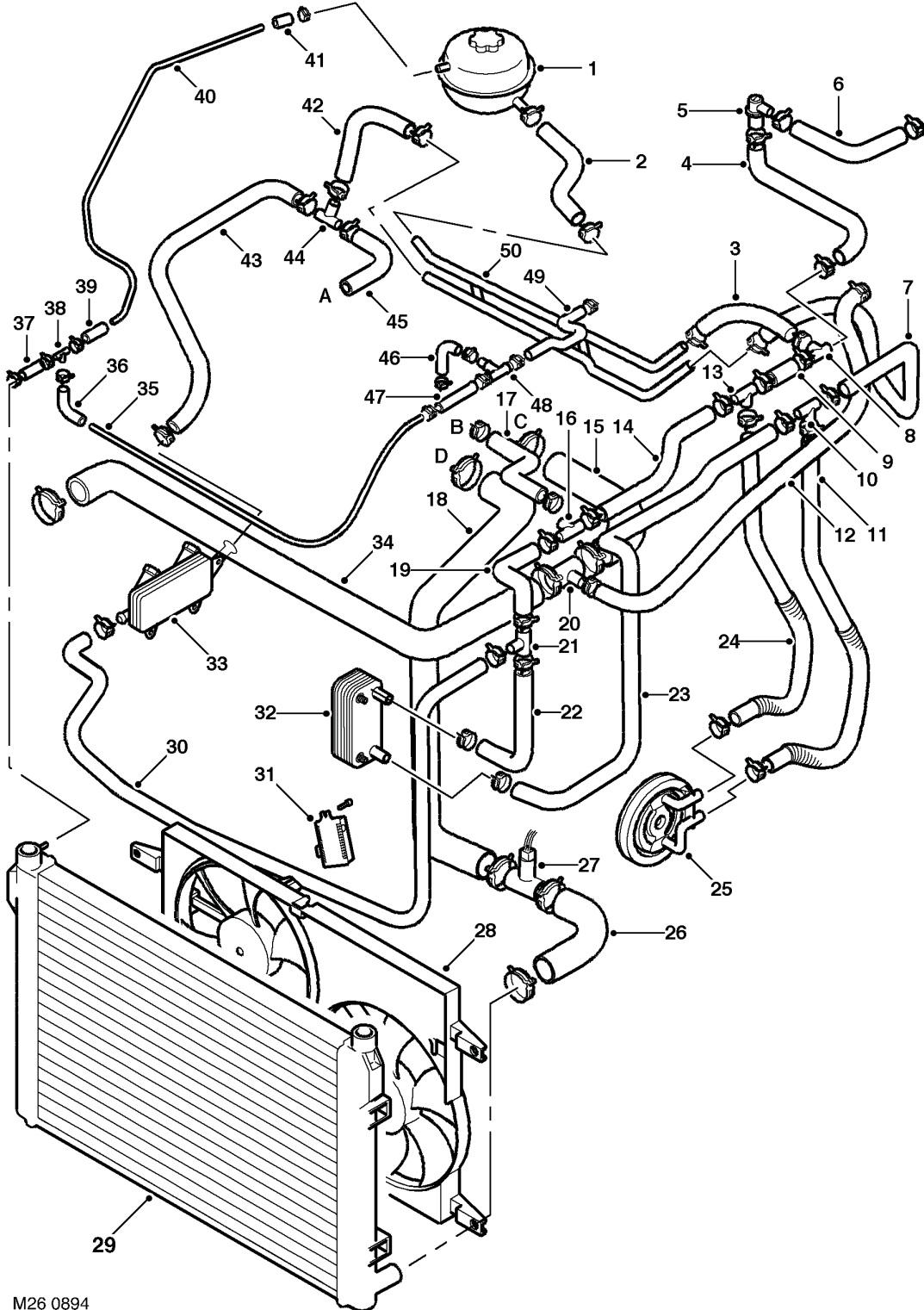


COOLING SYSTEM - K SERIES KV6

Cooling System Component Layout - Sheet 1 of 2



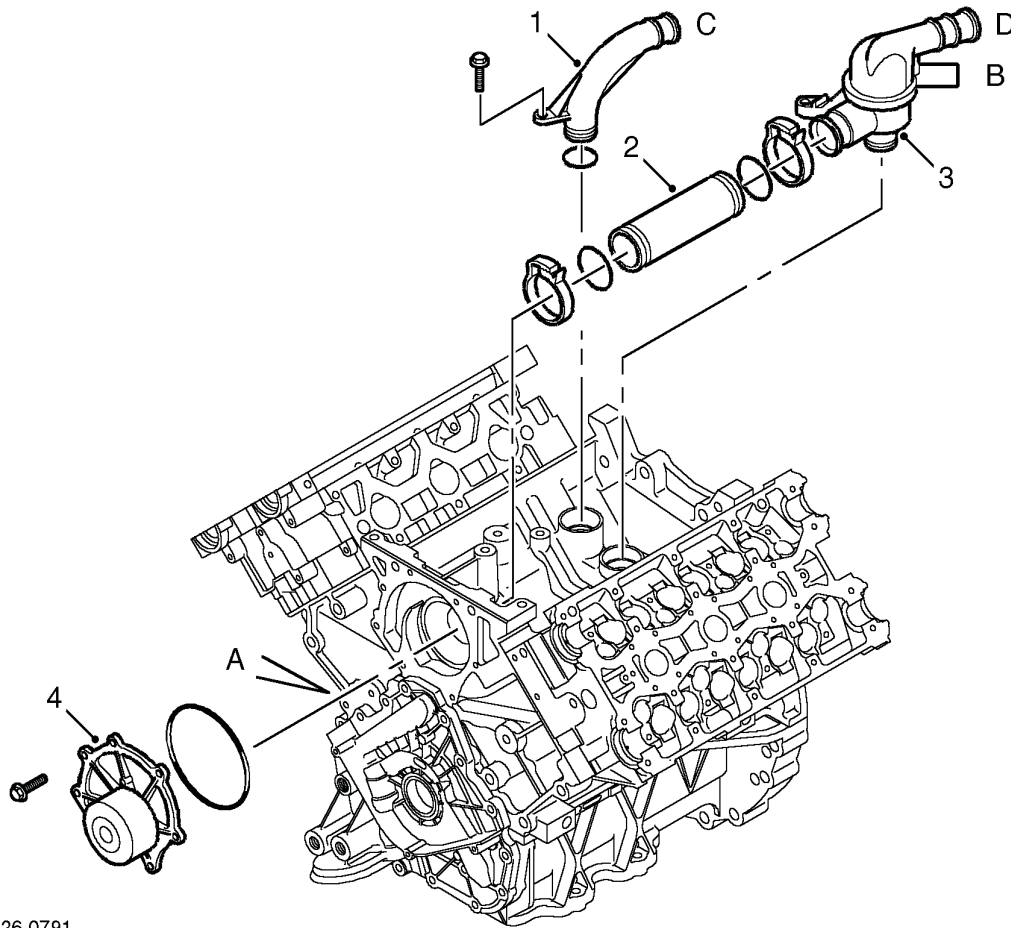
M26 0894



- 1 Expansion tank
- 2 Expansion tank return hose
- 3 Coolant rail to heater matrix return hose
- 4 Heater matrix return hose
- 5 Bleed screw elbow
- 6 Heater matrix return hose
- 7 Coolant rail to IRD cooler supply hose
- 8 Heater matrix return 'T' connector
- 9 Heater matrix return hose
- 10 IRD cooler supply 'T' connector
- 11 IRD cooler supply hose
- 12 Heater matrix supply hose
- 13 Heater matrix return 'T' connector
- 14 Heater matrix return hose
- 15 Engine to 'T' connector top hose
- 16 Heater matrix return 'T' connector (Up to 2003 Model Year) or Heater Diverter Valve (From 2003 Model Year)
- 17 Thermostat housing bypass hose
- 18 Sensor housing to engine bottom hose
- 19 Fluid cooler return hose
- 20 Top hose 'T' connector
- 21 Fluid cooler return 'T' connector
- 22 Transmission fluid cooler return hose
- 23 Transmission fluid cooler supply hose
- 24 IRD cooler return hose
- 25 IRD cooler
- 26 Radiator to sensor housing bottom hose
- 27 Thermostat monitoring sensor housing
- 28 Cooling fans
- 29 Radiator
- 30 Engine oil cooler return hose
- 31 Cooling fan ECU
- 32 Transmission fluid cooler
- 33 Engine oil cooler
- 34 'T' connector to radiator top hose
- 35 Inlet manifolds expansion pipe
- 36 Expansion pipe connector hose
- 37 Radiator expansion hose
- 38 Expansion pipe 'T' connector
- 39 Expansion pipe connector hose
- 40 Radiator and inlet manifolds expansion pipe
- 41 Expansion pipe connector hose
- 42 Cylinder block outlet to coolant rail hose
- 43 Engine oil cooler supply hose
- 44 Cylinder block outlet 'T' connector
- 45 Cylinder block outlet hose
- 46 LH inlet manifold expansion hose
- 47 Expansion pipe connector hose
- 48 Expansion pipe 'T' connector
- 49 RH inlet manifold expansion hose
- 50 Coolant rail

