

operating principle : ZF 4HP20 automatic gearbox SINCE RPO No. 07482

1 General : gear selection law

The operating point of the gearbox is defined by the following information :

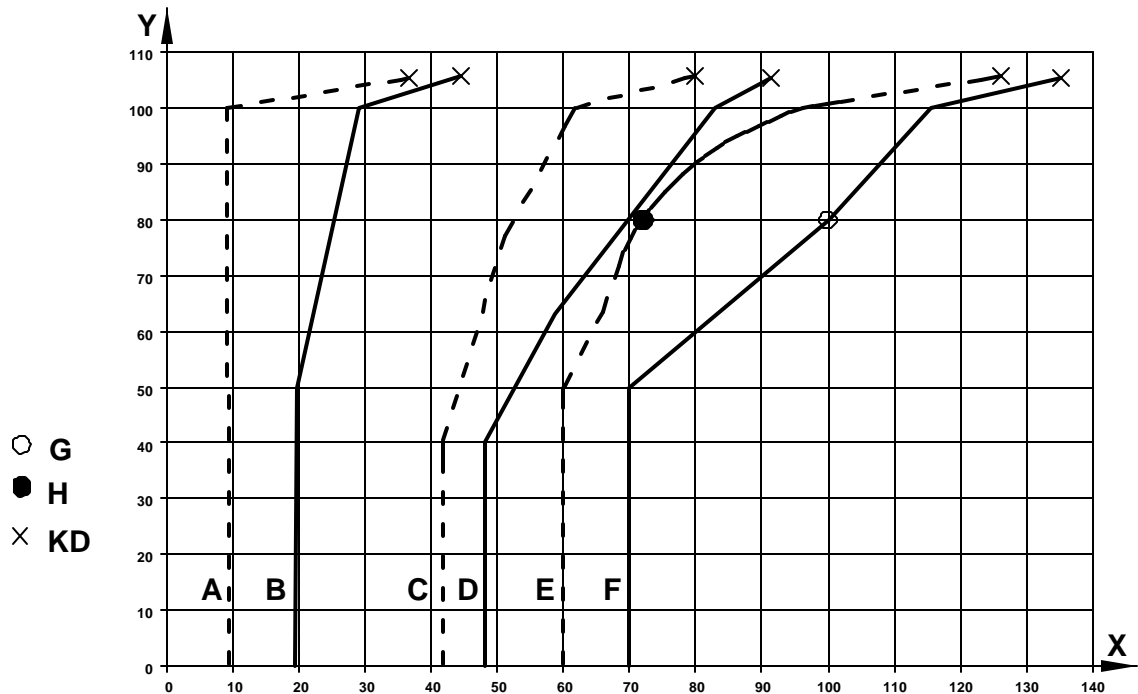
- throttle butterfly position
- vehicle engine load and speed

In operation, the decision to change gears is taken by the ECU using a set of graphs known as the "selection laws".

Each selection law includes :

- the gear change thresholds (upshifting and downshifting gears)
- the torque converter lock-up thresholds (lock-up graphs)
- the "kick-down" points

1.1 Gear selection graphs



- Fig. : 1 -

Example of a gear selection law (converter lock-up graphs not shown).

X - vehicle speed.

Y - position of the accelerator pedal (in %).

(A) graph depicting a change from 2nd gear to 1st gear.

(B) graph depicting a change from 1st gear to 2nd gear.

(C) graph depicting a change from 3rd gear to 2nd gear.

(D) graph depicting a change from 2nd gear to 3rd gear.

(E) graph depicting a change from 4th gear to 3rd gear.

(F) graph depicting a change from 3rd gear to 4th gear.

" G " example 1.

" H " example 2.

" KD " "kick-down" points (downshifting).

The gear change takes place when the operating point bisects the graph (increasing or decreasing speed).

N.B. : The gear change levels are different, when changing up and changing down, in order to prevent repeated gear changes.

In every case , the selection laws make it possible, in line with the driver's actions, to obtain an optimum vehicle performance.

If the accelerator pedal is fully depressed, the ECU automatically goes to the KD point (kick down).

