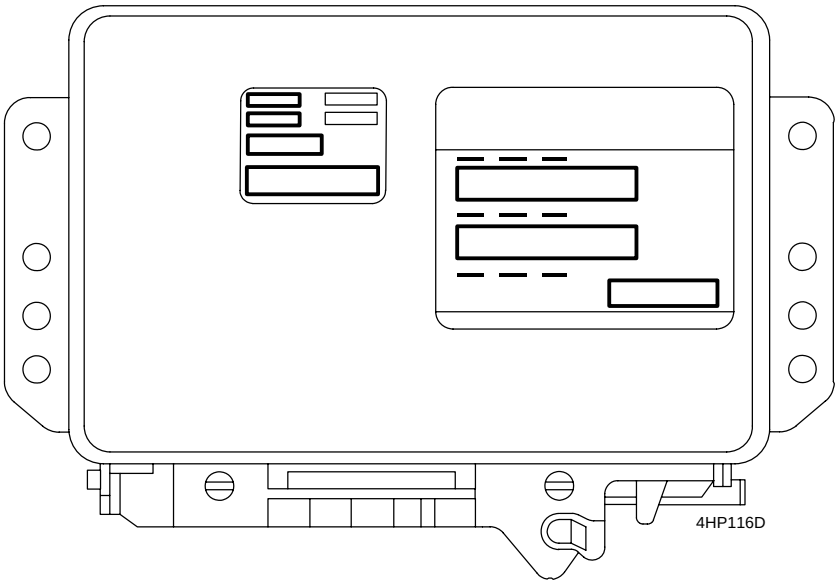
INFORMATION REQUIRED FOR OPERATION

INFORMATION		FUNCTION													
TYPE	SOURCE	Line pressure control	Gear changing decision	Gear changing management	Operating mode	Converter lock/slip	Autoadaptiveness	Torque reduction	Engine anti-stall	Idle speed regulation	Catalytic converter reheating	Engine protection	Safety of people	Transmission protection	Control panel display
Selector lever position	Multifunction switch PRND321		*				*	*		*	*		*	*	*
+/-	Switches		*												*
Set of strategies selected	ECO switch (NORMAL) SPORT SNOW		*		*	*	*								*
Throttle position	Engine ECU or potentiometer		*	*			*	*							
Kickdown request	Throttle position		*				*								
Braking	Stop switch		*		*		*		*				*		
Engine speed	Engine ECU	*			*	*	*	*	*			*		*	
Transmission input speed	Inductive sensor	*		*		*	*	*	*						
Transmission output speed	Inductive sensor		*			*	*					*	*	*	
Engine torque	Engine ECU or injector signal	*		*	*		*	*						*	
Transmission oil temperature	Thermistor	*	*	*	*	*	*	*			*			*	*

ZF 4HP20 AUTOMATIC TRANSMISSION

THE ECU

On the CITROËN XANTIA, the ECU is located in the engine compartment under the battery. The ECU inputs and outputs are performed by means of an 88 track connector.



The automatic transmission ECU using "FLASH EPROM" technology.

This new technology means that the ECU can be updated without it having to be removed in the event of a software upgrade (in order to solve a driving pleasure problem for example).

In effect, instead of replacing the ECU or the Eprom, the operation consists of "downloading" the ECU program into its memory from a suitable after-sales tool via the diagnostic socket.

I - ECU FUNCTIONS

The ECU performs the following functions.

A - GEAR CHANGING LAWS

The ECU has 10 gear changing laws which are used to adjust the transmission operation to the driver's driving style, to the chosen program and to internal and external conditions.

The following laws are therefore obtained:

- 6 laws: for auto-adaptivity,
- 1 law: for the snow program,
- 1 law: for depollution when cold (reheating),
- 2 laws: for temperature protection of the automatic transmission

B - PROGRAMS

The ECU manages 3 programs: auto-adaptive, sport and snow (upon driver's request).

C - AUTO-ADAPTIVITY

The ECU has an auto-adaptive program which it modifies in real time throughout the vehicle's life, adapting itself to its internal and external environment.

The ECU works in a closed loop permanently checking that its commands have been carried out whilst adapting itself to them.

The ECU therefore adapts itself to:

- the driver by memorising his driving style (sporty driving, economic driving...),
- the vehicle (empty, laden, towing, kickdown...),

- external conditions (going up or down a hill, low adherence, town..),
- the transmission (changing up or down gears, towing, kickdown temperature, oil degradation, mechanical wear of parts...),
- the engine (engine torque, speed, temperature...).

D - GEAR CHANGE UP PREVENTION DUE TO SUDDEN REMOVAL OF FOOT FROM ACCELERATOR

This function prevents the transmission from changing up to a higher gear when the foot is suddenly removed from the accelerator pedal; this allows the engine brake to be maintained whilst decelerating.

E - TORQUE REDUCTION

This function is used to increase driving pleasure by reducing the engine torque when changing gear.

This action consists of momentarily reducing the timing advance in accordance with a pre-programmed table.

F - IDLE SPEED COMPENSATION

This function is used to attenuate the dragging effect of the transmission when it is being driven through the engine management computer (idle reference speed).

G - CHANGE DOWN

The ECU is totally responsible for changing down the gears as a function of engine load, vehicle speed and driving conditions.

In particular, the ECU authorises a double change down (from 4th to 2nd and 3rd to 1st) and may force a single change down to increase engine braking (braking, going down hill...).

H - MANAGEMENT OF IMPOSED GEARS

The ECU is totally responsible for changing imposed gears in terms of operating and safety (changing limits).

I - KICKDOWN (K.D)

The kickdown function is given by the automatic transmission ECU following a switch to the full load position (load greater than 95%) and as a function of engine speed.

Warning: thick carpets may reduce accelerator pedal travel.

J - CONVERTER OPERATION

This function is used to optimise the operation of the converter by locking it to save fuel, by controlling it to filter out engine acyclisms or so as to permanently work out the engine torque increase value.

K - ADAPTATION OF THE GEAR CHANGING PRESSURE

The ECU alters the gear changing pressure (pressure on clutches and on brakes) as a function of various parameters (engine torque, gear changing times, internal clearance and wear...).

L - CONTROL PANEL DISPLAY

The ECU informs the driver of the position of the selector lever and the choice of program using the liquid crystal display on the control panel (on CITROËN XM and remodelled XANTIA).

The ECU may also warn the driver of a transmission problem by flashing the sport and snow display.

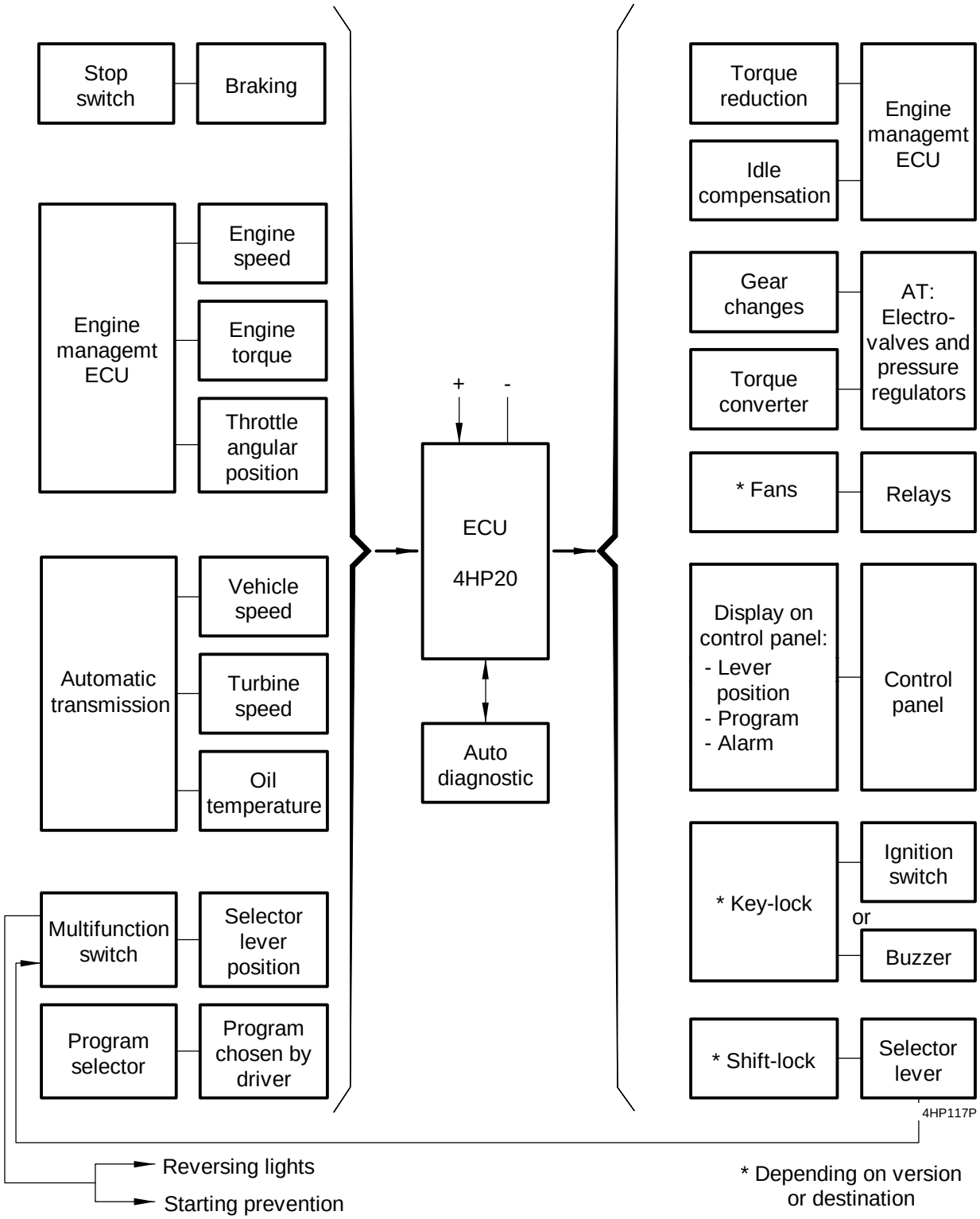
M - SAFETY - DIAGNOSTICS

The ECU permanently checks its supplies and that its sensors and actuators are working correctly. The ECU also has downgraded modes which ensure the safety of the mechanical components when a problem occurs in one or several of the system's components.

N - UPGRADES

The ECU can be updated by downloading.

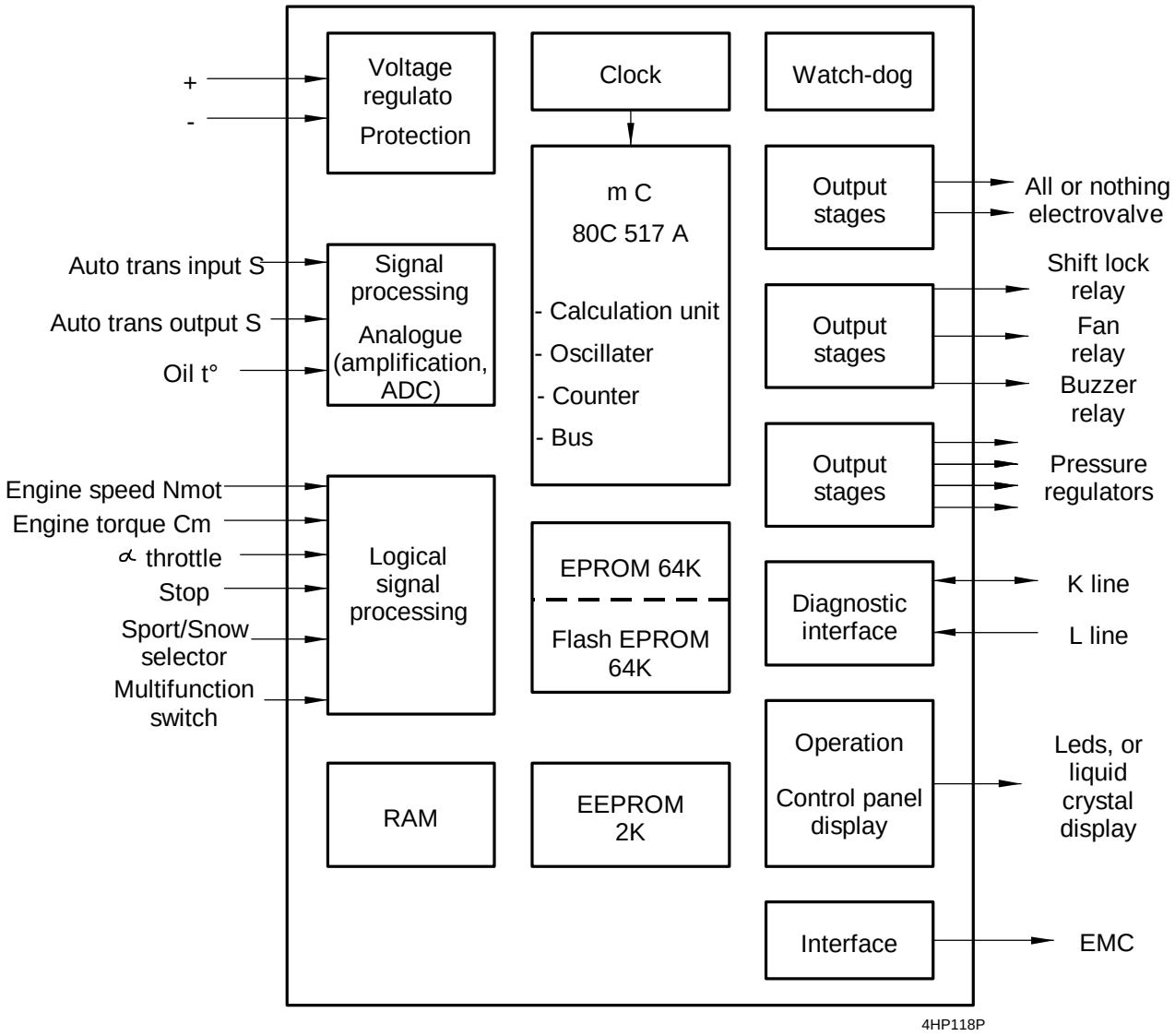
II - INPUTS/OUTPUTS



III - CONNECTIONS

1 - Control through negative of proportional electrovalve EDS4
3 - +12V supply for proportional electrovalves
4 - Control through negative of proportional electrovalve EDS6
5 - Control through negative of proportional electrovalve EDS3
6 - Power earth
8 - Selector lever position + information (multifunction switch)
9 - Selector lever position + information (multifunction switch)
10 - "Foot on brake pedal" + information (brake switch)
12 - "Snow" program selection - information (program button)
14 - Transmission output speed - information (transmission output speed sensor)
15 - Transmission output speed sensor screening
16 - turbine speed + information (turbine speed or transmission input speed sensor)
20 - - output signal for fan operation request
21 - Analogue earth for transmission oil temperature sensor
22 - Transmission oil temperature + information
23 - Turbine speed sensor screening
25 - Output for display (depending on vehicle)
28 - Earth for electrovalves
29 - Control through negative of proportional electrovalve EDS5
30 - Control through negative of all or nothing electrovalve MV1
31 - + 12V ignition on supply
32 - Control through negative of "Shift-lock" relay
33 - Control through negative of fixed electrovalve MV2
34 - Power earth
36 - Selector lever position + information (multifunction switch)
37 - Selector lever position + information (multifunction switch)
38 - Throttle α information from EMC
39 - Load information (engine torque) from EMC
40 - Rev counter information
42 - Transmission output speed + information (transmission output speed sensor)
44 - Turbine speed - information (transmission input speed sensor)
45 - "Sport" program selection - information (program button)
47 - L diagnostic line (not used)
49 - Key-lock control (depending on country)
50 - K diagnostic line
51 - Automatic transmission position / torque reduction request (to EMC)
52 - + 12V supply for fixed electrovalves MV1 and MV2
54 - + 12V ignition on supply
55 - Permanent battery + for saving autodiagnostic memory

IV - ECU ARCHITECTURE



RAM: Memory for intermediate calculations and for storing data learnt.

EEPROM: This contains: - all learnt data (autoadaptives)

- faults

EPROM: This contains the operating program, the strategies, the laws (characteristic curves), fault detection parameters.

Note: All data learnt whilst driving for the autoadaptation is stored in the RAM then transferred to the EEPROM when the ignition is switched off during a power latch phase (≈20 seconds). When the ignition is switched on, it returns to the RAM.

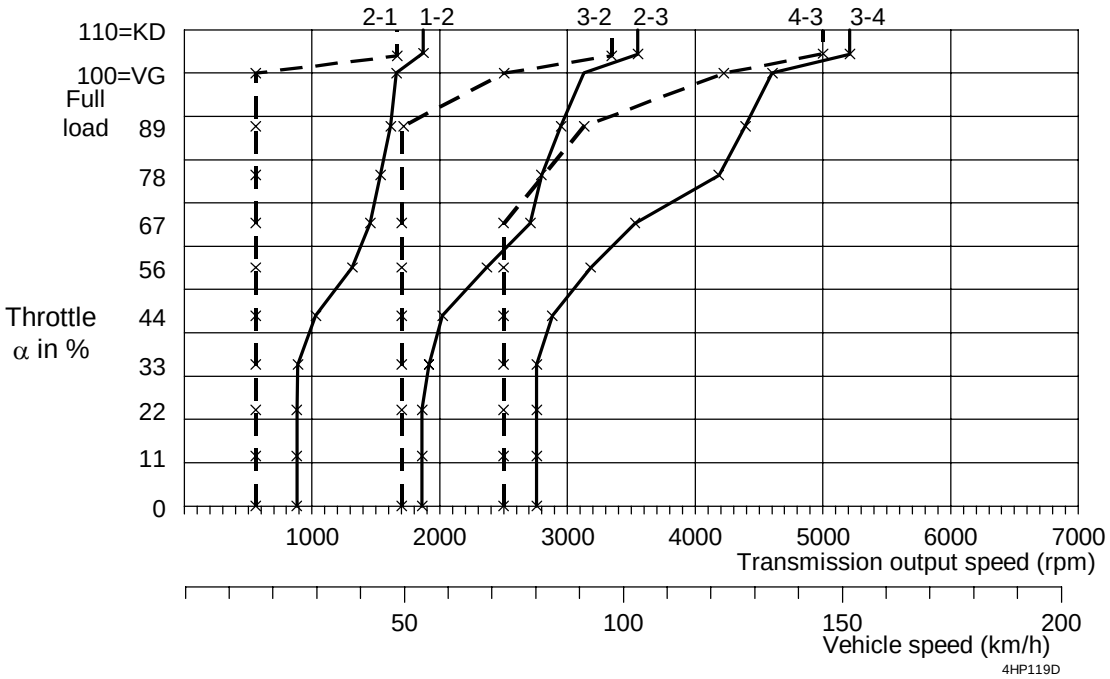
ZF 4HP20 AUTOMATIC TRANSMISSION

THE STRATEGIES

I - GEAR CHANGING LAWS

The vehicle's operating point is defined by two parameters: "throttle position" (driver's wishes) and "vehicle speed".
During automatic operation, the decision to change from one gear to another is taken from a set of curves f (throttle α; $S_{transmission\ output}$) which form the "gear changing laws".

Example of gear changing laws



A - NOTES

- A set of gear changing laws - we will see later on that there are several of these - offers all available forward gears if the driver has selected position "D". It defines the changing points and the gears to be changed.

- Two main criteria are used when defining a set of gear changing laws:
  - selection of the gear in which the most economical fuel consumption is achieved with respect to the resistance to forward movement (gear changing points are fairly low),
  - selection of the gear allowing maximum power possible to be accessed.

A set of laws is generally designed in accordance with one of these two criteria although a compromise is always sought.

Furthermore, it is desirable for the maximum possible instantaneous vehicle power to be available at any moment; thus, it should be possible to push the respective gear up to the maximum authorised engine speed before the transmission changes to another gear.

- Gear changing curves are different when changing up and when changing down. In effect, if a gear were to be changed at the same speed when changing up and changing down, a slight variation in throttle position would cause repeated gear changes which is called the "pumping effect".

- The intervals between gear changes are defined so that the next gear is changed to without any significant modification in traction force.

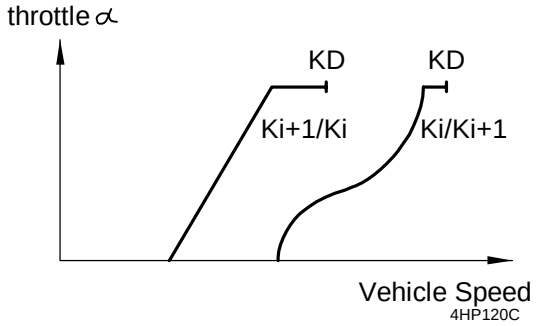
- The set of curves allows the transmission to change down two gears in one step.

B - INTERPRETING THE CURVES

1/2, 2/3 and 3/4 laws: the corresponding gear changes occur when the operating point curve crosses from the left (increasing vehicle speed) and if the vehicle is not already in second gear for the 1/2 law, in third gear for the 2/3 law or in fourth gear for the 3/4 law.

4/3, 3/2 and 2/1 laws: the corresponding gear changes occur when the operating point curve crosses them from the right (decreasing vehicle speed) and if the vehicle is not already in third gear for the 4/3 law, in second gear for the 3/2 law or in first gear for the 2/1 law.

C - KICK-DOWN FUNCTION



Under certain vehicle speed conditions, this function allows the upper gear changing limit to be reduced or for a lower gear to be changed to earlier.

To do this, the ECU has to receive the "kick down" load information.

When this information is present, the ECU offsets the gear changing limits, in other words the gear changing laws are replaced by six vehicle speed reference values called "kick down points".

In our application, the "kick down" points correspond in theory to maximum gear changing law points. In reality, the "kick down" information is effective for a throttle opening of more than 95% of the electrical travel of the potentiometer.

II - HOLD COMMAND

Automatic operation is maintained but the range of authorised gears may be limited by the selector lever.

For a selected range, it is not possible to change to a higher gear outside the range. However, changes to lower gears occur automatically as soon as a changing limit is crossed.

All gear changing management functions remain active.

Operating range 1:

Function identification: selector lever in position 1, program E or S. Range: 1st gear.

Changes to higher gears are locked and change downs to this range (4-3, 3-2, 2-1) occur as soon as the lower engine speed limit has been crossed.

