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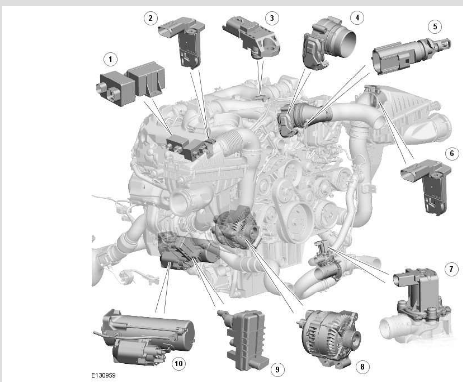
2011.0 RANGE ROVER (LM), 303-14A

ELECTRONIC ENGINE CONTROLS - TDV8 4.4L DIESEL (G1311597)

COMPONENT LOCATION SHEET 1 OF 4

NOTE:

Left-Hand Drive shown

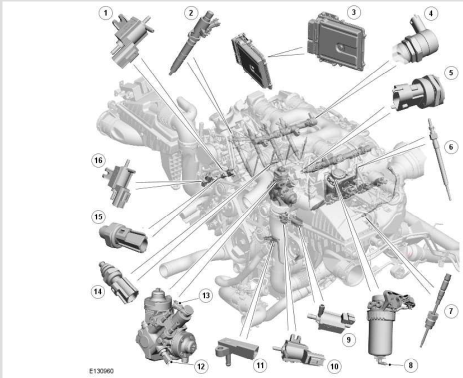


ITEM	PART NUMBER	DESCRIPTION
1	-	Glow plug modules
2		Mass Air Flow and Temperature (MAFT) sensor - Right Hand (RH)
3		Mass Air Pressure (MAP) sensor
4		Electric throttle
5		Air charge temperature sensor
6		Mass Air Flow and Temperature (MAFT) sensor - Left Hand (LH)
7		Boost air recirculation solenoid
8		Alternator
9		Variable turbocharger actuator
10		Starter motor solenoid

COMPONENT LOCATION SHEET 2 OF 4

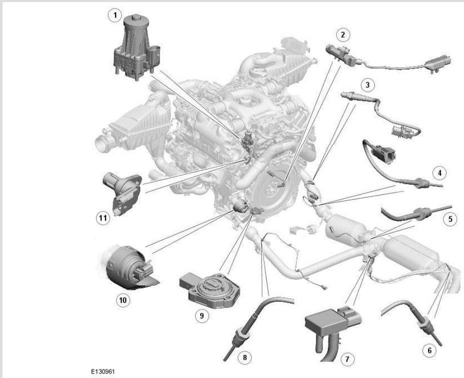
NOTE:

Left-Hand Drive shown



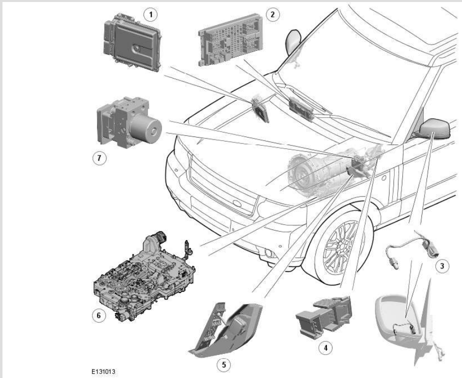
ITEM	PART NUMBER	DESCRIPTION
1	-	Active engine mounts solenoid
2		Fuel injector (8 off)
3		Engine Control Module (ECM)
4		Fuel pressure control valve
5		Fuel rail pressure sensor
6		Glow plug (8 off)
7		Exhaust manifold gas temperature sensor
8		Water-fuel-sensor
9		Turbine intake solenoid
10		Exhaust Gas Recirculation (EGR) electric actuator solenoid
11	-	Boost pressure sensor
12	-	Fuel temperature sensor
13	-	Fuel volume control valve
14	-	Engine Coolant Temperature (ECT) sensor
15	-	Oil pressure sensor
16	-	EGR cooling by-pass solenoid

COMPONENT LOCATION SHEET 3 OF 4



ITEM	PART NUMBER	DESCRIPTION
1	-	EGR motor valve
2		Crankshaft Position (CKP) sensor
3		Heated oxygen sensor (HO2S) - Pre Catalyst
4		Exhaust gas temperature sensor
5		Pre Diesel Particulate Filter (DPF) temperature sensor
6		Post DPF temperature sensor
7		Differential pressure sensor
8		Exhaust gas temperature sensor
9		Oil level and oil temperature sensor
10		Fixed vane turbocharger intake valve position sensor
11	-	Camshaft Position (CMP) sensor

COMPONENT LOCATION SHEET 4 OF 4



ITEM	PART NUMBER	DESCRIPTION
1	-	Engine Control Module (ECM)
2		Central Junction Box (CJB)
3		Ambient air temperature sensor
4		Brake switch
5		Accelerator Pedal Position (APP) sensor
6		Transmission Control Module (TCM)
7		Anti-lock Brake System (ABS) module

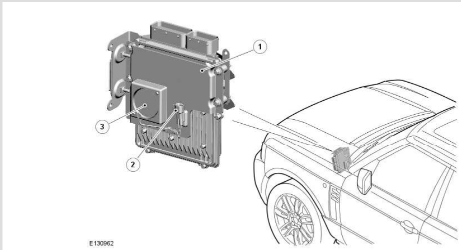
OVERVIEW

The TDV8 engine has an engine management system controlled by an engine control module (ECM) and is able to monitor, adapt and precisely control the fuel injection. The ECM uses multiple sensor inputs and precision control of actuators to achieve optimum performance during all driving conditions.

The ECM controls fuel delivery to all 8 cylinders via a Common Rail (CR) injection system. The CR system uses a fuel rail to accumulate highly pressurized fuel and feed the 8, electronically controlled injectors. The fuel rail is located in close proximity to the injectors, which assists in maintaining full system pressure at each injector at all times.

The ECM uses the drive by wire principle for acceleration control. There are no control cables or physical connections between the accelerator pedal and the engine. Accelerator pedal demand is communicated to the ECM by two potentiometers located in a throttle position sensor. The ECM uses the two signals to determine the position, rate of movement and direction of movement of the pedal. The ECM then uses this data, along with other engine information from other sensors, to achieve the optimum engine response.

ENGINE CONTROL MODULE (ECM)



ITEM	DESCRIPTION
1	ECM
2	Cooling fan electrical connector
3	Cooling fan

The ECM is located on the right-hand (RH) side rear corner of the engine compartment on left-hand drive (LHD) vehicles and on the left-hand (LH) side on right-hand drive (RHD) vehicles.

Inputs

The ECM processes information from the following input sources:

- crankshaft position (CKP) sensor
- camshaft position (CMP) sensor
- Fuel rail pressure sensor
- Turbine intake valve position sensor
- engine coolant temperature (ECT) sensor
- Oil temperature sensor
- Alternator
- Brake pedal switch
- Oil pressure switch
- Water in fuel sensor
- Air charge temperature sensor
- Fuel rail temperature sensor
- Pre-Catalyst temperature sensor Bank 1

- Post-Catalyst temperature sensor Bank 1
- Pre-Catalyst temperature sensor Bank 2
- diesel particulate filter (DPF) outlet temperature sensor
- mass air flow and temperature (MAFT) sensor Bank 1
- MAFT sensor Bank 2
- Ambient air temperature sensor
- manifold absolute pressure (MAP) sensor
- accelerator pedal position (APP) sensor
- Boost air pressure sensor
- Differential pressure sensor.

