

JAGUAR

**ON BOARD DIAGNOSTIC SYSTEM DESCRIPTION
5.0L V8 SC AJ 133 ENGINE MANAGEMENT SYSTEM**

Vehicle Coverage:
Jaguar F-Type 2014 MY

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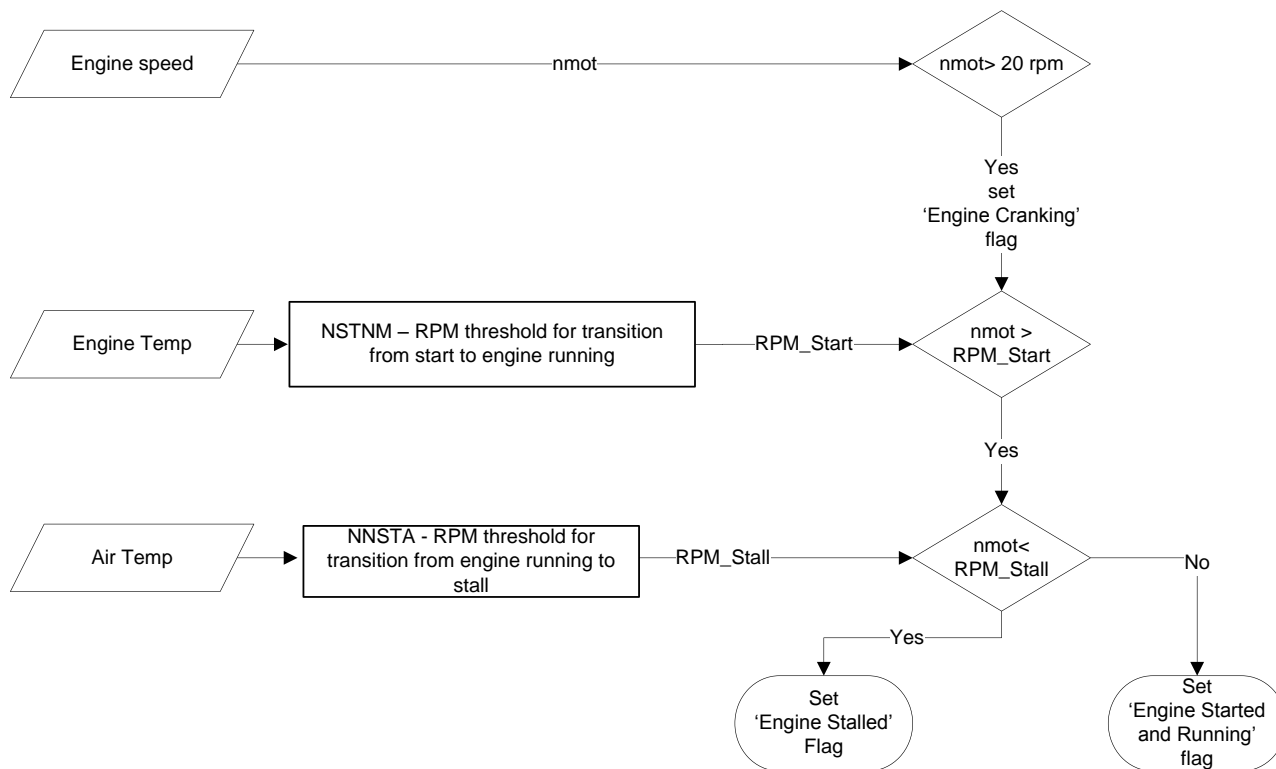
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1. Engine started and running

The engine is classified as cranking if the engine speed is greater than 20 rpm. An engine running condition is determined if the engine speed exceeds a coolant temperature based threshold and does not fall below an intake air temperature based threshold.

1.1. Engine Start – System Flowchart

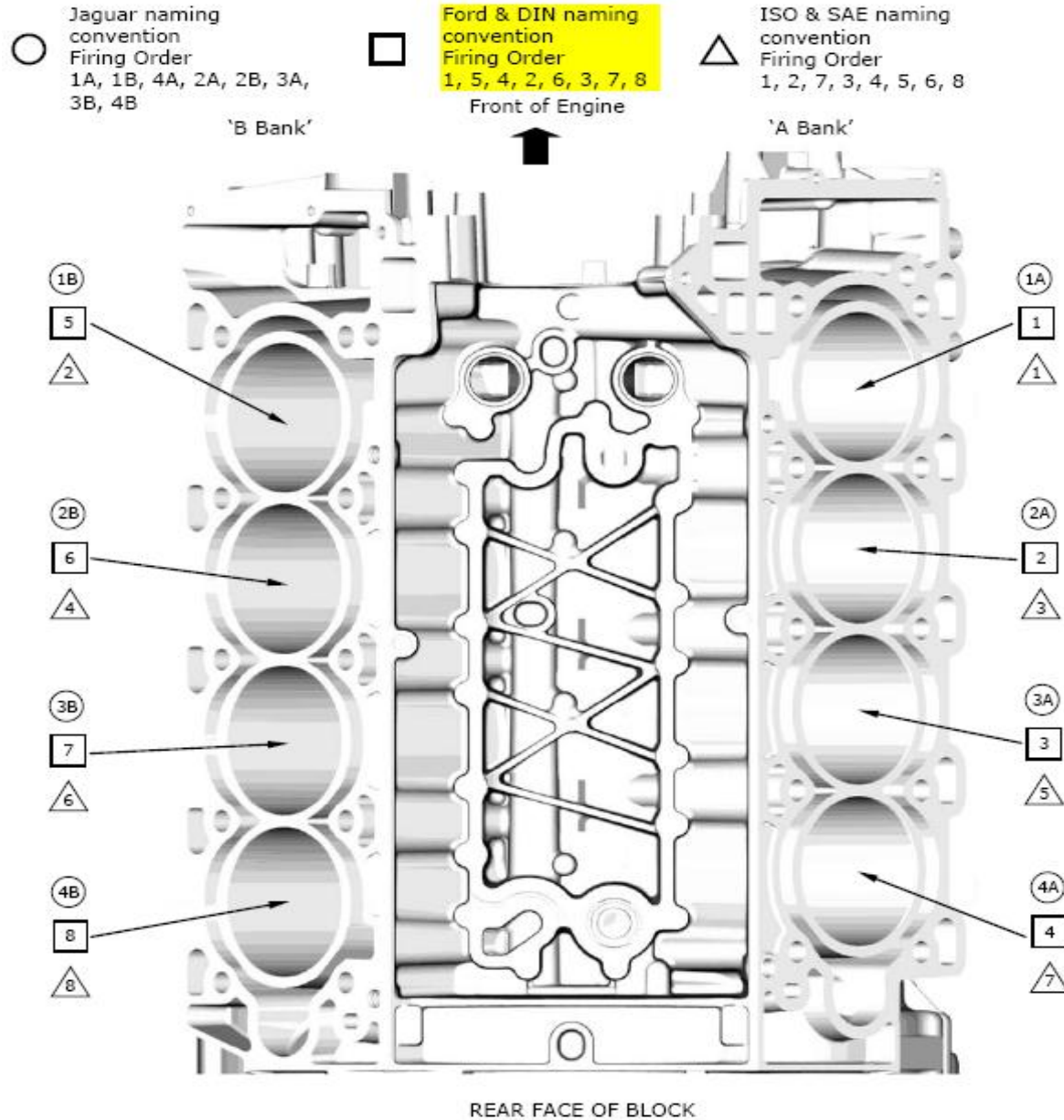


NSTNM						
°C	-15	0	20.25	39.75	60	80.25
rpm	920	840	760	640	640	640

NNSTA			
°C	-30	-9.75	20.25
rpm	120	120	120

2. Engine Cylinder Numbering and Firing Order

2.1. V8



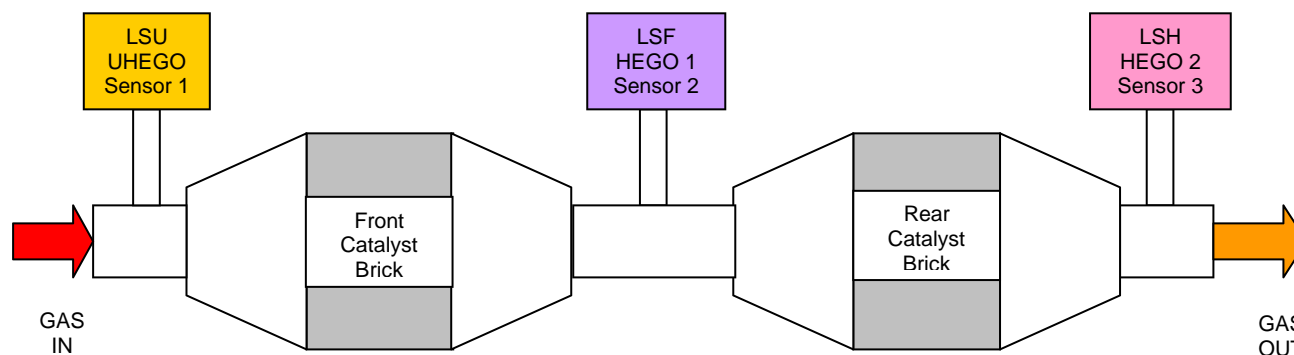
3. Catalyst Monitoring

3.1. Fault Codes

P0420 - Catalyst System Efficiency Below Threshold (Bank 1)

P0430 - Catalyst System Efficiency Below Threshold (Bank 2)

3.2. System Overview



The Bosch ME17 EMS provides stoichiometric homogenous fueling with a Pt/Ph/Rh three way catalytic convertor (TWC) to achieve the legislated HC, CO and NOx emission control. Each cylinder bank of the 'V' engine configuration has its own dedicated catalyst and sensor system. This system consists of a front and rear split catalysts with three sensors. Sensor 1 is a wide band UHEGO LSU sensor and is mounted upstream (engine side) of the front catalyst providing primary fueling control. The second (LSF) and third (LSH) sensors are binary HEGO sensors, the LSF being located between the pre and main catalysts with the LSH downstream of the main catalyst. The HEGO sensors are used to provide secondary fueling control to ensure efficient catalyst operation with the LSF sensor being used to monitor catalyst efficiency. Sensor and bank references are as follows, LSU - sensor 1, LSF - sensor 2 and LSH - sensor 3. Bank references are 1 and 2. For example 1, sensor 2 bank 1 refers to the LSF on bank 1 and sensor 1 bank 2 is the LSU sensor bank 2.

3.3. Strategy Description

3.3.1. Oxygen Storage Capacity (OSC) and catalyst efficiency evaluation

Legislation requires that if catalyst efficiency has dropped below 50% or exceeds OBD emission limits then a system fault must be diagnosed and declared. Catalytic conversion is dependent upon free oxygen in the catalyst and catalyst efficiency is determined through OSC assessment. This is achieved by actively removing the oxygen content in the catalyst (by using UHEGO controlled rich fuelling) and then introducing a known oxygen volume (UHEGO controlled lean fuelling) and observing HEGO activity. Differing OSC will give different HEGO activity, the analysis of which is used to determine catalyst condition.

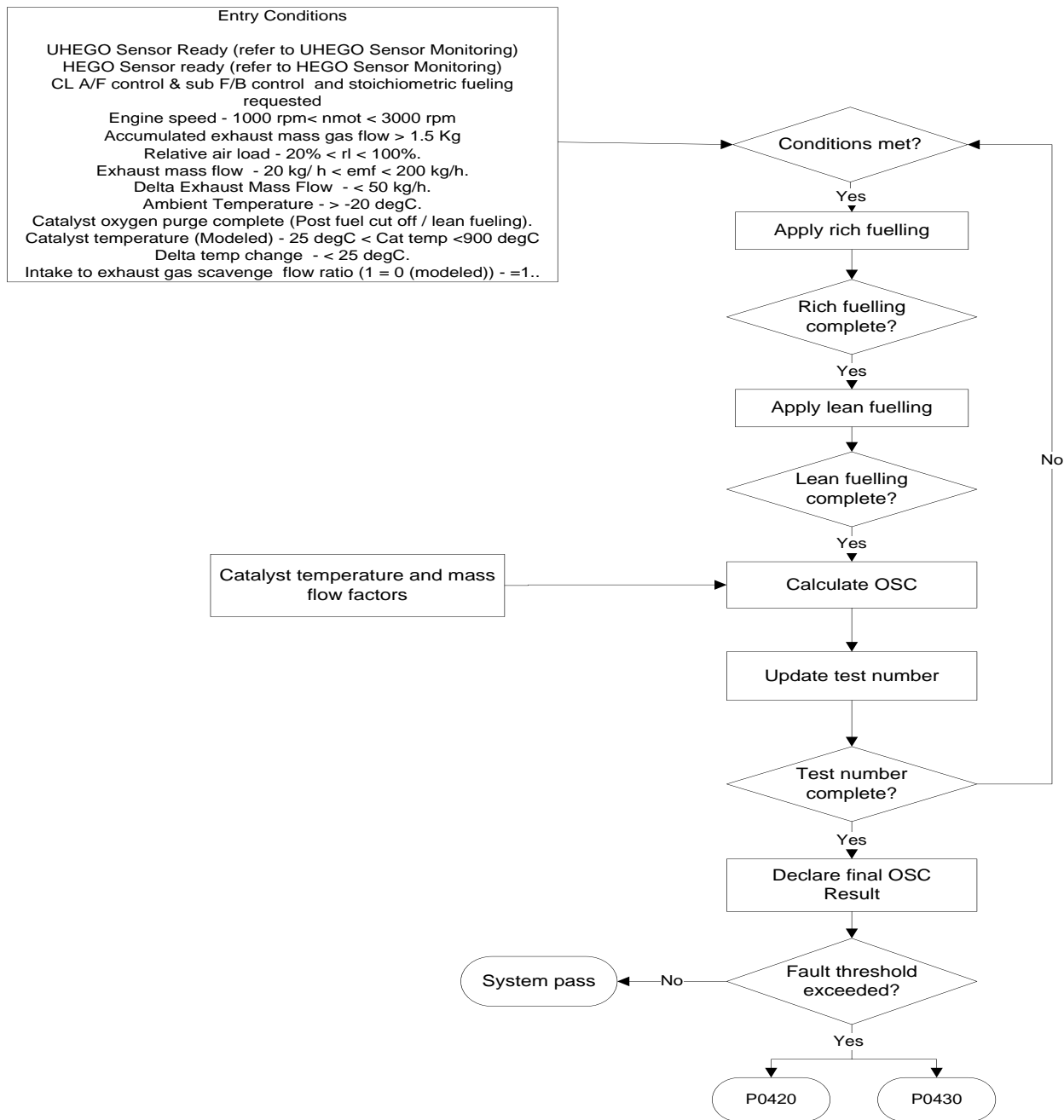
3.3.2. Diagnosis constraints

The monitor operates once per drive cycle. The efficiency analysis will only take place once the catalyst has reached acceptable operational conditions. Other conditions are used to ensure that steady state conditions are satisfied to avoid transient mass flow or temperature influences. Analysis can only take place if other system fault conditions are compatible. The conditions required for consistent analysis are outlined in 3.4. The diagnosis will not begin until these conditions are met and the diagnosis will suspend if the conditions are exited. If these conditions are met again then the diagnosis will continue, but if several diagnosis attempts are made without satisfactorily being completed or a time limit exceeded then the analysis is reset. A full diagnosis is made once per trip and the results stored for In Use Monitor Performance Ratio (IUMPR) reporting.

3.3.3. Failure Criterion

The rich to lean HEGO response is averaged over a number of rich lean shifts to determine the final OSC. The final OSC is then compared to a failure threshold and a pass or fail judgment made. This failure threshold is determined from a catalyst whose OSC is just sufficient enough to provide catalytic conversion that meets the legislative requirement. Two major factors that influence OSC are catalyst temperature and exhaust mass flow and the failure threshold is adjusted for these, allowing the HEGO analysis to provide consistent, repeatable analysis across all its operational ranges.

3.4. Catalyst Monitor Diagnosis – System Flowchart and Tables



Catalyst Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Catalyst Monitoring								
Catalyst efficiency bank A (DKATSPEB/DKATEVAL/DKATSP) KAT KAT2	P0420 P0430	Oxygen storage capacity assessment of catalyst	Oxygen storage capacity of catalyst assessed through rich to lean fuel changes. An averaged value over four results, weighted for mass flow and temperature is compared to the OSC of that for a limit catalyst. This ratio is then compared to a failure threshold.	See KFOSCD (table) (OSCKTD) Ratio = 1	UHEGO Sensor Ready - HEGO (LSF/LSH) Sensors ready - CL A/F control & sub F/B control and stoichiometric fueling requested - Engine speed - Accumulated exhaust mass gas flow - Relative air load - Exhaust mass flow - Delta Exhaust Mass Flow - Ambient Temperature - Catalyst oxygen purge complete (Post fuel cut off / lean fueling). Catalyst temperature (Modeled) - Delta catalyst temp change -	See description document '8. UHEGO Sensor Monitoring' See description document '9. HEGO Sensor Monitoring' 1080 rpm < nmot < 2000 rpm > 11.5 Kg RLKTDMM % < rl < RLKTDMM % (table) 20 kg/h < msabvvk < 120 kg/h < 35 kg/h > -48 °C 500 °C < tkivkm_w < 800 °C < 25 °C in 10s	20 s	2 Drive Cycles

Catalyst Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
					Fault codes that disable P0420	P013E, P0138, P0137, P0141, P0136, P0054, P013A, P0038, P0037, P0036, P2270, P2271, P0103, P0102, P0100, P00BD, P00BC, P010D, P010C, P010A, P00BF, P00BE, P010B, P0101, P0236 (Bnpl), P0236 (Bsig), P0236 (Pmax), P0236 (Pmin), P0236 (Psig), P0236 (Bmax), P0236 (Bmin), P0238, P0237, P06A6, P2177, P2178, P2187, P2188, P0496, P0497, P0300, P0133, P2231, P2626, P0118, P0117, P000D, P0024, P2095, P2094, P0023, P2091, P2090, P0013, P000B, P0014, P000C, P0021, P2093, P2092, P0020, P2089, P2088, P0010, P000A, P0011, P0032, P0031, P0030, P0135, P00D1 (npl), P00D1 (sig), P064D (max), P064D (min), P064D (npl), P064D (sig), P2237 (max), P2237 (npl), P2237 (sig), P0132, P0131, P2243, P2251, P0130, P2195, P2196, P0170, P0116 (Pmax), P0126, P0116 (Pnpl), P0116 (CSmax), P0116 (CSmin), P0119, P0134, P0501, P0500, P2135, P0040, P0300, P0459, P0458, P0444		
					Fault codes that disable P0430	P014A, P0158, P0157, P0161, P0156, P0060, P013C, P0058, P0057, P0056, P2272, P2273, P0496, P0497, P2179, P2180, P0103, P0102, P0100, P00BD, P00BC, P010D, P010C, P010A, P00BF, P00BE, P010B, P0101, P2189, P2190, P0236 (Bnpl), P0236 (Bsig), P0236 (Pmax), P0236 (Pmin), P0236 (Psig), P0236 (Bmax), P0236 (Bmin), P0238, P0237, P06A6, P0496, P0497, P0153, P2234, P2629, P0155, P00D3, P00D3, P0052, P0051, P0050, P064E (max), P064E (min), P064E (npl), P064E (sig), P2240 (max), P2240 (npl), P2240 (sig), P0152, P0151, P2247, P2254, P0150, P2197, P2198, P0173, P0118, P0117, P0154, P000D, P0024, P2095, P2094, P0023, P2091, P2090, P0013, P000B, P0014, P000C, P0021, P2093, P2092, P0020, P2089, P2088, P0010, P000A, P0011, P0116 (Pmax), P0126, P0116 (Pnpl), P0116 (CSmax), P0116 (CSmin), P0119, P0501, P0500, P2135, P0040, P0300, P0459, P0458, P0444		

RLKTDMM minimum relative air charge for catalyst diagnosis

P0420 - Catalyst efficiency bank A

P0430 - Catalyst efficiency bank B

input x	rpm	1080	1200	1520	2000	2200
output w	%	17	17	18	22	25

RLKTDMMX maximum relative air charge for catalyst diagnosis

P0420 - Catalyst efficiency bank A

P0430 - Catalyst efficiency bank B

input x	rpm	1080	1200	1520	2000	2200
output w	%	60	70	75	75	75

KFOSCD calculation of borderline OSC, 1st cat. bank 1/2 / map of end of life catalyst

P0420 - Catalyst efficiency bank A

P0430 - Catalyst efficiency bank B

		y \ x	450	500	550	600	650	700	750	800
input x	°C	20	12.8	13.6	14.4	15.2	16	16.8	17.6	17.6
input y	kg/h	30	12.8	13.6	14.4	15.2	16	16.8	16.8	17.6
output w	mg	40	12.8	12.8	13.6	15.2	15.2	16	16.8	16.8
		50	12	12.8	13.6	14.4	15.2	16	16	16
		60	12	12.8	13.6	14.4	15.2	15.2	16	16
		80	12	12.8	13.6	14.4	14.4	15.2	15.2	16
		100	12	12.8	12.8	13.6	14.4	14.4	15.2	15.2
		130	11.2	12	12.8	13.6	13.6	14.4	14.4	15.2

4. Misfire Monitoring

4.1. Fault Codes

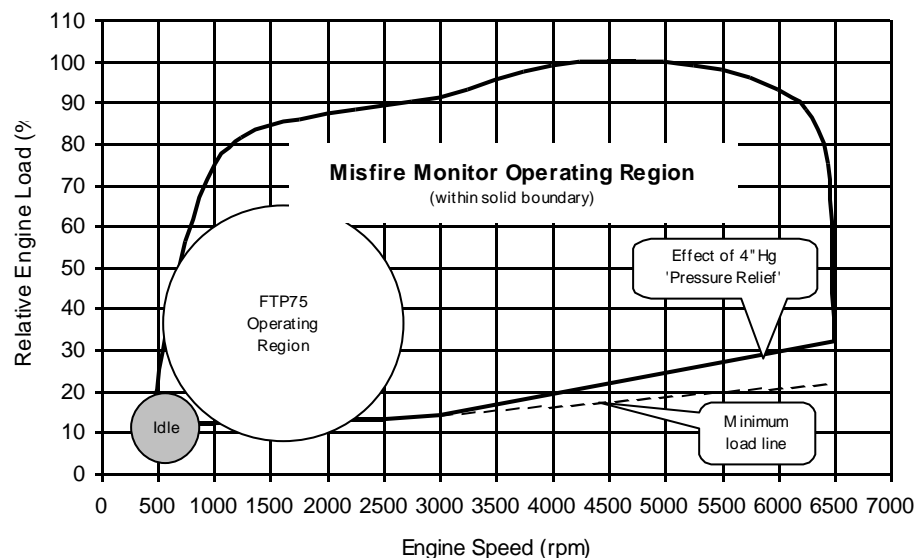
- P0300 - Random Misfire Detected
- P0301 - Cylinder 1 Misfire Detected
- P0302 - Cylinder 2 Misfire Detected
- P0303 - Cylinder 3 Misfire Detected
- P0304 - Cylinder 4 Misfire Detected
- P0305 - Cylinder 5 Misfire Detected
- P0306 - Cylinder 6 Misfire Detected
- P0307 - Cylinder 7 Misfire Detected (V8 only)
- P0308 - Cylinder 8 Misfire Detected (V8 only)
- P1315 - Misfire with the potential for Catalyst Damage

4.2. System Overview

The misfire detection monitor runs continuously and is designed to detect levels of misfire that can cause thermal damage to the catalyst or result in excessive tailpipe emissions. Determination of a misfire is made by analysis of changes in crankshaft speed, since a misfire will cause a fall in speed after a faulty firing event. This data is processed by three main algorithms to ensure the detection of all possible combinations of misfire.

The results of the misfire judgment process for each firing event are used to determine whether two failure levels have been met, 'catalyst damage' misfire and 'excess emissions' misfire. Each fault judgment process has its own failure threshold and calculation period.

The misfire monitor operates continuously within the boundaries of the regulated monitor operation window, as shown below.



Region of misfire monitor operation

After engine start, the monitor will be enabled as soon as the engine speed rises above the minimum operation speed (150 rpm below fully warm stabilised idle speed). 2 revolutions of crank angle data, i.e. one sample of data from each cylinder firing, must then be 'buffered' before any decisions can be made by the monitor.

4.3. Strategy Description

4.3.1. Introduction

Different sections of the monitor operate at different 'loop' rates. 4.4 details the decisions made for each firing event in approximate chronological order, although some steps may not be made every 'loop'. Further explanation of these decisions is given below:

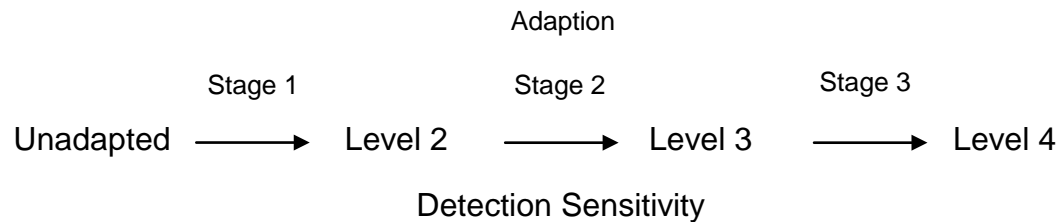
4.3.2. Recording segment time and position, and its manipulation

The monitor utilises a 60 tooth trigger wheel with 2 missing reference teeth and an inductive sensor. From the crank signal a 'crankshaft segment time' is formed from a relevant combustion stroke. This measurement is taken over a set crankshaft rotation (segment) whose length and starting point relative to TDC can be defined. The segment times of firing and non-firing events will be different. The combination of starting point and segment period can be optimized to maximize this difference and generate the most robust misfire detection possible. The segment time for each combustion stroke is then held in a buffer and is used to form an 'engine roughness measure'. This roughness value is used in the misfire judgment decision.

Due to the differing combustion conditions found during catalyst heating, a separate definition of start point and crank duration can be used which will improve post start misfire detection.

4.3.3. Adjustment of crank angle tolerance/engine roughness values

To accommodate for differences in production tolerances and combustion influences 'crankshaft adaption' can be applied to refine segment times and roughness values. The whole adaption process operates in three stages, each stage being designed to improve detection and produces four levels of sensitivity as shown below.



Stage one is a 'fuel off' adaption, accounts for mechanical differences such as irregular tooth profile and occurs during fuel cut off conditions. Stage one must be completed before any other adaption stage can begin. Stages two and three are a 'fuel on' condition and introduce the influences of combustion and apply over a speed and load matrix. Stage two will apply the same adaption for all loads at a particular speed that have been derived from a 'dominant' load site. Once this dominant adaption has been completed stage three adaption is allowed and will occur at the individual load points at that particular speed. The actual adaption value is calculated through interpolation of the relevant speed and load values in this matrix. Since there can be a mixture of adaption states, when interpolating the lowest adaption status of the calculation group is used.

Stage one adaption is applied to the crank segment times with stage two and three being applied to the processed engine roughness values and are cylinder specific.

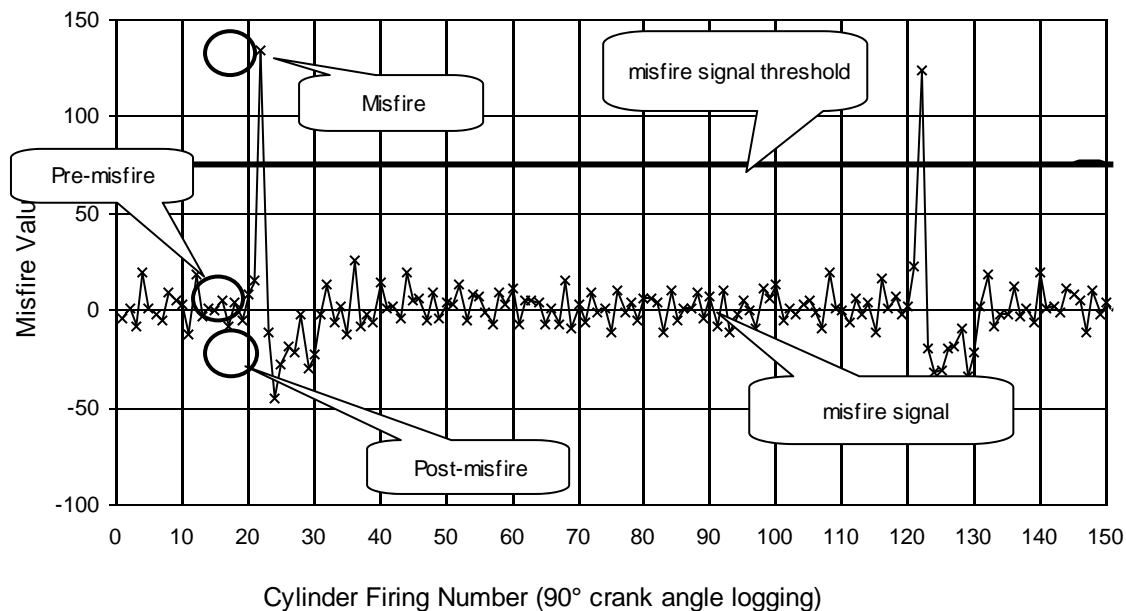
A separate adaption process is performed for the alternative catalyst heating segment set up.

4.3.4. Storing adaption values in back-up memory

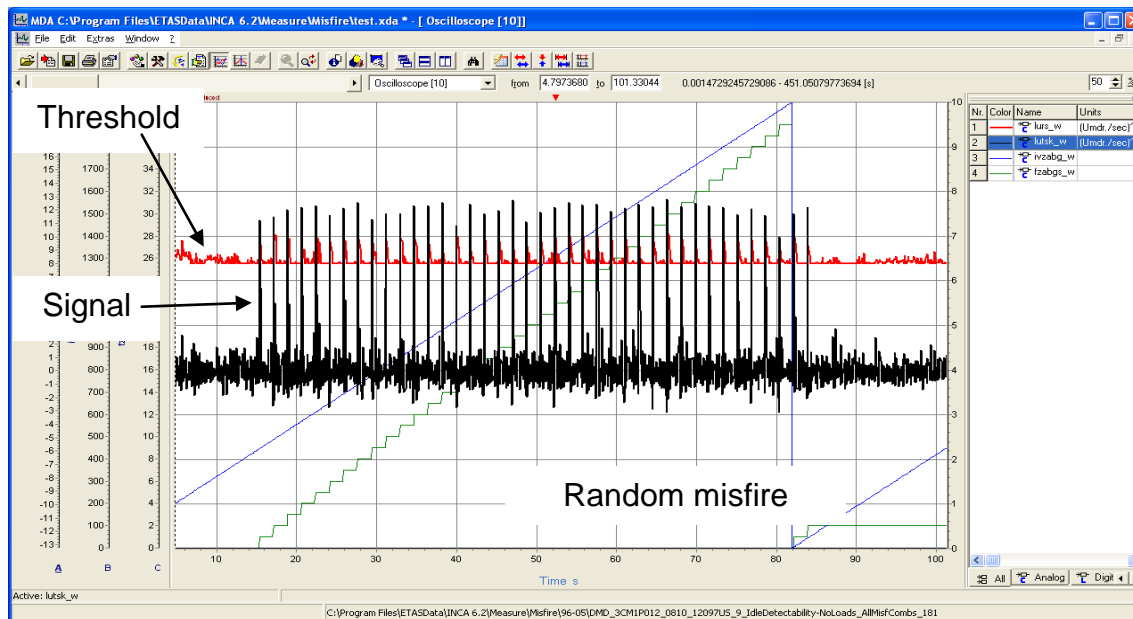
Adaption values are kept in non-volatile memory, which can only be reset by a service tester. Upon 'ignition on' these adaption values are copied to a backup memory and are initially used to calculate any signal corrections. The adaption procedure is controlled by a set of strict constraints. These safeguards ensure that where fault conditions, irregular running, dynamic effects or misfiring conditions are present, adaption will not occur and the process will be suspended or reset. If conditions are satisfied and sufficient adaption data is available then the backup adaption values can be updated. Upon 'ignition off' these backup values are used to update the non-volatile memory, thus being retained for the next trip.

4.3.5. Misfire 'signal' calculation and misfire judgement

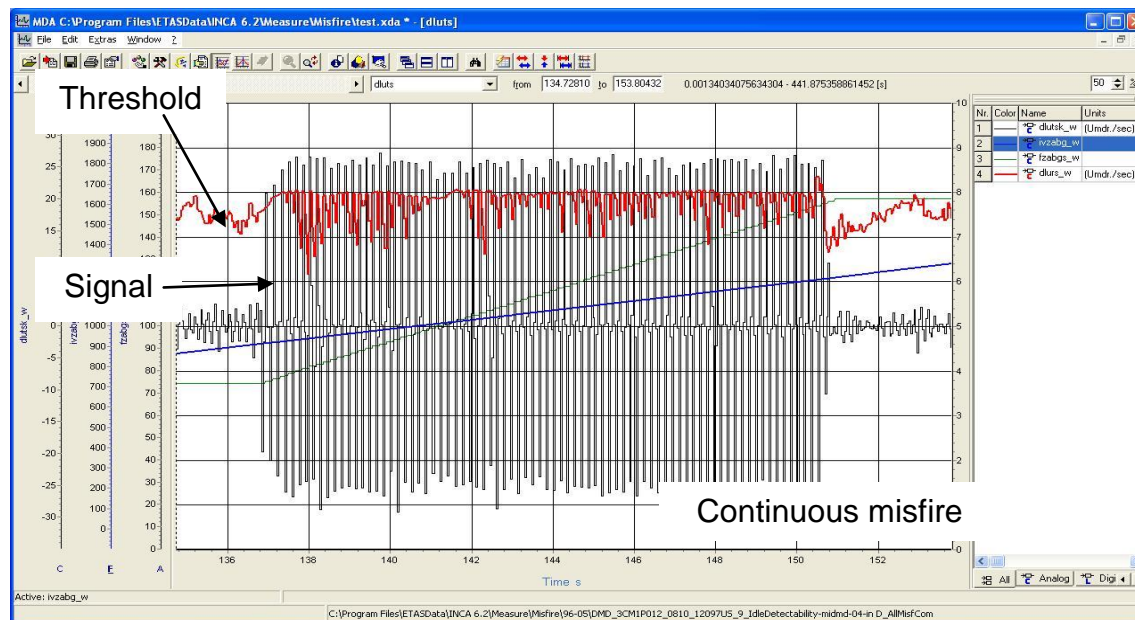
The three detection algorithms consist of a main method with two support methods which are specifically designed to detect certain 'patterns' of misfire. All methods operate using an 'OR' authority, the combination of which aims to maximize misfire detection probability. The basic misfire signal and decision process is as below



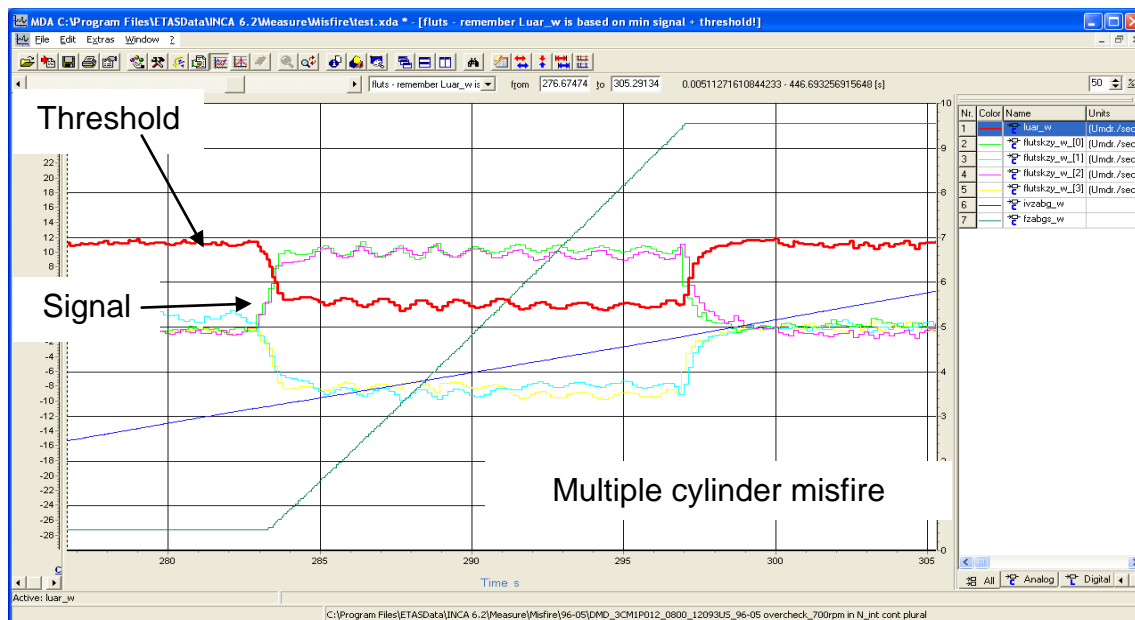
The main method will manipulate the crankshaft segment time into the engine roughness value by comparison of the segment times of two consecutive combustions for each cylinder. This value is then compared to a speed / load threshold and if this is exceeded, a misfire judgment is declared.



One of the support methods compares engine roughness values staggered by 360° crank angle and compares the result to a separate speed / load based threshold. This function enhances the ability to detect random and continuous misfire patterns on rotating cylinders.



The second support method is designed to aid in the detection of continuous misfire of one or more cylinders. It utilizes a low pass filter on the individual cylinder roughness values and compares this to a speed / load based threshold.



The relevant thresholds for all methods can be altered by a coolant based factor to allow for warm up effects on combustion. During catalyst heating the threshold can be adjusted to compensate for the differing combustion conditions to allow detection levels to be optimized. With each misfire judgment a cylinder counter is updated and used in later analysis.

4.3.6. Catalyst damage judgement

P1315 and specific misfiring cylinder codes. If 200 revolutions of misfire judgments have been made the monitor will make an assessment as to whether 'catalyst damage' levels of misfire have been exceeded or not. The failure level is determined from a look up table. The sum of individual cylinder misfire counters is then compared against this threshold.

4.3.7. Excess emissions judgement

P0300 and specific misfiring cylinder codes. An 'excess emission judgment' is made over a 1000 revolution period. The monitor will make an assessment as to whether 'emissions failure' levels of misfire have been exceeded or not. The failure level is a single threshold value. The sum of individual cylinder misfire counters is compared against this threshold and if exceeded a fault decision made. The declaration will be made as soon as the threshold is passed and does not wait until the end of the 1000 revolution block.

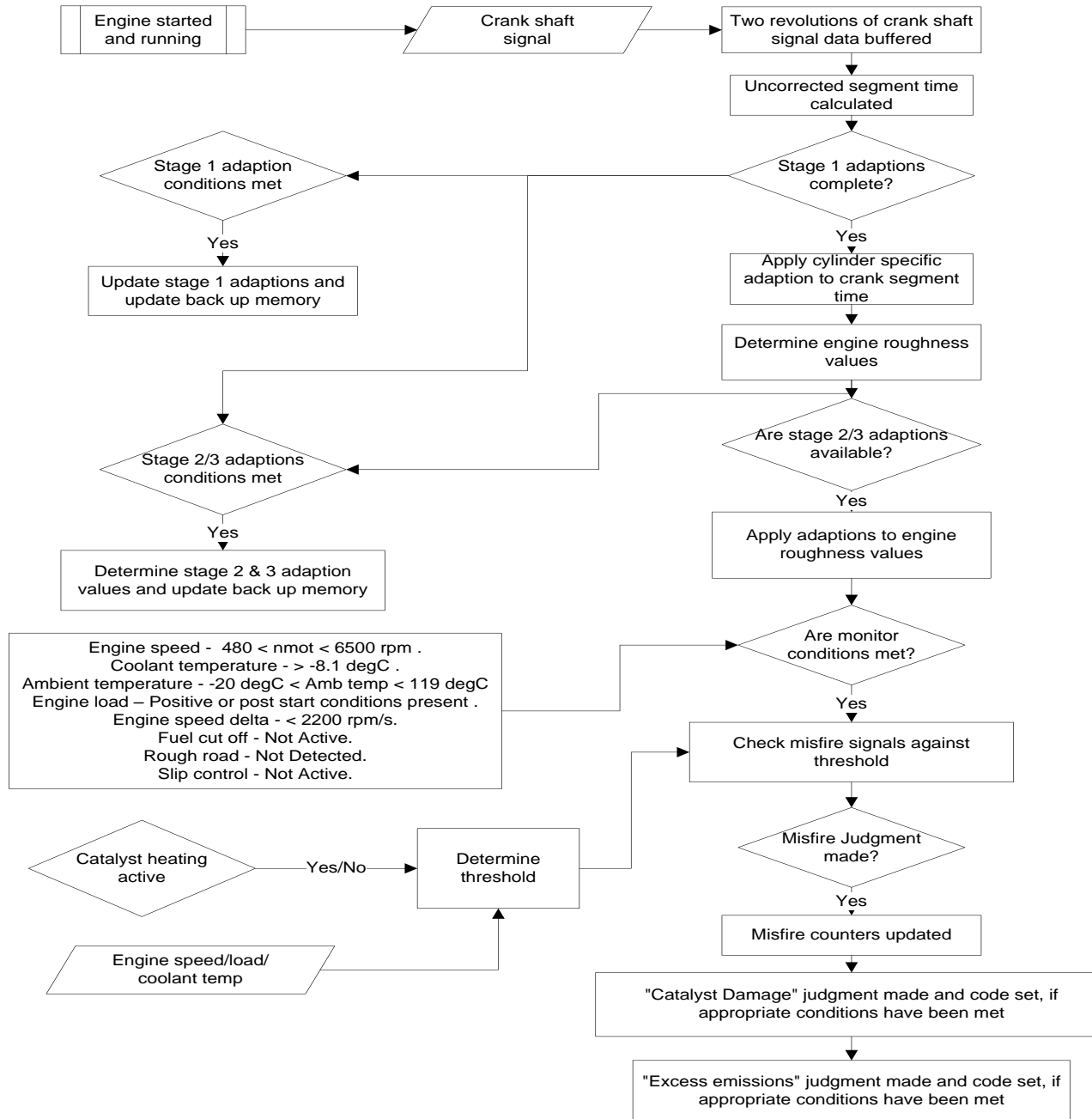
4.3.8. Monitor execution check

Different monitor enable conditions are checked depending upon the operating condition of the engine (for example, fewer conditions apply during engine start). If all the appropriate enable conditions are met the monitor execution flag is set.

