Porsche 928 1987 - 1995 Engine Control Systems

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Basic theory of LH Jetronic fuel Injection operation

The Porsche 928 from the 1987 through the end of production in 1995 used separate Bosch Jetronic LH Fuel Injection and EZK Spark Control modules.

The spark and fuel control systems obtain engine speed information from an inductive RPM sensor that connects to EZK module via pins 6 (-), 23 (+) and 24 (shielding). The EZK module pin 13 outputs an engine speed signal to LH module pin 1. It is important to understand that if the engine RPM signal is not propagated from the EZK to LH module, there will be no fuel injection. So it is wise to always check for spark first in a no-start condition.

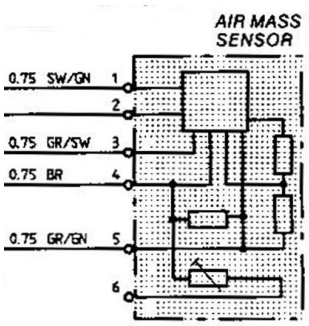
The fuel injector nozzles are provided 12V via the LH relay pin 87 any time the ignition switch is turned to the "on" position. The fuel injectors are actually ***"turned on"*** by the ground portion of the fuel injection circuit which is formed by the negative side of the fuel injectors to the LH module pin 18, to the LH Fuel Injection controller which provides the ***turn on*** switch to ground. For model years 1987 – 1988, all injectors are wired in parallel in a single circuit. In 1989, Porsche added an "Ignition Circuit Monitor" system to "turn off" one of the two banks of fuel injectors in the case of one of the ignition circuits fails.

The Temp II sensor provides engine coolant temperature information is to LH (pin 13) and EZK (pin 19). Two separate sensors are contained in one housing. The sensors are grounded by the engine block, so there are only two prongs on the Temp II sensor plug. The fuel and spark modules use engine temperature for cold start enrichment and proper tuning.

The inputs used by the to the Jetronic LH Fuel Injection module to calculate precise fuel injection quantities are:

- engine speed from EZK (LH pin 1)
- Mass Air Flow (LH pin 7)
- throttle position idle switch (LH pin 2) & wide open switch (LH pin 3)
- engine temperature (LH pin 13)
- A/C compressor (LH pin 14)
- Fuel type (LH pin 23)
- Oxygen sensor (LH pin 24)
- Code plug pin (LH pin 29)
- Automatic Transmission (LH pin 30) for idle speed drop

The Mass Airflow Sensor (MAF) provides a voltage signal to the LH which provides an accurate measurement of the mass of air that is being sucked into the engine. The connection is MAF pin 5 to the LH connector pin 7. The LH fuel injection controller uses this information as one of the variables needed to calculate the amount of fuel to inject into the cylinders. It is located in the center rear of the engine compartment under the air filter housing.



The MAF connections to the LH module and wiring color code are provided below.

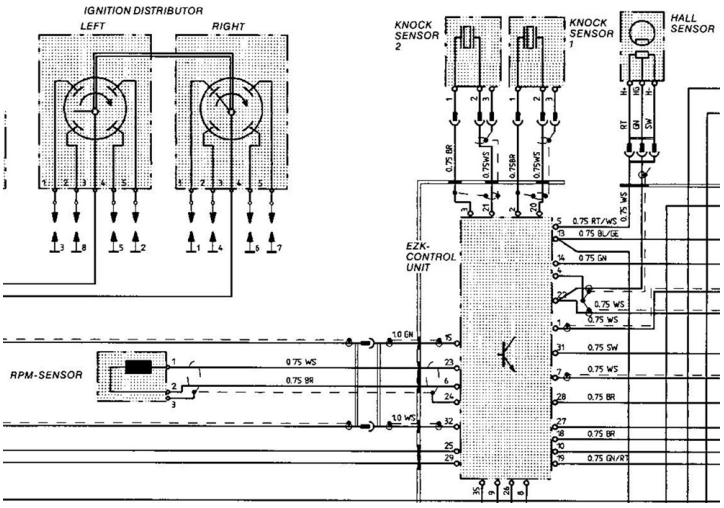
LH Pin	Signal	Gauge/Color	MAF Pin
6	Ground from MAF 2	0.75 Green/Black (GR/SW)	3
7	Voltage from MAF 3	0.75 Grey/Green (GR/GN)	5
8	MAF Burn-off	0.75 Black/Green (SW/GN)	1
Other Connection			
LH Relay Pin 87 – W23 Central Electric		0.75 Red/Yellow (RT/GE)	2
Ground point (MP) IX		0.75 Brown (BR)	4

