Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

Table of Contents

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

.01.00.00   CATALYST MONITORING

There are two diagnostic functions, which are used for monitoring of the catalyst efficiency. Both are based on measure of the Oxygen within the catalyst determined by at least two Oxygen sensors. Each of the functions can be correlated between Oxygen / Hydrocarbon and Oxygen/ Oxides of Nitrogen.

.01.01.00   Passive measurement of amplitude ratio

.01.01.01   General description

The method compares the signal amplitudes obtained from the downstream sensor to the modelled signal amplitudes. The modelled signal amplitudes are derived from a borderline catalyst. The data for borderline catalysts are taken from measurement results on real life deteriorated catalysts. In case the measured amplitudes exceed those of the model, the catalyst is considered defective. This information is evaluated within one single engine load and speed range (detection over full range of engine load versus speed).

According to the described operating principle the following main parts can be distinguished:

- **Computation of the amplitude of the downstream oxygen sensor:**
  The amplitude of the signal oscillations of oxygen sensor downstream catalyst is calculated. Extracting the oscillating signal component, computing the absolute value and averaging over time accomplish this.

- **Modelling of a borderline catalyst and of the signal amplitudes of the downstream oxygen sensor:**
  The model is simulating the oxygen storage capability of a borderline catalyst. The signal of the downstream oxygen sensor is simulated in the catalyst model based on real time engine operating data (e.g. A/F ratio and engine load). The amplitude of the modelled signal oscillations is calculated.

- **Signal and fault evaluation**
  The signal amplitudes of the downstream oxygen sensor are compared with the model for a given time. In case of the signal amplitudes of the downstream sensor exceed the modelled amplitudes, the oxygen storage capability of the catalyst falls short of the borderline catalyst model.

- **Check of monitoring conditions**
  It is necessary to check the driving conditions for exceptions where no regular Lambda control is possible, e.g. fuel cut-off. During these exceptions, and for a certain time afterwards, the computation of the amplitude values and the post processing is halted. Thus, a distortion of the monitoring information is avoided.

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

.01.01.02   Monitoring Structure

The catalyst temperature (model) activates the catalyst monitoring function if the catalyst temperature is above a predetermined value.

.01.01.03   Flow Chart Catalyst Monitoring

```
                    ┌──────────┐
                    │  Start   │
                    └────┬─────┘
           ┌─────────────┤
           │             ▼
    no     ◄────────◇ Enable?
                    Models stabilized?
                         │ yes
                         ▼
                  ┌──────────────────┐
                  │ Calculate:       │
                  │ - catalyst model │
                  │ - modeled sensor │
                  │ - downstream sensor │
                  └────────┬─────────┘
                           ▼
                  ┌──────────────────┐
                  │ Count accumulation │
                  │      time        │
                  └────────┬─────────┘
                           ▼
    no   ◄──────────◇ Time > limit
                           │ yes
                           ▼
         ◇ Modeled amplitude <      ─── yes ──►  Catalyst deteriorated
           downstream amplitude                         │
                    │ no                                 ▼
                    ▼                            Fault management
            Catalyst okay                              │
                    │                                  MIL
                    ▼
                  End  ◄───────────────────────────────┘
```

- 5 -

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy
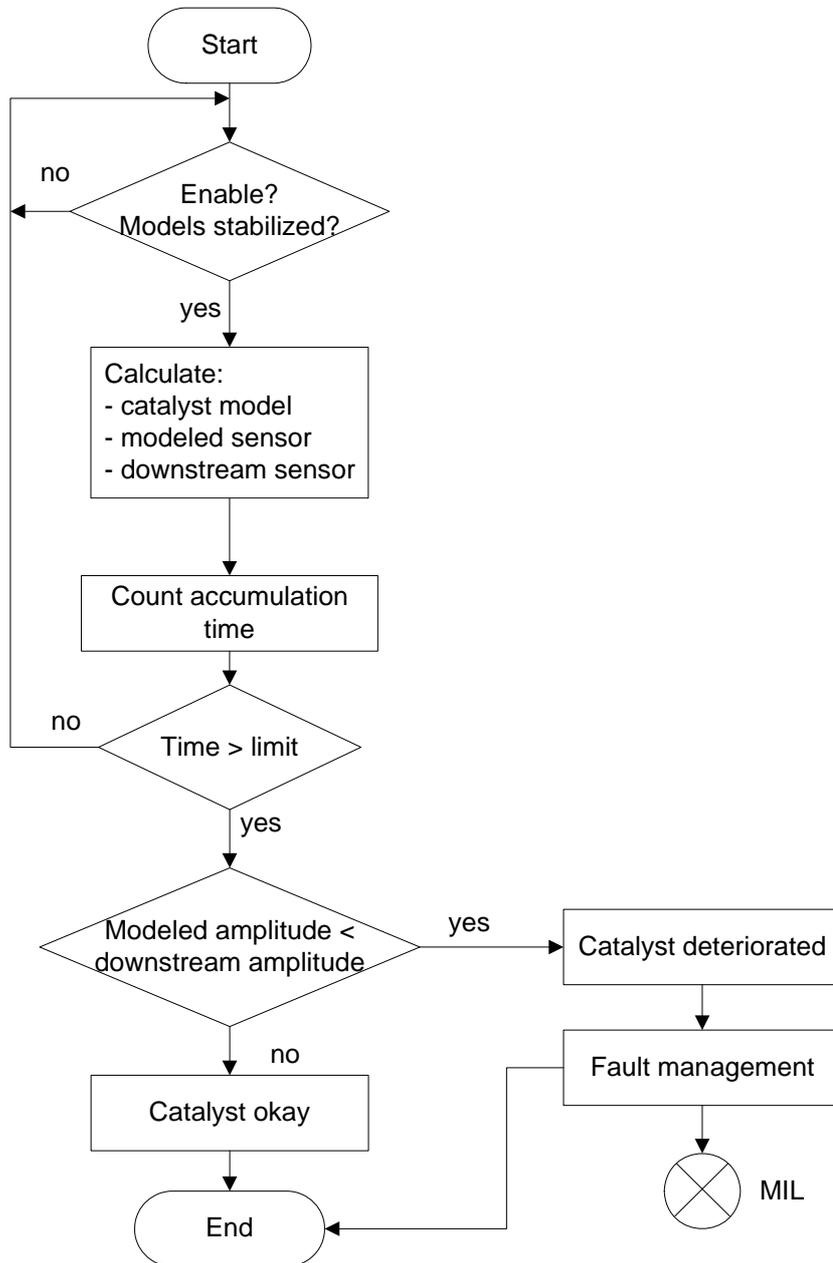
.01.02.00   Active measurement of OSC

.01.02.01   General description

The catalyst monitor is based on the determination of oxygen storage capability (OSC). The correlation between conversion efficiency and the OSC has been investigated on catalysts with various characteristics specifically concerning stages of aging correlated to exhaust emissions (HC/NOx). Therefore, the catalyst is diagnosed by comparing its storage capability against the storage capability of a borderline catalyst.

The oxygen storage capability (OSC) can be determined by one of the following two methods:

1. Oxygen reduction after fuel-cut (Quick pass of the monitor)

Oxygen is stored in the catalyst during fuel-cut conditions happening while driving the vehicle. After fuel-cut, the catalyst is operated with a rich air-fuel ratio (A/F) and the amount of removed oxygen is determined. If this passive test indicates an OSC value highly above the borderline catalyst, the catalyst is diagnosed without an error. This monitoring path can only generate a "pass" result.

2. Determination of Oxygen storage (active test)

For purposes of monitoring, the ECM cycles the A/F ratio by commanding a rich and a lean fuel mixture as follows.

- First, ECM commands a rich A/F ratio until a minimum of oxygen has been removed (cumulated rich gas > threshold).
- Then, the catalyst is operated with a lean A/F ratio commanded by ECM and the Oxygen Storage Capability is calculated from the oxygen mass stored in the catalyst as follows:

$$\text{OSC} = \int \text{air mass flow} * \text{lean mixture} (\lambda\text{-}1) * dt$$

- The catalyst is operated in this mode until the oxygen stored in the catalyst exceeds a calibrated limit or the downstream oxygen sensor indicates that the catalyst is completely saturated with oxygen.
- The catalyst is then diagnosed by comparing its oxygen storage capability to the calibrated threshold of a borderline catalyst.

.01.02.02 Monitoring Structure

According to the operating principle described above the following main parts of the monitor can be distinguished:
- Monitoring the amount of removed oxygen after fuel cut off
- Check of monitoring conditions for active test
- Lambda request (interface to lambda controller)
- Mixture enrichment in order to remove any stored oxygen
- Measurement of oxygen storage capacity (OSC) by lean A/F ratio operation
- Processing
- Fault detection
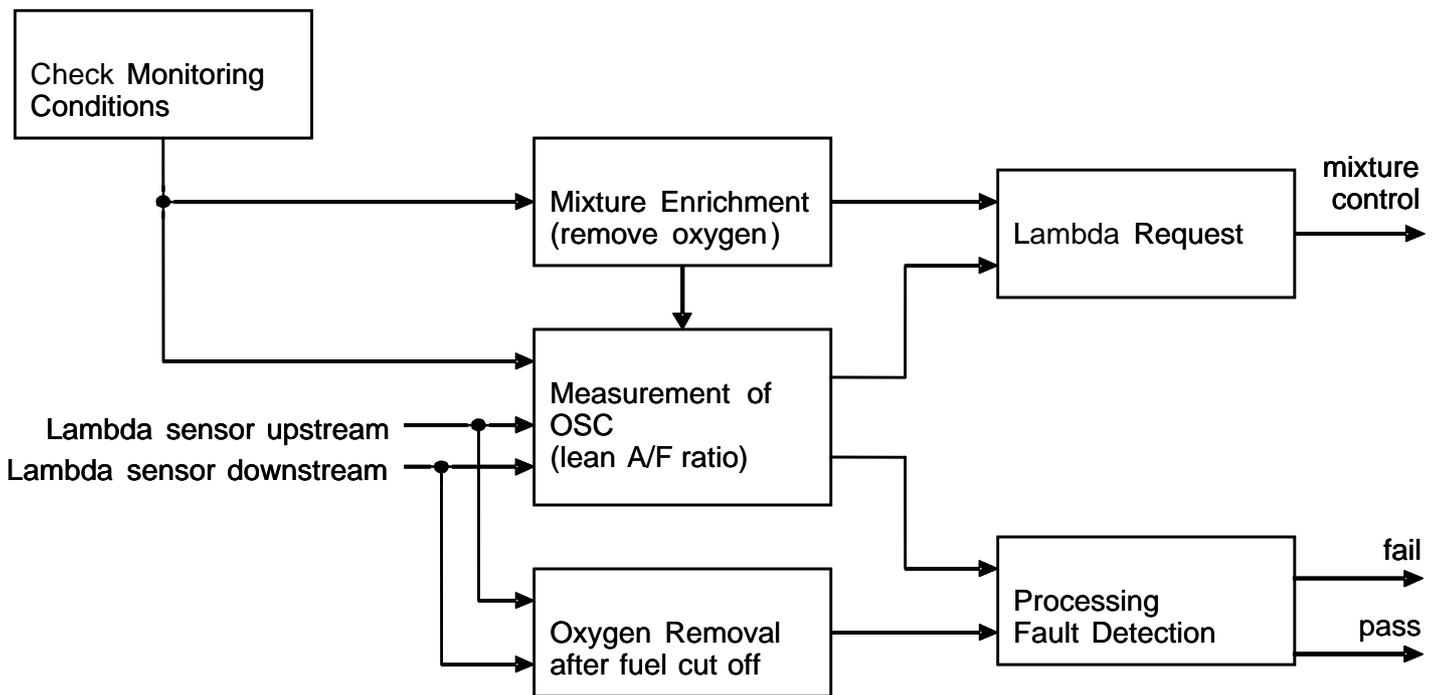
Processing:

After the measurement of the OSC, the OSC-value is normalized to the OSC-value of the borderline catalyst, which is taken from a map, depending on exhaust gas mass flow and catalyst temperature.

The final diagnostic result is calculated by averaging several, normalized OSC-values and compared to the threshold. The measurement of OSC can be carried out consecutive or stepwise.

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

For a catalyst system with 3 Oxygen-Sensors this measuring procedure can be applied to different portions. The different alternatives are shown in the table below.
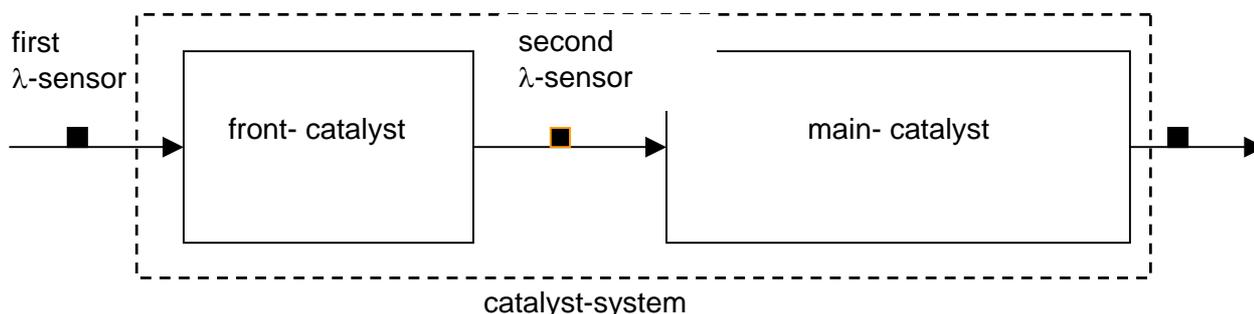
catalyst-system

Table 1: Necessary conditions to check the different catalyst volume

Secondary parameters	Front-catalyst	Main-catalyst	Catalyst-system
• First λ-sensor is active • Second λ-sensor is active • Modelled exhaust gas temp. in range	Quick pass		
• First λ-sensor is active • Second λ-sensor is active • Third λ-sensor is active • Modelled exhaust gas temp. In range		Quick pass	
• First λ-sensor is active • Second λ-sensor is active • Third λ-sensor is active • Modelled exhaust gas temp. In range	{Quick pass	Quick pass}	=> Quick pass
• First λ-sensor is active • Second λ-sensor is active • Modelled front exhaust gas temp. In range • Modelled main exhaust gas temp. In range • Exhaust- gas mass flow in range • Exhaust- gas mass dynamic in range	Measurement of OSC-calculation		
• First λ-sensor is active • Second λ-sensor is active • Third λ-sensor is active • Modelled front exhaust gas temp. In range • Modelled main exhaust gas temp. In range • Exhaust- gas mass flow in range • Exhaust- gas mass dynamic in range		Measurement of OSC-calculation	
• First λ-sensor is active • Third λ-sensor is active • Modelled front exhaust gas temp. In range • Modelled main exhaust gas temp. In range • Exhaust- gas mass flow in range • Exhaust- gas mass dynamic in range			Measurement of OSC-calculation

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

If the secondary parameters for the different catalyst portions are met at the same time, the diagnostic functions can run simultaneously.

According to table 1 the following result combinations are described in table 2.

Table 2: Results, which can be obtained after the diagnosis of the different catalyst volumes

Front catalyst	Main catalyst Or Catalyst system	Result
Quick pass	Quick pass	Both = pass
Quick pass	Measurement of OSC-calculation < threshold	front catalyst = pass main catalyst = Fail
Quick pass	Measurement of OSC-calculation > threshold	Both = pass
Measurement of OSC-calculation < threshold	Quick pass	front catalyst = Fail main catalyst = passe
Measurement of OSC-calculation > threshold	Quick pass	Both = pass
Measurement of OSC-calculation < threshold	Measurement of OSC-calculation < threshold	Both = fail
Measurement of OSC-calculation > threshold	Measurement of OSC-calculation > threshold	Both = pass
Measurement of OSC-calculation > threshold	Measurement of OSC-calculation < threshold	front catalyst = pass main catalyst = fail
Measurement of OSC-calculation < threshold	Measurement of OSC-calculation > threshold	front catalyst = fail main catalyst = pass

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

.01.02.03 Flow Chart Catalyst Monitoring

```
                         ┌─────────┐
                         │  Start  │
                         └─────────┘

              ◇ fuel cut off ? ◇ ──No──►   ◇ all monitoring conditions fulfilled ? ◇ ──No──►
                    │ Yes                            │ Yes
              ◇ catalyst temperature in range ? ◇ ──No──►   apply rich mixture to catalyst (oxygen removal)
                    │ Yes                            │
              calculate amount of oxygen after fuel cut off     accumulate amount of applied rich mixture
                    │                                │
              ◇ osc > calibration ? ◇ ──No──►   ◇ amount of rich mixture > calibration ? ◇ ──No──►
                    │ Yes                            │ Yes
                                             apply lean mixture to catalyst (oxygen storing)
                                                     │
                                             accumulate amount of oxygen stored in
                                                     │
                                             ◇ osc > calibration or catalyst saturated ? ◇ ──No──►
                                                     │ Yes
                                             ◇ number of measurements > threshold ? ◇ ──No──►
                                                     │ Yes
                                             mean - value calculation
                                                     │
                    ◄──NO── ◇ osc < threshold ? ◇ ──Yes──►
              ┌──────┐                                 ┌──────┐
              │ pass │                                 │ fail │
              └──────┘                                 └──────┘
                         ┌─────────┐
                         │   End   │
                         └─────────┘
```

.02.00.00   HEATED CATALYST MONITORING

Not applicable

.03.00.00   MISFIRE MONITORING

.03.00.01   General Description

The method of engine misfire detection is based on evaluating the engine speed fluctuations.

In order to detect misfiring at any cylinder, the torque of each cylinder is evaluated by metering the time between two ignition events, which is a measure for the mean value of the speed of this angular segment. This means, a change of the engine torque results in a change of the engine speed.

Additionally the influence of the load torque will be determined.
When the mean engine speed has been measured, influences caused by different road surfaces have to be eliminated (e.g. pavement, pot holes etc.).

This method consists of the following main parts:

-   Correction of normal changes of engine rpm and engine load

-   Data acquisition, adaptation of sensor wheel and typical engine behaviour is included

-   Calculation of engine roughness

-   Comparison with a threshold depending on operating point

-   Fault processing, counting procedure of single or multiple misfire events

.03.01.02   **Monitoring function description**

Data acquisition
The duration of the crankshaft segments is measured continuously for every combustion cycle and stored in a memory.

Sensor wheel adaptation
Within defined engine speed and load ranges the adaptation of the sensor wheel tolerances and the typical engine behaviour is carried out, if no misfire events are detected.
With progressing adaptation the sensitivity of the misfire detection is increasing.
The adaptation values are stored in a non-volatile memory and taken into consideration for the calculation of the engine roughness.

Misfire detection
The following operating steps are performed for each measured segment, corrected by the sensor wheel adaptation.

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

Detecting of multiple misfiring
If several cylinders are misfiring (e.g. alternating one combustion/one misfire event), the calculated engine roughness values may be so low, that the threshold is not exceeded during misfiring and therefore, misfiring would not be detected.

Based on this fact, the periodicity of the engine roughness value is used as additional information during multiple misfiring. The engine roughness values are filtered and a new multiple filter value is created. If this filter value increases due to multiple misfiring, the roughness threshold is decreased. By applying this strategy, multiple misfiring is detected reliably.

Calculation of the engine roughness threshold value
The engine roughness threshold value consists of the base value, which is determined by a load/speed dependent map.
During warm-up, a coolant-temperature-dependent correction value is added. In case of multiple misfiring the threshold is reduced by an adjustable factor.
Without sufficient sensor wheel adaptation the engine roughness threshold is limited to a speed dependent minimum value.
A change of the threshold towards a smaller value is limited by a variation of filter value (low pass filter).

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

Determination of misfiring

<u>Random misfire</u>
Comparing the engine roughness threshold value with the engine roughness value performs misfire detection.
If the engine roughness value is greater than the roughness threshold value a single misfire is detected. With this misfire determination it is possible to identify misfiring cylinders individually.

<u>Random misfire without valid adaptation</u>
To eliminate the influence of the missing flywheel adaptation each engine roughness value is compared with that one on the same flywheel segment on the intermittent revolution. Therefore single misfire events are detected reliable without determination of the flywheel tolerances.

<u>Continuous misfire on one or multiple cylinders</u>
To avoid noise effects, all engine roughness values are low pass filtered and the detection threshold is corrected by the mean value of the filters. Therefore the amplitude to noise ratio improves and the sensitivity for misfire detection of continuous misfiring cylinders increases.

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

Statistics, Fault processing:
Within an interval of 1,000 crankshaft revolutions, the detected number of misfiring events is totalled for each cylinder. If the sum of cylinder fault counters exceeds a predetermined value, a fault code for emission relevant misfiring is preliminary stored after completion of the first interval after engine has been started or the forth interval during a driving cycle where misfire has been detected.
In the case of misfire detection for one cylinder, the fault is determined by a cylinder selective fault code otherwise the fault code for multiple misfire will be stored additionally.

Within an interval of 200 crankshaft revolutions, the detected numbers of misfire events is weighted and totalled for each cylinder.
The weighting factor is determined by a load/speed dependent map.
If the sum of cylinder fault counters exceeds a predetermined value, the fault code for indicating catalyst damage relevant misfiring is stored and the MIL is illuminated with "on/off"-sequence once per second (blinking).
In case of misfire detection for one cylinder the fault is determined by a cylinder selective fault code otherwise the fault code for multiple misfiring will be stored additionally.
If catalyst damaging misfire does not occur any longer during the first driving cycle, the MIL will return to the previous status of activation (e.g. MIL off) and will remain illuminated continuously during all subsequent driving cycles if catalyst related misfire is detected again. However all misfire events where the catalyst can be damaged are indicated by a blinking MIL. If catalyst damage is not detected under similar conditions in the subsequent driving cycle the temporary fault code will be deleted.

In the case of catalyst related misfire, the Lambda closed loop system is switched to open-loop condition according to the basic air/fuel ratio calculation (Lambda=1).

All misfire counters are reset after each interval.

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

.03.00.03   Chart(s) and Flow Chart(s)

```
                    ┌─────────────────────┐
                    │  Start of monitoring │
                    │      procedure       │
                    └─────────────────────┘
                               │
                               ▼
                    ┌─────────────────────┐
                    │ Data acquisition     │
                    │ segment duration     │
                    └─────────────────────┘
                               │
                               ▼
                    ┌─────────────────────┐
                    │ Calculation of engine│
                    │ roughness and        │
                    │ threshold            │
                    └─────────────────────┘
                               │
                               ▼
                    ┌─────────────────────┐
                    │ Comparison of        │
                    │ threshold with       │
                    │ engine roughness     │
                    └─────────────────────┘
                               │
                               ▼
                         ◇ roughness >        no    ┌───────────────────────┐
                         ◇ threshold?   ──────────▶ │ Adaptive segment      │
                                                    │ duration correction   │
                              │ yes                 └───────────────────────┘
                              ▼
            no        ◇ Extreme engine       yes
       ◀──────────────◇ operating      ──────────▶
                      ◇ condition?

  MIL
  ⊗◀──┐
      │
┌─────────────────┐      ┌──────────────────────────┐
│ Fault code      │─────▶│ End of monitoring         │◀──────
│ management      │      │ procedure                 │
└─────────────────┘      └──────────────────────────┘
```

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

Paths for misfire and catalyst damaging misfire rate

```
                        ┌─────────────────────────────┐
                        │  Start of monitoring procedure │
                        └─────────────────────────────┘

        yes      ╱ Interval ╲    no            no    ╱ Interval ╲      yes
           ◄────╱  counter A  ╲────┐         ┌────────╲ counter B ╱────┐
                ╲  > 1,000?   ╱    │         │         ╲  >200?   ╱     │
                 ╲          ╱      │         │          ╲       ╱       │
                                   ▼         ▼                          ▼
              ┌──────────────────────┐   ┌──────────────────────────┐
              │  Interval counter A=0 │   │  Interval counter B=0     │
              │ Cylinder fault        │   │  Cylinder fault           │
              │ counters A1..An=0     │   │  counters B1..Bn=0        │
              └──────────────────────┘   └──────────────────────────┘

        yes     ╱ Misfire ╲   no                 no  ╱ Misfire ╲   yes
          ◄────╱  event?   ╲──────────────┐  ┌──────╲  event?  ╱────┐
               ╲          ╱               │  │       ╲        ╱      │
                                          │  │                       ▼
          ┌─────────────────────┐         │  │   ┌──────────────────────────┐
          │ Cilinder fault       │         │  │   │ Cylinder fault counter    │
          │ counter Ax+1         │         │  │   │ Bx+weighted value         │
          └─────────────────────┘         │  │   └──────────────────────────┘

         yes  ╱ Sum of fault ╲  no         │  │ no  ╱ Sum of fault ╲   yes
          ┌──╱ counters A1..An ╲───┐       │  └────╲ counters B1..Bn ╱───┐
             ╲ exceeds emission ╱           │        ╲ exceeds misfire  ╱   │
             ╲ relevant        ╱            │         ╲ frequency for   ╱    │
             ╲ misfiring      ╱             │          ╲ catalyst      ╱     │
             ╲ frequency?   ╱               │           ╲ damage?    ╱       │
          ▼                                 │                                 ▼
     ┌────────────────────────┐             │         ┌─────────────────────┐
  ⊗ ◄│ MIL on (2. driving cycle)│           │         │ MIL on at once       │◄─ ⊗
 MIL └────────────────────────┘             │         │ (blinking)           │  MIL
                                            ▼         └─────────────────────┘
                        ┌─────────────────────────────┐
                        │  End of monitoring procedure  │
                        └─────────────────────────────┘
```

.04.00.00   EVAPORATIVE SYSTEM DIAGNOSIS

.04.01.00   Leakage Check

.04.01.01   General description

The leakage diagnosis procedure is a pressure check of the EVAP system.
In order to perform the check, the EVAP system will be sealed and pressure applied by the leakage diagnosis pump (LDP). The pressure variation time is analysed by the ECM.

.04.01.02   Monitoring function description

The diagnosis procedure consists of the following steps:

1. Tank pressure check
    The first step of leakage diagnostics is the pressure check of fuel tank system by testing the reed switch. In case of an open reed switch, the fuel tank system has sufficient pressure for the sealed check and no further pressure has to be supplied to the fuel tank system by the LDP. The diagnosis is waiting until the EVAP purge valve is opened in order to purge the carbon canister. In case the reed switch remains open or the reed switch stuck open, the reed switch is defective.

    In the case the reed switch is closed, the LDP is switched on in order to supply pressure to the fuel tank system and the diagnostic is continued with the step 2 to 3 (as described below).

2. LDP Self-check procedure
    Closed check
    LDP control is disabled and the reed switch has to be closed otherwise the reed switch is defective.
    Close to open check
    LDP control is switched on once and the diaphragm has to move to the upper position. The time is measured between closed and open position of diaphragm detected by the reed switch. When the final upper position of diaphragm is reached in a certain time, then the check will be passed.

3. Leak check of EVAP system
    Fast pulse
    After the self check procedure, the LDP control supplies pressure to the fuel tank system with a pressure dependent number of compression strokes in a certain time. In order to supply pressure to the fuel tank system, the LDP can perform compression strokes in several attempts.

    EVAP system sealed check, measure stroke and measure phase
    The decrease of fuel tank pressure is measured via time of diaphragm movement followed by a compression stroke. Within a certain time, the LDP control is determined within at least four measurement strokes. The averaged time is a measure for the tightness of fuel tank system.

.04.01.03   Chart(s) and flow chart(s)

```
┌─────────────────────┐
│  start of monitoring │
│      procedure       │
└─────────────────────┘
```

fuel system pressure check

```
        ◇ reed switch           no
          closed?  ─────────────────────────►  ┌──────────────────────┐
              │                                 │  wait for opening of │
             yes                                │   EVAP purge valve   │
                                                └──────────────────────┘

                          no          ◇ reed switch    yes
                    ◄─────────────────   closed?  ──────────────►
                                                                  ┌──────────────────────────┐
                                                                  │  pressure in fuel  tank   │
                                                                  │ system detected, therefore│
                                                                  │   EVAP leak check and     │
                                                                  │    purge check passed     │
                                                                  └──────────────────────────┘

                  ┌──────────────────────┐                        ╭──────────────────────────╮
                  │ reed switch defective!│                       │ valve OK, leak detection  │
                  └──────────────────────┘                        │   pump OK, system OK      │
                                                                   ╰──────────────────────────╯
```

LDP
self check
procedure

```
  ┌──────────────────────┐
  │   switch on LDP once  │
  └──────────────────────┘

        ◇ reed            no     ┌──────────────────────┐
      switch open within a ─────►│ error for failed "close to open │
        certain time?            │        check"         │
              │                  └──────────────────────┘
             yes

             ● 1                                              ● 2
```

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

1

**Pump Phase
fast pulse**

**LDP switched on once folowed by a
measure phase where time is measured
until reed switch is closed again.
The open to close time is measured at
least four times and a an average is
calculated.**

**open to close time <
gross leak time** — **yes** → **sec. cond. for
gross leak fulfilled?** — **no**

no

yes

**open to close time <
small leak time** — **yes** → **sec. cond. for
small leak fulfilled?** — **no**

no

yes

**open to close time <
smallest leak time** — **yes** → **sec. cond. for
smallest leak fulfilled?** — **no**

no

yes

open EVAP purge valve

leak detection pump OK, system OK

2

gross leak detected

small leak detected

**smallest leak
detected**

fault management

MIL

.04.02.00   Purge Check

.04.02.01   General description

The purge flow through the EVAP Purge Valve is checked when the vehicle
is at rest during an idle condition and the Lambda controller is active.
The EVAP Purge Valve is opened while monitoring the Lambda controller
and the airflow through the throttle unit.

For rich or lean mixture through the EVAP Purge Valve:
Flow through the EVAP Purge Valve is assumed as soon as the Lambda
controller compensates for a rich or lean shift.

