ON-BOARD DIAGNOSTICS
GEMS Generic Engine Management System

Vehicle Coverage:
Discovery Series I 1996 to 1999 MY
Range Rover 38A 1995 to 1999 MY
Defender 90 1997 MY

1 Contents

2 Introduction

GEMS (Generic Engine Management System) is a combined electronic ignition and fuel injection system which also combines other features such as idle speed control, security functions and engine load management functions. GEMS has an internal fault monitoring system, which can be interrogated by a standard serial link.

GEMS controls the engine fuelling by providing full sequential fuel injection. Ignition is controlled by an Electronic Ignition (EI) System, which is provided by 4 double-ended ignition coils operating on the wasted spark principle. A fully synchronous system is realised by the incorporation of a Camshaft Position Sensor and with the inclusion of Knock Sensors, GEMS is able to detect and correct for knock, advancing or retarding each individual cylinder independently to give optimum performance.

The GEMS Engine Control Module (ECM) has various sensors fitted to the engine which give it information about how the engine is performing, how much air is entering, what throttle angle is requested, the current temperature of the air, fuel and engine coolant, the oxygen content in the exhaust, etc. The signals from these sensors are fed to the ECM which processes them and decides what actions to take on the information it has received, and feeds these to its actuators (injectors, coils etc.).

The ECM software essentially can be split into two parts, the system software and the tune data. The system software controls the overall operational strategy of the engine management system. The tune data is vehicle specific data such as the fuelling and ignition-mapped data, which the system software uses to control the engine management system for specific conditions. The system software and tune data are stored in Read Only Memory (ROM). The ECM also contains non-volatile memory in which learnt values and the Diagnostic Trouble Codes (DTCs) are stored.

2.1 Inputs and Outputs

Inputs

Crankshaft Position Sensor
Camshaft Position Sensor
Mass Air Flow Sensor
Throttle Position Sensor
Engine Coolant Temperature Sensor
Intake Air Temperature Sensor
Fuel Tank Temperature Sensor
Knock Sensors
Oxygen Sensors
Ignition Switch Sense
Road Speed
Fuel Level
Fuel Tank Pressure .... Discovery / Range Rover Advanced EVAP only
Gearbox Ignition Retard Request............................ Range Rover Automatic Transmission only
Air Conditioning Request... Where fitted

Heated Front Screen Request.................................. Not Defender
Transfer Box Fault..… Range Rover only
Security Signal
Park/Neutral Switch
Rough Road Signal
Air Conditioning Condenser Fan Relay request........ Where fitted

Outputs

Injectors
Ignition Coils
Idle Speed Control Stepper Motor
EVAP Canister Purge Valve
EVAP Canister Vent Valve................…….. Advanced EVAP only
Main Relay
Fuel Pump Relay
Engine Torque Signal................................. Range Rover Automatic Transmission only
Engine Speed Signal.................................. To Body Electronic Control Module (BeCM) Tachometer, Gearbox Range Rover only
Throttle Angle Signal..............................… Range Rover Automatic Transmission only
Air Conditioning Condenser Fan Relay....... Where fitted
Malfunction Indicator Lamp (MIL)
Fuel Used Signal....................................... Range Rover only
Air Conditioning Grant............................... Where fitted

3 On Board Monitoring

3.1 Catalyst Monitoring

3.1.1 Description

1. Diagnostic Trouble Codes:

Bank 1:	P0420
Bank 2:	P0430

The On Board Diagnostic (OBD) II system uses a 2 stage catalyst monitoring procedure. Stage 2 will only be invoked when the catalyst fails stage 1. Both stages are described in detail below.

2. Monitoring Procedure - Stage 1
During Stage 1 monitoring, lambda feedback control uses the upstream oxygen sensors as normal. When specified monitoring conditions are satisfied, the catalyst diagnostics module will obtain a count of downstream and upstream oxygen sensor peak edges OXY SENSOR MEAS EDGE COUNT D and OXY SENSOR MEAS EDGE COUNT U respectively. When OXY SENSOR MEAS EDGE COUNT U equals CAT UPS PEAK MAX, a difference is obtained between CAT UPS PEAKS MAX, and OXY SENSOR MEAS EDGE COUNT D to give CAT PEAKS DIFF.
The calculation repeats until the number of CAT PEAKS DIFF values calculated equals CAT CUSUM FULL. Each value of CAT PEAKS DIFF is subtracted from a threshold value CAT STAGE1 THRESH and a sum of the differences obtained CAT PKCUSUM.
If, before OXY SENSOR MEAS EDGE COUNT U equals CATS UPS PEAKS MAX, vehicle conditions change and the conditions listed in section 3 of this document are no longer satisfied, then the module stops receiving peak counts and the current count is discarded. The calculation of CAT PKCUSUM is held until the monitoring conditions are again satisfied, when its calculation is resumed with a new count of peak edges, until the number of CAT PEAKS DIFF included in CAT PKCUSUM equals CAT CUSUM FULL.
The cumulative sum CAT PKCUSUM is then compared against a threshold value CAT PKCUSUM THRESH. If it exceeds the threshold then the catalyst is suspected and Stage II is invoked, otherwise the catalyst is OK.
The two thresholds CAT STAGE1 THRESH and CAT PKCUSUM THRESH are related via the number of measurements in the cumulative sum, as follows:

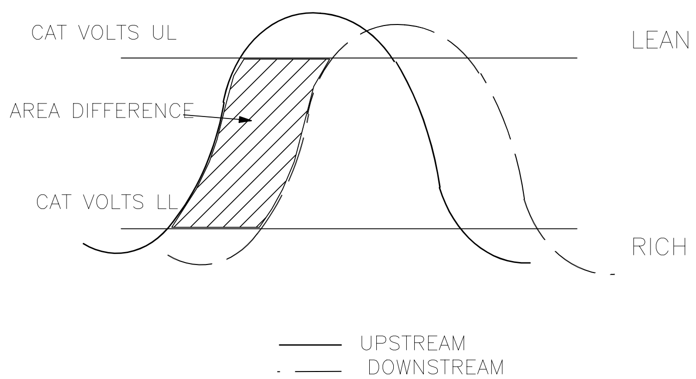
$$\text{CAT PKCUSUM} = \sum_{1}^{\text{CAT CUSUM FULL}} \max(0, (\text{CAT STAGE1 THRESH} - \text{CAT PEAKS DIFF}))$$

A flow chart describing the above procedure has been included.

3. Primary Detection Parameter - Stage 1
Edge Counts difference - derived from two oxygen sensors before and after the catalyst.

4. Criteria for Determining failing Stage 1
CAT PKCUSUM => CAT PKCUSUM THRESH = 20
CAT STAGE1 THRESH = 5

5. Monitoring Procedure - Stage 2
Catalyst Monitoring uses the integrated area-difference technique to give an accurate measure of the condition of the catalyst. This technique measures the differences in the waveforms from oxygen sensors immediately before and after the catalyst. During Stage 2 monitoring lambda feedback control is switched to use the downstream oxygen sensors.
From each monitored catalyst, two oxygen sensor voltages are obtained at regular time intervals. The voltages are clipped between CAT VOLTS LL and CAT VOLTS UL to give CAT LAMBDA DNS CLIP and CAT LAMBDA UPS CLIP. On the rich to lean transition the downstream clipped signal is subtracted from the upstream one. The difference is retained only if it yields a positive result. The differences are summed while the upstream oxygen sensor voltage is less than CAT VOLTS UL, and the resulting value gives a measure of the area CAT SUM OF DIFFS.



The value of CAT SUM OF DIFFS is then corrected for Air Mass Flow Rate (AMFR) by multiplying it by the following expression:
AMFR /(CAT MAXIMUM AMFR - AMFR) where CAT MAXIMUM AMFR is a constant set to the largest value that AMFR can reach for that engine.
The corrected value is called CAT NORM AREA DIFF.

This is averaged over a number of sensor switches, provided that the engine is operating at speed and load conditions, which are defined, as valid for catalyst monitoring. If the current value of CAT NORM AREA DIFF is taken from outside the valid speed and load conditions, then this value is discarded and the system prepares for the next oxygen sensor peak.

The value of CAT NORM AREA DIFF calculated as described above, is used to set up a Cumulative Sum (CAT ADCUSUM) to decide whether catalyst performance has deteriorated below the required level. This involves subtracting each value of CAT AREA DIFF received from a threshold value of area difference (CAT AREA DIFF THRESH), and summing the differences. When the number of CAT AREA DIFF values included in the sum equals CAT CUSUM FULL, then CAT ADCUSUM is compared against a threshold value (CAT ADCUSUM THRESH), and if it is greater than the threshold, then the catalyst is faulty. If CAT ADCUSUM is lower than this threshold then the catalyst is not faulty.

6. Primary Detection Parameter - Stage 2
Area Difference - measured in Volt seconds taken from two oxygen sensors before and after the catalyst.

7. Fault Criteria Limits - Stage 2
CAT AREA DIFF THRESH = 1200 (internal units) i.e.: 0.146 Volt seconds

CAT ADCUSUM THRESH = 3000 (internal units) i.e.: 0.366 Volt seconds

8. Monitoring Conditions
Engine speed and engine load must be in the highlighted area of the map:

Speed (RPM x1000)	Load (unitless)							
	0	1	2	3	4	5	6	7
0								
1								
2								
3								
4								
5								
6								
7								

Road speed must be greater than 20 mph.
Steady engine conditions must be true
The catalyst must be deemed to have reached "light off" indicated by the following:
Engine Coolant Temperature is > 70^0 C AND Average Oxygen Sensor Heater Supply < 90%.

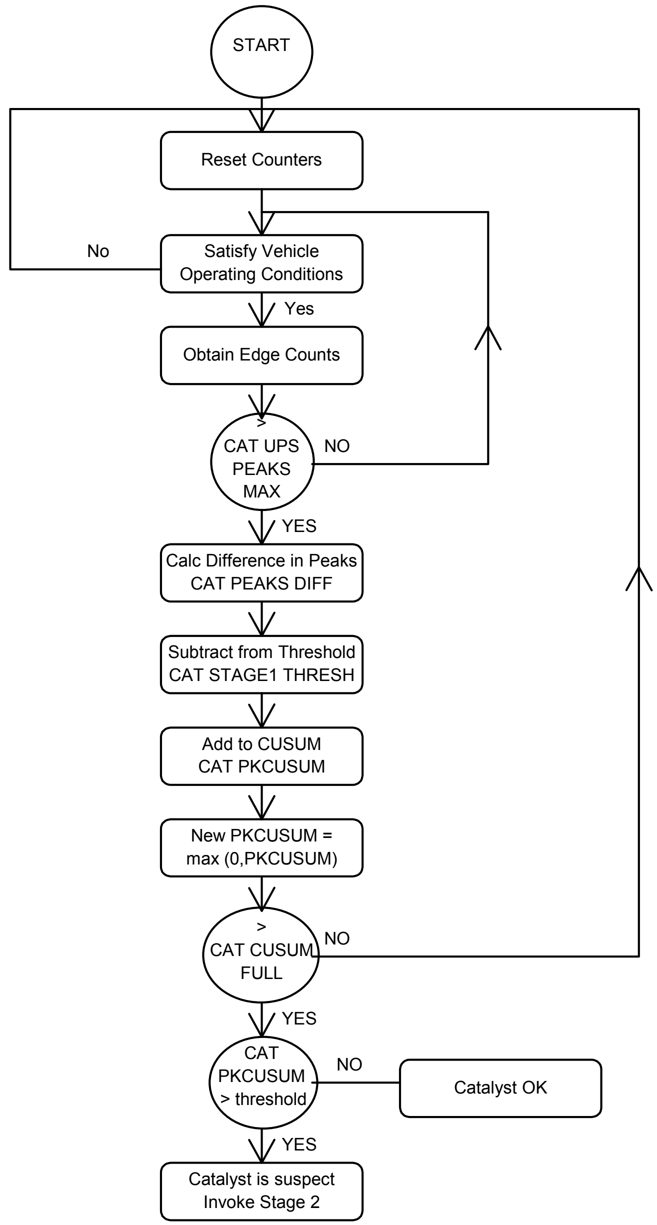
9. Monitoring Time Length / Frequency of Checks
The time taken for catalyst monitoring to complete the test depends on the switching frequency of the feedback control system, which in stage 2 depends on the catalyst's performance. If the switching frequency is taken as an average of 1.5 Hz then the stage 2 catalyst monitoring test will take 7x15x1/1.5 = 70seconds at stable valid conditions.
Stage 1 will take a similar amount of time to complete.

10. Criteria for Storing Diagnostic Trouble Code
Two successive trips where the catalyst monitoring system indicates a failed catalyst.

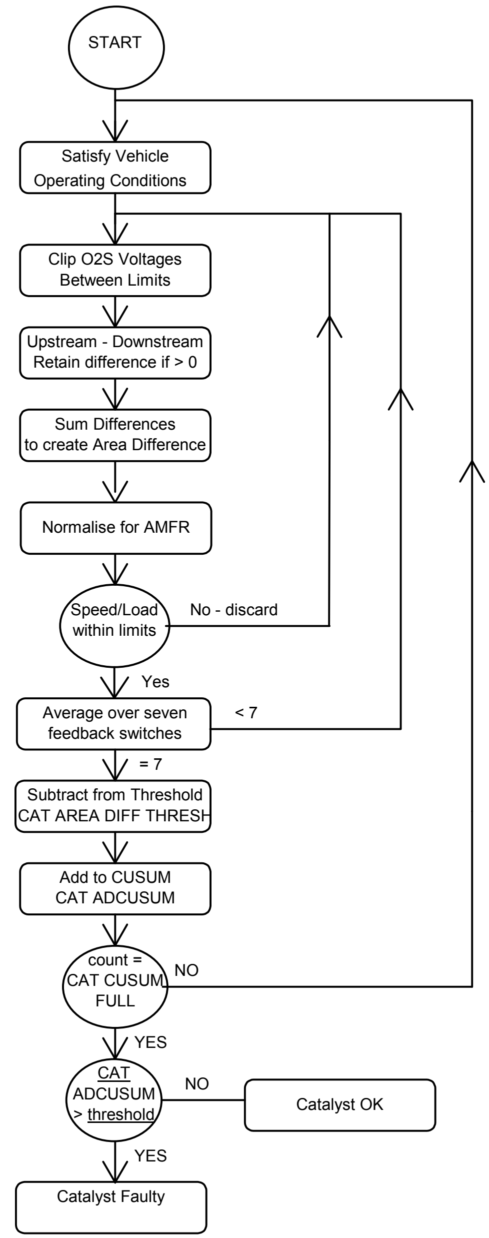
11. Criteria for Illuminating MIL
Two successive trips where the catalyst monitoring system indicates a failed catalyst.

12. Criteria for Determining Out of Range Input Signals
The oxygen sensors are subject to minimum and maximum voltage limits of 15mV and 4.985V respectively.

3.1.2 Monitoring Structure – Part 1



3.1.3 Monitoring Structure – Part 2



Catalyst Monitoring Operation								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
CATALYST Banks 1 & 2	P0420 P0430	Two Stage Method Front O2S verses Rear O2S integrated area difference Y Style Exhaust, one catalyst on each bank	Sum of area differences	0.366 Volt seconds	Vehicle Speed O2S Heater supply (current) ECT	> 20 MPH (steady-state constraints) < 90 % > 70 Celsius	< 70 sec (cumulative at 1.5 Hz)	2 successive trips

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.2 Misfire Monitoring

3.2.1 Description

1. Diagnostic Trouble Codes:
Individual DTCs for each cylinder, for either excess emissions or catalyst damage and corresponding multiple cylinder codes.

Catalyst Damage Bank A Misfire Fault	P1313
Catalyst Damage Bank B Misfire Fault	P1314
Excess Emissions Misfire Fault	P1316
Random / Multiple Misfire	P0300
Misfire Detected - Cylinder 1	P0301
Misfire Detected - Cylinder 2	P0302
Misfire Detected - Cylinder 3	P0303
Misfire Detected - Cylinder 4	P0304
Misfire Detected - Cylinder 5	P0305
Misfire Detected - Cylinder 6	P0306
Misfire Detected - Cylinder 7	P0307
Misfire Detected - Cylinder 8	P0308

2. Monitoring Procedure
Misfire detection using crankshaft period measurements has been implemented. Two algorithms compare changes in crankshaft period with respective threshold values that are speed and load dependant. If the change in crankshaft period exceeds the threshold value a misfire has occurred.
Percentage misfire is calculated over 200 or 1000 engine revolution blocks for each bank of cylinders and compared to threshold levels for excess emissions or catalyst damage. Whenever conditions are not suitable for misfire detection, engine revolution counting and misfire counting is suspended. When conditions are suitable, counting continues from the last updated values.

Catalyst Damage
The total percentage misfire indicated by the algorithm is calculated in blocks of 200 revolutions of the crankshaft. If this value exceeds the misfire rate that indicates catalyst damage (MF DIAG THRESH PCENT MF CAT), cylinder identification takes place and a misfire catalyst damage fault is present for the appropriate bank.

Excess Emissions
The percentage misfire (MF DIAG PCENT MF EMISS) is calculated in blocks of 1000 revolutions of the crankshaft using MF DIAG FIRE COUNT EMISS I as the revolution count. If the misfire rate is high enough to exceed specified emission limits, cylinder identification takes place and a misfire emission fault is present.

Cylinder Identification
Each misfire detected will be referenced to a particular cylinder. If the number of misfires occurring on a particular cylinder exceeds a given percentage of the total number of misfires from all the cylinders, then that cylinder is considered to be misfiring and a misfire cylinder number (1 to 8) fault is present. Otherwise a misfire on multiple cylinders fault is present.

3. Primary Detection Parameter
Engine speed changes processed over a series of engine firings.

4. Fault Criteria Limits
Misfire to exceed emissions limit - 2%
Misfire to cause catalyst damage - 15%

5. Monitoring Conditions
The engine must be stabilised after any rapid throttle excursion, fuel cut off condition or gear change. Monitoring is disabled during rough road conditions. The engine load must exceed a threshold, which is mapped with engine speed (to represent the positive/negative engine torque boundary).

Map of load/speed sites where misfire detection is active

Speed (RPM)	Load -Percentage															
	0	7	13	20	27	33	40	47	53	60	67	73	80	87	93	100
500			■	■	■	■										
750			■	■	■	■	■									
1000				■	■	■	■									
1250				■	■	■	■	■								
1500				■	■	■	■	■	■							
1750				■	■	■	■	■	■	■						
2000				■	■	■	■	■	■	■						
2250				■	■	■	■	■	■							
2500				■	■	■	■	■								
2750																
3250																
3750																
4000																
4250																
5000																
5500																

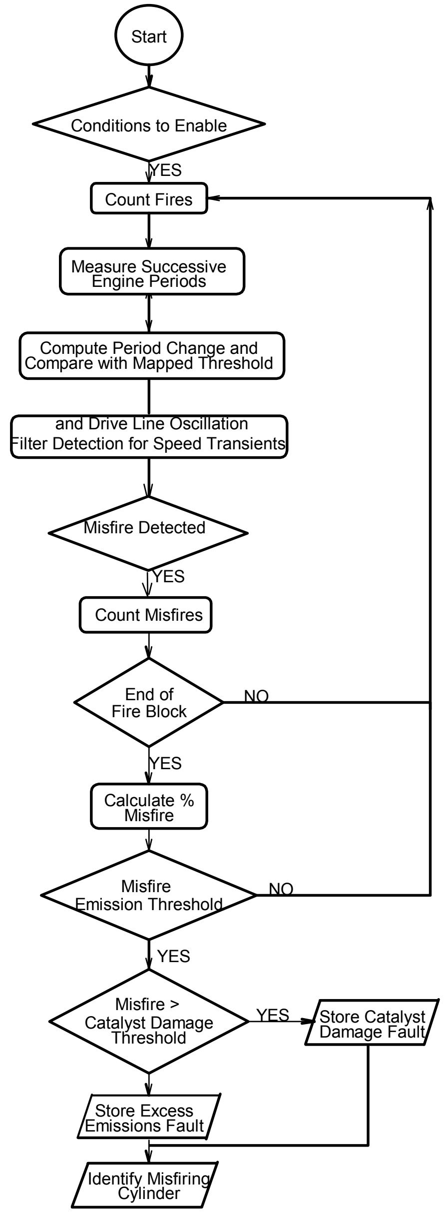
6. Monitoring Time Length / Frequency of Checks
The misfire percentage is checked at the end of every block of 200 or 1000 engine revolutions as required. The counting of engine revolutions is suspended during engine stabilisation as described above.

7. Criteria for Storing Fault Code
If catalyst damage levels of misfire are detected the fault code is stored immediately. If misfire above the emission threshold (only) is detected, then a set of conditions is stored. A DTC will be stored if misfire is detected on a subsequent driving cycle while the conditions are still stored. The conditions can be erased on intervening fault free driving cycles as allowed in OBD II regulations.

8. Criteria for Illuminating MIL
If catalyst damage levels of misfire are detected the MIL will be flashed for as long as the catalyst damage misfire level is present. If misfire above the emission threshold (only) is detected, then a set of conditions is stored. The MIL will be illuminated if misfire is detected on a subsequent driving cycle while the conditions are still stored. The conditions can be erased on intervening fault free driving cycles as allowed in OBD II regulations.

9. Criteria for Determining Out of Range Input Signals
The crankshaft position sensing system is subject to diagnostics, which detect more or less than the correct number of sensor transitions per engine revolution.

3.2.2 Monitoring Structure



Misfire Monitoring Operation

Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
MISFIRE	P0300	Crankshaft period (speed) fluctuation	Emissions threshold		Idle Speed Control step change	< 10	1000 revolutions	2 successive drive cycles
	P0301-P0308	Cylinder identification	Percent misfire in 1000 revolutions	> 2%	Engine Load Change	< 0.1221 g/stroke		
	P1313-P1316	through attributed misfire			Disable	Up to 1 s after fuel shut-off		
			Catalyst damage		Disable	Up to 1 s after gear change		
			Percent misfire in 200 revolutions	> 15%	Disable	ABS Rough Road Flag	200 revolutions	Immediately

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.3 Evaporative Emission System Monitoring

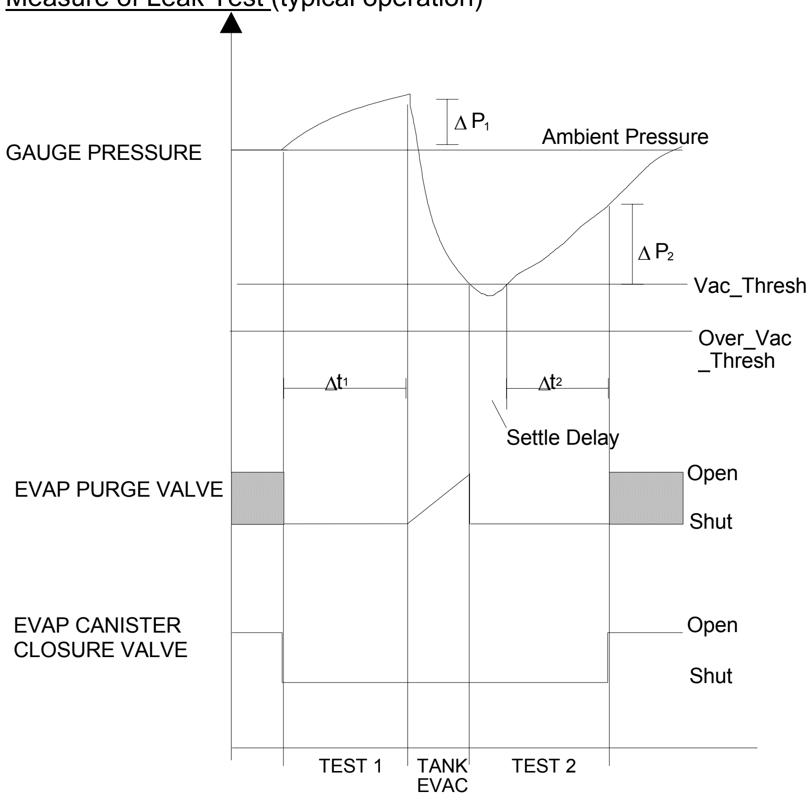
3.3.1 Description

1. Diagnostic Trouble Codes:

Evaporative Emission system 1 fault	P1496
Evaporative Emission system 2 fault	P1448
EVAP Canister Purge valve stuck open	P1440
Measure of leak test fault	P0442
EVAP Canister Purge valve circuit malfunction	P0443

2. Monitoring Procedure

Measure of Leak Test (typical operation)



When certain conditions are satisfied, the measurement of leak test is requested. This inhibits any other intrusive tests from being run.

The EVAP canister closure and EVAP canister purge valves are closed and the fuel tank pressure is allowed to rise for a period of time during which the pressure is continuously sampled. The EVAP canister purge valve is then ramped open to evacuate the tank until the pressure falls below a preset threshold. If the threshold is not reached within a time limit, a system fault is flagged.
The EVAP canister purge valve is closed again. If the pressure rises above the threshold before the settle delay has elapsed, a leak is suspected; otherwise, the test is passed.
After the settle delay, the rising pressure is continuously sampled for the same period as in the first part of the test. An estimate of the size of the leak is calculated using data recorded in both parts of the test. If the result exceeds a threshold, a leak fault is flagged.
To ensure that the tank is not subjected to excessive pressure or vacuum, the test is aborted if the fuel tank pressure moves outside a band. The test is also aborted if filtered feedback for purge falls below a threshold during evacuation of the tank.

EVAP Canister Purge Valve Stuck Open Test
The test compares the value of fuel tank pressure against a threshold. When the conditions for running the measure of leak test are valid and the EVAP canister closure valve is shut. If the value of fuel tank pressure is below the threshold, then an EVAP canister purge valve stuck open fault is present.

EVAP Canister Purge Valve PWM Drive Hardware Test.
The diagnostic test samples a Purge Diag PWM Buff Status to determine whether a fault has occurred, and if so a counter Purge Diag PWM Fault Cntr is incremented up, to a limit of Purge Diag PWM Fault Limit. Whenever Purge Diag PWM No Fault Limit consecutive no fault events occur, then decrement Purge Diag PWM Fault Cntr down to a limit of zero. If the count reaches Purge Diag PWM Fault Limit then an EVAP canister purge valve open or short circuit fault is present.

3. Primary Detection Parameter

Measure of Leak Test
Fuel tank pressure

EVAP Canister Purge Valve Stuck Open Test
Fuel tank pressure

EVAP Canister Purge Valve PWM Drive Hardware Test.
Hardware fault status from the EVAP Canister purge valve drive application specific integrated circuit (ASIC), which monitors line voltage before low side drive transistor.

4. Fault Criteria Limits

EVAP System 1 Fault
EVAP Diag Press Thresh +0.5kPa

EVAP System 2 Fault

EVAP Diag Press Thresh	+0.5kPa

<u>Measure of Leak Test Fault</u>

EVAP Diag Measure of Leak Thresh	50 (decimal)

<u>EVAP Canister Purge Valve PWM Drive Hardware Test.</u>

EVAP Canister Purge Diag PWM Fault Limit	255 samples

<u>EVAP Canister Purge Valve Stuck Open</u>

EVAP Diag Over Vac Thresh	-3.5kPa

5. Monitoring Conditions

The measure of leak test will not run (or shall abort) when the following faults or defaults are present:
Multiple cylinder misfire fault
Fuel tank pressure out of range
EVAP Canister Purge valve open or short circuit fault
Any fuel level sensor fault
Any oxygen sensor fault
Any oxygen sensor heater fault
Any intake air temperature fault

After a delay following the exit of the cranking condition, the EVAP diagnostic monitors for the following conditions to be true before the test is started:

- Manifold depression exceeds the EVAP threshold
- Road speed within range
- EVAP Canister Purge feedback adaptation above the EVAP Canister purge adaptation limit
- Closed loop fuelling is active on both banks
- Steady state conditions are present
- Fuel level within the EVAP range
- OBD-II warm up conditions are satisfied
- Fuelling feed back is off clamp on both banks
- Fuelling feed back is not in default
- Intake air temperature is above the EVAP limit

The EVAP Canister Purge Valve PWM hardware test occurs continuously

6. Monitoring Time Length / Frequency of Checks

The Measure of Leak Test diagnostic runs at a frequency of once per trip.
The hardware test runs at 10Hz.

