Published: 11-May-2011

Electronic Engine Controls - I6 3.2L Petrol -

Item	Specification
Heated oxygen sensor (H02S) removal*	Apply WD40 or equivalent
Heated oxygen sensor (H02S) threads	Apply suitable high temperature anti-seize compound to threads of sensor (Castrol Optimol)

*** Apply to area around sensor threads prior to attempting to remove sensor**

General Specification

Item	Specification
Engine management system:	
Make	Denso
Camshaft position sensor:	
Make	Denso
Type	MRE (hall affect)
Crankshaft position sensor:	
Make	Denso
Type	Variable reluctance

Torque Specifications

Description	Nm	lb-ft
Camshaft position (CMP) sensor bolt+	10	7
Catalyst monitor sensor	45	33
Catalyst monitor sensor harness support bolt	6	5
Crankshaft position (CKP) sensor Torx bolt	10	7
Engine control module (ECM) bracket bolts	6	4
Flywheel sensor bolt	10	7
Flywheel sensor bracket screws	10	7
Fuel rail pressure sensor	6	5
Heated oxygen sensor (H02S)++	45	33
Knock sensor retaining bolt	20	14
Mass air flow (MAF) sensor Torx screws	2	1

+ Apply clean engine oil to a new CMP sensor O-ring seal

++ Apply anti-seize lubricant to threads of sensor - See Lubricants

Part Number

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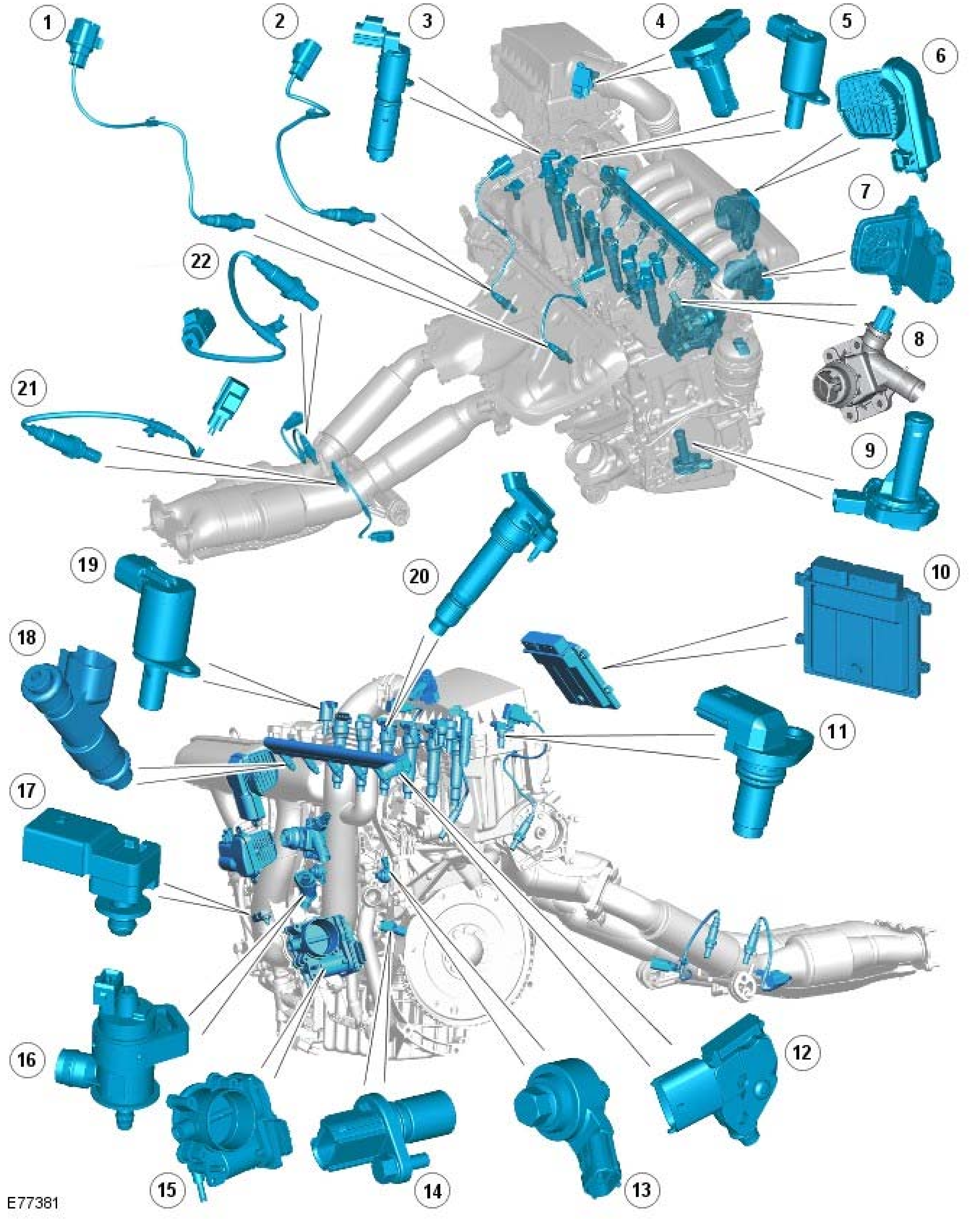
Electronic Engine Controls - I6 3.2L Petrol - Electronic Engine Controls

Description and Operation

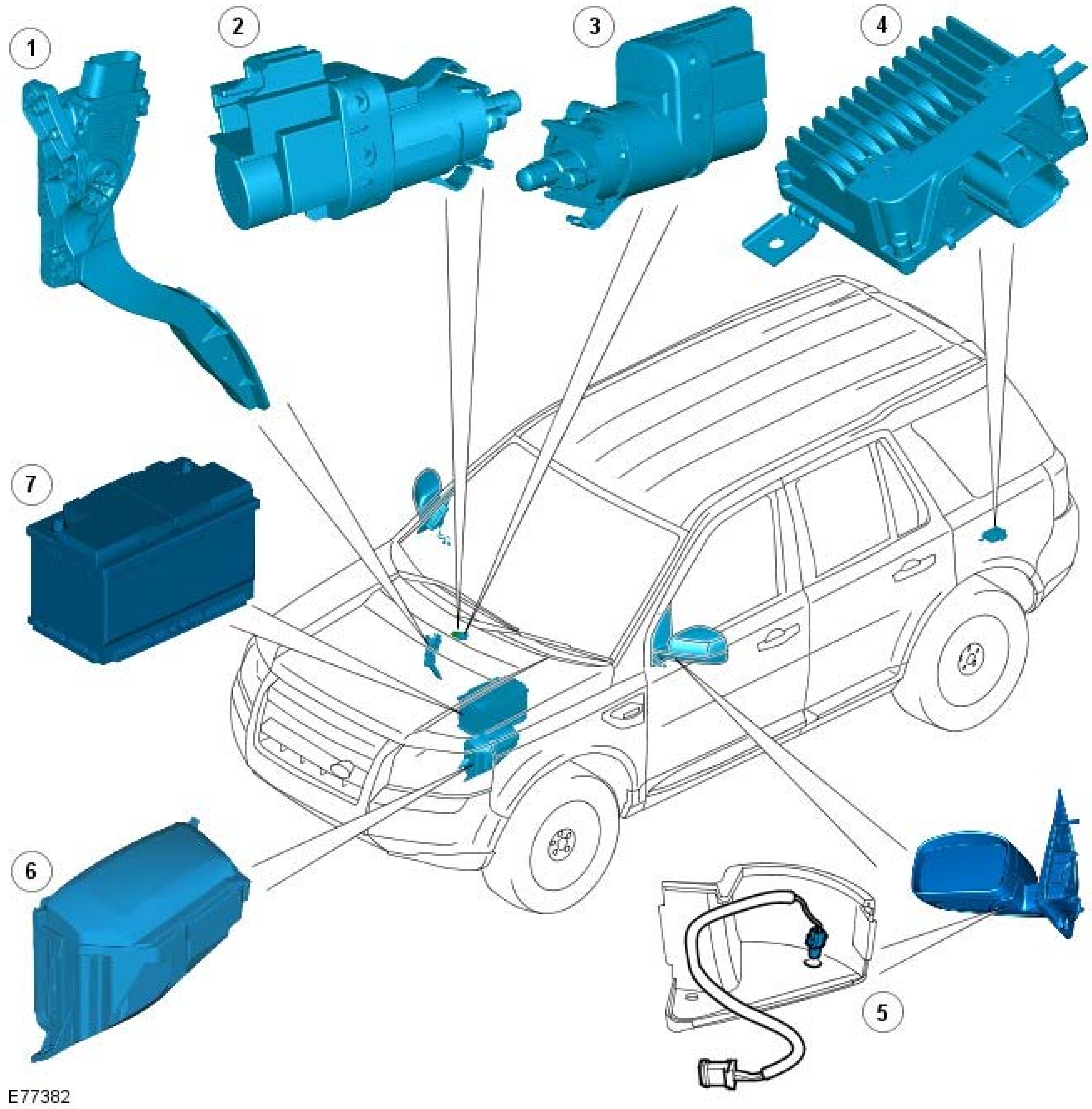
COMPONENT LOCATION SHEET 1 OF 2



Item	Part Number	Description
1	-	Heated Oxygen Sensor (HO2S) Pre-catalyst
2	-	HO2S Pre-catalyst

3		Variable Camshaft Timing (VCT) solenoid
4		Mass Air Flow (MAF) sensor
5		Camshaft Profile Switching (CPS) solenoid - rear
6		Plenum variable intake manifold valve
7		Intake tract variable intake manifold valve
8		Engine Coolant Temperature (ECT) sensor
9		Engine oil level/temperature sensor
10		Engine Control Module (ECM)
11		Camshaft Position (CMP) sensor (2 off)
12		Fuel rail temperature/pressure sensor
13		Knock sensors (2 off)
14		Crankshaft Position (CKP) sensor
15		Electric throttle
16		Purge valve
17		Manifold Absolute Pressure (MAP) sensor
18		Injectors (6 off)
19		CPS solenoid - Front
20		Ignition coil (6 off)
21		HO2S Post-catalyst
22		HO2S Post-catalyst

COMPONENT LOCATION SHEET 2 OF 2



Item		Description
1		Accelerator Pedal Position (APP) sensor
2		Speed control inhibitor switch
3		Stop lamp switch
4		Fuel Pump Driver Module (FPDM)
5		Ambient air temperature sensor
6		Battery Junction Box (BJB)
7		Battery

OVERVIEW

The Engine Control Module (ECM) controls the following:

- Engine fueling
- Ignition timing
- Closed loop fueling
- Knock control
- Idle speed control
- Emission control
- On Board Diagnostics
- Speed control.

The ECM controls engine fueling by providing sequential fuel injection to all cylinders. Ignition is controlled by a direct ignition system, provided by 6 plug top coils. The ECM is able to detect and correct for ignition knock on each cylinder and adjust the ignition timing for each cylinder to achieve optimum performance.