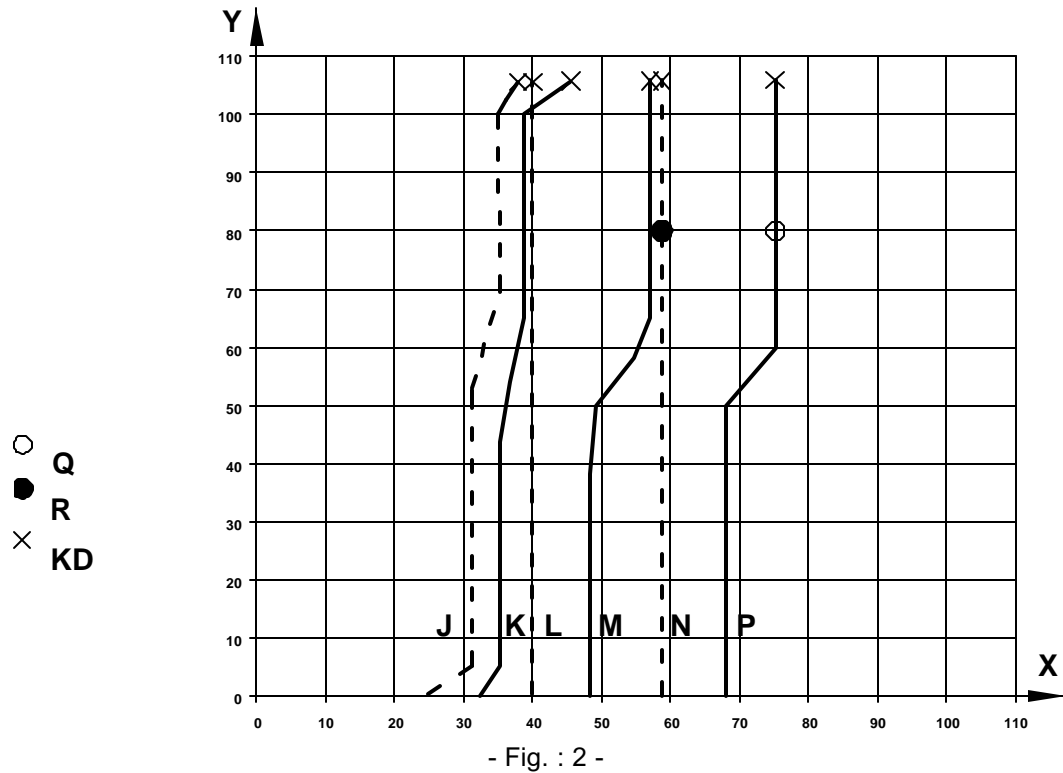
Example 1 : vehicle speed increasing :

- the accelerator pedal is depressed to 80 % of its travel
- the vehicle is in 3rd gear
- the gear changes up when the vehicle reaches a speed of 100 km/h

Example 2 : vehicle speed decreasing :

- the accelerator pedal is depressed to 80 % of its travel
- the vehicle is in 4th gear
- changing down takes place when the vehicle speed drops below 72 km/h

1.2 Converter lock-up graphs



- Fig. : 2 -

Example of lock-up graphs (gear selection graphs not shown).

X - vehicle speed.

Y - position of the accelerator pedal (in %).

(J) lock-up graph depicting 2nd gear to 1st gear change.

(K) lock-up graph depicting 1st gear to 2nd gear change.

" KD " "kick-down" points (downshifting).

(L) lock-up graph depicting 3rd gear to 2nd gear change.

(M) lock-up graph depicting 2nd gear to 3rd gear change.

(N) lock-up graph depicting 4th gear to 3rd gear change.

(P) lock-up graph depicting 3rd gear to 4th gear change.

" Q " example 1.

" R " example 2.

