Workshop Manual

System Description & Operation

Freelander

FREELANDER 2001 TO 2004 MY ONWARDS

WORKSHOP MANUAL - SYSTEM DESCRIPTION AND OPERATION

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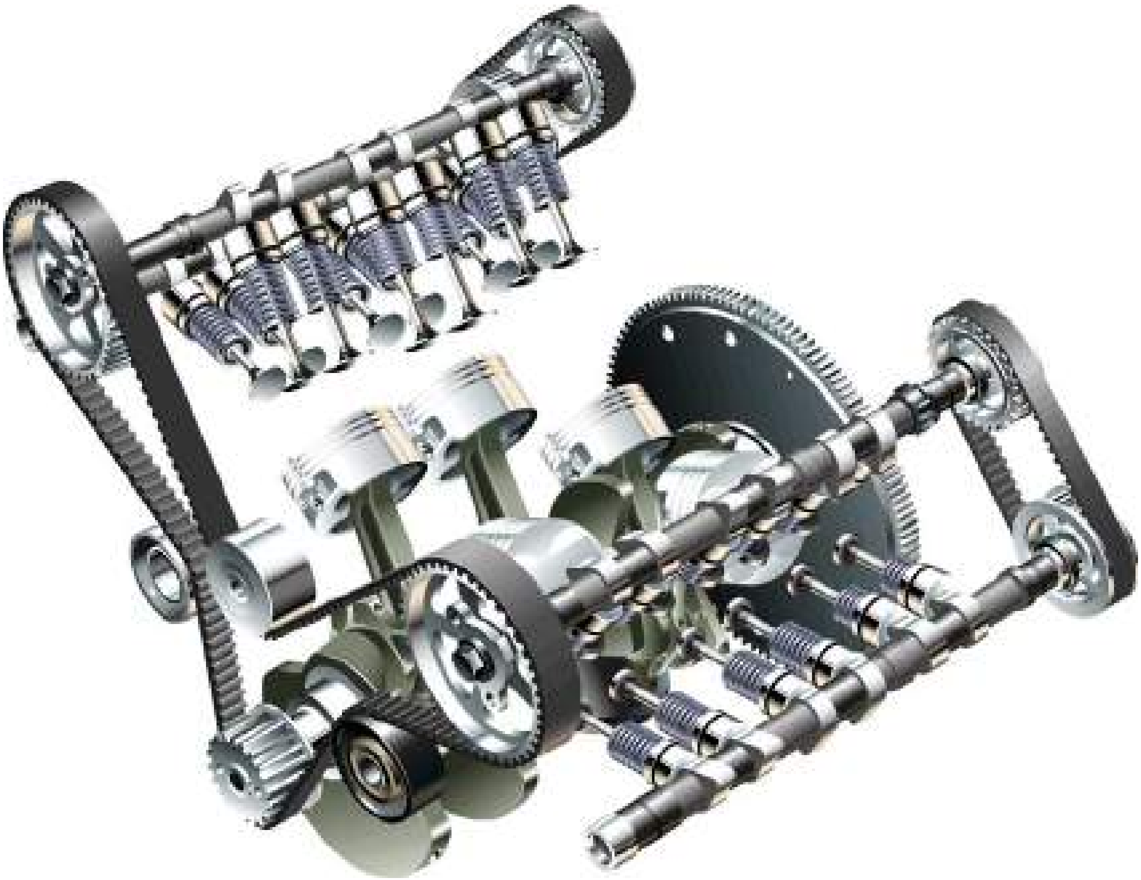
KV6 Engine – General View

M12 7452

KV6 Engine – Internal View



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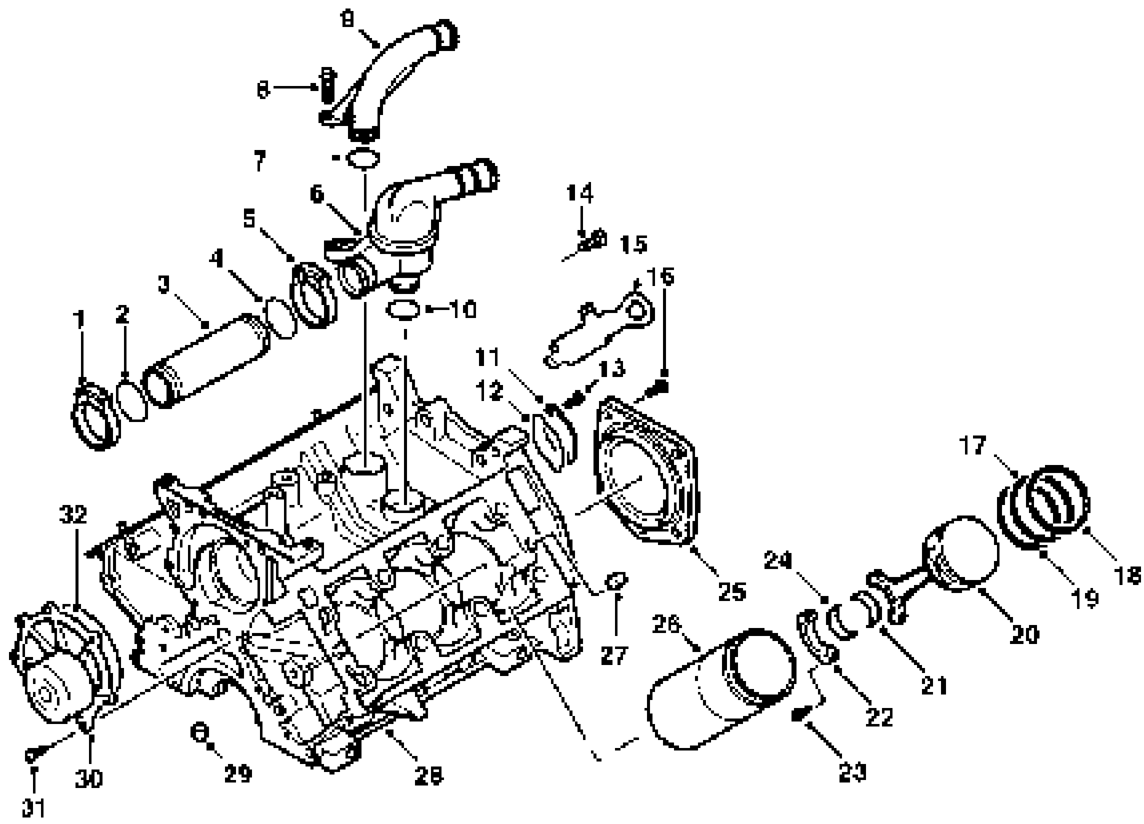
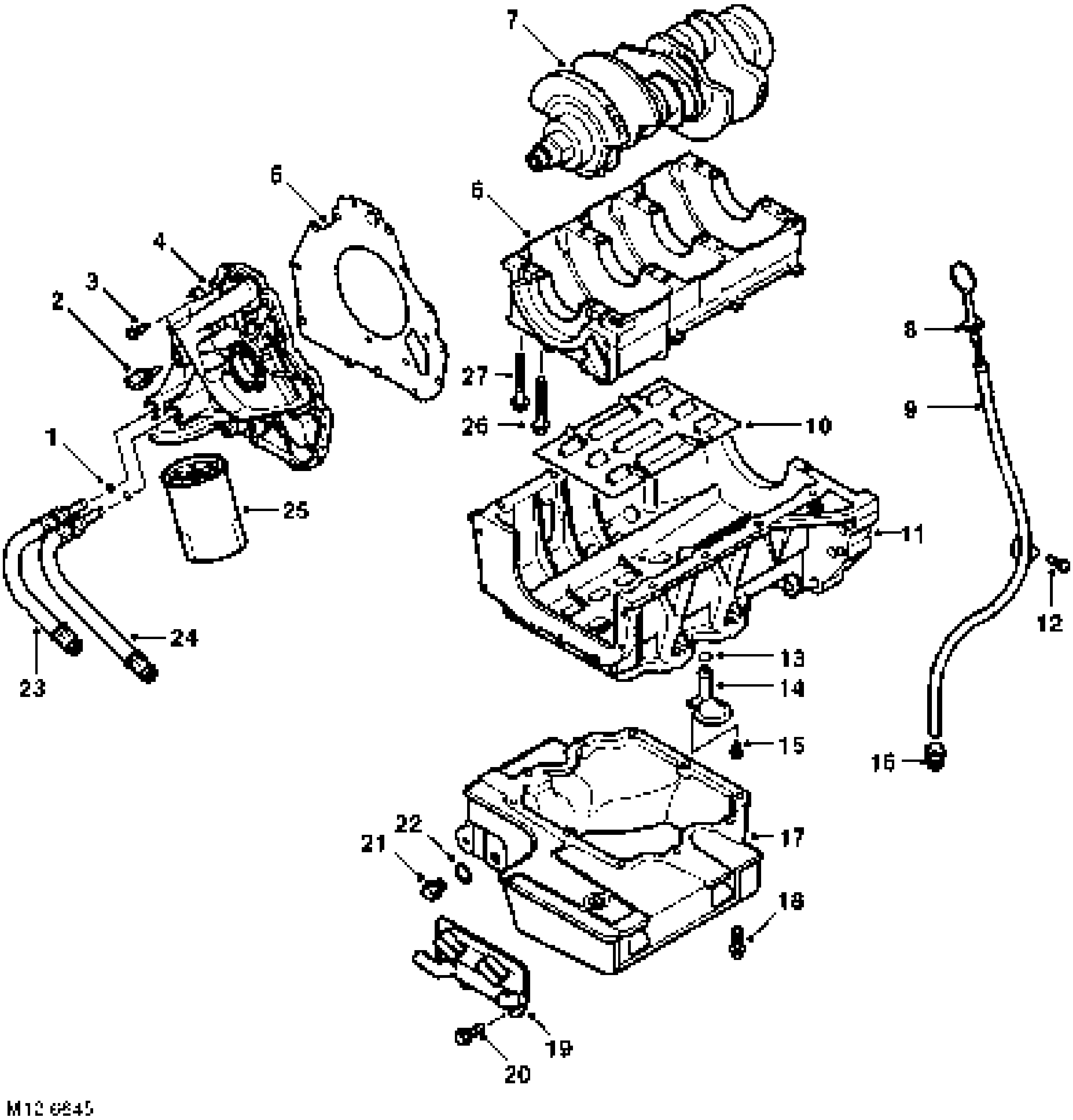
KV6 Engine – Cylinder Block Components



M12 6644

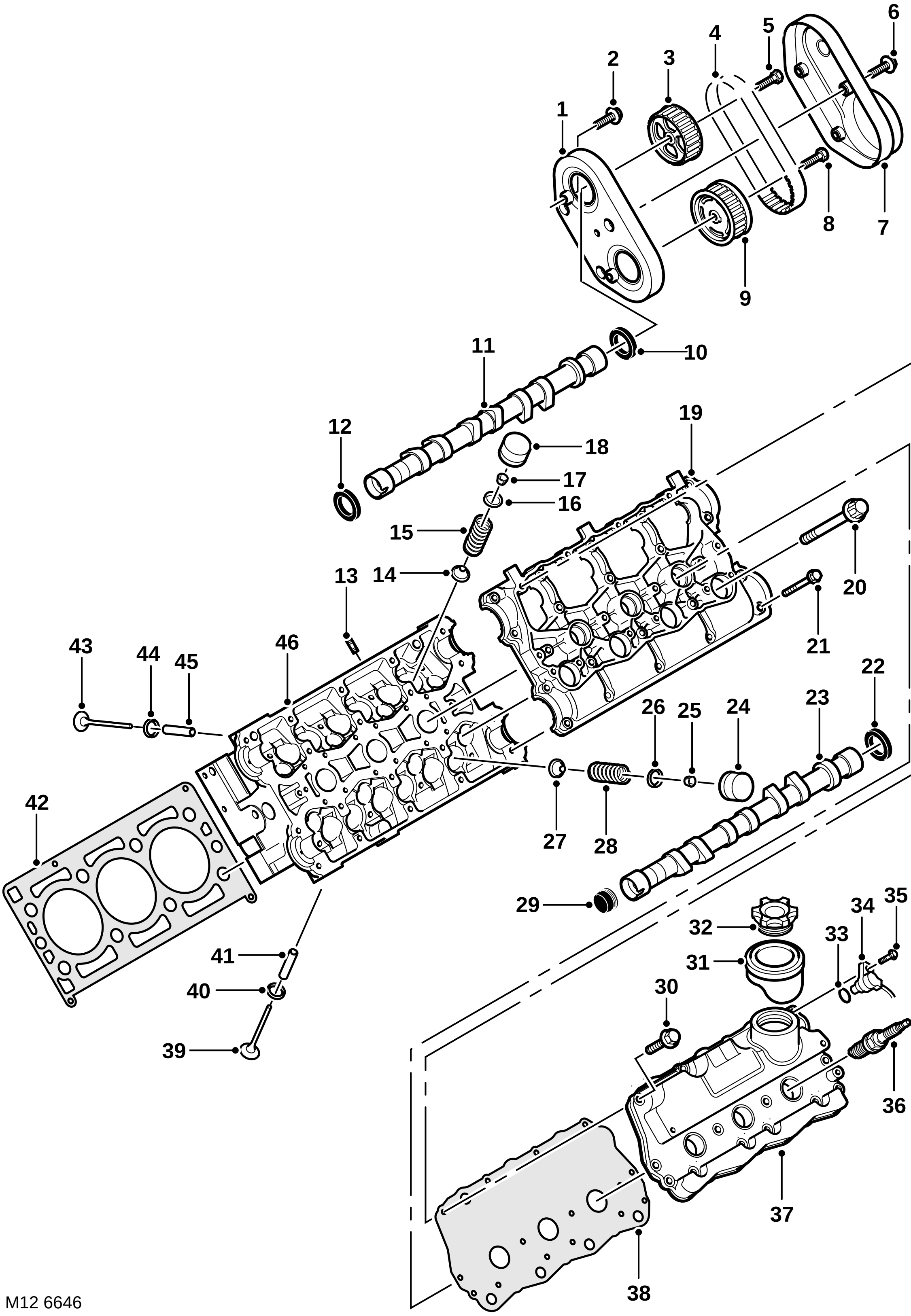
1 Clip – coolant pump to thermostat pipe
2 'O' ring – coolant pump to thermostat pipe
3 Pipe – coolant pump to thermostat
4 'O' ring – coolant pump to thermostat pipe
5 Clip – coolant pump to thermostat pipe
6 Thermostat housing
7 'O' ring – coolant outlet elbow to cylinder block
8 Bolt – coolant outlet elbow to cylinder block
9 Coolant outlet elbow
10 'O' ring – thermostat housing to cylinder block
11 Blanking plate – coolant outlet
12 Seal – blanking plate
13 Screw – blanking plate (2 off)
14 Bolt – engine lifting bracket, rear (2 off)
15 Engine lifting bracket – rear
16 Screw – crankshaft rear oil seal (5 off)
17 2nd compression ring
18 Top compression ring
19 Oil control ring
20 Piston
21 Big-end upper bearing shell
22 Big-end bearing cap
23 Bolt – big-end bearing cap to connecting rod (2 off per piston)
24 Big-end lower bearing shell
25 Crankshaft rear oil seal
26 Cylinder liner (6 off)
27 Dowel – cylinder block to cylinder head (4 off)
28 Cylinder block
29 Dowel – cylinder block to lower crankcase (4 off)
30 Engine coolant pump
31 Screw – coolant pump to cylinder block (7 off)
32 Seal – coolant pump to cylinder block

KV6 Engine – Crankshaft, Sump and Oil Pump Assembly



1 'O' rings – oil filter housing to oil cooler pipes
2 Oil pressure switch
3 Screw – oil pump to cylinder block (16 off)
4 Oil pump and oil filter housing assembly
5 Gasket – oil pump housing
6 Bearing ladder
7 Crankshaft
8 Dipstick
9 Dipstick tube
10 Baffle plate – lower crankcase extension
11 Lower crankcase extension
12 Screw – dipstick tube to cylinder block
13 'O' ring – oil pick-up pipe
14 Oil pick-up pipe with integral strainer
15 Screw – oil pick-up pipe to lower crankcase
16 Connector (quick fit) – dipstick tube to sump
17 Sump
18 Bolt – sump to lower crankcase (10 off; 5 x short, 5 x long)
19 Oil cooler
20 Bolt – oil cooler to sump (3 off)
21 Oil drain plug
22 Seal – oil drain plug
23 Pipe – oil cooler to oil filter housing
24 Pipe – oil filter housing to oil cooler
25 Oil filter cartridge
26 Bolt (long) – bearing ladder to cylinder block (8 off)
27 Bolt (short) – bearing ladder to cylinder block (8 off)

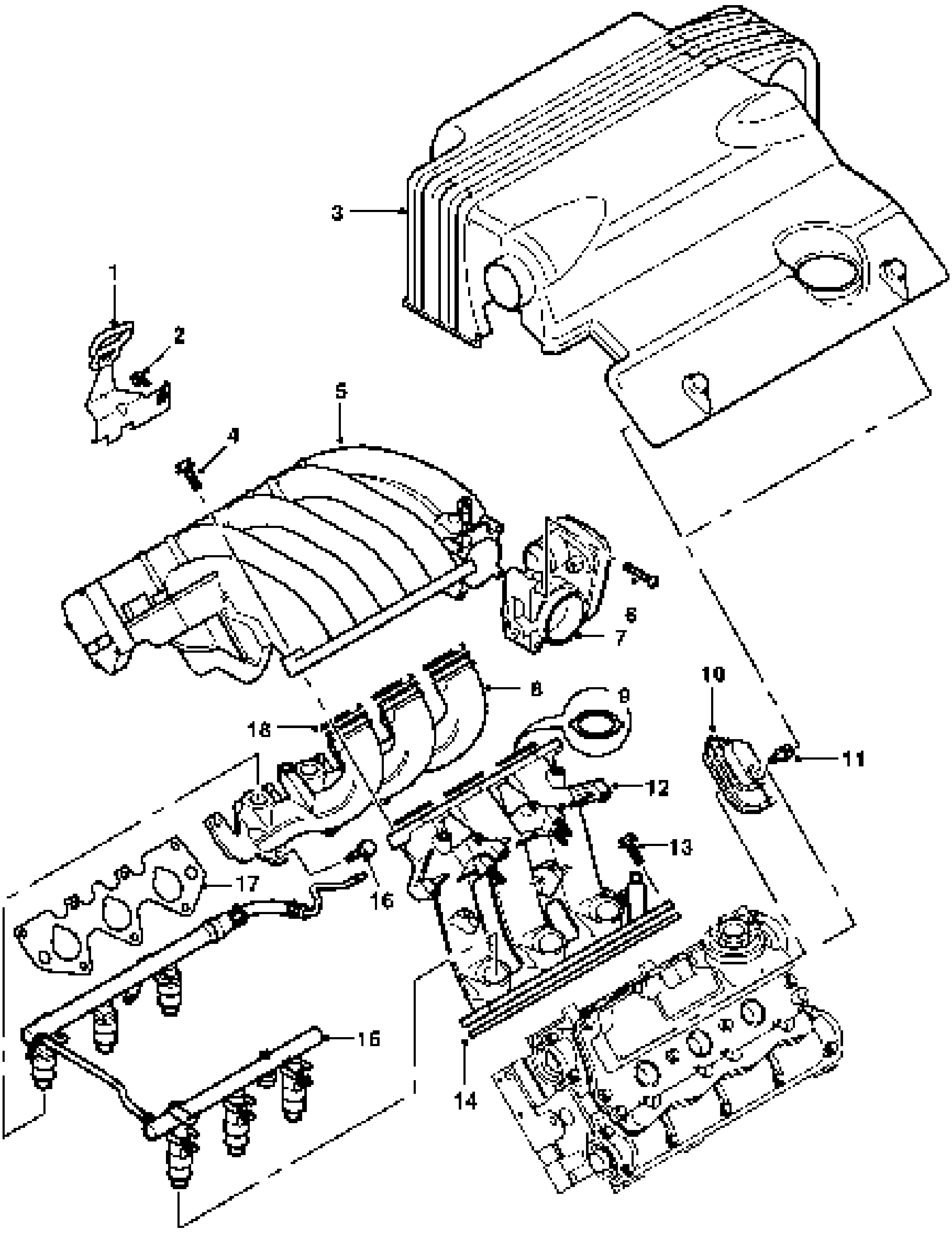
KV6 Engine – Cylinder Head Components



LH cylinder bank shown, RH cylinder bank similar

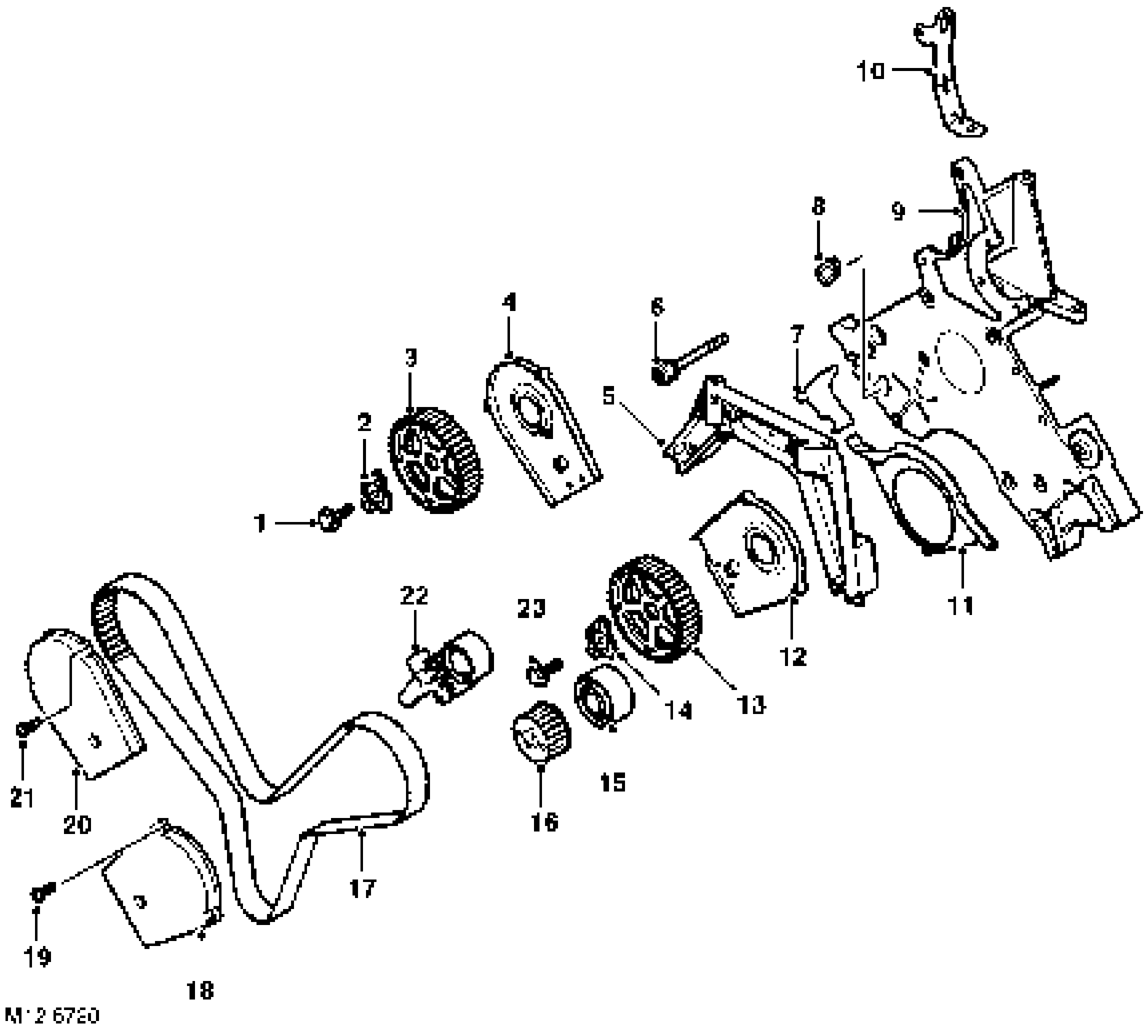
1 Rear drive belt inner cover
2 Bolt – camshaft rear drive belt inner cover (4 off)
3 Camshaft gear – rear inlet
4 Drive belt – rear camshaft
5 Bolt – inlet camshaft gear
6 Bolt – camshaft rear drive belt outer cover (3 off)
7 Rear drive belt outer cover
8 Bolt – exhaust camshaft gear
9 Camshaft gear – rear exhaust
10 Seal – inlet camshaft, rear oil
11 Inlet camshaft
12 Seal – inlet camshaft, front oil
13 Stud – cylinder head to intake manifold (2 off)
14 Valve stem oil seal – inlet (6 off)
15 Valve spring – inlet (6 off)
16 Valve spring cap – inlet (6 off)
17 Collet – inlet valve (12 off)
18 Tappet – inlet valve (6 off)
19 Camshaft carrier
20 Bolt – cylinder head (8 off)
21 Bolt – camshaft carrier to cylinder head (22 off)
22 Seal – exhaust camshaft, rear oil
23 Exhaust camshaft
24 Tappet – exhaust valve (6 off)
25 Collet – exhaust valve (12 off)
26 Valve spring cap – exhaust (6 off)
27 Valve stem oil seal – exhaust (6 off)
28 Valve spring – exhaust (6 off)
29 Seal – exhaust camshaft, front oil
30 Bolt – camshaft cover (14 off)
31 Seal – oil filler cap
32 Oil filler cap
33 'O' ring – CMP sensor
34 CMP sensor
35 Bolt – CMP sensor
36 Spark plug (3 off)
37 Camshaft cover
38 Gasket – camshaft cover
39 Inlet valve (6 off)
40 Valve seat insert – inlet (6 off)
41 Valve guide – inlet (6 off)
42 Gasket – cylinder head
43 Exhaust valves (6 off)
44 Valve seat insert – exhaust (6 off)
45 Valve guides – exhaust (6 off)
46 Cylinder head

KV6 Engine – Manifolds and Engine Cover Components



1 Strap – engine acoustic cover
2 Bolt – engine acoustic cover strap to manifold chamber
3 Engine acoustic cover
4 Bolt – manifold chamber to RH inlet manifold (4 off)
5 Manifold chamber
6 Bolt – throttle body assembly to manifold chamber (4 off)
7 Throttle body assembly
8 Inlet manifold, RH
9 Seal - manifold chamber to LH inlet manifold (3 off)
10 Guide block – HT lead
11 Stud – HT lead guide block/acoustic cover fixing
12 Inlet manifold, LH
13 Bolt – inlet manifold to cylinder head LH (7 off)
14 Gasket - inlet manifold to cylinder head (LH)
15 Fuel rail
16 Bolt – inlet manifold to cylinder head
17 Gasket – inlet manifold to cylinder head, RH
18 'O' ring - inlet manifold to top cover RH (3 off)

KV6 Engine – Camshaft Drive Belt Components



1 Bolt – timing gear to inlet camshaft (RH)
2 Hub – camshaft front timing gear (RH)
3 Camshaft front timing gear (RH)
4 Drive belt (front) backplate cover – RH
5 Engine mounting bracket
6 Bolt – engine mounting bracket to front plate (4 off)
7 Cover plate – drive belt
8 Blanking plug
9 Engine front plate
10 Engine lifting bracket – front
11 Cover – lower drive belt
12 Drive belt (front) backplate cover – LH
13 Camshaft front timing gear (LH)
14 Hub – camshaft front timing gear (LH)
15 Idler pulley – drive belt
16 Crankshaft timing gear
17 Drive belt – front
18 Front drive belt outer cover (LH)
19 Screw – front drive belt outer cover to inner cover, LH (3 off)
20 Front drive belt outer cover (RH)
21 Screw – front drive belt outer cover to inner cover, RH (3 off)
22 Tensioner assembly – front drive belt
23 Bolt – timing gear to inlet camshaft (LH)

Description

General

The KV6 is of all aluminium construction, with a 90° V configuration. The KV6 uses long cylinder head bolts engaging in threads 70 mm below the mating face of the cylinder block to attach the cylinder head to the cylinder block. This ensures sufficient structural stiffness to take advantage of the compressive strength of aluminium alloy and minimise tensile loadings. There are 8 cylinder head bolts for each cylinder head, located below the camshafts.

The engine features 24 valves, sequential fuel injection, liquid cooling and is transverse mounted. It is controlled by a Siemens engine management system utilising a range of sensors to constantly monitor and optimise engine performance.

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

Cylinder Block Components

The cylinder block components are described below:

Cylinder Block and Main Bearing Ladder

The cylinder block is constructed of an aluminium alloy and is cast in three sections:

- Cylinder block.
- Main bearing ladder.
- Lower crankcase extension.

For strength and rigidity, the main bearing ladder is manufactured from special alloy A357TF as used in manufacturing components in the aerospace industry. The main bearing ladder is secured to the cylinder block with 16 bolts, thus creating a very rigid crankcase 'box'. A separate outer crankcase extension adds further strength to the lower end of the cylinder block. The lower crankcase extension is sealed to the underside of the cylinder block, using jointing compound, and secured with 10 bolts. Fitted to the lower crankcase is an aluminium alloy sump.

Pistons and Cylinder Liners

The aluminium alloy, thermal expansion, lightweight pistons, with semi-floating gudgeon pins, are offset to the thrust side and are carried on forged steel connecting rods. Pistons and cylinder liners are supplied in two grades, 'A' and 'B' and are also colour coded to assist identification. The pistons are marked to ensure they are correctly oriented in the cylinder liner; the 'FRONT' mark should be toward the front of the engine.

The cylinder block is fitted with 'damp' cylinder liners, the bottom stepped half of the cylinder liner being a sliding fit into the lower part of the cylinder block. The liners are sealed in the block with a bead of sealant applied around the stepped portion of the cylinder liner. The top of the cylinder liner is sealed by a multi-layer steel cylinder head gasket when the cylinder head is fitted.

The cylinder liner diameters are smaller than the big-end forging of the connecting rods and need to be removed complete with pistons and connecting rods from the cylinder block.

Connecting Rods

The KV6 engine utilises forged steel H-sectioned connecting rods, with the gudgeon pin being an interference fit in the small end of the connecting rod. The big-ends are horizontally split.

Big-end bearing diametric clearance is controlled by selective bearing shells with three grades of thickness. The big-end upper and lower bearing shells are plain with locating tags.

Piston Rings
Each piston is fitted with two compression rings and an oil control ring. The top compression rings are chrome-plated steel. The 2nd compression rings are chrome-plated cast iron. The oil control rings have stainless steel top and bottom rails and integral expander rings.

Crankshaft, Sump and Oil Pump Components
The crankshaft and sump components are described below:

Crankshaft
The short, stiff crankshaft is supported on four main bearings, with each pair of crankpins mutually offset by 30° to give equal firing intervals. Cast in Spheroidal Graphite (SG) iron, the crankshaft has cold rolled fillets on all journals, except the outer mains, for toughness and failure resistance. End-float is controlled by thrust washer halves at the top and bottom of the rear main bearing.

Main Bearings
Oil grooves are provided in the upper halves of all the main bearing shells to supply oil, via drillings in the crankshaft, to the connecting rod big-end bearings. The lower halves of the bearing shells in the bearing ladder are plain.

Sump
The cast aluminium sump is a wet-type, sealed to the lower crankcase extension using sealant applied to the sump flange. The sump is fixed to the lower crankcase extension using 10 bolts. A baffle plate is fitted in the lower crankcase extension to minimise the effects of oil slosh.

An oil pick-up with integral strainer is located in the centre of the sump oil well, as a source for the supply of engine lubrication oil to the oil pump. Oil is sucked up though the end of the pick–up and strained to prevent solid matter from entering the oil pump.

Oil Pump
The oil pump is directly driven from the crankshaft. The oil pump housing includes the oil pressure relief valve, oil filter, oil pressure switch and return/supply outlets for the engine oil cooler.

Oil Filter
A full-flow, disposable canister-type oil filter is attached to the oil pump housing at the front of the engine.

Oil Cooler
A liquid cooled oil cooler keeps the engine lubrication oil cool, under heavy loads and high ambient temperatures.

The oil cooler is cooled by the engine cooling system and attached to a bracket secured to the front of the sump by three bolts. Oil is delivered to and from the oil cooler through hoses connected to the oil pump housing. Hoses from the engine cooling system are connected to two pipes on the oil cooler for the supply and return of coolant.

Oil Pressure Switch
The oil pressure switch is located in a port at the outlet side of the oil filter. It detects when a safe operating pressure has been reached during engine starting and initiates the illumination of a warning light in the instrument pack if the oil pressure drops below a given value.

Cylinder Head Components

The cylinder head components are described below:

Cylinder Head

The cross-flow cylinder heads are based on a four valve, central spark plug combustion chamber, with the inlet ports designed to induce swirl and control the speed of the induction charge. This serves to improve combustion and hence fuel economy, performance and exhaust emissions.

LH and RH cylinder heads are identical castings.

Camshafts

Twin camshafts on each cylinder bank are retained by a camshaft carrier, line bored with the cylinder head. The camshafts are located by a flange which also controls end-float. A crossover drive for the exhaust camshaft, from the rear of the inlet camshaft is by a short toothed belt, which allows for a much shorter and simpler run for the main camshaft drive belt at the front of the engine.

The exhaust camshaft drive gears have dampers integral with the gear to minimise torsional vibration. The inlet camshaft for the LH cylinder head incorporates a reluctor which is used in conjunction with the Camshaft Position (CMP) sensor to measure engine position. The CMP sensor is bolted to the LH camshaft cover.

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

Cylinder Head Gasket

The KV6 utilises a multi-layer stainless steel cylinder head gasket. The gasket comprises four stainless steel functional layers, and a stainless steel distance layer to maintain fitted thickness. A full embossment profile is employed to seal the combustion gases and half embossments are used to provide a durable fluid seal. Sealing characteristics are further enhanced by the application of a fluro-elastomer surface coating to all layers of the gasket.

Hydraulic Tappets

Self-adjusting, lightweight, hydraulic tappets are fitted on top of each valve and are operated directly by the camshaft. The valve stem oil seals are moulded onto a metal base which also acts as the valve spring seat on the cylinder head.

Valves

The exhaust valves are of the carbon break type. A machined profile on the valve stem removes any build up of carbon in the combustion chamber end of the valve guide. All valve seats are machined in three planes, improving valve to seat sealing.

Camshaft Cover and Engine Cover Components

The camshaft cover and engine cover components are described below:

Acoustic Cover

A moulded plastic acoustic cover is fitted over the engine to absorb engine generated noise. Foam is bonded on the inside surface of the acoustic cover and a rubber seal is fitted around the oil filler cap.

The acoustic cover is located on the engine by two rubber studs on the underside of the acoustic cover. A rubber strap, at the rear of the engine, and two quick release fasteners, at the front of the acoustic cover, secure the acoustic cover in position.

Resonators and part of the engine intake duct are integrated into the acoustic cover, and the engine air filter is installed in a compartment below a lid secured with two Torx bolts.

A metal foil heatshield is installed on the underside of the acoustic cover.

A rubber duct connects the engine intake duct in the acoustic cover to the RH inner wing. A further duct is installed between the inner and outer wings to draw engine air from the base of the A post.

Throttle Body Assembly

The throttle body is an electrically actuated unit controlled by the Engine Control Module (ECM). The position of the throttle plate is controlled by a DC motor and a return spring integrated into the throttle body. Two feedback potentiometers supply throttle plate position signals to the ECM for closed loop control.

Four Torx bolts secure the throttle body to the inlet manifold chamber. A rubber seal, keyed into a groove in the inlet manifold chamber, ensures the joint is air tight.

Inlet Manifold Chamber

The inlet manifold chamber is a sealed plastic assembly. The inlet manifold chamber combines plenum resonance for good low speed torque, with variable length primary tracts for optimum mid and high speed torque.

The throttle body assembly feeds into a 'Y' piece which separates into two secondary inlet pipes. The secondary pipes feed into two main plenums, one for each bank of three cylinders. At the closed end of the plenums is a balance valve, controlled by an electric actuator, that connects the two plenums together.

The variable intake system uses valves and actuators to vary the overall tract length of the inlet manifold chamber. The aluminium alloy inlet manifolds are sealed to each cylinder head with gaskets and to the inlet manifold chamber with 'O' rings and seals.

☞ **MANIFOLD AND EXHAUST SYSTEM - K SERIES KV6, DESCRIPTION AND OPERATION, Description.**

Operation

Lubrication Circuit
The lubrication system is of the full-flow filtration, force fed type.

Oil is drawn, via a strainer and pick-up pipe in the sump, through the bearing ladder and into a crankshaft driven oil pump which has an integral pressure relief valve. The strainer in the pick-up pipe prevents any ingress of foreign particles from passing through to the inlet side of the oil pump and damaging the oil pump and restricting oil drillings. The oil pressure relief valve in the oil pump opens if the oil pressure becomes excessive and diverts oil back around the pump.

Pressurised oil is pumped through a full-flow cartridge type oil filter, mounted on the oil pump housing. The lubrication system is designed so that a higher proportion of oil flow is directed to the cylinder block main oil gallery while a lower proportion of oil flow, (controlled by a restrictor in the oil filter housing), is directed to the engine oil cooler. The remainder of the oil flow from the outlet side of the oil filter is combined with the return flow from the oil cooler before being passed into the cylinder block main oil gallery.

The main oil gallery has drillings that direct the oil to the main bearings. Cross drillings in the crankshaft main bearings carry the oil to the connecting rod big-end bearings.

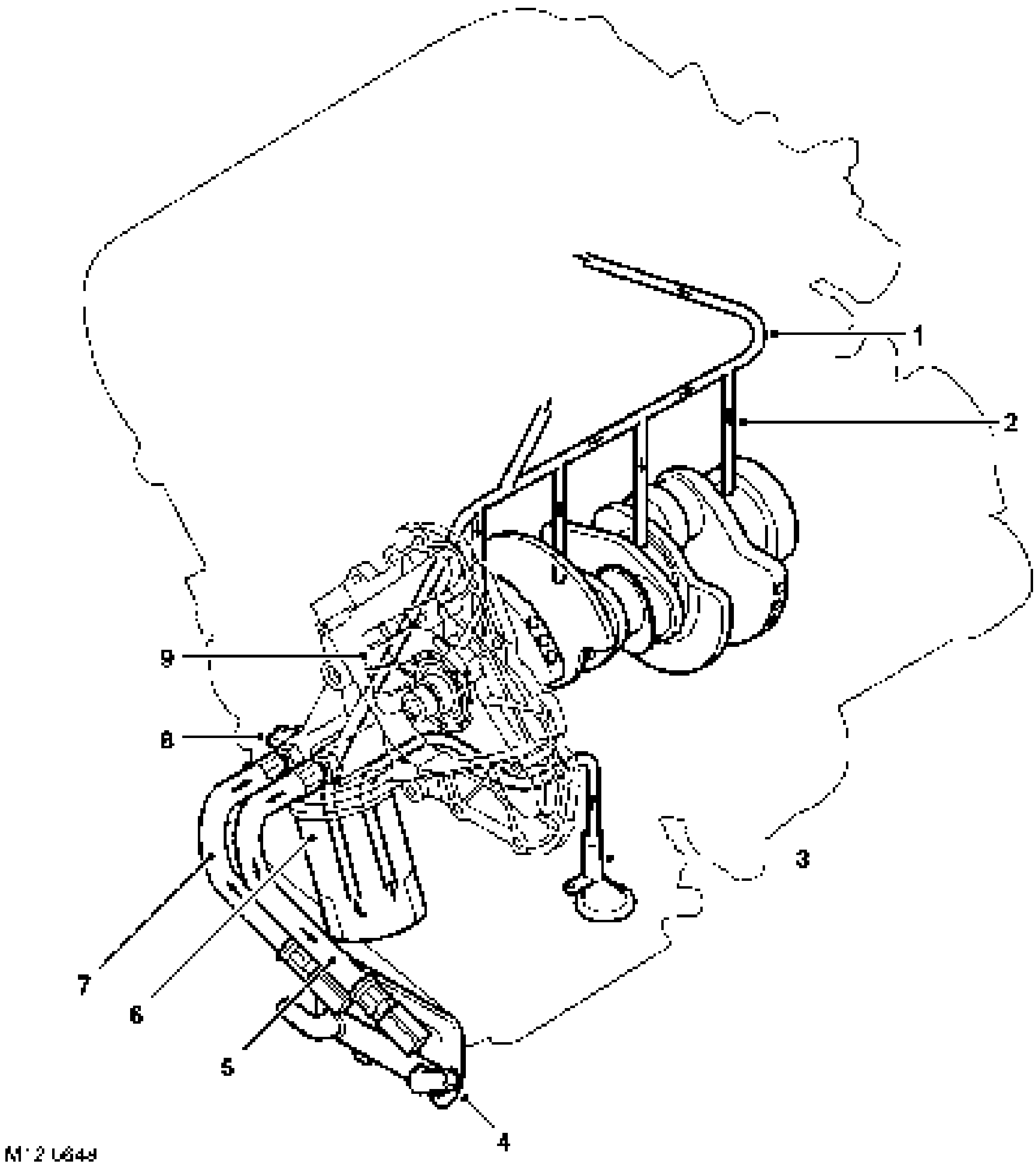
The oil pressure switch is located at the outlet side of the oil filter housing to sense the oil pressure level before the oil flow enters the main gallery in the engine block. A warning lamp in the instrument pack is illuminated if low oil pressure is detected.

Oil at reduced pressure is directed to each cylinder bank via two restrictors in the cylinder block/cylinder head locating dowels, one at the front on the LH bank and the other at the rear on the RH bank. Oil then passes through a drilling in the cylinder head to the camshaft carrier, where it is directed via separate galleries to the camshaft bearings and hydraulic tappet housings. Return oil from the cylinder head drains into the sump via the cylinder head bolt passages.

Crankcase Ventilation
A positive crankcase ventilation system is used to vent blow-by gas from the crankcase to the air intake system. The blow-by gas passes through a gauze oil separator in the camshaft cover, and then through hoses into the throttle housing and inlet manifold.

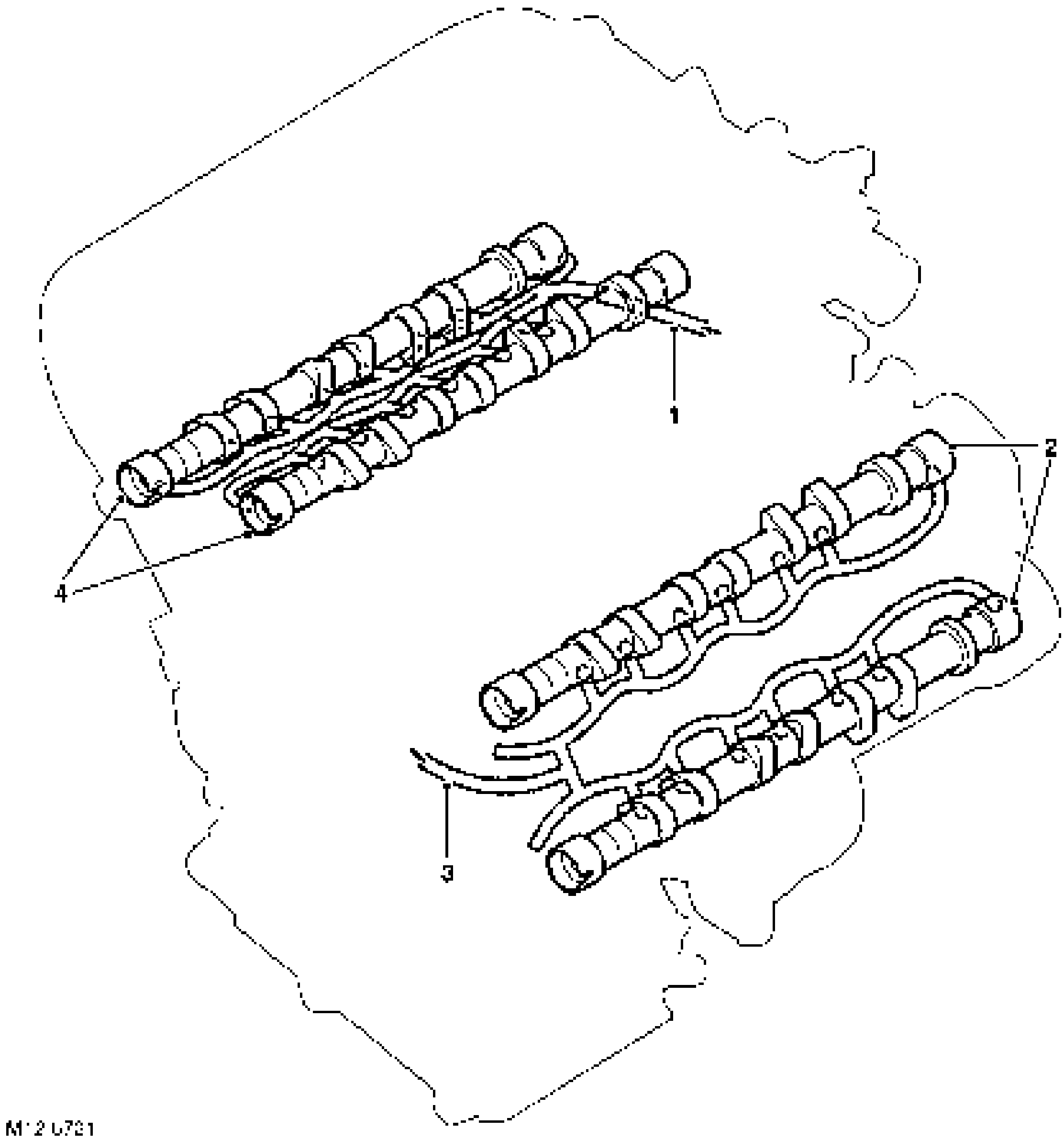
☞ **EMISSION CONTROL - K SERIES KV6, DESCRIPTION AND OPERATION, Description.**

Crankshaft Oil Supply



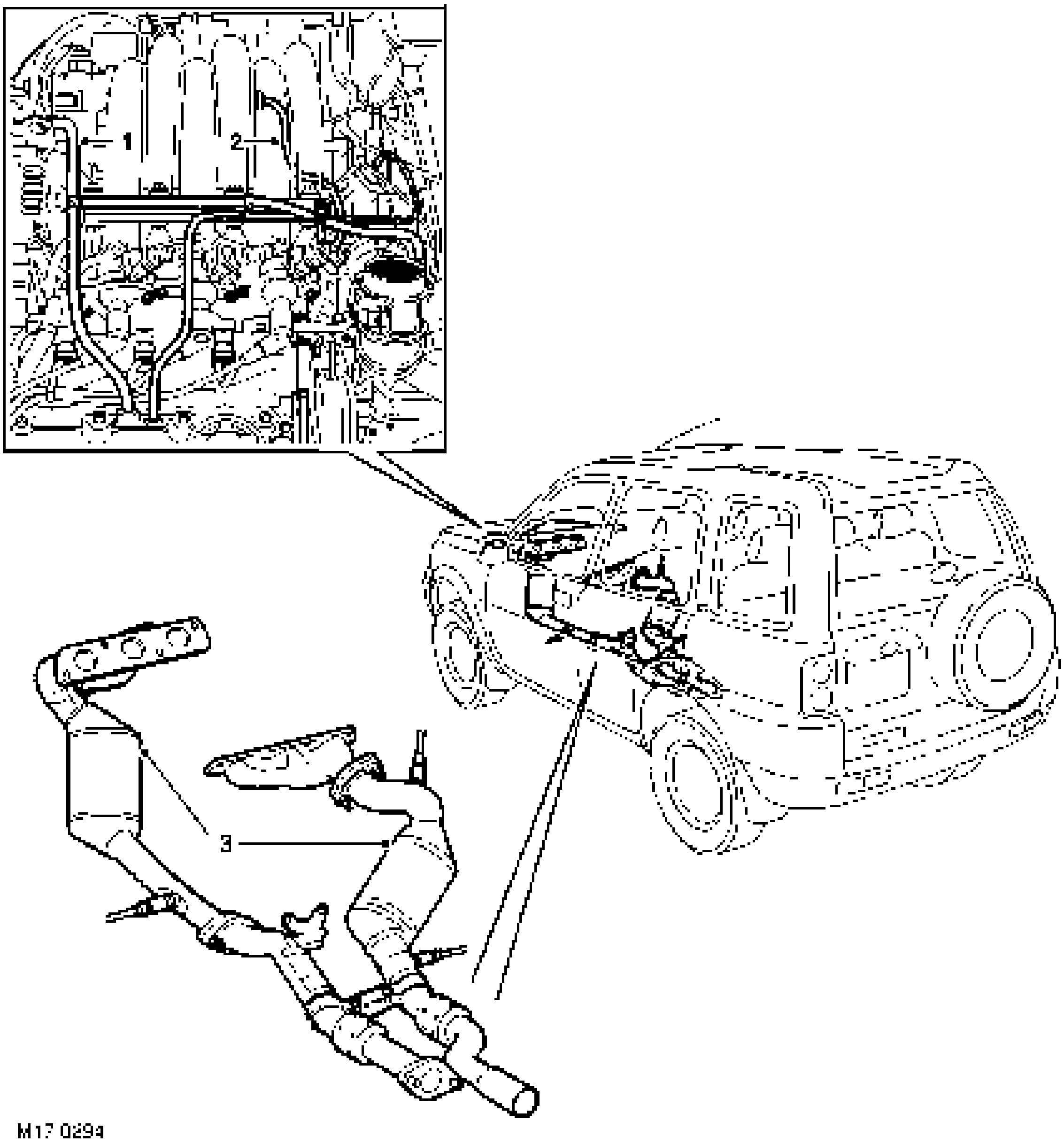
- **1** Cylinder block main oil gallery
- **2** Cross drillings to crankshaft main bearings
- **3** Oil pick-up pipe with integral strainer
- **4** Oil cooler
- **5** Oil cooler supply pipe
- **6** Oil filter cartridge
- **7** Oil cooler return pipe
- **8** Oil pressure switch
- **9** Oil pump with integral oil pressure relief valve

Cylinder Head Component Oil Supply



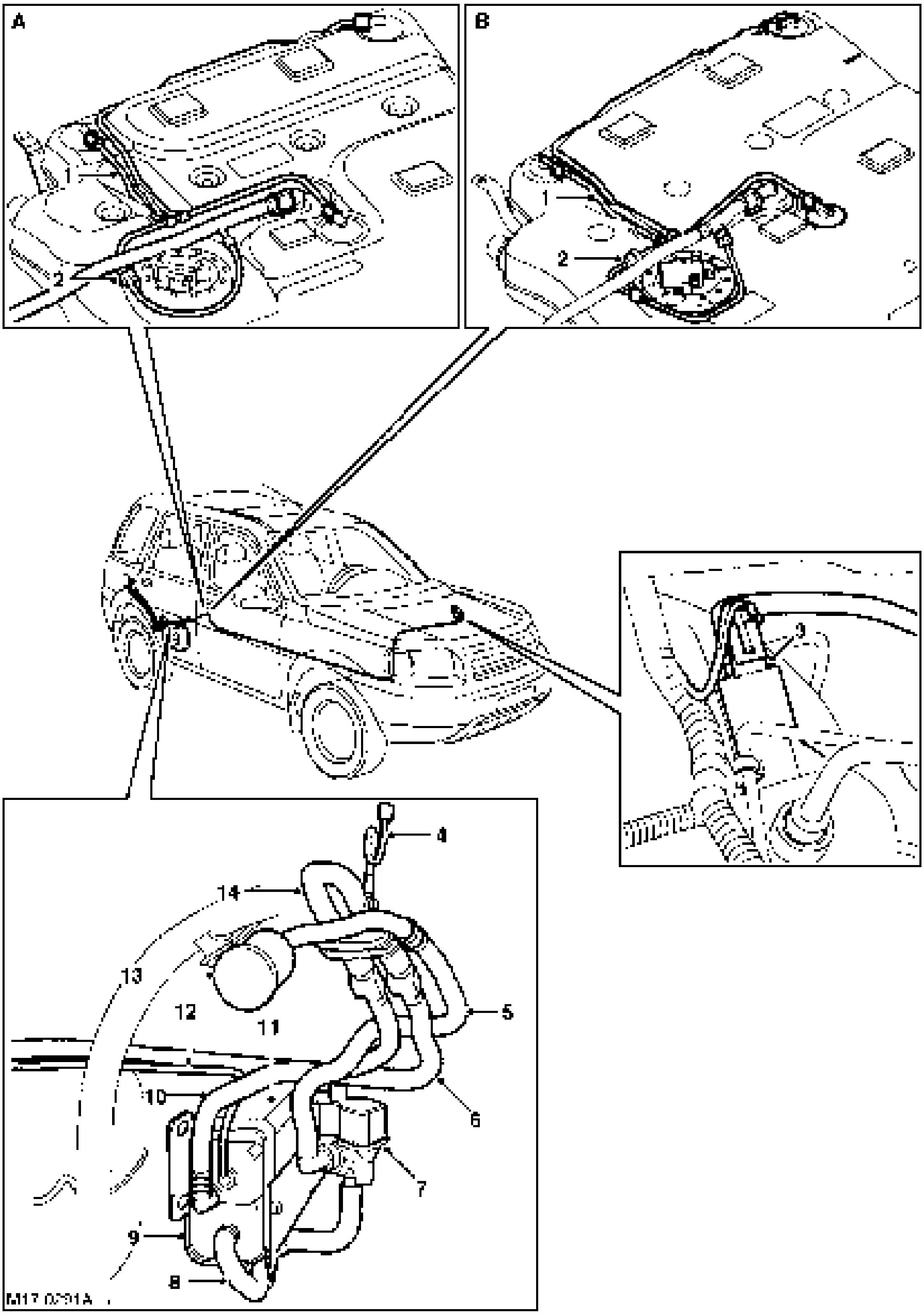
1 From RH cylinder block main gallery
2 LH cylinder head camshafts
3 From LH cylinder block main gallery
4 RH cylinder head camshafts

Emission Control Component Layout – Crankcase and Exhaust



1 Crankcase breather hose to intake duct
2 Crankcase breather hose to inlet manifold
3 Catalytic converters

Emission Control Component Layout – EVAP



A *= Vehicles up to 2002.5 Model Year*
B *= Vehicles from 2002.5 Model Year*

1 Fuel tank vent pipes
2 Two-way valve
3 Purge valve
4 Recirculation pipe
5 DMTL to air filter vent pipe
6 Fuel tank to vapour separator vent pipe
7 DMTL
8 Canister to DMTL vent pipe
9 Canister support bracket
10 Vapour separator to canister vent pipe
11 EVAP canister
12 Canister to purge valve vent pipe
13 Air filter
14 Vapour separator

Description

General

The vehicle is fitted with the following control systems to reduce emissions released into the atmosphere:

- Crankcase emission control.
- Exhaust emission control.
- Evaporative emissions (EVAP) control.

CAUTION: In many countries it is against the law for a vehicle owner or an unauthorised dealer to modify or tamper with emission control equipment. In some cases, the vehicle owner and/or the dealer may even be liable for prosecution.

The emission control systems fitted to the vehicle are designed to keep the emissions within the legal limits, at the time of manufacture, provided that the engine and the fuel system components are correctly maintained and in good mechanical condition.

Crankcase Emission Control System

The crankcase is vented via the oil drain passages in the cylinder blocks and cylinder heads and two ports in each camshaft cover. Plastic pipes connect the larger ports in the camshaft covers to the intake duct, on the upstream side of the throttle disc. The smaller ports in the camshaft covers are connected to the inlet manifold, downstream of the throttle body, also by plastic pipes. Each of the smaller ports incorporate a restrictor and a gauze oil separator to prevent oil being drawn out of the camshaft covers with the blow-by gases. Quick release locking collars and 'O' rings are used for all of the pipe connections with the camshaft covers, throttle body and air intake duct.

When the engine is running with the throttle disc closed, the depression downstream of the throttle disc draws crankcase gases into the inlet manifold through the smaller ports in the camshaft covers. Clean air, from the upstream side of the throttle disc, is drawn into the crankcase through the larger ports in the camshaft covers to limit the depression produced in the crankcase.

When the engine is running with the throttle disc wide open, the upstream and downstream sides of the throttle disc, and thus the two ports in each camshaft cover, are subjected to similar, relatively weak, depression levels. Crankcase gases are then drawn out of both ports in each camshaft cover, with the majority being drawn out of the unrestricted larger ports and into the throttle body.

At interim throttle disc positions the flow of the crankcase gases varies, between those produced at the closed and wide open throttle disc positions, depending on the depression levels produced upstream and downstream of the throttle disc.

Exhaust Emission Control

The engine management systems provide accurately metered quantities of fuel to the combustion chambers to ensure the most efficient use of fuel and to minimise the exhaust emissions. In some markets, to reduce the carbon monoxide and hydrocarbons content of the exhaust gases, catalytic converters are installed in the exhaust system. A catalytic converter is integrated into each downpipe close to the exhaust manifolds.

In the catalytic converters the exhaust gases are passed through honeycombed ceramic elements coated with a special surface treatment called 'washcoat'. The washcoat increases the surface area of the ceramic elements by a factor of approximately 7000. On top of the washcoat is a coating containing the elements which are the active constituents for converting harmful emissions into inert by-products. The active constituents consist of platinum and rhodium. Platinum adds oxygen to the carbon monoxide and the hydrocarbons in the exhaust gases, to convert them into carbon dioxide and water respectively. The rhodium removes oxygen from the Nitrous Oxides (NOx) to convert them into nitrogen.

The correct operation of the catalytic converters is dependent upon close control of the oxygen content of the exhaust gas. The quantity of oxygen in the exhaust gas is monitored by the Engine Control Module (ECM) using an input from the Heated Oxygen Sensor (HO2S) upstream of the catalytic converters. The ECM also monitors the condition of the catalytic converters using an input from the HO2S downstream of the catalytic converters.

EVAP Control

The EVAP control system reduces the level of hydrocarbons released into the atmosphere by fuel vapour venting from the fuel tank. A positive pressure leak detection function is incorporated to monitor the integrity of the system. The EVAP control system comprises:

- A two way valve.
- A vapour separator.
- An EVAP canister.
- A purge valve.
- A Diagnostic Module for Tank Leakage (DMTL).
- An air filter.
- Interconnecting vent pipes.

The EVAP control system is connected to the Onboard Refuelling Vapour Recovery (ORVR) valve and/or the roll over valves in the fuel tank. The ORVR valve and the roll over valves are float valves that allow inward and outward venting of the fuel tank, but prevent the escape of fuel into the vent pipes due to fuel slosh or if the vehicle overturns. The ORVR valve is normally closed when the fuel tank is full and normally open at all other fuel levels. The roll over valves are normally open at all fuel levels.

When the fuel tank is less than full, venting is unrestricted through the ORVR valve. Only when the fuel tank is full does venting occur, with changes of tank pressure, through the roll over valves and the two-way valve.

Vapour vented from the fuel tank passes through the EVAP control system to atmosphere. The EVAP canister absorbs fuel from the vapour and relatively fuel free air vents to atmosphere. Since there is a limit to the storage capacity of the EVAP canister, when the engine is running fuel is purged from the EVAP canister and burned in the engine.

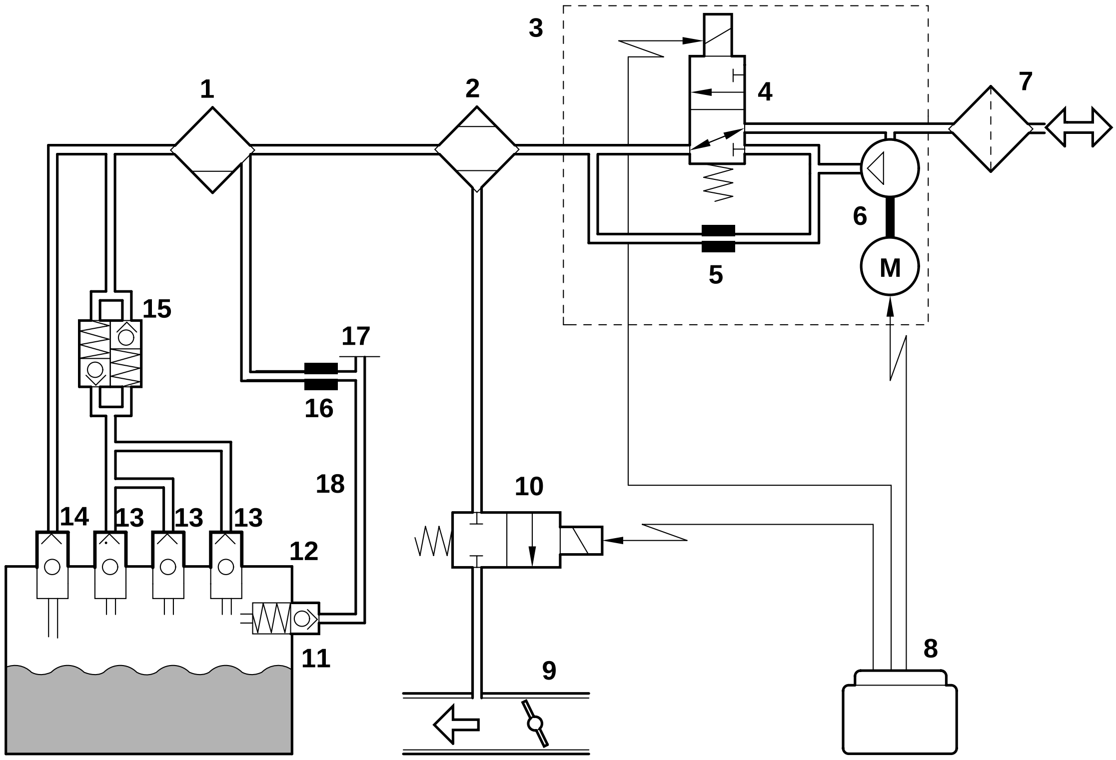
To reduce the load on the EVAP canister during refuelling, a proportion of the air expelled from the tank is recirculated through a pipe connected between the top of the vapour separator and the filler tube. The recirculation flow is induced by fuel in the filler tube flowing past a restrictor installed in the recirculation pipe connection on the filler tube. With the recirculation flow present, less fresh air enters the tank, which reduces the volume of vapour generated and fuel deposited in the EVAP canister.

The DMTL periodically checks the EVAP control system and fuel tank for leaks when the ignition is switched off.

On vehicles from 2002.5 model year – Modifications are introduced to increase the capacity of the fuel tank. The modification comprises a change to the vent line from the forward Roll Over Valve (ROV). The vent from the ROV now connects to the vent line between the two-way valve and the vapour separator. Venting from the forward ROV is no longer restricted by the two-way valve. The ROV now controls the refuelling nozzle shut-off. When the ROV closes, pressure in the tank increases, shutting off the refuelling nozzle. This modification allows up to 5 litres additional fuel to be added to the fuel tank.

The fuel tank on vehicles from 2002.5 model year also incorporates a new fabric sleeve over the filler pipe inlet in the fuel tank. The sleeve reduces the amount of vapour produced during refuelling and the subsequent load on the EVAP canister.

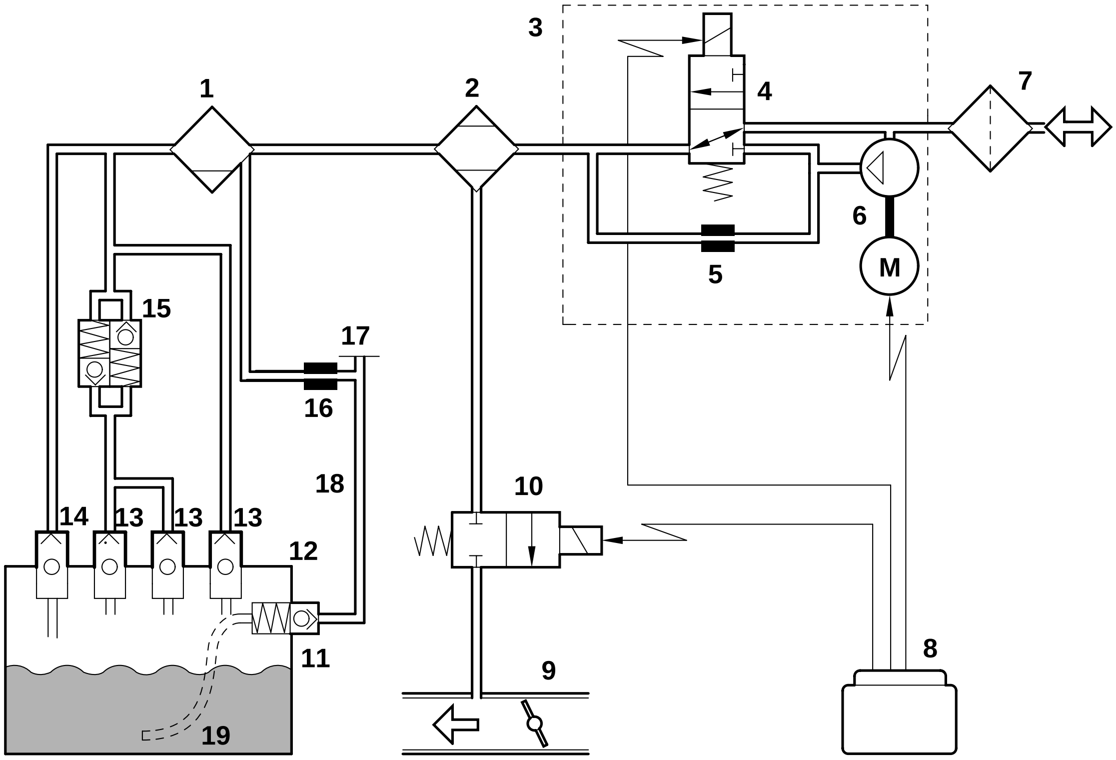
EVAP System Schematic – Vehicles up to 2002.5 Model Year



M17 0292

- **1** Vapour separator
- **2** EVAP canister
- **3** DMTL
- **4** Change-over valve
- **5** 0.5 mm (0.020 in) reference orifice
- **6** Air pump and motor
- **7** Air filter
- **8** ECM
- **9** Throttle body
- **10** Purge valve
- **11** Flap valve
- **12** Fuel tank
- **13** Roll over valve
- **14** ORVR valve
- **15** Two-way valve
- **16** Restrictor
- **17** Fuel filler cap
- **18** Filler tube

EVAP System Schematic – Vehicles from 2002.5 Model Year



M17 0362

1 Vapour separator
2 EVAP canister
3 DMTL
4 Change-over valve
5 0.5 mm (0.020 in) reference orifice
6 Air pump and motor
7 Air filter
8 ECM
9 Throttle body
10 Purge valve
11 Flap valve
12 Fuel tank
13 Roll over valve
14 ORVR valve
15 Two-way valve
16 Restrictor
17 Fuel filler cap
18 Filler tube
19 Fabric sleeve

Two-way Valve

The two-way valve limits the pressure and depression in the fuel tank and, during refuelling, induces automatic cut-off in the refuelling nozzle when the fuel in the tank reaches the full level. The two-way valve is installed in the vent pipe from the tank, next to the fuel pump assembly.

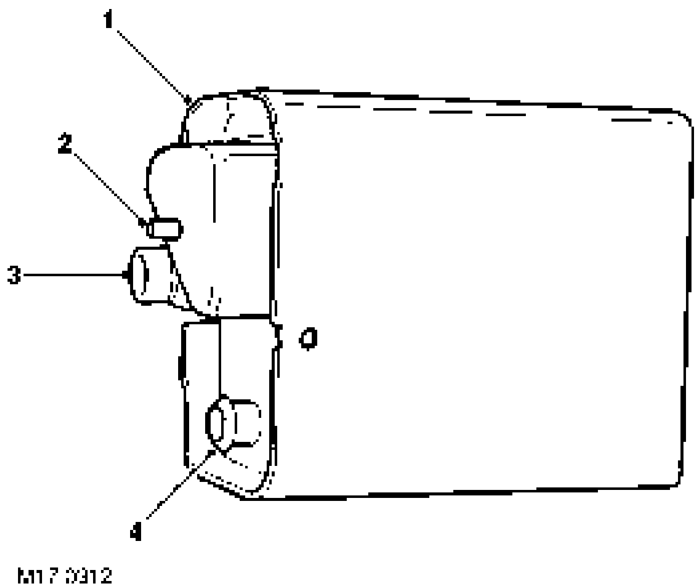
The two-way valve is a normally closed valve that opens, to release pressure from the fuel tank, at 18 to 50 mbar (0.26 and 0.73 lbf/in^2). Air is allowed to flow back into the fuel tank, as the pressure in the tank decreases, through a non return valve within the body of the two-way valve. The nominal opening pressure of the non return valve is 1 mbar (0.015 lbf/in^2).

During refuelling, if the fuel in the tank reaches the full level outward venting becomes restricted, which creates a back pressure in the filler tube and automatically closes the refuelling nozzle. The restriction is caused by the fuel closing the ORVR valve.

Vapour Separator
The vapour separator is installed at the front of the RH rear wheel arch, behind the wheel arch liner. The vapour separator prevents the charcoal in the EVAP canister being saturated with fuel, by separating any liquid from the vapour vented from the fuel tank. Separated fuel from the vapour separator drains back to the fuel tank through the vent pipe.

EVAP Canister
The EVAP canister is installed at the front of the RH rear wheel arch, behind the wheel arch liner. Charcoal in the EVAP canister absorbs and stores fuel from the vapour vented from the fuel tank. When the engine is running, fuel is purged from the EVAP canister when the purge valve opens and clean air is drawn through the charcoal.

EVAP Canister



1 Canister housing
2 Purge valve connection
3 Vapour separator connection
4 DMTL connection

Purge Valve
The purge valve is installed on the inlet manifold chamber, next to the throttle body, and connected to the EVAP canister by a vent pipe installed on the underside of the vehicle, next to the fuel delivery pipe.

The purge valve is controlled by the Engine Control Module (ECM) and remains closed below a preset coolant temperature and engine speed, to protect engine tune and catalytic converter performance. When engine operating conditions are suitable, the ECM opens the purge valve and the depression in the inlet manifold draws fuel vapour from the EVAP canister.

DMTL
The DMTL is connected to the atmospheric vent of the charcoal canister and incorporates an electric air pump, a normally open change-over valve and a 0.5 mm (0.020 in) reference orifice. The DMTL operates only after the ignition is switched off and is controlled by the ECM, which also monitors the air pump and the change-over valve for faults.

Air Filter
The air filter prevents dust being drawn into the EVAP system. A breather tube connects the DMTL to the air filter, which is located above the RH rear wheelarch liner, immediately below the fuel filler cap.

Leak Diagnostic Operation

To check the fuel tank and EVAP system for leaks, the ECM operates the air pump in the DMTL and monitors the current draw. Initially, the ECM establishes a reference current by pumping air through the reference orifice and back to atmosphere. Having established a reference current, the ECM then closes the change-over valve, which seals the EVAP system (the purge valve already being closed), and diverts the output from the air pump around the reference orifice and into the EVAP system.

When the change-over valve is first closed, the load on the pump drops to zero, then, provided there are no leaks, the pump begins to pressurise the EVAP system and the load and current draw of the pump begin to increase. By monitoring the rate and level of current increase, the ECM can determine if there is a leak in the system.

During the leak check, the ECM energises a heating element in the air pump to prevent condensation forming and producing an incorrect current reading.

Leaks are classified as minor (equivalent to hole diameter of 0.5 to 1.0 mm (0.02 to 0.04 in) or major (equivalent to hole diameter of 1.0 mm (0.04 in) or greater).

The ECM conducts a check for major leaks each time the ignition is switched off, provided the following baseline conditions are met:

- The ECM is in power down mode more than 3 seconds after the ignition is switched off.
- The vehicle speed is zero.
- The engine speed is zero.
- The pressure altitude (derived from engine load calculations) is below 1830 m (6000 ft).
- The engine coolant temperature is more than 2.25 °C (36 °F).
- The ambient temperature is between 0 and 40 °C (32 and 104 °F).
- The EVAP canister load factor is 3 or less (the load factor is a measure, between –1 and +30, of the amount of fuel vapour stored in the EVAP canister, where –1 is 0% fuel vapour, 0 is stoichiometric fuel vapour level and +30 is 100% saturated with fuel vapour).
- The fuel tank level is valid and between 15 and 85 % of the nominal capacity.
- The engine running time during the previous ignition on cycle was more than 20 minutes.
- Battery voltage is between 10.94 and 14.52 volts.
- The last engine off time was more than 150 minutes.
- No errors with the following functions or components:
  - Road speed.
  - EVAP system load monitoring.
  - Engine coolant temperature.
  - Ambient air temperature.
  - Fuel level.
  - Purge valve.
  - DMTL.

A check for minor leaks is only conducted after every 14th major leak check or after refuelling is detected.

At the end of the leak check the ECM stops the air pump and opens the change-over valve.

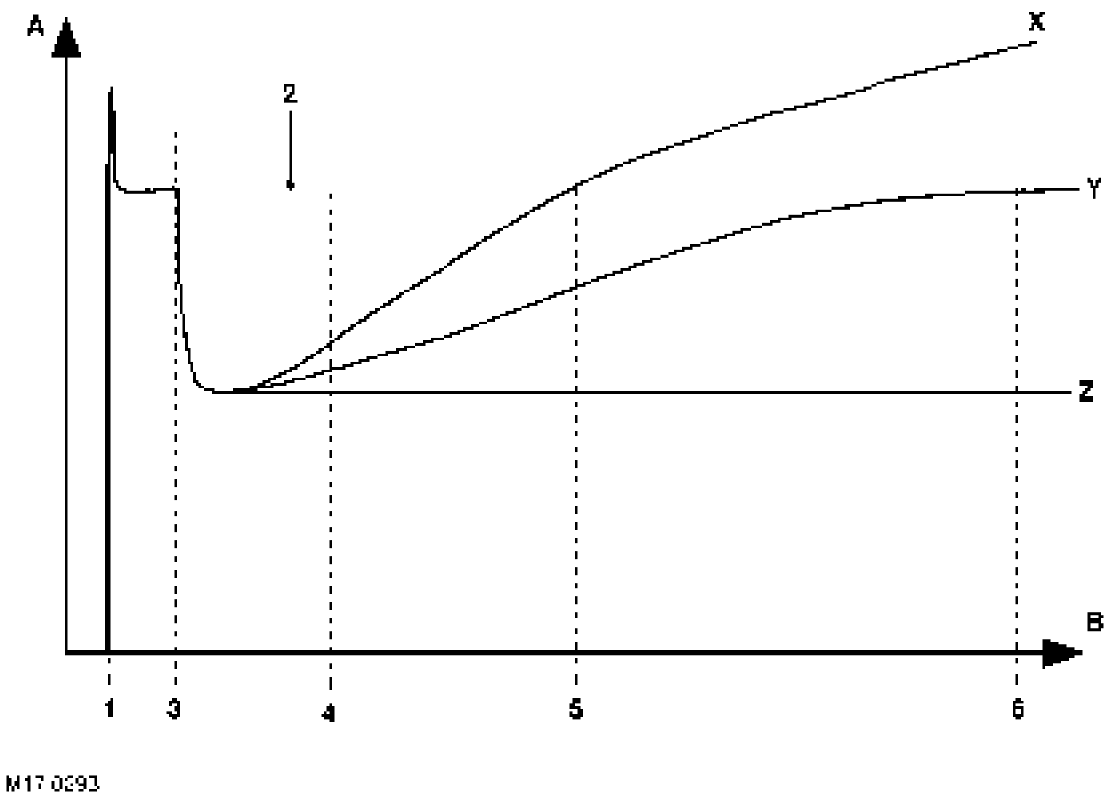
If the fuel filler cap is opened or refuelling is detected during the leak check, by a sudden drop in the current draw or rise in fuel level, the leak check is aborted.

If a leak is detected during the check, the ECM stores an appropriate fault code in memory. If a leak is detected on two consecutive checks, the ECM illuminates the MIL on the next drive cycle.

The duration of the leak check is between 40 and 270 seconds, depending on results and the level of fuel in the tank.

A leak test can be invoked using TestBook/T4, which overrides the baseline conditions requirement.

Leak Check Sequence



A = Pump motor current; B = Time

X = Current draw for tight system; Y = Current draw for minor leak; Z = Current draw for major leak

1 Pump motor energised: Air directed through reference orifice to atmosphere, to establish reference current.
2 Reference current.
3 Change-over valve energised: Air directed through EVAP canister into fuel tank.
4 Major leak check completed: If current is above stored value, no major leak present; if current is below stored value, major leak present.
5 Minor leak check completed, with no minor leak detected, when current exceeds reference value.
6 Minor leak check completed, with minor leak detected, when current stabilises at or below reference current.