After this procedure the EVAP Purge Valve is reset and the diagnosis is
completed.
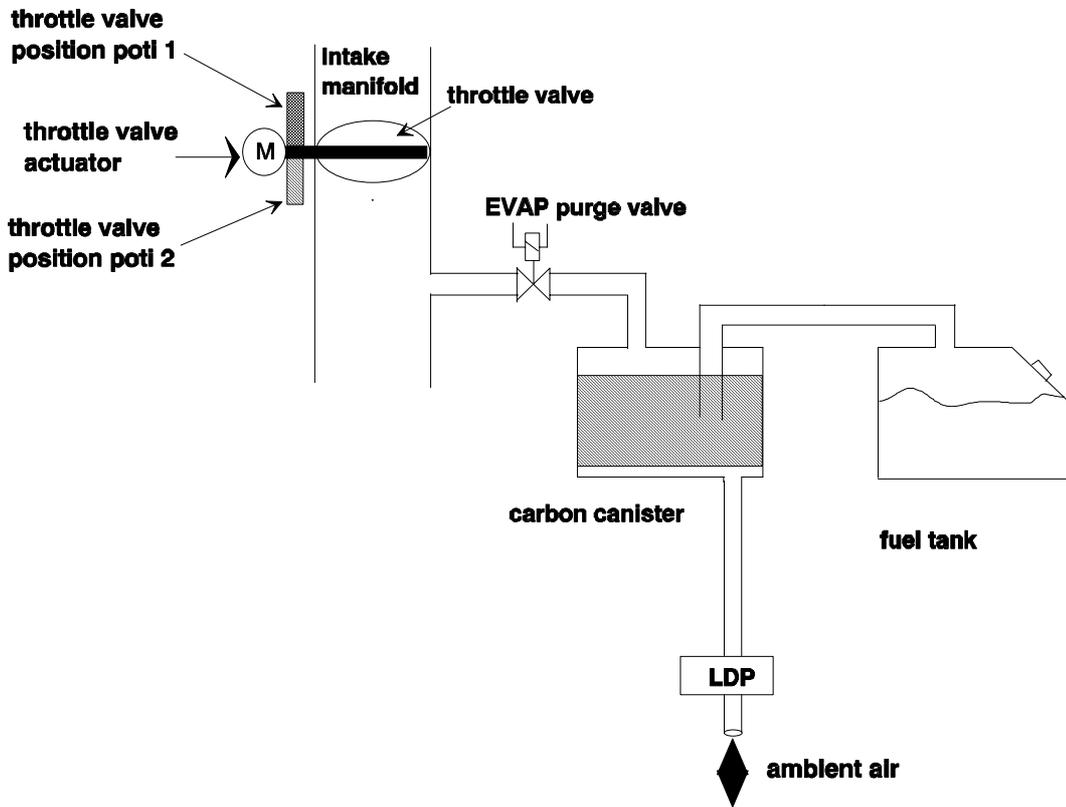
.04.02,02   **Monitoring function description**

For stoichiometric mixture flow through the EVAP Purge Valve:

In this case, the Lambda controller does not need to compensate for a deviation. However, when the EVAP Purge Valve is completely opened, the cylinder charge increases significantly. Therefore, flow through the throttle unit must be decreased in order to maintain the desired idle speed. Flow through the EVAP Purge Valve is assumed when the flow through the throttle unit is reduced by idle control. If both mixture compensation and reduction of the airflow through the throttle unit does not occur for two diagnosis cycles, then a defective EVAP Purge Valve is assumed and the MIL is illuminated.

.04.02.03   **Chart(s) and flow chart(s)**
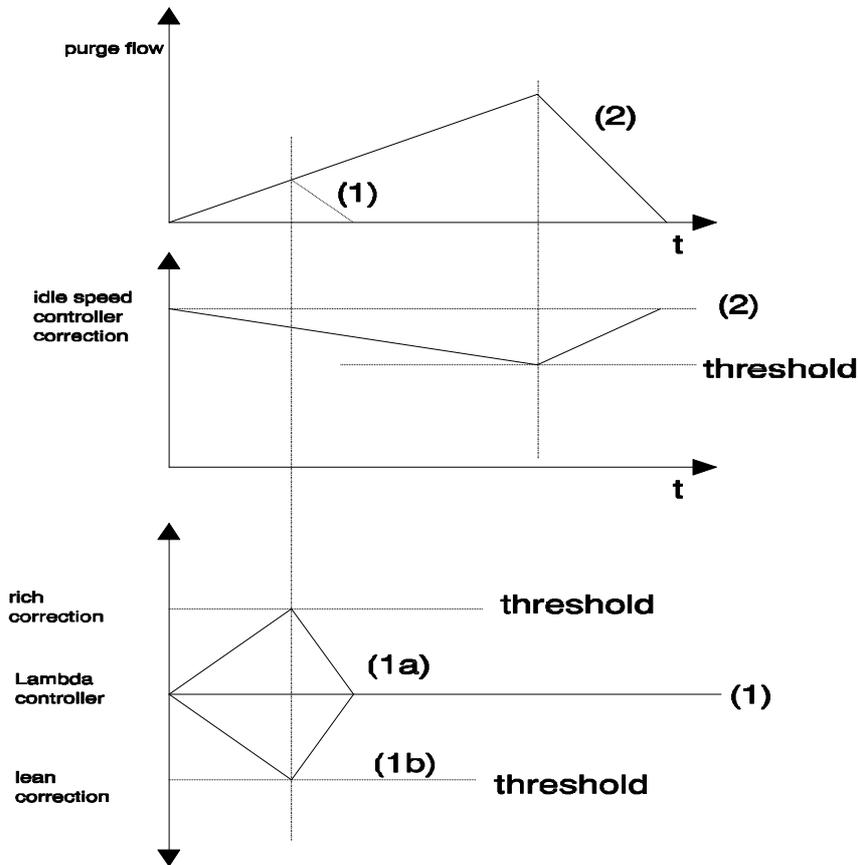
Open purge valve and monitor effects of purge flow:

(1)   Lambda purge flow <>1:   Abortion if fresh air (1a) or
                                                        HC (1b) detected

(2)   Lambda purge flow = 1:   Throttle unit actuator will reduce the flow rate
                                                     through the throttle due to additional flow through
                                                     purge valve

MIL will be illuminated if none of said effects occurs.

.05.00.00 SECONDARY AIR SYSTEM MONITORING

.05.01.00 Via lambda deviation

.05.01.01 General Description

After cold start condition (e.g. 5 .. 40°C) the Air system blows for a certain time air into the exhaust manifold. The exhaust gases will be enriched with oxygen and post combustion of HC and CO occurs. By this exothermic reaction the exhaust system will be heated and the time to reach the light-off temperature of the catalyst will be accelerated.
Principal sketch and main components of Air System: (example 4 cyl. Engine)
ECM;
Air pump relay
Air valve (solenoid valve)
Air valve (vacuum controlled)
AIR pump;
O2 Sensor;
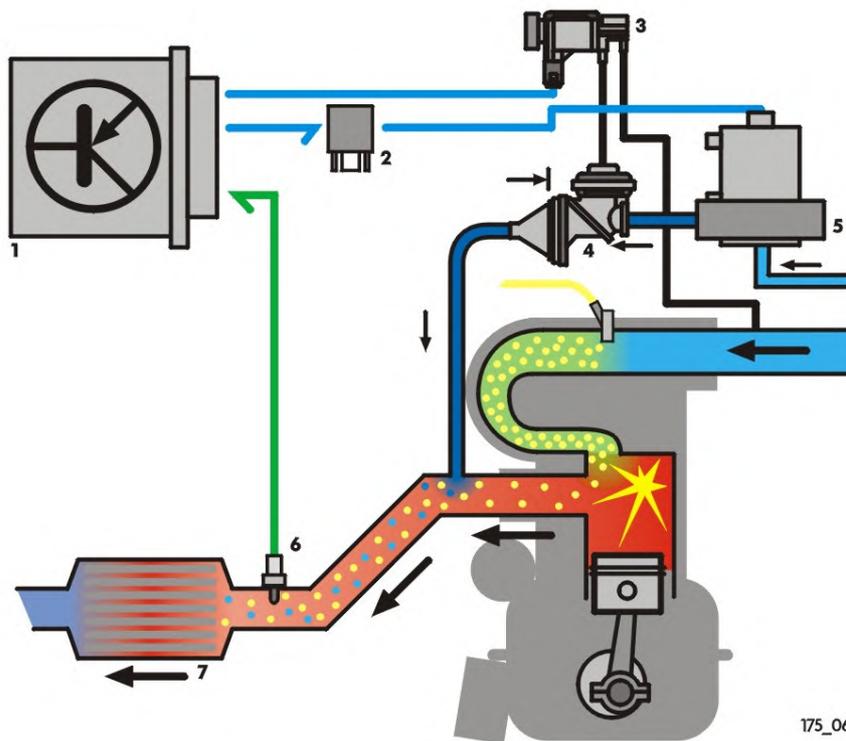
175_067

.05.01.02   Monitoring Structure

The following table shows an overview of the used function and monitor strategy for all test groups:

Test Group	Engine	Standard	Via Lambda deviation				Via exhaust temperature sensor			
			Passive check		Active check		Passive check		Active check	
			Functional	Flow Check	Functional	Flow Check	Functional	Flow Check	Functional	Flow Check
5ADXV01.8342	1.8T I-4 Turbo long.	Bin 8	-	-	Yes	-	-	-	-	-
5ADXV01.8356	1.8T I-4 Turbo	Bin 8	yes	-	yes	-	-	-	-	-
5ADXV01.8346	1.8T I-4 Turbo	LEV I	yes	-	yes	-	-	-	-	-
5VWXV02.0223	2.0l I-4	LEV II	-	-	Yes	-	-	-	-	-
5VWXV02.0224	2.0l I-4	ULEV II	-	-	Yes	-	-	-	-	-
5VWXV02.0227	2.0l I-4	PZEV	-	-	yes	-	yes	-	-	-
5VWXV02.0240	2.0l I-4 Turbo	ULEV II	-	-	Yes	-	-	-	-	-
5ADXV02.8334	2.8l V6 - 2 bank	LEV I	te	-	yes	-	-	-	-	-
5ADXV03.0344	3.0l V6 - 2 bank	LEV II			yes	yes	-	-	-	-
5ADXV04.2345	4.2l V8 - 2 bank	LEV I	yes	-	yes	-	-	-	-	-
5ADXT04.2348	4.2l V8 - 2 bank	Bin 10	yes	-	yes	-	-	-	-	-
5ADXV02.7343	2.7l V6T - 2 bank	LEV I	yes	-	yes	-	-	-	-	-
5VWXT03.2225	3.2 VR6 - 2 bank	LEV II	-	-	Yes	-	-	-	-	-
5VWXV02.8228	2.8 VR6 - 2 bank	LEV I	-	-	Yes	-	-	-	-	-
5VWXV03.2220	3.2 VR6 - 2 bank	LEV I	-	-	Yes	-	-	-	-	-
5VWXV04.0229	4.0l W8 – 2 bank	LEV I	-	-	Yes	-	-	-	-	-
5VWXV06.0221	6.0l W12 – 2 bank	LEV I	-	-	Yes	-	-	-	-	-
5VWXV06.0501	6.0l W12T – 2 bank	LEV I	-	-	Yes	-	-	-	-	-

The monitor of the secondary air system distinguish between two functions:
a)   Passive monitoring function will be carried out during normal secondary air injection
      While engine is cold started and
b)   Active monitoring function will be activated later during the driving cycle, if the passive
      Monitoring function has not a pass result.

At idle state or under part load engine condition, the secondary air pump is switched on and the valve opens either by pressure of the pump or vacuum operated by switching to "open", causing an increase in the air fuel ratio. The Oxygen Sensor control function (closed loop) enriches the mixture consisting of exhaust gas of the engine and secondary air until the Lambda integrator signal will meet a predetermined value (functional or flow check).

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

Check Conditions

<u>Passive Monitoring Function</u>
To start the passive monitoring function, following conditions have to be satisfied:

Oxygen sensor readiness
No engine restart (thermal energy introduced)
A certain time after engine start
Engine has been cold started
No output stage error from secondary air pump relay

<u>Active Monitoring Function</u>
To start the active monitoring function several conditions have to be satisfied:
No result or no "pass" result from passive monitoring function available.
Engine running at idle
Closed loop condition of the Lambda-control
Monitoring function not done before (for pump protection)
No output stage error from secondary air pump relay

Furthermore, if the diagnosis has already been started and one of the conditions has not been satisfied continuously, the process will be interrupted.

The following conditions have to be fulfilled additionally:

All adaptations of the air/fuel system are inhibited
The Lambda controller has been stabilized (waiting for several transients of the oxygen sensor signal)
The actual Lambda controller value has been stored
In case of an interrupt of diagnosis, the monitor can several time started again (different for each test group; see overview) during the same driving cycle if the monitor conditions are met.

.05.01.03   Chart(s) and flow chart(s)

Following charts shows the phases of the AIR monitoring via lambda deviation for passive and active monitoring.
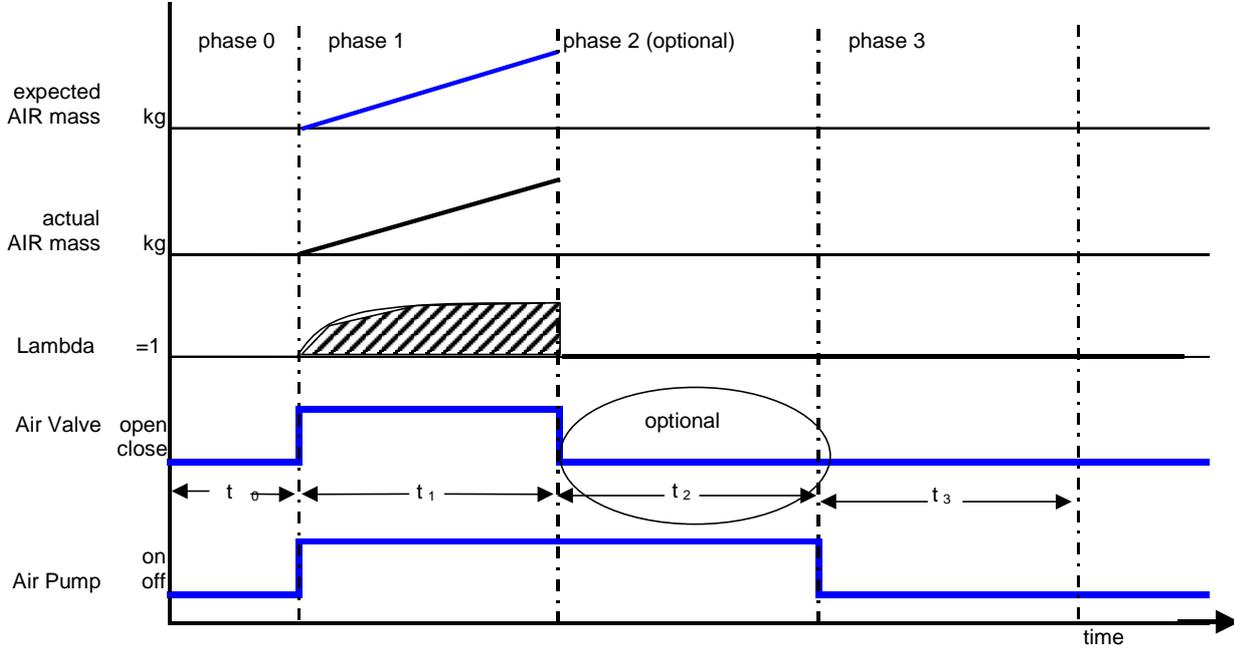
AIR system monitoring	
DTC's	See summary table
Sensors OK	ECTS, Front O2S
Secondary Parameter	See summary table
Monitor execution	Passive check during normal operation
Threshold	Malfunction criteria from summary table as relation between actual and expected AIR.

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

START

Adaptation inhibited
Start integration of air mass flow

PHASE 0

Timer 0 > t 0 — **no** / **yes**

start SAI mass flow

calculation of actual AIR mass flow with actual Lambda value

calculation of expected values of AIR mass flow

PHASE 1

timer 1 > t 1 ? — **no** / **yes**

-switch off AIR valve

calculate actual AIR mass flow with actual Lambda value

PHASE 2
(optional)

timer 2 > t 2 ? — **no** / **yes**

-switch off AIR pump
-start timer 3 for offset check

calculation of AIR mass offset at Lambda=1 (closed loop)

PHASE 3

timer 3 > t 3 ? — **no** / **yes**

offset correction of actual AIR mass value

calculation of relation between corrected actual and the nominal AIR mass flow

AIR mass > threshold? — **no** / **yes**

Fault AIR System

Fault management

END

MIL ⊗

.05.02.00   Via exhaust temperature sensor

.05.02.01   General Description

After cold start condition (e.g. 5 .. 40°C) the Air system blows for a certain time air into the exhaust manifold. The exhaust gases will be enriched with oxygen and post combustion of HC and CO occurs. By this exothermic reaction the exhaust system will be heated and the time to reach the light-off temperature of the catalyst will be accelerated.
Additional to the principal sketch above, those systems using an exhaust temperature sensor as an indicator of AIR mass.

.05.02.02   Monitor function description

Passive monitoring function

During normal secondary air injection the secondary air is indirect monitored via exhaust temperature using an exhaust temperature sensor. The measured exhaust temperature will be compared with modeled target temperatures contained in a map within ECM. After the secondary air injection ECM is calculating the amount of introduced thermal energy additionally. As long as the temperature sensor shows an increase in exhaust gas temperature and the thermal energy introduced (calculated by air mass times injected fuel), the secondary system will pass the monitor. No further active diagnostic will be performed.
If one of the expected conditions fails, e.g. the temperature sensor is not showing an increase of temperature or the thermal energy introduction is below an expected threshold, the active monitoring function will be carried out later in that driving cycle.

AIR System monitoring (via exhaust temperature sensor)	
DTC's	See summary table
Sensors OK	ECTS, Front O2S
Secondary Parameter	See summary table
Monitor execution	Passive check during normal operation
Threshold	Decision criteria for pass condition from summary table as relation between actual and expected AIR.

.05.02.03   Chart(s) and flow chart(s)

Passive Diagnostic
of Secondary Air System

```
         ┌─────────────────────────────────┐
         │  Start of Monitoring Procedure  │
         └─────────────────────────────────┘
                        │
                        ▼
no              ◇ No engine restart? ◇
◄───────────────
                        │ yes
                        ▼
no              ◇ ECTS within specified range? ◇
◄───────────────
                        │ yes
                        ▼
no              ◇ Time after engine start > threshold ◇
◄───────────────
                        │ yes
                        ▼
         ┌─────────────────────────────────┐
         │      Track exhaust              │
         │      temperature               │
         └─────────────────────────────────┘
                        │
                        ▼
         ┌─────────────────────────────────┐
         │      Calculate thermal         │
         │      energy                    │
         └─────────────────────────────────┘
                        │
                        ▼
    ◇ Exhaust temperature and thermal energy > thresholds? ◇   ── no ──►  ┌──────────────────────────┐
                        │                                                   │  Perform active          │
                        │ yes                                               │  Diagnostic Function     │
                        ▼                                                   │  later in that Driving   │
         ┌─────────────────────────────────┐                               │  Cycle                   │
         │   End of Monitoring Procedure   │◄──────────────────────────────┴──────────────────────────┘
         └─────────────────────────────────┘
```
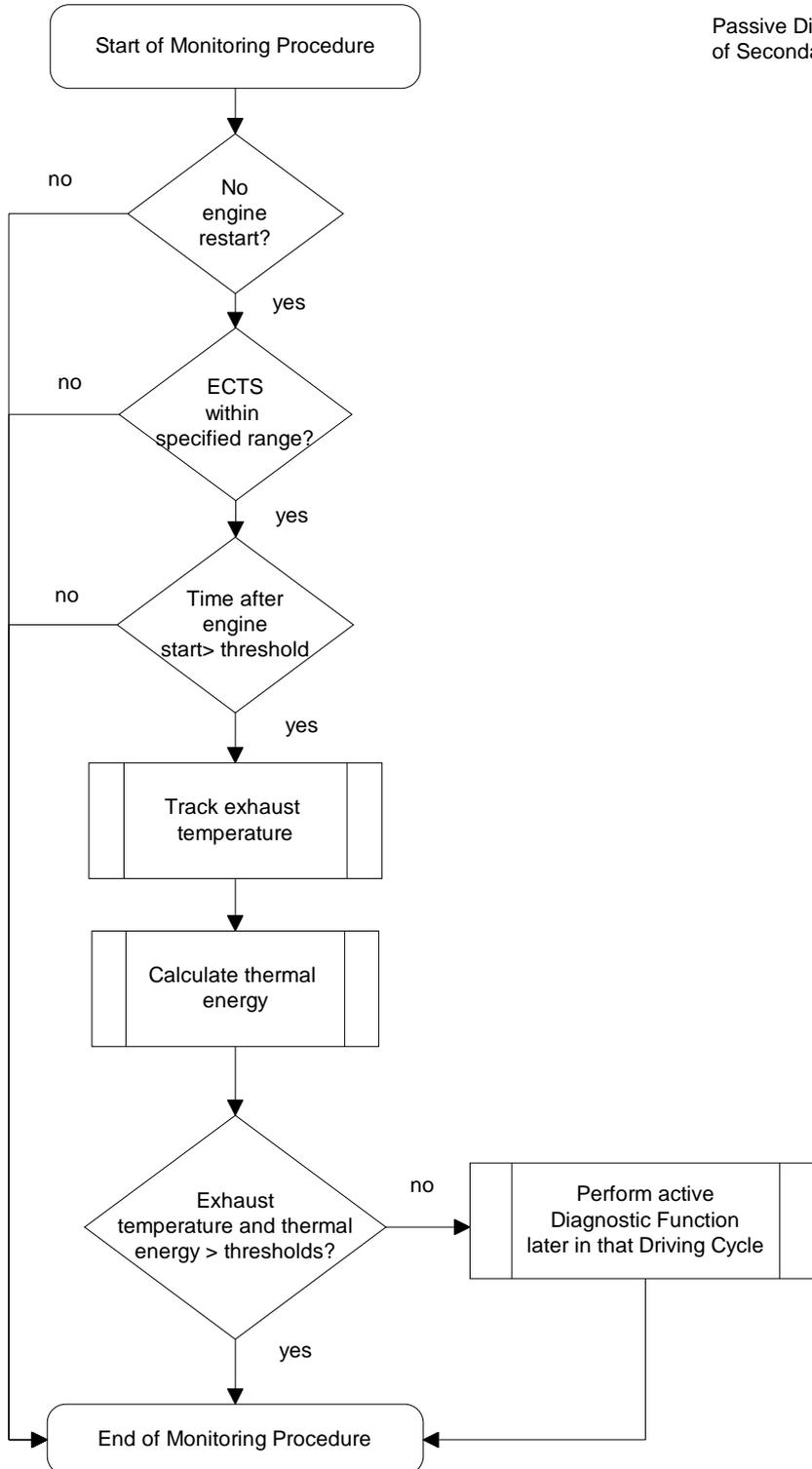
.06.00.00　　　Fuel System Monitoring

.06.00.01　　General Description

Mixture Pilot Control
The airflow sucked in by the engine and the engine speed is measured. These signals are used to calculate an injection signal**.** This mixture pilot control follows fast load and speed changes.

Lambda-controller
The ECM compares the Oxygen sensor signal upstream the catalyst with a reference value and calculates a correction factor for the pilot control.

.06.00.02　　Monitoring function description

Adaptive pilot control
Drifts and faults in sensors and actuators of the fuel delivery system as well as unmeasured air leakage influence the pilot control. The controller corrects amplitudes increases. If there are different correction values needed in different load speed ranges, a certain time passes until the correction is complete. The correction values will be determined in three different ranges.

Fuel trim
The basic air/fuel ratio control using the signal from the front O2 sensors(s) is corrected by an adaptation calculation. This adaptation results in a factor, which is applicable for the whole working range. (e.g. 20%)
A further trim control based on the signal(s) from the rear O2 sensor(s) is correcting the adaptation factor. Therefore this trim control is working in the same way in the whole range.
If the trim control reaches the allowed limit (e.g. 2%) the fault code for fuel delivery trim control is set.
Any deviation from the characteristic curve of oxygen sensor upstream catalyst due to poison will be detected by the control loop downstream catalyst.

.06.00.03   Chart(s) and flow chart(s)
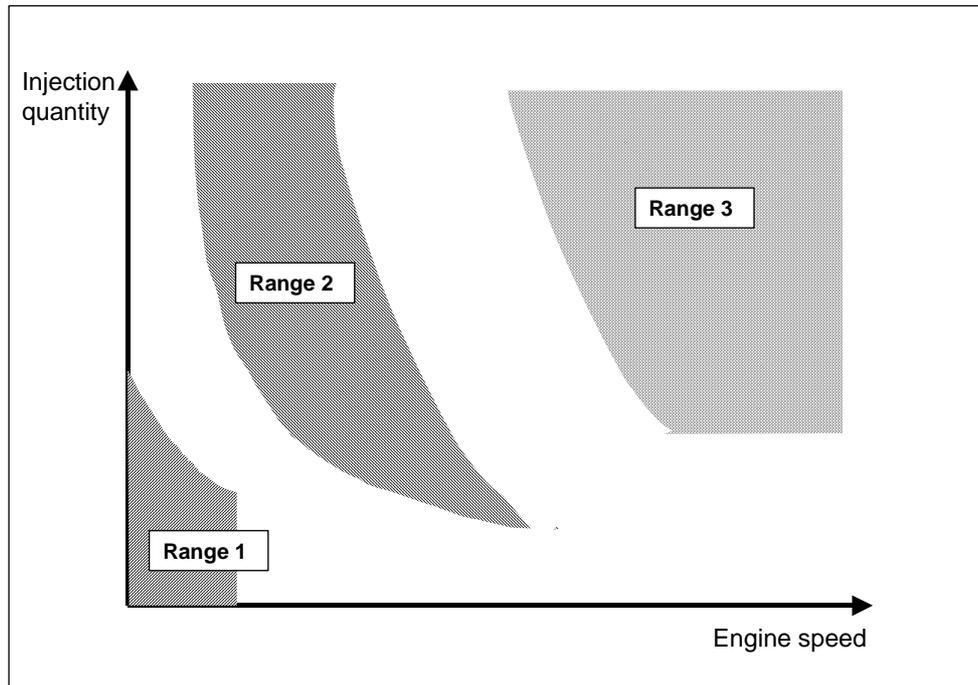
Lambda deviations in **range 1** are compensated by an additive correction value multiplied by an engine speed term**.** This creates an additive correction per time unit.

Lambda deviations in **range 2** are compensated by multiplication of a factor.

Lambda deviations in **range 3** are compensated by multiplication of a factor (optional depending on individual calibration).

A combination of all two (three) ranges will be correctly separated and compensated.

 Each value is adapted in its corresponding range only. But each adaptive value corrects the pilot control within the whole load/speed range by using a linear interpolation formula. The stored adaptive values are included in the calculation of the pilot control just before the closed loop control is active.

Diagnosis of the fuel delivery system

Faults in the fuel delivery system can occur which cannot be compensated for by the adaptive pilot control.

In this case, the adaptive values exceed a predetermined range.

If the adaptive values exceed their plausible ranges, then the MIL is illuminated and the fault is stored.

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

Start

Learning::
 ACV = additive correction value rang 1
LMCV = lower multiplicative correction value range 2
UMCV = upper multiplicative correction value range 3
MLCC= multip. learning correction coefficient range 2

ACV, LMCV
UMCV, MLCC remained
unchanged

yes

no

Wait until ACV,LMCV, UMCV, MLCC have
been activated for a certain time

Set cycle flag for correction values

Lower
threshold of MLCC<=
LMCV <= upper threshold
of MLCC

no

yes

UMCVmin <=
UMCV <= UMCVmax

no

yes

ACVmin <=
ACV <= ACVmax

no

yes

Fault management

MIL

End

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

Flow chart: Fuel trim

```
        ┌─────────────────────────────┐
        │  Start of monitoring         │
        │  procedure                   │
        └──────────────┬──────────────┘
                       │
        ┌──────────────▼──────────────┐
        │  read integrator value from │
        │  Lambda control downstream  │
        │  catalyst                   │
        └──────────────┬──────────────┘
                       │
               ┌───────▼───────┐
       no      │ abs(integrator│
       ◄───────│ value) >      │
               │ threshold?    │
               └───────┬───────┘
                    yes │
               ┌────────▼───────┐        ┌──────────────────┐
               │ start counter  │        │ stop counter t1  │
               │ t1             │        │                  │
               └────────┬───────┘        └──────────────────┘
                        │
               ┌────────▼────────┐      no
               │ Lambda control  │──────────►
               │ downstream      │
               │ catalyst active?│
               └────────┬────────┘
                    yes │
               ┌────────▼────────┐      no
               │ counter t1 >    │──────────►
               │ threshold?      │
               └────────┬────────┘
                    yes │
                                           MIL
               ┌────────▼────────┐        ⊗
               │ fault management│────────►
               └────────┬────────┘
                        │
        ┌───────────────▼──────────────┐
        │  End of monitoring procedure │
        └──────────────────────────────┘
```
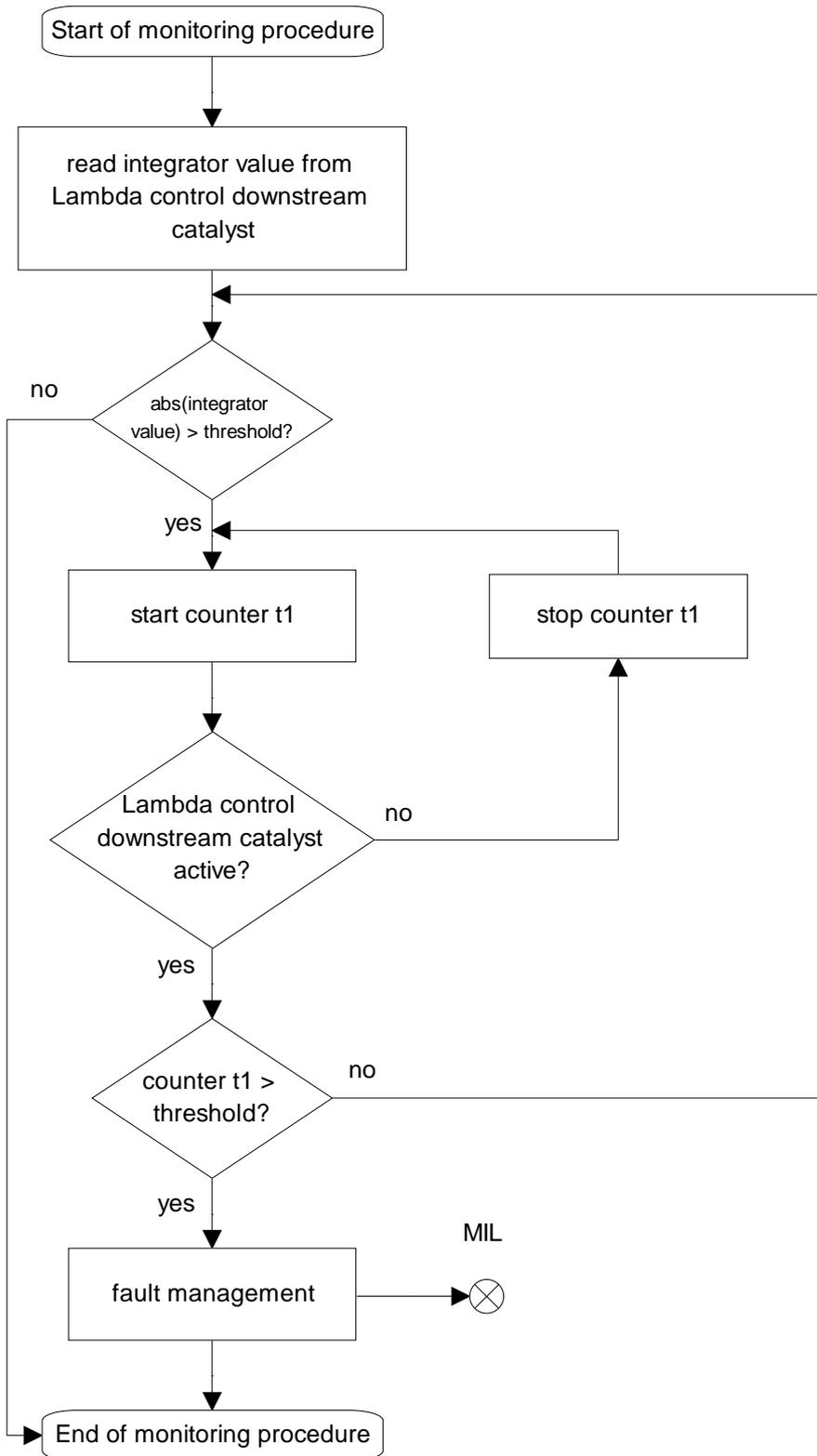
.07.00.00 OXYGEN SENSOR MONITORING

.07.01.00 Calibrations with ASIC CJ 110
.07.01.01 General Description

The Lambda control consists of a linear Oxygen sensor upstream catalyst and a 2-point oxygen sensor downstream catalyst.

