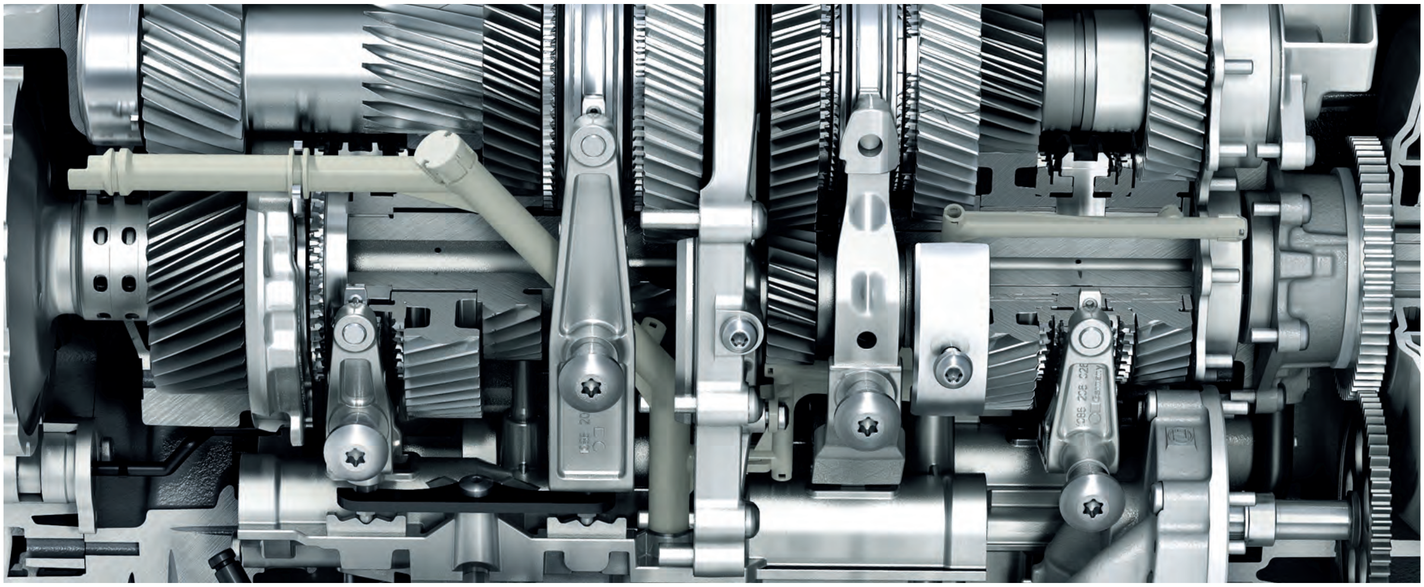


Transmission

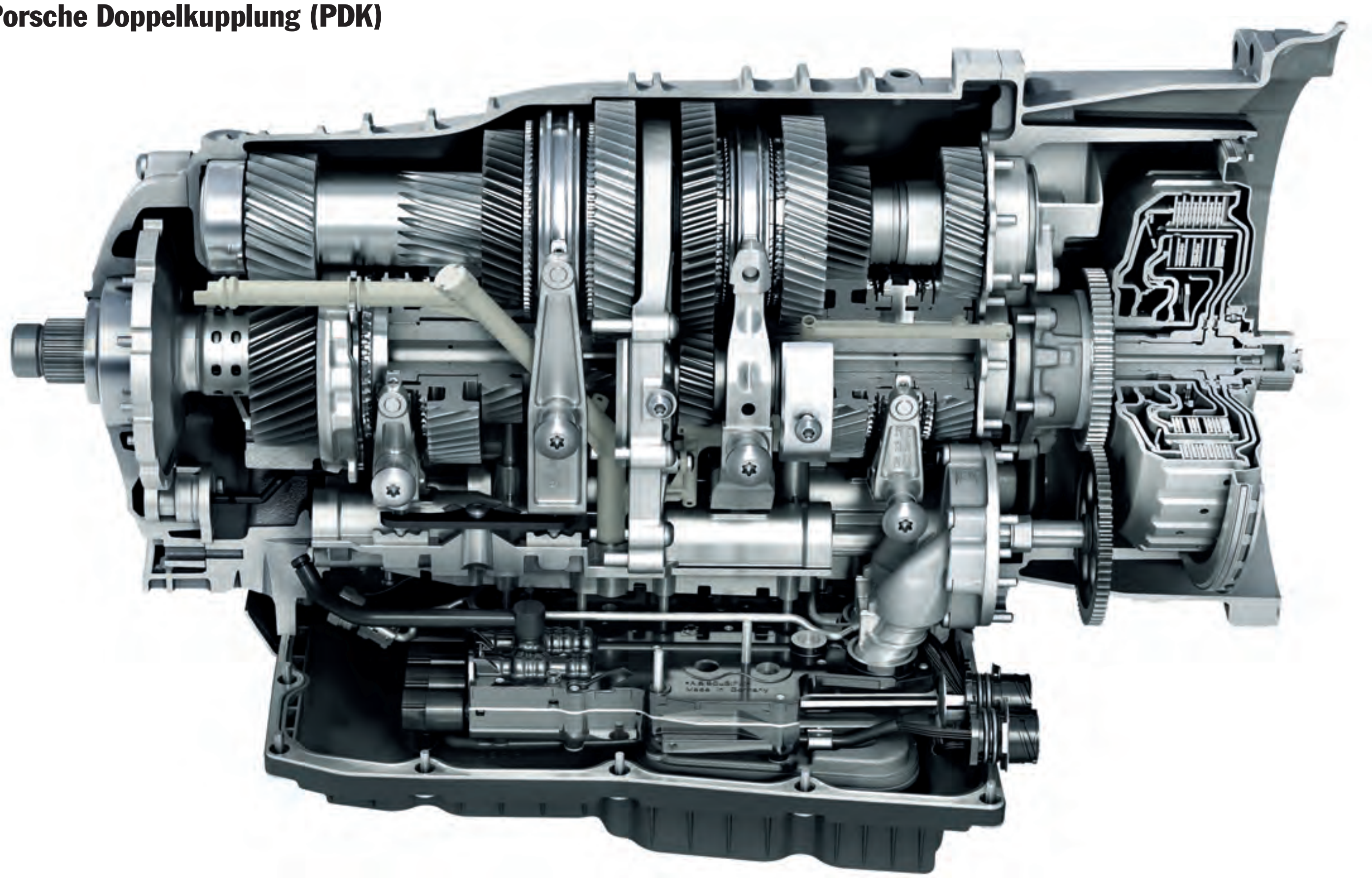
General Information

The Panamera S model will be available with a 6-speed manual transmission in Rest of World (RoW) markets. For the North American market, all three Panamera models will get the Porsche Doppelkupplung (PDK) transmission and an active all-wheel-drive Porsche Traction Management system (PTM), consisting of an electronically controlled, map-controlled multiple-disc clutch as standard equipment.

The Porsche Doppelkupplung (PDK) combines the driving dynamics and the superb mechanical efficiency of a manual transmission with the excellent shifting and driving comfort of a conventional automatic transmission without any noticeable interruption in traction. Both a manual mode, which indicates the recommended gear, and an automatic mode are available. As a result, the Porsche Doppelkupplung (PDK) meets the requirements of Panamera customers in terms of both sportiness and comfort.

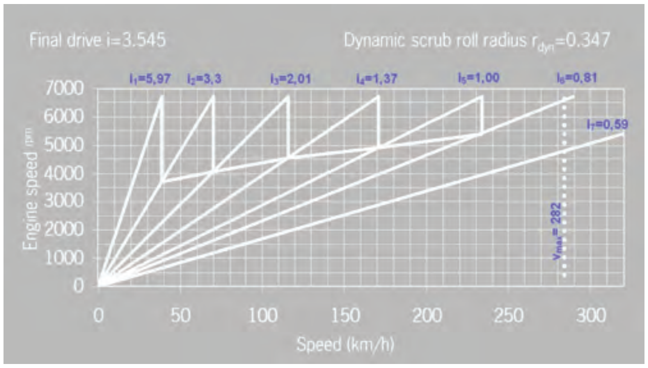
The principle familiar from the Porsche 911 was completely revised for this purpose and further optimized with regard to driving comfort. Among the numerous transmission concepts available, the Porsche Doppelkupplung (PDK) represents an innovative development in the top-end segment. It is standard equipment in the Panamera 4S and Panamera Turbo and available as an option in the Panamera S.

Porsche Doppelkupplung (PDK)

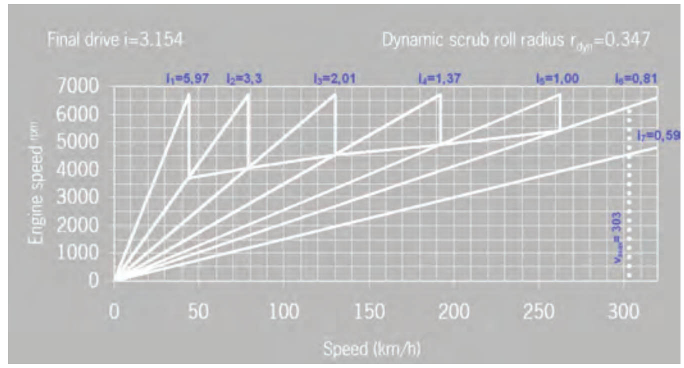


PDK Gear Ratios

The transmission (gear) ratios are identical in the naturally aspirated engine and the turbo engine; differences in gear ratios are caused by final-drive ratios.



Panamera S/4S

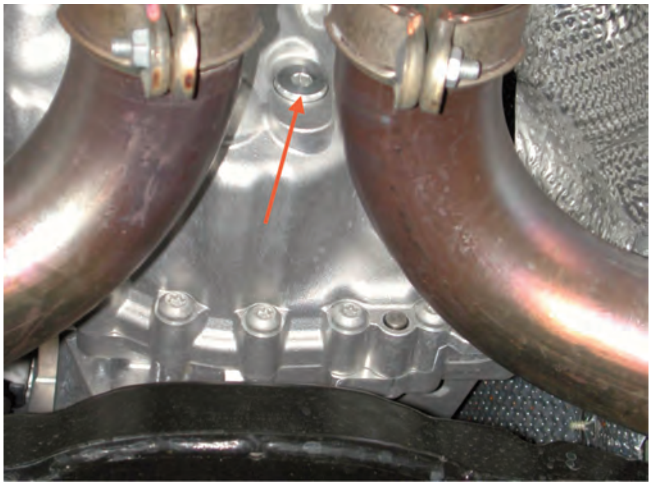


Panamera Turbo

	Panamera S	Panamera 4S	Panamera Turbo
Transmission type	C70.05	C70.35	C70.50
1st gear	12/47	12/47	12/47
i_{gear}	3.917	3.917	3.917
$i_{transmission}$	5.970	5.970	5.970
i_{total}	21.164	21.164	18.829
2nd gear	23/50	23/50	23/50
i_{gear}	2.174	2.174	2.174
$i_{transmission}$	3.308	3.308	3.308
i_{total}	11.727	11.727	10.433
3rd gear	31/41	31/41	31/41
i_{gear}	1.323	1.323	1.323
$i_{transmission}$	2.013	2.013	2.013
i_{total}	7.136	7.136	6.345
4th gear	39/35	39/35	39/35
i_{gear}	0.897	0.897	0.897
$i_{transmission}$	1.366	1.366	1.366
i_{total}	4.842	4.842	4.308
5th gear	35/23	35/23	35/23
i_{gear}	0.657	0.657	0.657
$i_{transmission}$	1.000	1.000	1.000
i_{total}	3.545	3.545	3.154
6th gear	49/26	49/26	49/26
i_{gear}	0.531	0.531	0.531
$i_{transmission}$	0.807	0.807	0.807
i_{total}	2.861	2.861	2.545
7th gear	57/22	57/22	57/22
i_{gear}	0.386	0.386	0.386
$i_{transmission}$	0.587	0.587	0.587
i_{total}	2.081	2.081	1.851
Reverse gear			
i_{gear}	4.570	4.570	4.570
Final-drive ratio	3.545	3.545	3.154

Transmission

Oil Type/Oil Quantity/Change Intervals



Since the final drive is located in a separate housing, the Porsche Doppelkupplung (PDK) transmission in the Panamera models manages with one oil chamber.