Outputs

The ECM outputs controlling signals to the following sensors and actuators:

- Boost air recirculation solenoid
- Boost air solenoid
- exhaust gas recirculation (EGR) throttle inlet actuator
- Fuel injectors
- EGR electric actuator
- Variable vane turbocharger actuator
- Fuel pressure control valve
- Fuel volume control valve
- EGR cooling by-pass solenoid
- Turbine intake solenoid
- Glow plug modules
- Active engine mount solenoid.

The ECM is connected to the vehicle harnesses via 2 connectors. The ECM contains data processors and memory microchips. The output signals to the actuators are in the form of ground paths provided by driver circuits within the ECM. The ECM driver circuits produce heat during normal operation and dissipate this heat via the ribbed casing. A fan, located on the ECM mounting bracket, assists with the cooling process by maintaining a constant airflow over the ribbed body of the module. The fan is controlled by the ECM via an internal temperature sensor.

The ECM performs self diagnostic routines and stores fault codes in its memory. These fault codes and diagnostics can be accessed using the Land Rover approved diagnostic system. If the ECM is to be replaced, the new ECM is supplied 'blank' and must be configured to the vehicle using the Land Rover approved diagnostic system. A 'flash' electrically erasable programmable read only memory (EEPROM) allows the ECM to be externally configured, using the Land Rover approved diagnostic system, with market specific or new tune information up to 14 times. If a fifteenth update is required the ECM must be replaced. The current engine tune data can be accessed and read using the Land Rover approved diagnostic system.

When a new ECM is fitted, it must also be synchronized to the central junction box (CJB) using the Land Rover approved diagnostic system. ECM's cannot be 'swapped' between vehicles.

The ECM is connected to the engine sensors which allow it to monitor the engine operating conditions. The ECM processes these signals and decides the actions necessary to maintain optimum engine performance in terms of driveability, fuel efficiency and exhaust emissions. The memory of the ECM is programmed with instructions for how to control the engine, this known as the strategy. The memory also contains data in the form of maps which the ECM uses as a basis for fueling and emission control. By comparing the information from the sensors to the data in the maps, the ECM is able to calculate the various output requirements. The ECM contains an adaptive strategy which updates the system when components vary due to production tolerances or ageing.

Some sensors receive a regulated voltage supplied by the ECM. This avoids incorrect signals caused by voltage drop during cranking.

The ECM receives a vehicle speed signal on a controller area network (CAN) bus connection from the anti-lock brake system (ABS) module. Vehicle speed is an important input to the ECM strategies. The ABS derives the speed signal from the ABS wheel speed sensors. The frequency of this signal changes according to road speed. The ECM uses this signal to determine the following:

- How much to reduce engine torque during gear changes
- When to permit speed control operation
- To control the operation of the speed control system
- Implementation of the idle strategy when the vehicle is stationary.

IMMOBILIZATION

The CJB receives information from related systems on the vehicle and before the CJB sends a mobilization signal to the ECM it will exchange encrypted data with the electric steering lock and the instrument cluster to authorize unlocking of the steering column. The instrument cluster only provides a ground for the steering lock motor. The CJB will enable the fuel pump relay which, on diesel vehicles operates the fuel pump.

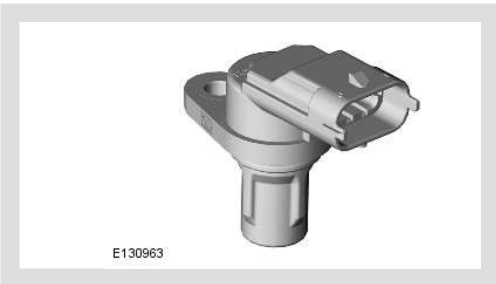
The CJB passes a coded data signal to the ECM using the high speed controller area network (CAN) bus to allow starting if all starting parameters have been met. The information is decoded by the ECM which will allow the engine to run if the information is correct.

The information is on a rolling code system and both the CJB and the ECM will require synchronisation if either component is renewed.

If the transmission selector is in the park position and the driver presses the brake pedal and simultaneously presses the start/stop button, the CJB interprets this as an engine crank request. Before the engine crank request is allowed, the CJB compares a brake pressure signal received from the ABS (anti-lock brake system) module. If the signal is greater than the stored threshold value, a crank request signal is sent to the ECM on the high speed CAN bus. For additional information, refer to: Anti-Theft - Passive (419-01B Anti-Theft - Passive, Description and Operation).

The ECM also protects the starter motor from inadvertent operation. The CJB receives an engine speed signal from the ECM via the instrument cluster. When the engine speed exceeds a predetermined value, the CJB prevents operation of the starter motor via an integral starter disable relay.

CAMSHAFT POSITION (CMP) SENSOR



The CMP sensor is located on the rear face of the LH cylinder head. The sensor tip protrudes through the face to pick up on the reluctor behind the camshaft pulley. The CMP sensor is a Hall effect type sensor.

The ECM uses the CMP sensor signal to determine if the piston in No. 1 cylinder is at injection top dead center (TDC) or exhaust TDC. Once this has been established, the ECM can then operate the correct injector to inject fuel into the cylinder when the piston is at injection TDC.

The sensor is a Hall effect sensor which is used by the ECM at engine start-up to synchronize the ECM with the CKP sensor signal. The ECM does this by using the CMP sensor signal to identify number one cylinder to ensure the correct injector timing. Once the ECM has established the injector timing, the CMP sensor signal is no longer used.

The CMP sensor receives a 5V supply from the ECM. Two further connections to the ECM provide ground and signal output.

If a fault occurs, an error is registered in the ECM. Two types of failure can occur; camshaft signal frequency too high or total failure of the camshaft signal. The error recorded by the ECM can also relate to a total failure of the crankshaft signal or crankshaft signal dynamically implausible. Both components should be checked to determine the cause of the fault.

If a fault occurs with the CMP sensor when the engine is running, the engine will continue to run but the ECM will deactivate boost pressure control. Once the engine is switched off, the engine will crank but will not restart while the fault is present.

CRANKSHAFT POSITION (CKP) SENSOR

The CKP sensor is located at the rear of the engine block on the left hand side. The sensor tip is aligned with a magnetic trigger which is attached to the crankshaft. The reluctor is a press fit on the end of the crankshaft. The trigger wheel must be carefully aligned to the crankshaft to ensure correct timing. The sensor produces a square wave signal, the frequency of which is proportional to engine speed.

The ECM monitors the CKP sensor signal and can detect engine over-speed. The ECM counteracts engine over-speed by gradually fading out speed synchronized functions. The CKP sensor is a Hall effect sensor. The sensor measures the magnetic field variation induced by the magnetized trigger wheel.

The trigger wheel has two missing teeth representing 12º of crankshaft rotation. The two missing teeth provide a reference point for the angular position of the crankshaft.

When the space with the two missing teeth pass the sensor tip, a gap in the signal is produced which the ECM uses to determine the crankshaft position. The air gap between the sensor tip and the ring is important to ensure correct signals are output to the ECM. The recommended air gap between the CKP sensor and the trigger wheel is between 0.4 mm and 1.5 mm.

The ECM uses the signal from the CKP sensor for the following functions:

- Synchronization.
- Determine fuel injection timing.
- Enable the fuel pump relay circuit (after the priming period).
- Produce an engine speed signal which is broadcast on the CAN bus for use by other systems.

MASS AIR FLOW AND TEMPERATURE (MAFT) SENSOR

Two MAFT sensors are located on the top cover of the air filter box. The sensors are downstream of the air filters and measure the air entering the clean air ducts to the turbocharger compressors.

NOTE:

The MAFT sensor which monitors the left-hand (LH) bank intake does not use the intake air temperature (IAT) portion of the sensor.

