Technical overview of the Carrera 4 AWD and Traction control system (PDAS) and all 964s ABS system.
By Adrian Streather

The following information is a brief overview of the more complex 964 systems. Hopefully it will provide 964 owners and fellow rennlisters with sufficient knowledge to allow a reasonable level of understanding of how these systems operate. This knowledge will I hope assist in reducing any repair costs. A full description of operation of these systems will be included in my book on the 964 currently being prepared by Bentley publishers. www.bentleypublishers.com or www.adrianstreather.com for more information.

All wheel drive (AWD) system

All wheel drive (AWD) is exclusive to the Carrera 4. This system is purely mechanical. Under normal driving conditions on dry roads, the drive torque is distributed 31% to the front axle and 69% to the rear axle.
An electronically controlled, hydraulic-mechanically activated traction control system called PDAS *(Porsche Dynamische Allrad Steurun*g, German for Porsche Dynamic All-wheel Control) works with the AWD mechanical components to enhance traction in adverse driving conditions and to overcome the ferreria effect “over steer leading to a spin”.

Principles of operation

The AWD gearbox is fundamentally the same as the rear wheel drive version with many common components, especially in the gearbox section.. Engine torque is transmitted to the gearbox via the flywheel and clutch assembly. The main difference is the addition of the drive assembly to the front wheels and the addition of the center differential (Power Transfer Unit). The gearbox drive is connected to the hollow shaft. The hollow shaft is connected to the power transfer unit. It is here that the drive is distributed 31% to the front and 69% to the rear. The rear drive is provided by the pinion shaft which runs from the PTU back to the rear differential. The front drive is provided by a purpose built flexible drive shaft mounted inside a static torque tube. This drive shaft is connected to the front final drive unit (front differential). Drive is transferred to all wheels via half shafts. Note; Failure of a rear half shaft requires the differential locks to be engaged to move.

WARNING —
The all wheel drive system is permanently engaged and can-not be switched off. Do not allow a Carrera 4 to be tested on a 2-wheel dynamometer. This applies equally to an officially sanctioned emission inspection station or a performance shop.

CAUTION —
Do not tow a Carrera 4 with two wheels on the ground. The safest technique is to transport the vehicle on a flatbed truck or trailer.

Traction control

The traction control system is described as Porsche Dynamic Allrad Steurung (PDAS) in German language documents and Porsche Dynamic Four-Wheel Drive (PDFD) in English language documents. This form of traction control system exclusive to the 964 Carrera 4 series among the 911 Carrera series.

Note: A similar system was developed in tandem by Porsche engineering for the Porsche 928 series from model year 1990. This system was called PSD and only acted on the rear wheels. PSD (928) and PDAS (964) control units are not interchangeable.

The PDAS is a non-integral electronically controlled, hydraulically activated, mechanical locking system. This system utilises the AWD G64 transmission and the differential locks are installed into the transmission. However system failure has no affect on the normal operation of the permanent AWD. The PDAS is activated and de-activated only when required to assist in retaining traction or grip.
The system was developed from the mechanically variable differential drive control system used in the Porsche 959 with its Paris-Dakar transmission. The Paris-Dakar transmission was also installed into the 20 964 Carrera C4RSs assembled at the Porsche motor sports department at Weissach Germany.

System purpose

The primary purpose of the traction control system is to enhance the advantages provided by the permanent AWD system. The traction control system is used to positively enhance the C4s handling using the already superior traction provided by the AWD. The traction control system has two differential locks.
The longitudinal (inter-axle) which provides a variable lock between the front axle and the rear axle and
The lateral (transverse lock) which provides a variable lock between the two rear wheels.
The lateral lock is applied to reduce the danger of over steer from the ferraria effect while driving the C4 in curves. “Anti-spin control”. This function works very well, but it is not infallible. It is still possible to spin a Carrera 4 if the limits
of the system are exceeded.
The longitudinal lock is used to stabilise the C4 when it is accelerated out of a curve. If for example one axle of the C4 is on ice and the other is on a dry surface, the wheels on ice could spin during acceleration. To counter this the longitudinal lock will be activated and it will send more drive or torque to the slower turning axle (the one of the dry surface). The lock will remain engaged until equal wheel speeds are restored. The drive ratio when the longitudinal differential lock is activated can be changed infinitely from 0 to 100% or 100 to 0% in fractions of a second.