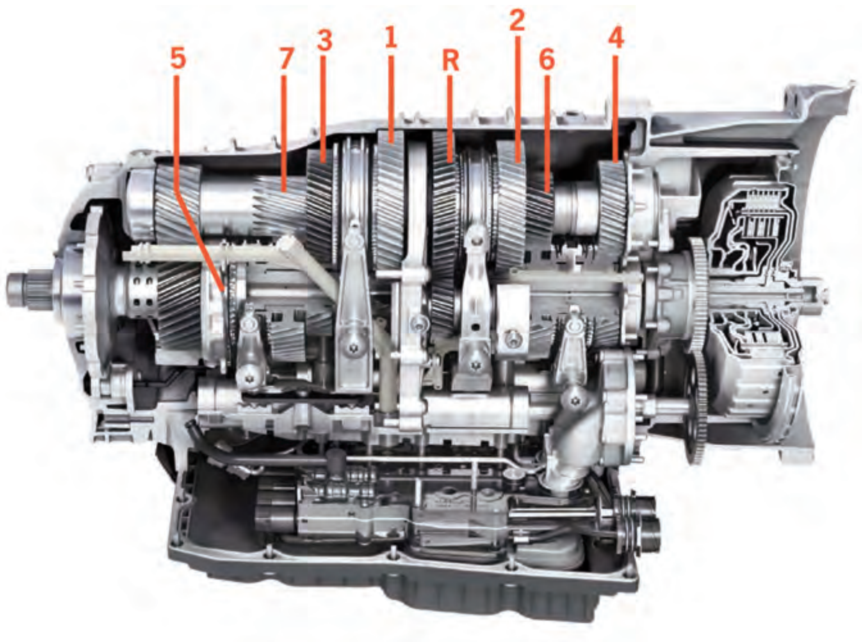
Pentosin Gear Oil FFL3 is used in this chamber. The oil chamber has a filling capacity of 8.5 liters, the oil must be changed every 60,000 miles (90,000 km) or every 6 years.

Viewed in the direction of travel, the oil inspection plug is located at the rear, in the middle, at the end of the transmission between the exhaust pipes (arrow). You can add oil/check the oil level in the same way that you do for the PDK in sports cars. The correct oil level is important for proper operation and long life of the transmission.

The following prerequisites must be met in order to check or correct the oil level:

- Engine must be idling
- Vehicle must be horizontal in both longitudinal and transverse axis
- Oil temperature between 86° F. and 104° F. (30° C. and 40° C.)
- Selector-lever position “P”
- Clutch cooling volume flow must be switched off (using PIWIS Tester in Oil fill mode)
- Retain the described states for approx. 1 minute to allow the oil to settle
- Open the screw plug on the oil overflow bore (see arrow) and collect the emerging oil until only drops of oil are emerging
- Once there is no more oil emerging, top up the clutch fluid until oil escapes from the oil overflow bore
- To avoid damaging the clutches, the procedure must be completed within 5 minutes (PIWIS Tester exits Oil fill mode automatically after 5 minutes)

Notes:



Porsche Doppelkupplung (PDK) **Layout**

The new Porsche Doppelkupplung (PDK) basically comprises a conventional manual transmission that has been split into two partial transmissions and a hydraulic control unit. At its core, the transmission has two multiple-disc clutches. One clutch is for the first transmission with the odd gear stages (1, 3, 5, 7) and the other clutch is responsible for the second transmission with the even gear stages and reverse gear (2, R, 4, 6). The hydraulic control unit uses a number of pressure valves to control both the multiple-disc clutches and the shift cylinders for engaging the desired gear ratio.

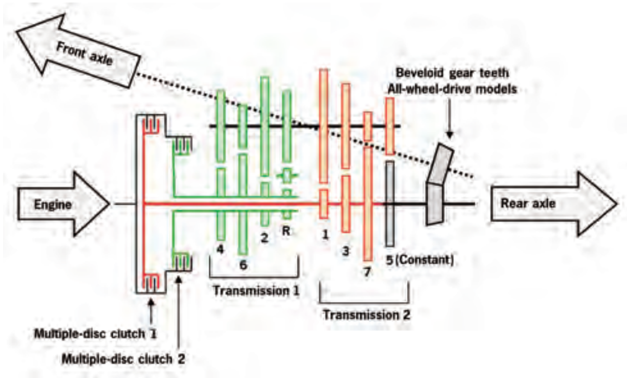
The particular feature of this transmission concept is that it provides a continuous flow of power between the engine and the final drive, even during a gear change. One of the two clutches is always closed in normal driving mode. The second clutch is open while the power is being relayed from the engine to the wheels via the first clutch and the first transmission; the next gear up or down will already be engaged in the second transmission depending on the driving situation and the shift strategy.

When changing gear, the first clutch opens as the second clutch simultaneously closes. Through this continuous and alternating gear change operation, the propulsion force, monitored by the engine, is changed over from one transmission to the other without any interruption in traction. In the PDK, the entire gear change itself involves complex fine tuning of the function processes between the two clutches and the gear stages of the individual transmissions.

The use of two clutches or transmissions makes it possible to execute gear changes smoothly without interrupting the traction. Rapid gear changes and short response times within just a few milliseconds are a further characterising feature of the Porsche Doppelkupplung (PDK). This is possible thanks to the principle of parallel gear preselection. The transmission control system assists here in preselecting and keeping ready the appropriate gear ratio for the particular driving state and driving situation in the inactive transmission.

Transmission

Transmission Concept



The new Porsche Doppelkupplung (PDK) is noted for the following customer benefits:

- Much faster gear shifts with no noticeable interruption in traction due to rapid change-over of disengagement and engagement operations, rapid gear changes and short response times; this ensures greater agility and more driving pleasure
- Outstanding driving comfort because of gentle, automated clutch and shift operations
- Direct connection to the engine (without rubber-band effect of a torque converter)
- Outstanding drive dynamics due to a short 1st gear that changes rapidly to the preselected 2nd gear
- Direct and fast multiple downshifts with spontaneous power requirements
- Much greater range of functions such as the Launch Control function (with optional Sport Chrono Package Plus) and performance oriented shift operations with increased torque
- Lower fuel consumption and emissions thanks to the additional 7th gear and a total ratio spread of 10.1 with a significantly reduced rev range
- Reduction in fuel consumption and CO2 emissions through high overall efficiency and a simplified Start Stop function
- Reduction in system weight of approx. 33 lbs. (15 kg) compared to a conventional all-wheel automatic system
- Dual-mass flywheel for reducing vibration and noise

The Porsche Doppelkupplung (PDK) comprises 7 gears and 1 reverse gear. Gears 1 to 6 have a sporty tuning and top speed is reached in 6th gear. The total ratio spread between the 1st and 7th gear of the transmission is 10.1.

This efficient arrangement of gear increments is unique in the passenger car segment. Together with short 1st gear, it ensures outstanding drive-off dynamics. In contrast, the 7th gear has a very high ratio and this makes it possible to increase comfort when driving long distances and also to improve fuel economy through reduced engine speeds.

Porsche developed the Porsche Doppelkupplung (PDK) in the 1980s for motor sports. The fact that there was no interruption in traction when changing gears gave it the edge over competitor vehicles. Shorter shifting times were possible and this considerably increased the race car's acceleration. In addition to these benefits, the PDK in the Panamera also helps to improve driving comfort, efficiency and fuel consumption.

Note!

Ratio spread is the gear ratio range of the transmission, i.e. the relationship between the largest gear ratio value and the smallest gear ratio value. This means that the transmission should use a crawling gear with a high gear ratio for very low speeds and a gear with a low gear ratio for overdrive mode.

Operation – Description

The Porsche Doppelkupplung (PDK) is operated primarily by the selector lever in the center console and the two ergonomic sliding switches on the steering wheel. In manual shift mode, the gear recommendation function in the instrument cluster helps to ensure optimized fuel consumption when driving. The Porsche Doppelkupplung (PDK) shift strategy is operated and thus influenced on a secondary level via the driving characteristics selected by the driver, in particular via the accelerator and brake pedals as well as steering wheel movements. In addition, the shift strategy of the Porsche Doppelkupplung (PDK) can be actively influenced by means of the SPORT and SPORT PLUS control buttons of the Sport Chrono Package Plus in the centre console, available as an optional extra. The selected driving mode and the gear indicator (1 to 7) are displayed in the digital display of the tachometer.

The ergonomic selector lever, familiar from Porsche sports cars, is used in the PDK. It is used to activate the basic functions: P (parking), R (reverse gear), N (neutral), D (drive) and M (manual). Manual mode is activated by tilting the selector lever to the left. The manual gate can be found here. The driver can shift up or down by tilting the selector lever forward (+) or back (-). This additional shift function provides the driver with the option, depending on the preferred way of operating, of performing a manual shift intervention on the selector lever or using the sliding switches on the steering wheel.

With the Porsche Doppelkupplung (PDK) in the Panamera, the selector lever positions at the support are relayed to the transmission control unit using electrical signals, except for the parking lock position (P). By separating the mechanical actuation from the electrical information processing in this way, it was possible to adapt the selector lever's mechanical system directly with extreme precision.

The PDK logo is displayed on the selector lever to enhance it visually and to indicate the new Porsche Doppelkupplung (PDK) technology. Both the selector lever panel and the cover of the selector and shift gate, designed as a spherical cap that also moves, feature a galvanised surface and have been matched to the interior design.

Notes:

3-Spoke Sports Steering Wheel

In combination with the Porsche Doppelkupplung (PDK), the new Panamera models with PDK feature two handy sliding switches integrated into the steering wheel spokes, which facilitate precise and straightforward shifting. Pressing the sliding switches forward shifts the PDK up, pressing them towards the driver from the back of the steering wheel shifts the PDK down. It makes no difference whether the right or the left sliding switch is used for changing gears. Holding the sliding switches allows the driver to shift up or down sequentially to the maximum or minimum permitted gear.