Operating range 2:

Function identification: selector lever in position 2, program E or S. Range: 1st or 2nd gear.

Changes to higher gears are locked and change downs to this range (4-3, 3-2) occur as soon as the lower engine speed limit has been crossed.

Changes from 1st gear to 2nd gear and change downs from 2nd gear to 1st gear correspond to the characteristic curves of the gear changes in normal mode, depending on the position of the program switch.

Operating range 3:

Function identification: selector lever in position 3, program E or S. Range: 1st, 2nd and 3rd gear

Changes from 3rd gear to 4th gear are locked, change downs from 4th gear to 3rd gear occur as soon as the corresponding lower engine speed limit has been crossed.

Changes from 1st gear to 2nd gear and from 2nd gear to 3rd gear as well as change downs from 3rd gear to 2nd gear and from 2nd gear to 1st gear correspond to the characteristic curves of the gear changes in normal mode, depending on the position of the program switch.

Case of reverse gear

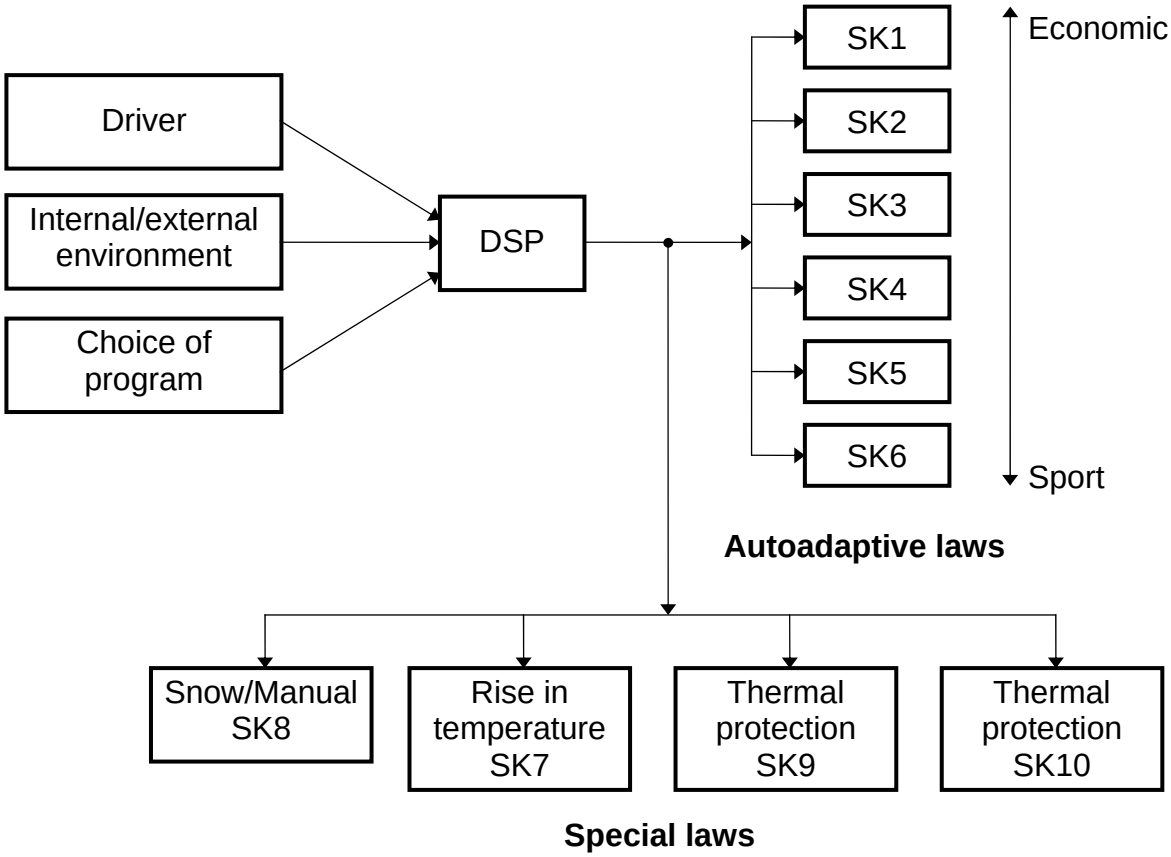
Selector lever in position R, reverse gear will not be engaged until the vehicle speed is below a certain limit.

Changing limit (order of size)

The ECU prevents the following gears from being selected above certain speeds:

- reverse gear - 10 km/h,
- 3rd hold - 165 km/h,
- 2nd hold - 110 km/h,
- 1st hold - 60 km/h.

III - PROGRAMS AND VARIOUS LAWS



DSP = Dynamisches schalt programm (autoadaptive gear changing program)
SK = Schalt kenn linie (characteristic gear changing curve)
The ECU has ten sets of gear changing laws and chooses the most suitable one depending on:

- the driver → his driving style,
- internal and external conditions,
- the program selected by the driver.

A switch allows the driver to select the following programs:

- automatic or economic or normal,
- sport,
- snow (and manual)

- **Normal program:**

  The ECU has 6 sets of gear changing laws, from the most economic to the most sporty. The ECU chooses the set of laws which, at a given moment, are most suited to the driver's driving style and to the surrounding conditions (road profile for example).

  The ECU systematically applies the normal program every time the ignition is switched on.

  Furthermore, the normal program starts:

  – when warm → on the set of laws memorised when the engine was switched off,

  – when cold → on set of laws SK2.

- **Sport program**

  The ECU only uses the most "sporty" sets of laws (SK5, SK6), and the criteria for changing to the immediately less "sporty" set of laws are less severe.

- **Snow program**

  – Selector lever in position D → The ECU adopts a specific set of laws and the engine is systematically started in 3rd gear as 1st and 2nd gear are prohibited. Also there is:

    . no kickdown nor double change down,

    . forced change down when going downhill,

    . forced change down when brake pedal operated.

  Both these functions are specially adjusted in this instance (snow program).

  – Selector lever in manual positions → only the gear corresponding to the position of the selector lever is possible;

    . position 3 → 3rd only ⎫
    . position 2 → 2nd only ⎬ This is the manual mode offered by the "snow" program
    . position 1 → 1st only ⎭

  Naturally, the engine overspeed safety (changing limits) cuts in when the lever is moved to an imposed position (3, 2 or 1).

- Special sets of laws:
  - Temperature rise laws: this cartographic map is designed to help the engine warm up and therefore to make the catalytic converter heat up quicker. For this, gear changing points are reduced.

    It is applied in the following conditions:

    For 130 seconds after the engine has been started (rev counter information) when the transmission temperature is less than 30°C.

    . Transmission temperature protection laws:

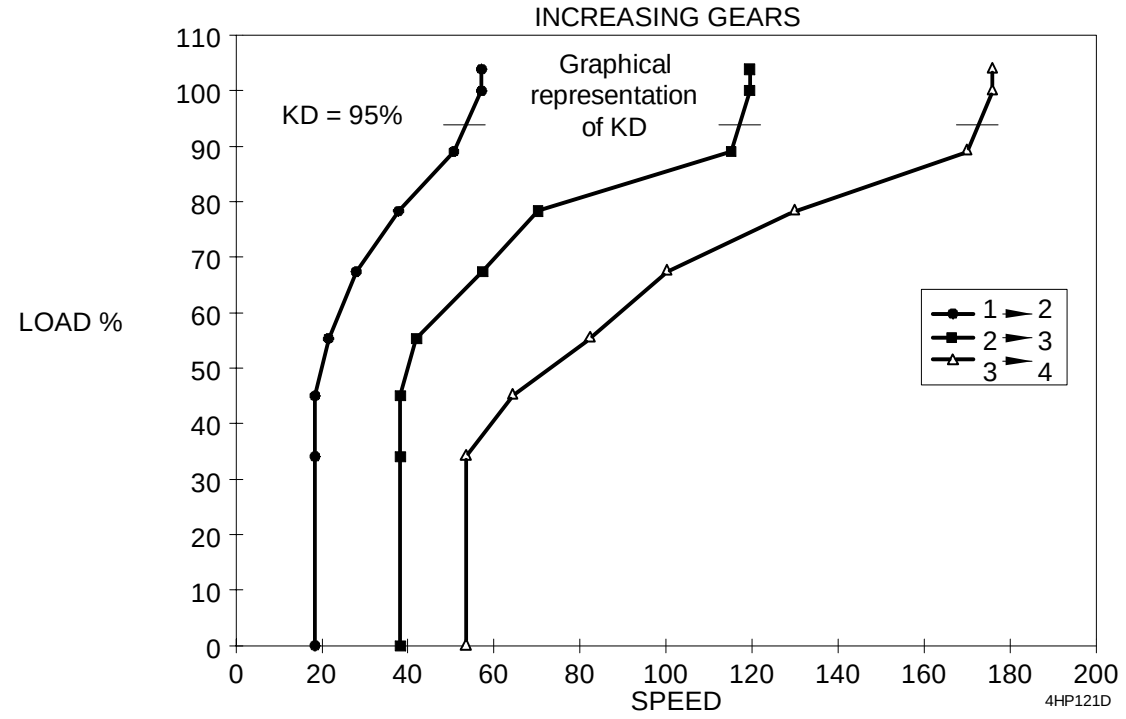
    The ECU has two cartographic maps which result in an increase in engine speed:

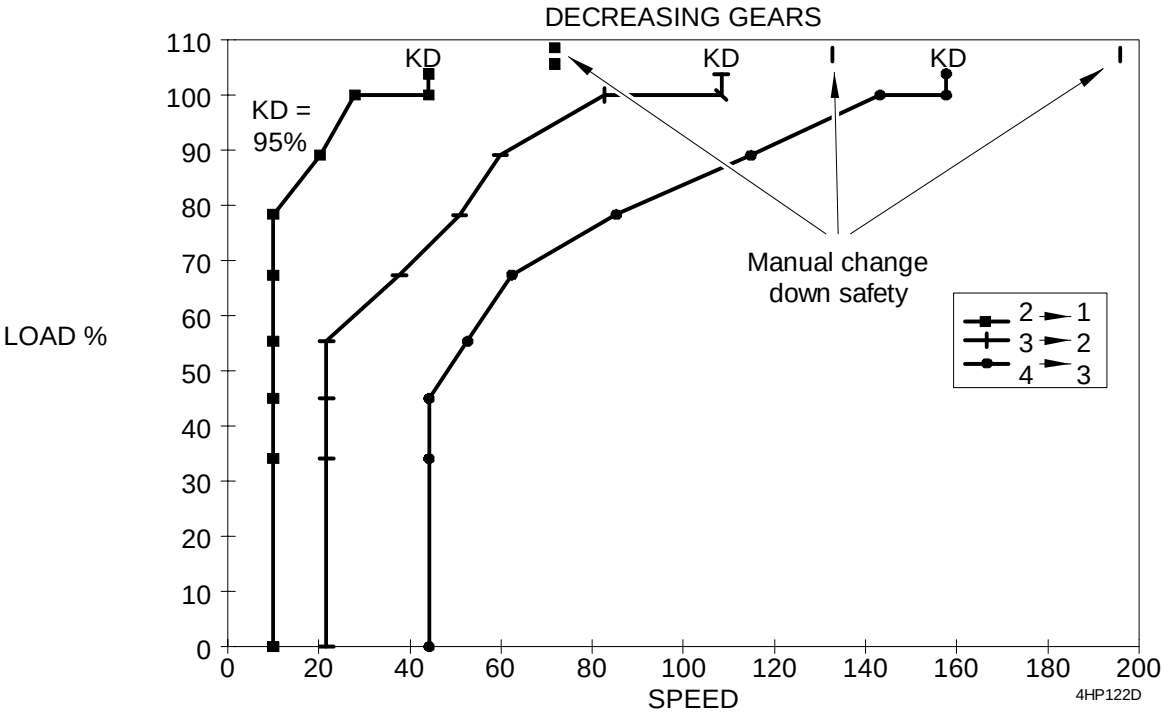
    - cartographic map N°1 if transmission temp. > 120°C,
    - cartographic map N°2 if transmission temp. > 118°C and town type driving.

Note: Temperature protection also effects the operation of the lock-up (reduction and even removal of slip)

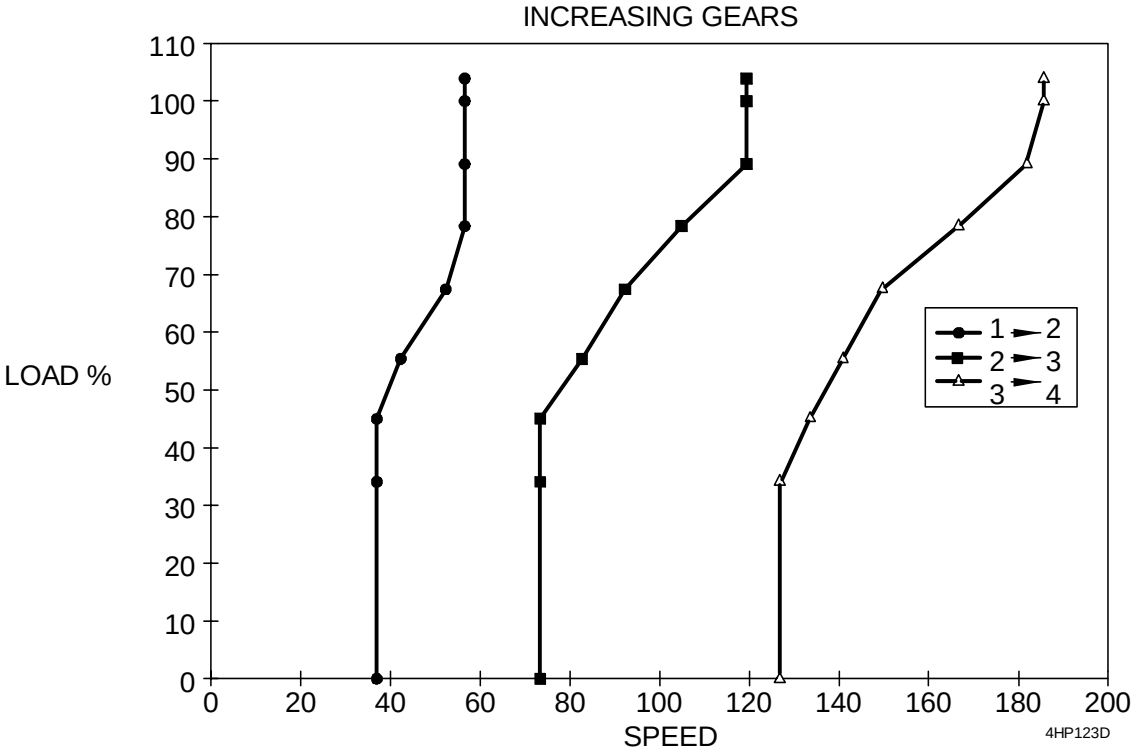
Examples of changing laws

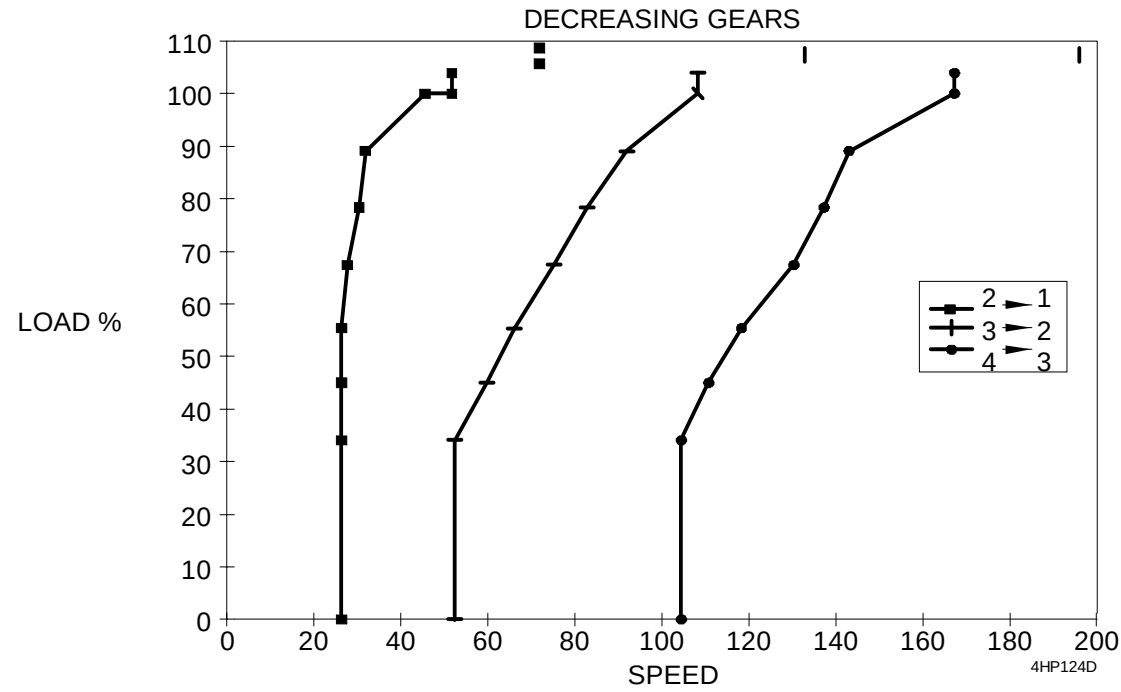
SK2 laws





SK5 laws





IV - DSP FUNCTION (AUTOADAPTIVE CHANGING LAWS)

A - INTRODUCTION

This function allows the ECU to alter the gear changing points automatically as a function of:

- the driver's wishes,
- the driver's style of driving (sporty or fuel economy),
- the vehicle load conditions (recognition of the increase in resistance to movement),
- the road profile (flat, mountain).

The last three parameters are represented by a modulation factor calculated as a function of all the variables the ECU has. The ECU can then choose the most suitable set of gear changing laws from the six it has in its memory. The gear changing points therefore change in real time.

1 - Adaptivity to load (increase gear)

The ECU can recognise an increase in the resistance to movement with respect to the vehicle's normal behaviour on flat road. Gears are therefore changed up slightly later in order to maintain sufficient torque at the wheel. Consequently, the frequency at which the gears are changed is reduced.

2 - Adaptivity to driver

The ECU can recognise the driver's actions so as to work out his style of driving and the traffic conditions (traffic jams for example).

The variables used are the following:

- accelerator position (throttle opening),
- speed at which accelerator is acted upon ($\frac{\Delta \alpha}{\Delta t} \rightarrow$ derivative)
- variation in the transmission output speed.

3 - Specific case: going downhill and braking

The ECU can anticipate changing down a gear in the following case:

- positive acceleration of the vehicle in the no load position and,
- action on the brake pedal.

It therefore anticipates changing down a gear after the brake pedal has been acted up for:

- 2 seconds on horizontal ground,
- 1 second when going downhill,
- 0.5 seconds in the "snow" program.

4 - Other functions

- Prevention from changing up a gear (locking of 2nd or 3rd gears) after the foot has suddenly been removed from the accelerator.
- Forced gear change down for prolonged braking (case of going downhill).

B - ADAPTIVE FUNCTION

1 - Parameters used

- Position of gas throttle $\rightarrow \alpha$/idle speed in x%.

The automatic transmission ECU receives the instantaneous position of the throttle α from the EMC, which corresponds to volts.

When the ignition is switched on, the ECU reads the position of the throttle α at idle speed. Then, it works out a throttle opening angle with respect to α (idle speed) where α/idle speed = α (instantaneous) - α (idle speed).

- Engine speed Nmot in rpm.
- Transmission output speed $\rightarrow$ Ns in rpm.
- Engine torque $\rightarrow$ Cm in mN.
- Transmission temperature $\rightarrow$ TAT in °C.
- "Braking" information $\rightarrow$ IBRAKE (0 or 1).
- "Pulling" or "deceleration" condition (0 or 1):

  The vehicle is said to be decelerating (i.e. when the vehicle is driving the engine) if α/idle speed < limit f (Nmot)

The following parameters come from the previous ones:

- travelling speed → Vveh in km/h

  This value is calculated from the gear ratios, the step down and differential torque as well as the circumference of the wheel.

- Acceleration → A+ or A- in m/s² where $|A| = \frac{\Delta Ns}{\Delta t}$

- Output torque → Cs in mN.

  This value is calculated from the gear ratios, the engine torque Cm and the converter torque, since the ECU has the characteristic curve of the torque of this converter in its memory.

- Filtered throttle angle → α/filt.idle1; α/filt.idle2

- Throttle gradient → α/idle speed - GR = $\frac{\Delta \alpha / \text{idle speed}}{\Delta t}$

2 - Description of the function

The ECU permanently calculates a "sportivity index" SP where $0 \leq SP \leq 1$ which allows it to opt for one of the six sets of gear changing laws which it has where:

SP = 0 → not sporty at all

SP = 1 → maximum sportivity

a - Principle

Four sportivity indices SP1, SP2, SP3 and SP4 are calculated simultaneously and in parallel where $0 \leq SPx \leq 1$, which are deemed to represent the driving style from various points of view.

The sportivity index SP which allows the most suitable set of laws to be chosen is equal to: MAX [SP1, SP2, SP3, SP4].

Five programmed values define six ranges of SP between 0 and 1, since there are six sets of laws; the ECU opts for a set of laws lx as a function of the range in which the calculated SP falls.

b - Processing parameters

α/idle speed is filtered $\Rightarrow$ α/filt.idle1 and α/idle.filt2

α/instantaneous filt.idle = α/previous filt.idle + K (α/instantaneous idle - α/previous filt. idle)

α/idle is received every 20 ms

$K \leq 1$ is the filtering coefficient where:

- K1 is used to obtain α/filt.idle1
- K2 is used to obtain α/filt.idle2
- α/filt.idle2 is more filtered than α/filt.idle1 $\Rightarrow$ K2 < K1

Cs is also filtered using the same principle.

The acceleration A is calculated once a second and the average over its last three values is taken.

c - Working out sportivity indices Spx

- SP1 = f (α/filt.idle1, A+) $\rightarrow$ cartographic map of 10 x 6 control points. SP1 takes into account the relationship between the positive acceleration of the vehicle and the driver's wishes:
  - α/filt.idle1 is the input value,
  - A+ is the parameter.
- SP2 = f (Ns, α/filt.idle2) $\rightarrow$ cartographic map of 6 x 4 control points. SP2 is used to locate the operating point, to prevent unnecessary gear changes and to vary the set of gear changing laws when travelling downhill for a prolonged period:
  - Ns is the input value,
  - α/filt.idle2 is the parameter.
- SP3 = f (Ns, A) $\rightarrow$ cartographic map of 6 x 11 control points. SP3 takes into account the relationship between the acceleration and the travelling speed:
  - Ns is the input value,
  - A is the parameter.