The MAFT sensor works on the hot film principle. Two sensing elements are contained within a film. One element is maintained at ambient (air intake) temperature, e.g. 25°Celsius (77°F). The other element is heated to 200°Celsius (392°F) above the ambient temperature, e.g. 225°Celsius (437°F). Intake air entering the engine passes through the MAFT sensor and has a cooling effect on the film. The ECM monitors the current required to maintain the 200°Celsius (392°F) differential between the two elements and uses the differential to provide a precise, non-linear, frequency based signal which equates to the volume of air being drawn into the engine.

The MAFT sensor output is a digital signal proportional to the mass of the incoming air. The ECM uses this data, in conjunction with signals from other sensors and information from stored fueling maps, to determine the precise fuel quantity to be injected into the cylinders. The signal is also used as a feedback signal for the exhaust gas recirculation (EGR) system.

The IAT sensor within the MAFT sensor incorporates a negative temperature coefficient (NTC) thermistor in a voltage divider circuit. The NTC thermistor works on the principle of decreasing resistance in the sensor as the temperature of the intake air increases. As the thermistor allows more current to pass to ground, the voltage sensed by the ECM decreases. The change in voltage is proportional to the temperature change of the intake air. Using the voltage output from the IAT sensor, the ECM can correct the fueling map for intake air temperature. The correction is an important requirement because hot air contains less oxygen than cold air for any given volume.

The MAFT sensor receives a 12V supply from the engine junction box (EJB) and a ground connection via the ECM. Two further connections to the ECM provide a mass air flow (MAF) signals and an IAT signal.

The IAT sensor receives a 5V voltage from the ECM and shares a ground with the MAF sensor. The signal output from the IAT sensor is calculated by the ECM by monitoring changes in the supplied voltage to the IAT sensor voltage divider circuit.

The ECM checks the calculated air mass against the engine speed. If the calculated air mass is not plausible, the ECM uses a default air mass figure which is derived from the average engine speed compared to a stored characteristic map. The air mass value will be corrected using values for boost pressure, atmospheric pressure and air temperature.

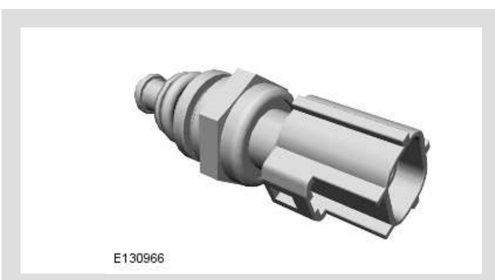
If the MAFT sensor fails the ECM implements the default strategy based on engine speed. In the event of a MAFT sensor signal failure, any of the following symptoms may be observed:

- Difficult starting
- Engine stalls after starting
- Delayed engine response
- Emission control inoperative
- Idle speed control inoperative
- Reduced engine performance.

If the IAT part of the sensor fails the ECM uses a default intake air temperature of -5°Celsius (23°F). In the event of an IAT sensor failure, any of the following symptoms may be observed:

- Over fueling, resulting black smoke emitting from the exhaust.
- Idle speed control inoperative.

ENGINE COOLANT TEMPERATURE (ECT) SENSOR



The engine coolant temperature (ECT) is located in the thermostat housing. The ECT sensor provides the ECM and the instrument cluster with engine coolant temperature status.

The ECM uses the temperature information for the following functions:

- Fueling calculations
- Limit engine operation if engine coolant temperature becomes too high
- Cooling fan operation
- Glow plug activation time.

The instrument cluster uses the temperature information for temperature gauge operation. The engine coolant temperature signal is also transmitted on the CAN bus by the instrument cluster for use by other systems.

The ECM ECT sensor circuit consists of an internal voltage divider circuit which incorporates an NTC thermistor. As the coolant temperature rises the resistance through the sensor decreases and vice versa. The output from the sensor is the change in voltage as the thermistor allows more current to pass to ground relative to the temperature of the coolant.

The ECM compares the signal voltage to stored values and adjusts fuel delivery to ensure optimum driveability at all times. The engine will require more fuel when it is cold to overcome fuel condensing on the cold metal surfaces inside the combustion chamber. To achieve a richer air/fuel ratio, the ECM extends the injector opening time. As the engine warms up the air/fuel ratio is leaned off.

The input to the sensor is a 5V reference voltage supplied from the voltage divider circuit within the ECM. The ground from the sensor is also connected to the ECM which measures the returned current and calculates a resistance figure for the sensor which relates to the coolant temperature.

The following table shows engine coolant temperature values and the corresponding sensor resistance and voltage values.

Coolant Temperature Sensor Response

TEMPERATURE (DEGREES CELSIUS)	RESISTANCE (KOHMS)	VOLTAGE (VOLTS)
-40	925	4.54
-30	496	4.46
-20	277	4.34
-10	160	4.15
0	96	3.88
10	59	3.52
20	37	3.09
30	24	2.62
40	16	2.15
50	11	1.72
60	7.5	1.34
70	5.6	1.04
80	3.8	0.79
90	2.9	0.64
100	2.08	0.49
110	1.56	0.38
120	1.19	0.29

TEMPERATURE (DEGREES CELSIUS)	RESISTANCE (KOHMS)	VOLTAGE (VOLTS)
130	0.918	0.22
140	0.673	0.17
150	0.563	0.14

If the ECT sensor fails, the following symptoms may be observed:

- Difficult cold
- Difficult hot
- Engine performance
- Temperature gauge inoperative or inaccurate reading.

In the event of ECT sensor signal failure, the ECM applies a default value of 80°Celsius (176°F) coolant temperature for fueling purposes.

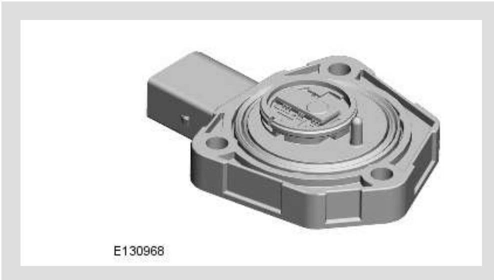
ENGINE OIL PRESSURE SENSOR

E130967

The oil pressure sensor, located in the front of the RH cylinder head, connects a ground input to the CJB when oil pressure is present. The sensor operates at a pressure of 0.15 to 0.41 bar (2.2 to 5.9 Psi).

The oil pressure sensor is connected directly to the CJB. The CJB outputs the engine oil pressure signals for use by the instrument cluster and the ECM. In the event of oil pressure falling below the operating threshold of the sensor, the CJB issues a message to display the low oil pressure warning in message center and also to illuminate the oil pressure warning lamp in the instrument cluster.

ENGINE OIL LEVEL AND TEMPERATURE SENSOR



The 4.4L V8 diesel engine is not fitted with a conventional dipstick. The dipstick is replaced with an ultrasonic oil level and temperature sensor which is located on the underside of the oil pan and secured with 3 screws.

The sensor uses ultrasonic pulses to determine the oil level in the oil pan. The level sensor sends an ultrasonic pulse vertically upward and measures the time taken for the pulse to be reflected back to the sensor from the upper surface of the oil. A second reference pulse is also transmitted across a reference distance. The time periods of the first and second pulses are compared and the sensor calculates the oil height in the oil pan. The sensor then converts the results into a pulse width modulation (PWM) signal to the engine control module (ECM) which converts the frequency of the signal into a oil level height.

The sensor uses an negative temperature coefficient (NTC) type sensor to determine the oil temperature. The temperature sensor is a NTC type which operates in the -30 Degrees Celsius to +150 Degrees Celsius temperature range. The sensor measures the oil temperature and converts the sensor signal into a PWM signal to the ECM which converts the frequency of the signal into an oil temperature. If the oil level is incorrect or a system fault occurs, a warning message is displayed in the instrument cluster message center.

