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Technical OBD description for VW /Audi with ME(D)17 ECMs

This description applies for the following OBD groups/ test groups:

OBD Group Name	Test group	Engine	Models	Standard	Controller / OBD II strategy
BBE-V	BBEXV06.84LA	6.8 V8T - 2 bank	Bentley Mulsanne	LEV II Bin 5	Bosch ME(D)17 BE-V

General statements:

- In case of monitors which are applicable only for specific OBD group(s) or test group(s) the specific OBD group(s) or test group(s) are mentioned to the description part.
- ME(D)17 means MED17 for FSI concepts and ME17 for MPI concepts.
- The sections “enable conditions” describe typical enable condition for the monitoring functions. All specific enable conditions for each monitor are described in the summary table, which is submitted separately.
- Disabling symptoms are described in the disabling matrix, which is submitted separately.

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10 ENGINE COOLANT SYSTEM MONITORING

10.1 General description

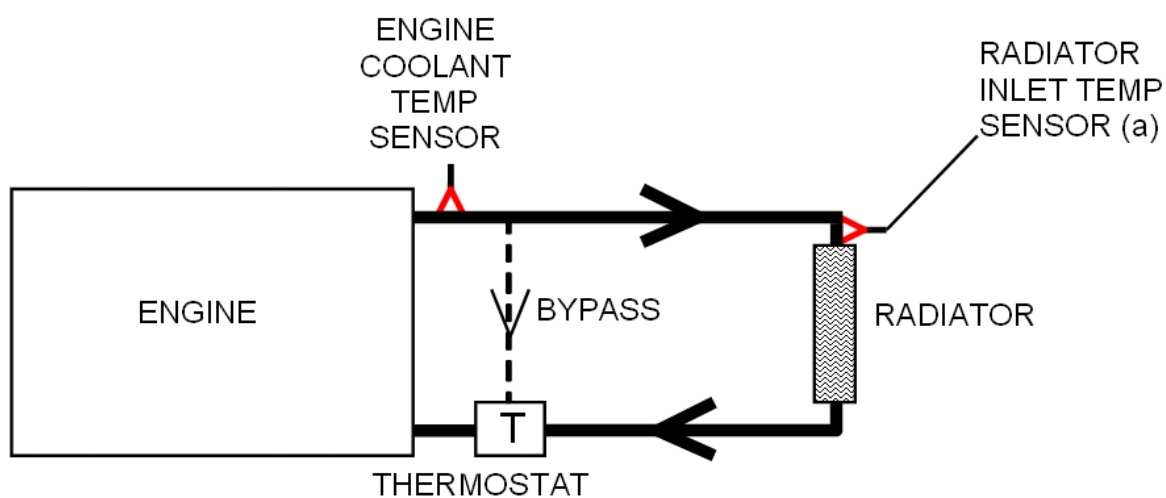
The engine cooling system consists of the following main parts :

- Radiator
- Engine Coolant Temperature Sensor
- Thermostat
- Bypass Cooling Circuit
- Main Cooling Circuit
- Radiator Temperature Sensor (certain OBD groups only)

During warm-up of the engine, the coolant flows first inside the bypass cooling circuit. After the coolant reaches a sufficient temperature the thermostat opens the main cooling circuit to integrate the engine coolant radiator.

The engine coolant temperature sensor measures a mixed temperature between the coolant coming from the bypass and main cooling circuits.

On some concepts, a radiator temperature sensor is used to measure the temperature at the inlet (OBD group BBE-V) of the radiator.



(a) OBD Group BBE-V only

Figure 1: Main elements of engine cooling system

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10.2 Concepts with radiator temperature sensor

Applicable only for test group:

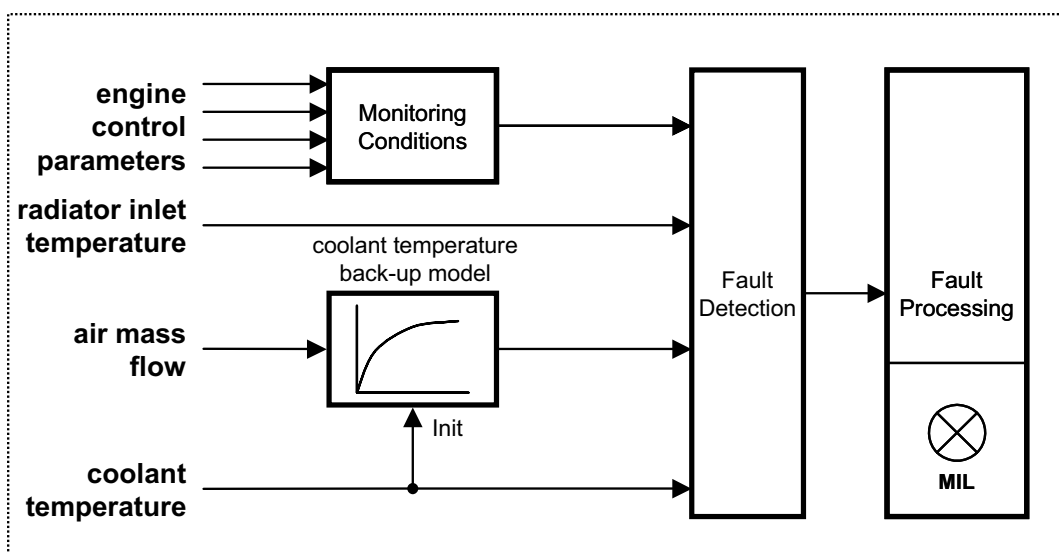
OBD Group Name	Test group	Engine	Models	Standard	Controller / OBD II strategy
BBE-V	BBEXV06.84LA	6.8 V8T - 2 bank	Bentley Mulsanne	LEV II Bin 5	Bosch ME(D)17 BE-V

10.2.1 Monitor Functional Description

The thermostat monitor checks for correct operation of the engine coolant system thermostat by comparing the Engine Coolant Temperature (ECT) with Radiator Inlet Temperature.

If the difference between ECT and radiator inlet temp is lower than a threshold for too long during the engine warm-up, then a Cooling System Performance fault is set when the engine coolant temperature back-up model has reached the final value. See Figure 16 for an overview of the strategy for the monitor.

The failure threshold depends on the radiator inlet temp at engine start up.



Strategy overview Thermostat Monitor

Figure 2: Strategy overview Thermostat Monitor

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10.2.2 Cooling System Performance (P2181)

In case that the difference between the engine coolant temperature after a sufficient mass air flow and radiator inlet temperature falls below a certain value for a calibrated time under normal driving conditions, the cooling system performance is considered to be reduced. Refer to Figure 17.

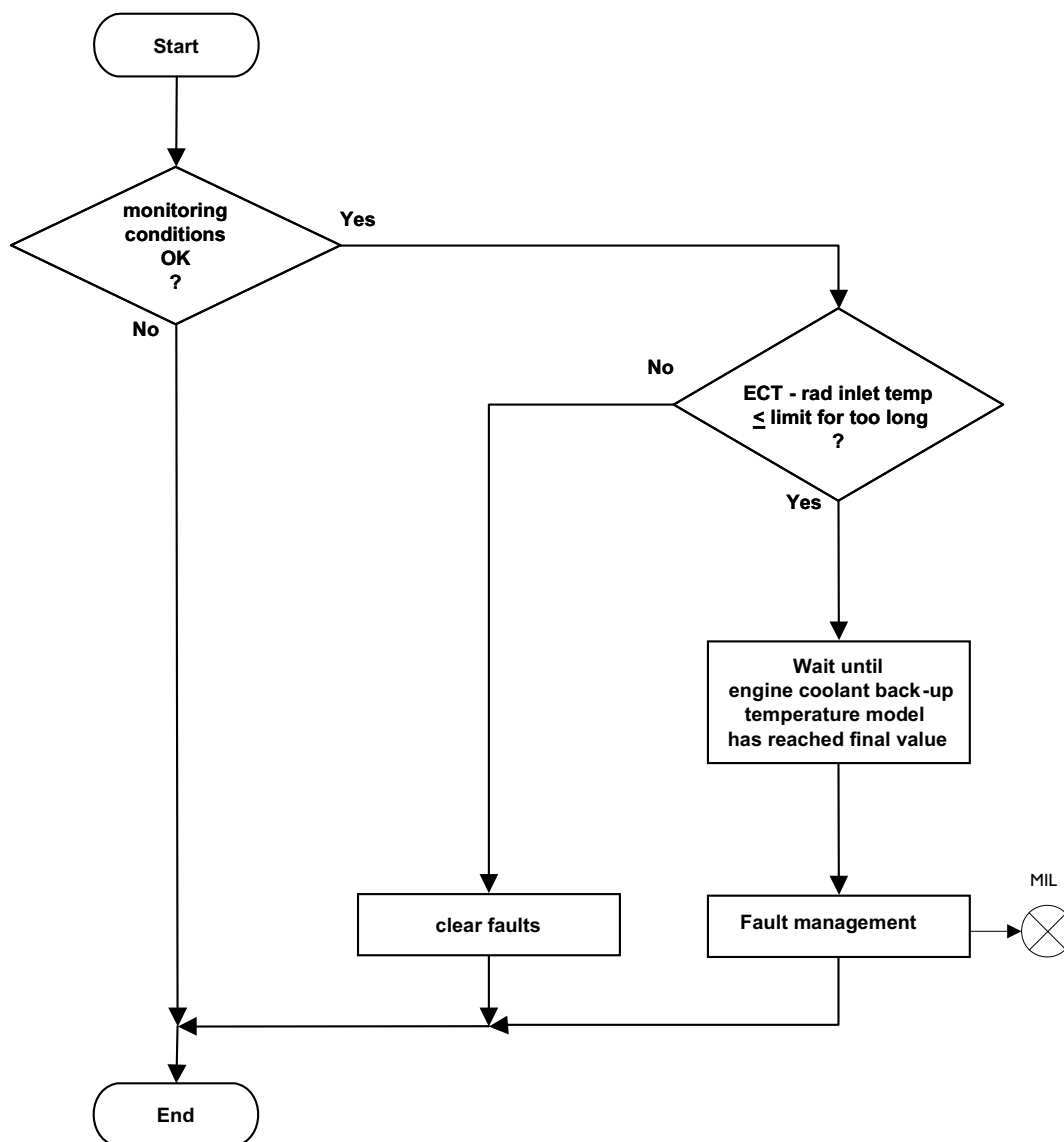


Figure 3: Flow Chart Cooling System Performance (P2181) using radiator inlet temperature sensor

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10.2.3 Engine Coolant Temperature Sensor Rationality (P0116)

In case that the engine coolant temperature does not fit to a reference model temperature in a certain range, the cooling system is defective or the sensor is not in a plausible range. Refer to Figure 18 and Figure 19.

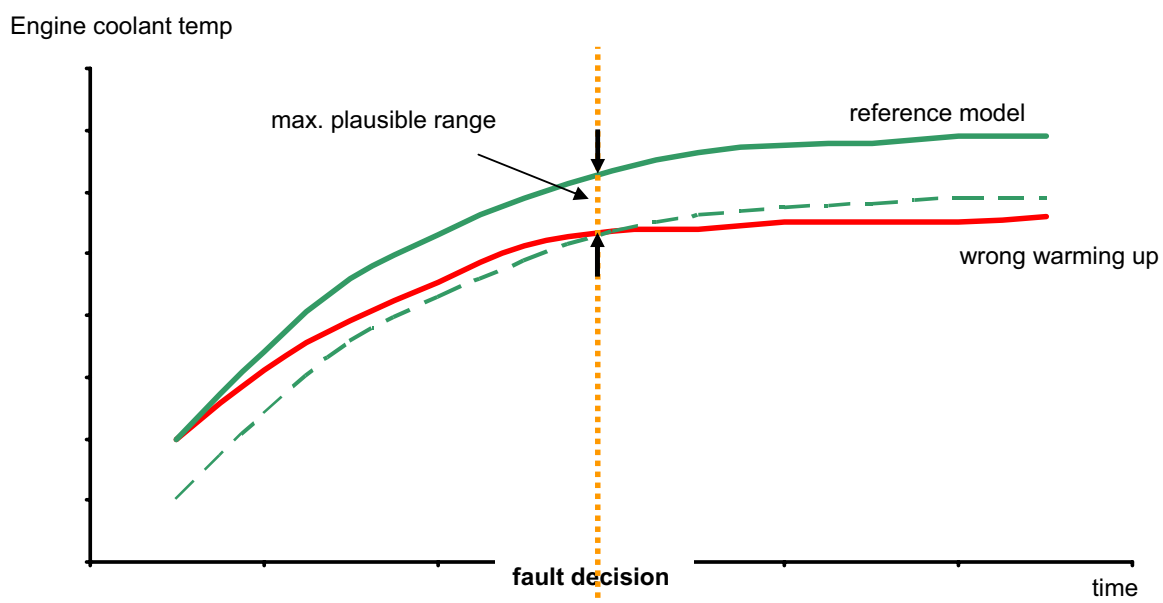


Figure 4: Coolant temperature Sensor Rationality Overview

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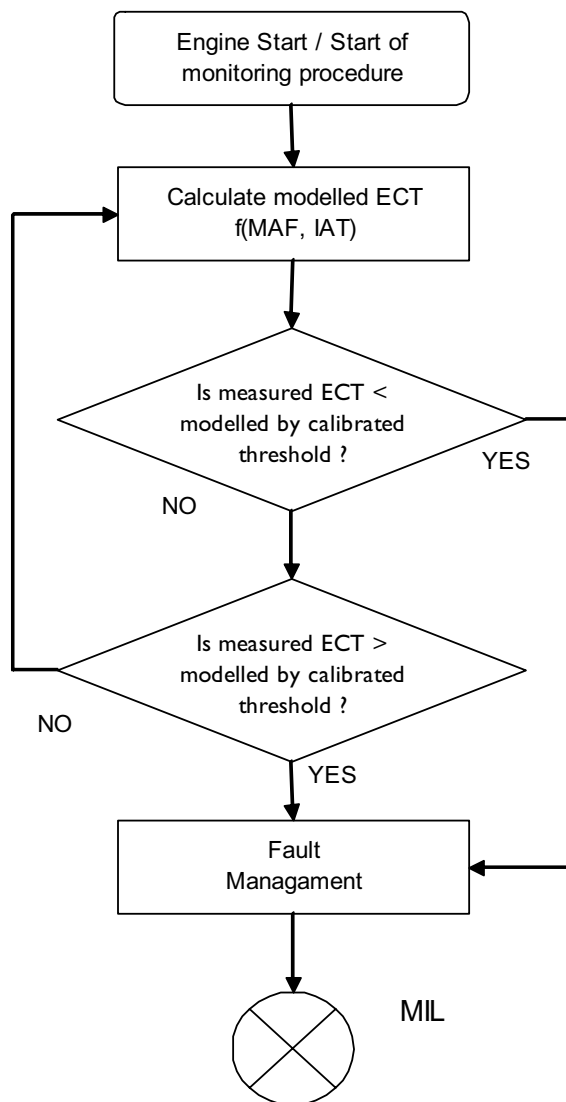


Figure 5: Flow Chart Coolant Temperature Sensor Rationality (P0116)

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10.2.4 Engine Coolant Temperature Sensor Stuck (P0116)

After engine start the system stores continuously the lowest and highest ECT above the thermostat control temperature for a driving cycle. In case that after several driving conditions the difference between ECT max and ECT min is lower than the threshold the sensor is stuck, independent of start temperature (Figure 20). Figure 21 is a flow chart of the function.

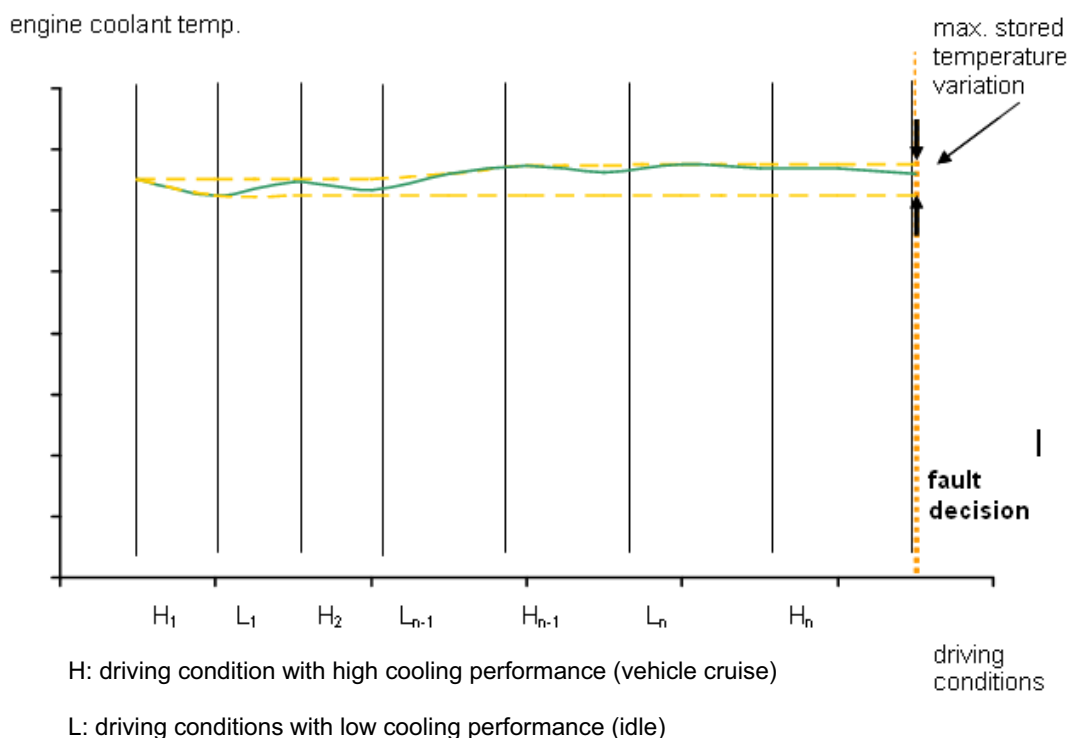


Figure 6: Coolant temperature Sensor Stuck Overview

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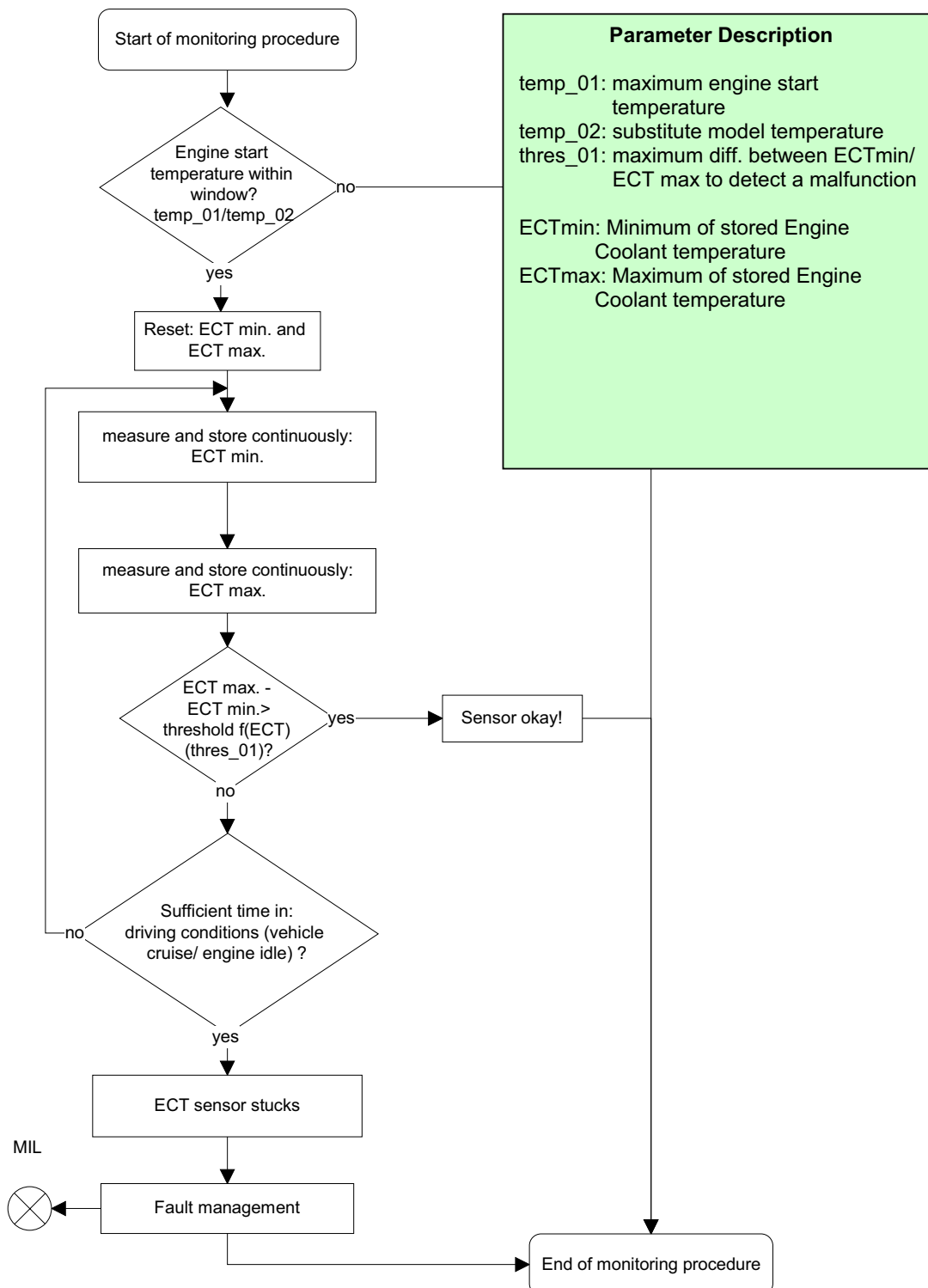


Figure 7: Flow Chart Engine Coolant Temperature Sensor Stuck (P0116)

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10.2.5 Engine Coolant Temperature Sensor Out of Range Check (P0115 / P0117)

The signal of Engine Coolant Temperature Sensor is evaluated and considered to be electrically out of range if either the upper or the lower thresholds is exceeded.

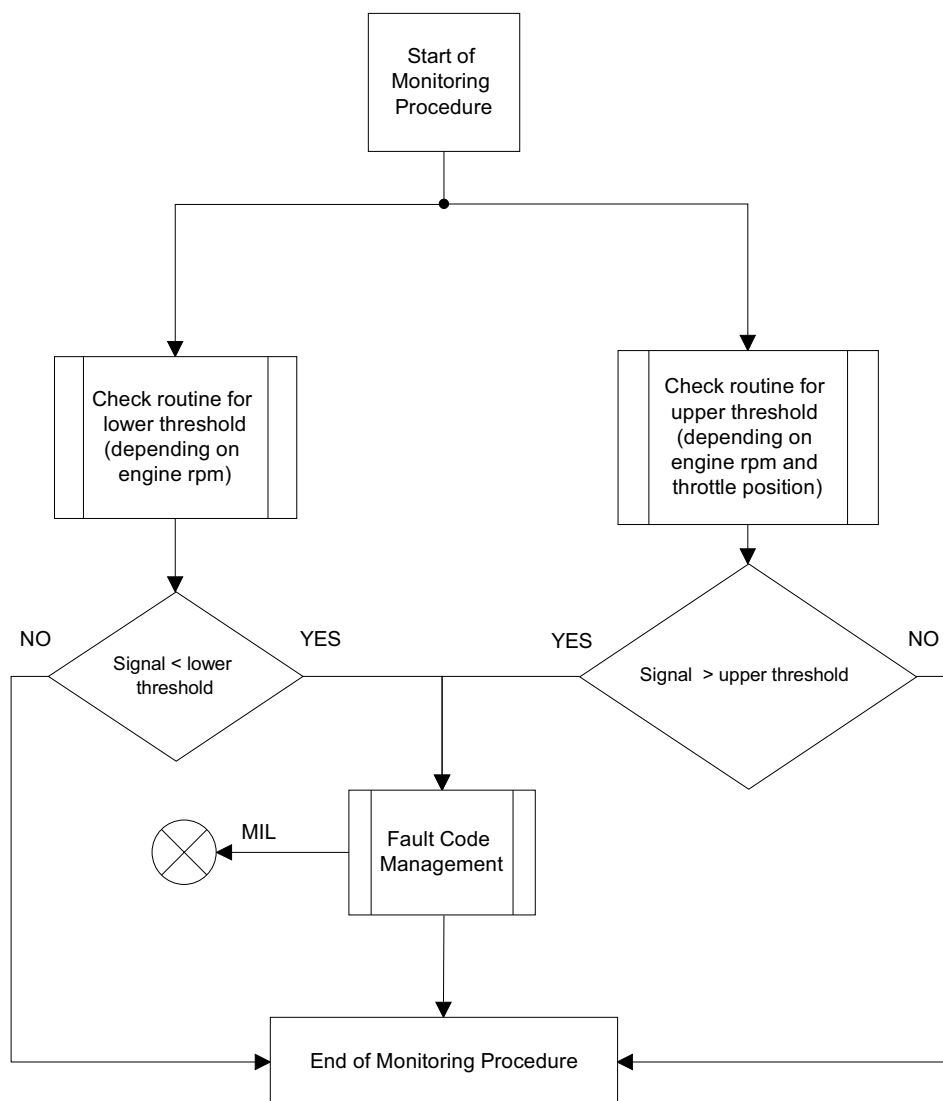


Figure 8: Flow Chart ECT Sensor Out of Range Check (P0115 / P0117)

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11 COLD START EMISSION REDUCTION STRATEGY MONITORING

11.1 General Description

This strategy comprises several different measures, initiated by the ECM, in order to reduce cold start exhaust gas emissions. The key parameters in the cold start emission reduction strategy (CSERS) are controlled by components which are included in and covered by the OBD II system. Any malfunction of one of these components would be indicated by the MIL.

The strategy is utilized to attain the catalyst operating temperature as quickly as possible. In terms of emission control, the cold start phase corresponds to the catalyst heating phase:

- The idle speed is increased within the specially defined “engine idle state” during the cold start phase. This measure is called “catalyst-heating idle speed increase” (refer to chapter 15.4.2)
- The ignition timing is retarded during the entire cold start phase
- The VVT camshaft timing is adapted in order to achieve optimum cylinder charging efficiency (refer to chapter 13.4)
- A cold-start specific high pressure adaptation in the fuel system is executed (refer to chapter 6.3.3)

These cold start measures are monitored by comparing the individual measured values/ranges to modeled values/ranges. Error detection is based on identifying deviations that result from these comparisons.

The following components influence the key parameters for the warm-up strategy:

1. Injection valves
2. Throttle unit
3. MAF / MAP
4. Ambient pressure sensor
5. Intake air temperature sensor
6. Ignition coils
7. Variable valve timing system
8. Camshaft/crankshaft alignment
9. Phase sensor
10. Engine speed sensor
11. Fuel pressure sensor

11.2 Monitoring function description

All of the components listed above are monitored by the OBD system during cold start at least for circuit continuity.

The components with influence on injection and ignition are also monitored by the misfire diagnostic function during the cold start. For all concepts which are not applied to chapter 11.4 a pull-back on ignition retard is allowed only in certain range during a cold start condition. This range will be determined by definition of the maximum value for ignition retard.

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11.3 Parameters of cold start condition

The parameters which determine cold start conditions are:

1. Mass air integral below threshold
2. Engine coolant start temperature within a range
3. Altitude below threshold

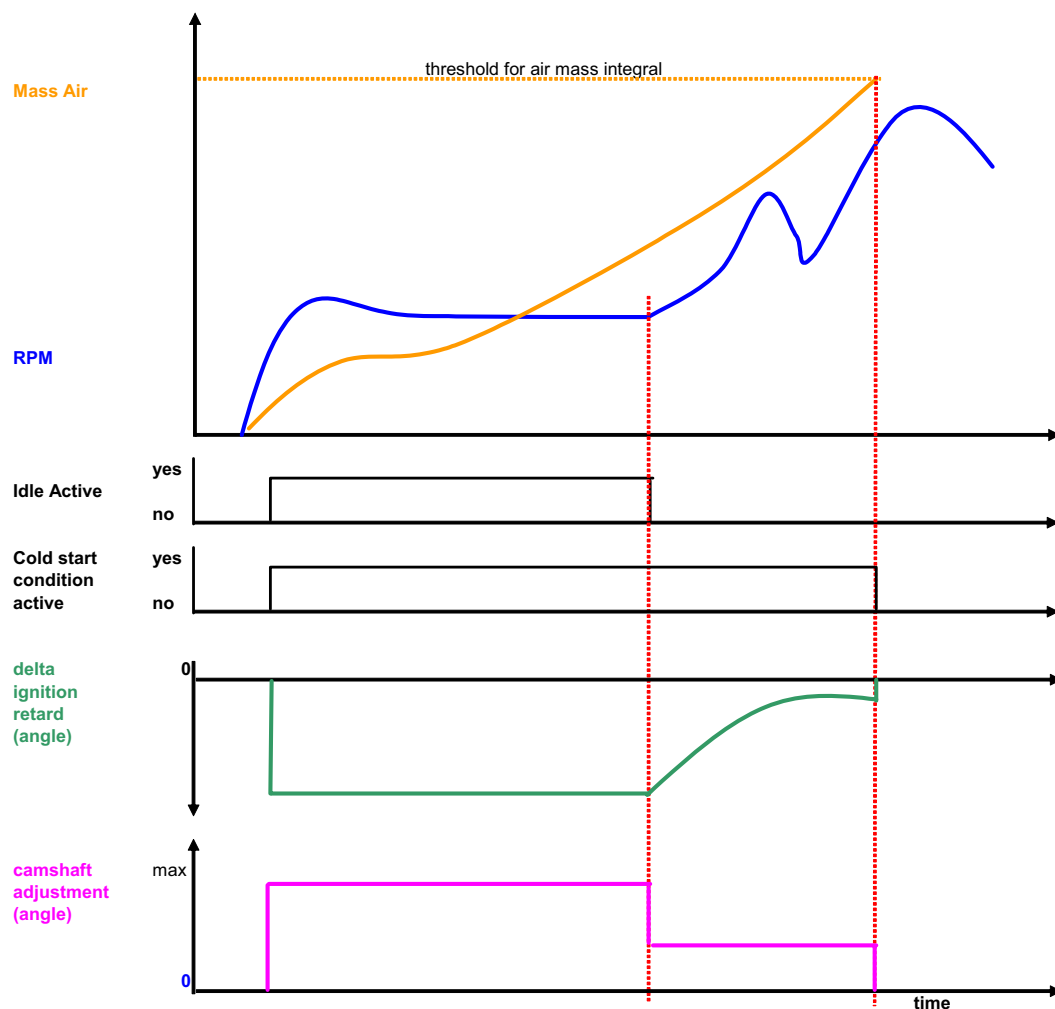


Figure 9: Cold start emission reduction strategy monitoring

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11.4 Ignition timing monitor during cold start

The final ignition timing request is monitored, based on the ignition timing efficiency. Monitoring of final commanded spark timing is based on monitoring spark efficiency during state “catalyst heating active”.

The spark timing monitor will be performed for two different engine operation modes: “idle” and “off-idle” (minimum duration for each mode has to be exceeded).

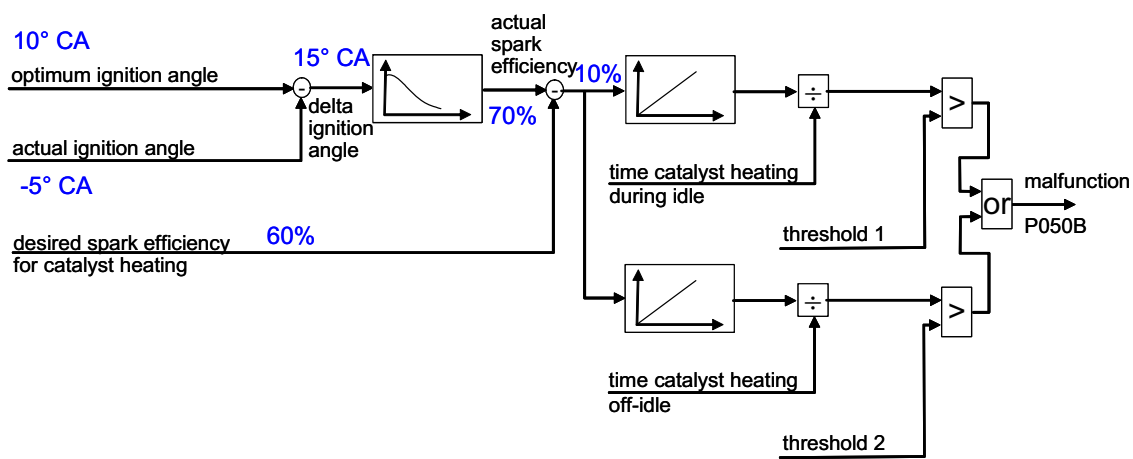


Figure 10: Overview - cold start ignition timing monitor

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11.4.1 Signal Range Fault in Idle Speed Range: P050B

Monitoring Strategy

This monitoring function assesses whether the difference between the actual ignition timing efficiency and the setpoint ignition timing efficiency exceeds an upper defined threshold value in idle speed.