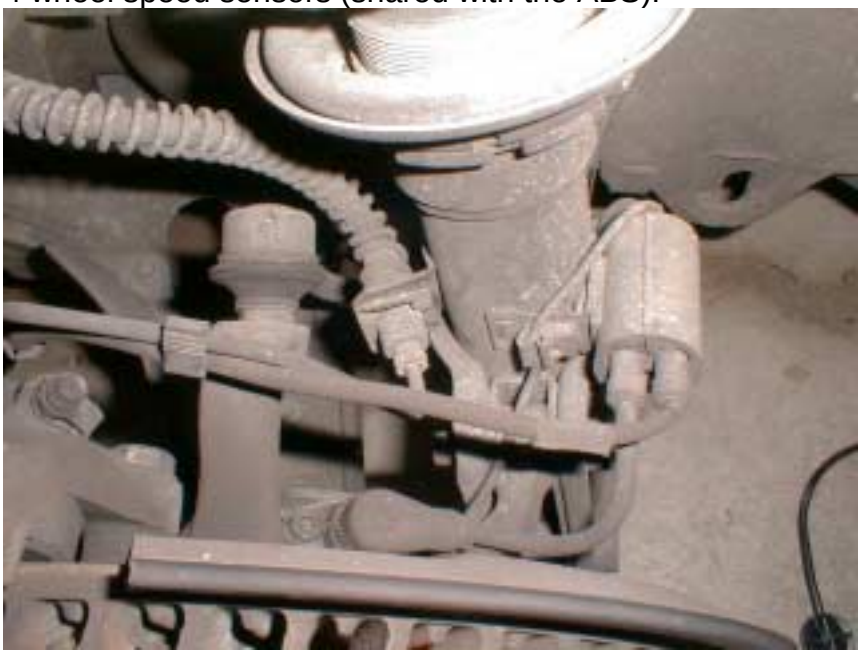
Note: If the brake pedal is depressed, the traction control system will automatically disengage, regardless of conditions.

Warning When either or both of the differential locks are activated, massive under steer will occur. It is possible to deactivate the system when these conditions are unwanted, by just tapping the brake pedal. This procedure requires practice and should not be utilised without some training in controlled conditions.

System components
Electronic control unit (shared with the ABS) located in the front right of the luggage compartment.

Note: The part number of the model year 1989 and 1990 PDAS/ABS control unit is 964 618 126 00. For model year 1991 and up the control unit part number was changed to 964 618 126 01. The –00 versions can be exchanged for a -01, but not vice versa.

4 wheel speed sensors (shared with the ABS).



Wheel speed sensor with combination plug (noise suppressor) photo by Tom Sharpes

Differential lock dual solenoid valve located behind the control unit.

Slave cylinder or differential lock actuator, one externally mounted in the power transfer unit and the other externally mounted in the rear of the G64 transmission. Mechanical actuation lever internally installed in the power transfer unit and the other internally installed in the rear differential.

Longitudinal differential lock integrated into the power transfer unit assembly.

Lateral differential lock integrated into the rear differential.

Lateral (transverse) accelerometer mounted in the centre tunnel forward of the gear stick.

Longitudinal accelerometer mounted in the centre tunnel forward of the gear stick. Used for the ABS system of the Carrera 4 only.

Note: Access to accelerometers is via a small panel on the right side of the tunnel. This panel is held in place by two self-tapping screws.

Traction control program activation knob located on the centre console.

Note: On model year 1989 C4s, the traction control activation knob is alone in the centre console. On model year 1990 C4s and up, the traction control knob is joined by the rear spoiler manual operation control knob. The traction control knob is the knob on the left.

Traction control activation indication system which consists of a yellow led mounted in the center console.

Warning system.

Under and Over voltage protection system.

Power interlock circuit (shared with the ABS)

Plumbing.

Wiring harness.

Component locations from left to right: PDAS/ABS control unit, differential lock dual solenoid valve, brake hydraulic boost pressure accumulator, ABS hydraulic unit. Photo by Yasutoshi Kikuchi

Component operation

Electronic control unit:

The electronic control unit is a small, multi-channel electronic computer. It is able to calculate from the signals received from the wheel speed sensors, speed of wheels, acceleration of wheels, speed of axles (mean value of wheel speeds) and the speed difference between axles.