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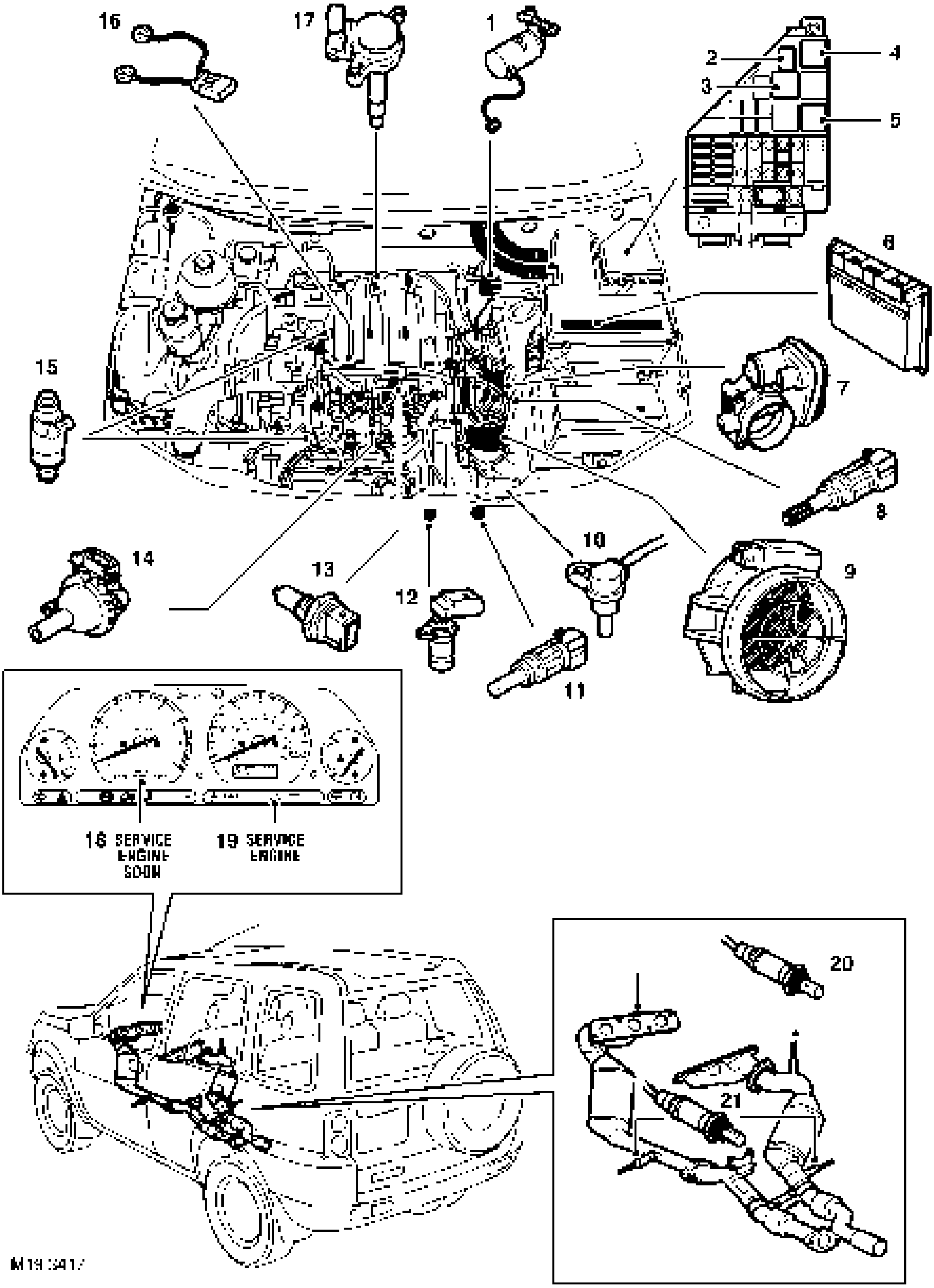
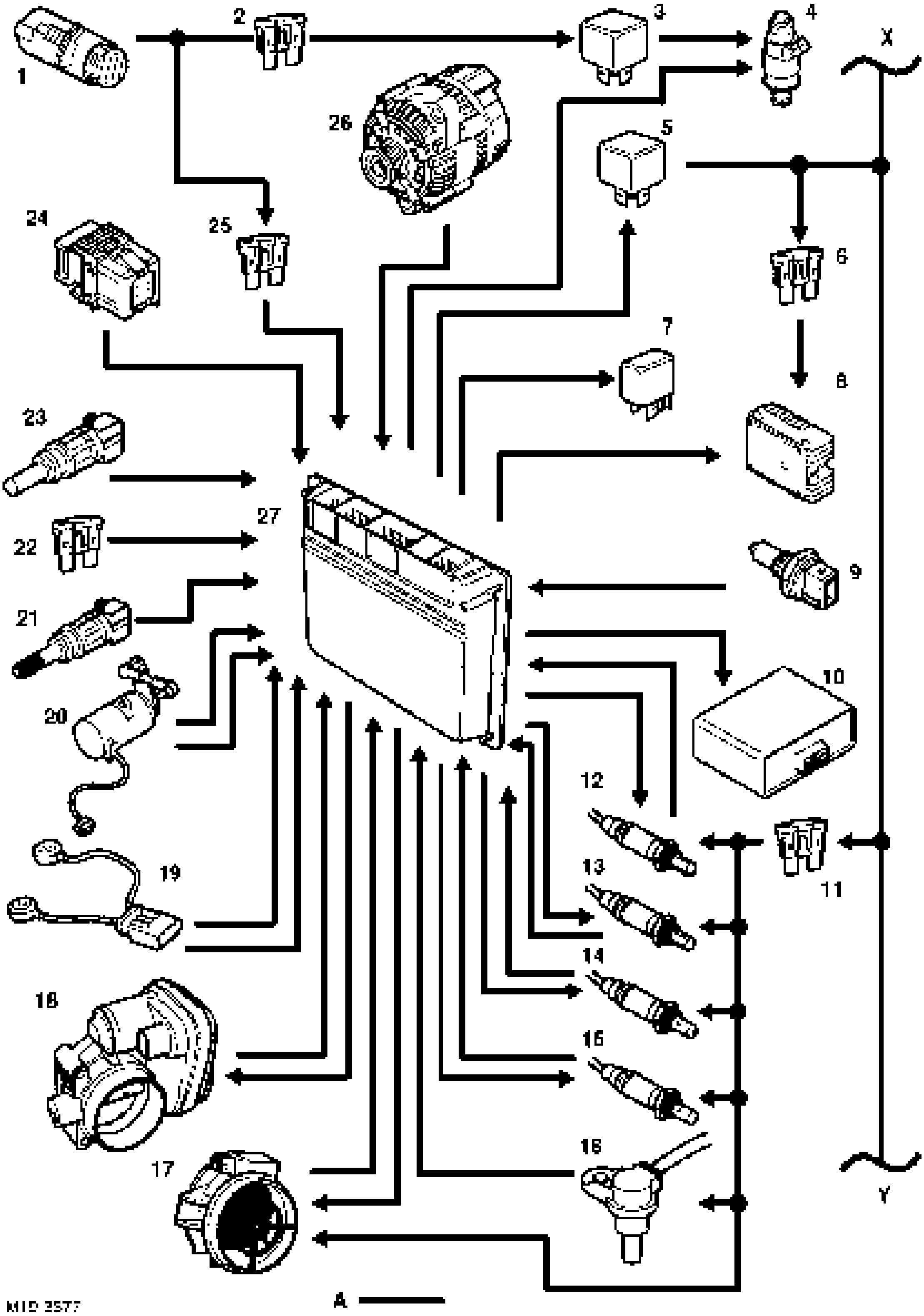
Engine Management System Component Location



1 APP sensor (Up to 2003 model year shown)
2 A/C compressor clutch relay
3 Main relay
4 ECM relay
5 Fuel pump relay
6 ECM
7 Electric throttle
8 IAT sensor
9 MAF sensor
10 CMP sensor
11 Thermostat monitoring sensor
12 CKP sensor
13 ECT sensor
14 LH bank ignition coil (x 3) (Up to 2003 model year shown)
15 Fuel injector (x 6)
16 Knock sensors
17 RH bank ignition coil (x 3) (Up to 2003 model year shown)
18 MIL
19 Engine malfunction lamp
20 Front HO2S (x 2)
21 Rear HO2S (x 2)

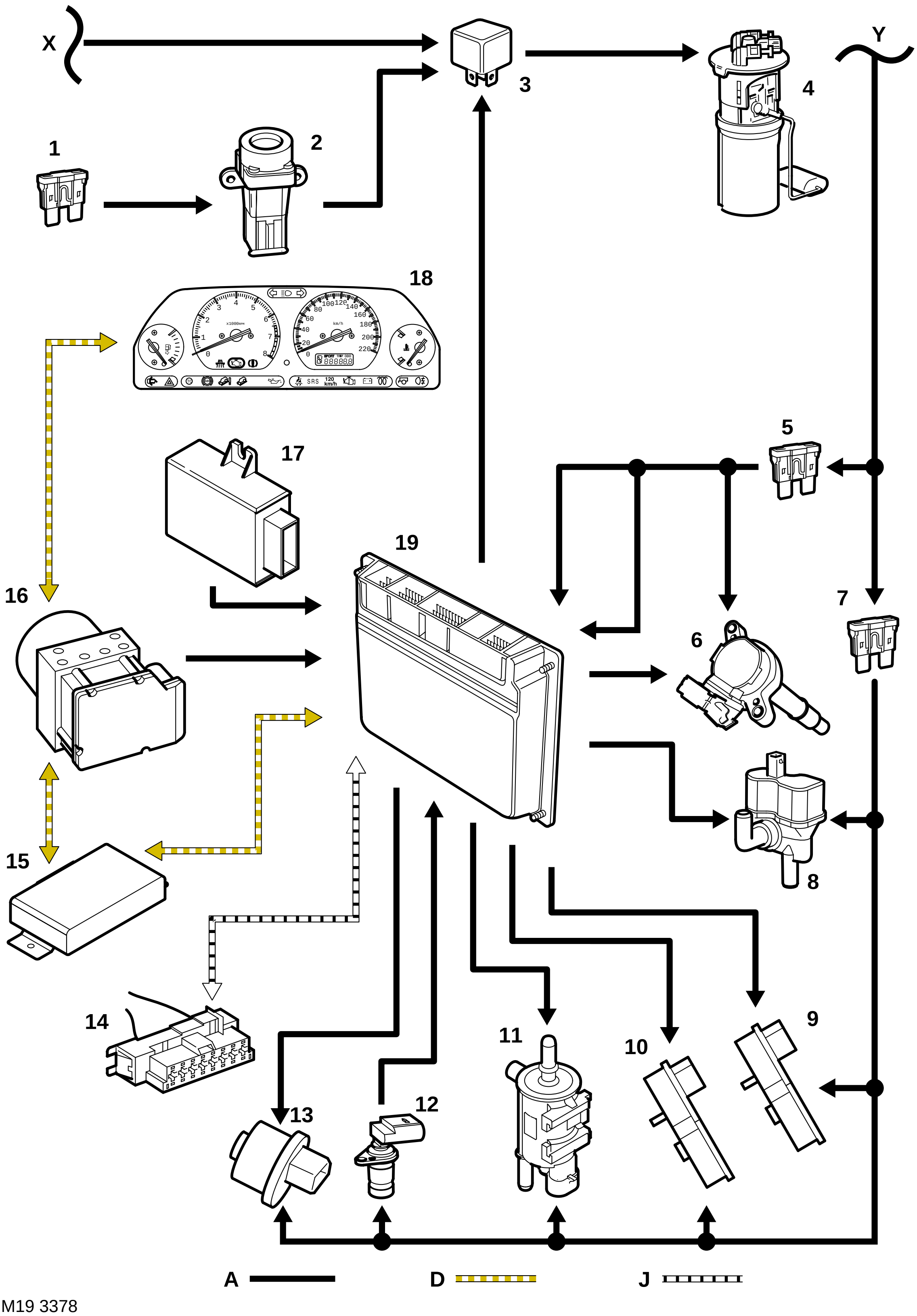
Engine Management System Control Diagram – Sheet 1 of 2



A = Hardwired connection

1 Ignition switch
2 Fuse 35, passenger compartment fusebox
3 ECM relay
4 Fuel injector (x 6)
5 Main relay
6 Fuse 4, engine compartment fusebox
7 A/C compressor relay
8 Cooling fan ECU
9 ECT sensor
10 Cruise control interface ECU
11 Fuse 3, engine compartment fusebox
12 LH front HO2S
13 RH front HO2S
14 LH rear HO2S
15 RH rear HO2S
16 CMP sensor
17 MAF sensor
18 Electric throttle
19 Knock sensors
20 APP sensor (Up to 2003 model year shown)
21 IAT sensor
22 Fuse 5, engine compartment fusebox
23 Thermostat monitoring sensor
24 Brake pedal sensor
25 Fuse 6, passenger compartment fusebox
26 Alternator
27 ECM

Engine Management System Control Diagram – Sheet 2 of 2



A = Hardwired connection; D = CAN bus; J = Diagnostic ISO 9141 K line

1 Fuse 10, engine compartment fusebox
2 Inertia fuel cut-off switch
3 Fuel pump relay
4 Fuel tank unit
5 Fuse 2, engine compartment fusebox
6 Ignition coil (x 6) (Up to 2003 model year shown)
7 Fuse 1, engine compartment fusebox
8 DMTL
9 VIS balance valve motor
10 VIS power valves motor
11 EVAP canister purge valve
12 CKP sensor
13 Vacuum enhancer solenoid valve – Up to 2003 model year
14 Diagnostic socket
15 EAT ECU
16 ABS modulator
17 Immobilisation ECU
18 Instrument pack
19 ECM

Description

General
The KV6 engine is fitted with a Siemens MS43 Engine Management System (EMS), which is an adaptive system that maintains engine performance at the optimum level throughout the life of the engine.

The EMS consists of an Engine Control Module (ECM) that uses inputs from engine sensors and from other vehicle systems to continuously monitor driver demand and the current status of the engine. From the inputs the ECM calculates the Air Fuel Ratio (AFR) and ignition timing required to match engine operation with driver demand, then outputs the necessary control signals to the electric throttle, fuel injectors and ignition coils. The ECM also outputs control signals to operate the:

- Air Conditioning (A/C) compressor.
  ☞ **AIR CONDITIONING, DESCRIPTION AND OPERATION, Description.**
- Engine cooling fans.
  ☞ **COOLING SYSTEM - K SERIES KV6, DESCRIPTION AND OPERATION, Description.**
- Evaporative emissions (EVAP) purge valve and Diagnostic Module for Tank Leakage (DMTL).
  ☞ **EMISSION CONTROL - K SERIES KV6, DESCRIPTION AND OPERATION, Description.**
- Fuel pump.
  ☞ **FUEL DELIVERY SYSTEM - K SERIES KV6, DESCRIPTION AND OPERATION, Description.**
- Variable Intake System (VIS).
  ☞ **MANIFOLD AND EXHAUST SYSTEM - K SERIES KV6, DESCRIPTION AND OPERATION, Description.**

The ECM also interfaces with the:

- Immobilisation ECU, for re-mobilisation of the engine fuel supply.
  ☞ **SECURITY, DESCRIPTION AND OPERATION, Description.**
- Cruise control interface ECU, to operate cruise control.
  ☞ **ENGINE MANAGEMENT SYSTEM - SIEMENS, DESCRIPTION AND OPERATION, Cruise Control Description.**
- Electronic Automatic Transmission (EAT) ECU, to assist with control of the gearbox.
  ☞ **AUTOMATIC GEARBOX - JATCO, DESCRIPTION AND OPERATION, Description.**

Sensor inputs and engine performance are monitored by the ECM, which illuminates the SERVICE ENGINE SOON (MIL) and/or the SERVICE ENGINE warning lamps in the instrument pack if a fault is detected.

As part of the security system's immobilisation function, a vehicle specific security code is programmed into the ECM and the immobilisation ECU during production. The ECM cannot function unless it is connected to an immobilisation ECU with the same code. In service, replacement ECM's are supplied uncoded and must be configured, using TestBook/T4, to learn the vehicle security code from the immobilisation ECU.

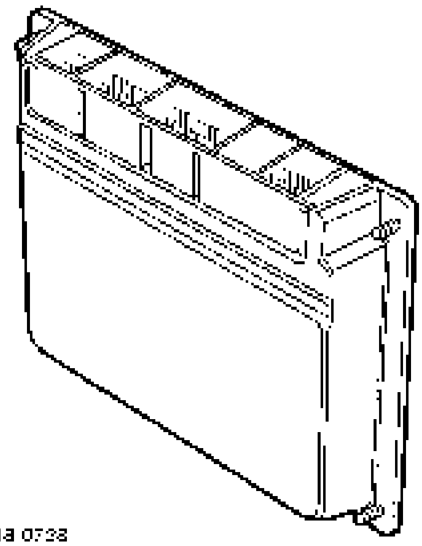
A 'flash' Electronic Erasable Programmable Read Only Memory (EEPROM) allows the ECM to be externally configured, using TestBook/T4, with market specific or new tune information up to 14 times. The current engine tune data can be accessed and read using TestBook/T4.

The ECM memorises the position of the crankshaft and the camshaft when the engine stops. During cranking on the subsequent start the ECM confirms their positions from sensor inputs before initiating fuel injection and ignition.

To achieve optimum performance the ECM is able to 'learn' the individual characteristics of an engine and adjust the fuelling calculations to suit. This capability is known as adaptive fuelling. Adaptive fuelling also allows the ECM to compensate for wear in engine components and to compensate for the tolerance variations of the engine sensors.

If the ECM suffers an internal failure, such as a breakdown of the processor or driver circuits, there is no back up system or limp home capability. If a sensor circuit fails to supply an input, where possible the ECM adopts a substitute or default value, which enables the engine to function, although with reduced performance in some cases.

ECM



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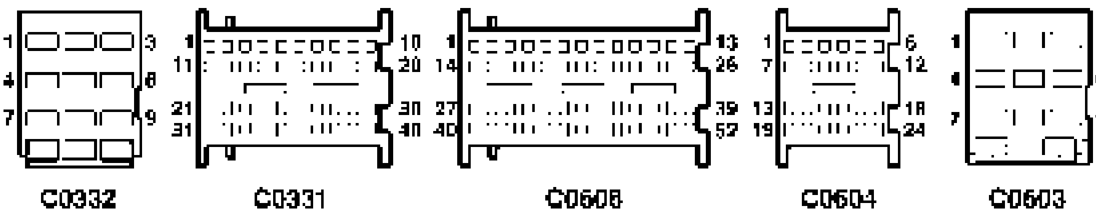
The ECM is located in the engine compartment, in the E-box. Five connectors provide the interface between the ECM and the vehicle wiring.

The E-box is a lidded container that provides a protected environment for the ECM and the EAT ECU. An open hub, centrifugal fan powered by an electric motor ventilates the E-box with air from the passenger compartment. Exhaust air from the E-box is directed back into the passenger compartment. The ventilating and exhaust air is routed between the passenger compartment and the E-box through plastic ducting and corrugated rubber hoses. Operation of the cooling fan is controlled by a thermostatic switch in the E-box. The thermostatic switch receives a power feed while the ignition switch is in position II. If the temperature in the E-box reaches 35 °C (95 °F) the thermostatic switch closes and connects the power feed to the fan, which runs to cool the E-box with air from the passenger compartment. When the temperature in the E-box decreases to 27 °C (81 °F), the thermostatic switch opens and stops the fan. To prevent the fan seizing up in colder climates, where it may not operate for long periods of time, the fan also receives a power feed direct from the starter circuit so that it runs each time the engine is cranked.

ECM Harness Connectors



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Connector C0331 Pin Details

Pin No.	Description	Input/Output
1 to 3	Not used	–
4	Engine cooling fan control	Output
5 and 6	Not used	–
7	APP sensor earth 2	–
8	APP sensor signal 2	Input
9	APP sensor supply 2	Output
10	Fuel pump relay coil	Output
11	Not used	–
12	APP sensor earth 1	–
13	APP sensor signal 1	Input
14	APP sensor supply 1	Output
15 to 19	Not used	–
20	DMTL pump motor	Output
21	Alternator load sensing	Input
22	Vehicle speed	Input
23	VIS balance valve position feedback	Input
24	Brake pedal sensor, Brake Lamp Switch (BLS) signal	Input
25	Not used	–
26	Ignition sense	Input
27	Cruise control MFL signal	Input
28	Brake pedal sensor, Brake Test Switch (BTS) signal	Input
29	A/C compressor clutch relay coil	Output
30	DMTL change-over valve	Output
31	Not used	–
32	Diagnostic ISO 9141 K line	Input/Output
33	Immobilisation ECU	Input
34	VIS power (butterfly) valves position feedback	Input
35	Not used	–
36	CAN bus high	Input/Output
37	CAN bus low	Input/Output
38	Thermostat monitoring sensor earth	–
39	Thermostat monitoring sensor signal	Input
40	Not used	–

Connector C0332 Pin Details

Pin No.	Description	Input/Output
1	Ignition coil 5	Output
2	Ignition coil 3	Output
3	Ignition coil 1	Output
4	Not used	–
5	Ignition earth	–
6	Not used	–
7	Ignition coil 4	Output
8	Ignition coil 6	Output
9	Ignition coil 2	Output

Connector C0603 Pin Details

Pin No.	Description	Input/Output
1	Ignition sense	Input
2 and 3	Not used	–
4	Electronic earth	–
5	Fuel injector earth	–
6	Power stage earth	–
7	Battery power supply	Input
8	Ignition power supply	Input
9	Ignition power supply	Input

Connector C0604 Pin Details

Pin No.	Description	Input/Output
1	LH bank front HO2S heater drive	Output
2 to 6	Not used	–
7	LH bank rear HO2S heater drive	Output
8 to 12	Not used	–
13	RH bank front HO2S heater drive	Output
14	LH bank front HO2S signal	Input
15	RH bank front HO2S signal	Input
16	LH bank rear HO2S signal	Input
17	Not used	–
18	RH bank rear HO2S signal	Input
19	RH bank rear HO2S heater drive	Output
20	LH bank front HO2S earth	–
21	RH bank front HO2S earth	–
22	LH bank rear HO2S earth	–
23	Main relay coil	Output
24	RH bank rear HO2S earth	–

Connector C0606 Pin Details

Pin No.	Description	Input/Output
1	MAF sensor signal	Input
2	Not used	–
3	Vacuum enhancer solenoid valve – Up to 2003 model year	Output
4	Not used	–
5	CMP sensor signal	Input
6	Not used	–
7	Throttle feedback potentiometer supply	Output
8	CKP sensor signal	Input
9	Not used	–
10	Throttle feedback potentiometer 2 signal	Input
11	VIS balance valve motor drive	Output
12 to 16	Not used	–
17	MAF sensor earth	–
18	CMP sensor earth	–
19	Throttle feedback potentiometer 1 signal	Input
20	Throttle feedback potentiometer earth	–
21	CKP sensor earth	–

Pin No.	Description	Input/Output
22	IAT sensor signal	Input
23	IAT sensor earth	–
24	ECT sensor signal	Input
25	ECT sensor earth	–
26 and 28	Not used	–
29	LH bank knock sensor	Input
30	LH bank knock sensor	Input
31	RH bank knock sensor	Input
32	RH bank knock sensor	Input
33	Fuel injector 1	Output
34	Fuel injector 3	Output
35	Fuel injector 5	Output
36	Fuel injector 2	Output
37	Fuel injector 6	Output
38	Fuel injector 4	Output
39 to 41	Not used	–
42	EVAP purge valve drive	Output
43	Throttle motor open drive	Output
44	Throttle motor close drive	Output
45 to 47	Not used	–
48	Knock sensors screen	Input
49	VIS power (butterfly) valves motor drive	Output
50	Not used	–
51	DMTL heater drive	Output
52	Not used	–

Controller Area Network (CAN) Bus

The ECM is connected to the Anti-lock Braking System (ABS) modulator, EAT ECU and the instrument pack by the CAN bus.

Electric Throttle

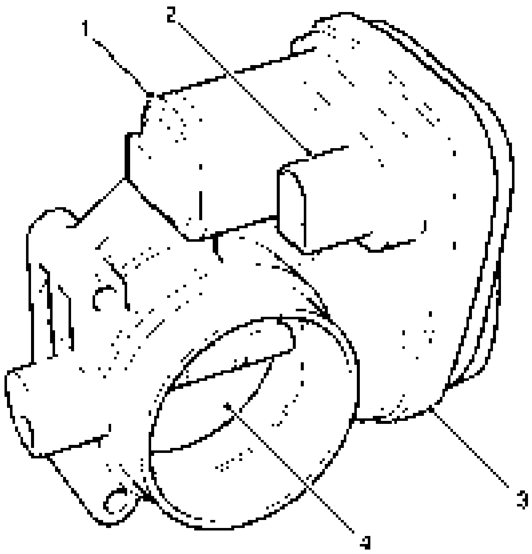
The electric throttle controls the air flow into the engine. In addition to the normal engine power control function, the electric throttle allows the cruise control, idle speed control and engine speed limiting functions to be performed without the need for additional hardware.

The electric throttle consists of a throttle body which incorporates a throttle plate driven by a DC motor via reduction gears. A return spring biases the throttle plate in the closed direction.

Operation of the DC motor is controlled by the ECM, which outputs two Pulse Width Modulated (PWM) signals to an H bridge drive circuit in the motor. The ECM varies the speed and direction of the motor by varying the duty cycle of the PWM signals.

To enable closed loop control, the position of the throttle plate is supplied to the ECM by two feedback potentiometers in the throttle body. The feedback potentiometers have a common 5 volt supply and a common ground connection from the ECM, and produce separate linear signal voltages to the ECM proportional to the position of the throttle plate. The ECM uses the signal from feedback potentiometer 1 as the primary signal of throttle plate position, and the signal from feedback potentiometer 2 for plausibility checks.

- The signal from feedback potentiometer 1 varies between 0.5 volt (0% throttle open) and 4.5 volts (100% throttle open)
- The signal from feedback potentiometer 2 varies between 4.5 volts (0% throttle open) and 0.5 volt (100% throttle open)



1 DC motor
2 Electrical connector
3 Reduction gear/ feedback potentiometer
4 Throttle plate

While the ignition is on, the ECM continuously monitors the two feedback potentiometers for short and open circuits and checks the feedback potentiometer signals, against each other and the inputs from the Accelerator Pedal Position (APP) sensor, for plausibility. If a fault is detected in the feedback potentiometer signals or the DC motor, the ECM:

- Stores a related fault code in memory.
- Illuminates the SERVICE ENGINE warning lamp in the instrument pack.
- Adopts a throttle limp home mode or disables throttle control, depending on the nature of the fault.

The throttle limp home mode adopted depends on the nature of the fault:

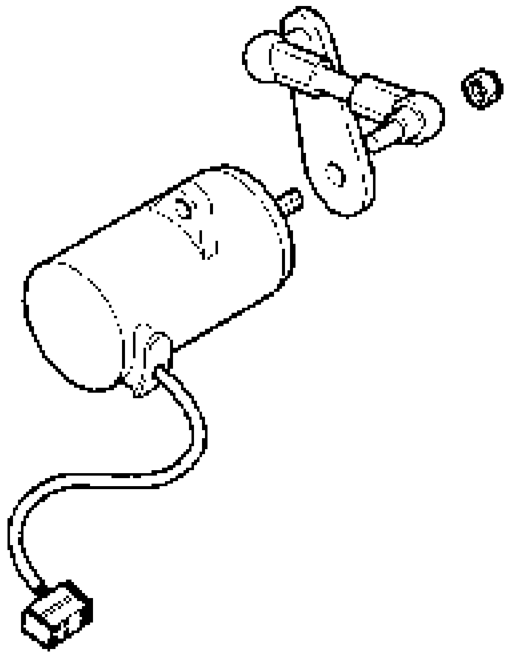
- If there is a fault with one feedback potentiometer, or the throttle position controller in the ECM, the ECM limits vehicle acceleration by limiting throttle plate opening.
- If there is a fault with both feedback potentiometers, the ECM uses fuel injection cut-off to limit engine speed to 1300 rev/min maximum.

EMS Sensors

The EMS incorporates the following sensors:

- An APP sensor.
- A Crankshaft Position (CKP) sensor.
- A Camshaft Position (CMP) sensor.
- A Mass Air Flow (MAF) sensor.
- An Intake Air Temperature (IAT) sensor.
- An Engine Coolant Temperature (ECT) sensor.
- A thermostat monitoring sensor.
- Four Heated Oxygen Sensors (HO2S).
- Two knock sensors.

APP Sensor – Up to 2003 Model Year



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The APP sensor enables the ECM to determine the throttle position requested by the driver on the accelerator pedal.

The APP sensor is installed on the pedal box and consists of a twin track potentiometer with wipers driven by a linkage connected to the accelerator pedal. Each potentiometer track has a 5 volt supply and ground connection from the ECM, and produces a linear signal voltage to the ECM proportional to the position of the accelerator pedal. The signal voltage from track 1 of the potentiometer is approximately double that of the signal voltage from track 2.

From the sensor signals, the ECM determines driver demand as a percentage of pedal travel, where 0% is with the pedal released and 100% is with the pedal fully depressed. Driver demand is then used to calculate throttle angle, fuel quantity and ignition timing. The ECM also outputs driver demand on the CAN system, for use by the brake and gearbox control systems.

The ECM stores the signal values that correspond with closed and wide open throttle, and adapts to new values to accommodate component wear or replacement.

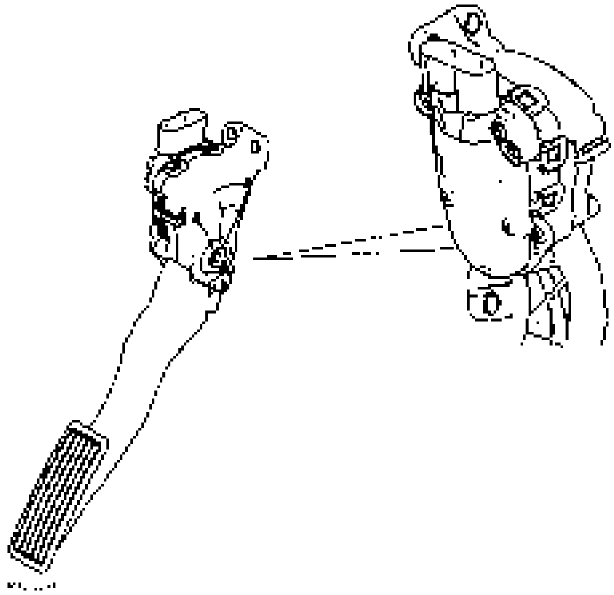
The signals from the APP sensor are monitored by the ECM for short and open circuits and plausibility. If a fault is detected, the ECM:

- Stores a related fault code in memory.
- Illuminates the SERVICE ENGINE warning lamp in the instrument pack.
- Inhibits the driver demand message on the CAN bus, which disables the Hill Descent Control (HDC) function of the ABS modulator and reduces the performance of the automatic gearbox (harsh gear changes and loss of kickdown).
- Adopts a throttle limp home mode.

The throttle limp home mode adopted depends on the nature of the fault:

- If a fault is detected with one potentiometer track, the ECM limits vehicle acceleration by limiting throttle plate opening.
- If a fault is detected with both potentiometer tracks, the ECM uses the throttle plate to run the engine at a fixed speed of 1472 rev/min while the brake pedal is released, and idle speed (750 rev/min) while the brake pedal is pressed or if there is a brake pedal sensor fault.
- If there is a process fault in the ECM, the ECM either uses fuel injection cut-off to limit engine speed to 1300 rev/min or disables fuel injection to stop the engine.

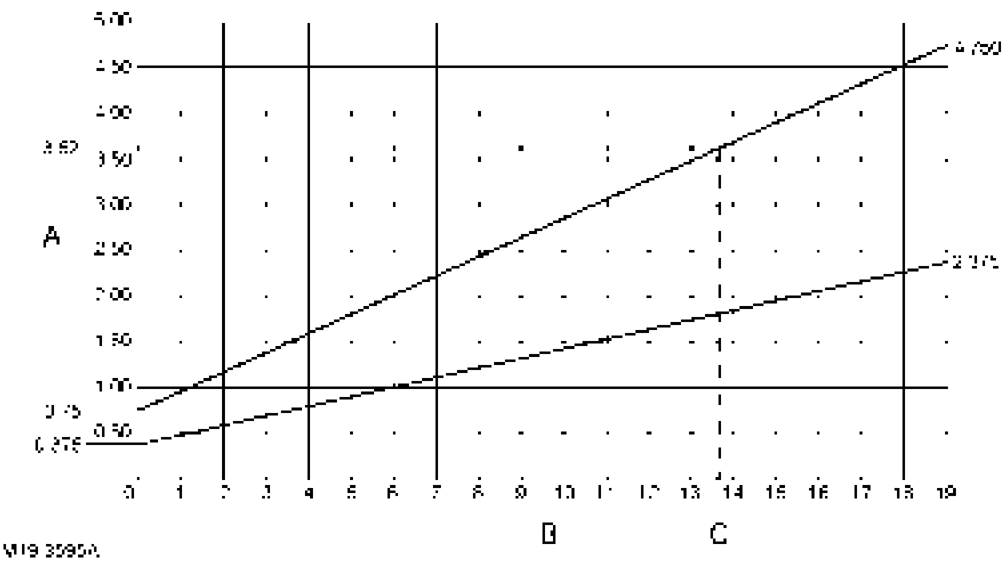
Accelerator Pedal Position (APP) Sensor – From 2003 Model Year



The APP sensor is attached to a bracket on the bulkhead. The throttle pedal is an integral part of the sensor. The pedal is attached to the sensor and rotates an internal pair of sensing elements. The pedal is also connected to two springs which provide a resistance force to pedal movement to improve feel and control.

The sensor comprises two resistance tracks (potentiometers) and two sliding contacts which are connected directly to the pedal. The sensor receives a 5V reference voltage from the ECM and outputs a linear voltage relative to the pedal position. The use of a pair of potentiometers ensures that an output signal is available should one of the tracks develop a fault.

APP Sensor Output Graph



A = Voltage
B = Pedal angle (degrees)
C = Full throttle

The ECM monitors the output signals from the APP sensor and determines the position, rate of change and direction of the throttle pedal movement. The ECM stores values which relate to closed throttle and wide open throttle and can adapt new values to compensate for component wear or replacement.

The ECM uses the closed throttle APP sensor signal to initiate idle speed control and enable an overrun fuel reduction strategy.

The APP sensor signals are also broadcast on the CAN bus and are used by the EAT ECU to determine the correct points for gearshifts and kickdown.

The ECM supplies a regulated 5V output to the APP sensor and an earth path for the potentiometer tracks. The earth path is also used as a screen to protect the integrity of the signals.

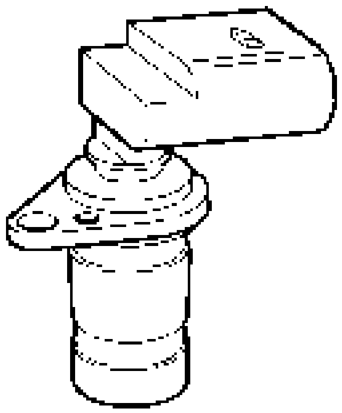
If the APP sensor fails to output a signal, the ECM uses a fail-safe mode which increases the idle speed to 1250 rev/min. The ECM will not respond to movement of the throttle pedal. In the event of a total failure to output a position signal, the following symptoms will be observed:

- No throttle pedal response
- Failure of emission control
- Automatic transmission kickdown inoperative.

The APP sensor can be tested using the following procedure:

1. Apply a 5V supply to pins 1and 2. Connect pins 4 and 5 to earth.
2. With the sensor in the idle position, check the output voltage at pin 3 – the reading should be approximately 0.73V.
3. With the sensor in the idle position, check the output voltage at pin 6 – the reading should be approximately 0.36V.

CKP Sensor



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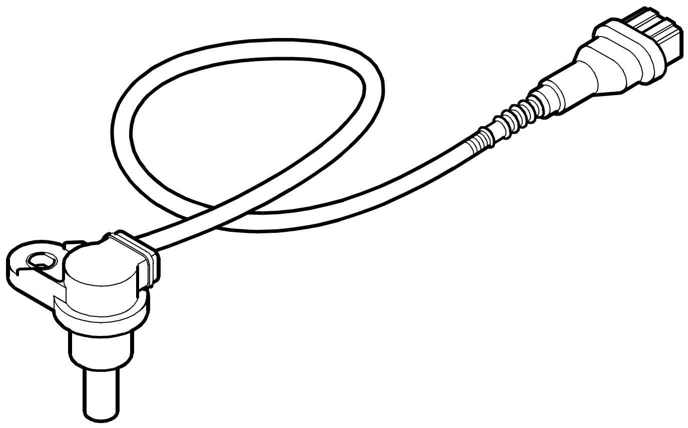
The CKP sensor provides the ECM with a digital signal of the rotational speed and angular position of the crankshaft, for use in ignition timing, fuel injection timing and fuel injection quantity calculations. To determine the exact position of the crankshaft in the engine cycle, the ECM must also use the input from the CMP sensor.

The CKP sensor is mounted on the front of the gearbox housing, in line with the outer circumference of the torque converter. The sensing tip of the CKP sensor is adjacent to a reluctor ring formed in the periphery of the torque converter. The reluctor ring has 58 teeth spaced at 6° intervals. A gap equivalent to two missing teeth, 36° After Top Dead Centre (ATDC) of No. 1 cylinder, provides the ECM with a reference point.

The CKP sensor operates using the Hall effect principle. A permanent magnet inside the sensor applies a magnetic flux to a semiconductor, which receives a power supply from the main relay. The output voltage from the semiconductor is fed to the ECM. As the gaps between the poles of the reluctor ring pass the sensor tip the magnetic flux is interrupted, causing a fluctuation of the output voltage and producing a digital signal.

If the CKP sensor fails the ECM immediately stops the engine.

CMP Sensor



M19 2837A

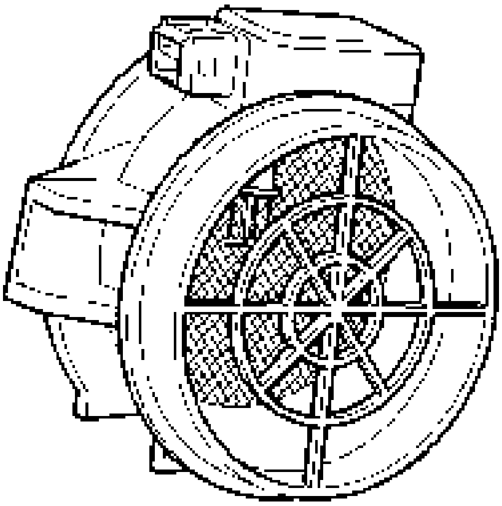
The CMP sensor provides a signal which enables the ECM to determine the position of the camshaft relative to the crankshaft. This allows the ECM to synchronise fuel injection for start and run conditions.

The CMP sensor is located on the camshaft cover of the LH (front) cylinder bank, at the opposite end to the camshaft drive, in line with a 'half moon' reluctor on the exhaust camshaft. The reluctor comprises a single tooth which extends around 180° of the camshaft circumference.

The CMP sensor operates using the Hall effect principle. A permanent magnet inside the sensor applies a magnetic flux to a semiconductor, which receives a power supply from the main relay. The output voltage from the semiconductor is fed to the ECM. As the gap in the reluctor passes the sensor tip, the magnetic flux is interrupted, causing a fluctuation of the output voltage and producing a digital signal.

If the CMP sensor fails during engine running, the engine will run normally until turned off, but will not restart until the CMP sensor input is restored.

MAF Sensor



M18 0712

The MAF sensor provides a signal which the ECM uses for engine load calculations.

The MAF sensor is a hot film type, and is located in the intake system between the air filter housing and the throttle body.

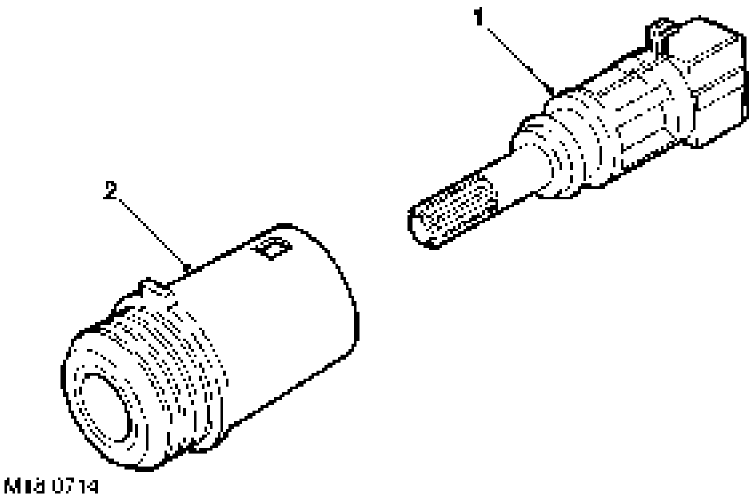
A closed-loop control circuit in the MAF sensor maintains a thick film resistor at a constant 200°C (392°F) above ambient temperature. The current required to maintain the temperature of the thick film resistor, against the cooling effect of the air flowing through the sensor, provides a precise, non-linear, measure of the air mass entering the engine.

The MAF sensor receives a battery voltage power supply and generates an output signal to the ECM, between 0 and 5 volts, which is proportional to the air mass drawn into the engine.

In the event of a MAF sensor signal failure, the following symptoms may be apparent:

- During driving engine speed may dip before recovering.
- Difficult starting.
- Engine stalls after starting.
- Delayed throttle response.
- Reduced engine performance.

IAT Sensor



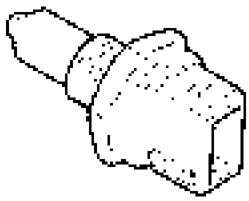
1 Sensor
2 Housing

The IAT sensor provides a signal that enables the ECM to adjust ignition timing and fuelling quantity according to the intake air temperature, thus ensuring optimum performance, driveability and emissions.

The IAT sensor is a Negative Temperature Coefficient (NTC) thermistor located in a plastic housing installed in the intake duct between the MAF sensor and the throttle body. The sensor is a push fit in the housing and sealed by an 'O' ring. A clip is integrated into the sensor to secure it in the housing.

If the input from the IAT sensor fails, the vehicle will continue to run. The ECM will substitute a default value using the information from the speed/load map to run the engine, but adaptive fuelling will be disabled.

ECT Sensor



M18 0715

The ECT sensor provides the ECM with a signal voltage that varies with coolant temperature, to enable the ECM to adapt the fuelling quantity and ignition timing with changes of engine temperature.

The ECT sensor is located between the cylinder banks, between cylinders 3 and 6.

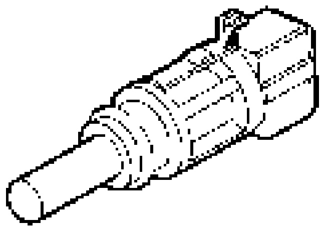
The ECT sensor consists of an encapsulated Negative Temperature Coefficient (NTC) thermistor which is in contact with the engine coolant. As the coolant temperature increases the resistance across the sensor decreases and as the coolant temperature decreases the sensor resistance increases. To determine the coolant temperature, the ECM supplies the sensor with a regulated 5 volts power supply and monitors the return signal voltage. The ECM also outputs the coolant temperature on the CAN system, to operate the coolant temperature gauge.

If the ECT signal is missing, or outside the acceptable range, the ECM assumes a default temperature reflecting a part warm engine condition. This enables the engine to function, but with reduced driveability when cold and increased emissions, resulting from an over rich mixture, when the engine reaches normal operating temperature. The ECM will also switch on the cooling fans to prevent the engine and gearbox from overheating.

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

Engine coolant Temperature °C (°F)	Sensor Resistance kΩ
- 40 (- 40)	75.501
- 30 (-22)	39.764
-20 (-4)	21.883
-10 (14)	12.452
0 (32)	7.353
10 (50)	4.482
20 (68)	2.814
30 (86)	1.814
40 (104)	1.199
50 (122)	0.8109
60 (140)	0.5601
70 (158)	0.3945
80 (176)	0.2829
90 (194)	0.2064
100 (212)	0.1529
110 (230)	0.1149
120 (248)	0.08761
130 (266)	0.06762
140 (284)	0.05281
150 (302)	0.04171

Thermostat Monitoring Sensor

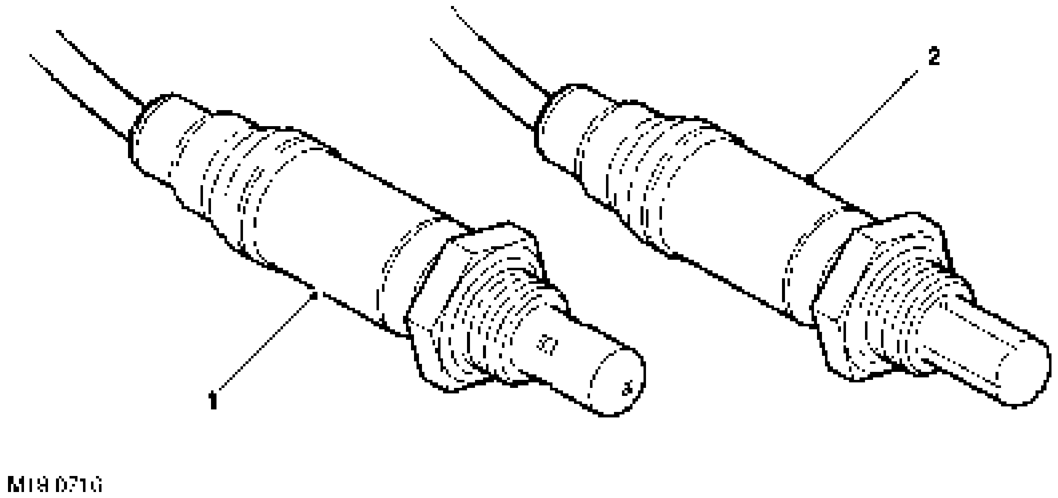


M18 0715

The input from the thermostat monitoring sensor is used by the ECM to monitor the operation of the cooling system thermostat and to control the operation of the engine cooling fans.

The thermostat monitoring sensor is a NTC thermistor installed in a plastic 'T' piece in the radiator bottom hose. The sensor is a push fit in the T piece and sealed by an 'O' ring. A clip is integrated into the sensor to secure it in the T piece.

HO2S



1 Rear HO2S

2 Front HO2S

The EMS has four HO2S:

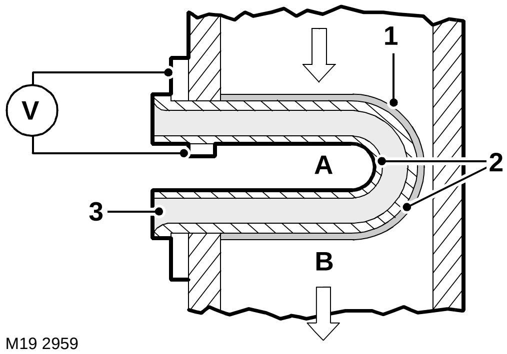
- One upstream of each catalytic converter, identified as LH and RH front HO2S.
- One downstream of each catalytic converter, identified as LH and RH rear HO2S.

The LH and RH front HO2S enable the ECM to determine the AFR of the mixture being burned in each cylinder bank of the engine. The LH and RH rear HO2S enable the ECM to monitor the performance of the catalytic converters and the front oxygen sensors, and trim fuel.

Each HO2S consists of a sensing element with a protective ceramic coating on the outer surface. The outer surface of the sensing element is exposed to the exhaust gas, and the inner surface is exposed to ambient air. The difference in the oxygen content of the two gases produces an electrical potential difference across the sensing element. With a rich mixture, the low oxygen content in the exhaust gas results in a higher sensor voltage. With a lean mixture, the high oxygen content in the exhaust gas results in a lower sensor voltage.

During closed loop control, the voltage of the two front HO2S switches from less than 0.3 volt to more than 0.5 volt. The voltage switches between limits every two to three seconds. This switching action indicates that the ECM is varying the AFR within the Lambda window tolerance, to maximise the efficiency of the catalytic converters.

Sectioned View of HO2S



A = Ambient air; B = Exhaust gases

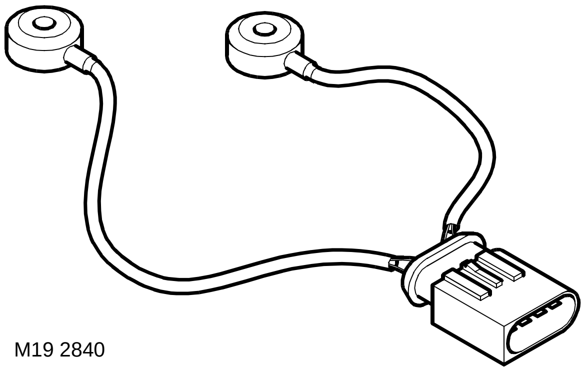
1 Protective ceramic coating
2 Electrodes
3 Zirconium oxide

The material of the sensing element only becomes active at a temperature of approximately 300 °C (570 °F). To shorten the warm up time and minimise the emissions from a cold start and low load conditions, each HO2S contains a heating element powered by a supply from the main relay. The earth paths for the heating elements are controlled by the ECM. On start up, the current supplied to the heating elements is increased gradually to prevent sudden heating from damaging the ceramic coating. After the initial warm up period the ECM modulates the earth of the heating elements, from a map of engine speed against mass air flow, to maintain the HO2S at the optimum operating temperature.

The nominal resistance of the heating elements is 6 Ω at 20°C (68°F).

If an HO2S fails, the ECM illuminates the MIL. If a front HO2S fails the ECM also adopts open loop fuelling and catalytic converter monitoring is disabled. If a rear HO2S fails, catalytic converter and front HO2S monitoring is disabled.

Knock Sensors



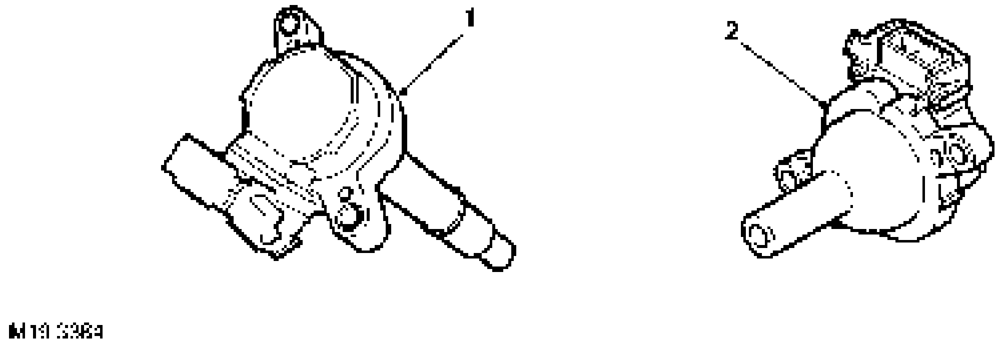
M19 2840

The knock sensors enable the ECM to operate the engine at the limits of ignition advance, for optimum efficiency, without combustion knock damaging the engine. The ECM uses two knock sensors, one for each cylinder bank, located between the cylinder banks on cylinders 3 and 4.

The knock sensors consist of piezo ceramic crystals that oscillate to create a voltage signal. During combustion knock, the frequency of crystal oscillation increases, which alters the signal output to the ECM. The ECM compares the signal to known signal profiles in its memory. If the onset of combustion knock is detected the ECM retards the ignition timing for a number of cycles. When the combustion knock stops, the ignition timing is gradually advanced to the original setting.

The knock sensor leads are of different lengths to prevent incorrect installation.

Ignition Coils – Up to 2003 Model Year



1 RH bank ignition coil

2 LH bank ignition coil

The ECM uses a separate ignition coil for each spark plug. The ignition coils for the LH bank spark plugs are positioned on the forward tracts of the inlet manifold and connected to the spark plugs with High Tension (HT) leads. The ignition coils for the RH bank spark plugs are of the plug top design, secured to the camshaft cover with 2 screws.

Each ignition coil has 3 connections in addition to the spark plug connection; an ignition feed from the main relay, an earth wire for the secondary winding and a primary winding negative (switch) terminal. The switch terminal of each ignition coil is connected to a separate pin on the ECM to allow independent switching. The ignition coils are charged whenever the ECM supplies an earth path to the primary winding negative terminal. The duration of the charge time is held relatively constant by the ECM for all engine speeds. Consequently, the dwell period increases with engine speed. This type of system, referred to as Constant Energy, allows the use of low impedance coils with faster charge times and higher outputs.

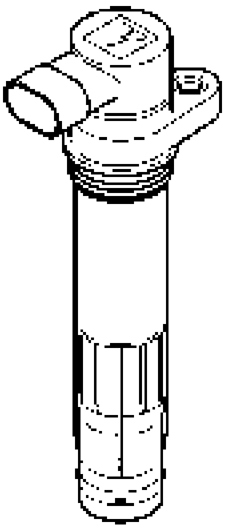
The ECM calculates the dwell period using inputs from the following:

- Battery voltage (main relay).
- CKP sensor.
- Ignition coil primary current (internal ECM connection).

The spark is produced when the ECM breaks the primary winding circuit. This causes the magnetic flux around the primary winding to collapse, inducing HT energy in the secondary coil, which can only pass to earth by bridging the air gap of the spark plug.

Ignition related faults are monitored indirectly by the misfire detection function.

Ignition Coils – From 2003 Model Year



M18 0904

A new 'pencil' type ignition coil is introduced at 2003 model year. This coil is used on all six cylinders and replaces the two coils used previously. The ECM uses a separate ignition coil for each spark plug. The ignition coils are of the plug top 'pencil' design which attach to the top of the spark plug. The coils are secured to the camshaft cover with a screw. The coil has a ribbed area which seals the coil in the spark plug hole in the cylinder head, preventing the ingress of moisture and debris around the spark plug. These coils eliminate the requirement for HT leads which in turn improves the ignition system reliability.

Each coil has a three pin female connector which provide for a battery voltage ignition feed from the main relay, an earth for the secondary winding and a primary winding negative (switch) terminal. The switch terminal of each coil is connected to a separate pin on the ECM to allow independent switching.

The ignition coils are charged when the ECM provides an earth path to the primary winding negative terminal. The duration of the charge time is maintained relatively constant by the ECM for all engine speeds with the dwell period increasing with engine speed. This type of system, referred to as constant energy, allows the use of low impedance coils with faster charge times and higher outputs. The dwell period is calculated by the ECM using a closed loop system to limit the current in the system and minimise output energy at low engine speeds. The ECM calculates the dwell angle using the following inputs for reference:

- Battery voltage (from main relay)
- CKP sensor
- Ignition coil primary current (from internal connection within the ECM).

The primary coil has a resistance of approximately 0.547Ω. The secondary coil resistance cannot be measured due to a diode in the secondary winding. The ECM monitors the ignition system using the misfire detection function.

The spark is produced when the ECM breaks the primary coil winding circuit. This causes the magnetic flux around the primary winding to collapse, inducing HT energy in the secondary coil, which can only pass to earth by bridging the air gap of the spark plug.

Ignition Timing

The ECM calculates ignition timing using inputs from the following sensors:

- CKP sensor.
- MAF sensor.
- Knock sensors.
- TP sensor (idle only).
- ECT sensor.

At start up and idle the ECM sets ignition timing by referencing the ECT and CKP sensors. Once above idle the ignition timing is controlled according to maps stored in the ECM memory and modified according to additional sensor inputs and any adaptive value stored in memory. The maps keep the ignition timing within a narrow band that gives an acceptable compromise between power output and emission control. The ignition timing advance and retard is controlled by the ECM in order to avoid combustion knock.

Knock Control

The ECM uses active knock control to prevent combustion knock damaging the engine. If the knock sensor inputs indicate the onset of combustion knock, the ECM retards the ignition timing for that particular cylinder by 3°. If the combustion knock indication continues, the ECM further retards the ignition timing, in decrements of 3°, for a maximum of 15° from where the onset of combustion knock was first sensed. When the combustion knock indication stops, the ECM restores the original ignition timing in increments of 0.75°.

To reduce the risk of combustion knock at high intake air temperatures, the ECM retards the ignition timing if the intake air temperature exceeds 55 °C (169 °F). The amount of ignition retard increases with increasing air intake temperature.

Idle Speed Control

The ECM controls the engine idle speed using a combination of fuelling, ignition timing and the electric throttle.

When the engine idle speed fluctuates the ECM initially varies the ignition timing, which produces rapid changes of engine speed. If this fails to correct the idle speed, the ECM also adjusts the electric throttle and fuelling.

Misfire Detection

The ECM uses the CKP sensor input to monitor the engine for misfires. As the combustion charge in each cylinder is ignited the crankshaft accelerates, then subsequently decelerates. By monitoring the acceleration/ deceleration pulses of the crankshaft the ECM can detect misfires.

Low fuel level:

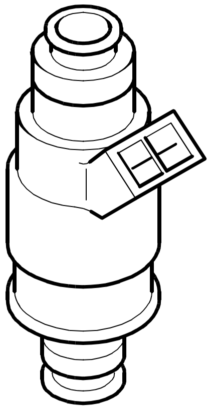
When the fuel tank is almost empty there is a risk that air may be drawn into the fuel system, due to fuel 'slosh', causing fuel starvation and misfires. To prevent false misfire faults being logged, the ECM disables misfire detection if it receives a low fuel level message on the CAN bus. Fuel tank content is monitored by the instrument pack, which transmits the low fuel level message if the fuel tank content decreases to less than 15% (8.85 litres; 2.34 US galls).

Rough road disable:

When the vehicle is travelling over a rough road surface the engine crankshaft is subjected to torsional vibrations caused by mechanical feedback from the road surface through the transmission. To prevent misinterpretation of these torsional vibrations as a misfire, the misfire monitor is disabled when a road surface exceeds a roughness limit programmed into the ECM. The roughness of the road is calculated by the ABS modulator, from the four ABS sensor inputs, and transmitted to the ECM on the CAN bus.

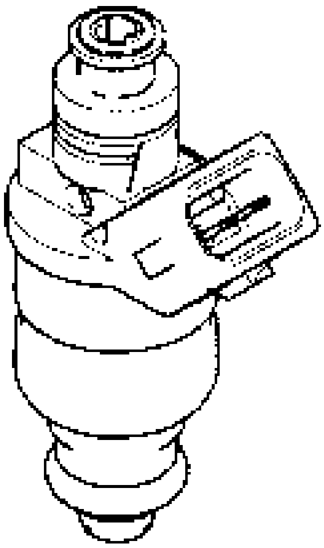
Fuel Injectors

Fuel Injector – Up to 2003 Model Year



M19 2845A

Fuel Injector – From 2003 Model Year



M19 3597

Up to 2003 Model Year

A split stream, air assisted fuel injector is installed for each cylinder. The injectors are located in the inlet manifolds and connected to a common fuel rail assembly.

Each injector contains a pintle type needle valve and a solenoid winding. The needle valve is held closed by a return spring. An integral nozzle shroud contains a ported disc, adjacent to the nozzles. 'O' rings seal the injector in the fuel rail and the inlet manifold.

The solenoid winding of each injector receives a 12 volt supply from the ECM relay in the engine compartment fusebox. To inject fuel, the ECM supplies an earth path to the solenoid winding, which energises and opens the needle valve. When the needle valve opens, the two nozzles direct a spray of atomised fuel onto the back of each inlet valve. Air drawn through the shroud and ported disc improves atomisation and directional control of the fuel. The air is supplied from a dedicated port in the intake duct via a plastic tube and tracts formed in the gasket face of the intake manifolds.

From 2003 Model Year

New injectors are introduced for 2003 model year. The air assist feature is deleted and a standard design injector installed. The deletion of the air assist injectors also required modifications to the fuel rail, inlet manifold and clean air duct.

The injectors are located in the inlet manifold and sealed with O-ring seals. The injectors are attached to the fuel rail with clips and sealed with O-ring seals. A two pin connector on the injector allows for the attachment of the engine harness connector.

Each injector contains a pintle type needle valve and a solenoid winding. The needle valve is held closed by a return spring. The solenoid winding of each injector receives a 12 volt supply from the ECM relay in the engine compartment fusebox. To inject fuel, the ECM supplies an earth path to the solenoid winding, which energises and opens the needle valve. When the needle valve opens, the two nozzles direct a spray of atomised fuel onto the back of each inlet valve.

All Models

Each injector delivers fuel once per engine cycle, during the inlet stroke. The ECM calculates the open time (duty cycle) of the injectors from:

- Engine speed.
- Mass air flow.
- Engine temperature.
- Accelerator pedal position (i.e. driver demand).

The fuel in the fuel rail is maintained at a pressure of 3.5 bar (51 lbf/in^2) by a pressure regulator incorporated into the pump unit in the fuel tank. An accumulator is attached to the LH fuel rail, to damp out pressure pulses from the pump and ensure that the pressure in the fuel rail is constant. A Schraeder valve is installed in the fuel rail, above the accumulator, to provide a pressure test connection for maintenance.

The nominal resistance of the injector solenoid winding is 13 - 16 Ω at 20°C (68°F).

Evaporative Emissions (EVAP) Purge Valve

The ECM provides a PWM earth path to control the operation of the purge valve. When the ECM is in the open loop fuelling mode the purge valve is kept closed. When the vehicle is moving and in the closed loop fuelling mode the ECM opens the purge valve.

When the purge valve is open fuel vapour is drawn from the EVAP canister into the inlet manifold. The ECM detects the resultant enrichment of the AFR, from the inputs of the front HO2S, and compensates by reducing the duty cycle of the fuel injectors.

Variable Intake System (VIS) Valves

The ECM operates the two VIS valve motors to open and close the VIS valves in a predetermined sequence based on engine speed and throttle opening. Each VIS valve motor has a permanent power feed from the main relay, feedback and signal connections with the ECM, and a permanent earth connection. When the engine starts, the VIS valve motors are both in the valve open position. To close the VIS valves, the ECM applies a power feed to the signal line of the applicable VIS valve motor. To open the VIS valves, the ECM disconnects the power feed from the signal line and the VIS valve motor is closed by the power feed from the main relay.

Warning Lamps

Two warning lamps in the instrument are used to indicate faults with the engine management system. The engine malfunction lamp consists of an amber SERVICE ENGINE legend and is illuminated to indicate the detection of a non emissions related fault. The Malfunction Indicator Lamp (MIL) consists of an amber SERVICE ENGINE SOON legend and is illuminated to indicate the detection of an emissions related fault. The ECM operates the warning lamps, by communicating with the instrument pack on the CAN bus. If a fault that can cause catalytic converter damage is detected, the warning lamps flash. For other faults the warning lamps are continuously illuminated.

Diagnostics
The ECM incorporates On Board Diagnostics (OBD) software that complies with market legislation current at the time of manufacture. During engine operation the ECM performs self test and diagnostic routines to monitor the performance of the engine and the EMS. If a fault is detected the ECM stores a related Diagnostic Trouble Code (DTC, also known as a 'P' code) in a non volatile memory and, for most faults, illuminates the engine SERVICE ENGINE (MIL) and/or the SERVICE ENGINE SOON warning lamps. Codes are retrieved using TestBook/T4, which communicates with the ECM via an ISO 9141 K line connection from the diagnostic socket.

P Code No.	Component/Signal	Fault Description	Warning Lamp		Drive Cycle
			SERVICE ENGINE (MIL)	SERVICE ENGINE SOON	
0030	Pre CAT LH bank HO2S heater	Open circuit	Yes	No	C
0031	Pre CAT LH bank HO2S heater	Short circuit to earth	Yes	No	C
0032	Pre CAT LH bank HO2S heater	Short circuit to battery	Yes	No	C
0036	Post CAT LH bank HO2S heater	Open circuit	Yes	No	C
0037	Post CAT LH bank HO2S heater	Short circuit to earth	Yes	No	C
0038	Post CAT LH bank HO2S heater	Short circuit to battery	Yes	No	C
0050	Pre CAT RH bank HO2S heater	Open circuit	Yes	No	C
0051	Pre CAT RH bank HO2S heater	Short circuit to earth	Yes	No	C
0052	Pre CAT RH bank HO2S heater	Short circuit to battery	Yes	No	C
0056	Post CAT RH bank HO2S heater	Open circuit	Yes	No	C
0057	Post CAT RH bank HO2S heater	Short circuit to earth	Yes	No	C
0058	Post CAT RH bank HO2S heater	Short circuit to battery	Yes	No	C
0100	MAF sensor signal	Open circuit	No	No	—
0101	MAF sensor signal	Signal implausible	Yes	No	B
0102	MAF sensor signal	Short circuit to earth	Yes	No	A
0103	MAF sensor signal	Short circuit to battery	Yes	No	A
0105	ECM internal ambient pressure sensor	Circuit malfunction	No	No	—
0107	ECM internal ambient pressure sensor	Short circuit to earth	Yes	No	A
0108	ECM internal ambient pressure sensor	Open circuit or short circuit to battery	Yes	No	A
0109	ECM internal ambient pressure sensor	Circuit intermittent	No	No	—
0112	IAT sensor	Short circuit to earth	Yes	No	B
0113	IAT sensor	Open circuit or short circuit to battery	Yes	No	B
0116	ECT sensor	Signal implausible	Yes	No	B
0117	ECT sensor	Short circuit to earth	Yes	No	B
0118	ECT sensor	Open circuit or short circuit to battery	Yes	No	B
0122	Throttle potentiometer 1	Open circuit or short circuit to earth	Yes	Yes	B

P Code No.	Component/Signal	Fault Description	Warning Lamp		Drive Cycle
			SERVICE ENGINE (MIL)	SERVICE ENGINE SOON	
0123	Throttle potentiometer 1	Short circuit to battery	Yes	Yes	B
0125	ECT sensor	Open circuit, short circuit to ground or signal implausible	No	No	—
0128	Thermostat monitoring sensor	Low coolant temperature – thermostat stuck open	Yes	No	B
0130	LH bank front HO2S signal	Open circuit	Yes	No	C
0131	LH bank front HO2S signal	Short circuit to earth	Yes	No	C
0132	LH bank front HO2S signal	Short circuit to battery	Yes	No	C
0133	LH bank front HO2S signal	Slow response	Yes	No	C
0134	LH bank front HO2S signal	Signal not switching	Yes	No	C
0135	LH bank front HO2S heater circuit	Open circuit or short circuit to battery or earth	No	No	—
0136	LH bank rear HO2S signal	Open circuit	Yes	No	C
0137	LH bank rear HO2S signal	Short circuit to earth	Yes	No	C
0138	LH bank rear HO2S signal	Short circuit to battery	Yes	No	C
0139	LH bank rear HO2S signal	Slow response	Yes	No	C+
0140	LH bank rear HO2S signal	No activity	Yes	No	C+
0141	LH bank rear HO2S heater circuit	Open circuit or short circuit to battery or earth	No	No	—
0150	RH bank front HO2S signal	Open circuit	Yes	No	C
0151	RH bank front HO2S signal	Short circuit to earth	Yes	No	C
0152	RH bank front HO2S signal	Short circuit to battery	Yes	No	C
0153	RH bank front HO2S signal	Slow response	Yes	No	C
0154	RH bank front HO2S signal	Signal not switching	Yes	No	C
0155	RH bank front HO2S heater circuit	Open circuit or short circuit to battery or earth	No	No	—
0156	RH bank rear HO2S signal	Open circuit	Yes	No	C
0157	RH bank rear HO2S signal	Short circuit to earth	Yes	No	C
0158	RH bank rear HO2S signal	Short circuit to battery	Yes	No	C
0159	RH bank rear HO2S signal	Slow response	Yes	No	C
0160	RH bank rear HO2S signal	No activity	Yes	No	C+
0161	RH bank rear HO2S heater circuit	Open circuit or short circuit to battery or earth	No	No	—
0171	LH bank lambda control	Fuelling too lean	Yes	No	C
0172	LH bank lambda control	Fuelling too rich	Yes	No	C
0174	RH bank lambda control	Fuelling too lean	Yes	No	C
0175	RH bank lambda control	Fuelling too rich	Yes	No	C
0201	Fuel injector 1	Open circuit	Yes	No	A
0202	Fuel injector 2	Open circuit	Yes	No	A
0203	Fuel injector 3	Open circuit	Yes	No	A
0204	Fuel injector 4	Open circuit	Yes	No	A
0205	Fuel injector 5	Open circuit	Yes	No	A
0206	Fuel injector 6	Open circuit	Yes	No	A
0222	Throttle potentiometer 2	Open circuit or short circuit to earth	Yes	Yes	B
0223	Throttle potentiometer 2	Short circuit to battery	Yes	Yes	B
0261	Fuel injector 1	Short circuit to earth	Yes	No	A
0262	Fuel injector 1	Short circuit to battery	Yes	No	A
0264	Fuel injector 2	Short circuit to earth	Yes	No	A
0265	Fuel injector 2	Short circuit to battery	Yes	No	A
0267	Fuel injector 3	Short circuit to earth	Yes	No	A

P Code No.	Component/Signal	Fault Description	Warning Lamp		Drive Cycle
			SERVICE ENGINE (MIL)	SERVICE ENGINE SOON	
0268	Fuel injector 3	Short circuit to battery	Yes	No	A
0270	Fuel injector 4	Short circuit to earth	Yes	No	A
0271	Fuel injector 4	Short circuit to battery	Yes	No	A
0273	Fuel injector 5	Short circuit to earth	Yes	No	A
0274	Fuel injector 5	Short circuit to battery	Yes	No	A
0276	Fuel injector 6	Short circuit to earth	Yes	No	A
0277	Fuel injector 6	Short circuit to battery	Yes	No	A
0301	Cylinder 1	Misfire detected	Yes	No	B
0302	Cylinder 2	Misfire detected	Yes	No	B
0303	Cylinder 3	Misfire detected	Yes	No	B
0304	Cylinder 4	Misfire detected	Yes	No	B
0305	Cylinder 5	Misfire detected	Yes	No	B
0306	Cylinder 6	Misfire detected	Yes	No	B
0313	Misfire detection	Misfire detected at low fuel level	Yes	No	B
0327	LH bank knock sensor	Open circuit	Yes	No	B
0332	RH bank knock sensor	Open circuit	Yes	No	B
0335	CKP sensor	Open circuit or No signal	No	No	A
0336	CKP sensor	Signal implausible	No	No	A
0337	CKP sensor	Short circuit to earth	No	No	—
0338	CKP sensor	Short circuit to battery	No	No	—
0339	CKP sensor	Open circuit/no signal	No	No	—
0340	CMP sensor	Open circuit/no signal	Yes	No	A
0341	CMP sensor	Signal implausible	Yes	No	A
0351	Ignition coil 1	No spark	No	No	A
0352	Ignition coil 2	No spark	No	No	A
0353	Ignition coil 3	No spark	No	No	A
0354	Ignition coil 4	No spark	No	No	A
0355	Ignition coil 5	No spark	No	No	A
0356	Ignition coil 6	No spark	No	No	A
0420	LH bank catalytic converter	Efficiency below threshold – light off too long	Yes	No	C
0430	RH bank catalytic converter	Efficiency below threshold – light off too long	Yes	No	C
0441	Diagnostics	EVAP purge flow test failure	Yes	No	B
0442	EVAP system	Minor leak	Yes	No	F
0443	Purge valve	Short circuit to battery	Yes	No	A
0444	Purge valve	Open circuit	Yes	No	A
0445	Purge valve	Short circuit to earth	Yes	No	A
0455	EVAP system	Major leak	Yes	No	F
0500	Vehicle speed signal	Signal implausible	Yes	No	B
0505	ECM idle speed control	System malfunction	Yes	No	A
0600	CAN Bus	CAN bus off	Yes	No	A
0606	ECM	Processor fault	Yes	No	A
1071	LH bank front HO2S	Too lean	Yes	No	C
1072	LH bank front HO2S	Too rich	Yes	No	C
1074	RH bank front HO2S	Too lean	Yes	No	C
1075	RH bank front HO2S	Too rich	Yes	No	C
1101	MAF sensor	Signal implausible for throttle angle	No	No	—

P Code No.	Component/Signal	Fault Description	Warning Lamp		Drive Cycle
			SERVICE ENGINE (MIL)	SERVICE ENGINE SOON	
1113	ECM internal ambient pressure sensor	Automatic section failure	No	No	—
1115	Thermostat monitoring sensor	Coolant temperature stuck high	No	No	B
1117	Thermostat monitoring sensor	Short circuit to earth	Yes	No	B
1118	Thermostat monitoring sensor	Open circuit or short circuit to battery	Yes	No	B
1119	Thermostat monitoring sensor	Short circuit to earth	No	No	—
1122	APP sensor potentiometer 1	Open circuit or short circuit to earth	No	Yes	—
1123	APP sensor potentiometer 1	Short circuit to battery	No	Yes	—
1132	LH bank front HO2S	Heating defective	Yes	No	C
1133	RH bank front HO2S	Heating defective	Yes	No	C
1134	LH bank front HO2S	Slow response time	Yes	No	C
1135	LH bank front HO2S	Rich to lean time slow	Yes	No	C
1136	LH bank front HO2S	Lean to rich time slow	Yes	No	C
1141	Throttle potentiometer 1	Ratio of throttle potentiometer 1 signal to air flow implausible	Yes	Yes	B
1142	Throttle potentiometer 2	Ratio of throttle potentiometer 2 signal to air flow implausible	Yes	Yes	B
1146	LH bank lambda control	Downstream fuel trim above lean delay time	Yes	No	C
1147	RH bank lambda control	Downstream fuel trim above lean delay time	Yes	No	C
1148	LH bank lambda control	Downstream fuel trim above rich delay time	Yes	No	C
1149	RH bank lambda control	Downstream fuel trim above rich delay time	Yes	No	C
1150	LH bank lambda control	Downstream fuel trim fault at low fuel level	Yes	No	C
1151	RH bank lambda control	Downstream fuel trim fault at low fuel level	Yes	No	C
1152	RH bank front HO2S	Slow response	Yes	No	C
1153	RH bank front HO2S	Rich to lean time slow	Yes	No	C
1154	RH bank front HO2S	Lean to rich time slow	Yes	No	C
1155	LH bank rear HO2S	Heating defective	Yes	No	C
1160	RH bank rear HO2S	Heating defective	Yes	No	C
1161	LH bank front HO2S	Too rich	Yes	No	C
1162	LH bank front HO2S	Too lean	Yes	No	C
1163	RH bank front HO2S	Too rich	Yes	No	C
1164	RH bank front HO2S	Too lean	Yes	No	C
1165	LH bank lambda control	HO2S fault detected at low fuel level	Yes	No	C
1166	RH bank lambda control	HO2S fault detected at low fuel level	Yes	No	
1167	LH bank rear HO2S	Signal implausible	No	No	
1168	RH bank rear HO2S	Signal implausible	No	No	
1180	LH bank rear HO2S	Slow response	Yes	No	C+
1181	RH bank rear HO2S	Slow response	Yes	No	C+

P Code No.	Component/Signal	Fault Description	Warning Lamp		Drive Cycle
			SERVICE ENGINE (MIL)	SERVICE ENGINE SOON	
1227	APP sensor potentiometer 2	Open circuit or short circuit to earth	No	Yes	—
1228	APP sensor potentiometer 2	Short circuit to battery	No	Yes	—
1231	Fuel pump relay	Short circuit to earth	No	No	A
1232	Fuel pump relay	Short circuit to battery	No	No	A
1320	Misfire detection	Reluctor adaption fault	No	No	B
1321	Misfire detection	Reluctor tooth pattern fault	No	No	B
1322	Ignition system	Ignition fault on more than two cylinders	No	No	A
1351	Ignition coil 1	Short circuit to battery	No	No	A
1352	Ignition coil 2	Short circuit to battery	No	No	A
1353	Ignition coil 3	Short circuit to battery	No	No	A
1354	Ignition coil 4	Short circuit to battery	No	No	A
1355	Ignition coil 5	Short circuit to battery	No	No	A
1356	Ignition coil 6	Short circuit to battery	No	No	A
1383	Ignition feedback resistor	Open circuit	No	No	A
1391	Ignition coil 1	Spark duration too short	No	No	A
1392	Ignition coil 2	Spark duration too short	No	No	A
1393	Ignition coil 3	Spark duration too short	No	No	A
1394	Ignition coil 4	Spark duration too short	No	No	A
1395	Ignition coil 5	Spark duration too short	No	No	A
1396	Ignition coil 6	Spark duration too short	No	No	A
1450	DMTL pump motor	Change-over valve stuck	Yes	No	A
1451	DMTL pump motor	Reference current unstable	Yes	No	A
1452	DMTL pump motor	Reference current below limit	Yes	No	A
1453	DMTL pump motor	Reference current above limit	Yes	No	A
1454	DMTL change-over valve	Short circuit to battery	Yes	No	A
1455	DMTL change-over valve	Short to earth	Yes	No	A
1456	DMTL change-over valve	Open circuit	No	No	—
1470	VIS balance valve motor	Valve always open	No	No	B
1471	VIS balance valve motor	Valve always closed	No	No	B
1472	VIS power/ butterfly valves motor	Valves always open	No	No	B
1473	VIS power/ butterfly valves motor	Valves always closed	No	No	B
1474	VIS balance valve motor	Short circuit to battery	No	No	B
1475	VIS balance valve motor	Open circuit or short circuit to earth	No	No	B
1476	VIS power/ butterfly valves motor	Short circuit to battery	No	No	B
1477	VIS power/ butterfly valves motor	Open circuit or short circuit to earth	No	No	B
1488	DMTL pump motor	Open circuit or short circuit to earth	Yes	No	—
1489	DMTL pump motor	Short circuit to earth	Yes	No	A
1490	DMTL pump motor	Short circuit to battery	Yes	No	A
1537	A/C compressor clutch relay	Short circuit to earth	No	No	A
1538	A/C compressor clutch relay	Short circuit to battery	No	No	A
1540	APP sensor	Both signals implausible	Yes	Yes	B
1541	APP sensor	Signal implausible	No	Yes	—
1564	Cruise control interface ECU	MFL signal bit pattern implausible	No	No	A

P Code No.	Component/Signal	Fault Description	Warning Lamp		Drive Cycle
			SERVICE ENGINE (MIL)	SERVICE ENGINE SOON	
1565	Cruise control interface ECU	MFL signal switch state implausible, circuit high voltage	No	No	—
1566	Cruise control interface ECU	MFL signal period time error, circuit low voltage	No	No	—
1567	Cruise control interface ECU	MFL signal SET/+ switch state implausible	No	No	A
1569	Cruise control interface ECU	MFL signal time out	No	No	A
1572	Brake pedal sensor	BLS signal defective or BTS signal active	No	No	—
1573	Brake pedal sensor	BTS signal defective	No	No	—
1574	Brake pedal sensor	Signals implausible	No	No	A
1575	Brake pedal sensor	APP sensor to brake sensor inputs implausible	No	Yes	B
1576	Brake pedal sensor	APP sensor to brake sensor inputs high	No	No	B
1577	Brake pedal sensor	APP sensor to brake sensor inputs low	No	No	B
1621	Serial link with immobilisation ECU	Timeout	No	No	A
1624	Serial link with immobilisation ECU	Code not accepted	No	No	A
1625	ECM, throttle monitoring/ self test	Internal fault	Yes	Yes	A
1626	ECM, throttle monitoring/ self test	Engine torque monitoring problem	Yes	Yes	B
1627	ECM, throttle monitoring/ self test	Engine speed monitoring problem	Yes	Yes	B
1628	ECM, throttle monitoring/ self test	PWM signal 1 duty cycle threshold exceeded for <1 second	Yes	No	B
1629	ECM, throttle monitoring/ self test	PWM signal 2 duty cycle threshold exceeded for >1 second	Yes	Yes	B
1630	ECM, throttle monitoring/ self test	Throttle position control deviation	Yes	Yes	B
1631	Throttle	Motor power stage fault	Yes	Yes	A
1636	ECM, throttle monitoring/ self test	Throttle motor adaption not completed	Yes	Yes	A
1637	ECM, throttle monitoring/ self test	Throttle motor lower adaption not plausible	Yes	Yes	A
1638	ECM, throttle monitoring/ self test	Throttle motor upper adaption not plausible	Yes	Yes	A
1639	ECM, throttle monitoring/ self test	Throttle motor spring test not completed	Yes	Yes	A
1641	CAN bus	Bus off	No	No	—
1645	CAN bus link with ABS ECU	Timed out	No	No	A
1646	CAN bus link with EAT ECU	Timed out	Yes	No	A
1647	CAN bus link with instrument pack	Timed out	No	No	A
1666	Serial link with immobilisation ECU	Wrong code	No	No	A
1669	ECM cooling fan signal	Open circuit or short to battery	No	No	A
1670	ECM cooling fan signal	Open circuit	No	No	A

P Code No.	Component/Signal	Fault Description	Warning Lamp		Drive Cycle
			SERVICE ENGINE (MIL)	SERVICE ENGINE SOON	
1671	ECM cooling fan signal	Short to battery	No	No	A
1672	Serial link with immobilisation ECU	Code implausible	No	No	A
1676	ECM, throttle monitoring/ self test	Engine torque versus driver demand implausible	No	Yes	B
1677	ECM, throttle monitoring/ self test	Engine speed versus driver demand implausible	No	No	B
1678	Throttle	Potentiometer 1 defective	Yes	Yes	B
1679	Throttle	Potentiometer 2 defective	Yes	Yes	B
1689	Brake vacuum enhancer solenoid valve – Up to 2003 model year	Short circuit to battery	No	No	A
1690	Brake vacuum enhancer solenoid valve – Up to 2003 model year	Short circuit to earth	No	No	A
1691	Brake vacuum enhancer solenoid valve – Up to 2003 model year	Open circuit	No	No	A
1692	Main relay	Main relay fault	No	No	A
1697	Ambient pressure	Value not plausible	No	No	A
1698	Ambient pressure	Failure value stored	No	No	A
1699	Ambient pressure	Learning not successful	No	No	A
2122	APP sensor - Potentiometer 1	Short circuit to earth or open circuit	Yes	Yes	A
2123	APP sensor - Potentiometer 1	Short circuit to battery	Yes	Yes	A
2127	APP sensor - Potentiometer 2	Short circuit to earth or open circuit	Yes	Yes	A
2128	APP sensor - Potentiometer 2	Short circuit to battery	Yes	Yes	A
2138	APP sensor - Potentiometer comparison	Switch D/E voltage correlation	No	Yes	B

Drive Cycles

A number of different drive cycles are defined by OBD legislation for fault diagnosis. Each drive cycle is a precise routine which the engine or vehicle must undergo to produce the conditions that enable the ECM to perform diagnostic routines. TestBook/T4 can be used to view the status and results of the diagnostic routines performed by the ECM. When a fault code is stored, it will indicate, via TestBook/T4 and the Diagnostic P code list, the drive cycle required to verify a repair.