4.3.9. Rough road

A rolling average of 'delta' wheel speed data is calculated from ABS vehicle speed data that is transmitted over the CAN network. This data is compared to calibrated thresholds to determine if the vehicle is being driven over a rough surface that causes misdiagnosis of a misfire. If a rough road judgment is made the appropriate flag is set and taken into account the next time monitor execution conditions are checked.

4.4. Misfire Monitor – System Flowchart and Tables



Misfire Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Misfire Monitoring								
(DMDMIL) Random Misfire Detected	P0300	Crank speed fluctuation	Misfire at catalyst damage level (200 rev block) or Misfire at excess emissions level:	> See Misfire Charts Below > 2.60 %	Engine speed - Coolant temperature - Ambient temperature - Engine load - Engine speed delta - Fuel cut off - Altitude - Rough road - Slip control -	480 < nmot < 6500 rpm > -8.1 °C -20 °C < tumg < 119 °C Positive or post start condition < 2200 rpm/s Not Active. < 9900 ft Not Detected Not Active	Depends on engine speed, misfire pattern and time after engine start	1 Drive Cycle for catalyst damage 2 Drive Cycles for excess emissions
Misfire cylinder 1	P0301							
Misfire cylinder 2	P0302							
Misfire cylinder 3	P0303							
Misfire cylinder 4	P0304							
Misfire cylinder 5	P0305							
Misfire cylinder 6	P0306							
Misfire cylinder 7	P0307							
Misfire cylinder 8	P0308							
Catalyst damaging misfire	P1315							
Misfire at low fuel level	P131A							
					Fault codes that disable P0300 P0336, P0335 Fault codes that disable P0301 P0351, P2301, P2300 Fault codes that disable P0302 P0352, P2304, P2303 Fault codes that disable P0303 P0353, P2307, P2306 Fault codes that disable P0304 P0354, P2310, P2309 Fault codes that disable P0305 P0355, P2313, P2312 Fault codes that disable P0306 P0356, P2316, P2315 Fault codes that disable P0307 P0357, P2319, P2318 Fault codes that disable P0308 P0358, P2322, P2321			

Catalyst Damage Misfire Percentage

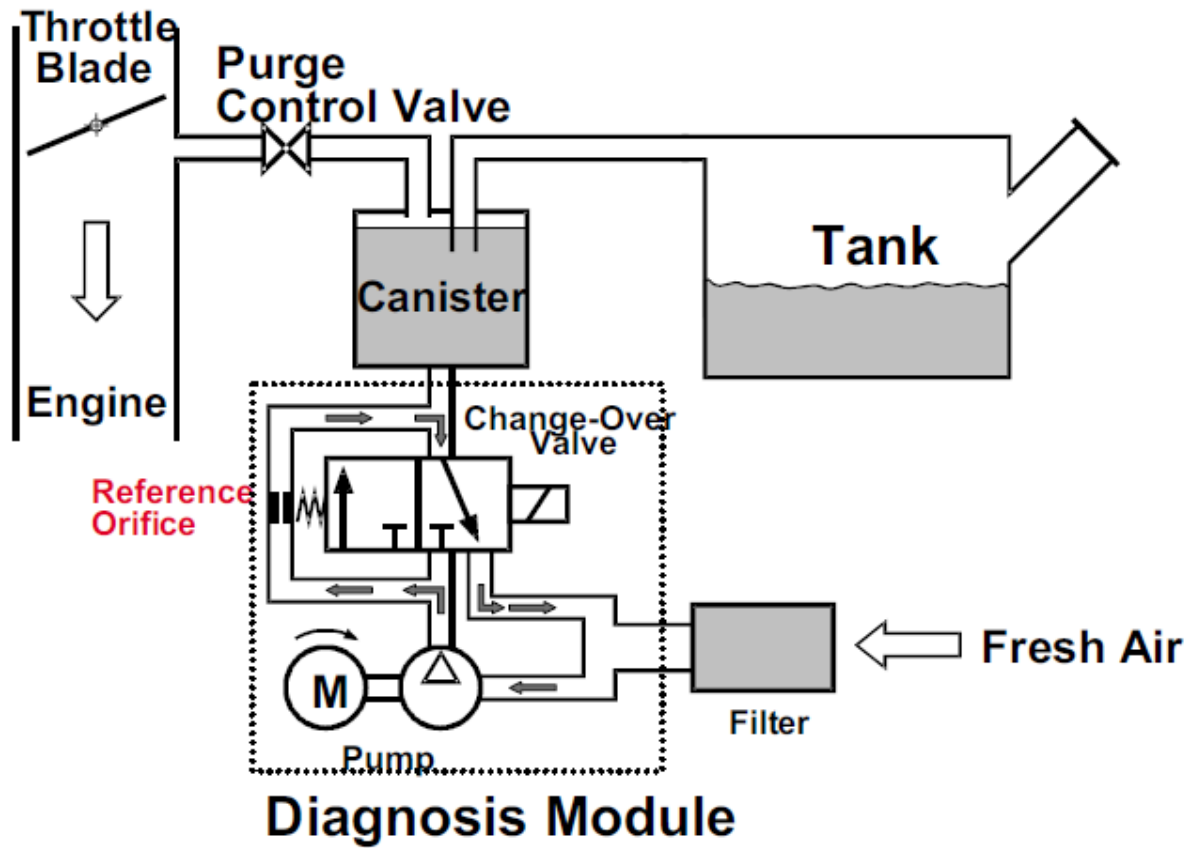
		Engine Speed rpm					
		1480	2240	3000	4000	5000	5760
Engine Load %	20%	5.5%	5.5%	5.5%	5.5%	2.5%	2.5%
	25%	5.5%	5.5%	2.5%	2.5%	2.5%	2.5%
	30%	5.5%	5.5%	2.5%	2.5%	2.5%	2.5%
	45%	5.5%	2.5%	2.5%	2.5%	2.5%	2.5%
	60%	5.0%	2.5%	2.0%	2.0%	2.5%	2.5%
	80%	5.0%	5.0%	2.5%	2.5%	2.5%	2.5%

5. Evaporative System Monitoring

5.1. Fault Codes

- P0442 - Evaporative Emission System Leak Detected (small leak)
- P0456 - Evaporative Emission System Leak Detected (very small leak)
- P0457 - Evaporative Emission System Leak Detected (fuel cap loose/off)
- P2406 - Reference current high (See Summary Table)
- P2405 - Reference current low (See Summary Table)
- P2407 - Reference current plausible (See Summary Table)
- P043F - Reference current frequency high (See Summary Table)
- P043E - Reference current frequency low (See Summary Table)
- P2404 - COV current low (See Summary Table)
- P2402 - Pump electrical high (See Summary Table)
- P2401 - Pump electrical low (See Summary Table)
- P2400 - Pump electrical open circuit (See Summary Table)
- P2420 - COV electrical high (See Summary Table)
- P2419 - COV electrical low (See Summary Table)
- P2418 - COV electrical open circuit (See Summary Table)
- P240C - Pump heater high (See Summary Table)
- P240B - Pump heater low (See Summary Table)
- P240A - Pump heater open circuit (See Summary Table)

5.2. System Schematic



5.3. System Description

The evaporative monitoring system being used permits the detection of leaks with a diameter of 0.5 mm (20 thousandths of an inch) or greater.

This is achieved by means of a pressure test of the system. This is performed by the Diagnostic Module - Tank Leakage (DMTL), which is an electrically operated pump fitted to the atmospheric air intake of the charcoal canister.

The test proceeds in 2 stages:

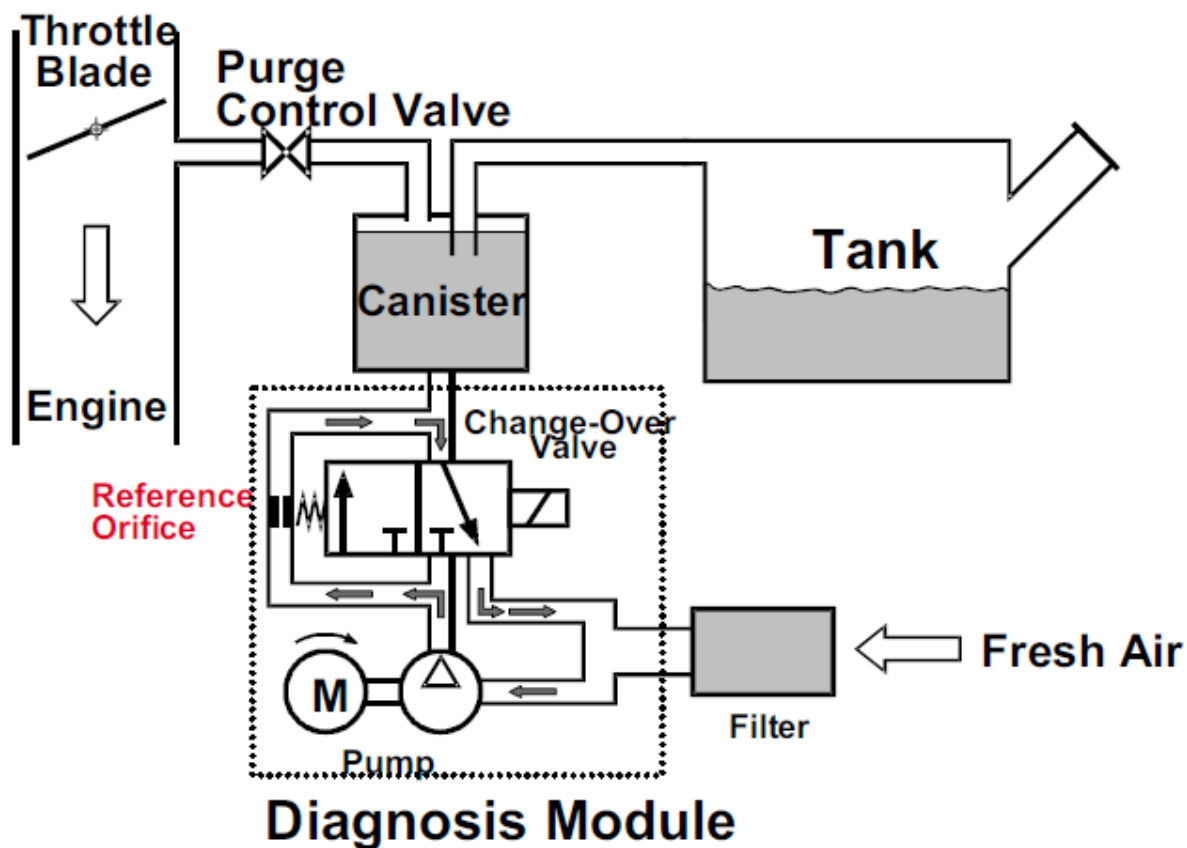
Reference Leak Measurement - The pump operates against the reference restriction within the DMTL. The Engine Control Module measures the current consumption and speed of the pump motor during this phase.

Leak Measurement - The solenoid in the DMTL is operated in order to shut off normal purge air flow into the charcoal canister. The pump can now pressurize the fuel tank and vapor handling system. The Engine Control Module again measures the current consumed and speed of the pump motor. A comparison based upon these parameters forms the basis of the Evaporative System Monitor.

The actual process is as shown in 5.5 Evaporative System Monitoring – System Flowchart

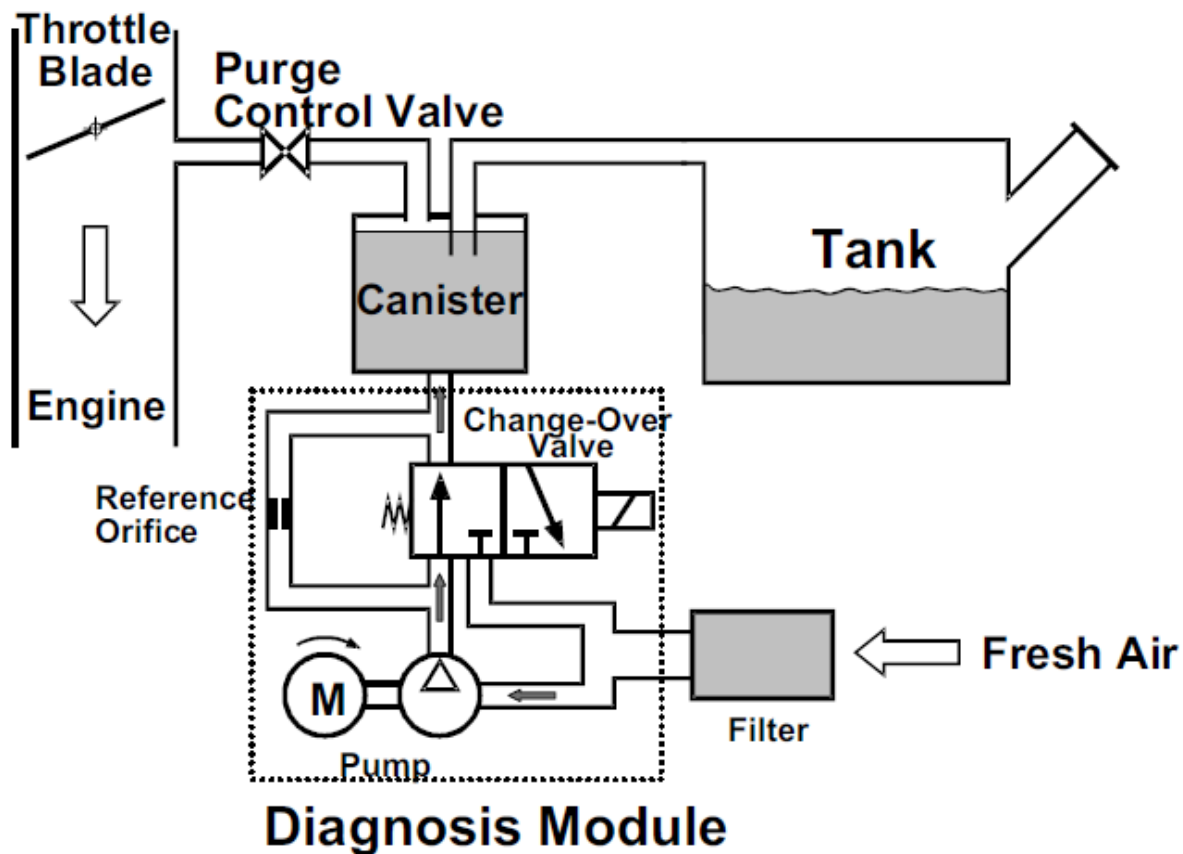
5.4. Fault Determination

5.4.1. Reference Leak Measurement



In the reference position the evaporative system is sealed off and the pump is forced to act through the reference orifice (0.5 mm). The pump speed and electrical pump current will depend on size of reference leak and these are measured. The volume flow of the pump will equal the volume flow of the leak and this can be determined from the pump speed. The actual volume flow depends upon ambient air temperature, ambient pressure and on the increased pressure due to the pump. From these measurements the actual pump pressure can be characterized from the pump current.

5.4.2. Tank Measurement



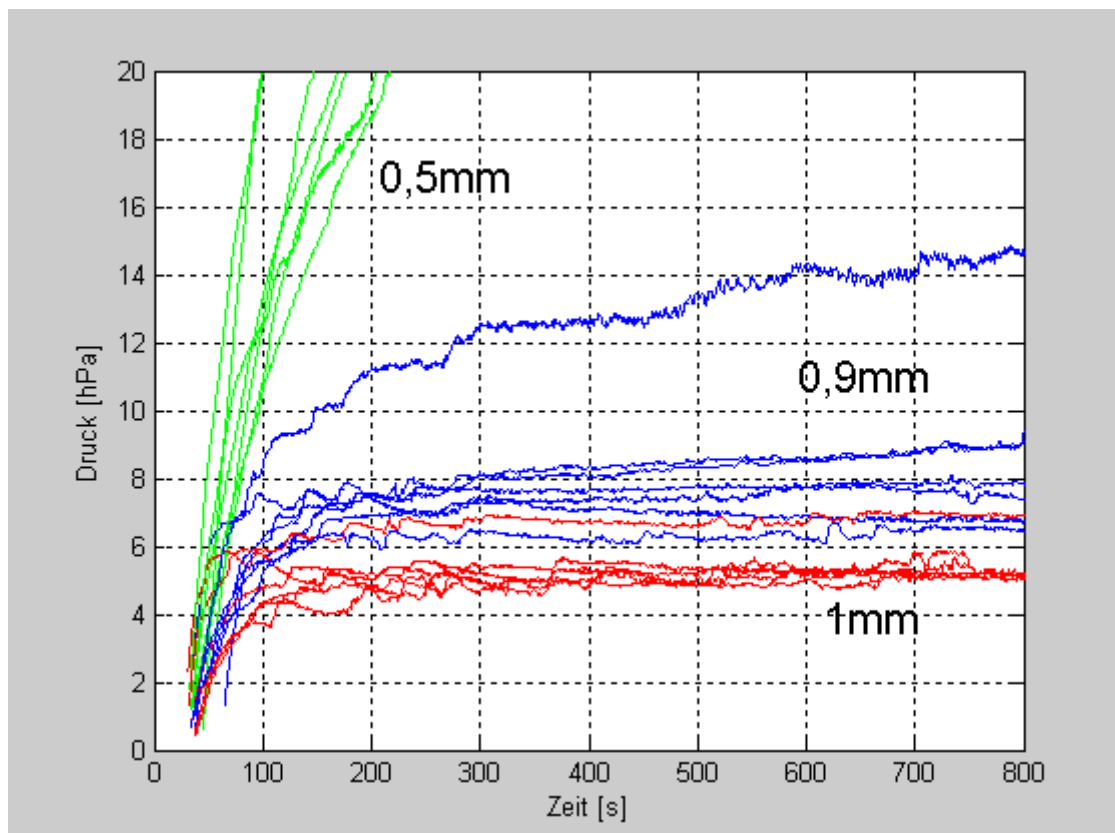
The valve is now changed to allow the pump to act on the tank side of the purge control valve. Again, in this case, the volume flow of the pump equals the volume flow of the leak. By comparing the pump current during the reference measurement and tank filling (relative current) an approximation to the tank pressure can be made.

5.4.3. Fault Assessment

The actual fault analysis is split into a large leak check followed by a small leak check.

5.4.3.1. Small Leak / Rough Leak (> 0.040 inch)

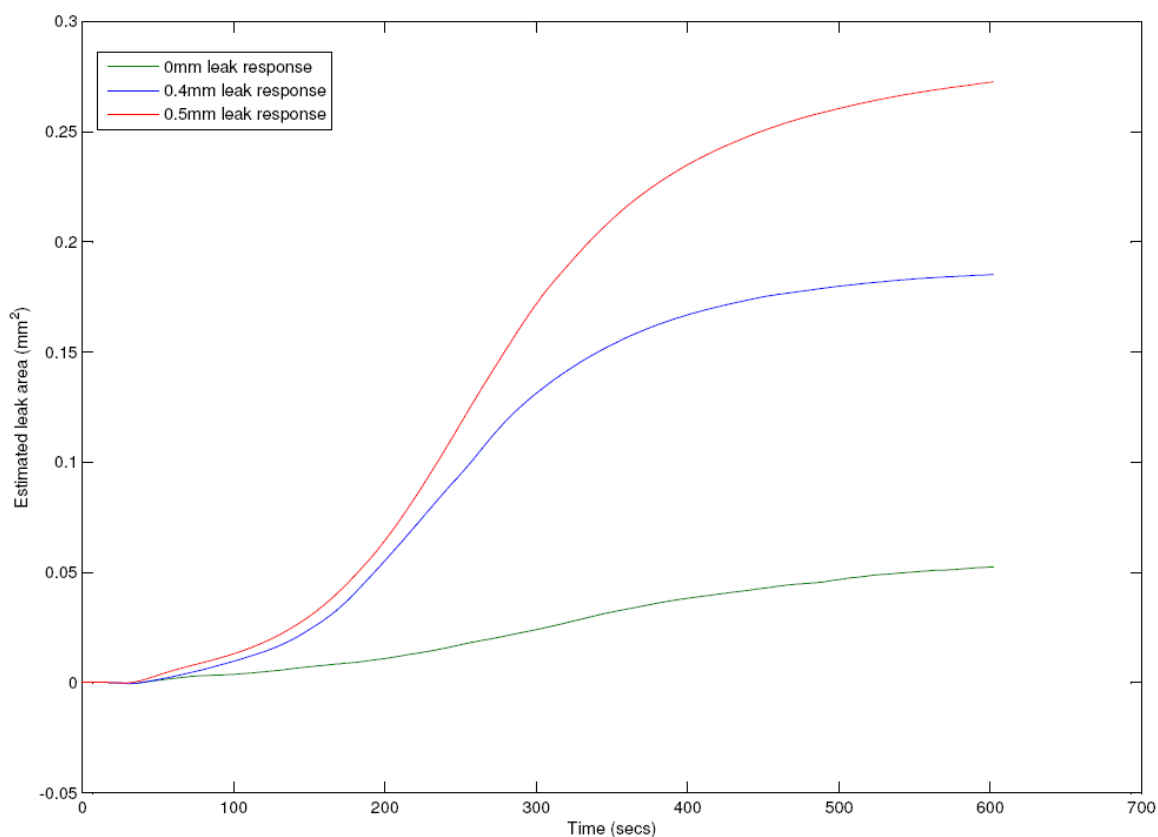
In the case of a small leak the pressure in the tank will never reach a sufficiently high stabilized pressure (see below). A pressure comparison is made and if a stabilized tank pressure is below a threshold and this occurs within a 'actual leak test time' then a fault is declared.



5.4.3.2. Very Small Leak (0.020 inch)

Due to the smaller tank pressure differential with a very small leak and sealed system an alternative algorithm is used. A recursive least squares (RLS) analysis of the system parameters (relative pressure and volume flow) are used to estimate a leakage size. Using this method separation of borderline leak states can be made (see below). The result of the leak is calculated when the tank pressure is greater than a threshold or the variance of the estimated area is smaller than a threshold and the minimum time of the test is over. If the estimated area is greater than a threshold then a leak is found else a tight system is declared.

The logic for MIL illumination and storage of service \$03 (confirmed), \$07 (fault during present or last completed drive cycle) or \$0A (permanent) fault codes follows the normal OBD II rules, with two fails leading to a MIL and a confirmed DTC.



5.4.3.3. Fuel Cap Warning Message

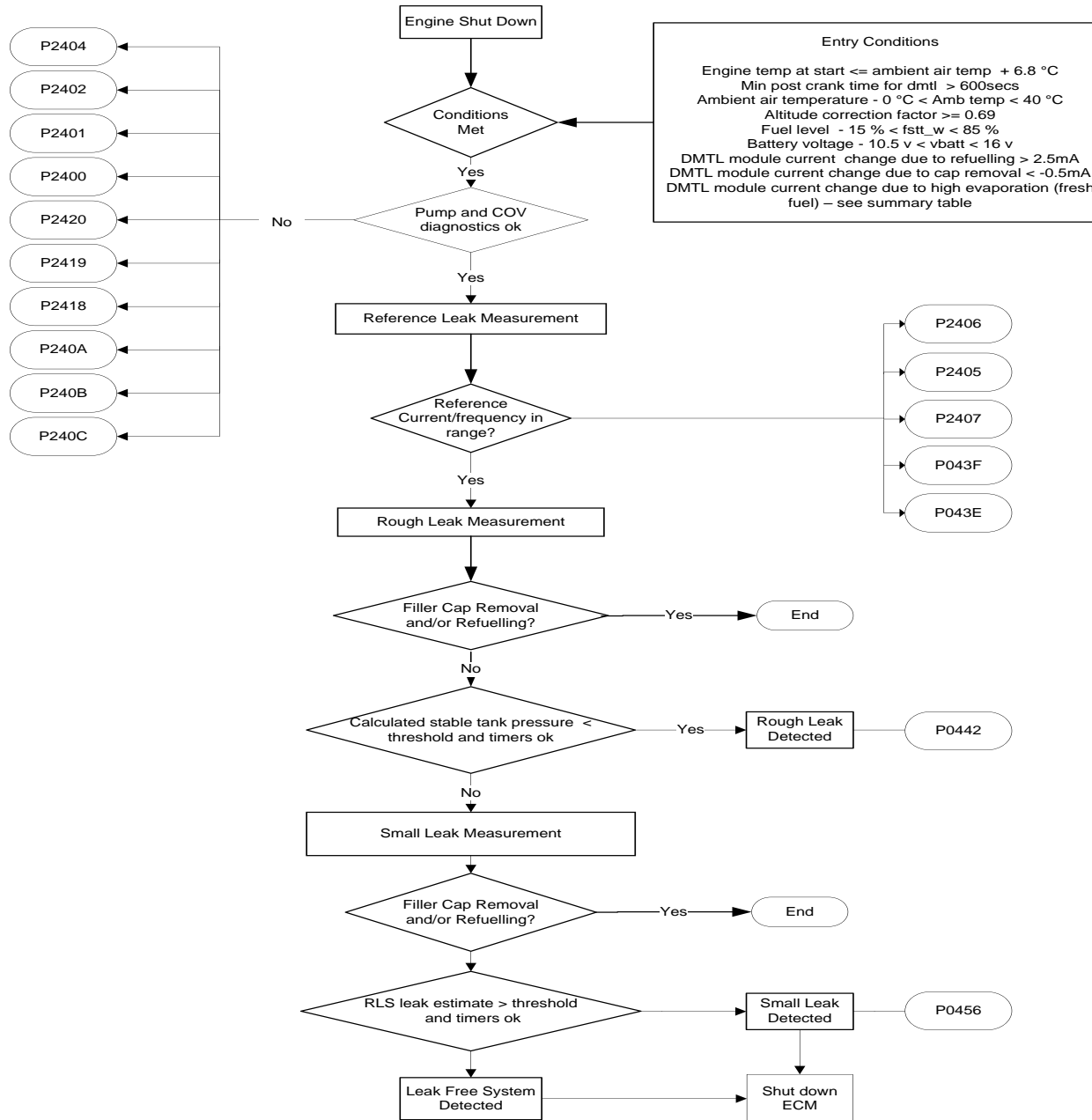
Since incorrect fastening of the gas cap can often result in MIL illumination and storage of a leak fault. Jaguar Land Rover displays a message on the instrument pack that states "Check Fuel Filler Cap" or "Check Filler Cap".

The message appears when the diagnostic first flags, giving the customer the opportunity to check the gas cap before the diagnostic runs again and leads to MIL illumination. The message will not be displayed at the next key on.

5.4.3.4. Filler Cap Removal and Re-Fueling

In the case where the tank cap is opened during the DMTL diagnosis the tank pressure drops to atmospheric pressure suddenly. A parallel drop in pump current is also seen. If a refueling should take place during a diagnostic routine the gas vapors displaced by the liquid cannot pass easily to the environment or be directed through the active charcoal filter as the DMTL valve is closed. Therefore pressure builds up in the tank rapidly, which can be recognized in the rapidly increasing pump current. To be able to detect both conditions a band-pass filtered pump current is used. When the tank cap is opened the current will fall under a threshold and an open tank cap declared. During refueling the filtered pump current rises above a threshold and a refueling event is declared.

5.5. Evaporative System Monitoring – System Flowchart and Tables



Fuel Evaporative Leak Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Fuel Evaporative Leak Monitoring								
rough leak <i>TESG</i> (DDMTLDFC)	P0442	Pressure test of system using ECM driven pump	Tank pressure change stable and	< 0.05 KPa	Engine temp at start -	\leq ambient air temp (tumg) + 6.75 °C > 600 s $0\text{ °C} < \text{tumg} < 40\text{ °C}$ < 8369 ft 15 % < fstt_w < 85 % $10.7\text{ v} < \text{vbatt} < 16.1\text{ v}$ > 1.2 mA < -0.5 mA See KLD RIPAB (table)	From 200 s to 400 s	2 Drive Cycles
small leak <i>DMTK</i>	P0456		Tank pressure and	< 0.9 KPa	Min post crank time for dmtl -			
			Time without pressure change and	> 25 s	Ambient temperature -			
			Actual leak test time	> 200 s	Altitude -			
			Estimated leakage area and	> 0.18 mm ²	Fuel level -			
			Tank pressure and	< 6.5 KPa	Battery voltage -			
			Actual leak test time and	> 850 s	DMTL module current change due to refueling -			
			Tank pressure	< ref tank pressure (prediff_w) * 2	DMTL module current change due to cap removal -			
Reference current high <i>DMTLmax</i>	P2406		DMTL module current	> 40 mA	DMTL module current change due to high evaporation (fresh fuel) -			
low <i>DMTLmin</i>	P2405		DMTL module current	< 15 mA				
plausible <i>DMTLsig</i>	P2407	During reference stage : if DMTL module current max minus DMTL module current min	> 0.6 mA					
Reference current frequency high <i>DMTLFREQmax</i>	P043F	During reference stage : if DMTL module current frequency	> 120 Hz					
low <i>DMTLFREQmin</i>	P043E	During reference stage : if DMTL module current frequency	< 60 Hz					
plausible <i>DMTLnpl</i>	P2404	Difference DMTL module current between ref and idle states	$\leq 2\text{ mA}$					
					Fault codes that disable P2406, P2405, P2407, P043F, P043E or P2404 P2420, P2418, P2402, P2401, P2400, P0688, P2419, P0118, P0117, P0116 (Pnpl), P0116 (Pmax), P0119, P0116 (CSmax), P0126, P0116 (CSmin), P0501, P0500, P0459, P0458, P0444			

Fuel Evaporative Leak Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Leak Detection (cont)								
Open gas cap during driving <i>CFCmax</i> (DDMTLCGC)	P0457	Check filler cap diagnostic ran during driving after a rough leak or small leak or refueling event detected	The leak check diagnostic is forced to run under driving conditions. If a leak is flagged then 'Check Fuel Filler Cap' is displayed in the instrument pack.		Vehicle speed - Min post crank time for - Ambient pressure pu_w minus stored ambient pressure Rough leak set Or Refueling detected by fuel level sensor	25 mph < vfzg < 75 mph > 600 s -0.15 KPa < p < 0.15 KPa B_edmtg = 1 and rough leak cycle flag B_zdmtg = 1	From 200 s to 400 s	No
					Fault codes that disable P0442 or P0456	P2420, P2418, P2402, P2401, P2400, P0688, P0501, P0500, P2419, P0118, P0117, P0116 (Pmax), P0126, P0116 (Pnpl), P0116 (CSmax), P0116 (CSmin), P0119, P0459, P0458, P0444		
Electrical continuity checking leak detection pump								
Power stage high <i>DMPMEmax</i> low <i>DMPMEmin</i> <i>DMPMEsig</i>	P2402 P2401 P2400	Short to battery or jammed Short to ground Open circuit	Power stage internal check		Leak detection module state -	operating	0.2s	2 Drive Cycles
valve high <i>DMMVEmax</i> low <i>DMMVEmin</i> <i>DMMVEsig</i>	P2420 P2419 P2418	Short to battery Short to ground Open circuit	Power stage internal check					
heater circuit high <i>DHDMTEmax</i> Low <i>DHDMTEmin</i> <i>DHDMTEsig</i> (DDMTLHWE)	P240C P240B P240A	Short to battery Short to ground Open circuit	Power stage internal check					

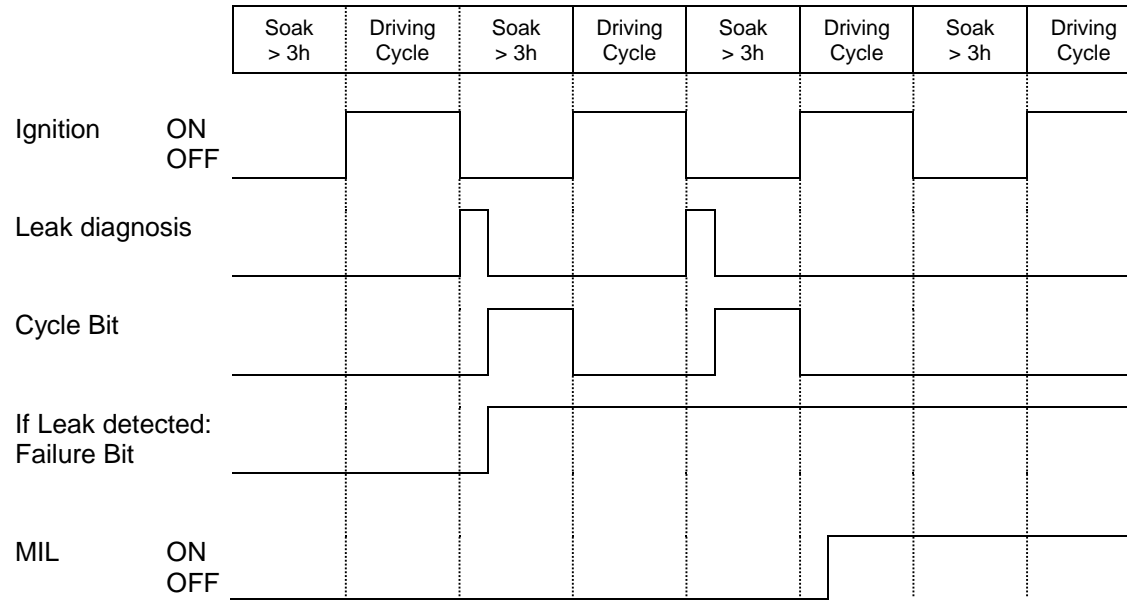
Fuel Fuel Evaporative Leak Monitoring

KLDRIPAB - Value to abort the test due to high evaporation or high fuel level

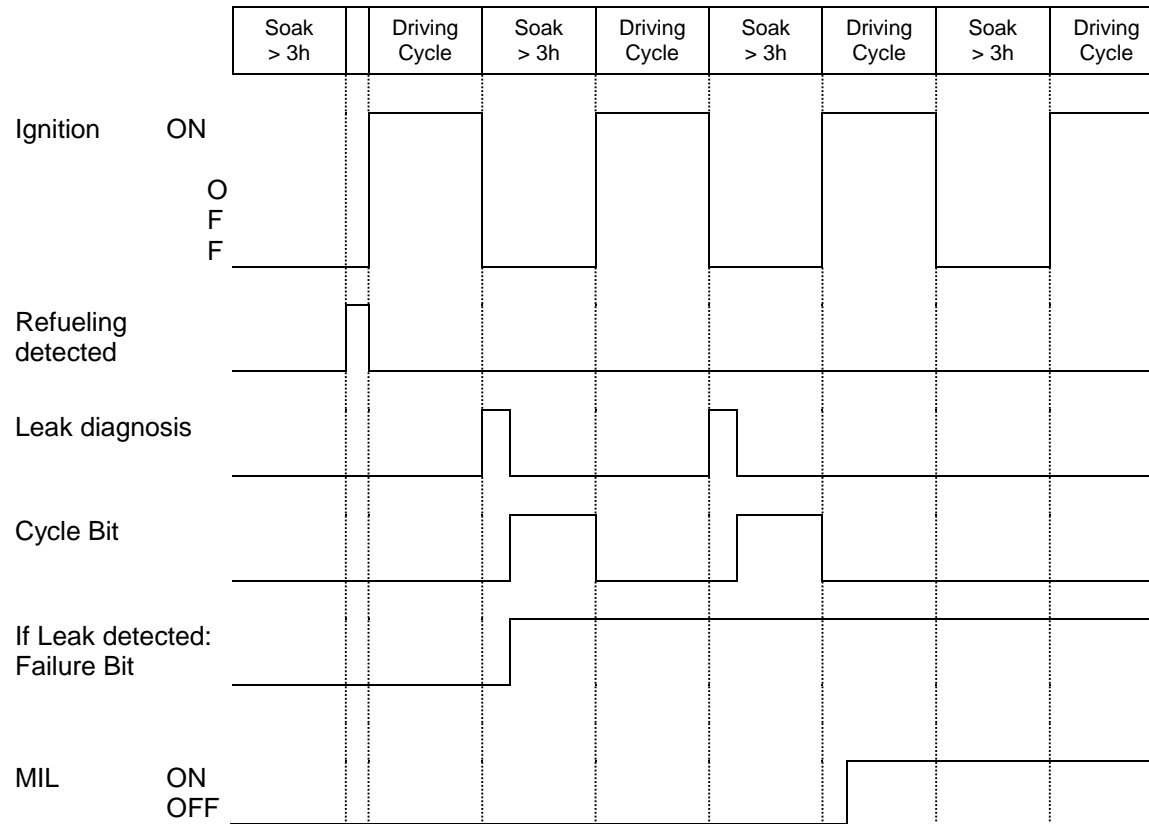
input x	mA	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00
output w		0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14

5.6. Diagnosis Frequency and MIL Illumination

No refueling detected; leak > 0.040"



After refueling detected; leak > 0.020"

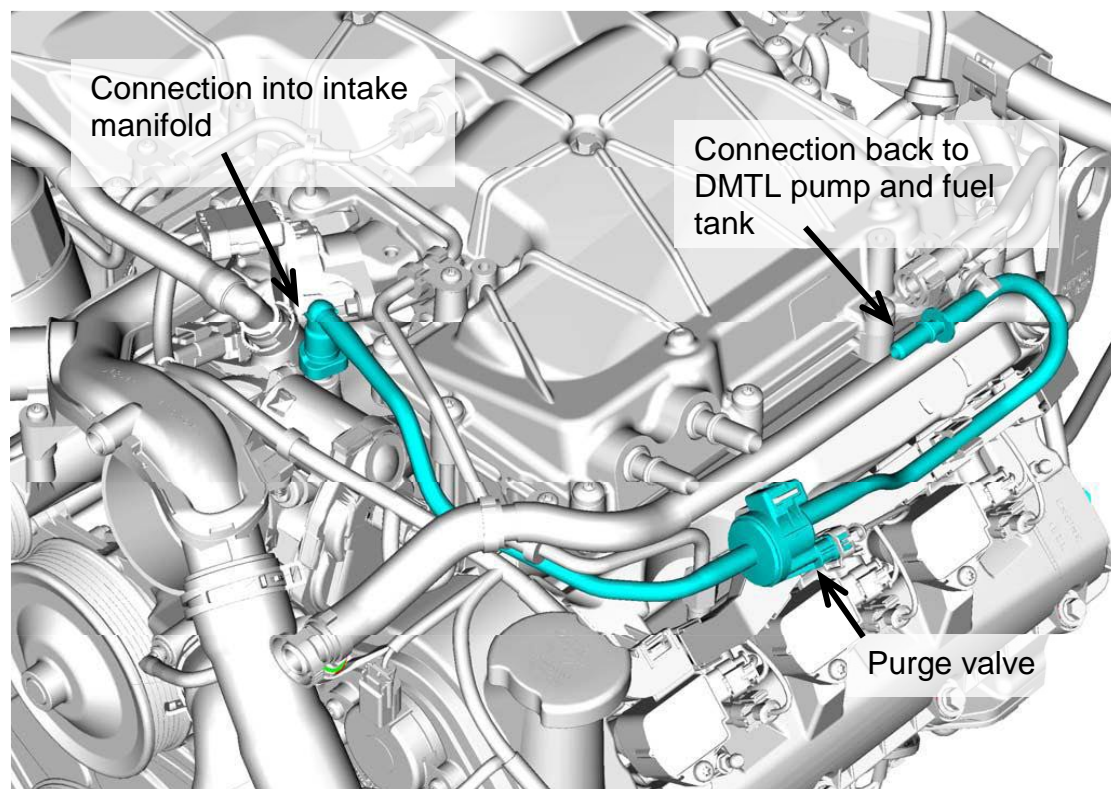


6. Purge Valve Monitoring

6.1. Fault Codes

- P0496 - Evaporative Emission System High Purge Flow
- P0497 - Evaporative Emission System Low Purge Flow
- P0444 - Evaporative Emission System Purge Control Valve A Circuit Open
- P0458 - Evaporative Emission System Purge Control Valve Circuit Low
- P0459 - Evaporative Emission System Purge Control Valve Circuit High

6.2. System Schematic



6.3. System Description

The purge diagnostic uses the DMTL pump to apply pressure into the purge system whilst the engine is running. It runs once per trip and requires the completion of a valid fault free tank leak check to have been completed. The basis to the fault analysis, as with the tank diagnostic, is the measurement and analysis of the pump current. Again comparisons of system measurements against a reference measurement are used.

6.4. Fault Determination

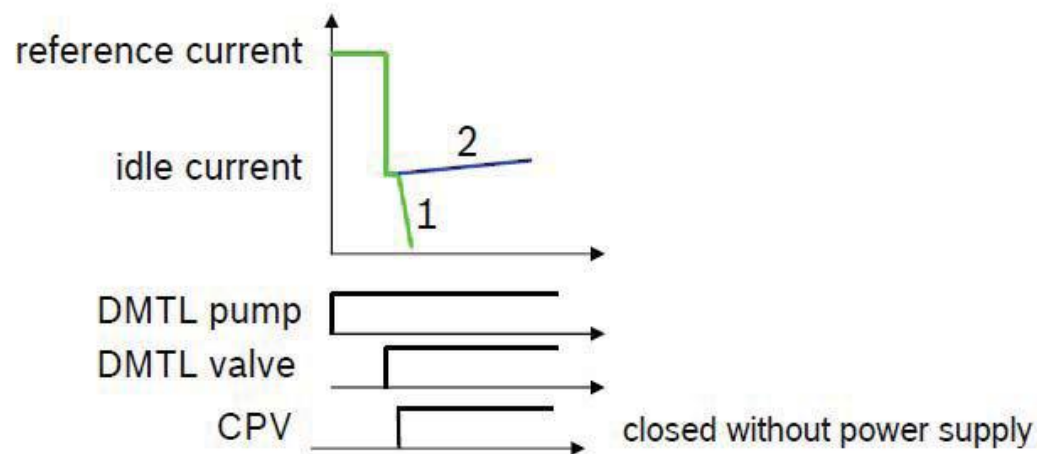
6.4.1. Reference Leak Measurement

This is performed during the tank leak diagnostic. The values for reference current and idle current are measured in a similar manner to that shown below. The difference between these currents is stored.