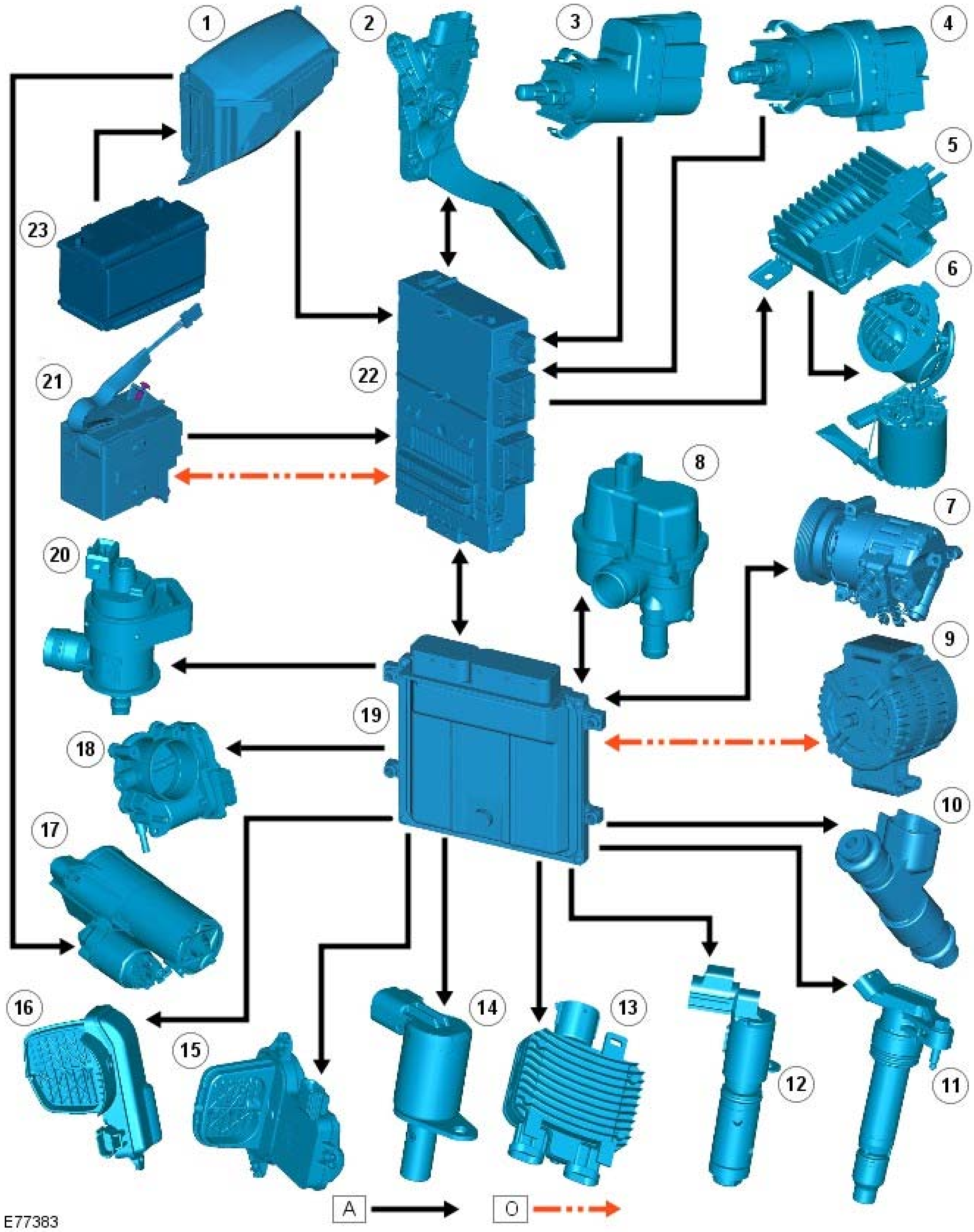
The ECM uses a torque-based strategy to generate the torque required by the driver and other vehicle control modules. The ECM uses various sensors to determine the torque required from the engine. The ECM also interfaces with other vehicle electronic control modules via the high speed Controller Area Network (CAN) bus, to obtain additional information (for example road speed from the Anti-lock Brake System (ABS) module). The ECM processes these signals and decides how much torque to generate. Torque is then generated by using various actuators to supply air, fuel and spark to the engine.

The ECM also uses an electronic throttle system which comprises the electric throttle assembly and an Accelerator Pedal Position (APP) sensor.

The ECM also interfaces with the immobilization system to help prevent the vehicle being started without proper authorization.
For additional information, refer to: Anti-Theft - Active (419-01, Description and Operation).

CONTROL DIAGRAM SHEET 1 OF 2

NOTE: **A** = Hardwired; **N** = Medium speed CAN bus; **O** = Local Interconnect Network (LIN) bus

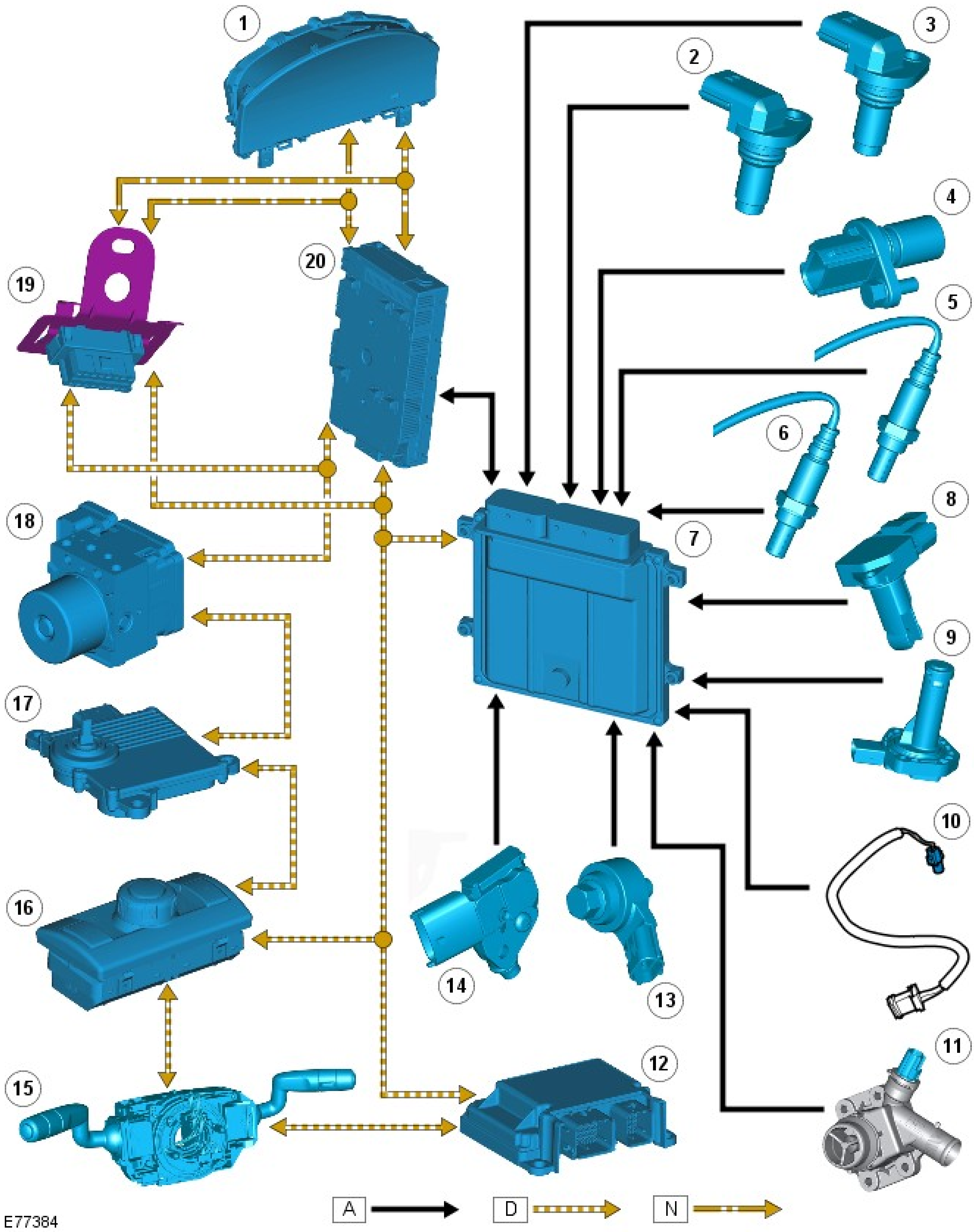


Item		Description
1		BJB
2		APP sensor
3		Speed control inhibit switch
4		Stop lamp switch
5		FPDM
6		Fuel pump
7		Air Conditioning (A/C) compressor

8		Fuel tank leakage monitoring module (North American Specification (NAS) only)
9		Generator
10		Injectors (6 off)
11		Ignition coils (6 off)
12		VCT solenoid
13		Electric fan control module
14		CPS solenoids- front/rear
15		Intake tract variable intake manifold valve
16		Plenum variable intake manifold valve
17		Starter motor
18		Electric throttle
19		ECM
20		Purge valve
21		Start/stop switch
22		Central Junction Box (CJB)
23		Battery

CONTROL DIAGRAM SHEET 2 OF 2

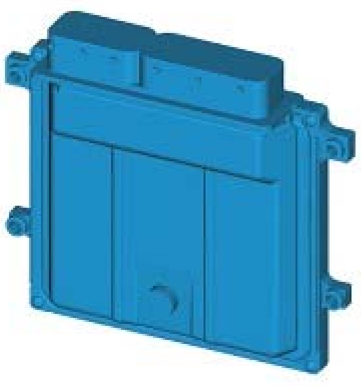
NOTE: **A** = Hardwired; **D** = High speed CAN bus; **N** = Medium speed CAN bus



Item		Description
1		Instrument cluster
2		Intake CMP sensor
3		Exhaust CMP sensor
4		CKP sensor
5		Pre-catalyst HO2S
6		Post catalyst HO2S
7		ECM

8		MAF/IAT
9		Engine oil level/temperature sensor
10		Ambient Air Temperature (AAT) sensor
11		ECT sensor
12		Restraints Control Module (RCM)
13		Knock sensors (2 off)
14		Fuel rail temperature/pressure sensor
15		Clockspring
16		Terrain response control module
17		Transmission Control Module (TCM)
18		ABS module
19		Diagnostic socket
20		CJB

ENGINE CONTROL MODULE (ECM)



E88726

The ECM is located on a bracket in a central position on the engine compartment firewall. The ECM is attached to a housing and secured with 4 screws. The housing is located in the bracket and locked in position.

The ECM is supplied with battery voltage from fuses located in the BJB. A permanent battery supply is provided to ensure adaptive data is not lost when the engine is switched off.

A regulator, located within the ECM, supplies a 5V current to internal components such as the micro-processor unit. Other components or functions requiring full battery voltage are controlled by external relays or internal power stages.

The micro-processor within the ECM receives signals from different components and control modules and uses a program within the ECM software to interpret the signal information and issue signals which relate to how the engine components and functions should be controlled.

The ECM receives inputs from the following:

- CMP sensors
- CKP sensor
- Fuel rail pressure sensor
- MAF sensor
- Knock sensors
- Fuel rail temperature/pressure sensor
- ECT sensor
- Engine oil level/temperature sensor
- Manifold Absolute Pressure (MAP) sensor
- Electric throttle - Throttle Position (TP) sensor
- APP sensor
- Fuel tank leakage monitoring module (NAS only)
- Cooling fan control
- Heated Oxygen sensors (HO2S)
- Stop lamp switch (via Central Junction Box (CJB))
- Speed control inhibit switch
- Intake Air Temperature (IAT) sensor
- Ambient Air Temperature (AAT) sensor
- Transmission Control Module (TCM).

The ECM sends outputs to the following:

- Main relay
- Air Conditioning (A/C) relay
- Fuel injectors
- Ignition coils
- Engine cooling fan control
- Electric throttle
- Electric fuel pump driver module
- Variable Camshaft Timing (VCT) solenoids
- Starter relay control
- Variable intake manifold control valves
- Variable inlet cam profile switching solenoid valves
- Transmission Control Module (TCM).

SENSORS

The ECM optimizes engine performance by interpreting signals from numerous vehicle sensors and other inputs. Some of these signals are produced by the actions of the driver, some are supplied by sensors located on and around the engine and some are supplied by other vehicle systems.

Camshaft Position (CMP) Sensor

E88727

Two CMP sensors are located in the camshaft housing at the Left Hand (LH) end of the engine. The sensors are located in a hole in the housing and are secured with a screw. There is a CMP sensor for each camshaft.

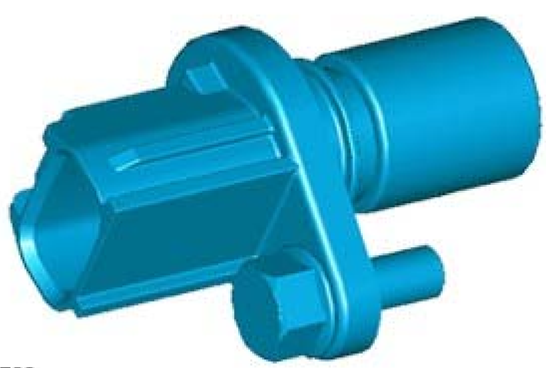
The CMP sensors monitor the position of the camshafts to establish ignition timing order, fuel injection triggering and for accurate Variable Camshaft Timing (VCT) operation. The ECM can also use the CMP sensors to determine which cylinder has a misfire or knock using the CMP signal output.

The CMP sensor is a Hall-effect sensor which switches a 5V supply from the ECM on and off. The supply is switched when teeth machined onto a pulse wheel on the camshaft pass by the tip of the sensor. The teeth are of differing shapes, so the ECM can determine the exact position of the camshaft at any time. When one of the teeth passes by the sensor tip, a signal is transmitted to the ECM which can vary between 0 and 5V. The signal is high when a tooth is directly adjacent to the sensor and is low when the tooth is away from the sensor.

Failure of one or both of the sensors will result in the ECM using a default map for ignition timing and knock control will be disabled.

The ECM monitors the sensor for correct function and can diagnose and store fault codes for sensor faults. These can be retrieved using a Land Rover approved diagnostic system.

Crankshaft Position (CKP) Sensor



E88728

The CKP sensor is located on the forward side of the transmission torque converter housing, in line with the engine flywheel.