COOLING SYSTEM - K SERIES KV6

Cooling System Component Layout - Sheet 2 of 2



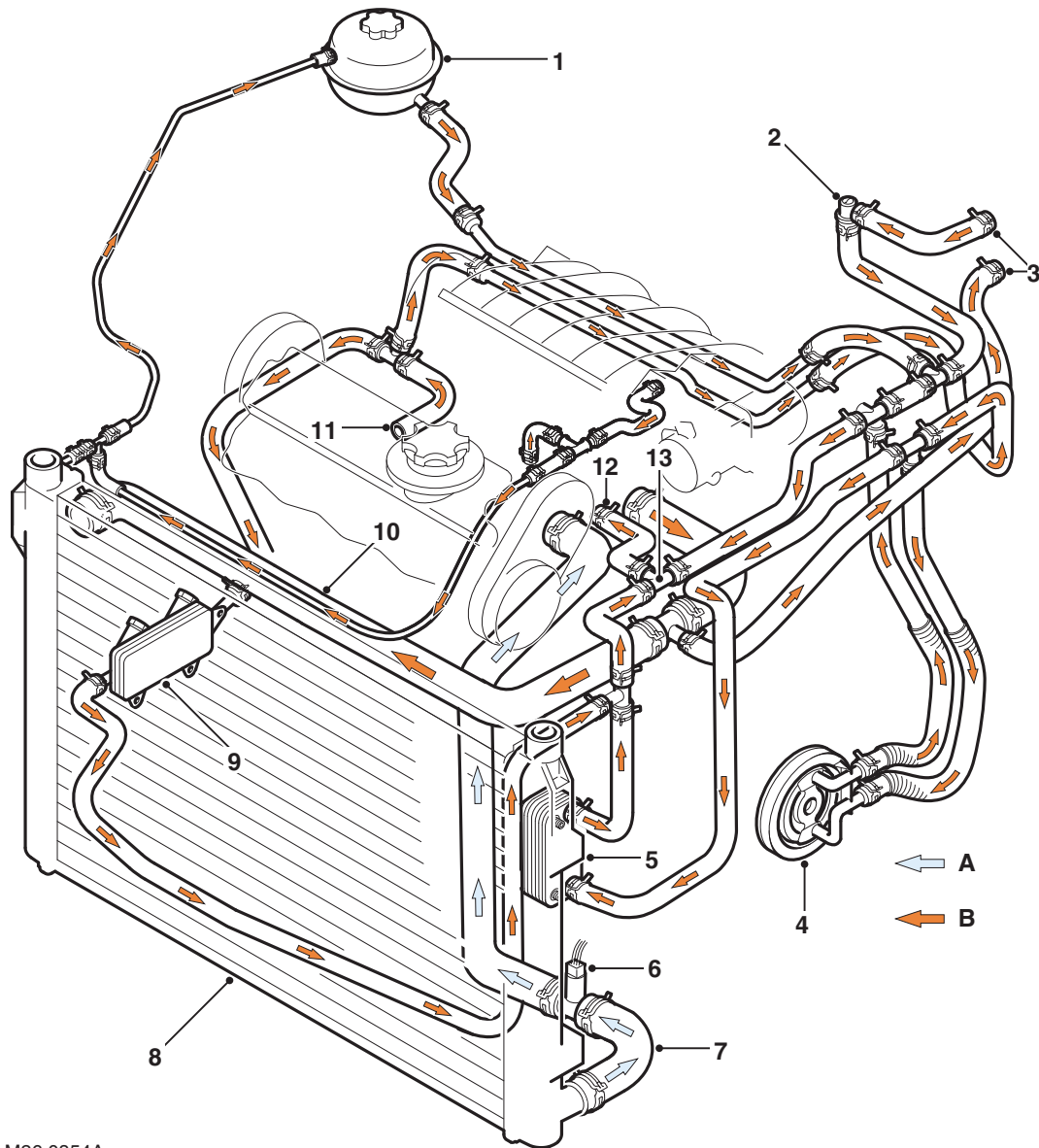
For connections A to D, see sheet 1

- 1 Outlet elbow
- 2 Pipe - thermostat to pump

- 3 Thermostat housing assembly
- 4 Coolant pump



Cooling System Coolant Flow



M26 0854A

A = Cold; B = Hot

- | | |
|---|---|
| 1 Expansion tank | 8 Radiator |
| 2 Bleed screw | 9 Engine oil cooler |
| 3 Heater matrix connections | 10 Top hose |
| 4 IRD cooler | 11 Cylinder block outlet connection |
| 5 Transmission fluid cooler | 12 Thermostat bypass connection |
| 6 Thermostat monitoring sensor (NAS only) | 13 Heater diverter valve (From 2003 Model Year) |
| 7 Bottom hose | |

COOLING SYSTEM - K SERIES KV6

Description

General

The engine cooling system maintains the engine within the optimum operating temperature range under varying ambient temperature and engine load conditions. In addition, the system cools the engine oil, the Intermediate Reduction Drive (IRD) and the transmission fluid, and provides the heat source for passenger compartment heating. The system consists of:

- A coolant pump.
- A radiator.
- A Pressure Relief Thermostat (PRT).
- An expansion tank.
- Interconnecting hoses and coolant rail.
- Two cooling fans
- Heater diverter valve (From 2003 Model Year)

Engine oil and transmission fluid are cooled by plate type heat exchangers. The engine oil cooler is attached to the sump at the front of the engine. The transmission oil cooler is attached to the front of the gearbox. The IRD is cooled by an internal plate type heat exchanger incorporated into the IRD lubrication circuit.

Coolant Pump

The rotor type coolant pump is integrated into the front of the engine, between the cylinder blocks. The pump is driven by the camshaft timing belt via a plain pulley installed on the pump rotor shaft. The pulley also acts as an idler pulley for the camshaft timing belt.

Radiator