The control unit contains a safety circuit which will detect erroneous signals in the electronic control unit as well as defects in wire harness and plug connections. The safety circuit also monitors battery voltage. If battery voltage drops below the specified value, the PDAS will be inhibited until battery voltage again reaches the specified value. In addition to the monitoring function, safety circuit also has an active section, the test cycle, also known as “BITE” (Built in test equipment). The test Cycle is an integrated test program that checks the control unit and the dual solenoid valve when the ignition is switched on (see beginning of this chapter to see how long the PDAS and ABS warn lamps may remain on for after engine start. A further test program is initiated at a road wheel speed of 7 kph which checks the wheel speed sensor inputs.

Wheel speed sensors:

The rotary motion of wheels is picked up by inductive sensors and sent to the electronic control unit in form of electric signals.

Speed sensors consist basically of a magnetic core and a coil. The pole piece is surrounded by a magnetic field. As the road wheel turns the teeth of pulse gears move through this magnetic field. This changes the magnetic flux and induces alternating voltage in the coil. This alternating voltage changes its frequency according to the wheel speed and consequently can be used to measure the road wheel speed.

Dual differential lock solenoid valve

This unit contains two separate solenoids. One is connected to the longitudinal lock slave cylinder and the other to the lateral lock slave cylinder. The control unit will open and close the respective solenoids to pressurise the hydraulic system to activate the locks as required.

Slave cylinder

Hydraulic force for the operation of the multiple clutch plate assemblies of each differential locks is provided by a slave cylinder.

Longitudinal (inter-axle) differential lock

Is installed into the power transfer unit. The differential lock consists of a multi clutch and friction plate assembly. The plate assembly is actuated by a lever mechanism which itself is operated by the slave cylinder. Pressure being supplied to the slave cylinder is controlled which makes the clutch application variable. One set of plates is effectively connected by a gear arrangement to the input shaft to the power transfer unit (rear axle drive) and the other set are effectively connected by another gear arrangement to the output shaft of the power transfer unit (front axle drive). When the lock is activated and the clutch and friction plates come together the rear axle and front axle are directly connected together. How much torque or drive transferred is dependent upon the hydraulic pressure being applied to the slave cylinder. Initial pressure starts at 40 bar.

Lateral (transverse) differential lock
Is installed into the rear differential assembly and is very similar in operation to the longitudinal differential lock, except the multi-plate clutch assembly is effectively connected to each rear axle.
Note: The contact pressure of both the differential locks multiple plate stacks could be so great in an extreme case, that the locking torque would exceed 1000 Nm.

Note: Differential lock clutch or multi-plate stacks
Both differential locks use the same clutch inner plates. These clutch plates had Gylon friction liner on both sides until replaced by Valeo as described in Porsche technical service bulletin 39306 issued September 1993.
The friction-lined plates or the outer clutch plates are also the same. However because they have a spiral groove for oil supply they must installed correctly because of the different direction of rotation between the longitudinal and lateral locks.

Lateral (transverse) accelerometer
The accelerometer is a simple moving mass device which provides an output of between 0-5VDC to the control unit. The accelerometer is axis is mounted at 90 degrees to normal driving line. The signal provided to the control unit provides the sideways acceleration of the C4 in a curve or the tendency to start to spin.

Longitudinal accelerometer
Is the same construction as the lateral unit but is mounted with its axis along the normal driving line of the C4. It provides acceleration and deceleration data to the ABS section of the control unit. This data is used by the ABS section of the control unit to determine if ABS or PDAS is to be used. PDAS can only be used when the C4 is accelerating and ABS can only be used when the C4 is decelerating.

Note: Whilst this accelerometer is used by the ABS section of the control unit it is included in this section because only the C4 is fitted with such an accelerometer. It is not installed on all other versions of the 964 with ABS only.

Traction control program
The traction control program is activated in the control unit by turning the knob to the right for less than 10 seconds. Activation can be accomplished from 0 to 30 kph (0 – 19 mph). Once the system is activated both the centre and rear differential locks will be engaged and fully locked. They will remain engaged until a speed of approximately 40 kph is reached. At this speed the locks will be automatically de-activated and the traction control will return to automatic mode. The driver can de-activate the system before 40 kph by turning the control knob to the left. The purpose of this system is to help dig the C4 out of deep sand or snow.

Traction control activation indication:
The yellow led used for traction control activation indication will only come on when; PDAS is in the automatic mode (normal) and when the rear differential lock only is activated or
When the traction control program is activated and it flash continuously until the traction control program is automatically de-activated or manually de-activated by the driver.