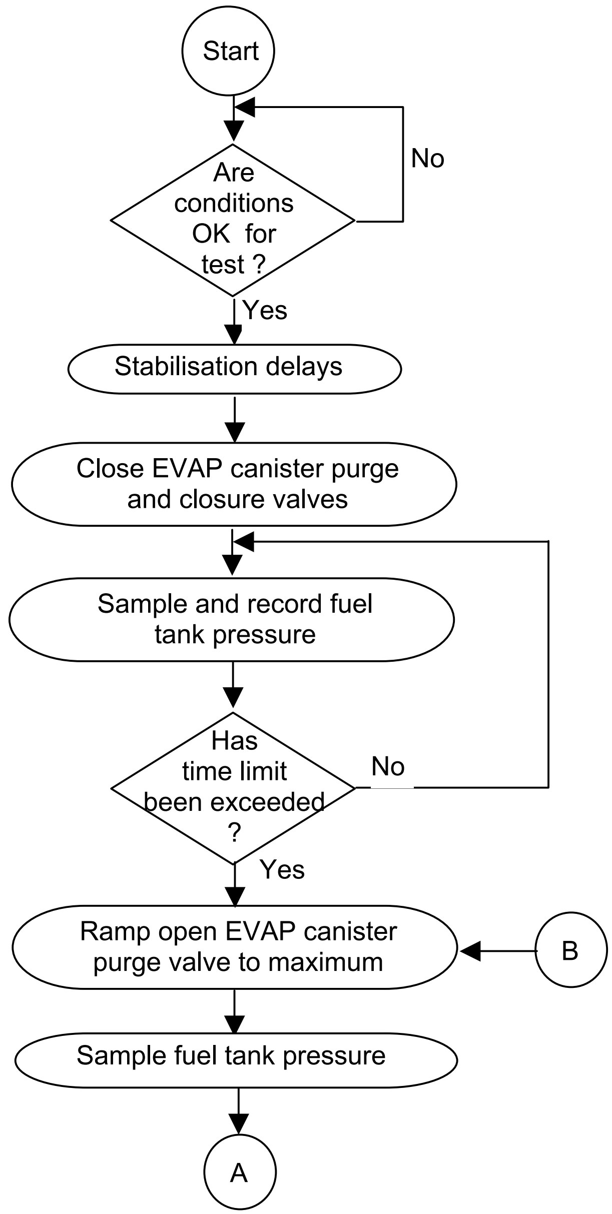
7. Criteria for Storing a Diagnostic Trouble Code

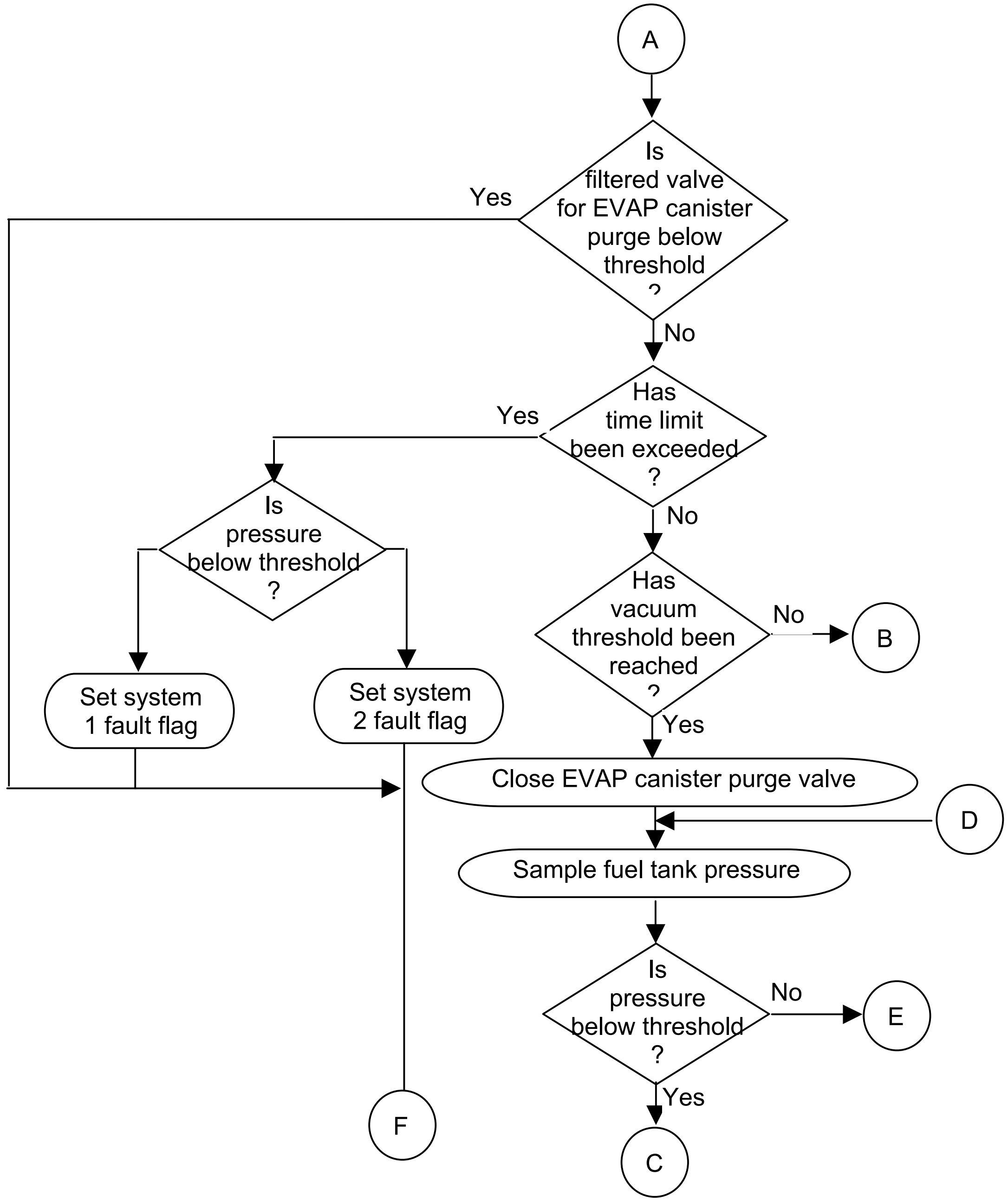
Two successive trips where the diagnostic routines indicate a fuel system leak or a failed EVAP canister purge valve or EVAP canister purge valve circuit.

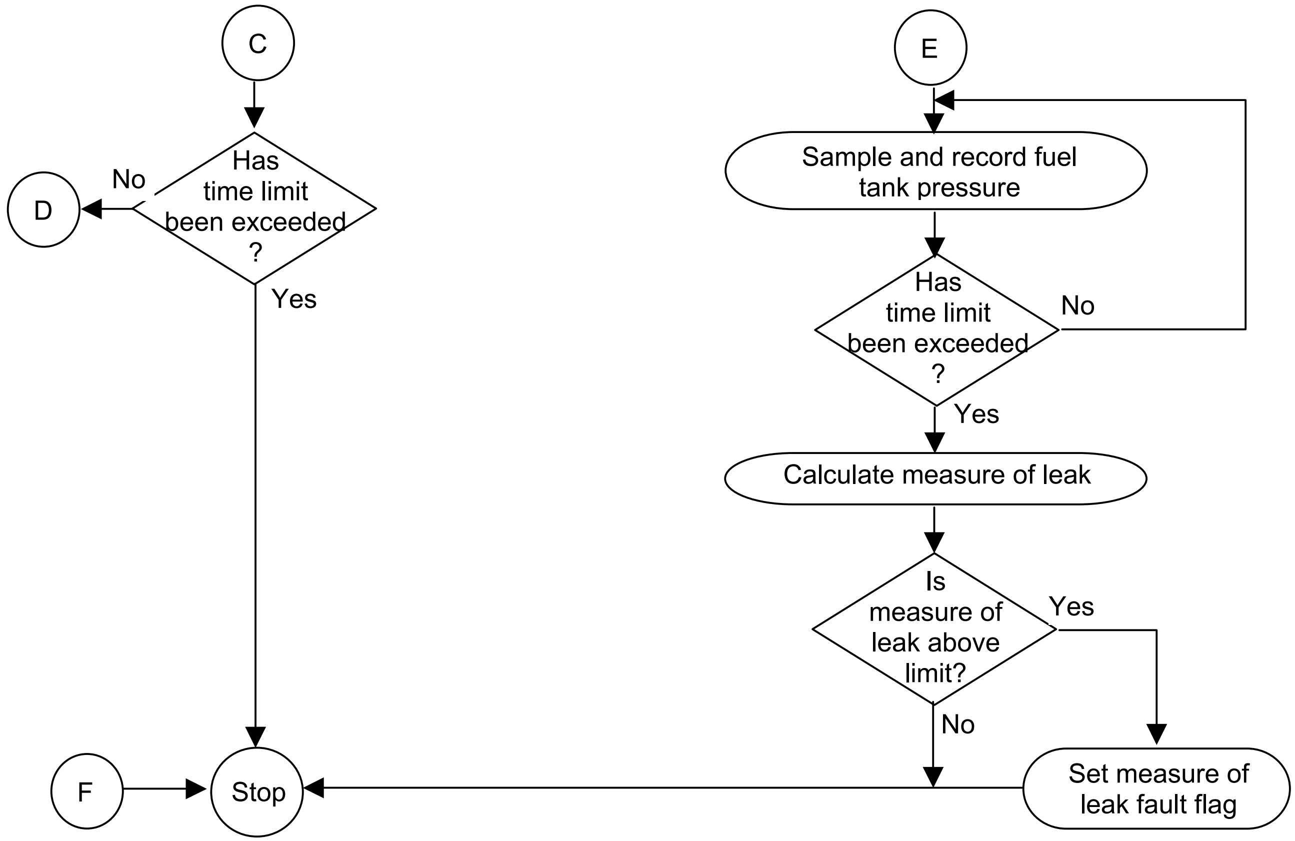
8. Criteria for Illuminating MIL
Two successive trips where the diagnostic routines indicate a fuel system leak or a failed EVAP canister purge valve or EVAP canister purge valve circuit.

9. Criteria for Determining Out of Range Input Signals
The hardware sampling technique monitors non-linear signals; the criteria will be signal/no signal.

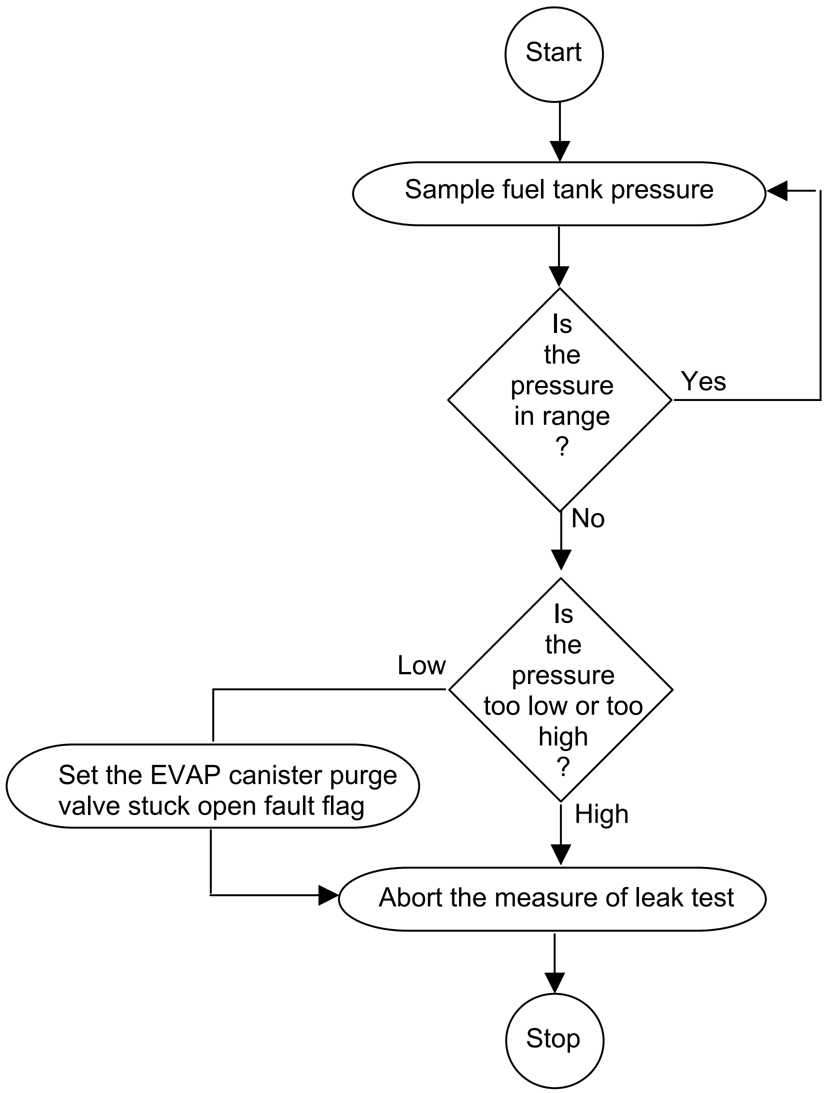
3.3.2 Monitoring Structure – Measure of leak Test



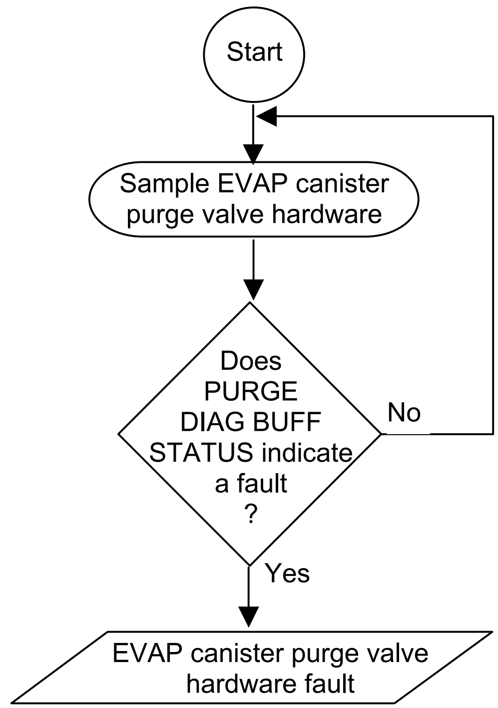

A
Is filtered valve for EVAP canister purge below threshold ?
Yes
No
Has time limit been exceeded ?
Yes
No
Is pressure below threshold ?
Set system 1 fault flag
Set system 2 fault flag
Has vacuum threshold been reached ?
No
B
Yes
Close EVAP canister purge valve
D
Sample fuel tank pressure
Is pressure below threshold ?
No
E
Yes
C
F


C
Has time limit been exceeded ?
No
D
Yes
E
Sample and record fuel tank pressure
Has time limit been exceeded ?
No
Yes
Calculate measure of leak
Is measure of leak above limit?
Yes
No
Set measure of leak fault flag
F
Stop

3.3.3 Monitor Structure – EVAP Canister Purge Valve Stuck Open Test



3.3.4 Monitor Structure – EVAP Canister Purge Valve PWM Drive Hardware Test



Evaporative Emission System Monitoring

Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
ADVANCED EVAP LEAK DETECTION SYSTEM	P1496 P1448 P0442	Gross leak fault System fails to attain vacuum of 1.94kPa within 25 seconds And Fine leak fault	Vacuum or Measure of leak figure	> 0.32 kPa <= 0.32 kPa > 100	Road speed Throttle position (voltage) Engine speed Manifold Pressure Intake air temperature Time after engine start Fuel level and no slosh detected Fuel control system EVAP canister purge feedback adaptation	15 < v < 50 mph 0 < volts < 1.1 V 700< RPM< 2000 < 90 kPa > - 7ºC > 760 seconds 3.45 V < sensor voltage < 4.2 V In closed loop > Threshold	test time ~60 secs	2 successive trips
EVAPORATIVE SYSTEM (EVAP canister purge valve only)	P0443 P1440 P0441	Circuit continuity (pulse width modulation controller) EVAP canister purge valve stuck open EVAP canister purge flow test (Stoichiometric purge checked by # of ISC steps)	Controller fault counter Fuel tank pressure Fuelling feedback correction Total adaptive o/s	254 -3.5 KPa < 5 % < 6 steps	Controller buffer status EVAP conditions met Fuel control Disable Disable Disable Disable Disable System settling delay	TRUE Engine running Closed loop EVAP canister purge valve continuity fault ISC motor fault O2S fault O2S heater fault Mass airflow rate sensor fault 15 minutes after engine cranking	25 sec (continuous)	2 successive trips

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.4 EVAP Canister Closure Valve

3.4.1 Description

1. Diagnostic Trouble Codes:

EVAP canister closure valve malfunction:	P0446
EVAP canister closure valve performance:	P1447

2. Monitoring Procedure

<u>EVAP Canister Closure Valve PWM Drive Hardware Test</u>

The diagnostic test samples Close Valve Diag PWM Buff Status to determine whether a fault has occurred, and if so a counter Close Valve Diag PWM Fault Cntr is incremented up, to a limit of Close Valve Diag PWM Fault Limit. If no fault event occurs, then decrement Close Valve Diag PWM Fault Cntr down to a limit of zero. If the count reaches the limit Close Valve Diag PWM Fault Limit then an EVAP canister closure valve open or short circuit fault is present.

<u>EVAP Canister Closure Valve Performance Test</u>

The test compares the value of fuel tank pressure against a threshold, during normal purge operation. If the value of FUEL TANK PRESS VOLTS is less than CLOSE VALVE BLOCKED PRESS, then an appropriate fault counter is incremented up to a limit of close valve blocked diagnostic fault limit. Otherwise the fault counter is decremented down to a limit of zero. If the fault counter reaches the limit then an EVAP canister closure valve flow fault is present.

3. Primary Detection Parameter

<u>EVAP Canister Closure Valve PWM Drive Hardware Test</u>

Hardware fault status from EVAP canister closure valve drive ASIC which monitors line voltage before low side drive transistor.

<u>EVAP Canister Closure Valve Performance Test</u>

Fuel tank pressure - Measured in volts, the outcome of a potential divider calculation.

4. Fault Criteria Limits

EVAP Canister Closure Valve Diag PWM Fault Limit	50 samples
EVAP Canister Closure Valve Blocked Pressure	-3.5 kPa

5. Monitoring Conditions

The EVAP canister closure valve PWM drive hardware test occurs continuously.
The performance test will take place during normal purge operation.

6. Monitoring Time Length / Frequency of Checks

The frequency of the EVAP canister closure valve diagnostic is 10Hz.

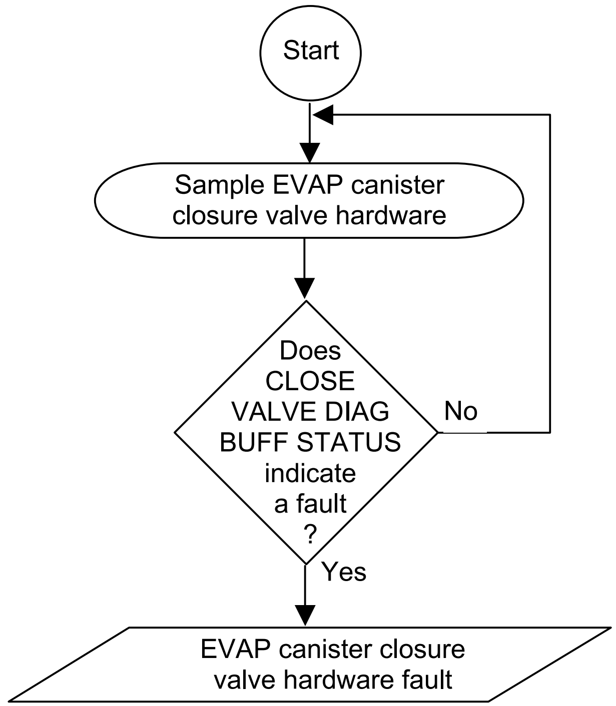
7. Criteria for Storing a Diagnostic Trouble Code

Two successive trips where the diagnostic routines indicate a failed valve or valve circuit.

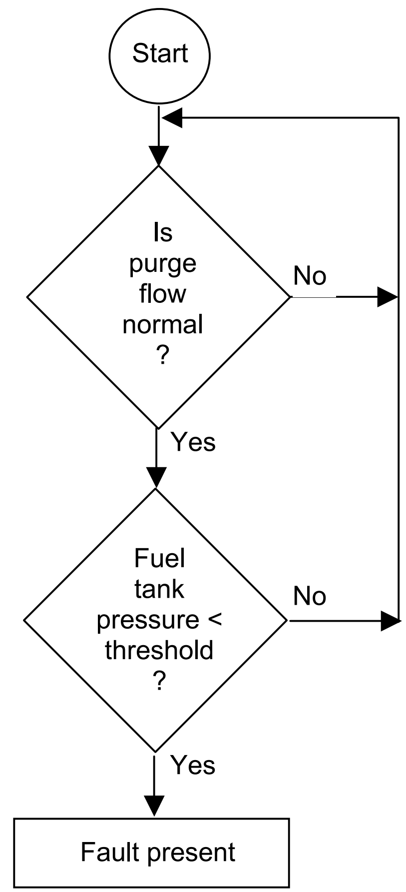
8. Criteria for Illuminating MIL
Two successive trips where the diagnostic routines indicate a failed valve or valve circuit.

9. Criteria for Determining Out of Range Input Signals
The hardware sampling technique monitors non-linear signals; the criteria will be signal/no signal.

3.4.2 Monitor Structure – EVAP Canister Closure Valve PWM Drive Hardware Test



3.4.3 Monitor Structure - Performance Test



EVAP Canister Closure Valve								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
EVAP CANISTER PURGE CLOSURE VALVE	P0446 P1447	Hardware drive test poor performance	EVAP Canister Purge Closure Valve P.W.M. Buff status Fuel tank pressure	fault/no fault -3.5KPa	ECU status normal purging	active engine running	50 samples	2 successive trips

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.5 Oxygen Sensor and Fuel System Monitoring

3.5.1 Description

1. Diagnostic Trouble Codes:

Oxygen Sensor indicates rich fault - Bank 1	P1138
Oxygen Sensor indicates rich fault - Bank 2	P1158
Oxygen Sensor indicates lean fault - Bank 1	P1137
Oxygen Sensor indicates lean fault - Bank 2	P1157
Oxygen Sensor low voltage Bank 1 Sensor 1	P0131
Oxygen Sensor low voltage Bank 1 Sensor 2	P0137
Oxygen Sensor low voltage Bank 2 Sensor 1	P0151
Oxygen Sensor low voltage Bank 2 Sensor 2	P0157
Oxygen Sensor high voltage Bank 1 Sensor 1	P0132
Oxygen Sensor high voltage Bank 1 Sensor 2	P0138
Oxygen Sensor high voltage Bank 2 Sensor 1	P0152
Oxygen Sensor high voltage Bank 2 Sensor 2	P0158
Oxygen Sensor Response Rate fault Bank 1 Sensor 1	P0133
Oxygen Sensor Response Rate fault Bank 2 Sensor 1	P0153
System too lean, Bank 1	P0171
System too lean, Bank 2	P0174
System too rich, Bank 1	P0172
System too rich, Bank 2	P0175
Oxygen Sensor High Mark Space Ratio Fault Bank 1	P1137
Oxygen Sensor Low Mark Space Ratio Fault Bank 1	P1138
Oxygen Sensor High Mark Space Ratio Fault Bank 2	P1157
Oxygen Sensor Low Mark Space Ratio Fault Bank 2	P1158
Oxygen Sensor Circuit Malfunction (Period) Bank 1 Sensor 1	P0130
Oxygen Sensor Circuit Malfunction (Period) Bank 2 Sensor 1	P0150
Oxygen Sensor Circuit Malfunction (Period) Bank 1 Sensor 2	P0136
Oxygen Sensor Circuit Malfunction (Period) Bank 2 Sensor 2	P0156
Lean Fuelling Fault	P1171
Rich Fuelling Fault	P1172
Long term fuel trim too lean, banks 1&2 (FMFR)	P1176
Long term fuel trim too rich, banks 1&2 (FMFR)	P1177
Long term fuel trim too lean, banks 1&2 (AMFR)	P1178
Long term fuel trim too rich, banks 1&2 (AMFR)	P1179

FMFR = Fuel Mass Flow Rate
AMFR = Air Mass Flow Rate

2. Monitoring Procedure

Summary

The oxygen sensors are tested as the first stage in a suspected fuel system fault. There are further periodic tests on the response rates of the sensors. These are compared against reference rates. If the measured response rate is lower than the reference then the test will fail. The output voltage is range checked. If these tests are not passed then the appropriate fault count will be incremented; otherwise it will decrement to zero. If the count reaches a given threshold then a fault is present.

Integrator clamp tests will also be performed on the control sensors. If any of the fuelling feedback integrators reach their clamp values, then a fuelling change followed by additional smaller fuelling changes (if required) will be introduced up to a maximum fuelling change limit, to try and move the integrator off its clamp value. If this is successful then a fuelling fault is suspected and the fuelling system diagnostics are performed. If it is not successful and the sensor passed the range test above, then an indeterminate (failed to switch) fault is present. The fuelling system diagnostics can diagnose a number of faults depending on the state of the feedback integrators.

Range Check

The output voltage of each fitted sensor is monitored to check that it is within range. If the output voltage is less than a calibrated minimum voltage or greater than maximum voltage then an appropriate fault counter will be incremented. If the voltage is in range then the counter is decremented to zero. If the counter reaches a predetermined limit then a range fault is present; the fault will remain present until the counter reaches zero.

Response Rate Measurements

The response rates of the controlling oxygen sensors are measured. This measurement will take place during the normal sensor switching, which occurs in closed loop control. If either of the response times in the Lean to Rich direction or the Rich to Lean direction are greater than their respective maximum limits, then the appropriate response rate fault counter will be incremented; the counters will be decrement to zero if the appropriate response time is less than its limit. If either counter reaches its maximum value then the appropriate response rate fault is present. The fault will remain present until the counter reaches zero.

Mark Space Ratio Measurements

The Mark/Space Ratio (MSR) of the controlling oxygen sensors is calculated to give an indication of the Dynamic Lambda to which the engine management system is controlling. The Oxygen Sensor Measured Mark Space Ratio value is calculated within the ECM's Oxygen Sensor Signal Measurement strategy and then averaged over a number of iterations of this strategy. If the average value is not within the required limits then a fault counter pertaining to Mark Space Ratio faults will be incremented; otherwise it will be decrement until zero. The limits will be of a minimum MSR and maximum MSR. These limits will be mapped against engine speed and load. If the counter reaches a predetermined limit then a Mark Space Ratio fault is present; the fault will remain present until the counter reaches zero.

Switching Period Measurements

If the oxygen sensor period is greater than Oxy_Sens_Diag_Max_Period_C then a fault counter Oxy_Sens_Diag_Period_Faults [A, B] will be incremented every time Oxygen Sensor Feedback switches {for the bank in question}. If the period is within the range then the fault counter is decremented to zero. If the counter reaches the value Oxy_Sens_Diag_Fault_Limit_C, then a fault will remain present until the counter reaches zero.

Oxygen Sensor Clamp Tests

If the integrator is on the enleanment clamp with EVAP Canister purge disabled then the fuelling is reduced by an amount Oxy_Sens_Diag_Enlean_Percent and the system waits for a period Oxy_Sens_Diag_Clamp_Test_Time. If the integrator does not move off the clamp then the fuelling is reduced by Oxy_Sens_Diag_L_Extra_Percent amount and the system again waits for a period

Oxy_Sens_Diag_Clamp_Test_Time. This will be repeated until the integrator moves off clamp or the fuelling has reached a maximum permitted fuelling change. If the fuelling change(s) caused the integrator to move off clamp then a fuelling fault is suspected and further fuel system diagnostics will be performed; if not then an Oxygen Sensor Failed to Switch Lean fault is present. All fuelling changes will be removed at this time.
If the integrator is on the enrichment clamp then the fuelling is increased by an amount Oxy_Sens_Diag_Enrich_Percent and the system waits for a period Oxy_Sens_Diag_Clamp_Test_Time. If the integrator does not move off the clamp then the fuelling is increased by Oxy_Sens_Diag_R_Extra_Percent amount and the system again waits for a period Oxy_Sens_Diag_Clamp_Test_Time. This will be repeated until the integrator moves off clamp or the fuelling has reached a maximum permitted fuelling change. If the fuelling change(s) caused the integrator to move off clamp then a fuelling fault is suspected and further system diagnostics will be performed; if not then an Oxygen Sensor Failed to Switch Rich fault is present. All fuelling changes will be removed at this time.
Note: Each bank's clamp test is considered to be a single intrusive test, only one test can be active at a time, with initial priority given to bank 1.

Fuelling System Clamp Tests
All diagnostic fuelling changes will be removed before performing the tests below.
If an integrator returns to its clamp within a time designated by Oxy_Sens_Diag_Clamp_Delay then the conditions below will be applied. If this is not the case then this test is abandoned until again triggered by the oxygen sensor diagnostics.
While a bank is on clamp, an appropriate fault counter for each bank will be incremented. If the bank moves off clamp then the counter will decrement until zero. An integrator clamp test for bank A or B is considered to be complete if the fault counter reaches zero or the fault limit. If the value of the fault counter reaches its limit value a clamp fault is present; the fault will remain present until the counter reaches zero. All clamp faults for that bank will be cleared when the counter reaches zero. When a clamp fault is present the conditions below will be applied to determine which fault is present.

(1). One integrator is at the maximum enrichment clamp and the other not at the maximum enrichment clamp; a Reduced Fuel Flow Fault is present for the appropriate bank.

(2). Both integrators are on the maximum enrichment clamp; a Lean Fuelling Fault is present. This diagnostic will be disabled if the fuel level is less than the permissible fuel level for the diagnostic.

(3). One integrator is at the maximum enleanment clamp and the other is not at the maximum enleanment clamp; an Excess Fuel Flow Fault is present for the appropriate bank.

(4). Both integrators are on the maximum enleanment clamp; a Rich Fuelling Fault is present.

Long Term Fuel Trim Diagnostics
These tests monitor the performance of the Adaptive Fuelling System. If the corrections it applies exceed limits, then the appropriate fault is present. The fault remains until the system returns to within limits. The checks performed are detailed below.
If the ADAP_FMFR_CORR value is greater than FUEL_DIAG_MAX_POS_FMFR_CORR then a MAX_POSITIVE_FMFR_CORR_FAULT is present.
If the ADAP_FMFR_CORR value is less than FUEL_DIAG_MAX_NEG_FMFR_CORR then a MAX_NEG_FMFR_CORR_FAULT is present.
If the ADAP_AMFR_CORR value is greater than FUEL_DIAG_MAX_POS_AMFR_CORR then a MAX_POSITIVE_AMFR_CORR_FAULT is present.
If the ADAP_AMFR_CORR value is less than FUEL_DIAG_MAX_NEG_AMFR_CORR then a MAX_NEGATIVE_AMFR_CORR_FAULT is present.

3. Primary Detection Parameter
Range Check
Oxygen Sensor Voltage - See Range Test Monitoring Structure.

Response Rate Measurements
The rise and fall times of the oxygen sensor output signal between two voltage levels.

Mark Space Ratio Calculations
The calculated ratio for each state that the output signal will attain during normal closed loop fuelling.

