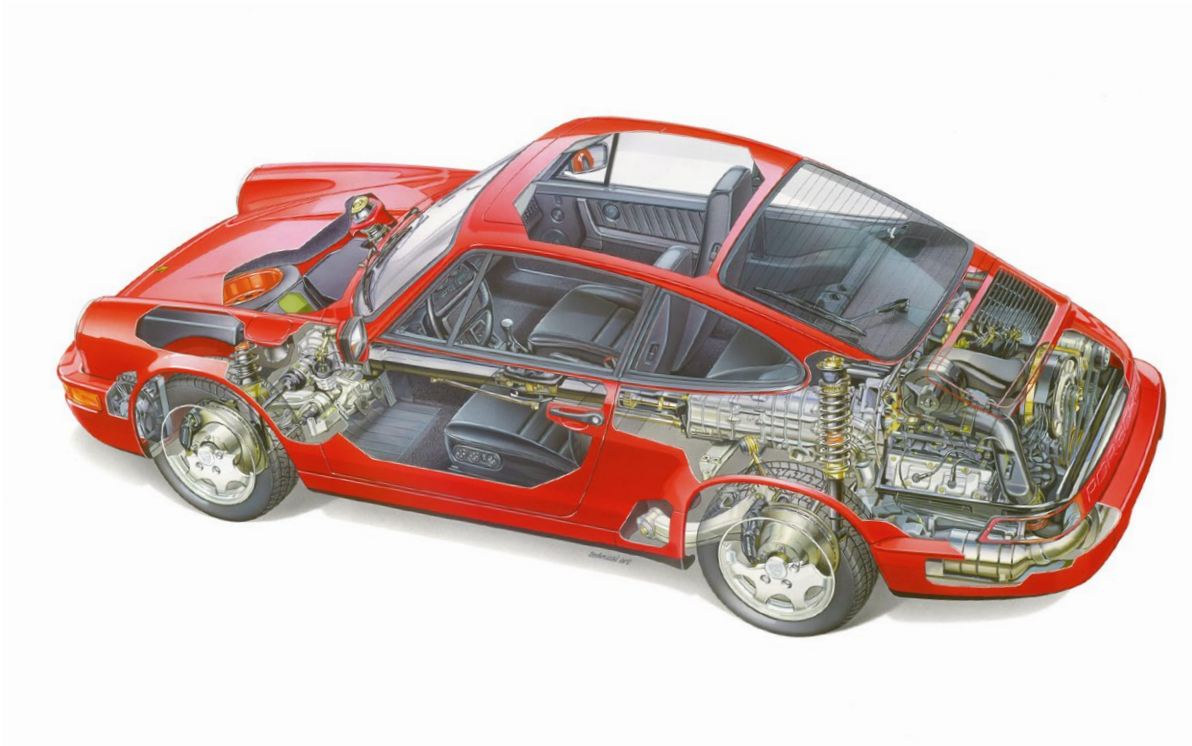




PORSCHE



## **30 years of all-wheel drive in the Porsche 911**

Press Kit

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## Highlights

# **The milestones of Porsche all-wheel drive development**

The latest Porsche Traction Management (PTM) used in the 911 is the very embodiment of sporty all-wheel drive. Its intelligent nature improves agility on bends, stability when performing highly dynamic manoeuvres, and traction. PTM represents the current pinnacle of how all-wheel drive has evolved in Porsche series-production sports cars over more than 30 years. Porsche all-wheel drive has its roots in motor racing. In 1984, it helped the Type 953 to win the Paris-Dakar Rally; in 1986, the 959 super sports cars with electronically controlled variable all-wheel drive celebrated a double victory.

## **1988: World premiere of the electronically controlled all-wheel drive in the 911 series-production model**

The first 911 road vehicle with all-wheel drive as standard celebrated its world premiere in 1988. The Type 964 Porsche 911 Carrera 4 used a planetary gear set as a centre differential to distribute propulsion force. In addition, multi-disc locks were placed between the front and rear axles (as a centre-differential lock) and on the rear axle (as a controlled differential lock).