Enable Conditions

- Engine running in idle speed
- Ignition timing retard for catalyst heating is active
- Requested ignition timing efficiency < threshold value (enough spark retard commanded)

Malfunction Criteria

The monitoring function is activated only when the requested ignition timing efficiency is low enough that the monitoring threshold can be exceeded when a malfunction is present.

To detect a fault, the difference between the actual ignition timing efficiency and the setpoint ignition timing efficiency is integrated, and the corresponding time accumulated to generate a quotient of these two values in a later phase. The calculation of the integrator value and the time counter is temporarily stopped when the setpoint ignition timing efficiency exceeds a calibrated threshold value. As soon as the efficiency is again below this threshold value, the integration and the time counter are continued.

When a calibrated minimum dwell time in idle speed is reached and the catalyst heating phase has ended, the value of the quotient described above is determined and used as a basis for assessing faults. When the value of this quotient exceeds a calibrated threshold, a fault is detected.

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Flowchart

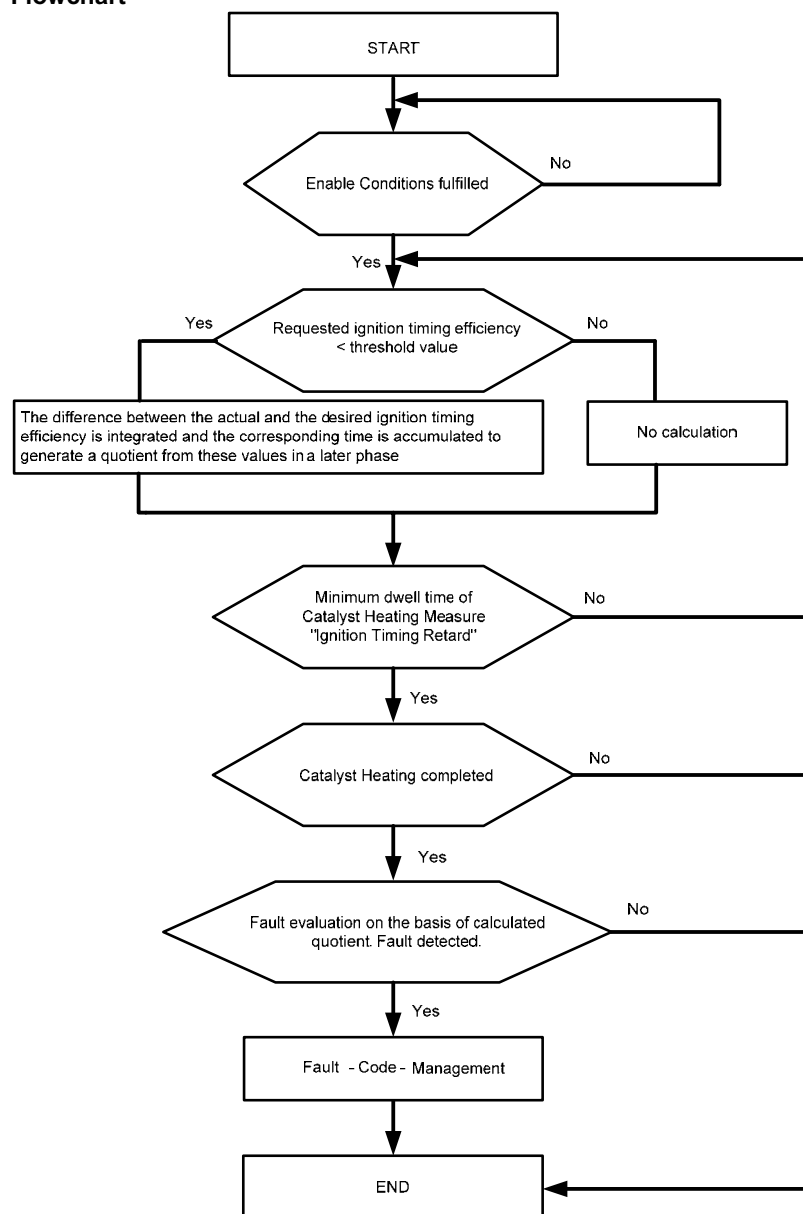


Figure 11: Flow chart ignition timing monitoring - idle speed

In-use monitoring performance ratio

Incrementing the numerator:

The numerator is incremented when the conditions for the defined "idle speed" operating state are fulfilled for longer than a calibratable minimum dwell time, and when the catalyst heating is completed.

Incrementing the denominator:

The denominator is incremented when the conditions for incrementing the general denominator are fulfilled, and when, in accordance with CCR (d) (4.3.2.) (E) (ii), retarded ignition timing for catalyst heating has been active for a cumulative time greater than or equal to ten seconds.

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11.4.2 Signal Range Fault in Off-Idle Operation: P13EA

Applicable only for test groups:

OBD Group Name	Test group	Engine	Models	Standard	Controller / OBD II strategy
BBE-V	BBEXV06.84LA	6.8 V8T - 2 bank	Bentley Mulsanne	LEV II Bin 5	Bosch ME(D)17 BE-V

Monitoring Strategy

This monitoring function assesses whether the difference between the actual ignition timing efficiency and the setpoint ignition timing efficiency exceeds an upper or falls below a lower defined threshold.

Enable Conditions

- Engine running in off-idle
- Ignition timing retard for catalyst heating active
- Requested ignition timing efficiency < threshold value (enough spark retard commanded)

Malfunction Criteria

The monitoring function is activated only when the requested ignition timing efficiency is low enough that the monitoring threshold can be exceeded when a malfunction is present.

To detect a fault, the difference between the actual ignition timing efficiency and the setpoint ignition timing efficiency is integrated, and the corresponding time is accumulated to generate a quotient of these to values in a later phase. The calculation of the integrator value and the time counter are temporarily stopped when the setpoint ignition timing efficiency exceeds a calibrated threshold value. As soon as the efficiency is again below this threshold value, the integration and the time counter are continued.

When a calibrated minimum dwell time in off-idle operation is reached and the catalyst heating phase has been completed, the value of the quotient described above is determined and used as a basis for assessing faults.

When the value of this quotient exceeds a calibrated threshold, a fault is detected.

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Flowchart

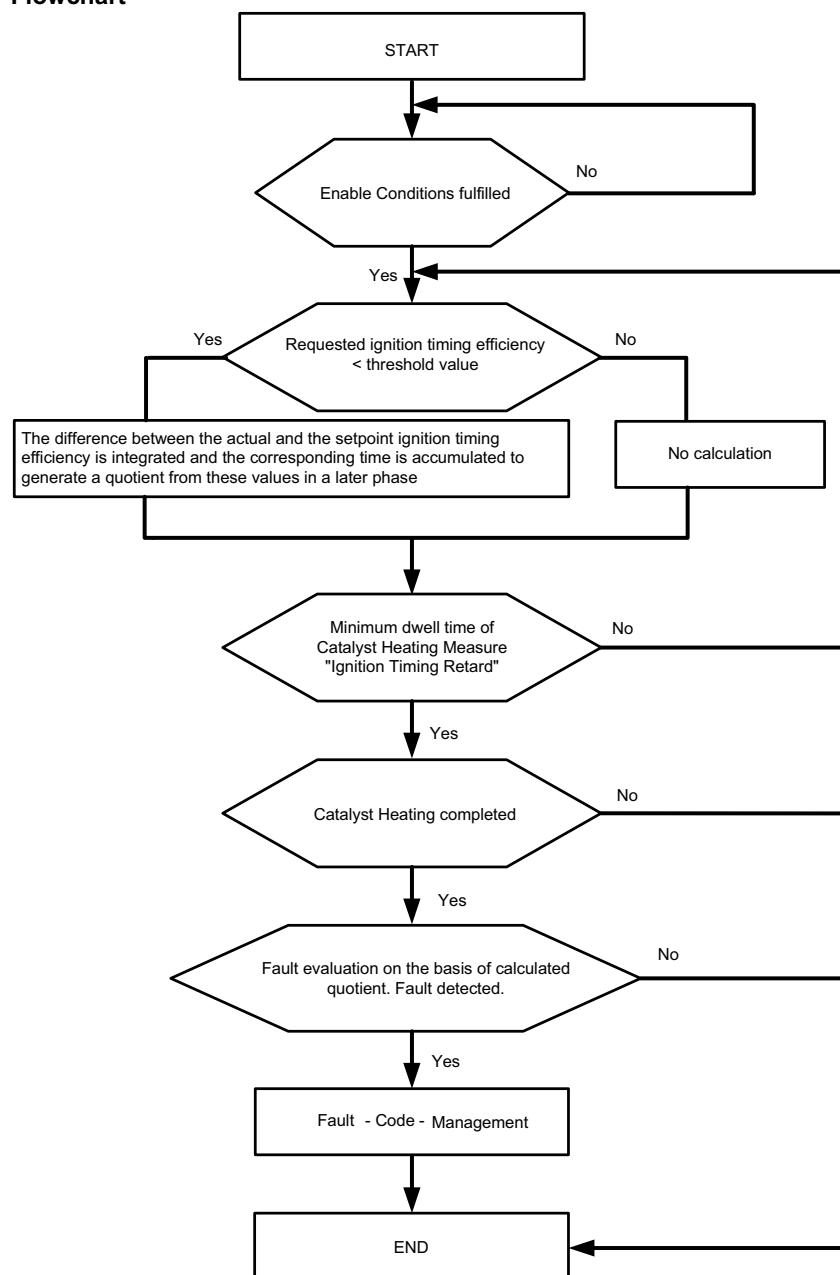


Figure 12: Flow chart ignition timing monitoring – off-idle

In-use monitoring performance ratio

Incrementing the numerator:

The numerator is incremented when the conditions for the defined "off-idle" operating state are fulfilled for longer than a calibratable minimum dwell time, and when catalyst heating is completed.

Incrementing the denominator:

The denominator is incremented when the conditions for incrementing the general denominator are fulfilled, and when, in accordance with CCR (d) (4.3.2.) (E) (ii), retarded ignition timing for catalyst heating has been active for a cumulative time greater than or equal to ten seconds.

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12 AIR CONDITIONING (A/C) SYSTEM COMPONENT MONITORING

Result of presentation at ARB on September, 28th 2004:

12.1 General Description

The engine control module recognizes the air conditioning status (on or off) as a torque request and compensates the engine torque demand accordingly.

The status of the air conditioning system does not result in use of a different strategy regarding ignition or fuel injection.

The components of the air conditioning system are not used for OBD functions and can not disable monitors.

This applies to both separate and integrated climatic control modules. Integrated climatic control modules may be a separated part of the ECM as "box in a box" unit.

12.2 Monitoring Concept

The air conditioning system is not monitored by the OBD II system for the following reasons:

- Sensors of the air conditioning system are not used within OBD as an input signal.
- Actuators of the air conditioning system are not used as an OBD output component.
- Air conditioning system components can not disable any of the OBD monitors.
- Any failure mode of the air conditioning system does not cause exhaust emissions to exceed 1.5 times the applicable standard.
- Possible failures of the air conditioning system may result in reduction or loss of cooling efficiency during SC03. In this case the vehicle runs with lower load and the emission would not increase.

Determination of the influence on exhaust emissions of the air conditioning (AC) under the condition of following failure modes:

1. AC switched/commanded on → AC compressor mechanically disabled

Result:

The FTP 75 / SC03 results are within normal variation on all concepts.

Therefore there is no other strategy used than the mentioned torque compensation.

2. AC switched/commanded off → AC compressor running always

Result:

The FTP 75 results are higher than the comparable results from a FTP 75 conducted according legal requirements caused by additional load. The FTP 75 results do not exceeded the applicable standard.

Therefore the failure modes of the AC do not exceed the criteria of "1.5 times of any applicable standard."

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13 VARIABLE VALVE TIMING AND/OR CONTROL (VVT) SYSTEM MONITORING

13.1 Intake and Exhaust Camshaft Adjustment, Bank 1/2

OBD Group Name	Test group	Engine	Models	Standard	System configuration
BBE-V	BBEXV06.84LA	6.8 V8T - 2 bank	Bentley Mulsanne	LEV II Bin 5	single camshaft adjustment (pushrod actuated)

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13.1.1 General Description

The variable valve timing system allows displacement in a uniform direction of the valve timing of all the valves driven by each camshaft. Therefore the size and position of the valve overlap can be changed on engines with two overhead camshafts and adjusted to the individual gas exchange rate, thereby improving the operating characteristics at part load and full load. On engines with a single camshaft (e.g. OBD Group BBE-V), variable valve timing enables simultaneous adjustment of all valve control events relative to crankshaft.

Intake camshaft adjustment



Exhaust camshaft adjustment

Figure 13: Variable Valve Timing system, VW AG

Monitoring of the camshaft adjustment continuously checks whether the camshaft adjustment angle reaches the setpoint value within a defined period of time following an adjustment request. At this point a distinction is made between two fault types: "camshaft adjustment too slow" and "camshaft adjustment setpoint value not attained".

13.1.2 Camshaft Adjustment Slow Response, P000A/P000B/P000C/P000D

Intake side, bank 1: P000A; intake side, bank 2: P000C

Exhaust side, bank 1: P000B; exhaust side, bank 2: P000D

Monitoring Strategy

The difference between the setpoint value and the actual value of the camshaft adjustment angle is compared against a threshold value at a defined point in time.

Enable Conditions

- Modeled oil temperature within a defined range
- Engine speed greater than threshold value
- Time after engine start greater than threshold value

Malfunction Criteria

If all enable conditions are fulfilled, a continuous comparison of setpoint and actual values will detect an adjustment request. If the difference between the setpoint and actual value exceeds a defined angle, the two values are stored. After a defined time interval the setpoint and actual values are compared again. If the difference between setpoint and actual values still exceeds a defined angle, a fault is diagnosed.

The setpoint values are continuously monitored from the time an adjustment request is detected until the fault diagnosis produces a result. If an adjustment request leads to a reversal of direction during this period, the current monitoring is canceled and restarted at the next adjustment request. If a fault is detected, the type of fault is determined after a defined monitoring period has elapsed. The actual value at the start of the monitoring

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is compared against the actual value at the end of the monitoring period. If the difference between the two actual values is greater than a defined threshold value, the fault "camshaft adjustment too slow" (slow response) is detected. If the threshold value is not exceeded, the fault "camshaft adjustment setpoint value not attained" (target error) is detected.

A fault is registered in the fault memory only if the fault has occurred a defined number of times, as ascertained by means of a fault counter that registers the monitoring results "camshaft adjustment too slow" and "camshaft adjustment setpoint value not attained". Following a fault entry the fault counter is reset.

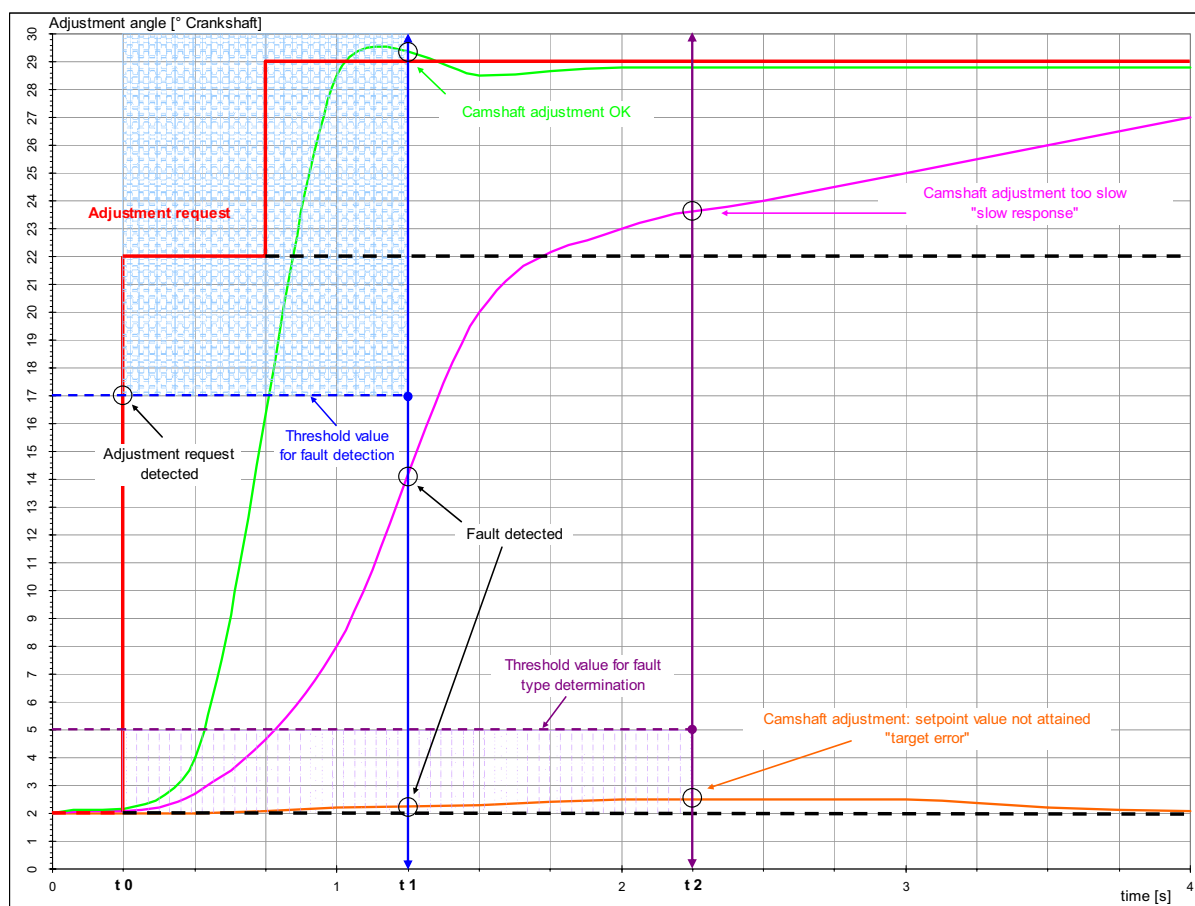


Figure 14: Camshaft adjustment monitoring mode of operation

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Flowchart

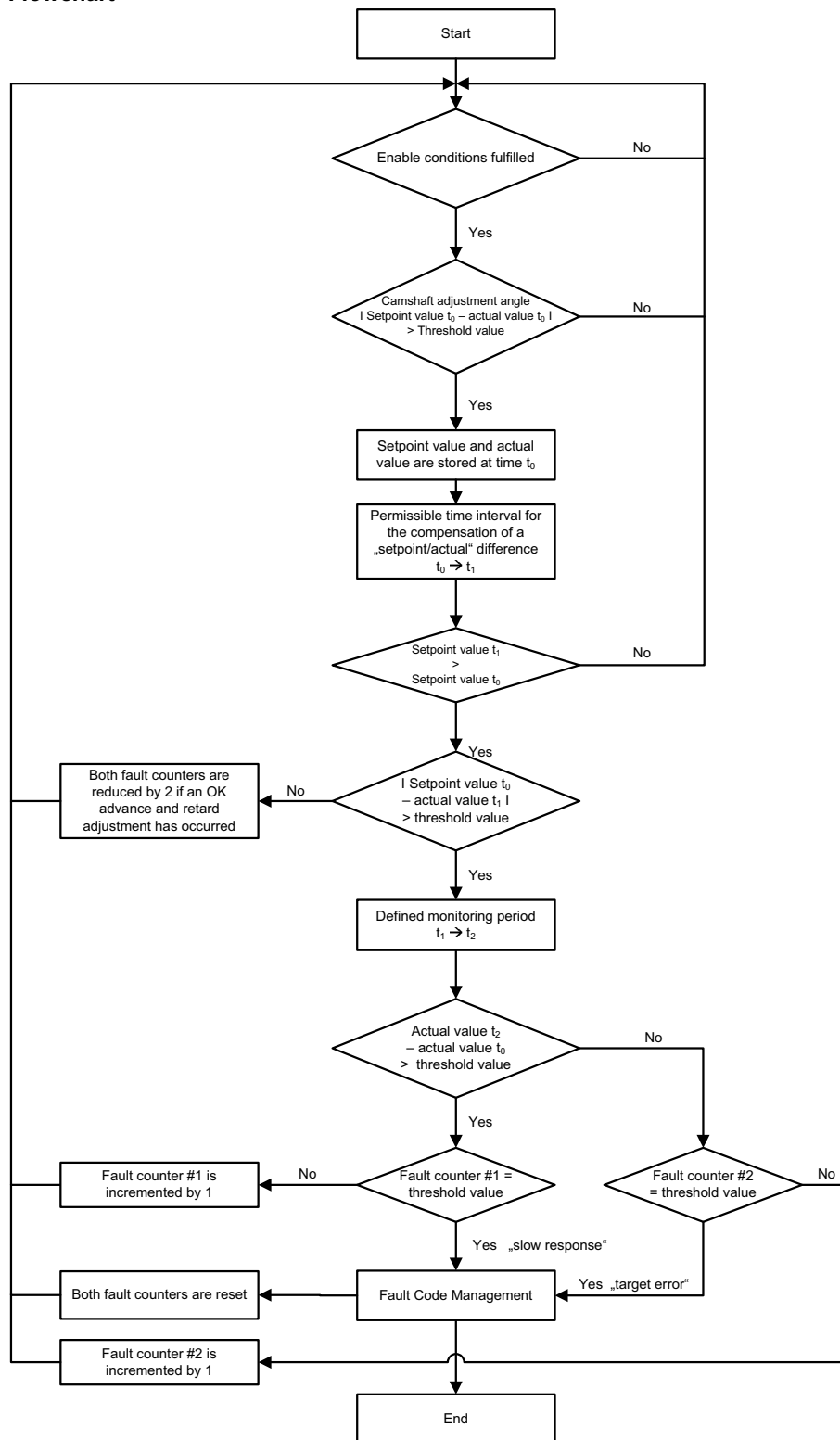


Figure 15: Flowchart of camshaft adjustment monitoring

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In-Use Monitor Performance Ratio

Numerator:

The numerator is incremented by one after the cycle flag of the camshaft adjustment monitoring is set.

Denominator:

The denominator is incremented by one when the conditions for incrementing the general denominator according to CCR (d) (4.3.2.) (F) (ii) are fulfilled and the camshaft is changed by a defined value cumulatively for 10 s or twice for 2 s.

13.1.3 Camshaft Adjustment Target error, P0011/P0014/P0021/P0024

Intake side, bank 1: P0011; intake side, bank 2: P0021;
Exhaust side, bank 1: P0014; exhaust side, bank 2: P0024;

Monitoring Strategy

The difference between the setpoint value and the actual value of the camshaft adjustment angle is compared against a threshold value at a defined point in time.

Enable Conditions

- Modeled oil temperature within a defined range
- Engine speed greater than threshold value
- Time after engine start greater than threshold value

Malfunction Criteria

Monitoring of the camshaft adjustment continuously checks whether the camshaft adjustment angle reaches the setpoint value within a defined period of time following an adjustment request. At this point a distinction is made between two fault types: "camshaft adjustment too slow" and "camshaft adjustment setpoint value not attained".

If all enable conditions are fulfilled, a continuous comparison of setpoint and actual values will detect an adjustment request. If the difference between setpoint and actual values exceeds a defined angle, the two values are stored. After a defined time interval the setpoint and actual values are compared again. If difference between the setpoint and actual values still exceeds a defined angle, a fault is diagnosed.

The setpoint values are continuously monitored from the time an adjustment request is detected until the fault diagnosis produces a result. If an adjustment request leads to a reversal of direction during this period, the current monitoring is canceled and restarted at the next adjustment request. If a fault was detected, the type of fault is determined after a defined monitoring period has elapsed. The actual value at the start of the monitoring is compared against the actual value at the end of the monitoring period. If the difference between the two actual values is greater than a defined threshold value, the fault "camshaft adjustment too slow" (slow response) is detected. If the threshold value is not exceeded, the fault "camshaft adjustment setpoint value not attained" (target error) is detected.

A fault is registered in the fault memory only if the fault has occurred a defined number of times, as ascertained by means of a fault counter that registers the monitoring results "camshaft adjustment too slow" and "camshaft adjustment setpoint value not attained". Following a fault entry the fault counter is reset.

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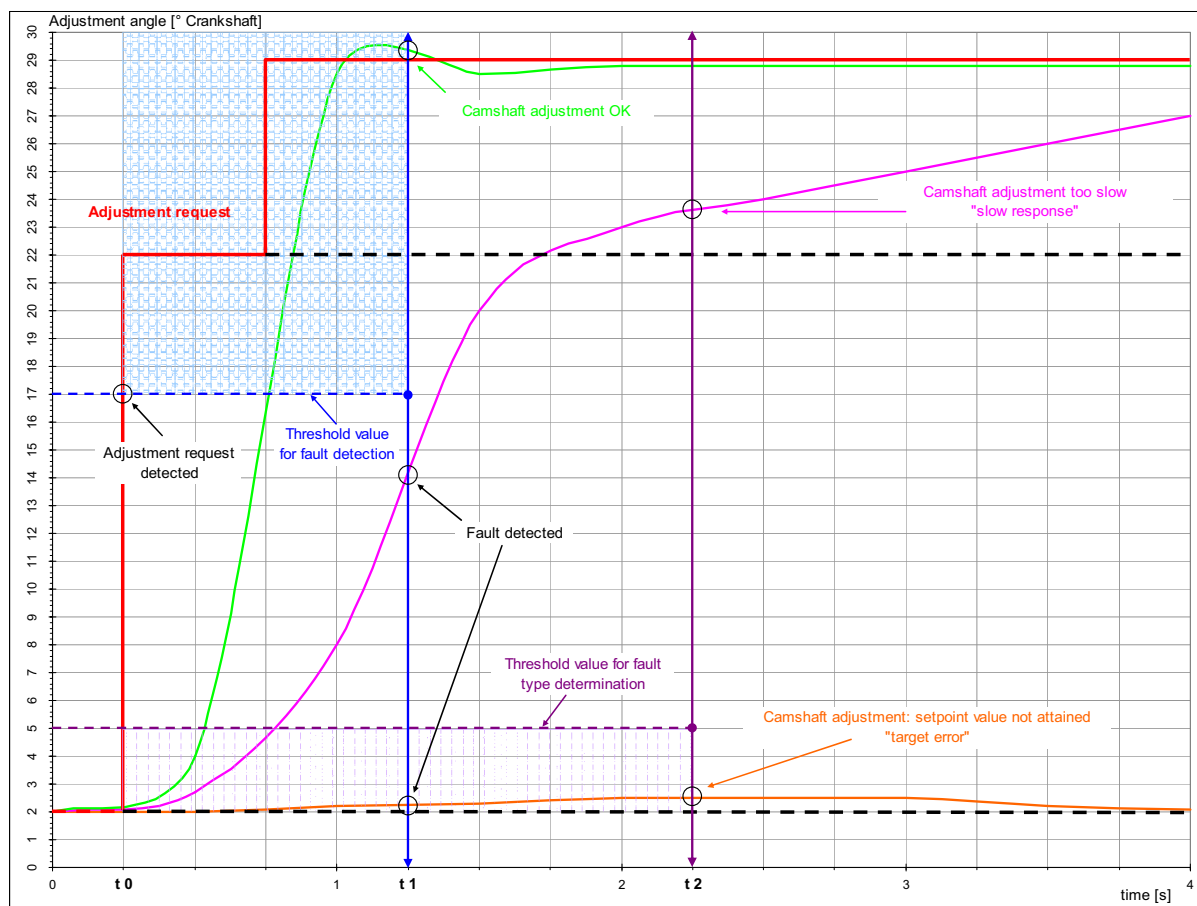


Figure 16: Camshaft adjustment monitoring mode of operation

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Flowchart

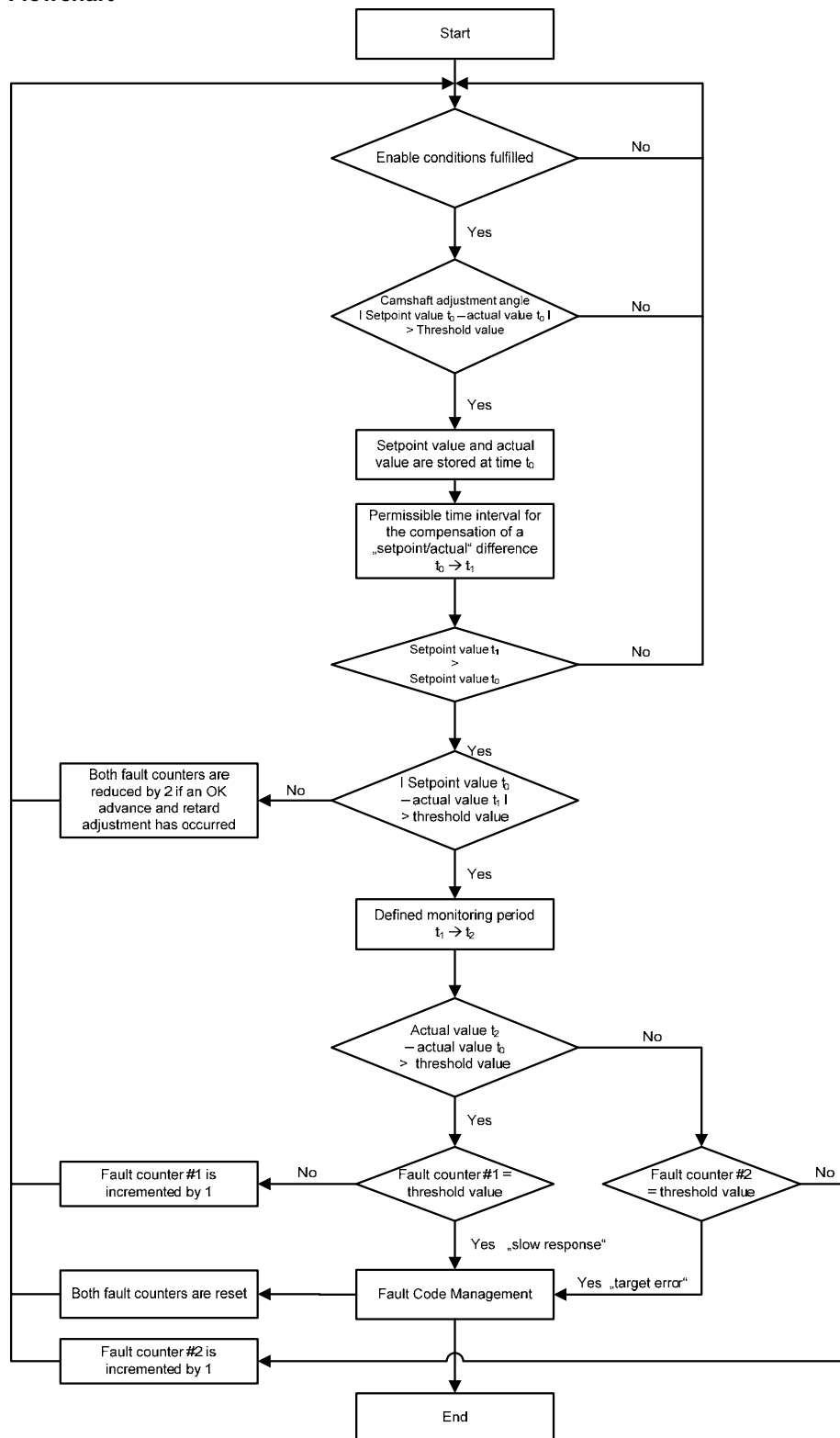


Figure 17: Flowchart of camshaft adjustment monitoring

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In-Use Monitor Performance Ratio

Numerator:

The numerator is incremented by one after the cycle flag of the camshaft adjustment monitoring is set.

Denominator:

The denominator is incremented by one when the conditions for incrementing the general denominator according to CCR (d) (4.3.2.) (F) (ii) are fulfilled and the camshaft is changed by a defined value cumulatively for 10 s or twice for 2 s.

13.2 VVT system monitoring during cold start

The camshaft control is monitored by the camshaft timing monitoring function.

This function monitors whether the actual camshaft positions are close enough to the setpoint positions for the catalyst heating phase.

Signal Range Fault

Intake Side, Bank 1: P052A; Intake Side, Bank 2: P052C

Outlet Side, Bank 1: P054A; Outlet Side, Bank 2: P054C

Monitoring Strategy

This monitoring function assesses whether the difference between the actual camshaft position and the setpoint camshaft position exceeds an upper or falls below a lower defined threshold value for longer than a defined time period.

Enable Conditions

- Engine running
- Camshaft control activated
- Commanded camshaft timing correction for catalyst heating is active

Malfunction Criteria

A malfunction is detected when the camshaft actuator is blocked and the camshaft will not reach a setpoint value within a defined time period. To this purpose, the difference between the setpoint value and the actual value of each camshaft is compared to a calibrated threshold value which is determined based on the engine speed and the modeled oil temperature.

