# DISCOVERY
# 3.0 LITRE V6 DIESEL (10MY EU5)
# ON-BOARD DIAGNOSTICS
# ENGINE MANAGEMENT SYSTEM

**Ref:** DGAA8

# 1 Contents

## 3 Key Assumptions

EOBD monitors are, generally, of a continuous type and a subset of the normal engine operating and service diagnostics systems.
All emissions systems actuators are equipped with at least the means to detect open and short circuits where technically feasible.

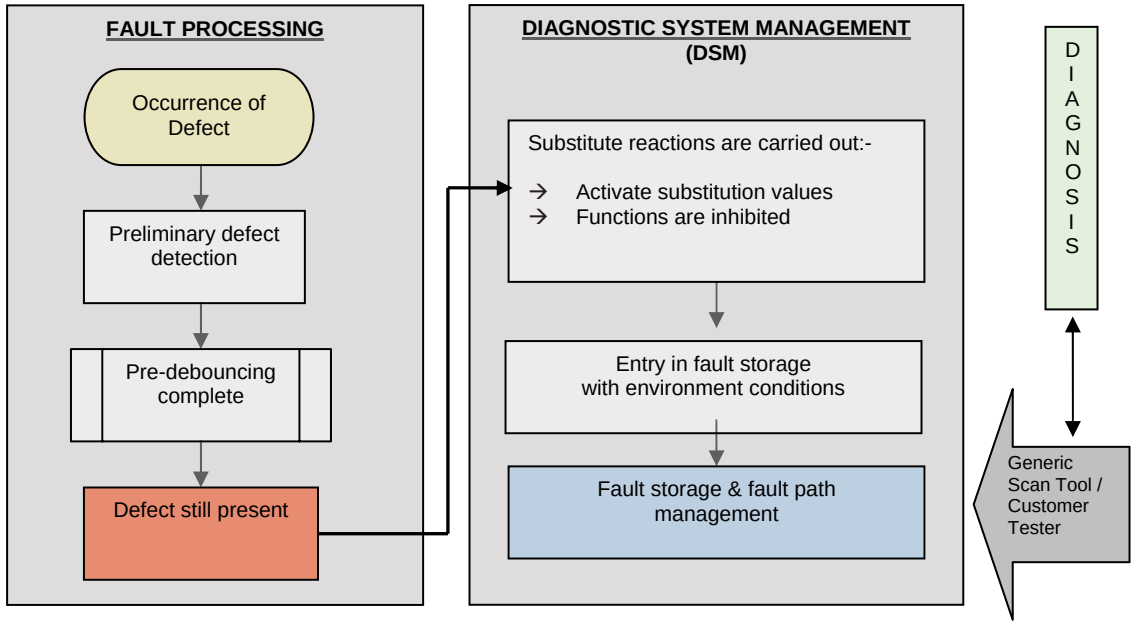
All emissions systems sensors are equipped with a minimum of range check and closed / open circuit checks where technically feasible [where the range check will not be sufficient].

The system includes the means to determine that the monitors have run.

- There is no catalyst monitor.
- In case of a detected failure the MIL will be activated if:
  - EOBD emissions thresholds are exceeded immediately or
  - EOBD thresholds are likely to be exceeded in the long term as a direct result of the failure mode
  - The EOBD System cannot function correctly

# 4 Diagnostic System Management (DSM)

**Monitor Entry and Fault Flagging:** Basic design – Diagnostic fault path management: actual error memory and error path management.




The error state corresponding to each error test is determined in the diagnostic functions. In addition, a check is made for each error test to see whether, from ignition ON, a valid result is present. For this, the test results are pre-debounced for time, events or special handling.

The diagnostic functions summarize the individual test results in error paths. Normally, an error path is assigned to one physical component and consists of up to 4 individual error tests.

All the path states are managed by error handling in a status array. In the event of an error, an entry for the defective path is additionally generated in the error memory. Ambient conditions and additional management data for the defective error are stored in this entry. The diagnostic functions can read out the information again from the status array.

# 5 Engine Coolant Temperature Sensor (ECT)

## 5.1 Summary

The emissions control strategies including injection parameters and EGR are a function of engine temperature (measured through Coolant Temperature).

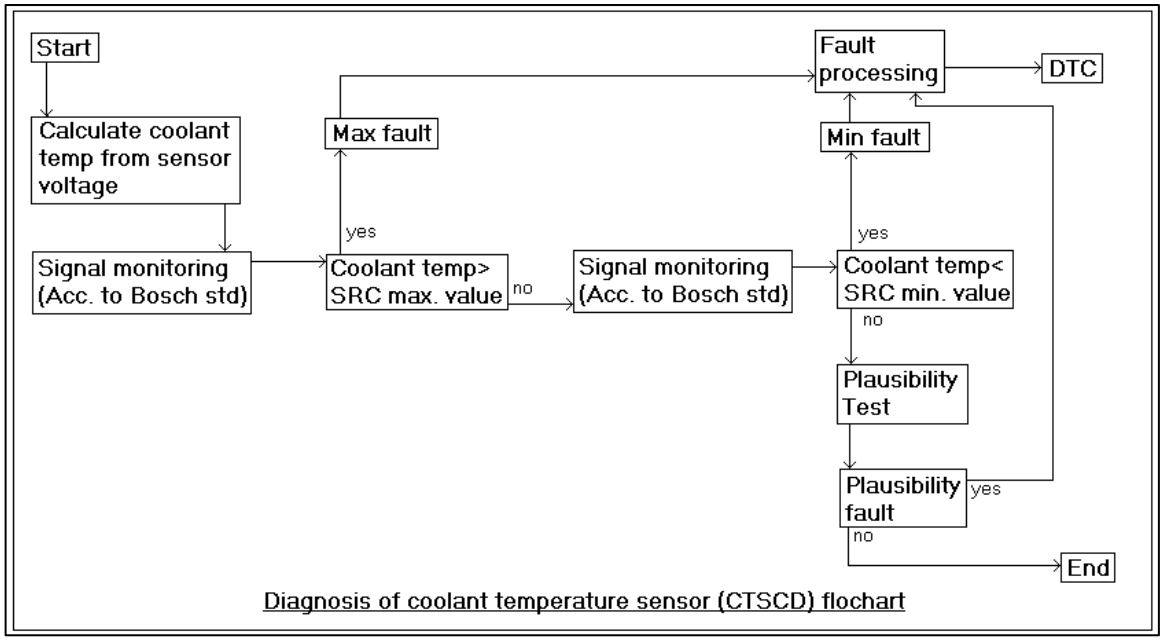
Temperature is used to define a 'Warm-Up-Cycle'. Consequently, **failure is MIL active**.

Default mode: substitute value.

Signal Range Check detects short circuit to ground, power or open circuit.

Plausibility check identifies satisfactory function (error if no calibrateable minimum rise after engine start).

**Detailed Analysis: Monitor Entry and Fault Flagging**




Diagnosis of coolant temperature sensor (CTSCD) flochart

## 5.2 Functional Overview, Description, Monitoring & Substitute Function

The raw value is checked and transformed to an analogue value using the linearization curve. The check consists of a signal range check (SRC).
If the valid ranges are exceeded the error messages are reported after the debouncing times have elapsed. If the raw value returns to the valid range, the errors are healed again after the debouncing times have elapsed.

The plausibility test is only carried out when no range error is present.

The coolant temperature is acquired after engine start. A timer is started when the engine speed and injection quantity is above calibrateable values; and the cycle flag is not set for the dynamic error path (once per driving cycle). After expiry of the timer, a plausibility defect is reported if the rate of increase of the coolant temperature and the coolant temperature is too low.

The plausibility test is aborted before expiry of the timer if the rate of increase of the coolant temperature or the value of coolant temperature is sufficiently high.

After detection of range or plausibility errors the fuel temperature is supplied as a cold substitute value after engine start for a calibrateable time after which a substitute value is used.

There is no healing condition associated with the plausibility check (within the same driving cycle).

Engine cooling fan speed is determined in normal function, being calculated using the engine coolant temp substitute value.

## 5.3 DTC Table

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Engine Coolant Teperature Sensor [Downstream] | P0116 | defect fault check for Absolute plausibility test | Absolute check on ECT sensor value. Coolant temperature must reach a minimum temperature after a given time at a calibrateable engine speed and load, if the starting temperature is below a calibrateable threshold. | 3rd Cycle | Once per drive cycle | Two Type 1 Cycles | One Type 1 Cycles |

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Engine Coolant Temperature Sensor [Downstream | P0116 | defect fault check for dynamic plausibility test | Dynamic check on ECT sensor value. Coolant temperature must increase by a minimum temperature after a given time at a calibrateable engine speed and load, if the starting temperature is below a calibrateable threshold. | 3rd Cycle | Once per drive cycle | Two Type 1 Cycles | One Type 1 Cycles |
| | P0116 | Physical Range Check high for CEngDsT | Physical Range Check on the coolant temperature. Maximum temperature limit | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P0116 | Physical Range Check low for CEngDsT | Physical Range Check on the coolant temperature. Minimum temperature limit | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P0116 | SRC High for Engine coolant temperature(down stream) | Signal Range Check High on ECT sensor | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P0116 | SRC low for Engine coolant temperature(down stream) | Signal Range Check Low on ECT sensor | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |

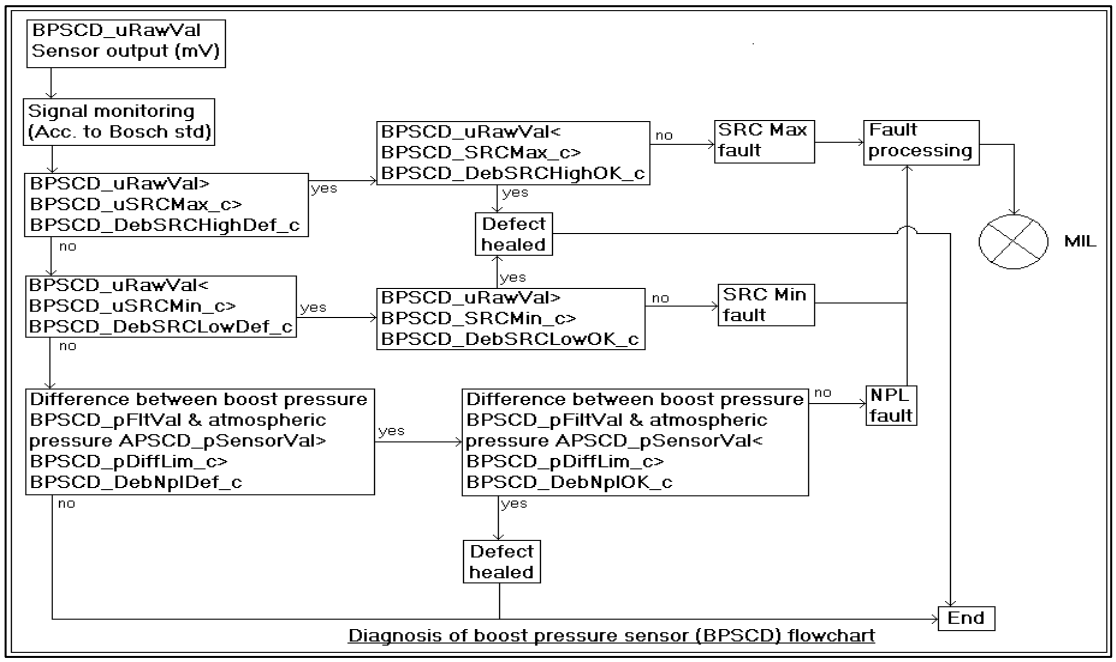
# 6 Manifold Absolute Pressure (MAP) Sensor

## 6.1 Summary

Failure results in elevated emissions within specified limits. MAP is used to feedback control Variable Nozzle Turbocharger (VNT) on Variable Geometry Turbocharger (VGT) models and the waste gate on Fixed Geometry Turbo-charger (FGT) variants; to calculate air density and therefore limits Air Flow Rate (AFR); calculate turbo outlet temperature.

Default modes: zero boost; engine torque limitation; EGR off **therefore MIL active.**

**Detailed Analysis: Monitor Entry and Fault Flagging**



## 6.2 Functional Overview, Description, Monitoring & Substitute Function

The function acquires the boost pressure via Angolgue-to-Digitial-Converter (ADC) input. The raw value is linearised and monitored for compliance with the signal range. The linearised and the non-linearised boost pressure are outputted.

If an SRC is detected, it is reported to the DSM and the respective error debouncing is started. If the SRC error is no longer detected, the respective healing is started.

The plausibility check is only carried out if no SRC / Signal error has occurred for either of the sensor signals. The plausibility check and SRC is inhibited if an error has occurred in the sensor supply used.