The control and outputs of the LH module are listed below:

- diagnostics (LH pin 12)
- fuel injection ground path (LH pin 18)
- fuel pump relay ground (LH pin 20)
- LH relay (LH pin 21)
- check engine light (Pin 22)
- engine load signal (LH pin 25) to EZK
- emissions carbon canister vent valve (LH pin 27)
- fuel consumption (LH pin 31) for trip computer
- idle speed control (LH pin 33) 100 Hz variable duty cycle signal
- intake manifold resonance flap (LH pin 34)

Theory of operation EZK Spark Control

The 928 has two independent four cylinder spark systems. Ignition circuit 1 is comprised of cylinders 1,4,6,7 and the right side coil and distributor. Ignition circuit 2 is comprised of cylinders 2,3,5,8 and the left side coil and distributor.

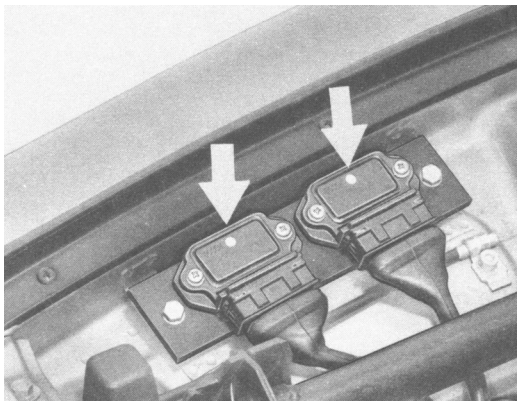


The EZK spark system uses the following inputs to calculate optimum spark timing:

- throttle position idle switch (EZK pin 8) & wide open switch (EZK pin 26)
- engine load information from the LH (EZK pin 9)
- coding inputs (EZH pins 10, 27 and 28)
- inductive RPM sensor (EZK pin 23)
- Hall effect cam position sensor (EZK pin 5 and 22)
- two spark knock sensors (EZK pins 20 and 21)
- automatic transmission protection (EZK pin 25)
- engine temperature (EZK pin 19)

The output of the EZK system is:

- Pulse to ignition final stage 1 (EZK pin 32)
- Pulse to ignition final stage 2 (EZK pin 15)



The two separate ignition final stage modules are located at the front of the engine compartment ahead of the radiator. These modules provide the primary input to the spark coils. The secondary output of the spark coil is the spark that is channeled to the correct spark plug by the distributor.

The Ignition Circuit Monitoring Relay

The 928 S4 and newer engines have two separate ignition circuits. Ignition circuit 1 is comprised of cylinders 1,4,6,7, and the right side coil and distributor. Ignition circuit 2 is comprised of cylinders 2,3,5,8, and the left side coil and distributor. If there is a failure in one of the ignition circuits, raw fuel is pumped out of the cylinders and into the exhaust system. When the raw fuel hits the hot catalytic converters a fire may occur – OUCH!

From model year 1989 onwards, Porsche added the *Ignition Circuit Monitoring Relay* as a safety feature. This circuit is completely independent of the LH injection system. It is identified in the workshop manual wiring diagram as the *Ignition Control Circuit*. The function of the system is to turn off the fuel injection to the failing ignition circuit. The inputs to the relay are two exhaust temperature sensors that provide input to the relay. If one of the ignition circuits fails, the “Ignition Circuit Monitoring Relay” shuts off the pulse signal to all of the fuel injectors of the affected circuit.