When a fault has been rectified and the fault P codes cleared from the applicable ECU using TestBook/T4, the following drive cycles must be performed to ensure that the fault has been corrected and to ensure that no other fault codes are subsequently stored. The above P Code table shows the applicable drive cycle required when a particular P code has been recorded.

WARNING: Ensure that the drive cycles are performed in a safe area and do not endanger other road users. Observe all local highway laws when performing the drive cycles.

The following drive cycle procedures relate to the drive cycle letters shown in the Diagnostic P Code table

Drive Cycle A

1. Move the ignition switch to position II for 30 seconds.
2. Make sure that the engine coolant temperature is less than 60°C (140°F).
3. Start the engine and allow to idle for 2 minutes.
4. With TestBook/T4 connected to the vehicle diagnostic socket, check for fault codes.
5. Investigate and rectify any fault codes found and perform the relevant drive cycle procedure for the fault codes.

Drive Cycle B

1. Move the ignition switch to position II for 30 seconds.
2. Make sure that the engine coolant temperature is less than 60°C (140°F).
3. Start the engine and allow to idle for 2 minutes.
4. Perform two light accelerations (0 to 35 mph with light throttle pedal pressure).
5. Perform two medium accelerations (0 to 45 mph with moderate throttle pedal pressure)
6. Perform two hard accelerations (0 to 55 mph with heavy throttle pedal pressure).
7. With the vehicle stationary, allow the engine to idle for 2 minutes.
8. With the engine still running and TestBook/T4 connected to the vehicle diagnostic socket, check for fault codes.
9. Investigate and rectify any fault codes found and perform the relevant drive cycle procedure for the fault codes.

Drive Cycle C

1. Move the ignition switch to position II for 30 seconds.
2. Make sure that the engine coolant temperature is less than 60°C (140°F).
3. Start the engine and allow to idle for 2 minutes.
4. Perform two light accelerations (0 to 35 mph with light throttle pedal pressure).
5. Perform two medium accelerations (0 to 45 mph with moderate throttle pedal pressure)
6. Perform two hard accelerations (0 to 55 mph with heavy throttle pedal pressure).
7. Cruise at a constant 60 mph for 8 minutes.
8. Cruise at a constant 50 mph for 3 minutes.
9. With the vehicle stationary, allow the engine to idle for 3 minutes.
10. With the engine still running and TestBook/T4 connected to the vehicle diagnostic socket, check for fault codes.
11. Investigate and rectify any fault codes found and perform the relevant drive cycle procedure for the fault codes.

Drive Cycle C+

1. This is an extended Drive Cycle C to enable the internal diagnostic process to be completed which is not achieved by Drive Cycle C. Perform this additional drive cycle after the 3 minute idle is completed and when prompted by TestBook/T4.
2. Perform medium acceleration to 60 mph and hold for 10 seconds.
3. Release the throttle pedal and allow the vehicle to decelerate to 50 mph.
4. Perform a second medium acceleration to 60 mph and hold for 10 seconds
5. Release the throttle pedal and allow the vehicle to decelerate to 50 mph.
6. Repeat steps 4 and 5 a further 13 times until 15 acceleration/decelerations cycles have been performed.
7. With the engine still running and TestBook/T4 connected to the vehicle diagnostic socket, check for fault codes.
8. Investigate and rectify any fault codes found and perform the relevant drive cycle procedure for the fault codes.

NOTE: DRIVE CYCLE C and C+ – Faults in the following areas also have an associated 'Readiness Test' that must be flagged as 'completed' before the technician can verify that the problem in that are is rectified:

- *Catalytic Converter fault*
- *Evaporative Loss System (EVAP) fault*
- *HO2S fault*
- *HO2S heater fault.*

Although these tests are normally completed within Drive Cycle C, select the 'Readiness Test' icon on the TestBook/ T4 screen to verify that the test has been flagged as completed.

Drive Cycle D

1. Move the ignition switch to position II for 30 seconds.
2. Make sure that the engine coolant temperature is less than 60°C (140°F).
3. Start the engine and allow to idle for 2 minutes.
4. Perform two light accelerations (0 to 35 mph with light throttle pedal pressure).
5. Perform two medium accelerations (0 to 45 mph with moderate throttle pedal pressure)
6. Perform two hard accelerations (0 to 55 mph with heavy throttle pedal pressure).
7. Cruise at a constant 60 mph for 5minutes.
8. Cruise at a constant 50 mph for 5minutes.
9. Cruise at a constant 35 mph for 5minutes.
10. With the vehicle stationary, allow the engine to idle for 2minutes.
11. With the engine still running and TestBook/T4 connected to the vehicle diagnostic socket, check for fault codes.
12. Investigate and rectify any fault codes found and perform the relevant drive cycle procedure for the fault codes.

Drive Cycle E

1. Make sure that the fuel tank is at least $^1/_4$ (25%) full.
2. Perform Drive Cycle A.
3. Switch off the engine and allow the vehicle rest undisturbed for 20 minutes.
4. Move the ignition switch to position II.
5. With TestBook/T4 connected to the vehicle diagnostic socket, check for fault codes.
6. Investigate and rectify any fault codes found and perform the relevant drive cycle procedure for the fault codes.

Drive Cycle F

1. For P codes requiring this drive cycle, TestBook/T4 will provide guidance to force the actuator or function through a diagnostic routine to confirm correct operation.

Operation

Engine Starting

When the ignition switch is in position II a power feed is connected from the ignition switch to the ECM relay and the ECM. The ECM then initiates 'wake up' routines and energises the main and fuel pump relays.

When the engine cranks, provided a valid mobilisation signal is received from the immobilisation ECU, the ECM initiates throttle control, fuelling and ignition to start and maintain control of the engine as necessary to meet driver demand. If no mobilisation code is received from the immobilisation ECU, or the code is invalid, the ECM inhibits fuel injection and ignition to prevent the engine from starting.

The electrical circuit from the fuel pump relay to the fuel pump is routed through the fuel cut-off inertia switch, located below the E-box in the engine compartment. In the event of a collision the switch breaks the circuit to prevent further fuel being delivered to the engine. The switch is reset by pressing down the centre of the rubber cover on the top of the switch.

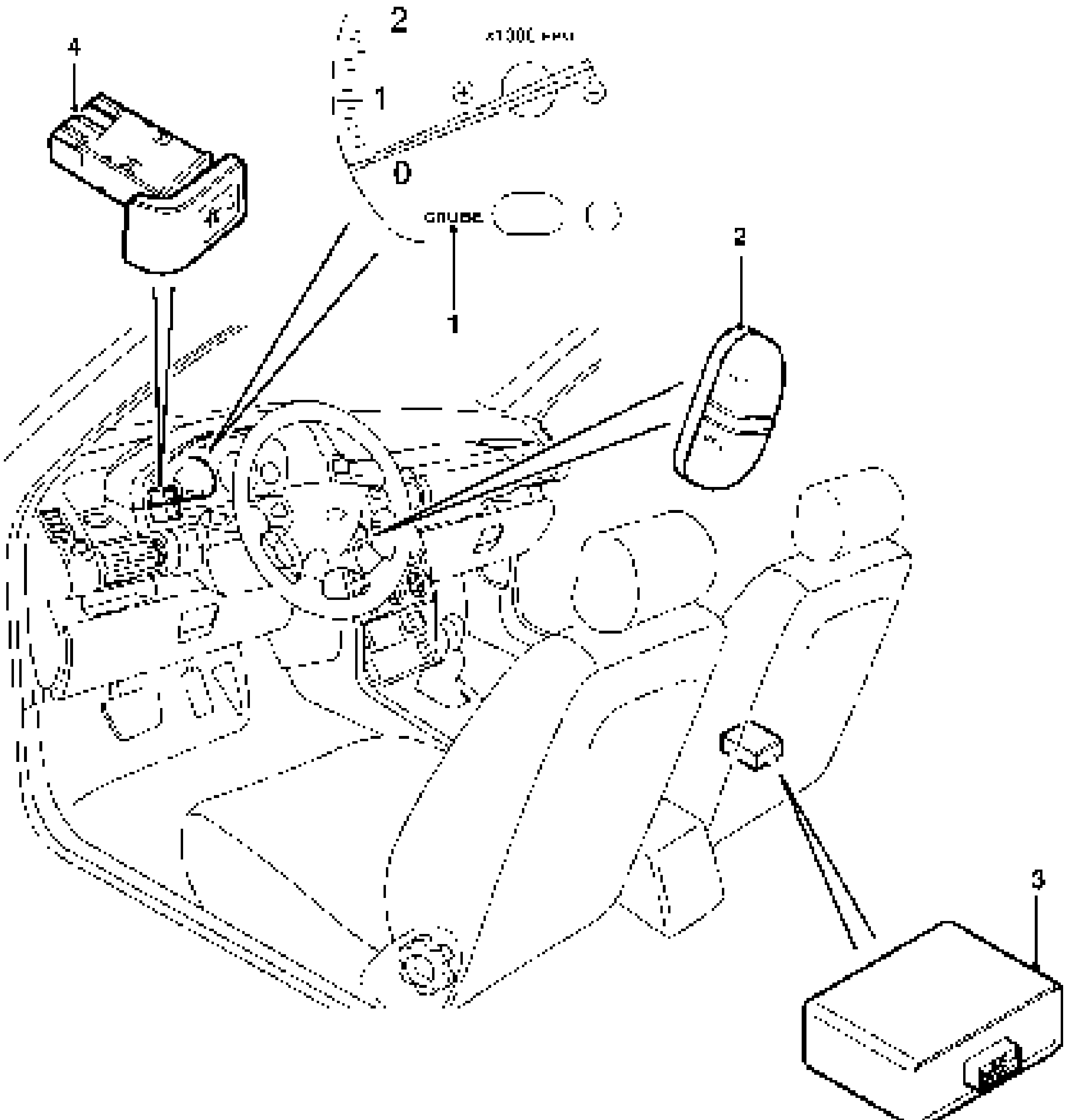
During the start sequence, the ECM also illuminates the MIL, as a bulb check. While the ignition switch is in position II the MIL is continuously illuminated. The MIL is extinguished when the ignition switch turns to position III and the engine starts.

Engine Stopping

When the ignition switch is turned to position I, the ECM switches off the ignition coils and fuel pump to stop the engine and the ECM relay de-energises to disconnect the power feed to the fuel injectors. The ECM continues to energise the main relay until the power down functions are completed. Power down functions include the fuel tank leak check, engine cooling and memorising data for the next start up. If neither a fuel tank lank check nor engine cooling are required, the power down process takes approximately 10 seconds.

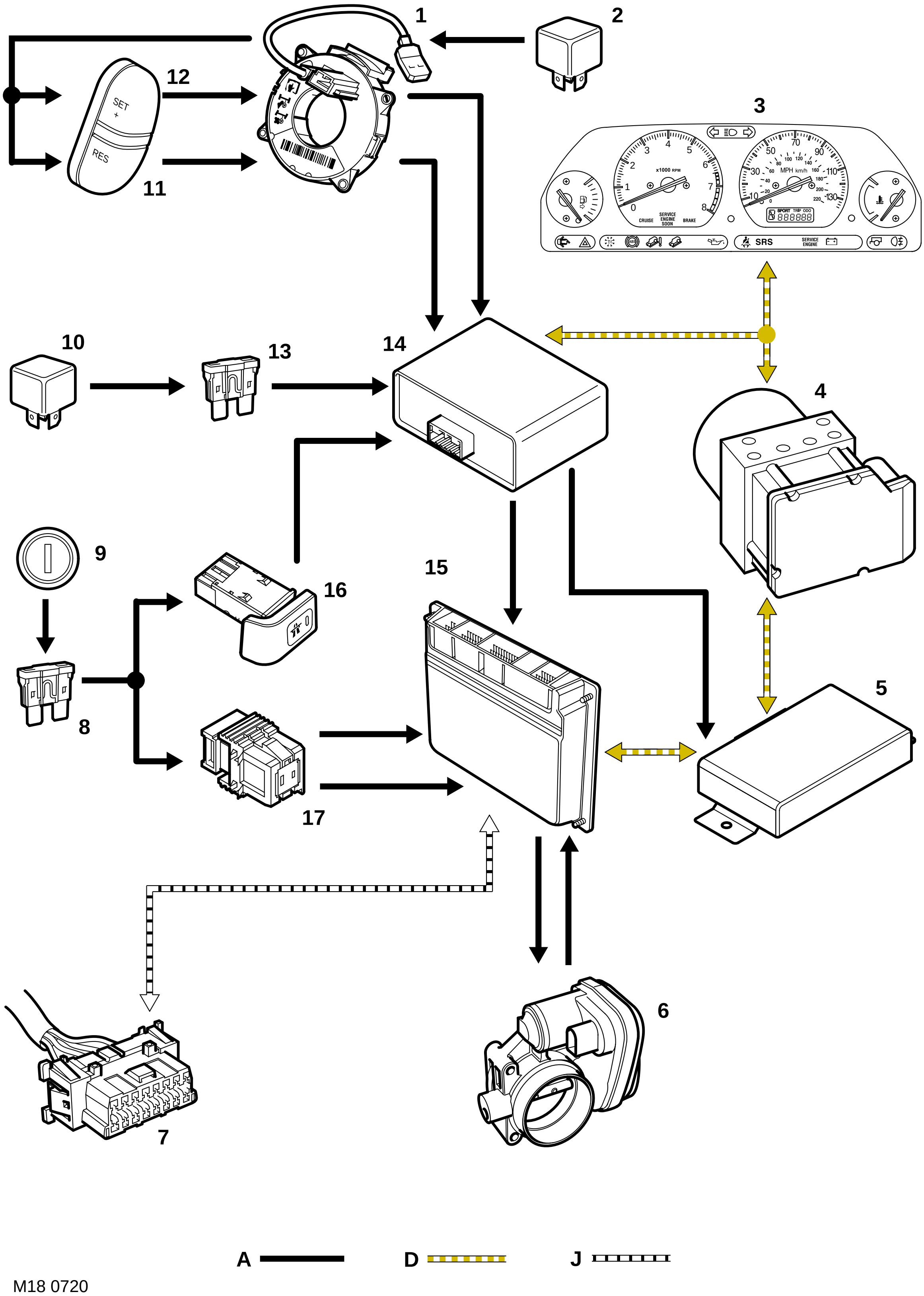
When the power down process is completed, the ECM de-energises the main relay and enters a low power mode. In the low power mode, maximum quiescent drain is 0.5 mA.

Cruise Control Component Location



1 Warning lamp
2 Steering wheel switches
3 Interface ECU
4 Master switch

Cruise Control System Control Diagram



A = Hardwired connection; D = CAN bus; J = Diagnostic ISO 9141 K line bus

1 Rotary coupler
2 Horn relay
3 Instrument pack
4 ABS modulator
5 EAT ECU
6 Electric throttle
7 Diagnostic socket
8 Fuse 8, passenger compartment fusebox
9 Ignition switch
10 Main relay
11 RES switch
12 SET+ switch
13 Fuse 7, passenger compartment fusebox
14 Interface ECU
15 ECM
16 Master switch
17 Brake pedal sensor

Cruise Control Description

General

The cruise control system is integrated with the engine management system and uses throttle intervention to automatically maintain a set vehicle speed. Once engaged, the system can also be used to accelerate the vehicle without using the accelerator pedal. The cruise control system consists of:

- A master switch.
- SET+ and RES steering wheel switches.
- An interface ECU.
- A warning lamp.

The system also uses:

- Inputs from the brake pedal sensor and the Anti-lock Braking System (ABS) modulator.
- The Engine Control Module (ECM).

The Controller Area Network (CAN) bus is used by the cruise control system for the exchange of data between the interface ECU, ECM, EAT ECU, ABS modulator and instrument pack.

Cruise control is enabled when the master switch is pressed. Once enabled, the cruise control system is operated using the steering wheel switches. The steering wheel switches output signals to the interface ECU, which then signals the ECM. The ECM then adjusts the throttle to maintain the vehicle at the set speed.

The cruise control warning lamp provides a visual indication of when the system is engaged.

Master Switch

The master switch controls an ignition feed to the interface ECU to enable the system. The switch is a mechanically latching push switch installed on the outboard side of the instrument pack. An amber LED in the switch remains illuminated while the switch is latched.

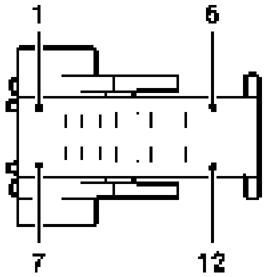
Steering Wheel Switches

The steering wheel switches, SET+ and RES, are non latching push switches that engage and disengage cruise control and adjust the set speed. While pressed, the switches connect a power feed from the battery, via the coil of the horn relay and the rotary coupler, to the interface ECU.

Interface ECU

The interface ECU converts the analogue signals from the steering wheel switches into serial data messages, known as Multi-Function Logic (MFL) messages, which are interpreted by the ECM to operate cruise control. The interface ECU also controls the output of a cruise engaged signal to the EAT ECU. The interface ECU is installed below the RH front seat, under a plastic protective cover.

Interface ECU Harness Connector (C1959)



M18 0762

Pin No.	Description	Input/Output
1	System earth	-
2	MFL signal	Output
3	SET+ switch	Input
4	RES switch	Input
5	CAN bus low (L line)	Input/Output
6	CAN bus high (K line)	Input/Output
7	Cruise control master switch	Input
8	Ignition power supply	Input
9	Cruise control engaged signal	Output
10 to 12	Not used	-

MFL Messages
The interface ECU outputs one of three MFL messages, RESUME, SET or OFF, on a serial link to the ECM. The power feed from the main relay to the interface ECU drives the MFL messages. While the master switch is selected off, only the OFF MFL message can be transmitted. When the master switch is selected on, the power feed from the switch enables the interface ECU to send either the SET or RESUME MFL messages, depending on the inputs from the steering wheel switches and the cruise control status message from the CAN bus. When the master switch is first switched on, the output of the RESUME message is automatically inhibited until after the first engagement of cruise control.

Cruise Engaged Signal
When cruise control is engaged, the interface ECU outputs battery voltage on a connection to the EAT ECU to provide a cruise control engaged signal. The EAT ECU uses the signal to switch between normal and cruise control modes of operation.

Warning Lamp
The warning lamp indicates the status of the cruise control system. Located in the instrument pack, the warning lamp illuminates when cruise control is engaged, and consists of an amber CRUISE legend.

CAN System

The following CAN messages are used for control of the cruise control system:

- Cruise control status, from the ECM. To advise the interface ECU if the ECM cruise control mode is active or inactive. Also used by the instrument pack to operate the cruise control warning lamp.
- Road speed, produced by the ABS modulator from ABS sensor inputs. Used by the ECM for monitoring vehicle speed.
- Accelerator pedal position, from the ECM. Used by the EAT ECU for gear change control.
- Gear lever position, from the EAT ECU. Used by the ECM to ensure the vehicle is in drive for cruise control operation.

Brake Pedal Sensor

Outputs from the brake pedal sensor are supplied to the ECM to enable the system to detect when the brakes are applied. The brake pedal sensor is a Hall effect sensor that produces two outputs. Both outputs should be 0 to 2 volts while the brake pedal is released. When the brake pedal is pressed, the Brake Lamp Switch (BLS) output increases to between 6 and battery volts, the Brake Test Switch (BTS) output increases to between 10 and battery volts.

ECM

The ECM incorporates a software module and associated components to enable cruise control operation by direct control of the electric throttle. In addition to controlling the throttle, the software module monitors hardwired and CAN bus inputs to the ECM and prevents or suspends cruise control operation when the vehicle is not in the correct driving configuration.

Cruise Control Operation

General

When the ignition is switched on, the interface ECU receives a power feed from the main relay and initialises the MFL serial link to the ECM. The ECM is in the normal fuelling mode and outputs the cruise control inactive message on the CAN bus. The interface ECU ignores inputs from the steering wheel switches.

When the master switch is pressed, the LED in the master switch illuminates and a second power feed is connected to the interface ECU to enable the system.

Engagement

Cruise control is engaged by pressing the SET+ steering wheel switch. On receipt of the input from the SET+ switch, the interface ECU outputs a SET MFL message. Provided the vehicle is in the correct driving configuration, when the ECM receives the SET message it stores the current vehicle speed in memory as the set speed. The ECM then adjusts the throttle as necessary to maintain the vehicle at the set speed, and changes the CAN bus message of cruise control status to active.

The vehicle is in the correct driving configuration, when:

- The brakes are off.
- The gearbox is in drive.
- The vehicle is moving at a road speed between 22 and 125 mph (35 and 200 km/h).
- Electronic Traction Control (ETC) is not active.

On receipt of the cruise control active message on the CAN bus, the instrument pack illuminates the cruise control warning lamp and the interface ECU outputs the hardwired cruise control engaged signal to the EAT ECU. On receipt of the cruise control engaged signal, the EAT ECU adopts the cruise control mode, which uses a gear change map less sensitive to changes of accelerator pedal position, to prevent unnecessary gear changes. This improves operating refinement for a minor loss of performance.

Acceleration

While cruise control is engaged, the vehicle can be accelerated using either the SET+ switch or the accelerator pedal. Each momentary press (less than 0.5 second) of the SET+ switch causes the interface ECU to output a SET MFL message to the ECM, which then increments the set speed by 0.6 mph (1 km/h) and accelerates the vehicle to the new set speed. If the switch is held on, the interface ECU repeatedly sends the SET MFL message until the switch is released. While it receives the messages, the ECM keeps incrementing the stored set speed and accelerating the vehicle. When the switch is released and the messages stop, the ECM adopts the increased vehicle speed as the new set speed.

If the accelerator pedal is used to accelerate the vehicle, the ECM reverts to normal throttle control when it detects the demand from the accelerator pedal sensor exceeds that of the current throttle setting. Provided the demand from the accelerator pedal sensor does not increase vehicle speed by more than 10 mph (16 km/h) above the set speed, for more than 30 seconds, cruise control remains engaged and the set speed is resumed once the accelerator pedal is released. If the SET+ switch is pressed before the accelerator pedal is released, the higher speed is adopted as the new set speed.

Suspend/Resume

Cruise control can be manually suspended and resumed (at the previous set speed) using the RES steering wheel switch. The ECM automatically suspends cruise control if one of the conditions required to enable the system is no longer present, e.g. the brakes are applied. Cruise control is also automatically suspended by the ECM if:

- The vehicle speed increases to more than 10 mph (16 km/h) above the set speed for more than 30 seconds, e.g. when travelling downhill or using the accelerator pedal to override cruise control.
- Engine speed increases too rapidly, e.g. if their is a fault in the gearbox or the gearbox goes into neutral.
- The vehicle decelerates too rapidly, e.g. when the brakes are applied.

Suspend
When the RES switch is pressed, the interface ECU outputs the OFF MFL message to the ECM. On receipt of the OFF MFL message, and when automatically suspending cruise control, the ECM reverts to normal fuelling control and changes the cruise control message on the CAN bus to inactive. The set speed is retained in memory by the ECM. On receipt of the cruise control inactive CAN bus message, the instrument pack extinguishes the cruise control warning lamp and the interface ECU switches off the cruise control engaged signal to the EAT ECU. The EAT ECU then returns to its previous operating mode.

Resume
While cruise control is suspended, when the RES switch is pressed the interface ECU outputs the MFL RESUME message to the ECM. Provided the vehicle is in the correct driving configuration, on receipt of the RESUME MFL message the ECM engages cruise control at the previous set speed and changes the CAN bus cruise control message back to active. The instrument pack then illuminates the cruise control warning lamp again and the interface ECU outputs the cruise engaged signal to switch the EAT ECU back to the cruise control mode.

Cancelling
Cruise control is cancelled by pressing the master switch. When cruise control is cancelled, the LED in the master switch extinguishes and the power feed to the interface ECU is disconnected to disable the system. If cruise control is engaged when the master switch is pressed, the interface ECU and the ECM respond in the same way as when cruise control is suspended, except that the interface ECU no longer reacts to inputs from the steering wheel switches.

During the same ignition cycle, if the master switch is pressed again, the interface ECU is re-enabled. Since the output of the RESUME MFL message is inhibited until after the first engagement of cruise control, the interface ECU will not react to an input from the RES switch, and the set speed in the ECM memory is effectively lost to the system. Cruise control only re-engages if the SET+ switch is pressed, when, provided the vehicle is in the correct driving configuration, the ECM adopts the current vehicle speed as the new set speed.

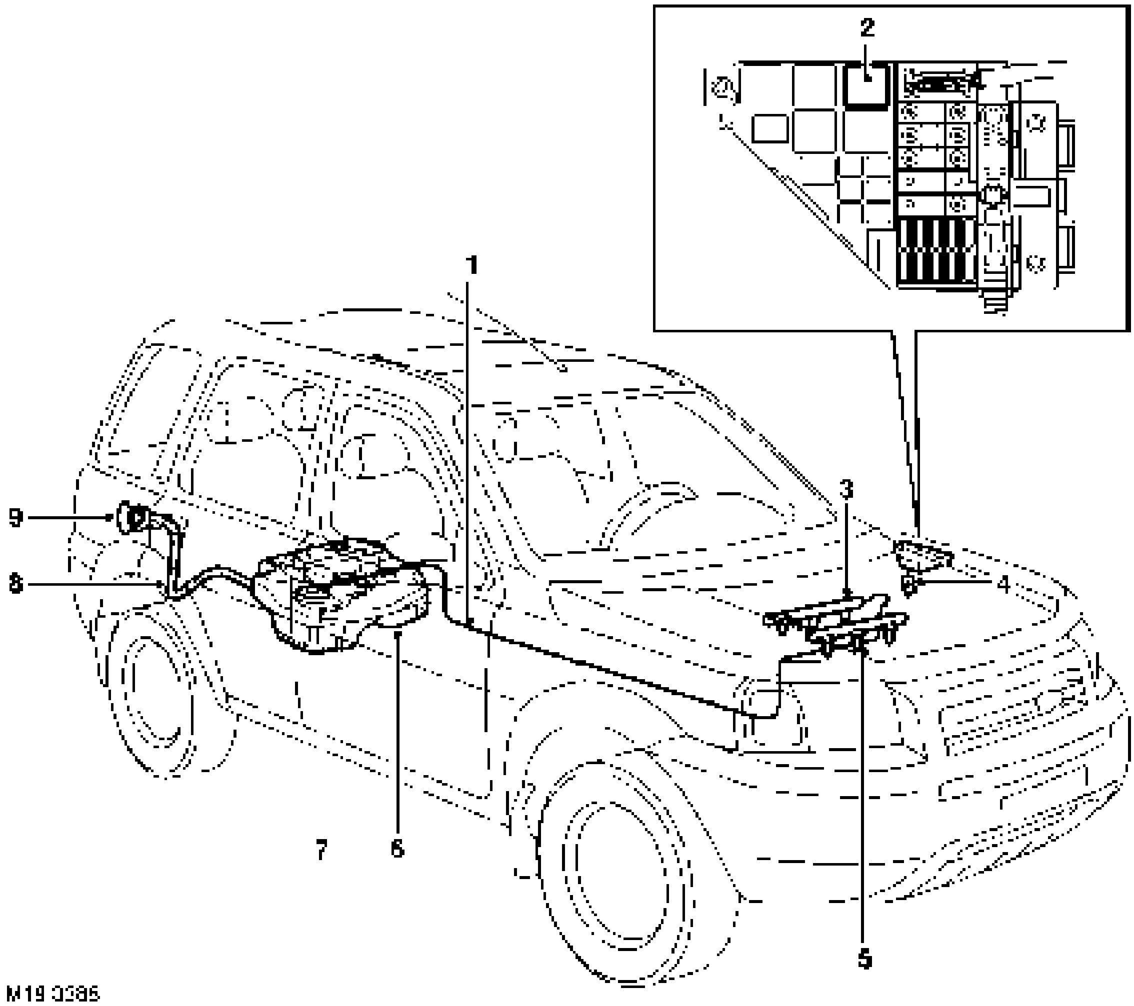
Diagnostics
The ECM monitors the MFL serial link to check for faults with the interface ECU. The MFL signal contains a toggle bit which the interface ECU changes to a different state every second to indicate that the interface ECU is operating correctly and receiving a valid CAN bus signal. If a fault occurs with the CAN bus signal or the interface ECU, the toggle bit remains unchanged and the ECM interprets the unchanged toggle bit as a fault. If the interface ECU fails to output the MFL signal, the ECM also interprets the lack of a signal as a fault.

If a fault is detected, the ECM disables cruise control for the remainder of the ignition cycle and stores a related fault code in memory. The fault codes can be accessed using TestBook/T4, which communicates with the ECM via an ISO 9141-2 K line from the diagnostic socket.

The ECM monitors the two inputs from the brake pedal position sensor and disables cruise control if a fault is detected. The ECM can detect open circuits and implausible inputs. However, simultaneous short circuits to 0 volt in both inputs cannot be detected and, if this occurs, cruise control operates but does not suspend operation when the brake pedal is pressed.

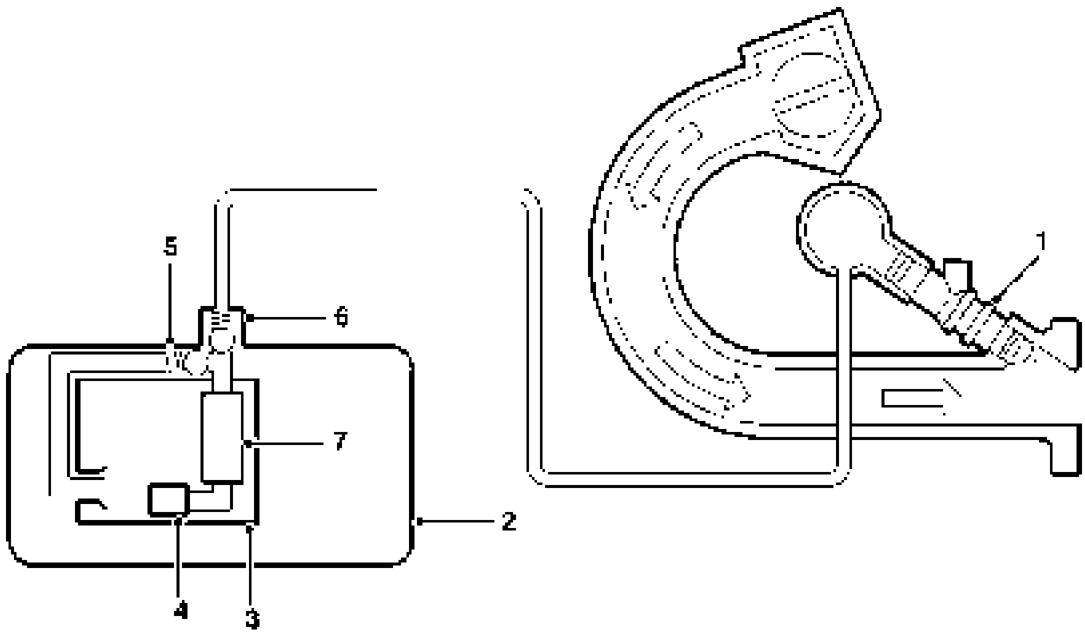
The ECM resets the cruise control system at the beginning of each ignition cycle and operates normally if a previously detected fault is no longer present.

Fuel Delivery System Component Layout



1 Fuel feed pipe
2 Fuel pump relay
3 Fuel rail
4 Inertia fuel cut-off switch
5 Fuel injector
6 Fuel tank
7 Fuel pump
8 Filler tube
9 Fuel filler cap

Fuel Delivery System Schematic



1 Fuel injector
2 Fuel tank
3 Swirl pot
4 Fuel filter
5 Pressure regulator valve
6 Non return valve
7 Fuel pump

Description

General
The fuel delivery system consists of a fuel tank containing an electric fuel pump to supply fuel at a constant pressure to the engine fuel rail. A pipe, routed along the underside of the vehicle, connects the fuel pump to the fuel rail.

Fuel Tank
The fuel tank is located on the underside of the vehicle, forward of the rear suspension subframe. The tank is constructed from moulded plastic and is retained by a tubular cradle which is secured to the vehicle floorpan with four bolts. A heat shield is installed on the LH side of the support cradle to protect the tank from heat radiated by the exhaust system. A fire shield is installed on the RH side of the support cradle.

The fuel tank has a nominal capacity of 60 litres (15.85 US gallons). An aperture in the top surface of the tank allows for the fitment of the fuel pump.

On vehicles from 2002.5 model year – The fuel tank capacity is increased by 4litres (0.8 gallons) to 64 litres (14.0 gallons). This is achieved by modifications to the tank venting system.

The top of the fuel tank filler tube is located in the RH rear wing panel and is closed by a lockable filler cap. The bottom of the filler tube is connected to the tank by a flexible tube secured with clamps. a flap valve in the fuel tank, at the connection point with the filler tube, prevents vapour from escaping once refuelling is completed and also prevents fuel from escaping if the filler cap or filler tube are damaged in an accident.

During refuelling and with the fuel filler cap installed, the tank is ventilated to atmosphere through vent pipes that connect an Onboard Refuelling Vapour Recovery (ORVR) valve and the three roll over valves in the tank to the Evaporative emissions (EVAP) system.
☞ **EMISSION CONTROL - K SERIES KV6, DESCRIPTION AND OPERATION, Description.**

The location of the vent pipe connections on the fuel tank ensures an air space remains in the tank after filling, to allow for heat expansion of the fuel.

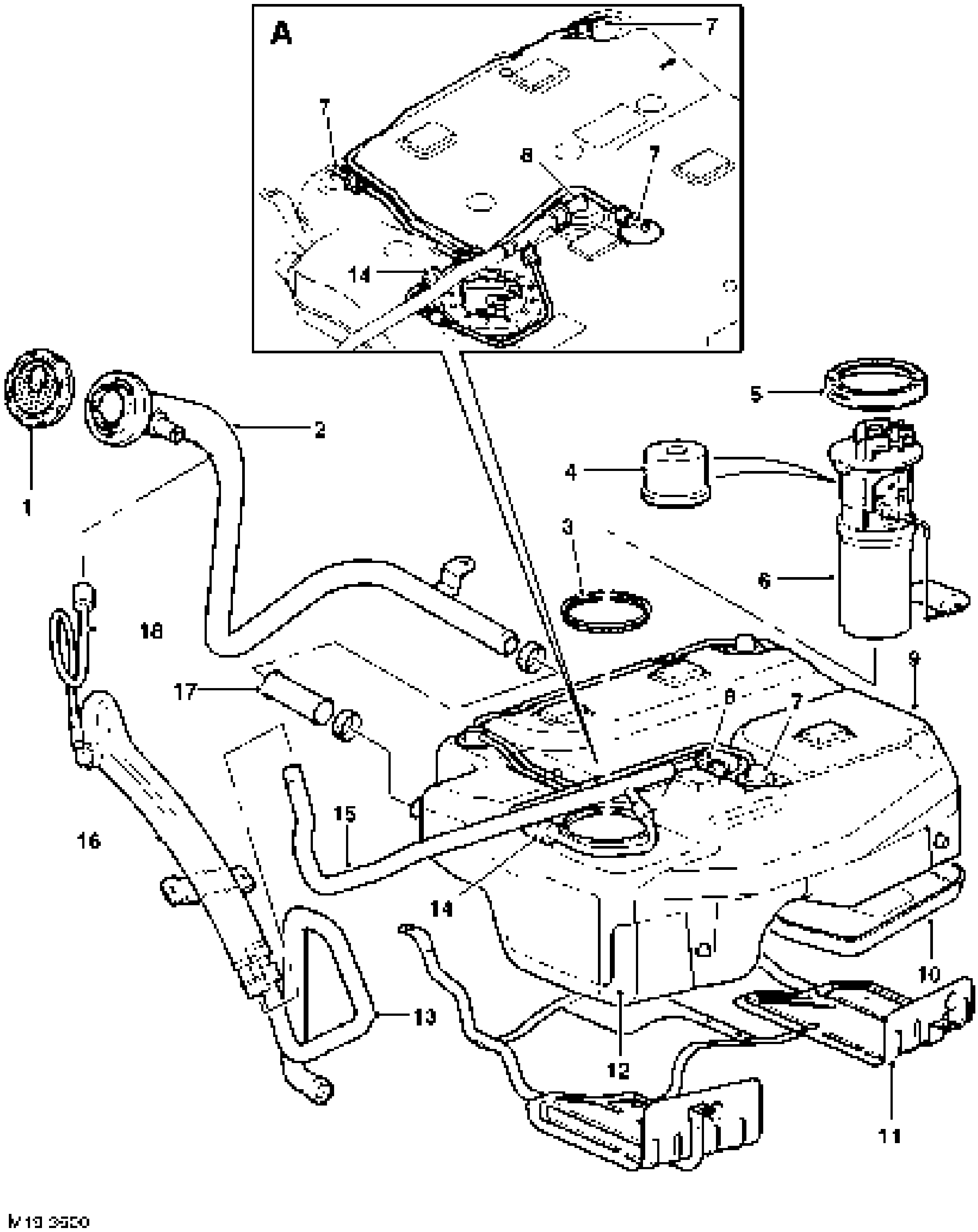
The ORVR valve and roll over valves are float valves that prevent fuel from entering the EVAP system vent pipes due to fuel slosh or if the vehicle overturns.

On vehicles from 2002.5 model year – Modifications are introduced to increase the capacity of the fuel tank. The modification comprises a change to the vent line from the forward ROV. The vent line from the ROV now connects to the vent line between the two-way valve and the vapour separator. Venting from the forward ROV is no longer restricted by the two-way valve. The ROV now controls the refuelling nozzle shut-off. When the ROV closes, pressure in the tank increases shutting off the refuelling nozzle. This modification allows an additional 5 litres (1.1 gallons) of fuel to be added to the tank.

There is a fabric sleeve fitted to the filler pipe inlet in the tank. This reduces the amount of vapour produced during refuelling and subsequent load on the EVAP canister.

NOTE: When defuelling the tank with a vacuum pump, the fabric sleeve can become inverted and may initially cause problems during subsequent refuelling by shutting off the refuelling nozzle prematurely. After several attempts at refuelling, the fabric sleeve should straighten out and allow refuelling as normal.

Fuel Tank and Fuel Pump



A *= From 2002.5 Model Year*

- **1** Fuel filler cap
- **2** Filler tube
- **3** Seal
- **4** Fuel filter
- **5** Locking ring
- **6** Fuel pump assembly
- **7** Roll over valve
- **8** ORVR valve
- **9** Fuel tank
- **10** Fire shield
- **11** Cradle
- **12** Heat shield
- **13** Vent pipe from vapour separator to EVAP canister
- **14** Two-way valve
- **15** Vent pipe from fuel tank to vapour separator
- **16** Vapour separator
- **17** Flexible tube
- **18** Recirculation pipe

Fuel Pump

The fuel pump is a submersible electric pump located in the top face of the fuel tank. A notched locking ring retains the fuel pump in the tank and requires a special tool for removal and installation. An access panel below the rear passenger seats provides access to the fuel pump for maintenance. The top face of the fuel pump has an electrical connector with power and ground connections to the pump and the fuel gauge rotary potentiometer. A quick fit coupling provides attachment for the fuel feed pipe. A non return valve in the pump outlet prevents fuel draining from the feed pipe back into the tank when the pump is stopped.

The fuel pump is housed in a plastic body which incorporates a coarse mesh filter and a serviceable fine mesh filter. The bottom part of the body forms a swirl pot which maintains a constant fuel level at the pump pick-up. A pressure regulator in the pump body ensures that the fuel rail and the injectors are supplied with fuel at a constant pressure of 3.5 bar (51 lbf/in^2). The regulator relieves excess fuel from the pump outlet back to the swirl pot.

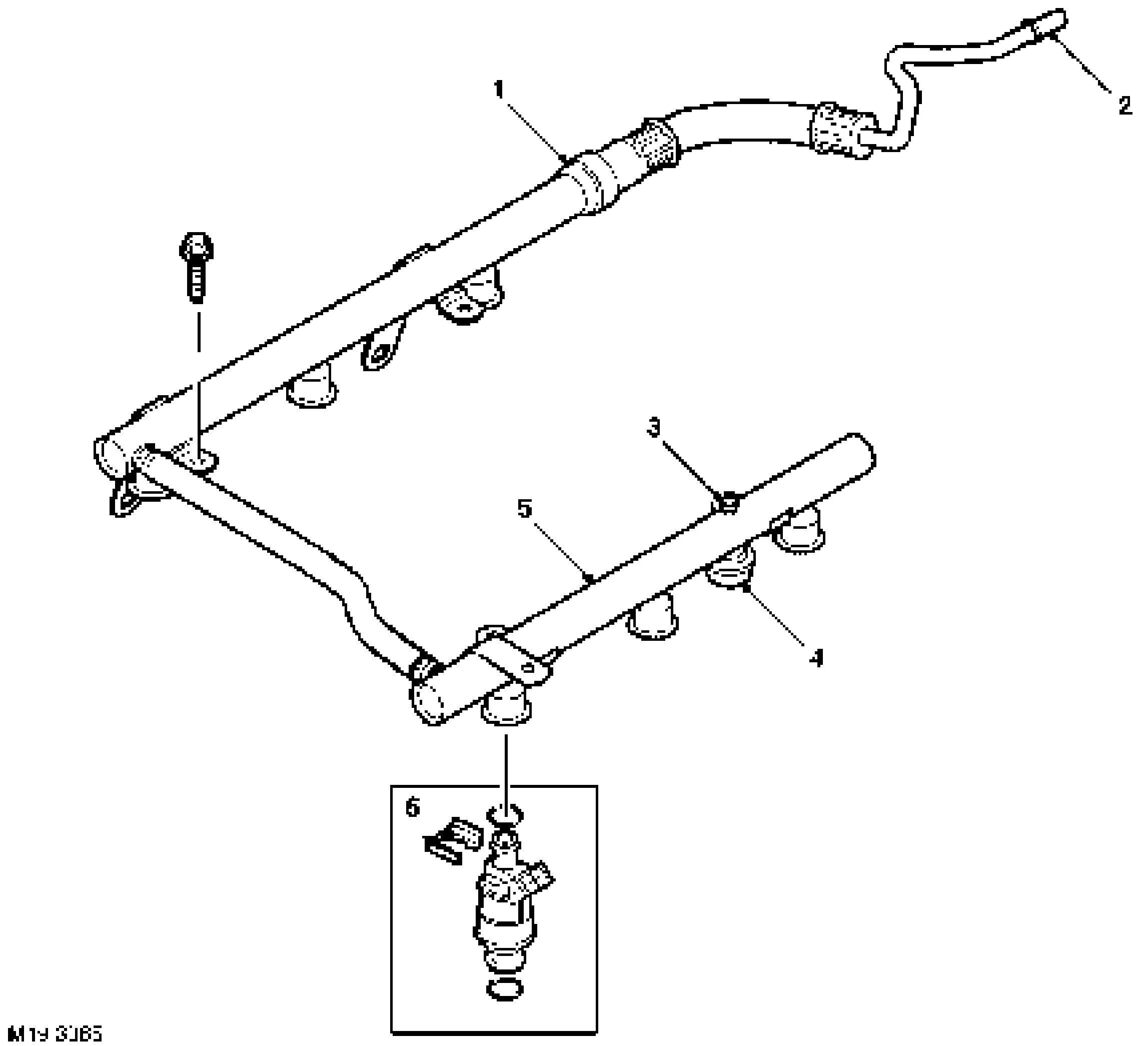
Fuel Rail

Three fuel injectors are installed in each inlet manifold and connected to the fuel rail. The injectors are sealed in the fuel rail and the inlet manifolds by 'O' ring seals. A quick release coupling connects the feed pipe from the fuel tank to the fuel rail.

An accumulator is attached to the fuel rail, to damp out pressure pulses from the pump and ensure that the pressure in the fuel rail is constant.

A Schraeder valve is installed above the accumulator to provide a pressure test connection for maintenance.

Fuel Rail and Injectors



1 Quick release coupling
2 To fuel feed pipe
3 Dust cap and Schraeder valve
4 Accumulator
5 Fuel rail
6 Fuel injector

Operation

The fuel pump is controlled by the Engine Control Module (ECM), which switches the fuel pump relay in the engine compartment fuse box to control the power feed to the pump. The electrical circuit for the fuel pump incorporates an inertia fuel cut-off switch attached to the LH front suspension turret. In a collision above a preset deceleration speed, the switch breaks the circuit to the fuel pump to stop the delivery of fuel to the engine. The switch is reset by pressing the rubber top.

WARNING: Ensure there are no fuel leaks and confirm the integrity of the fuel system before resetting the fuel shut-off switch.

The fuel pump outputs more fuel than the maximum load requirement of the engine, in order to maintain a constant pressure in the fuel rail under all running conditions.

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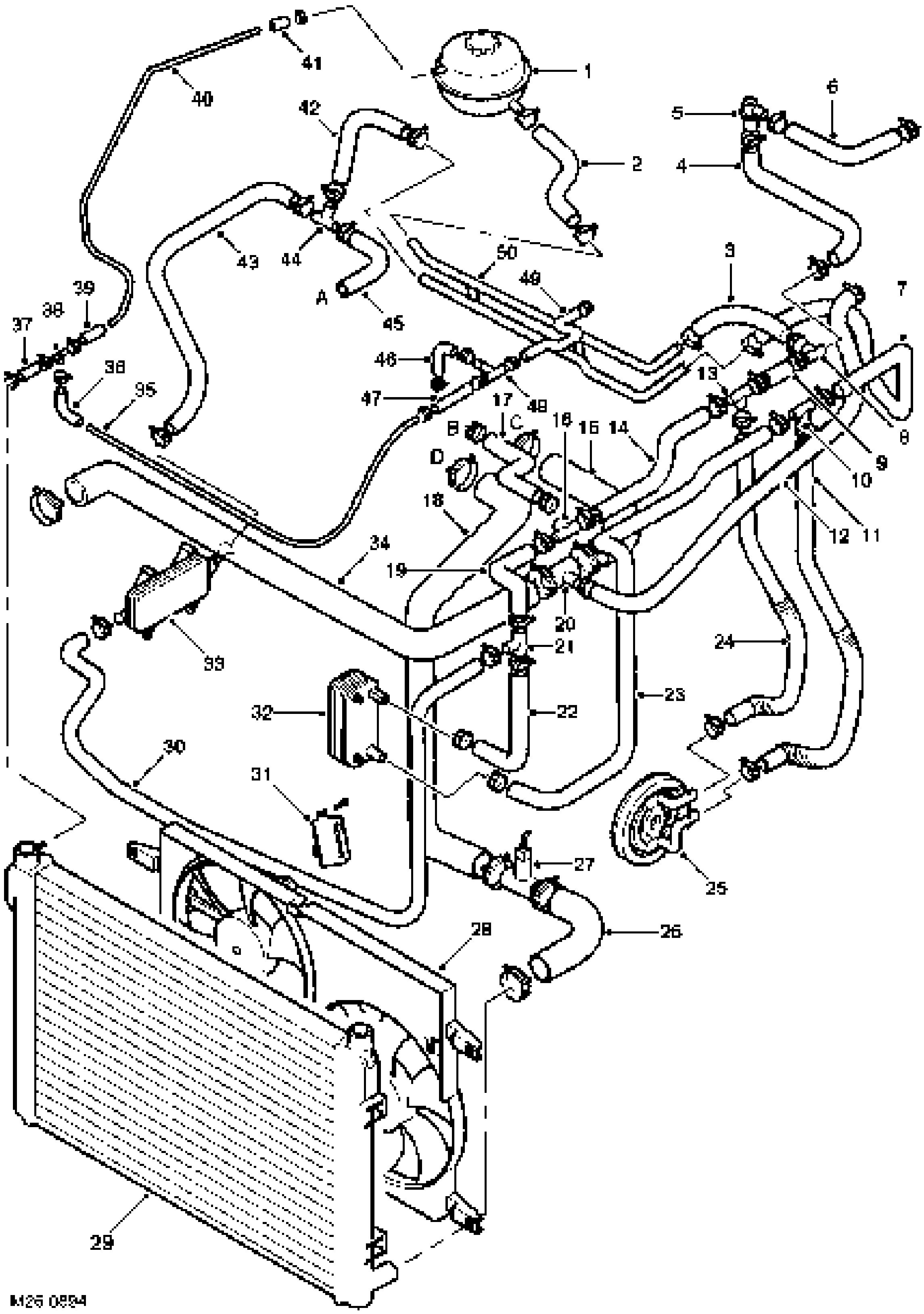
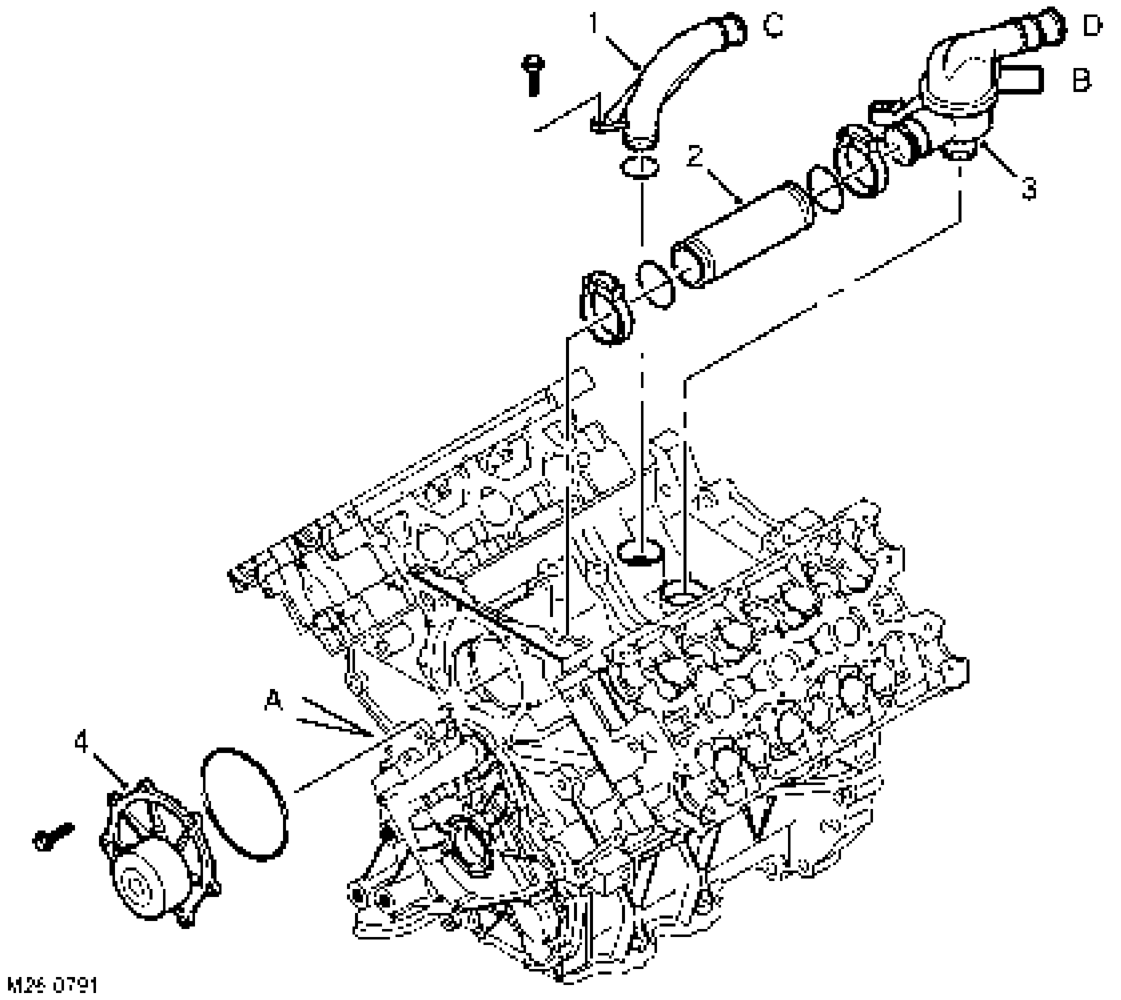
Cooling System Component Layout - Sheet 1 of 2



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

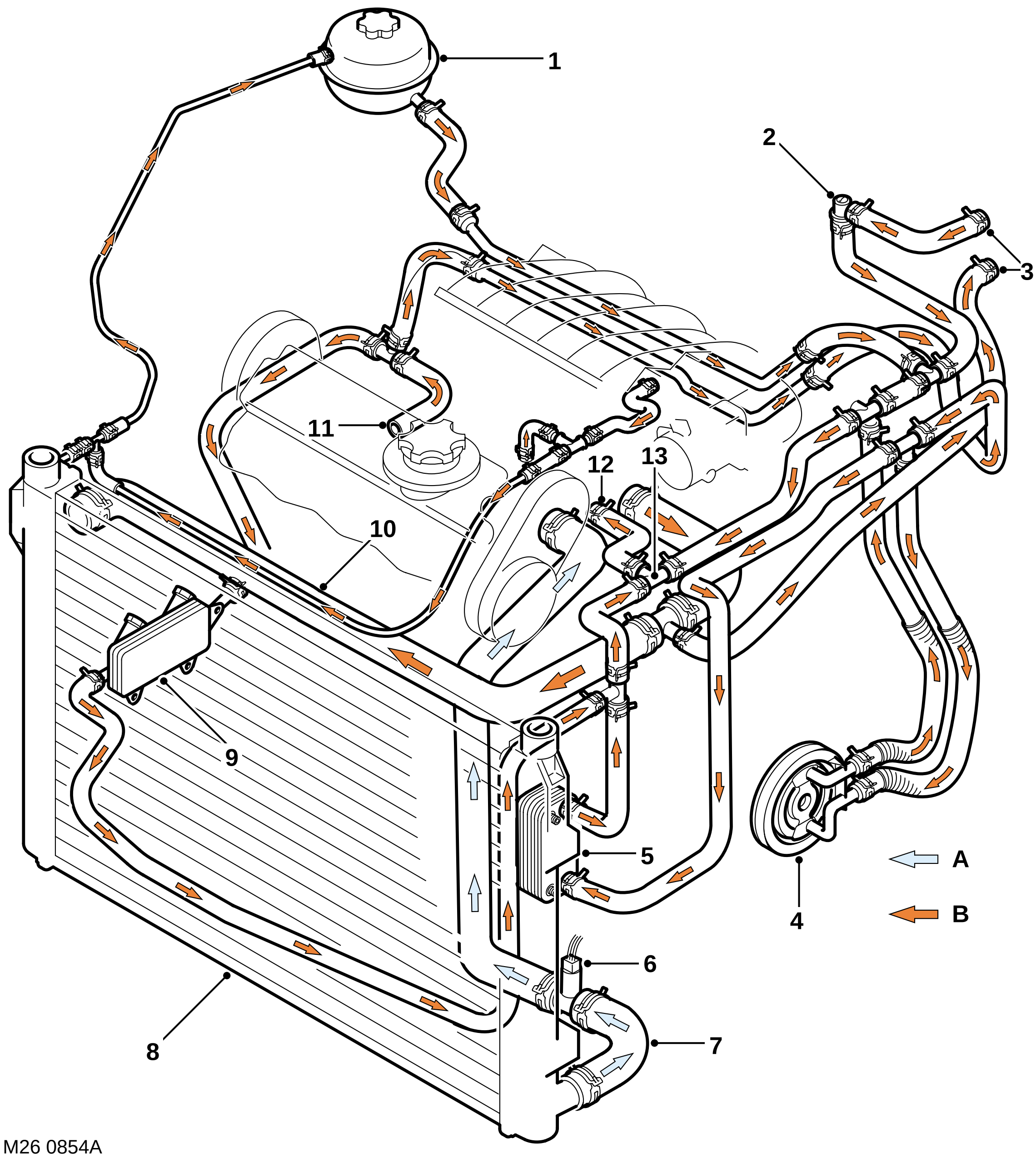
Cooling System Component Layout - Sheet 2 of 2



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



A = Cold; B = Hot

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

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/in^2). 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).

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 assists 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

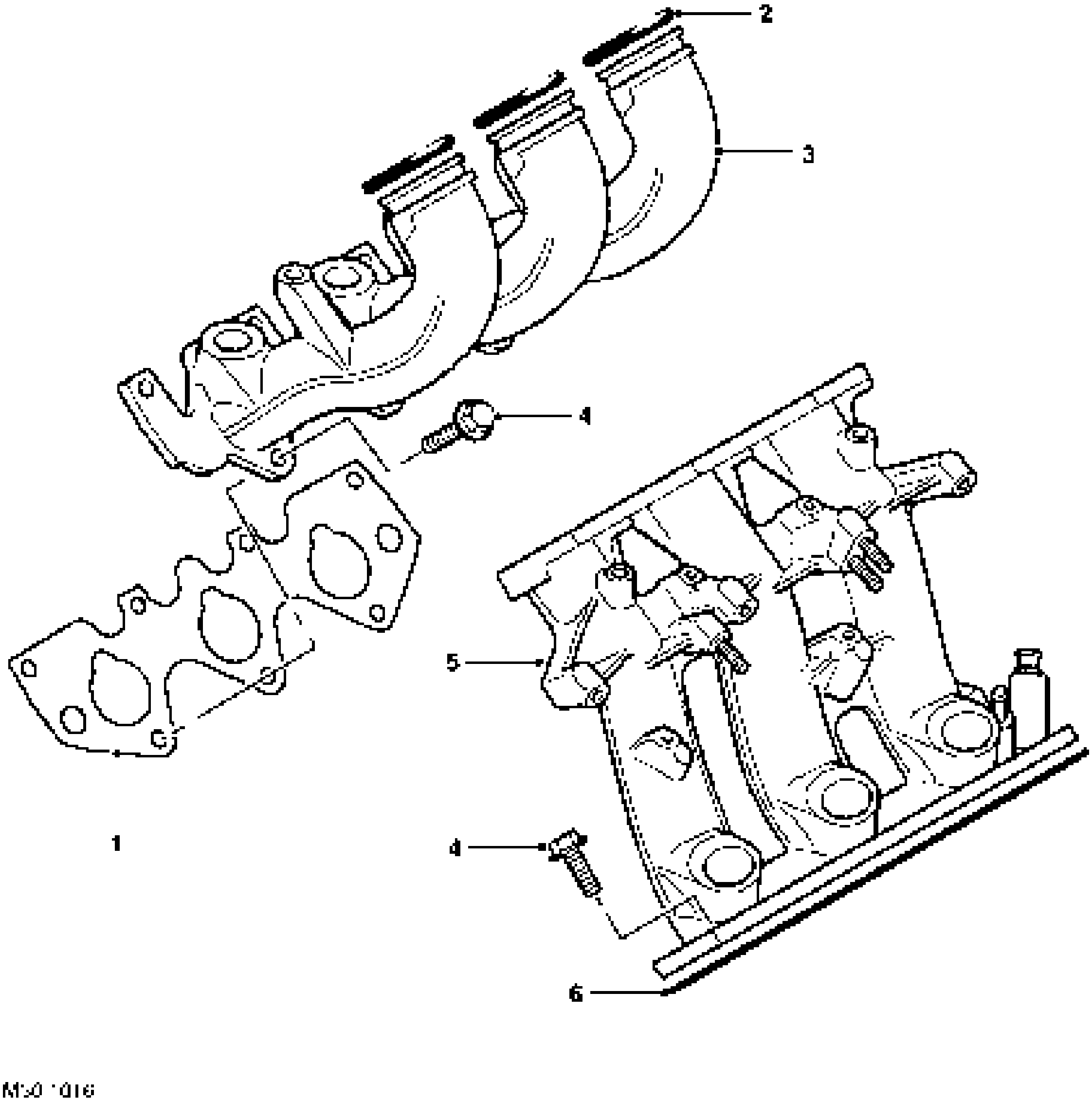
The cooling fan ECU monitors the speed of the cooling fans, from the current draw of the motors, and incorporates strategies to protect the motors from electrical overload if the fans are seized or heavily loaded (e.g. by debris or during wading).

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.

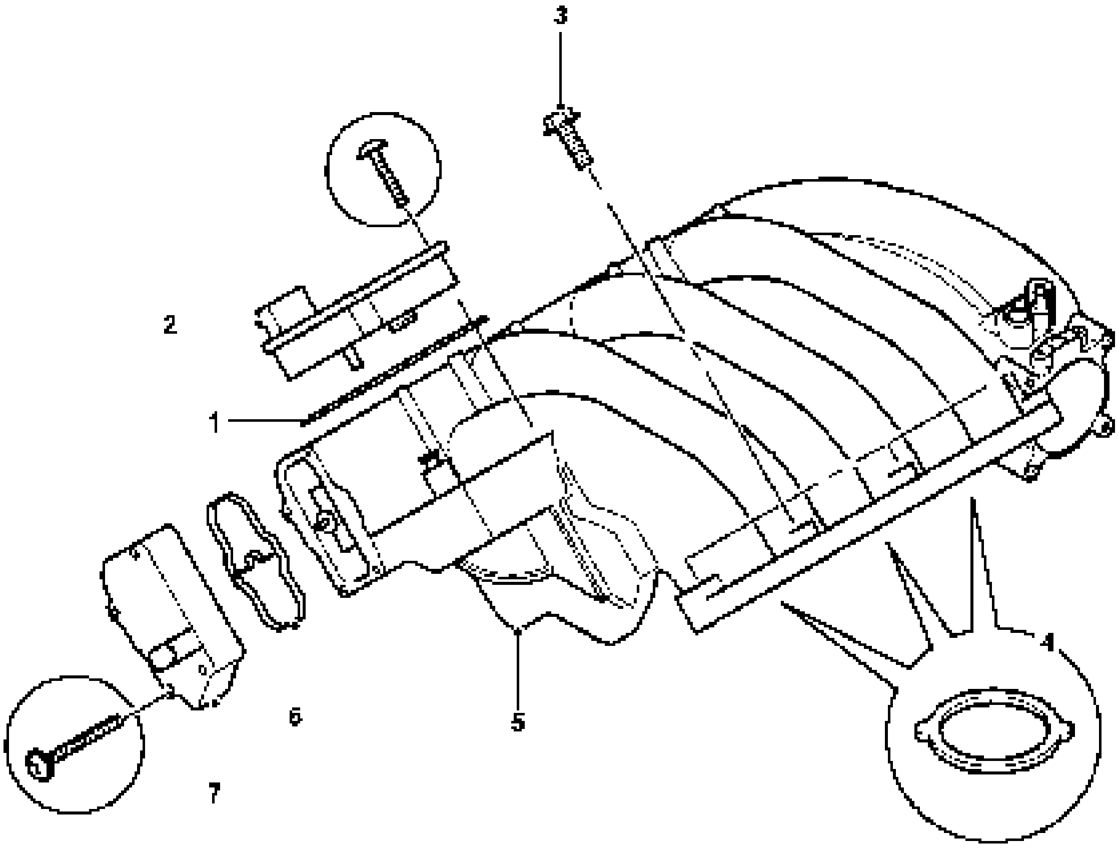
When one of the cooling fans is not running, the cooling fan ECU runs the other cooling fan at maximum speed.

Inlet Manifold Component Layout



1 Gasket RH
2 'O' ring (3 off)
3 Inlet manifold RH
4 Flanged bolt (14 off)
5 Inlet manifold LH
6 Gasket LH

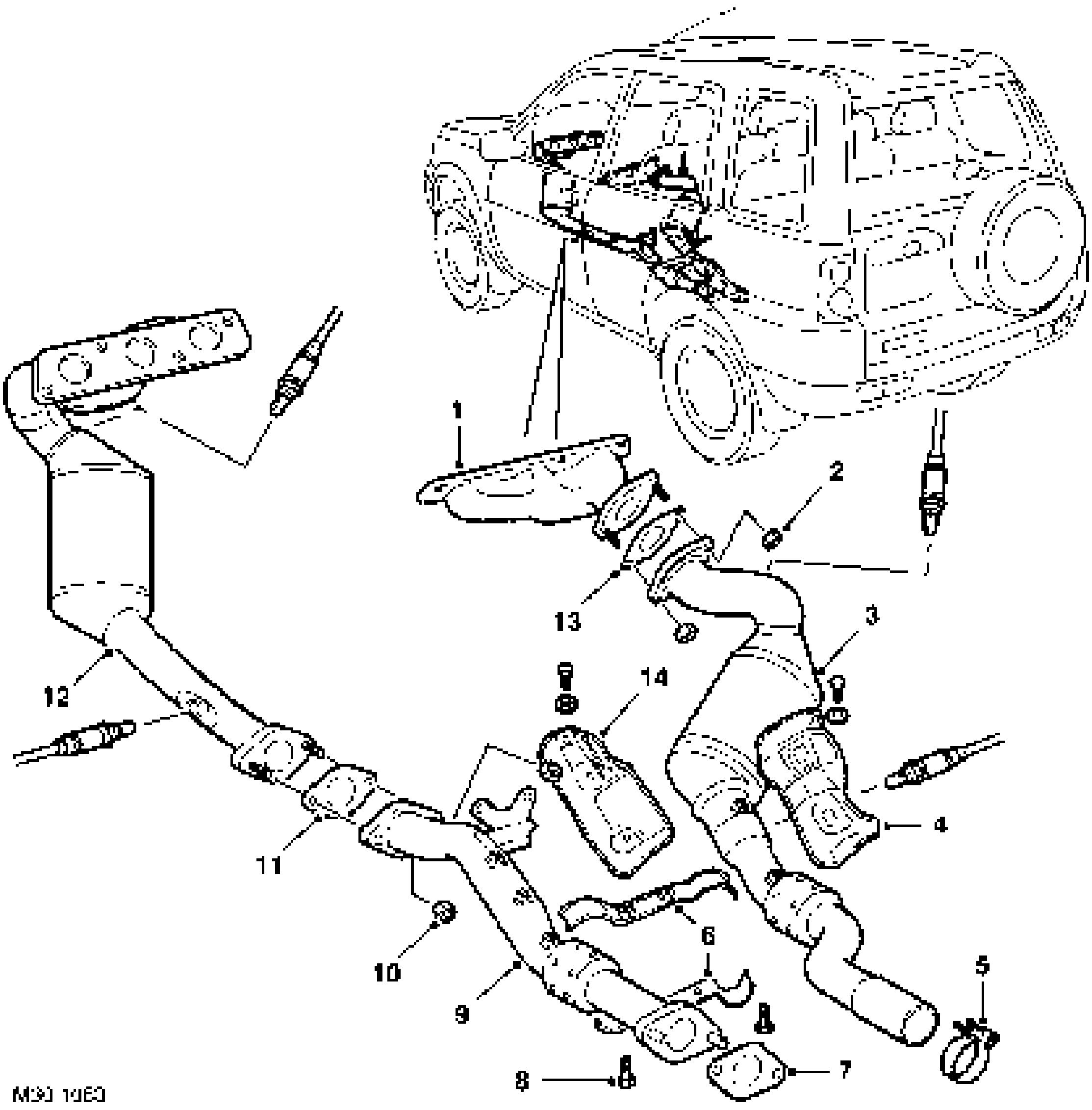
Inlet Manifold Chamber Component Layout



M30 1017

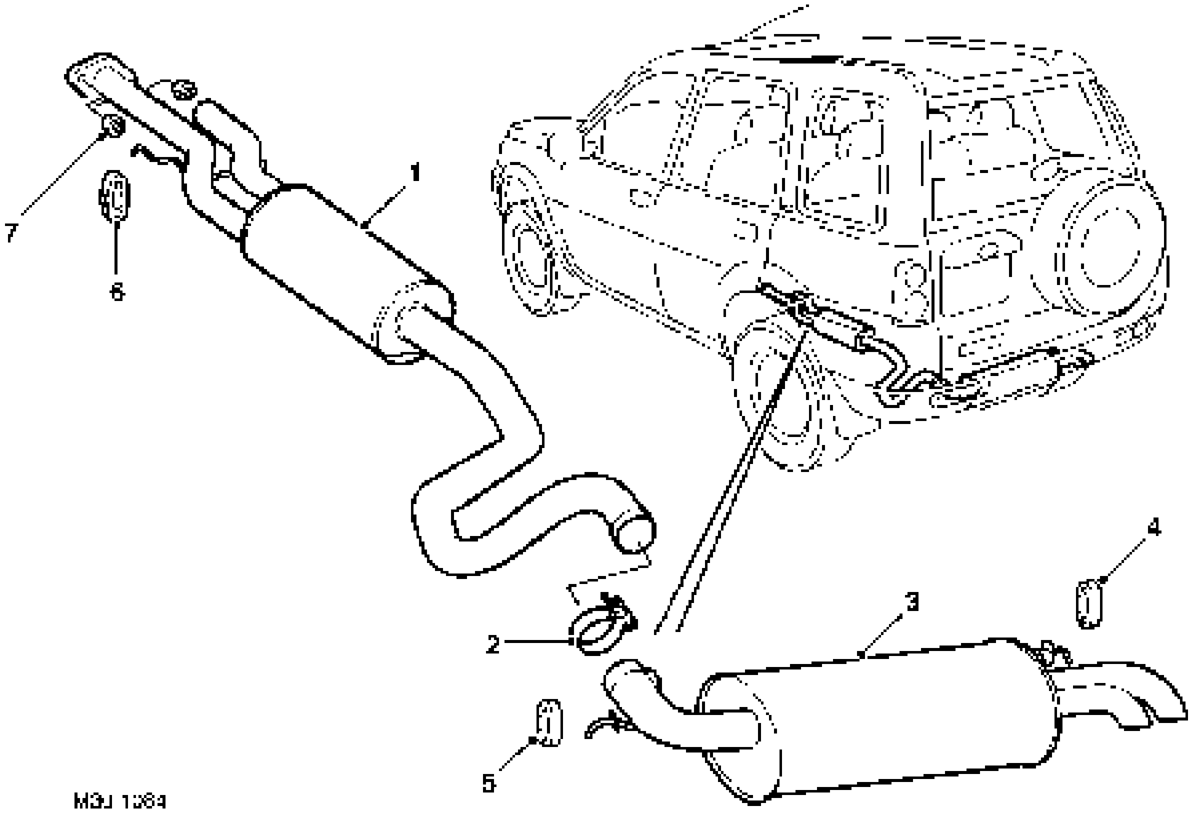
1 Seal
2 Power valve motor – Variable Intake System (VIS)
3 Flanged bolt (4 off)
4 Seal (3 off)
5 Inlet Manifold Chamber
6 Seal
7 Balance valve motor – (VIS)

Exhaust System Component Layout – Sheet 1 of 2



1 RH manifold
2 Nut – RH catalytic converter and downpipe to manifold (x 2)
3 RH catalytic converter and downpipe
4 Heatshield
5 Pipe clamp
6 Bracing clamp
7 Gasket
8 Bolt – bracing clamp (x 2)
9 LH downpipe
10 Nut – LH downpipe to manifold and catalytic converter (x 2)
11 Gasket
12 LH manifold and catalytic converter
13 Gasket
14 Heatshield

Exhaust System Component Layout – Sheet 2 of 2



1. Intermediate pipe
2. Pipe clamp
3. Tail silencer
4. Mounting rubber
5. Mounting rubber
6. Mounting rubber with restraint
7. Nut – intermediate pipe to downpipes (x 2)

Description

Inlet Manifolds

The inlet manifold on the KV6 engine is located on the top of the engine, between the cylinder banks. The manifolds direct intake air into the cylinders where it is mixed with fuel delivered by the injectors prior to ignition in the cylinders. The inlet manifold comprises left and right hand cast aluminium inlet manifolds and a plastic moulded inlet manifold chamber.

Two handed aluminium inlet manifolds are secured to the cylinder heads using fourteen bolts and sealed with one piece composite gaskets. Three injectors, which are sealed with 'O' rings, are located in each manifold and are retained in position by the fuel rail. The fuel rails are secured to each manifold using two bolts. A coolant outlet is located in the left hand end of each manifold and a vacuum take-off point is located on the left hand manifold. Three 'O' rings and three moulded seals provide the seal between the inlet manifolds and the inlet manifold chamber.

Inlet Manifold Chamber

The inlet manifold chamber is a one piece plastic moulding which is fitted on the inlet manifolds and secured with four bolts. Three 'O' rings and three moulded seals locate in recesses and seal between the inlet manifold chamber and the inlet manifolds.

The inlet manifold chamber features a single throttle body which feeds into a 'Y' piece, which separates into two secondary pipes. The secondary pipes connect to two main plenums, one for each bank of cylinders. At the closed end of the plenums is a balance valve which is operated by an electric motor. This valve enables the two plenums to be connected together.

From the two plenums, the primary tract length to the cylinder head face is approximately 500 mm. Each of these tracts has a side junction with a power valve leading to a short inlet tract plenum, approximately 350 mm from the cylinder head. Each power valve is connected to a link rod which is operated by a single electric motor.

Exhaust System

The manifolds and exhaust system is of welded steel construction and consists of five main parts;

- A RH (rear) manifold.
- A LH (front) manifold and catalytic converter.
- A RH downpipe and catalytic converter.
- A LH downpipe.
- An intermediate pipe.
- A tail silencer.

Close coupled catalytic converters are incorporated into the system to achieve fast converter light-off times after starting the engine. Heated Oxygen Sensors (HO2S) are installed upstream and downstream of each catalytic converter, to enable the ECM to exercise closed loop control of the air:fuel ratio and to monitor catalytic converter performance.

To reduce heat loss, the exhaust manifolds, the pipes between the exhaust manifolds and the catalytic converters, and the ends of the catalytic converters, are double walled with an air gap between the walls.

The system is suspended from the underside of the vehicle on mounting rubbers and a bracket on the downpipe and rear catalytic converter.

RH Manifold

The three branch manifold is fitted to the RH cylinder head. A composite gasket seals the manifold to the cylinder head and four studs and nuts secure the manifold in position.

LH Manifold and Catalytic Converter

The front manifold and catalytic converter consists of a three branch manifold and a catalytic converter integrated into a common assembly. A composite gasket seals the manifold to the LH cylinder head and four studs and nuts secure the manifold in position. Threaded bosses are welded into the pipe at each end of the catalytic converter to accommodate the HO2S.

RH Downpipe and Catalytic Converter

The RH downpipe and catalytic converter is connected between the RH manifold and the intermediate pipe. The flanged connection with the RH manifold is sealed with a metal gasket. The slip joint connection with the intermediate pipe is secured with a clamp. Threaded bosses are welded into the downpipe at each end of the catalytic converter to accommodate the HO2S. A flexible joint is incorporated into the downpipe, near the connection with the intermediate pipe, to absorb engine vibration. Brackets welded to the top of the downpipe accommodate anchor nuts for the attachment of a heatshield.