## **1994: Second generation with passive hang-on system**

Porsche presented the second-generation all-wheel drive in 1994, in the Type 993 911. The system was constructed as a hang-on all-wheel; if there is a difference in speed between the directly driven rear axle and the front axle, a passive viscous coupling transfers some of the propulsion force to the front axle. This system was transferred virtually unchanged for use in the 996 generation 911 Carrera and 911 Turbo models.

## **2002: Porsche Traction Management premieres in the Cayenne**

The era of Porsche Traction Management began in 2002 with the Cayenne. At this point, PTM is a permanent all-wheel drive system with a central transfer case that distributes propulsion force to the front and rear axles at a ratio of 38:62. In addition, a reduction gear and an electronically controlled centre-differential lock deliver full off-road capability, as you would expect for an SUV. The first PTM also impressed with its driving dynamics capabilities.

## **2006: The first 911 with PTM**

In 2006, with the Type 997 911 Turbo, Porsche presented a PTM version that had been enhanced specifically for sports cars; it featured an electronically controlled and electro-magnetically actuated multi-plate clutch with ball ramp reinforcement. This active, fully variable system distributes propulsion force between the permanently driven rear axle and the front axle much more quickly and accurately than the passive viscous coupling used in the previous version. In 2008, this system was also used in the 911 Carrera 4 models of the second generation of 997; in the first generation, they still had the all-wheel drive with viscous coupling.

## **2009 and 2013: Panamera and Macan with 911 technology**

The all-wheel drives of most Panamera models (from 2009) and all Macan versions (from 2013) also have a controlled multi-plate clutch. The control strategy is based on that of the 911 and as such helps to ensure that the Panamera and Macan deliver best-in-class driving dynamics that are typical of a sports car.

## **2013: Latest PTM – even more efficient**

The latest, most advanced, PTM version was first put to use in 2013 in the 911 Turbo of the first 991 generation. In contrast to the previous system, which was used with the 911 Carrera 4 models right up to the second generation of the 991 in 2015, the newly developed multi-plate clutch is now controlled electro-hydraulically rather than electro-mechanically. This has advantages in terms of performance thanks to faster and more accurate control of propulsion force in relation to traction, driving stability and steerability.

The latest all-wheel drive

## **Porsche Traction Management for greater agility, stability and traction**

The sporty all-wheel drive is a Porsche innovation. Invented by Ferdinand Porsche in 1900, revisited again and again, enhanced, and a feature of series-production models for 30 years. Over the course of 118 years, one of the most powerful propulsion systems in the world has been created: Porsche Traction Management (PTM). The latest generation of the system is a feature of the 911 Carrera 4, 911 Targa 4 and 911 Turbo, the Cayenne and the Macan, as well as most Panamera models – in each case tailored and tuned to the specific requirements.

The principle philosophy for any Porsche with active PTM is the same: Enhanced driving dynamics, improved driving safety, increased traction for an even sportier driving experience. This is why Porsche developed its own all-wheel-drive system, which has long been the benchmark in terms of speed, compactness and intelligence. It distributes drive torque between the front and rear axles actively and very quickly. Permanent monitoring of driving status means PTM can be actively pre-set to respond to different driving situations: For example, sensors continuously monitor the speeds of all four wheels, the longitudinal and lateral acceleration of the vehicle, as well as the steering angle.

By evaluating all sensor data, it is possible to adjust the distribution of propulsion force to the front axle as quickly and effectively as possible. For example, if the rear wheels are at risk of spinning when accelerating, more propulsion force is transmitted forwards. On bends, however, propulsion force is distributed to the front wheels only to the extent that lateral support of the tyres on the front axle is not negatively impacted. The advantage of PTM is most evident in wet and snowy conditions: This is where the acceleration capacity of a Porsche with PTM is simply stunning.

## Optimum application of physical possibilities

PTM exploits the physical conditions in order to achieve optimum improvement of the driving dynamics. The axle loads change depending on the driving situation. This dynamic shifting of wheel load allows the tyres to transmit varying degrees of force during the journey based on the axle and position. For example, when driving in a straight line uphill, the rear wheels will bear a heavier burden and can transmit greater forces. In this case, PTM reduces the torque transmitted to the front axle.

