928 Diagnostics

A project by:

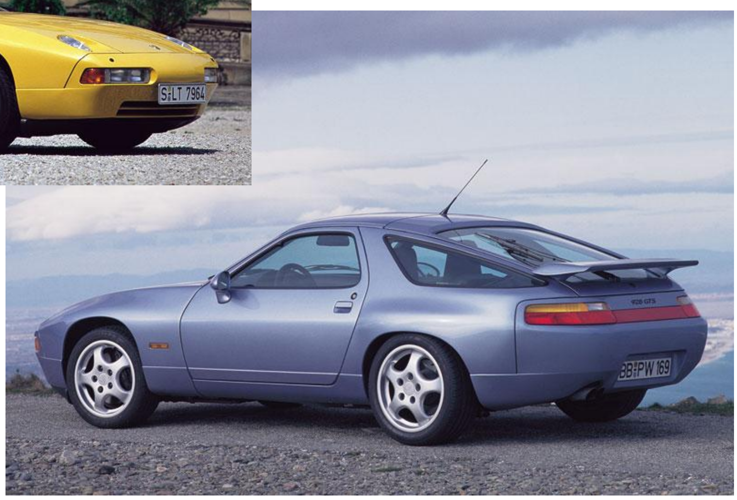
Paul Moers
Theo Jenniskens

June 2011

http://928-ecu-repair.com
http://928gts.jenniskens.eu

Index

Porsche….
There is no substitute



1. Introduction

The Porsche 928 is one of the finest sports cars Porsche ever made. It is timeless in design and one of a kind in the way luxury and performance are combined. However, this wonderful car is also a complex piece of machinery and from the moment of the first development drafts on, it was clear that electronics would play an important role in the management and controls of this car. Developed in the early 70's the car started life in 1978 as the 928. It then developed into the 928S model, the S2, S4, GT, and GTS. In 1986, Porsche started using advanced Bosch Automotive Electronics for several car functions and engine management, and in 1987 the first controllers that had internal diagnostics and fault memory were fitted.

Porsche developed a few diagnostic tools to cope with these new electronic features such as the 9268. This was a handheld device with a small display providing code messages. It used a simple binary signal to retrieve information from the controllers.
Later Bosch marketed the more advanced KTS300 (Porsche 9288) which became famous under the name of the Bosch "Hammer" because of its shape. This is a more versatile tool than the 9268 and was able to provide test signals, information, check sensor signals, and read fault codes from several models and controllers.
Porsche also developed a PST2 diagnostic PC and the Bosch KTS500 for use in their workshops. These were even more advanced and updated for modern Porsche models of today.

In 2005 Porsche 928 enthusiasts in the Netherlands under the name of "928-ecu-repair" started working on the protocols of this diagnostic system basically to understand and maybe develop an affordable and versatile diagnostic system. Because the 928s are starting to age and show flaws in the electric and electronic systems an affordable diagnostic tool was called for. These age related problems include the ECU break down and malfunctioning actuators and sensors. Troubleshooting without tools is not the easiest job. This tool was developed to solve this problem. It was developed purely from studying the system and monitoring the data. Therefore, no copyrights have been breached. It is intended for both personal use and workshops. The interface and software deals with Porsche 928 controllers dating from 1987 onwards, thus S4, GT, and GTS models.

The 1987 and 1988 models had a 12pin socket to plug in the diagnostic device. This rectangular socket was intended for the 9268 interface that was also used in the 944 models in that time. A separate cable for this version will have to be ordered.

In 1989, Porsche redesigned the diagnostics wiring loom and fitted the 19pin diagnostics connector socket under a cover at the passenger side seat. (LHD)

The 928 Diagnostic Software connects to these interface connections, and communicates with the following 928 controllers (if fitted):

- LH, injection controller;
- EZK, ignition controller;
- RDK, tire pressure controller;
- ABS, anti locking brake system controller;
- PSD, Porsche slip differential controller (built inside the ABS box);
- Alarm, alarm and central locking controller;
- Airbag, then airbag controller.

Diagnostic Capability by Model Year

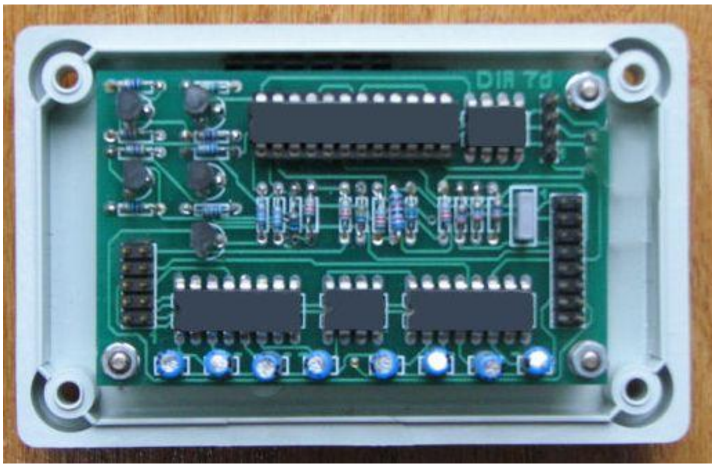
Year	Controller Installed with Diagnostics Functions? (Yes/No)							Diagnostic Port Connector	
	LH	EZK	RDK	PSD	Airbag	Alarm	Digital Instru-ment Cluster [2]	19-way	12-way
1987	Yes[1]	Yes[1]	No	No	No	No	No	No	Yes
1988	Yes	Yes	No	No	No	No	No	No	Yes
1989	Yes	Yes	M482	No	No	No	Yes	Yes	No
1990	Yes	Yes	Yes	Yes	US only	No	Yes	Yes	No
1991	Yes	Yes	Yes	Yes	Yes[3]	Yes	Yes	Yes	No
1992	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
1993	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No
1994	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No
1995	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No

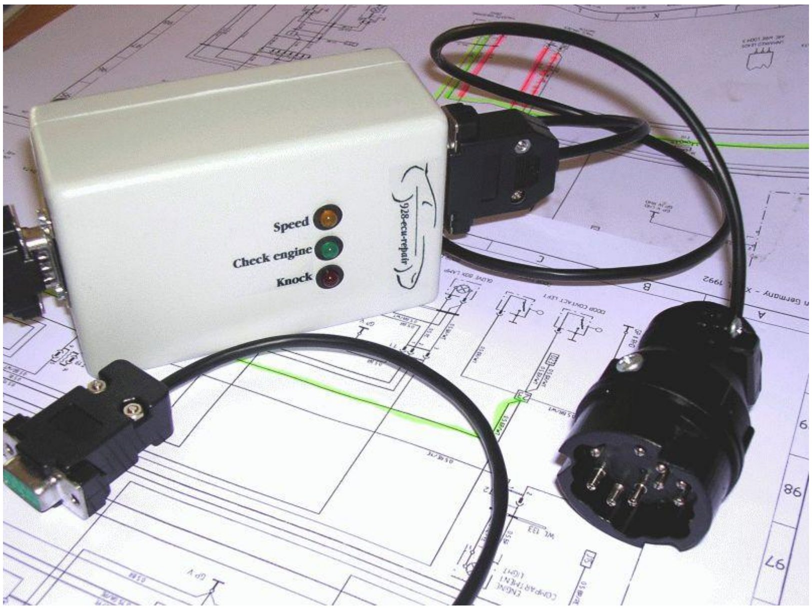
Note 1. The late 1987 model was the first 928 with diagnostic capabilities. Diagnostics are only possible if the ecu says DIA on the label or with updated firmware, which brings the ecu up to 1988 standard with the DIA features.

Note2. The digital instrument cluster comes in different software versions K25-K29 with different capabilities.

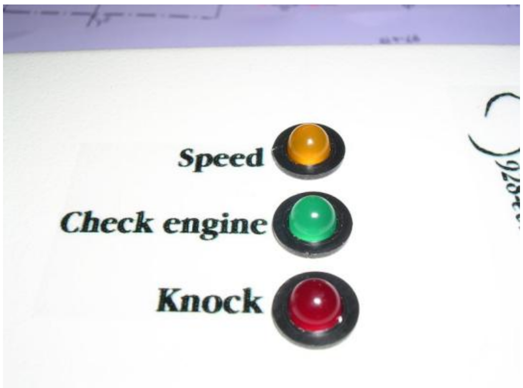
Note 3. The airbag was an option for the left hand steering 1991 models in RoW and standard in the 1990/1991 US/CDN models. In feb 1991 it became standard. Since Porsche changes MY series during summer vacation, you might see an early 1991 without an airbag and a late one with Airbag.

This document describes the software and functions used in the Porsche 928 Diagnostic System.





Interface module DT9xx.



LED’s on DT9xx.

2. General

The diagnostic system consists of a cable between the diagnostics port of the 928 and the interface box plus a cable to the PC-RS232 or -USB port, and PC software.

Important: There are two PC based diagnoses products in the market:

1. The first series is the **DT9xx**. This series is based on PC-RS232.
2. The second series, the **UDT999**, launched June 2011 is based on PC-USB port.

The software on PC is able to cope with both series!

We have been working long and hard to make this software and develop the interface. To prevent someone from stealing and reverse engineering we decided to protect the software. This protection links software and hardware together as a unique pair. You are free to install the software on more than one PC but the software will only work with the one specific interface it is linked to.

2.1. Requirements.

The software is very dependent on a good working PC that has a constant performance. This is due to the nature and design of the serial bus in the windows operating system. Therefore using software that runs simultaneously while the diagnostic system is running, is *not* recommended as this may cause transmission errors and hang-ups.

A basic PC or notebook is required using Windows 2000, XP, Vista, or Windows 7 (32/64) operating system. Other versions are not supported. We recommend a 1 GHz CPU to ensure good stability of the 928 Diagnostics program.

For **DT9xx** series a serial port is required too, but since some newer notebooks lack a serial RS232 port, we have successfully tested a USB to Serial converter, which we can optionally offer. Due to the many compatibility problems with USB converters on the market, we only offer support for the one that we offer.

or

This converter is capable of transferring at 600kbit/s and uses the FTDI chip. This ensures full compatibility with RS232 devices. It is compatible with Windows 98/2000/XP/Vista/Windows7 (32 and 64bits). We have experienced USB converter problems with very slow PC's, so a 1 GHz CPU is recommended.

The **UDT999** has already a USB connection towards PC so the user does not need an additional converter (in fact the converter is build in the UDT) but can use the driver of the converter.

Despite meeting system requirements the diagnostic system software may sometimes experience trouble connecting to any ECU.

This is not a bug in the program but a communication design issue. To cope with this, you will notice that each module test handles 3 retry's before announcing a failure to connect. Switching the ignition off and on again or manual retry using the connect button may be required upon a failure to connect.

2.2. Installing the software

In the package you will find a CD containing the software and a driver CD if you choose to have also the USB option. We also have the latest software, driver and documentation available for you to download from our forum server. Http://forum.jenniskens.eu

If the USB-converter plus USB-driver (for DT9xx series) or USB-driver only for UDT999 series is used, you will need to install the supplied driver first, which is on the CD. This is done by either executing the driver install program (like FTDI driver CDM 2.02.04.exe) or using the software from the CD that was in the USB converter package. New versions of windows (like windows7) offer a driver search on the internet which may install the driver automatically for you. To install the software from the CD, put the CD in the drive, connect the USB converter, and wait until windows says it has found a new device, and it then automatically finds the drivers on the CD. The CD can then be removed.
The virtual comport driver (VCP) translates the USB signal to a new comport device on your PC. The com port is typically not the Com1 port (default setting) but on Com4 up to Com9. Many laptops have a built-in modem configured for com1 or com3. You will not get an error message from the DT928 system, but the tool tries to connect to your modem instead of the USB-Serial adapter located on Comport 8 or 9. This is a common mistake.
From the Windows Device Manager screen, select "View devices by type", then "Ports (COM & LPT)". Select the USB serial port and click Properties. Select the "Port Settings" tab, then click Advanced. Choose the required COM port number from the list and click OK. Please refer to chapter 9.1 for more info.

Installing the software form the CD or the download is very easy. There are two ways, Manual, or Automatic install:

1. Manual: copy the directories from your CD onto your hard drive in any preferred folder. Make a shortcut on your desktop to run the executable program, or use windows explorer to navigate to the program. Uninstalling is simply deleting the directories and shortcuts.
2. Automatic: run the setup “setup_DT928.exe” or “setup_UDT999.exe” which is located in the CD setup folder or on the downloaded files. The setup contains all the necessary files in itself so none of the other files is needed anymore. Upon activation of the program, it starts and shows an installation routine that takes care of everything for you, and sets up the system. It also creates an un-install option to easily remove the program from your system if needed.

One common mistake is running the software directly from CD. That will not work. The program writes in the config file and creates log files. Those will not be successful on a CD which is a read-only device. Use either option 1 or 2 to install properly.

2.3. Connecting the System

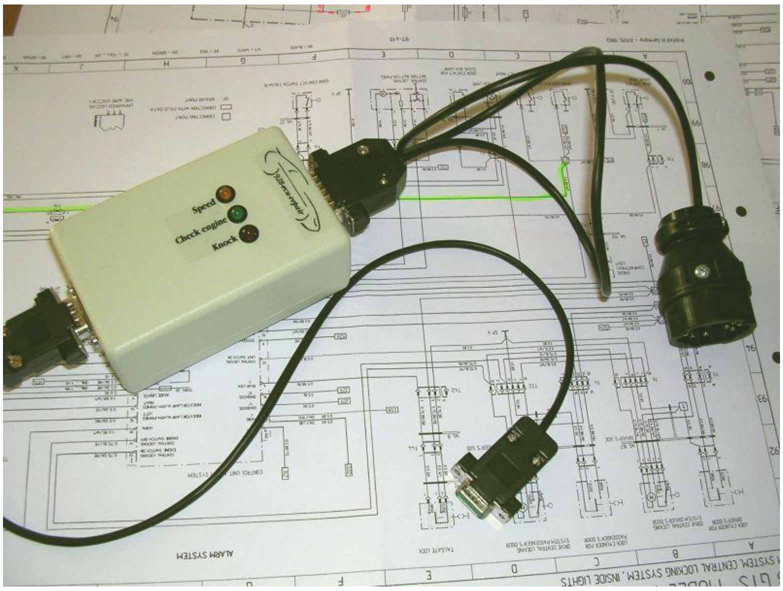
Power to the interface is provided by the car, and is active when the car's ignition is switched to the on position. Power consumption is minimal and it will not drain the battery.

The interface box **DT9xx** also shows LED's for signals. The Red LED is for the "knock" signal, Yellow is "Speed", and Green is "Check Engine" signal.

The interface box **UDT999** also shows LED's for signals. The Red LED is for "ignition on" signal, Yellow is "Speed", and Green is "Check Engine" signal.

These signals will be explained in more detail in the next chapters.

From the '89 models onwards an electronic dash is fitted in the 928, which is capable of displaying some diagnostic information and providing some test functions. The 928 Diagnostics software enables you to switch on the special diagnostic mode in the electronic instrument panel.



Interface module DT9xx with cables connected.

Interface module UDT999 with USB connection.

The interface cable DT9xx to the 19pin diagnostic socket

We decided to connect both PC cable and diagnostic port cable plug into the interface box connector, which makes it very versatile. It enables you to also use a specific cable for the 12pin rectangular socket (1987/1988 model 928s4, similar to the 944s2).

This is the 12pin diagnostic cable for the 1987/1988 928 models.

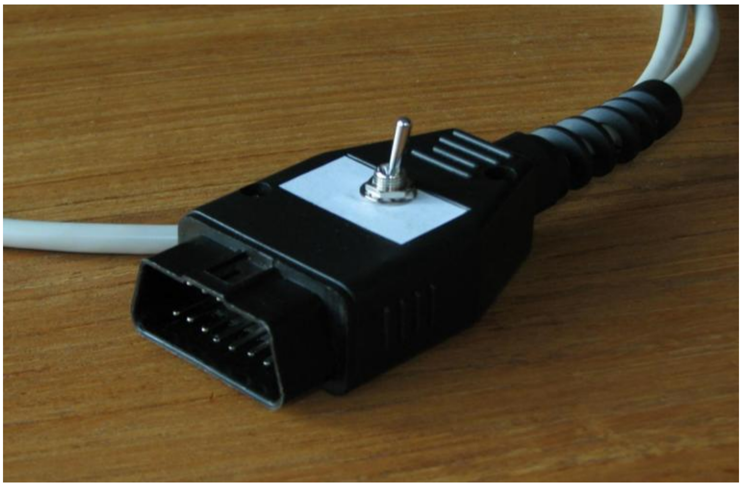
Finally the serial 9-pin serial cable (for DT9xx series) connects the diagnostic interface to the PC-COM port or USB cable (for UDT999 series) connects the diagnose interface to the PC-USB port.

Default comport setting in the software is com1, but your specific situation may vary and require adjustment. Please refer to chapter 9.1 for setting and testing the comport.
One good check to do now is test if the communication to the ecu's in the car is setup. This can be done by the following procedure:

- Connect the interface and PC , connect the interface to the car.
- Start the software and go to the settings tab.
- Switch on the ignition. The green light will probably go on.
- Verify that you have switched to the correct port.
- Push the K-line button. This triggers the K line to switch state, which should be reflected on the left field showing a response from the system. A response indicates a working communication over the configured port, no more. This is a very useful test to verify serial port communications.

Porsche 993 series:

Both diagnose tool series are capable to work with the Porsche 993 '> 95'. But these Porsche series has a different connector. These cars use an OBDII-16P connector. The second difference between this type of car and previous model the 993 '< 96' is that this model has **two K-**lines (two diagnose buses). Some ECU's are connected to the first bus and some to the second bus. That is the reason why there is a small switch mounted on the OBDII-16P connector. If the user is not able to connect to a certain ECU, set the switch to another position and the other diagnose bus of the car is now connected to the UDT999 or DT9xx series. Try again to connect.



This is the 16P-OBDII connector with on top a switch to select one of the two diagnoses buses.

The following ECU's in the 993 are connected to the K bus (pin3 of OBDII):

➔ Airbag, Tiptronic, ABS, Climate and Alarm.

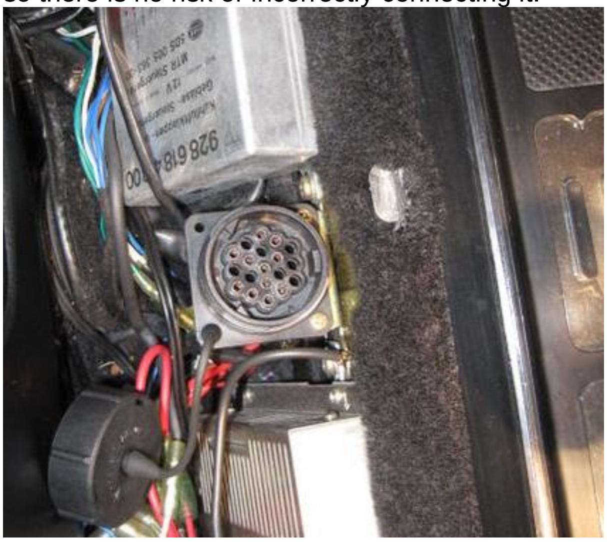
And which ECU is connected to the other K-bus (pin7 of OBDII):

➔ Motronic.

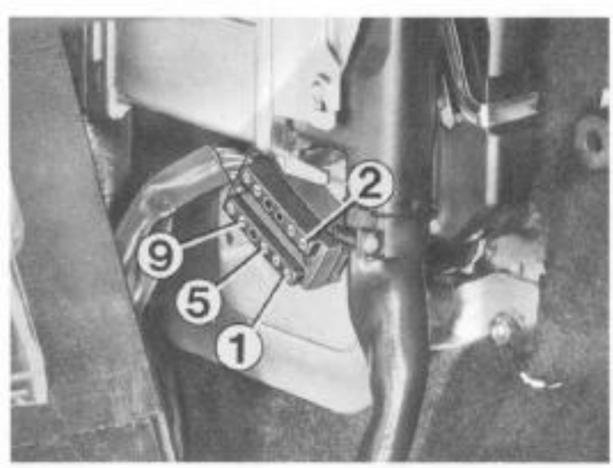
2.4. Locating the diagnostic port in your car

The early 928, MY 1987 and 1988 have a 12pin rectangular diag port connector and all 928 models starting 1989 have a 19pin round connector.