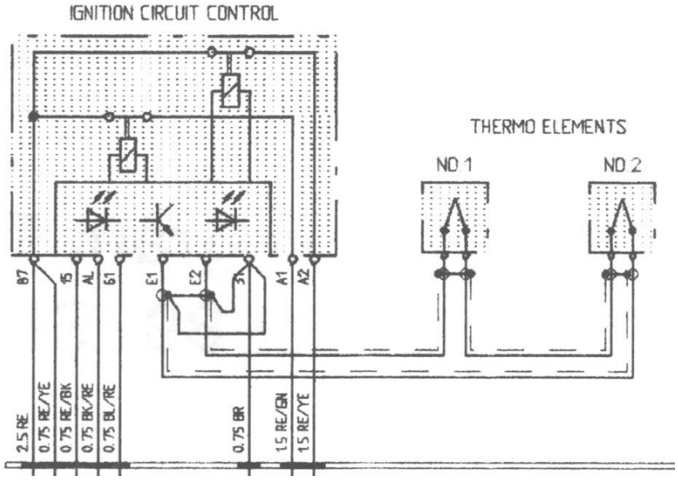
As you might imagine, the symptoms of a shut down ignition circuit are a significant reduction in power and a rough running engine. For trouble shooting, you need to determine if the shut-down is due to a failed ignition circuit or a failure of the Ignition Circuit Monitoring Relay itself.

The first step is to quickly identify which circuit is affected. Look at the clear relay module that is fitted next to the EZK spark control unit in the passenger compartment.

When ignition circuit 1 (cylinders 1,4,6,7) is shut-down, a red LED is illuminated.

When ignition circuit 2 (cylinders 2,3,5,8) is shut-down, a green LED is illuminated.

Check the ignition circuits and repair as necessary. If no problem is found with the ignition circuit, there may be a failure of the Ignition Circuit Monitoring Relay circuit, the signals to test are:



1. Terminal 31: ground
2. Ground must be present at terminal AL when the ignition switch is in the off position.
3. Battery voltage must be present at terminals A1, A2, 15 and 87 when the ignition is in the on position.
4. Battery voltage must be present at terminals AL and 61 when the engine is running.
5. A Voltage value of approximately 2.7 V must be present at both terminals E1 and E2 when the ignition is in the on position.
6. The resistance between E1 and E2 is approximately 5 – 10 Ohms (measured at the disconnected relay socket).

The temperature sensors that fit in the exhaust system should also be inspected.

Common No-Start Diagnostics for the Porsche 928

This information is for 1987 to 1995 Porsche 928s. Diagnostics should be only be performed by a trained technician. If you are a do-it-yourselfer, you are responsible for yourself and your Porsche! Do not attempt tests and repairs that you cannot safely complete. This information is provided solely as friendly advice; Electronik Repair, Inc. accepts no responsibility for the outcome of any work done by those reading these webpages. For more detailed step-by-step instructions, consult the Porsche factory workshop manuals.

a. Check Relays: A relay is an electrical mechanical device that enables high current load switching controlled by a small current signal. The Porsche 928 uses relays to control many of electrical circuits. Many 928 are still operating with their original relays, so failures are common. The main relays for engine start are:

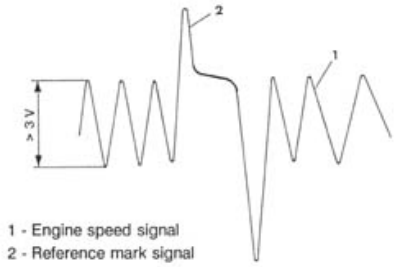
	1987 - 1989	1990 +	Power Supply for:
Fuel Pump Relay	XX	XXVI	Fuel Pump and O2 Sensor
EZK Relay	XVI	XXII	LH and EZK control Unit
LH Relay	XXV	XXV	Fuel Injectors
Starter	XIV	V	Starter
[Horn Relay	XII	XVI	Horn]

Note: The horn relay is the same relay type as the LH and fuel pump relay (and starter relay for automatic transmission cars). So if your horn works, the horn relay may be removed from its socket and swapped with these other relays for testing purposes (or in an emergency as a spare). Bridging relay socket position 30 and 87 closes that circuit and removes relay functionality as an issue for testing. To identify the positions for bridging, match the relay pin numbers that are marked on the bottom of the relay to their corresponding position on the relay socket.

b. Testing the engine RPM sensor. The EZK spark control is the system master, if engine rotation signals are not provided to the EZK, spark will not be generated and the EZK will not provide a turn-on signal to the LH Jetronic fuel injection system. (Note: if your engine has spark, this test and the EZK output stage tests are not necessary).