The self-steering properties of the vehicle can also be manipulated in a targeted way thanks to longitudinal distribution of drive torque. Oversteering as an example: In line with the circle of forces, a tyre can only transmit a specific maximum force, which must be split between longitudinal and lateral force. The more strongly the driver accelerates and thus introduces longitudinal forces, the less lateral support the tyres of a driven axle can establish. When the remaining potential for transmittable lateral force is exhausted, the tyres slip (when taking bends, for example) and the rear end of a rear-wheel-drive vehicle pushes outward. If the all-wheel drive transfers more drive torque to the front axle at this point, the longitudinal force to the rear wheels is reduced and the tyres can transmit more lateral force accordingly. The effect: The vehicle stabilises.

## Teamwork: Assistance systems support PTM with optimum power distribution

A key benefit of Porsche Traction Management is that it works efficiently with all driving dynamics systems and these systems complement each other for the benefit of the driver. The most significant partner system is Porsche Stability Management, which controls power distribution to all four wheels on an even more individual basis using the anti-slip regulation (ASR) and automatic brake differential (ABD) functions. The optional Porsche Torque Vectoring Plus (PTV Plus), which also communicates directly with the PTM control system, delivers a further increase in the all-wheel driving dynamics, depending on the model and equipment. PTV Plus works on the basis of variable torque distribution through individual braking interventions at the rear wheels, as well as an electronically controlled rear differential lock, and improves steering behaviour and steering precision.

The technical basic function of Porsche Traction Management is the same across all model lines: As with a conventional rear-wheel drive, engine power is transmitted directly to the rear axle via the transmission. In principle, this means that every Porsche features the easy-to-control handling of a rear-wheel-drive. A second downforce on the transmission output is directed to a multi-plate clutch, via which the front axle drive can be engaged on a fully variable basis. With this hang-on system, two features in particular truly demonstrate the expertise involved: the intelligent control algorithm and the responsiveness of the system.

For the Cayenne and the Macan, PTM has been enhanced to include additional functions that guarantee extensive off-road properties for the SUVs. The control concept follows a clear rule: If the route is difficult, the car simply must remain easy to drive. All systems have been optimised for off-road use, with the aim of improving traction on off-road terrain. The driver can call up the off-road capabilities at the touch of a button, and with the Cayenne this can even be done in stages.

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The history of the all-wheel drive at Porsche

## From the Lohner-Porsche to the 911 Turbo

One of the first cars to feature all-wheel drive was a Porsche, and it was a sports car: Ferdinand Porsche designed and built the Lohner-Porsche racing car with four electric wheel-hub motors. In 1947, Porsche developed the Type 360, better known as the Cisitalia racing car. It became legendary not only because of its twelve-cylinder supercharged engine and the lightweight construction throughout, but also because of its engageable all-wheel drive. This design was again based on the idea that, on bends or on road surfaces with low coefficients of friction, drive power can be fully and safely transformed into propulsion.

In 1981, Porsche began using all-wheel drive for non-racing cars. At the International Motor Show in Frankfurt, the company presented the study of a 911 Turbo Cabriolet with all-wheel drive. In 1984, Porsche revisited the idea and designed the Type 953 with engageable all-wheel drive for the Paris-Dakar Rally, at which it promptly took overall victory. Experiences with the 953 led to the 959 super sports car being manufactured; it was launched in 1985 and was really ahead of its time in terms of its overall technology. With front-wheel drive that engaged via the multi-plate clutch and a rear differential lock also actuated via the multi-plate clutch, it created the basic concept for the Porsche all-wheel drive. These centre-differential and differential locks were actuated both manually and automatically. The concept is still a feature of PTM today. The double victory of the Porsche 959 at the 1986 Paris-Dakar Rally is legendary.