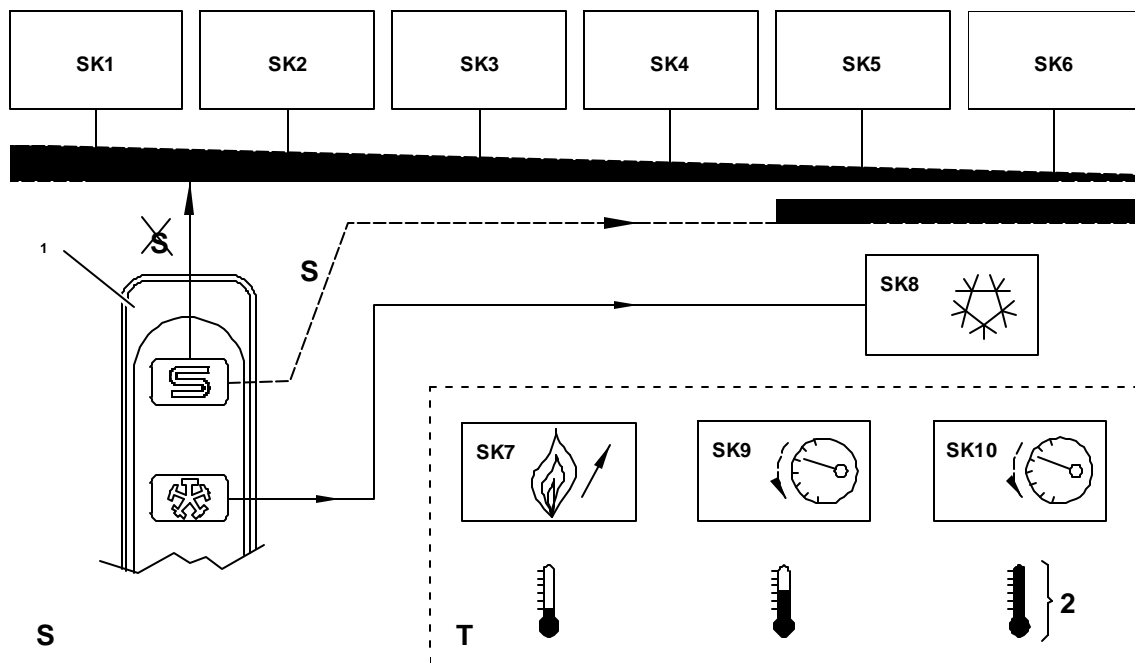
Example 1 : vehicle speed increasing :

- the accelerator pedal is depressed to 80 % of its travel
- the vehicle is in 3rd gear
- torque converter lock-up takes place once the vehicle speed reaches 75 km/h

Example 2 : vehicle speed decreasing :

- the accelerator pedal is depressed to 80 % of its travel
- the vehicle is in 4th gear
- the torque converter is unlocked once the vehicle speed drops below 58 km/h

2 Programs and selection laws



- Fig. : 3 -

S - "normal" operating laws.

T - gearbox reheating and protection laws.

" 1 " programme selector connection.

" 2 " gearbox oil temperature information.

(SK1 - SK6) gear changing laws.

(SK7) reheating law.

(SK8) snow law.

(SK9 - SK10) thermal protection laws.

The ECU uses 10 selection laws :

- 6 auto-adaptive laws
- 1 law specific to the "snow" program
- 1 engine and gearbox reheating law
- 2 thermal protection laws

The memorised laws allow double downshifting.

N.B. : For gearboxes which are purely hydraulically-controlled there is only one set of selection laws.

N.B. : The operating mode "imposed gears" limits the number of available gears . It uses the same selection thresholds as for "automatic" operation.

The SK1 gear changing law is the most economical.

The SK6 gear changing law is the most sporty.

The ECU controls 3 driving programs :

- normal (auto-adaptive parameters)
- sport (auto-adaptive parameters)
- snow

The driver can select the desired program by pressing the corresponding button.

