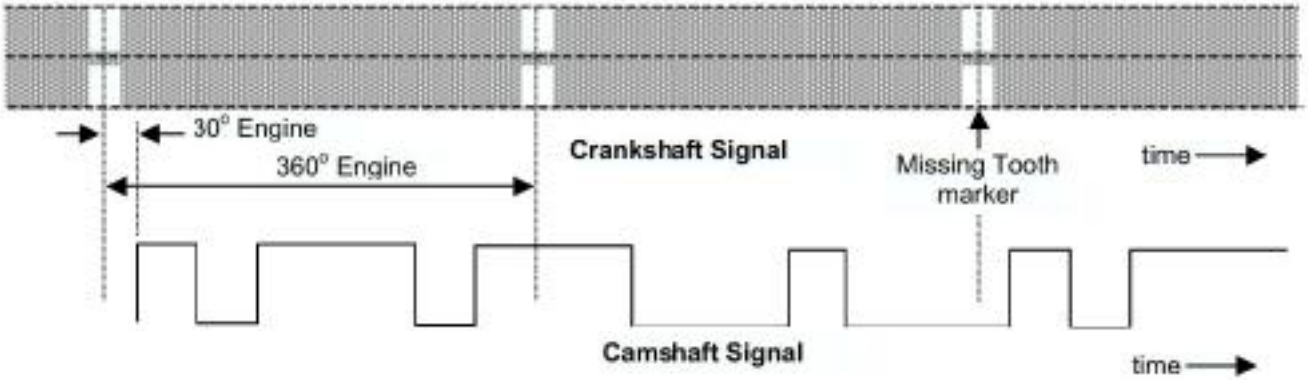
4.10 Camshaft Position Sensor

4.10.1 Description

This is a Hall effect sensor producing four pulses for every two engine revolutions. The sensing element is positioned between 0 and 2mm from the side of the cam gear wheel. The sensor is, in effect, a magnetically operated electrical switch, switching a battery supply level voltage on or off dependent on the position of the cam gear wheel with respect to the sensor.



The cam gear wheel has four slots machined in it enabling cylinder identification every 90°. The signal is used for cylinder recognition; enabling sequential fuel injection, knock control and cylinder identification for diagnostic purposes.

The system checks the camshaft position sensor signal at every software reference mark i.e., 54° before top dead centre (2 teeth after the reluctor 2nd missing tooth). A fault condition is recognised if the signal does not change state (high to low or low to high voltage) every crankshaft revolution.

Camshaft Position Sensor								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
Camshaft Position Sensor	P0340	rationality check	signal sequence	incorrect signal	crankshaft revolutions	> 100 revolutions	0.500 sec/ continuous	two driving cydes

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.

4.11 Engine Coolant Temperature Sensor

4.11.1 Description

This sensor is a temperature dependant resistor (thermistor), which is a Negative Temperature Co-efficient (NTC) type, i.e. resistance decreases with increasing temperature. The sensor forms part of a voltage divider chain with a pull up resistor within the ECM. The change in resistance relates to change in the ECT.

The sensor is vital to the correct running of the engine as a richer mixture is required at lower block temperatures for good quality starts and smooth running, leaning off as the temperature rises to maintain emissions and performance. Should the sensor fail there is a software ECT warm-up model which will supply a changing default value during the warm up stage of the engine, based upon IAT. After the software model reaches 60°C ECT, a fixed default value of 85°C is used. The model also forms part of the diagnostics for the ECT sensor, in conjunction with open and short circuit tests.

A fault condition is recognised if the ECM is powered up and the ECT sensor resistance exceeds a minimum or maximum threshold, or the difference between the ECT model and the temperature indicated by the ECT sensor is greater than a threshold.

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	P0117 P0118	circuit continuity range check (min) range check (max)	voltage resistance	> 34.166 kΩ (-35.25°C) < 70.96Ω (139.5°C)			0.180 sec/ continuous	two driving cycles
	P0116	rationality check (temperature model = ƒ [IAT, air mass, time])	difference to model temperature	> -20.25°C			2.54 sec/ continuous	

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.

4.12 Mass Airflow Sensor and Intake Air Temperature Sensor

The MAF sensor is a combined MAF sensor and IAT sensor.

4.12.1 Mass Airflow Sensor

4.12.2 Description

Airflow is determined by the cooling effect of the intake air passing over a "hot film" element contained within the device. The higher the air flow the greater the cooling effect and the lower the electrical resistance of the 'hot film" element. The signal from the device is then used by the ECM to calculate the MAF into the engine.