- SP4 = f (Cs, Ns) $\rightarrow$ cartographic map of 9 x 9 control points:
  - the filtered value Cs is used as an input value,
  - the travelling speed is used as a parameter (vehicle speed Vveh) which is calculated directly from Ns $\Rightarrow$ SP4 is used to take the vehicle's load state into account.

    SP4 is only calculated in the following cases:

    - if - 0.810g $\leq$ A $\leq$ 0.0506 g

      and

    - if the oil temperature limit is moving. In effect, if the transmission temperature is less than + 50°C when starting the engine, SP4 is not included when working out the final SP and this condition lasts for a period of x seconds.

      This avoids falsifying the calculations since Cs depends on Cm where Cm was calculated from the basic injection time TB which is very high when starting. In reality, the timer is set to zero.

d - Working out the set of gear changing laws Skx

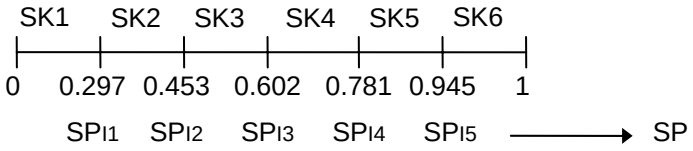
Reminder: SP = Max [SP1, SP2, SP3, SP4]; it is recalculated once a second then filtered:

SPinstantaneous filtered = SPprevious filtered + K [SPinstantaneous - SPprevious filtered] where K = filtering coefficient; its calibrated value varies depending on the direction in which SP is changing.

SPfiltered is the input value which is used to determine the set of laws lx applied at the moment in question.

SKx = f (SPfiltered); x = 1 to 6

Each of the 6 gear changing laws SK1 ------ SK6 corresponds to an SP interval defined by 5 calibrated intermediate values SPI_1 -----SPI_5:



$0 \leq SPfiltered < SPI_1 \Rightarrow SK1$

$SPI_1 \leq SPfiltered < SPI_2 \Rightarrow SK2$

$SPI_2 \leq SPfiltered < SPI_3 \Rightarrow SK3$

$SPI_3 \leq SPfiltered < SPI_4 \Rightarrow SK4$

$SPI_4 \leq SPfiltered < SPI_5 \Rightarrow SK5$

$SPI_5 \leq SPfiltered \leq 1 \Rightarrow SK6$

The set of gear changing laws is updated every second.

SP is no longer updated when the travelling speed Vveh is less than 17 km/h. The current set of laws is maintained and the most recently calculated SP is stored in the EEPROM. This storage process is performed every 10 minutes.

Entering the DSP function after the starting phase

- If transmission temperature $\geq 50°C \rightarrow$ the last sportivity index SP stored in the EEPROM is used when the ECU is switched off $\rightarrow$ the first set of laws are therefore used again.
- If transmission temperature $< 50°C \rightarrow$ the set of laws SK2 are used until a temperature of 50°C is reached, with the aim of containing pollutant emissions.

e - Safety function

Aim

As the sportivity index SP is calculated permanently, the set of gear changing laws can be changed at any moment, including at stabilised engine speed (constant travelling speed, no α/idle speed activity). If this change in the set of laws is performed immediately, a gear change may occur. In some cases, this gear change must be prevented for safety and comfort reasons.

Take an example:

A driver takes the motorway. Imagine that he drives down the slip road "nervously" and quickly returns to SK4. If he then finds himself behind a lorry without being able to overtake immediately, the transmission will change down a gear, changing into 3rd gear $\rightarrow$ the Vveh and α/idle speed information decrease; due to the filtering and the average calculated, these parameters decrease progressively although in the mean time the vehicle has stabilised itself. Their variation will possibly at the start still be included in the range corresponding to SK4 then will switch to the range corresponding to SK3, probably leading to 4th gear being selected $\rightarrow$ uncomfortable, safety compromised.

Description of the function

The function consists of replacing the set of gear changing laws used at a given moment with the set of laws which has just been calculated only if a defined "throttle activity" is detected, or else when a gear change (changing up, changing down, gear selection) has started.

"Throttle activity" definition:

Where: SP applied and SP theoretical

↳ SP calculated which should normally be taken into account

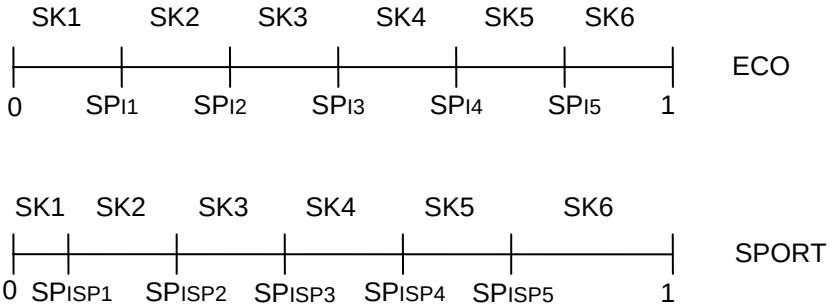
Whilst SPtheoretical = SPapplied, the position of the throttle α/idle speed is constantly copied into the memory $\rightarrow$ α/copied idle speed.

As soon as SPtheoretical differs from SPapplied, and therefore when a change in gear changing laws is requested, α/copied idle speed is blocked. The change to the requested set of laws is only applied when one of the following conditions is fulfilled:

- SPtheoretical > SPapplied and α/idle speed $\geq$ α/copied idle speed + 5.098% (increase in gear changing program, change down anticipated).
- SPtheoretical < SPapplied and α/idle speed < α/copied idle speed - 5.098% (decrease in gear changing program, change up anticipated).
- SPtheoretical > SPapplied and α/idle speed > 90.2%.
- SPtheoretical < SPapplied and α/idle speed < 10.2%.
- A gear change has started (changing up/down, gear selection).

f - Case of "sport" program

The "sport" button is engaged; in this case, operation is still autoadaptive and the sportivity index is calculated normally. In theory, the solution is to use specific intermediate values of SP_I (SP_{ISP}) such that, for an SP calculated in the same way as for the ECO program, a higher set of gear changing laws is used (more sporty) - the sets of laws are the same as in ECO.



In our application, we have kept the same SP_I, but the minimum set of gear changing laws is imposed; this is SK5.

The driver therefore changes to SK6 when the calculated SP is between 0.945 (SP_{I5}) and 1, like for the ECO program.

g - Substitution program E-PROG

If the autoadaptive gear changing program (DSP) cannot be applied (one or several parameters not available for example), the ECU uses a specific emergency mode set of laws SK11.

h - Short duration function SESP

For information purposes - this is not active in our application.

Objective

If a great deal of power is required, a "more sporty" set of gear changing laws may be required for a short duration.

Description

This function is active when, for Ns > calibrated limit, $\frac{\Delta \alpha / \text{idle speed}}{\Delta t}$ > limit (calibrated positive value). In this case, the set of gear changing laws which is immediately higher is implemented. The gear corresponding to this new set of laws is then engaged.

This function is quit either when a gear is changed up or when α/idle speed < calibrated limit. The set of gear changing laws determined by the calculation is then switched to, and the gear corresponding to this set of laws is engaged.

The calculation algorithm continues to work in the background whilst the SESP function is active.

C - SPECIFIC FUNCTIONS

1 - Recognition of vehicle going downhill

The vehicle is going downhill, if:

$$\left.\begin{array}{l} \alpha/\text{filt.idle2} < 9.804\% \\ \text{and } 33 \text{ km/h} < Ns < 109 \text{ km/h} \end{array}\right\} \Rightarrow \text{Downhill flag} = 1$$

2 - Gear change up prevention (HSV)

a - Aim

This function is used to prevent gears being changed up when not required when the accelerator pedal is released quickly.

It is active regardless of which set of gear changing laws is being used.

b - Description

The function is active if in "CHANGE DOWN "

and 0 > α/idle speed - GR > 133%/s.

When the function is active, no upward gear changes resulting from the instantaneous gear change law are authorised. However, gear changes down are allowed and the DSP adaptive calculation continues in the background. This function is deactivated when one of the following conditions is fulfilled:

* [vehicle pulling] and [α/idle speed > limit f (Nmot) = 8 to 80%] and [timer = 0.5 seconds elapsed]; the timer is started as soon as "vehicle pulling" and α/idle speed > limit.

* Vveh < 20 km/h

* Vveh > limit f (gear engaged, downhill flag status, snow flag status)

  ↓ 0 or 1 ↓ 0 or 1

* Vveh > Vveho + Δ Veh where:

  Vveho = Vveh at the point where the 0.5 s timer is triggered

  Δ Vveh = f (gear ratio, downhill flag status, snow flag status) = 9.6 km/h in our application

When the function is deactivated, the gear is determined by the active set of laws → gear changes up are authorised.

3 - Forced gear changes down when braking (ZRS)

a - Aim

This function is used to anticipate gear changes down, so as to provide the engine brake and therefore save the brakes over a long downhill (slope). It may be active regardless of the set of gear changing laws used.

b - Description

The function is active if, for a duration the value of which depends on the status of the downhill flag, the brake pedal is applied (brake flag = 1) and the vehicle is "changing down".

When the function is active, independently to the active set of gear changing laws, a gear is changed down as soon as the safety conditions are satisfied (engaging safety limits) and when:

Vveh < limit f (gear engaged) = 30 km/h - 155 km/h
and, - 0.4 g < γ < 0. A gear will be changed down more easily when

$\gamma = \frac{\Delta Vveh}{\Delta t}$

travelling downhill.

For as long as the above conditions are fulfilled, all upward gear changes - based on the active set of laws - are forbidden.

Case of several gear changes down

After a forced gear change down, if the conditions are once again fulfilled, a second gear change down may be performed if a specific bit f (set of gear changing laws used, downhill flag) = 1.

The function is stopped if one of the following conditions is fulfilled:

* Brake flag = 0

  and, α/idle speed > limit (calibrated value)

  and timer f ($Flag_{snow}$, $Flag_{downhill}$) has elapsed; this timer is triggered when $Flag_{brake}$ = 0 and α/idle speed > limit.

* Vveh < limit f (set of gear changing laws, $Flag_{snow}$)

* Vveh > limit f (gear engaged, $Flag_{downhill}$, $Flag_{snow}$)

* Vveh > Vveho + Δ Vveh f (gear engaged, $Flag_{downhill}$, $Flag_{snow}$)

  Vveho = Vveh at the instant when the timer described above is triggered.

When the function is stopped, the gear is once again worked out by the active set of gear changing laws.

Case where "gear change up prevention" is already active:

If the conditions of the ZRS function are fulfilled, a forced gear change down may be performed if the specific bit f (set of gear changing laws used, downhill flag) = 1.

4 - Temperature protection functions SKTEMP

These functions are available in the DSP (SK1 to SK6), sport and snow (SK8) programs.

a - Specific gear changing laws in the event of high temperature.

Aim

Two independent and specific sets of gear changing laws are used to encourage high engine speeds in order to ensure a sufficient flow through the radiators, or to limit converter slip if the allowable oil temperature in the transmission is exceeded.

Description

* If $T°_{AT} > 120°C \rightarrow$ Set of laws SK9 activated

* If $T°_{AT} > 118°C$
and 6 km/h < Vveh < 32.5 km/h
and α/filt.idle2 < 20%
} Set of laws SK10 activated

SK9 contains a lock-up law containing the "open", "controlled" and "closed" states; this set of laws is not covered by the safety function, given its importance in terms of transmission protection.

SK10 is of "driving in town" type.

If $T°_{AT} < 117°C \rightarrow$ SK9 is no longer applied

If $T°_{AT} < 115°C \rightarrow$ SK10 is no longer applied

The DSP program is still calculated in the background when SK9 or SK10 is active.

b - Specific function of the lock-up in the event of high temperature

This function is used to prevent the lock-up from being in the "controlled" state when the oil temperature is high, in order to limit the temperature of the lock-up track.

If $T°_{AT} > 125°C \rightarrow$ change to a specific lock-up law which only contains the "open" and "closed" states.

There is a range for 2nd, 3rd and 4th gears.

In practice, the normal law is used replacing the "controlled" state with the "closed" state.

This function is available in the DSP (SK1 to SK6), sport, snow, SK9, SK10, and SK8 (warm up) programs.

This function is removed for $T°_{AT} < 2°C$.

c - Engine radiator fan control

The transmission temperature is to be lowered by lowering the temperature of the engine coolant.

The fan unit is engaged when $T°_{AT} > 200°C$. It is disengaged when $T°_{AT} < 197°C$.

This function is therefore not active.

5 - Warm up function WARML

In order to limit pollutant emissions when the engine is warning up, the catalytic converter must quickly reach its operating temperature. To do this, the engine must rotate at relatively high engine speeds for a certain amount of time after starting. The solution consists of using a specific set of gear changing laws SK7 during this operating phase.

If, when starting the engine, (Nmot $\geq$ 576 rpm), 15°C < T°AT < 30°C, SK7 is applied for 132.6s.

PRIORITY OF FUNCTIONS

1 - E.PROG

2 - SKTEMP

3 - SESP

4 - WARML

5 - DSP

V - ADAPTIVE REGULATION OF LINE PRESSURE

A - AUTOADAPTIVITY TO ENGINE TORQUE

The ECU alters the maximum value of line pressure depending on the turbine torque to be transmitted.

It therefore adjusts the line pressure:

- between 15.5 and 18 bar in 1st and reverse gears,
- between 5.5 and 8.8 bar in the other gears.

The ECU imposes a line pressure of 15.5 - 18 bar in the following cases
if:
- a gear is being changed,
- downgraded mode is operational (transmission is locked in 3rd hydraulic)

In stabilised mode, the ECU can switch the pressure from one value to another depending on the turbine torque:

- 5.5 - 8.8 bar for turbine torque $\leq$ 230 mN,
- 15.5 - 18 bar for turbine torque > 230 mN.

B - AUTOADAPTIVITY TO GEAR CHANGES

A gear is always changed to another in the same way: a clutch or a brake is emptied whilst another clutch or brake is being filled.

Furthermore, free wheels are not used in this transmission either for the following reasons:

- so as not to interrupt the transmission of movement,
- so as not to damage the internal mechanics of the transmission,
- so as to obtain maximum comfort/driving pleasure (no hesitation).

when changing gears, and a defined overlap must be created for the receiver which is closing and for the one which is opening. In the receiver which is filling up, the pressure, starting from zero, should reach 16 bar; in the receiver which is being emptied, the pressure, starting from 16 bar, should reach zero.

For the ECU, this therefore involves defining the exact value at which the pressure should be (which is falling or rising) at a given instant t between the start of the gear changing operation and the instant when the new gear is selected.

Furthermore, a pressure rise of short duration is caused in the cylinder during the filling phase so as to obtain a very short gear changing time (less than 500 ms).

This is operated by proportional electrovalves, where the operating COR, defined by the ECU, corresponds to the desired pressure value.

Logically, the ECU works out the suitable value of pressure and converts it into an RCO value.

The instantaneous value of rising pressure is calculated as a function of the following criteria:

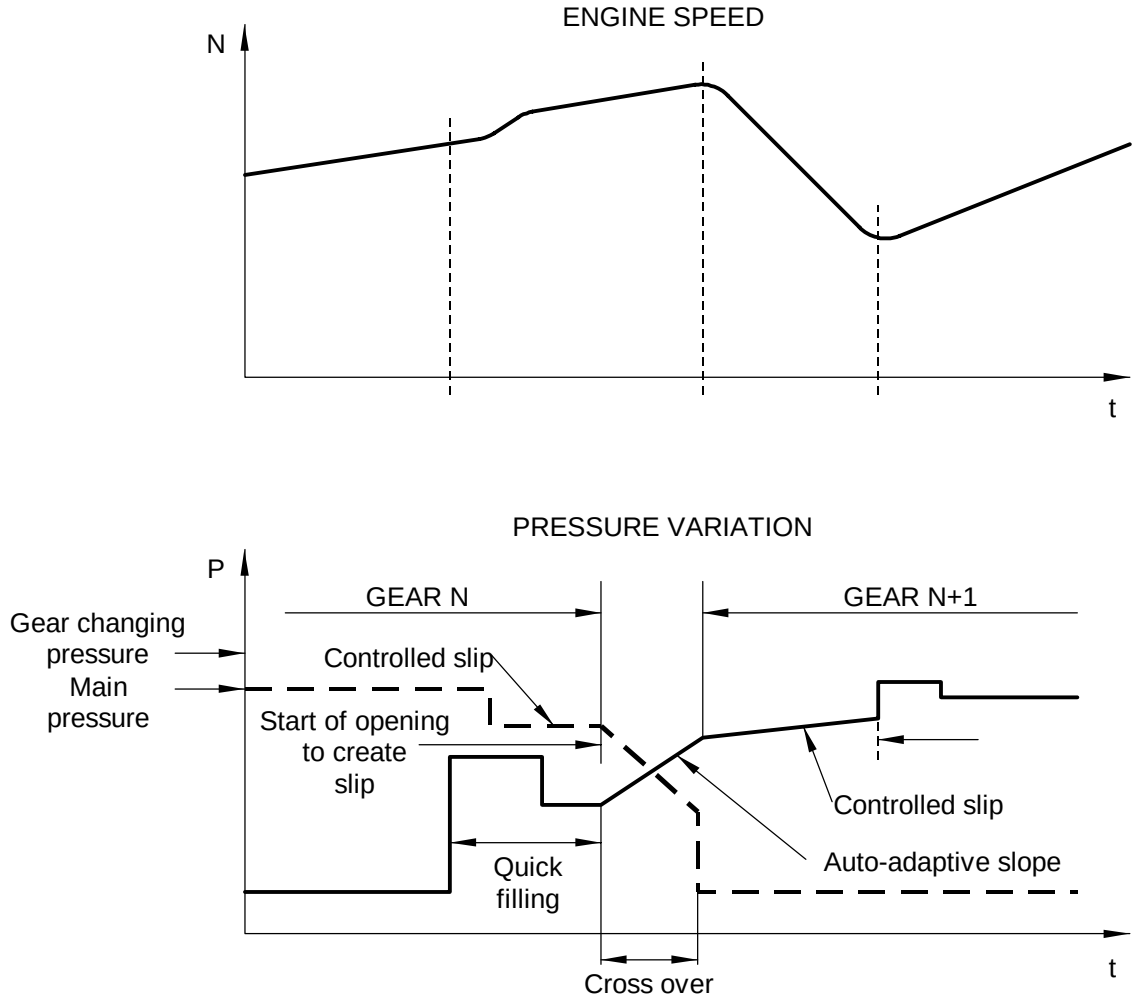
- engine torque,
- engine speed difference to be handled,
- converter torque conversion,
- transmission oil temperature,
- constant,
- current gear and type of changing (upward, downward)
- pulling/downhill.

The receiver overlap is defined as a function of the load of the receiver which is opening. Where necessary, the process of the operation can be corrected as a function of the variations in turbine speed; this is the autoadaptivity taking the sets of parts which may be specific to each transmission into account.

Note: The reactions of the turbine speed and the gear changing time allow the ECU to provide autoadaptation for the gear changing management function. Wear of mechanical parts can also be taken into account (the discs of the cylinders for example). The adaptation values are worked out as a function of the gear change and the load class and are stored in the non volatile memory.

Note: The load of a receiver is worked out as a function of engine speed and turbine torque. A table gives the "load class" depending on the range in which the load value is situated.

Illustration of the gear changing process



VI - OPERATING THE LOCK-UP CLUTCH

The lock-up can have one of the following three states:

- open,
- controlled,
- closed.

in order to optimise its operation to the driving conditions.

A - NEED FOR THE VARIOUS STATES

Open state:

- multiplication of torque (starting off, power take up),
- anti-stall function,
- maximum filtering,
- lock-up track cooling function.

Controlled state:

- filtering of engine acyclisms,
- filtering of load variation hesitations,
- improved fuel consumption,
- use of engine brake,
- oil cooling.

Closed state:

- improved fuel consumption,
- oil cooling,
- use of engine brake,
- lock-up track cooling function.

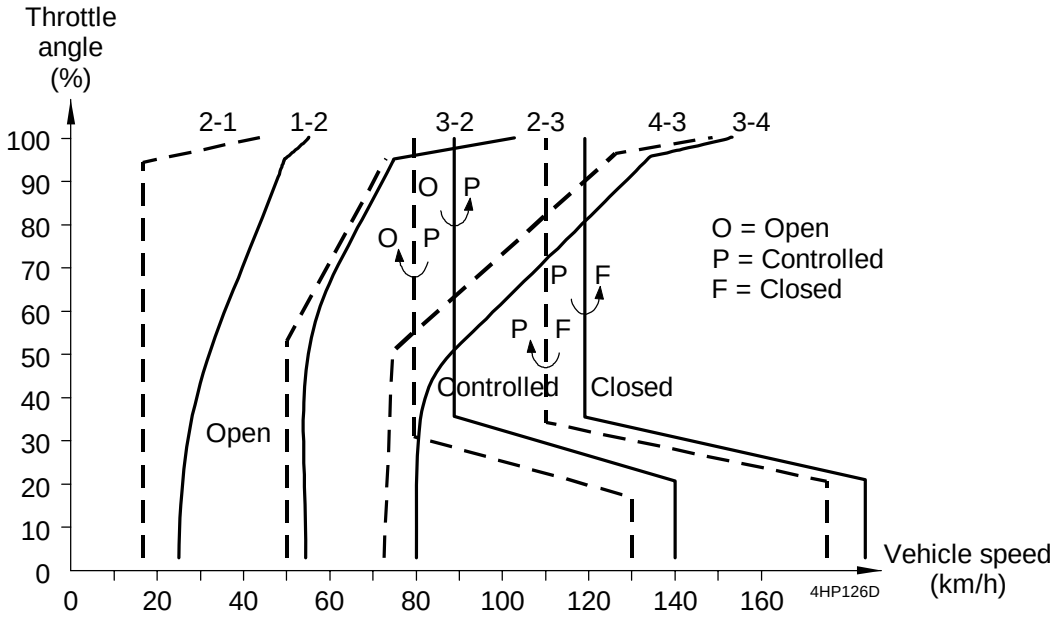
B - STRATEGY

For each set of gear changing laws, and for each gear (2nd, 3rd or 4th), the ECU has a network of curves f (Ns, α/idle speed) which define the state of the lock-up. Each network contains 2 curves defined by 10 points which delimit the "lock-up open", "lock-up controlled or regulated" and "lock-up closed" zones; each curve is separate so as to obtain hysteresis.