6.4.2. Purge System Measurement

During the purge test the DMTL pump is initially activated in the reference condition i.e. through the reference orifice only. A new reference current for the purge test is determined from this and is independent of the tank leak reference measurement. Following the reference current measurement an 'idle current' is measured. This is the result of the current obtained shortly after the DMTL solenoid is opened allowing the pump to act on the evaporative system with the CPV closed. Shortly after a stable idle current has been established the CPV is opened with three possible outcomes.

CPV and purge line ok. If the pump current decreases sharply this indicates that the purge valve has opened and that the purge lines are not blocked because the pump is being asked to do little work (i.e. build up pressure).
CPV stuck closed or purge lines are blocked. If the current slowly increases, then pressure is being produced which indicates either a stuck valve or blocked purge pipes.
CPV stuck open. In this case the pump will be acting on the pressure in the purge pipe system. Under non-boost conditions this will be manifold pressure and in this case the idle current will be lower than that for a normal system.



Results: 1 CPV and line to turbo OK
 2 CPV stuck closed or defect line to turbo

6.4.3. Fault Assessment

6.4.3.1. CPV stuck open

P0496. A comparison is made based upon the difference between the reference and idle current measured under this condition and that stored during the tank diagnostics. For a stuck open condition this difference will be greater than that for the reference condition. If the measured difference is greater than the reference difference multiplied by a calibration factor then a fault is declared.

6.4.3.2. CPV stuck closed or purge lines are blocked

P0497. Following the CPV test closure the pump current is measured. For a good system this current should drop below a current threshold, but if this threshold is exceeded for a time period then this indicates a faulty system and a fault is declared.

6.5. Purge Flow Monitoring – System Flowchart and Tables



Purge Valve Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Evaporative Purge Valve								
Circuit continuity <i>TEVEmax</i> <i>TEVEmin</i> (DTEVE) <i>TEVEsig</i>	P0459	Short to battery	Power stage internal check		Ignition switch - Battery voltage -	On >10.7 v	0.2 s	2 Drive Cycles
	P0458	Short to ground						
Purge valve stuck closed <i>TESmin</i> (DTEDFPSV)	P0444	Open circuit						
	P0497	The Canister Purge System with engine running uses the DMTL module as a pressure sensor	As purge valve opens, if filtered DMTL module current => Current threshold for minimum error. The input to DITESMIN is the difference between reference and idle obtained from the DMTL reference measurement.	DITESMIN after 5 s	Ambient air temperature Altitude After start timer for DMTL module Fuel level Engine Coolant temperature Battery voltage Closed loop purge control active Vehicle speed	3 °C < tumg < 37.5 °C < 8752 ft > 600 s < 85% > 70 °C 10.5 v < vbatt < 16 v 10 mph < vfzg < 75 mph	10 s	

DITESMIN - minimum difference current to detect minimum error TES

input x	mA	2.00	4.00	6.00	8.00	9.00
output w	mA	0.50	0.90	1.00	1.00	1.00

Purge Valve Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Evaporative Purge Valve (cont)								
Purge valve stuck open <i>TESmax</i> (DTEDFPSV)	P0496	The Canister Purge System with engine running uses the DMTL module as a pressure sensor	When purge valve test active, if DMTL pump current between ref and idle > Current threshold for maximum error.	DMTL reference idle current difference x 1.2	Ambient air temperature Altitude After start timer for DMTL module Fuel level Engine Coolant temperature Battery voltage Closed loop purge control active Vehicle speed	0 °C < tumg < 40 °C < 9900 ft > 600 s < 85% > 70 °C 10.7 v < vbatt < 16.1 v 10 mph < vřzg < 75 mph	10 s	2 Drive Cycles
					Fault Codes that disable P0496 or P0497	P0103, P0102, P0100, P00BD, P00BC, P010D, P010C, P010A, P00BF, P00BE, P010B, P0101, P0507, P0506, P0505, P0236 (Bnpl), P0236 (Bsig), P0236 (Pmax), P0236 (Pmin), P0236 (Psig), P0236 (Bmax), P0236 (Bmin), P0238, P0237, P06A6, P2419, P2405, P2404, P0501, P0500, P000D, P0024, P2095, P2094, P0023, P2091, P2090, P0013, P000B, P0014, P2176 (Unpl), P0153, P0133, P000C, P0021, P2093, P2092, P0020, P2089, P2088, P0010, P000A, P0011, P0335, P2234, P2231, P0155, P00D3, P00D3, P0052, P0051, P0050, P0032, P0031, P0030, P0135, P00D1 (npl), P00D1 (sig),		
					Fault Codes that disable P0496 or P0497	P064E (max), P064E (min), P064E (npl), P064E (sig), P064D (max), P064D (min), P064D (npl), P064D (sig), P2629, P2626, P2240 (max), P2240 (npl), P2240 (sig), P2237 (max), P2237 (npl), P2237 (sig), P0152, P0151, P0132, P0131, P2247, P2243, P2254, P2251, P0150, P0130, P2197, P2198, P0173, P2195, P2196, P0170, P0116 (Pmax), P0126, P0116 (Pnpl), P0116 (CSmax), P0116 (CSmin), P0119, P0154, P0134, P2135, P0300, P0459, P0458, P0444, P0118, P0117		

7. Fuel System Monitoring

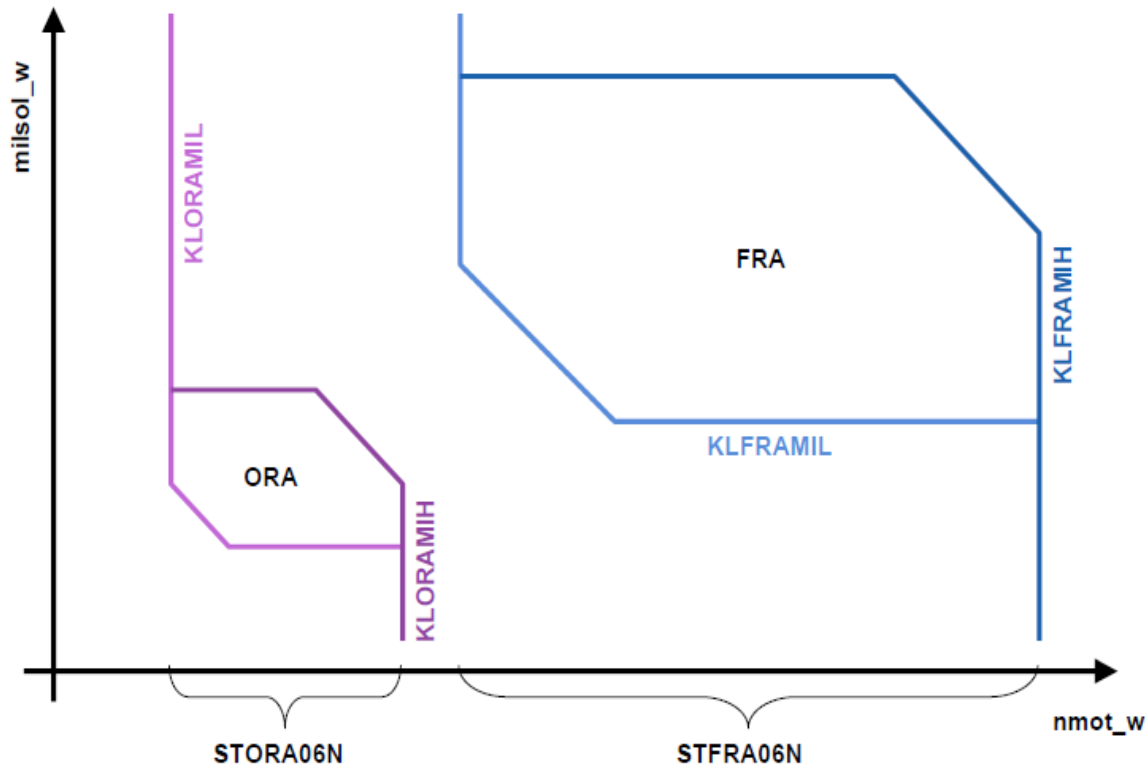
7.1. Fault Codes

- P2187 - System Too Lean at Idle (Bank 1)
- P2188 - System Too Rich at Idle (Bank 1)
- P2189 - System Too Lean at Idle (Bank 2)
- P2190 - System Too Rich at Idle (Bank 2)
- P2177 - System Too Lean Off Idle (Bank 1)
- P2178 - System Too Rich Off Idle (Bank 1)
- P2179 - System Too Lean Off Idle (Bank 2)
- P2180 - System Too Rich Off Idle (Bank 2)

7.2. System Description

The fuel system diagnostic monitors the long term fuel trim adaptations to check if any of the adaptation points has reached its rich or lean limit indicating that no more adaptation is possible. This will not immediately lead to higher emissions, because the short term fuel trim can take care of additional errors in the fuelling system.

The long term fuel trim is calculated from the UHEGO sensor, and is split into additive and multiplicative terms. The additive term (ORA) accounts for inlet air leaks and have a major influence at low air mass flows. The multiplicative term (FRA) accounts for mass flow, fuel pressure or temperature measurement errors and although it applies throughout the load and speed range, it is more prominent at higher measurement factors. The areas of *greater* prominence are as shown below.



Below are some faults that illustrate cases which could cause higher emissions:

- **Air leakage after the MAF sensor**

If there is an air leakage after the MAF sensor, this will result in unmeasured air being added to the intake charge. The short term and long term fuel trim will adjust the fuel amount to achieve a homogenous A/F mixture, and if the leakage is large enough, the diagnostic will detect a lean fault. This fault has its greatest influence at low engine loads.

- **Other faults leading to a lean Air-Fuel mixture**

If for example there is a fault which results in decreased fuel, this could also affect the short term and long term fuel trim. If this difference from the target pressure is large enough, then the diagnostic will detect a lean fault. This fault has its greatest influence at high engine loads.

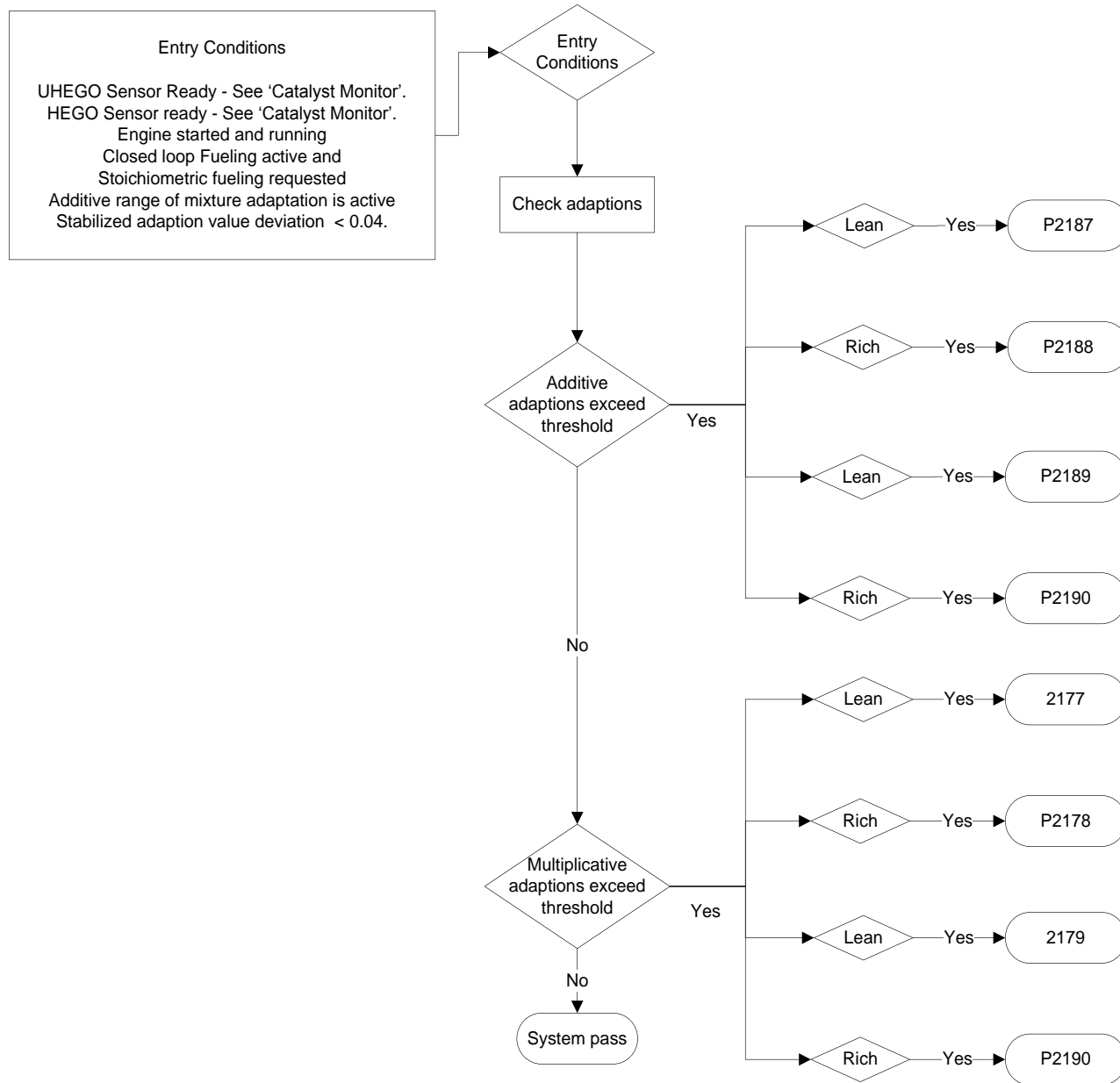
- **MAF sensor which is biased rich**

If the MAF sensor measures less air than is passing the sensor, then this will result in a rich combustion mixture. If the deviation is large enough, then the diagnostic will detect a rich fault.

- **Other faults leading to a rich Air-Fuel mixture**

If the fuel pressure regulator is faulty, the injectors are worn, or there is another fault which will result in a rich air-fuel mixture, then the diagnostic will detect a rich fault.

7.3. Fuel System Monitoring – System Flowchart and Tables



Fuel System Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Fuel System								
<i>ORAm_{ax}</i>	P2187	Fuelling adaptations at idle	If excessively lean	< -5.48 %	UHEGO Sensor Ready - HEGO Sensors ready - Engine started and running - Closed loop Fueling active and Stoichiometric fueling requested - Additive range of mixture adaptation is active Stabilized adaption value deviation -	See 'Catalyst Monitor' See 'Catalyst Monitor' Active < 0.03 for 200ms	0.2 s	2 Drive Cycles
<i>ORAm_{in}</i>	P2188		If excessively rich	> 5.48 %				
<i>ORA2_{max}</i>	P2189							
<i>ORA2_{min}</i>	P2190							
(DKVS)								
<i>FRA_{max}</i>	P2177	Fuelling adaptations off idle	If excessively lean	< 0.77 %	UHEGO Sensor Ready - HEGO Sensors ready - Closed loop Fueling active and Stoichiometric fueling requested - multiplicative range of mixture adaptation is active.	See 'Catalyst Monitor' See 'Catalyst Monitor' Active		
<i>FRA_{min}</i>	P2178		If excessively rich	> 1.23 %				
<i>FRA2_{max}</i>	P2179							
<i>FRA2_{min}</i>	P2180							
					Fault codes that disable Fuel System monitoring			
P054C, P054A, P000D, P0024, P2095, P2094, P0023, P2091, P2090, P0013, P000B, P0014, P2135, P2176 (Unpl), P0153, P0133, P052C, P052A, P000C, P0021, P2093, P2092, P0020, P2089, P2088, P0010, P000A, P0011, P0016 (MntErr), P0016 (OfsErr), P0018 (MntErr), P0018 (OfsErr), P0017 (MntErr), P0017 (OfsErr), P0019 (MntErr), P0019 (OfsErr), P0336 (Errsig), P0335, P2234, P2231, P0155, P00D3, P00D3, P0052, P0051, P0050, P0032, P0031, P0030, P0135, P00D1 (npl), P00D1 (sig), P064E (max), P064E (min), P064E (npl), P064E (sig), P064D (max), P064D (min), P064D (npl), P064D (sig), P2629, P2626, P2240 (max), P2240 (npl), P2240 (sig), P2237 (max), P2237 (npl), P2237 (sig), P0152, P0151, P0132, P0131, P2247, P2243, P2254, P2251, P0150, P0130, P0040, P0300, P2197, P2198, P0173, P2195, P2196, P0170, P007B (max), P007B (npl), P007B (CSmax), P007B (CSmin), P007D, P007C, P007E, P0459, P0458, P0444, P0116 (Pmax), P0126, P0116 (Pnpl), P0116 (CSmax), P0116 (CSmin), P0118, P0117, P0119, P0154, P0134, P0459, P0458, P0444								

Fuel System Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Fuel System - Secondary Feedback Adaption								
Bank A Sub feedback too lean <i>PLLSUmax</i>	P2195	Sub feedback adaption outside limit value	Sub feedback trim value	> 0.07	UHEGO Sensor Ready - HEGO Sensors ready -	See 'Catalyst Monitor' See 'Catalyst Monitor'	0.2 s	2 Drive Cycles
Bank A Sub feedback too rich <i>PLLSUmin</i>	P2196	Sub feedback adaption outside limit value	Sub feedback trim value	< -0.07	Closed loop Fueling active and Stoichiometric fueling requested for-	> 30 s		
Bank B Sub feedback too lean <i>PLLSU2max</i>	P2197	Sub feedback adaption outside limit value	Sub feedback trim value	> 0.07				
Bank B Sub feedback too rich <i>PLLSU2min</i>	P2198	Sub feedback adaption outside limit value	Sub feedback trim value	< -0.07				
(DPLLSU)								
					Fault codes that disable bank 1 Secondary Fuel System monitoring	P2270, P2271, P0133, P2626, P0032, P0031, P0030, P0135, P00D1 (npl), P00D1 (sig), P064D (max), P064D (min), P064D (npl), P064D (sig), P2237 (max), P2237 (npl), P2237 (sig), P0132, P0131, P2243, P2251, P0130, P0134, P0040		
					Fault codes that disable bank 2 Secondary Fuel System monitoring	P2272, P2273, P0153, P2629, P0155, P00D3 (npl), P00D3 (sig), P0052, P0051, P0050, P064E (max), P064E (min), P064E (npl), P064E (sig), P2240 (max), P2240 (npl), P2240 (sig), P0152, P0151, P2247, P2254, P0150, P0154, P0040		
Fuel System - Secondary Trim								
Bank A <i>FTDLFnpl</i> Bank B <i>FTDLFnpl2</i>	P0170 P0173	Secondary fuel trim check	If the lamda trim offset from the 3 rd sensor exceeds a threshold a fault is set	+/- 0.02	UHEGO Sensor Ready - HEGO Sensors ready - Closed loop Fueling active and Stoichiometric fueling requested	See 'Catalyst Monitor' See 'Catalyst Monitor' > 30 s	0.2 s	2 drive Cycles
(DLRHKFT)					Fault codes that disable P0170	P2274, P2275		
					Fault codes that disable P0173	P2276, P2277		

Fuel System Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
High Fuel Pressure System								
High Pressure Rise Time <i>STHDRmax</i> (<i>DSTHDR</i>)	P00C6	High pressure fuel system pressure rise checked during engine start	If the system pressure during start is below a pressure dependent on temperature and engine revolutions then a fault is declared	See KFPROFSHD (table) and KLRSTHDR (table)	Engine temperature at start - Fuel rail pressure - High pressure start requested. Condition hot start (Fuel system has been able to heat up/ fuel vaporization).	-48 °C < ect1 < 143 °C ≤ 2.1 MPa	Dependent upon temp	2 Drive Cycles
					Fault Codes that disable P00C6	P0251, P0254, P0088 (Rmax), P0087 (Rmin), P0191 (Rnpl), P0191 (Rsig), P0253, P0193, P0192, P0256, P0259, P0258		

KFPROFSHD - Threshold for rail pressure

		y \ x	-37	-32	-10	0	9	10
input x	°C	0.20	2.7	11.2	5.2	3.0	3.0	2.5
input y		0.40	2.7	11.2	10.0	5.2	3.0	2.5
output w	Mpa	0.80	2.7	11.2	10.0	5.2	3.0	2.5
		0.95	2.7	11.2	10.0	5.2	3.0	2.5

KLRSTHDR - Number of synchros for waiting for high fuel pressure

input x	°C	-40	-20	0	20	40	90
output w		48	48	24	24	24	24

Fuel System Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
High Fuel Pressure System (cont)								
Controller <i>HDRPLmax</i>	P228F	Checks if the pressure control is plausible. It looks to see if the controller activity is within limits	If a filtered value of the controller output is above or below a threshold then a fault is declared	> 2 MPa	Engine started and running. High fuel pressure regulation.	5% < rkmeeff_w < 240%	2 s	2 Drive Cycles
	<i>HDRPLmin</i>			< -2 MPa				
Pressure <i>HDRmax</i>	P0088	Checks if the pressure control is plausible. It looks to see if the fuel rail pressure activity is within limits	If a filtered value of the pressure set point and actual pressure is above or below a threshold then a fault is declared	< -2.2 MPa	Fuel mass - After start counter - Not in fuel cut.	> 2 s	1 s	
	<i>HDRmin</i> (DKVBDEPL)			> 2.2 MPa				
Sensor range check <i>DSKVRmax</i>	P0088	Out of range check	Unfiltered rail pressure real value	> 22 MPa			1 s	
	<i>DSKVRmin</i> (DDSKV)	Out of range check	Unfiltered rail pressure real value for	< 0.1 MPa 1 s				
<i>DSKVRnpl</i>	P0191	Pressure and fueling checks	If the relative rail pressure is below a threshold before start an error suspicion flag is set. If fueling adaption is outside range then a fuelling fault is suspected and pressure plausible fault set	< 0.4 Mpa for 30 s < 0.85 < -2.48 %			30 s	
			If the relative rail pressure is above a threshold before start an error suspicion flag is set. If fueling adaption is outside range then a fuelling fault is suspected	> 1.5 MPa > 1.15 > 3 %				
					Fault Codes that disable P228E & P228F	P0088 (PRmax), P0087 (PRmin), P0087 (min), P0251, P0256, P0254, P0259, P0253, P0258, P0088 (VRmax), P0087 (VRmin), P0191 (Rnpl), P0191 (Rsig), P0193, P0192		
					Fault Codes that disable P0087 & P0088 (pressure rationality)	P0251, P0256, P0254, P0259, P0253, P0258, P0088 (Rmax), P0087 (Rmin), P0191 (Rnpl), P0191 (Rsig), P0193, P0192		
					Fault Codes that disable P0191, P0087 & P0088 (sensor rationality)	P0193, P0192		

Fuel System Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
High Fuel Pressure System (cont)								
High pressure fuel pump (MFPSDIA)	<i>MfPsOpenLoad</i>	P0251	Check for Mass Flow Valve Powerstage for Open Load.	Monitors voltage during the idle state, DFC is raised if test voltage between threshold for three successive tests	1.4 v ~3.2 v	Ignition switch - Battery Voltage -	On 6 v < vbatt < 18 v	0.3 ms 2 Drive Cycles
	<i>MfPsOpenLoad2</i>	P0256						
	<i>MfPsShCirBattLowSide</i>	P0254	Check for Mass Flow Valve Powerstage for Short Circuit to Battery on the Low Side of MSV.	Monitor checks voltage within the HPFP Output stages with the expected values during idle phase. DFC is raised if test voltage is exceeds threshold for three successive tests.				
	<i>MfPsShCirBattLowSide2</i>	P0259						
<i>MfPsShCirGndLowSide</i>	P0253	Check for Mass Flow Valve Powerstage for Short Circuit to Ground on the Low Side of MSV	Monitor checks voltage within the HPFP Output stages with the expected values during off state. DFC is raised if test voltage is less than threshold for three successive tests	< 1.4 v				
<i>MfPsShCirGndLowSide2</i>	P0258							

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.		
Fuel Supply Pressure Sensor (low pressure)										
Fuel system pressure (DDSKVND)	<i>DSKVNRmax</i>	P008B	Unfiltered low pressure raw value	Range check max	> 1100 KPa	Ignition switch - Battery voltage -	On > 10.5 v	1 s 2 Drive Cycles		
	<i>DSKVNRmin</i>	P008A		Range check max	< 100 KPa					
	<i>NDRmax</i>	P008B	Rationality - measured versus target	Difference below a threshold	< -180 KPa				condition low pressure sensor raw value valid	60 s
	<i>NDRmin</i>	P008A		Difference above a threshold	> 150 KPa					
	<i>NDRnpl</i> <i>NDRsig</i> (DDECOSPL)	P0089	Pump duty cycle check	A fault is raised if the pump duty cycle is below or above for set time	< -12 % > 20 % > 5 s				The pump control module and the fuel pump must be active. The current operating state must not be initial fueling.	5 s
					Fault Codes that disable P0089, P008A (ndr) or P008B (ndr)	P025D, P025C, P062A, P0627, P2542, P2541, P008B (Rmax), P008A (Rmin)				
Fuel Pressure System (low)										
low pressure sensor (GGDSND)	<i>DSKVNDmax</i>	P2542	Out of range check	FLPS Voltage (1175 kPa)	> 4.85 v	Ignition switch - Battery voltage -	On > 10.5 v	0.6 s 2 Drive Cycles		
	<i>DSKVNDmin</i>	P2541	Out of range check	FLPS Voltage (25 kPa)	< 0.15 v					
				for	> 0.6 s					

Fuel System Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Fuel Pressure Sensor (high)								
FRPS high input <i>DSKVmax</i>	P0193	Out of range check	FRPS Voltage (26.0 MPa)	> 4.80 v	Ignition switch -	On	0.6 s	2 Drive Cycles
FRPS low input <i>DSKVmin</i> (GGDSKV)	P0192	Out of range check	FRPS Voltage (0.0 MPa) For	< 0.2 v > 0.6s	Battery voltage -	> 10.5 v		
<i>DSKVSSig</i>	P0191	Signal Stuck Check	Monitors the voltage over a number of injection cycles. If the voltage deviation does not exceed a threshold then a stuck sensor is declared.	< 0.049 V For 2 s	Engine speed - Unfiltered rail pressure - injected fuel mass mean voltage rail pressure	120 rpm < nmot < 4520 rpm > 3 MPa > 5 % < 4.5 v	2 s	
Fuel Rail Temperature								
TFUEL high input <i>TFUELEmax</i>	P0183	Out of range check	TFUEL Voltage (0 °C)	> 4.92 v	Ignition switch -	On	0.6 s	
TFUEL low input <i>TFUELEmin</i> (GGTFUEL)	P0182	Out of range check	TFUEL Voltage (143 °C) for	< 0.15 v > 2 s	Battery voltage -	> 10.5 v		
<i>TFUELRmax</i>	P0181	Out of range check	TFUEL Temp	> 143.25 °C				
<i>TFUELRmin</i>	P0181	Out of range check	TFUEL Temp for	< -48 °C 10 s				
<i>TFUELRnpl</i> <i>TFUELRsig</i> (DPLTFUEL)	P0181 P0168	Actual fuel rail temperature is continuously compared against modeled temperature	If the temperature difference is below or above threshold npl or sig faults are set for	> +/- 50 °C > 10 s			10 s	
Fuel Level Sender								
(DFSTTDFP) <i>FSTESsig</i>	P2065	CAN Signal check	Checks for quality factor for CAN fuel level signal		Ignition Switch -		0.1 s	No
<i>FSTESig</i>	P0460				Battery voltage -	> 10.5 v		
Low Fuel Level <i>TANKLnpl</i> (DTANKL)	P131A	Fuel Level check	If the fuel level is below 2 liters then this flag is set if there is a fault for fuel rail pressure control or idle speed control or high-pressure start or uhego / hego sensor or fuelling adaptations or misfire or boost pressure control		Ignition Switch - Battery voltage -	On > 10.5 v	0.2 s	

Fuel System Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Fuel Level Sender Rationality Check								
<i>FSTRmax</i>	P0461	A modeled value of fuel tank level is compared to the measured value and the difference between the two is integrated. If the integrated difference exceeds 14 litres, then a fault is suspected with one of the sensor signals	<u>Fuel level signal 1 stuck</u> Level change during time to consume 5 l, when the integrated difference between the modeled and measured fuel levels has exceeded 14 l.	< 0.1 l	Vehicle speed	>= 6.2 mph	10 s	No
<i>FSTRSmax</i> (DFSTTDFP)	P2066	If one of the level signals then changes by less than 0.1 litres during the time it takes the integrated difference to change by an additional 5.0 litres, then a fault is detected.	<u>Fuel level signal 2 stuck</u> Level change during time to consume 5 l, when the integrated difference between the modeled and measured fuel levels has exceeded 14 l.	< 0.1 l				

7.4. Fuel Injector Monitoring Tables

Fuel Injector Monitoring								
Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Fuel Injectors								
inj 1	<i>HDEVH_MAX / MIN_0</i>	Short circuit to battery (max error) or Short circuit to ground (min error) of the HDEV power stage high-side	Monitor checks voltages of control signals within the powerstage controlling the fuel injector and compares these with the expected voltage levels during the injection cycle.		Engine started and running. Battery voltage -	> 10.5 v	0.5 s	2 Drive Cycles
inj 5	<i>HDEVH_MAX / MIN_1</i>							
inj 4	<i>HDEVH_MAX / MIN_2</i>							
inj 2	<i>HDEVH_MAX / MIN_3</i>							
inj 6	<i>HDEVH_MAX / MIN_4</i>							
inj 3	<i>HDEVH_MAX / MIN_5</i>							
inj 7	<i>HDEVH_MAX / MIN_6</i>							
inj 8	<i>HDEVH_MAX / MIN_7</i>							
inj 1	<i>HDEVL_MAX / MIN_0</i>	Short circuit to battery (max error) or Short circuit to ground (min error) of the HDEV power stage low-side	Tests for short circuit to battery or short circuit to ground of the Low Side Drive circuit of fuel injector					
inj 5	<i>HDEVL_MAX / MIN_1</i>							
inj 4	<i>HDEVL_MAX / MIN_2</i>							
inj 2	<i>HDEVL_MAX / MIN_3</i>							
inj 6	<i>HDEVL_MAX / MIN_4</i>							
inj 3	<i>HDEVL_MAX / MIN_5</i>							
inj 7	<i>HDEVL_MAX / MIN_6</i>							
inj 8	<i>HDEVL_MAX / MIN_7</i>							
inj 1	<i>HDEVL_NPL_0</i>	Booster time-out of the HDEV power stage (low-side non plausible error)	Monitor checks voltages of control signals within the powerstage controlling the fuel injector and compares these with the expected voltage levels during the injection process Booster time fault, the DC/DC converter did not build up the required voltage in					
inj 5	<i>HDEVL_NPL_1</i>							
inj 4	<i>HDEVL_NPL_2</i>							
inj 2	<i>HDEVL_NPL_3</i>							
inj 6	<i>HDEVL_NPL_4</i>							
inj 3	<i>HDEVL_NPL_5</i>							
inj 7	<i>HDEVL_NPL_6</i>							
inj 8	<i>HDEVL_NPL_7</i>							
inj 1	<i>HDEVH_NPL_0</i>	Short circuit between high-side and low-side of the HDEV power stage (high-side non plausible error)	Monitor checks voltages of control signals within the powerstage controlling the fuel injector and compares these with the expected voltage levels during the injection process Booster time fault, the DC/DC converter did not build up the required voltage in					
inj 5	<i>HDEVH_NPL_1</i>							
inj 4	<i>HDEVH_NPL_2</i>							
inj 2	<i>HDEVH_NPL_3</i>							
inj 6	<i>HDEVH_NPL_4</i>							
inj 3	<i>HDEVH_NPL_5</i>							
inj 7	<i>HDEVH_NPL_6</i>							
inj 8	<i>HDEVH_NPL_7</i>							

Fuel Injector Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Fuel Injectors (cont)								
inj 1	<i>HDEVL_SIG_0</i>	P0201	Checks whether the Low Side drive is connected to the fuel injector	Monitor checks voltages of control signals within the powerstage controlling the fuel injector and compares these with the expected voltage levels during the injection process	Engine started and running. Battery voltage -	> 10.5 v	0.5 s	2 Drive Cycles
inj 5	<i>HDEVL_SIG_1</i>	P0205						
inj 4	<i>HDEVL_SIG_2</i>	P0204						
inj 2	<i>HDEVL_SIG_3</i>	P0202						
inj 6	<i>HDEVL_SIG_4</i>	P0206						
inj 3	<i>HDEVL_SIG_5</i>	P0203						
inj 7	<i>HDEVL_SIG_6</i>	P0207						
inj 8	<i>HDEVL_SIG_7</i>	P0208						
Powerstage SPI Check (INJVLVPS_DIA)	<i>HDEVK_min_0</i>	P2146	High Pressure Injection Valve Communication check	Fault is set if SPI communication min error reported	Ignition switch -	On	0.5 s	
	<i>HDEVK_min_1</i>	P2149	High Pressure Injection Valve Communication check	Fault is set if SPI communication min error reported				
	<i>HDEVK_npl_0</i>	P2147	High Pressure Injection Valve Communication check	Fault is set if SPI communication plausibility error reported				
	<i>HDEVK_npl_1</i>	P2150	High Pressure Injection Valve Communication check	Fault is set if SPI communication plausibility error reported				
	<i>HDEVK_sig_0</i>	P2152	High Pressure Injection Valve Communication Signal Failure	No signal detected				
	<i>HDEVK_sig_1</i>	P2155	High Pressure Injection Valve Communication Signal Failure	No signal detected				

8. UHEGO Sensor Monitoring

8.1. Fault Codes

P064D - Internal Control Module O2 Sensor Processor Performance - Bank 1
P064E - Internal Control Module O2 Sensor Processor Performance - Bank 2
P00D1 - HO2S Heater Control Circuit Range/Performance (Bank 1, Sensor 1)
P00D3 - HO2S Heater Control Circuit Range/Performance (Bank 2, Sensor 1)
P0135 - O2 Sensor Heater Circuit (Bank 1, Sensor 1)
P0155 - O2 Sensor Heater Circuit (Bank 2 Sensor 1)
P2231 - O2 Sensor Signal Circuit Shorted to Heater Circuit (Bank 1, Sensor 1)
P2234 - O2 Sensor Signal Circuit Shorted to Heater Circuit (Bank 2, Sensor 1)
P0131 - O2 Sensor Circuit Low Voltage (Bank 1, Sensor 1)
P0151 - O2 Sensor Circuit Low Voltage (Bank 2 Sensor 1)
P0132 - O2 Sensor Circuit High Voltage (Bank 1, Sensor 1)
P0152 - O2 Sensor Circuit High Voltage (Bank 2 Sensor 1)
P2626 - O2 Sensor Positive Current Trim Circuit Open (Bank 1, Sensor 1)
P2626 - O2 Sensor Positive Current Trim Circuit Open (Bank 2, Sensor 1)
P2237 - O2 Sensor Positive Current Control Circuit Open (Bank 1, Sensor 1)
P2240 - O2 Sensor Positive Current Control Circuit Open (Bank 1, Sensor 1)
P2243 - O2 Sensor Reference Voltage Circuit Open (Bank 1, Sensor 1)
P2247 - O2 Sensor Reference Voltage Circuit Open (Bank 2, Sensor 1)
P2251 - O2 Sensor Negative Current Control Circuit Open (Bank 1, Sensor 1)
P2254 - O2 Sensor Negative Current Control Circuit Open (Bank 2, Sensor 1)
P0134 - O2 Sensor Circuit No Activity Detected (Bank 1, Sensor 1)
P0154 - O2 Sensor Circuit No Activity Detected (Bank 2, Sensor 1)
P0133 - O2 Sensor Circuit Slow Response (Bank 1, Sensor 1)
P0153 - O2 Sensor Circuit Slow Response (Bank 2 Sensor 1)

8.2. System Overview

The diagnosis of the Upstream UHEGO sensor consists of the analysis of all the components that are required to produce a valid fueling signal. It is split into two groups, heater and sensor signal diagnosis, these being split further into circuit and performance diagnosis. Circuit tests are continuously performed whereas performance checks run once per drive cycle.

8.3. 'UHEGO Sensor Ready' Conditions

UHEGO sensor ready conditions are set once the Nernst cell resistance check confirms that the sensor temperature is above 685 degC. This check is made in combination with the UHEGO sensor heater control and diagnostics. Any failure in the heater control or sensor diagnostics will set the UHEGO ready flag to 'not ready' and the failure faults declared.

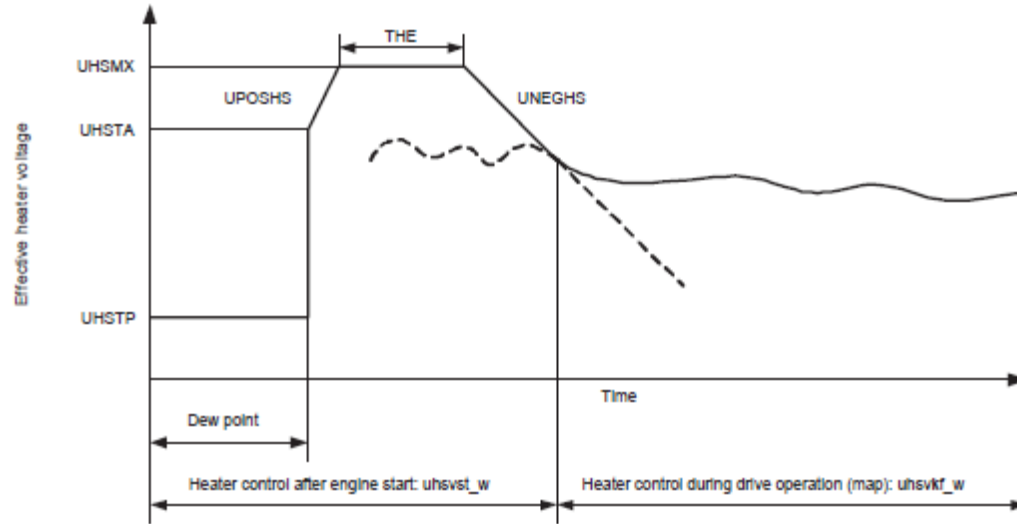
8.4. Sensor Heater Control

The main task of the heater control is to bring the oxygen sensor to its optimum operation temperature as soon as possible and to operate it at a constant ceramic temperature independently from ambient conditions allowing exact lambda control. The heater control utilizes a fixed 10 ms PWM voltage signal which is applied in controlled 'bursts' yielding an 'effective heater voltage' and heater power.

Post start, condensation water can accumulate in a cold exhaust gas system. If this water was to hit the hot sensor ceramic, it could damage the sensor. In order to avoid this, the sensor is operated with reduced heater power during 'dew point' conditions. As soon as dew point end is reached and engine temperature is high enough, the effective heater voltage is stepped up. The step height depends on the exhaust gas temperature at the sensor position. At lower temperatures the step height is reduced to prevent high thermal stress. Subsequently the heater voltage is raised in the form of a ramp until it reaches its maximum value. This maximum value is maintained for a period dependent upon start temperature after which heater voltage is controlled dependent upon the measured sensor temperature and exhaust mass flow.

8.4.1. Valid sensor resistance has been measured

During the heater control process the ceramics resistance is being measured and if the 'Valid sensor resistance has been measured' flag is set, then a temperature conversion is made. This temperature can then be used for the 'UHEGO Sensor Ready' declaration. A valid resistance is one in which no faults in the sensor have been determined and no trimming control of the sensor is being performed. Trimming control is a process where an internal ECU reference resistance is used to compensate the Nernst cell resistance for any ageing effects.



8.4.2. Dew point assessment

Condensate is the result of the high water content of the exhaust gas condensing on the cold surfaces on or in the exhaust system. The amount of condensate is influenced by the temperature differential of the cold surfaces of the exhaust system and the exhaust gas. Surface temperatures are influenced by start temperature, ambient temperature, engine shut down time, stop temperatures and engine operational conditions prior to stopping. Exhaust temperature conditions are mainly affected by start and operational conditions. A model is formed introducing these factors and predicts when the temperature rise of the exhaust pipe surfaces close to the sensor position are sufficiently high enough that 'Dew point conditions' are passed. The need for fast introduction of sensor readiness and fuel control coupled with the protection of the sensor for warranty costs means that a highly accurate working model is required.

8.5. Heater Diagnostics

8.5.1. Heater Powerstage/control circuit analysis

P064D and P064E. Fault recognition, read-out and storage of the power stage fault information is done within the Powerstage hardware. Fault verification and OBD-fault storage is done within the EMS software. This is performed by observing the fault status information placed in an error-trace-buffer. If a fault has been signaled a counter is activated which has been set with a non-calibrateable time (300 ms). After this time has elapsed, a verification test pulse is initiated in order to confirm the fault. One calculation raster later (100 ms) the verification check is performed. If, during the verification check, the same fault is recognized, the fault is considered to be verified. Faults which cannot be definitely detected are neglected.

8.5.2. Heater Control Diagnosis

P0135, P0155, P00D1 and P00D3. The diagnosis of closed-loop heating control monitors the calibration resistor and the duty cycle for heating control of the oxygen sensor. Three error states can exist, signal error, signal plausibility (P00D1) and signal max (P0135). *Signal error* compares the measurement of the resistance compensation with a threshold. The signal compensation is determined by measuring the internal calibration resistance and comparing that with its known value and applying an offset. If the difference exceeds a threshold for a set period of time then the Nernst resistance measurement can no longer be considered reliable and a fault is declared. *Signal plausibility* is defined as the desired temperature of the ceramic not being reached during control operation. If the heater control PWM signal is still controlling high i.e. applying heating current to the heater, and the temperature does not reach a desired usable threshold within a time period then a *max fault* is set.

8.5.3. Heater Influence on Nernst Cell

P2231 and P2234. When the heater is switched on or off it can cause periodic disturbances in the O2 signal. If these disturbances become too large, the signal can no longer be used and an error is set.