A plausibility error is detected, if below an engine speed threshold the absolute value of the difference of boost pressure and atmospheric error is too high for a calibrateable time. In this case, a defect of the boost pressure sensor is assumed and a default value is used for the boost pressure.

If the absolute value of the difference and the engine speed are below the limits above for a calibrateable time the boost pressure sensor is regarded as healed.

## 6.3 DTC Table

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Turbocharger Boost Pressure Sensor | P006A | MAP - Mass or Volume Air Flow Correlation | Comparison of modelled AFS versus actual to detect a lack of air intake integrity | 3rd Cycle | Active when EGR flow is disabled | Two Type 1 Cycles | One Type 1 Cycles |
| | P0237 | Diagnostic fault check for SRC low in air pressure upstream of intake valve sensor | Signal Range Check low on MAP sensor | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P0238 | Diagnostic fault check for SRC high in air pressure upstream of intake valve sensor | Signal Range Check High on MAP sensor | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |

# 7 Atmospheric Air Pressure Sensor (APS)

## 7.1 Summary

The atmospheric pressure is used to modify fuelling, EGR and boost pressure controls under high altitude conditions to avoid turbocharger damage and excessive smoke. This sensor is integral to the Engine Control Module (ECM).

Default modes: Upon failure of the APS sensor, or of the MAP-APS correlation test, the atmospheric pressure is calculated from the boost pressure sensor; if both sensors have failed a default value is used.

Faults are 'MIL active' as the sensor is integral in the ECM and its emissions effects cannot be fully demonstrated.

## 7.2 Functional Overview, Description, Monitoring & Substitute Function

In normal operation, the output value of the atmospheric pressure sensor is determined from the linearization curve as a function of the sensor raw value.

Plausibility monitoring detection: An error is set if the difference between the boost pressure and atmospheric pressure exceeds the calibrated threshold whilst the difference between the boost pressure and the exhaust pressure upstream of the particulate filter is below the calibrated minimum.

## 7.3 DTC Table

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Atmospheric air pressure sensor | P2226 | Atmospheric pressure sensor plausibility check | 10 seconds to elapse in after run to allow intake pressure wave to subside | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |

# 8 Mass Air Flow Sensor (MAF)

## 8.1 Summary

EGR is closed loop controlled to desired MAF and valve position signals [it is the air intake flow rate that is demanded to match the fuelling].

Default modes: zero EGR; substitute value for air mass flow rate.

Substitute value for air mass per cylinder calculated from engine speed.

Signal Range Check (SRC) detects mass airflow beyond thresholds as well as short to ground, power or open circuit and intermittent faults.

The sensor is tested for offset drift plausibility in the after-run period; the fault caused by failing this test is **non-MIL**.

The sensor is also dynamically tested for plausibility of sensitivity drift when entry conditions are met. These faults detect the sensor in range, but drifting high or low, and are **MIL**

Due to the zero EGR default mode of the remaining monitors, **faults are MIL active.**

## 8.2 Functional Overview, Description, Monitoring & Substitute Function

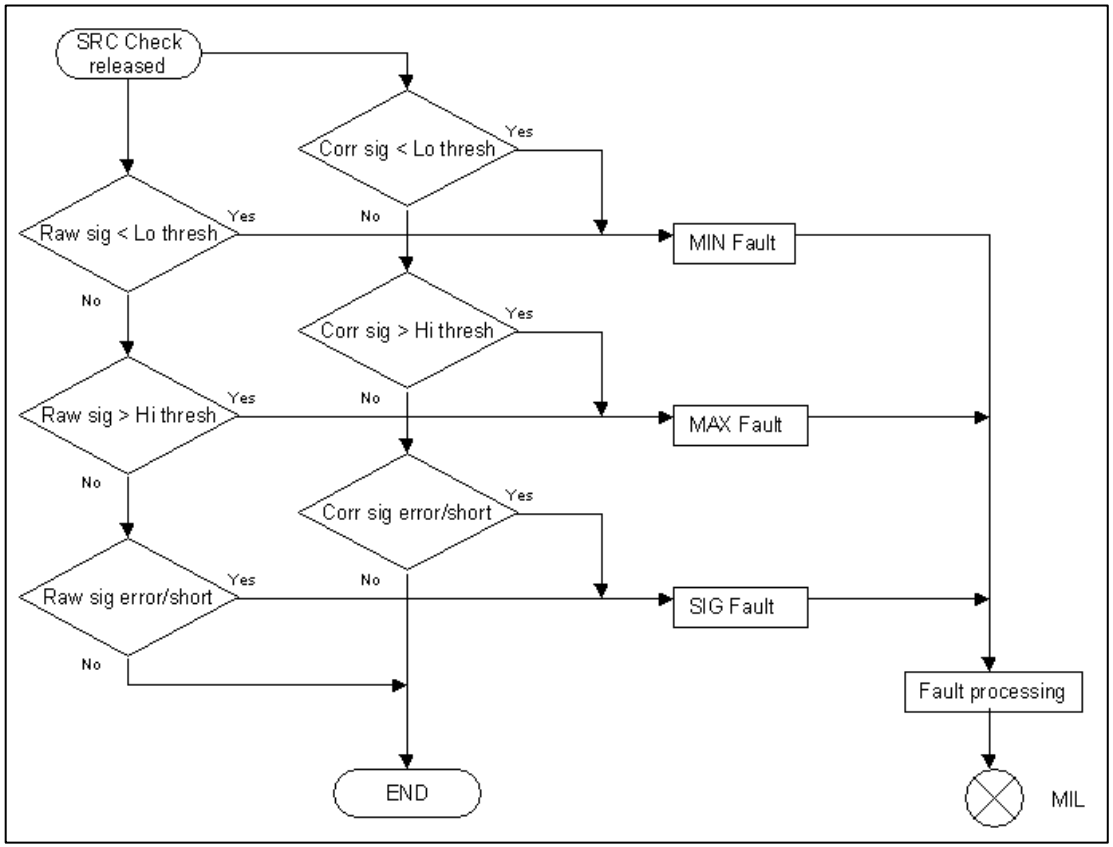
Monitoring is only allowed within calibrateable battery voltage limits.

The signal range check low is released if the averaged engine speed is within thresholds.

The signal range check high is released at ECM initialisation; it is inhibited if the injected fuel quantity exceeds a reference value (as a function of engine speed).

The SRC high is re-enabled if injected fuel quantity falls below reference quantity for sufficient time.

In the case of short circuit to power, ground or signal interruption (differentiation between these three errors is not possible) an error is set and finalised after debounce time. The error is healed is reset if the error clears for debounce time.




**Monitor Entry and Fault Flagging**

Plausibility check is carried out to determine if the sensor-offset drift is within limits. The check is conducted at zero airflow: during the after run period.

The check is not released until a time delay has elapsed since engine stop.

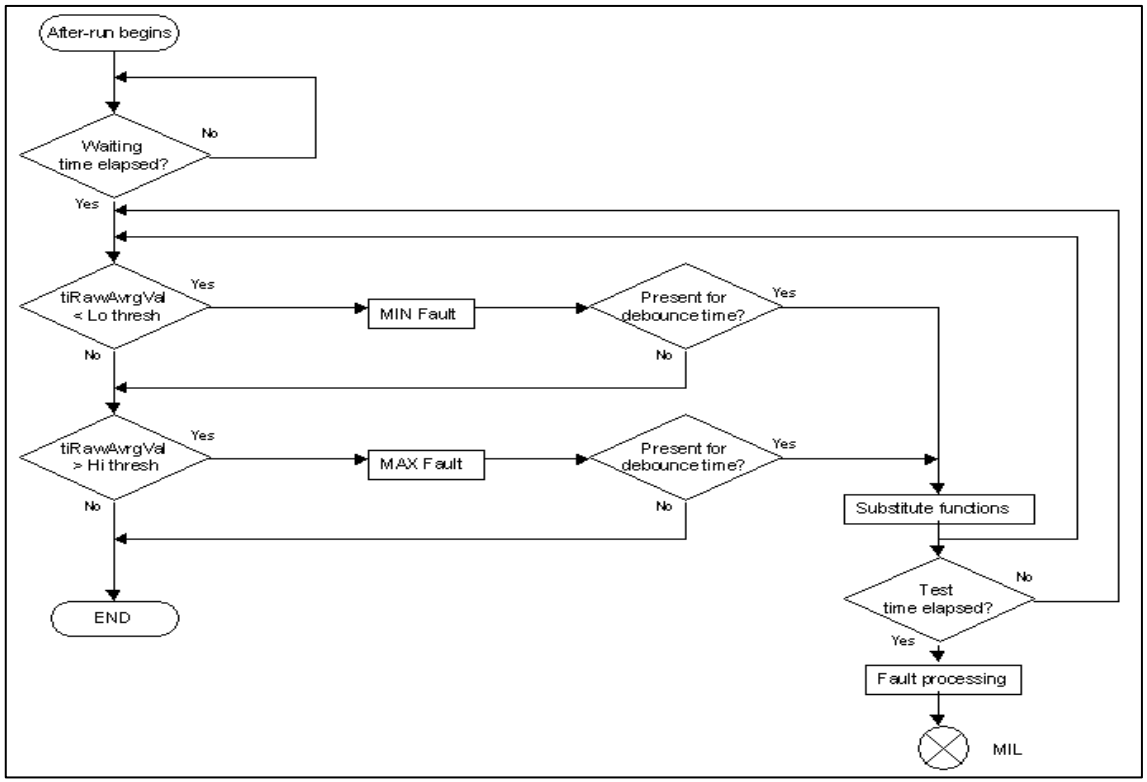
**Sensor offset drift low and high**

If the plausibility check is released, an averaged sensor reading is taken and compared to thresholds. If the value is less than the lower threshold for debounce time sensor offset drift low is detected as finally defective and substitute functions are activated.

The check continues and if the signal value rises above the lower threshold for debounce time the sensor offset drift low condition is detected as finally healed, reset and the substitute functions are withdrawn.

If the value is greater than the upper threshold for debounce time sensor offset drift high is detected and substitute functions are activated. The check continues and if the signal value falls below the upper threshold for debounce time the sensor offset drift high condition is detected as finally healed, reset and the substitute functions are withdrawn.

**Plausibility of MAF sensor offset drift**



The plausibility check of sensor sensitivity drift monitoring will only be released if all the main entry conditions listed above are satisfied.

To avoid false air system controller errors during service diagnostic actuator tests, the plausibility of sensitivity drift monitoring can be inhibited during these operations through configuration of a bit mask.

For the plausibility check the corrected air mass flow is compared with a reference mass flow signal for closed EGR calculated with the gas equation. An error is detected if a defined deviation occurs.

To achieve the above, the calculated normalised air mass flow ratio is compared with calibrateable limits; specific release conditions must be met for each of the upper and lower sensitivity drift limit checks.

**Lower sensitivity drift limit check**

The check is released as long as all of the main entry conditions are satisfied, it is not inhibited by any service diagnostic actuator tests, engine speed is within the testing range and boost pressure is above its threshold.

If the check is released, the normalised air mass ratio is monitored. If it falls below the failure threshold sensitivity drift low error is detected as preliminary defective. If the error remains for the debounce time it is reported as finally defective and the substitute function is activated.

If the normalised air mass ratio rises above its threshold the error is detected as preliminary healed and finally healed after the debounce time and the substitute function is withdrawn.