Display in Instrument Cluster

Gearshifts for the Porsche Doppelkupplung (PDK) are displayed in the instrument cluster. The display is based on the PDK concept that has been used in sports cars. The familiar displays of the selector lever position (drive mode) and the numerical gear indicator are located in the tachometer.

Other displays in the instrument cluster:

- A flashing selector lever position in the instrument cluster means that the selector lever is between two positions.
- “Transmission temperature too high” prompts the driver to change his driving style. “Warning jerks” can be felt when driving off and the engine power may be restricted. Do not hold the vehicle on a hill, for example, using the accelerator pedal - use the brake pedal instead. Reduce engine load. Stop the vehicle in a suitable place if possible, and allow the engine to run in selector lever position “N” or “P” until the warning disappears.
- “Transmission emergency run” in white letters means that the vehicle can still be driven, but you should call in at a workshop.
- “Transmission emergency run” in red letters means that the vehicle can only be brought to a stop, after which it can no longer be driven.
- If the selector lever is accidentally changed from P or N into a gear (due to a fault or improper use) without pressing the brake, this gear will also “flash” on the display and no power transmission will occur. To drive off, the brake must be pressed and the selector lever shifted from “P” or “N” into the required gear again.
- A flashing selector lever position “R” or “D” means that the selector lever was engaged without pressing the footbrake or only the reduced driving program is available when the message “Transmission emergency run” appears.

Shift Indicator

The consumption-oriented shift indicator (A) to the right of the digital speed display on the tachometer helps the driver to develop a more fuel-efficient driving style. The shift indicator lights up as a recommendation to shift up to the next gear, depending on the selected gear, engine speed and accelerator pedal position. The shift indicator is only active when “SPORT PLUS” is deactivated. When the shift indicator lights up, you should shift up into the next highest gear.

Gearshift Strategy

The center console includes a SPORT (1) and a SPORT PLUS (2) button. The basic shifting characteristic curves change, depending on which button is pressed.

Driving in selector lever position "M", Sport and Sport Plus button not active
Upshifts and downshifts can be performed both on the steering wheel and using the selector lever. Shifting comfort is adaptive over the entire operating range and adapts to suit the driver's individual driving style.
For improved shifting comfort, the engine torque is reduced during gear changes. Downshifts in deceleration state are accomplished with very little intermediate throttle application and are therefore hardly perceptible. To avoid under-revving and the associated loss of driving comfort, the current gear is switched down to the next-lowest gear at engine speeds of less than approx. 1100 rpm. An upshift at the engine speed limit is only accomplished if there is a kickdown in the speed limiting range (panic shifting). The vehicle always moves off in 2nd gear. The Launch Control function (racing start) is not available.

Driving in selector lever position "M", Sport button active
Upshifts and downshifts can be performed both on the steering wheel and using the selector lever. Gearshift comfort is therefore adaptive over the entire operating range and adapts to suit the driver's individual driving style, but basic sportiness is increased. The engine torque is reduced only slightly while changing gears. Downshifts in deceleration state are accomplished with intermediate throttle application. To avoid under-revving and the associated loss of driving comfort, the current gear is switched down to the next-lowest gear at engine speeds of less than approx. 1100 rpm. An upshift at the engine speed limit takes place if there is a kickdown in the engine speed limit range (panic shifting). The vehicle always moves off in 2nd gear. The Launch Control function (racing start) is not available.

Driving in selector lever position "M", Sport Plus button active
Upshifts and downshifts can be performed both on the steering wheel and using the selector lever. Gearshifts are not adaptive and are purely power-oriented, with a corresponding loss of comfort. In addition, the engine torque is not reduced while changing gears. Downshifts in deceleration state involve quick and audible intermediate throttle application with a sporty sound. To avoid under-revving and the associated loss of driving comfort, the current gear is switched down to the next-lowest gear at engine speeds of less than approx. 1100 rpm. An upshift at the engine speed limit takes place if there is a kickdown in the engine speed limit range (panic shifting). The vehicle always moves off in 1st gear. 7th gear is not used in this program. The Launch Control function (racing start) is also available.

Driving in selector lever position "D", Sport and Sport Plus button not active
When the selector lever is moved to position "D", an extremely intelligent driving program is activated. Shifting adapts continuously and almost seamlessly to the driving style and route profile over the entire operating range. Gearshifts and gear-changing speeds here are changed from economic/comfortable to sporty. Gearshifts are basically performed with more emphasis on comfort. Also for improved comfort, the engine torque is reduced during upshifts and downshifts. Downshifts in deceleration state and deceleration downshifts are accomplished with very little intermediate throttle application and are thus hardly perceptible. The vehicle moves off in 2nd gear.

Driving in selector lever position "D", Sport active
An extremely intelligent driving program is also activated in this position and shifting adapts continuously and almost seamlessly to the driving style and route profile over the entire operating range. Basic sportiness is increased with faster pick-up and slower deceleration. Gearshifts are more power-oriented and the engine torque is only reduced slightly during upshifts and downshifts.

Downshifts in deceleration state and deceleration downshifts are accomplished with intermediate throttle application and are therefore audible. The vehicle moves off in 2nd gear. 7th gear is avoided for the most part and is engaged only at higher speeds.

Driving in selector lever position "D", Sport Plus active
Shift map adaptations are not active in this program. The most sporty map is activated permanently. Gearshifts are performance-oriented with reduced shifting comfort. Downshifts in deceleration state and deceleration downshifts are accomplished with intermediate throttle application and are therefore very audible. Gear changes are performance-oriented and the engine torque is not reduced during upshifts and downshifts. The vehicle moves off in 1st gear. 7th gear is not available. The racing start function is also available.

Adaptation of shifting characteristic curves to driving style and route profile
Various measured values such as accelerator pedal position, change in speed of accelerator pedal depression, longitudinal and lateral acceleration, vehicle speed and engine speed and the steering angle are used to adapt the shifting characteristic curves almost continuously to the driving style and route profile. This adaptation is performed in "Normal" mode (no sport buttons pressed) and sometimes in "Sport" mode. No adaptation is performed in "Sport Plus" mode. When this adaptation is selected, the shift program not only takes the driving style into consideration, but also road resistance. Changes in road resistance are particularly noticeable when driving uphill and downhill. In addition, the PDK control unit calculates an altitude correction factor, i.e. since the volumetric efficiency of the engine decreases as the altitude increases, the driver automatically accelerates more and the transmission would switch to a more shift-conducive map. This is detected by the altitude sensor and the optimal map is made available to the driver.

Special Functions

Launch Control (racing start function)
This function is available both in selector lever positions "D" and "M" in Sport Plus mode. Preconditions are as follows: Vehicle stationary, brake applied, kickdown active. The function is triggered by releasing the brake. The double clutch in the transmission now allows optimum wheel slip for maximum acceleration. Stress on components increases significantly when driving off at maximum acceleration compared with driving off "normally". In addition, the components in the clutches are exposed to high levels of thermal stress. Therefore, the clutches are cooled with the maximum cooling volume flow to protect the components.

Prevention of downshifts in deceleration state, e.g. when approaching a corner (Fast Off)
If the driver decelerates, i.e. releases the accelerator pedal quickly, when approaching a corner, the currently engaged gear is retained. If the driver also applies the brakes now, downshifts adapted to the vehicle speed are performed so that engine braking torque is available when approaching a bend and the vehicle can be accelerated out of the bend in the optimum gear. If the accelerator pedal is now moved towards throttle valve "open" again, gear changes are performed once again according to the driver's requests. This function responds differently, depending on which mode was selected. If "Normal" mode is selected, the function is only activated for a high negative accelerator pedal gradient. In "Sport" mode, the function is activated for a medium negative accelerator pedal gradient, while it is activated for a low negative accelerator pedal gradient in "Sport Plus" mode.

Downshifts while braking (Fast Back)
A downshift is initiated immediately if the driver switches quickly (within approx. 1 second) from accelerating to braking. However, the sportiness characteristic and the selected mode dictate how early a downshift is initiated.

Gear retention while cornering
Lateral acceleration is detected via the lateral-acceleration sensor (single component with yaw rate sensor), which is located under the center console and works for the PSM system, and the engaged gear is retained, depending on the shift map, engaged gear and lateral acceleration.

Special Functions (cont'd)

Active switching to a sporty map
For increased spontaneity, the system switches to a sporty and dynamic map when the driver uses fast, positive accelerator pedal movements. The previous map is then activated again afterwards. This function is intended, for example, for situations in which a driver is driving at an extremely comfortable speed on a country road, but now decides to overtake and wants the vehicle to drive dynamically for a short time.

Manual momentary intervention in selector lever position "D"
To enable manual downshifts even in the automatic gear-selection gate, for example:

- when approaching a corner
- when entering speed zones/small towns
- when driving downhill

the upshift and downshift buttons (both on the steering wheel and on the selector lever) are active in the automatic gear-selection gate. In other words: PDK transmission switches to the manual program when the corresponding button is pressed. "M" appears in the instrument cluster and the requested gearshift is performed. At the same time, an 8-second timer is started in the control unit. If the upshift or downshift button is pressed again within this 8 seconds, the timer is restarted.

The PDK transmission automatically switches back to Automatic mode ("D" appears in the instrument cluster) if:

- the timer runs out, no cornering is performed and the vehicle is not in deceleration state
- the selector lever is moved from "D" to "M" and back to "D"

Automatic upshifts and downshifts at the engine speed limits remain active. The deceleration downshift function is also active.

Warm-up Program

The warm-up map is a shift program with raised gear-changing points, which has the effect of heating the catalytic converters to their operating temperature as quickly as possible. The engine and transmission also reach their operating temperature more quickly with this map. The coolant temperature of the engine is checked when the engine is started. If the temperature is less than approx. 68° F. (20° C.), the warm-up programme is activated and is deactivated again when the coolant temperature reaches 86° F. (30° C.).

Overheating Protection

Various measures are implemented on the transmission in order to protect the transmission and double clutch from overheating. The temperature sensor, which is installed above the hydraulic control unit and measures the oil sump temperature, is used for this purpose. A calculation model which calculates the clutch temperature from the engine torque and the slip at the clutch, is also used. Overheating protection is activated in several stages and actively prompts the driver to adapt his driving style in advance.

If the temperature continues to rise (oil sump temperature > 293° F./145° C.), stage two is activated. This means that jerking continues. The engine torque and kickdown revs are reduced more drastically in this case. The white warning "Transmission temperature too high" appears in the instrument cluster. Another fault is stored in the fault memory.

If the temperature rises even further (oil sump temperature > 302° F./150° C.), the red warning "Transmission emergency run" appears in the instrument cluster. Shortly afterwards, the double clutch is opened completely and power transmission is no longer available. Another fault is stored in the fault memory. If the driver now presses the accelerator, the vehicle will drive off, but not with the usual level of comfort. After implementing these measures, the transmission activates a special shift program in which gear changes are performed very slowly and uncomfortably. Once the temperature falls below a certain temperature threshold, the transmission reverts to its normal program.

Transmission

Clearly perceptible jerking occurs in the first stage (at an oil sump temperature > 275° F./135° C.) due to continuous opening and closing at drive-off or crawling speed, thereby prompting the driver to change the driving situation. Engine torque and kickdown revs are also reduced and a fault is stored in the control unit.