.07.01.02 Monitoring function description

The sensors are monitored by several single monitoring procedures under the following basic conditions.

- Engine operates in a specific range of speed/load map and
- Modelled catalyst temperature is above a specific value

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

The following checks will be performed on the linear oxygen sensor upstream catalyst:

Heater Coupling Check (P0130)
This monitoring will detect any short circuits between sensor heater and the Nernst cell of the Oxygen sensor by monitor the Lambda signal. The amplitude signal of Lambda is untypical and changed in the same velocity than heater duty cycle.

Response Check (P0133)
Any change in the dynamic behaviour of the Oxygen sensor due to ageing, heater fault or contamination will be detected by check of actual amplitude ratio check with stored values.

Signal activity and rationality checks (P0130)
The Lambda value of oxygen sensor upstream catalyst is compared to the sensor voltage downstream catalyst. Additionally, a check is performed by checking the sensor voltage range. Three diagnostics paths cover the air fuel ratio range of Lambda value (e.g. Lambda=1, lean, rich). A corresponding reaction of sensor voltage downstream catalyst is expected. (See chart)

The following checks will be performed on the oxygen sensor downstream catalyst:

Oscillation Check (P0139)
The function checks whether the sensor output voltage of oxygen sensor downstream catalyst always remains above or below a specified threshold.

Fuel cut off Check (P0139)
During coasting, the ECM is monitoring the downstream sensor voltage, which has to go under a specific lean threshold.

Output voltage (P0137), Short to battery (P0138) and signal activity check (P0140)
In case the rear O2 sensor readiness is given a certain sensor signal is expected. If the sensor is bellow or above some signal thresholds, a fault will be stored.

.07.01.03   Chart(s) and flow chart(s)

Front O2 Sensor

to
4.8 V

lean

λ = 1,05

λ = 1,005
λ = 1
λ = 0,995

λ = 0,95

rich   0.0 V

rich

lean

Rear O2 Sensor

0,7 V

Oscillation stuck in control target

0,3 V

Fuel cut off check

0.0 V

Based on the sensor comparison malfunction will be detected if:
- Front sensor near lambda = 1 and rear sensor shows >0.7V or < 0,3 V
- Front sensor lean (lambda > 1.05) and rear sensor rich (>0.7V)
- Front sensor rich (lambda > 1.05) and rear sensor lean (<0.3V)
- Rear sensor is not oscillation at reference point (e.g.0.6V)
- During fuel cut off rear sensor signal goes not under threshold (e.g. 0.2V)

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

Front O2 Sensor Heater Coupling Monitoring	
DTC's	P0130
Threshold 1	Malfunction signal change / msec; typical value: 2 (V/ms)
Threshold 2 / 3	Typical value: 200 °C / 25sec
Threshold 4	Monitor time length: 30 amplitudes

```
                  ( Start of monitoring procedure )
                                |
                                v
                           / Heater  \        no
                          <  active   >----------------+
                           \         /                 |
                                | yes                   |
                                v                       |
                  +---------------------------+         |
                  | read 1 signal voltage (L1)|         |
                  +---------------------------+         |
                                |                       |
                                v                       |
                  +----------------------------+        |
                  | read 2 nd signal voltage (L2)|      |
                  +----------------------------+        |
                                |                       |
                                v                       |
                          / abs(L1-L2)> \    no          |
                         <   threshold 1 >-------------->|
                          \             /               |
                                | yes                    |
                                v                        |
                       / exh. temp. model> \             |
                      <    threshold 2       >--- no ---->|
                       \                    /            |
                                | yes                     |
                                v                         |
                      / time after engine \              |
                     <  start>theshold 3    >--- no ---->|
                      \                     /            |
                                | yes                     |
                                v                         |
                  +---------------------------+          |
                  |     start counter t1      |          |
                  +---------------------------+          |
                                |                         |
                                v               no         |
                        / t1> threshold 4 \--------------+
                       <                   >
                        \                 /
                                | yes
                                v
                        +-------------------+        MIL
                        | Fault management  |------->(X)
                        +-------------------+
```

- 36 -
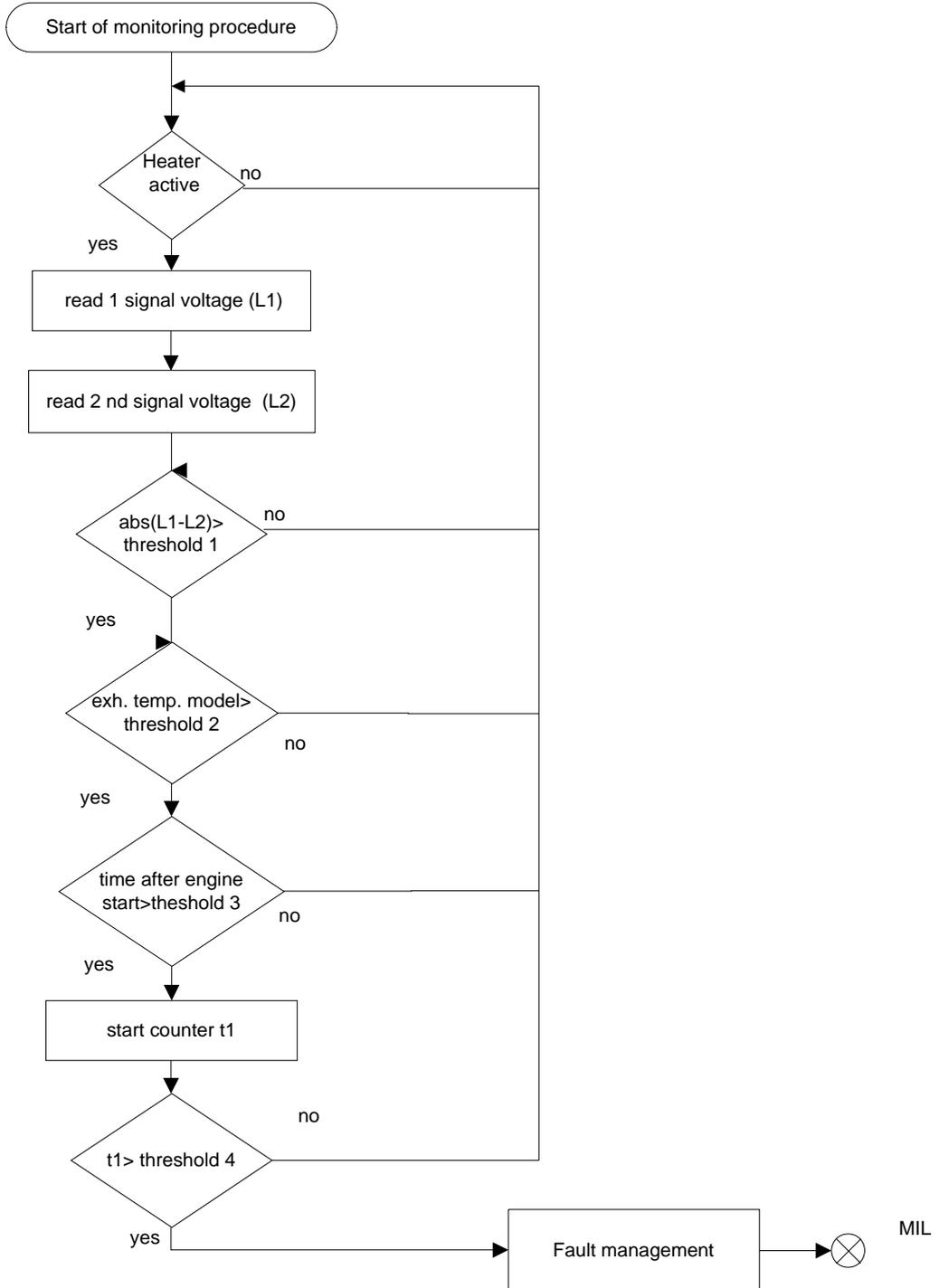
Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

Front O2 Sensor Response Check	
DTC's	P0133
Threshold 1	Malfunction criteria
Limit	Monitor time length 30 amplitudes

```
                    ┌─────────────────────────────┐
                    │  Start of monitoring procedure │
                    └─────────────────────────────┘
                                   │
         ┌─────────────────────────┤
         │                      ◆
      no │              closed loop?
         │                      │ yes
         │                      ◆
      no │          Within engine rpm window?
         │                      │ yes
         │                      ◆
      no │          Within engine load window?
         │                      │ yes
         │                      ◆
      no │          artificial modulation active?
         │                      │ yes
         │            ┌──────────────────────┐
         │            │  read actual amplitude │
         │            └──────────────────────┘
         │                      │
         │            ┌──────────────────────┐
         │            │  read target amplitude │
         │            └──────────────────────┘
         │                      │
         │   ┌───────────────────────────────────┐
         │   │ Calculate and filter ratio of target│
         │   │ and actual amplitude. Calculate the │
         │   │      sensor dynamic value.          │
         │   └───────────────────────────────────┘
         │                      │
         │                      ◆
      no │          dynamic value < threshold1
         │                      │ yes
         │                      ◆
      no │          counted diagnostic results>limit?
         │                      │ yes
         │          ┌──────────────────┐
      MIL ⊗ ◄───────│  fault management │
                    └──────────────────┘
```
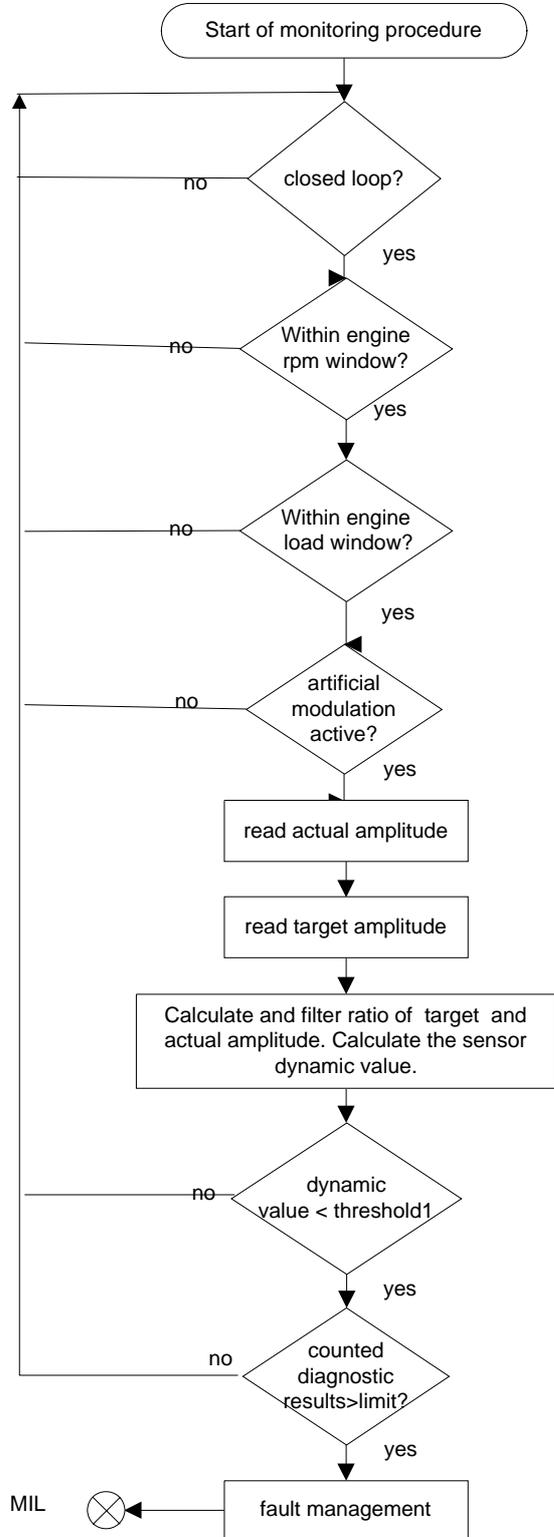
Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

Rear O2 Sensor Oscillation check	
DTC's	P0139
Threshold 1 and 2	Malfunction Criteria; typical values: 0.58 .. 0.6V
Limit	Monitor time length 30 amplitudes

```
                    ┌──────────────────────────┐
                    │ Start of monitoring       │
                    │ procedure                 │
                    └──────────────────────────┘
                                │
          no              ◇ rear Lambda
    ◄───────────────────  control active? ◇
                                │ yes
                                │
          no              ◇ no fault stored ? ◇
    ◄───────────────────
                                │ yes
                                │
                          ◇ sensor voltage>threshold1    no
                            within time t1? ◇ ─────────────►
                                │ yes                        │
                                │                            ▼
                          ◇ sensor voltage < threshold2   ┌──────────────────┐
                            within time t1? ◇    no ──────►│ test function    │
                                │ yes                      │ rich or lean     │
                                │                          │ operation        │
                                │                          └──────────────────┘
                                │                            │
                                │                      ◇ correct          no
                                │                        reaction of sensor ─────►
                                │                        voltage? ◇
                                │                            │ yes          │
                                ▼                            │              ▼
                          ┌──────────────┐                  │     ┌──────────────────┐   ⊗
                          │ sensor okay  │                  │     │ Fault management │   MIL
                          └──────────────┘                  │     └──────────────────┘
```

- 38 -
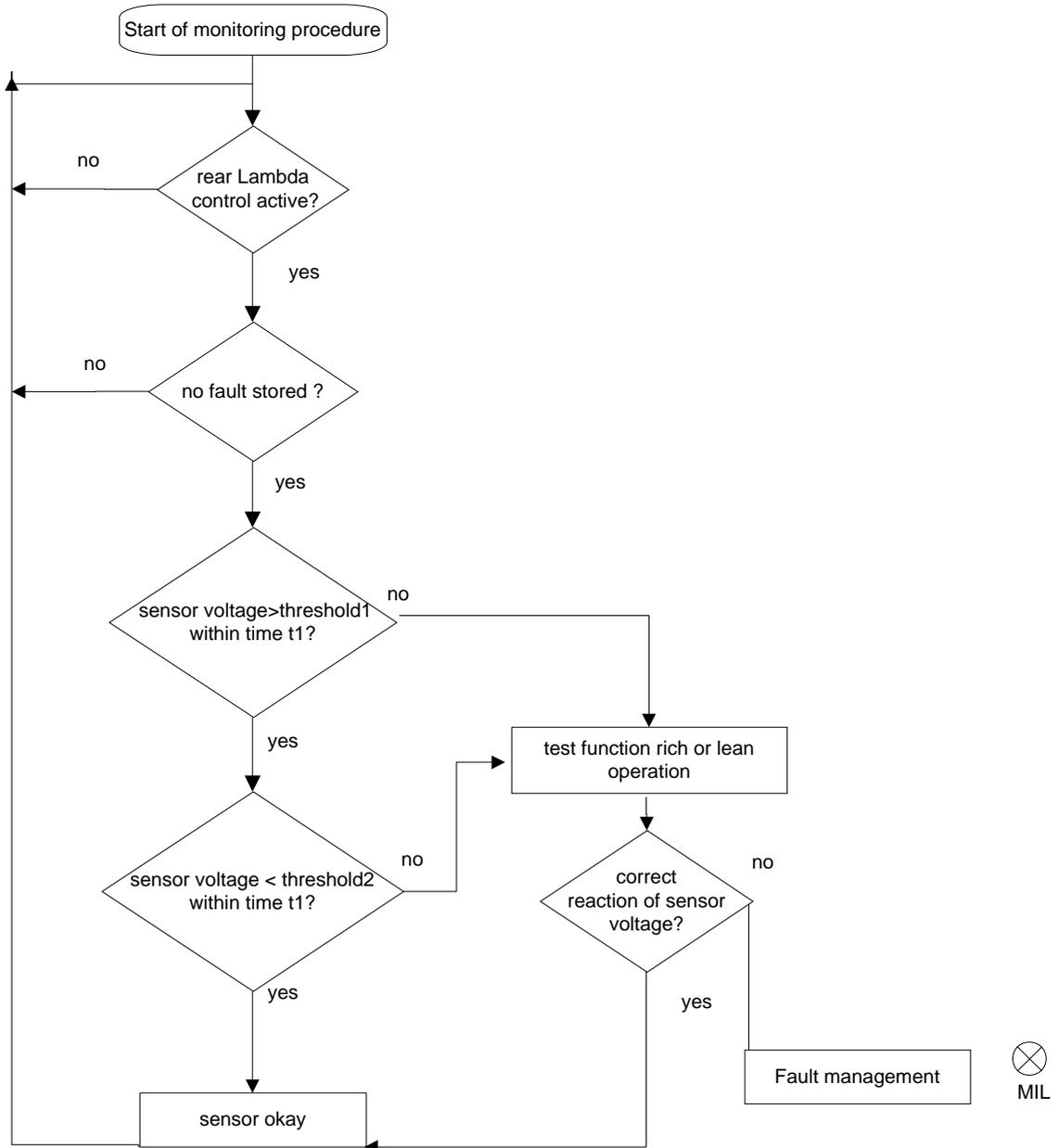
Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

Rear O2 Sensor Fuel Cut Off Check	
DTC's	P0139
Time t1	Duration of fuel cut off phase; Typical value 5s
Threshold	Malfunction criteria; typical value: < 0.2V

Start of monitoring procedure

fuel cut off condition active?

no → wait for next fuel cut off condition (coasting)

yes

fuel cut off time > t1

no

yes

sensor voltage < threshold?

no → fault management → MIL

yes

sensor okay

End of monitoring procedure
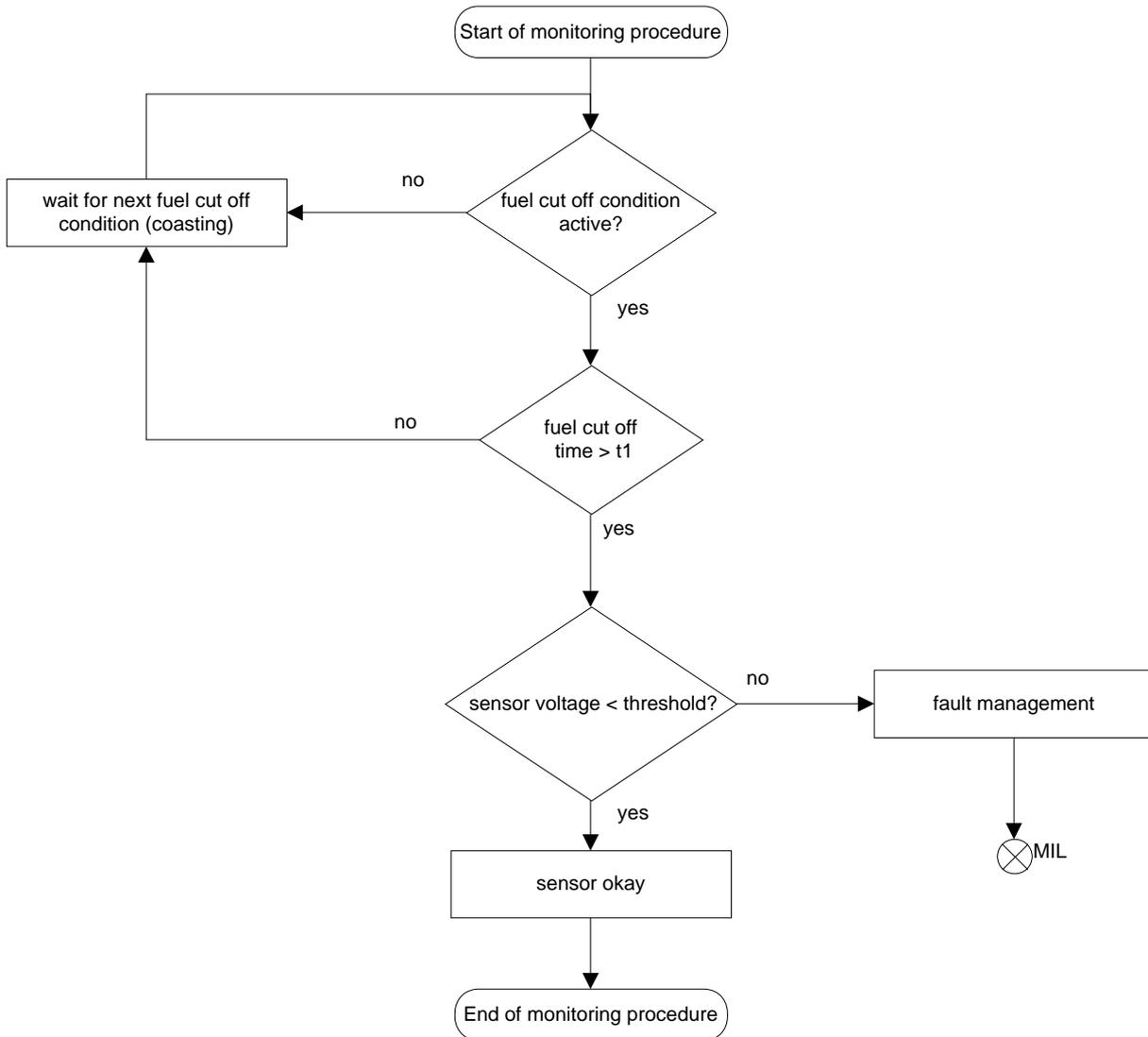
.07.02.00   **Oxygen Sensor Heater Monitoring**
.07.03.01   **General description (ASIC CJ 110)**

For proper function of the Lambda sensor, the sensor element must be heated.

.07.02.02   **Monitor function description**

Linear Oxygen sensor upstream catalyst Any fault in regard to sensor heater will either result in a lost or in a delay of sensor readiness. The diagnosis measures the time between the heater is switched on and the oxygen sensor readiness. The sensor readiness is indicated by a corresponding sensor voltage variation.

Oxygen sensor downstream catalyst (2 point sensor)
For diagnostic of the sensor heater a specific current pulse is supplied via a load resistance and the voltage is measured. The intern resistance of the sensor heater is calculated with the voltage deviation. The result will be compared with a reference map resistance, which considers ageing and sampling deviations. In case of internal resistance > map resistance the diagnosis stores a fault and the MIL will be illuminated.

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

07.02.03   Chart(s) and Flow Chart(s)

Oxygen Sensor Heater Upstream Catalyst	
DTC's	P0135
Time t1 / t2	Duration full heating; typical value 25s / 70s
Time t3	Duration fuel cut off; typical value 3 s
Threshold 1	Malfunction criteria; delta lambda
Threshold 2	Malfunction criteria; sensor voltage
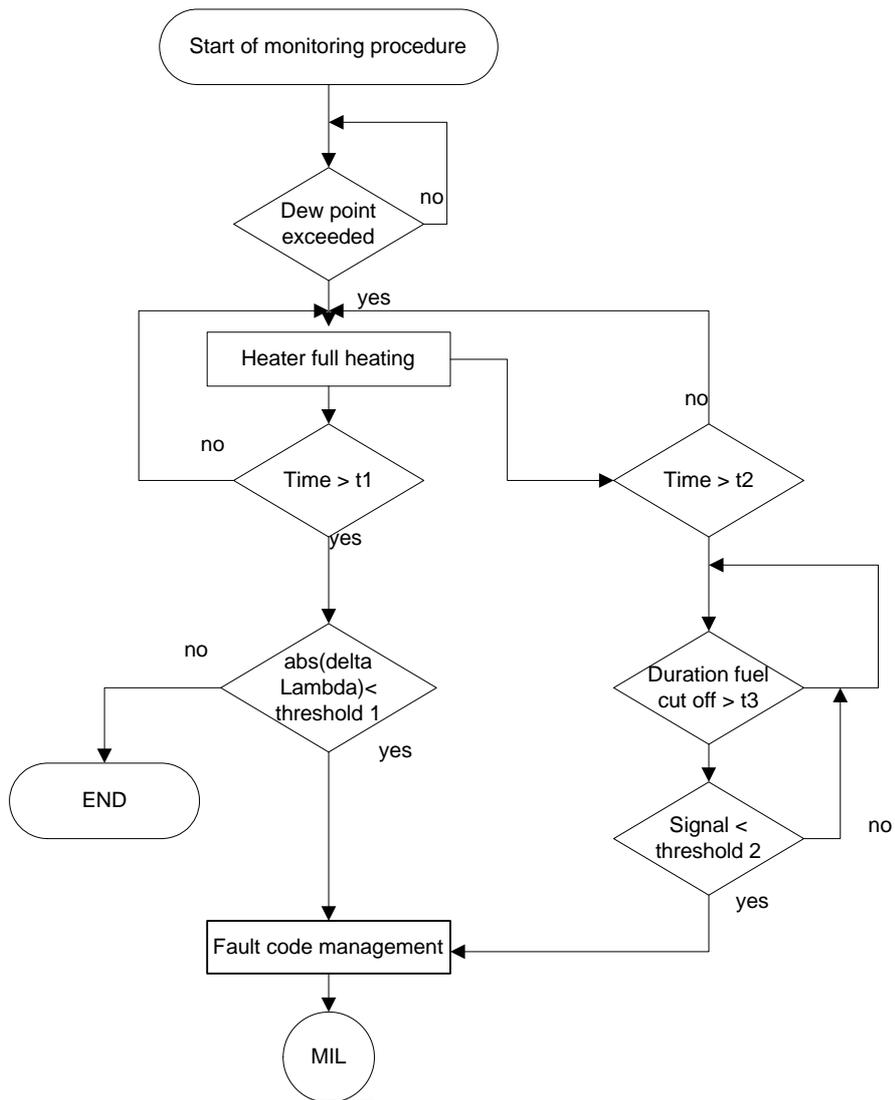
Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

Oxygen Sensor Heater downstream Catalyst	
DTC's	P0141
Enable criteria	Modelled exhaust temperature, IAT
Ri < Rmap	Comparison of actual and calculated resistance

Heater sensor downstream catalyst

```
Start of monitoring procedure
        │
    enable diagnosis?  ──no──┐
        │yes                  │
    time for dew point        │
    exceeded > time ?  ──no───┤
        │yes                  │
    sensor voltage within     │
    permissible range  ──no───┤
        │yes                  │
    store normal sensor w/o pulse
        │
    enable current pulse
        │
    hold sensor output
        │
    store sensor voltage during current pulse
        │
    calculate internal resistance Ri
        │
    Ri < Rmap  ──no──► Fault management ──► MIL ⊗
        │yes                  │
    End of monitoring procedure
```

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

.07.03.00 Calibrations with ASIC CJ 125/120

.07.03.01   **General Description**

The Lambda control consists of a linear Oxygen sensor upstream catalyst and a 2-point oxygen sensor downstream catalyst.

.07.03.02   **Monitor function description**

The following checks will be performed on the linear oxygen sensor upstream catalyst:

Rationality Check
Any deviation from the characteristic curve of oxygen sensor upstream catalyst due to poison, ceramic cracks, characteristic shift down (CSD) or a leakage between both Oxygen sensors will be detected by the control loop downstream catalyst and by comparison of the sensor signals.
The integrator value of the second control loop detects small shifts of the sensor characteristic to lean or to rich. The signal comparison during steady state conditions quickly detects major deviations in sensor characteristics caused by serious faults (e.g. ceramic cracks).

For the fault decision the downstream Oxygen sensor has to be checked too (Oscillation and/or fuel cut-off check).

Heater Coupling Check
This monitoring function will detect any short circuits between sensor heater and the Nernst cell of the Oxygen sensor by watching the Lambda signal. The ECM checks the Lambda value variation. The heater is operated by a pulsating signal with a frequency of two Hertz. The sensor signal characteristic is checked for noises with a significant level and a frequency of the heater operation. If the level of noises is greater than a threshold, a low resistance short cut between heater and pump current or the current of the Nernst cell is detected.

Dynamic Check
Any change in the dynamic behaviour of the Oxygen sensor due to ageing, heater fault or contamination will be detected by check of actual amplitude ratio check with stored values.

