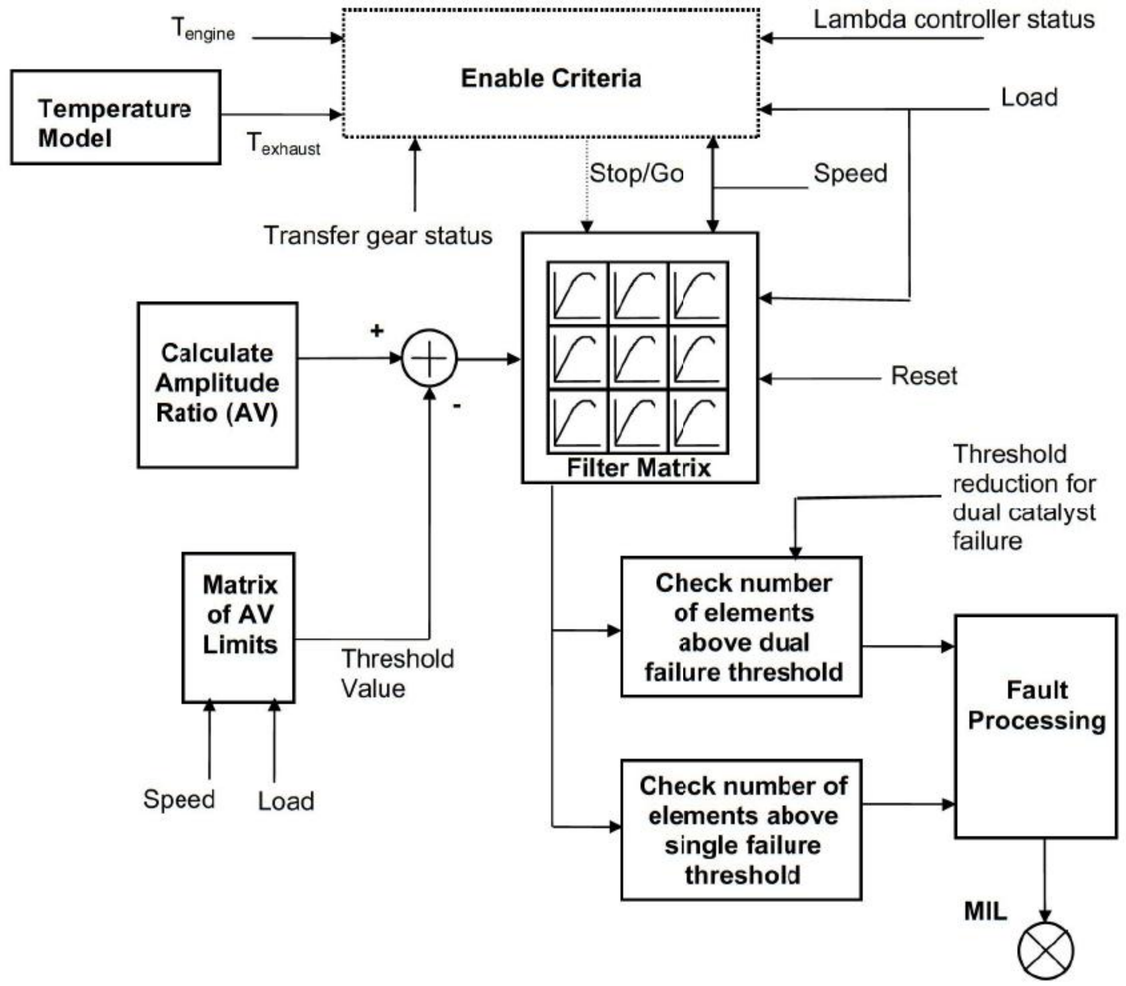
4.1.3 Block Diagram of system Operation



Catalyst Monitoring Operation – Discovery Series II

Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
Catalyst Bank 1	P0420	oxygen storage capability	rear oxygen sensor amplitude exceeds the modelled amplitude of a borderline catalyst (1.75 x standard (Hydrocarbon - (HC) emissions))	> 0.4023	engine speed engine load	1200 < rpm < 1800 between 1.8 and 3.8 msec at 1200 Rpm to between 1.9 and 4.15 msec at 1800 rpm	100 sec/ once per driving cycle	two driving cycles
					catalyst temperature (model) transfer gears	> 332 °C high range		
Bank 2	P0430			> 0.4023	fuel system status EVAP canister purge vapour factor enable conditions	closed loop < 10.0 valid for > 0.8 sec		