Upshift suppression for 7th gear
7th gear is designed as an overdrive on the Porsche Doppelkupplung (PDK). This means that in various driving situations (high road resistance, for example), the vehicle would decelerate when 7th gear was engaged. As a result, 7th gear is not engaged in such situations.

Upshift interruption
In automatic transmissions, the time that elapses between triggering a change in speed and starting to change speed is called the response time. Naturally, this response time depends on the shift program and the shifting characteristic curve.During this time, the driver does not yet notice that the gear change has already started. If the driver's intention changes (the driver quickly removes his foot from the accelerator, for example), the upshift that has started is interrupted provided the engine speed remains unchanged.

One-touch hold function
The one-touch button on the steering wheel or the selector lever must be held in a downshift ("-") or upshift ("+") direction in order to engage the lowest or highest possible gear in the manual gate. Tipping the button back initially triggers the first gear change in accordance with the touch command. The next-lowest or next-highest gear is then always engaged by holding the button. This saves the driver from having to touch the button repeatedly. This function is switched off after 25 seconds to prevent malfunctions.

Stationary decoupling
When the vehicle comes to a stop, the clutch is generally opened as long as the brakes are applied. However, the clutch remains slightly engaged in order to take full advantage of crawling. The reason for this measure is reduced fuel consumption.

Drive-Off Assistant
If the vehicle is stopped on an incline, the driver will apply the brake and set a certain brake pressure. When the driver now switches from the brake pedal to the accelerator pedal in order to drive off, the set brake pressure is maintained for as long as it takes for the vehicle to drive off. This prevents the vehicle from rolling back while the driver is switching pedals.

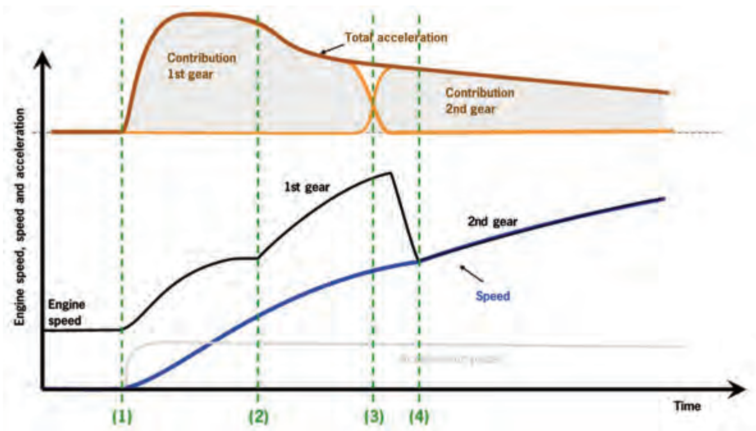
Tow-starting/towing
Never lift the vehicle at just one axle when towing all-wheel-drive vehicles. The vehicle cannot be tow-started, nor should this be attempted due to the risk of serious damage to the transmission.

When the engine is not running, adequate lubrication of the transmission is not guaranteed. Therefore the following points must be observed:

1. Engage selector-lever position "N"
2. Top speed = 30 mph (50 km/h)
3. Maximum towing distance = 30 miles (50 km)
4. In the case of long towing distances, the all-wheel-drive vehicle must be transported on a trailer.

Notes:

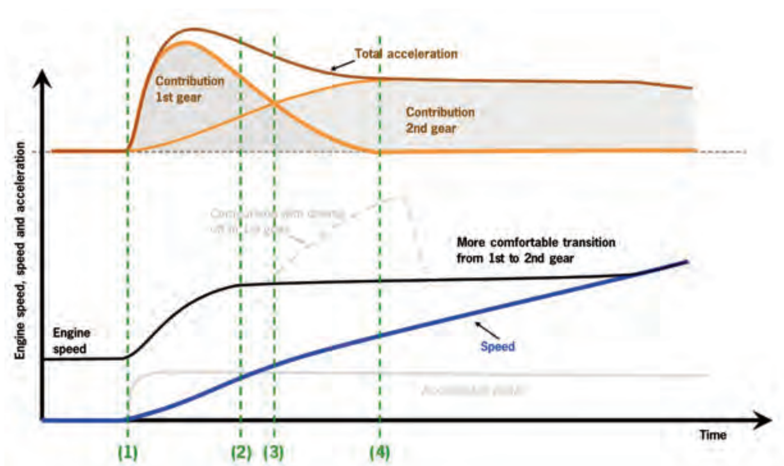
Driving off in manual or with accelerator pedal position > 60%



Procedure when driving off:

(1) Driver presses the accelerator pedal, acceleration begins, clutch 1 enters the slip phase, vehicle moves off
(2) Slip phase ends for clutch 1, further acceleration is accomplished with closed clutch
(3) Clutch 1 opens while clutch 2 closes, short transition phase
(4) Gear change has been completed, further acceleration is accomplished in 2nd gear

Driving off with accelerator pedal position approx. 10% to 60%



The implementation of comfort mode when driving off represents an innovative development. With this feature, the large drive-off torque of 1st gear is used to build up acceleration at low to average partial loads, depending on the driver request and driving program. The subsequent upshift into 2nd gear is performed seamlessly by means of an intelligent clutch slip management system in the two clutches. The result is an impressive drive-off performance that is both extremely comfortable and smooth.

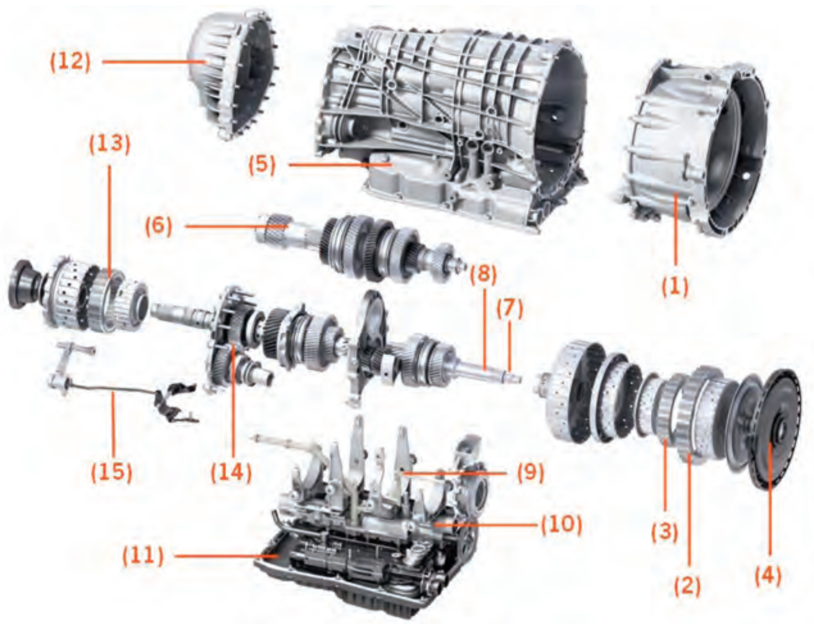
Procedure when driving off:

(1) Driver presses the accelerator pedal, both 1st and 2nd gear are engaged, both clutches enter the slip phase
(2) Engine speed is constant, clutch 2 begins to close
(3) Clutch 2 closes, engine speed remains constant
(4) Clutch 2 is closed, further acceleration in 2nd gear without any increase in engine speed

Transmission

Porsche Doppelkupplung (PDK) **Design**

1 - Clutch housing
2 - Disc pack, first clutch
3 - Disc pack, second clutch
4 - Dual-mass flywheel
5 - Transmission housing
6 - Output shaft
7 - Drive shaft 1
8 - Drive shaft 2
9 - Gearshift swinging fork
10 - Cylinder assembly (gearshift swinging forks)
11 - Oil pan with oil filter
12 - All-wheel Housing (4WD)
13 - Electronically controlled multiple-disc clutch
14 - Beveloid gear teeth (4WD)
15 - Parking lock actuator



The Porsche Doppelkupplung (PDK) features two multiple-disc clutches operating in oil. Compared to a system with dry clutches, the design of the wet-running multiple-disc clutches increases thermal stability.

Advantages of wet-running multiple-disc clutches compared to dry clutches:

- Good mechanical load capacity for high torques in a compact design
- Good thermal load capacity even under extreme loads
- Better clutch engagement response
- Long service life due to less friction plate wear
- Greater comfort and driving dynamics

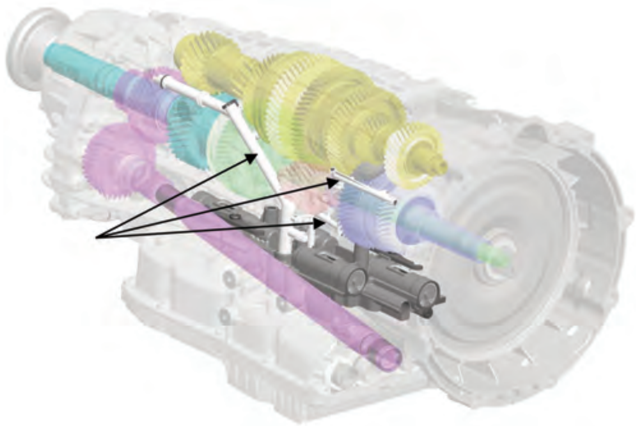
The two transmissions in the Porsche Doppelkupplung (PDK) each comprise a multiple-disc clutch and a drive shaft. Each transmission thus has the functional design of a manual transmission and an extremely compact construction. The drive shafts of the transmission act on a common countershaft and from there on the output shaft via a constant. The output shaft is connected via the drive flange to the cardan shaft, which drives the wheels via the rear axle differential. In the all-wheel version, the downforce is provided by the hang-on all-wheel clutch, the beveloid gear wheel set and the connecting shaft directly onto the front-axle final drive and therefore onto the drive shafts of the wheels. The clutches and the shift functions of the individual transmissions are controlled by way of a hydraulic control unit in the bottom part of the transmission.

The oil injection lubrication feature in the Porsche Doppelkupplung (PDK) is another factor in the increased efficiency. This is a type of circulation lubrication in which the oil is injected into the friction point. The gear wheels therefore no longer have to turn in the oil bath, as they do with splash lubrication. Churning losses can therefore be avoided.

The Porsche Doppelkupplung (PDK) has one oil chamber that serves the gear wheels and clutch via a shared oil circuit. Compared to a solution that has two separate oil chambers between the clutch and the gear housing, the advantage of this design is that an extra oil chamber division is not required. This not only reduces the weight of the transmission but also ensures a more compact construction. The weight aspect is also a consideration in the plastic design of the oil pan with integrated oil filter.

