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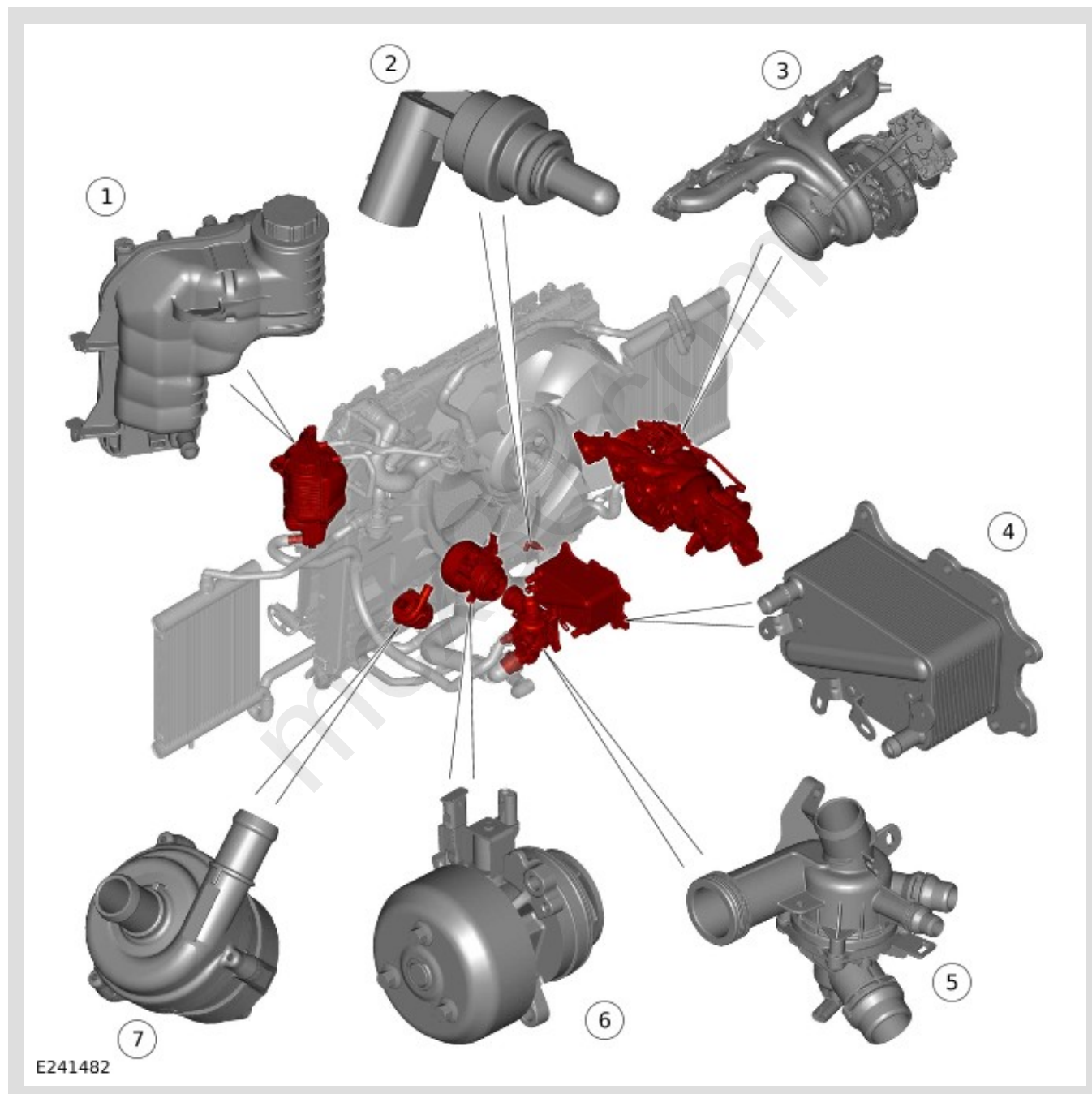
2020.0 DEFENDER (LE), 303-03C

ENGINE COOLING – INGENIUM I6 3.0L PETROL (G2341927)

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COMPONENT LOCATION

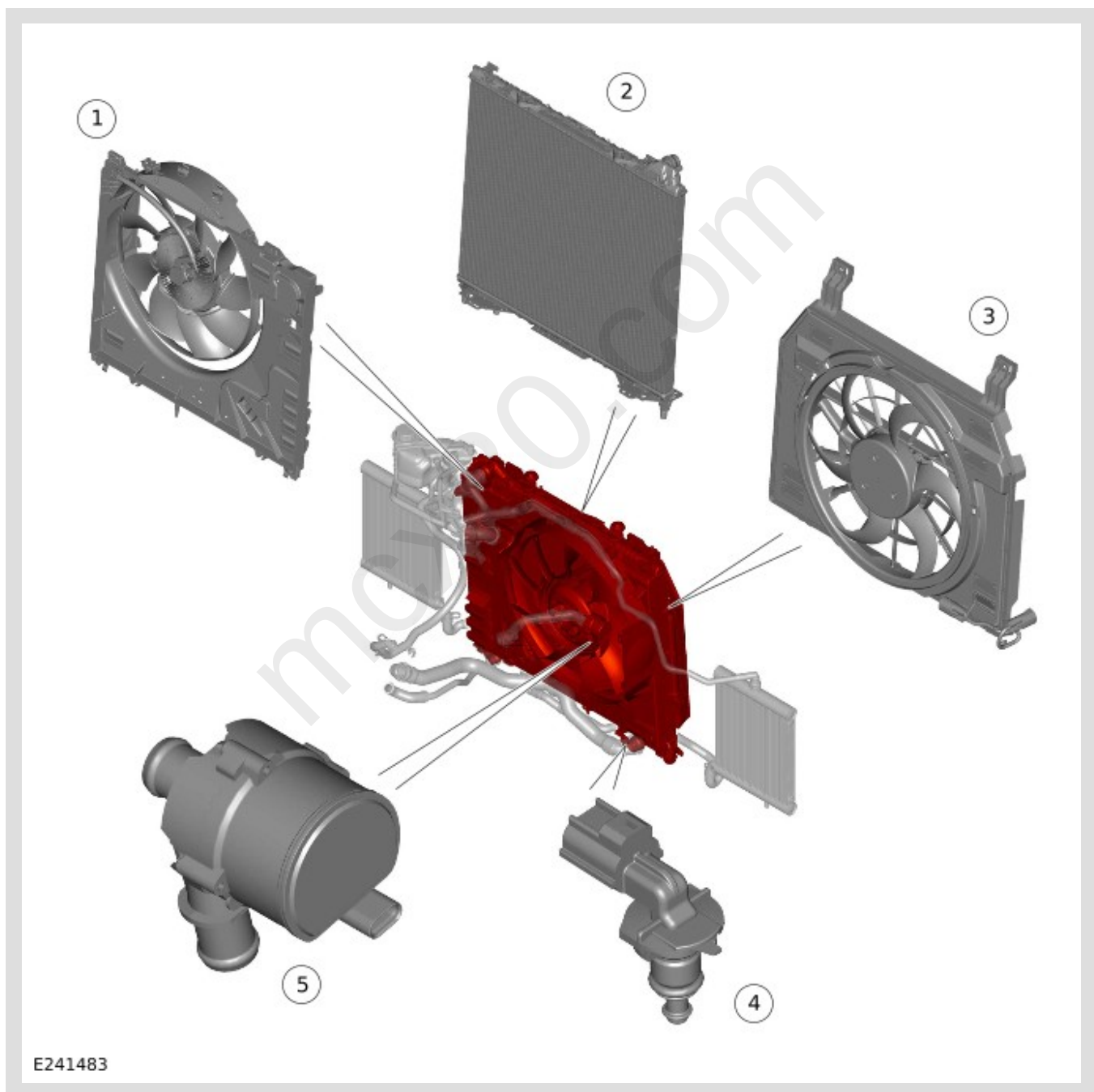
COMPONENT LOCATION - 1 OF 2



ITEM	DESCRIPTION
1	Coolant expansion tank
2	Engine Coolant Temperature (ECT) sensor - Cylinder block outlet

ITEM	DESCRIPTION
3	Turbocharger
4	Oil cooler
5	Electric thermostat
6	Variable coolant pump
7	Charge air coolant pump

COMPONENT LOCATION - 2 OF 2



ITEM	DESCRIPTION
1	Viscous cooling fan

ITEM	DESCRIPTION
2	Radiator
3	Electric cooling fan
4	Radiator outlet temperature sensor
5	Auxiliary coolant pump

OVERVIEW

The engine cooling system maintains the engine within an optimum temperature range under changing ambient and engine operating conditions. The system is a pressurized coolant expansion tank system.

The engine cooling system also provides:

Heating for:

- The passenger compartment.
 - For additional information, refer to: [Heating and Ventilation](#) (412-01 Climate Control, Description and Operation).
 - For additional information, refer to: [Fuel Fired Booster Heater](#) (412-02 Auxiliary Climate Control, Description and Operation).
- The electric throttle.
 - For additional information, refer to: [Intake Air Distribution and Filtering](#) (303-12C Intake Air Distribution and Filtering - INGENIUM I6 3.0L Petrol, Description and Operation).

Cooling for:

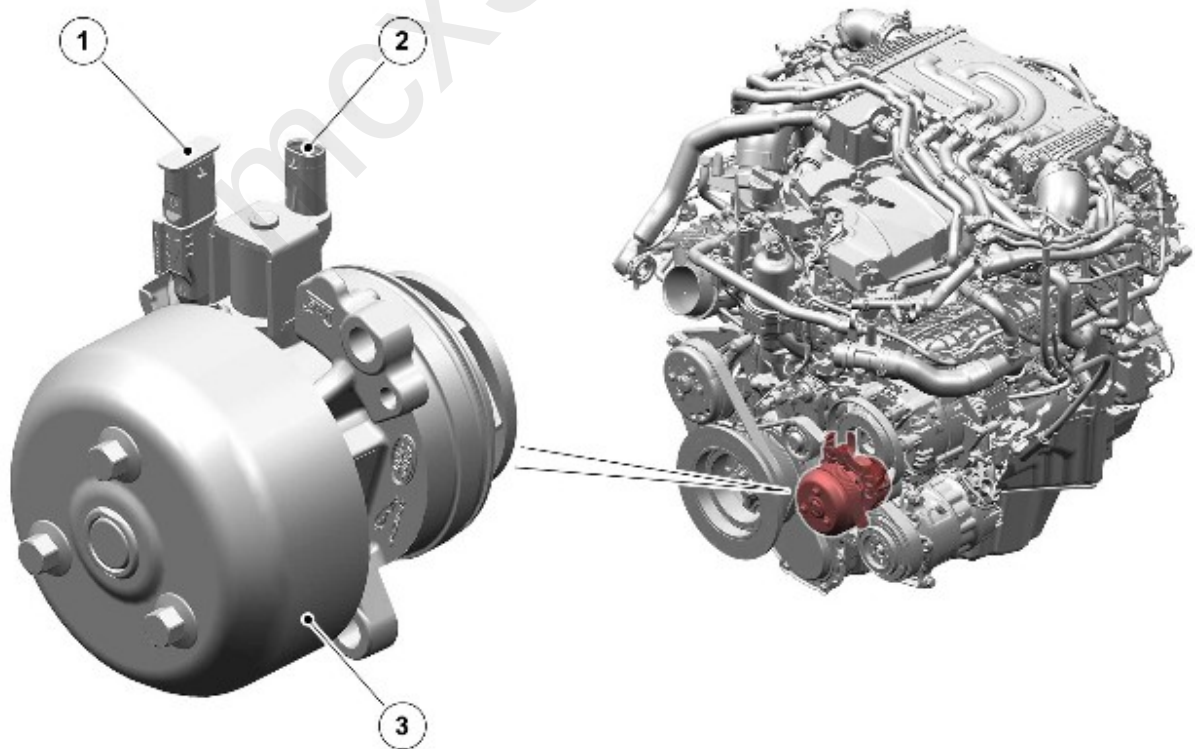
- The engine oil cooler.
 - For additional information, refer to: [Engine](#) (303-01C Engine - INGENIUM I6 3.0L Petrol, Description and Operation).
- The Automatic Transmission Fluid (ATF) cooler
 - For additional information, refer to: [Transmission Cooling](#) (307-02 Transmission/Transaxle Cooling, Description and Operation).
- The charge air cooler.
 - For additional information, refer to: [Intake Air Distribution and Filtering](#) (303-12C Intake Air Distribution and Filtering - INGENIUM I6 3.0L Petrol, Description and Operation).
- The turbocharger.
 - For additional information, refer to: [Turbocharger](#) (303-04F Fuel Charging and Controls - Turbocharger - INGENIUM I6 3.0L Petrol, Description and Operation).

The primary components of the engine cooling system are the:

- Connecting hoses and pipes
- Engine coolant
- Variable coolant pump
- Auxiliary coolant pump
- Electric thermostat
- Radiator
- Coolant expansion tank
- Electric cooling fan
- Viscous cooling fan
- Charge air coolant pump
- Charge air cooler
- Charge air cooler radiators
- The Automatic Transmission Fluid (ATF) cooler.

DESCRIPTION

VARIABLE COOLANT PUMP



E237059

ITEM	DESCRIPTION
1	Electrical connector - Variable coolant pump shroud solenoid
2	Electrical connector - Variable coolant pump shroud position sensor
3	Pulley

The variable coolant pump is installed at the front left of the cylinder block. A pulley attaches to the pump flange. The ratio of crankshaft speed to variable coolant pump speed is 1:1.45.

For additional information, refer to: [Accessory Drive](#) (303-05C Accessory Drive - INGENIUM I6 3.0L Petrol, Description and Operation).

The Powertrain Control Module (PCM) controls the variable coolant pump to give the minimum flow to support all cooling requests from the engine components. The variable coolant pump has a shroud inside that slides over the impeller to control the quantity of engine coolant pumped into the engine. The purpose is only to pump the minimum quantity of engine coolant necessary around the engine. This decreases the load on the engine and improves fuel consumption and emissions.

Variable flow functionality is used during warm-up, contributing to the whole engine thermal management strategy. The internal pressure within the variable coolant pump acts against a return spring in the variable coolant pump housing. The variable coolant pump shroud solenoid is open without a signal from the PCM. Therefore the variable coolant pump shroud returns to its base position under spring force, resulting in full flow from the variable coolant pump.