LH Downpipe

The LH downpipe connects the LH manifold and catalytic converter to the intermediate pipe. Flanged connections at each end of the downpipe are sealed with metal gaskets. A flexible joint is incorporated into the downpipe, near the connection with the intermediate pipe, to absorb engine vibration. A bracing clamp attaches the LH downpipe to the RH downpipe and catalytic converter. A bracket on the LH downpipe attaches the system to the Intermediate Reduction Drive (IRD). Additional brackets welded to the top of the downpipe accommodate anchor nuts for the attachment of a heatshield.

Intermediate Pipe

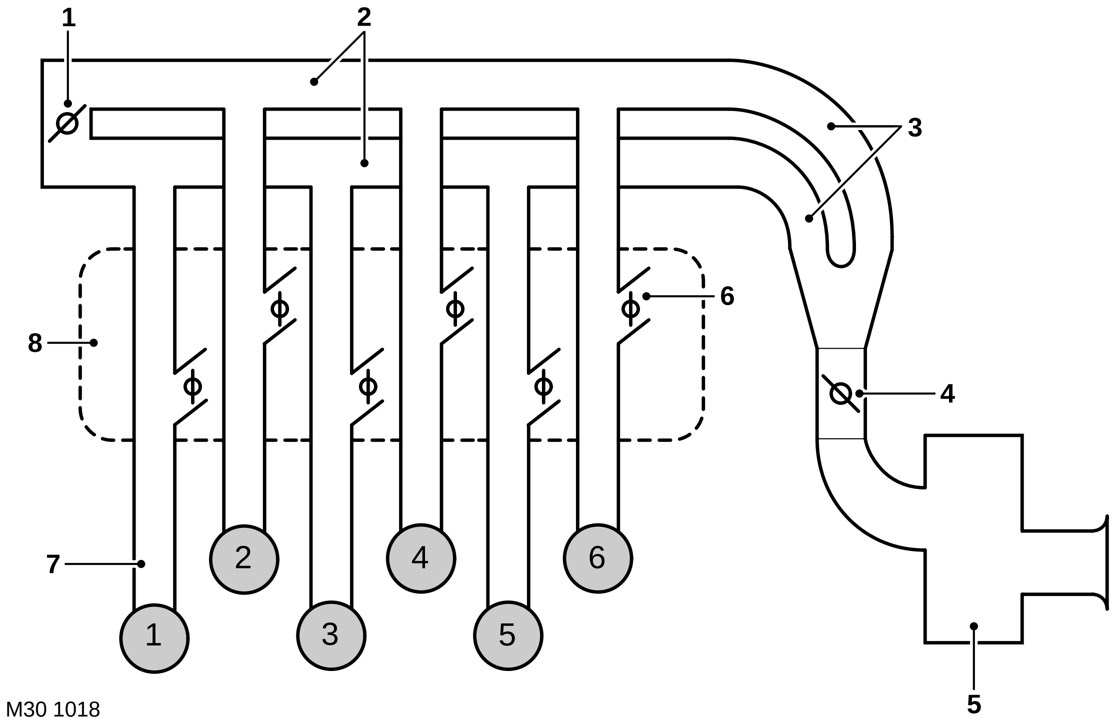
The intermediate pipe connects the downpipes to the tail silencer. A silencer is incorporated into the front of the intermediate pipe, and the rear end of the pipe is formed to pass over the rear suspension.

Tail Silencer

The tail silencer comprises a silencer, a connecting pipe and two tail pipes. The curved connecting pipe is welded to the left hand end of the silencer and mates with the intermediate pipe. The slip joint between the tail silencer and the intermediate pipe is secured with a clamp.

Operation

Inlet Manifold Chamber – Variable Intake System (VIS)



1 Balance valve
2 Main plenums
3 Secondary tracts
4 Throttle housing
5 Air cleaner
6 Power valves (6 off)
7 Primary tracts
8 Short tract plenum

The VIS operates in three conditions:

- Low speed
- Mid-range
- High speed.

Low Speed

At low speed the balance valve and power valves are closed. This effectively allows the engine to breathe as two, three cylinder engines, each having a separate plenum and long primary tracts. The primary and secondary tracts and the plenum volume are tuned to resonate at 2700 rev/min, giving peak torque at this speed.

Mid-Range

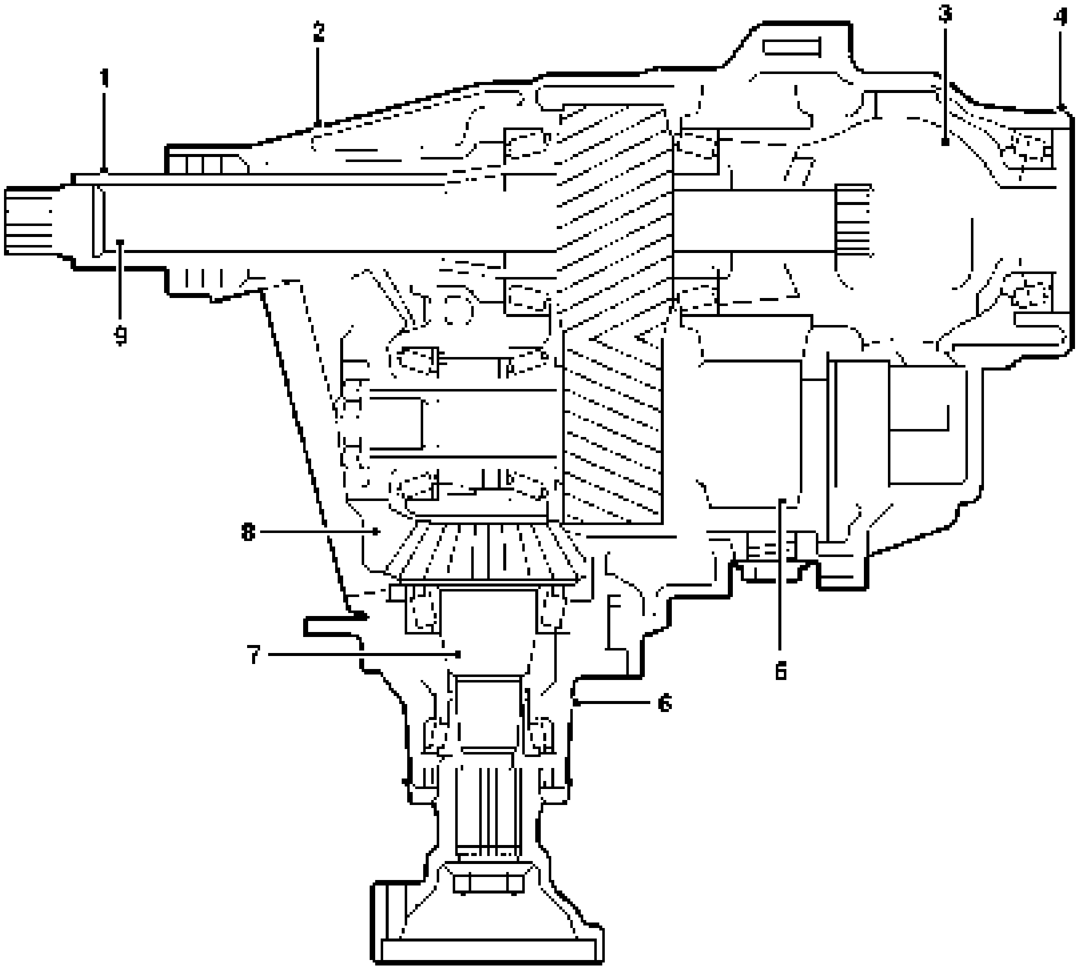
For increased mid-range torque performance, the plenums are connected using the balance valve. The power valves remain closed. This allows the engine to use the long primary tract length, which is tuned with the balance valve to produce maximum torque at 3750 rev/min.

High Speed

At high engine speeds the balance valve remains open and the six power valves are opened. This allows the engine to breathe from the short tract plenum via the short primary tract lengths. These lengths and diameters are tuned to produce a spread of torque from 4000 rev/min upwards, with maximum power produced at 6250 rev/min.

The manifold also gives an improvement in part load fuel consumption. At part load, throughout the emissions cycle the manifold operates as at high speed. The pressure dynamics significantly reduce the pump losses below 4000 rev/min resulting in improved fuel consumption.

Intermediate Reduction Drive



M41 7683

1 Primary shaft
2 Main casing
3 Differential unit
4 RH Housing
5 Laygear
6 Pinion housing
7 Rear output pinion
8 Hypoid gear set
9 Intermediate shaft

Description

Intermediate Reduction Drive (IRD)

The IRD is fitted in place of the conventional transfer box and is attached to the automatic gearbox. The combination of the two units provides drive to the front and rear wheels. The IRD incorporates a differential unit to control the proportion of drive delivered to each front wheel and, in addition, it operates in conjunction with the viscous coupling to give the vehicle a self-sensing four wheel drive system. The main casing, cover and pinion housing are manufactured from cast aluminium.

The unit comprises of a main casing, a RH housing, primary shaft, an intermediate shaft, a differential unit, a laygear, hypoid gear set, a rear output pinion and a pinion housing.

An oil cooler, connected to the vehicle cooling system, is fitted to prevent overheating of the IRD lubricating fluid.

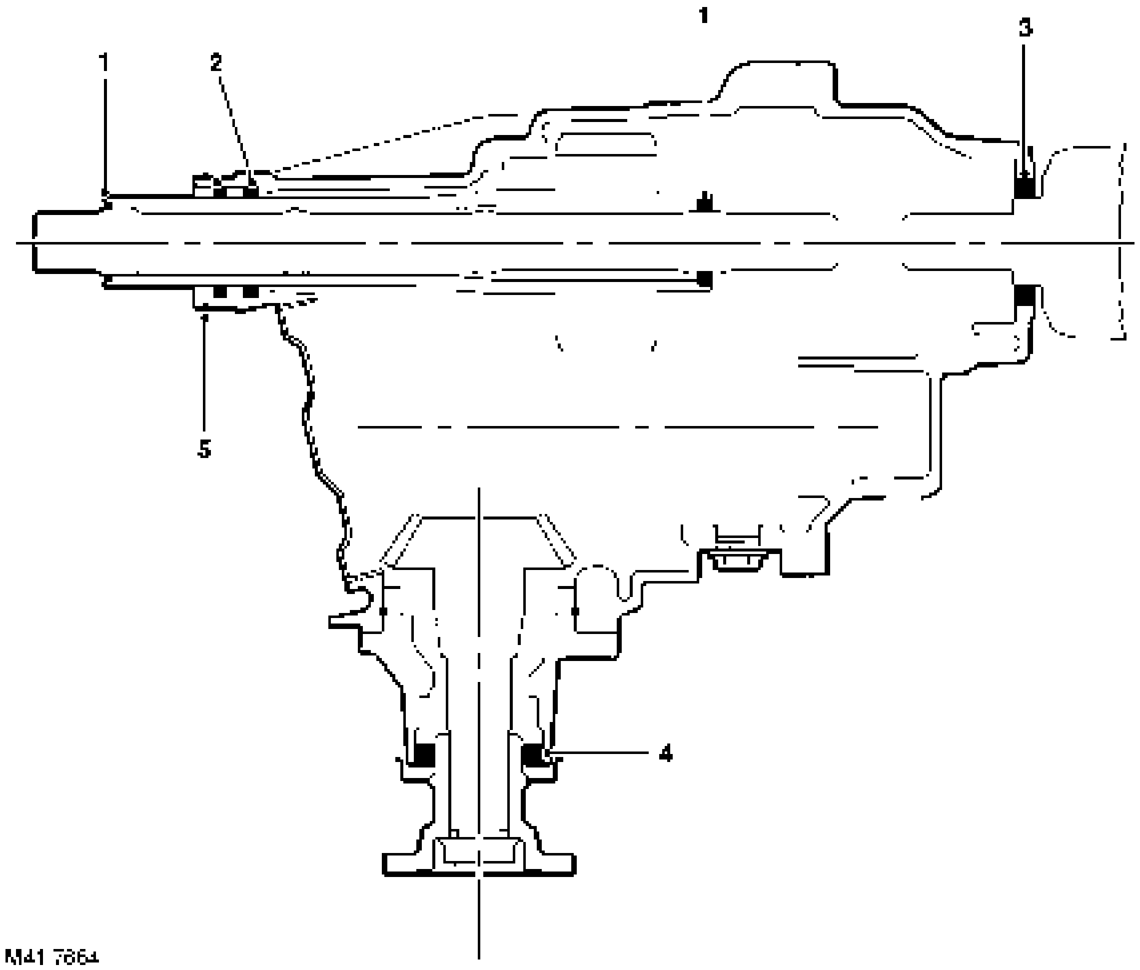
The main casing also incorporates the oil level/drain plugs and a breather outlet. There are a total of seven taper roller bearings and one parallel roller bearing supporting the primary shaft, differential and output shaft assemblies.

Four seals, internal to the IRD, are used to prevent mixing of the IRD and gearbox lubricating fluids.

Operation

Drive is transmitted from the gearbox to the IRD primary shaft via the splined hub in the gearbox final drive gear carrier. The drive is then transmitted from the primary shaft gear, which is integral with the primary shaft, to the layshaft which in turn drives the differential for the front driveshafts, and via a bevel drive gear and pinion to drive the rear axle. The intermediate shaft passes through the centre of the IRD primary shaft, and is the drive link between the IRD differential, and the left-hand front driveshaft, passing through the centre of the final drive carrier.

Oil Seals



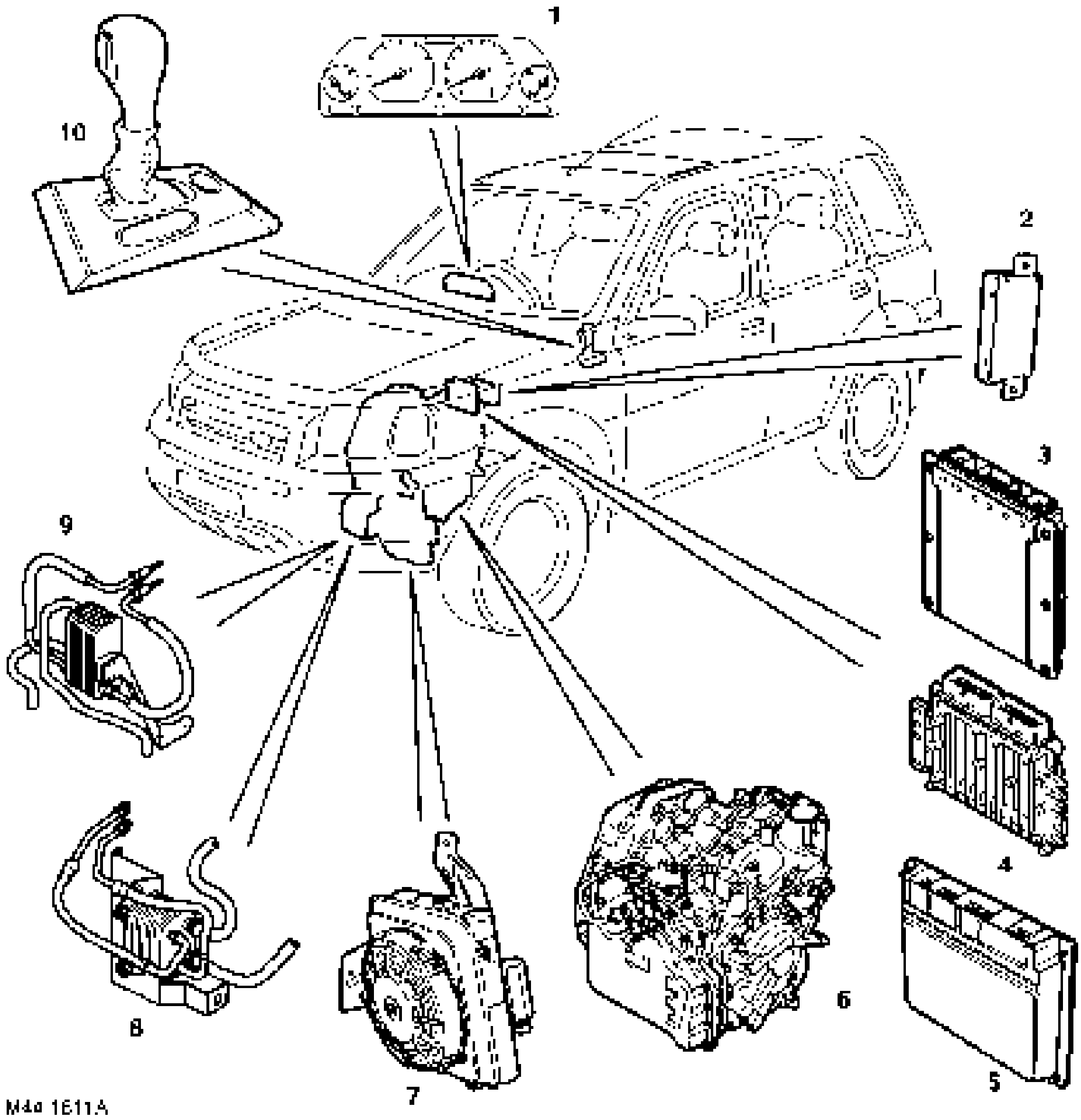
1 Primary shaft outer oil seal
2 Primary shaft inner oil seals
3 RH drive shaft oil seal
4 Pinion housing oil seal
5 'O' ring seal

Externally, three oil seals prevent lubricating oil escaping from the gearbox and the IRD unit. The gearbox gear case houses the oil seal for the left-hand front driveshaft, and the RH housing on the IRD unit houses the oil seal for the right-hand front driveshaft, with the remaining oil seal located in the pinion housing of the IRD.

There are also four internal oil seals in the IRD unit. Two smaller diameter oil seals are fitted internally at each end of the primary shaft. These prevent oil ingress along the intermediate shaft from the IRD unit at the differential end. At the opposite end, the seal prevents oil ingress from the gearbox along the intermediate shaft. Two larger oil seals are fitted in the main casing where the IRD unit enters the gearbox. The inner oil seal prevents oil ingress from the IRD primary shaft entering into the area between the two seals, and the outer oil seal prevents oil ingress from the gearbox entering the same area.

On the underside of the main casing is a 'tell-tale' drilling which is positioned between the inner and outer primary shaft oil seals. Oil leakage from the drilling will indicate either a faulty inner or outer primary shaft oil seal. An 'O' ring seal, fitted in a machined groove, seals the IRD main casing to the gearbox housing.

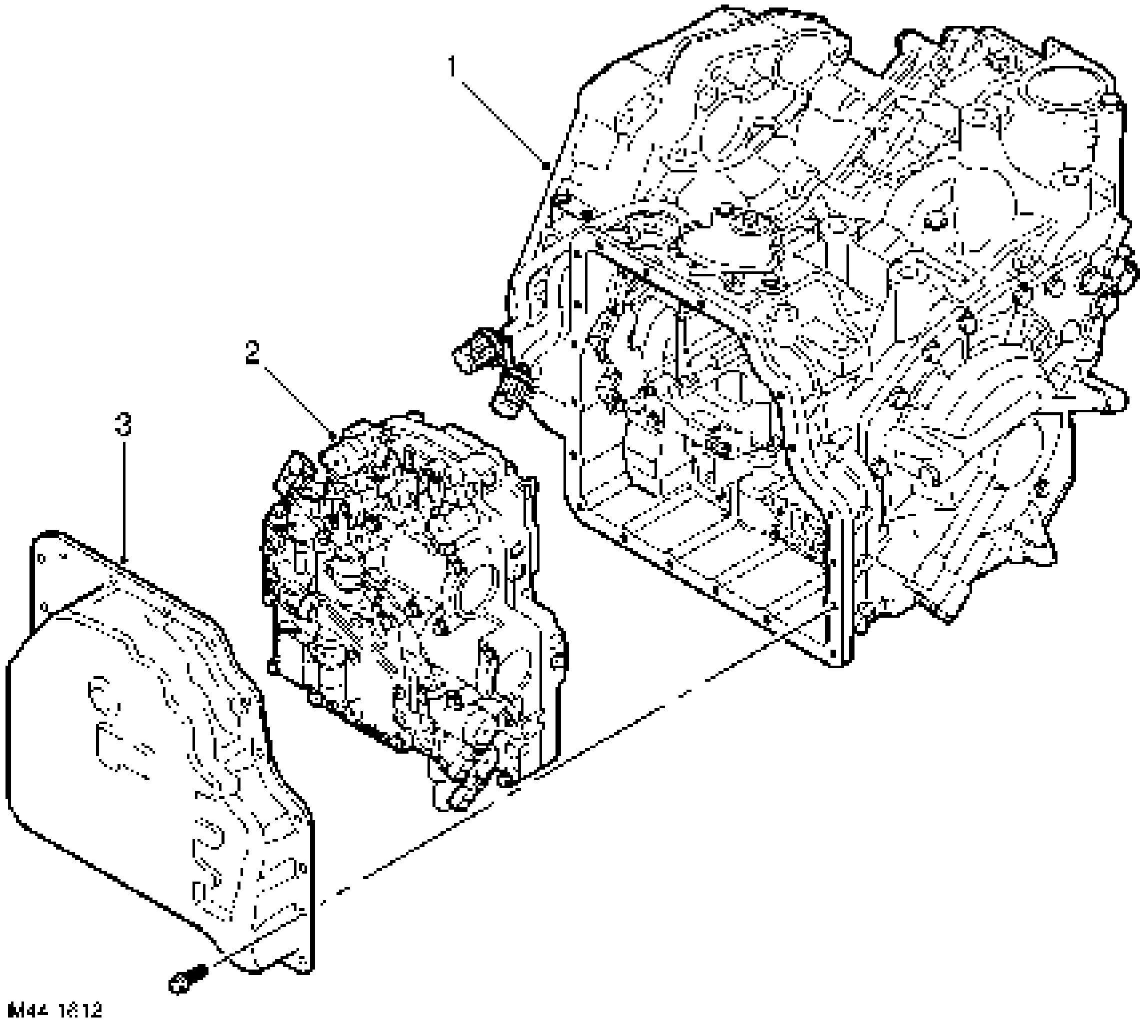
JATCO Automatic Gearbox Component Location



RHD model shown

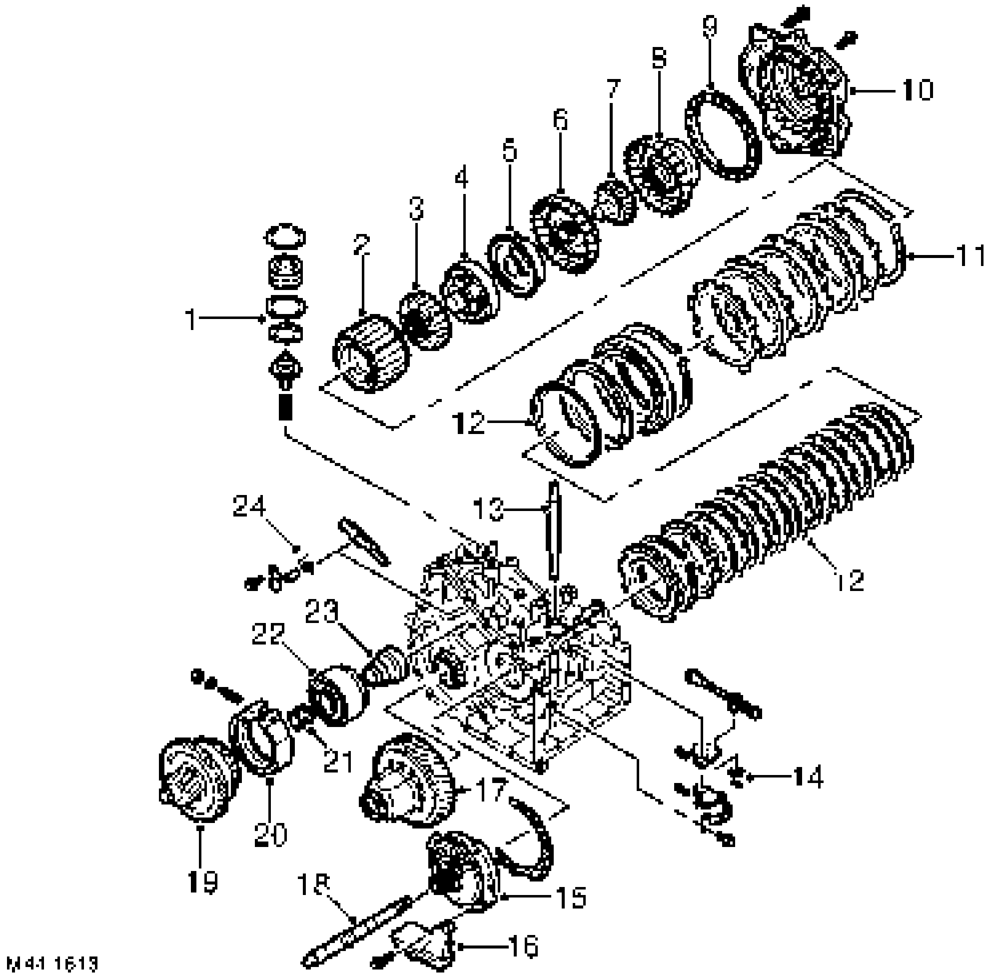
1. Instrument pack
2. Electronic Automatic Transmission (EAT) ECU
3. Engine Control Module (ECM) - Td4
4. Engine Control Module (ECM) - Non NAS KV6
5. Engine Control Module (ECM) – NAS KV6
6. JATCO CommandShift gearbox
7. Air blast fluid cooler (Td4 hot climate models)
8. Fluid cooler (KV6 models)
9. Fluid cooler (Td4 cold climate models)
10. Selector lever assembly

JATCO Automatic Gearbox



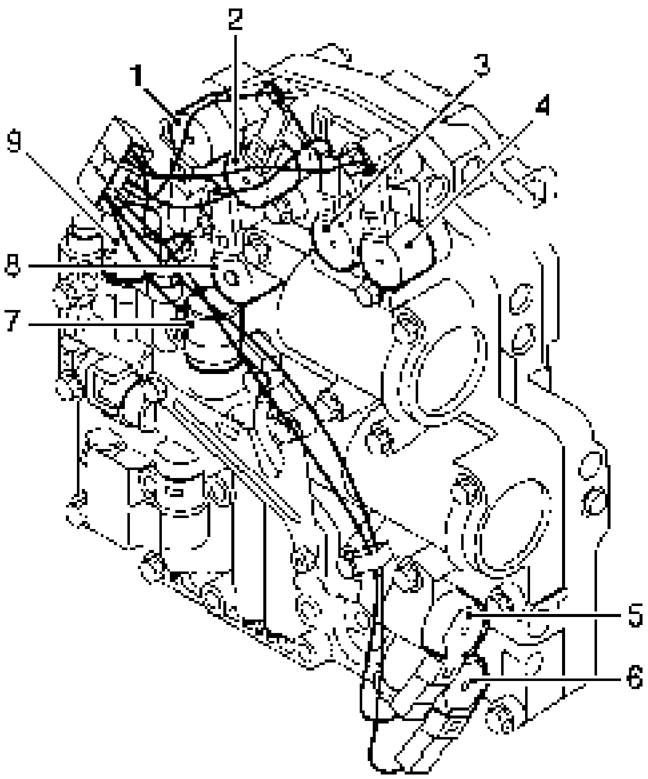
1 Gearbox
2 Solenoid valves and valve block
3 Fluid pan

JATCO Automatic Gearbox - Exploded View



1 Band servo
2 Low clutch
3 Internal gear
4 Rear planetary carrier
5 Front planetary carrier
6 Low clutch hub
7 High clutch hub
8 Reverse and high clutch assembly
9 Return spring
10 Side cover
11 2-4 brake
12 Low and reverse brake
13 Manual shaft
14 Parking component
15 Oil pump
16 Oil strainer
17 Differential gear
18 Input shaft
19 Reduction gear
20 Reduction brake band
21 Sun gear
22 Direct clutch
23 One way clutch inner race
24 Parking mechanism

JATCO Automatic Gearbox - Valve Block and Solenoid Valves



M441814

1 Shift solenoid valve A
2 Reduction timing solenoid valve
3 Shift solenoid valve B
4 Shift solenoid valve C
5 2-4 brake duty solenoid valve
6 2-4 brake timing solenoid valve
7 Low clutch timing solenoid valve
8 Lock-up solenoid valve
9 Line pressure duty solenoid valve

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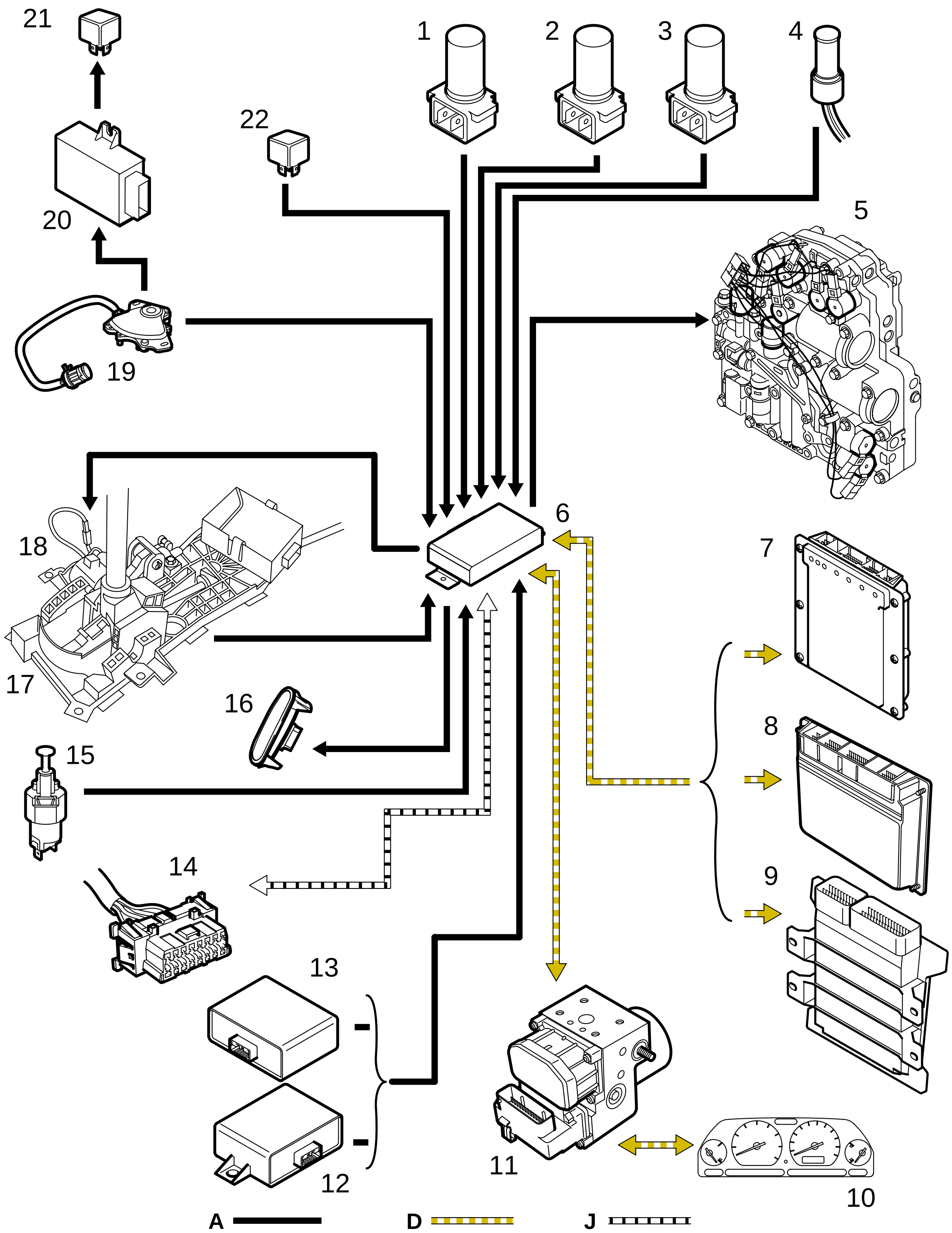
JATCO Automatic Gearbox Control Diagram



A = Hardwired; D = CAN Bus; J = Diagnostic ISO 9141 K Line

1 Intermediate speed sensor
2 Vehicle speed sensor
3 Turbine speed sensor
4 Fluid temperature sensor
5 Solenoid valves and valve block
6 EAT ECU
7 ECM – Td4
8 ECM – NAS KV6
9 ECM – Non NAS KV6
10 Instrument pack
11 ABS ECU/modulator
12 Cruise control ECU (non NAS KV6)
13 Cruise control interface ECU (Td4 and NAS KV6)
14 Diagnostic socket
15 Brake switch
16 PRND421S/M LED Module
17 Sport/manual switch
18 Shift interlock solenoid
19 Selector and inhibitor switch
20 Immobilisation ECU
21 Starter relay
22 Main relay

Description

General

The JATCO JF506E automatic gearbox is an electronically controlled, five speed gearbox which incorporates software to enable the gearbox to operate as a semi-automaticgearbox. The transmission, previously known as 'Steptronic', is designated 'CommandShift' from 2003 model year.

The gearbox can be operated as a conventional automatic gearbox by selecting P, R, N, D, 4, 2 or 1 on the selector lever. Moving the selector mechanism across the gate to the 'S/M' position, sends a signal to the Electronic Automatic Transmission (EAT) ECU and puts the gearbox into sport/manual mode.

In sport mode, the gearbox still operates as a conventional automatic transmission, but the unit becomes more responsive to driver demands. Lower gears will be held longer and the transmission will downshift more readily. This gives increased acceleration and improves vehicle response.

When in sport mode, if the selector lever is moved to the + or - positions, the system will automatically change to operate in manual mode. Manual gear changes can be performed sequentially using the selector lever. Movement of the selector lever in the forward (+) direction changes the gearbox up the ratios and movement in a rearward (-) direction changes the gearbox down the ratios.

Gearbox operation is controlled by the EAT ECU and the Engine Control Module (ECM) which communicate via a Controller Area Network (CAN) Bus. The EAT ECU receives information from the ECM and gearbox sensors to calculate the appropriate gear ratio for the conditions and controls solenoid valves to operate the gearbox as required.

The advantages gained with the electronically controlled gearbox are smoother gear changes, quicker and more accurate gear change scheduling and reduced fuel consumption through improved engine/gearbox speed matching.

CommandShift JATCO Automatic Gearbox

The JATCO five speed automatic gearbox is similar to conventional electronically controlled transmissions but provides the driver with an additional manual mode feature. Manual mode allows the driver to electronically select the five forward gear ratios and operate the gearbox as a semi-automatic manual gearbox.

The individual gear ratios are achieved through three planetary gear sets. The components of the planetary gear sets are driven or locked by means of four multi-plate clutches, two multi-plate brakes, one brake band and two one-way clutch assemblies. Torque is transmitted from the gearbox to the final drive through a reduction gear.

Gearbox Casing

Refer to JATCO Automatic Gearbox illustration.

The gearbox casing contains the input shaft transmitting the power into the drive train. The drive train is made up of the planetary gear sets and clutches.

The clutches and brake bands control which elements of the planetary gear sets are engaged and their direction of rotation, to produce the P and N selections, five forward ratios and one reverse gear ratio. Power output is from the drivetrain through a reduction gear into a differential.

Gear Ratios

Gear	Ratio
1st	3.474
2nd	1.948
3rd	1.247
4th	0.854
5th	0.685
Reverse	2.714
Final Drive Ratio	3.66

Valve Block and Solenoid Valves
Refer to JATCO Automatic Gearbox - Valve Block and Solenoids illustration.

The gearbox uses nine solenoid valves located on the valve block. The solenoid valves are energised/de-energised by the EAT ECU to control the gearbox fluid flow around the gearbox to supply clutches, brakes and brake band (gear change scheduling), fluid to the torque converter, lubrication and cooling.

Each solenoid valve is controlled separately by the EAT ECU. All nine solenoid valves can be classified into two types by their operating mode. Three of them are duty solenoid valves and the remaining six are on-off solenoid valves.

Each solenoid valve consists of an internal coil and needle valve. A voltage is passed through the coil of the solenoid to actuate the needle valve. The needle valve opens and closes the fluid pressure circuits. On-off solenoid valves close the fluid pressure circuits in response to current flow.

Duty solenoid valves repeatedly turn on and off in 50 Hz cycles. This opens and closes the fluid circuits allowing a higher level of control on the circuits. For example, smooth operation of the lock-up clutch in the torque converter to eliminate harsh engagement/ disengagement.

All of the solenoid valves are supplied with battery voltage and an earth path by the EAT ECU.

On/Off Solenoid Valves
The on/off solenoid valves are:
- Shift solenoid valve A
- Shift solenoid valve B
- Shift solenoid valve C
- Low clutch timing solenoid valve
- Reduction timing solenoid valve
- 2-4 brake timing solenoid valve.

The EAT ECU switches the on/off solenoid valves to open and close in response to vehicle speed and throttle opening.

Shift solenoid valves A, B and C are used to engage the different gear ratios within the gearbox. The position of these solenoid valves at any one time determines the gear selected.

Shift Solenoid Valve Activation

Shift Solenoid Valve	1st Gear	2nd Gear	3rd Gear	4th Gear	5th Gear
A	X	O	X	X	O
B	O	O	O	X	X
C	O	X	X	O	O
X = Solenoid Valve Off O = Solenoid Valve On					

The reduction timing solenoid valve, low clutch timing solenoid valve and 2-4 timing solenoid valve are used by the EAT ECU to control the timing of the gear shift changes.

These solenoid valves carry out three main functions:
- **Shift timing control:** For some shifts these three solenoid valves are used to assist line pressure control or 2-4 brake pressure control.
- **Line pressure cut back:** When the gearbox takes up the drive there should be a high line pressure present. The EAT ECU controls the low clutch timing solenoid valve which is related to the vehicle speed in order to switch the fluid circuit of the line pressure to on or off therefore controlling cut back.
- **Reverse inhibition:** If the vehicle exceeds 6 mph (10 km/h) and Reverse (R) is selected, the EAT ECU switches the low clutch timing solenoid valve on. This drains the gearbox fluid from the reverse clutch, therefore the clutch will be unable to engage.

Duty Solenoid Valves

The duty solenoid valves are:

- Lock-up duty solenoid valve
- Line pressure duty solenoid valve
- 2-4 duty brake solenoid valve.

The lock-up duty solenoid valve is used by the EAT ECU to control the lock-up of the torque converter depending upon the vehicle speed and throttle position.

The EAT ECU will actuate the lock-up solenoid valve, which operates the lock-up control valve to direct fluid to either lock or unlock the torque converter.

The line pressure duty solenoid valve and 2-4 duty brake solenoid valve are used by the EAT ECU to control fluid line pressure in the gearbox.

The EAT ECU calculates the line pressure by using the engine speed, vehicle speed and throttle angle. The EAT ECU then actuates the solenoid valves accordingly to achieve the required line pressure.

The solenoid valves can fail in the following ways:

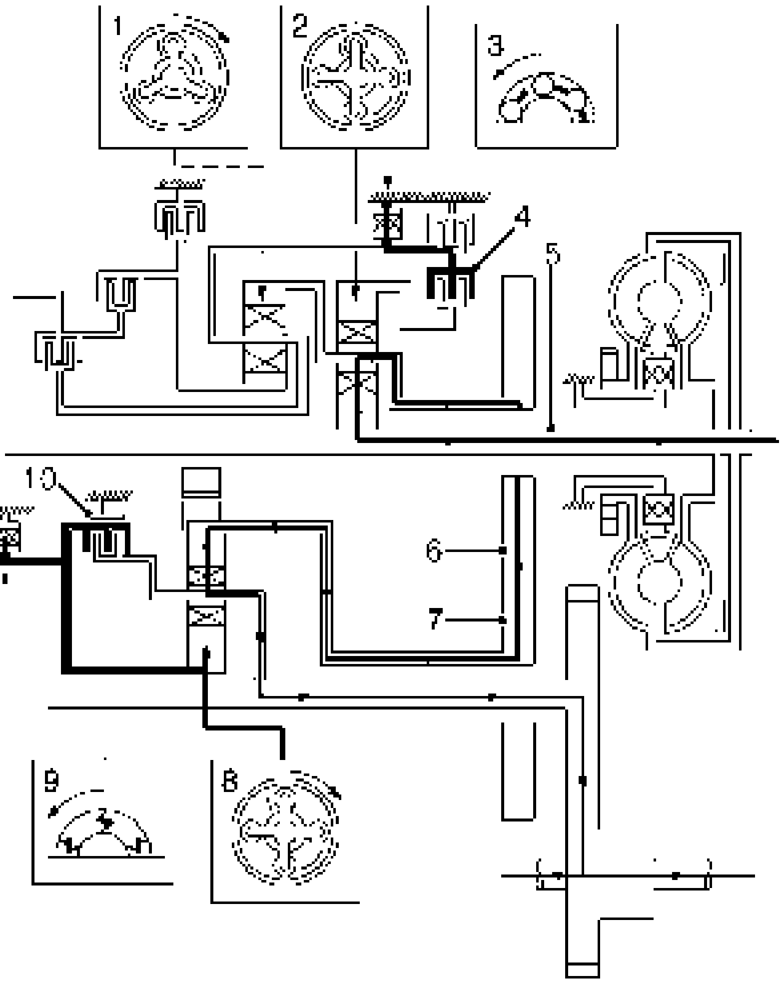
- Open circuit
- Short circuit to 12 or 5 volts
- Short circuit to earth.

In the event of a solenoid valve failure any of the following symptoms may be observed:

- Gearbox selects fourth gear only (shift solenoid valve failure)
- Gearbox will not upshift to fourth gear (timing solenoid valve failure)
- Increased fuel consumption and emissions (lock-up solenoid valve failure)
- Gear shifts will have no torque reduction therefore gear changes will be very harsh (line pressure duty solenoid valve failure)
- No pressure control will occur therefore gear changes from fifth gear will be very harsh (2-4 brake duty solenoid valve failure).

Power Flows
The following figures show the power flow in the gearbox for each forward gear and reverse.

1st Gear (D selected)

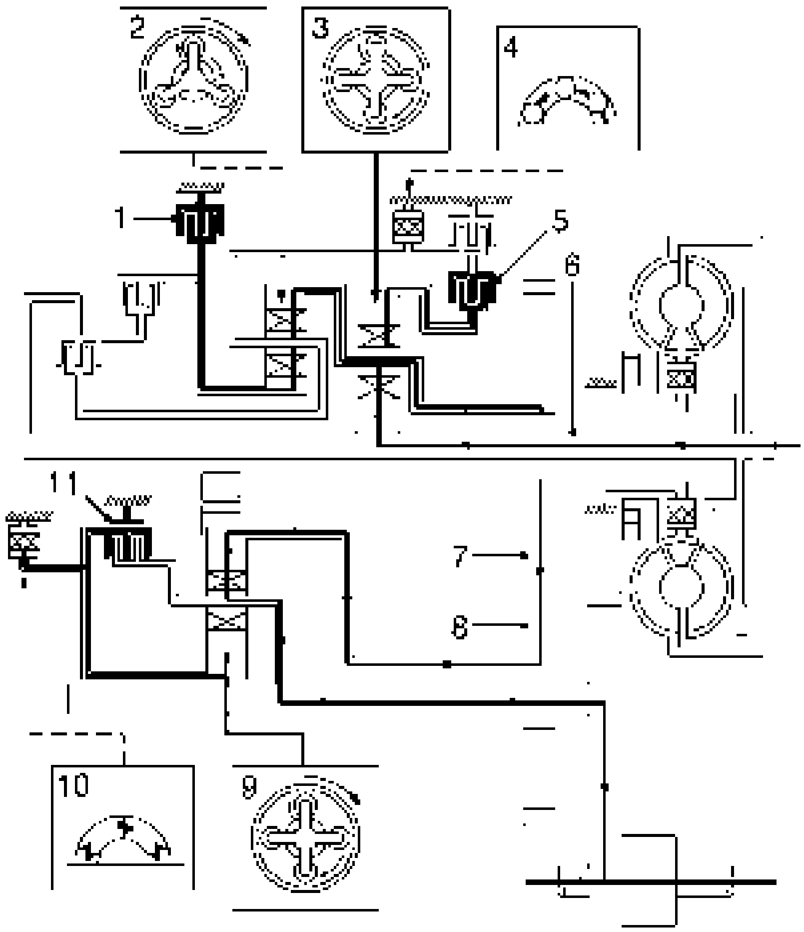


M44 1516

1 Front planetary gear
2 Rear planetary gear
3 Low one-way clutch
4 Low clutch
5 Input shaft
6 Output gear
7 Idler gear
8 Reduction planetary gear
9 Reduction one-way clutch
10 Reduction brake

On 1st gear selection, the low clutch and the reduction brake are engaged. During acceleration in 1st gear, the low one-way clutch and the reduction clutch are locked. Power flows from the input shaft to the rear sun gear to rotate it clockwise and the rear pinion gear rotates anti-clockwise. The rear internal gear tries to rotate clockwise. However, because the internal gear is connected to the low one-way clutch through the low clutch, the rear internal gear cannot rotate. Consequently, the rear planetary carrier and the output gear rotate clockwise. The output gear rotation is transmitted to the reduction internal gear by the idler gear. The reduction brake locks the reduction sun gear. The reduction gear rotates clockwise and makes the reduction planetary carrier rotate clockwise simultaneously. The reduction gear rotates clockwise and transmits the power to the final drive and out to the road wheels.

2nd Gear (D selected)

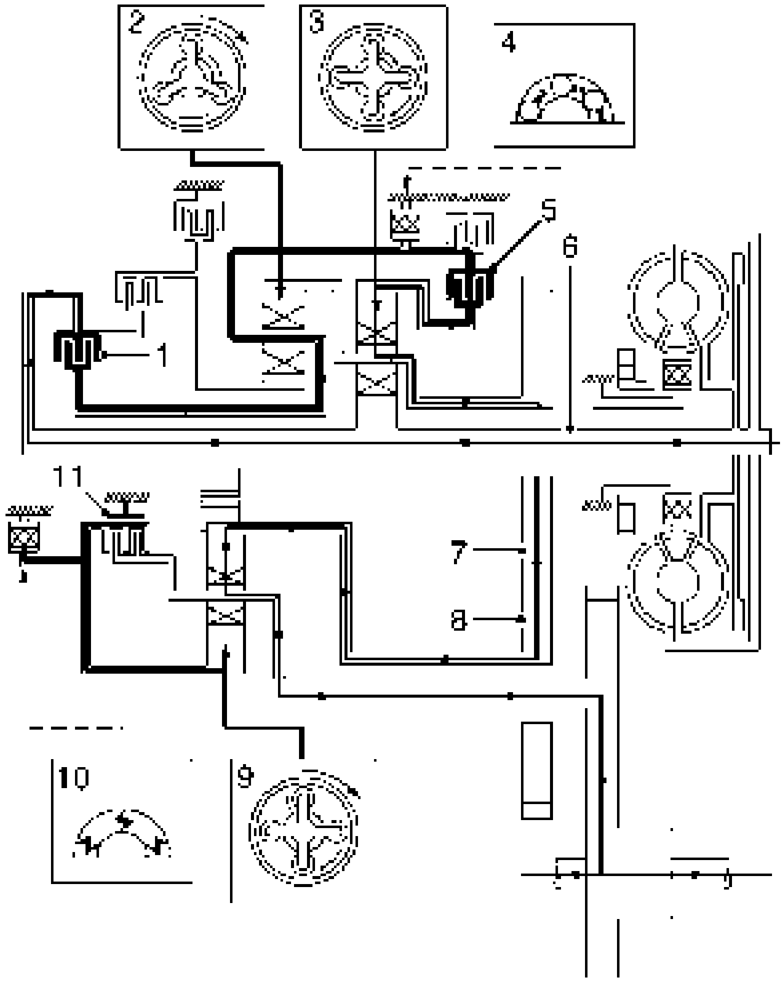


M44 1L17

1 2-4 brake
2 Front planetary gear
3 Rear planetary gear
4 Low one-way clutch
5 Low clutch
6 Input shaft
7 Output gear
8 Idler gear
9 Reduction planetary gear
10 Reduction one-way clutch
11 Reduction brake

On 2nd gear selection, the low clutch, the 2-4 brake, and the reduction brake are engaged. During acceleration in 2nd gear, the reduction one-way clutch is locked. Power flows from the input shaft to the rear sun gear to rotate it clockwise and the rear pinion gear rotates anti-clockwise. The 2-4 brake locks the front sun gear. The front pinion gear rotates clockwise to force the front planetary carrier to rotate clockwise. The driven power rotates the front internal gear clockwise. The output gear rotates faster due to the front internal gear rotation. The output gear rotation is transmitted to the reduction gear. The reduction gear rotates clockwise and transmits the power to the road wheels in the same way as 1st gear.

3rd Gear (D selected)

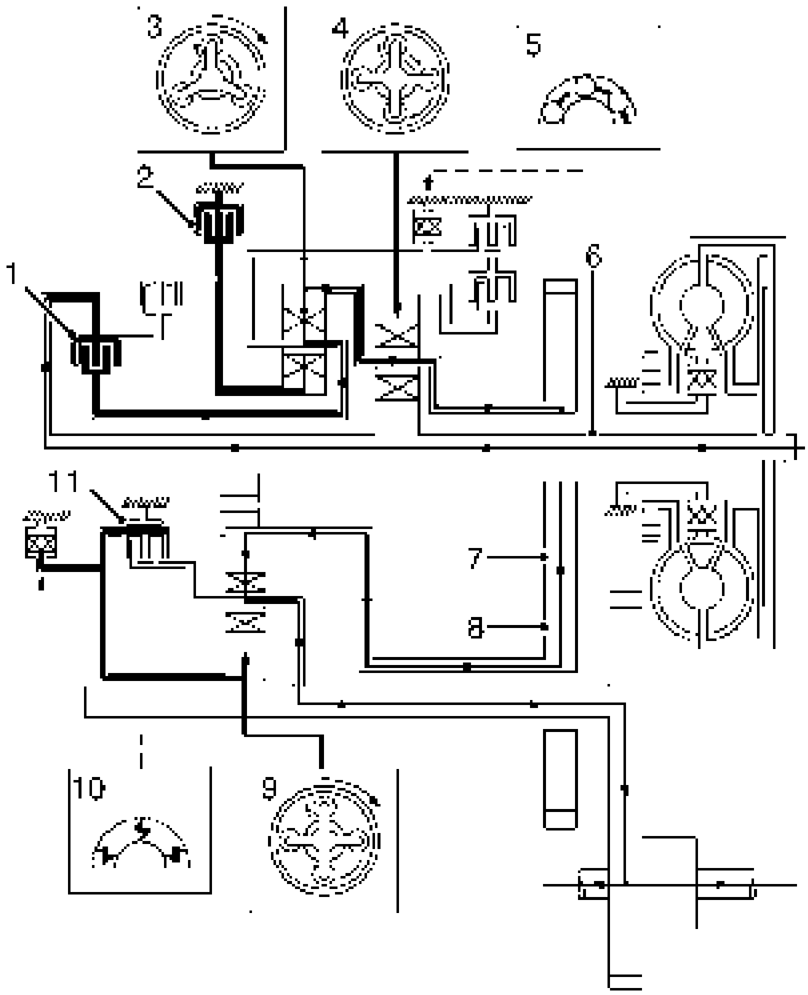


M44 1618

1 High clutch
2 Front planetary gear
3 Rear planetary gear
4 Low one-way clutch
5 Low clutch
6 Input shaft
7 Output shaft
8 Idler gear
9 Reduction planetary gear
10 Reduction one-way clutch
11 Reduction brake

On 3rd gear selection, the high clutch, the low clutch, and the reduction brake are engaged. During acceleration in 3rd gear, the reduction one-way clutch is locked. Power flows from the input shaft in a clockwise direction to the high clutch through the front planetary carrier. The front planetary carrier is connected to the rear internal gear by the low clutch. The rear internal gear rotates clockwise at the same speed as the input shaft. The rear sun gear rotates clockwise at the same speed because it is connected to the input shaft and the rear internal gear. The rear pinion does not rotate. The rear planetary carrier rotates in the same direction and speed as the input shaft. The power flow from the rear planetary carrier is transmitted to the reduction gear via the output gear, idler gear, reduction internal gear, and the reduction planetary carrier. The power is then transmitted to the road wheels in the same way as 1st gear.

4th Gear (D selected)

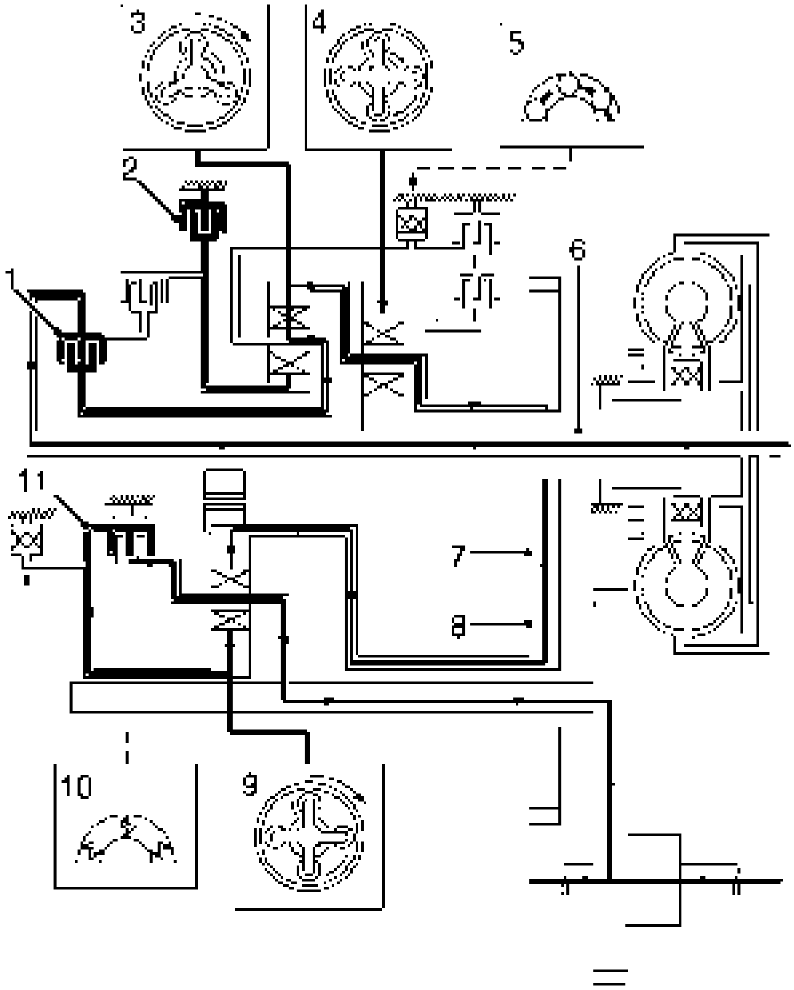


M44 1619

- **1** High clutch
- **2** 2-4 brake
- **3** Front planetary gear
- **4** Rear planetary gear
- **5** Low one-way clutch
- **6** Input shaft
- **7** Output shaft
- **8** Idler gear
- **9** Reduction planetary gear
- **10** Reduction brake
- **11** Reduction one-way clutch

On 4th gear selection, the high clutch, 2-4 brake, and the reduction brake are engaged. During acceleration in 4th gear, the reduction one-way clutch is locked. Power flows from the input shaft to the front planetary carrier to rotate clockwise by the high clutch. The 2-4 brake locks the front sun gear. The front pinion gear rotates clockwise and forces the front planetary carrier to rotate clockwise simultaneously. This allows the front internal gear to rotate clockwise and transmit power to the reduction internal gear via the output gear and idler gear. The rotational speed of the planetary carrier is faster than 3rd gear because of the rotation of the internal gear. Power is then transmitted to the road wheels in the same way as 1st gear.

5th Gear (D selected)

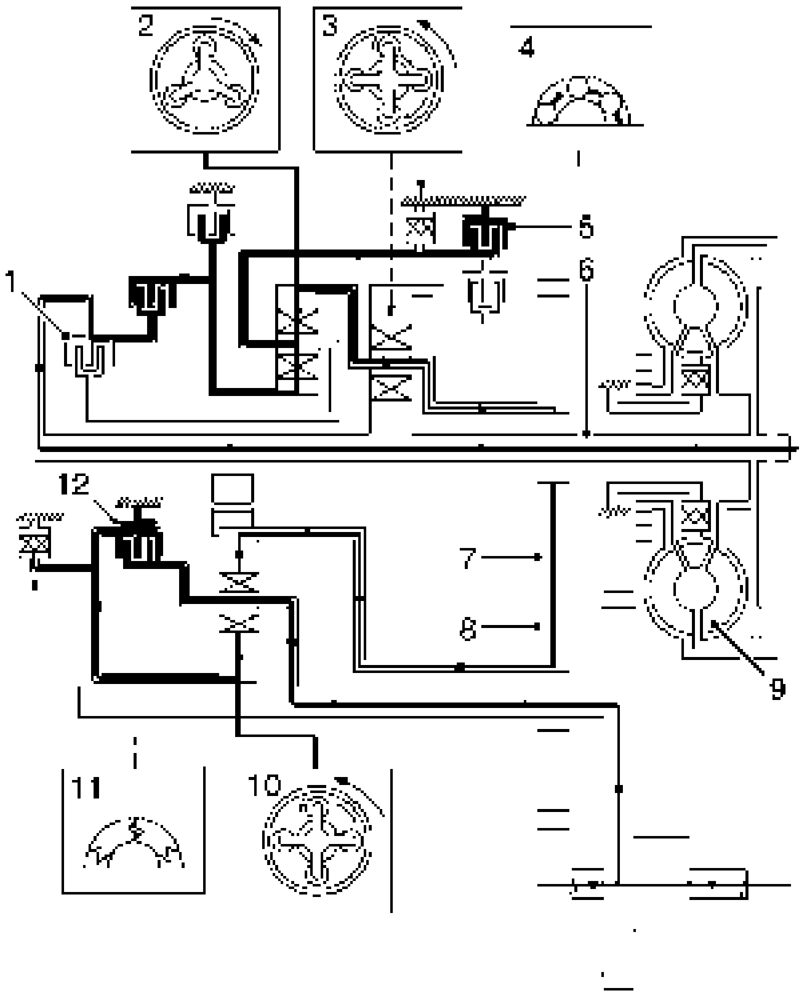


M44 1L22

1 High clutch
2 2-4 brake
3 Front planetary gear
4 Rear planetary gear
5 Low one-way clutch
6 Input shaft
7 Output shaft
8 Idler gear
9 Reduction planetary gear
10 Reduction one-way clutch
11 Direct clutch

On 5th gear selection, the high clutch, direct clutch, and the 2-4 brake are engaged. Power flows from the input shaft and is transmitted to the reduction internal gear by the high clutch in the same way as in 4th gear. This power is transmitted through the reduction sun gear, final drive and direct clutch to drive the road wheels.

Reverse Gear

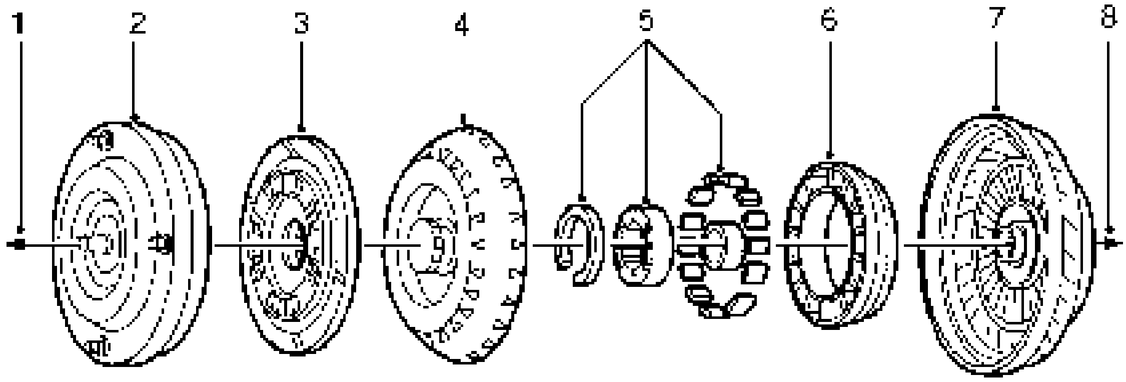


M44 1521

1 Reverse clutch
2 Front planetary gear
3 Rear planetary gear
4 Low one-way clutch
5 Low reverse brake
6 Input shaft
7 Output gear
8 Idler gear
9 Torque converter
10 Reduction planetary gear
11 Reduction one-way clutch
12 Reduction brake

On reverse gear selection, the reverse clutch, the low and reverse brake, and the reduction brake are engaged. Power flows from the input shaft to the reverse clutch and the front sun gear. The low and reverse brake is engaged, locking the front planetary carrier in position. When the front sun gear rotates clockwise, the front planetary carrier remains locked. The front pinion gears rotate anti-clockwise, forcing the internal gear and output gear to rotate anti-clockwise. The output gear rotation is transmitted to the reduction internal gear by the idler gear. The reduction brake locks the reduction sun gear, the reduction planetary carrier rotates in the reverse direction to the forward ranges and transmits drive to the road wheels through the final drive.

Torque Converter



M44 1622

1 To engine
2 Torque converter cover welded to the impeller
3 Lock-up clutch
4 Turbine
5 One-way clutch
6 Stator
7 Impeller
8 To gearbox

The torque converter is located inside the torque converter housing which is on the engine side of the gearbox casing.

The torque converter acts as the coupling element between the engine and gearbox. The driven power from the engine is transmitted hydraulically and mechanically in certain gears and operating conditions, through the torque converter lock-up clutch to the gearbox. The torque converter is connected to the engine by a drive plate.

The torque converter consists of an impeller, stator and turbine. The engine drives the impeller, while the turbine drives the gearbox.

The stator is situated between the impeller and turbine on a one-way clutch. The impeller picks up fluid and throws it out into the turbine, thereby causing it also to rotate and transmit power.

The stator redirects the fluid thrown back by the turbine, so that it re-enters the impeller in the same direction of rotation as the impeller and at the most efficient angle.

The one-way clutch prevents the stator from moving backwards, so that this accurate redirection of fluid can be achieved. When the engine is idling the impeller throws out very little fluid. The turbine is not forced to turn, and the power is not transmitted to the gearbox.

As engine speed increases the impeller throws out more fluid. The turbine begins to turn and picks up speed as the engine speed rises. As the speed of the turbine increases the fluid is thrown against the back of the stator, causing it to turn in the same direction.

When turbine speed approaches impeller speed, centrifugal force in both units is almost equal and all three components move at nearly the same rate. This is called the 'coupling point'.

The torque multiplication or drive ratio varies until a one to one coupling point is reached.

To achieve the power required to climb a hill, the driver depresses the accelerator pedal and the torque converter reacts by increasing the torque multiplication.

When driving on a flat road at cruising speed, the power required is not as great and therefore, the torque converter stays at one to one.

Torque Converter Lock-Up Mechanism

In a torque converter there is always a certain amount of slip between the impeller and turbine. This will contribute to a reduction in fuel economy especially during high speed cruising.

This is eliminated by the torque converter lock-up mechanism. The lock-up mechanism is attached to the turbine and controls a lock-up clutch which is integral with the torque converter.

The lock-up mechanism comprises a lock-up solenoid valve, a lock-up control valve and a lock-up clutch.

The lock-up control is provided by the EAT ECU which operates the lock-up solenoid valve. The EAT ECU controls lock-up clutch engagement and release according to the lock-up schedule programmed into the ECU and the vehicle speed and throttle angle.

The lock-up mechanism operates with the gearbox in 'D' (normal mode 4th and 5th gears) and in manual 4th and 5th gears. In an emergency condition when high fluid temperatures are reached, the EAT ECU can also operate the lock-up mechanism in 2nd and 3rd gears to help reduce fluid temperatures.

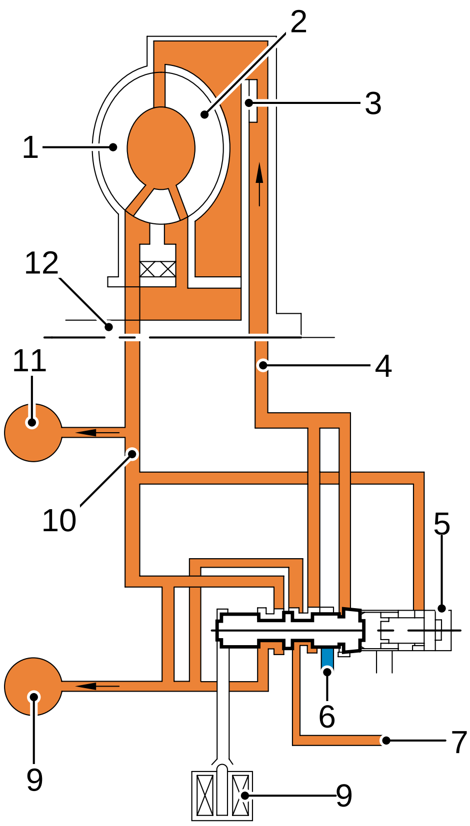
In addition to the lock and unlock conditions, the lock-up control can also initiate smooth lock-up, coast lock-up and lock-up prohibition control.

Smooth lock-up minimises lock-up shock by smoothly and slowly engaging the lock-up clutch.

Coast lock-up control maintains the lock-up condition after the throttle pedal has been released in the lock-up range at certain high speed driving. This prevents the lock-up control switching between the locked and unlocked condition caused by repeated on-off use of the throttle pedal.

Lock-up prohibition control prevents clutch lock-up within the range if the fluid temperature is below 40°C (104°F). This promotes faster warm-up of the gearbox fluid. This strategy is also used by the EAT ECU to prevent lock-up in 1st gear, park, reverse and neutral ranges.

Unlock Condition

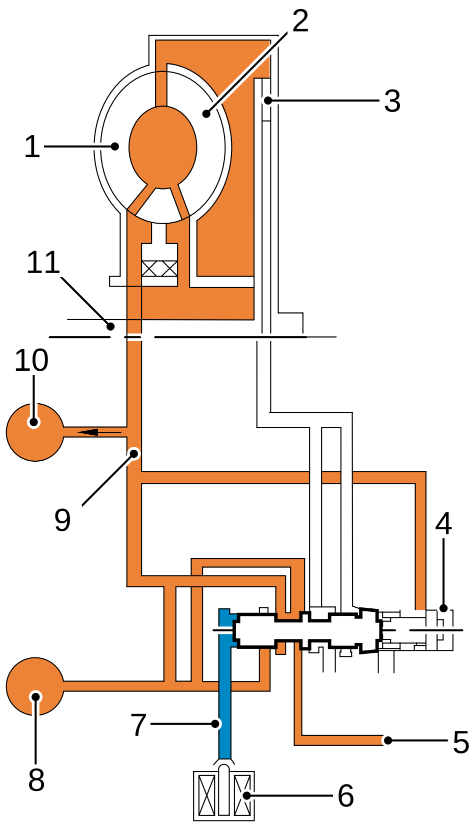


M44 1623

1 Impeller
2 Turbine
3 Lock-up clutch
4 Release pressure
5 Lock-up control valve
6 Drain port
7 Torque converter pressure
8 Lock-up solenoid
9 Fluid cooler
10 Torque converter applied pressure
11 Lubrication
12 Input shaft

The unlock release pressure is supplied via the control valve to the lock-up clutch. The pressure forces the clutch mechanism away from the torque converter and moves the lock-up mechanism into the unlock condition. The torque converter pressure is decayed to the drain port, removing the applied pressure from the torque converter, allowing the clutch mechanism to move.

Lock-Up Condition



M44 1624

1 Impeller
2 Turbine
3 Lock-up clutch
4 Lock-up control valve
5 Torque converter pressure
6 Lock-up solenoid
7 Pilot pressure
8 Fluid cooler
9 Torque converter applied pressure
10 Lubrication
11 Input shaft

The EAT ECU operates the lock-up solenoid, which in turn supplies pilot pressure to the control valve. The control valve moves under the influence of the pilot pressure, blocking the release pressure feed to the lock-up clutch and re-directing it to the other side of the clutch mechanism.

With the release pressure removed, the lock-up clutch moves and engages with the torque converter, moving the lock-up mechanism into the locked condition.

Smooth Lock-Up

Smooth lock-up occurs as the mechanism moves from the unlock to the locked condition. Torque converter release pressure is lowered gradually preventing a sudden lock-up clutch engagement, reducing lock-up shock.

The lock-up solenoid is a driven duty solenoid operating at 50Hz. The lock-up control valve has a pressure regulation device which reacts to torque converter release pressure and solenoid pilot pressure.

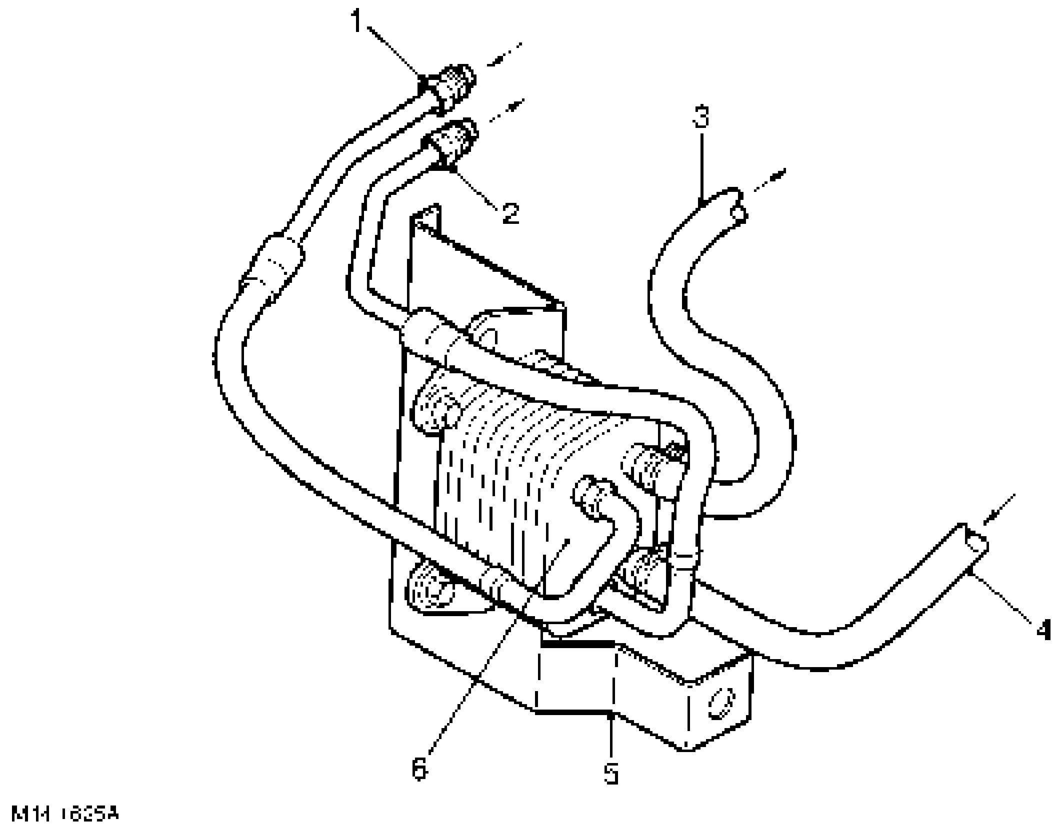
As the solenoid is operated, the pilot pressure is gradually applied to the control valve. This moves the valve, partially exposing the release pressure to a drain port.

The control valve is moved against an opposing spring by the increasing pilot pressure. The release pressure is decayed proportionally in response to the increasing pilot pressure allowing the clutch to smoothly engage with the torque converter.

Fluid Cooling

Fluid cooling is performed by a dedicated fluid cooler for the gearbox. On KV6 cold climate models, a water cooled fluid cooler is located at the front of the gearbox.

Fluid Cooler KV6



Cooler from all except NAS and Gulf States models shown; cooler for NAS and Gulf States models similar

1 Gearbox fluid feed pipe
2 Gearbox fluid return pipe
3 Engine coolant feed hose
4 Engine coolant return hose
5 Mounting bracket
6 Fluid cooler

The fluid cooler is located on a bracket at the front of the gearbox. The cooler comprises cores which allow fluid to flow across from one side of the cooler to the other. Each core is surrounded by a water jacket which allows engine coolant to flow around the cooler.

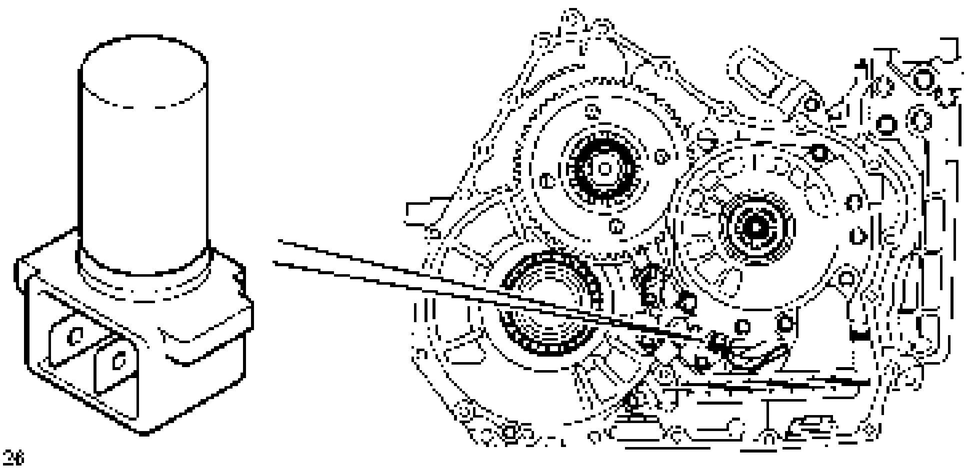
The cooler is connected to the gearbox by metal pipes and flexible hoses, and to the engine cooling system by coolant hoses.

The gearbox fluid flows from the gearbox to the upper connection on the fluid cooler. The fluid then flows through the cores in the cooler which are surrounded by engine coolant which cools the gearbox fluid. The fluid exits the fluid cooler via the lower connection and is returned to the gearbox.

The engine coolant flows from the cylinder block, to the lower coolant connection on the fluid cooler. The coolant exits the cooler via the upper connection and flows to the thermostat housing.

Sensors
The EAT ECU sets correct gear change scheduling using three speed signal inputs: intermediate speed, turbine speed and vehicle speed in conjunction with a throttle position signal from the ECM.

Intermediate Speed Sensor



M44 1626

The intermediate speed sensor is located within the gearbox. The EAT ECU uses this sensor to ensure correct gear engagement and to monitor the amount of slip within the gearbox.

The EAT ECU calculates the slip within the gearbox by comparing the difference between the inputs from the intermediate speed sensor and the turbine speed sensor.

The intermediate speed sensor detects the output gear rotation speed and sends an electrical output to pin 51 of the EAT ECU which also supplies an earth path for the sensor on ECU pin 20.

The sensor is an inductive sensor that produces a sinusoidal output at a frequency of 54 pulses per revolution of the output gear.

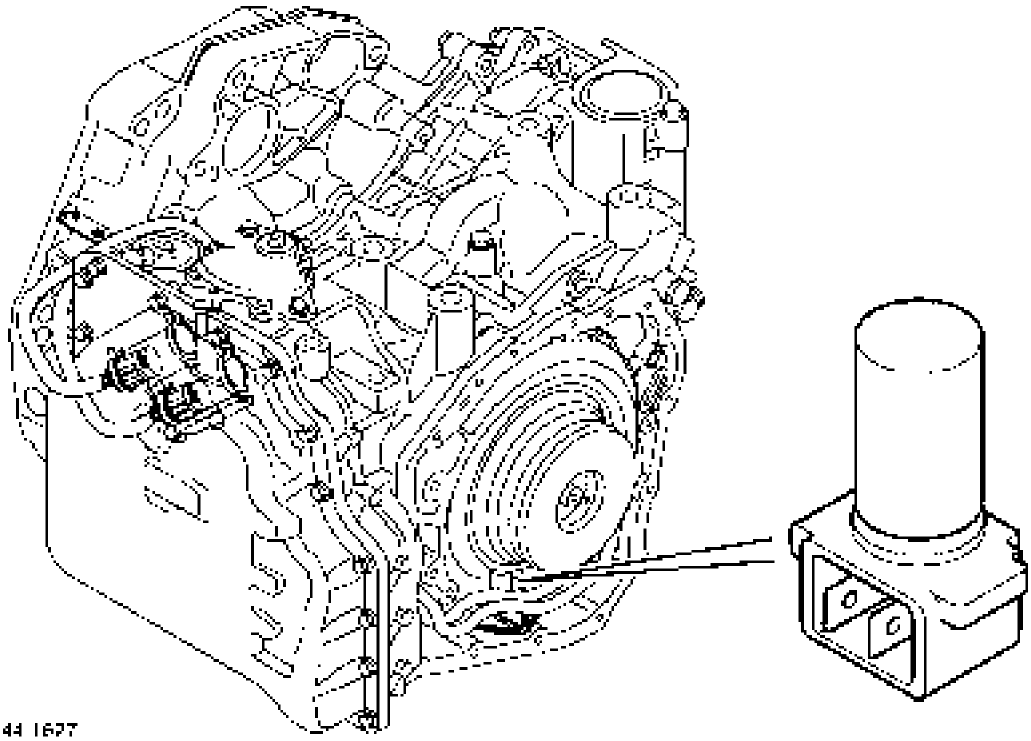
The intermediate speed sensor can fail in the following ways:
- Sensor open circuit
- Short circuit to 5 or 12 volts
- Short circuit to earth.

The EAT ECU will detect sensor failure if the vehicle speed exceeds 25 mph (40 km/h) and the sensor output is equivalent to less than 600 rev/min for two seconds.