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

Catalyst Monitoring Operation – Range Rover 38A

Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
Catalyst Banks 1 and 2 (Dual catalyst deterioration)	P0420 P0430	oxygen storage capability	amplitude ratio of O2S, rear/front (1.5 x standard + 4K (HC emissions))	> 0.5 (min. 4 of 4 samples per cylinder bank)	engine speed engine load catalyst temperature (model) IAT	1000 < rpm < 2800 1.2< TL msec <4.0 > 300 °C > -9.75 °C	250 sec/ once per driving cycle	two driving cycles
Bank 1 or 2 (Single catalyst deterioration)				> 0.75 (min. 4 of 4 samples for one cylinder bank)	transfer gears fuel system status EVAP canister purge vapour factor time after start	high range closed loop < 10.0 > 69.12 sec		

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

4.2 Misfire Monitoring

4.2.1 Description

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

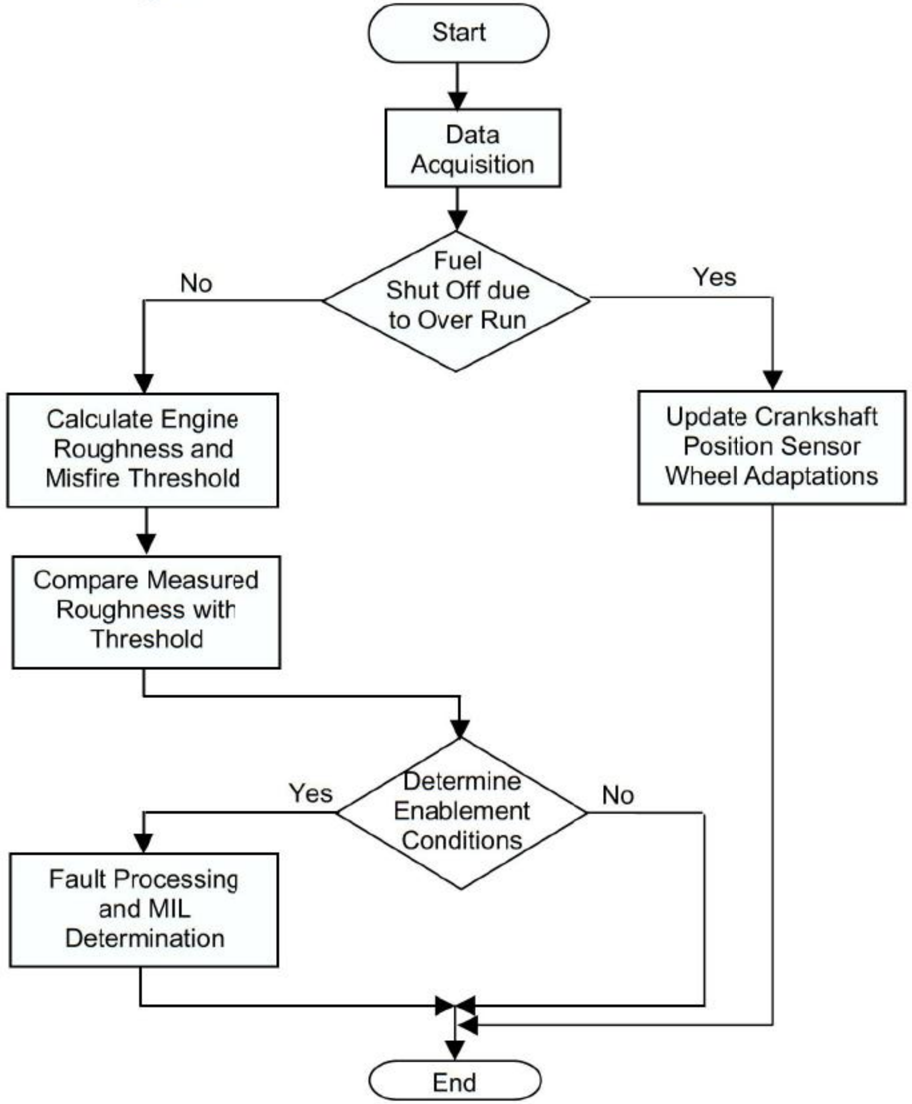
In order to detect misfiring in any cylinder, the torque of each cylinder is evaluated by recording the time between two ignition events; this is a measure of the mean value of the speed for this angular segment. Since a change in the engine torque results in a change of the engine speed. Additionally, the influence of the load torque at the wheels needs to be determined. This is to take account of the influences of different road surfaces, e.g. pavement, pot holes etc.

If the mean engine speed is measured, influences caused by road surfaces have to be eliminated.

This method consists of the following main parts:

- Data acquisition, including adaptation of the sensor wheel.
- Calculation of engine roughness.
- Comparison with a threshold, which depends on the operating conditions.
- Identification of extreme conditions, during which misfire detection cannot be enabled due to a risk of falsely detecting misfire.
- Fault processing, counting procedure of single misfire events, recording of any diagnostic trouble codes and MIL illumination.

4.2.2 Monitoring Structure



1. Data Acquisition

The duration of the crankshaft segments is measured continuously for every combustion cycle.

