THE ELECTROPNEUMATIC FRONT AXLE LIFT SYSTEM OF THE PORSCHE 997 GT3

Similar to racing cars, the new 911 GT3 lies very close to the road in order to achieve high driving dynamics. The resulting restrictions in day-to-day usability can be compensated by using an additional lift system at the front axle. Porsche uses an electropneumatic system here.

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MOTIVATION

The GT3 chassis is 30 mm lower compared to the 911 Carrera, permitting a low centre of gravity and favourable aerodynamics. The lower chassis also reduces the ground clearance and the ramp approach angle compared to conventional vehicles which can sometimes become apparent in everyday situations. This above all affects the front chassis area when the vehicle is driven onto ramps, up driveways and over speedblockers in urban and residential areas. The front axle lift system developed by the Motor Sport department in Weissach can help prevent the vehicle bottoming out in these situations. Together with the system supplier, Ventrex Automotive, it was possible to develop the system for the market within a very brief time. The electropneumatic system, now available as an option for the new 911 GT3 for the first time, significantly enhances day-to-day usability. It allows the vehicle to be raised by around 30 mm at the front up to a speed of around 50 km/h. This can prevent damage to the body and allows, for example, speedblockers to be crossed with a much lower risk of bottoming out.

SYSTEM FUNCTION AND OPERATION

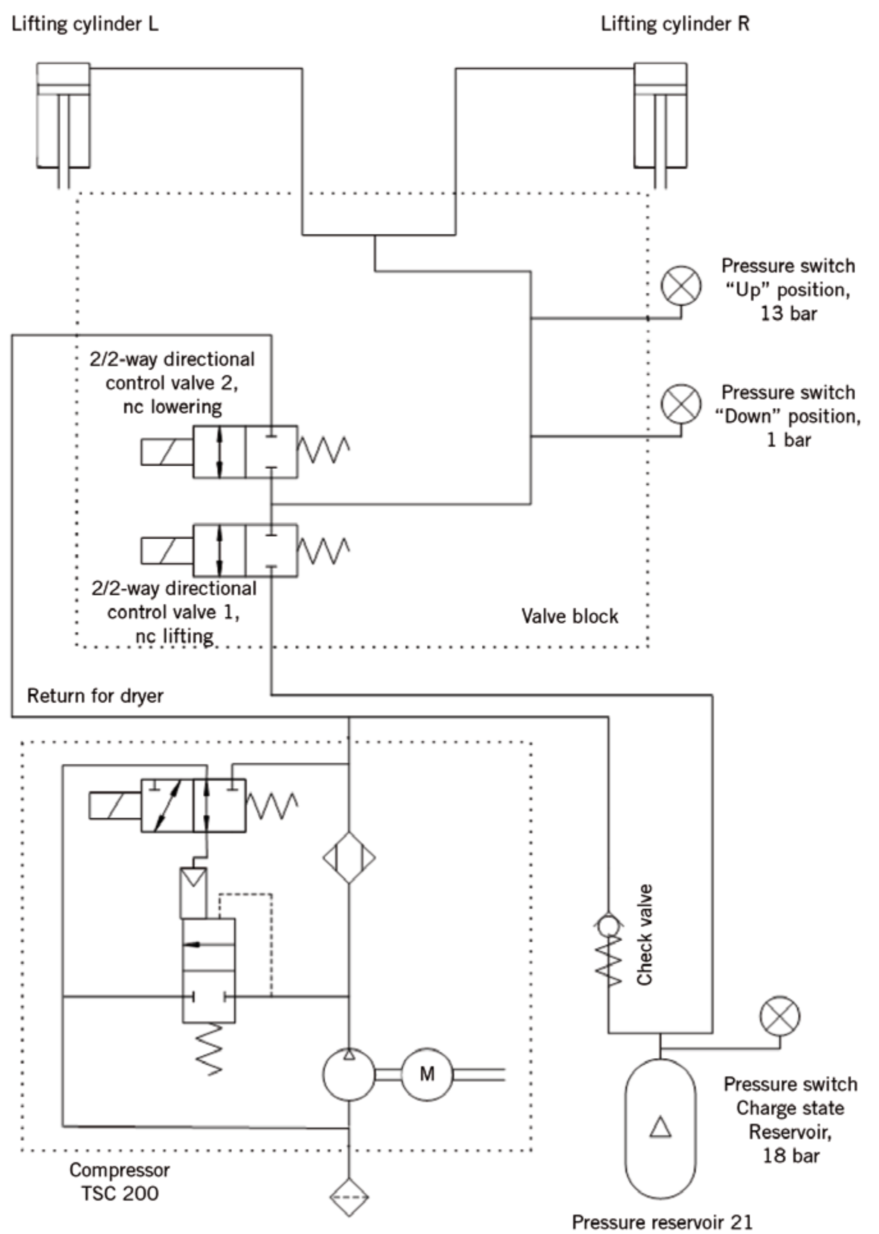
The main components of the electropneumatic front axle lift system are the function module, the special front axle shock absorbers and the electronic control unit. The function module, shown in ❶, provides the compressed air and includes a compressor, a pressure reservoir and a valve block.

