Issued: 09/20/05

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OBD System Description of Siemens VDO ECU MS45

Siemens VDO ECU MS45 is used for following Test Groups:

6BMXV03.0SMG (ULEV): 330Ci SMG, 330Cic SMG
6BMXT03.0E83 (LEV LDT2): X3 2.5, X3 3.0 MT
6BMXV02.5M56 (SULEV): 325CiA
6BMXB03.0UL2 (ULEV II): 325Ci, 325Cic, 330Ci, 330Cic, X3 3.0A

9.1. Catalyst Monitoring

9.1.1. Diagnosis Overview

The ECM tests the catalyst system during steady state driving by cycling the fueling LEAN and then RICH for a calibrated number of cycles while monitoring the oxygen storage capacity (OSC). Prior to the Catalyst test the canister purge valve is completely closed or completely opened with low canister purge value. This is to eliminate the influence of canister vapors on the downstream sensor during the test.

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 OSC is based on the integrated (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.

9.1.2. Monitoring Function

Catalyst monitoring is based on the monitoring of the oxygen storage capability by comparing the signals of the O2 sensor upstream and downstream the catalyst.

The engine control results in regular lambda oscillations of the exhaust gas. These oscillations are damped by the storage activity of the catalyst. The amplitude of the remaining lambda oscillations downstream the catalyst indicates the oxygen storage capability.

If all monitoring conditions are fulfilled, then a special defined A/F-modulation will be done. The relation of the deviations between the current downstream-sensor-signal to the average value of the downstream-sensor-signal is a sign for catalyst condition. The catalyst system is considered malfunctioning, if after a specified number of monitoring cycles the average of the ratios exceeds a threshold. The corresponding fault code is stored.

9.2. Prem Air – Sensor

Only used for Test Group: **6BMXV02.5M56 (SULEV)**

9.2.1. Environmental air catalyst diagnosis overview

EAC stands for Environmental Air Catalyst,
EACD for Environmental Air Catalyst Diagnosis.
The diagnosis evaluates the measured temperature from the EAC-sensor.
A characteristic behavior is expected, depending on the driving situation.
Therefore 3 driving situations are detected.

- CDN_1 means accelerating under "average city conditions"
  or
- CDN_2 means conditions after idle-speed phase
  or
- CDN_3 means conditions after driving followed by an idle-speed phase.
  (This Monitor completes on every FTP Cycle)

The number of active conditions (CDN_x) increases the counter (CTR_TCC_EAC).

Another counter (CTR_FRC_EAC) counts the number of events, when the expected
Prem-air sensor temperature behavior for the respective CDN_x is reached.

To detect a working system (no error) it is checked, that for a certain number of
detected active conditions (CTR_TCC_EAC) an accordingly number of good events
(CTR_FRC) has been counted; otherwise the system is detected malfunctioning
(error detect, MIL on)

9.2.2. Driving Condition 1 – average city condition

To start the driving condition 1 check
the Manifold Air Flow must increase more than a calibrated threshold, within a calibrated time.

After condition 1 has been met,
the following conditions must be fulfilled:

Vehicle speed < [km/h] threshold
Engine speed > threshold
Manifold air flow increase > threshold
within a calibrated time
Engine speed increase > threshold
within a calibrated time.

If the conditions above are fulfilled, the driving condition 1 (average city condition) is enabled for C_T_MIN_EAC_CDN_1_1 a calibrated time.

9.2.3. Driving Condition 2 – after idle

Engine status was in idle for > calibrated time.
Manifold air flow increase > threshold
for a calibrated time.
Engine speed increase > threshold
for a calibrated time.
Driving Condition 2 is enabled for 2 a calibrated time.

9.2.4. Driving Condition3 – after high-speed

Detection of vehicle high-speed
Vehicle speed > km/h threshold
Ambient temperature < threshold
Manifold air flow integral > threshold

After leaving the high-speed condition,
the engine speed must go to idle state, with the vehicle speed < C_VS_MAX_EAC_IS km/h threshold,
these conditions must be reached within C_T_MAX_EAC_CDN_3 a calibrated time limit.
The condition CDN3 is enabled for a calibrated time.

9.3. Misfire Monitoring

9.3.1. 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 ignition events, which is a measure for the mean value of the speed of this angular segment. This means, a change of the engine torque results in a change of the engine speed.
It is also an influence of the load torque. This means, the influences of different road surface, e. g. pavement, pot holes 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.

Sensor wheel adaptation:
Within a defined engine speed range and during fuel cut-off, the adaptation of the sensor wheel tolerances, instead of the misfire detection, is carried out.
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.

9.3.2. Statistics, Fault processing:

Emission Limit: (e) (3.2.2)

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: (e) (3.2.1)

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 are 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 not cut-off (Per customer request)
4. No downstream fuel trim.

All misfire counters are reset after each interval.

9.4. EVAP-System Leak Diagnostic (DM-TL)

9.4.1. Evaporative System Leak Measurement

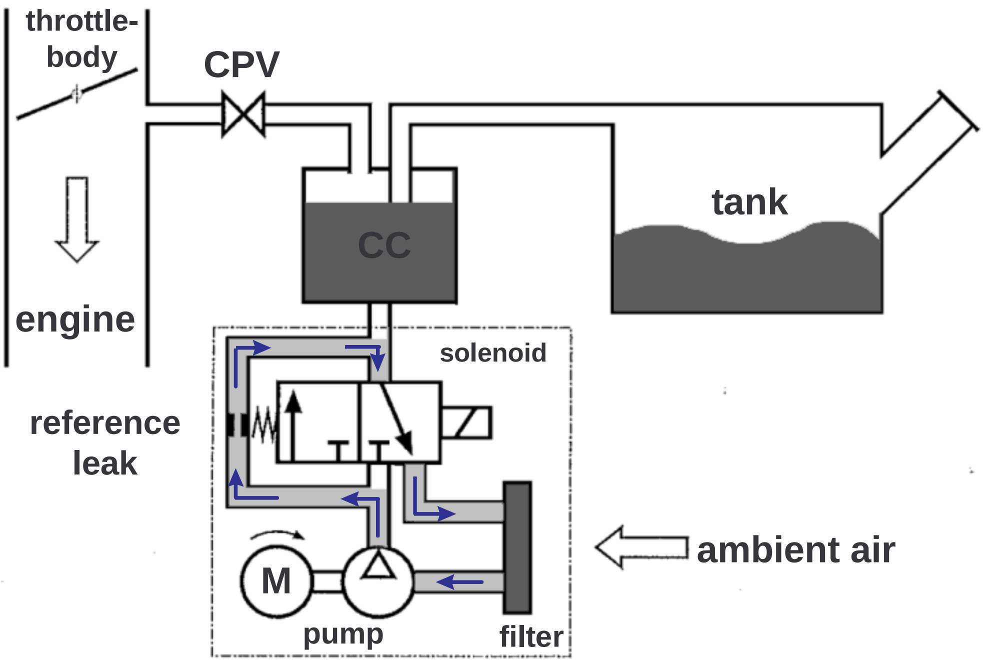
9.4.1.1. General Description of Leak Measurement

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 **D**iagnostic **M**odule-**T**ank **L**eakage (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:

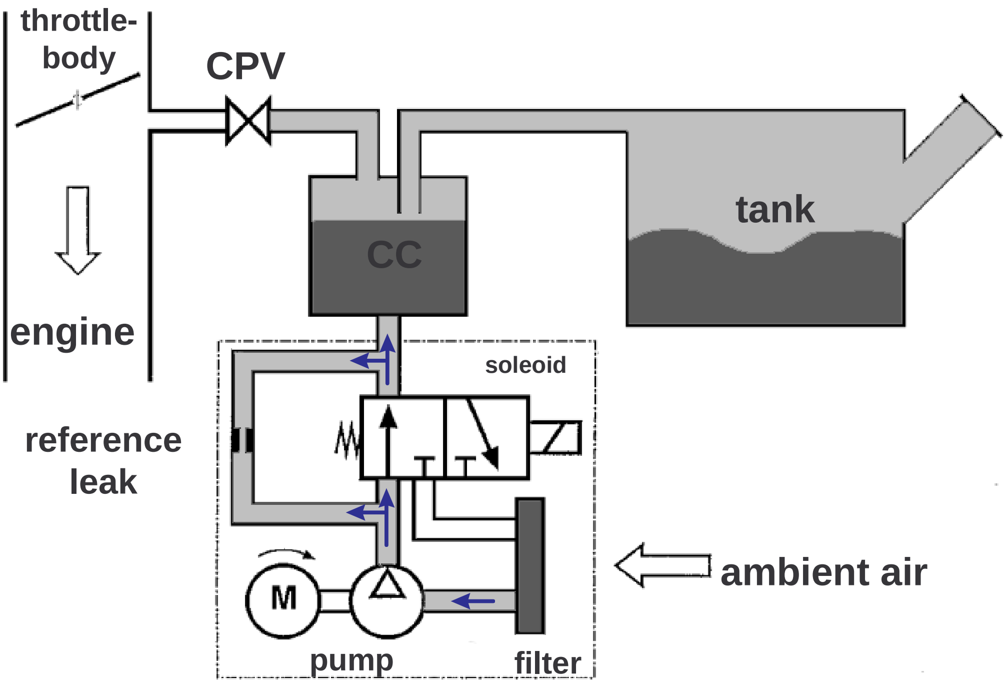
a) During the Reference Leak Measurement, the electrical actuated pump delivers through the reference restriction.

The engine-management system measures the pump's electrical current consumption in this section.



1) Figure EVAP chapter a)

b) During the Leak Measurement, the electrical 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 a measure for the leakage in the tank.



2) Figure EVAP chapter b)

0.02 inch diagnosis:

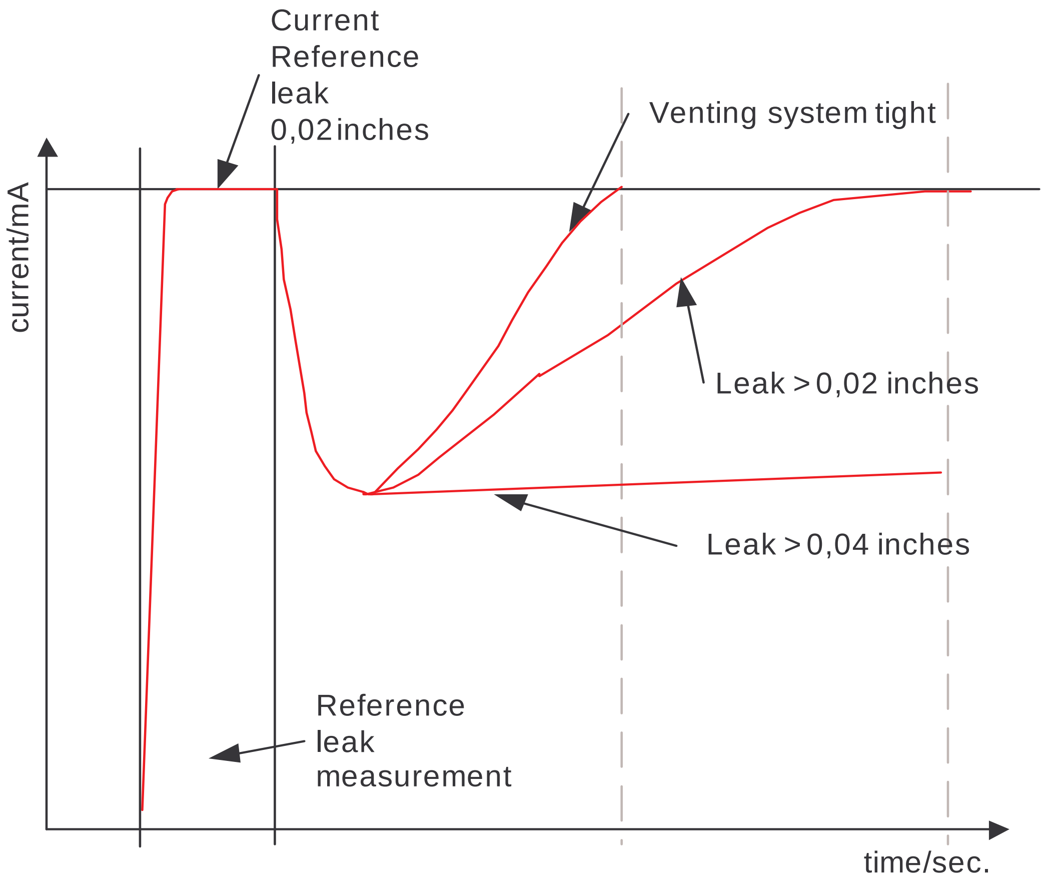
The first step of the diagnosis is the reference measurement - the result of the pump reference current is stored (picture in chapter a: " EVAP chapter a) ").
After the solenoid switches, the venting system is pressurized
(picture in chapter b: " EVAP chapter b) ").
In the rough leak measurement the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

0.04 inch diagnosis:

The first step of the diagnosis is also the reference measurement - the result of the pump reference is stored (picture in chapter a EVAP chapter a)).
After the solenoid switches, the venting system is pressurized
(picture in chapter b: " EVAP chapter b) ").
In the rough leak phase (time) the pump current must reach the rough leak threshold 1 (rough 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 rough leak threshold 1 is not reached in the rough leak time, the rough leak threshold 2 must be reached in an additional time (rough leak threshold 2 = idle 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 rough leak threshold 2 is also not reached, a leak > 0.04 inches is detected.

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

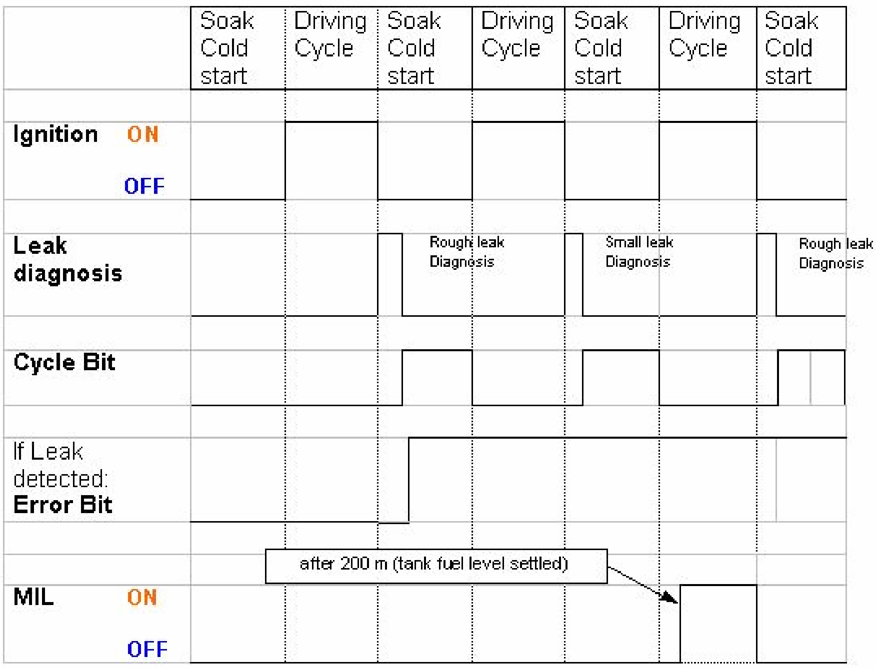


3) Figure EVAP: typical current

c) After this test the remaining pressure in the Evaporative System is bled off through the charcoal canister by switching off the pump and solenoid.

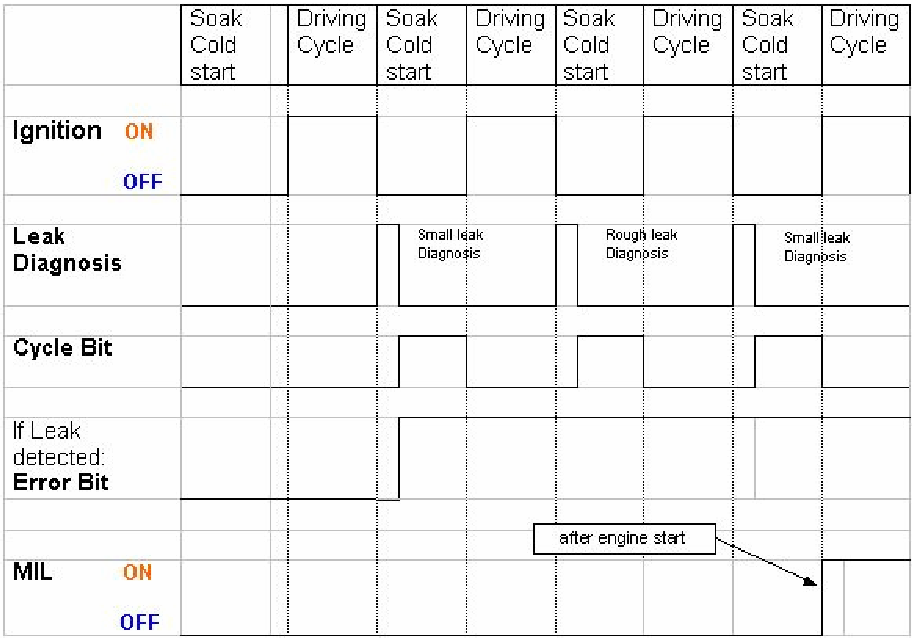
9.4.1.2. Diagnosis Frequency and MIL illumination

9.4.1.2.1. Diagnosis Frequency and MIL illum.: Leak > 0.04 inch



4) Figure EVAP

9.4.1.2.2. Diagnosis Frequency and MIL illum.: Leak > 0.02 inch



5) Figure EVAP

9.4.2. EVAP (Functional check canister purge solenoid)

9.4.2.1. Monitoring the canister purge solenoid:

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

Step 1: based on the activated charcoal filter (ACF) load degree
Step 2: based on
the engine speed change at idle speed, and
the deviation of lambda-controller
Step 3: based on the difference between the measured air mass-flow before
and during a CPS opening

9.4.2.2. Monitoring function

The first check of the CPS is based on the ACF- load degree. The "Canister Load diagnosis" is calculated permanently until the complete check CPS is finished.