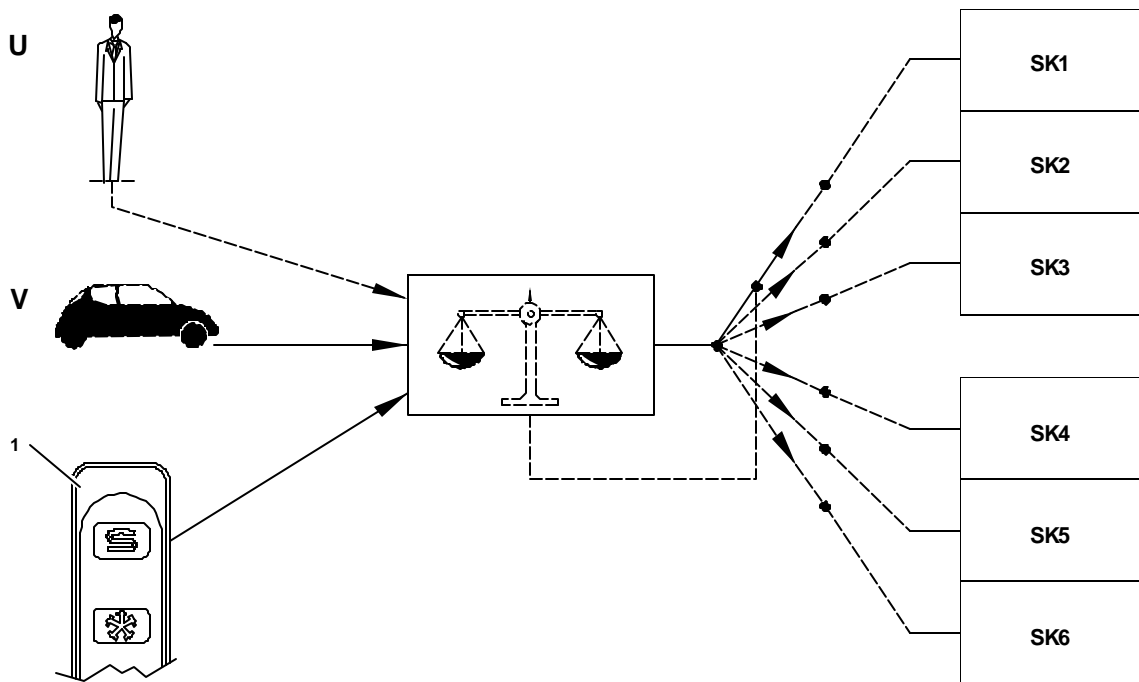
The selected program is shown on the control panel by the corresponding lamp illuminating.

The economical driving program is selected by pressing the button of the program currently activated.

When the ignition is switched on, the gearbox systematically sets itself in the "normal" program (auto-adaptive).

2.1 "normal" program , "sport" program

The ECU adapts the gearbox operation to the road, engine load and driving style.



- Fig. : 4 -

U - driver parameters.

V - vehicle parameters.

(SK1 - SK6) gear changing laws.

" 1 " programme selector connection.

The ECU adapts gear changes as a function of the following elements :

- driving style
- program selected by the driver
- road profile : adherence to road surface , unevenness of road
- gearbox : oil temperature , wear state
- motor : charging , engine speed , temperature

The main information used is as follows :

- throttle position information
- throttle position change speed
- average throttle position
- variation in gearbox output speed (output speed sensor)
- the vehicle acceleration (engine torque)
- vehicle speed

2.1.1 "normal" program

Program suited to normal driving (favouring economic fuel consumption).

The ECU adapts the gearbox operation to the road, engine load and driving style.

The ECU uses all gear changing laws (SK1 to SK6).

N.B. : When starting from cold, the ECU uses the SK2 law.

N.B. : When starting from hot, the ECU uses the law which was active before the ignition was switched off.

2.1.2 "sport" program

Program suited to a sporty driving style (to the detriment of the fuel consumption).

Gear changes take place at high engine speeds (favouring vehicle performance).

The ECU uses 2 selection laws : SK5 and SK6 (sporty laws).

2.2 "snow" program

Program suited to driving on surfaces with poor grip.

Special features :

- selection of the 1st gear is prevented . Lever in position D
- gear changes occur less frequently than in the other programs
- allows a smooth performance (no sudden variation in torque to the wheels)
- forced downshifting when braking
- the gear engaged corresponds to the position of the gear lever (if the vehicle speed so allows)

In position " D ", starting will take place in 2nd gear.

3 Specific laws

3.1 Reheating law

This operating law is activated in the following conditions : if the gearbox oil temperature is between 15 °C and 30 °C inclusive on starting the engine.

This law :

- is activated for 130 seconds
- is deactivated at the end of the timed period

3.2 Thermal protection laws

The thermal protection laws are used :

- improved cooling of the gearbox oil
- to protect the gearbox

N.B. : The SK9 law is activated when the gearbox oil temperature limit is exceeded.

The SK10 law is activated under the following conditions :

- high gearbox oil temperature
- urban type driving

Characteristics.	Oil temperature.	
	Law activated.	Law deactivated.
SK9.	120 °C.	117 °C.
SK10.	118 °C.	115 °C.