Wire and IC-Check
The hardware of the Oxygen sensor consists of an IC (CJ 125) with the capability of self-diagnostics. The self-diagnostic functions of the IC detects communication faults between ECM and the sensor, insufficient voltage supply, shorts in the sensor lines to ground and to battery.
Open wire on the four sensor lines, adjustment line (IA), virtual mass line (VM), pump current line (IP) and Nernst voltage (UN) will be detected by a system plausibility check. The evaluations of the system plausibility is based on sensor voltage, internal resistance, target Lambda, actual Lambda and the reaction of the controller.

The following checks will be performed on the oxygen sensor downstream catalyst:

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

Oscillation Check
The function checks whether the sensor output voltage of the oxygen sensor downstream catalyst always remains above or below a specified threshold.

Fuel cut off Check
During coasting, the ECM is monitoring the downstream sensor voltage, which has to go below a specific lean threshold. The diagnostic is enabled if coasting was detected for a specific time.
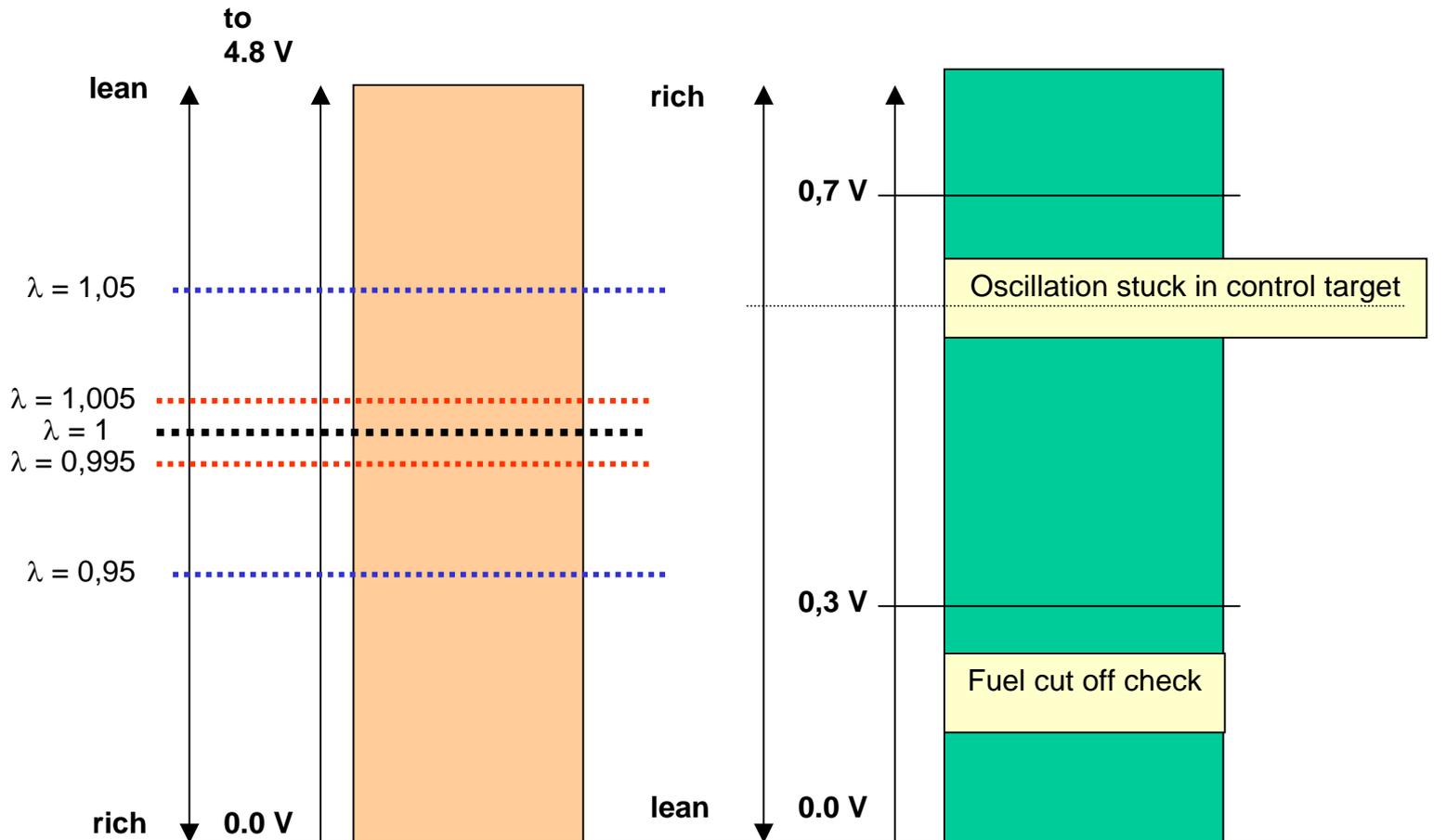
Signal check, short to battery check and signal activity check
In case the rear O2 sensor readiness is given a certain signal voltage is expected. If the sensor is bellow or above some signal thresholds, a fault will be stored.

.07.03.03   **Chart(s) and Flow Chart(s)**

Flow chart: Rationality Monitoring (Oxygen Sensor Upstream Catalyst)

Lambda Plausibility Check

```
        ┌──────────────────────────────┐
        │  Start of monitoring procedure │
        └──────────────────────────────┘
                      │
        ┌──────────────────────────────┐
        │    Lambda controller check     │
        └──────────────────────────────┘
                      │
              ◇ sensor downstream
                no heater fault and ──── no
                    ready?
                      │ yes
        ┌──────────────────────────────┐
        │      read Lambda value         │
        │       upstream sensor          │
        └──────────────────────────────┘
                      │
        ┌──────────────────────────────┐
        │    read voltage downstream     │
        │            sensor              │
        └──────────────────────────────┘
                      │
               ◇ Lambda= 1? ── no ──→ ◇ Lambda = ── no ──→ ◇ Lambda = ── no
                      │ yes              lean side?           rich side?
                      │                    │ yes                │ yes
              ◇ threshold1 <
                Lambda<threshold2
                and voltage <lean threshold ── no
                or voltage > rich threshold?
                      │ yes          ◇ Lambda > Lambda
                      │                (lean) and voltage > ── no
                      │                threshold(rich)?
                      │                    │ yes
        ┌──────────────────────┐
        │   start delay counter  │ ←────────      ◇ Lambda < Lambda
        └──────────────────────┘                   (rich) and voltage< ── no
                      │                              threshold (lean)?
              ◇ delay counter >
                threshold? ── yes ──→  ┌────────────────┐
                      │ no             │    Perform      │
                                       │  Oscillation    │
                                       │     Check       │
                                       └────────────────┘
                                              │
                            ┌──────────────────────────────┐
                            │   End of monitoring procedure  │
                            └──────────────────────────────┘
```

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

Flow chart: Oscillation Monitoring (Oxygen Sensor Downstream Catalyst)
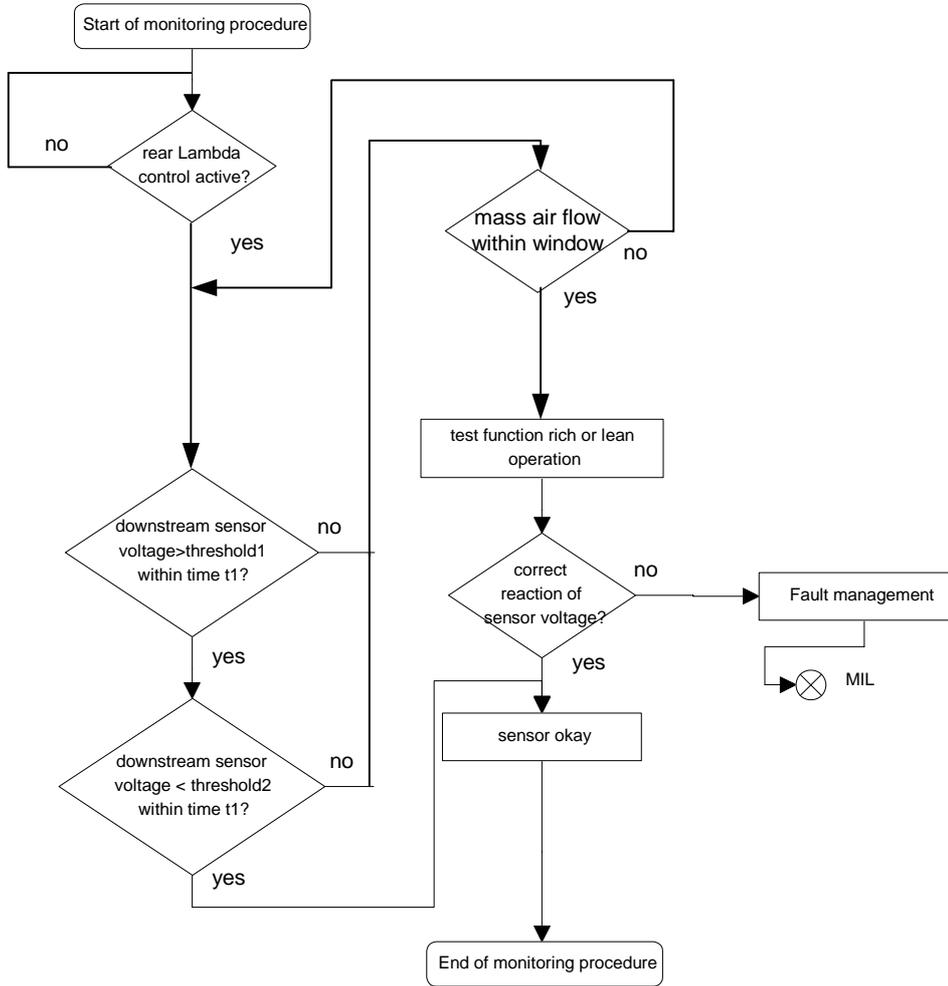
Flow Chart: Fuel Cut-Off Monitoring (Oxygen Sensors Downstream Catalysts)

See other calibrations.

.07.04.00   **Oxygen Sensor Heater Monitoring (ASIC CJ 125/120)**
.07.04.01   **General description**

For proper function of the Oxygen sensors, the sensor element must be heated up. The heating up is controlled by the heater control.

.07.04.02   **Monitor function description**

Linear Oxygen sensor upstream catalyst
Any fault in regard to sensor heater will either result in a lost or in a delay of sensor readiness.

Oxygen sensor downstream catalyst (2 point sensor)
For diagnostic of the sensor heater a specific current pulse is supplied via a load resistance and the voltage is measured. The intern resistance of the sensor heater is calculated with the voltage deviation. The result will be compared with a reference resistance map, which considers ageing and sampling deviations. In case of internal resistance > map resistance the diagnosis stores a fault and the MIL will be illuminated.
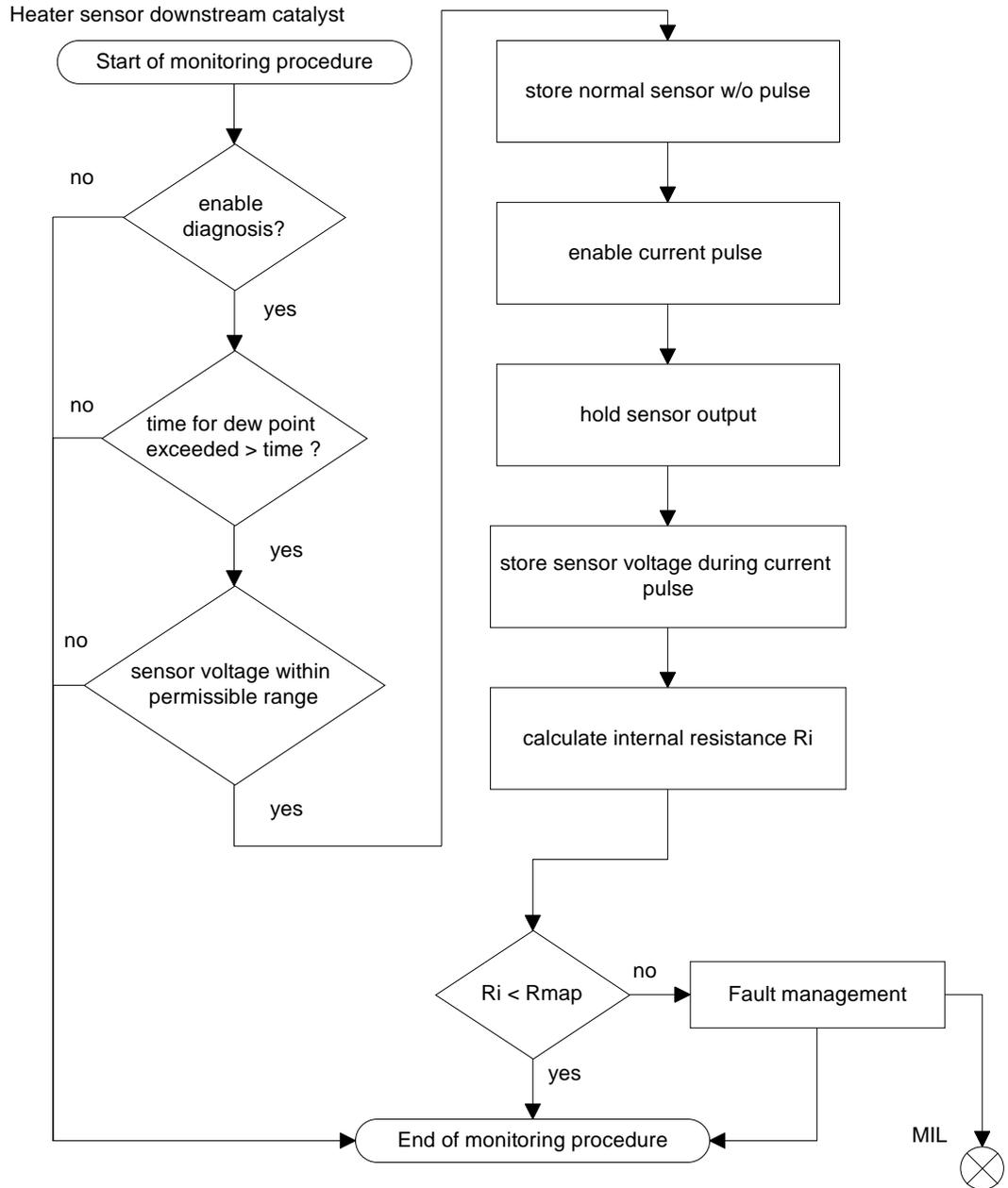
Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy Chart(s) and Flow Chart(s)

Flow Chart: Oxygen Sensor Heater Control Upstream Catalyst

LSU Heater Control Monitor

Start of Monitoring Procedure

Check of Entry Conditions
Heater Final Stage okay?
Wiring of Sensor okay?
Sensor IC okay?
Calibration Resistor okay?
Battery Voltage within range?
Heater Control active?

Entry Conditions okay? — no

yes

Fuel cut off not active
Modelled exhaust gas temperature > Threshold
Heater Power = Max. Power?

heater control active
Modelled exhaust gas temp. < Threshold 2?

Conditions fulfilled? — no

Conditions fulfilled? — no

Internal Resistance < Min. Threshold?

yes

Sensor Element Temp. Threshold? — no

Heater duty cycle < thresh. — no

no

yes

yes

MIL

yes

Fault Management

Heater Okay!

End of Monitoring Procedure

Flow Chart: Oxygen Sensors downstream catalyst

See other calibrations

.07.05.00   **SULEV applications**
.07.05.01   **General description**

The Lambda control consists of a linear Oxygen sensor (LSU) upstream catalyst and two Oxygen sensors (LSF1 and LSF2) downstream front catalyst and post main catalyst. The control loops downstream catalysts correct deviations of the upstream oxygen sensor (LSU).

All three sensors are monitored by several single monitoring procedures under the following basic conditions.

.07.05.02   **Monitor function description**

<u>The following checks will be performed on the linear oxygen sensor (LSU) upstream catalyst:</u>

<u>Plausibility Check</u>
Any deviation from the characteristic curve of oxygen sensor upstream catalyst due to poison, ceramic cracks, characteristic shift down (CSD) or a leakage between booth Oxygen sensors (LSU and LSF 1) will be detected by the control loop downstream catalyst and by comparison of the sensor signals.
The integrator value of the second control loop detects small shifts of the sensor characteristic to lean or to rich. The signal comparison during steady state conditions quickly detects major deviations in sensor characteristics caused by serious faults (e.g. ceramic cracks).

For the fault decision the Oxygen sensor downstream the first portion of the catalyst has to be checked too (Oscillation and/or fuel cut-off check).

<u>Heater Coupling Check</u>
This monitoring function will detect any short circuits between sensor heater and the Nernst cell of the Oxygen sensor by watching the Lambda signal. The ECM checks the Lambda value variation. The heater is operated by a pulsating signal with a frequency of two Hertz. The sensor signal characteristic is checked for noises with a significant level and a frequency of the heater operation. If the level of noises is greater than a threshold, a low resistance short cut between heater and pump current or the current of the Nernst cell is detected.

<u>Dynamic Check</u>
Any change in the dynamic behavior of the Oxygen sensor due to aging, heater fault or contamination will be detected by watching the slope of the Lambda value during the switch from lean to rich fuel mixture (natural frequency control of fuel mixture active). If the slope of the sensor signal exceeds a specific value the monitoring function is calculating the ratio of actual Lambda slope versus target Lambda slope. If a specific numbers of those slope ratios are less than a threshold, a fault is detected.

<u>Check for Sensor at ambient air (out of exhaust system)</u>
Under the condition of active injection valves and a Lambda value of < 1.6, a voltage significant less than 4.2 V is expected at the self-diagnostic IC of the LSU.

<u>Wire and IC-Check</u>

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

The hardware of the Oxygen sensor consists of an IC (CJ 125) with the capability of self-diagnostics. The self-diagnostic functions of the IC detects communication faults between ECM and the sensor, insufficient voltage supply, shorts in the sensor lines to ground and to battery.
Open wire on the four sensor lines, adjustment line (IA), virtual mass line (VM), pump current line (IP) and Nernst voltage (UN) will be detected by a system plausibility check. The evaluations of the system plausibility is based on sensor voltage, internal resistance, target Lambda, actual Lambda and the reaction of the controller.

The following checks will be performed on the oxygen sensors (LSF1 and LSF2) downstream catalyst:

Oscillation Check
The function checks whether the sensor output voltage of oxygen sensors (LSF 1 and LSF2) downstream catalyst always remains above or below a specified threshold.

The second control loop is designed as a natural frequency control and based on the Oxygen sensor (LSF1) post front catalyst. The voltage of the LSF1 triggers the change of fuel mixture. If the trigger point is not crossed although the control loop is closed, a timer is started. In case of no signal change within a specific time, ECM enforces a specific mixture change while watching Oxygen sensor (LSF1) voltage.

In case of Oxygen sensor (LSF1) signal shows permanently "lean" voltage, ECM is forcing an enrichment of mixture. If sensor voltage shows still lean, a "stuck low" fault is detected.

In case of Oxygen sensor (LSF1) signal shows permanently "rich" voltage, ECM enables lean out of mixture. If sensor voltage shows still rich, ECM is watching the sensor signal during the next coasting condition. In case of no signal change during coasting, a "stuck high" fault is detected.

The third control loop is designed as commanded control and based on the Oxygen sensor (LSF2) post main catalyst. The controller maintains an optimal constant voltage of the third control loop. The target voltage depends on the operating point and is taken from a map. During active control, the target voltage switches between rich and lean. In case of no reaction of the Oxygen sensor (LSF2) output according the commanded control, ECM is forcing the same enrichment/ lean out of fuel mixture in order to monitor the sensor output voltage.

Fuel cut off Check

During coasting, the ECM is watching the downstream sensor voltage, which has to go under a specific lean threshold. The diagnostic is enabled if coasting was detected for a specific time and the integrated air mass exceeds a specific threshold.
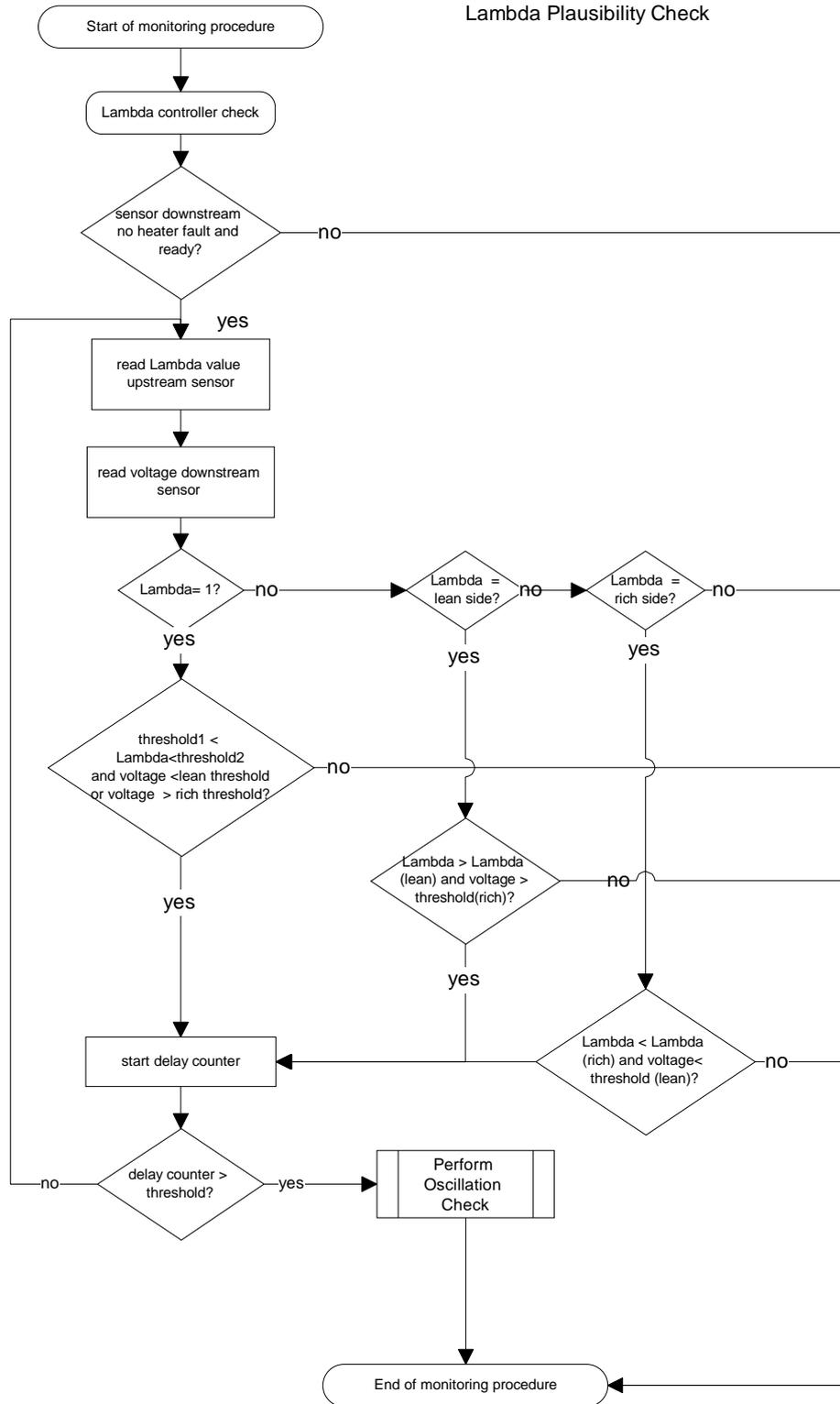
Offset monitoring Oxygen sensor (LSF1) downstream first portion of the catalyst

If the integral portion of the third control loop is exceeding a specific threshold while commanded control is active, an offset fault for the Oxygen sensor post front catalyst is detected.

Monitoring of electrical errors of sensor upstream and downstream catalyst

Implausible voltages

ADC-voltages exceeding the maximum threshold VMAX are caused by a short circuit to UBatt.

ADC-voltages falling below the minimum threshold VMIN are caused by a short circuit of sensor signal or sensor ground to ECM ground.

An open circuit of the sensors (upstream and downstream catalyst) can be detected, if the ADC-Voltage is remaining in a specified range after the sensor has been heated.

.07.05.03   **Chart(s) and flow chart(s)**
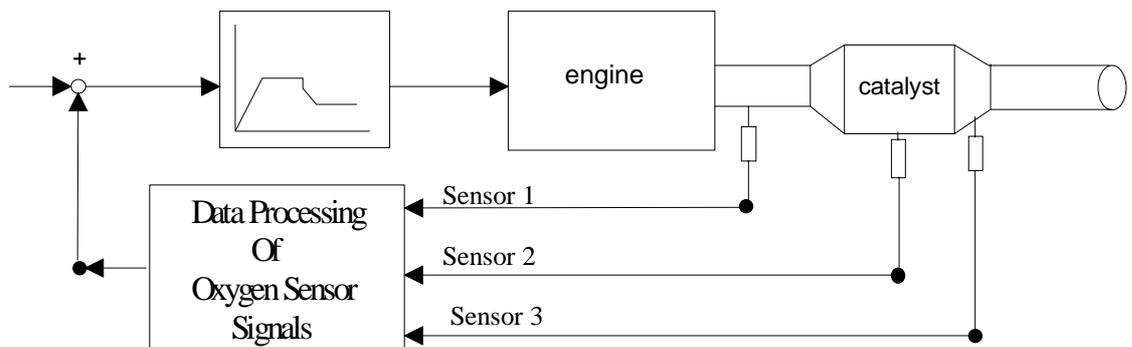
Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

Flow chart: Plausibility Monitoring (LSU O2 Sensor Upstream Catalyst)
SULEV applications

Lambda Plausibility Check
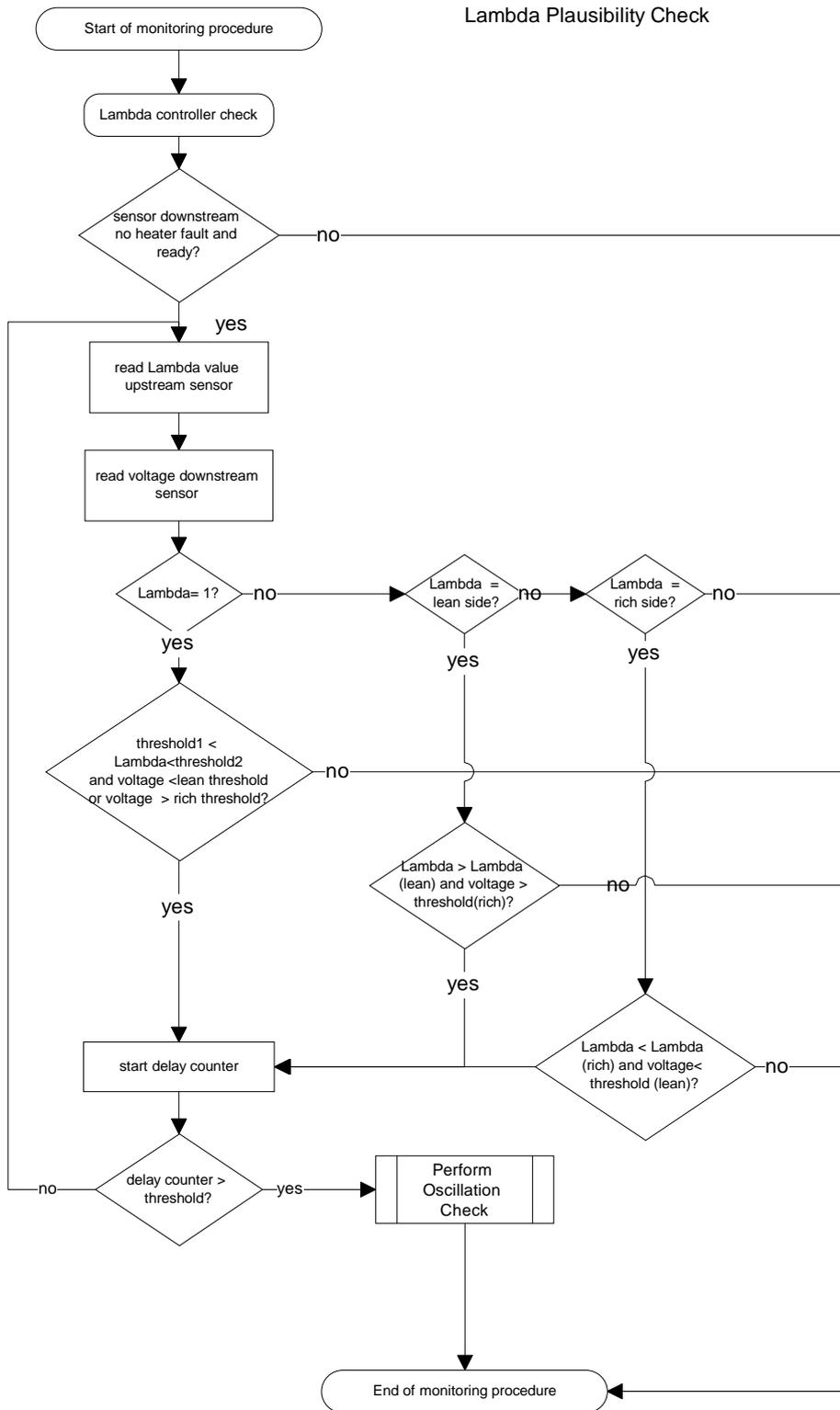
Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