During the next check, the CPS is evaluated based on the engine speed change at idle speed. To this effect, the CPS is opened for a short time and the engine speed monitored for a certain period.

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

During this check the lambda deviation will also be checked.

In step 3 the CPS is considered on the basis of the measured mass air flow before and during a CPS opening phase.

If the CPS is detected to be not OK after all three checks have been passed (end of step 4), then the error is set.

9.5. Fuel Level Sensor

The diagnosis of the fuel level sensor signal, which is received via CAN bus, consists of a CAN signal check and a plausibility check.

9.5.1. Fuel Level Sensor circuit continuity check

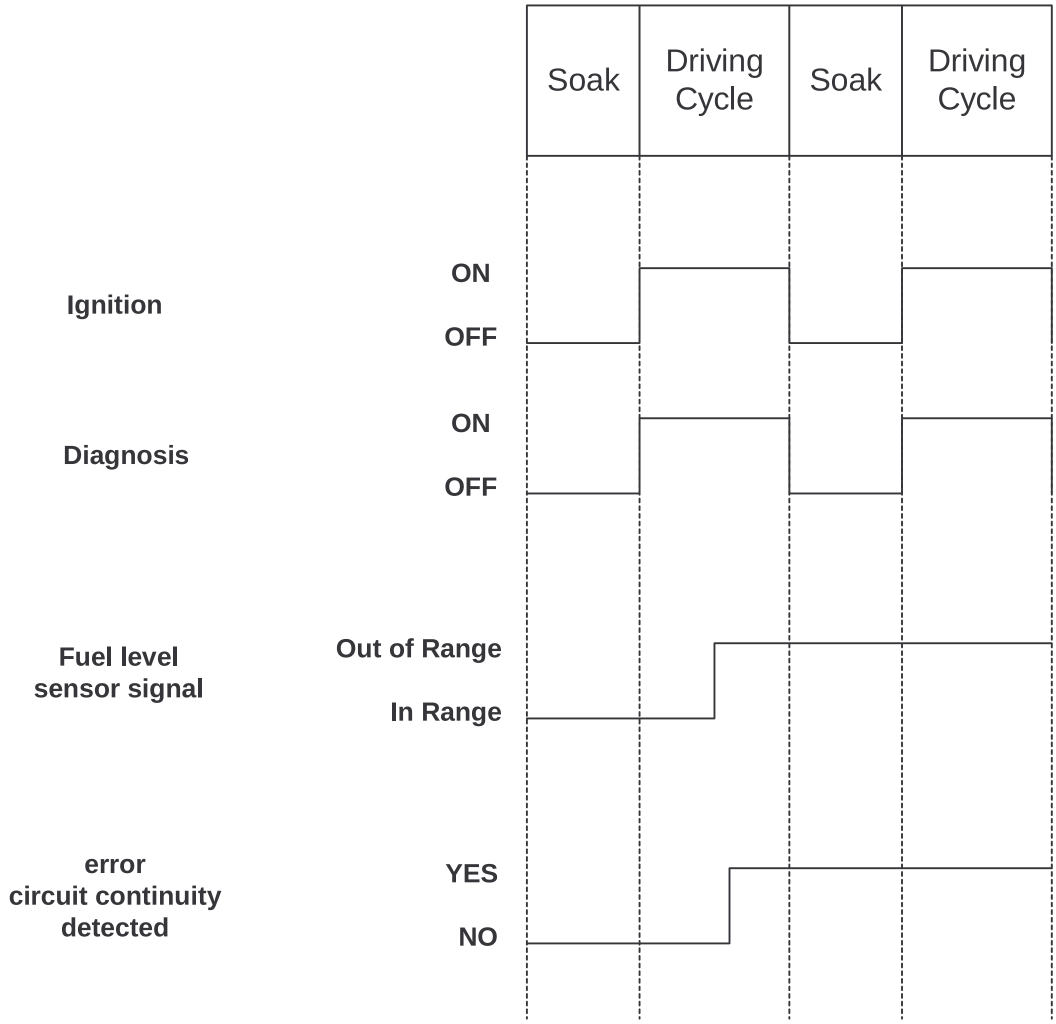
The signal of the fuel level sensor is monitored concerning the valid range. This range depends on the used fuel level sensor.
If the fuel level sensor signal is out of the valid range, an electrical malfunction (short circuit to ground or interruption) is detected and an appropriate fault code is set.

9.5.2. Fuel Level Sensor signal rationality check (plausibility error)

The engine management system of every BMW has the capability to calculate fuel consumption. For the fuel level sensor plausibility check, this calculated consumption is compared with the difference of the fuel level signal. When the calculated fuel consumption reaches an appropriate and predetermined amount (for example five gallons), the calculated fuel consumption is compared to the change in fuel level as indicated by the fuel level sensors. If the difference is greater than the applicable threshold value, a stuck fuel level sensor fault is detected and an appropriate fault code is set.

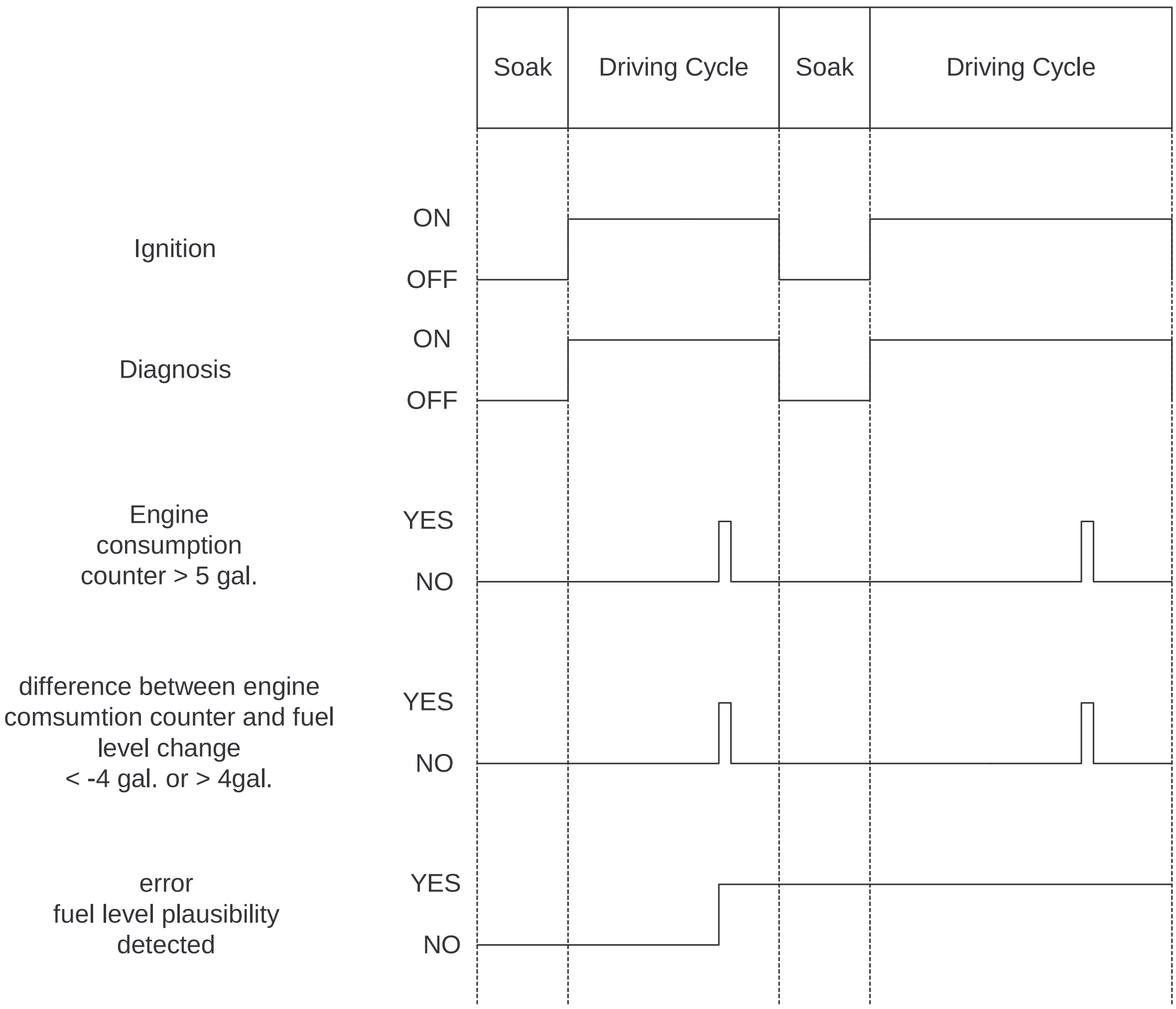
If a fault is present, the OBD II EVAP leak monitor will run using a substitute value of 85% total fuel tank volume.
The 85% substitute value will assure that in every case the required 0.020 inch leak is detected by the OBD II system.

9.5.3. FLS diagnosis frequency FLS circuit continuity check



6) Figure continuity check

9.5.4. FLS diagnosis frequency
FLS signal rationality check (plausibility error)



7) Figure FLS diagnosis

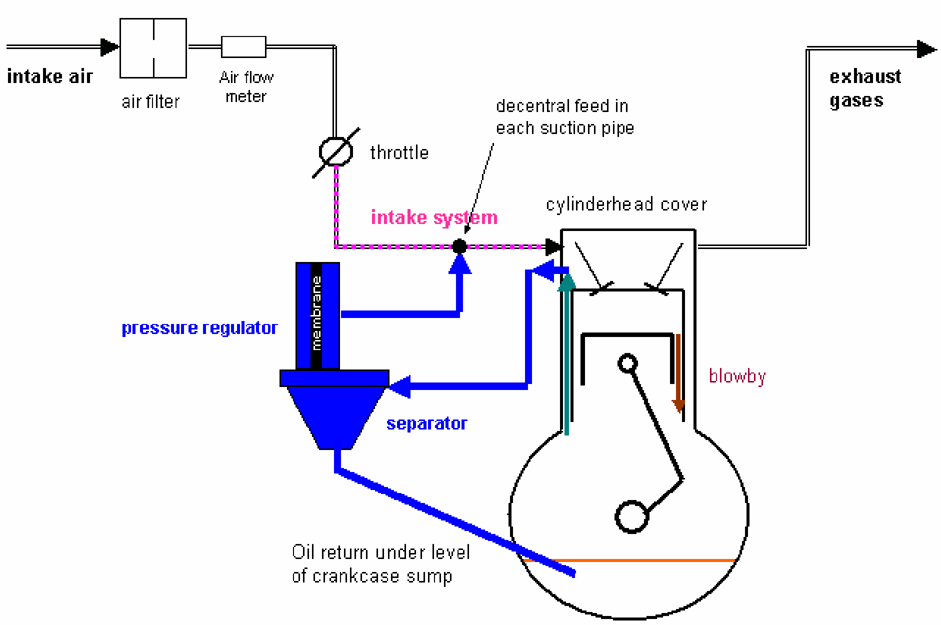
9.6. Positive Crankcase Ventilation (PCV) System

9.6.1. General description of the PCV-System:

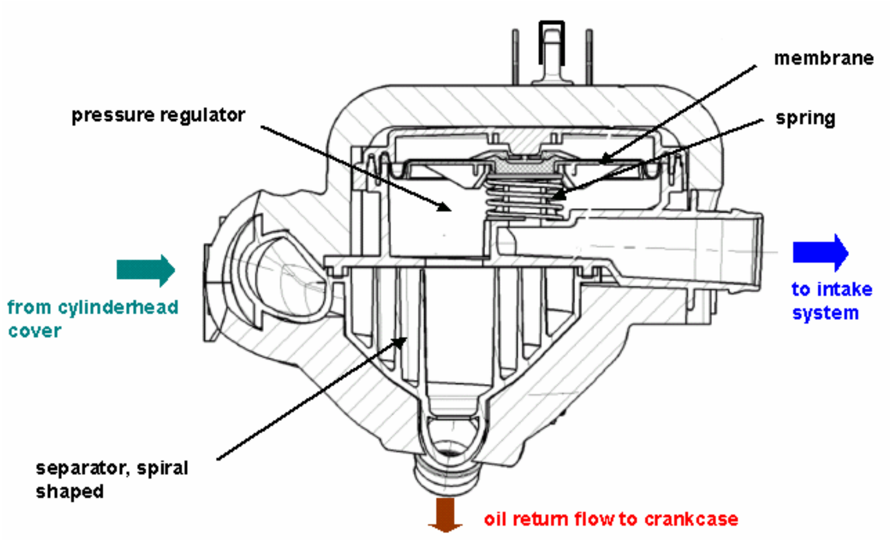
There are 3 tubes connected to the engine: The first of them conducts the blow by gases from the cylinder head cover to the separator, where the oil is separated from the air and lead back by a second tube to the crankcase sump.
A third tube directs the cleaned blow by gases via the intake system to the combustion. The pressure regulator makes sure that the high vacuum level between crankcase and ambient air will be reduced if needed.

9.6.2. Diagnosis of a leakage in the PCV-System:

A disconnection or leakage in the PCV-System is indicated by a rough or stalling engine and results in a reaction within the fuel system (fuel trim deviation).
In this case a fault code will be stored by the fuel system monitoring.



8) Figure PCV- system



9) Figure PCV - system

9.7. Secondary Air System diagnosis

9.7.1. Secondary Air System diagnosis (based on binary – lambda sensor) for Test Group 6BMXT03.0E83

9.7.1.1. Diagnosis Overview / Monitoring Function:

The diagnosis is used to check if the minimum secondary air flow is available to warm up the catalyst, thus a damaged pump or a blocked valve or a lost tube can be detected.

The test consists of three steps (step 2 cannot be performed in ECU Siemens MS 45):

Step 1:

After the operative – readiness of the lambda-sensors it is checked if the mixture is in a lean range for a certain time. The diagnosis and secondary-air operation can be interrupted sometimes in high engine speed or engine-load ranges because the rate of secondary air flow is then to low for catalyst heating and diagnosis.

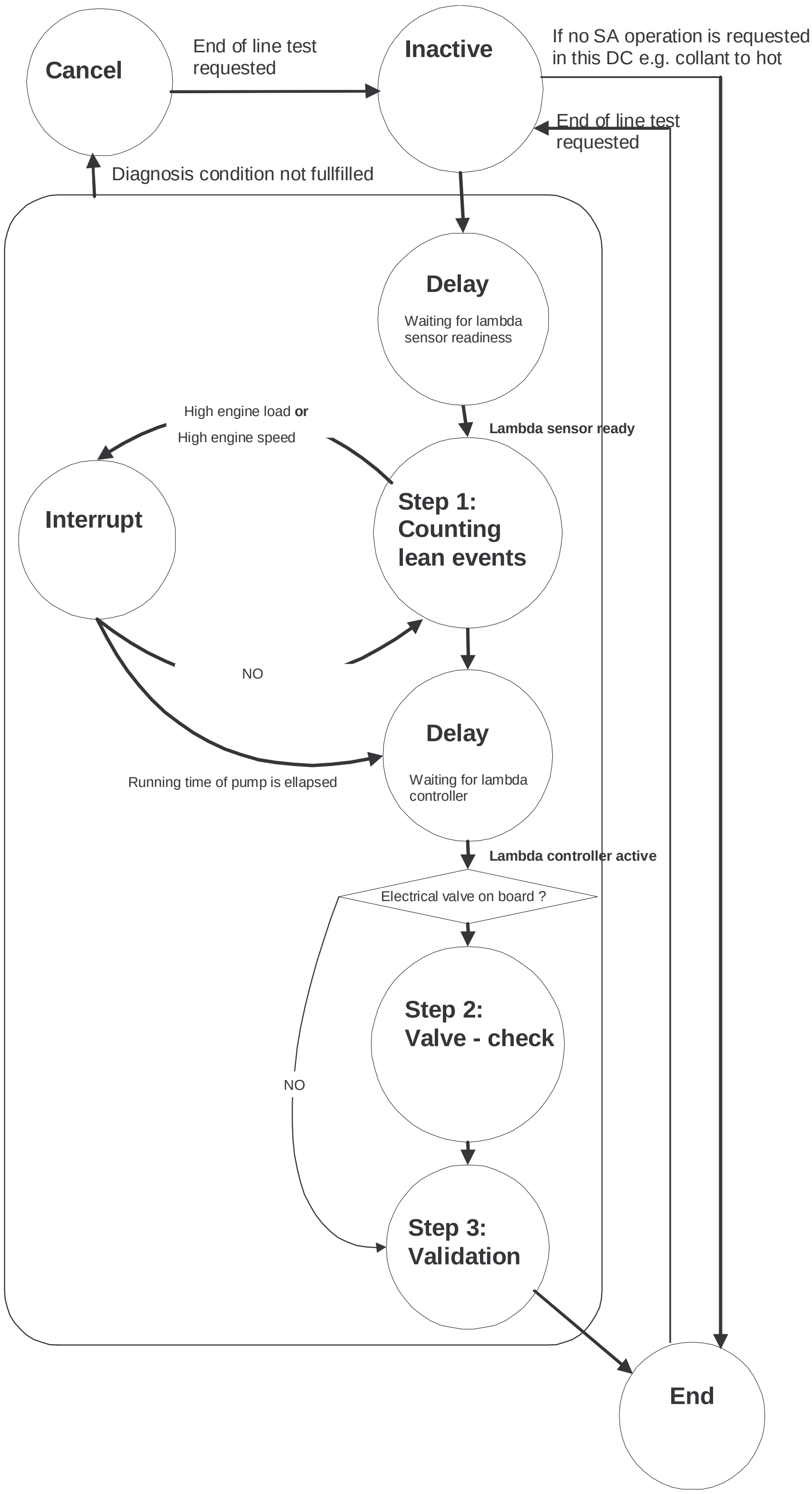
Step 2:

Valve - check (deactivated at ECU Siemens MS 45 because only applicable for electrical valves).