The 19 pin cable is connected to the diagnostic port under the side cover next the passenger seat. This cable only fits in only one way so there is no risk of incorrectly connecting it.



The 12 pin socket is located on the ecu mounting bracket very close to the EZK ecu.



The optional 12pin rectangular cable has numbers on the socket assembly that provides orientation and proper installation. Please be aware that the connector must only installed in the correct way. The pins in the connector must match the ones in the socket. It is as simple as that.

2.5. Using the software.

You will notice that each screen has a help button in the lower right corner which is “generic help”, and each tab has a help button too, which provides “specific content help”. When you press the help button, a help window opens with information very similar to content of this manual.

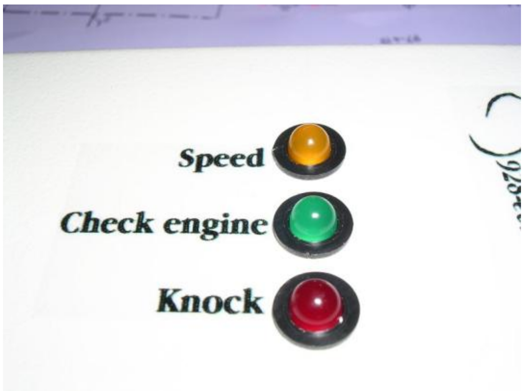
- **It is best to start the program and have it running on your PC prior to switching on the ignition of the car.** It does happen sometimes that the ecu's of the car get into an undefined state and refuses to communicate. Turning off/on the ignition will resolve this, but starting the software first does prevent it.
- When using the software you need to bear in mind that the electrical power consumption of the 928 is substantial, and a battery is easily depleted when the engine is not running. Deep discharge of a car battery is bad for its condition and is irreversible. Therefore, you should minimize the time that the ignition is turned on when the engine is not running. Again, it is not the DT928 system that depletes the battery, but it's the car's electrical system.
- The dialogue between car electronics and the software is timing dependant. Do not run any software on the PC simultaneously as this may interfere with diagnostic software and trigger communication errors with the interface and ECU's.
- Moving windows on screen during PC-ECU communication may cause communication errors and may even cause hang-ups of the software. Restarting and reconnecting should fix this.
- If you have a 928 with a digital instrument cluster (89 onwards), the instrument panel will initially show "diagnostic connector attached" when powering up. This is normal behavior of the software communicating with the instrument cluster. A small modification is possible to the early interface units to prevent this. See the documentation on our server.
- We have seen error reports while communicating, related to a broken fuse on one of the ecu's, basically a missing 12v power to the ecu. But any defective ecu may do the same. Since the diagnostic system of the 928 is designed as a bus structure, a failure of one ecu can cause errors in communication to any other (perfectly good) ecu. The error typically reports like "@ERROR BLOCKLENGTH=0xfc" and "@ERROR 0xfc during transmission detected, expected EOM". These messages indicate data link interference of some sort. Resolve by unplugging all the ecu's and switch them on the bus one by one, thus identifying the problem maker.
- If you connect or disconnect the diagnostic system to your car while the engine is running you may experience stalling of the engine. This is caused by the many interrupts that happen when you slide the connector into place. The hundreds of triggers are just too much for the ecu's to handle and the ecu's will stop. You have to restart your engine to resolve. We recommend that the connector is inserted before starting the engine and removed when the engine is shut off.

2.6. Interface module lights

The 928 diagnostic system has three LED lights mounted in the box. The lights represent the following signals:

- Yellow: Speed. This is the output of the speed sensor mounted on the center-top of the flywheel. It flickers when the engine is running and is almost steady on when you are driving. When starting you should see the light flash slowly as the engine is turning very low rpm. Absence of the flashing light is a malfunction and will block the car from starting.
- Green: Check engine, warning signal from the ecu's reporting the MIL code. See next chapter for explanation.

- Red, for DT9xx series: Knock, the knock signal is shown by turning the led on. It lights up briefly, as the knock signal only exists for a very short moment.
- Red, for UDT999 series: Ignition on.

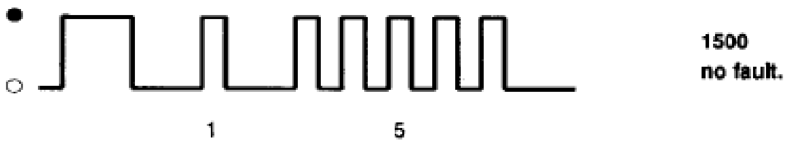


LEDS on DT9xx series.

2.7. Check Engine code

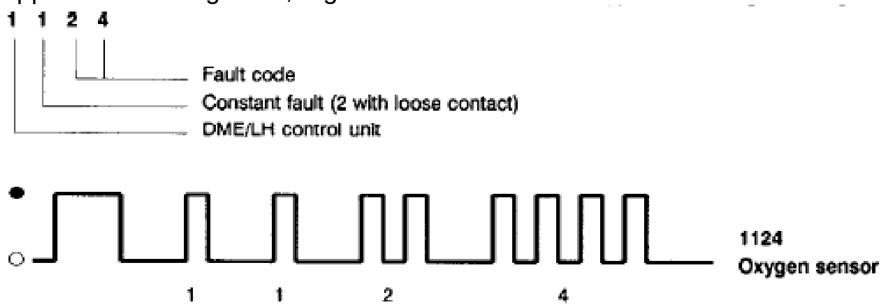
The 928 has two ways of signaling fault conditions: using the check engine light (flashing) or via the bus communication (DTC codes). The “check engine” signal was the first possibility for automotive electronics to report trouble. The MIL (Malfunction Indicator Light) was introduced. From 1991 onwards Californian legislation prescribes a warning lamp which lights up if a part relevant to the exhaust gas fails. The DTC code was then developed to provide this information and became part of the latter OBD (on Board Diagnosis) systems. In model year 1987 Porsche introduced the first DTC capable ecu’s in the 928s4 models.
Our software reports the DTC codes. You have a “check-engine” light on the interface module that also reports the flash code. Generally speaking, the check engine is the same code as the last two digits of the DTC code. Not all codes are communicated via the check engine feature.
When powering on the interface module by switching on the ignition, the check engine may light up until the interface is connected with the controller. The ecu then controls the check engine light.

The interpretation of the flash signal is explained in the workshop manual vol 1a, page D24/28-29. A short summary:
As a function check of the warning lamp, it lights up when the ignition is switched on and goes out once the engine is running when this is started without depressing the accelerator. The warning lamp has a flashing code to indicate a defective fault path.
To trigger off the flashing code, fully depress the accelerator pedal with the engine off and the ignition on for 3 seconds until the Malfunction Indicator Lamp flashes. Then remove foot from accelerator. (Be aware: not all 928 models support this function)
If no fault is recorded, i.e. no warning came from the indicator light, there appears the flashing code



○ = Lamp-on ● = Lamp-off

If the warning light did indicate a warning, i.e. there is a fault, there appears a flashing code, e.g.



The check engine light can also be taken directly form the LH ecu pin 22. This is the signal linked to the MIL is presented in your 928 model. You can add a 12v LED to show it if required.

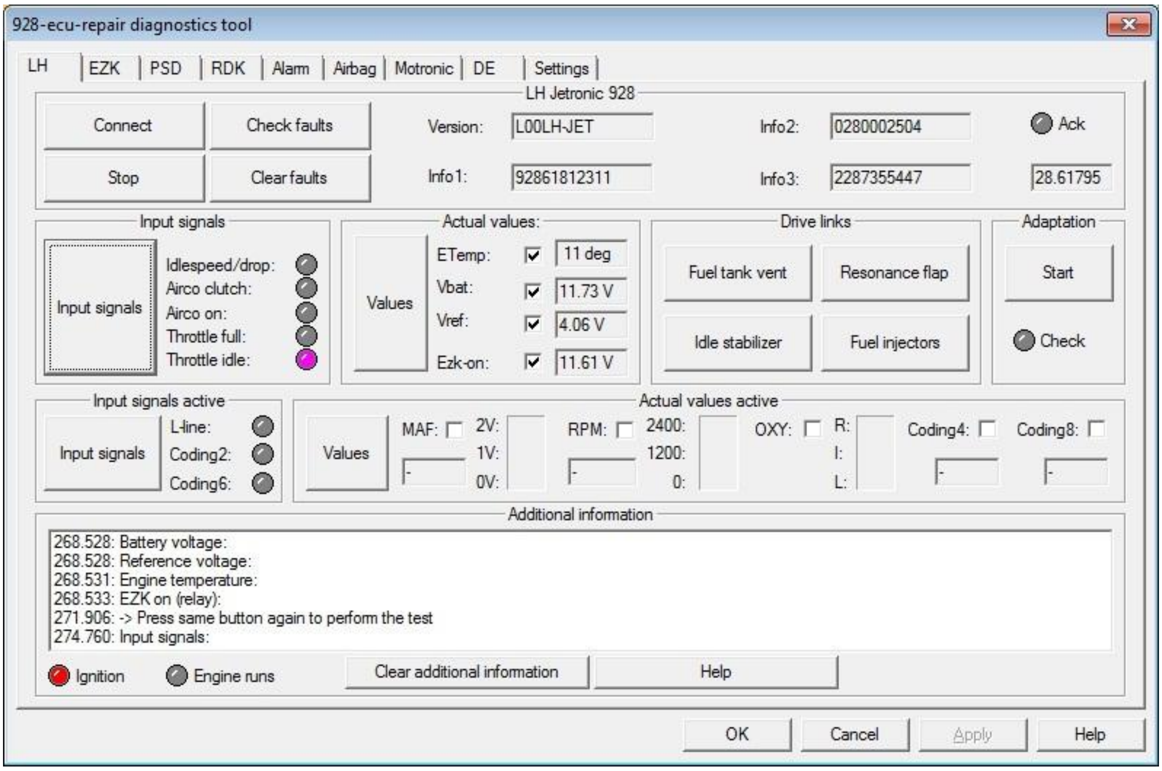
2.8. Safety issue

The diagnostic interface and software communicate with the controllers and are able to exercise functionality inside the controllers. It is also possible to start the engine, put the car in gear, and perform some tests while driving. This creates a serious risk. If the diagnostic test triggers the ecu to behave unexpectedly, a harmful situation can develop. Sound advice is to keep the car in neutral or park gear when the engine is running, or drive in a safe environment.
To avoid accidents, we strongly advise not to drive the car with a laptop on the passenger seat and watch the diagnostics while driving. Get help from someone to drive your car while you watch the diagnostics on the PC perform.

2.9. Multi Lingual version

The DT9xx and UDT999 system comes in a multi lingual design starting version v178. This means that the settings tab offers functionality to change the language from English to your preferred language. For the sake of clarity all screens in this manual are shown in English, but you will see in the settings chapter that you can change this to your own likings.

3. LH injection controller



Introduction

The LH controller tab of the diagnostic software starts when the software is run for the first time. The LH controller is responsible for the fuel management in the 928, and takes care of injecting the correct amount of fuel through the injectors at the correct time. To be able to do this, the computer inside the LH module evaluates sensor readings from the MAF (airflow sensor), the Lambda (Oxygen sensor), the EZK (ignition module) and the Temp II sensor (engine temperature).

Interrogating the LH controller creates an extra load on the small CPU power inside the LH controller. Therefore, you will experience that the LH controller will have difficulties connecting when the engine is running. Unstable idle when the engine is running is normal behavior. The LH will stop working with the tool connected at approximately 2500rpm. The engine will stall. At standstill with ignition switched on you should not see any difficulties.

As mentioned before in §2.4, it is best to start the software prior to turning on the ignition.

The following is a brief explanation of functions and controls:

Ignition light:

If 12v is supplied through the car (ignition switch turned on) the light will show red and signals that the system is ready to accept commands.

Engine runs

The light turns blue when the controller knows that the engine is running. This is just verification.

Clear additional information

The diagnostic software is designed to show information on what is actually happening while communicating with the LH ecu. Mostly this will present quite technical information but you will recognize some state and self-explanatory messages that may help and guide diagnosis. All other information can safely be ignored. By pushing the “clear additional information” button you simply wipe the log on the screen.

Connect to LH

When the command button is pushed the software tries to connect to the LH ECU, and tries to retrieve LH version, PCB number, Part number and Software version. All this information is stored in the firmware (software) of the LH controller. If all is o.k., the information will show in the appropriate fields in the screen. This is also verification that communication with the ECU has been established. The system is designed to retry 3 times if a failure to connect exists.
If it still failed to connect, the message "Cannot connect to LH, turn-off and -on the ignition and try again" appears.

These figures will show up on your screen depending on the model year of your car:

1987	S4	L00LH-JET	928.618.123.10	0.280.002.504	2287355832
1988	S4	L00LH-JET	928.618.123.11	0.280.002.504	2287355447
1988	CS/SE	??	928.618.123.12	0.280.002.506	??
1989/90	S4	L01LH-JET	928.618.123.13	0.280.002.507	2287356487
1989/90	GT/CS	L01LH-JET	928.618.123.14	0.280.002.506	2287356486
1991	S4	L01LH-JET	928.618.123.25	0.280.002.508	2287356877
1991	GT	L01LH-JET	928.618.123.26	0.280.002.509	2287356878
1992/95	GTS	L01LH-JET	928.618.123.30	0.280.002.514	2287357477

Stop

This stops the communication with the LH controller. The Ack signal will stop flashing, and the package counter stops incrementing.

Ack

The Ack (acknowledgement) light is blue when active and signals communication of data between controller and software. It is normal that it blinks during a session. Just below the light, a communication indicator is shown which displays the actual bytes per second data transfer to and from the ecu. If this indicator goes to zero during a session this indicates that communication has stopped. If this occurs, then restarting the communication should resolve this.

Fault memory: check faults

Using this button will interrogate and display the stored fault codes of the LH ECU. If the system reports an “unknown fault”, the message "Please send the information CMD + Data on screen to 928-ecu-repair@hetnet.nl" appears. Please inform us and we will get in touch with you. We will try to diagnose your problem and provide a software upgrade if required.

Fault codes that may be presented by the 928 Diagnostics system are listed below. Additional information regarding DTC codes and troubleshooting can be found in the WSM, Vol. 1A, page. D 24/28-1 through D 24/28-29

928 Fault Memory of LH control Unit

DTC Code	***WSM Ref Page***	***Test Point***	***Description***

1_11	D 24-11	1	Power supply voltage too high/too low LH control unit
1_12	D 24-11	2	Idle speed contact (ohm) short to ground
1_15	D 24-12	2	Open circuit (ohms)
1_13	D 24-13	3	Full load contact (ohms)
1_14	D 24-14	4	Engine temperature sensor II (ohms)
1_21	D 24-15	5	Air Mass sensor
1_22	D 24-16	6	Idle speed control (V)
1_23	D 24-17	7	Oxygen regulation (rich)
1_24	D 24-18	8	Oxygen regulator Control (lean)
1_25	D 24-18	9	Oxygen sensor – Open circuit
1_31	D 24-19	10	Injection circuit shut down
1_41	D 24-19	11	Defective control unit

Fault memory: clear faults
Using this button will send a message to the LH controller to clear all stored fault codes in the LH controller.

Input signals
This button starts the checks of sensors and displays their current state by turning on or off the adjacent blue light:

- **Idle-speed drop.** This signal is required for the automatic transmission version of the 928. When the transmission lever is in any other that P or N position, a signal is sent to the controller that the idle speed should be lowered 100-200rpm to avoid overheating of the transmission oil. Therefore, the light should go on when the lever is in R-D-3-2 position and off in the P-N position.
- **Airco clutch.** This light signals that power is applied to the Freon pressure switch which feeds the power to the AC compressor clutch, and thus the compressor is actively running and driven by the engine drive belt. By pushing the AC button, the AC clutch is energized via the relay in the AC console. It feeds the evaporator freeze (ice) switch that connects through the pressure switch in serial with the clutch coil. The AC clutch signal that you see is read from the LH ecu electronics, and represents the voltage between the ice/freeze switch and the low/high pressure switch. It is interconnected on the CEB. So you will see this light go on if the AC button is pushed on, the console including the relay works, the freeze/ice switch is closed (no ice), and power is applied to the low/high pressure switch. If that one is closed too (no low pressure and no high pressure), the clutch engages. The high/low pressure switch is located on the side of the drier. The air conditioner compressor is switched off via this switch when reaching a pressure of approx. 27 bar or a lower limit of approx. 2.2 bar. (just to avoid confusion: there’s also a high temp switch mounted on top of the AC dryer, but that only signals the cooling fans to go to full mode via the fan controller and is not part of the clutch system)
- **Airco on.** This light signals that the AC button on the dash is pushed and therefore the system is supposed to go active. It is however possible that other switches (like freeze or low pressure) prevent the system from going active. The signal AC on is read from the LH ecu and represents the voltage of the AC-relay output that feeds into the freeze switch. It signals only that you have the system is powered on.
- **Throttle full.** This light signals that the gas pedal has opened the throttle valve under the intake to its wide-open position and activated the micro switch at the valve (switch closed). This switch is also called the WOTS, the Wide Open Throttle Switch. Worth mentioning is that WOT starts anywhere from about 2/3 to 3/4 throttle as far as the switch is concerned. If

full load switch is faulty, always open, there will be no full load enrichment. If full load switch has a short circuit, enrichment will be too early and consequently fuel consumption too high. The ecu will also retard the ignition 10 degrees upon full throttle signal. There is a slight possibility that extensive full throttle operation, but without the switch closing, could result in engine damage on some earlier LH engines. Later engines have the knock sensors to help avoid damage, and the LH automatically enriches the mixture when it sees open throttle operation.

- **Throttle idle.** The light signals that the gas pedal is in idle position and the throttle valve under the intake is closed. This activated the micro switch (closed) at the valve. If idle speed switch has a break, there will be no coasting shutoff. If idle speed switch has a short circuit, there will be a single cut out at high idle speed. One additional note: the idle switch will move the ignition (EZK) to the idle map, 10˚ BTDC. To improve throttle response, the ignition is immediately advanced when the idle switch opens.

Actual Values:

You can select each value you want to monitor by tagging the check box on the appropriate field. You can select more than one field if you'd like. Tagging many options at once however will slow down the update. A log file is created and each field is presented in this log file. This makes importing it into spreadsheets or databases easy. By pushing the Values button, the process of acquiring the actual values is initiated, and it can be stopped by pushing it again. Each field is now discussed in more detail:

Actual Values: ETemp

This value represents the engine temperature as seen by the ecu. The data is derived from the Temp II sensor which informs the ecu about the temperature and the required mixture enrichment to keep the engine run smooth when cold. The ecu picks up the signal from the double temp-II sensor (one part is LH and one is EZK) and feeds it into a analogue/digital converter. The output of that converter is shown on the screen. The value is depending on temperature conditions locally, but 15-30C is a normal value when cold. One thing that is remarkable but normal behavior: the temperature starts off at 75C or so, but as soon as the engine starts to warm up it calibrates to the correct value and gradually climbs up as the engine warms up.

Actual Values: Vbat

This value represents the measured battery voltage. This is a more precise measurement than the gauge in the dash, as the ecu converts the operating value into a digital output. A typical value is 12.0 volt with engine off and 13.2 volt when the engine is running. A low voltage may cause the ecu to reset and cause erratic behavior.

Actual Values: Vref

This voltage represents a internal reference voltage which the ecu uses to precisely manage the fuel mixture. It is part of the lambda closed loop system. A typical value should be 4.00 volt. Any value which is substantially different will cause the system to deliver a wrong mixture and may cause engine damage, high CO values, as well as erratic behavior like severe idle surge and stalling.