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Flowchart

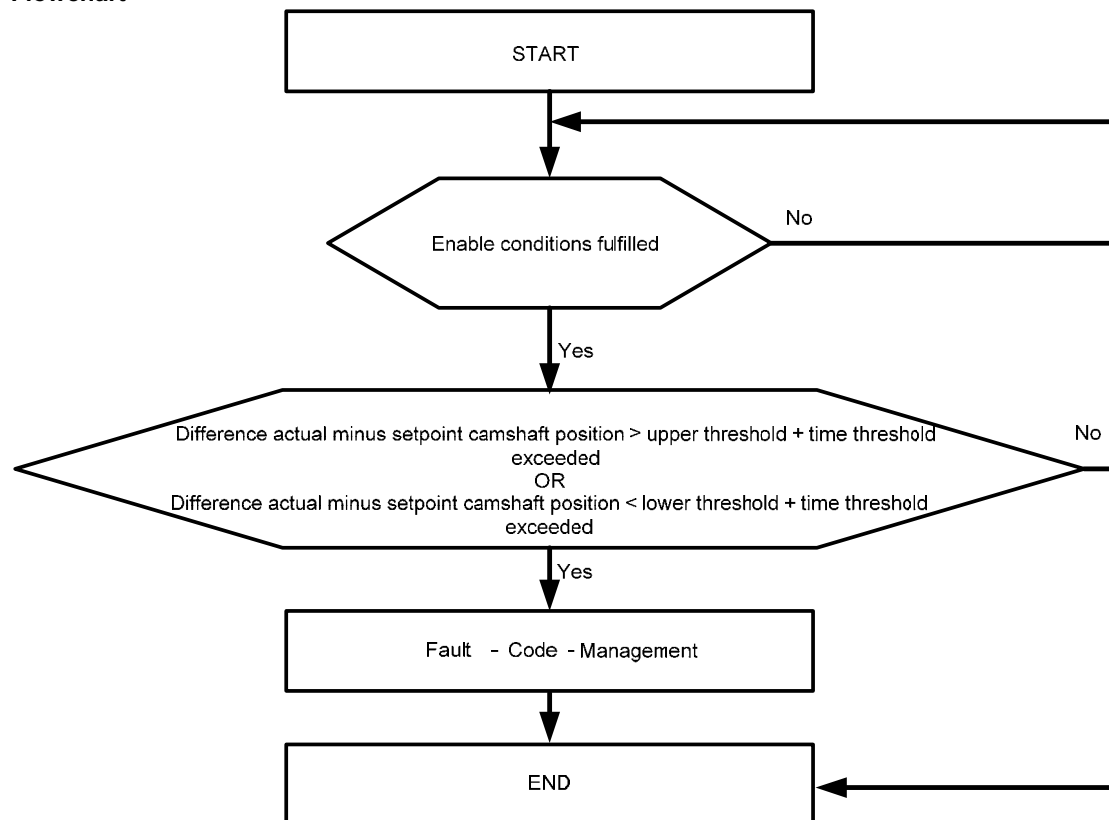


Figure 18: Flow chart camshaft monitoring, signal range

In-Use Monitoring Performance Ratio

Incrementing the Numerator:

The numerator is incremented when the engine is running, the camshaft control is activated, the catalyst heating phase is active, and the defined minimum waiting time of the diagnostic has elapsed.

Incrementing the Denominator:

The denominator is incremented when the conditions for incrementing the general denominator are fulfilled, and when, in accordance with CCR (d) (4.3.2.) (E) (ii), the commanded camshaft timing correction for catalyst heating has been active for a cumulative time greater than or equal to ten seconds.

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14 COMPREHENSIVE COMPONENTS MONITORING

14.1 Injection valve

Check is performed while using 15.24 Output Stage Check

14.2 Ignition coil

Check is performed while using 15.24 Output Stage Check

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14.3 Idle Speed Control

14.3.1 Idle Speed Control (warm engine)

14.3.1.1 General Description

The idle speed should be as constant as possible under any operating condition. It should be set so as to allow a fast throttle response while also maintaining optimum exhaust gas emission levels and fuel consumption. The idle speed control regulates the air mass provided to the engine at idle speed.

14.3.1.2 Engine Speed Less Than Setpoint Value – P0506

Monitoring Strategy

The difference between the setpoint engine idle speed and the actual engine idle speed is compared against a calibrated threshold value.

Enable Conditions

- Vehicle speed = 0 km/h
- Engine running at idle speed (accelerator pedal angle = 0)
- Altitude < 2700 m above sea level
- Engine temperature > threshold value
- Intake air temperature > threshold value

Malfunction Criteria

If the engine speed remains below the threshold value for longer than a defined time period, a fault is detected. A "low engine speed" fault is present if the difference between the setpoint engine speed and the actual engine speed remains greater than a positive threshold value for longer than a defined time period and if the integrator of the idle speed control has reached its maximum.

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Flowchart

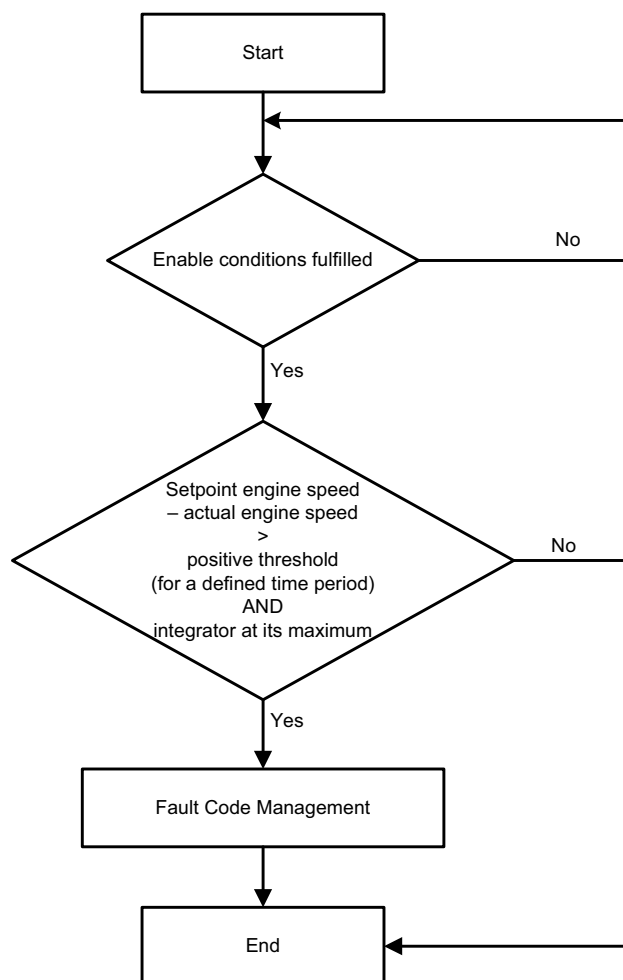


Figure 19: Engine speed below setpoint value – P0506

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14.3.1.3 Engine Speed Greater Than Setpoint Value – P0507

Monitoring Strategy

The difference between the setpoint engine idle speed and the actual engine idle speed is compared against a calibrated threshold value.

Enable Conditions

- Vehicle speed = 0 km/h
- Engine running at idle speed (accelerator pedal angle = 0)
- Altitude < 2700 m above sea level
- Engine temperature > threshold value
- Intake air temperature > threshold value

Malfunction Criteria

If the engine speed remains greater than the threshold value for longer than a defined time period, a fault is detected. An "engine speed too high" fault is present if the difference between the setpoint engine speed and the actual engine speed remains below a negative threshold value for longer than a defined time period and if the integrator of the idle speed control has reached its minimum.

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Flowchart

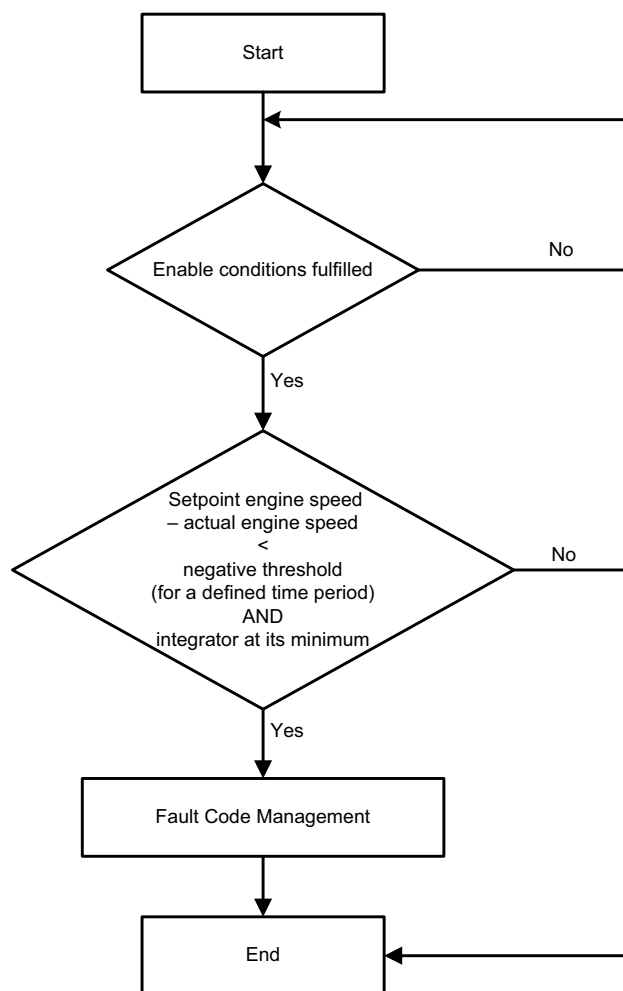


Figure 20: Engine speed greater than setpoint value – P0507

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14.3.1.4 Rationality Fault – P0506

Monitoring Strategy

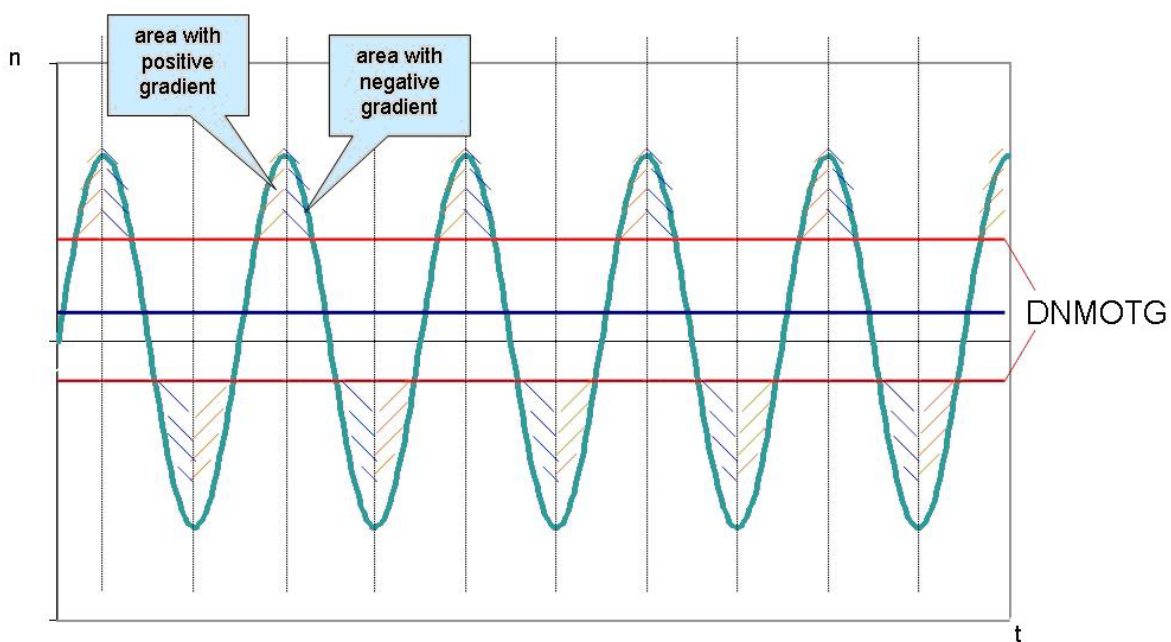
Monitoring for engine surges or impermissible engine speed oscillations

Enable Conditions

- Vehicle speed = 0 km/h
- Engine running at idle speed (accelerator pedal angle = 0)
- Altitude < 2700 m above sea level
- Engine temperature > threshold value
- Intake air temperature > threshold value

Malfunction Criteria

A rationality fault is detected when engine speed oscillations greater than the setpoint idle speed oscillation repeatedly occur and the total sum of the areas formed by these positive and negative engine speed gradients exceeds a calibrated threshold (see illustration below).



DNMOTG: Setpoint idle speed oscillation

Figure 21: Fault detection of engine surges or engine speed oscillations - rationality fault

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Flowchart

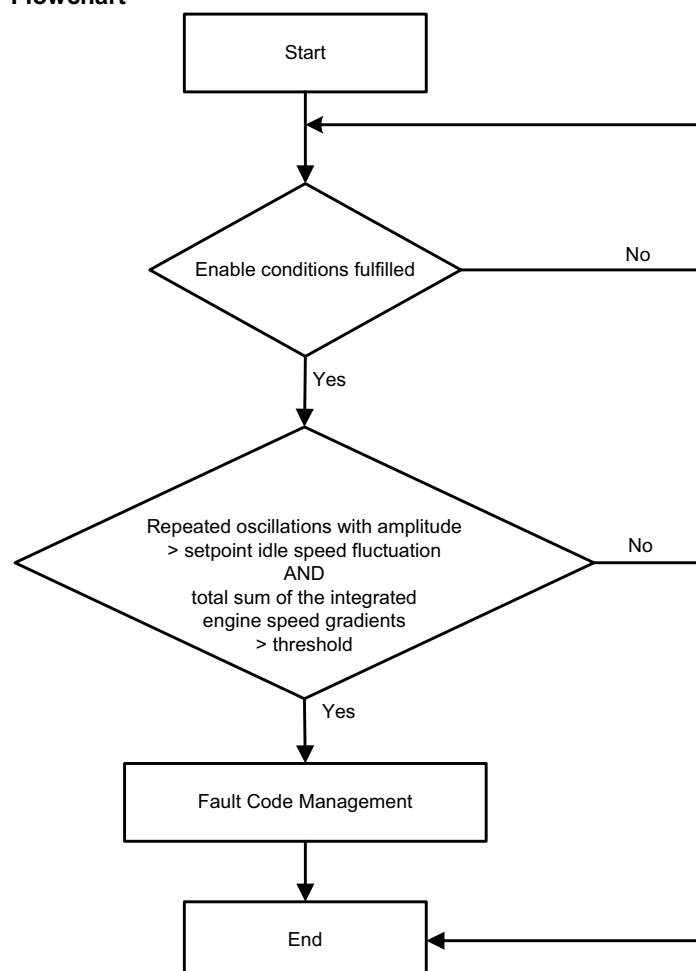


Figure 22: Rationality fault – P0506

In-Use Monitor Performance Ratio

Incrementing the numerator

The numerator is incremented when the dwell time at idle speed that would be necessary for the integration part of the idle controller to reach its maximum given an existing fault has elapsed and the additional waiting period of the diagnostic has elapsed.

Incrementing the denominator

The denominator is incremented when the conditions for incrementing the general denominator in accordance with CCR (d) (4.3.2.) (E) (ii)) are fulfilled.

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14.3.2 Idle control check during cold start

The idle speed increase helps the catalyst reach its operating temperature faster by completing more combustion cycles per time unit than in normal idle speed and thus achieving higher mass air flow rates.

14.3.2.1 Signal Range Fault: P050A

Monitoring Strategy

The engine speed must not exceed the upper threshold value or fall below the lower threshold value for longer than a defined time period.

Enable Conditions

- Altitude less than 2700 meters above sea level
- Engine running in idle speed (accelerator pedal position = 0)
- Vehicle speed = 0
- catalyst heating active

Malfunction Criteria

A malfunction is detected when the engine speed exceeds the upper or falls below the lower threshold value for longer than the defined time period. An overspeed malfunction is detected when the difference between the actual engine speed and the setpoint engine speed exceeds the upper threshold value for longer than a defined time period.

An underspeed malfunction is detected when the difference between the actual engine speed and the setpoint engine speed falls below the lower threshold value for longer than a defined time period.

Flowchart

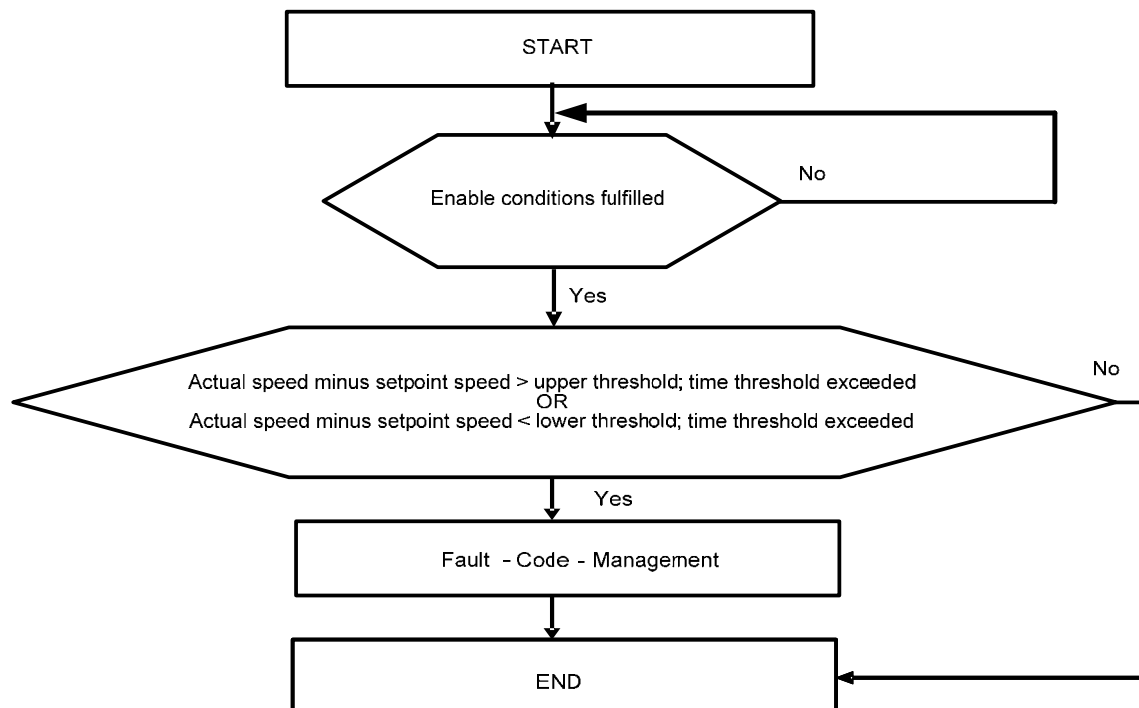


Figure 23: Flow chart catalyst-heating idle speed increase, signal range fault

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In-use monitoring performance ratio

Incrementing the numerator

The numerator is incremented when the dwell time in idle speed that would be necessary for the integration part of the idle controller to reach its maximum in case of an existing fault, has elapsed, and the additional waiting period of the diagnostic has passed.

Incrementing the denominator

The denominator is incremented when the conditions for incrementing the general denominator are fulfilled, and when, in accordance with CCR (d) (4.3.2.) (E) (ii), the commanded idle speed increase for catalyst heating has been active for a cumulative time greater than or equal to ten seconds.

14.3.2.2 Rationality Fault: P050A

Monitoring Strategy

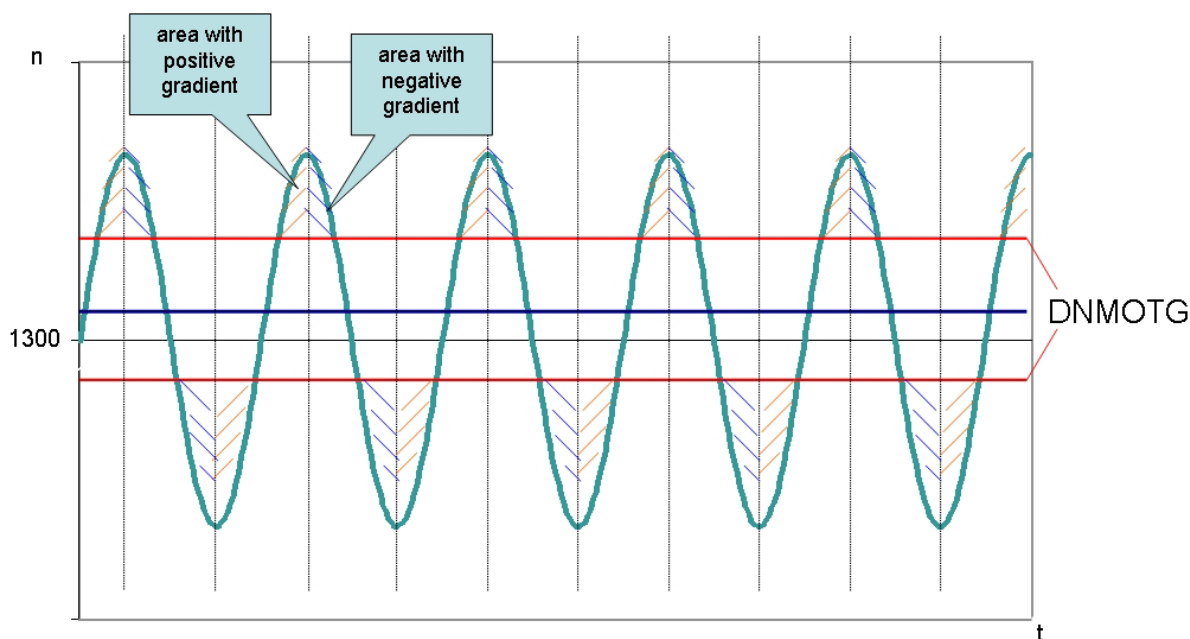
Monitoring for engine surge or impermissible engine speed oscillations

Enable Conditions

- Altitude less than 2700 meters above sea level
- Engine running in idle speed (accelerator pedal position = 0)
- Vehicle speed = 0
- Commanded idle speed increase for catalyst heating is active

Malfunction Criteria

A rationality fault is detected when engine speed oscillations greater than the setpoint idle speed fluctuation permanently occur and the total sum of the areas formed from these positive and negative engine speed gradients exceed a calibratable threshold (see illustration below).



DNMOTG: setpoint idle speed fluctuation

Figure 24: Catalyst-Heating Idle Speed Increase, Rationality Fault

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Flowchart

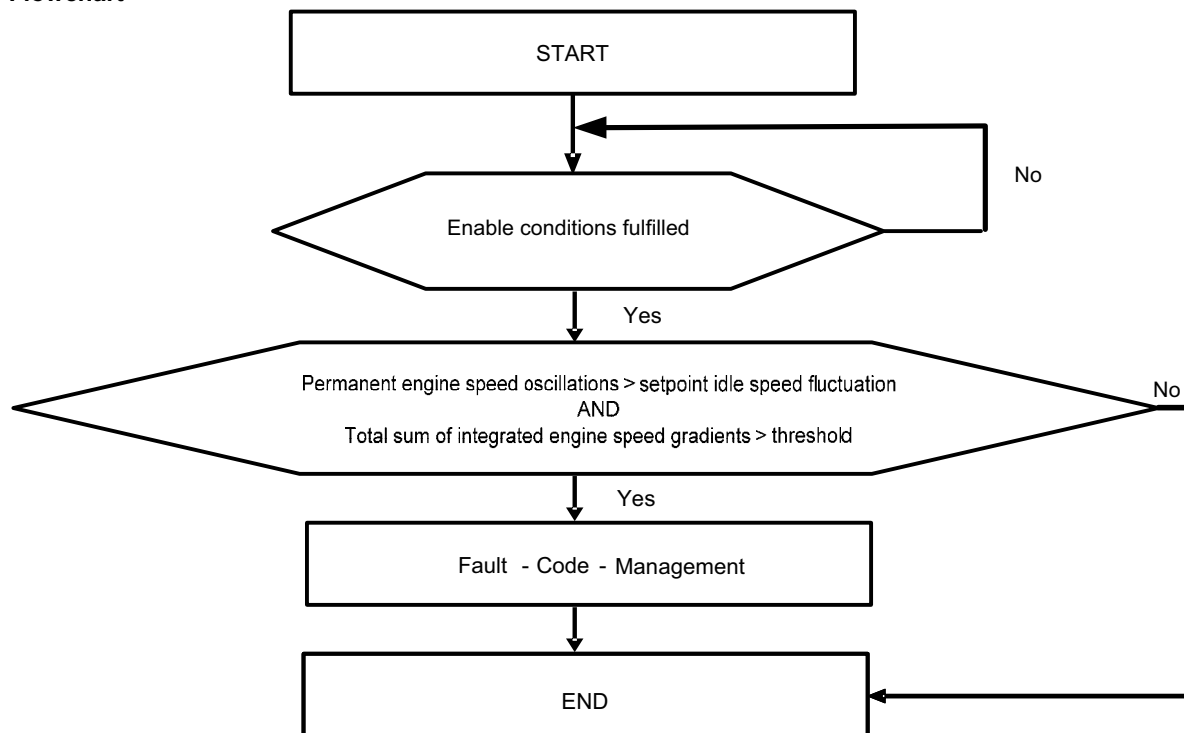


Figure 25: Flowchart Catalyst-Heating Idle Speed Increase, Rationality Fault

14.4 Engine speed sensor

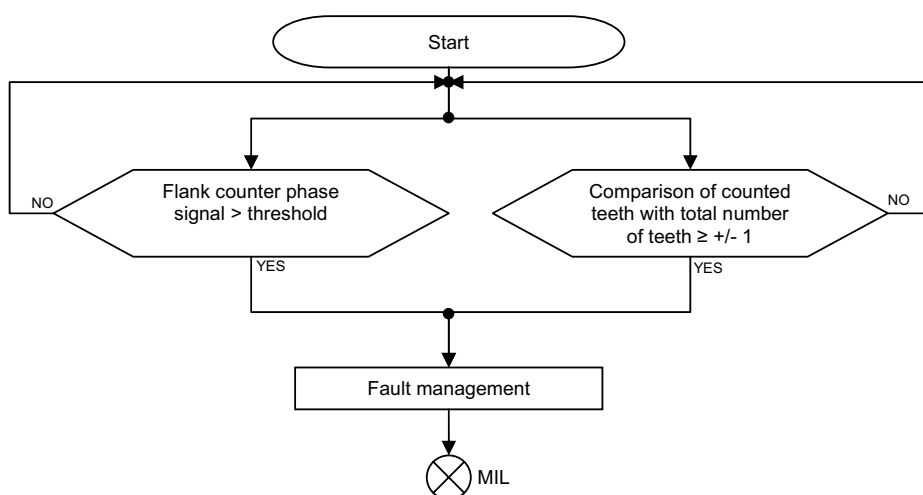


Figure 26: Flow chart engine speed sensor

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14.5 Signal range check for input sensor

Refer to Input / Output table in applicable OBD Group submission for list of sensors.

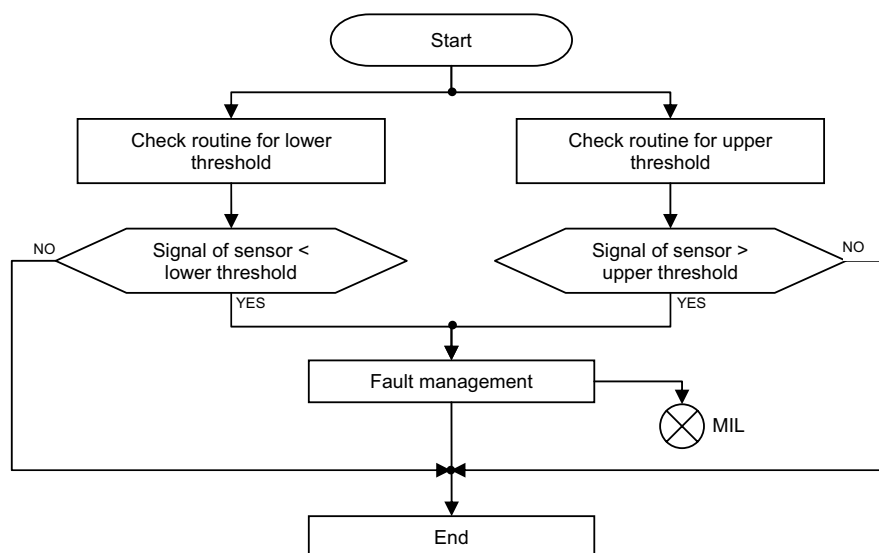


Figure 27: Flow chart signal range check for input sensor

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14.6 Mass air flow sensor monitoring (MAF) - Twin MAF Sensor System

Applicable only for test group

OBD Group Name	Test group	Engine	Models	Standard	Controller / OBD II strategy
BBE-V	BBEXV06.84LA	6.8 V8T - 2 bank	Bentley Mulsanne	LEV II Bin 5	Bosch ME(D)17 BE-V

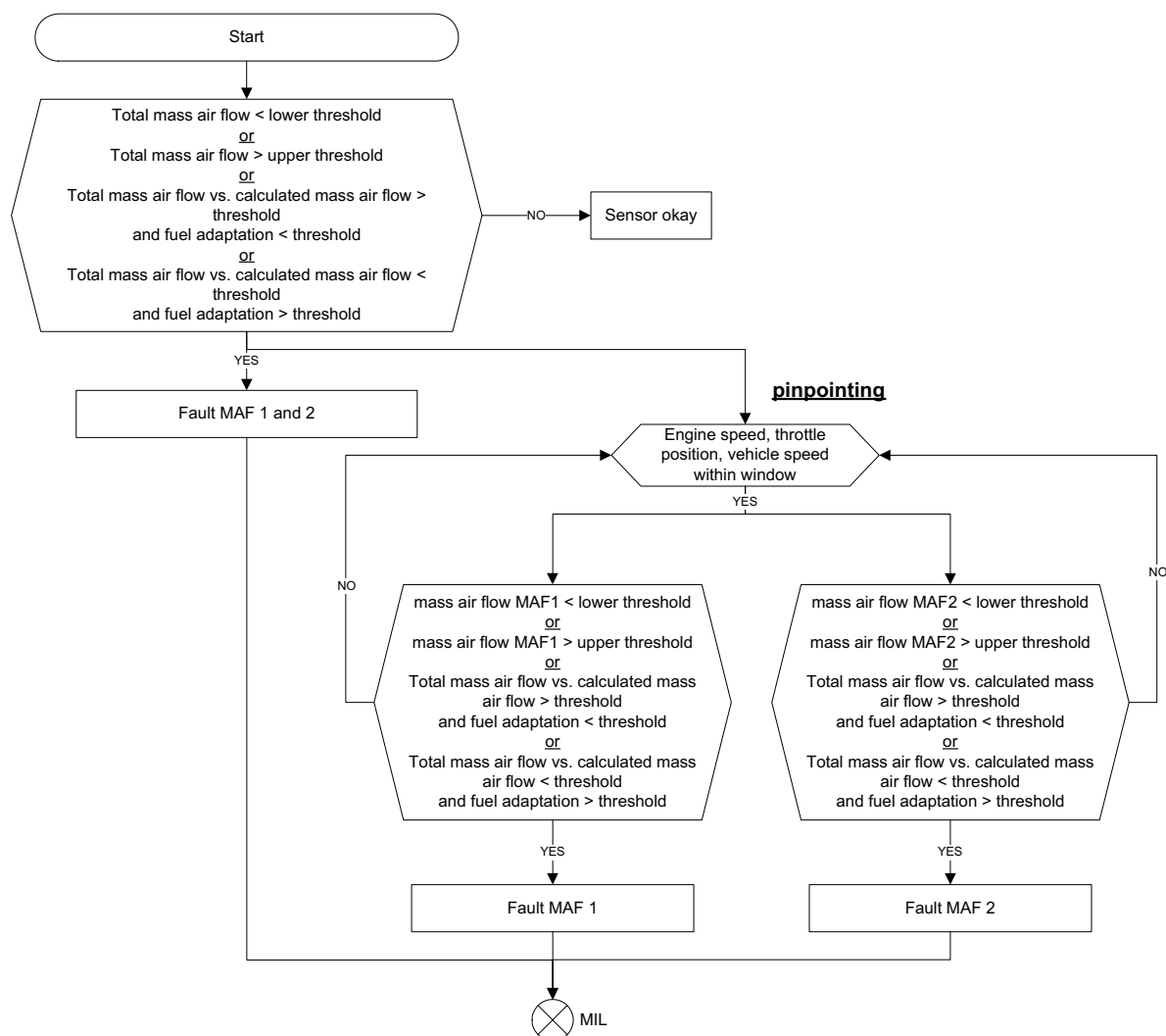


Figure 28: Flow chart MAF rationality monitoring (twin MAF sensor system)

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14.6.1 Additional checks for Twin MAF Sensor, Single Throttle Body System

Applicable only for test group

OBD Group Name	Test group	Engine	Models	Standard	Controller / OBD II strategy
BBE-V	BBEXV06.84LA	6.8 V8T - 2 bank	Bentley Mulsanne	LEV II Bin 5	Bosch ME(D)17 BE-V

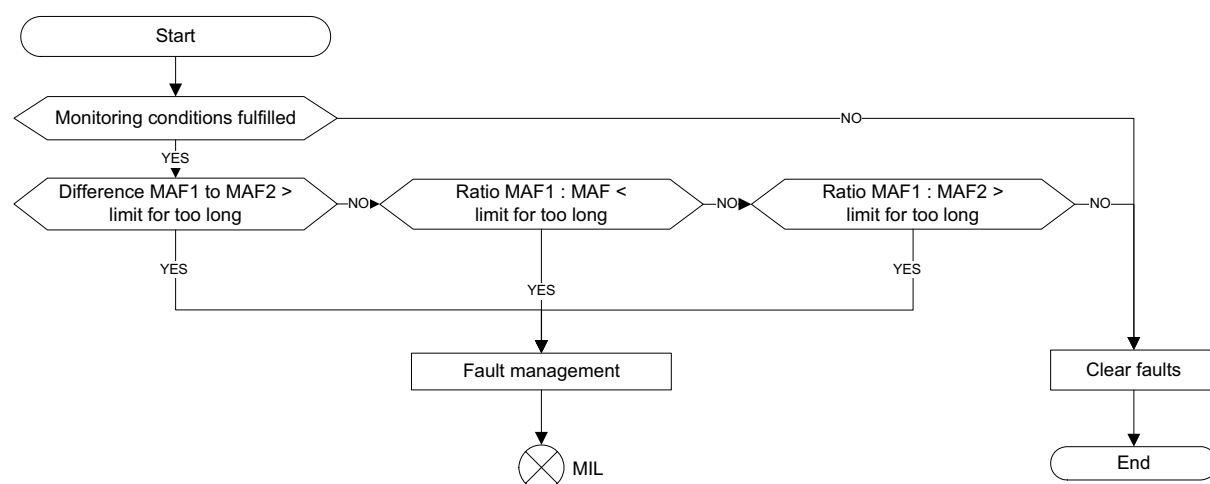


Figure 29: Flow Chart: Unbalanced Signal Check of MAF Sensors

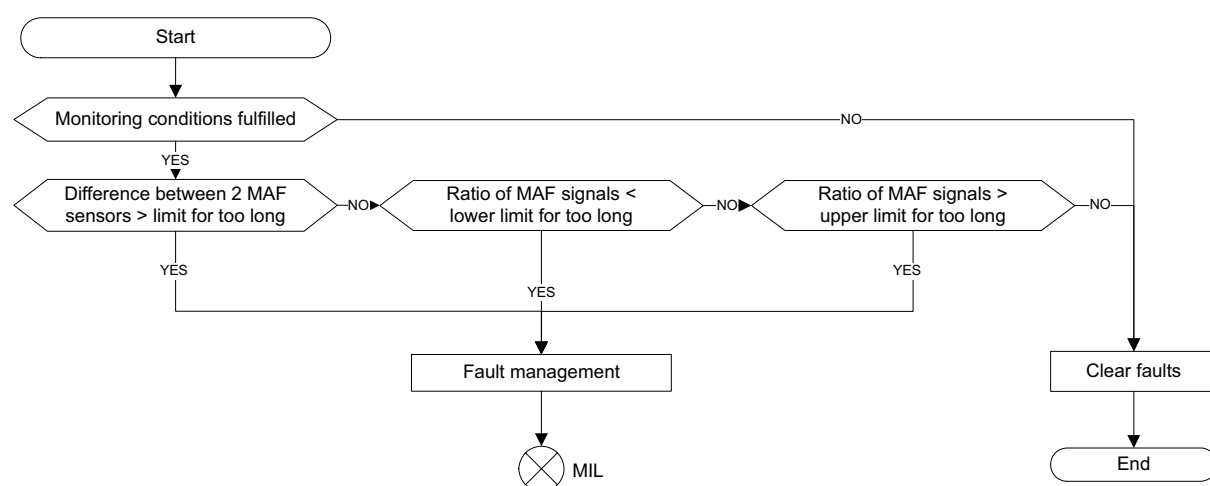


Figure 30: Flow chart cross check of mass air flow sensors

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14.6.2 Correlation Air temperature intake manifold/ MAF intake air

General description

The main parts, that belong to the cross check, are shown in Figure 49.