If the oil level is incorrect or a system fault occurs, a warning message is displayed in the instrument cluster message center. The messages that follow can be displayed in the message center:

WARNING	SYSTEM STATUS
ENGINE OIL LOW (Amber warning triangle displayed)	The oil is at the minimum level for safe operation. Top-up with 1 liter (1.8 pints) of oil.
ENGINE OIL HIGH (Amber warning triangle displayed)	This warning is displayed when the engine is started, if the oil is above the maximum level for safe operation. Stop the vehicle as soon as safety permits and seek qualified assistance to have the engine oil drained, before driving the vehicle.
ENGINE OIL CRITICALLY LOW (Red warning triangle displayed)	The oil is below the minimum level for safe operation. Stop the vehicle as soon as safety permits and top-up with 2.0 liters (3.52 pints) of oil. Wait for 10 minutes, re-check the oil level reading and top-up again if necessary.
ENGINE OIL LEVEL MONITOR SYSTEM FAULT (Amber warning triangle displayed)	A fault with the oil level monitoring system is indicated. Seek qualified assistance as soon as possible.

OIL LEVEL CHECK

The engine oil level is automatically monitored and is displayed in the trip computer area of the message center.

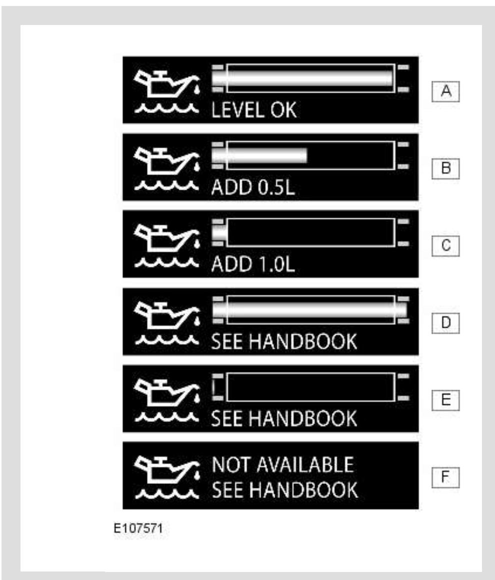
The steps that follow allow the driver to view the current 'average' engine oil level providing the following parameters are met:

- It is recommended that a reading is taken after a journey (when the oil is hot)
- The engine is stopped and the transmission is in park
- The vehicle is parked on level ground
- 10 minutes has passed after stopping the engine (to allow the oil level to stabilize).

Press the 'TRIP' button on the end of the LH steering column multifunction switch repeatedly, until the oil can icon is displayed at the bottom of the message center.

NOTE:

The system will not give a reading until the oil level has stabilized.



ITEM	DESCRIPTION
A	Oil at recommended level. No top-up required
B	Add 0.5 litres (0.9 pint) of oil
C	Add 1 litre (1.8 pints) of oil
D	Oil above maximum for safe operation. Do not drive vehicle. Seek qualified assistance
E	Oil level below minimum for safe operation. Add 2.0 liters (3.52 pints) of oil, then recheck level
F	Oil level stabilizing, oil level not available. Wait ten minutes and then recheck the oil level display
	If this display is accompanied by the warning message 'ENGINE OIL LEVEL MONITOR SYSTEM FAULT', a fault with the oil level monitor is indicated. Seek qualified assistance

ENGINE OIL TOP-UP

CAUTION:

Failure to use an oil that meets the required specification, could cause excessive engine wear, a build-up of sludge and deposits and increase pollution. It could also lead to engine failure and invalidation of vehicle warranty.
Overfilling with oil could result in severe engine damage.

Use the procedure that follows to replenish the engine oil level:

- With the ignition on, but the engine not running, unscrew the oil filler cap.
- Add the appropriate quantity of oil (as indicated by the message center oil level display). Wait 10 minutes to allow the oil level to stabilize and re-check the level. Clean up any oil spilled during topping up.
- Once the correct level is achieved, refit the filler cap and hand-tighten securely until one click is heard.

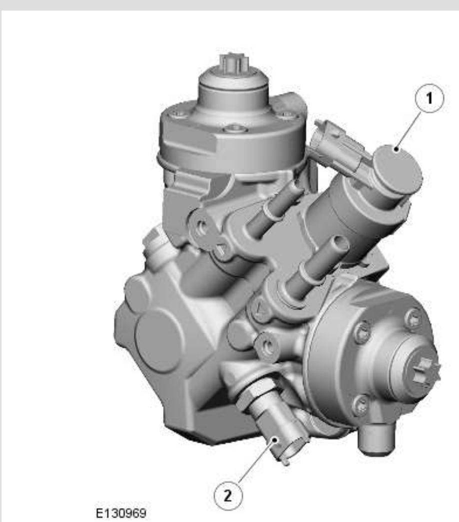
NOTES:

- The approximate quantity of oil required to raise the level from the minimum level of safe operation to the maximum, is 1.5 litres (2.6 pints).
- The ignition must be left on during the top-up, so that the electronic dipstick can register and display the new oil level. This enables an accurate level re-check.

LIVE READING/AVERAGE RESET

A procedure is available to allow the technician to access the actual engine oil level, rather than the average engine oil level which is available to the driver. An additional procedure is also available to reset the average engine oil level. For additional information, refer to: Engine Oil Vacuum Draining and Filling (303-01A Engine - TDV8 4.4L Diesel, General Procedures).

FUEL METERING VALVE AND FUEL TEMPERATURE SENSOR



ITEM	DESCRIPTION
1	Fuel metering valve
2	Fuel temperature sensor

The fuel metering valve and the fuel temperature sensor are located on the engine mounted High Pressure (HP) fuel pump.

FUEL METERING VALVE

The fuel metering valve is incorporated into the HP fuel pump. The fuel metering valve returns unwanted fuel back to the tank (or Low Pressure (LP) system). This avoids unused fuel being pressurized by the HP stage of the pump, only to be returned back to LP system by the fuel rail pressure control valve, wasting energy and heating the fuel.

The fuel metering valve receives a power supply from the engine management relay and a 15A fuse in the EJB.

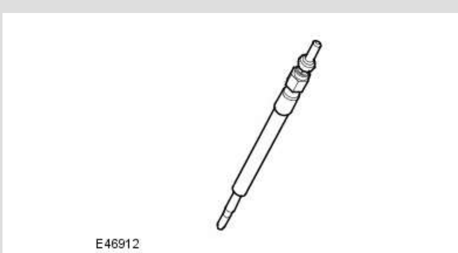
FUEL TEMPERATURE SENSOR

The sensor is a NTC sensor which is connected to the ECM by two wires. The ECM fuel temperature sensor circuit consists of an internal voltage divider circuit which incorporates a NTC thermistor. As the fuel temperature rises the resistance through the sensor decreases. The output from the sensor is the change in voltage as the thermistor allows more current to pass to ground relative to the temperature of the fuel.

The ECM monitors the fuel temperature constantly. If the fuel temperature exceeds 85°Celsius (185°F), the ECM invokes an engine 'derate' strategy. This reduces the amount of fuel delivered to the injectors in order to allow the fuel to cool. When this occurs, the driver may notice a loss of performance.

The wires to the fuel temperature sensor are monitored by the ECM for short and open circuit. The ECM also monitors the 5V supply. If a failure occurs a fault is recorded in the ECM memory and the ECM uses a default fuel pressure value.

GLOW PLUGS



Three glow plugs are located in each of the cylinder heads, on the inlet side. The glow plugs and the glow plug modules are a vital part of the engine starting strategy. The glow plug system has a glow plug installed in the inlet side of each cylinder. The glow plugs heat the combustion chambers before and during cranking, to aid cold starting, and after the engine starts to reduce emissions and engine noise when idling with a cold engine. Glow plug operation is controlled by 2 glow plug modules and the ECM. The use of glow plugs helps reduce the amount of additional fuel required on start-up, and consequently reduces the emission of black smoke. The use of glow plugs also reduces the amount of injection advance required, which reduces engine noise, particularly when idling with a cold engine.