As components warm up, the flow request increases in 4 stages. The engine coolant flow control continues until the complete powertrain system, including the transmission, achieves its operating temperature.



NOTE:

Flow percentages are approximate values.

The flow modes of the variable coolant pump are the following:

- Level 1 = 15% of the total flow.
- Level 2 = 25% of total flow.
- Level 3 = 50 % of total flow.
- Level 4 = 100% (Maximum flow).



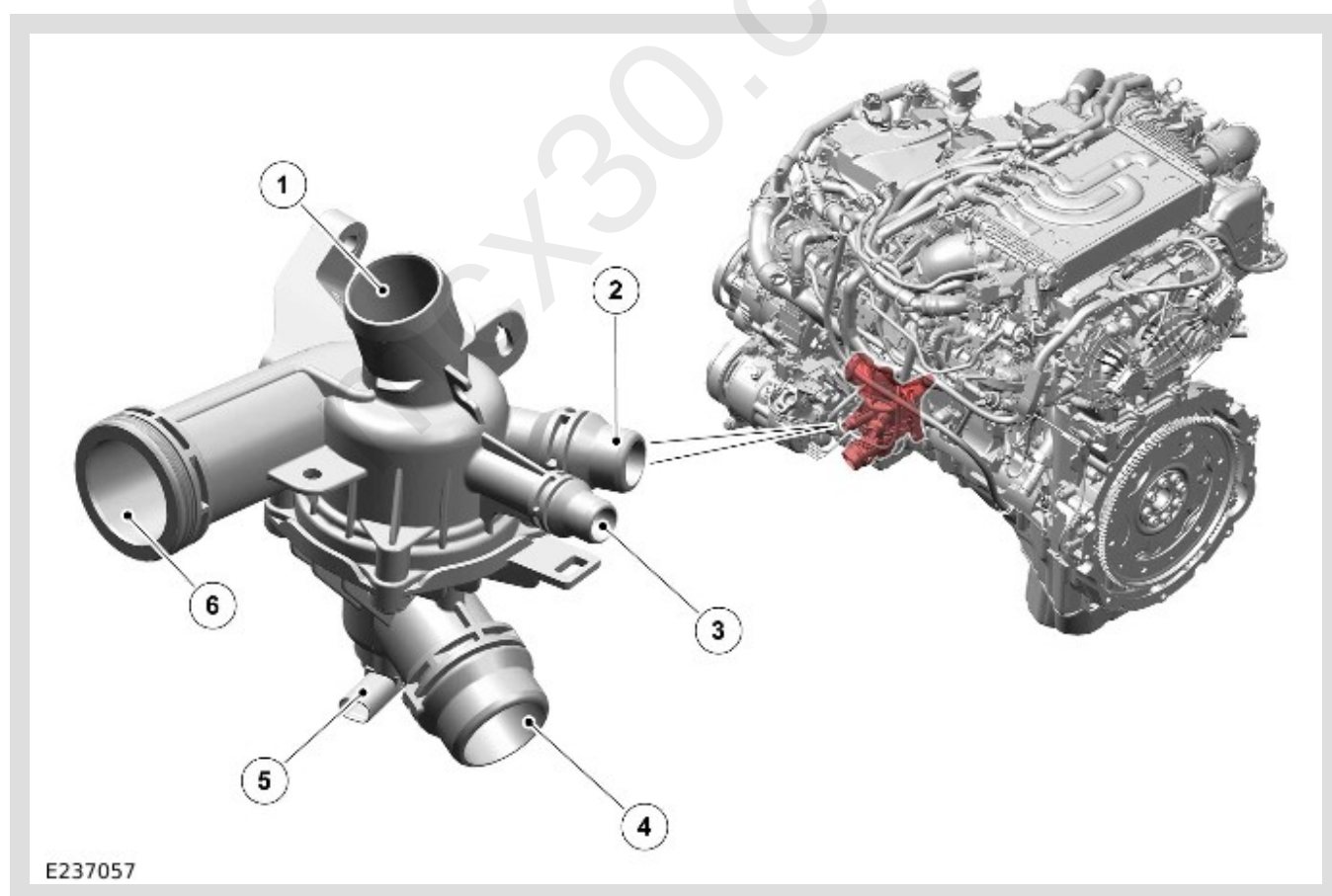
NOTE:

If engine is not running, the default pump shroud position is Level 4 or fully unshrouded (safety position).

The Powertrain Control Module (PCM) receives input signals from the following components to calculate the level of coolant flow required:

- Engine speed - Crankshaft position (CKP) sensor
- Engine Coolant Temperature (ECT) sensor
- Cylinder head temperature sensor
- Radiator outlet temperature sensor
- Ambient Air Temperature (AAT) sensor
- Cylinder block temperature sensor
- Engine oil pressure and temperature sensor
- Engine torque
- Fuel consumption (modeled in the PCM)
- Automatic Transmission Fluid (ATF) temperature from the Transmission Control Module (TCM)
- HVAC control module (HVAC) demand.

ELECTRIC THERMOSTAT



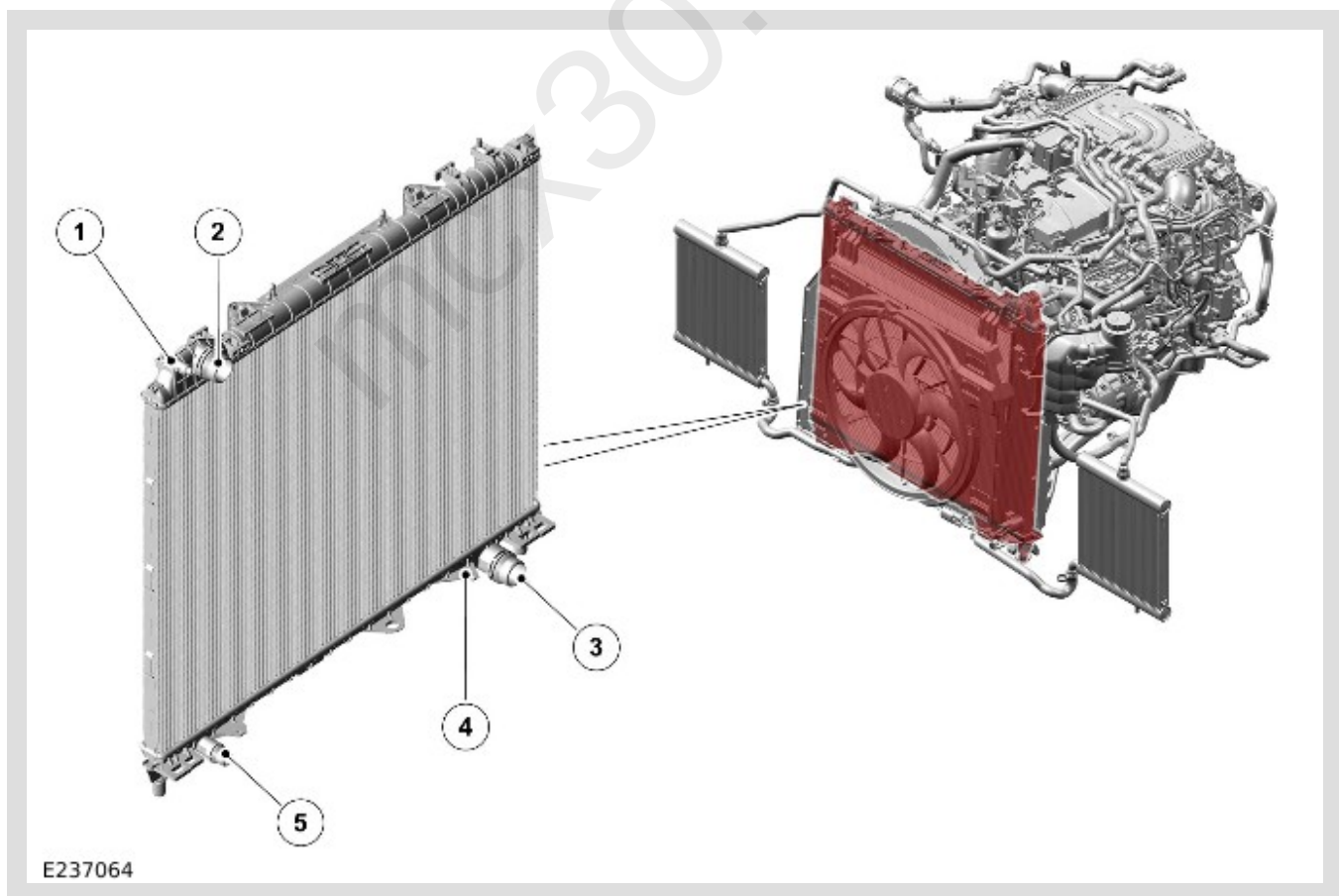
ITEM	DESCRIPTION
1	Hose connection - Engine outlet

ITEM	DESCRIPTION
2	Hose connection - Turbocharger, heater core and automatic transmission fluid return
3	Hose connection - Coolant expansion tank
4	Hose connection - Radiator lower hose
5	Electrical connector - Heater element
6	Hose connection - Variable coolant pump

The electric thermostat contains a wax expansion element that incorporates a heater element. When energized, the heater element heats the wax expansion element, partially controlling the thermostat function along with engine coolant temperature control. Operation is therefore activated not only by the Engine Coolant Temperature (ECT), but as specified by the Powertrain Control Module (PCM). This enables a finer control of the opening and closing of the electric thermostat.

The increased wax expansion element temperature provides higher ECT during part load conditions and at low speed cycles. The increased ECT results in reduced friction in the engine, improved combustion in the cylinders and reduced fuel consumption and emissions. The heater element regulates the ECT during high load conditions and speed points. This protects the engine from thermal overload.

RADIATOR



ITEM	DESCRIPTION
1	Hose connection - Coolant expansion tank
2	Upper hose - Engine coolant inlet
3	Lower hose - Engine coolant outlet
4	Radiator drain plug
5	Hose connection - Automatic Transmission Fluid (ATF) cooler

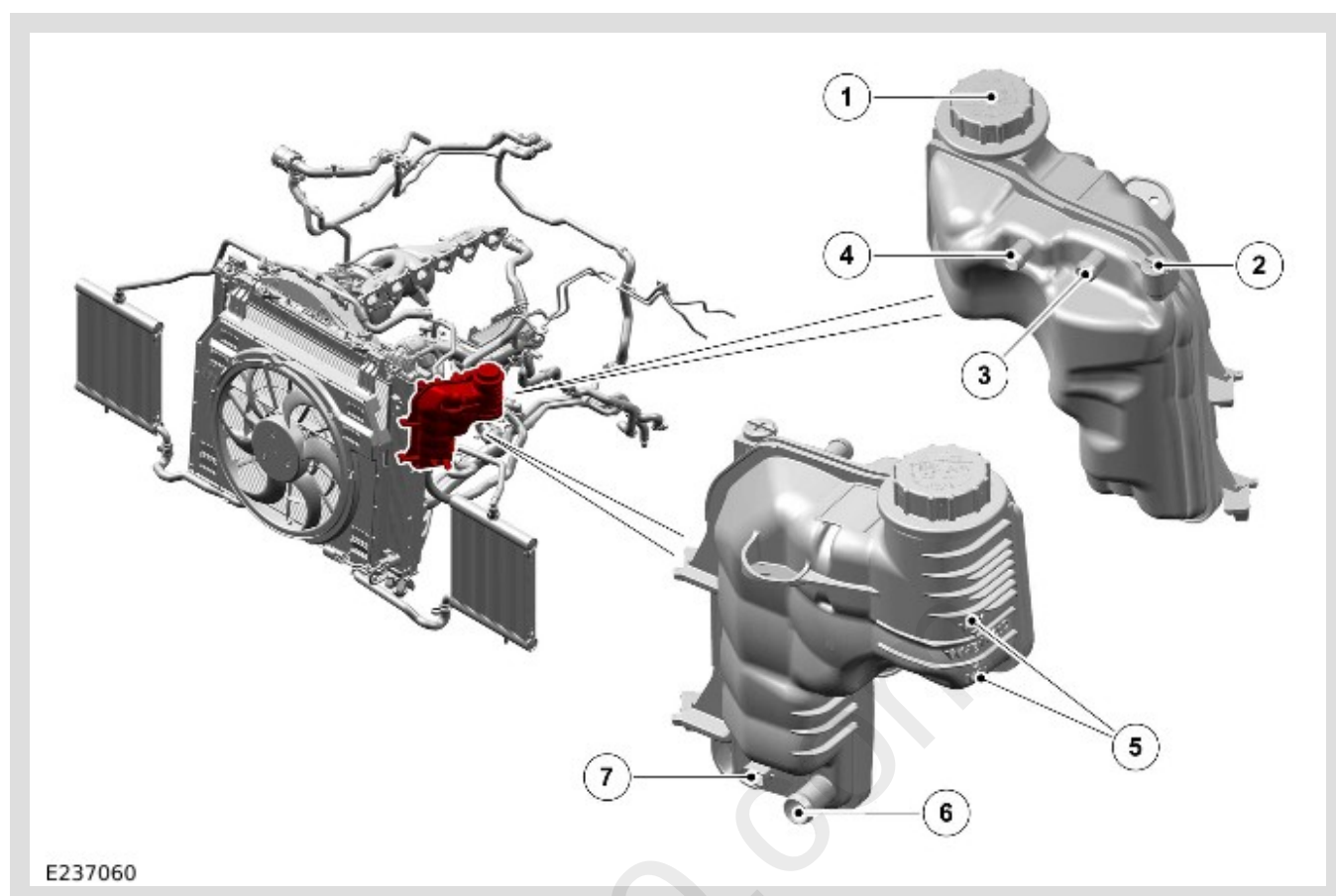
The radiator is a vertical flow type with an aluminum core and plastic end tanks in the upper and lower position of the radiator. The radiator uses brazed aluminum tube technology to reduce weight.

The radiator locates in the vehicle by locating spigots and supports integrated into the end tanks. The supports are installed in rubber isolator bushes in the lower support bracket. The upper mounting of the radiator is through the hood latch panel attached to the vehicle body.

A drain plug integrates on the bottom of the radiator. Engine coolant outlet and inlet connections are incorporated into the upper and lower end tanks respectively.