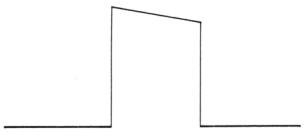
The first test to perform is a resistance test. It is best to start the measurements at the spark control module connector, since the test verifies the complete circuit. You will need to fabricate a test lead to with a blade to plug into the connector. The resistance reading should be between 600 - 1600 Ohms at EZK connector pins 23 (+) and 6 (-). If the test does not yield the desired results, disconnect the engine speed sensor plug to the wiring harness and test at that point.

The RPM sensor input to the EZK is from an inductive RPM sensor. Inductive RPM sensors generate voltage so a VOM can be used for testing the sensor, you would see the needle of an analog voltmeter twitch when set to the AC scale. Use caution if testing at greater RPM than start-crank speeds, the voltage can be much higher.



An oscilloscope is needed to verify the pulse shape, as illustrated above. The minimum speed signal (1) voltage is 3.0 V (AC) and Reference Mark Signal (2) output is 5V (AC) when the engine is cranking. EZK pins 23 and 6 are connected to the RPM sensor. EZK pin 24 is the shielding of the sensor cable.

c Testing the EZK spark module RPM Output: The EZK module provides the signal to turn on the LH fuel injection module; it is the circuit from EZK connector pin 13 to LH connector Pin 1. Check for circuit continuity, if the wire is broken or the connection isn't clean, the car will not start.



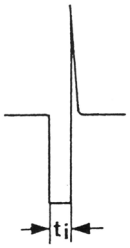
This is what the EZK pin 13
output looks like on an oscilloscope.

d. Testing the fuel pump circuit: The circuit from LH Pin 20 goes to the Fuel Pump Relay pin 85, check for continuity between these two points. From the Fuel Pump Relay pin 87 the circuit passes through fuse 42 then to the fuel pump motor. Pull the fuse, check the fuse, and clean the connectors. Check the continuity of this path. Bridge Fuel Pump Relay socket points 30 and 87; the fuel pump should run. If the pump does not run, check for battery voltage at the "+" terminal of the fuel pump and check for a good connection from the "-" terminal to ground.

e. Check for Voltage to Relays: There should be 12V (nominal battery voltage) at the fuel pump, EZK and LH relay pins 30 at all times. This same circuit connects to LH connector Pin 4, check for 12V there too. If there is no voltage, check the + battery connector, which is the point where this circuit begins.

f. LH to Relay connection test: The LH relay pin 85 connects to LH connector pin 21, check for continuity between these two points.

g. Testing the circuit to fuel injectors: The LH connector pin 18 connects to all the fuel injectors. The LH controller functions as the switch from the fuel injector to ground. With the LH relay jumpered between pins 30 and 87, there should be 12 V at LH connector pin 18. [Model Year 1989 and newer 928s have a spark monitoring system, consult the wiring schematics and workshop manuals for specifics].

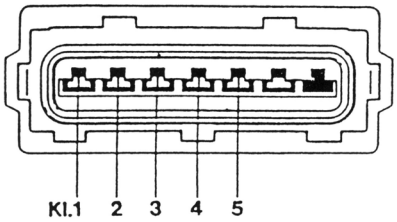


When the engine is cranking, an oscilloscope
should show the fuel injection pulse as illustrated above.

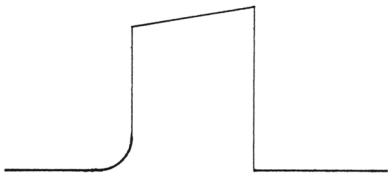
The 12V falls to 0V for period t_i and then a brief spike up to 12V.

The period t_i is a function of the on time of the fuel injector as initiated by the LH fuel injection controller.

h. Test EZK Output Stage Control Signal. The EZK unit sends a signal to the spark output stage control modules, which are located in the front of the 928 just behind the bumper on the right side (as you face toward the engine compartment with the hood open). Remove the cover and inspect the two connections, they should be clean and free of corrosion.



Connect an oscilloscope positive test lead to pin 5 and the negative test lead to pin 2 of the disconnected output stage plug (image above).