The sensor is secured with a bolt into a bracket attached to the gear housing. A reluctor ring is fitted to the outer diameter of the crankshaft flexplate and the sensor reacts to the gaps in the reluctor ring to determine engine speed and position information. The sensor has 2 wires from the ECM sensor ground and a feedback signal.

The CKP sensor is an inductive type sensor which produces a sinusoidal output voltage signal. This voltage is induced by the proximity of the moving reluctor ring gaps, which excite the magnetic flux around the tip of the sensor when each gap passes. This output voltage will increase in magnitude and frequency as the engine speed rises determined by an increase in the speed at which the gaps on the reluctor ring pass the sensor. The signal voltage can be as low as 0.1V at low engine speeds and up to 100V at high engine speeds. The ECM does not react to the output voltage (unless the voltage is extremely low or high), instead it measures the time intervals between each pulse (signal frequency). The signal is determined by the number of gaps passing the sensor, and the speed at which they pass. The reluctor ring has 2 gaps missing to give the ECM a synchronization point and determine the position of the crankshaft. The CKP sensor signal is also used for misfire detection.

The signal produced by the CKP sensor is critical to engine running. Failure of the sensor when the engine is running will result in the engine stopping immediately. The engine can be restarted using signals from the CMP sensors but the engine speed will be limited to 3000 rpm and the Malfunction Indicator Lamp (MIL) will be illuminated.

The ECM monitors the sensor for correct function and can diagnose and store fault codes for sensor faults. These can be retrieved using a Land Rover approved diagnostic system.

Fuel Rail Pressure / Temperature Sensor

E 88729

The fuel rail pressure/temperature sensor is located on the LH end of the fuel rail. The ECM supplies the combined pressure and temperature sensor with a 5V reference voltage and a ground and measures the returned signals for pressure and temperature.

Fuel pressure

The fuel pressure sensor is a peizo resistor type sensor. The sensor receives a 5V reference voltage from the ECM and produces an analogue signal of between 0 and 5V depending on the pressure sensed. Low pressure gives a low voltage output and consequently high pressure gives a higher voltage output. The ECM uses this pressure signal to adjust the fuel pump module output pressure by sending controlling signals to the FPDM and for injector timing.

The ECM monitors the fuel pressure sensor for faults and can store fault related codes. These can be retrieved using a Land Rover approved diagnostic system. Sensor operation can also be checked using a Land Rover approved diagnostic system to check fuel pressure. If no fuel pressure is in the fuel rail, the sensor will read and output atmospheric pressure.

Fuel Temperature

The fuel temperature sensor is a Negative Temperature Co-efficient (NTC) sensor. The sensing thermistor element resistance decreases as the sensor temperature increases. The ECM supplies the sensor with a 5V reference voltage and a ground and measures the returned signal as a temperature.

The resistance in the sensor changes with fuel temperature. A low fuel temperature will result in a high voltage being returned to the ECM and high fuel temperature will return a low voltage reading of between 0 - 5V.

The ECM monitors the fuel temperature sensor for faults and can store fault related codes. These can be retrieved using a Land Rover approved diagnostic system. The ECM uses the ECT temperature signal as a default but only up to a maximum of 100°C (212°F).

Mass Air Flow (MAF) / Intake Air Temperature (IAT) Sensor

E 88730

The MAF/IAT sensor is located in the outlet pipe from the air cleaner housing. The combined MAF/IAT functions are connected to the ECM on separate wires. The sensor has an extended moulding which is located in a central position in the air flow through the air cleaner housing outlet pipe, through which the air flow and temperature are measured.

Mass Air Flow (MAF) Sensor

The MAF sensor measures the mass of air being drawn into the engine. The air mass is calculated by the cooling effect of inlet air passing over a 'hot film' element contained within the sensor. The higher the air flow, the greater the cooling effect on the element which in turn lowers the electrical resistance of the 'hot film' element. The ECM uses this resistance value to calculate the air mass or volume of air flowing into the engine.

The MAF sensor receives a battery voltage supply via the ECM and the main relay. The ECM provides a ground and a signal path for the resistance signal from the 'hot film' sensor. The analogue signal from the MAF sensor varies between 0.5 and 5V. Low air flow gives a low voltage and high air flow gives a high voltage.

The MAF signal is used by the ECM to determine:

- the correct fuel quantity (injection period) to maintain the correct air/fuel ratio required for correct operation of the engine and the catalysts
- the ignition timing
- the engine load.

The ECM monitors the MAF sensor for faults and can store fault related codes. These can be retrieved using a Land Rover approved diagnostic system.

Intake Air Temperature (IAT) Sensor

The IAT sensor measures the temperature of the intake air entering the engine. The sensor is a temperature dependant resistor (thermistor). The thermistor is a NTC sensor element. The element resistance decreases as the sensor temperature increases. The ECM supplies the sensor with a 5V reference voltage and a ground and measures the returned signal as a temperature.

The resistance in the sensor changes with intake air temperature. A low intake air temperature will result in a high voltage being returned to the ECM and high intake air temperature will return a low voltage reading of between 0 - 5V.

The ECM monitors the IAT sensor for faults and can store fault related codes. These can be retrieved using a Land Rover approved diagnostic system. If the IAT sensor fails, the ECM uses a default temperature value using the fuel rail pressure/temperature sensor.

Knock Sensors

E 88731

Two knock sensors are located on the front of the engine and are each secured to threaded holes in the engine cylinder block with a bolt. The knock sensors are used by the ECM to monitor combustion knocking or vibration generated by ignition combustion. The knock sensors are each connected to the ECM via a twisted pair of wires which reduces electrical interference disrupting the signal produced.

Each knock sensor contains a peizo-ceramic crystal which produces a voltage when an external force applies pressure or load on it. When the engine is running, compression waves produced by the combustion process, creates pressure waves which pass through the engine cylinder block. These pressure waves are detected by the knock sensors and the deflection of the crystal caused by the pressure waves causes the sensors to produce an output signal. The signals are passed to the ECM which compares them with stored mapped signals in its memory.

The ECM can then determine when the correct combustion occurs in individual cylinders. If incorrect combustion detonation is detected, the ECM can retard the ignition timing on that cylinder for a number of combustion cycles. The ignition timing will be gradually returned to its optimal settings. If the knock is still detected the ECM will increase the injection period, which has a cooling effect on that cylinder.

The signals from the knock sensors are used in conjunction with the CMP sensors and the CKP sensor to determine the ignition cycle and therefore identify which cylinder is knocking. The ECM is programmed to use ignition maps based on high quality 95-98 RON fuel. If fuel of a poor quality such as 91 RON is used the engine may suffer from knock (pinking) for a period of time. The ECM is capable of learning and adapting to the low grade fuel and will modify its internal ignition mapping to compensate for the low grade fuel. This feature of the ECM is called adaption.

If one or both knock sensors fail or the signal becomes implausible, the ECM will cancel closed loop control of the ignition system. The ECM will use a default 'safe' ignition map to ensure the pre-detonation does not damage the engine by setting maximum retard control on spark advance. The driver may notice 'pinking' under certain driving conditions and a loss of performance. The ECM monitors the knock sensors for faults and can store fault related codes. These can be retrieved using a Land Rover approved diagnostic system.

Engine Coolant Temperature (ECT) Sensor

E88732

The ECT sensor is located in the thermostat housing, on the front of the engine, below the inlet manifold. The ECT sensor is a thermistor type sensor used by the ECM to monitor the engine coolant temperature. The ECM uses the temperature information for the following functions:

- regulate the injection period
- set engine idle target speed
- control the engine cooling fan(s)
- determine operation of the A/C compressor
- determine operation of the purge valve and catalytic converter heating function.

The sensor is a Negative Temperature Co-efficient (NTC) thermistor element. The element resistance decreases as the sensor temperature increases. The ECM supplies the sensor with a 5V reference voltage and a ground and measures the returned signal as a temperature.

The ECT sensor is important to the correct running of the engine as a richer mixture is required at low engine coolant temperatures for efficient starting and smooth cold running. As the engine coolant temperature increases, the ECM uses the temperature signal from the sensor to lean off the fuel mixture to maintain optimum emissions and performance.

The ECM monitors the ECT sensor for faults and can store fault related codes. These can be retrieved using a Land Rover approved diagnostic system. If the ECT sensor fails, the ECM uses a default value of 90°C (194°F). The electric fan control module is sent a default coolant temperature value of 105°C (221°F) and switches the cooling fan on permanently.

Engine Oil Level / Temperature Sensor

E88733

The engine oil level/temperature sensor is located on the underside of the engine and is secured in the engine oil pan with 3 screws and is sealed with an O-ring seal. The ECM supplies the sensor with a 5V reference voltage and two wires supply the temperature and oil level signals back to the ECM.

Two types of engine oil level/temperature sensor are used. On earlier models a capacitive oil level sensor is fitted and was replaced by an ultrasound level sensor on later models. The principle of the temperature sensor is the same in both sensor types. The sensors can be identified by differences in the sensor housings; the capacitive sensor has the electrical connector moulded square to the base of the sensor, the ultrasonic sensor has the connector moulded at a slight angle to the base of the sensor.

The ECM uses both the oil level and temperature signals to calculate the oil level. Temporary oil level changes caused by hill driving or cornering are taken into account by the ECM using additional information such as vehicle speed and engine load.

Engine Oil Level Sensor - Capacitance Type

The engine oil level sensor comprises two capacitive gauge elements. These measure the resistance to electrical current passing through the engine oil.

There are two capacitors, one measuring the permittivity of the oil and a second with two plates set vertically measuring the height. The second capacitor will have a proportion of oil and air between the plates and since the permittivity of air is different to that of oil, the permittivity reading will change as the level of oil decreases and the air between the plate gap increases. This permittivity reading is compared to that of the oil (taken by the first capacitor) and an oil level is derived.

Engine Oil Level Sensor - Ultrasound Type

The engine oil level sensor uses an ultrasonic pulse, which is reflected back from the surface of the oil. The time it takes for this signal to return to the sensor is turned into a PWM signal and is sent to the ECM. The ECM determines the time taken for the ultrasonic pulse signal to be received and calculates it into an oil level figure.

Engine Oil Temperature Sensor

The engine oil temperature sensor is a Positive Temperature Co-efficient (PTC) thermistor element. The element resistance increases as the sensor temperature decreases. The ECM supplies the sensor with a 5V reference voltage and a ground and measures the returned signal as a temperature. A low oil temperature will result in a low voltage being returned to the ECM and high oil temperature will return a high voltage reading.

The ECM monitors the engine oil level/temperature sensor for faults and can store fault related codes. These can be retrieved using a Land Rover approved diagnostic system. If the sensor fails, the ECM uses the engine coolant temperature sensor signal value as a substitute.

Manifold Absolute Pressure (MAP) Sensor

E88734

The MAP sensor is located in the lower part of the intake manifold. The MAP sensor measures the absolute pressure in the intake manifold. The sensor is a semi-conductor type sensor which responds to pressure acting on a membrane within the sensor, altering the output voltage. The sensor receives a 5V reference voltage and a ground from the ECM and returns a signal of between 0.5 - 4.5V to the ECM. A low pressure returns a low voltage signal to the ECM and a high pressure returns a high voltage.

The MAP sensor detects quick pressure changes in the intake manifold after the electric throttle. The signal is used in conjunction with the MAF sensor signal to calculate the injection period.

The ECM monitors the engine MAP sensor for faults and can store fault related codes. These can be retrieved using a Land Rover approved diagnostic system. If the sensor fails, the ECM uses the MAF/IAT sensor signal value as a substitute.

Electric Throttle

E88735

The electric throttle is located at the entrance of the intake manifold and is secured to the manifold with four Torx head bolts. The throttle also provides for the connection of the air cleaner housing outlet pipe which is secured to the throttle body with a clip.

The electric throttle comprises the throttle body, a round throttle disc which is actuated by a damper motor and a throttle position sensor. The electric throttle is controlled by the ECM and receives positional signals from the TP sensor. If a failure of the motor occurs, the throttle disc is returned to its closed position by the springs, with limited engine speed available to the driver.

Spindle Damper Motor

The motor is a DC damper motor which drives a gear wheel and two springs; one for opening and one for closing. The motor rotates the spindle to which the throttle disc is attached. PWM signals from the ECM control the damper motor to adjust the position of the throttle disc, regulating the amount of air entering the inlet manifold for combustion.

Movement of the motor is achieved by changing the polarity of the power supply to the DC motor, allowing it to be operated in both directions. The throttle disc and the motor has two maximum positions; throttle disc closed which allows minimal air flow through the electric throttle into the intake manifold and throttle disc open which allows maximum air flow into the intake manifold.

