OBDII Description for Model Year 2008 E60, E61, E82, E88, E90, E92, E93 / Engine N54 / Siemens ECU MSD80 / LEVII Bin 5

Revised version – for US car dealer

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1.1 Catalyst Monitoring

P0420/P0430

1.1.1 Diagnostic overview

Catalyst monitoring is based on the monitoring of the **o**xygen **s**torage **c**apability (OSC) by comparing the signals of the O2 sensor upstream and downstream of the catalyst.
The engine control stimulates the regular lambda oscillations of the exhaust gas. These oscillations are needed for best possible catalyst conversion. They are damped by the storage activity of the catalyst. The amplitude of the remaining lambda oscillations downstream the catalyst indicates the oxygen storage capability.
The efficiency of the catalyst system is tested during steady state driving by cycling the air fuel ratio LEAN and then RICH for a calibratable number of cycles while monitoring the OSC.
Prior to the catalyst test the canister purge valve is closed or opened with low canister purge value. This is to eliminate the influence of canister vapors on the downstream sensor during the test.

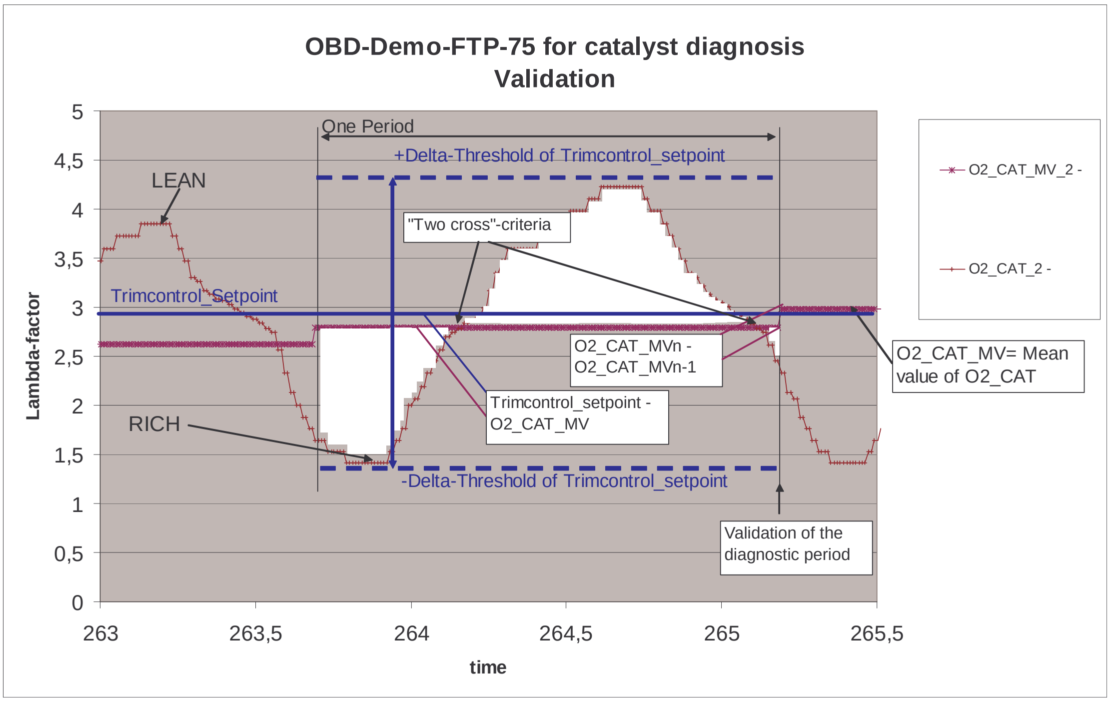
1.1.2 Monitoring function

If all monitoring conditions are fulfilled, then a special defined A/F-modulation will be done.
The first lean to rich cycle of the test is only used to establish an average voltage value of the downstream sensor voltage. During subsequent cycles the calculation of the OSC is based on the accumulated value of the difference between the average value of the previous lean to rich cycle and the measured instantaneous voltage during the current lean to rich cycle.

The relation of the deviation between the current downstream-sensor-signal to the average value of the downstream-sensor-signal is a lead for catalyst condition.
The catalyst system is considered malfunctioning, if after a specified number of monitoring cycles the average of the accumulated deviation exceeds a threshold. The corresponding fault code is stored.

Validation of the calculated sensor signals (O2_cat_i) of one period:

1) monitoring two cross criteria (calculated sensor signal has to cross the mean value characteristic curve twice)
2) monitoring of delta threshold for minimum and maximum of trim control set-point (O2 _CAT is a calculated value, taking O2 rear signal as a basis)
3) difference of mean value of the calculated sensor signals related to one period to the next one [(O2_CAT_MV$_n$) –(O2_CAT_MV$_{n-1}$)]



Variables list:

Siemens Parameter SAM/Specification	Description
EFF_CAT_DIAG	result value of cat diagnosis
CTR_CAT_DIAG	counter increment

1.2 Heated Catalyst Monitoring

A heated catalyst is not embedded.

1.3 Misfire Monitoring

P0300, P0301, P0302, P0303, P0304, P0305, P0306

1.3.1 Monitoring function

The method of engine misfire detection is based on evaluating the engine speed fluctuations. The engine torque is a function of engine speed, engine load and the moment of inertia.
In order to detect misfiring at any cylinder, the torque of each cylinder is evaluated by metering the time between two ignitions, which is a measure for the mean value of the speed of this angular segment. A change of the engine torque results in a change of the engine speed.
It is also an influence of the load torque, such as the influences of different road surface, e.g. pavement, potholes etc. If the mean engine speed is measured, influences caused by road surfaces have to be eliminated.

This method consists of following main parts:

Data acquisition:
The duration of the crankshaft segments is measured continuously for every combustion cycle.

Segment time adaptation (P1396):
Within a defined engine speed range and during fuel cut-off, the segment time adaptation, instead of the misfire detection, is carried out. If the segment time adaptation is out of the maximum adaptation range, failure P1396 is stored. With progressing adaptation the sensitivity of the misfire detection is increasing. The adaptation values are stored and taken into consideration for the calculation of the engine roughness.

Calculation of the engine roughness:
The engine roughness is derived from the differences of the segment durations.
Different statistical methods are used to distinguish between normal changes of the segment duration and the changes due to misfiring.

Determination of misfiring:
Misfire detection is performed by comparing the engine roughness threshold value with the engine roughness value. If the threshold is exceeded, single misfire is detected. The decision, whether the threshold shortfall of the irregular running is evaluated, depends on the monitoring conditions.

1.3.2 Statistics, fault processing

Emission Limit:
If the sum of cylinder(s) misfire counters within 1000 revolutions is 4 times exceeding a predetermined value during a driving cycle, or during the first 1000 revolutions, the fault code for emission relevant misfiring is temporary stored. If the following driving cycle is also above the emission limits, the MIL will be switched on and a cylinder selective or global fault will be stored.

Catalyst Damage:
If the weighted sum of cylinder(s) misfire counters within 200 revolutions is exceeding a predetermined value the fault code for catalyst damage relevant misfiring is stored and the cylinder with the highest rate will be switched off and the MIL will be switched on immediately. If two cylinders are switched off and the misfire rate is still above the damage limits, MIL is flashed immediately. If one of the cylinder selective counters is exceeding the predetermined threshold the following measures take place:

1. The lambda closed loop system is switched to open-loop condition.
2. The cylinder individual fault code is stored or if multiple cylinders, then the global fault code is set.
3. Fuel supply of the misfiring cylinder(s) is cut-off (per customer request)
4. No downstream fuel trim.

All misfire counters are reset after each interval.

1.4 Evaporative - System Leak Diagnosis (Module DM-TL)

1.4.1 EVAP system leak measurement

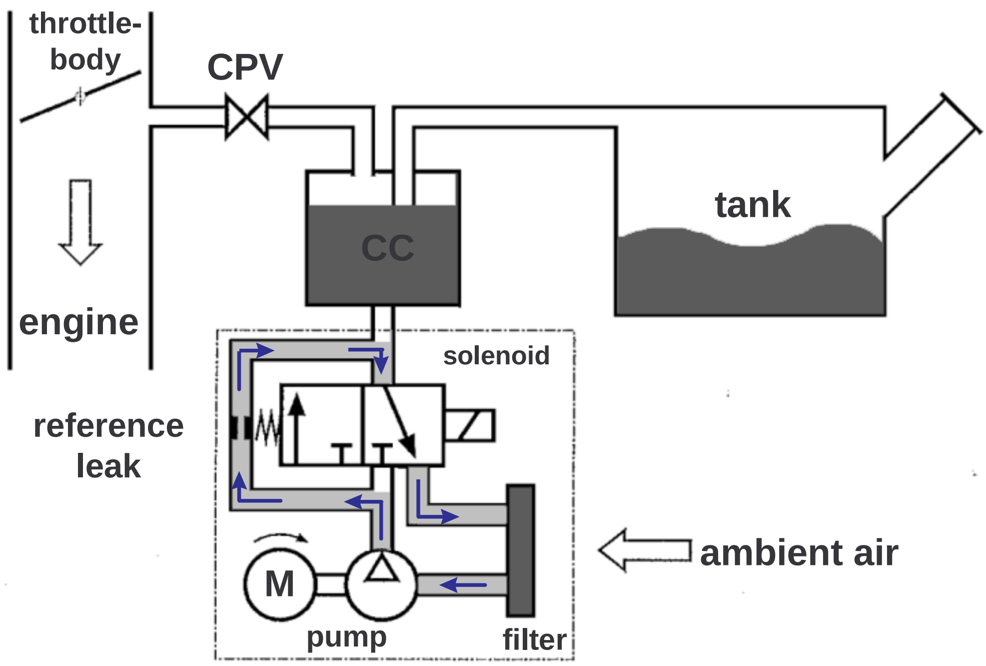
P0442, P0456, P1434, P1447, P1448, P1449

1.4.1.1 Monitoring function - Leak detection

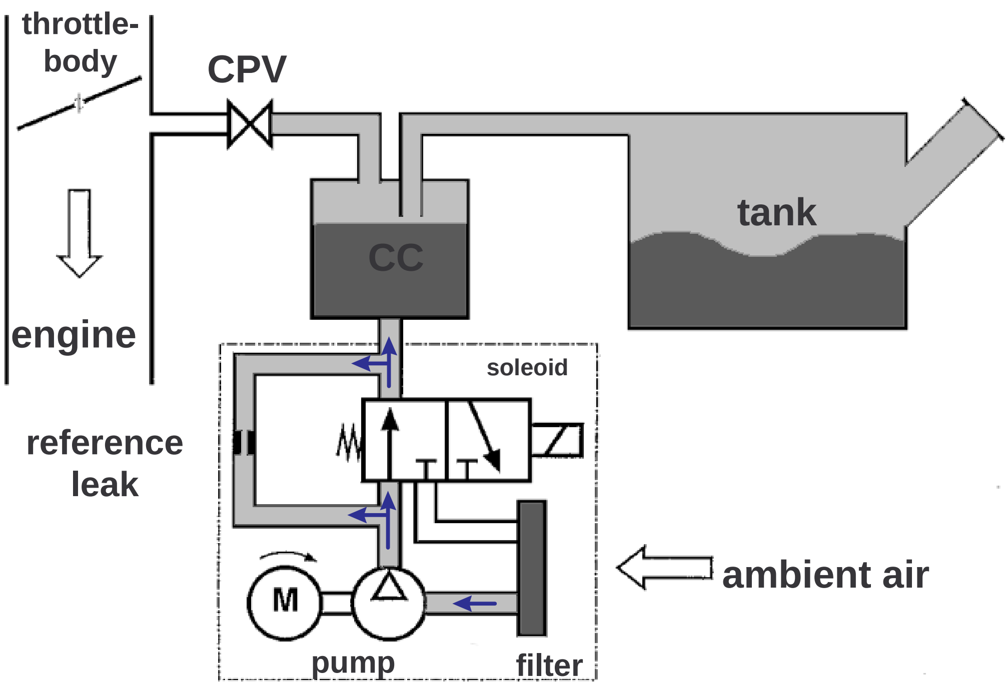
The evaporative system monitoring permits the detection of leaks in the evaporative system with a diameter of 0.02 inches and up.

By means of a Diagnostic Module Tank Leakage (DM-TL), an electrical actuated pump located at the atmospheric connection of the evaporative canister, a pressure test of the evaporative system is performed in the following order:

During the Reference Leak Measurement, the electrical actuated pump delivers through the reference restriction. The engine-management system measures the pump's electrical current consumption in this section.



a) During the Leak Measurement, the electrically actuated pump delivers through the charcoal canister into the fuel-tank system. The pressure in the evaporative system may be up to 2.5 kPa depending on the fuel level in the tank. The engine-management system measures the pump's electrical current consumption. A comparison of the currents of the reference leak measurement and the leak measurement is an indication of the leakage in the tank.



<u>0.02 inch diagnosis, very small leak:</u>

P0456

The first step of the diagnosis is the reference measurement, the result of the pump reference current is stored (picture in chapter a). After the solenoid switches, the venting system is pressurized (picture in chapter b). In the small leak measurement the small leak threshold is reached, if the leak is smaller than 0.04 inch and then the small leak measurement phase follows. When the DM-TL current reaches the reference current within the very small leak time, the system is tight (leak smaller than 0.02 inch), otherwise a very small leak between 0.02 – 0.04 inches is detected.

0.04 inch diagnosis, small leak:
P0442

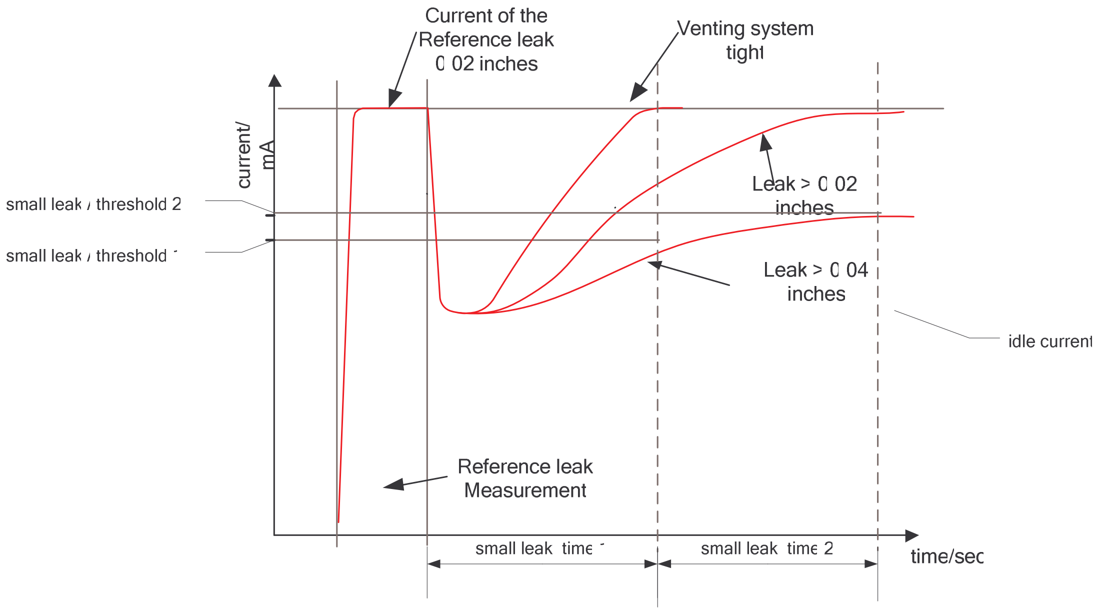
The first step of the diagnosis is also the reference measurement, the result of the pump reference is stored (picture in chapter a). After the solenoid switches, the venting system is pressurized (picture in chapter b). In the small leak phase (time) the pump current must reach the small leak threshold 1:

Small leak threshold 1 = idle current pump + K1 x (reference current – idle current). Factor K1 is between 0.16 and 0.28 depending on the characteristic current value of the pump (reference current – idle current), this value is various in every pump.

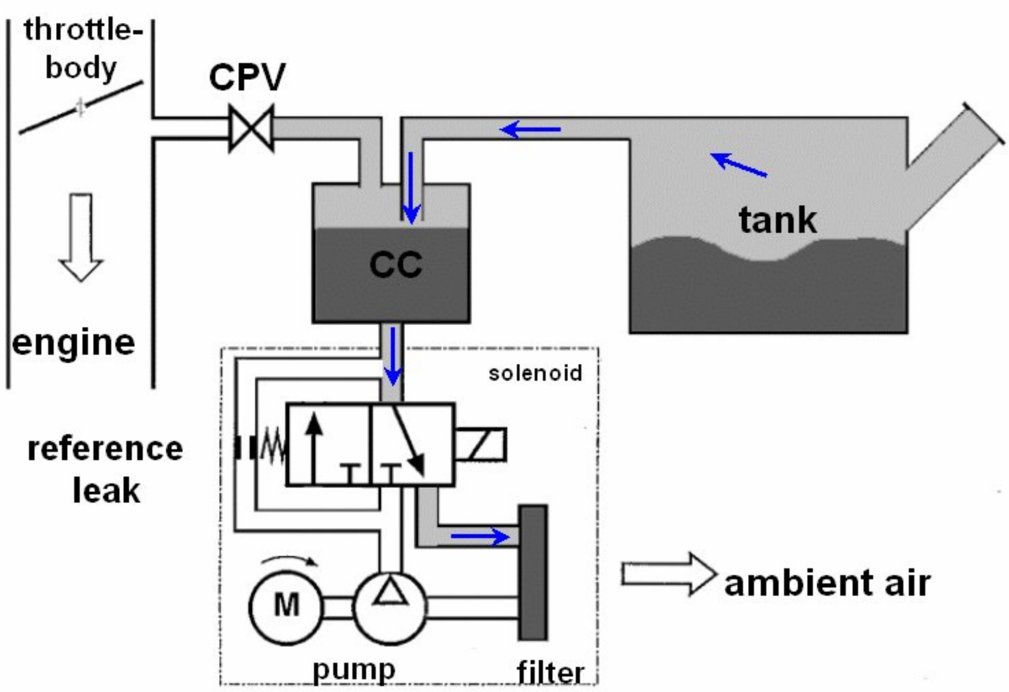
If the small leak threshold 1 is not reached in the small leak time, the small leak threshold 2 must be reached in an additional time small leak threshold 2 = reference current pump - K2 x (reference current – idle current). Factor K2 is between 0.60 and 0.80 depending on the characteristic current value of the pump (reference current – idle current).

If the small leak threshold 2 is also not reached, a leak > 0.04 inches is detected.

In the diagram below is the typical current of a tight system, a 0.02 inch leak, and a leak > 0.04 inches.



b) After the test the remaining pressure in the evaporative system is bled off through the charcoal canister by switching off the pump and solenoid.