8.6. Signal Diagnostics

8.6.1. Integrated Circuit (IC) Electrical monitoring

The IC diagnosis for the UHEGO detects electrical errors on the signal lines UN (Nernst voltage), VM (virtual ground), IA (compensation line) and IP (pump line). These electric errors can be caused by short circuits to battery voltage, to ground or by line interruptions.

P0131, P0151, P0132 and P0152. Short to ground and Short to battery. Short circuits are detected by self-diagnosis based on voltage comparators integrated in every connection pin.

P2626 and P2629. Open circuit detected on IA (calibrating line). The combination of the trimming resistor in the sensor connector and the calibration resistor in the ECU assures that the pump current op amp will produce the correct sensor characteristic. If a line break is present in the calibration line and pump current is present then the amplifier voltage output will be high. To ensure that there is pump current present then lambda conditions cannot be stoichiometric. For diagnosis consistency overrun/fuel cut off conditions are required (i.e. lean fuelling). As a further secondary condition, the exhaust gas temperature must be within a preset range.

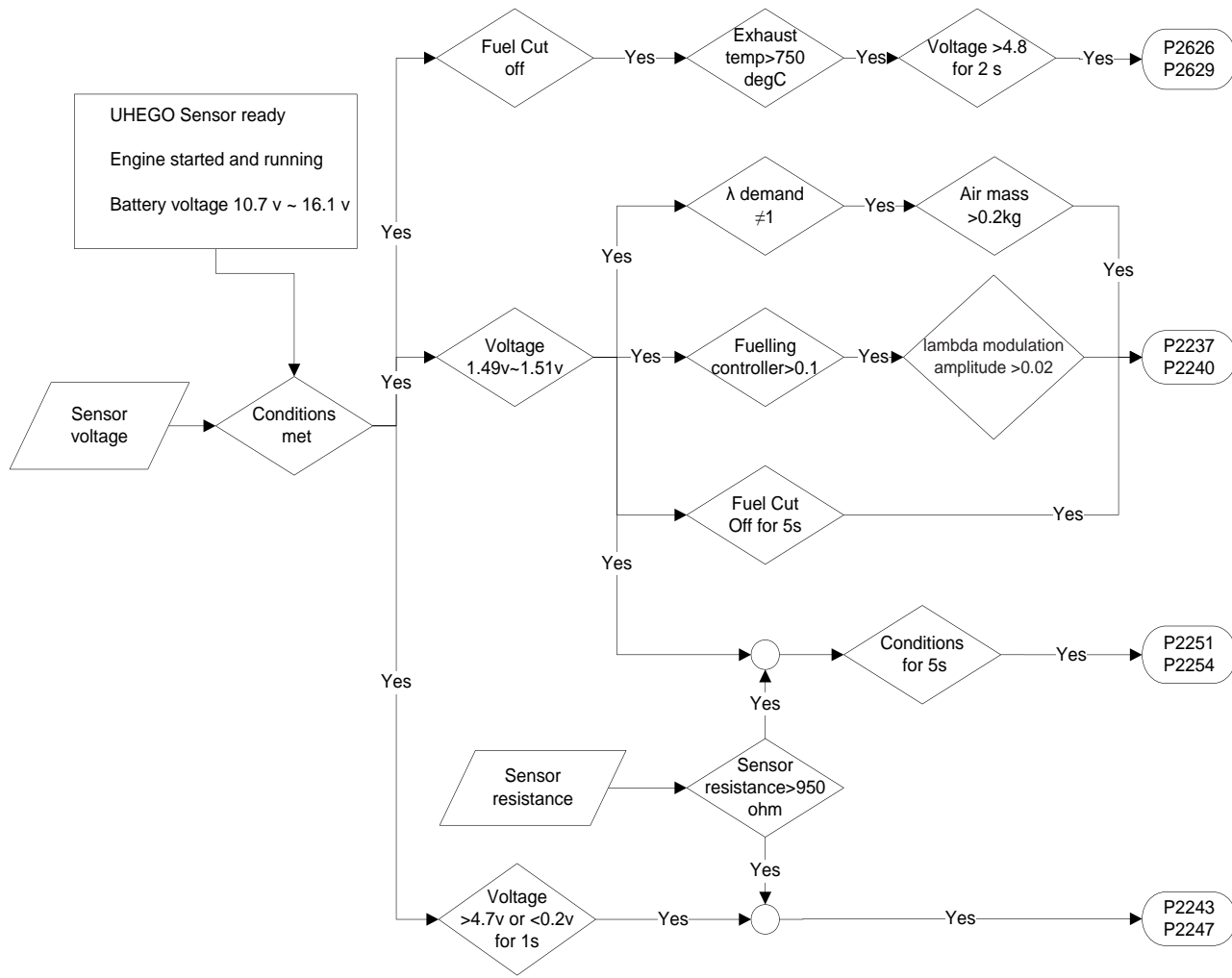
P2237 and P2240. Open circuit detected at IP line (pump current line). If the pump current line is broken then the amplifier will see a zero pump current condition and its output will be 1.5 V. If this condition exists for 3 seconds then three methods are used to diagnose such a condition.

- If non-stoichiometric fuelling is demanded and the amplifier output still indicates a stoichiometric 1.5 V output then an air mass integration is executed. If this integrated air mass exceeds a limit then a fault is diagnosed. This air mass count will be reset if the output voltage deviates outside 1.5 V. The air mass count will suspend if a stoichiometric fuelling demand is requested for less than a period, demands for greater than that period result in an air mass count reset.
- If the observed output indicates a stoichiometric fuelling (1.5 V) and stoichiometric fuelling is demanded then the response to an active fuelling change is made. This can either be through normal operation when the fuelling controller is observed to exceed a threshold or through the request of a forced fuelling step. If during this fuelling change the voltage output is still 1.5 V then a fault is diagnosed.
- If, during an overrun fuel cut event the voltage has not moved away from 1.5 V after a period of time a fault is diagnosed.

P2243 and 2254. Line interruption of sensor line UN (Nernst Cell Voltage). If the UN line is broken then the sensor resistance will become implausibly high. This will invoke a reaction from the heater control to increase its heat output. This will have negligible effect upon the sensor resistance and after the heating cycle, the sensor voltage will converge to 0 or 5 V. If these conditions are met then a line interruption of the UN line fault is diagnosed.

P2251 and P2251. Line interruption of sensor line VM (Virtual Ground). If the VM line is broken the sensor resistance will also become implausibly high. Again this will invoke a reaction from the heater and it will begin its heating cycle. Following this the signal voltage will be set at 1.5 V, as the pump current cannot discharge down the VM line. If these conditions are met then a line interruption of the VM line fault is diagnosed.

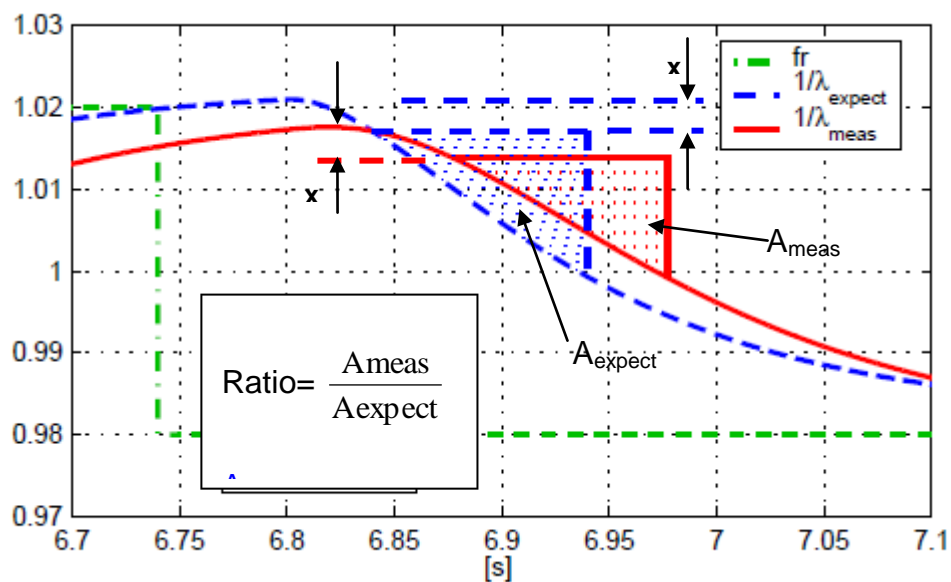
8.6.2. UHEGO Signal Diagnostics – System Flowchart



8.6.3. Sensor Dynamics

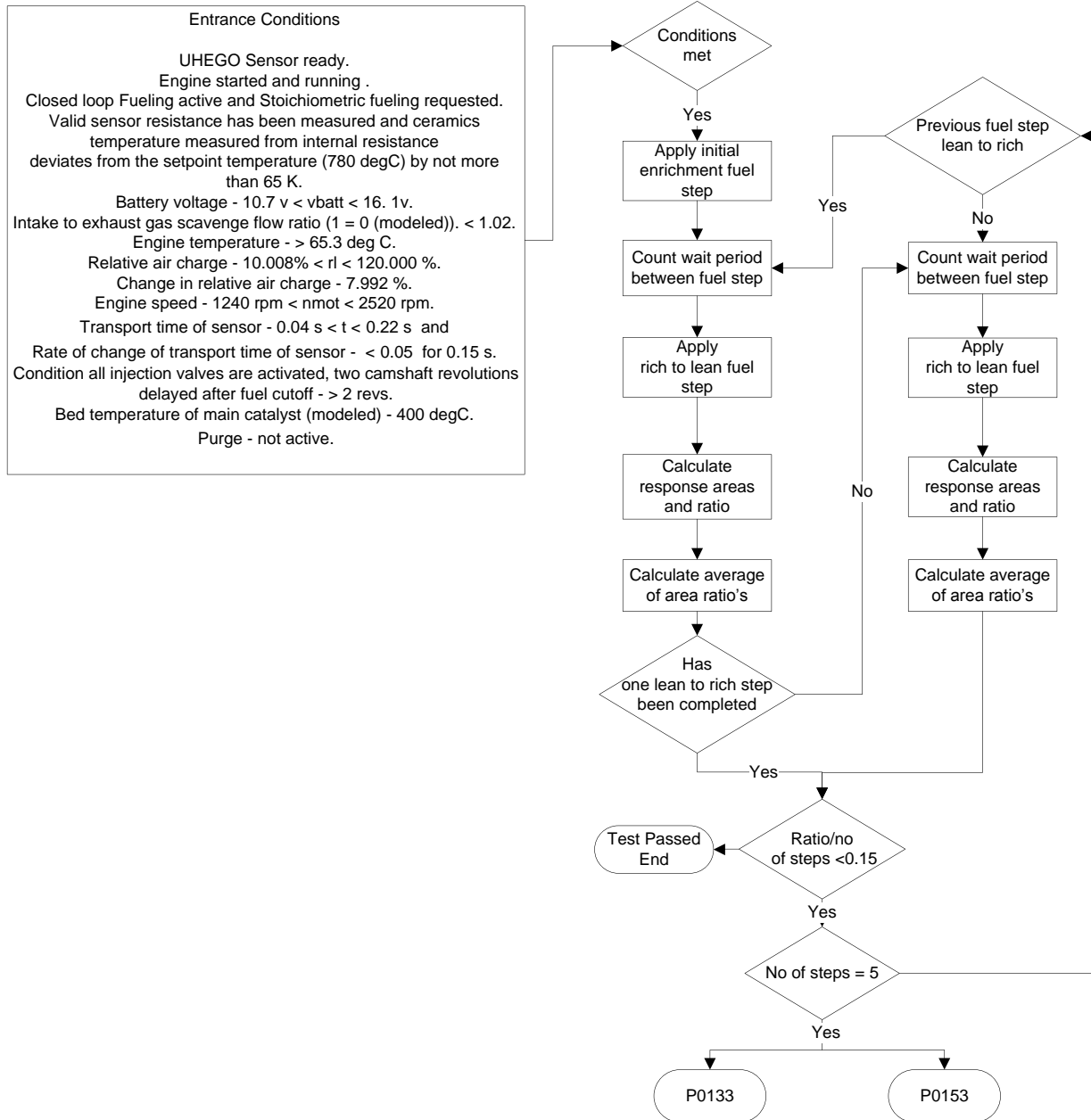
P0134 and P0154. Voltage diagnosis. Checks the output voltage of the UHEGO controller for plausibility. In general the output voltages are considerably lower at a value for lambda that is near to 1 than the ‘in air’ voltage. Such a fault can occur if the lambda sensor – although electrically connected - is not fitted or not fitted properly in the exhaust-system branch. The diagnostic compares the sensor voltage to ‘in air’ voltage threshold.

P0133 and P0153. Sensor response rate. Slow lambda sensors may lead to increased exhaust emissions or corrupt OBD monitors which make use of the lambda sensor signal. OBD legislation requires that a fault code be set if the slowing of the lambda sensor increases exhaust emissions beyond the OBD limits or deteriorates the performance of OBD monitors. The function uses intrusive step-changes of the injected fuel quantity (f_r). When such an event occurs, the measured lambda signal is compared to the expected signal. Starting with the reaction to the fuel step, the area between the inverted lambda signal and a horizontal line through a start value is determined for both the expected ($1/\lambda_{\text{expect}}$) and the measured signal ($1/\lambda_{\text{meas}}$), and the quotient between measured and expected area is computed. This start value is defined as a quantity of signal change following the detection of the change in signal (x) and the period is the same calibrated time. The slower the lambda sensor is, the smaller the area and thus the smaller that the quotient will be.



The actual analysis occurs over a number of fuel steps to increase accuracy and robustness. The number of fuel steps depends upon the results of the ratio check. If the ratio is large and above a threshold then the sensor is acting normally and the test sequence ended. If the ratio is below the threshold then another fuel step is requested and a ratio decision made. This continues until a maximum number of steps are reached. If the diagnostic calls for more fuel steps the actual decision is made on the average of these ratios divided by the number of steps. A sensor can exhibit a reduction in transient time which consists of a reduction of the of the lambda sensor signal gradient with respect to the gradient of the real lambda value, as well as an increase response-time faults, which consist in a retarded reaction of the lambda sensor signal to lambda changes. These faults can occur during rich to lean or lean to rich fueling changes (asymmetric) or symmetrically independent of the direction of the fuel change. All six fault patterns can be detected using quotient area calculation. Before the analysis begins a certain number of entrance conditions need to be satisfied to ensure that a reliable result is obtained. This is a non-continuous diagnostic that will attempt to run during a drive cycle whenever the entry conditions are met until a decision has been made. The monitor will not then operate again until the next drive cycle. The process is shown in the following flowchart.

8.6.4. UHEGO Sensor Dynamics – System Flowchart



8.7. UHEGO Sensor Monitoring Tables

Oxygen Sensor Monitoring Upstream								
Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Oxygen Sensors Upstream (UHEGO)								
slow response <i>DYLSUmin</i> <i>DYLSU2min</i> (DDYLSU)	P0133 P0153	Measures response of sensor too induced fuelling shifts	Integrated response rate of expected signal compared with Integrated response rate of measured signal over a maximum number of steps.	< 0.2 5 steps	UHEGO Sensor ready - Engine started and running. Closed loop Fueling active and Stoichiometric fueling requested. Valid sensor resistance has been measured. Battery voltage - Engine temperature - Relative air charge - Change in relative air charge - Engine speed - Transport time of sensor - And Rate of change of transport time of sensor - Condition all injection valves are activated, two camshaft revolutions delayed after fuel cutoff - Bed temperature of main catalyst (tkivkm) - Purge - Or accumulated purge flow	See 'catalyst Monitoring' Condition: RI Validi flag 10.7 v < vbatt < 16. 1 v > 45.75 °C 24 % < rl < 65 % 4.80 %.in 0.5 s 1240 rpm < nmot < 3720 rpm 0.04 s < zlrs_w < 0.18 s < 0.04 s for 0.15 s > 2 revs > 400 °C not active > 3g	10 s	2 Drive Cycles
					Fault codes that disable P0133	P0040, P000D, P0024, P2095, P2094, P0023, P2091, P2090, P0013, P000B, P0014, P000C, P0021, P2093, P2092, P0020, P2089, P2088, P0010, P000A, P0011, P0032, P0031, P0030, P0135, P00D1, P00D1, P064D (max), P064D (min), P064D (npl), P064D (sig), P2237 (max), P2237 (npl), P2237 (sig), P0132, P0131, P2243, P2251, P0130, P2195, P2196, P0170, P0134, P0496, P0497, P0459, P0458, P0444		
					Fault codes that disable P0153	P0155, P00D3, P00D3, P0052, P0051, P0050, P064E (max), P064E (min), P064E (npl), P064E (sig), P2240 (max), P2240 (npl), P2240 (sig), P0152, P0151, P2247, P2254, P0150, P0040, P2197, P2198, P0173, P0154, P000D, P0024, P2095, P2094, P0023, P2091, P2090, P0013, P000B, P0014, P000C, P0021, P2093, P2092, P0020, P2089, P2088, P0010, P000A, P0011, P0496, P0497, P0459, P0458, P0444		

Oxygen Sensor Monitoring Upstream

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.	
Oxygen Sensors Upstream (UHEGO)									
Diagnosis of Heater	<i>HSVsig</i>	P00D1	Monitoring of the calibration resistor in the ECU for plausibility: Condition: RI flag	If the difference between the Nernst resistance and the calibration resistance is above a threshold for a fixed period a fault is declared (Condition: RI Invalid flag)	> 45 ohm for > 2 s	Battery voltage - Engine Speed - Condition heater switched on.	10.7 v < vbatt < 16. 1 v Cranking or Engine started and running.	2 s	2 Drive Cycles
	<i>HSV2sig</i>	P00D3							
	<i>HSVnpl</i>	P00D1	Sensor temperature plausibility – at start	If the sensor temperature has not reached an acceptable temperature in fixed period a fault is declared	< 725 °C After 30 s	Battery voltage - Engine Speed - Engine temperature at start - Condition heater switched on. Valid sensor resistance has been measured. Condition all injection valves are activated, two camshaft revolutions delayed after fuel cutoff -	10.7 v < vbatt < 16. 1 v Cranking or Engine started and running. > -9.75 °C Condition: RI Valid flag	70 s	
	<i>HSV2npl</i> (DHRLSU)	P00D3							
		P0135 P0155	Sensor temperature plausibility demand – Normal running	If the temperature of ceramics of LSU is below a threshold and the PWM demand to the heater circuit is above a threshold for an unacceptable period of time a fault is diagnosed.	< 725 °C > 90 % For > 60 s	Battery voltage - Engine Speed - Sensor temperature plausibility – at start Valid sensor resistance has been measured. Not in fuel cut for And modeled exhaust temperature (tavso) -	10.7 v < vbatt < 16. 1 v Engine started and running. Completed Condition: RI Valid flag 50 s > 350 °C	60 s	
					Fault codes that disable P0135 and P00D1 (npl)	P2626, P0032, P0031, P0030, P2237 (max), P2237 (npl), P2237 (sig), P0132, P0131, P2243, P2251, P064D (max), P064D (min), P064D (npl), P064D (sig), P0300			
					Fault codes that disable P0155 and P00D3 (npl)	P2629, P0052, P0051, P0050, P2240 (max), P2240 (npl), P2240 (sig), P0152, P0151, P2247, P2254, P064E (max), P064E (min), P064E (npl), P064E (sig), P0300			

Oxygen Sensor Monitoring Upstream

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Oxygen Sensors Upstream (UHEGO)								
Heater control circuit <i>HSVEmax</i>	P0032	Short to battery	Duty cycle for sensor heater	> 4 %	Battery voltage - Engine Speed -	10.7 v < vbatt < 16. 1 v Cranking or Engine started and running.	10 s	2 Drive Cycles
<i>HSVE2max</i>	P0052	Short to battery	Duty cycle for sensor heater	> 4 %				
<i>HSVEmin</i>	P0031	Short to ground	Duty cycle for sensor heater	< 97 %				
<i>HSVE2min</i>	P0051	Short to ground	Duty cycle for sensor heater	< 97 %				
<i>HSVEsig</i>	P0030	Open circuit	No Duty cycle					
(DHRLSUE) <i>HSV2Esig</i>	P0050	Open circuit	No Duty cycle					
Diagnosis of <i>HELUSig</i> influence of <i>HELUS2sig</i> heater on nernst cell (DHELSU)	P2231 P2234	UHEGO current oscillation implausible – heater switching can influence the sensor signal by increasing the rate of change of sensor current. If the disturbance is to big then a fault is declared.	Rate of change of sensor current	> 190 µA	UHEGO Sensor ready - Engine Speed - Battery voltage - Relative load - Engine speed - Exhaust gas temperature in front of pre-catalyst out of model (tavvkm) - Duty cycle for lambda sensor heater - Closed loop Fueling active and Stoichiometric fueling requested - Lambda actual value between - Condition all injection valves are activated, two camshaft revolutions delayed after fuel cutoff -	See 'catalyst Monitoring' Cranking or Engine started and running. 10.7 v < vbatt < 16. 1 v > 30 %. < 3000 rpm < 800 °C 20 % < tahrlsu < 80 % = 1 0.95 < λ < 1.05 > 2 revs	15 s	
					Fault codes that disable P2231	P064D (max), P064D (min), P064D (npl), P064D (sig), P0300		
					Fault codes that disable P2234	P064E (max), P064E (min), P064E (npl), P064E (sig), P0300		

Oxygen Sensor Monitoring Upstream

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Oxygen Sensors Upstream (UHEGO)								
Voltage diagnosis UHEGO <i>ULSU_{np1}</i> <i>ULSU_{2np1}</i> (DULSU)	P0134	Checks the output voltage of the UHEGO controller for plausibility i.e. the sensor is fitted correctly and exposed to the exhaust gas flow.	If the controller voltage is outside a defined range then a plausibility fault raised	Acceptable range 2.71 v ~4.81 v	UHEGO Sensor ready - Engine Speed - Condition all injection valves are activated, two camshaft revolutions delayed after fuel cutoff - Required lambda referred to lambda sensor fitting location -	See 'Catalyst Monitoring' Cranking or Engine started and running. > 2 revs. < 1.6.	10 s	2 Drive Cycles
	P0154							
					Fault codes that disable P0134	P0135, P00D1 (npl), P00D1 (sig), P2626, P0032, P0031, P0030, P2237 (max), P2237 (npl), P2237 (sig), P0132, P0131, P2243, P2251, P064D (max), P064D (min), P064D (npl), P064D (sig)		
					Fault codes that disable P0154	P0155, P00D3, P00D3, P2629, P0052, P0051, P0050, P2240 (max), P2240 (npl), P2240 (sig), P0152, P0151, P2247, P2254, P064E (max), P064E (min), P064E (npl), P064E (sig)		
<i>LSVV_{np1}</i>	P0040	Checks to see if the connectors are fitted to the correct bank specific sensor	Fuelling regulation on each bank is opposite (lean rich / rich lean). If the expected lambda is not seen and exceeds a threshold for a time period then a fault is declared	1.20 / 0.8 5 s	UHEGO Sensor ready - Engine Speed - Battery voltage -	See 'catalyst Monitoring' Cranking or Engine started and running. 10.7 v < vbatt < 16. 1 v		
					Fault codes that disable P0040	P054C, P054A, P052C, P052A, P000D, P0024, P000B, P0014, P000C, P0021, P000A, P0011		

Oxygen Sensor Monitoring Upstream

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Oxygen Sensors Upstream (UHEGO)								
Electrical monitor IC	<i>LSUKSmax</i> P0132	Short to battery	Power stage internal check		Ignition - Battery voltage - UHEGO Sensor ready -	On 10.7 v < vbatt < 16.1 v See 'catalyst Monitoring'	0.2 s	2 Drive Cycles
	<i>LSUKS2max</i> P0152							
	<i>LSUKSmin</i> P0131	Short to ground						
	<i>LSUKS2min</i> P0151							
	<i>LSUIAsig</i> P2626	Open circuit detected at IA (calibrating line)	Sensor voltage for	> 4.8 v > 2 s	Battery voltage - In fuel cut. Exhaust temperature (tavvkm) -	10.7 v < vbatt < 16.1 v < 750 °C	3 s	
	<i>LSUIA2sig</i> (D1CLSU)							
	<i>LSUIPmax</i> P2237	Open circuit detected at IP line (pump current line)	During $\lambda \neq 1$ desired conditions voltage indicates $\lambda = 1$ for an accumulated air flow mass or If the sensor stays within $\lambda = 1$ limits during a forced fueling change (lambda controller output observation) or If the sensor stays within $\lambda = 1$ limits during overrun/fuel cut for a time period	1.49v ~ 1.51v 0.2 kg or 1.49v ~ 1.51v > 0.1 or 1.49v ~ 1.51v for > 5 s	UHEGO Sensor ready - Engine Speed - Battery voltage -	See 'catalyst Monitoring' Engine started and running. 10.7 v < vbatt < 16.1 v	5 s	
	<i>LSUIP2max</i> P2240							
	<i>LSUIPnpl</i> P2237							
	<i>LSUIP2npl</i> P2240							
	<i>LSUIPsig</i> P2237							
	<i>LSUIP2sig</i> P2240							
						Fault codes that disable P2237	P0133, P0135, P00D1 (npl), P00D1 (sig)	
					Fault codes that disable P2240	P0153, P0155, P00D3, P00D3		
<i>LSUUNsig</i> P2243	Line interruption of sensor line UN (Nernst Cell Voltage)		Sensor signal voltage high or low whilst implausibly high resistance condition exist	> 4.7 v or < 0.2 v For 1 s > 950 ohm	UHEGO Sensor ready - Engine Speed - Battery voltage -	See 'catalyst Monitoring' Engine started and running. 10.7 v < vbatt < 16.1 v	1s	
<i>LSUUN2sig</i> P2247								
<i>LSUVMsig</i> P2251	Line interruption of sensor line VM (Virtual Ground)		Sensor signal voltage whilst and implausibly high resistance condition exist	1.47v ~ 1.53v for 5 s > 950 ohm			5 s	
<i>LSUVM2sig</i> P2254								
<i>ICLSUmax</i> / <i>ICLSUmin</i> <i>ICLSUnpl</i> / <i>ICLSUsig</i> P064D	Internal IC fault of UHEGO		Short to Vbatt Short to ground		UHEGO Sensor ready - Engine Speed -	See 'catalyst Monitoring' Cranking or Engine started and running.	0.2 s	
<i>ICLSU2max</i> / <i>ICLSU2min</i> <i>ICLSU2npl</i> / <i>ICLSU2sig</i> P064E								
			Condition communication error of SPI interface to evaluation IC Condition write error at INIT register of evaluation IC of LSU		Battery voltage -	10.7 v < vbatt < 16.1 v	10 s	

9. HEGO (LSF AND LSH) Sensor Monitoring

9.1. Fault Codes

P0138 - O2 Sensor Circuit High Voltage (Bank 1 Sensor 2)
P0158 - O2 Sensor Circuit High Voltage (Bank 2 Sensor 2)
P0144 - O2 Sensor Circuit High Voltage (Bank 1 Sensor 3)
P0164 - O2 Sensor Circuit High Voltage (Bank 2 Sensor 3)
P0137 - O2 Sensor Circuit Low Voltage (Bank 1 Sensor 2)
P0157 - O2 Sensor Circuit Low Voltage (Bank 2 Sensor 2)
P0143 - O2 Sensor Circuit Low Voltage (Bank 1 Sensor 3)
P0163 - O2 Sensor Circuit Low Voltage (Bank 2 Sensor 3)
P0136 - O2 Sensor Circuit (Bank 1 Sensor 2)
P0156 - O2 Sensor Circuit (Bank 2 Sensor 2)
P0142 - O2 Sensor Circuit (Bank 1 Sensor 3)
P0162 - O2 Sensor Circuit (Bank 2 Sensor 3)
P0141 - O2 Sensor Heater Circuit (Bank 1 Sensor 2)
P0161 - O2 Sensor Heater Circuit (Bank 2 Sensor 2)
P0147 - O2 Sensor Heater Circuit (Bank 1 Sensor 3)
P0167 - O2 Sensor Heater Circuit (Bank 2 Sensor 3)
P0038 - HO2S Heater Control Circuit High (Bank 1, Sensor 2)
P0037 - HO2S Heater Control Circuit Low (Bank 1, Sensor 2)
P0036 - HO2S Heater Control Circuit (Bank 1, Sensor 2)
P0058 - HO2S Heater Control Circuit High (Bank 2, Sensor 2)
P0057 - HO2S Heater Control Circuit Low (Bank 2, Sensor 2)
P0056 - HO2S Heater Control Circuit (Bank 2, Sensor 2)
P0044 - HO2S Heater Control Circuit High (Bank 1, Sensor 3)
P0043 - HO2S Heater Control Circuit Low (Bank 1, Sensor 3)
P0042 - HO2S Heater Control Circuit (Bank 1, Sensor 3)
P0064 - HO2S Heater Control Circuit High (Bank 2, Sensor 3)
P0063 - HO2S Heater Control Circuit Low (Bank 2, Sensor 3)
P0062 - HO2S Heater Control Circuit (Bank 2, Sensor 3)
P0054 - HO2S Heater Resistance (Bank 1, Sensor 2)
P0060 - HO2S Heater Resistance (Bank 2, Sensor 2)
P0055 - HO2S Heater Resistance (Bank 1, Sensor 3)
P0061 - HO2S Heater Resistance (Bank 2, Sensor 3)

9.2. System Overview

As for the UHEGO sensor, the HEGO sensor diagnostics consist of the analysis of all the components that are required to produce a valid fueling signal and are split into two groups, heater and sensor signal diagnosis. Again, these can be split further into circuit and performance diagnosis. Circuit tests are continuously performed whereas performance checks run once per drive cycle. Certain diagnosis for LSF and LSH are identical and will be described in generic terms. Unique diagnosis will be specifically referred to in application to LSF or LSH.

9.3. 'HEGO Sensor Ready' Conditions

Before the sensor is classified as ready for use several conditions have to be satisfied. First the sensor has to be up to temperature and temperature control must be active. This is explained in section 9.4 Sensor Heater Control. The second is to ensure that the sensor is indicating plausible voltages. The HEGO sensor is a binary sensor and will give definitive high or low voltage levels. The voltage check looks to see if sensor output departs from the voltage band around 0.45 V (defined by upper and lower voltages 0.4 V ~ 0.6 V, when the sensor is not deemed ready) but is lower than an absolute maximum 1.08 V. Because of the electrical circuit in the ECU, leaving the 0.45 V band means that the internal resistance of the Nernst cell has fallen below a certain threshold indicating that the ceramic temperature is sufficiently high. (Note the actual temperature condition monitor is performed by a resistance check and not a voltage check). At high temperatures the rich branch of the sensor characteristics drops, and the 0.45 V band is then defined as 0.4 V ~ 0.5 V. If the sensor voltage does not leave the 0.45 V band although the sensor is sufficiently heated a sensor fault is assumed. Under these circumstances and if a signal wire break is not detected, then after 20 s the 'Sensor Ready' condition is forced. These will enable function 9.6.3.3 'Range or Signal Stuck' to operate and detect a functioning sensor (i.e. apply a controlled fuel ramp and observe sensor voltage for correct reaction). Any failure in the heater control or sensor diagnostics will set the HEGO ready flag to 'not ready' and a fault is declared.

9.4. Sensor Heater Control

The HEGO sensor heater control acts in a similar method as for the UHEGO sensor. The main difference is that each sensor will operate with different Dew Point models because of the different sensor locations.

9.5. Heater Diagnostics

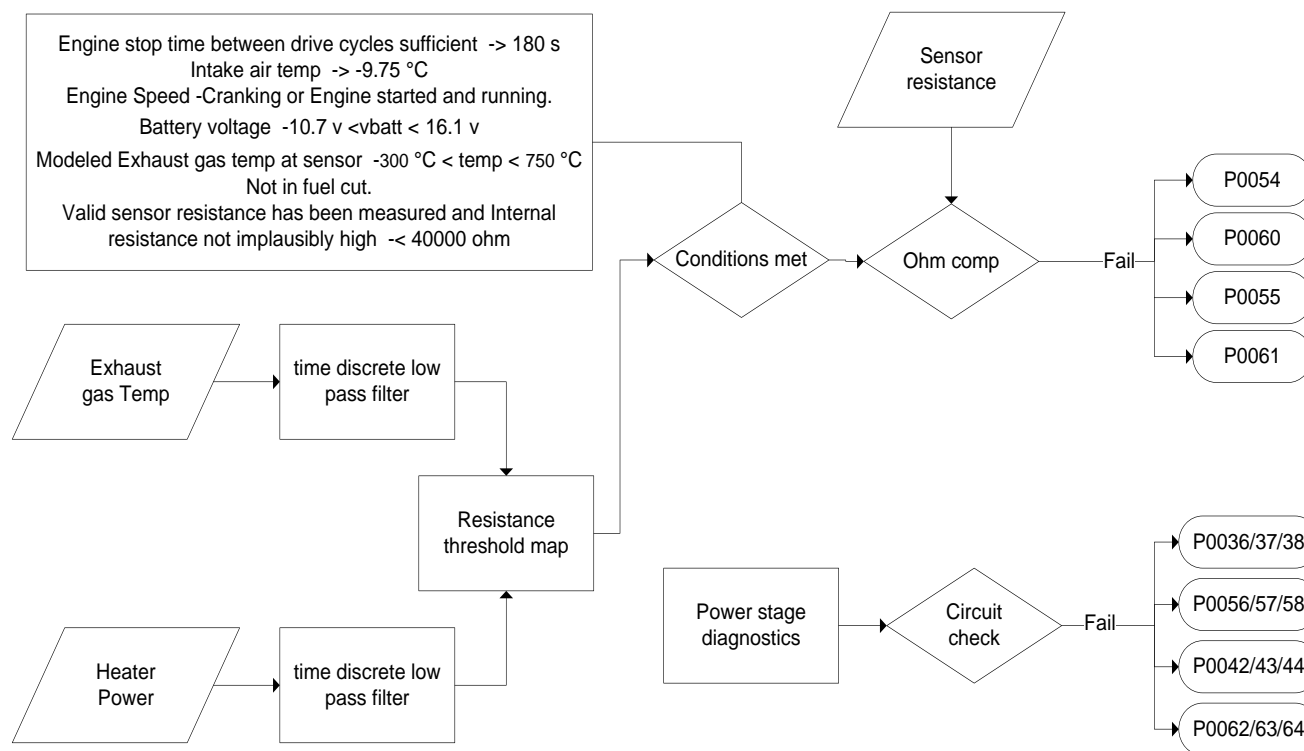
9.5.1. Heater power stage monitoring

P0036, P0037, P0038, P0056, P0057, P0058, P0042, P0043, P0044, P0062, P0063 and P0064. Fault recognition, read-out and storage of the power stage fault information is done within the Powerstage hardware. Fault verification and OBD-fault storage is done within the EMS software. This is performed by observing the fault status information placed in an error-trace-buffer. If a fault has been signaled a counter is activated which has been set with a 'non-calibrateable' time (300 ms). After this time has elapsed, a verification test pulse is initiated in order to confirm the fault. One calculation raster later (100 ms) the verification check is performed. If, during the verification check, the same fault is recognized, the fault is considered to be verified. Faults which cannot be definitely detected are ignored.

9.5.2. Heater monitoring

P0050, P0055, P0060 and P0061. There is a correlation between ceramic temperature and internal resistance. For a sensor with defective heating, the ceramic temperature is lower compared to that of a fault free sensor, meaning the internal resistance of the sensor will be higher in comparison. The diagnostic compares the internal resistance of the heater to a threshold. This threshold is dependent on filtered values of exhaust gas temperature, exhaust mass flow and heater power.

9.5.3. HEGO Heater Monitor – System Flowchart



9.6. Signal Diagnostics

9.6.1. Electrical monitoring

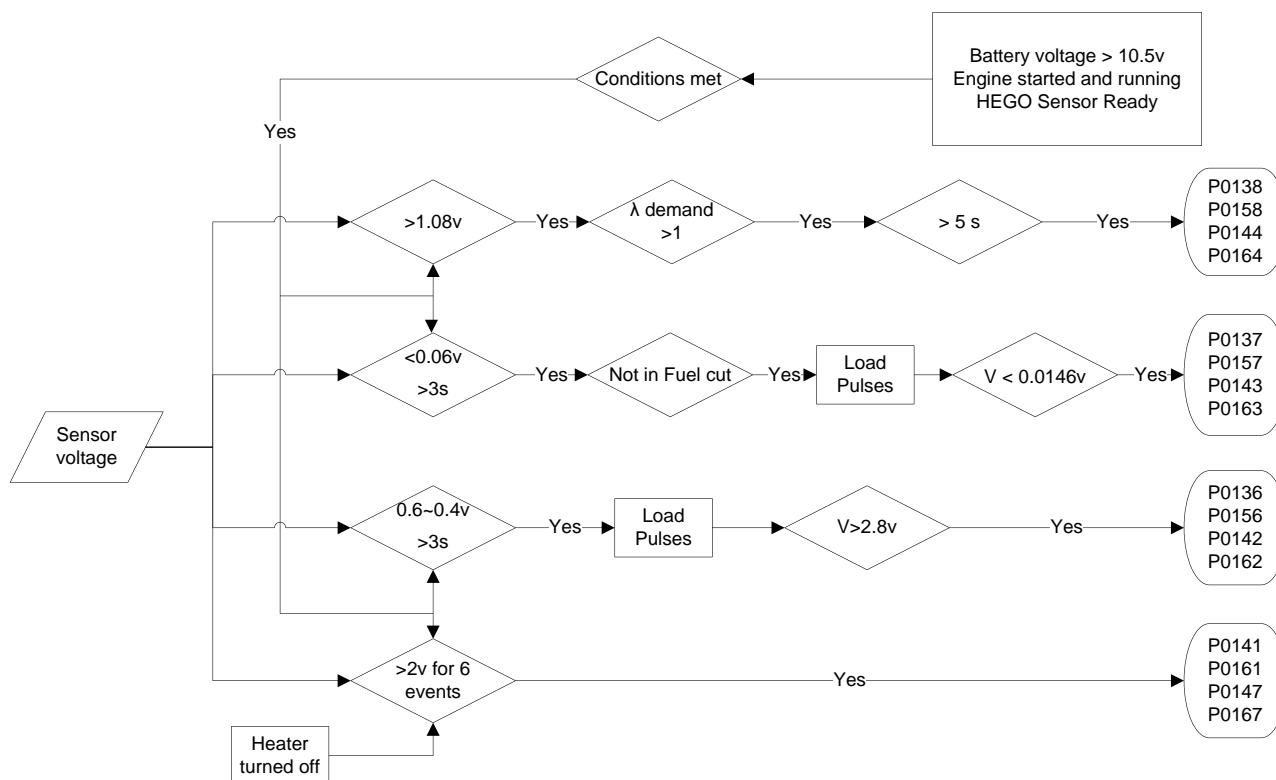
P0138, P0158 P0144 and P0164. Sensor voltage short to battery voltage. Sensor voltage stuck high for an implausible period whilst lambda demand is not rich.

P0137, P0157, P0143 and P0163. Sensor short to ground. If the sensor voltage is below a threshold for an implausible period whilst not in fuel cut or oxygen neutralization, a fault suspicion is raised. Further observations of sensor voltage are made after 3 load pulses. These load pulses are the application of a controlled voltage pulse across the sensor. For the case of a short to ground if the difference between the measured sensor voltage during the load pulse is below a threshold then a fault is confirmed.

P0136, P0156, P0142 and P0162. Sensor wire break if the sensor voltage stays between limits for an implausible time then a load pulse is requested. For a wire break if the difference between the measured sensor voltage during the load pulse is above a threshold, then a fault is confirmed.

P0141, P0161, P0147 and P0167. Sensor and heater short circuit. If this short circuit exists then a voltage change in the sensor voltage will occur during heater switch off. If this voltage change is greater than a threshold for a number of heater turn off events, then a fault is declared.

9.6.2. HEGO Electrical Monitoring – System Flowchart



9.6.3. HEGO Sensor dynamics

HEGO sensor dynamics are diagnosed for three performance deterioration deficiencies. Delayed response, transient response and range or stuck response. The delayed and transient response checks are made in order to ensure correct catalyst efficiency diagnosis, so these checks are only performed on the LSF sensor.

9.6.3.1. Delayed response

P013F, P014B, P013E and P014A. (LSF Only). The delayed response monitor checks the sensor's 'time to respond' reaction to a fueling step change. The actual time taken for a sensor to react to a fueling change is affected by three components, the oxygen storage dynamics of the catalyst, travel time of the exhaust gas and the actual response time of the sensor. The oxygen storage dynamics of the catalyst are modeled based upon oxygen storage capacity and exhaust mass gas flow which will give a catalyst response time for a fueling change. Similarly, the exhaust gas travel time is modeled based upon exhaust gas mass flow. The sum of these times will give the delay to any fueling change that the sensor will be exposed. The subtraction of these two factors from the total time that a fueling change is seen by the sensor, is the actual response time of the sensor. The actual analysis occurs over a number of forced fueling swings in a rich to lean fueling step change, once entrance conditions are met. The final result is filtered from these step changes and if the delay time is sufficient to exceed emissions or affect catalyst diagnosis as defined by a threshold, then a fault is raised. The monitor will run once per drive cycle.