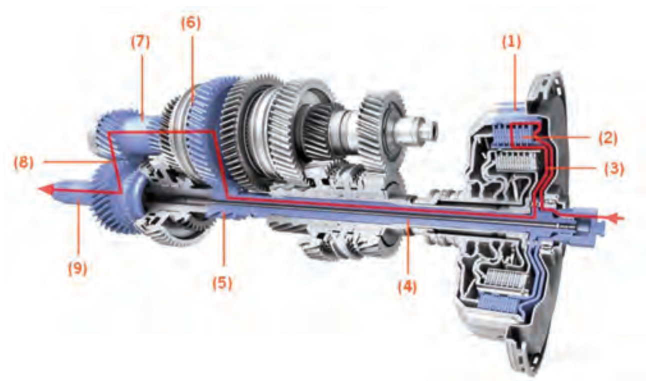
The function of the vibration-balancing damping mass is performed by a new dual-mass flywheel in the Porsche Doppelkupplung (PDK). This new dual-mass flywheel is integrated between the engine and the transmission and absorbs engine vibrations. By filtering noise and vibrations, the dual-mass flywheel also ensures comfortable driving in the lower rpm range. This helps to further reduce fuel consumption.

Gear Wheel Lubrication



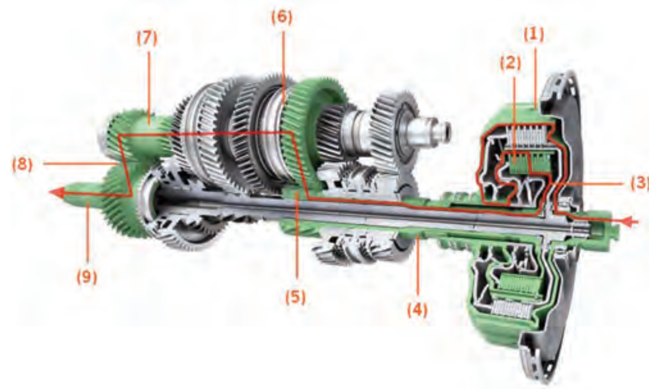
Since the countershaft (yellow) is positioned on the top of the transmission due to its design, it does not churn the oil. While churning losses are reduced, adequate lubrication of the transmission is still not guaranteed. To ensure that optimum lubrication of the gear wheels is achieved, additional oil splash tubes (arrow) are installed in the transmission.

Power Flow on Transmission 1, 1st Gear



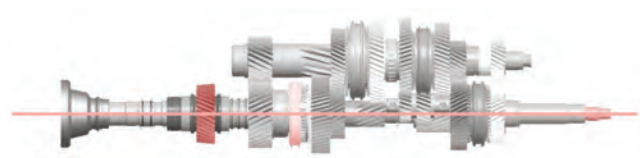
By tracing the flow of power in 1st gear, for example, it can be seen that the engine power is transmitted to the disc pack of the first clutch (1) by means of the pot-shaped outer disc carrier (2). From there, the power passes via the associated, likewise pot-shaped inner disc carrier (3) to the drive shaft of the 1st transmission (4). The splines for the 1st gear are located on this shaft (5). Passing via the corresponding gear wheels and the synchronisation (6), the power then reaches the countershaft (7), and from there via the constant (8) to the output shaft. The output shaft (9) is connected via the drive flange to the cardan shaft, which drives the wheels via the rear axle differential. In the all-wheel version, the downforce is provided by the hang-on all-wheel clutch, the beveloid gear wheel set and the connecting shaft directly onto the front-axle final drive.

Power Flow on Transmission 2, 2nd Gear



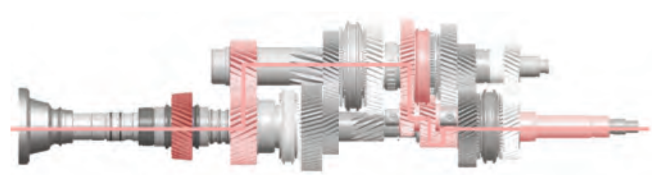
By tracing the flow of power in 2nd gear, it can be seen that the engine power is transmitted to the disc pack of the second clutch (1) by means of the pot-shaped outer disc carrier (2). From there, the power passes via the associated, likewise pot-shaped inner disc carrier (3) to the hollow drive shaft of the 2nd transmission (4). The splines for 2nd gear are located on this shaft (5). The power then reaches the countershaft (7) via the corresponding gear wheels and the synchronisation (6). The additional distribution of power takes place as for the 1st transmission via the constant (8) to the output shaft. The output shaft (9) is connected via the drive flange to the cardan shaft, which drives the wheels via the rear axle differential. In the all-wheel version, the downforce is provided by the hang-on all-wheel clutch, the beveloid gear wheel set and the connecting shaft directly onto the front-axle final drive.

Power Flow on Transmission 1, 5th Gear



In 5th gear, drive shaft 1 is connected to the constant with the result that the power flows directly through the transmission at a ratio of 1:1.

Power Flow on Transmission 2, Reverse Gear



The flow of power in reverse gear.

Transmission

Porsche Traction Management (PTM)

The active all-wheel-drive system, Porsche Traction Management (PTM), which is standard in the new Panamera 4S and Panamera Turbo, is designed to influence longitudinal and lateral dynamics. The system provides increased driving stability, traction and more agile handling, depending on the driving situation.

PTM comprises the following systems:

- Active all-wheel drive with an electronically controlled, map-controlled, hydraulically activated multiple-disc clutch
- Automatic Brake Differential (ABD)
- Anti-slip regulation (ASR)

Benefits of Porsche Traction Management (PTM)

General benefits:

- Extremely agile and dynamic
- Very good traction and vehicle stability
- Good control of the vehicle and driving safety in extreme driving situations

Compared to conventional all-wheel drives:

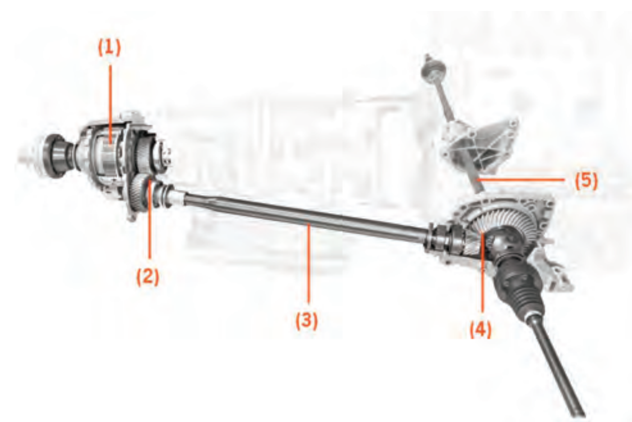
- Reduced weight and consumption due to its compact construction
- Improved driving performance thanks to the low centre of gravity of the engine

Other features:

- Further improved traction with Automatic Brake Differential (ABD)
- Further improved vehicle stability during acceleration with anti-slip regulation (ASR)

Porsche Traction Management (PTM) actively improves vehicle handling and increases traction in the new all-wheel-drive Panamera models. Strictly speaking, driving dynamics and traction are one and the same thing since the transitions within the systems are performed smoothly. Here is a example: Only when a vehicle has good traction, i.e. the tires do not build up any excess slip, can lateral forces also be transferred. This means steering control for the front axle, and lateral support for the rear axle. Drive wheel spin can be reduced - or ideally, eliminated completely - using PTM.

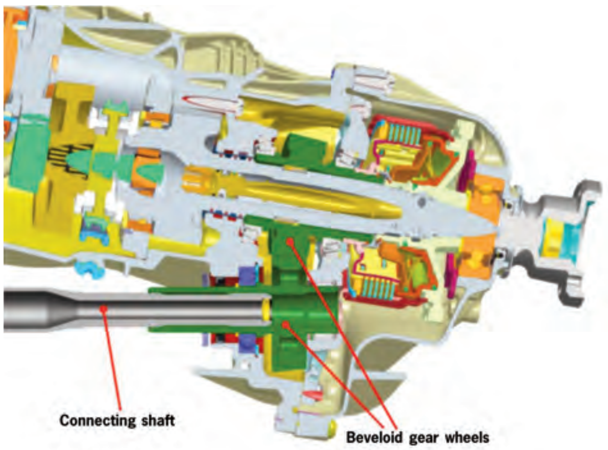
With PTM, the active all-wheel drive in the Panamera is designed as a controlled hang-on all-wheel which has been integrated into the main housing of the Porsche Doppelkupplung (PDK). The electronically controlled multiple-disc clutch installed in the PDK regulates the distribution of drive power between the full-time drive rear axle and the front axle in a way that is fully variable without a fixed basic distribution. Permanent monitoring of driving conditions enables the system to respond to different driving situations. Sensors continuously monitor various parameters, including the speeds of all 4 wheels, axial and lateral acceleration of the vehicle and the steering angle.



1 - Electronically controlled multiple-disc clutch
2 - Beveloid gear teeth
3 - Connecting shaft
4 - Front-axle differential
5 - Front drive-through axle through the engine

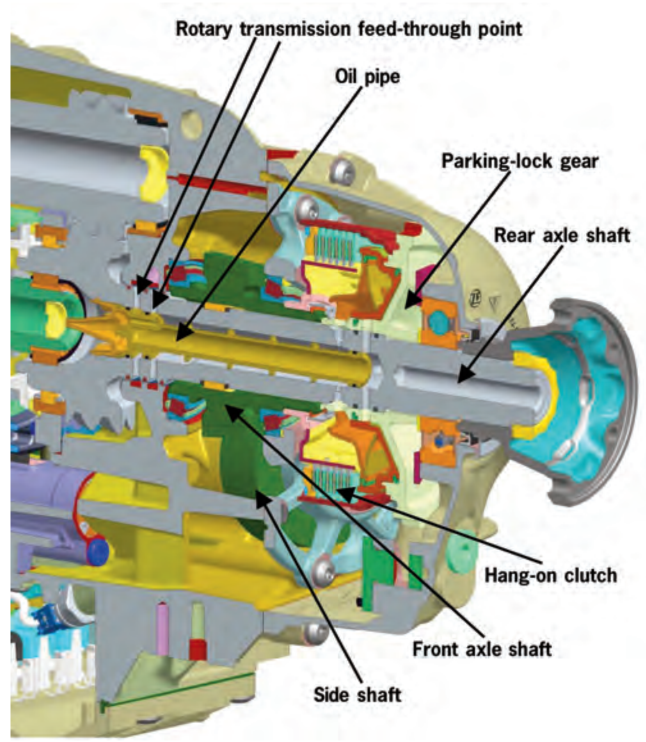
If the rear wheels are turning during acceleration, for example, additional drive power (if necessary up to 100% more) is distributed forward through greater intervention of the multiple-disc clutch. The all-wheel drive is therefore fully variable. ASR also reduces wheelspin. In bends, only the right amount of drive power reaches the front wheels to ensure optimum lateral support.

Drive power is transmitted to the front-axle differential via a beveloid gear in the hang-on all-wheel. The helical gear wheels mesh in two planes, permitting the connecting shaft to the front-axle differential to be installed at an inclination of 11 degrees. Compared to a conventional transfer gear, this solution is more compact and is approx. 6.6 lbs. (3 kg) lighter. The weight reduction continues with the hollow connecting shaft fitted to the front-axle final drive.