Note: C4s were not delivered with the green PDAS activation lamp installed.

Warning system.
Failures are indicated by the warning system (central informer) to the driver depending upon the system causing the problem. In the PDAS/ABS system there are three distinct failures which are indicated differently to the driver to allow immediate recognition of the problem and to allow the driver to take the appropriate action.

Hydraulic boost pressure failure;
Is indicated by the illumination of the PDAS warn lamp, the brake pressure warn lamp, the master warn lamp and the warn horn will sound. This combination of warn lamps and the warn horn tells the driver that the brake hydraulic boost pressure is below approximately 102 bar and the traction control system will not operate at this pressure.

Brake fluid level low;
Is indicated by the illumination of the PDAS warn lamp, the brake pressure warn lamp and the master warn lamp. The PDAS warn lamp is again advising the driver that the traction control system will not operate when the brake fluid level is below minimum

System failure (PDAS or ABS);
Is indicated by the illumination of the PDAS and ABS warn lamps, the master warn lamp and the warning horn will sound. This combinations of warnings advises the driver that a component failure has been detected in either the PDAS or ABS systems and that both have been disabled.

Under and over-voltage protection:
Under-voltage protection (less than 9.9VDC) is provided by the safety circuit of the control unit. An under voltage condition is indicated to the driver by the illumination of the PDAS and ABS warn lamps and the yellow traction control program led in the center console. No warning horn will sound in an under voltage condition.

Note: It is quite common to have this condition after a prolonged period of inactivity in a C4. All three lamps will extinguish at approximately 7 kph as long as the electrical system is operating correctly.

Over voltage protection (voltage equal to or greater than 22VDC) is provided by relay R34. Over-voltage is indicated to the driver by many warn lamps including PDAS and ABS illuminating. This is known as the Christmas tree effect.

Power interlock circuit
In the event of a PDAS or ABS failure the ABS valve and system power interlock relay on the ABS hydraulic unit will be de-energised and power will be removed from the control unit removing both systems from use until the problem is rectified.
Note: The PDAS and ABS are completely independent from each other. Only one system is allowed to operate at any one time. The only link between the two systems is the power interlock because Porsche designed the systems to disable each other in the event of a failure in either system.

Plumbing.
Solid metal pipe, high pressure plumbing is used to connect the brake boost pressure accumulator to the dual differential lock solenoid valve and from the solenoid valve to

each of the differential lock slave cylinders. The return pressure line is via the dual solenoid valve and then to the brake fluid reservoir.
Wiring harness.
The control unit is connected via a 55 pin connector into the C4s wiring loom system.

System description of operation:
The PDAS system requires a supply of pressurised brake fluid. This pressure fluid is provided by the brake hydraulic boost system. Pressure fluid is tapped off the pressure accumulator and supplied via one high pressure solid line to the differential lock dual solenoid valve. The pressure fluid supply is divided up inside the solenoid valve to provide pressure fluid to the longitudinal and lateral differential locks. The brake hydraulic boost system is described in chapter 7.
There are two specific actions carried out by the traction control system.
a). If the control unit recognises that a given difference in speed is exceeded by comparing the axle speeds an initial pressure of approximately 40 bar will be built up in the longitudinal lock hydraulic system and to the slave cylinder. The slave cylinder acts upon a clutch lever assembly. The clutch lever assembly acts upon the differential lock clutch plate stack. This stack consists of two sets of clutch plates. One set is connected to the input drive shaft in the power transfer unit (rear axle) and the other set is connected to the output drive shaft in the power transfer unit (front axle). As the clutch plate stack is forced together drive or torque transfer is possible from the fast rotating axle to the slow rotating axle.
If the increase in the difference in axle speed continues, the pressure applied to the slave cylinder and eventually the clutch stack is increased in steps with constant control of wheel speeds until perfect traction is reached. When the difference in speed returns to the tolerance range (0.8 kph), the locking torque will be reduced in steps by discharging pressure in the slave cylinder for the longitudinal lock
b). If there is a ferreria effect (over-steer causing tending towards causing a spin) while driving in a curve the control unit recognises this and immediately applies pressure to the lateral differential lock slave cylinder which then via the clutch lever mechanism, forces the differential lock clutch stack together which locks the rear wheels together. The under steer created by this action counters the over-steer. Application of the lateral differential lock is designed in such a manner, that the rear-end dominated characteristics of the C4 is maintained with maximum exploitation of the co-efficient of friction. Locking torque is reduced in steps once the over steer has been corrected.