Throttle Position (TP) Sensor

The TP sensor is housed in the electric throttle assembly and is used to check the position of the throttle disc. Two permanent magnets in the sensor connected to the throttle disc affect two Hall effect sensors. As the spindle is rotated the magnets rotate around the Hall effect sensors and produce offset analogue signals back to the ECM. The ECM compares these signals to stored values to ensure that they show an accurate throttle disc position. The offset signals are that one Hall effect sensor produces a higher voltage as the throttle angle increases and the other sensor produces a lower voltage as the throttle angle increases.

The ECM performs a self test and a calibration routine on the throttle disc position at each ignition cycle. This is achieved by the ECM powering the damper motor to fully close the throttle disc and then fully open the throttle disc.

The ECM monitors the DC damper motor and the TP sensor for faults and can store fault related codes. These can be retrieved using a Land Rover approved diagnostic system.

Accelerator Pedal Position (APP) Sensor

E88736

The APP sensor is located on the accelerator pedal. The sensor comprises a plastic housing which contains two potentiometers and an analogue/digital converter. The potentiometers are connected to a common shaft which is actuated by movement of the accelerator pedal.

The APP sensor provides the ECM and the CJB with information relating to the position of the accelerator pedal. The ECM uses this information to actuate the damper motor in the electric throttle assembly to move the throttle disc to the correct angle in relation to the pedal position.

The APP sensor receives a fused 12V supply from the CJB, which is controlled by the ignition relay in the BJB. The CJB also provides the sensor with a ground. The sensor provides two outputs; the analogue output is transmitted directly to the CJB, which in turn issues the signal to the ECM on the CAN bus, the second output is the Pulse Width Modulation (PWM) signal which is transmitted directly to the ECM. Both the analogue and PWM signals transmit the same positional information.

The ECM uses the PWM signal to calculate the required position of the electric throttle disc in the electric throttle. In the event of a failure of the PWM signal, the ECM uses the analogue signal received from the CJB as a replacement. If the analogue signal is also incorrect or missing, the ECM limits the maximum engine speed to 2000 rpm.

The PWM and the analogue signal are used for diagnosing faults with the APP sensor. If the ECM detects a difference between the analogue and PWM signals a fault code is stored. The ECM will use the signal with the lowest value for electric throttle control. The APP sensor position and any stored fault codes can be read using a Land Rover approved diagnostic system.

Heated Oxygen (HO2S) Sensors

E88737

Four HO2S are used by the ECM to measure the oxygen content of the exhaust gasses leaving the engine. Two upstream sensors measure the gasses before they pass through the catalytic converter and two additional downstream sensors measure the gasses after they have passed through the catalytic converter.

The HO2S receive a fused power supply from the main relay in the BJB. Each HO2S is also connected to the ECM on three wires which provide a PWM control of the sensor heating coil, a ground and a signal line.

HO2S Preheating

The HO2S (often referred to as a Lambda (λ) sensor) only operates efficiently at temperatures above 300°C (572°F). The normal operating temperature is between 300°C and 850 °C (572°F and 1562°F) and the HO2S is electrically preheated so it reaches the optimum working temperature quickly. Another reason for the preheating is to maintain a normal operating temperature to prevent condensation which could damage the sensor.

The sensor heating coil is a PTC resistor. The heating coil is supplied with battery voltage via the main relay and provided with a ground by the ECM. When the ECM provides the ground the current will pass through the coil. When the sensor is cold, the resistance through the PTC resistor is low and a high current will pass through the coil. The ECM provides a PWM ground initially. As the PTC resistor heats up the resistance increases reducing the current flow. This is sensed by the ECM which gradually reduces the PWM ground to a continuous ground.

The coil is heated immediately following an engine start for a period of approximately 20 seconds and also during low load conditions when the temperature of the exhaust gasses is insufficient to maintain the optimum sensor temperature. The ECM controls the application of the PWM signal to prevent sensor damage due to thermal shock caused by the sensor heating too quickly. The ECM can diagnose faults in the heater coil and record fault codes which can be retrieved using a Land Rover approved diagnostic system.

Upstream HO2S

Two upstream HO2S are used and are located in each exhaust manifold, between the engine and the catalytic converter. The HO2S comprises a solid electrolyte Zirconium dioxide cell surrounded by a gas permeable ceramic. The output voltage from the sensor is dependent on the level of O_2 passing through the permeable ceramic coating. Nominal voltage for λ=1 is 300 to 500mV. As the fuel/air mixture becomes richer (λ<1) the voltage rises to up to 900mV. As the mixture becomes weaker (λ>1) the voltage falls towards 0mV.

The upstream HO2S is used by the ECM to monitor the oxygen content of the exhaust gasses leaving the engine before they reach the catalytic converter. The ECM will check the output from the HO2S to determine the combustion mixture and ensure λ=1 is obtained. λ=1 is the optimum air/fuel ratio which relates to a mixture of 14.7 kg air per 1 kg of fuel (14.7:1).

The HO2S uses current regulation and outputs a linear signal dependent on the ratio of exhaust gas oxygen to ambient oxygen. The oxygen content of the exhaust gasses is measured by comparing it with ambient air drawn into the HO2S.

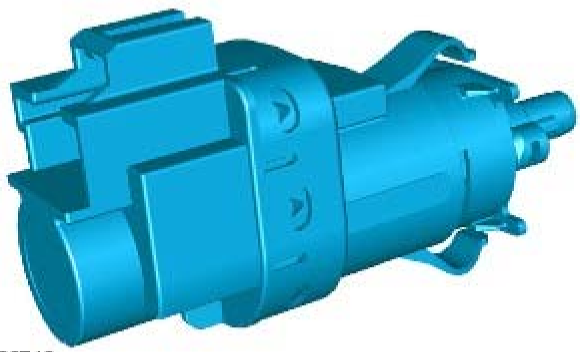
Downstream HO2S

Two downstream HO2S are used and are located in the each exhaust system after the starter catalytic converter. The downstream HO2S are used by the ECM to monitor the oxygen content of the exhaust gasses leaving the catalytic converter. The ECM can use this information to check (when the conditions for catalyst diagnostics have been met) for correct operation of the catalytic converter.

The ECM uses the information from the downstream HO2S to enhance the signals from the upstream HO2S.

The downstream HO2S are similar in their construction to the upstream HO2S with the exception of the output signal to the ECM. The output signal is a binary signal where the amplitude of the signal curve changes considerably when the oxygen content in the exhaust gasses changes. The oxygen content of the exhaust gasses leaving the catalytic converter are measured by comparing it with ambient air drawn into the HO2S.

Stop Lamp Switch



E 88748

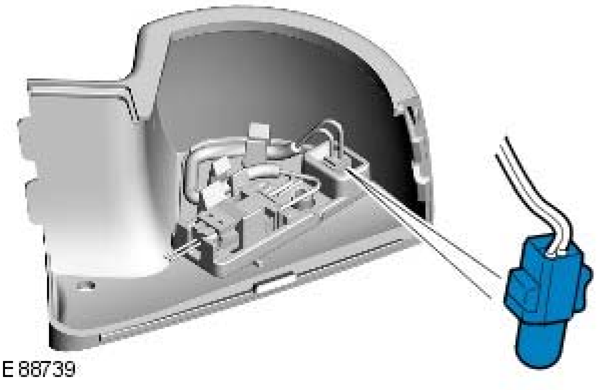
The stop lamp switch is attached to the brake pedal bracket, adjacent to the speed control inhibit switch. When the brake pedal is pressed, a plate on the pedal moves away from the switch plunger allowing the plunger to extend and complete the switch contacts.

The switch receives a permanent, fused battery voltage via the BJB and the CJB. The switch is connected to the ECM which provides the ground path. The ground (battery voltage signal) is used by the ECM as a switch operation signal. The ground from the switch is routed via the CJB to the ECM which allows the CJB to also determine the switch operation.

The CJB uses the completed ground when the switch is operated to activate the stop lamps.

The ECM can diagnose the operation of the stop lamp switch and the status of the switch can be read using a Land Rover approved diagnostic system.

Ambient Air Temperature (AAT) Sensor



E88739

The AAT sensor is located in the underside of the Left Hand (LH) exterior door mirror. The sensor is a Negative Temperature Co-efficient (NTC) thermistor element. The element resistance decreases as the sensor temperature increases which produces a low signal voltage. The ECM supplies the sensor with a 5V reference voltage and a ground and measures the returned signal voltage as an outside temperature.

The AAT signal is used by the ECM for a number of functions including engine cooling fan control and A/C compressor displacement control. The ECM also transmits a message on the high speed CAN bus relating to the current outside temperature for use by other control modules.

The ECM can diagnose the operation of the AAT sensor and the sensor output values can be read using a Land Rover approved diagnostic system.

Fuel Pump Driver Module (FPDM)

E88740

The FPDM is located in the LH rear corner of the luggage compartment, behind the trim panel and is secured to the LH chassis longitudinal with 2 screws.

The FPDM receives a battery supply via the fuel pump relay in the CJB. The relay is energised by the CJB when a request is received from the ECM. Two wires connect the FPDM to the fuel pump motor and a ground is via a body ground point. The ECM is connected to the FPDM on a single wire and this is used to control the pump pressure output and consequently the pump output pressure. The ECM uses signals from the MAP sensor, the fuel rail pressure/temperature sensor and the MAF/IAT sensor to determine and control the pump output.

The ECM outputs a PWM signal to the FPDM. The frequency of the signal determines the duty cycle of the FPDM which subsequently controls the pump pressure output. The frequency of the PWM signal represents half of the 'on' time of the pump. If the ECM outputs a PWM signal of 50% on time, the FPDM will operate the pump at 100% (permanently on). If the ECM outputs a PWM signal of 5%, the FPDM will operate the pump at 10% on time. The FPDM will only operate the fuel pump if it receives a PWM signal from the ECM of between 4% and 50%. If the ECM requires the pump to be stopped, the ECM transmits a PWM signal at a cycle of 75%.

If the power supply to the FPDM from the CJB or the fuel pump relay is disrupted for any reason, the fuel pump will not operate. The FPDM is monitored by the ECM for faults. Faults with the FPDM are stored in the ECM as fault codes which can be retrieved using a Land Rover approved diagnostic system.

Variable Camshaft Timing (VCT) Solenoid

E88741

The VCT solenoid is located in the LH end of the cylinder head and is secured with a bolt. The VCT solenoid is a valve which controls the oil flow to the VCT unit.

The VCT solenoid receives a fused battery supply via the main relay. The ECM provides a pulsed ground for the solenoid.

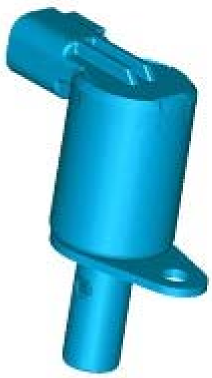
The VCT solenoid comprises an electro-magnetic valve with a spring loaded piston. Slots in the piston allows oil to be channelled to the VCT unit. The VCT unit rotates the inlet camshaft to adjust the camshaft timing as required. The direction in which the camshaft is rotated is dependent on the chamber in the VCT unit which is supplied with oil pressure from the slot in the VCT solenoid piston.
For additional information, refer to: Engine - 3.2L (303-01, Description and Operation).

An oil filter is located in the intake channel for the VCT solenoid to prevent contaminants affecting the function of the valve.

Operation of the valve is controlled by the ECM. The ECM provides a PWM ground for the VCT solenoid. This allows oil to be directed to different chambers in the VCT unit at variable rates, allowing the camshaft angle position to be controlled smoothly and precisely.

The ECM can diagnose the operation of the VCT solenoid and store fault related codes. The codes can be read using a Land Rover approved diagnostic system.

Camshaft Profile Switching (CPS) Solenoid - Front / Rear



E88747

Two CPS solenoids are located at each end of the cylinder head, adjacent to the inlet camshaft and are each secured with a bolt. The CPS solenoids supply oil pressure to the hydraulic tappet locking pins allowing the camshaft profile to be changed. Each solenoid controls the oil pressure supply to the hydraulic tappet locking pins on 3 cylinders.
For additional information, refer to: Engine - 3.2L (303-01, Description and Operation).

The CPS solenoids receive a fused battery supply via the main relay. The ECM provides a ground for the solenoid, which actuates a valve within the solenoid allowing oil pressure to adjust the camshaft profile.

The ECM can diagnose the operation of the CPS solenoids and store fault related codes. The codes can be read using a Land Rover approved diagnostic system.

Ignition Coils

E88742

Six plug top coils are used on the i6 engine and are located in recesses in the top of the cylinder head. The coils are controlled by the ECM and receive a fused, battery voltage supply via the main relay. The ECM controls the spark timing and production by switching the primary circuit of each coil to ground allowing the charge which has built up in the coil to produce a spark at the spark plug.

Each coil contains a power stage which controls the primary current and the ECM sends a signal to each coil to operate the power stage switching at the appropriate time. Each coil has a feedback wire to the ECM which allows the ECM to diagnose each individual coil and store fault related codes. The codes can be read using a Land Rover approved diagnostic system.