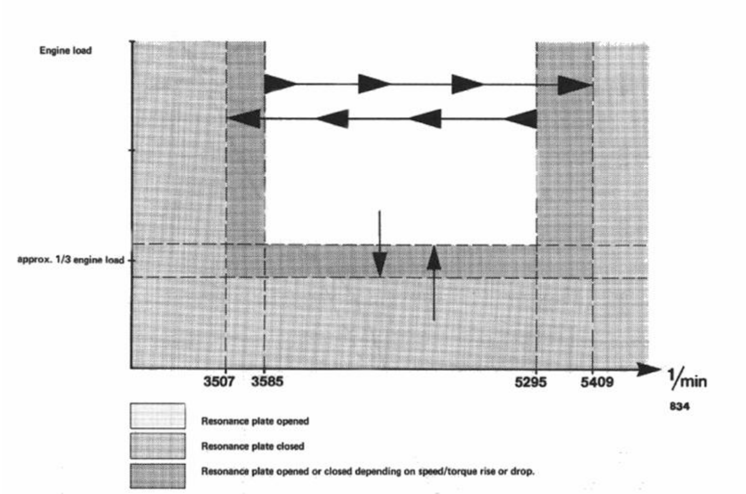
Actual Values: Ezk-on

This voltage represents the signal that is sent from the EZK ecu to the LH ecu to switch it on. Remember that the EZK will have to be operational and ready before the LH will become active and is able to start fuel injection. Obviously, this signal needs to be active (12v approximately) or the LH will not work and the engine will not start. The normal voltage is 12v, and may differ a bit from the Vbat which you see on the same screen. As soon as the ignition is switched on and the tool is connected properly to the LH (communication running), You should see a 12v signal here.

Drive Links:
Fuel tank Vent
The 928 has a fuel tank breather system. This system prevents fuel vapor from escaping to open air. A carbon canister is part of this system and absorbs excess vapor. These filters have to be purged from time to time. The 928 has an automatic system for this. In order to meter the additional fuel quantity correctly that is drawn off from the carbon canister after evaporation has occurred, a solenoid valve is fitted in the line.
Operation: A diaphragm valve controlled by the throttle valve is located in the line off the carbon canister. This valve is operated by the LH ecu when the engine is at operating temperature. At idle, no vacuum is applied, and the valve is closed. When the throttle valve is opened, vacuum is applied at the diaphragm valve, causing the valve to open and allowing the gases to escape to the diaphragm valve. This valve is timed by the LH control unit with a frequency of 6 Hz.
Similar to the trigger signal of the injection valves, the duration of this signal is dependent on the intake air flow rate. When the intake air flow rate is low, the tank ventilation valve receives only a short timer signal, when flow rate is high, the timer signal length increases. This ensures that the correct purge air quantity is added in accordance with the intake air quantity.

Testing this system is done by activating the switch. A faint click can be heard at the valve, just in front of the main windscreen washer tank. The test repeats itself every second until another function is selected.

Resonance flap
The V8 engine in the 928 is not using a balanced firing line a flat 6. Have a look at the firing order. This changes the airflow resonances in the intake. What you're aiming to do is match the natural frequency of the container, which in this case is the system of plenum and intake runners, to that of pistons (or the air charge within the cylinder) but also allowing for the valve timing. The Porsche 928 S4 uses a twin plenum set up connecting up equal phase cylinders. The twin plenum set up balance pipe is usually closed, acting as a twin plenum at low speeds, then opens in the mid range only two become a twin plenum again about 3600 rpm.
The 928 S4, GT and GTS use a resonance flap in the intake manifold balance pipe. Between 3585 and 5409 rpm, the ecu activates the resonance flap. This changes the internal airflow in the “high rise” manifold. By doing this, the airflow is optimized for the lower and upper rpm ranges providing the linear power curve that the 928 is famous for. At 3585 rpm and 1/3 of the load signal, the LH controller sends a signal to a relay in front of the driver-side cylinder bank, which applies vacuum to a vacuum actuator located underneath the intake manifold. This will cause the “flappy” valve to turn 90 degrees. At 5409 rpm it closes again. To avoid oscillation, it has a configured hysteresis. Here’s a picture:



A system functional test is performed by clicking on the button “Resonance Flap”. This action can be heard as a rather loud click in the intake body, and seen when you remove the rubber cover on top of the intake manifold. It helps to make a marker on the axis of the flappy or attach a magnetic pointer. You will notice the axis of the flappy valve rotate 90 degrees. The test repeats itself every second until another function is selected.

Another test: the flappy is activated briefly, just once, every time the engine is started. You can verify this.

One thing to keep in mind: the actuator operates on vacuum from the vacuum booster. If the system has a severe vacuum leak, the vacuum contained in the system will diminish rapidly and leave the actuator inoperable. This is obviously not a fault in the actuator itself, but in the vacuum system.

Even despite of a running engine, there is sometimes not enough vacuum to engage the system when severe leaks in the system exist. The vacuum actuators in the dash are a commonly seen cause for these leaks. To check for a flappy actuator leak, attach the vacuum from the plenum directly to the flappy vacuum line (the one that goes under the intake from the vacuum relay in front of the coolant temp sensor). When actuated, pinch the supply hose (rubber) and thus remove the vacuum source. The flappy should hold position.

Idle stabilizer

The 928 has an idle management system that provides a managed idle control by applying a bypass air stream over the closed intake valve. This is the IACV, the **I**dle **A**ir **C**ontrol **V**alve, sometimes also called the idle valve or the ISCV, Idle Speed Control Valve. At idle, the throttle idle switch is active, and the system knows it needs to take control of stabilizing the engine rpm at approx 700. The LH ecu sends a signal to a rotary valve that opens the airflow in the valve-bypass hose. By modulating this 12v signal, the amount of air is regulated and thus the idle rpm is managed. Clicking on this button sends an impulse to the ecu to fully open and fully close the valve. A clear and loud click can be heard under the intake. This is proof that the valve opens fully and closes again after (spring loaded). The LH is unable to find out if the valve is really fully open as the valve is not equipped to provide electrical feedback. This audible feedback is your proof that it works. It should be a clear, regular sound, same pitch over and over. Hesitations could indicate that the valve gets mechanically stuck or doesn’t turn smoothly.The device is operated electrically and does not require vacuum.

The test repeats itself every second until another function is selected.

Fuel injectors
The fuel injectors of the 928 are a multi point - single control setup. The LH ecu fires all injectors at the same time during normal operation. This creates a fuel mixture in the intake cavities that is sucked in during intake when the intake valve opens. When you use this function, all injectors are triggered. At the engine, all eight injectors make a clicking sound simultaneously. It helps to put a screwdriver on a specific injector and put your ear on the screwdriver to listen to the clicks and verify that the injector coil opens the needle to inject fuel. The test repeats itself every second until another function is selected.

Adaptation: start
The 928 has a LH ecu that is able to adjust itself to the car's conditions via adaptation. It has a learning mode where it knows how rpm, airflow, fuel pulse width and lambda values are related and uses this information to maximize fuel economy, performance, and comfort.
Adaptation is called for when the car has problems running a smooth idle, lacking power, or is using excessive amounts of fuel. This may be caused by misinterpreted sensor signals or by using signals which are influenced by a previous technical problem. The "brain" then needs to be reset to start a fresh adaptation. When performing the adaptation, it attempts to set the idle rpm to 675 or 775 if it is low for whatever reason. However, if the idle is high, you may be looking at an air leak and the LH is not able to compensate for that other than shutting down the idle control valve. A typical phenomena if a leak or bad MAF exists, is that the idle gets very high (1000+ rpm) after the idle adaptation, and only resets temporarily after battery power disconnect.

The adaptation starts with a warm engine, i.e. the car needs to be at normal operating temperature. Clicking on the "start" button in the adaptation pane initiates a dialogue that needs to be followed strictly. In the additional information window you will get instructions.

- First step: check if the Throttle idle switch operates as expected. The pre 1991 ecu's will not perform the adaptation routine when the idle switch is not closed.
- Next: Shut down the engine. If you click on the "start" button while the engine is still running, you will get a message that says: "please turn ignition OFF and press button <Start> again".
- Next step: click on the <Start> button. This message will appear: "please turn ignition ON and start the engine within 6 seconds". Please start the engine as instructed.
- Next step: now the adaptation phase runs and the system searches for optimal values. Please be patient. You will notice engine sound and rpm fluctuate. The Adaptation check light will become active (green) and blink the code 1411 as a sequence. After one minute, the routine ends and you can shutdown the engine. A trick to adjust also to worst conditions is to run the headlights during adaptation. This will give a slightly higher rpm at normal idle but a more stable rpm when lights are on.

The Idle adaptation takes time. The ECU sends a sequence of 2 times 4 digits: 1411. Like Morse code. After the first 4 digits (when decoded correctly) it does another sequence, and awaits the 1411 code again. Finally it says Idle adaptation ready. It is the ECU itself that actually performs the idle adaptation, and not the diagnostic system.

A normal idle rpm for a considered:
S4 or GTS is 675 ± 25
GT is775 ± 25

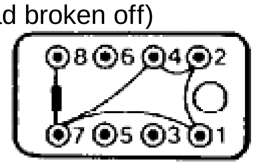
Porsche states in the WSM (D24-28) that it is best to remove the 12v from the ecu (battery cable) prior to performing the adaptation test. We have not seen any difference in the outcome when leaving the 12v connected. Removing the 12v clears any previously stored parameter values from then ecu memory. Porsche also say that it is a good thing to perform this adaptation test after each inspection routine to assure optimal fine adjustment.

Adaptation: check
This is derived from the check-engine light that informs the software about the adaptation process. It will flash during the process and ends with the 1411 code.

Input signals active
This area is only active when the tool is connected to the LH while the engine is running. Some considerations: the LH experiences difficulties communicating to the diagnostic system and managing the engine properly. This results is over-fuelling the engine which causes very rough running and even stalling. This is ok for a short period of time but should be considered bad when doing this for more that 3 minutes continuously. The catalytic converter may become red-hot by the unburned fuel in the exhaust. Be aware of this!

⇒ ***Note:*** *on cars starting 1989 you need a special modification of the interface to perform connection to the LH when the engine is running. Otherwise no LH connection can be made when the engine runs. Please contact us for details. In DT928 systemss supplied after May 2008 this modification is already included.*

Coding plug. This on/off signal is taken from inside the LH ecu and reports what the ecu sees. It is set by the coding plug, externally from the ecu. Failure to show the correct reading may be related to a defective ecu or a wrong coding plug. (I've also seen a coding plug pushed in reversed. The locating pin between 1 and 2 had broken off)



- L-line: is the L-line activity
- Coding 2: this is active on all cars
- Coding 6: this is active on ECE non CAT, coding plug 928.607.431.00 (manual) or 928.607.432.00 (automatic)

Actual values active
This area is only active when the tool is connected to the LH while the engine is running. Some considerations: the LH experiences difficulties communicating to the diagnostic system and managing the engine properly. This results is over-fuelling the engine which causes very rough running and even stalling. This is ok for a short period of time but should be considered bad when doing this for more that 3 minutes continuously. The catalytic converter may be-

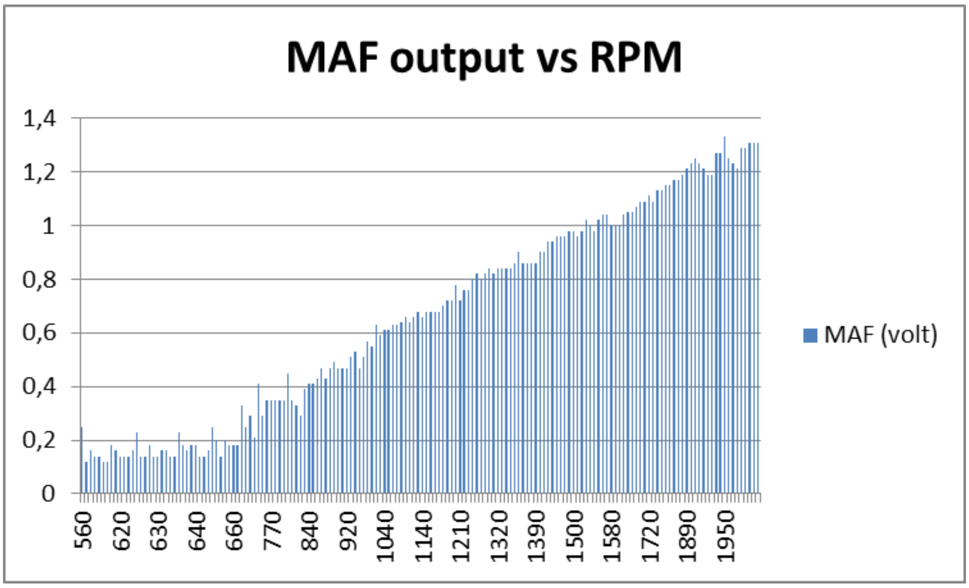
come red-hot by the unburned fuel in the exhaust. Be aware of this!
Note: on cars starting 1989 you need a special modification of the interface to perform connection to the LH when the engine is running. Otherwise no LH connection can be made when the engine runs. Please contact us for details. In DT systems supplied after May 2008 this modification is already included.

- **MAF**. This is the actual output of the Mass Airflow Sensor as evaluated in real time by the ecu. Based on this information the ecu manages the fueling. The function can be activated by flagging the checkbox. The actual value is shown in the adjacent field and also a bar-graph is shown to visualize. Any too high or too low MAF reading indicates a problem, but not necessarily a defective MAF sensor. Further troubleshooting is required. Here's a small table of what is considered to be a normal reading:

RPM	***MAF 928S4***	***MAF 928GTS***
675		0,16 volt
800	0,31 volt	0,35 volt
1000	0,45 volt	0,55 volt
1200	0,57 volt	0,73 volt
1400	0,71 volt	0,88 volt
1600	0,84 volt	1,02 volt
1800	0,96 volt	1,14 volt
2000		1,35

Be aware that a 4.7L, 5L, and 5.4L have different volume at displacement at the same rpm. There are two possible problems. The sensor output gets out of spec, which causes the engine to perform badly, or the sensor breaks down completely (like a broken sensor wire). If the hot wire inside the MAF fails it gives two pre-set fuel injector opening times- 3.5milliseconds when the engine speed is less than 2000rpm, and 6.3mS when the engine speed is over 2000rpm. Because this is a crude approximation the car will run rich or lean, but it's good enough to drive the car to a workshop.
Checking the MAF sensor:
Connections 6 and 9: Specification: 200 - 400 ohms
Connections 6 and B Specification: 130 - 260 ohms
Connections 8 and 9 Specification: 70 - 140 ohms
Connections 6 and 7 Specification: 40 - 300 ohms
Connections 7 and 8 Specification: 100 - 500 ohms
Connections 27 and 6 Specification: 2 - 3 k-ohms at 20 °C / 68 °F

- **Rpm**: This is the actual output of the Mass Airflow Sensor as evaluated in real time by the ecu. Based on this information the ecu manages the fueling. The function can be activated by flagging the checkbox. The actual value is shown in the adjacent field and also a bar-graph is shown to visualize.
Since it is possible to log both MAF output and Rpm output (both made active) you can make a graph of the data found in your log file. It should look similar to this graph from my GTS when you present it in Microsoft Excel:



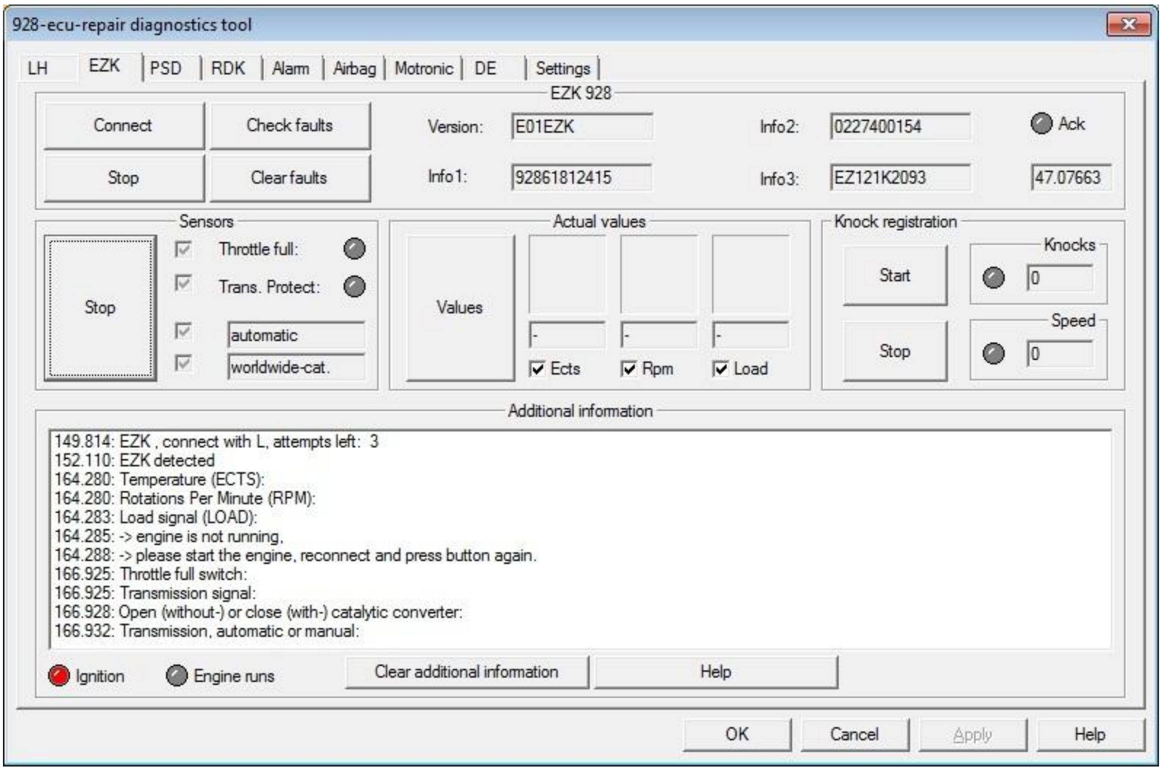
The engine will not cope with high rpm's so it is advised to only test this to about 2000 rpm.

- **Oxy**. This is the actual output of the O2 (Lambda, Oxygen) sensor. Based on this information the ecu manages the fueling. The function can be activated by flagging the checkbox. The actual value is shown in the adjacent graph. It shows 3 states: R. I, and L. "R" is the Rich fueling state, "L" is the lean state. The "I" state is the "inactive" state. This happens when the O2 sensor is warming up (or defective). After about 15 seconds it should be hot and start to operate. While driving the car it will normally switch form Lean to Rich state in a frequency of 3Hz. When idling the frequency may become 1Hz (1x per second switch from R to L). This is how it operates when the diagnostic system is not connected to the ecu.
  However: due to the limitations of the LH ecu you will not be able to see this behavior completely. As stated before, the LH has difficulties managing both communication and managing the engine, which results in seriously over-fueling the engine, causing a fluctuating idle rpm. The reading of the Oxy will almost always show Rich (R). There's two things you can do to verify the O2 sensor operation:
  - See that the warm up cycle goes from (I) to (R) in about 15 seconds. Failure to do so will make the ecu stay in open-loop operation, and thus it will never adjust the fuel mixture to the optimum value (Stoichiometric Combustion).
  - Push the gas to maybe 2000 rpm and then suddenly lift the gas pedal. The engine will cut fuel which will result in lean condition. As soon as the engine starts fueling it will get rich again.