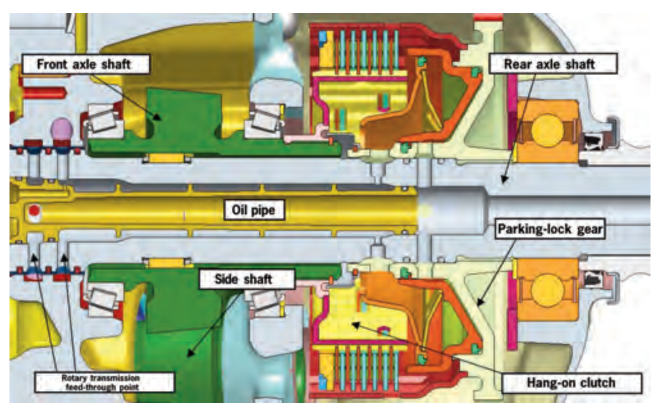


Another innovation in this segment is the front-axle differential, which is bolted directly on to the engine. The front drive-through axle through the engine keeps the engine in the Panamera sitting particularly low. This lowers the center of gravity and improves driving properties. A particularly compact and low-weight design is characteristic of this area also.

PTM works with the enhanced Porsche Stability Management system to ensure that power is distributed appropriately for excellent propulsion in every driving situation: on long straights and in tight corners as well as on surfaces with varying levels of grip. The Automatic Brake Differential (ABD) feature also improves traction. When the brake control systems are actuated, PTM disengages the front axle completely to facilitate PSM interventions on individual wheels.



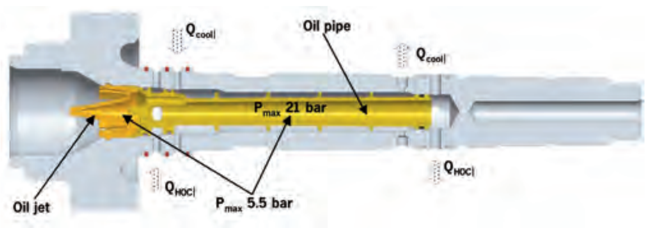
Depending on driving conditions, the torque is distributed from the hang-on clutch (HOC) to the axles according to load to guarantee permanent traction for all wheels. The inner disc carrier on the HOC is pressed onto the front axle shaft, which is connected to the side shaft via beveloid gear teeth. The outer disc carrier of the HOC is firmly welded to the parking-lock gear and is mounted on the rear axle shaft. Like the double clutch, the HOC is a wet clutch and is supplied with oil through the oil pipe.



Notes:

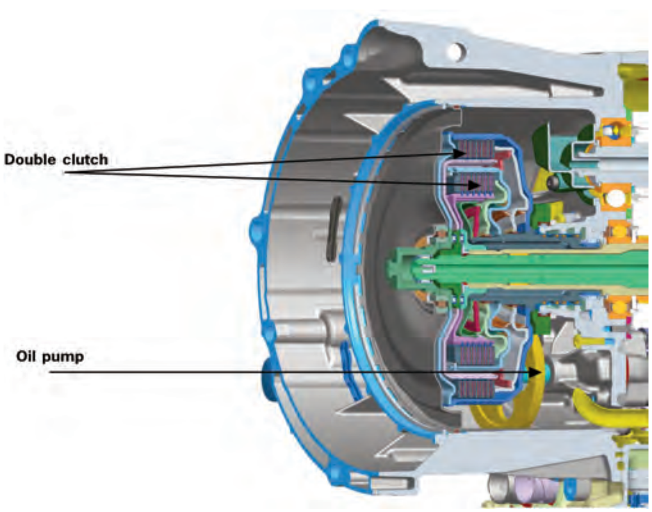
Transmission

Rear Axle Shaft With Oil Pipe and Oil Jet



The oil for actuating the HOC flows at a maximum pressure of 304 psi (21 bar) directly through the oil pipe. The cooling oil travels between the oil pipe and the inner wall of the rear axle shaft to the HOC at a maximum pressure of 80 psi (5.5 bar). Some of the cooling oil is routed to the oil jet and from there injected into the drive shaft to cool/lubricate the bearings.

Double Clutch



The wet-running double clutch is a central module of the Porsche Doppelkupplung (PDK). With its wide range of technical features, it meets the functional requirements of the transmission control system, thereby shaping the special character of this transmission concept. Very fast response times, low inertia and good, comfortable friction values combined with good economic viability allow both very sporty driving with highly dynamic gear changing as well as comfortable cruising.

For safety reasons, the clutches are opened when they are depressurized and inactive. The radial arrangement of the disc packs provides the best combination from the points of view of performance and space.

The wet-running double clutches installed in the Panamera transmissions come in two size:

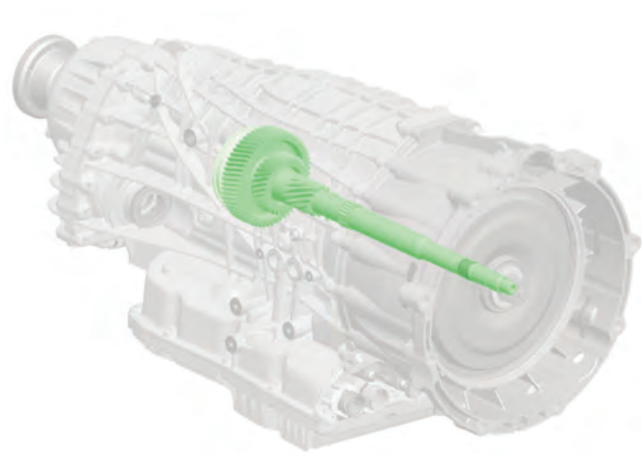
- One for the aspirated models for engine torques up to 520 Nm
- One for the turbo model for engine torques up to 750 Nm

The double clutch for the aspirated models is identical to the double clutch in the sportscars. The oil pump is designed to output a maximum of 67 liters.

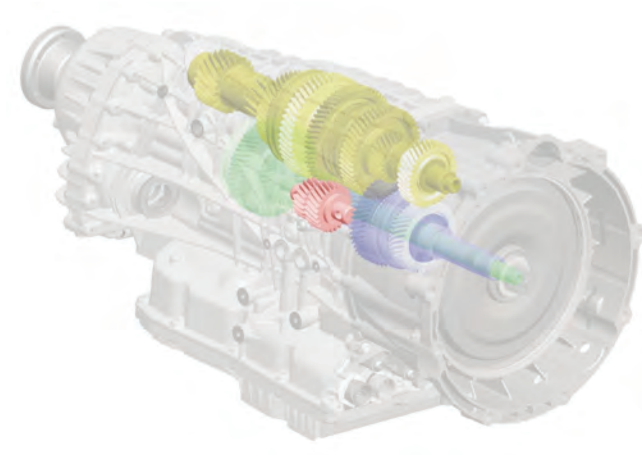
Careful selection of pad type, pad dimensions and usage as well as uniform distribution of thermal load and oil flow in the disc pack, along with the corresponding oil types, are prerequisites for comfort and performance over the service life. Low drag torques even at low temperatures and good resistance at high speeds guarantee comfort and excellent sportiness, but are also important safety requirements.

The friction discs comprise a steel carrier and a friction material made from paper. Paper is perhaps a misnomer, since it is a high-performance fiber more do to the production method than to the product. This fiber matrix is produced on a paper-making machine, in which an aqueous paper slurry (fibers and fillers) is dried on a strainer and bonded to a steel carrier.

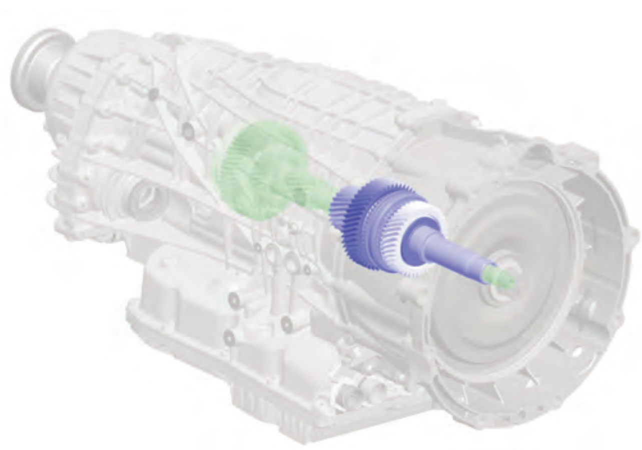
Shafts and Gears



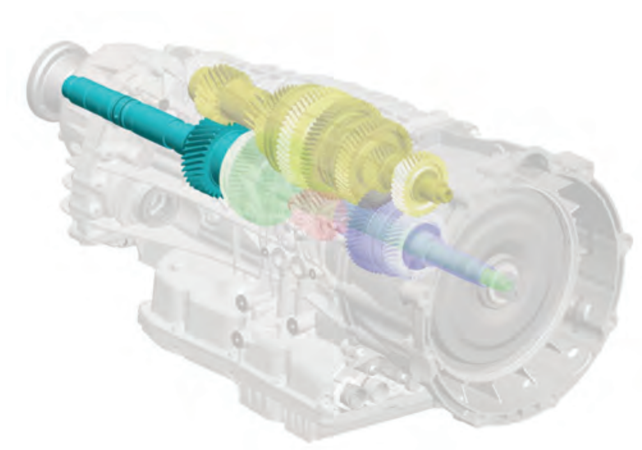
Driveshaft 1



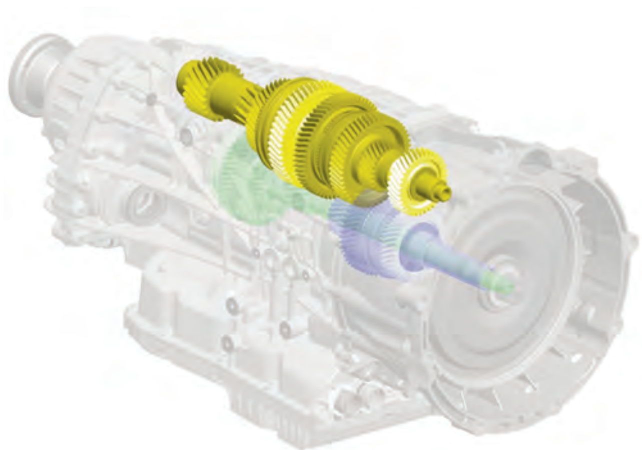
Intermediate Gear Wheel for Reverse Gear (red)



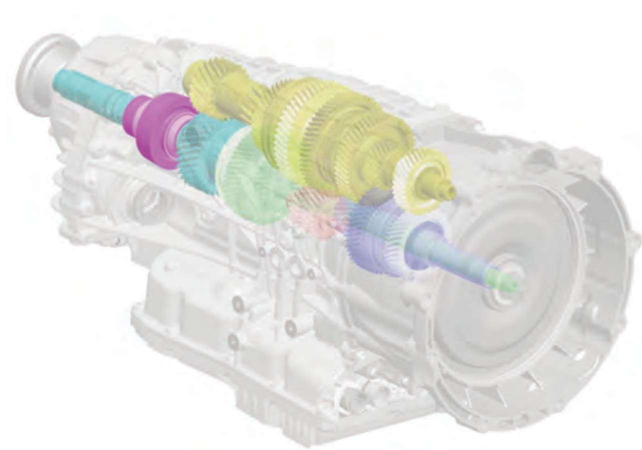
Driveshaft 2



Rear Axle Shaft



Counter Shaft



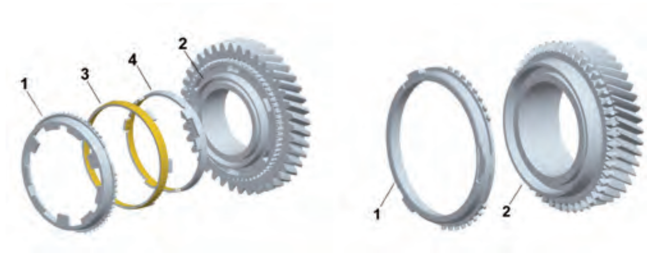
Front Axle Shaft

Shafts and Gears (cont'd)

Rear Axle Shaft

Complete Gear Wheel Set

Syncronization



Triple cone synchronization is used for reverse, 1st, 2nd and 3rd gear. The use of three friction cones has resulted in a considerable reduction in synchronizing forces. This reduces shifting forces when engaging gears. The first friction cone comprises the friction cone of the clutch hub of the loose gear wheel (2) and the inner cone of the inner ring (4). The second friction cone comprises the outer cone of the inner ring (4) and the inner cone of the intermediate ring (3). The third friction cone comprises the outer cone of the intermediate ring (3) and the inner cone of the synchronizer ring (1). Single cone synchronization is used for 4th, 5th, 6th and 7th gear. The cones from the clutch hub (2) and the cones of the synchronizer rings (1) form the friction cone.