### **911 Carrera 4: The first 911 with all-wheel drive made its debut 30 years ago**

When Porsche presented the Type 964 911 in 1988, a number after the model designation heralded a new era: The 911 Carrera 4 was the brand's first series-production sports car with all-wheel drive – and it featured a pioneering new design. Porsche called the innovation a “differential slip-controlled” drive across all four wheels. This means that drive torque is first transmitted from the manual transmission to a longitudinal transfer case designed as a planetary gear set; from there, provided the lock control is not enabled, it is always split in the same ratio: 69 per cent for the rear axle, 31 per cent forwards via an enclosed transaxle shaft. The manner of adjustment was innovative. Slippage at indi-



vidual wheels was detected by the ABS sensors and prevented by hydraulic locks. Two electronically controlled multi-disc locks controlled the flow of forces to the front axle and between the wheels of the rear axle. The effect: Permanent optimisation of traction and driving stability, handling on bends, and load change response.

### **1994: New all-wheel drive system with viscous coupling – hang-on instead of permanent all-wheel drive**

In 1994, Porsche resumed development of the all-wheel drive with the 993 generation 911 Carrera 4. The 911 Turbo now also used all four wheels to transmit power for the first time. With both models, Porsche switched to a simpler system design, which helped it to launch the lightest all-wheel drive system on the market at that time. The system was designed as a hang-on all-wheel drive, with the rear axle being directly driven and, in the event of speed differences between the front and rear axles, a passive viscous coupling that transmitted some of the propulsion force to the front axle. So the viscous coupling replaced the transfer case and controlled multi-plate clutch for the front axle drive. As a result, the all-wheel drive 911 was effectively dominant to the rear when under load, in a similar way to a rear-wheel drive but much more stable. A conventional differential lock and an automatic brake differential (ABD) were used on the rear axle.

The role of the viscous coupling was to automatically distribute drive torque between the axles, depending on slip at the rear wheels. The ABD built into the all-wheel drive model as standard used the ABS sensors to detect the slip at the individual wheels and provided a corresponding braking torque at the spinning wheel via the control unit. With different coefficients of friction on the right and on the left, the propulsion force was initially moved continuously by the rear axle differential lock to the wheel with increased power transmission. If a wheel began to spin, it was decelerated by the ABD, and drive torque at the level of the braking torque was transmitted to the opposite wheel. This feature was particularly helpful to the driver when experiencing problems starting the vehicle on wet or slippery road surfaces.

Porsche stuck with this concept for the Type 996 911; the difference was that the viscous coupling ran in the oil bath of the front axle drive unit and was therefore effectively cooled even under high load. The transaxle tube was omitted from the 996 generation due to weight and in order to create space

for the water cooling pipes. Instead of a rigid connection between the transmission fastened directly to the engine and the front axle drive unit (via a central tube), drive was supplied to the front axle via an exposed cardan shaft.

## **2002: The Cayenne introduces Porsche Traction Management (PTM)**

In 2002, Porsche presented the Cayenne as a third model line – and it featured completely new all-wheel drive technology. In basic mode, Porsche Traction Management (PTM) transmitted 62 per cent of engine power to the rear wheels and 38 per cent to the front wheels. However, using an electronically controlled multi-plate clutch operated by an electric motor as a variable centre-differential lock, it was possible to vary the distribution ratio according to the driving situation and so actively influence longitudinal and lateral dynamics. In addition, a rocker switch made it possible to manually engage a centre-differential lock for intensive off-road use.

PTM had a decisive influence on the driving dynamics of the Cayenne. The map-controlled centre-differential lock and an optional rear differential lock didn't simply respond to a lack of traction at the front or rear axle. In addition, sensors also detected vehicle speed, lateral acceleration, steering angle and accelerator control, so that PTM was able to calculate the optimum degree of lock for both axles and assign the necessary drive torque to the axles. PTM was therefore a forward-looking system that delivered great agility when taking bends and excellent driving stability when changing lanes, both at high speeds and when driving more slowly on ice and snow.