When the engine is cranked, the signal should look like the oscilloscope trace above. If no signal is observed, check the continuity of EZK connector pins 15 and 32 to their respective spark output stage connector pin 5. If there is continuity, the EZK unit may be faulty.

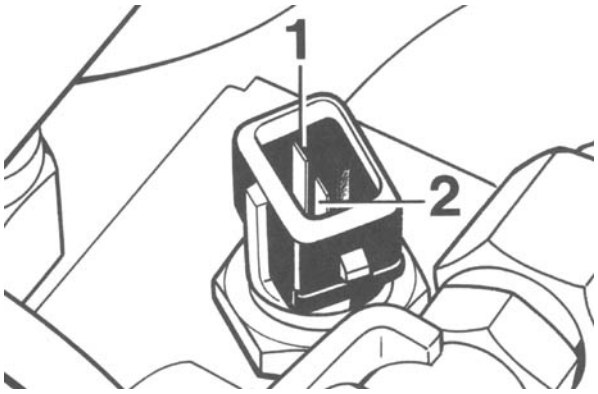
i. What else could it be? If all of these items check out OK, and the fuel pump is functioning, then potential problems could be the system fuel pressure is too low; fuel filter or pipes are restricted, fuel injectors are not functioning correctly, or .... the LH Jetronic fuel injection module is not functioning correctly and requires a rebuild.

Check for Spark. Use caution, the 928 spark system produces high voltage and can cause death or serious injury. Use a *spark jump* test tool. If there is spark, then the ignition system is working, there is no need to test the engine RPM speed sensor or EZK output stage. Focus on fuel related issues.

Check Power and Ground connections. These connections are key points to inspect and clean. Start with the battery terminals, the multiple wires on the "+" connector must have a clean and tight connection. Remove all the fuses and clean the spade connectors. Check the ground strap between the engine and chassis. The LH fuel injection module is grounded via Pin 17 to chassis ground point VIII, measure the resistance between LH connector Pin 17 and a chassis ground point (see LH diagram). Resistance should read as close to zero as possible. If it reads a high resistance, a corroded ground connection at MP VII or cut in the wire could be the problem. Anywhere you see a brown (ground) wire bolted to the chassis, remove the bolt and clean the connection.

Check the Temp Sensor II. [applicable to all LH systems, beginning with Euro/ROW 1984 and US spec 1985]. If the ambient engine temperature is too warm to check the Ohm reading at colder temperatures (0C/32F), remove the Temp II sensor from the engine and immerse it in cold ice water. A failure mode of the sensor is to go open circuit (infinite resistance) at cold temperature. A cold test is necessary to confirm functionality of the temperature sensor for cold start.

To check the Temp Sensor II, you'll need an Ohm meter. Remove the connector to the Temp Sensor II. There are two prongs on the sensor. There are two separate temperature sensors housed in the one sensor body.



Note the orientation of the protruding alignment notch on the outside of the sensor. Prong 1 is the sensor for the Electronic Ignition and prong 2 is the sensor for the LH fuel injection. Clip one of the ohm meter leads to prong 2 (LH) and clip the other lead to a ground point. **Do NOT connect the Ohm meter leads between the two prongs of the sensor.**

Repeat the resistance measurements for prong 1 (Electronic Ignition). The proper Temp Sensor II resistance measurements are:

0 C / 32 F: 4.4 to 6.0k Ohm
15 - 30 C / 59 - 86 F: 1.4 to 3.6k Ohm
40 C / 104 F: 0.9 to 1.3k Ohm
60 C / 140 F: 480 to 720 Ohm
80 C / 176 F: 250 to 390 Ohm

If the resistance readings are not correct range, the temperature sensor must be replaced. If the resistance readings are in the correct range at the sensor, there could be a problem with wiring to the LH controller or the connector itself could be corroded. Measure the resistance from the Temp II sensor connector to the LH and spark controller connectors to confirm the circuit is good.

Checking the Mass Airflow Sensor (MAF) [applicable to all LH systems, beginning with Euro/ROW 1984 and US spec 1985].

Test the Hot Wire Resistance. Unplug the connector to the MAF. Connect the test leads of an Ohm meter to terminals 3 and 5 of the MAF. The resistance specs are 3.6 to 4.1 Ohm.