- **Coding 4 and coding 8**
  Coding 4 and coding 8 refer to values taken from the coding plug. Unlike the other coding values these are variable signals and the values are the actual voltages as seen by the ecu analog-digital voltage converter.
  - Coding 4: this is active on all cars, and should read a voltage of about 0.16 volt
  - Coding 8: This value is related to resistor in a CAT equipped 928 and from the CO potentiometer in a non-CAT 928. This is active when the 150 ohms resistor is in, on all cars except ECE, so CAT

equipped cars with coding plug 928.607.438.00, 439.00, 440.00 and 441.00 The normal value you will see is 0.7- volt

4. EZK ignition controller



Introduction

The EZK is the ignition module and works closely together with the LH module. Its task is to provide a spark based on the engine position and state (temperature, load, etc). It is capable of learning the characteristics of the engine and adapting itself to these conditions. Another nice feature is the capability to adjust to differences in fuel quality by adjusting the timing of the ignition. The following functions and controls are common with the EZK tab on the diagnostic tool:

Ignition light

If 12v is supplied through the car (ignition switch turned on) the light will show red and signals that the system is ready to accept commands.

Engine runs

The light turns blue when the controller knows that the engine is running. This is just verification.

Clear additional information

The diagnostic software is designed to show information on what is actually happening while communicating with the EZK ecu. Mostly this will present quite technical information but you may recognize some state and self-explanatory messages that may help and guide diagnosis. All other information can safely be ignored. By pushing the “clear additional information” button you wipe the log on the screen.

Connect to EZK

When the command button is clicked on the software tries to connect to the EZK ecu and retrieve EZK version, PCB number, Part

number and Software version. All this information is stored in the firmware (software) of the EZK controller. If all is o.k. this information will show in the appropriate fields in the screen. This is also verification that communication with the ecu has been established. The system is designed to retry 3 times if a failure to connect exists.
If it fails to connect after three tries then the message "Cannot connect to EZK, turn-off and -on the ignition and try again" appears.

These figures will show up on your screen depending on the model year of your car:

1987	S4	??	928.618.124.10	0.227.400.035	??
1988	S4	E00EZK	928.618.124.11/12/14	0.227.400.035	EZ121K2062
1988	CS/SE	??	928.618.124.13	0.227.400.043	??
1989/91	S4	E01EZK	928.618.124.15	0.227.400.154	EZ121K2093
1989/91	GT/CS	E02EZK	928.618.124.22	0.227.400.164	EZ121K2182
1992/95	GTS	E01EZK	928.618.124.30	0.227.400.197	EZ121K2218

Stop
This stops communication with the EZK controller. The Ack signal will stop flashing, and the package counter stops incrementing.

Ack
The Ack (acknowledgement) light is blue when active and signals communication of data between controller and software. It is normal that it blinks during a session. Just below the light, a communication indicator is shown which displays the actual bytes per second data transfer to and from the ecu. If this indicator goes to zero during a session this indicates that communication has stopped. If this occurs, then restarting the communication should resolve this.

Fault memory: check faults
Using this button will interrogate and display the stored fault codes of the EZK ecu. Additional information regarding DTC codes and troubleshooting can be found in the WSM, Vol. 1A, page. D 28-1 through D 28-15

928 Fault Memory for EZK Control Unit

DTC Code	***WSM Ref Page***	***Test Point***	***Description***
2_12	D 28-5	1	Idle speed contact (ohms) ground short break
2_13	D 28-6	2	Full load contact (ohm) ground short
2_14	D 28-7	3	Temperature sensor II (ohm)
2_15	D 28-7	4	Idle or full load contact
2_21	D 28-7	5	Load signal
2_26	D 28-7	6	Transmission protection switch (automatic transmission only)
2_31	D 28-8	7	Knock sensor I (front of engine)
2_32	D 28-9	8	Knock sensor II (rear of engine, air filter side)
2_33	D 28-9	9	Control unit (knock sensor)
2_34	D 28-9	10	Hall signal change
2_33	D 28-10	11	Control unit faulty

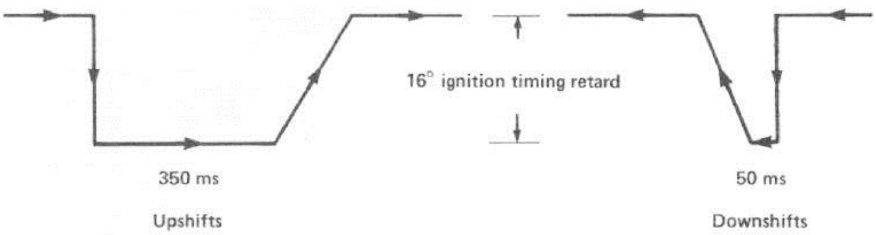
Fault memory: check faults
Using this button will interrogate and display the stored fault codes of the EZK ECU. If the system reports an “unknown fault”, the message "Please send the information CMD + Data on screen to

928-ecu-repair@hetnet.nl" appears. Please inform us and we will get in touch with you. We will try to diagnose your problem and provide a software upgrade if required.

Sensors
This button triggers the adjacent fields to be updated real-time. You can select each value you want to monitor by tagging the check box on the appropriate field. You can select more than one field if you'd like. Each function is explained separately:

Throttle full
The 928 has a throttle position switch, which reports to both LH and EZK the throttle valve position. If the throttle is fully open the signal light turns on. This is also called the WOT position.

Trans Protect
When a 928 has an automatic transmission (for 1987 models onwards), the "Automatic Transmission Protective Circuit" is implemented (called "transmission protect" here). Since the engine generates a very high torque which has to be absorbed by the shift elements in the automatic transmission while shifting, the torque has to be reduced for the shifting from 1^{st} into 2nd and 3rd gears when making very high partial load or full load shifts at an engine speed of more than 4000 rpm. Therefore, a considerable reduction of engine power for fractions of a second during up shifts 1 to 2 and 2 to 3 as well as downshifts 3 to 2 and 2 to 1. The information is used by the EZK to temporarily retard the ignition timing by 16 degrees to prevent damage to the transmission gears when switching under load. Normal ignition timing value is reached again within one second.



For this purpose the holder of brake band B1 has a switch, which puts out information to the EZK control unit both while opening and closing. The ignition timing is retarded 16 ° for 350 ms immediately after receiving this information, which in turn reduces the engine torque by approximately 25 %. Afterwards the ignition timing is advanced in steps within 150 ms to the original ignition timing value. When downshifting under load there will be the same torque reduction, but only for 50 ms. Should the switch in the transmission be detected as being faulty, quick speed changes, as occurring during shifts, will also cause retarding of the ignition timing (emergency run program).
A normal situation would show the light illuminated only when the transmission is in second gear. The transmission protection switch must close while changing from first to second gear (Display < 1 Ohm) and open when changing from second to third gear (Display infinite Ohm). The transmission protection switch must also close when changing down from third to second gear and open when changing down from second to first gear. The EZK triggers on the transition of the signal, not on the state of the signal.
One more remark: the transmission protect switch is a pressure switch. It operates based on fluid pressure in the transmission.

So be aware that it needs the engine to run, drive the transmission fluid pump, and generate fluid pressure in the transmission.

Coding

The 928 has a coding information plug which tells the EZK what type of car it is fitted to and what configuration is required. The coding information is shown in two boxes. It will show if this is a car with automatic or manual transmission. Automatic cars have idle speed reduction and retard ignition during 2nd to 3rd automatic gearshift to avoid damage. You will see this feature in the LH screen but the coding plug will also have to inform the EZK about the transmission type. The second box will show if the car is equipped with a catalytic converter or not, and for what area in the world the car is preset.

Actual Values:

You can select each value you want to monitor by tagging the check box on the appropriate field. You can select more than one field if you'd like. Tagging many options at once however will slow down the update. A log file is created and each field is presented in this log file. This makes importing it into spreadsheets or databases easy. By pushing the Values button, the process of acquiring the actual values is initiated, and it can be stopped by pushing it again. Each field is now discussed in more detail:

ECTS

ECTS is the **E**ngine **C**oolant **T**emperature **S**ensor. This sensor is located in the coolant stream, just above the water pump, slightly to the passenger side of the engine (LHD). This NTC sensor has a resistance that varies with the temperature of the coolant. This signal is transferred to the EZK and tells the controller how hot the engine is. This information is required to adjust ignition timing. The sensor is basically a double sensor, and the second part informs the LH controller about the engine temperature. A normal operating temperature reading is 85C but it should be within the 80-90 degrees Celsius range. This temperature value is shown in the box next to the button. A blue bar-display to the right helps put the value into perspective of the allowed range.
When starting the engine and immediately connecting to the EZK, pushing the ECTS button and looking at the reading, you may see the calibration process of the ecu. It starts at approximately 60, quickly in about 15 seconds increasing to 255, and then switching to operating mode showing the correct reading of the actual temperature in degrees Celsius, which should gradually increase from maybe 15 to about 80.

RPM

This tells the EZK how many revolutions per minute the engine is making at the moment. The sensor is located at the back of the engine and uses a hall sensor to detect a marker on the flywheel. This signal is transferred to the EZK and the information is required to adjust ignition timing. A normal idle rpm is 675 ± 25 for a S4 or GTS, 775 ± 25 for a GT. The value is shown in the box next to the button. A blue bar-display to the right helps put the value into perspective of the allowed range.

LOAD

This tells the EZK how much load the engine has to cope with. It is a signal derived from the LH controller and expressed in nanoseconds. The signal is derived from the MAF sensor data. The load signal varies with the load on the engine. A value of 70 µSec to 80 uSec at idle speed is normal. The load will increase when you blip the gas or put the engine in gear, moving off. The actual value is shown in the box next to the button. A blue bar-display to the right helps putting the value into perspective of the allowed range.

Knock registration: start
The 928 uses two knock sensors, both mounted inside the "V " of the engine. These piëzo pickups listen to the engine and detect any pre-detonation. This information is sent to the EZK, which retards timing to prevent further knocks.
Knocking can be recognized by knocking combustion (maybe caused by poor grade of gasoline) or mechanical engine noise. It sounds like marbles in the engine hitting the pistons.
In the normal load range of the engine it is very close to the knock limit of the ignition curve, through which combustion knocks and therefore also ignition timing corrections for each cylinder occur more or less frequently. If a knock is sensed during combustion, the ignition timing for the relevant cylinder is retarded by 3˚. If the knock condition persists, ignition is retarded up to 9˚ in steps of 3˚ for each knock occurring, if the engine speed is above 3500 rpm. At speeds below 3500 rpm, correction is performed. If no knock condition is detected anymore, ignition timing is returned in small increments up to the optimal value. This correction process may take several seconds to settle again. The knock system is able to detect which cylinder is showing the knock, using the info from the knock sensor (front/rear), hall sensor (1^{st} or 2^{nd} part of the 4 stroke).

A sensor malfunction would make the ignition timing advance to where it damages the engine. The Ezk is designed to detect a sensor fault and if this happens it retards the timing by 6 degrees. This seemed like a safe margin when the Ezk was designed.

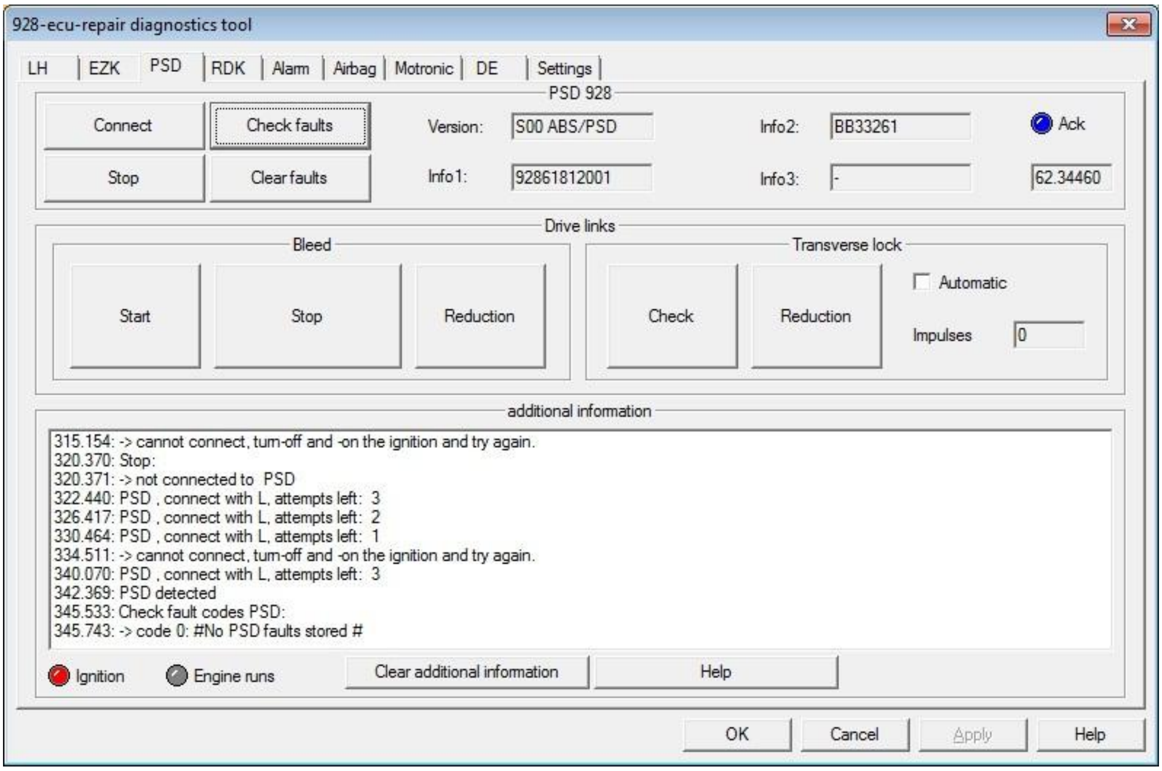
It is recommended that a fault diagnosis be carried out prior to registering the engine knocks, in order to exclude other factors that might influence knock regulation. When running the knock test the engine must be at operating temperature, and the test performed while test driving the car or with the car on a roller dynamometer.

The number of "knocks" registered by the sensors is calculated each time for 10,000 ignition firings. The registration of knocks should be performed if there are customer complaints about, for example, poor engine performance or high fuel consumption.

By clicking the start button the test starts. Speed and number of knocks detected are shown in the adjacent boxes. The test will terminate itself after 10,000 firings. A perfectly good working engine should normally register 5-20 knocks, especially when test-driving in an aggressive manner and using roz95 or roz98 fuel. Roz100 (V-power or similar high octane rated fuels) may help to reduce the number of knocks. A knock report of over 50 knocks must be considered as abnormal and needs further investigation. Knocks will make the EZK retard the engine to prevent this from occurring and thus performance will suffer. A defective knock sensor will be reported as an error when checking the fault code report.

Knock registration: stop
This terminates the knock registration test.

5. PSD Porsche Slip Differential



Introduction

All 928 models starting manufacturing year 1990 are equipped with the electronically controlled Porsche Slip Differential. This slip differential is designed to partially lock and unlock the drive wheels under heavy load. Unlocking is to be understood as disconnecting the drive axles from each other so that power moves from one wheel to the other. This locking ranges from 0 to 100%. A hydraulic slave cylinder on the side of the transmission case is activated by a high-pressure hydraulic system based on requirements. A 3-ton hydraulic pressure compresses the 20 pieces of transmission friction plates to achieve up to 100% locking. Expect pressures of 140-180 bar so safety measures apply when working on the PSD unit. You will find the system fitted in the rear left wheel well after removing the cover plate.

What it does

It works like this: when the controller detects that the car is moving, and the rear wheels are spinning in relation to the front wheels it is all ok and the system is in rest. But when one of the rear wheels shows excessive revolutions compared to the other wheel a single wheel spin is detected and power is moved to the other wheel to compensate. Also a potential traction problem at higher speeds is detected, especially in fast curves. There are ranges that the PSD works on:

1. Traction control while moving off.

   Pressure depending on wheel acceleration is building up in the transverse lock when the control unit recognizes a slip of a wheel through comparison of the wheel speed values. System pressure is increased in steps, until the slipping wheel again rotates in the permitted speed range and then held constant in a predetermined minimum time. Pressure build up depends on wheel acceleration, in other words:

pressure build up happens faster when acceleration is fast. Pressure is dropped in small steps.

2. Acceleration from driving in curves
   The driven wheel on the inside of the curve tends to slip and propulsion is reduced when driving in curves with high transverse acceleration. A locking torque depending on the vehicle's acceleration, road speed, and recognized curve is introduced to prevent this.
3. Ferraria effect (accelerator pedal released in curve)
   Rear wheel driven cars tend to oversteer when the pedal is released suddenly while driving in a curve. Oversteer can be reduced considerably through application of correct locking torque.

To be able to perform well the PSD relies on information provided by the ABS sensors and the acceleration sensor. The transverse acceleration sensor is mounted under the driver seat to indicate transverse vehicle acceleration.

For those of you who are looking for the PSD controller box it is a separate PCB inside the ABS controller.

Flushing and bleeding the PSD system.
The PSD system operates on DOT4 brake fluid, and due to hygroscopic effects of the fluid it needs to be replaced every two years. When replacing hydraulic fluid, the system you must bleed the system to remove any old fluid and air trapped in the system. WSM page D 39-202d explain the process. It does not describe the flushing however. A practical approach is as follows:
1. Carefully clean the reservoir, and both bleed valves.
2. Remove as much fluid as possible from the reservoir.
3. Attach bleed hose to the valve on top of the actuator solenoid.
4. Fill up fluid reservoir. Always avoid sucking in air.
5. Turn on ignition to build up pressure, pump stops when ready.
6. Turn off ignition, pressure remains in the system.
7. Gently open bleed valve and let fluid escape.
8. Close bleed valve.
9. Repeat from step #4 to fill up reservoir until 0.3 L is replaced.
10. Then use the tool and the bleed process to purge and bleed the high-pressure line and the slave cylinder.

Diagnostic system PSD functions and controls:
Ignition light
If 12v is supplied through the car (ignition switch turned on) the light will show red and signals that the system is ready to accept commands.

Clear additional information
The diagnostic software is designed to show information on what is actually happening while communicating with the PSD ecu. Mostly this will present quite technical information but you may recognize some state and self-explanatory messages that may help and guide diagnosis. All other information can safely be ignored. By clicking on the "clear additional information" button you wipe the log on the screen.

Connect to PSD
When the command button is pushed the software tries to connect to the PSD ecu, and tries to retrieve PSD version, RB number, and Part number. All this information is stored in the firmware (soft-

ware) of the PSD controller. If all is o.k. the information will show in the appropriate fields in the screen. This is also verification that communication with the ecu has been established. The system is designed to retry 3 times if a failure to connect exists. After three tries the message "Cannot connect to PSD, turn-off and -on the ignition and try again" appears.
The PSD is a controller which is designed to work with diagnostics only when the engine is not running, so when ignition is merely switched to on.

These figures will show up on your screen depending on the model year of your car:

1990/95	S4/GT/GTS	S00 ABS/PSD	928.618.120.01	BB33261

Stop
This stops the communication with the PSD controller. The Ack signal will stop flashing, and the package counter stops incrementing.

Ack
The Ack (acknowledgement) light is blue when active and signals communication of data between controller and software. It is normal that it blinks during a session. Just below the light, a communication indicator is shown which displays the actual bytes per second data transfer to and from the ecu. If this indicator goes to zero during a session this indicates that communication has stopped. If this occurs, then restarting the communication should resolve this.

Fault memory: check faults
Using this button will interrogate and display the stored fault codes of the PSD ECU. If the system reports an “unknown fault”, the message "Please send the information CMD + Data on screen to 928-ecu-repair@hetnet.nl" appears. Please inform us and we will get in touch with you. We will try to diagnose your problem and provide a software upgrade if required.
Additional information regarding DTC codes and troubleshooting can be found in the WSM, Vol. 3 page. D 39-201 through D 39-260 and Vol 4 page 45-08 through 45-10

928 Fault Memory for PSD Control Unit

DTC Code	***WSM Ref Page***	***Test Point***	***Description***
11	*D 39 230*	*1*	Transverse lock valve
12	*D 39 232*	*2*	Transverse acceleration sensor - Short/Open circuit
13	*D 39 233*	*3*	Transverse Acceleration sensor faulty
14	*D 39 234*	*4*	Regulating tolerance - transverse lock
15	*D 39 235*	*5*	Control unit
21	*D 39 236*	*6*	ABS speed sensor front left
22	*D 39 237*	*7*	ABS speed sensor front right
23	*D 39 238*	*8*	ABS speed sensor rear right
24	*D 39 238*	*9*	ABS speed sensor rear left
31	*D 39 240*	*10*	ABS valve front left
32	*D 39 240*	*11*	ABS valve front right
33	*D 39 240*	*12*	ABS valve rear axle
34	*D 39 241*	*13*	Valve relay
35	*D 39 245*	*14*	Return pump

Note on PSD and ABS sensor failures: the PSD is responsible for feeding the ABS speed sensor signal to the RDK via pin 10,12,16,and pin53. Failure of the PSD will cause a RDK error too. Furthermore the front left ABS sensor output (#16) is used for vehicle speed on model 1991/1992, which changed to rear left sensor (#12) in model 1993. So expect to see these things related to each other.