2. Crankshaft Position Sensor Wheel Adaptation

Within a defined engine speed range and during fuel cut-off, the adaptation of the crankshaft position sensor wheel tolerances is performed. As the adaptation process progresses, the sensitivity of the misfire detection is increased. The adaptation values are stored in non-volatile memory and are taken into consideration during the calculation of the engine roughness.

3. Misfire Detection

The following steps are performed for each measured segment, corrected by the appropriate crankshaft position sensor wheel adaptation.

3.1 Calculation of the engine roughness

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

3.2 Detection of multiple misfiring

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

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

3.3 Calculation of the engine roughness threshold value

The engine roughness threshold value consists of the base value, which is determined from a load and speed dependent map. During warm-up an ECT dependent correction value is added. For multiple misfiring the threshold is reduced by an adjustable factor. Before sufficient crankshaft position sensor wheel adaptation has occurred, the engine roughness threshold is limited to a speed dependent minimum value. A change of the threshold towards a smaller value is limited by a variation constant.

4.0 Determination of misfiring

Misfire detection is performed by comparing the engine roughness threshold with the engine roughness value.

4.1 Statistics, fault processing

Within an interval of 1000 crankshaft revolutions the detected misfire events are summed for each cylinder. If the sum of all cylinder misfire incidents exceeds a predetermined value, the preliminary diagnostic trouble code for emission relevant misfiring is stored. If only one cylinder is misfiring, a cylinder selective diagnostic trouble code is stored. If more than one cylinder is misfiring, the diagnostic trouble code for multiple misfiring is also stored. If the misfire is again detected on a subsequent drive cycle, then the MIL is illuminated and the appropriate diagnostic trouble code is stored.

Within an interval of 200 crankshaft revolutions the detected number of misfiring events is weighted and calculated for each cylinder. The weighting factor is determined by a load and speed dependent map.

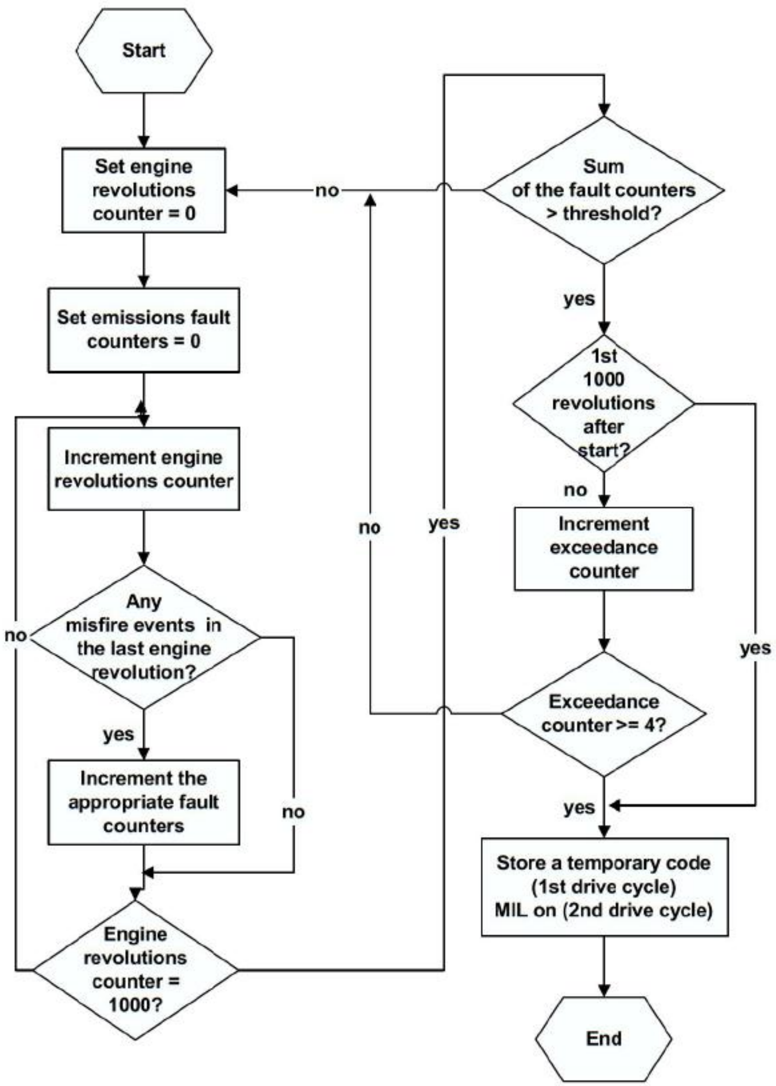
If the sum of cylinder misfire incidents exceeds a predetermined value the diagnostic trouble code for indicating catalyst damage relevant misfiring is stored and the MIL is illuminated at once (flashing).