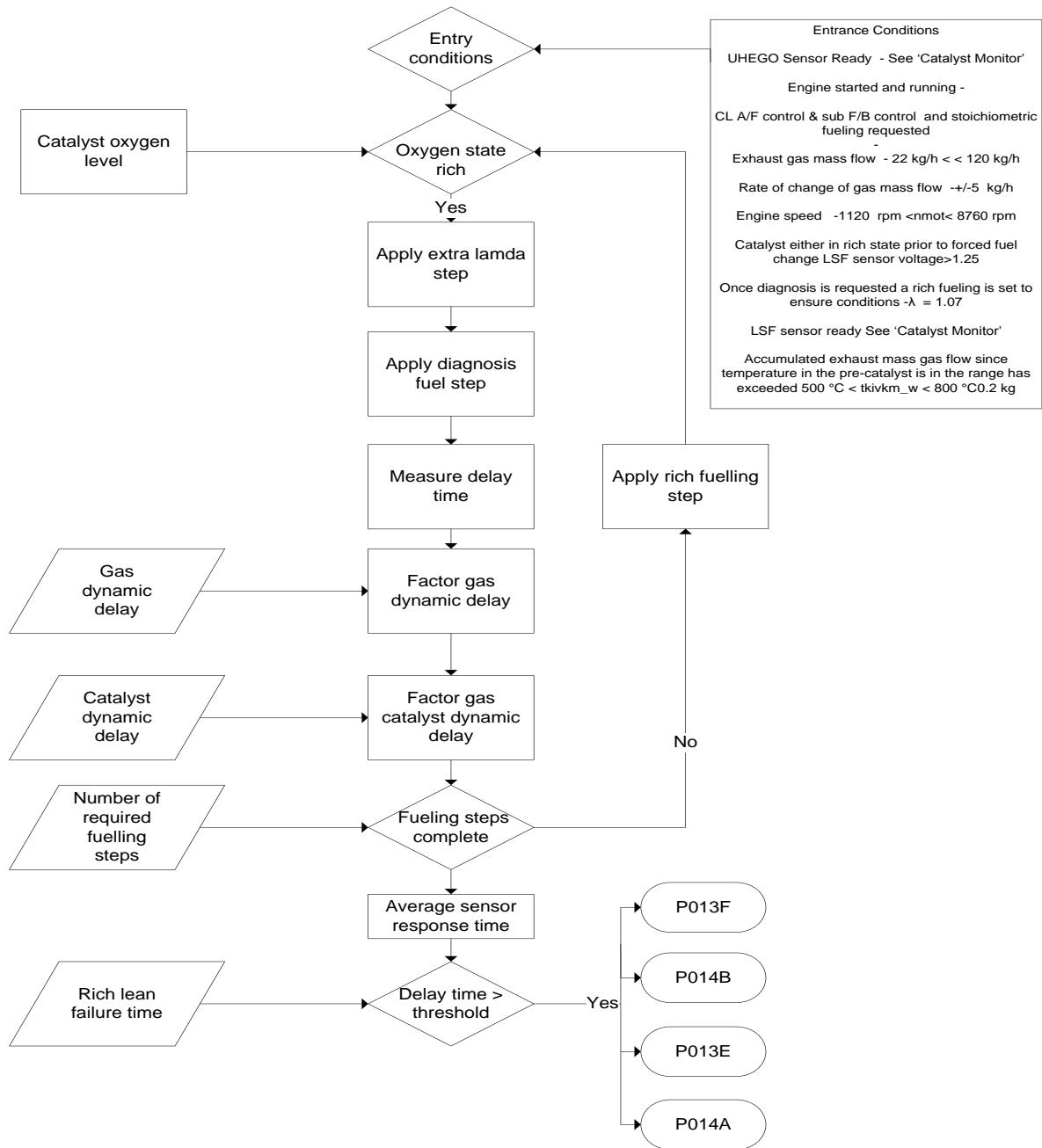
9.6.3.2. Transient response

P013B, P013D, P013A and P013C. (LSF Only). The transient response monitor checks the sensor's rate of response whilst reacting to a fuel cut off event. The voltage output of the sensor is filtered and compared with its previous value based upon a fixed time delay. During the fuel cut event the maximum 'response gradient' is filtered and converted to a response time. A slow sensor will have a small response gradient and a large time constant. A correctly acting sensor will have a larger response gradient and a smaller time constant. If this time constant is sufficient to exceed emissions or affect catalyst diagnosis as defined by a threshold then a fault is raised. The monitor will run once per drive cycle.

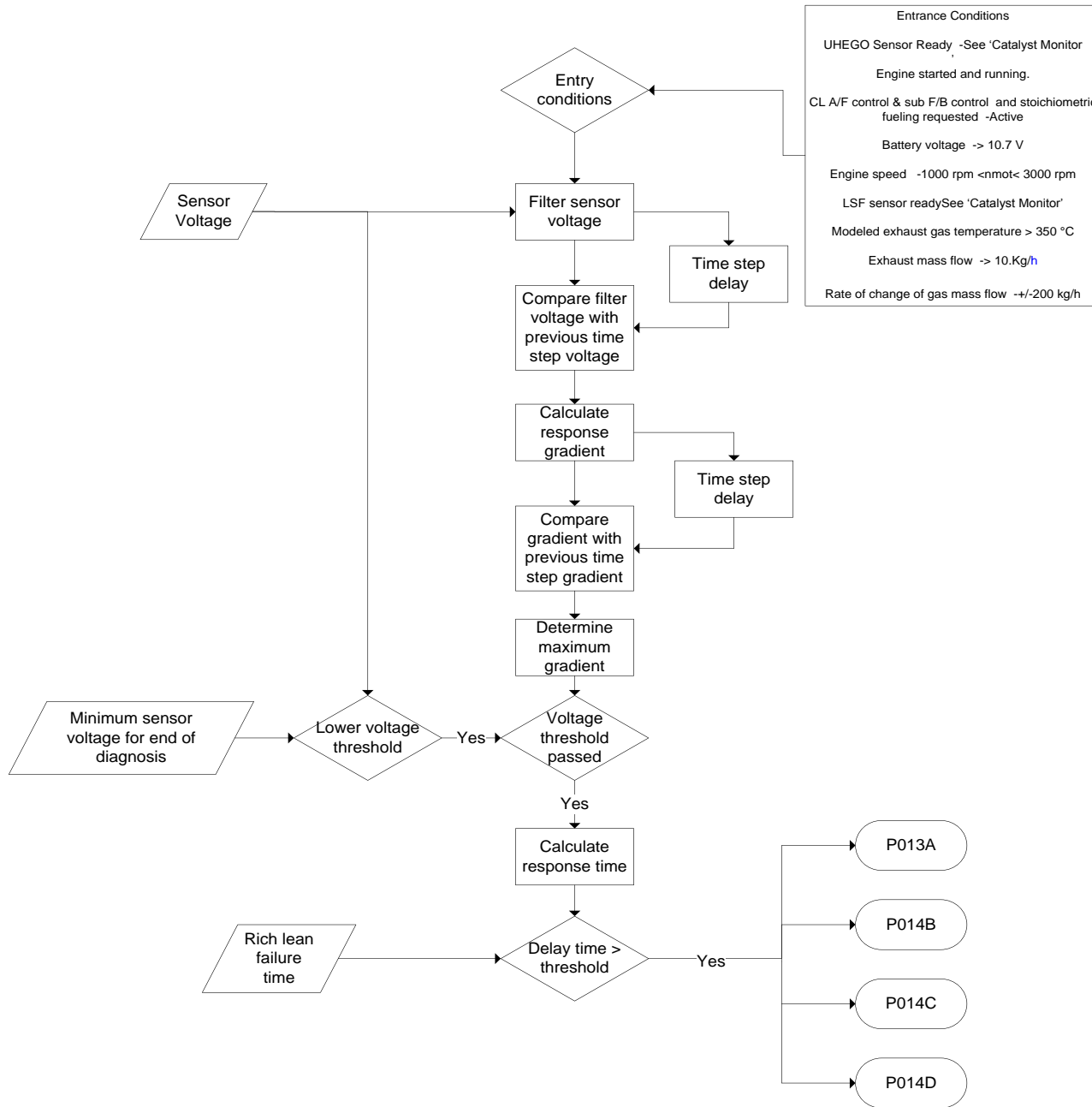
9.6.3.3. Range or signal stuck

P2270, P2271, P2272, P2273, P2274, P2275, P2276 and P2277. The range check or signal stuck diagnostic checks the signal voltage level to see if it is stuck high, stuck low or not responding. During normal operation a normally operating sensor should see high and low voltage levels in response to rich and lean fueling events. A comparison is made to find the maximum or minimum between a filtered sensor voltage and the previous maximum or minimum voltage. This is then compared to thresholds to establish if the sensor voltage has achieved rich or lean readings. If they have not seen rich or lean voltage levels then active fueling ramps are applied. If the sensor voltage does not show rich or lean readings after these fueling ramps, then a fault is diagnosed. In addition, during fuel cut off events of sufficient duration that ensure that each sensor should be reading lean voltage levels, then a voltage comparison is made and faults diagnosed if voltage readings are not showing lean voltage levels.

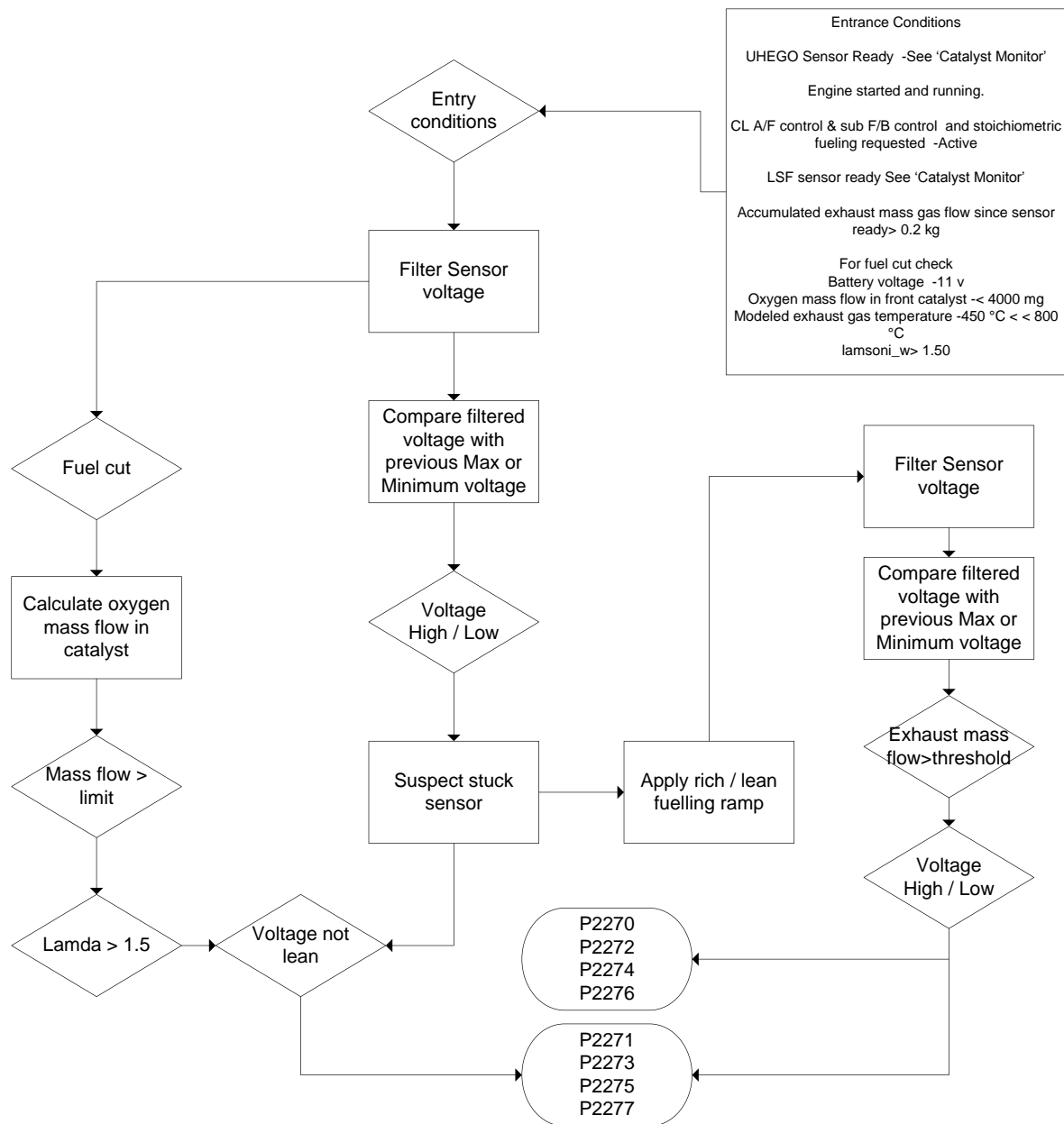
9.6.3.4. Delayed response – System Flowchart



9.6.3.5. Transient response – System Flowchart



9.6.3.6. Range or signal stuck – System Flowchart



Entrance Conditions

- UHEGO Sensor Ready -See 'Catalyst Monitor'
- Engine started and running.
- CL A/F control & sub F/B control and stoichiometric fueling requested -Active
- LSF sensor ready See 'Catalyst Monitor'
- Accumulated exhaust mass gas flow since sensor ready> 0.2 kg
- For fuel cut check
 - Battery voltage -11 v
 - Oxygen mass flow in front catalyst -< 4000 mg
 - Modeled exhaust gas temperature -450 °C < < 800 °C
 - lamsoni_w> 1.50

9.7. HEGO (LSF and LSH) Sensor Monitoring Tables

Oxygen Sensor Monitoring Downstream LSF and LSH								
Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Oxygen Sensors Downstream (HEGO LSF AND LSH)								
Electrical monitoring								
<i>HEGOS2B1ElecMax</i>	P0138	Sensor voltage short to V Batt	Sensor voltage stuck high for implausible period whilst lambda demand is non-rich.	> 1.9 v for > 0.1 s	HEGO Sensors ready - Battery voltage - Engine Speed -	See 'catalyst Monitoring' > 10.7 v Cranking or Engine started and running.	5 s	2 Drive Cycles
<i>HEGOS2B2ElecMax</i>	P0158							
<i>HEGOS3B1ElecMax</i>	P0144							
<i>HEGOS3B2ElecMax</i>	P0164							
<i>HEGOS2B1ElecMin</i>	P0137	Sensor short to ground	If the sensor voltage is below a threshold for an implausible period whilst not in fuel cut or oxygen neutralization a fault suspicion is raised. Further observations of sensor voltage are made after 3 load pulses. These load pulse are the application of controlled voltage pulse across the sensor. For the case of a short to ground if the difference between the measured sensor voltage during the load pulse is below a threshold then a fault is confirmed.	< 0.06 v for > 3 s			3 s	
<i>HEGOS2B2ElecMin</i>	P0157							
<i>HEGOS3B1ElecMin</i>	P0143							
<i>HEGOS3B2ElecMin</i>	P0163							
<i>HEGOS2B1ElecSig</i>	P0136	Sensor wire break	If the sensor voltage stays between limits for implausible time then a load pulse is requested. For a wire break if the difference between the load pulse sensor voltage is above a threshold a fault is confirmed.	1.2 v ~ 1.9 v for > 3 s			3 s	
<i>HEGOS2B2ElecSig</i>	P0156							
<i>HEGOS3B1ElecSig</i>	P0142							
<i>HEGOS3B2ElecSig</i>	P0162							
<i>HEGOS2B1ElecNpl</i>	P0141	Sensor and heater short circuit	If this short circuit exists then a voltage change in the sensor voltage will occur during heater turn off. If this voltage change is greater than a threshold for a number of heater turn off events then a fault is declared.	> 2 v for 6 events			6 events	
<i>HEGOS2B2ElecNpl</i>	P0161							
<i>HEGOS3B1ElecNpl</i>	P0147							
<i>HEGOS3B2ElecNpl</i> (HEGO_OBDElec)	P0167							
					Fault codes that disable P0138, P0136 or P0141	P0038, P0037, P0036		
					Fault codes that disable P0158, P0156 or P0161	P0058, P0057, P0056		
					Fault codes that disable P0144, P0142 or P0147	P0044, P0043, P0042		
					Fault codes that disable P0164, P0162 or P0167	P0064, P0063, P0062		

Oxygen Sensor Monitoring Downstream LSF and LSH

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Oxygen Sensors Downstream (HEGO LSF AND LSH)								
Heater power stage monitor								
HEGOS2B1HtrPsMax	P0038	Powerstage transistor voltage check	Monitors the voltage drop at the power stage transistor during the switching of the PWM heater control expected voltage levels.		Battery voltage - Engine Speed -	10.7 v < vbatt < 16.1 v Cranking or Engine started and Running.	0.2 s	2 Drive Cycles
HEGOS2B1HtrPsMin	P0037							
HEGOS2B1HtrPsSig	P0036							
HEGOS2B2HtrPsMax	P0058							
HEGOS2B2HtrPsMin	P0057							
HEGOS2B2HtrPsSig	P0056							
HEGOS3B1HtrPsMax	P0044							
HEGOS3B1HtrPsMin	P0043							
HEGOS3B1HtrPsSig	P0042							
HEGOS3B2HtrPsMax	P0064							
HEGOS3B2HtrPsMin	P0063							
HEGOS3B2HtrPsSig	P0062							
(HEGO_OBDHtrPs)								
Heater monitoring								
HEGOS2B1HtgNpl	P0054	There is a correlation between ceramic temperature and internal resistance. With a sensor with defective heating, the ceramics temperature usually is lower compared to that of a faultless sensor. This means that the internal resistance of the sensor is higher when compared to a fault free heated sensor.	The internal resistance of the heater is compared to a threshold. This threshold is dependent on filtered values of exhaust gas temperature and heater power. If the resistance is higher than this threshold then a fault is declared	see resRiThresDHtg_MAP (table)	Engine stop time between drive cycles sufficient - Intake air temp - Engine Speed - Battery voltage - Modeled Exhaust gas temp at sensor - Not in fuel cut. Valid sensor resistance has been measured and Internal resistance not implausibly high -	> 180 s > -9.75 °C Cranking or Engine started and running. 10.7 v < vbatt < 16.1 v 300 °C < temp < 750 °C < 40000 ohm	5 s	
HEGOS2B2HtgNpl	P0060							
HEGOS3B1HtgNpl	P0055							
HEGOS3B2HtgNpl	P0061							
(HEGO_OBDHtg)								
					Fault codes that disable P0054	P0038, P0037, P0036		
					Fault codes that disable P0060	P0058, P0057, P0056		
					Fault codes that disable P0056	P0044, P0043, P0042		
					Fault codes that disable P0061	P0064, P0063, P0062		

resRiThresDhtg_MAP - Internal resistance threshold for heater performance diagnosis

		y \ x	200	300	400	500	550
input x	°C	0.6	700	700	700	700	700
input y	Ht pwr	0.7	700	700	700	700	700
output w	Ohm	0.8	700	700	700	700	700
		0.9	700	700	700	700	700
		1.0	700	700	700	700	700

Oxygen Sensor Monitoring Downstream LSF and LSH								
Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Oxygen Sensors Downstream (HEGO LSF AND LSH)								
Transient response		Transient response. Checks for reduction in the transient signal gradient during a rich to lean fueling event.	The voltage output of the sensor is filtered and compared with its previous value based upon a fixed time delay. During the fuel cut event the maximum 'response gradient' is filtered and this converted to a response time. A slow sensor will have a small response gradient and a large time constant. If the constant is above a threshold a fault is declared.		UHEGO Sensor Ready - Engine Speed - CL A/F control & sub F/B control and stoichiometric fueling requested - Battery voltage - Engine speed -	See 'Catalyst Monitor' Cranking or Engine started and running. Active > 10.7 v 1000 rpm < nmot < 3000 rpm	3 s	2 Drive Cycles
For sensor 2 (LSF) Rich to lean HEGOS2B1PT1RL HEGOS2B2PT1RL (DDYLSTR)	P013A P013C			Rich to lean Failure time threshold	> 0.8 s	LSF sensor ready Modeled exhaust gas temperature (tafso) - Exhaust mass flow -	See 'Catalyst Monitor' >350 °C > 10 Kg/h	
					Fault codes that disable P013A	P0038, P0037, P0036, P2270, P2271, P0496, P0497, P2231, P2195, P2196, P0170, P0130, P0134, P0133, P0135, P00D1 (npl), P00D1 (sig), P2626, P0032, P0031, P0030, P2237 (max), P2237 (npl), P2237 (sig), P0132, P0131, P2243, P2251, P0040, P064D (max), P064D (min), P064D (npl), P064D (sig)		
					Fault codes that disable P013C	P0058, P0057, P0056, P2272, P2273, P2234, P0496, P0497, P2197, P2198, P0173, P0150, P0154, P0153, P0155, P00D3, P00D3, P2629, P0052, P0051, P0050, P2240 (max), P2240 (npl), P2240 (sig), P0152, P0151, P2247, P2254, P064E (max), P064E (min), P064E (npl), P064E (sig), P0040		

Oxygen Sensor Monitoring Downstream LSF and LSH

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Oxygen Sensors Downstream (HEGO LSF AND LSH)								
Delayed response		Delayed response. Checks for reduction in the sensor response to a forced rich to lean fueling event.	If the time taken for sensor voltage to pass a threshold from the start of forced fuel event is above a threshold then a fault is declared.		UHEGO Sensor Ready - Engine Speed - CL A/F control & sub F/B control and stoichiometric fueling requested Exhaust gas mass flow - Rate of change of gas mass flow - Catalyst in rich state prior to forced fuel change – sensor voltage - Once diagnosis is requested a lean fueling is set to ensure conditions - LSF sensor ready	See 'Catalyst Monitor' Cranking or Engine started and running. Active 22 kg/h < msabvkv < 120 kg/h -7 kg/h < Δ msabvkv < 7 kg/h > 1.25 v λ > 1.07 See 'Catalyst Monitor'	3 s	2 Drive Cycles
For sensor 2 (LSF) Rich to lean	HEGOS2B1DlyRL P013E HEGOS2B2DlyRL P014A (DDYLSRESP)							
					Fault codes that disable P013E	P0038, P0037, P0036, P2270, P2271, P0496, P0497, P0133, P2231, P2626, P0032, P0031, P0030, P0135, P00D1 (npl), P00D1 (sig), P064D (max), P064D (min), P064D (npl), P064D (sig), P2237 (max), P2237 (npl), P2237 (sig), P0132, P0131, P2243, P2251, P0130, P0040, P2195, P2196, P0170, P0134,		
					Fault codes that disable P014A	P0058, P0057, P0056, P2272, P2273, P0496, P0497, P0153, P2234, P2629, P0155, P00D3, P00D3, P0052, P0051, P0050, P064E (max), P064E (min), P064E (npl), P064E (sig), P2240 (max), P2240 (npl), P2240 (sig), P0152, P0151, P2247, P2254, P0150, P2197, P2198, P0173, P0154, P0040,		

Oxygen Sensor Monitoring Downstream LSF and LSH

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Oxygen Sensors Downstream (HEGO LSF AND LSH)								
Range Check		Range Check. Check the voltage level of the sensor to see if it is stuck high, low or not responding.	A filtered sensor voltage is compared to its self and compared for its maximum and minimum values. If the max and minimum values do not exceed rich and lean thresholds then the sensor voltage is considered stuck. If a stuck state is suspected then forced lean and rich fueling ramps are applied and sensor reaction observed. A fault is declared if no sensor reaction is observed. An additional check is also made during fuel cut events that if the oxygen mass in the catalyst has exceeded calibrated level a lean voltage is seen.	> 0.71 v < 0.20 v	UHEGO Sensor Ready - Engine Speed - CL A/F control & sub F/B control and stoichiometric fueling requested - LSF sensor ready Accumulated exhaust mass gas flow since sensor ready For fuel cut check Battery voltage - Oxygen flow since fuel cut - Modeled exhaust gas temperature - Lamda at end of fuel cut -	See 'Catalyst Monitor' Cranking or Engine started and running. See 'Catalyst Monitor' See 'Catalyst Monitor' > 0.20 kg > 10.7 > 4000 mg 450 °C < tafso < 800 °C > 1.50	10 s	2 Drive cycles
HEGOS2B1TarLean	P2270							
HEGOS2B1TarRich	P2271							
HEGOS2B2TarLean	P2272							
HEGOS2B2TarRich	P2273							
					Fault codes that disable P2270 or P2271	P2177, P2178, P0300, P0496, P0497, P0459, P0458, P0444		
					Fault codes that disable P2272 or P2273	P2179, P2180, P0300, P0496, P0497, P0459, P0458, P0444		
HEGOS3B1TarLean	P2274							
HEGOS3B1TarRich	P2275							
HEGOS3B2TarLean	P2276							
HEGOS3B2TarRich	P2277							
(HEGOD_LimDs)				> 0.74 v < 0.30 v	LSH sensor ready Accumulated exhaust mass gas flow since sensor ready For fuel cut check Battery voltage - Oxygen flow since fuel cut - Modeled exhaust gas temperature - Lamda at end of fuel cut -	See 'Catalyst Monitor' > 0.2 kg > 10.7 v > 4000 mg 450 °C < tahso < 800 °C > 1.50		
					Fault codes that disable P2274 or P2275	P2177, P2178, P0496, P0497, P0300, P0459, P0458, P0444		
					Fault codes that disable P2276 or P2277	P2179, P2180, P0496, P0497, P0300, P0459, P0458, P0444		

10. Individual Cylinder AFR Monitor

10.1. Fault Codes

P219C - Cylinder 1 Air-Fuel Ratio Imbalance
P219D - Cylinder 2 Air-Fuel Ratio Imbalance
P219E - Cylinder 3 Air-Fuel Ratio Imbalance
P219F - Cylinder 4 Air-Fuel Ratio Imbalance
P21A0 - Cylinder 5 Air-Fuel Ratio Imbalance
P21A1 - Cylinder 6 Air-Fuel Ratio Imbalance
P21A2 - Cylinder 7 Air-Fuel Ratio Imbalance (V8 only)
P21A3 - Cylinder 8 Air-Fuel Ratio Imbalance (V8 only)

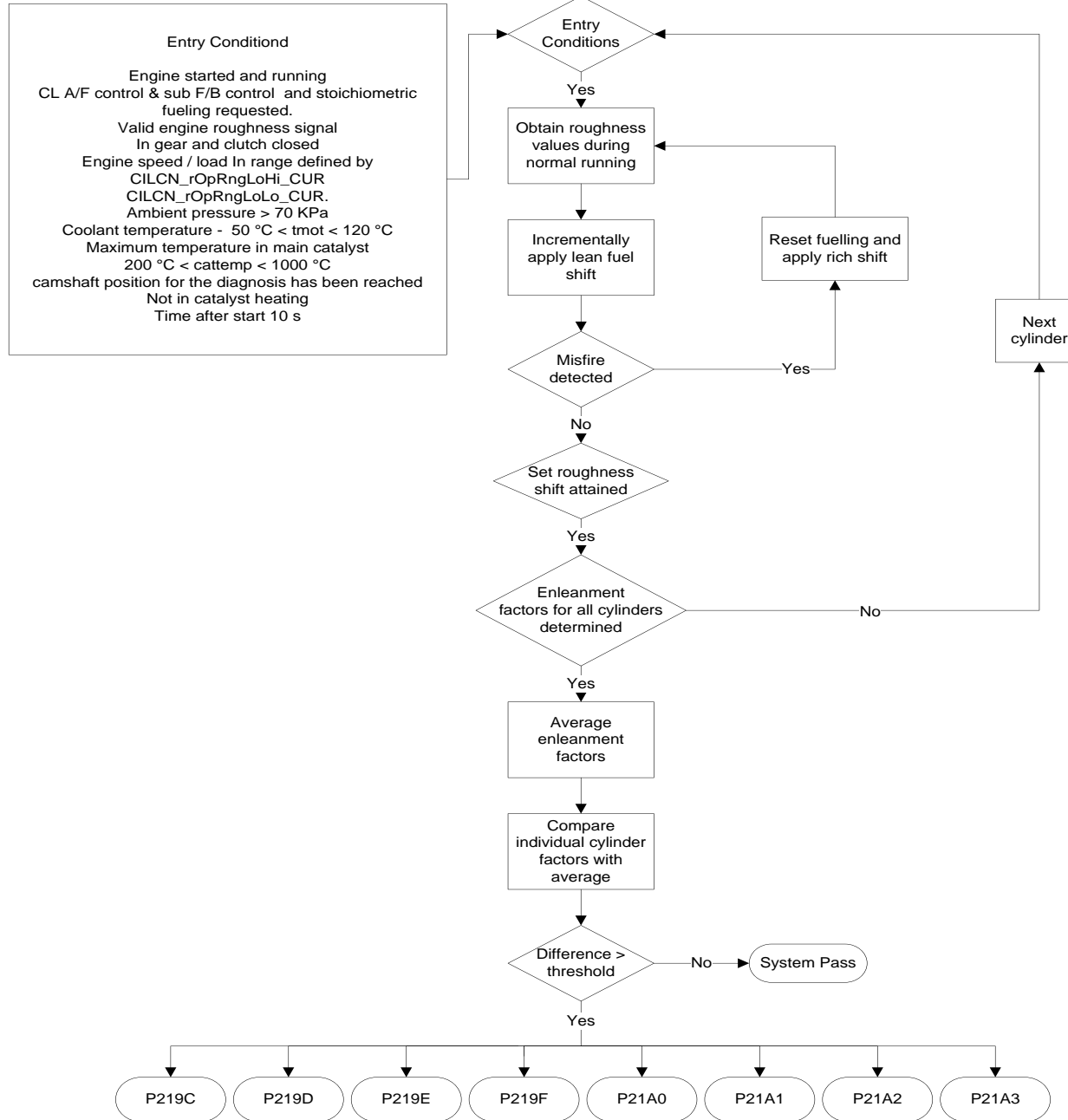
10.2. System Description

An imbalance in individual cylinder air-fuel-ratio operating conditions is assessed using an enleanment roughness judgement method. Once the entry conditions have been met, roughness values for a cylinder, based upon crankshaft speed deviation, is determined then the fuelling to the selected cylinder is leaned out. This enleanment continues until a set roughness shift has been met or misfire detected. If misfire is detected the process is reset and a rich fuelling offset applied before the enleanment process is repeated. During this enleanment a rich fuel bias is applied to the remaining cylinders to compensate for the enleanment. This process is repeated for all cylinders and can occur simultaneously or in individual steps during a drive cycle and the data stored for later analysis.

10.3. Fault Decision

Once a set 'enleanment' data is gathered an average of the lean shift fuelling factors is made. The individual factors are then compared against the average and if the difference is greater than a threshold then a fault is declared.

10.4. Individual Cylinder AFR Monitor – System Flowchart and Tables



Individual Cylinder AFR Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Individual Cylinder AFR								
Cyl 1 Cyl 2 Cyl 3 Cyl 4 Cyl 5 Cyl 6 Cyl 7 Cyl 8 (DAFIMRAW)	P219C P219D P219E P219F P21A0 P21A1 P21A2 P21A3	An imbalance in individual cylinder air-fuel-ratio operating conditions is assessed using an enleanment roughness judgement method. The amount of fuel enleanment is obtained for all cylinders to achieved a given roughness value (measured from crank shaft speed deviation).	Once a set 'enleanment' data is gathered an average of the lean shift fuelling factors is made. The individual factors are then compared against the average and if the difference is greater than a threshold then a fault is flagged. A lean and rich decision can be made for all cylinders and the cylinder bank.	> 1.1	Engine started and running. CL A/F control & sub F/B control and stoichiometric fueling requested - Valid engine roughness signal. In gear and clutch closed. Engine speed / load range - Ambient pressure - Coolant temperature - Maximum temperature in main catalyst - Not in catalyst heating. Time after start -	Active. CILCN_rOpRngLoHi_CUR (table) CILCN_rOpRngLoLo_CUR (table) 50 °C < ect1 < 120 °C 200 °C < ctemp < 1000 °C > 10 s	Depend s upon drive cycle time	2 Drive Cycles

Individual Cylinder AFR

CILCN_rOpRngLoHi_CUR

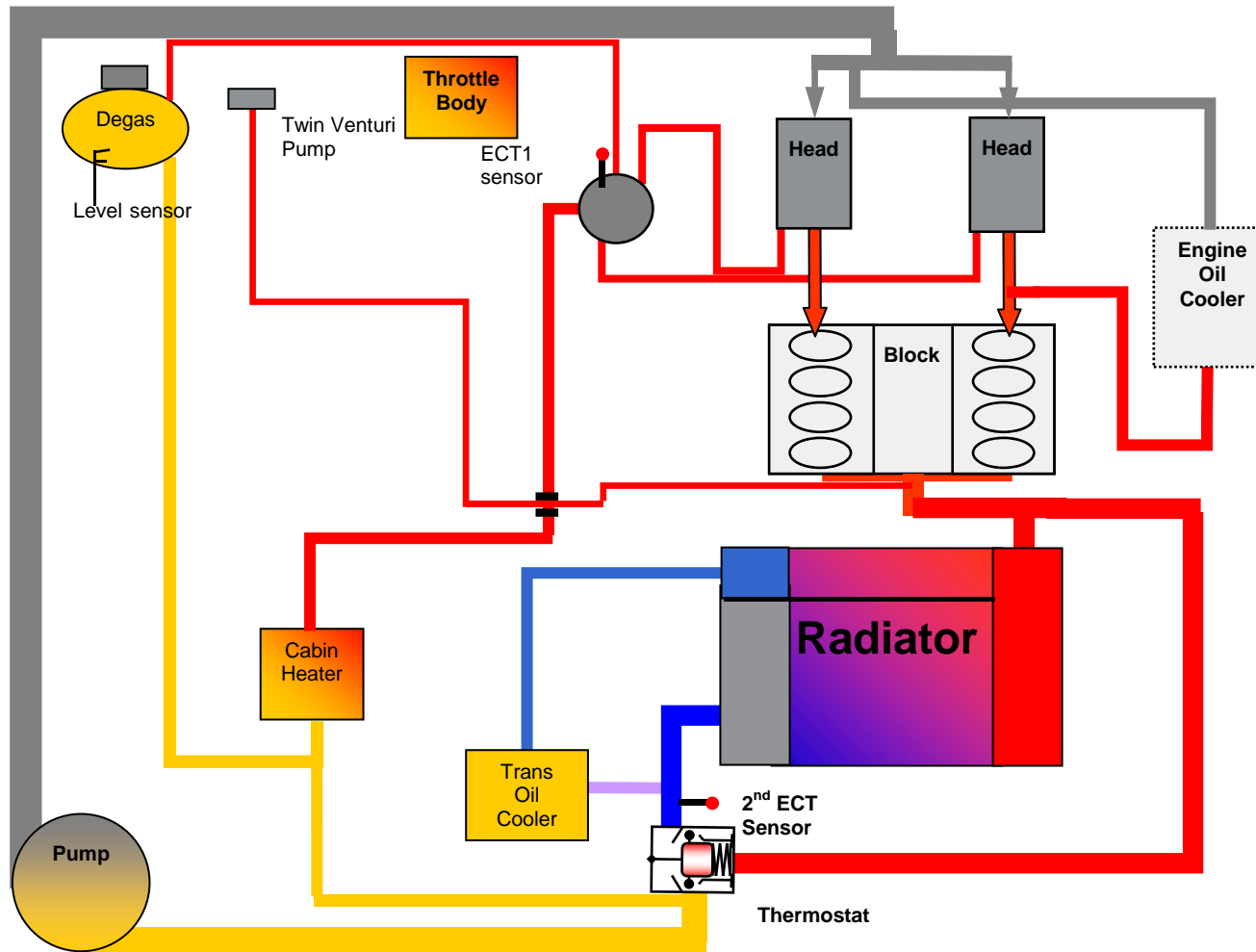
input x	rpm	960	1000	1240	1520	2520	2560
output w	%	0	39.75	60	60	60	0

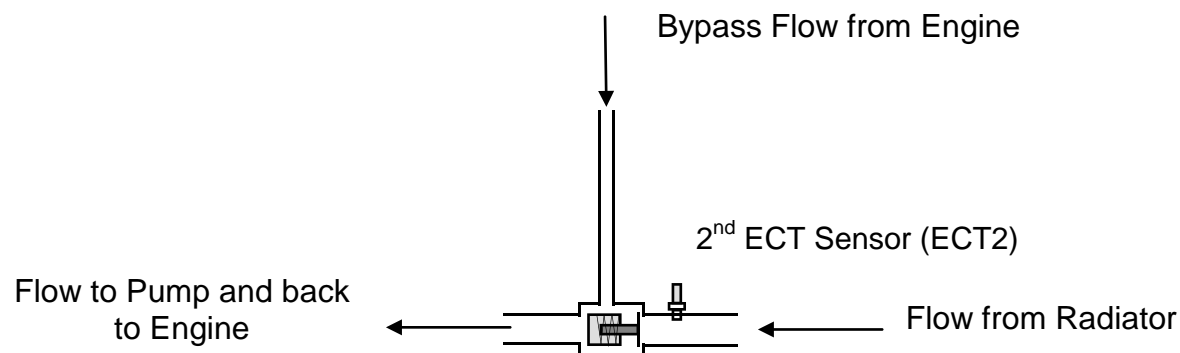
CILCN_rOpRngLoLo_CUR

input x	rpm	960	1000	1240	1520	2520	2560
output w	%	191.25	24.75	24.75	24.75	24.75	191.25

11. Engine Cooling System - Thermostat Monitoring

11.1. System Schematic





11.2. System Description

P0128. The detection of a malfunctioning thermostat is determined through the use of a second coolant temperature sensor at the radiator outlet (ECT2). If a thermostat is incorrectly allowing coolant through the radiator, then the radiator out temperature will increase before the engine reaches its normal operating temperature.

A fault threshold is determined at start from the following look up table:

ECT2 at engine start (degC)	-20.3	0.0	15.0	30.0	45.0	60.0
Fault threshold (degC)	60.0	45.0	33.8	24.0	14.3	9.8

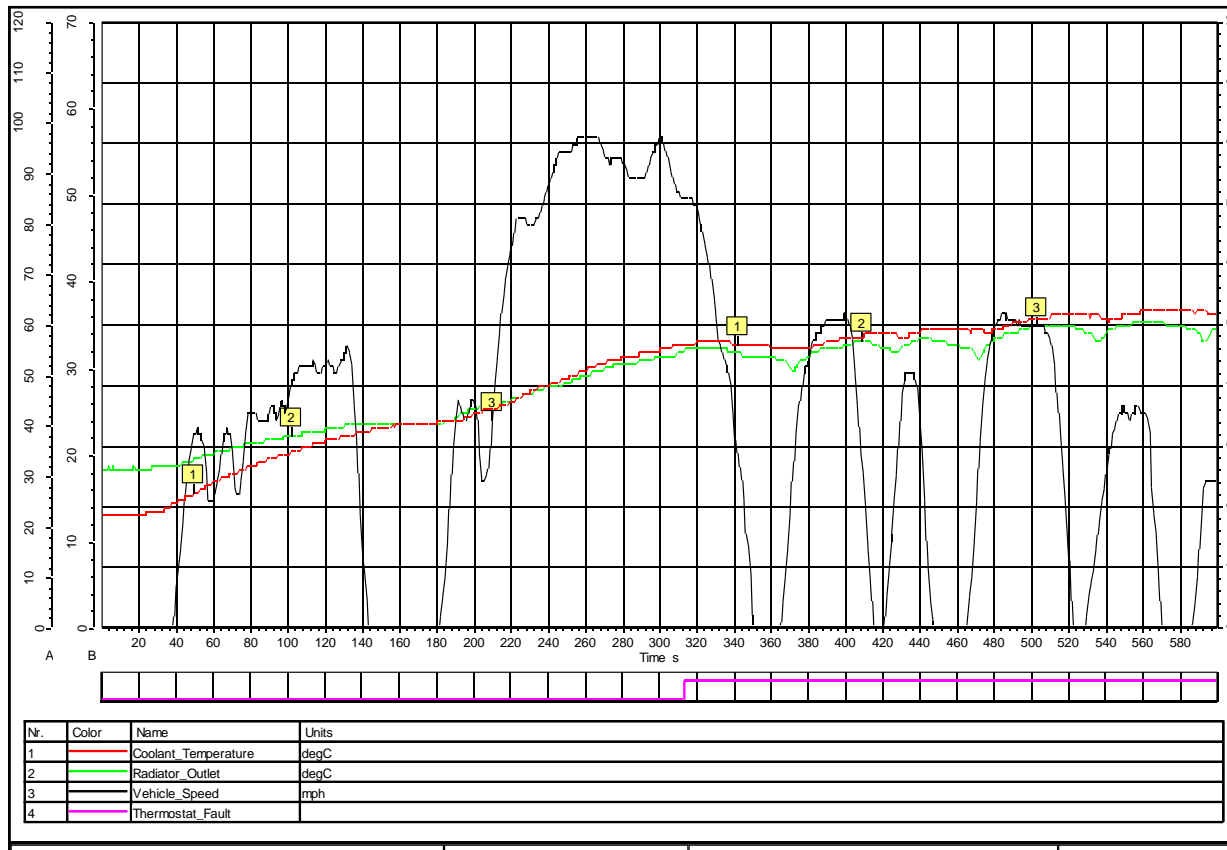
Provided the following entry conditions are true:

- Engine speed between 560 and 5400 rpm
- Ambient temperature between -7.0 and 60.0 degrees C
- Engine coolant temperature at start between -7.0 and 60.0 degrees C
- Proportion of vehicle operation time at idle is less than 50%

Then if the radiator outlet temperature (ECT2) rises by more than the fault threshold before the engine coolant temperature (ECT1) has exceeded 80 degrees C, then a fault is declared. 80 degrees C is the highest temperature required to enable other diagnostics and is 11 degrees C (20 F) below the nominal thermostat temperature.

A second check is conducted based on the modeled value of ECT1. If the modeled temperature exceeds a threshold for a set period but the measured ECT1 is still below the diagnostic enablement temperature of 80 degrees C, then a thermostat fault is declared.