Test the hot wire signal. Connect the plug to the MAF. Remove the LH relay and bridge terminals 30 and 87.

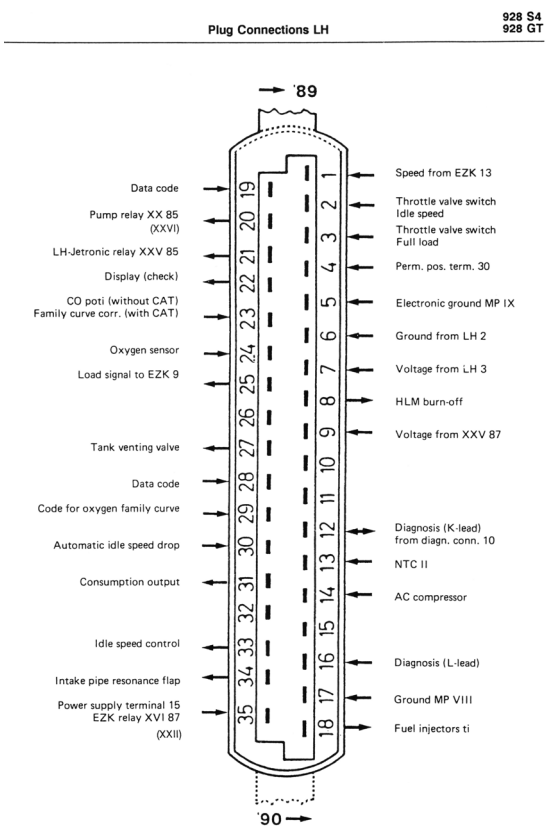
Connect the volt meter test leads to terminals 6 and 7 of the LH connector. Blow air into the hot wire of the MAF, the voltage reading must change (~ 1.6 - 5V).

Checking the hot wire burn-off circuit. Run the engine with the MAF installed and connected. When the engine is > 60C, rev the engine to above 2000 RPM. Stop the engine, turn off the ignition. After a delay of approx. 4 seconds, the hot wire must glow for approx. 1 second.

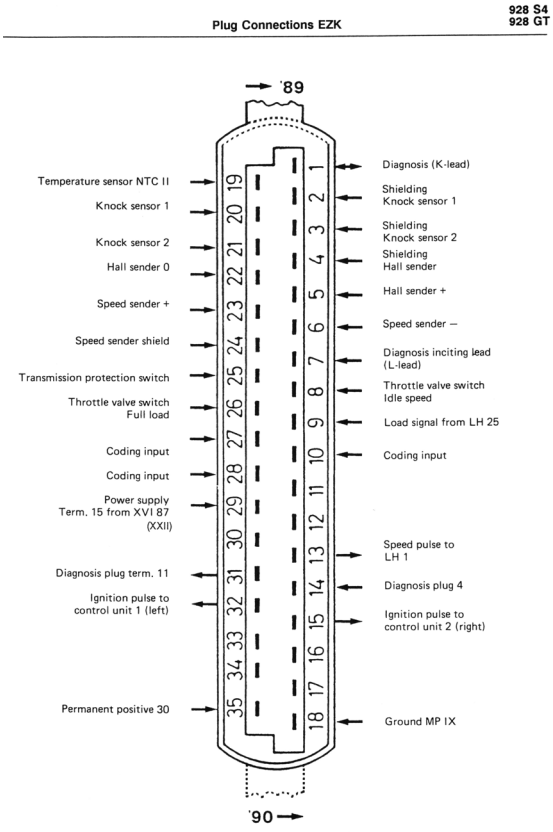
"Limp-Home" mode. The engine will run with the MAF disconnected. However, if the engine is cold, you may need to hold the throttle open when cranking to start the engine. This allows the car to be driven to a repair shop. The LH defaults to the follow pulsewidth:

RPM < 2000 RPM: 3.5 mS
RPM > 2000 RPM: 6.3 mS

With the limp home mode, you can imagine there are just a few RPM regions where the injection pulse provides the proper fuel mixture. However, unplugging the MAF provides a good test to see if your MAF is dead. If the engine runs better with the MAF disconnected, it is likely your MAF is not functioning.



LH Module Connector



EZK Module Connector