Especially when the engine is decelerating, and for an engine speed above a calibrated limit, the lock-up is in controlled mode.

Note: If the transmission temperature is too high, the ECU promotes the controlled and closed states in order to limit the slip inside the converter.

Example of lock-up operating law (for a specific set of gear changing laws and for a specific gear).



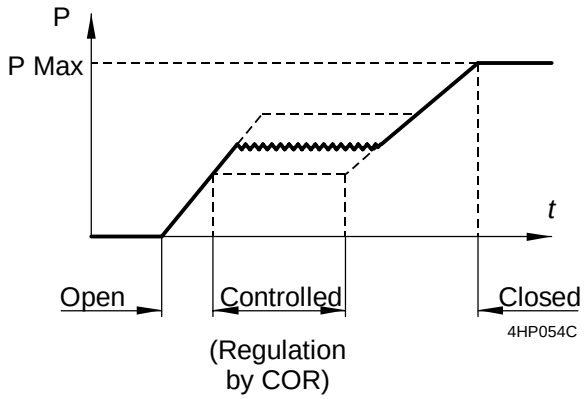
The operating curves above are typical "4th gear" curves

If the lock-up operating law specifies that it must be in the controlled state, it is up to the ECU to work out the most suitable value of slip.

This value is defined by a difference between the engine speed and the turbine speed (N input to transmission). The value of this difference is given in a cartographic map f (α/idle speed, Nmot).

After operating the proportional electrovalve designed for this purpose, the ECU checks that the actual engine speed is indeed the same as the speed from the cartographic map which is therefore the desired speed.

Illustration of the operating pressure



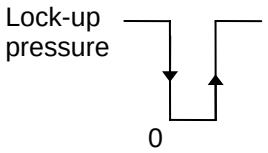
Features:

The controlled state is particularly delicate and complex to manage in the following cases:

- During variations caused by the engine speed; the desired slip, in other words the difference between the engine speed and the turbine speed, is determined and managed in an open loop using a specific strategy.

- If the vehicle switches from the "pulling" state to the "decelerating" state, the ECU must invert the sign of the value of the difference in engine speed (ΔN = turbine speed - engine speed and not the inverse).

  Physically, the operation is difficult to perform; so that transmission occurs correctly, the pressure exerted on the lock-up is set to zero for a fraction of a second.



Anti-stalling function: Torque converter lock-up released depending on turbine speed and turbine and brake speed deceleration.

VII - SAFETY FUNCTIONS

- Safety when changing down: a lower gear is only changed to automatically or forcibly if the final engine speed is below a limit. Where necessary, the gear change is delayed until conditions authorise it.

- Protection at overspeeds:

  If Nmot > limit
dNmot/dt > limit } A fault is detected by the diagnostic function $\Rightarrow$
MFS $\neq$ "N" or "P" switch to downgraded mode

  (MFS: Multifunction switch)

VIII - FUNCTIONS PERFORMED BY THE ENGINE MANAGEMENT COMPUTER (EMC)

A - INFORMATION SUPPLIED TO THE EMC FROM THE AUTOMATIC TRANSMISSION

The EMC is informed by a logical 1 or 0 signal on terminal 42.

1 - Working out the "drive" state or "parking/neutral" state

- P/N → signal 1,
- Drive → signal 0.

2 - Recognition of change from P/N → D

When moving off, the signal must be 1. Therefore, if it then changes from 1 to 0, after a short confirmation time, the ECU recognises the change to D.

3 - Recognition of change from D → P/N

If the signal changes from 0 to 1, after a fairly long confirmation time, the ECU recognises the change to P/N (so as not to confuse it with a gear change).

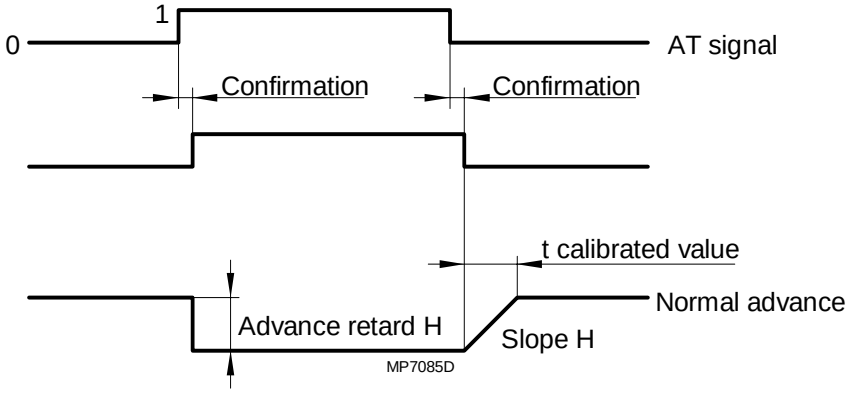
Feature: For Reverse gear information, a specific line is used (terminal 47). The signal is of a logical 0 or 1 type. Reverse gear is selected if the signal = 1 (12V). For as long as "Reverse" = 1, this information allows the torque to be decreased by retarding the advance f (α/idle speed). This function is not active for the moment.

B - RETARDING THE ADVANCE WHEN CHANGING GEARS

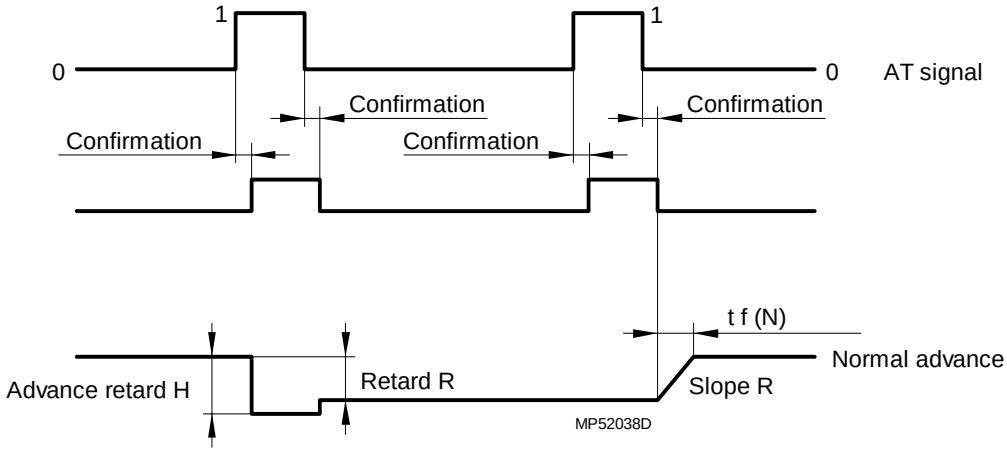
The automatic transmission ECU informs the M.P. 7.0 ECU of gear changes on the D-P/N line (terminal 42). So as to improve gear changing comfort, the M.P. 7.0 ECU reduces the torque by reducing the advance f (N, TB) which varies depending on the direction of gear change.

Key: H → upward gear change
R → deceleration

- Upward gear change.



- Deceleration.



Note: When changing from 0 to 1, the time for which the signal remains on 1 allows the M.P. 7.0 ECU to recognise:

- P/N state or,
- upward gear change,
- deceleration.

C - AUTOMATIC TRANSMISSION PROTECTION

At very low vehicle speeds (Vveh < 5km/h approximately) or when there is a fault on the vehicle speed sensor line, if P/N is changed to D or 1st or 2nd or 3rd or R, a timer f (T°coolant) is triggered. During this timer, if the driver accelerates and if N > limit f (T°coolant) or T_B > limit f (N, T°coolant), the ECU cuts off the injection so as to cause a large drop in torque in order to protect the transmission.

Injection is restarted when the engine speed gradient reaches a limit f (T°eng).

Injection picks up progressively until it reaches Ticalculated.

The increment is of the type Ti calculated x Ktake-up where Ktake-up depends on the number of ignitions which occurred since the injection was cut off which represents the time for which the fuel was cut off.

The table which Ktake-up comes from is specific to the "Automatic transmission protection" function.

In addition, the optimum advance is applied from when injection is restarted to when Ti calculated is reached.

D - ANTI-STALLING

The idle speed reference value and the additional air regulation function depend on the position of the transmission (P/N, gear engaged).

- In drive, the air precommand is increased as a function of coolant temperature so as to overcome the additional load inflicted on the engine.

- To regulate the idle speed in a closed loop, the reference value is specific depending on coolant temperature, so as to prevent the vehicle from being driven.

ASSOCIATED FUNCTIONS

I - CONTROL PANEL DISPLAY

To inform the driver of the position of the selector lever and which program is currently being used, the ECU controls:

- an LED display → remodelled XANTIA,
- a liquid crystal display (LCD) → XM, on the control panel using an input consisting of logical 0 - 12 V signals

Furthermore, the ECU can inform the driver of a problem in the system by causing the LEDs or LCD corresponding to the Sport and Snow program to flash.

A - COMMUNICATIONS PROTOCOL

As soon as the engine is started, the automatic transmission ECU regularly sends the display signals which are separated from each other by intervals which last for a number of bits between 6 and 15.

A signal consists of two pieces of information:

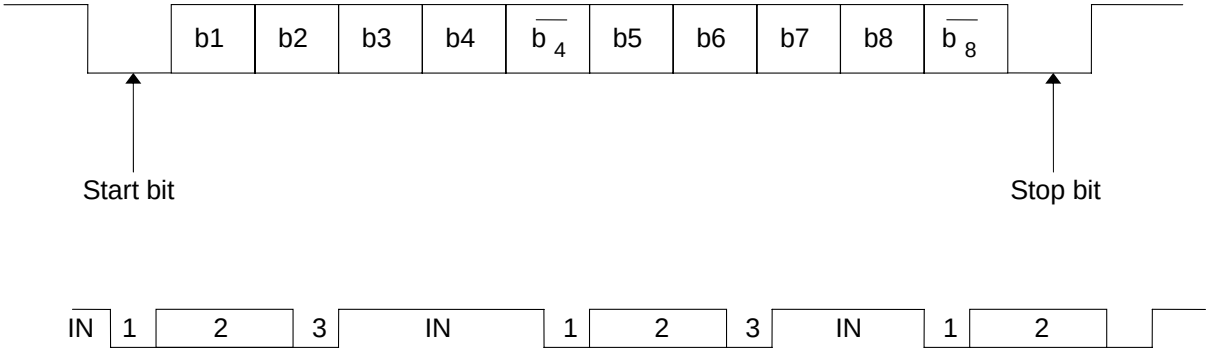
- the position of the selector lever,
- the program selected by the driver,

and consists of 12 bits:

- 8 information bits - b1 to b8 where
  - b1 b2 b3 b4 → lever position,
  - b5 b6 → program selected,
  - b7 b8 → fault indication

- 2 inverted bits $\overline{b}4$ and $\overline{b}8$ for creating transitions and therefore to allow the display to resynchronise itself at least once every 5 bits when the byte is being transmitted,
- 1 start bit (0),
- 1 stop bit (0).

The bits are numbered in the order in which they are received:



1 : start bit.

2 : 10 bits (data + transitions).

3 : stop bit.

IN : interval.

B - MEANING OF THE BITS

1 - b_1, b_2, b_3, b_4

b_1 b_2 b_3 b_4	LED DISPLAY	LIQUID CRYSTAL DISPLAY	TYPE
0 0 0 0	P	P	position P
0 0 0 1	R	R	position R
0 0 1 0	N	N	position N
0 0 1 1	D	D	position D
0 1 0 0	3	3	position 3
0 1 0 1	2	2	position 2
0 1 1 0	1	1	position 1
0 1 1 1	P flashing	P flashing	intermediate position between P and R
1 0 0 0	R flashing	R flashing	intermediate position between R and N or R and P
1 0 0 1	N flashing	N flashing	intermediate position between N and D or N and R
1 0 1 0	D	4	4th gear
1 0 1 1	N flashing	N flashing	Positions D or R requested but not selected
1 1 0 0	not illuminated	- (bar)	gear change between D, 3, 2 and 1
1 1 0 1	3 flashing	3 flashing	Position 3 requested but not selected
1 1 1 0	2 flashing	2 flashing	Position 2 requested but not selected
1 1 1 1	1 flashing	1 flashing	Position 1 requested but not selected

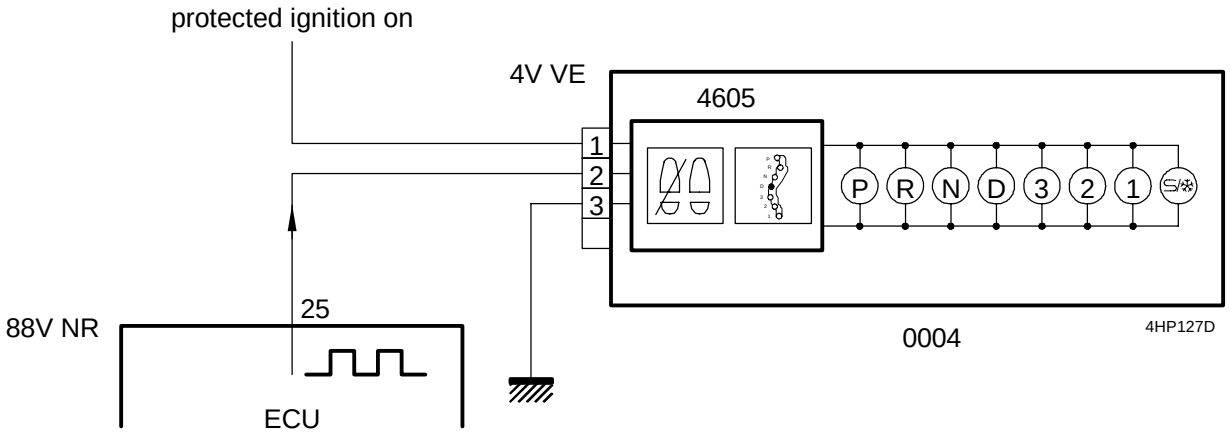
2 - b_5, b_6

b_5 b_6	MEANING	LED DISPLAY	LC DISPLAY
0 0	ECO program	none	ECO
0 1	SPORT program	LED 1	SPORT
1 1	SNOW program	LED 2	SNOW

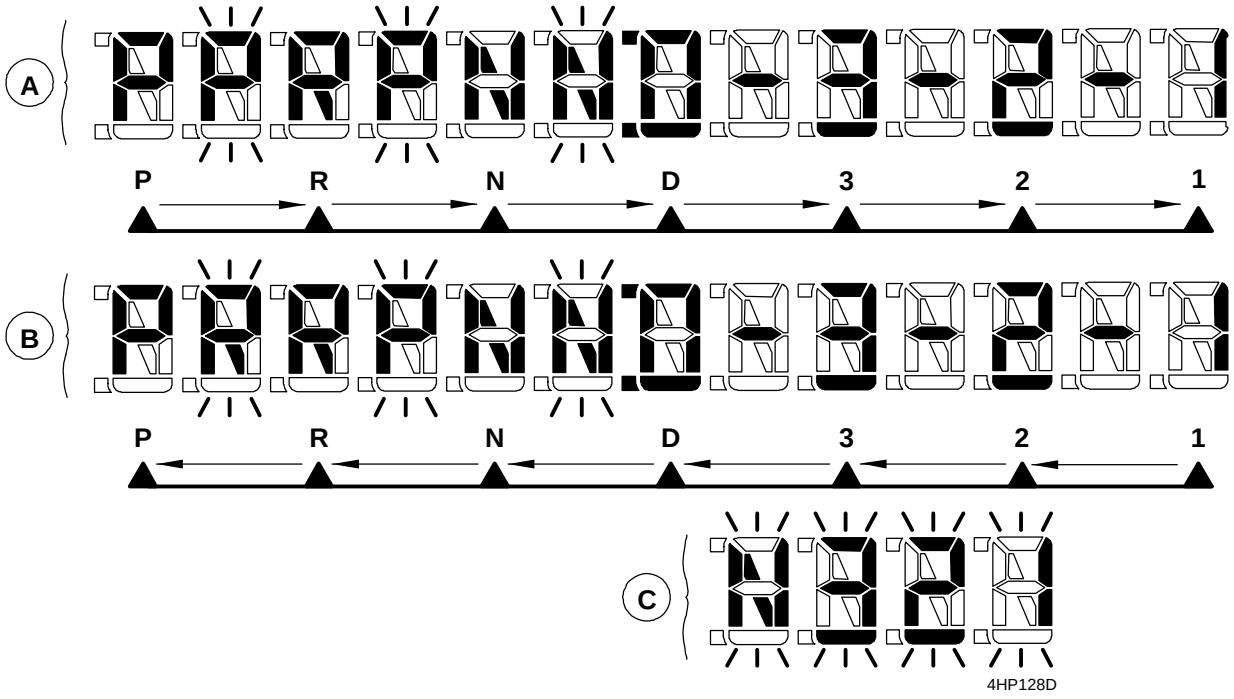
3 - b_7, b_8

b_7 b_8	MEANING
0 0	No faults
0 1	Causes Sport or Snow LCD or LEDs to flash

Remodelled XANTIA



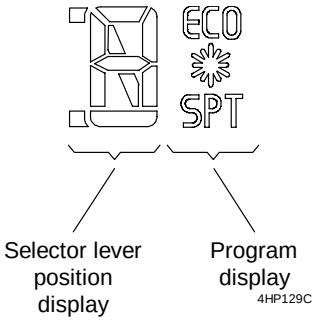
XM



A - Reminder of selector lever position from P → 1

B - Reminder of selector lever position from 1 → P

C - Gear selected but not engaged



ZF 4HP20 AUTOMATIC TRANSMISSION

II - OPERATION OF REVERSING LIGHTS

Every time the selector lever is moved to position R, the reversing lights are illuminated by the multifunction switch (see sensors and information chapter).

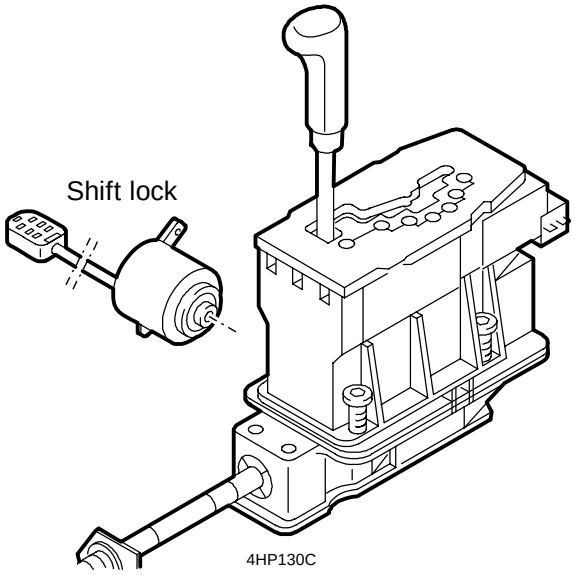
III - STARTING PREVENTION

The multifunction switch prevents the starter motor from operating unless the selector lever is in the P or N positions. To do this, it controls the starting relay (see sensors and information chapter).

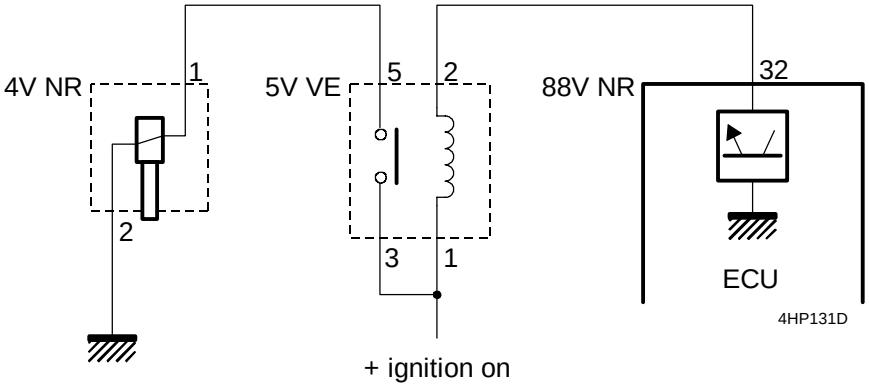
IV - SHIFT-LOCK

The shift-lock function is a safety function which requires the brake pedal to be pressed before the selector lever can be moved from position P to another position when the ignition key is in the + ignition on (or engine running) position.
It ensures:

- that the driver is present (by pressing on the brake pedal) before allowing the engine to drive the vehicle,
- that the vehicle does not move off suddenly when a gear is engaged.



This function is performed by an actuator, located in the central console and controlled by the ECU through a relay.



Description of the function

The actuator must be operated so as to unlock the selector lever in two cases:
Case 1: normal unlocking

"lever in position P" and "ignition on" and "press and hold brake pedal down".

Note: To prevent the actuator being operated unnecessarily, it is not supplied in the following instance: ignition on (or engine running depending on case), brake pedal pressed then lever moved to position P. In this case, which corresponds to the normal configuration when the vehicle is stationary, a 5 second timer is started. The actuator is only supplied after the timer has elapsed if the driver is still pressing the brake pedal. The actuator can be unlocked before the end of the timer by releasing the pedal and then pressing it again. In all other cases (order in which information arrives not the same as above), the actuator is supplied instantly.

Case 2: locking prevention when the vehicle is moving
"lever in position P" and "ignition on (engine running accepted)" and "vehicle speed > 3 km/h".

The actuator control is interrupted either by leaving the + engine running or P position or by releasing the brake pedal.

Specific case
The SL actuator cannot withstand a permanent supply.

However, it is acceptable to limit the control to a duration greater than or equal to 1 minute whilst complying with the following condition: after the timer has expired, after the pedal has been released briefly, the actuator must be operated instantaneously and it must be operational (sufficient force developed).

Downgraded mode
If the function uses an ECU which can detect faults in the information tested (either the "lever in P", "pressure on brake pedal", "vehicle speed > 3 km/h" or "position of ignition key" information), it should be possible to prevent the actuator from working electrically. In a case such as this, an emergency function called a release should be available: using a tool or a key, this allows the lever to be manually unlocked from position P.