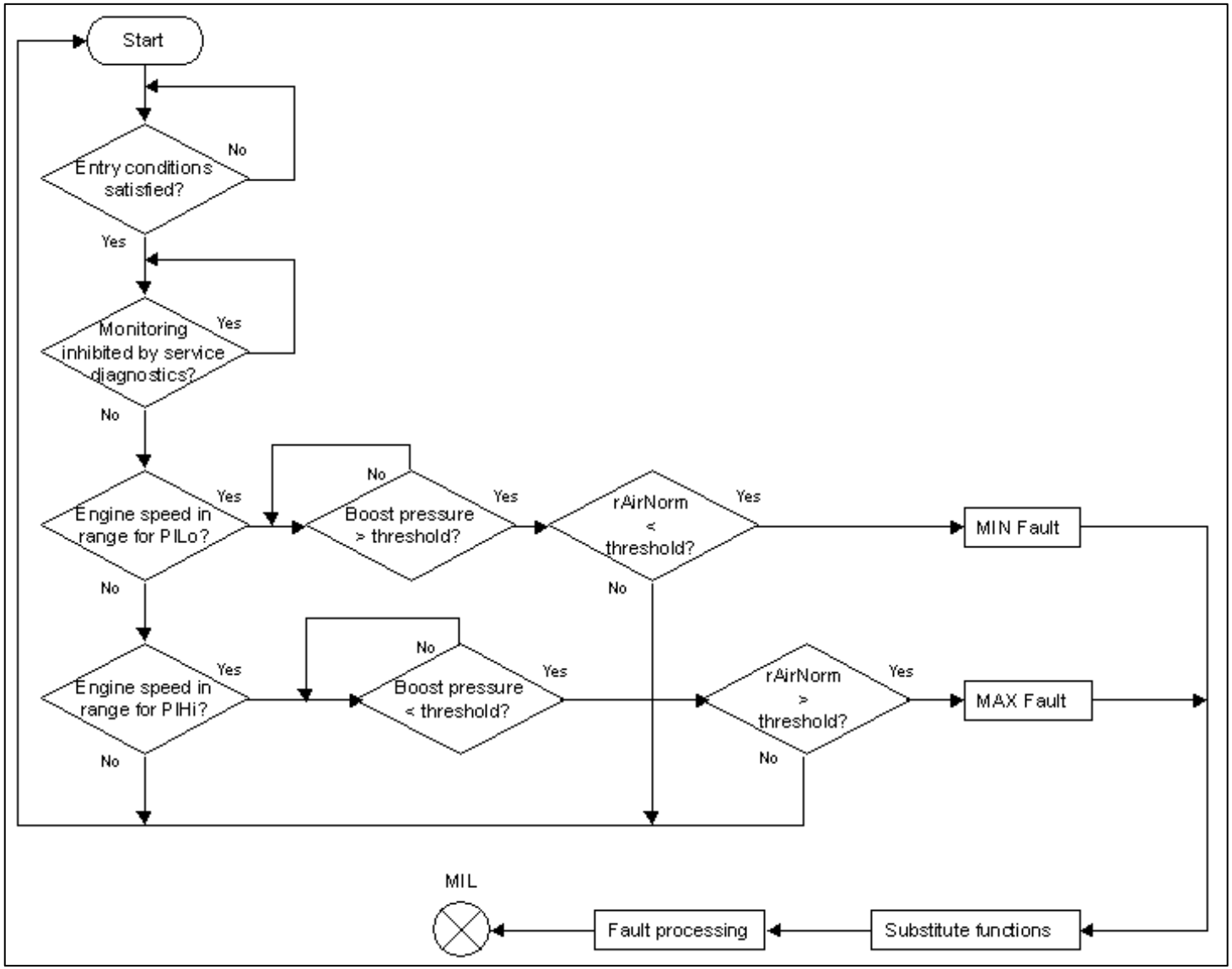
**Upper sensitivity drift limit check**

The release of the check is the same as for the lower limit check, except that the engine speed entry window is defined and the boost pressure must be below the threshold.

If the check is released and the value rises above the failure threshold sensitivity drift high error is detected as preliminary defective. If the error remains for the debounce time it is reported as finally defective and the substitute function is activated.

If the value falls the error is detected as preliminary healed and finally healed after the debounce time when the substitute function is withdrawn.

**Plausibility of MAF sensor sensitivity drift**



## 8.3 DTC Table

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Mass Air Flow Sensor | P00BC | Air Mass flow minimum diagnostic(Bank B2) | Minimum airflow threshold Bi-turbo B2 | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P00BC | Air Mass flow minimum diagnostic(Bank B2) | Minimum airflow threshold Mono-turbo B2 | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P00BD | Air Mass flow maximum diagnostic(Bank B2) | Maximum airflow threshold Bi-turbo B2 | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P00BD | Air Mass flow maximum diagnostic(Bank B2) | Maximum airflow threshold Mono-turbo B2 | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P00BE | Air Mass flow minimum diagnostic(Bank B1) | Minimum airflow threshold Bi-turbo B1 | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P00BE | Air Mass flow minimum diagnostic(Bank B1) | Minimum airflow threshold Mono-turbo B1 | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P00BF | Air Mass flow maximum diagnostic(Bank B1) | Maximum airflow threshold Bi-turbo B1 | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P00BF | Air Mass flow maximum diagnostic(Bank B1) | Maximum airflow threshold Mono-turbo B1 | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P0101 | Offset drift high error for HFM sensor | Engine Off AFS feedback maximum threshold B2 | 3rd Cycle | Takes average of AFS sensor feedback at Key Off Engine Stop | Two Type 1 Cycles | One Type 1 Cycles |
| | P0101 | Offset drift low error for HFM sensor | Engine Off AFS feedback minimum threshold B2 | 3rd Cycle | Takes average of AFS sensor feedback at Key Off Engine Stop | Two Type 1 Cycles | One Type 1 Cycles |
| | P0102 | SRC low error for raw value in HFM6 sensor | Voltage Input outside limits, debounced (low) | 3rd Cycle | Key On, No sensor supply errors | Two Type 1 Cycles | One Type 1 Cycles |

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Mass Air Flow Sensor | P0103 | SRC high error for raw value in HFM6 sensor | Voltage Input outside limits, debounced (high) | 3rd Cycle | Key On, No sensor supply errors | Two Type 1 Cycles | One Type 1 Cycles |
| | P010B | Offset drift high error for HFM sensor | Engine Off AFS feedback maximum threshold B1 | 3rd Cycle | Takes average of AFS sensor feedback at Key Off Engine Stop | Two Type 1 Cycles | One Type 1 Cycles |
| | P010B | Offset drift low error for HFM sensor | Engine Off AFS feedback minimum threshold B1 | 3rd Cycle | Takes average of AFS sensor feedback at Key Off Engine Stop | Two Type 1 Cycles | One Type 1 Cycles |
| | P010C | SRC low error for raw value in HFM6 sensor | Voltage Input outside limits, debounced (low) | 3rd Cycle | Key On, No sensor supply errors | Two Type 1 Cycles | One Type 1 Cycles |
| | P010D | SRC high error for raw value in HFM6 sensor | Voltage Input outside limits, debounced (high) | 1st Cycle (3rd off) | Key On, No sensor supply errors | None | One Type 1 Cycles |

# 9 Crankshaft Position Sensor [Engine Speed / Timing Sensor] (CKP)

## 9.1 Summary

60-2 tooth pattern with comparison of tooth speed and expected gap durations. A Comprehensive Component Monitor (CCM) is incorporated for safety critical reasons - engine is automatically shut down for non recoverable errors. PCL is illuminated.

No EOBD content except for circuit continuity check incorporated in to existing CCM.

Emissions test not possible because of engine shut down default mode.

**Fault is not MIL active as engine shut down occurs in case of this fault.**

## 9.2 Functional Overview, Description, Monitoring & Substitute Function

A precise recording of the engine position is a prerequisite for most engine functions to run correctly.

A meta state monitoring function is employed over which no additional special monitoring entity has been created. Safety against malfunctioning is provided indirectly by the protection policies of EDC17 and the operating system.

For 3.0L V6 Diesel, the temporary position signal error for the crankshaft position sensor and the camshaft phase sensor (see below) are replaced with an offset threshold fault, which will result in an engine shutdown.

At present there are no requirements for limp home functions, so the engine can only be operated when the sensors are fully intact or when the phase sensor is reported defective during operation. All other defects lead to engine stop.

# 10 Camshaft Position [Phasing] Sensor (CMP)

## 10.1 Summary

The cam position sensor is used to determine cylinder phasing. Existing CCM incorporated for safety critical reasons: continuously monitors for signal within [calibrateable] limits.

Does not affect running engine; engine will not start if the signal unacceptable at start-up. PCL is illuminated.

No EOBD content because it is not possible to conduct a standard prep and emissions test.

**Fault is not MIL active.**

## 10.2 Functional Overview & Monitoring

This function evaluates the phase sensor signal. The engine position is computed from the sequence of the slopes and, if applicable, the levels. The current position is computed by comparing the recorded signal with the applied values. The signal is broken down into segments whose characteristics are described in the application. An absolute engine position can be calculated by a unique allocation of the segments of the recorded signal based on the phase sensor signal.

Without a functioning increment system and a plausible phase sensor signal, a current engine position cannot be computed based on the phase sensor signal. Therefore the engine will not start.

# 11 Voltage Monitors

## 11.1 Summary

Three channels of regulated sensor supply are utilised within the ECM.

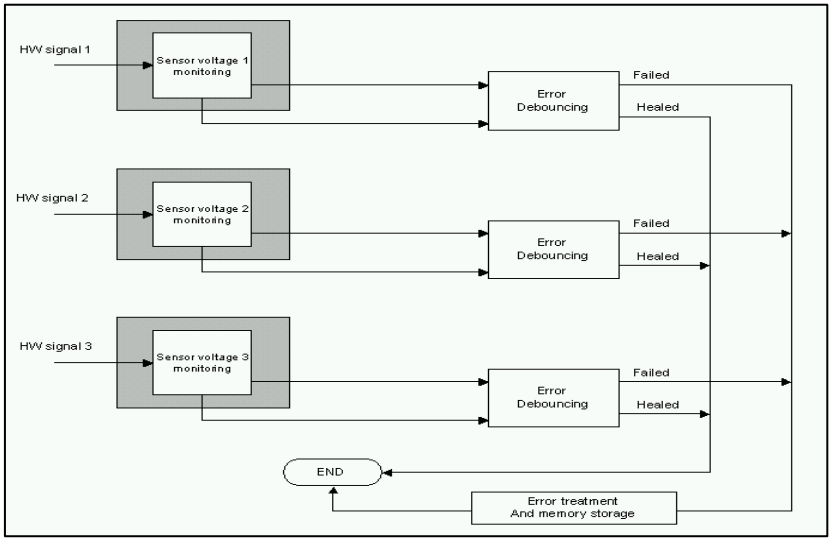
Channel 1 is used for sensitive components (e.g. Rail Pressure Sensor) and results in torque limitation (limp-home mode) with PCL. On the DPF variants EGR is also shut off by this fault hence the code is MIL

Channel 2 relates to emissions related components (e.g. EGR Valve Position Sensor) and is MIL active. On the DPF variants EGR is also shut off by this fault hence the code is MIL

Channel 3 is used for critical components including Crankshaft Position Sensor and failure of these sensors causes forced engine shut-off. On the DPF variant the code has been calibrated to MIL but the fact that the engine is shut off means that in reality it will not progress to MIL on.

## 11.2 Functional Overview, Description, Monitoring & Substitute Function

Comparators in the hardware monitor the sensor supply voltages. The detection thresholds are fixed in the hardware and therefore are not calibrateable. There are separate error paths for each of the supplies. Error detection and healing are time debounced, with separate parameter sets for each of the supplies.



## 11.3 DTC Table

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Sensor Supply | P0A94 | Error Sensor supplies 1 | Monotone increase of the quantity axis points above the basic torque values. Only then can the basis data to be evaluated by interpolation as a curve of torque above quantity. In turn, the prerequisite for this condition is a strictly monotone increase of the quantity axis points above the torque axis. | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P0A94 | Error Sensor supplies 2 | Monotone increase of the quantity axis points above the basic torque values. Only then can the basis data to be evaluated by interpolation as a curve of torque above quantity. In turn, the prerequisite for this condition is a strictly monotone increase of the quantity axis points above the torque axis. | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P0A94 | Error Sensor supplies 3 | Monotone increase of the quantity axis points above the basic torque values. Only then can the basis data to be evaluated by interpolation as a curve of torque above quantity. In turn, the prerequisite for this condition is a strictly monotone increase of the quantity axis points above the torque axis. | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |

# 12 EGR Valve Position Sensor [See Also Valve Actuator]

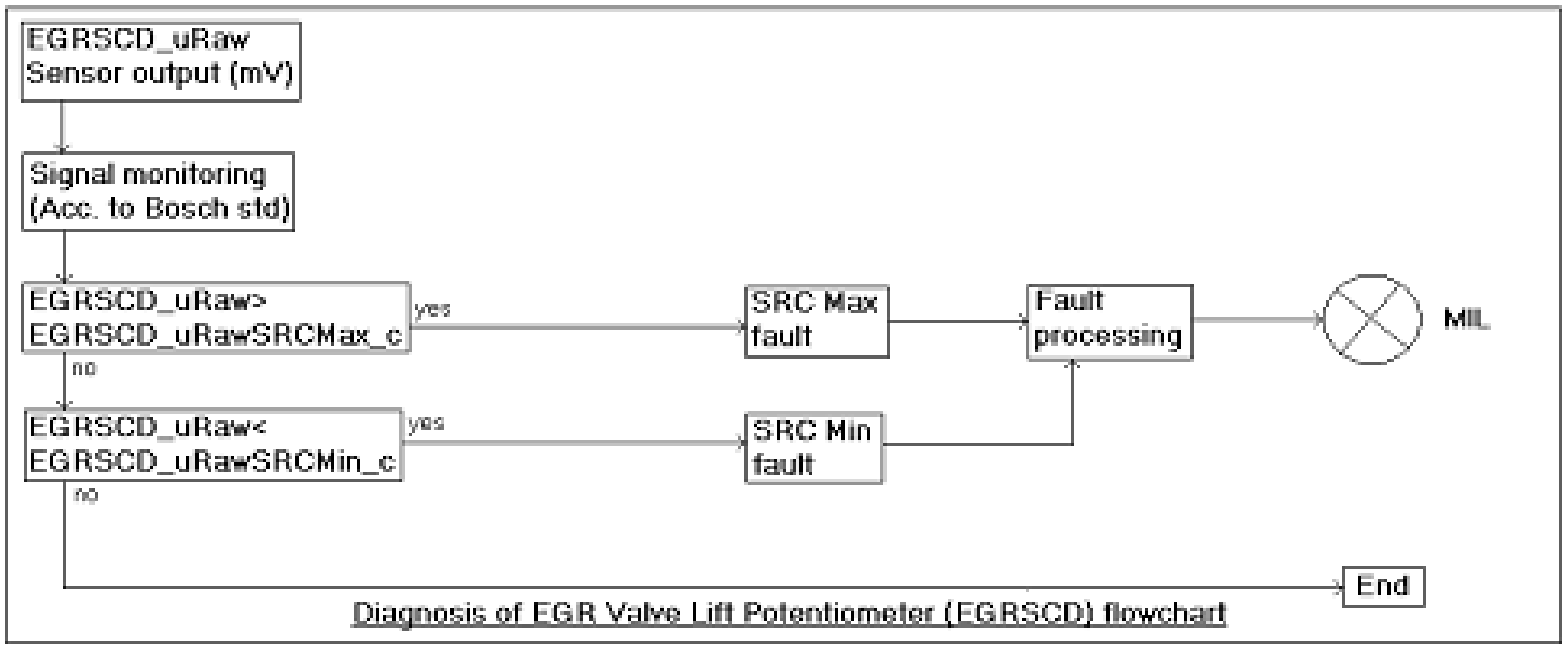
## 12.1 Summary

The EGR valve is controlled to a desired valve lift position via fast open loop control and slow closed loop control by means of the Lift Pot. Major errors in potentiometer reading low are likely to cause elevated NOx engine out emissions; errors in potentiometer reading high are likely to cause elevated engine out Particulate Matter emissions.

The Signal Range Check faults are checked continuously, and failure results in default to zero EGR therefore **fault is MIL active.**

The valve-closed position is adapted in afterrun after every drive cycle, and is monitored such that a short- or long-term drift of the valve-closed position can be identified. These faults are **non-MIL.**

**Detailed Analysis: Monitor Entry and Fault Flagging**



## 12.2 Functional Overview, Description, Monitoring & Substitute Function

The following sub-functions are implemented in this component driver:

- Static monitoring (Signal Range Check)
- Sensor supply monitoring
- Offset position correction
- Zero point offset adaptation
- In case of errors in the sensor supply the signal range checks are aborted and a substitute value is activated.

## 12.3 DTC Table

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| EGR Valve | P0403 | Open load error for Bank1 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P0403 | Over current error for Bank1 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P0403 | Over temperature error for Bank1 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P0403 | Temperature dependent over current error for Bank1 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P0403 | Under voltage error for Bank1 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P0404 | Short circuit over load error for Bank1 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P0405 | Short circuit to ground on Out1 error for Bank1 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| EGR Valve | P0405 | Short circuit to ground on Out2 error for Bank1 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P0405 | Short circuit to ground error for Bank1 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P0406 | Short circuit to power on Out1 error for Bank1 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P0406 | Short circuit to power on Out2 error for Bank1 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P0406 | Short circuit to power error for Bank1 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P0409 | No load error for Bank1 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P0409 | DFC for SRC max(in case of Analog input) | Voltage Input outside limits, debounced | 3rd Cycle | Key On, No sensor supply errors | Two Type 1 Cycles | One Type 1 Cycles |
| | P0409 | DFC for SRC min(in case of Analog input) | Voltage Input outside limits, debounced | 3rd Cycle | Key On, No sensor supply errors | Two Type 1 Cycles | One Type 1 Cycles |
| | P042E | Permanent negative governor deviation for B1 | The control deviation of the EGR Valve position is the difference between the setpoint and the actual position. If this is above a threshold for a time it determines a fault condition. | 3rd Cycle | Requires EGR Active plus no faults on H bridge and feedback sensors | Two Type 1 Cycles | One Type 1 Cycles |

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| EGR Valve | P042F | Permanent positive governor deviation for B1 | The control deviation of the EGR Valve position is the difference between the setpoint and the actual position. If this is above a threshold for a time it determines a fault condition. | 3rd Cycle | Requires EGR Active plus no faults on H bridge and feedback sensors | Two Type 1 Cycles | One Type 1 Cycles |
| | P044A | No load error for Bank2 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P044A | DFC for SRC max(in case of Analog input) | Voltage Input outside limits, debounced (Max) | 3rd Cycle | Key On, No sensor supply errors | Two Type 1 Cycles | One Type 1 Cycles |
| | P044A | DFC for SRC min(in case of Analog input) | Voltage Input outside limits, debounced (Min) | 3rd Cycle | Key On, No sensor supply errors | Two Type 1 Cycles | One Type 1 Cycles |
| | P044C | Short circuit to ground error for Bank2 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P044D | Short circuit to power error for Bank2 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P045A | Open load error for Bank2 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P045A | Over current error for Bank2 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P045A | Over temperature error for Bank2 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P045A | Temperature dependent over current error for Bank2 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| EGR Valve | P045A | Under voltage error for Bank2 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P045B | Short circuit over load error for Bank2 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P045C | Short circuit to ground on Out1 error for Bank2 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P045C | Short circuit to ground on Out2 error for Bank2 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P045D | Short circuit to power on Out1 error for Bank2 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P045D | Short circuit to power on Out2 error for Bank2 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P045E | Permanent negative governor deviation for B2 | The control deviation of the EGR Valve position is the difference between the setpoint and the actual position. If this is above a threshold for a time it determines a fault condition. | 3rd Cycle | Requires EGR Active plus no faults on H bridge and feedback sensors | Two Type 1 Cycles | One Type 1 Cycles |
| | P045F | Permanent positive governor deviation for B2 | The control deviation of the EGR Valve position is the difference between the setpoint and the actual position. If this is above a threshold for a time it determines a fault condition. | 3rd Cycle | Requires EGR Active plus no faults on H bridge and feedback sensors | Two Type 1 Cycles | One Type 1 Cycles |

# 13 Common Rail Pressure Sensor

## 13.1 Summary

The fuel supply pump achieves desired rail pressure by closed loop control on rail pressure sensor. Incorrect rail pressure will result in incorrect quantity and quality of fuel injection with consequent emissions effects. If sensor reads high, injected quantity will be low (PWM control of injector) and vice-versa.

Desired Rail pressure is a calibrated factor varying with engine speed (and load).

Default modes: engine shut down (PCL on). **Not MIL active.**

Range check detects short circuit to ground, power or open circuit.

Sensor tested for offset drift during start up and/or over-run.

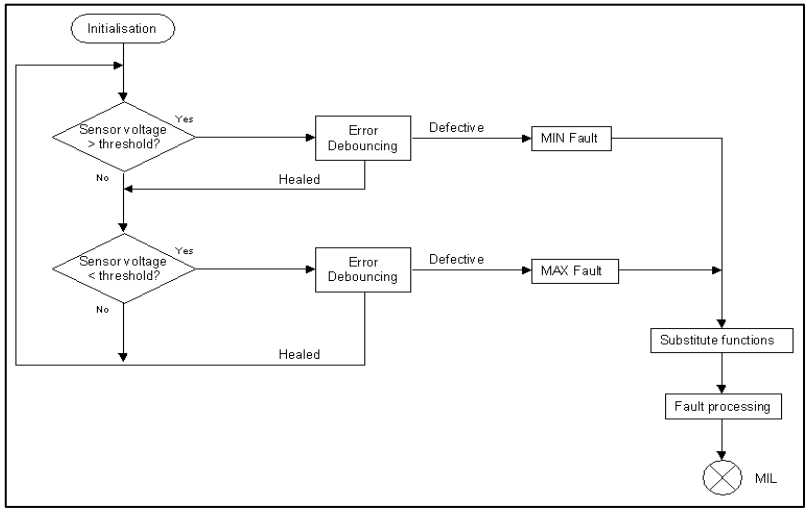
## 13.2 Functional Overview, Description, Monitoring & Substitute Function

The rail pressure sensor is continuously monitored during signal acquisition by an analogue input signal range check.

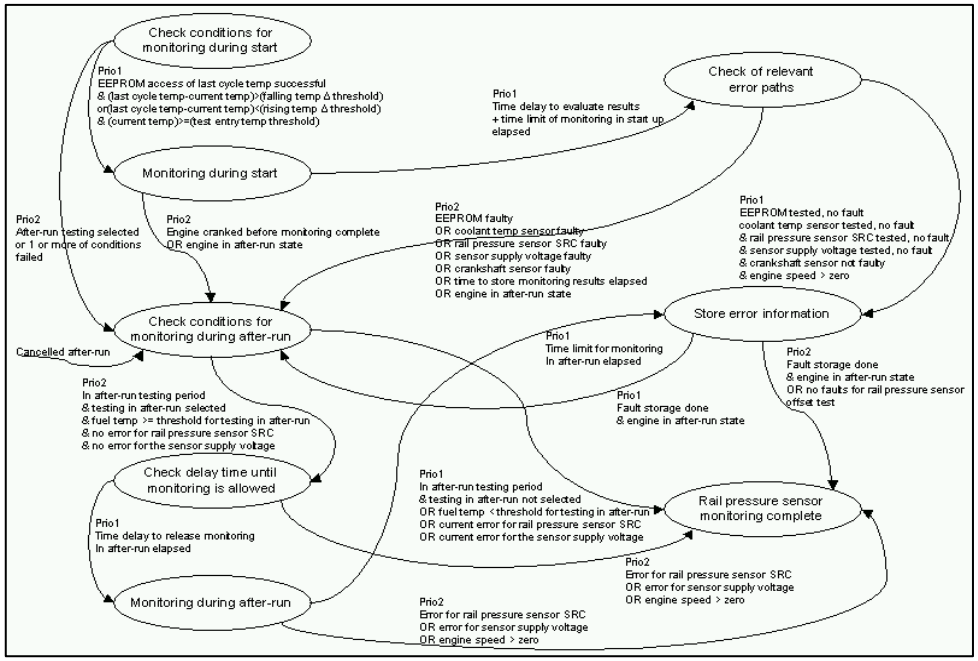
If the sensor raw voltage rises above the upper failure threshold sensor SRC high is detected as preliminary defective. If the error remains for the debounce time the error is detected as finally defective, and the substitute function is activated. If the sensor raw voltage subsequently falls the error is not healed until the next ECM reset.

The detection of sensor low output errors is similar.

## Rail Pressure Sensor Signal Range Check




## Rail pressure sensor offset monitoring state diagram



## 13.3 DTC Table

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Rail Pressure Sensor | P0192 | Sensor voltage below lower limit | Raw sensor voltage drops below limiting value. Also, if uncorrected raw sensor voltage drops below its value | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P0193 | Sensor voltage above upper limit | Raw sensor voltage exceeds limiting value. Also, if uncorrected raw sensor voltage exceeds its value | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |

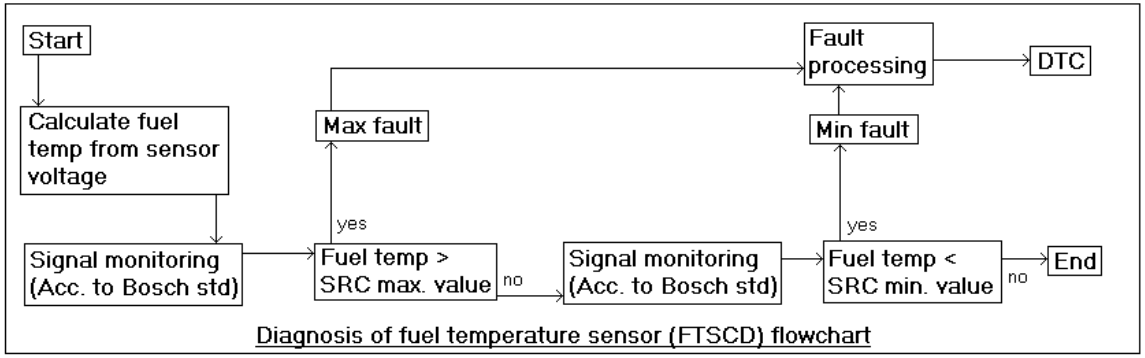
# 14 Common Rail Fuel Temperature Sensor

## 14.1 Summary

The desired rail pressure or fuelling may be limited at elevated temperatures to protect the FIE components. A failure of the fuel temperature input may therefore lead to the application of the rail pressure or fuelling limit. Sensor failure does not result in emissions in excess of EOBD thresholds.

Default modes: temperature high.