Component locations from left to right: ABS hydraulic unit, Battery, Brake hydraulic boost pump. Photo by Michael Wu.

System corrections and tolerances:
The following correction factors are integrated into the control unit to compensate for differences in speed whilst driving in curves or because of different rolling radii.

Curve driving correction factor:
A correction value for the switching limit is determined in conformance with the driven radius by evaluating the wheel speed information while driving in tight curves, so that there is no premature operation of the longitudinal (inter axle) differential lock while driving slowly in a tight curve at less than 30 kph (19 mph).

Rolling radius correction factor:
The control unit calculates a “rolling radius” correction factor while driving straight ahead. This correction factor is 6% maximum.

Rolling radius tolerance:
For the purpose of explanation instead of using rolling radius data, rotations per km (mile) will be used. It is easier to work out the figures. The original Carrera 4 was fitted with Bridgestone RE71 205/55ZR16 and 225/50ZR16 tyres fitted to 6JX16 front wheels and 8JX16 rear wheels. These wheel and tyre assemblies rotated at 531 times per km (851 times per mile). This information was pre-programmed into the PDAS/ABS control unit of the C4 and the ABS control units of the Carrera 2.
In order to calculate wheel speed the control unit requires to know the distance traveled by the wheel in a specific period of time. 531 rotations in one minute gives a wheel speed of 60 kph. The rolling radius correction factor allows a change of a

maximum of 6% between the front set of wheels and the rear set of wheels when travelling in a straight line.
Note: The pre-programmed data was changed slightly in model year 1991 for the introduction of 17 inch wheels. The change was minor and makes no difference to this explanation.
Why is this important? Wheels and tyres are changed as the years go by. New 964 owners want their 964s to look more modern and kool. The original setup is either never know or forgotten. If a wheel and tyre assembly is changed to one which is outside of the 6% differential limit one of two things can happen.
a). If just the front pair or rear pair of wheel and tyre assemblies are outside of the allowable limit the PDAS/ABS or ABS control units will detect this and inform the driver by the warn system that the system (s) has failed. The most common error is made when changing the front pair of wheels and tyres. Either a wide front tyre with a too high profile or winter tyres with too high profile.
b). If the entire set of wheels and tyres are replaced with assemblies which are all outside of the 6% differential limit the PDAS/ABS or ABS systems cannot detect the change. The control units will continue to calculate the data based on the pre-programmed information. However the results of these calculations will now be incorrect. Most 964 owners install larger diameter wheels and wider tyres. This increase in rolling radius or rotations per mile will have a significant impact on the operation of the systems and in extreme cases impact the safety of the 964. The larger wheel and tyre assemblies rotate less per km or mile than before. However the system which cannot detect the problem will continue to use the original rotation (rolling radius) data for its calculations. This means that the calculated wheel speed will be lower than the actual wheel speed. The effect of this will be to delay the onset of traction control assistance and conversely will apply ABS assistance too early. Warnings related to this tolerance can be found in the 911 Carrera 2/4 and Turbo owner manuals.

ABS (anti-blocking system)

Introduction.

The 964 Carrera 4 was the first of the 911 series to be fitted with an ABS. The Porsche 928 and Porsche 944s were fitted with ABS earlier. The system installed in the 964s is based on the system installed in the Porsche 928 and some parts which make up the 964 system have 928 part numbers.
Note: The Turbo series, the turbo looks and the RS series all use the ABS hydraulic unit part number 928 355.955.00 and the Carrera 2/4 and RS America use part number 964.355.955.00

The ABS system is;
A 3-channel, 4-wheel speed sensor non-integral system. The is a channel for the front left brake circuit, the front right circuit and the rear brakes circuit.

Note: Non-integral means that the ABS is added to the brake system but the normal split brake system is isolated from the ABS in the event of an ABS failure.

Identical in operation on all versions of the 964s whether fitted with vacuum boosted or hydraulically boosted brakes system.

Why is ABS installed?
The anti block system is an important contribution to improvement of active safety In the 964 series. It prevents the locking of wheels while braking the car and therefore guarantees full steerability and directional control. In addition, the stopping distance is optimal regardless of road surface conditions. However it is still the responsibility of the driver to adapt their driving habits to the road and weather conditions as well as the pertinent traffic situation. The main advantage of ABS is in the directional stability and steerability of the in a dangerous situation which includes self induced problems namely from, panic braking especially even in curves when entering them too fast. A another advantage of ABS is the lack of flat spots on tyres from sharp braking, since the wheels no longer lock.