Flow chart: Oscillation Monitoring (LSF1/2 O2 Sensor Downstream Catalyst)

```
                   ┌──────────────────────────┐
                   │ Start of monitoring       │
                   │ procedure                 │
                   └──────────────────────────┘
                                │
                                ▼
          no          ╱ rear Lambda ╲
      ◄───────────────   control active?
                        ╲             ╱
                                │ yes
                                ▼
          no          ╱             ╲
      ◄───────────────  no fault stored ?              ┌─────────────────────────┐
                        ╲             ╱                 │ test function rich or    │
                                │ yes                   │ lean operation           │
                                ▼                       └─────────────────────────┘
                     ╱ downstream sensor ╲   no                      │
                       voltage>threshold1  ──────┐                   ▼
                       within time t1?           │        ╱ correct    ╲    no
                        ╲                 ╱        │          reaction of    ──────►  ┌──────────────────┐
                                │ yes             │          sensor voltage?         │ Fault management │
                                ▼                 │        ╲             ╱            └──────────────────┘
                     ╱ downstream sensor ╲   no    │               │ yes                      │
                       voltage < threshold2 ───────┤               ▼                          ▼
                       within time t1?             │      ┌──────────────┐              ⊗  MIL
                        ╲                 ╱         │      │ sensor okay  │
                                │ yes              │      └──────────────┘
                                ▼                  │               │
                   ┌──────────────────────────┐    │               │
                   │ End of monitoring         │◄───┘◄──────────────┘
                   │ procedure                 │
                   └──────────────────────────┘
```
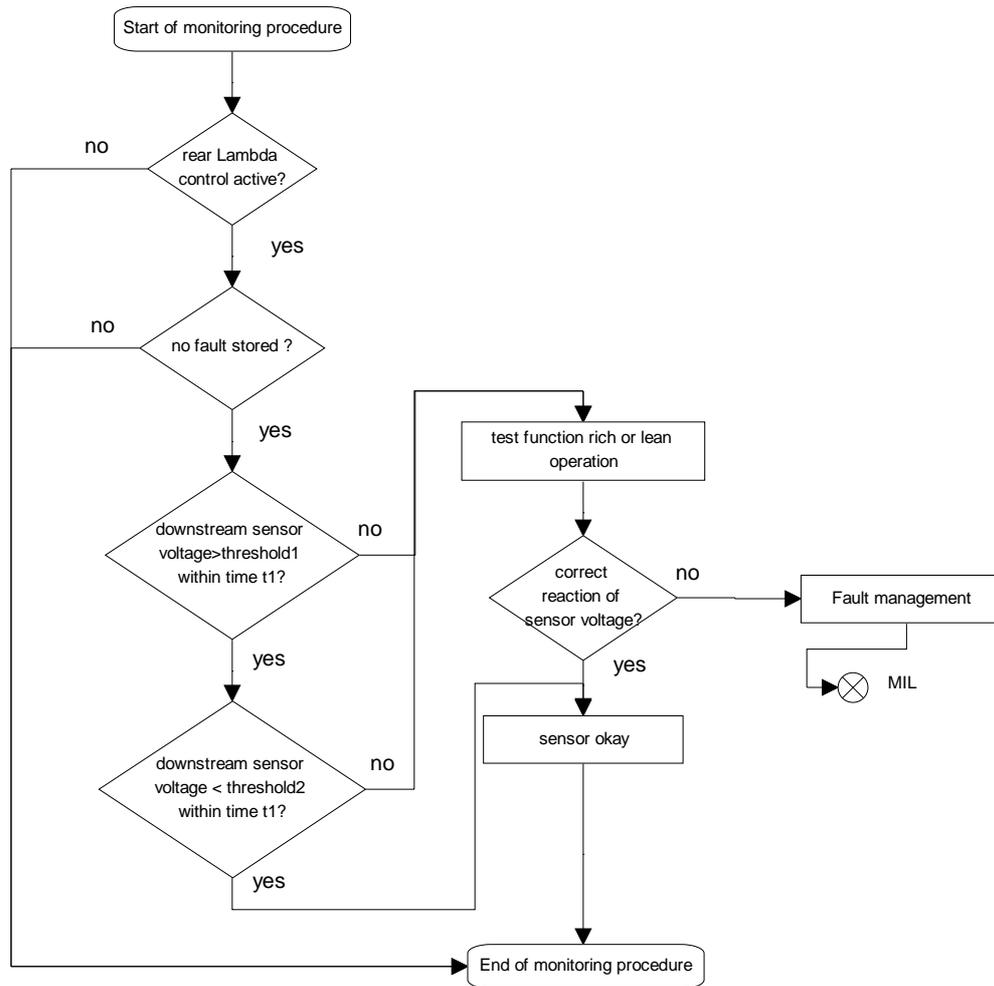
Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

Fuel Cut-Off Monitoring (LSF1/LSF2, Oxygen Sensors Downstream Catalysts

Fuel cut-off check

```
                              ┌──────────────────────┐
                              │  Start of monitoring │
                              │      procedure        │
                              └──────────────────────┘
                                         │
                                         ▼
┌────────────────────┐       no       ╱◇╲
│ wait for next fuel  │◄──────────────◇    ◇
│  cut off            │               ◇ fuel cut off ◇
│ condition (coasting)│               ◇ condition active? ◇
└────────────────────┘                ╲◇╱
        ▲                                │ yes
        │                                ▼
        │              no             ╱◇╲
        └────────────────────────────◇ fuel cut off ◇
                                      ◇   time > t1   ◇
                                      ╲◇╱
                                        │ yes
                                        ▼
                                    ╱◇╲
                                   ◇ downstream   ◇    no    ┌──────────────────┐
                                   ◇ oxygen sensor ◇────────►│ fault management │
                                   ◇ voltage <      ◇        └──────────────────┘
                                   ◇ threshold?     ◇                 │
                                    ╲◇╱                                ▼
                                      │ yes                          ⊗ MIL
                                      ▼
                              ┌──────────────┐
                              │  sensor okay │
                              └──────────────┘
                                      │
                                      ▼
                           ┌────────────────────────┐
                           │ End of monitoring procedure │
                           └────────────────────────┘
```
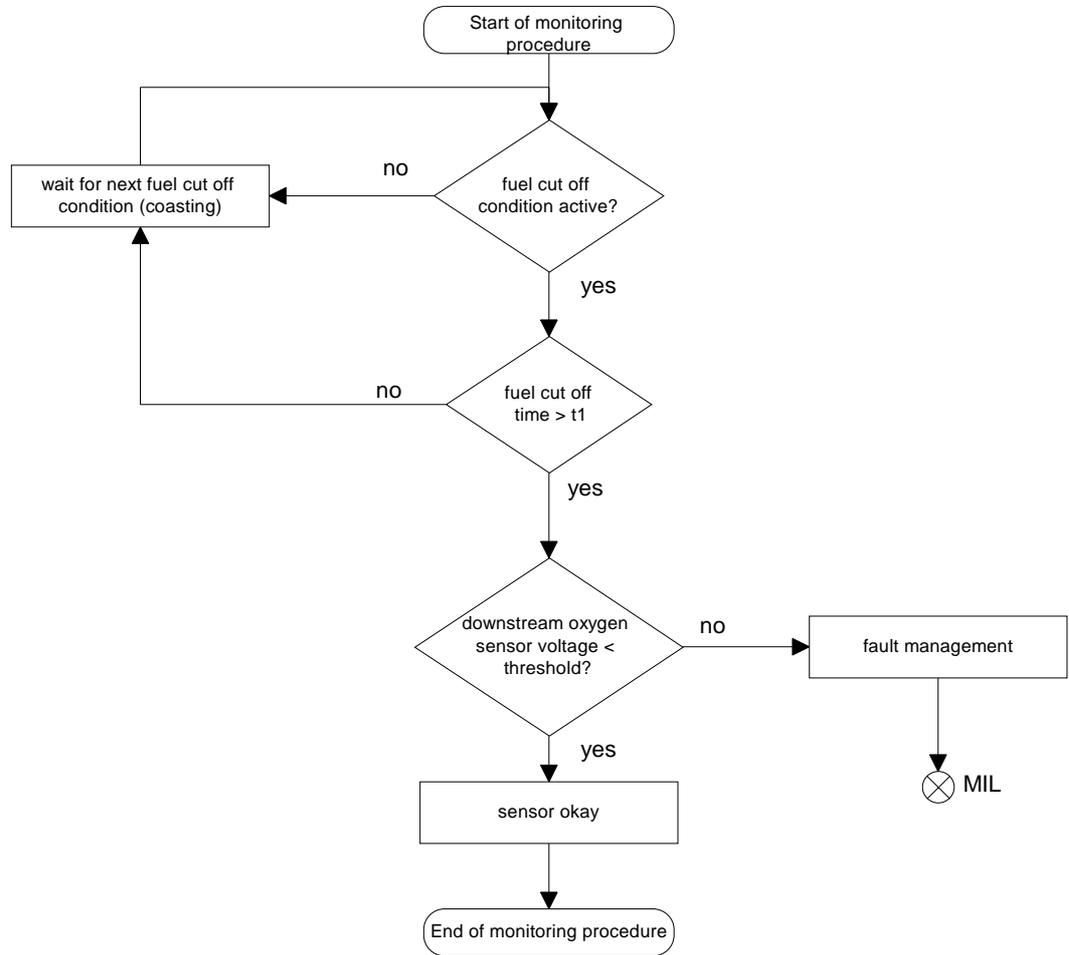
Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

Oxygen Sensors Monitor Heater Coupling (LSF1 / LSF2)

Diagnostic for Heater Coupling
(Sensors downstream Catalysts)

Start of Monitoring Procedure

Heater off
(Voltage Drop)?

no

yes

increment counter 1

Slope of
Sensor Signal
> Threshold?

no

yes

increment counter 2

Counter 1 > Threshold 1?
Counter 2 < Threshold 2?

no

Fault Management

yes

Sensor okay

End of Monitoring Procedure
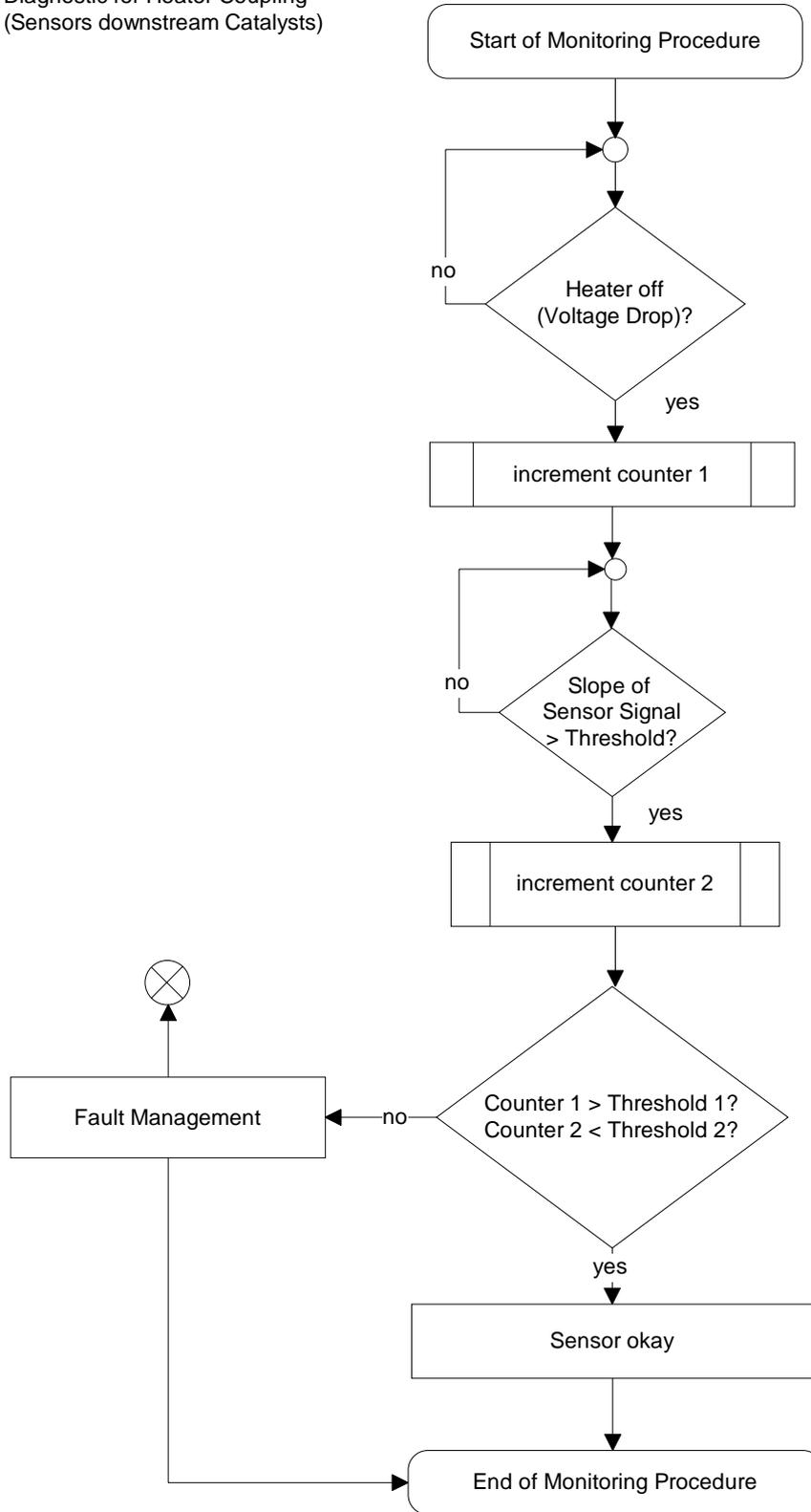
.07.06.00   Oxygen Sensor Heater Monitoring (SULEV)
.07.06.01   General description

For proper function of the Oxygen sensors, their ceramic elements must be heated. A non-functioning heater delays or prevents either the sensor readiness (LSU) or the proper signal output (LSF1/LSF2) for closed loop control and thus influences emissions.

Oxygen sensor upstream catalyst (LSU)

The heater control loop is integrated within the oxygen sensor hardware and has to achieve a target temperature of about 750 °C of the ceramic element.

Oxygen sensors downstream catalysts (LSF1 and LSF2)

For diagnostic of the sensor heater a specific current pulse is supplied via a load resistance and the voltage is measured. The intern resistance of the sensor heater is calculated with the voltage deviation. The result will be compared with a reference map resistance, which considers aging and sampling deviations. In case of internal resistance > map resistance the diagnosis stores a fault and the MIL will be illuminated.

.07.06.02   Monitor function description)

Monitoring Structure (Oxygen sensor upstream catalyst)

Heater Monitoring of Linear Oxygen Sensor Upstream Catalyst

Operating readiness
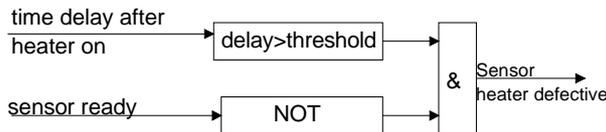
Power stage (final stage)
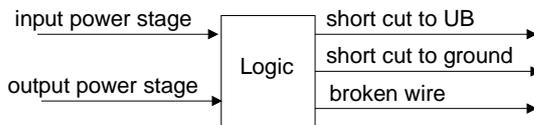
Heater Control Loop
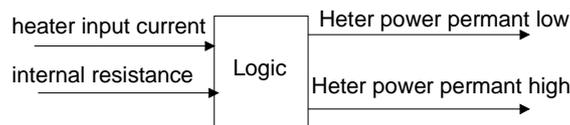
Characteristics: - Switch on of sensor heater is ECM controlled

Monitoring Structure (Oxygen Sensor Downstream Catalyst)
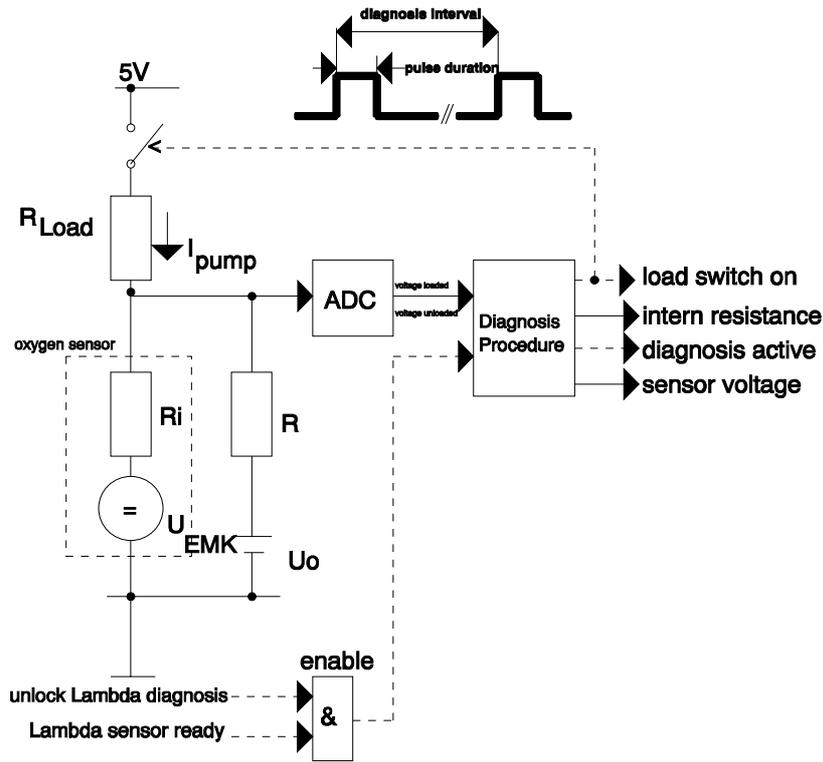
.07.06.03   Chart(s) and Flow Chart(s)

Flow Chart: LSU, Oxygen Sensor Heater Control Upstream Catalyst (SULEV calibration)

```
                              ( Start of Monitoring Procedure )          LSU Heater Control Monitor

                              Check of Entry Conditions
                              Heater Final Stage okay?
                              Wiring of Sensor okay?
                              Sensor IC okay?
                              Calibration Resistor okay?
                              Battery Voltage within range?
                              Heater Control active?

                              < Entry Conditions okay? >—no

                                      yes

 Engine Start Temp.>Threshold?        No Coasting for a Time> t          No Misfire?
 Shut-Off-Time>Threshold?             Commanded Exhaust Modell           Commanded Exhaust Model
 Heater on continously?               Temperature> Min. Threshold?       Temp.>Threshold 1?
                                      Heater Power = Max. Power?         Actual Exhaust Temp.< Threshold 2?

no—< Conditions fulfilled? >     no—< Conditions fulfilled? >       < Conditions fulfilled? >—no

        yes                              yes                              yes

no—< Sensor Element          < Internal              < Sensor Element        < Heater Ratio
     Temp.< Threshold? >       Resistance              Temp.< Threshold? >—no   Minimum? >—no
                               < Min. Threshold? >
        yes                  no        yes                 yes                       yes

                                               MIL
                                               (X)
                              Fault Management

 Heater Okay!

                              ( End of Monitoring Procedure )
```

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

Flow Chart: LSF1/LSF2, Oxygen Sensors downstream catalyst

SULEV applications

Heater sensor downstream catalyst

```
Start of monitoring procedure

        enable diagnosis?          no

            yes

        time for dew point          no
        exceeded > time ?

            yes

        sensor voltage within       no
        permissible range

            yes

store normal sensor w/o pulse
        ↓
enable current pulse
        ↓
hold sensor output
        ↓
store sensor voltage during current pulse
        ↓
calculate internal resistance Ri
        ↓
Ri < Rmap   no →   Fault management
    yes

End of monitoring procedure

MIL ⊗
```
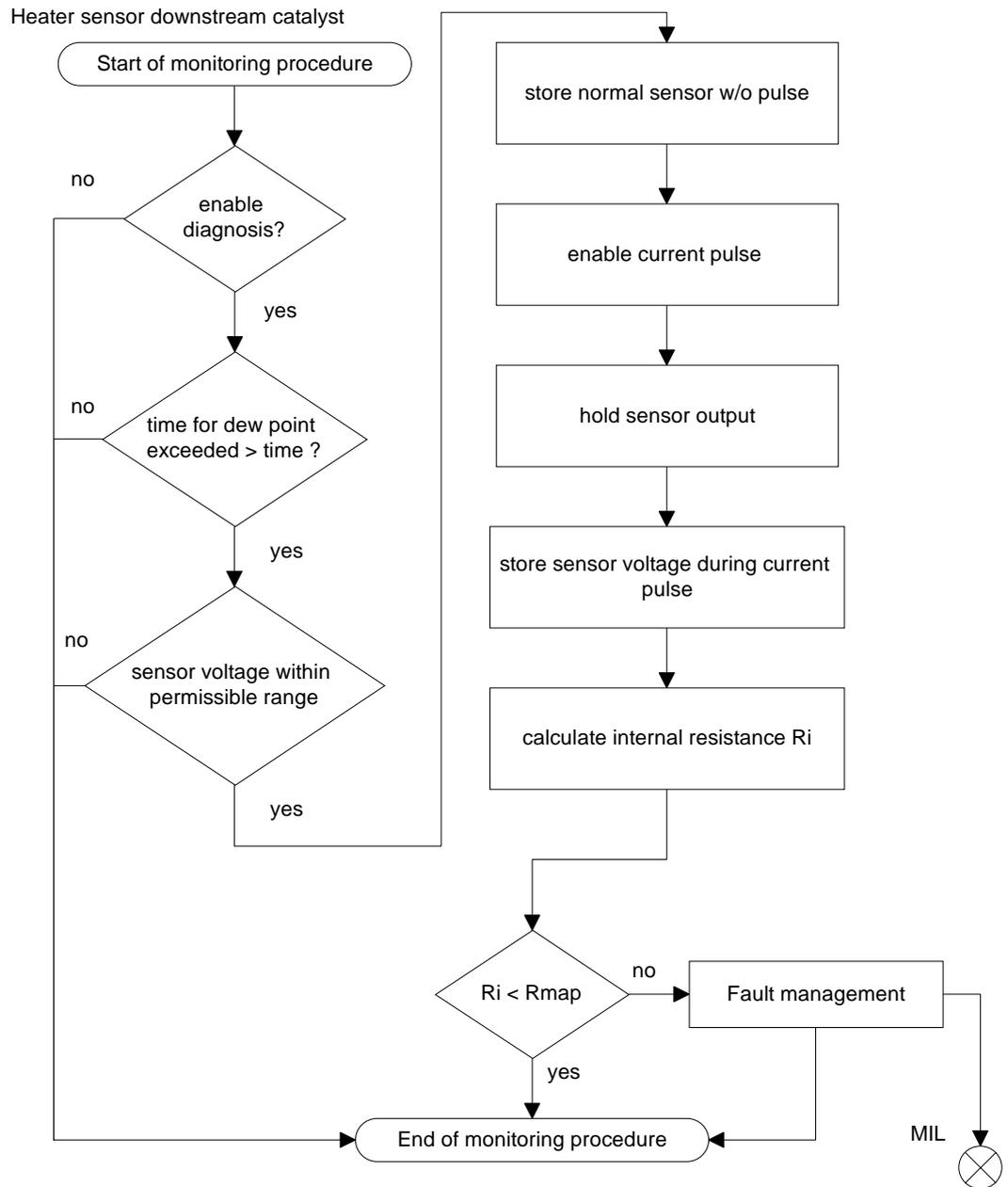
.08.00.00   EGR Monitoring

Not applicable

.09.00.00 PCV MONITORING

The PCV system assures that no gas from the crankcase system escapes into the atmosphere.

All connectors which are not necessary to open during typical maintenance / repair actions are implemented as hard to open.

All easy to open connectors are monitored by the OBD system.

.10.00.00 ENGINE COOLANT SYSTEM MONITORING

.10.01.00   General description

The engine cooling system consists of five main parts.
1. The Engine Cooler
2. The Engine Coolant Temperature Sensor
3. The Thermostat Valve
4. The small Cooling Circuit
5. The large Cooling Circuit

During heating up the Engine the coolant flows first inside the small cooling circuit. After the coolant reach a sufficient temperature the thermostat valve will open the large cooling circuit to integrate the engine cooler.
The engine coolant temperature sensor measures a mixed temperature between the coolant coming from the small and large cooling circuit.
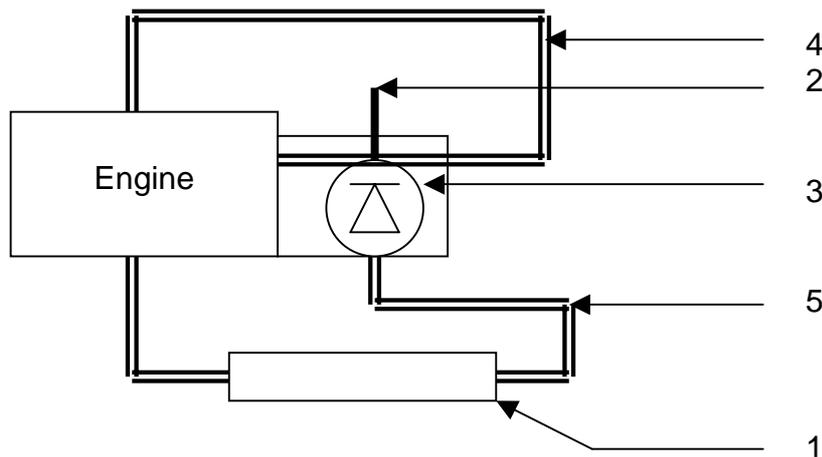
.10.01.02   Monitor Functional Description

The engine cooling system-monitoring strategy consists of two main diagnostic parts.
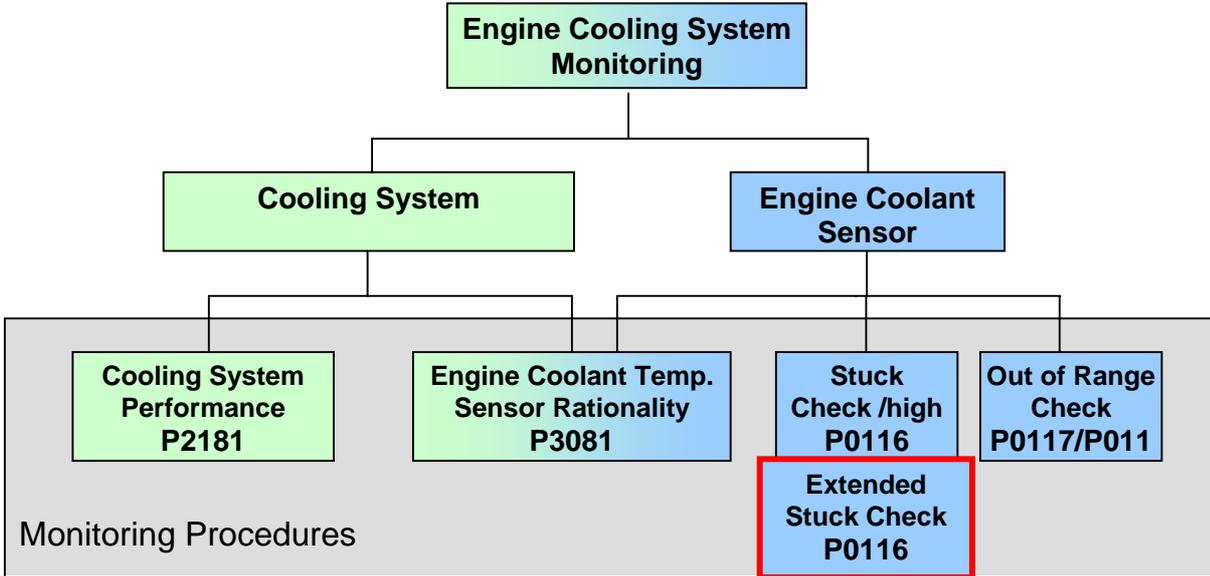
Each of the engines cooling monitoring function has its own special engine temperature range in which it will be enabled.
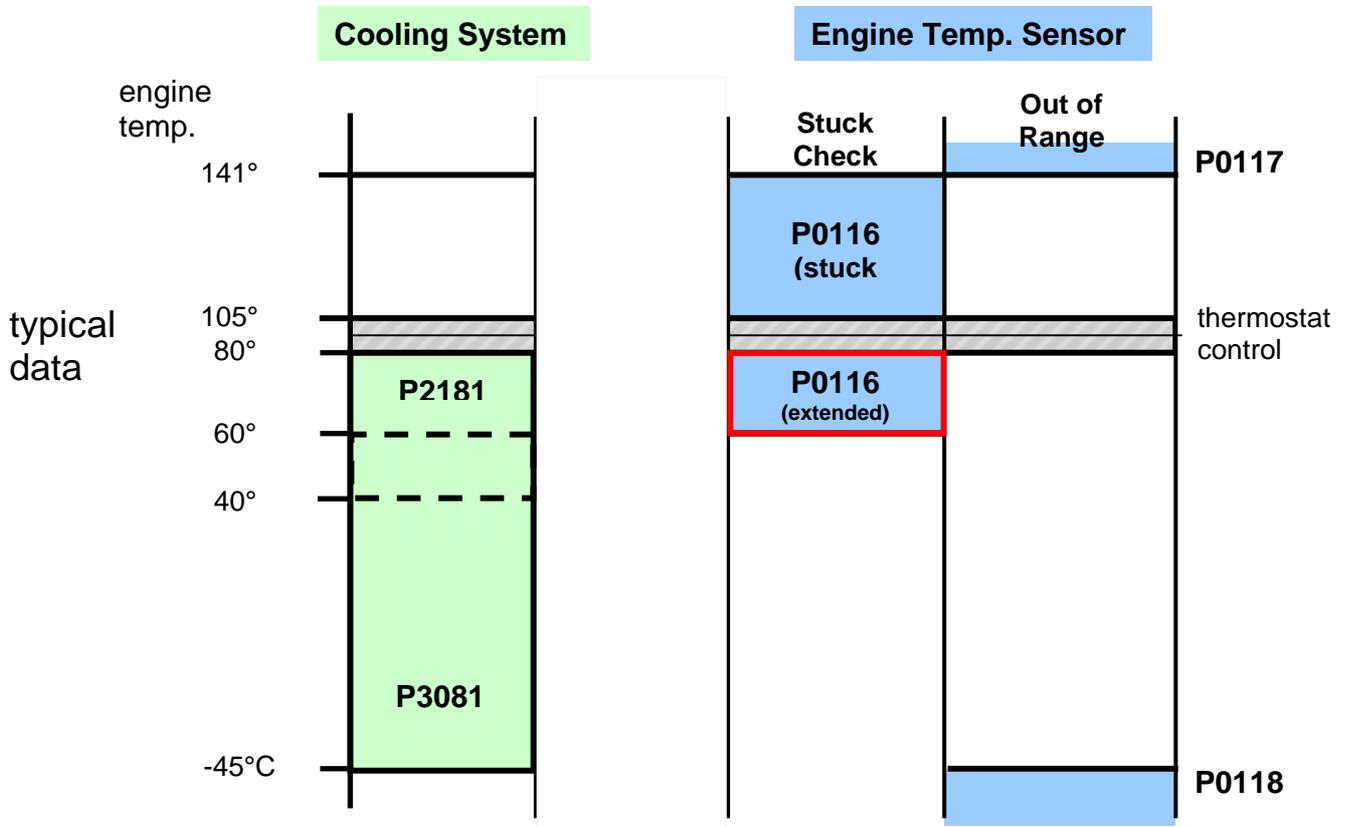
.10.03.00 **Charts and Flow Charts**