The radiator is a cross flow type with an aluminium matrix and moulded plastic end tanks. The bottom of the radiator is located in rubber bushes on the front lower crossmember. The top of the radiator is secured to the bonnet locking platform by threaded retainers. The top hose connects the radiator to a coolant outlet elbow in the cylinder block. The bottom hose connects the radiator to the thermostat housing.

Pressure Relief Thermostat (PRT)

The PRT is installed in a housing located in a coolant outlet port in the cylinder block, between the cylinder banks. The thermostat housing incorporates inlet connections for the bottom hose and the return hose from the IRD cooler/heater/ transmission cooler. A pipe connects the outlet side of the thermostat housing to the coolant pump inlet.

The thermostat is located in the inlet side of the cooling circuit, which provides a more stable control of the coolant temperature in the engine. The housing contains a wax element and a spring loaded by-pass flow valve. The PRT senses all parameters such as engine speed, engine heat input and ambient temperature and reacts according to the actual operating conditions of the engine.

The wax element thermostat is used to maintain the coolant at the optimum temperature for efficient combustion and assist engine warm-up. The thermostat is closed at low coolant temperatures with the flow being controlled by the by-pass valve. When the coolant temperature reaches approximately 88°C (190°F), the thermostat begins to open and is fully open at approximately 102°C (216°F).

**Expansion Tank**

The expansion tank is installed in the rear RH corner of the engine compartment. The expansion tank provides a reservoir of coolant and accommodates the increase in coolant volume produced by heat expansion. A cap on the expansion tank provides a system filling point and incorporates a pressure relief valve that releases pressure from the system if it exceeds 1 bar (14.5 lbf/in²). Expansion pipes connect the expansion tank to the radiator and the inlet manifolds. A hose connects an outlet on the expansion tank to the coolant rail.