Switching Period Measurements
The measured time for a sensor to complete a full switching cycle.

Oxygen Sensor Clamp Tests
The output of an integration equation, normally observed as percentage enrichment or enleanment of fuelling – short term fuel trim.

Fuelling System Clamp Tests
An integrator swing from the clamp within a time, defined by the fault counter operation speed.

Long Term Fuel Trim Tests.
Adaptive Fuel Mass Flow rate correction

4. Fault Criteria Limits

Range Check

Oxygen Sensor Minimum Voltage	0.015 V
Oxygen Sensor Maximum Voltage	4.98 V

Response Rate Measurements

Oxygen Sensor Maximum Rich to Lean Time	0.235 seconds
Oxygen Sensor Maximum Lean to Rich Time	0.349 seconds

Mark Space Ratio Calculations

Oxygen Sensor Minimum MSR -	An 8x8 map of speed and load sites - values from 0 to 13.7
Oxygen Sensor Maximum MSR -	An 8x8 map of speed and load sites - values from 25.4 to 39.1

Switching Period measurements

Maximum oxygen sensor switching period	1.2 seconds

Oxygen Sensor Clamp Tests

Oxygen Sensor clamp test time	7 seconds

Fuelling System Clamp Tests.

Fault counter limit	20 seconds

Long Term Fuel Trim Tests.

FUEL_DIAG_MAX_POS_FMFR_CORR	+0.62 g/s (injector fuel flow rate)
FUEL_DIAG_MAX_NEG_FMFR_CORR	-0.62 g/s (injector fuel flow rate)
FUEL_DIAG_MAX_POS_AMFR_CORR	+5.48 kg/hr (air mass flow rate)
FUEL_DIAG_MAX_NEG_AMFR_CORR	-5.48 kg/hr (air mass flow rate)

5. Monitoring Conditions

(1). Oxygen Sensor Diagnostics will only run when the Engine Stabilised [i.e.-internally calculated value] flag is set; and closed loop fuelling is active. If this is not the case then all fault counts will be suspended but not cleared; any clamp tests, which are in progress, will be aborted

(2). Oxygen Sensor Period Diagnostics will only run when the Local Engine Stabilised Flag is set. This is a Global Engine Stabilised based off unsigned delta air per stroke. This Local Flag activates when the driver oscillates the throttle.

(3). All tests will be abandoned if the oxygen sensor heater diagnostics report a fault with the heater for the sensor in question, or the heater control algorithm is inactive.

(4). Response rate tests will not run when fuelling feedback is on clamp or when a fault has been detected which affects fuelling feedback control (i.e. misfire, injector failure or coil failure).

(5). Clamp tests will only run above an engine coolant temperature threshold and a throttle position threshold. Clamp tests will be disabled if:
A misfire fault has been detected on that bank
An injector fault has been detected on that bank
An ignition coil fault has been detected
An Oxygen Sensor signal is out of range (on that sensor)
An Oxygen Sensor response rate fault has been detected (on that sensor)
A mass airflow sensor fault has been detected during the current journey
A throttle position sensor fault has been detected

(6) Fuel system clamp tests will be disabled when Oxygen sensor clamp tests are disabled or when fuelling feedback control is not using the normal Oxygen sensor.

(7). While oxygen or fuel system clamp tests are running on one bank then clamp tests on the other bank cannot be started.

(8). When clamp tests have been completed on either bank, they will not be repeated for the remainder of that trip.

(9). The response rate and switching period diagnostics are only performed when the air mass flow rate exceeds a predetermined minimum, otherwise all fault counters are frozen.

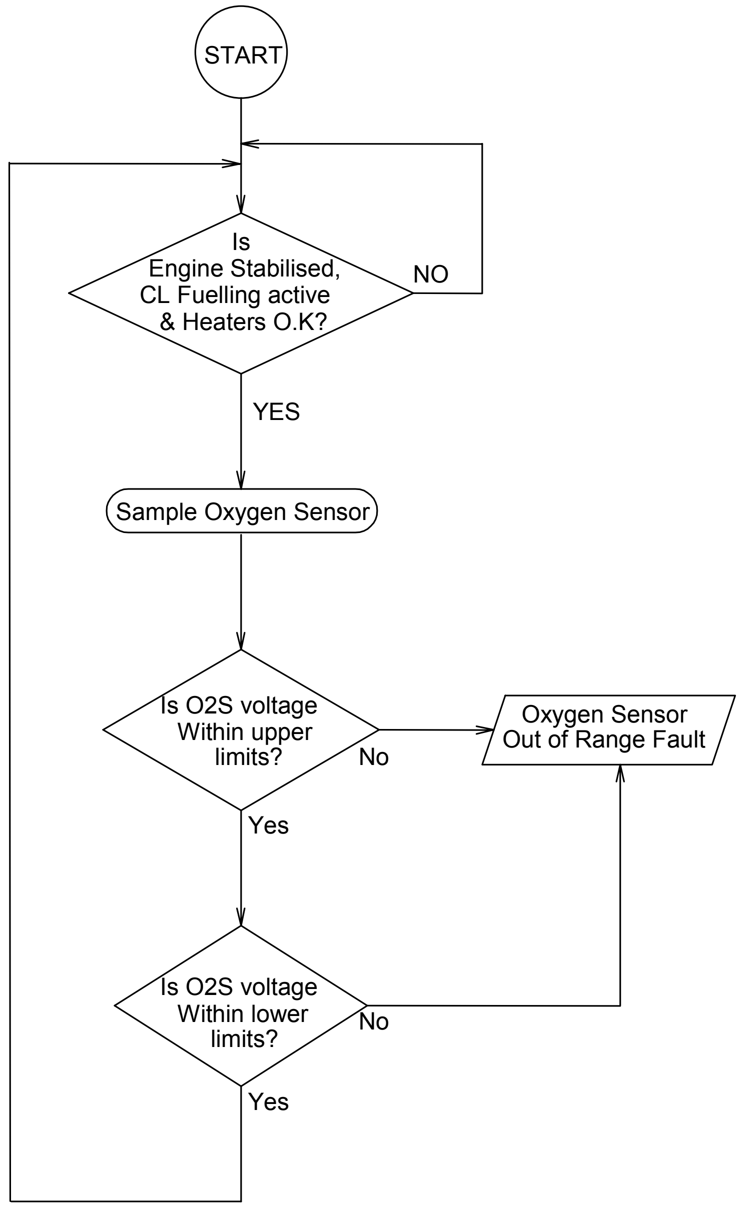
6. Monitoring Time Length / Frequency of Checks
The frequency of the oxygen sensor and fuel system diagnostic is 10Hz.

7. Criteria for Storing Diagnostic Trouble Codes
If the Oxygen Sensor and Fuel System Diagnostic indicates a failure, then a set of conditions are stored. A diagnostic trouble code will be stored if a failure is detected on a subsequent driving cycle while the conditions are still stored. The conditions can be erased on intervening fault free driving cycles as allowed in OBD II regulations.

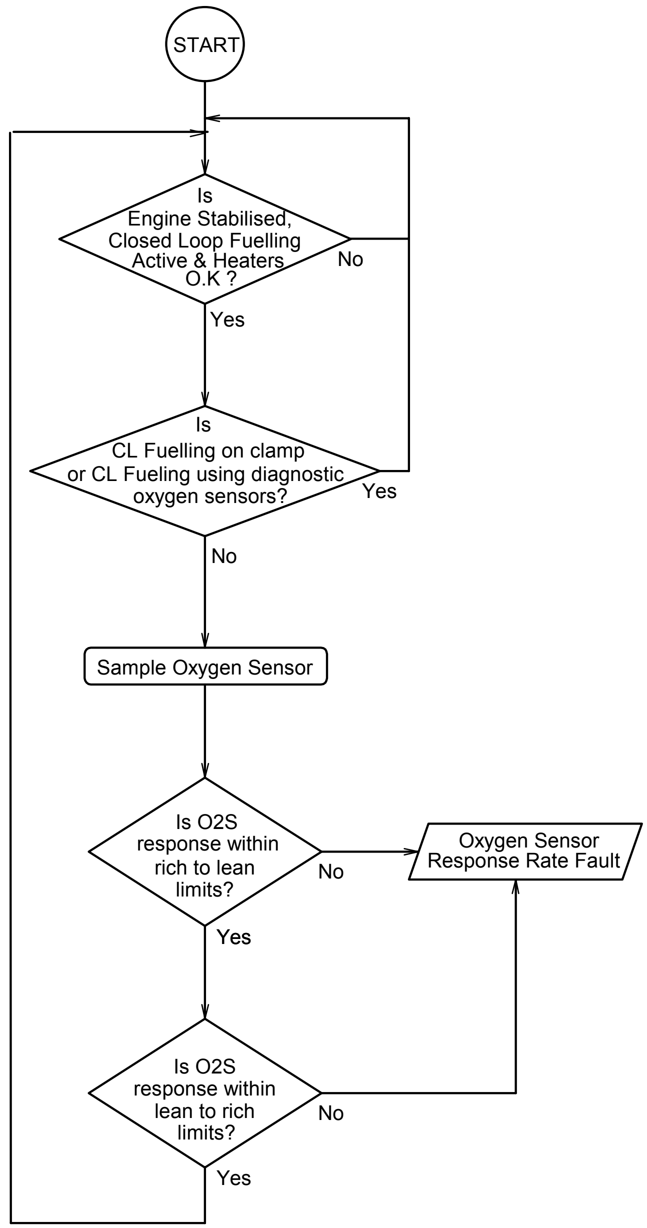
8. Criteria for Illuminating MIL
If the Oxygen Sensor and Fuel System Diagnostic indicates a failure, then a set of conditions are stored. The MIL will be illuminated if a failure is detected on a subsequent driving cycle while the conditions are still stored. The conditions can be erased on intervening fault free driving cycles as allowed in OBD II regulations.

9. Criteria for Determining Out of Range Input Signals
The Oxygen Sensor is subject to low and high voltage limits of 0.015V & 4.98V respectively as above.

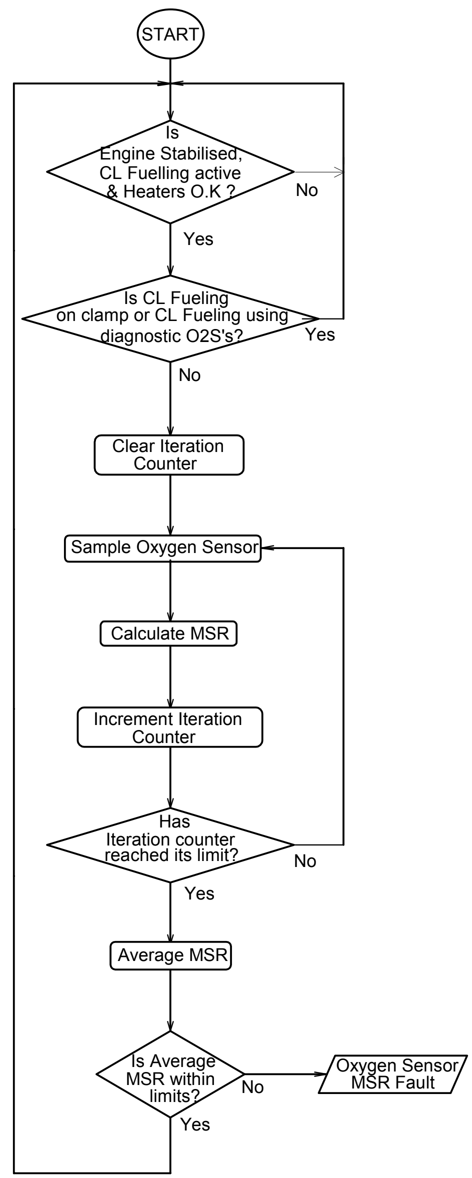
3.5.2 Monitoring Structure – Range Test



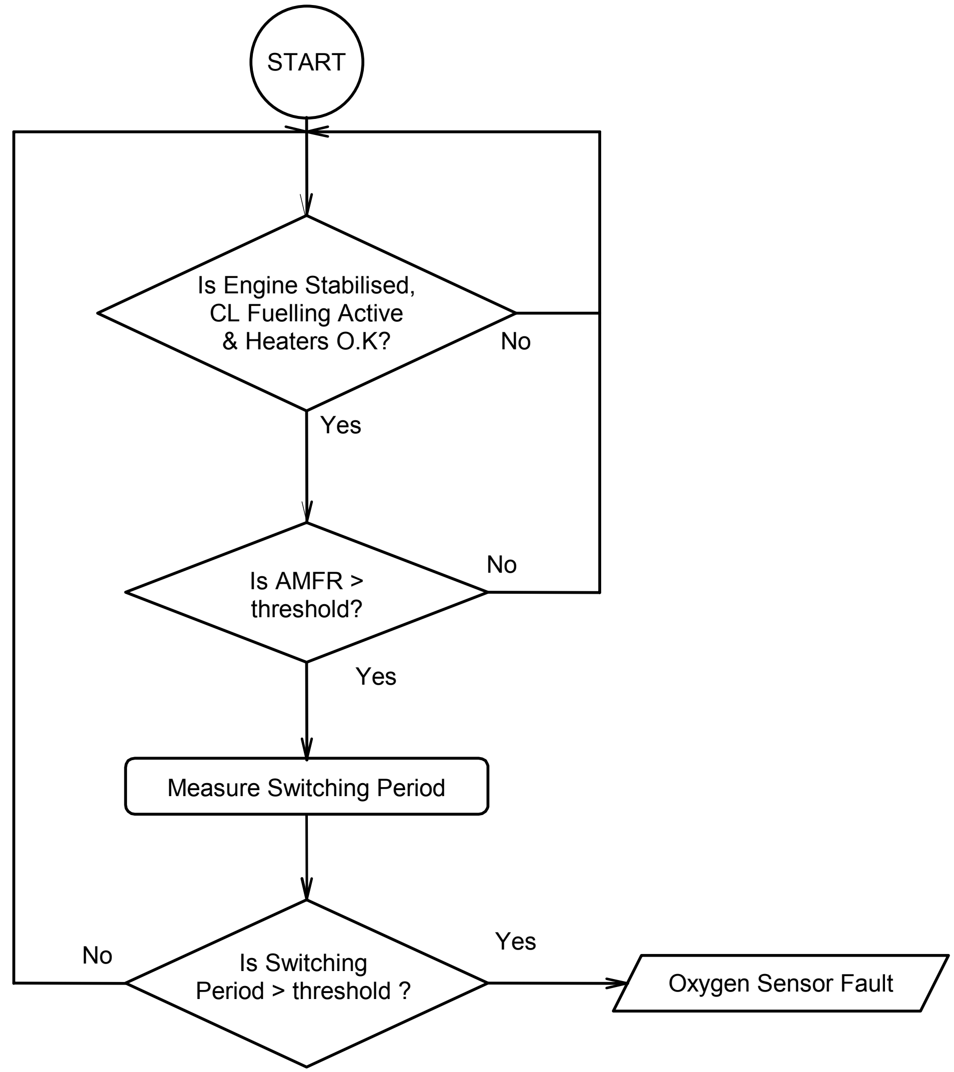
3.5.3 Monitoring Structure – Response Rate Measurements



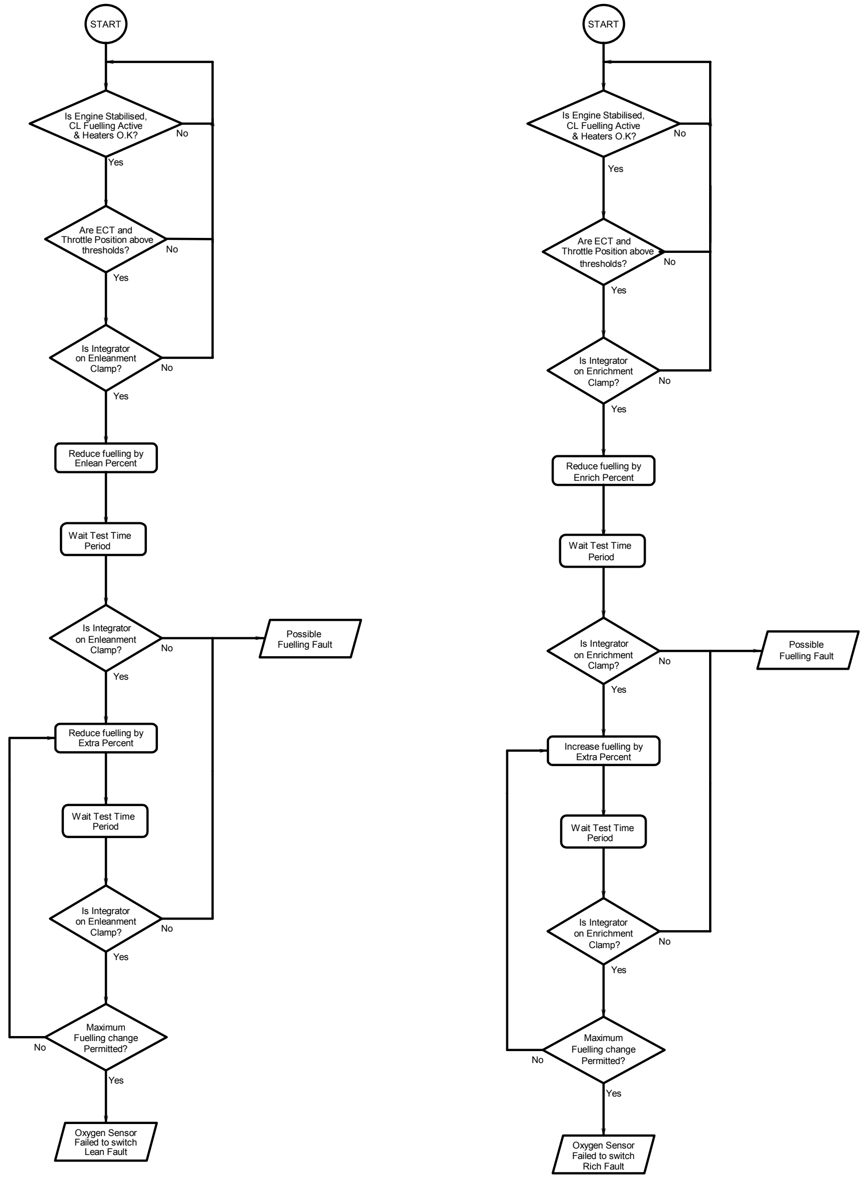
3.5.4 Monitoring Structure – Mark Space Ratio Calculations



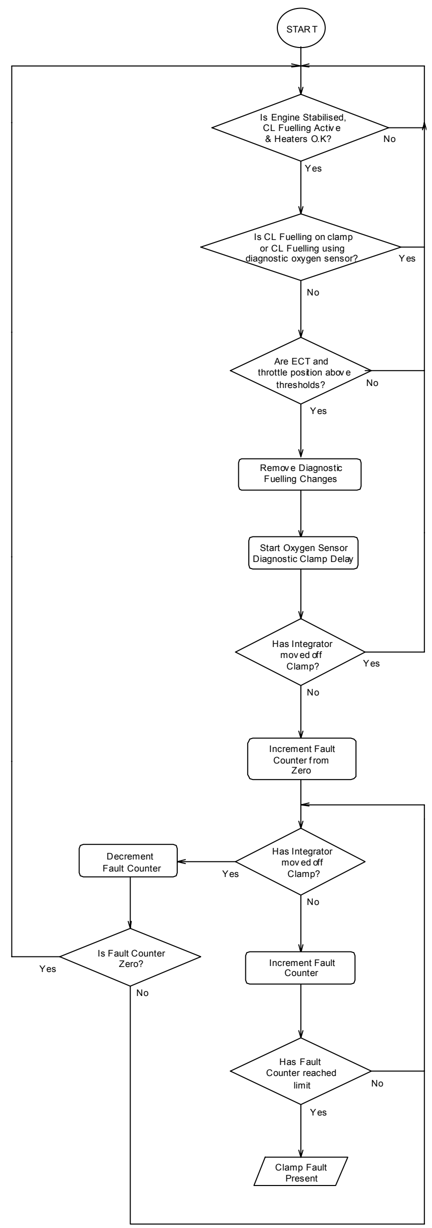
3.5.5 Monitoring Structure – Oxygen Sensor Period Tests



3.5.6 Monitoring Structure – Oxygen Sensor Clamp Tests



3.5.7 Monitoring Structure - Fuel System Clamp Tests



Oxygen Sensor and Fuel System Monitoring

Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
OXYGEN SENSORS Banks 1 & 2 Front & Rear (Integrated with fuel system)	P0130- P0133 P0136- P0139 P0150- P0153	Signal range	Minimum O2S voltage (titanium sensor) Maximum O2S voltage (titanium sensor)	< 0.015 volts > 4.98 volts	Fuel control Disable	Closed loop O2S heater faults	25 sec	2 successive trips
	P0156- P0159 P1137- P1138 P1157- P1158	Response rate (slope check)	Maximum rich to lean time Maximum lean to rich time (between rich & lean thresholds 3.13 v & 1.13 v)	< 0.235 sec < 0.349 sec	Mass airflow rate Fuel control Disable Disable Disable	90 kg/hr Closed loop O2S heater faults Misfire, injector, coil faults Maximum or minimum fuel trim enabled	25 sec	2 successive trips
		Mark Space Ratio Check	Outside permissible range	Mapped with speed/load			25 sec	2 successive trips
		Switching period check	High period limit	> 1.2 sec	Mass airflow rate	40 kg/hr	25 sec	2 successive trips
		Clamp test (short term fuel trim)	O2 percentage enleanment O2 percentage enrichment	>20% >20%	Fuel control ECT TP output EVAP Canister Purge flow status Disable Disable Disable Disable Disable Disable Disable	Closed loop > 70 Celsius > 0.12 v (open) Off Test in progress opposite bank O2S out of range O2S response rate failure O2S heater faults Injector fault on same bank Mass airflow rate fault (current) TP fault	7 sec (once a trip)	2 successive drive cycles

Oxygen Sensor and Fuel System Monitoring

Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
					Disable	Misfire, injector, coil faults		
FUEL SYSTEM (integrated with O2 system)	P1171- P1172 P1176- P1179 P0171- P0172 P0174- P0175	 Clamp test (short term FT) Long term FT	Fault counter - Maximum Positive Fuel Mass Flow Rate - Maximum Negative Fuel Mass Flow Rate - Maximum Positive Air Mass Flow Rate - Maximum Negative Air Mass Flow Rate	> 200 > 24% (0.62 gm/s) < -24% (-0.62 gm/s) > 26% (5.48 kg/hr) < -26% (-5.48 kg/hr)	Fuel control ECT TP output Disable Disable Disable Disable Disable Disable Disable Disable	Closed loop > 70 Celsius > 0.12 v (open) Test in progress opposite bank O2S out of range O2S response rate failure O2S heater faults Injector fault on same bank Mass airflow rate fault (current) TP fault Misfire, injector, coil faults	20 sec	

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.5.8 Oxygen Sensor Heater Monitoring Description

1. Diagnostic Trouble Codes:

O2S Upstream Heater - Hardware driver Open Circuit (both heaters)	P1185
O2S Upstream Heater - Hardware driver Short Circuit	P1186
O2S Upstream Heater - Inferred Open Circuit Fault (one heater)	P1187
O2S Upstream Heater - Inferred Open Circuit Fault 2 (both heaters)	P1188
O2S Upstream Heater Circuit Inferred Low Resistance1 Fault	P1189
O2S Upstream Heater Circuit Low Resistance Fault	P1190
O2S Downstream Heater - Hardware driver Open circuit (both heaters)	P1191
O2S Downstream Heater - Hardware driver Short Circuit	P1192
O2S Downstream Heater - Inferred Open Circuit Fault (one heater)	P1193
O2S Downstream Heater - Inferred Open Circuit Fault 2 (both heaters)	P1194
O2S Downstream Heater Circuit Inferred Low Resistance1 Fault	P1195
O2S Downstream Heater Circuit Low Resistance Fault	P1196

2. Monitoring Procedure

Problems with the oxygen sensor heaters will be diagnosed using a number of tests. The heaters are connected to the ECM in pairs, (one pair upstream of the catalyst, and one pair downstream of the catalyst). Some tests use the ECM hardware to detect faults; other tests use the closed loop tip temperature control system to indicate faults. If the closed loop system is unable to control tip temperature satisfactorily then a number of faults can be detected depending on the type of error. If these tests are not passed then a fault count will be incremented, otherwise it will be decremented. If the count reaches a given threshold then a fault is present.

<u>One Heater Open Circuit</u>

If the value of AVERAGE OUTPUT is lower than HEATER DIAG MIN AVERAGE OUTPUT then it is assumed that one heater in the pair is open circuit and the counter HEATER DIAG OPEN CIRCUIT FAULT2 will be incremented, if not the counter will be decremented. Counting will only take place with engine speed less than HEATER DIAG LOW SPEED THRESHOLD and engine load less than HEATER DIAG LOW LOAD THRESHOLD and the engine has stabilised.

If the fault counter reaches the value HEATER DIAG AVE OP FAULT LIMIT then a fault is present, the fault will remain present until the counter has decremented to zero. The counter will be limited to a maximum value of HEATER DIAG AVE OP FAULT LIMIT.

<u>Both Heaters Open Circuit.</u>

Both heaters open circuit can be detected in two ways:

i. Firstly, the hardware can detect a complete open circuit directly.

ii. Secondly, if HEATER CURRENT is less than a threshold HEATER DIAG CURRENT MIN and BATTERY VOLTAGE is greater than a threshold HEATER DIAG MIN BATTERY VOLTAGE then the counter HEATER DIAG HIGH RESISTANCE FAULT is incremented, if not the counter is decremented.

If the fault counter reaches the value HEATER DIAG FAULT LIMIT then a fault is present, the fault will remain present until the counter has decremented to zero. The counter will be limited to a maximum value of HEATER DIAG FAULT LIMIT.

One (or both) Heaters Short Circuit
A short circuit (low resistance) can be detected in three possible ways:
i. Firstly, for a dead short, the hardware can detect the fault.
ii. Secondly, if HEATER CURRENT is greater than HEATER DIAG CURRENT THRESHOLD then the counter HEATER DIAG LOW RESISTANCE FAULT2 will be incremented, if not the counter will be decremented. Counting will only take place when the engine has stabilised.
If the fault counter reaches the value HEATER DIAG FAULT LIMIT then a fault is present, the fault will remain present until the counter has decremented to zero. The counter will be limited to a maximum value of HEATER DIAG FAULT LIMIT.
iii. Thirdly, if the value of AVERAGE OUTPUT is greater than HEATER DIAG MAX AVERAGE OUTPUT then it is assumed that one heater in the pair is low resistance and the counter HEATER DIAG RESIST1 CNTR is incremented, if not the counter is decremented down to a limit of zero. Counting will only take place with ENGINE SPEED greater than HEATER DIAG HIGH SPEED THRESHOLD and ENGINE LOAD greater then HEATER DIAG HIGH LOAD THRESHOLD.
If the fault counter reaches the value HEATER DIAG AVE OP FAULT LIMIT then a fault is present, the fault will remain present until the counter has decremented to zero. The counter will be limited to a maximum value of HEATER DIAG AVE OP FAULT LIMIT.

All tests are repeated on two heater channels - Upstream, Downstream.

3. Primary Detection Parameter
HEATER CURRENT and AVERAGE OUTPUT calculated as part of the closed loop tip temperature control system.

4. Fault Criteria Limits

HEATER DIAG CURRENT MIN	0.25A	
HEATER DIAG BATTERY VOLTAGE	12V	
HEATER DIAG MIN AVERAGE OUTPUT	10 %	
HEATER DIAG MAX AVERAGE OUTPUT	50 %	
HEATER DIAG CURRENT THRESHOLD	7.1 A	
HEATER DIAG FAULT LIMIT	255	(@ 10Hz)
HEATER DIAG AVE OP FAULT LIMIT	2000	(@ 10Hz)

5. Monitoring Conditions
One Heater Open Circuit
Closed loop tip temperature control is active when the engine is fully warm.
Closed loop fuelling feedback control is active when: -
Engine speed ≤1000RPM
Engine load ≤ 25%

Both Heaters Open Circuit.
i. & ii. Engine must be running.

One (or both) Heaters Short Circuit
i. & ii. Engine must be running.
iii. Engine speed > 4000rpm } NB this test operates outside the Federal Test Procedure conditions,
Engine load > 70% } and is therefore not considered part of a "trip".

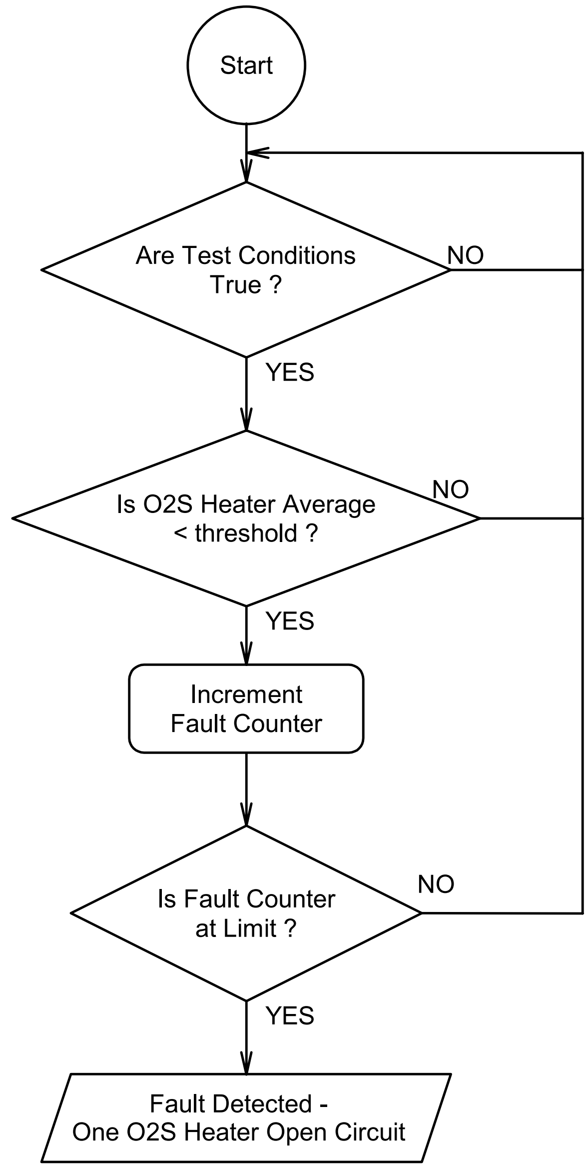
6. Monitoring Time Length / Frequency of Checks
The frequency of the Oxygen Sensor Heater Diagnostic is 10Hz.