1.4.1.2 Monitoring function - Pump current diagnosis

P1434, P1447, P1448, P1449

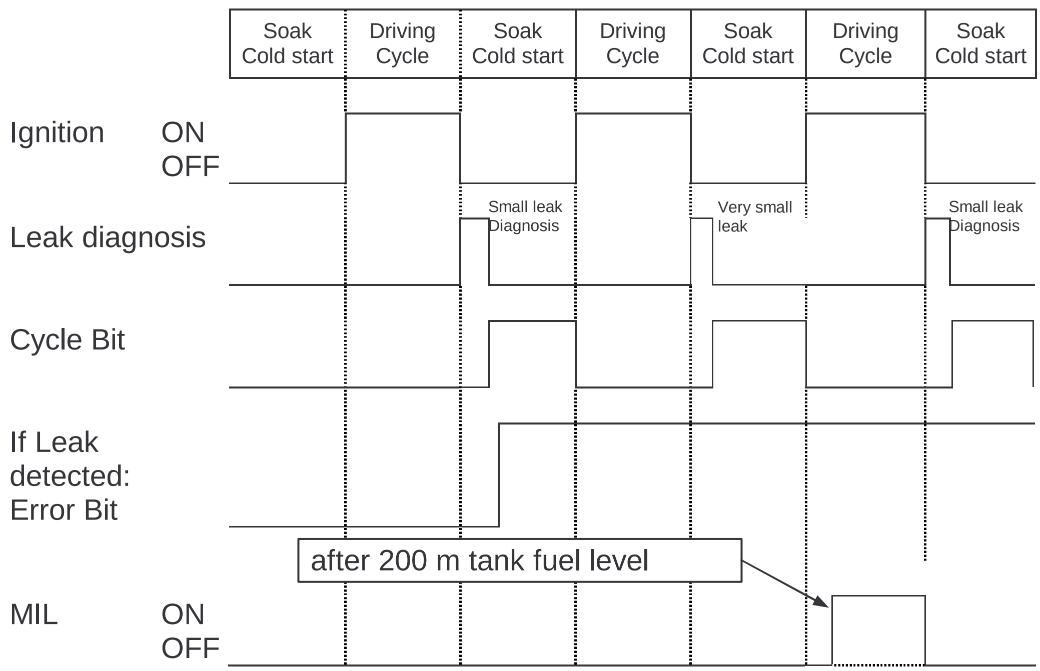
In the reference measurement phase the current of the DM-TL is checked, if the current consumption is smaller than 15 mA a defect pump/motor is detected, and P1448 is stored. If a current consumption of bigger than 40 mA is measured also a defect pump/motor is detected, and the P1449 is stored.

After the reference measurement the electrical solenoid is switched and the venting system is tight. The solenoid is checked by comparison of the reference current and the idle current immediately after the solenoid has switched.
If the difference between the two currents (reference current – idle current) > 2 mA is not reached, the DTC P1447 is stored.

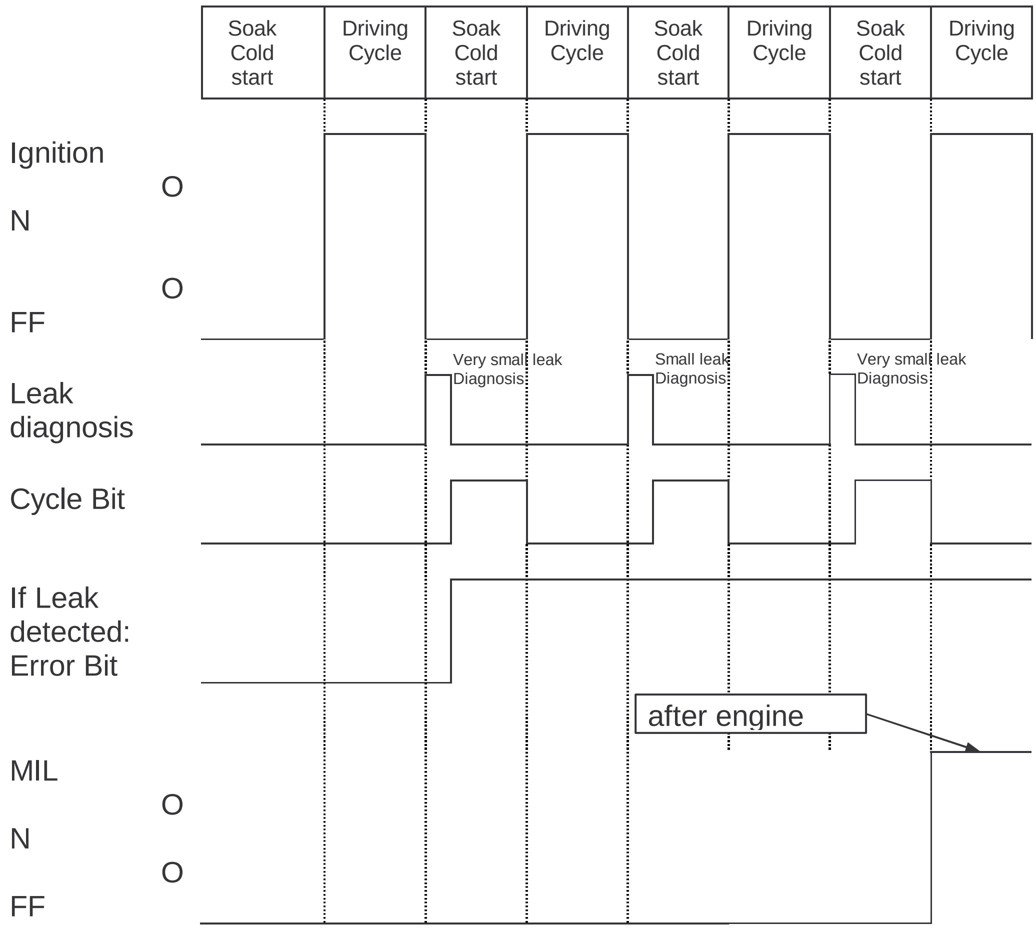
The P1434 fault code is set, if current fluctuations (caused by humidity in the DM-TL) > 1 mA are detected.

1.4.1.3 Diagnosis frequency and MIL illumination

Diagnosis frequency and MIL illumination - no refueling detected, leak > 0.04 inches



Diagnosis frequency and MIL illumination - after refueling detected, leak > 0.02 inches



1.4.2 EVAP - Functional check canister purge solenoid (CPS)

P0440

1.4.2.1 Monitoring function

The diagnosis is used for the functional test of the CP solenoid (CPS).
The test consists of two checks.

The first check of the CPS is based on the active charcoal filter (ACF) amount. The "canister load diagnosis" is calculated permanently until the complete check CPS is finished.

If amount is above threshold ok is detected.
If amount is below threshold, the next step will be performed.

During the next check, the CPS is evaluated based on manifold pressure controller deviation in idle speed. To this effect, the CPS is opened for a short time and the engine speed monitored for a certain period. Additionally the deviation of lambda-controller (rich mixture) is monitored.

After this check has been enabled for the first time, it is requested during each idle speed phase as long as the conditions are met. This is repeated as long as a result has been reached. This check is not bound to one idle speed phase, but can be distributed to several idle speed phases.

If the CPS is detected to be not ok three times, the error is set.

1.5 Secondary Air System Monitoring

A secondary air system is not built in.

1.6 Fuel System Monitoring

1.6.1 Lambda adaptation

P0171, P0174, P0172, P0175

1.6.1.1 Monitoring function

The fuel system diagnosis uses two different monitors. The first one is the evaluation of the percentage of the long term fuel adaption. The other one is the evaluation of the percentage of the physical limits of the short term fuel trim.

The monitoring of the short term fuel trim is active during all engine states except during deceleration fuel cut-off. The evaluation of the long term fuel trim is active during its learning process and is not active during canister purge phases of the evaporative system. Because of this an additional learning process can be started in case of large deviations of the short term fuel trim and the evaluation can run. After the enable conditions are met different counters are started for both evaluations. If no condition is present the end diagnostic counter will decrement from a calibratable value to zero and a passing decision is made.

If a lean condition is present and total fuel control is above the calibratable threshold two timers are started. If the lean threshold counter exceeds the calibratable threshold before the reset timer has decrement from calibratable threshold to zero a lean error is set.

If a rich condition is present and total fuel control is below the calibratable threshold two timers are started. If the rich threshold counter exceeds the calibratable threshold before the reset timer has decremented from a calibratable threshold to zero a rich error is set.

The time counters are increased while “lambda controller” or “lambda adaptation” exceed minimum or maximum threshold.
The error is detected as soon as one of the time counters reaches its maximum value.

1.6.2 Trim Control Plausibility Monitoring

P2096, P2098, P2097, P2099

1.6.2.1 Monitoring function

The trim control plausibility monitoring detects a high deviation of the I-share of lambda trim control. If it exceeds given thresholds the following malfunction is detected:

- fuel trim above limit

If the above mentioned malfunction is detected, the corresponding fault code is stored.

	B1S1	**B2S1**
air fuel mixture too rich	P2097	P2099
air fuel mixture too lean	P2096	P2098

1.6.3 Diagnosis of Injector Aging

P119D/P119E

1.6.3.1 Monitoring function

A small proportion of the short term fuel deviation is used for diagnostic injector aging and is stored as injector adaption value in a separate map. The values of the separate map will be renewed every time the mileage achieves 497 miles.

A fault is stored if the injector adaption exceeds a calibratable minimum or maximum threshold.

1.6.4 High Pressure Fuel Control System

P3283, P3284, P3003, P3090

1.6.4.1 Monitoring function

For gasoline direct fuel injection a high pressure fuel control system is necessary for fuel preparation and metering as shown in Figure 3. The low fuel pressure from the fuel pump module within the tank is increased by the high pressure fuel pump and adjusted to a desired set-point fuel pressure.

The high pressure fuel system consists of a common fuel rail for all high pressure Piezo-injection valves, a fuel rail pressure sensor, a high pressure fuel pump with a built-in fuel volume control valve and overpressure-valve.

In dependence of engine load and engine speed, high pressure has to be adjusted to values between 5 and 20 MPa. Therefore the fuel pressure in the rail is measured and controlled with help of the fuel volume control valve. According to the desired fuel-mass and fuel pressure set-point value the pre-control calculates the driver-signal for the fuel volume control valve. This calculated driver-signal is additionally controlled by a closed loop control using the measured fuel pressure and the desired set-point value as input.

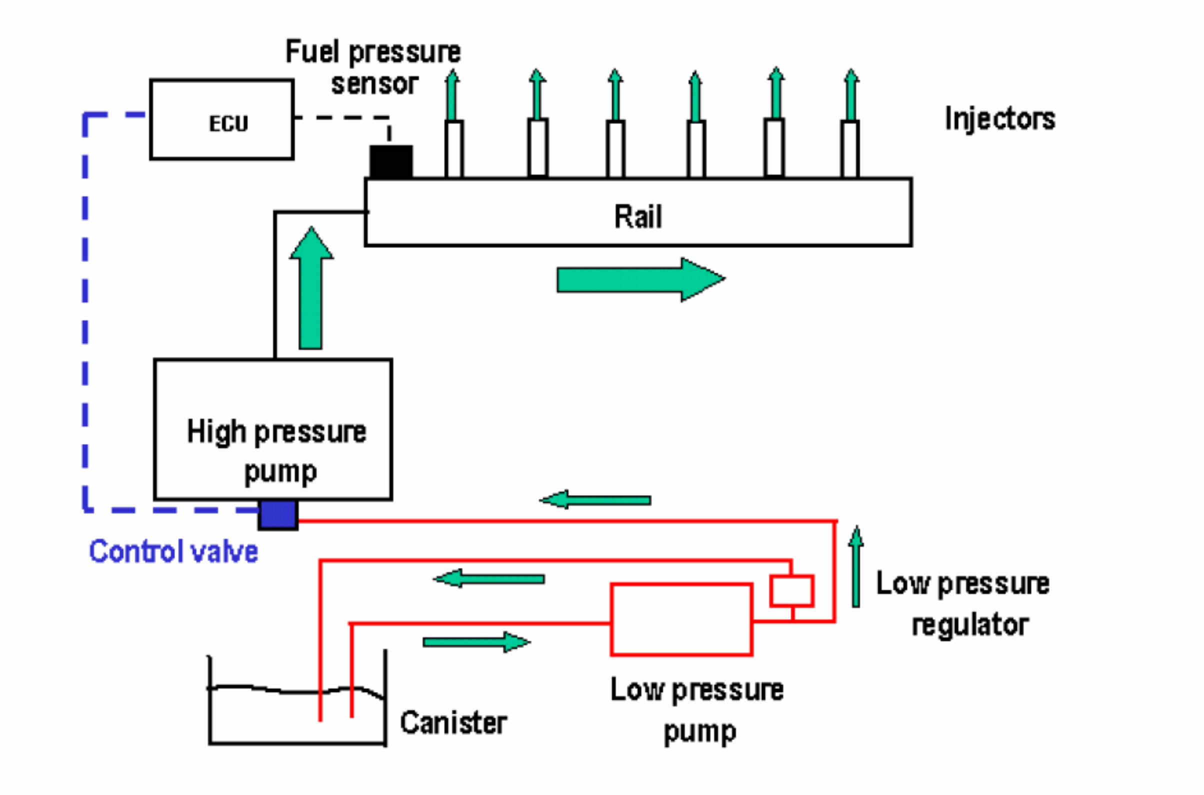


Figure 1: Overview of low and high pressure system

The high pressure system diagnosis consists of a rationality check and analyses in principle the difference between the measured fuel pressure and the set-point fuel pressure. The diagnosis finds out whether or not the set-point value of the fuel rail pressure can be adjusted by the high pressure fuel control.

A not adjustable fuel rail pressure (to high) is detected if the measured fuel pressure is greater than the desired set-point fuel pressure with the result that the difference of these two values (set-point - measured) is negative. If the negative difference lies below a calibrated threshold for a calibrated period of time, a malfunction is detected and a maximum fault High Pressure System monitoring is set.

A not adjustable fuel rail pressure (to low) is detected if the measured fuel pressure is less than the desired set-point fuel pressure with the result that the difference of these two values is positive. If the positive difference exceeds a calibrated threshold for a calibrated period of time, a malfunction is detected and a minimum fault High Pressure System monitoring is set.

The fuel mass plausibility diagnosis checks the plausibility of the high pressure sensor signal.
The diagnosis compares the output of the lambda-controller and lambda-adaptation with the output of the closed-loop controller.

A too high pressure sensor signal is detected if the lambda-controller or the lambda-adaptation shows a rich combustion while the fuel pressure controller is below a calibrated threshold.

A too low pressure signal is detected if the lambda-controller or the lambda-adaptation shows a lean combustion while the fuel pressure controller is above a calibrated threshold.

1.7 Oxygen Sensor Monitoring linear upstream / binary downstream

1.7.1 Upstream Oxygen Sensor Monitoring (linear)

1.7.1.1 Upstream Oxygen Sensor - Short Circuit Monitoring

P0131, P0151, P0132, P0152

1.7.1.1.1 Monitoring function

The oxygen sensor circuit monitoring detects the following malfunctions by evaluating the error information received from oxygen sensor microcontroller:

- short circuit of sensor signal to battery voltage
- short circuit of sensor signal to ECM ground

If one of the above mentioned malfunctions is detected, the corresponding fault code is stored.

	B1S1	**B2S1**
short circuit to ground	P0131	P0151
short circuit to battery voltage	P0132	P0152

1.7.1.2 Upstream Oxygen Sensor - Open Circuit Monitoring

P112C, P112D, P2626, P2629, P2243, P2247

1.7.1.2.1 Monitoring function

The oxygen sensor circuit monitoring detects the following malfunctions by evaluating the error information received from oxygen sensor monitoring functions:

	B1S1	**B2S1**
reference voltage failure – (UN)	P2243	P2247
virtual ground failure – (VM) and pumping current failure – (IP)	P112C	P112D
trim current failure – (IA)	P2626	P2629

If one of the above mentioned malfunctions is detected, the corresponding fault code is stored.

1.7.1.2.2 Monitoring description

This function determines, if an open circuit in any of the four electric lines *(Reference Voltage, Virtual Ground, Pumping Current and Trim Current)* is present in the **w**ide **r**ange **a**ir **f**uel (WRAF) sensor.
This function shall be triggered only if one of the following diagnosis is active (to set the readiness bit), which are 'Upstream Oxygen Sensor - Signal Monitoring during Fuel Cut-off' and 'Upstream Oxygen Sensor - Heater Monitoring'. The function shall go to the state = “active” only if one of the above diagnosis detected a fault.

(Reference Voltage)
If a heater error exists and sensor voltage is too low, while the internal resistance measurement is turned off, an open circuit in the line reference voltage occurred. Before the internal resistance measurement is turned off, the sensor temperature-failure P3026/P3027 is stored.

(Virtual Ground) or (Pumping Current)
An open circuit in line virtual ground or in the line pumping current can be detected if the sensor signal stocks near lambda 1. The sensor non-activity can be detected by the Oxygen Sensor Signal Monitoring during fuel cut-off (signal voltage below e.g. 2.1 V *) in fuel cut-off).

(Trim Current)
If the sensor shows an augmented gain, i.e. the sensor signal is higher than the nominal characteristic line, the plausibility test during the fuel cut-off phase shall detect this symptom (signal voltage above e.g. 5,6 V *) during fuel cut-off) and an open circuit is assigned to the line trim current.

)* For exact values please have a look at the summary table!

1.7.1.3 Upstream Oxygen Sensor - Signal Controller Monitoring

P3022, P3023, P3024, P3025

1.7.1.3.1 Monitoring function

This function will detect an error during the initialization and/or operation of a WRAF sensor controller through SPI communication. Information communicated from the Basic Software (BSW) is used for initialization and communication between application software (ASW) and the controller. This is used to determine if the function is working properly.

After an ECU reset, the WRAF sensor controller is started and the diagnosis determines the time until the initialization, has been performed in the allowed time. If not successful, then a DTC will be stored. If this is successful, then the difference is checked between the present error counter and the stored value of this error counter at ECU reset, (switching from Key "OFF" to Key "ON") or at clearing error memory and after each function call, in case a difference between both counters was found.
If there is a difference, another counter is incremented. If this counter is higher than a threshold, a SPI communication error is stored.

	B1S1	**B2S1**
Communication error	P3022	P3023
Initialization error	P3024	P3025

All of the above checks are performed internal to the ECU.

1.7.1.4 Upstream Oxygen Sensor - Signal Activity Check

P2414, P2415

1.7.1.4.1 Monitoring function

The oxygen sensor signal activity check monitors if the sensor is attached to the exhaust pipe and whether the exhaust is sampled correctly (no leakage). A malfunction is detected if the oxygen sensor voltage is above a threshold (shows too lean mixture in part load or full load)

If the above mentioned malfunction is detected, the corresponding fault code is stored.

B1S1	B2S1
P2414	P2415

1.7.1.5 Upstream Oxygen Sensor - Swapped Sensors Check

P0040

1.7.1.5.1 Monitoring description

This function will detect if the Oxygen Sensor wire harness has been cross connected, i.e., Bank 1 with Bank 2. This is performed by the use of the output of the fuel correction (lambda controller) of each bank. If this control is on opposite limit at bank 1 and bank 2, the sensors are swapped and the corresponding fault code is stored.

Corresponding fault code:

P0040

1.7.1.6 Upstream Oxygen Sensor - Active Signal Check (Shift to lean / rich)

P2195, P2197, P2196, P2198

1.7.1.6.1 Monitoring description

This function shall deliver information indicating that the sensor characteristic line has a shift to lean (Characteristic Shift Down) or to rich, which shall be done by summarizing all similar failure symptoms of this kind.
In dependence of the shift strength there are three different paths followed by this diagnosis:

1. Strong shift to lean/rich: If the lambda sensor upstream shows a rich signal while downstream lambda sensor signal is lean (or vice versa) and additionally the lambda controller goes to its limit, this error is recognized by the upstream sensor plausibility check.

2. Middle strong shift to lean/rich: If the trim controller goes to its limit but the lambda controller does not, the downstream oxygen sensor **signal activity check** (P114A, P114B, P114C, P114D) recognizes that the system has a problem and a failure code is stored. Referring to this failure entry, the downstream active test is triggered. It detects that the problem is in the upstream oxygen sensor, which is showing a characteristic line shift to lean or to rich. The appropriate DTC will be stored along with the downstream sensor signal activity check DTC.