**Detailed Analysis: Monitor Entry and Fault Flagging**




Flow diagram

## 14.2 Functional Overview, Description, Monitoring & Substitute Function

This component driver consists of: Static monitoring (signal range check) and transient response.

During analogue signal evaluation, the converted raw value is checked and transformed. The check consists of a signal range check (SRC). If the valid ranges are exceeded error messages are reported after the debouncing as elapsed. If the raw value returns to the valid range, the errors are healed again after the debouncing times have elapsed.

Fuel temperature updated every 100 ms.

## 14.3 DTC Table

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Fuel Temperature Sensor | P0181 | Physical Range Check high for fuel temperature | Measured temp outside limit (High) | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P0181 | Physical Range Check low for fuel temperature | Measured temp outside limit (Low) | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P0182 | SRC low for fuel temperature sensor | Voltage Input outside limits, debounced (Low) | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P0183 | SRC high for fuel temperature sensor | Voltage Input outside limits, debounced (High) | 3rd Cycle | Engine running | Two Type 1 Cycles | One Type 1 Cycles |

# 15 Particulate Filter Differential Pressure Sensor [DPF Models]

## 15.1 Summary

The particulate filter differential pressure sensor is used to check the functionality and integrity of the particulate filter.
Failures are MIL active. Default mode: Diesel Particular Filter (DPF) clogged or blocked.

## 15.2 Functional Overview, Description, Monitoring & Substitute Function

Monitoring is conducted as follows:

**Signal range & enhanced signal range checks** detect circuit continuity faults.

**Plausibility is determined by checking** differential pressure reading across the particulate filter as a function of the calculated exhaust gas flow rate whilst the engine is running. This check is only conducted provided engine operating conditions are above minimum thresholds and regeneration is not in progress i.e. coolant temperature, engine speed and load within operating range.

**Engine off plausibility check** of differential pressure reading before the engine starts or after run: If the measured differential pressure across the particle filter is greater than a fixed value the non-plausibility defect is recorded.

**Dynamic plausibility:** An error is set if the differential pressure sensor signal fails to change by a calibrated amount after a transient increase in exhaust volume flow rate is detected.

**Filter integrity**: When the differential pressure across the particulate filter is below the minimal threshold (dependant on the calculated exhaust gas volume flow) the low filtration efficiency condition is detected.

**Overcharged filter detection:** When the differential pressure across the particulate filter is above the overload threshold (dependent on the calculated exhaust gas volume flow) the overload condition is detected.

**Clogged filter detection:** When the differential pressure across the particulate filter is above the maximal (clogged) threshold, dependant on the calculated exhaust gas volume flow the clogged condition is detected.

**Destroyed:** An error is set if the maximum differential pressure is below the calibrated minimum threshold.

**Hose Line:** An error is set if the filtered differential pressure is less than the calibrated minimum threshold.

**Engine Protection:** An error is set if, due to high differential pressure, a particulate filter regeneration has been forced.

**Soot mass deviation:** An error is set if the difference between the simulated and calculated soot mass either falls below the calibrated minimum threshold or rises above the calibrated maximum threshold.

## 15.3 DTC Table

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Emission Control Loops | P151B | Error path for monitoring | Total quantity correction from FMO exceeds mapped value | 3rd Cycle | Active at Key On (happens once per cycle) | Two Type 1 Cycles | One Type 1 Cycles |
| | P151C | Error path for monitoring | Total quantity correction from FMO exceeds mapped value | 3rd Cycle | Active at Key On (happens once per cycle) | Two Type 1 Cycles | One Type 1 Cycles |
| Particulate Filter | P244A | Diagnostic fault check for min deviation measure from simulated and measured | Destroyed particulate filter, or dismounted. | 1st Cycle | Requires engine speed / load / on time / coolant temp / enviromental temp / exhuast pressure flow / no hose line errors / engine state after run | One Type 1 Cycles | One Type 1 Cycles |
| | P2452 | DPF Hose Line connection check | Exhaust flow exceeds min value | 3rd Cycle | Engine running | Two Type 1 Cycles | One Type 1 Cycles |
| | P2454 | Signal range check DPF Pressure Sensor | Pressure voltage signal outside limits, debounced | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P2455 | Signal range check DPF Pressure Sensor | Pressure voltage signal outside limits, debounced | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P2463 | Diagnostic fault check for Maximum soot mass | Soot level above max level for futher customer regeneration | 3rd Cycle | Engine running | Two Type 1 Cycles | One Type 1 Cycles |
| DPF Pressure | P2452 | Plausibility of DPF pressure | Pressure out of limits | 3rd Cycle | Engine running | Two Type 1 Cycles | One Type 1 Cycles |
| | P2453 | Plausibility of DPF pressure | Pressure out of limits | 3rd Cycle | Engine running | Two Type 1 Cycles | One Type 1 Cycles |

# 16 Catalyst Temperature Sensor(S)

## 16.1 Summary

The pre catalyst temperature sensor is used as part of the control for the regeneration of the Diesel particulate filter, and forms part of the functionality and integrity check of the particulate filter.

## 16.2 Functional Overview, Description, Monitoring & Substitute Function

The pre catalyst temperature sensor is monitored for range and plausibility.

Failure may result in an inability to regenerate the DPF and are therefore **MIL active.**

Default conditions: a default value is substituted if a fault is detected.

**Max range**: Provided monitor entry conditions are met, [Engine temperature, speed and load greater than calibrated minima] an error is set if the sensor raw voltage output > calibrated maximum.

**Min range**: An error is set if the sensor raw voltage output < calibrated minimum.

**Gradient error:** Provided monitor entry conditions are met, [Engine temperature, speed and load greater than calibrated minima; no regeneration in progress] an error is set if the sensor output gradient exceeds a calibrated maximum.

**Plausibility:** An error is set if the difference between actual exhaust temperature and modelled exhaust temperature falls outside of a calibrateable band.

## 16.3 DTC Table

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Temperature sensor upstream of cat Primary bank | P0428 | Diagnostic Fault Check for enhanced SRC-Max of First exhaust gas temperature | Voltage input outside limts, but in range. Over temp detection | 3rd Cycle | Engine running | Two Type 1 Cycles | One Type 1 Cycles |

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Temperature sensor upstream of cat Primary bank Temperature sensor upstream of cat Primary bank | P0436 | Voltage stuck in range | Voltage input stuck low in range | 3rd Cycle | Engine running state >120s | Two Type 1 Cycles | One Type 1 Cycles |
| | P0437 | SRC Low USB2 | Voltage Input outside limits, debounced. | 3rd Cycle | Engine running, requires speed load conditions to be met. >49 c coolant .12mg inj fuel for > 25s >1000rpm | Two Type 1 Cycles | One Type 1 Cycles |
| | P0438 | SRC High USB2 | Voltage Input outside limits, debounced. | 3rd Cycle | Engine running, requires speed load conditions to be met. >49 c coolant .12mg inj fuel for > 25s >1000rpm | Two Type 1 Cycles | One Type 1 Cycles |
| Temperature sensor downstream of particulate filter | P2033 | Diagnostic Fault Check for enhanced SRC-Max of third exhaust gas temperature | Voltage input outside limts, but in range. Over temp detection | 3rd Cycle | Engine running | Two Type 1 Cycles | One Type 1 Cycles |

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Temperature sensor downstream of particulate filter | P242C | SRC Low TpfltDS | Voltage Input outside limits, debounced. | 3rd Cycle | Engine running, requires speed load conditions to be met. >49 c coolant .12mg inj fuel for > 55s >1000rpm | Two Type 1 Cycles | One Type 1 Cycles |
| | P242D | SRC high TPfltDS | Voltage Input outside limits, debounced. | 3rd Cycle | Engine running, requires speed load conditions to be met. >49 c coolant .12mg inj fuel for > 55s >1000rpm | Two Type 1 Cycles | One Type 1 Cycles |
| Temperature sensor downstream of cat Primary bank | P043C | SRC High for TOxiCatDs Temperature | Voltage Input outside limits, debounced. | 3rd Cycle | Engine running, requires speed load conditions to be met. >49 c coolant .12mg inj fuel for > 35s >1000rpm | Two Type 1 Cycles | One Type 1 Cycles |

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Temperature sensor downstream of cat Primary bank | P043D | SRC High for TOxiCatDs Temperature | Voltage Input outside limits, debounced. | 3rd Cycle | Engine running, requires speed load conditions to be met. >49 c coolant .12mg inj fuel for > 35s >1000rpm | Two Type 1 Cycles | One Type 1 Cycles |

# 17 Exhaust Gas Recirculation (EGR) Valve

## 17.1 Summary

The EGR valve is controlled to a desired valve lift position via fast open loop control and slow closed loop control by means of the Lift Pot.

Failure results in default to zero EGR therefore fault is MIL active. Jammed valve faults can cause unpredictable emissions levels depending on the position in which the valve sticks; hence this is also a MIL active fault.

Monitoring is conducted for:

- Lower mechanical stop
- Open-loop controlled closing (pull-down)
- Permanent control deviation
- Jammed valve

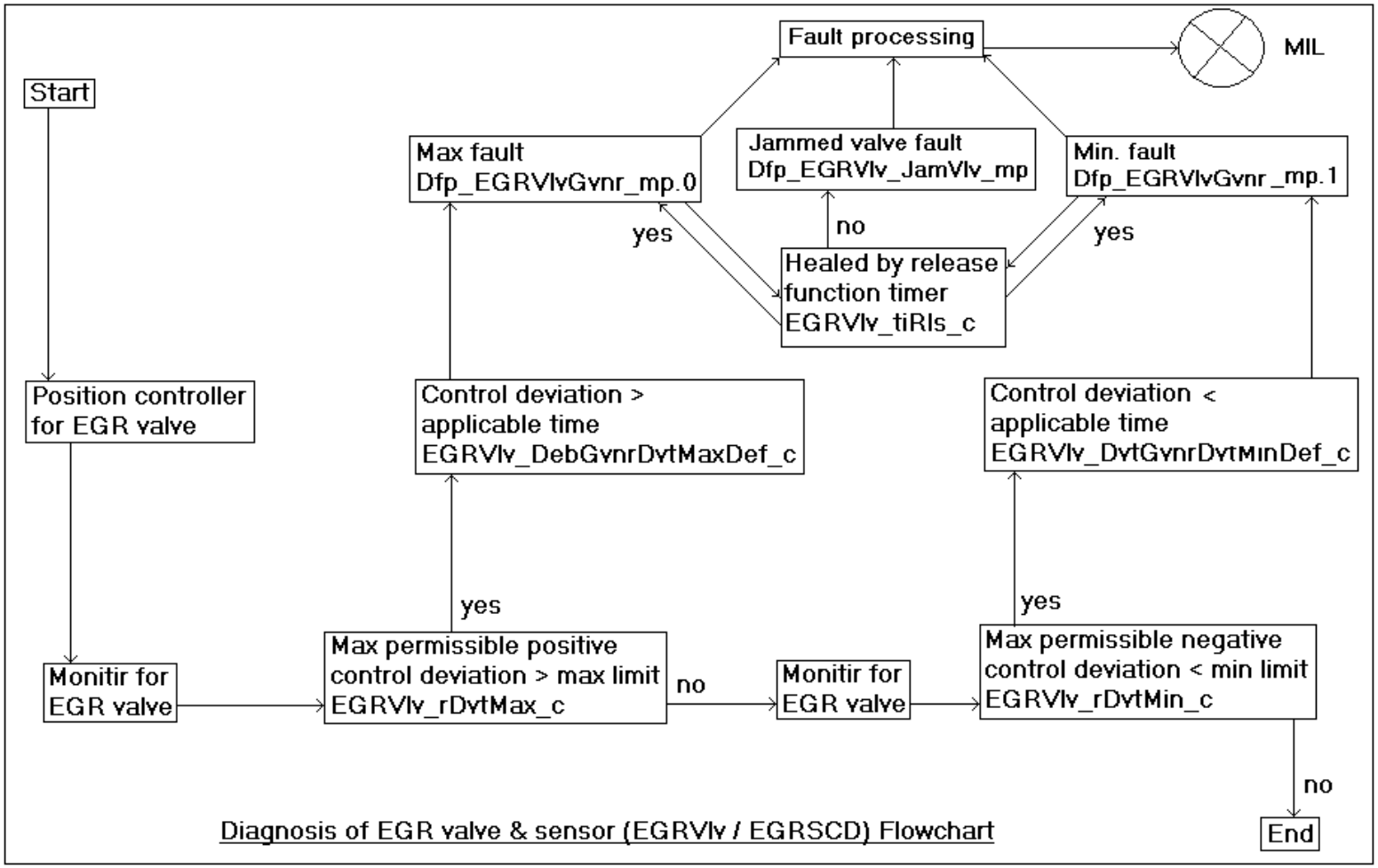
Depending on the monitoring status the system may implement special reactions:

- Pull-down integrator
- Release function
- Switching off the power stage

Signal Range Check detects short circuit to power, ground or open circuit.