7. Criteria for Storing Diagnostic Trouble Code
Two successive trips where the Oxygen Sensor Heater Diagnostic indicates a failed Oxygen Sensor Heater.

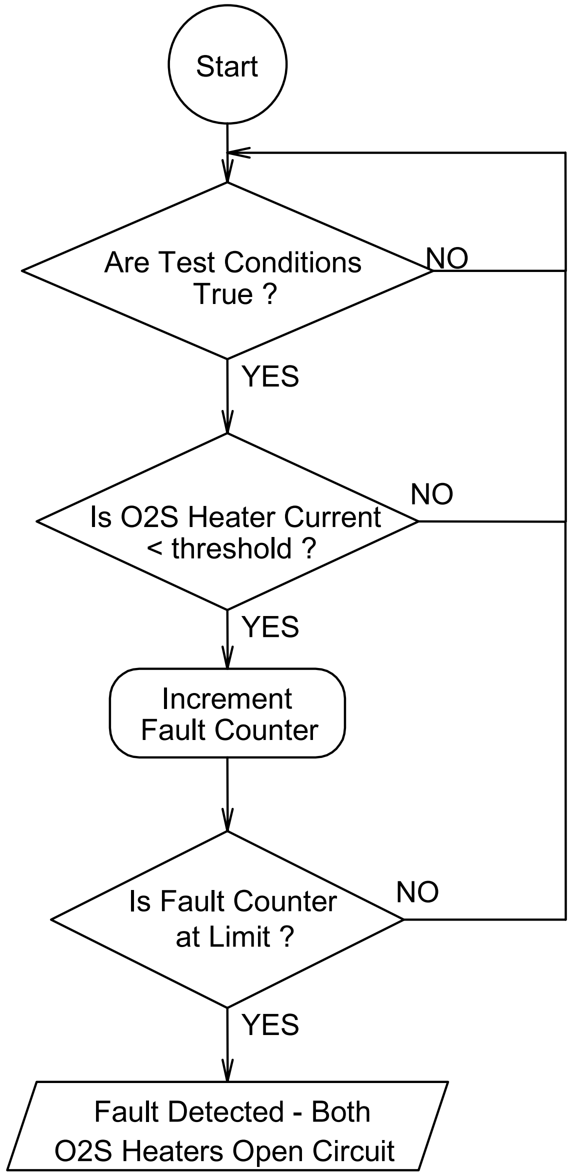
8. Criteria for Illuminating MIL
Two successive trips where the Oxygen Sensor Heater Diagnostic indicates a failed Oxygen Sensor Heater.

9. Criteria for Determining Out of Range Input Signals
The input signal is subjected to the diagnostics as above.

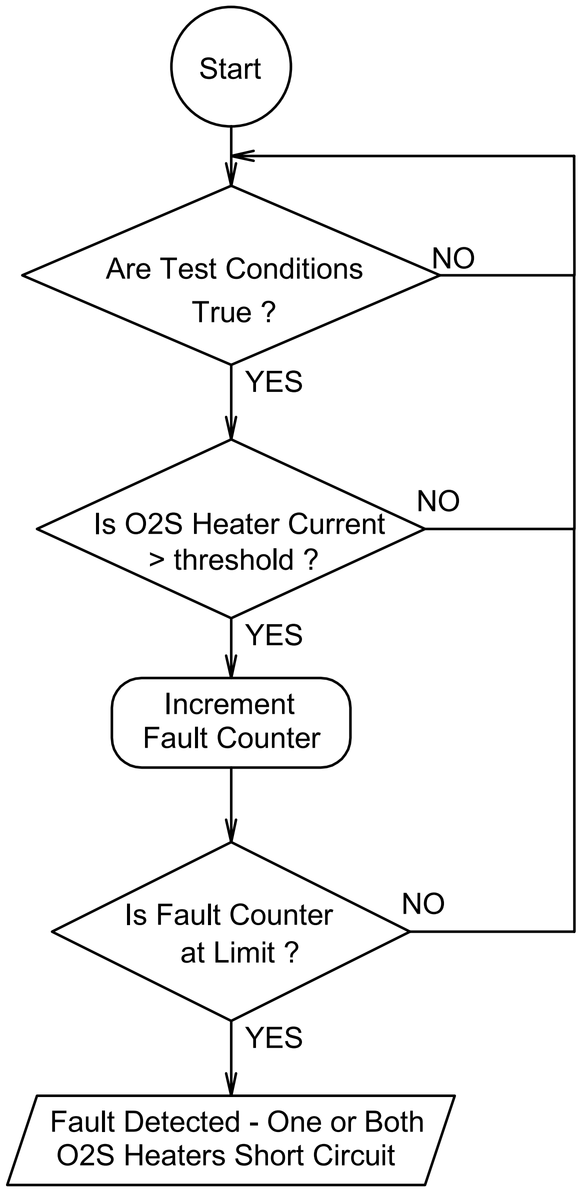
3.5.9 Oxygen Sensor Heater Monitoring Structure – One O2S Heater Open Circuit



3.5.10 Oxygen Sensor Heater Monitoring Structure – Both O2S Heaters Open Circuit



3.5.11 Oxygen Sensor Heater Monitoring Structure – One (or both) O2S Heaters Short Circuit



Oxygen Sensor Heater Monitoring								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
O2 SENSOR HEATERS Upstream & Downstream	P1185-P1196	Heater current	Heater current (open/short)	<0.25 A or >7.1 A	Battery Voltage	>7.58 V	200 sec	2 successive trips
		Closed-loop sensor tip Temperature control system	Fault counter (open) Fault counter (short) Average output	>= 1600 >= 150 < 10 %	Fuel control CL tip control status Engine speed Load ECT	Closed loop Active <= 1000 RPM 30-70% > 70 Celsius	25 sec	
	P1185-P1196	Heater current	Heater current (open/short)	<0.25 A or >7.1 A	Battery Voltage	>7.58 V		2 successive trips

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.6 Fuel Tank Pressure Sensor Monitor

3.6.1 Description

1. Diagnostic Trouble Codes:

Fuel tank pressure sensor low fault:	P0452
Fuel tank pressure sensor high fault:	P0453
Fuel tank pressure sensor performance fault:	P0451

2. Monitoring Procedure

<u>Summary</u>

The resistance of the fuel tank pressure sensor changes in relation to the pressure difference between the fuel tank and ambient pressure. Through connection to the input resistor networks of the ECM any disconnection of the sensor can generate both high and low input voltages, which are outside the normal operating voltage range. These are detected to diagnose a fuel tank pressure fault in the system.

<u>Range Test</u>

If the value of FUEL TANK PRESS VOLTS is less than FUEL TANK PRESS DIAG MIN VOLT THR or more than FUEL TANK PRESS DIAG MAX VOLT THR, then an appropriate fault counter is incremented up to a limit of fuel tank pressure diagnostic fault limit. Otherwise the fault counter is decremented down to a limit of zero. If the fault counter reaches the limit then a fuel tank pressure sensor fault is present.

<u>Rationality Test</u>

The test on the fuel tank pressure sensor comprises of comparing the output from the fuel tank pressure sensor with a tolerance band around ambient pressure. This is done during conditions of minimal vapour generation within the fuel tank.

3. Primary Detection Parameter

Fuel tank pressure - Measured in volts, the outcome of a potential divider calculation.

4. Fault Criteria Limits

Fuel Tank Pressure - Low out of range	0V
Fuel Tank Pressure - High out of range	6V
Error between fuel tank pressure and ambient pressure	> 1 kPa or < -0.3 kPa

5. Monitoring Conditions

The range test will take place when the EVAP canister closure valve is open.

The rationality check will take place when the engine coolant temperature is between two thresholds, intake air temperature is between two thresholds, EVAP canister purge flow rate is below a threshold and the EVAP canister closure valve is open.

6. Monitoring Time Length / Frequency of Checks

The frequency of the fuel tank pressure diagnostic is 40Hz.

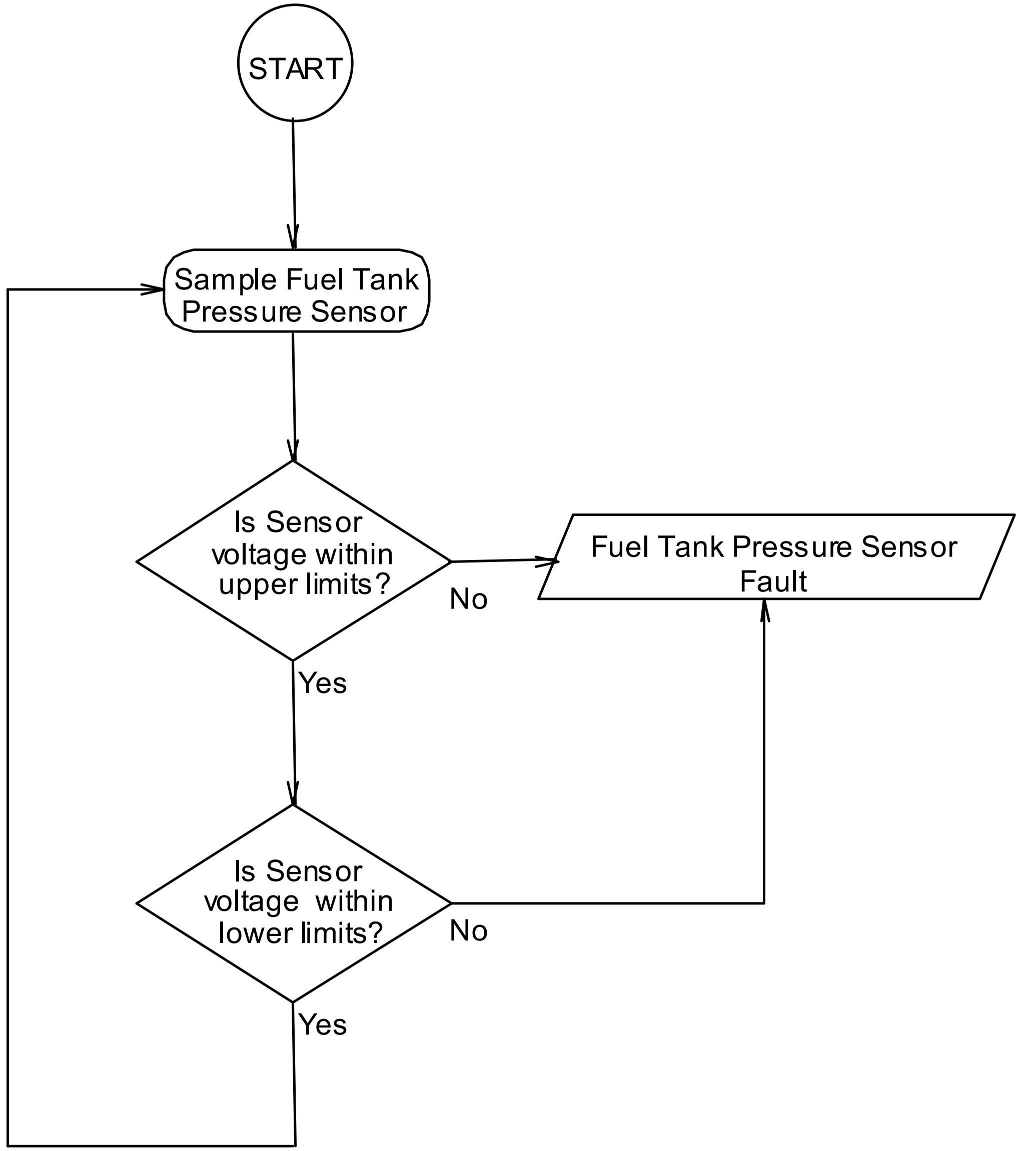
7. Criteria for Storing Fault Code

Two successive trips where the fuel tank pressure diagnostic indicates a failed fuel tank pressure sensor.

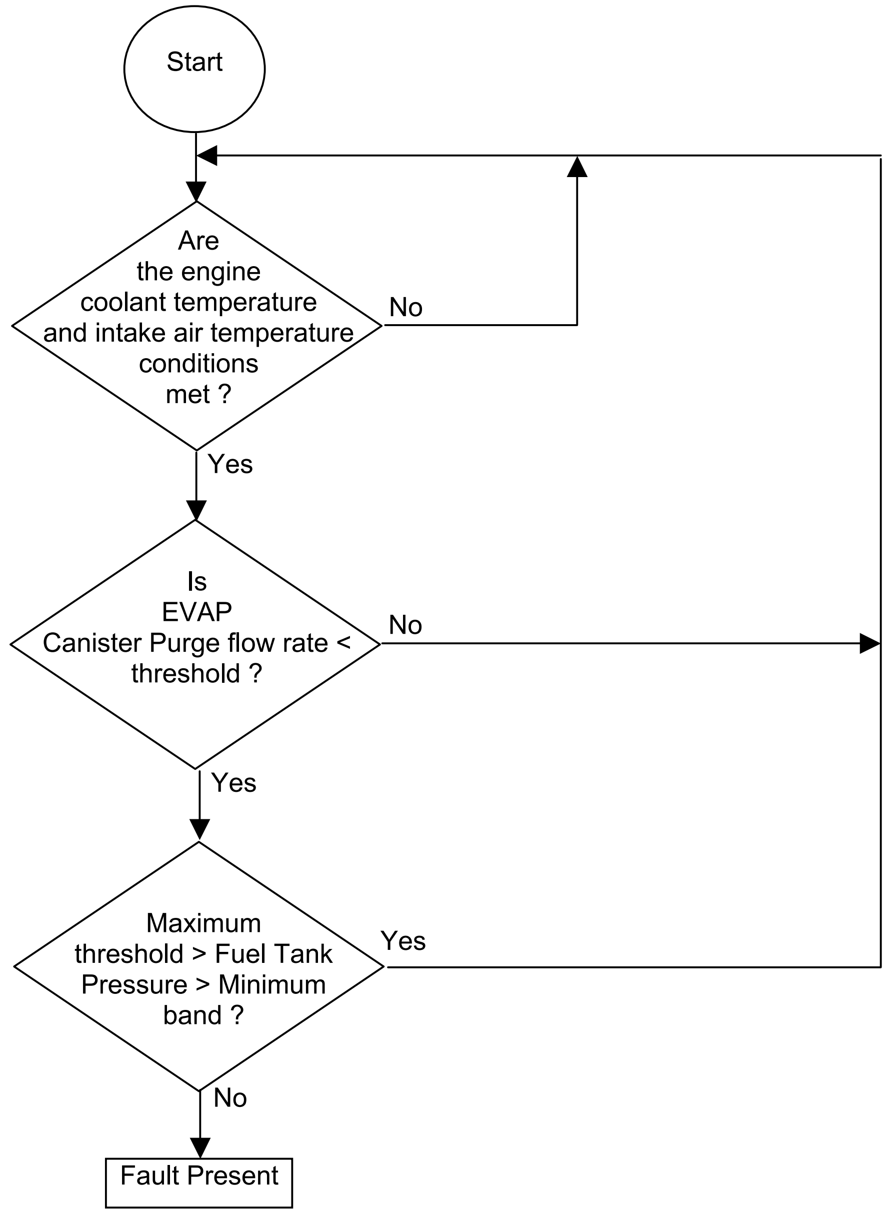
8. Criteria for Illuminating MIL
Two successive trips where the fuel tank pressure diagnostic indicates a failed fuel tank pressure sensor.

9. Criteria for Determining Out of Range Input Signals
The fuel tank pressure sensor is subject to the range test above.

3.6.2 Monitoring Structure – Range Test



3.6.3 Monitoring Structure – Rationality Test



Fuel Tank Pressure Sensor Monitor								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
FUEL TANK PRESSURE SENSOR	P0452/3 P0451	Out of range check Rationality check	high voltage low voltage fuel tank pressure	5V 0V >1.0KPa or <-0.3KPa	ECM status EVAP Canister Closure Valve Ignition Engine ECT IAT	active open on stalled >-7º C and <35º >-7º C and <35º C	20 sec 20sec	2 successive trips 2 successive trips

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.7 Crankshaft and Camshaft Position Sensor

3.7.1 Description

1. Diagnostic Trouble Codes:

Crankshaft Position Sensor Circuit Malfunction	P0335
Crankshaft Position Sensor Range/Performance	P0336
Camshaft Position Sensor Circuit Malfunction	P0340

2. Monitoring Procedure

Summary

Problems with the crankshaft and camshaft position sensors will be detected by cross - checking each sensor's output, identifying when one sensor is operating and the other is not. A missing tooth check will test that all tooth edges are being correctly detected and that there is a missing tooth present. As the crankshaft speed sensor is central to engine management system operation there is no default operation, which would allow the car to run when there is a crankshaft position sensor circuit malfunction.

Crankshaft Position Sensor Check

If more than CRANK DIAG MAX CAM PULSES camshaft position sensor pulses are detected during CRANK DIAG MIN TEST TIME, while the engine is in STALL, then a crankshaft position sensor fault is present.
When the engine enters CRANKING mode, implying the crankshaft position sensor is operational, there is no crankshaft position sensor circuit malfunction present.

Camshaft Position Sensor Check

If CRANK DIAG MIN CRANK REVS crankshaft revolutions occur from exiting STALL conditions, without CAM SIGNAL VERIFIED being detected, then there is a camshaft position sensor fault present. There is no fault present if CAM SIGNAL VERIFIED is detected on every engine revolution for CRANK DIAG MIN ENG REVS.

Crankshaft Range / Performance Check

Missing teeth are expected to be NO OF TEETH ON WHEEL crankshaft teeth apart.
If the number of crankshaft position inaccurate fault event occurs then the fault event counter should be incremented by one, up to a limit of CRANK DIAG FAULT LIMIT. Every time the tooth count equals the actual number of teeth between missing teeth then decrement the fault event counter by one, down to a limit of zero.
If the fault event count reaches CRANK DIAG FAULT LIMIT then there is a crankshaft position inaccurate fault present. There is no fault present only when the fault event counter reaches zero. The fault event counter is cleared to zero at the start of a trip.

3. Primary Detection Parameter
Crankshaft Position Sensor – Crankshaft Position sensor signal edges.
Camshaft Position Sensor – Camshaft Position sensor signal edges.

4. Fault Criteria Limits
General - presence or not of sensor edges.

Crankshaft Position Sensor Check
The non-existence of at least 6 CRANK DIAG MAX CAM PULSES within the minimum CRANK DIAG MIN TEST TIME period of 9 seconds. Indicating an average speed of 80 rpm.

Camshaft Position Sensor Check
The non-setting of the Camshaft Position signal verified flag within the limit of CRANK DIAG MIN CRANK REVS' 100 revolutions.

Crankshaft Range / Performance Check
NO OF TEETH ON WHEEL constant is dependent upon the sensor wheel design (35 teeth), a fault is registered if the tooth count total between missing teeth is out by one or more.

5. Monitoring Conditions
The crankshaft position sensor check will be run if the engine is in stall.
The camshaft position sensor check will be run if the engine has exited stall and battery voltage is greater than 8V.
The missing tooth position check will run when the engine is running.

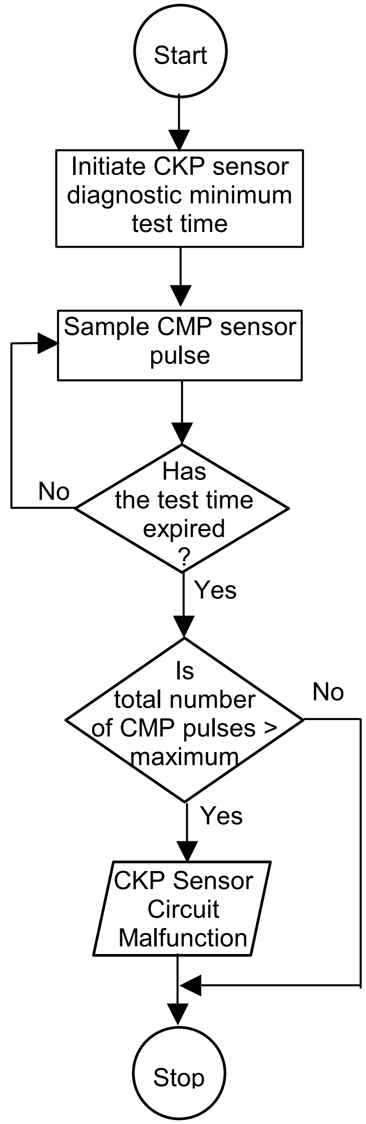
6. Monitoring Time Length / Frequency of Checks
The crankshaft position sensor check will be run if the engine is in stall.
The camshaft position sensor check will be run if the engine has exited stall.
The missing tooth position check will be run once every engine revolution.

7. Criteria for Storing a Diagnostic Trouble Code
Two successive trips where the diagnostic routines indicate a failed crank or cam sensor.

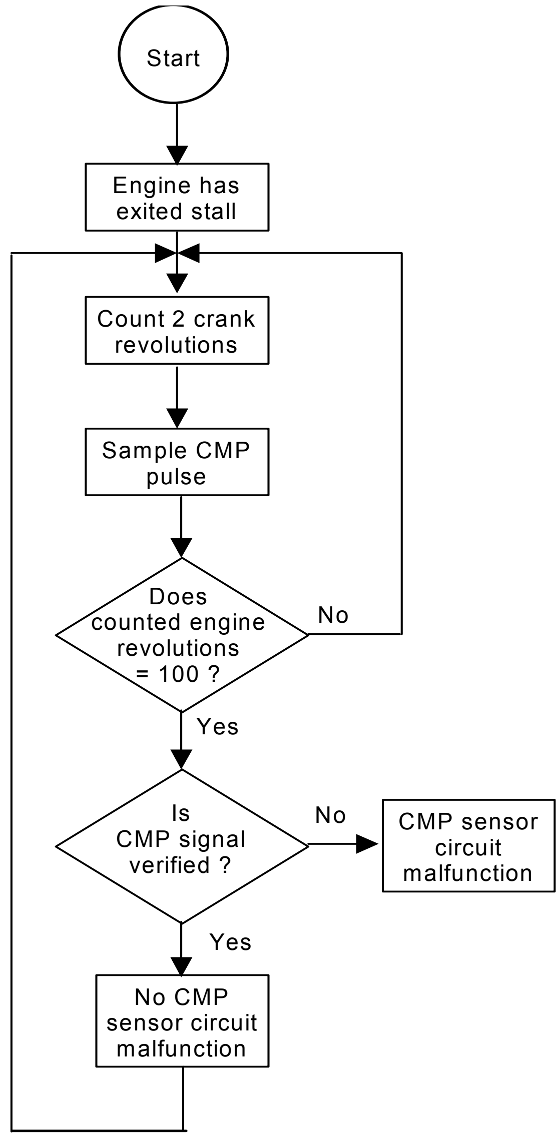
8. Criteria for Illuminating MIL
Two successive trips where the diagnostic routines indicate a failed crank or cam sensor.

9. Criteria for Determining Out of Range Input Signals
The crank / cam sensors produce non-linear outputs; the criteria will be signal/no signal.

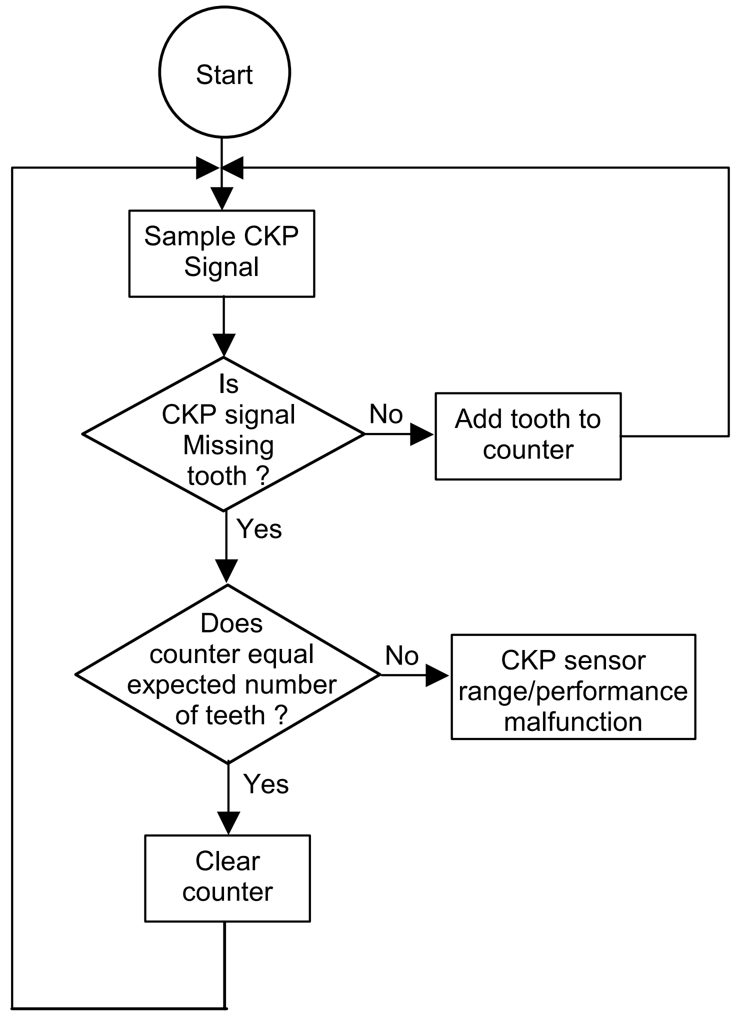
3.7.2 Monitoring Structure – Crankshaft Position Sensor Check



3.7.3 Monitoring Structure – Camshaft Position Sensor Check



3.7.4 Monitor Structure – Crankshaft Position Range/Performance Check



Crankshaft and Camshaft Position Sensor

Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
CRANKSHAFT & CAMSHAFT POSITION SENSORS	P0335-P0336 P0340	CMP sensor signal verification	CMP sensor pulses	None	Engine status	Running	6 camshaft revolutions	2 successive trips
		Camshaft position check	Cam/Crank signal ratio	Non linear	Engine status B+	Exiting stall > 8 v	100 revolutions	
		Crankshaft position check	Missing CMP pulses in 9 seconds	>= 6	Engine status	Stalling	9 seconds	
		Missing tooth check	Crankshaft Missing Tooth fault counter	>=254			254 crankshaft	
			- Total tooth count between missing teeth	<> 35	Engine status	Running	revolutions	

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.8 Engine Coolant Temperature Sensor

3.8.1 Description

1. Diagnostic Trouble Codes:

Engine Coolant Temperature Sensor - Low out of range	P0117
Engine Coolant Temperature Sensor - High out of range	P0118
Engine Coolant Temperature Sensor - Warm up time fault	P0125
Engine Coolant Temperature Sensor - Falling temperature fault	P0116

2. Monitoring Procedure

Problems with the engine coolant temperature sensor will be detected using a number of tests. A range check will test for input values outside expected limits. A time to warm-up test will check that the sensor is responding to the rise in engine coolant temperature caused by the engine running. The engine coolant temperature in stall is used to index a map of expected warm-up times. This checks that the engine has gone into closed loop fuelling within a given time, (the engine coolant information is the only sensor it depends upon). A falling temperature test will check for abnormal falls in temperature once a temperature rise has been detected. This test uses a tracker which follows the normal engine coolant temperature rise but at a lower temperature. The tracker is not allowed to decrease and is limited at a maximum value. If the measure engine coolant temperature falls below the tracker a fault is flagged. If the range tested is not passed then the appropriate fault count will be incremented, otherwise it will be decremented. If the count reaches a given threshold then a fault is present.

3. Primary Detection Parameter

Engine Coolant Temperature - measured in Volts, the outcome of a potential divider calculation.

4. Fault Criteria Limits

Engine Coolant Temperature - Low out of range	0.059 V - equivalent to 145^{o}C
Engine Coolant Temperature - High out of range	4.922 V - equivalent to –40^{o}C
Engine Coolant Temperature - Warm up time limit, [closed loop fuel]	typically 90 seconds at 20^{o}C start temperature
Engine Coolant Temperature - Falling temperature tracking limit	65^{0}C
Engine Coolant Temperature - Warm up temperature	18^{0}C
Engine Coolant Temperature -Tracker Lag	25^{0}C

5. Monitoring Conditions

The range check will take place whenever there is power to the ECM.
The warm-up time test will start each time the condition 'Engine_Running' is true.
The falling temperature test will start each time the condition 'Engine_Running' is true.

6. Monitoring Time Length / Frequency of Checks

The frequency of the Engine Coolant Thermistor diagnostic is 2Hz.