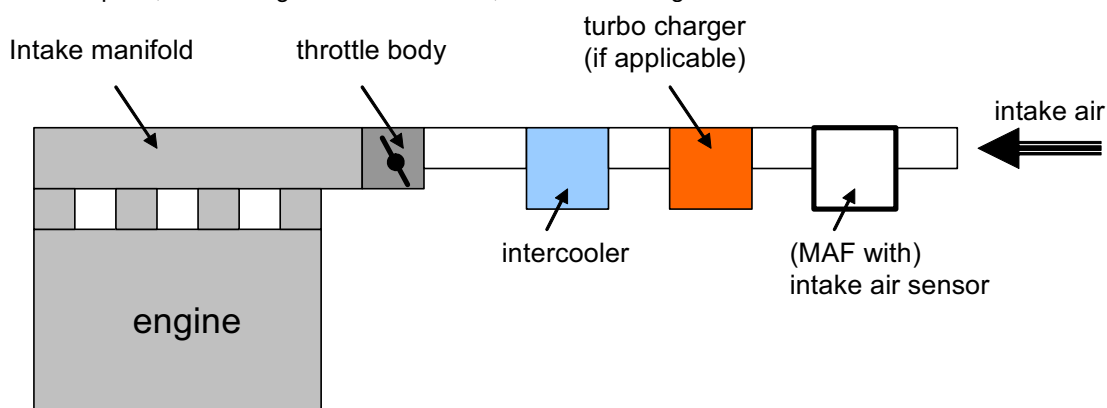


Figure 31: Overview - main parts for cross check

To run a cross check it is necessary to compare the two temperature signals during the cold start. In this case the MAF air temperature and intake manifold air temperature have to be in an sufficient range.

Monitor structure

In case that the difference between MAF air temperature and the intake manifold air temperature is to big during a cold-start, the monitoring system detects a "correlation fault" between these both sensor signals.

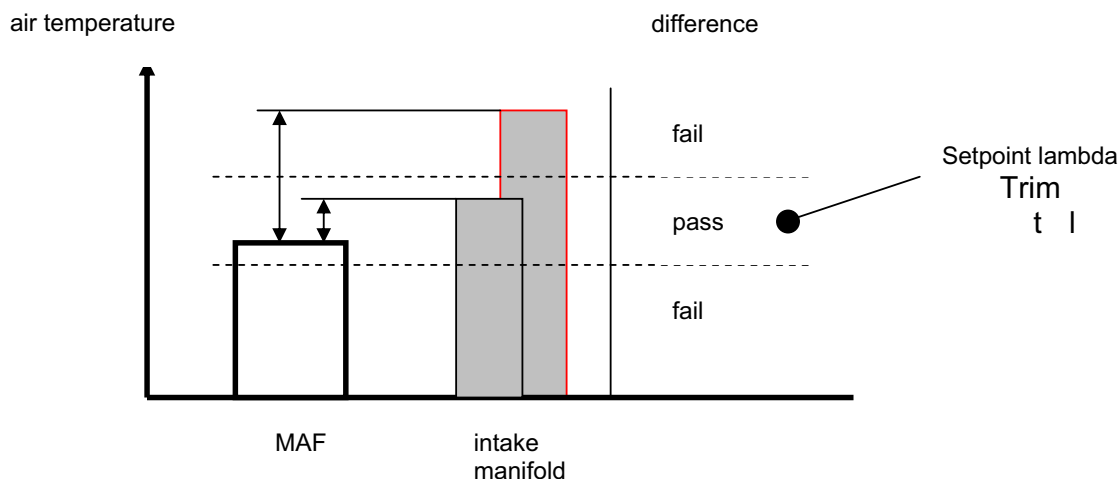


Figure 32: Correlation air temperature intake manifold / MAF intake air

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Flowchart

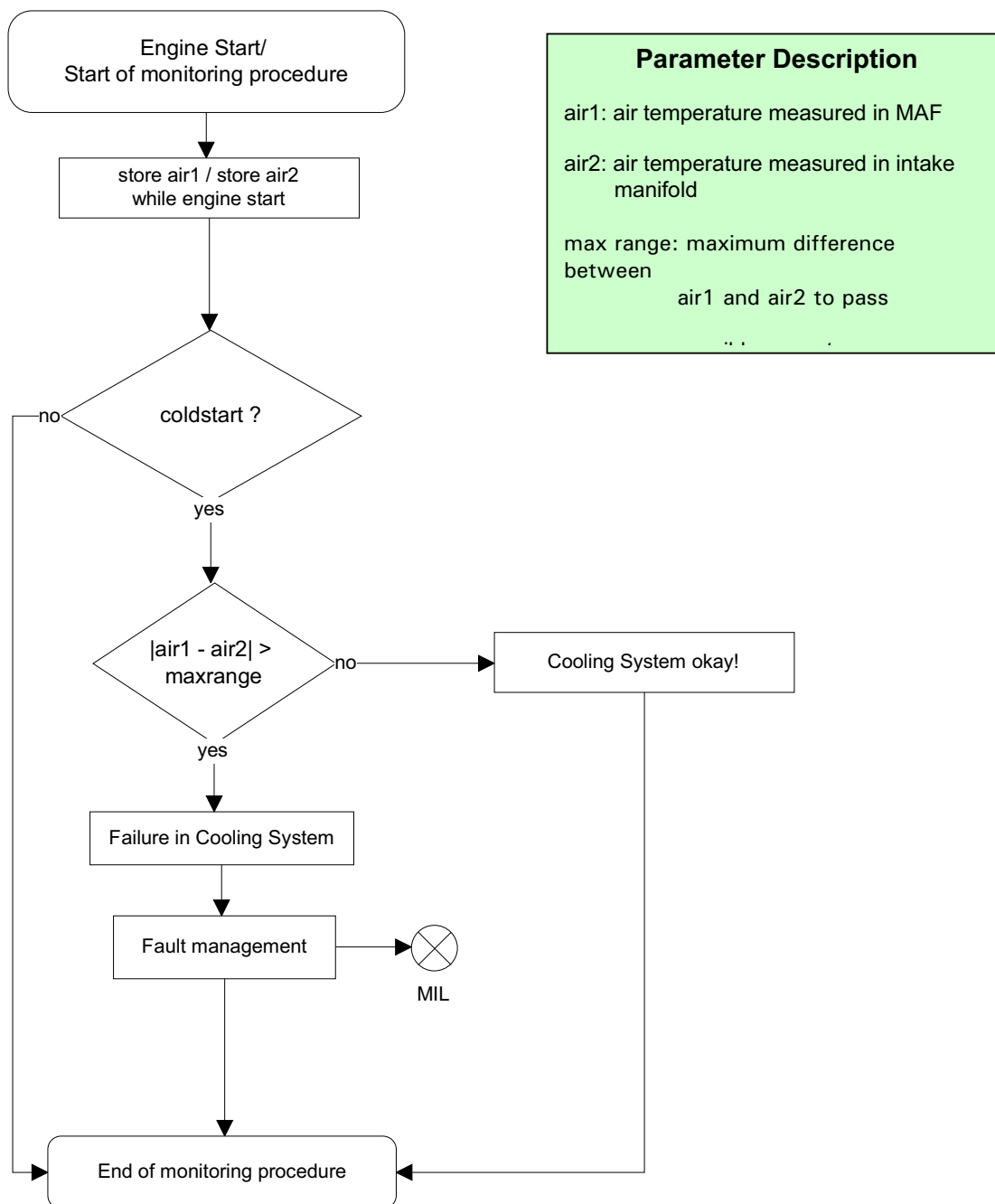


Figure 33: Flow chart - correlation air temperature intake manifold / MAF intake air

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14.7 Manifold absolute pressure sensor monitoring (MAP)

Applicable only for test groups

OBD Group Name	Test group	Engine	Models	Standard	Controller / OBD II strategy
BBE-V	BBEXV06.84LA	6.8 V8T - 2 bank	Bentley Mulsanne	LEV II Bin 5	Bosch ME(D)17 BE-V

14.7.1 General description

The manifold absolute pressure sensor (MAP sensor) is monitored over the entire working range for electrical and rationality failures. The rationality monitor of the manifold absolute pressure (MAP) sensor consists of three different and independent checks.

- Check at engine start
- Threshold model check
- Adaptation value check

The MAP sensor is used for the engine load calculation and any deviation of the sensor might cause a Lambda deviation, which is compensated by the Lambda adaptation, being monitored by the fuel system diagnostic. If none of the MAP sensor specific monitors detects an error although a higher deviation of the MAP sensor is present, the fuel system diagnostic will detect this failure finally before emissions exceed the applicable OBD thresholds.

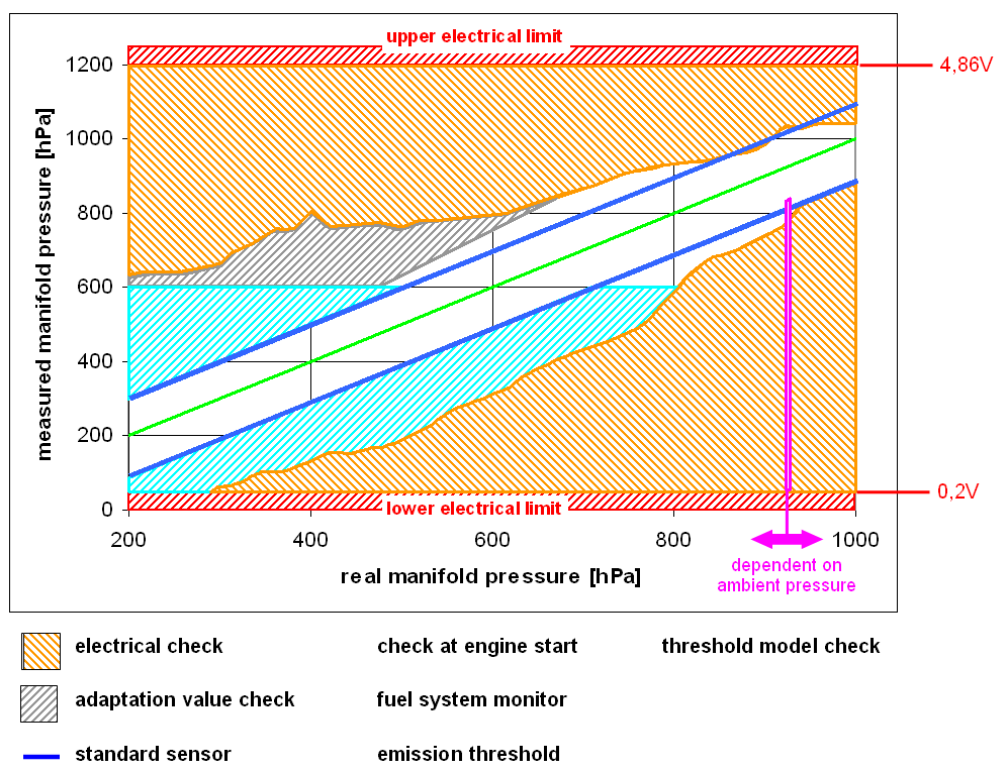


Figure 34: Overview - detection of MAP-sensor failures through different checks

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Figure 52 shows the entire working range of the MAP sensor and identifies the monitoring functions for failure detection. The working ranges of the different monitoring function overlap each other. The check with the quickest failure detection is shown here.

14.7.2 Monitoring function description

MAP sensor electrical monitor

A fault code is stored, if the measured voltage of the MAP sensor exceeds applicable limits (e.g. lower than 0.2 V or higher than 4.86 V) for an applicable time (e.g. one second). The electrical monitoring functions are enabled with key-on.

MAP sensor check at engine start

With “key-on” and while engine is cranking, the manifold absolute pressure is compared with the ambient pressure. A malfunction is detected if the manifold absolute pressure at “key-on” is below the ambient pressure minus the tolerances (e.g. 60 hPa) of both sensors (MAP and AMP).

The monitor runs once in a driving cycle during the first engine revolutions and only up to a calibrated time after engine start (e.g. 25 seconds).

To ensure that the monitoring function is not influenced by a manifold being still evacuated due to a fast engine restart, the time after last engine stop has to be greater than a calibrated value (e.g. 5 seconds).

To ensure stable monitoring conditions a “normal” engine start is necessary. An engine start is “normal” if manifold pressure difference at “key-on” compared to that at “engine start” (engine speed greater than calibrated value (e.g. 330 rpm) must be less than a calibrated value (e.g. 300 hPa).

This monitoring function is disabled caused by failures in the following systems

- Manifold absolute pressure sensor electrical circuit
- Intake air temperature
- Ambient pressure sensor
- Camshaft position sensor
- Throttle

This check may be disabled by other errors too, please refer to the “DTC Inhibitor List” for the specific OBD group or test group.

MAP sensor threshold model check

The ‘model check’ continuously calculates a minimum and maximum threshold model for manifold absolute pressure based on the actual values of mass airflow, throttle valve angel, camshaft position and ambient pressure. The calculation of the model takes into account the tolerances of all parts, which can influence the manifold absolute pressure. All physical effects influencing the measured manifold pressure (e.g. pulsation) are integrated, hence the actual maximum or minimum threshold model values represents the highest or lowest pressures of a normal functioning system respectively, with highest tolerances in the corresponding direction at the actual engine operation point.

If the measured value from the MAP sensor exceeds one of the modelled threshold values for a calibrated period of time (e.g. 2 seconds), a malfunction is detected and a fault code is stored.

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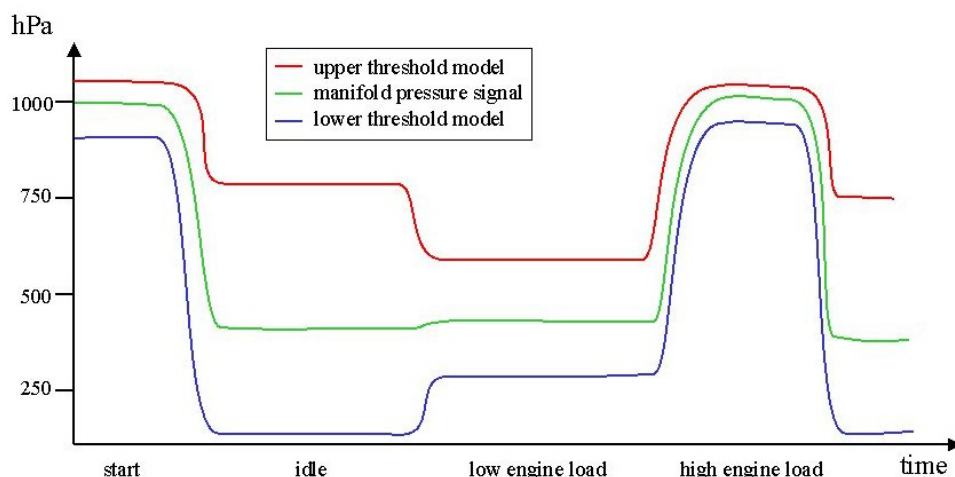


Figure 35: Principal functionality of the threshold model check

The threshold model check is enabled after a calibrated number of camshaft revolutions (e.g. 10 revolutions) to ensure proper engine running.

The threshold model check is disabled due to an error in the following systems

- Manifold absolute pressure electrical circuit
- Intake air temperature
- Ambient pressure sensor
- Camshaft position sensor
- Throttle

This check may be disabled by other errors too, please refer to the “DTC Inhibitor List” for the specific OBD group or test group.

Failure detection is possible over the entire range of engine load. In order to prevent a false error healing, a passing result of the diagnostic is only possible in the upper engine load ranges as indicated in figure above.

The normalised difference is calculated continuously according to:

$$\text{normalized difference} = \frac{\text{upper threshold} - \text{lower threshold}}{\text{upper threshold} + \text{lower threshold}}$$

This threshold is usually reached at average partial load or during accelerations. When the value falls below the threshold for the first time in a driving cycle, the numerator is incremented. The error detection is possible at any time and independent of the normalised difference.

MAP sensor adaptation value check

At low intake manifold pressures, the intake manifold pressure model must take large tolerances into account particularly for the throttle valve. To run the diagnostics, it must be ensured that the influence of other disturbance variables is minimised. For this purposes an adaptation value check is implemented. A defective intake manifold pressure sensor is learnt by the adaptation as an offset. This offset must be distinguished from a leakage in the intake manifold as well as from various tolerances with large mass flow rates (e.g. ambient pressure sensor tolerances, camshaft tolerances, etc.).

For this, three operating ranges with the following mass air flows are compared:

- Throttle valve model
- Intake manifold model

The deviation is learnt by the adaptation using a different value for every operating range.

Within a given adaptation range the main influence on the mass air flow is given by the components as follows:

Range 1: Throttle valve

Range 2: Intake manifold pressure sensor

Range 3: Ambient pressure sensor

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The adaptation values are calculated for diagnostic purposes only. They are always taken into account for all engine operating ranges of mass air flow calculation from the throttle valve model. They have no influence on the engine load calculation from MAP-sensor.

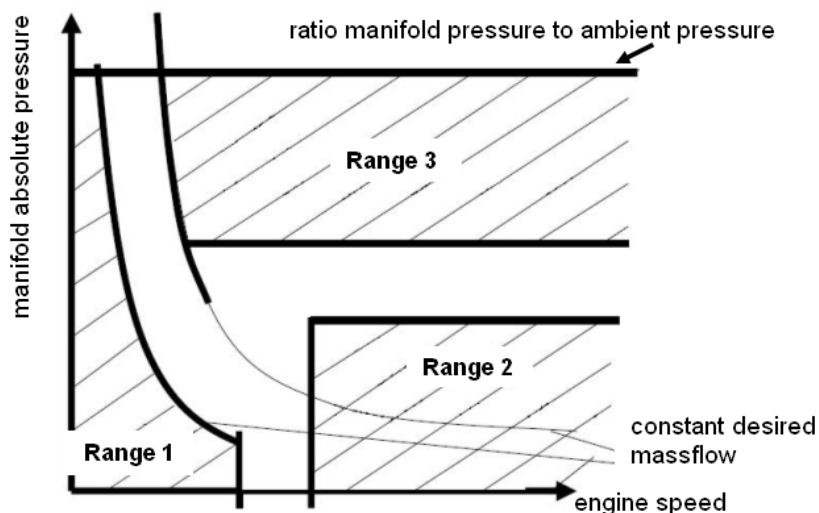


Figure 36: chart of three adaptation ranges to separate different influences

Separated adaptation ranges are necessary in order to determine the influences of an error on different adaptation values.

In the ranges, the following effects have a dominant influence:

Range 1: Leakage in the intake manifold

At the same throttle valve angel, the mass air flow rate calculated for the intake manifold sensor increases while the mass flow rate from the throttle valve remains constant. At higher mass air flow rates, the magnitude of a leakage on the entire mass air flow decreases.

Range 2: manifold pressure sensor error

A deviation of the intake manifold sensor has a constant influence on the mass air flow calculation from the pressure sensor signal. The relative influence is greater at lower intake manifold pressures. In operating "range 2", a pressure sensor deviation differs from a leakage in the intake manifold. In this range, detection of a manifold absolute pressure sensor error is possible.

Range 3: Influence caused by tolerances of the ambient pressure sensor, camshaft, etc.

With greater mass air flow rates through the throttle valve, the influences of tolerances for the ambient pressure sensor and the camshafts affect the mass flow rate calculations significantly. The magnitude of leakages and small pressure sensor deviations decreases at higher mass air flow rates.

The physical incorporation of the values allows the system to adapt to the individual influences in accordance with their physical effect and therefore allows a distinction between the individual influences

The adaptation of a value is conducted as follows:

As long as the enable and operating conditions are met for an adaptation value within a dedicated range, the actual deviation of both mass flow rates is learnt for the relevant adaptation value. The time counter is running in parallel while the adaptation is carried out. Once a calibrated time (such as 1 second / 8 seconds / 5 seconds) has elapsed for each range, the system evaluates the change in the adaptation value. If the change is minimal (e.g. 0.1 kg/h or 3 hPa), the adaptation value is reliable. The "adaptation counter" for a successful adaptation within the actual range is increased, if the counters of the other ranges are greater than or equal to the actual counter. This ensures that an evaluation of the adaptation values is carried out only, if the areas were run separately and the adaptation values in every range have been stabilised.

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The adaptation sequence for the first adaptation in a driving cycle is predefined (range1, 2, 3). Only if the adaptation value in the previous ranges is reliable, the subsequent range can be adapted. This prevents unnecessary adaptation of deviations for the mass air flow rates by tolerances affecting all operating ranges.

If the change in the adaptation values within the time period is larger than a calibrated value (e.g. greater than 0.4 kg/h or 10hPa), all counters are reset and the entire adaptation process is started again from the beginning. This is necessary to ensure that all adaptation areas are reactivated if large deviations occur suddenly before the evaluation of the adaptation values is completed.

The adaptation value from "range 2" is monitored to evaluate the intake manifold sensor. To ensure that all influences are separated into the relevant adaptation values, an evaluation is valid only, if the adaptation counters of all ranges exceeding a calibrated value (e.g. 2).

In case the adaptation value exceeds during the evaluation in "range 2" the failure thresholds (e.g. ± 60 hPa), an error is detected.

The time counters are only restarted upon the predetermined period length has elapsed.

For adaptation in any range the following conditions have to be fulfilled:

- Time after engine start > applicable value (e.g. 1 s)
- No "wide-open throttle" engine operating point
- EVAP purge valve check not active
- No fuel cut off
- Manifold pressure ratio to ambient pressure < applicable value (e.g. 0.85)
- Engine speed in range (e.g. 500-6000 rpm)
- Throttle not under "high stress" *
- Manifold pressure plus adaptation value > applicable value (optional parameter)
- No evacuation of brake booster to manifold (optional)

* "High stress" to the throttle is defined as follows:

Following "high stress" operation of the engine, deviations in the mass flow rates may occur due to the thermal expansions causing modified flow behaviour of the throttle valve. This may lead to false failure detection. In this case the adaptation is interrupted for an applicable time following "high stress" engine operation (e.g. for 20 s). "High stress" is given if engine speed and engine load are above a certain threshold (e.g. 3000 rpm with 60% load) for an applicable time (e.g. 60 s).

Temporary interruptions (e.g. < 1 s) to the conditions defining "high stress" are ignored.

The ranges are defined by the following conditions:

Range 1:

- Desired mass flow in range (e.g. 5-25 kg/h)
- Engine speed below applicable value (e.g. < 800 rpm)

Range 2:

- Engine speed above applicable value (e.g. > 1400 rpm)
- Manifold pressure plus adaptation value below applicable value (e.g. < 425 hPa)

Range 3:

- Desired mass flow above applicable value (e.g. > 40 kg/h)
- Manifold pressure plus adaptation value above applicable value (e.g. > 550 hPa)

The adaptation value check is disabled due to an error in the following systems:

- Manifold absolute pressure electrical circuit
- Throttle valve

This check may be disabled by other errors too, please refer to the "DTC Inhibitor List" for the specific OBD group or test group.

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Error management MAP sensor monitoring

If one of the three plausibility checks detects an error, the plausibility monitor stores a fault code.

Since the '**threshold model check**' and the '**adaptation value check**' allow incrementing of the IUMPR numerator, it is just incremented once in a driving cycle.

In-Use Monitoring Performance (IUMPR)

The adaptation value stabilisation may require a longer time for the adaptation phase based on the actual engine operating condition in customer's hand. For this reason the "adaptation and time counters" are doubled ("Shadow Counters") to trigger incrementing of the numerator according to the "worst case duration" of the adaptation process.

As required for a successful adaptation within a specific range, the IUMPR related "time counters" are individually calibrated for each adaptation range (e.g. 5 seconds / 20 seconds/ 17 seconds). If the IUMPR related "adaptation counters" exceed their individually calibrated value (e.g. 5), incrementing of the numerator is allowed.

The "shadow counter" calibration accounts for the possible "adaptation counter reset event" caused by greater (implausible) changes in the adaptation value.

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14.7.3 Flow charts manifold absolute pressure sensor monitoring

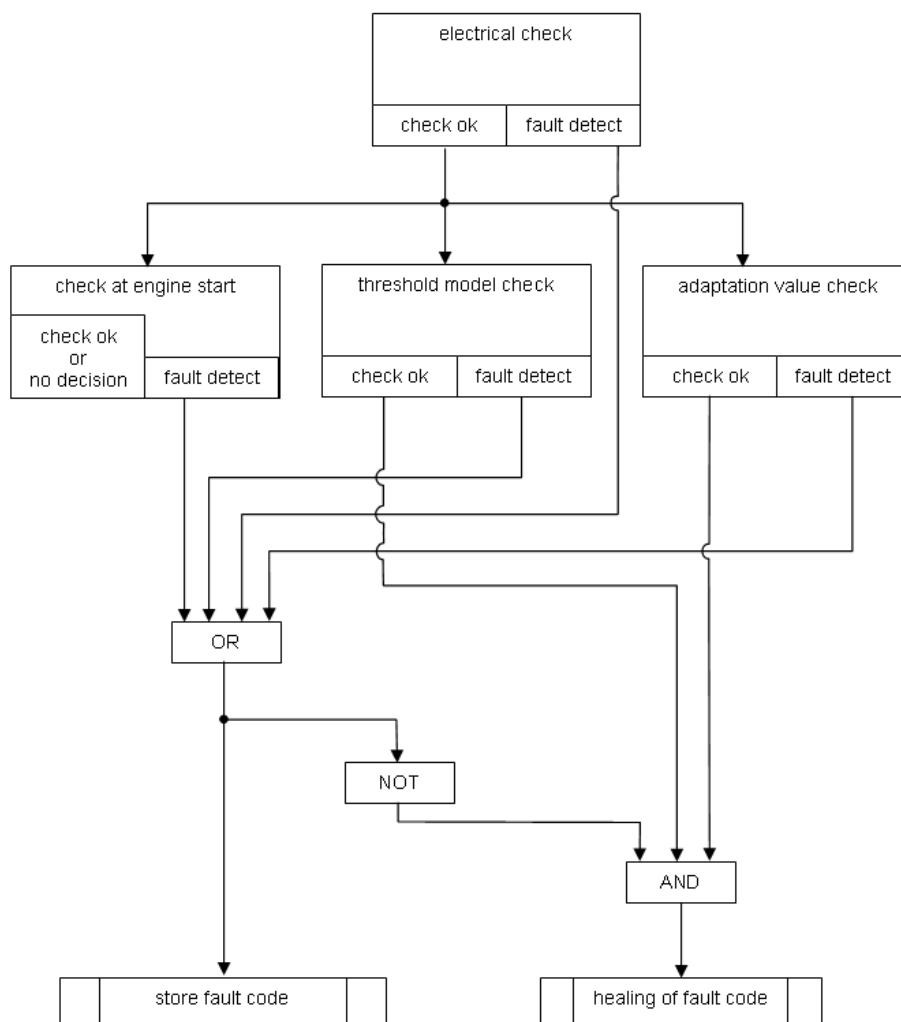


Figure 37: Flow chart manifold absolute pressure sensor monitoring

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Flow chart 'Electrical check'

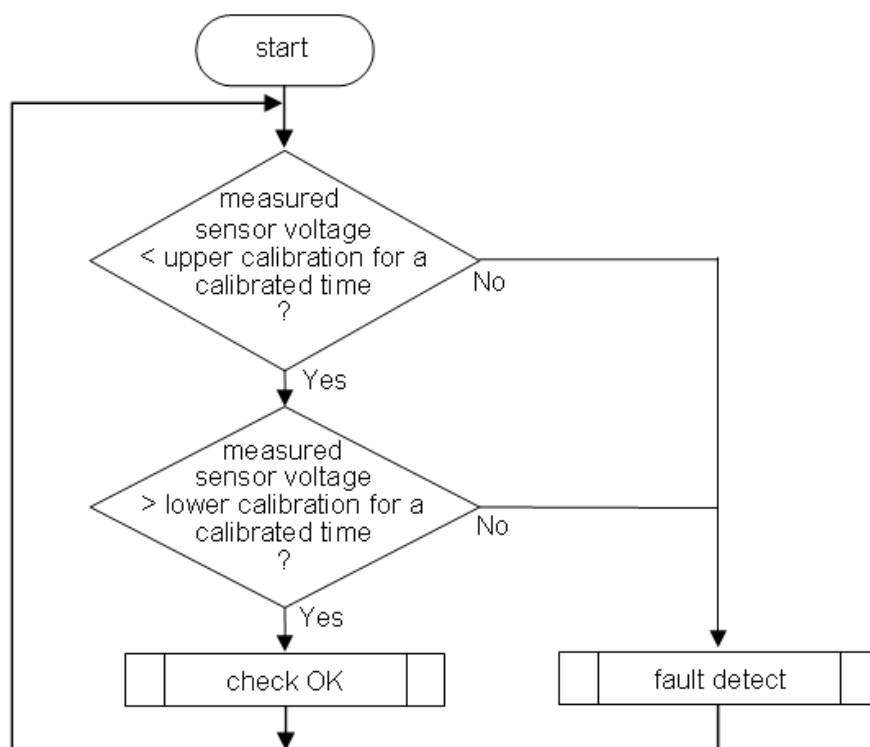


Figure 38: Flow chart electrical check MAP sensor monitoring

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Flow chart 'Check at engine start'