The compressor generates the required system pressure of 18 bar and delivers it to the pressure reservoir. A pressure switch permanently monitors the pressure level in the reservoir and the compressor automatically adjusts the pressure if necessary. The pressure reservoir has a capacity of 2 l. Two electromagnetic valves on the valve block control the pressure build-up in the front axle shock absorbers. This valve block also accommodates two other pressure switches that provide the basic information for the vehicle lift position.

The conventional suspension strut at the front axle is used as a pneumatic cylinder for the lift function. Pneumatic connecting lines conduct the compressed air generated in the function module into the corresponding working chambers of the shock absorbers. The overall system is controlled by a modular electronic control unit which processes system information such as the vehicle speed and the air pressure in the pressure reservoir and shock absorbers.

The driver operates the lift function with a button in the centre console. When the driver activates the lift function by pressing the button, the 'lift valve' on the valve block opens and allows compressed air to flow from the pressure reservoir into the corresponding front axle shock absorber chambers, as shown in ❷. When the pressure of 13 bar required for the raised position is reached, this is detected by a pressure switch and signalled to the control unit. The "lift valve" is then

❶ Function module which comprises the compressor, the valve block and the pressure reservoir



❷ Pneumatic layout of the front axle lift system

closed again automatically and the "LIFT" logo in the instrument cluster indicates the raised position to the driver. The pressure built up in the shock absorber chambers causes the shock absorbers to extend by around 20 mm. This extension of the suspension struts raises the body by around 30 mm at the front edge of the front spoiler.

The driver can also press the button to lower the body. Pressing the button when the vehicle is in the raised position opens the "lower valve" and the air can escape from the shock absorber chambers. As the pressure decreases in the shock absorber chambers, the shock absorbers return to their original length. The designated pressure switch detects when the pressure has been fully relieved and signals this to the control unit. The vehicle has returned to its original position; this is indicated to the driver when the "LIFT" logo goes out.

SAFETY FUNCTIONS

For safety reasons, the control system includes various blocking conditions for which activation of the lift system is prevented or interrupted.

Activation of the lift system is permitted only if the vehicle has not exceeded a speed of 50 km/h. This limit prevents the changed vehicle aerodynamics of the raised vehicle from affecting the driving dynamics. If the speed limit is exceeded in raised position, the vehicle is automatically lowered to the basic level again.

Lowering of the vehicle is permitted only when the doors are closed. This condition prevents damage to the doors when parking over raised objects such as a kerb.

Frequent operation of the lift function in succession imposes a constant demand on the compressor to maintain the required system pressure. This can place a great thermal load on the compressor, especially if the outside temperatures are high. For this reason, a protective function continuously monitors the compressor temperature. The temperature switch sends a signal to the control unit if the maximum permissible temperature is exceeded. The lifting function will then be deactivated until the compressor is ready for use again.