What does the ABS do?

ABS will start to regulate if brakes are applied in the range of locking limits
The regulation (comparable with cadence braking in very fast sequence) is reported to the driver by a pulsating brake pedal. The diagram shows the interrelation of braking force, cornering force and slip. An increase in braking force causes a very fast reduction In cornering force and consequently in directional control and steerability of wheels. No steering correction is possible when wheels have locked (100 % slip or skid). The operating range of ABS is designed to always provide sufficient cornering force with simultaneous Introduction of maximum possible braking force. ABS regulates the braking pressure In a range of 4 to 20 % slip or skid (964 moving straight ahead).

System components:

The major components are;
ABS hydraulic unit mounted in the left rear of the luggage compartment.
Note: In the 964 series the rear brake bias valve is mounted externally to the ABS hydraulic unit. It is connected between the rear brakes system outlet from the hydraulic unit and to the rear brakes by plumbing. It is not mounted into the hydraulic unit as in other applications.

Carrera 2 ABS hydraulic unit. Photo by Tom Sharpes
Note the position of the rear brake bias regulator. This is the round component on the bottom left of the ABS hydraulic unit with the pipe coming out of the top.

Electronic control unit mounted in the right front of the luggage compartment
Note: The Carrera 4 series has a combined 55 pin PDAS (traction control) and ABS control unit All other 964 series use a 35 pin stand alone control unit. The functions of the ABS section of the PDAS/ABS control unit is almost identical to the stand alone control units. The ABS circuit in the C4 also receives acceleration and deceleration information from the accelerometers installed in the C4 only. This is the ensure only traction control or ABS can operate at one time. They are not permitted to function together.


RS America ABS control unit: Photo by Jason Andreas.

Wheel speed sensors. one mounted to each wheel rotor.

Longitudinal accelerometer (Carrera 4 only)

3 Relays including one with over voltage protection installed. Two relays are mounted on top of the ABS hydraulic unit, motor control and valve control and the other is relay R34 installed in the central electric.
Note: The relay which provides the over voltage protection is R34

Warning system

Hydraulic plumbing.

Wiring

Basic component operation
ABS hydraulic Unit
The hydraulic unit consists of three fast operating electric solenoid valves and a return delivery pump. One each of the electric solenoid valves is allocated to the left and right front wheel brakes as well as the mutually regulated rear wheel brakes. The hydraulic unit can change the hydraulic pressure to the wheel brake cylinders independently of pressure in the brake master cylinder. However, a higher pressure than that of the brake master cylinder is not possible. Depending on the amperage, with which the electric solenoid valves are activated, the hydraulic pressure in wheel brake cylinders can be

“increased” the pressure building up phase,
“maintained” the pressure holding phase
“reduced” the pressure relieving phase.

Speed Sensors
The rotary motion of wheels is picked up by inductive sensors and sent to the electronic control unit in form of electric signals.
Speed sensors consist basically of a magnetic core and a coil. The pole piece is surrounded by a magnetic field. As the road wheel turns the teeth of pulse gears move through this magnetic field. This changes the magnetic flux and induces alternating voltage in the coil. This alternating voltage changes its frequency according to the wheel speed and consequently can be used to measure the road wheel speed.
Note: The 6% wheel and tyre rolling diameter differential for the PDAS traction control system also applies to the ABS system. If this differential is exceeded erratic operation of the ABS system may result.

The electronic control unit
Is a small, multi-channel electronic computer, in which acceleration, deceleration and slip values are derived from electric signals of the speed sensors and in the Carrera 4 accelerometers as well. The control unit provides control commands for the electric solenoid valves in the hydraulic unit.
The entire signal process can be divided functionally into three sections.
Signal Processing Section
The signal processing section has the task of deriving acceleration, deceleration and wheel slip control values from the speed sensor signals in a suitable form for the logic section.
Logic Section
The logic section calculates the necessary brake pressure correction in an extremely complex procedure, whereby an adapting or learning process takes place.
The logic section puts out commands for pressure build-up, pressure holding and pressure drop to electric solenoid valves in the hydraulic unit.
Safety Circuit
The safety circuit will detect erroneous signals in the electronic control unit as well as defects in wire harness and plug connections on hydraulic unit and relays. ABS is switched off when a failure is discovered. The safety circuit also monitors battery voltage. If battery voltage drops below the specified value, ABS will also be switched off until battery voltage again reaches the specified value. In addition to the monitoring function, safety circuit also has an active section, the test cycle, also known as “BITE” (Built in test equipment). The test Cycle is an integrated test program that checks the control unit when the ignition is switched on (see beginning of this chapter to see how long the ABS warn lamp may remain on for after engine start for the various 964 versions) and a further test program is initiated at a road wheel speed of 7 kph which checks the wheel speed sensor inputs.
Note: Testing at 7 km/h can be felt, because the return pump in the ABS hydraulic unit will run briefly. Very hard to hear though.