A low temperature zone is located at the left side of the radiator and provides cooled engine coolant for the Automatic Transmission Fluid (ATF) cooler.

COOLANT EXPANSION TANK



ITEM	DESCRIPTION
1	Coolant expansion tank filler cap
2	Bleed screw
3	Pipe connection - Engine
4	Pipe connection - Radiator
5	Minimum and maximum level markings
6	Pipe connection - Electric thermostat
7	Engine coolant level sensor

The pressurized coolant expansion tank continuously separates the air from the cooling system. A continuous vent into the coolant expansion tank through a hose connected to the engine prevents air locks from forming in the cooling system.

The coolant expansion tank is located on the left of the radiator and bolted onto the hood latch panel. A filler cap, a bleed screw and a level sensor are incorporated into the coolant expansion tank.

The coolant expansion tank provides the following functions:

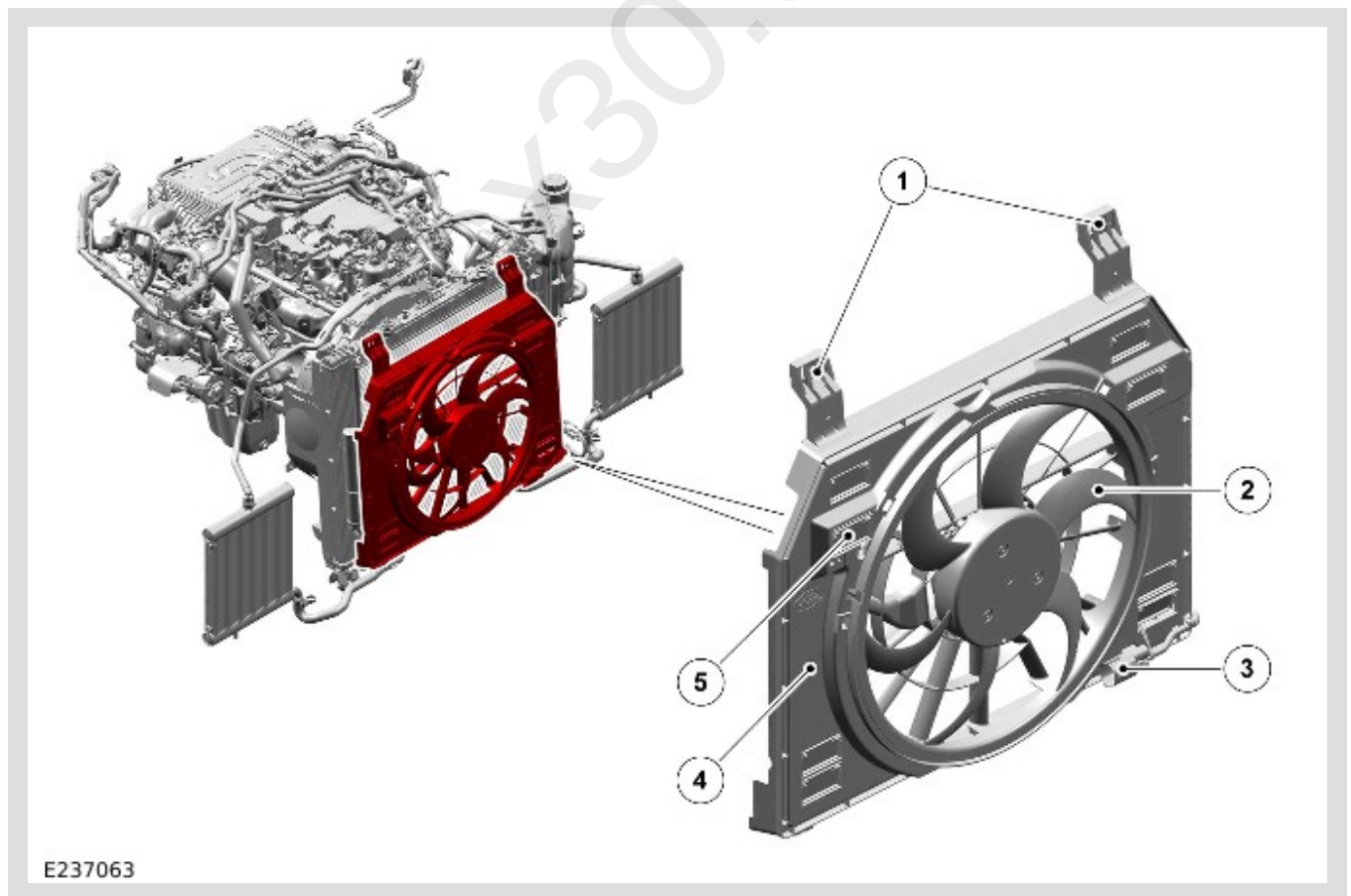
- The service fill.
- Engine coolant expansion during warm up.
- Air separation during operation.
- System pressurization by the filler cap
- Coolant level sensing.

Minimum and maximum level markings are molded on the coolant expansion tank body. The coolant expansion tank has an air space above the maximum level, approximately 0.5 liter (0.13 gallon) to 1 liter (0.26 gallon). The air space allows the engine coolant to expand.

The engine coolant level sensor locates in a sealed cavity at the bottom of the coolant expansion tank body. A float with an integral magnet is located inside the coolant expansion tank. The coolant level sensor contains a switch that reacts to the position of the magnetic float. The coolant level sensor is hardwired to the Body Control Module (BCM)/ Gateway Control Module (GWM).

The magnetic float is designed to float very close to the bottom of the tank, significantly below the MIN cold fill coolant level. The magnetic float in this position does not indicate float failure, for example sinking or sticking. The float has a travel distance of approximately 15 mm (0.59 in) from the bottom of the tank.

ELECTRIC COOLING FAN



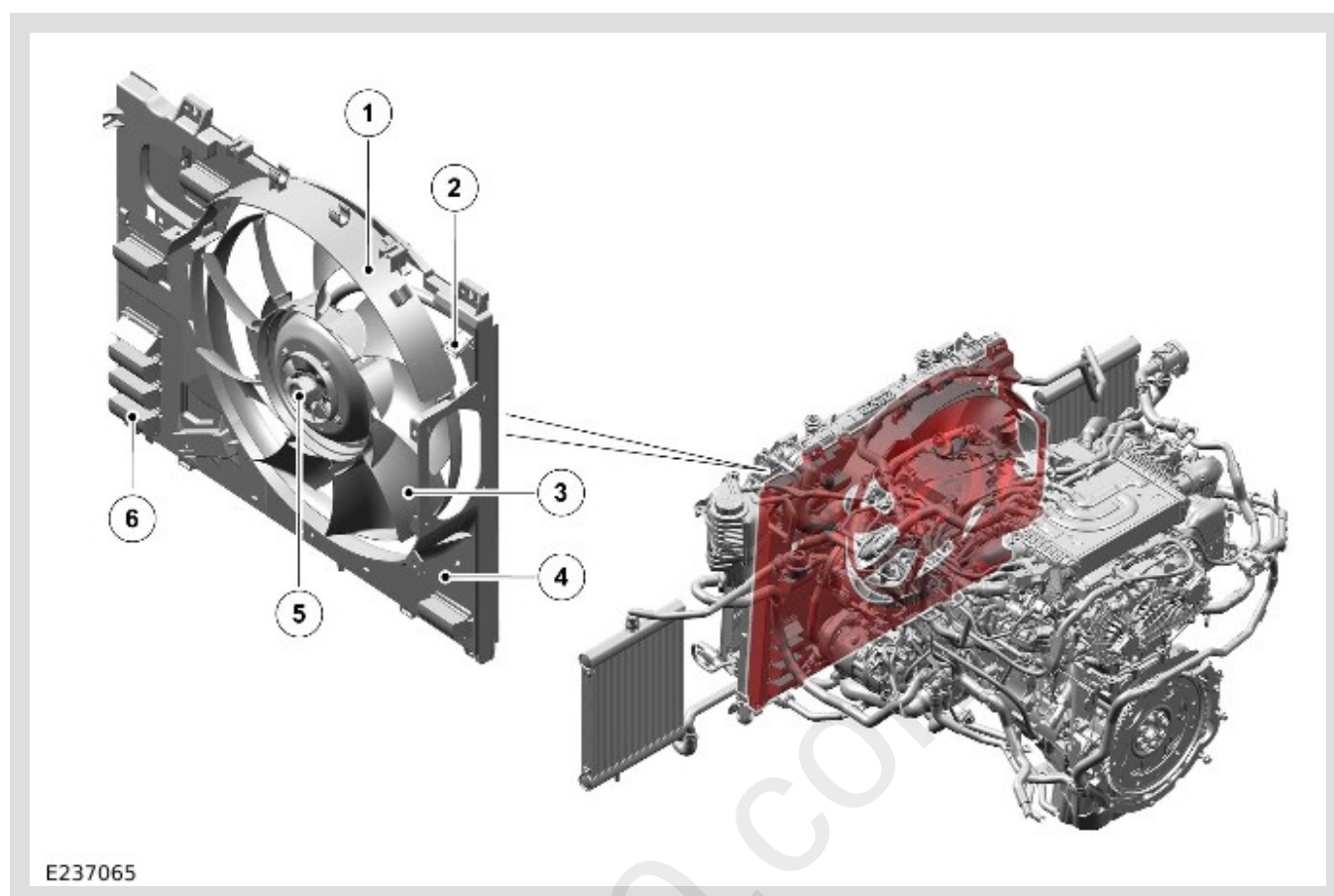
ITEM	DESCRIPTION
1	Mounting bracket (quantity 2)
2	Electric cooling fan blade (quantity 6)
3	Electrical connector
4	Electric cooling fan shroud
5	Electric cooling fan air flow flap (quantity 8)

The electric cooling fan is installed in the front of the Air Conditioning (A/C) condenser. The electric cooling fan is operated by the electric cooling fan control module which is integrated into the electric cooling fan motor. The Powertrain Control Module (PCM) controls the electric cooling fan control module with a Pulse Width Modulation (PWM) signal.

The electric cooling fan control module is provided with:

- Power supply from the Engine Junction Box (EJB).
- Ignition signal from the PCM relay in the EJB.
- PWM signal from the PCM.
- Ground.

VISCOUS COOLING FAN



ITEM	DESCRIPTION
1	Upper shroud
2	Electrical connector
3	Electric cooling fan blade
4	Lower shroud
5	Nut
6	Air flow flap (quantity 7)

The viscous cooling fan is installed behind the radiator. The viscous cooling fan functions as a normal fan, but with electronic control over the level of engagement of the viscous clutch. The Powertrain Control Module (PCM) controls the level of engagement to optimize fan speed for all operating conditions.

A securing nut attaches the cooling fan to a drive pulley. The drive pulley is mounted on the front of the engine and driven by the accessory drive system.

For additional information, refer to: [Accessory Drive](#) (303-05C Accessory Drive - INGENIUM I6 3.0L Petrol, Description and Operation).

NOTE:

The nut on the viscous cooling fan has a right-hand thread.

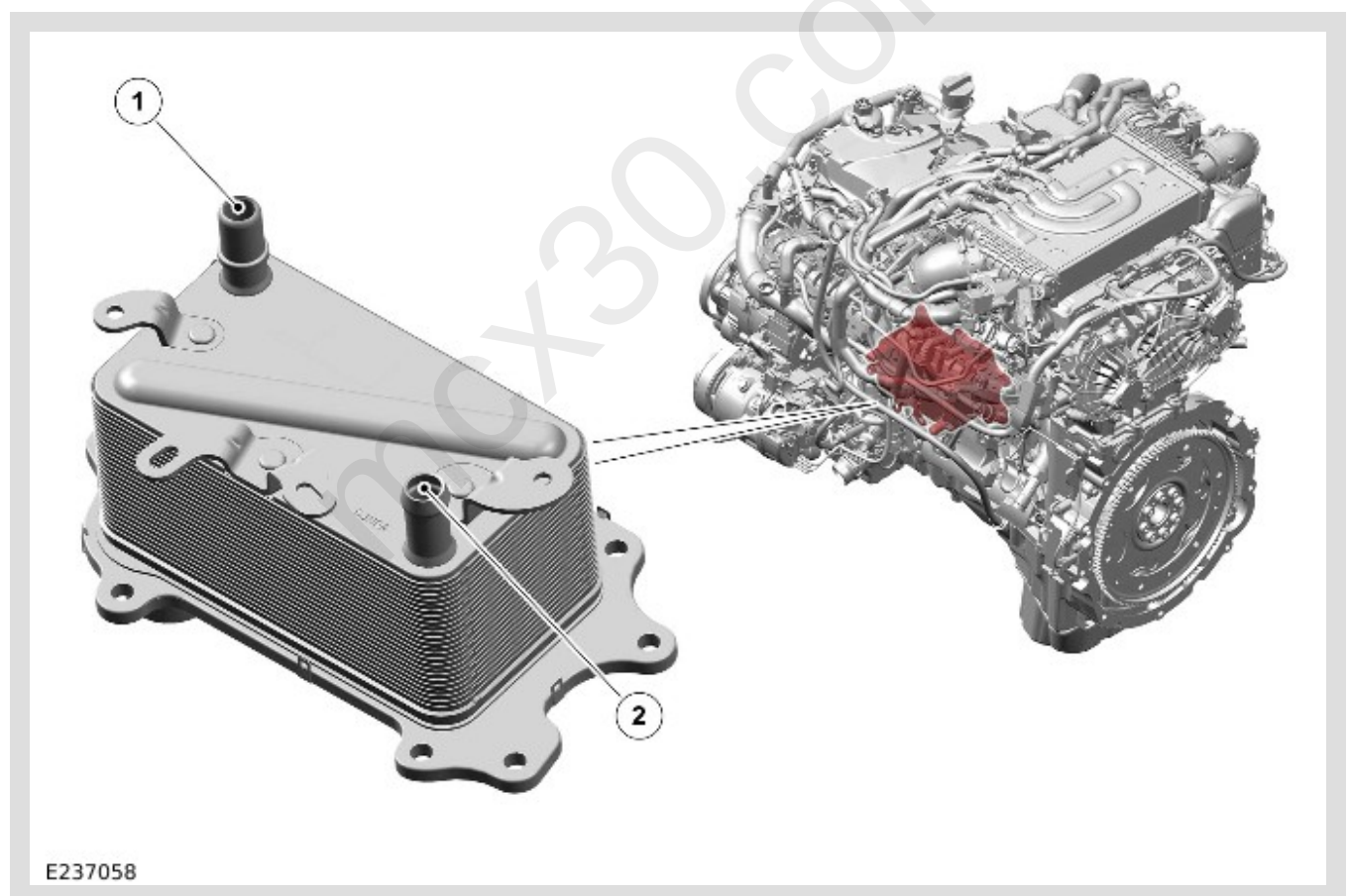
The viscous cooling fan has the following hardwired connections:

- Power supply from the PCM relay in the Engine Junction Box (EJB) (quantity 2)
- Pulse Width Modulation (PWM) signal from the PCM
- Fan speed signal to the PCM
- Ground.