Control limit deviation checks that valve position satisfactorily follows demand [e.g. detects sticking and/or non functional valve].

**Detailed Analysis: Monitor Entry and Fault Flagging**



## 17.2 Functional Overview, Description, Monitoring & Substitute Function

The lower mechanical stop is detected if the position set point is below or equal to the threshold value and the position actual value is below the threshold value for a preset time. Stop detection is reset as soon as the position set point exceeds the threshold value.

Positive permanent control deviation is detected if the valve position control deviation is above the threshold and if the control deviation is present at least for a calibrateable time. Healing of the positive permanent control deviation takes place if no positive permanent control deviation is detected for a calibrateable time.

Negative permanent control deviation is detected in a similar manner to positive control deviation.

If a permanent control deviation is detected and if it remains present for sufficient time, i.e. the intervention of the release function is not successful, the valve is detected as jammed. In this case monitoring for permanent control deviation is shut off. Thus healing is no longer possible.

## 17.3 DTC Table

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| EGR Valve | P0401 | negative governor deviation below limit | EGR flow rate maximum threshold | 3rd Cycle | Active when EGR controller is active. | Two Type 1 Cycles | One Type 1 Cycles |
| | P0402 | Positive governor deviation above limit | EGR flow rate maximum threshold | 3rd Cycle | Active when EGR controller is active. | Two Type 1 Cycles | One Type 1 Cycles |
| | P0403 | Open load error for Bank1 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P042E | Permanent negative governor deviation for B1 | The control deviation of the EGR Valve position is the difference between the setpoint and the actual position. If this is above a threshold for a time it determines a fault condition. | 3rd Cycle | Requires EGR Active plus no faults on H bridge and feedback sensors | Two Type 1 Cycles | One Type 1 Cycles |

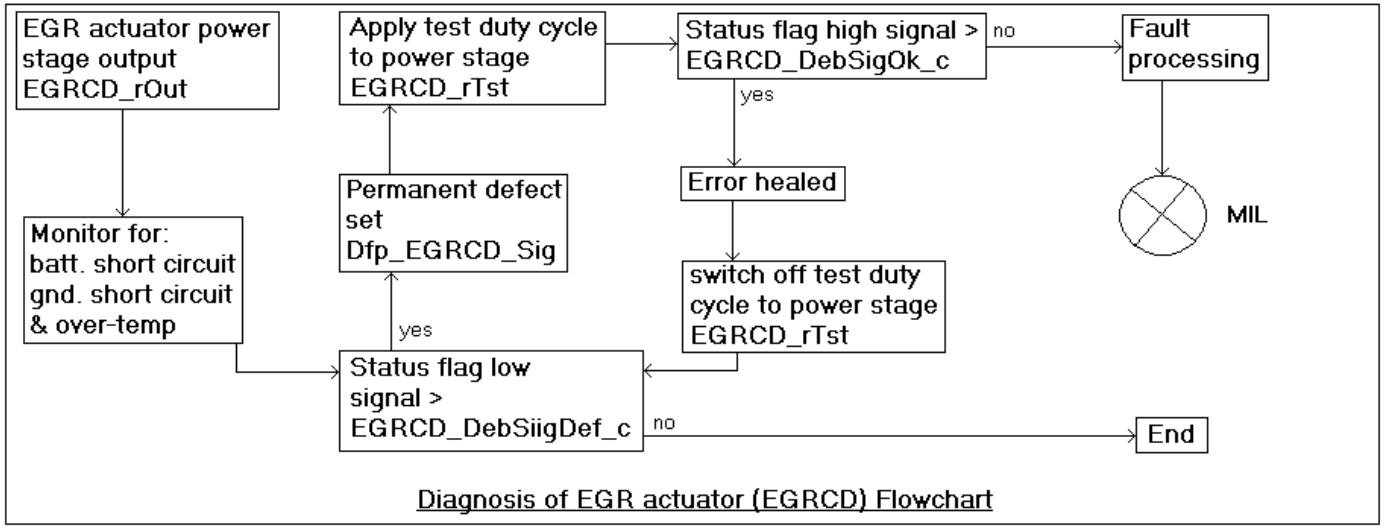
| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| EGR Valve | P042F | Permanent positive governor deviation for B1 | The control deviation of the EGR Valve position is the difference between the setpoint and the actual position. If this is above a threshold for a time it determines a fault condition. | 3rd Cycle | Requires EGR Active plus no faults on H bridge and feedback sensors | Two Type 1 Cycles | One Type 1 Cycles |
| | P045A | Open load error for Bank2 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P045E | Permanent negative governor deviation for B2 | The control deviation of the EGR Valve position is the difference between the setpoint and the actual position. If this is above a threshold for a time it determines a fault condition. | 3rd Cycle | Requires EGR Active plus no faults on H bridge and feedback sensors | Two Type 1 Cycles | One Type 1 Cycles |
| | P045F | Permanent positive governor deviation for B2 | The control deviation of the EGR Valve position is the difference between the setpoint and the actual position. If this is above a threshold for a time it determines a fault condition. | 3rd Cycle | Requires EGR Active plus no faults on H bridge and feedback sensors | Two Type 1 Cycles | One Type 1 Cycles |

# 18 Exhaust Gas Recirculation (EGR) Actuator

## 18.1 Summary

The EGR valve is electrically activated with position sensing. This section deals with electrical checks only – functional aspects are covered under lift potentiometer / position sensor section.

**Detailed Analysis: Monitor Entry and Fault Flagging**




## 18.2 Functional Overview, Description, Monitoring & Substitute Function

The power stage is monitored for a short circuit to power, short circuit to ground and over temperature errors.

The Status Flag is debounced to recognise it as a permanent defect.

Immediately after recognition of a permanent defect, a test duty cycle is given out to the power stage at intervals. Additionally high to low transitions are provided on the disable pin to start the healing during provisional and permanent defect states. If status pin goes high and remains at high for a period then the error is considered healed. Normal duty cycle resumes on PWM output pin and high to low transitions on disable pin are switched off.

## 18.3 DTC Table

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| EGR Actuator | P0404 | Short circuit over load error for Bank1 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P0405 | Short circuit to ground on Out1 error for Bank1 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P0406 | Short circuit to power on Out1 error for Bank1 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P044C | Short circuit to ground error for Bank2 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P044D | Short circuit to power error for Bank2 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P045B | Short circuit over load error for Bank2 | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |

# 19 High Pressure Fuel Pump

## 19.1 Summary

The engine controls fuel supply and pressure by means of a Volume Control Valve (VCV), known as the metering unit (MeUnCD). This controls the fuel supplied to the Bosch High pressure pump, and is closed loop controlled via the Rail Pressure Sensor. Standard PWM output circuit checks apply.

## 19.2 Functional Overview, Description, Monitoring & Substitute Function

The 3.0L V6 Diesel engine has a fuel rail pressure control valve (PCV) that is used in conjunction with the volume control valve (VCV) in the fuel metering unit (see previous section) to optimally control fuel rail pressure.

Fuel Rail pressure is controlled in three closed loop modes:

- VCV (Metering Unit) controlled mode
- PCV controlled mode
- Complete Pressure Control (CPC) mode - both PCV & VCV closed loop

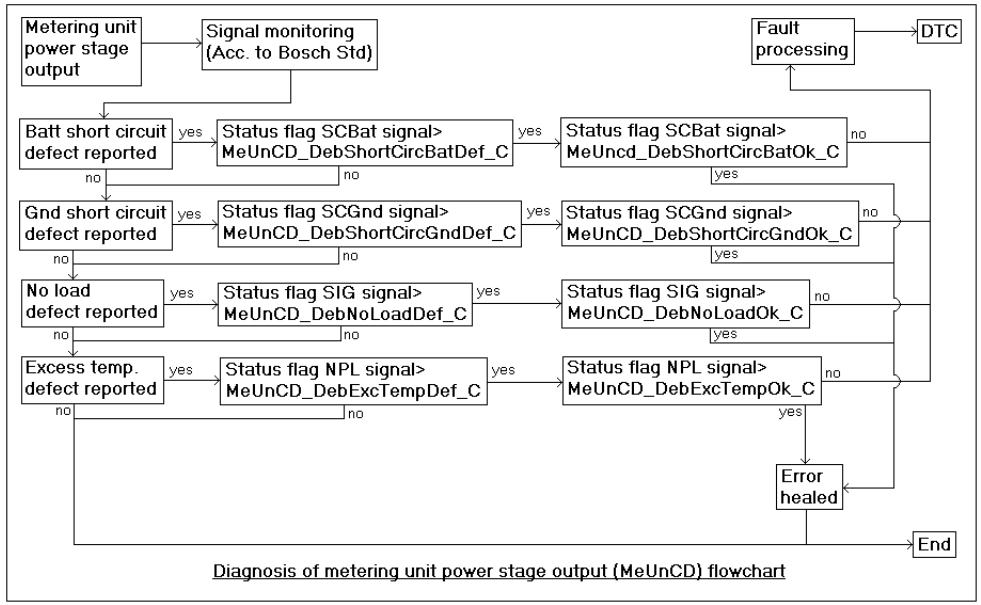
3.0L V6 Diesel default conditions are engine speed limitation or shut down.

Signal Range Check of the AD channels detects voltage and current out of range.

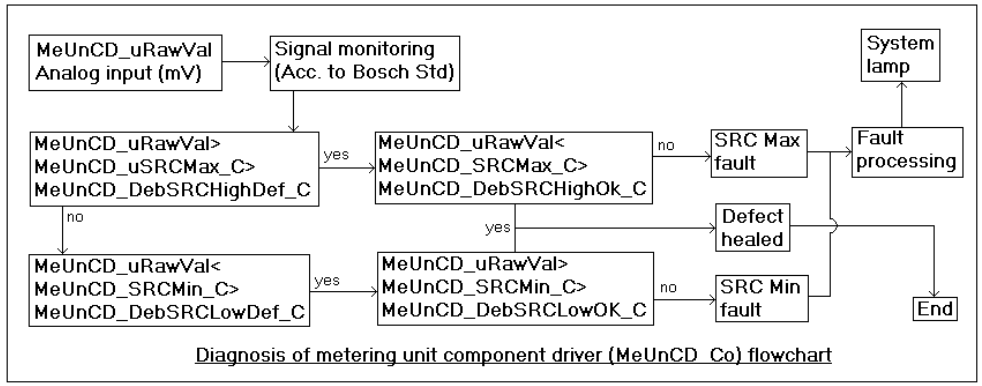
PWM power stage check detects short circuit to power, ground, open circuit or excess temperature.

Faults are MIL active, depending on the reaction taken.

## Detailed Analysis: Monitor Entry and Fault Flagging




Diagnosis of metering unit power stage output (MeUnCD) flowchart




Diagnosis of metering unit component driver (MeUnCD_Co) flowchart

## 19.3 DTC Table

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| High Pressure Fuel Control | P0087 | maximum negative rail pressure deviation with closed pressure control valve exceeded | Rail pressure govenor deviation falls below limiting value and if set value for PCV falls below limiting value | 3rd Cycle | Engine Running | Two Type 1 Cycles | One Type 1 Cycles |
| | P0087 | minimum rail pressure exceeded | Rail pressure falls below limiting value | 3rd Cycle | Engine Running | Two Type 1 Cycles | One Type 1 Cycles |
| | P0088 | maximum positive deviation of rail pressure exceeded | Rail pressure governor deviation exceeds limiting value | 3rd Cycle | Engine Running | Two Type 1 Cycles | One Type 1 Cycles |
| | P0088 | maximum positive deviation of rail pressure exceeded concerning set value PCV | Rail pressure govenor deviation exceeds limiting value and if set value for PCV reaches limit value.<br><br>Rail pressure exeeded and maximum position of pressure control valve reached. | 3rd Cycle | Engine Running | Two Type 1 Cycles | One Type 1 Cycles |
| | P0088 | maximum rail pressure exceeded | Rail pressure exceeds limiting value | 3rd Cycle | Engine Running | Two Type 1 Cycles | One Type 1 Cycles |
| | P0090 | open load of pressure control valve output | no load connected to the powerstage | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P0090 | over temperature of device driver of pressure control valve | power stage over temperature | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P0091 | short circuit to ground of pressure control valve output | short circuit to ground | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| High Pressure Fuel Control | P0092 | short circuit to power of pressure control valve output | Short circuit to power | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| Device Driver For Metering Unit | P0251 | open load of metering unit output | no load connected to the powerstage | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P0251 | over temperature of device driver of metering unit | power stage over temperature | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P0253 | short circuit to ground of metering unit output | short cicuit to ground | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P0254 | short circuit to power of metering unit output | Short cicuit to power | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| Pressure Control Valve | P0091 | signal range check low error of pressure control valve AD-channel | Voltage Input outside limits, debounced | 3rd Cycle | Key On, No sensor supply errors | Two Type 1 Cycles | One Type 1 Cycles |
| | P0092 | signal range check high error of pressure control valve AD-channel | Voltage Input outside limits, debounced | 3rd Cycle | Key On, No sensor supply errors | Two Type 1 Cycles | One Type 1 Cycles |

# 20 Fuel Injectors

## 20.1 Summary

The requirements are detection of "gross timing or fuelling failure" and "single failure". Common rail injectors are independent electrically controlled units (1 per cylinder). Injection is by pilot, main and post injection. Post injection is primarily used to raise exhaust temperatures to levels suitable for DPF regeneration.