The main part of the glow plug is a tubular heating element which protrudes into the combustion chamber of the engine. The heating element contains a spiral filament encased in magnesium oxide powder. At the tip of the tubular heating element is the heater coil. Behind the heater coil, and connected in series, is a control coil. The control coil regulates the heater coil to ensure that it does not overheat.

Each bank of glow plugs is connected via a separate harness to its respective glow plug module. Each glow plug module is controlled by glow plug software contained within the ECM.

There are three phases of glow plug activity:

- Pre-heat
- Crank heat
- Post heat

For additional information, refer to: Glow Plug System (303-07B Glow Plug System - TDV8 4.4L Diesel, Description and Operation).

In the event of glow plug failure, the engine may be difficult to start and excessive smoke emissions may be observed after starting.

The glow plug warning lamp also serves a second function within the Electronic Diesel Control (EDC) system. If a major EDC system fault occurs, the glow plug warning lamp will be illuminated permanently and a message generated in the instrument cluster. The driver must seek attention to the engine management system at a Land Rover dealer as soon as possible.

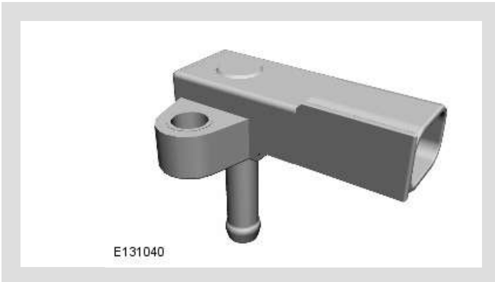
BOOST PRESSURE CONTROL

Boost control is controlled by the ECM using information from the MAP sensor and the Boost Air Pressure sensor.

Boost control is achieved by the use of a direct drive electric actuator. The actuator is attached to the side of the turbo unit and is connected with the control mechanism via a linkage. The electric actuator works on the torque motor principal and has integrated control module.

The electric actuator moves the control vanes through an 60 degree stroke and has the capability to learn its own maximum stroke positions. The electric actuator is controlled via pulse width modulation (PWM) signals from the ECM.

BOOST AIR PRESSURE SENSOR



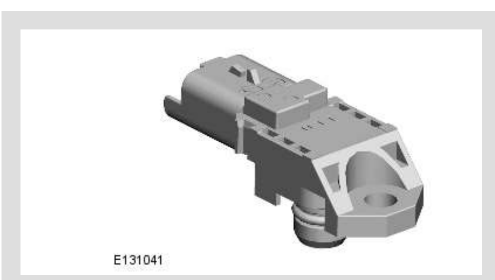
The boost air pressure sensor is located on a bracket on the upper LH rear of the fan cowl. The sensor is connected via a hose to the secondary fixed vane turbocharger compressor outlet duct. The hose allows the sensor to measure the turbocharger compressor outlet pressure. The sensor provides a voltage signal to the ECM relative to the output charge air pressure from the secondary fixed vane turbocharger.

The boost air pressure sensor has a 3 pin connector which is connected to the ECM and provides a 5V reference voltage from the ECM, a signal input to the ECM and a ground connection.

The boost pressure sensor uses a diaphragm transducer to measure pressure. The ECM uses the boost pressure sensor signal for the following functions:

- Maintain manifold boost pressure
- Reduce exhaust smoke emissions when driving at high altitude
- Control of the EGR system
- To help smooth control of the mono to bi and bi to mono turbocharger transitions
- To aid the air path diagnostics.

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR



A single MAP sensor is located after the electric throttle. The sensor provides a voltage signal to the ECM relative to the intake manifold pressure and temperature.

The MAP sensor has a 3 pin connector which is connected to the ECM and provides a 5V reference voltage from the ECM, a signal input to the ECM and a ground connection.

The MAP sensor uses a diaphragm transducer to measure the air pressure.

The ECM uses the MAP sensor signal for the following functions:

- Maintain manifold boost pressure.
- Reduce exhaust smoke emissions when driving at high altitude.
- Control of the EGR system.
- Control of the vacuum control module.

If the MAP sensor fails, the ECM uses a default pressure of 1013 mbar (14 lbf/in²). In the event of a MAP sensor failure, the following symptoms may be observed:

- Altitude compensation inoperative (black smoke emitted from the exhaust).
- Active boost control inoperative.

FUEL RAIL PRESSURE CONTROL VALVE

E130970

The fuel pressure control valve is incorporated into the forward end of the common fuel rail for the right-hand (RH) cylinder bank. The control valve regulates the fuel pressure within the fuel rails and is controlled by the ECM. The control valve is a PWM controlled solenoid valve.

When the solenoid is de-energized, an internal spring holds an internal valve closed. At fuel pressure of 100 bar (1450 lbf/in2) or higher, the force of the spring is overcome, opening the valve and allowing fuel pressure to decay into the fuel return pipe. When the pressure in the fuel rail decays to approximately 100 bar (1450 lbf/in2) or less, the spring force overcomes the fuel pressure and closes the valve. When the ECM energizes the solenoid, the valve is closed allowing the fuel pressure to build. The pressure in the fuel rail in this condition can reach approximately 2000 bar (29000 lbf/in2).

The ECM constantly monitors the fuel pressure and activates the fuel pressure control valve accordingly to control the fuel rail pressure within the required parameters. Relieved fuel from the fuel rails is directed through the fuel rail leak-off pipe to the low pressure fuel filter return circuit.

The ECM controls the fuel rail pressure by operating the control valve solenoid using a PWM signal. By varying the duty cycle of the PWM signal, the ECM can accurately control the fuel rail pressure and hence the pressure delivered to the injectors according to engine load. This is achieved by the control valve allowing a greater or lesser volume of fuel to pass from the high pressure side of the pump to the un-pressurized fuel return line, regulating the pressure on the high pressure side.

The fuel pressure control valve receives a PWM signal from the ECM of between 0 and 12V. The ECM controls the operation of the control valve using the following information to determine the required fuel pressure

- Fuel rail pressure
- Engine load
- APP sensor position
- Engine coolant temperature
- Engine speed.

In the event of a total failure of the fuel pressure control valve, the engine will not start. In the event of a partial failure of the fuel pressure control valve, the ECM will activate the solenoid with the minimum duty cycle which results in the injection quantity being limited.

FUEL RAIL PRESSURE SENSOR

The fuel rail pressure sensor is located in the forward end of the common fuel rail for the LH cylinder bank. The sensor is screwed into a threaded port in the end of the fuel rail.

The fuel pressure sensor is a piezo-resistive type sensor containing an actuating diaphragm. Deflection of the diaphragm provides a proportional signal (output) voltage to the ECM, dependant on the fuel pressure within the fuel rails.

INJECTORS

ITEM	DESCRIPTION
1	Harness connection
2	HP connection
3	Control piston
4	Nozzle needle
5	Nozzle HP chamber
6	Nozzle spray holes
7	Valve mushroom
8	Fuel return
9	Valve piston
10	Piezo actuator

There are 8 electronic fuel injectors (one for each cylinder) located in a central position between the four valves of each cylinder. The ECM divides the injectors into two banks of 4 with the cylinders.

Each injector is supplied with pressurized fuel from the fuel rail and delivers finely atomized fuel directly into the combustion chambers. Each injector is individually controlled by the ECM which operates each injector in the firing order and controls the injector opening period via PWM signals. Each injector receives a 12V supply from the ECM and, using programmed injection/timing maps and sensor signals, determines the precise pilot and main injector timing for each cylinder. If battery voltage falls to between 6 and 9V, fuel injector operation is restricted, affecting emissions, engine speed range and idle speed. In the event of a failure of a fuel injector, the following symptoms may be observed:

- Engine misfire
- Idle irregular
- Reduced engine performance
- Reduced fuel economy
- Difficult starting
- Increased smoke emissions.