In the event of an intermediate speed sensor signal failure any of the following symptoms may be observed:
- Upshift to 5th gear inoperative
- Torque reduction request from the EAT ECU to the ECM inoperative.

A failure of the sensor will generate a 'P' code which can be retrieved using TestBook/T4 or any Keyword 2000 diagnostic tool.

Turbine Speed Sensor



The turbine speed sensor is located within the gearbox and is used by the EAT ECU to monitor the input shaft speed. The EAT ECU uses this sensor to ensure the correct gear ratio is selected and to ensure that there is not excessive slip within the gearbox drive train.

The turbine speed sensor detects the input shaft speed (turbine speed) and sends an electrical output to pin 24 of the EAT ECU which also supplies an earth path for the sensor on ECU pin 20.

The sensor is an inductive sensor that produces a sinusoidal output at a frequency of 36 pulses per revolution of the input shaft.

The turbine speed sensor can fail in the following ways:

- Sensor open circuit
- Short circuit to 12 or 5 volts
- Short circuit to earth.

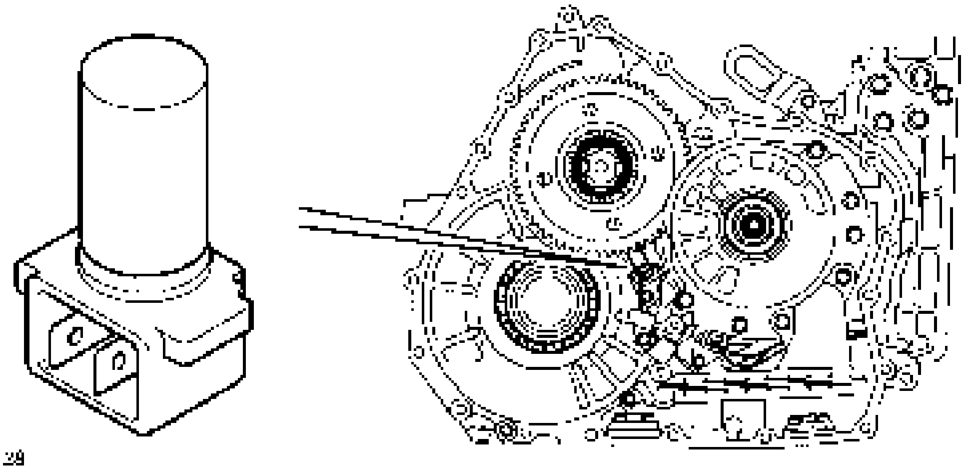
The EAT ECU will detect sensor failure if the vehicle speed exceeds 25 mph (40 km/h) and the engine speed is above 1300 rev/min, but the turbine speed is below 600 rev/min for two seconds.

In the event of a turbine speed sensor signal failure any of the following symptoms may be observed:

- Upshift to 5th gear inoperative
- Torque reduction request from the EAT ECU to the ECM inoperative.

A failure of the sensor will generate a 'P' code which can be retrieved using TestBook/T4 or any Keyword 2000 diagnostic tool.

Vehicle Speed Sensor



M44 1629

The vehicle speed sensor is located within the gearbox. The EAT ECU uses this sensor to monitor the rotational speed of the parking gear and calculate this reading into a vehicle speed. The EAT ECU also monitors the vehicle speed using a signal from the ABS ECU.

The vehicle speed sensor detects the parking gear rotation speed and sends an electrical output to pin 5 of the EAT ECU which also provides an earth path for the sensor.

The sensor is an inductive sensor that produces a sinusoidal output at a frequency of 18 pulses per revolution of the parking gear.

The EAT ECU uses the signal to calculate the following:

- Amount of engine torque reduction required during gear changes
- Notify the EAT ECU when the vehicle is stationary, for creep control.

The vehicle speed sensor can fail the following ways:

- Sensor open circuit
- Sensor short circuit to 12 or 5 volts
- Sensor short circuit to earth.

The EAT ECU will detect sensor failure if the ABS ECU speed signal is more than 25 mph (40 km/h) but the vehicle speed sensor reading is less than 3 mph (5 km/h) for more than two seconds.

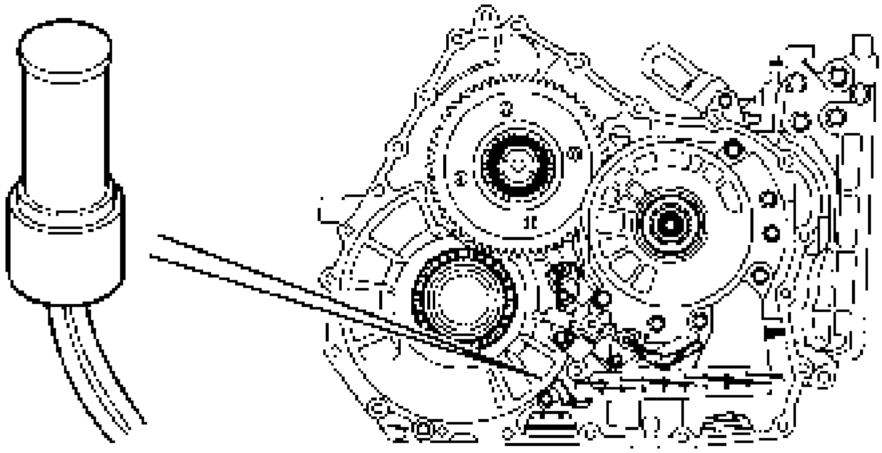
In the event of a vehicle speed sensor signal failure any of the following symptoms may be observed:

- Upshift to 5th gear inoperative
- Torque reduction request from the EAT ECU to the ECM inoperative.

If a failure of the vehicle speed sensor occurs and the ABS ECU speed signal is functional, the EAT ECU will control gear shifting using the ABS ECU signal.

If both the vehicle speed sensor and the ABS ECU speed signals fail, the EAT ECU will lock the gearbox in fourth gear (fail-safe mode) and inhibit torque converter lock-up control.

Fluid Temperature Sensor



The fluid temperature sensor is located within the gearbox on the valve block. The EAT ECU uses this sensor to monitor the gearbox fluid temperature.

When the fluid is cold, the EAT ECU changes gear at higher engine speeds to promote faster fluid warm-up. If the fluid temperature becomes too high, the EAT ECU transmits a cooling request on the CAN link to the ECM to operate the cooling fans.

The fluid temperature sensor has an electrical output to pin 39 of the EAT ECU which also provides an earth path for the sensor.

The fluid temperature sensor is a negative temperature coefficient sensor. As the temperature rises, the resistance in the sensor decreases. As temperature decreases, the resistance in the sensor increases and the output voltage to the EAT ECU changes in proportion.

The output voltage from the sensor is in the range of 0 - 2.5 Volts with the lower voltage representing the highest temperature.

The change in resistance is proportional to the temperature of the gearbox fluid. From the resistance of the sensor, the EAT ECU calculates the temperature of the gearbox fluid. Should the fluid temperature sensor fail the EAT ECU uses the last recorded EAT ECU value as a default value.

Fluid Temperature Sensor Resistance Values

Temperature °C (°F)	Resistance kΩ
-40 (-40)	54.90
-20 (-4)	16.70
0 (32)	6.02
20 (68)	2.50
40 (104)	1.16
60 (140)	0.59
80 (176)	0.33
100 (212)	0.19
120 (248)	0.12
140 (284)	0.08

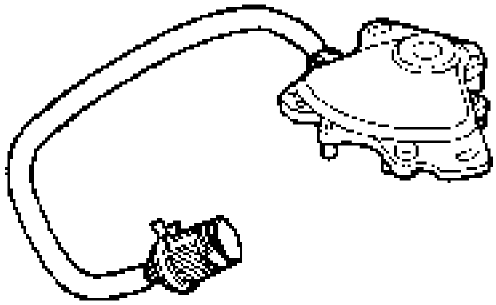
The fluid temperature sensor can fail in the following ways:

- Sensor open circuit
- Short circuit to 12 or 5 volts
- Short circuit to earth.

The EAT ECU will detect temperature sensor failure when the vehicle speed exceeds 12.5 mph (20 km/h) and the temperature sensor provides a reading of less than -30°C (-22°F). In the event of a fluid temperature sensor signal failure any of the following symptoms may be observed:

- Upshift to 5th gear inoperative
- Torque reduction request from the EAT ECU to the ECM inoperative.

Selector and Inhibitor Switch



M44 1630

The selector and inhibitor switch is located on the selector shaft on top of the gearbox and connected to the main harness by a 10 pin connector (C0244).

While the ignition is on, the selector and inhibitor switch receives a battery voltage power feed from the main relay. In some markets, in order to illuminate the LED module whenever the key is in the ignition switch, the selector and inhibitor switch also receives a battery voltage power feed from an illumination relay installed behind the centre console.

Where fitted, operation of the illumination relay is controlled by the passive coil on the ignition switch. When the key is installed in the ignition switch the illumination relay energises to connect the power feed to the selector and inhibitor switch. When the main relay is energised by the ECM, the illumination relay de-energises and the power feed to the selector and inhibitor switch is taken from the main relay.

The EAT ECU and the LED module are provided with a voltage output from the selector and inhibitor switch that corresponds with the gear position the driver has selected. Seven sets of contacts in the selector and inhibitor switch which are operated by the selector shaft. Each set of contacts corresponds to one of the seven selector lever positions (PRND421). Only one set of contacts will supply battery voltage to the EAT ECU and the LED module at any one time. The EAT ECU monitors the switch outputs every 10 ms.

A pair of contacts are provided for the crank inhibit circuit. The contacts are only closed when the selector lever is in the 'P' and 'N' positions.

The two contacts are wired in series with the immobilisation ECU. When the selector lever is in any position other than 'P' or 'N', the feed from the ignition switch to the immobilisation ECU is broken by the open contacts, preventing starter motor operation.

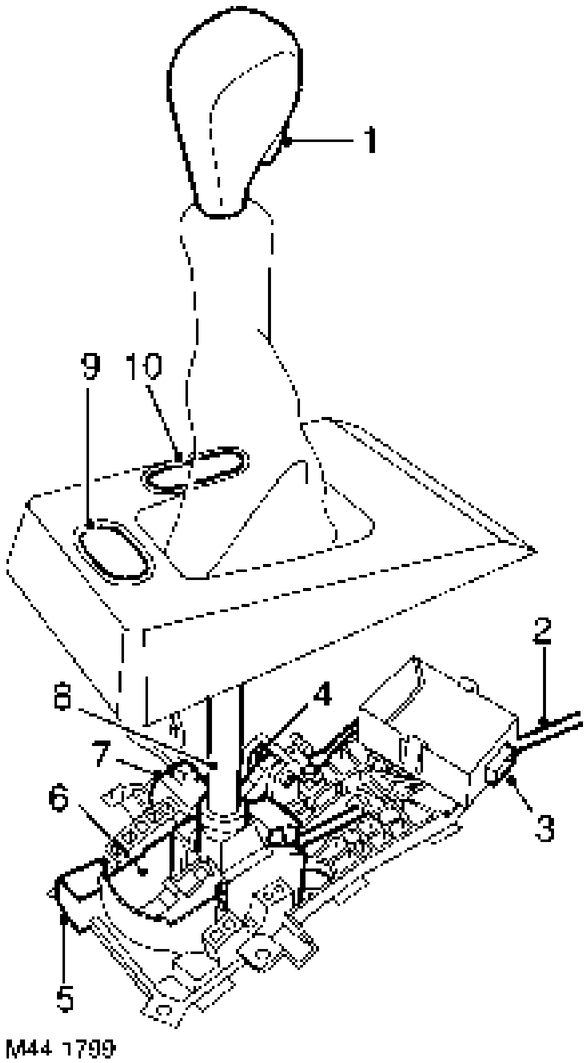
In the event of a selector and inhibitor switch signal failure, any of the following symptoms may be observed:

- Upshift to 5th gear inoperative
- Torque converter lock-up inoperative
- Torque reduction request from the EAT ECU to the ECM inoperative
- Cranking disabled if fault is on the two inhibitor switch contacts.

Gear Selector Lever Assembly
The gear selector lever assembly comprises a shift lock solenoid, a key interlock mechanism (if fitted), an LED module and a sport/manual switch.

A nylon cast plate provides the location for the selector lever components. The plate is secured to the floor pan with six integral studs and nuts. A rubber boot protects the assembly from dirt and moisture under the vehicle and also isolates vibrations from the lever.

The selector lever is attached to a gimbal mounting which allows gear selection of PRND421 in a forward and backward direction and selection between automatic and sport/manual in a left and right transverse direction. When sport/manual mode is selected, the lever can be moved in a forward or backward direction to select + or - for manual operation.



1 Park/Reverse release button
2 Selector cable
3 Mirror fold ECU or ICE remote control interface unit (if fitted - reference only)
4 Key interlock mechanism (selected markets only)
5 Sport/manual switch connector
6 Sport/manual switch
7 Shift interlock solenoid
8 Selector lever
9 HDC switch
10 LED Module

There are seven selector lever positions:

- **P (Park)** - prevents the vehicle from moving by locking the gearbox.
- **R (Reverse)** - select only when vehicle is stationary and the engine is at idle.
- **N (Neutral)** - no torque transmitted to the drive wheels.
- **D (Drive)** - this position uses all five forward gears. Normal position selected for conventional driving.
- **4** - this position uses 1st to 4th gears only.
- **2** - this position uses 1st and 2nd gears only.
- **1** - this position uses 1st gear only.
- **S/M (Sport/Manual - CommandShift)** - this position uses all five gears as in 'D', but will shift up at higher engine speeds, improving acceleration.
- **+ and -** - movement of the selector lever in the +/- positions, when the selector lever is in the 'S/M' position, will operate the gearbox in manual (CommandShift) mode, allowing the driver to manually select all five forward gears.

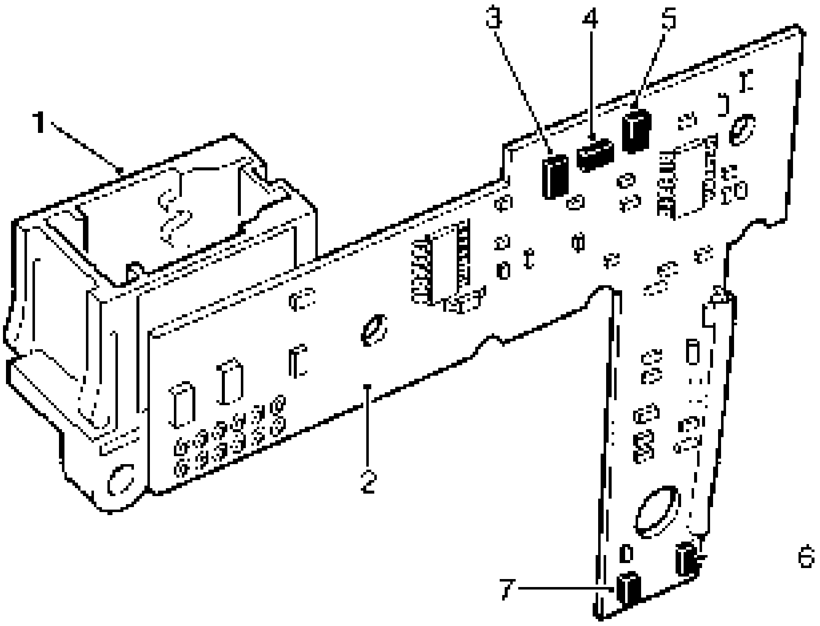
The selector lever position is displayed to the driver on the LED module in the centre console and in the instrument pack and corresponds with the position of the selector lever. The LED module illumination and instrument pack display is determined by the selector and inhibitor switch assembly on the gearbox, with the exception of the 'S/M' LED and the 'Sport' instrument pack display which are operated by a hall effect sensor located on the sport/manual switch.

The automatic gearbox incorporate an interlock solenoid at the bottom of the lever, which, when the ignition switch is in position II, prevents the lever being moved from Park unless the foot brake is applied.

In some markets, the gear selector lever also incorporates a key interlock mechanism, operated by the selector lever and a Bowden cable connected to the ignition key barrel. The mechanism prevents the ignition key being removed from the barrel unless the selector lever is in the Park position. The mechanism also prevents the selector lever moving from the Park position until the ignition switch has turned from position 0 to position I or above.

☞ **STEERING, DESCRIPTION AND OPERATION, Description.**

Sport/Manual Switch



1 Connector
2 PCB
3 '4' sensor
4 'D' sensor
5 'N' sensor
6 '+' (plus) sensor
7 '-' (minus) sensor

The sport/manual switch comprises a PCB and connector socket which is located to the left of the selector lever and is an integral part of the selector lever assembly and cannot be serviced separately. The switch is connected to the main harness by a twelve pin connector.

The sport/manual switch has five proximity sensors which correspond to the D, N, 4 and +/- positions. The selector lever has two targets. An upper target is aligned with the DN4 sensors and the lower target is aligned with the +/- sensors.

When the selector lever is in the D position, the D sensor is aligned with the target and the EAT ECU receives a signal that D is selected. When the selector lever is moved to the S/M (sport) position, the target moves away from the sensor. This is sensed by the ECU which then initiates sport mode.

The sensors in the N and 4 positions inform the ECU that D has been deselected, but not to the S/M position, preventing the ECU from incorrectly initiating sport mode.

When the selector lever is moved to the S/M position, the target moves away from the D sensor. If the EAT ECU does not receive a signal from either the 4 or N sensors, it determines that sport has been selected. The lower target is positioned between the two sensors for +/- selection. If the selector lever is not moved to the +/- positions, the ECU keeps the gearbox in sport mode. If the ECU senses a signal from either the + or - sensor, it initiates manual mode and selects the manual gear selection requested. Manual mode will be maintained until the ECU senses a signal from the D sensor.

Shift Interlock Solenoid

The shift interlock solenoid is controlled by the EAT ECU. When the ignition switch is in position II, with the selector lever in the Park position, the EAT ECU supplies a power feed to the shift interlock solenoid. The shift interlock solenoid energises and extends a pin into the selector lever, locking the lever in Park.

While the selector lever is in Park, when the EAT ECU senses the brake pedal being pressed, it de-energises the shift interlock solenoid and the solenoid pin retracts, allowing the selector lever to be moved. When the selector lever is in any position other than Park, the shift interlock solenoid remains de-energised after the brake pedal is released, and the lever is free to be moved through the remainder of the range.

LED Module

The LED module is located in the selector lever surround and is secured with two integral clips. The module is connected to the main harness by a 12 pin connector (C0675).

The LED module illuminates the applicable LED for the P, R, N, D, 4, 2, 1 and S/M positions. When the side lamps are switched on, all the LED's are illuminated at a low intensity, with the selected gear lever position LED illuminated at a higher intensity.

Selector Cable

The selector cable is a Bowden type cable that connects the selector lever to an input lever on the gearbox.

A 'C' clip secures the outer cable to the selector lever assembly; the gearbox end of the outer cable is secured to a bracket on the gearbox by an integral clip. The inner cable is adjustable at the connection with the gearbox input lever.

Brake Switch

The brake switch is located on the pedal box below the fascia. The EAT ECU uses this switch to monitor brake pedal application status. The information is input to pin 43 of the EAT ECU on a hardwired connection from the switch.

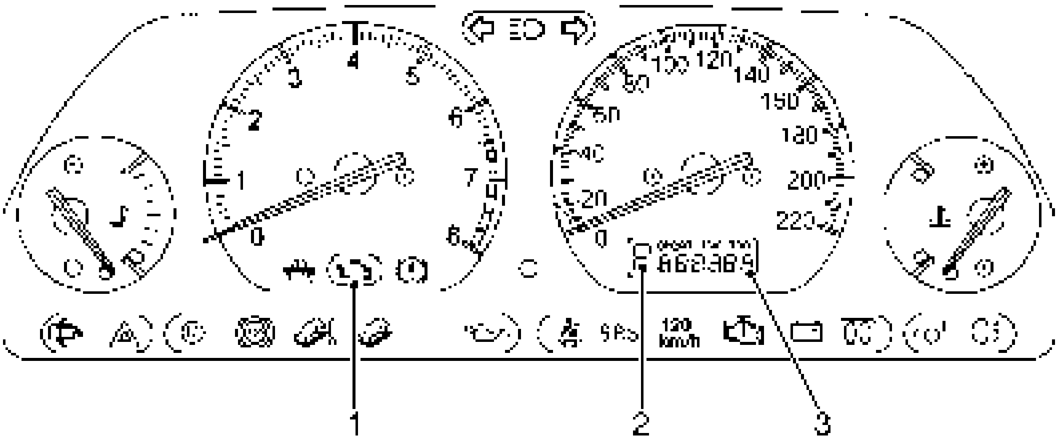
The EAT ECU can allow the gearbox to apply more engine braking therefore slowing down the vehicle in a shorter distance and reducing brake pad wear. The EAT ECU achieves engine braking by applying the low and reverse clutches.

The brake switch can fail in the following ways:

- Switch open circuit
- Short circuit to 12 or 5 volts
- Short circuit to earth.

In the event of a brake switch signal failure, extra gearbox braking will not occur and the shift lock solenoid (if fitted) will not function.

Instrument Pack
The instrument pack displays gearbox selection and fault information in the LCD and can illuminate the MIL for OBD emission related faults.



M44 1532

1 MIL (SERVICE ENGINE SOON on NAS models)
2 Gearbox mode display
3 Liquid Crystal Display (LCD)

The gearbox related displays in the instrument pack are controlled by the ECM which transmits CAN message signals to operate the lamps and the LCD.

Malfunction Indicator Lamp (MIL)
The MIL is an amber warning lamp located in the instrument pack. The warning lamp shows a SERVICE ENGINE SOON legend. The lamp is illuminated by a CAN message from the ECM on receipt of a CAN message from the EAT ECU.

Emission related faults are detected by the OBD feature in the EAT ECU and will illuminate the MIL in the instrument pack.

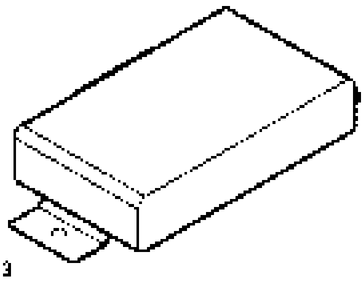
Liquid Crystal Display (LCD)
The LCD is located in a central position in the instrument pack. In addition to displaying the odometer and trip meter, the LCD also displays the current gearbox status. The following table shows the characters displayed and their definition.

Character	Description
P	Park
R	Reverse
N	Neutral
D	Drive
D^{Sport}	Sport Mode
1	Manual 1st ratio
2	Manual 2nd ratio
3	Manual 3rd ratio
4	Manual 4th ratio
5	Manual 5th ratio
4 and F Flashing alternately	Severe fault detected - Limp home mode strategy initiated

The EAT ECU transmits the selector lever position through the CAN bus to the ECM. The ECM processes this information and passes it to the instrument pack in the form of CAN messages to display the gearbox status.

If the gearbox develops a fault and adopts the limp home mode, the LCD will alternately display 'F' and 4'' to alert the driver that a fault has occurred and limp home mode is operational.

Electronic Automatic Transmission (EAT) ECU



The EAT ECU is located in the Environmental box (E-box) in the engine compartment, adjacent to the ECM. The ECU is connected to the vehicle wiring by a 54 pin connector (C0932).

The EAT ECU uses a 'flash' Electronic Erasable Programmable Read Only Memory (EEPROM). This enables a new or replacement EAT ECU to be externally configured. EEPROM also allows the EAT ECU to be updated with new information and market specific data.

To input new information and market specific data the EAT ECU must be configured using TestBook/T4. The EEPROM allows the ECU to be reconfigured as many times as necessary to meet changing specifications and legislation.

The EAT ECU memorises the signal values of the gearbox sensors and actuators. These stored values ensure optimum gearbox performance is achieved at all times.

This information is lost if battery voltage is too low, for example if the battery becomes discharged. The EAT ECU reverts to default readings on first engine start after a battery discharge or disconnection. The EEPROM facility in the ECU allows the stored values to be re-learnt, ensuring optimum gearbox performance.

If these signals are not within the EAT ECU stored parameters, the ECU will make adjustments to the operation of the gearbox through the actuators to provide optimum driveability and performance.

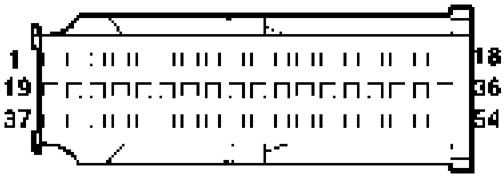
The inputs from the sensors constantly updates the EAT ECU with the current operating condition of both the gearbox and the engine. The ECU compares this current information with mapped information stored within its memory. The ECU will make any required adjustment to the operation of the gearbox through the following actuators:

- Gear control solenoid valves
- Lock-up solenoid valve
- Line pressure solenoid valve.

The EAT ECU also interfaces with the following:

- Engine Control Module (ECM) via the CAN
- Instrument pack via the CAN
- Diagnostic socket via the ISO 9141 K line.

Connector C0932 Pin Details



M44 1634

The following table shows the harness connector face view and pin numbers and input/output information.

Pin No.	Description	Input/Output
1	Diagnostic ISO 9141 K Line	Input/Output
2	Not used	-
3	2/4 brake duty solenoid valve	Output
4	2/4 brake timing solenoid valve	Output
5	Vehicle speed sensor	Input
6	Not used	-
7	Selector 3rd range switch	Input
8	Selector 2nd range switch	Input
9	Earth	Input
10	Reduction timing solenoid valve	Output
11	Not used	-
12	CAN Bus - Low	Input/Output
13	CAN Bus - Low 2	Input/Output
14	Shift solenoid valve B	Output
15	Shift solenoid valve A	Output
16	Lock-up duty solenoid valve	Output
17	Solenoid valves - Earth	Input
18	Line pressure duty solenoid	Output
19	Selector shift up (+) sensor	Input
20	Sensors - Earth	Input
21	Intermediate shaft speed sensor	Input
22	Not used	-
23	Not used	-
24	Turbine speed sensor	Input
25	Selector 'N' range switch	Input
26	Selector 'R' range switch	Input
27	Selector 'D' range switch	Input
28	Kick down inhibit	Input
29	Not used	-
30	Selector 'P' range switch	Input
31	Normal (drive) mode switch	Input
32	Not used	-
33	CAN Bus High	Input/Output
34	CAN Bus High 2	Input/Output
35	Not used	-
36	12V battery voltage from main relay	Input
37	Selector shift down (-) sensor	Input

Pin No.	Description	Input/Output
38	Earth	Input
39	Fluid temperature sensor	Input
40	Not used	-
41	Sport / Manual hold switch	Input
42	Not used	-
43	Brake switch signal	Input
44	Not used	-
45	Selector 4th range switch	Input
46	Not used	-
47	Not used	-
48	Shift lock solenoid fault	Input
49	Cruise control engaged signal	Input
50	Shift lock solenoid earth	Input
51	Not used	-
52	Shift solenoid valve C	Output
53	Low clutch timing solenoid valve	Output
54	12V battery voltage from main relay	Input

Main Relay

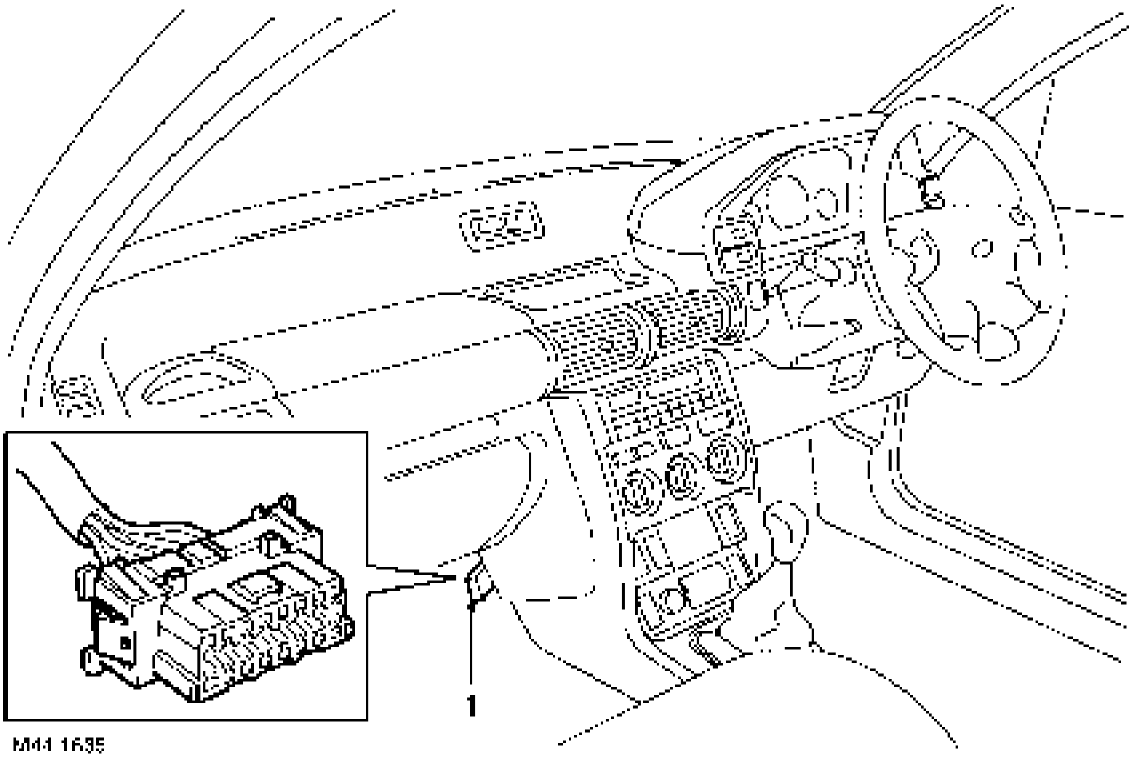
The main relay is located in the engine compartment fusebox and supplies battery voltage to the EAT ECU, in addition to other vehicle components. The main relay is energised by the ECM when the ignition is switched on.

When the ignition is switched off, the ECM will maintain the main relay in an energised state for several minutes. This allows for cooling fan operation to continue after the engine has been switched off and allows other vehicle ECU's to remain active. The EAT ECU remains active for a short period after the ignition is switched off to allow EEPROM fault code data to be stored.

In the event of a main relay failure, any of the following symptoms may be observed:

- The gearbox will be locked in 4th gear (limp home mode)
- No CAN communications will be available.

Diagnostics
A diagnostic socket allows the exchange of information between the EAT ECU and TestBook/T4. The diagnostic socket is located behind the centre console, in the passenger footwell.



1 Diagnostic socket

The diagnostic socket is connected to the EAT ECU on an ISO 9141 K Line. The system uses a 'P' code diagnostic strategy and can record faults relating to gearbox operation. The codes can be retrieved using TestBook/T4 or any diagnostic tool using Keyword 2000 protocol.

Diagnostic Trouble Codes (DTC)
The following table lists P codes, affected components and fault description.

The diagnostics related to diagnostic trouble codes introduced by ECD3 are disabled on vehicles built prior to the ECD3 compliance date.

JATCO P Code Table

P Code	Applicability	Component	Correct Operation / Value	Description of Fault and Rectification Action
P0702	All	GND return (sensor earth)	–	Short circuit to battery – Check wiring and connections
P0705	All	Selector and inhibitor switch input	Selected range 12V Other ranges 0V	Multiple signal or No signal – Check wiring and connections – Renew turbine sensor
P0710	All	ATF temperature sensor	Refer to Fluid Temperature Sensor – Fluid temperature sensor resistance values table	Signal out of range – Check wiring and connections – Check sensor resistance – Renew transmission harness assembly/sensor

P Code	Applicability	Component	Correct Operation / Value	Description of Fault and Rectification Action
P0715	All	Turbine speed sensor	Approximately 550Ω at 20°C (68°F)	No signal – Check wiring and connections – Renew turbine speed sensor
P0720	All	Vehicle speed sensor	Approximately 550Ω at 20°C (68°F)	No signal – Check wiring and connections – Renew vehicle speed sensor
P0730	From 2002MY	Torque converter lock-up clutch	Gear ratio revolutions monitored	Mechanical failure – Physical inspection required
P0731	All	1st gear ratio	Up/Down shifts from 1st to 5th can be sensed	Out of range – Incorrect ratio when 1st gear selected – Check shift solenoids, wiring and connections – Investigate transmission
P0732	All	2nd gear ratio	Up/Down shifts from 1st to 5th can be sensed	Out of range – Incorrect ratio when 2nd gear selected – Check shift solenoids, wiring and connections – Investigate transmission
P0733	All	3rd gear ratio	Up/Down shifts from 1st to 5th can be sensed	Out of range – Incorrect ratio when 3rd gear selected – Check shift solenoids, wiring and connections – Investigate transmission
P0734	All	4th gear ratio	Up/Down shifts from 1st to 5th can be sensed	Out of range – Incorrect ratio when 4th gear selected – Check shift solenoids, wiring and connections – Investigate transmission
P0735	All	5th gear ratio	Up/Down shifts from 1st to 5th can be sensed	Out of range – Incorrect ratio when 1st gear selected – Check shift solenoids, wiring and connections – Investigate transmission
P0736	All	Reverse gear ratio	Reverse operative	Out of range – Investigate transmission
P0743	All	Lock-up duty solenoid	Approximately 12.6Ω at 20°C (68°F)	Open circuit or short circuit to earth/battery – Check wiring and connection – Renew lock-up duty solenoid
P0748	All	Line pressure duty solenoid	Approximately 2.9Ω at 20°C (68°F)	Open circuit or short circuit to earth/battery – Check wiring and connection – Renew line pressure duty solenoid
P0753	All	Shift solenoid A	Approximately 16Ω at 20°C (68°F)	Open circuit or short circuit to earth/battery – Check wiring and connection – Renew shift solenoid A
P0758	All	Shift solenoid B	Approximately 16Ω at 20°C (68°F)	Open circuit or short circuit to earth/battery – Check wiring and connection – Renew shift solenoid B

P Code	Applicability	Component	Correct Operation / Value	Description of Fault and Rectification Action
P0763	All	Shift solenoid C	Approximately 16Ω at 20°C (68°F)	Open circuit or short circuit to earth/battery – Check wiring and connection – Renew shift solenoid C
P0790	All	Mode switch input	Activated switch 0V Other switch 12V	Multiple signal – Check wiring and connections – Renew mode switch
P1562	All	Power supply voltage	10 – 16V engine idling	Out of range – Check wiring and connections and battery condition
P1605	All	EAT ECU EEPROM	EEPROM updated by EAT ECU following ignition off and before main relay opens	Error flag set – Clear flag. Power was disconnected from EAT ECU before main relay opened
P1715	All	Intermediate speed sensor	Approximately 550Ω at 20°C (68°F)	Open circuit – Check wiring and connections – Renew intermediate speed sensor
P1717	From 2002MY	Low clutch timing solenoid	Approximately 16Ω at 20°C (68°F)	Open circuit or short to earth/battery – Check wiring and connections – Renew low clutch timing solenoid
P1718	From 2002MY	Reduction timing solenoid	Approximately 16Ω at 20°C (68°F)	Open circuit or short to earth/battery – Check wiring and connections – Renew reduction timing solenoid
P1719	From 2002MY	2–4 brake timing solenoid	Approximately 16Ω at 20°C (68°F)	Open circuit or short to earth/battery – Renew 2–4 brake timing solenoid
P1748	All	2-4 brake duty solenoid	Approximately 2.9Ω at 20°C (68°F)	Open circuit or short to earth/battery – Check wiring and connections – Renew 2-4 brake duty solenoid
P1776	From 2002MY	Torque down request to engine failed	Engine responds to transmission torque down requests (smooth shifts)	Lack of engine response – Check engine management system
P1815	All	CommandShift (manual) +/- switch input signals	Up/Down shifts from 1st to 5th using CommandShift can be sensed	Multiple signals/No signal – Check wiring and connections – Renew Sport/Manual switch
P1825	All	Shift interlock ECU	Shift interlock operates	Shift interlock ECU failure – Renew shift interlock ECU
P1840	All	CAN Bus	All CAN bus components operate correctly	CAN Bus malfunction – No CAN messages or incorrect messages – Check wiring and connections – Check engine management system and instrument pack

P Code	Applicability	Component	Correct Operation / Value	Description of Fault and Rectification Action
P1841	All	CAN Bus monitoring	All CAN bus components operate correctly	CAN Bus malfunction – No CAN messages or incorrect messages – Check wiring and connections – Check engine management system and instrument pack
P1842	All	CAN level monitoring	All CAN bus components operate correctly	CAN bus malfunction – No CAN messages or incorrect/incompatible messages – Check wiring and connections – Check engine management system and instrument pack
P1844	From 2002MY	Engine RPM (speed signal)	ECM transmits engine speed on CAN	Error flag set – Check wiring and connections – Check engine management system
		Engine temperature signal	ECM transmits ECT sensor signal on CAN	Error flag set – Check wiring and connections – Check engine management system
		Throttle angle signal	ECM transmits throttle angle on CAN	Error flag set – Check wiring and connections – Check APP sensor – Check engine management system
		Virtual throttle angle	ECM transmits virtual throttle angle on CAN	Error flag set – Check wiring and connections – Check APP Sensor – Check engine management system
		CAN bus error – missing engine control module	All CAN bus components operate correctly	Check ECM and EAT ECU wiring and connections – Check engine management system/Instrument pack

Controller Area Network (CAN) Bus
The CAN bus is a high speed broadcast network between the ECM, instrument pack, ABS ECU and the EAT ECU allowing fast exchange of data between the ECU's every few microseconds.

The bus comprises two wires which are identified as CAN low (L) and CAN high (H). The wires are twisted together to minimise the electromagnetic interference (noise) produced by the CAN messages.

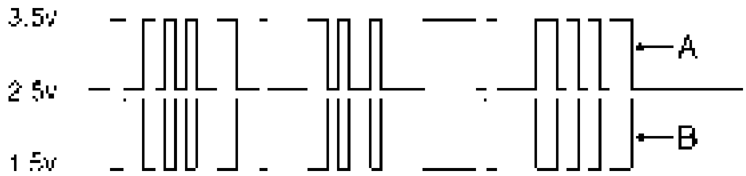
To prevent message errors from electrical reflections, 120Ω resistors are incorporated into the CAN wire terminals of the ECM, instrument pack, ABS ECU and the EAT ECU.

CAN messages consist of a signal which is simultaneously transmitted, in opposite phase, on both wires. CAN L switches between 2.5 and 1.5 volts, while CAN H switches between 2.5 and 3.5 volts. This causes a potential difference between the two lines to switch between 0 volt (logic 1) and 2 volts (logic 0) to produce the digital signal message.

In the event of a CAN bus failure any of the following symptoms may be observed:

- Transmission defaults to 4th gear
- Torque converter lock-up control is disabled
- Transmission of torque reduction message to the ECM is inhibited.

CAN Bus Switching



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EAT ECU CAN Messages
The following table lists CAN message inputs and outputs from and to the EAT ECU.

Inputs	Outputs
Actual engine torque	Cooling request
Engine coolant temperature	Current/Target gear
Engine friction	Gear selector lever position
Engine speed	Gear shift in progress
Engine speed signal error	Gearbox fault status
Engine torque error	Torque reduction request
Ignition switch status	Gearbox MIL Status
Actual engine torque	Gear shift mode
Estimated engine torque	
Throttle angle (driver demand)	
Torque reduction status	
Engine MIL status	
Hill descent activity status	

CAN Inputs

- *Actual engine torque.* This message from the ECM indicates the actual engine torque produced at any one time. The EAT ECU uses this message to control gear shift scheduling.
- *Engine coolant temperature.* This message from the ECM is used by the EAT ECU for OBD diagnostic functions and to detect when the engine has completed a 'warm up' cycle.
- *Engine friction.* This message from the ECM is the current frictional torque losses within the engine and is expressed as a percentage of maximum engine torque. The EAT ECU uses this message to control gear shift scheduling.
- *Engine speed.* This message from the ECM is used by the EAT ECU to calculate gearbox oil pressure to assist control of gear shift scheduling.
- *Engine speed signal error.* This message from the ECM informs the EAT ECU if there is a fault with the engine speed calculation. If necessary, the EAT ECU then adjusts gearbox operation to prevent possibility of mechanical damage.
- *Engine torque error.* This message from the ECM informs the EAT ECU that torque values received are incorrect and there is an ECM torque measurement error.
- *Estimated engine torque* This message from the ECM informs the EAT ECU of the level of torque that the engine is producing. The EAT ECU uses this message to control gearshift scheduling.
- *Ignition switch status.* This message from the ECM is produced when the ECM energises the main relay. The EAT ECU uses this message to initiate the power-down routine at ignition off.
- *Actual engine torque.* This message from the ECM is the theoretical engine torque for current throttle setting and engine operating conditions. This is the same as the actual engine torque unless torque reduction in progress and is expressed as a percentage of maximum engine torque. The EAT ECU uses this message to control gear shift scheduling.
- *Throttle angle.* This message from the ECM informs the EAT ECU of the throttle angle (driver demand). The EAT ECU uses this message to control gear shift scheduling.
- *Torque reduction status.* This message from the ECM informs the EAT ECU of the success of a torque reduction request.
- *Engine MIL status.* This message from the ECM indicates to the EAT ECU that the MIL has been illuminated by the ECM. The EAT ECU will disable OBD fault monitoring.
- *Hill descent activity status.* This message from the ABS ECU informs the EAT ECU that HDC has been requested. Providing the selector lever is in position 1 or R, the EAT ECU enters HDC mode and assists the ABS with engine braking.

CAN Outputs

- *Cooling request.* Request for additional cooling of the transmission fluid. The ECM switches on, or increases the speed of the cooling and, if fitted, condenser fans.
- *Current/Target gear.* Informs the ECM what gear is currently engaged or, if a gear shift is in progress, the gear to which the gearbox is shifting. Used by the ECM for engine load change prediction.
- *Gear selector lever position.* The EAT ECU transmits a signal to the ECM of the gear selector lever position selected by the driver. The ECM outputs a CAN message to the instrument pack to display the selection in the LCD
- *Gear shift in progress.* Informs the ECM when a gear shift is in progress. Used at idle speed to compensate for engine load changes during the gear shift.
- *Gearbox fault status.* The EAT ECU uses this signal to display the status of the EAT ECU. If a gearbox fault occurs, the EAT ECU will generate this message to alternately display 'F' and '4' in the instrument pack LCD and initiate the default strategy for the gearbox.
- *Torque reduction request.* Requests the ECM to reduce engine torque for a gear shift (equivalent to lifting off the throttle in manual gearbox models). Amount of torque reduction required expressed as a percentage of maximum engine torque.
- *Gearbox MIL status.* The EAT ECU transmits a signal to the ECM that there is a gearbox fault which will increase emissions above an acceptable level. The ECM outputs a message to the instrument pack which illuminates the MIL.
- *Gear shift mode.* This signal is used to display the currently selected gearshift mode, drive, sport or manual, in the instrument pack LCD. This signal is originated from the EAT ECU.

Operation

General

The EAT ECU controls the following functions:

- Gear shift scheduling
- Lock-up control
- Line pressure control
- Driving mode engagement
- Sport mode engagement
- Manual (CommandShift) mode engagement
- Reverse inhibit
- Hill mode strategy engagement
- Downhill recognition
- Cruise mode engagement
- Cooling strategy engagement
- Selector position display
- Driving mode display
- Fault status
- Fault code storage
- Emergency/Fail-safe program control.

Gear Shift Scheduling

The EAT ECU uses the relationship between the vehicle speed and the throttle position to carry out gear shift scheduling. Depending on these inputs, the EAT ECU controls gear selection using the three shift solenoid valves located in the valve block.

Lock-Up Control

The EAT ECU monitors the relationship between vehicle speed and throttle position to calculate when to lock-up the torque converter.

Lock-up control is possible in 4th and 5th gears. For example, lock-up is possible at high speed cruising with low throttle position. Torque converter lock-up is also provided in 2nd and 3rd gears when high fluid temperatures are detected by the ECU.

A refinement to the torque converter lock-up system is the reduction of harshness or shock during torque converter lock-up.

The EAT ECU controls the lock-up solenoid valve to provide a smooth lock-up function. The solenoid is operated slowly, and gradually varies the fluid pressure to the lock-up control valve. This causes the lock-up clutch to engage slowly, producing a smooth operation.

To promote engine warm-up at low temperatures, the EAT ECU will inhibit lock-up if the gearbox fluid temperature is below 40°C (104°F).

Line Pressure Control
Line pressure refers to the operating fluid pressure that is supplied to the multi-plate clutches, multi-plate brakes and brake band within the gearbox.

Line pressure control provides smooth vehicle operation and gear shift action. The line pressure control is continuously responding to current driving conditions to regulate and deliver the optimum operating pressure at all times. For example, line pressure is lower under normal operating conditions than it would be under hard acceleration.

The EAT ECU controls line pressure by actuating the line pressure solenoid valve in the valve block. The ECU calculates the line pressure required by using engine speed, vehicle speed and throttle position.

High line pressures will cause very harsh gearshifts and gear engagement. Low line pressure will cause gearshifts to take an excessive amount of time to change, which will quickly burn out the clutches, brakes and brake band within the gearbox.

Driving Modes
There are five different driving modes that the driver can select:
- Normal mode
- Sport mode
- Manual (CommandShift) mode
- Hill Descent Control (HDC) mode
- Cruise mode.

Normal, sport, cruise and HDC modes are selected manually by the driver. Fast off and stop go modes are controlled by the EAT ECU responding to driving conditions.

The different modes are selected by the gear selector lever or, in the case of cruise mode and HDC, a separate switch. The gear change scheduling is altered to correspond with the mode selected.

Normal Mode
On power up the EAT ECU always initialises normal mode. In this mode all automatic/adaptive modes are active. Normal mode uses gear shift and lock-up maps which allows vehicle operation which is a compromise between performance, fuel consumption and emissions.

Sport Mode
In sport mode the EAT ECU controls the gearbox to downshift more readily and use gear change schedules that hold the lower gears for longer at high engine speeds. This enhances acceleration and vehicle responsiveness. Sport mode is selected by moving the gear selector lever to the 'S/M' position. 'Sport' is displayed in the instrument pack LCD when this mode is selected.

Manual (CommandShift) Mode
Manual mode allows the driver to operate the gearbox as a semi-automatic, CommandShift gearbox. The driver can change up and down the five gears with the freedom of a manual transmission.

Gearshift maps programmed in the EAT ECU protect the engine at high engine speeds by automatically changing up to prevent engine over speed and changing down to prevent stalling.

Manual mode is entered by moving the selector lever to the 'S/M' position and then moving the lever to either the + or - positions to move the gearbox up and down the five gear ratios. Manual mode is exited by moving the selector back to position 'D'.

HDC Mode

The HDC mode assists the ABS in controlling the descent of the vehicle in either 1st gear ratio or reverse gear ratio. HDC mode is initiated by selecting 1 or R on the selector lever, depressing the HDC button adjacent to the selector lever and throttle pedal released (low demand position). The instrument pack illuminates the HDC warning lamp and the LCD will display the selected gear (1 or R).

The EAT ECU will maintain the selected gear ratio and apply engine braking to assist the ABS in controlling the vehicle's descent.

Cruise Mode

Cruise control is activated by depressing the cruise control switch in the centre console. When cruise control is active, the EAT ECU senses this as a hardwired input from the interface unit. In cruise mode the EAT ECU uses a dedicated gearshift map to control the gearbox and assist in maintaining the set vehicle speed. The gearbox cruise mode is cancelled by applying the brake pedal or deselecting cruise control. Cruise mode is suspended when the throttle demand is increased and is reinstated when the pedal is released and the set speed resumed. Cruise mode is also suspended when the suspend switch on the steering wheel is pressed.

Reverse Inhibit

If the vehicle exceeds 6 mph (10 km/h) in the forward direction, and Reverse (R) gear is selected, the EAT ECU switches on the low clutch timing solenoid valve in the valve block, which drains the fluid from the reverse clutch.

This function prevents the gearbox from engaging reverse gear when the vehicle is moving in a forward direction, so preventing damage to the gearbox.

Hill Mode

Hill mode modifies the gearbox shift pattern to assist driveability on steep gradients. The EAT ECU detects the conditions to activate hill mode by monitoring the engine torque values, throttle angle and engine speed. This mode also assists driving at high altitudes and trailer towing.

Downhill Recognition

On downhill slopes there is a tendency for automatic gearboxes to upshift due to the increase in vehicle speed and the decrease in throttle angle.

The reduction in engine braking causes the driver to use the brakes. A downhill slope is recognised by EAT ECU as an increase in vehicle speed with the decrease in throttle angle.

When a downhill slope is recognised and the brakes are applied, the shift pattern is over-ruled and the gearbox shifts down a gear if engine speed allows. The downhill mode is cancelled upon application of the throttle.

Cooling Strategy

The purpose of the cooling strategy is to reduce engine and gearbox temperatures during high load conditions, for example when towing trailers. Under these conditions the engine and gearbox may generate excessive heat.

While in any gear other than 5th, or in 5th gear with the vehicle speed above 38 mph (61 km/h), if the gearbox fluid temperature increases to 127°C (260°F), the EAT ECU employs the cooling strategy.

This strategy consists of a separate shift and torque converter lock-up map that allows torque converter lock-up or gear changes to occur outside of their normal operating parameters.

This will reduce either the engine speed or the slip in the torque converter, therefore reducing the heat generated.

The EAT ECU cancels the cooling strategy when gearbox fluid temperature decreases to 120°C (248°F).

Engine Cooling Fan
If the gearbox fluid temperature increases to 110°C (230°F), the EAT ECU sends a cooling request message to the ECM on the CAN bus. The ECM then switches the engine cooling fan on, or if it is already on, keeps it on, to maintain the air flow through the fluid cooler.

The EAT ECU cancels the cooling request when the fluid temperature decreases to 100°C (212°F).

Diagnostics
If the EAT ECU detects a failure in an associated component, a fault code will be stored in the EAT ECU memory. TestBook/T4 is used to retrieve these fault codes to identify the cause of the failure.

Gearbox Fault Status
If the EAT ECU detects a fault with the gearbox system it will enter a fail safe mode. There are many fail safe modes the EAT ECU can adopt.

The EAT ECU will adopt the fail safe mode most acceptable for the driver and will ensure the least amount of damage to the gearbox.

When a fault is detected a CAN message is sent from the EAT ECU to the instrument pack and the MIL will be illuminated if the fault is related to OBD. If the ECU is able to implement a limp home mode, the instrument pack LCD will display '4' and 'F' alternately as the gearbox status display. Some faults may not display '4' and 'F' in the instrument pack, but the driver may notice a reduction in shift quality.

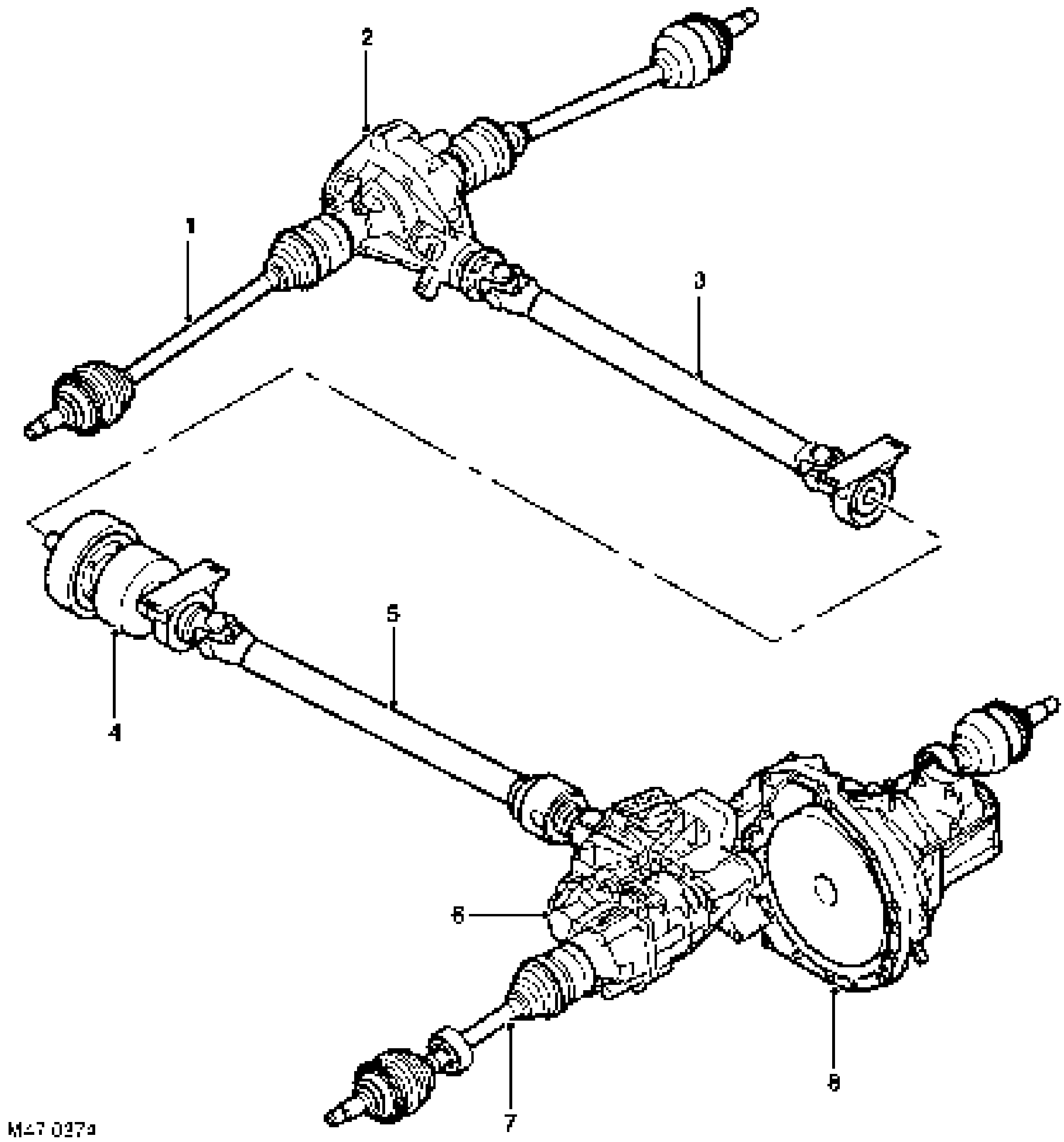
Engine Speed and Throttle Monitoring
The ECM constantly supplies the EAT ECU with information on engine speed and throttle angle through messages on the CAN bus. This information is used by the EAT ECU to calculate the correct timing of gear changes.

If the messages are not received from the ECM, the EAT ECU will implement a back-up strategy to protect the gearbox from damage, whilst allowing the vehicle to be driven.

In the event of an engine speed signal failure any of the following symptoms may be observed:
- Decrease in fuel economy
- Increase in engine emissions.

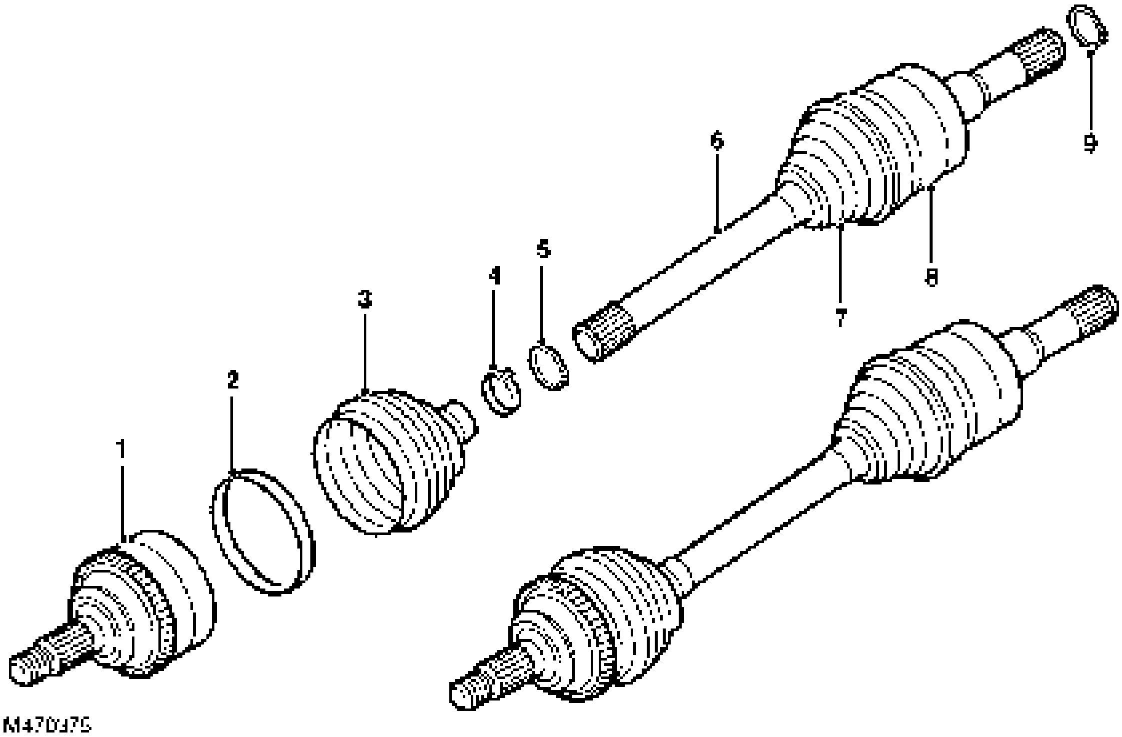
In the event of a throttle position signal failure, any of the following symptoms may be observed:
- Harsh gear changes
- No kickdown
- Torque reduction request inhibited.

Drive Shaft and Propeller Shaft Component Layout



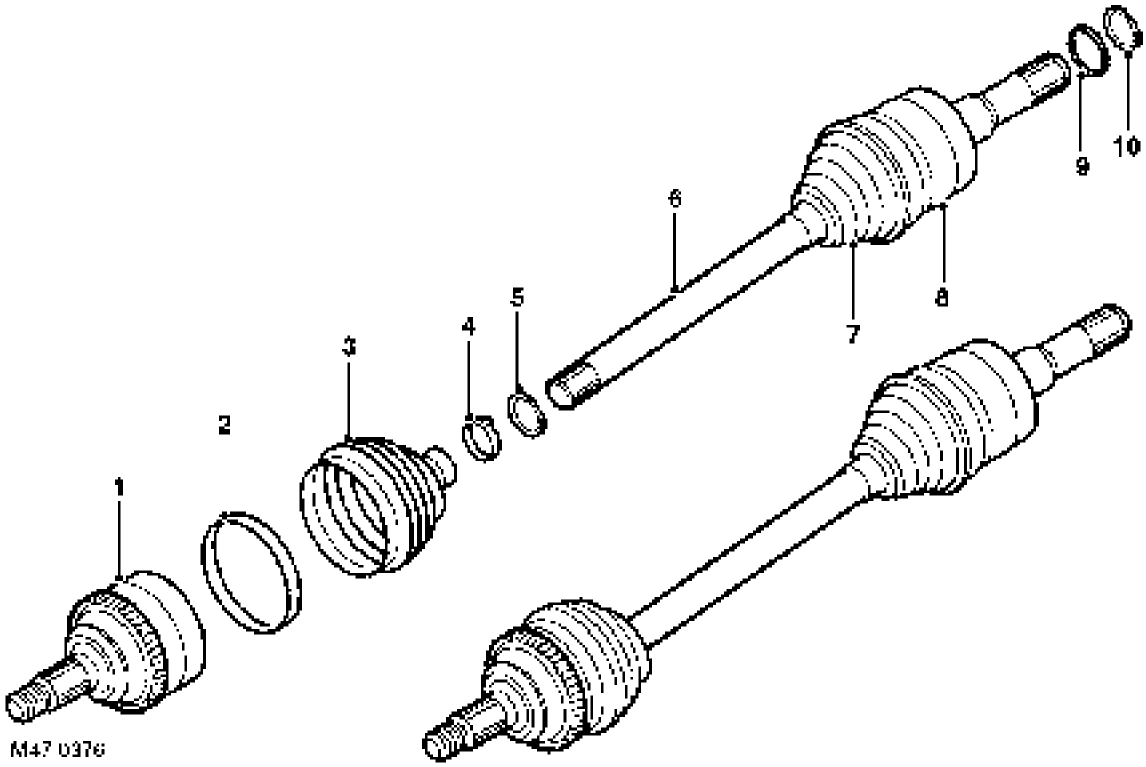
1 Rear drive shaft
2 Final drive unit
3 Rear propeller shaft
4 Vicous Coupling Unit (VCU)
5 Front propeller shaft
6 Intermediate reduction drive (IRD)
7 Front drive shaft
8 Gearbox

Front Drive Shaft Components



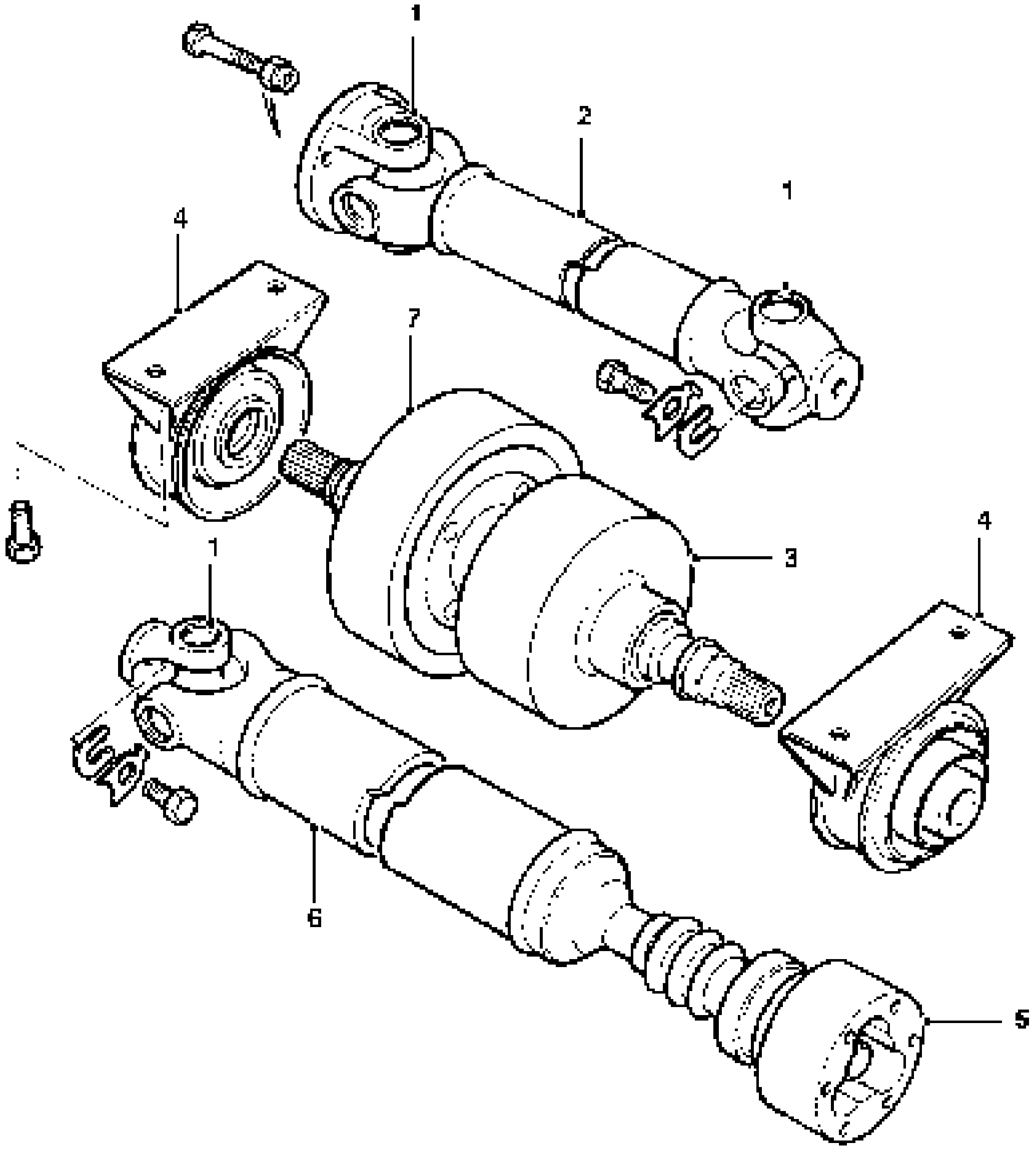
1 Outer joint
2 Clamp
3 Gaiter
4 Clamp
5 Circlip
6 Shaft
7 Gaiter
8 Inner joint
9 Circlip

Rear Drive Shaft Components



1 Outer joint
2 Clamp
3 Gaiter
4 Clamp
5 Circlip
6 Shaft
7 Gaiter
8 Inner joint
9 Flinger - oil seal
10 Circlip

Propeller Shaft and VCU Components



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1 Universal joint
2 Rear propeller shaft
3 VCU
4 Propeller shaft bearing
5 Coupling
6 Front propeller shaft
7 Torsional damper (K1.8 models only)

Description

Drive/Propeller Shafts
Two drive shafts transmit drive from the intermediate reduction drive (IRD) to the front wheels, and to two further drive shafts transmit drive from the final drive (differential) unit to the rear wheels.

Two propeller shafts and a viscous coupling unit (VCU) transmit drive from the IRD to the final drive unit.

Drive Shafts
All four drive shafts are of similar construction, the main difference being in the lengths of the front and rear drive shafts which differ between engine fitments.

Each drive shaft comprises a solid shaft with inner and outer constant velocity joints. The inner joint is of the tripode type with spherical bushing to reduce sliding resistance; the shaft and inner joint are one assembly. The outer joint is of the ball and socket type, with a splined connection between the joint and the shaft. The joints are packed with grease and protected by gaiters.

Front Propeller Shaft
The front propeller shaft consists of a thin walled tube with a coupling welded to the front end and a conventional universal joint welded to the rear end. The coupling bolts to the output flange of the IRD. The universal joint is splined to the input shaft of the VCU and secured by a bolt which is locked by a tabwasher and a 'U' washer.

The coupling reduces vibration and accommodates both angular movement (10 degrees maximum) and axial movement (50 mm maximum) between the propeller shaft and the IRD.

The universal joint incorporates serviceable, sealed needle bearings.

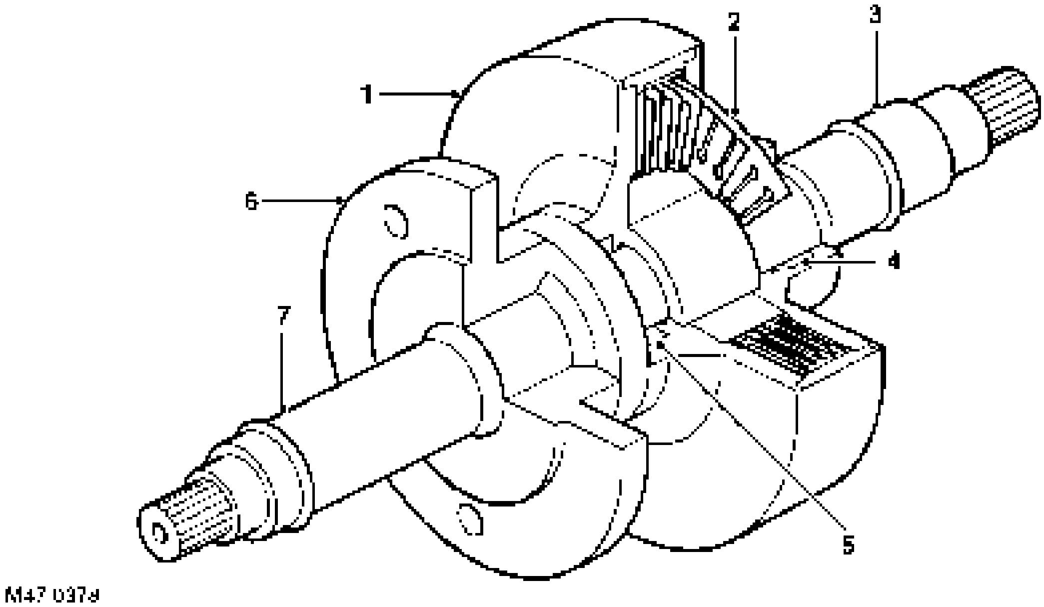
VCU
The VCU automatically controls the transfer of drive to the rear wheels by limiting the speed differential between the front and rear propeller shafts. The unit is supported in two propeller shaft bearings attached to the floor cross member.

The VCU comprises a short cylinder which contains an input shaft supported in a roller bearing race at the front and a ball bearing race at the rear. Within the cylinder, slotted discs are alternately attached to the outer surface of the input shaft and the inner surface of the cylinder. An output shaft is welded onto the rear of the cylinder. The input shaft is attached to the front propeller shaft and the output shaft is attached to the rear propeller shaft.

On models with 1.8 K Series engines, a torsional damper is bolted to a flange on the output shaft.

The cylinder is a sealed unit filled with a silicon jelly. The viscosity of the silicon jelly increases when subjected to shear. When there is a speed differential between the front and rear propeller shafts, adjacent slotted discs in the VCU rotate in relation to each other. The shearing action of the rotating slotted discs increases the viscosity and resistance to rotation of the silicon jelly.

Section Through VCU



1 Cylinder
2 Slotted discs
3 Input shaft
4 Roller bearing
5 Ball bearing
6 Torsional damper flange (K1.8 models only)
7 Output shaft

The rear wheels are 0.8% under driven, so in most conditions the vehicle is effectively front wheel drive, with the rear wheels turning the rear propeller shaft slightly faster than the IRD drives the front propeller shaft. Since the speed differential is low, the increase in viscosity of the silicon jelly is marginal and there is little resistance to relative rotation of the slotted discs.

When there is a significant speed differential between the front and rear propeller shafts , e.g. the front wheels lose traction or traversing rough terrain, the viscosity and resistance to rotation of the silicon jelly increases to a level that slows or stops relative rotation of the slotted discs. With the front and rear propeller shafts locked together, drive is thus transferred from the IRD to the rear wheels.

Propeller Shaft Bearings

The two propeller shaft bearings are identical, and each consist of a roller bearing race mounted into a centre bearing housing. The bearing is sealed-for-life and is a press fit on the input/output shaft of the VCU. Bearing covers and flingers prevent the ingress of moisture.

Rear Propeller Shaft

The rear propeller shaft consists of a thin walled tube with a conventional universal joint welded to each end. The rear universal joint is bolted to the input flange of the final drive unit. The front universal joint is splined to the output shaft of the viscous coupling unit and secured by a bolt which is locked by a tabwasher and a 'U' washer. Both universal joints incorporate serviceable, sealed needle bearings.

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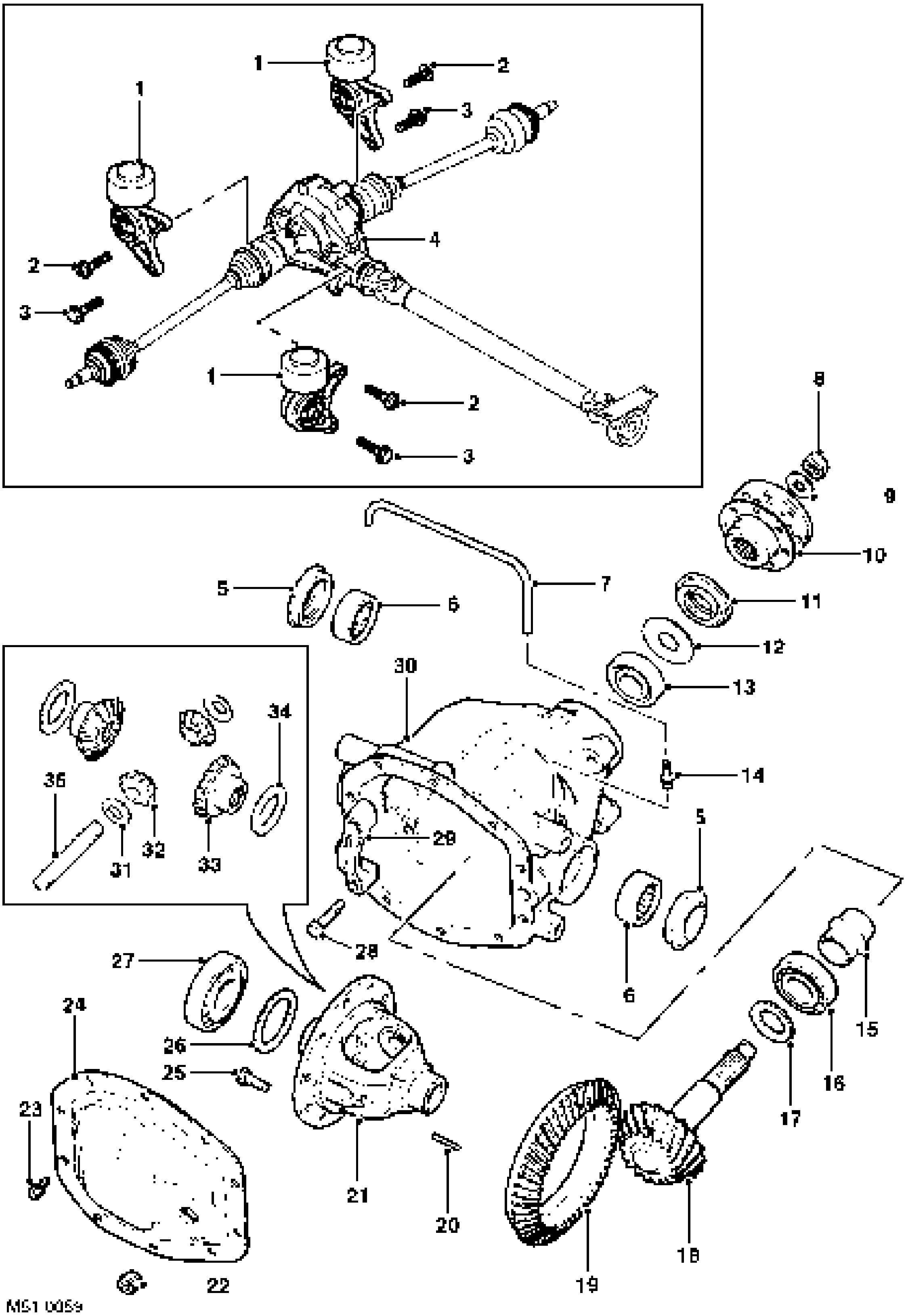
Rear Differential



1 Bushed mounting (3 off)
2 Flanged screw (3 off)
3 Flanged bolt (3 off)
4 Differential assembly
5 Oil seal (2 off)
6 Needle roller bearing (2 off)
7 Breather tube
8 Pinion nut
9 Washer
10 Flange
11 Mudshield
12 Oil slinger
13 Taper roller bearing
14 Vent valve
15 Collapsible spacer
16 Pinion bearing
17 Shim kit
18 Pinion shaft and gear
19 Crown wheel
20 Roll pin
21 Differential case
22 Plug - Filler/Level
23 Bolt (10 off)
24 Cover
25 Bolt (10 off)
26 Shim (2 off)
27 Bearing (2 off)
28 Bolt (4 off)
29 Bearing cap (2 off)
30 Pinion housing
31 Belleville washer (2 off)
32 Planet gear (2 off)
33 Sun wheel (2 off)
34 Clutch pack (2 off)
35 Cross pin

Description

Rear Differential
The rear differential assembly serves to convert the "angle of drive" through 90° and distribute drive, in the desired proportions, to both rear wheels. The type of rear differential fitted is an integral carrier housing hypoid-gear in which the centre line of the drive pinion is mounted below the centre line of the ring gear. To minimise weight, the differential housing is manufactured in aluminium alloy. The assembly is secured to the rear subframe by three rubber bushed mountings.

The differential housing incorporates the drive pinion gear shaft, which is supported by two opposed taper roller bearings fitted to the pinion and cups assembled into the carrier housing. The pinion bearing pre-load is controlled by a collapsible spacer and the torque of the pinion nut. The pinion position is controlled by a selective shim located between the inner pinion bearing cone and the pinion gear head.