Longitudinal accelerometer (Carrera 4 only)
Note: The operation of this accelerometer is explained in the Carrera 4 traction control system section.

Relays:
The relays mounted on the ABS hydraulic unit provide interlocked power for the electronic control unit as well a power for the return motor and the commands to the solenoid valves. Over voltage protection is provided by the power distribution relay R34.

Warning system
A failure is indicated to the driver by the illumination of the ABS warn lamp coming on and the warning horn sounding.. In the event of a detected failure the ABS will be switched off and completely isolated from the normal brake circuit. This ensure normal braking systems are not affected nor degraded in any way.

Note: A detected failure of the ABS system by the C4 PDAS/ABS control unit will also result in the de-activation of the PDAS and generally vice versa unless the PDAS failure is related to brake pressure or fluid level problems.

Voltage protection specifications which activate the ABS warn lamp
Under voltage: below 9.9 VDC
Note: An under voltage condition in the Carrera 4 is indicated by the PDAS, ABS warn lights as well the traction control activation yellow led illuminated. Once battery voltage is at the correct level all these lights will go out. It is quite common to have this condition after a prolonged period of inactivity.
Over voltage: above 22VDC (regulator failure in the alternator)
Note: An over voltage condition in all 964versions will often result in more than just the ABS warn lamp being illuminated.

System operation
It is very important to understand that the ABS can only activated when the brake pedal is de-pressed and the measured wheel speed (not the actual traveling speed of the 964) is 10 kph (7 mph) or less.
The ABS system is tested every time the ignition is turned on and the 964 is driven above 7 kph as previous described, but the system is not active. The ABS power, command and over voltage relays are armed, the control unit is constantly calculating but no commands from the control unit can be provided to the solenoid valves unless the conditions for activation are met.
Under all normal conditions including normal braking the ABS system is held in the Pressure Building Up Phase. This means that the three electric solenoid valves are without electric power. Pressure coming from the brake master cylinder can be applied effectively in full amount to each brake caliper. This solenoid valve position is given for every “normal brake application”, ie; when regulation is not required. If the system fails, all three valves remain in this position to guarantee normal brake operation.

When the brake pedal is pressed and the control unit via the wheel speed sensors detects either the front left, front right or a rear wheel starting to slip the ABS will then activate. The first mode the solenoid valve or valves adopts is the Pressure Holding Phase. If the braked wheel reaches the lock limit by way of hydraulic pressure from the brake master cylinder, further pressure increase in the wheel brake cylinder will be prevented. The solenoid will receive current of approx. 2 amperes, the solenoid valve piston is activated and outlet as well as inlet of the solenoid valve are closed.

Hydraulic pressure between hydraulic unit and wheel brake cylinder remains constant regardless of the pressure being applied to the brake pedal by the driver.
Warning: If and when the ABS activates do not attempt to pump the brake pedal or to take the foot off the pedal. Once activated the driver must allow the ABS system to do its work.

If during the pressure holding phase the wheel or wheels continue to move towards a slip or a skid the control unit will then command the solenoid valve (s) into the Pressure relieving phase. A current higher than 5 amperes is applied to the electric solenoid valve which causes a greater piston stroke. The outlet of the solenoid valve is opened and hydraulic fluid flows to pump reservoir and to the return delivery pump. Return delivery pump returns the brake fluid into the brake master cylinder against existing pressure. A damper is provided in each brake circuit to suppress the delivery noise. The pump always runs during regulation, even if return delivery is not required. The switching of the solenoid valves between the hold and relieving conditions is what provides the modulating action of the brake pedal which is felt by the driver.

Once the slip or skid has been successfully dealt with, power is removed from the solenoid valve(s) and the system returns to the pressure build up phase which allows full master cylinder pressure to the brake calipers to be resumed.