Step 3:

after the secondary air function is finished the result of step 1 must be validated. Due to the lambda controller it is checked if the mixture is in a "normal" lambda-range (not lean) to ensure the car has no lean-problem.

9.7.1.2. Overview:



10) Figure Secondary Air System overview

9.7.2. Secondary – Air – System diagnosis (based on secondary–air–flow meter) for Test Groups:

6BMXV03.0SMG
6BMXB03.0UL2
6BMXV02.5M56

9.7.2.1. Diagnosis Overview / Monitoring Function:

The diagnosis is used to check if the minimum secondary air flow is available to warm up the catalyst, thus a damaged pump or a blocked valve or a lost tube can be detected.

The test consists of five steps for Siemens ECU MS 45:

Step 1 (Heating delay)
The diagnosis will be started after a delay time, heating time of secondary-air-flow meter = SAFM, approx: 200ms (Bubble 1)

Step 2 (Sensor signal plausibility)
Before the main diagnosis is started it is checked if the SAFM signal is plausible. If the signal is not plausible the diagnosis is aborted. The minimum and maximum value of SAFM-signal will be determined during the SA operation:

- If the difference of maximum and minimum value is equal to 0 then the SAFM-signal is stuck (Bubble 2.1).
- If the SAFM-signal does not exceed a absolute threshold during a certain time or is 0 then there is a open load or short circuit (Bubble 2.2).

Step 3 (Component monitoring)

During the start of secondary air pump (SAP) and opened secondary air valve (SAV) the signal of secondary air mass flow meter (SAFM) can be used for the detection of a blocked SA-tube / SA-valve or damaged SA-pump.

- If the SAFM-signal is very low and the difference between the maximum and the minimum value of SAFM signal is low then the SA-tube or the SA-valve is blocked
  The measured signal of the SAFM are the pulsations of the SA-pump (Bubble 3.1).

- If the SAFM-signal is very low and the difference between the maximum and the minimum value of SAFM signal is high then the SA-valve is open but the SA-pump is not blowing => The measured signal of the SAFM are the pulsations of the Exhaust-gas (Bubble 3.2).

Step 4 (Flow monitoring)

This part of diagnosis considers the detection of leaky SA-system or an error in the secondary air flow, thus a minimum secondary air mass flow should be guaranteed. The measured SAFM-signal is compared to a modeled flow value

If the signal is to low for a certain monitoring time (integration of signal = flow) then the minimum air mass flow to warm up the catalyst can not be ensured (Bubble 4.1).

If the signal is to high for a certain monitoring time (integration of signal = flow) then a leaky SA – system can be assumed (Bubble 4.2).

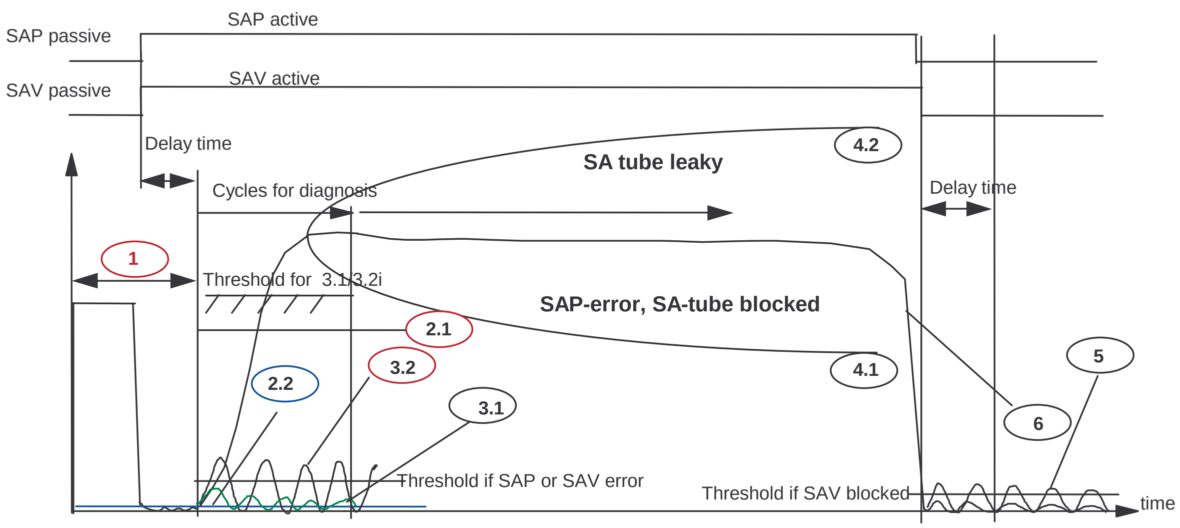
Step 5 (Detection of open blocked valve after SA operation)

At the end of secondary air function it is possible, that the SAV is blocked in open position due to contamination. For this reason (lambda-control starts after the secondary air function) it is necessary to check the function of SAV after a delay time.

At high engine load (in order to get exhaust pulsations) a difference value between the minimum and the maximum SAFM-signal will be compared with a threshold.

If the SAFM-signal is over a threshold and the difference between the maximum and the minimum value of SAFM signal is high then the SA-valve is still open => The measured signal of the SAFM are the pulsations of the Exhaust-gas (Bubble 5).

9.7.2.2. Overview:



1) Delay time to heat the sensor		
2.1) Stuck signal	or	2.2) No or low signal => Open load or short circuit
3.1) SA – tube / SA – valve blocked	or	3.2) SA – pump error
4.1) SA – flow to low => Blocked system	or	4.2) SA – flow to high => Leaky system
5) SAV blocked => Pulsations of exhaust gas		
6) No error		

11) Figure Secondary Air System – air flow meter

9.8. Ambient Temperature Monitoring

9.8.1. CAN based Ambient Temperature – signal diagnosis

9.8.1.1. General Description

The purpose of this diagnosis is to detect electrical faults as defined in OBDII requirements. The input signal is analog from CAN. If an error is present on CAN signal, an error symptom is set and an error counter is debounced.

9.8.1.2. Error Symptom

Signal error

9.8.2. Ambient Temperature Signal Plausibility Check

9.8.2.1. 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 temperature-difference to oil temperature exceeds the threshold for a anti-bounce time.

The error validation is only performed if all electrical diagnosis 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.

9.8.2.2. Error Symptoms

Ambient temperature not plausible

9.8.2.3. Input parameters for monitoring

- ECT
- radiator outlet temperature
- engine state
- engine stop time
- ambient temperature after engine stop (last driving cycle)
- ambient temperature at start
- actual ambient temperature
- vehicle speed
- engine run time after start

9.9. Fuel System Monitoring

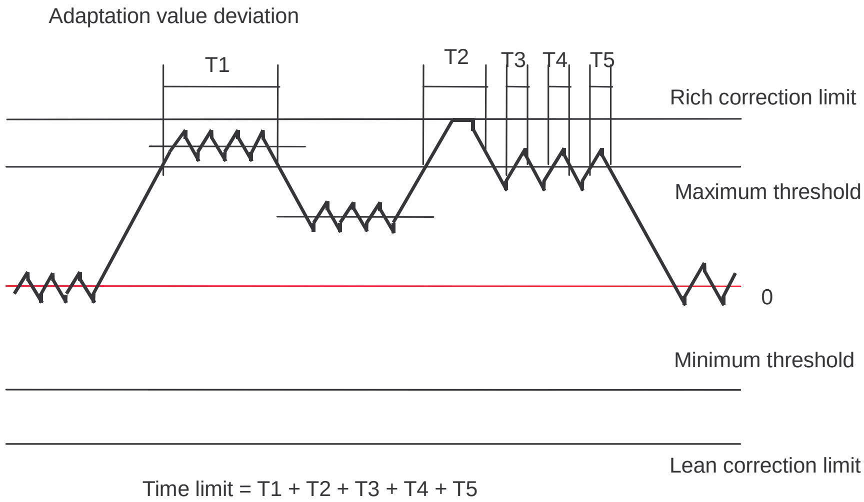
9.9.1. Diagnosis Overview / Monitoring Function:

The ECM monitors the fuel system control continuously during all engine states except PUC (decel fuel cut-off). After the enable conditions are met, a counter is started. At this point the ECM evaluates the total percentage of short and long term fuel control. If no condition is present the end diagnostic counter will decrement from a calibrated value to zero and a passing decision is made.

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

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

The time counter is increased while " lambda controller + lambda adaptation" exceed minimum or maximum threshold.
The error is detected as soon as the time counter reaches its maximum value.



12) Figure Fuel System Monitoring

9.9.1.1. Similar Conditions Function

When the engine management system recognizes a failure in the misfire or fuel systems, the engine management system is required to record the conditions present when the fault occurred. These conditions recorded include engine speed, engine load (MAF), and warm up status of the first event that resulted in the storage of a code. These conditions stored are referred to as similar **conditions**

Once the similar conditions are meant without a failure in the misfire or fuel system, the flag is set to 1. Once this flag is set, the driving cycle counter for that failure can be decremented.

The code and stored freeze frame conditions may be erased, if similar conditions are not encountered during the next 80 driving cycles immediately following the initial detection of the malfunction.

The MIL may be extinguished after three sequential driving cycles in which similar conditions have been encountered without exceeding the fuel system diagnostic thresholds.

9.9.2. Trim Control Plausibility Monitoring

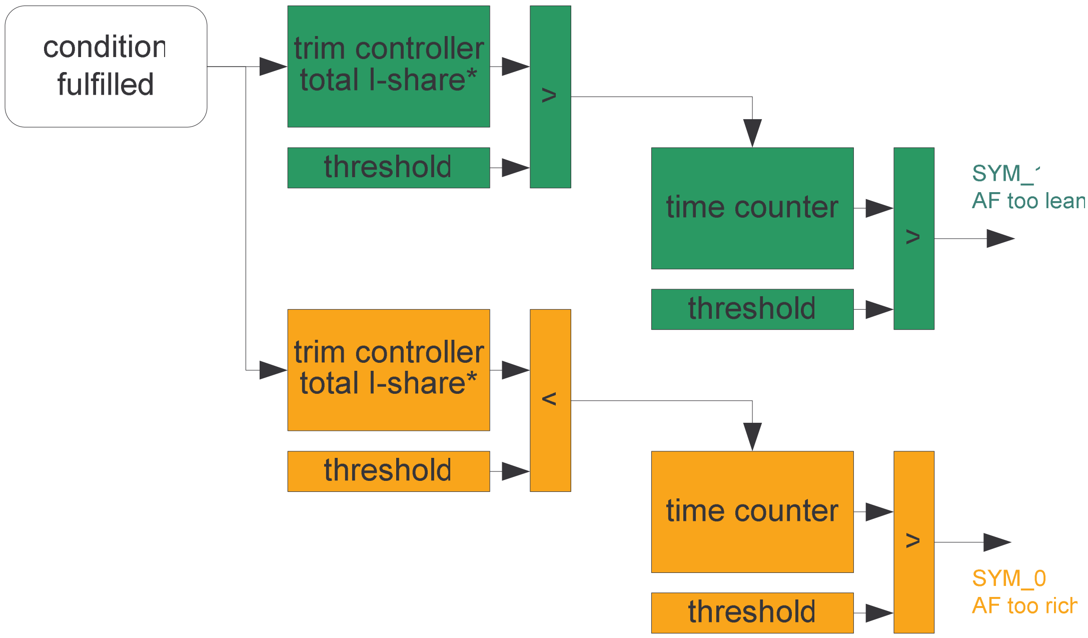
9.9.2.1. Monitoring function:

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

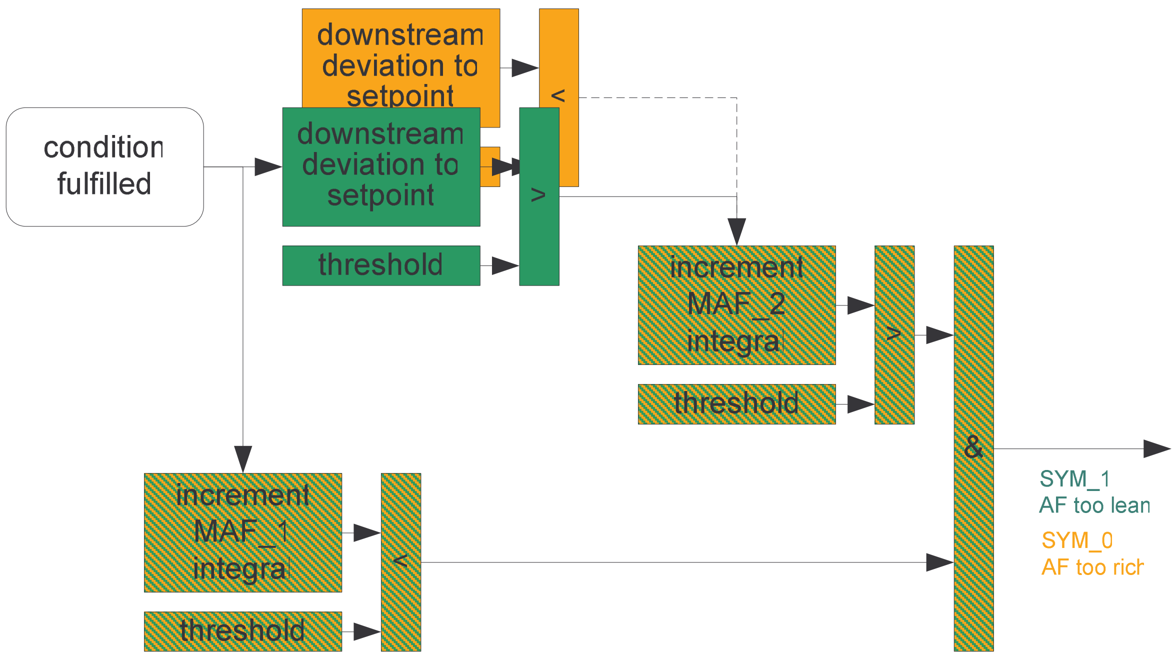
If the above mentioned malfunction is detected, the corresponding fault code is stored.

9.9.2.2. Dynamic Fuel Trim Diagnosis- Monitoring Trim Controller I-Share



13) Figure Dynamic Fuel Trim Monitoring - I-Share

9.9.2.3. Dynamic Fuel Trim Diagnosis - Monitoring of Trim Controller Deviation



14) Figure Dynamic Fuel Trim – Controller Deviation

9.10. Oxygen Sensor Monitoring linear upstream / binary downstream

For Test Groups
6BMXV03.0SMG
6BMXB03.0UL2
6BMXV02.5M56

9.10.1. Upstream Oxygen Sensor Monitoring (linear):

9.10.1.1. Oxygen Sensor Monitoring - Short Circuit

9.10.1.1.1. 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
- Short circuit of sensor signal to ECM ground

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

9.10.1.2. Oxygen Sensor Monitoring - Open Circuit

9.10.1.2.1. 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)	P2626	P2629
• - Virtual Ground Failure – (VG)	P2237	P2240
• - Pumping Current Failure – (IP)	P2243	P2247
• - Trim Current Failure – (IA)	P2251	P2254

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

9.10.1.2.2. 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 WRAF Sensor.

This function shall be triggered only if one of the following diagnosis is active (to set the readiness bit), which are Plausibility Check, Plausibility during fuel cutoff, and Sensor Heater OBD2. The function shall go to the state = “active” only if one of the above diagnosis debounced a fault. In this state, if a heater OBD2 error exists, the WRAF sensor controller oscillator used to measure the sensor internal resistance shall be disabled in order to allow a stable plausibility error detection. After the deactivation of this function the oscillator shall be enabled.