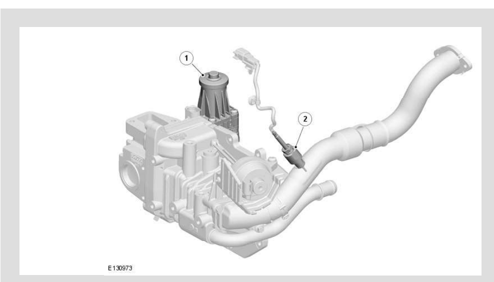
The ECM monitors the wires for each injector for short circuit and open circuit, each injector and the transient current within the ECM. If a defect is found, an error is registered in the ECM for the injector in question.

EXHAUST GAS RECIRCULATION (EGR) SYSTEM

The EGR system comprises:

- EGR modulator
- EGR cooler
- Associated connecting pipes

EGR Valve and Cooler



ITEM	DESCRIPTION
1	EGR valve motor
2	EGR temperature sensor

The EGR modulator and cooler are a combined unit.

The combined EGR modulator and cooler is located in the vee between the cylinder heads. The cooler side of the EGR is connected to the vehicle cooling system thermostat housing, via hoses. The inlet exhaust side is connected directly into the cross-over pipe at the rear of the engine which connects the undefined (undefined) and RH exhaust manifolds. The exhaust gas passes through the cooler or are by-passed and is expelled via the actuator and a metal pipe into the inlet manifold.

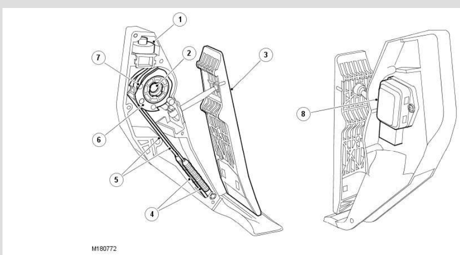
The EGR modulator is a solenoid operated valve which is controlled by the ECM. The ECM uses the EGR modulator to control the amount of exhaust gas being re-circulated in order to reduce exhaust emissions and combustion noise. The EGR is enabled when the engine is at normal operating temperature and under cruising conditions.

The EGR modulator receives a 12V supply from the ECM and is controlled using a PWM signal. The PWM duty signal of the solenoid ground is varied to determine the precise amount of exhaust gas delivered to the cylinders.

The modulator is operated through its full range at each engine shut down, to clear any carbon deposits that may have built up whilst the engine was running.

In the event of a failure of the EGR modulator, the EGR function will become inoperative. The ECM can monitor the EGR modulator solenoid for short circuits and store fault codes in the event of failure. The modulator can also be activated for testing using the Land Rover approved diagnostic system.

ACCELERATOR PEDAL POSITION (APP) SENSOR

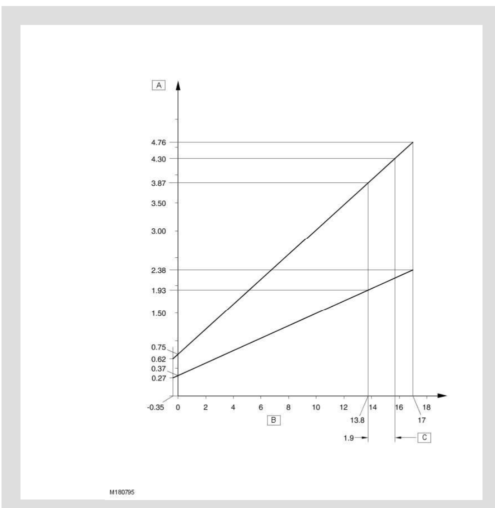


ITEM	DESCRIPTION
1	Detente mechanism
2	Sensor spigot
3	Pedal
4	Springs
5	Cables
6	Bush
7	Drum
8	accelerator pedal position (APP) sensor

The APP is incorporated into the pedal assembly. The sensor is a twin track rotary potentiometer type.

The APP sensor is located in plastic housing which is integral with the throttle pedal. The housing is injection molded and provides location for the APP sensor. The sensor is mounted externally on the housing and is secured with two Torx screws. The external body of the sensor has a six pin connector which accepts a connector on the vehicle wiring harness.

The sensor has a spigot which protrudes into the housing and provides the pivot point for the pedal mechanism. The spigot has a slot which allows for a pin, which is attached to the sensor potentiometers, to rotate through approximately 90°, which relates to pedal movement. The pedal is connected via a link to a drum, which engages with the sensor pin, changing the linear movement of the pedal into rotary movement of the drum. The drum has two steel cables attached to it. The cables are secured to two tension springs which are secured in the opposite end of the housing. The springs provide 'feel' on the pedal movement and require an effort from the driver similar to that of a cable controlled throttle. A detente mechanism is located at the forward end of the housing and is operated by a ball located on the drum. At near maximum throttle pedal movement, the ball contacts the detente mechanism. A spring in the mechanism is compressed and gives the driver the feeling of depressing a 'kickdown' switch when full pedal travel is achieved.

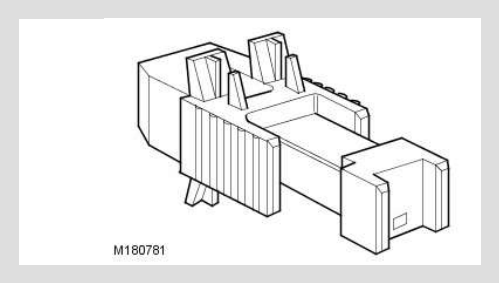


ITEM	DESCRIPTION
A	Voltage
B	APP sensor angle
C	Kick down angle

The APP sensor has two potentiometer tracks which each receive a 5V input voltage from the ECM. Track 1 provides an output of 0.5V with the pedal at rest and 2.0V at 100% full throttle. Track 2 provides an output of 0.5V with the pedal at rest and 4.5V at 100% full throttle. The signals from the two tracks are used by the ECM to determine fueling for engine operation and also by the ECM and the transmission control module (TCM) to initiate a kickdown request for the automatic transmission.

The ECM monitors the outputs from each of the potentiometer tracks and can determine the position, rate of change and direction of movement of the throttle pedal. The 'closed throttle' position signal is used by the ECM to initiate idle speed control and also overrun fuel cut-off.

BRAKE LAMP SWITCH



The brake lamp switch is located on the pedal box and is operated by the brake pedal. The switch is a Hall effect switch which detects the position of the brake pedal and determines when the driver has applied the brakes. The switch is connected directly to the ECM.

The brake switch consists of an inner sensor in an outer mounting sleeve. To ensure correct orientation, the sensor is keyed to the mounting sleeve and the mounting sleeve is keyed to the pedal mounting bracket. Mating serrations hold the sensor in position in the mounting sleeve. While the brakes are off, the tang on the brake pedal rests against the end of the sensor. When the brake pedal is pressed, the tang moves away from the sensor and induces a change of sensor output voltages. This is sensed by the ECM which detects that the brake pedal has been applied. The ECM uses the brake signal for the following:

- To limit fueling during braking
- To inhibit/cancel speed control if the brakes are applied.

In the event of a brake switch failure, the following symptoms may be observed:

- Speed control inactive
- Increased fuel consumption.

ELECTRIC THROTTLE

The electric throttle body is located in the intake tract to the air intake manifold. The electric throttle controls the volume of air allowed into the inlet manifold by means of a direct current (DC) motor which controls a butterfly valve in the body of the throttle. The motor is controlled by the ECM which operates the motor in response to driver inputs from the APP sensor and other engine related sensors to provide the correct air flow to the intake manifolds.