Fault memory: clear faults
Using this button will send a message to the PSD controller to clear all stored fault codes in the PSD controller.

Bleed: start
The PSD has two bleed valves. Here is a short description of the fluid renew and system bleed process.

1. remove the rear left wheel
2. remove the wheel arch liner or the cover plate at the rear (depending on manufacturing year of your car)
3. clean the PSD reservoir and cap
4. remove cap and inner filter
5. use a suction to remove all fluid from the reservoir
6. put in new fluid in reservoir
7. locate the bleed valve on top of the pressure valve
8. attach a hose on the bleed valve and open the valve
9. switch on ignition, notice the PSD pump adding more fluid.
10. close valve when new fluid reaches the hose
11. attach a hose on the bleed valve just above the PSD line
12. open the slave bleed valve at the right side of the final drive
13. turn on ignition and bleed the slave cylinder using the diagnostic system (details follow in next paragraph)
14. close bleed valve when fresh fluid reaches the drain hose
15. fill up reservoir, check for leaks and close up

The diagnostic system takes part in bleeding the slave cylinder of the PSD. To start the bleeding process:

- Turn on ignition. When ignition is turned on the pressure pump builds up a pressure of 180 bar in the pressure reservoir and then cuts out.
- Connect the tool to the PSD ecu
- Open the bleed valve on top of the PSD slave cylinder.
- Push the start button. This will send a message to the PSD controller to clock (pulse) the lock solenoid valve and allow fluid to escape from the bleeding valve. After 25 seconds the ecu will start pulsing the lock solenoid which will pulsate fluid into the hydraulic system. The hydraulic pump will build up pressure as soon as the pressure in the pressure reservoir drops below the threshold. You absolutely need to keep an eye on the reservoir and make sure it stays filled to avoid sucking in air. It uses up fluid quite rapidly. You can stop and restart then process any time.
- When you see no more bubbles of old fluid coming from the drain hose, you can close the valve. Make sure you prevent air sucking back into the system. I personally close the valve while the system is bleeding.

Bleed: stop
Using this button will stop the bleeding process. The bleeding valve then needs to be closed now. If possible, close the valve while bleeding. The ecu stops sending messages to the solenoid to bleed the system.

Bleed: reduction

This is the last step of the bleed process. Using this button releases the pressure from the hydraulic system and the transverse lock will be released. The status will be shown in the additional information box. Close the fluid reservoir cover now. Best is to check for any PSD fault messages in the controller, reset them if present, perform a test drive, and check again for faults.

Transverse lock: check

The pressure build up procedure for the transverse lock is started when the button is pushed and increments in steps by pressing again. The number of impulses is shown in the adjacent box. This test enables you to test the partial-locking capabilities of the PSD. You will hear a clear clack-sound from the PSD, which will change in pitch when you have reached the PSD limit. This normally happens when the counter is at 6 pulses. If possible, you should test the actual locking of the final drive by trying to turn the wheels or on a test rig. The Transverse lock check is limited to 20 pulses as this should give a full lock.

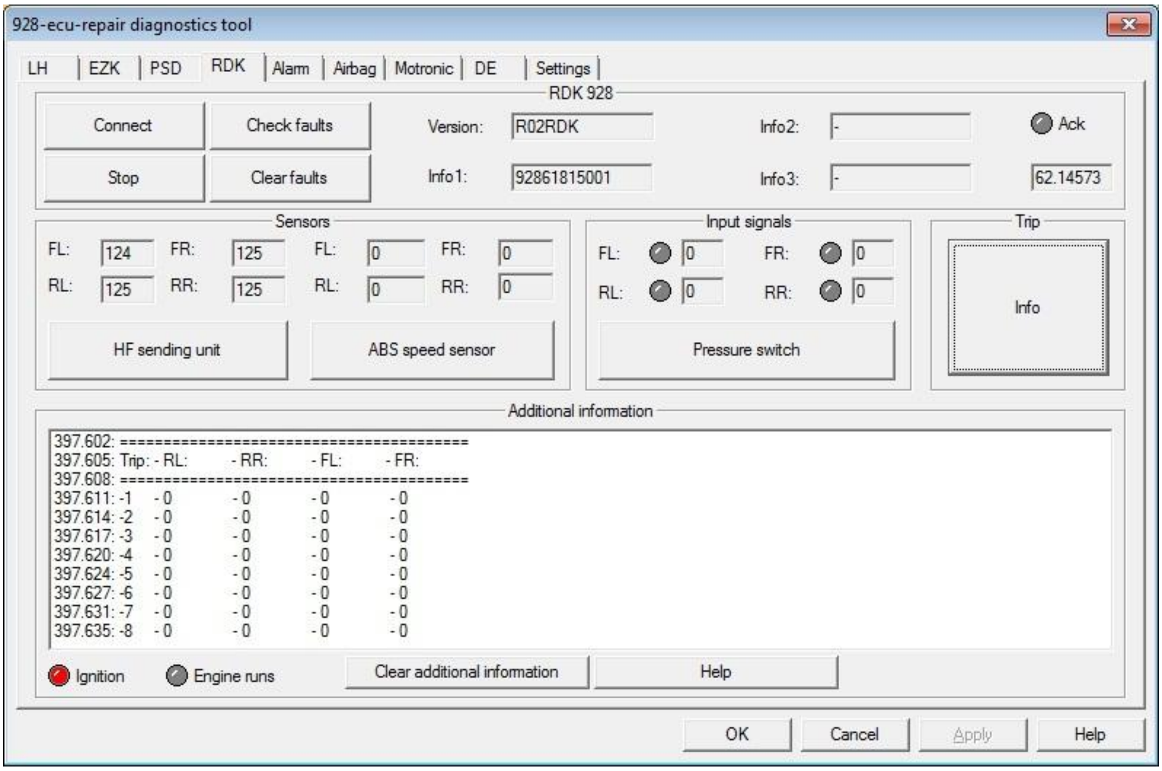
Transverse lock: reduction

Using this button will release the pressure in the transverse lock. The status will be shown in the additional information box.

Transverse lock: automatic

This is a neat testing feature. The transverse lock buttons are used to manually operate the lock, but there is also an automatic feature implemented like the earlier Hammer has. If this check box is checked, the transverse lock automatically engages to a full lock and the user is instructed on the screen to turn the wheels and verify the lock. Obviously, this requires the car to be lifted at both rear wheels simultaneously.

6. RDK tire pressure controller



Introduction

The RDK is short for the German term **R**eifen **D**ruck **K**ontrolle. This is the tire pressure monitoring system and consists of sensors mounted in the wheel rims that function as pressure switches, and High Frequency senders, mounted at the wheel hub assembly. The HF senders produce a High Frequency signal for the pressure switches to operate. Diaphragm switches mounted in the wheel rim pass the HF sender when the wheel turns and inductive coupling is established.

The diaphragm of the pressure switch mounted in the wheel rim acts as part of an oscillation circuit when the switch is closed. Low pressure will open the switch, and the oscillation circuit is inactive. Current flows in the pressure switch oscillating circuit are detected by the sender as a load and generate a pulse signal to the RDK. The information is fed from the RDK to the instrument cluster and shows which wheel is causing a low pressure or pressure loss warning.

The RDK controller comes in different versions. You will see a version R00RDK, R01RDK or R02RDK in the version box. Typically, the R02RDK sends more fault code messages to the diagnostic system. From control unit version 02 (introduced in the 1991 model year) on, the RDK control unit contains an event memory that stores data on any pressure loss events at one or more tires during the last 8 journeys made by the vehicle. It also indicates the road speed at which the event occurred, and whether either one or two pressure-sensing switches were open. This event memory permits conclusions to be reached regarding unnatural pressure losses at one or more wheels. A journey starts when you turn on the ignition. The tool displays events starting from the most recent down to the oldest, and every new event deletes the oldest one from memory.

The startup of the RDK unit is somewhat special. Upon turning on the ignition, the RDK starts by performing a self test and instrument cluster lamp test. The lamp goes out when you start the engine. Then after driving at least 20 meters at 5 km/h speed, the RDK enables its active mode and starts to monitor the pressure sensors. To be able to see that car move, the RDK uses the ABS sensor pulses to determine the wheels turning. This also serves as an interesting way to check the ABS sensors via the RDK. This is pretty special since the ABS itself is not able to do this. The PSD is only able to log an error, no real time data, but the RDK reports the output of the ABS sensors in real time.

The RDK has a temperature compensation, as pressure is related to the tire temperature. Pressure rises 0.1 bar per 10C. However it can happen that severe temperature drops trigger an alarm. An alarm can also occur at very high speeds, as the air gets pushed to the outside of the tire by the rotational speed. Increase the pressure with 0.3 bar and make pressure on opposite sides equal. It is important to drive the car without pressure alarms and do repairs if the correct pressure does not resolve the problems. Do not over inflate the tire. The correct procedure is to inflate the tire that triggers the alarm by 0.5 bar above the required value, and watch for any more warnings. If warnings still appear you need repairs.
Always make sure that the tire pressure is the same on opposite side.

**note: when you lift the car on all 4 wheels, don’t get confused by misinterpreting the data. Both rear wheels will turn at the same time, causing sensors on both to produce on-screen results. The front wheels are independent.

Overview of RDK controls and functions:

Ignition light
If 12v is supplied through the car (ignition switch turned on) the light will show red and signals that the system is ready to accept commands.

Clear additional information
The diagnostic software is designed to show information on what is actually happening while communicating with the RDK ecu. Mostly this will present quite technical information but you may recognize some state and self-explanatory messages that may help and guide diagnosis... All other information can safely be ignored. By pushing the “clear additional information” button you wipe the log on the screen.

Connect to RDK
When the command button is pushed, the software tries to connect to the RDK ecu and to retrieve RDK version, and Part number. All this information is stored in the firmware (software) of the RDK controller. If all is o.k., the information will show in the appropriate fields in the screen. This is also verification that communication with the ecu has been established. The system is designed to retry 3 times if a failure to connect exists. If the 928 is equipped with an electronic dash, a warning will be shown on the dash that the RDK system is switched off. This is normal behavior. As soon as the diagnostic system disconnects from the RDK the display will be restored. If it still fails to connect, the message "Cannot connect to RDK, turn-off and -on the ignition and try again" appears.

These figures will show up on your screen depending on the model year of your car:

1990	S4	R01RDK ??	928.618.150.01
1991/92	S4/GT/GTS	R02RDK	928.618.150.01

The RDK was M482 option in the 1989 model

Stop
This does what you may expect: it stops the communication with the RDK controller. The Ack signal will stop flashing, and the package counter stops incrementing.

Ack
The Ack (acknowledgement) light is blue when active and signals communication of data between controller and software. It is normal that it blinks during a session. Just below the light, a communication indicator is shown which displays the actual bytes per second data transfer to and from the ecu. If this indicator goes to zero during a session this indicates that communication has stopped. If this occurs, then restarting the communication should resolve this.

Fault memory: check faults
Using this button will interrogate and display the stored fault codes of the RDK ECU. If the system reports an “unknown fault”, the message "Please send the information CMD + Data on screen to 928-ecu-repair@hetnet.nl" appears. Please inform us and we will get in touch with you. We will try to diagnose your problem and provide a software upgrade if required.
Additional information regarding Fault codes and troubleshooting can be found in the WSM, Vol. 4 page. 44-301 through 44-314

928 Fault Memory for RDK control Unit

Fault Code	***WSM Ref Page***	***Description***
1	*44-306*	HF sending unit - rear left
2	*44-307*	HF sending unit - rear right
3	*44-307*	HF sending unit - front left
4	*44-307*	HF sending unit - front right
5	*44-307*	ABS speed sensor - rear left
6	*44-308*	ABS speed sensor - rear right
7	*44-308*	ABS speed sensor - front left
8	*44-309*	ABS speed sensor front right
9	*44-309*	RDK warning light – Combi-Instrument
10	*44-309*	Wiring harness/data RDK to Combi-Instrument
11	*n/a*	Power supply
18	*44-309*	Data line - interruption – not present

Note: there is another fault code 18 for RDK as per the WSM, but it is not a real code; it is reported even though no underlying fault condition exists. This condition is a falsely reported error code (pg 44-305) that can be ignored and cleared.

Note on RDK and ABS sensor failures: the PSD is responsible for feeding the ABS speed sensor signal to the RDK via pin 10,12,16,and pin53. Failure of the PSD will cause a RDK error too. Furthermore the front left ABS sensor output (#16) is used for vehicle speed on model 1991/1992, which changed to rear left sensor

(#12) in model 1993. So expect to see these things related to each other.

Fault memory: clear faults
Using this button will send a message to the RDK controller to clear all existing fault conditions from memory.

HF Sending unit
The 928 has a High Frequency sending unit at each wheel and the signal at these senders can be checked by pressing the button. A reading of approximately 125-150 will be displayed for each sensor, which is ok. The reading may vary a little when turning the wheel. Wheels are identified as Front Left, Front Right, Rear Left, Rear Right, as seen from behind the car.

ABS speed sensors
The test button will activate the ABS pulse detection at each wheel and by turning the wheels you should see the value increment with wheel speed. The reading is per wheel and when driving a straight line, both front sensors and both rear sensors should end up at approximately the same reading.
Testing the RDK can be done at standstill, on a lift, jack, or when slowly driving. If you drive slowly you can see the ABS signal going into higher readings resulting from the wheel speed. The reading will be about 10 to 12 when you drive the car at idle rpm and go up to 20 when driving about 30 km/h. The RDK will stop communicating with the diagnostics when exceeding approximately 35km/h. This is likely a safety feature of the RDK, which is not documented in manuals.

Pressure switch
Activate the button and gently rotate each wheel until the lamp signal on the screen for the appropriate wheel changes from off to on, and back to off. That verifies operation. Two pressure switches are fitted in the rim well, positioned 180 degrees apart. The RDK will signal a pressure loss error if the pressure switch is open due to low tire pressure. You should be able to verify the function of each sensor when it gets in range of the HF sender unit.
The pressure switch test also has a counter field to each sensor. This counter field resets when the pressure switch button is pressed. When the wheels turn the light lights up the counter is incremented. This helps identifying intermittent faults. You may experience difference in counter reading when driving slowly. This is normal behavior. We recommend to drive very slowly in a straight line and repeat the test several times before drawing any conclusions.
The RDK will stop communicating with the diagnostics when exceeding 30km/h. This is likely a safety feature of the RDK, which is not documented in manuals.

When you lift the car on all 4 wheels for this test, don't get confused by misinterpreting the data. Both rear wheels will turn at the same time, causing sensors on both to produce on-screen results.

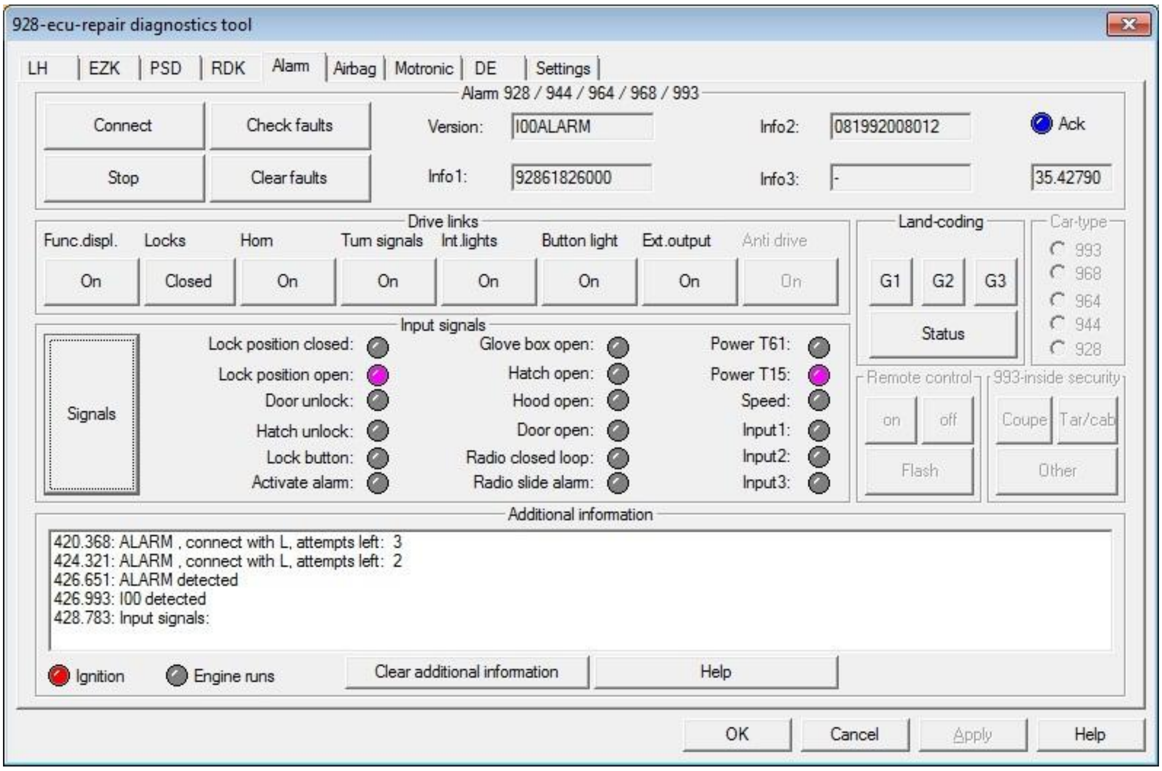
Trip, Pressure loss Trip info (only RDK v02)
From new RDK version R02, which was released in 1991, a new feature is available: the Trip log feature. The new RDK keeps track of events during previous journeys, and logs these in the ecu memory.
This function can be activated by pushing the info button. The software then interrogates the RDK and displays this event information provided by the RDK. A trip should be understood as each

cycle in which the car goes from ignition on to off. Each entry shifts down when you turn on ignition. Journey number -1 is the most recent one. So the last known error from the log phases out after 8 sequential trip cycles. When you push the button “Trip” the information display will report the RDK events during these last 8 trips. You will see per wheel the event, and the speed at which it occurred. Understanding the report requires you to read from the oldest entry (-8) back to the most recent entry (-1). Also combinations of pressure loss on more than one wheel within one trip are possible and shown if applicable.

Intermittent pressure loss reports may indicate pressure to be just too low, too close to the trigger limit, big differences in temperatures, which make pressure fluctuate, or a faulty sensor. In the workshop manual, a pressure loss is not considered a fault in the RDK, so no fault will be reported by the check-fault function. There is no reset function to this event log.

The workshop manual describes a procedure for setting the correct pressure and validating the pressure threshold of the sensors. Refer to WSM vol 4 page 44-413

7. Alarm controller



Introduction

The Alarm controller in the 928 comes in two versions. The older s4 models have a simple small cigarette box sized black alarm device and a separate window/sunroof controller, both without any diagnostics. Starting in 1991, the alarm controllers were integrated into one unit with diagnostic functions and located under the front passenger seat (LHD). This is the box that has diagnostics and is detailed here.

The alarm controller is not made by Bosch or Hella as you would expect, but by Megamos (Fa. Delphi/Megamos (02261 9710 or www.megamos.de))

This new style Alarm ECU comes in two versions (4 part numbers: 928.618.260.00-928.618.260.03) and is used in a variety of Porsches, like 928, 964, 968,and 993. Porsche is unclear about the differences. When connecting you may see a I00 version or a I01 version. The latter seems to have extra features like a result memory log.