A suppressor is mounted on the camshaft cover adjacent to ignition coil 3 to prevent interference from the coils and/or the injectors affecting audio operation.

Fuel Injectors

E88743

Six fuel injectors are used on the i6 engine and are located on the inlet side of the cylinder head. The injectors are sealed in the cylinder head with O-ring seals and held in position by the fuel rail.

The injectors receive a fused battery voltage supply via the main relay. The ECM operates the injectors by grounding solenoid valves in the injector. When the ground is applied the solenoid valve operates and the injector sprays pressurized fuel from the fuel rail into the cylinder intake ports. The amount of fuel injected and the timing of the injection period is controlled by the ECM using data from other sensors.

The ECM can monitor the injector operation by monitoring the ground line from the injector. Each injector can be diagnosed by the ECM and fault codes stored. The codes can be read using a Land Rover approved diagnostic system.

Variable Intake System (VIS)

The VIS changes the length of the inlet manifold using two ECM controlled actuators which move flaps to control the air flow. The actuators operate singularly or together to adjust the length of the inlet tract.

Using an 'H' bridge, the intake and plenum actuator's internal electronics changes the actuator motor's polarity and therefore the flap position. At each flap position change, the DC actuator motor is powered for approximately 0.5 seconds. The worm gear design ensures that the flap remains in the desired position, even when the electric motors are not powered.

Intake Tract Variable Manifold

E88744

The ECM controls the position of the flaps by modulating the relevant actuator's control signal. If the signal shifts from low (approximately 1 volt) to high (approximately 10 volts) the internal electronics interpret it as the flap must close. If the signal shifts from high to low, the flap must open.

At engine speeds of less than 3800 rpm both the intake and plenum flaps are closed. At engine speeds of approximately 3800 rpm and higher the intake flap begins to open, effectively shortening the length of the intake manifold. At engine speeds of 4800 rpm or higher both the intake and plenum flaps are open, providing the shortest length of intake manifold.

VIS Flap Functionality

Engine Speed	Intake Tract Flap	Plenum Intake Flap	Effect
Less than 3800 rpm	Closed	Closed	Long tracts
3800 to 4800 rpm	Open	Closed	Short tracts
More than 4800 rpm	Open	Open	Open plenum

Plenum Variable Intake Manifold

E88745

The ECM diagnoses via the actuator if the flap has assumed the correct position. It does this, by comparing the desired air flow with the actual air flow. A fault code is stored if the deviations are outside the tolerances. The codes can be read using a Land Rover approved diagnostic system.

If an actuator fails and the flap is in the open position, it is not possible to remove the actuator and flap assembly from the inlet manifold. A small indentation on the body of the actuator allows for a 3 mm Allen key to be pushed through the thin membrane wall of the actuator housing. The Allen key can be engaged in the spindle of the actuator motor which allows the flap to be turned to the closed position and consequently the actuator and flap assembly can then be removed from the intake manifold.

Purge Valve

E88746

The purge valve is located on a bracket on the inlet manifold, above the electric throttle. The valve has a hose connection on the bottom which connects into the electric throttle and allows the fuel vapors to be drawn into the inlet manifold. A larger connection on the side of the valve is connected via a pipe to the evaporative (EVAP) emission canister which is located in the LH wheel arch behind the liner.

The purge valve controls the flow of fuel vapor from the EVAP canister to the engine intake manifold. Vacuum in the intake manifold draws the vapor from the canister once the purge valve is open and burns the vapor as part of the combustion process.

The ECM controls the operation of the purge valve when engine operating conditions are correct to add the fuel vapor to the combustion process. The valve is an electro-magnetic solenoid valve which receives a fused battery voltage supply via the main relay. The ECM uses a PWM ground to control the operation of the valve. By altering the frequency of the PWM ground signal, the ECM can control the rate at which valve is open. This allows the ECM to precisely control the amount of fuel vapor passing from the EVAP canister.
For additional information, refer to: Evaporative Emissions (303-13, Description and Operation).

The ECM can diagnose faults with the purge valve and store fault related codes. The codes can be read using a Land Rover approved diagnostic system.

Fuel Tank Leakage Monitoring Module (NAS only)

E 88750

The fuel tank leakage monitoring module is located in the LH rear wheel arch, adjacent to the EVAP canister. A port on the side of the module provides for the attachment of a dust filter, through which fresh air is drawn into the EVAP canister. A port on the underside of the module is connected by a short curved hose to the EVAP canister. This connection allows fresh air to be drawn into the canister during the purge process and also allows the system to be pressurized by the module for leakage testing.

The fuel tank leakage monitoring module receives a fused battery voltage supply via the main relay. The module is connected to the ECM which provides a ground for the module when leak detection is required.

The fuel tank leakage monitoring module comprises an electric air pump, a solenoid valve and a heater element. The air pump is used to pressurize the EVAP system for leak testing. The solenoid valve is normally open, but closes when energized by the ECM to close the system to allow it to be pressurized. The PTC heater element is used to warm the pump before operation.

The fuel tank leakage monitoring system periodically checks the EVAP system and the fuel tank vent system for leaks when the ignition is off. The system can also be activated for a diagnostic check by the ECM.

The ECM checks for leaks in the system by operating the air pump in the fuel tank leakage monitoring module. The module air pump is activated and the ECM monitors the current draw on the air pump motor. A reference orifice is provided in the module which allows the ECM to make a comparison and establish a reference figure for measuring the current draw on the air pump motor when air is pumped through the orifice.
For additional information, refer to: Evaporative Emissions (303-13, Description and Operation).

The ECM can diagnose faults with the air pump and the solenoid valve and store fault related codes. These codes can be read using a Land Rover approved diagnostic system.

Speed Control Inhibit Switch


E88738

The speed control inhibit switch is attached to the brake pedal bracket, adjacent to the stop lamp switch. When the brake pedal is pressed, a plate on the pedal moves away from the switch plunger allowing the plunger to extend and complete the switch contacts.

The switch receives a power supply from the CJB which senses the completed ground path when the switch is operated. The switch has two functions; it is used for starting purposes when the brake pedal must be pressed before engine cranking is allowed and it is used to suspend speed control operation when speed control is active and the brake pedal is pressed.

The CJB can diagnose the operation of the speed control inhibit switch and the status of the switch can read using a Land Rover approved diagnostic system.

Main Relay

The main relay is located in the BJB. The operation of the main relay is controlled by the ECM which provides a ground path for the main relay coil, energizing the relay and closing the relay contacts.

The main relay supplies battery voltage to the following engine sensors and actuators:

- Electric throttle - TP sensor (via ECM)
- Fuel injectors
- Ignition coils
- Coil Capacitor
- Variable inlet cam profile switching solenoid - front and rear
- Intake tract variable manifold motor
- Plenum variable intake manifold motor
- HO2S
- Purge valve
- Fuel tank leakage monitoring pump (NAS only).

Air Conditioning (A/C) Pressure Sensor

The refrigerant pressure sensor provides the Air Temperature Control (ATC) module with a pressure input from the high pressure side of the refrigerant system. The refrigerant pressure sensor is hardwired to the ECM, which uses the signal to control operation of the A/C compressor and to calculate the additional load on the engine when the A/C compressor is operating.

The ECM also broadcasts the refrigerant high pressure value over the high speed Controller Area Network (CAN) bus to the CJB. The CJB relays the signal to the ATC module over the medium speed CAN bus to increase the amount of recirculated air if required.

Air Conditioning (A/C) Relay

The A/C relay is located in the BJB. The operation of the A/C relay is controlled by the ECM which provides a ground path for the A/C relay coil, energizing the relay and closing the relay contacts.

When the relay contacts are closed, battery voltage is supplied via the relay to the A/C compressor clutch. The ECM controls the operation of the variable displacement compressor using a signal line to the compressor and received signals from the A/C pressure sensor.

Air Conditioning Compressor Control

Compressor displacement is controlled by the ECM based on current evaporator temperature and target evaporator temperature signals received from the ATC module. From these values the ECM calculates the required compressor displacement and provides a Pulse Width Modulated (PWM) signal to the compressor solenoid valve. The compressor solenoid valve is mounted on the rear of the compressor and interprets the PWM signal as a displacement value and alters the position of the internal swash plate accordingly.

The ECM will also reduce the displacement of the A/C compressor to its minimum level if 'full throttle' or automatic transmission 'kick down' is requested. This feature is not present on Gulf specification vehicles. Compressor clutch engagement is controlled by the ECM.

Engine Cooling Fan Control

The ECM has a hardwired connection with the cooling fan control module. The ECM outputs a PWM signal to the fan control module which relates to the required fan speed. The fan speed is determined by factors such as engine coolant temperature and A/C operation. The fan control module reacts to the received signal by controlling the operating voltage of the fan motors. The fan control module confirms the fan speed operation on the same connection back to the ECM.

Starter Motor Relay

The starter motor relay is located in the BJB. The operation of the starter motor relay is controlled by the ECM which provides a ground path for the relay coil, energizing the relay and closing the relay contacts. When the relay contacts are closed, battery voltage is supplied, via the starter motor relay, to the starter module solenoid coil. The starter solenoid is energized and connects the starter motor with a direct battery feed to operate the starter motor.

Once the engine has started, the ECM removes the starter motor relay ground, opening the relay contacts and terminating the battery feed to the starter solenoid, which in turn stops the operation of the starter motor.
For additional information, refer to: Starting System - 3.2L (303-06, Description and Operation).

Fuel Pump Module

The fuel pump is controlled by the FPDM which in turn is controlled by the ECM. The FPDM provides positive and negative feeds to the fuel pump motor which is controlled with a PWM output. The fuel pump is run for 2 seconds to prime the fuel system once ignition on is sensed by the ECM.
For additional information, refer to: Fuel Tank and Lines (310-01, Description and Operation).

Malfunction Indicator Lamp (MIL)

The MIL is located in the instrument cluster and is illuminated by a CAN message from the ECM when an emission related fault occurs. The ECM also illuminates the MIL when requested to do so by the TCM and to perform a bulb check when the ignition is switched on. There is no MIL illumination for non emission related engine management faults. All engine faults are recorded with a Diagnostic Trouble Code (DTC) which can be retrieved using a Land Rover approved diagnostic system.
For additional information, refer to: Electronic Engine Controls - 3.2L (303-14, Diagnosis and Testing).

Generator Feedback Signal

The generator has a Local Interconnect Network (LIN) bus connection direct to the ECM. The LIN bus is used by the ECM to request voltage for battery charging and to monitor the fault status of the generator.

PRINCIPLES OF OPERATION

Starting Process

The ECM will only allow engine crank, spark and injector functions when the following conditions are met:

- A hardwired Park/Neutral signal is received from the Transmission Control Module (TCM)
- A hardwired ignition signal is received from the CJB
- A hardwired crank request signal is received from the CJB
- Encrypted data exchange between the instrument cluster and the ECM is verified.

Before the CJB will send the hardwired ignition signal, it must satisfactorily complete the following:

- Exchange encrypted data with the start control module to validate the remote handset.

Additionally, before the CJB will send the hardwired crank request signal it must receive the following signals:

- Brake signal from the speed control inhibit switch
- Hardwired transmission in Park (P) or Neutral (N) signal from the selector lever assembly.

With the remote handset inserted in the start control module and the stop/start button is pressed, the start control module issues battery voltage high signal on the LIN bus connection to the CJB and the fuel pump is run for 2 seconds to prime the fuel system. The CJB uses this signal together with the stop lamp switch signal and issues a crank request message on the high speed CAN bus to the ECM.

The ECM, on receipt of the crank request message, then provides a power and ground supply to the starter relay in the BJB, closing the relay contacts. Battery voltage is supplied via a fuse through the starter relay and is passed to the starter motor solenoid coil. The coil is energized, closing the solenoid contacts and allowing a fuse battery voltage supply direct from the battery to operate the starter motor and crank the engine and simultaneously switch the fuel pump on.

The ECM operates the starter motor until the engine starts which is determined by the engine speed exceeding a pre-determined value.

Auto Start

The ECM has an auto start function which allows the engine to continue cranking if the stop/start button is released. The starter motor will operate until the engine starts or a pre-determined period of time has elapsed which is based on engine coolant temperature. Low engine coolant temperatures allow longer crank times. If the engine does not rotate or the engine speed is low, the ECM removes the power supply and ground from the starter relay stopping the crank process.

Start Prevention

Operation of the starter motor will not be allowed or will be interrupted if:

- the engine is running and the engine speed has exceeded a predetermined speed
- the encrypted data exchange between the instrument cluster, ECM, CJB and start control module has failed to identify the remote handset
- the gear selector lever is not in the park 'P' or neutral 'N' position. The signal is determined from a signal from the TCM and also the transmission mounted position switch
- the brake pedal is not pressed.