The viscous cooling fan is operated by the Viscous Cooling Fan Control Module (VCFCM), integrated into the drive unit, which is controlled by the PCM.

To control the cooling fan, the PCM varies the duty cycle of the PWM signal. The VCFCM translates the duty cycle into a fan target speed and sets the level of engagement of the viscous clutch accordingly.

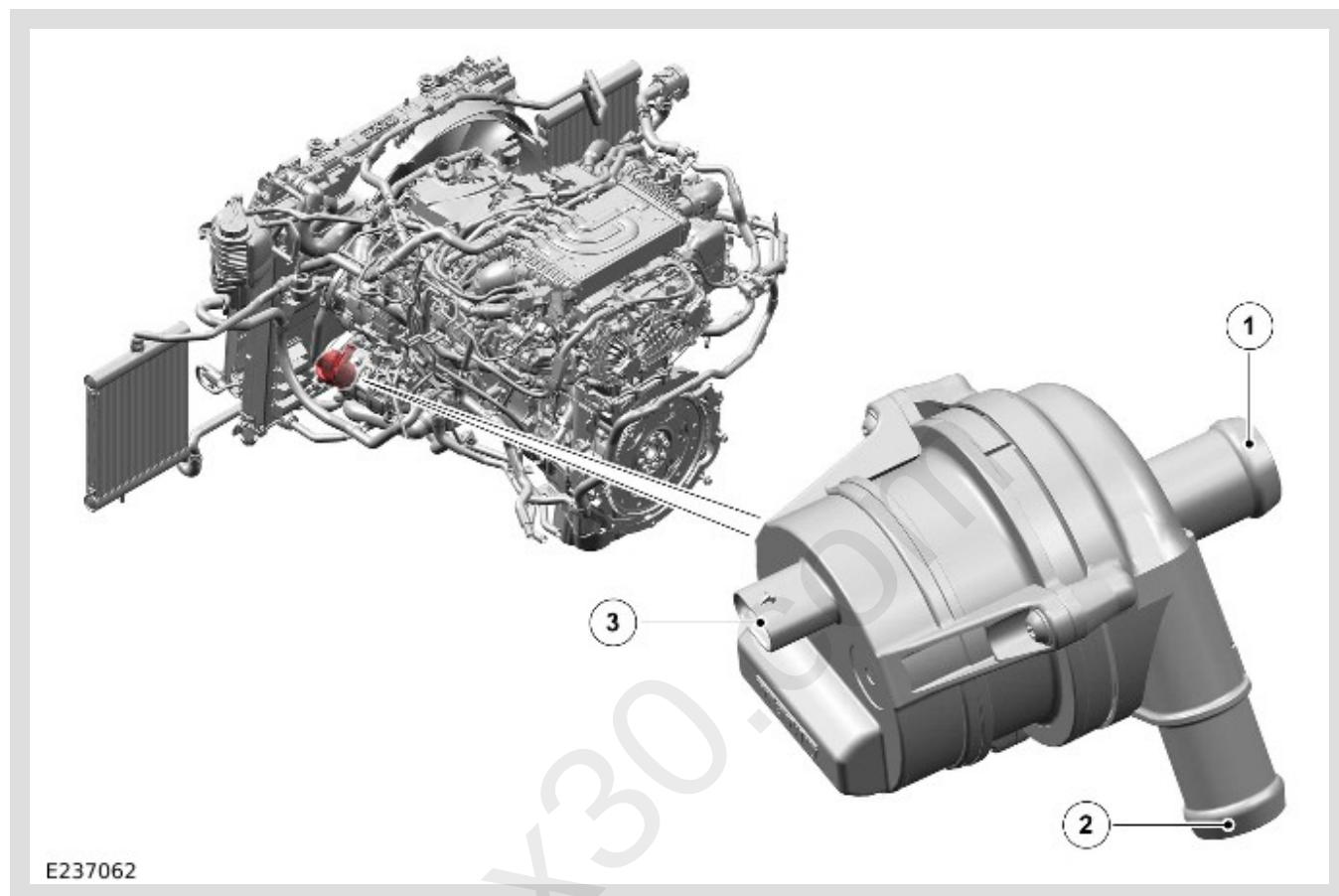
OIL COOLER



ITEM	DESCRIPTION
1	Hose connection - Engine coolant outlet
2	Hose connection - Engine coolant inlet

The oil cooler is installed at the left side of the cylinder block. The oil cooler is an aluminum housing comprising louvred fins and plates. The plates allow a cross-flow of engine oil and engine coolant through the oil cooler. The engine coolant decreases the temperature of the hot engine oil in the oil cooler. The engine oil and engine coolant do not mix in the oil cooler.

CHARGE AIR COOLANT PUMP

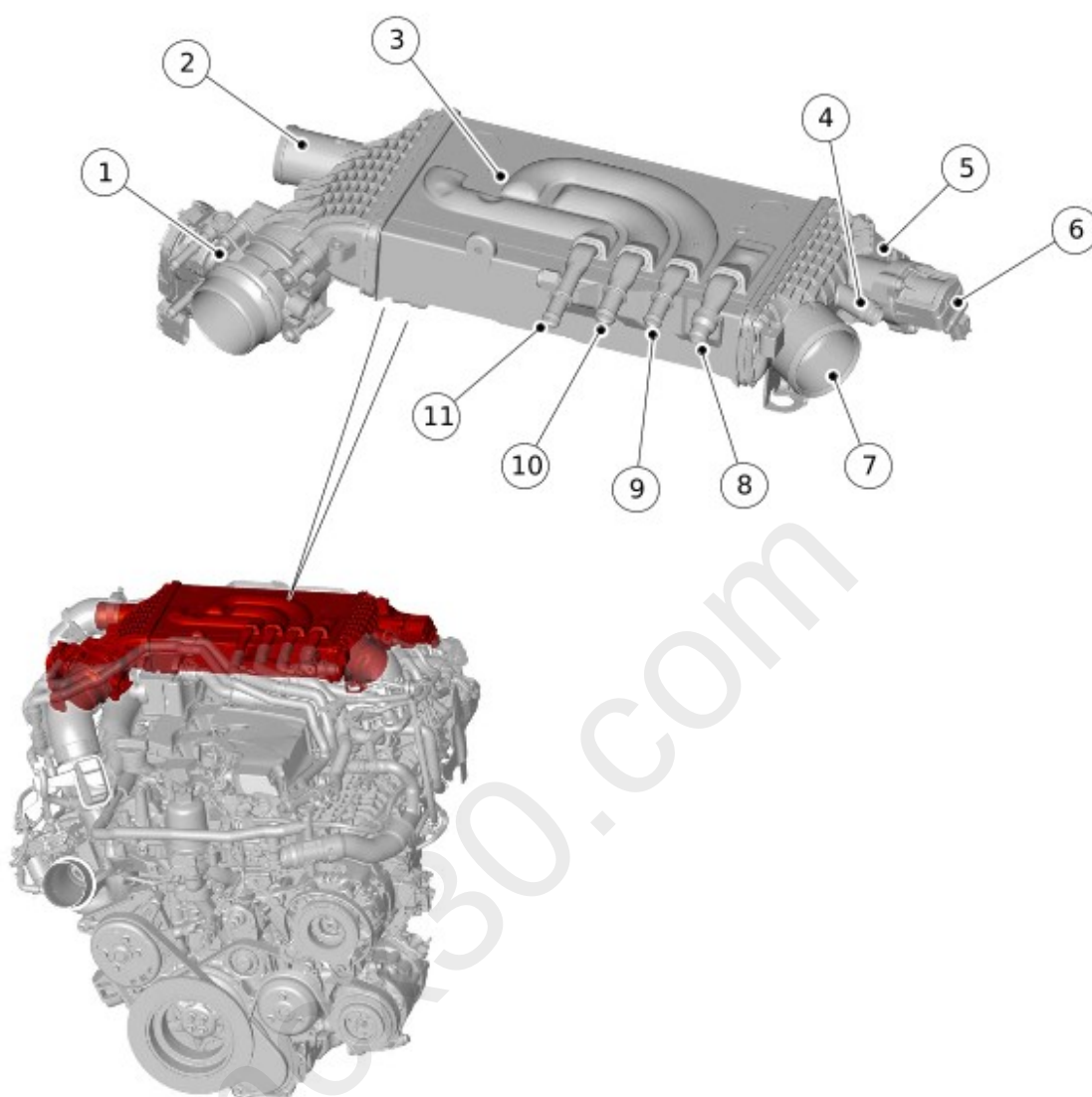


ITEM	DESCRIPTION
1	Hose connection - Engine coolant inlet
2	Hose connection - Engine coolant outlet
3	Electrical connector - Powertrain Control Module (PCM)

The charge air coolant pump is installed on the shroud of the viscous cooling fan. The charge air coolant pump circulates the engine coolant from the charge air cooler radiator to the charge air cooler. The Powertrain Control Module (PCM) controls the operation of the charge air coolant pump through a Pulse Width Modulation (PWM) signal.

For additional information, refer to: [Supercharger Cooling](#) (303-03D Supercharger Cooling - INGENIUM I6 3.0L Petrol, Description and Operation).

CHARGE AIR COOLER



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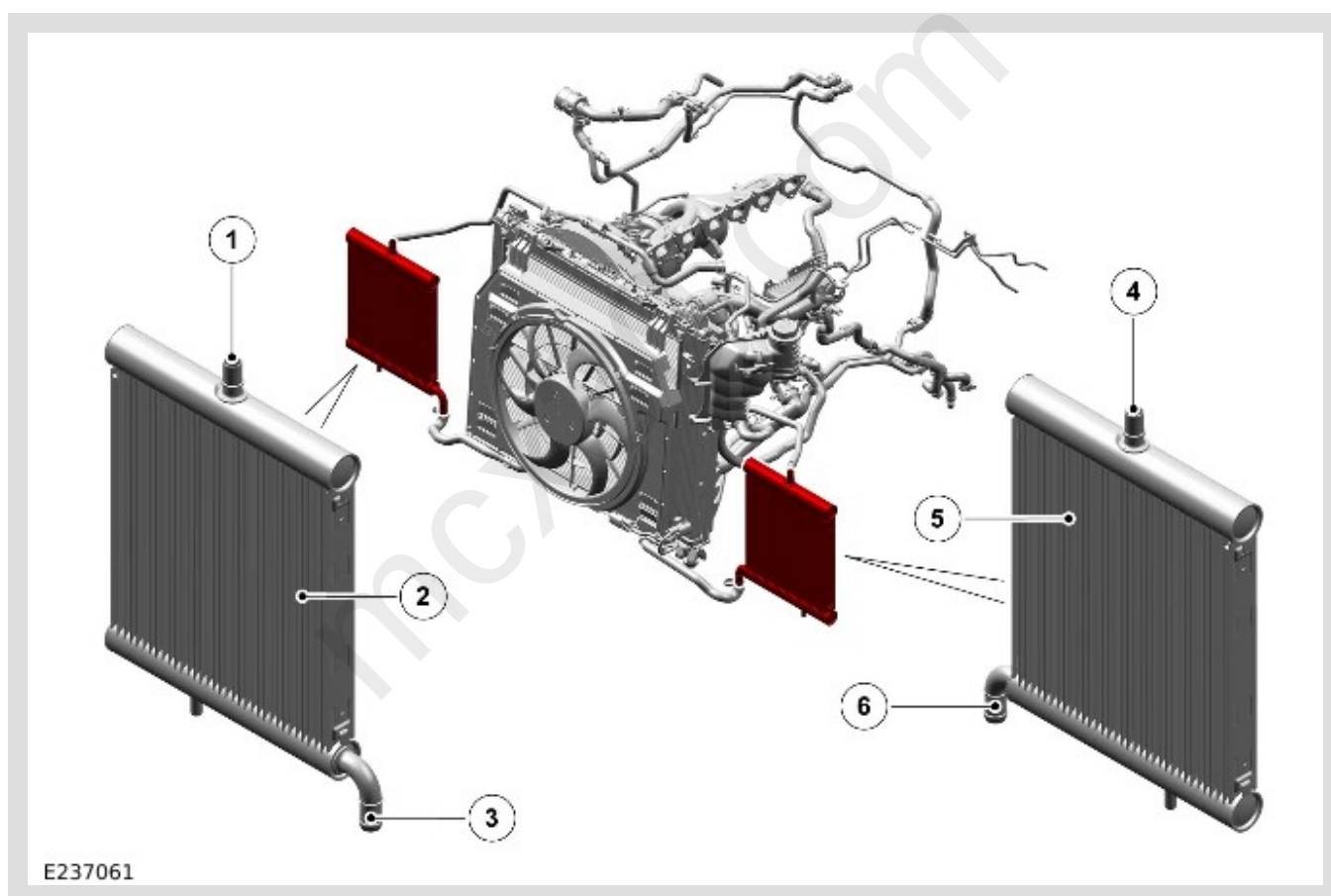
ITEM	DESCRIPTION
1	Electric supercharger bypass valve
2	Electric supercharger inlet
3	Charge air cooler
4	Air intake system hose connection
5	Charge air pressure and temperature sensor
6	Compressor Bypass Valve (CBV)
7	Electric throttle hose connection

ITEM	DESCRIPTION
8	Coolant inlet from low temperature radiator
9	Coolant outlet to low temperature radiator
10	Coolant inlet from engine
11	Coolant outlet to main radiator

The charge air cooler is an air-to-liquid heat exchanger, providing charge air cooling in combination with an electrical coolant pump.

For additional information, refer to: [Supercharger Cooling](#) (303-03D Supercharger Cooling - INGENIUM I6 3.0L Petrol, Description and Operation).