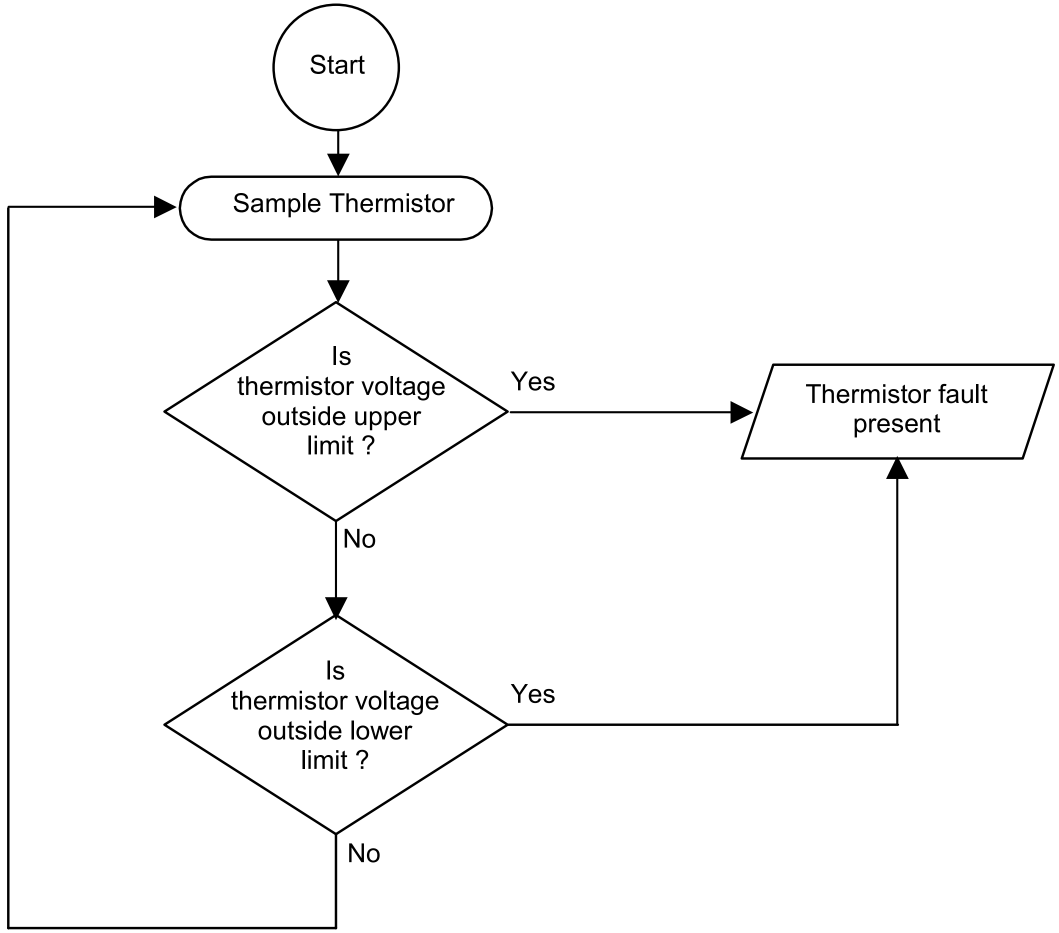
7. Criteria for Storing a Diagnostic Trouble Code

Two successive trips where the Engine Coolant Thermistor diagnostic indicates a failed water temperature sensor.

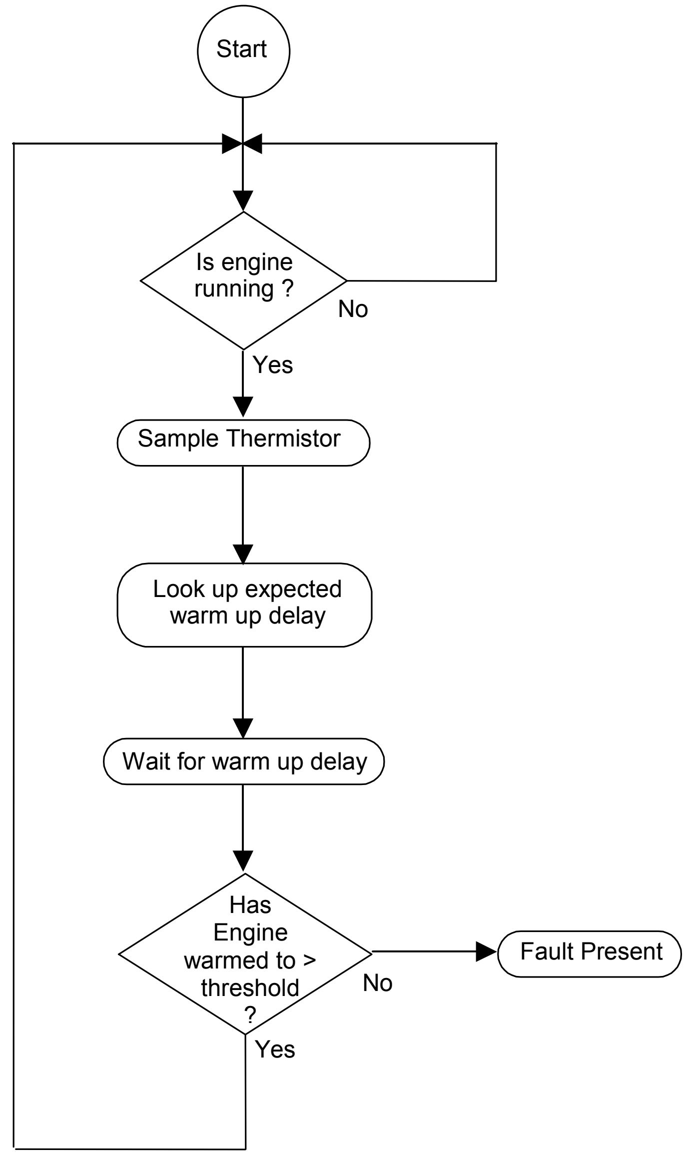
8. Criteria for Illuminating MIL
Two successive trips where the engine coolant thermistor diagnostic indicates a failed water temperature sensor.

9. Criteria for Determining Out of Range Input Signals
The engine coolant temperature thermistor is subject to maximum and minimum voltage limits of 0.211 V and 4.912 V respectively.

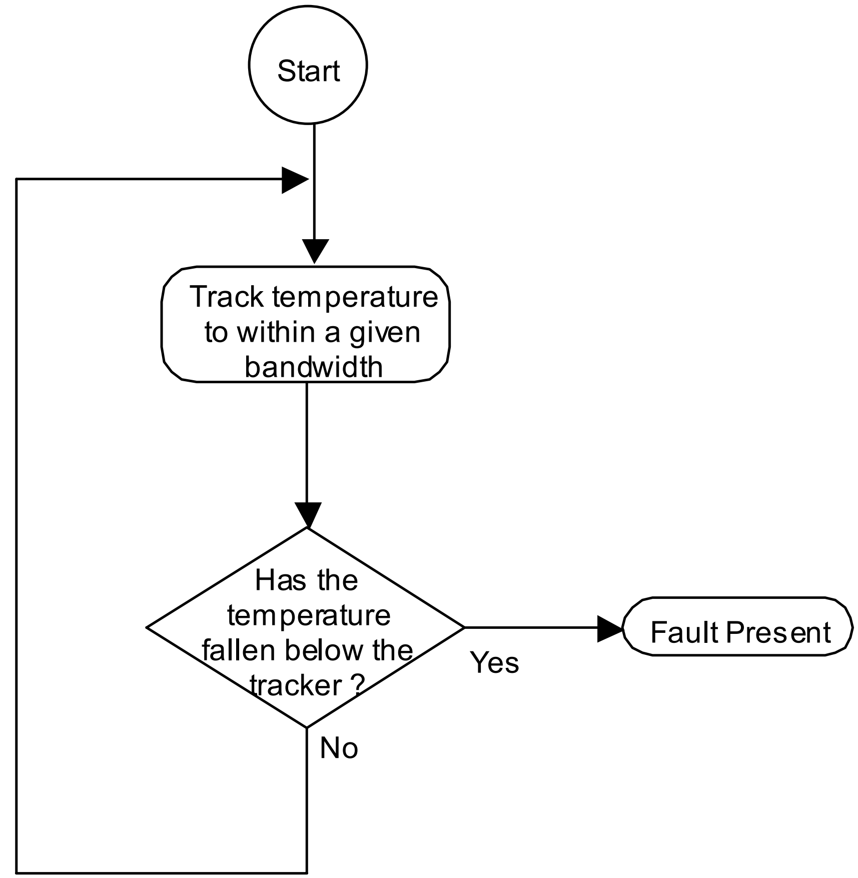
3.8.2 Monitor Structure – Range Check



3.8.3 Monitor Structure – Engine Warm-up Time Check



3.8.4 Monitor Structure – Falling Temperature Check



Engine Coolant Temperature Sensor

Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
ENGINE COOLANT TEMPERATURE SENSOR (Input CC)	P0116-P0118	Out of range check	Low ECT sensor temperature limit (high voltage)	< -40 ^{0}C	ECM status	Active	20 sec (continuous)	2 successive trips
			High ETC sensor temperature limit (low voltage)	> 145 ^{0}C	ECM status	Active		
		Falling temperature check (rationality)	ECT sensor temperature change	> 25 ^{0}C decrease	ECT Engine status	> 65 ^{0}C Running	4 sec (continuous)	
	P0125	Time to CL operation (20 ^{0}C)	Closed loop timer	Mapped v start temperature	Engine status	Running	Typically 90 sec at 20 ^{0}C	

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.9 Mass Airflow Sensor

3.9.1 Description

1. Diagnostic Trouble Code:

Mass Airflow Circuit - Low Input	P0102
Mass Airflow Circuit - High Input	P0103
Mass Airflow Circuit Range / Performance Problem	P0101

2. Monitoring Procedure

Summary

Faults with the mass airflow sensor will be detected using three tests. A low range check will look for out of range values. Faults will be detected if the following circumstances are present, no signal (open circuit) at any time with the engine running, or high signal output below a given engine speed. An additional low signal check is performed with the throttle angle and engine speed above threshold values.

Low Range Check

The average value of the mass airflow sensor voltage is compared to lower limits (AIRFLOW DIAG AFM MIN VOLTAGE) when the engine is running. If the voltage is less than this limit then a counter is incremented, otherwise it is decremented. If the counter reaches a threshold limit, then a fault is present.

High Signal Check

The average value of the mass airflow sensor voltage is compared to an upper limit (AIRFLOW DIAG AFM MAX VOLTAGE) when the engine speed below a threshold (AIRFLOW DIAG AFM TEST SPEED). If the voltage is greater than this limit then a counter is incremented, otherwise it is decremented. If the counter reaches a threshold limit, then a fault is present.

Low Signal Check

A low signal test will check for a mass airflow sensor output consistent with other engine parameters.
If the airflow meter gives a low signal when both throttle angle and engine speed are above thresholds (AIRFLOW DIAG THANG THRESH & AIRFLOW DIAG SPEED THRESH respectively), then a fault is present.
If the tests are not passed then the appropriate fault counter, (AIRFLOW DIAG FAULT LIMIT), will be incremented, otherwise it will be decremented. If the count exceeds a given threshold then a fault is present.

3. Primary Detection Parameter
Airflow sensor signal voltage - measured at the ECM input.

4. Fault Criteria Limits

Mass airflow sensor - Low out of range	350mV
Mass airflow sensor - High rationality limit	4.5V
Mass airflow sensor - Low rationality limit	1.1V

5. Monitoring Conditions
The low range check will take place whenever the engine is running; the high signal check will take place when the engine speed is below a given threshold. The low signal check occurs when the throttle angle and engine speed are above respective thresholds.
AIRFLOW DIAG AFM TEST SPEED, the maximum engine speed for the high signal check, 1000 rpm.
AIRFLOW DIAG THANG THRESH, the absolute throttle potentiometer volts, must be above 2.5V.
AIRFLOW DIAG SPEED THRESH, the minimum engine speed for the low signal test, 1500 rpm.
AIRFLOW DIAG FAULT LIMIT, the amount of fault events required to flag a fault, 40.
The Low Signal Check is inhibited whenever there is a fault present with the throttle position input

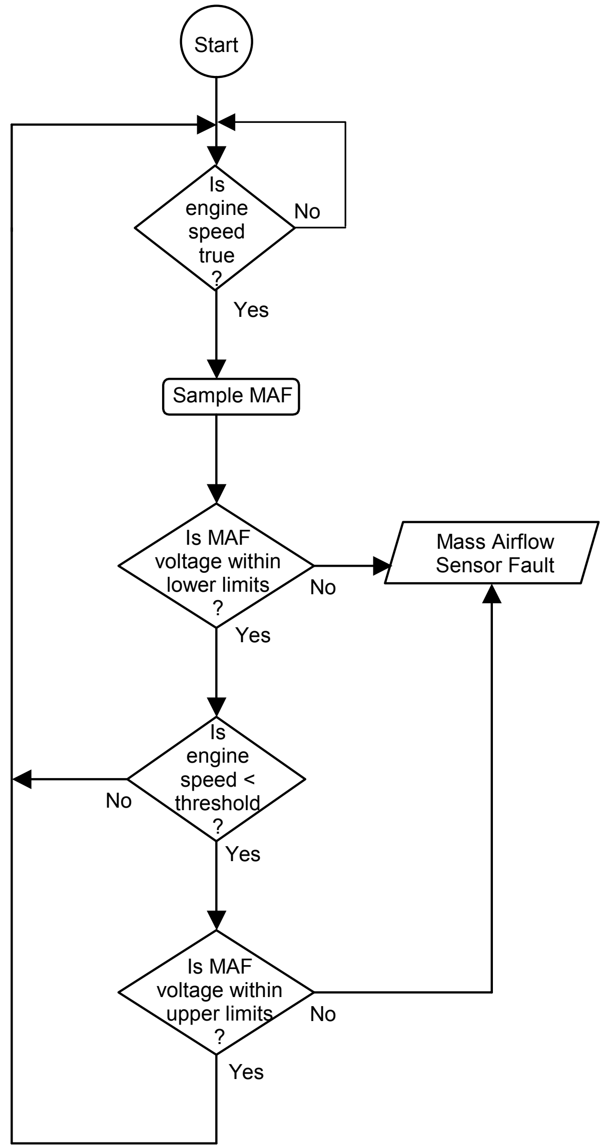
6. Monitoring Time Length / Frequency of Checks
The frequency of the mass airflow sensor Diagnostic is 10Hz, throughout all engine-operating conditions.

7. Criteria for Storing a Diagnostic Trouble Code
Two successive trips where the mass airflow sensor diagnostic indicates a failed mass airflow sensor.

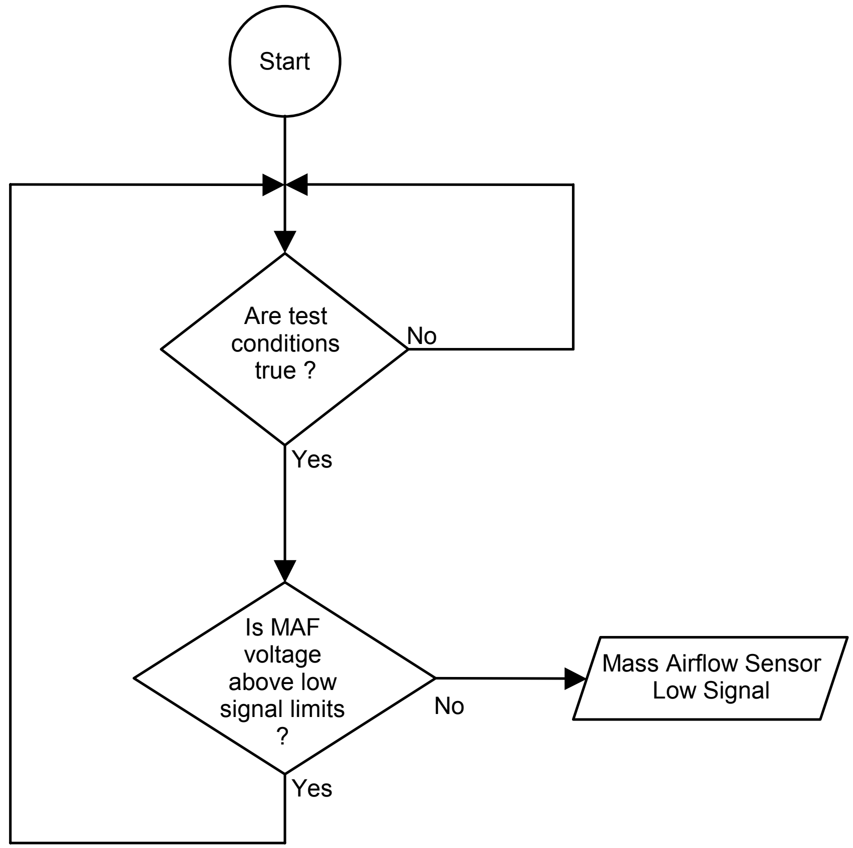
8. Criteria for Illuminating MIL
Two successive trips where the mass airflow sensor diagnostic indicates a failed mass airflow sensor.

9. Criteria for Determining Out of Range Input Signals
The mass airflow meter voltage is range tested as described above. The engine speed signal is checked for the correct number of teeth on the wheel between missing teeth. The throttle angle input is subject to maximum & minimum range checks.

3.9.2 Monitoring Structure – Low Range Check and High Rationality Check



3.9.3 Monitoring Structure – Low Signal Check



Mass Airflow Sensor								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
MASS AIRFLOW SENSOR (Input CC)	P0101-P0103	Out of range check	Low MAF voltage limit	< 0.350 v	Engine status	Running	4 sec	2 successive trips
			High MAF voltage limit	> 4.5 v	Engine speed	< 1000 RPM		
		Rationality cross check	Mass Airflow fault counter	40	MAF voltage Engine speed TP voltage	< 1.1 v > 1500 RPM > 2.44 v	0.1 sec (continuous)	

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.10 Intake Air Temperature Sensor

3.10.1 Description

1. Diagnostic Trouble Codes:

Intake Air Temperature Circuit Low Input	P0112
Intake Air Temperature Circuit High Input	P0113
Intake Air Temperature Sensor Rationality Check	P0111

2. Monitoring Procedure

Range Check

Problems with the intake air temperature sensor are detected using a range test. The range test tests for input values outside expected limits. If the range tested is not passed then the appropriate fault count will be incremented, otherwise it will be decremented. If the counter reaches a given threshold then a fault is present. While fault counting is in progress a back-up value of intake air temperature will be supplied to avoid problems of incorrect values reaching the rest of the system.

Rationality Check

Once the engine coolant temperature has stabilised hot, the output of the intake air temperature sensor is compared at low and high airflow conditions. The test relies on the fact that the under bonnet temperature causes the intake air temperature to rise at idle compared to high airflow conditions, where the real external ambient temperature is being read. These tests will check that the sensor is correctly mounted and connected. The tests are two-sided, but only one flow chart has been shown.

3. Primary Detection Parameter

Intake Air Temperature - measured as thermistor voltage.

4. Fault Criteria Limits

Intake Air Temperature Circuit Low Input	0.059V - equivalent to 145^{o}C
Intake Air Temperature Circuit High Input	4.922V - equivalent to –40^{o}C
Intake Air Temperature rise/fall during rationality check	approx 3^{o}C

5. Monitoring Conditions

The range check will take place whenever there is power to the ECM.

For the rationality check, the following conditions must be met in consecutive order:

i. engine coolant temperature is above a threshold (70^{o}C).

ii. engine operates at a constant mass airflow rate for a period of time.

iii. the average mass airflow rate changes at a certain rate.

iv. engine maintains the new mass airflow rate for the period of time that the sensor output test is being conducted.

If any of the conditions fail to be true, the test is restarted.

6. Monitoring Time Length / Frequency of Checks

The frequency of the Air Thermistor Diagnostic is 2Hz.

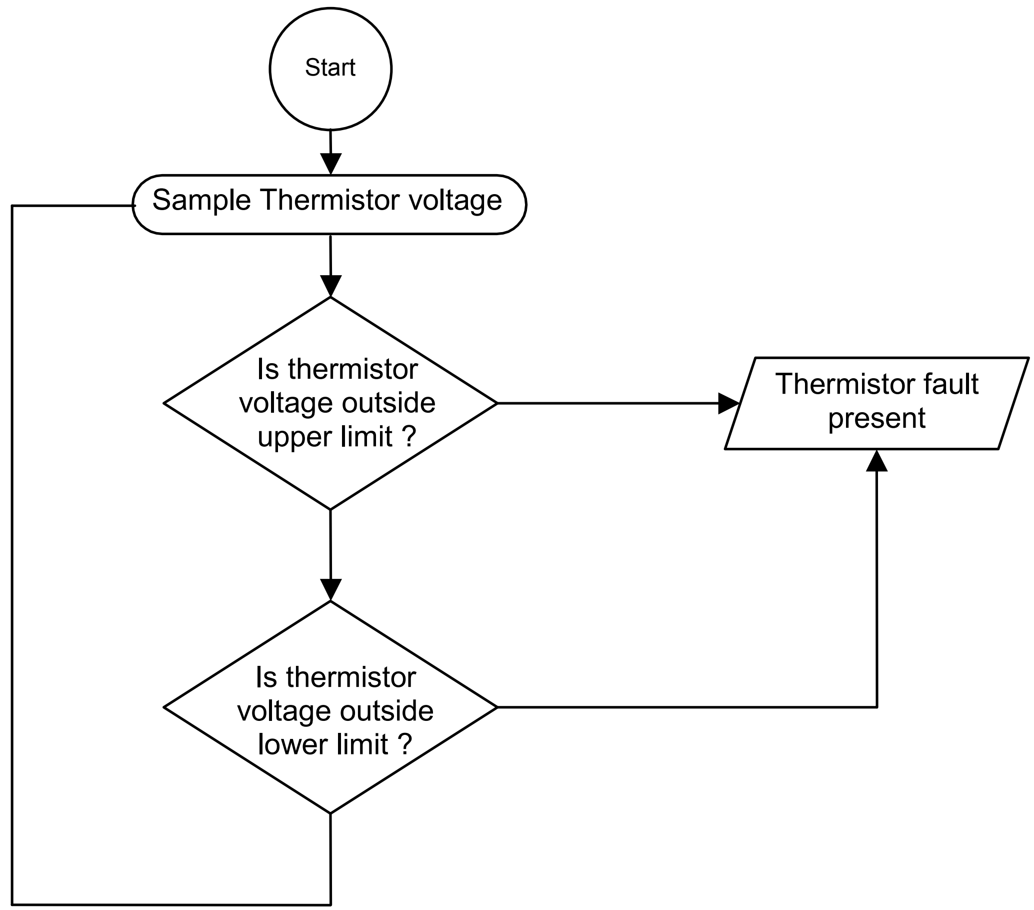
The rationality check will take place at least once per trip.

7. Criteria for Storing a Diagnostic Trouble Code
Two successive trips where the air thermistor diagnostic indicates a failed intake air temperature sensor.

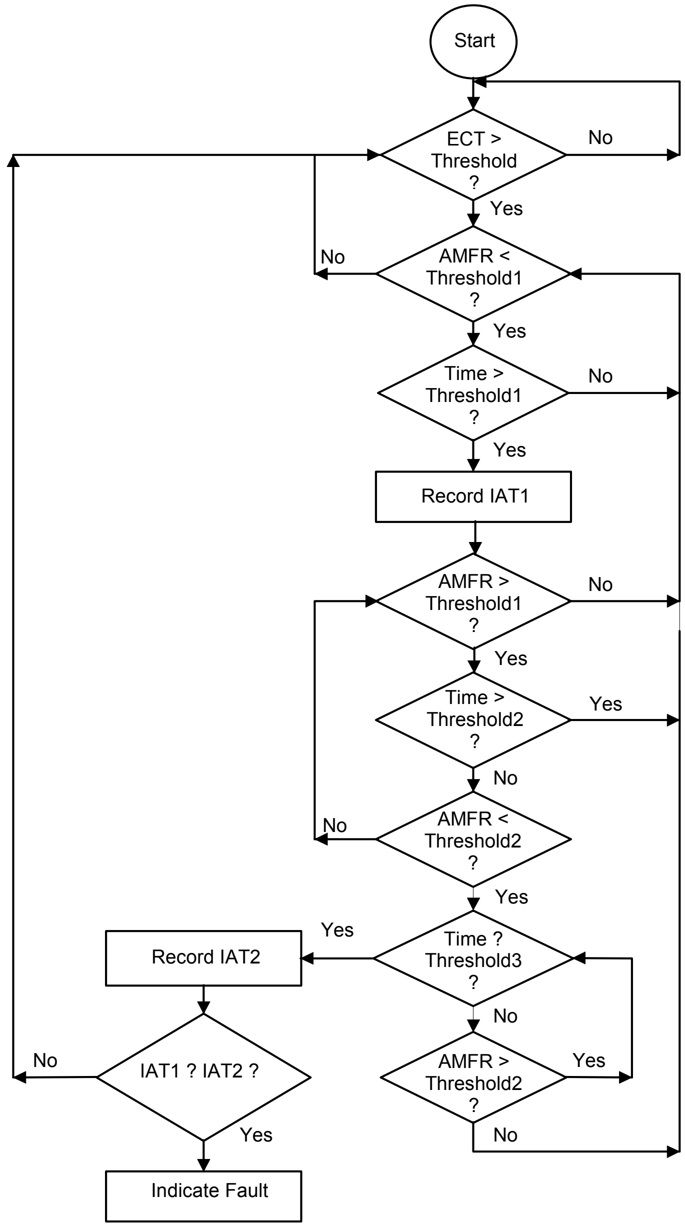
8. Criteria for Illuminating MIL
Two successive trips where the air thermistor diagnostic indicates a failed intake air temperature sensor.

9. Criteria for Determining Out of Range Input Signals
Range check as above.

3.10.2 Monitor Structure – Range Check



3.10.3 Monitor Structure – Rationality Check



Intake Air Temperature Sensor								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
INTAKE AIR TEMPERATURE SENSOR with auxiliary air backup (Input CC)	P0111-P0113	Out of range check Rationality check	Low IAT temperature limit (high voltage) High IAT temperature limit (low voltage) Change in IAT temperature with change in air flow	< -40°C > 145°C < 1°C	ECU status ECU status Change in AMFR ECT	Active Active > 47 Kg/hr ≥ 80°C ≤ 50 mph	20 sec (continuous) 25 sec	2 successive trips 2 successive trips

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.11 Knock Sensor

3.11.1 Description

1. Diagnostic Trouble Codes:

Knock background noise low, bank B	P0332
Knock background noise high, bank B	P0333
Knock background noise low, bank A	P0327
Knock background noise high, bank A	P0328
Continuous knock detected, bank A	P0326
Continuous knock detected, bank B	P0331

The knock sensor is a 'Piezo-electric accelerometer' producing an output voltage proportional to mechanical vibration produced by the engine. The ECM receives the signal, filters out any noise and calculates if the engine is knocking. Due to the cam and crank signals supplying information regarding the position of the engine in its cycle, the ECM can work out exactly which cylinder is knocking and will retard the ignition, within limits, on that particular cylinder until the knock disappears. It then advances the ignition again to find the optimum ignition point for that cylinder at that situation (i.e. fuel type, intake air temperature etc). The ECM is able to adjust each cylinder timing for knock independently so all eight cylinders could have different advance angles all at the same time.
When the knock control is unable to adjust the background noise average to within a predefined band over a certain time, then a low or high background noise knock fault is present.
If one or more cylinders has reached its maximum knock correction value and stays there for a certain time i.e. continuous knock, then a continuous knock fault is present.
N.B. If the camshaft position sensor fails, then knock control will be disabled.

Knock Sensor								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
KNOCK SENSORS	P0327/P0328 P0332/P0333	Background Noise	Knock gain adjustment at maximum		Knock detection Engine speed	Enabled & no knock detected ≥ 5000 rpm	255 engine revolutions	None
	P0326/P0331	Continuous knock detection	Cylinder knock correction at maximum	11.9^{o}C	Engine load Knock detection	≥ 20 Enabled	255 engine revolutions	

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.12 Throttle Position Sensor

3.12.1 Description

1. Diagnostic Trouble Codes:

Throttle Position Sensor - Low out of range	P0122
Throttle Position Sensor - High out of range	P0123
Throttle Position Sensor - Signal error fault	P0121

2. Monitoring Procedure

Summary.

Problems with the throttle potentiometer will be detected using a range test. If this test is not passed then the appropriate fault counter will be incremented, otherwise it will be decremented. If the count reaches a given threshold then a fault is present.

Range check.

A voltage being read from the sensor will be compared to upper and lower limits TPOT DIAG MAX VOLTAGE and TPOT DIAG MIN VOLTAGE. If the voltage is outside these limits then a fault counter will be incremented, if not then the counter will be decremented until zero. If the value of the fault counter reaches the limit value TPOT DIAG FAULT LIMIT then a range fault is present, the fault will remain present until the counter reaches zero. The test for maximum voltage will not be performed at high engine loads as full throttle can cause the maximum voltage to be read. The load threshold below which this test can be performed is TPOT DIAG MAX TEST LOAD. Also the fault counter will not be incremented until all of the required conditions for maximum voltage test to fail have been present for greater than a time TPOT DIAG RANGE DELAY.

Signal Error Fault

The system calculates a value for the current air mass flow rate through the engine based on the throttle signal, engine rpm, intake air temperature and ISC valve position. This estimate is compared to the real measured air mass flow rate. If the difference between the two values is greater than a given percentage, then a fault counter is incremented. If the difference is less, then the fault counter is decremented. A different percentage limit is applied in each direction (estimate > actual and actual > estimate).

3. Primary Detection Parameter

Throttle voltage - measured in volts, the output of an Analogue to Digital converter circuit.

4. Fault Criteria Limits

Throttle Position Sensor - Low out of range	40mV
Throttle Position Sensor - High out of range	4V
Throttle Signal Error (Lower than actual)	300 %
Throttle Signal Error (Higher than actual)	450 %

5. Monitoring Conditions

The low range check will take place whenever there is power to the ECM; the high range check will take place when the engine speed and load is above and below a prescribed threshold respectively; and the system is in a steady state condition. The signal error check is performed at steady state conditions when both engine speed and engine load are above respective thresholds.