Typical Time to Detection for a failed Thermostat during Normal Driving

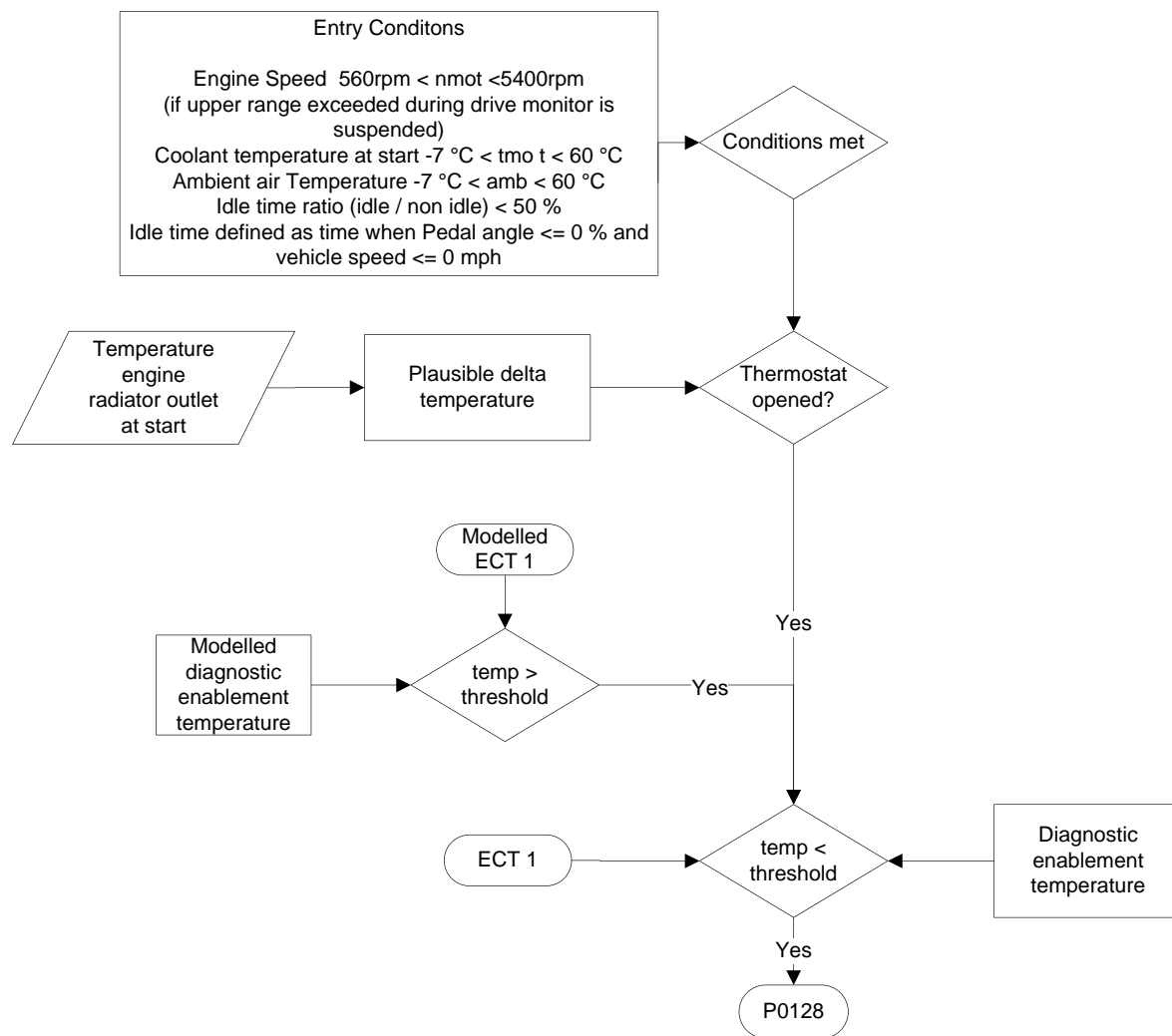


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Fault Detection at 312 seconds

11.3. Thermostat Monitoring – System Flowchart and Tables



Thermostat Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Thermostat Monitor								
<i>THMnp/</i> (DTHM)	P0128	Comparison of temperatures from ECT 1 and ECT 2.	An open thermostat condition is determined based upon an engine start temperature differential model. If the thermostat is open and the actual main coolant temperature ECT1 is below the temperature that enables all other diagnostics then a fault is declared. In addition, if the modeled ECT1 value goes above a threshold for a set period a check is made to see if actual ECT 1 has exceeded the diagnostic enablement threshold. If not a thermostat fault flag is set.	KDLDTATKA (table) < 80.3 °C 81.8 °C 125 s < 80.3 °C	Engine Speed (if upper range exceeded during drive monitor is suspended) Coolant temperature at start - Ambient air Temperature - Idle time ratio (idle / non idle) – Idle time define as time when (Pedal angle - Vehicle speed -)	520 rpm < nmot < 9000 rpm -7 °C < ect1 < 60 °C -7 °C < tumg < 60 °C < 50 % <= 0 % <= 0 mph	Depends upon drive cycle time	2 Drive Cycles

KDLDTATKA - Characteristic line for delta temperature for thermostat open detection

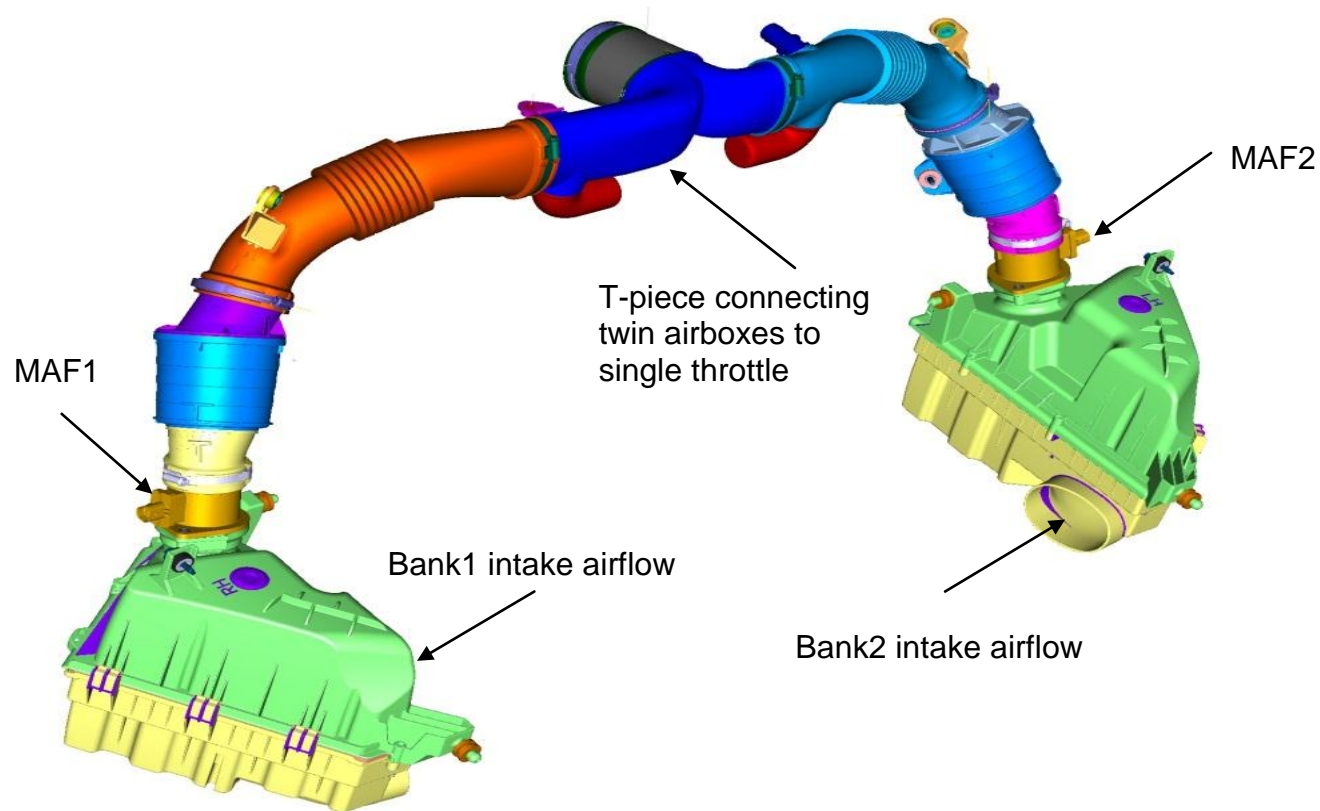
input x	°C	-20.25	0	15	30	45	60
output w	°C	60	45	33.8	24	14.3	9.8

12. Comprehensive Component Monitoring

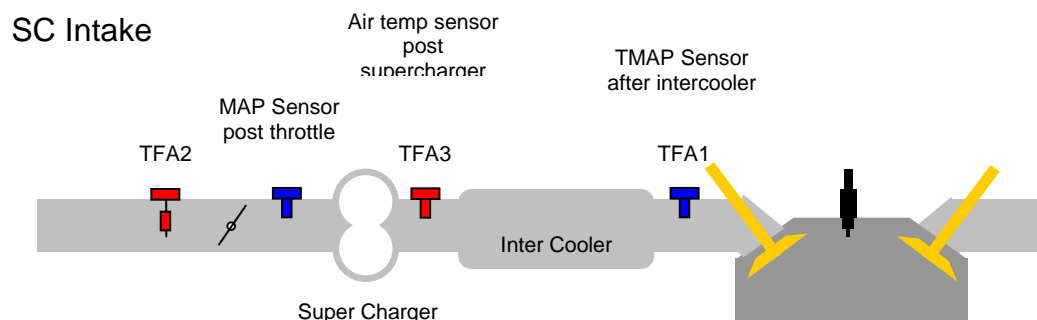
12.1. Intake Air Temperature Sensor Monitor

The V6 SC and V8SC engines have a twin airbox / airflow meter intake system feeding into a single throttle housing.

Schematic



12.1.1. Super Charged Variants



For the supercharged variant there are three temperature measurements made these being post intercooler, pre throttle and post supercharger.

12.1.1.1. TMAP/TFA1 (Post intercooler) Intake Air Temperature Sensor Monitor

12.1.1.1.1. Fault Codes

- P007D - Intake Air Temperature Sensor 1 Circuit High (Bank 1)
- P007C - Intake Air Temperature Sensor 1 Circuit Low (Bank 1)
- P007E - Intake air temperature sensor 1 Circuit (Bank 1): electrical check
- P007B - Intake Air Temperature Sensor 1 Circuit Range/Performance (Bank 1)

12.1.1.1.2. Electrical Monitor

P007D, P007C and P007E. These monitors run continuously. The voltage output from the sensor is compared to absolute maximum and minimum thresholds and a suitable code set if exceeded. Additionally, it tests for a loose connection of the temperature sensor by comparing the difference between the temperature sensor voltage and a low pass filtered value with a 2 second time constant (P007E). If a loose contact occurs, the signal will show a series of step changes between the sensor voltage and the open circuit voltage. Normally, this temperature does not change rapidly, so there should be only a small difference between the signal and the filtered signal. If this difference exceeds a threshold then a fault is declared.

12.1.1.1.3. Rationality Monitor

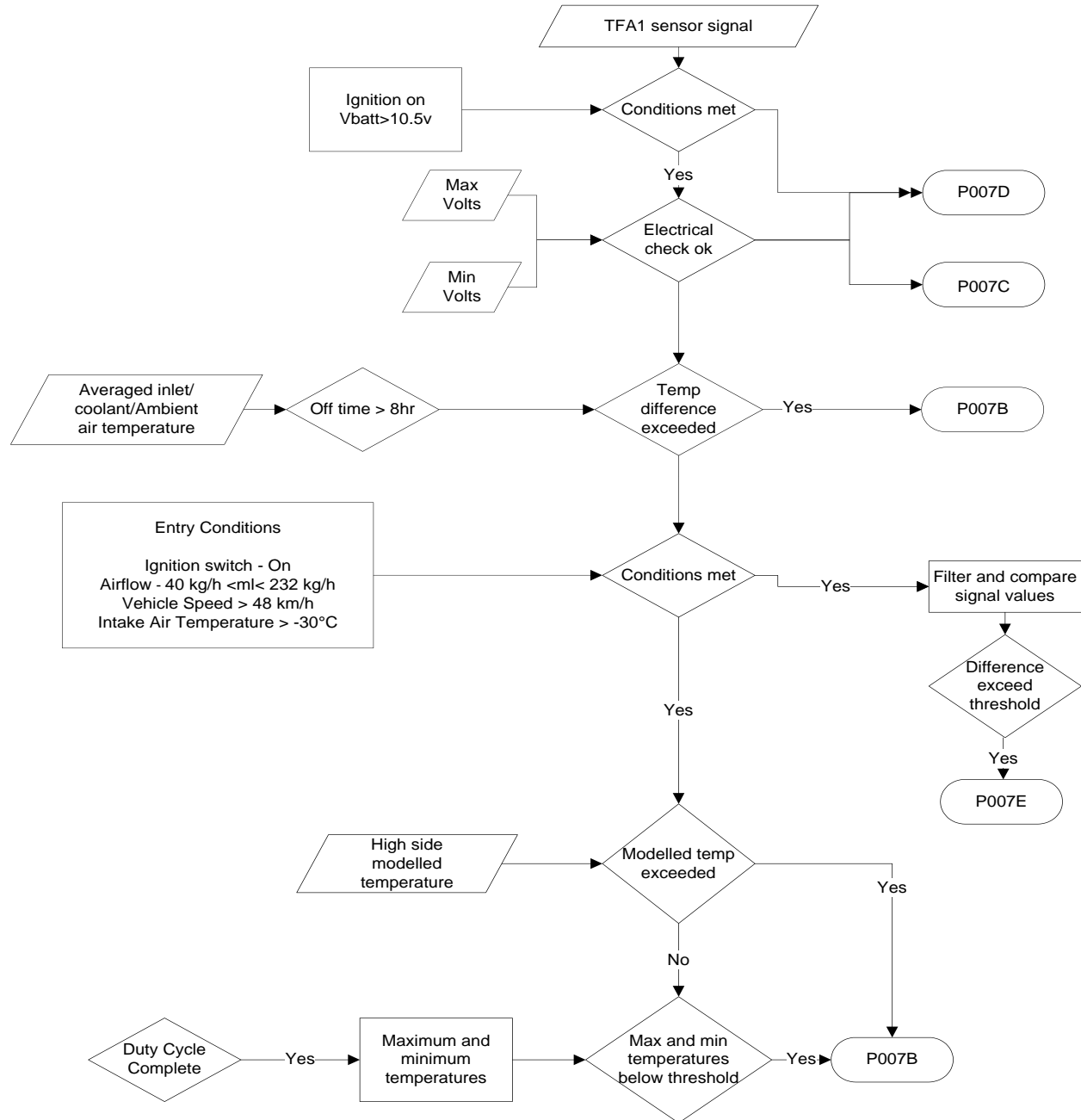
P007B. High Side Check. A maximum air temperature model is formed using inputs from ambient air and engine coolant temperatures and the TFA1 signal is continuously compared to this. If the modeled intake air temperature is less than the actual intake air temperature for a given period then a high fault is declared.

P007B. Stuck Sensor. A stuck sensor is declared if the maximum and minimum temperatures are less than a threshold as measured over a sufficiently large duty cycle. A large duty cycle is defined if the number of operational phases with normally higher intake air temperature (High phase) and lower intake air temperature (Low phase) are encountered since vehicle start.

12.1.1.1.4. Cold Start Monitor

P007B. Range check at start. An average of the Intake temperatures / Coolant1 / Ambient air Temperature sensor values during an engine OFF period is calculated. If the particular sensor value minus the average value is greater than a sensor specific threshold for any period of time, then a fault is declared.

12.1.1.1.5. TFA1 Monitoring – System Flowchart and Tables(SC Variant)



TFA1 Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
TFA1 – SC. Intake air temperature sensor post intercooler								
Electrical check high input <i>TASREmax</i> low input <i>TASREmin</i> (DCTFA) <i>TASREnpl</i>	P007D	Out of range check	TFA1 voltage (-39.8 °C)	> 4.9 v	Engine started and running		1 s	2 Drive Cycles
	P007C	Out of range check	TFA1 voltage (129.8 °C) For	< 0.15 v > 1 s	Battery voltage - Coolant Temp - Air Mass Flow - Vehicle Speed - Engine temp at start -	> 10.5 v > 40 °C < 52 kg/h < 318.75 mph > - 25 °C		
	P007E	Test for a loose connector/ intermittent fault and compares a raw and filtered sensor reading.	Changes in temperature are normally not rapid. If the difference exceeds a threshold then a fault is declared.	> 0.32 v for 1 s				
Plausibility - High Check <i>TASRRmax</i> (DPLTFA1)	P007B	Actual intake/charge air temperature is continuously compared against modeled temperature	If the modeled temperature is greater than the actual temperature for 5 seconds then declare a fault	See KFTFA1MX (table) 10 s	Ignition switch - Airflow - Vehicle Speed - for	On 52 kg/h < ml < 300 kg/h >30 mph > 10 s	10 s	
Plausibility - Stuck Check <i>TASRRnpl</i>	P007B	The vehicle must complete a set number of high phases (condition for high intake air temperature) and a set number of low phases (condition for low intake air temperature) to allow a judgment to be made.	Sensor temperature at start is compared to sensor temperature when fully warm. If the difference between the two is less than a calibrateable threshold then declare a fault	< 3 °C	Ignition switch - High phase Air Mass Flow - Vehicle Speed - Coolant Temp - Integrated mass flow - for Low Phase Air Mass Flow - Vehicle Speed - for	On > 3 < 40 kg/h < 7 mph > 60 °C > 10 kg > 5 s > 3 48 kg/h < ml < 352 kg/h > 25 mph > 5 s	Depends upon drive cycle time	
Range check <i>TASRCSmax</i> At start <i>TASRCSmin</i> (DOTMCS)	P007B	A comparison of intake air temp TFA1 against the average of TFA1, TFA2, TFA3 Coolant1 and Ambient Air sensor values at engine start	If the sensor value plus / minus the average value is greater than a calibrateable threshold for period then declare a fault	> +/-20 °C for > 2 s	Ignition switch - Battery voltage - After engine off time	On > 10.5 v > 28800 s	2 s	

TFA1 Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
TFA1 – SC. Intake air temperature sensor post intercooler (con't)								
					Fault Codes that disable P007B (Rmax) or (Rnpl)	P007D, P007C, P007E, P0116 (Pmax), P0126, P0116 (Pnpl), P0116 (CSmax), P0116 (CSmin), P0118, P0117, P0119, P0500, P0501, P0500		
					Fault Codes that disable P007B (CSmax) & (CSmin)	P0113, P0112, P0114, P0072, P0073, P007D, P007C, P007E, P0118, P0117, P0119, P0500, P0501		

KFTFA1MX - high-side TFA1 maximum temperature threshold

		y \ x	20	80	100
input x	°C	-30	40	91	115
input y	°C	20	50	91	120
output w	°C	60	70	100	125

12.1.1.2. TFA2 (Pre-Throttle) Intake Air Temperature Sensor Monitor

12.1.1.2.1. Fault Codes

- P0113 - Intake Air Temperature Sensor 1 Circuit High (Bank 1)
- P0112 - Intake Air Temperature Sensor 1 Circuit Low (Bank 1)
- P0114 - Intake air temperature sensor 1 Circuit (Bank 1): electrical check
- P0111 - Intake Air Temperature Sensor 1 Circuit Range/Performance (Bank 1)

12.1.1.2.2. Electrical Monitor

P0113, P0112 and P0114. These monitors run continuously. The voltage output from the sensor is compared to absolute maximum and minimum thresholds and a suitable code set if exceeded. Additionally, it tests for a loose connection of the temperature sensor by comparing the difference between the temperature sensor voltage and a low pass filtered value with a 2 second time constant (P0114). If a loose contact occurs, the signal will show a series of step changes between the sensor voltage and the open circuit voltage. Normally, this temperature does not change rapidly, so there should be only a small difference between the signal and the filtered signal. If this difference exceeds a threshold then a fault is declared.

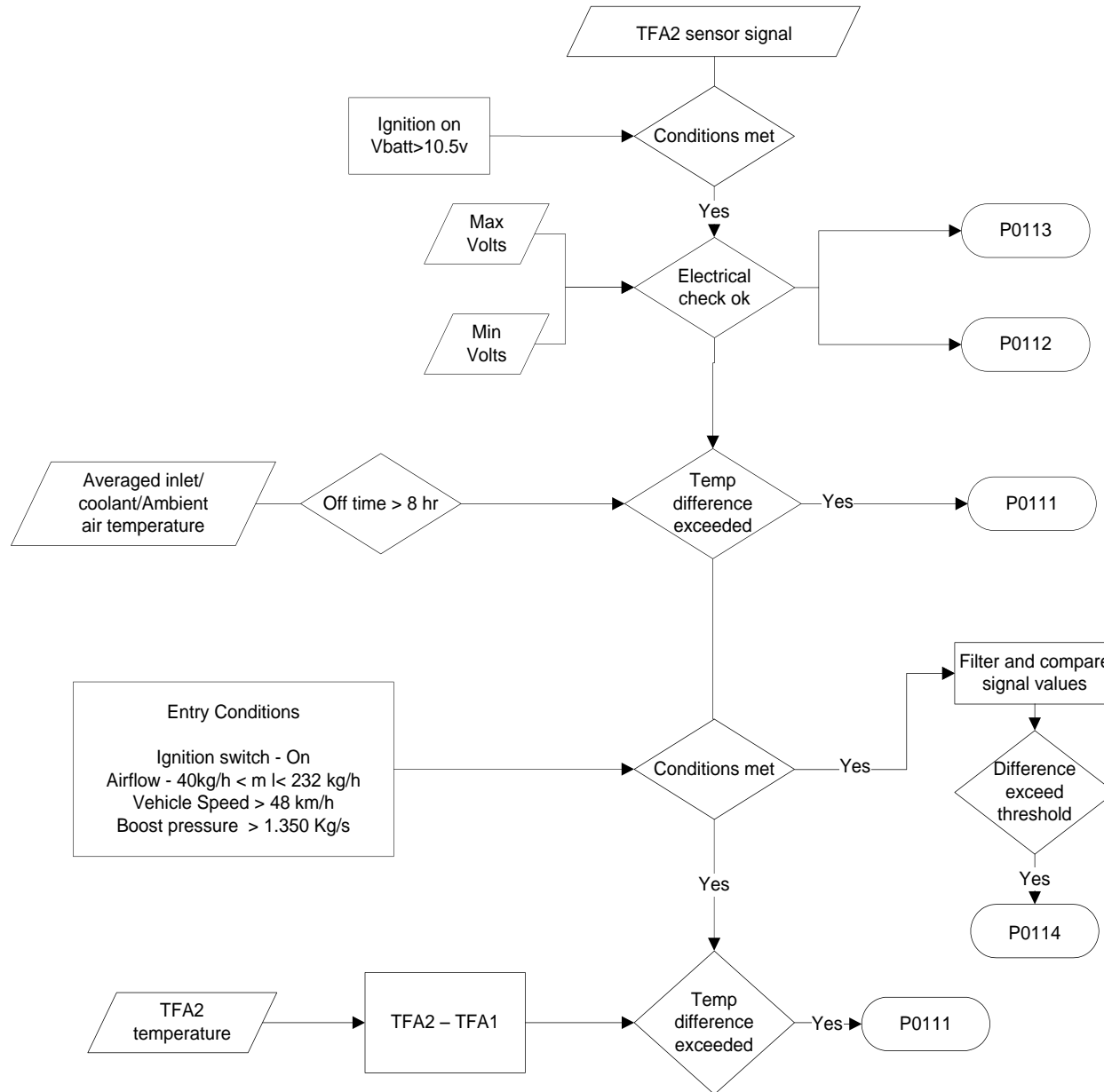
12.1.1.2.3. Rationality Monitor

P0111. TFA2 is continuously subtracted from TFA1. If $TFA2 - TFA1$ is greater than a max or minimum threshold for period of time then a max or minimum fault is declare.

12.1.1.2.4. Cold Start Monitor

P0111. An average of the Intake temperatures / Coolant1 / Ambient air Temperature sensor values during an engine OFF period is calculated. If the particular sensor value minus the average value is greater than a sensor specific threshold for any period of time, then a fault is declared.

12.1.1.2.5. TFA2 Monitoring – System Flowchart and Table



TFA2 Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.	
TFA2 – SC. Intake air temperature sensor before throttle									
electrical check high input <i>TAVDEmax</i>	P0113	Out of range check	TFA2 voltage (-39.8 °C)	> 4.9 v	Engine started and running		0.2 s	2 Drive Cycles	
low input <i>TAVDEmin</i> (DCTFA)	P0112	Out of range check	TFA2 voltage (140.2 °C) For	< 0.1 v > 0.2 s	Battery voltage - Coolant Temp -	> 10.5 v > 40 °C			
<i>TAVDEnpl</i> (GGTFA)	P0114	Test for a loose connector/ intermittent fault and compares a raw and filtered sensor reading.	Changes in temperature are normally not rapid. If the difference exceeds a threshold then a fault is declared.	> 0.32v for > 1 s	Air Mass Flow - Vehicle Speed – Engine temp at start	< 52 kg/h < 318.75 mph > -24.75 °C			
Plausibility - Max Check <i>TAVDRmax</i>	P0111	TFA2 is continuously subtracted from TFA1	If TFA2 – TFA1 (positive) is greater than a calibrateable threshold for period of time then report a fault	> 35.25 °C for 5 s	Ignition switch - Airflow Vehicle Speed Boost pressure	On 48 kg/h < m l < 352 kg/h >25 mph > 1.10 Kg/s			5 s
Plausibility - Min Check <i>TAVDRmin</i>	P0111	TFA2 is continuously subtracted from TFA1	If TFA2 – TFA1 (negative) is greater than a calibrateable threshold for period of time then report a fault	> 85.50 °C for 5 s					
Range check <i>TAVDCSmax</i> At start <i>TAVDCSmin</i> (DOTMCS)	P0111	A comparison of intake air temp TFA2 against the average of TFA1, TFA2, TFA3 Coolant1 and Ambient Air sensor values at engine start	If the sensor value plus / minus the average value is greater than a calibrateable threshold for period then declare a fault	> +/-20 °C for > 2 s	Ignition switch - Battery voltage - After engine off time	On > 10.5 v > 28800 s	2 s		
					Fault Codes that disable P0111 (max) & (min)	P0113, P0112, P0114, P00BD, P00BC, P00BF, P00BE, P010B, P0101, P0236 (Bnpl), P0236 (Bsig), P0236 (Pmax), P0236 (Pmin), P0236 (Psig), P0236 (Bmax), P0236 (Bmin), P0103, P0102, P0100, P010D, P010C, P010A, P0238, P0237, P007D, P007C, P007E, P0501, P0500, P06A6			
					Fault Codes that disable P0111 (CSmax) & (CSmin)	P0113, P0112, P0114, P0072, P0073, P007D, P007C, P007E, P0118, P0117, P0119			

12.1.1.3. TFA3 (Supercharger out) Intake Air Temperature Sensor Monitor

12.1.1.3.1. Fault Codes

- P0098 - Intake Air Temperature Sensor 2 Circuit High (Bank 1)
- P0097 - Intake Air Temperature Sensor 2 Circuit Low (Bank 1)
- P0099 - Intake Air Temperature Sensor 2 Circuit Intermittent/Erratic (Bank 1)
- P0096 - Intake Air Temperature Sensor 2 Circuit Range/Performance (Bank 1)

12.1.1.3.2. Electrical Monitor

P0098, P0097 and P0099. These monitors run continuously. The voltage output from the sensor is compared to absolute maximum and minimum thresholds and a suitable code set if exceeded. Additionally, it tests for a loose connection of the temperature sensor by comparing the difference between the temperature sensor voltage and a low pass filtered value with a 2 second time constant (P0099). If a loose contact occurs, the signal will show a series of step changes between the sensor voltage and the open circuit voltage. Normally, this temperature does not change rapidly, so there should be only a small difference between the signal and the filtered signal. If this difference exceeds a threshold then a fault is declared.

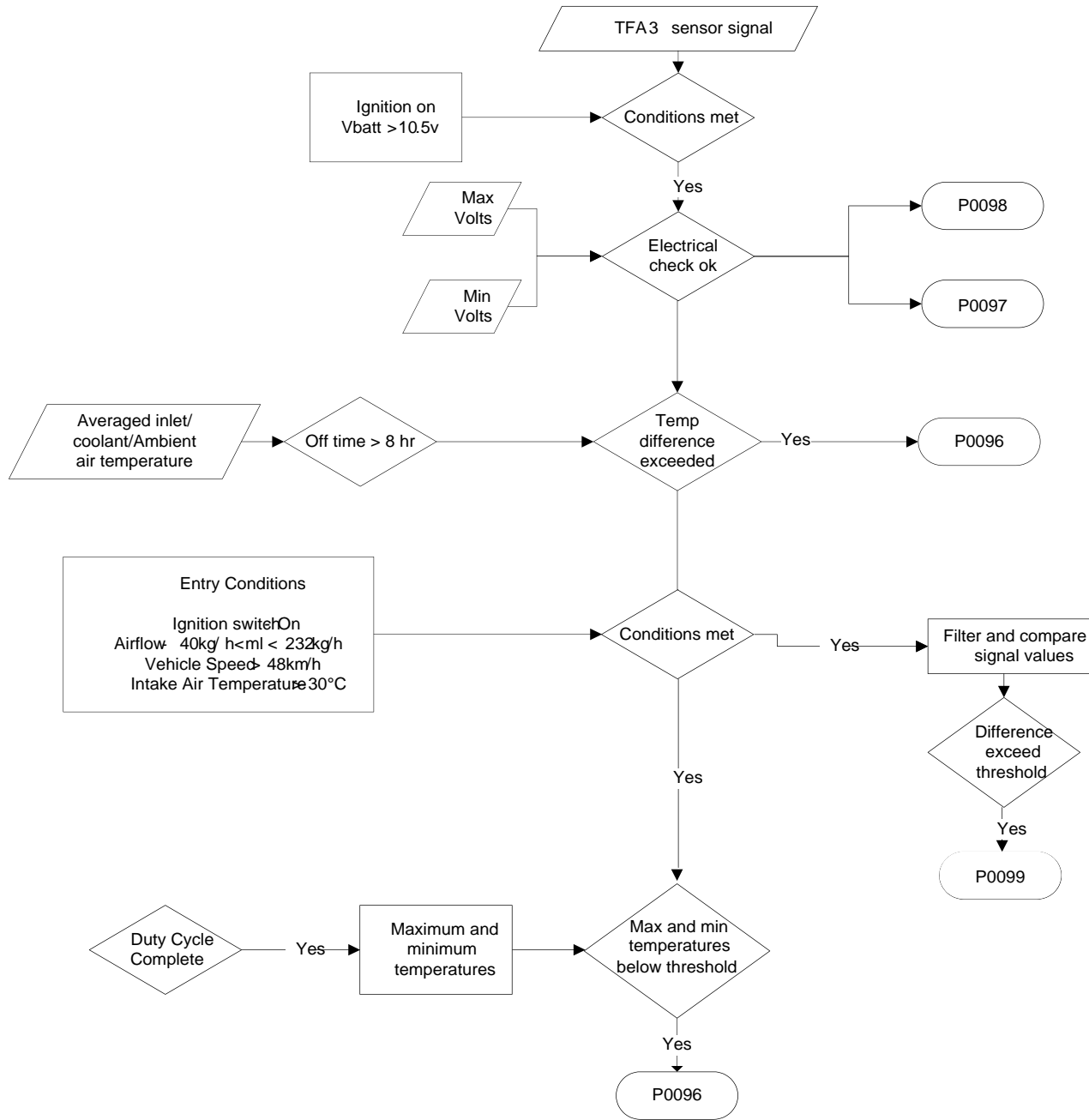
12.1.1.3.3. Rationality Monitor

P0096. A stuck sensor is declared if the maximum and minimum temperatures are less than a threshold as measured over a sufficiently large duty cycle. A large duty cycle is achieved if the number of operational phases with normally higher intake air temperature (High phase) and lower intake air temperature (Low phase) are encountered since vehicle start.

12.1.1.3.4. Cold Start Monitor

P0096. An average of the Intake temperatures / Coolant1 / Ambient air Temperature sensor values during an engine OFF period is calculated. If the particular sensor value minus the average value is greater than a sensor specific threshold for any period of time, then a fault is declared.

12.1.1.3.5. TFA3 Monitoring – System Flowchart and Table



TFA3 Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
TFA3 – SC. Intake air temperature sensor post supercharger.								
electrical check high input TAVLLKELECCmax low input TAVLLKELECCmin (DCTFA3)	P0098	Out of range check	TFA3 voltage (-39.8 °C)	> 4.96 v	Engine started and running		0.2 s	2 Drive Cycles
	P0097	Out of range check	TFA3 voltage (199 °C) For	< 0.05 v > 0.2 s	Battery voltage - Coolant Temp -	> 10.5 v > 40 °C		
TAVLLKELECCnpl	P0099	Test for a loose connector/ intermittent fault and compares a raw and filtered sensor reading.	Changes in temperature are normally not rapid. If the difference exceeds a threshold then a fault is declared.	> 0.32 v for 1 s	Air Mass Flow - Vehicle Speed - Engine temp at start	< 52 kg/h < 318.75 mph > -24.75 °C	2 s	
Plausibility - Stuck Check TAVLLKPLAUSnpl	P0096	The vehicle must complete a set number of high phases (condition for high intake air temperature) and a set number of low phases (condition for low intake air temperature) to allow a judgment to be made.	Sensor temperature at start is compared to sensor temperature when fully warm. If the difference between the two is less than a calibrateable threshold then declare a fault	< 1.50 °C	Ignition switch - High phase Air Mass Flow - Vehicle Speed - Coolant Temp - Integrated mass flow - for Low Phase Air Mass Flow - Vehicle Speed - for	On > 3 < 40 kg/h < 7 mph > 60 °C > 10 kg > 5 s > 3 48 kg/h < ml < 352 kg/h > 25 mph > 5 s	Depends upon drive cycle time	
Range check at start TAVLLKCOLDSTRTmax TAVLLKCOLDSTRTmin	P0096	A comparison of intake air temp TFA3 against the average of TFA1, TFA2, TFA3 Coolant1 and Ambient Air sensor values at engine start	If the sensor value plus / minus the average value is greater than a calibrateable threshold for period then declare a fault	> +/-20 °C for > 2 s	Ignition switch - Battery voltage - After engine off time	On > 10.5 v > 28800s	2 s	

12.2. Mass Airflow Sensor Monitors

12.2.1. Fault Codes

P0100 - Mass or Volume Air Flow Sensor, A, Circuit

P115D - Mass Air Flow Circuit Offset

P0101 - Mass or Volume Air Flow Sensor, A, Circuit Range/Performance

P010B - Mass or Volume Air Flow Sensor, B, Circuit Range/Performance

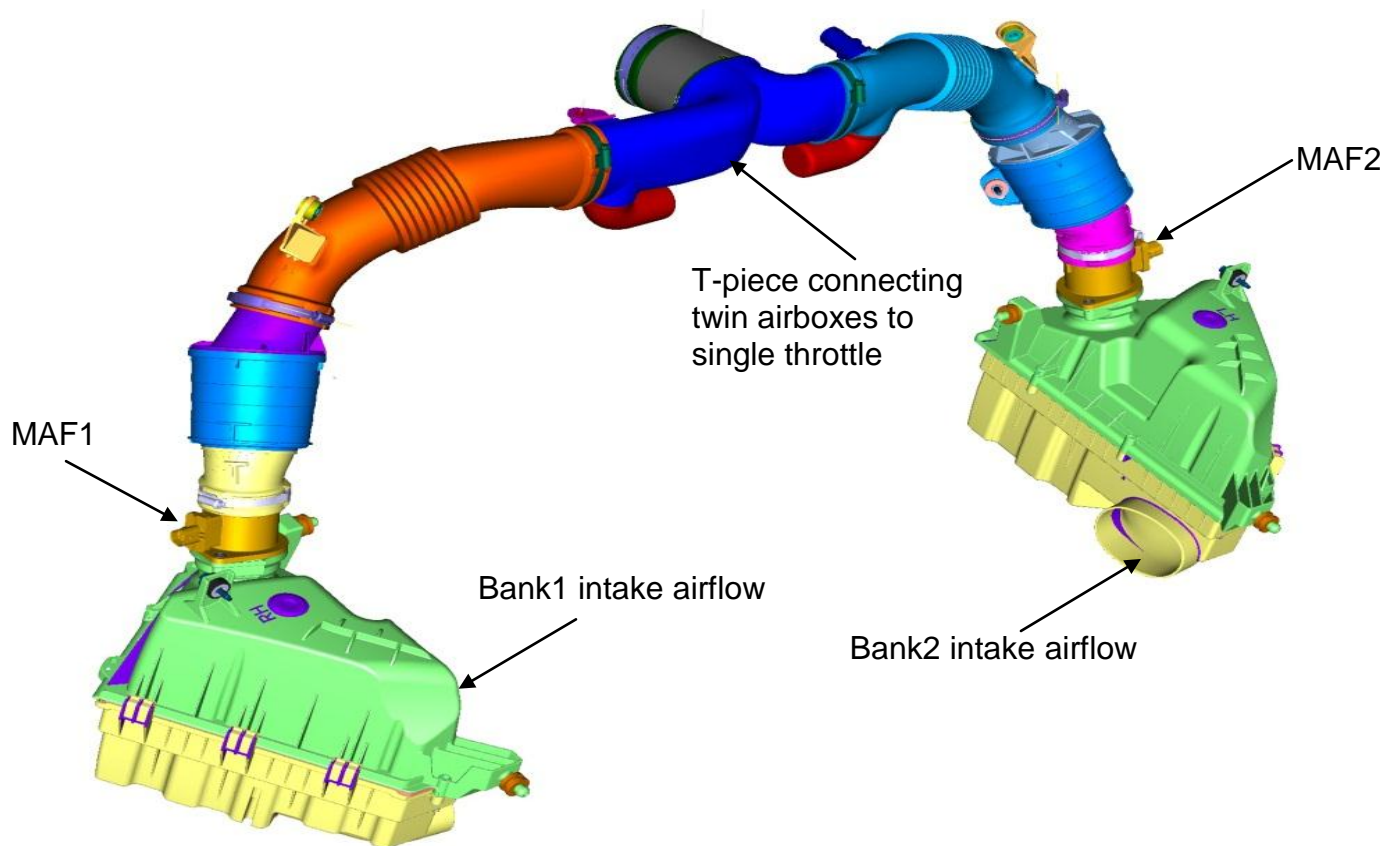
P00BD - Mass or Volume Air Flow A Circuit Range/Performance -Air Flow Too High

P00BC - Mass or Volume Air Flow A Circuit Range/Performance - Air Flow Too Low

P00BF - Mass or Volume Air Flow B Circuit Range/Performance -Air Flow Too High

P00BE - Mass or Volume Air Flow B Circuit Range/Performance - Air Flow Too Low

Schematic



As previously stated in the inlet temperature section, The V6SC and V8SC engines have a twin airbox / airflow meter intake system feeding into a single throttle housing.

12.2.2. Electrical check

P0100. These monitors run continuously. Electrical continuity problems with the two air flow meters are reported using standard powerstage diagnostics.

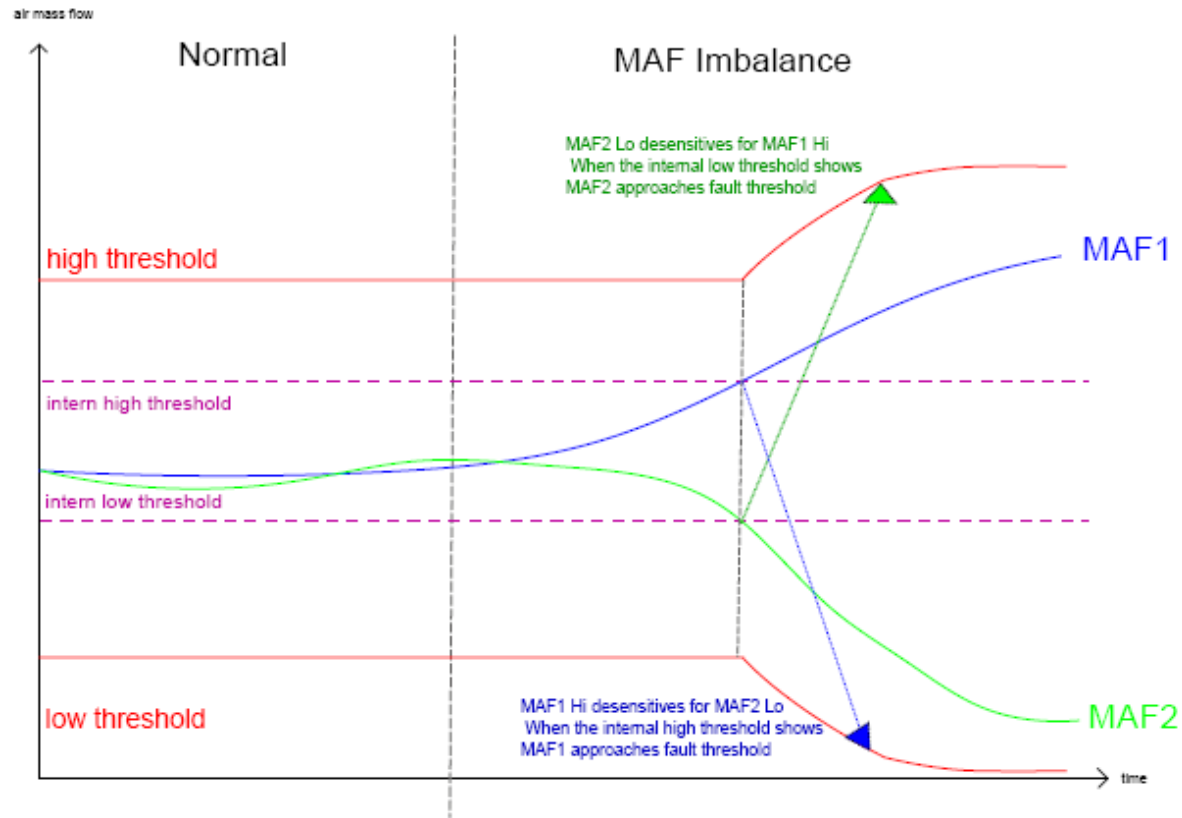
12.2.3. Cross Flow Compensation Range and Plausibility Check

P00BD, P00BC, P00BF and P00BE As the engine uses two intakes, each with a separate mass airflow sensor and a single throttle, then any of the air for each of the eight cylinders can pass through either of the throttles. This means that if there is a difference in air pressure between the two intakes, then there will be a difference in air flow through each of the intakes. This is most likely to occur due to side winds and in extreme cases can result in air flowing out through one of the intake ducts. The monitor is able to identify this flow imbalance between the two sides of the intake system, so that the limits maybe adjusted in order to remove any tendency for false diagnosis of a sensor.