Engine Stop Process

To stop the engine the stop/start button must be pressed. Forcibly removing the remote handset from the start control module will not stop the engine. On models with automatic transmission, once the engine has stopped the remote handset will not be released by the start control module until the transmission selector lever is in the Park (P) position.

Throttle Control

The ECM controls the positioning of the throttle disc in the electric throttle using information from the APP sensor and the TP sensor. Data from the A/C pressure sensor, TCM, ECT sensor, MAF sensor and the MAP/IAT sensor is also used to determine the correct throttle control.

The two Hall effect sensors in the TP sensor are designated 1 and 2. Both sensors output an increasing voltage as the throttle disc angle increases. Small air flows through the throttle require comprehensive regulation, therefore the voltage rise in one of the sensors increases more quickly than the other sensor which gives accurate control of the throttle and ensure the throttle disc is in the correct position.

The ECM monitors the signals from both sensors to ensure they are within the minimum and maximum thresholds and that the signals correspond to the same throttle disc position. If there is a difference in the signals the ECM uses a default throttle signal calculated from the electric throttle load, engine speed and air pressure and temperature signals. The sensor whose output signal is closest to the calculated throttle disc angle will be used as the correct output. A fault code will be recorded for the other sensor and this can be read using a Land Rover approved diagnostic system. The ECM then monitors the remaining sensor output signal and compares it against the calculated value. If a difference in the comparison occurs the ECM will discount the output from both sensors and disable the electric throttle control and revert to a limp home mode. The throttle disc has springs for opening and closing and the ECM can measure the load applied by these springs for a load signal. If a fault occurs which prevents the damper motor from being operated, the springs return the throttle disc to a position which allows a throttle opening large enough to allow the vehicle to driven, but with reduced drive ability.

Throttle Adaptions

The ECM has a learning adaption which allows the ECM to calculate the precise control required for the electric throttle damper motor. The adaption process is performed when the ignition is on and the engine is not running. The throttle disc is moved by the damper motor to the fully closed position and the ECM records the values output by the TP sensor potentiometers.

If the permanent battery supply to the ECM has been removed, then previous adaptions will have been lost. If adaptions are stored, then the ECM compares the stored adaption values with the current throttle angle and uses an average of the stored and current values to create the new adaption value.

If the electric throttle unit has been replaced, the power supply must be removed from the ECM to erase all previously stored adaption values.

Fuel Pressure Regulation

Fuel pressure regulation is controlled by the ECM to respond to fuel pressure demand and provides stepless control of the pump output using the FPDM to control the pump operation. The ECM can vary the fuel pressure to between 55.1 lbf/in^2 (3.8 bar) and 72.5 lbf/in^2 (5 bar). The high pressure is only used in extreme conditions such as heavy engine loads and engine starts.

The ECM uses the signals from the fuel rail pressure/temperature sensor to determine information regarding the pressure and temperature of the fuel and provide precise injection periods, improving engine starting under all conditions. The advantage of controlling the fuel pump output pressure are that pump power consumption is reduced, lowering the load on the power supply system and reducing fuel consumption, improved service life of the pump and reduced fuel pump noise.

NOTE: When the ignition is switched off the FPDM reduces the fuel line pressure regulation to 29 lbf/in^2 (2 bar) to help reduce injector leakage.

Knock Control

Knock occurs in a cylinder when the fuel and air self ignites at the wrong timing. This can occur either before or after the spark is produced. The fuel mixture can ignite in different areas of the combustion chamber and results in a fast combustion process creating several separate fuel combustions which together combine to produce a mechanical knocking sound. The sounds produce a certain type of vibration through the engine cylinder block and these are detected by the knock sensors. The two knock sensors detect knocks on cylinders 1, 2 and 3 and 4, 5 and 6 respectively.

The vibrations act upon the peizo crystals within the sensors which results in a voltage being produced which is sensed by the ECM. The ECM, using the CMP sensors and the CKP sensor, can determine which cylinder(s) are knocking. The ECM is able to filter the signal to detect vibrations created during normal engine operation and discard them from the knock detection. The ignition timing is gradually advanced until the knocking is detected once again.

Once the ECM has determined knocking is occurring using other inputs such as catalytic converter temperature for example in addition to the signals from the knock sensors, it first retards the ignition timing and subsequently richens the air/fuel if required.

Variable Camshaft Timing (VCT) Control

The inlet camshaft is controlled by the ECM using the VCT solenoid. The exhaust camshaft is fixed and its timing cannot be changed.

Both camshafts are driven indirectly from the crankshaft via a chain. The chain is driven from a shaft in the gear housing assembly.
For additional information, refer to: Engine - 3.2L (303-01, Description and Operation).
The VCT allows the ECM to adust the inlet camshaft position in relation to the crankshaft, altering the timing of the opening and closing of the inlet and exhaust valves relative to the crankshaft position. This allows the ECM to provide increased engine performance, improved idle quality and reduced emissions.

The position of the inlet camshaft is determined by the ECM using signals from the CKP sensor and the CMP sensors. The ECM can then use the VCT solenoid valve to control the angle of the camshaft by controlling the flow of oil to the VCT unit.

The camshaft is secured to the rotor in the VCT unit. Oil pressure supplied to either side of the VCT unit from the VCT solenoid valve can rotate the rotor and hence the camshaft in either direction. The VCT solenoid is operated by the ECM using PWM, high frequency switching which provides rapid and precise control of the inlet camshaft position. The inlet camshaft position can be adjusted within 40 degrees of crankshaft rotation.

Camshaft Profile Switching (CPS) Control

The inlet camshaft has, in addition to the VCT control, a CPS function which is also controlled by the ECM. The CPS control can vary the valve lift height and duration of the camshaft lobes by adjusting the area of the hydraulic tappet which acts on one of two cam lobe profiles. The CPS control is via two CPS solenoid valves, located at each end of the inlet camshaft. The CPS solenoid valves control the position of hydraulic tappet assemblies which can be set in one of two positions; low and high.

Two CPS solenoids are used so that the hydraulic tappets can be adjusted when no load is applied, for example the cam lobes are off the hydraulic tappets and the cam base circle is acting on the tappet, this keeps the stress on components to a minimum. One CPS solenoid supplies oil pressure to the hydraulic tappets of cylinders 1, 2 and 4 and the second CPS solenoid supplies oil pressure to the tappets of cylinders 3, 5 and 6.

At engine start and at low engine oil temperatures (below 40°C (104°F)) the ECM does not direct engine oil pressure to the hydraulic tappets and therefore the hydraulic tappets are in their spring loaded, low position.
For additional information, refer to: Engine - 3.2L (303-01, Description and Operation).

Ignition Control

The ECM calculates the optimum ignition timing based on pre-programmed maps and information from the following sensors:

- CKP sensor
- CMP sensors
- MAF sensor
- ECT sensor
- Electric throttle TP sensor
- Knock sensors
- TCM
- Ignition coils.

During engine starting the ECM uses a fixed ignition setting. When the engine has started and the vehicle is being driven, the ECM adjusts the ignition timing accordingly using other parameters such as engine speed, load and temperature.

Once the engine has reached its normal operating temperature, the ECM monitors the signals from the knock sensors. If any of the cylinders produce knocking, the ignition timing for that cylinder will be retarded until the knocking has stopped. The ignition is then gradually advanced back to the normal timing or until the knocking re-occurs.

The ECM uses information from the TCM to provide torque limitation during transmission shifts. The ignition timing is adjusted to momentarily reduce the engine torque output to give a smooth transmission shift and reduce load on the transmission.

Air Conditioning (A/C) Compressor Control

The ECM controls the operation of the A/C compressor and reacts to requests from the ATC module via the high speed CAN bus. The compressor is a variable displacement unit and the ECM controls, via a solenoid, the displacement of the compressor to adjust load during certain driving conditions.

During engine start-up, moving from a standstill and under hard acceleration, the ECM sets the minimum displacement of the compressor to reduce the effect on the engine torque output. The ECM uses information from the ATC module, the A/C pressure sensor, the electric throttle TP sensor and the ECT sensor to determine compressor control. The ATC module transmits climate control and driver requests to the ECM and the ECM determines the priority of these requests over engine performance.

Published: 20-Jul-2011

Electronic Engine Controls - I6 3.2L Petrol - Electronic Engine Controls

Diagnosis and Testing

Principles of Operation

For a detailed description of the electronic engine controls, refer to the relevant Description and Operation section in the workshop manual.
REFER to: Electronic Engine Controls (303-14A Electronic Engine Controls - I6 3.2L Petrol, Description and Operation).

Inspection and Verification

CAUTION: Diagnosis by substitution from a donor vehicle is **NOT** acceptable. Substitution of control modules does not guarantee confirmation of a fault, and may also cause additional faults in the vehicle being tested and/or the donor vehicle.

NOTE: For diagnostic purposes the cylinders are divided into two banks: Bank 1 - Cylinder numbers 1, 2 and 3. Bank 2 - Cylinders 4, 5 and 6.

1. Verify the customer concern.
2. Visually inspect for obvious mechanical or electrical faults.

Visual Inspection

Mechanical	Electrical
• Engine oil level • Cooling system coolant level • Fuel level • Fuel contamination/grade/quality • Throttle body • Variable valve timing (VVT) units	• Fuses • Wiring harness • Electrical connector(s) • Sensor(s) • Variable valve timing (VVT) solenoids • Engine Control Module (ECM) • Transmission Control Module (TCM)

3. If an obvious cause for an observed or reported concern is found, correct the cause (if possible) before proceeding to the next step.
4. Use the approved diagnostic system or a scan tool to retrieve any diagnostic trouble codes (DTCs) before moving onto the symptom chart or DTC index.
    - Make sure that all DTCs are cleared following rectification.

Symptom Chart

Symptom (general)	Symptom (specific)	Possible causes	Action
Non-Start	Engine does not crank	• Security system /Immobilizer engaged • Engine control module (ECM) relay fault • Battery discharged • Starting system fault • Engine seized	Check that the security system is disarmed. Check the ECM relay operation. Check the battery and starter systems. Refer to the electrical guides. Check that the engine turns by hand.
	Engine cranks, but does not fire	• Low/contaminated fuel • Ignition system fault • Fuel system fault • Crankshaft position (CKP) sensor fault • Engine control module (ECM) fault	Check the fuel level and condition. Check for DTCs indicating ignition, fuel or sensor faults. Rectify as necessary. Refer to the warranty policy and procedures manual if an ECM is suspect.
	Engine cranks and fires, but will not start	• Evaporative emissions purge valve fault • Fuel system fault • Spark plugs fouled/incorrect gap • Ignition coil fault(s)	Check for DTCs indicating evaporative emissions, fuel or ignition system faults. Rectify as necessary.
Difficult to start	Difficult to start cold	• Check coolant anti-freeze content • Battery discharged • Crankshaft position (CKP) sensor fault	Check the coolant anti-freeze content. Check the battery condition and state of charge. Check for DTCs indicating a sensor, fuel system or evaporative emissions system fault. Rectify as necessary.