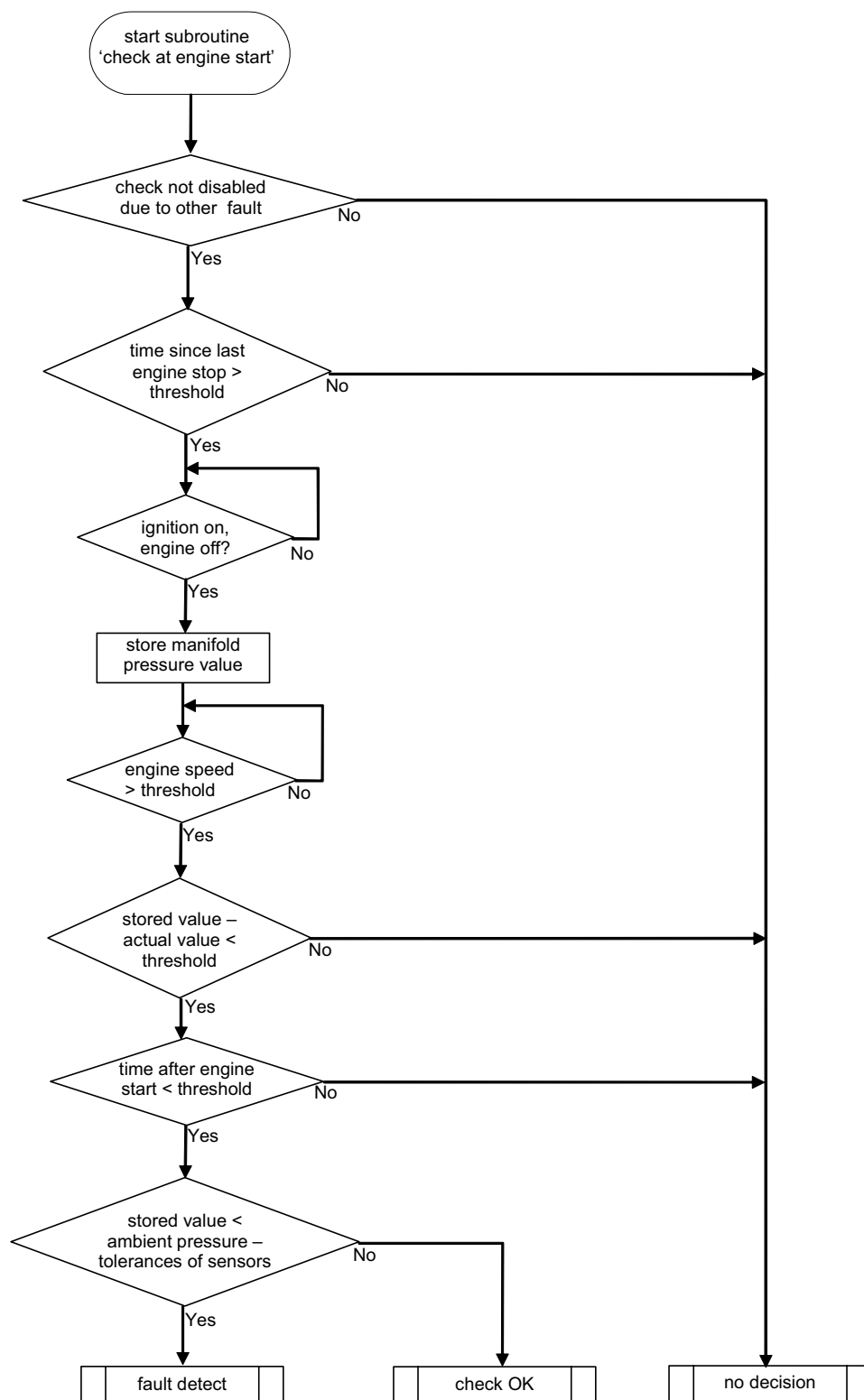


Figure 39: Flow chart check at engine start MAP sensor monitoring

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Flow chart 'Threshold model check'

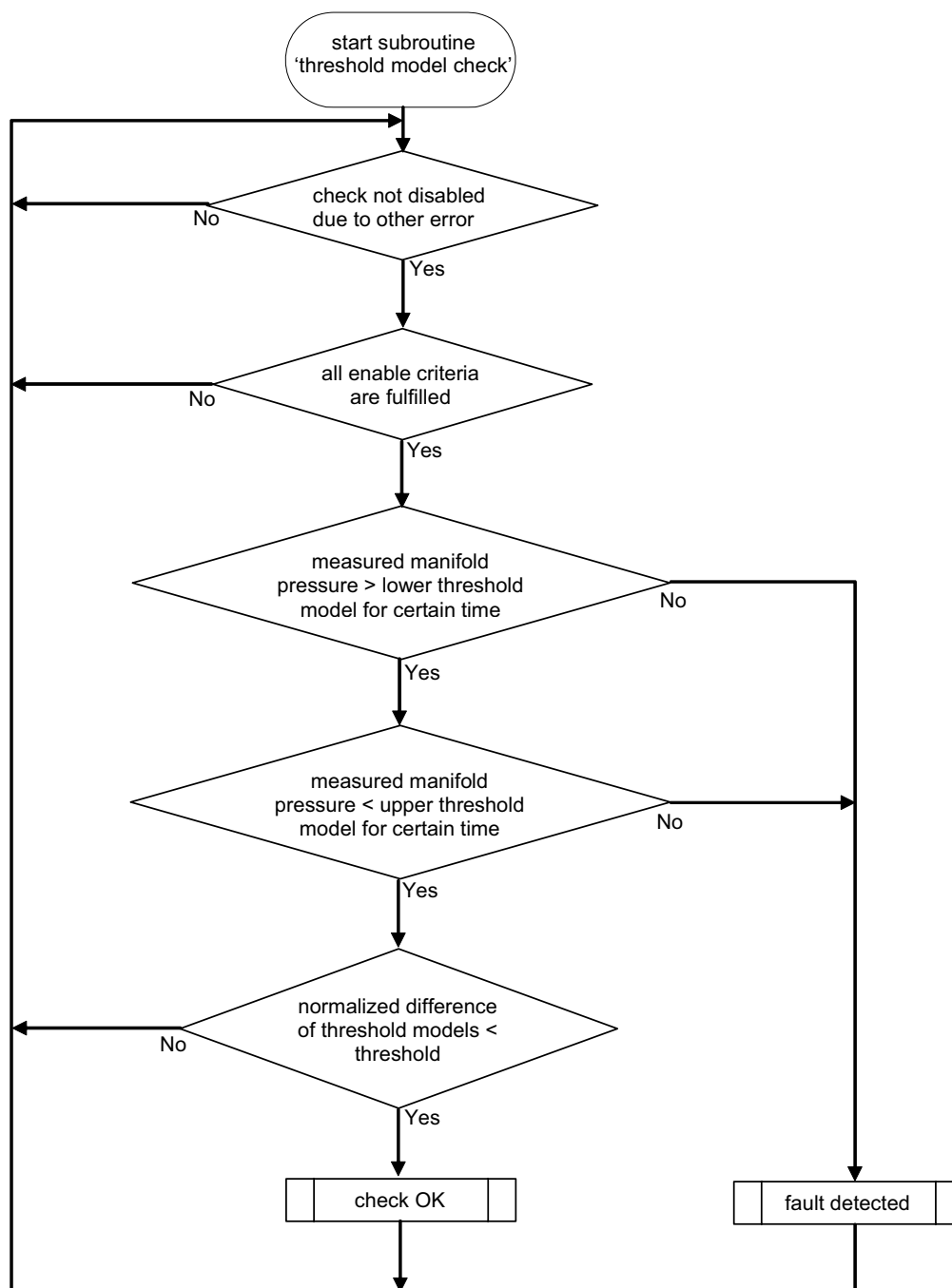


Figure 40: Flow chart threshold model check MAP sensor monitoring

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Flow chart 'Adaptation value check'

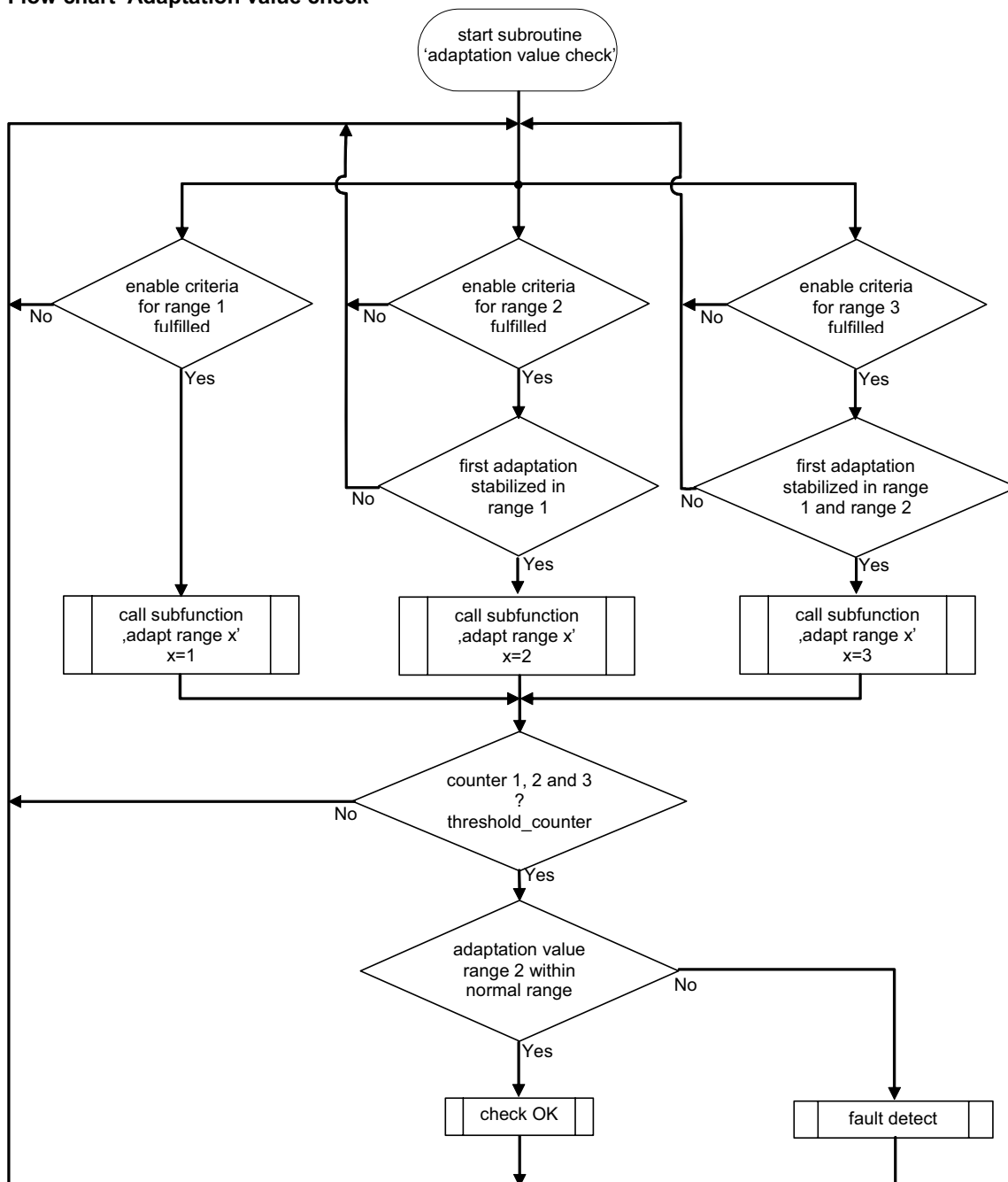


Figure 41: Flow chart adaptation value check MAP sensor monitoring

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Flow chart 'Adapt value range x'

(x = 1; 2; 3)

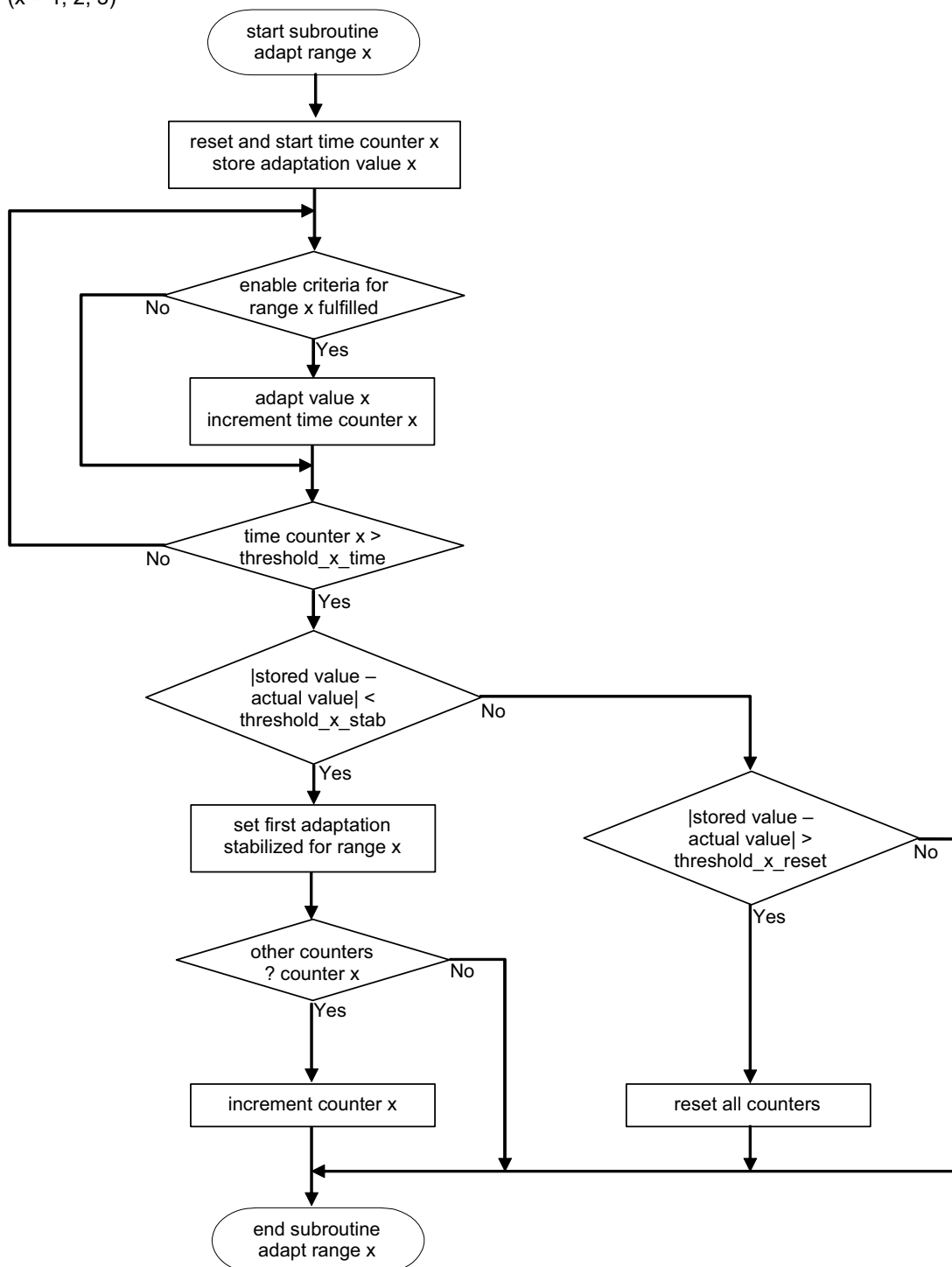


Figure 42: Flow chart adapt value range 1,2,3 MAP sensor monitoring

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Flow chart 'IUMPR for MAP-sensor diagnostic'

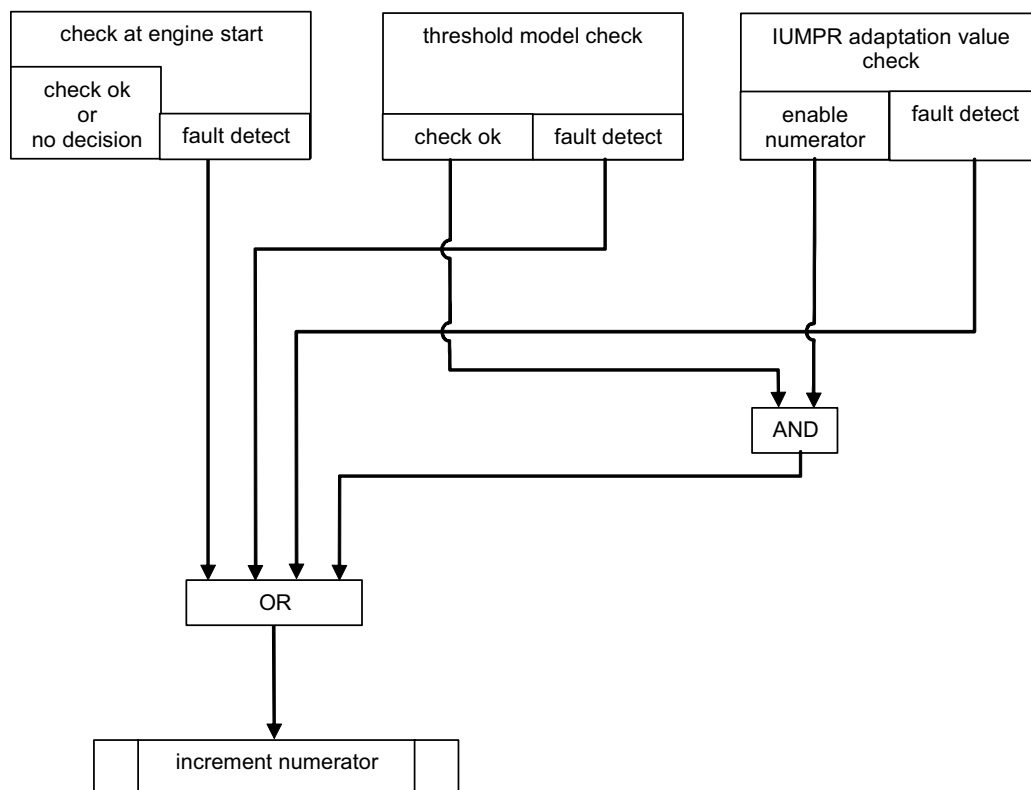


Figure 43: Flow chart IUMPR for MAP sensor monitoring

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Flow chart 'IUMPR adaptation value check'

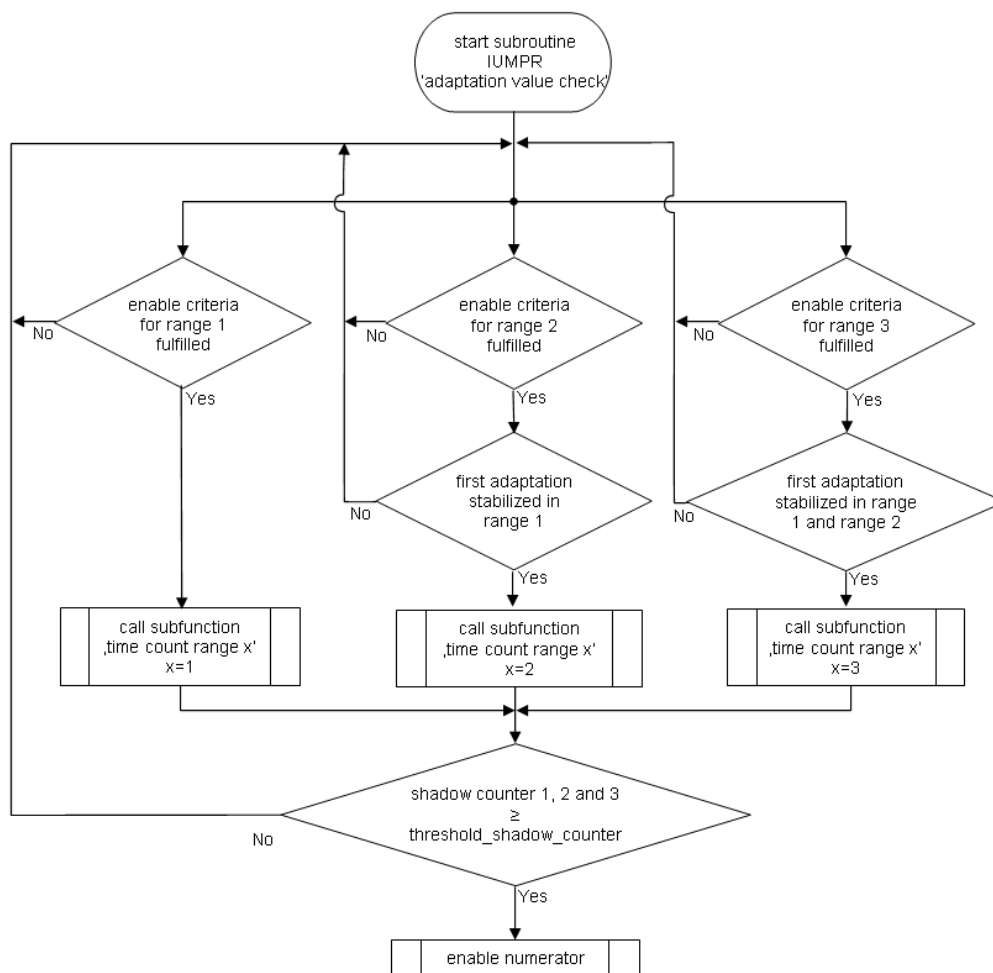


Figure 44: Flow chart IUMPR adaptation value check for MAP sensor monitoring

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Flow chart 'IUMPR time count range x'
(x = 1, 2, 3)

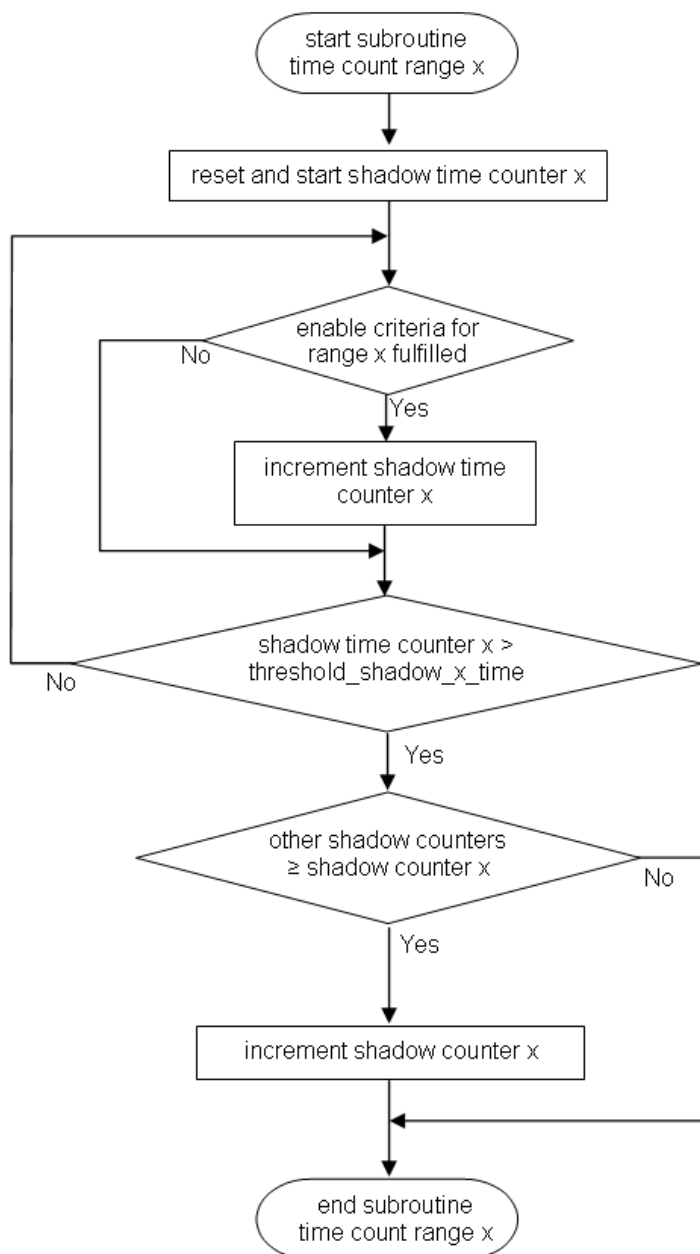


Figure 45: Flow chart IUMPR time count range 1, 2, 3 for MAP sensor monitoring

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14.7.4 Additional MAP Sensor response check

Applicable only for test group

OBD Group Name	Test group	Engine	Models	Standard	Controller / OBD II strategy
BBE-V	BBEXV06.84LA	6.8 V8T - 2 bank	Bentley Mulsanne	LEV II Bin 5	Bosch ME(D)17 BE-V

14.7.4.1 General Description

MAP sensor signal oscillations are used to monitor Cylinder Deactivation system for correct functionality. This monitor checks that the MAP sensor dynamic response is adequate to detect CD system malfunctions.

The monitor records the minimum and maximum MAP seen in one engine cycle (two revolutions), and subtracts minimum from maximum to get the amplitude. This is then compared to a threshold in a look up table to determine whether an error is present.

The monitor runs continuously, but is disabled if any of the other MAP sensor faults are detected.

Enable conditions are:

1. rpm within limits
2. rpm change less than threshold during engine cycle
3. Ratio of (MAP)/(pressure upstream of throttle) within limits
4. MAP change less than threshold during cycle

If the enable conditions are breached during the current engine cycle, the minimum and maximum MAP values are reset, and a new engine cycle count is started when the enable conditions are satisfied.

If an error is present for 30 out of 50 engine cycles, then a "Manifold Absolute Pressure/Barometric Pressure Circuit Range/Performance" fault is detected.

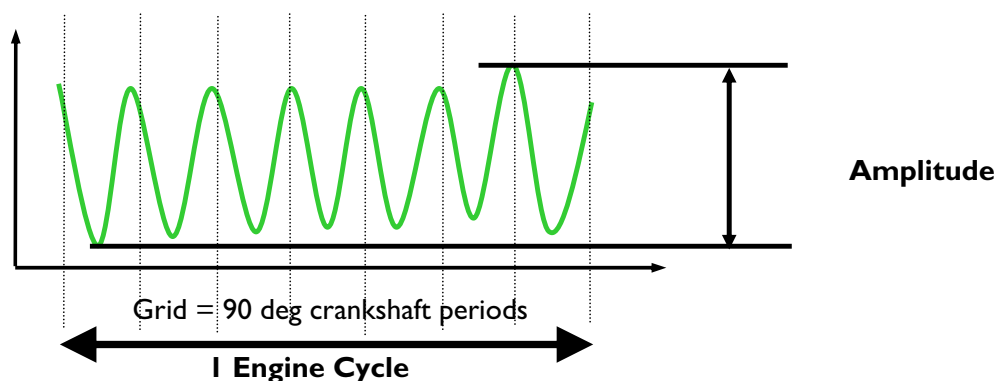


Figure 46: MAP sensor response check monitoring principle

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14.7.4.2 Flow chart

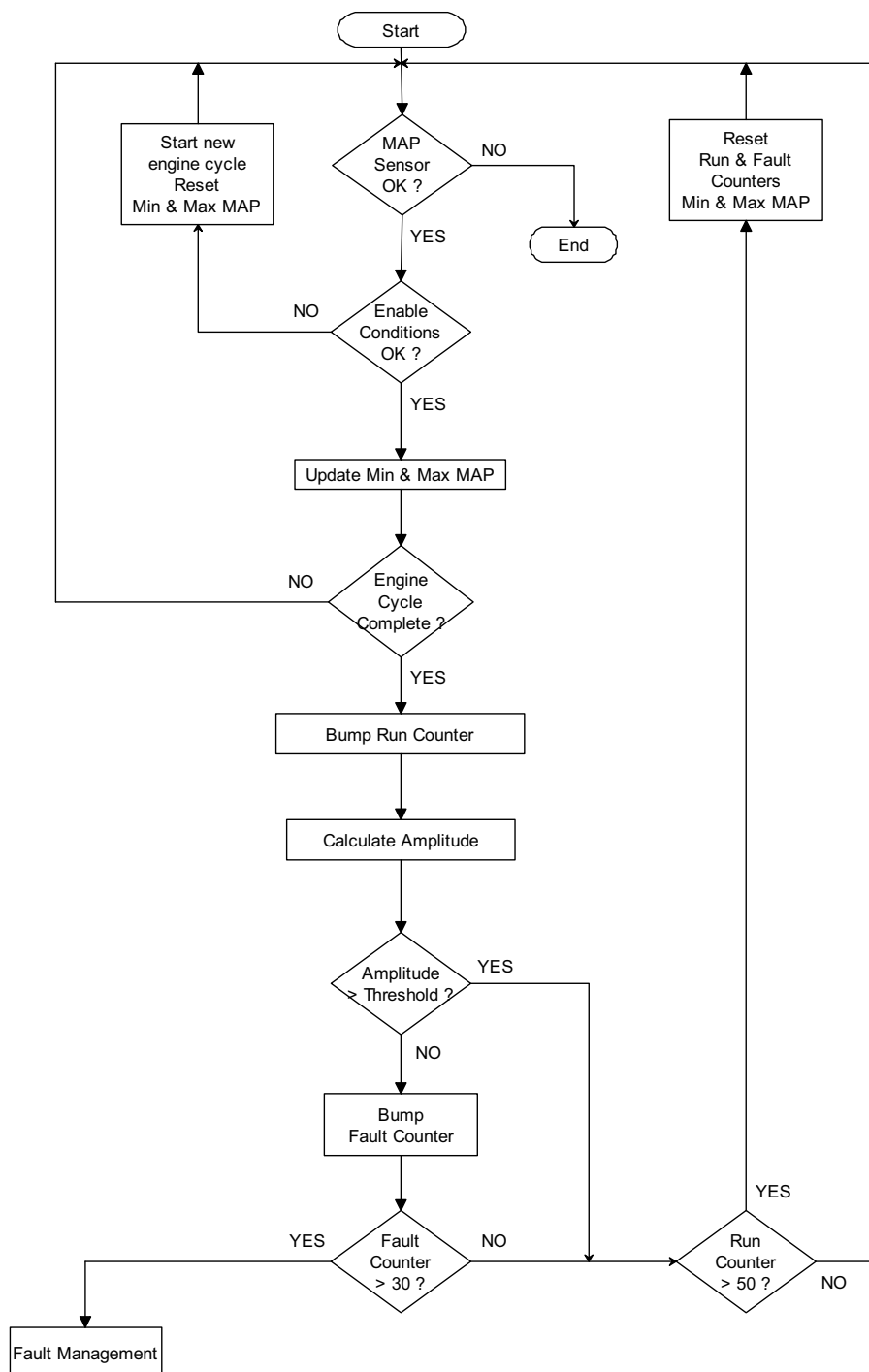


Figure 47: Flow chart MAP sensor response check monitoring

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14.8 Vehicle speed sensor (VSS)

14.8.1 Vehicle Speed Signal Monitoring via ESP/ABS

Applicable only for test groups:

OBD Group Name	Test group	Engine	Models	Standard	Controller / OBD II strategy
BBE-V	BBEXV06.84LA	6.8 V8T - 2 bank	Bentley Mulsanne	LEV II Bin 5	Bosch ME(D)17 BE-V

14.8.1.1 General Description

The vehicle speed signal faults detected by the ESP/ABS control module are transmitted to the ECM via the FlexRay/CAN bus by means of an OBD error nibble (= half-byte = 4 bits) which contains the fault information of each wheel speed sensor. Obtaining the fault information, the ECM forwards it to its fault memory. A fault code is only registered in the ECM if none of the wheel speed sensors provides the ESP/ABS control module with a valid signal, and thus the MIL is commanded on if none of the wheel speed sensors is fault-free.

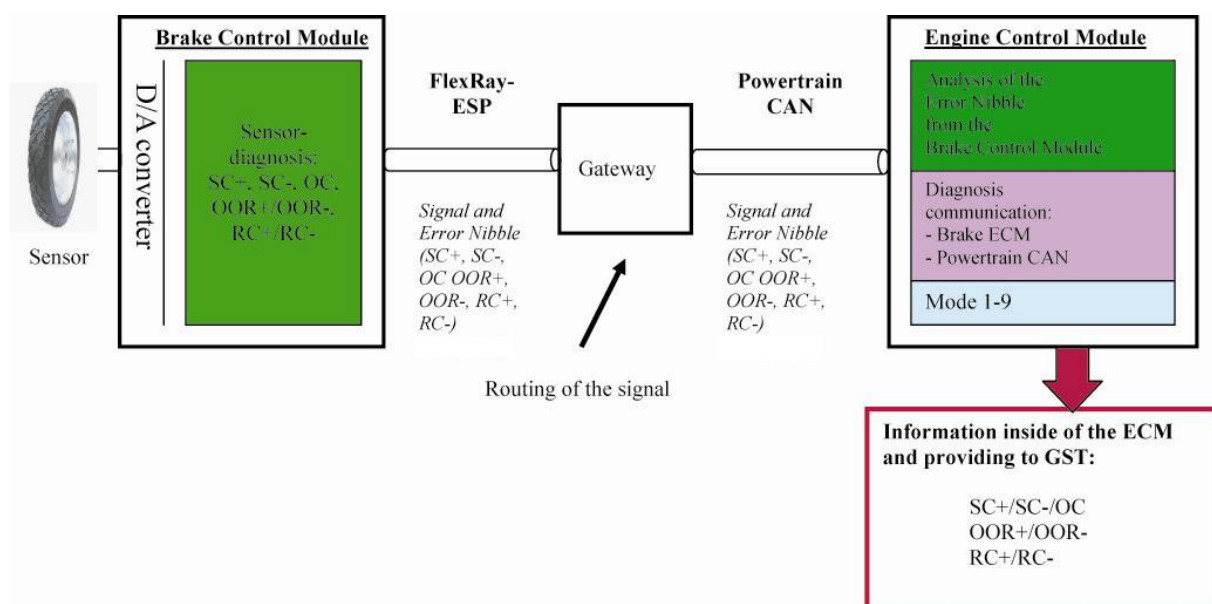


Figure 48: Schematic presentation of brake control module and engine control module

14.8.1.2 Vehicle Speed Signal faulty – P0501/P0502

Monitoring Strategy

The EPS/ASB fault memory is read out.