The ECM has 5 connections to the electric throttle motor; a 5V reference voltage, a signal connection back to the ECM for butterfly position, a ground and 2 12V motor feeds to operate the motor in each direction to open or close the butterfly valve.

DIESEL PARTICULATE FILTER (DPF) CONTROL

A diesel particulate filter (DPF) is fitted which collects the particulate matter produced during the combustion process and reduces the particulates entering the atmosphere.

The DPF is located in the exhaust system, downstream of the catalytic converter. A major feature of the DPF is its ability for regeneration. Regeneration is the burning of particulates trapped by the filter to prevent obstruction to the free flow of exhaust gasses. The regeneration process is controlled by the ECM and takes place at calculated intervals and is not noticeable by the driver of the vehicle.

For details of the DPF and the regeneration processes refer to the relevant exhaust system section. For additional information, refer to: Exhaust System (309-00B Exhaust System - TDV8 4.4L Diesel, Description and Operation).

Regeneration is most important, since an overfilled filter can damage the engine through excessive exhaust back pressure and can itself be damaged or destroyed.

The exhaust gas and DPF temperatures are controlled by the DPF software located in the ECM. The DPF software monitors the load status of the DPF based on driving style, distance traveled and signals from a differential pressure sensor and temperature sensors located before and after the DPF in the exhaust system. When the particulate loading of the DPF reaches predetermined levels, the DPF is actively regenerated by adjusting, in conjunction with the ECM, various engine control functions such as:

- fuel injection
- intake air throttle
- EGR
- turbocharger boost pressure control.

The regeneration process is possible because of the flexibility of the common-rail fuel injection engine which provides precise control of fuel flow, fuel pressure and injection timing which are essential requirements to promote the efficient regeneration process.

The ECM contains the DPF software which controls and monitors the DPF and the regeneration process. The software is broken down into three separate modules; a DPF supervisor module, a DPF fuel management module and a DPF air management module, which interact with each other to provide precise DPF control.

These three modules are controlled by a fourth software module known as the DPF co-ordinator module. The co-ordinator module manages the operation of the other modules when an active regeneration is requested. The DPF supervisor module is a sub-system of the DPF co-ordinator module.

DPF CO-ORDINATOR MODULE

The DPF co-ordinator module reacts to a regeneration request from the supervisor module by initiating and controlling the following DPF regeneration requests:

- EGR cut-off
- Turbocharger boost pressure control
- Engine load increase
- Control of air pressure and temperature in the intake manifold
- Fuel injection control.

When the supervisor module issues a regeneration request, the co-ordinator module requests EGR cut-off and a regeneration specific turbocharger boost pressure control. It then waits for a feedback signal from the EGR system confirming that the EGR valve is closed.

NOTE:

The EGR valve is open at idle to allow reduced NO_x. EGR is not used during part load due to intake manifold contamination.

When the EGR valve is closed, the co-ordinator module initiates requests to increase engine load by controlling the intake air temperature and pressure.

Once confirmation is received that intake conditions are controlled or a calibration time has expired, the co-ordinator module then changes to a state awaiting an accelerator pedal release manoeuver from the driver. If this occurs or a calibration time has expired, the co-ordinator module generates a request to control fuel injections to increase exhaust gas temperature.

DPF FUEL MANAGEMENT MODULE

The DPF fuel management module controls the following functions:

- Timing and quantity of the four split injections per stroke (pilot, main and two post injections).
- Injection pressure and the transition between the three different calibration levels of injection.

The above functions are dependant on the condition of the catalytic converter and the DPF.

The controlled injection determines the required injection level in addition to measuring the activity of the catalytic converter and the DPF. The fuel management calculates the quantity and timing for the four split injections, for each of the three calibration levels for injection pressure, and also manages the transition between the levels.

The two post injections are required to separate the functionality of increasing in-cylinder gas temperatures and the production of hydrocarbons. The first post injection is used to generate the higher in-cylinder gas temperature while simultaneously retaining the same engine torque output produced during normal (non-regeneration) engine operation. The second post injection is used to generate hydrocarbons by allowing unburnt fuel into the catalytic converter without producing increased engine torque.

DPF AIR MANAGEMENT MODULE

The DPF air management module controls the following functions:

- EGR control
- Turbocharger boost pressure control
- Intake air temperature and pressure control.

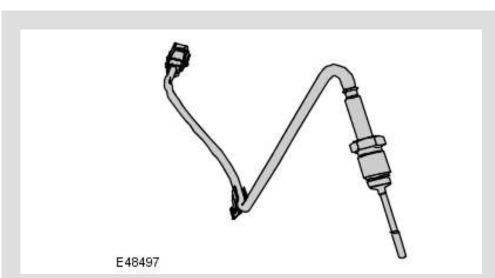
During active regeneration, the EGR operation is disabled and the closed-loop activation of the turbocharger boost controller is calculated. The air management module controls the air in the intake manifold to a predetermined level of pressure and temperature. This control is required to achieve the correct in-cylinder conditions for stable and robust combustion of the post injected fuel.

Restricting the air intake during DPF regeneration has the following functions:

- Increase in engine load
- Slower combustion
- Reduction in the mass of air taken in
- A reduction in the speed of the exhaust gases and therefore an increase in the time for which the gases are in the catalytic converter.

The module controls the intake air temperature by actuating the EGR throttle and by adjustment of the turbocharger boost pressure control.

DPF TEMPERATURE SENSORS



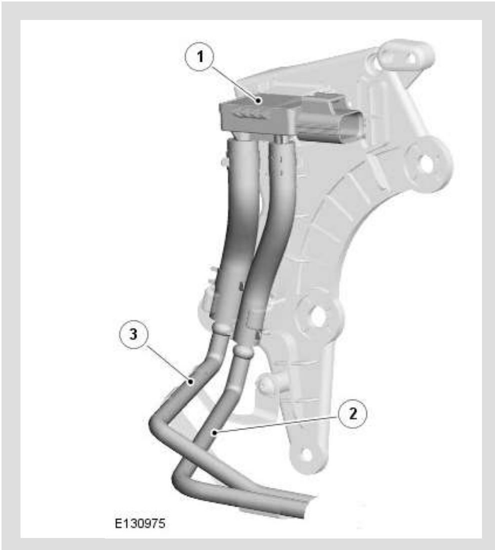
Three temperature sensors are used in the DPF system. One is located in the LH fixed vane turbocharger outlet, another sensor is located before the DPF and the one further sensor is located after the DPF.

The sensors measure the temperature of exhaust gas exiting the turbocharger, before it passes through the DPF and after it has passed through the DPF and provides the information required by the ECM to calculate the DPF temperature. The information is used, in conjunction with other data, to estimate the amount of accumulated particulate and to control the DPF temperature.

The sensors are NTC type resistors, which measure the temperature of the exhaust gases. The resistance, and subsequently the voltage at the sensor will decrease as the exhaust gas temperature increases.

In the event of a fault in a temperature sensor, the ECM uses a substitute value of 350°C (1202°F).

DIFFERENTIAL PRESSURE SENSOR



ITEM	DESCRIPTION
1	Low pressure connection
2	High pressure connection
3	Electrical connector

The differential pressure sensor is located on the rear of the transfer box, adjacent to the DPF.

The differential pressure sensor is used by the DPF software to monitor the condition of the DPF. Two pipe connections on the sensor are connected by pipes to the inlet and outlet ends of the DPF. The pipes allow the sensor to measure the inlet and outlet pressures of the DPF.

As the amount of particulates trapped by the DPF increases, the pressure at the inlet side of the DPF increases in comparison to the DPF outlet. The DPF software uses this comparison, in conduction with other data, to calculate the accumulated amount of trapped particulates.