3. Mild shift to lean/rich: The trim controller I-share goes to its limit but the lambda controller does not. The trim control plausibility monitoring (P2096, P2097, P2098, P2099) recognizes that the system has a problem and a failure code is stored. Referring to this failure entry, the downstream active test is triggered. It detects that the problem is in the upstream oxygen sensor, which is showing a characteristic line shift to lean or to rich. The appropriate DTC will be stored along with the fuel correction DTC.

1.7.1.7 Upstream Oxygen Sensor - Signal Dynamic Monitoring (Slow Response)

P0133, P0153

1.7.1.7.1 Monitoring function

The oxygen sensor signal dynamic monitoring detects greater deviations of the dynamic behavior of the sensor signal compared to the nominal behavior, controlled by the lambda controller.
The change of the dynamic behavior is caused by problems of the electrical connection (e.g. open circuit), extreme aging of the sensor or a low sensor temperature which slows down the sensor compared to the nominal behavior.
The monitoring is based on an amplitude criterion, i.e. the relation between the amplification of the oxygen sensor and the model is monitored and detects the following malfunction:

- sensor signal too slow

If the above mentioned malfunction is detected, the corresponding fault code is stored.

B1S1	**B2S1**
P0133	P0153

1.7.1.8 Upstream Oxygen Sensor - Signal Monitoring During Fuel Cut-off

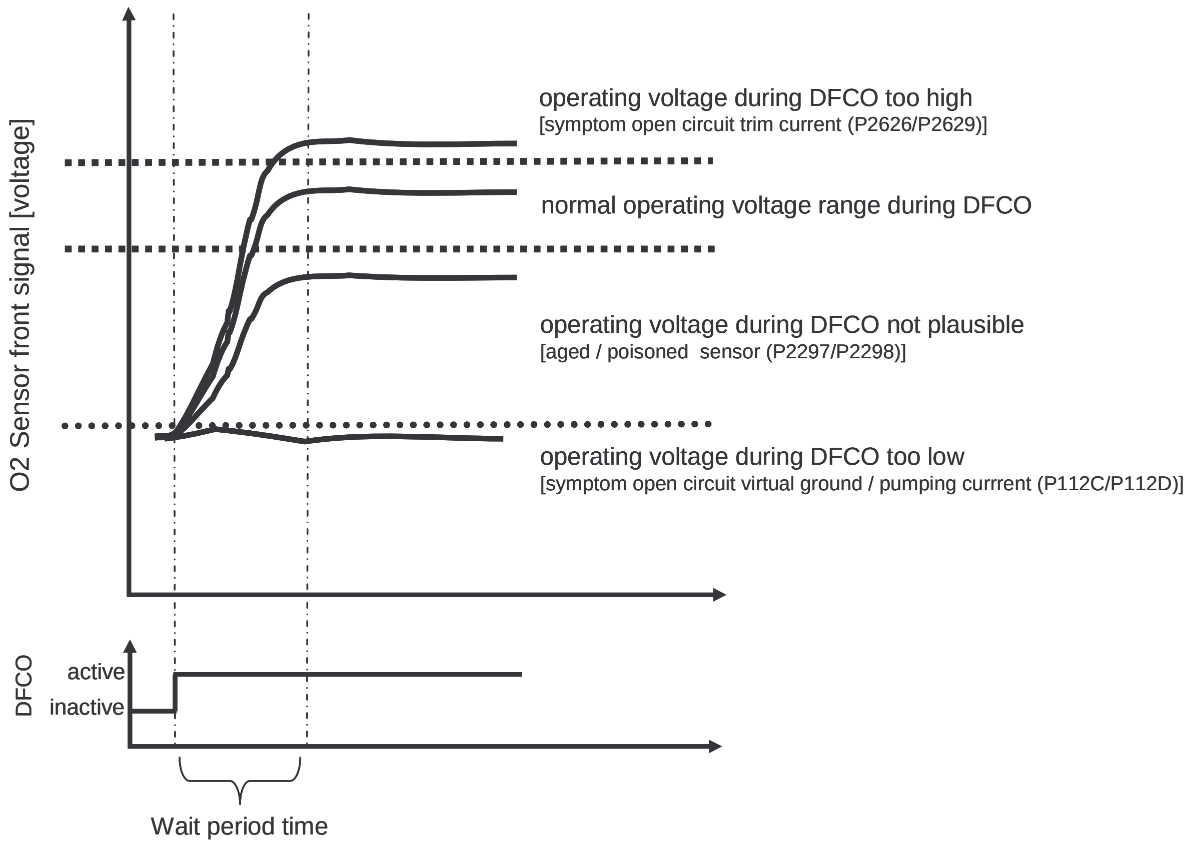
P2297, P2298

1.7.1.8.1 Monitoring function

The oxygen sensor signal monitoring during fuel cut-off detects if the oxygen sensor signal is not plausible during fuel cut-off. A malfunction is detected if the oxygen sensor voltage is outside the "normal operating voltage range during DFCO" (see figure below).
If the oxygen sensor signal voltage is within the range "operating voltage during DFCO not plausible" (see figure below) the signal is not plausible. If the above mentioned malfunction is detected, the corresponding fault code is stored.

B1S1	**B2S1**
P2297	P2298

If the oxygen sensor signal voltage is above a threshold during fuel cut-off or below a threshold then the open circuit diagnostic function is triggered (see chapter 'Upstream Oxygen Sensor - Open Circuit Monitoring'). The fault processing continues in this function.



1.7.1.9 Upstream Oxygen Sensor - Heater Monitoring

P3026, P3027, P0135, P0155, P165F, P166F

1.7.1.9.1 Diagnostic overview

The purpose of this function is to detect oxygen sensor heater failures that would lead to an increase in emissions beyond the thresholds stated in the appropriate regulations.

The diagnosis shall be carried out by determining whether the measured oxygen sensor ceramic temperature falls below set limits over a number of measurement cycles. The evaluations of the diagnosis cycle are determined after the completion of a limited number of monitoring cycles.

Deviations in the oxygen sensor ceramic temperature or the oxygen sensor not being operatively ready in a timely manner (because of a too low temperature) can lead to an increase in emissions above the applicable standards or prevent the sensor signal from being used as a diagnostic system monitoring device. Deviations may occur due to, for example, ageing of the heater element, defective wiring, increased heater circuit connector contact resistance, defective heater driver etc.

1.7.1.9.2 Monitoring function

The diagnosis strategy is based on a statistical evaluation of the oxygen sensor ceramic temperature over a pre-defined number of monitoring cycles.
The oxygen sensor ceramic temperature shall be obtained indirectly via the measured internal resistance of the sensor.

If the sensor is not ready after a defined time (e.g. 30 sec after start)* the sensor is set to forced readiness mode and the Upstream Oxygen Sensor Heater Monitoring is started.

Three cases can appear:

- sensor temperature is invalid (no measurement of sensor temperature possible because of an ECU internal (electrical) failure)
à P165F/P166F is stored

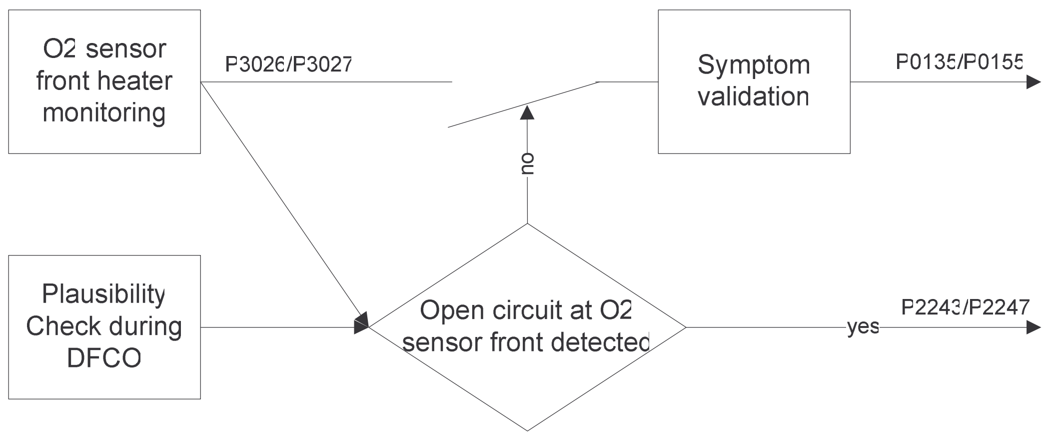
- sensor temperature is below a threshold
à normal failure detection time

- sensor temperature is below a threshold for sensor activation
à immediate failure storing

A low sensor temperature can be caused by a weak heater or a open circuit in the temperature measurement line (line UN). After a low sensor temperature has been detected, the general temperature failure is stored (P3026/P3027). Then the open circuit diagnosis is triggered to check, if an open circuit in line UN is present. If there is an open circuit, then open circuit fault code (P2243/P2247) is stored (see chapter 'Oxygen Sensor Monitoring - Open Circuit' and picture below). If there is no open circuit present, then the heater fault code is stored (P0135/P0155).

)* For exact values please have a look at the summary table!

	B1S1	**B2S1**
sensor temperature too low	P3026	P3027
heater power too low	P0135	P0155
sensor temperature invalid	P165F	P166F



1.7.1.10 Upstream Oxygen Sensor - Heater Circuit Monitoring

P0030, P0050, P0031, P0051, P0032, P0052

1.7.1.10.1 Monitoring function

The oxygen sensor heater circuit monitoring detects the following malfunctions by evaluating the error information received from the power stage:

- Heater O2 sensor front short circuit to battery voltage
- Heater O2 sensor front short circuit to ground
- Heater O2 sensor front open circuit

If one of the above mentioned malfunctions is detected, the corresponding fault code is stored.

	B1S1	**B2S1**
short circuit to ground	P0031	P0051
short circuit to battery voltage	P0032	P0052
open circuit	P0030	P0050

1.7.2 Downstream Oxygen Sensor Monitoring (binary)

1.7.2.1 Downstream Oxygen Sensor - Circuit Monitoring

P0137, P157, P0138, P158, P0140, P0160

1.7.2.1.1 Monitoring function

The oxygen sensor electrical monitor detects the following malfunctions:

- O2 Sensor rear signal short circuit to battery voltage
- O2 Sensor rear signal short circuit to ground
- O2 Sensor rear signal open circuit

If one of the above mentioned malfunctions is detected, the corresponding fault code is stored.

	B1S2	**B2S2**
short circuit to ground	P0137	P0157
short circuit to battery voltage	P0138	P0158
open circuit	P0140	P0160

1.7.2.2 Downstream Oxygen Sensor - Signal Dynamic Check during Fuel Cut-off (DFCO)

P0139, P0159

1.7.2.2.1 Monitoring function

Sensor signal dynamic monitoring is performed at fuel cut-off during coasting conditions. To enable the diagnosis the voltage of the O2 sensor rear has to be above a threshold before entering DFCO.

After entering DFCO the signal falls from fuel trim correction set-point (e.g. 0.68 V) to a voltage near 0 mV. A malfunction is detected, if the sensor signal is not below a threshold after a short time on DFCO. This short time is needed to guarantee a completely purged exhaust pipe.

If this malfunction is detected, the corresponding fault code is stored.

	B1S2	**B2S2**
failure during fuel cut-off	P0139	P0159

1.7.2.3 Downstream Oxygen Sensor - Dynamic / Transition Time in Sensor Midpoint Range Monitoring

P1130, P1131

1.7.2.3.1 Monitoring function

This function monitors the transition time in sensor midpoint range of the downstream sensor voltage. When a fuel cut-off phase starts, the following steps will be executed:

- sensor voltage must be above a threshold (signal must be rich enough, to measure the transition time)

Remark: Usually the signal starts at fuel trim control set-point (e.g. 0.68 V)

- sensor voltage value is stored (= "start-value")

- transition time measurement is started, when the signal is at 70% of start value

Remark: The measurement start and stop- value are relative to the start value, to measure always the transition time around the sensor midpoint range

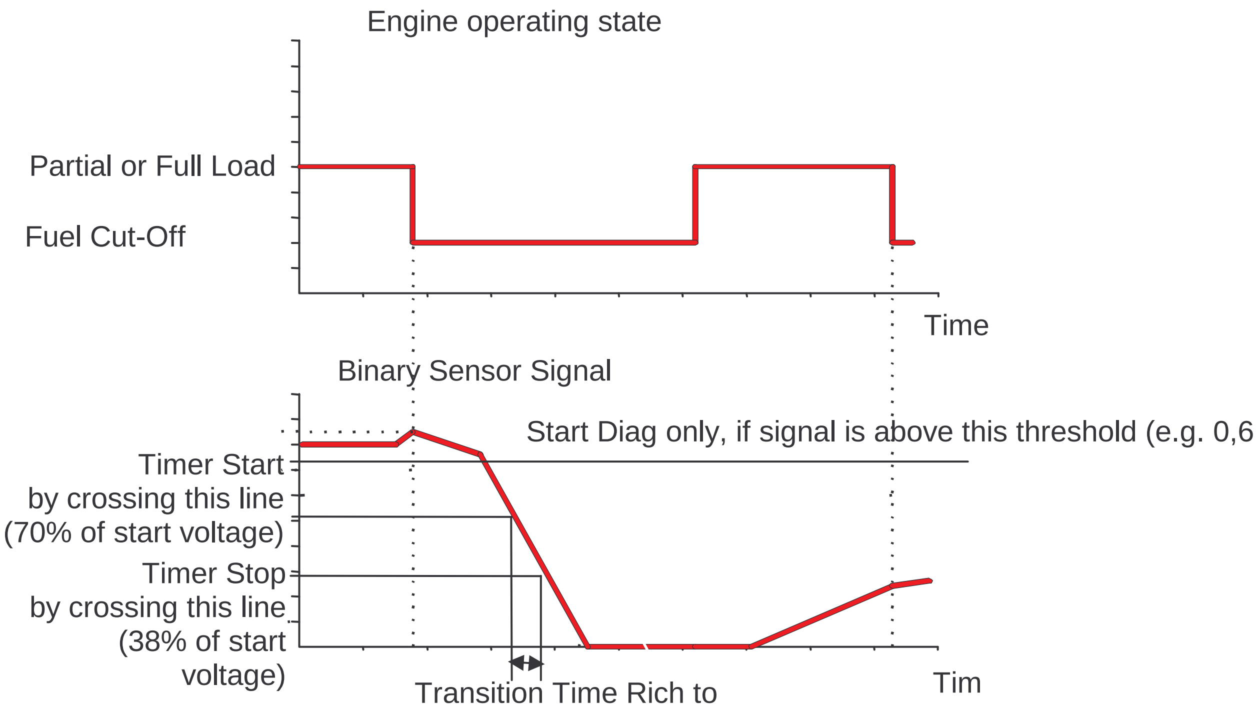
- transition time measurement is finished, when the signal is at 38% of start value

- measured transition time is corrected over mass air flow

The transition time is represented by a cycle counter. This transition time is measured over a defined number of fuel cut-off phases. The minimum value after the defined number of fuel cut- off phases is compared with a failure threshold.

If this value is above a threshold, a malfunction is detected and the corresponding fault code is stored.

	B1S2	**B2S2**
transition time in the midpoint range too high	P1130	P1131


Engine operating state
Partial or Full Load
Fuel Cut-Off
Time
Binary Sensor Signal
Start Diag only, if signal is above this threshold (e.g. 0,6
Timer Start
by crossing this line
(70% of start voltage)
Timer Stop
by crossing this line
(38% of start
voltage)
Transition Time Rich to
Tim

1.7.2.4 Downstream Oxygen Sensor – Signal Activity Check

P114A, P114C, P114B, P114D

1.7.2.4.1 Monitoring function

The diagnosis monitors the downstream sensor voltage during active fuel trim controller p- share. If the fuel trim control is active, the downstream sensor voltage has to be in range between a maximum and minimum threshold. If all monitoring conditions are fulfilled a mass air flow integral is incremented (MAF_1, see picture below). After reaching its threshold the integral is reset and incremented again as long as the conditions are fulfilled.
If the voltage is outside the mentioned band of maximum and minimum threshold)*, a second mass air flow integral is incremented simultaneously (MAF_2, see picture below). If this integral is over a threshold before the first integral reaches its limit, a malfunction is detected.
This fault will be stored too, if the downstream sensor voltage does not switch to rich before the integral reaches a threshold after a fuel cut-off phase

If one of the above mentioned malfunctions is detected, the corresponding fault code is stored. Referring to this failure entry the "Downstream Active Test" is triggered to decide the root cause of the downstream sensor behavior (see chapter "Downstream Oxygen Sensor - Signal Check").

	B1S2	**B2S2**
downstream sensor voltage too low	P114B	P114D
downstream sensor voltage too high	P114A	P114C

)* For exact values of thresholds etc. please have a look at the summary table!

1.7.2.5 Downstream Oxygen Sensor - Signal Check (Stuck lean/rich, Swap)

P2270, P2272, P2271, P2273, P0041

1.7.2.5.1 Monitoring function

Downstream Active Test:
This monitor is an enhancement of the Downstream Oxygen Sensor - Signal activity check and the Trim Control Plausibility Monitoring. Its purpose is to determine, why the rear sensor signal is not plausible.

The monitor will only be enabled, if a fuel correction fault was detected and a malfunction code is stored (P2096 – P2097 – P2098 – P2099)
OR
if the rear sensor signal activity check has detected, that the rear sensor signal is very rich or very lean and the corresponding malfunction fault code is stored (P114A – P114B – P114C – P114C)

If one of the listed fault codes is stored, this diagnosis will be enabled to determine if the root cause of the malfunction is due to a stuck signal or characteristic line shift of the upstream O2 sensor or due to a stuck signal or a system malfunction (i.e. vacuum leak, injector, etc.) of the downstream O2 sensor.

If it has been determined that the upstream O2 signal was the root cause of the fuel correction fault, the appropriate DTC will be stored along with the fuel correction or with the downstream sensor signal activity DTC (see chapter ' Upstream Oxygen Sensor - Active Signal Check (Shift to lean / rich) ').

If it has been determined that the downstream sensor signal was the root cause of the fuel correction fault, the appropriate DTC (see table below) will be stored along with the fuel correction **or** with the downstream sensor signal activity DTC.
This function will also detect, if the oxygen sensor wire harness has been cross connected, i.e., Bank 1 with Bank 2. When this failure is present, the downstream sensor voltages of bank 1 and 2 are on opposite limits.

If one of the above mentioned malfunctions is detected, the corresponding fault code is stored.

	B1S2	**B2S2**	
downstream sensor stuck rich	P2271	P2273	
downstream sensor stuck lean	P2270	P2272	
downstream sensors interchanged			P0041

1.7.2.6 Downstream Oxygen Sensor – Heater Plausibility Monitoring

P0141, P0161

1.7.2.6.1 Monitoring function

For proper function of the oxygen sensor, the sensor element must be heated.
A non functioning heater delays the sensor readiness for closed loop control and thus influences emissions.
The monitoring strategy is based on the comparison of the O2 sensor resistance to a threshold in conditions where the exhaust temperature is low enough to cause an increase of internal resistance in cases where the heating power is insufficient.
The cooling energy of the exhaust gas is calculated and compared to a calibrated threshold, and the diagnosis is activated if the cumulated cooling energy is equal or exceeds the threshold.
Then the O2 sensor resistance is compared to a threshold, and if the resistance higher than the threshold, an O2 sensor heater malfunction is detected and the corresponding fault code is stored.

Corresponding fault code:

O2 sensor heater rear bank 1 too weak	P0141
O2 sensor heater rear bank 2 too weak	P0161

1.7.2.7 Downstream Oxygen Sensor - Heater Circuit Monitoring

P0036, P0056, P0037, P0057, P0038, P0058

1.7.2.7.1 Monitoring function

The purpose of this monitor is to detect errors within the O2 Sensor Heater Circuit. The signal for the O2 sensor heater is pulse-width modulated. The signal of the power stage is monitored internally by the integrated circuit (IC). This IC can distinguish between three symptoms:

- Heater O2 sensor rear short circuit to battery voltage
- Heater O2 sensor rear short circuit to ground
- Heater O2 sensor rear open circuit

If one of the above mentioned symptoms is present, a malfunction is detected and the corresponding fault code is stored.