Enable Conditions

These diagnostics in the brake control module are run continuously; hence no enable conditions are defined.

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Malfunction Criteria

In the ESP/ABS control module, the individual fault states of the wheel speed sensors are mapped to an error nibble, and in the ECM they are classified either as electrical faults or rationality faults and assigned to a P-Code, respectively. The MIL is commanded on if none of the individual signals from the wheel speed sensors is assessed as fault-free.

ESP/ABS control module	Error nibble	ECM		
Short to ground	\$0001	Electrical faults	P0502	MIL ON, if no wheel speed sensor is available
Short to battery	\$0010			
Open circuit	\$0011			
Signal too high	\$0100	Rationality faults	P0501	
Signal too low	\$0101			
Rationality check, high	\$0110			
Rationality check, low	\$0111			

Figure 49: Fault states mapped to error nibble

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14.9 Throttle position sensor (throttle unit with E-gas actuator)

The throttle body consists of two potentiometers (reversed voltage logic). During the first start, the potentiometer characteristics are adapted and stored. The diagnosis monitors the corrected values of potentiometer 1 and 2. In case of a higher difference than a threshold value both signals are compared to the engine load to determine and disable the faulty one. A fault code will be stored and the MIL will be illuminated.

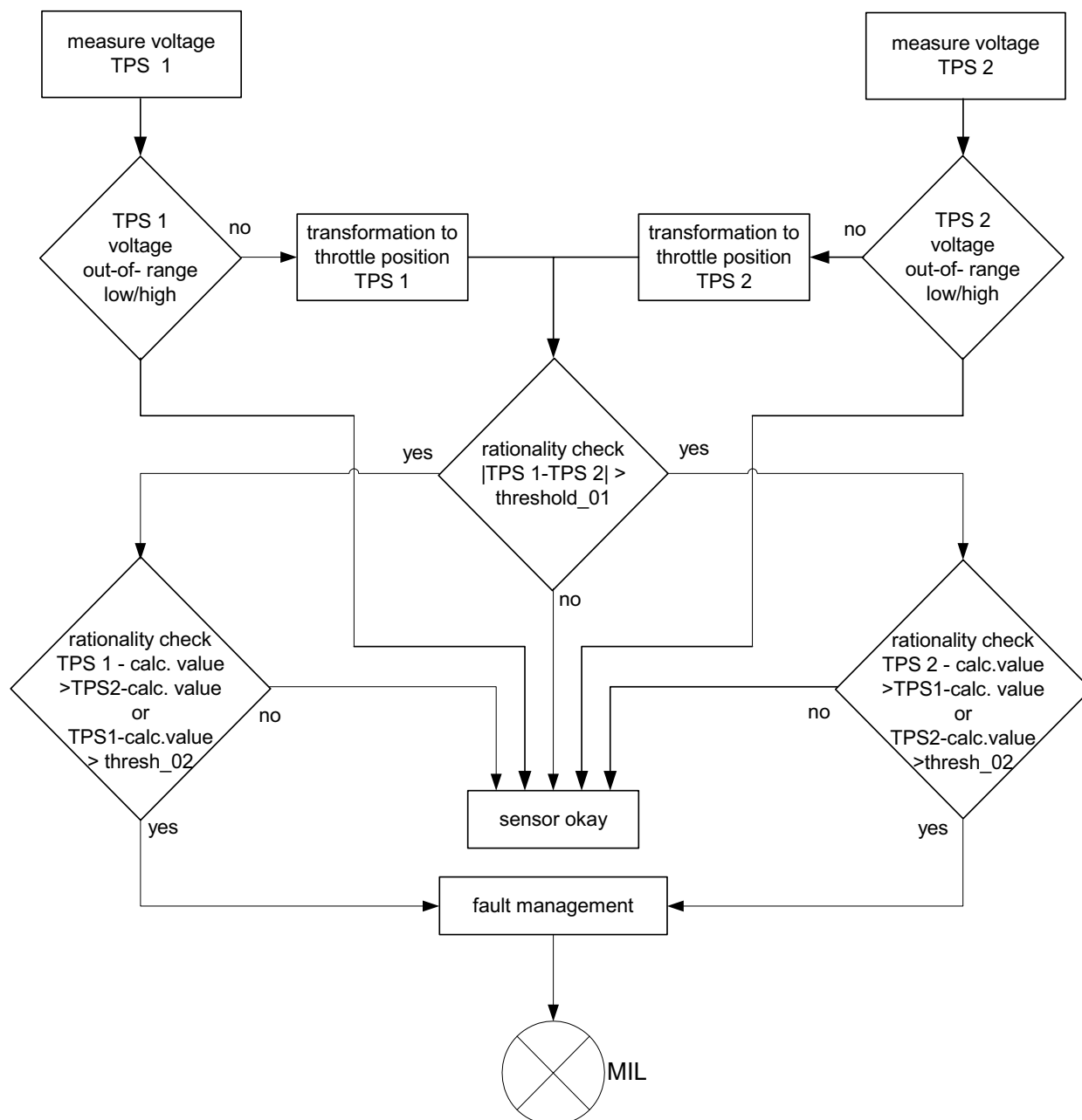


Figure 50: Flow chart throttle position sensor (TPS)

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14.10 Accelerator pedal position sensor (APPS)

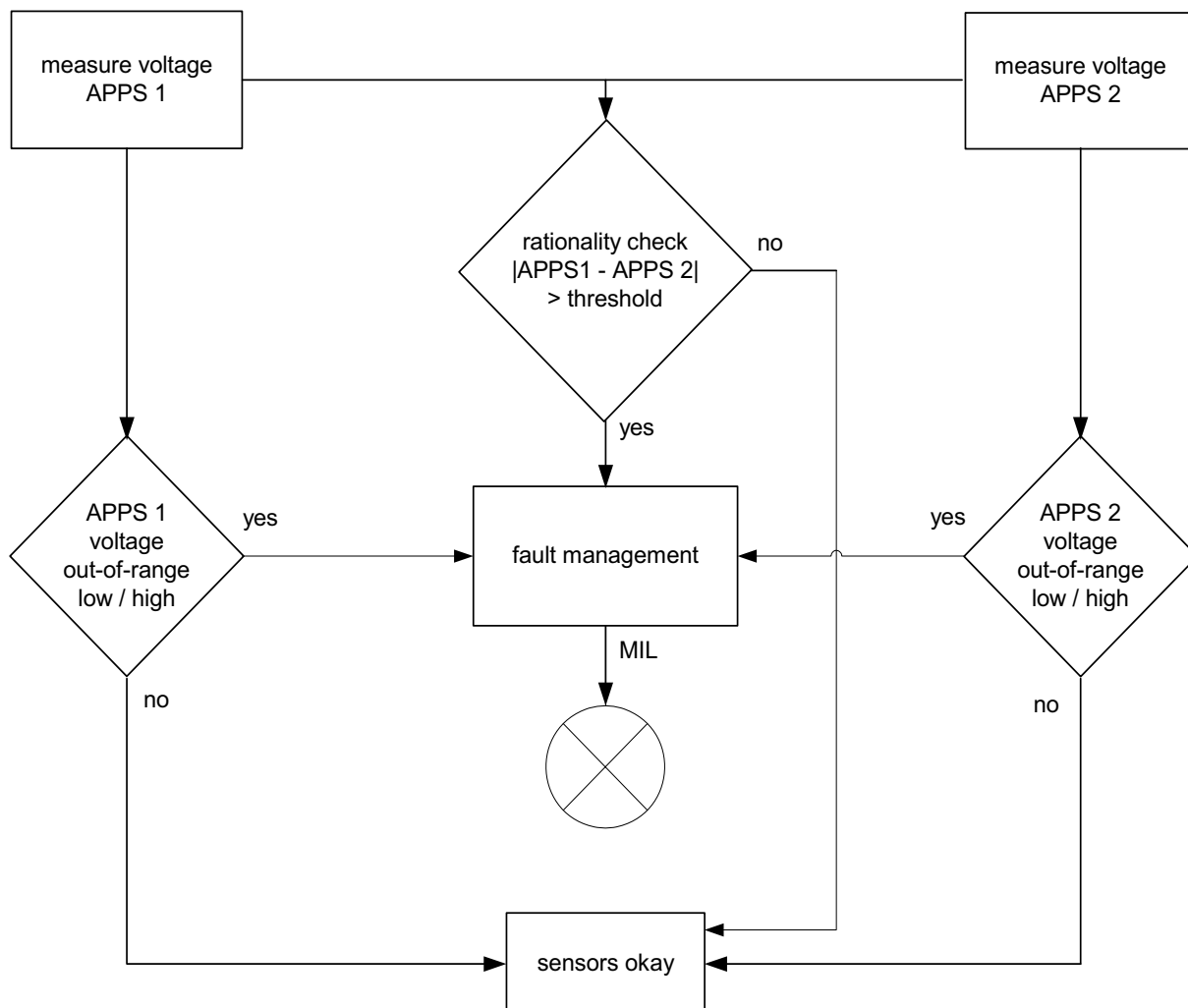


Figure 51: Flow chart accelerator pedal position sensor

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14.11 Camshaft position (CMP) sensor

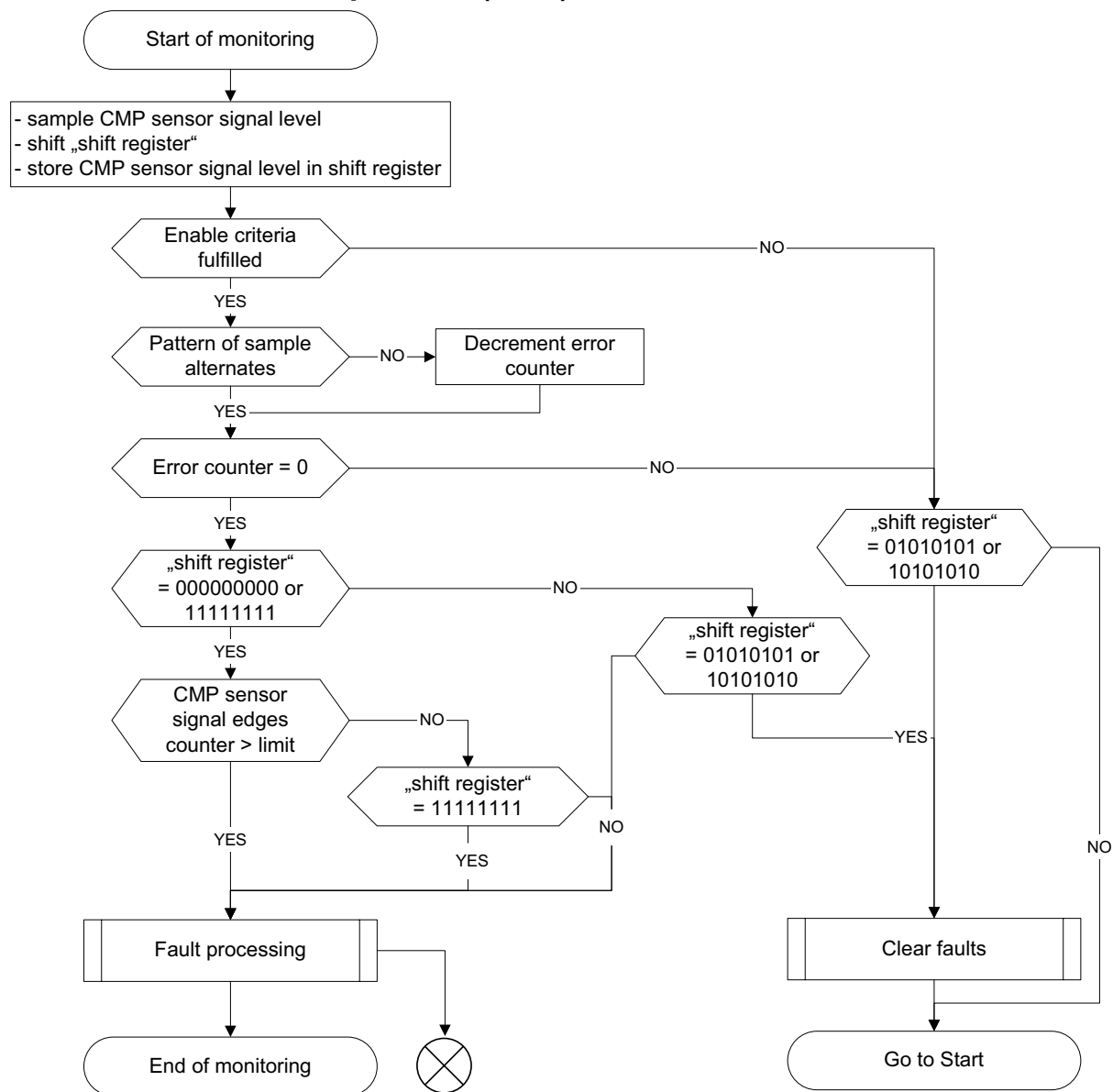


Figure 52: Flow chart for camshaft position (CMP) sensor monitoring

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14.12 Radiator Temperature Sensor

Applicable only for test groups:

OBD Group Name	Test group	Engine	Models	Standard	Controller / OBD II strategy
BBE-V	BBEXV06.84LA	6.8 V8T - 2 bank	Bentley Mulsanne	LEV II Bin 5	Bosch ME(D)17 BE-V

14.12.1 General Description

The radiator inlet temperature sensor monitor checks for circuit continuity faults (see Figure 76) and the rationality of the radiator inlet temperature signal (see Figure 77 & Figure 78).

14.12.2 Monitoring Structure

Refer to Figure 75.

If the radiator inlet temperature exceeds the upper limit for too long, then a short circuit to ground is detected, and an Engine Coolant Temperature Sensor 2 Circuit Low fault is set.

If the radiator inlet temperature is below the lower limit for too long, then a short circuit to battery or open circuit is detected, and a Engine Coolant Temperature Sensor 2 Circuit fault is set.

There are two rationality checks. The lower rationality test takes place immediately after a cold engine start, and the upper rationality test occurs when the engine reaches the thermostat opening temperature.

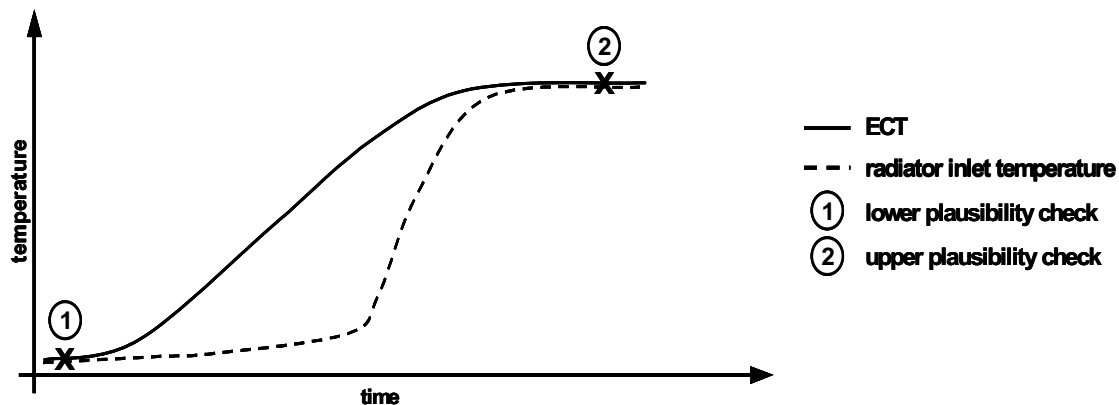


Figure 53: Overview of Radiator inlet temperature Sensor rationality checks

In the lower rationality test, the radiator inlet temperature is compared with ECT immediately after engine start when a “cold start” is detected. The difference between ECT and the radiator inlet temperature is calculated and compared to positive (ECT greater than radiator inlet temperature) and negative (ECT less than radiator inlet temperature) thresholds that are dependant on ECT and radiator inlet temperature at start up.

If the temperature difference exceeds one of the thresholds for too long, an “Engine Coolant Temperature Sensor 2 Circuit Range/Performance” fault is set.

“Cold Start” is detected by checking how long the engine has been shut off. This is modelled using ECT & AAT at engine shut off and ECT at engine start, and is cross-checked with the clock in the instrument panel. If the engine shut down time is long enough, then “cold start” is detected and the lower rationality test is enabled.

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If the engine is shut off during a warm up cycle before the thermostat opens, the check against the positive threshold will be disabled for the next engine start. This is because, under these conditions, it is possible to have a high positive difference between ECT and radiator inlet temperature at engine restart.

In the upper rationality check, the radiator inlet temperature is compared with ECT immediately after the thermostat regulating temperature is reached. If the difference exceeds a threshold for too long, an "Engine Coolant Temperature Sensor 2 Circuit Range/Performance" fault is set.

14.12.3 Continuity Check Monitoring

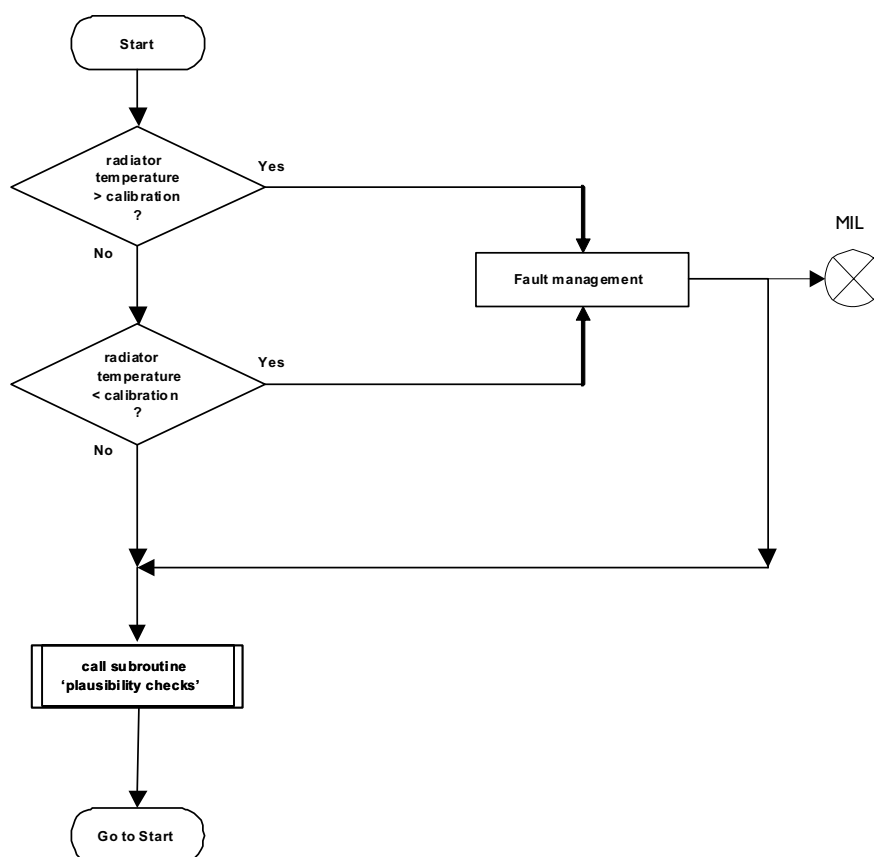


Figure 54: Flow Chart for Radiator inlet temperature Sensor Continuity check monitoring

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14.12.4 Radiator inlet temperature Sensor Lower Rationality Check

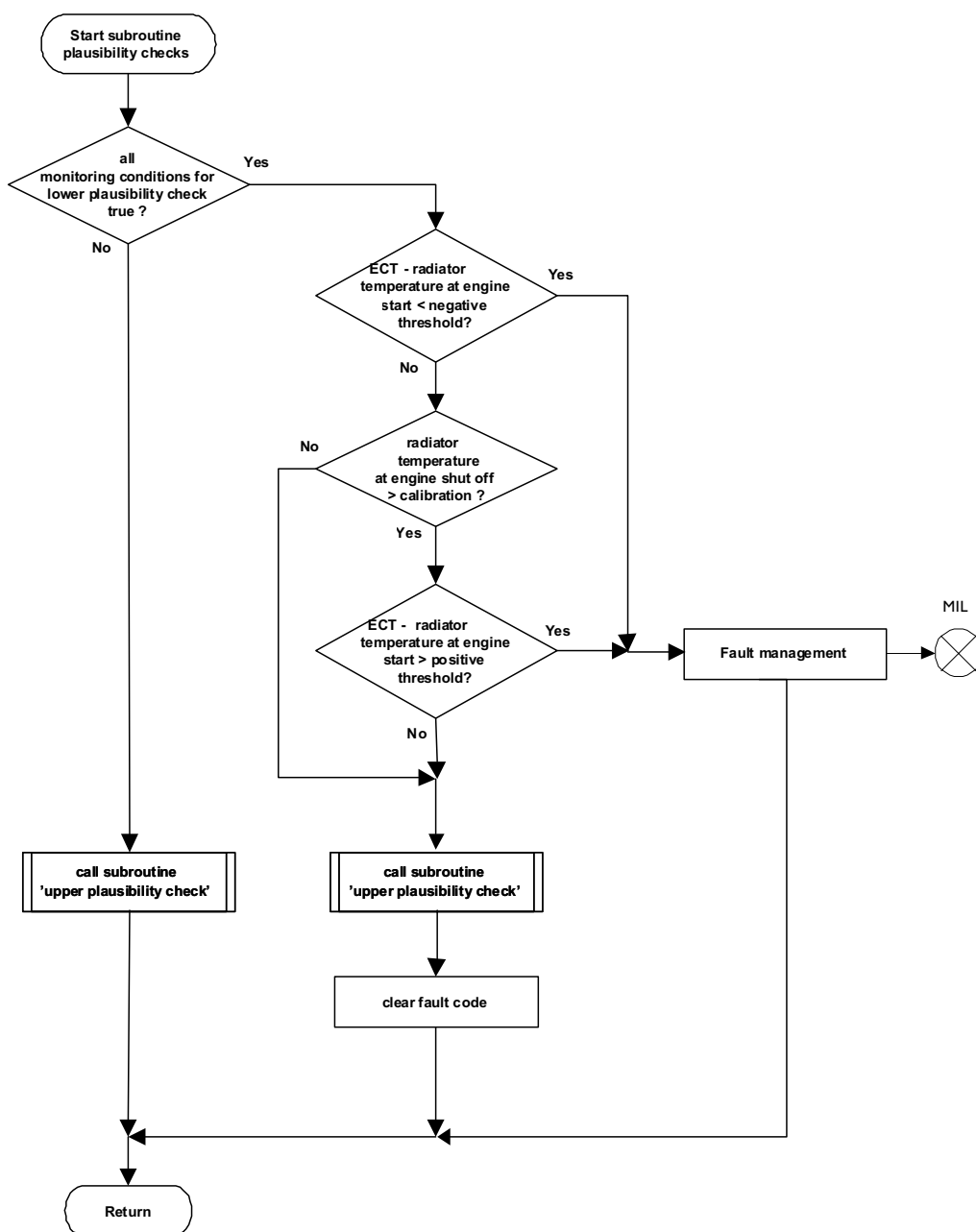


Figure 55: Flow Chart for Radiator inlet temperature Sensor lower Rationality check monitoring

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14.12.5 Radiator inlet temperature Sensor Upper Rationality Check

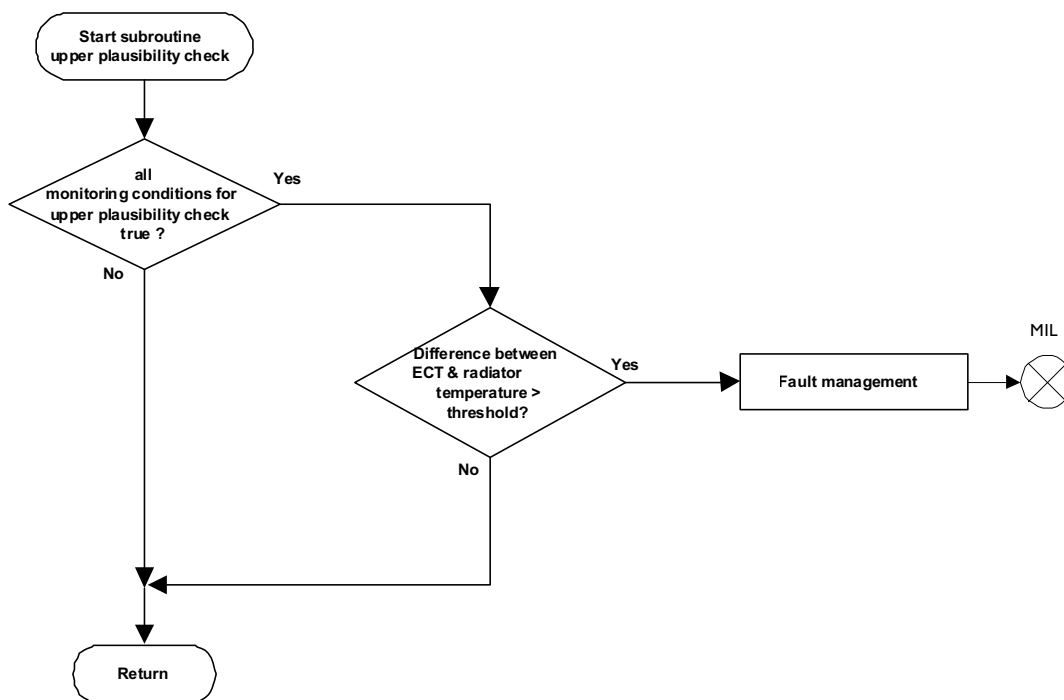


Figure 56: Flow Chart for Radiator inlet temperature Sensor Upper Rationality check monitoring

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14.13 Atmospheric Pressure Sensor

14.13.1 General description

The atmospheric pressure sensor monitor checks for circuit continuity, out of range signals and a rationality check.

14.13.2 Monitoring function description

Circuit Continuity

If the atmospheric pressure exceeds an upper limit for too long, a short circuit to battery is detected and a Atmospheric Pressure Circuit High fault is set.

If the atmospheric pressure stays below a lower limit for too long, a short circuit to ground is detected and a Atmospheric Pressure Circuit Low fault is set.

Range Check

If the atmospheric pressure exceeds an upper limit for too long, out of range high is detected, and a Atmospheric Pressure Circuit fault is set.

If the atmospheric pressure stays below a lower limit for too long, out of range low is detected, and a Atmospheric Pressure Circuit fault is set.

Key On, Engine Off (KOEO) Check

The KOEO check compares the atmospheric pressure at KOEO with the value stored at the last engine shut down. If this is not the same, and the atmospheric pressure is not similar to the upstream throttle pressure at KOEO, an Atmospheric Pressure Circuit Range/Performance fault is set.

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14.13.3 Flow charts atmospheric sensor monitoring

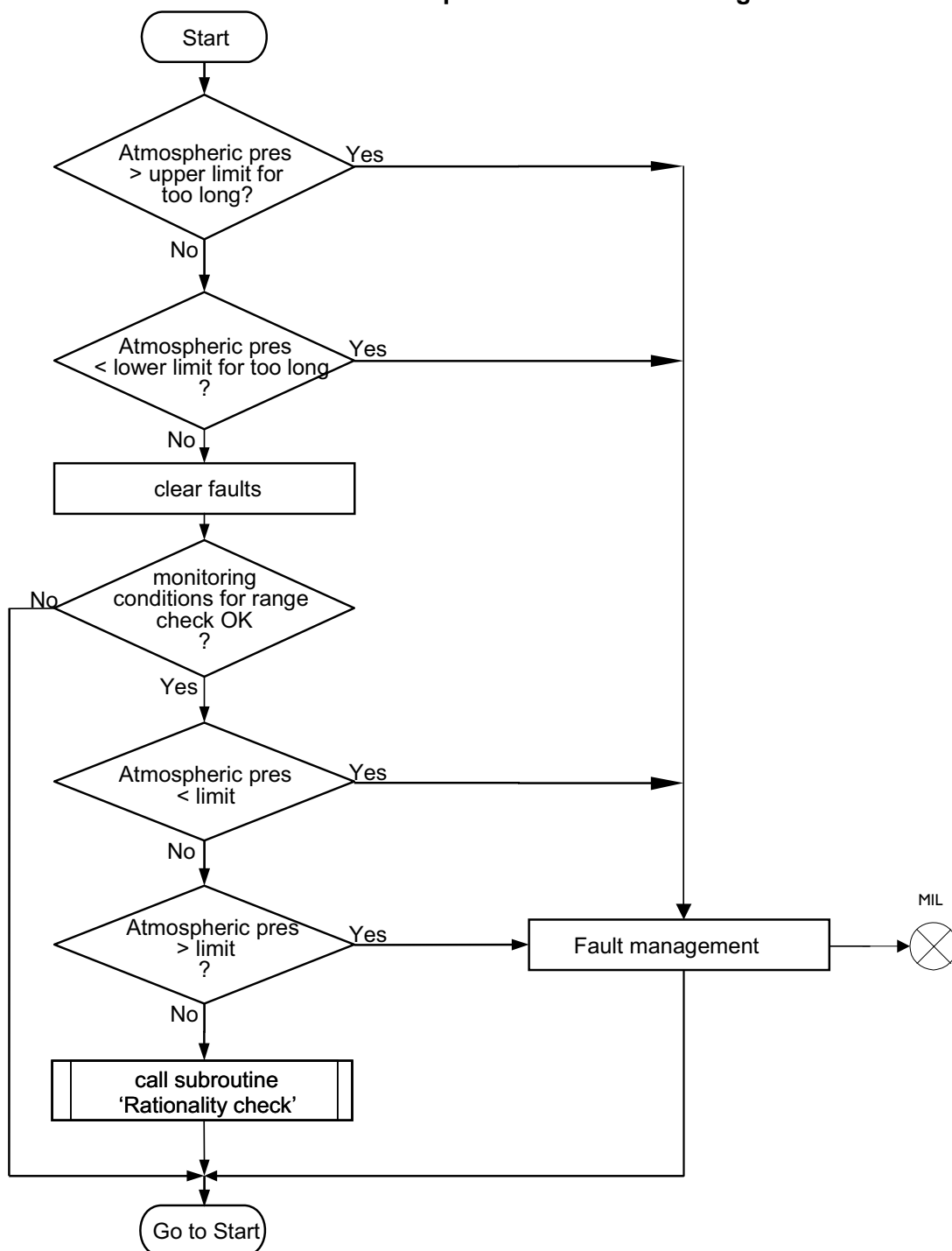


Figure 57: Flow chart atmospheric sensor monitoring

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Flow chart atmospheric sensor monitoring - sub-routine "rationality check"

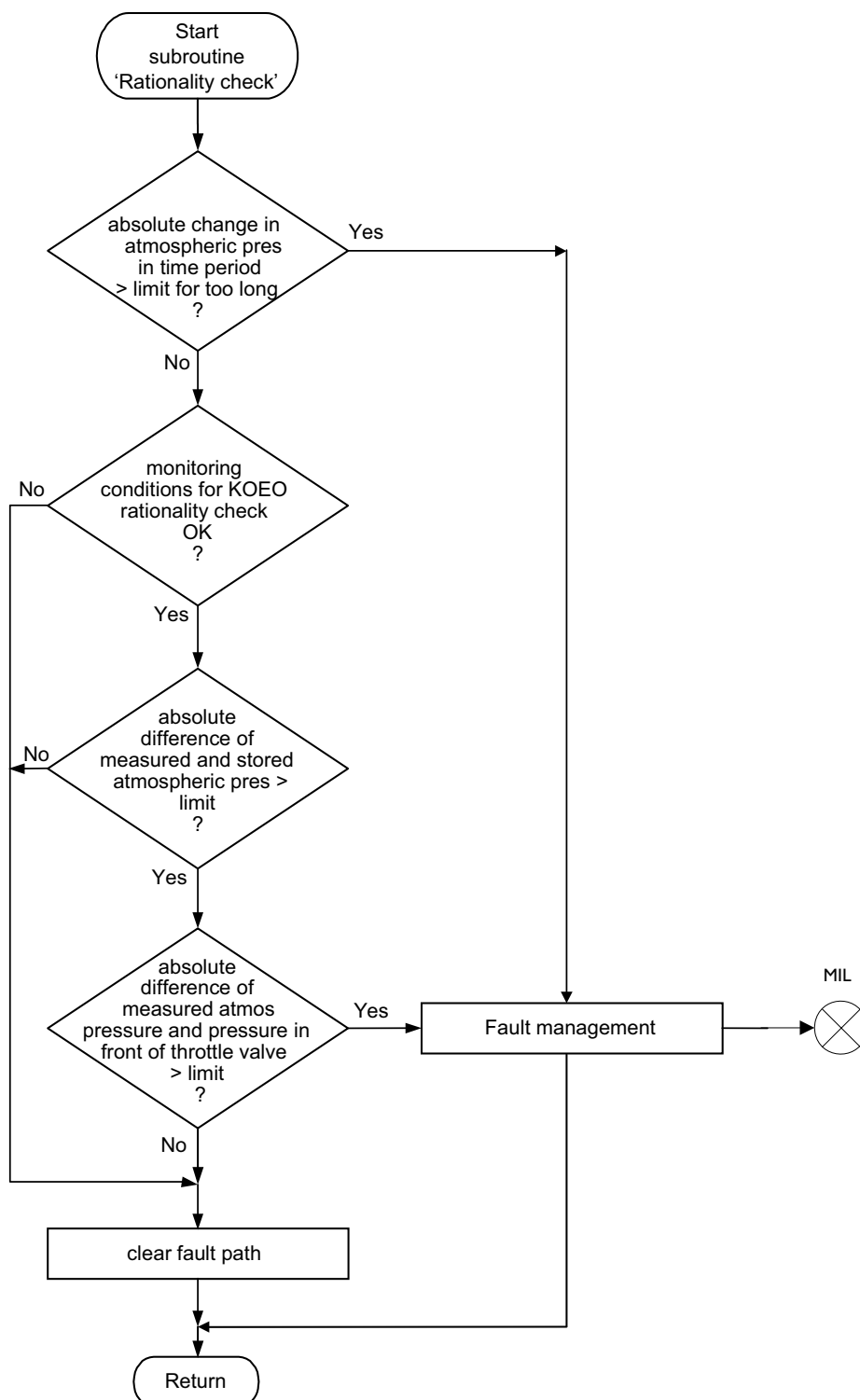


Figure 58: Flow chart atmospheric sensor monitoring - sub-routine "rationality check"

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14.14 Ambient Air Temp Monitor - Concepts with two AAT sensors

Applicable only for test groups

OBD Group Name	Test group	Engine	Models	Standard	Controller / OBD II strategy
BBE-V	BBEXV06.84LA	6.8 V8T - 2 bank	Bentley Mulsanne	LEV II Bin 5	Bosch ME(D)17 BE-V

Monitoring Structure

One AAT is present within the airflow meter serving each bank of the engine. The AAT sensors are monitored for circuit continuity according to the description contained within the “Generic Output Stage Check” section of this document.