During the diagnosis state “active” a timer shall run waiting for OBD2 heater monitor to complete. If a heater OBD2 error could be detected, the timer should be stopped and a symptom set, otherwise it should run until it reaches the max value.

(Reference Voltage)

If a heater error and a plausibility error (symptom “sensor too rich/lean”) or an open circuit error in the line Reference Voltage exists.

(Virtual Ground)

An open circuit in line Virtual Ground can be detected if a heater OBD2 fault is present and the sensor is not active anymore, i.e. its signal stuck near lambda 1. The sensor non-activity can be detected by anyone of the following diagnosis: plausibility (symptom is “sensor not active”), or plausibility during PUC (symptom signal too low).

(Pumping Current)

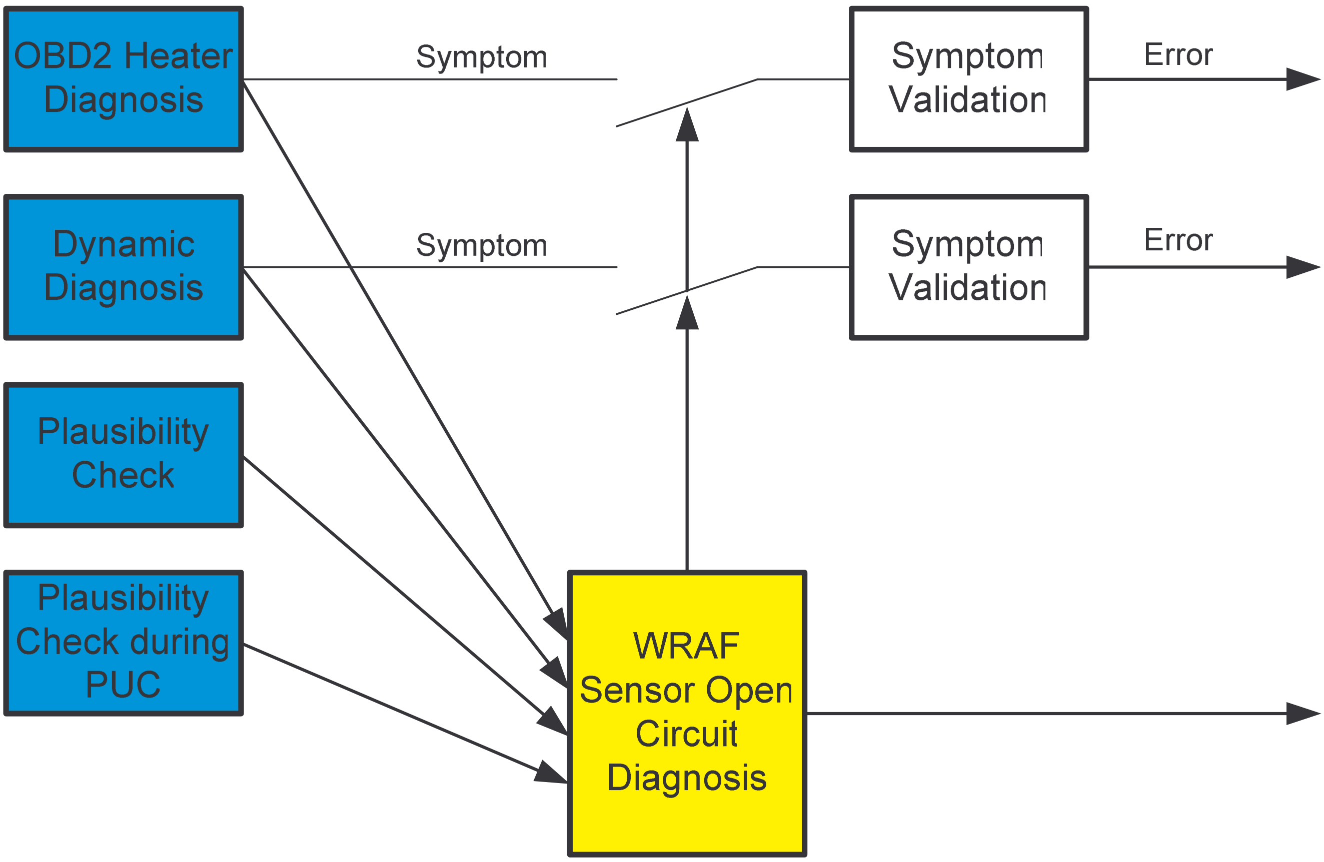
If the delayed diagnosis timer expired, it is assumed that no heater OBD2 fault exists. A plausibility (symptom is “sensor not active”), or plausibility during PUC (symptom signal too low) indicates that an Open circuit in the line Pumping Current occurred.

(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 cutoff phase shall detect this symptom and an Open Circuit is assigned to the line Trim Current.

9.10.1.2.3. Oxygen Sensor Diagnosis Manager

Failure entry only if no open circuit error was detected.



15) Figure Oxygen Sensor Monitoring - Open Circuit

9.10.1.3. WRAF Sensor Controller Monitoring

9.10.1.3.1. Diagnosis Overview:

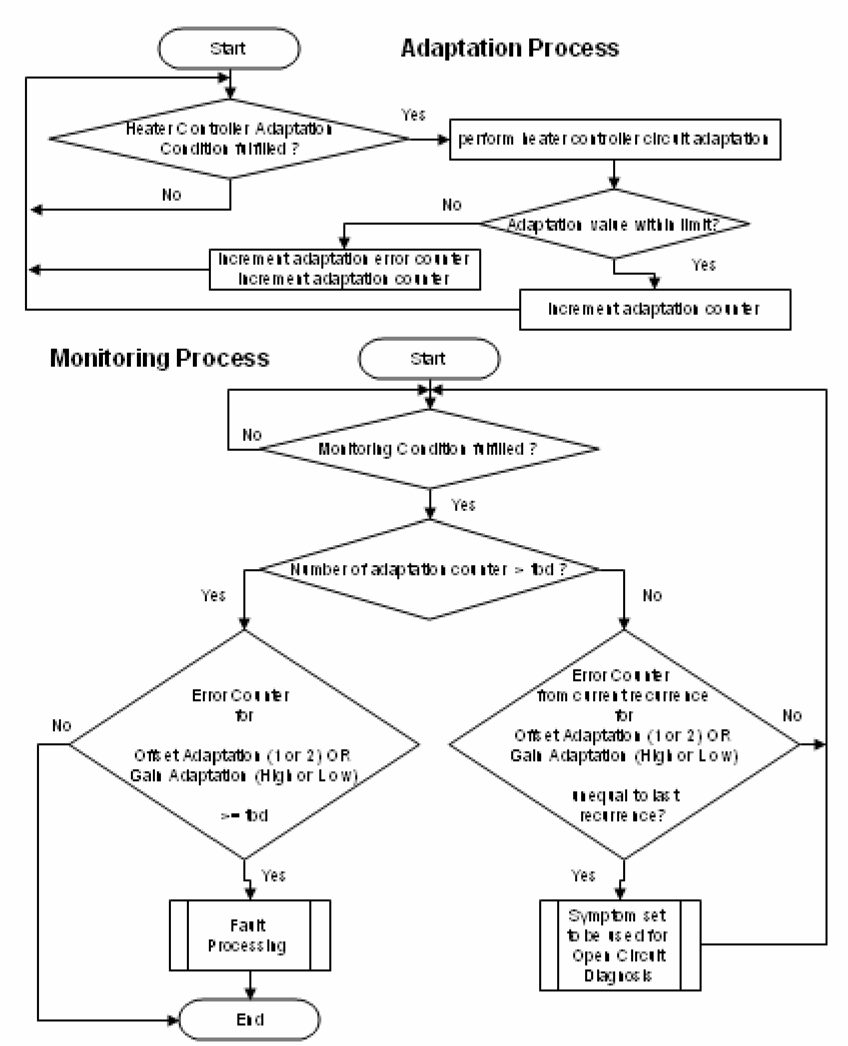
This function shall detect an error during the initialization and/or operation of a WRAF sensor controller, which uses an SPI communication. Information from the Basic Software (BSW) concerning the initialization and the communication between ASW and the controller: This is used to determine if the function is working properly.

9.10.1.3.2. Monitoring Function:

After an ECU reset, the WRAF sensor controller is started and the diagnosis determines if 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 entered.

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

9.10.1.3.3. WRAF Sensor Controller Monitoring



16) Figure WRAF Sensor Controller Monitoring

9.10.1.4. Oxygen Sensor Signal Activity Check

9.10.1.5. Upstream Oxygen Sensor - swapped sensor check

Monitoring Description: (P0040)

This function will detect if the Oxygen Sensor wire harness has been cross connected, ie, Bank 1 with Bank 2. This is performed by the use of the O2 signal of each bank and is performed internal to the ECU.

9.10.1.6. Oxygen Sensor Signal Up-Stream "Characteristics Shift Down Rich/Lean" Active Check

Monitoring Function (P2195 – P2196
P2197 – P2198)

This monitor is an enhancement of the Fuel Correction Diagnosis. Its purpose is to help determine the root cause of the failure for fuel correction. The monitor will only be enabled if a fuel correction fault has been detected and a malfunction code has been stored, ie, P2096 – P2097 – P2098 – P2099.

If a fuel correction malfunction exists, this diagnosis will be enabled to determine if the root cause of the malfunction is due to a stuck signal of the upstream O2 sensor or a system malfunction, ie. Vacuum leak, injector, etc…
If it has been determined that the O2 signal was the root cause of the fuel correction fault, the appropriate DTC will be stored along with the fuel correction DTC.

9.10.1.7. Oxygen Sensor Signal Dynamic Monitoring (Slow Response)

9.10.1.7.1. 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. an air-fuel mixture forced stimulation is imposed and the oxygen sensor amplitude is measured. The result is normalized with the nominal amplification of a nominal oxygen sensor and the minimum amplification of a slow oxygen sensor (both stored in a calibration map). In case the normalized amplitude factor is lower than the calibrated threshold, a symptom is present and is validated by checking if no oxygen sensor open circuit was already detected. Once the symptom is valid the following malfunction is detected:

Sensor signal too slow

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

9.10.1.8. Upstream Oxygen Sensor Heater Monitoring (P0135 / P0155

9.10.1.8.1. Diagnosis 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 operative readiness of the sensor exceeds a time threshold, or whether the measured oxygen sensor ceramic temperature exceeds or 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 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.

9.10.1.8.2. Monitoring Function:

The diagnosis strategy is based on the detection via one of two methods, both cases being emissions relevant.

First, the time to operative readiness shall be checked and second, a statistical evaluation of the oxygen sensor ceramic temperature over a pre-defined number of monitoring cycles shall be carried out, whereby if the temperature should fall out of pre-set bounds a calibrated number of times during the complete diagnosis cycle, a fault shall be detected as being present.

The oxygen sensor ceramic temperature shall be obtained indirectly via the measured internal resistance of the sensor.

The diagnosis will be carried out at minimum, once per driving cycle or may be permitted to repeat, dependent on the conditions. Only the temperature deviation detection method can be repeated, as the sensor warm-up phase is usually only carried out once per driving cycle. The diagnosis shall require a number of monitoring cycles, to permit statistical evaluation of the results.

Once the enable conditions have been met, the monitor shall determine whether the raw operative readiness has been detected. If not, and a max time equals or exceeds a threshold, dependent on the start temperature of the sensor, then an exaggerated forced stimulation shall be requested. This will provide lambda conditions under which the raw operative readiness may more easily be detected.

The function shall determine whether the full operative readiness has been detected. If not, then the time to operative readiness detection method shall be carried out. An Internal timer shall be reset, the diagnosis enable conditions flag shall be set and the diagnosis shall be declared as being “Available”. The timer shall be checked against a threshold. Should it equal or exceed the threshold, then the operative readiness flag has not been detected in a timely manner and the error symptom shall be set and the appropriate DTC stored.

9.10.1.9. Upstream Oxygen Sensor Heater Circuit Monitoring

9.10.1.9.1. Monitoring function:

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

- - HO2S Up SCVB
- - HO2S Up SCG
- - HO2S Up Open circuit

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

Downstream Oxygen Sensor Monitoring (binary):

9.10.1.10. Oxygen Sensor Circuit Monitoring

9.10.1.10.1. Monitoring function:

The oxygen sensor electrical monitor detects the following malfunctions:

- - HO2S Down signal SCVB
- - HO2S Down signal SCG
- - HO2S Down Signal Open Line

Furthermore the following plausibility and activity monitoring is carried out:

- sensor signal plausibility and signal activity monitoring is performed during coasting conditions during fuel cut-off (Slow Response)

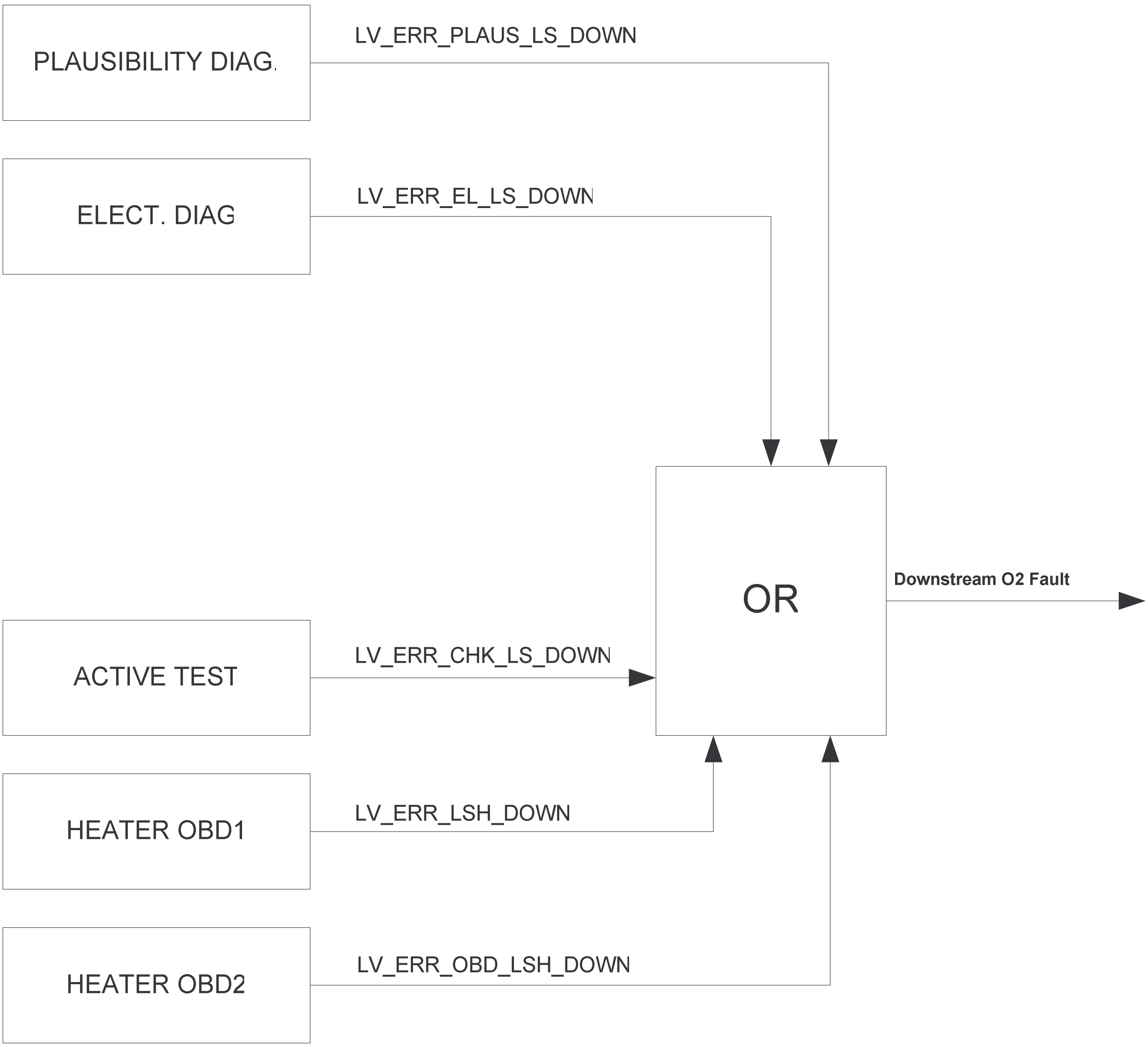
If one of the above mentioned malfunctions is detected, the corresponding fault code is stored.

A malfunction is detected, if the sensor signal is permanently above the minimum threshold.

9.10.1.10.2. Monitoring description: (P0041)

This function will detect if the Oxygen Sensor wire harness has been cross connected, ie, Bank 1 with Bank 2. This is performed by the use of the O2 signal of each bank. This is performed internal to the ECU.