Hoses and Coolant Rail

The coolers and the heater matrix are connected together, by hoses and the coolant rail, in a circuit from the outlets at the right front corner of the cylinder block and the top hose to the return hose connection on the thermostat housing. The hoses connected to the IRD cooler are covered by heat shielding to protect them from heat radiated by the exhaust system. A bleed screw in the heater outlet hose enables air to be bled from the system during filling.

Cooling Fans

The two cooling fans are variable speed electric fans installed in a housing attached to the rear of the radiator. The motor of each cooling fan is powered by a supply from a cooling fan ECU installed behind a cover in the top left corner of the cooling fan housing. An air scoop on the cooling fan housing directs cooling air over the ECU.

Heater Diverter Valve – From 2003 Model Year

The heater diverter valve increases the flow of coolant through the heater matrix at low engine speeds to improve the low engine speed heater performance.

The valve comprises a spring loaded valve integrated into the 'T' connector on the thermostat by-pass hose. The construction and operating principles of the valve is similar to that of the pressure relief thermostat (PRT).

COOLING SYSTEM - K SERIES KV6

Operation

General

When the engine is running, the coolant pump draws coolant through the pipe connected to the thermostat housing and pumps it through the outlet at the right front corner of the cylinder block and through the cooling jackets in the cylinder block, cylinder heads and inlet manifolds. From the outlet at the right front corner of the cylinder block, the coolant flows through the hoses and the coolant rail to the IRD cooler, the engine oil cooler and the transmission fluid cooler. From the top of the cylinder block, coolant flows through the outlet elbow and the top hose to the heater matrix. Coolant returning to the thermostat housing, from the cylinder block, the coolers and the heater matrix, bypasses the thermostat and flows back to the coolant pump inlet to begin the cycle again.

Coolant also flows through the expansion pipes to the expansion tank, from where it is drawn back into the system through the expansion tank outlet hose connected to the coolant rail. The increase in coolant volume, created by heat expansion, reduces the air space in the expansion tank, which pressurises the system and raises the boiling point of the coolant.

Coolant flows through the radiator, from the top of the RH end tank to the bottom of the LH end tank, and is cooled by air passing through the radiator. When required, the two cooling fans provide additional air flow through the radiator, particularly when the vehicle is stationary. Operation of the cooling fans is controlled by the ECM via the cooling fan ECU. The temperature of the cooling system is monitored by the ECM using inputs from the thermostat monitoring sensor and the Engine Coolant Temperature (ECT) sensor located in the cylinder block, to the left of the thermostat housing.

 **ENGINE MANAGEMENT SYSTEM - SIEMENS, DESCRIPTION AND OPERATION, Description.**

Pressure Relief Thermostat (PRT)

The thermostat is exposed to 85% hot coolant from the engine on one side and 15% cold coolant returning from the radiator bottom hose on the other side. This allows the thermostat to react to the ambient conditions and provide coolant control for both winter and summer use. Hot coolant from the engine passes via holes in the by-pass flow valve into a tube which surrounds 85% of the thermostat sensitive area. Cold coolant from the radiator conducts through the remaining 15% of the sensitive area. In cold ambient conditions, the engine temperature is raised by approximately 10°C (50°F) to compensate for the heat loss of 15% exposure to the cold coolant returning from the bottom hose. This improves heater performance and engine warm-up.

The by-pass flow valve is held closed by a light spring and operates to further assist engine and heater warm-up. When the main valve is closed and the engine speed is at idle, the coolant pump does not produce sufficient flow and pressure to overcome the spring and open the valve. In this condition the valve prevents coolant circulating through the by-pass circuit and directs coolant through the heater matrix only. This provides a higher flow of coolant through the heater matrix improving passenger comfort in cold conditions.

When the engine speed increases above idle, the coolant pump produces a greater flow and pressure than the heater circuit can accommodate. The build up of pressure acts on the flow valve, overcoming the spring pressure, opening the valve and relieving the pressure in the heater circuit. The valve then modulates to provide maximum coolant flow through the heater matrix and allowing excess coolant to flow into the by-pass circuit to provide the engine's cooling requirements at higher engine speeds. The thermostat then regulates the flow through the radiator to maintain the engine at the optimum temperature. Maximum opening of the thermostat, and therefore maximum flow through the radiator, occurs if the coolant temperature reaches 102°C (216°F).