In addition, a cross-check is performed between the two AAT sensors. A fault is diagnosed (P2199) if the modulus of the difference between the two sensors exceeds a calibrated threshold, as assessed during a finite period of time following a cold start. The strategy for cold start detection is described below.

Cold Start Detection

To detect a cold-start this method uses the information of the intake air temperature sensor.

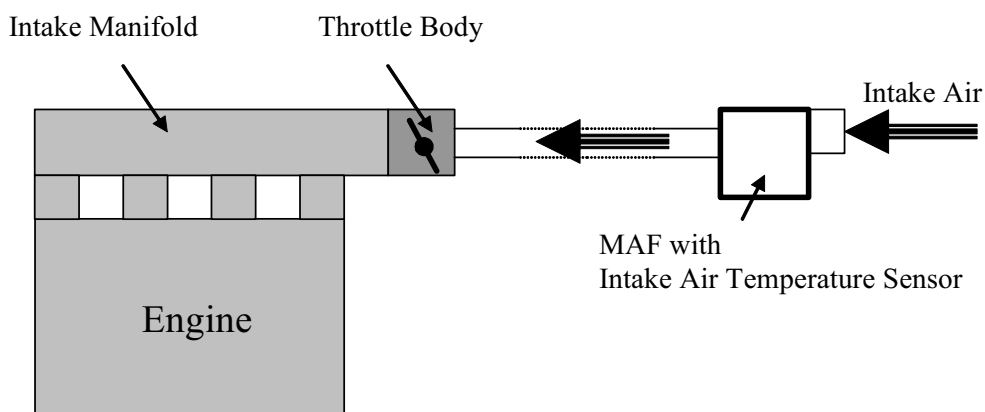


Figure 59: Location of intake air temperature sensor within mass air flow sensor

Under sufficient conditions of the previous driving cycle, the gradient of the intake air temperature will be monitored at the beginning of the actual driving cycle. If a negative gradient is monitored the function identifies a warm-start. If no negative gradient is monitored the function identifies a cold-start.

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Monitoring Principle

To describe the gradient the intake air temperature during engine start will be compared with the minimum intake air temperature until a sufficient time and air flow. In case that no negative gradient of the intake air sensor signal is monitored a cold start is detected.

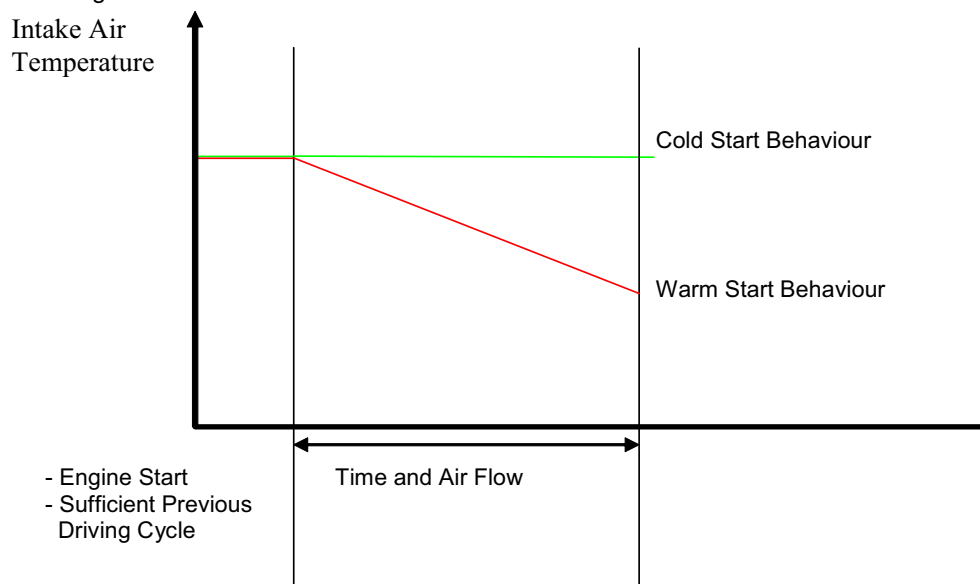


Figure 60: Cold start detection monitoring principle

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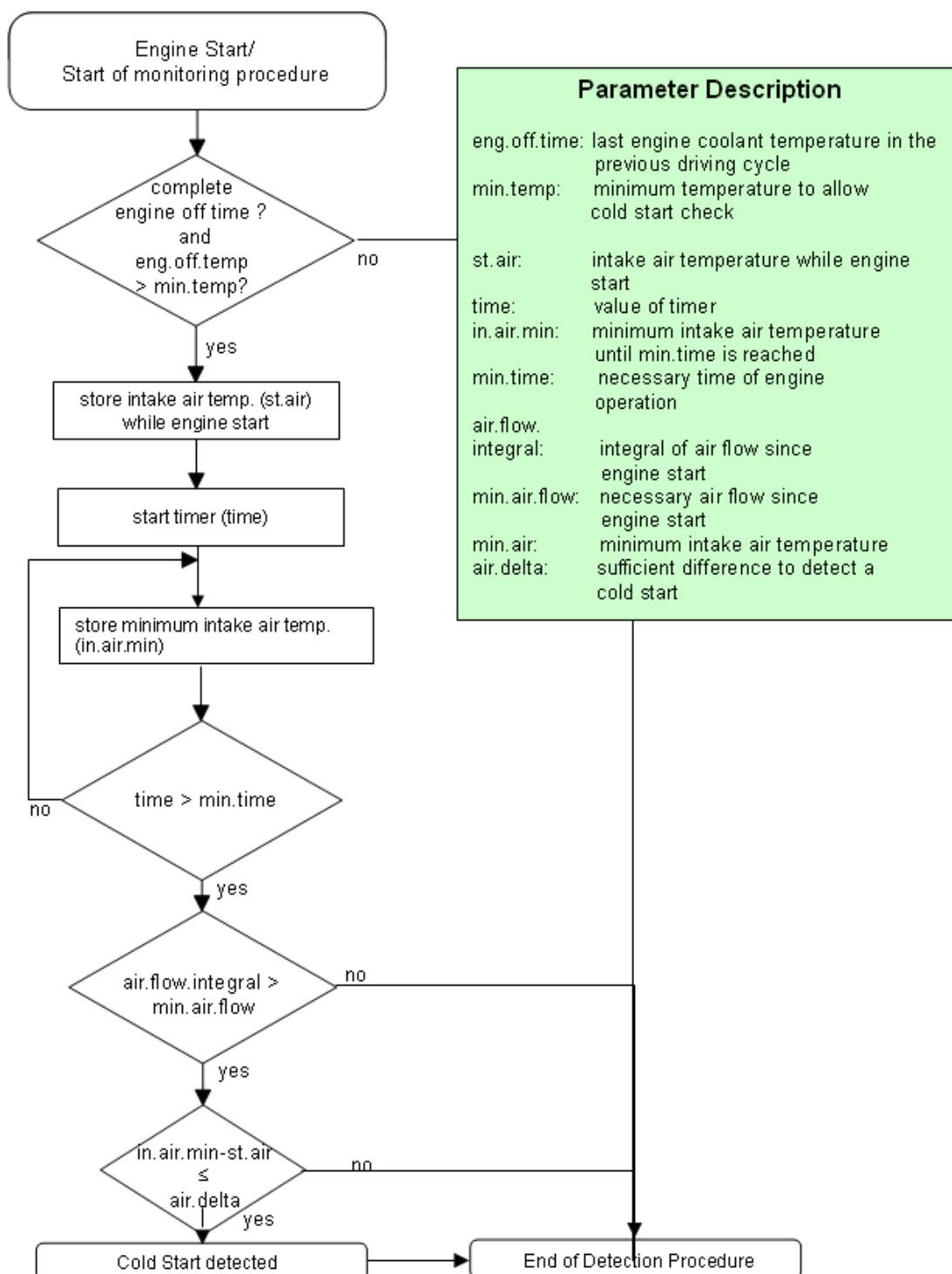


Figure 61: Flow Chart: Cold start detection

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14.15 Fuel pump relay

Check is performed while using 15.24 Output Stage Check

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14.16 Fuel Rail Pressure Monitoring (MPI)

Applicable only for test groups

OBD Group Name	Test group	Engine	Models	Standard	Controller / OBD II strategy
BBE-V	BBEXV06.84LA	6.8 V8T - 2 bank	Bentley Mulsanne	LEV II Bin 5	Bosch ME(D)17 BE-V

14.16.1 General Description

The fuel rail pressure (FRP) monitor checks that the FRP relative to manifold absolute pressure (MAP) is within upper and lower limits.

The fuel system incorporates two fuel pumps that are controlled independently. One pump runs permanently (when the engine is running) and the second pump is activated when the engine fuel demand is high. The injectors are fed from a single fuel rail, and fuel is returned to the tank via two pressure regulators which maintain the FRP at 400 kPa relative to MAP.

14.16.2 Monitoring Structure

Refer to Figure 90.

A defective fuel system is detected if (FRP – MAP) remains below the lower limit for too long, and Fuel Rail/System Pressure - Too Low fault is set. If the second fuel pump has already been activated, the engine torque is limited. If only the first fuel pump is active, the second will be activated.

A defective fuel system is also detected if (FRP – MAP) remains above the upper limit, and Fuel Rail/System Pressure - Too High fault is set.

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14.16.3 Flow Chart

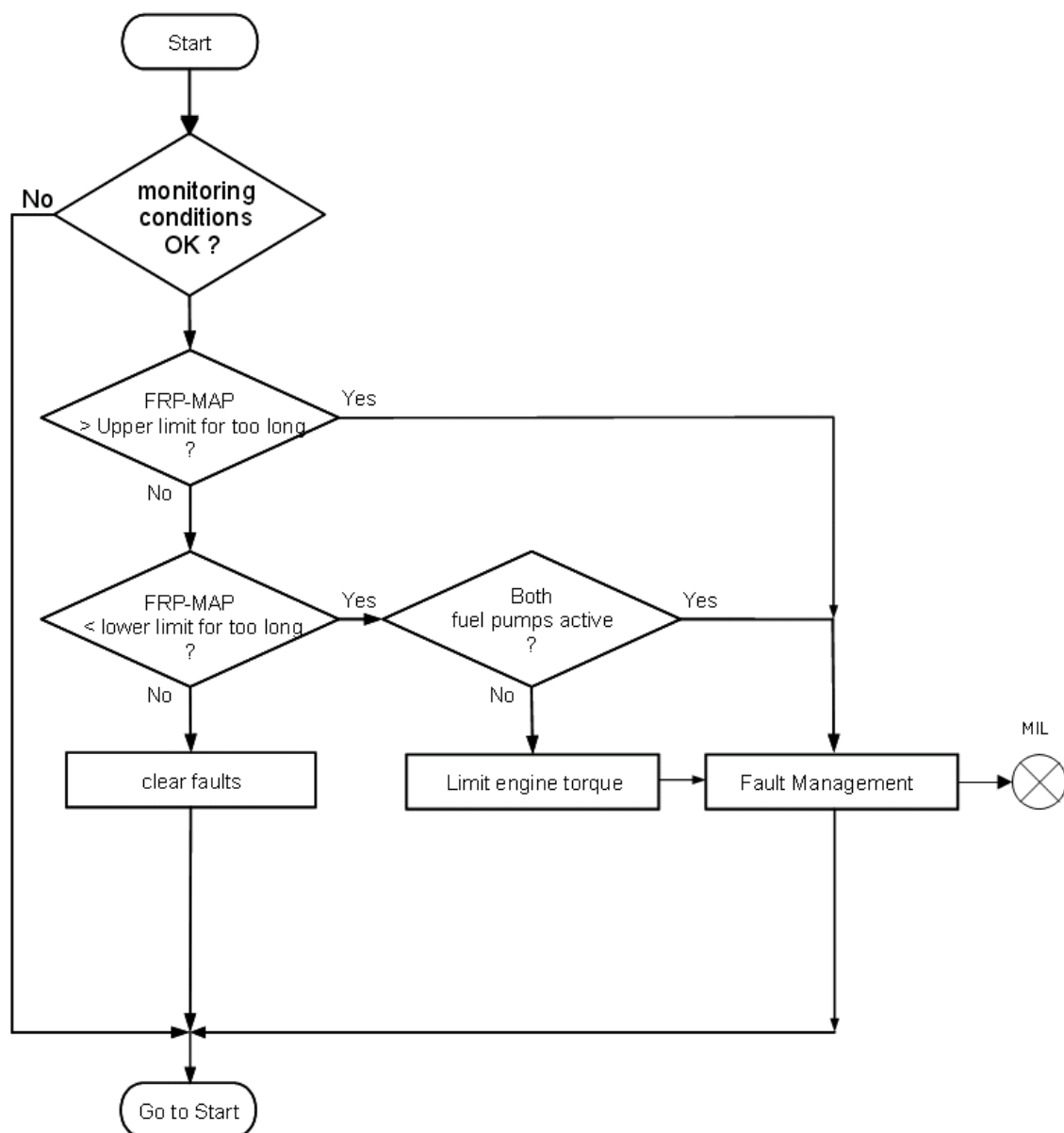


Figure 62: Flow Chart for Fuel Rail Pressure Monitoring

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14.17 Fuel Rail Pressure Sensor Monitoring (MPI)

Applicable only for test groups:

OBD Group Name	Test group	Engine	Models	Standard	Controller / OBD II strategy
BBE-V	BBEXV06.84LA	6.8 V8T - 2 bank	Bentley Mulsanne	LEV II Bin 5	Bosch ME(D)17 BE-V

14.17.1 General Description

The fuel rail pressure (FRP) sensor monitor includes:

- Circuit continuity check that compares the FRP sensor signal voltage with an upper and lower limit to detect open and short circuits.
- A range check that compares the fuel rail pressure with an upper and lower limit to detect signals that are out of range.

14.17.2 Monitoring Structure

Refer to Figure 91.

Circuit continuity check

If the measured value from the FRP sensor exceeds the upper voltage limit for too long a period of time, a short circuit to battery or open circuit is detected and a circuit fault is recorded.

If the measured value from the FRP sensor lies below the lower voltage limit for too long a period of time, a short circuit to ground is detected and a circuit low fault is recorded.

Range check

If the FRP exceeds the upper pressure limit for too long a period of time, an “out of range error” (pressure too high) is detected and a circuit range/performance fault is recorded.

If the FRP undershoots the lower pressure limit for too long a period of time, an “out of range error” (pressure too low) is detected and a circuit range/performance fault is recorded.

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14.17.3 Flow chart

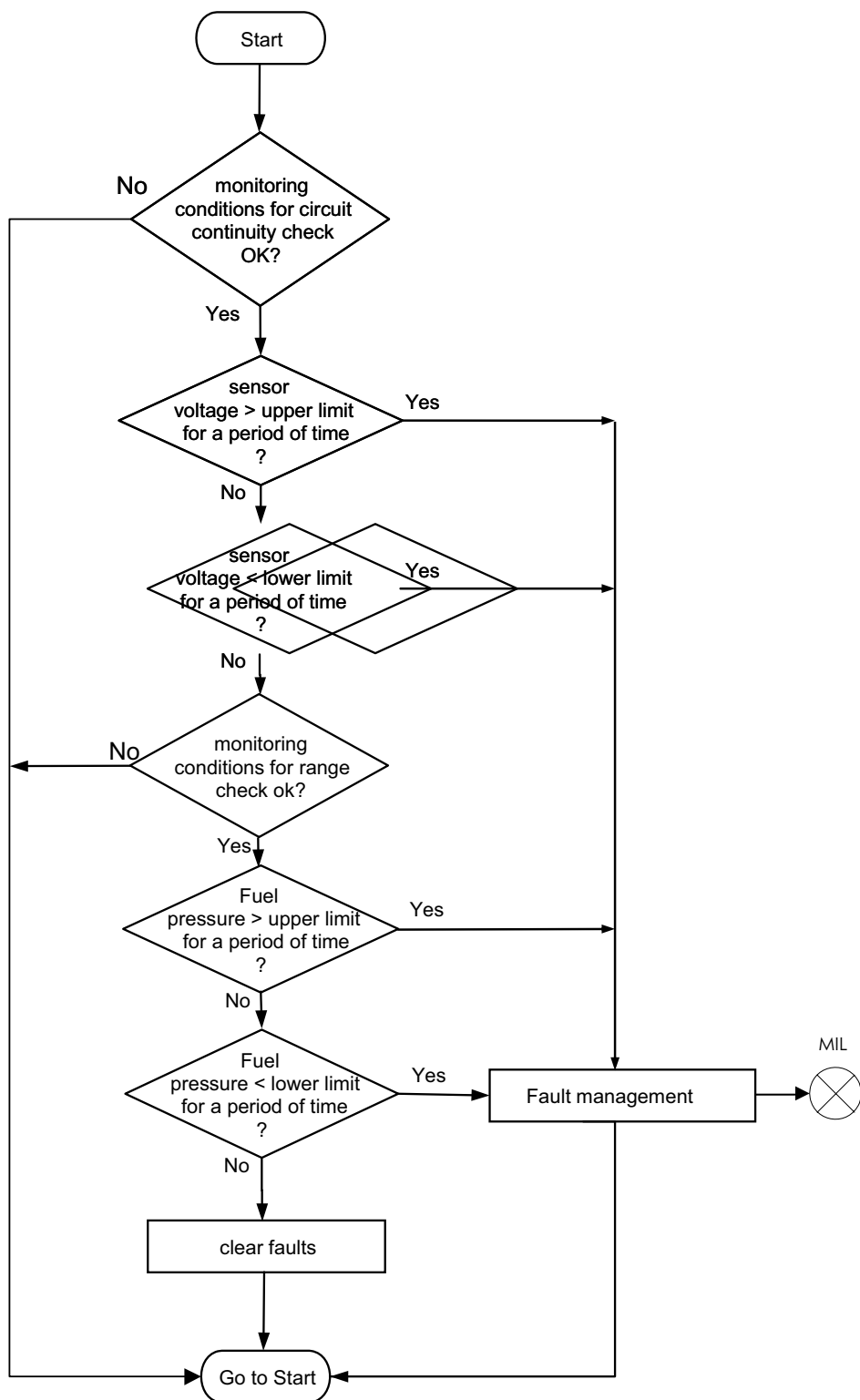


Figure 63: Flow Chart for Fuel Rail Pressure Monitoring

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14.18 Knock sensor monitoring (KS)

14.18.1 General description

The knock sensor signals are evaluated and processed in a custom integrated circuit (IC). This IC is controlled by the ECM microprocessor and the processed signals from the knock IC are sent to the microprocessor for knock control and diagnosis.

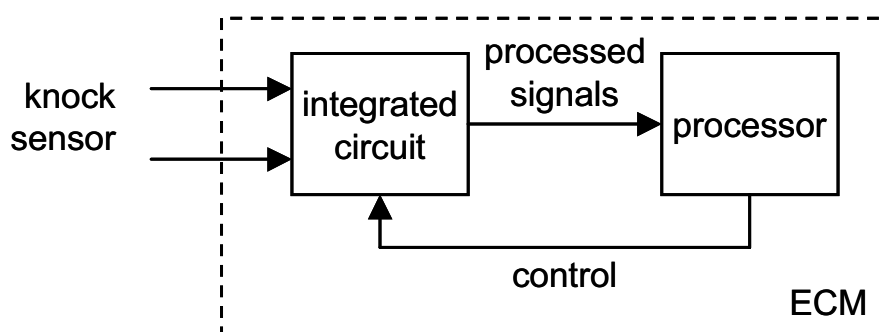


Figure 64: Overview knock sensor signal

The knock sensor monitor checks for electrical circuit faults and signal plausibility. In some cases, it can also detect excessive engine noise due to (for example) piston or valve gear problems.

14.18.2 Monitoring function description

Zero test

For monitoring purposes the knock sensor signals can be switched off and the integrated circuit is operated with a "zero signal" as input. The zero signal is integrated in the circuit and the integrator output at the beginning (int_beg) and at the end (int_end) of a monitoring window is used for diagnostics.

Integrator check

The first part monitors the integrator value at the beginning of the measuring window, which is typically about 715 mV. If the absolute value of the difference between integrator and 715 mV exceeds a limit on a number of occasions, a Knock Control System Error fault is set.

Integrator gradient check

A second check is performed by monitoring the gradient of the integrator. The difference in the integrator output between the end and beginning of the measuring window is compared against a limit. If the absolute value of this difference exceeds the limit on a number of occasions, a Knock Control System Error fault is set.

Monitoring structure pulse test

For monitoring purposes the knock sensor signals can be switched off and the integrated circuit is operated with a "test pulse" as input.

For an advanced diagnosis a test pulse can be generated at the input of the knock control circuit. In this mode, the test pulse signal is integrated instead of the signal from the knock sensors.

The integral of the test pulse is calculated in a monitoring window. The test pulse signal is integrated in the circuit and the integrator output at the beginning (int_beg) and at the end (int_end) of a monitoring window is used for diagnostics.

Therefore the content of the signal integrator at the beginning of the measuring window is subtracted from its content at the end of the window. If the difference is below a limit for a number of samples, a Knock Control System Error fault is set.

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Monitoring structure knock sensor monitor

A reference signal (uref) is calculated based on the knock sensor signal. This reference value represents the basic noise of the current cylinder being monitored.

If uref exceeds the upper limit for a number of samples, a Knock Sensor Circuit High fault is set.

If uref stays below the lower limit for a number of samples, a Knock Sensor Circuit Low fault is set.

14.18.3 Flow charts knock control monitoring

Flow chart knock control monitoring - zero test

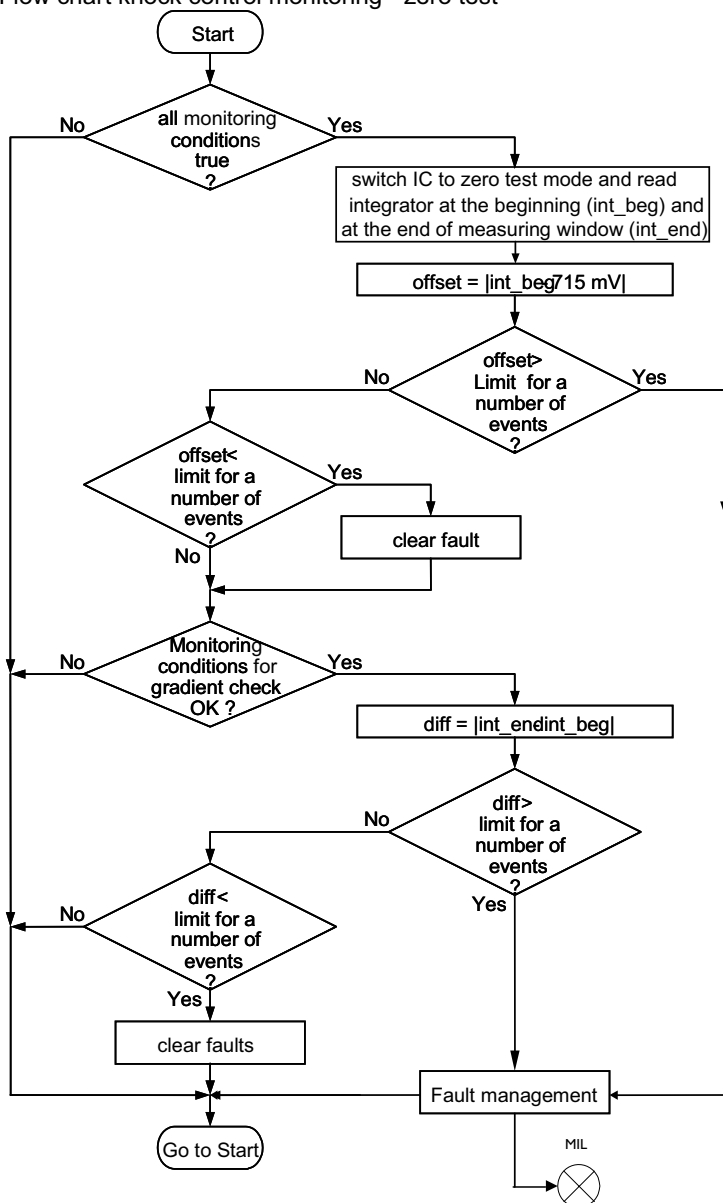


Figure 65: Flow chart knock control monitoring - zero test

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Flow chart knock control monitoring - pulse test

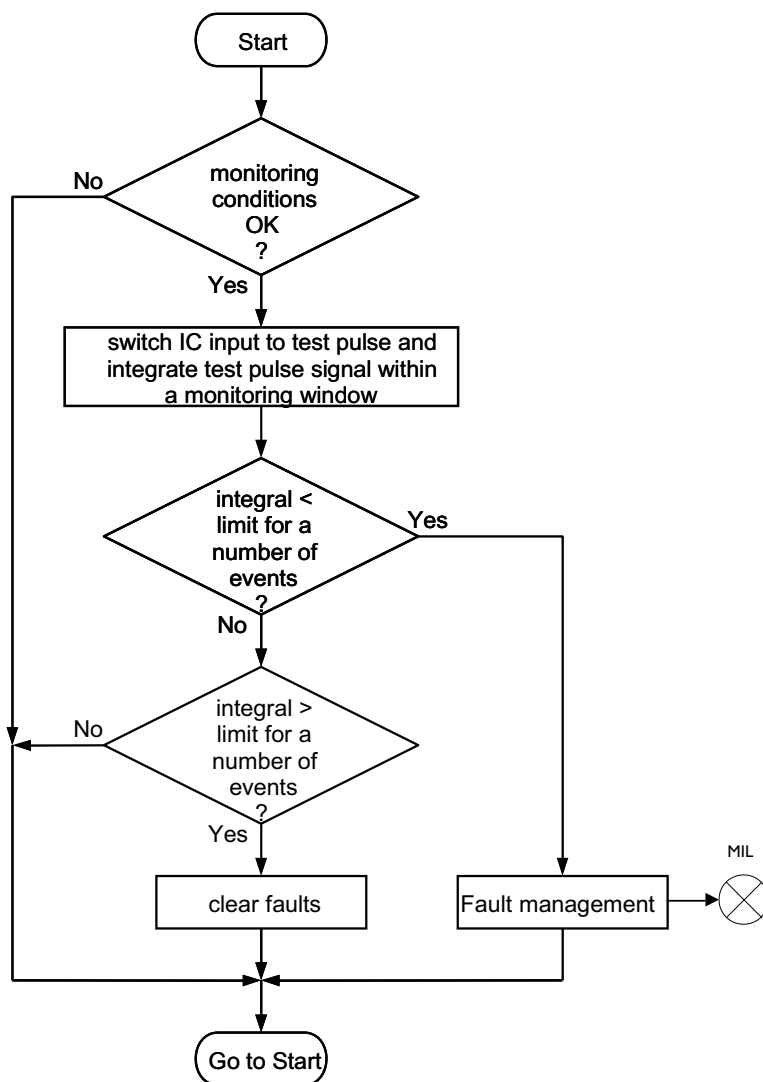


Figure 66: Flow chart knock control monitoring - pulse test

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Flow chart knock control circuit monitoring

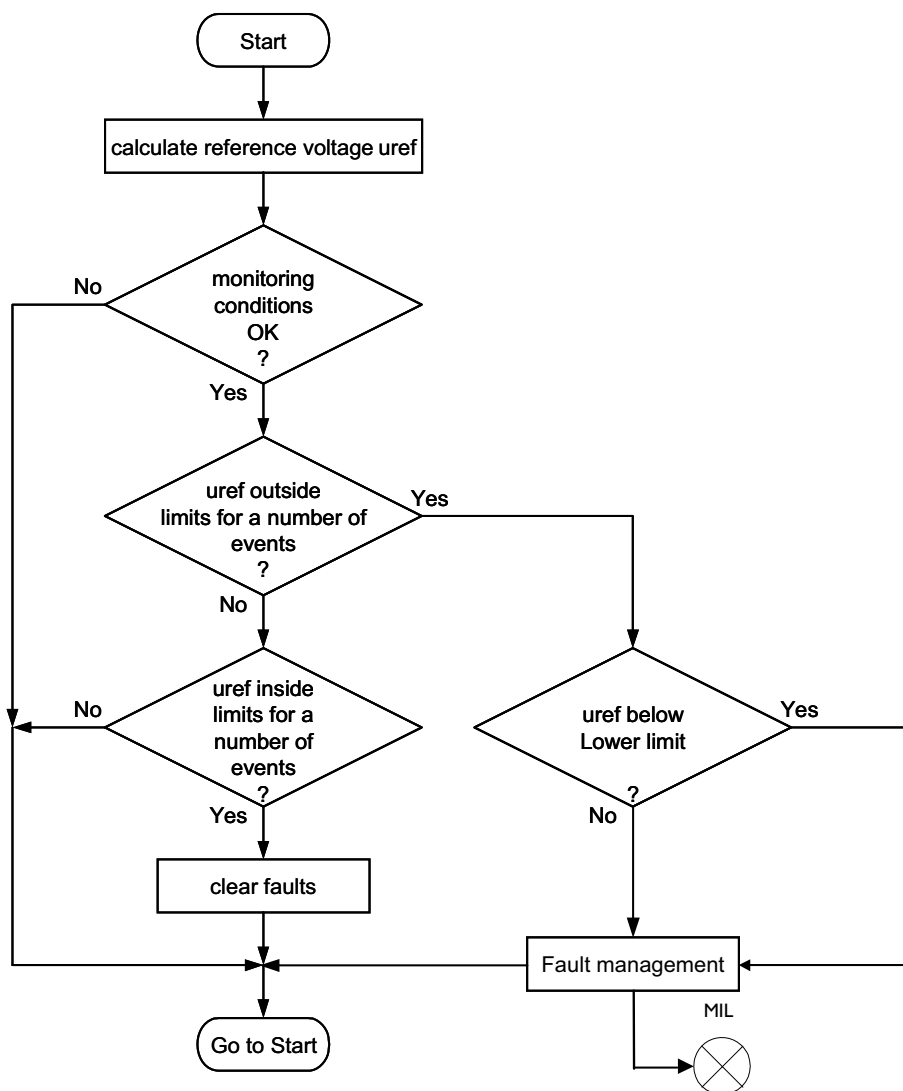


Figure 67: Flow chart knock control circuit monitoring

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14.19 Automatic Transmission Monitor

VW/Audi has different basic Automatic transmission systems. For each of these systems we are providing an OBD II summary table. Common OBD description from VW/Audi table TCM Groups show the references between transmission type and test groups.

14.20 Output Stage Check

The output stages are integrated in manufacturer specific IC's:

The IC has a binary diagnostic line (e.g. SJ401).

If the control line of one stage has a different signal than the output line, the logic circuit inside the IC detects a malfunction. The logic circuit within the IC can separate the type of fault to a short circuit to minus, an open line, or a short circuit to plus. The check result will be sent to the ECM via diagnosis line.