TPOT DIAG MAX TEST LOAD, defined in units of air per stroke:	16%
TPOT DIAG RANGE DELAY allows engine load to rise after snap opening of the throttle:	2 seconds
TPOT DIAG FAULT LIMIT, required number of fault events to flag a fault:	40
TPOT DIAG XCHK SPEED THRESH, used in signal error check:	600rpm
TPOT DIAG XCHK LOAD THRESH, used in signal error check:	19.9 %

6. Monitoring Time Length / Frequency of Checks

The frequency if the throttle potentiometer diagnostic is 40Hz.

7. Criteria for Storing Fault Code

Two successive trips where the throttle potentiometer monitoring system indicates a failed potentiometer.

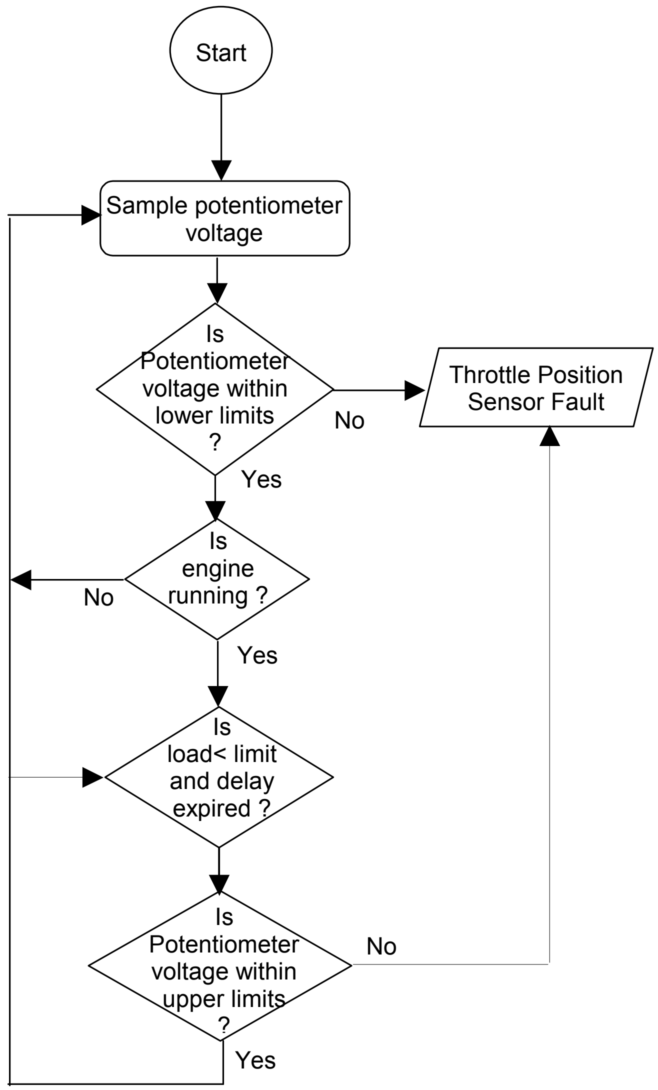
8. Criteria for Illuminating MIL

Two successive trips where the throttle potentiometer monitoring system indicates a failed potentiometer.

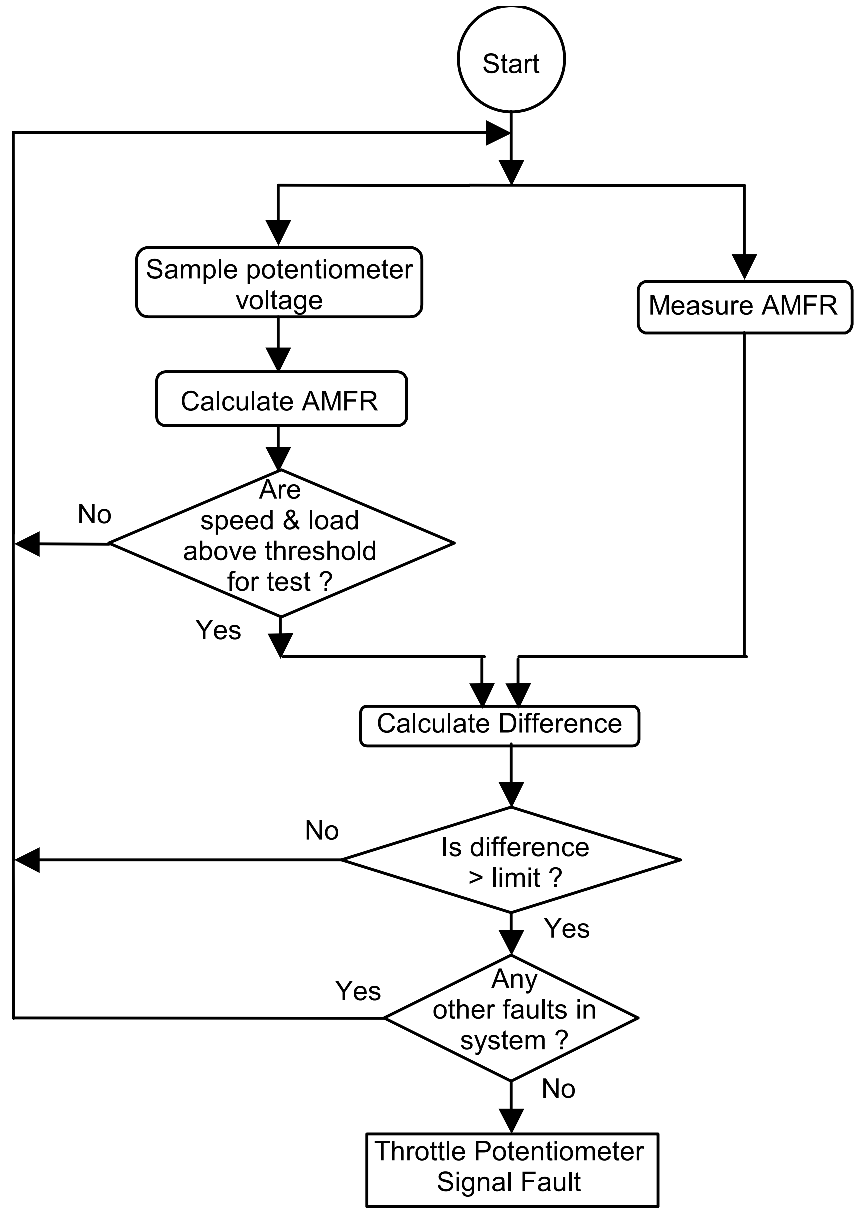
9. Criteria for Determining Out of Range Input Signals

The throttle potentiometer is subject to a minimum and maximum voltage limit of 40mV and 4.0V respectively.

3.12.2 Monitoring Structure – Throttle Potentiometer Range Test



3.12.3 Monitor Structure – Throttle Potentiometer Signal Fault



Throttle Position Sensor								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
THROTTLE POSITION SENSOR (Input CC)	P0121- P0123	Out of range check	TP Sensor fault counter - A) Low TP Sensor voltage limit - B) High TP Sensor voltage limit	200 < 0.060 v > 4.0 v	 ECU status Load Disable	 Active < 14% 2s after snap throttle	4 sec (continuous)	2 successive trips
		Signal error check	Ratio of estimated and measured air mass flow rate Ratio of measured and estimated air mass flow rate	>3:1 High >4.5:1 Low	Engine speed Engine load	>600rpm >19.9%	4 sec	2 successive trips

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.13 Engine Control Module Self Test

3.13.1 Description

1. Diagnostic Trouble Code:

ECM Self Check Fault	P0605

2. Monitoring Procedure
The ECM uses EEPROM to store long term adapted values, tune set-up values, DTC's and freeze frame data etc. If the EEPROM becomes corrupted then the system cannot perform as designed. The ECM will then revert to default data to allow the vehicle to continue running.
The EEPROM also stores a set of data, which holds the EEPROM_Calibration_Data. This data is used to determine whether the EEPROM has become corrupted. It is assumed that if this data is corrupt then the adaptive and tune data etc will also be corrupt.

The ECM attempts to restore data from two separate sets of locations in the EEPROM. Each set of locations holds a copy of the entire set of data to be stored in EEPROM.

The ECM checks each piece of data it restores using a Cyclic Redundancy Check (CRC). If this check fails then the ECM will try to retrieve the copy of that piece of data from the alternative memory location. This data is also subjected to a cyclic redundancy check. If the second check fails then the system will use a default for this piece of data and copy it to both sets of locations.

If both sets of EEPROM_Calibration_Data Cyclic Redundancy Checks fail, then the system will recognise that there is an internal ECM fault present.

3. Primary Detection Parameter
The test uses stored digital data from several memory locations.

4. Fault Criteria Limits
Both sets of EEPROM_Calibration_Data retrieved from the EEPROM must fail the cyclic redundancy check.

5. Monitoring Conditions
The ECM always performs this test.

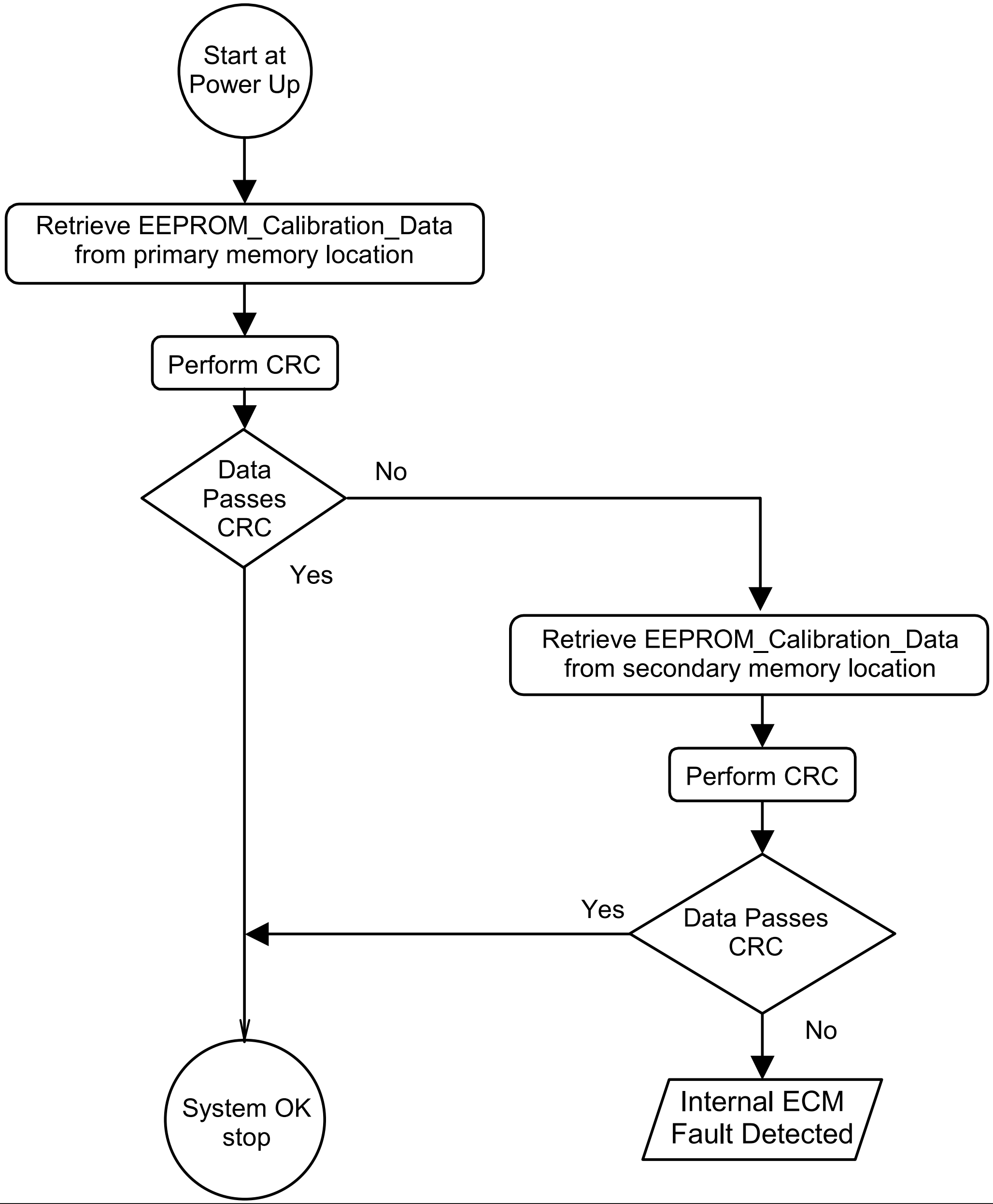
6. Monitoring Time Length / Frequency of Checks
The ECM performs the test immediately after power is restored from a dormant state. The test takes no more than 3 seconds to complete.

7. Criteria for Storing a Diagnostic Trouble Code
A diagnostic trouble code will be stored immediately if the ECM cannot retrieve valid data from the EEPROM.

8. Criteria for Illuminating MIL
The MIL will be illuminated immediately if the ECM cannot retrieve valid data from the EEPROM.

9. Criteria for Determining Out of Range Input Signals
The data is subjected to a cyclic redundancy check.

3.13.2 Monitor Structure



Engine Control Module Self Test								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
ECM SELF CHECK	P0605	Verify data integrity	CRC status of primary data	Failed	CRC status of secondary data	Failed	3 sec	Immediately
		Verify timing	Watchdog timer (not OBD II supported) (will try to reinitialise ECM if failure occurs)	Out of spec	Engine status	Running		No MIL illumination

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.14 Fuel Level Sensor

3.14.1 Description

1. Diagnostic Trouble Codes:

Fuel level sensor fault:	P0460 (P1199 for pre 1997MY vehicles)
Fuel level rationality fault:	P0461

2. Monitoring Procedure

Range Check

The resistance of the fuel level sensor changes in relation to the level of fuel in the tank. Through connection to the input resistor networks of the ECM; any disconnection of the sensor at different points in the harness can generate both high and low input voltages, which are outside the normal operating voltage range. These are detected to diagnose a fuel level fault in the system.
If the value of FUEL LEVEL VOLTS is less than FUEL LEVEL DIAG MIN VOLTS or more than FUEL LEVEL DIAG MAX VOLTS, then an appropriate fault counter is incremented up to a limit of FUEL LEVEL DIAGNOSTIC FAULT LIMIT. Otherwise the fault counter is decremented down to a limit of zero. If the fault counter reaches the limit then a fuel level sensor fault is present.

Rationality Check

The rationality test on the fuel tank level sensor consists of monitoring the fuel level sensor output and ensuring that the output value changes during a period of time. This test will check that the sensor float is not stuck or holed. The test can be passed either through fuel slosh or a drop in level due to fuel usage. To ensure that the test can be completed even where the vehicle is being used for successive short journeys, the test parameters are stored at power down and retrieved at the next power up.

3. Primary Detection Parameter
Fuel level - Measured in volts, the outcome of a potential divider calculation.

4. Fault Criteria Limits

Fuel Level - Low out of range	0.49V
Fuel Level - High	4.8V

Fuel Level change must be less than 2 litres for a period of time greater than 59 minutes

5. Monitoring Conditions
The range test will take place only when the engine is running.
The rationality test will take place when the vehicle speed is greater than 50 mph.

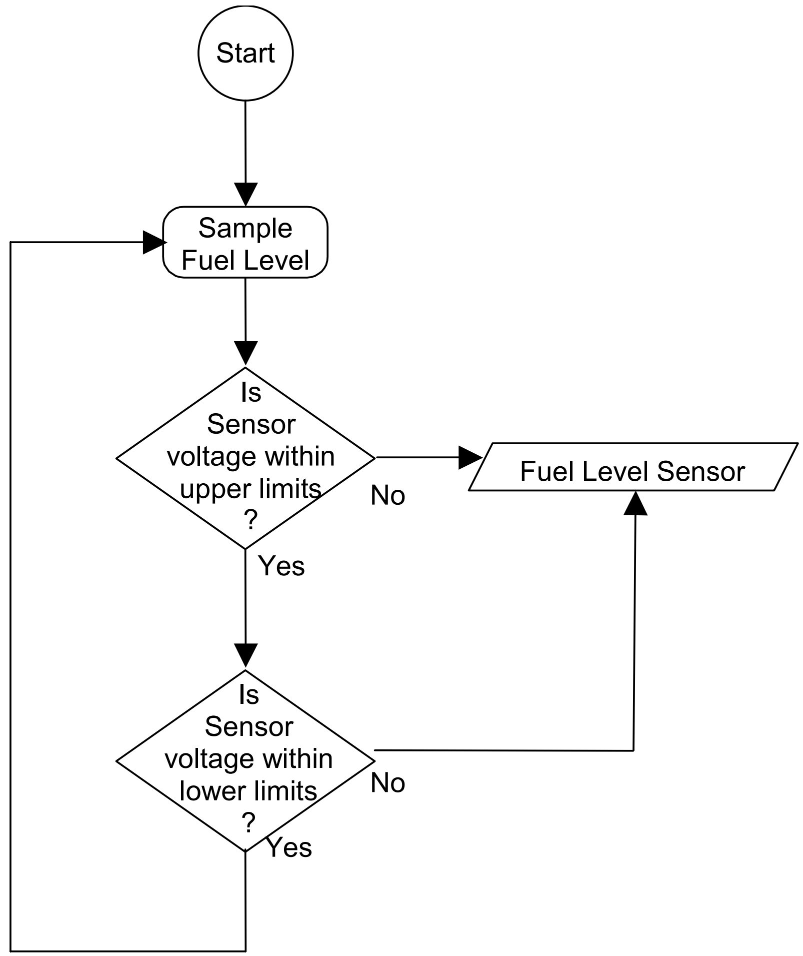
6. Monitoring Time Length / Frequency of Checks
The frequency of the fuel level diagnostic is 2Hz.

7. Criteria for Storing a Diagnostic Trouble Code
Two successive trips where the fuel level diagnostic indicates a failed fuel level sensor.

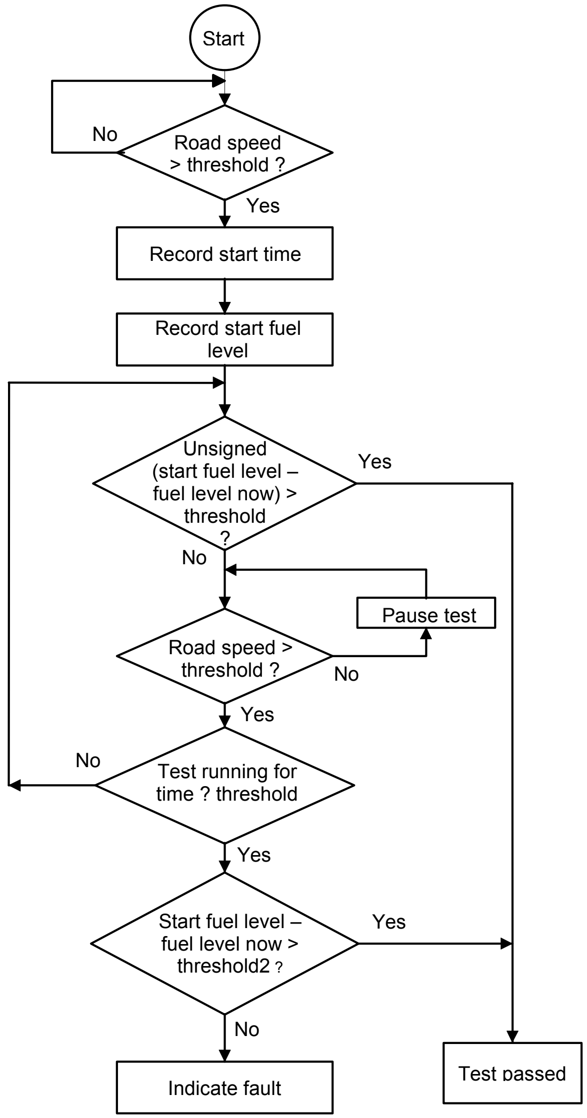
8. Criteria for Illuminating MIL
Two successive trips where the fuel level diagnostic indicates a failed fuel level sensor.

9. Criteria for Determining Out of Range Input Signals
The fuel level sensor is subject to the range test above.

3.14.2 Monitoring Structure – Range Test



3.14.3 Monitoring Structure – Rationality Check



Fuel Level Signal								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
FUEL LEVEL SENSOR (Input CC)	P0460 (P1199 for pre 1997MY vehicles)	Out of range check	Fuel level sensor fault counter - A) Low FLS voltage limit - B) High FLS voltage limit	≥255 < 0.49 v > 4.8 v	 Engine status Engine status	 Running Running	120 sec	2 successive trips
	P0461	Rationality check	Change in fuel level	< 2 litres	Vehicle speed	> 50 mph	59 min	2 successive trips

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.15 Vehicle Speed Sensor

3.15.1 Description

1. Diagnostic Trouble Code:

Vehicle Speed Sensor Malfunction	P0500

2. Monitoring Procedure

Summary

Problems with the vehicle speed sensor will be detected using a number of tests. An engine load test will check for a sustained high engine load being present within a given range of engine speeds and a low road speed. A check is performed using the gearbox retard request signal from the electronic automatic gearbox. If these requests are being received with a low road speed then the test will fail

Engine Load Test

If the engine load is above a constant, RS DIAG LOAD THRESHOLD for a time greater than RS DIAG LOAD TIME with the engine speed above RS DIAG ENGINE SPEED MIN and RS DIAG LOW ROAD SPEED is true then a fault counter (RS DIAG LOAD FAULTS) will be incremented. Should the test be passed then the fault counter will be decremented to until zero. If the value of the fault counter reaches the limit value RS DIAG FAULT LIMIT then a road speed fault is present.

Gear Change Request Check

On electronic automatic vehicles a signal is sent from the automatic transmission control module to request an ignition retard to smooth out gear changes. This signal, GEAR CHANGE REQUEST, will be monitored and if it occurs when RS DIAG LOW ROAD SPEED is true then a fault count RS DIAG GEAR FAULTS will be incremented. On each ignition retard request when RS DIAG LOW ROAD SPEED is false and also on each transition of the neutral/drive switch state NDSWITCH OUTPUT the fault counter is decremented. If the value of the fault counter reaches the limit value RS DIAG GEAR FAULT LIMIT then a gear change fault is present until the counter reaches zero.

3. Primary Detection Parameter
Road Speed - Road speed sensor edges indicating > 1 mph.
Presence of 30 gear change requests during low road speed conditions.

4. Fault Criteria Limits
Presence or not of road speed sensor edges

5. Monitoring Conditions
The check for road speed will occur under conditions where engine load and speed suggest that the engine is working against genuine road loads (not ancillary loads).
RS DIAG LOAD THRESHOLD - 80% load
RS DIAG LOAD TIME, a time period ensuring that load is constant, 5 seconds.
RS DIAG ENGINE SPEED MIN, 2500 rpm
RS DIAG FAULT LIMIT 40 events

The check for a gear change request signal from the automatic transmission control module is performed whenever there is a low vehicle speed indicated from the vehicle speed sensor.

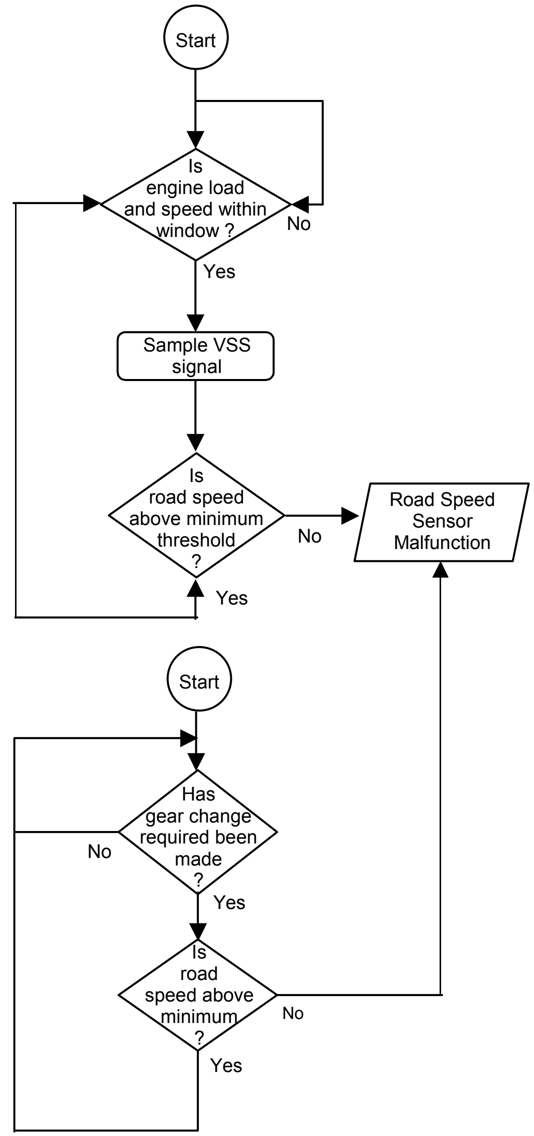
6. Monitoring Time Length / Frequency of Checks
The vehicle speed sensor diagnostic operates at a frequency of 10Hz.

7. Criteria for Storing a Diagnostic Trouble Code
Two successive trips where the vehicle speed diagnostic indicates a failed vehicle speed sensor.

8. Criteria for Illuminating MIL
Two successive trips where the vehicle speed diagnostic indicates a failed vehicle speed sensor.

9. Criteria for Determining Sensor Functionality
The vehicle speed sensor produces a non-linear output; the criteria will be signal/no signal.

3.15.2 Monitoring Structure



Vehicle Speed Sensor

Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
VEHICLE SPEED SENSOR (Input CC)	P0500	VSS signal verification Engine load test (rationality) Reduced speed for gear change smoothing check	VSS pulses VSS fault counter - vehicle speed Shift smoothing fault counter - Gear change requests	0 detected 40 ≤ 1 MPH =30	 Load Engine speed Transmission type Vehicle speed	 ≥ 70% for > 5 sec ≥ 1900 RPM Electronic A/T ≤ 1 MPH	5 sec 100 msec (continuous) 30 gear shifts	2 successive trips

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.16 Power Supplies

3.16.1 Description

1. Diagnostic Trouble Code:

System Voltage Malfunction	P0560
System Voltage Low	P0562
System Voltage High	P0563

2. Monitoring Procedure
Two measurements of battery voltage are made, one coarse resolution and one fine resolution. The coarse resolution signal is subjected to out of range limits; whilst the fine resolution signal has a rationality check performed which ensures that the measured battery voltage is reasonably high when the engine speed is high. This ensures that the alternator is charging correctly.

3. Primary Detection Parameter
The two battery voltage measurements both come from an ADC input. The battery voltage is scaled down using a different potential divider in each case to provide the two measurements.

Battery Voltage -	Fine resolution = 0 to 16 V
	Coarse resolution = 0 to 32 V

4. Fault Criteria Limits

Out of range limits:	Low voltage: 3V
	High voltage: 29V
Rationality check	10.5V

5. Monitoring Conditions
The range test is conducted at all times.
The rationality check is carried out when engine speed > 1600rpm

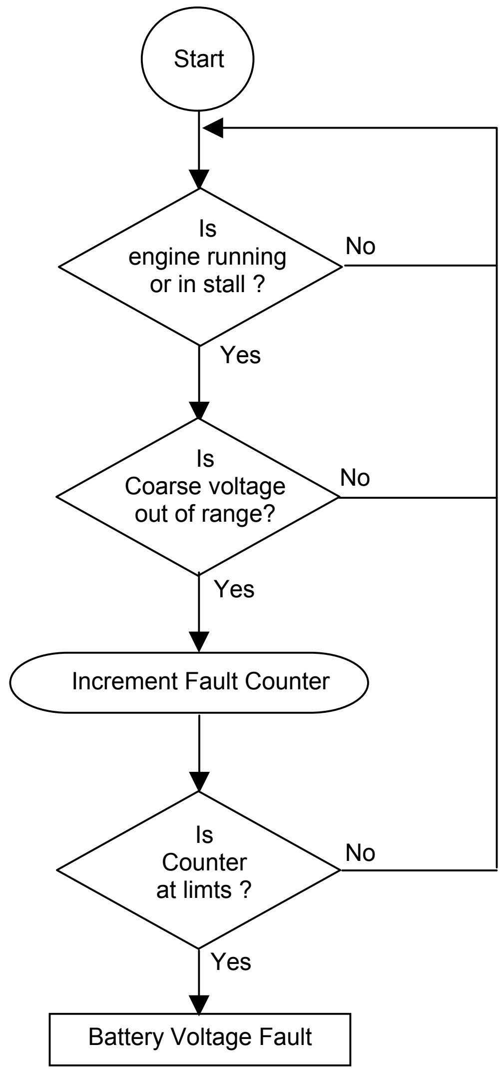
6. Monitoring Time Length / Frequency of Checks
The tests are performed continuously.

7. Criteria for Storing a Diagnostic Trouble Code
Two successive trips where the battery voltage diagnostic indicates a fault.

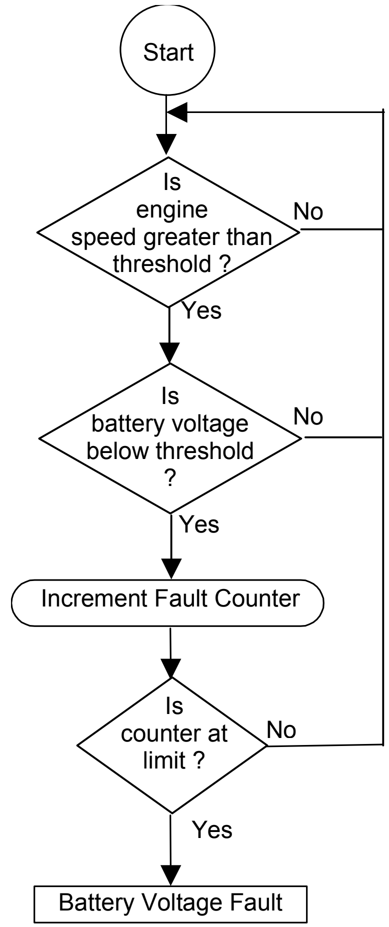
8. Criteria for Illuminating MIL
Two successive trips where the battery voltage diagnostic indicates a fault.