Operation of the thermostat is monitored by the Engine Control Module (ECM) using an input from the thermostat monitoring sensor in the bottom hose.

**Heater Diverter Valve – From 2003 Model Year**

At low engine speeds the heater diverter valve is closed, allowing only a bleed flow of coolant through the engine oil and transmission fluid coolers. This increases the coolant flow through the heater matrix improving heater performance.

As the engine speed increases, the increased output from the coolant pump opens the heater diverter valve allowing the full flow of coolant through the engine oil and transmission fluid coolers and the heater matrix.

Cooling Fan Control

The ECM controls the operation of the variable speed cooling fans via a Pulse Width Modulated (PWM) signal to the cooling fan ECU. The cooling fan ECU regulates the voltage of a common power feed to the two fans, and relates the voltage to the duty cycle of the PWM signal.

The ECM varies the duty cycle of the PWM signal between 3 and 90% to vary the cooling fan speed. At duty cycles between 3 and 9% the cooling fans are off. When the duty cycle goes above 9% the cooling fans come on at minimum speed, then increase in speed, in proportion to the increase in the duty cycle, up to maximum speed at a duty cycle of 90%. If the duty cycle is less than 3% or more than 90%, the cooling fan ECU interprets the signal as an open or short circuit and runs the cooling fans at maximum speed to ensure the engine and gearbox do not overheat.

The speed of the cooling fans varies between a minimum of 750 rev/min, at 6 volts and a maximum of 4000 rev/min at nominal battery voltage. To reduce the noise from the cooling fans they are driven at slightly different speeds, except when running at minimum and maximum speeds. Stepped speed changes occur at 1500 rev/min (RH cooling fan), 1450 and 2600 rev/min (LH cooling fan) to improve refinement.

Control Inputs

While the engine is running, the ECM adjusts the speed of the cooling fans in response to inputs from:

- The thermostat monitoring sensor, for engine cooling. The fans come on at minimum speed if the coolant temperature goes above 90°C (194°F), and progressively increase to maximum speed at a coolant temperature of 102°C (216°F).
- The A/C system, via the instrument pack and the CAN bus, for refrigerant system cooling.
- The EAT ECU, via the CAN bus, for gearbox cooling.

If there is a conflict between requested cooling fan speeds from the different inputs, the ECM adopts the highest requested speed.

As part of the power down routine, when the ignition is switched off, if the ambient air temperature is more than 15°C (59°F) the ECM samples the coolant temperature using the input from the Engine Coolant Temperature (ECT) sensor. If the coolant temperature is more than 106°C (223°F), the ECM signals for the cooling fans to come on. The speed of the cooling fans is in proportion to the coolant temperature, from minimum speed at >106°C (>223°F) to maximum speed at 115°C (239°F). The cooling fans are switched off after 5 minutes or when the coolant temperature decreases to 106°C (223°F), whichever occurs first.

Motor Protection

The cooling fan ECU monitors the speed of the cooling fans, from the current draw of the motors, and incorporates strategies to protect the motors from electrical overload if the fans are seized or heavily loaded (e.g. by debris or during wading).

When the duty cycle of the PWM signal indicates the cooling fans should be switched on, the cooling fan ECU initially outputs 2.5 volts to the motors to produce a 'soft' start. When the cooling fan ECU detects the motors are running satisfactorily, it then increases the outputs to the appropriate voltages for the required cooling fan speeds. If a motor fails to start within 3 seconds, the cooling fan ECU switches off the output to the affected motor, waits for 5 seconds and then tries another soft start. If the second soft start fails, after a further wait of 5 seconds the cooling fan ECU outputs 6 volts to the motor in an attempt to get it started. If the motor starts, the cooling fan ECU then increases the output to the appropriate voltage for the required cooling fan speed. If the motor fails to start within 4 seconds, the cooling fan ECU switches the output off, then, provided the cooling fans are still requested on, periodically invokes the start routine in an attempt to get the motor running.

If a cooling fan is already running and then seizes or becomes heavily loaded, the cooling fan ECU switches off the output to the affected motor, then periodically invokes the start routine, while the cooling fans are still requested on, in an attempt to get the motor running again.

When one of the cooling fans is not running, the cooling fan ECU runs the other cooling fan at maximum speed.