	B1S2	**B2S2**
short circuit to ground	P0037	P0057
short circuit to battery voltage	P0038	P0058
open circuit	P0036	P0056

1.7.3 Closed Loop Lambda Control - Enable conditions

Closed loop lambda control is enabled (with a delay) at the start of a driving cycle and can be temporary or permanently deactivated during the driving cycle. The turn-on delay at the start of a driving cycle is described by the following enable conditions:

- the upstream oxygen sensor operability is detected i.e. the upstream HO2'S operating temperature has been reached
- a calibrated delay time, after end of engine start, has elapsed

Only for linear Lambda Sensor - Disable conditions

- the A/F ratio set-point value lies below oxygen sensor's measurable limit

Closed loop lambda operation is further deactivated during a driving cycle when any of the following conditions are fulfilled:

- during fuel cut-off or cylinder shut-off and immediately afterwards till a calibrated integrated mass air flow threshold is exceeded
- the mass air flow is below a calibrated threshold that leads to the minimum possible injection time

1.8 Exhaust Gas Recirculation (EGR) System Monitoring

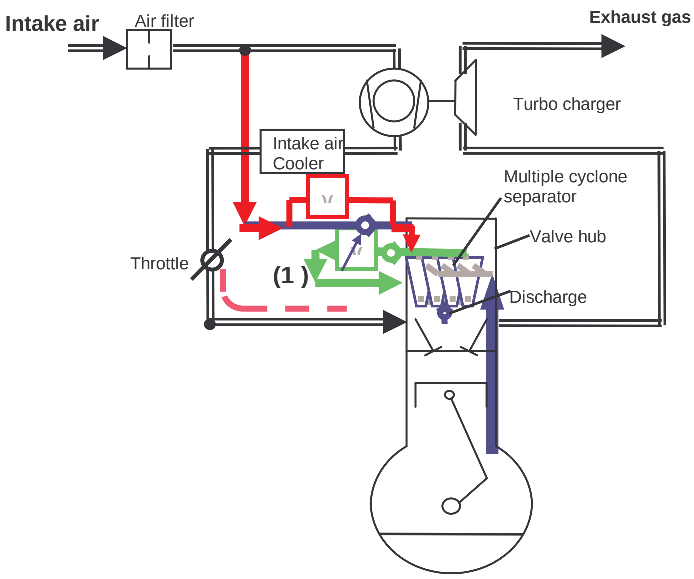
An Exhaust Gas Recirculation (EGR) System is not embedded.

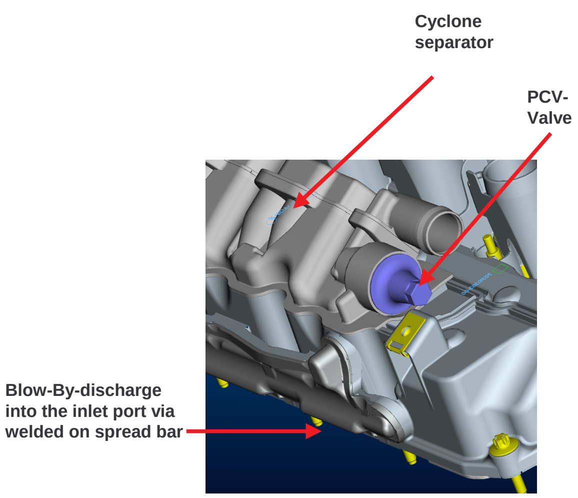
1.9 Positive Crankcase Ventilation (PCV) System

The PCV-architecture of the turbo charged new 6-cylinder engine N54 is designed as a two way ventilation system. This two way ventilation system is designed in two separate connections between crankcase and intake manifold (please see figure).

Connection (1) is used at part load and ends after the turbo charger in the intake manifold. The PCV-valve used in this path is fastened directly to the crankcase. The line between the PCV-valve and the intake manifold is designed as an integrated system combined with valve hub.

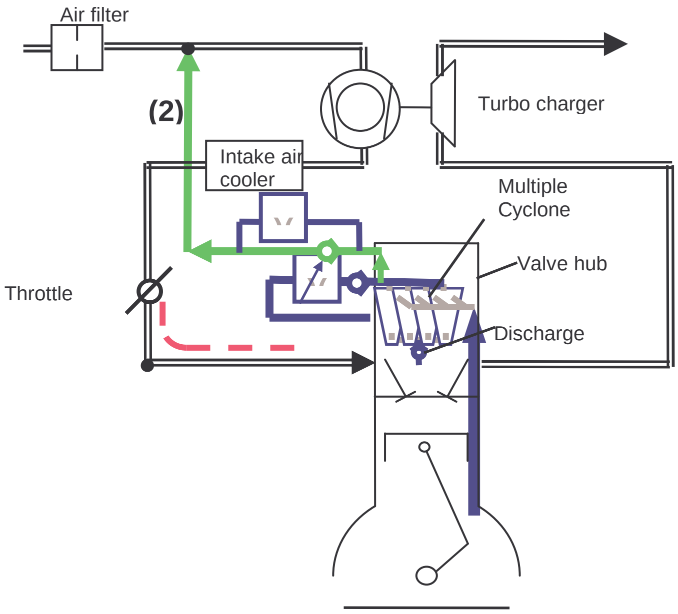
Part load:



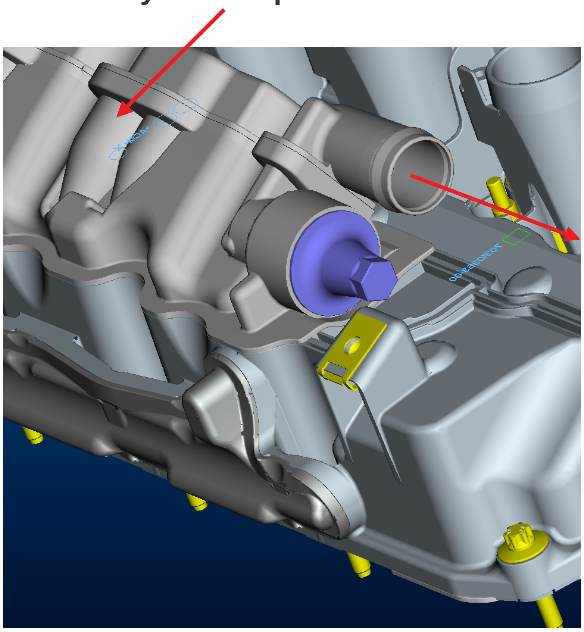


Connection (2) is used at high load and ends before the turbo charger in the intake manifold. In this line, including a separate check valve, a disconnection isn't possible without demolition of the concerned parts.

Full load:



Cyclone separator



Pipe in front of the compressor

1.10 Engine Cooling System Monitoring

1.10.1 Thermostat

P0128

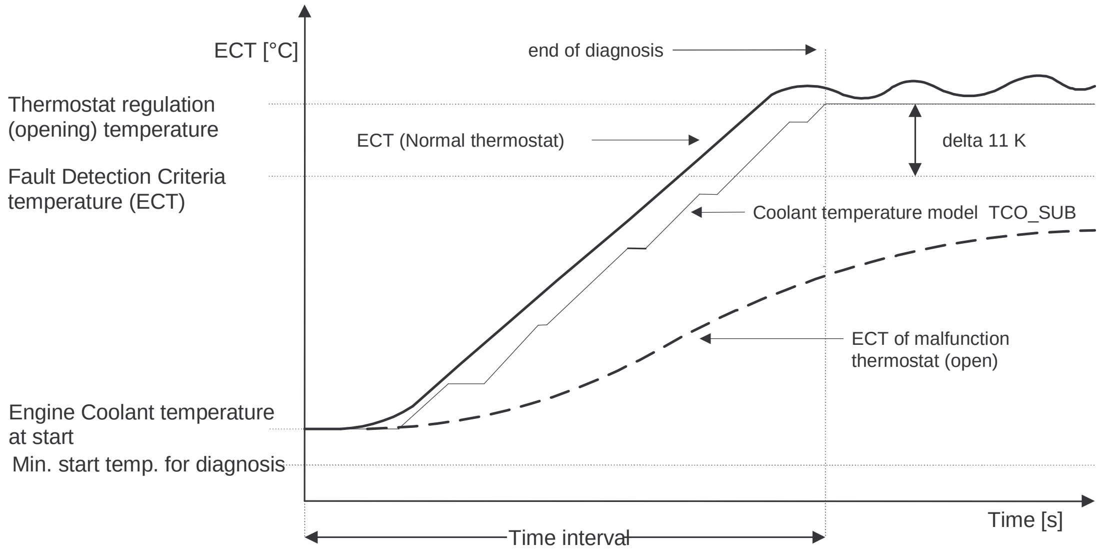
1.10.1.1 Monitoring function

The coolant thermostat monitoring is done to detect a slow warm-up due to heat losses through thermostat and radiator. It is based on the comparison of the measured ECT sensor signal and the calculated ECT model (TCO_SUB).
The ECT model calculation is depending on the speed of the water pump, engine load and ambient temperature.

A malfunctioning coolant thermostat is detected, if the calculated ECT model has exceeded the threshold 1 (P0128) and the measured ECT sensor signal remains below threshold 2 (P0128).

Before a malfunctioning coolant thermostat is entered into failure memory, the conditions concerning low load, coasting duration and IAT during the monitoring are checked. If the monitoring conditions are met, the coolant thermostat is entered into failure memory. Otherwise the coolant thermostat monitoring is inhibited for this driving cycle.

Example of Monitoring Method:



A comparison between the measured engine coolant temperature (ECT) and the fault detection criteria temperature is done after a specific time interval. The interval itself is based on the engine coolant temperature model.

As soon as the model temperature exceeds the thermostat regulation (opening) temperature and all other monitoring conditions are fulfilled at the same time, a valid diagnosis occurs.

At that time, if the measured engine coolant temperature is higher than Fault detection criteria (thermostat regulation temperature -11°K), the thermostat is concluded as normal thermostat.

On the contrary, if the measured coolant temperature is lower than Fault detection criteria (thermostat regulation temperature -11°K), the thermostat is concluded as opened stuck thermostat.

The thermostat regulation (opening) temperature is determined by the hardware. It is always 97°C. The fault detection criteria for the thermostat is therefore 86°C.

The ECT-sensor is not directly at the thermostat. This results in a temperature difference between ECT and Thermostat. Therefore we use calculated models:

Modelled ECT	99°C
Fault detection ECT (Modelled ECT-11°K)	88°C
Thermostat regulation Temperature	97°C
Thermostat fault detection criteria (Therm. Reg. Temp. – 11°K)	86°C

1.10.2 Engine Coolant Temperature (ECT) Monitoring

1.10.2.1 Electrical Engine Coolant Temperature Diagnosis - Electrical check

P0117, P0118

1.10.2.1.1 Monitoring function

The purpose of this diagnosis is to detect electrical faults of the sensor signal. The input signal is analog from a NTC and has to be in a calibratable range. Short circuit to ground can be detected immediately. Short circuit to voltage battery or open circuit is detected, if conditions of Intake Air Temperature and Time After Start are fulfilled. If an error symptom is detected, the error counter is de-bounced.

Error Symptoms

- short circuit to voltage battery or open circuit
- short circuit to ground

1.10.2.2 Coolant Temperature Gradient Diagnosis

P3198

1.10.2.2.1 Monitoring function

The purpose of this diagnosis is to detect an implausible gradient on the coolant temperature signal. The diagnostic function checks whether the difference between one measured coolant temperature value and the succeeding value is too big.

Error Symptom

ECT signal gradient error

1.10.2.3 Coolant Temperature Stuck Diagnosis

P3199

1.10.2.3.1 Monitoring function

The purpose of this diagnosis is to detect a stuck coolant temperature signal. The diagnostic function checks if after a variation of the calculated coolant temperature also a variation of the measured coolant temperature is detected. The range of required variation depends on ECT at engine start.

For RBM handling the Cold Start Denominator will be considered.

Error Symptom

ECT signal stuck error

1.10.2.4 Coolant Temperature Stuck in Range Diagnosis

P316A

1.10.2.4.1 Monitoring function

The purpose of this diagnosis is to detect a coolant temperature signal that is stuck in high range. The diagnostic function checks if after a certain time the engine has been stopped, the engine temperature has reached a plausible (low) value, i.e. the engine has cooled down.
If the measured engine temperature at engine start is above a calibratable threshold and the diagnosis conditions are fulfilled, the error is set. The threshold depends on Intake Air Temperature at Start and the Time Engine was stopped.

For RBM handling the Cold Start Denominator will be considered.

Error Symptom

ECT signal stuck in range error

1.10.3 Engine off Timer Monitoring

P1515

1.10.3.1 Monitoring function

The engine off time is calculated using a relative time counter obtained from the instrumentation via CAN message. The difference in value of the relative time counter at last engine stop and at current engine start is compared to the corresponding values of ECT. An error is detected when engine off time is adjudged too small after a relatively large drop in ECT, or, conversely, when engine off time is too large after a small drop in ECT.

Error Symptoms

- engine off time not plausible to ECT (Symptom 3)

1.11 Cold Start Emission Reduction Strategy Monitoring

All parameters, that are relevant during the cat heating phase, are monitored by standard monitoring functions:

e.g. MSV80-N51/N52

Relevant Components during Cat Heating Phase						Impact of faulty Component on Cat Heating Parameter				
Comp./System	**Parameter**	**needed for**	**Component Diagnosis**	**Diagnosis during Cat Heating**	**Emission Impact > 1,5xGW**	**Idle Speed**	**Ignition Angle**	**Engine Lambda**	**Transmission Shifting Point**	**Camshaft Position**
Secondary Air	Secondary Air Mass	Enleanment exhaust gas	Secondary Air diagnosis	Yes	Yes, dep. to variant and emission class			X		
Injection Valve	Injection time	Enrichment lambda_engine < 1 Enleanment lambda_engine > 1	Output stage diagnosis Misfire detection Fuel supply diagnosis	Yes Yes no	none	X	X	X		
Mass Air Flow Sensor	Air Mass - Input for maps	Larger overlap, VANOS End position	Air mass flow sensor diagnosis Air mass model diagnosis Fuel supply diagnosis	Yes Yes no	none	X	X	X		
Throttle Position	Angle	Mass Air Flow	Power stage, accelerator pedal diagnosis	Yes	none	X	X	X		
Valvetronic	Valve Lift	Load-control	Valvetronic electrical / mechanical diagnosis Air mass model diagnosis	Yes Yes	none	X	X	X		
Phase Sensor (Camshaft)	Valve overlap	Larger overlap	RPM sensor diagnosis	Yes	none					X
Camshaft Position Actuator	Valve overlap	Larger overlap	Output Stage diagnosis Camshaft position actuator	Yes Yes	none					X
RPM Sensor	Engine Speed	Idle speed increase	RPM sensor diagnosis	Yes	none	X				
Idle Speed	Engine Speed	EVAP, Camshaft Position	Idle speed diagnosis	Yes	none	X				X
CAN-Communication with Transmission	CAN-bus	Shifting point	Timeout CAN-message	Yes	none	X			X	
Coolant Temperature Sensor	Temperature	Input for maps	Electrical plausibility Stuck signal	Yes no	Yes	X	X	X	X	X
ECM	Signals	Calculation	Self Check RAM,ROM,W-dog	Yes	- - -					
Ignition	Ignition angle	Optimum: retarded ignition	Misfire detection	Yes	Yes, dep. to emission class		X			

Illustration *Standard monitoring functions during Cat Heating - Overview*

To fulfill the legal requirements, the monitoring of the idle speed is now extended to the cold start phase. In case of an error, the specific DTC's:

- P1561 Cold Start Idle Air Control System RPM lower than expected
- P1562 Cold Start Idle Air Control System RPM higher than expected

are set. Look at illustration *Idle speed control*

During cat heating, it is essential to make sure, that enough thermal energy is applied to the catalyst to heat it up as quick as possible.
Therefore it is target to limit the ignition timing to the earliest possible value during the cat heating phase.

If there would be a demand for more torque and therefore for an advanced ignition timing beyond the limits, the engine would be allowed to stall instead of fulfilling the demand.
The torque limits are calibrated the way that the emissions stay below 1.5 times of the limits.

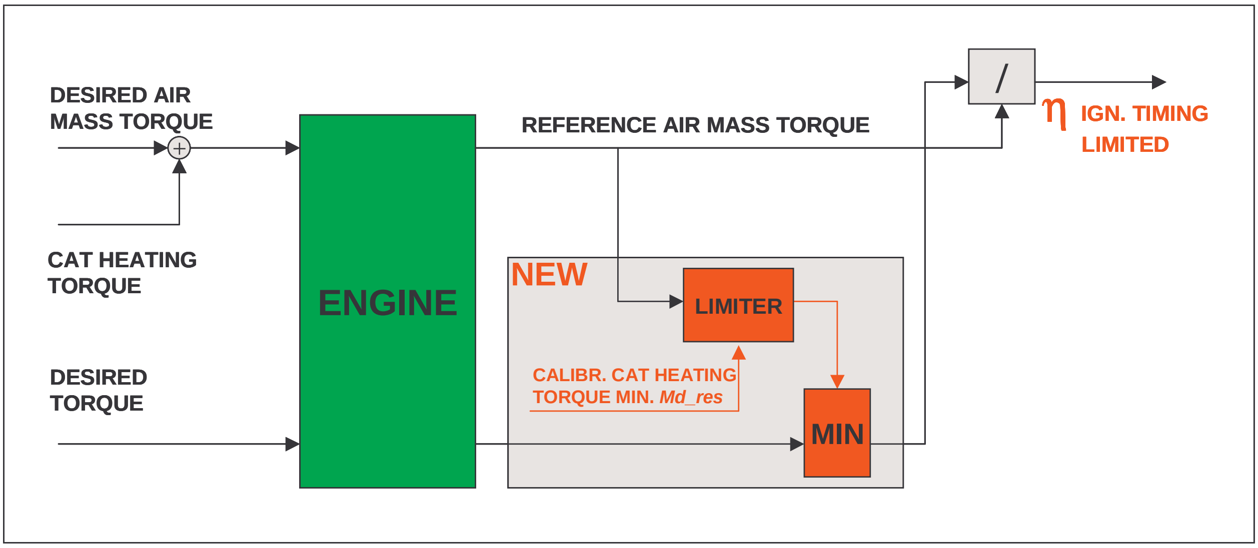


Illustration *Control of air mass torque during cat heating*

Known System:

During normal driving, the ignition timing desired torque corresponds to the air mass desired torque, which determines the ignition timing. During the cat heating phase, the cat heating torque is added to the air mass desired torque, resulting in a higher reference air mass torque.
The efficiency, desired torque divided by the reference torque, determines the ignition timing.

New System (BMW-development):

The earliest possible ignition timing is determined by the limitation of the torque reserve to a minimum value during the cat heating phase. For this, the required minimum cat heating torque is subtracted from the reference air mass torque. The thus reduced efficiency leads to a safe ignition retard and limits the ignition timing during the cat heating measures.

Limitation of ignition timing to the earliest possible ignition timing during the cat heating phase by limitation of torque reserve to the minimum required torque reserve.