N.B. : In the snow program, the snow law is prioritised over the thermal protection law.

4 Other auto-adaptive functions

4.1 Prevention of gear change-up (sudden removal of foot from pedal)

This function prevents gear upshifting when the foot is suddenly removed from the accelerator pedal (engine braking on deceleration).

N.B. : This function is also activated when the vehicle is travelling downhill , accelerator pedal released.

4.2 Temporary increase in sporty driving performance

This function is activated if the accelerator pedal is suddenly pressed down while in the "normal" program.

The ECU temporarily switches to a more sporty law which allows better acceleration.

4.3 Gear locking following a change of law

Under certain conditions the gear engaged is locked after the ECU has changed laws.

The gear is unlocked under the following conditions :

- foot released from the accelerator pedal
- acceleration of the vehicle after a programmed timed period

4.4 Auto-adaptivity when changing gears

The ECU takes account of the ageing of the gearbox using auto-adaptive parameters.

The auto-adaptive parameters are used to modulate pressure rises in the clutches and the brakes.

5 Changing down on braking

Changing down when braking is auto-adaptive.

The ECU fully controls downshifting as a function of the following parameters :

- engine load
- vehicle speed
- depending on the driving conditions

In some cases, the ECU can impose a double downshift (from 4 to 2 or from 3 to 1) or a single downshift to increase engine braking.

In some cases, downshifting may be forbidden in order to maintain engine braking.

6 Hydraulic functions

6.1 Regulating the main hydraulic pressure

The value of the main hydraulic pressure is determined by the gearbox ECU according to the engine torque.

This hydraulic pressure allows the clutches and brakes to be activated.

The hydraulic pressure may be continuously regulated :

- between 15,5 and 18 bars : when changing gear and in gear 1 and reverse gear
- between 5,5 and 8,8 bars : in gears 2, 3, 4 and N

N.B. : Back-up mode : the main hydraulic pressure can vary between 15,5 and 18 bars.

6.2 Controlling the lock-up clutch

The lock-up clutch may be in one of the following states :

- declutched state
- clutched state
- controlled state

The declutched state allows :

- multiplication of the engine torque on starting
- the engine anti-stall function
- filtering of engine acyclisms
- improved cooling of the clutch lining
- improved oil viscosity (when cold) and improved reheating of the engine

The clutched state allows :

- decreased fuel consumption
- improved cooling of the gearbox oil excessively high oil temperature
- engine braking to be obtained during certain operating phases
- prevention of slipping

The torque converter can be locked-up (shunted) in gears 1, 2, 3 and 4.

The controlled state is used to :

- filtering of engine acyclisms
- to optimise the driving agreement

The torque converter lock-up thresholds form an integral part of the selection laws.

7 Displaying faults - operation in degraded modes

7.1 Displaying faults

The "sport" and "snow" warning lamps flash simultaneously to indicate a fault.

Possible fault causes :

- break in the connection between the gearbox ECU and the instrument panel
- operating fault in the gearbox management system

Certain system faults are indicated by the "sport" and "snow" warning lamps flashing :

- engine speed signal
- gearbox input speed
- gearbox output speed
- multifunction switch connections
- throttle position signal (throttle potentiometer via the injection ECU)
- gearbox oil temperature sensor
- ignition controlled + supply
- battery voltage
- engine torque signal
- solenoid valve
- solenoid valve
- pressure regulator 3
- pressure regulator 4
- pressure regulator 5
- pressure regulator 6
- engine torque reduction signal
- ECU
- actuators supply output
- engaged gear coherence
- overspeed protection
- gear selection check
- "shift lock" gear lever locking (XANTIA)

7.2 Operation in degraded modes

In the event of a gearbox malfunction, there exist 2 possible configurations depending on the severity of the fault :

- gearbox in back-up mode with a substitute programme (the default values are used)
- gearbox in back-up mode with an emergency programme

N.B. : The transmission therefore remains in 3rd or 4th hydraulic.

CAUTION : Selection of back-up mode : if there is a fault, a snatching may be experienced when engaging the lever in positions " P " or " R ".

CAUTION : In the hydraulic back-up mode, gear engagement protection can not be assured.