Notes:

Parking Lock

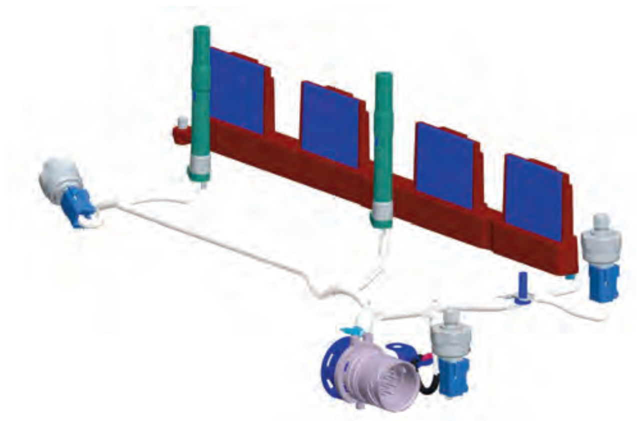
Even if the vehicle is in gear, it cannot be prevented from rolling back in the same way as with a manual transmission because the clutches are opened in a depressurized state and thus do not stop the vehicle from moving. The parking lock prevents the vehicle from rolling away, as with an automatic transmission. When the vehicle is stationary, the parking lock is engaged (purely mechanically) using a selector lever and blocks the rear axle shaft via a stop which engages in the splines of the parking-lock gear. In this way, the connecting shaft that is driven via the rear axle shaft is blocked.

The pawl is positioned by the connecting shaft in the guide bush. If the parking lock is engaged using the selector lever, the pawl pushes the stop out of its neutral position against the parking-lock gear. The stop engages in the splines of the parking-lock gear and blocks the rear axle shaft. When the parking lock is disengaged, the pawl is pulled back out of the guide bush and the stop can occupy the unlocked position again through the spring force of the spring.

Sensor Technology

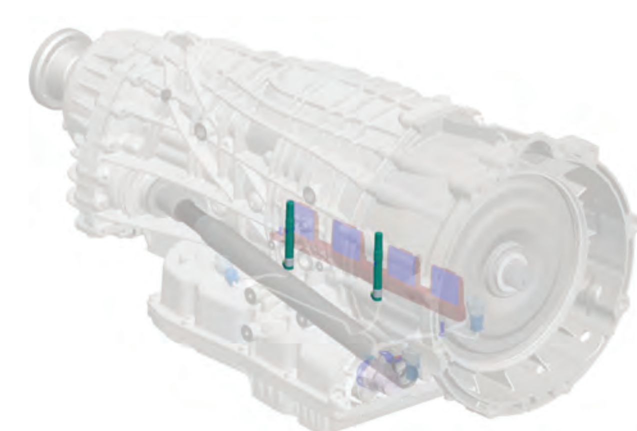
Various sensors are used for recording engine speed, temperature, pressure and distance signals:

- 4 distance sensors (combined in one housing)
- 2 speed sensors
- 2 (2WD) or 3 (4WD) pressure sensors
- 1 temperature sensor



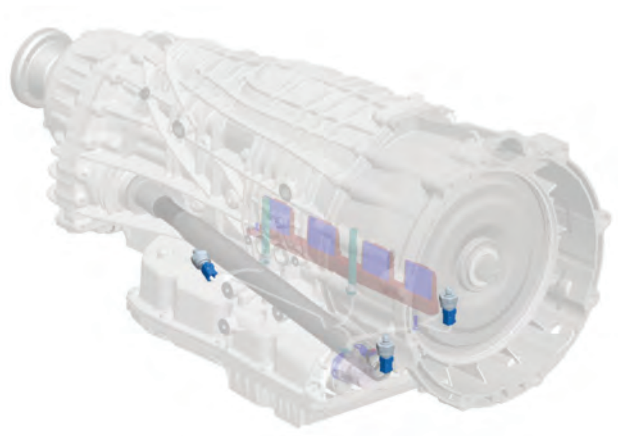
The distance, speed and pressure sensors and the temperature sensor are connected by a wiring harness and their lines are routed outwards via the 16-pin connector. The distance and speed sensors and the temperature sensor are connected permanently to the wiring harness. The two solenoid valves and the six (2WD) or seven (4WD) pressure adjusters are connected by a second wiring harness. The wiring of this sensor is routed outwards via a 20-pin connector. The sensors are all located in the transmission. Sensors can be replaced from the outside after the oil pan and the hydraulic control unit are removed.

Speed Sensors



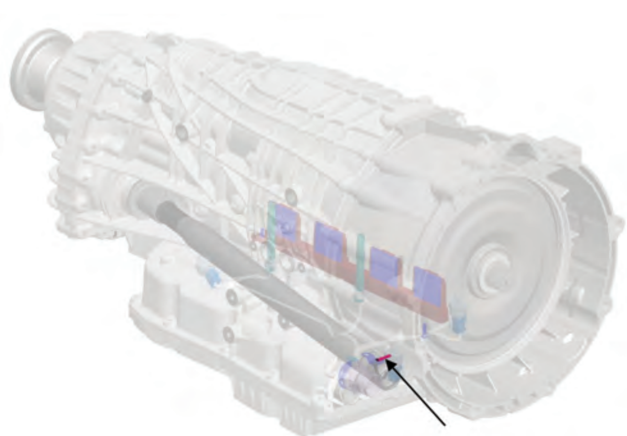
There are two Hall-effect sensors in each speed sensor.

Pressure Sensors



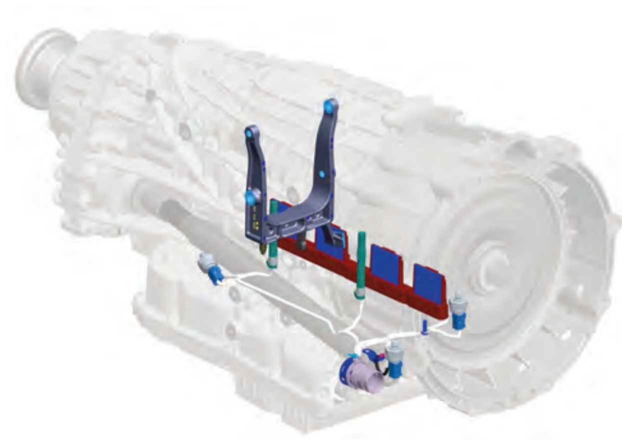
The pressure sensors for measuring the clutch pressure values are read directly at the rotary transmission feed-through point. They are installed inside the housing and are connected to the wiring harness by connectors. As the 4WD transmission has an additional clutch, the hang-on clutch, it also has an additional pressure sensor.

Temperature Sensor



The temperature sensor is used to record the sump temperature of the hydraulic oil. It is a temperature dependent resistor.

Distance Sensors



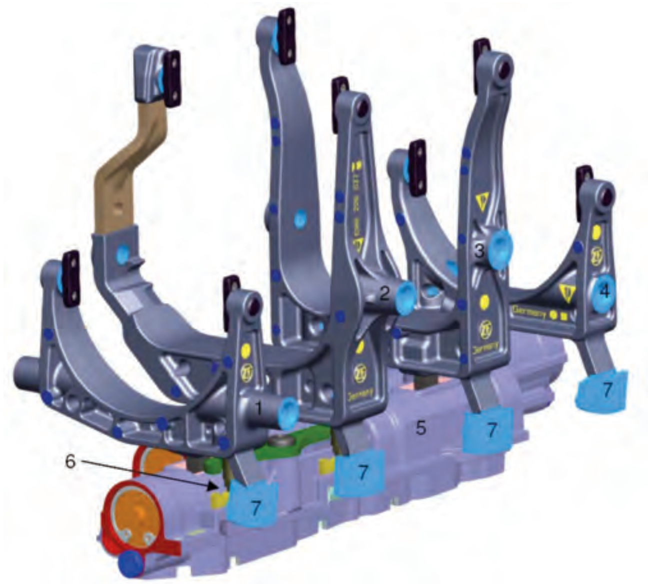
All four gearshift swinging forks have an aluminum damping element in the bottom section which dampens the signals being sent from the distance sensor. Each gearshift swinging fork is assigned a distance sensor, which converts the movement of the shift rod into a distance-proportional PWM signal.

Operating principle of the distance sensors:

The distance sensor works according to the eddy-current principle, i.e. a conductive material (a rectangular-shaped aluminium damping element on the gearshift swinging fork) drains energy from the oscillatory circuit, which leads to damping and a change in frequency in the oscillatory circuit of the sensor element. The principle is not magnetic, i.e. the gearshift swinging fork, shaped as a damping element, works as a sensor to deliver a frequency-dependent output signal depending on the overlap of the displacement sensing coil.

For every swivel arm or sensor island there is a sensing coil for measuring distance and a sensing coil for calculating the gap between the swivel arm and the printed circuit board. These sensing coils consist of a printed circuit board coil that is adapted to the geometry of the gearshift swinging fork. The position of the damping element's edge is calculated from a geometric perspective and output via the interfaces to an appropriate PWM signal. The sensor can detect two degrees of freedom (the gap between the damping element and the printed circuit board) and distance (angle of the gearshift swinging fork). The height coil is always completely covered by the damping element as it provides a frequency-proportional signal regarding the gap between the damping element and the printed circuit board.