Symptom (general)	Symptom (specific)	Possible causes	Action
		• Fuel system fault • Evaporative emissions purge valve fault	
	Difficult to start hot	• Injector leak • Fuel system fault • Fuel temperature sensor fault • Intake air temperature (IAT) sensor fault • Mass air flow (MAF) sensor fault • Evaporative emissions purge valve fault • Ignition system fault	Check for DTCs indicating an injector, fuel system or sensor fault. Check the evaporative emission and ignition systems. Rectify as necessary.
	Difficult to start after hot soak (vehicle standing after engine has reached operating temperature)	• Injector leak • Fuel system fault • Fuel temperature sensor fault • Intake air temperature (IAT) sensor fault • Mass air flow (MAF) sensor fault • Evaporative emissions purge valve fault • Ignition system fault	Check for DTCs indicating an injector, fuel system or sensor fault. Check the evaporative emission and ignition systems. Rectify as necessary.
	Engine cranks too fast/slow	• Battery discharged • Starting system fault • Compressions high/low	Check the battery condition and state of charge. Check the starter system. Refer to the electrical guides. Check the engine compressions. Rectify as necessary.
Engine stalls	Engine stalls soon after start	• Breather system disconnected/restricted • Air filter restricted • Fuel line fault • Engine control module (ECM) relay fault • Mass air flow (MAF) sensor fault • Ignition system fault	Check the engine breather and intake systems. Check the fuel lines for leakage, etc.. Check for DTCs indicating an ECM relay, sensor or ignition system fault. Rectify as necessary.
	Engine stalls on overrun	• Engine control module (ECM) relay fault • Throttle position (TP) sensors fault	Check for DTCs indicating an ECM relay or TP sensor fault. Rectify as necessary.
	Engine stalls at steady speed	• Engine control module (ECM) relay fault • Crankshaft position (CKP) sensor fault • Throttle position (TP) sensors fault	Check for DTCs indicating an ECM relay or sensor fault. Rectify as necessary.
	Engine stalls with speed control enabled	• Engine control module (ECM) relay fault	Check for DTCs indicating an ECM relay fault. Rectify as necessary.
	Engine stalls when manoeuvring	• Additional engine loads (power steering, air conditioning (A/C), etc.) • Engine control module (ECM) relay fault • Throttle position (TP) sensors fault • Transmission malfunction • Controller area network (CAN) malfunction	Check the accessory drive systems. Check for DTCs indicating an ECM relay, sensor, transmission or CAN fault. Rectify as necessary.
Poor driveability	Engine hesitates/poor acceleration	• Fuel line fault • Fuel pump fault • Injector leak • Fuel pressure fault • Throttle position (TP) sensors fault	Check the fuel lines and intake air system. Check for DTCs indicating a fuel pump or pressure fault. Check for DTCs indicating a TP sensor or motor fault. Check for DTCs indicating an ignition, sensor or transmission fault. Check the APP sensor for full movement,

Symptom (general)	Symptom (specific)	Possible causes	Action
		• Throttle motor fault • Ignition system fault • Heated oxygen sensor (HO2S) fault • Transmission malfunction • Restricted accelerator pedal travel (carpet, etc.) • Accelerator pedal position (APP) sensor fault	etc.. Rectify as necessary.
	Engine backfires	• Fuel pump fault • Fuel line fault • Mass air flow (MAF) sensor fault • Heated oxygen sensor (HO2S) fault • Ignition system fault • Sticking variable valve timing (VVT) hub • Accelerator pedal position (APP) sensor fault	Check the fuel pump and lines. Check for DTCs indicating a sensor, ignition or VVT fault. Rectify as necessary.
	Engine surges	• Fuel pump fault • Fuel line fault • Mass air flow (MAF) sensor fault • Throttle position (TP) sensors fault • Throttle motor fault • Ignition system fault	Check the fuel pump and lines. Check for DTCs indicating a sensor or ignition system fault. Rectify as necessary.
	Engine detonates/knocks	• Fuel pump fault • Fuel line fault • Fuel quality • Knock sensor (KS)/circuit malfunction • Mass air flow (MAF) sensor fault • Heated oxygen sensor (HO2S) fault • Sticking variable valve timing (VVT) hub • Barometric pressure (BARO) sensor malfunction (internal engine control module (ECM) fault)	Check the fuel pump and lines. Check the fuel for contamination and correct grade. Check for DTCs indicating a sensor, VVT or ECM fault. Rectify as necessary. Refer to the warranty policy and procedures manual if an ECM is suspect.
	No throttle response	• Accelerator pedal position (APP) sensor fault • Throttle position (TP) sensors fault • Throttle motor fault	Check for DTCs indicating a sensor or throttle motor fault. Rectify as necessary.
	Speed control inhibited or disabled	• Default mode enabled • Speed control switch(es) • Throttle position (TP) sensors fault • Controller area network (CAN) fault	Check the message center for default messages. Check for DTCs indicating a speed control, sensor or CAN fault. Rectify as necessary.
	Poor throttle response	• Breather system disconnected/restricted • Accelerator pedal position (APP) sensor fault • Throttle position (TP) sensors fault • Engine coolant temperature (ECT) sensor fault • Mass air flow (MAF) sensor fault • Transmission malfunction	Check the engine breather system. Check for DTCs indicating a sensor or transmission fault. Rectify as necessary.

Symptom (general)	Symptom (specific)	Possible causes	Action
	Engine defaults, warning light and messages. Refer to the owner handbook	• Throttle position (TP) sensors fault • Mass air flow (MAF) sensor fault • Engine coolant temperature (ECT) sensor fault	Check for DTCs indicating a sensor fault. Rectify as necessary.

DTC Index

NOTE: If a control module or component is suspect and the vehicle remains under manufacturer warranty, refer to the Warranty Policy and Procedures manual (section B1.2), or determine if any prior approval program is in operation, before the replacement of a component.

NOTE: Generic scan tools may not read the codes listed, or may read only five digit codes. Match the five digits from the scan tool to the first five digits of the seven digit code listed to identify the fault (the last two digits give additional information read by the manufacturer approved diagnostic system).

NOTE: When performing voltage or resistance tests, always use a digital multimeter (DMM) accurate to three decimal places, and with an up-to-date calibration certificate. When testing resistance always take the resistance of the DMM leads into account.

NOTE: Check and rectify basic faults before beginning diagnostic routines involving pinpoint tests.

NOTE: Inspect connectors for signs of water ingress, and pins for damage and/or corrosion.

NOTE: If diagnostic trouble codes are recorded and, after performing the pinpoint tests, a fault is not present, an intermittent concern may be the cause. Always check for loose connections and corroded terminals.

For a complete list of all Diagnostic Trouble Codes (DTCs) that could be logged on this vehicle, please refer to Section 100-00REFER to: Diagnostic Trouble Code (DTC) Index - I6 3.2L Petrol, DTC: Engine Control Module (ECM) (100-00 General Information, Description and Operation).

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Electronic Engine Controls - I6 3.2L Petrol - Camshaft Position (CMP) Sensor

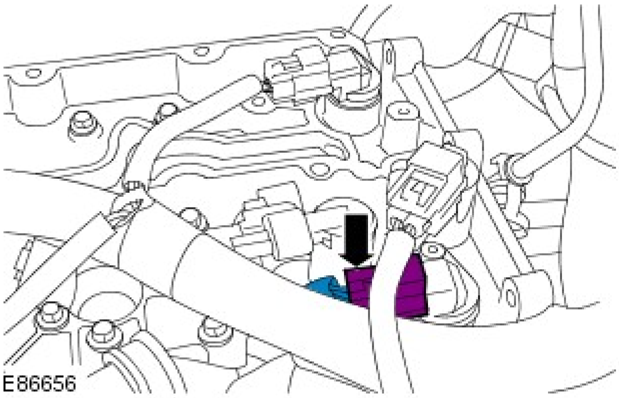
Removal and Installation

Removal

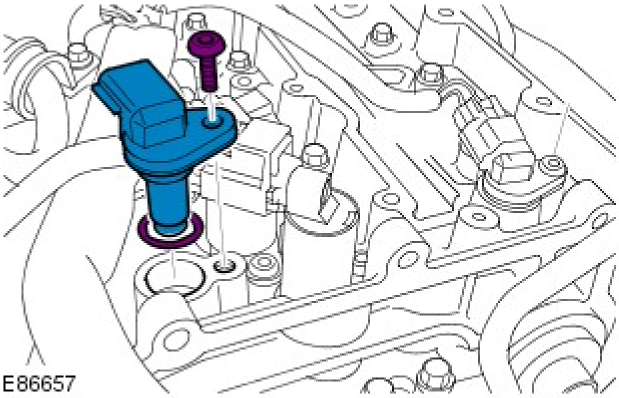
NOTE: Removal steps in this procedure may contain installation details.

1. Remove the engine cover.

   Refer to: Engine Cover - I6 3.2L Petrol (501-05 Interior Trim and Ornamentation, Removal and Installation).



2.



3. CAUTIONS:

   Note the fitted position of the special washer.

   Discard the seal.

   Torque: 10 Nm

Installation

1. CAUTIONS:

   Make sure that the mating faces are clean and free of corrosion and foreign material.

   A new O-ring seal is to be installed.

   To install, reverse the removal procedure.

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Electronic Engine Controls - I6 3.2L Petrol - Crankshaft Position (CKP) Sensor

Removal and Installation

Removal

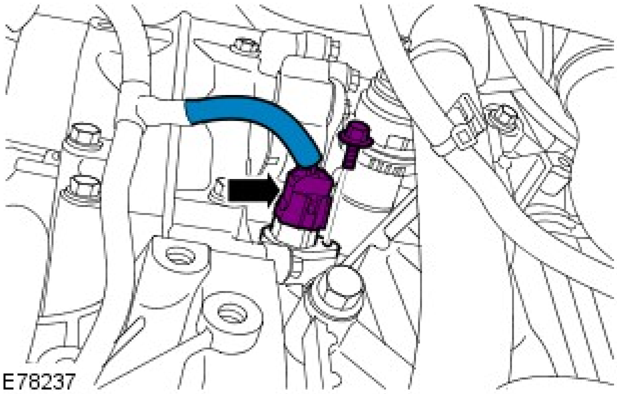
NOTE: Removal steps in this procedure may contain installation details.

1. WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

   Raise and support the vehicle.

2. Remove the engine undershield.

   Refer to: Engine Undershield (501-02 Front End Body Panels, Removal and Installation).



3. *Torque:* 10 Nm

Installation

1. To install, reverse the removal procedure.

Published: 11-May-2011

Electronic Engine Controls - I6 3.2L Petrol - Engine Coolant Temperature (ECT) Sensor

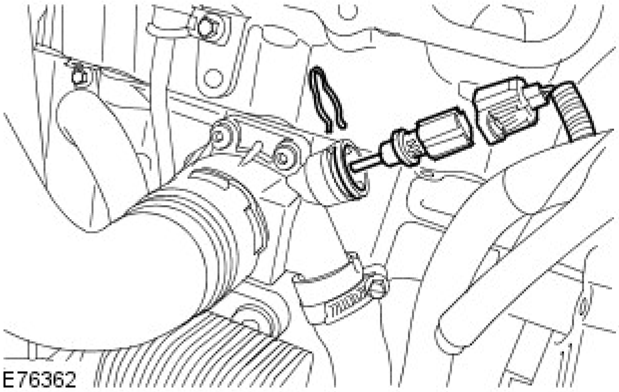
Removal and Installation

Removal

NOTE: Removal steps in this procedure may contain installation details.

1. Raise and support the vehicle.
2. Remove the intake manifold assembly.

   Refer to: Intake Manifold (303-01A Engine - I6 3.2L Petrol, Removal and Installation).



3. CAUTIONS:

   Be prepared to collect escaping fluids.

   Note the fitted position of the seal.

   Remove the ECT sensor.

Installation

1. CAUTION: Make sure that the mating faces are clean and free of foreign material.

   To install, reverse the removal procedure.

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Electronic Engine Controls - I6 3.2L Petrol - Heated Oxygen Sensor (HO2S)

Removal and Installation

Special Tool(s)

	310-121 Wrench, H02S

Removal

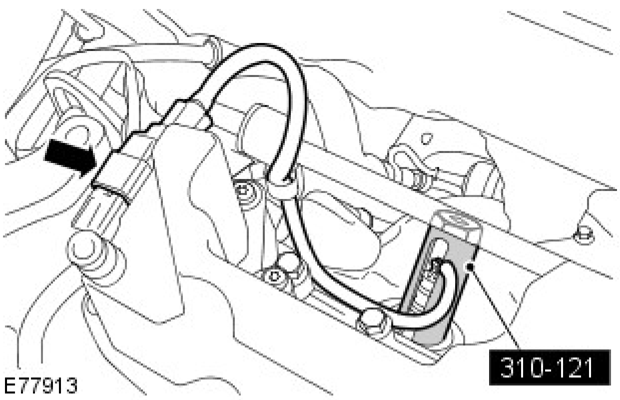
1. Remove the engine cover.

   Refer to: Engine Cover - I6 3.2L Petrol (501-05 Interior Trim and Ornamentation, Removal and Installation).

2. WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

   Raise and support the vehicle.

3. Disconnect the heated oxygen sensors (HO2S) electrical connectors.



4. Using the special tool, remove the heated oxygen sensor (HO2S).

   Special Tool(s): 310-121

Installation

1. For H02S anti-seize compound information, refer to the specification section.

2. CAUTION: Make sure the anti-seize compound does not contact the HO2S tip.

   Apply anti-seize compound to the sensor threads.

3. Install the HO2S.

   Special Tool(s): 310-121
   Torque: 45 Nm

4. Connect the HO2S electrical connector.

5. Install the engine cover.

   Refer to: Engine Cover - I6 3.2L Petrol (501-05 Interior Trim and Ornamentation, Removal and Installation).

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Electronic Engine Controls - I6 3.2L Petrol - Catalyst Monitor Sensor

Removal and Installation

Special Tool(s)

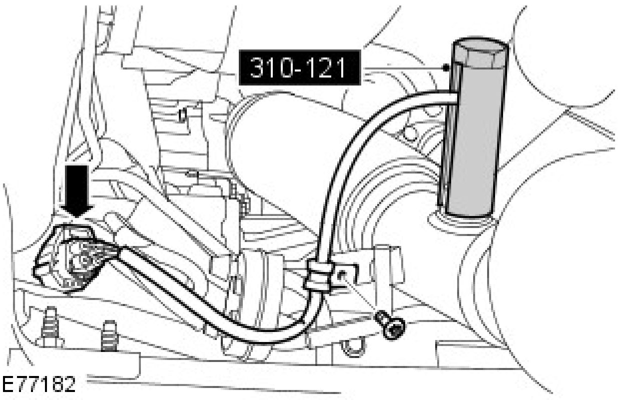
	310-121 Wrench, H02S

Removal

1. WARNING: Make sure to support the vehicle with axle stands.

   Raise the vehicle on a lift.

2.
   - *Torque:* 6 Nm



3.
   - *Torque:* 45 Nm
   - *Special Tool(s):* 310-121

Installation

1. To install, reverse the removal procedure.

2. NOTE: For NAS vehicles only.

   If required, carry out a long drive cycle.

   Refer to: Powertrain Control Module (PCM) Long Drive Cycle Self-Test (303-14A, General Procedures).

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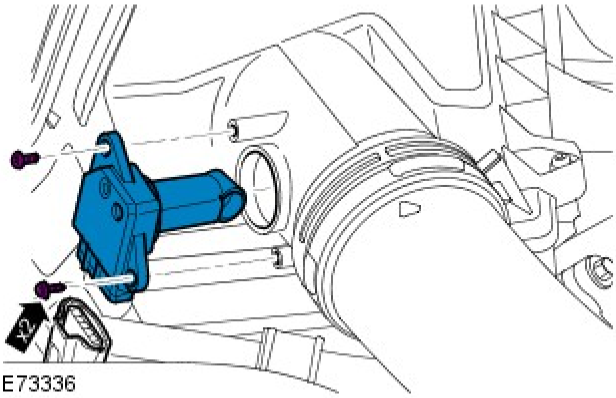
Electronic Engine Controls - I6 3.2L Petrol - Mass Air Flow (MAF) Sensor

Removal and Installation

Removal



E73336

1. *Torque:* 2 Nm

Installation

1. To install, reverse the removal procedure.

2. NOTE: For NAS vehicles only.

   If required, carry out a short drive cycle.

   Refer to: Powertrain Control Module (PCM) Short Drive Cycle Self-Test (303-14A, General Procedures).

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Electronic Engine Controls - I6 3.2L Petrol - Manifold Absolute Pressure (MAP) Sensor

Removal and Installation

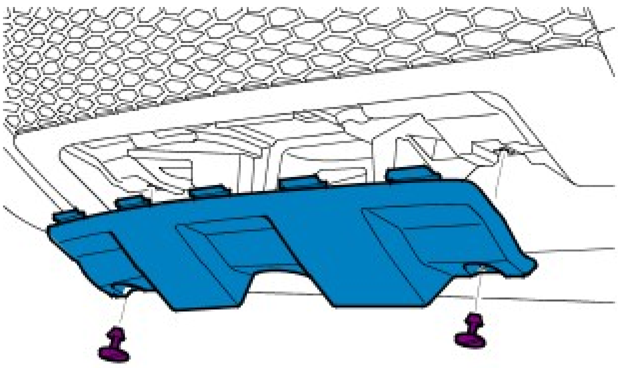
Removal

1. WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

   Raise and support the vehicle.

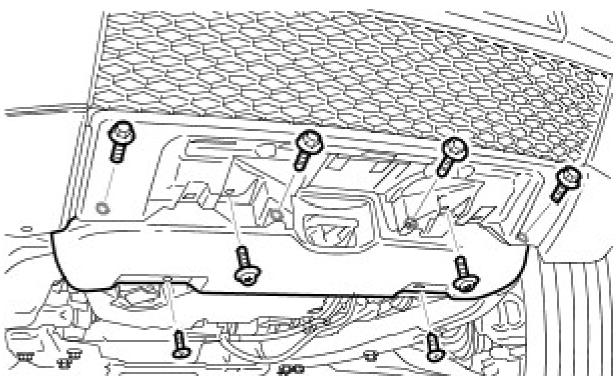
2. Remove the engine undershield.

   Refer to: Engine Undershield (501-02 Front End Body Panels, Removal and Installation).



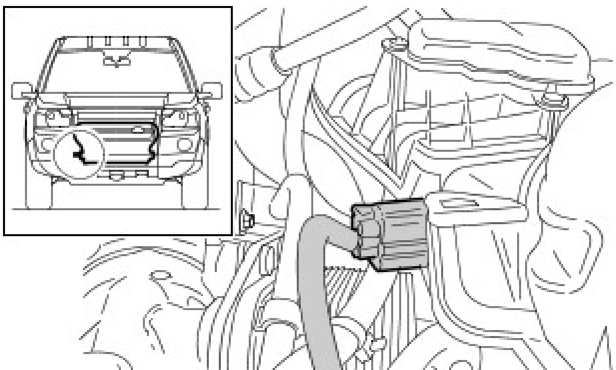
E73341

3.



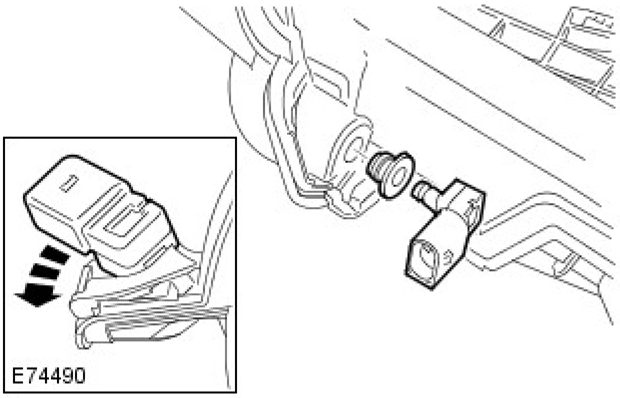
E74476

4.



E74479

5.



6.

Installation

1. To install, reverse the removal procedure.

2. NOTE: For NAS vehicles only.

   If required, carry out a short drive cycle.

   Refer to: Powertrain Control Module (PCM) Short Drive Cycle Self-Test (303-14A, General Procedures).

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Electronic Engine Controls - I6 3.2L Petrol - Engine Control Module (ECM)

Removal and Installation

Removal

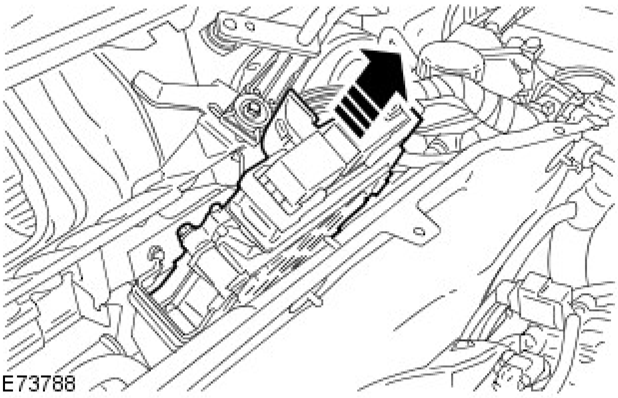
NOTE: Removal steps in this procedure may contain installation details.

1. Remove the cover and disconnect the battery ground cable.

   Refer to: Specifications (414-00 Battery and Charging System - General Information, Specifications).

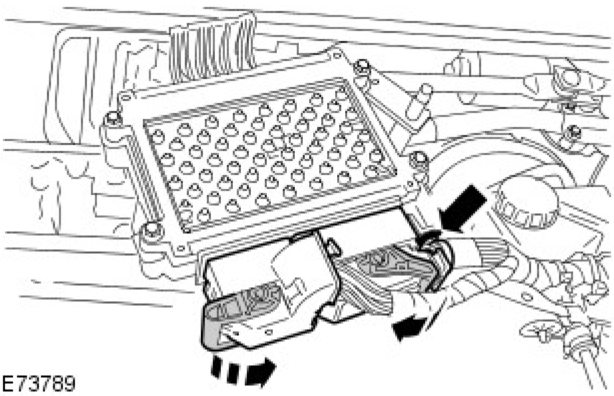
2. Remove the plenum chamber panel.

   Refer to: Plenum Chamber (412-01 Climate Control, Removal and Installation).



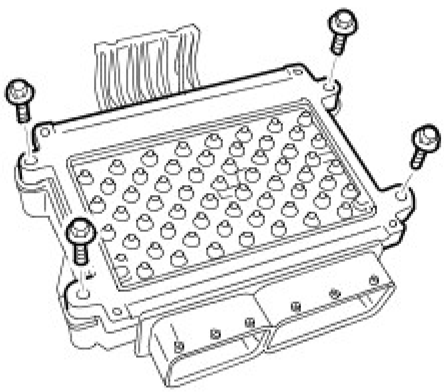
E73788

3.



E73789

4. Petrol ECM shown, diesel similar.



E73790

5. *Torque:* 6 Nm

Installation

All vehicles

1. To install, reverse the removal procedure.

Vehicles with diesel particulate filter (DPF)

2. Renew the engine oil and filter.

   Refer to: Engine Oil Draining and Filling (303-01B Engine - TD4 2.2L Diesel, General Procedures).

All vehicles

3. If a new component has been installed, configure using Land Rover approved diagnostic equipment.

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Electronic Engine Controls - I6 3.2L Petrol - Fuel Rail Pressure (FRP) Sensor

Removal and Installation

Removal

NOTE: Removal steps in this procedure may contain installation details.

1. Remove the cover and disconnect the battery ground cable.

   Refer to: Specifications (414-00 Battery and Charging System - General Information, Specifications).

2. Remove the fuel rail.

   Refer to: Fuel Rail (303-04A Fuel Charging and Controls - I6 3.2L Petrol, Removal and Installation).

3. *Torque:* 6 Nm

Installation

1. To install, reverse the removal procedure.

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Electronic Engine Controls - I6 3.2L Petrol - Front Knock Sensor (KS)

Removal and Installation

Removal

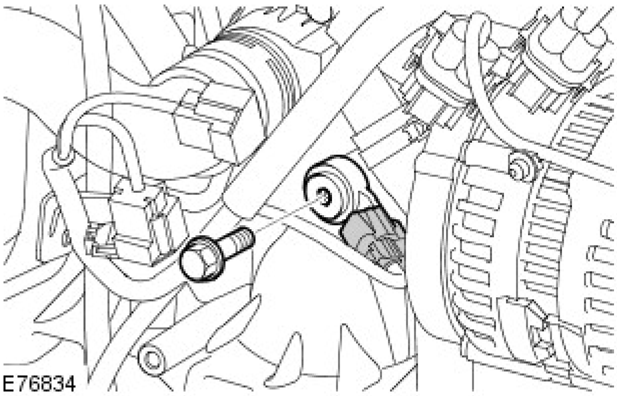
NOTE: Removal steps in this procedure may contain installation details.

1. WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

   Raise and support the vehicle.

2. Remove the oil cooler assembly.

   Refer to: Oil Cooler (303-01A Engine - I6 3.2L Petrol, Removal and Installation).



3. CAUTIONS:

   Make sure that the mating faces are clean and free of corrosion and foreign material.

   Mark the components to aid installation.

   Remove the knock sensor (KS).

   Torque: 20 Nm

Installation

1. To install, reverse the removal procedure.

Published: 11-May-2011

Electronic Engine Controls - I6 3.2L Petrol - Rear Knock Sensor (KS)

Removal and Installation

Removal

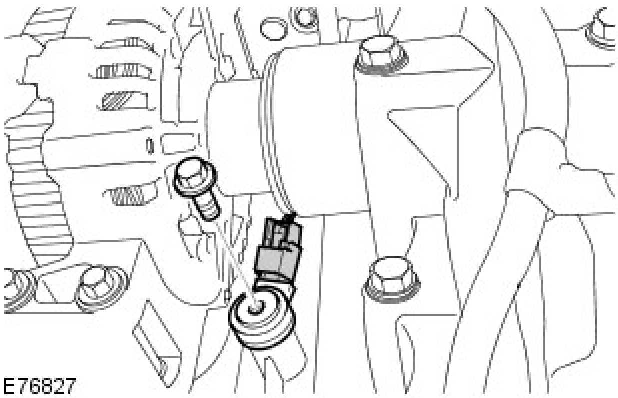
NOTE: Removal steps in this procedure may contain installation details.

1. WARNING: Do not work on or under a vehicle supported only by a jack. Always support the vehicle on safety stands.

   Raise and support the vehicle.

2. Remove the intake manifold.

   Refer to: Intake Manifold (303-01A Engine - I6 3.2L Petrol, Removal and Installation).



3. CAUTIONS:

   Make sure that the mating faces are clean and free of corrosion and foreign material.

   Mark the components to aid installation.

   Remove the knock sensor (KS).

   Torque: 20 Nm

Installation

1. To install, reverse the removal procedure.