A short overview of controls and functions:

Ignition light

If 12v is supplied through the car (ignition switch turned on) the light will show red and signals that the system is ready to accept commands.

Clear additional information

The diagnostic software is designed to show information on what is actually happening while communicating with the Alarm ecu. Mostly this will present quite technical information but you may recognize some state and self-explanatory messages that may help and guide diagnosis. All other information can safely be ignored. By pushing the “clear additional information” button, you wipe the log on the screen.

Connect to Alarm
When the command button is pushed the software tries to connect to the Alarm ecu retrieve Alarm version, and Part number. All this information is stored in the firmware (software) of the Alarm controller. If all is o.k., the information will show in the appropriate fields in the screen. This is also verification that communication with the ecu has been established. The system is designed to retry 3 times if a failure to connect exists. If after three tries it fails then the message "Cannot connect to Alarm, turn-off and -on the ignition and try again" appears.

These figures will show up on your screen depending on the model year of your car:

1987/91	S4/GT/GTS	I00ALARM	928.618.260.00	081992008012
1987/92	S4/GT/GTS	I00ALARM	928.618.260.01	
none	none		928.618.260.02	
1987/91	S4/GT/GTS		928.618.260.03	

Stop
This stops the communication with the ALARM controller. The Ack signal will stop flashing, and the package counter stops incrementing.

Ack
The Ack (acknowledgement) light is blue when active and signals communication of data between controller and software. It is normal that it blinks during a session. Just below the light, a communication indicator is shown which displays the actual bytes per second data transfer to and from the ecu. If this indicator goes to zero during a session this indicates that communication has stopped. If this occurs, then restarting the communication should resolve this.

Fault memory: check faults
This button interrogates and displays the stored fault codes of the Alarm ecu. The alarm fault codes are unusual because the controller does not log any alarm incidents during activation, but instead logs the abnormal conditions at the time of activation. If any faults are stored, the software will display the error messages. Three types of error messages are possible. They will be shown sequentially in the information screen.
If the system reports an “unknown fault”, the message "Please send the information CMD + Data on screen to 928-ecu-repair@hetnet.nl" appears. Please inform us and we will get in touch with you. We will try to diagnose your problem and provide a software upgrade if required.
Additional information regarding fault codes and troubleshooting can be found in the Service Info Tech Manual of the 1998 928s4/gt, page 9-5 through 9-21 and WSM Volume 6, page D90-1; "Diagnosis / troubleshooting alarm system"

Here are some the error messages that may appear:

Fault #	Alarm Fault Messages:
01	Control unit defective
02	Voltage failure term 30 with active alarm system
03	Voltage failure during alarm output
04	Position of the drives implausible
05	Doors open during activation
06	Engine compartment open during activation

07	Luggage compartment open during activation
08	Glove compartment open during activation
09	Input 2 to ground during activation
10	Central lock button closed during activation
11	Input 1 to ground during activation
12	Input 3 to positive during activation
13	Position switch on drive closed during activation
14	Position switch on drive open during activation
15	radio (closed loop) interrupted during activation
16	Radio contact to ground during activation
17	Tailgate lock switch closed during activation

The fault codes in the Alarm unit work a bit different that the other controllers. The ecu does not report a normal DTC code, but an encoded message that carries multiple fault codes. The software presents them as clear and readable text in the information window.

Fault memory: clear faults
This button will send a message to the Alarm controller to clear all existing fault conditions from memory.

Drive links
This range of functions can be tested individually by pushing the on / off buttons respectively.

1. Function display: This function tests the LED in the doorposts that signals when the system is active. This button turns the led on and off by command. The doors need to be closed for this test.
2. Locks: This function engages and disengages the door locks. The doors need to be closed for this test. You should hear a clear click when the doors lock.
3. Horn: This function activates the horn as if it had been triggered by the alarm. You will hear the horn loud and clear.
4. Turn Signals: This function turns on and off all 4 turn/indicator signals. This is clearly visible at all four corners.
5. Interior lights: This function turns on and off all interior lights. This is clearly visible in the car.
6. Button Light: This will turn the button (button) light in the center console on and off which should be clearly visible.
7. External output: this is not used in standard setup.
8. Anti Drive: this is a feature that prevents the car to drive off when on alarm. It is not available in a 928 but intended for the 993 versions. Therefore it is disabled in the 928 system.

Remote control
This is a feature that enables you to remotely switch the alarm on and off by a hand sender. It is not available in a 928 but intended for the 993 versions. Therefore it is disabled in the 928 system.

Car type
The alarm ecu can be used in different Porsche models. Each has specific features. This control is not available in the 928 version, and selecting any car will not make a difference in behavior for a 928.

Input Signals
When the button “Input signals” is pressed the signal monitoring becomes active and is constantly updated. The lamps provide information on the current state of the switches.

- **Lock Position closed** : **Position switches at drive motors.** These switches show the position of the lock thus informing the alarm system of locked state. Both doors have a lock position switch. The display will the show closed status. If any door lock is closed, the light will turn on. So if one lock is open and one is closed, both lights (open and closed) will be on. This is an abnormal situation that should not occur in normal operation as both locks lock simultaneously when using the key or button.

- **Lock Position open** : **Position switches at drive motors.** These switches show the position of the lock thus informing the alarm system of un-locked state. Both doors have a lock position switch. The display will show the open status. If any door lock is closed, the light will turn on. So if one lock is open and one is closed, both lights (open and closed) will be on. This is an abnormal situation that should not occur in normal operation as both locks lock simultaneously when using the key or button.

- **Door Unlock** : **Micro switch for deactivation of alarm.** Active when the key is turned to un-lock the system. The un-lock-engage-switch is engaged.

- **Hatch Unlock** : **Hatch unlock switch.** Active when the hatch is opened with the key. The hatch-open-switch will become engaged. This switch is only briefly active when the lock disengages to open the lock. It is separate from the hatch open switch, and mounted in the upper part of the lock assembly.

- **Lock Button** : **Central locking system button.** This is lit when the central locking button on the center console is pushed.

- **Activate Alarm** : **Micro switch for activation of alarm.** Active when the key in any door is turned right to lock the system. The lock-engage-switch is engaged.

- **Glove Open** : **Glove compartment button.** Active when the glove compartment is open. The glove compartment-open-switch is engaged.

- **Hatch Open** : **Hatch open switch**. This switch is closed when you open the hatch at the rear. It also triggers the interior lights.

- **Hood Open** : **Engine compartment switch.** Active when the hood is open. The hood-open-switch is engaged.

- **Doors Open** : **Door contacts.** Active when either door is open. The door-open-switch is engaged. It also triggers the interior lights.

- **Radio** : **Radio closed loop.** 12v power is routed through the radio. Breaking the 12v loop triggers an alarm condition.

- **Radio slide** : **Alarm contact radio bracket.** A signal that is grounded to the radio chassis. Removing the radio from the alarm slide triggers an alarm condition by grounding the cable.

- **<u>Power T61</u>** : **Term61** is carrying 12v power, basically saying the engine is running as it is charging the battery. This signal will also come on when the interior lights are switch on by the controller (hatch or doors open)

- **<u>Power T15</u>** : **Term15** is carrying 12v power, basically saying that the switched power is applied. This power is switched on by turning the ignition key to the on-position, even without starting.
- **<u>Speed</u>** : **Speed signal.** Active when a speed signal is present. When the wheels turn, the speed signal is seen and causes a trigger.

- **<u>Input 1</u>** Optional input for accessory equipment

- **<u>Input 2</u>** Optional input for accessory equipment

- **<u>Input 3</u>** Optional input for accessory equipment

Land Coding

The Alarm controller has the ability to be set to different configurations. There are 3 choices, each changing the alarm signal to a different setup.

- **G1** When pushing the G1 button the alarm is set to the RoW (Rest of World) configuration. If an alarm occurs and set to RoW, the horn sounds in intervals, max 30 seconds, turn signal flashes max 5 minutes together with the interior lights.
- **G2** When pushing the G2 button the alarm is set to the CH (Switzerland) configuration. If an alarm occurs and set to CH, the horn sounds continuously for max 30 seconds.
- **G3** When pushing the G3 button the alarm is set to the USA (United States) configuration. If an alarm occurs and set to USA, the horn sounds in intervals, max 4 minutes, turn signal flashes max 8 minutes together with the interior lights.
- **Status** The status button reports the current configuration of the alarm controller.

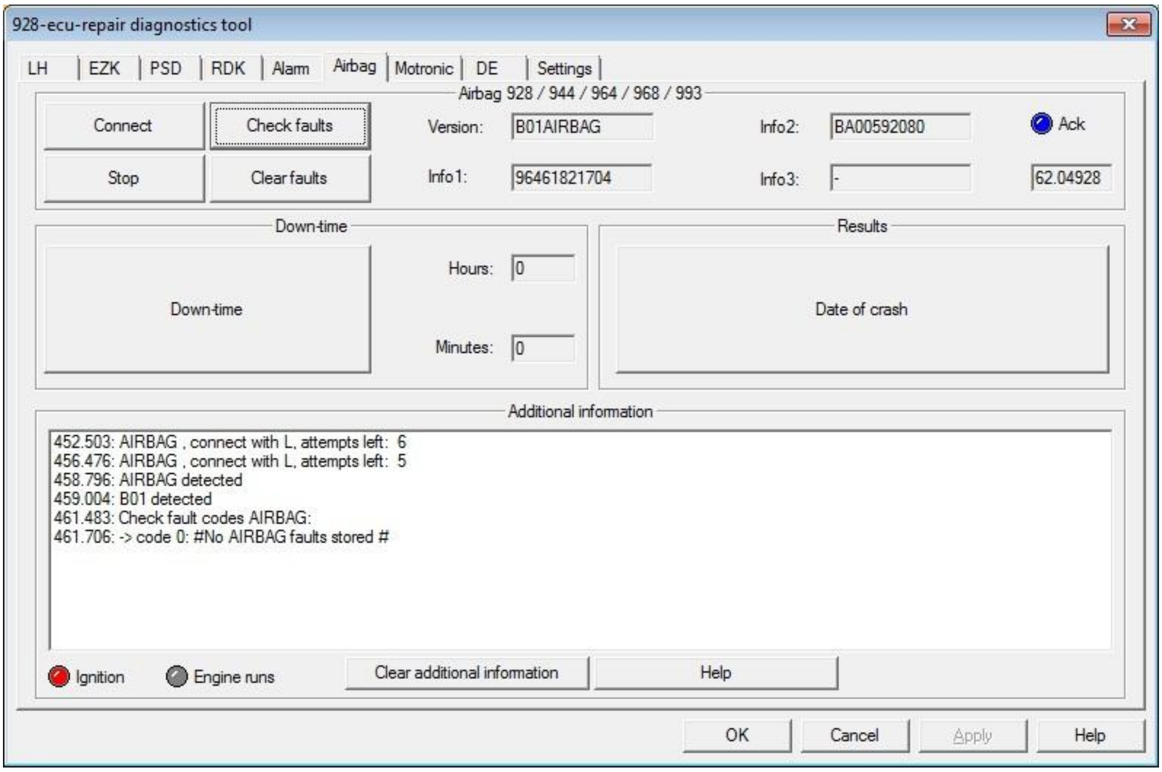
993 inside security

The 993 has a interior monitoring system that can be configured for different models of the 993. This does not apply to the 928 and is therefore not functional.

Tips and tricks

- After enabling the alarm, the led flashes quickly for 10 seconds (sort of a self test) and then starts to blink slowly, showing it is in armed state.
- If at a fault condition exists when enabling the alarm, there is no quick flashing, and after 10 seconds only the working alarm triggers are enabled and monitored in the alarm controller. This state is shown as a double flash pattern.
- If you turn the key to lock the car, and you hold into the locking position for a few seconds, the system starts to automatically close any open windows and sunroof.
- If you open the hatch without opening the doors, and you close it, the alarm is activated again 10 seconds after closing the hatch.
- You can arm the alarm by turning the lock key 3 times in succession. This enables you to turn the alarm on even if the central locking is inoperative, so despite of the doors being locked.

8. Airbag controller



Introduction

The Airbag controller manages the airbag system and identifies any possible malfunctions. There are no drive links. Drive links would be to test the function of the airbag which seems not appropriate here.

There are two airbag configurations: one with driver airbag only; and one with both passenger and driver airbags. The 2-airbag system consists of two sensors and two airbags, plus the management controller which is mounted in the center console in the very front of the footwell flap. The driver side airbag has one pickup sensor, as the passenger side has two sensors. The sensors are purely mechanical spring loaded roller-switches that are designed to move with the right direction and impact to make contact. That triggers the control unit and activates the airbag(s) deployment.

The airbag check light should light when turning on the ignition, and go out after approximately 5 seconds. If not, further diagnosis is required. Be aware that this is a safety device that your life may depend on.

For your safety never work on an airbag system with battery power connected, and always wait for 20 minutes after isolating the battery ground strap to allow capacitor discharge in the control unit. (as of software version B01 20min waiting time changed to 5min). Never change the airbag wiring or mounting.

The Airbag is a controller which is designed to work with diagnostics only when the engine is not running but only when ignition is merely switched to on.

The Airbag controller can be tested for operation readiness in two ways:

- by switching on ignition. The airbag warning light in the dash should go on, and go off after approximately 5 seconds
- by switching the ignition to on and then pulling the instrument cluster fuse for about 30 seconds. That should post a fault code 58 (warning light, short circuit to Ub or ground , no fault present)

As of software release B01 there is a small change:

- by switching on ignition. The airbag warning light in the dash should go on, and go off after approximately 5 seconds (2,5 sec as of production date June 12 1992)
- by switching the ignition to on and then pulling the instrument cluster fuse for about 30 seconds. That should post a fault code 30 (Airbag warning light, signal implausible, no fault present)

A maximum number of 11 faults can be stored in the controller's memory. You should erase the fault that is stored in the controller.

A short overview of controls and functions follows:

Ignition light
If 12v is supplied through the car (ignition switch turned on) the light will show red and signals that the system is ready to accept commands.

Clear additional information
The diagnostic software is designed to show information on what is actually happening while communicating with the Airbag ecu. Mostly this will present quite technical information but you may recognize some state and self-explanatory messages that may help and guide diagnosis. All other information can safely be ignored. By pushing the "clear additional information" button you wipe the log on the screen.

Connect to Airbag
When the command button is pushed, the software tries to connect to the Airbag ecu and tries to retrieve Airbag version, and Part number. All this information is stored in the firmware (software) of the Airbag controller. If all is o.k., the information will show in the appropriate fields in the screen. This is also verification that communication with the ecu has been established. The system is designed to retry 3 times if a failure to connect exists.
If it after three tries it has still not connected then the message "Cannot connect to Airbag, turn-off and -on the ignition and try again" appears.

These figures will show up on your screen depending on the model year of your car:

1990/95	S4/GT/GTS	B01AIRBAG	964.618.217.04	BA00596613
1992/95	GTS	B01AIRBAG	944.618.217.02	AA00054496

Stop
This stops the communication with the Airbag controller. The Ack signal will stop flashing, and the package counter stops incrementing.

Ack
The Ack (acknowledgement) light is blue when active and signals communication of data between controller and software. It is nor-

mal that it blinks during a session. Just below the light, a communication indicator is shown which displays the actual bytes per second data transfer to and from the ecu. If this indicator goes to zero during a session this indicates that communication has stopped. If this occurs, then restarting the communication should resolve this.

Fault memory: check faults
Using this button will interrogate and display the stored fault codes of the Airbag ECU. If the system reports an "unknown fault", the message "Please send the information CMD + Data on screen to 928-ecu-repair@hetnet.nl" appears. Please inform us and we will get in touch with you. We will try to diagnose your problem and provide a software upgrade if required.
Additional information regarding DTC codes and troubleshooting can be found in the WSM, Vol. V, page D 68-1 through D 68-28

928 Fault Memory for Airbag control Unit software version B00

DTC Code	***WSM Ref Page***	***Test Point***	***Description***
3_11	D 68-7	1	Left front sensor closed once
3_12	D 68-7	2	Left front sensor closed several times
3_13	D 68-7	3	Right front sensor closed once
3_14	D 68-7	4	Right front sensor closed several times
3_15	D 68-7	5	Left front sensor closed permanently
3_16	D 68-7	6	Right front sensor closed permanently
3_17	D 68-8	7	Contact resistance to UB from left front sensor
3_18	D 68-8	8	Contact resistance to UB from right front sensor
3_19	D 68-8	9	Contact resistance against earth/ground from left front sensor
3_20	D 68-8	10	Contact resistance against earth/ground from right front sensor
3_21	D 68-8	11	Left front sensor Short-circuit to UB
3_22	D 68-9	12	Right front sensor Short-circuit to UB
3_25	D 68-9	13	Left front sensor Earth/ground resistance too high
3_26	D 68-9	14	Right front sensor Earth/ground resistance too high
3_27	D 68-9	15	Right front sensor Break in feed line
3_28	D 68-9	16	Left front sensor Break in feed line
3_29	D 68-9	17	Left front sensor Line resistance too high
3_30	D 68-10	18	Right front sensor Line resistance too high
3_33	D 68-10	19	Ignition condenser 1 Capacitance too low
3_34	D 68-10	20	Ignition condenser 2 Capacitance too low
3_35	D 68-10	21	Ignition condenser 1 Contact resistance too high
3_36	D 68-10	22	Ignition condenser 2 Contact resistance too high
3_37	D 68-11	23	Ignition pill circuit 1 Contact resistance to UB
3_38	D 68-12	24	Ignition pill circuit 2 Contact resistance to UB
3_39	D 68-12	25	Ignition pill circuit 3 Contact resistance to UB
3_40	D 68-12	26	Ignition pill circuit 1 Short-circuit to UB
3_41	D 68-12	27	Ignition pill circuit 2 Short-circuit to UB
3_42	D 68-12	28	Ignition pill circuit 3 Short-circuit to UB
3_43	D 68-13	29	Ignition pill circuit 1 Contact resistance to earth / ground
3_44	D 68-13	30	Ignition pill circuit 2 Contact resistance to earth / ground
3_45	D 68-13	31	Ignition pill circuit 3 Contact resistance to earth / ground
3_46	D 68-13	32	Ignition pill circuit 1 Short-circuit to earth/ground
3_47	D 68-13	33	Ignition pill circuit 2 Short-circuit to earth/ground
3_48	D 68-13	34	Ignition pill circuit 3 Short-circuit to earth/ground

3_49	D 68-14	35	Ignition pill circuit 1 break
3_50	D 68-15	36	Ignition pill circuit 2 break
3_51	D 68-15	37	Ignition pill circuit 3 break
3_52	D 68-15	38	Ignition pill circuit 1 resistance too low
3_53	D 68-15	39	Ignition pill circuit 2 Resistance too low
3_54	D 68-16	40	Ignition pill circuit 3 Resistance too low
3_55	D 68-16	41	Ignition pill circuit 1 Resistance too high
3_56	D 68-16	42	Ignition pill circuit 2 Resistance too high
3_57	D 68-16	43	Ignition pill circuit 3 Resistance too high
3_58	D 68-16	44	Warning lamp: Short-circuit to UB or earth / ground Fault
3_59	D 68-16	45	Break in circuit at warning lamp
3_60	D 68-17	46	Defective diagnosis unit
3_61	D 68-17	47	Ignition current correct (after crash)
3_62	D 68-17	48	Ignition current correct (after crash)
3_65	D 68-17	49	Ignition pill current has flowed (after crash)
3_67-105	D 68-17	50	Control unit defective (internal fault)

Note: The term UB refers to voltage supply
Note: Ignition pill circuit 1: driver's airbag, Ignition pill circuit 2 and 3: passenger's airbag
Note: On test point 50 a fault code can be displayed in the range of 67-105. On the 9268 tester, code 60 is always displayed if the fault is in range of 67-105.