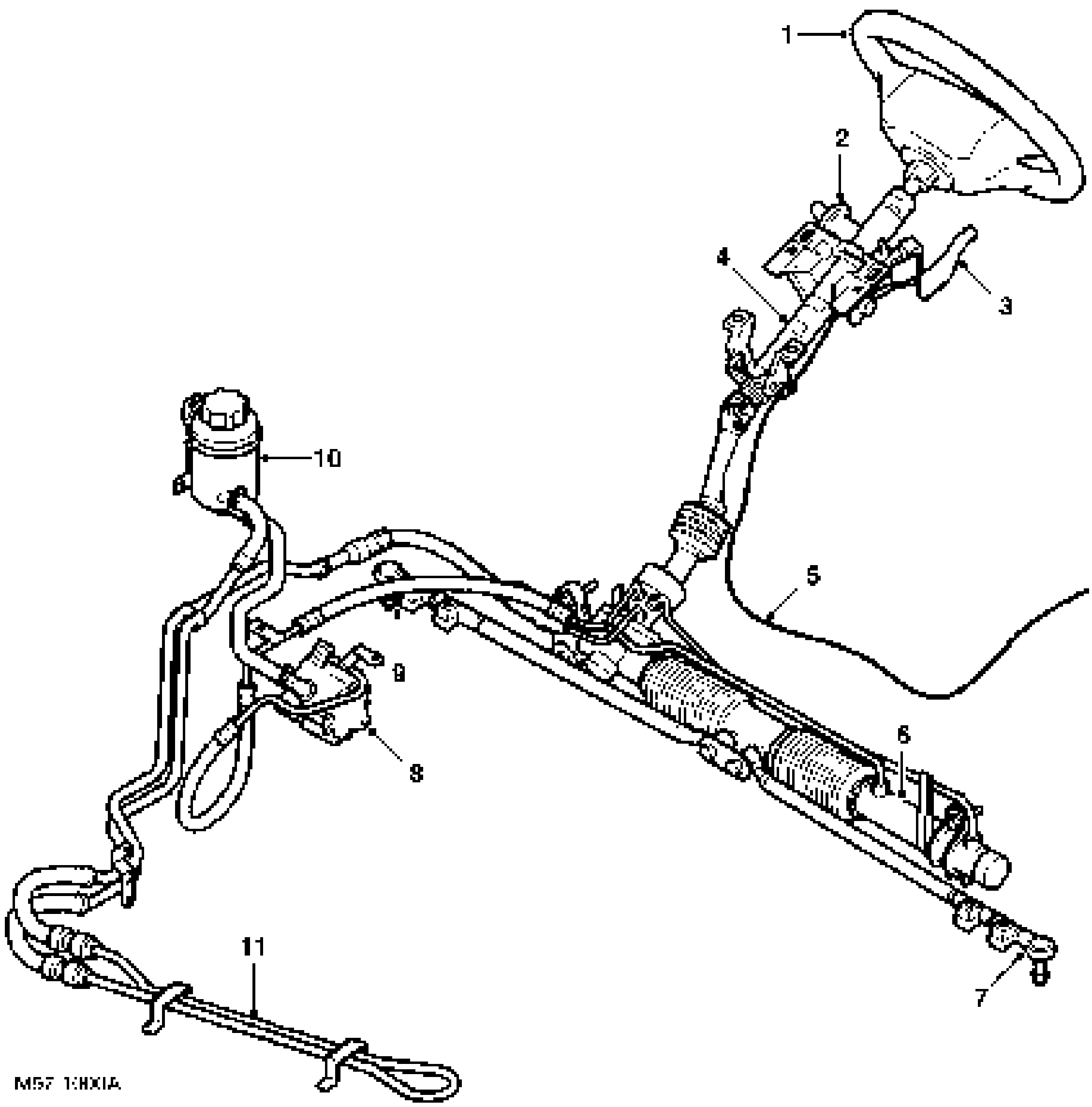
The differential assembly is supported by two opposed taper roller bearings. The bearing cups are secured in the housing by removable bearing caps. Shims are located between the differential bearing cones and differential case for controlling differential bearing pre-load and ring gear to pinion gear backlash.

The differential casing rear cover is manufactured from pressed steel and is sealed to the casing with RTV silicone sealant. The cover also incorporates the oil filler plug. A breather is located in the top of the differential casing to prevent pressurisation of the casing.

The pinion oil seal, which is fitted in the differential casing, is referred to as a "labyrinth" type seal and is especially designed to prevent contaminant ingress. The oil seal works in conjunction with a pressed steel shield, referred to as a "flinger" which is pressed on to the pinion drive flange. The two drive shafts are also sealed by "labyrinth" type oil seals fitted in the differential housing.

The differential oil level should be maintained to the bottom of the filler plug. No oil changes are specified.

Steering Components - KV6



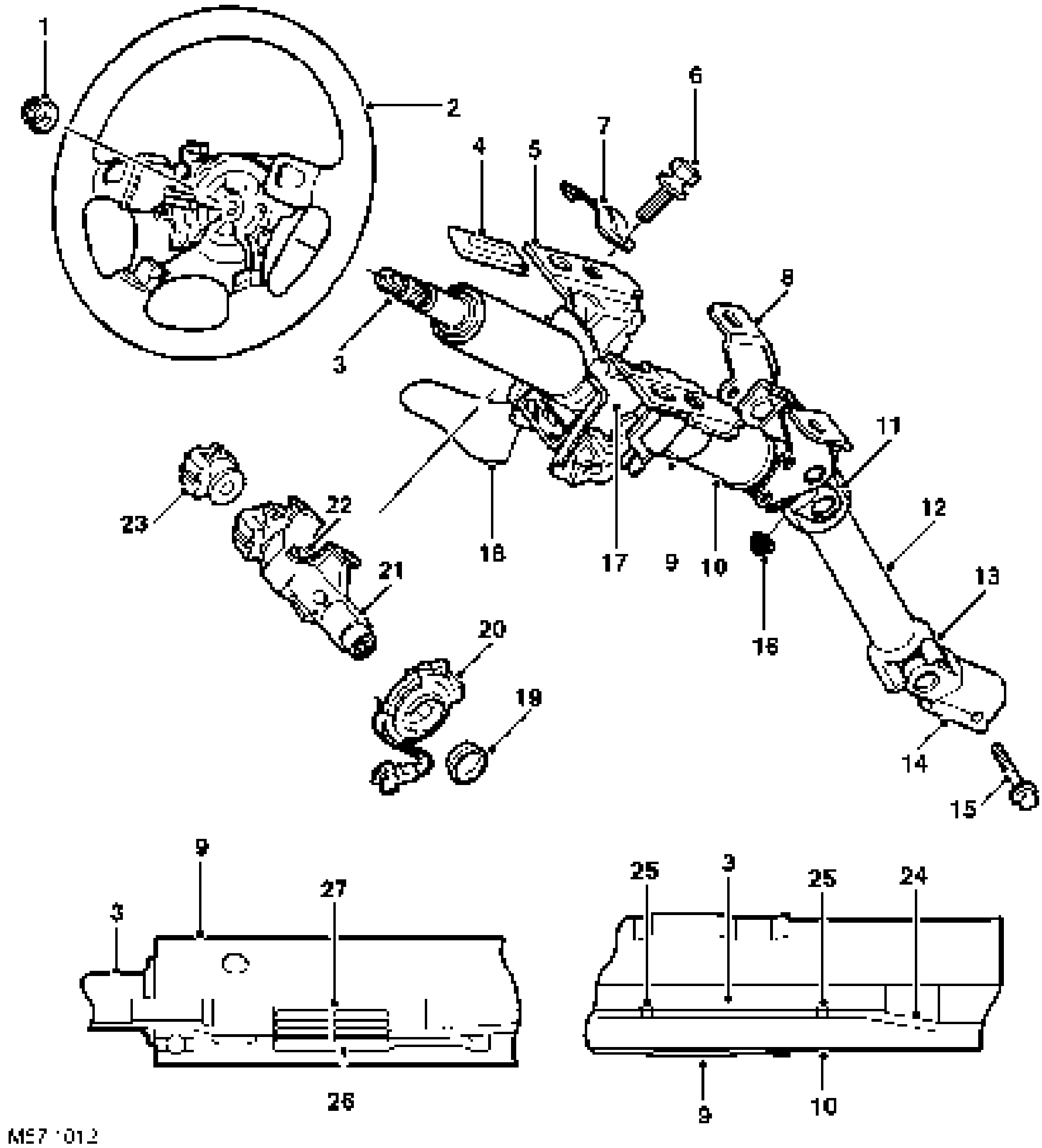
RHD shown, LHD similar

1 Steering wheel
2 Ignition switch/column lock assembly
3 Column adjuster
4 Telescopic column
5 Key interlock cable (if fitted)
6 Steering rack
7 LH track rod end
8 PAS pump
9 RH track rod end
10 Reservoir
11 Fluid cooler

Description

General
The major steering components comprise a shock absorbing telescopic steering column, a Power Assisted Steering (PAS) rack, a PAS pump, a fluid reservoir, a fluid cooler and fluid pipes and hoses.

Steering Column



1 Locknut
2 Steering wheel
3 Upper shaft
4 'U' Clip (2 off)
5 'Curling' plate (2 off)
6 Shear bolt (2 off)
7 Clamp plate
8 Lower mounting
9 Upper column tube
10 Lower column tube
11 Universal joint
12 Intermediate shaft
13 Universal joint
14 Adaptor
15 Clamp bolt
16 Locknut – mounting (2 off)
17 Upper mounting
18 Column adjuster
19 Light ring – ignition switch
20 Transponder coil
21 Steering column lock assembly
22 Lock bolt
23 Ignition switch
24 Lower shaft
25 Injection moulded shear pins
26 Lock collar
27 Wave form interference ring

The steering column design incorporates an energy absorbing mechanism to reduce driver impact loads in the event of a collision. The column is mounted on four captive studs which are located in an extension to the bulkhead. The two lower mountings are fixed and cannot move when loads are applied to them. The upper mounting is designed to disengage or deform when a load is applied, allowing the column to collapse in the event of an accident. The steering column is adjustable to allow the steering wheel to be moved vertically up or down to the desired position. The steering column is not serviceable and must be replaced as a complete assembly if necessary.

The upper column tube is telescopic and can slide over the lower column tube. The upper column tube provides for the location of the steering lock and ignition switch and also the steering switch gear and a rotary coupler. The rotary coupler provides the electrical connection for the steering wheel mounted airbag and the switches for the horn and, where fitted, In-Car Entertainment (ICE) and cruise control.

The central shaft comprises of two parts and is located in bearings in the upper and lower column tubes. The upper shaft is located inside the lower shaft. Mating cross holes in each shaft are connected by nylon injection moulded shear pins.

The upper shaft is splined to accept the steering wheel. The lower shaft is connected by a universal joint to the intermediate shaft. A second universal joint on the opposite end of the intermediate shaft is attached to a split adaptor. The adaptor is splined and mates with the splined input shaft from the steering rack.

The upper mounting bracket has two open slots with a PTFE coated, metal 'U' clip over each slot. Two soft metal 'curling' plates are riveted to the mounting bracket and cover the slots.

The mounting studs pass through the 'U' clips and the curling plates. The lock nuts that retain the upper mountings to the bulkhead extension are tightened to between 12 and 15 Nm. This torque figure controls the breakout load required to move the upper mounting brackets from the studs in the bulkhead extension and is critical to the crash performance of the column.

Energy absorption is achieved by the following mechanism: When an axial load is applied to the steering column, the mounting bracket deforms or slides out of the 'U' clips and the curling plates deform. The 'U' clips remain captive on the studs When the column mounting moves, the upper column tube slides on the lower column tube and allows approximately 63 mm (2.5 in.) maximum of axial movement. The nylon shear pins holding the upper and lower shafts together shear, allowing the central shaft to telescope the same amount as the column tubes.

In the event of a collision where the steering rack itself moves, the two universal joints in the column allow the intermediate shaft to articulate, minimizing movement of the column towards the driver. If movement continues after articulation of the intermediate shaft, the nylon shear pins retaining the two halves of the central shaft shear causing the shafts to 'telescope' together reducing further column intrusion.

The steering wheel comprises a cast centre and wire frame onto which the soft polyurethane foam is moulded. A horn switch is located at each side of the wheel. On models with a high specification ICE system and/or cruise control, additional switches are located on the steering wheel for control of one or both features. All switches are connected by wires to the rotary coupler connector.

Protection for the drivers face and upper torso is provided by an SRS airbag located in the centre of the steering wheel under a plastic cover.

☞ **RESTRAINT SYSTEMS, DESCRIPTION AND OPERATION, Description.**

The column adjuster is located on the left hand side of the steering column and allows the steering column and wheel to be tilted up or down over a range of approximately 3.5° or 30 mm (1.2 in) of vertical movement of the steering wheel. The column adjuster comprises a bolt which passes through each side of the column upper mounting bracket. The column adjustment lever is attached to a two-start left hand threaded nut which screws onto the bolt.

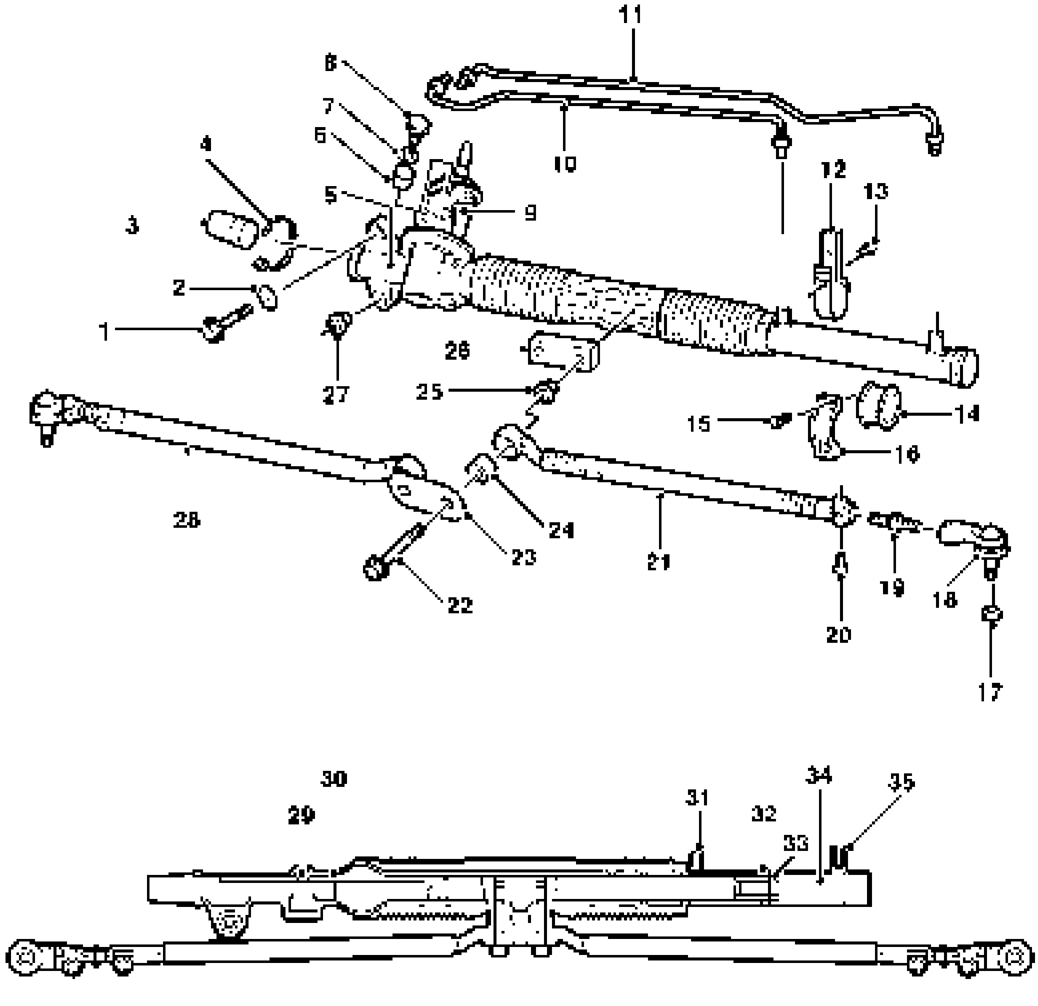
When the lever is lowered the nut is slackened and allows the column to be moved up or down to the desired position. Lifting the lever upwards tightens the nut, clamping the mounting bracket to the column, retaining the steering column in the selected position. The nut tightening torque is 10.5 Nm (7.7 lbf.ft) which gives the correct 'feel' to the lever operation.

The steering lock houses the ignition switch, ignition illumination light ring, key lock barrel and the security system transponder coil.

The steering lock is attached to the upper column with a clamp plate and two shear bolts. The bolts are tightened to a torque which shears off the heads of the bolts preventing easy removal of the steering lock.

The steering lock operates by a bolt, which emerges when the ignition key is turned to position 0 and the ignition key removed. The bolt engages in a lock collar located on the upper shaft in the upper column tube. The lock collar is attached to the upper shaft by a 'wave form' interference ring, which allows the lock collar to slip on the upper shaft if a torque of 200 Nm (147.5 lbf.ft) or higher is applied. This prevents the bolt being sheared, by someone forcibly turning the steering wheel while the steering lock is engaged, yet still effectively locks the steering. The steering lock is also designed to be resistant to slide hammer and shock retraction.

Steering Rack



RHD shown, LHD similar

1 Flanged bolt (2 off)
2 Washer (lower bolt only)
3 Dust cover
4 Tie
5 Steering rack casting
6 Non return valve
7 Seal
8 Adaptor
9 Valve unit
10 Feed pipe (6 mm diameter)
11 Feed pipe (10 mm diameter)
12 Pipe support bracket
13 Bolt
14 Rack mounting cushion
15 Bolt (2 off)
16 Rack mounting bracket
17 Nut (2 off)
18 Track rod end (2 off)
19 Turnbuckle (2 off)
20 Bolt (4 off)
21 Track rod LH
22 Track rod bolt (2 off)
23 Support plate
24 Inner track rod bush (2 off)
25 Spacer (2 off)
26 Slider and bush assembly
27 Mounting bush (2 off)
28 Track rod RH
29 Steering pinion
30 Steering rack
31 Cylinder annulus port
32 Piston seal
33 Piston bolt
34 Cylinder
35 Cylinder full area port

The steering rack is unique in having the track rods mounted at a central location on the rack. The track rods are very long and combined with the optimized steering geometry provide low levels of 'bump steer'.

The steering rack is mounted in the engine compartment on the lower part of the bulkhead. The rack is retained with two bolts through cast lugs near the valve unit and two bolts which secure a clamp over the opposite end of the rack. The lower bolt through the cast lug is fitted with a large washer. The steering rack is handed for left and right hand drive vehicles.

The rack requires 3.2 turns from lock to lock and the rack and pinion has an overall ratio of 19.6 : 1.

A valve unit is fitted to one end of the steering rack and connects, via a splined input shaft, to the adaptor of the steering column. The valve unit has four hydraulic connections; a pressure feed from the PAS pump, a return line to the reservoir and two pressure lines to the annulus and full area of the hydraulic cylinder.

An input shaft, installed through the valve unit, is connected to a pinion gear which drives on a rack which, in turn is connected to the piston rod in the hydraulic cylinder.

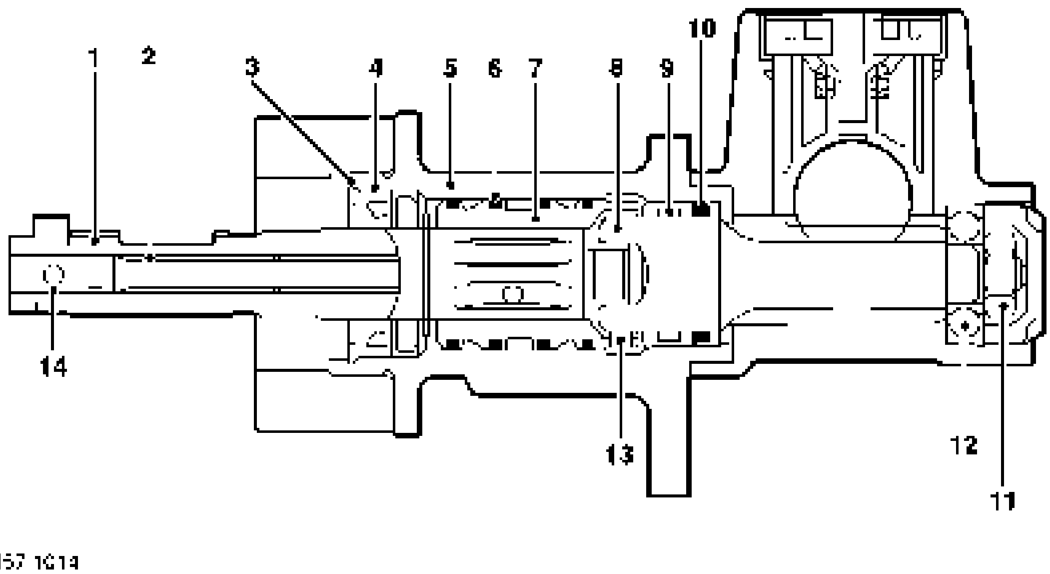
At a central position on the rack are two threaded holes which allow for the attachment of the track rods. Rubber bellows cover the movement area of the rack.

Two hydraulic ports, one at each end of the hydraulic cylinder of the rack, are connected by metal pipes to the valve unit. The ports supply hydraulic pressure to the annulus and full area of the cylinder. The annulus end of the cylinder is supplied with PAS pump outlet pressure and the full area end of the cylinder is supplied with pressure regulated by the valve unit. The cylinder end of the piston rod is fitted with a piston which houses a piston seal.

The track rods are fitted with rubber bushes which are hard enough to give positive feel to the steering but at the same time reduce unwanted feedback through the track rod. Each track rod is fitted with a track rod end. The track rod end is a ball joint which locates on an extended bracket on the suspension strut and secured with a lock nut. A turnbuckle is screwed into the track rod and the track rod end and allows for the adjustment of the steering alignment.

The track rods are located on a bushed slider which locates on the rack. Two spacers are located between the slider and the track rods. Two flanged bolts secure the track rods to the rack.

Valve Unit



1 Input shaft
2 Torsion bar
3 Circlip
4 Oil seal
5 Valve housing
6 PTFE ring (4 off)
7 Outer sleeve
8 Pinion shaft
9 Bearing
10 Oil seal
11 Nut
12 Bearing
13 Pin - pinion shaft to outer sleeve
14 Pin - input shaft to torsion bar

The valve unit is an integral part of the steering rack. The principal function of the valve unit is to provide maximum power assistance (i.e. when parking) with minimum effort required to turn the steering wheel.

The cast outer casing of the valve unit has four ports which provide the connections for pressure feed from the PAS pump, return to the fluid reservoir and pressure feeds from the valve unit to the annulus area and the full area of the cylinder. A non return valve and seal is fitted in the pressure feed port from the PAS pump.

The valve unit comprises an outer sleeve, input shaft, torsion bar and a pinion shaft. The valve unit is coaxial with the pinion shaft which is connected to the steering column via the input shaft. The valve unit components are located in a housing which is attached to a mating casting on the steering rack main body and secured with screws.

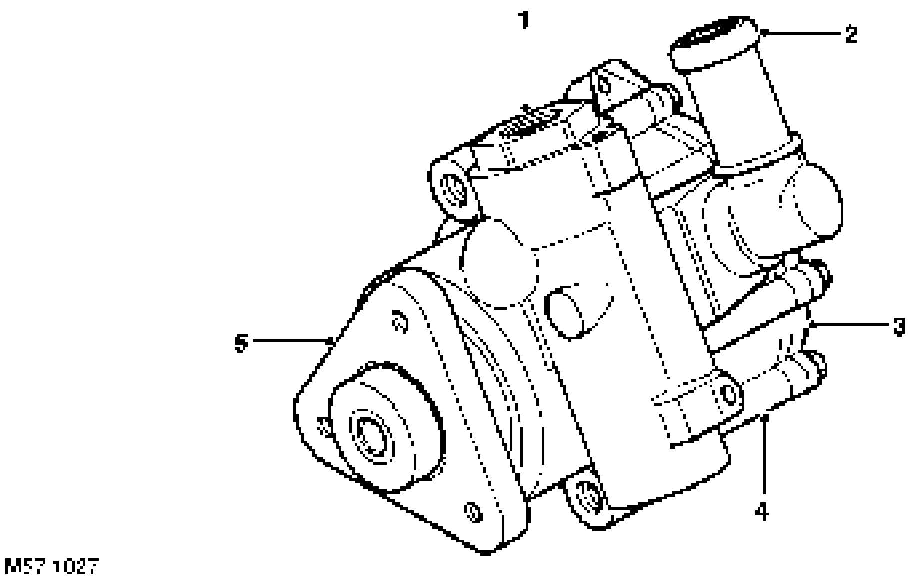
The outer sleeve is located in the main bore of the valve unit. Three annular grooves are machined on its outer diameter. PTFE rings are located between the grooves and seal against the bore of the valve unit. Holes are drilled radially in each annular groove through the wall of the sleeve. The bore of the outer sleeve is machined to accept the input shaft. Six equally spaced slots are machined in the bore of the sleeve. The ends of the slots are closed and do not continue to the ends of the outer sleeve. The radial holes in the outer sleeve are drilled into each slot.

The input shaft is splined at its outer end. The inner end of the input shaft forms a dog-tooth which mates with a slot in the pinion shaft. The fit of the dog-tooth in the slot allows a small amount of relative rotation between the input shaft and the pinion shaft before the dog-tooth contacts the wall of the slot. This ensures that, if the power assistance fails, the steering can be operated manually without over stressing the torsion bar. The central portion of the input shaft has equally spaced longitudinal slots machined in its circumference. The slots are arranged alternately around the input shaft.

The torsion bar is fitted inside the input shaft and is an interference fit in the pinion. The torsion bar is connected to the input shaft by a drive pin, fitted after hydraulic balancing. The central diameter of the torsion bar is machined to a smaller diameter than at each end. The smaller diameter allows the torsion bar to twist in response to torque applied from the steering wheel in relation to the grip of the tyres on the road surface.

The pinion shaft has machined teeth on its central diameter which mate with the teeth on the steering rack. A slot machined in the upper end of the pinion shaft mates with the dog-tooth on the input shaft. The pinion shaft locates in a cast housing which is part of the steering rack and rotates on ball and roller bearings.

Power Assisted Steering (PAS) Pump



Td4 pump shown, K1.8 and KV6 pumps similar

1 Outlet connection
2 Inlet connection
3 Cover
4 Body
5 Drive flange

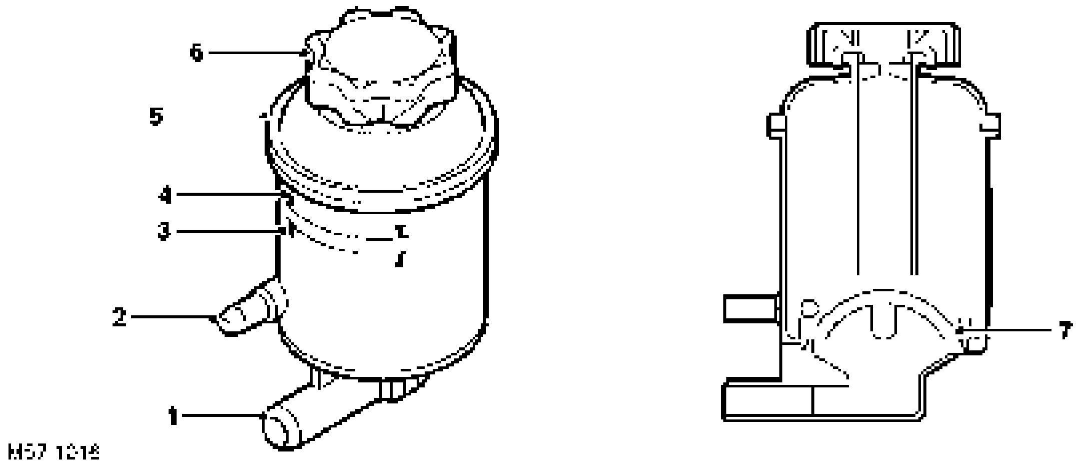
The vane type PAS pump supplies hydraulic pressure to the steering rack valve unit. The PAS pump is driven by a Poly Vee belt from the crankshaft pulley. A self adjusting tensioner is fitted to maintain the correct belt tension.

The PAS pump comprises a body and cover which house the internal components of the pump. A pressure relief valve assembly is installed in the body. The relief valve also incorporates a flow control valve. The pressure relief valve limits the maximum pressure to between 120 and 127 bar (1740 and 1842 lbf/in^2). The flow control valve limits the maximum flow to between 5.0 and 6.0 l/min (1.32 and 1.58 US gal/min).

A shaft runs longitudinally through the pump. One end of the shaft has a drive flange which accepts the drive pulley. The opposite end is closed by the cover. The shaft runs in bearings located in the body. Oil seals at each end of the shaft prevent the leakage of hydraulic fluid.

An oval cam ring is located in the body. Ten roller vanes are housed in a carrier and rotate within the cam ring. The carrier is mounted in the centre of the shaft and receives positive drive from the shaft via a drive pin. The carrier is seated against an end plate which is located in the cover. The front of the carrier is covered by a port plate which is located against a seal plate in the body. The port plate controls the fluid flow into and out of the roller vanes during their cycle.

Fluid Reservoir



1 Supply connection
2 Return connection
3 Lower fluid level mark
4 Upper fluid level mark
5 Reservoir body
6 Cap
7 Filter assembly

The fluid reservoir is mounted in the right hand side of the engine compartment on a bracket attached to the inner wing.

The reservoir comprises a body, a cap and a filter assembly. The reservoir has a capacity to the upper level mark of 335 cc.

An 'O' ring seal in the cap prevents leakage. The cap is pushed onto the latch and turned through 90° to lock. A breather hole is incorporated in the cap to allow changes in fluid level during operation.

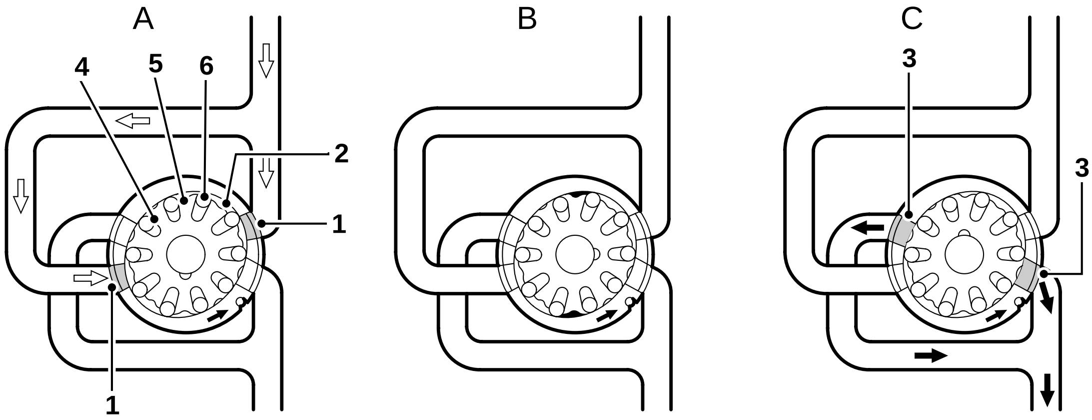
A filter assembly is fitted into the bottom of the reservoir. The filter is made from fine nylon mesh which is moulded into the frame of the filter. The filter removes particulate matter from the fluid before it is drawn into the supply connection and is non-serviceable.

The primary function of the fluid reservoir is to hold a surplus of hydraulic fluid in the system to allow for expansion and contraction of the fluid due to temperature variations. The fluid level ensures that the supply connection is covered with fluid at all operational attitudes. Any air that may be present in the hydraulic system will be exhausted from the fluid at the reservoir.

High Pressure Hose
The high pressure hose connecting the PAS pump to the valve unit incorporates an attenuator. The attenuator comprises a bullet shaped valve which is located between two spiral wound springs. The valve operates as a restrictor to damp pressure pulses from the PAS pump, reducing noise and strain on downstream components. The attenuator is integral with the hose and cannot be serviced separately.

Operation

PAS Pump Operation



M57 1017

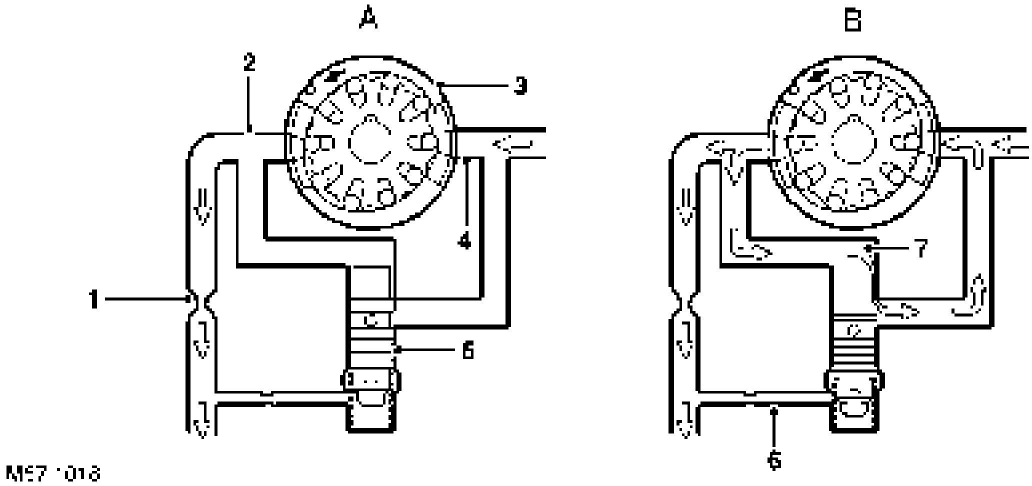
1 Inlet port
2 Roller vane chamber
3 Discharge port
4 Cam
5 Carrier
6 Roller vanes

As the pump rotates, centrifugal force causes the roller vanes to move outwards in the slots in the carrier and contact the cam ring. As the carrier rotates, the cam ring form causes the space between the rollers to increase. The increasing volume between the roller vanes causes a depression which draws fluid into the space between the rollers.

As the carrier continues to rotate, the inlet port is closed to the roller vanes which have drawn the fluid, trapping the fluid between the rollers. As the carrier rotates further, the cam form causes the space between the roller vanes to decrease, pressurizing the fluid between the rollers.

On further rotation of the carrier the roller vanes reach the discharge port and fluid is displaced under pressure from between the roller vanes into the discharge port. The space between each pair of rollers is subjected to this cycle twice for every revolution of the pump.

Pump Flow Control Valve Operation



1 Metering orifice
2 Discharge port
3 Pump
4 Inlet port
5 Flow control valve
6 Relief valve passage
7 Recirculation passage

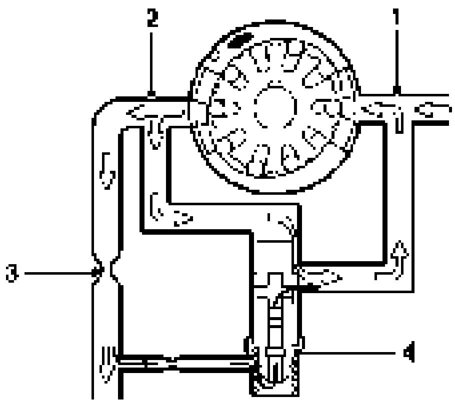
The pump is a positive displacement type pump and potential output from the pump increases proportionally with engine speed. The flow control valve maintains a constant predetermined flow to the control unit regardless of engine speed. The flow control valve controls the flow of fluid and increases or decreases the flow discharged from the pump to compensate for engine speed variations.

With the engine at idle the discharge flow from the pump is low and the full flow from the pump is delivered to the valve unit. As engine speed increases, the flow delivered by the pump increases proportionally. A pressure difference is created between each side of the metering orifice as the engine speed increases, the higher pressure being felt at the pump side of the metering orifice. This higher pressure is also felt at the top of the flow control valve via the recirculation passage. The lower pressure on the discharge side of the metering orifice is felt at the bottom of the flow control valve via the relief valve passage.

When the pressure at the top of the flow control valve exceeds the rating of the flow control valve spring, the valve begins to open against the spring pressure and the lower pressure at the discharge side of the metering orifice. Fluid is allowed to flow through the recirculation passage and recirculate through the pump.

As engine speed increases, the flow control valve is pushed down further, increasing the flow through the recirculation passage.

Pump Pressure Relief Valve Operation



M57 1019

- **1** Inlet port
- **2** Discharge port
- **3** Metering orifice
- **4** Pressure relief valve

The pressure relief valve is located in the centre of the flow control valve. If the pressure on the discharge side of the metering orifice reaches a predetermined level, a spring loaded ball in the centre of the valve will lift from its seat and allow pressurized fluid to recirculate within the pump.

The pressure relief valve will operate if the discharge from the pump is restricted, steering held at full lock. If the discharge from the pump is completely blocked, all fluid discharged will be recirculated through the pump. As no fresh fluid is drawn into the pump from the reservoir, the fluid temperature inside the pump will increase quickly. Consequentially, periods of operation of full lock should be kept to a minimum to avoid overheating the pump and the fluid within it.

Steering Rack Operation

Rotary movement of the steering wheel is transferred via the steering column to the input shaft of the valve unit on the steering rack. The rotary movement of the input shaft is converted into linear movement of the steering rack through the rack and pinion. With the engine running and the PAS pump operating, pressurised fluid is available to the steering rack for power assistance.

Neutral Position

With no movement of the steering wheel being applied, the slots in the outer sleeve and the input shaft are so aligned that the fluid flows across the valve unit with minimal restriction. Some pressure is applied to the full area port and the annulus port which in turn is felt at either side of the piston in the hydraulic cylinder. With the forces approximately equal on each side of the cylinder, the steering remains in the neutral position. Fluid delivered from the PAS pump is returned from the valve unit via the fluid cooler back to the reservoir. With minimal restriction across the valve unit and through the return hose, the pressure applied to each side of the piston is very low.

Right Steering (RHD Models; Left Steering on LHD Models)
Clockwise (on RHD, anti-clockwise on LHD) rotation of the steering wheel rotates the input shaft and the torsion bar in the same direction. The slots in the input shaft move out of their neutral alignment with the slots in the outer sleeve, as the torsion bar twists, and restricts the flow back to the reservoir. This restriction causes the supply pressure from the PAS pump to increase. The increased PAS pump pressure is directed to the annulus side of the hydraulic cylinder. Due to the relative displacement of the slots, the full area side of the cylinder is opened to return, producing a pressure difference across the piston. This results in a linear output force along the rack which provides the power assistance to turn the road wheels in the appropriate direction.

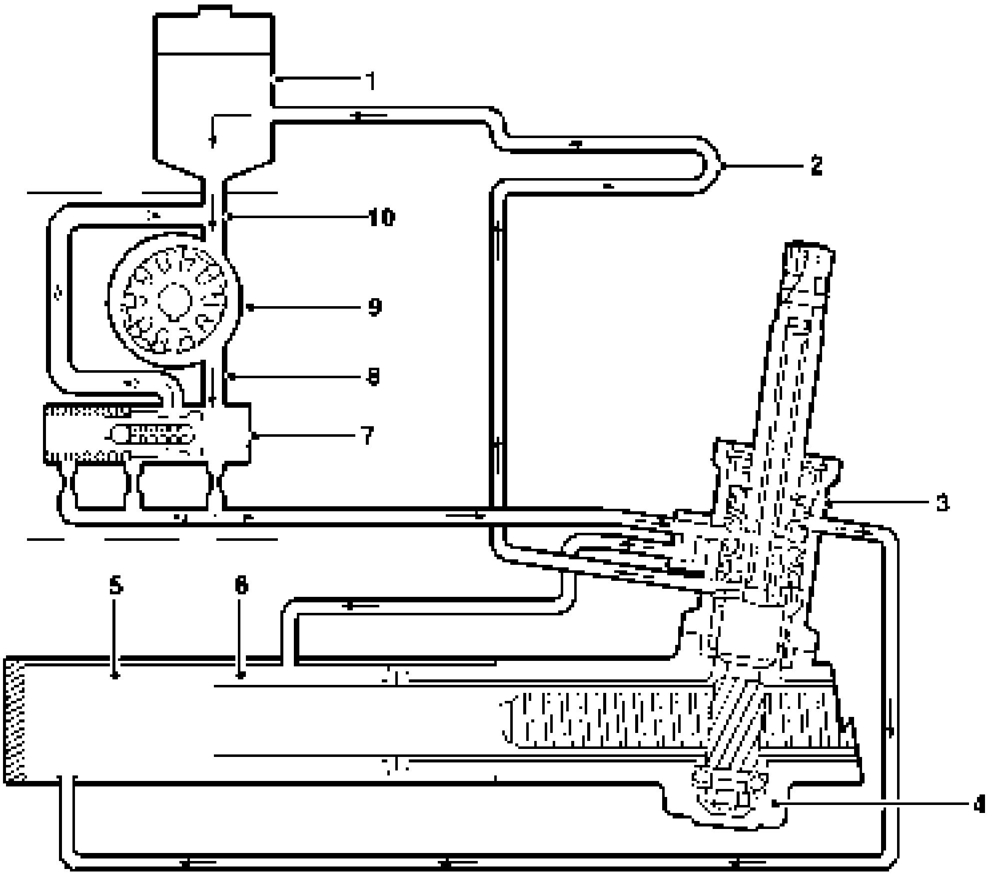
Left Steering (RHD Models; Right Steering on LHD Models)
Anti-clockwise (on RHD, clockwise on LHD) rotation of the steering wheel rotates the input shaft and the torsion bar in the same direction. The slots in the input shaft move out of their neutral alignment with the slots in the outer sleeve, as the torsion bar twists, and restricts the flow back to the reservoir. This restriction causes the supply pressure from the PAS pump to increase. The increased PAS pump pressure is directed to the annulus side of the hydraulic cylinder. Due to the relative displacement of the slots the increased PAS pump pressure is also applied to the full area side of the cylinder. The difference in effective areas on each side of the piston produces a linear output force along the rack which provides the power assistance to turn the road wheels in the appropriate direction.

Progressive Assistance
Progressive power assistance is dependent on the amount of road wheel resistance opposing the turning of the front wheels. When the steering wheel is turned to the left or right, the rotary movement is transferred through the steering column to the input shaft which rotates the same amount as the steering wheel. The rotary movement is also transferred from the input shaft to the torsion bar. If the road wheel resistance is high, e.g. when parking, the torsion bar will twist. The twisting of the torsion bar means that the rotary movement of the pinion and the outer sleeve is less than that of the input shaft.

The twisting of the torsion bar moves the slots in the input shaft and the torsion bar out of alignment. The greater the resistance of the road wheels to the steering rotary movement, the greater the misalignment of the slots in the input shaft and outer sleeve. As the misalignment becomes greater, the restriction in the return flow of fluid to the reservoir increases and therefore the fluid pressure applied to the hydraulic cylinder also increases. As the fluid pressure increases, so does the amount of assistance provided.

When the road wheel resistance reduces or less effort is applied to the steering wheel, the reduced torque applied to the input shaft allows the torsion bar to unwind. This reduces the misalignment between the slots in the input shaft and the outer sleeve, reducing the fluid pressure applied to the hydraulic cylinder and therefore the amount of assistance provided.

Hydraulic Circuit Operation



M57 1020

1 Reservoir
2 Fluid cooler
3 Valve unit
4 Steering rack and pinion gear
5 Full area pressure chamber
6 Annulus pressure chamber
7 Flow control/relief valve
8 Discharge port
9 PAS pump
10 Low pressure suction line

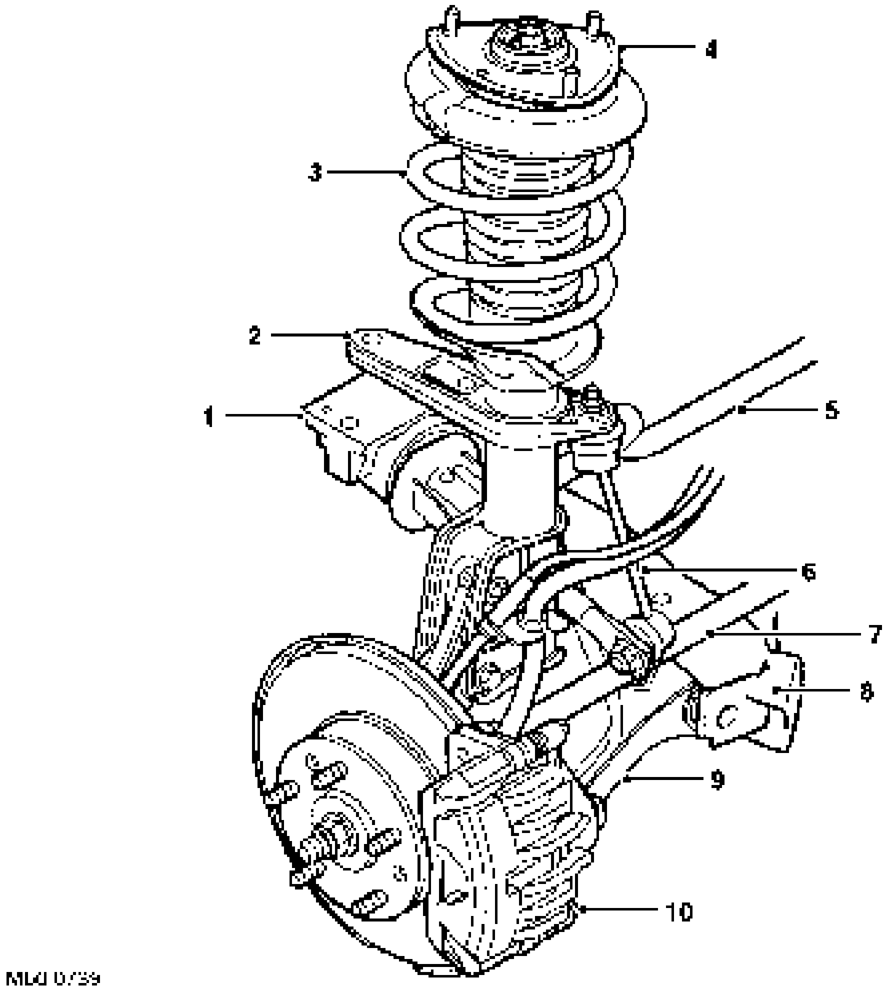
When the engine is started, the PAS pump draws fluid from the reservoir down the low pressure suction line. The fluid passes through the PAS pump and emerges as pressurised fluid at the discharge port. The attenuated high pressure hose transports the pressurised fluid to the steering gear valve unit.

If no steering effort is applied, there is minimal restriction within the system and the supply pressure from the pump is low. Minimal pressure is applied, via the valve unit, to each side of the piston in the hydraulic cylinder and the full flow from the PAS pump returns to the reservoir via the fluid cooler.

If steering effort is applied in either direction, the return flow of fluid to the reservoir is restricted, causing the supply pressure from the PAS pump to increase. The pressurised fluid is directed to the hydraulic cylinder, via the valve unit, providing power assistance to reduce the steering effort required. The fluid displaced by the movement of the piston in the cylinder is returned through the valve unit to the reservoir via the fluid cooler.

The fluid cooler reduces the fluid temperature which prolongs the life of the hoses and seals in the system.

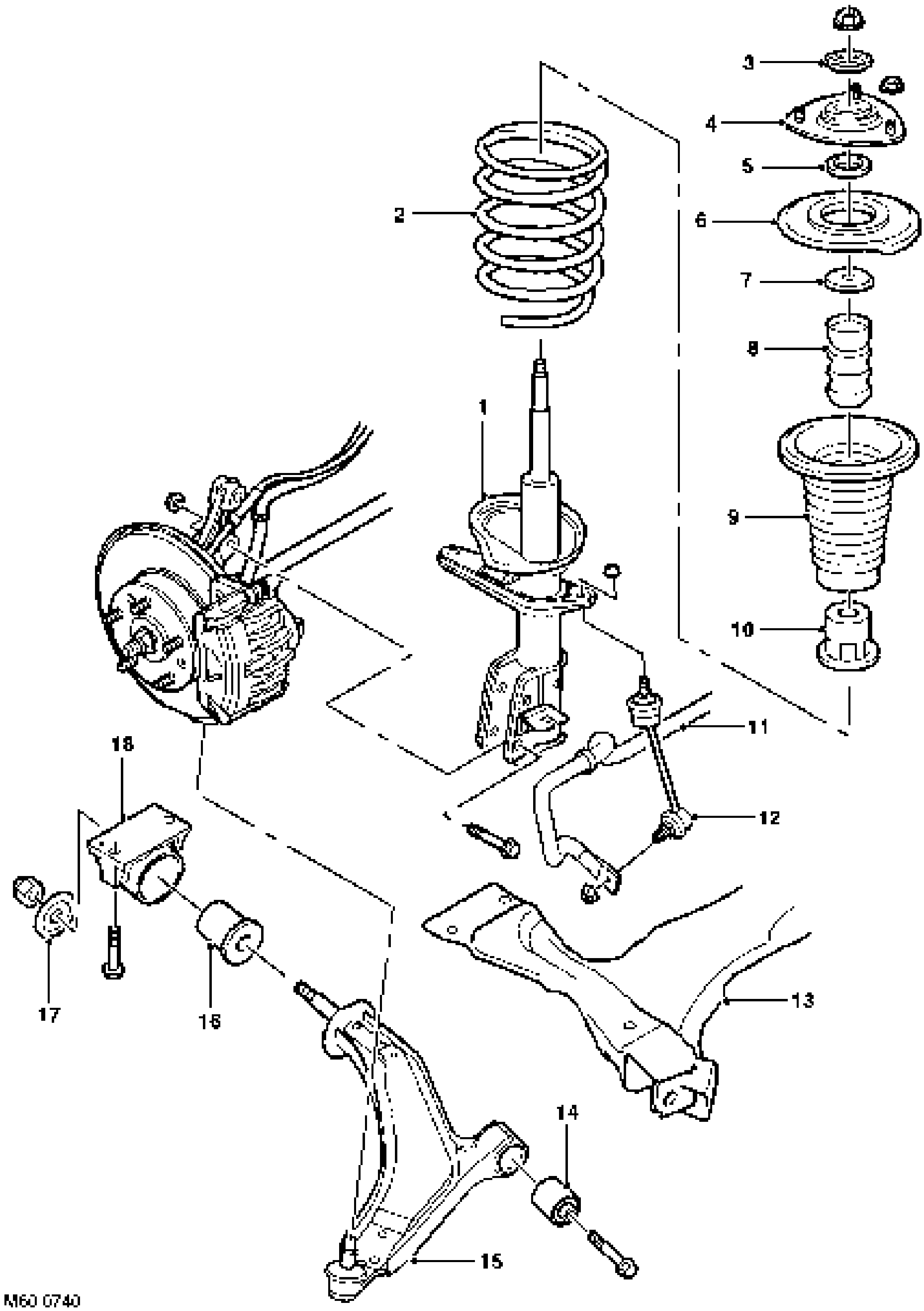
Front Suspension Component Location



RH Front suspension shown, LH is mirror image

1 Bush and housing assembly
2 Damper
3 Road spring
4 Top mount
5 Anti-roll bar
6 Anti-roll bar link
7 Drive shaft
8 Front subframe
9 Lower arm
10 Brake calliper and hub assembly

Front Suspension Component Detail



RH Front suspension shown, LH is mirror image

1 Damper
2 Road spring
3 Rebound washer
4 Top mount
5 Bearing
6 Spring seat
7 Bump washer
8 Spring aid
9 Dust cover
10 Bump cup
11 Anti-roll bar
12 Anti-roll bar link
13 Subframe
14 Bush
15 Lower arm
16 Bush
17 Snubber washer
18 Rear bush housing

Description

General
The front suspension comprises two MacPherson strut dampers with coil springs, two lower suspension arms and an anti-roll bar. A front subframe is bolted to the body and provides mounting points for the lower suspension arms. Each damper has a steering arm which provides for the attachment of the track rods from the power steering rack.

The suspension is designed to allow longitudinal movement of the wheel, which allows the wheel to move rearwards and upwards in response to surface undulations. The longitudinal movement allows the springs and dampers time to react to surface changes which improves ride quality.

MacPherson Struts
The left and right hand dampers are handed but otherwise similar in construction. The front dampers are similar to the rear dampers but have slightly different damping characteristics. The damping characteristics of the front dampers also differs between model variants. The spring rates also differ between the front and rear suspension and model variants.

The damper has a forged steering arm which provides for the attachment of the track rod via a ball joint and the anti-roll bar link. The damper body is fabricated from thick walled tubing and has welded brackets for attachment of the swivel hub. A smaller welded bracket provides for the attachment of the brake hose to the calliper and the ABS sensor cable.

Each damper is fitted with a coil spring. The coil spring locates in a fabricated seat and is retained in a partially compressed condition on the damper by a spring seat, top mount and nut. The top mount is fitted with three studs which locate in mating holes in the inner wing turret. The top mount is fitted with a bearing which allows the damper rod to rotate when the steering is turned.

On vehicles fitted with air conditioning, the front springs are approximately 5 mm longer. This maintains the correct ride height with respect to the additional weight of the air conditioning equipment.

On 'Sport' derivatives (2004 MY), the suspension is 30mm lower and the springs and dampers are 30% stiffer than standard models.

The following spring data table shows the colour codes, spring free length and the number of coils applicable to each model:

Front Suspension			
Model	**Spring Colour Code**	**Spring Free Length**	**Total No. of Coils**
KV6 without A/C	YELLOW/BLUE	367mm (14.45in)	6
KV6 with A/C	YELLOW/WHITE	371mm (14.61in)	6
Models with sport suspension (2004MY)	GREY/ORANGE	308.5mm (12.03in)	5.5

A spring aid and a bump cup are fitted to the damper to prevent shock loads when the damper is fully compressed. A dust cover prevents the ingress of dirt and water to maintain the integrity of the chromium plated damper rod.

The damper functions by restricting the flow of hydraulic fluid through internal galleries within the damper. A chromium plated damper rod moves axially within the damper. As the rod moves, its movement is limited by the flow of fluid through the galleries thus providing damping of undulations in the terrain. The damper rod is sealed at its exit point from the damper body to maintain fluid within the unit and to prevent the ingress of dirt and moisture. The seal also acts as a wiper to keep the rod outer diameter clean.

Anti Roll Bar

The anti-roll bar is mounted to the upper face of the front subframe in two places. Rubber bushes fitted to the anti-roll bar are held in position by two clamps retained with bolts. The outer ends of the anti-roll bar are each connected to a link, which in turn is attached to the damper.

The links have a ball joint at each end. The link transmits suspension movements directly to the anti-roll bar. The design of the links reduces the steer effects commonly found in this type of suspension.

Lower Suspension Arms

The lower suspension arms are fabricated from steel and each arm is handed. The arms are attached at two pivot points. The forward end of the arm contains a bush and is attached to lugs on the front subframe with a bolt. A spigot on the rear mounting of the arm engages with a bush and housing assembly and is retained with a snubber washer and a nut. A ball joint is located on the outer part of the arm and is connected to the swivel hub and secured with a nut.

The two pivot bushes have a significant role in vehicle handling. The bushes control the longitudinal movement of the wheel due to braking, acceleration or surface undulations.

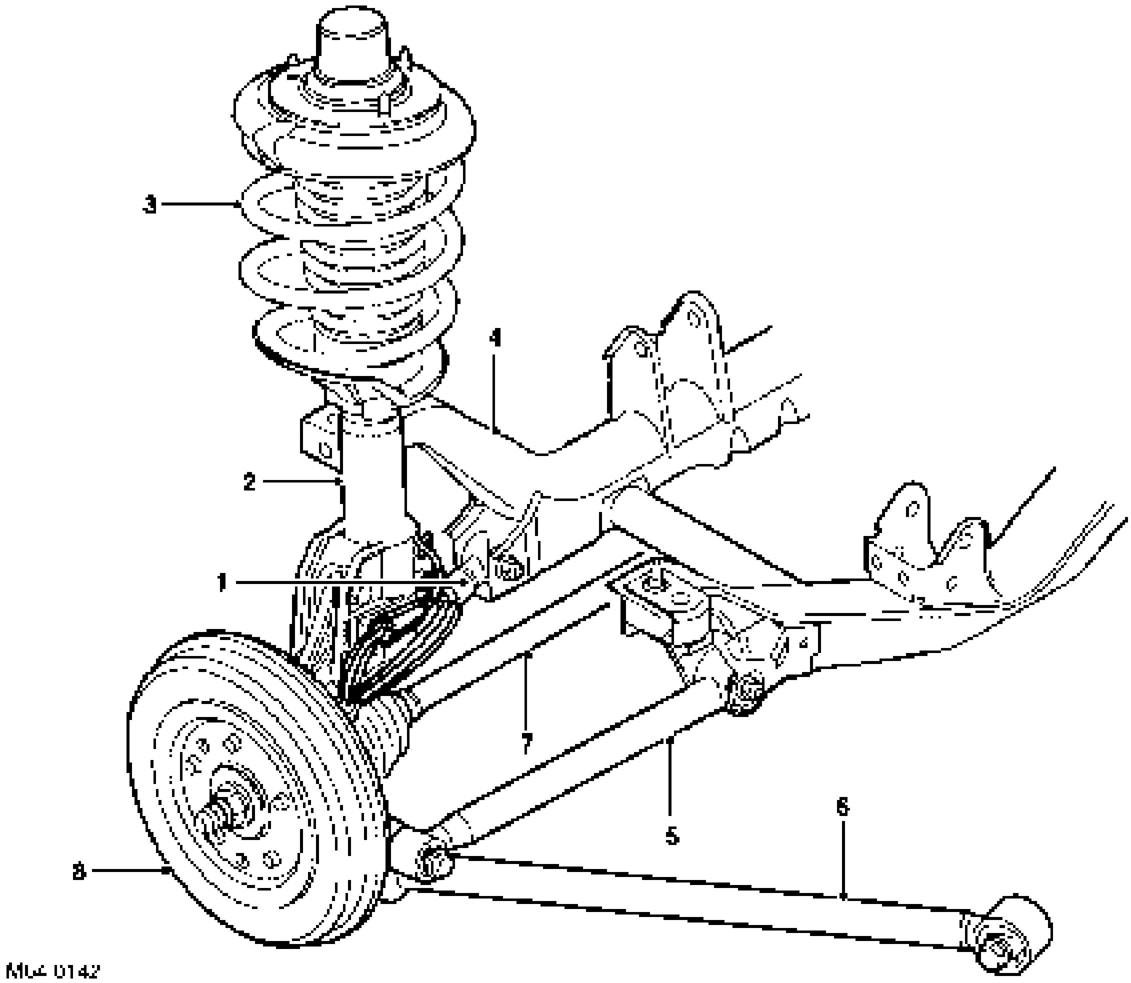
Front Bush

The front bush is located at a specified angle to the axis of rotation of the lower suspension arm. The front bush is deflected radially and axially as the wheel moves rearwards. The angle of the bush ensures that the wheel moves directly rearward reducing the effects of longitudinal steer to a minimum.

Rear Bush

The rear bush is mounted on the axis of rotation of the lower suspension arm. In the radial direction the bush is relatively soft in its construction. In the axial direction, the bush is very soft for the first 2 mm of movement. Snubbing areas to the front and rear of the bush provides a progressive increase in the hardness of the bush as the deflection of the wheel increases. The rear bush controls the amount that the wheel can move forward or rearward.

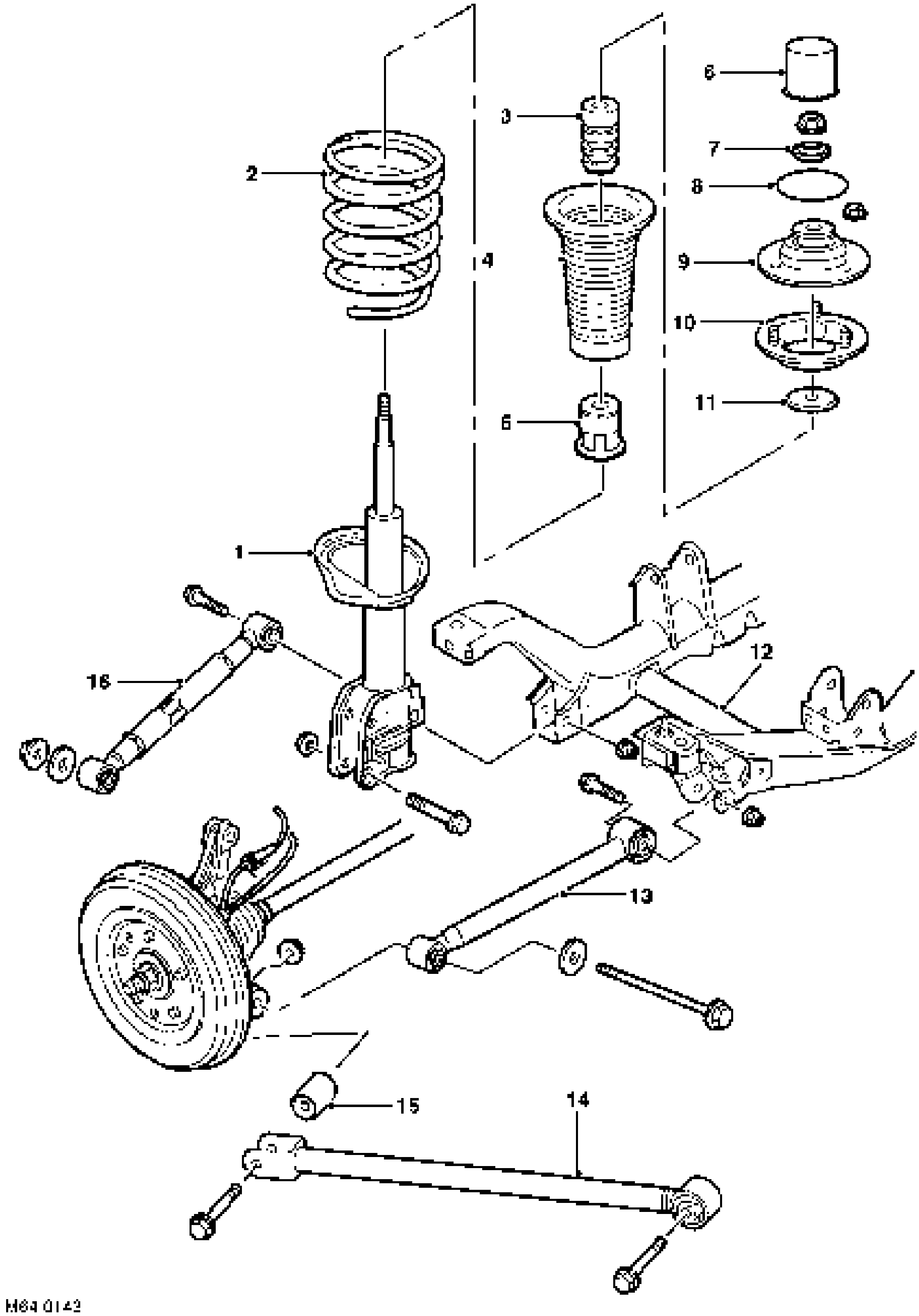
Rear Suspension Component Location



RH Rear suspension shown, LH is mirror image

1. Adjustable transverse link
2. Damper
3. Road spring
4. Rear subframe
5. Fixed transverse link
6. Trailing link
7. Drive shaft
8. Brake and hub assembly

Rear Suspension Component Detail



RH Rear suspension shown, LH is mirror image

1 Damper
2 Road spring
3 Spring aid
4 Dust cover
5 Bump cup
6 Cover
7 Rebound washer
8 Seal
9 Top mount
10 Spring seat
11 Bump plate
12 Rear subframe
13 Fixed transverse link
14 Trailing link
15 Bush
16 Adjustable transverse link

Description

General

The rear suspension comprises two MacPherson strut dampers with coil springs and two sets of three links (known as "trapezoidal links"). A rear subframe is bolted to the body and provides the mounting points for the fixed and adjustable links. The third link is known as the trailing link and is attached from the hub carrier to the body.

The suspension is designed to allow longitudinal movement of the wheel, which allows the wheel to move rearwards and upwards in response to surface undulations. The longitudinal movement allows the springs and dampers time to react to surface changes and improves ride quality.

MacPherson Struts

The left and right hand dampers are handed but otherwise similar in construction. The rear dampers are similar to the front dampers but have slightly different damping characteristics.

The damper body is fabricated from thick walled tubing and has welded brackets for attachment of the hub carrier. Two smaller welded brackets provide for the attachment of the brake hose to the brake pipe and the ABS sensor cable.

Each damper is fitted with a coil spring. The coil spring locates in a fabricated seat and is retained in a compressed condition on the damper by a top mount and nut. The top mount is fitted with three studs which locate in mating holes in the inner wing turret and retained with three self locking nuts. A bump plate is fitted which accommodates a spring aid. The bump plate is sealed against the inner wing turret to prevent the ingress of moisture into the interior load space.

The spring rates differ between the front and rear suspension.

On 'Sport' derivatives (2004 MY), the suspension is 30mm lower and the springs and dampers are 30% stiffer than standard models.

The following spring data table shows the colour codes, spring free length and the number of coils applicable to each model:

Rear Suspension			
Model	**Spring colour code**	**Spring Free Length**	**Total No. of Coils**
All models except those with sport suspension	WHITE/BLUE	349.86mm (13.774in)	6.4
All models with sport suspension (2004MY)	ORANGE/ ORANGE	311mm (12.24in)	6.8

A spring aid and a bump cup are fitted to the damper to prevent shock loads when the damper is fully compressed. A dust cover prevents the ingress of dirt and water to maintain the integrity of the chromium plated damper rod.

The damper functions by restricting the flow of a hydraulic fluid through internal galleries within the damper. A chromium plated damper rod moves laterally within the damper. As the rod moves, its movement is limited by the flow of fluid through the galleries thus providing damping of undulations in the terrain. The damper rod is sealed at its exit point from the damper body to maintain fluid within the unit and to prevent the ingress of dirt and moisture. The seal also acts as a wiper to keep the rod outer diameter clean.

Trapezoidal Links

Three links make up the trapezoidal linkage. The fixed transverse link is fabricated and is not adjustable. The adjustable transverse link comprises a tube, threaded at each end. A threaded fitting is screwed into each end of the tube and locked with lock nuts to a prescribed distance between centres. Each fitting has a pressed bush installed. The trailing link is fabricated and is not adjustable.

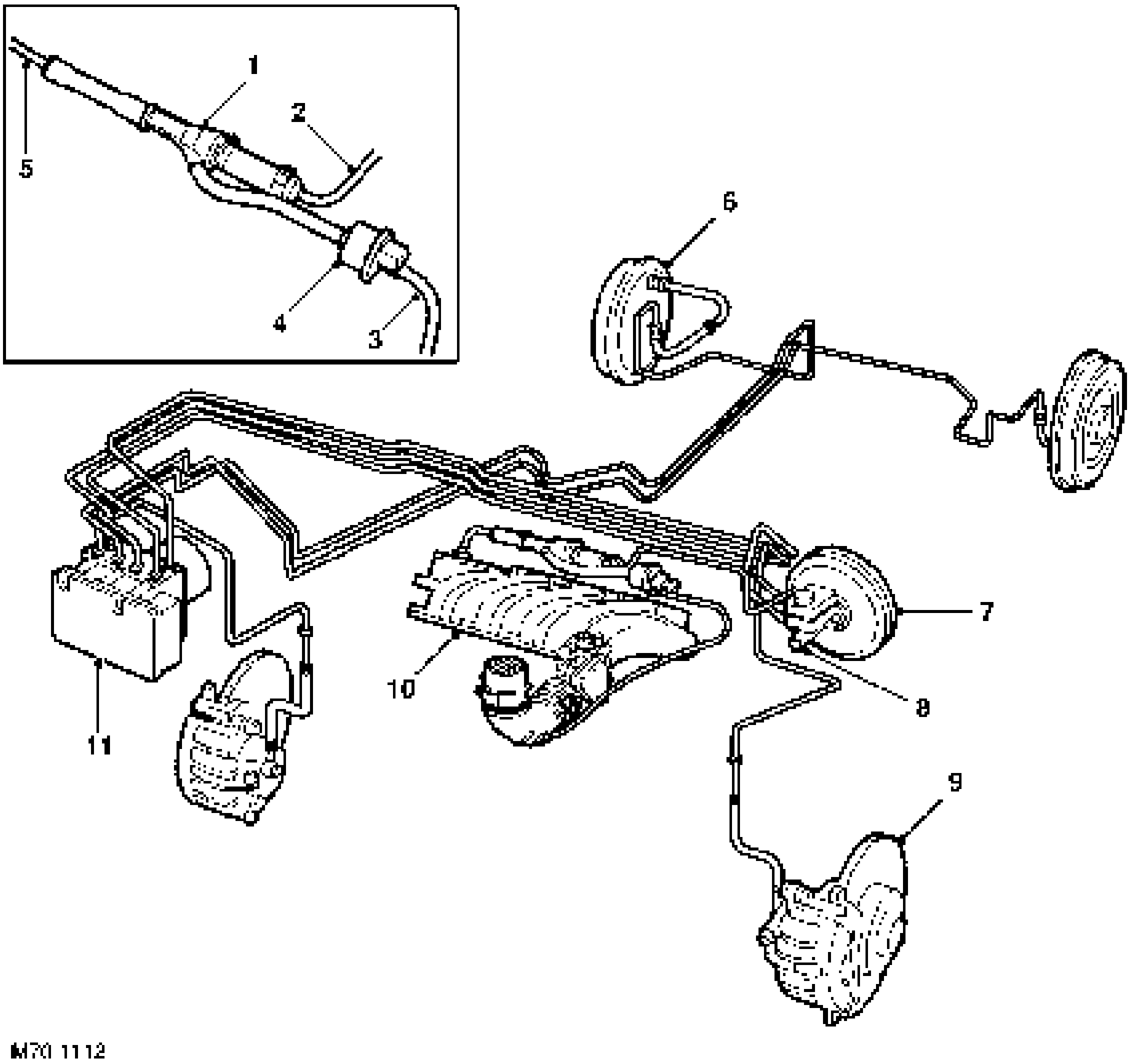
The fixed transverse link is bushed at each end and is located in the forward mounting of the rear subframe and the forward attachment on the hub. The adjustable transverse link is also bushed at each end and is located in the rearward mounting of the rear subframe and the rearward attachment on the hub. The fixed transverse link and the adjustable transverse link are attached to the rear subframe with individual bolts and nuts and are attached to the hub with a single bolt and nut with a washer at each end.

The trailing link is bushed at one end. The bushed end is located in a separate bracket which is bolted to the body. The link is secured with a bolt which screws through the bracket into a captive nut in the body rail. The opposite end is forked and locates over a bushed lug on the hub and secured with a bolt and nut.

The fixed transverse links, the adjustable transverse links and the trailing link have a significant role in the vehicle handling. The bushes in each link control the longitudinal movement of the wheel due to braking, acceleration or surface undulations.

The adjustable transverse link allows for the toe-in of the wheel to be adjusted if necessary. The fixed transverse link is slightly shorter than the adjustable link which promotes a small amount of toe-in during cornering. This also minimizes the effects of bump steer. The bush attaching the fixed transverse link to the rear subframe has a very soft initial movement rate which becomes progressively harder as the rate of deflection increases. The three remaining bushes in the fixed transverse and the adjustable transvserse links are of hard construction which give precise handling and minimizes transient steer effects. The soft bush allows for small amounts of toe-in during cornering.

Brake System Layout (KV6)



LHD shown, RHD similar

NOTE: The vacuum enhancer solenoid valve (item 4) is applicable to all models except NAS KV6 from 2003 model year onwards.

1 Vacuum enhancer venturi valve
2 Vacuum pipe from brake servo
3 Air feed pipe from intake duct
4 Vacuum enhancer solenoid valve
5 Vacuum pipe from inlet manifold
6 Rear brake
7 Brake servo assembly
8 Master cylinder assembly
9 Front brake
10 Engine inlet manifold
11 ABS modulator/ECU

Description

General
Vehicle braking is provided by disc brakes on the front wheels and drum brakes on the rear wheels. The foot brakes are operated by a diagonally split, dual circuit hydraulic system with vacuum servo power assistance. A cable operated handbrake operates on the two rear brakes.

The ABS features 4-wheel electronic traction control and hill descent functions as well as anti-lock braking and electronic brake distribution.

Slip Control System
Freelander incorporates an electronic slip control system. Up to 2002 MY, this consists of a TEVES Mk 20 ABS modulator and passive ABS sensors. From 2002 MY onwards, a TEVES Mk 25 ABS modulator and active ABS sensors are installed. Both systems incorporate the same features, as follows:
- Anti-lock braking system
- Hill descent control
- Electronic traction control
- Electrical brake-force distribution
- CAN communication link

Both systems communicate via CAN with the Engine Control Module (ECM), the instrument pack and the Electronic Automatic Transmission (EAT) ECU. The systems comprise the following components:
- Electronic control unit
- Modulator
- ABS sensors
- Mechanical brake switch
- Brake fluid level switch
- HDC relay and switch
- Accelerometer

Electronic Control Unit
The Electronic Control Unit (ECU) determines the speed and acceleration of each wheel, controls appropriate hydraulic functions and monitors system operation for fault conditions and interfaces to other vehicle systems. The ECU is attached to the Modulator unit and is mounted underbonnet on the RHS valence behind the headlamp.

Under the following conditions the ECU is programmed to switch off the main software driver which will result in the illumination and disabling of the ABS, TC, HDC and EBD warning lamps:
- If the IGN voltage drops to values, which are not sufficient to maintain a stabilised, supply voltage for the processors. This voltage is below the functional operating voltage of 8 volts. The controller will invariably switch on again when the minimum operating voltage of 10 volts is reached.
- If the following failures or errors are detected:
  - Valve failure
  - Failure of two ABS sensors
  - Main driver failure
  - Redundancy error
  - Over voltage

The ECU will also inhibit the ABS function, traction control, hill descent control and illuminate their respective warning lamps without switching off the main driver in the following circumstances:
- Ignition voltage supplied to the ABS ECU < 8 volts
- Failure of one or more of the ABS sensors
- Pump motor failure

If there is a CAN error message from the ECM or the EAT ECU, or if there is a brake pedal switch fault, the ABS ECU disables the ETC and HDC functions and illuminates the related warning lamps.

Hydraulic Modulator
The hydraulic unit of the modulator consists of a pump and 12 solenoid operated valves, accumulator and damper chambers. During normal braking where ABS intervention is not required, brake fluid passes straight through de-energised inlet valves (normally open). Where ABS intervention is required, pressure is maintained at a wheel by closing the appropriate inlet valve. When pressure needs to be released from a brake circuit, the appropriate outlet valve is opened (when outlet valve is opened the inlet valve must be closed) and the brake fluid is allowed to flow into the reservoir. Brake fluid is returned, via the return pump, to the Master cylinder line via the damper chamber

Brake Fluid Pressure - (Inlet)
The hydraulic circuit of the ABS modulator consists of the Primary and Secondary feeds from the Brake Master cylinder. These are fed into the modulator by two Ø 6 mm. brake pipes. The input pipes are easily distinguished by their size, compared to the four Ø 4.76 mm. outlet pipes.

The ECU can detect electrical failure of each of the inlet valves and will generate relevant fault codes which can be accessed via TestBook/T4.

Brake Fluid Pressure - (Outlet)
The hydraulic outlet circuit of the ABS modulator consists of the four pipes leading to the front calipers and rear brake drums. The four pipes transmit the brake fluid usually at the pressure determined by the drivers brake application, but during ABS, EBD, TC and HDC intervention at the pressures modified by the ABS ECU. The pipes are attached by a series of clips into the body and terminate at the caliper/drum via a flexible hose.

The ABS ECU can detect electrical failure of each of the outlet valves and will generate relevant fault codes which can be accessed via TestBook/T4.

ABS Sensors
Up to 2002 MY

An ABS sensor is fitted to each of the four hub carriers. These sensors inform the ABS ECU about the speed of each of the road wheels. This measurement is fundamental to the operation of the braking features. The harness wires that connect the sensors to the ABS unit are twisted pairs. Since the sensors are reluctor devices (passive sensor) no output is available when the road wheels are not turning. Thus, the ABS ECU is unable to test the sensor or the pole wheel fully until the vehicle is moving.

The exciter rings for the ABS sensors are fitted to the outer diameter of the constant velocity joint on each drive shaft, and shielded by the hub centre boss.

From 2002 MY

An active ABS sensor is installed in each of the four wheel hub carriers to provide the ABS ECU with a speed signal from each road wheel. Each of the ABS sensors is positioned in close proximity to the inboard seal of the related wheel bearing and secured with a bolt. The seals, which rotate with the wheels, each contain a magnetic element incorporating 48 pole pairs.

The ABS sensors operate using the Hall effect principle. A permanent magnet inside the sensor applies a magnetic flux to a semiconductor, which receives a power supply from the ABS ECU. When the wheels rotate, the pole pairs in the seals induce voltage fluctuations in the ABS sensors that are converted into square wave signals and output to the ABS ECU. The frequency of the signal is proportional to wheel speed.

Since the sensors are active devices, an output is available when the road wheels are not turning, which enables the ABS ECU to check the sensor while the vehicle is stationary.

All ABS Sensors

Failures or malfunctions relating to the ABS sensors and connections are detected by the ABS ECU. In the event of failure of two or more of the ABS sensors the ABS ECU switches off the system and illuminates the ABS, TC, EBD, and HDC warning lamps.

If a single sensor fails the ABS ECU maintains the minimum functions to provide safe operation and illuminates the ABS, TC, and HDC warning lamps.

Mechanical Brake Switch
A mechanical brake pedal switch is used to illuminate the stop/brake lamps on the vehicle because of its high current carrying/switching capabilities. It is also used to input the status of the brake pedal to the ABS ECU. This switch is a double contact switch where the Brake Lamp Switch (BLS) contacts are open and the Brake Test Switch (BTS) contacts are closed when the brake pedal is at rest. When the pedal is depressed, the BLS contacts close and BTS contacts open, supplying 12 volts to the brake/stop lamps and indicating to the ABS ECU that the pedal has been operated. When the pedal is depressed there is a time when both the BLS and the BTS contacts are closed, which allows the ABS ECU to perform a plausibility check on the switch. The switch used is a carry over from the Range Rover.

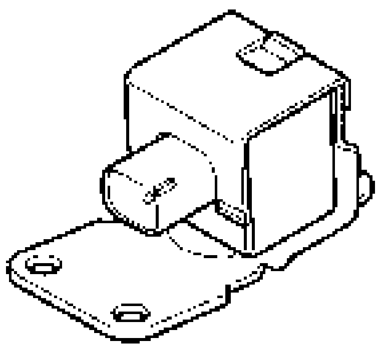
A Hall effect brake pedal position sensor is installed adjacent to the mechanical brake switch. This is not used by the brake system but by other system ECU's which are not compatible with the outputs from a mechanical switch.

Brake Fluid Level Switch
The Brake Fluid Level Switch (BFLS) is a Reed switch located in the brake fluid reservoir. The BFLS is connected to the ABS ECU and to earth. The BFLS is closed when the brake fluid level is above the minimum limit. If the brake fluid level decreases below the minimum limit, the BFLS opens and the ABS ECU sends a CAN message to the instrument pack to activate the brake warning lamp.

Hill Descent Control Relay and Switch
The HDC relay is located inside the engine compartment fusebox. The HDC switch is a latching switch mounted on the gear lever surround.

Accelerometer
The accelerometer (sometimes known as the "G" sensor) is mounted near the centre-line of the vehicle alongside the handbrake lever. It provides information to the ABS ECU regarding vehicle longitudinal acceleration.

The ABS ECU uses the input from the accelerometer to corroborate the inputs from the ABS sensors, e.g. if all four wheels are spinning, the input from the accelerometer enables the ABS ECU to determine the true speed of the vehicle.