## **The first PTM for the Porsche 911**

In 2006, electronic PTM was used in a modified form in the Type 997 911 Turbo. Here, the core element was an electro-magnetically actuated multi-plate clutch that was used to transmit propulsion force to the front axle as required. The clutch of the 911 Turbo was designed for a peak torque of 400 Newton meters, which in practice almost never occurred: Even at 300 Newton meters, the front wheels lost their grip on dry road surfaces and began to spin.

With a maximum response time of 100 milliseconds, PTM responded more quickly to load change than the engine and the driver did. In practice, this meant: Great agility on narrow country roads, outstanding traction and incredibly safe driving, even when carrying out extreme driving manoeuvres at high speed. In order to perform these dynamic driving tasks, the Porsche designers programmed PTM with five key basic functions; to this day, the Porsche all-wheel drive still essentially works on these principles:

- Basic torque distribution: In everyday driving, the control system continuously distributes engine torque between the front and rear axles in accordance with the current driving situation by engaging the front axle drive in a defined way. For this purpose, the torque required at the front axle is determined on a millisecond basis. If the system detects a lane change, for example, it engages the front-wheel drive to a greater or lesser extent based on the speed. The driver will experience this as a significant increase in stability, especially at very high speeds.
- Guided control: Using typical parameters, PTM is able to detect dynamic changes to the driving status at an early stage and avoid slip in advance. When starting the car, for example, the system determines how fast the driver is accelerating. Even before the engine can translate this request to accelerate into torque, the PTM locks the multi-plate clutch enough to prevent the wheels from spinning as much as possible. Only in extreme cases, such as when both rear wheels are grinding on sheet ice without any traction, is enough engine torque transmitted to the front wheels to cause them to spin. This means that, even when starting the vehicle, all four wheels are under the greatest possible propulsion force and optimum acceleration is achieved. An exception to this is a racing start via "Launch Control" in conjunction with the PDK transmission. If this is required, PTM locks the multi-plate clutch before the vehicle is started in order to guarantee maximum traction.
- Slip controller: Due to its high torque, a 911 is able to reach the traction limit of the rear axle in a short burst of speed, especially on a wet road surface. More torque and therefore propulsion force is transmitted to the front axle through stronger engagement of the multi-plate clutch. It was in 2006, that the 911 Turbo first featured this detection and control of longitudinal acceleration.

- Oversteer correction: If the rear end of the vehicle pushes outwards on a bend due to disruptive influences such as wet leaves, greater propulsion force is transmitted to the front axle in order to stabilise the vehicle in a dynamic way. A further benefit of PTM is the way in which the steering angle is taken into account when distributing power to the front axle. If the driver countersteers to correct an oversteer, PTM adapts the propulsion force to the front axle and the vehicle stabilises even more quickly.
- Understeer correction: On the other hand, if the front wheels of the sports car are pushing out of the bend, PTM reduces the torque to the front axle. In both cases, PTM uses the precision sensors to respond before the driver has even noticed any instability. The result is fast, active stabilisation of the vehicle for efficient and dynamic driving on bends, as there are fewer braking interventions at individual wheels by the PSM stability system.

## **Panamera and Macan with all-wheel drive like sports cars**

The PTM of the 911 became the master model for the all-wheel drive of the Panamera, which celebrated its world premiere in 2009, and of the Porsche Macan, which was launched as the fifth Porsche model line in 2013. Porsche Traction Management has continued to evolve with each new generation. In 2013, the focus with the new 911 was on increasing positioning accuracy as well as the torque that could be transmitted to the front axle. Since then, the system – which now features electro-hydraulic actuation of the newly developed multi-plate clutch – has been able to identify an economical style of driving based on the driving situation and the driver's requirements and reduces transmission of drive torque to the front axle. This reduces overall power dissipation. PTM also supports the "coasting" that is characteristic of Porsche, in conjunction with the PDK transmission. The PTM clutch will open if the vehicle is coasting without drive. So the all-wheel system reduces braking torque and therefore also fuel consumption. The latest PTM also brings performance benefits. There are improvements in terms of driving dynamics, agility and driving stability thanks to faster and more precise control of propulsion force via the new multi-plate clutch. Acceleration is improved by transmitting higher torques over the front axle, which allows the increased engine power to be transferred to the road also.