CHARGE AIR RADIATORS

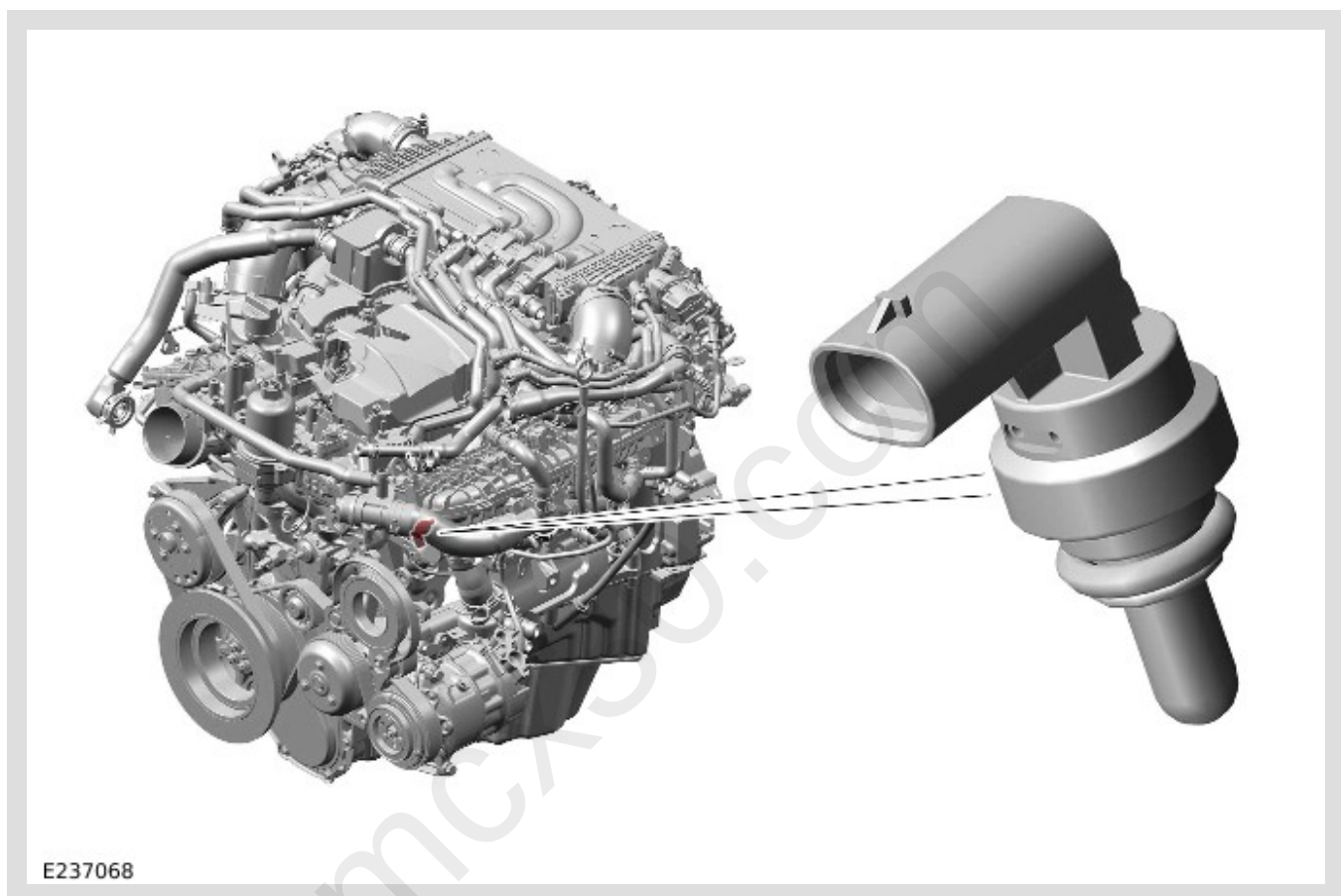


ITEM	DESCRIPTION
1	Hose connection - Engine coolant inlet
2	Right charge air radiator
3	Hose connection - Engine coolant outlet
4	Hose connection - Engine coolant outlet

ITEM	DESCRIPTION
5	Left charge air radiator
6	Hose connection - Engine coolant inlet

The charge air radiators are located behind the front bumper. The charge air coolant pump circulates the engine coolant from the charge air radiators to the charge air cooler. The radiator is a vertical flow type with an aluminum core.

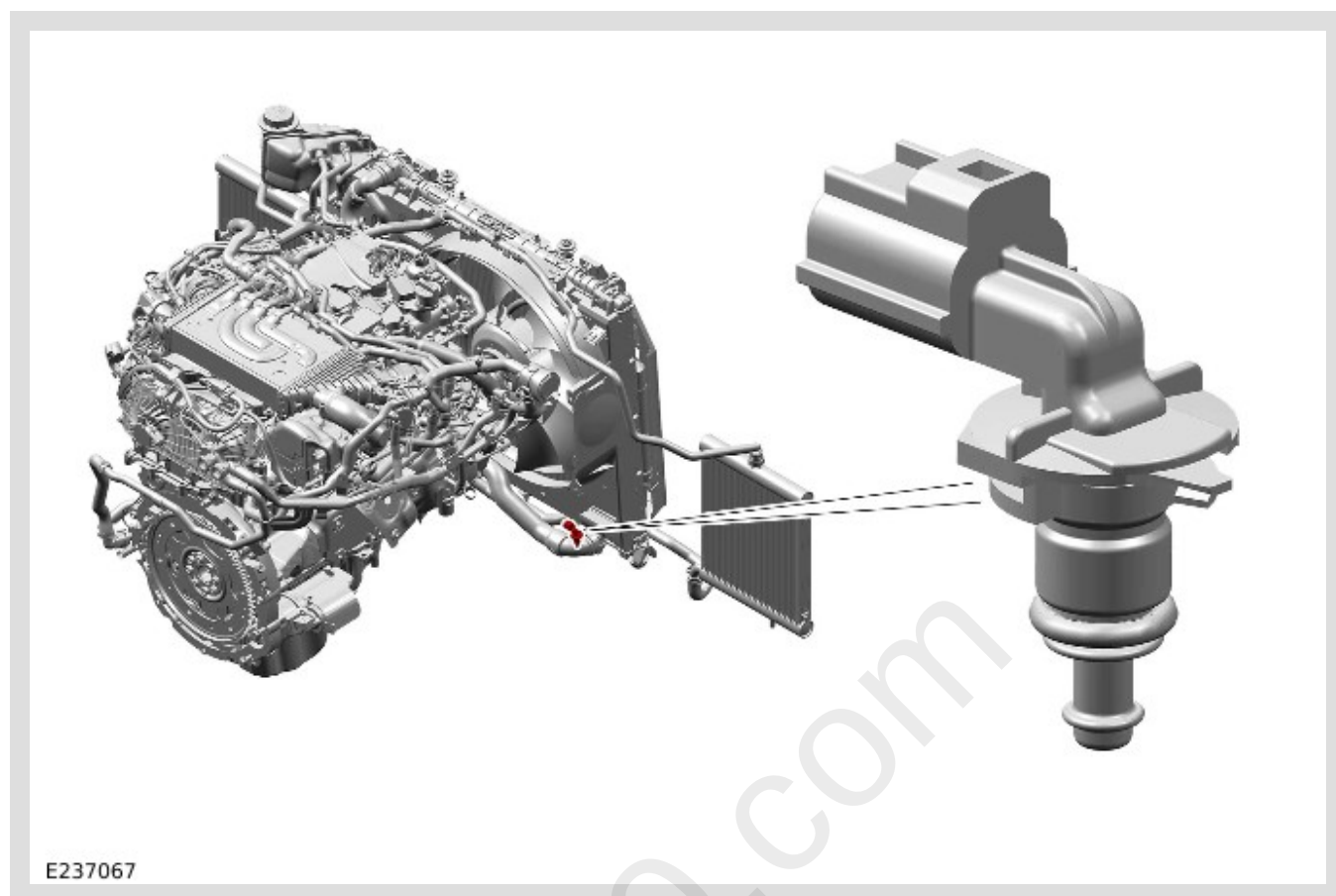
ENGINE COOLANT TEMPERATURE SENSOR - CYLINDER BLOCK OUTLET



The Engine Coolant Temperature (ECT) sensor is installed in the engine coolant bypass rail which is installed on the left side of the cylinder block. The ECT sensor measures the temperature of the engine coolant from the cylinder block. The signal from the ECT sensor is sent to the Powertrain Control Module (PCM) through hardwired connection.

For additional information, refer to: [Electronic Engine Controls](#) (303-14B Electronic Engine Controls - INGENIUM I6 3.0 L Petrol, Description and Operation).

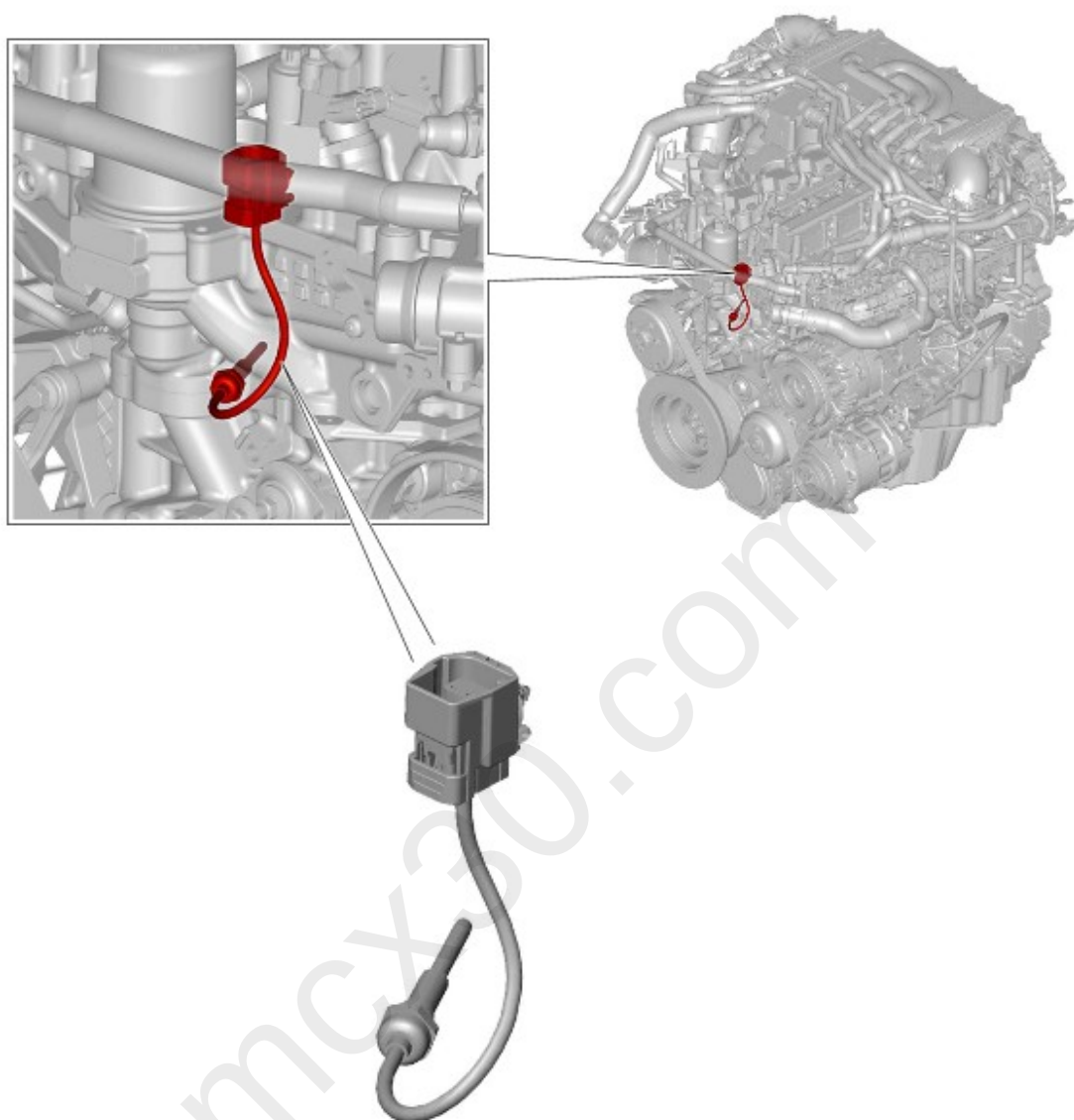
RADIATOR OUTLET TEMPERATURE SENSOR



The radiator outlet temperature sensor is installed in the lower hose. The radiator outlet temperature sensor measures the temperature of the engine coolant from the radiator. The signal from the radiator outlet temperature sensor is sent to the Powertrain Control Module (PCM).

For additional information, refer to: [Electronic Engine Controls](#) (303-14B Electronic Engine Controls - INGENIUM I6 3.0 L Petrol, Description and Operation).