## 20.2 Functional Overview, Description, Monitoring & Substitute Function

A range of electrical checks is conducted which determine wiring /connection errors and faults with the electrical stages of the injectors.

Default modes are engine shut down or fuel quantity limitation (depending on fault).

Faults are 'MIL active' except in case of engine shut down.

Injector diagnostics are performed via the piezo power stages. The diagnostics consist of two areas, each of the piezo power stages have diagnostics associated with them and each of the individual injectors have diagnostics associated with them. Piezo power stage diagnostics consists of initialisation, ECU, plausibility and functional monitors. Injector diagnostics consists of timing and charging/discharging monitors. Permanent faults are set via a debounce counter.

There are two banks of piezo power stages, each driving two injectors.

Diagnostics are active from key on. Plausibility diagnostics are active at key on provided that there are no initialisation errors.

If measured fuel pressure is in range and there are no faults logged for the rail pressure sensor then testing is enabled.

Injector charging and discharging times are compared to upper and lower thresholds for pre, main and post injection events. If any of the times fall outside of the range the injector time out of range an error is set. Additionally if the discharge times are significantly different to the charge times, an error is set.

If the number of injections is limited due to charge balance or software faults a series of errors can be set.

During the engine build stage the individual injectors have to have their adjustment factors programmed in to the engine management module. If this process is not carried out or there is some corruption of the stored adjustment factors errors can be set.

## 20.3 DTC Table

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Fuel Injectors | P0201 | Open circuit between actuator and ecu (Injector 1) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P0202 | Open circuit between actuator and ecu (Injector 2) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P0203 | Open circuit between actuator and ecu (Injector 3) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P0204 | Open circuit between actuator and ecu (Injector 4) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P0205 | Open circuit between actuator and ecu (Injector 5) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P0206 | Open circuit between actuator and ecu (Injector 6) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P0216 | Number of injections is limited by runtime | Number of requested injections > number possible due to SW scheduling | 3rd Cycle | Engine running | Two Type 1 Cycles | One Type 1 Cycles |

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Fuel Injectors | P0261 | Short circuit between low side of actuator and power (Injector 1) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P0261 | short circuit of high side to low side [Short across the actuator] (Injector 1) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P0261 | short circuit between 2 or more actuators on discharge side of the actuator (Injector 1) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P0264 | Short circuit between low side of actuator and power (Injector 2) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P0264 | short circuit of high side to low side [Short across the actuator] (Injector 2) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P0264 | short circuit between 2 or more actuators on discharge side of the actuator (Injector 2) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P0267 | Short circuit between low side of actuator and power (Injector 3) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P0267 | short circuit of high side to low side [Short across the actuator] (Injector 3) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Fuel Injectors | P0267 | short circuit between 2 or more actuators on discharge side of the actuator (Injector 3) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P0270 | Short circuit between low side of actuator and power (Injector 4) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P0270 | short circuit of high side to low side [Short across the actuator] (Injector 4) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P0270 | short circuit between 2 or more actuators on discharge side of the actuator (Injector 4) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P0273 | Short circuit between low side of actuator and power (Injector 5) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P0273 | short circuit of high side to low side [Short across the actuator] (Injector 5) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P0273 | short circuit between 2 or more actuators on discharge side of the actuator (Injector 5) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P0276 | Short circuit between low side of actuator and power (Injector 6) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Fuel Injectors | P0276 | short circuit of high side to low side [Short across the actuator] (Injector 6) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P0276 | short circuit between 2 or more actuators on discharge side of the actuator (Injector 6) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P02CD | UUp-voltage after pre-control, and temperature-, and NVC-correction exceeds OBD-limit (Injector 1) | Actuator setpoint voltage for injector 0 exceeds OBD limit | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P02CF | UUp-voltage after pre-control, and temperature-, and NVC-correction exceeds OBD-limit (Injector 2) | Actuator setpoint voltage for injector 2 exceeds OBD limit | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P02D1 | UUp-voltage after pre-control, and temperature-, and NVC-correction exceeds OBD-limit (Injector 3) | Actuator setpoint voltage for injector 4 exceeds OBD limit | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P02D3 | UUp-voltage after pre-control, and temperature-, and NVC-correction exceeds OBD-limit (Injector 4) | Actuator setpoint voltage for injector 1 exceeds OBD limit | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P02D5 | UUp-voltage after pre-control, and temperature-, and NVC-correction exceeds OBD-limit (Injector 5) | Actuator setpoint voltage for injector 3 exceeds OBD limit | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P02D7 | UUp-voltage after pre-control, and temperature-, and NVC-correction exceeds OBD-limit (Injector 6) | Actuator setpoint voltage for injector 5 exceeds OBD limit | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Fuel Injectors | P02EE | Discharge-time-governor input exceeds OBD-limit [Piezo discharge time exceeded threshold] (Injector 1) | Discharge time deviation for injector 0 larger than OBD limit | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P02EE | Voltage-governor input exceeds OBD-limit (Injector 1) | Actuator setpoint voltage deviation for injector 0 larger than OBD limit | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P02EE | non-classifiable error [Has an error but not known] (Injector 1) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P02EF | Discharge-time-governor input exceeds OBD-limit [Piezo discharge time exceeded threshold] (Injector 2) | Discharge time deviation for injector 2 larger than OBD limit | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P02EF | Voltage-governor input exceeds OBD-limit (Injector 2) | Actuator setpoint voltage deviation for injector 2 larger than OBD limit | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P02EF | non-classifiable error [Has an error but not known] (Injector 2) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P02F0 | Discharge-time-governor input exceeds OBD-limit [Piezo discharge time exceeded threshold] (Injector 3) | Discharge time deviation for injector 4 larger than OBD limit | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P02F0 | Voltage-governor input exceeds OBD-limit (Injector 3) | Actuator setpoint voltage deviation for injector 4 larger than OBD limit | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Fuel Injectors | P02F0 | non-classifiable error [Has an error but not known] (Injector 3) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P02F1 | Discharge-time-governor input exceeds OBD-limit [Piezo discharge time exceeded threshold] (Injector 4) | Discharge time deviation for injector 1 larger than OBD limit | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P02F1 | Voltage-governor input exceeds OBD-limit (Injector 4) | Actuator setpoint voltage deviation for injector 1 larger than OBD limit | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P02F1 | non-classifiable error [Has an error but not known] (Injector 4) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P02F2 | Discharge-time-governor input exceeds OBD-limit [Piezo discharge time exceeded threshold] (Injector 5) | Discharge time deviation for injector 3 larger than OBD limit | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P02F2 | Voltage-governor input exceeds OBD-limit (Injector 5) | Actuator setpoint voltage deviation for injector 3 larger than OBD limit | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P02F2 | non-classifiable error [Has an error but not known] (Injector 5) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P02F3 | Discharge-time-governor input exceeds OBD-limit [Piezo discharge time exceeded threshold] (Injector 6) | Discharge time deviation for injector 5 larger than OBD limit | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Fuel Injectors | P02F3 | Voltage-governor input exceeds OBD-limit (Injector 6) | Actuator setpoint voltage deviation for injector 5 larger than OBD limit | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P02F3 | non-classifiable error [Has an error but not known] (Injector 6) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P062B | non-classifiable error [Has an error but not known] | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P062D | Actuator ADC voltage below lower limit (Bank 1) | Voltage Input outside limits, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P062D | Short circuit to ground between ECU and Injector (Bank 1) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P062D | Short circuit to power between ECU and Injector (Bank 1) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P062E | Actuator ADC voltage above upper limit (Bank 2) | Voltage Input outside limits, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |
| | P062E | Short circuit to ground between ECU and Injector (Bank 2) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Fuel Injectors | P062E | Short circuit to powerbetween ECU and Injector (Bank 2) | Failure detected by the hardware, debounced | 3rd Cycle | Requires injector to be driven (or attempt to) | Two Type 1 Cycles | One Type 1 Cycles |

# 21 Engine Control Module (ECM) Internal Faults

## 21.1 Summary

Significant internal ECM failures have diagnostic routines to identify failure.
ECM internal functions and components monitored include:-

- Analogue to Digital converter (ADC)
- EEPROM
- Time Processing Unit (TPU)
- Module self-monitoring 'Watchdog'
- Processor temperature

Concern failure modes may cause adverse vehicle functionality, including shut down of the ECM. Failures of this type result in PCL warning lamp or engine off and are **not MIL active** with the exception of analogue to digital convertor faults.

## 21.2 DTC Table

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Monitoring alarm task period MoCSOP | P060A | OS timeout in the shut off path test. Failure setting the alarm task period. | Alarm task cannot be started | 1st Cycle (3rd off) | Active at Key On (happens once per cycle) | none | on 1st cycle |
| Monitoring CJ945 overvoltage detection ABE shut-off MoCSOP | P060A | Diagnostic fault check to report the error in overvoltage monitoring | ABE cannot be activated by overvoltage | 1st Cycle (3rd off) | Active at Key On (happens once per cycle) | none | on 1st cycle |
| | P060A | Diagnostic fault check to report the error in undervoltage monitoring | ABE cannot be activated by undervoltage | 1st Cycle (3rd off) | Active at Key On (happens once per cycle) | none | on 1st cycle |
| Monitoring CY320 WDA shut-off test MoCSOP | P060A | Diagnostic fault check to report that WDA is not working correct | injection shut-off via WDA not possible | 1st Cycle (3rd off) | Active at Key On (happens once per cycle) | none | on 1st cycle |

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Monitoring of the SPI during SOP test MoCSOP | P060A | Too many SPI errors during MoCSOP execution. | Too many SPI errors during MoCSOP execution. | 1st Cycle (3rd off) | Active at Key On (happens once per cycle) | none | on 1st cycle |
| Monitoring of timing of query-response-communication during SOP test MoCSOP | P060A | Wrong set response time | Wrong set response time | 1st Cycle (3rd off) | Active at Key On (happens once per cycle) | none | on 1st cycle |
| Monitoring time-out of shut-off path test MoCSOP | P060A | Diagnostic fault check to report that it was impossible to perform any injection | SOP test cannot be finished in time | 1st Cycle (3rd off) | Active at Key On (happens once per cycle) | none | on 1st cycle |
| Monitoring of the AD converter testvoltage conversion MoCADC | P060B | Diagnostic fault check to report the ADC test voltage error | conversion of testvoltage out of limits | 1st Cycle (3rd off) | Starts with ECU wakeup | none | on 1st cycle |
| Monitoring of the AD converter comparison of two independent AD converters MoCADC | P060B | Diagnostic fault check to report the comparison error in ADC monitoring | conversion deviation between both ADC | 1st Cycle (3rd off) | Starts with ECU wakeup | none | on 1st cycle |

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Monitoring of the AD converter monitoring of reference voltage of ADCs MoCADC | P060B | Diagnostic fault check to report the error in Voltage ratio in ADC monitoring | voltage ratio out of limits | 1st Cycle (3rd off) | Starts with ECU wakeup | none | on 1st cycle |
| ECU | P062D | DC/DC converter shut off | Failure detected by the hardware, debounced | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P062D | DC/DC converter failed | Failure detected by the hardware, debounced | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P062E | DC/DC converter shut off | Failure detected by the hardware, debounced | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| ECU | P062E | DC/DC converter failed | Failure detected by the hardware, debounced | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| Self Monitoring | P0A09 | Reported UnderVoltage of Supply | Voltage out of range Low | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |
| | P0A10 | Diagnostic fault check to report the error in overvoltage monitoring | Voltage out of range High | 3rd Cycle | Active at Key On | Two Type 1 Cycles | One Type 1 Cycles |

# 22 Turbocharger System

## 22.1 Summary

The turbocharger system consists of two turbochargers in a parallel sequential dual-mode turbocharger arrangement. Calibration maps are used to model the pressure ratio across the turbo's based on air flow. As the maps are threshold maps, an offset is applied to give the required separation. The calibration maps are then used to optimise the detection region and effectively zero the error where the normal operation is not clearly distinguishable from a failure condition.