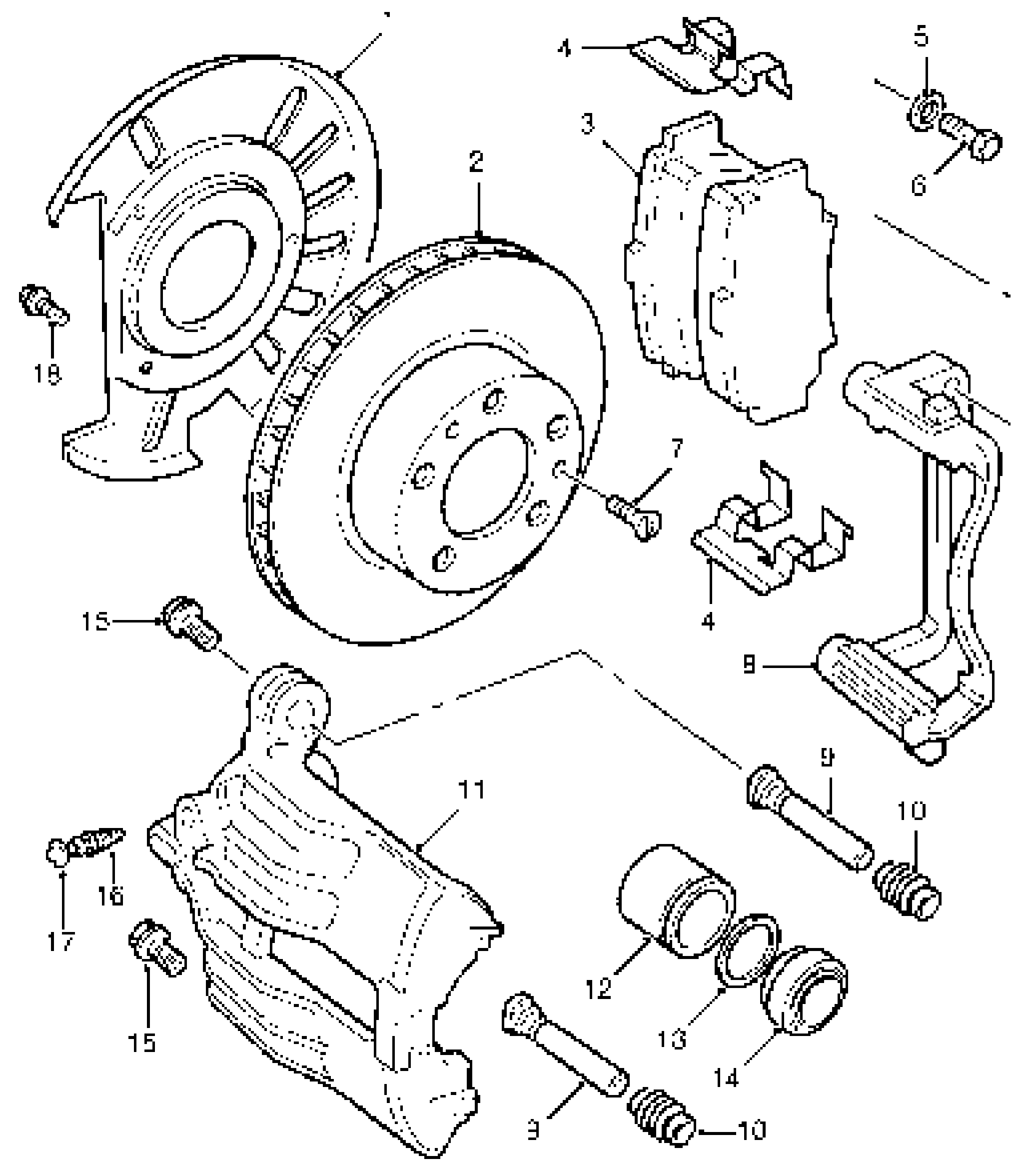


M70 1164

Front Brakes
The front brakes each comprise a hub mounted, single piston caliper assembly and a vented disc. The inboard side of the disc is protected by a mudshield.

When hydraulic pressure is supplied to the caliper, the piston extends and forces the inner pad against the disc. The caliper body reacts and slides on the guide pins to bring the outer pad into contact with the disc.

Front Brake Components



M70 1343

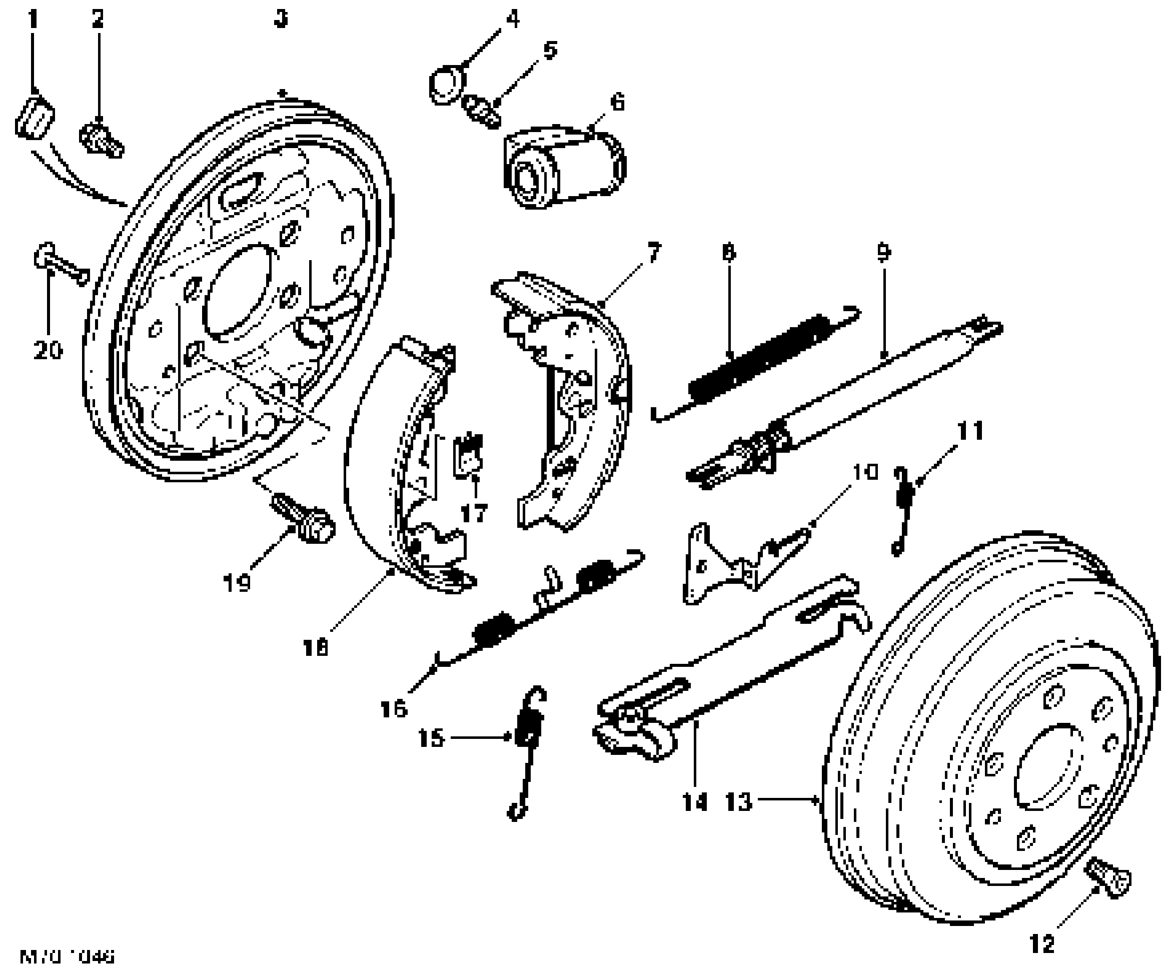
1 Mudshield
2 Brake disc-vented
3 Brake pads
4 Pad retainer
5 Washer
6 Caliper fixing bolt
7 Brake disc fixing screw
8 Caliper carrier
9 Guide pin
10 Guide pin dust cover
11 Caliper body
12 Piston
13 Piston seal
14 Piston dust cover
15 Guide pin bolt
16 Bleed screw
17 Bleed screw cap
18 Mudshield fixing bolt

Rear Brakes
The rear brakes each comprise a hub mounted backplate and drum containing leading and trailing brake shoes when operated by the foot brake. An adjuster rod is incorporated to automatically adjust the brake shoes to compensate for wear of the brake linings. Adjustment occurs during operation of the foot brake.

When hydraulic pressure is supplied to the wheel cylinder, the cylinder extends and forces the brake shoes against the drum.

When a force is supplied to the shoes via the hand brake lever and cables, both brake shoes become leading.

Rear Brake Components



1 Blanking plug
2 Wheel cylinder fixing bolt
3 Backplate
4 Bleed screw cap
5 Bleed screw
6 Wheel cylinder
7 Leading brake shoe
8 Upper shoe return spring
9 Adjuster rod
10 Adjuster lever
11 Anti rattle spring
12 Drum fixing screw
13 Brake drum
14 Hand brake strut
15 Adjuster lever spring
16 Lower shoe return spring
17 Shoe retaining pin spring clip
18 Trailing brake shoe
19 Backplate fixing bolt
20 Shoe retaining pin

Hydraulic System
The hydraulic unit of the modulator consists of a pump, 12 solenoid operated valves and accumulator and damper chambers. Each brake unit has its own inlet and outlet valves.

The hydraulic system operates the brakes in response to brake pedal movement.

For normal brake operation, brake pedal movement is assisted by the brake servo assembly and transmitted to the master cylinder assembly. The master cylinder assembly converts brake pedal movement to hydraulic pressure. Primary and secondary brake pipe circuits supply the hydraulic pressure to the brakes: the primary circuit supplies the front left and rear right brakes; the secondary circuit supplies the front right and rear left brakes.

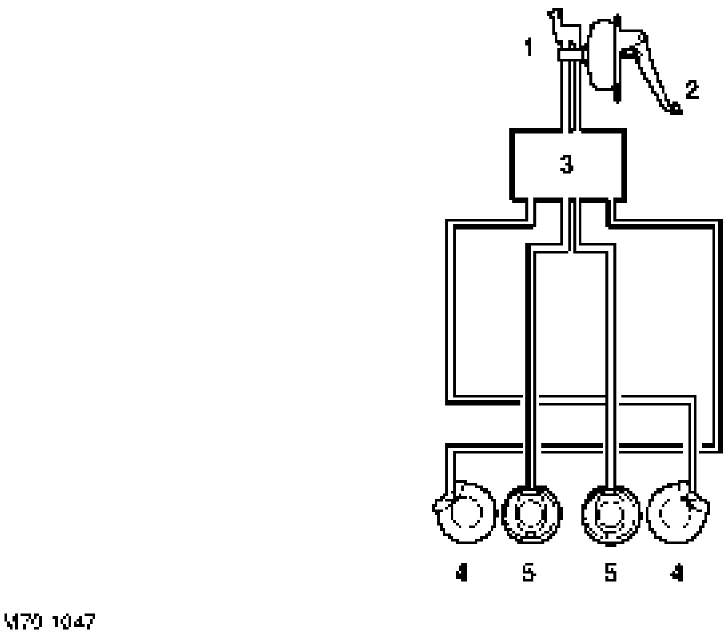
A red, brake warning lamp in the instrument pack illuminates if the fluid level in the hydraulic system falls to an unsafe level. The brake fluid level is checked via a level switch in the brake fluid reservoir.

On right hand drive vehicles the brake fluid reservoir is remotely located on a bracket on the bulkhead. Left hand drive vehicles have the brake fluid reserver in the usual position on top of the master cylinder.

Vacuum for the brake servo assembly is obtained from the engine inlet manifold.

To reduce operating noise, sleeving is installed on some of the brake pipes in the engine compartment and the pipes are located in sprung pipe clips.

ABS Hydraulic System Schematic



1 Servo/Master cylinder assembly
2 Brake pedal
3 ABS modulator
4 Front brake
5 Rear brake

Brake Servo Assembly
The brake servo assembly provides power assistance to reduce the pedal load when braking.

The assembly is attached to the front of the pedal box and comprises a circular housing containing a diaphragm, push rods, valve and filter. A push rod at the rear of the housing is connected to the brake pedal. The vacuum line is connected to a port in the front face of the housing.

With the brake pedal released and the engine running, vacuum pressure is present on both sides of the diaphragm. When the brake pedal is pressed, the rear push rod moves forward and opens the valve to allow atmospheric pressure through the filter into the pedal side of the diaphragm. The pressure differential acting on the diaphragm increases the pressure being applied by the brake pedal, which is transmitted to the master cylinder via the forward push rod.

If the servo fails, the hydraulic system will still function but will require greater pedal effort due to the lack of vacuum assistance.

Vacuum Enhancer System
Vehicles from 2003 model year – The vacuum enhancer solenoid valve is no longer fitted to vehicles from 2003 model year onwards. On these vehicles the solenoid valve is removed, but the venturi valve and associated piping is retained. On this system the vacuum enhancement is still required, but due to the deletion of the air assist injectors, the vacuum enhancement can be permanently operated.

The vacuum enhancer system increases the relatively low vacuum available from the inlet manifold to increase braking assistance. The system consists of a venturi valve, a solenoid valve and associated pipes.

The venturi valve is installed in the vacuum pipe between the brake servo and the inlet manifold. An air feed pipe, from the intake duct upstream of the throttle body via the solenoid valve, is also connected to the venturi valve. Internal ducts in the venturi valve connect the brake servo and air feed ports to the inlet manifold port. The duct connecting the air feed port to the inlet manifold port incorporates the venturi. A check valve, integrated into the brake servo port, prevents the reverse flow of air and fuel vapour to the brake servo.

The solenoid valve controls the air feed to the venturi valve. Operation of the solenoid valve is controlled by the ECM.

To improve engine idle speed refinement, when the gearbox lever is in Park or Neutral, the solenoid valve is closed and the brake servo senses the vacuum in the inlet manifold via the venturi valve. When the gearbox lever is selected to positions other than Park or Neutral, the ECM energises the solenoid valve and air from the upstream side of the throttle body is fed to the venturi valve. The air flows through the venturi valve into the inlet manifold. As the air flows through the venturi in the venturi valve, it increases in velocity and decreases in pressure, resulting in an increase in the vacuum sensed by the brake servo. Depending on ambient conditions and engine speed, the vacuum enhancer system increases inlet manifold vacuum by a maximum of approximately 40%.

Master Cylinder Assembly
The master cylinder assembly produces hydraulic pressure to operate the brakes when the brake pedal is pressed. The assembly is attached to the front of the brake servo assembly, and comprises a cylinder containing two pistons in tandem. The rear piston produces pressure for the primary circuit and the front piston produces pressure for the secondary circuit.

The brake fluid reservoir is located either on top of the master cylinder assembly (LH drive vehicles) or above the master cylinder on a bracket on the bulkhead (RH drive vehicles). The reservoir is internally divided to provide an independent supply of fluid to each brake circuit, and so prevent a single fluid leak from disabling both primary and secondary brake circuits.

Should a failure occur in one circuit, the remaining circuit will still operate effectively, although brake pedal travel and vehicle braking distances will increase. If the fluid level in the reservoir is too low, the brake fluid level switch in the reservoir filler cap breaks a contact to the ABS ECU, which sends a CAN message to illuminate the brake warning lamp in the instrument pack.

ABS Master Cylinder

When the brake pedal is pressed, the front push rod in the brake servo assembly pushes the primary piston along the cylinder bore. This produces pressure in the primary pressure chamber which, in conjunction with the primary spring, overcomes the secondary spring and simultaneously moves the secondary piston along the cylinder bore. The initial movement of the pistons, away from the piston stops, closes the primary and secondary centre valves. Further movement of the pistons then pressurizes the fluid in the primary and secondary pressure chambers, and thus the brake circuits. The fluid in the chambers, behind the pistons, is unaffected by movement of the pistons and can flow unrestricted through the feed holes between the chambers and the reservoir.

When the brake pedal is released, the primary and secondary springs push the pistons back down the bore of the cylinder. As the pistons contact the piston stops, the primary and secondary centre valves open, which allows fluid to circulate unrestricted between the two hydraulic circuits and the reservoir, through the centre valves, the chambers behind the pistons and the feed holes.

ABS
The ABS is a full time, four channel system that gives individual speed control of all four wheels to provide the vehicle with anti-lock braking (ABS), Electronic Traction Control (ETC.) Hill Descent Control (HDC) and Electronic Brake force Distribution (EBD) functions.

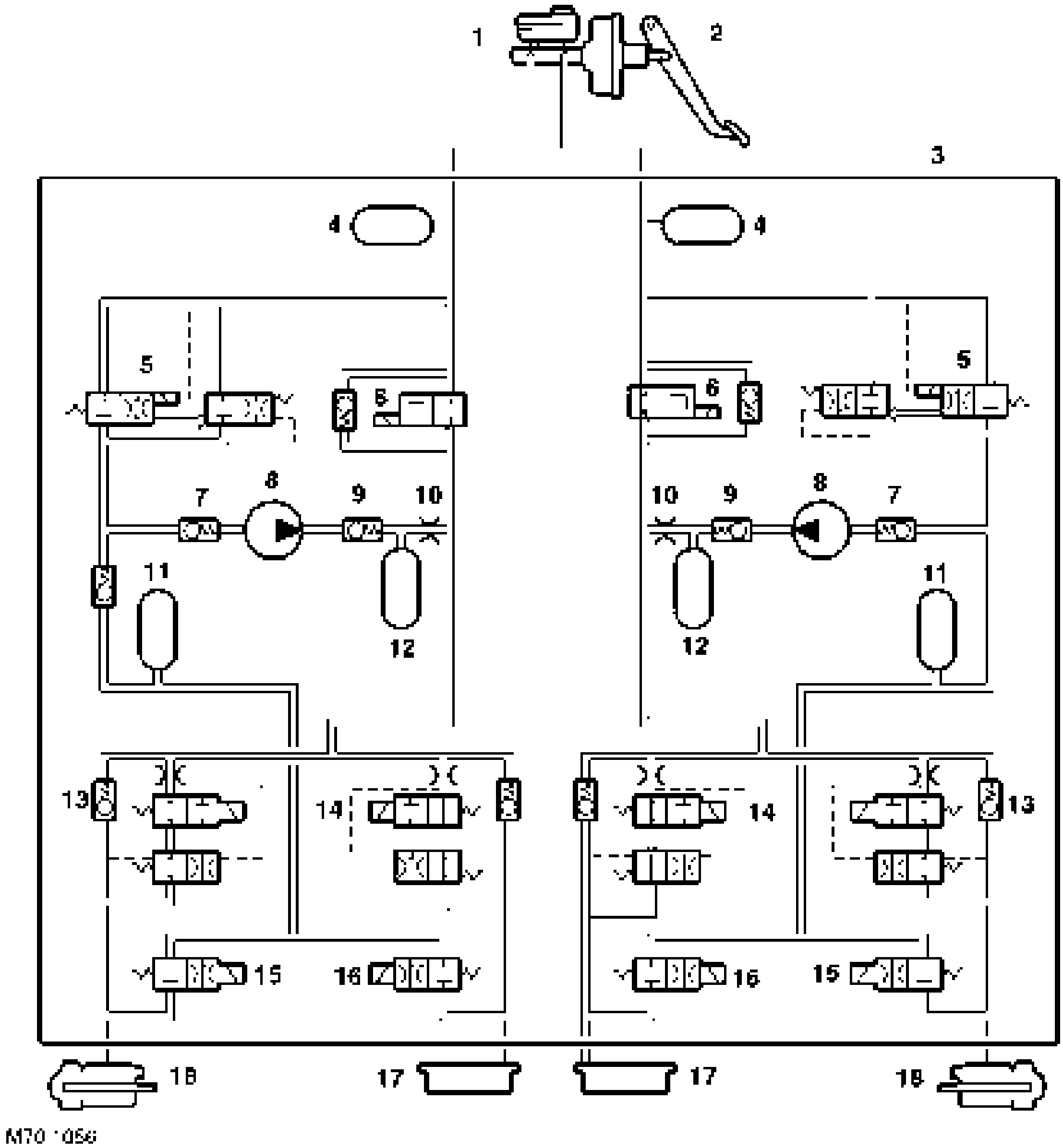
ABS Modulator
The ABS modulator controls the supply of hydraulic pressure to the brakes in response to inputs from the ABS ECU. The modulator is attached by three mounting bushes to a bracket on the RH inner wing, and connected to the primary and secondary hydraulic circuits downstream of the master cylinder assembly. A multi-pin connector links the ABS modulator to the vehicle wiring.

Internal passages in the ABS modulator, separated into primary and secondary circuits, connect to the various components that control the supply of hydraulic pressure to the brakes. Separation valves and check valves control the flow through the internal circuits. Damper chambers and restrictors are included in each circuit to refine system operation. Inlet and outlet solenoid valves control the flow to the individual brakes. An accumulator is connected to each circuit to absorb flow surges. A common return pump is connected to both circuits to provide a pressure source and return fluid to the reservoir.

The ABS modulator has three operating modes:

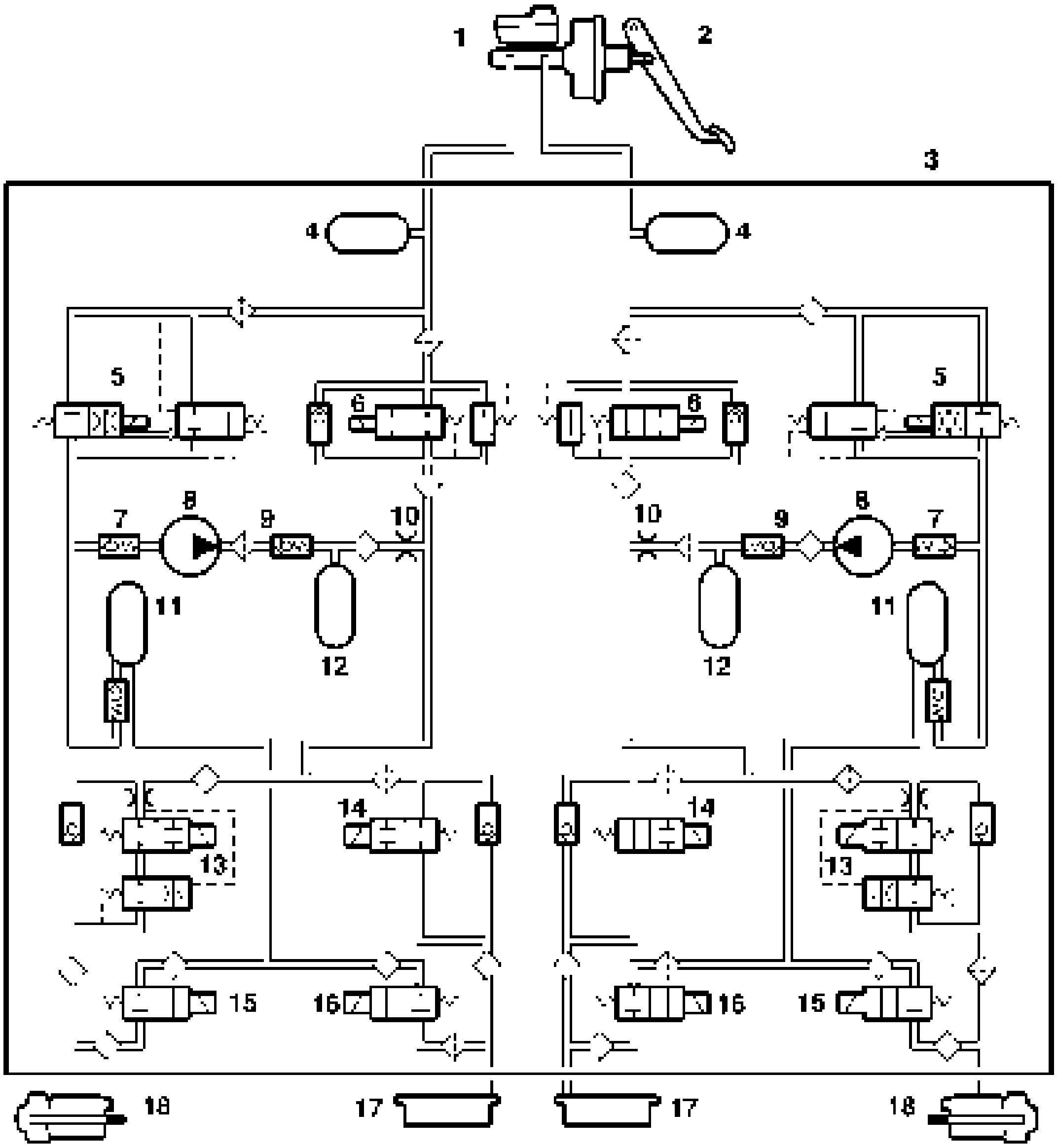
- Normal braking mode: When the brake pedal is pressed, pressurized fluid from the master cylinder assembly flows through the open separation valves and inlet valves to operate the brakes.
- ABS braking mode: When in the normal braking mode, if the ABS ECU detects that a wheel is about to lock, it energizes the inlet and outlet solenoid valves of the related brake and starts the return pump. The inlet solenoid valve closes to isolate the brake from pressurized fluid; the outlet solenoid valve opens to release pressure from the brake into the return pump circuit. The brake releases and the wheel begins to accelerate. The ABS ECU then operates the inlet and outlet valves to control the supply of hydraulic pressure to the brake and apply the maximum braking effort (for the available traction) without locking the wheel.
- Active braking mode: When ETC or HDC are enabled, and the ABS ECU determines that active braking is required, it starts the return pump. Hydraulic fluid, drawn from the reservoirs through the master cylinder, is pressurized by the return pump. The ABS ECU then operates the inlet and outlet solenoid valves to control the supply of hydraulic pressure to the individual brakes and slow the wheel(s).

ABS Modulator Schematic (Up To 2002 MY)



1 Master cylinder
2 Brake pedal
3 ABS modulator
4 Pulsation damper
5 Solenoid valve
6 Separation valve
7 One way check valve
8 ABS pump
9 Check valve
10 Restrictor valve
11 Low pressure accumulator
12 Damper chamber
13 Check valve
14 Inlet valve
15 Outlet valve
16 Outlet valve
17 Rear brake
18 Front brake

ABS Modulator Schematic (From 2002 MY)



M70 1117

1 Master cylinder
2 Brake pedal
3 ABS modulator
4 Pulsation damper
5 Shuttle valve
6 Separation valve (with integrated pressure relief valve)
7 Check valve
8 Return pump
9 Check valve
10 Restrictor
11 Low pressure accumulator
12 Damper chamber
13 Front brake inlet valve
14 Rear brake inlet valve
15 Front brake outlet valve
16 Rear brake outlet valve
17 Rear brake
18 Front brake

ABS ECU

The ABS ECU controls the operation of the ABS modulator to provide the ABS, ETC and HDC functions. It also operates warning lamps in the instrument pack to provide the driver with status information on each function. The ABS ECU is attached to the ABS modulator. Incorporated into the ABS ECU are integrated circuits and software for system control and diagnostics. An electrical connector interfaces the unit with the vehicle wiring.

The warning lamps consist of:

- An amber ABS graphic.
- An amber ETC graphic.
- Two inclined vehicle graphics for HDC, one amber (fault), which includes an exclamation mark, and one green (information).

The warning lamps are Light Emitting Diodes (LED) installed on the printed circuit board of the instrument pack and cannot be replaced separately.

When the ignition is switched on, the ABS ECU performs a 'bulb' check of the warning lamps as part of the power up procedure. If a warning lamp remains illuminated after the bulb check, a fault has been detected and repair action is required. On a serviceable system:

- The ETC and HDC warning lamps are extinguished after 2 to 3 seconds.
- Up to 2002 MY, the ABS warning lamp is extinguished briefly, after 1.3 to 2 seconds, then remains illuminated until vehicle speed exceeds 4.4 mph (7 km/h).
- From 2002 MY, the ABS warning lamp is extinguished briefly, after 1.3 to 2 seconds, is illuminated again for a further 0.5 second and then extinguished.

The ABS ECU continually calculates vehicle speed using the inputs from all four ABS sensors. Vehicle speed is used as a reference against which individual wheel speeds are monitored for unacceptable acceleration or deceleration. Vehicle speed is also output to the instrument pack for the speedometer.

Operation

ABS

The purpose of ABS is to prevent vehicle wheels locking during brake application, thus maintaining vehicle steerability and stability. This allows the vehicle to be steered while the brakes are applied, even under emergency conditions, and to avoid obstacles where there is sufficient space to redirect the vehicle.

WARNING: ABS is an aid to retaining steering control and stability while braking:

- ***ABS cannot defy the natural laws of physics acting on the vehicle.***
- ***ABS will not prevent accidents resulting from excessive cornering speeds, following another vehicle too closely, aquaplaning, etc.***
- ***The additional control provided by ABS must never be exploited in a dangerous or reckless manner which could jeopardise the safety of driver or other road users.***
- ***The fitting of ABS does not imply that the vehicle will always stop in a shorter distance.***

NOTE: During normal braking the feel of the brake pedal on vehicles equipped with ABS will be the same as that on non ABS vehicles. During anti-lock braking operation the driver will experience feedback in the form of a pulsating brake pedal and solenoid/pump motor noise from the ABS modulator.

The anti-lock braking function is automatically enabled whenever the ABS modulator is in the normal braking mode.

While the anti-lock braking function is enabled, if the ABS ECU detects a wheel decelerating faster than the average, indicating it is about to lock, it operates the ABS modulator in the ABS braking mode for the affected wheel.

ABS ECU Connector Pin Details (Up To 2002 MY)

Pin No.	Description	Input/Output
1	System earth	–
2	Front LH ABS sensor	Input
3	Front LH ABS sensor	Input
4	Not used	–
5	Rear RH ABS sensor	Input
6	Rear RH ABS sensor	Input
7	Not used	–
8	ISO 9141 K line	Input/Output
9	Accelerometer supply	Output
10	Accelerometer earth	–
11	Brake switch (BTS contacts)	Input
12	Ignition power supply	Input
13 and 14	Not used	–
15	Battery power supply	Input
16	CAN bus 1 low (connection with instrument pack)	Input/Output
17	CAN bus 1 high (connection with instrument pack)	Input/Output
18	Brake switch (BLS contacts)	Input
19	Road speed signal	Output
20	Not used	–
21	Accelerometer signal	Input
22 to 27	Not used	–
28	Hill descent switch	Input
29	System earth	–
30	Front RH ABS sensor	Input
31	Front RH ABS sensor	Input
32	Not used	–
33	Rear LH ABS sensor	Input
34	Rear LH ABS sensor	Input

Pin No.	Description	Input/Output
35	Not used	–
36	CAN bus 2 low (connection with ECM/EAT ECU)	Input/Output
37	CAN bus 2 high (connection with ECM/EAT ECU)	Input/Output
38 and 39	Not used	–
40	HDC relay coil	Output
41	Brake fluid level switch	Input
42	Not used	–
43	Battery power supply	Input

ABS ECU Connector Pin Details (From 2002 MY)

Pin No.	Description	Input/Output
1	Battery power supply (for return pump)	Input
2	Diagnostic ISO 9141 K line	Input/Output
3	Not used	–
4	Ignition power supply	Input
5	Not used	–
6	HDC switch	Input
7 and 8	Not used	–
9	Brake fluid level switch	Input
10	Not used	–
11	CAN bus 1 high (connection with instrument pack)	Input/Output
12	Not used	–
13	CAN bus 2 low (connection with ECM/EAT ECU)	Input/Output
14	Not used	–
15	CAN bus 1 low (connection with instrument pack)	Input/Output
16	System earth	–
17 to 23	Not used	–
24	Accelerometer earth	–
25	Not used	–
26	Accelerometer supply	Output
27 to 31	Not used	–
32	Battery power supply (for solenoid valves)	Input
33	Front RH ABS sensor earth	–
34	Front RH ABS sensor signal	Input
35	HDC relay coil	Output
36	Rear LH ABS sensor signal	Input
37	Rear LH ABS sensor earth	–
38	Brake switch (BLS contacts)	Input
39	Road speed signal	Output
40	Accelerometer signal	Input
41	Brake switch (BTS contacts)	Input
42	Rear RH ABS sensor earth	–
43	Rear RH ABS sensor signal	Input
44	CAN bus 2 high (connection with ECM/EAT ECU)	Input/Output
45	Front LH ABS sensor signal	Input
46	Front LH ABS sensor earth	–
47	System earth	–

Traction Control

This feature uses brake intervention to prevent wheel slippage (i.e. wheel speed faster than vehicle reference speed) during attempts to accelerate or on a slippery road surface. This is done by the ECU, which monitors the speed of each wheel. If any wheel is spinning faster than others, brake pressure is applied to that wheel to slow it down, bringing it in line with other wheel speeds, thus providing the optimum traction between the road surface and each vehicle tyre. Traction control will not function with speeds above 50 km/h.

If ETC is required and the brake pedal is not depressed, the ECU starts the re-circulation pump to draw fluid into the system from the master cylinder. Additional valves are required for the purpose of controlling the volumetric flow. The Continental TEVES system uses two additional solenoid valves in each brake circuit. As the pump starts up, the separation valve blocks the delivery line to the master cylinder and diverts the fluid flow to the pump circuit. The changeover, or electric shuttle valves, control fluid flow from the master cylinder and reservoir. Actual wheel control takes place in the same way as ABS via the control of the individual inlet and outlet valves. Excess volumetric flow of the pump is routed via the pressure relief valve, which is integrated into the separation valve on the Continental TEVES system.

The traction control warning lamp is amber in colour and is illuminated in the following circumstances/conditions:

- It illuminates for a minimum of 2 seconds when TC is active or longer if TC is active for longer than 2 seconds
- During the initialisation phase and a following test phase controlled by the microprocessor
- In the event of TC fault condition
- Fully 'on' when manual disable TC function is operated
- Flashing when brakes are hot (over 350 °C)
- When the controller is switched off, for as long as ignition voltage is supplied to the ABS ECU
- During diagnostics

To allow the vehicle to be tested on two wheel rolling roads there is a feature which allows the ETC function to be disabled. To disable ETC, the brake pedal has to be operated 10 times within 10 seconds of turning the ignition on. When traction control is disabled, the ETC warning lamp will be illuminated in the instrument pack and no wheel braking will occur during this period. Also, the road speed signal will be an average of the two rotating wheels and no ABS sensor or accelerometer faults will be registered during this period.

The ETC function can be re-enabled at the start of a subsequent ignition cycle by again operating the brake pedal 10 times within 10 seconds of turning the ignition on. Alternatively, the ABS ECU will automatically re-enable the ETC function when it receives a 4.4 mph (7 km/h) speed signal from all four ABS sensors.

Should the ETC (or HDC) be active for long periods the temperature of the brakes may cause damage to the brake components (disks, drums, pads and shoes). To prevent this there is a safety feature that disables the ETC or HDC if it considers the system is overheating. The system functions by the ABS calculating the brake temperature. When the first temperature limit (350°C) is reached the ETC warning lamp will start to flash (if HDC is also 'ON' then the HDC fault lamp will also flash). When the second temperature limit (400°C) has been reached the warning lights will continue to flash but the ETC and HDC functionality will become inactive. Should HDC be active as the second temperature limit is reached the HDC will fade out gradually. System functionality will return when the brakes have returned to the third limit (300°C).

Hill Descent Control
This feature allows the vehicle speed to be controlled during a hill descent using the vehicle Brakes. This feature has to be selected using the Hill descent switch with the selected gear being 'first' or 'reverse' and the brakes below 350°C.

When HDC is selected by operating the latching HDC switch, the HDC information warning lamp is illuminated continuously to indicate HDC is available. If conditions are not met to enable HDC operation, after the switch is operated, the warning lamp flashes. When going downhill and HDC is selected the vehicle will maintain a target speed by applying the brakes. The target speed will be relative to the throttle pedal position. If the slope is not steep enough and the speed is less than the target speed, the vehicle will not accelerate to reach the target speed. The HDC function is brakes intervention only.

Minimum target speeds with the throttle closed are 6 mph (9.6 km/h) in first gear and 4 mph (6.5 km/h) in reverse gear. The first gear target speed is decreased to 4.4 mph (7 km/h) if rough terrain or sharp bends (detected from ABS sensor inputs) are encountered while already travelling at the minimum target speed. Minimum target speeds are increased at cold idle to prevent conflict between the brakes and the engine caused by HDC trying to impose a lower vehicle speed than is normal for the increased engine speeds at cold idle. Minimum target speeds at cold idle are 7.5 mph (12 km/h) in first gear and 4.4 mph (7 km/h) in reverse gear.

During active braking, the brakes are operated in axle pairs on one or both axles. The braking effort is distributed between the front and rear axles as necessary to maintain vehicle stability. Distribution of the braking effort is dependant on direction of travel and braking effort being applied. To prevent wheel lock, anti-lock braking is also enabled during active braking.

The ABS ECU incorporates a fade out strategy that, if a fault occurs or HDC is deselected during active braking, provides a safe transition from active braking to brakes off. The fade out strategy increases the target speed at a low constant acceleration rate, independent of actual throttle position. If active braking is in operation, this causes the braking effort to be gradually reduced and then discontinued. The HDC information warning lamp flashes while fade out is in progress.

If the clutch is disengaged during active braking, the HDC information warning lamp flashes after a delay of 3 seconds. After 60 seconds, if the clutch is still disengaged, the HDC fault warning lamp flashes and active braking operation fades out.

To prevent the brakes overheating, the ABS ECU monitors the amount of active braking employed and, from this, calculates brake temperature. If the ABS ECU determines brake temperature has exceeded a preset limit, it extinguishes the HDC information warning lamp and flashes the HDC fault warning lamp to indicate that HDC should be deselected. If active braking continues and the ABS ECU determines that brake temperature has increased a further 50 C, it fades out active braking and disables HDC. After fade out, the HDC fault warning lamp continues to flash, while HDC is selected, until the ABS ECU calculates brake temperature to be at an acceptable level. This calculation continues even if the ignition is turned off, so turning the ignition off and back on will not reduce the disabled time. When the ABS ECU calculates the brake temperature to be acceptable, it extinguishes the HDC fault warning lamp and illuminates the HDC information warning lamp to indicate HDC is available again. The disabled time is dependant on vehicle speed.

Diagnostics
While the ignition is on, the diagnostics function of the ABS ECU monitors the system for faults. In addition, the return pump is tested by pulsing it briefly immediately after the engine starts provided vehicle speed exceeded 4.4 mph (7 km/h) during the previous ignition cycle. If a fault is detected at any time, the ABS ECU stores a related fault code in memory and illuminates the appropriate warning lamps in the instrument pack. If a fault exists in a warning lamp circuit, the lamp will not illuminate during the lamp check at ignition on, but, provided there are no other faults, the related function will otherwise be fully operational.

Checks Performed By Diagnostics

Fault	Status of Warning Lamps				Default Strategy
	ABS	ETC	HDC Fault	HDC Information	
ABS ECU internal failure	On	On	On	Off	ABS: Disabled. ETC: Disabled. HDC: Disabled.
ECM input failure	Off	On	On	Off*	ABS: Enabled. ETC: Disabled. HDC: Immediately disabled if not in active braking mode, faded out then disabled if in active braking mode.
Sticking throttle	Off	Off	On	Off*	ABS: Enabled. ETC: Disabled. HDC: Immediately disabled if not in active braking mode, faded out then disabled if in active braking mode.
Implausible gear position input	Off	Off	On	Off*	ABS: Enabled. ETC: Enabled. HDC: Immediately disabled if not in active braking mode, faded out then disabled if in active braking mode.
No reference earth	On	On	On	Off	ABS: Disabled. ETC: Disabled. HDC: Disabled.
Failure of ABS sensor	On	On	On	Off†	ABS: Enabled. ETC: Enabled. HDC: Immediately disabled if not in active braking mode, faded out then disabled if in active braking mode.
Failure of 2 ABS sensors	On	On	On	Off*	ABS: Enabled on unaffected hydraulic circuit (if applicable), disabled on affected hydraulic circuit(s). ETC: Disabled. HDC: Immediately disabled if not in active braking mode, faded out then disabled if in braking mode.
Failure of more than 2 ABS sensors	On	On	On	Off	ABS: Disabled. ETC: Disabled. HDC: Disabled.
Failure of input valve	On	On	On	Off	ABS: Enabled on unaffected hydraulic circuit (if applicable), disabled on affected hydraulic circuit(s). ETC: Disabled. HDC: Immediately disabled if not in active braking mode, faded out then disabled if in braking mode.
Failure of more than one input valve	On	On	On	Off*	ABS: Enabled on unaffected hydraulic circuit (if applicable), disabled on affected hydraulic circuit(s). ETC: Disabled. HDC: Immediately disabled if not in active braking mode, faded out then disabled if in braking mode.

Fault	Status of Warning Lamps				Default Strategy
	ABS	ETC	HDC Fault	HDC Information	
Failure of output valve	On	On	On	Off*	ABS: Enabled on unaffected hydraulic circuit (if applicable), disabled on affected hydraulic circuit(s). ETC: Disabled. HDC: Immediately disabled if not in active braking mode, faded out then disabled if in braking mode.
Failure of more than one output valve	On	On	On	Off*	ABS: Enabled on unaffected hydraulic circuit (if applicable), disabled on affected hydraulic circuit(s). ETC: Disabled. HDC: Immediately disabled if not in active braking mode, faded out then disabled if in braking mode.
Battery short in more than two input or output valve circuits	On	On	On	Off	ABS: Disabled. ETC: Disabled. HDC: Disabled.
Return pump fault	On	On	On	Off	ABS: Disabled. ETC: Disabled. HDC: Disabled.
HDC relay fault	Off	Off	On	Off*	ABS: Enabled. ETC: Enabled. HDC: Enabled.
Supply voltage out of limits	On	On	On	Off*	ABS: Enabled. ETC: Disabled. HDC: Immediately disabled if not in active braking mode, faded out then disabled if in active braking mode.
* = Flashes if HDC faded out; † = Flashes if HDC in active braking mode					

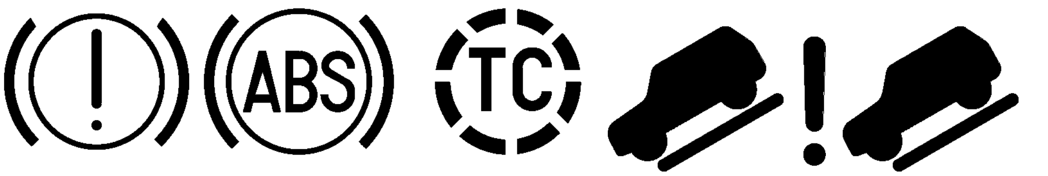
Electrical Data

Component resistance and voltage values are detailed below:

Component	Resistance, Ohms
HDC relay coil	73 to 89
ABS sensor (up to 2002 MY)	950 to 1100
ABS sensor (from 2002 MY)	1 maximum
Inlet solenoid valve	5.9 to 7.3
Outlet solenoid valve	3.0 to 3.6

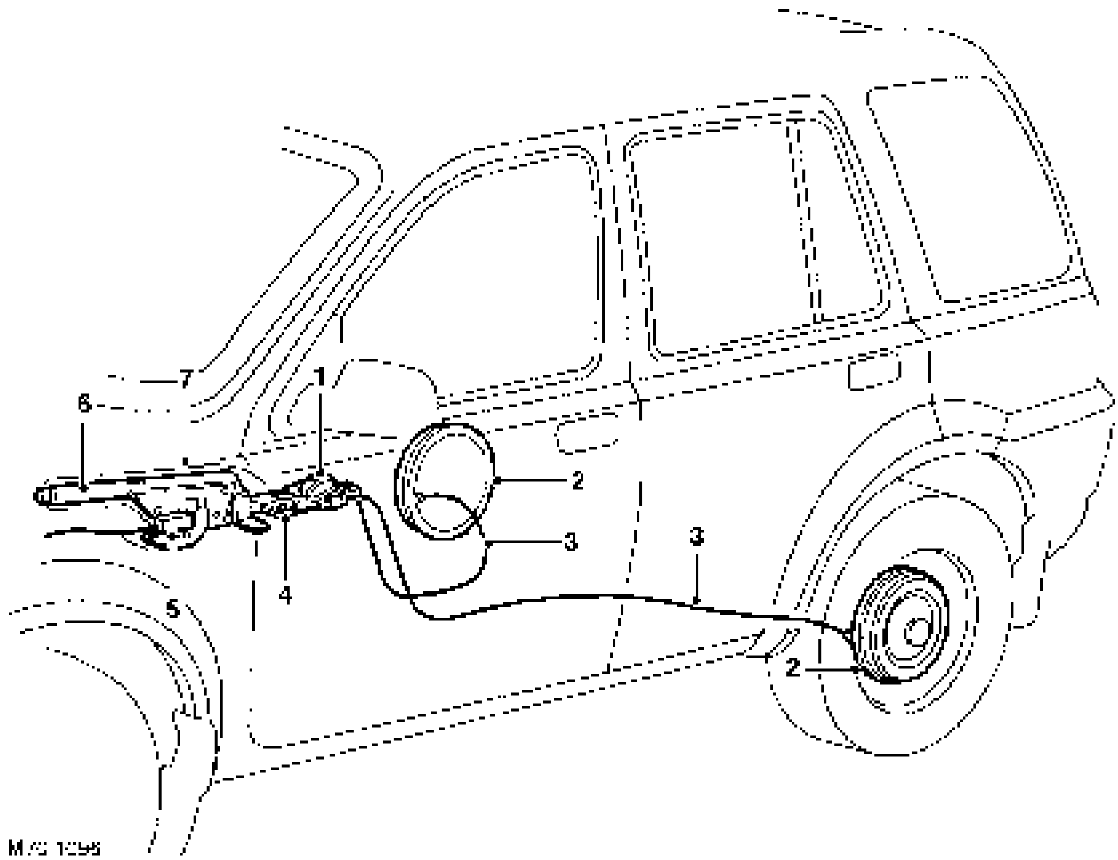
Component	Signal
First gear switch	Earth when first gear selected. Open circuit when first gear not selected.
HDC switch	Battery voltage when HDC selected. Open circuit when HDC not selected.
Reverse gear switch	Battery voltage when reverse gear selected. Open circuit when reverse gear not selected.

ABS System Failure Warning Lamps



Operating Condition	**Brake/ EBD (Red)**	**ABS (Amber)**	**ETC (Amber)**	**HDC Fault (Amber)**	**HDC Information (Green)**
Bulb check (ABS warning lamp only flashes off if there are no faults stored in the ABS ECU):					
Up To 2002 MY	On for 1.7 seconds	On for 1.7 seconds, off for 0.5 second, on until vehicle speed >7 km/h then off	On for 1.7 seconds	On for 1.7 seconds	On for 1.7 seconds
From 2002 MY	On for 2.7 seconds	On for 1.7 seconds, off for 0.5 second, on for 0.5 second then off	On for 2.7 seconds	On for 2.7 seconds	On for 2.7 seconds
Normal operation (no faults detected)	Off	Off (after lamp check)	Off	Off	Off
Hand brake on	On	Off	Off	Off	Off
Low brake fluid	On	Off	Off	Off	Off
ABS failure	Off	On	On	On	Off
ETC failure	Off	Off	On	On	Off
ABS and EBD failure	On	On	On	On	Off
ABS ECU not connected	On	On	On	On	Off
Diagnostic mode	On	On	On	On	On
ETC disabled mode	Off	Off	On	On	Off
HDC selected, conditions not met for HDC operation	Off	Off	Off	Off	Flashes at 2Hz
HDC selected, HDC is available and vehicle ready for descent	Off	Off	Off	Off	On
HDC failure	Off	Off	Off	On	Off
Brakes overheated	Off	Off	Flashes at 2Hz	Flashes at 2Hz (if HDC selected)	-

Handbrake Component Layout



1 Cable/Console bracket
2 Rear brake
3 Rear brake cable
4 Cable equaliser
5 Warning switch
6 Handbrake lever
7 Gaiter

Description

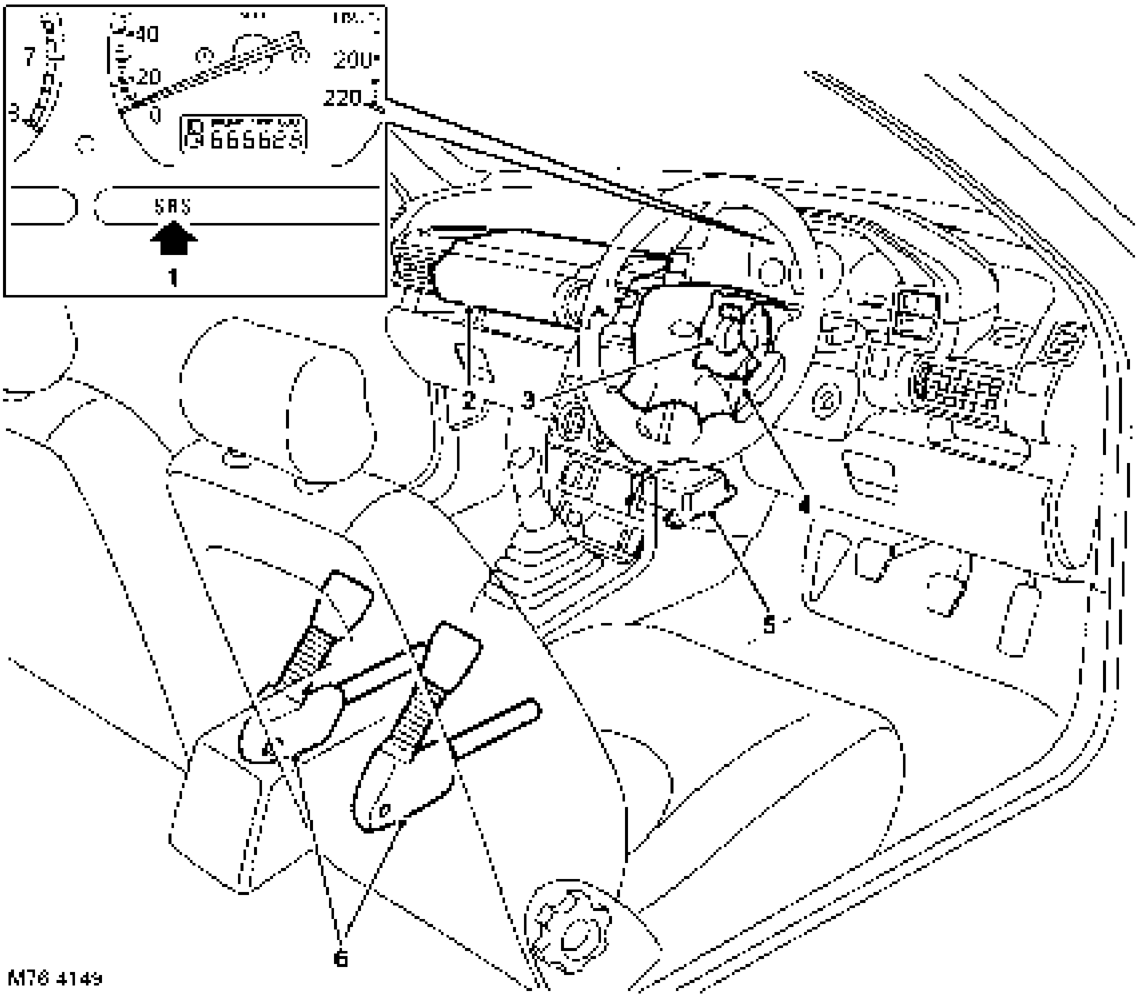
The handbrake operates on both rear brakes via two handbrake cables, a cable equaliser and an intermediate rod on the handbrake lever.

As the handbrake lever is applied, movement is transmitted by the intermediate rod and the cable equaliser to the two handbrake cables. Each handbrake cable pulls on a lever on the trailing brake shoe. The lever pivots against the brake's adjuster rod, which forces the brake shoes apart and brings the brake linings into contact with the drum.

The cables are adjusted by the handbrake adjust nut that locates the cable equaliser on the intermediate rod.

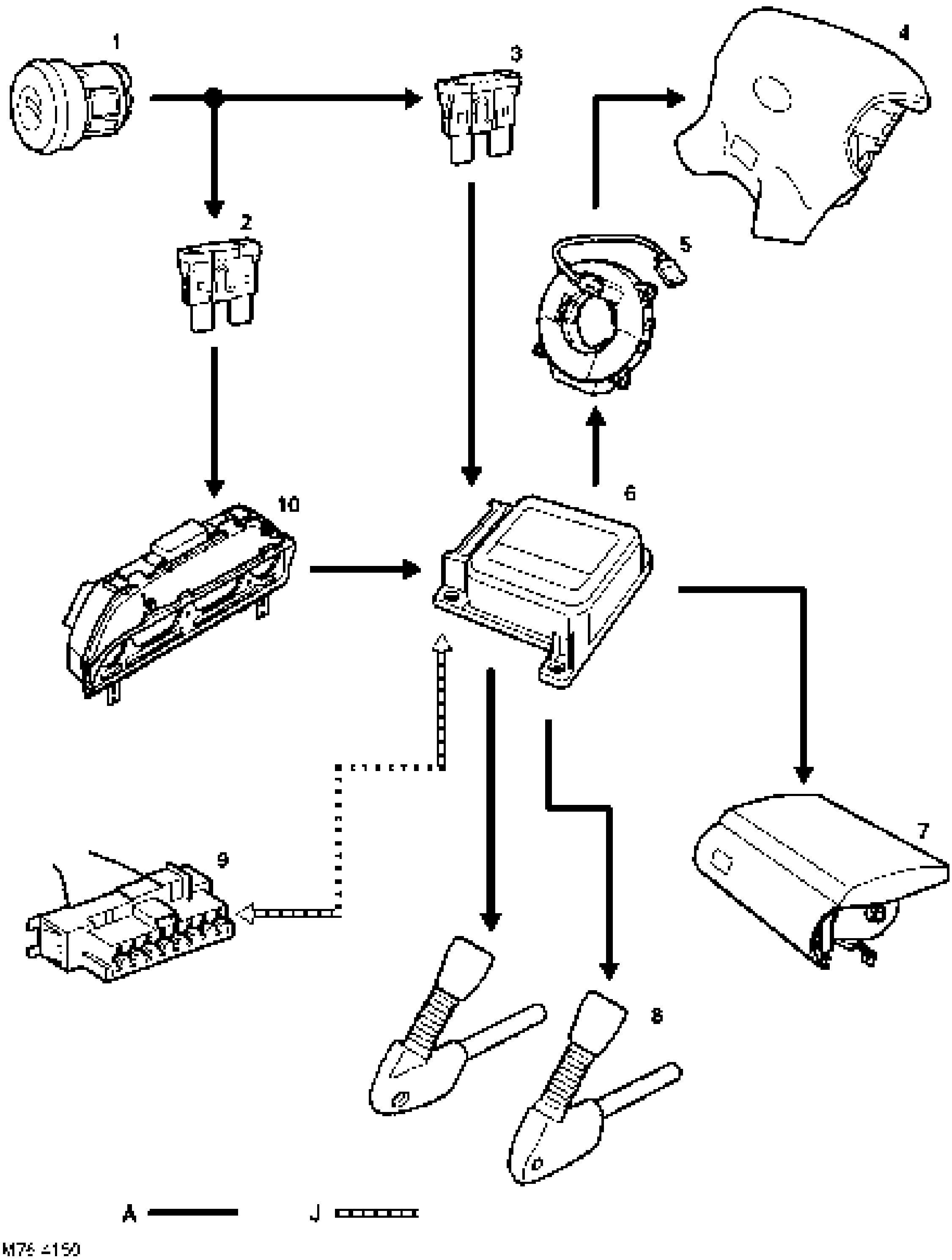
A warning switch, on the base of the handbrake lever, operates the brake warning lamp in the instrument pack. When the handbrake is applied and the ignition is on, the warning switch connects an earth to the instrument pack and illuminates the brake warning lamp. In some markets, the central control unit performs a bulb check of the brake warning lamp each time the ignition is switched on.

SRS Component Layout



1 SRS warning lamp
2 Passenger's airbag module
3 Rotary coupler
4 Driver's airbag module
5 Airbag DCU (pre 2002 MY version shown)
6 Seat belt pretensioners

SRS Control Diagram



A = Hardwired connections; J = Diagnostic ISO 9141 K line bus

1 Ignition switch
2 Fuse 8, passenger compartment fusebox
3 Fuse 36, passenger compartment fusebox
4 Driver's airbag module
5 Rotary coupler
6 Airbag DCU (pre 2002 MY version shown)
7 Passenger's airbag module
8 Seat belt pretensioners
9 Diagnostic socket
10 Instrument pack

Description

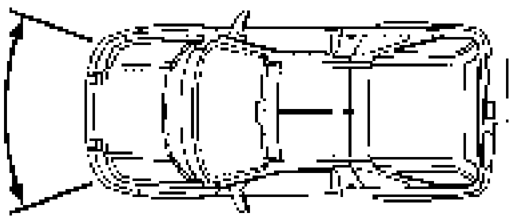
General
The Supplementary Restraint System (SRS) provides additional protection for front seat occupants during a frontal collision above a preset severity. The SRS is an electronically controlled, single point sensing system. The system comprises:

- An airbag Diagnostic Control Unit (DCU).
- A driver's airbag module.
- A front passenger's airbag module.

NOTE: In some markets an optional stowage bin is installed in place of the front passenger's airbag module.

- Two front seat belt pretensioners.
- A warning lamp.

Impact Zone for SRS Activation (Approximate)

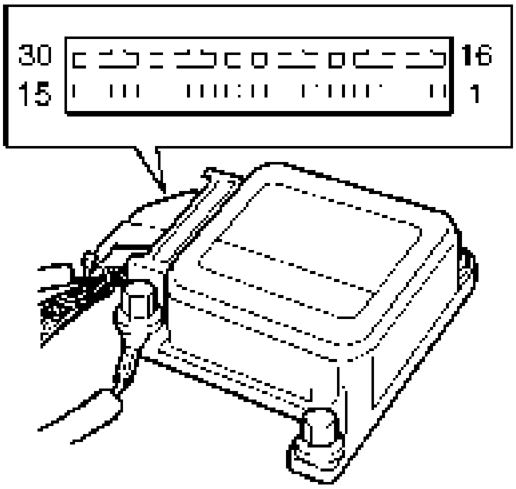


M76 4151

Interconnecting wiring for the system is integrated into the vehicle harnesses. A rotary coupler connects the vehicle harness to the driver's airbag module. An ISO 9141 K line (bi-directional) serial communication link connects the airbag DCU to the vehicle's diagnostic socket.

The system is operational only while the ignition is on. With the ignition on, any frontal collision is detected by the airbag DCU. If the impact is above the preset severity, the DCU sends out simultaneous fire signals to the airbag modules and the seat belt pretensioners. The airbag modules then deploy protective airbags in front of the driver and front seat passenger, and the seat belt pretensioners retract to tighten the front seat belts. Collision detection to full deployment of the airbags and pretensioners takes approximately 45 milliseconds.

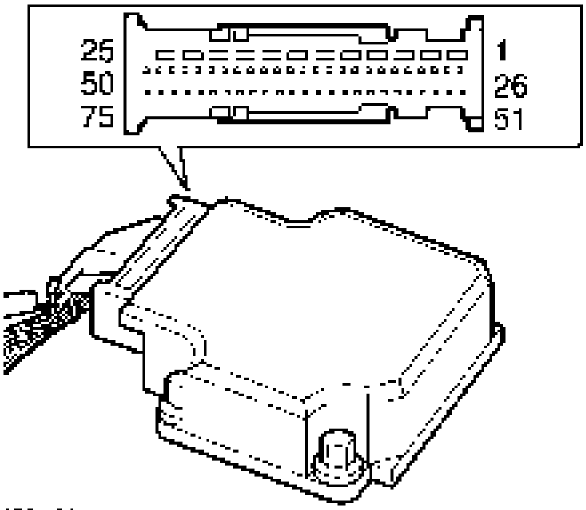
Airbag DCU (Up To 2002 MY)



M76 4152

The airbag DCU controls the operation of the system and also contains the collision detection sensors. The airbag DCU is attached to a bracket on the transmission tunnel, directly below the heater. On pre 2002 MY vehicles, a vehicle earth connects to one of the fixings. A multi-pin connector provides the airbag DCU connection with the vehicle harness.

Airbag DCU (From 2002 MY)



M76 4321

Incorporated into the airbag DCU is a mechanical safing sensor, an electronic single point sensor and integrated circuits for control and diagnostics. The mechanical safing sensor is a normally open switch that closes at the preset deceleration limit. The single point sensor is an accelerometer that produces an output proportional to the vehicle's deceleration.

Power Back-up

The airbag DCU incorporates capacitors to ensure the system will function if the external power supply is disconnected during a collision:

- Up to 2002 MY, the DCU incorporates a hardware capacitor, that provides power for 200 milliseconds to enable system operation and collision recording, and individual capacitors that provide power for 150 milliseconds for each fire signal output.
- From 2002 MY, the DCU incorporates individual capacitors that provide power for 150 milliseconds for each airbag fire signal output.

The capacitors are kept charged while the ignition is on by a dc-dc voltage converter incorporated into the airbag DCU. It can take up to 10 minutes from the ignition being switched off for the energy stored in the capacitors to fully dissipate and make the system inert.

Airbag DCU Connector Pin Details (Up To 2002 MY)

Pin No.	Description	Input/Output
1	RH pretensioner (+ve)	Output
2	RH pretensioner (-ve)	Output
3	LH pretensioner (+ve)	Output
4	LH pretensioner (-ve)	Output
5	Power supply	Input
6	Vehicle earth	–
7	SRS warning lamp	Output
8	Not used	–
9	ISO 9141 K line	Input/Output
10	Driver airbag module (+ve)	Output
11	Driver's airbag module (-ve)	Output
12	Not used	-
13	Passenger's airbag (+ve)	Output
14	Passenger's airbag (-ve)	Output
15 to 30	Not used	-

Airbag DCU Connector Pin Details (From 2002 MY)

Pin No.	Description	Input/Output
1 to 25	Not used	–
26	Ignition power supply	Input
27	SRS warning lamp	Output
28	Vehicle earth	–
29	Driver airbag module (–ve)	Output
30	Driver airbag module (+ve)	Output
31	Passenger's airbag (+ve)	Output
32	Passenger's airbag (–ve)	Output
33	LH pretensioner (–ve)	Output
34	LH pretensioner (+ve)	Output
35	RH pretensioner (–ve)	Output
36	RH pretensioner (+ve)	Output
37 to 53	Not used	–
54	ISO 9141 K line	Input/Output
55 to 75	Not used	–

Airbag Modules
During a frontal collision each airbag module deploys a gas filled bag to form a protective cushion between the front seat occupant and the steering wheel or fascia/windshield. The driver's airbag module is attached to the centre of the steering wheel. The passenger's airbag module is installed in the fascia, above the glovebox.

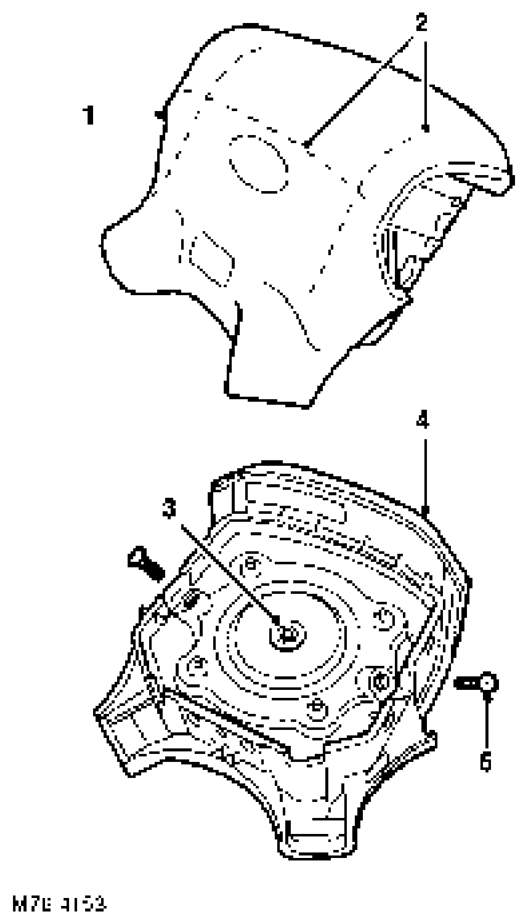
Each airbag module has a gas generator attached to a folded airbag installed in a housing. The driver's airbag has an inflated volume of 60 litres (2.12 ft^3); the passenger's airbag has an inflated volume of 150 litres (5.30 ft^3). The gas generator of the driver's airbag module is filled with a nitrocellulose based material; the gas generator of the passenger's airbag module is filled with a sodium azide based material.

The outlet of the gas generators incorporates a filter screen to prevent solid combustion by-products entering the airbag during deployment. An igniter (squib) in each generator provides an ignition source when triggered by a fire signal from the airbag DCU. A 2 pin connector provides the interface between the igniter and the vehicle wiring.

On the driver's airbag module, the housing is closed by a cover that forms the steering wheel centre pad; split lines are formed in the inner surface of the cover to direct the airbag through the required exit point during deployment. On the passenger's airbag module, the housing is closed by a trim panel profiled to match the fascia; a tethered deployment door forms an integral part of the trim panel.

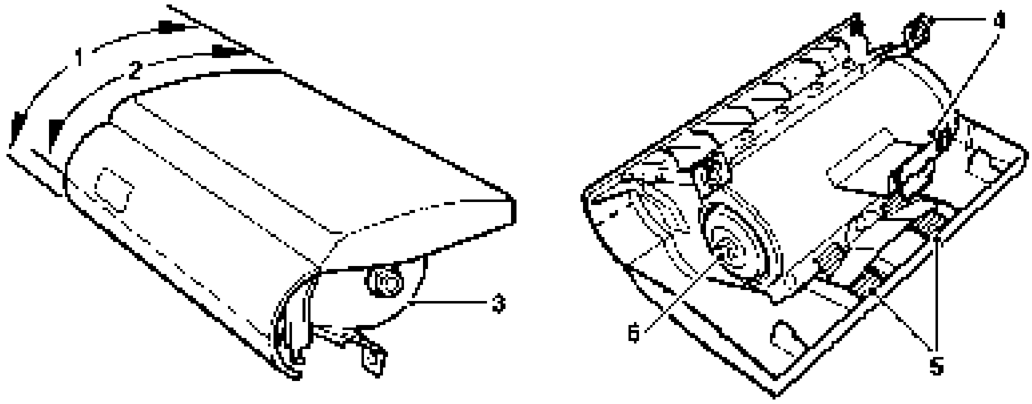
Both airbag modules operate in the same way. On receipt of a fire signal from the airbag DCU, the igniter ignites the material in the gas generator. The burning material rapidly produces a large amount of nitrogen gas which passes through the filter screen into the airbag, forcing the airbag to unfold. On the driver's airbag module, the unfolding airbag ruptures the cover along the split lines; on the passenger's airbag module, the unfolding airbag breaks the deployment door fixings to the module housing and trim panel, and the deployment door lifts off the fascia (but remains tethered to the module housing). Once free of the housing the airbag inflates to its full extent. Vents in the airbag prevent excess pressure bursting the bag and, as soon as the material in the gas generator is exhausted, allows the airbag to instantly deflate.

Driver's Airbag Module Components



1 Cover
2 Split lines
3 Electrical connector
4 Housing
5 Fixing

Passenger's Airbag Module Components



M76 4154

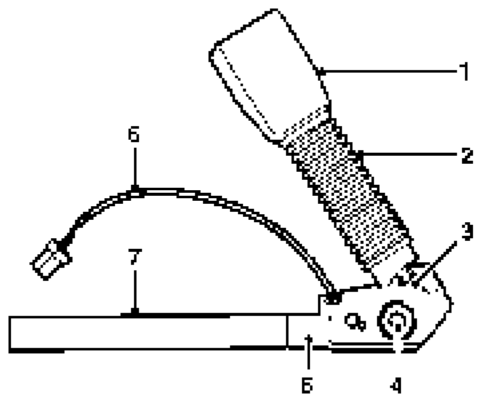
- **1** Trim panel
- **2** Deployment door section
- **3** Housing
- **4** Fixing bracket
- **5** Tethers
- **6** Electrical connector

Seat Belt Pretensioners
During a frontal collision the seat belt pretensioners tighten the front seat belts to ensure the occupants are securely held in their seats. A pretensioner is integrated into the buckle assembly of each front seat belt.

The two pretensioners are handed, but otherwise identical. Each pretensioner has a tube containing propellant and a piston. The piston is attached to steel cables, the opposite ends of which are attached to the seat belt buckle. An igniter (squib) in the base of the tube provides an ignition source when triggered by a fire signal from the airbag DCU. A fly lead with a 2 pin connector links the igniter to the vehicle wiring.

On receipt of a fire signal from the airbag DCU, the igniter ignites the propellant. The burning propellant rapidly produces nitrogen gas that drives the piston along the tube, pulling on the cables and drawing the buckle towards the buckle assembly fixing point on the seat.

Seat Belt Pretensioner Components



M75 4155

- **1** Seat belt buckle
- **2** Gaiter
- **3** Steel cables
- **4** Fixing
- **5** Igniter
- **6** Fly lead
- **7** Piston tube

SRS Warning Lamp
The SRS warning lamp provides system status information for the driver. The lamp consists of a non serviceable LED behind a red SRS graphic, which is located below the speedometer in the instrument pack.

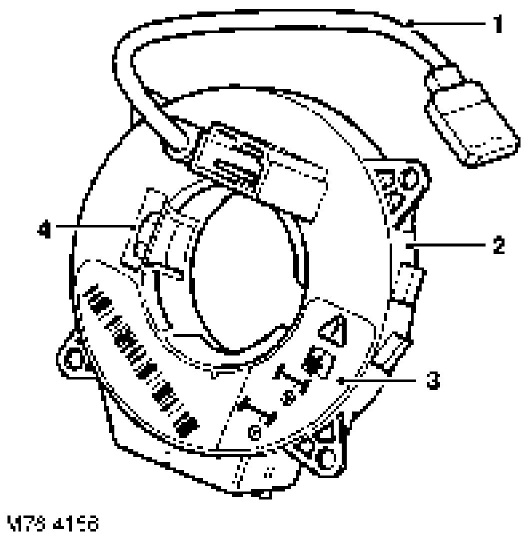
Rotary Coupler
The rotary coupler is installed on the steering column to provide the interface between the fixed wiring harness and the moveable driver's airbag module. In addition to the wiring for the driver's airbag module, the rotary coupler also provides the interface for the following switches which, depending on equipment level, can also be incorporated into the steering wheel:

- Horn switches.
- ICE system control switches.
- Cruise control system switches.

A rotating link harness is encapsulated into a plastic cassette comprising outer and inner housings with integral connectors. Screws attach the outer housing to the steering column switch assembly and the inner housing is keyed to the steering wheel by its connector. The inner housing can turn a maximum of five revolutions in relation to the outer housing. For maintenance purposes the inner housing incorporates a position indicator wheel; a white segment is visible on the wheel when the rotary coupler is centralised. To prevent breaking the rotating link harness, both the steering and the rotary coupler must be centralised when removing and installing the steering wheel.

A new rotary coupler has a blue locking tab which ensures the unit is locked at its factory centred position. The peg should remain intact until just before steering wheel fitment.

Rotary Coupler Components



1 Fly lead (to airbag module)
2 Outer housing
3 Inner housing
4 Position indicator wheel

Operation

General

When the ignition is switched on, the airbag DCU performs a bulb check of the SRS warning lamp as part of the power up procedure. The lamp should be extinguished after approximately 5 seconds, indicating that the system is fully operational. If the lamp remains illuminated, a fault has been detected and repair action is required.

While the ignition is on, data from the single point sensor is continuously monitored by the airbag DCU. If the data from the single point sensor indicates vehicle deceleration is at or above the preset limit, and the mechanical safing sensor is closed, the DCU interprets this as a collision that requires deployment of the airbags and retraction of the seat belt pretensioners. It then activates transistors to send fire signals to the airbag modules and the seat belt pretensioners. On pre 2002 MY vehicles, the airbag DCU simultaneously records in memory the following information:

- The error code of the last permanent fault (if any) detected before the collision.
- Internal program information about the collision as seen by the airbag DCU.
- The diagnostic status of the airbag and seat belt pretensioner circuits before deployment.
- The voltage of each power backup capacitor before deployment.
- Information on the airbag DCU internal program status.

NOTE: If external power is lost during the collision, recording of the last three above items only occurs if there is sufficient power in the backup capacitors after outputting the fire signals.

After deployment, the airbag DCU enters a crash locked mode and illuminates the SRS warning lamp. In the crash locked mode the airbag DCU is permanently disabled and must be replaced during subsequent repair action. Crash locked mode cannot be cleared using TestBook/T4.

Diagnostics

While the ignition is on the diagnostic function of the airbag DCU monitors the SRS for faults. If a fault is detected, the airbag DCU stores a related fault code in memory and switches the earth output to illuminate the SRS warning lamp. With a supply voltage range fault, the warning lamp is illuminated only for the duration of the fault. With all other faults, including intermittent faults, the warning lamp is illuminated for the remainder of the drive cycle. At the next ignition on, if the fault is still present the warning lamp remains illuminated after the lamp check; if the fault does not recur, the warning lamp extinguishes but the fault code remains stored in memory. On pre 2002 MY vehicles, an intermittent fault will be cleared from memory if 40 drive cycles are completed without its recurrence.

After detecting a fault, the system may retain some operational capability. If a fault is detected in an airbag or pretensioner circuit, the circuit may be disabled, depending on the fault; the other airbag and pretensioner circuits remain operational and their related components will still be deployed in a collision. If an internal or power supply fault is detected, the complete system will be disabled. If a fault exists in the SRS warning lamp circuit, the lamp will not illuminate during the lamp check at ignition on, but, provided there are no other faults, the system will otherwise be fully operational.

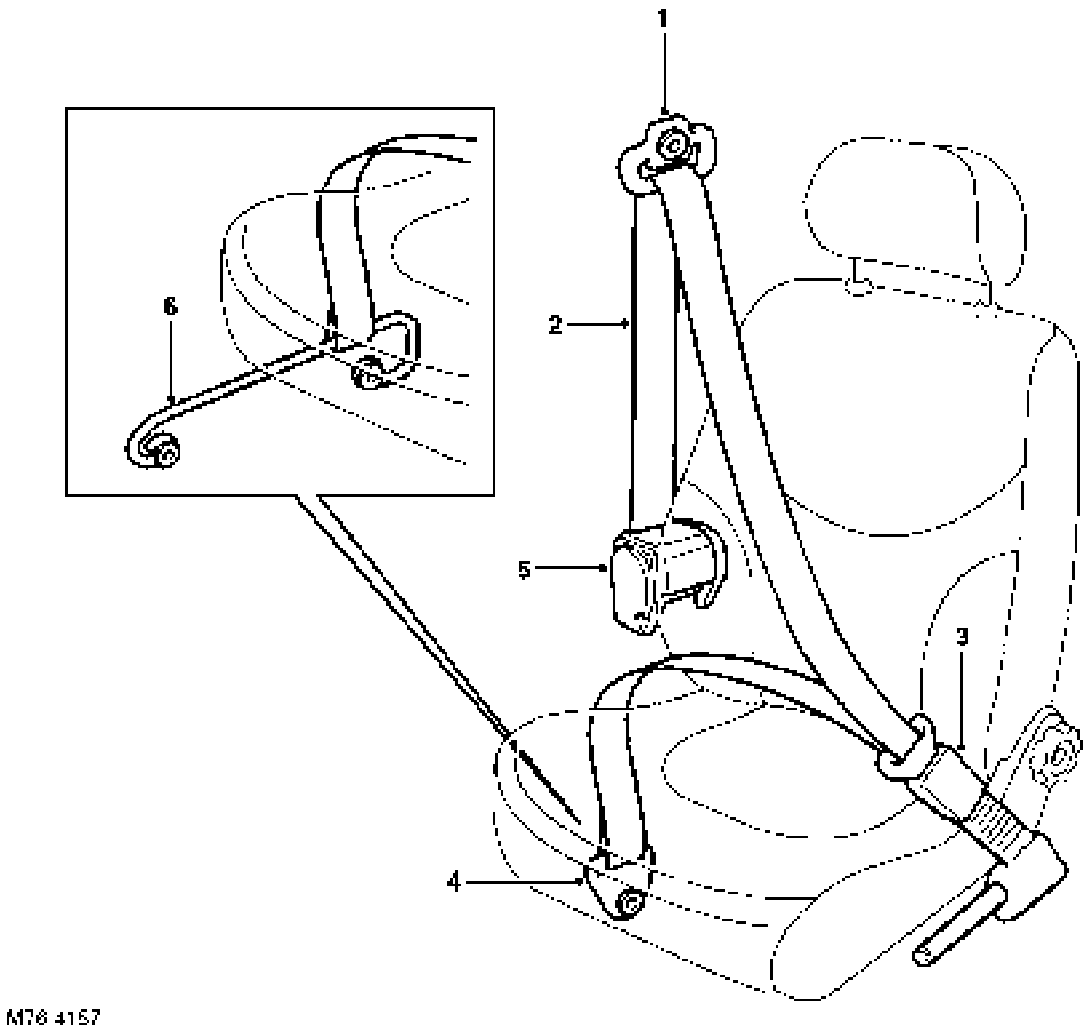
Fault code retrieval and fault diagnosis of the SRS can only be done using TestBook/T4. Additional SRS information that can be read using TestBook/T4 is the:

- Airbag DCU bar code.
- Evolution number of the hardware and software, and the algorithm level.
- Status of the crash locked mode.
- Vehicle Identification Number (VIN) data.