CYLINDER HEAD TEMPERATURE SENSOR



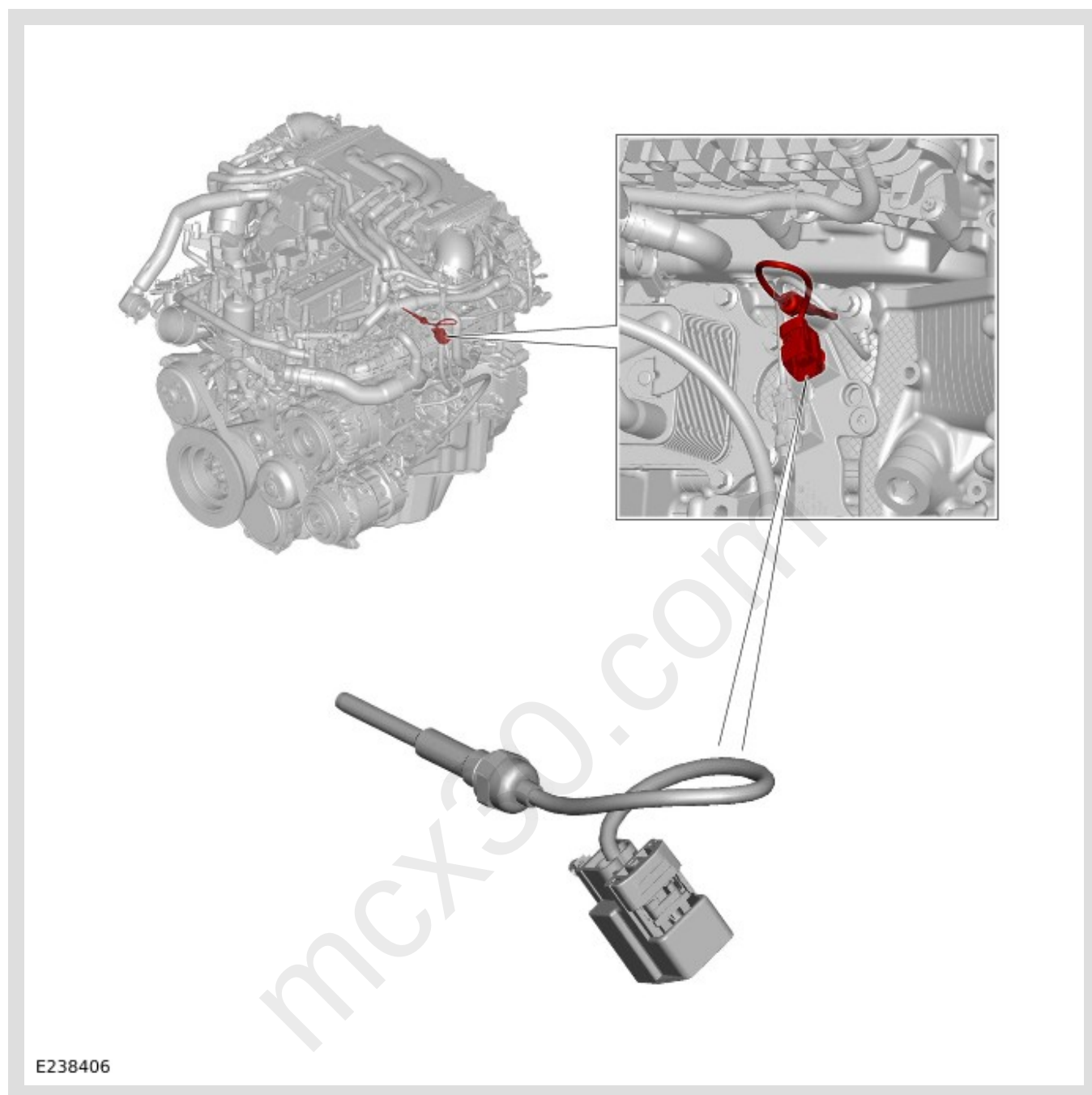
E238405

The cylinder head temperature sensor is located in a threaded hole in the front of the cylinder head. The threaded hole is located adjacent to the oil filter housing and the cylinder head engine coolant outlet pipe.

The sensor is a Negative Temperature Coefficient (NTC) resistor type sensor with a 2-pin connection.

For additional information, refer to: [Electronic Engine Controls](#) (303-14B Electronic Engine Controls - INGENIUM I6 3.0 L Petrol, Description and Operation).

CYLINDER BLOCK TEMPERATURE SENSOR

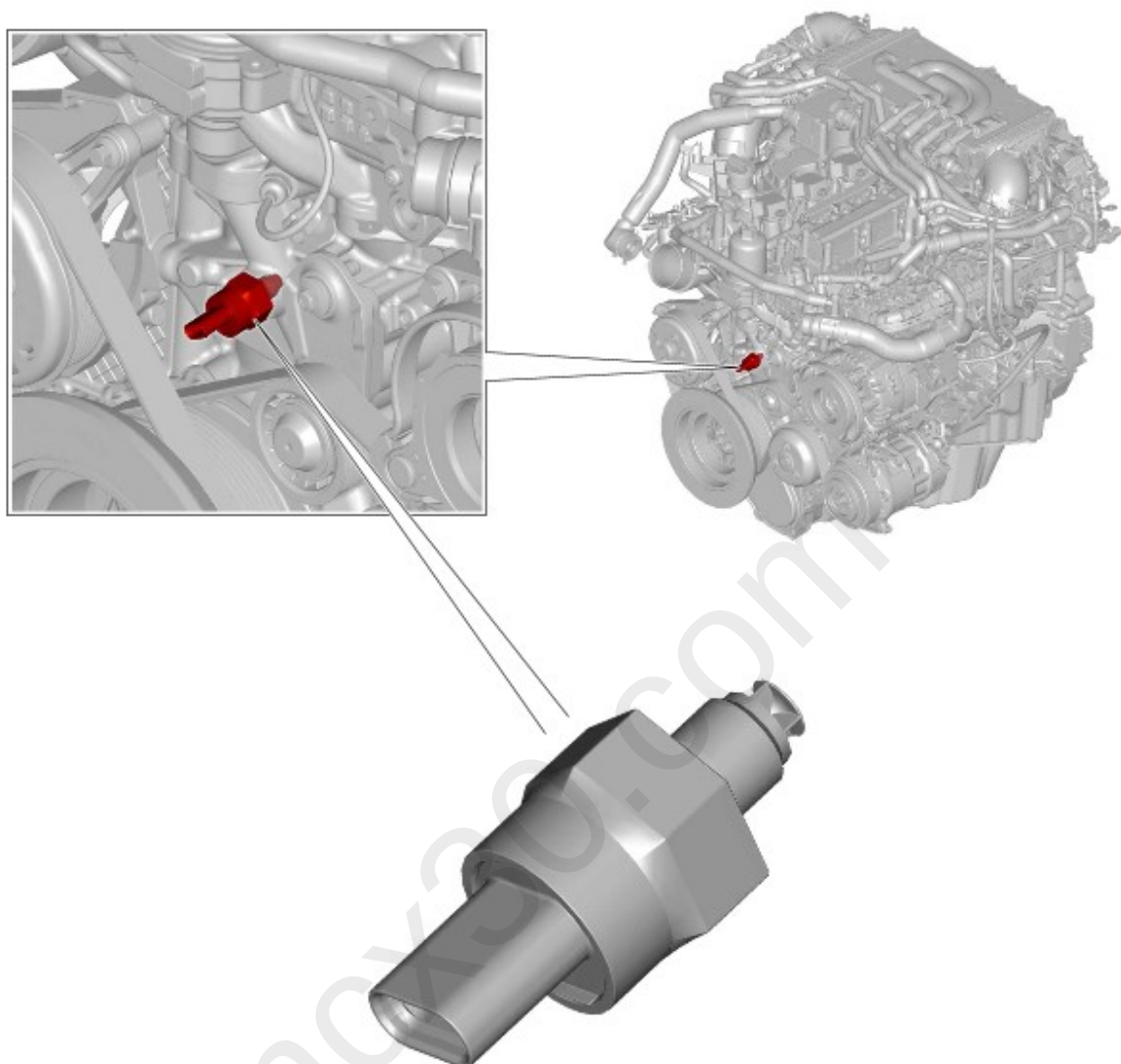


The cylinder block temperature sensor is located in a threaded hole on the left side of the cylinder block.

The sensor is a Negative Temperature Coefficient (NTC) resistor with a 2-pin connection.

For additional information, refer to: [Electronic Engine Controls](#) (303-14B Electronic Engine Controls - INGENIUM I6 3.0 L Petrol, Description and Operation).

OIL PRESSURE AND TEMPERATURE SENSOR



E238410

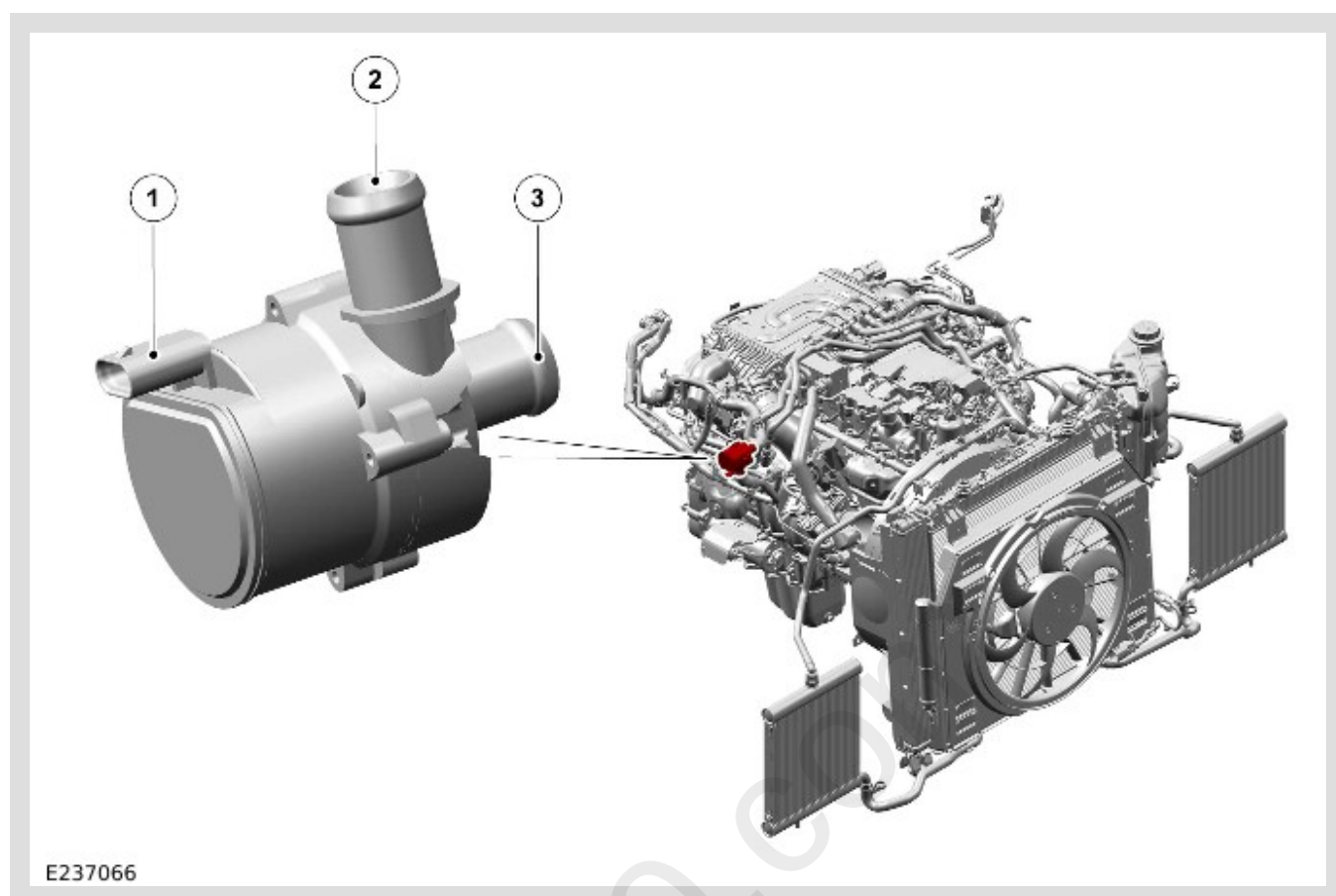
The oil pressure and temperature sensor is located at the front of the cylinder block. The sensor is located in a threaded hole in the cylinder block.

The oil pressure and temperature sensor has a 3-pin connector.

The sensor provides a Pulse Width Modulation (PWM) signal that contains information about the self-diagnosis of the sensor, pressure and temperature.

For additional information, refer to: [Electronic Engine Controls](#) (303-14B Electronic Engine Controls - INGENIUM I6 3.0 L Petrol, Description and Operation).

AUXILIARY COOLANT PUMP



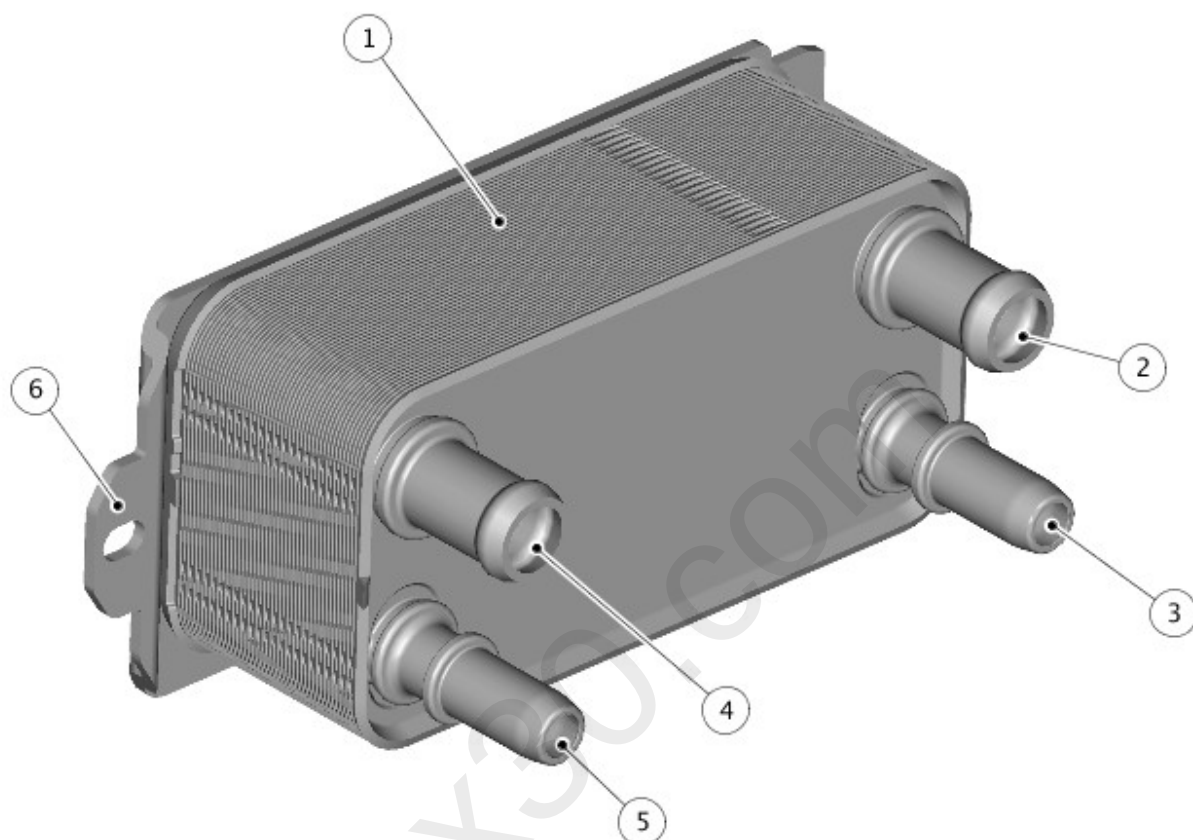
ITEM	DESCRIPTION
1	Electrical connector - Powertrain Control Module (PCM)
2	Hose connection - Engine coolant inlet
3	Hose connection - Engine coolant outlet

The auxiliary coolant pump is an electric pump attached in a bracket, in the right side of the engine compartment. When the engine is turned off, the auxiliary coolant pump provides engine coolant flow to prevent engine coolant boiling in the turbocharger. The auxiliary coolant pump also pumps the engine coolant from the cylinder block to the heater core.