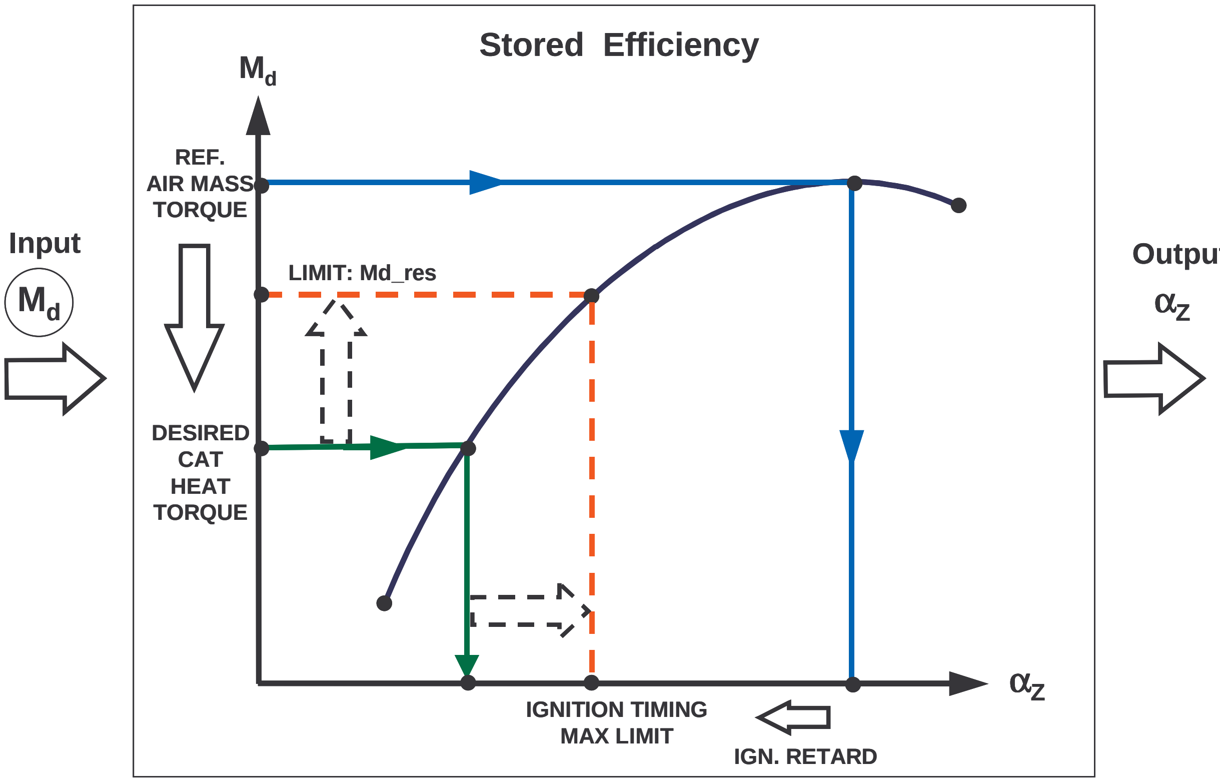


Illustration Diagram torque *characteristic line and ignition timing*

The maximum ignition timing after cold start with new BMW method:

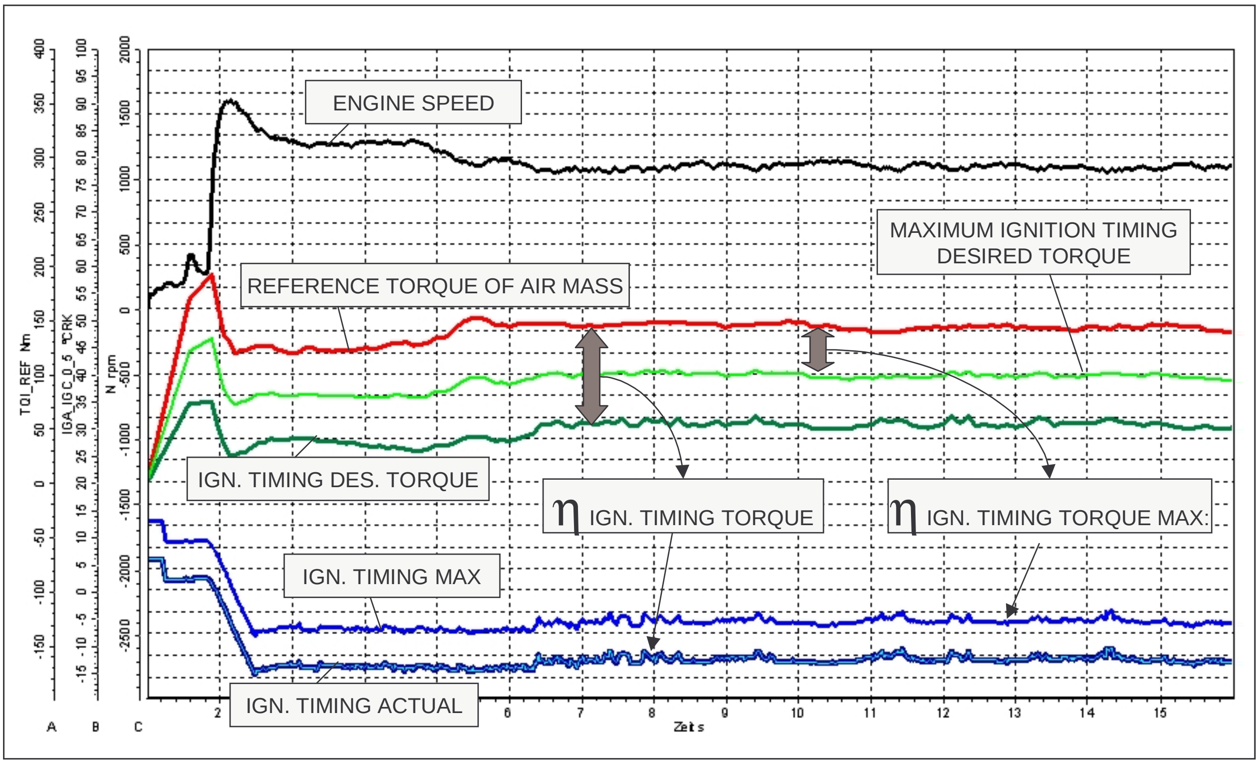


Illustration *Measuring Data*

1.12 Air Conditioning (A/C) System Component Monitoring

This diagnose system is not embedded.

1.13 Camshaft and Crankshaft Sensor including Valve Timing

1.13.1 Camshaft Sensor

1.13.1.1 Variable Camshaft Timing (Vanos) (detection of mechanical IVVT error)

P0012, P0015

The BMW-Vanos is a combined hydraulic and mechanical camshaft control unit, managed by the ECU. The double Vanos allows the engine to control valve-timing continuously for both intake and exhaust camshafts. The electronically control of the Vanos positions is dependant on engine speed, load and temperature.

The diagnosis is monitoring the correct mechanical function of the variable camshaft timing. The diagnosis carries out a continuous rationality check of the Vanos function.
If a malfunction is detected, an error bit will be set and sent to the Error management module. This module produces the final information for setting the corresponding DTC.

The diagnostic strategy for inlet and exhaust camshaft is identical.

1.13.1.1.1 Monitoring function

In this diagnosis module the difference between the actual and target position of the Vanos units (“control deviation”) is checked. If the calculated difference between these two positions exceeds the established threshold, a counter is started. The counter is incremented twice per crank revolution (but not exceeding 10 msec-rates).
If the counter exceeds a limit (also adjustable), a Rationality Fault (DTC) is stored.

The control deviation diagnosis has got an interface to the Rate-Based Monitoring module.

A <u>In-use monitor performance Ratio:</u>

The incrementing of the numerator, denominator, and the ratio calculation for the Variable Camshaft Timing monitor is executed by the Rate-Based Monitoring module. Like all monitors for which a standardized track and report in-use performance is required, the Variable Camshaft Timing monitor reports to the RBM-module via status flags - see description of RBM module.

B <u>Conditions for incrementing the Numerator:</u>

The numerator is incremented if and only if the monitor is not inhibited due to stored faults and the diagnostic has been performed and a fault would have been detected.

C <u>Conditions for incrementing the Denominator:</u>

The denominator is incremented if the monitor is not inhibited due to stored faults, the general driving conditions have been fulfilled and all additional physical conditions for incrementing have been fulfilled.

1.13.1.2 Camshaft Position Sensor (CMP)

P0340, P0365, P1300, P130A, P0344, P1554, P1553, P0016, P0017

The purpose of the diagnosis is to detect when the camshaft reference position is outside the designed range relative to the engine position from crankshaft and to detect a signal which is not valid.

The diagnostic strategy for inlet and exhaust camshaft is identical.

1.13.1.2.1 Monitoring function

The detection of each camshaft position is done by an active hall sensor and a cam wheel, "3 asymmetric teeth". The camshaft sensor delivers 3 high and 3 low phases of different length per 720°CRK. The high or low pegel of the signal at the reference gap of the crankshaft signal determines the position of the engine within the combustion cycle. With that information, a engine position is calculated from the crankshaft position sensor within a range from 0 to 720 °CRK.

<u>The following malfunctions are detected:</u>

- CMP sensor signal plausibility	P0340 / P0365
- CMP sensor signal segment period	P1300 / P130A
- CMP sensor signal loss of synchronization	P0344 / P0369
- CMP sensor signal reference to CRK position	P1554 / P1553
- CMP sensor signal jump of chain	P0016 / P0017

1.13.1.2.2 Diagnosis of signal plausibility

P0340, P0365

The monitor checks once per combustion cycle the edge counter of the camshaft. If the edge counter has not changed during the last cycle, a cycle counter is incremented. When the counter reaches a threshold, the error CAM_plaus is delivered to the error management.

1.13.1.2.3 Diagnosis of period length

P1300, P130A

The monitor checks at every edge of the CMP signal the length of the last signal period. If the difference to the designed length exceeds a max value, the corresponding de-bounce counter is incremented. When the counter reaches a threshold the error CAM_period is delivered to the error management.

1.13.1.2.4 Diagnosis of synchronization state

P0344

The camshaft signal acquisition synchronizes on the camshaft sensor signal by evaluating the pattern of the measured long and short periods of the signal. Synchronization is lost if the last measured period does not fit to the pattern. After a synchronization has been established, the monitor checks at every new signal edge whether the camshaft is still synchronized or not. If the camshaft is not synchronized, the corresponding de-bounce counter is incremented. If the camshaft is still synchronized, the de-bounce counter is incremented. When the counter reaches a threshold, the error CAM_sync is delivered to the error management.

1.13.1.2.5 Diagnosis of mechanical reference position

P1554, P1553

The monitor checks at least once per driving cycle the position of the camshaft signal edges compared to the crankshaft position while the camshaft is in lock position (VANOS passive).

The deviation of all camshaft edges compared to the designed position is averaged. Each time the deviation of one of the camshaft signal edges exceeds a max value, the corresponding de-bounce counter is incremented. When the counter reaches a threshold the error CAM_ref_crk_cam is delivered to the error management.

1.13.1.2.6 Diagnosis of mechanical chain jump

P0016, P0017

The diagnosis is performed after the reference position adaptation. The learned position of each camshaft signal edge is stored in the non volatile RAM of the ECU as an adaptation value. Before storing the value, the new adapted value is compared with the stored value. If the deviation exceeds a max value, the error CAM_one_tooth_off is delivered to the error management and the new value is not stored in RAM. With this diagnosis a chain jump of the timing chain is detected.

The diagnosis of the mechanical chain jump has got an interface to the Rate-Based Monitoring module.

A In-use monitor performance Ratio:

The incrementing of the numerator and denominator for the diagnosis of chain jump is executed by the Rate-Based Monitoring module. Like all monitors for which a standardized track and report in-use performance is required, the diagnosis monitor reports to the RBM-module via status flags - see description of RBM module.

B Conditions for incrementing the Numerator:

The numerator is incremented if and only if the monitor is not inhibited due to stored faults and the diagnostic has been performed and a fault would have been detected.

C Conditions for incrementing the Denominator:

The denominator is incremented with every driving cycle.

1.13.1.3 Camshaft Crankshaft synchronization

P0341, P0369

The purpose of the diagnosis is to validate the camshaft signal used for synchronization. First the intake camshaft is selected for synchronization. If validation fails, the exhaust camshaft signal will be selected for synchronization. If validation also fails, no synchronization will be established.

1.13.1.3.1 Monitoring function

The diagnosis is performed at every edge of the selected camshaft signal and at the reference gap of the CKP sensor signal. The distance (in crankshaft degrees) between events is compared to the stored camshaft signal pattern. For each signal edge the distance must fit to the designed position in the pattern plus / minus a tolerance. The tolerance is expanded by the range of the variable valve timing, when the camshaft is not in lock position.

The following malfunctions are detected:

- intake CMP sensor signal not valid for synchronization	P0341
- exhaust CMP sensor signal not valid for synchronization	P0369

The monitor eliminates with every event the edges from the list of all 6 cam edges, which are not insides the pattern. If a calibrated number of camshaft signal edges were detected and the list of remaining signal edges contains at least one edge, the camshaft signal is valid for synchronization. If no edge is left in the list, synchronization failed and is started again. If a calibrated number of synchronizations failed, the error is delivered to the error management. Afterwards, and only if synchronization fails with the intake camshaft, the same procedure is started with the exhaust camshaft.

1.13.2 Crankshaft Position Sensor (CRK)

P0335, P0370, P0373

The purpose of this diagnostic is to check the integrity of the crankshaft sensor signal and/or electrical malfunctions. (Open line, SCG, SCVB)

1.13.2.1 Monitoring function

The detection of crankshaft position is done by an active hall sensor and a crank wheel, "e.g. 60 minus 2 teeth". A reference gap, "e.g. of two teeth" allows the detection of the top dead center of cylinder 0. The crankshaft sensor delivers a certain number of high and low phases per 360°CRK. The transition from high to low is a falling edge; from low to high is a rising edge. Only the falling edges are counted. The difference between two falling edges is 6° CRK.

The following malfunctions are detected:

- missing CRK sensor signal	P0335
- no plausible CRK signal	P0335
- wrong tooth number	P0370
- wrong tooth period	P0370
- sync error	P0373

A teeth counter is incremented at every falling edge of the CRK sensor signal. If plus or minus two teeth are detected during the last 360° CRK at the reference gap, the tooth number de-bounce counter will be incremented. If the counter exceeds a limit, a CRK tooth error is delivered to the error management.

If more then two teeth plus or minus are detected the CRK looses synchronization and a CRK sync de-bounce counter will be incremented. If the counter exceeds a limit, a CRK sync error is delivered to the error management.

The detection of a tooth period error is done by an acceptance window. The expected tooth period is multiplied and divided with an engine speed dependency factor. The result is a bottom and a top limit of tooth period, in which the transition from high to low of the electrical signal has to occur. If a tooth period is not valid, the tooth period error de-bounce counter will be incremented. If the counter exceeds a limit, a CRK tooth per error is delivered to the error management.

Detection of implausible crankshaft signal is based on the detection of CAM signals without receiving correct CRK signal. If 12 or more CAM edges are detected (eg. 2 working cycles), without valid synchronization of the crankshaft, then CRK plaus error is detected and delivered to the error management. If no CRK signal at all is received, the symptom is “missing signal”, else the symptom is “implausible signal”.

1.14 Comprehensive Component Monitoring OBD II Siemens VDO function definition

1.14.1 Strategy

Principle:

- **Sensors** that can affect emissions or are used to monitor other component / system are monitored for circuit continuity and short to battery voltage and / or to ground using high and low voltage signal limit.

- **Actuators** that can affect emissions or are used to monitor other component / system are monitored by power stage voltage check for valid signals.

- For some of sensors or actuators, plausibility checks are included to ensure proper operation of the components.

1.14.1.1 Monitoring Strategy for sensors:

Sensor signals out of a defined range are regarded as circuit malfunctions shorted to BATT, GND or Open circuit.

1.14.1.2 Monitoring Strategy for actuators:

Invalid actuator output signals at power stage are regarded as circuit malfunctions shorted to BATT, GND or Open circuit.

1.14.1.3 Rationality Check:

Components are checked for the integrity of their values. This is accomplished by the use of a model or other sensor inputs. If a component does not function as expected or the integrity is in question (values are not within a threshold) it is considered out of range / plausible.

1.14.2 Fuel Level Sensor (FLS)

1.14.2.1 Monitoring overview

The diagnosis of the fuel level sensor signal consists of a circuit continuity check and a rationality check.

1.14.2.2 FLS electrical circuit continuity check

P2068, P2067, P0463, P0462

1.14.2.2.1 Monitoring function

The signal of the fuel level sensor is monitored concerning the valid range. This range depends on the used fuel level sensor.

If the left or right fuel level sensor signal is above the upper threshold, a short circuit plus is detected. If the left or right fuel level sensor signal is below the lower threshold, an appropriate fault code for the left or right sensor is set.

FLS electrical short-circuit to battery right	P2068
FLS electrical short-circuit to ground right	P2067
FLS electrical short-circuit to battery left	P0463
FLS electrical short-circuit to ground left	P0462