The measured airflow is used in determining the fuel quantity to be injected in order to maintain the stoichiometric air fuel ratio required for correct operation of the engine and exhaust catalysts. Should the device fail there is a software backup strategy that will be evoked once a fault has been diagnosed. A fault is detected if the MAF signal exceeds the maximum or minimum threshold for a given speed range or the difference between the calculated load and the actual MAF signal is too great.

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	P0102	range check (min)	air flow verses engine Speed 4.0 litre 4.6 litre	<2.43 g/sec(@ 800 rpm) To 8.96 g/sec(@ 5000 rpm)	engine speed	> 400 rpm > 200 rpm (for > 0.3 sec)	0.5 sec/ continuous	two driving cycles
	P0103	range check (max)		>40.0g/sec to 224.5g/sec > 46.7g/sec to 248.9g/sec (1000 RPM to 5400 rpm)		> 200 rpm (for > 0.3 sec)	0.3 sec/ continuous	
	P0101	rationality check (low/high)	comparison of calculated load (engine speed and throttle position) to actual MAF signal	adaptation factor (af) 1.5 < af < 0.35	engine speed engine load ECT	800< rpm< 4000 2<TL msec<6.5 > -9.75° C	immediately/ continuous	

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.

4.12.3 Intake Air Temperature Sensor

4.12.4 Description

The IAT sensor is a temperature dependent resistor (thermistor), i.e. the resistance of the sensor varies with temperature. The thermistor is an NTC type element, which means that the sensor resistance decreases as the sensor temperature increases. The sensor forms part of a voltage divider chain with an additional resistor in the ECM. The voltage from this network changes as the sensor resistance changes, relating the IAT to the voltage measured by the ECM.

A fault is detected if the resistance of the sensor exceeds a minimum or maximum threshold.

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	P0113	circuit continuity range check (max)	voltage resistance	<82.7• •(>139.5°C)			0.20 sec/ continuous	two driving cycles
	P0112	range check (min)		>29.9k• •(<-35.25°C)	time after start engine load fuel system status	> 100 sec idle not in ORFCO (all above for > 10 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.

4.13 Knock Sensor

4.13.1 Description

The ECM uses active knock control, which serves to prevent engine damaging pre-ignition or detonation under all operating conditions enabling the engine to operate without additional safety margins. For the ECM to be able to determine the point at which a cylinder is pre-detonating, 2 piezo ceramic sensors are mounted on the engine block. Each sensor monitors all 4 cylinders in a bank (i.e. cylinders 1, 3, 5 & 7, and cylinders 2, 4, 6 and 8) by converting the engine block noise into a suitable electrical signal, which is then transmitted back to the ECM via a shielded cable. The signal is then processed within the ECM to identify the data that characterises knocking.

There are three knock sensor diagnostic checks during which a fault is detected if: -

1. The sensor signal is less than the minimum engine rpm dependant threshold.
2. The sensor signal is greater than the maximum engine rpm dependant threshold.
3. The error counter for the verification of knock internal circuitry is exceeded.

Knock Sensor								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold Value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
Knock Sensor		sensor reference voltage check	sensor reference voltage (10 samples)		knock control	active (for at least 50 engine revolutions)	approximately 20 engine revolutions/ continuous	No MIL illumination
Bank 1	P0327			from <2.44 mV at 2000 rpm to <25.02mV at 5200 rpm	engine speed	> 2200 rpm (and not changing dynamically)		
Bank 2	P0332							
Bank 1	P0328			from>207.5mV at 2000 rpm to >622.6mV at 5200 rpm				
Bank 2	P0333							
	P0606	response to test Signal	integrator output (3 samples)	< 3.51V	ECT	> 60 °C	approximately 740 engine revolutions/ continuous	
		null test **OR**	integrator output (3 samples) integrator change **AND** engine speed	> 3.353V > 45.5V/sec < 4200 rpm				

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.

4.14 Throttle Position Sensor

4.14.1 Description

The sensor is a variable resistor, which is used to determine the position of the throttle plate and the rate of change in its angle. A software strategy within the ECM enables the closed throttle position to be learnt, enabling the sensor to be fitted without the need for adjustment. The signal is used by the ECM as part of the transient fuelling strategy and to determine the closed throttle position for idle speed control, in conjunction with road speed.

The signal is not only checked for range (exceeds a minimum or maximum threshold), but also for plausibility against MAF. If the load-monitoring fault is stored, it is indicative of a blocked air filter or collapsed air intake duct etc. It is also probable that the altitude adaptation factor is incorrect under these conditions.