The auxiliary coolant pump has power supply from a relay in the Engine Junction Box (EJB).

The Powertrain Control Module (PCM) controls the operation of the auxiliary coolant pump. The PCM controls the auxiliary coolant pump with a Pulse Width Modulation (PWM) signal.

AUTOMATIC TRANSMISSION FLUID COOLER



E208048

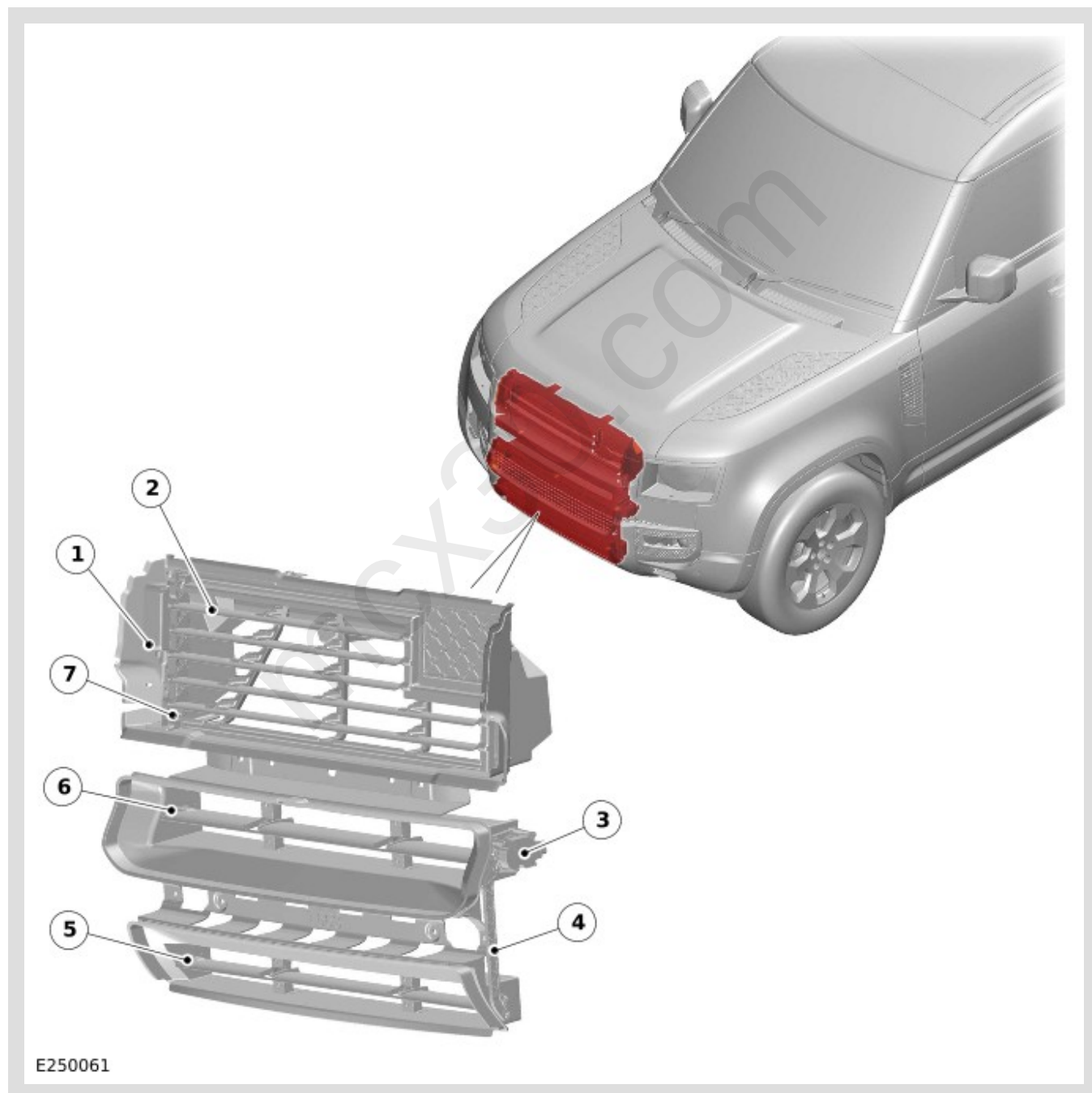
ITEM	DESCRIPTION
1	Automatic Transmission Fluid (ATF) cooler
2	Hose connection - Engine coolant inlet
3	ATF fluid outlet connection
4	Hose connection - Engine coolant outlet
5	ATF fluid inlet connection
6	ATF cooler housing

The Automatic Transmission Fluid (ATF) cooler locates at the front left of the underbody. The ATF cooler is a heat exchanger, comprises louvred fins and plates in an aluminum housing. The plates allow a cross-flow of ATF and engine coolant through the ATF cooler.

The plates are immersed in engine coolant from the ATF warming valve. This provides cooling of the ATF by the temperature differential between the ATF and the engine coolant.

For additional information, refer to: [Transmission Cooling - Vehicles With: 8HP70 8-Speed Automatic Transmission AWD](#) (311-03 Automatic Transmission Cooling, Description and Operation).

ACTIVE GRILLE AIR SHUTTER



ITEM	DESCRIPTION
1	Upper active grille motor

ITEM	DESCRIPTION
2	Upper active grille vane (quantity 5)
3	Lower active grille motor
4	Lower active grille link
5	Lower active grille vane (bottom)
6	Lower active grille vane (center)
7	Upper active grille link

The active grille air shutter is installed behind the front bumper. The active grille air shutter incorporates moveable vanes that control the air flow into the upstream main air duct.

The active grille air shutter has 2 electric motors. The motors have power supply from the Powertrain Control Module (PCM) relay in the Engine Junction Box (EJB). The PCM controls the motors through a Local Interconnect Network (LIN) bus. The vanes are connected through the vane link. When the active grille motor drives the active grille link, all vanes move in unison.

ENGINE COOLANT

The engine coolant is silicate free and must not be mixed with conventional engine coolant.

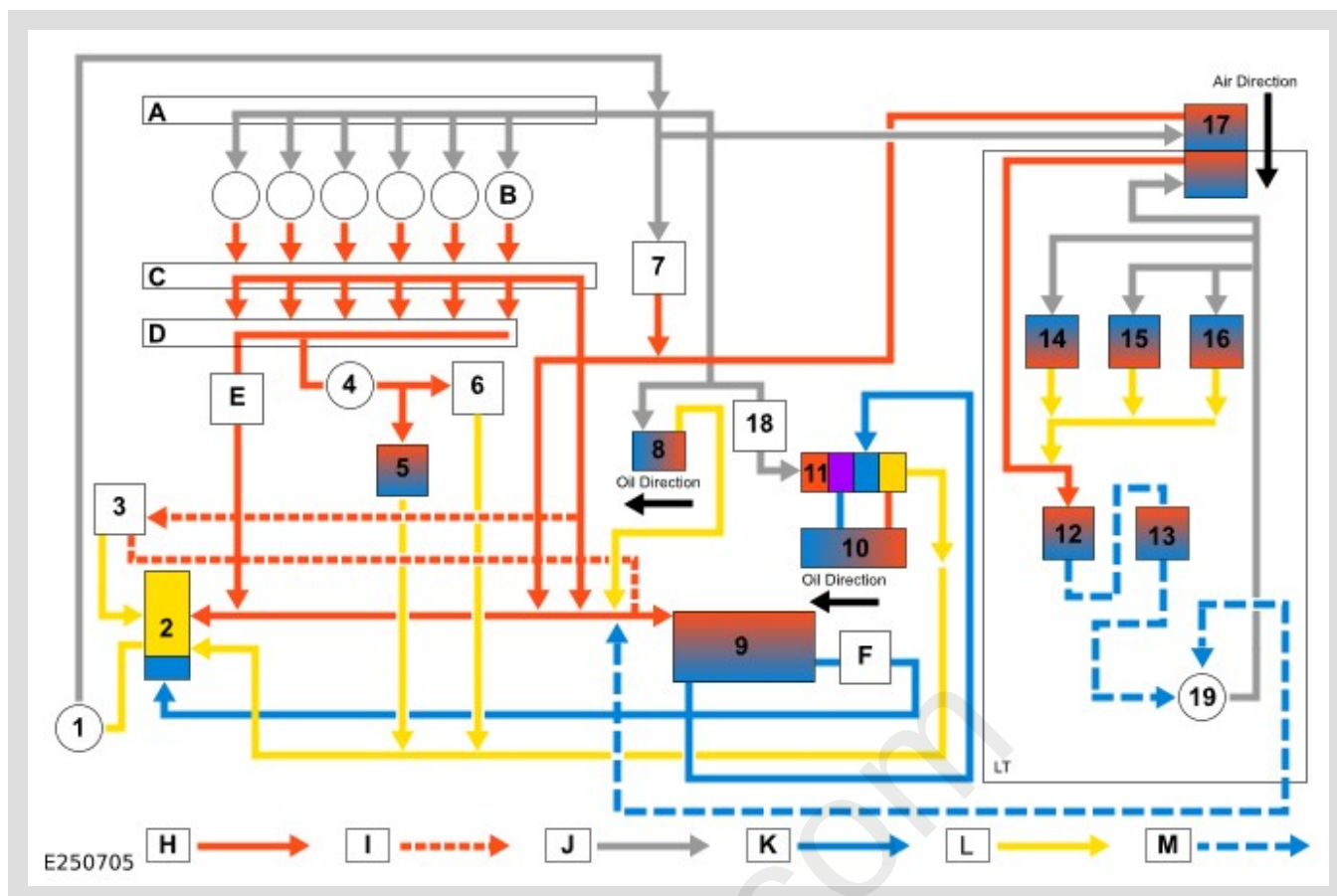
CAUTION:

Cooling system anti-leak products (pellets or fluid) must not be used in Jaguar Land Rover (JLR) coolant circuits.

For additional information, refer to: [Specifications](#) (303-03C Engine Cooling - INGENIUM I6 3.0L Petrol, Specifications).

OPERATION

Engine Coolant Circuit Flow Diagram



H = HOT COOLANT: I = HOT COOLANT BLEED ROUTE: J = HIGH PRESSURE COOLANT FROM PUMP: K = LOW PRESSURE COLD COOLANT RETURN TO PUMP: L = HOT COOLANT RETURN: M = LOW PRESSURE COLD COOLANT RETURN AND BLEED ROUTE.

ITEM	DESCRIPTION
A	Cylinder head inlet rail
B	Cylinder 1 at the front of the engine
C	Cylinder head outlet rail
D	Cylinder block outlet
E	Engine Coolant Temperature (ECT) sensor - Cylinder block outlet
F	Radiator outlet temperature sensor
1	Variable coolant pump
2	Electric thermostat
3	Coolant expansion tank
4	Auxiliary coolant pump
5	Heater core
6	Turbocharger
7	Electric throttle

ITEM	DESCRIPTION
8	Engine oil cooler
9	Radiator
10	Automatic Transmission Fluid (ATF) cooler
11	ATF warming valve
12	Right charge air radiator
13	Left charge air radiator
14	Powertrain Control Module (PCM)
15	Electric supercharger
16	Electric supercharger bypass valve
17	Charge air cooler
18	ATF cooler thermostatic valve
19	Charge air cooler coolant pump

When the engine is running, the variable coolant pump circulates the engine coolant through the engine cooling system.

At engine start up, the shroud of the variable coolant pump is partially shrouded. The variable coolant pump limits coolant flow in the engine cooling system. When required, the HVAC control module (HVAC) can request the variable coolant pump shroud to open to provide additional flow of the engine coolant.

When the engine coolant is cold, the electric thermostat is closed. This forces coolant through the bypass route back to the variable coolant pump.

When the engine coolant reaches operating temperature, the electric thermostat begins to open. The engine coolant flows through both the bypass route and radiator system to provide the required engine cooling.

When the electric thermostat is fully open, the majority of the engine coolant is directed through the radiator and the Automatic Transmission Fluid (ATF) cooler.

Expansion and contraction of the engine coolant is accommodated by an air space in the coolant expansion tank and the compliance of the flexible hoses.

ELECTRIC THERMOSTAT

Operation of the electric thermostat heater element is controlled by the Powertrain Control Module (PCM) upon the following inputs:

- Engine torque
- Engine speed

- Vehicle speed
- Engine Coolant Temperature (ECT)
- Cylinder block temperature
- Radiator outlet temperature
- Ambient Air Temperature (AAT)
- Intake air mass flow
- Terrain Response mode selection.

The electric thermostat receives voltage from the Engine Junction Box (EJB). The PCM relay controls the voltage. The electric thermostat is also provided with a hardwired connection to the PCM and a ground connection. When the PCM regulates the temperature of the coolant system, the PCM supplies a ground path for the heater element in the electric thermostat. This causes the wax element to expand and increase the stroke of the main valve, opening the radiator flow route.

The electric thermostat opening strategy

TEMPERATURE	POSITION
Below 101°C (213°F)	The electric thermostat is closed
Between 101°C (213°F) and 111°C (234°F)	The electric thermostat starts to open
Above 111°C (234°F)	The electric thermostat is fully open

ENGINE COOLANT LEVEL SENSOR

When the coolant level in the coolant expansion tank is sufficient, the magnetic float is in the top position. In this position the magnetic field closes the switch contacts in the coolant level sensor. When the coolant level drops significantly below the MIN cold fill coolant level, the magnetic float descends, thus the switch contacts disconnected. The open circuit is sensed by the BCM/ GWM, which sends a signal to the Instrument Panel Cluster (IPC) to display the "Coolant Level Low" warning message. The message is sent on the High Speed (HS) Controller Area Network (CAN) Human Machine Interface (HMI) systems bus.