1.14.2.2.2 FLS diagnosis frequency of FLS circuit continuity check

short circuit battery

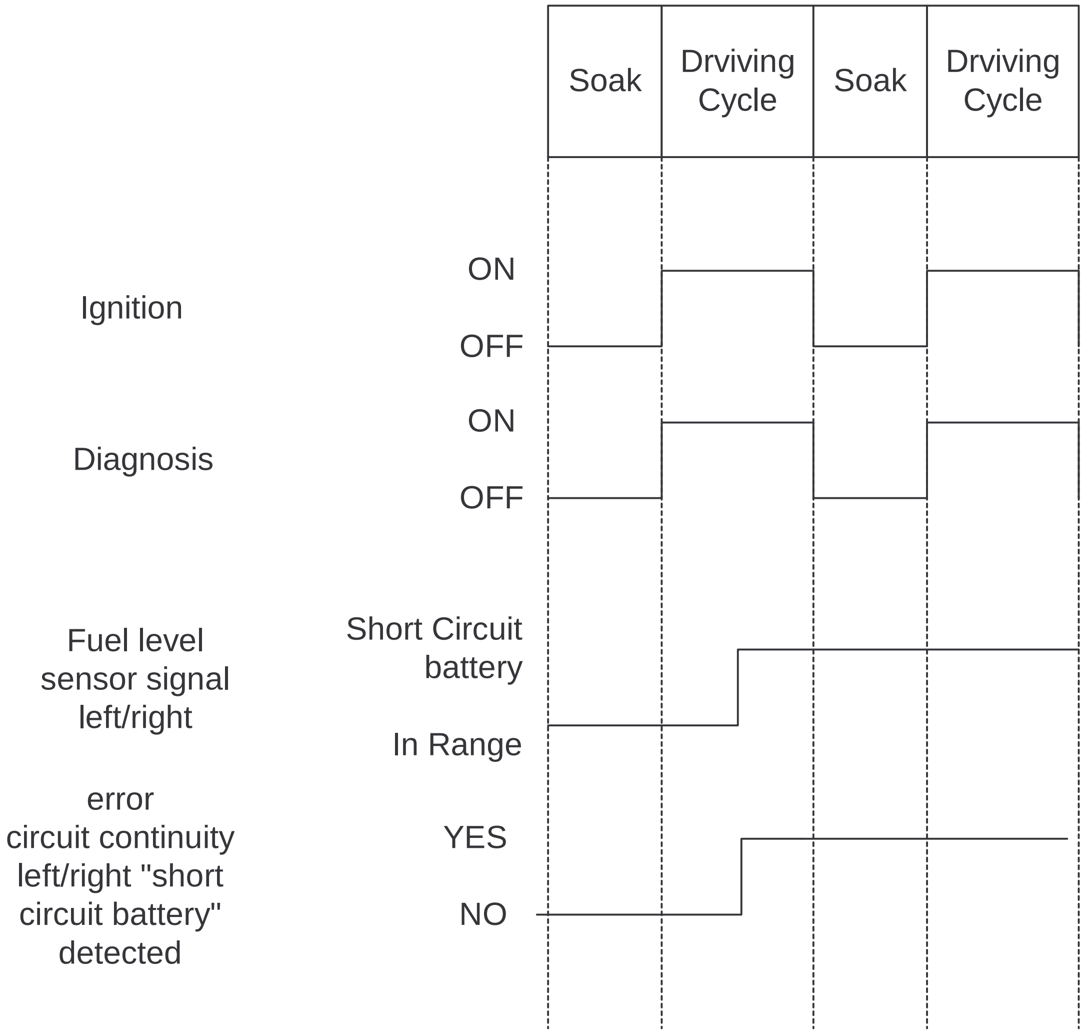
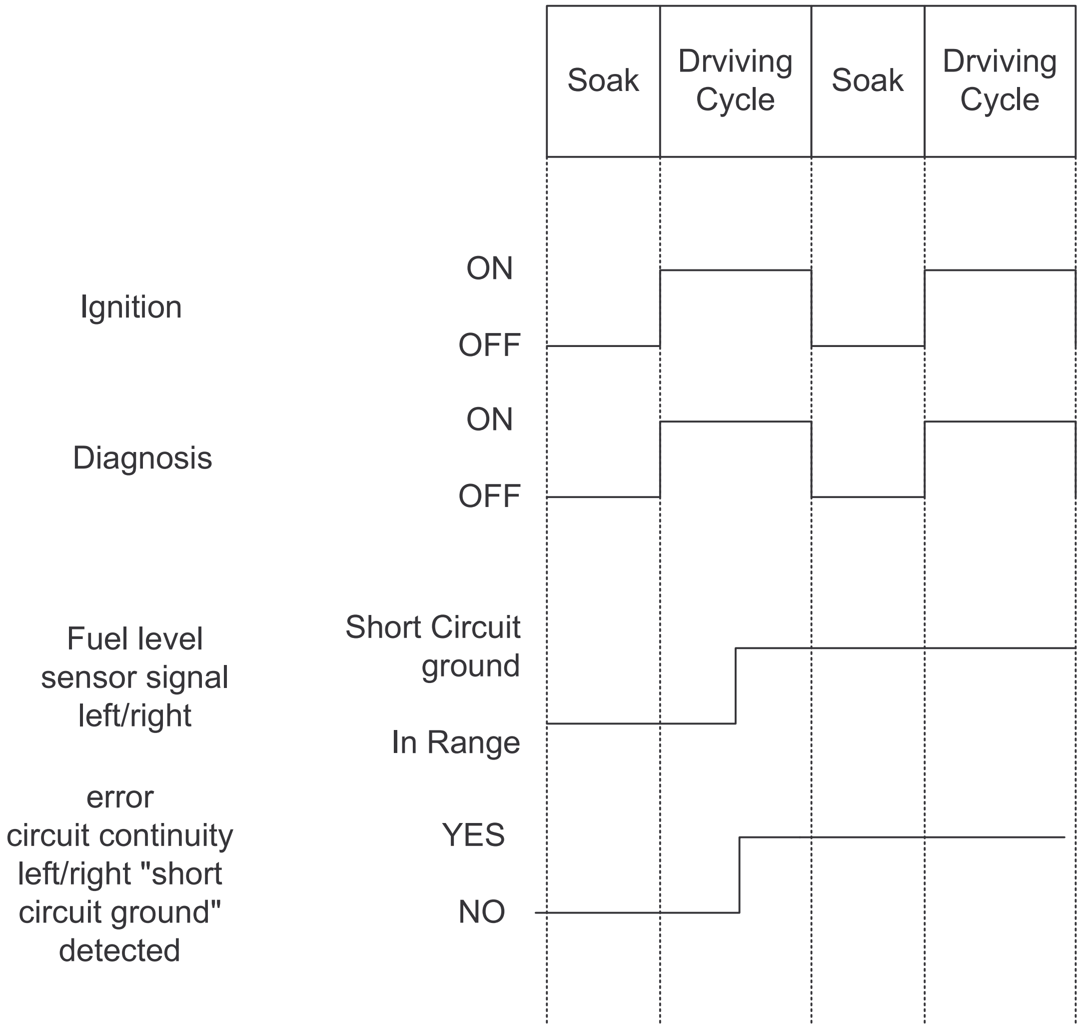


Figure 2

short circuit ground



1.14.2.3 FLS signal rationality check (plausibility error)

P0461

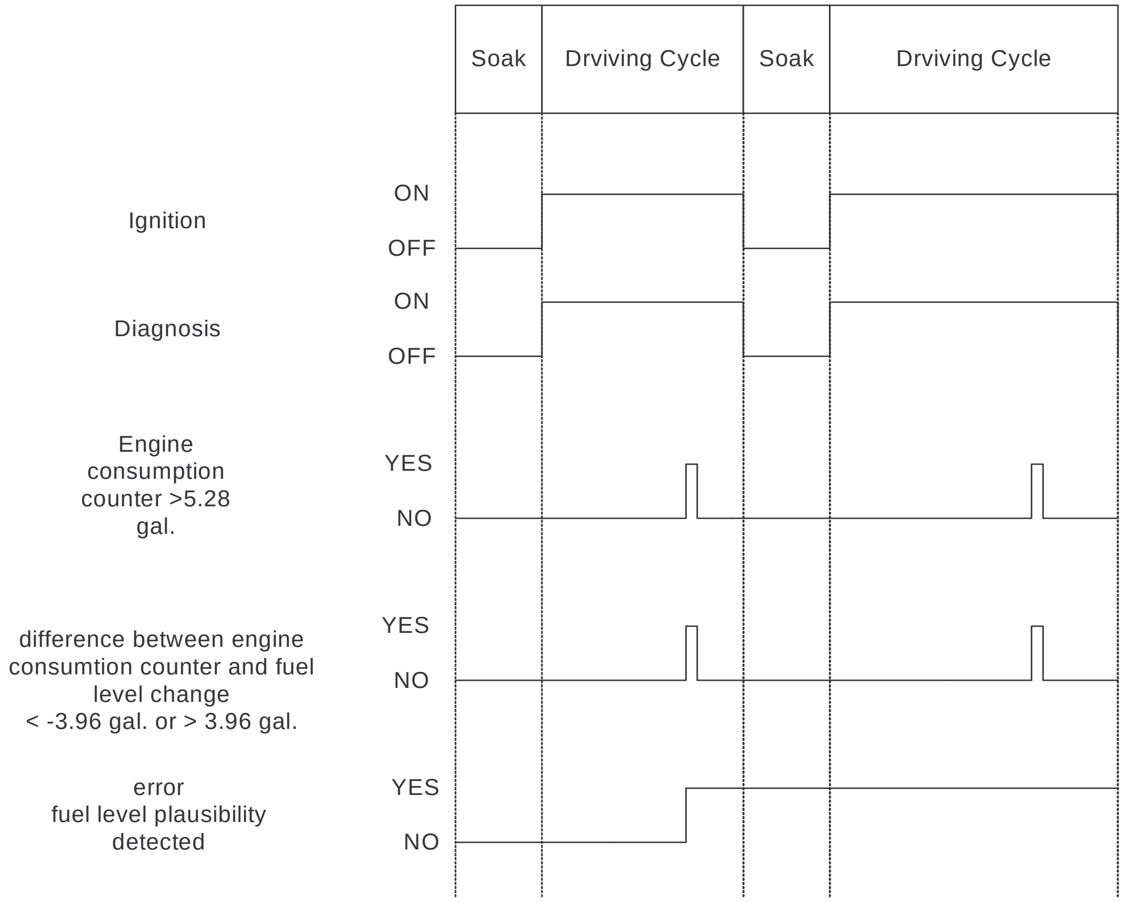
1.14.2.3.1 Monitoring function

The engine management system has the capability to calculate (sum up) the fuel consumption. For the fuel level sensor plausibility check, this calculated consumption is compared with the decreasing of the fuel level signal. When the calculated value for fuel consumption reaches an appropriate and predetermined value (e.g. five gallons), the calculated fuel consumption is compared to the difference of the fuel level as indicated by the fuel level sensors (between starting calculation and current). In case of the difference is greater than the applicable threshold value, a fuel level sensor fault is detected and an appropriate fault code is set.

If a fault is present, the OBD II EVAP leak monitor will run using a substitute value of 85% total fuel tank volume.
The 85% substitute value will assure that in every case the required 0.020 inch leak is detected by the OBD II system.

fuel-signal plausibility	P0461

1.14.2.3.2 FLS diagnosis frequency of FLS rationality check (plausibility error)



1.14.3 Ambient Temperature Monitoring

1.14.3.1 CAN based Ambient Temperature - Signal Diagnosis

P0072, P0073

1.14.3.1.1 General description

The purpose of this diagnosis is to detect electrical faults as defined in OBDI requirements. The input signal is a CAN message of instrument cluster. If an error is detected by the instrument cluster, the error symptom is sent via CAN to the ECU. The ECU then de-bounces the error and stores it in the error management.

Error Symptoms

- short circuit to vbatt or open line
- short circuit to ground

1.14.3.2 Ambient Temperature - Signal Plausibility Check

P0071

1.14.3.2.1 General description

This diagnosis is performed in order to detect a stuck or not plausible TAM signal which cannot be detected by electrical range diagnosis.

The first part, just after start looks on the change of ambient temperature and compares the start and stop temperature. If the check is positive the diagnosis is finished. In negative case diagnosis runs to next step during warm up phase.

The error detection is only performed if the monitoring conditions for time after start, engine state idle speed, time of engine stop, ECT and ambient temperature are fulfilled. The plausibility error is detected if the absolute value of the temperature-difference between the arithmetic mean of engine coolant temperature ECT and temperature intake air TIA and the ambient temperature TAM (in formula: ABS (absolute value) of [(ECT+TIA) x 0,5 – TAM)]) exceeds the threshold for an anti-bounce time.

The error validation is only performed if all electrical diagnoses for ECT and radiator outlet temperature are finished and the vehicle was driven with a certain vehicle speed. If both conditions are true and an error was detected, then the error is set for this driving cycle and the diagnosis is switched off.

For RBM handling the Cold Start Denominator will be considered.

Error Symptoms

- ambient temperature not plausible

1.14.4 Intake Air Temperature (IAT) Monitoring

1.14.4.1 Electrical Intake Air Temperature Diagnosis

P0112, P0113

1.14.4.1.1 General description

The purpose of this diagnosis is to detect electrical faults as defined in OBDI requirements. The input signal is analog from a NTC and has to be in a calibratable range. Short circuit to ground can be detected immediately, short circuit to voltage battery or open load after a delay time. If an error symptom is detected, the error counter is de-bounced.

Error Symptoms

- Short circuit to voltage battery or open load
- Short circuit to ground

1.14.4.2 Intake Air Gradient Check

P115E

1.14.4.2.1 General description

The purpose of this diagnosis is to detect an implausible jump discontinuity and implausible gradient on the intake air temperature signal. If a jump discontinuity is located, the error is not de-bounced and is registered in error management. If an implausible gradient is detected, the error is de-bounced.

Error Symptoms

- Signal gradient not plausible

1.14.4.3 Intake Air Plausibility Check

P0111, P111E, P111F

1.14.4.3.1 General description

This diagnosis checks IAT integrity for a plausible range and signal stuck.

For the range detection, IAT has to be within coolant temperature and ambient temperature window. If IAT is outside of the range plus an offset, the error symptom is set and the error counter is de-bounced.

If the vehicle was driven with a certain vehicle speed for a calibratable time (IAT sensor cool down) and afterwards the vehicle was in idle for a calibratable time (IAT sensor hot up), the IAT signal must have moved. If the signal has not moved after a calibratable number of cool down/hot up phases, a stuck IAT signal is detected and the error is de-bounced.

For RBM handling the Cold Start Denominator will be considered.

Error Symptoms

- Signal too high
- Signal too low
- Signal not plausible

1.14.5 Electronic Throttle Control Monitor (ETC)

1.14.5.1 Electronic Throttle Control (ETC) Power Stage Diagnosis (H-bridge)

P1636

1.14.5.1.1 General description

The ETC - H-Bridge IC continually checks the MTC if there is a short circuit to battery voltage or ground. In addition the IC is able to detect overtemperature. This is performed internally to the ECU.

1.14.5.2 Electronic Throttle Control (ETC) Adaption and Start Check

1.14.5.2.1 ETC spring check (start routine)

P1694, P169A

This Diagnosis checks if the throttle spring is working correctly and if the throttle limp home position can be reached. The diagnosis is performed at the beginning of every driving cycle at ignition "Key ON" position.

1.14.5.2.2 ETC adaptation diagnosis

P1632, P1633, P1634, P1635, P1644

After the initial engine start and / or component change, the characteristic Potentiometer values for the limp home position and the lower mechanical stop are learned within an adaptation routine. The values are stored at the end of the driving cycle in the non-volatile memory.

If the adaption conditions are not fulfilled or one of the adaption steps can not be ended successfully, the corresponding errors (DTC's) are stored.

1.14.5.3 Electronic Throttle Control (ETC) Motor Control Performance

P1637, P1638, P1639

1.14.5.3.1 General description

This diagnosis is able to detect a too slow or jammed actuator. The given pulse width modulation signal (MTCPWM) exceeds the position controller permissible maximum value for longer than designated (Max short or Max Long) time.

If either of the times is exceeded, the appropriate DTC will be stored.

Also if a maximum allowed difference between throttle actual value and set-point value is exceeded, a DTC is stored.

1.14.5.4 Electronic Throttle Control (ETC) air supply rationality check

P1417

If
P1639 active OR
P1637 active OR
P1636 active OR
P1632 active OR
P1633 active OR
P1694 active OR
P1644 active OR
P1634 active OR
P169A active OR
P1635 active OR
[(P0122 active OR P0123 active) AND (P0222 active OR P0223 active)]

the composite error P1417 will be stored.

1.14.6 ISC (Idle Speed Control) Actuator

1.14.6.1 Idle Speed Control Rationality Diagnosis

P0506, P0507, P1561, P1562

1.14.6.1.1 Monitoring function

This diagnosis monitors the stability of the idle speed. If the actual idle speed is not within a calibratable range, above or below the idle speed set-point then the failure criteria is fulfilled. The appropriate DTC will be stored.

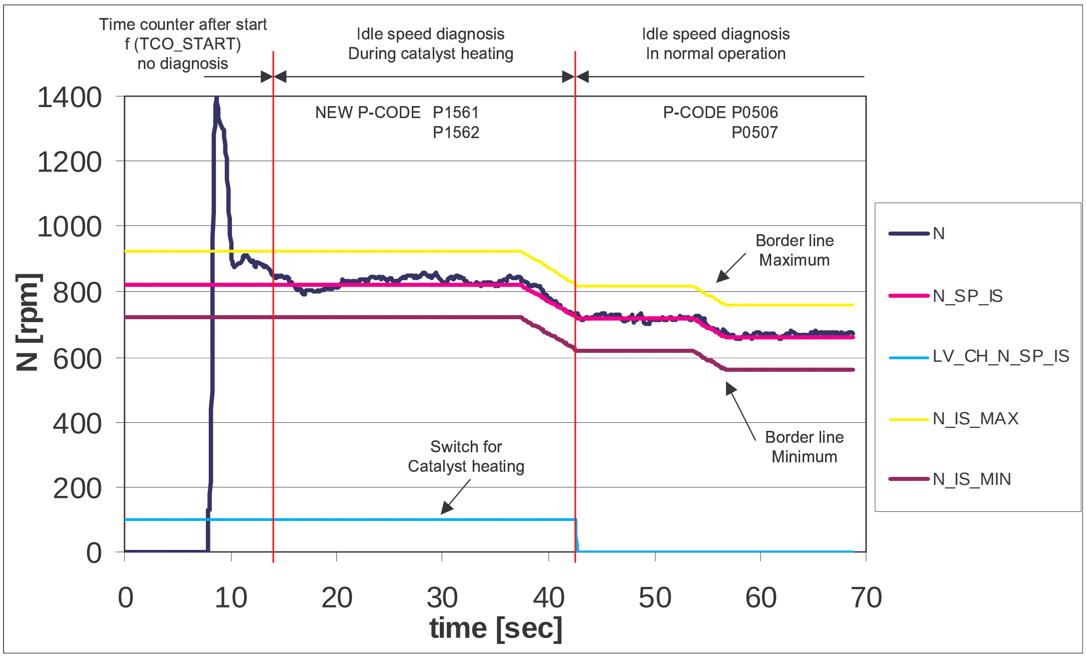


Illustration *Idle speed control*

Variable list:

EMS Parameter	Description
N	engine speed
N_SP_IS	idle speed setpoint
LV_CH_N_SP_IS	catalyst heating by increased idle speed
N_IS_MAX	maximum idle speed
N_IS_MIN	minimum idle speed