Cooling System Performance (P2081)

In case that the engine coolant temperature does not reach an certain value after a sufficient mass air flow under normal driving conditions, the cooling system performance is considered to be reduced.

correct engine
warm-up

engine coolant temp.

fault detection threshold (thres_03)

wrong engine
warm- up

decision

intake air mass flow
integral
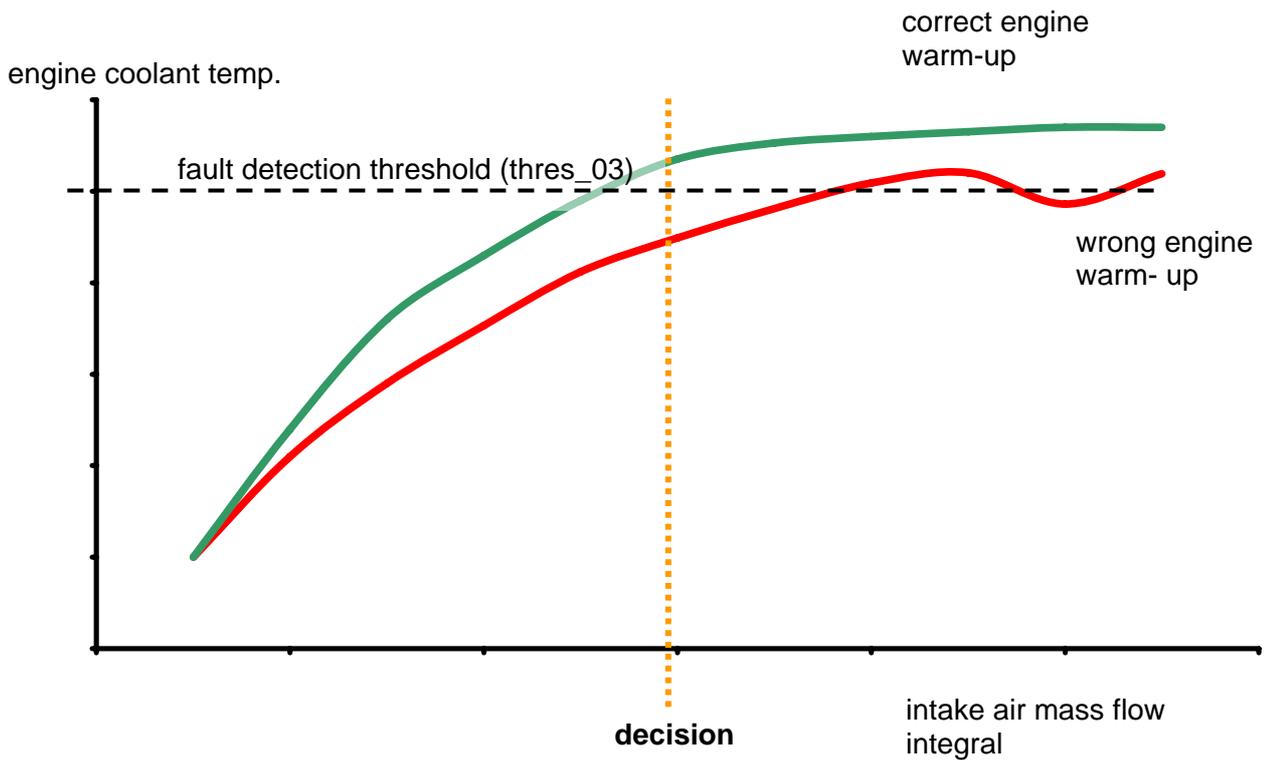
Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

Flow Chart Cooling System Performance (P2081)
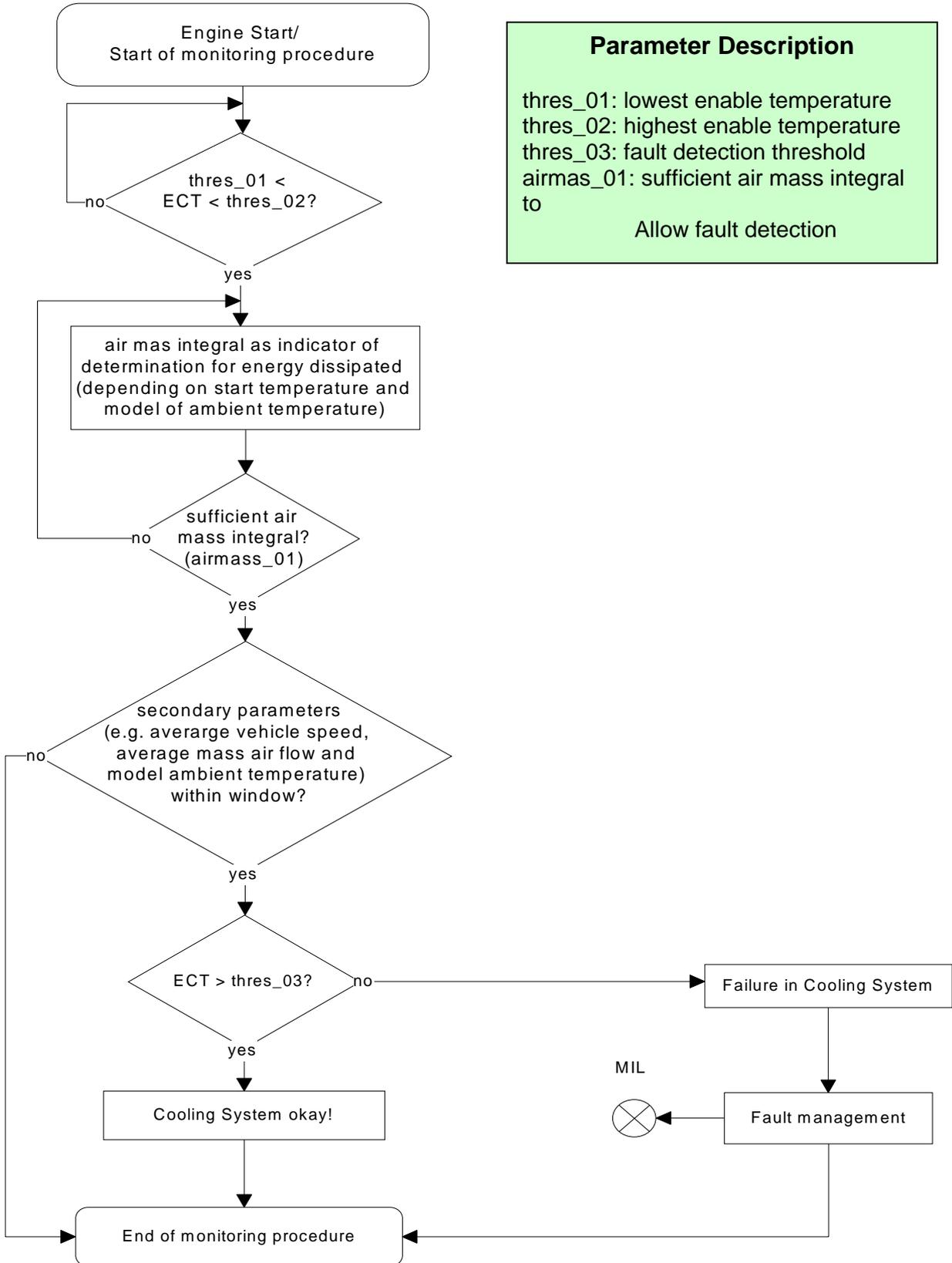
```
┌─────────────────────────────┐        ┌──────────────────────────────────┐
│      Engine Start/          │        │    Parameter Description          │
│  Start of monitoring proc.  │        │                                    │
└─────────────────────────────┘        │ thres_01: lowest enable temp.     │
              │                         │ thres_02: highest enable temp.    │
              ▼                         │ thres_03: fault detection thresh. │
         thres_01 <                     │ airmas_01: sufficient air mass     │
    no ◄  ECT < thres_02?               │ integral to                        │
              │                         │                                    │
             yes                        │      Allow fault detection         │
              │                         └──────────────────────────────────┘
              ▼
   air mas integral as indicator of
   determination for energy dissipated
   (depending on start temperature and
      model of ambient temperature)
              │
              ▼
         sufficient air
    no ◄  mass integral?
         (airmass_01)
              │
             yes
              ▼
       secondary parameters
    (e.g. averarge vehicle speed,
    average mass air flow and
 no ◄ model ambient temperature)
       within window?
              │
             yes
              ▼
        ECT > thres_03?  ── no ──►  Failure in Cooling System
              │
             yes                         MIL
              ▼                     ⊗ ◄── Fault management
       Cooling System okay!
              │
              ▼
    End of monitoring procedure  ◄──────
```

Engine Coolant Temp. Sensor Rationality (P3081)

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

engine coolant temp.

max. plausible range

reference model

wron warming up

fault decision

time
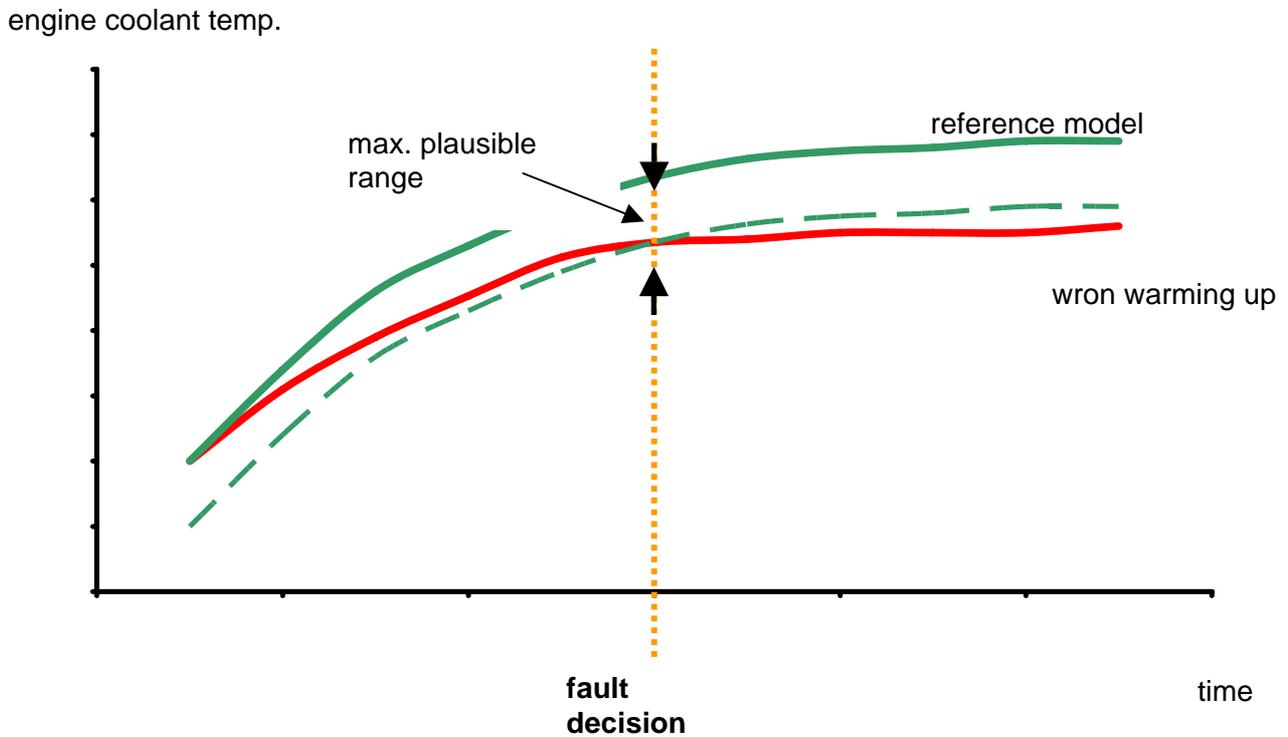
Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

Flow Chart Coolant Temperature Sensor Rationality (P3081)

```
┌─────────────────────────┐
│      Engine Start/      │
│ Start of monitoring     │
│      procedure          │
└─────────────────────────┘
             │
             ▼
┌─────────────────────────┐
│ Calculate ECT Model     │
│ f(MAF,IAT)              │
│ until Model max. value  │
│ (modmx_01)              │
└─────────────────────────┘
             │
             ▼
        ╱ECT Model -╲
       ╱ Measured    ╲ ──yes──┐
       ╲ ECT> range_01?╱       │
        ╲            ╱         │
            │no                │
            │                  ▼
            │          ┌──────────────────┐        MIL
            │          │ Fault management │ ──────> ⊗
            │          └──────────────────┘
            ▼                  │
┌─────────────────────────┐   │
│ End of monitoring       │◄──┘
│ procedure               │
└─────────────────────────┘
```

Parameter Description

modmx_01: maximum reference
temperature model value

range_01: maximum deviation error to
detect a malfunction

ECT: Engine Coolant Temperature
MAF: Mass Air Flow Sensor
IAT: Intake Air Temperature

Engine Coolant Temperature Sensor Stuck High (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 stuck at high values.

engine coolant temp.
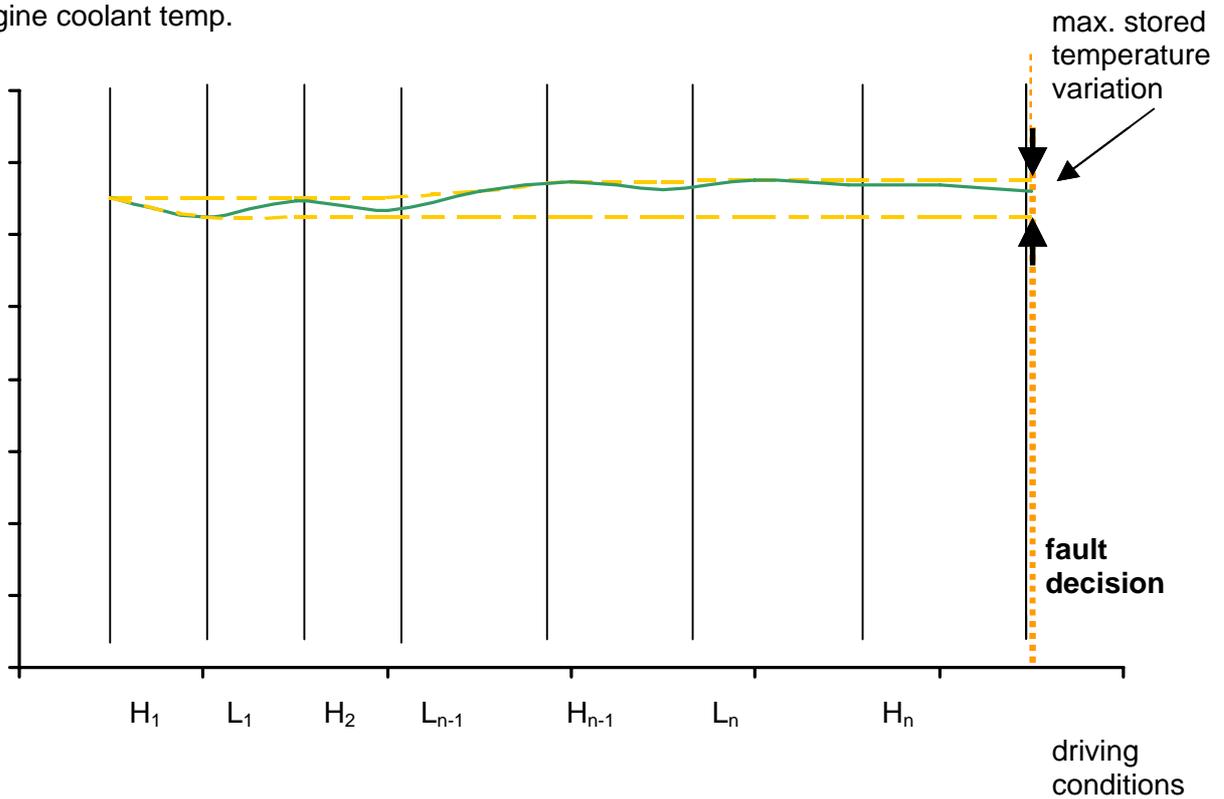
max. stored temperature variation

fault decision

H₁ L₁ H₂ L_{n-1} H_{n-1} L_n H_n

driving conditions

H: driving condition with high cooling performance (vehicle cruise)

L: driving conditions with low cooling performance (idle)

Flow Chart Engine Coolant Temperature Sensor Stuck High (P0116)

```
┌──────────────────────────────┐
│ Start of monitoring procedure │
└──────────────────────────────┘
                │
                ▼
        ╱ Engine start ╲
       ╱ temperature within ╲ ─── no ───►
       ╲ window?          ╱
        ╲ temp_01/temp_02 ╱
                │
               yes
                ▼
        ┌──────────────────┐
        │ Reset: ECT min. and │
        │ ECT max.          │
        └──────────────────┘
                │
                ▼
        ┌──────────────────────────────┐
        │ measure and store continuously: │
        │ ECT min.                       │
        └──────────────────────────────┘
                │
                ▼
        ┌──────────────────────────────┐
        │ measure and store continuously: │
        │ ECT max.                       │
        └──────────────────────────────┘
                │
                ▼
        ╱ ECT max. -  ╲
       ╱ ECT min.>     ╲ ── yes ──► ┌────────────┐
       ╲ threshold f(ECT) ╱         │ Sensor okay! │
        ╲ (thres_01)?   ╱           └────────────┘
                │
               no
                ▼
        ╱ Sufficient time in: ╲
  no ──╱ driving conditions (vehicle ╲
       ╲ cruise/ engine idle) ?    ╱
        ╲                        ╱
                │
               yes
                ▼
        ┌──────────────────┐
        │ ECT sensor stucks │
        └──────────────────┘
                │
MIL             ▼
 ⊗ ◄── ┌──────────────────┐
        │ Fault management  │
        └──────────────────┘
```

┌──────────────────────────────┐
│ End of monitoring procedure   │
└──────────────────────────────┘

Parameter Description

temp_01: maximum engine start
temperature
temp_02: substitute model temp
thres_01: maximum diff. between ECTmin/
ECT max to detect a malfunction

ECTmin: Minimum of stored Engine
Coolant temperature
ECTmax: Maximum of stored Engine
Coolant temperature

Engine Coolant Temperature Sensor Stuck Low (P0116)

After engine start the system stores continuously the lowest and highest ECT below 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 stuck at low values.

engine coolant temp.
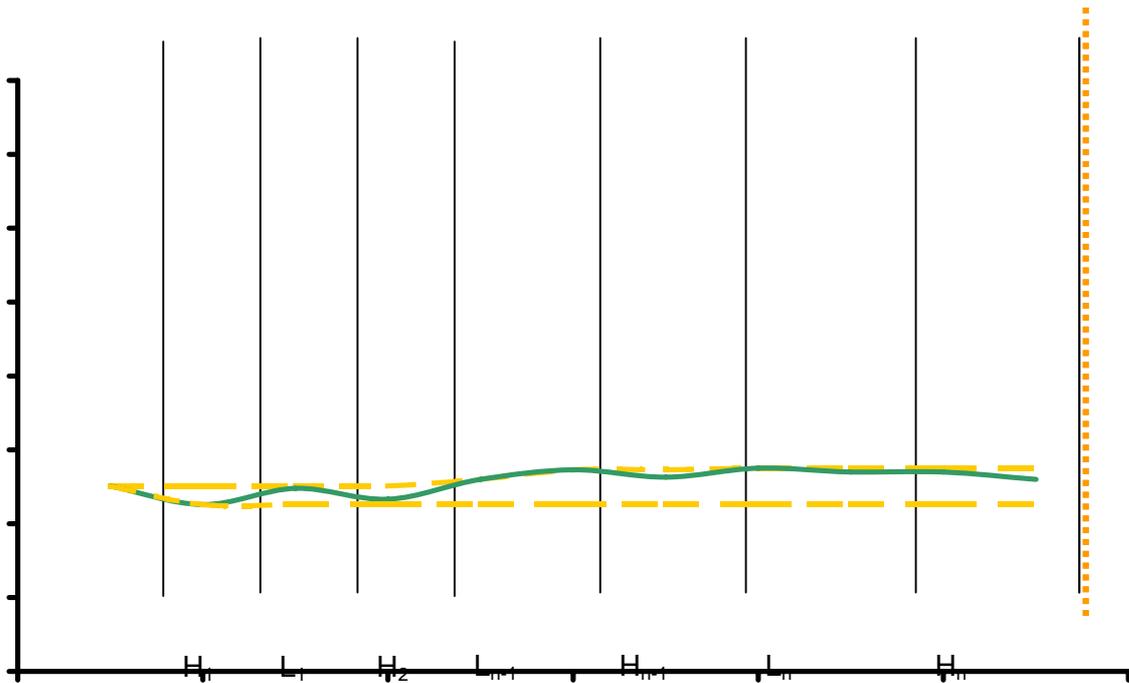
H: driving condition with high cooling performance (vehicle cruise)

L: driving conditions with low cooling performance (idle)

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

Flow Chart Engine Coolant Temperature Sensor Stuck Low (P0116)

```
            ┌─────────────────────────────┐
            │ Start of monitoring procedure│
            └─────────────────────────────┘
                          │
                          ▼
                     ╱╲╱╲╱╲╱╲
                  Engine start
              temperature within        ──no──┐
                   window?                     │
               temp_01/temp_02                 │
                     ╲╱╲╱╲╱╲╱                  │
                          │                    │
                         yes                   │
                          ▼                    │
            ┌─────────────────────────┐        │
            │ Reset: ECT min. and     │        │
            │ ECT max.                │        │
            └─────────────────────────┘        │
                          │                    │
          ┌───────────────▼──────────────┐     │
          │                              │     │
          │   ┌─────────────────────────┐│     │
          │   │ measure and store       ││     │
          │   │ continuously: ECT min.  ││     │
          │   └─────────────────────────┘│     │
          │              │               │     │
          │              ▼               │     │
          │   ┌─────────────────────────┐│     │
          │   │ measure and store       ││     │
          │   │ continuously: ECT max.  ││     │
          │   └─────────────────────────┘│     │
          │              │               │     │
          │              ▼               │     │
          │         ECT max. -           │     │
          │         ECT min.>    ──yes── ► Sensor okay!
          │       threshold f(ECT)       │     │
          │         (thres_01)?          │     │
          │              │               │     │
          │             no               │     │
          │              ▼               │     │
          │       Sufficient time in:    │     │
          └─no── driving conditions      │     │
                 (vehicle cruise/        │     │
                  engine idle) ?         │     │
                          │                    │
                         yes                   │
                          ▼                    │
              ┌─────────────────────┐          │
              │ ECT sensor stucks   │          │
              └─────────────────────┘          │
  MIL                   │                      │
                        ▼                      │
   ⊗ ◄── ┌─────────────────────┐               │
         │ Fault management    │               │
         └─────────────────────┘               ▼
                                    ┌───────────────────────────┐
                                    │ End of monitoring procedure│
                                    └───────────────────────────┘
```

Parameter Description

temp_01: maximum engine start
             temperature
temp_02: substitute model temperature
thres_01: maximum diff. between ECTmin/
             ECT max to detect a
malfunction

ECTmin: Minimum of stored Engine
             Coolant temperature
ECTmax: Maximum of stored Engine
             Coolant temperature

Flow Chart Engine Coolant Temperature Sensor Stuck Test (all temperatures above threshold) (P0116)

Monitoring of engine temperature during normal DCY <u>and</u> during engine shut off time
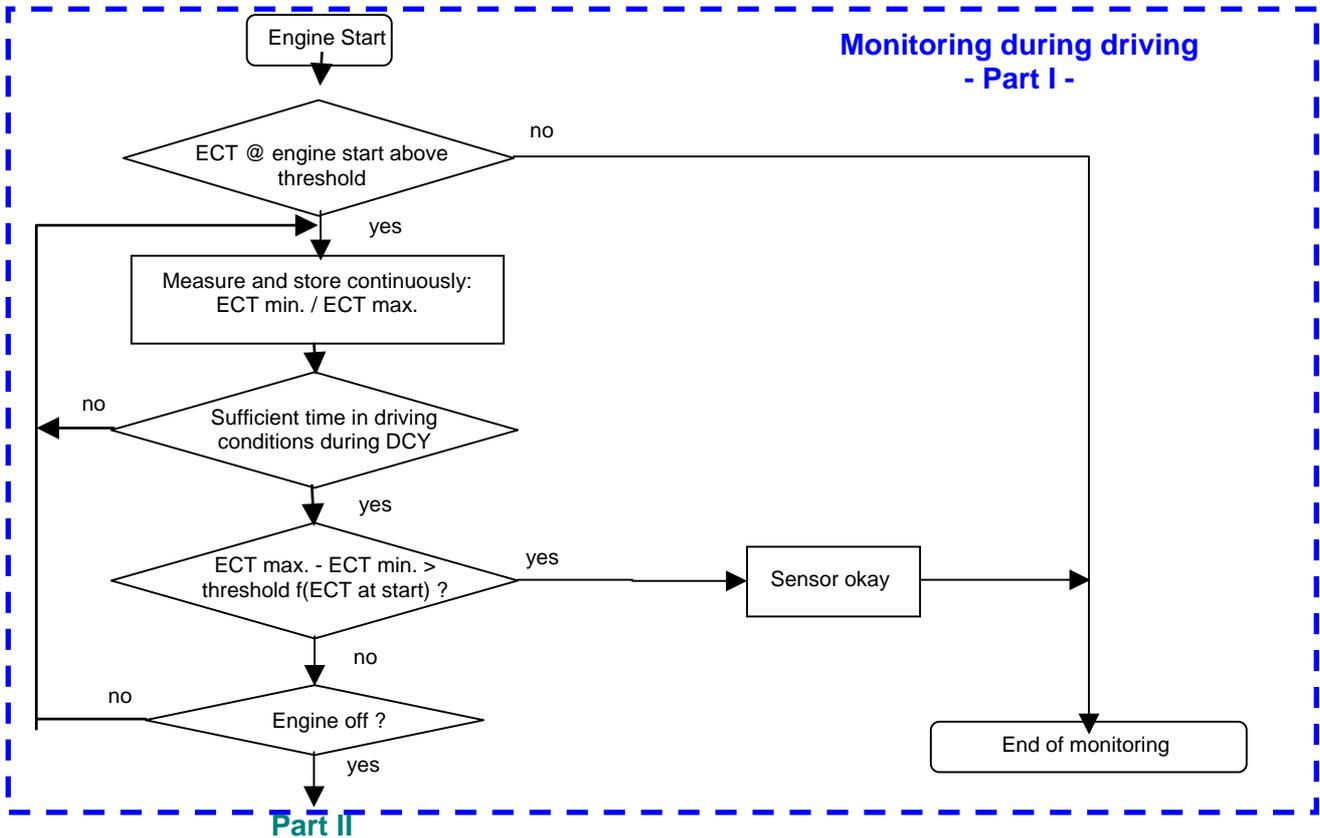
Part I:

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy
Monitoring of engine temperature during normal DCY and during engine shut off time

Part II:
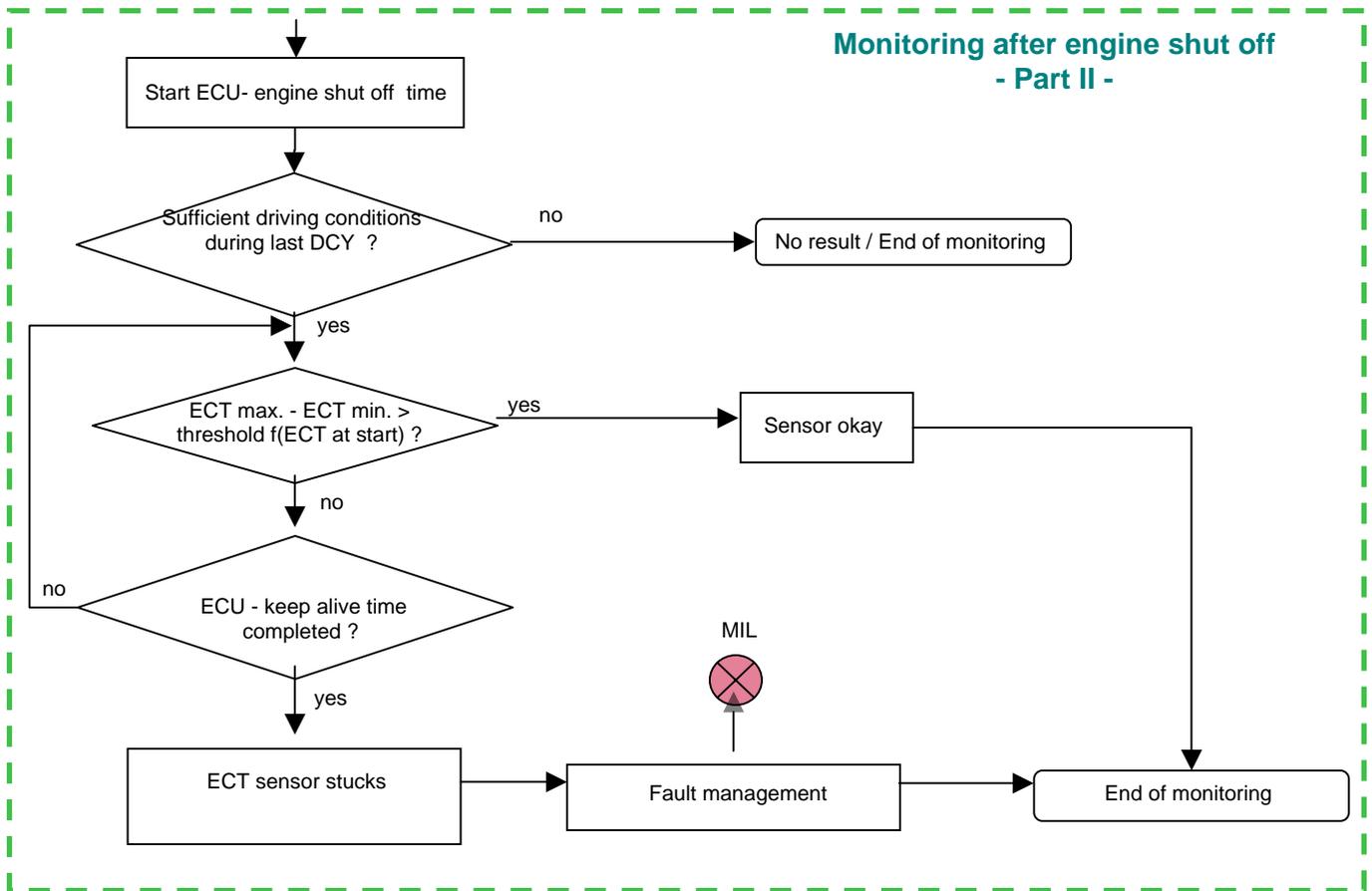
Engine Coolant Temperature Sensor Out of Range Check (P0118 / P0117)