For additional information, refer to: [Message Center](#) (413-08 Message Center, Description and Operation).

ELECTRIC COOLING FAN

The Powertrain Control Module (PCM) receive signals from the engine coolant temperature sensor and the HVAC control module (HVAC). Then the PCM determines when to operate the electric cooling fan. The PCM also adjusts the electric cooling fan demand to compensate for the ram effect of vehicle speed.

The PCM varies the duty cycle of the Pulse Width Modulation (PWM) signal to the engine cooling fan control module between 0 and 100%. The logic from PCM operates the electric cooling fan motor in 1 of 4 modes:

- Off.
- Minimum speed.

- Linear variable speed between minimum and maximum speeds.
- Maximum speed.

In hot operating conditions, the electric cooling fan may continue to operate for up to 5 minutes after the engine has been switched off.

The electric cooling fan control module monitors for over and under input voltage, a stalled motor and a partially stalled motor. In case of any faults detected, the electric cooling fan control module temporarily connects the PWM signal to ground. The length of time the PWM signal connected to ground varies between 2 and 8 seconds, depending on the fault. The electric cooling fan control module repeats the notification process at 5 second intervals until the fault is cleared. When there is more than 1 fault, only the highest priority fault is notified to the PCM.

The fault priorities in descending order are the following:

- Over voltage
- Under voltage
- Stalled motor
- Partially stalled motor.

The PCM records a related Diagnostic Trouble Code (DTC) for faults notified by the engine cooling fan control module. The PCM signals the BCM through the Flexray. The BCM/GWM transmits the signal to the Instrument Panel Cluster (IPC) to display a warning message.

The signal goes through the HS CAN Human Machine Interface (HMI) systems bus.

The nominal operating voltage for the electric cooling fan is from 9V to 16V. When the input voltage is outside of the limits, the engine cooling fan control module stops operation of the electric cooling fan. In addition the electric cooling fan control module notifies the PCM of the fault. The electric cooling fan operation resumes when the input voltage increases to 9.5V, or decreases to 15.5V, respectively.

The electric cooling fan control module checks the electric cooling fan motor speed in each 2 seconds after the fan is energized. If the speed is 0, the electric cooling fan control module determines the electric cooling fan motor is stalled and tries a restart. For a restart, the engine cooling fan control module disconnects the power from the electric cooling fan motor. Then the engine cooling fan control module immediately reconnects the power at an increased current level.

The electric cooling fan control module tries up to 6 restarts of a stalled motor, increasing the output current each time. If the electric cooling fan motor remains stalled after the sixth restart, the electric cooling fan control module waits 40 seconds. Afterwards the electric cooling fan control module notifies the PCM of the fault and begins the start process again.

The electric cooling fan control module incorporates 2 temperature sensors. Sensor 1 is used to calculate the temperature of the micro-controller. Sensor 2 is used to compensate for the self-heating of the inductor. Sensor 2 aims to reduce the power if the temperature is too high and to stop the motor in case of an over-temperature condition.

The system behaves according the following table depending on the sensor's temperature measurements.

Sensor 1 Temperature Thresholds

THRESHOLDS	VALUE
TH1	120°C (248°F)
TH2	145°C (293°F)

Sensor 2 Temperature Thresholds

THRESHOLDS	VALUE
TH1	135°C (275°F)
TH2	145°C (293°F)

If the temperature goes above TH2, the system stops the motor immediately. After a delay of 120 seconds the diagnostic feedback is sent back. The fan is switched on again if the temperature goes below TH1.

When a fault occurs with the ignition signal or the PWM signal, these are the electric cooling fan speeds set by the electric cooling fan module:

SIGNAL	FAULT	FAN SPEED	
		IGNITION ON	IGNITION OFF
Pulse Width Modulation (PWM)	Duty cycle implausible	Maximum	OFF
PWM	Frequency out of range	Maximum	OFF
PWM	Open circuit	Maximum	OFF
PWM	Short circuit to battery	Maximum (provided cooling fan is not damaged)	OFF
PWM	Short circuit to ground	Maximum (provided cooling fan is not damaged)	OFF
Ignition	Open circuit	OFF	OFF
Ignition	Short circuit to battery	According to PWM duty cycle	Maximum
Ignition	Short circuit to ground	OFF (Powertrain Control Module (PCM) relay fuse may blow)	OFF

VISCOUS COOLING FAN

To control the viscous cooling fan, the PCM sends a Pulse Width Modulation (PWM) signal to the Viscous Cooling Fan Control Module (VCFCM). The PCM varies the duty cycle of the PWM signal between 0 and 100% to vary the clutch engagement and thus fan speed.

If the PWM signal is outside the 0 to 100% range,

- The VCFCM interprets the signal as an open or short circuit
- And runs the fan at minimum speed to make sure the fan does not overspeed.

If the electrical connections to the viscous fan are disconnected the fan is idle and the engine may overheat. The PCM records a related Diagnostic Trouble Code (DTC) for faults notified by the VCFCM and signals the BCM through the FlexRay bus. The BCM/GWM transmits the signal to the Instrument Panel Cluster (IPC) to display a warning message.

The signal goes through the HS CAN Human Machine Interface (HMI) systems bus.

ACTIVE GRILLE AIR SHUTTER

Normal driving operation

The Powertrain Control Module (PCM) determines the active grille vane position from the thermal condition of the vehicle, which is an output of the fan control logic.

The vane position depends on the following:

- The engine coolant temperature
- The Air Conditioning (A/C) demand
- The ambient air temperature
- The fuel temperature
- The Terrain Response mode selection.

If vehicle speed reaches 180 km/h (112 mph) the vanes move to the fully open position. The vanes resume a calculated opening position when vehicle speed decreases to 140 km/h (87 mph).

If the electric cooling fan continues to operate after the engine stop (after-run), the vanes remain open. When the electric cooling fan stops, the vanes close and the motor sends a signal to the PCM indicating that it is ready to power down.

Calibration mode

When the PCM shuts down, the active grille vane motor loses its memory. Therefore a calibration is required, when the ignition is switched ON. Except if the PCM has remained active between ignition OFF and ignition ON, for example electric cooling fan after-run.

Calibration only commences after the engine has started.

The calibration process opens and closes the vanes to find the end stops and range of motion between them. This range of movement is checked and if the range is within the specified limits, the cycle is passed. This cycle can take up to 16 seconds.

The calibration cycle is a total of 6 open/close attempts. If the first attempt fails, as soon as a position demand exceeds 45%, the software completes the 5 remaining attempts. These continue 1 after the other, until they either pass a calibration or fail all 6 attempts.

A 'Calibration Failed Fault' Diagnostic Trouble Code (DTC) is only be stored if the calibration fails from the first attempt and all attempts are completed. The vanes are to be commanded to open as much as possible. If the first calibration passes, then a 'Calibration Failed Fault' DTC cannot be set until the next drive.

**NOTE:**

The active grille air shutter vane motor is very sensitive to voltage drops from engine cranking and may trigger a further calibration.

Jet Wash Mode

Jet wash mode allows the motor to fully open the vanes and then power down so that the radiator can be cleaned.

To activate jet wash mode:

- Start and run the engine.
- Stop the engine and set the ignition OFF.
- Set the ignition to ON.
- Select Terrain Response (TR) sand mode.
- Set the ignition to OFF.

This sequence prevents to enter jet wash mode accidentally when the ignition is switched OFF in sand mode.

The vanes are default to be fully open even the calibration is completed or not. (See calibration mode section above)

When the position feedback shows that the vanes are fully open, the motor indicates to the PCM that it is ready to power down.

Diagnostics

If there is a fault with the active grille air shutter, the 'Engine Over Temperature' warning is displayed in the Instrument Panel Cluster (IPC). For each fault, a flag is set and after a calibrated de-bounce time, a DTC is stored in the PCM.

The following faults can be detected:

- Mechanical blockage fault - Motor encounters too much resistance and stalls. Max torque = 0.7 - 0.8 Nm (6.2 - 7 lbin). If blocked, the motor try to re-calibrate up to maximum number of attempts as described in the calibration section.
- Calibration failed fault - Fault stored if all calibration attempts have failed in that drive cycle.
- Electrical fault - Motor reports an internal electrical fault.
- Supply voltage fault - Motor supply voltage falls outside the range 7.5V - 17.5V.

- Thermal shutdown fault - Motor circuits exceed their inbuilt temperature threshold.
- Disconnect fault - Linkage between the motor and the vanes becomes disconnected.
- Local Interconnect Network (LIN) bus communication fault and Node detection fault
 - A fault with the active grille vane motor, its signal wire or its supply that causes a breakdown in signals to the PCM.

If the motor is still operational and only the signal wire has a short circuit/open circuit:

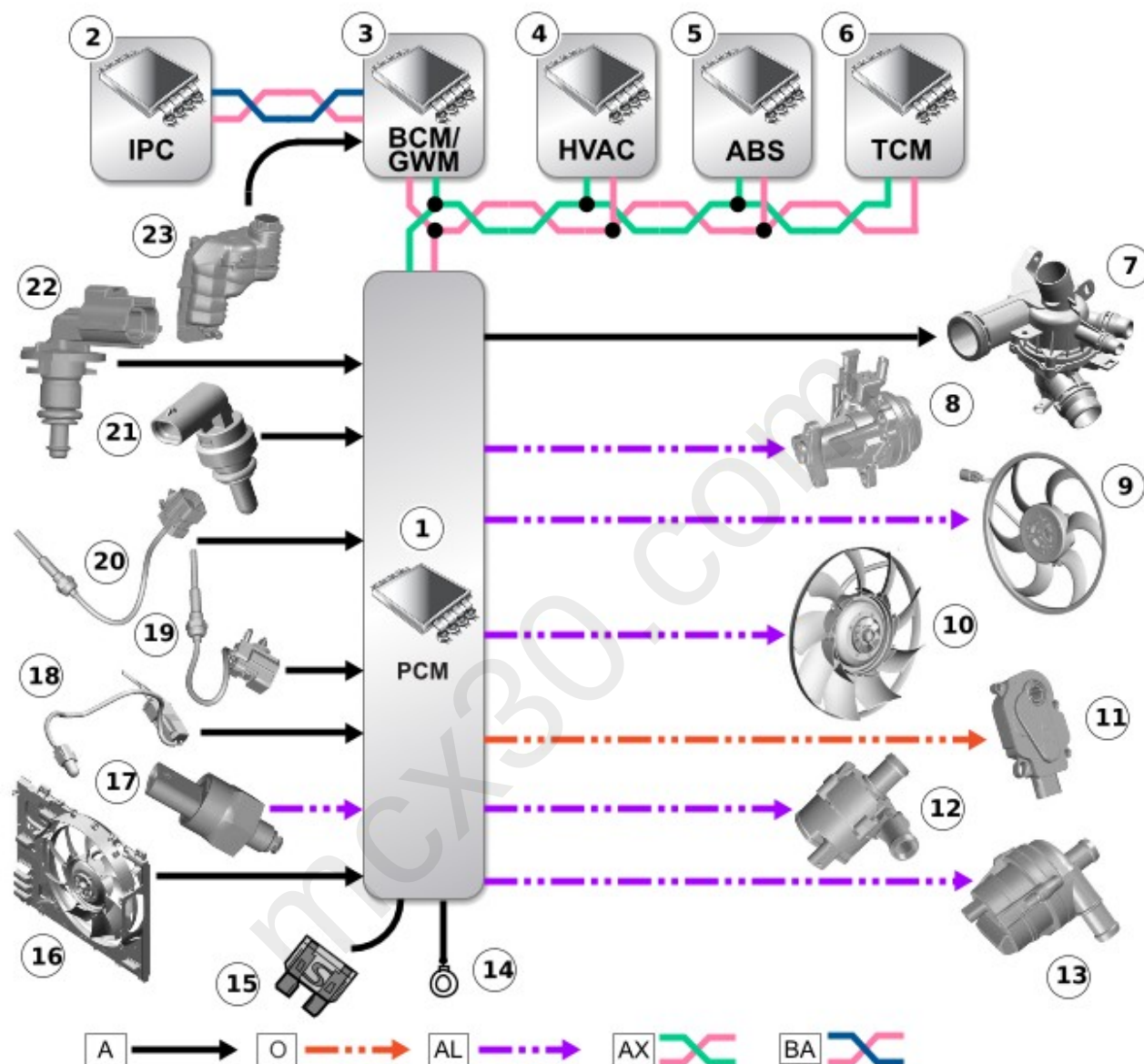
- After 10 seconds of not receiving a signal, the active grille vane motor turns the vanes fully open.

DIAGNOSTICS

The Powertrain Control Module (PCM) records any Diagnostic Trouble Codes (DTCs) and related data. The DTCs and related data are read using the Jaguar Land Rover (JLR) approved diagnostic equipment. The JLR approved diagnostic equipment reads live data and activates certain components.

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CONTROL DIAGRAM



E250062

A = HARDWIRED: O = LOCAL INTERCONNECT NETWORK (LIN): AL = PULSE WIDTH MODULATION (PWM): AX = FLEXRAY: BA = HIGH SPEED (HS) CONTROLLER AREA NETWORK (CAN) HUMAN MACHINE INTERFACE (HMI) SYSTEMS BUS.

ITEM	DESCRIPTION
1	Powertrain Control Module (PCM)
2	Instrument Panel Cluster (IPC)
3	Body Control Module/Gateway Module (BCM/GWM)

ITEM	DESCRIPTION
4	HVAC control module (HVAC)
5	Anti-lock Brake System (ABS) control module
6	Transmission Control Module (TCM)
7	Electric thermostat
8	Variable coolant pump
9	Electric cooling fan
10	Viscous cooling fan
11	Active grille motor
12	Auxiliary coolant pump
13	Charge air coolant pump
14	Ground
15	Power supply
16	Viscous cooling fan speed signal
17	Engine oil pressure and temperature sensor
18	Ambient Air Temperature (AAT) sensor
19	Cylinder block temperature sensor
20	Cylinder head temperature sensor
21	Engine Coolant Temperature (ECT) sensor
22	Radiator outlet temperature sensor
23	Engine coolant level sensor