$U_{batt}=16V$	normal working situations	short circuit to ground	Short circuit to battery	wiring defective
U_{in}	low high	high	low	high
U_{out} / I_{out}	low high	$<0.25-0.37 U_{Batt}$	$>2.2-3.0A$	$<0.65-0.84 U_{Batt}$
Fault detection	no fault	fault	fault	fault

$U_{batt}=8V$	normal working situations	short circuit to ground	Short circuit to battery	wiring defective
U_{in}	low high	high	low	high
U_{out} / I_{out}	low high	$<0.22-0.4 U_{Batt}$	$>2.2-3.0A$	$<0.54-0.78 U_{Batt}$
Fault detection	no fault	fault	fault	fault

U_{in} input voltage
 U_{out} output voltage
 I_{out} output current

Figure 68: Signal tables of output stage check

To identify which components use the output stage check please refer to the respective OBD Group summary matrix.

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14.21 Cylinder Deactivation

Applicable only for test group

OBD Group Name	Test group	Engine	Models	Standard	Controller / OBD II strategy
BBE-V	BBEXV06.84LA	6.8 V8T - 2 bank	Bentley Mulsanne	LEV II Bin 5	Bosch ME(D)17 BE-V

14.21.1 General description

Correct functionality of the CD system is monitored by observing the manifold absolute pressure (MAP) oscillations. When the engine is running on all cylinders, MAP oscillates at 4 times crankshaft frequency (V8 engine = 4 intake strokes/revolution); when in deactivation MAP oscillates at 2 times crankshaft frequency (alternate cylinders are deactivated) with greater amplitude. There is a significant difference in the mean MAP over the 90 degree crankshaft segment for a deactivated cylinder compared to an active cylinder which is sufficient to decide if the cylinder is drawing air out of the manifold or not.

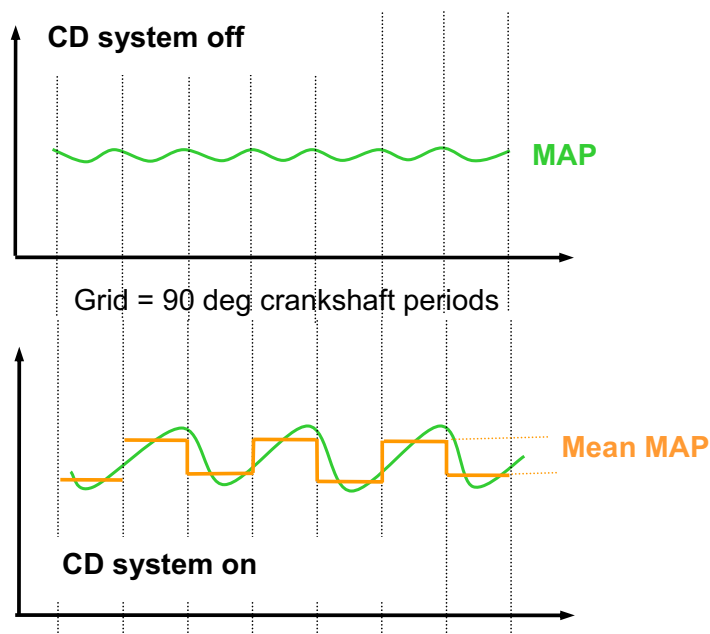


Figure 69: Overview CD system monitoring principle

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14.21.3 Flow chart

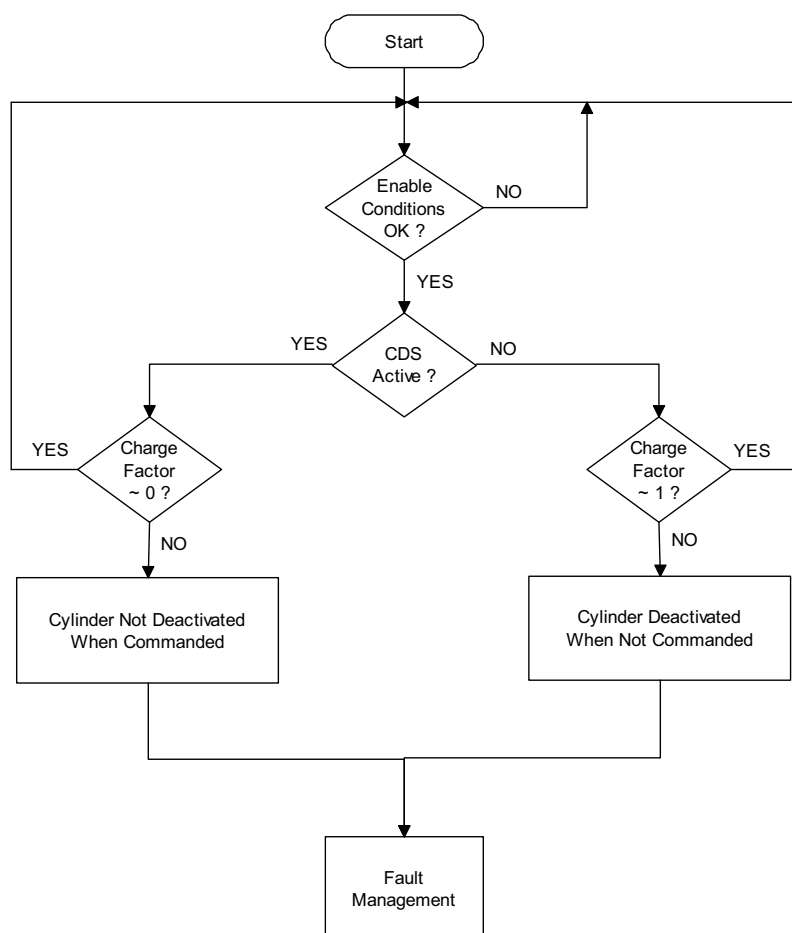


Figure 70: Flowchart CD system monitoring

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15 OTHER EMISSION CONTROL OR SOURCE SYSTEM MONITORING

15.1 Intake manifold runner flap monitoring

15.1.1 General Description

To improve the robustness of the combustion in terms of fuel preparation, especially at low load conditions, an electrical motor driven 2-point intake manifold runner flap system is introduced.

The target position of the flaps is shown in the engine operation map beside.

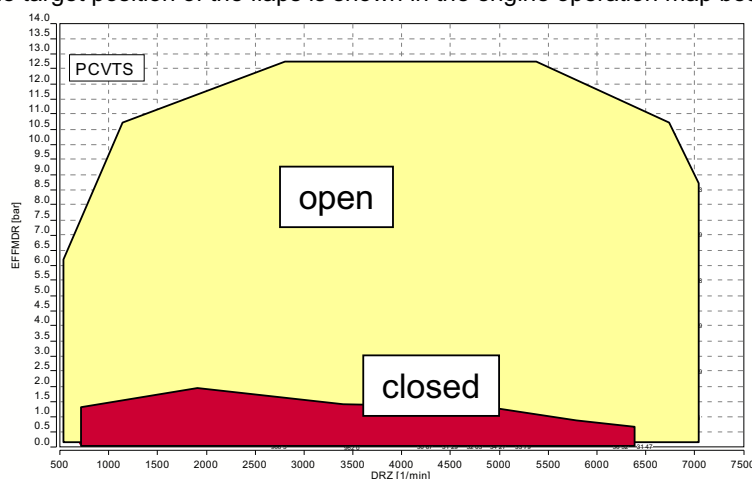


Figure 71: Intake manifold runner flap position while engine operation

The intake manifold runner flaps are located directly in the inlet area of each cylinder. The position control sensor is located inside of the actuator unit.

The spring-driven default position for the flaps is open.

15.1.2 Monitoring function description

Component:

Several electrical and rationality checks are implemented to monitor the correct runner flap position and system reaction. The main signal for those monitor is the sensor position signal voltage.

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15.1.3 Charts and flow charts

Electrical fault	
DTC's	P2008
Malfunction 1	Signal duty cycle > 80% and ECM power stage failure
Malfunction 2	Deviation > 5% and ECM power stage failure
Examples:	Open circuit, shorted wires, internal hardware failure
Rationality check	
DTC's	P2015
Malfunction 1	Signal duty cycle > 80%
Malfunction 2	Deviation > 5%
Examples:	High friction, stuck flaps,

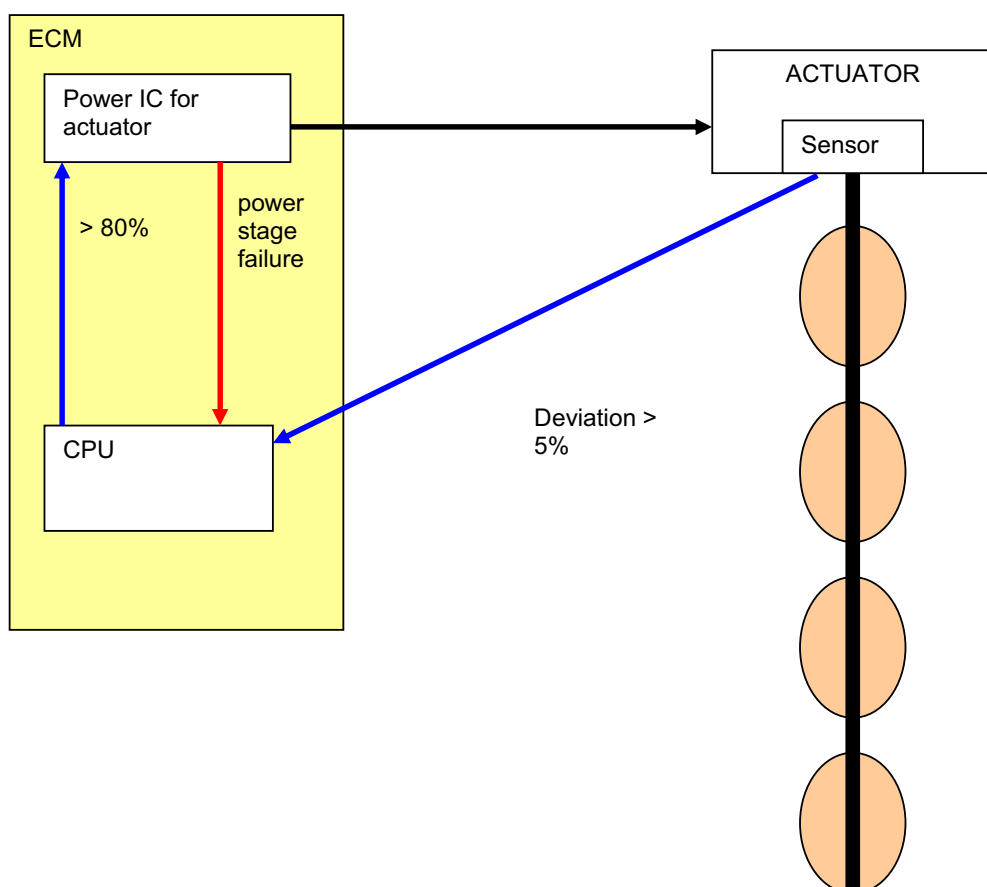


Figure 72: intake manifold runner flap monitoring (part 1)

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Electrical fault	
DTC's	P2016 / P2016
Malfunction 1	Short to ground, open circuit / Short to battery
Rationality check	
DTC's	P2016 / P2016 (once per driving cycle)
Malfunction 1	Sensor sent signal below mechanical linkage but no electrical fault.
Malfunction 2	Sensor sent signal above mechanical linkage but no electrical fault.
Function description	After ignition off the flaps are in the default open position. During keep alive time, an intrusive check will be performed: Flaps commanded closed: mechanical limit < 3.6V expected Flaps commanded open : mechanical limit > 1.3 V is expected
Example for failure	broken shaft

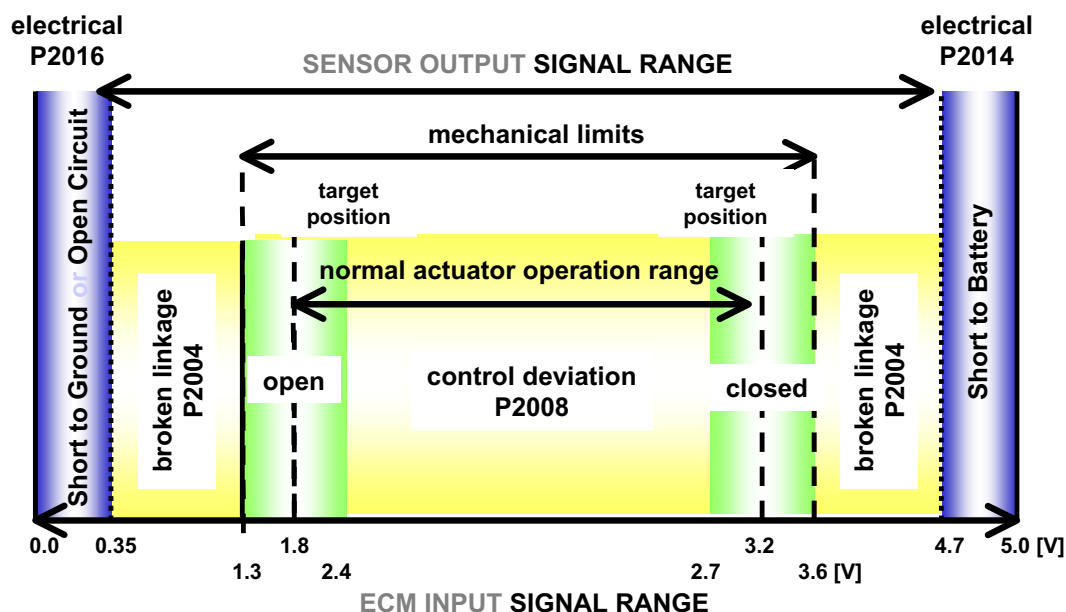


Figure 73: intake manifold runner flap monitoring (part 2)

15.1.4 System design

please refer to VW/Audi Common OBD description sect. 2.1.3

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15.2 Engine off timer monitoring

15.2.1 General Description

Some monitoring functions require the information that a cold start situation is present on a motor vehicle with an internal combustion engine. A cold start situation is for example detected by temperature sensors fitted to the vehicle, however the temperature values provided by the sensors are not fully reliable. This is because the impact of varying ambient air temperatures and different mounting locations with their different thermal conditions may have a negative influence on the accuracy of the temperature values. As an alternative to the evaluation of the temperature values provided by the temperature sensors, a cold start situation can generally also be detected on the basis of an engine-off time provided by the engine control module.

15.2.2 Engine-Off Time Rationality Check in the case of an engine restart during ECM Keep Alive Time

15.2.2.1 Engine-off time implausible – too long – P150A

Monitoring Strategy

The engine-off time provided by the instrument cluster is compared against the ECM keep alive time.

Enable Conditions

- Ignition on
- CAN communication active

Malfunction Criteria

If the difference between the engine-off time provided by the instrument cluster and the engine-off time obtained from the ECM keep alive time counter is greater than a positive upper threshold value, an implausibly long engine-off time is detected.

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Flowchart

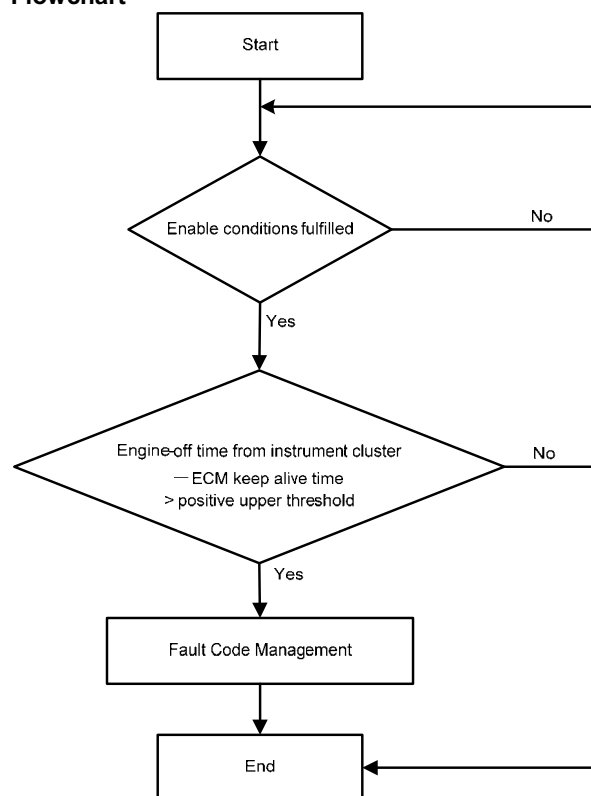


Figure 74: Engine off-time implausible - too long – P150A

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15.2.2.2 Engine-off time implausible – too short – P150A

Monitoring Strategy

The engine-off time provided by the instrument cluster is compared against the ECM keep alive time.

Enable Conditions

- Ignition on
- CAN communication active

Malfunction Criteria

If the difference between the engine-off time provided by the instrument cluster and the engine-off time obtained from the ECM keep alive time counter is less than a negative lower threshold value, an implausibly short engine-off time is detected.

Flowchart

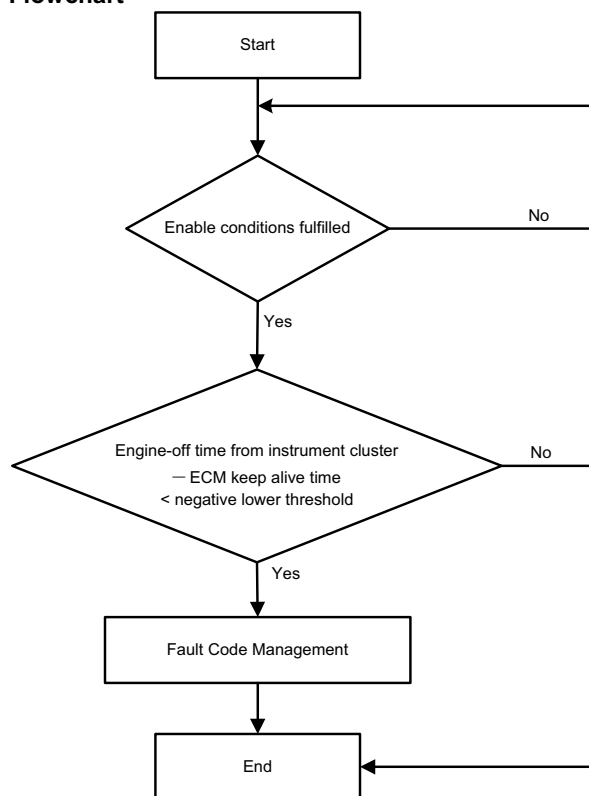


Figure 75: Engine-off time implausible - too short – P150A

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15.2.3 Engine-Off Time Rationality Check in the case of an engine restart post to ECM Keep Alive Time

In this case, the engine-off time provided by the instrument cluster control module can only be assessed as “implausible – too short”, as the ECM keep alive time has a defined limit, after which the engine-off time cannot be assessed as “implausible – too long”, because after the ECM keep alive time, it will always be greater than the maximum keep alive time, and thus a comparison does not provide a result.

15.2.3.1 Engine-off time implausible - too short – P150A

Monitoring Strategy

The engine-off time provided by the instrument cluster is compared against the maximum ECM keep alive time.

Enable Conditions

- Ignition on
- CAN communication active

Malfunction Criteria

If the difference between the engine-off time provided by the instrument cluster and the maximum engine-off time obtained from the ECM keep alive time counter is less than a negative lower threshold value, an implausibly short engine-off time is detected.

Flowchart

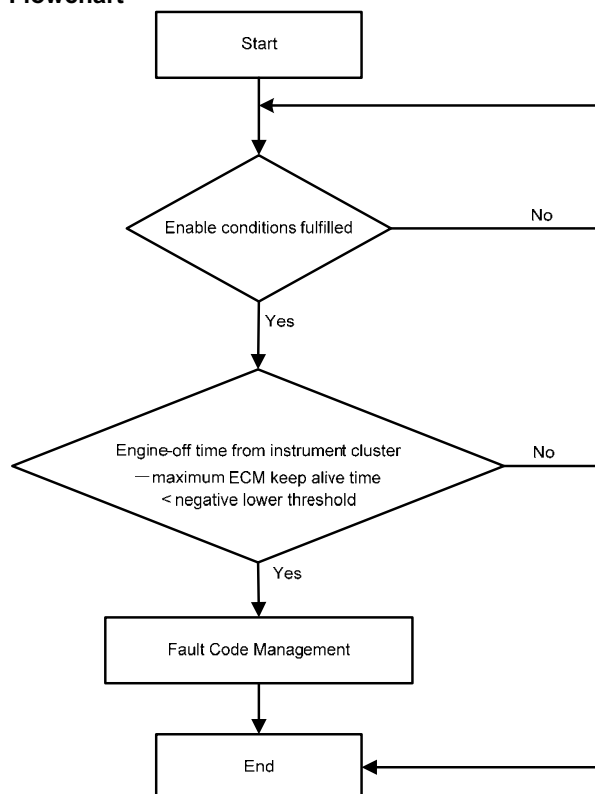


Figure 76: Engine-off time implausible - too short - post to ECM keep alive time – P150A

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16 EXEMPTIONS TO MONITOR REQUIREMENTS

17 RESERVED

18 PARAMETERS AND CONDITIONS FOR CLOSED LOOP OPERATION

General

The highest conversion efficiency of the catalyst is given in a small window of air-fuel mixture close to the ratio of $\lambda=1$. Therefore a combination of two (three for SULEV) control loops are used to achieve the conditions for highest conversion capability of the catalyst. The first control loop uses the signal of the first Oxygen sensor (pre catalyst) to correct the air fuel ratio by adjusting the injection time. The second and third control loop uses the signals of the middle (SULEV) and post catalyst Oxygen sensors. These control loops perform a fine tuning of the air / fuel ratio to optimize the catalytic conversion.

The first control loop has a quicker response time than the post control loops which are depending on the death time of the exhaust systems. Therefore the adjustment ranges for the post control loops are restricted and the response time is larger than the one of the first control loop.

Conditions for closed loop operation of the first control loop

The main condition for closed loop is a proper heated up Oxygen sensor and the dew point must be exceeded. To guaranty the Oxygen sensor readiness the heat-up strategy starts depending on engine temperature first on a low level of heater power. Upon the exhaust temperature reaches a level where no liquid water is expected to be in the exhaust system the heater power is controlled to achieve normal ceramic temperature of the Oxygen sensor. The ceramic temperature has to be $>350^{\circ}\text{C}$ for binary and $>685^{\circ}\text{C}$ linear sensors. Specific temperatures are mentioned in the individual summary tables of the concepts.

Additional heat-up of the Oxygen sensor is caused by the thermal energy of the exhaust gas. The engine management system evaluates permanently engine temperature and thermal energy introduced to calculate the exhaust temperature based on a model. The main value therefore is the integrated air mass after engine start. Upon the integrated air mass exceeds an applicable threshold, depending on engine start temperature, the dew point is exceeded. In that case, the heater power will be increased until the sensor readiness is achieved and sensor is considered to be ready for closed loop control.

The criteria for sensor readiness of a binary sensor are:

- no fault from heater final stage check
- Sensor signal is out of a range $0,4\text{V} < \text{sensor voltage} < 0,5\text{V}$
- heater power $> 50\%$ within a certain time (typically 8-10 s)

The criteria for sensor readiness of the linear are:

- no fault from LSU-Heater, LSU-Signals and LSU-IC
- LSU is heated up to a ceramic-temperature of $> 685^{\circ}\text{C}$ or the internal sensor resistor $R_i < 130\Omega$.

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Parameters evaluated to begin closed loop (first control loop)

The target is to begin closed loop operation in a very early state after engine start. However closed loop is delayed if engine is operated according the catalyst heat-up strategy. In the table below the importance parameters are listed.

Parameter / System	Condition/Evaluation	Monitor
Oxygen Sensor	No fault detected in Oxygen sensor, wiring of the sensor or the sensor IC (linear sensors).	Oxygen sensor monitor for the front sensor(s)
Dew Point exceeded	Exhaust Temperature > threshold, calculated based on mass air flow integral.	Monitor of the mass air flow meter (out of range, rationality)
Oxygen Sensor Readiness	Sensor heated up, evaluated based on heater resistance.	Monitored by diagnostic of the heater control.
Mass Air Flow	Integrated air mass > threshold	Out of range / rationality
Oxygen Sensor Heater	OBD evaluation on sensor heater finished without fault	Oxygen sensor heater monitor.
Engine Load	Calculated value based on mass air flow and fuel injection.	Fuel system monitor, mass air flow meter monitor
Engine Temperature	Signal used to trigger the model calculation.	Monitor for engine coolant temperature sensor (out of range, rationality). Monitor of the cooling system (rationality).
Intake Air Temperature	Signal used to trigger the model calculation.	Monitor for the intake air temperature sensor (out of range)
Secondary Air System	No fault in the secondary air system is detected by OBD.	Monitor for the secondary air system.
Fuel injectors	OBD evaluation on injectors finished without fault	Monitor for the fuel injectors (out of range). Fuel system monitor
Ignition system	OBD evaluation on ignition system finished without fault. No misfire detected.	Monitor for the ignition system (out of range). Misfire monitor.

Figure 77: Parameters and conditions to begin closed loop operation

Continuity of closed loop operation (first control loop)

The closed loop operation is the most dominant operation mode for the fuel system. Despite that fact, there are operating conditions of the engine where closed loop control must be temporary disabled.

Parameter / System	Condition/Evaluation	Monitor
Target Lambda	Control range is within normal values of Lambda (0.8< λ <1.5)	Fuel system monitor, mass air flow meter monitor, oxygen sensor monitor
Engine load	Engine load is too low, to control the exhaust lambda value during SAI (typically relative engine load<15%)	Fuel system monitor, mass air flow meter monitor, oxygen sensor monitor
Secondary air injection	During the monitor of air injection the target Lambda is commanded to determine deviation cause by air mass.	Fuel system monitor, mass air flow meter monitor
Fuel Injection	Injection time is not at minimum threshold. Injection is not disabled. Fuel cut is not commanded (e.g. coasting)	Monitor for the ignition/injection system (out of range). Misfire monitor. Fuel system monitor

Figure 78: Continuity of closed loop operation

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Typical Values

Given a normal cold started FTP (around 20°C) most of the concepts reaches the closed loop condition for the first control loop within 20s to 60s. Additionally closed loop is forced depending on engine start temperature after a maximum time.

Engine Start Temperature	Time, when closed loop is forced
Temperature $\geq 10^{\circ}\text{C}$	120 s
Temperature $\geq -6.7^{\circ}\text{C}$ and $< 10^{\circ}\text{C}$	300 s

Figure 79: Engine start temperature and time to reach closed loop

19 PARAMETERS / CONDITIONS FOR 2ND CLOSED LOOP OPERATION

Conditions for closed loop operation of the second control loop

As already mentioned under "General" the 2nd control loop optimizes the adjustments of the first control loop over a longer time to achieve the maximum conversion of the catalyst in a very small window of air/fuel ratio close to $\text{Lambda}=1$. The second control loop uses a binary Oxygen sensor which is operated at a target value of sensor output voltage. Deviations from the target voltage are corrected by adjusting the air/fuel ratio until the target voltage is achieved again. The controller of the 2nd control loop is a combination of proportional and integral (PI-) controller. The proportional and the integral portion of the controller have individual enable criteria.

Parameters evaluated to begin closed loop (second control loop)

Enable criteria for P-portion of the controller

The proportional-portion of the controller corrects short term deviations and achieves the target sensor output voltage.

Parameter / System	Condition/Evaluation	Monitor
Closed loop condition for the first control loop. Minimum of integrated mass air flow passed.	No fault detected in wiring of the sensor or the sensor IC (linear sensors). Fuel control performs normal, no fault is detected and fuel control is not temporarily disabled.	Oxygen sensor monitor for the front sensor(s). Monitor of the mass air flow meter (out of range, rationality). Fuel system monitor
Oxygen Sensor for 2 nd control loop readiness	Sensor heated up, a minimum power was delivered to the heater, sensor voltage has left the voltage range of a cold sensor	Monitored by diagnostic of the heater monitor and sensor wiring monitor.
Catalyst model temperature	Exhaust Temperature > threshold, calculated based on mass air flow integral, ignition timing, lambda value, vehicle speed.	Monitor of the mass air flow meter (out of range, rationality) Fuel system monitor, oxygen sensor monitor, vehicle speed sensor monitor
Variable Valve Timing System (if applicable)	No fault detected	VVT monitor
Secondary Air System	No fault detected	AIR System monitor
EVAP purge System	No fault detected	EVAP purge monitor
Mass Air Flow Meter	No fault detected	Mass Air Flow Meter monitor
Controller range for the first control loop is not at the threshold limit.	Controller for the first control loop not at minimum or maximum threshold	Oxygen sensor monitor

Figure 80: Enable criteria for P-portion of the controller

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Enable criteria for adaptive I-portion of the controller (additionally)

The integral-portion of the controller corrects permanent deviations / shifts over a longer time by adjusting the adaptation.

Parameter / System	Condition/Evaluation	Monitor
Engine speed/load within a normal operating range	Engine Speed within 1500-4000 rpm Engine Load within 20-60% (Typical values; may differ on individual concepts)	Engine Speed Sensor monitor, Mass Air Flow Meter monitor, fuel system monitor.
Carbon Canister of the EVAP system	High load of carbon canister indicated during EVAP purge.	EVAP purge monitor.
Minimum of integrated mass air flow passed and P-portion of controller achieves target range for Oxygen sensor voltage already..	Oxygen sensor voltage of 2 nd control loop, P-portion of controller for 2 nd control loop	Oxygen sensor monitor for secondary sensor(s). Fuel system monitor

Figure 81: Enable criteria for adaptive I-portion of the controller (additionally)

Typical Values (second control loop)

Given a normal cold started FTP (around 20°C) most of the concepts reaches the closed loop condition for the second control loop within 60s to 100s.

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20 DETERMINATION OF CALCULATED LOAD AND FUEL TRIM VALUES

20.1 Calculated Load Values

22.1.1 Spark Ignition, MAF Sensor, Turbocharged concepts

Applicable only for test groups

OBD Group Name	Test group	Engine	Models	Standard	Controller / OBD II strategy
BBE-V	BBEXV06.84LA	6.8 V8T - 2 bank	Bentley Mulsanne	LEV II Bin 5	Bosch ME(D)17 BE-V

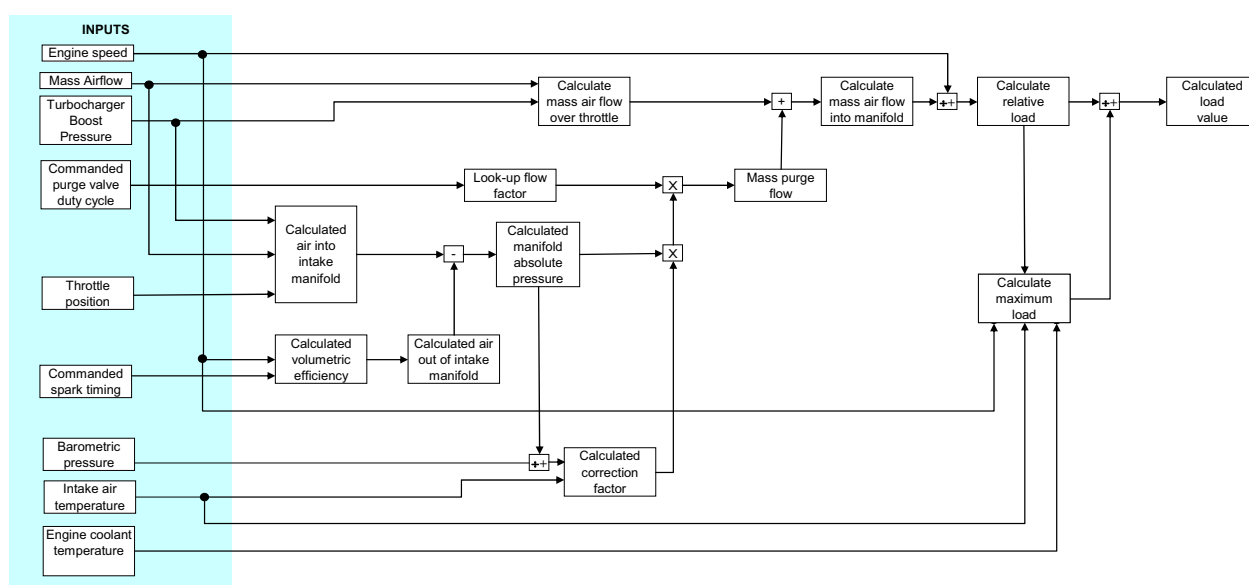


Figure 82: Block Diagram: Calculated Load Value: Spark Ignition, MAF Sensor, Turbocharged

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20.2 Fuel Trim Values

The description of "Lambda-Control Strategies" within the "Fuel System Monitoring" section of this document includes reference to fuel trim values.

21 REVISIONS

Page	Date	Content	Remark
ALL	12-11-09	MY11 initial	A.Geisen
Multiple	20-Apr-10	Test group name BBEXV06.8TTC amended to BBEXV06.84LA. Addition of descriptions for: Additional misfire detection description with Cylinder Deactivation system. VVT description. Additional MAP Sensor response check. Cylinder Deactivation.	D Leather
Part I: 25-26			
Part II : 36			
Part II: 81-82			
Part II: 119-121			