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy
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.

```
                          ┌─────────────┐
                          │  Start of   │
                          │  Monitoring │
                          │  Procedure  │
                          └──────┬──────┘
                                 │
              ┌──────────────────┴──────────────────┐
              │                                      │
    ┌─────────▼─────────┐                  ┌─────────▼─────────┐
    │ Check routine for │                  │ Check routine for │
    │ lower threshold   │                  │ upper threshold   │
    │ (depending on     │                  │ (depending on     │
    │                   │                  │              )    │
    └─────────┬─────────┘                  └─────────┬─────────┘
              │                                      │
     NO       ▼        YES          YES              ▼        NO
         ◇ Signal < lower ◇─────────────────◇ Signal > upper threshold ◇
           threshold                                  
              │                    │                           │
              │         ┌──────────▼──────────┐                │
          ⊗ ◄── MIL ──  │    Fault Code       │                │
              │         │    Management       │                │
              │         └──────────┬──────────┘                │
              │                    │                           │
              │         ┌──────────▼──────────────┐            │
              └────────►│ End of Monitoring Procedure│◄─────────┘
                        └────────────────────────────┘
```
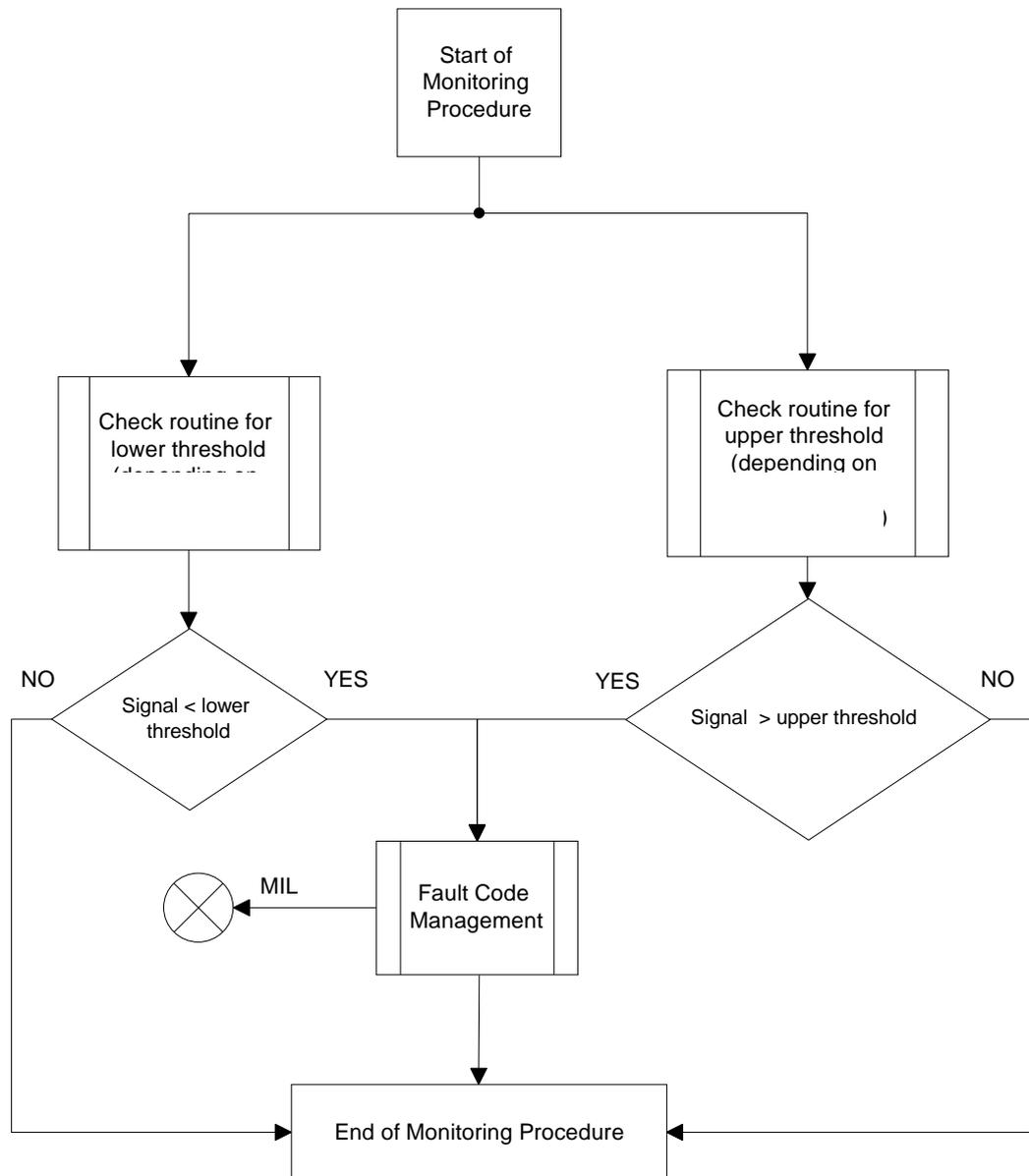
.11.00.00   **COLD START EMISSION REDUCTION STRATEGY MONITORING**
Not applicable

.12.00.00   **AIR CONDITIONING (A/C) SYSTEM COMPONENT MONITORING**
Not applicable

.13.00.00   **VARIABLE VALVE TIMING AND/OR CONTROL (VVT) SYSTEM MONITORING**
Not applicable

.14.00.00   **DIRECT OZON REDUCTION (DOR) SYSTEM MONITORING**
Not applicable

.15.00.00   **PARTICULATE MATER (PM) TRAP MONITORING**
Not applicable

.16.00.00   **COMPREHENSIVE COMPONENTS MONITORING**
Flow Charts in addition to the summary table explanations:

.16.01.00   **Injection Valve**
Check is performed while using Output Stage Check 16.09.12:

.16.02.00   **Fuel Pump Relay**
Check is performed while using Output Stage Check 16.09.12:

.16.03.00   Idle Controller

(Idle Control Check)

```
┌─────────────────────────────┐
│ Start of Monitoring Procedure│
└─────────────────────────────┘
              │
              ▼
┌─────────────────────────────┐
│   Check of Enable Criteria   │◄──┐
└─────────────────────────────┘   │
              │                    │
              ▼                    │
         ◇ Enable                  │
   NO ◄── Conditions               │
         fulfilled? ◇              │
              │ YES                │
              ▼                    │
┌─────────────────────────────┐   │
│ Check Idle Controller for   │   │
│ max. and min. Threshold     │   │
└─────────────────────────────┘   │
              │                    │
              ▼                    │
      ◇ Idle Controller @         │
        max. Limit                 │
        and Engine rpm < Idle rpm  │ YES
        - 80 rpm and Engine Load ◇ ───┐
        < Threshold?               │  │
              │ NO                  │  │
              ▼                     │  │
      ◇ Idle Controller @          │  │
        min. Limit                  │  │
        and Engine rpm > Idle rpm ◇ ─┐│ YES
        + 80 rpm                    ││
              │ NO                  ││
              └─────────────────────┘│
                                     ▼
                        ┌─────────────────────────┐
                        │ Fault Code Management    │──► ⊗ MIL
                        └─────────────────────────┘
```
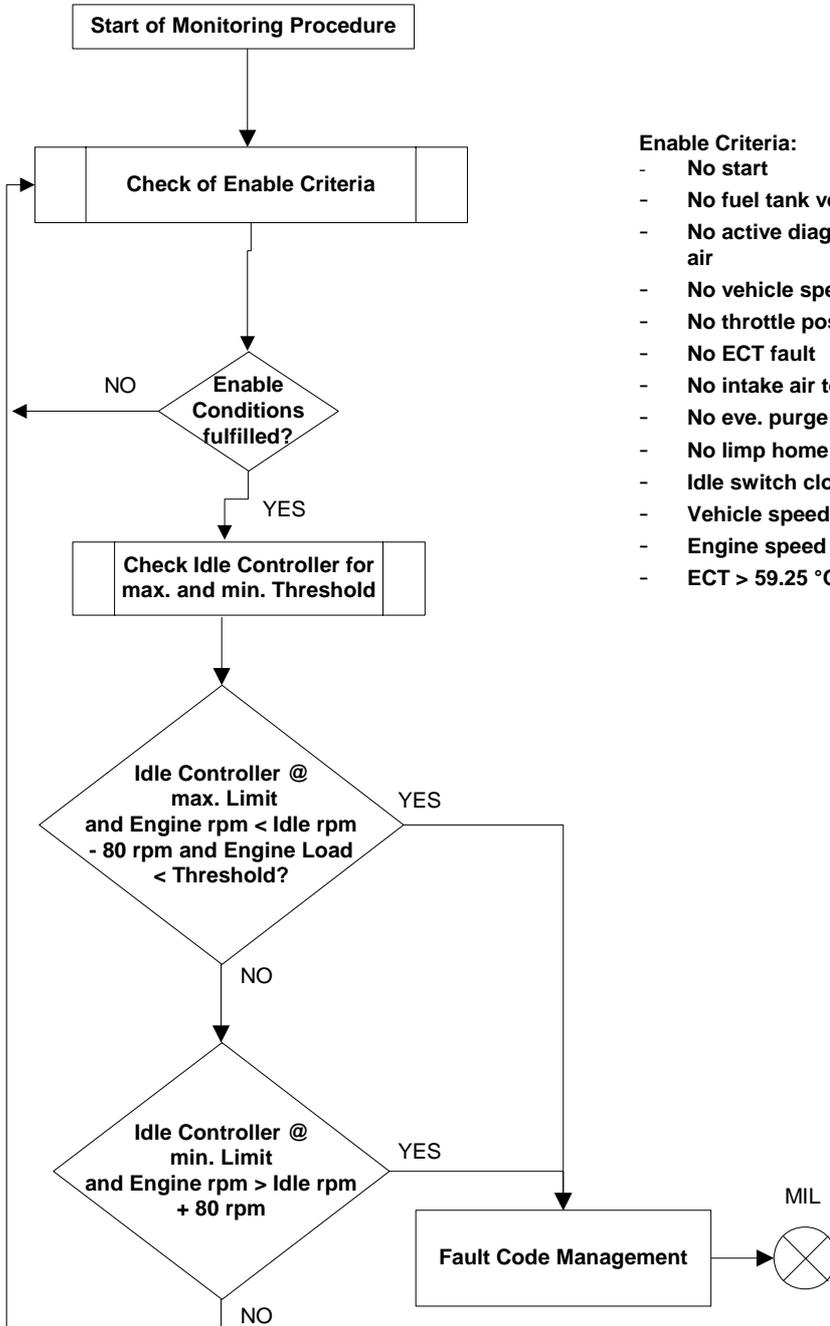
Enable Criteria:
- **No start**
- **No fuel tank ventilation with high degree of saturation**
- **No active diagnosis of EVAP system and secondary air**
- **No vehicle speed fault**
- **No throttle position fault**
- **No ECT fault**
- **No intake air temperature fault**
- **No eve. purge valve fault**
- **No limp home of engine speed sensor**
- **Idle switch closed**
- **Vehicle speed = 0 mph**
- **Engine speed @ idle**
- **ECT > 59.25 °C**

.16.04.00   Engine Speed Sensor:
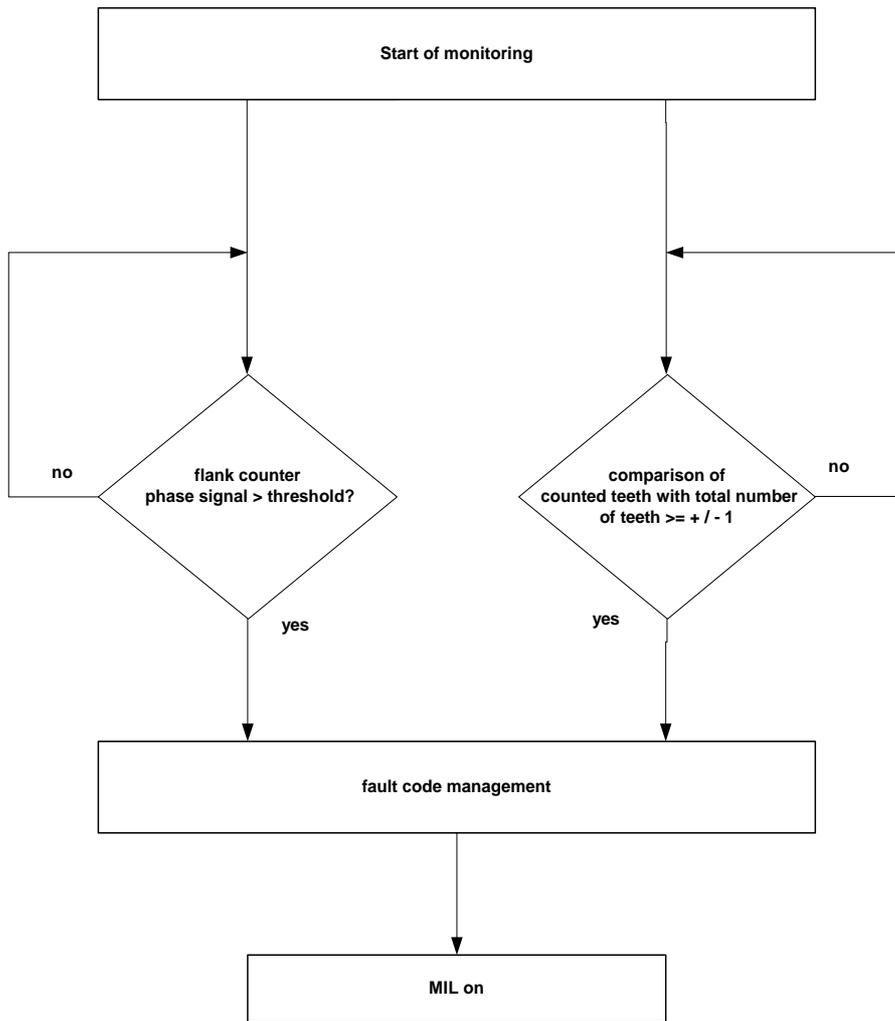
```
                    ┌─────────────────────────────┐
                    │      Start of monitoring     │
                    └─────────────────────────────┘

         ┌──────────────────┐        ┌──────────────────┐
         │                  │        │                  │
    no        flank counter              comparison of          no
           phase signal > threshold?  counted teeth with total number
                                         of teeth >= + / - 1

              yes                        yes

                    ┌─────────────────────────────┐
                    │     fault code management    │
                    └─────────────────────────────┘

                             ┌──────────────┐
                             │    MIL on     │
                             └──────────────┘
```

.16.05.00   Warm-up Bypass valve:
          (Not applicable)

.16.06.00 Signal Range Check for different sensor

IAT
MAF
ECT
Camshaft position sensor
Charge pressure control valve

```
                    ┌──────────────┐
                    │   Start of   │
                    │  monitoring  │
                    │  procedure   │
                    └──────────────┘
                           │
              ┌────────────┴────────────┐
              │                         │
     ┌────────────────┐        ┌────────────────┐
     │ Check routine  │        │ Check routine  │
     │ for lower      │        │ for upper      │
     │ threshold      │        │ threshold      │
     └────────────────┘        └────────────────┘
              │                         │
          ◇ signal of              ◇ signal of
  NO       sensor        YES   YES    sensor        NO
     ←──  < lower  ──────→   ←──────  > upper  ──→
         threshold                   threshold
              │                         │
              │      ┌──────────────┐   │
         ⊗ ←MIL──    │    Fault     │   │
              │      │  Management  │   │
                     └──────────────┘
                           │
              ┌──────────────────────┐
              │  End of Monitoring    │
              │      Procedure        │
              └──────────────────────┘
```
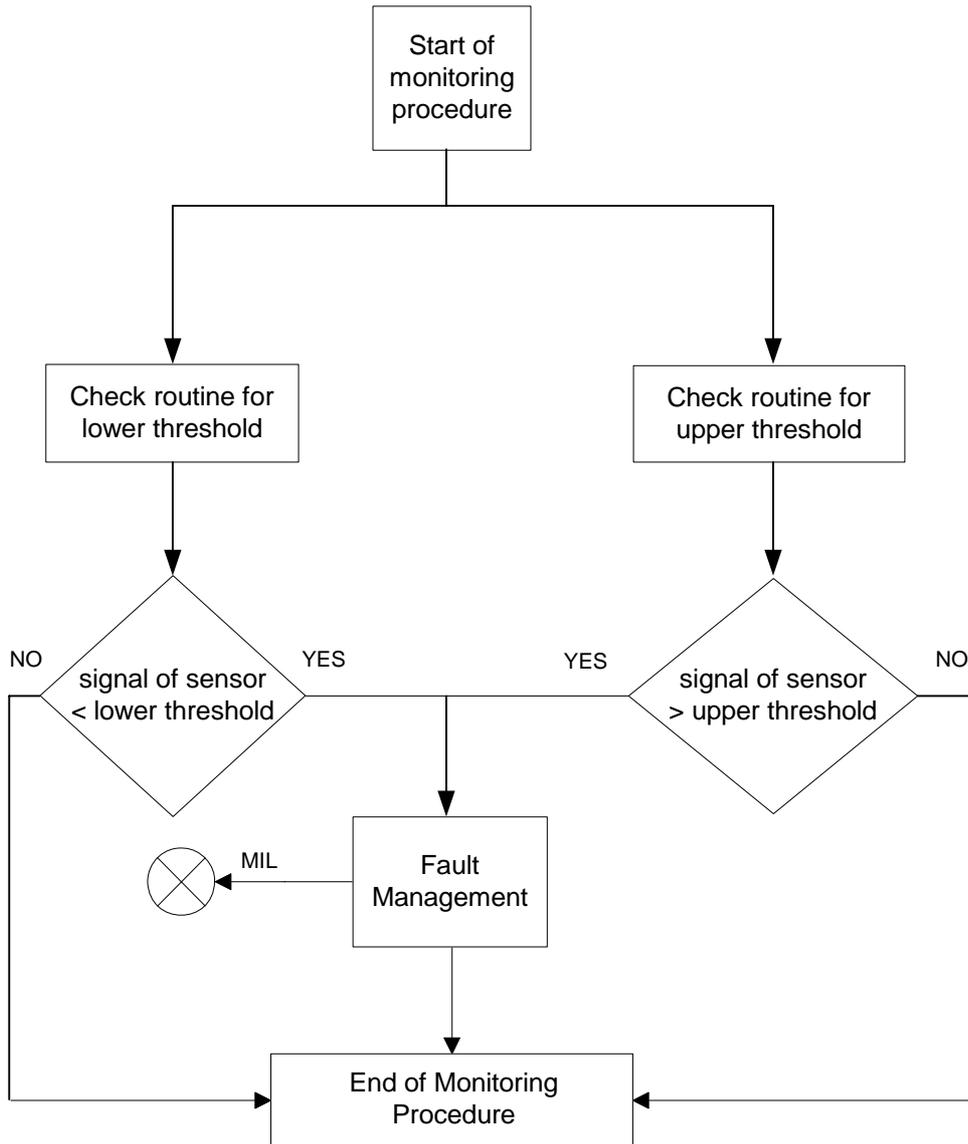
.16.07.00   Rationality Mass Air Flow Sensor (MAF)

One MAF Sensor System:
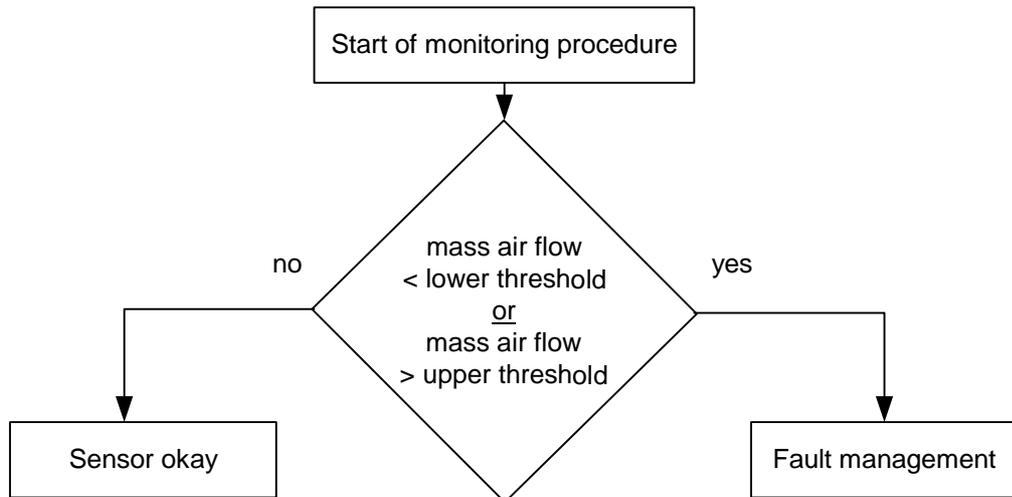
```
                    ┌─────────────────────────────┐
                    │ Start of monitoring procedure│
                    └─────────────────────────────┘

                              mass air flow
                              < lower threshold
          no                        or                      yes
                              mass air flow
                              > upper threshold

    ┌──────────────┐                              ┌──────────────────┐
    │ Sensor okay  │                              │ Fault management │
    └──────────────┘                              └──────────────────┘


additional options for some calibrations:


    mass air flow vs.                              mass air flow vs.
    calculated mass air flow                       calculated mass air flow
    > threshold                                    < threshold
    and                                            and
    fuel system adaptation                         fuel system adaptation
    < threshold                                    > threshold

  yes                                                              yes

         no                                              no
                    ┌──────────────┐
                    │ Sensor okay  │
                    └──────────────┘

                    ┌──────────────────┐
                    │ Fault management │
                    └──────────────────┘

                              ⊗   MIL
```
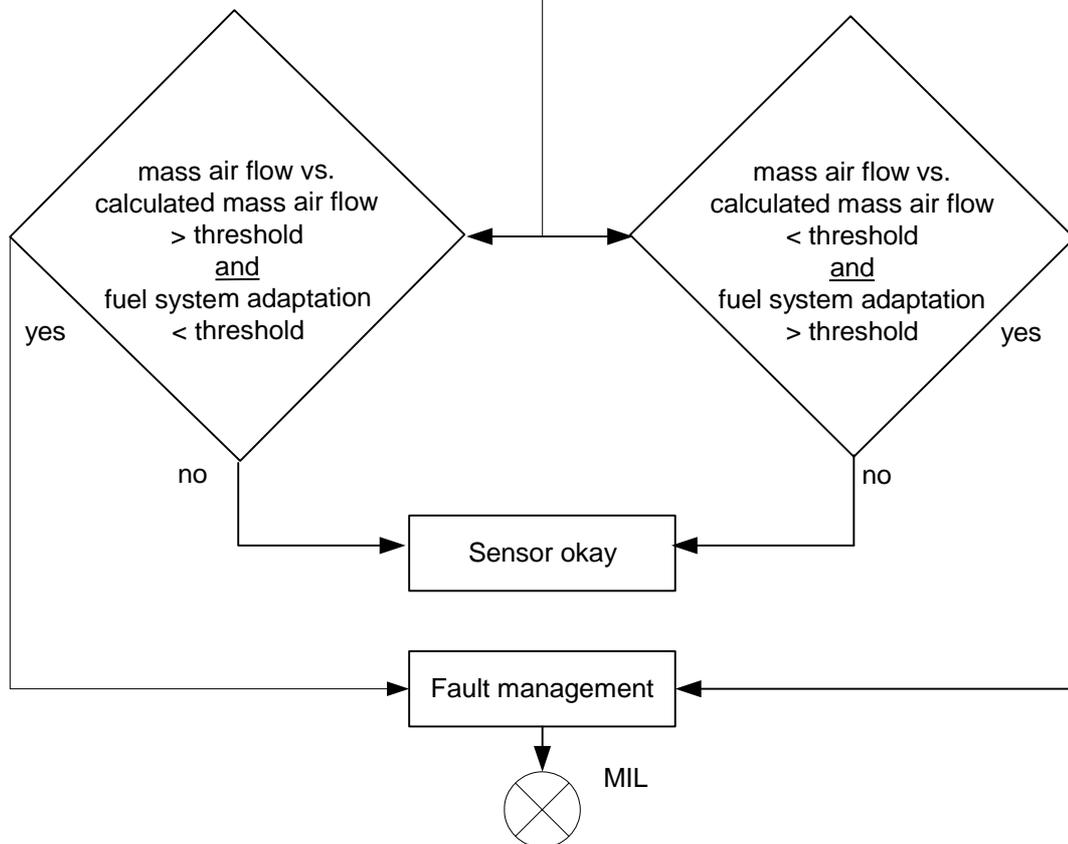
Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

Two MAF Sensors System:

Start of monitoring procedure

total mass air flow < lower threshold
or
total mass air flow > upper threshold
or
total mass air flow vs. calculated mass air flow
> threshold
and fuel adaptation < threshold
or
total mass air flow vs. calculated mass air flow
< threshold
and fuel adaptation > threshold

no → Sensors okay

yes

Fault MAF 1 and 2 → MIL

no

pinpointing:

engine speed,
throttle position,
vehicle speed
within window

yes

mass air flow MAF1 < lower threshold
or
mass air flow MAF1 > upper threshold
or
total mass air flow vs calculated mass air flow
> threshold
and fuel adaptation < threshold
or
total mass air flow vs calculated mass air flow
< threshold
and fuel adaptation > threshold

no

mass air flow MAF2 < lower threshold
or
mass air flow MAF2 > upper threshold
or
total mass air flow vs calculated mass air flow
> threshold
and fuel adaptation < threshold
or
total mass air flow vs calculated mass air flow
< threshold
and fuel adaptation > threshold

no

yes

MIL

yes

Fault MAF 1 → MIL ← Fault MAF 2

.16.08.00   Vehicle Speed Sensor (VSS)

```
            ┌─────────────────────┐
            │  Start of Monitoring │
            │      Procedure       │
            └──────────┬──────────┘
                       │
                       ▼
                    ╱──────╲
                   ╱ engine  ╲        NO
                  ╱ rpm within ╲───────────────┐
                  ╲  det. range? ╱              │
                   ╲──────╱                     │
                       │ YES                    │
                       ▼                        │
                    ╱──────╲                    │
                   ╱ coasting ╲     NO           │
                  ╱ condition? ╲────────────────┤
                   ╲──────╱                     │
                       │ YES                    │
                       ▼                        │
            ┌─────────────────────┐             │
            │ ‖  Check of VSS  ‖  │             │
            │ ‖    Signal      ‖  │             │
            └──────────┬──────────┘             │
                       │                        │
                       ▼                        │
                    ╱──────╲                    │
                   ╱Frequency╲     NO            │
                  ╱ of VSS Signal ╲─────────────┤
                  ╲ < lower      ╱              │
                   ╲ threshold? ╱               │
                       │ YES                    │
                       ▼                        │
     ⊗◄────────┌─────────────────────┐         │
    MIL        │ ‖ Fault Code     ‖  │         │
               │ ‖ Management     ‖  │         │
               └──────────┬──────────┘         │
                          │                    ▼
                          └──►┌──────────────────────────┐
                              │ End of Monitoring Procedure│
                              └──────────────────────────┘
```