9.10.1.11. Function Overview: Downstream Binary O2 Sensor Diagnosis



17) Figure Downstream Binary O2 Sensor

9.10.1.12. Down-Stream Oxygen Sensor Heater Circuit Monitoring

9.10.1.12.1. Monitoring Function Circuit

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 heater resistance to an absolute threshold during coasting conditions where the exhaust temperature is sufficiently low as to cause the sensor ceramic temperature to fall outside normal operating levels, in cases where the heating power is insufficient.

The cooling energy of the exhaust gas is calculated and compared to a calibrated threshold.

The heater monitor is active if the calculated energy is equal or exceeds the threshold.

Then the O2 sensor heater is compared to a calibrated threshold. If the heater resistance is equal or exceeds the threshold, an O2 sensor heater malfunction is detected.

9.10.1.12.2. Monitoring Function Powerstage

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 powerstage is monitored internally by the driver. The driver can distinguish between three symptoms:

- - HO2S Down SCVB
- - HO2S Down SCG
- - HO2S Down Open Line

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

9.10.1.13. Oxygen Sensor Signal Down-Stream "Characteristics Shift Down Rich/Lean" Active Check

9.10.1.13.1. Monitoring Function:

This monitor is an enhancement of the Fuel Correction Diagnosis. Its purpose is to help determine the root cause of the failure for fuel correction. The monitor will only be enabled if a fuel correction fault has been detected and a malfunction code has been stored, ie, P2096 – P2097 – P2098 – P2099.

If a fuel correction malfunction exists, this diagnosis will be enabled to determine if the root cause of the malfunction is due to a stuck signal of the Upstream O2 sensor or a system malfunction, ie. Vacuum leak, injector, etc… If it has been determined that the O2 signal was the root cause of the fuel correction fault, the appropriate DTC will be stored along with the fuel correction DTC.

(See Flowcharts)

B1S2 – P2270 stuck lean
B2S2 – P2272 stuck lean
B1S2 – P2271 stuck rich
B2S2 – P2273 stuck rich

9.11. Oxygen Sensor Monitoring binary upstream / binary downstream

For Test Group: **6BMXT03.0E83**

9.11.1. Upstream Oxygen Sensor Monitoring (Binary)

9.11.1.1. Oxygen Sensor Circuit Monitoring (Low Voltage) (High Voltage) (Open Circuit)

9.11.1.1.1. Monitor Description:

There are five diagnostic trouble codes for this monitor. The purpose is to detect if the O2 signal circuit is shorted to ground (low signal) or an air leak is present, Voltage (high signal), or an Open Circuit causing the signal to be not active or at bias voltage.

For a “cold sensor” it is possible to detect a SCG fault just after Engine START. This diagnosis is performed during the same operation of the electrical checks. The timer is started after Engine START. When the timer has elapsed (calibrated time), the diagnosis checks if the sensor voltage is in a valid range. If no error is detected, the diagnosis is ended and the “Hot – test” is applied. During the hot test, the O2 sensor resistance is checked. If the resistance is within a threshold, the senor is considered to be functioning properly. The electrical diagnosis is a continuous monitor. The Hot and Cold diagnosis is inhibited if there is an O2 sensor DTC stored. (See Summary Table for thresholds)

9.11.1.1.2. Monitoring function:

The oxygen sensor circuit monitoring detects if the O2 sensor voltage is above or below a calibrated threshold or if not active, (stuck at Bias Voltage). The error information is received from oxygen sensor to the ECU: The ECU monitors the oxygen sensor circuit internally. The Hot & Cold diagnosis is performed only after the engine has started and the conditions have been fulfilled. (See summary table for enable conditions)

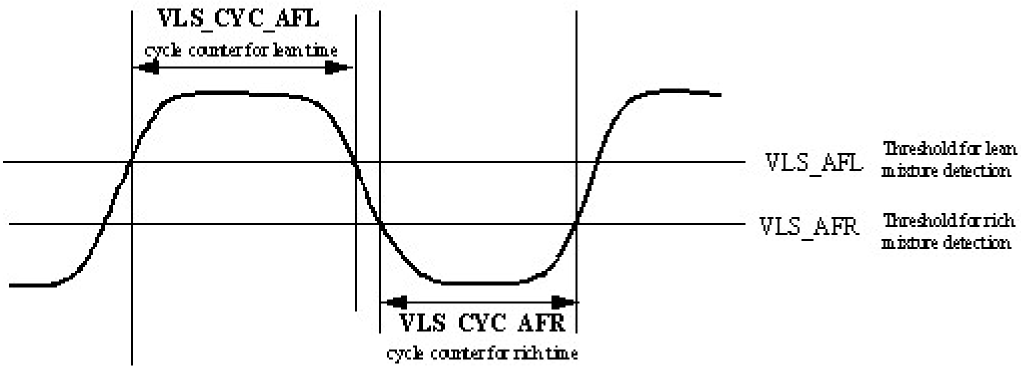
If one of the malfunctions mentioned above is detected, the corresponding fault code is stored.

9.11.1.2. Oxygen Sensor (Up-Stream) Signal Dynamic Monitoring (Slow Response) (Switching Times)

9.11.1.2.1. Monitoring function O2 Frequency Check:

At each lambda control cycle, the lean and the rich duration are measured and accumulated separately. At the same time, the limit of lean or rich period which depends on mass air flow rate and engine speed is also added up. After a counter is increased up to a pre-defined calculation times, the accumulated lean and rich duration and the accumulated limit are compared. The O2 sensors are regarded as having malfunction in control frequency, if the accumulated lean or rich period is higher than the accumulated limit.

Sensor signal too slow (see figure 18 below):

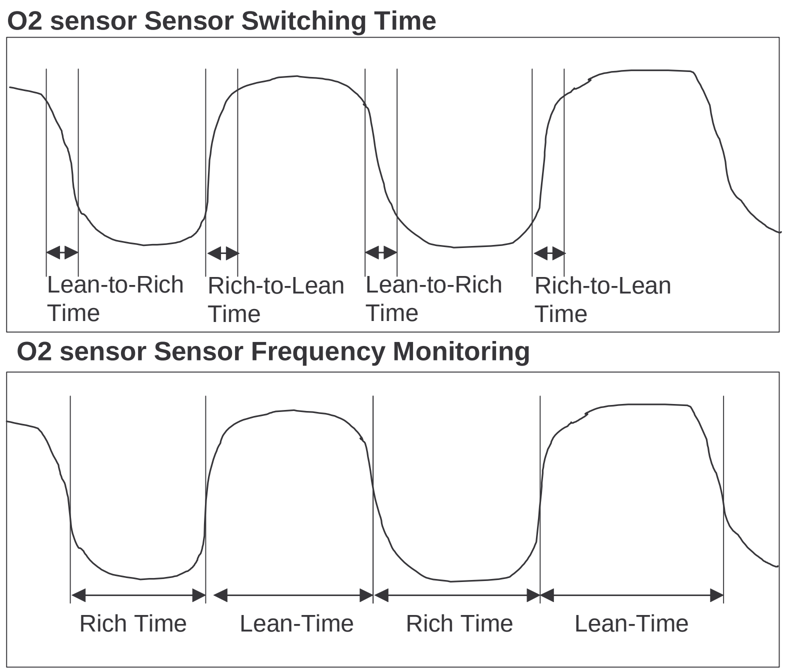


18) Figure Oxygen Sensor Monitoring – Signal

9.11.1.2.2. O2 Switching Time Monitoring:

At every lean-to-rich or rich-to-lean switching event, each actual switching time is added up. At the same time, the maximum limit for lean-to-rich or rich-to-lean switching time depending on air flow rate are also added up as criteria.
After a counter is increased up to a pre-defined calculation times, the accumulated switching time and the criteria are compared. The O2 sensors are regarded as malfunction in response rates, if the accumulated switching time is higher than the criteria (see figure 2 below).

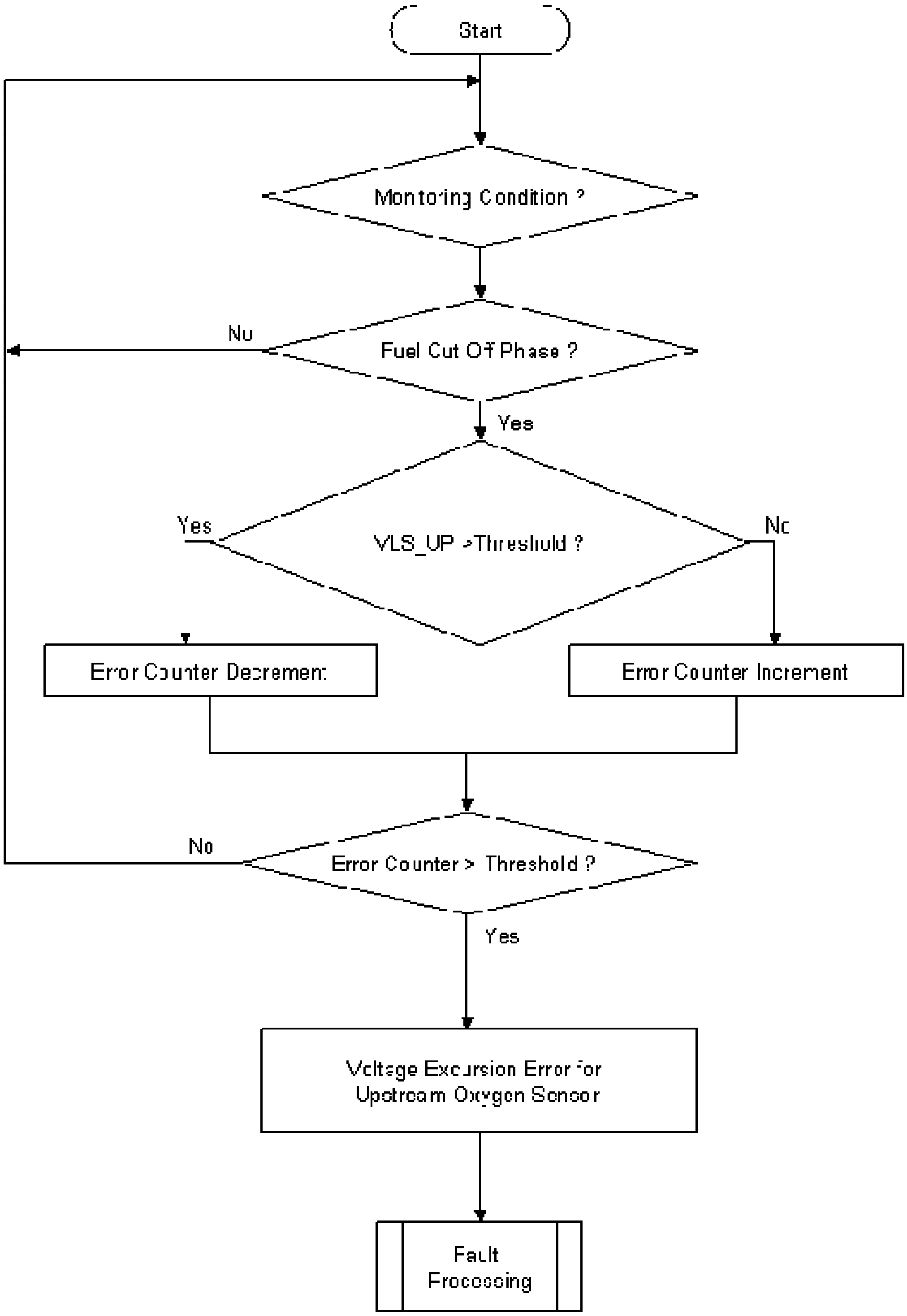
Sensor Switching Time (see figure 19 below):



19) Figure Sensor switching time

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

9.11.1.2.3. Up-Stream Oxygen Sensor Rationality during Fuel Cut-Off



20) Figure Ox-Sensor Rationality

9.11.1.3. Oxygen Sensor Heater Circuit Monitoring (Up-Stream)

9.11.1.3.1. Monitoring function

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

- - Short circuit of sensor signal to battery voltage
- - Short circuit of sensor signal to ECM ground
- - Open circuit

9.11.1.3.2. Rationality:

This function determines the rationality of the upstream(or downstream) O2 sensor heater fault if the measured upstream (or downstream) O2 sensor resistance is lower than the predetermined threshold after a number of monitoring cycles have been carried out.

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

9.11.2. Downstream Oxygen Sensor Monitoring (Binary)

9.11.2.1. Oxygen Sensor Circuit Monitoring (Low Voltage) (High Voltage) (Open Circuit)

9.11.2.1.1. Monitor Description:

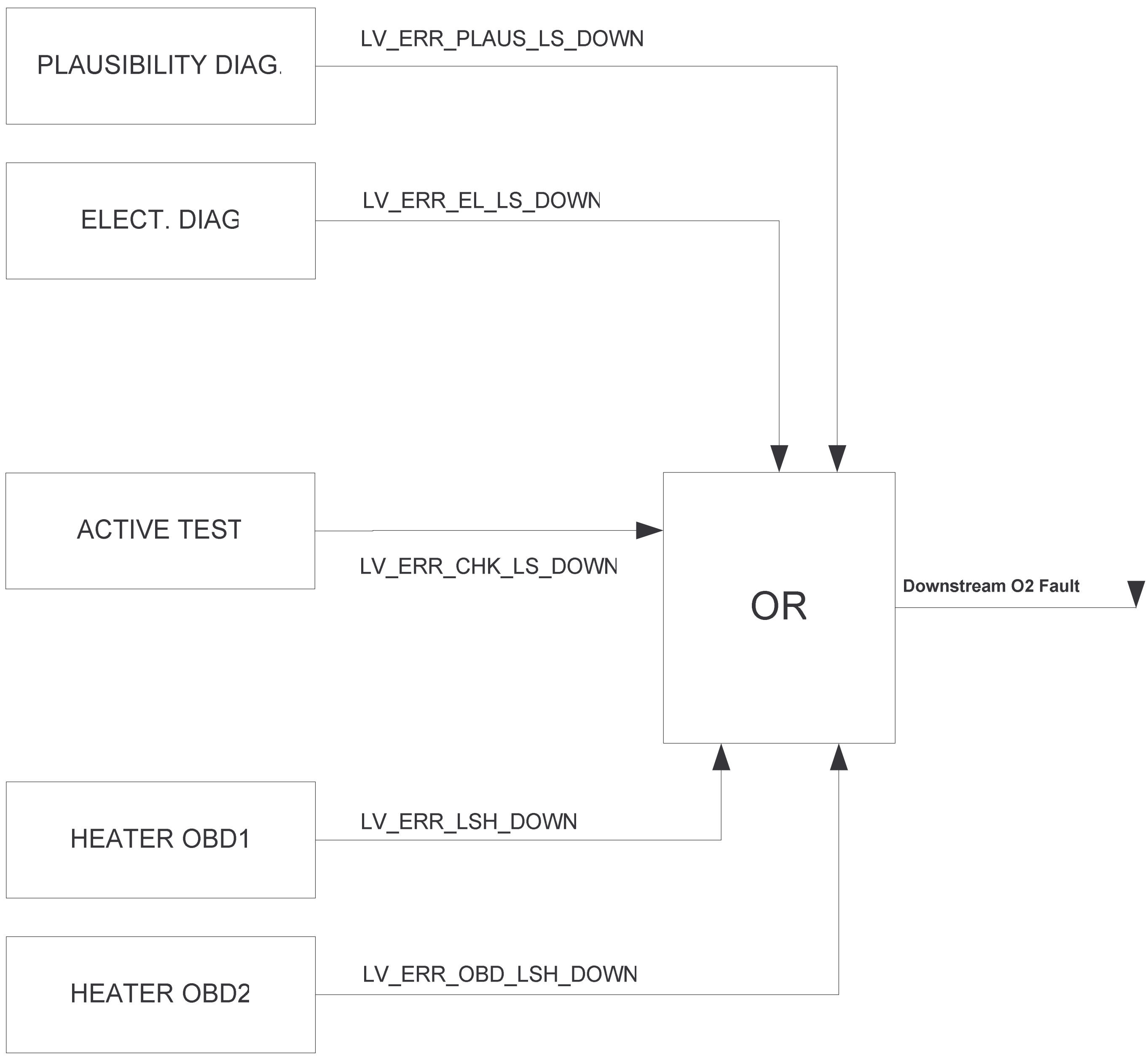
There are three diagnostic trouble code for this monitor, the purpose is to detects if the O2 signal circuit is shorted to ground (low signal) or an air leak is present, Voltage (high signal), or an Open Circuit causing the signal to be not active or at bias voltage.

9.11.2.1.2. Monitoring function:

The oxygen sensor circuit monitoring detects if the O2 sensor voltage is above or below a calibrated threshold or if not active, stuck at Bias Voltage. The error information is received from oxygen sensor to the ECU: The ECU monitors the HO2S circuit internally.