9. Criteria for Determining Out of Range Input Signals
The engine speed signal is subject to its own diagnostic strategy.

3.16.2 Monitor Structure – Out of Range Test



3.16.3 Monitor Structure – Rationality Check



Battery Voltage								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
BATTERY VOLTAGE	P0560 P0562-P0563	Voltage range Rationality	Low battery voltage measurement High battery voltage measurement Low battery voltage measurement	< 5.75 V > 24 V < 10 V	Engine speed	>1600 rpm	10 sec 10 sec 10 sec	2 successive trips

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.17 Fuel Tank Temperature Sensor

3.17.1 Description

1. Diagnostic Trouble Codes:

Fuel Tank Temperature Sensor Circuit High Input	P0183
Fuel Tank Temperature Sensor Circuit Low Input	P0182
Fuel Tank Temperature Sensor Rationality Check	P0181

2. Monitoring Procedure

Range Check

Problems with the fuel tank temperature (FTT) sensor are detected using a range test. The range test tests for input values outside expected limits. If this test is not passed then the appropriate fault counter will be incremented, otherwise it will be decremented. If the counter reaches a given threshold then a fault is present. While fault counting is in progress a back-up value of fuel tank temperature will be supplied to avoid the problems of incorrect values reaching the rest of the system.

Rationality Check

The test on the fuel tank temperature sensor comprises of comparing the output from the sensor with a tolerance band based around the value of engine coolant temperature.
A fuel tank temperature test will check that the sensor does not have an altered resistance characteristic or the sensor has not fallen off.

3. Primary Detection Parameter
Fuel Tank Temperature - measured as thermistor voltage.

4. Fault Criteria Limits

Fuel Tank Temperature – Low voltage (out of range)	< 0.0585 V (i.e. > 145 ^{0}C)
Fuel Tank Temperature – High voltage (out of range)	> 4.895 V (i.e. < -45 ^{0}C)
Error between fuel tank temperature and engine coolant temperature	> 20 ^{0}C or < -120 ^{0}C

5. Monitoring Conditions
The range check will take place whenever there is power to the ECM.
The rationality check will take place once the engine has been running for a time > 40 seconds.

6. Monitoring Time Length / Frequency of Checks
The frequency of the fuel tank temperature diagnostic is 2Hz.

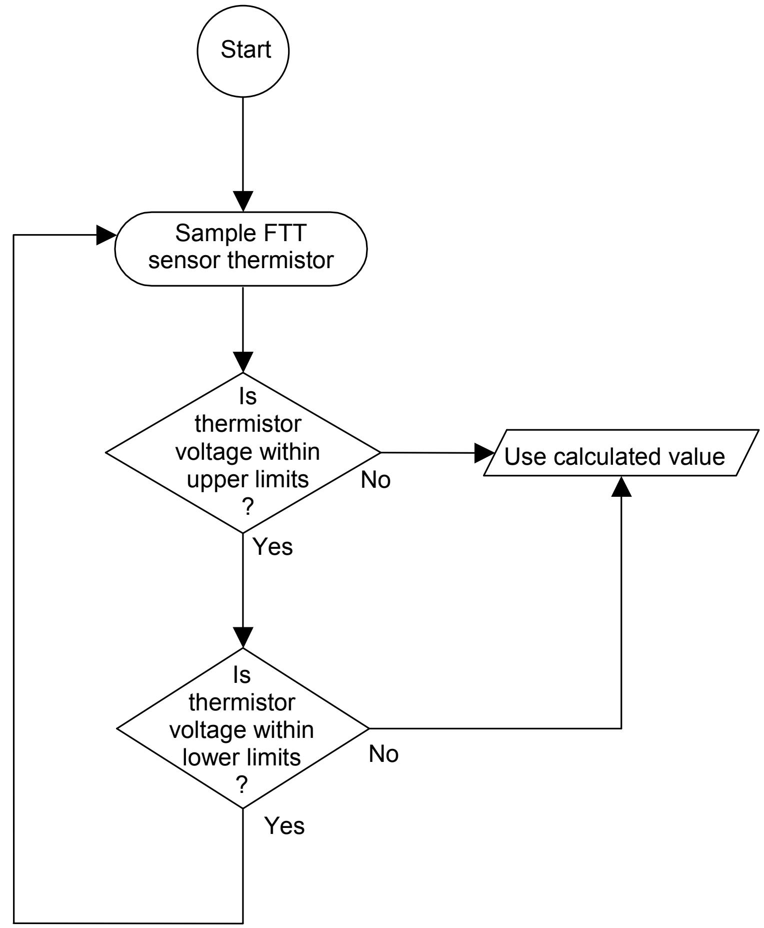
7. Criteria for Storing a Diagnostic Trouble Code
Two successive trips where the fuel tank temperature diagnostic indicates a failed fuel tank temperature sensor.

8. Criteria for Illuminating MIL
Two successive trips where the fuel tank temperature diagnostic indicates a failed fuel tank temperature sensor.

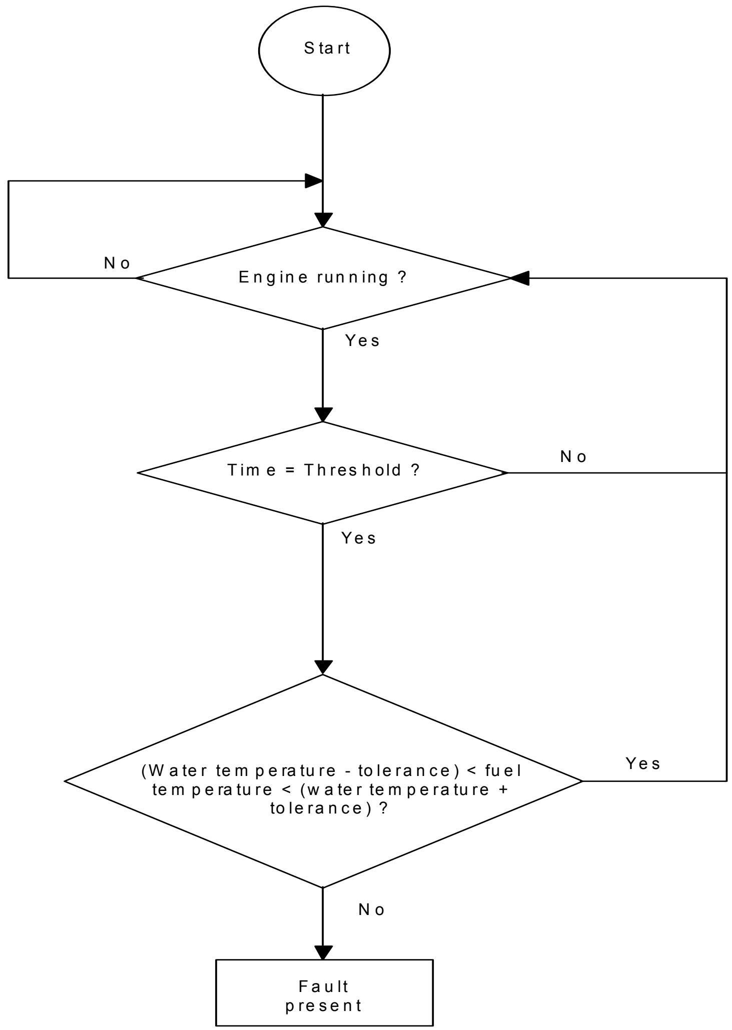
9. Criteria for Determining Out of Range Input Signals

The fuel tank temperature thermistor is subject to range testing as above.

3.17.2 Monitor Structure – Range Check



3.17.3 Monitor Structure – Rationality Check



Fuel Tank Temperature Sensor

Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
FUEL TANK TEMPERATURE SENSOR	P0183 P0182	Out of range check	high voltage low voltage	 < 0.0585 V (i.e.>145 ºC)	Ignition	On	14 s (continuous)	2 trips
	P0181	Validity check	fuel temperature – engine coolant temperature	≥ 20 ºC or ≤ -120 ºC	Engine running	For at least 40s	Up to 54 s (continuous)	2 trips

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.18 Transfer Box Interface

3.18.1 Description

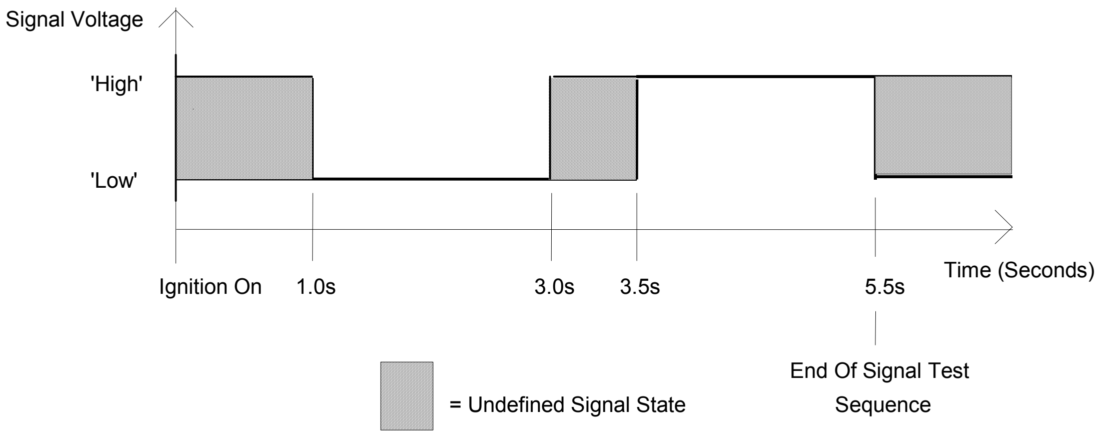
1. Diagnostic Trouble Codes:

Transfer Box Fault	P1701
Transfer Box Link Electrical Fault	P1703
Transfer Box Link Short Circuit	P1708

2. Monitoring Procedure

Electrical Checks

At pre-determined times following ignition key 'ON', the transfer box controller will drive the link to the ECM low and then high again in order to check for line integrity. Depending on the outcome of this test, electrical faults of the link can be determined.
The timing diagram below shows the requirements:



Transfer Box Fault

If the transfer box controller decides thee is a fault present, it will drive the link to the ECM low. The ECM will then illuminate the MIL and store the appropriate DTC.

3. Primary Detection Parameter
Digital (high/low) input from the Transfer Box Controller.

4. Fault Criteria Limits

Electrical Checks

The link must be driven low within 1.0s of ignition key 'ON' and then high again within a further 2.5s. The link must stay high for at least 2.0s. (See the timing diagram above.)

Transfer Box Fault
The transfer box controller must drive the link low for at least 2 seconds before fault is stored.

5. Monitoring Conditions
The electrical checks are done after every ignition key 'ON'.
The electrical checks will be aborted if the battery voltage drops below 8V.
The system monitors constantly for a Transfer Box fault, provided there are no electrical faults.

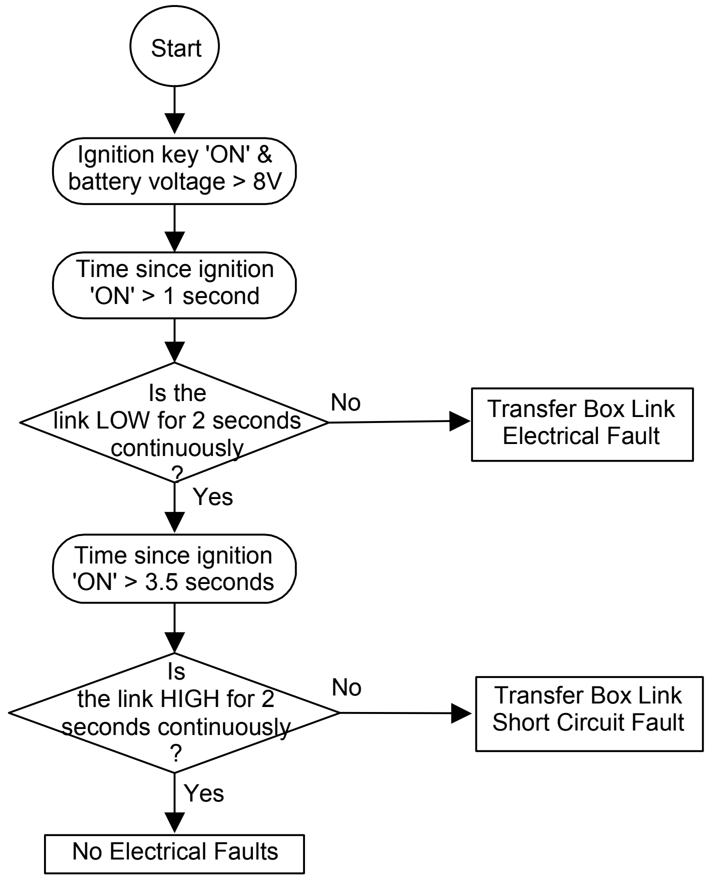
6. Monitoring Time Length / Frequency of Checks
The electrical check takes 5.5 seconds and is carried out once after ignition key 'ON'
Whilst looking for a Transfer Box Fault, the link is monitored at a 10Hz-sampling rate for the rest of the ignition 'ON' cycle.

7. Criteria for Storing a Diagnostic Trouble Code
A DTC will be stored immediately after detecting a fault.

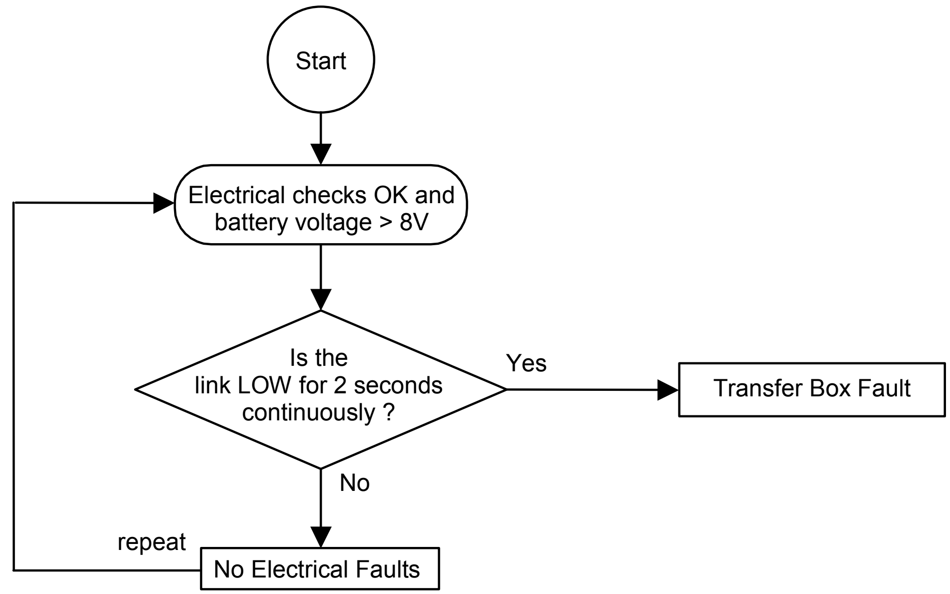
8. Criteria for Illuminating MIL
The MIL will be illuminated immediately after detecting a fault.

9. Criteria for Determining Out of Range Input Signals
Electrical checks are performed as described above.

3.18.2 Monitor Structure – Electrical Check



3.18.3 Monitoring Structure – Transfer Box Fault



Transfer Box Interface								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
TRANSFER BOX INTERFACE	P1701 P1703	Handshake at ignition on	Fail to switch line high/low	Failed			5.5 s	2 successive trips
	P1708	Transfer box fails to engage high range	Fail to engage	Failed			2.0 s after receipt of signal from transfer box	2 successive trips

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.19 Park/Neutral Position Switch

3.19.1 Description

1. Diagnostic Trouble Codes:

High Load Neutral/Drive Fault	P1514
Gear Change Neutral/Drive Fault	P1516
Cranking Neutral/Drive Fault	P1517

2. Monitoring Procedure

Summary

Problems with the Park/Neutral Position (PNP) Switch will be detected using a number of tests. Two tests check whether the switch is incorrectly indicating neutral, by detecting high load conditions or gear changes. A single test checks whether the switch is incorrectly indicating drive, by detecting cranking. If the tests are not passed then the appropriate fault counter will be incremented. If the counter reaches a given threshold then a fault is present. While a fault is present a default value for the Park/Neutral Position Switch will be supplied to the rest of the system.

Cranking Test

The drive position test will test for engine conditions that indicate that the gearbox is in neutral yet the switch reads drive.

The drive position test involves monitoring whether CRANKING mode has been entered. Upon entry to CRANKING mode then a delay of a minimum period of NEUT DRV DIAG CRK INIT DELAY should occur to allow the systems voltages to recover from any start-up transients. The park/neutral position switch is then sampled during the remaining cranking period. The sampling technique is required to avoid the effects of electrical noise during CRANKING. Any switch samples that read drive while CRANKING are fault events. If a greater proportion of samples than NEUT DRV DIAG CRK PERCENT MIN indicate drive, then there is a fault present.

Once cranking mode is entered, wait for NEUT DRV DIAG CRK INIT DELAY. As long as the engine is still cranking then start sampling, recording both the total number of samples and the number of those switch samples that were fault events, i.e. switch reads drive. Only stop sampling once the engine stops cranking or the total number of samples is NEUT DRV DIAG CRK SAMPLES MAX.

As long as at least a minimum of NEUT DRV DIAG CRK SAMPLES MIN samples have occurred before the end of the cranking period, then continue the test.

The proportion of samples that indicate drive will be calculated; if NEUT DRV DIAG CRK PERCENT MIN indicates drive then this indicates the switch is in drive hence there is a fault present.

Neutral Position Test

(i). High Load Test.

This test establishes that there is a false indication of neutral from the park/neutral position switch whilst the gearbox is in drive by checking for high engine load whenever high engine speed is seen in neutral. High load indicates that the vehicle is in gear, and low load implies neutral. The test operates as follows:

1. While in neutral, if the engine load exceeds the NEUT_DRV_HIGH_LOAD_THRESH when the engine speed exceeds NEUT_DRV_DIAG_ENGINE_SPD_MIN, then the fault counter is incremented. If the counter reaches NEUT_DRV_DIAG_HIGH_LOAD_FAULT_LIMIT then a fault is recorded.
2. While in neutral, if the engine load is less than or equal to the NEUT_DRV_DIAG_HIGH_LOAD_THRESH when the engine speed still exceeds NEUT_DRV_DIAG_ENGINE_SPD_MIN, then decrement the fault counter.
3. If the park/neutral position switch equals drive, then the fault counter is decremented down to a limit of zero.

(ii). Gear Change Test

The test involves monitoring for gear change requests while the switch indicates neutral. This can be done by monitoring for ignition alteration due to the presence of the GEAR_CHANGE_IN_PROGRESS flag, which occurs during gear changes. If a gear change request occurs while the park/neutral position switch indicates neutral, then the gear change fault event counter will be incremented. If a gear change request occurs while the neutral drive switch indicates drive, then decrement the gear change fault event counter. If the counter reaches NEUT_DRV_DIAG_GEAR_FAULT _LIMIT then a fault is recorded.

3. Primary Detection Parameter

Park/neutral position switch input - an internal state generated from the voltage output of the park/neutral position switch.

4. Fault Criteria Limits

High load Test - false indication of neutral from the park/neutral position switch whilst the gearbox is in drive.
Cranking Test - Indication from engine conditions that the gearbox is in neutral yet the switch reads drive.
Gear Change Test - indication from the GEAR_CHANGE_IN_PROGRESS flag that a gear change is in progress when the park/neutral position switch indicates that the gearbox is in neutral.

5. Monitoring Conditions

Cranking Test - The engine status is cranking.
NEUT_DRV_DIAG_CRK_INIT_DELAY, used to ensure that the system's voltages is stable, 1.0sec
NEUT_DRV_DIAG_CRK _SAMPLES_MAX, maximum number of samples taken to verify switch functionality, 50
NEUT_DRV_DIAG_CRK_SAMP_MIN, minimum number of samples taken to verify switch functionality, 15
NEUT_DRV_DIAG_CRK_PERCENT_MIN, minimum percentage of drive indications from samples taken required to indicate a fault, 90

High Load Test - The engine load must be equal to or below 80% and the engine speed must be equal to or above 1500RPM, the water temperature above 80^{0}C and the gearbox does not indicate a fault.

Gear Change Test - The gearbox does not indicate a fault and the engine is not in stall.

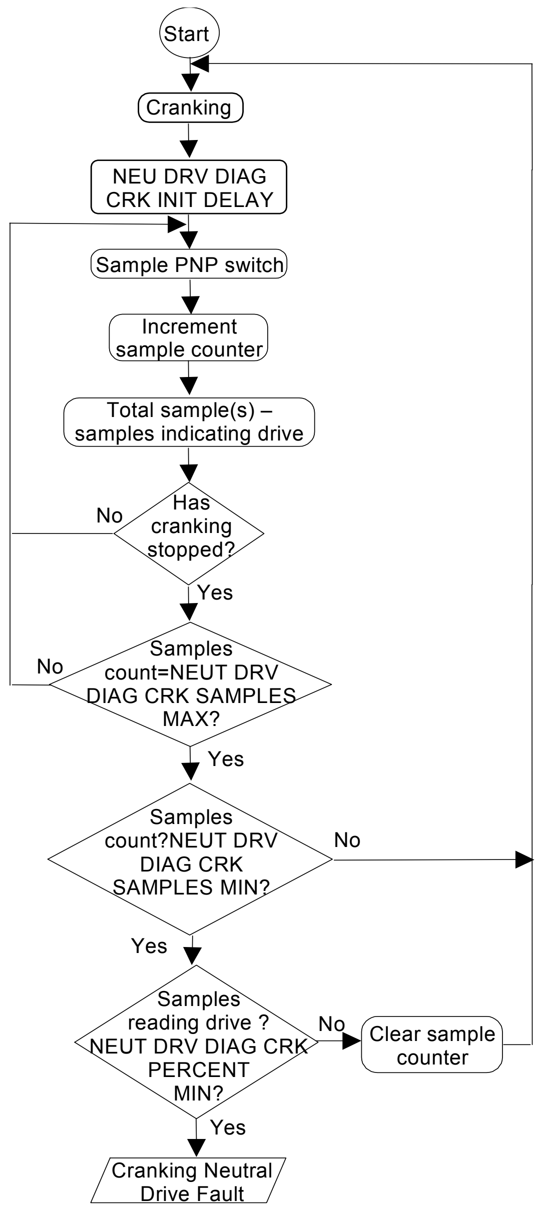
6. Monitoring Time Length / Frequency of Checks
The frequency of the park/neutral position switch diagnostic is 10Hz.

7. Criteria for Storing a Diagnostic Trouble Code
Two successive journeys where the diagnostic indicates a failed park/neutral position switch.

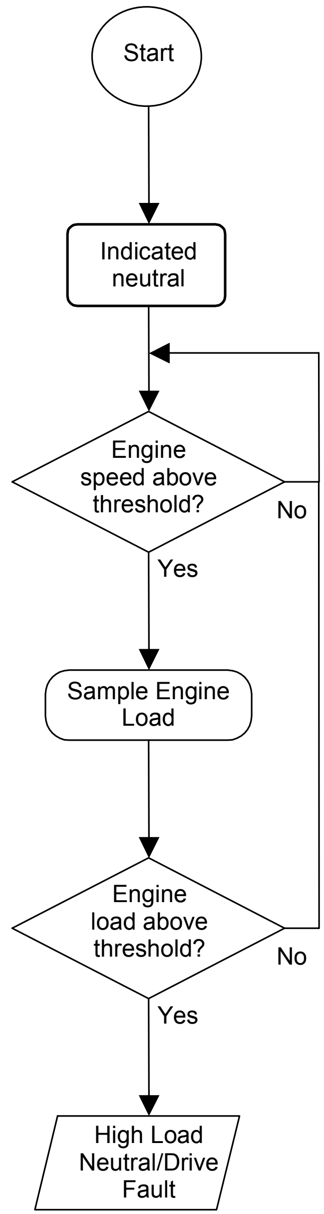
8. Criteria for Illuminating MIL
The MIL will not be illuminated.

9. Criteria for Determining Out of Range Input Signals
The park/neutral position switch produces a non-linear output; the criteria will be signal/no signal.

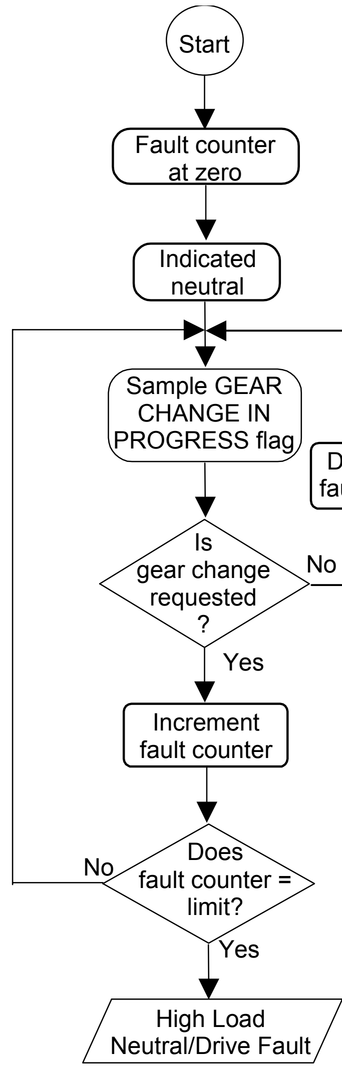
3.19.2 Monitor Structure – Cranking Test



3.19.3 Monitoring Structure – Neutral Position Test High Load Test



3.19.4 Monitoring Structure – Neutral Position Test Gear Change Test



Park/Neutral Position Switch								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
PARK/ NEUTRAL POSITION **SWITCH** (Input CC)	P1514-P1517	Verify drive position	Diagnostic event counter – Park/ Neutral Position Switch status	15 ≤ samples ≤ 50 Drive	Transmission type Engine status Failure rate of samples	Electronic automatic Cranking after 1s delay ≥ 90 %	6 sec	2 successive trips
		Verify neutral position A) High load check	High Load fault counter – Park/ Neutral Position Switch status	≥120 Neutral	Transmission type Engine speed Load Coolant temperature Disable	Automatic ≥ 1500 RPM ≥ 80 % ≥ 70 Celsius Transmission fault	12 sec	
		B) Gear change check	Gear change fault counter – Park/ Neutral Position Switch status	≥ 30 Neutral	Transmission type Transmission status Disable	Electronic automatic Gear shift in progress Transmission fault	30 gear shifts	

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.20 Fuel Injectors

3.20.1 Description

1. Diagnostic Trouble Codes:

Cylinder 1 Injector Circuit Malfunction	P0201
Cylinder 2 Injector Circuit Malfunction	P0202
Cylinder 3 Injector Circuit Malfunction	P0203
Cylinder 4 Injector Circuit Malfunction	P0204
Cylinder 5 Injector Circuit Malfunction	P0205
Cylinder 6 Injector Circuit Malfunction	P0206
Cylinder 7 Injector Circuit Malfunction	P0207
Cylinder 8 Injector Circuit Malfunction	P0208
Cylinder 1 Injector Circuit open/short to ground	P1201
Cylinder 2 Injector Circuit open/short to ground	P1202
Cylinder 3 Injector Circuit open/short to ground	P1203
Cylinder 4 Injector Circuit open/short to ground	P1204
Cylinder 5 Injector Circuit open/short to ground	P1205
Cylinder 6 Injector Circuit open/short to ground	P1206
Cylinder 7 Injector Circuit open/short to ground	P1207
Cylinder 8 Injector Circuit open/short to ground	P1208

2. Monitoring Procedure

Summary

Problems with the injectors are detected using two tests, the first cannot distinguish between open circuit and short to battery or ground faults. The second isolates the short to battery condition.

Injector Hardware Test

This test determines whether the flag, INJ DIAG INJ BUFF STATUS [1.NCYLS] indicates a fault event while the vehicle status is ENGINE RUNNING. If a fault event has occurred, then increment that injectors' fault counter, INJ DIAG INJ FAULT CNTR [1.NCYLS], up to a limit of INJ DIAG FAULT LIMIT. If INJ DIAG NO FAULT LIMIT consecutive no fault events occur, then that injectors' fault counter is decremented, down to a limit of zero. If the count reaches INJ DIAG FAULT LIMIT then an injector hardware fault is present.

Injector Open Circuit or Ground Short Test

This test determines whether the flag, INJ DIAG INJ BUFF STATUS [1.NCYLS] indicates a fault event while the engine is in the STALL condition or during ECU POWER DOWN. If a fault event has occurred, then increment that injectors' fault counter, INJ DIAG OC FAULT CNTR [1.NCYLS], up to a limit of INJ DIAG FAULT LIMIT. If INJ DIAG NO FAULT LIMIT consecutive no fault events occur, then decrement that injectors' fault counter, down to a limit of zero. If the count reaches INJ DIAG FAULT LIMIT then an injector open circuit or ground short fault is present.

3. Primary Detection Parameter
Hardware fault status from injector drive ASIC which monitors line voltage before low side drive transistor.

4. Fault Criteria Limits
Injector Diagnostic Fault limit = 10; limit used to define that there is a fault present with the injector.
Injector Diagnostic/no Fault limit = 40; limit used to define that there is not a fault present with the injector.

5. Monitoring Conditions
The injector hardware diagnostic will be run when the vehicle status is engine running. The injector open circuit or ground short test will be run when the engine is in stall or during ECM power down.