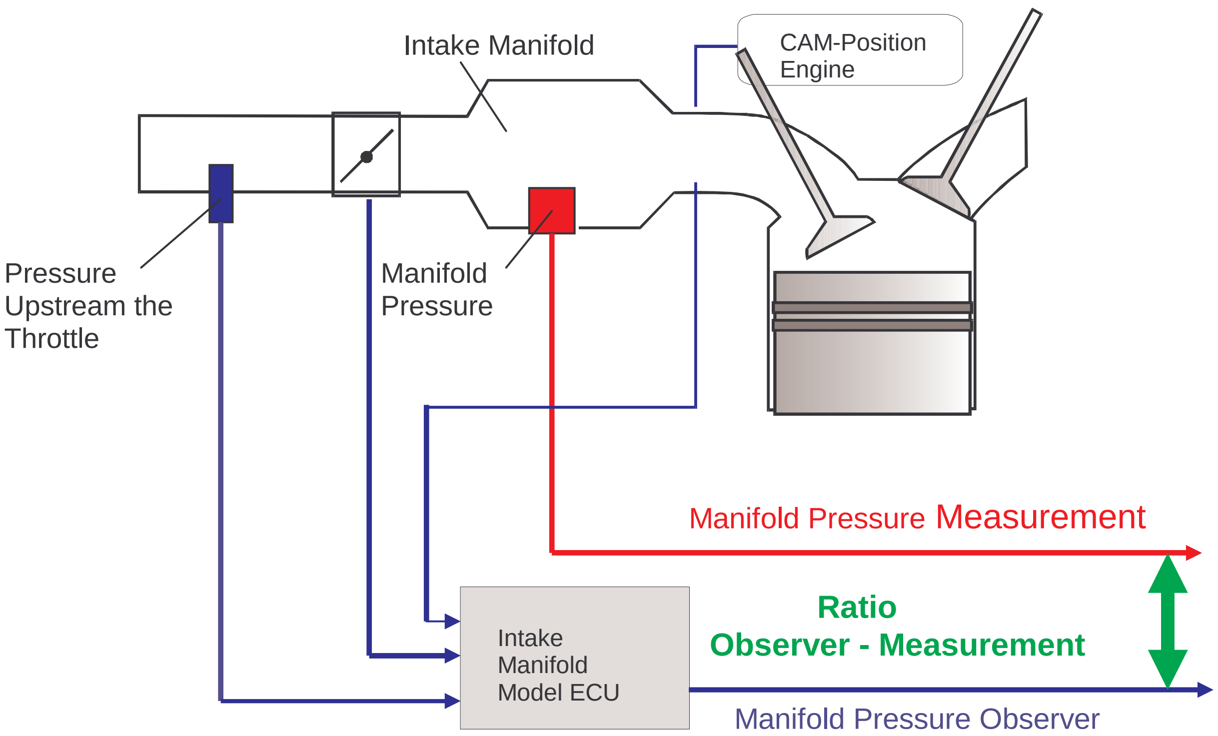
1.14.7 Manifold Pressure

1.14.7.1 Manifold Pressure Throttle Position Sensor - Rationality check

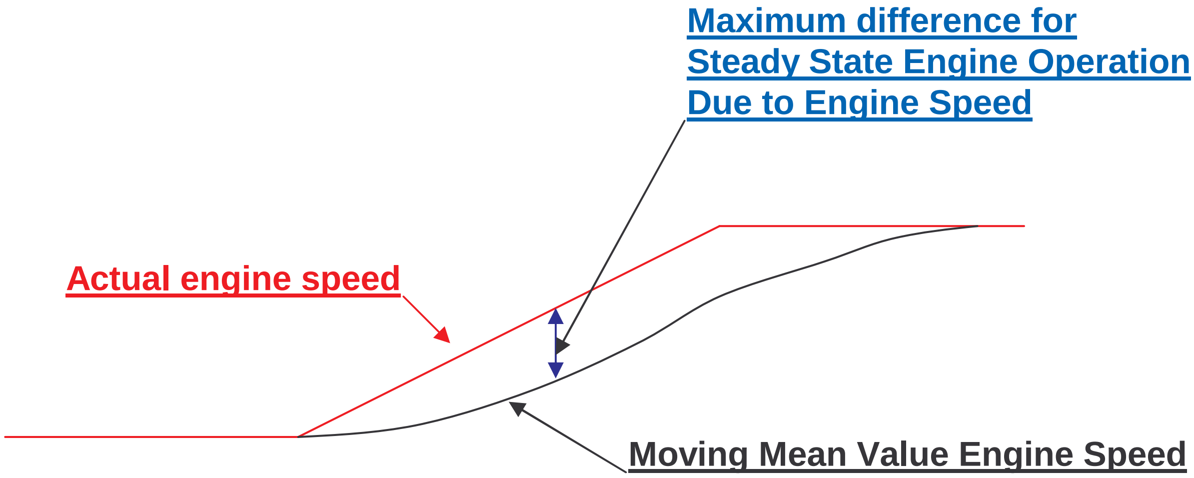
P112E, P112F

1.14.7.1.1 Monitoring function

The main function of the throttle body is to control the pressure in the intake manifold. The absolute pressure in the intake manifold is also measured by the manifold pressure sensor.
Due to the pressure in intake manifold, the engine speed and the position of the inlet and outlet camshaft an air mass flow into the cylinder is calculated (speed density system). Also an air mass flow at the throttle body is calculated. Out of the mass balance between the in- and out flowing mass flows and the volume of the intake manifold, it is possible to calculate the pressure in the intake manifold (manifold pressure observer). The ratio between the calculated manifold pressure and the measured manifold pressure is observed. Therefore a controller is used. The target of the controller is that the output of the manifold pressure observer - the calculated manifold pressure - is equal to the measured manifold pressure. Therefore the flow coefficient of the throttle body is corrected. If the correction of the flow coefficient of the throttle body exceeds a threshold depending on engine speed and load a malfunction of the manifold pressure measurement or the throttle position acquisition or a leakage of the intake manifold is detected.



In the monitoring conditions a limited dynamic condition is checked for engine speed an engine load. Only under steady state engine operating the diagnosis is possible due to dynamic effects.
To recognize dynamic engine operation (for example engine speed), the actual engine speed is compared with a moving mean value of the engine speed (PT1-behaviour). The difference between the actual engine speed and the moving mean value of the engine speed must not exceed a value, which can be calibrated. Also the time constant T of the PT1 term can be calibrated. The load dynamic is calculated identical to the engine speed dynamic.

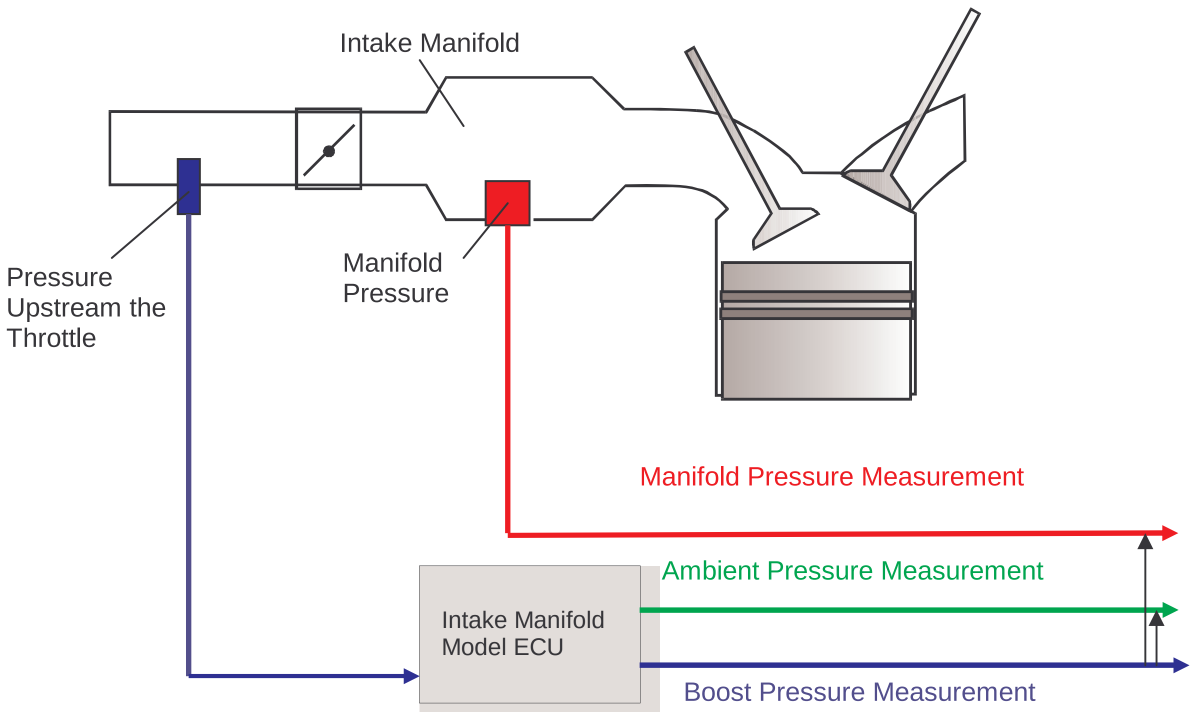


1.14.7.2 Manifold Pressure Sensor - Rationality check

P129B

1.14.7.2.1 Monitoring function

The absolute pressure in the intake manifold is measured by the manifold pressure sensor.
If the engine is not running (engine speed = 0) the measured pressure of the intake manifold pressure sensor located downstream of throttle body is the same as the measured pressure of the boost pressure sensor in the intake manifold system upstream the throttle.
In addition in the ECU the ambient pressure is measured. If the measured manifold pressure is different to both of the other two pressure measurements a fault of the manifold pressure measurement is detected. Both of the differences (Manifold Pressure to Boost Pressure and Manifold Pressure to Ambient Pressure) must exceed a calibratable threshold depending on the sensor tolerances.



1.14.8 Vehicle Speed Signal

1.14.8.1 Vehicle speed sensor - signal plausibility check
P0503

1.14.8.1.1 Monitoring function

A vehicle speed signal plausibility error is detected if at calibratable engine speed-, mass air flow- and time thresholds the vehicle speed signal = 0.

Error symptom

vehicle speed not plausible	P0503

1.14.8.2 Vehicle speed sensor - signal check
P0500

1.14.8.2.1 Monitoring function

A vehicle speed signal error is set if neither a vehicle speed signal is available from ECU-PIN nor a signal is received from CAN (11H / 12H).

Error symptom

no vehicle speed signal	P0500

1.14.9 Knock Sensor

P0326, P0327, P0328, P1327, P1328, P135B

1.14.9.1 General description

The purpose of the diagnosis is to detect faults of the knock sensor. Therefore the signal range and dynamics of a low pass filtered knock signal is checked.

If the signal range exceeds a upper or lower threshold a failure is detected.

An implausible knock signal is detected by using a statistical analysis. The difference between filtered knock signal and raw knock signal is estimated for a certain number of combustion cycles.

All error symptoms are de-bounced.

Error Symptoms

- Noise level above valid range
- Noise level below valid range
- Knock sensor signal not plausible

1.14.10 Injection Deactivation

P140E, P142E, P142F

1.14.10.1 General description

The Injection Deactivation is a diagnosis to protect the catalysts for overheating. In fact it is an additional fuel pressure diagnosis with a very short diagnostic time and an early reaction with deactivation of some injectors. Additional there is an evaluation of the fuel tank level. If the tank level is low there will be a change of the DTC to provide better information's for the workshop.

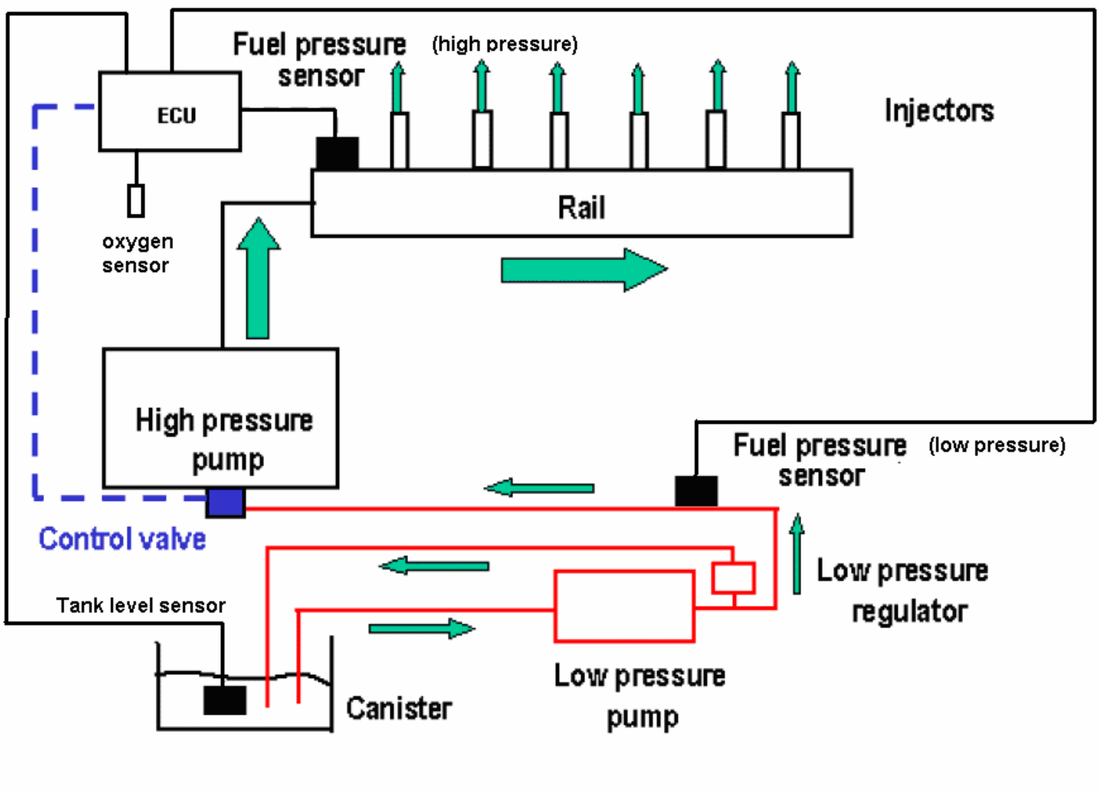


Figure 3: Overview of low and high pressure system

The diagnosis evaluates first an air-fuel deviation. This check analyses the difference between the measured air fuel ratio and the set-point air fuel ratio and analyses the short term fuel trim. Both checks detect only the lean side of mixture. If a lean deviation occurs the diagnosis compares the difference between measured pressure and the set-point of the high pressure and the absolute value of the high pressure sensor with a threshold or checks the absolute value of the low pressure sensor. Then a DTC is set and the reaction is the shut-off of an amount of injectors. This reaction avoids overheating of the catalysts. The decision of which DTC is stored will be affected by the fuel tank level (≈ 0 litre).

1.14.11 Flow Charts Comprehensive Monitoring

1.14.11.1 Throttle Position Sensor - Electrical check
P0122, P0123, P0222, P0223

1.14.11.2 Throttle Position Sensor - Plausibility check
P0121, P0221

1.14.11.3 Fuel Rail Pressure Sensor - Electrical check
P0190, P0192

1.14.11.4 Fuel Pressure Regulator - Electrical check
P0090, P0091, P0092

1.14.11.5 Supercharger Boost Sensor (Pressure up throttle (PUT)) - Electrical check
P0237, P0238

1.14.11.6 Thermostat - Electrical check
P0597, P0598, P0599

1.14.11.7 Camshaft Position Actuator - Electrical check
P0010, P0013, P2088, P2090, P2089, P2091

1.14.11.8 Injector Valve Diagnosis - Electrical check
P0201, P0202, P0203, P0204, P0205, P0206,
P310B, P310E, P311B, P311E, P312B, P312E

1.14.11.9 Manifold Absolute Pressure Sensor (MAP) - Electrical check
P119A, P119B

1.14.11.10 CAN Communication
U112A, U112B, U1101, U110E, U110F, U1110

1.14.11.11 Pedal Position Sensor - Range check
P2120, P164C, P1625

1.14.11.12 Ambient Pressure Sensor - Electrical check
P2228, P2229

1.14.11.13 Ambient Pressure Sensor - Rationality check
P321E, P321F

1.14.11.14 EVAP – DMTL Valve - Electrical check
P2418, P2419, P2420

1.14.11.15 EVAP – DMTL Heater - Electrical check
P240A, P240B, P240C

1.14.11.16 EVAP – DMTL Pump - Electrical check
P2400, P2401, P2402

1.14.11.17 EVAP – Purge Control Valve - Electrical check
P0444, P0458, P0459

1.15 Listing of all ECM Input and Output Signals

BMW signal naming	BMW [N54 turbo]	Pin	Signal naming MSD80.0 [MSD80.1] (MSD80.2)	MSD80.0	OBD II relevant
PT CAN_(low)	D_CANL	1_01	CAN-Low	CAN_L	No
Automatikstart/optional parallel	A_S_START	1_02	start signal/optional parallel	START	No
Generatorschnittstelle	D_BSD	1_03	generator interface	BSD	No
Bremslichts. Signal	E_S_BLS	1_04	brakelight switch	BLS	No
Abgasklappe	A_S_AKL	1_05	exhaust flap	EF	No
Masse Temperatur Kühlwasseraustritt	M_TKA	1_06	ground coolant outlet temperature sensor	GND	Yes
Fahrerwunsch Geber 2	E_A_FWG2	1_07	pedal value sensor 2	PVS_2	No
Elektr. Lüfter getaktet	A_T_ELUE	1_08	cooling fan	CFA	No
Luftklappe	A_T_LKS	1_09	air flap	AF	No
Masse Pedalwertgeber 1	M_FWG1	1_10	ground pedal value sensor 1	GND	No
Spannungsversorgung 5V (PWG1)	A_U_FWG1	1_11	supply voltage PVS1	PVS1_VCC	No
PTC Heizung	A_T_PTC	1_12	PTC Heater	PTCH	No
(MSA) [Sekundärluftpumpe] Reserve	A_S_SLP	1_13	(MSA) [secondary air pump]	RES_OUT_7 opt.	not used
PT CAN_(high)	D_CANH	1_14	CAN-High	CAN_H	No
Wegfahrsperre, EWS4	D_EWS	1_15	imobilizer EWS4	IMOB	No
Bremsl. Tests.- Signal	E_S_BLTS	1_16	brakelight test switch	BTS	No
Fahrzeuggeschwindigkeit	E_F_DFAHR	1_17	wheel speed	WHEEL	Yes
Kupplungss. -Signal	E_S_KUP	1_18	clutch switch	CLU_SWI	No
Temperaturfühler Kühlwasseraustritt	E_A_TKA	1_19	coolant outlet temperature	TCO_EX	not used
Fahrerwunsch Geber 1	E_A_FWG1	1_20	pedal value sensor 1	PVS_1	No
Motor Drehzahl	A_F_TD	1_21	engine speed signal	ESS	Yes
Redundante Kl15	E_S_KL15_3	1_22	stabilized_V_ Ignition	V_IG_3_ext	No
Masse Pedalwertgeber 2	M_FWG2	1_23	ground pedal value sensor 2	GND	No
Spannungsversorgung 5V (PWG2)	A_U_FWG2	1_24	supply voltage PVS2	PVS2_VCC	No
[Sekundärluftmassenmesser] Reserve3	E_A_HFMS	1_25	[secondary mass air flow meter]	RES_IN_3 opt.	not used
EBox-Lüfter	A_S_EBOXL	1_26	cooling fan Ebox	CFA_EBOX	No
Zündschloss Kl.15	E_S_KL15	2_01	ignition key Kl.15	V_IG	No
Reserve [Masse Lambdasonde 3] (Masse Bremsdrucksensor)	NC	2_02	[ground lambda sensor downstream 3] (ground vacuum sens)	GND	not used
Sporttaster (Fahrdynamikkontrolle)	E_A_FDC	2_03	sport switch	E_A_FDC	NO
Multifunktionslenkrad	D_FGRD	2_04	multifunctional steering wheel	MSW	No
Pumpstrom, Stetige-Lambdas. v Kat 2	A_I_LSVP2	2_05	pump current output 2	LSL_IA_2	Yes
Pumpzelle, Stetige-Lambdas. v Kat 1	E_A_LSVP1	2_06	pump current measurement 1	LSL_IP_1	Yes
Pumpzelle, Stetige-Lambdas. v Kat 2	E_A_LSVP2	2_07	pump current measurement 2	LSL_IP_2	Yes
Lineare Lambdasonde/ Referenzzelle vor Kat 1	E_A_LSVR1	2_08	linear lambda sensor upstream 1	LS_UP_1	Yes
Lineare Lambdasonde/ Referenzzelle vor Kat 2	E_A_LSVR2	2_09	linear lambda sensor upstream 2	LS_UP_2	Yes
Masse Lambdasonde vor Kat 1	M_LSV1	2_10	ground lambda sensor upstream 1	VGND_1	Yes
Masse Lambdasonde vor Kat 2	M_LSV2	2_11	ground lambda sensor upstream 2	VGND_2	Yes
Heizung Lambdasonde vor Kat 1	A_T_LHV1	2_12	lambda sensor heater upstream 1	LSH_UP_1	Yes
Heizung Lambdasonde vor Kat 2	A_T_LHV2	2_13	lambda sensor heater upstream 2	LSH_UP_2	Yes
Reservespannung (Spannung Bremsunterdrucksensor)	A_U_RES2	2_14	spare voltage	VS_VCC	not used
(Bremsunterdrucksens)	NC	2_15	(vacuum sens)	NC	not used
Reserve [DMTL Pumpe] (DMTL Pumpe)	A_S_DMTLP	2_16	[DMTL pump] (DMTL pump)	RES_OUT_6 opt.	Yes
Reserve [DMTL Heizung] (DMTL Heizung)	A_S_DMTLH	2_17	[DMTL heater] (DMTL heater)	RES_OUT_2 opt.	Yes
Pumpstrom, Stetige-Lambdas. v Kat 1	A_I_LSVP1	2_18	pump current output 1	LSL_IA_1	Yes
Lambdasonde hinter Kat 2	E_A_LSH2	2_19	lambda sensor downstream 2	LS_DOWN_2	Yes
Lambdasonde hinter Kat 1	E_A_LSH1	2_20	lambda sensor downstream 1	LS_DOWN_1	Yes
Relais Klimakompressor	A_S_KOREL	2_21	relay air conditioning compressor	RLY_ACC	No