Additional information regarding DTC codes and troubleshooting can be found in the 964 WSM, Vol. V, page D 68-22 through D 68-24

928 Fault Memory for Airbag control Unit software from version B01 onwards

DTC Code	***WSM Ref Page***	***Test Point***	***Description***
10	D 68-23	 1 2 3 4 5 6	Ignition circuits: - closed once - closed several times - permanently closed - contact resistance to Ub - contact resistance to ground - coupled 1/3 or 2/3
11	D 68-24	7	Left front sensor – resistance too high
12	D 68-24	8	Right front sensor – resistance too high
21	D 68-25	9	Ignition pill circuit 1 – resistance too high/low
22	D 68-26	10	Ignition pill circuit 2 – resistance too high/low
23	D 68-26	11	Ignition pill circuit 3 – resistance too high/low
30	D 68-26	12	Warning light Airbag – signal implausible
31	D 68-26	13	Warning light Airbag – control unit defective
40-47	D 68-26	13	Warning light Airbag – control unit defective
50-54	D 68-26	13	Warning light Airbag – control unit defective
60-62	D 68-26	13	Warning light Airbag – control unit defective
70			Crash entry – only if airbag is triggered

Any other faults: Check secondary ignition circuits, and reset fault.

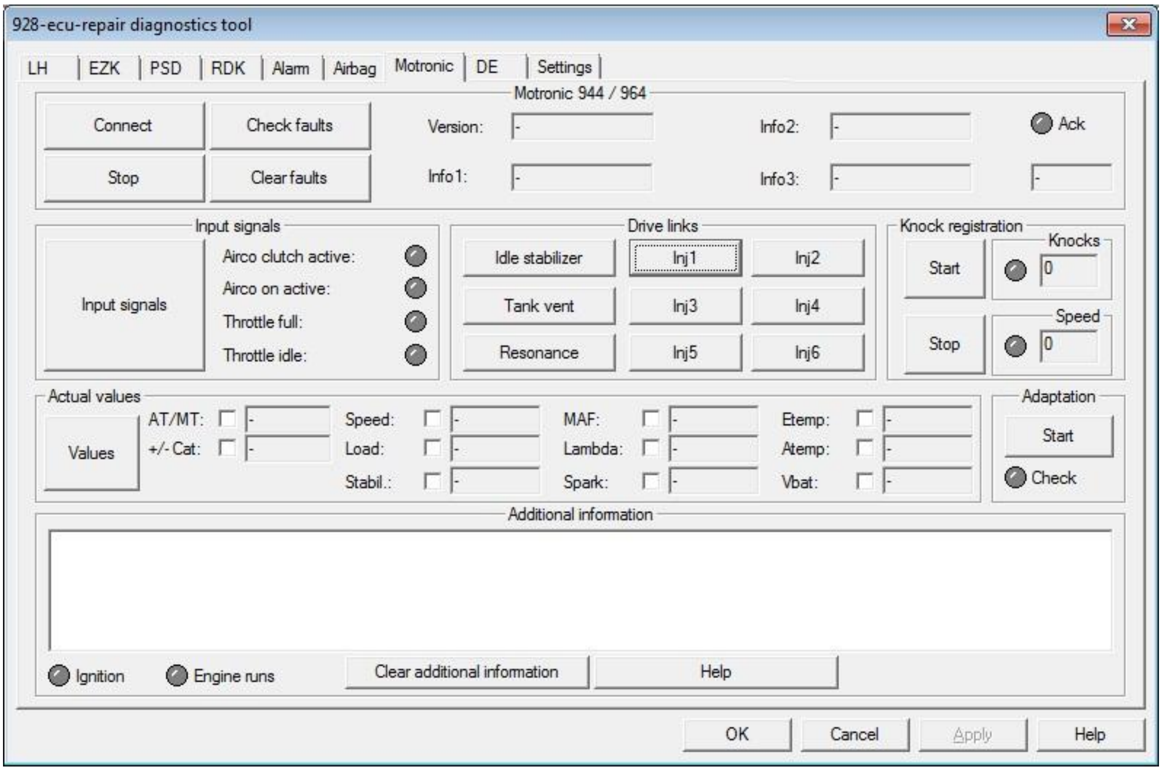
Fault memory: clear faults
Using this button will send a message to the Airbag controller to clear all existing fault conditions from memory.

Downtime

Pushing this button checks the controller for any downtime registered. Any downtime is displayed in the adjacent boxes on the screen. Downtime is something the controller detects whenever an unexpected power failure occurs. The ecu registers the period of time the power failure existed. As soon as the car starts up the digital dash checks the airbag controller and finds out if any downtime exists. If so, a red warning will be shown on the digital instrument cluster. When the reset lever at the steering column is used to clear the message, a warning light for airbag problems remains on while driving. The only way to reset the alarm on the instrument cluster is to reset the controller. This airbag alarm condition can be reset by using the clear fault memory button.
One more thing to mention: the controller logs downtime to a maximum of 99 hours and 59 minutes. If this maximum downtime is exceeded the “>” sign will be shown.

Date of Crash (Result)
Pushing this button checks the controller for any crash information stored in the controller. This is useful to determine if and when the unit has been part of an accident. The date and time will be shown in the information window, and should be zero..

9. Motronic controller



Introduction

The Motronic controller manages the engine in the 944s2, 968 and 964 models. This ecu manages fuel injection and ignition The diagnostic software module checks the system and identifies any possible malfunctions. There are several drive links. The Motronic ecu was used in 944, 968 and 964 models. The software checks the version of the ecu and adjusts some of the controls as they are not applicable for the version of the ecu.

The following is a brief explanation of functions and controls:

Ignition light:

If 12v is supplied through the car (ignition switch turned on) the light will show red and signals that the system is ready to accept commands.

Engine runs

The light turns blue when the controller knows that the engine is running. This is just verification.

Clear additional information

The diagnostic software is designed to show information on what is actually happening while communicating with the Motronic ecu. Mostly this will present quite technical information but you will recognize some state and self explanatory messages that may help and guide diagnosis. All other information can safely be ignored. By pushing the “clear additional information” button you simply wipe the log on the screen.

Connect to Motronic

When the command button is pushed the software tries to connect to the Motronic ECU, and tries to retrieve Motronic version, PCB number, Part number and Software version. All this information is stored in the firmware (software) of the ECU. If all is o.k. the infor-

mation will show in the appropriate fields in the screen. This is also verification that communication with the ECU has been established. The system is designed to retry 3 times if a failure to connect exists.
If it still failed to connect, the message "Cannot connect to Motronic, turn-off and -on the ignition and try again" appears.
The Motronic is designed to connect also when the engine is running, as long as 2000 rpm are not exceeded.

Stop
This stops the communication with the Motronic controller. The Ack signal will stop flashing, and the package counter stops incrementing.

Ack
The Ack (acknowledgement) light is blue when active and signals communication of data between controller and software. It is normal that it blinks during a session. Just below the light, a communication indicator is shown which displays the actual bytes per second data transfer to and from the ecu. If this indicator goes to zero during a session this indicates that communication has stopped. If this occurs, then restarting the communication should resolve this.

Fault memory: check faults
Using this button will interrogate and display the stored fault codes of the LH ECU. If the system reports an “unknown fault”, the message "Please send the information CMD + Data on screen to 928-ecu-repair@hetnet.nl" appears. Please inform us and we will get in touch with you. We will try to diagnose your problem and provide a software upgrade if required.

Fault codes that may be presented by the Diagnostics system are listed below. Additional information regarding DTC codes and troubleshooting can be found in the 964 WSM, Vol. 1, DME diagnosis, page D 24/28-1 through D 24/28-33

Fault Memory of Motronic control Unit

DTC code	WSM ref page	Test-point	Description
11			Battery voltage, too low
12			Idle switch, short to ground
13			Full load switch, short to ground
14			Engine temperature
15			Idle contact
21			Airflow sensor
22			Activation of idle stabilizer
23			Lambda control, outside min. range
24			Lambda control, short to ground
25			Airtemp sensor, short to ground
31			Knock sensor 1
32			Knock sensor 2
33			Knock computer
34			Hall signal
41			Computer defect
43			Tank ventilation, op. circ/ground short
44			Resonance plate, op. circ/ground short
45			Fault lamp, op. circ/ground short
51			Injection valve cylinder 1, op. circ/ground short
52			Injection valve cylinder 2, op. circ/ground short
53			Injection valve cylinder 3, op. circ/ground short
54			Injection valve cylinder 4, op. circ/ground short
55			Injection valve cylinder 5, op. circ/ground short
56			Injection valve cylinder 6, op. circ/ground short

Fault memory: clear fault

Using this button will send a message to the Motronic controller to clear all stored fault codes in the Motronic controller.

Input signals
This button starts the checks of sensors and displays their current state by turning on or off the adjacent blue light:

- **Airco clutch.** This light signals that power is applied to the AC compressor clutch via the pressure switch, and thus the compressor is actively running and driven by the engine drive belt. By pushing the AC button the AC clutch is energized via the relay in the AC console. It feeds the evaporator freeze (ice) switch that connects through the pressure switch in serial with the clutch coil. The AC clutch signal that you see is read from the LH ecu electronics, and represents the voltage between the ice/freeze switch and the low/high pressure switch. It is inter connected on the CEB. So will you see if the AC console including the relay works, the freeze/ice switch is closed (no ice), and power is applied to the low/high pressure switch. If that one is closed too (no low pressure and no high pressure), the clutch engages. The high/low pressure switch is located on the side of the drier. The air conditioner compressor is switched off via this switch when reaching a pressure of approx. 27 bar or a lower limit of approx. 2.2 bar. (just to avoid confusion: there's also a high temp switch mounted on top of the AC dryer, but that only signals the cooling fans to go to full mode via the fan controller and is not part of the clutch system)
- **Airco on.** This light signals that the AC button on the dash is pushed and therefore the system is supposed to go active. It is however possible that other switches (like freeze or low pressure) prevent the system from going active. The signal AC on is read from the Motronic ecu and represents the volt-

age of the AC-relay output that feeds into the freeze switch. It signals only that you have the system is powered on.

- **Throttle full.** This light signals that the gas pedal has opened the throttle valve under the intake to its wide open position and activated the micro switch at the valve (switch closed). This switch is also called the WOTS, the Wide Open Throttle Switch. Worth mentioning is that WOT starts anywhere from about 2/3 to 3/4 throttle as far as the switch is concerned.
- **Throttle idle.** The light signals that the gas pedal is in idle position and the throttle valve under the intake is closed. This activated the micro switch (closed) at the valve.

Please be aware: the text in this chapter is
Preliminary
and subject to changes.
The yellow highlighted areas are under review.

Fuel tank Vent

The 944s2/968/964 have a fuel tank breather system. This system prevents fuel vapor from escaping to open air. The Motronic controller opens the electric valve in the intake distributor for a longer or shorter period as function of the load during engine operation at operating temperature. The opening period is determined by a ground pulse from the control unit. The valve is not activated permanently. The test must be performed within 7 minutes from starting the engine at operating temperature. After this, interrupt the tank venting valve operation for 75 sec and then continue. This tank vent connects the fuel tank breather hose to the intake, thus sucking the gasses into the engine intake. Testing this system is done by activating the switch. A faint click can be heard at the valve in the engine bay. The test repeats itself every second until another function is selected. Refer to Carrera 2/4 WSM page D24/28 -19

Resonance plate

The 944s2/968/964/993 have a tuning flap in the intake manifold. The DME control unit activates a vacuum controlled diaphragm valve which either opens or closes the resonance flap.
The resonance flap is closed between 3.000 rpm and 5.500 rpm and at a throttle angle of > 60º.
Due to the ignition sequence, the intake system is alternatively supplied by both tanks. Due to the firing order, air is drawn in alternating manner from both intake tank systems. If resonances occur, the intake frequency of one row of cylinders matches the natural frequency of the pressure vibrations in the respective tank. The natural frequency is determined by the geometry of the intake pipes, the resonance pipe, and the tanks. A crucial factor however, is the total length of the pipe from the actual intake cylinder to the next cylinder being supplied, the distribution into intake and resonance pipe lengths as well as the depth of the tank in the direction of the flow. In the no-current state, the resonance flap is open. As soon as the ignition is switched on, however, it is triggered and closed. If the DME control unit detects that the engine is being started, the resonance flap is opened again.

A system test is performed by clicking on the button “Resonance Plate”. This action can be heard as a rather loud click in the intake body. You will notice the axis of the valve rotate 90 degrees. The test repeats itself every second until another function is selected.

One thing to keep in mind: the actuator operates on vacuum from the vacuum booster. If the system has a severe vacuum leak, the vacuum contained in the system will diminish rapidly and leave the actuator inoperable. This is obviously not a fault in the actuator itself, but in the vacuum system. Even despite of a running engine, there is sometimes not enough vacuum to engage the system when severe leaks in the system exist.

Idle stabilizer
The car has an idle management system that provides a managed idle control by applying a bypass air stream over the closed intake valve. This is the IACV, the **I**dle **A**ir **C**ontrol **V**alve. At idle, the throttle idle switch is active, and the system knows it needs to take control of stabilizing the engine rpm at approx 800 (880 +/-40 for a 964). The Motronic ecu sends a signal to a rotary valve that opens the airflow in the valve-bypass hose. By modulating this 12v signal, the amount of air is regulated and rpm managed. Clicking on this button sends an impulse to the ecu to fully open and fully close the valve. A clear and loud click can be heard under the intake. The test repeats itself every second until another function is selected.

Fuel injectors
The fuel injectors of the 964 are a multi point- multi control setup, but the 944s2 and 968 are single-control. The diagnostic software adapts to this condition. The Motronic 944/968 ecu fires all injectors at the same time during normal operation and the 964 can fire individually. This injector firing creates a fuel mixture in the intake cavities that is sucked in during intake when the intake valve opens. When you use this function, the selected injector is triggered. At the engine the selected injector(s) make(s) a clicking sound. The sound is damped and faint. It helps to put a screw driver on a specific injector and put your ear on the screwdriver to listen to the clicks and verify that the injector coil opens the needle to inject fuel. The test repeats itself every second until another function is selected.

Knock registration: start
The 944s2/968/964 use two knock sensors, both mounted on the engine. These piëzo pickups listen to the engine and detect any pre-detonation. This information is sent to the Motronic ECU which retards timing to prevent further knocks.
Knocking can be recognized by knocking combustion (maybe caused by poor grade of gasoline) or mechanical engine noise. It sounds like marbles in the engine hitting the pistons.
In the normal load range of the engine it is very close to the knock limit of the ignition curve, through which combustion knocks and therefore also ignition timing corrections for each cylinder occur more or less frequently. The number of “knocks” registered by the sensors is calculated each time for 10,000 ignition firings. The registration of knocks should be performed if there are customer complaints about, for example, poor engine performance or high fuel consumption.

It is recommended that a fault diagnosis be carried out prior to registering the engine knocks, in order to exclude other factors that might influence knock regulation. When running the knock test the engine must be at operating temperature, and the test performed while test driving the car or with the car on a roller dynamometer.

By clicking the start button the test starts. Speed and number of knocks detected are shown in the adjacent boxes. The test will terminate itself after 10,000 firings. A perfectly good working engine should normally register 5-20 knocks, especially when test-driving in an aggressive manner and using roz95 or roz98 fuel. Roz100 (V-power or similar high octane rated fuels) may help reduce knocks. A knock report of over 50 knocks must be considered as abnormal and need further investigation. Knocks will make the ECU retard the engine to prevent this occurring and thus performance will suffer. A defective knock sensor will be reported as an error when checking the fault code report.

Knock registration: stop
This terminates the knock registration test.

Actual Values:
You can select each value you want to monitor by tagging the check box on the appropriate field. You can select more than one field if you'd like. Tagging many options at once however will slow down the update. A log file is created and each field is presented in this log file. This makes importing it into spreadsheets or databases easy. By pushing the Values button, the process of acquiring the actual values is initiated, and it can be stopped by pushing it again. Each field is now discussed in more detail:

Actual values: AT/MT
This indicates if the car is equipped with a manual or an automatic transmission.

Actual values: +/- Cat
This indicates if the car is equipped with a Catalytic converter.

Actual values: Speed
This indicates the actual rpm of the engine in revolutions per minute. A normal value is about 800 at idle, not in gear. (880 +/- 40 for a 964)

Actual values: Load
This indicates engine load at the given time in ms. A normal value is 1.750 ms at idle and warm in a 944s2.

Actual values: Stabil.
This indicates the activation of the idle stabilizer. It shows a percentage of the activation of the idle stabilizer, reflecting the opening angle and thus the amount of air bypassing the closed throttle valve in the intake. 60% is a normal value for a 944s2.

Actual values: MAF
This indicates actual value of the MAF airflow sensor as it is seen by the Motronic ecu. A normal value is 0.177 at a 944s2 at idle.

Actual values: Lambda
This indicates actual value of the Lambda Oxygen sensor as it is seen by the Motronic ecu. The lambda sensor is a narrowband type. This means that it fluctuates between 0.4 and 0.7 volts in cycles of about 100 msec. This results in a rich/lean adjustment every time the transition is made. If you look at the reading on the screen it does not give you a steady value, but it will be unstable. If it gives a steady value there's something wrong. Further analysis of the sensor data would be required to see if it works properly and in the right frequency. A slowly changing (lazy) lambda sensor is also cause for trouble and will result in a overly rich or lean engine with related problems like High CO or hesitation at accelerating. One more thing: the lambda needs to be hot to operate. A 12v heater element is embedded to aid the warm up process, but effectively you need to have a warm engine (exhaust) to get useful data.

Actual values: Spark

This indicates spark advance. The normal advance value is about 0 +/- 3 degrees at 880 rpm +/- idle and warm.

Actual values: Etemp
This indicates actual value of the Engine temp sensor as it is seen by the Motronic ecu. A normal value is 85 at a 944s2 at idle and operating temperature.

Actual values: Atemp
This indicates actual value of the Air temp sensor as it is seen by the Motronic ecu. A normal value is 32 at a 944s2 at idle and operating temperature, but this is depending on environment conditions like ambient temperature of course.

Actual values: Vbat
This indicates actual value of the Battery voltage as it is seen by the Motronic ecu. A normal value is 13 to 13.5 volt.

Adaptation start
The Motronic ecu is able to adjust itself to the car's conditions via adaptation. It is a learning mode where it knows how ignition timing, airflow, fuel pulse width and lambda values are related and uses this information to maximize fuel economy, performance, and comfort.
Adaptation is called for when the car has problems running a smooth idle, lacking power, or is using excessive amounts of fuel. This may be caused by misinterpreted sensor signals or by using signals which are influenced by a previous technical problem. The "brain" then needs to be reset to start a fresh adaptation.

The adaptation starts with a warm engine, i.e. the car needs to be at normal operating temperature. Clicking on the "start" button in the adaptation pane initiates a dialogue that needs to be followed strictly. In the additional information window you will get instructions.

- First step: check if the Throttle idle switch operates as expected. The ecu will not perform the adaptation routine when the idle switch is not closed.
- Next: Click on the "start" button. You will get a message that says: "please turn ignition OFF and press button <Start> again". Please do so.
- Next step: click on the "start" button again. This message will appear: "please turn ignition ON and start the engine within 6 seconds". Please start the engine as instructed.
- Next step: now the adaptation phase runs and the system searches for optimal values. Please be patient. You will notice engine sound and rpm fluctuate. After one minute, the routine ends and you can shutdown the engine. A trick to adjust also to worst conditions is to run the headlights during adaptation. This will give a slightly higher rpm at normal idle but a more stable rpm when lights are on.