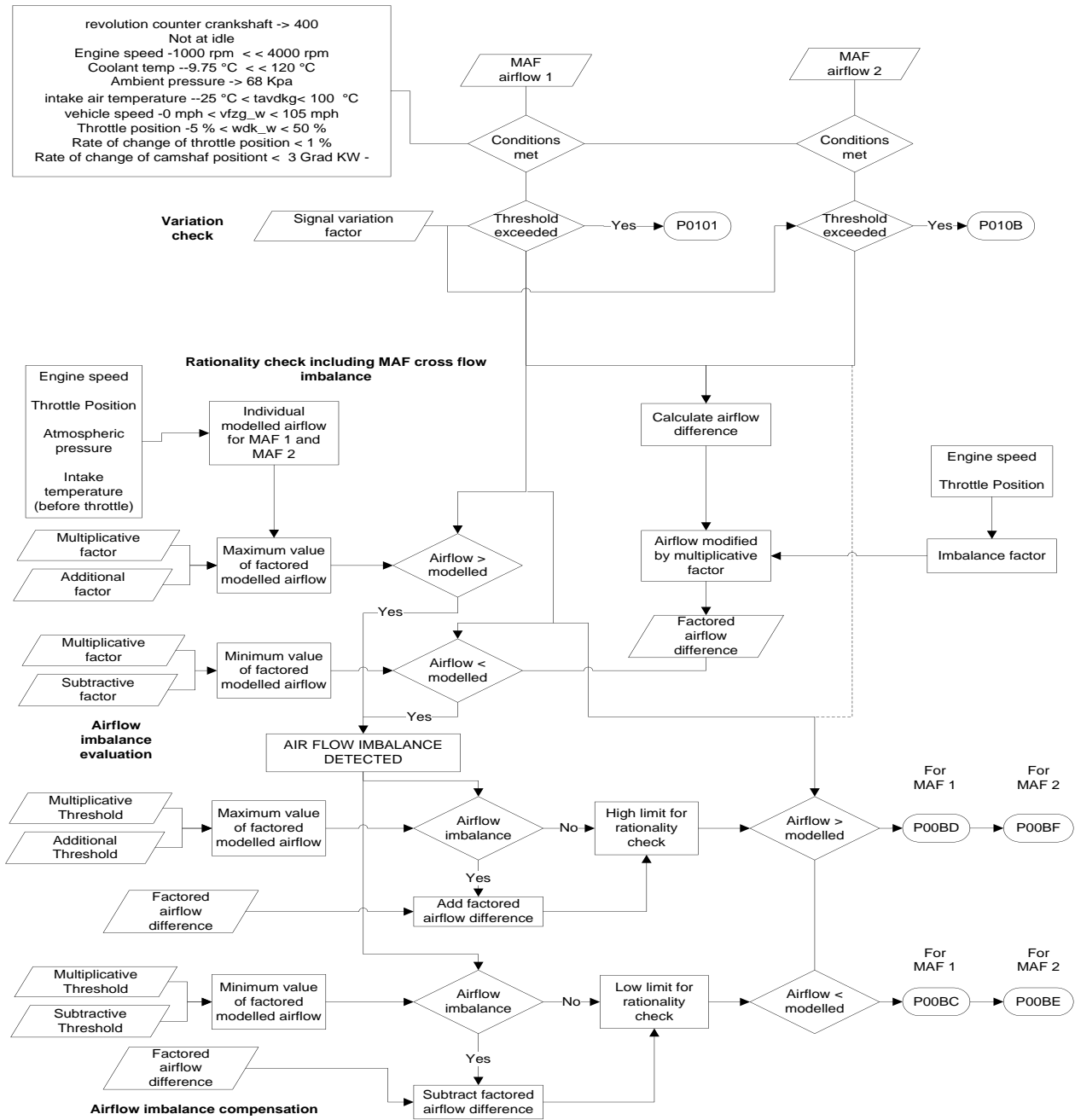
Flow imbalance is determined by comparing each MAF sensor reading with the estimated value. If it is lower than a pre-determined proportion of the estimated value, then the high fault threshold for the other MAF sensor is increased by an amount that depends on the difference between the two MAF sensor readings. If it is higher than a pre-determined proportion of the estimated value, then the low fault threshold for the other MAF sensor is decreased by an amount that depends on the difference between the two MAF sensor readings.

In cases of imbalance, both sensor readings move equally in opposite directions, the appropriate fault thresholds will be adjusted and no false fault detection will occur. If a single sensor is faulty, then it can only alter a fault threshold for the opposing sensor, its monitor is unaffected and will therefore flag a fault.

The flow chart below and the following graphs explain the operation of this diagnostic.



12.2.4. MAF Monitoring – System Flowchart and Tables



Mass Airflow Meter Sensor Monitoring

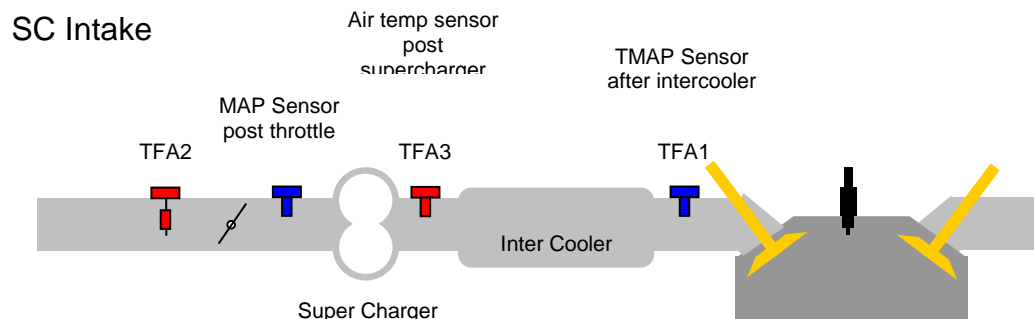
Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters		Time Req.	MIL illum.	
Mass Airflow Meter									
MAF high input	<i>HFM1Emax</i>	P0103	Out of range check	MAF PWM signal	> 2100.00 μ s	Ignition switch - Engine speed - Battery voltage -	On Cranking > 10.5 v	0.2 s	2 Drive Cycles
		<i>HFM2Emax</i>							
MAF low input	<i>HFM1Emin</i>	P0102	Out of range check	MAF PWM signal	< 66 μ s				
		<i>HFM2Emin</i>							
	<i>HFM1Esig</i>	P0100	Signal check	No PWM signal detected					
	<i>HFM2Esig</i>	P010A							
<i>Rationality check</i>									
	<i>HFM1PLMAX</i>	P00BD	Rationality - measured versus estimate based on TP & RPM with compensation for altitude and temperature.	Measured mass airflow for either sensor varies from a modeled airflow by the maximum of an additional/subtractive or multiplicative thresholds.	max of + 12 kg/h or x 1.3	Engine revolutions since start - Not at idle Engine speed - Coolant temp - Ambient pressure - intake air temperature - vehicle speed - Throttle position - Rate of change of throttle position Rate of change of camshaft position -	> 400	10 s	
	<i>HFM1PLMIN</i>	P00BC							
	<i>HFM2PLMAX</i>	P00BF							
	<i>HFM2PLMIN</i>	P00BE							
			In addition, due to MAF imbalance, if the airflow difference is greater than the maximum of an additional/subtractive or multiplicative factors the imbalance airflow is added/subtracted to the threshold	min of - 12 kg/h or x 0.7					
			Fault conditions have to be present for time period of	max of 3 kg/h or x 1.05					
				min of 3 kg/h or x 0.95					
				10 s					
Variation Check	<i>HFMV2max</i> <i>HFMVmax</i>	P010B P0101	Signal variation check	If the actual airflow changes by a non plausible factor then a fault is declared	> 2 Kg/h in 10ms	Throttle angle and engine speed Throttle angle and engine speed	> 15 % > 1500 rpm < 8 % < 800 rpm		

Mass Airflow Meter Sensor Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
					Fault Codes that disable P00BC, P00BD, P00BE, P00BF P0039, P0034, P0033, P2565, P2564, P132B (npl), P003A (max), P003A (min), P132B (sig), P0111 (Rmax), P0111 (Rmin), P0113, P0112, P0114, P0111 (CSmax), P0111 (CSmin), P012B, P012B, P012B, P2282, P012B, P012B, P012B, P2229, P2228, P2227 (sig), P0069, P012B (Bmax), P2176 (Unpl), P0103, P0102, P0100, P010D, P010C, P010A, P0236 (Bnpl), P0236 (Bsig), P0236 (Pmax), P0236 (Pmin), P0236 (Psig), P0236 (Bmax), P0236 (Bmin), P0238, P0237, P007B (max), P007B (npl), P007B (CSmax), P007B (CSmin), P007D, P007C, P007E, P2234, P2231, P2629, P2626, P2197, P2198, P0173, P2195, P2196, P0170, P0193, P0192, P0153, P0133, P0155, P00D3, P00D3, P0052, P0051, P0050, P0032, P0031, P0030, P0135, P00D1 (npl), P00D1 (sig), P2240 (max), P2240 (npl), P2240 (sig), P2237 (max), P2237 (npl), P2237 (sig), P0152, P0151, P0132, P0131, P2247, P2243, P2254, P2251, P0150, P0130, P0154, P0134, P064E (max), P064E (min), P064E (npl), P064E (sig), P064D (max), P064D (min), P064D (npl), P064D (sig), P0300, P0236, P2135, P000D, P0024, P2095, P0023, P2091, P0013, P000B, P0014, P000C, P0021, P2093, P0020, P2089, P0010, P000A, P0011, P06A6, P2094, P2090, P2092, P2088, P0040, P0336, P0335, P0459, P0458, P0444, P0016, P0016, P0018, P0018, P0017, P0017, P0019, P0019, P0500, P0501			
					Fault Codes that disable P0101 or P010B P2176 (Unpl), P0103, P0102, P0100, P010D, P010C, P010A, P2135, P0335			

12.3. Intake Pressure Sensor Monitors

12.3.1. Super Charged Variants



12.3.1.1. TMAP Pressure Monitor

12.3.1.1.1. Fault Codes

- P0238 - Turbocharger/Supercharger Boost Sensor "A" Circuit High
- P0237 - Turbocharger/Supercharger Boost Sensor "A" Circuit Low
- P0236 - Turbocharger/Supercharger Boost Sensor "A" Circuit Range/Performance

12.3.1.1.2. Electrical Monitor

P0238 and P0237. The voltage output from the sensor is compared to absolute maximum and minimum thresholds and a suitable code set if exceeded.

12.3.1.1.3. Range Check, Rationality and Signal Monitor

P0236. The range check compares the pressure readings with an upper and lower threshold and a suitable code set if exceeded.

P0236. Rationality check. The manifold pressure sensor monitor compares the measured manifold pressure with an estimated pressure which is calculated by a model. The model that determines the estimated pressure uses look-up tables which have engine speed and throttle angle as inputs for deriving its model base and compensation values for intake air temperature, atmospheric pressure and VVT, from which the estimated pressure is calculated. If the difference between the actual and estimated values is greater or less than a threshold then a fault is declared. The monitors have the ability to make a normal judgment followed by a failed judgment or vice versa, as the monitors run continuously whilst the entry conditions are met.

P0236. Signal variation check. The maximum and minimum sensor readings are cyclically updated. If operating conditions are encountered that mean the difference between maximum and minimum should be sufficiently large but they are less than a threshold then the signal variation check has failed. A check is made to see if a sensor is frozen. If a sensor is frozen, it is not faulty but temporarily invalid and during the time in which it is detected as frozen, the model-based diagnosis is inhibited. A frozen sensor is suspected if at start, at sufficiently low ambient temperatures, a comparison of maximum and minimum manifold pressures does not exceed a threshold during the start process. The diagnostics are restored one engine temperatures have exceeded a threshold for a given period.

P0236 Signal check at start. At start, the manifold pressure sensor reading is compared to an average of the MAP/TMAP/Ambient pressure sensor values if a defined soak period has been completed. If the difference greater than a failure threshold then a fault is declared. In addition a check is made to ensure that during certain atmospheric conditions that throttle icing does not cause false diagnostic reporting.

12.3.1.2. MAP Pressure Monitor – Pressure Downstream of Throttle

12.3.1.2.1. Fault Codes

P012D - Turbocharger/Supercharger Inlet Pressure Sensor Circuit High
P012C - Turbocharger/Supercharger Inlet Pressure Sensor Circuit Low
P012B - Turbocharger/Supercharger Inlet Pressure Sensor Circuit Range/Performance

12.3.1.2.2. Electrical Monitor

P012D and P012C. The voltage output from the sensor is compared to absolute maximum and minimum thresholds and a suitable code set if exceeded.

12.3.1.2.3. Range Check, Rationality and Signal Monitor

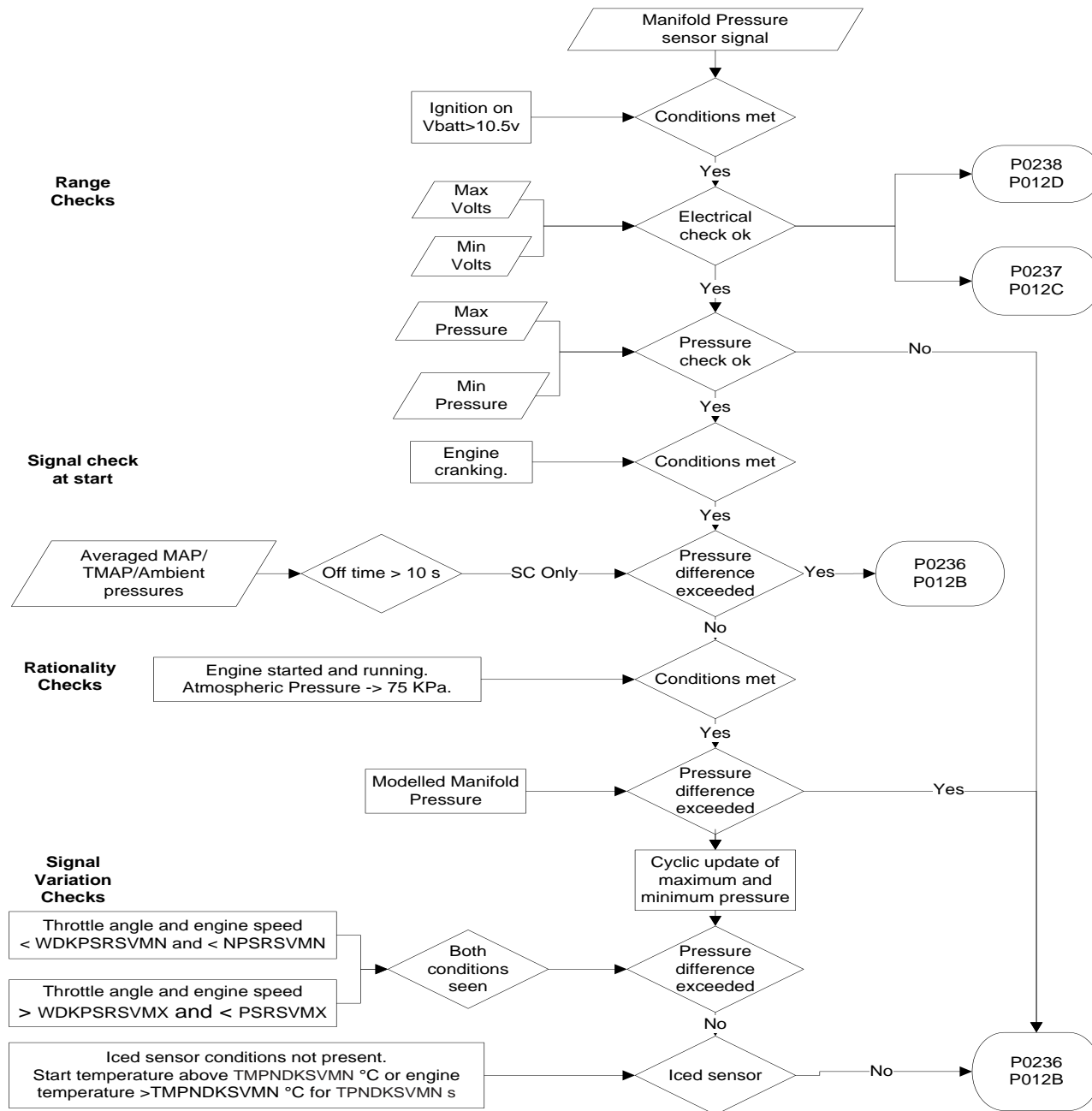
P012B. The range check compares the pressure readings with an upper and lower threshold and a suitable code set if exceeded.

P012B. Rationality check. The manifold pressure sensor monitor compares the measured manifold pressure with an estimated pressure which is calculated by a model. The model that determines the estimated pressure uses look-up tables which have engine speed and throttle angle as inputs for deriving its model base and compensation values for intake air temperature, atmospheric pressure and VVT, from which the estimated pressure is calculated. If the difference between the actual and estimated values is greater or less than a threshold then a fault is declared. The monitors have the ability to make a normal judgment followed by a failed judgment or vice versa, as the monitors run continuously whilst the entry conditions are met.

P012B. Signal variation check. The maximum and minimum sensor readings are cyclically updated. If operating conditions are encountered that mean the difference between maximum and minimum should be sufficiently large but they are less than a threshold then the signal variation check has failed. A check is made to see if a sensor is frozen. If a sensor is frozen, it is not faulty but temporarily invalid and during the time in which it is detected as frozen, the model-based diagnosis is inhibited. A frozen sensor is suspected if at start, at sufficiently low ambient temperatures, a comparison of maximum and minimum manifold pressures does not exceed a threshold during the start process. The diagnostics are restored one engine temperatures have exceeded a threshold for a given period.

P012B. Signal check at start. At start, the manifold pressure sensor reading is compared to an average of the MAP/TMAP/Ambient pressure sensor values if a defined soak period has been completed. If the difference greater than a failure threshold then a fault is declared. In addition a check is made to ensure that during certain atmospheric conditions that throttle icing does not cause false diagnostic reporting.

12.3.2. MAP/TMAP Monitoring – System Flowchart and Tables



TMAP Pressure Sensor Monitoring								
Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
TMAP Pressure Sensor (SC engine only – Manifold pressure)								
TMAP high input <i>PSREmax</i>	P0238	Out of range check	MAP voltage (310 kPa)	> 4.80 v	Ignition switch -	On	0.2 s	2 Drive Cycles
TMAP low input <i>PSREmin</i> (GGDSS)	P0237	Out of range check	MAP voltage (6.8 kPa) for	< 0.20 v > 0.2 s	Battery voltage -	> 10.5 v		
<i>PSRBmax</i>	P0236	Out of range check	MAP pressure	> 220 KPa	Engine speed -	420 rpm < nmot < 3500 rpm	2 s	
<i>PSRBmin</i> (DPLPSR)	P0236	Out of range check	MAP pressure for	< 50 KPa > 2 s	Not in fuel cut Throttle position -	14 %		
<i>PSRBmax</i> (BGDSAD)	P0236	Out of range check at start	MAP Pressure at start	> 140 KPa	Within 2 revolutions of 'engine cranking' set and engine speed -	< 400rpm	0.1 s	
Plausibility <i>PSRPmax/min</i>	P0236	Modeled manifold pressure is continuously compared against the actual manifold pressure	If the difference between modeled manifold pressure is greater than the actual manifold pressure for a period of time then report a failure (for both positive and negative error)	> 28 KPa for 4 s	Engine speed - Not in fuel cut Throttle position -	420 rpm < nmot < 3500 rpm 14 %	4 s	
<i>PSRBsig</i> <i>PSRBnpl</i>	P0236 P0236	Pressure check at start	Averages MAP/TMAP/Ambient pressure sensor values at start after a defined soak period and compares them to a threshold.	> +/-6 KPa	Ignition switch - Battery voltage - Engine speed - Soak time -	On > 10.5 v Cranking 5 s	5 s	
MAP leak check plausibility <i>LZSRnpl</i> (BGADAP)	P2282	Air Leak Between Throttle Body and Intake Valve. Continuously monitor the difference between modeled manifold pressure and actual manifold pressure	If the difference between modeled manifold pressure and actual manifold pressure is greater than a calibrateable threshold for a calibrateable period of time then declare a fault.	> for 2 s	Air Mass Flow - manifold pressure/Pressure upstream of throttle Time after engine start Engine speed – No purge diagnostic running for > 5 sec No electrical faults with MAP or Throttle sensors	5 kg/h < ml < 30 kg/h 0.2 < vpsrvd < 0.58 > 5 sec 520 rpm < nmot < 6520 rpm	2 s	

TMAP Pressure Sensor Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
TMAP Pressure Sensor (SC engine only – Manifold pressure) (con't)								
					Fault Codes that disable P0237 or P0238	P06A6		
					Fault Codes that disable P0236 (Bmax), (Bmin), (Bnpl) or (Bsig)	P0039, P0034, P0033, P2565, P2564, P132B (npl), P003A (max), P003A (min), P132B (sig), P0238, P0237		
					Fault Codes that disable P0236 (Pmax), (Pmin) or (Psig)	P0111 (Rmax), P0111 (Rmin), P0113, P0112, P0114, P0111 (CSmax), P0111 (CSmin), P2229, P2228, P2227, P0069, P0039, P0034, P0033, P2565, P2564, P132B (npl), P003A (max), P003A (min), P132B (sig), P0236 (Bnpl), P0236 (Bsig), P0236 (Pmax), P0236 (Pmin), P2176 (Unpl), P0238, P0237, P007B (max), P007B (npl), P007B (CSmax), P007B (CSmin), P007D, P007C, P007E, P0118, P0117, P2135, P0116 (Pmax), P0126, P0116 (Pnpl), P0116 (CSmax), P0116 (CSmin), P0119, P2095, P0023, P2091, P0013, P2093, P0020, P2089, P0010, P000D, P0024, P000B, P0014, P2135, P000C, P0021, P000A, P0011, P2094, P2090, P2092, P2088,		

MAP Pressure Sensor Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
MAP Pressure Sensor (SC engine only – pressure downstream of throttle)								
MAP high input <i>PNDKEmax</i>	P012D	Out of range check	MAP voltage (257 kPa)	> 4.87 v	Ignition switch -	On	0.2 s	2 Drive Cycles
MAP low input <i>PNDKEmin</i>	P012C	Out of range check	MAP voltage (10 kPa) for	< 0.25 v > 0.2 s	Battery voltage -	> 10.5 v		
<i>PNDKBmax</i>	P012B	Out of range check	MAP pressure	> 110 KPa	Engine speed -	420 rpm < nmot < 4500 rpm	0.1 s	
<i>PNDKBmin</i>	P012B	Out of range check	MAP pressure for	< 11 KPa > 2 s	Not in fuel cut Throttle position -	9 %		
<i>PNDKBmax</i>	P012B	Out of range check at start	MAP Pressure at start	> 140 KPa	Within 2 revolutions of 'engine cranking' set and engine speed -	< 400rpm	0.1 s	
Plausibility <i>PNDKPxmax/min</i>	P012B	Modeled manifold pressure is continuously compared against the actual manifold pressure	If the difference between modeled manifold pressure is greater than the actual manifold pressure for a period of time then report a failure (for both positive and negative error)	> 25 KPa for 4 s	Engine speed - Not in fuel cut Throttle position -	420 rpm < nmot < 4500 rpm 9 %	4 s	
<i>PNDKPsig</i>	P012B	Signal variation check - stuck sensor	Comparison of the signal is made over a time period and if it is expected that the signal should change and does not exceed a threshold a fault is set	< 5 KPa	Ignition switch - Battery voltage - Coolant temperature at start - Not in fuel cut Throttle angle and engine speed Throttle angle and engine speed for -	On > 10.5 v > -8.25 °C < 5 % and < 1000 rpm > 10 % and < 1500 rpm 1 s	1s	
<i>PNDKBsig</i> <i>PNDKBnpl</i>	P012B	Pressure check at start	Averages MAP/TMAP/Ambient pressure sensor values at start after a defined soak period and compares them to a threshold.	> +/- 6 KPa	Ignition switch - Battery voltage - Engine speed - Soak time -	On > 10.5 v Cranking 5 s	0.2 s	
					Fault Codes that disable P012C or P012D	P06A6		
					Fault Codes that disable P012B (Bmax), (Bmin), (Bnpl) or (Bsig)	P012D, P012C, P0039, P0034, P0033, P2565, P2564, P132B (npl), P003A (max), P003A (min), P132B (sig)		
					Fault Codes that disable P012B (Pmax), (Pmin) or (Psig)	P012B (Bmax), P012B (Bmin), P012B (Bnpl), P012B (Bsig), P012D, P012C, P0039, P0034, P0033, P2565, P2564, P132B (npl), P003A (max), P003A (min), P132B (sig), P2135		

Barometric Pressure Sensor Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Barometric Pressure Sensor								
<i>PURmax</i>	P2229	Out of range check	Ambient Pressure	> 114 KPa	Ignition switch -	On	2 s	2 Drive Cycles
<i>PURmin</i> (DPLPU)	P2228	Out of range check	Ambient Pressure For	< 50 KPa >2 s	Battery voltage -	> 10.5 v		
Signal <i>PURsig</i>	P2227	Atmospheric pressure will only change at a slow rate of change. The monitor looks for any irregular changes through continuous measurement	A filtered value of pressure is compared with its self over a time step differential. The difference is compared an upper and lower tolerance.	+/-1.5 KPa	Ignition switch - Battery voltage -	On > 10.5 v	2 s	2 Drive Cycles
Plausibility <i>PURnpl</i>	P0069	Last drive check and model comparison check	Last drive check. Compares a stored last value from the previous drive cycle with the current value 5 second after start. If the difference exceeds the threshold a fault suspicion is declared.	+/-1.5 KPa				
			If a fault is suspected from the Last drive check then maximum and minimum modeled values based the manifold pressure sensor are compared with the ambient pressure value. A fault is confirmed if theses values are exceeded.	< 5 kpa > 10 KPa			0.2 s	
<i>PURnpl</i> <i>PURsig</i>	P0069 P2227	Pressure check at start	Averages MAP/TMAP/Ambient pressure sensor values at start after a defined soak period and compares them to a threshold.	> +/- 2.5 KPa	Ignition switch - Battery voltage - Engine speed - Soak time -	On > 10.5 v Cranking 5 s	5 s	2 Drive Cycles
					Fault Codes that disable P0069, P2227, P2228 or P2229	P012B (Bnpl), P012B (Bsig), P012B (Pmax), P012B (Pmin), P012B (Psig), P012B (Bmax), P012B (Bmin), P012D, P012C, P2176 (Unpl), P012D, P012C, P2176, P0236, P0236, P2135, P06A6		

12.4. Coolant Temperature Sensor Monitor ECT 1

12.4.1. Fault Codes

P0118 - Engine Coolant Temperature Sensor 1 Circuit High
P0117 - Engine Coolant Temperature Sensor 1 Circuit Low
P0119 - Engine Coolant Temperature Sensor 1 Circuit Intermittent/Erratic
P0116 - Engine Coolant Temperature Sensor 1 Circuit Range/Performance

12.4.2. Electrical Monitor

P0118, P0117 and P0119 These monitors run continuously. The voltage output from the sensor is compared to absolute maximum and minimum thresholds and a suitable code set if exceeded. Additionally, it tests for a loose connection of the temperature sensor by comparing the difference between the temperature sensor voltage and a low pass filtered value with a 2 second time constant (P0119). If a loose contact occurs, the signal will show a series of step changes between the sensor voltage and the open circuit voltage. Normally, this temperature does not change rapidly, so there should be only a small difference between the signal and the filtered signal. If this difference exceeds a threshold then a fault is declared.

12.4.3. Rationality Monitor

P0116 High Side Check. A maximum coolant temperature model is formed using inputs from ambient air and mass air flow being initialized from a filtered coolant temperature. The coolant temperature signal is continuously compared to this. If the modeled coolant temperature is less than the actual coolant temperature then a high fault is declared.

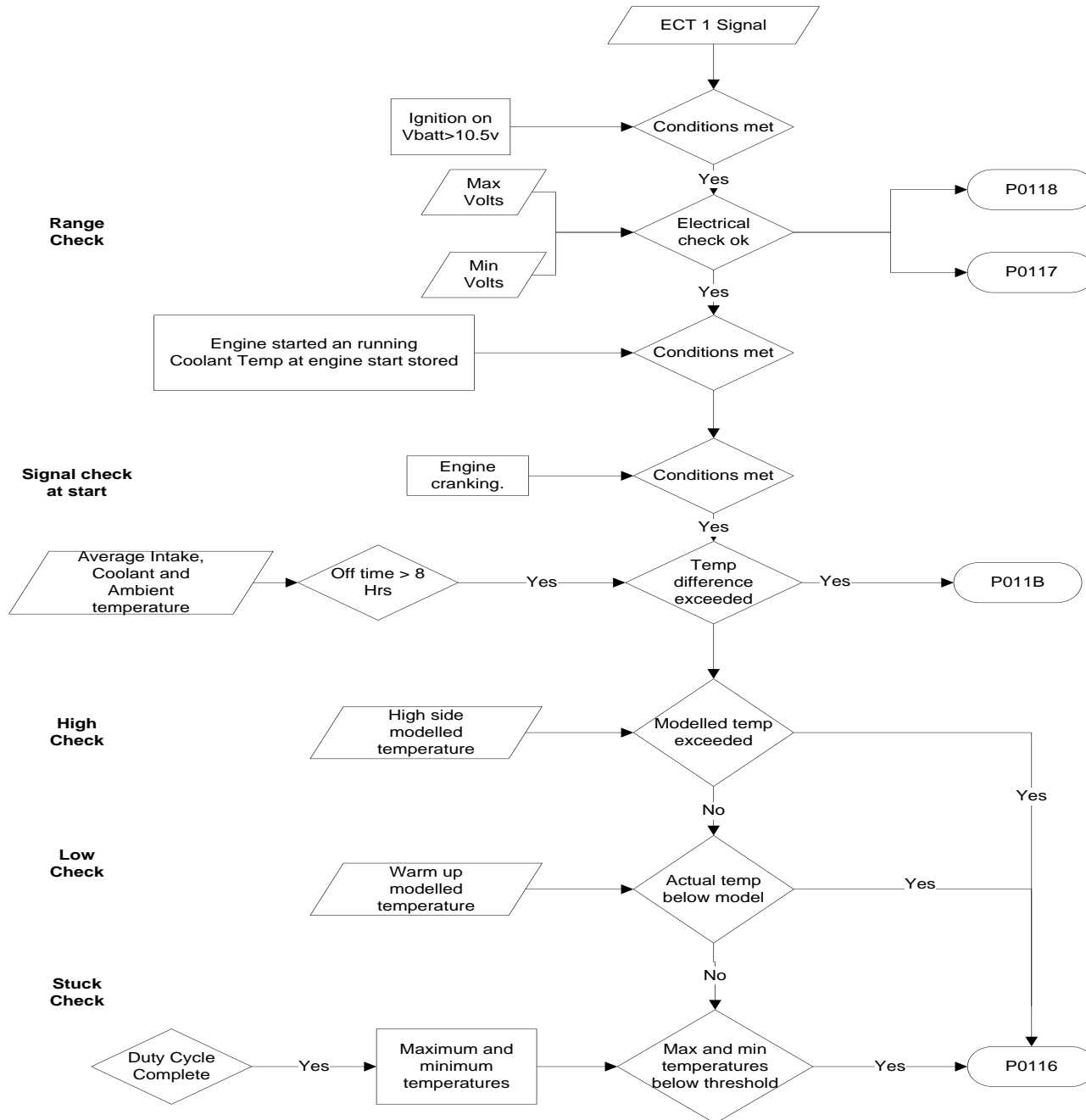
A stuck sensor is declared if the maximum minus minimum temperatures are less than a threshold as measured over a duty cycle. A duty cycle is defined if the number of operational phases with normally higher intake air temperature (High phase) and lower intake air temperature (Low phase) have been encountered since vehicle start.

Low Side Check. The temperature value from the sensor is compared with a warming-up model, which represents the slowest warm-up of the engine in faultless condition. The model is formed using inputs from ambient temperature and mass air flow being initialized from a filtered coolant temperature. If the coolant temperature is below that of the model then a fault is declared.

12.4.4. Cold Start Monitor

P011B. An average of the Intake air temperatures / Coolant1 / Ambient air Temperature sensor values during an engine OFF period is calculated. If the particular sensor value minus the average value is greater than a sensor specific threshold for any period of time, then a fault is declared.

12.4.5. Coolant Sensor Monitor – System Flowchart and Tables



Coolant Temperature Sensor Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Engine Coolant Temperature (ECT 1)								
electrical check high input <i>TME_{max}</i> low input <i>TME_{min}</i> (DCTCW)	P0118	Out of range check	ECT 1 voltage (-39.8 °C)	> 4.9 v	Ignition switch -	On	2 s	2 Drive Cycles
	P0117	Out of range check	ECT 1 voltage (143.3 °C) For	< 0.1 v > 2 s	Battery voltage -	> 10.5 v		
TME _{enpl}	P0119	Test for a loose connector/ intermittent fault and compares a raw and filtered sensor reading.	Changes in temperature are normally not rapid. If the difference exceeds a threshold then a fault is declared.	> 0.75 v				
Plausibility - Low Check <i>TMP_{min}</i> (DPLTCW)	P0126	Actual coolant sensor value is continuously compared against a lowest modeled coolant sensor value.	If the actual coolant sensor value is less than the modeled coolant sensor value (minus a calibrateable tolerance) for ANY time period then declare a fault.	Sensor < Dynamic Modeled Value - 9°C	Engine started an running		0.2 s	
Plausibility - Stuck Check <i>TMP_{npl}</i>	P0116	The vehicle must complete a set number of high phases (condition for high heat input) and a set number of low phases (condition for low heat input) to allow a judgment to be made.	If the actual sensor value has NOT increased by a calibrateable amount (dependant on engine start temperature) when the engine is fully warm, then declare a fault.	See table KLDTMFXTM	Ignition switch - High phase Vehicle Speed - Air Mass Flow - Modeled temperature - for - low Phase Vehicle Speed Air Mass Flow - or In fuel cut for -	On > 3 0 mph < vfzg < 13 mph 8 kg/h < ml < 64 kg/h > -48 °C > 5 s >3 25 mph < vfzg < 90 mph 72 kg/h < ml < 352 kg/h	Depends upon drive cycle time	
Plausibility - High Check <i>TMP_{max}</i>	P0116	Actual coolant sensor value is continuously compared against a highest modeled coolant sensor value.	If the actual coolant sensor value (-9°C) is greater than the modeled coolant sensor value for ANY time period then declare a fault.	Sensor-9°C > Dynamic Modeled value	Engine started and running Engine speed - integrated air mass flow -	> 1320 rpm > 2 Kg	0.2 s	
Range check <i>TMCS_{max}</i> at start <i>TMCS_{min}</i>	P0116	A comparison of coolant temp against the average of TFA1, TFA2, TFA3 Coolant1 and Ambient Air sensor values at engine start	If the sensor value plus / minus the average value is greater than a calibrateable threshold for period then declare a fault	+/- 20.25 °C 2 s	Ignition switch - Battery voltage - After engine off time	On > 10.5 v > 28800 s	2 s	

Coolant Temperature Sensor Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Engine Coolant Temperature (ECT 1) (con't)								
					Fault Codes that disable P0116 (min), (max) or (npl)	P00BD, P00BC, P00BF, P00BE, P010B, P0101, P0236 (Bnpl), P0236 (Bsig), P0236 (Pmax), P0236 (Pmin), P0236 (Psig), P0236 (Bmax), P0236 (Bmin), P0103, P0102, P0100, P010D, P010C, P010A, P0238, P0237, P06A6, P0118, P0117, P0119, P0501, P0500		
					Fault Codes that disable P0116 (CSmin) or (CSmax)	P0113, P0112, P0114, P0072, P0073, P007D, P007C, P007E, P0118, P0117, P0119		

Coolant Temperature

KLDTMFXTM - charact. line delta TMOT- threshold for not plausible fixed signal

input x	°C	-40	-15	20	55	75	80	110	120
output w	°C	3.8	3	2.3	2.3	2.3	0.8	0.8	0.8

12.5. Radiator Out Temperature Monitor ECT 2

12.5.1. Fault Codes

P2185 - Engine Coolant Temperature Sensor 2 Circuit High

P2184 - Engine Coolant Temperature Sensor 2 Circuit Low

P2183 - Engine Coolant Temperature Sensor 2 Circuit Range/Performance

12.5.2. Range Monitor

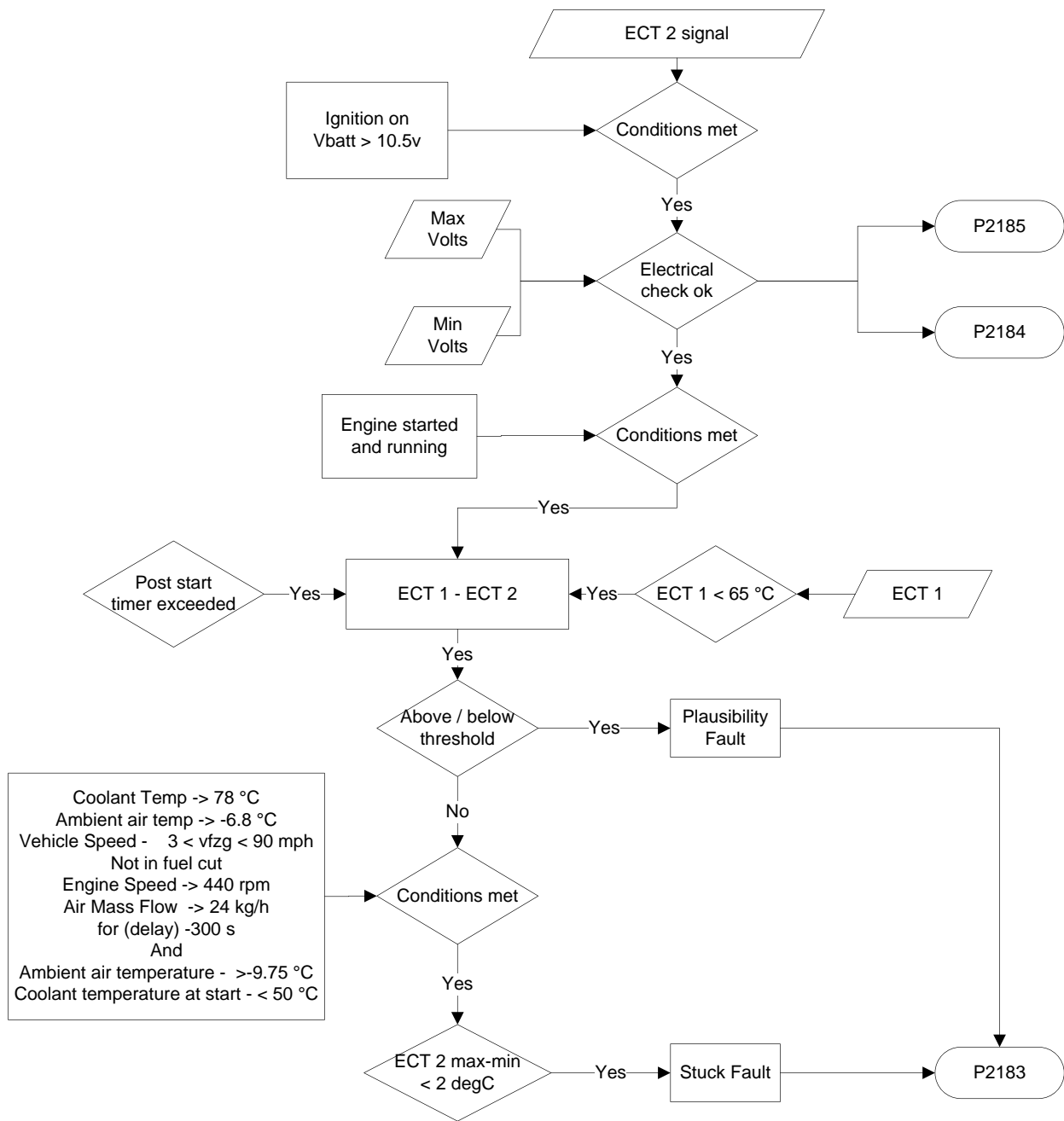
P2185 and P2184. These monitors run continuously. The output from the sensor is compared to absolute maximum and minimum thresholds and a suitable code set if exceeded.

12.5.3. Rationality Monitor

P2183. Plausibility - Sensor biased high or low at start. At engine start, after a given engine stop period, the temperature difference between the sensors is calculated. If this difference is above or below a threshold then a fault code is set.

P2183. Stuck check - When fully warm the difference in the maximum and minimum radiator out temperature is calculated. If this difference is below a threshold then a fault is declared.