V - KEY-LOCK

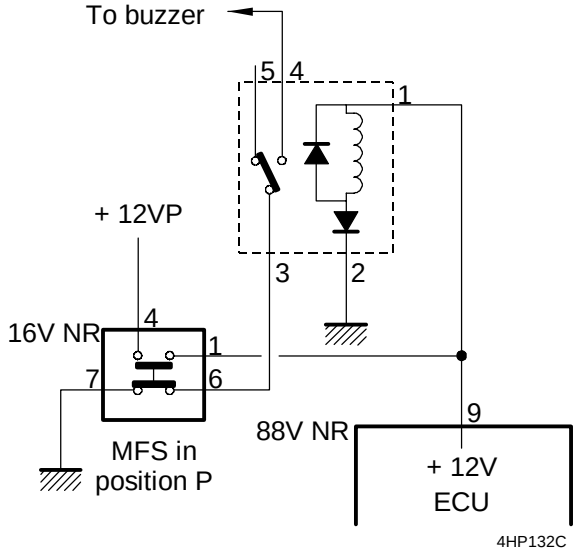
The key lock function is a safety function which requires the selector lever to be put into position P before the ignition key can be removed (the ignition switch cannot be moved from position A to position ST).
This:

- prevents the steering wheel from being locked by the steering lock when the vehicle is moving,
- along with the shift lock function, encourages the driver only to leave his vehicle with the lever in position P.

This ECU function is performed by an actuator located near to the ignition switch:

- selector lever not in position P → actuator not supplied → key locked,
- selector lever in position P → actuator supplied → key unlocked.

This function may be replaced by a buzzer which warns the driver that he is removing the ignition key although the selector lever is not in position P.



MFS = multi function switch

For information: Key-lock operating logic

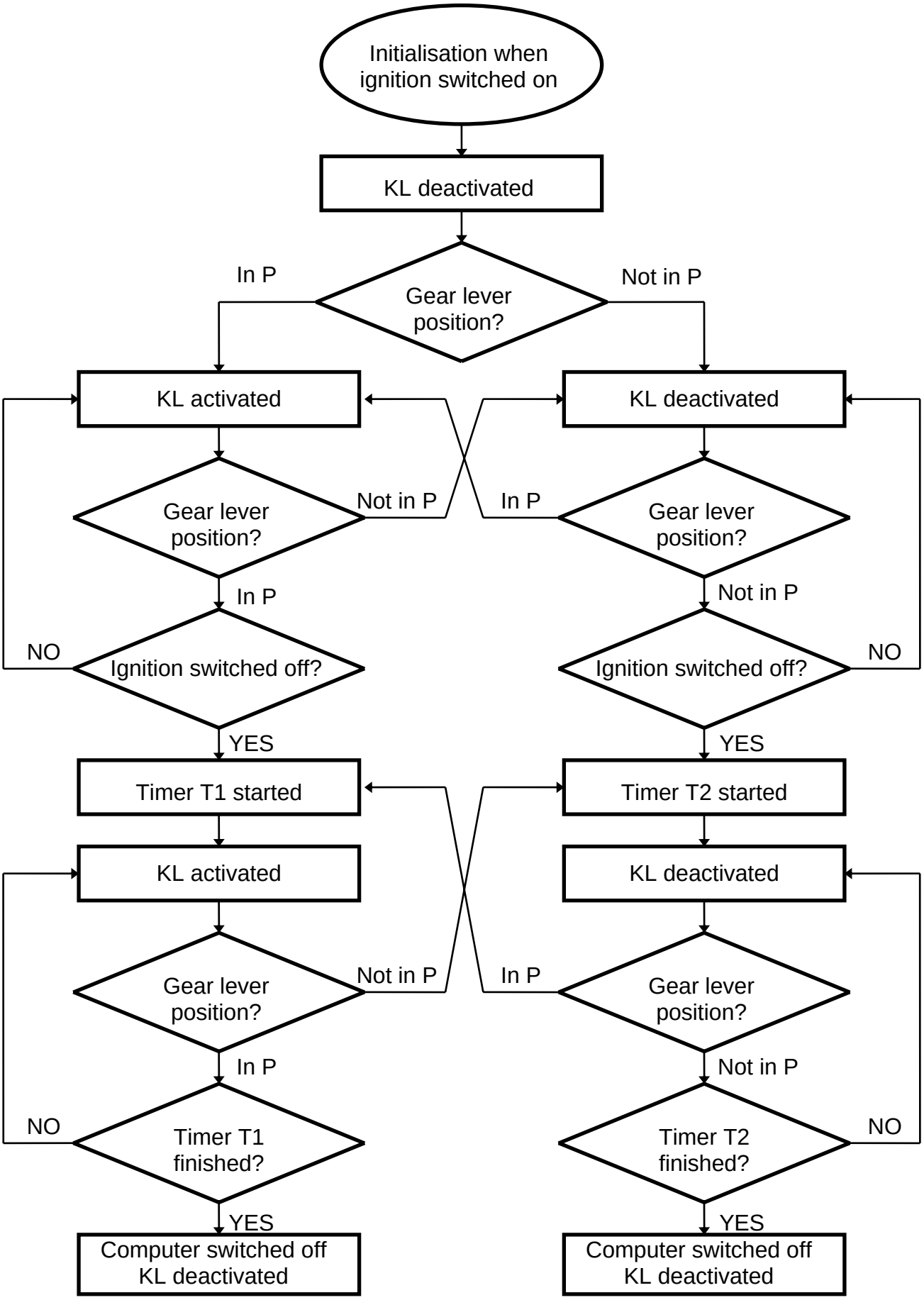
T1: Gives the driver a time delay between switching off the engine (key moved from M to A) and removing the key (key moved from A to St) → = 1 to several minutes.

T2: This monitors the return from P for a limited time after the ignition has been switched off to allow the key to be unlocked as soon as position P is returned to → = ¼ hour to several hours.

Downgraded mode:

If the ECU detects a fault in the "lever in P" or "ignition key position" information:

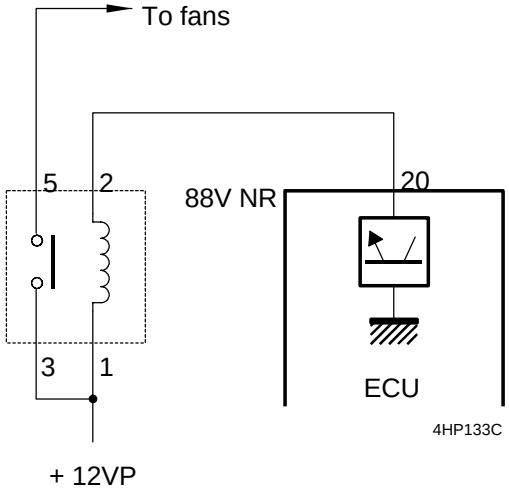
- either the key-lock is supplied as soon as the correct information is present,
- or a tool or a key can be used to manually unlock the lever from position P.



ZF 4HP20 AUTOMATIC TRANSMISSION

VI - OPERATING THE FANS

The ECU operates the fans by earthing a relay.



ZF 4HP20 AUTOMATIC TRANSMISSION

DIAGNOSTIC

I - GENERAL

A - AIM

The aim of the auto-diagnostic is to:

- warn the driver should a system operating fault arise,
- help the repair technician locate the origin of the fault or faults.

B - RECORDING FAULTS

The auto-diagnostic records permanent faults as well as temporary system operating faults.

These faults, after being recorded, are permanently memorised even after the vehicle has been switched off and can only be erased following a voluntary action by the repair technician; faults can only be erased after they have been read to ensure that memorised faults are viewed at least once by repair staff.

Faults are stored in the memory under a fault code in the chronological order in which they appear.

C - CLASSIFYING FAULTS

Fault are classified into two categories:

- serious faults requiring the vehicle to be repaired immediately (risk of damaging transmission, safety of passengers jeopardised…): as soon as they are detected, the driver may be warned by certain lights flashing,
- minor faults which do not require immediate repair: when these appear, the driver is not warned but the faults are stored in the ECU's non volatile memory.

Major faults have priority over minor faults.

D - DETECTING FAULTS

The ECU permanently monitors:

- its peripherals (sensors and actuators),
- the actual gear engaged (input speed / output speed),
- the converter slip (engine speed / turbine speed),
- the gear changing time (actual time / theoretical time),
- the operating temperature.

And finally, the ECU can detect:

- 42 permanent or temporary faults detected on the input and output signals, by analysing the decline in their electrical characteristics or by performing a coherence check,
- 3 automatic transmission operating faults:
  - fault whilst changing a gear (due to a pressure regulator being blocked for example),
  - two gears engaged at the same time, or slipping of a clutch,
  - excess engine speed.

E - DOWNGRADED MODE

When a problem occurs, and so as to protect the transmission as well as to ensure the comfort of the vehicle's occupants, the ECU can activate one of its sliding scale emergency or replacement modes (13 downgraded modes).

Depending on the type of fault, the ECU chooses the following downgraded modes from amongst three types:

- 3rd hydraulic (4th if activated whilst driving),
- maintain gear engaged (until the ignition is switched off then 3rd hydraulic engaged),
- replacement value (absent data recomposed or replaced).

Whilst driving, this program might appear in the form of:

- a restriction in transmission functions (e.g. can no longer change gears or no kickdown),
- no display on the control panel (sport and snow lights flash) for major faults,
- the transmission being operated electronically with pre-programmed characteristics (gears can be changed alone),
- juddering when moving lever from P to R and from N to R.

II - SERIAL COMMUNICATIONS WITH THE ELIT TESTER

Master / slave type exchange (the tester and the ECU take it in turns to be emitter and receiver):

- after a word is sent by the master, this word is returned to it by the slave along with the information indicating that it has been correctly received,
- after receiving the reply from the slave, the master is ready to send a second word.

Transmission speed: 9600 baud

The tester uses the following connections: Ubat, Earth, K line and L line (in the future).

Various functions offered by K (and L) lines:

- reading of recorded faults,
- reading of parameters (measured values),
- simulation,
- initialisation of auto-adaptives,
- downloading,
- erasing of faults,
- identification of ECU.

Reading memorised faults

For each memorised fault, the ECU's reply message is structured in the following way:

- fault code,
- nature of the fault (open circuit, short circuit...),
- type of fault (permanent, temporary),
- associated contexts,
- age of the fault (50 counter).

Reading parameters

Variables:

- engine speed: rpm,
- transmission input speed: rpm,
- transmission output speed: rpm,
- engine torque signal: 28 Nm (when stationary),
- lock-up: open - controlled - closed (up to 2000 rpm converter slip), 1st and 2nd gears always open, 3rd and 4th gears always closed (direct drive) or controlled (regulated converter slip of approximately 50 rpm),
- throttle angle: 0 % no load, 99 % full load,
- transmission oil temperature: C°.

Pressures:

- gear engaged: 1-2-3-4 or R,
- lever position: P.R.N.D.3.2.1,
- regulator: number 3, --- mA
- regulator: number 4, --- mA
- regulator: number 5, --- mA
- regulator: number 6, --- mA

} Reference values

- electrovalve MV1: 1 or 0
- electrovalve MV2: 1 or 0

The value varies from 159 mA to 768 mA depending on gear engaged.

Digital inputs and outputs:

- stop lights input: 0 or 1.

External controls:

- lever position: P.R.N.D.3.2.1,
- gear engaged: 1-2-3-4 or R,
- program(s): normal - sport - snow,
- DPS: ECU selection from amongst 6 gear changing laws depending on driving conditions,
- normal: SK1.SK2.SK3.SK4.SK5.SK6,
- sport: SK5.SK6,
- snow: winter (position D),
- snow: manual (position 1.2.3).

Specific program called warm up when the transmission temperature is less than 30° C when the ignition is switched on for a duration of 135 seconds.

Simulation

→ Activation of various electrovalves.

Downloading to the ECU

This is performed using the ELIT diagnostic tool. Downloading allows the automatic transmission ECU to be updated or to be upgraded in line with an EMC upgrade.

Important: updating using downloading must always be performed on both automatic transmission and engine management ECUs.

Initialising the ECU

This is performed using the ELIT.

The ECU should be initialised in the following cases:

- ECU replaced,
- transmission replaced,
- downloading.

This consists of emptying the faults memory in order to erase all the auto-adaptation values.

Road test:

The ECU permanently adapts itself to the transmission.

Therefore, when replacing the transmission, the ECU or another component of the transmission, a road test must be performed.

Choose a route which allows frequent gear changes and uses all gears.

This test is absolutely essential so that the electronics can adapt themselves to the transmission by comparing the reference values to the actual values.

The difference recorded is then stored in order to allow optimum gear changing pleasure.

III - DESCRIPTION OF THE DIAGNOSTIC

A - LIST OF FAULTS

Test conditions:

- 0 → when operating,
- I → when initialising (ignition on)

Return to normal:

- 0 → when operating,
- I → when initialising
- N → NO return

FUNCTIONS	CONTROL PANEL WARNING	EMERGENCY MODE	TEST CONDITIONS	RETURN TO NORMAL
Engine speed	yes	S1	0	I
Turbine speed	yes	S1	0	I
Transmission output speed	yes	S1	0	I
Throttle position information	no	S6 - S12	0	I
Multifunction switch	yes	S0	0	I
Engine torque signal	no	S9	0	I
Oil temperature	no	S3	0	0
Program selector	no	None	Test impossible	N
Stop switch	no	S8	0	0
+ actuator supply (regulator electrovalves)	no	SW*	0	I
+ permanent	no	S5	I	I
Ignition on	no	SW*	0	0
Earth	no	None	Test impossible	N
Electrovalves (individually) short circuit to + or open circuit/short circuit	yes	S0	0/I	I
Regulators (individually) short circuit to + or open circuit/short circuit	yes	S0	0	I
Torque reduction request output	yes	S7	0	I
ECU RAM	no	S0	I	I
EEPROM	yes / no	S5/S0	I	I
ROM / EPROM	no	S0	0	N
Watchdog	no	S0	I	I
Actuator control stage	yes	S0	I	I
Engaged gear coherence	yes	S0	0	I
Overspeed protection				
Gear changing operation	yes	S1	0	I
Shift lock command	yes	S0	0	I
Key lock command	no	None	0	I
Fan command	no	None	0	I
Lever position / program indicator	no	None	Test impossible	N

SW = Software function → normal operation where possible.

List of emergency modes:

TYPE	EMERGENCY MODE
S0	3rd hydraulic (4th if the fault occurs whilst driving in 4th then 3rd when the ignition is switched off then on again). Positions P, R, N are authorised. No reverse gear protection.
S1	Gear engaged maintained then S0 upon return to P/N Lockup open
S3	Oil temperature replacement value 60°C for normal program 120°C for lock up program
S5	EEPROM substitution function
S6	Throttle position value f (engine speed, engine torque)
S7	No change down upon kickdown
S8	Stop switch info replacement depending on function $\rightarrow$ Lockup = brake active $\rightarrow$ DSP = brake not active
S9	Recalculated value function (throttle α, engine speed)
S12	Specific SK11 law

Note: Changing to 3rd hydraulic when driving in 4th might cause an engine overspeed. This is why the 3rd hydraulic emergency mode engages 4th gear until the ignition is switched off.

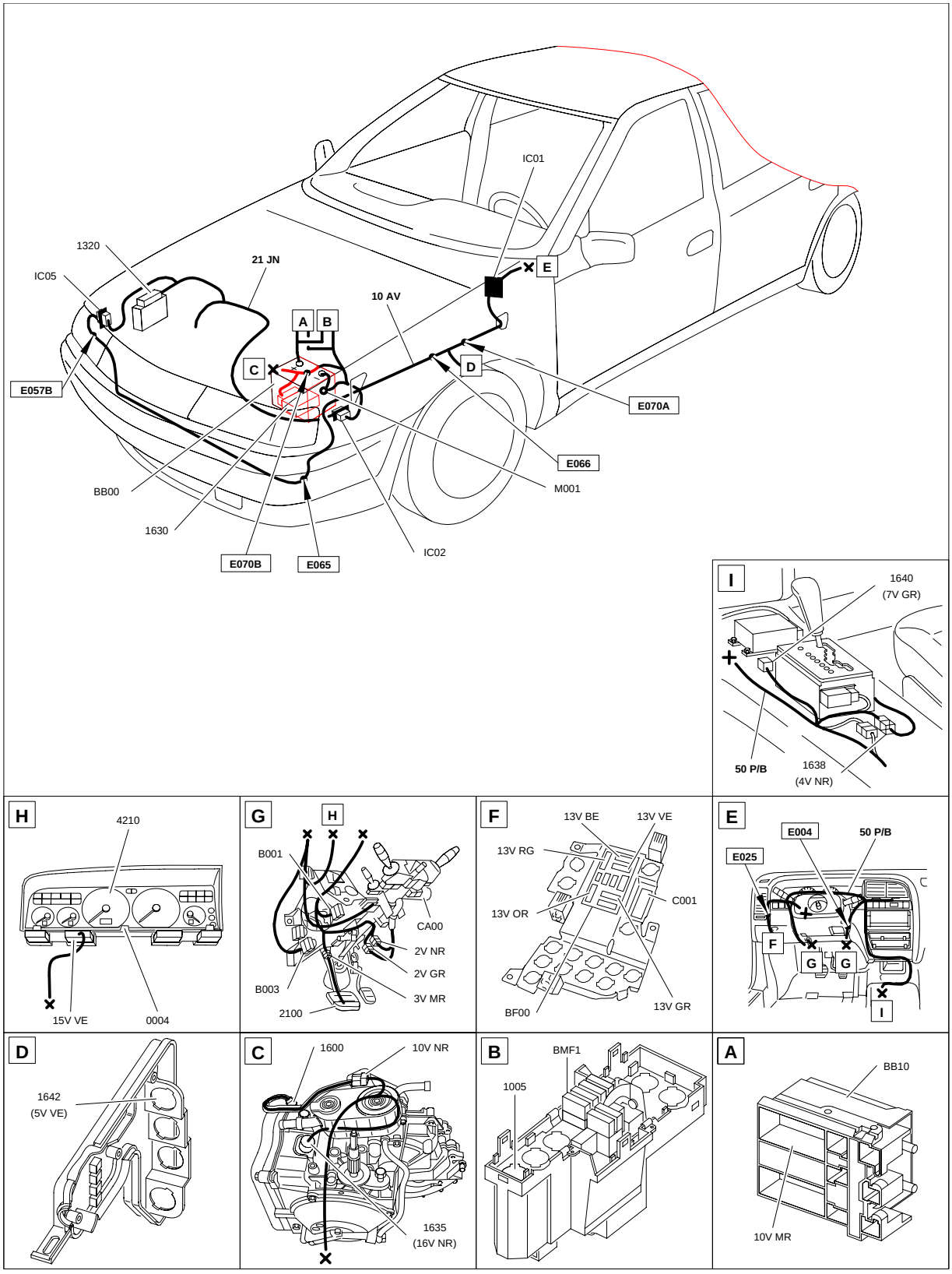
ZF 4HP20 AUTOMATIC TRANSMISSION

WIRING DIAGRAM

I - LAYOUT

II - INSTALLATION

III - LOCATION



4HP136P

ZF 4HP20 AUTOMATIC TRANSMISSION

IV - PARTS LIST

B001 - Positive equipotential socket
B003 - Earth equipotential socket
BB00 - Battery
BB10 - Supply unit
BF00 - Passenger compartment fuse box
BMF1 - Maxi fuse box
C001 - Diagnostic connector
CA00 - Ignition switch
M001 - Earth
0004 - Control panel
1005 - Starting prevention relay
1320 - Engine management computer
1600 - Selector lever position switch (MFS)
1630 - Automatic transmission ECU
1635 - Automatic transmission electro-hydraulic unit
1638 - Automatic transmission lever locking actuator (shift lock)
1640 - Automatic transmission program selector
1642 - Gear lever locking actuator control relay
2100 - Stop switch
10 - Start-up / current generation function
15 - Cooling function
22 - Reversing lights function
30 - Passenger compartment lighting function
64 - Electrically operated door mirrors function
73 - Cruise control function

AFTER-SALES OPERATIONS

I - DOWNLOADING TO THE ECU

Updating the ECU software is performed by downloading. This operation is performed in after-sales using an ELIT or a LEXIA/PROXIA.

II - INITIALISING THE ECU

The ECU is initialised by means of an ELIT or LEXIA / PROXIA type diagnostic tool.

This procedure is to be performed with care since it resets all the auto-adaptives memorised by the ECU.
It is performed after:

- replacing the ECU,
- replacing the transmission,
- downloading.

Conditions: Ignition on, vehicle stationary, lever in P or N, then follow the procedure on the diagnostic tool.

III - TESTING AFTER THE WORK

The ECU permanently adapts itself to the transmission. Therefore, when replacing the transmission, the ECU or another component of the transmission, a road test must be performed choosing a route which allows frequent gear changes and uses all gears.

This test is absolutely essential so that the electronics can adapt themselves to the transmission by comparing the reference values to the actual values. The difference recorded is then stored in order to allow optimum gear changing pleasure.

IV - LIST OF AUTHORISED OPERATIONS ON THE 4HP20 TRANSMISSION IN AFTER-SALES DURING THE FIRST YEAR OF WARRANTY*

- Drain and fill the transmission.
- ECU initialisation procedure (auto-adaptives).
- Replace ECU (after APPROVAL).
- Replace transmission (after APPROVAL).
- Replace selector lever position switch.
- Replace load potentiometer.
- Replace speedo control.
- Replace engine speed sensor.
- Replace heat exchanger.
- Replace the converter and its gasket.
- Replace the seal on the driveshaft.
- Replace the selector control.
- Replace the "shift-lock".

The operating procedures for the various authorised operations are given in the corresponding after-sales brochure.
Replacing the whole 4HP20 transmission or its ECU must be subject to prior approval.

This approval is given by the Regional Headquarters for France.

The point of sale fills in the "request for replacement approval" (copy enclosed) and sends this duly completed request to the Regional Headquarters.

After being analysed, additional technical assistance will be proposed in order to complete the diagnostic or replacement approval will be faxed back to the point of sale on the approval request.