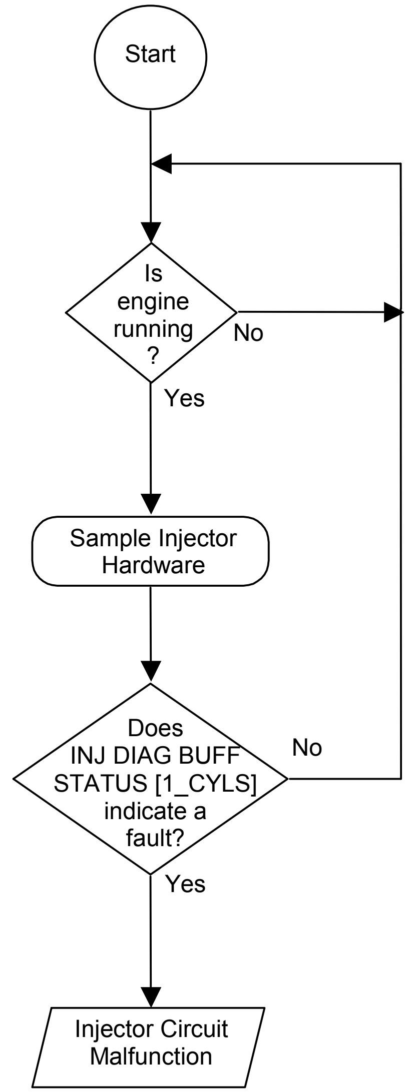
6. Monitoring Time Length / Frequency of Checks
The injector hardware diagnostic will be run at a frequency of 10Hz whilst the engine is running.
The injector open circuit or ground short test will be run whenever the engine is in the stall condition or during ECM power down.

7. Criteria for Storing a Diagnostic Trouble Code
Two successive trips where the diagnostic routines indicate a failed injector or injector circuit.

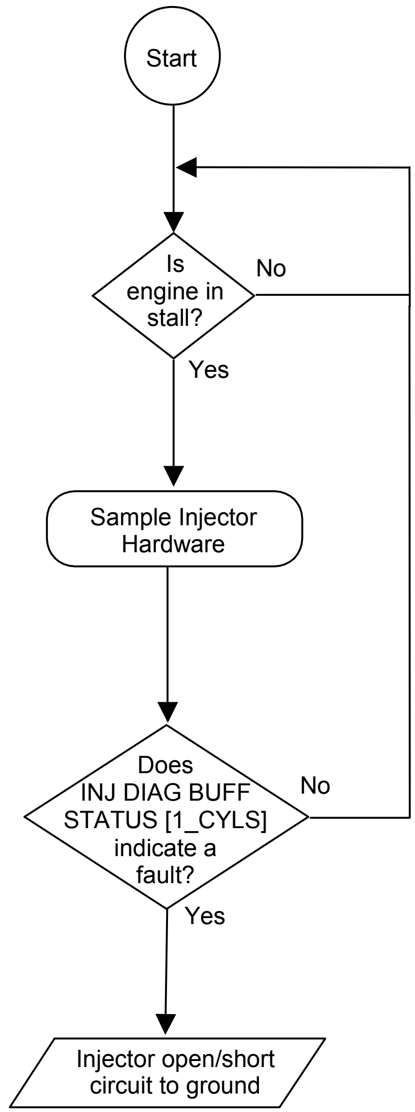
8. Criteria for Illuminating MIL
Two successive trips where the diagnostic routines indicate a failed injector or injector circuit.

9. Criteria for Determining Out of Range Input Signals
The injector diagnostic sampling technique monitors non-linear signals; the criteria will be signal/no signal.

3.20.2 Monitor Structure – Injector Hardware Test



3.20.3 Monitor Structure – Injector Open Circuit or Ground Short Test



Fuel Injectors								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
FUEL SYSTEM (integrated with O2S system)	P0201-P0208 P1201-P1208	Fuel injector circuit malfunctions A) Hardware diagnostic B) Short/GND to battery diagnostic	Injector fault counter Injector open circuit no fault counter	= 10 = 40	Engine status Engine status	Running Stall or ECM power down	1 sec (continuous)	2 successive drive cycles

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.21 Idle Speed Control

3.21.1 Description

1. Diagnostic Trouble Codes:

Idle Speed Control System RPM Lower Than Expected	P0506
Idle Speed Control System RPM Higher Than Expected	P0507
Idle Speed Control System Open Circuit	P1508
Idle Speed Control System Short Circuit	P1509

2. Monitoring Procedure

Summary

The open and short circuit tests check for hardware fault events by sampling the stepper motor coils' fault status lines of the Serial Output Devices.

The closed loop mode test monitors the cumulative opening and closing idle speed control steps, during closed loop control, a fault event being registered when the cumulative steps applied in either an opening or closing direction exceed threshold values, without causing a corresponding increase or decrease in airflow rate.

Closed Loop Test

At the start of any closed loop idle speed control, the airflow is sampled, ISC DIAG INIT AIRFLOW, and from that point, the count of the cumulative opening and closing idle speed control steps, ISC CUM STEP SUM CNTR is monitored. No further action is taken until ISC CUM STEP SUM CNTR is greater than ISC DIAG CLOSING STEP THRESH in the closing direction, or is greater than ISC DIAG OPENING STEP THRESH in the opening direction. Then the airflow is sampled again, ISC DIAG FINAL AIRFLOW, and the difference between ISC DIAG FINAL AIRFLOW and ISC DIAG INIT AIRFLOW calculated.

If ISC CUM STEP SUM CNTR is greater than ISC DIAG CLOSING STEP THRESH in the closing direction, and the airflow decrease is less than ISC DIAG CLOSING AIRFLOW THRESH, then a closed loop fault event has occurred. If the airflow decreases by more than ISC DIAG CLOSING AIRFLOW THRESH, then the test was passed.

If ISC CUM STEP SUM CNTR is greater than ISC DIAG OPENING STEP THRESH in the opening direction, and the airflow increase is less than ISC DIAG OPENING AIRFLOW THRESH, then a closed loop fault event has occurred. If the airflow increases by more than ISC DIAG OPENING AIRFLOW THRESH, then the test was passed.

If a fault event has occurred the fault event counter, ISC DIAG CL FAULT CNTR, up to a limit of ISC DIAG CL FAULT LIMIT is incremented. If the test was passed then the closed loop fault event counter is decremented, down to a limit of zero.

If the fault event counter reaches ISC DIAG CL FAULT LIMIT then a fault is present. If ISC DIAG CUM STEP CNTR is greater than ISC DIAG OPENING STEP THRESH in the opening direction then an ISC engine speed low fault is present, otherwise an ISC engine speed high fault is present.

If the fault event counter equals zero, there are no ISC engine speed low, or high, faults present.

If ISC STABILITY OCCURRED indicates that the stepper motor adaptive offset has been updated during closed loop control, then re-sample ISC DIAG INIT AIRFLOW, and calculate the airflow difference from this new value. The ISC CUM STEP SUM CNTR will have been reset, so monitor the cumulative step count from this new value.

Short Circuit Test
The short circuit test checks for short circuit fault events by sampling the stepper motor coils' fault status lines, ISC DIAG STATUS [A, B, C, D], of the Serial Output Device, which indicate the fault status of the coils.

To check for short circuits, ISC DIAG STATUS [A, B, C, D] are sampled during the three most recent stepper motor steps, which were stepped in the same direction, guaranteeing that at some point the potential differences across both coils will reverse. For any stepper position, one of the ends of a shorted coil will indicate a fault on the fault status lines. Using the three most recent samples of a coils' fault status lines, if for each sample, either end of the coil indicates a fault, there is a short circuit fault event.

At the start of stepper referencing, as indicated by STEPPER REFERENCING IN PROGRESS being set, the fault event counter, ISC DIAG SHORT FAULT CNTR is cleared. If a test results in a short circuit fault event on either coil then the hardware fault event counter is incremented up to a limit of ISC DIAG SHORT FAULT LIMIT. If, during the ISC position referencing, the fault event counter reaches ISC DIAG SHORT FAULT LIMIT, there is an ISC short circuit fault present.

Open Circuit Test
The open circuit test checks for open circuit fault events by sampling the stepper motor coils' fault status lines, ISC DIAG STATUS [A, B, C, D], of the Serial Output Device.

During the open circuit test, compare the fault status signal at each end of a coil. If the ends of a coil have different values for the fault status, then there is an open circuit fault event. Thus, sample ISC DIAG STATUS [A, B, C, D], and if either A and B are not the same, or C and D are not the same, then there is an open circuit fault event.

When the coils go tristate, as indicated by STEPPER COILS TRISTATE being set, clear the fault event counter, ISC DIAG OC FAULT CNTR. If a fault event occurs on either coil, increment the fault event counter, ISC DIAG OC FAULT CNTR. At least ISC DIAG OC FAULT LIMIT consecutive open circuit tests should occur during one power down test.
If the fault event counter reaches ISC DIAG OC FAULT LIMIT, there is an ISC open circuit fault present.

3. Primary Detection Parameter
Closed Loop Test
Difference in airflow with respect to cumulative opening and closing of the stepper motor, i.e. slope of airflow Vs stepper position.

Short Circuit Test
Hardware fault status from stepper motor drive ASIC which monitors line voltage before low side drive transistor.

Open Circuit Test
Hardware fault status from stepper motor drive ASIC which monitors line voltage before low side drive transistor. Hardware fault status from stepper motor drive ASIC which monitors line voltage

4. Fault Criteria Limits

Closed Loop Test

ISC DIAG CLOSING STEP THRESH	30 steps
ISC DIAG OPENING STEP THRESH	50 steps
Airflow Per Step = 0.3kg/hr/step	
ISC DIAG CLOSING AIRFLOW THRESH	0.3 x 30 = 9Kg/hr @ 30 steps
ISC DIAG OPENING AIRFLOW THRESH	0.3 x 50 = 15Kg/hr @ 50 steps

Short Circuit Test

ISC DIAG SHORT FAULT LIMIT = 63; limit used to define that there is a fault present with the stepper motor.

Open Circuit Test

ISC DIAG OC FAULT LIMIT = 50; limit used to define that there is a fault present with the stepper motor.

5. Monitoring Conditions

Closed Loop Test

Closed Loop idle Speed Control is active.
Engine coolant temperature is above 70^{o}C.
The engine speed is above a limiting value: 800rpm
The vehicle speed sensor does not indicate a fault.
The ISC open circuit test does not indicate a fault.
The ISC short circuit test does not indicate a fault.

Short Circuit Test

The vehicle status is power down.
The ISC power down referencing routine is taking place.

Open Circuit Test

The vehicle status is power down.
The power is not removed from the ISC circuitry.
The ISC coils are tristate, as indicated by the internal flag, STEPPER COILS TRISTATE.

6. Monitoring Time Length / Frequency of Checks

The frequency of the ISC diagnostic routine is 10Hz.

7 Criteria for Storing a Diagnostic Trouble Code

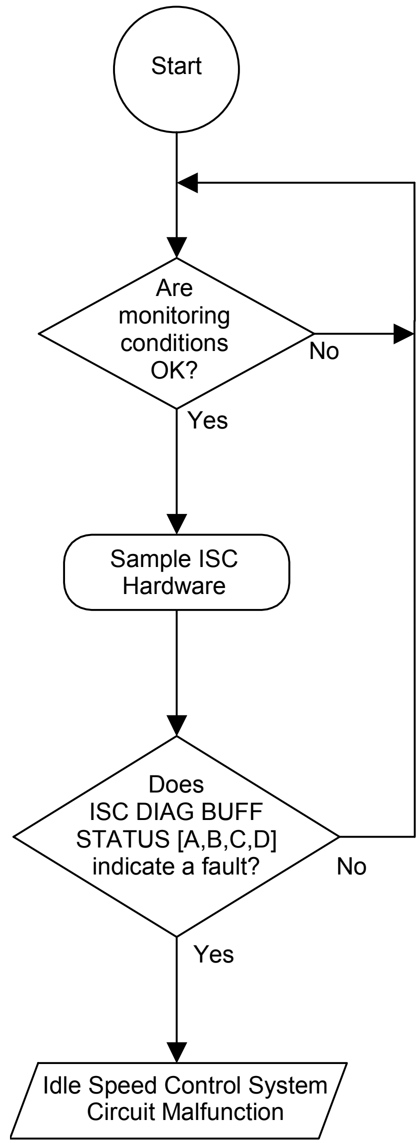
Two successive trips where the diagnostic routine indicates a failed stepper or stepper circuit.

8. Criteria for Illuminating MIL

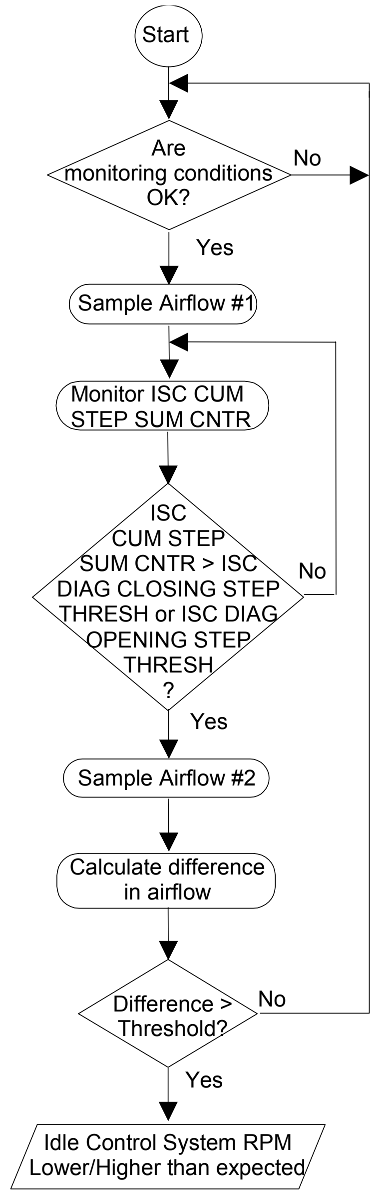
Two successive trips where the diagnostic routine indicates a failed stepper or stepper circuit.

9. Criteria for Determining Out of Range Input Signals
The mass airflow sensor is subject to out of range limits of 350mv and 4.5V.

3.21.2 Monitoring Structure – Short/Open Circuit Test



3.21.3 Monitor Structure – Closed Loop Test



Idle Speed Control Valve

Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
IDLE SPEED CONTROL VALVE	P0506- P0507 P1508-	Circuit continuity check A) Short circuit	Short Circuit fault counter	= 63	Engine status ISC status	Power down Referencing	5 sec (once per trip)	2 successive trips
(Output CC)	P1509	B) Open circuit	Open Circuit fault counter	= 50	Engine status ISC status ISC coils status Fuel control	Power down Energized Tristate Closed loop	3 sec (once per trip)	
		Correlation of MAF change to ISC steps check A) Closing throttle change in MAF B) Opening throttle change in MAF	Closing throttle IAC step counter - Decrease in MAF Opening throttle IAC step counter - Increase in MAF	< 6kg/hr @ > 30 steps < 10kg/hr @ > 50 steps	ISC status ECT Engine speed Disable Disable Disable	Active (C\L mode) > 75 Celsius > 800 RPM VSS fault Open circuit fault Closed circuit fault	0.1 sec	

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.22 Malfunction Indicator Lamp (MIL)

3.22.1 Description

1. Diagnostic Trouble Code:

MIL Line Fault	P1607

2. Monitoring Procedure
Whenever a fault event status is detected from the MIL drive hardware, a fault counter is incremented. When there is no fault event status from the MIL drive hardware the fault counter is decremented. When the fault counter reaches a given threshold there is a MIL lamp open or short circuit fault present.

3. Primary Detection Parameter
Hardware fault status from the MIL drive ASIC, which monitors line voltage before low side drive transistor.

4. Fault Criteria Limits
255 continuous fault events detected from the MIL drive ASIC.

5. Monitoring Conditions
Continuous

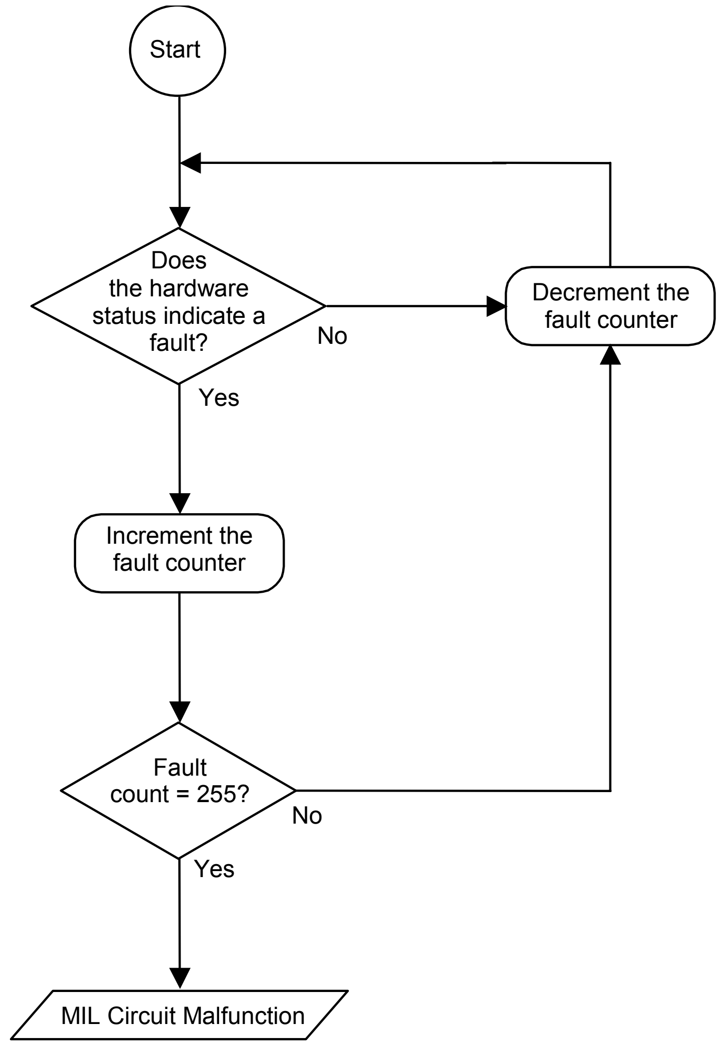
6. Monitoring Time Length / Frequency of Checks
The hardware fault status is checked every 10ms.

7. Criteria for Storing a Diagnostic Trouble Code
Two successive trips where the diagnostic routines indicate a failed MIL or MIL circuit.

8. Criteria for Illuminating MIL
Two successive trips where the diagnostic routines indicate a failed MIL or MIL circuit.

9. Criteria for Determining Out of Range Input Signals
The MIL monitoring procedure uses non-linear signals; the criteria will be signal/no signal.

3.22.2 Monitoring Structure



Malfunction Indicator Lamp								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
MIL CHECKING	P1607	Circuit continuity check (Attempts to illuminate the MIL in case of an intermittent fault)	ASIC fault counter - Low side transistor line voltage	= 255	All conditions	N/A	2.55 sec	2 successive trips

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.23 Ignition Coils

3.23.1 Description

1. Diagnostic Trouble Codes:

Ignition Coil 1 - early ignition coil activation fault	P1371
Ignition Coil 2 - early ignition coil activation fault	P1372
Ignition Coil 3 - early ignition coil activation fault	P1373
Ignition Coil 4 - early ignition coil activation fault	P1374
Ignition Coil 1 - no ignition coil activation fault	P1361
Ignition Coil 2 - no ignition coil activation fault	P1362
Ignition Coil 3 - no ignition coil activation fault	P1363
Ignition Coil 4 - no ignition coil activation fault	P1364

2. Monitoring Procedure

Summary

Problems with the ignition coils will be detected using two tests.

The tests work by monitoring the coil current status signal when the ignition coils are turned on during normal engine running. The status signal indicates that a threshold coil current has been reached, fully charging the coil. The coils are monitored to detect lack of full charge activation or early activation of the coils, a coil fault event occurring in either case.

If these tests are not passed then appropriate fault counter will be incremented, otherwise it will be decremented. If the count reaches a given threshold then a fault is present.

No Activation Test.

If the coil current status signal has not been asserted between the start and end of the coil activation period then there is a coil fault event, as long as the engine and battery conditions would normally guarantee that the signal would be asserted. Thus a coil fault event occurs if the COIL_CHARGE_EXPECTED flag is set, yet this logic signal was not asserted between the coil turn-on point and the coil turn-off point.

If a coil fault event has occurred, the relevant ignition fault event counter is incremented up to a predetermined limit. If this limit is reached then a no ignition coil activation fault is present. If the ignition coil fault event does not occur after a test then the relevant fault event counter is decremented, down to a limit of zero. When a fault event counter reaches zero then there is no fault present.

Early Activation Test

When the coil is requested to be activated, if the above coil charge signal is asserted earlier than would normally be expected, then there is a coil fault event. Thus a coil fault event occurs if a measured dwell time is less than the minimum expected dwell time. If the relevant fault counter reaches a predetermined limit then an early ignition coil activation fault is present.

If the ignition coil fault event does not occur after a test then the relevant ignition fault event counter is decremented, down to a limit of zero. When the fault event counter reaches zero no fault is present.

3. Primary Detection Parameter
Primary coil current status provided by the ignition coil drive ASIC, which compares coil current with a fixed (fully charged coil) threshold.

4. Fault Criteria Limits
No Activation Test
The presence or not of coil charge status signal within coil turn-on and turn-off point

Early Activation Test
Minimum expected time to fully charge the coil of 2ms

5. Monitoring Conditions
Lack of Activation Test
There must be a minimum battery voltage of 10 Volts for either test.
There is a maximum engine speed during which the tests will operate, i.e. 3500 rpm, to allow sufficient coil charge discharge time.

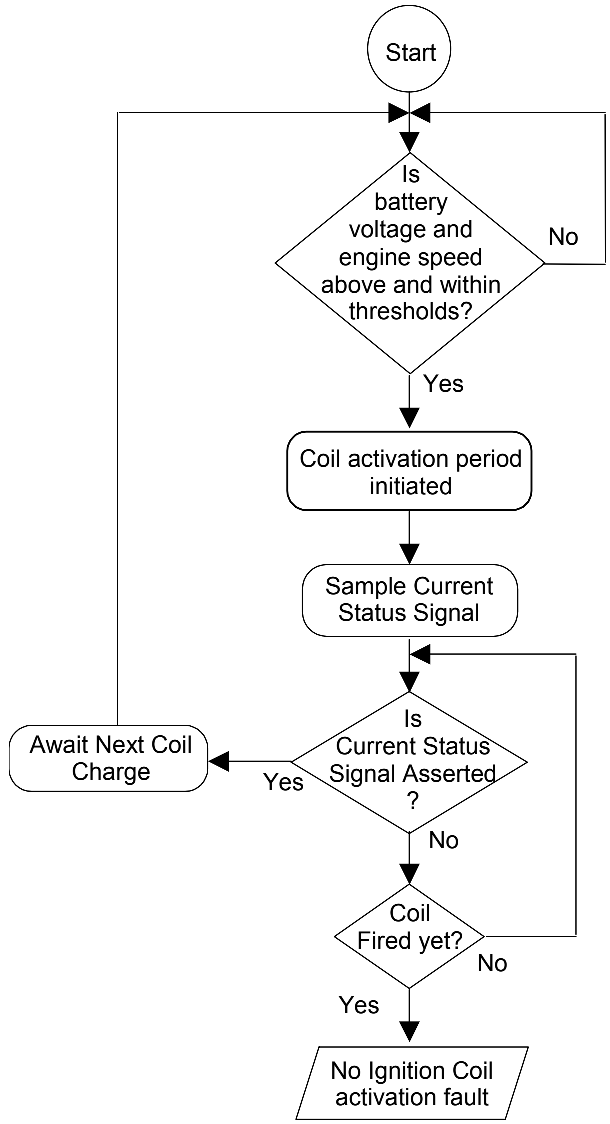
6. Monitoring Time Length / Frequency of Checks
The tests will be run every engine revolution, (double ended coils).

7. Criteria for Storing a Diagnostic Trouble Code
Two successive trips where the diagnostic routine indicates a failed coil/charging circuit.

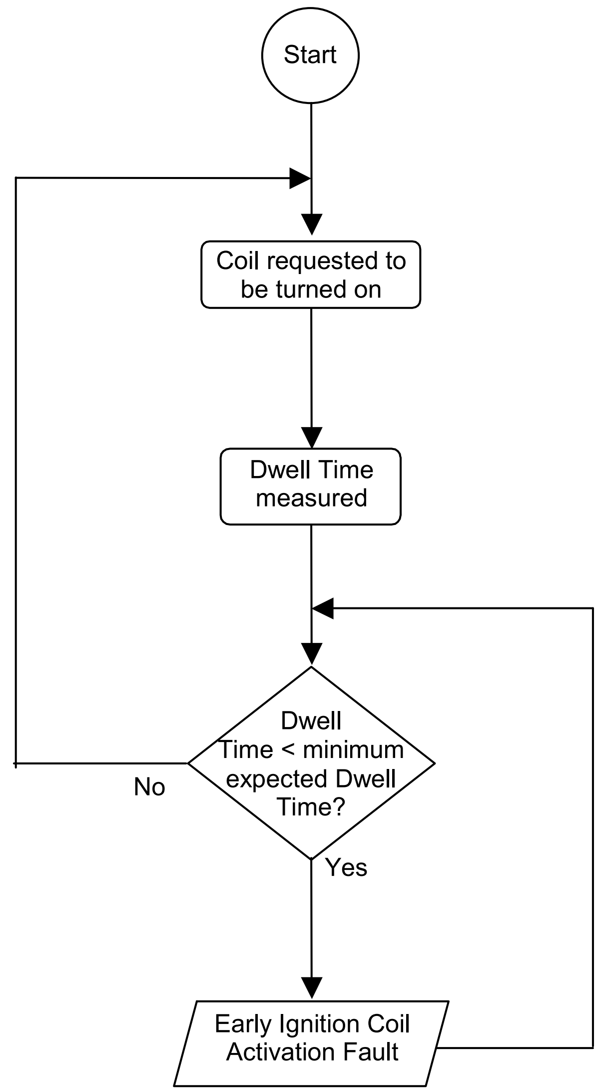
8. Criteria for Illuminating MIL
Two successive trips where the diagnostic routine indicates a failed coil/charging circuit.

9. Criteria for Determining Out of Range Input Signals
The coil current status signal is input as a digital high/low signal.

3.23.2 Monitoring Structure – No Activation Test



3.23.3 Monitoring Structure – Early Activation Test



Ignition Coils								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
IGNITION COIL	P1361-P1364 P1371-P1374	Coil tenderisation verification Early activation check	Coil fault counter – Maximum primary circuit Current Dwell time	≥254 6.2 amps < 2msec	 Battery voltage Engine speed Ignition status	 ≥ 10 v ≤ 3500 RPM Coil activation interval	 254 revolutions 254 revolutions	2 successive trips

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.24 Automatic Transmission Interface (Range Rover Only)

3.24.1 Description

1. Diagnostic Trouble Codes:

Automatic Transmission Control Module has signalled a fault condition to the ECM (Range Rover only)	P1775
Automatic Transmission Control Module ignition retard request duration fault (Range Rover only)	P1776
Automatic Transmission Control Module ignition retard request line fault (Range Rover only)	P1777

Engine Torque Signal
The engine torque signal is calculated by the ECM and output to the Automatic Transmission (A/T) Control Module as a 12 volt Pulse Width Modulation (PWM) signal format. The Warm up status of the ECM is passed on start-up for OBDII purposes

Throttle Angle Signal
Once again, a signal produced and output by the ECM directly to the Automatic Transmission Control Module (in a 12 volt PWM signal format). This signal is used with the other two signals to calculate when a gear change is necessary. If a fault occurs with this signal then the control module assumes a default throttle angle. Also used to indicate engine coolant temperature at start.

Ignition Retard (Torque Reduction)
The Automatic Transmission Control Module calculates the optimum shift point and in order to produce a smooth gear change sends a torque reduction signal to the ECM, which retards the ignition so reducing the engine torque to allow a smooth shift.

Engine Speed Signal
The engine speed signal is output by the ECM to the Automatic Transmission Control Module via the BeCM. The signal comprises of a 12 volt square wave with 4 pulses for every engine revolution.

Automatic Transmission Interface (Range Rover Only)								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
AUTOMATIC TRANSMISSION INTERFACE	P1775-	Verify handshaking between ECM & A/T Control Module	Consecutive MIL line pulses due to transmission fault.	5 pulses	Engine status	Not stalling	100 msec	Immediately
	P1777	Ignition retard request line	PWM signal	10%< PWM <14%	Pulse period	20 msec		
		Ignition retard request timeout	Duration of request	> 4 sec	Engine status Disable	Running Ignition retard request line fault	4 sec	2 successive trips
		Out of range check (TCM	PWM signal	10%> PWM >93%	Engine status	Running		Immediately

Automatic Transmission Interface (Range Rover Only)								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
		signal hardware) (Ignition retard request line fault)			Fuel control ECT Disable	Closed loop > 70 °C Ignition retard request line fault		

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.

3.25 Rough Road Signal

3.25.1 Description

1. Diagnostic Trouble Codes:

ABS - rough road signal line permanently at ground or open circuit	P1317
ABS - rough road signal line permanently at 12V	P1318

The ABS (where fitted) or rough road detection control module uses all four wheel speed signals to determine if the vehicle is on a surface liable to give false indication of misfire. This is signalled to the ECM, which disables misfire detection under these conditions the. The diagnostic checks the integrity of the link by confirming the line switches high / low.
Though the Defender doesn't have ABS, wheel sensors and a special ABS Control Module are fitted to provide a rough road signal.

Rough Road Signal								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
ROUGH ROAD SIGNAL	P1317-P1318	Handshake at ignition on	Fail to switch line high / low	Failed			5.5 sec	None (misfire enabled)

If the above table does not include details of the following enabling conditions: - intake air and engine coolant temperature, vehicle speed range, and time after engine start-up then the state of these parameters has no influence upon the execution of the monitor.