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

9.11.2.2. Function Overview: Downstream Binary O2 Sensor Diagnosis



21) Figure Downstream Binary O2 Sensor Diagnosis

9.11.2.3. Down-Stream Oxygen Sensor Heater Circuit Monitoring

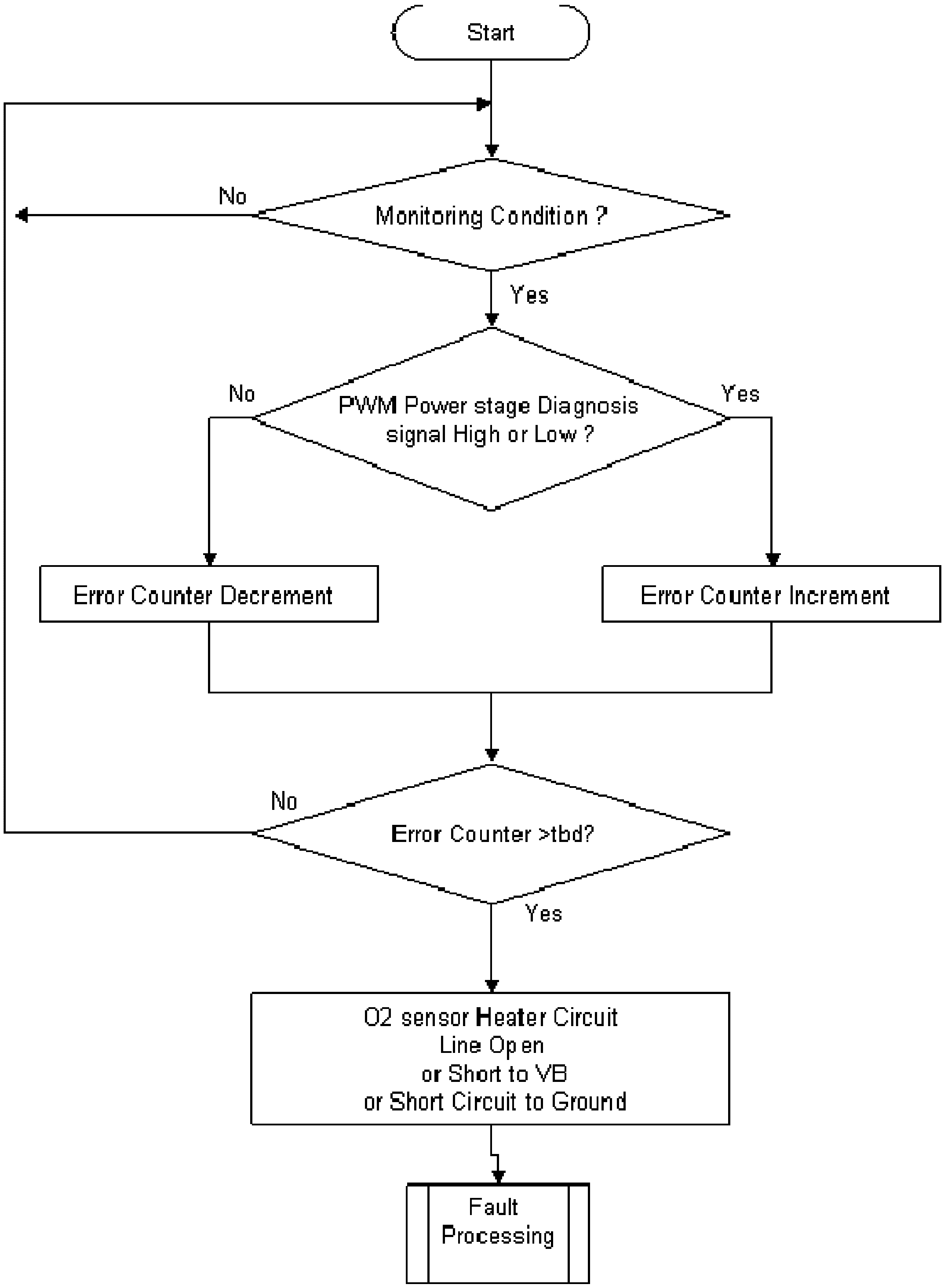
9.11.2.3.1. Monitoring Function, Powerstage:

The purpose of this monitor is to detect errors within the downstream O2 Sensor Heater Circuit. The signal for the O2 sensor heater is pulse- width modulated. The signal of the powerstage is monitored internally by the driver. The driver can distinguish between three symptoms:

- -HO2S Down SCVB
- -HO2S Down SCG
- -HO2S Down Open Line

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

9.11.2.3.2. Flowchart heater circuit monitoring



22) Figure Down-Stream Oxygen Sensor Heater Circuit Monitoring

9.11.2.4. Down-Stream O2 Sensor Active Monitor

9.11.2.4.1. Monitoring Function:

If a fuel trim fault has been detected, This diagnostic is then used to determine the cause of the failure. If the down-stream sensor is Stuck High / Low
the corresponding DTC will be stored.

B1S2 – P2270 stuck lean
B2S2 – P2272 stuck lean
B1S2 – P2271 stuck rich
B2S2 – P2273 stuck rich

9.12. 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 HO2S' operating temperature has been reached
- a calibrated delay time, after end of engine start, has elapsed
- the engine coolant temperature must have exceeded a calibrated threshold or the modeled engine coolant temperature (substitute for a faulty temperature sensor minimum) must have exceeded a calibrated threshold after a calibrated period of time
- no secondary air activity
- Closed loop lambda operation is disabled during the driving cycle, if the following operating condition, which permits only mixture enrichment by the lambda controller, is fulfilled:
- when Catalyst overheating prevention is active.

- **only for linear Lambda Sensor:**
- the A/F ratio set-point value lies below oxygen sensor's measurable limit - in this case only A/F mixture enrichment can be executed by the lambda control (no closed loop operation) the moment the set-point value exceeds the measurable threshold.
- 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 the oxygen sensor again starts indicating correct values (the waiting time depends on integrated mass airflow or on a calibrated delay time).
- the mass air flow is below a calibrated threshold that leads to the minimum possible injection time.
- Secondary air system active

Only for binary Lambda Sensors:

- Catalyst purge function (fuel enrichment) active.

Closed loop lambda control is permanently deactivated during a driving cycle if any of the following errors exist:

- a catalyst damaging misfire rate
- Injection valve errors on the related cylinder bank.
- Ignition coil error on the related cylinder bank
- Upstream lambda sensor error present
- Upstream lambda sensors swapped detected

9.13. Engine Coolant Temperature (ECT) Monitoring

9.13.1. Electrical Coolant Temperature Diagnosis

9.13.1.1. General Description

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 cut to ground can be detected immediately, short cut to voltage battery or open load after a delay time. If an error symptom is detected, the error counter is de-bounced.

9.13.1.2. Error Symptoms

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

9.13.2. Coolant Temperature Plausibility Check

9.13.2.1. For Test Group 6BMXV03.0SMG and 6BMXT03.0E83

9.13.2.1.1. General Description

Above a coolant temperature threshold (OBD II requirement), a plausibility check between the measured coolant temperature increase and the calculated coolant temperature increase is made (only if the vehicle is equipped with catalyst and lambda sensors). The diagnosis is only performed once per driving cycle.

At the transition from engine stop to engine start, a timer is initialized from a table. If start has elapsed, the timer is started. At a transition again to start or engine pull fuel cut off or engine stop, the timer is interrupted.

If the timer has elapsed and the calculated coolant temperature is over a threshold, the plausibility check with measured coolant temperature increase is started.

9.13.2.1.2. Error Symptom

Signal not plausible

9.13.2.2. For Test Group 6BMXB03.0UL and 6BMXV02.5M56

Coolant Temperature Plausibility Check
(Time to Reach Closed Loop) Check

9.13.2.2.1. General Description

There are two different strategies / functions that can be used to determine if sufficient coolant temperature has been reached to enable Closed Loop Fueling.

ECT Model Based vs. Actual ECT:

This function detects if ECT has reached sufficient temperature to allow closed loop fuel using an ECT model vs. measured ECT. If this error is detected then the ECT model temp is used and the diagnostic trouble code (P0125) will be stored. The error will latch for this drive cycle (until power latch occurs).

9.13.2.2.2. Monitoring Function:

Above a coolant temperature threshold (OBD II requirement), a check between the measured coolant temperature increase and the calculated coolant temperature increase is made. The diagnosis is only performed once per driving cycle.

At the transition from engine stop to engine start a timer is initialized from a table based on engine run time vs. engine coolant temperature (ECT). If the engine stalls, the timer is stopped, at a transition again to start the timer is reset and the diagnosis resumes.

When the timer has reached the threshold, if the calculated coolant temperature (model) is greater than the measured coolant temperature, than insufficient temperature to reach closed loop is detected. A P0125 will be stored.

Note: WRAF O2 Sensors

If forced closed loop occurs, one or more of the following DTC's will be stored.
To be filled in for project specifics:

Example: WRAF
B1S1- P2243 / B2S1- P2247 (OC Ref. Voltage)
B1S1- P2237 / B2S1- P2240 (OC Pumping Current)
B1S1- P2251 / B2S1- P2254 (Virtual Gnd)
B1S1- P0135 / B2S1- P0155 (HO2S Heater Malfunction)

9.13.3. Coolant Temperature Stuck Diagnosis

9.13.3.1. General Description

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.

9.13.3.2. Error Symptom

ECT signal stuck error

9.13.3.3. Input parameters for monitoring

Measured ECT
Calculated ECT

9.13.4. Coolant Temperature Gradient Diagnosis

9.13.4.1. General Description

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.

9.13.4.2. Error Symptom

ECT signal gradient error

9.13.4.3. Input parameters for monitoring

measured ECT

9.14. Thermostat

9.14.1. For Test Groups 6BMXB03.0UL2 and 6BMXV02.5M56

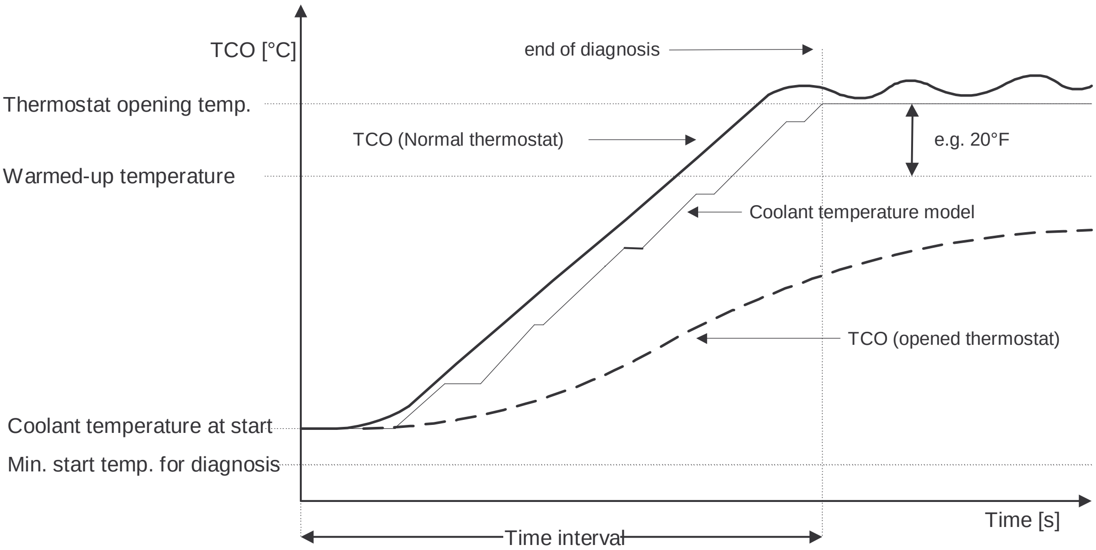
9.14.1.1. Description of the Engine Coolant Thermostat Monitoring

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 engine load/speed and the intake air temperature.
A malfunctioning coolant thermostat is detected, if the calculated ECT model has exceeded the threshold 1* and the measured ECT sensor signal remains below threshold 2*. (* see Summary Table)
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.

9.14.1.2. The input parameters used for monitoring are:

- Engine coolant temperature
- Intake air temperature
- Ambient air
- Engine load

9.14.1.3. Example of Monitoring Method:



23) Figure Thermostat Example

A comparison between the measured coolant temperature and the "warmed-up temperature" is done after a specific time interval. The interval itself is based on the coolant temperature model (Function of intake air mass).

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

At that time, if the measured coolant temperature is higher than warmed-up temperature, the thermostat is concluded as normal thermostat.

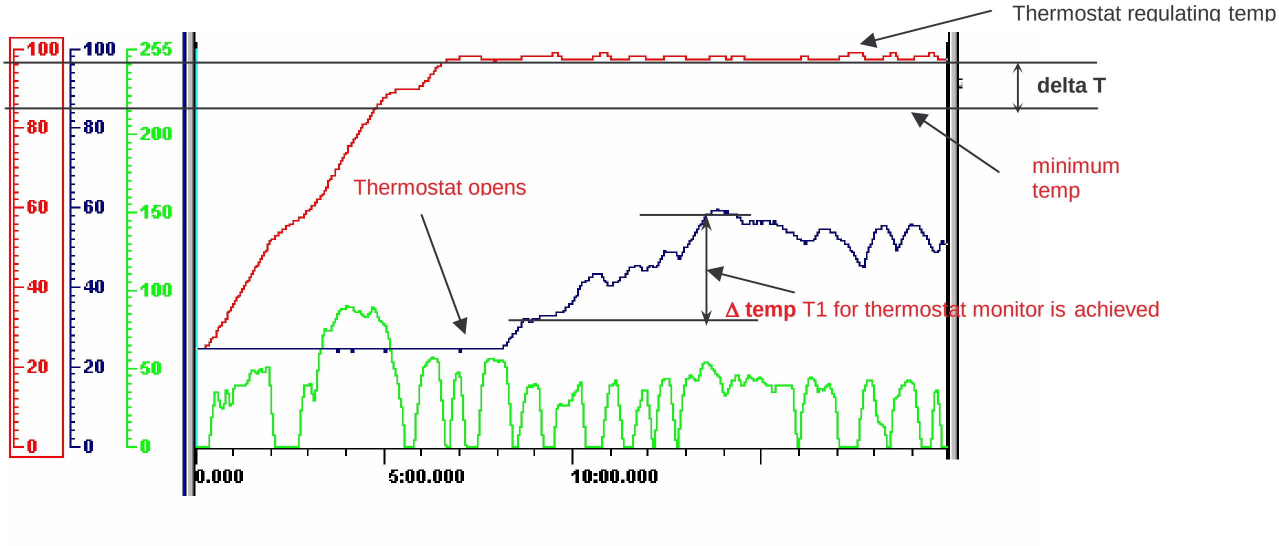
On the contrary, if the measured coolant temperature is lower than warmed-up temperature, the thermostat is concluded as opened stuck thermostat.

9.14.2. For Test Groups 6BMXV03.0SMG and 6BMXT03.0E83

9.14.2.1. Description of the thermostat monitoring strategy

The BMW-engines have a common cooling system with an Engine Coolant Temperature (ECT) and a Radiator Outlet Temperature (ROT) Sensor. Furthermore a mechanical thermostat is a part of this system. The temperature movement of the ROT- Sensor validates the proper function of the thermostat, as described more detailed on the following pages.

Thermostat opens and closes normally



24) Figure Thermostat is working properly

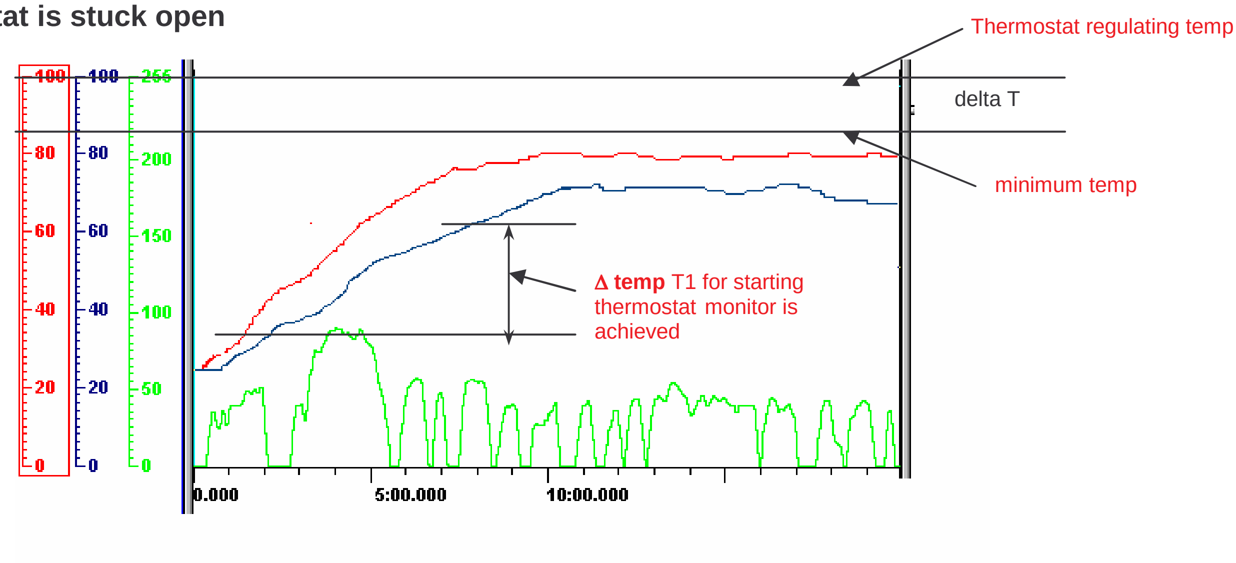
This figure represents the proper working system (thermostat opens and closes as expected)

Description of the curves:

The ECT increases until the operating temperature is reached. Up to this moment the ROT is still constant. After the thermostat has opened, the ROT increases.