12.5.4. Radiator Out Temperature Monitor – System Flowchart and Table



Radiator Out Temperature Sensor Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.	
Radiator out coolant (ECT 2)									
Range Check	<i>TKAEmax</i>	P2185	Out of range check	ECT 2	> 138.75 °C	Ignition switch - Battery voltage -	On > 10.5 v	0.2 s	2 Drive Cycles
		<i>TKAEmin</i> (GGTKA)	P2184	Out of range check	ECT 2 for > 2 s				
Signal Check - Plausible Low	<i>TKARmax</i>	P2183	Check for a hanging sensor at start - to identify if ECT2 is biased high or low.	At engine start the temperature difference between ECT 1 and ECT 2 is calculated. If this difference is above or below a threshold based upon ECT 2 temperature then a fault is declared	KLSTKAP (table) KLSTKAN (table)	Engine speed - Coolant Temp - Engine stop time	Passed from cranking to start < 65 °C > 8 hrs	2 s	
Signal Check - Sensor stuck	<i>TKARsig</i>	P2183	Check for a stuck or un responsive sensor	When fully warm, and the entrance conditions met, after a set delay the difference in the max and min ECT 2 temperatures are calculated. If this difference is below a threshold then a fault is declared.	< KLDTTKAFX (table)	Coolant Temp - Ambient air temp - Vehicle Speed - Not in fuel cut - Engine Speed - Air Mass Flow - for (delay) - and Ambient air temperature - Coolant temperature at start -	> 78 °C > -6.8 °C 3 mph < vfx < 90 mph > 440 rpm > 24. kg/h 300 s > -9.75 °C < 50 °C	Depends upon drive cycle time	

KLSTKAP - upper Limit for lower area

input x	°C	-30	-10	0	30	50	100
output w	°C	20	20	20	20	20	20

KLSTKAN - lower Limit for lower area

input x	°C	-30	0	15	30	45	60
output w	°C	-20	-20	-20	-20	-20	-20

KLDTTKAFX - Curve for calculation of B_tkarsig

input x	°C	-10	5	50	90	120	135
output w	°C	1.5	0.8	0.8	0.8	1.5	2.3

13. Additional Tables

13.1. Cold Start Emission Reduction Strategy Performance Tables

Cold Start Ignition Timing Monitoring								
Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Cold Start Emission Reduction Strategy Performance								
Ignition Timing Performance (DETAKH)	P050B (idle) (pt_ld)	When catalyst heating is active diagnostic calculates the difference between the current ignition angle efficiency and the desired ignition angle efficiency. The differences are integrated separately for idle (detkhlav_w) and part load conditions (detkhtav_w). The integrated differences are divided by the time in which idle or part load was active. The calculated average deviations are compared with different thresholds for idle (mxetkhl_w) and part load (mxetkhtl_w) and in the case these thresholds are exceeded an error is set. The evaluation of the results is only allowed when the time inside idle or part load is greater than a minimum necessary time constant.	For idle :- detkhlav_w once tkhindle_w For part load :- detkhtav_w once tkpload_w	> mxetkhl_w > 6 s > mxetkhtl_w > 4 s	Catalyst heating active Altitude - Time delay after start - Relative air charge - Engine speed change - For idle :- Vehicle speed Idle flag set Desired engine efficiency For part load :- Vehicle speed - Idle flag not set Desired engine efficiency -	< 9135 ft > 3 s < 10 % < 280 rpm in 1 s = 0 mph < 0.97 > 3 mph < 0.97	8 s for idle 8 s for off idle	2 Drive Cycles
					Fault Codes that disable P050B	P2229, P2228, P0069, P2227, P054C, P054A, P052C, P052A, P000D, P0024, P000B, P0014, P000C, P0021, P000A, P0011, P0500, P0501		

Cold Start Camshaft Position Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Cold Start Emission Reduction Strategy Performance (cont)								
Cold start Intake A camshaft position timing over advanced <i>ENWCSmax</i> <i>ENWCS2max</i> (DNWCS)	P052A P052C	The intake camshaft adjustment is monitored by checking the camshaft adjustment angles during cold start catalyst heating conditions. For this purpose, the sign-dependant difference between setpoint value and actual value is compared to a threshold dependant on oil temperature and engine speed.	A setpoint/actual deviation is classified as detected as soon as there is a difference between setpoint angle and actual angle for more than	>10 °CrS > 5 s	catalyst heating with help of camshaft adjustment active VVT Active		5 s	2 Drive Cycles
					Fault Codes that disable P052A	P0341, P0343, P0342, P0346, P0348, P0347, P06A7, P06A6, P2089, P2088 P0010, P0016 (MntErr), P0016 (OfsErr), P0018 (MntErr), P0018 (OfsErr), P0017 (MntErr), P0017 (OfsErr), P0019 (MntErr), P0019 (OfsErr), P0336 (Errsig), P0335		
					Fault Codes that disable P052C	P0341, P0343, P0342, P0346, P0348, P0347, P06A7, P2093, P2092, P0020, P06A6, P0016 (MntErr), P0016 (OfsErr), P0018 (MntErr), P0017 (MntErr), P0017 (OfsErr), P0019 (MntErr), P0019 (OfsErr), P0336 (Errsig), P0335		

Cold Start Camshaft Position Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Cold start Exhaust B camshaft position timing over advanced ANWCSmax ANWCS2max (DNWCS)	P054A P054C	As above	A setpoint/actual deviation is classified as detected as soon as there is a difference between setpoint angle and actual angle more than	>10 °CrS for 5 s	catalyst heating with help of camshaft adjustment active VVT Active		5 s	2 Drive Cycles
					Fault Codes that disable P054A	P0366, P0368, P0367, P0391, P0393, P0392, P06A7, P0016 (MntErr), P0016 (OfsErr), P0018 (MntErr), P0018 (OfsErr), P0017 (MntErr), P0017 (OfsErr), P0019 (MntErr), P0019 (OfsErr), P0336 (Errsig), P0335, P06A6, P2091, P2090, P0013		
					Fault Codes that disable P054C	P0366, P0368, P0367, P0391, P0393, P0392, P06A7P0016 (MntErr), P0016 (OfsErr), P0018 (MntErr), P0018 (OfsErr), P0017 (MntErr), P0017 (OfsErr), P0019 (MntErr), P0019 (OfsErr), P0336 (Errsig), P0335, P06A6, P2095, P2094, P0023		

Cold Start Fuel Pressure Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Cold Start Emission Reduction Strategy Performance (cont)								
Cold start fuel pressure Performance - max/min error <i>HDRKHmax</i> <i>HDRKHmin</i> (DKVBDEPL)	P053F	The diagnostic checks if the high rail pressure can be adjusted by the MSV control circuit and if there is an implausible deviation between the actual MSV control value of the actuator and desired control value during cold start catalyst heating conditions.	Filtered control deviation of high pressure control	< -2.2 Mpa For 3 s	Catalyst heating active After start counter	> 5 s	5 s	2 Drive Cycles
				> 2.2 Mpa For 3 s				
					Fault Codes that disable P053F	P0251, P0256, P0254, P0259, P0253, P0258, P0088 (Rmax), P0087 (Rmin), P0191 (Rnpl), P0191 (Rsig), P0193, P0192		
Catalyst heating Injector output <i>InjCatHeatgErr</i> (InjSyG_CatHeatgDsmDiag)	P168F	Monitors the injection output Whilst in catalyst heating	The number of faulty combustions during catalyst ceating is devided by the total number of combustions. If this ratio exceeds a threshold a fault is declared	0.1	Catalyst heating active		20 s	2 Drive Cycles

13.2. Supercharger control Valve Monitoring Table

Supercharger Control Valve Monitoring								
Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Supercharge Control Valve								
Circuit continuity (DKRK)	<i>KRKEmax</i>	P0039	Short to battery	Power stage internal check	Ignition switch - Battery voltage -	On > 11 v	0.2 s	2 Drive Cycles
	<i>KRKEmin</i>	P0034	Short to ground					
Sensor Voltage	<i>KRKEenpl</i>	P0033	Open circuit	SCV Voltage SCV Voltage for	> 4.8 v < 0.2 v 0.2 s	Ignition switch - Battery voltage - Engine Coolant temperature - Intake Air Temperature -	On > 11 v -40 °C < ect1 < 143.25 °C -40 °C < tans < 60 °C	10 s
	<i>KRKLmax</i>	P2565	Out of range check					
<i>KRKLmin</i> (GGKRK)	<i>KRKLmin</i>	P2564	Out of range check	If the PWM signal exceeds a threshold for a time period a Fault flag is set	> 50 % for 10 s	On > 11 v -40 °C < ect1 < 143.25 °C -40 °C < tans < 60 °C	10 s	2 s
	<i>KRKsig</i>	P132B	PWM output observation					
<i>KRKnpf</i>	P132B	Valve actual/desired position check	If the desired and actual valve position exceeds a threshold for a set time a fault flag is set	> 20 % for 2 s	Ignition switch - Battery voltage - Engine Coolant temperature - Intake Air Temperature -	On > 11 v -40 °C < ect1 < 143.25 °C -40 °C < tans < 60 °C	10 s	2 s
<i>KRK0max</i> <i>KRK0min</i> (DKRK)	P003A	Adaption check	If the sensor voltage at the mechanical stop position exceeds a threshold then a fault is set	> 1.75 v	Ignition switch - Battery voltage - Engine Coolant temperature - Intake Air Temperature -	On > 11 v -40 °C < ect1 < 143.25 °C -40 °C < tans < 60 °C	0.2 s	2 s

13.3.Ambient Temperature Sensor Monitoring Table

Ambient Temperature Sensor Monitoring								
Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Ambient Temperature Sensor								
Range Check <i>TUMEmax</i> <i>TUMEmin</i> (BGTUMG)	P0073	Out of range check	Amb TS	> 140.25 °C	Ignition switch -	On.	4 s	2 Drive Cycles
	P0072	Out of range check	Amb TS For	< -46.50 °C > 4 s	Battery voltage -	> 10.5 v		
Plausibility <i>TUMNpl</i> <i>TUMPsig</i>	P0071	Actual ambient temperature is compared against model temperature	If difference is above threshold for any time fault is declared	+/- 35 °C > 2 s	Engine started and running. Coolant temp - Air mass flow - Intake Air Temperature -	82 °C < ect1 < 104 °C 52 kg/h < mf < 352 kg/h -40 °C < tans < 55 °C		
Range check <i>TUMCSmax</i> At start <i>TUMCSmin</i>	P0071	A comparison of Ambient temp against the average of TFA1, TFA2, TFA3 Coolant1 and Ambient Air sensor values at engine start	If the sensor value plus / minus the average value is greater than a calibrateable threshold for period then declare a fault	> +/-20 °C for > 2 s	Ignition switch - Battery voltage - After engine off time	On > 10.5 v > 28800 s	2 s	
					Fault Codes that disable P0071 (npl) or (sig)	P0073, P0072, P0111 (Rmax), P0111 (Rmin), P0111 (CSmax), P0111 (CSmin), P0113, P0112, P0114, P00BD, P00BC, P00BF, P00BE, P010B, P0101, P0236 (Bnpl), P0236 (Bsig), P0236 (Pmax), P0236 (Pmin), P0236 (Psig), P0236 (Bmax), P0236 (Bmin), P0103, P0102, P0100, P010D, P010C, P010A, P0238, P0237, P0116 (Pmax), P0126 , P0116 (Pnpl), P0116 (CSmax), P0116 (CSmin), P0335, P06A6, P0501, P0500, P0118, P0117, P0119		
					Fault Codes that disable P0071 (CSmax) or (CSmin)	P0113, P0112, P0114, P0072, P0073, P007D, P007C, P007E, P0119, P0118, P0117		

13.4.Sensor Supply Voltage and Main Relay Monitoring Table

Sensor Supply Voltage and Main Relay Monitoring								
Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Sensor Supply Monitor								
SSpMon1 SspMon2 (SSpMon1Err) SspMon3	P06A6 P06A7 P06A8	Sensor supply voltage check	Voltage between	4.8 v ~ 5.2 v	Ignition switch - Battery voltage -	On > 10.5 v	0.2 s	2 Drive Cycles
Main Relay Monitoring								
<i>MRlyErlyOpngRng</i>	P068A	Early opening engine running	Shut down counter	4	Transition from ignition off to on.		0.7 s	

13.5. Knock Sensor Monitoring Table

Knock Sensor Monitoring								
Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Knock Sensor								
<i>KnDetSens1PortAMax / Bmax</i>	P0328	Short circuit sensor 1 Vbatt	Monitor measures the sensor signal voltage and compares it against a threshold which could only be breached if the signal in an error state		Engine speed - Knock control is active.	> 1600 rpm	0.2 s	2 Drive Cycles
<i>KnDetSens1PortAMin / BMin</i>	P0327	Short circuit sensor 1 ground						
<i>KnDetSens2PortAMax / Bmax</i>	P0333	Short circuit sensor 2 Vbatt						
<i>KnDetSens2PortAMin / Bmin</i>	P0332	Short circuit sensor 2 ground						
<i>KnDetSens3PortAMax / Bmax</i>	P032D	Short circuit sensor 3 Vbatt						
<i>KnDetSens3PortAMin / BMin</i>	P032C	Short circuit sensor 3 ground						
<i>KnDetSens4PortAMax / Bmax</i>	P033D	Short circuit sensor 4 Vbatt						
<i>KnDetSens4PortAMin / BMin</i>	P033C	Short circuit sensor 4 ground						
(KnDetLTest)								
<i>KS1max</i>	P0328	Monitors knock sensor voltage for knock sensor 1. Monitor checks for harness breaks, disconnected sensors or short circuit of wires to power or ground.	Knock sensor voltage measured for knock sensor 1, is standardized according to the measured voltage and power stage amplification value being used. Standardized value is compared with a value, mapped against engine speed. Fault is raised if standardized knock sensor voltage is greater(max) or less (min) than the mapped value for 3 seconds				3 s	
<i>KS1min</i>	P0327							
(DKRS)								
<i>KS2max</i>	P0333	Monitors knock sensor voltage for knock sensor 2. Monitor checks for harness breaks, disconnected sensors or short circuit of wires to power or ground.	Knock sensor voltage measured for knock sensor 2, is standardized according to the measured voltage and power stage amplification value being used. Standardized value is compared with a value, mapped against engine speed. Fault is raised if standardized knock sensor voltage is greater(max) or less (min) than the mapped value for 3 seconds					
<i>KS2min</i>	P0332							
(DKRS)								

Knock Sensor Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Knock Sensor (cont)								
<i>KS3max</i> <i>KS3min</i> (DKRS)	P032D P033D	Monitors knock sensor voltage for knock sensor 1. Monitor checks for harness breaks, disconnected sensors or short circuit of wires to power or ground.	Knock sensor voltage measured for knock sensor 1, is standardized according to the measured voltage and power stage amplification value being used. Standardized value is compared with a value, mapped against engine speed. Fault is raised if standardized knock sensor voltage is greater(max) or less (min) than the mapped value for 3 seconds				3 s	
<i>KS4max</i> <i>KS4min</i> (DKRS)	P033D P033C	Monitors knock sensor voltage for knock sensor 2. Monitor checks for harness breaks, disconnected sensors or short circuit of wires to power or ground.	Knock sensor voltage measured for knock sensor 2, is standardized according to the measured voltage and power stage amplification value being used. Standardized value is compared with a value, mapped against engine speed. Fault is raised if standardized knock sensor voltage is greater(max) or less (min) than the mapped value for 3 seconds					

13.6. Ignition Coil Driver Monitoring Table

Ignition Coil Driver Monitoring								
Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Ignition Coil Drives								
cyl 1 cyl 5 cyl 4 cyl 2 cyl 6 cyl 3 cyl 7 cyl 8	<i>IgnCIPsOpenLoad0</i> <i>IgnCIPsOpenLoad4</i> <i>IgnCIPsOpenLoad3</i> <i>IgnCIPsOpenLoad1</i> <i>IgnCIPsOpenLoad5</i> <i>IgnCIPsOpenLoad2</i> <i>IgnCIPsOpenLoad6</i> <i>IgnCIPsOpenLoad7</i>	P0351 P0355 P0354 P0352 P0356 P0353 P0357 P0358	Open load (signal error) of IgnCIPs power stage	Monitor reads the voltage of the ECM Terminal connected to the coil igniter and compares this with an expected voltage profile. The signal is diagnosed with respect to open circuit, Short circuit to battery and short circuit to ground		Engine started and running. Battery voltage -	> 10.5 v	0.1 s 2 Drive Cycles
cyl 1 cyl 5 cyl 4 cyl 2 cyl 6 cyl 3 cyl 7 cyl 8	<i>IgnCIPsShCirBatt0</i> <i>IgnCIPsShCirBatt4</i> <i>IgnCIPsShCirBatt3</i> <i>IgnCIPsShCirBatt1</i> <i>IgnCIPsShCirBatt5</i> <i>IgnCIPsShCirBatt2</i> <i>IgnCIPsShCirBatt6</i> <i>IgnCIPsShCirBatt7</i>	P2301 P2313 P2310 P2304 P2316 P2307 P2319 P2322	Short circuit to battery (max error) of the IgnCIPs power stage	Monitor reads the voltage of the ECM Terminal connected to the coil igniter and compares this with an expected voltage profile. The signal is diagnosed with respect to open circuit, Short circuit to battery and short circuit to ground				
cyl 1 cyl 5 cyl 4 cyl 2 cyl 6 cyl 3 cyl 7 cyl 8	<i>IgnCIPsShCirGnd0</i> <i>IgnCIPsShCirGnd4</i> <i>IgnCIPsShCirGnd3</i> <i>IgnCIPsShCirGnd1</i> <i>IgnCIPsShCirGnd5</i> <i>IgnCIPsShCirGnd2</i> <i>IgnCIPsShCirGnd6</i> <i>IgnCIPsShCirGnd7</i>	P2300 P2312 P2309 P2303 P2315 P2306 P2318 P2321	Short circuit to ground (min error) of the IgnCIPs power stage Open load (signal error) of IgnCIPs power stage	Monitor reads the voltage of the ECM Terminal connected to the coil igniter and compares this with an expected voltage profile. The signal is diagnosed with respect to open circuit, Short circuit to battery and short circuit to ground				
(IGNCLPS_DIA)								
<i>IgnCIPsDevSpiErr1</i> <i>IgnCIPsDevSpiErr2</i>		P0350	SPI Communication error of the IgnCIPs power stage	Encoded bit wise device communication signal not received				
<i>IgnCIPsDevInitErr1</i> <i>IgnCIPsDevInitErr2</i>		P0350	SPI Communication between ignition microcontrollers and ignition driver module	Encoded bit wise device communication signal not verified				
<i>IgnCIPsDevIdentErr1</i> <i>IgnCIPsDevIdentErr2</i>		P0350	Identification of IC error of the IgnCIPs power stage	Encoded bit wise device identification not verified				

13.7.Vehicle Speed Determination Table

Vehicle Speed Determination Monitoring								
Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Vehicle Speed Determination								
<i>VehVPlaus</i>	P0501	Plausibility defect for vehicle speed	Actual engine torque - average torque Engine speed - Vehicle speed - for	>150 Nm > 2500 rpm < 2 mph 5 s	Ignition switch - Battery voltage -	On > 10.5 v	5 s	2 Drive cycles
<i>VehVSign</i> (<i>VehV_VD/DD/2MED</i>)	P0500	Signal error for vehicle speed over CAN	CAN signal error detection					
Fault Codes that disable P0501						P0500		

13.8.Throttle Monitoring Tables

Throttle Monitoring									
Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.	
Throttle Monitoring									
Throttle Assembly Fault <i>DVEEmax</i> <i>DVEEmin</i> <i>DVEEnpl</i> <i>DVEEsig</i> (DDVE)	P2103	Throttle motor harness or throttle driver shorted high	Throttle motor PWM signal exceeding	+/- 80% for > 0.6 ms	Ignition switch - Battery voltage -	On > 8 v	0.6 s	2 Drive Cycles	
	P2108								Throttle motor harness or throttle driver shorted low
	P2101	Motor harness / assembly shorted together or driver shorted positive to negative.							
	P2100	Foreign object preventing free motion of the throttle blade.							
Throttle valve 1st potentiometer - Min error <i>DK1Pmin</i> Max error <i>DK1Pmax</i> Sig <i>DK1Pnpl</i>	P0122	Voltage check	Throttle position sensor 1 is checked to be within valid range.	0.17 v ~ 4.6 v			5 s		
	P0123	Throttle position sensor check	Sensor 1 differs from Sensor 2 TPS1 differs from calculated throttle position by (calculated from air charge).				> 6.3 %.		0.5 s
	P0121						> 9 %		
Throttle valve 2nd potentiometer - Min error <i>DK2Pmin</i> Max error <i>DK2Pmax</i> sig <i>DK2Pnpl</i>	P0222	Voltage check	Throttle position sensor 2 is checked to be within valid range.	0.17 v ~ 4.6 v			5 s		
	P0223	Throttle position sensor check	Sensor 1 differs from Sensor 2 Sensor 2 differs from calculated throttle position by (calculated from air charge).				> 6.3 %.		0.5 s
	P0221						> 9 %		
Difference fault between throttle sensor 1 and 2 <i>DKnpl</i>	P2135	Error state	Error reported if error state in either throttle position sensor reported				0.5 s		

13.9.Throttle Monitoring Tables

Throttle Monitoring								
Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Throttle Monitoring (cont)								
Return spring check open (spg_opn) & (spg_cls) <i>DVEAsig & DVEFmax</i>	P2119	During initialisation the spring check is performed	The throttle is opened >12% above limphome position. If this is not achieved within 0.20s a fault stored. At >12% the powerstage is disabled and the return spring should naturally close the throttle. If a position >3% of limphome position present after 0.7s a fault is logged.		Ignition switch -	On	1 s	2 Drive Cycles
DVEVnpl	P0121	Throttle amplification check	If the amplification or offset factors are outside limits	1% ~ 4 % -0.1 V ~ 0.1 V				
limphome air position (limp_home_pos) <i>DVENnpl</i>	P2119	Adaption position check – limphome position plausibility	Limphome position should be. or TPS1 voltage at limphome position should be within.	1.8 % ~ 17.5 % or 0.15 v ~ 0.16 v			1 s	
DV-E position deviation <i>DVELnpl</i>	P061F	Requested/actual throttle position comparison	Requested throttle position deviates from measured throttle position by a factor Note if the engine is not running and the engine or ambient temperature below threshold an extra factor is added	> 4 % for > 0.5 s < 5 °C and additional 3 %	Engine started and running. Battery voltage - Ignition switch -	> 8 v On	0.5 s	
DLR outside valid control range - Max Fault <i>DVERmax</i> Min Fault <i>DVERmin</i>	P2112	Throttle motor duty check	Throttle motor PWM signal exceeding a threshold for given period	+/- 80 % for > 0.6 s			0.6 s	
	P2111							
Incorrect throttle adaption <i>DVEUBmax/min</i> <i>DVEUnpl & DVEUWnpl</i> (DDVE)	P2176	Throttle adaption check	Adaptions not set		Full ECU power down followed by ignition On without starting engine Battery voltage -	ignition off > 60 s for 30 s > 10 v	30 s	

13.10. Acceleration Pedal Position Sensor Monitoring Table

Acceleration Pedal Position Sensor Monitoring								
Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Acceleration Pedal Position device driver Sensor 2								
Signal Range Check High for APP2 <i>SRCHighAPP2</i>	P2128	PWM Frequency check	If duty Cycle is above threshold for a time period then high fault declared	> 94 % for > 0.25 s			0.25 s	2 Drive Cycles
Signal Range Check Low for APP2 <i>SRCLowAPP2</i> (APP_DD2)	P2127	PWM Frequency check	If duty Cycle is below threshold for a time period then low fault declared	< 4 % for > 0.25 s			0.25 s	
					Fault Codes that disable P2127 or P2128	P06A7		
Acceleration Pedal Position device driver Sensor 1								
Signal Range Check High for APP1 <i>SRCHighAPP1</i>	P2123	Can signal check	The analogue signal should be in the range 6% to 90%. If the signal is above a threshold the signal is deemed high	> 94 %	Ignition switch -	On	1 s	2 Drive Cycles
Signal Range Check low for APP1 <i>SRCLowAPP1</i> (APP_DD1)	P2122	Can signal check	The analogue signal should be in the range 6% to 90%. If the signal is below a threshold the signal is deemed high	< 4 %			1 s	
					Fault Codes that disable P2122 or P2123	P06A6		
Acceleration Pedal Position Plausibility								
Plausibility Check between APP1 and APP2 (syncAPP)	P2138	Signal comparison	Both accelerator pedal inputs (analogue & PWM) should be within a threshold for a time period.	< 6 % > 0.4 s	Ignition switch -	On	0.4 s	2 Drive Cycles

13.11. ECM Monitoring Tables

ECM Monitoring								
Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
ECM Monitoring								
<i>EEPEraseErr, EEPRdErr & EEPWrErr (EEP)</i>	P062F	EEPROM performance (erase), (read) & (write)	EEPROM emulation lifetime exceeded		Ignition switch -	On	0.2 s	2 Drive Cycles
ECU fault - monitoring module error	P060A	Internal software fault of the ECM	Internal error reaction checks indicate that the software is not functioning as expected					
<i>MoCComctErrMM</i>	P061D	Internal ECU check (FICtOff)	Diagnosed ECU fault which leads to an injection quantity limitation.					
ECU fault - injection quantity limitation <i>MoFAirFICtOff</i>	P061D	Cylinder fuel correction check (FICyl)	Individual cylinder fuel corrections were found not plausible, internal software error.					
ECU fault - in check of cylinder individual fuel corrections <i>MoFAirFICyl</i>	P061D	(FilgPrdc)	Predicted air mass was found not plausible, internal software error					
Check of predicted air mass failed <i>MoFAirFilgPrdc</i>	P0169	Mixture correction factor check (Gkc)	Plausibility check of the mixture correction factors					
ECU fault or sensor in mixture check <i>MoFGkc</i>	P0169	Fuelling mode check (Modc)	Incorrect fuelling mode active, internal software error					
ECU fault - comparison of lambda and operation mode <i>MoFModc</i>	P0169	Relative fuel mass check (Rlc)	Relative fuel mass not plausible, internal software error.					
ECU fault or sensor in r-comparison <i>MoFRlc</i>	P0563	Internal ECU check - supply voltage check	Max voltage	> 5.2 v				
Supply <i>MonUMaxSupply1</i>	P0562		Min voltage	< 5 v				
Voltage <i>MonUMinSupply1</i>	P0643							
<i>MonUMaxSupply2</i>	P0642							
<i>MonUMinSupply2</i>	P0653							
<i>MonUMaxSupply3</i>	P0652							
<i>MoFICOL1</i>	P0606	Internal ECU check - Monitoring of injection cut off from level1 (FICOL1)	Internal error reaction checks indicate that the software is not functioning as expected					
<i>MoFICOL2</i>	P0606	Internal ECU check - Monitoring of injection cut off from level2 (FICOL2)	Internal error reaction checks indicate that the software is not functioning as expected					
<i>OCWDAActv, OCWDACom & OCWDAOvrVltg</i>	P0606	Internal ECU check - throttle drive communication WDA/ABE. (Actv), (Com) & (OvrVltg)	Internal check to ensure throttle driver communication is plausible					

ECM Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
ECM Monitoring (cont)								
Monitoring of accelerator pedal position <i>MoFAPP</i>	P060D	Compares both accelerator pedal inputs against each other	if the difference between each signal is greater than allowed	> 3.91 %	Ignition switch - Battery voltage -	On. > 10.5 v	0.1 s	2 Drive Cycles
Fault of engine speed check <i>MoFESpd</i>	P060C	Engine speed calculation based upon ignition angle monitor Internal software error.	Calculated speed is compared with measured engine speed Engine speed calculation was found not plausible	> 320 rpm	Engine started and running.			
ECU fault - ignition timing <i>MoFZwc</i>	P061C	Torque check	Torque changes for given ignition change are compared	> 11.0				
Fault of torque – comparison <i>MoFTrqCmp</i>	P061A	Delivered / requested torque check	Delivered Torque not plausible to requested torque, internal software error.					

13.12. Network Management Tables

Network Management Monitoring								
Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Network Management								
CAN Bus Communication (VCTCan) <i>NM_BusOffA</i> CAN level (Nm_Std) <i>Nm_IDCheck</i>	U0002	Can Signal Check	CAN High shorted to ground CAN low shorted to +12v	Signal high/low	Ignition switch - Battery voltage -	On > 10.5 v	0.2 s	2 Drive Cycles
	U0300	Rationality check	Comparison between CAN level of TCM and CAN level of Vehicle	Not equal			0.1 s	
Lost Communication With Anti-Lock Brake System (ABS) Control Module MS(EngECU) <i>NodeMon_ABS</i>	U0121	CAN signals missing from ABS module.	ABS CAN ID not received.	No ID.			0.2 s	
Plausibility fault from ABS alive counter <i>BrkABSAlivePlausErr</i>	U0415	Vehicle speed alive counter signal check from ABS module.	Vehicle speed alive counter signal loss or timing error.	Not equal			0.1 s	
Plausibility of faulty ABS Checksum transmission <i>BrkABSCRC8PlausErr</i>	U0415	Vehicle speed alive counter signal check from ABS module.	Checksum from ABS ECU not equal to ECU internal calculated vehicle speed signal checksum	Not equal				
Plausibility of faulty vehicle speed alive counter <i>BrkABSCSPlausErr</i>	U0415	Vehicle speed alive counter signal check from ABS module.	Checksum from ABS ECU not equal to ECU internal checksum	Not equal				
Plausibility fault from VehicleSpeedCounter <i>BrkVehSpdAlivePlausErr</i>	U0415	Vehicle speed signal check from ABS module.	Vehicle speed alive counter signal loss or timing error.	Not equal				
Plausibility fault by the VehicleSpeed Checksum <i>BrkVehSpdCSPlausErr</i>	U0415	Vehicle speed signal check from ABS module.	Checksum from ABS ECU not equal to ECU internal checksum	Not equal				
Lost Communication With (TCM) Transmission Control Module MS(EngECU) <i>NodeMon_TCM</i>	U0101	CAN signals missing from TCM	TCM CAN ID not received.	No ID.			0.2 s	
Value of MinuteCounter is not plausible <i>GlbDaTiPlaus</i>	P2610	Can Signal Check	Can signal not available	No signal			0.1s	
MinuteCounter signal not available via CAN <i>GlbDaTiSig</i>	P2610							
function monitoring: fault of ECU ADC- low idle test pulse <i>MoCADCNTF</i>	P060B	Check for correct conversion of cyclic voltage signal	A known voltage pulse signal is applied and expected conversion verified					

Network Management Monitoring

Component/System	Fault Code	Malfunction Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameters	Enable Conditions	Time Req.	MIL illum.
Network Management (cont)								
function monitoring: fault of ECU ADC - test voltage MoCADCTst (MOCADC)	P060B	Check for correct conversion of fixed voltage signal	The ADC-test voltage-check reads a fixed test voltage and checks the converted value for valid values				0.1s	2 Drive Cycles
Engine off timer check BGTENGSCheck	P2610	Engine Off Time is not plausible in comparison with real shutdown period.	Generates estimated engine off time from cool down rate of engine coolant and compares this value against body control module estimate of engine off time	>3600 s				
					Fault Codes that disable P2610	P062F		
Initialization of CAN/LIN controller Nm_SysInit Nm_CtlInit	U1A14	CAN/LIN communication check	Fault set when Volcano layer isn't able to initialize.				0.1s	
MIL request by automatic gearbox GbxMILReq	P0700	MIL request by automatic gearbox	MIL request by automatic gearbox	CAN signal				
MIL request by ABS-ECU BrkMILReq	P25A2	MIL request by ABS-ECU	MIL request by ABS-ECU	CAN signal				

14. Additional Information

14.1. Diagnostic Test Mode Compliance

The OBD system of the engine and gearbox control modules uses ISO standard 15765-4 to communicate with off board test equipment. The messages comply with SAE J1979, modes \$01 through \$04, modes \$06, \$07, \$09 and \$0A (permanent fault codes).

The basic algorithm used by the ECM for the calculation of the Calibration Verification Number has previously been used by Land Rover in the 2005 model year Range Rover. This was approved by ARB staff at a meeting on November 4th, 2003. The algorithm has had some minor changes since 2005. The memory area is now split into three ranges and the start and finish points for these ranges are varied by Bosch for different applications. A single CVN is now reported, in order to comply with the requirement for a single CAL ID, and one CVN for that CAL ID.

The algorithm used by the TCM for the calculation of the Calibration Verification Number was also approved by ARB staff at the meeting on November 4th, 2003.

The VIN reported to a scan tool in response to a Mode\$09, PID\$02 request is programmed once only when a vehicle is built or if a new ECM is fitted. This is in order to comply with (g)(4.8.2).

The read-out and the deletion of fault information is also possible using "IDS" service equipment. Please refer to a Land Rover repair manual or the service repair information websites at:

<http://topix.landrover.jlrext.com/topix/i18n/index>

14.2. Stored Engine Conditions - Mode\$02

The engine conditions present at the time of fault detection are stored in the ECM memory according to the requirements of the OBD regulation.

14.3.Communication of Monitor Test Results - Mode\$06

Diagnostic test results are output to a scan tool in accordance with the requirements of Mode\$06 of the SAE J1979 standard. The following table shows the allocation of monitor identifiers, test identifiers, unit and scaling identifiers and which DTCs are associated with each of the test results.

OBD MID	On-Board Diagnostic Monitor Name	Test ID	Description	Unit & Scaling ID	Associated DTC
00	OBD Monitor IDs supported (\$01 - \$20)	-			
01	Oxygen Sensor Monitor Bank 1 - Sensor 1	83	Pre-catalyst oxygen sensor response test	05	P0133
		85	Pre-catalyst oxygen sensor response test1 – 3.0 V6 SC only	05	P0133
		84	Pre-catalyst oxygen sensor offset test	85	P2096
02	Oxygen Sensor Monitor Bank 1 - Sensor 2	05	Oxygen sensor 2 transition time	10	P013A
		82	Oxygen sensor 2 delay time rich to lean	10	P013E
		83	Oxygen sensor 2 offset lean	0A	P2270
		84	Oxygen sensor 2 offset rich	0A	P2271
03	Oxygen Sensor Monitor Bank 1 – Sensor 3	83	Oxygen sensor 3 offset lean	0A	P2274
		84	Oxygen sensor 3 offset rich	0A	P2275
05	Oxygen Sensor Monitor Bank 2 - Sensor 1	83	Pre-catalyst oxygen sensor response test	05	P0153
		85	Pre-catalyst oxygen sensor response test1 – 3.0 V6 SC only	05	P0133
		84	Pre-catalyst oxygen sensor offset test	85	P2098
06	Oxygen Sensor Monitor Bank 2 - Sensor 2	05	Oxygen sensor 2 transition time	10	P013C
		82	Oxygen sensor 2 delay time rich to lean	10	P014A
		83	Oxygen sensor 2 offset lean	0A	P2272
		84	Oxygen sensor 2 offset rich	0A	P2273
07	Oxygen Sensor Monitor Bank 2 – Sensor 3	83	Oxygen sensor 3 offset lean	0A	P2276

OBD MID	On-Board Diagnostic Monitor Name	Test ID	Description	Unit & Scaling ID	Associated DTC
		84	Oxygen sensor 3 offset rich	0A	P2277
20	OBD Monitor IDs supported (\$21 - \$40)	-			
21	Catalyst Monitor Bank 1	84	Catalyst oxygen storage capability	2F	P0420
22	Catalyst Monitor Bank 2	84	Catalyst oxygen storage capability	2F	P0430

OBD MID	On-Board Diagnostic Monitor Name	Test ID	Description	Unit & Scaling ID	Associated DTC
35	VVT Monitor Bank 1	80	Inlet camshaft control target error test	9C	P0026
		81	Inlet camshaft control slow response test	9C	P0026
		82	Exhaust camshaft control target error test	9C	P0027
		83	Exhaust camshaft control slow response test	9C	P0027
		84	Inlet camshaft locking control test	9C	P0016
		85	Exhaust camshaft locking control test	9C	P0017
		86	Camshaft profile switching (5.0 V8 NA only)	05	P003C
36	VVT Monitor Bank 2	80	Inlet camshaft control target error test	9C	P0021
		81	Inlet camshaft control slow response test	9C	P0021
		82	Exhaust camshaft control target error test	9C	P0024
		83	Exhaust camshaft control slow response test	9C	P0024
		84	Inlet camshaft locking control test	9C	P0018
		85	Exhaust camshaft locking control test	9C	P0019
		86	Camshaft profile switching (5.0 V8 NA only)	05	P003E
3B	EVAP Monitor (0.040")	8B	Rough leak	FE	P0442
3C	EVAP Monitor (0.020")	84	Small leak	05	P0456
3D	Purge Flow Monitor	8D	Purge system low flow test using the DMTL	0D	P0497
		8C	Purge system stuck open test using the DMTL	0D	P0496
40	OBD Monitor IDs supported (\$41 - \$60)	-			
41	Oxygen Sensor Heater Monitor Bank 1 - Sensor 1	85	Pre-catalyst oxygen sensor heater performance test	16	P0135

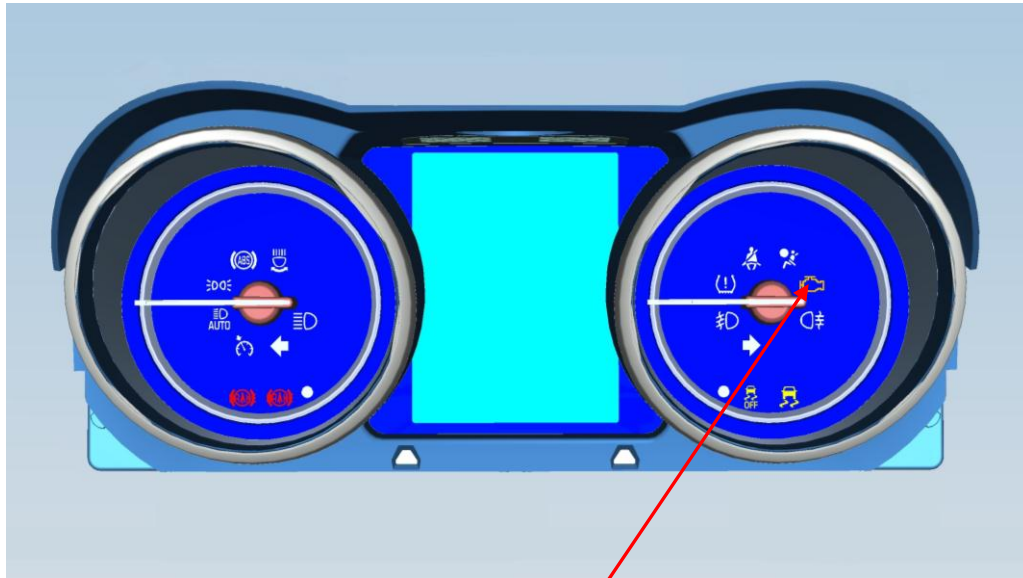
OBD MID	On-Board Diagnostic Monitor Name	Test ID	Description	Unit & Scaling ID	Associated DTC
42	Oxygen Sensor Heater Monitor Bank 1 - Sensor 2	81	Pre-catalyst oxygen sensor heater performance test	14	P0054
43	Oxygen Sensor Heater Monitor Bank 1 - Sensor 3	81	Pre-catalyst oxygen sensor heater performance test	14	P0055

OBD MID	On-Board Diagnostic Monitor Name	Test ID	Description	Unit & Scaling ID	Associated DTC
45	Oxygen Sensor Heater Monitor Bank 2 - Sensor 1	85	Pre-catalyst oxygen sensor heater performance test	16	P0155
46	Oxygen Sensor Heater Monitor Bank 2 - Sensor 2	81	Pre-catalyst oxygen sensor heater performance test	14	P0060
47	Oxygen Sensor Heater Monitor Bank 2 - Sensor 3	81	Post-catalyst oxygen sensor heater resistance test	14	P0061
60	OBD Monitor IDs supported (\$61 - \$80)	-			
80	OBD Monitor IDs supported (\$81 - \$A0)	-			
81	Fuel System Monitor Bank 1 – 3.0 V6 SC	A1	Cylinder 1 imbalance monitor	1E	P219C
		A3	Cylinder 2 imbalance monitor	1E	P219D
		A5	Cylinder 3 imbalance monitor	1E	P219E
82	Fuel System Monitor Bank 2 – 3.0 V6 SC	A1	Cylinder 4 imbalance monitor	1E	P219F
		A3	Cylinder 5 imbalance monitor	1E	P21A0
		A5	Cylinder 6 imbalance monitor	1E	P21A1
81	Fuel System Monitor Bank 1 – 5.0 V8	A1	Cylinder 1 imbalance monitor	1E	P219C
		A3	Cylinder 2 imbalance monitor	1E	P219D
		A5	Cylinder 3 imbalance monitor	1E	P219E
		A7	Cylinder 4 imbalance monitor	1E	P219F
82	Fuel System Monitor Bank 2 – 5.0 V8	A1	Cylinder 5 imbalance monitor	1E	P21A0
		A3	Cylinder 6 imbalance monitor	1E	P21A1
		A5	Cylinder 7 imbalance monitor	1E	P21A2
		A7	Cylinder 8 imbalance monitor	1E	P21A3

OBD MID	On-Board Diagnostic Monitor Name	Test ID	Description	Unit & Scaling ID	Associated DTC
A0	OBD Monitor IDs supported (\$A1 - \$C0)	-			
A2	Misfire Cylinder 1 Data	0B	Exponential Weighted Moving Average for Cyl#1	24	P0301
		0C	Stored misfire event during last/current DCY for Cyl#1	24	P0301
A3	Misfire Cylinder 2 Data	0B	Exponential Weighted Moving Average for Cyl#2	24	P0302
		0C	Stored misfire event during last/current DCY for Cyl#2	24	P0302
A4	Misfire Cylinder 3 Data	0B	Exponential Weighted Moving Average for Cyl#3	24	P0303
		0C	Stored misfire event during last/current DCY for Cyl#3	24	P0303
A5	Misfire Cylinder 4 Data	0B	Exponential Weighted Moving Average for Cyl#4	24	P0304
		0C	Stored misfire event during last/current DCY for Cyl#4	24	P0304
A6	Misfire Cylinder 5 Data	0B	Exponential Weighted Moving Average for Cyl#5	24	P0305
		0C	Stored misfire event during last/current DCY for Cyl#5	24	P0305
A7	Misfire Cylinder 6 Data	0B	Exponential Weighted Moving Average for Cyl#6	24	P0306
		0C	Stored misfire event during last/current DCY for Cyl#6	24	P0306
A8	Misfire Cylinder 7 Data 5.0 V8 only	0B	Exponential Weighted Moving Average for Cyl#7	24	P0307
		0C	Stored misfire event during last/current DCY for Cyl#7	24	P0307
A9	Misfire Cylinder 8 Data 5.0 V8 only	0B	Exponential Weighted Moving Average for Cyl#8	24	P0308
		0C	Stored misfire event during last/current DCY for Cyl#8	24	P0308

14.4. Drawing and Location of the Malfunction Indicator Light

JAGUAR F-Type



Malfunction Indicator Light (MIL)

14.5. Location of the Data Link Connector

The connector is located in the driver's foot well on the lower face of the dash assembly.

Jaguar F-Type



Data Link Connector

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