* For UK, contact warranty department at Citroën UK or follow After Sales procedure for UK RHD vehicles.

dealer stamp

REPLACEMENT APPROVAL REQUEST **

☐ **4HP20 TYPE AUTOMATIC TRANSMISSION**
☐ **4HP20 TYPE ECU**

DATE:

IDENTIFICATION	INFORMATION		
1/ Completed by:	Mr:		
2/ Tel / Fax:	Tel: Fax:		
3/ VIN:	N°:		
4/ Transmission and/or ECU n°	Transmission n°: ECU n°:		
5/ Mileage:	Miles:		
6/ Warranty start date:	.../.../...		
7/ Is the vehicle immobilised?:	YES		NON
8/ Description of the problem:			
9/ Oil level at 80° C (eg: maximum):			
10/ Lever position in which fault appeared:	P-R-N-D-3-2-1*		
11/ In which program did the fault appear:	Snow	Normal	Sport
12/ At what speed did the fault appear (mph):			
SELECTOR CONTROL			
13/ Correct setting:	YES		NON
14/ Coherence between indication of selector lever compared to control panel of P to 1:			
USING THE DIAGNOSTIC TOOL			
15/ Transmission ECU identification:			
16/ Engine ECU identification:			
FAULT READING			
17/ Title:			
18 Input or output speed of gears involved (rpm):			
19/ Gear engaged:	4-3-2-1-Rev*		
20/ Changing:	Up		Down
21/ Lock-up:	Open	Controlled	Closed
MEASUREMENT OF PARAMETERS			
.....			
ENGINE COMPUTER MEMORY			
22/ Are there any faults, if so which ones?			

23/ DR/SUBSIDIARY/IMPORTER answer:.....	
24/ Replacement approval n°:	N°

☐ : Tick the box *: Circle the relevant letter(s) or number(s)

** UK version may differ

ZF 4HP20 AUTOMATIC TRANSMISSION

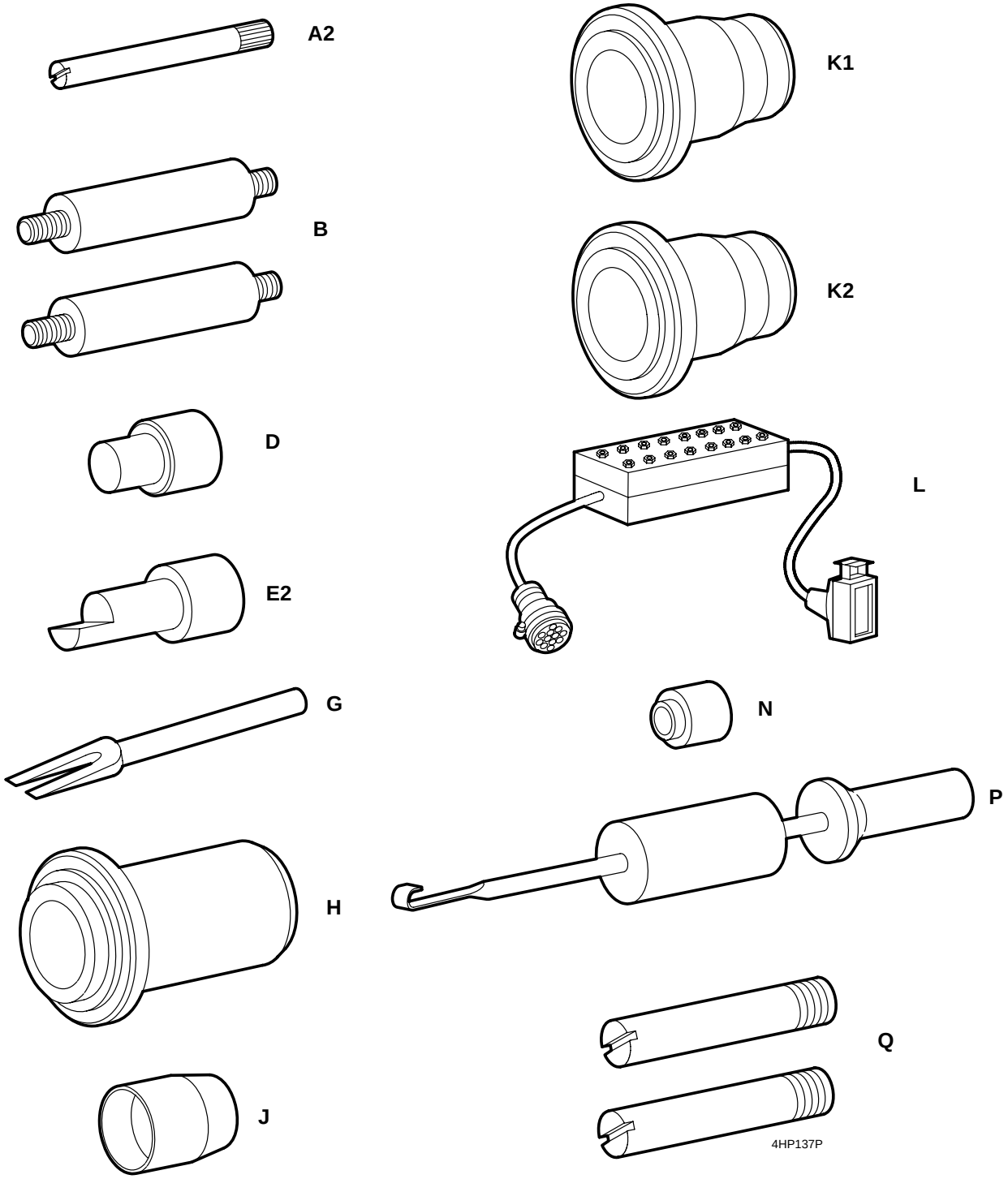
V - SPECIAL TOOLING

8010-T kit.

Part number = OUT 308 010 T.

PART N°	WORKSHOP REF.	DESCRIPTION
	A2	Pin for removing transmission
	B	Tool for D/P converter (x 2)
	D	Drift for removing driveshaft seals
	E2	Tool for supporting converter
	G	Ball joint extractor
	H	Tool for fitting converter seal
	J	Sleeve for fitting seals
	K1	Tool for fitting RH driveshaft seal (red)
	K2	Tool for fitting LH driveshaft seal (black)
	L	Test harness
	N	Tool for fitting selector shaft seal
	P	Inertia extractor
	Q	Guide for refitting transmission (x 2)

8010-T



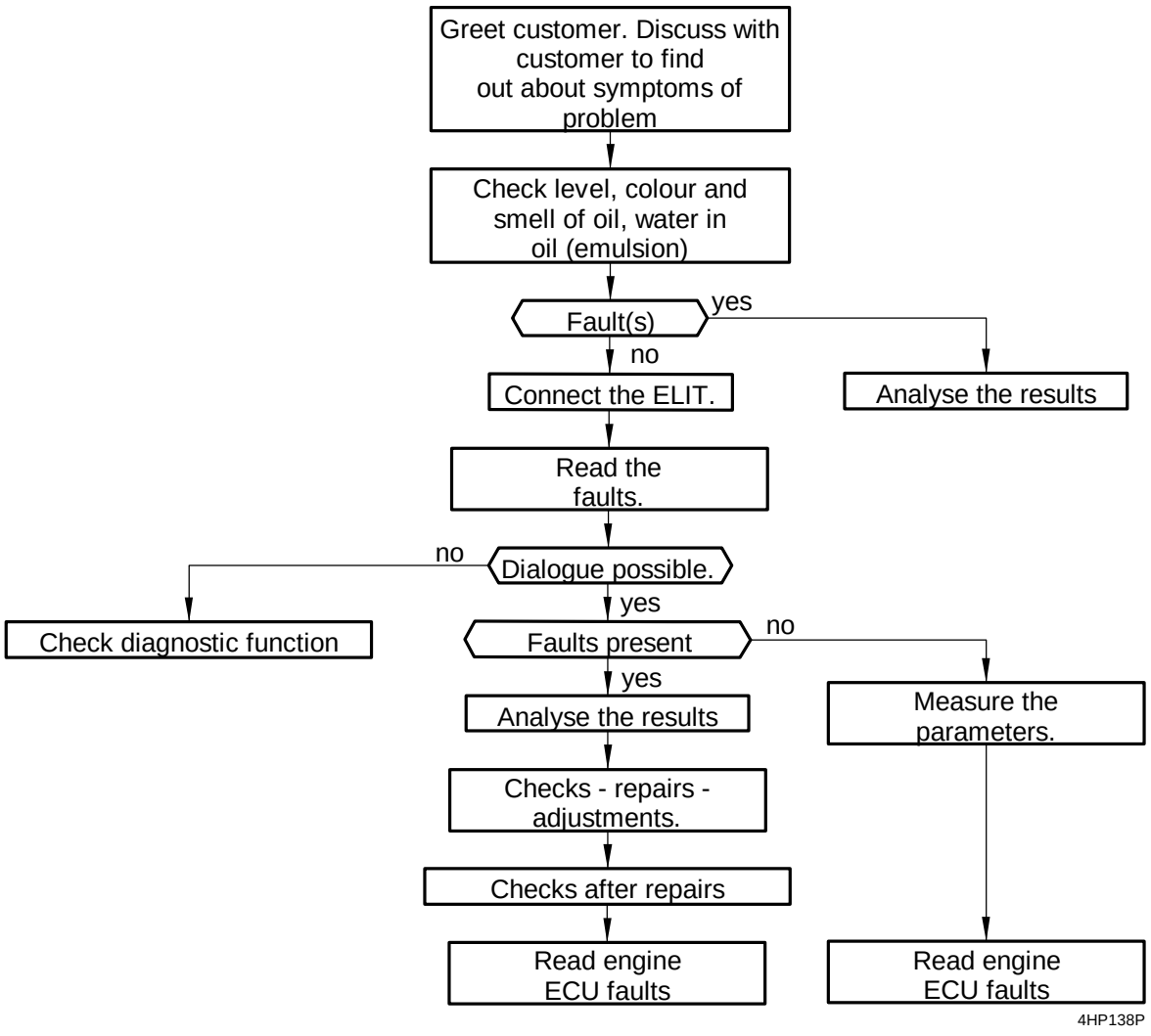
ZF 4HP20 AUTOMATIC TRANSMISSION

ZF 4HP20 AUTOMATIC TRANSMISSION

DIAGNOSTIC - LOCATING FAULTS

I - TRANSMISSION REPAIR PROCEDURE

IMPORTANT: When searching for a fault on this transmission, proceed in the following order.



Note: Sometimes, after checking the oil, a road test may have to be performed to confirm the symptoms.

IMPORTANT: After replacing the ECU or the transmission only, or downloading, carry out an initialisation procedure. Gear changes of varying qualities may be experienced for a certain amount of time (ECU adapting parameters to transmission).

A - SPECIFIC CASE

Points to check: check the oil level:

- nature of the complaint,
- situation under which problem occurs (engine speed, vehicle speed, load, selector position).

Road test in presence of customer:

- customer's manner of driving (nervously, very economically, possible incorrect operations),
- external influences acting on the vehicle (temperature, road surface),
- selector position from P to 1 passing through R, N, D, 3, 2,
- choice of program: Sport - Snow - ECO,
- operate the selector slowly and check if its position agrees with the display on the control panel.

B - SEARCHING FOR FAULTS

The automatic transmission may show symptoms of faults which can be categorised in the following way:

- gear changing quality,
- operating faults,
- leaks.

1 - Problems with gear changing quality

Note: If gear changes suddenly deteriorate or if gears do not change at all, this may be the result of an emergency or replacement program. The customer is warned of this problem by the S and N lights both flashing simultaneously.

Warning: In an emergency program, there is a severe bang when changing from P/R or N/R.

Perform a road test:

- note the situations in which the gear changing quality is faulty,
- try the 3 programs,
- note which gears cannot be engaged,
- can the reason for the complaint be reproduced over a short period, sporadically or did it just happen once?
- check the oil level and quality,
- read the fault codes with the ELIT.

2 - Transmission operating fault(s)

Faulty drive in Forward or Reverse gears.

Check in the following order:

- oil level and quality,
- road test,
- read the fault codes with the ELIT.

In some cases, it may be wise to read the fault codes of the ignition-injection ECU.

II - ANALYSE THE RESULTS

A - OIL CONDITION

To focus the fault finding procedure, remove the dipstick and smell the oil: does it smell burnt?

Engine running, take a small sample of oil (approximately 0.2 litres) to check whether there are any impurities in it (dust, metal particles).

Abnormal operation and even destruction of a clutch will lead to the oil heating up which might be filled with impurities.

B - DIALOGUE IMPOSSIBLE

Check:

- the diagnostic line,
- the + permanent ECU supply,
- the ECU supply with ignition on,
- the operation of the diagnostic unit,
- if these checks are correct, perform a test with a new ECU.

C - DIALOGUE POSSIBLE

Warning:	Faults are detected by the ECU and the auto-diagnostic indicates that a function is faulty. The fault may be on the component in question, its wiring or the ECU itself.

If no faults are signalled, measure the parameters.

If one of the peripheral components of the transmission or the supply (+12V) is faulty, the ECU switches to downgraded mode: this downgraded mode varies depending on which component is faulty.

D - VISUAL WARNING IN THE EVENT OF FAULTS

1 - Flashing of the Sport and Snow warning lights - display of last gear selected

Automatic transmission fault.

2 - Flashing of Sport and Snow warning lights (without gear being displayed)

Transmission fault between automatic transmission and control panel display.

E - EMERGENCY AND REPLACEMENT PROGRAM

1 - 4th hydraulic then 3rd hold after starting: P.R.N. possible

- If a fault occurs on one of the following components, the automatic transmission will remain in 3rd hydraulic permanently.
- ECU.
- ECU supply.
- Electrovalves supply.
- Pressure regulators.
- Multifunction switch.
- Speed sensor (transmission input and output).
- Gear monitoring.

2 - Oil temperature 120 or 60° C depending on phases

Possible origin(s) of fault:

- oil sensor or electrical line.

3 - Does not change to Kick-Down

Have to use lever to change down.

Kickdowns possible without moving the lever, only authorised with no load.

Possible origin(s) of fault:

- throttle potentiometer (throttle not opening fully - adjustment of accelerator cable),
- EMC.

The automatic transmission ECU uses a substitute value.

Warning: An incorrect carpet may prevent the KD function.

4 - Gears do not change in position D, the same gear is maintained

When changing to position N or P, moves off in 4th hydraulic.

If the engine is stopped, 3rd hydraulic is selected.

Possible origin(s) of the fault:

- engine speed information,
- transmission output speed sensor.

F - QUICK DIAGNOSTIC

1 - Faults relating to the adjustment of the selector control

Vehicle moves forward or backward with selector in position (N).

Possible to start engine with selector in position (N) but not in position (P).

Difference between control panel display and selector lever position.

2 - Faults requiring the transmission to be removed and replaced

Vehicle no longer driven in forward nor reverse gears.

Oil level correct, the vehicle does not move, selector in position D-3-2-1.

Oil level correct, slipping when moving off, selector in position D, noise in reverse gear.

When warm, no vehicle drive in all selector lever positions. The vehicle starts after being stopped for a few minutes.

3 - Fault requiring the multifunction switch to be checked on the transmission

Engine can be started in all selector lever positions.

Engine can be started, in position P or N (may also be caused by a faulty relay or electrical harness).

4 - Abnormal noise or vibrations

Metallic noise when idling from the converter cover.

Check:

- the converter mounting bolts are tight,
- condition of the converter drive plate (split).

Noise when starting (starter motor action), check plate is tight on converter and condition of converter cover.

Grinding from the oil pump pinions, check the transmission oil level.

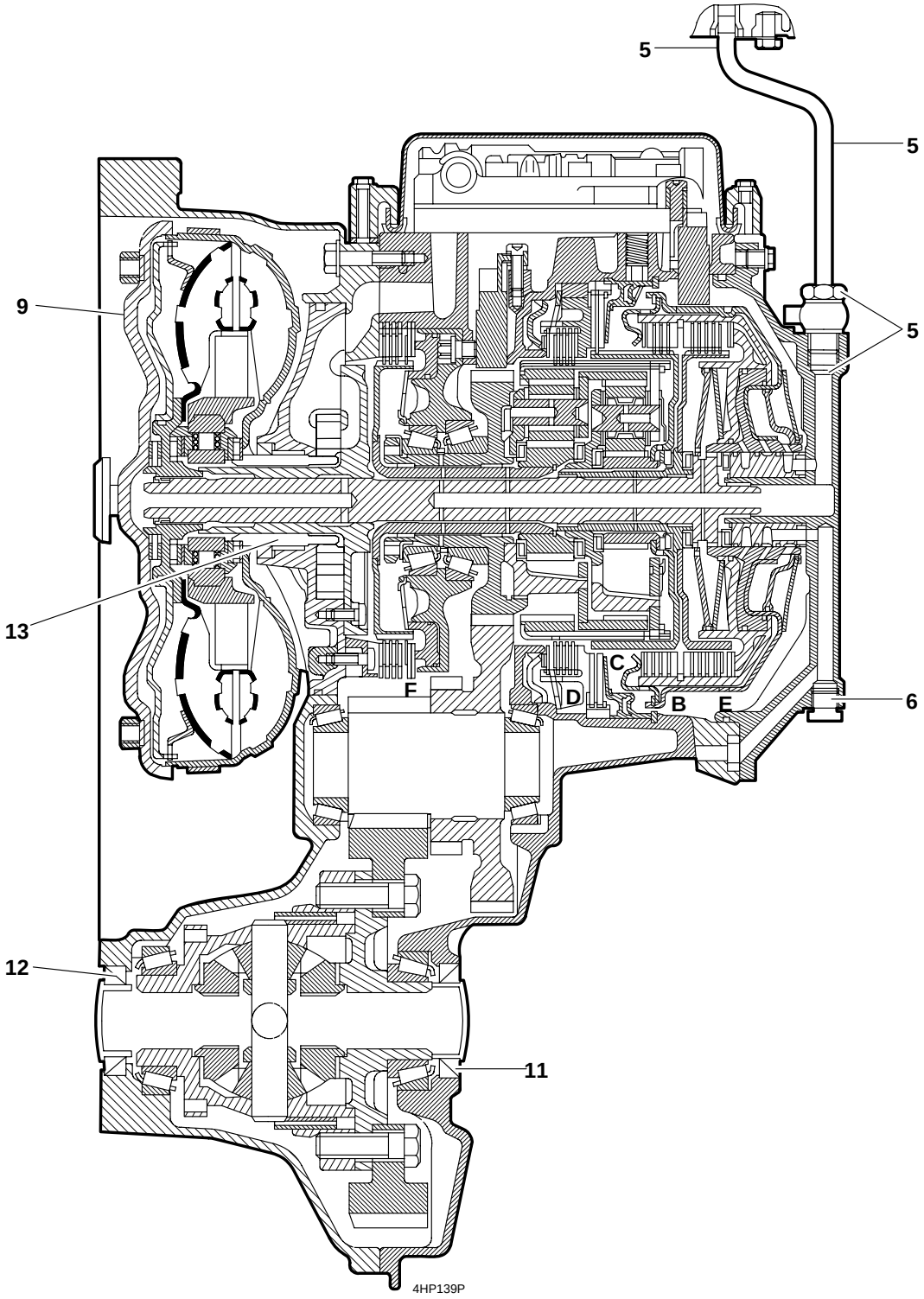
5 - Faults relating to the EMC

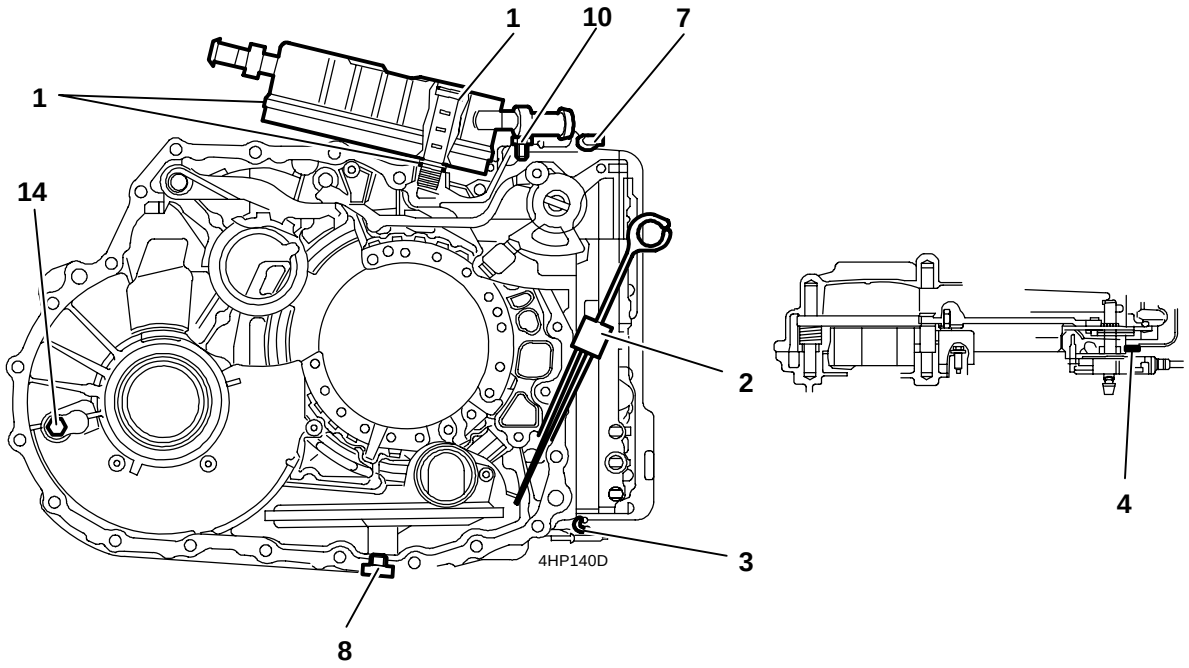
- downgraded gear changing quality (torque reduction),
- lock-up always open (engine speed).

III - AUTOMATIC TRANSMISSION OIL LEAKS

A fall in the oil level may lead to a drop in pressure or premature wear of the clutches.

IMPORTANT: Check the oil level after all repairs.