By measuring the pressure difference between the DPF inlet and outlet air flow and the DPF temperature, the DPF software can determine if the DPF is becoming blocked and requires regeneration.

A DPF is recognized as overloaded if the differential pressure under certain operating conditions exceeds the overload limit calculated by the ECM. The DPF software may start regeneration attempts but be unable to complete them. These attempts are counted by the ECM and, if the maximum number of regeneration attempts is reached, a fault entry is recorded in the ECM at the next ignition on cycle.

The DPF software performs the following checks using the DPF differential pressure sensor:

- Plausibility check
- Diesel particulate filter efficiency
- Diesel particulate filter overloaded
- Diesel particulate filter clogged
- Monitoring of the maximum regeneration attempts in the lower load range.

TERRAIN RESPONSE ™

The 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 are 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 TdV8 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 behavior to customers.

GENERATOR

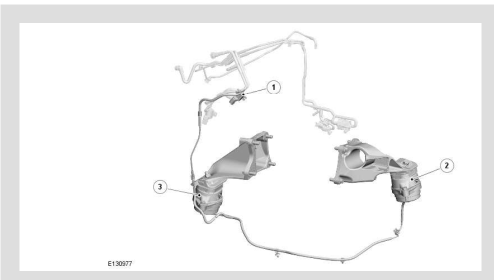
The generator has a multifunction voltage regulator for use in a 14V charging system with 6÷12 zener diode bridge rectifiers.

The ECM monitors the load on the electrical system via a 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 maximize any recharge ability, but at high temperatures the charge voltage must be restricted to prevent excessive gassing of the battery with consequent water loss. For additional information, refer to: Generator (414-02A Generator and Regulator - TDV8 4.4L Diesel, Description and Operation).

The generator has a smart charge capability that will reduce the electrical load on the generator reducing torque requirements, this is implemented to utilize 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 cluster on the CAN bus to illuminate the charge warning lamp.

ACTIVE ENGINE MOUNTS



The active engine mount system comprises:

- Two engine mounts
- Vacuum control solenoid
- Connecting vacuum pipes

The ECM controls the engine mounts via the vacuum control solenoid. The mounts are on (i.e. Solenoid activated which makes mounts soft) at idle speed, and are switched off when the engine speed goes above a predetermined threshold. The threshold is temperature and engine speed dependant, above 20º Celsius the mounts are switched off when the engine speed increases to 900 rpm. Below 20º Celsius the mounts are switched off when the engine speed increases to 1150 rpm.

WATER IN FUEL SENSOR

The water in fuel sensor is located in the base of the fuel filter and is hardwired to the ECM. The sensor operates on the principle of differing resistance values to the transmission of current through water and fuel. When the volume of water in the fuel reaches 85 cm3 or more, the sensor value is sensed by the ECM. The ECM transmits a message on the high speed CAN bus to the instrument cluster which displays a message 'WATER IN FUEL VISIT DEALER' in the message center.For additional information, refer to: Fuel Tank and Lines (310-01B Fuel Tank and Lines - TDV8 4.4L Diesel, Description and Operation).

VISCOUS FAN CONTROL

Regulation of the coolant temperature is achieved via engagement of the electro-viscous fan assembly. This is controlled by a PWM signal with a duty cycle of between 0 and 100%, provided by the ECM and derived from inputs based on:

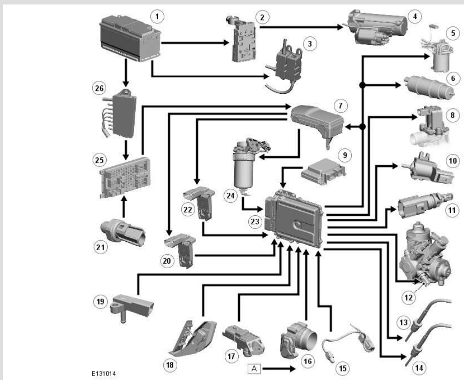
- Coolant temperature
- Ambient air temperature
- Engine inlet air temperature
- air conditioning (A/C) system pressure
- A/C switch operation
- Transmission oil temperature

Fan speed control is variable; however, because the fan is driven directly from the engine, the maximum fan speed available is tied to engine speed. At high engine speeds the fan is progressively disengaged to protect the clutch unit. This system provides very high levels of fan power, up to 5 kilo Watts (kW), with enhanced noise and fuel economy benefits compared to mechanically controlled viscous fans. For additional information, refer to: Electronic Engine Controls (303-14A Electronic Engine Controls - TDV8 4.4L Diesel, Description and Operation).

CONTROL DIAGRAM SHEET 1 OF 2

NOTE:

A = Hardwired



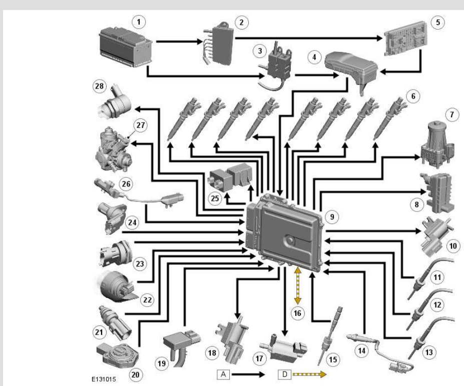
ITEM	PART NUMBER	DESCRIPTION
1	-	Battery
2	-	400A Megafuse
3		Battery Junction Box (BJB) 2
4	-	Starter motor
5		In-tank fuel pump
6		Secondary fuel pump
7		Engine Junction Box (EJB)
8		Boost air recirculation solenoid
9		Restraints Control Module (RCM)
10		Boost air solenoid
11		Air charge temperature sensor
12		Fuel temperature sensor
13		Pre-catalyst temperature sensor - Bank 1
14		Pre-catalyst temperature sensor - Bank 2
15		Ambient air temperature sensor
16		Electric throttle
17	-	Manifold Absolute Pressure (MAP) sensor

ITEM	PART NUMBER	DESCRIPTION
18		Accelerator Pedal Position (APP) sensor
19	-	Boost air pressure sensor
20	-	Mass Air Flow and Temperature (MAFT) sensor - Bank 1
21	-	Oil pressure switch
22	-	Mass Air Flow and Temperature (MAFT) sensor - Bank 1
23	-	Engine Control Module (ECM)
24	-	Water in fuel sensor
25	-	Central Junction Box (CJB)
26	-	BJB

CONTROL DIAGRAM SHEET 2 OF 2

NOTE:

A = Hardwired; **D** = High speed Controller Area Network (CAN) bus



ITEM	PART NUMBER	DESCRIPTION
1		Battery
2	-	BJB
3	-	BJB 2
4		EJB
5		CJB
6		Fuel injector (8 off)
7		Exhaust Gas Recirculation (EGR) valve motor

ITEM	PART NUMBER	DESCRIPTION
8		Variable turbocharger actuator
9		ECM
10		Active engine mount solenoid
11		Diesel Particulate Filter (DPF) outlet temperature sensor
12		Pre-catalyst temperature sensor
13		Post catalyst temperature sensor
14	-	Heated Oxygen Sensor (HO2S)
15		Exhaust manifold gas temperature sensor
16	-	High speed Controller Area Network (CAN) connections to other vehicle systems
17		Turbine intake solenoid
18		EGR cooling by-pass solenoid
19		Differential pressure sensor
20		Oil level and oil temperature sensor
21		Engine Coolant Temperature (ECT) sensor
22		Fixed vane turbocharger intake valve position sensor
23		Fuel rail pressure sensor
24	-	Camshaft Position (CMP) sensor
25	-	Glow plug module (2 off)
26	-	Crankshaft position (CKP) sensor
27	-	Fuel volume control valve
28	-	Fuel pressure control valve