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	P0122 P0123	range check (min) range check (max)	voltage	< 0.195V (3.9%) > 4.83V (96%)	engine speed	> 400 rpm (for > 2.0 sec)	0.05 sec/ continuous	two driving cycles
	P0101	rationality check (low/high)	comparison of calculated load (engine speed and throttle position) to actual MAF signal	adaptation factor 1.5 < af < 0.35	engine speed engine load ECT	800< rpm <4000 2.0<TL msec< 6.5 > -9.75° C	immediately/ continuous	

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.

4.15 Engine Control Module Self Test

4.15.1 Description

The ECM performs a number of self-test integrity diagnostics on its interral hardware and software to check for faults. An error is detected if the ECM receives no CAN messages for at least 0.8 seconds, the calculated checksums at power down do not match the values stored in flash Electrically Erasable Programmable Read Only Memory (EEPROM) or the internal or external RAM fails a read/write test.

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	P0600	bus check	no CAN messages	> 0.800 sec			immediately/ continuous	two driving cydes
	P0601	self check of ROM contents	invalid checksum		at power down		0.20/0.30 sec	
	P0603	external RAM check	fails read/write test					
	P0604	internal RAM check	fails read/write test		at power up			

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.

4.16 Fuel Level Sensor

4.16.1 Description

This input is required as part of the misfire detection system in order to record if a 'low fuel' situation was present when misfire was detected and logged as a fault. On Range Rover 38A the ECM is required to read an analogue fuel level input and determine the 'low fuel' condition from this signal. Discovery Series II had an active high digital input until 2000MY, at which point this input also became an analogue signal.

There are three fuel level input diagnostic checks, during which a fault is detected if: -

1. The input signal is less than a minimum voltage threshold.
2. The input signal is greater than a maximum voltage threshold.
3. The percentage difference between the fuel consumption calculated by the ECM and the change in the fuel tank level is greater than a threshold.

Fuel Level Sensor								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
Fuel Level Sensor	P0460	rationality check between the fuel consumption calculated by the ECM and the change in fuel tank level	calculated fuel consumption - change in fuel tank level	< -21.5% **or** > 20.4% (37.6% if tank full, which is defined as tank level > 91.4%)	total fuel used distance traveled transfer gears	> 21.5% > 0.62 miles high range	immediately/ continuous	no MIL illumination (leak detection defaults to enabled)
	P0462	range check (min)	voltage	< 0.49V			10.0 sec/	
	P0463	range check (max)		> 4.294V			continuous	

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.

4.17 Vehicle Speed Signal

4.17.1 Description

The vehicle speed signal is transmitted from either the Self Levelling, Anti-lock Braking System (SLABS) or the ABS control module. This signal is then passed by the ECM to the automatic TCM via the CAN bus. The ECM has input diagnostics for this signal; the SLABS/ABS signal is compared to the vehicle speed signal on CAN from the automatic TCM, derived from the main gearbox output shaft speed; if the difference is greater than a threshold then a fault is detected.

Vehicle Speed Signal								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
Vehicle Speed Signal	P0501	plausibility check	difference to calculated speed	> 31.1 mph	vehicle speed	> 49.7 mph	10.0 sec/ continuous	two driving cycles

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.

4.18 Power Supplies

4.18.1 Description

The ECM requires a permanent battery level voltage supply and a switched battery level voltage supply. The switched voltage supply is controlled by the ECM via a relay based on the condition of the ignition switch input (key position 2). At "key off" the ECM will maintain the switched supply active until various internal self-checks have been completed.

There are three battery voltage plausibility checks during which a fault is detected if: -

1. The battery voltage supply is less than a minimum voltage threshold.
2. The battery voltage supply is greater than a maximum voltage threshold and a jump-start condition has not been detected.
3. The battery voltage supply is less than a voltage threshold 60 seconds after the engine has been started.

Battery Voltage								
Component/ System	Fault Codes	Monitoring Strategy Description	Malfunction Criteria	Threshold value	Secondary Parameter	Enable Conditions	Time Required	MIL Illumination
Battery Voltage	P0560	battery voltage plausibility checks	battery voltage	< 2.55V			immediately/ continuous	no MIL illumination
	P0562		battery voltage	< 9.05V	time since engine start	> 60.0 sec		
	P0563		battery voltage	> 16.03V	jump start (vehicle speed = 0 and voltage > 15.0V)	not detected		

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.