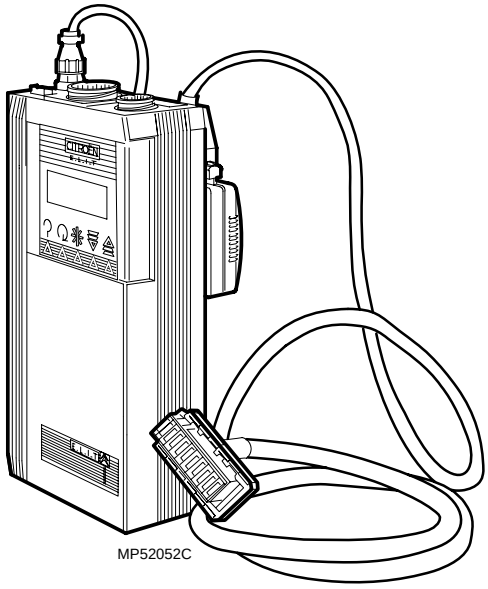


N°	ORIGIN OF LEAK	REMEDIES
1	Heat exchanger	Check for the presence and condition of the sealing rings on the socket bolts and replace seals or exchanger
2	Dipstick	Check that dipstick goes all the way down Check seal - Replace O-rings
3	Oil housing seal	Check tightness of bolts Replace oil housing seal (check tightening torque)
4	Selector shaft between multifunction switch and transmission housing	Check seal
5	Tubular connection between front cover and transmission housing	Check seals Check tightness Check tube visually
6	Front cover	Check seals Check tightness and condition of O-ring
7	Electrical connector	Check seals and tightness
8	Oil drain plug: differential transmission	Check seals and tightness
9	Engine flange, transmission around converter	Condition of converter seal Check if engine oil or transmission oil (crankshaft-converter sealing ring)
10	Transmission breather	Check oil level
11	Left hand driveshaft	Condition of lip seal
12	Right hand driveshaft	Condition of lip seal
13	Between transmission housing and converter housing	Damaged seal Replace transmission (if necessary)
14	Overflow plug on converter cover	Condition-tightness

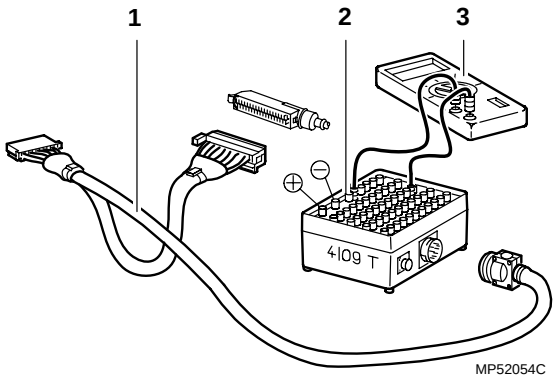
IV - PRESENTATION

A - DIAGNOSTIC TOOLING

1 - ELIT unit: 4125-T



2 - Terminal box: 4109-T

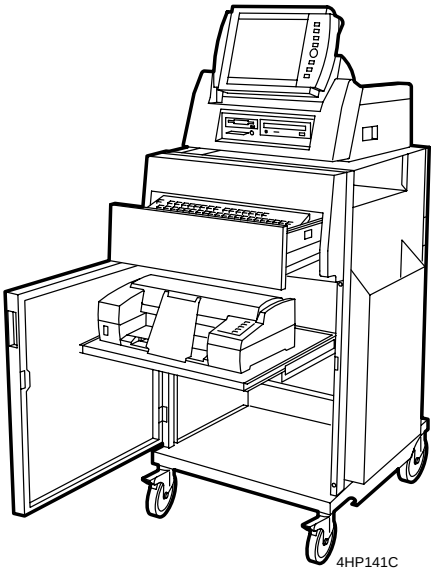


1 - Electrical harness (depending on application)

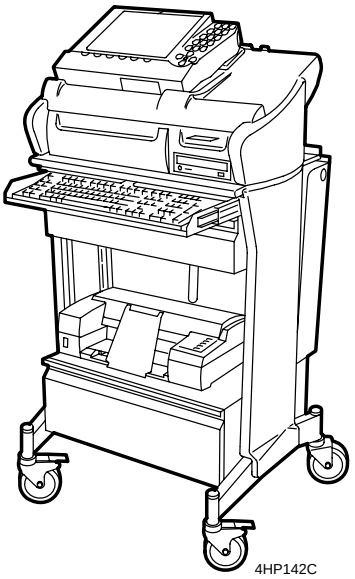
2 - Terminal box

3 - Multimeter

3 - PROXIA station: 4165-T



4 - LEXIA station: 4171-T



V - DIAGNOSTIC: AUTOMATIC TRANSMISSION 4HP20

A - DIAGNOSTIC TOOLING

1 - ELIT unit: 4125-T

This is used for:

- reading faults,
- erasing faults,
- measuring parameters,
- simulation,
- initialising auto-adaptives,
- updating the ECU using downloading.

2 - PROXIA station: 4165-T

This is used for:

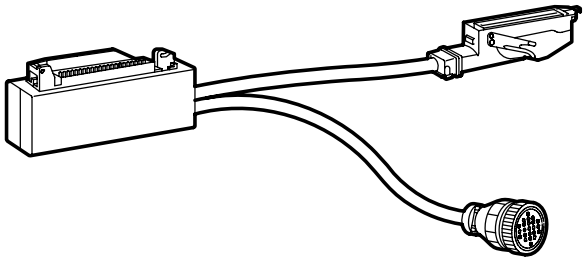
- reading faults,
- erasing faults,
- measuring parameters,
- testing actuators,
- initialising auto-adaptives,
- updating the ECU using downloading,
- viewing wiring diagrams.

3 - LEXIA station: 4171-T

This is used for:

- reading faults,
- erasing faults,
- measuring parameters,
- testing actuators,
- initialising auto-adaptives,
- updating the ECU using downloading,
- viewing wiring diagrams.

4 - Terminal box: 4109-T. Harness: 4187-T



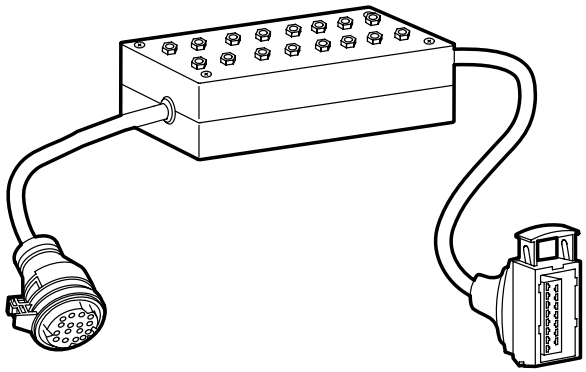
4HP143C

This tool, using a voltmeter and an ohmmeter, is used to check:

- sensors,
- actuators,
- the automatic transmission harness.

Warning:	On the XANTIA, the automatic transmission ECU is located under the battery which has to be removed in order to connect the test harness. Follow the initialisation procedures for ECUs on the vehicle after repairing them and reconnecting the battery.

5 - KOSTAL socket control harness and function selector connector: 8010-T (L)



Using an ohmmeter, this tool is used for checking:

- sensors, electrovalves and regulators located on the hydraulic unit via the KOSTAL socket,
- the multifunction switch.

B - FAULT FINDING TABLE

1 - List of faults

1 - Engine speed signal
2 - Transmission input speed
3 - Transmission output speed
4 - Multifunction switch
5 - Throttle position signal (load potentiometer through injection ECU)
6 - Transmission oil thermistor
7 - Ignition on supply
8 - Battery voltage
9 - Engine torque signal
10 - Electrovalve 1
11 - Electrovalve 2
12 - Pressure regulator 3
13 - Pressure regulator 4
14 - Pressure regulator 5
15 - Pressure regulator 6
16 - Engine torque reduction signal
17 - ECU
18 - Actuator supply output
19 - Gear engaged coherence
20 - Overspeed protection
21 - Gear changing control
22 - Shift lock, XANTIA
23 - Fan unit control
24 - Stop switch
25 - Key lock

Warning: The stop switch fault is memorised every time the ignition is switched on. Press the brake pedal to make the stop switch fault disappear before reading the faults whether in overall test or test by function.

Warning: Before working on the transmission, complete the diagnostic process by reading the faults on the injection ECU.

IMPORTANT: For all faults and problems signalled on the automatic transmission, check the oil level and quality.

2 - Fault 1. Engine speed signal

COMPO-NENTS LOCATIONS	ECU CONNECTOR	ECU TERM.	COMPO-NENT TERMINAL	CONTROL VALUES	EMERG. MODE
Engine speed information through injection ECU 1320	Connected	40-28	43-19	Test device(s): diagnostic tool in parameter reading. Display in parameter reading of engine speed to be compared with value given by rev counter on control panel. Check no fault relating to engine speed sensor in injection ECU. Deal with injection ECU faults first then erase them.	Maintain gear engaged whilst driving. Switch to 3rd hydraulic after prior return to position P or N
				Test device(s): voltmeter. Engine running (regardless of engine speed): 6.5 < U < 7 volts Engine off, ignition on: U ≈ U battery. Ignition off: U ≈ 4.8 volts (for an open circuit on engine speed information, U ≈ 8 Volts)	
	Disconnected	40	43	Test device(s): ohmmeter. Check the continuity and the insulation with respect to earth and to battery + of the connection: auto. trans. ECU - injection ECU.	

3 - Fault 2. Automatic transmission input speed

COMPO-NENTS LOCATIONS	ECU CONNECTOR	ECU TERM.	COMPO-NENT TERMINAL	CONTROL VALUES	EMERG. MODE
Turbine speed sensor in hydraulic unit cover 1635	Connected			Test device(s): diagnostic tool in parameter reading. The value must follow the engine speed plus slip of converter. " lockup " closed (converter locked up): the input speed should be equal to the engine speed	Maintain gear engaged whilst driving. Switch to 3rd hydraulic after prior return to position P or N
		16 - 28 44 - 28		Test device(s): voltmeter in AC position: the voltage rises with engine speed. Voltmeter in DC position: U ≈ 2.3 V, engine off, ignition on	
	Disconnected	16 - 44	15 - 16 KOSTAL	Test device(s): ohmmeter, R ≈ 830 ohms. Check the continuity and the insulation with respect to earth and to battery + of the connection: auto. trans. ECU - hydraulic ECU.	

4 - Fault 3. Automatic transmission output speed

COMPO-NENTS LOCATIONS	ECU CONNECTOR	ECU TERM.	COMPO-NENT TERMINAL	CONTROL VALUES	EMERG. MODE
Auto. trans. output speed sensor on hydraulic unit cover 1635	Connected	14 - 28 42 - 28		Test device(s): voltmeter in AC position: the voltage rises with vehicle speed. Test device(s): Voltmeter in DC position: U ≈ 2.3 V, engine off, ignition on	Maintain gear engaged whilst driving. Switch to 3rd hydraulic after prior return to position P or N
	Disconnected	42 - 14	1 - 2 KOSTAL	Test device(s): ohmmeter, R ≈ 830 ohms. Check the continuity and the insulation with respect to earth and to battery + of the connection: auto. trans. ECU - hydraulic ECU.	

5 - Fault 4. Multifunction switch

The lever position is given by the combination of the state of 4 switches.

If the ECU sees a combination which does not correspond to a recognised position, a fault is detected.

If the detected fault has disappeared, it is declared temporary the next time the ignition is switched on.

COMPO-NENTS LOCATIONS	ECU CONNECTOR	ECU TERM.	COMPO-NENT TERMINAL	CONTROL VALUES	EMERG. MODE
Multifunction switch 1600 on the transmission housing	Connected			Test device(s): diagnostic tool in parameter reading. Check that the physical position of the lever corresponds to that read by the ECU. Check the adjustment of the connecting cable with the lever	.
		55 - 28	Fuse F7 (BB10)	Test device(s): voltmeter. Check + permanent supply of switch and ECU. Otherwise check fuse F7. If the fuse has blown, check there is no short circuit to earth. If the supply is correct, check the operation of the switch (See sub-section C, paragraph 6)	Maintain gear engaged whilst driving Switch to 3rd hydraulic when ignition switched on
	Disconnected			Test device(s): ohmmeter. Check the continuity and the insulation with respect to earth and to battery + of the connection: auto. trans. ECU - multifunction switch. If the connections are correct, check the operation of the switch (see sub-section C, paragraph 6)	

Warning: If the ECU does not recognise the position P, the ECU no longer authorises the "shift lock" lever to be unlocked by pressing the brake pedal.

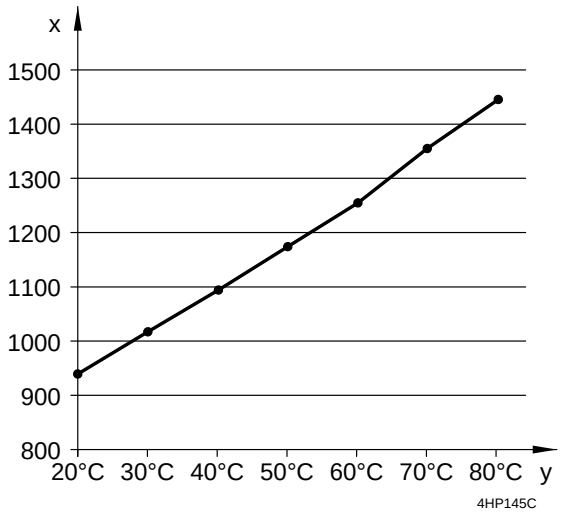
6 - Fault 5. Throttle position signal (load potentiometer through injection ECU)

COMPO-NENTS LOCATIONS	ECU CONNECTOR	ECU TERM.	COMPO-NENT TERMINAL	CONTROL VALUES	EMERG. MODE
Throttle position information via injection ECU 1320	Connected			Test device(s): diagnostic tool. Check there are no faults on the throttle potentiometer in the petrol injection ECU. Deal with faults on the injection ECU first then erase them. Press the accelerator pedal to vary the load. Check that the fault seen by the auto. trans. ECU has changed to temporary then erase it. Check by reading parameters with diagnostic tool that when in the full load position on accelerator pedal, there is a load greater or equal to 95% allowing the kickdown function to be activated, otherwise adjust the accelerator cable	Substitution value set up from load information and engine speed
		38-28	31-19 injection ECU	Test device(s): voltmeter. Engine off, ignition on, CAS function unlocked, 0 % load, pedal released, U ≈ 8.3 V Load 50 %, U ≈ 5.2 V. Load 100 % "full load", U ≈ 2.3 V The kickdown function is active in the 95/100% of throttle load range. For an open circuit on driver's wishes information U ≈ 10 V	
	Disconnected	38	31 injection ECU	Test device(s): ohmmeter. Check the continuity and the insulation with respect to earth and to battery + of the connection: auto. trans. ECU - injection ECU.	

7 - Fault 6. Automatic transmission oil thermistor

COMPO-NENTS LOCATIONS	ECU CONNECTOR	ECU TERM.	COMPO-NENT TERMINAL	CONTROL VALUES	EMERG. MODE
Oil thermistor on hydraulic unit housing 1635	Connected	22 - 21		Test device(s): voltmeter. The voltage varies as a function of temperature. At 21°C: U ≈ 0.93 V At 60°C: U ≈ 0.97 V For an open circuit: U ≈ 5 V	Substitution values: 60°C or 120 °C, depending on driving conditions. Activation of fan units when substitution value is 120 °C
	Disconnected		4 - 9 KOSTAL	Test device(s): ohmmeter. Check the resistance of the probe as a function of temperature (see graph below)	

Note: As the probe is welded directly to the harness inside the hydraulic unit, replacing it requires the harness to be changed.



X = ohms.

Y = °C.

8 - Fault 7. Ignition on supply

COMPO-NENTS LOCATIONS	ECU CONNECTOR	ECU TERM.	COMPO-NENT TERMINAL	CONTROL VALUES	EMERG. MODE
Ignition on supply		54,31 - 6,34	Fuse A (BMF1)	Test device(s): voltmeter. Ignition off: U = 0 V. Ignition on: 8 V < U < 16 V	

9 - Fault 8. Battery voltage

COMPO-NENTS LOCATIONS	ECU CONNECTOR	ECU TERM.	COMPO-NENT TERMINAL	CONTROL VALUES	EMERG. MODE
Permanent + supply	Connected	55 - 28	Fuse F7 (BF00)	Test device(s): voltmeter. Ignition off: 8 V < U < 16 V	

10 - Fault 9. Engine torque signal

COMPO-NENTS LOCATIONS	ECU CONNECTOR	ECU TERM.	COMPO-NENT TERMINAL	CONTROL VALUES	EMERG. MODE
Engine torque information through injection ECU 1320	Connected	39 - 28	6- 19 injection ECU	Test device(s): voltmeter. Position P, engine running: U ≈ 9.2 V at stabilised speed, increases with acceleration and decreases with deceleration Engine off, ignition on: U ≈ 11 V. Ignition off: U ≈ 4.8 V (for an open circuit on the torque signal U ≈ 8 V)	Substitution value set up from engine load and speed information
	Disconnected	39	6 injection ECU	Test device(s): ohmmeter, Check the continuity and the insulation with respect to earth and to battery + of the connection: auto. trans. ECU - injection ECU.	

11 - Fault 10. Electrovalve 1

COMPO-NENTS LOCATIONS	ECU CONNECTOR	ECU TERM.	COMPO-NENT TERMINAL	CONTROL VALUES	EMERG. MODE
Electro-valve 1 in hydraulic unit housing 1635	Connected	52 - 30		Test device(s): voltmeter. Engine running, position P: U ≈ U battery As EV1 is constantly operated: engine off, position P: activate the electrovalve using the diagnostic tool. The voltage goes from U battery to 0 V	Switch to 4th hydraulic when driving. Switch to 3rd hydraulic when ignition switched on
	Disconnected		3 - 12 KOSTAL	Test device(s): ohmmeter. R ≈ 32 ohms. Check the continuity and the insulation with respect to earth and to battery + of the connection: Auto. trans. ECU - hydraulic unit	

Note: If the oil temperature fault is also present, check that the KOSTAL socket on the hydraulic unit is correctly clipped in first.

12 - Fault 11. Electrovalve 2

COMPO-NENTS LOCATIONS	ECU CONNECTOR	ECU TERM.	COMPO-NENT TERMINAL	CONTROL VALUES	EMERG. MODE
Electro - valve 2 in hydraulic unit housing 1635	Connected	52 - 33		Test device(s): voltmeter. Engine running, position P: U ≈ U battery Engine off, position P: activate the electrovalve using the diagnostic tool. The voltage goes from U battery to 0 V	Switch to 4th hydraulic when driving. Switch to 3rd hydraulic when ignition switched on
	Disconnected		3 - 13 KOSTAL	Test device(s): ohmmeter. R ≈ 32 ohms. Check the continuity and the insulation with respect to earth and to battery + of the connection: auto. trans. ECU - hydraulic unit.	

Note: If the oil temperature fault is also present, check that the KOSTAL socket on the hydraulic unit is correctly clipped in first.

13 - Fault 12. Pressure regulator 3 (converter operation)

COMPO-NENTS LOCATIONS	ECU CONNECTOR	ECU TERM.	COMPO-NENT TERMINAL	CONTROL VALUES	EMERG. MODE
Pressure regulator 3 in hydraulic unit housing 1635	Connected	3 - 5		Test device(s): voltmeter. Engine off, ignition on ("lock up" open): U ≈ 1 V, (I = 159 mA), regardless of lever position ("lock up" open) The converter is only controlled from 2nd gear depending on driving conditions. Converter locked up, ("lock up" closed): U ≈ 4.6 V (I = 768 mA), regardless of lever position	Switch to 4th hydraulic when driving. Switch to 3rd hydraulic when ignition switched on
	Disconnected		6 - 5 KOSTAL	Test device(s): ohmmeter. R ≈ 6 ohms. Check the continuity and the insulation with respect to earth and to battery + of the connection: auto. trans. ECU - hydraulic unit.	

Note: If the oil temperature fault is also present, check that the KOSTAL socket on the hydraulic unit is correctly clipped in first.

14 - Fault 13. Pressure regulator 4

COMPO-NENTS LOCATIONS	ECU CONNECTOR	ECU TERM.	COMPO-NENT TERMINAL	CONTROL VALUES	EMERG. MODE
Pressure regulator 4 in hydraulic unit housing 1635	Connected	3 - 1		Test device(s): voltmeter. Engine running, position P: U ≈ 4.6 V (I = 768 mA) Engine off, position R: U ≈ 1 V. Other positions: U ≈ 4.6 V	Switch to 4th hydraulic when driving. Switch to 3rd hydraulic when the ignition is switched on
	Disconnected		7 - 5 KOSTAL	Test device(s): ohmmeter. R ≈ 6 ohms. Check the continuity and the insulation with respect to earth and to battery + of the connection: auto. trans. ECU - hydraulic unit.	

Note: If the oil temperature fault is also present, check that the KOSTAL socket on the hydraulic unit is correctly clipped in first

15 - Fault 14. Pressure regulator 5

COMPO-NENTS LOCATIONS	ECU CONNECTOR	ECU TERM.	COMPO-NENT TERMINAL	CONTROL VALUES	EMERG. MODE
Pressure regulator 5 in hydraulic unit housing 1635	Connected	3 - 29		Test device(s): voltmeter. Engine running, position P: U ≈ 1 V, (I = 159 mA) (idle position) Engine off, position P, N, R: U ≈ 1.1 V Other positions: U ≈ 5.2 V	Switch to 4th hydraulic when driving. Switch to 3rd hydraulic when the ignition is switched on
	Disconnected		10 - 5 KOSTAL	Test device(s): ohmmeter. R ≈ 6 ohms. Check the continuity and the insulation with respect to earth and to battery + of the connection: auto. trans. ECU - hydraulic unit.	

Note: If the oil temperature fault is also present, check that the KOSTAL socket on the hydraulic unit is correctly clipped in first

16 - Fault 15. Pressure regulator 6

COMPO-NENTS LOCATIONS	ECU CONNECTOR	ECU TERM.	COMPO-NENT TERMINAL	CONTROL VALUES	EMERG. MODE
Pressure regulator 6 in hydraulic unit housing 1635	Connected	3 - 4		Test device(s): voltmeter. Engine running, position P: U ≈ 4.6 V, (I = 768 mA) (maximum opening) Engine off, position R: U ≈ 1.1 V Other positions: U ≈ 5.2 V	Switch to 4th hydraulic when driving. Switch to 3rd hydraulic when the ignition is switched on
	Disconnected		11 - 5 KOSTAL	Test device(s): ohmmeter. R ≈ 6 ohms. Check the continuity and the insulation with respect to earth and to battery + of the connection: auto. trans. ECU - hydraulic unit.	