10. Climate Ecu (911 series)

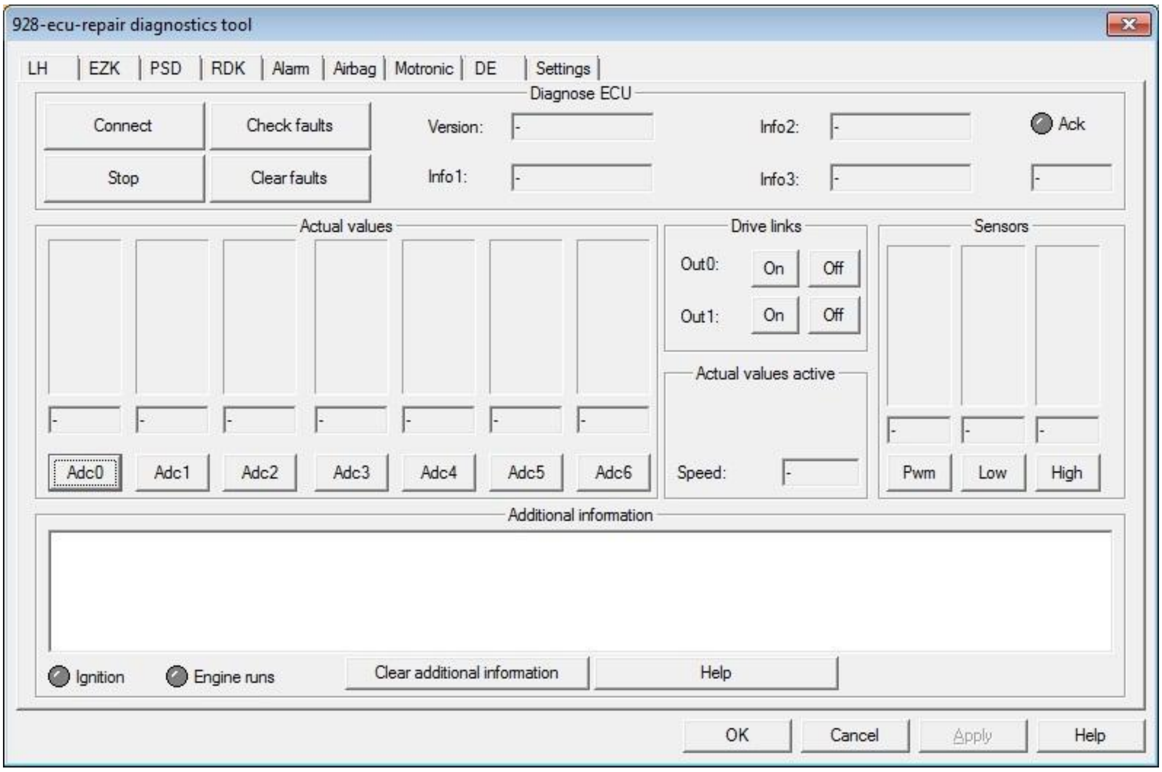
11. PDAS Ecu (911 series)

12. Tiptronic Ecu (968, 911 series)

13. ABS5 Ecu (911 series)

14. Motronic Ecu (911 series)

15. Diagnostic Ecu



Introduction

The LH is only partially equipped to investigate signals during its operational use. It is pretty busy to manage the engine and too slow to keep up with more complex data acquisition. Therefore we decided to develop a **pcb to expand the LH ecu.** This is called the

DE module. It is not (!) a feature of any standard LH, but a specialty that can be bought from us. Its purpose is to provide more runtime data that is accurate and available during normal driving, and will not interfere with the LH’s normal business.
We will be able to provide features like MAF reading, Injector pulse, enable/disable fuel pump, measure the load pulse, and so on.

This DE module is still in development and has not finished yet. You will see the DE tab in your screen but it is not available yet. If this feature is interesting to you, watch for our future updates and upgrades.

What does the screen show?

Ignition light:
If 12v is supplied through the car (ignition switch turned on) the light will show red and signals that the system is ready to accept commands.

Engine runs
The light turns blue when the controller knows that the engine is running. This is just verification.

Clear additional information
The diagnostic software is designed to show information on what is actually happening while communicating with the Motronic ecu. Mostly this will present quite technical information but you will recognize some state and self explanatory messages that may help and guide diagnosis. All other information can safely be ignored. By pushing the “clear additional information” button you simply wipe the log on the screen.

Connect to DE
When the command button is pushed the software tries to connect to the DE module inside the LH ECU, and tries to retrieve DE version, PCB number, Part number and Software version. All this information is stored in the firmware (software) of the DE. If all is o.k. the information will show in the appropriate fields in the screen. This is also verification that communication with the ECU has been established. The system is designed to retry 3 times if a failure to connect exists.
If it still failed to connect, the message "Cannot connect to DE, turn-off and -on the ignition and try again" appears.
The DE is designed to connect also when the engine is running, and will have no impact on the normal LH operation in which it resides.

Stop
This stops the communication with the DE module. The Ack signal will stop flashing, and the package counter stops incrementing.

Ack
The Ack (acknowledgement) light is blue when active and signals communication of data between controller and software. It is normal that it blinks during a session. Just below the light, a communication indicator is shown which displays the actual bytes per second data transfer to and from the ecu. If this indicator goes to zero during a session this indicates that communication has stopped. If this occurs, then restarting the communication should resolve this.

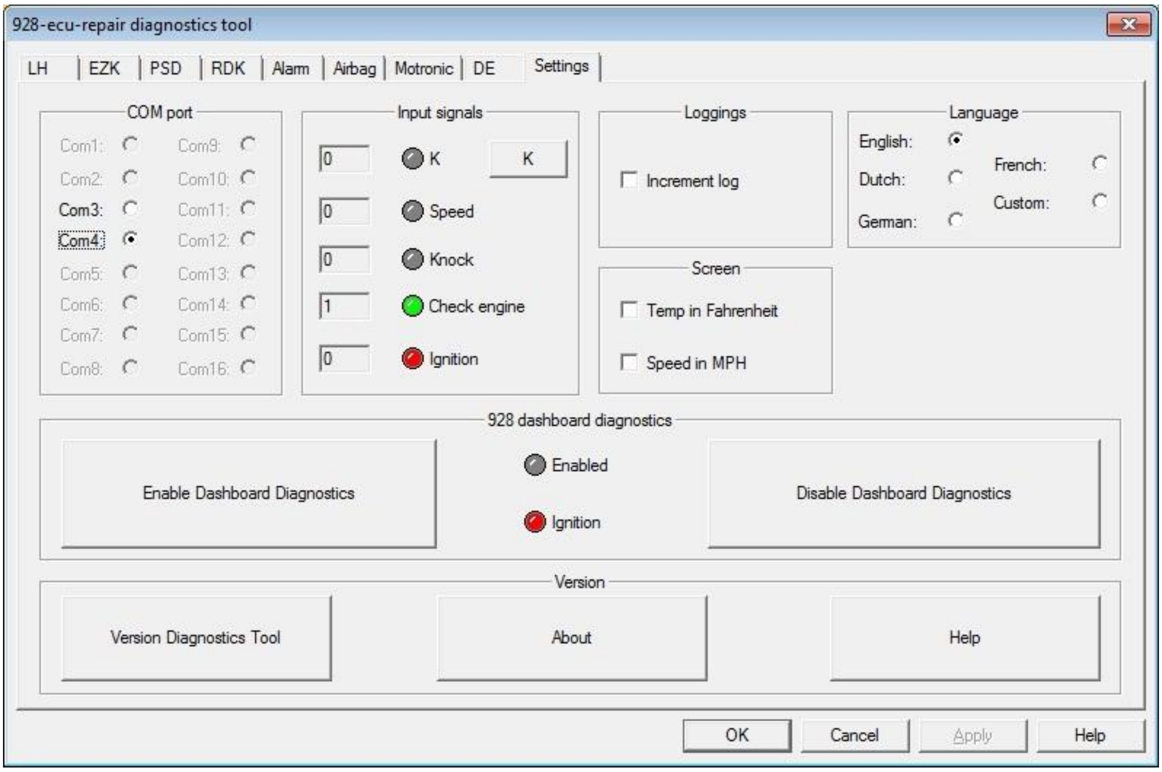
Actual values
The actual values shows a series of Adc displays, which will act as an analogue signal to digital value converter. It allows you to measure a signal like the MAF or O2 voltage.

Drive links
The drive links functions offer a possibility to operate a switch of invoke a signal. Think of the possibility to activate the fuel pump at any time, even with the engine off, or disable the fuel pump (and make sure nobody will be able to start anymore (anti-theft?)

Sensors
The sensors area shows three possible sensors to evaluate. One is Pulse Width Modulation (like the idle stabilizer or the injector pulse), one is low and one is high value.

Note: again I emphasize that this DE module is under development and not for sale yet. We are prototyping right now.

Settings

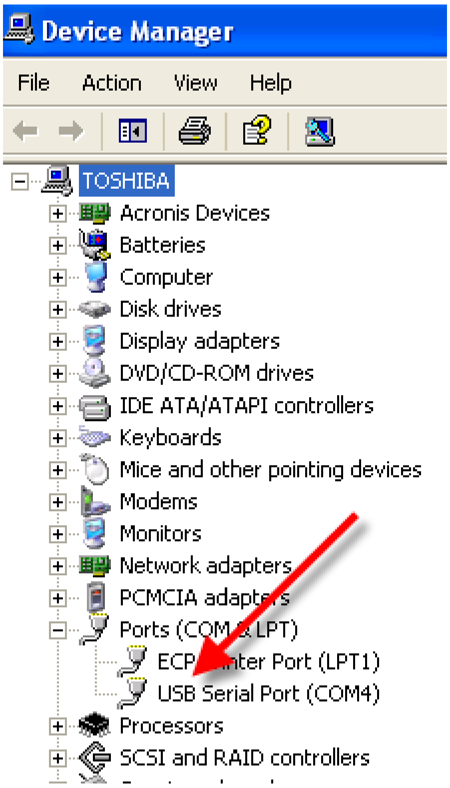


This Tab is intended to provide access to specific settings.
A short overview of controls and functions follows:

15.1. Com port settings

The software uses the COM port of the PC to communicate with the interface to the 928 electronics. This comport is normally the COM1, but since you may use a different hardware configurations, you can adjust the default comport by using the comport selector control. Your selection is saved in the file DIAG_928.TXT file as a default preference. The existing ports in your configuration are shown, non-existing ports are grey-ed out. Be aware that your previous port is remembered. If you use a USB converter it needs to be connected to be able to select the port. The system will automatically try to use the last selected port which is recorded in the settings. If your configuration has changed since last saved setting, you may end up communicating to a non-existing port which will obviously fail.

When you start to use the USB to serial converter you will need to install the driver CD. The CD is supplied with the converter. This driver translates the USB signal to a virtual com port on your PC. It will show on your PC like this:



In this example the port is assigned to com4.

Windows automatically assigns a new comport to your system when a new USB comport adapter is connected. If a system has seem many different adapters it is possible that is has assigned a com port beyond com9. To correct this, please go into the system hardware device manager of your windows PC, select the port, select advanced options, and open the com port number dialog. This is where you can define your preferred port number. Make sure you don't overlap with an existing port. Vista requires a PC to reboot to make the change effective. XP does not.

A total absence or serial ports triggers a message that informs you about the port configuration problem, Please look into this at your PC. This is designed behavior.

One of the things you must be aware of. is that port recognition only happens when you start the program. So, connecting the USB interface will have to be done prior to starting the program. Otherwise you will not see the USB-com port in the application software.

15.2. Input signals

The interface module uses some signals to communicate with the car's electronics. The signals are shown here. An explanation is documented below:

Check Engine	Engine MIL light, signals engine flash code
Speed	Speed signal from the flywheel sensor
Knock	Knock sensor signal from the ecu
K-line	K line signal from the diagnostic bus
Ignition	Ignition switched on (12v)

There's one neat function button: "K". Pushing this button triggers the K line to switch state, which should be reflected on the left field

showing a response from the system. A response indicates a working communication over the configured port, no more. This is a very useful test to verify serial port communications. The best procedure is this:
Start the software and go to the settings tab, connect the interface to the car and to the PC, turn ignition on, notice the green light on the interface and on the screen (check engine LED), verify the purple LED on/off state when pushing then K-line button on and off. Now, to avoid the possibility that you are looking at an internal modem port or such, unplug the RS232 cable between PC serial port and the interface, and test the K-line again. It should <u>not be responding</u> anymore as the cable is now disconnected!!! If it still responds you are probably setting the wrong PC port to communicate with.

15.3. Increment Log file

The software automatically saves a log file upon program exit. If you want to keep the log file for a review and prefer an automatic version number, you can use this check box. It will create a new successive number for each log. The log file number is taken from a parameter in the DIAG_928.TXT file. The log file is normally residing in the same directory as where the Diagnostics software is run from. But Windows 7 is doing this in a different way. You need to look for the files in the directory:

<local disk>\Users\<username>\Appdata\Local\VirtualStore\ProgramFiles\Diagnostics Porsche\software\

15.4. Temp in Fahrenheit

This checkbox makes all temperature presentations show in Fahrenheit when checked. Otherwise all temperatures are shown in degrees Celsius. Your selection is saved in the file DIAG_928.TXT file as a default preference.

15.5. Language setting

This feature enables you to select the desired language. The software uses an external text table which resides in a subdirectory of the application. Based on your language selection and the TAB you select on the screen, a different text file is used. The format is like this: diag_[group]_[Language code].txt. For example: “diag_cmd_fr.txt” will be used as French language table for the commands used and “diag_but_fr.txt” is the French buttons text. These files can be altered so they can be adapted to your needs but we supplied 4 languages already preset, and one which is meant to be customized by the customer. It is however important that the sequence is **<u>always</u>** maintained. There is one special language option: custom. The custom option enables you to make your own version, like Swede, Fin, Portuguese or whatever pleases you. You will also find a language file for the settings tab itself. Please do not change the preset ones, change the custom version if you’d like.

15.6. Enable Digital Dash diagnostic mode

From 1989 onward 928s were equipped with a “digital dash”. The digital dash is capable of displaying sensor information, fault conditions, and providing some function tests. The first step in enabling this function is by clicking on the “enable Dashboard Diagnostics” button. Once pressed the light between the buttons illuminates. “Disable Dashboard Diagnostics” switches this function off.

The second step is to push the left lower column lever to the front for at least 3 seconds. Then you will see the display respond with diagnostic messages and software version of the cluster. If you pull the lever back you enter the language setting mode (not available on all models).

The digital dash will respond with a diagnostic announcement and then report a software version. Some versions support an extended error check.

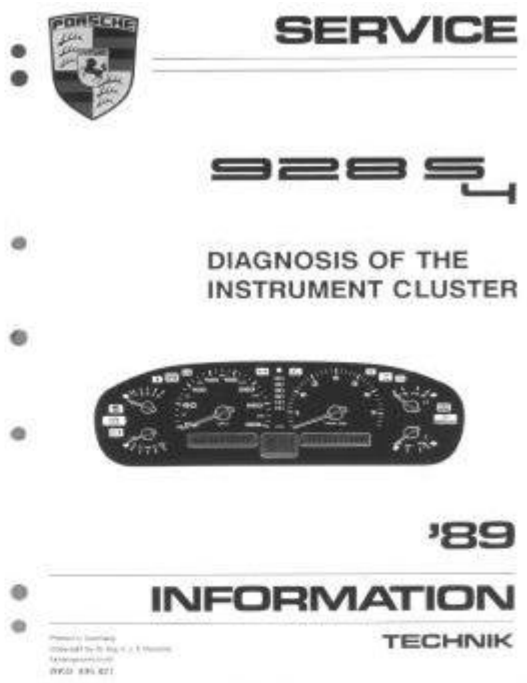
K18	First version (1989->)	Fixed language setting (German, French, Italian or English) which cannot be changed. Units can be changed from metric to US by pulling the stalk twice in a second
K21	Modified version 1989->	Error check available, language choice available but volatile when power is disconnected
K25	90 S4 model	Error check available. Language setting can be changed via the diagnostic mode enabled at the diagnostics socket.
K26	90 GT model	Error check available, the system looses the language and units settings when power is off for a long time. It enables a user to set a new 0-km pcb to the correct setting (just once)
K28	model?	No error check possible, settings are preserved when power is disconnected
K29	1992-> GTS model	No error check possible, settings are preserved when power is disconnected

The different versions also have different test capabilities.
K25 and K26 - K, E, L, R, P
K29 – only K
Others not known
The extended error check of this instrument cluster is not documented, but this is how it works. First turn the ignition~~start the engine~~ and switch on the instrument cluster diagnostics. This enables the pin 5 and 13 on the connector.
Then push the operating lever forward for a few seconds. That will make the instrument display PORSCHE - DIAGNOSE.

Next push the lever down for a few seconds and depending upon the software version you will see in the display: S-R-N-M-L-K-H-G-E-D-B-A subsequently. Possibly: E=Ezk, K=Kombi instrument, L=LHjectronic, R=RDK, S=ABS/PSD, A=Alarm. An error may look like Fehler01 K18 03/250 We can not provide a clear error description at this moment.

There is a separate manual on diagnosis using the digital dash instrument panel which can be downloaded from our web server at: http://forum.jenniskens.eu . The digital dash instrument can provide additional information and functions to what the diagnostic software can offer. Just to name a few: outside temp sensor value, Term15 actual voltage, oil pressure value, Term61 alternator voltage, coolant pressure switch state, CAT monitor, etc. It has another fine feature. It is able to store some fault conditions like oil pressure alarm or toothed belt alarm. This enables you to check for conditions that may have happened in the past.

For your reference here is a picture of the front of the manual is provided here:



15.7. Other functions on the Settings Tab

You get the Diagnostic system version and information about the software you are using by pushing the appropriate buttons. Since the software is copy protected you will find a reference to your order in this screen. Please provide this information when asking for support.

16. Service and Support

The hardware and software that we offer was thoroughly tested before shipping. For the unlikely event that the product fails to function according to specification we offer one year full repair warranty (send in and return). Transportation and any tampering or misuse is excluded from this warranty.

Despite of our thoroughness it is still possible that some error condition is shown wrong or missed in the design. We ask for your understanding, as we had to reverse engineer almost all functions and features since Porsche did not share this information publicly. We would like to know if any conditions exist and encourage you to get in touch with us via email (928-ecu-repair@hetnet.nl). We will provide bug fixes and updates free of charge for everyone who bought the product.

The diagnostic interface uses a standard RS232 interface. Many new notebooks only carry USB ports so a USB to serial interface converter is called for. Due to the many compatibility problems with USB converters on the market, we only provide support for the one that we offer.

Last, but not least, we would like to bring our **928 LH ecu repair service** to your attention. We offer diagnose and repair of broken LH ecu's and MAF's at a fair price. Please visit our website at http://www.928-ecu-repair.com or http://928gts.jenniskens.eu

We hope that our product will be very useful for you and appreciate your comments and thoughts to improve it.

16.1. Contact

If you would like to get in touch with us, please do not hesitate to contact us via e-mail at one of these addresses:

Theo Jenniskens: 928diag@jenniskens.livedsl.nl
Paul Moers: 928-ecu-repair@hetnet.nl

We would appreciate any testimonials, and suggestions or comments that you might have to improve our product.

17. References and Acknowledgements

Several resources have been used to design, develop and build this diagnostic system. Just to name a few:

Internet:
Andy Whittaker's website on OBD and OBD2
Rennlist Discussion Forum
http://www.troublecodes.net/
http://freediag.sourceforge.net/
http://www.obd2-interface.netfirms.com/

Porsche manuals:
928 S4 '89 - Diagnosis of the Instrument Cluster
928S4 PSD
Test Plan ABS 928 944 all yrs
928 Diagnosis w 9288 (Hammer)
928 Airbag System
Oxygen Sensor & Catalytic Converter
87 Test Plan EZF and LH
944S 928S4 '89 – Diagnosis of EZK, LH with Tester9268
928 Air Flow Controlled Fuel Injection
Service Info Tech 1990 S4 GT (and others)

We would like to thank Barry and Jason for their review work and comments.

A special thank you goes out to Claus Schweiker who helped us a lot with the translation into German language.

Also we would like to thank Peter from P&P parts, http://www.porsche-parts.nl for the help, advice, and support during the many times he let us use his workshop equipment to aid our developments.

18. Disclaimer