Furthermore, a so-called anti-play function is integrated to prevent unnecessary up and down movements of the vehicle and the associated burden on the compressor. It limits the number of lifting activations to six within 60 s. If this number is exceeded, a corresponding protective function is triggered and manual activation of the lifting function remains blocked for 2 min.

Linking the system to an automatic headlight leveling system provides another safety aspect. This ensures that oncoming traffic is not blinded when the vehicle is raised at the front axle.

STATE OF THE ART

Some competitors also offer a lift system for the front axle and various retrofit solutions are available on the market as well. However, these systems are generally operated by hydraulics and require extensive modifications to the existing vehicle. By contrast, the electropneumatic system in the new 911 GT3 offers better performance and greater day-to-day usability.

With the special system structure in the new 911 GT3, the driving comfort and the suspension as well as damping characteristics are not impaired in any way in the lowered position.

❸ Lift system at the front axle of the GT3

The system requires around 4 s to raise the axle completely, permitting rapid availability in case of obstacles that appear suddenly or have to be crossed in traffic. The driver can press a button on the operating panel to activate the lifting function without having to stop and wait for the end of the lifting process.

The compact component configuration allowed the lift system to be integrated into the existing vehicle architecture of the GT3 with little effort, ❸. In terms of driving dynamics, the system is ideally accommodated in the lowest possible installation situation in the centre tunnel. The low system weight of only 6 kg also ensures that the driving dynamics of the GT3 are not impaired.

Moreover, the air-operated lift system is much less sensitive compared to a system operated with oil. Air is compressible and the occurring pressure peaks (for example, when crossing a road irregularity) are only fractions of those encountered when using incompressible media such as oil. Above all, the lower pressures subject the seals to much lower loads and no environmentally harmful fluids emerge in the event of leaks.

The integration of the lift system into the vehicle network architecture permitted an ideal display and feedback concept for the driver. The instrument informs the driver about the current lift position and indicates any system faults. A light-emitting diode in the operating button additionally provides feedback about the current status of the lift function.

COMPONENTS

A wheel-guiding suspension strut with an upside-down shock absorber has been installed in the GT3 for several vehicle generations, ❹. With this shock absorber system, the shock absorber tube, guided in two plain bushes in an outer tube, performs the task of guiding the wheel. The actual shock absorber piston rod sticks out of the bottom of the shock absorber tube and is in turn bolted together with the outer tube base.

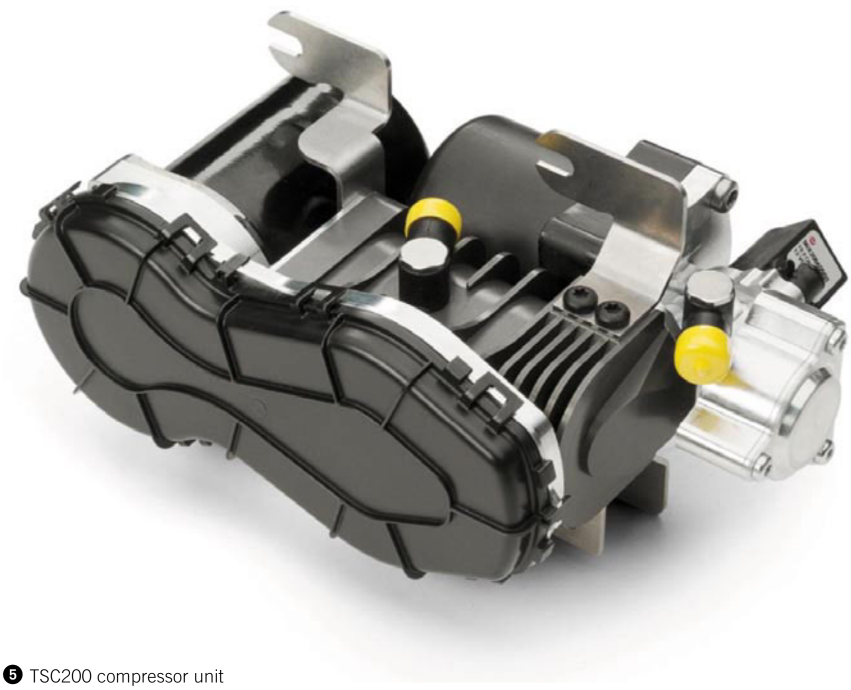
This design results in a hollow space between the guide tube and outer tube. The volume of this space changes with the suspension compression and can therefore be used as a pneumatic cylinder. In order to use the shock absorber for this purpose, the outer tube had to be modified. It was fitted with a separate base which is constructed with or without seals and compressed air connection depending on the type (with/without lift system). The stop buffer integrated into the pressure space was also provided with air guide channels which are required to admit air and release it from the suspension strut.