Note: If the oil temperature fault is also present, check that the KOSTAL socket on the hydraulic unit is correctly clipped in first

17 - Fault 16. Engine torque reduction signal

Retard advance when changing gear:

COMPO-NENTS LOCATIONS	ECU CONNECTOR	ECU TERM.	COMPO-NENT TERMINAL	CONTROL VALUES	EMERG. MODE
Torque reduction information to injection ECU 1320	Connected	51 - 28	42-19 injection ECU	Test device(s): voltmeter. Engine off, ignition on, positions P, N: U ≈ 9.2 V, other positions: U ≈ 0 V For an open circuit on the torque reduction line, regardless of the lever position: U ≈ 0 V	No kickdown function
	Disconnected	51	42 injection ECU	Test device(s): ohmmeter. Check the continuity and the insulation with respect to earth and to battery + of the connection: auto. trans. ECU -Injection ECU	

18 - Fault 17. ECU

Erase the fault and check that the fault does not reappear, otherwise test with a new ECU.

19 - Fault 18. Actuator supply output

This fault is only detected when the ignition is switched on:

<table>
<tr><th>COMPO-NENTS LOCATIONS</th><th>ECU CONNECTOR</th><th>ECU TERM.</th><th>COMPO-NENT TERMINAL</th><th>CONTROL VALUES</th><th>EMERG. MODE</th></tr>
<tr><td rowspan="2">Supply line sectioner function
in the ECU</td><td>Connected</td><td rowspan="2">Supply for regulators 3- 6,34
supply for electro-valves
52 - 6,34</td><td></td><td>Test device(s):
voltmeter.
Actuators supplied:
> 7.5 Volts.
Actuators not supplied:
< 7.5 Volts.</td><td rowspan="2">Switch to 4th hydraulic when driving.
Switch to 3rd hydraulic when the ignition is switched on</td></tr>
<tr><td>Disconnected</td><td>5 - 3
KOSTAL</td><td>Test device(s):
ohmmeter.
Check the continuity and absence of a short circuit to battery + and earth on the regulator and electrovalves supply outputs. If these two checks are correct, test with a new ECU</td></tr>
</table>

20 - Fault 19. Coherence with gear engaged

The difference between the input and output speeds of the transmission is too great for the gear engaged.

IMPORTANT: For all faults and problems signalled on the automatic transmission, check the oil level and quality.

COMPO-NENTS LOCATIONS	ECU CONNECTOR	ECU TERM.	COMPO-NENT TERMINAL	CONTROL VALUES	EMERG. MODE
Transmission input and output speed sensors, in the hydraulic unit housing 1635	Connected			Test device(s): diagnostic tool in parameter reading. Compare the turbine and vehicle speeds for the gear engaged. Check that the status of the electrovalves and regulators corresponds to the expected gear (see sub-section D, paragraph 1). If the fault reappears after erasing it, there is a mechanical fault; brake wear, internal oil leak, electrovalve or regulator seizing	Switch to 4th hydraulic when driving. Switch to 3rd hydraulic when the ignition is switched on
				Test device(s): ohmmeter, voltmeter. Check the engine speed signal and the transmission input and output sensors as specified in sub-section B, paragraphs 2, 3, 4	

21 - Fault 20. Over speed protection

Engine speed or turbine speed greater than maximum limits.

IMPORTANT: For all faults and problems signalled on the automatic transmission, check the oil level and quality.

COMPO-NENTS LOCATIONS	ECU CONNECTOR	ECU TERM.	COMPO-NENT TERMINAL	CONTROL VALUES	EMERG. MODE
Engine speed and turbine speed information	Connected			Test device(s): diagnostic tool in parameter reading. Check that there is no interference on the engine speed and turbine speed. Compare these values to the engine speed given by the injection ECU and the display on the control panel	Switch to 4th hydraulic when driving. Switch to 3rd hydraulic when the ignition is switched on
				Test device(s): ohmmeter, voltmeter. Check the engine speed signal and the transmission input and output sensors as specified in sub-section B, paragraphs 2, 3, 4	

22 - Fault 21. Gear change control

There is no variation in speed information after changing a gear.

IMPORTANT: For all faults and problems signalled on the automatic transmission, check the oil level and quality.

COMPO-NENTS LOCATIONS	ECU CONNECTOR	ECU TERM.	COMPO-NENT TERMINAL	CONTROL VALUES	EMERG. MODE
Transmission input and output speed sensors, in the hydraulic unit housing 1635	Connected			Test device(s): diagnostic tool in parameter reading. Compare the turbine and vehicle speeds for the gear engaged. Check that the status of the electrovalves and regulators corresponds to the expected gear (see sub-section D, paragraph 1). If the fault reappears after erasing it, there is a mechanical fault; brake wear, internal oil leak, electrovalve or regulator seizing	Maintain gear engaged whilst driving. Switch to 3rd hydraulic after prior return to position P or N
				Test device(s): ohmmeter, voltmeter. Check the electrovalve and regulator supplies (see sub-section B, paragraph 8)	

23 - Fault 22. Shift lock

COMPO-NENTS LOCATIONS	ECU CONNECTOR	ECU TERM.	COMPO-NENT TERMINAL	CONTROL VALUES	EMERG. MODE
Lever locking relay 1642	Connected	32 - 34		Test device(s): voltmeter. Gear selector lever in position P. Brake pedal pressed: U = 0 V. Brake pedal released: U = U battery	No "shift lock" position: lever remains locked in position P and must be released manually
	Disconnected		1 - 2 (5 green tracks)	Test device(s): ohmmeter. Check the relay coil, R ≈ 60 ohms. Check continuity and insulation	

Note: If the lever remains locked although there is no "shift lock" fault, check the lever release actuator (see sub-section C, paragraph 4).

24 - Fault 23. Fan unit control

COMPO-NENTS LOCATIONS	ECU CONNECTOR	ECU TERM.	COMPO-NENT TERMINAL	CONTROL VALUES	EMERG. MODE
	Connected	20 - 34		Test device(s): voltmeter. The fan unit relay is activated when the oil temperature is greater than 120°C	
	Disconnected			Test device(s): ohmmeter. R ≈ 400 ohms.	

25 - Fault 24. Stop switch

No action on the brake pedal has been detected since the ignition was switched on:

COMPO-NENTS LOCATIONS	ECU CONNECTOR	ECU TERM.	COMPO-NENT TERMINAL	CONTROL VALUES	EMERG. MODE
Brake pedal switch 2100	Connected	10 - 34		Test device(s): voltmeter. Ignition on Brake pedal released: U = 0 V. Brake pedal pressed: U ≈ U battery	No "shift lock" position: the lever is locked in position P and must be released manually
	Disconnected	10 - 54		Test device(s): ohmmeter. Stop lights disconnected (including third stop light). Brake pedal released: R = infinity. Brake pedal pressed: R ≈ 0 ohms	

Warning: The stop switch fault is memorised every time the ignition is switched on. Press the brake pedal to make the fault disappear before reading the faults with the diagnostic tool whether in general test or test by function.

26 - Fault 25. Key lock

COMPO-NENTS LOCATIONS	ECU CONNECTOR	ECU TERM.	COMPO-NENT TERMINAL	CONTROL VALUES	EMERG. MODE
	Connected	49 - 34		Test device(s): voltmeter. Gear selector lever in position P: U = 0 V. Other positions: U ≈ U battery	
	Disconnected			Test device(s): ohmmeter. Check the relay coil, R ≈ 88 ohms. Check continuity and insulation	

C - ELECTRICAL TESTS

1 - Diagnostic connection

COMPONENTS LOCATIONS	ECU CONNECTOR	ECU TERMS.	COMP. TERMS.	CONTROL VALUES
Central diagnostic socket C001 in passenger compartment	Disconnected	50 - 28		Test device(s): voltmeter. Disconnect the ECU connector, connect the diagnostic tool to the 30 track socket: check U = U battery on terminal 50
		50	Terminal G1 (brown 30 track)	Test device(s): ohmmeter. Check the continuity and the insulation with respect to earth of the diagnostic connection

2 - Reversing lights control

Test devices: multimeter, multifunction switch test harness:

COMPONENTS LOCATIONS	ECU CONNECTOR	ECU TERMS.	COMP. TERMS.	CONTROL VALUES
Reversing lights function 2630 2635, reverse gear info for indexed rear view mirror. Gear selector lever in position R	Disconnected		Reversing lights supply, fuse F12 (BBF00)	Test device(s): voltmeter. Ignition on, check +12 Volts supply between terminal 8 on harness side and earth: U = U battery Otherwise check fuse F12
			8 - 9 black 10 track connector	Test device(s): ohmmeter. Gear selector lever in position R: R = 0 ohm. Other positions: R = infinity. Check the insulation with respect to earth
			9 - black 10 track connector. Harness side	Check the reversing lights circuit between terminal 9 and earth: R ≈ 2.3 ohms (2630 and 2635 in parallel)

Note: This information, provided by the multifunction switch, is independent to the automatic transmission ECU.

3 - Starting authorisation

Test devices: multimeter, multifunction switch test harness:

COMPONENTS LOCATIONS	ECU CONNECTOR	ECU TERMS.	COMP. TERMS.	CONTROL VALUES
Starter motor relay 1005 Multifunction switch 1600 on transmission housing. Gear selector lever in position P, N	Disconnected		Harness side: 7/earth (black 10 tracks)	Test device(s): voltmeter. Ignition on, check the +12 Volt supply of the relay, between terminal 7 and earth: U ≈ U battery
			Harness side: 6/earth (black 10 tracks)	Test device(s): ohmmeter. Check the starter motor relay coil between terminal 6 and earth: R ≈ 63 ohms
			6/7 (black 10 tracks)	Test device(s): Ohmmeter. Gear selector lever in position P, N: R = 0 ohm. Other positions, R = infinity

Note: This information, provided by the multifunction switch, is independent to the automatic transmission ECU.

4 - Gear lever release actuator

COMPONENTS LOCATIONS	ECU CONNECTOR	ECU TERMS.	COMP. TERMS.	CONTROL VALUES
Gear lever release actuator 1638, in the console at the base of the lever	Connected		Harness side: 1 - 2 (black 4 tracks)	Test device(s): voltmeter. Ignition on, gear selector lever in position P, brake pedal pressed, check +12 Volt supply between terminals 1 and 2: U ≈ U battery. Otherwise check there are no faults preventing the "shift lock" and check relay 1642, (see sub-section B, paragraph 23)
			1 - 2 (black 4 tracks)	Test device(s): ohmmeter. Check the actuator coil between terminals 1 and 2: R ≈ 12 ohms

5 - Program selector

Depending on the style of driving, the ECU chooses the most suitable gear changing law program (programs 1 to 5 ranging from more economical driving to more sporty driving). The driver can select specific programs using the sport / snow switch:

COMPONENTS LOCATIONS	ECU CONNECTOR	ECU TERMS.	COMP. TERMS.	CONTROL VALUES
Program switch supply			4 - 6	Test device(s): voltmeter. Ignition on: U ≈ 12 V. Otherwise check fuse F2
Snow program selection	Connected			Test device(s): diagnostic tool in parameter reading. Snow light illuminated: selection: snow. Program: 8 (Lever in position P, R, D). Program: manual (Lever in position 1, 2, 3)
		12 - 28	2 - 6	Test device(s): voltmeter. Ignition on: U ≈ 0 V. Other selection: U ≈ 10 V
	Disconnected	12	2	Test device(s): ohmmeter. Check the continuity and the insulation with respect to earth
Sport program selection	Connected			Test device(s): Diagnostic tool in parameter reading. Sport light illuminated: sport selection Program: 4. (or program 5 depending on driving)
		45 - 28	7 - 6	Test device(s): voltmeter. Ignition on: sport: selection U ≈ 0 V. Other selection: U ≈ 10 V
	Disconnected	45	7	Test device(s): ohmmeter. Check the continuity and the insulation with respect to earth
Normal program selection	Connected			Test device(s): Diagnostic tool in parameter reading. Sport and snow lights extinguished: selection normal. Program: 2. (or program 1 - 5 depending on driving)
		45 - 28	7 - 6	Test device(s): voltmeter. Ignition on: U ≈ 10 V.
		12 - 28	2 - 6	
	Disconnected	45	7	Test device(s): ohmmeter. Check the continuity and the insulation with respect to earth
		12	2	

6 - Multifunction switch

Test device(s): ohmmeter, switch test harness or harness 4187-T and terminal box:

LEVER POSITION	36	37	9	8		ECU CONNECTOR
	2	3	4	5	BLACK 16 TRACK SWITCH CONNECTOR	
P	∞	R = 0 ohm	∞	∞	1	55
*	∞	R = 0 ohm	R = 0 ohm	∞		
R	∞	∞	R = 0 ohm	∞		
*	∞	∞	R = 0 ohm	R = 0 ohm		
N	∞	∞	∞	R = 0 ohm		
*	R = 0 ohm	∞	∞	R = 0 ohm		
D	R = 0 ohm	R = 0 ohm	∞	R = 0 ohm		
*	R = 0 ohm	R = 0 ohm	R = 0 ohm	R = 0 ohm		
3	R = 0 ohm	∞	R = 0 ohm	R = 0 ohm		
*	R = 0 ohm	R = 0 ohm	R = 0 ohm	R = 0 ohm		
2	R = 0 ohm	R = 0 ohm	R = 0 ohm	∞		
*	R = 0 ohm	R = 0 ohm	R = 0 ohm	R = 0 ohm		
1	∞	R = 0 ohm	R = 0 ohm	R = 0 ohm		

Note: Combinations marked "" correspond to intermediate positions. The role of combinations marked "*" is to have just a single line changing state when changing from one recognised position to another.*

Note: As the ECU connector is disconnected for this test, the lever must be released manually to remove it from position P.

Test device(s): voltmeter, harness 4187-T, terminal box:

LEVER POSITION	36	37	9	8	ECU CONNECTOR
P	0 V	U battery	0 V	0 V	6
*	0 V	U battery	U battery	0 V	
R	0 V	0 V	U battery	0 V	
*	0 V	0 V	U battery	U battery	
N	0 V	0 V	0 V	U battery	
*	U battery	0 V	0 V	U battery	
D	U battery	U battery	0 V	U battery	
*	U battery	U battery	U battery	U battery	
3	U battery	0 V	U battery	U battery	
*	U battery	U battery	U battery	U battery	
2	U battery	U battery	U battery	0 V	
*	U battery	U battery	U battery	U battery	
1	0 V	U battery	U battery	U battery	

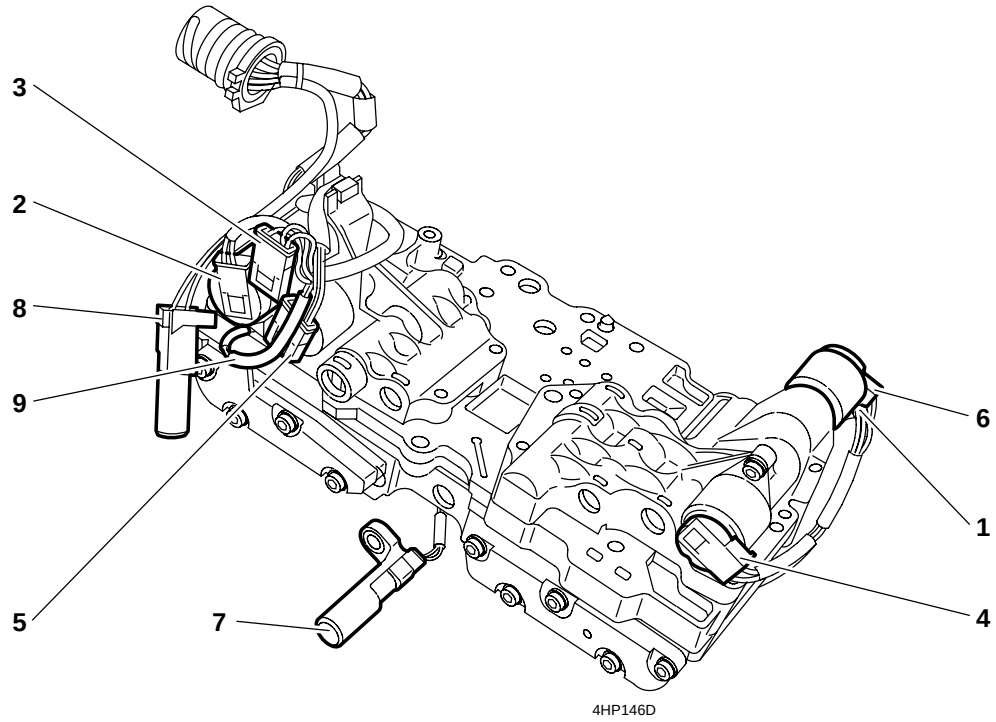
Note: Combinations marked "" correspond to intermediate positions. The role of combinations marked "*" is to have just a single line changing state when changing from one recognised position to another.*

7 - Hydraulic unit

Test device(s): ohmmeter, KOSTAL test harness or harness 4187-T and terminal box:

COMPO-NENTS	52	3	44	14	22		ECU CONNECTOR
	3	5	16	2	9	KOSTAL CONNEC-TOR	
EL1	R ≈ 32 ohms	∞	∞	∞	∞	12	30
EL2	R ≈ 32 ohms	∞	∞	∞	∞	13	33
REG3	∞	R ≈ 6 ohms	∞	∞	∞	6	5
REG4	∞	R ≈ 6 ohms	∞	∞	∞	7	1
REG5	∞	R ≈ 6 ohms	∞	∞	∞	10	29
REG6	∞	R ≈ 6 ohms	∞	∞	∞	11	4
Input speed	∞	∞	R ≈ 830 ohms	∞	∞	15	16
Output speed	∞	∞	∞	R ≈ 830 ohms	∞	1	42
Oil temperature	∞	∞	∞	∞	X	4	21

X: resistance which varies with temperature



1 - Electrovalve 1 (green base, violet and grey wires)
2 - Electrovalve 2 (green base, violet and green wires)
3 - Pressure regulator 3 (black base, violet and yellow wires)
4 - Pressure regulator 4 (black base, violet and red wires)
5 - Pressure regulator 5 (black base, violet and blue wires)
6 - Pressure regulator 6 (black base, violet and white wires)
7 - Transmission input speed sensor (turbine) (brown wires)
8 - Transmission output speed sensor (yellow wires)
9 - Oil temperature sensor

D - OPERATION

1 - Operation of electrovalves and pressure regulators

SELECTOR LEVER POSITION	GEAR ENGAGED	OPERATION OF ELECTROVALVES **		OPERATION OF PRESSURE REGULATORS			
		EL1	EL2	EDS3	EDS4	EDS5	EDS6
P		1	1	159mA	768mA	159mA	768mA
R	R	1	1	159mA	159mA	159mA	159mA
N		1	1	159mA	768mA	159mA	768mA *
D	1	1	1	159mA	768mA	768mA	768mA
	2	1	0	X	768mA	768mA	159mA
	3	1	0	X	768mA	159mA	768mA
	4	1	0	X	159mA	159mA	159mA
3	1	1	1	159mA	768mA	768mA	768mA
	2	1	0	X	768mA	768mA	159mA
	3	1	0	X	768mA	159mA	768mA
2	1	1	1	159mA	768mA	768mA	768mA
	2	1	0	X	768mA	768mA	159mA
1	1	1	1	159mA	768mA	768mA	768mA

** status 1: electrovalve operated

status 0: electrovalve at rest

* : except when snow program selected

X : varies depending on converter lock-up

159 mA "lock up" open

768 mA "lock up" closed

(converter lock up)

Note: When the 2 electrovalves are not operated, the automatic transmission is put into 3rd hydraulic when the ignition is switched on.

Warning: In 3rd hydraulic, reverse gear can be selected but this action produces a large bang.

Note: The currents of the pressure regulators shown when reading parameters using the diagnostic tools are the reference values and not the measurements of the operating currents.

2 - Kickdown

The kickdown function is active in the 95 / 100 % of throttle load range.

Using the diagnostic tool in parameter reading mode, check that when the accelerator pedal is fully pressed (full load position), there is a load greater than or equal to 95% thus activating the kickdown function, otherwise adjust the accelerator cable.

E - DOWNLOADING TO THE ECU

1 - Updating the ECU by downloading

The downloading operation is used to update the automatic transmission ECU or to modify it following a change to the injection ECU.

IMPORTANT: Every time a downloading operation is performed to the automatic transmission ECU, the injection ECU must be updated (and vice versa).

IMPORTANT: After every downloading operation, initialise the auto-adaptives of the automatic transmission ECU.

2 - Initialising the auto-adaptives

Accessed from the "SPARE PARTS" menu, the auto-adaptive initialisation function is used to initialise the auto-adaptive parameters recorded by the automatic transmission ECU.

WARNING: After initialising the auto-adaptives, gear changes may vary in quality whilst the ECU adapts itself to the vehicle.

F - SYMPTOMS OCCURRING DUE TO THE ABSENCE OF A FAULT ON THE DIAGNOSTIC TOOL

1 - No dialogue between the ECU and the diagnostic tool

Check the supply and earth of the ECU.

Check the diagnostic line (see sub-section C, paragraph 1).

Perform a test with a new ECU. If the ECU is faulty, the transmission will be in 3rd hydraulic when the ignition is switched on.

Warning:	In 3rd hydraulic, reverse gear can be selected but this action produces a large bang.

2 - Cannot start engine, lever in position P, N

Starting authorisation function via the multifunction switch:

- check that the injection ECU has been unlocked by the coded anti-start,
- check the starting authorisation (see sub-section C, paragraph 3).

3 - Cannot release lever from position P by pressing brake pedal

"Shift lock" function:

- check that the stop switch fault has disappeared after pressing the brake pedal,
- check that the ECU fitted deals with the "shift lock" function,
- check that the Ecu recognises position P of the gear lever. Check the adjustment of the selector control cable,
- check the multifunction switch (see sub-section C, paragraph 6),
- check the gear lever release actuator (see sub-section C, paragraph 4).

4 - Reversing lights do not illuminate with selector lever in position R

Check the reversing lights control (see sub-section C, paragraph 2).

5 - No noticeable effect when selecting sport / snow

Check that the ECU recognises the selections requested (see sub-section C, paragraph 5).

6 - No drive, lever in position D, whilst an imposed gear has not been requested previously then no gear changes after returning to position D

Short circuit to positive on line 4 of the multifunction switch:

- check that the ECU recognises the gear lever position,
- check the multifunction switch (see sub-section C, paragraph 6).

Note: This fault is combined with the absence of the gear lever locking (position P not recognised).

ZF 4HP20 AUTOMATIC TRANSMISSION