When the radiator outlet temperature reaches a certain temperature delta (actual radiator outlet temperature to radiator outlet temperature at engine start) (this delta depends on the engine type), the thermostat monitor runs and the thermostat is diagnosed (ECT is within the temperature range delta T).

Thermostat is stuck open



25) Figure Thermostat is stuck open

This figure 2 represents the malfunction-case of the system (thermostat is stuck open)

Description of the curves:

Due to the thermostat is stuck open ("stuck open" means, that the thermostat is not closed regular and a smallest opening leads to the same result as a fully open thermostat since there are no intermediate conditions), the engine coolant temperature (ECT) rises but does not reach the thermostat regulating temperature.

Also:

Due to the stuck-open thermostat the Radiator Outlet Temperature rises very quickly after engine start.

When the radiator outlet temperature exceeds a calibrated temp-difference related to the ROT at engine start, the thermostat monitor is performed and the open stuck thermostat will be detected (ECT is definitely not in the temperature range within delta T). As a result a fault code P0128 will be stored inside the ECU.

9.15. Coolant Temperature Radiator Outlet (ROT) Monitoring

9.15.1. Electrical ROT Diagnosis

9.15.1.1. General Description

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 calibrated range. Short cut to ground can be detected immediately, short cut to voltage battery or open load after a delay time. If an error symptom is detected, the error counter is de-bounced.

9.15.1.2. Error Symptoms

Short circuit to battery or open load
Short circuit to ground

9.15.2. ROT Plausibility Check

9.15.2.1. General Description

The diagnosis is based on monitoring the alternation of ROT signal, positive and negative changes in three phases.

Just after start, if ECT and TIA is below a calibrated threshold, a too high ROT can be detected by comparison of ECT at start and ROT at start.

During warm – up phase (long term check, with no error detection) the diagnosis will only run if ECT at start and IAT lies within a tunable range after engine start. Minimum and maximum ROT are continuously updated from engine start, after first being initialized to ROT at power up. The difference between these two values, is also calculated. When this value exceeds a minimum threshold then the
diagnosis is finished with a positive rationality check result.

After opening of thermostat, the long term check with error detection starts. The error detection is based on a change of ROT after the opening temperature of the thermostat is reached and following the vehicle/engine is driven under certain conditions (vehicle speed, part load, engine speed, opening of thermostat) for a delay time. However, should one condition drop below the threshold or the engine exit part load state during this tunable period, then the timer is reinitialized/incremented.

9.15.2.2. Error Symptom

- ROT too high after start
- ROT is not plausible

9.15.2.3. Input parameters for monitoring

- ECT
- ROT
- engine speed
- IAT
- actuation pulse-width modulation of thermostat
- vehicle speed

9.16. Intake Air Temperature (IAT) Monitoring

9.16.1. Electrical Intake Air Temperature Diagnosis

9.16.1.1. 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 calibrated range. Short cut to ground can be detected immediately, short cut to voltage battery or open load after a delay time. If an error symptom is detected, the error counter is de-bounced.

9.16.1.2. Error Symptoms

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

9.16.2. Intake Air Plausibility Check

9.16.2.1. General Description

The diagnosis checks IAT for a plausible range and if the signal is stuck. For the range detection IAT has to be within coolant temperature and ambient temperature. If IAT is outside of the range plus an offset, the error symptom to high / to low is set and the error counter is debounced.
The diagnosis works if the vehicle was driven with a certain vehicle speed and minimum engine load for a calibrated time (cool down of hot IAT). Afterwards the vehicle was for a calibrated recurrence in idle for a certain time (hot up of cold IAT) below a vehicle speed threshold and the IAT signal was not moving then a stuck IAT signal is detected and the error is debounced.

9.16.2.2. Error Symptoms

- Signal to high
- Signal to low
- Signal not plausible

9.16.2.3. Input parameters for monitoring

- ECT
- Ambient temperature at start and continuously
- IAT
- Vehicle speed
- Engine speed
- Mass air flow

9.17. Crankshaft and Camshaft Sensor including Valve Timing

9.17.1. Camshaft position sensor (CMP)

9.17.1.1. Monitoring Function:

The following malfunctions are detected:
- no CMP sensor signal
- no plausible CMP sensor signal
- CMP sensor, open line or short circuit

The monitor checks at every crankshaft revolution whether the CMP signal has changed once within a specified teeth range of the flywheel (sensed by the CKP sensor).
The signal is implausible if no change of its polarity or no valid position compared to the crankshaft is detected.
A malfunction of the camshaft position sensor is detected and the corresponding fault code is stored, if one of the above mentioned malfunctions is present.

Further knock control, VVT activation, VVT monitoring and super charger operation are not allowed.
Valid windows of crankshaft teeth number for the CMP sensor diagnosis:

Inlet rising edge	tooth a – b
Inlet falling edge	tooth c – d
Outlet rising edge	tooth e – f
Outlet falling edge	tooth g – h

9.17.2. Variable CAM Timing (Solenoid Valve Diagnosis)

9.17.2.1. Monitoring function

The purpose of the diagnosis is to detect electrical faults in the IVVT unit.

- Short circuit of sensor signal to battery voltage
- Short circuit of sensor signal to ECM ground
- circuit open load

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

9.17.3. Variable CAM Timing (Diagnosis of mechanical reference position)

9.17.3.1. Monitoring function

The goal of this diagnosis is to see if the CAM-edge change lies in the permissible expected range. A hysteresis range is set around the expected CRK position in which the error free CAM-ramp change is expected.
If a ramp change does not occur in this CRK range then an error (debounced) is detected.

9.17.4. Variable CAM Timing (detection of mechanical IVVT error)

9.17.4.1. Monitoring function

Purpose of this diagnosis is to distinguish between a mechanical or an electrical problem of the IVVT-system.
The error detection algorithm starts as soon as a trigger from the IVVT-adhesion detection is received, indicating that the reaction of a certain camshaft on increased energization is not sufficient.

9.17.5. Crankshaft position sensor (CRK)

9.17.5.1. Monitoring Function

The detection of crankshaft position is done by an active hall sensor and a crank wheel with 60 minus 2 teeth. A reference gap of two teeth allows the detection of the top dead center of cylinder 0. The crankshaft sensor delivers 58 high and 58 low phases per 360°CRK. The transition from high to low is a falling edge, from low to high is a rising edge. The difference between the edges is 6° CRK. Only the falling edges are counted.

The following malfunctions are detected:
- no CRK sensor signal
- no plausible CRK sensor signal

An engine position error is detected if at reference gap one or more teeth were missed or too much during the last 360° CRK.
The detection of tooth period error is done by an acceptance window. The expected tooth period is multiplied and divided with an engine speed depending factor. The result is a bottom and a top limit of tooth period in which the transition from high to low electrical signal error has to occur. If a tooth period is not valid, the tooth period error debounce counter will be incremented with an engine state depending increment.
Detection of implausible crankshaft signal is based on the detection of CAM signals without receiving CRK signal; it is done at previous engine (crank- or cam-) synchronization if cam edges are detected.

9.18. Electronic Throttle Control Monitor

9.18.1. Electronic Throttle Control (ETC) Motor Control Circuit (P1636)

9.18.1.1. Monitoring Descriptions:

ETC Driver diagnosis (H-bridge): 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.

9.18.1.2. ETC spring check (start routine): (P1675, P1694)

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.

9.18.1.3. ETC adaptation diagnosis: (P1632, P1633, P1634, P1635)

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 conditions are not fulfilled, the malfunction errors (DTC's) are stored.

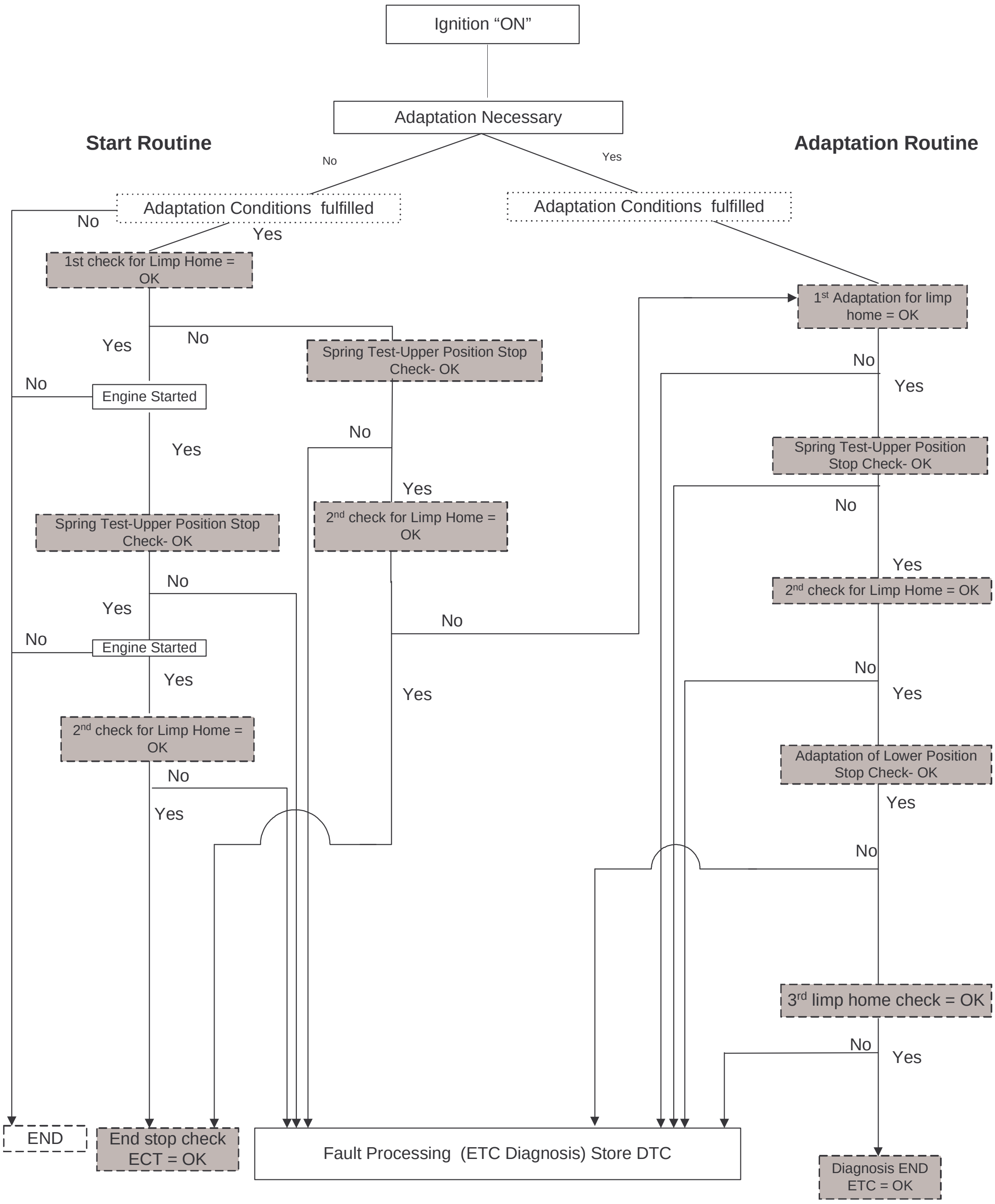
9.18.1.4. Electronic Throttle Control (ETC) Motor Control Performance (P1637, P1638, P1639)

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 are exceeded, the appropriate DTC will be stored.

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

9.18.1.5. Throttle Actuator (ETC) (Controller Diagnosis)



26) Figure ETC

9.19. ISC (Idle Speed Control) Actuator

9.19.1. General Description:

The purpose of this diagnosis is to detect electrical faults of the idle speed controller circuit. The controller is PWM modulated, inverse output signals are used for continuous activation of the opening and closing of a double-wound coil actuator.

The error detection is activated at Key "ON". The following errors are detected:
Short to ground
Short to voltage
Open Circuit

If any of the above errors are detected during opening or closing of the controller, the appropriate DTC will be stored.

9.19.2. Idle Speed Control - Rationality Diagnosis

General Description:

This diagnosis detects the stability of the idle speed. If the commanded idle speed and the actual idle speed is not with-in a calibrated value, above or below commanded, the idle speed is considered to be out of range.

If the above failure conditions are detected, the appropriate DTC will be stored.

9.20. Electrical Oil Temperature Monitoring

9.20.1.1. General Description

The purpose of this diagnosis is to detect electrical faults as defined in OBDII requirements. The input signal is analog from a NTC and has to be in a calibrated range. Short to ground can be detected immediately, short to battery or open line after a delay time.
If an error symptom is detected, the error counter is debounced.

9.20.1.2. Error Symptoms

Short to battery or open line
Short to ground

9.21. Comprehensive Component Monitoring OBD II Siemens VDO function definition

9.21.1. 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.

9.21.2. Monitoring Strategy for sensors:

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

9.21.3. Monitoring Strategy for actuators:

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

9.21.4. 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.

9.22. Listing of all ECM Input and Output Signals

Signal naming	BMW	Pin	(Signal naming by EMS2000)	SIEMENS	Pin	OBDII Rel.
Digital inputs						
Bremslichtschalter	E_S_BLS	424	brakelight switch	BLS	F24	No
Bremslichttestschalter	E_S_BLTS	428	brakelight test switch	BTS	F28	No
Kupplungsschalter	E_S_KUP	423	clutch switch	CLU_SWI	F23	No
Tankdeckelschalter	E_S_TADE	425	fuel cap switch	FUC_SWI	F25	Not used
Startsignal	E_S_START	406	start signal	START	F6	No
Öldruck	E_S_OLD	316	oil pressure	POIL	M16	No
Fahrzeuggeschwindigkeit (ABS)	E_F_DFAHR	422	wheel speed	WHEEL	F22	Yes
Ölniveaugeber	E_F_OLN	350	oil level sensor	LOIL	M50	No
Kurbelwellensensor	E_P_KWG	303	crankshaft position sensor	CRK	M3	Yes
Nockenwellengeber 1 Einlaß	E_P_NWGE1	329	camshaft position sensor inlet 1	CAM_IN_1	M29	Yes
Nockenwellengeber 1 Auslaß	E_P_NWGA1	330	camshaft position sensor exhaust 1	CAM_EX_1	M30	Yes
Reserveeingang	E_S_RES1	434	reserve digital input 1	SPARE_DIG_1	F34	No
CAN						
Lokaler CAN-Low	D_LOCANL	431; 351	local CAN-Low	LOCAN_L	F31; M51	No
Lokaler CAN-High	D_LOCANH	435; 338	local CAN-High	LOCAN_H	F35; M38	No
Fahrzeug CAN-Schnittstelle LOW	D_CANL	203; 437	CAN-Low	CAN_L	P3; F37	Yes
Fahrzeug CAN-Schnittstelle HIGH	D_CANH	204;436	CAN-High	CAN_H	P4; F36	Yes

Signal naming	BMW	Pin	(Signal naming by EMS2000)	SIEMENS	Pin	OBDII Rel.
Analog inputs						
Heißfilmluftmassenmesser	E_A_HFM	301	mass air flow meter	MAFM	M1	Yes
Heißfilmluftmassenmesser Sekundärluft	E_A_HFMS	415	mass air flow meter secondary air	MAFMS	F15	Yes
Lambdasonde/ Referenzzelle vor Kat1	E_A_LSVR1	220	lambda sensor upstream 1	LS_UP_1	P20	Yes
Lambdasonde/ Referenzzelle vor Kat2	E_A_LSVR2	222	lambda sensor upstream 2	LS_UP_2	P22	Yes
Lambdasonde hinter Kat 1	E_A_LSH1	216	lambda sensor downstream 1	LS_DOWN_1	P16	Yes
Lambdasonde hinter Kat 2	E_A_LSH2	214	lambda sensor downstream 2	LS_DOWN_2	P14	Yes
Reserve Analogeingang 1	E_A_RES1	302	reserve analog1	SPARE_AN_1	M2	No
Reserve Analogeingang 2	E_A_RES2	348	reserve analog2	SPARE_AN_2	M48	No
Reserve Analogeingang 3	E_A_RES3	211	reserve analog3	SPARE_AN_3	P11	No
Electrical Sport switch 1	E_A_FDC1	401	sound flap switch 1	SOF_SWI_1	F1	No
Ozonsensor 1	E_A_PREM1	401	premium air upstream	03_UP	F1	Not used
Electrical Sport switch 2	E_A_FDC2	411	sound flap switch 2	SOF_SWI_2	F11	No
Ozonsensor 2	E_A_PREM2	411	premium air downstream	03_DOWN	F11	Not used
NTC- Wasser (Motortemperatur)	E_A_TMOT	328	coolant temperature	TCO	M28	Yes
Temperaturfühler Kühlwasseraustritt	E_A_TKA	439	coolant outlet temperature	TCO_EX	F39	Yes
Ansauglufttemperatur	E_A_TANS	327	intake air temperature	TIA	M27	Yes
Öltemperatursensor	E_A_TOEL	344	oil temperature	TOIL	M44	Yes
Drosselklappengeber1	E_A_DKG1	331	throttle position sensor 1	TPS_1	M31	Yes
Drosselklappengeber2	E_A_DKG2	332	throttle position sensor 2	TPS_2	M32	Yes
Fahrerwunsch 1 (PWG1) Geber	E_A_FWG1	408	pedal value sensor 1	PVS_1	F8	No
Fahrerwunsch 2 (PWG2) Geber	E_A_FWG2	413	pedal value sensor 2	PVS_2	F13	No