As additional measures, it was necessary to modify the seal between the outer tube and shock absorber tube and to change the shock absorber seal package and fix it in axial direction for a secure seat under pressure application.

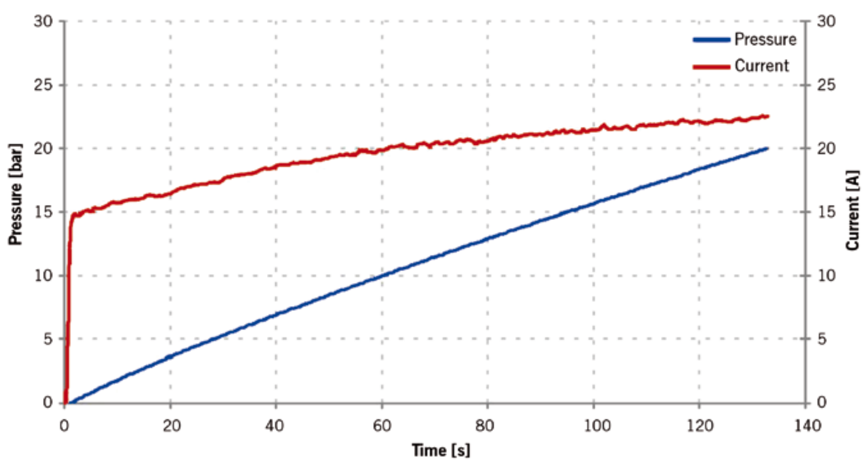
Overall, the result is a very simple lift suspension strut which is nearly neutral in terms of cost, space requirement and weight compared to a conventional suspension strut.

The TSC200 compressor used, ❺, meets the high demands in terms of size, weight, performance and sound emission.

❹ Front axle shock absorber with compressed air chamber of the lift function



❺ TSC200 compressor unit



❻ TSC200 supply characteristic

It is a new development from Ventrex Automotive. The compressor (maintenance-free dry-running compressor) functions according to a two-stage principle and thereby realises an ideal relationship between size and performance. The compressor, driven by a high-speed DC motor via a toothed belt, is characterised by its quiet operation.

An integrated adsorption air dryer with regeneration function reduces the water content in the compressed air and includes both a drain valve unit and a maximum pressure limiting function. The compact unit measures 224 x 148 x 84 mm, weighs only 2.4 kg and is fastened via elastomer decoupling elements to the unit carrier of the function module.

A special feature of the compressor is its modular design. Different power variants can be realised as required by adapting the drive ratio and possibly the motor; active fan cooling can be integrated as an option. The supply diagram, ❻, shows the compressor characteristic selected for use in the GT3 lift system.

SUMMARY

The electropneumatic lift system in the 911 GT3 meets the high demands for weight, reliability and function. Above all, the pneumatic version of the system has allowed advantages to be achieved compared to hydraulic systems already on the market. The system's convincing features include short lifting times and simple, safe operation. The driving dynamics properties of the 911 GT3 are not affected, despite the greater day-to-day usability.