- The low error is evaluated by subtracting the low threshold from the current pressure ratio.
- The high error is evaluated by the difference between the high threshold and the current pressure ratio.
- The lower threshold value is the upper band limit, naming is related to the low air mass flow which corresponds to a high pressure ratio across the compressor (e.g. compressor surge or recirculation valve stuck shut).
- The higher threshold value is the lower band limit, naming is related to the high air mass flow which corresponds to a low pressure ratio across the compressor (e.g. due to a leakage or recirculation valve stuck open).
- The error is defined as positive if the limits are outside the range and negative if the value is inside the expected range.

## 22.2 Functional Overview, Description, Monitoring & Substitute Function

Diagnosis during steady states (mono or bi turbo mode):-
The non-transition diagnosis is done to detect boost leaks on either bank (high errors) and compressor surge (low errors). The error which reflects the operation of the pressure ratio outside the defined trajectory band is limited and passed to an integrator element. The errors are integrated as long as no transition is active, and the integration results are compared with a threshold in order to evaluate the raw errors. After a time up/down debouncing, the certain DTC’s are set/reset.

The integration is performed only as long as no transition is active and in the current operation mode the diagnosis is disabled by a mask function, otherwise the integrators are reset to "0" and the error debouncing is not executed (i.e. even if the integrator is reset to "0", the healing of a potential error will not start). The integrator elements output is limited between the limits.

- The turbocharger actuator motor is switched off in case of errors to components that may cause irreversible damage to the turbocharger. This also leads to EGR shutdown.
- Default mode is engine torque output limitation and EGR shut down for selected faults.
- Faults leading to EGR shut down default mode are **'MIL active'**

## 22.3 DTC Table

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Turbocharger Boost | P023D | Overboost | Too high boost pressure with in injected fuel | 3rd Cycle | Engine overrun, no faults on sensors | Two Type 1 Cycles | One Type 1 Cycles |
| | P2263 | Boost Pressure govenor deviation | Unable to control to desired boost pressure | 3rd Cycle | Engine running | Two Type 1 Cycles | One Type 1 Cycles |

# 23 Intake Air Flow Throttle

## 23.1 Summary

The Intake Air Flow Control throttle [sometimes referred to as 'EGR Throttle'] position is used for smooth engine shut-off and improving EGR range during DPF Regeneration events. It is closed loop feedback controlled from the EGR throttle position sensor.

The EGR throttle position sensor diagnostics incorporate monitoring for circuit continuity, valve jamming, long & short time drifts and persistent governor demand deviations.

## 23.2 Functional Overview, Description, Monitoring & Substitute Function

For DPF variants, engine-running failures result in default to zero EGR – these faults are **MIL active.**

**Signal Range check:** If the valid ranges are exceeded a max or min range check fault is flagged.

**Circuit Continuity:** Checks for open circuit or short circuit to power or ground.

**Long Time and Short Time Drift:** An error is flagged if the change in fully closed and fully open valve position exceeds calibrated maxima. Separate assessments are conducted for short and long term errors.

**Governor Deviation [failure to reach desired position]:** Monitoring of permanent control deviation is only carried out if the position control of the throttle valve is within a certain state. Positive permanent control deviation is detected if the control deviation is above a calibrateable threshold and if the control deviation is present at least for the debounce time. Similarly, a negative deviation is detected for control deviations below a calibrateable threshold for a duration equal to the debounce time.

**Jammed Valve:** If a permanent control deviation fault is identified, the software attempts to recover the position deviation by means of the release function. If the deviation is not healed for the duration of the release function, a jammed valve is detected and monitoring for permanent control deviation is switched off, also making healing impossible. A timer is started when a jammed valve is detected, and when the timer reaches the calibrated value, monitoring for permanent control deviation detection is reactivated and if the position deviation fault is still present the release function process is started again. Permanent control deviation is also reactivated if the engine is stopped and restarted. This enables repeated breaking free immediately after each start in an effort to unstick the valve.

The inhibit function of the jammed valve error flag inhibits EGR function and in early versions enters torque limited operation.

## 23.3 DTC Table

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Electric Throttle Valve | P0407 | Short circuit to ground error | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P0408 | Short circuit to power error | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P046E | Fault path for short time drift | shortterm drift of endstop position diagnostic | 3rd Cycle | Disabled | Two Type 1 Cycles | One Type 1 Cycles |
| | P0486 | No load error | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P0487 | Open load error | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P0487 | Over current error | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P0487 | Over temperature error | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P0487 | Short circuit to power on Out1 error | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P0487 | Short circuit to power on Out2 error | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P0487 | Short circuit to ground on Out1 error | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P0487 | Short circuit to ground on Out2 error | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Electric Throttle Valve<br>Electric Throttle Valve | P0487 | Short circuit over load error | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P0487 | Temperature dependent over current error | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P0487 | Under voltage error | Failure detected by the hardware, debounced | 3rd Cycle | Requires valve to be driven | Two Type 1 Cycles | One Type 1 Cycles |
| | P1334 | Fault path for long time drift | Longterm drift of endstop position diagnostic | 3rd Cycle | Checked at Key Off when actuator adaption takes place. | Two Type 1 Cycles | One Type 1 Cycles |
| | P140F | DFC for SRC max(in case of Analog input) | Voltage Input outside limits, debounced | 3rd Cycle | Key On, No sensor supply errors | Two Type 1 Cycles | One Type 1 Cycles |
| | P140F | DFC for SRC min(in case of Analog input) | Voltage Input outside limits, debounced | 3rd Cycle | Key On, No sensor supply errors | Two Type 1 Cycles | One Type 1 Cycles |

# 24 Car Configuration File Data Checks (CCF)

## 24.1 Summary

Within the ECM there are a number of fault paths designed to detect errors with the car configuration file data (CCF).

These data are programmed into the ECM at the end of the vehicle assembly line. The fault paths detect errors in the flashing process or problems with the integrity of the dataset flashed into the ECM.

Within the Land Rover organisation these codes are assigned as MIL codes as the presence of accurate configuration data is essential for compliance with local emissions regulations.

## 24.2 DTC Table

| Component | Fault Code | Monitoring Strategy | Fault Detection Criteria | MIL Activation criteria | Secondary Parameters | Preconditioning | Demonstration test |
|---|---|---|---|---|---|---|---|
| Monitoring of the ROM MoCROM | P0605 | Diagnostic fault check to report multiple error while checking the complete ROM-memory | checksum error in memory block | 1st Cycle (3rd off) | Requires Afterun | none | on 1st cycle |
| Monitoring of the SPI MoCCom | P0606 | Diagnostic fault check to report errors in SPI-communication | corrupted SPI-communication with CY320 | 1st Cycle (3rd off) | Starts with ECU wakeup | none | on 1st cycle |
| Monitoring of the query-response-communication MoCCom | P0606 | Diagnostic fault check to report errors in query-/response-communication | corrupted query-response communication | 1st Cycle (3rd off) | Starts with ECU wakeup | none | on 1st cycle |
| Monitoring of query-response-communication during SOP test MoCSOP | P060C | Loss of synchronization sending bytes to the MM from CPU. | corrupted answer of CPU to MM | 1st Cycle (3rd off) | Active at Key On (happens once per cycle) | none | on 1st cycle |

## 25 Inspection Maintenance Readiness Code

I/M readiness information indicates whether a full diagnostic check has been completed since computer memory was last cleared. Information available to the test equipment or diagnostic tool includes all the non-continuous monitors.

**Tamper Protection**

The EOBD System shall meet ISO DIS 15031-7 / SAE J2186 - Diagnostic Data Link Security requirements, to write-protect any re-programmable computer code. Additional data will be stored in the ECM Vehicle Identification Block to enable retrieval of VIN (although VIN may not be in the VID block for all vehicles). CALID (CALibration ID) identifies the specific calibration and is defined as 16 alphanumeric characters: calibration name, type of vehicle, release date, release engineer and version number.. CALID will be tracked for all initial releases, running changes and field fixes.

To achieve this data retrieval J1979 Mode 09 will be implemented for VIN and CALID.

**Serial Data Link Connector (DLC)**

The connection between the vehicle and the diagnostic tester shall comply with ISO DIS 15031-3 "Road vehicles – Communication between vehicle and external test equipment for emissions-related diagnostics - Part 3: Diagnostic connector and related electrical circuits: specification & use", dated 1 November 2001. The installation position must be subject to agreement of the approval authority such that it is readily accessible by service personnel but protected from accidental damage during normal conditions of use.

**Serial Data Link Communication Protocol**

The Communication Protocol used by the EOBD system will conform to ISO DIS 15765-4 "Road vehicles – Diagnostics on Controller Area Network (CAN) – Part 4: Requirements for emissions related systems", dated 1 November 2001

Basic diagnostic data and bi-directional control information will be provided using the format and units as described in ISO DIS 15031-5 "Road vehicles – Communication between vehicle and external test equipment for emissions-related diagnostics – Part 6: Diagnostic trouble code definition" and will be available to Test equipment and diagnostics tools meeting the requirements of ISO DIS 15031-4 "Road vehicles – Communication between vehicle and external test equipment for emissions-related diagnostics – Part4: External test equipment", dated 1 November 2001.

**Serial Data Link MIL Illumination**

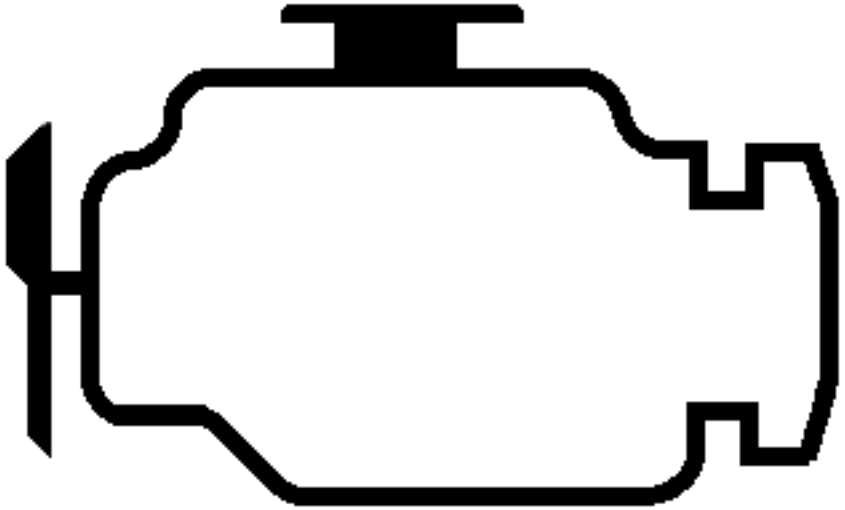
The instrument cluster on some vehicles uses the ISO DIS 15031-4 / SAE J1850 serial data link to receive and display various types of information from the ECM. For example, the engine coolant temperature information displayed on the instrument cluster comes from the same ECT sensor used by the ECM for all its internal calculations.

These same vehicles use the CAN link to illuminate the MIL rather than a circuit, hard-wired to the ECM. The ECM periodically sends the instrument cluster a message, which tells it to turn on or turn off the MIL. Due to its limited capabilities, the instrument cluster does not generate or store Diagnostic Trouble Codes.

## 26 Glossary Of Terms

| | |
|---|---|
| A/D | Analogue to Digital |
| CALID | CALibration IDentification |
| CID | Camshaft Identification. |
| CKP | Crankshaft Position |
| CMP | Camshaft Position |
| CVN | Calibration Verification Number |
| DPF | Diesel Particulate Filter |
| DSM | Diagnostic System Management |
| DTC | Diagnostic Trouble Code |
| ECM | Engine Control Module |
| ECU | Electronic Control Unit – generic term for all modules |
| ECT | Engine Coolant Temperature |
| EDC | Electronic Diesel Control (Bosch generic term) |
| EGR | Exhaust Gas Re-circulation. |
| EOBD | European On Board Diagnostics |
| EVP | EGR Valve Position |
| EVR(V) | Electronic Vacuum Regulator (Valve) |
| FACM | Fuel Additive Control Module |
| FGT | Fixed Geometry Turbocharger |
| Fid | Function Identifier |
| MAF | Mass Air Flow |
| MAP | Manifold Absolute Pressure |
| MIL | Malfunction Indicator Lamp |
| NPL | Non Plausibility |
| PCL | Powertrain check lamp |
| PCM | Powertrain Control Modules (an ECM or a TCM) |
| PWM | Pulse Width Modulated (signal) |
| SAE | Society of Automotive Engineers |
| SCP | Short Circuit to Power |
| SCG | Short Circuit to Ground |
| SREA | Simple Rotary Electronic Actuator (for turbocharger) |
| SRC | Signal Range Check |
| TCM | Transmission Control Module |
| VID | Vehicle IDentification |
| VIN | Vehicle Identification No. |
| VGT | Variable Geometry Turbocharger |
| WAL | Warning Lamp |

## 27 MIL Symbol



ISO MIL Symbol to be used on all Bosch EOBD Applications.