Shifting



The Porsche Doppelkupplung (PDK) transmission for the Panamera is shifted using gearshift swinging forks consisting of the following individual parts:

1 - Gearshift swinging fork for 4th/6th gear
2 - Gearshift swinging fork for 2nd/reverse gear
3 - Gearshift swinging fork for 1st/3rd gear
4 - Gearshift swinging fork for 7th/5th gear
5 - Shifting unit with shifting pistons
6 - Shifting unit with detents
7 - Sender for shifting unit

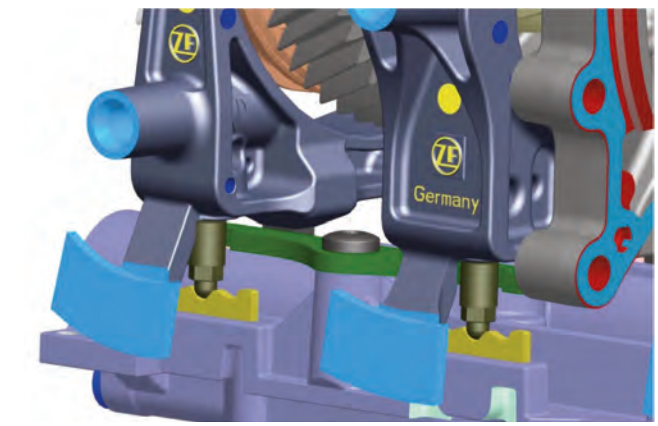
The gearshift swinging forks are actuated hydraulically via the shifting unit using the shifting pistons and are used to shift the synchronizers and thus to change gears. They transfer the shifting forces generated in the actuator hydraulics to the synchronizers' operating elements. Each gearshift swinging fork actuates two synchronizers and therefore two gears. Once the gear is engaged, the gearshift swinging fork is depressurized. The gear is held securely and without strain by detent in traction/deceleration mode by positive engagement of the toothing. Each gearshift swinging fork has an aluminum sender (7) for recording signals via the transmission distance sensors.

There are two different stipulations when numbering the gearshift swinging forks. The numbers must be counted once according to the specification for the transmission software and once according to the geometric arrangement of the gearshift swinging forks in the transmission, beginning with the clutch bell-housing. The distance sensors and therefore the gearshift swinging fork travel are also arranged according to this specification.

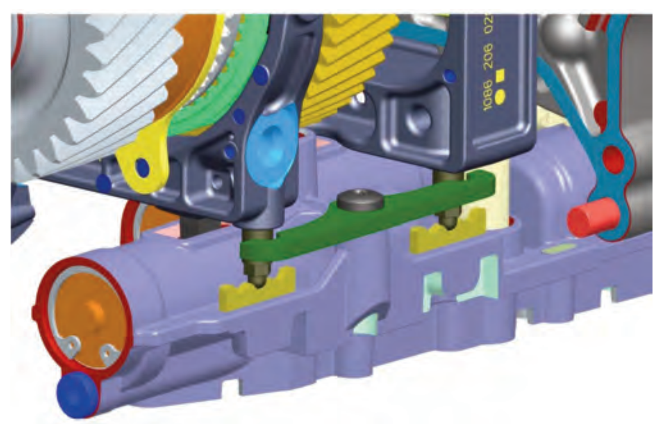
Shifting Interlock

The gearshift swinging forks in a transmission are locked against each other. In transmission 2, gearshift swinging fork 3 (1st/3rd gear) is locked against gearshift swinging fork 4 (5th/7th gear. In transmission 1, gearshift swinging fork 1 (4th/6th gear) is locked against gearshift swinging fork 2 (2nd/reverse gear.

The gearshift swinging forks are locked in the neutral and end positions. The shift throw from neutral into the locked engaged positions of the gears is nominally the same for all gearshift swinging forks. The mechanical neutral position is nominally 0 mm shift throw, in accordance with the characteristic of the transmission sensors.

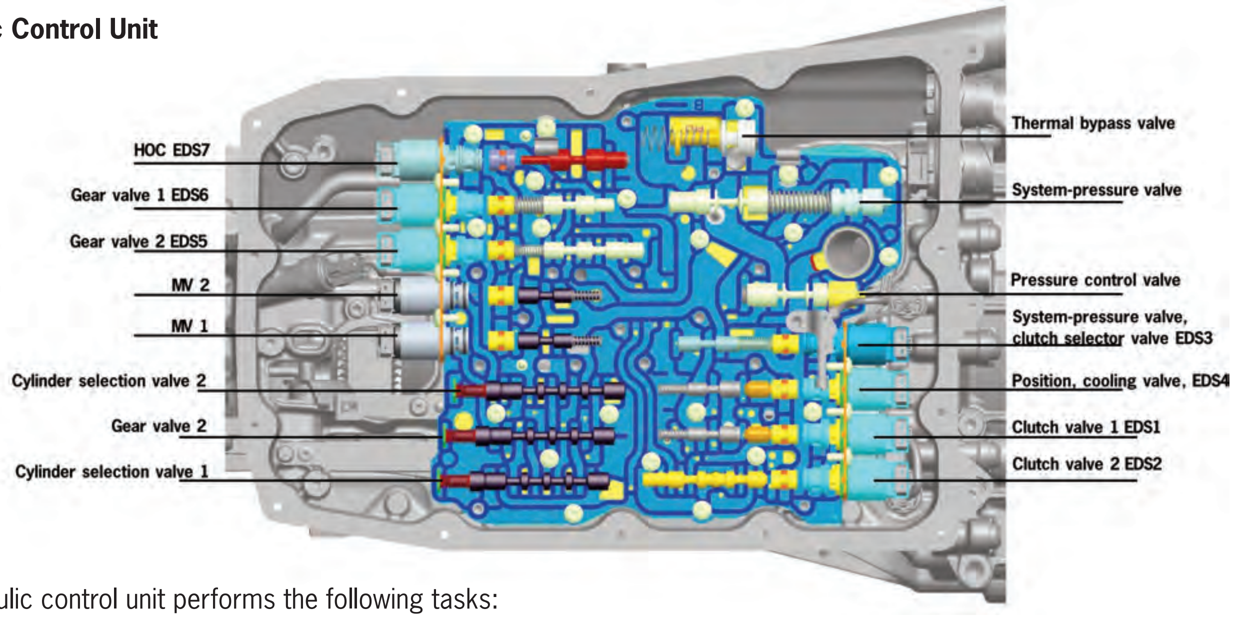


Locking mechanism for 4/6, 2/reverse in neutral, no gear engaged.



Locking mechanism for 1/3, 7/5 in neutral, no gear engaged.

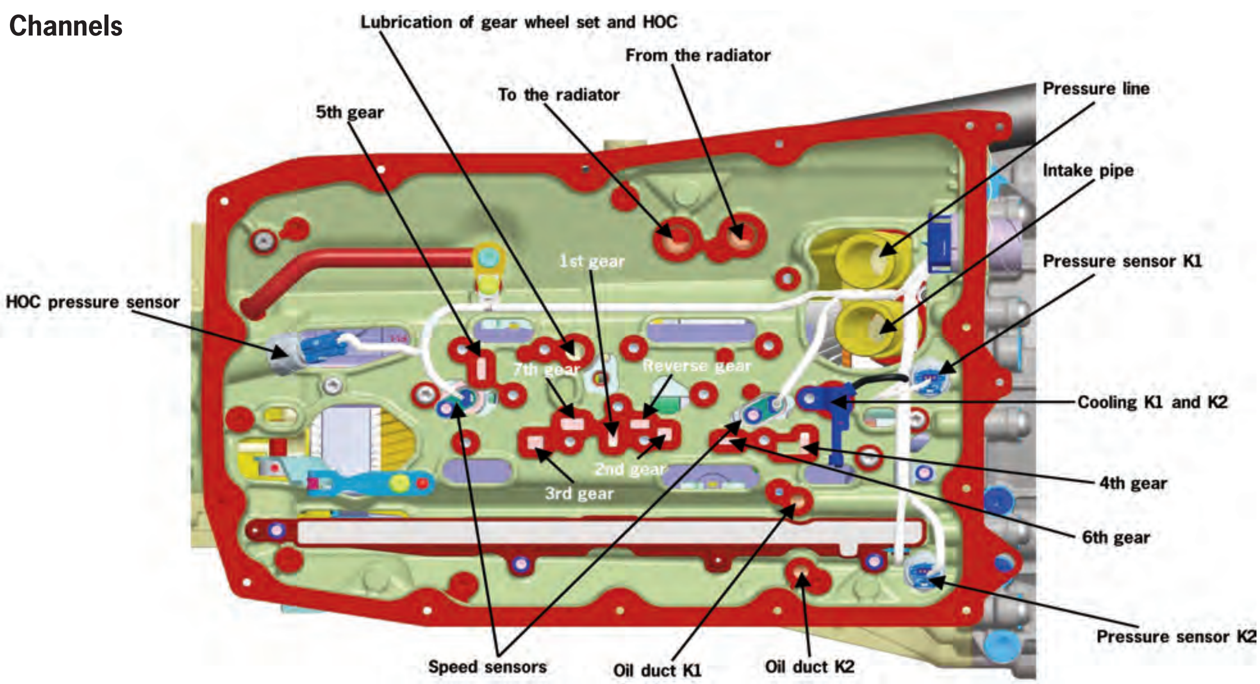
Hydraulic Control Unit



The hydraulic control unit performs the following tasks:

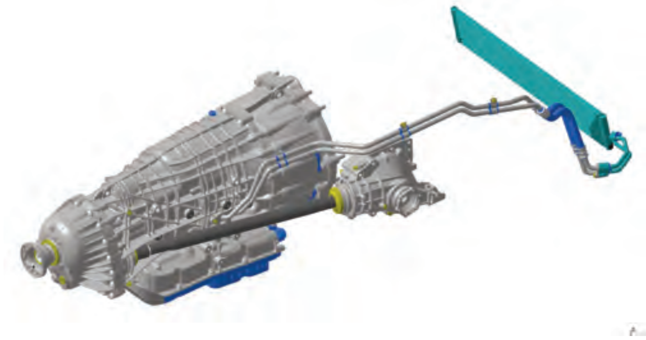
- Controls the system and reduces pressure
- Supplies oil to the actuators, clutches, actuating cylinders, cooling system and lubrication system
- Activates the clutches and actuating cylinders
- Provides emergency hold functions in mechanical transmission limp-home mode

Pressure Channels



The pressure channels of the gears run directly into the shifting unit behind. The oil ducts for actuating the two clutches and the cooling-flow oil duct for the double clutch pass through the transmission housing, across into the clutch bell-housing, reaching the rotary transmission feed-through point via the centering plate. The oil duct for lubricating the gear wheel set extends to the oil line, which branches off to the gear wheels and oils these.

Transmission Cooling



A separate radiator is located at the front of the vehicle to cool the transmission oil. The cooling flow to the radiator is not controlled by a thermostat (the transmission oil temperature would be too high due to the thermal management). Instead, it is controlled by a control valve located in the hydraulic control unit.

Limited Slip Differential

The advantages in terms of driving dynamics are boosted once again by the electronically controlled rear-axle differential lock with variable locking effect. The rear-axle differential lock improves traction if required during extreme lateral acceleration, when accelerating on surfaces with varying levels of grip and when accelerating out of tight bends. Electronic braking intervention (ABD) for traction control is used less frequently.

During load changes in a bend, the vehicle turns in less and remains more in line as a result of the yawing moment produced by the rear-axle differential lock. Any turn-in response triggered by abrupt deceleration is significantly reduced. Extreme acceleration can make the vehicle oversteer, e.g. on race circuits, which experienced drivers find easier to control. On the all-wheel-drive models, the rear-axle differential lock supports the driving dynamics of the controlled all-wheel system, Porsche Traction Management (PTM).

Notes: