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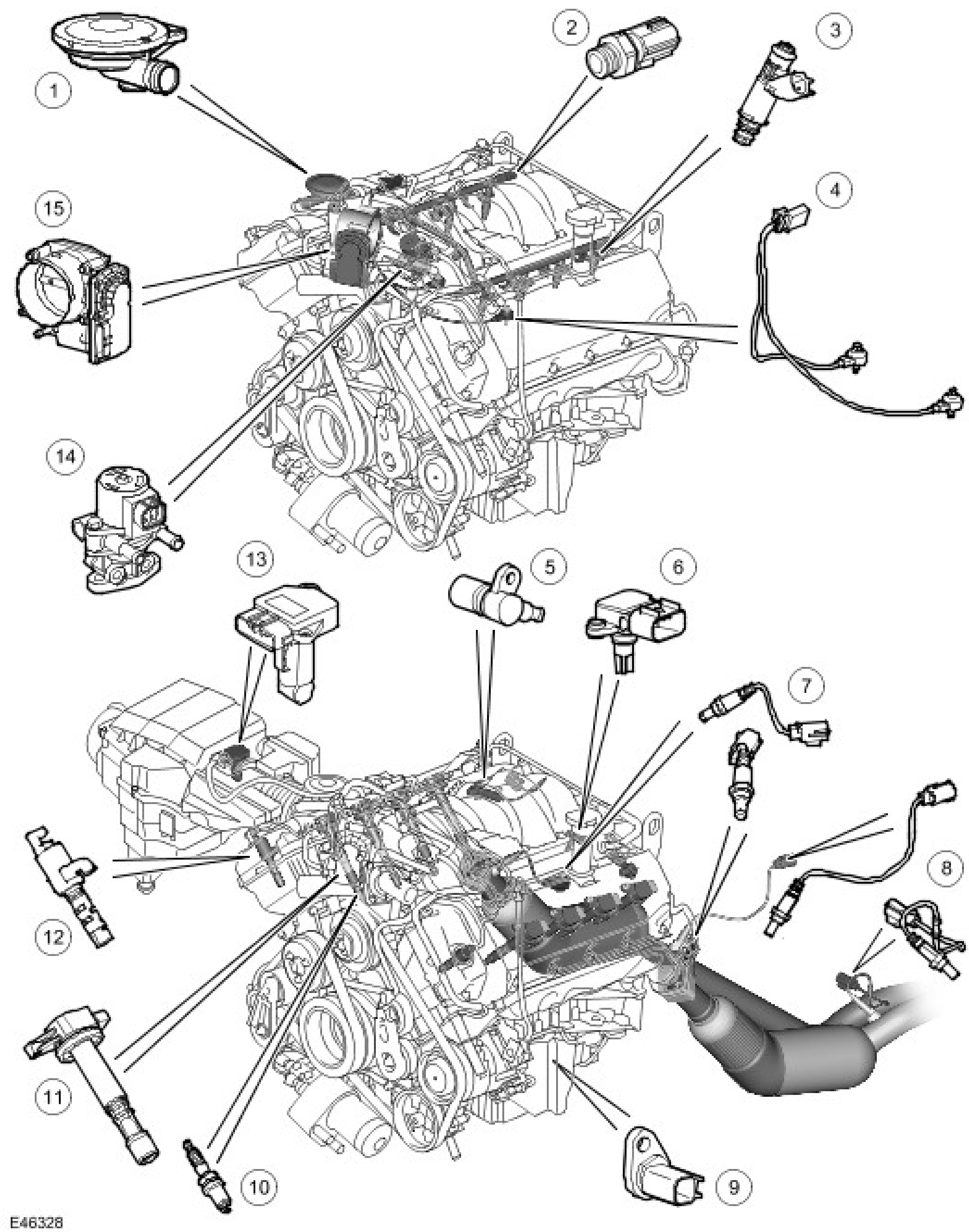
Electronic Engine Controls

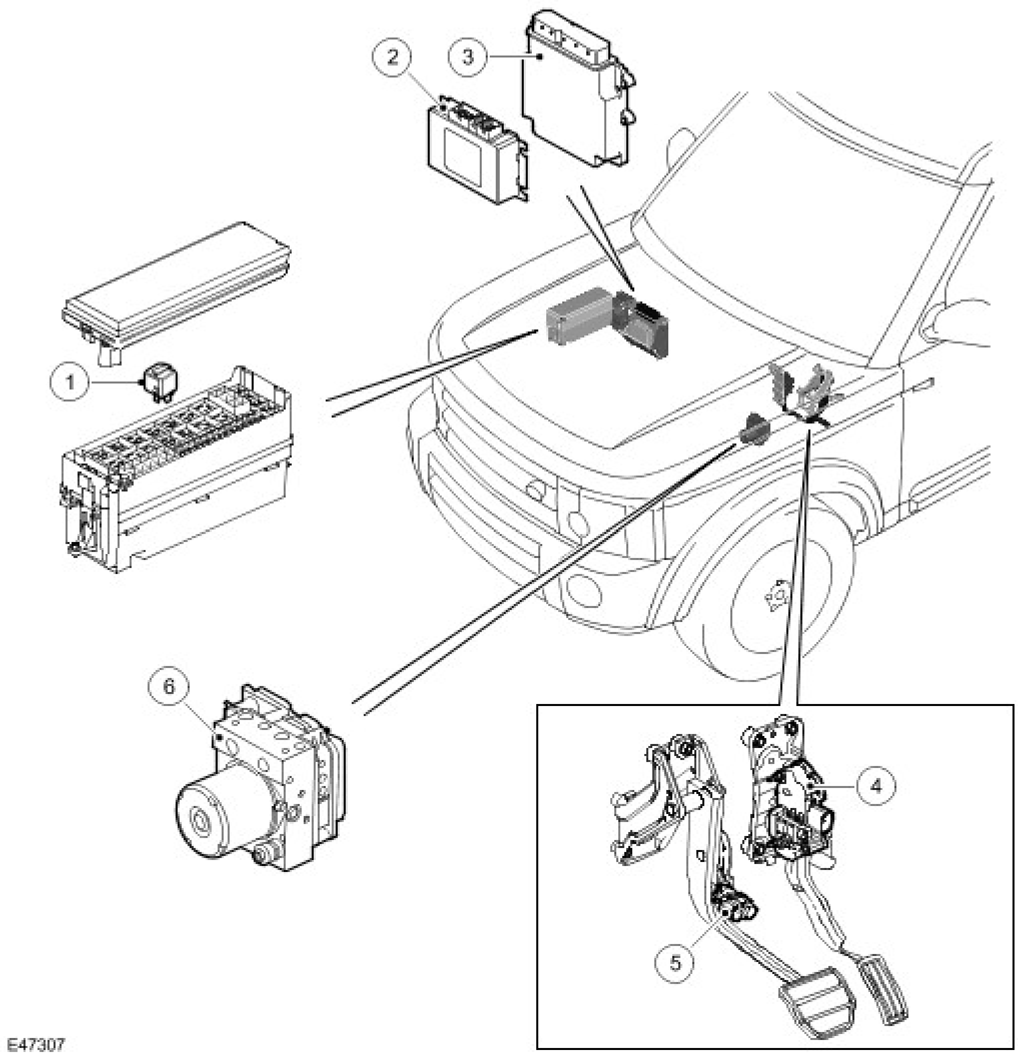
4.4 Liter Electronic Engine Controls-Component Location (Sheet 1of 2)



Item	Part Number	Description
1	-	Crankcase ventilation valve (PCV)
2	-	Fuel rail temperature sensor
3	-	Injectors
4	-	Knock sensor

5	-	Camshaft position sensor (CMP)
6	-	Manifold Absolute Pressure sensor (MAP)
7	-	Universal Heated Exhaust Gas Oxygen (UHEGO) sensors
8	-	Heated Exhaust Gas Oxygen (HEGO) sensors
9	-	Crankshaft position sensor
10	-	Spark plugs
11	-	Ignition coils
12	-	Variable Valve Timing (VVT) oil control solenoid
13	-	Mas Air Flow (MAF) sensor
14	-	Exhaust Gas Recirculation (EGR) valve
15	-	Electric throttle

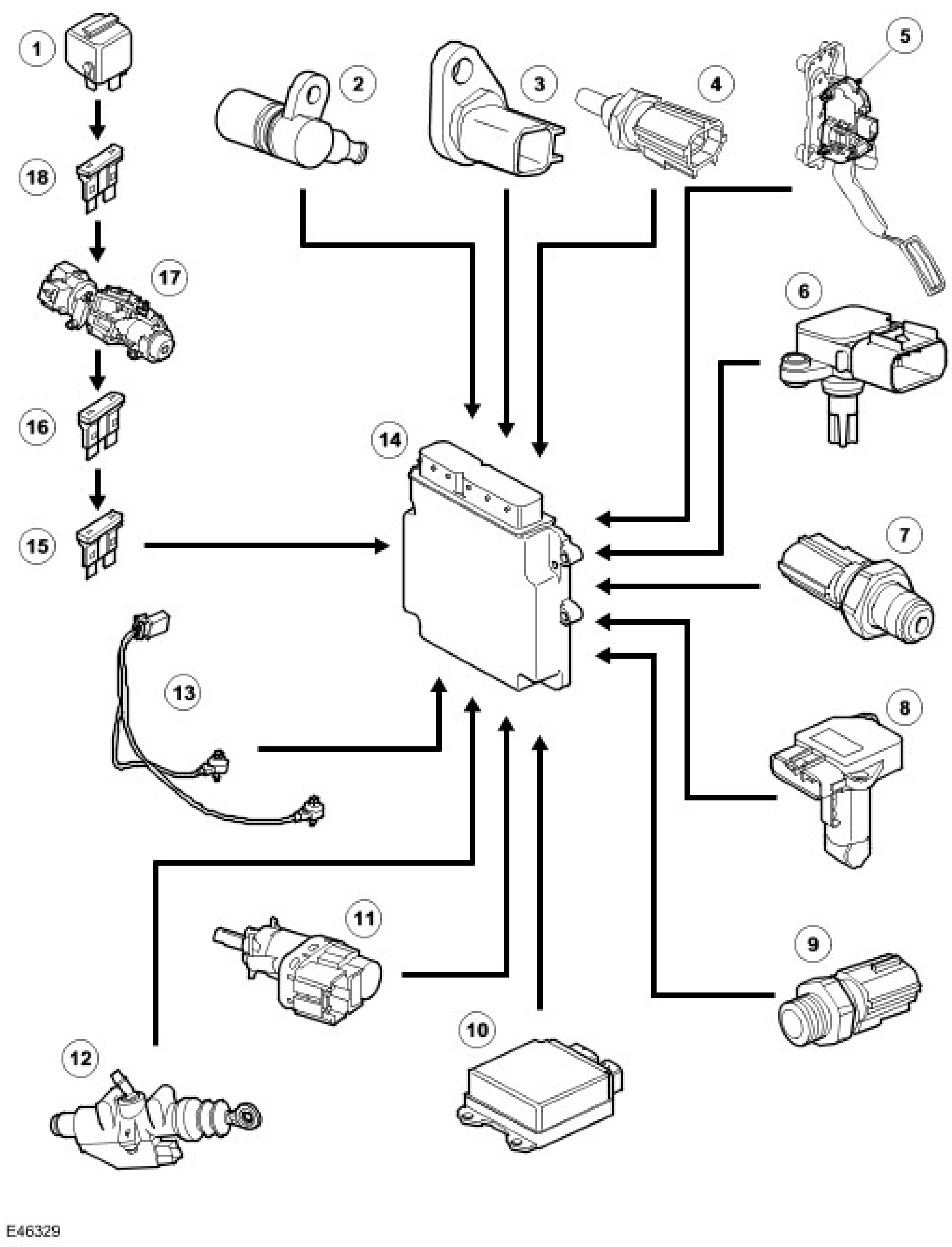
4.4 Liter Electronic Engine Controls-Component Location (Sheet 2 of 2)



Item	Part Number	Description
1	-	Main relay
2	-	Transfer box control module
3	-	Engine Control Module (ECM)

4	-	Accelerator Pedal Position sensor (APP)
5	-	Brake light switch
6	-	Antilock Braking System (ABS) control module

4.4 Liter Electronic Engine Controls-Input Control Diagram (Sheet 1 of 2)



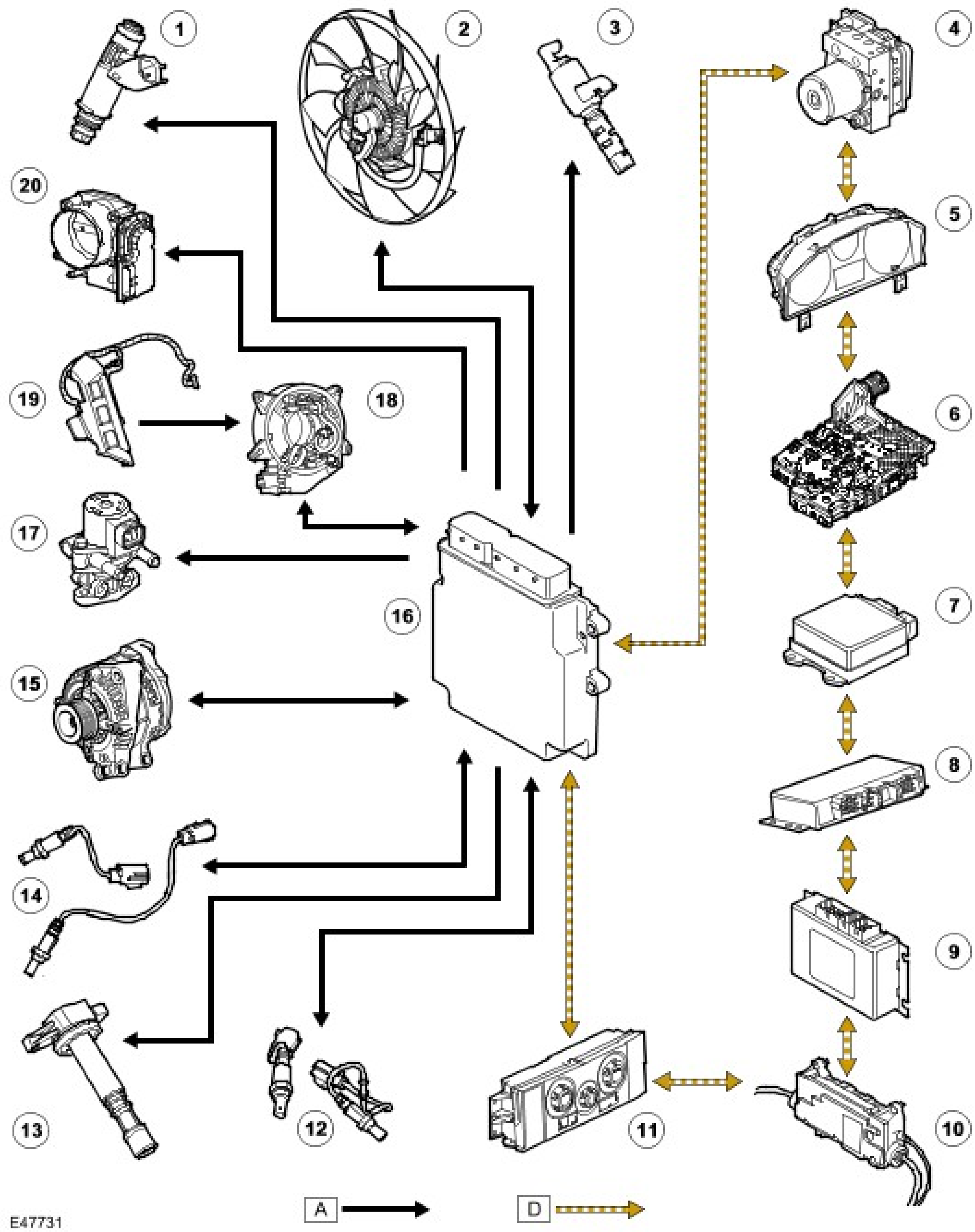
Item	Part Number	Description
1	-	Main relay
2	-	Camshaft sensor (CMP)
3	-	Crankshaft position sensor (CKP)
4	-	Engine Coolant Temperature sensor (ECT

5	-	Accelerator Pedal Position sensor (APP)
6	-	Manifold Absolute Pressure Sensor (APP)
7	-	Engine oil temperature sensor
8	-	Mass Air Flow/Inlet Air Temperature sensor (MAF/IAT)
9	-	Fuel rail temperature sensor
10	-	Restraints control module
11	-	Brake light switch
12	-	Clutch switch (Not used)
13	-	Knock sensors
14	-	ECM
15		Fuse 60 P
16	-	Fuse 25 P
17	-	Ignition switch
18	-	Fuseable link 11 E

4.4 Liter Electronic Engine Controls-Control Diagram (Sheet 2 of 2)

NOTE :

A= Hardwired D= CAN



Item	Part Number	Description
1	-	Injectors
2	-	Engine cooling fan
3	-	Variable Valve Timing (VVT) oil control solenoids
4	-	ABS control module
5	-	Instrument pack
6	-	EAT control module
7	-	Restraints control module
8	-	Differential control module
9	-	Transfer box control module
10	-	Electric park brake control module

11	-	ATC control module
12	-	UHEGO
13	-	Ignition coils
14	-	HEGO
15	-	Generator
16	-	ECM
17	-	EGR valve
18	-	Clock spring
19	-	Speed control switches
20	-	Electric throttle

GENERAL

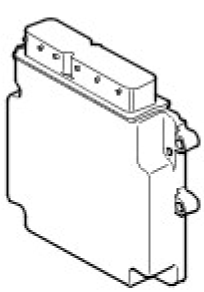
The V8 4.4 Liter engine is controlled by a Engine Control Module (ECM) manufactured by DENSO. The Engine Management System (EMS) controls the following:

- Engine fuelling
- Ignition timing
- Closed loop fuelling
- Knock control
- Idle speed control
- Emission control
- On Board Diagnostic
- Interface with the immobilisation system
- Speed control

The ECM controls the engine fuelling by providing sequential fuel injection to all cylinders. Ignition is controlled by a direct ignition system, provided by eight 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 ECU's. The EMS uses various sensors to determine the torque required from the engine. The EMS also interfaces with other vehicle electronic control modules's, via the CAN bus, to obtain additional information (e.g. road speed from the ABS control module). The EMS 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 (electronic throttle, injectors, coils, etc.).

ENGINE CONTROL MODULE (ECM)



E46330

The ECM is located in the E-Box in the plenum area on the LH side of the engine compartment attached to the bulkhead.

System ECM has the following inputs:

- Engine fuelling
- Ignition timing
- Closed loop fuelling
- Knock control

- Idle speed control
- Emission control
- On Board Diagnostic
- Interface with the immobilisation system

The ECM outputs to the following:

- Throttle Actuator
- Ignition coils (x8)
- Oxygen sensor heaters (4)
- Fuel injectors (8)
- EGR stepper motor
- Variable Valve Timing Oil Valves (2)
- Purge Valve
- Engine Cooling Fan
- Fuel pump relay
- Starter Relay
- Air conditioning condenser fan module
- EMS Main Relay
- Viscous Fan Control
- Generator Control
- Power Assisted Steering
- Diagnostic Module Tank Leakage (DMTL) (NAS Only)

ECM Connector C0634 Pin Out Table

Pin No	Description	Input/Output
1	CAN	Input/Output
2	CAN	Input/Output
3	Generator monitor	Input
4	UHEGO Bank A ground	-
5	UHEGO Bank B ground	-
6	Not used	-
7	Not used	-
8	Not used	-
9	Not used	-
10	Not used	-
11	CKP ground	-
12	CMP sensor bank A ground	-
13	CMP sensor bank B ground	-
14	UHEGO sensor bank B signal	Input
15	Electronic throttle body ground	-
16	MAF ground	-
17	HEGO ground	-
18	Not used	-
19	Knock sensor 1 ground	-
20	Knock sensor 2 ground	-
21	Knock sensor 3 ground	-
22	Knock sensor 4 ground	-
23	Electronic throttle body 5V supply	Output
24	Fuel pump relay	Output
25	Not used	-
26	Not used	-

27	Not used	-
28	Not used	-
29	Radiator temperature sensor	Input
30	Crank sensor signal	Input
31	Not used	-
32	Not used	-
33	CMP signal bank B	Input
34	CMP signal bank A	Input
35	Not used	-
36	UHEGO signal bank A	Input
37	UHEGO signal bank A ground	-
38	UHEGO signal bank B ground	-
39	Fuel temperature sensor	Input
40	Fuel pressure sensor	Input
41	Not used	Input
42	Not used	Input
43	Knock sensor 1 +	Output
44	Knock sensor 2 +	Output
45	Knock sensor 3 +	Output
46	Knock sensor 4 +	Output
47	Generator control	Output
48	E-box fan	Output
49	Not used	-
50	EGR stepper motor 4	Output
51	EGR stepper motor 3	Output
52	EGR stepper motor 2	Output
53	EGR stepper motor 1	Output
54	Ignition coil cylinder 4 B	Output
55	Ignition coil cylinder 4 A	Output
56	Ignition coil cylinder 3 B	Output
57	Not used	-
58	Not used	-
59	Not used	-
60	Not used	-
61	Not used	-
62	Not used	-
63	Not used	-
64	Not used	-
65	Not used	-
66	Not used	-
67	Not used	-
68	Not used	-
69	Not used	-
70	MAF	Input
71	Purge valve	Output
72	Starter relay -	-

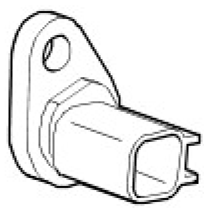
73	Throttle body power supply	Output
74	Throttle valve open direction -	Output
75	Throttle valve open direction +	Output
76	UHEGO Heater bank A	Output
77	UHEGO Heater bank B	Output
78	Injector cylinder 4B	Output
79	Injector cylinder 4A	Output
80	Injector cylinder 3B	Output
81	Injector cylinder 3A	Output
82	Injector cylinder 2B	Output
83	Injector cylinder 2A	Output
84	Injector cylinder 1B	Output
85	Injector cylinder 1A	Output
86	VVT bank A	Output
87	VVT bank B	Output
88	Viscous fan control	Output
89	Not used	-
90	Oil temperature sensor	Input
91	Throttle body monitor signal	Input
92	Starter motor relay +	Output
93	Not used	-
94	Viscous fan request	Input
95	Purge valve	Output

ECM Connector C0635 Pin Out Table

Pin No	Description	Input/Output
1	Signal ground 1	-
2	Power ground 1	-
3	Power ground 3	-
4	Power ground 2	-
5	ECM power	Input
6	APP sensor ground 1	-
7	APP sensor ground 2	-
8	Not used	-
9	Not used	-
10	Not used	-
11	Not used	-
12	Park/ Neutral signal	Input
13	Not used	-
14	Not used	-
15	Not used	-
16	EMS relay	Output
17	Crank request	Output
18	CAN +	Output
19	APP sensor 2 power	Output

20	Fuel pump control	Output
21	Not used	-
22	Not used	-
23	Not used	-
24	APP sensor 1 signal	Output
25	Not used	-
26	Brake light switch	Input
27	Not used	-
28	Not used	-
29	Not used	-
30	Ignition switch	Input
31	CAN +	Input
32	APP sensor 1 power	Output
33	DMTL	Output
34	Not used	-
35	Cruise switch -	Output
36	Cruise switch +	Input

CRANKSHAFT POSITION SENSOR (CKP)



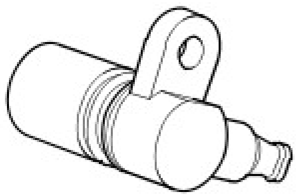
E46331

The crankshaft position sensor is mounted at the rear underside of the engine near the transmission bell housing. Connection between the sensor and the harness is via a link harness and a two-way connector. Both wires go directly to the ECM. The sensor produces the signal which enables the ECM to determine the angle of the crankshaft, and the engine rpm. From this, the point of ignition, fuel injection, etc. is calculated. If the signal wires are reversed a 3° advance in timing will occur, as the electronics within the ECM uses the falling edge of the signal waveform as its reference / timing point for each tooth.

The reluctor is pressed into the flywheel and has a "tooth" pattern based on 36 teeth at 10° intervals and approximately 3° wide: one of the teeth is removed to provide a hardware reference mark which is 60 degrees BTDC No.1 cylinder. Because of the crankshaft sensor's orientation, the target wheel uses windows machined into the face, rather than actual teeth.

The sensor operates by generating an output voltage caused by the change in magnetic field that occurs as the windows pass in front of the sensor. The output voltage varies with the speed of the windows passing the sensor, the higher the engine speed, the higher the output voltage. Note that the output is also dependent on the air gap between the sensor and the teeth (the larger the gap, the weaker the signal, the lower the output voltage). The ECM transmits the engine speed to other vehicle ECU's on CAN.

CAMSHAFT POSITION SENSOR (CMP)



E46332

Two sensors are located at the rear of the engine, in the cylinder head (one per bank), above the rear cylinders. This is a Variable Reluctor Sensor (VRS) 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 variable cam inlet is parked in the retarded position and can advance up to 48 degrees.

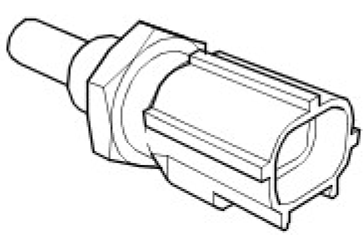
The camshaft timing wheel is a sintered component which has four teeth on it to enable the EMS to detect cylinder identification. The signal is used for:

- Variable inlet cam timing
- Cylinder recognition
- Enabling sequential fuel injection
- Knock control
- Cylinder identification for diagnostic purposes.

Failure symptoms include:

- Ignition timing reverting to the base mapping, with no cylinder correction.
- Active knock control is disabled, along with its diagnostic (Safe ignition map - loss of performance).
- Quick cam / crank synchronisation on start disabled.
- Variable cam timing is disabled

ENGINE COOLANT TEMPERATURE SENSOR (ECT)

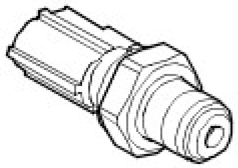


E47309

The sensor is located at the front of the engine in the water pipe below the throttle body. The ECT sensor is a thermistor used to monitor the engine coolant temperature. The engine coolant temperature 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.

The sensor has an operating temperature range of -30 Degrees Celsius to 125 Degrees Celsius. When a defective coolant sensor is detected, the ECM uses the oil temperature sensor value.

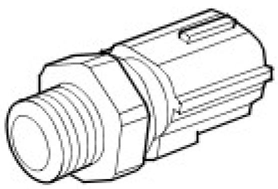
ENGINE OIL TEMPERATURE SENSOR



E46333

Oil temperature is monitored through a temperature sensor mounted in the oil system. This component is a NTC (negative temperature coefficient) . The sensor is mounted next to the oil pressure sensor at the front of the engine and locates into the oil filter bracket.

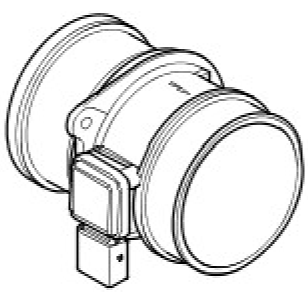
FUEL RAIL TEMPERATURE SENSOR



E47606

The fuel rail temperature sensor measures the temperature of the fuel in the fuel rail. This input is then used to deliver the correct quantity of fuel to the engine. Operating Range -40 Degrees Celsius to 150 Degrees Celsius. The fuel rail temperature sensor is fitted on the rear of the right hand bank (bank A) fuel rail.

MASS AIR FLOW/INLET AIR TEMPERATURE SENSOR (MAF/IAT)



E47308

The air flow meter is located in the clean air duct immediately after the air filter box.

The air mass flow is determined by the cooling effect of inlet 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 ECM then uses this signal from the Mass Air Flow meter to calculate the air mass flowing into the engine.

The measured air mass flow is used in determining the fuel quantity to be injected in order to maintain the stichometric air/fuel mixture 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.

The following symptoms may be observed if the sensor fails:

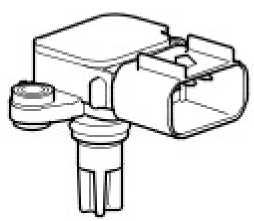
- During driving the engine RPM might dip, before recovering.

- Difficulty in starting or start - stall.
- Poor throttle response / engine performance.
- Lambda control and idle speed control halted.
- Emissions incorrect.
- AFM signal offset

The Inlet Air Temperature (IAT) sensor is integrated into the Mass Air Flow meter. It is a temperature dependent resistor (thermistor), i.e. the resistance of the sensor varies with temperature. This thermistor is a negative temperature coefficient (NTC) type element meaning 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 sensor changes as the sensor resistance changes, thus relating the air temperature to the voltage measured by the ECM.

The ECM stores a 25°C default value for air temperature in the event of a sensor failure.

MANIFOLD ABSOLUTE PRESSURE SENSOR (MAP)



E47588

The MAP sensor provides a voltage proportional to the absolute pressure in the intake manifold. This signal allows the load on the engine to be calculated and used within the internal calculations of the ECM. The sensor is located on the rear of the air intake manifold.

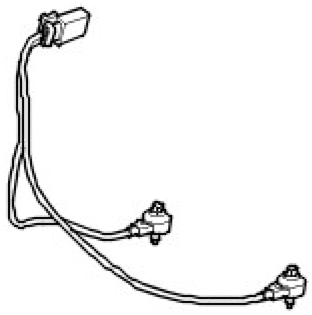
Pin No	Description
1	MAP signal
2	Sensor supply
3	Not used
4	Sensor ground

The output signal from the MAP sensor, together with the CKP and IAT sensors, is used by the ECM to calculate the amount of air induced into the cylinders. This enables the ECM to determine ignition timing and fuel injection duration values.

The MAP sensor receives a 5V supply voltage from pin 48 of ECM connector C0634 and provides an analogue signal to pin 69 of ECM connector C0634, which relates to the absolute manifold pressure and allows the ECM to calculate engine load. The ECM provides a ground for the sensor via pin 11 of ECM connector C0634.

If the MAP signal is missing, the ECM will substitute a default manifold pressure reading based on crankshaft speed and throttle angle. The engine will continue to run with reduced drivability and increased emissions, although this may not be immediately apparent to the driver. The ECM will store fault codes which can be retrieved using T4.

KNOCK SENSORS



E47296

The V8 EMS has two knock sensors located in the V of the engine, one per cylinder bank. The sensors are connected to the ECM via a twisted pair.

The knock sensors produce a voltage signal in proportion to the amount of mechanical vibration generated at each ignition point. Each sensor monitors the related cylinder bank.

The knock sensors incorporate a piezo-ceramic crystal. This crystal produces a voltage whenever an outside force tries to deflect it, (i.e. exerts a mechanical load on it). When the engine is running, the compression waves in the material of the cylinder block, caused by the combustion of the fuel/air mixture within the cylinders, deflect the crystal and produce an output voltage signal. The signals are supplied to the ECM, which compares them with `mapped' signals stored in memory. From this, the ECM can determine when detonation occurs on individual cylinders. When detonation is detected, the ECM retards the ignition timing on that cylinder for a number of engine cycles, then gradually returns it to the original setting.

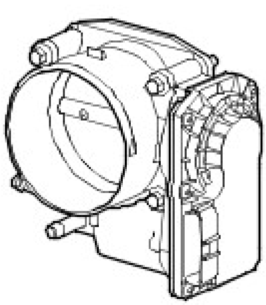
Care must be taken at all times to avoid damaging the knock sensors, but particularly during removal and fitting procedures. The recommendations regarding torque and surface preparation must be adhered to. The torque applied to the sensor and the quality of the surface preparation both have an influence over the transfer of mechanical noise from the cylinder block to the crystal.

The ECM uses the signals supplied by the knock sensors, in conjunction with the signal it receives from the camshaft sensor, to determine the optimum ignition point for each cylinder. The ignition point is set according to preprogrammed ignition maps stored within the ECM. The ECM is programmed to use ignition maps for 98 RON premium specification fuel. It will also function on 91 RON regular specification fuel and learn new adaptions. If the only fuel available is of poor quality, or the customer switches to a lower grade of fuel after using a high grade for a period of time, the engine may suffer slight pre-ignition for a short period. This amount of pre-ignition will not damage the engine. This situation will be evident while the ECM learns and then modifies its internal mapping to compensate for the variation in fuel quality. This feature is called adaption. The ECM has the capability of adapting its fuel and ignition control outputs in response to several sensor inputs.

The ECM will cancel closed loop control of the ignition system if the signal received from either knock sensor becomes implausible. In these circumstances the ECM will default to a safe ignition map. This measure ensures the engine will not become damaged if low quality fuel is used. The MIL lamp will not illuminate, although the driver may notice that the engine 'pinks' in some driving conditions and displays a drop in performance and smoothness.

When a knock sensor fault is stored, the ECM will also store details of the engine speed, engine load and the coolant temperature.

ELECTRONIC THROTTLE



E47298

The V8 EMS incorporates an electric throttle control system. The electronic throttle body is located on the air intake manifold in the engine compartment. The system comprises three main components:

- Electronic throttle control valve
- Accelerator pedal position sensor (APP)
- ECM

When the accelerator pedal is depressed the APP sensor provides a change in the monitored signals. The ECM compares this against an electronic “map” and moves the electronic throttle valve via a pulse width modulated (PWM) control signal which is in proportion to the APP angle signal. The system is required to:

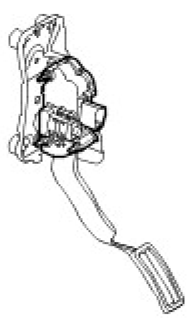
- Regulate the calculated intake air load based on the accelerator pedal sensor input signals and programmed mapping.
- Monitor the drivers input request for cruise control operation.
- Automatically position the electronic throttle for accurate cruise control.
- Perform all dynamic stability control throttle control interventions.
- Monitor and carry out maximum engine and road speed cut out.

A software strategy within the ECM enables the throttle position to be calibrated each ignition cycle. When the ignition is turned ON, the ECM performs a self test and calibration routine on the electronic throttle by opening and closing the throttle fully.

Electronic Throttle Pin Out Table

Pin No	Description
1	Motor -
2	Motor +
3	Sensor ground
4	Sensor 2 signal
5	Sensor 1 signal
6	5 volt supply

ACCELERATOR PEDAL POSITION SENSOR (APP)



E47297

The APP sensors are located on the accelerator pedal assembly.

The APP sensors are used to determine the driver's request for vehicle speed, acceleration and deceleration. This value is used by the ECM and the throttle is opened to the correct angle by an electric motor integrated into the throttle body.

The APP Sensor signals are checked for range and plausibility. Two separate reference voltages are supplied to the pedal. Should one sensor fail, the other is used as a 'limp – home' input. In limp home mode due to an APP signal failure the ECM will limit the maximum engine speed to 2000 rpm.

Accelerator Pedal Position Sensor (APP) Pin Out Table

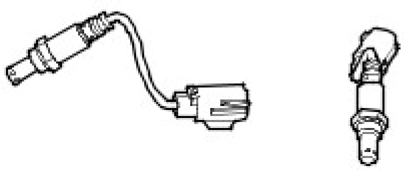
Pin No	Description

1	APP2 ground
2	APP 1 demand
3	APP 1 ground
4	Not used
5	APP 2 demand
6	Supply 2, 5 volt
7	Supply 1, 5 volt
8	Not used

OXYGEN SENSORS

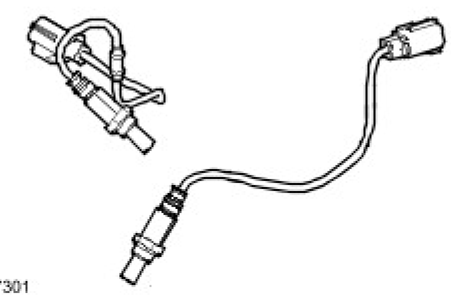
There are four oxygen sensors located in the exhaust system. Two upstream before the catalytic converter and two down stream after the catalytic converter. The sensor monitors the level of oxygen in the exhaust gases and is used to control the fuel/air mixture. Positioning a sensor in the stream of exhaust gasses from each bank enables the ECM to control the fuelling on each bank independently of the other, allowing much closer control of the air / fuel ratio and catalyst conversion efficiency.

Upstream Oxygen Sensors



E47300

Downstream Oxygen Sensors



E47301

The oxygen sensors need to operate at high temperatures in order to function correctly. To achieve the high temperatures required, the sensors are fitted with heater elements that are controlled by a PWM signal from the ECM. The heater elements are operated immediately following engine start and also during low load conditions when the temperature of the exhaust gases is insufficient to maintain the required sensor temperatures. A non-functioning heater delays the sensor’s readiness for closed loop control and influences emissions. The PWM duty cycle is carefully controlled to prevent thermal shock to cold sensors.

UHEGO (Universal Heated Exhaust Gas Oxygen) sensors also known as Linear or "Wide Band" sensors produces a constant voltage, with a variable current that is proportional to the oxygen content. This allows closed loop fuelling control to a target lambda, i.e. during engine warm up (after the sensor has reached operating temperature and is ready for operation). This improves emission control.

The HEGO sensor uses Zirconium technology that produces an output voltage dependant upon the ratio of exhaust gas oxygen to the ambient oxygen. The device contains a Galvanic cell surrounded by a gas permeable ceramic, the voltage of which depends upon the level of O2 defusing through. Nominal output voltage of the device for l =1 is 300 to 500m volts. As the fuel mixture becomes richer (l<1) the voltage tends towards 900m volts and as it becomes leaner (l>1) the voltage tends towards 0 volts. Maximum tip temperature is 1,000 Degrees Celsius for a maximum of 100 hours.

Sensors age with mileage, increasing their response time to switch from rich to lean and lean to rich. This increase in response time influences the ECM closed loop control and leads to progressively increased emissions. Measuring the period of rich to lean and lean to rich switching monitors the response rate of the upstream sensors.

Diagnosis of electrical faults is continually monitored in both the upstream and downstream sensors. This is achieved by checking the signal against maximum and minimum threshold, for open and short circuit conditions.

Oxygen sensors must be treated with the utmost care before and during the fitting process. The sensors have ceramic material within them that can easily crack if dropped / banged or over-torqued. The sensors must be torqued to the required figure, (40-50Nm), with a calibrated torque wrench. Care should be taken not to contaminate the sensor tip when anti-seize compound is used on the thread. Heated sensor signal pins are tinned and universal are gold plated. Mixing up sensors could contaminate the connectors and affect system performance.

Failure Modes

- Mechanical fitting & integrity of the sensor.
- Sensor open circuit / disconnected.
- Short circuit to vehicle supply or ground.
- Lambda ratio outside operating band.
- Crossed sensors bank A & B.
- Contamination from leaded fuel or other sources.
- Change in sensor characteristic.
- Harness damage.
- Air leak into exhaust system.

Failure Symptoms

- Default to Open Loop fuelling for the particular cylinder bank
- High CO reading.
- Strong smell of H02S (rotten eggs) till default condition.
- Excess Emissions.

It is possible to fit front and rear sensors in their opposite location. However the harness connections are of different gender and colour to ensure that the sensors cannot be incorrectly connected. In addition to this the upstream sensors have two holes in the shroud, whereas the down stream sensors have four holes in the shroud for the gas to pass through.

GENERATOR

The Generator has a multifunction voltage regulator for use in a 14V charging system with 6÷12 zener diode bridge rectifiers.

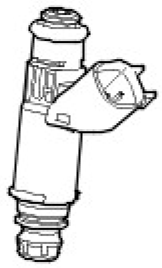
The ECM monitors the load on the electrical system via PWM signal and adjusts the generator output to match the required load. The ECM also monitors the battery temperature to determine the generator regulator set point. This characteristic is necessary to protect the battery; at low temperatures battery charge acceptance is very poor so the voltage needs to be high to maximise any rechargeability, but at high temperatures the charge voltage must be restricted to prevent excessive gassing of the battery with consequent water loss.

The Generator has a smart charge capability that will reduce the electrical load on the Generator reducing torque requirements, this is implemented to utilise the engine torque for other purposes. This is achieved by monitoring three signals to the ECM:

- Generator sense (A sense), measures the battery voltage at the Central Junction Box(CJB).
- Generator communication (Alt Com) communicates desired Generator voltage set point from ECM to Generator.
- Generator monitor (Alt Mon) communicates the extent of Generator current draw to ECM. This signal also

transmits faults to the ECM which will then sends a message to the instrument pack on the CAN bus to illuminate the charge warning lamp. For additional information, refer to Generator (414-02B Generator and Regulator - 4.4L)

FUEL INJECTORS

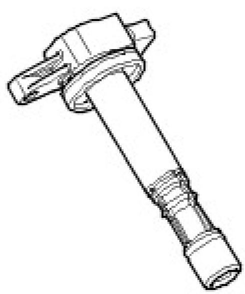


E47305

The engine has 8 fuel injectors (one per cylinder), each injector is directly driven by the ECM. The injectors are fed by a common fuel rail as part of a 'returnless' fuel system. The fuel rail pressure is regulated to 4.5 bar by a fuel pressure regulator which is integral to the fuel pump module, within the fuel tank. The injectors can be checked by resistance checks. There is a fuel pressure test Schrader valve attached to the fuel rail on the front LH side for fuel pressure testing purposes. The ECM monitors the output power stages of the injector drivers for electrical faults.

The injectors have a resistance of 13.8 Ohms ± 0.7 Ohms @ 20 Degrees Celsius For additional information, refer to Fuel Charging and Controls (303-04B Fuel Charging and Controls - 4.4L)

IGNITION COILS



E47306

The V8 engine is fitted with eight plug-top coils that are driven directly by the ECM. This means that the ECM, at the point where sufficient charge has built up, switches the primary circuit of each coil and a spark is produced in the spark plug. The positive supply to the coil is fed from a common fuse. Each coil contains a power stage to trigger the primary current. The ECM sends a signal to each of the coils power stage to trigger the power stage switching. Each bank has a feedback signal that is connected to each power stage. If the coil power stage has a failure the feedback signal is not sent, causing the ECM to store a fault code appropriate to the failure.

The ECM calculates the dwell time depending on battery voltage and engine speed to ensure constant secondary energy. This ensures sufficient secondary (spark) energy is always available, without excessive primary current flow thus avoiding overheating or damage to the coils.

The individual cylinder spark timing is calculated from a variety of inputs:

- Engine speed and load.
- Engine temperature.
- Knock control.
- Auto gearbox shift control.
- Idle speed control.

For additional information, refer to Engine Ignition (303-07B Engine Ignition - 4.4L)

FUEL PUMP RELAY

The V8 engine has a returnless fuel system. The system pressure is maintained at a constant 4 bar (59 Psi), with no reference to intake manifold pressure. The fuel is supplied to the injectors from a fuel pump fitted within the fuel tank. The electrical supply to this fuel pump is controlled by the ECM via a relay and an Inertia Switch which will turn the fuel off upon a vehicle impact. The fuel system is pressurised as soon as the ECM is powered up, the pump is then switched off until engine start has been achieved.

VISCOUS FAN CONTROL

The ECM controls a viscous coupled fan to provide engine cooling. The ECM supplies the fan with a PWM signal that controls the amount of slippage of the fan, thus providing the correct amount of cooling fan speed and airflow. The EMS uses a Hall Effect sensor to determine the fan speed. For additional information, refer to Engine Cooling (303-03B Engine Cooling - 4.4L)

VARIABLE VALVE TIMING (VVT)

Variable valve timing is used on the V8 engine to enhance low and high speed engine performance and idle speed quality.

For each inlet camshaft the VVT system comprises:

- VVT unit
- Valve timing solenoid

The VVT system alters the phase of the intake valves relative to the fixed timing of the exhaust valves, to alter:

- The mass of air flow to the cylinders.
- The engine torque response.
- Emissions.

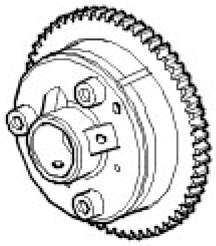
The VVT unit uses a vane type device to control the camshaft angle. The system operates over a range of 48 degrees and is advanced or retarded to its optimum position within this range.

The VVT system is controlled by the ECM based on engine load and speed along with engine oil temperature to calculate the appropriate camshaft position.

The VVT system provides the following advantages:

- Reduced engine emissions and improved fuel consumption which in turn improves the engines internal EGR effect over a wider operating range.
- Enhanced full load torque characteristics.
- Improved fuel economy through optimised torque over the engine speed range.

Variable Valve Timing Unit


E47303

The VVT unit is a hydraulic actuator mounted on the end of the inlet camshaft. The unit advances or retards the camshaft timing to alter the camshaft to crankshaft phase. The ECM controls the VVT timing unit via a oil control solenoid. The oil control solenoid routes oil pressure to the advance or retard chambers either side of the vanes within the VVT unit.

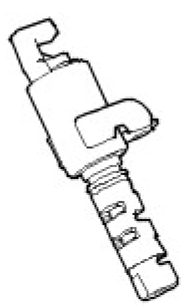
The VVT unit is driven by the primary drive chain and rotates relative to the exhaust camshaft. When the ECM requests a retard in camshaft timing the oil control solenoid is energised which moves the shuttle valve in the solenoid to the relevant position allowing oil pressure to flow out of the advance chambers in the VVT unit whilst simultaneously allowing oil pressure into the retard chambers.

The ECM controls the advancing and retarding of the VVT unit based on engine load and speed. The ECM sends an energise signal to the oil control solenoid until the desired VVT position is achieved. When the desired VVT position is reached, the energising signal is reduced to hold the oil control solenoid position and consequently desired VVT position. This function is under closed loop control and the ECM can sense any variance in shuttle valve oil pressure via the camshaft position sensor and can adjust the energising signal to maintain the shuttle valve hold position.

VVT operation can be affected by engine oil temperature and properties. At very low oil temperatures the movement of the VVT mechanism will be slow due to the high viscosity of the oil. While at high oil temperatures the low oil viscosity may impair the VVT operation at low oil pressures. The oil pump has the capacity to cope with these variations in oil pressure while an oil temperature sensor is monitored by the ECM to provide oil temperature feedback. At extremely high oil temperatures the ECM may limit the amount of VVT advance in order to prevent the engine from stalling when returning to idle speed.

VVT does not operate when engine oil pressure is below 1.25 bar. This is because there is insufficient pressure to release the VVT units internal stopper pin. This occurs when the engine is shut down and the VVT unit has returned to the retarded position. The stopper pin locks the VVT unit to the camshaft to ensure camshaft stability during the next start up. For additional information, refer to Engine (303-01B Engine - 4.4L)

Valve Timing Solenoid

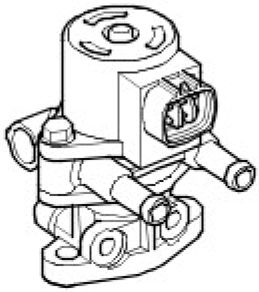

E47302

Valve Timing Solenoid

The valve timing solenoid controls the position of the shuttle valve in the bush carrier. A plunger on the solenoid extends when the solenoid is energised and retracts when the solenoid is de-energised.

When the valve timing solenoids are de-energised, the coil springs in the bush carriers position the shuttle valves to connect the valve timing units to drain. In the valve timing units, the return springs hold the ring pistons and gears in the retarded position. When the valve timing solenoids are energised by the ECM, the solenoid plungers position the shuttle valves to direct engine oil to the valve timing units. In the valve timing units, the oil pressure overcomes the force of the return springs and moves the gears and ring pistons to the advanced position. System response times are 1.0 second maximum for advancing and 0.7 second maximum for retarding. While the valve timing is in the retarded mode, the ECM produces a periodic lubrication pulse. This momentarily energises the valve timing solenoids to allow a spurt of oil into the valve timing units. The lubrication pulse occurs once every 5 minutes.

EXHAUST GAS RECIRCULATION (EGR) VALVE



E47299

The Exhaust Gas Recirculation (EGR) valve is an electrically controlled valve that allows burned exhaust gas to be recirculated back into the engine. The EGR valve consists of a stepper motor that opens and closes the valve in steps. Since exhaust gas has much less oxygen than air, it is basically inert. It takes the place of air in the cylinder and reduces combustion temperature. As the combustion temperature is reduced, so are the oxides of nitrogen (NOx).

The EGR valve is located on the intake manifold with a pipe connecting the exhaust manifold to the valve. Connection between the sensor and the harness is via a six-way connector. For additional information, refer to Engine Emission Control (303-08B Engine Emission Control - 4.4L)

ECM ADAPTIONS

The ECM has the ability to adapt the values it uses to control certain outputs. This capability ensures the EMS can meet emissions legislation and improve the refinement of the engine throughout its operating range.

The components which have adaptions associated with them are:

- The APP sensor
- The HO2S
- The MAF/IAT sensor
- The CKP sensor
- Electric throttle body.

UHEGO/HEGO and MAF/IAT Sensor

There are several adaptive maps associated with the fuelling strategy. Within the fuelling strategy the ECM calculates short-term adaptions and long term adaptions. The ECM will monitor the deterioration of the oxygen sensors (HEGO and UHEGO) over a period of time. It will also monitor the current correction associated with the sensors.

The ECM will store a fault code in circumstances where an adaption is forced to exceed its operating parameters. At the same time, the ECM will record the engine speed, engine load and intake air temperature.

CKP Sensor

The characteristics of the signal supplied by the CKP sensor are learned by the ECM. This enables the ECM to set an adaption and support the engine misfire detection function. Due to the small variation between different flywheels and different CKP sensors, the adaption must be reset if either component is renewed, or removed and refitted. It is also necessary to reset the flywheel adaption if the ECM is renewed or replaced. The ECM supports four flywheel adaptions for the CKP sensor. Each adaption relates to a specific engine speed range. The engine speed ranges are detailed in the table below:

Adaptions	Engine Speed, rev/min
1	1800 - 3000
2	3001 - 3800
3	3801 - 4600
4	4601 - 5400

Misfire Detection

Legislation requires that the ECM must be able to detect the presence of an engine misfire. It must be able to detect misfires at two separate levels. The first level is a misfire that could lead to the vehicle emissions exceeding 1.5 times the Federal Test Procedure (FTP) requirements for the engine. The second level is a misfire that may cause catalyst damage.

The ECM monitors the number of misfire occurrences within two engine speed ranges. If the ECM detects more than a predetermined number of misfire occurrences within either of these two ranges, over two consecutive journeys, the ECM will record a fault code and details of the engine speed, engine load and engine coolant temperature. In addition, the ECM monitors the number of misfire occurrences that happen in a 'window' of 200 engine revolutions. The misfire occurrences are assigned a weighting according to their likely impact on the catalysts. If the number of misfires exceeds a certain value, the ECM stores catalyst-damaging fault codes, along with the engine speed, engine load and engine coolant temperature.

The signal from the crankshaft position sensor indicates how fast the poles on the flywheel are passing the sensor tip. A sine wave is generated each time a pole passes the sensor tip. The ECM can detect variations in flywheel speed by monitoring the sine wave signal supplied by the crankshaft position sensor.

By assessing this signal, the ECM can detect the presence of an engine misfire. At this time, the ECM will assess the amount of variation in the signal received from the crankshaft position sensor and assigns a roughness value to it. This roughness value can be viewed within the real time monitoring feature, using T4. The ECM will evaluate the signal against a number of factors and will decide whether to count the occurrence or ignore it. The ECM can assign a roughness and misfire signal for each cylinder, (i.e. identify which cylinder is misfiring).

T4 Diagnostics

The ECM stores faults as Diagnostic Trouble Codes (DTC), referred to as 'P' codes. The 'P' codes are defined by OBD legislation and, together with their associated environmental and freeze frame data, can be read using a third party scan tool or T4. T4 can also read real time data from each sensor, the adaptive values currently being employed and the current fuelling, ignition and idle settings.

P Code No	Component/ Signal	Fault Description
P0011	CMP/CKP/VVT	Bank A CMP/CKP Position error high , VVT retard position high
P0012	CMP/CKP/VVT	Bank A CMP/CKP Position error low, VVT retard position low
P0021	CMP/CKP/VVT	Bank B CMP/CKP Position error, VVT retard position high
P0022	CMP/CKP/VVT	Bank B CMP/CKP Position error low , VVT retard position low
P0026	VVT	Bank A circuit malfunction range high/ low
P0028	VVT	Bank B circuit malfunction range high/ low
P0031	UHEGO	Bank A heater control circuit low
P0032	UHEGO	Bank A heater control circuit high
P0051	UHEGO	Bank B heater control circuit low
P0052	UHEGO	Bank B heater control circuit high
P0069	HAC	Sensor circuit/range performance
P0071	Ambient air temperature sensor	Range performance
P0072	Ambient air temperature sensor	Circuit low input
P0073	Ambient air temperature sensor	Circuit high input
P0075	VVT	Bank A open circuit
P0076	VVT	Bank A short to ground

P0077	VVT	Bank A short to battery
P0081	VVT	Bank B open circuit
P0082	VVT	Bank B short to ground
P0083	VVT	Bank B short to battery
P0087	Fuel pressure system	Low fault
P0088	Fuel pressure system	High fault
P0089	Fuel pressure system	Noise fault
P0093	Fuel pressure system	Large leak
P0096	IAT	Sensor range performance
P0101	AFM	Circuit range performance
P102	AFM	Circuit low input
P103	AFM	Circuit high input
P0106	MAP	Sensor range performance
P0107	MAP	Circuit low input
P0108	MAP	Circuit high input
P0111	IAT	Stuck high/ low at engine start, stuck high
P0112	IAT	Sensor 1 circuit low input
P0113	IAT	Sensor 1 circuit high input
P0116	ECT	Implausible signal
P0117	ECT	Circuit low input
P0118	ECT	Circuit high input
P0121	Throttle circuit 1 and 2	Range/ performance
P0122	Throttle circuit 1	Low input
P0123	Throttle circuit 1	High input
P0125	ECT	Insufficient coolant temperature for closed loop control
P0128	Thermostat monitor	Low coolant temperature – thermostat stuck open
P0131	UHEGO	Bank A short circuit to ground
P0132	UHEGO	Bank A Short circuit to battery
P0133	UHEGO	Bank A slow response
P0136	HEGO	Bank A adaptions
P0137	HEGO	Bank A short circuit to ground
P0138	HEGO	Bank A short circuit to battery
P0139	HEGO	Bank A slow response
P0140	HEGO	Bank A no activity
P0141	HEGO	Bank A heater control circuit malfunction
P0151	UHEGO	Bank B short circuit to ground
P0152	UHEGO	Bank B short circuit to battery
P0153	UHEGO	Bank B slow response
P0156	HEGO	Bank B adaptions
P0157	HEGO	Bank B short circuit to ground
P0158	HEGO	Bank B short circuit to battery
P0159	HEGO	Bank B slow response
P0160	HEGO	Bank B no activity
P0161	HEGO	Bank B heater control circuit malfunction
P00171	lambda control	Bank A too lean
P0172	lambda control	Bank A too rich

P0174	lambda control	Bank B too lean
P0175	lambda control	Bank B too rich
P0181	Fuel rail temperature sensor	Temperature signal implausible
P0182	Fuel rail temperature sensor	Circuit low input
P0183	Fuel rail temperature sensor	Circuit high input
P0191	Fuel rail pressure sensor	Range /performance
P0192	Fuel Rail Pressure Sensor	Low Input
P0193	Fuel Rail Pressure Sensor	High Input
P0196	Oil temperature sensor	Range/performance
P0197	Oil temperature sensor	Low input
P0198	Oil temperature sensor	High input
P0201	Injector Circuit	Malfunction - Cylinder 1
P0202	Injector Circuit	Malfunction - Cylinder 2
P0203	Injector Circuit	Malfunction - Cylinder 3
P0204	Injector Circuit	Malfunction - Cylinder 4
P0205	Injector Circuit	Malfunction - Cylinder 5
P0206	Injector Circuit	Malfunction - Cylinder 6
P0207	Injector Circuit	Malfunction - Cylinder 7
P0208	Injector Circuit	Malfunction - Cylinder 8
P0222	APP sensor 2	Low input
P0223	APP sensor 2	High input
P0227	APP sensor 1	Low input
P0228	APP sensor 1	High input
P0229	APP sensor	Intermittent fault
P0297	Active speed control	Vehicle over speed condition
P0300	Misfire	Random/ multiple cylinder misfire
P0301	Misfire	Cylinder 1
P0302	Misfire	Cylinder 2
P0303	Misfire	Cylinder 3
P0304	Misfire	Cylinder 4
P0305	Misfire	Cylinder 5
P0306	Misfire	Cylinder 6
P0307	Misfire	Cylinder 7
P0308	Misfire	Cylinder 8
P0313	Misfire	Misfire under low fuel condition
P0316	Misfire	Misfire detected in first 1000 revs
P0326	Knock sensor	Sensor 1 high/low performance error
P0327	Knock sensor	Bank A sensor low input fault
P0328	Knock sensor	Bank A high input fault
P0331	Knock sensor	Sensor 2 high/low performance error
P0332	Knock sensor	Bank B sensor low input fault
P0333	Knock sensor	Bank A high input fault
P0335	Crank sensor	Sensor circuit malfunction during crank/ running
P0336	Crank sensor	Range/performance fault
P0340	Intake CMP sensor bank A	Fault during cranking/running
P0341	Intake CMP sensor bank A	Range/performance fault

P0345	Intake CMP sensor bank B	Fault during cranking/running
P0346	Intake CMP sensor bank B	Range/performance fault
P0351	Ignition coil	Circuit malfunction cylinder 1
P0352	Ignition coil	Circuit malfunction cylinder 2
P0353	Ignition coil	Circuit malfunction cylinder 3
P0354	Ignition coil	Circuit malfunction cylinder 4
P0355	Ignition coil	Circuit malfunction cylinder 5
P0356	Ignition coil	Circuit malfunction cylinder 6
P0357	Ignition coil	Circuit malfunction cylinder 7
P0358	Ignition coil	Circuit malfunction cylinder 8
P0365	Exhaust CMP sensor bank A	Fault during cranking/running
P0366	Exhaust CMP sensor bank A	Range/performance fault
P0390	Exhaust CMP sensor bank B	Fault during cranking/running
P0391	Exhaust CMP sensor bank B	Range/performance fault
P0401	EGR system	Insufficient flow detected
P0403	EGR system	Valve circuit high/low input
P0405	Differential pressure sensor sensor	Short to ground
P0406	Differential pressure sensor sensor	Short to battery
P0409	Differential pressure sensor sensor	Range performance
P0420	Catalyst system bank A	Efficiency below threshold
P0430	Catalyst system bank	Efficiency below threshold
P0441	Purge valve	Range performance
P0442	DMTL	Medium leak detected
P0447	DMTL	Short to ground
P0448	DMTL	Short to battery
P0455	DMTL	Large leak detected
P0456	DMTL	Small leak detected
P0458	Purge valve	Short to ground
P0459	Purge valve	Short to battery
P0461	Fuel level sensor	Range/performance fault
P0480	Radiator fan module	Control circuit malfunction
P0493	Viscous fan	Speed Out of range
P0501	Vehicle speed	Range/performance malfunction
P0504	Brake switch	Circuit malfunction
P0506	Idle control system	RPM lower than expected
P0507	Idle control system	RPM lower than expected
P0512	Crank request circuit	High/low input
P0513	Security key	Key invalid
P0532	Air conditioning refrigerant pressure sensor	Low input
P0533	Air conditioning refrigerant pressure sensor	High input
P0560	Battery back up	Malfunction
P0562	Sensor power supply	Low input
P0563	Sensor power supply	High input
P0566	Cruise control cancel switch	ON fault
P0567	Cruise control resume switch	ON fault

P0568	Cruise control	Low/high input
P0569	Decelerate/set/inch switch	ON fault
P0570	Accelerate/set/inch switch	On fault
P0574	Cruise control	Speed monitoring
P0576	Cruise control	Low input
P0577	Cruise control	High input
P0604	ECM self test	RAM error
P0605	ECM self test	ROM error
P0606	ECM self test	Processor error
P0616	Starter relay	Low input
P0617	Starter relay	High input
P0627	Primary fuel pump	No commands received
P0628	Fuel pump	Electrical low
P0629	Fuel pump	Electrical high
P0633	Security	No ID in ECM
P0634	ECM temperature	Internal temperature too high
P0646	Air conditioning clutch relay	Low input
P0647	Air conditioning clutch relay	High input
P0661	Manifold valve output drive 1	Open circuit or short circuit to ground
P0662	Manifold valve output drive 1	Short circuit to battery
P0664	Manifold valve output drive 2	Open circuit or short circuit to ground
P0665	Manifold valve output drive 2	Short circuit to battery
P0668	ECM temperature sensor	Short to ground
P0669	ECM temperature sensor	Short to battery
P0687	EMS control relay	Relay malfunction
P0831	Clutch switch circuit A	Low input
P0832	Clutch switch circuit A	High input
P0834	Clutch switch circuit B	Low input
P0835	Clutch switch circuit B	High input
P0851	Park / Neutral Switch	Input Circuit Low
P0852	Park / Neutral Switch	Input Circuit High
P1136	E Box fan	Fan malfunction
P1146	Generator command line	Low input/ communication error
P1155	HEGO Heater bank A	Heater performance
P1160	UHEGO Bank A	Slow activation
P1197	UHEGO Bank A	Slow activation/open shorted
P1198	UHEGO Bank B	Slow activation/open shorted
P1233	Secondary fuel pump	Output circuit open
P1234	Primary fuel pump	No commands received
P1236	Primary fuel pump	Pump not working when requested
P1244	Alternator command line	High input
P1260	Security limited start	Theft attempt
P1339	Secondary fuel pump	Driver circuit output low/high
P1452	DMTL	Reference current too low
P1453	DMTL	Reference current too high
P1482	DMTL heater control circuit	Low

P1483	DMTL heater control circuit	High
P1582	Flight recorder	Data stored
P1624	Security ID	ID transfer process failed
P1629	Generator	FR line failure
P1632	Generator	Charge system failure
P1646	UHEGO sensor bank A	Slow activation/ control module open shorted
P1647	UHEGO sensor bank B	Slow activation/ control module open shorted
P1670	E Box fan	Malfunction low
P1671	E Box fan	Malfunction high
P1697	Cruise control	Shorter/Longer switch ON fault
P1700	Low gear ratio	plausibility check
P2066	Secondary fuel pump	Range check
P2070	Manifold valve output drive 1	Performance check stuck open/closed
P2071	Manifold valve output drive 2	Performance check stuck open/closed
P2101	Electric throttle	Range performance
P2103	Electric throttle	Throttle duty at 100% continuously
P2105	Electric throttle	MIL request duel fuel cut off
P2106	Intended reduced availability	Reconfiguration failure
P2118	Electric throttle system	Over current detection by hardware
P2119	Electric throttle	Throttle stuck open
P2122	APP sensor	Circuit 2 low input
P2123	APP sensor	Circuit 2 high input
P2228	HAC sensor	Circuit low
P2229	HAC sensor	Circuit high
P2299	Accelerator pedal	Brake override
P2401	DMTL Pump	Ground short
P2402	DMTL Pump	Battery short
P2404	DMTL Pump	Noise/reference leak fault
P2450	DMTL	COV stuck open
P2451	DMTL	COV stuck closed
P2503	Charging system	Voltage low
P2504	Charging system	Voltage high
P2601	Water pump	Performance fault
P2610	Engine off timer	Timer malfunction
P2632	Secondary fuel pump driver circuit	Output circuit open
P2633	Secondary fuel pump driver circuit	Output low
P2634	Secondary fuel pump driver circuit	High input
P6365	Primary fuel pump	Pump not working when requested
P2636	Secondary fuel pump	Low flow/ performance

TERRAIN RESPONSE ™

Terrain Response ™ system allows the driver to select a program which will provide the optimum settings for traction and performance for prevailing terrain conditions.

As part of Terrain Response ™ there will be different throttle pedal progression maps associated with different Terrain Response ™ modes. The two extremes are likely to be a sand map (quick build up of torque with pedal travel) and grass/gravel/snow (very cautious build up of torque).

The TdV6 implementation of throttle progression is based on a fixed blend time. The torque will blend from that on one map to that on the new map (for the same pedal position) over a fixed time. This means blending will always take the same amount of time but when the torque change is small the torque increase over time will be small, whilst if the torque change is greater then the torque increase over time will be steeper. The resulting acceleration of the vehicle will depend on the torque difference between the two maps as well as on the gear and range selected. The worst case blending that could ever occur has been calibrated to match the blend rate for petrol derivatives as closely as possible, so as to give a transparent behaviour to customers. For additional information, refer to Ride and Handling Optimization (204-06 Ride and Handling Optimization)

CENTRAL JUNCTION BOX

The ECM is connected to ignition switch I and II. When the ignition is turned on 12V is applied to the Ignition Sense input. The ECM then starts its power up routines and turns on the ECM main relay; the main power to the ECM and it's associated system components. When the ignition is turned OFF the ECM will maintain its powered up state for up to 20 minutes while it initiates its power down routine and on completion will turn off the ECM main relay. The ECM will normally power down in approximately 60 seconds, do not disconcert the battery until the ECM is completely powered down.