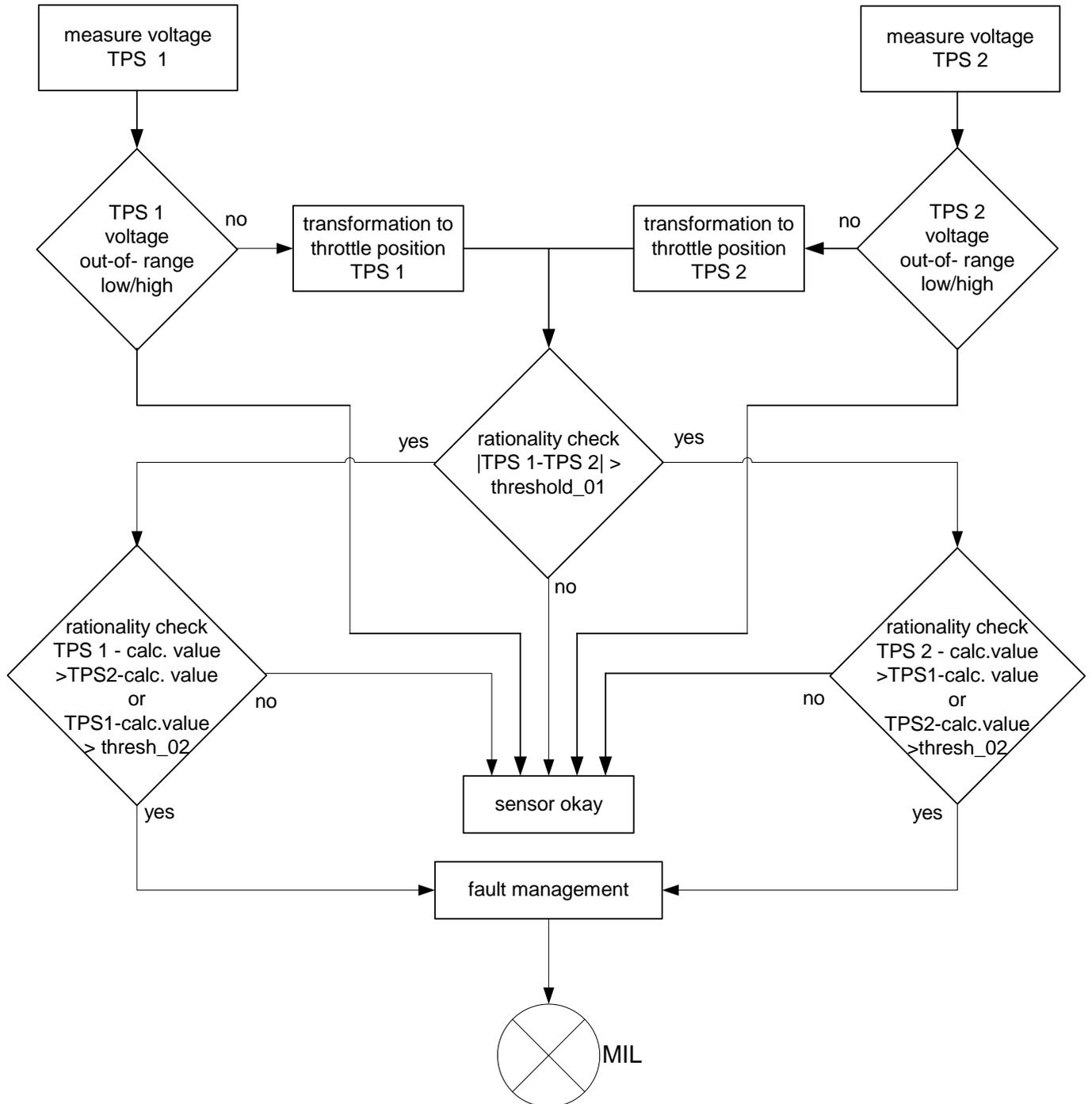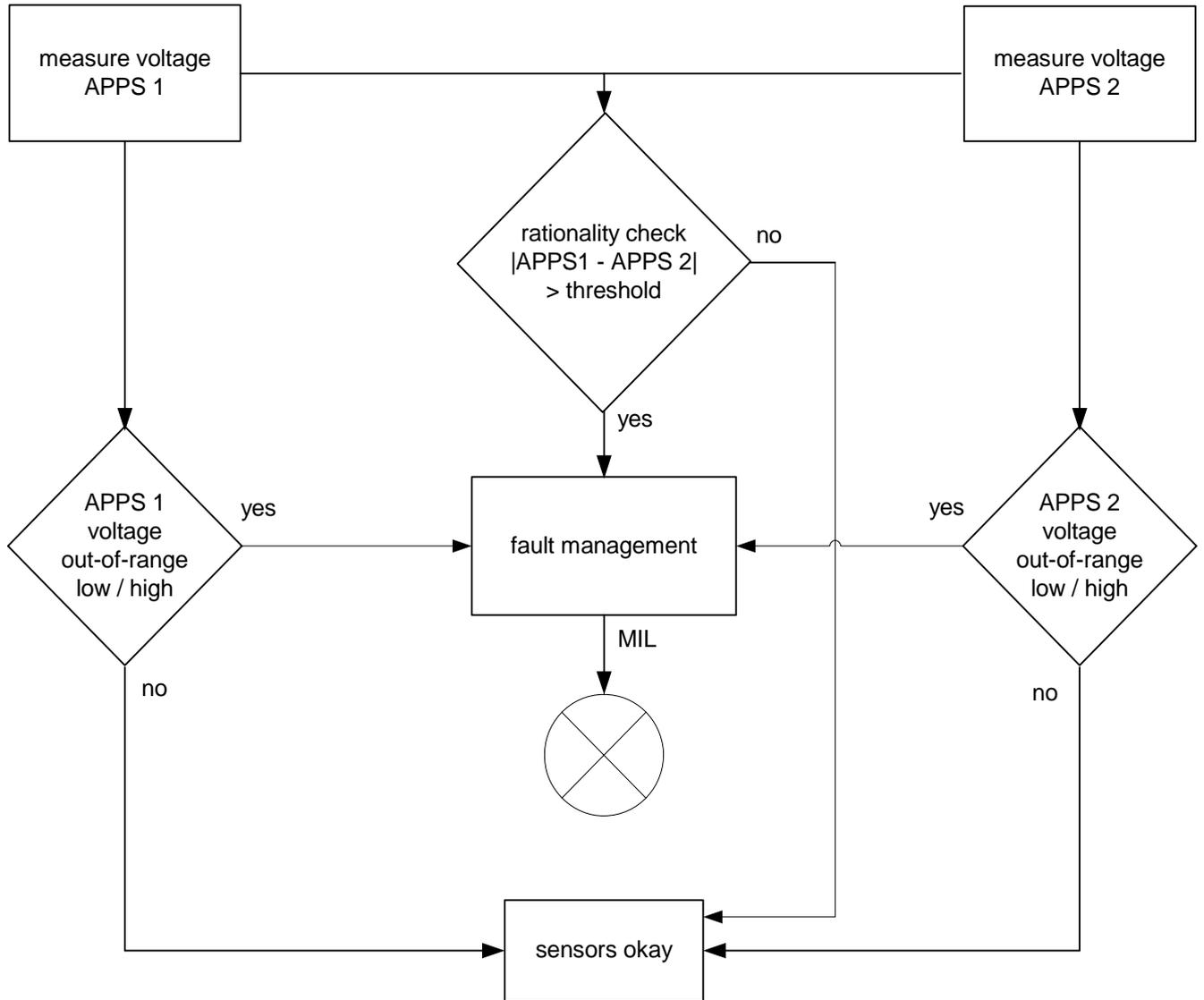**.16.09.00   Throttle Position Sensor (throttle unit with E-gas actuator)**

The throttle body consists of two potentiometers (reversed voltage logic).
During the first start, the potentiometer characteristics are adapted and
stored. The diagnostic monitors the corrected values of potentiometer 1
and 2. In the 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.

```
┌─────────────────┐                                              ┌─────────────────┐
│ measure voltage │                                              │ measure voltage │
│     TPS  1      │                                              │     TPS 2       │
└─────────────────┘                                              └─────────────────┘
         │                                                                │
         ▼                                                                ▼
      ◇ TPS 1          no    ┌──────────────┐      ┌──────────────┐  no    ◇ TPS 2
      voltage         ────►  │transformation│      │transformation│ ◄────   voltage
    out-of- range            │to throttle   │      │to throttle   │       out-of- range
      low/high               │position TPS 1│      │position TPS 2│         low/high
         │                   └──────────────┘      └──────────────┘            │
         │                          │                     │                    │
         │              yes   ◇ rationality check  yes                         │
         │            ────────   |TPS 1-TPS 2| >   ─────────                   │
         │                        threshold_01                                 │
         │                            │ no                                     │
         ▼                            │                                        ▼
  ◇ rationality check                 │                           ◇ rationality check
    TPS 1 - calc. value               │                             TPS 2 - calc.value
    >TPS2-calc. value                 │                             >TPS1-calc. value
         or            no             │              no                 or
    TPS1-calc.value  ────────    ┌──────────┐    ────────         TPS2-calc.value
    > thresh_02                  │sensor okay│                     >thresh_02
         │ yes                   └──────────┘                          │ yes
         │                            │                                │
         └──────────────►  ┌──────────────────┐  ◄────────────────────┘
                           │ fault management │
                           └──────────────────┘
                                    │
                                    ▼
                                   ⊗ MIL
```

.16.10.00   **Accelerator pedal position sensor (APPS)**

| measure voltage APPS 1 | | measure voltage APPS 2 |

rationality check
|APPS1 - APPS 2|
> threshold

no

yes

| APPS 1 voltage out-of-range low / high | yes → fault management ← yes | APPS 2 voltage out-of-range low / high |

no

MIL

⊗

no

sensors okay

.16.11.00 **Camshaft Position Sensor**

Camshaft Position Monitor

```
        ┌─────────────────────────────┐
        │ Start of monitoring procedure│
        └──────────────┬──────────────┘
                       │
                       ▼
        ┌─────────────────────────────┐
        │ Camshaft not steered (torque │
        │   position) and determination:│
        │        rated-value           │
        └──────────────┬──────────────┘
                       │
                       ▼
                  ◇ |actual value|>
                     threshold?  ──── yes ──────────┐
                       │                            │
                       no                           │
                       ▼                            │
        ┌─────────────────────────────┐            │
        │ Camshaft steered (power position)│        │
        │  and determination: rated-value │         │
        └──────────────┬──────────────┘            │
                       │                            │
                       ▼                            │
                  ◇ |actual value|>                 │
                     threshold?  ──── yes ──────────┤
                       │                            │
                       no                           │
                       ▼                            ▼              MIL
        ┌─────────────────────┐      ┌─────────────────────┐    ⊗
        │ Camshaft adjustment okay!│  │  Fault management   │────
        └──────────┬──────────┘      └──────────┬──────────┘
                   │                            │
                   ▼                            │
        ┌─────────────────────────┐             │
        │ End of monitoring procedure │◄─────────┘
        └─────────────────────────┘
```
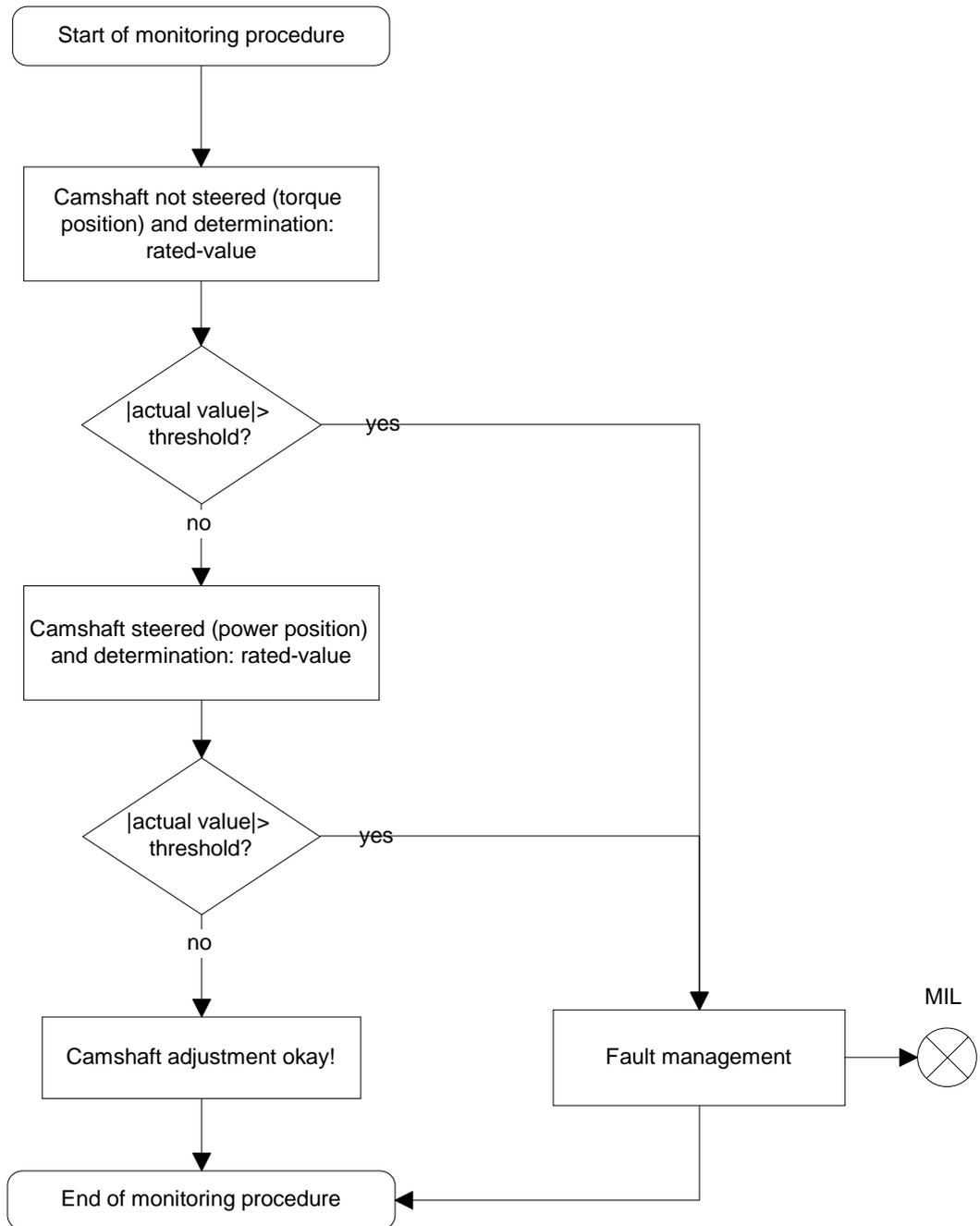
.16.12.00 Boost Pressure Control Valve

```
                              ┌──────────────┐
                              │    Start     │
                              └──────────────┘
                                     │
          no                  ╱──────────────╲
      ◄───────────────────── ◄    Enable?     ►
                              ╲──────────────╱
                                     │
                                    yes
                                     │
                              ┌──────────────────────┐
                              │ Comparison of actual │
                              │ charge pressure (cp) │
                              │ with modeled charge  │
                              │ pressure             │
                              └──────────────────────┘
              no                                        no
        ╱──────────────╲                        ╱──────────────╲
       ◄ Actual cp >     ►                      ◄ Actual cp +    ►
       ◄ modeled cp +    ►                      ◄ threshold<     ►
        ╲ threshold     ╱                        ╲ modeled cp    ╱
                │                                       │
               yes                                     yes
                │                                       │
    ┌───────────────────────┐              ┌───────────────────────┐
    │ Charge pressure too   │              │ Charge pressure too   │
    │ high                  │              │ low                   │
    └───────────────────────┘              └───────────────────────┘
                │                                       │
                └──────────►  Fault management  ◄───────┘
                                     │
                                     │
                                    ⊗  MIL
                                     │
                              ┌──────────────┐
                              │     End      │
                              └──────────────┘
```
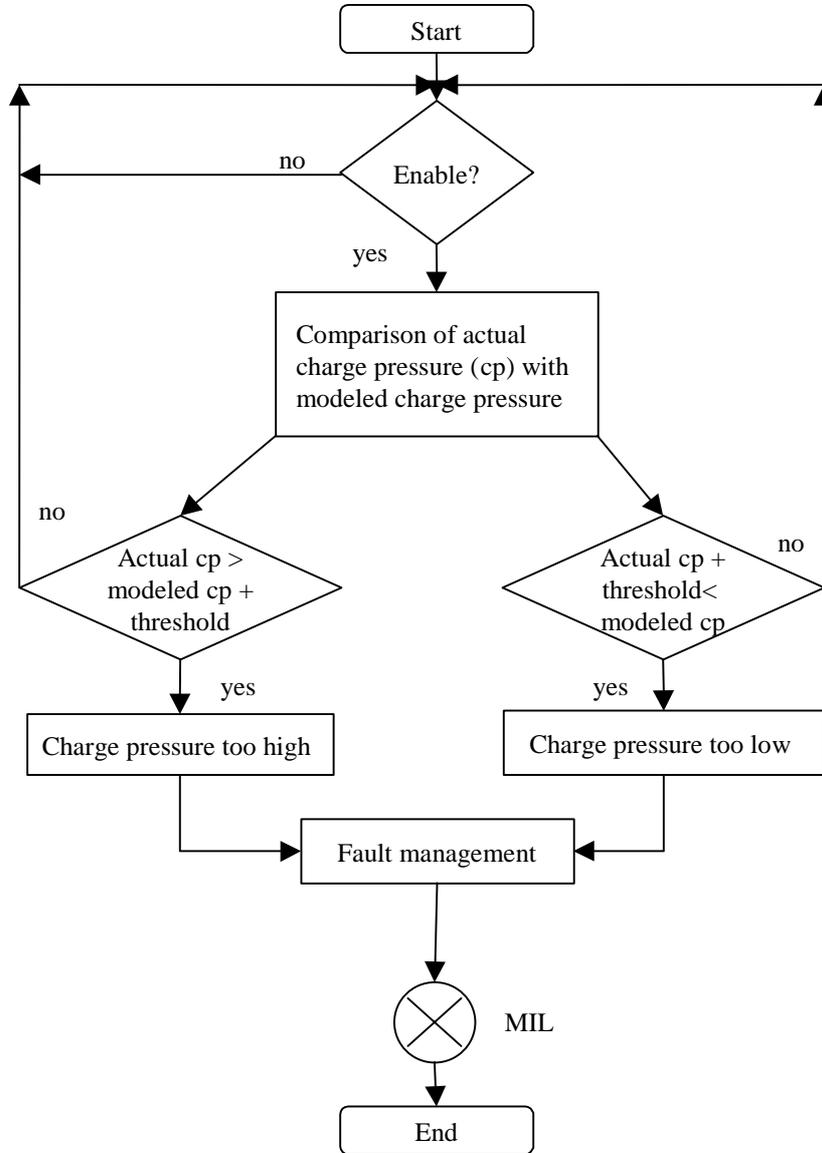
.16.13.00   Engine Start Delay Relay (SULEV)

Engine Start Delay Relay

Start of monitoring procedure

Signals on lines "KL50" and "KL50R"

KL50   high / low

KL50R   high / low

Delay Time

engine coolant temperature > min. threshold and < max. threshold? — no

yes

Signal on KL 50? — no

yes

Start counter with signal high on KL50, stop counter with signal high on KL50R and calculate delay time!

Delay time > min. threshold?

yes

Delay time < max. threshold? — no — engine cranking? — no — starter not active and delay signal

yes

yes

starter not active and no delay signal

MIL

Fault management

End of monitoring procedure

.16.14.00 Exhaust Temperature Sensor (SULEV)

.16.14.01 General Monitoring Description

The exhaust temperature sensor (ETS) is monitored for rationality during engine cold start, where engine coolant temperature, intake air temperature and exhaust temperature are expected within the same temperature range ("stuck high" check).

.16.14.02 Monitor function description

After engine has been cold started the slope of ETS is monitored and should not be higher than a max. Threshold and not lower than a min. threshold.

Both plausibility checks are completed before the ETS information is used in other monitors (e.g. secondary air).

Additionally the final stage check monitors for shorts to ground or to battery.

.16.14.03   Chart(s) and Flow Chart (s)

Exhaust Temperature Sensor (ETS) Monitoring

```
             ┌─────────────────────────────┐
             │  Start of monitoring procedure │
             └─────────────────────────────┘
                          │
                          ▼
                    ╱─────────────╲
                   ╱ Voltage ETS    ╲        no
                  ╱  <max. and       ╲───────────────┐
                  ╲  >min. Threshold? ╱               │
                   ╲─────────────────╱                │
                          │ yes                       │
                          ▼                           │
      ┌───────────────────────────────────────────┐  │
      │ Engine Cold Start Condition:               │  │
      │ Intake Air Temperature(IATS) within range? │  │
      │ Engine Coolant Temperature (ECTS) within   │  │
      │ range?                                      │  │
      │ IATS-ECTS<threshold?                        │  │
      │ Engine shut-off temperature > threshold?    │  │
      └───────────────────────────────────────────┘  │
                          │                           │
                          ▼                           │
                    ╱─────────────╲                   │
           no      ╱  Cold Start    ╲                 │
        ┌─────────╱   Condition?     ╲                │
        │         ╲                  ╱                │
        │          ╲────────────────╱                │
        │                 │ yes                       │
        │                 ▼                           │
        │    ┌─────────────────────────────┐          │
        │    │ Calculate average of IAT and ECT! │     │
        │    └─────────────────────────────┘          │
        │                 │                           │
        │                 ▼                           │
        │           ╱─────────────╲                   │
        │          ╱    ETS          ╲      no         │
        │         ╱  in range of      ╲───────────────┤
        │         ╲ average temperature╱              │
        │          ╲   +/- 25K?       ╱               │
        │           ╲────────────────╱                │
        │                 │ yes                       │
        │                 ▼                           │
        │           ╱─────────────╲                   │
        │          ╱    Delta        ╲                │
        │         ╱ exhaust temp.<500K?╲   no          │
        │         ╲      or           ╱───────────────┤
        │         ╲    Delta          ╱               │
        │          ╲exhaust temp.>150K?╱              │
        │           ╲────────────────╱                ▼
        │                 │ yes          ┌──────────────────┐    MIL
        │                 │              │ Fault management │──────⊗
        │                 ▼              └──────────────────┘
        │    ┌─────────────────────────────┐    │
        └───▶│  End of monitoring procedure │◀───┘
             └─────────────────────────────┘
```
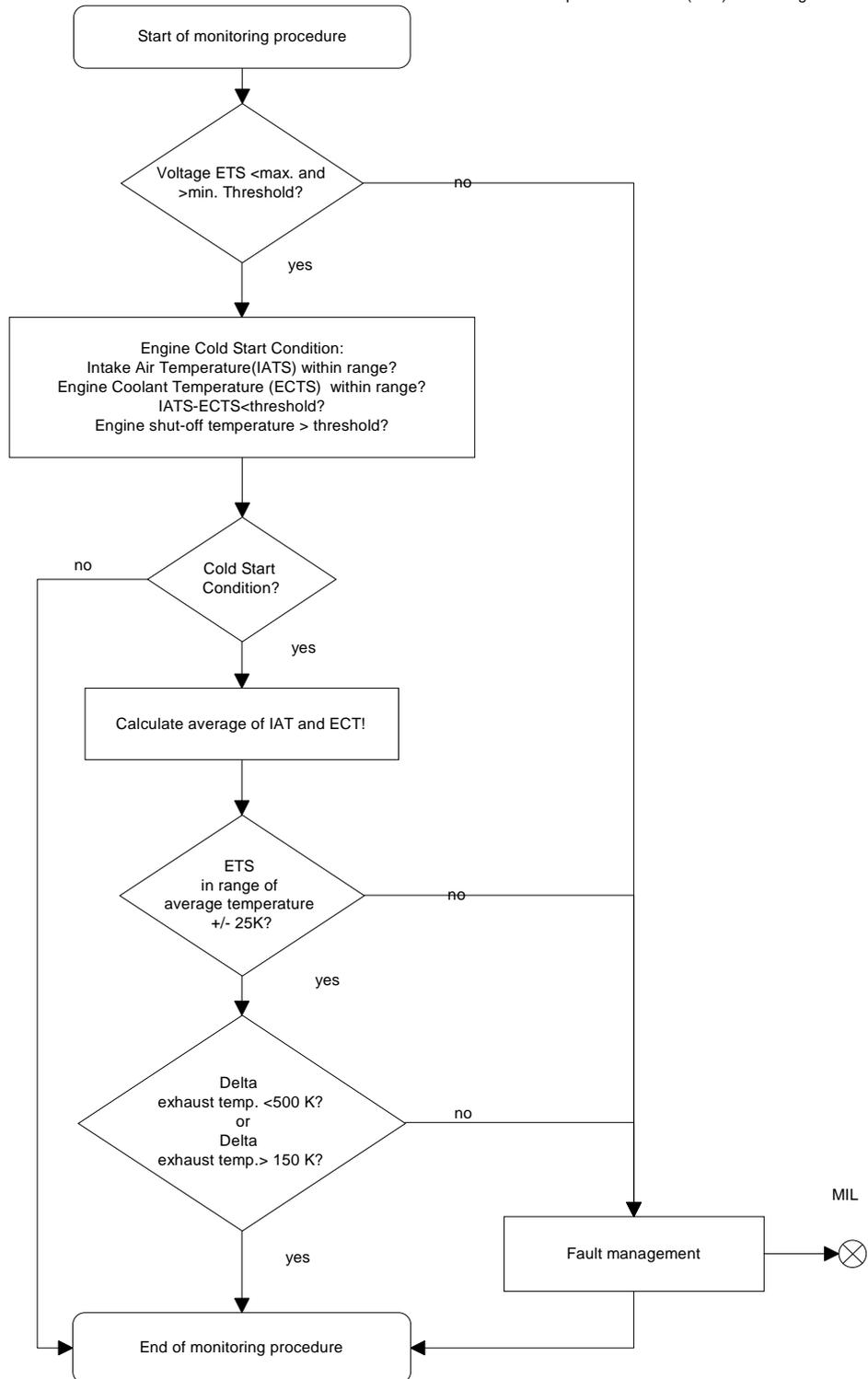
.16.15.00............**reserved**

.16.16.00............**reserved**

- 87 -

.16.17.00............**reserved**

.16.18.00............**reserved**

.16.19.00............**reserved**

.16.20.00 **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.

.16.21.00 **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.
Signal tables of output stage check

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	faut	faut

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	faut	fault

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

.17.00.00   OTHER EMISSION CONTROL OR SOURCE SYSTEM MONITORING
N.A.

.18.00.00   EXEMPTIONS TO   MONITOR REQUIREMENTS
N.A.

.19.00.00   RESERVED
N.A.

.20.00.00 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 is 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 optimise 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 °C for binary and >685 °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 due 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 0,4V<sensor voltage<0,5V
- 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°C or the internal sensor resistor Ri < 130 Ω.

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

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 airflow 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 airflow 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.

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

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

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.

Vehicles produced in MY 2004 and MY 2005

Engine Start Temperature	Time, when closed loop is forced
Temperature$\geq$ 10 °C	120 s
Temperature $\geq$-6.7 °C and < 10°C	300 s

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

.21.00.00 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 optimises 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 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 airflow 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 2nd 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 airflow 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

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

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, and 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 airflow passed and P-portion of controller achieves target range for Oxygen sensor voltage already.	Oxygen sensor voltage of 2nd control loop, P-portion of controller for 2nd control loop	Oxygen sensor monitor for secondary sensor(s). Fuel system monitor

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.

.22.00.00   PARAMETERS / CONDITIONS FOR CLOSED LOOP OPERATION ON SULEV

General

The SULEV concept consists of 2 catalysts and 3 control loops. The first control loop uses the Oxygen sensor pre catalyst (LSU) in the same manner conventional concepts does. The Oxygen sensor between the two bricks (LSF1) of the catalyst is the input for the second and the Oxygen sensor after the last brick (LSF2) is the input for the third control loop. Both sensors are binary Oxygen sensors. The closed loop operation of each of the control loops are in a depending order of 1st, 2nd and 3rd control loop.
In comparison to post catalyst control loop on conventional concepts the 2nd and 3rd control loop are high precision loops with specific requirements for short-term correction and long-term adaptation. The driving conditions have to be stable and constant to allow any corrections by these control loops. The allowed correction steps are much smaller in comparison to post catalyst control loop applications on conventional concepts.

Conditions for closed loop operation of the first control loop

The conditions for closed loop operation of the first control loop on the SULEV concept are the same as described for conventional concepts.

Conditions for closed loop operation of the second control loop

The second control loop on the SULEV concept is designed as natural frequency control loop and is based on a binary Oxygen sensor. The controller has the same capability in achieving maximum conversion on the first brick of the catalyst by using a proportional adjustment range for short-term correction and an integral adjustment range for long-term adaptation (PI-controller). Both controller ranges have individual conditions for closed loop operation.

Enable criteria for P-portion of the controller of second control loop (SULEV)

The proportional-portion of the controller corrects short-term deviations.

Parameter / System	Condition/Evaluation	Monitor
Closed loop condition for the **first control loop**. Minimum of integrated mass airflow 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 2nd 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.
Engine Coolant Temperature	Engine coolant temperature has raised above a limit value of 50 °C (Typical temperature value; may differ on specific application)	Engine Coolant Temperature Sensor Monitor. Engine Cooling System Monitor.
Catalyst model temperature	Exhaust Temperature > threshold (above light-off temperature), calculated based on mass airflow 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	Controller for the first control loop not at minimum or maximum threshold	Oxygen sensor monitor

Enable criteria for adaptive I-portion of the controller second control loop (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 1500-5000 rpm Engine Load within 15-100% (Typical values; may differ on individual concepts)	Engine Speed Sensor monitor, Mass Air Flow Meter monitor, and 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 airflow passed and P-portion of controller achieves target range for Oxygen sensor voltage already.	Oxygen sensor voltage of 2nd control loop, P-portion of controller for 2nd control loop	Oxygen sensor monitor for secondary sensor(s). Fuel system monitor

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 80s.

Conditions for closed loop operation of the third control loop

The third control loop is designed like the second control loop on conventional concepts and achieves the maximum conversion of the 2nd brick of the catalyst. The controller consists of very restricted correction ranges for the short-term proportional and the long-term integral adaptive portion (PI-controller). Both controller ranges have individual conditions for closed loop operation.

Enable criteria for P-portion of the controller of third control loop (SULEV)

The proportional-portion of the controller corrects short-term deviations.

Parameter / System	Condition/Evaluation	Monitor
Closed loop condition for the **first control loop**. Minimum of integrated mass airflow 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
Closed loop condition for the **second control loop**. Minimum of integrated mass airflow passed.	No fault detected in LSU System (Sensor, wiring, IC) and no fault at LSF1 and LSF2. Fuel control performs normal, no fault is detected and fuel control is not temporarily disabled.	Oxygen sensor monitor for the front sensor(s). Oxygen sensor monitor for the first downstream sensor(s) and Oxygen sensor monitor for the second downstream sensor(s). Monitor of the mass air flow meter (out of range, rationality). Fuel system monitor
Oxygen Sensor for 3rd 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 (above light-off temperature), calculated based on mass airflow 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	Controller for the first control loop not at minimum or maximum threshold	Oxygen sensor monitor

(**LSU**: Linear Oxygen Sensor, **LSF1**: 1st Binary Oxygen Sensor, **LSF2**: 2nd Binary Oxygen Sensor)

Bosch Motronic ME 7, ME 7.1, ME 7.1.1, ME 7.5 System Strategy

Enable criteria for adaptive I-portion of the controller third control loop (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 2700-3500 rpm Engine Load within 25-45% (Typical values; may differ on individual concepts)	Engine Speed Sensor monitor, Mass Air Flow Meter monitor, and 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 airflow passed and P-portion of controller achieves target range for Oxygen sensor voltage already.	Oxygen sensor voltage of 2nd control loop, P-portion of controller for 2nd control loop	Oxygen sensor monitor for secondary sensor(s). Fuel system monitor

Typical Values (third control loop)

Given a normal cold started FTP (around 20°C) most of the concepts reaches the closed loop condition for the third control loop within 90s to 100s.