Signal naming	BMW	Pin	(Signal naming by EMS2000)	SIEMENS	Pin	OBDII Rel.
Internal inputs						
Interne Widerstandsmessung linear lambda 2 (int)	(UR_2)	intern	internal resistance lin. Lambda 2 (int)	UR_2	intern	Yes
Interne Widerstandsmessung linear lambda 1(int)	(UR_1)	intern	internal resistance lin. Lambda 1 (int)	UR_1	intern	Yes
Tankleckerkennungssystem Diagnose (int)	(DMTL_DIAG)	intern	DMTL diagnosis (int)	DMTL_Leak	intern	Yes
Steuergerätetemperatur (int)	(ECU_TEMP)	intern	ECU internal temperature (int)	TECU	intern	No
Drosselklappen-Geber 1x2 (int)	(TPS1x2)	intern	throttle position sensor 1x2 (int)	TPS1x2	intern	Yes
Interner Umgebungsdrucksensor (int)	(AMP)	intern	internal ambient pressure sensor (int)	AMP	intern	Yes
Klopf-IC Ausgangssignal (int)	(KI)	intern	knock ic output (int)	KI	intern	Yes
Spgs.versorgung FWG1/DKG Diagnose (int)	(PVS1TPS_DIAG)	intern	supply voltage PVS1/TPS diagnosis (int)	PVS1TPS_DIAG	intern	No
Spgs.versorgung FWG2 Diagnose (int)	(PVS2_DIAG)	intern	supply voltage PVS2 diagnosis (int)	PVS2_DIAG	intern	No
Ref.spannung HFM Diagnose (int)	(MAFM_DIAG)	intern	reference voltage MAFM diagnosis (int)	MAFM_DIAG	intern	Yes
Diagnose (int)	(V_IG)	intern	ignition key Kl.15 (int)	V_IG	intern	No
UBat HR Kl.87 (int)	(V_EL)	intern	main relay Kl.87 (int)	V_EL	intern	No
Knock inputs						
Klopfsensor 1A (Diff.- Signal)	E_A_KS1A	346	knock sensor 1A	KNKS_1_A	M46	Yes
Klopfsensor 1B (Diff.- Signal)	E_A_KS1B	333	knock sensor 1B	KNKS_1_B	M33	Yes
Klopfsensor 2A (Diff.- Signal)	E_A_KS2A	347	knock sensor 2A	KNKS_2_A	M47	Yes
Klopfsensor 2B (Diff.- Signal)	E_A_KS2B	334	knock sensor 2B	KNKS_2_B	M34	Yes

Signal naming	BMW	Pin	(Signal naming by EMS2000)	SIEMENS	Pin	OBDII Rel.
Interfaces						
Diagnose (Programmierstation)	D_TXD2	432; 103	diagnostic interface	DIAG_DL	F32; V3	No
Wegfahrsperre, EWS 3	D_EWS	433	Immobilizer	IMOB	F33	No
Generatorschnittstelle	D_BSD	319	generator interface	BSD	M19	No
Multifunktionslenkrad/ Schnittst.	D_FGRD	427	multifunctional steering wheel	MSW	F27	No
Prem-Air Sensor Schnittstelle	D_BSD	425	EAC sensor interface	BSD	F25	No
Power supply						
Fzg. Pin Kl.15	E_U_15	426; 101	ignition key Kl.15	V_IG	F26; V1	No
Hauptrelais	E_U_HR	108	main relay Kl.87	V_EL	V8	No
Dauerplus Kl.30	E_U_30	107	direct battery Kl.30	VB	V7	No
Spannungsversorgung 5V (PWG1)	A_U_FWG1	409	supply voltage PVS1	PVS1_VCC	F9	No
Spannungsversorgung 5V (PWG2)	A_U_FWG2	414	supply voltage PVS2	PVS2_VCC	F14	No
Spannungsversorgung 5V (DKG1,2)	A_U_DKG	305	supply voltage TPS	PVS1TPS_VCC	M5	Yes
Referenz 5V HFM5	A_U_HFMREF	304	reference voltage MAFM	MAFM_VCC	M4	Yes
Sensor Supply Module 3	A_U_SENS3	324	spare voltage 5V	SENS3_VCC	M24	Yes
Reserve Spannung 5V zusätzl. 5V Versorgung	A_U_SENS4	416	spare voltage 5V	SENS4_VCC	F16	Yes

Signal naming	BMW	Pin	(Signal naming by EMS2000)	SIEMENS	Pin	OBDII Rel.
Output signals						
Drehzahl	A_F_TD	417	engine speed signal	ESS	F17	Yes
Elektr. Lüfter 1 (getaktet)	A_T_ELUE1	404	cooling fan 1	CFA_1	F4	No
Sekundärluftventil	A_S_SLV	339	secondary air valve	SAV	M39	Yes (only SULEV)
DMTL Heizung	A_S_DMTLH	402	DMTL Heater	DMTLH	F2	Yes
EBox-Lüfter	A_S_EBOXL	419	cooling fan Ebox	CFA_EBOX	F19	No
Tankentlüftungsventil	A_T_TEV	321	canister purge solenoid	CPS	M21	Yes
Zündspule 1	A_P_ZSZ1	506	ignition coil 1	IGC0	Z6	No
Zündspule 2	A_P_ZSZ5	501	ignition coil 2	IGC1	Z1	No
Zündspule 3	A_P_ZSZ3	504	ignition coil 3	IGC2	Z4	No
Zündspule 4	A_P_ZSZ6	509	ignition coil 4	IGC3	Z9	No
Zündspule 5	A_P_ZSZ2	507	ignition coil 5	IGC4	Z7	No
Zündspule 6	A_P_ZSZ4	508	ignition coil 6	IGC5	Z8	No
Einspritzventil 1	A_P_EVZ1	313	injection valve 1	IV_0	M13	Yes
Einspritzventil 2	A_P_EVZ5	311	injection valve 2	IV_1	M11	Yes
Einspritzventil 3	A_P_EVZ3	326	injection valve 3	IV_2	M26	Yes
Einspritzventil 4	A_P_EVZ6	308	injection valve 4	IV_3	M8	Yes
Einspritzventil 5	A_P_EVZ2	306	injection valve 5	IV_4	M6	Yes
Einspritzventil 6	A_P_EVZ4	307	injection valve 6	IV_5	M7	Yes
Außlaßvanos Ansteuerung 1	A_T_NWA1	309	infinitely variable valve timing inlet 2	IVVT_EX_1	M9	Yes
Einlaßvanos Ansteuerung 1	A_T_NWE1	310	infinitely variable valve timing inlet 1	IVVT_IN_1	M10	Yes
Leerlauffüllungssteller schliessen	A_T_LLFSS	322	idle speed actuator close	ISA _CLOSE	M22	Yes
Leerlauffüllungssteller öffnen	A_T_LLFSO	323	idle speed actuator open	ISA_OPEN	M23	Yes
Heizung Lambdasonde vor Kat 1	A_T_LHV1	201	lambda sensor heater upstream 1	LSH_UP_1	P1	Yes
Heizung Lambdasonde vor Kat 2	A_T_LHV2	202	lambda sensor heater upstream 2	LSH_UP_2	P2	Yes
Heizung Lambdasonde hinter Kat 1	A_T_LHH1	206	lambda sensor heater downstream 1	LSH_DOWN_1	P6	Yes
Heizung Lambdasonde hinter Kat 2	A_T_LHH2	212	lambda sensor heater downstream 2	LSH_DOWN_2	P12	Yes
Abgasklappe	A_S_AKL	418	exhaust flap	EF	F18	No
Relais Klimakompressor	A_S_KOREL	429	relay air conditioning compressor	RLY_ACC	F29	No
Elektrische Kraftstoffpumpe	A_T_EKP	410	electric fuel pump	EFP	F10	No
Haupt-Relais (Ansteuerung)	A_S_HR	223; 109	main relay	RLY_MAIN	P23; V9	Yes
Automatikstart	A_S_START	440	start relay	RLY_START	F40	No
Sekundärluftpumpe Stufe 1	A_T_SLP1	403	secondary air pump 1	SAP_1	F3	Yes (only SULEV)
Schaltsaugrohr	A_S_DISA	340	variable intake manifold	VIM	M40	Yes
Pumpe Tankleckdiagnose	A_S_DMTLP	420	tank leakage detection pump	DMTLP	F20	Yes
Ventil Tankleckdiagnose	A_S_DMTLV	430	tank leakage detection valve	DMTLV	F30	Yes
Elektr. Geregeltes Thermostat	A_S_KFK	312	el. controlled thermostat	ECT	M12	Yes
Reserveausgang	A_S_RES1	352	spare output 1	SPARE_OUT_1	M52	No

Signal naming	BMW	Pin	(Signal naming by EMS2000)	SIEMENS	Pin	OBD II Rel.
Linear lambda sensor circuit						
Pumpstrom, Stetige-Lambdas. v Kat 1	A_I_LSVP1	213	pump current output 1	LSL_IA_1	P13	Yes
Pumpstrom, Stetige-Lambdas. v Kat 2	A_I_LSVP2	215	pump current output 2	LSL_IA_2	P15	Yes
Pumpzelle, Stetige-Lambdas. v Kat 1	E_A_LSVP1	219	pump current measurement 1	LSL_IP_1	P19	Yes
Pumpzelle, Stetige-Lambdas. v Kat 2	E_A_LSVP2	221	pump current measurement 2	LSL_IP_2	P21	Yes
H-bridge						
Ansteuerung 1 Drosselklappe	A_T_MDK1	342	throttle actuator out 1	MTC1	M42	Yes
Ansteuerung 2 Drosselklappe	A_T_MDK2	343	throttle actuator out 2	MTC2	M43	Yes
Not connected						
nicht angeschlossen	n.c.	102	not connected	n.c.	V2	Not used
nicht angeschlossen	n.c.	218	not connected	n.c.	P18	Not used
nicht angeschlossen	n.c.	224	not connected	n.c.	P24	Not used
nicht angeschlossen	n.c.	318	not connected	n.c.	M18	Not used
nicht angeschlossen	n.c.	502	not connected	n.c.	Z2	Not used
nicht angeschlossen	n.c.	503	not connected	n.c.	Z3	Not used

Issued: 09/20/05

Signal naming	BMW	Pin	(Signal naming by EMS2000)	SIEMENS	Pin	OBD II Rel.
Ground						
Masse Elektronik	M_EL3	104	ground electronic	GND_EL3	V4	No
Masse Einspritzventile	M_EV	105	ground injection	GND_IV	V5	Yes
Masse Endstufen	M_ES	106	ground power	GND_PWR	V6	No
Masse Lambdasonde vor Kat 1	M_LSV1	207	ground lambda sensor upstream 1	LS_UP_1_GND	P7	Yes
Masse Lambdasonde hinter Kat 2	M_LSH2	208	ground lambda sensor downstream 2	LS_DOWN _2_GND	P8	Yes
Masse Lambdasonde vor Kat 2	M_LSV2	209	ground lambda sensor upstream 2	LS_UP_2_GND	P9	Yes
Masse Lambdasonde hinter Kat 1	M_LSH1	210	ground lambda sensor downstream 1	LS_DOWN _1_GND	P10	Yes
Masse Elektronik	M_ANALOG	314	ground analog (MAFM)	ANALOG_GND	M14	Yes
Masse Drosselklappengeber	M_DKG	315	ground throttle position sensor	TPS_GND	M15	Yes
Masse Motortemperaturfühler	M_TMOT	335	ground coolant temperature sensor	TCO_GND	M35	Yes
Masse Nockenwellengeber 1 Einlaß	M_NWGE1	336	ground camshaft position sensor inlet 1	CAM_IN_1_GND	M36	Yes
Masse Digital (KWG)	M_DIGIT	337	ground digital (CRK)	DIGITAL_GND	M37	Yes
Masse Nockenwellengeber 1 Auslaß	M_NWGA1	349	ground camshaft position sensor exhaust 1	CAM_EX_1_GND	M49	Yes
Masse elektr. (HFM2-Masse)	M_EL2	405	ground electronic	GND_EL2	F5	No
Fahrerwunsch 1 (PWG1) Masse	M_FWG1	407	ground pedal value sensor 1	PVS1_GND	F7	No
Fahrerwunsch 2 (PWG2) Masse	M_FWG2	412	ground pedal value sensor 2	PVS2_GND	F12	No
Masse Temperatur Kühlwasseraustritt	M_TKA	438	ground coolant outlet temperature	TCO_EX_GND	F38	Yes
Masse Zündung	M_ZDG	505	ground ignition	GND_IG	Z5	No
Masse Öltemperatur	M_TOEL	345	ground oil temperature	TOIL_GND	M45	Yes
Reservemasse	M_RES1	317	ground spare 1	SPARE_GND1	M17	No
Reservemasse	M_RES2	320	ground spare 2	SPARE_GND2	M20	No
Reservemasse	M_RES3	325	ground spare 3	SPARE_GND3	M25	No
Reservemasse	M_RES4	341	ground spare 4	SPARE_GND4	M41	No
Reservemasse	M_RES6	205	ground spare 6	SPARE_GND6	P5	No
Reservemasse	M_RES7	217	ground spare 7	SPARE_GND7	P17	No

Table 1 Listing of all ECM Input and Output Signals

9.23. Location of the Data Link Connector

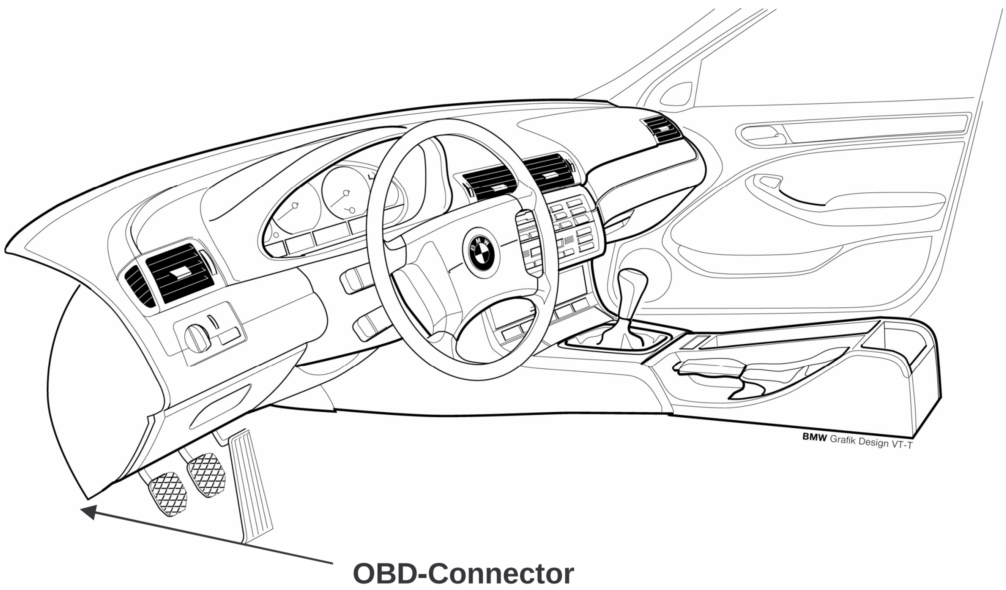
9.23.1. Location of the Data Link Connector for following Test Groups (models):

6BMXB03.0UL2 (325Ci, 325Ci conv., 330Ci, 330Ci conv.)

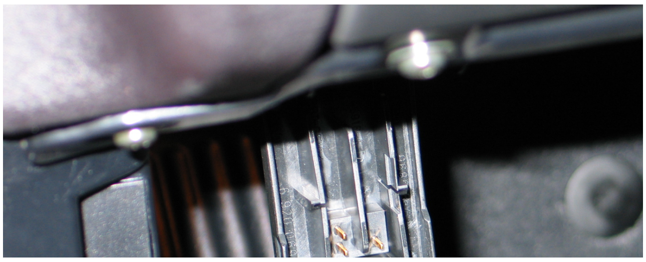
6BMXV03.0SMG (330Ci, 330Ci conv.)

6BMXV02.5M56 (325Ci)

The diagnostic plug is located on the underside of the dashboard to the left of the driver (see diagram) and is fitted with a hinged cover, which hinges away from the driver. This cover has the letters OBD on it and includes also an electrical function (resistance).



27) Figure Location of Data Link Connector 3-series



28) Figure Position DLC and opened cover 3-series

29) Figure Front side DLC cover 3-series