If the cylinder selective count exceeds the predetermined threshold the following measures are instituted:

- The oxygen sensor closed loop system is switched to open loop.
- The appropriate cylinder selective DTCs is/are stored.
- If more than one cylinder is misfiring, the DTC for multiple misfire is also stored.

All misfire counters are reset after each interval.

4.2.3 Fault Processing for Emissions Relevant Misfire



Misfire Monitoring Operation - Discovery

Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
Misfire	P0301 to P0308 P0300 P1300	crankshaft speed fluctuation multiple misfire	Federal Test Procedure (FTP) emissions Threshold	> 1.875 %/ 1000 revolutions	engine speed load change (after start) speed change (after start)	520 < rpm < 5400 < 1.20 ms/rev (< 130.8 ms/rev) < 4000 rpm/sec (< 20 000 rpm/sec)	1000 revolutions up to twice in one drive cycle/ continuous	two driving cycles
			catalyst damage	8.6 to 16.8 % at 600 rpm 7.4 to 14.6 % at 1000 rpm 2.0 to 10.7 % at 2000 rpm 1.9 to 9.9 % at 3000 rpm 1.8 to 8.3 % at 4000 rpm 1.8 to 5.0 % at 5000 rpm	engine load rough road (ABS) gear change traction control transfer gears re-enablement delay (not active after engine start)	Positive not set not active not active high range 20 revolutions	200 revolutions/ continuous	immediately

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

Misfire Monitoring Operation – Range Rover

Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
Misfire	P0301 to P0308 P0300 P1300	crankshaft speed fluctuation multiple misfire	FTP emissions threshold	> 2.0 %/ 4000 ignitions	engine speed load change	520 < rpm < 5400 < 0.10 ms/ignition	1000 revolutions/ continuous	two driving cycles
			catalyst damage 4.0 litre 4.6 litre	4.0 % to 15.9 % 3.8 % to 19.3 % for the speeds and loads encountered during the FTP	speed change engine load rough road (ABS) traction control transfer gears time after start	< 720 rpm/sec positive not set not active high range > 5.0 sec	200 revolutions/ continuous	immediately

Misfire Monitoring Operation – Range Rover

Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
	P1319	low fuel level check	Fuel level	< 15%	misfire detection status	diagnostic trouble code stored	Immediately/ continuous	immediately

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

4.3 Secondary Air Injection System Monitoring

4.3.1 Description

The secondary air injection system consists of an electric pump that is controlled by the ECM via a relay. Air is supplied by the pump to two vacuum operated control valves, one per cylinder bank. From each of the control valves air is delivered to the exhaust ports of the centre two cylinders of each cylinder bank. The vacuum signal is switched via an ECM controlled solenoid valve. A vacuum reservoir ensures that there is always sufficient depression to operate the control valves.

Diagnosis of the secondary air injection system can take place in two steps. There is a passive diagnostic which checks for a lean shift in the signals from the front oxygen sensors during secondary air injection operation and there is an active check, which only runs if the passive check fails to achieve sufficient test results in any drive cycle. The active test has two parts; firstly the secondary air injection pump will be run with the control valves shut. If the valves are leaking or stuck open, the feedback fuelling will shift lean and a fault will be detected. If the valve check is passed, then the valves will be opened and if sufficient secondary airflow exists, then the fuelling will be shifted lean. If the lean shift is less than the required threshold, then a fault is stored.

Additionally, a total absence of secondary injection airflow does not cause the vehicle to exceed the appropriate monitoring threshold. Therefore the system only requires a functional check for the presence of secondary air.

Passive Secondary Air Injection Diagnostic

For this test to run the front O2 sensors must have been ready for operation for longer than a certain time, the secondary air injection system must be operating, the engine speed and load must be within a pre-determined window, engine airflow must be less than an altitude dependent threshold and the ECT must be greater than a threshold.

The front O2 sensors are monitored over a time period and the minimum voltage value recorded. When a second timer expires, a test counter is incremented and the minimum sensor value is compared with a threshold. If the voltage is less than the threshold then a counter of good test results is incremented. When the test counter reaches a threshold, the number of good test results is compared with a limit value. If the number of good results is greater than the limit then the Secondary Air Injection system is functioning correctly, otherwise a fault is stored and the MIL is illuminated on the next drive cycle, if the fault is again present.

Active Secondary Air Injection Diagnostic

If on any drive cycle during which secondary air injection operation has occurred, there are insufficient passive diagnostic test results for fault determination. The system will then attempt to perform an active check of the secondary air injection system. For an active test to occur, the vehicle must be at rest with the engine idling, feedback fuel control enabled, below an altitude threshold, with the engine having been running for longer than a pre-determined time and secondary air injection not operating. If the EVAP canister purge is operating, then it will be ramped down to zero.