Reserve [DMTL Ventil] (DMTL Ventil)	A_S_DMTLV	2_22	[DMTL valve] (DMTL valve)	RES_OUT_3 opt.	Yes
Masse Lambdasonde hinter Kat 1	M_LSH1	2_23	ground lambda sensor downstream 1	GND	Yes
Masse Lambdasonde hinter Kat 2	M_LSH2	2_24	ground lambda sensor downstream 2	GND	Yes
Heizung Lambdasonde hinter Kat 2	A_T_LHH2	2_25	lambda sensor heater downstream 2	LSH_DOWN_2	Yes
Heizung Lambdasonde hinter Kat 1	A_T_LHH1	2_26	lambda sensor heater downstream 1	LSH_DOWN_1	Yes
Dauerplus Kl.30	E_U_30	3_01	direct battery Kl.30	VB	No
Batterie nach Hauptrelais	E_U_HR	3_02	main relay Kl.87	V_EL	No
Batterie nach Hauptrelais	E_U_HR	3_03	main relay Kl.87	V_EL	No
Masse Elektronik (gebrückt mit 3_05 und 3_06)	M_EL	3_04	ground electronic	GND_EL	Yes
Masse Einspritzung (gebrückt mit 3_04 und 3_06)	M_PIEZO	3_05	ground DC/DC converter	GND_EL	Yes
Masse Zündung (gebrückt mit 3_05 und 3_04)	M_ZUE	3_06	ground ignition	GND_IG	Yes
Zündspule Zylinder 1 (Zündspule Zylinder 1)	A_P_ZSZ1	4_01	ignition coil 0	IGC0	No
Zündspule Zylinder 2 (N.C.)	A_P_ZSZ2	4_02	ignition coil 4	IGC4	No
Zündspule Zylinder 3 (Zündspule Zylinder 4)	A_P_ZSZ3	4_03	ignition coil 2	IGC2	No
Zündspule Zylinder 4 (N.C.)	A_P_ZSZ4	4_04	ignition coil 5	IGC5	No
Zündspule Zylinder 5 (Zündspule Zylinder 3)	A_P_ZSZ5	4_05	ignition coil 1	IGC1	No
Zündspule Zylinder 6 (Zündspule Zylinder 2)	A_P_ZSZ6	4_06	ignition coil 3	IGC3	No
Ansteuerung 1 Abgas Rückführventil	A_T_AGR1 opt.	5_01	exhaust gas recirculation valve 1	EGR1	not used
Ansteuerung 2 Abgas Rückführventil	A_T_AGR2 opt.	5_02	exhaust gas recirculation valve 2	EGR2	not used
Mengensteuerventil (Reserve X)	A_T_MSV	5_03	Flow control valve	FCV	Yes
HFM Signal digital/SIMAF[HFM Signal digital/SIMAF] (Nullgangsensor)	E_P_HFM_TL	5_04	(NGS)	SIMAF	not used
Reserve [Sekundärluftventil 1] (Masse Nullgangsensor)	A_S_SLV1	5_05	[sec air valve1] (ground NGS)	RES_OUT_1_opt.	not used
Reserve [Lambda Heizer3] (Spannungsversorgung Nullgangsensor)	A_U_NGS	5_06	[LS heater downstream 3] (supply voltage NGS)	NGS_VCC	not used
Masse Kraftstoffdrucksensor für EKP	M_KDS	5_07	ground fuel pressure fuel pump	GND	No
Spannungsversorgung Kraftstoffdrucksensor	A_U_KDS	5_08	supply voltage fuel pressure sensor	FUPPU_VCC	No
Masse Abgasrückführventil [Masse Drucksensor v. DK]	M_PVDK	5_09	ground exhaust gas recirculation valve [gnd press sens inlet]	GND	Yes
AGR Feedback [Absolutdruck vor DK]	E_A_PVDK	5_10	EGR feedback [pressure throttle inlet]	EGR_FB	not used
Spannungsversorgung 5V (AGR) [PVDK]	A_U_PVDK	5_11	supply voltage EGR [PT_IN]	EGR_VCC	not used
[Umluftventil] Motorlager	A_T_ULV	5_12	[recirculation air valve] active engine brackets	AEB	not used
Haupt-Relais Ansteuerung/optional parallel	A_S_HR	5_13	main relay/optional parallel	RLY_MAIN	No
Spannungsversorgung 5V (DKG1,2)	A_U_DKG	5_14	supply voltage TPS	TPS_VCC	Yes
Ansteuerung 1 Drosselklappe	A_T_MDK1	5_15	throttle control out 1	MTC1	Yes
Ansteuerung 2 Drosselklappe	A_T_MDK2	5_16	throttle control out 2	MTC2	Yes
[Temperatur vor Drosselklappe] (Thermischer Ölniveausensor)/simaf_vorhalt	E_A_TVDK opt.	5_17	[temperature throttle inlet] (thermal oil sensor)/simaf_vorhalt	TTI	Yes
[Smart ACV] Schaltsaugrohr 2	A_T_ACV opt.	5_18	[smart ACV] variable intake manifold 2	VIM_2	not used
Klopfsensor 1B (Diff.- Signal)	E_A_KS1B	5_19	knock sensor 1B	KNKS_1_B	Yes
Klopfsensor 2B (Diff.- Signal)	E_A_KS2B	5_20	knock sensor 2B	KNKS_2_B	Yes
Abgastemperatur 1	E_A_THK1	5_21	Exhaust gas temperature 1	TEG_1 opt.	not used
Lokaler CAN-High	D_LOCANH	5_22	local CAN-High	LOCAN_H	No
Tankentllüftungsventil	A_T_TEV	5_23	canister purge solenoid	CPS	Yes
Soundklappe	A_S_ESK	5_24	sound flap	SF	No
Referenz 5V Heißfilmluftm. sens [Referenz für HFM_TL]	A_U_HFMREF_TL opt.	5_25	reference voltage MAFM [reference voltage MAFMTL]	MAFM_VCC	not used
Heißfilmluftmassenmesser [HFM vor Turbo]	E_A_HFM_TL	5_26	mass air flow meter [mass air flow turbo]	MAFM	not used

Masse Heißfilmluftmassenmesser [Masse HFM_TL]	M_HFM_TL	5_27	ground mass air flow meter [gnd mass air flow turbo]	GND	not used
Ansauglufttemperatur [Ansauglufttemperatur Turbolader]	E_A_TANS_TL	5_28	intake air temperature [temperature intake air turbo]	TIA	not used
Kurbelwelleng.- Signal	E_P_KWG	5_29	crankshaft position sensor	CRK	Yes
Masse Kurbelwellengeber	M_KWG	5_30	ground crankshaft position sensor	GND	Yes
Spannungsversorgung 5V (SDF) [PNDK]	A_U_PNDK	5_31	supply voltage MAP sensor [PT_OUT]	MAP_VCC	Yes
Masse Saugrohrdrucksensor [Masse P nach DK]	M_PNDK	5_32	ground manifold air pressure [gnd pressure throttle outlet]	GND	Yes
Saugrohrdifferenzdrucksensor [P nach DK]	E_A_PNDK	5_33	manifold air pressure [pressure throttle outlet]	MAP	Yes
Druck Kraftstoffpumpe / Kraftstoffniederdrucksensor	E_A_KDS	5_34	Fuel pressure fuelpump	FUPPU	No
Generatorschnittstelle	D_BSD	5_35	generator interface	BSD	No
Drosselklappengeber2	E_A_DKG2	5_36	throttle position sensor 2	TPS_2	Yes
Drosselklappengeber1	E_A_DKG1	5_37	throttle position sensor 1	TPS_1	Yes
Masse Drosselklappengeber	M_DKG	5_38	ground throttle position sensor	GND	Yes
(Ölpumpe) Drucksteuerventil	A_T_OLP opt.	5_39	(oil pump) preasure control valve	PCV opt.	jumper to 7-15
Schaltsaugrohr1 Reserve	A_T_RES12 opt.	5_40	variable intake manifold 1	VIM_1	not used
Klopfsensor 1A (Diff.- Signal)	E_A_KS1A	5_41	knock sensor 1A	KNKS_1_A	Yes
Klopfsensor 2A (Diff.- Signal)	E_A_KS2A	5_42	knock sensor 2A	KNKS_2_A	Yes
Masse Abgastemperatur 1	M_THK1 opt.	5_43	ground exhaust gas temperature 1	GND	not used
Local CAN_(low)	D_LOCANL	5_44	local CAN-Low	LOCAN_L	No
Einspritzventil Zylinder 1 - Common (Einspritzventil Zylinder 1 - Common)	A_P_EVZ1P	6_01	injection valve 0 - Common	IV_0P	Yes
Einspritzventil Zylinder 2 - Common (N.C.)	A_P_EVZ2P	6_02	injection valve 4 - Common	IV_4P	Yes
Einspritzventil Zylinder 3 - Common (Einspritzventil Zylinder 4 - Common)	A_P_EVZ3P	6_03	injection valve 2 - Common	IV_2P	Yes
Einspritzventil Zylinder 4 - Common (N.C.)	A_P_EVZ4P	6_04	injection valve 5 - Common	IV_5P	Yes
Einspritzventil Zylinder 5 - Common (Einspritzventil Zylinder 3 - Common)	A_P_EVZ5P	6_05	injection valve 1 - Common	IV_1P	Yes
Einspritzventil Zylinder 6 - Common (Einspritzventil Zylinder 2 - Common)	A_P_EVZ6P	6_06	injection valve 3 - Common	IV_3P	Yes
Einspritzventil Zylinder 1 (Einspritzventil Zylinder 1)	A_P_EVZ1M	6_07	injection valve 0	IV_0N	Yes
Einspritzventil Zylinder 2 (N.C.)	A_P_EVZ2M	6_08	injection valve 4	IV_4N	Yes
Einspritzventil Zylinder 3 (Einspritzventil Zylinder 4)	A_P_EVZ3M	6_09	injection valve 2	IV_2N	Yes
Einspritzventil Zylinder 4 (N.C.)	A_P_EVZ4M	6_10	injection valve 5	IV_5N	Yes
Einspritzventil Zylinder 5 (Einspritzventil Zylinder 3)	A_P_EVZ5M	6_11	injection valve 1	IV_1N	Yes
Einspritzventil Zylinder 6 (Einspritzventil Zylinder 2)	A_P_EVZ6M	6_12	injection valve 3	IV_3N	Yes
(HDP5)	NC opt.	7_01	(HDP5 pump)	NC	not used
Reserve (Spannung Öldrucksens)	A_U_OLD	7_02	supply POIL	POIL_VCC	not used
Öldruck [Öldruck vorhalt]	E_A_OLD	7_03	oil pressure	OILP	not used
NTC- Wasser (Motortemperatur)	E_A_TMOT	7_04	coolant temperature	TCO	Yes
VANOS Einlass	A_T_NWE	7_05	infinitely variable valve timing inlet	IVVT_IN	Yes
Reserve (Masse Öldrucksensor)	M_OLD	7_06	(ground oil press sens)	GND	not used
Reserve [Wastegate1]	A_T_WG1	7_07	[wastegate 1]	RES_OUT_5opt.	No
Masse Raildruckfühler	M_RDF	7_08	ground fuel rail pressure	GND	Yes
Raildruckfühler	E_A_RDF	7_09	Fuel rail pressure	FUP	Yes
Spannungsversorgung 5V (RDF)	A_U_RDF	7_10	supply voltage FUP sensor	FUP_VCC	Yes
NWG.-Sign. (Einlaß)	E_P_NWGE	7_11	camshaft position sensor inlet	CAM_IN	Yes
NWG.-Sign. (Auslaß)	E_P_NWGA	7_12	camshaft position sensor exhaust	CAM_EX	Yes
Öldruck	E_S_OLD opt.	7_13	oil pressure	POIL	No
Reserve [Wastegate 2]	A_T_WG2	7_14	[wastegate 2]	RES_OUT_opt.8	No
(Ölpumpe) Drucksteuerventil opt.	A_T_OLP	7_15	(oil pump) pressure control valve opt.	PCV	No
Appl. CAN_(high)	D_APPLI_CANH	7_16	application CAN-High	CAN_AH	No
Masse Motortemperaturfühler	M_TMOT	7_17	ground coolant temperature sensor	GND	Yes
Vanos Auslass	A_T_NWA	7_18	infinitely variable valve timing exhaust	IVVT_EX	Yes

Elektr. Geregeltes Thermostat	A_S_KFK	7_19	el. controlled thermostat	ECT	Yes
Appl. CAN_(low)	D_APPLI_CANL	7_20	application CAN-Low	CAN_AL	No
Reserve	A_U_RES2	7_21			not used
Kubelgehäuselüf. H	A_S_BBH	7_22	Blow by Heater	BBH	No
Reserve [Masse Lambdasonde 3] (Masse Bremsdrucksensor)	M_RES2	7_23	[ground lambda sensor downstream 3] (ground vacuum sens)	GND	not used
Masse Nockenwellengeber Einlaß	M_NWGE	7_24	ground camshaft position sensor inlet	GND	Yes
Masse Nockenwellengeber Auslaß	M_NWGA	7_25	ground camshaft position sensor exhaust	GND	Yes
Generatorschnittstelle	D_BSD	7_26	generator interface	BSD	No

1.16 Location of the Data Link Connector

1.16.1 Location of the Data Link Connector for following models:

335i, 335xi, 335Ci, 335Cxi, 335Ci Conv., 135is, 135is Conv.

Figure: Position DLC for **3 series** and **1 series** models and closed cover

The DLC is located at the lower left A-pillar and under a cover. This cover has the letters OBD on it.

1.16.2 Location of the Data Link Connector for following models:

535i, 535xi, 535iT, 535xiT

Figure: Position DLC for **5 series** models and closed cover

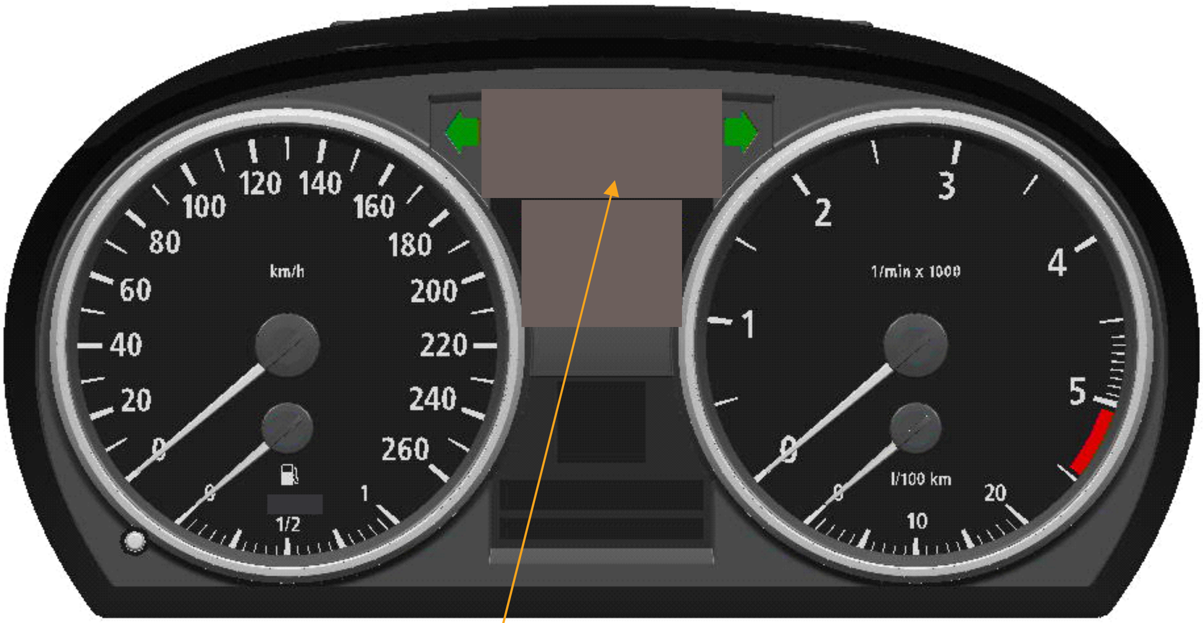
The DLC is located at the lower left A-pillar and under a cover. This cover has the letters OBD on it.

1.17 Drawing and Location of the Malfunction Indicator Light

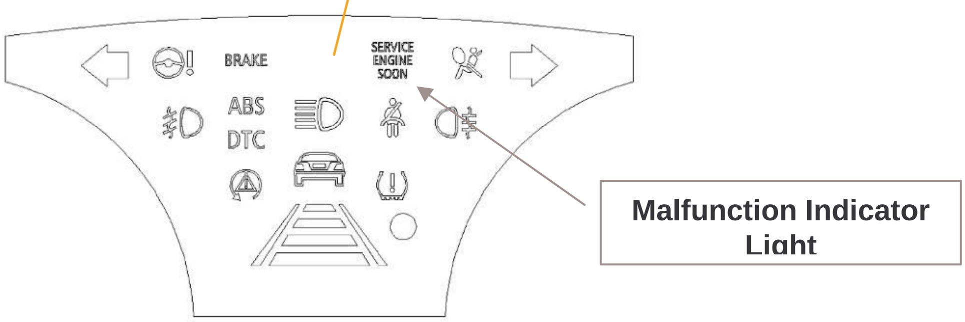
1.17.1 Drawing and Location of the Malfunction Indicator Light for following models:

335i, 335xi, 335Ci, 335Cxi, 335Ci Conv., 135is, 135is Conv.

Complete Instrument panel (European Version)

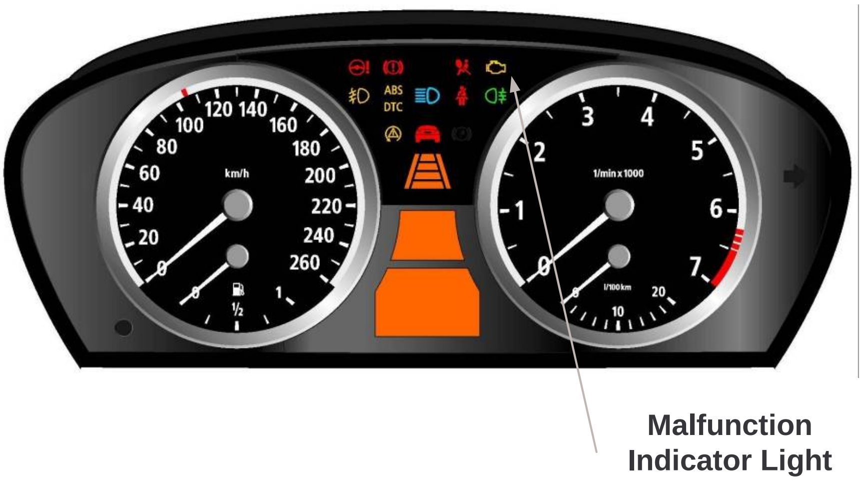


Detail (US Version)



1.17.2 Drawing and Location of the Malfunction Indicator Light for following models:

535i, 535xi, 535iT, 535xiT



1.18 Calculated load and fuel trim determination

The calculated engine load "LOAD_CLC [%]" is based on the calculated mass air flow Speed Density-System – The Air Mass Flow for a suction stroke is a function of the intake system manifold pressure and the air temperature

Strategy:

A 2-dimensional map is used to interpolate the calculated engine load "LOAD_CLC [%]" depending on calculated mass air flow and engine speed. A weighting factor is applied to compensate the altitude influence.

The calculation is performed as follows:

LOAD_CLC [%] = LOAD_CLC_RAW
f (calculated mass air flow, engine speed) x (101.3 kPa / ambient pressure) x 100%

with:

LOAD_CLC	calculated engine load in % with altitude correction
LOAD_CLC_RAW	calculated engine load in % without altitude correction