Diagnostic checks performed by the airbag DCU include:

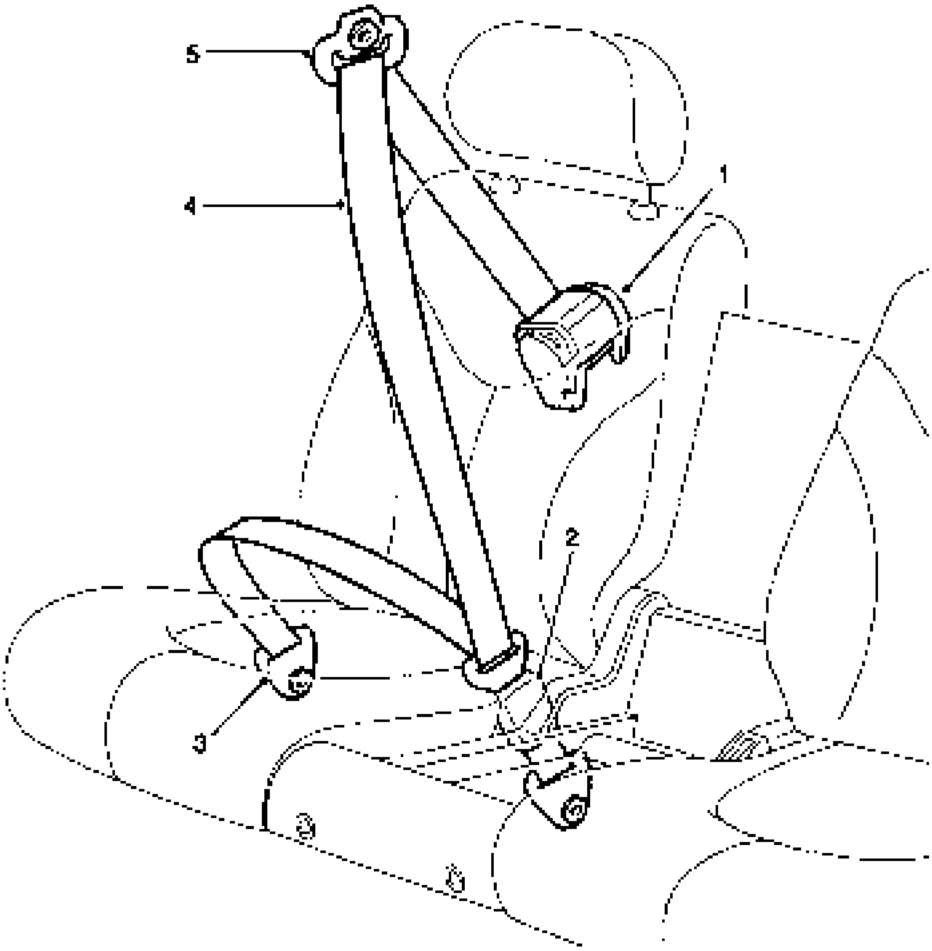
- Monitoring of the airbag and pretensioner circuits for open/short circuits.
- Internal errors.
- Supply voltage (limits are: 8.6 to 19.0 V at power up, 6.0 to 19.0 V during drive cycle up to 2002 MY; 10.0 to 16.5 during normal operation from 2002 MY onwards).

Front Seat Belt Components



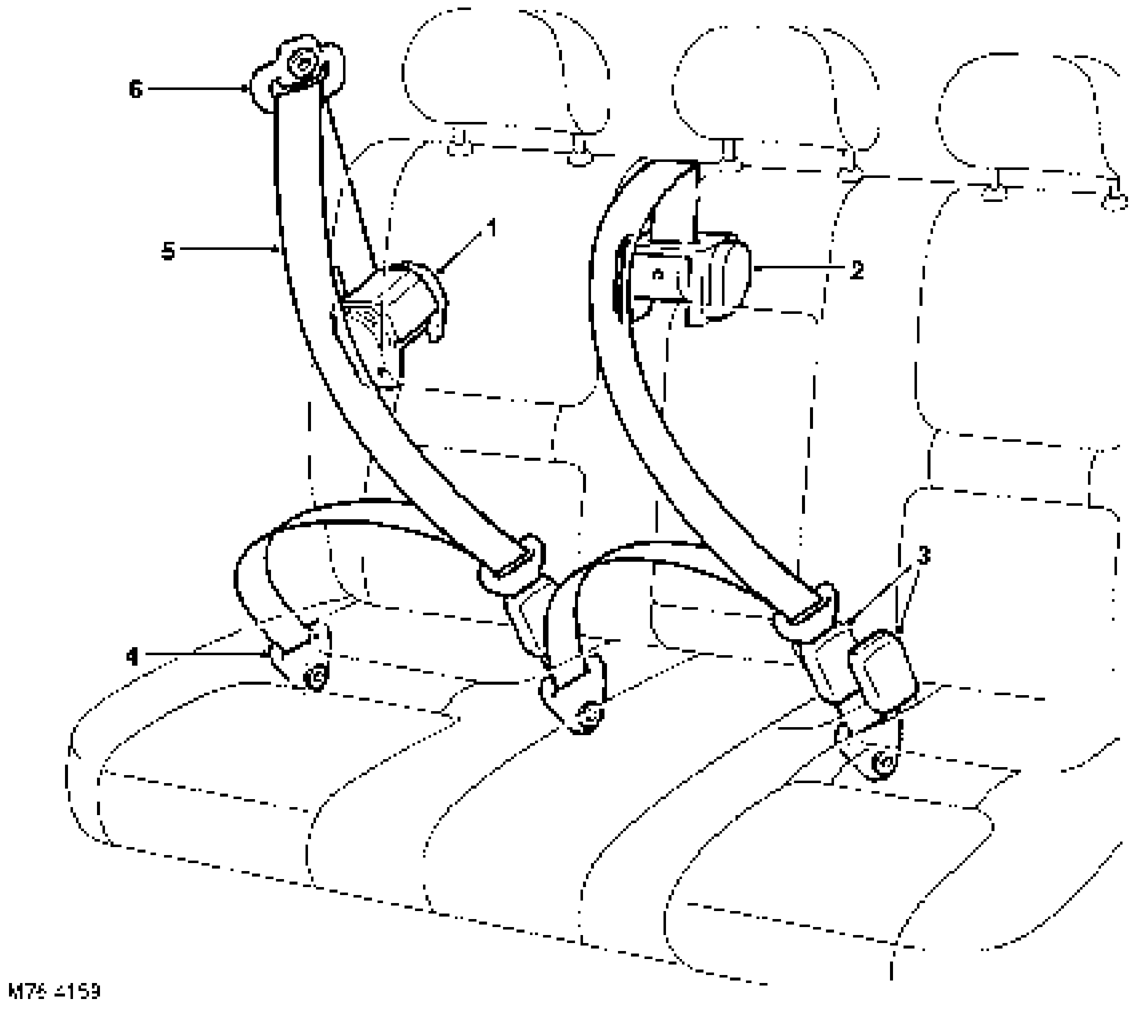
1 Upper mounting
2 Webbing
3 Buckle
4 Webbing anchor point (5 door models)
5 Inertia reel
6 Webbing anchor point (3 door models)

Rear Seat Belt Components - Three Door Models



1 Inertia reel
2 Buckle
3 Webbing anchor point
4 Webbing
5 Upper mounting

Rear Seat Belt Components - Five Door Models



1 Outboard inertia reel
2 Centre inertia reel
3 Buckles
4 Webbing anchor point
5 Webbing
6 Upper mounting

Description

General
Seat belts are provided as the primary restraint for all occupants. An inertia reel, three point seat belt is installed at each seat position. A load limiter feature is incorporated into the inertia reels.

The inertia reel of the driver's seat belt is the Emergency Locking Retractor (ELR) type and the inertia reel for all of the passenger seat belts are the Automatic Locking Retractor (ALR) type. In all other markets ELR inertia reels are fitted at all seat positions.

Both types of inertia reel incorporate a liftshaft locking system with webbing sensor and car sensor activating mechanisms. The webbing sensor activates the locking system if the webbing is subjected to a sharp pull. The car sensor activates the locking system if the vehicle is subjected to sudden deceleration or a severe tilt angle.

Front Seat Belts
The inertia reel of each front seat belt is attached to the related B/C post, behind the finishers. The webbing runs from the inertia reel, through an upper mounting attached to a height adjuster on the B/C post, to an anchor point either at the base of the B/C post (five door models), or on a bar attached to the inner sill (three door models).

The buckle assembly for each belt, consisting of a buckle attached to a flexible stalk and an integrated pretensioner, is secured to the inboard side of the related front seat frame.

Rear Seat Belts
Inertia reel seat belts are installed for all of the rear seats.

Three Door Models
The inertia reel of each rear seat belt is attached to a bracket on top of the related rear suspension turret, behind the loadspace rear quarter trim. The webbing runs from the inertia reel, through an upper mounting on the D post, to an anchor point in the rear wheel arch.

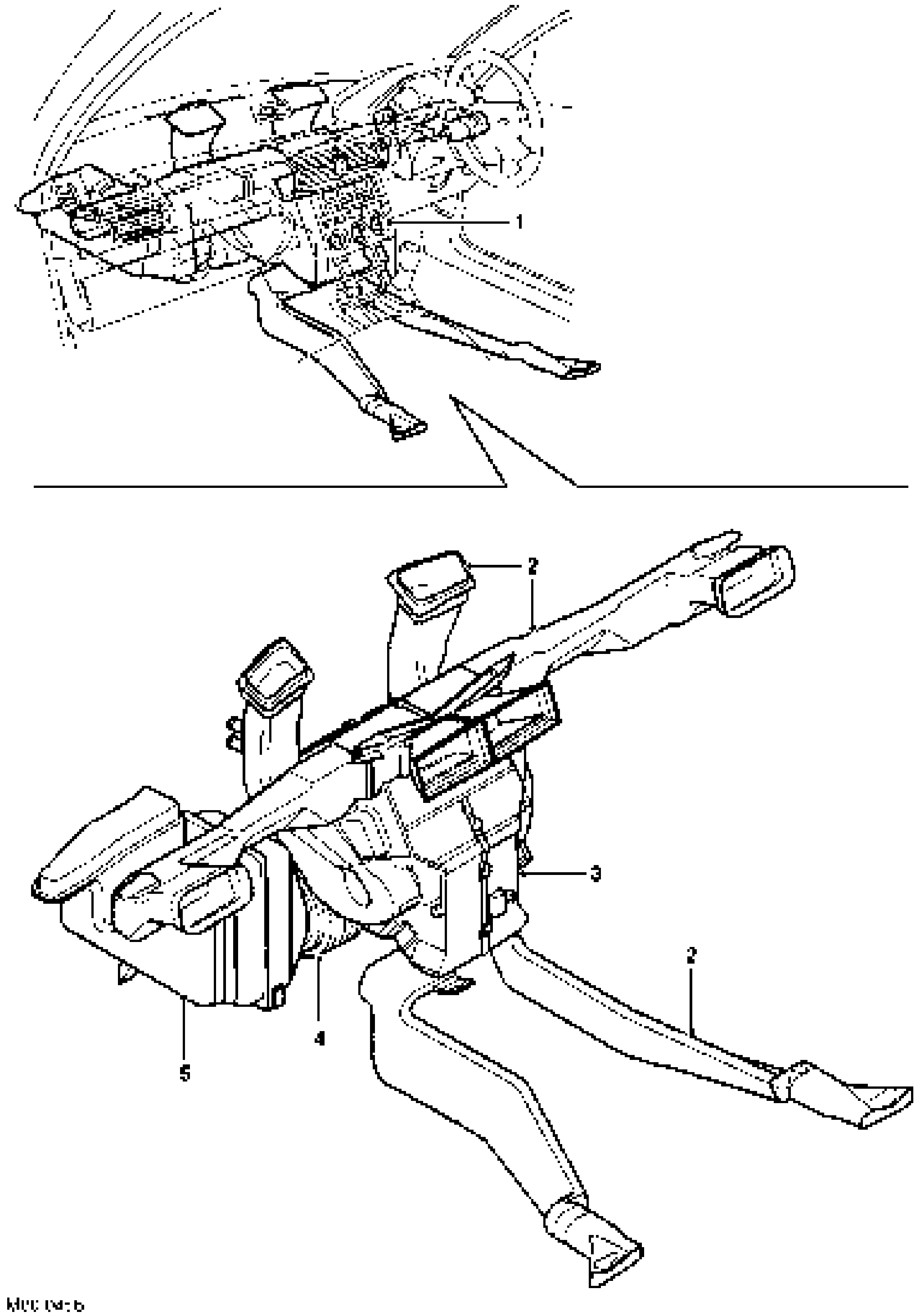
The buckle for each belt is directly attached to the inboard side of the related rear seat frame.

Five Door Models
The inertia reel of each outboard rear seat belt is attached to the related D post, behind the D/E post finisher. The webbing runs from the inertia reel, through an upper mounting on the D post, to an anchor point in the rear wheel arch.

The inertia reel for the centre rear seat belt is installed in a recess in the back of the rear seat. The webbing runs from the inertia reel, over the top of the seat, to an anchor point in the lower frame of the right rear seat.

The buckle assembly for each belt, consisting of a buckle attached to a length of webbing, is fixed to the lower frames of the rear seats. The buckle assembly for the right seat belt shares an anchor point with the webbing of the centre seat belt.

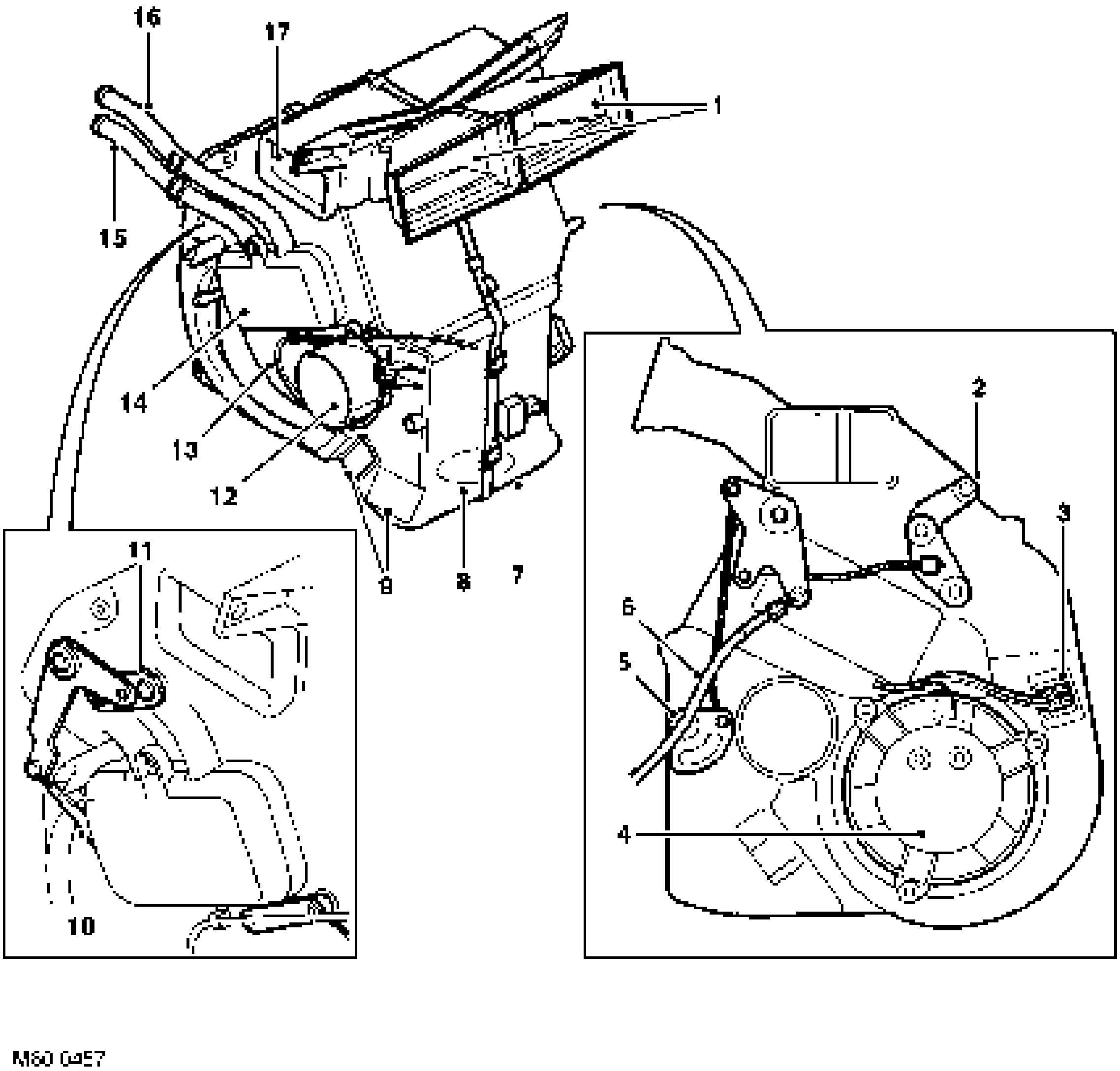
Heating and Ventilation System Component Layout



RHD shown, LHD similar

1 Control panel
2 Distribution ducts
3 Heater assembly
4 Connector hose
5 Air inlet duct

Heater Assembly Components



RHD shown, LHD similar

1 Centre face level air outlets
2 Fresh air flap lever
3 Resistor pack
4 Blower motor and impeller fan
5 Main distribution flap lever
6 Distribution control cable
7 Casing
8 Rear footwells air outlet
9 Front footwell air outlets
10 Blend flap control cable
11 Blend flap lever
12 Windscreen and side window air outlet
13 Heater matrix 'close off' flap and control cable
14 Heater matrix cover
15 Engine coolant feed
16 Engine coolant return
17 Outer face level air outlet

Description

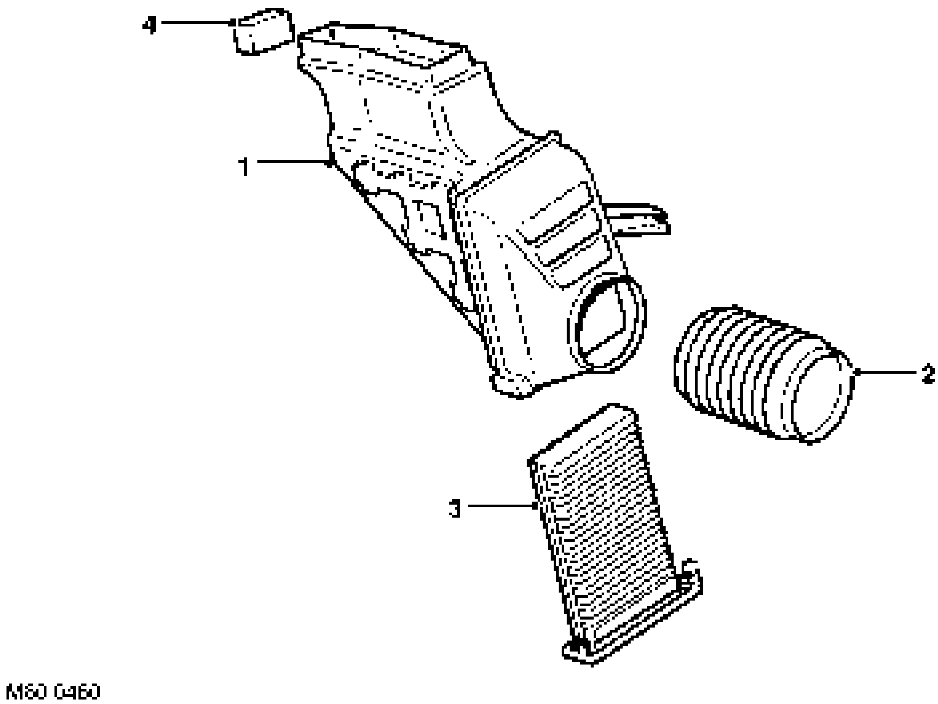
General

The heating and ventilation system controls the temperature and distribution of air supplied to the vehicle interior. Air is drawn into a heater assembly through a connector hose and an air inlet duct or, on vehicles with air conditioning, the cooling unit.

☞ **AIR CONDITIONING, DESCRIPTION AND OPERATION, Description.**

In the heater assembly, the air can be heated and supplied as required to fascia and floor level outlets. An electrical variable speed blower, and/or ram effect when the vehicle is in forward motion, forces the air through the system. Temperature, distribution and blower controls are installed on a panel on the centre console.

Air Inlet Duct



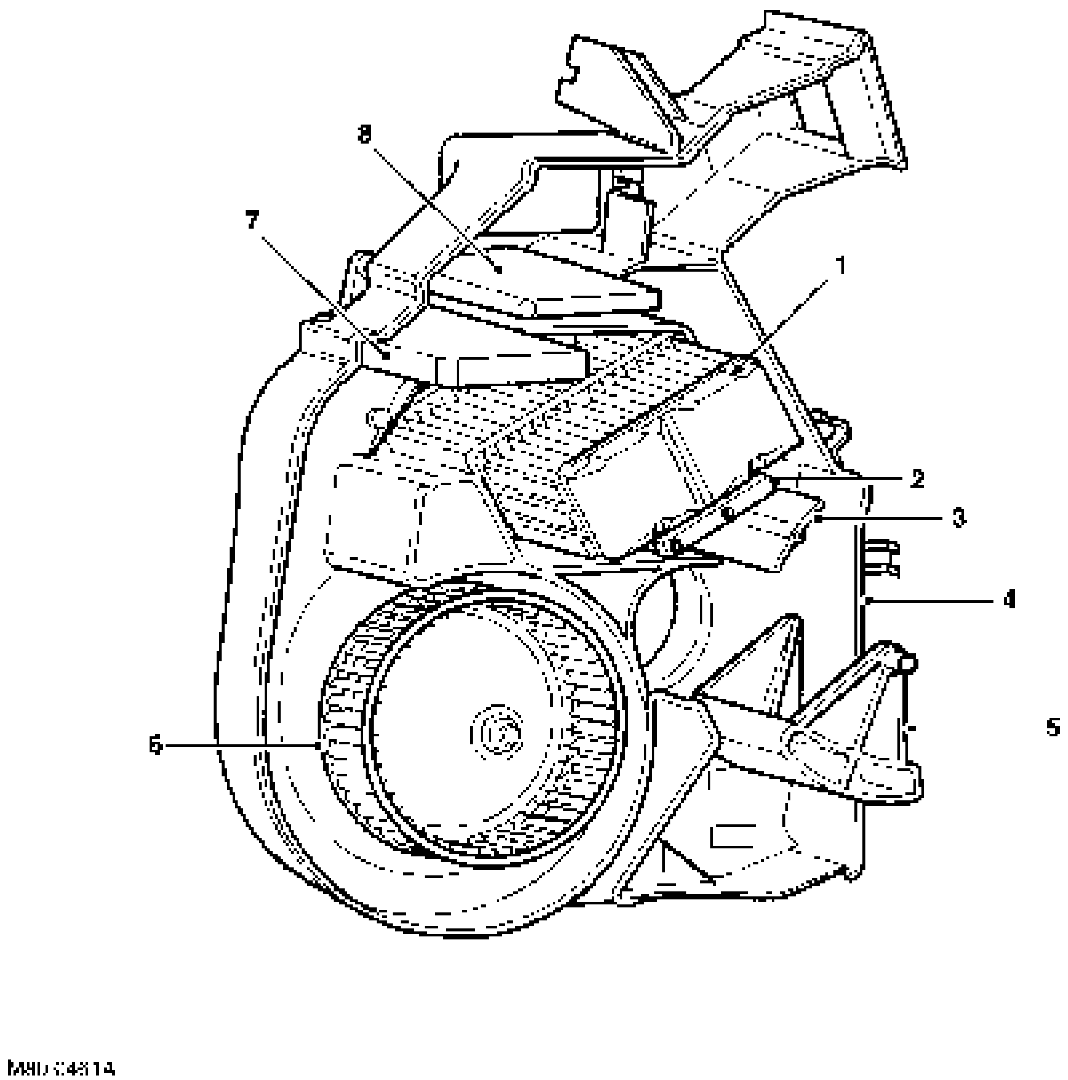
RHD (non aircon) shown, LHD (non aircon) similar

1 Air inlet duct
2 Connector hose
3 Pollen filter
4 Foam block

The air inlet duct connects the passenger's side of the plenum to the heater assembly, to provide the fresh air inlet. The upper end of the duct locates in a slot in the body and the lower end of the duct is connected to the heater assembly via a corrugated connector hose. A pollen filter is installed in the air inlet duct and retained by two scrivets.

Heater Assembly

Interior View of Heater Assembly



RHD shown, LHD similar

1 Heater matrix
2 PTC heater (where fitted)
3 Heater matrix 'close off' flap
4 Casing
5 Distribution main flap
6 Blower fan
7 Blend flap
8 Distribution fresh air flap

The heater assembly heats and distributes air as directed by selections made on the control panel. The assembly is installed on the vehicle centre-line, between the fascia and the engine bulkhead.

The heater assembly consists of a two-piece plastic casing containing a blower, resistor pack, heater matrix and control flaps. Integral passages guide the air through the casing from the inlet to the distribution outlets. A wiring harness connects the blower and resistor pack to the blower switch on the control panel.

Blower

The blower controls the volume of air being supplied to the distribution outlets. The blower is installed in the driver's side of the casing and consists of an open hub, centrifugal fan powered by an electric motor. The open end of the fan surrounds the air inlet, which is on the passenger's side of the casing. The blower switch and the resistor pack control the operation of the blower, which can be selected to run at one of four speeds.

Resistor Pack

The resistor pack supplies reduced voltages to the blower motor for blower speeds 1, 2 and 3. For blower speed 4, the resistor pack is bypassed and battery voltage drives the motor at full speed. The pack is installed in the RH side of the casing, in the air outlet from the blower fan, so that any heat generated is dissipated by the air flow.

Heater Matrix

The heater matrix provides the heat source to warm the air being supplied to the distribution outlets. It is installed in the LH side of the casing behind a protective cover. The matrix is a copper and brass, two pass, fin and tube heat exchanger. Engine coolant is supplied to the matrix through two brass tubes that extend through the bulkhead into the engine compartment. When the engine is running, coolant is constantly circulated through the heater matrix by the engine coolant pump.

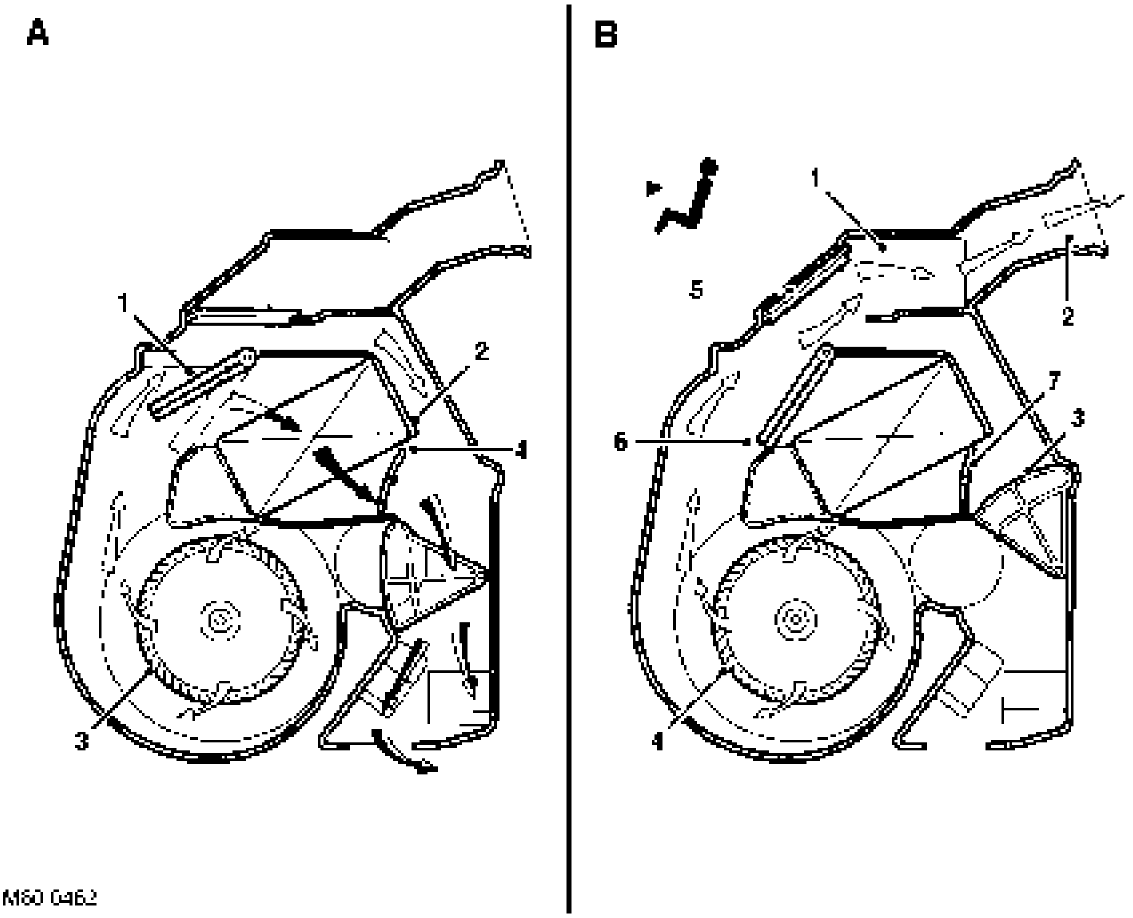
Control Flaps

Four control flaps are installed in the heater assembly to control the temperature and distribution of air. A blend flap controls the temperature by directing air inlet flow through or away from the heater matrix. Two distribution flaps control the air flow distribution to the selected vents, and an extra flap closes the air path from the off side of the heater matrix to the blend chamber to reduce heat pick-up causing a rise in temperature at the foot and defrost outlets in comparison to the temperature at the face vent outlets.

Blend Flap: The blend flap regulates the flow of air through the heater matrix to control the temperature of the air leaving the heater assembly. It consists of a hinged flap between the cold air bypass and the heater matrix. The flap hinge is connected to a lever mechanism on the LH side of the casing. A control cable is installed between the lever mechanism and the temperature knob on the control panel to operate the flap. Turning the temperature knob turns the flap and varies the proportions of air going through the cold air bypass and the heater matrix. The proportions vary, between full bypass no heat and no bypass full heat, to correspond with the selection on the temperature knob. When the flow is split between the cold air bypass and the heater matrix, the two flows are mixed downstream of the heater matrix to produce an even air temperature at the individual outlets.

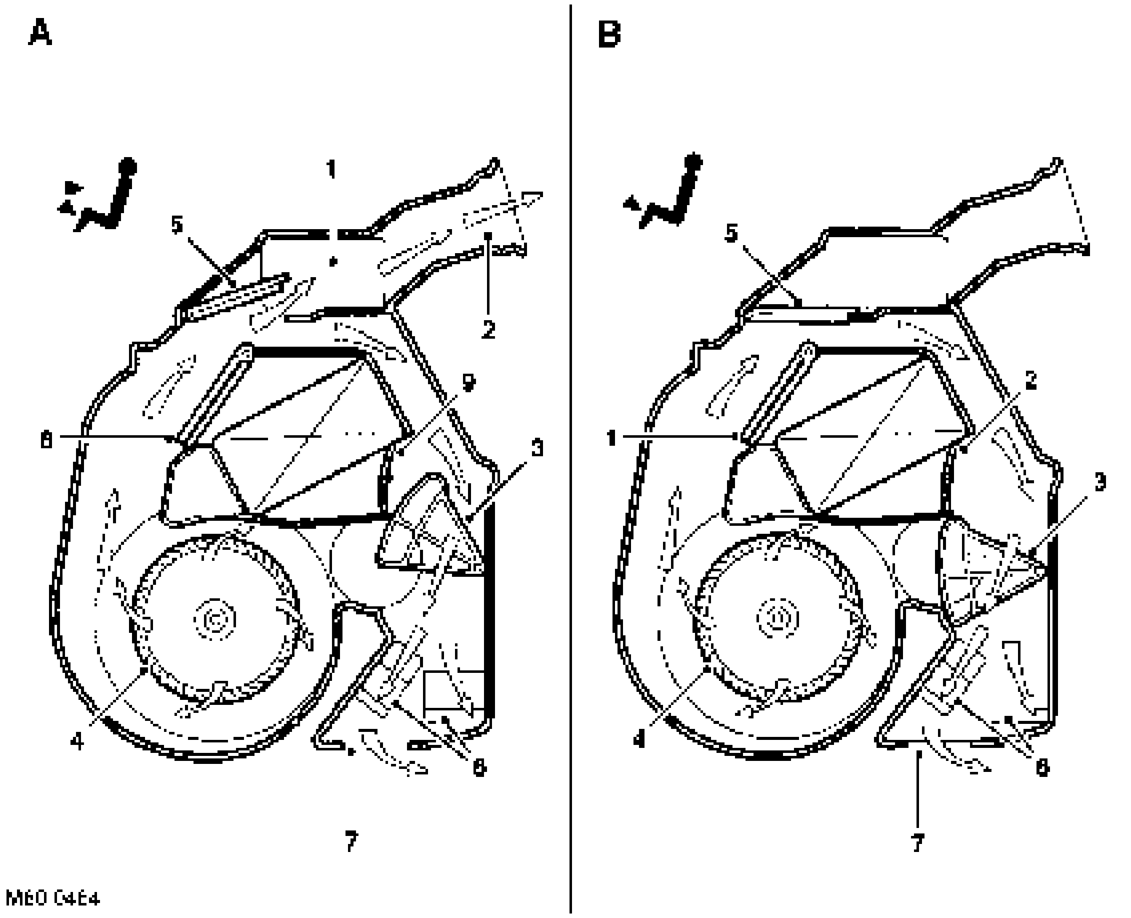
A flap on the air outflow side of the heater matrix is used to close off the path of cold air flowing around the bypass route from picking up heat from the matrix in the blend chamber and so prevent an increase in air temperature when the airflow is diverted to the foot or defrost outlets. The flap hinge is connected to a lever mechanism on the LH side of the casing. A control cable is installed between the lever mechanism and the temperature knob on the control panel to operate the flap. Turning the temperature knob turns the flap. When unheated air is required and the temperature control is at its minimum setting, the 'close-off' flap is completely shut to prevent thermal pick-up. As the temperature control knob is turned up to select a higher ambient temperature, the 'close-off' flap is opened to allow the passage of air flow through the heater matrix to the blend chamber.

Distribution Flaps: A main flap and a fresh air flap control the flow of air to the distribution outlets in the casing. The main flap is a rotating segment that controls the flow to the windscreen/side window and footwell outlets. The fresh air flap is a hinged door that controls the flow to the face level outlets. The hinge of each flap is connected to a common lever mechanism on the RH side of the casing. A control cable is installed between the mechanism and the distribution knob on the control panel to operate the flaps together. Turning the distribution knob turns the flaps to direct air through the corresponding outlets in the casing.



A Temperature Control
- **1** Temperature control flap (partially open)
- **2** Heater Matrix
- **3** Blower
- **4** Heater Matrix 'close off' flap (partially open)

B Face Level Distribution Control
- **1** Outer face level air outlet
- **2** Centre face level air outlet
- **3** Distribution main flap
- **4** Blower
- **5** Distribution fresh air flap
- **6** Temperature control flap
- **7** Heater matrix 'close-off' flap

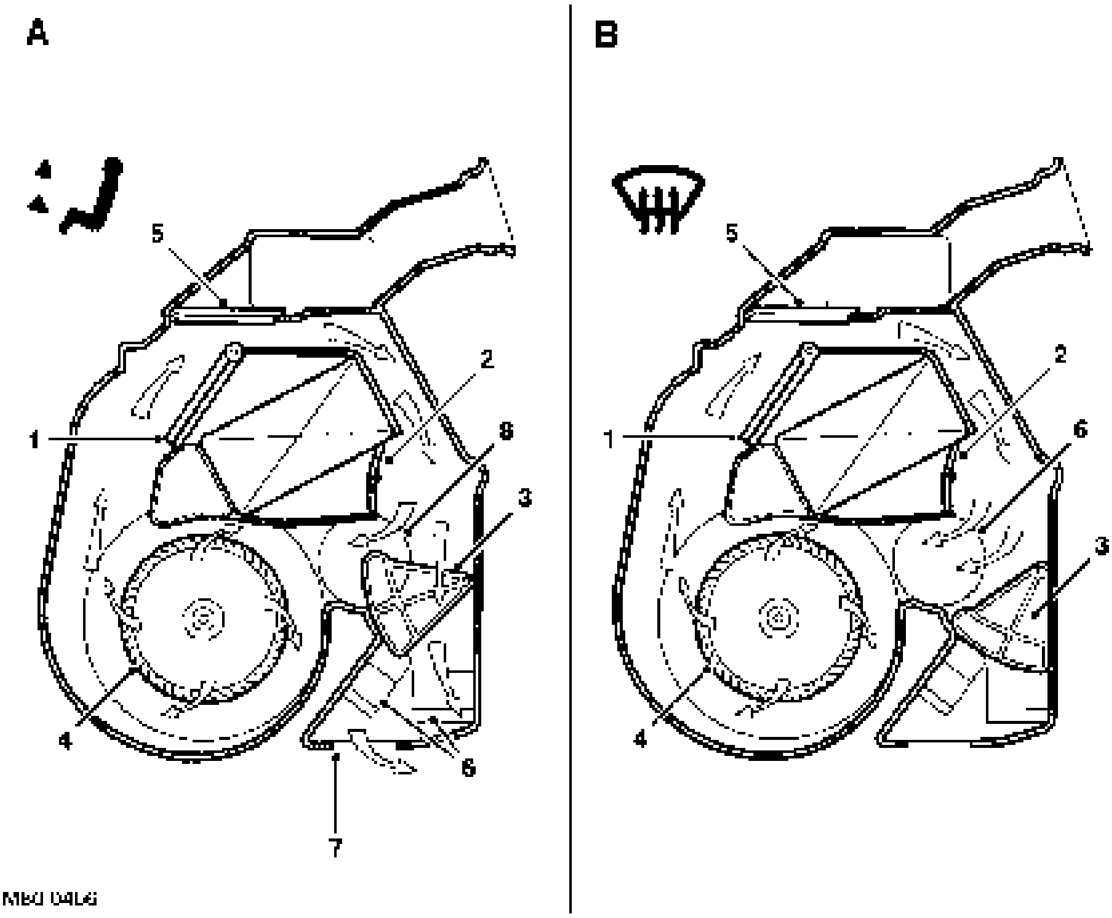


A Face Level and Footwells Distribution Control

1. Outer face level air outlet
2. Centre face level air outlet
3. Distribution main flap
4. Blower
5. Distribution fresh air flap
6. Front footwell air outlets
7. Rear footwells air outlet
8. Temperature control flap
9. Heater matrix 'close-off' flap

B Footwells Distribution Control

1. Temperature control flap
2. Heater matrix 'close-off' flap
3. Distribution main flap
4. Blower
5. Distribution fresh air flap
6. Front footwell air outlets
7. Rear footwells air outlet



A Footwells and Windscreen/Side Window Demist Distribution Control

1. Temperature control flap
2. Heater matrix 'close-off' flap
3. Distribution main flap
4. Blower
5. Distribution fresh air flap
6. Front footwell air outlets
7. Rear footwells air outlet
8. Windscreen and side window air outlet

B Windscreen/Side Window Demist Distribution Control

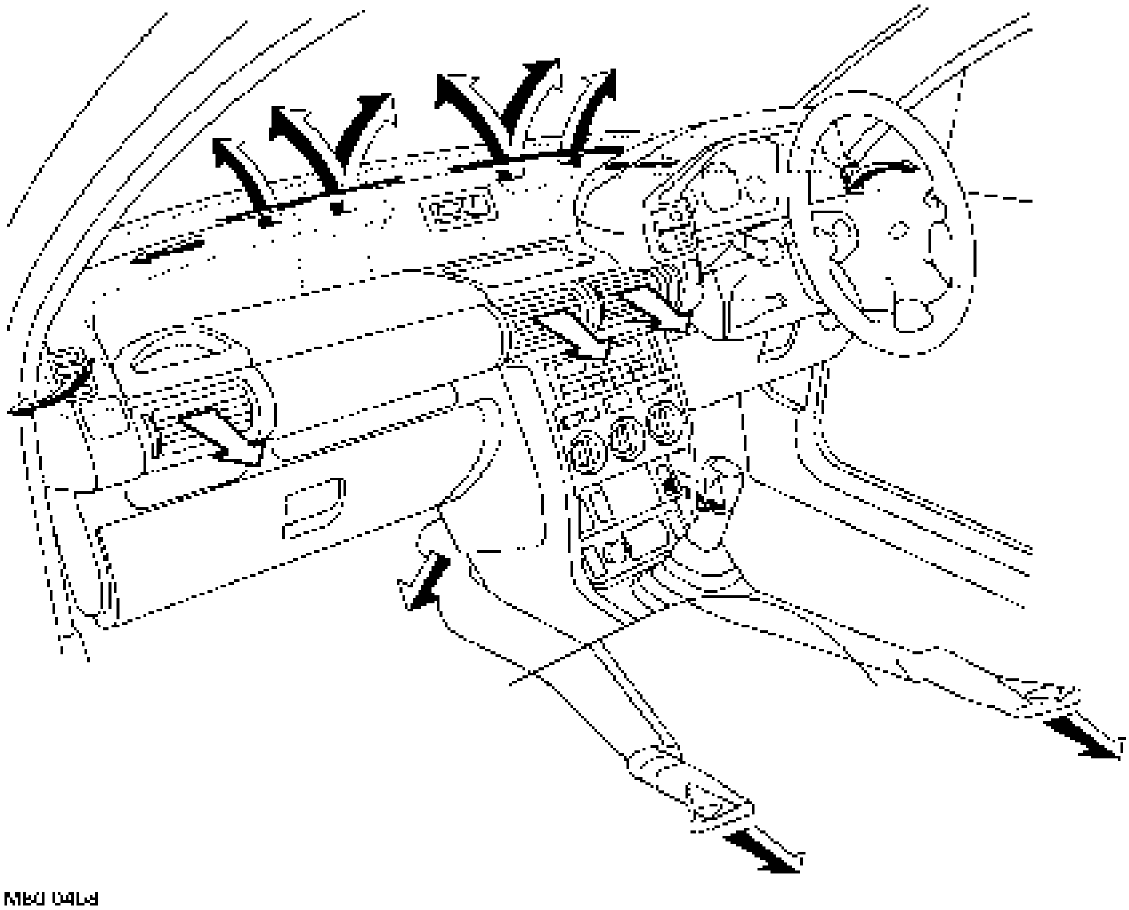
1. Temperature control flap
2. Heater matrix 'close-off' flap
3. Distribution main flap
4. Blower
5. Distribution fresh air flap
6. Windscreen and side window air outlet

Distribution

Air from the heater assembly is distributed around the vehicle interior through fascia and floor level outlets. Fascia outlets consist of fixed vents for the windscreen and side windows, and adjustable vent assemblies for face level air. Floor level outlets consist of fixed vents for the front and rear footwells.

The front footwell vents are integrated into the heater assembly. Two central vent assemblies for face level air are connected directly onto the related outlets of the heater assembly. Air for the rear footwell, outer face level vent assemblies and windscreen/side windows is distributed through ducts.

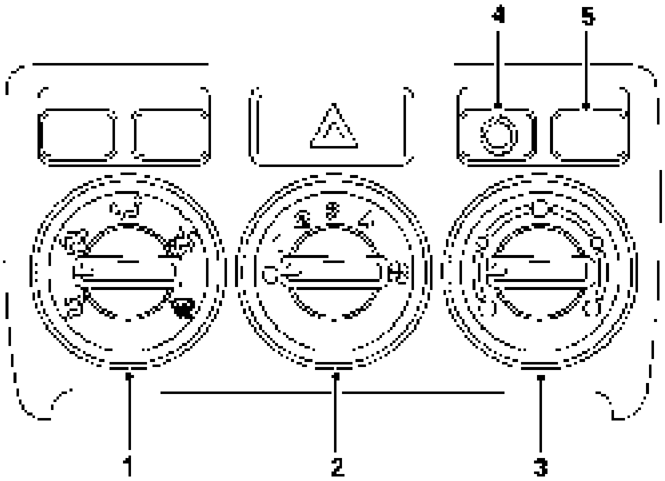
Fascia Outlets



Ducts
The rear footwell ducts extend along each side of the transmission tunnel and vent into the rear footwells from below the front seats. The outer face level ducts attach to the underside of the fascia and connect to the vent assembly at each end of the fascia. The windscreen/side window ducts connect to a duct integrated into the top of the fascia.

Vent Assemblies
The vent assemblies allow occupants to control the flow and direction of face level air. Each vent assembly incorporates a thumbwheel to regulate flow and moveable vanes to control direction.

Heating and Ventilation Controls



M60 0469

1 Distribution control knob
2 Blower fan speed control knob
3 Temperature control knob
4 Fresh/recirculated air selection switch
5 Air conditioning selection switch (where fitted)

Rotary knobs are installed on the centre console to control air distribution, blower speed and air temperature. The air distribution and temperature knobs operate cables connected to the control flaps in the heater assembly. The blower speed knob operates a rotary switch in the blower's electrical circuit. Graphics on the control panel indicate the function and operating positions of the controls.

Operation

Air flow through the heater assembly is directed to the outlets selected by the distribution control knob. The temperature of the air from all except the face level vents depends on the setting of the temperature control knob. Hot air is available from the face level vents only when the temperature control knob is at the maximum heat setting. As the temperature control knob is turned towards cold, the temperature of the air from the face level vents rapidly decreases to ambient (non A/C vehicles) or evaporator outlet temperature (A/C vehicles). The forward speed of the vehicle and the setting of the blower control knob determines the volume of air flowing through the system.

Air Distribution
Turning the distribution knob on the control panel turns the control flaps in the heater assembly to direct air to the corresponding fascia and footwell outlets.

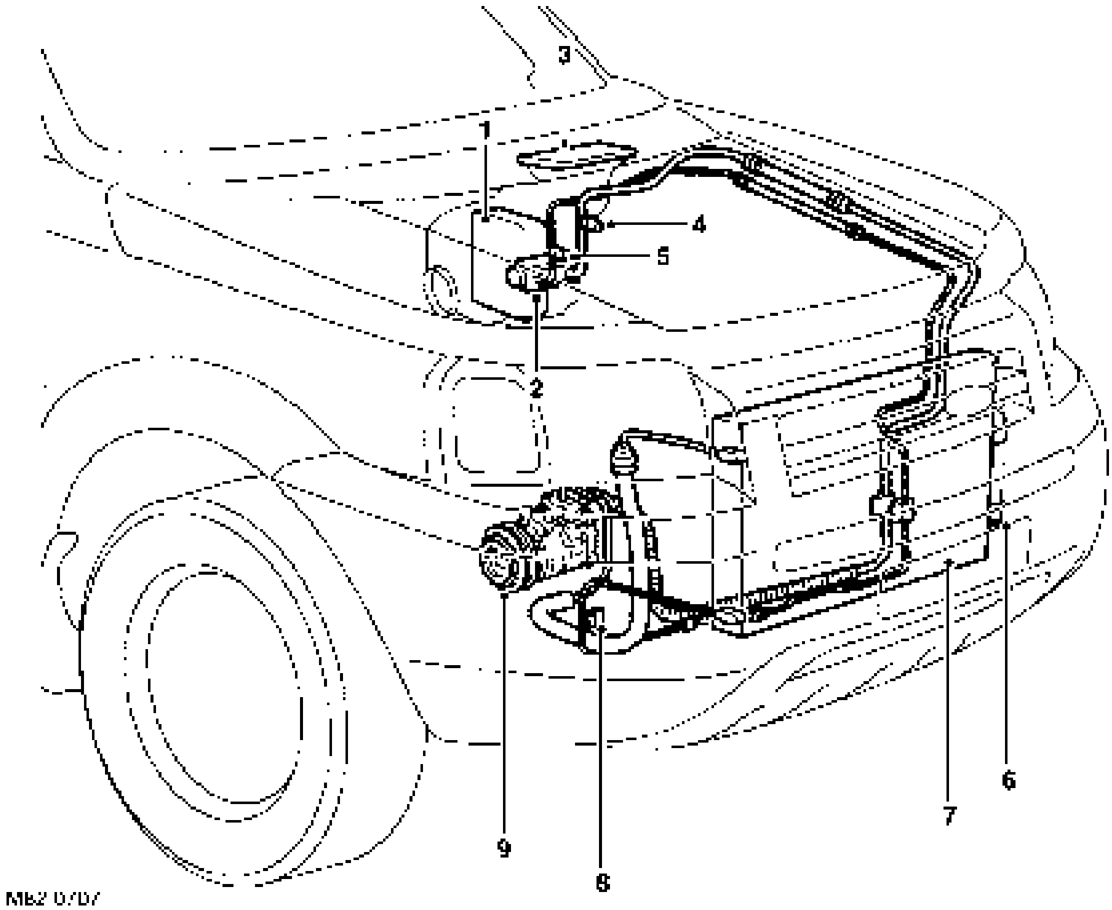
Air Temperature
Turning the temperature knob on the control panel turns the related blend flaps in the heater assembly. The blend flaps vary the proportion of air going through the cold air bypass and the heater matrix. The proportion varies, between full bypass/no heat and no bypass/full heat, to correspond with the position of the temperature knob.

Blower Speed
The blower can be selected 'off', or to run at one of four speeds. While the ignition is on and the blower switch is set to positions 1, 2, 3 or 4, ignition power energises the blower relay, which supplies battery power to the blower. At switch positions 1, 2 and 3, the blower switch also connects the blower to different earth paths through the resistor pack, to produce corresponding differences of blower operating voltage and speed. At position 4, the blower switch connects an earth direct to the blower, bypassing the resistor pack, and full battery voltage drives the blower at maximum speed.

Fresh/Recirculated Inlet Air
When the recirculated air switch is latched in, the indicator LED in the switch illuminates and an earth is connected to the recirculated air side of the fresh/recirculated air servo motor. The fresh/recirculated air servo motor then turns the control flaps in the air inlet duct to close the fresh air inlet and open the recirculated air inlets.

When the latch of the recirculated air switch is released, the indicator LED in the switch extinguishes and the earth is switched from the recirculated air side to the fresh air side of the fresh/recirculated air servo motor. The fresh/recirculated air servo motor then turns the control flaps in the air inlet duct to open the fresh air inlet and close the recirculated air inlet.

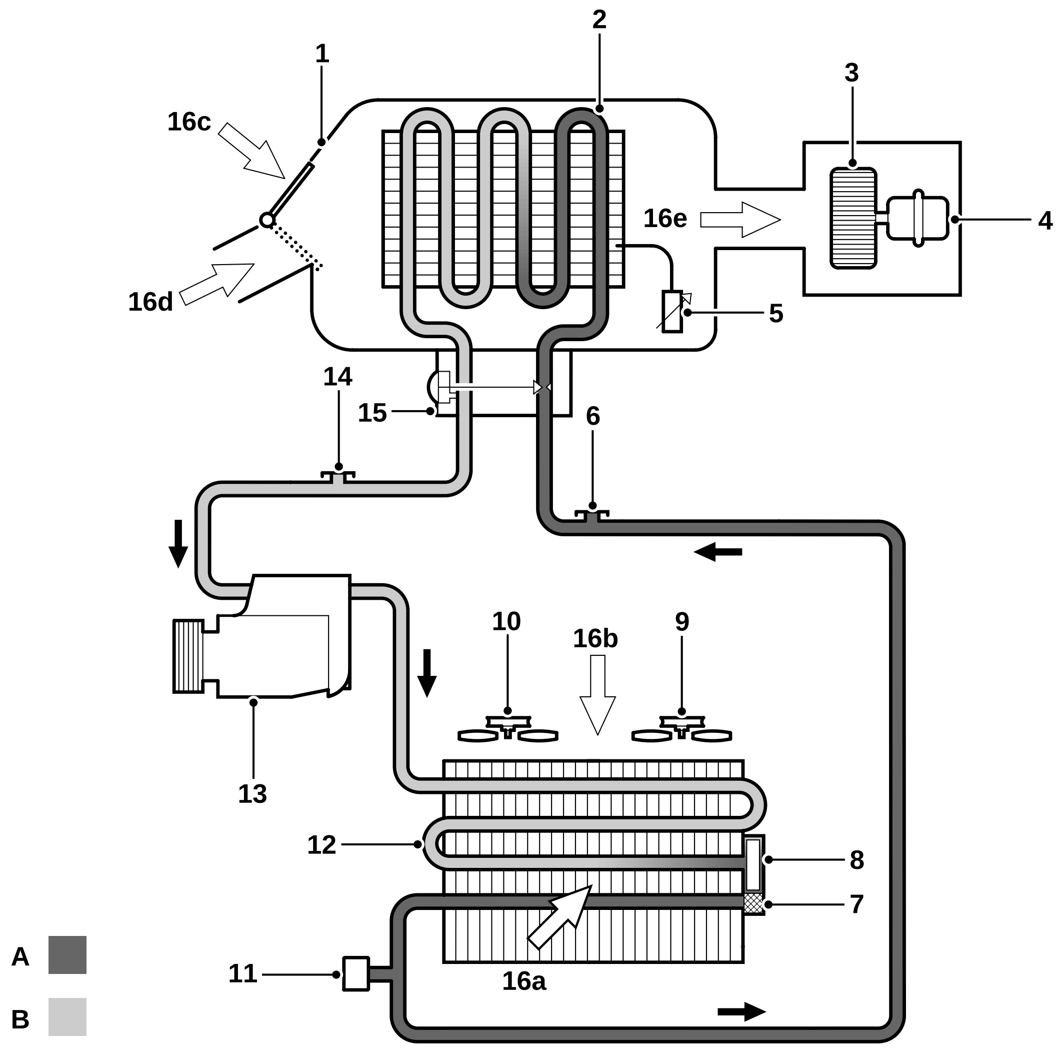
A/C Refrigerant System Component Layout – KV6 Series Engines



RHD shown, LHD similar

1 Evaporator
2 Thermostatic expansion valve
3 Air inlet unit
4 Low pressure servicing connection
5 High pressure servicing connection
6 Modulator
7 Condenser
8 Refrigerant pressure sensor
9 Compressor

A/C System Schematic Layout

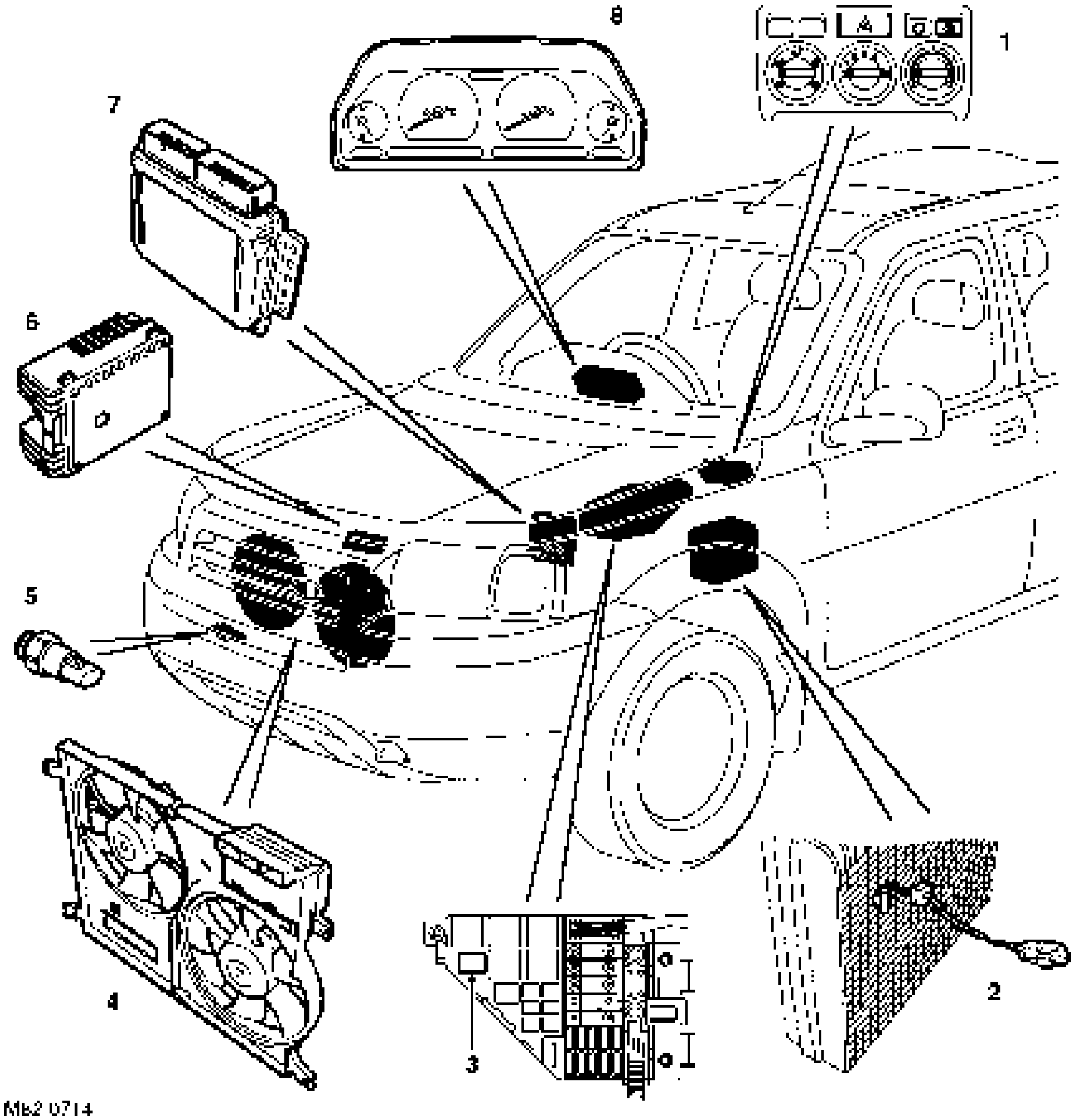


M82 0710

A = Refrigerant liquid; B = Refrigerant vapour

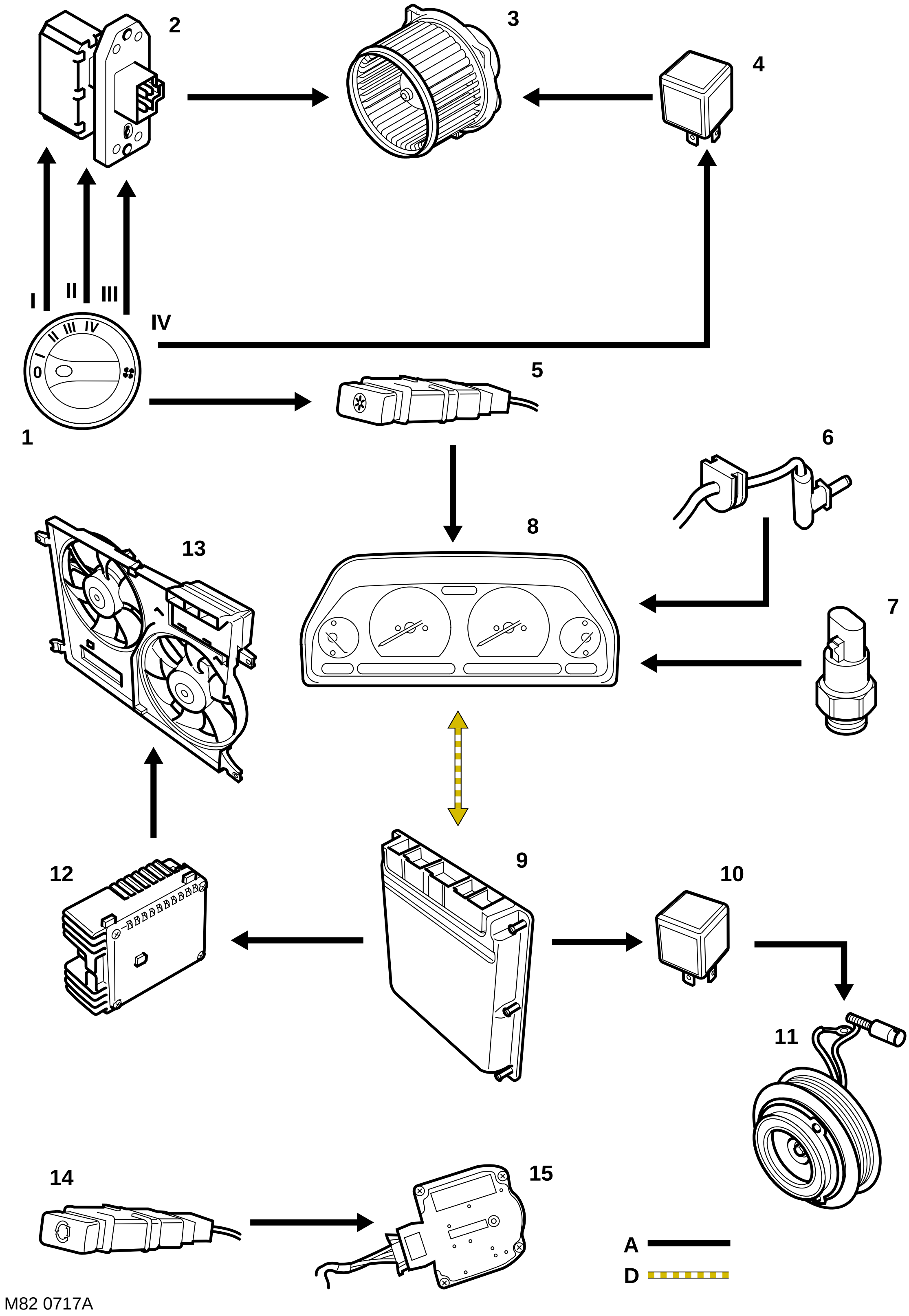
1 Cooling unit
2 Evaporator
3 Blower
4 Heater assembly
5 Evaporator temperature sensor
6 High pressure servicing connection
7 Filter (in modulator)
8 Desiccant (in modulator)
9 Cooling/condenser fan 1
10 Cooling/condenser fan 2
11 Refrigerant pressure sensor
12 Condenser
13 Compressor
14 Low pressure servicing connection
15 Thermostatic expansion valve
16 Air flows:
- **a** Ambient air flow through condenser
- **b** Cooling fan forced air flow through condenser
- **c** Recirculated air flow
- **d** Ambient air flow through evaporator
- **e** Cooled air flow to vehicle interior (via heater assembly)

A/C Control Component Layout



1 Control panel
2 Evaporator temperature sensor
3 Compressor control relay
4 Cooling/condenser fans
5 Refrigerant pressure sensor
6 Cooling/condenser fan controller
7 Engine Control Module (ECM)
8 Instrument pack

A/C System Control Schematic



A = Hardwired; D = CAN Bus

1 Blower switch
2 Resistor pack
3 Blower motor
4 Blower motor relay
5 Air conditioning switch
6 Evaporator temperature sensor
7 Refrigerant pressure sensor
8 Instrument pack
9 Engine Control Module (ECM)
10 A/C compressor clutch relay
11 Compressor clutch
12 Cooling/condenser fan controller
13 Cooling/condenser fans
14 Fresh/recirculated air switch
15 Recirculated air motor

Description

General

Where fitted, the air conditioning system supplies cooled and dehumidified, fresh or recirculated air to the interior of the vehicle. Air is cooled by drawing it through the matrix of an evaporator. The air is then ducted into the heater assembly, from where it is distributed to the vehicle interior through the heating and ventilation system air ducts.

In the heater assembly, the temperature of the air distributed to the vehicle interior can be adjusted by passing a proportion, or all, of the cooled air through the heater matrix. The volume of air being distributed is controlled by the variable speed blower in the heater assembly. For details of temperature control and distribution.

☞ **HEATING AND VENTILATION, DESCRIPTION AND OPERATION, Description.**

The air conditioning system uses a pressure sensor and evaporator temperature sensor to provide operating condition feedback to the engine management system to enable the ECM to predict engine load and run the cooling fans in response to changing atmospheric conditions and driver demand.

Refrigerant System

The refrigerant system is a sealed closed loop system which is charged with Refrigerant R134a as the heat transfer medium. It works in combination with a blower unit, blend unit and control system to achieve the desired air temperature. ND-8 oil is added to the refrigerant to lubricate the internal components of the compressor. The refrigerant system comprises of the following main components connected together by refrigerant lines:

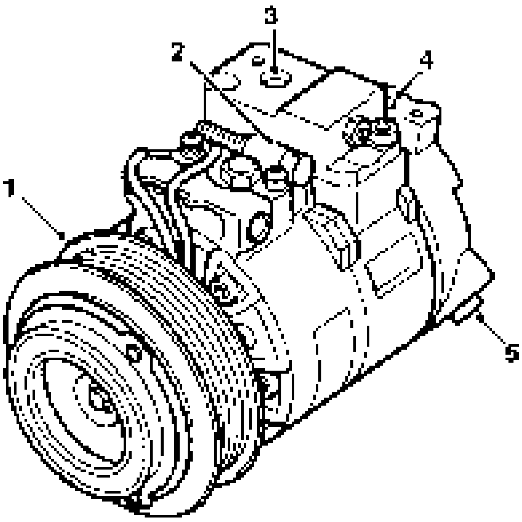
- Compressor (variable load)
- Condenser (with modulator)
- Thermostatic expansion valve
- Evaporator

To accomplish the transfer of heat, the refrigerant is circulated around the system, where it passes through two pressure/temperature regimes. In each of the pressure/temperature regimes, the refrigerant changes state, during which process maximum heat absorption or release occurs. The low pressure/temperature regime is from the thermostatic expansion valve, through the evaporator to the compressor; the refrigerant decreases in pressure and temperature at the thermostatic expansion valve, then changes state from liquid to vapour in the evaporator, to absorb the heat. The high pressure/temperature regime is from the compressor, through the condenser and modulator (receiver/drier), back into the condenser where it is supercooled and then to the thermostatic expansion valve. The refrigerant increases in pressure and temperature as it passes through the compressor, then releases heat and changes state from vapour to liquid in the condenser.

Fan blown air is passed through the evaporator where it is cooled by absorption due to the low temperature refrigerant in the evaporator. Most of the moisture held in the air is condensed into water by the evaporator and drains away beneath the vehicle via a drain tube.

The compressor receives the returned low pressure, warm, vaporised refrigerant from the evaporator to complete the refrigeration cycle.

Compressor



1 Pulley
2 Clutch connector
3 Inlet connection
4 Outlet connection
5 Control valve vent

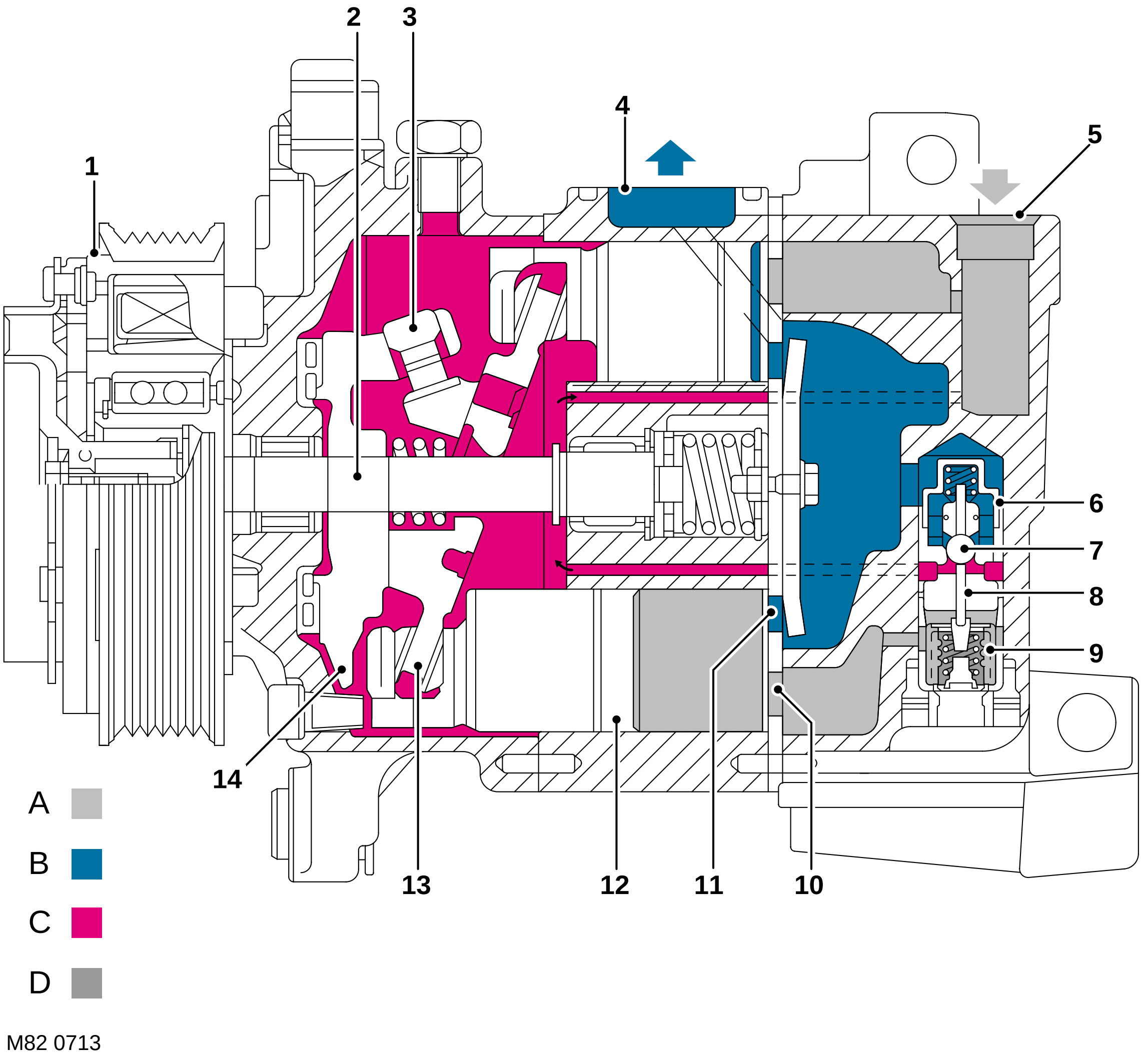
A variable displacement compressor is driven from the crankshaft via the ancillary drive belt. An electro-mechanical clutch is used to engage and disengage the drive between the drive belt pulley and the compressor. Operation of the compressor clutch is controlled by the Engine Control Module (ECM).

Power to the A/C compressor clutch is via the normally open contacts of an associated A/C compressor clutch relay which is located in the engine compartment fusebox. When the coil of the relay is grounded by the ECM, the relay contacts close and the clutch is powered to engage the compressor to the drive belt pulley.

When the compressor is operational, pressurised refrigerant is circulated through the system. The compressor pressurises low pressure, warm, vaporised refrigerant which it receives from the evaporator, causing the refrigerant vapour to become very hot. The high pressure vaporised refrigerant is passed from the compressor to the condenser mounted in front of the radiator. The refrigerant increases in pressure and temperature as it passes through the compressor, then releases heat and changes state from vapour to liquid in the condenser.

The compressor is attached to a mounting bracket on the engine, and is a seven cylinder swash plate unit with variable displacement. Operation of an electrically actuated clutch is controlled by the Engine Control Module (ECM).

Sectioned View of Compressor



A = Inlet pressure; B = Outlet pressure; C = Servo pressure; D = Ambient air pressure

- **1** Clutch and pulley assembly
- **2** Shaft
- **3** Guide pin
- **4** Outlet port
- **5** Inlet port
- **6** Control valve assembly
- **7** Ball valve
- **8** Push rod
- **9** Diaphragm
- **10** Suction valve
- **11** Discharge valve
- **12** Piston
- **13** Swash plate
- **14** Lug plate

The compressor consists of a housing which contains a shaft mounted in radial and thrust bearings. A lug plate is pressed onto the shaft and the clutch and pulley assembly is splined to the end of the shaft at the front of the housing. A swash plate is installed on the shaft and connected to the lug plate by two guide pins. The swash plate is a sliding fit on the shaft and biased away from the lug plate by a spring. The outer circumference of the swash plate is engaged in the ends of seven pistons, which are located in cylinders equally spaced around the housing interior. Two pressure chambers in the rear of the housing are connected to inlet and outlet ports in the housing wall. Suction and discharge valves, between each cylinder and the chambers, control the flow of vapour into and out of the cylinders. A control valve assembly regulates a servo (control) pressure supplied through drillings in the housing of the chamber containing the swash plate.

The control valve assembly consists of a ball valve operated by a push rod connected to a diaphragm. Spring and atmospheric pressure on one side of the diaphragm are opposed by inlet pressure on the opposite side of the diaphragm, and also by outlet pressure and a spring acting on the ball valve. The ball valve controls a flow of vapour from the outlet pressure chamber to produce the servo pressure in the swash plate chamber.

When the engine is running and A/C is off, the clutch is de-energised and the compressor pulley freewheels under the influence of the drive belt. Vapour pressures are equalised throughout the compressor. The spring between the lug plate and the swash plate holds the swash plate at the minimum tilt angle (to minimise load during system start-up).

When A/C is requested, the electro-magnetic clutch is engaged and the pulley turns the central shaft of the compressor. The lug plate and the swash plate turn with the shaft, and the movement of the angled swash plate produces reciprocating movement of the pistons. Vapour from the inlet pressure chamber is drawn into the cylinders, compressed, and discharged into the outlet pressure chamber, producing a flow around the refrigerant circuit.

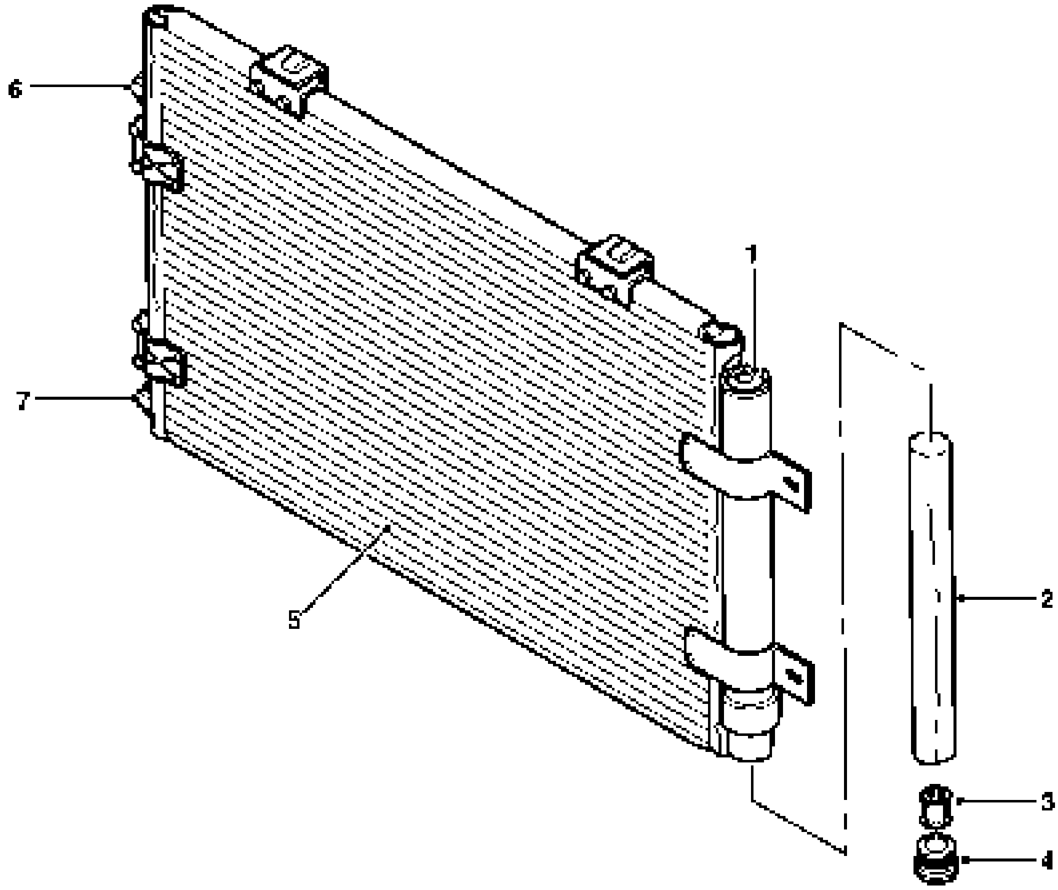
The flow rate through the compressor is determined by the length of the piston stroke, which is controlled by the tilt angle of the swash plate. The tilt angle of the swash plate is set by the servo pressure and compressor inlet pressure acting on the pistons during their induction stroke. A relative increase of inlet pressure over servo pressure moves the pistons along their cylinders to increase the swash plate tilt angle, the piston stroke and the refrigerant flow rate.

The control valve regulates the servo pressure in the swash plate chamber as a function of inlet pressure, so that the flow rate of the compressor matches the thermal load at the evaporator, i.e. the more cooling effort that is required in the cabin of the vehicle, corresponds to a higher thermal load and flow rate. Servo pressure varies between inlet pressure and inlet pressure + 1 bar (14.5 $lbf.in^2$).

On start-up, the compressor inlet pressure is relatively low. In the control valve, the diaphragm and push rod hold the ball valve open. This allows a restricted flow of outlet pressure through the ball valve into the swash plate chamber, which maintains the swash plate at a low tilt angle. As the refrigerant flows through the evaporator and absorbs heat (i.e. as the thermal load increases) the pressure of the vapour entering the compressor increases. In the control valve, the increased inlet pressure causes the diaphragm and push rod to move to close the ball valve. The resultant reduction in swash plate chamber pressure, together with the increase in inlet pressure, causes pistons on their induction stroke to move the swash plate to a higher tilt angle and increase the piston stroke and the refrigerant flow through the compressor. When the thermal load of the evaporator decreases, the subsequent decrease in pressure of vapour entering the compressor causes the control valve to open. This increases the swash plate chamber pressure, which in turn reduces the tilt angle of the swash plate and the refrigerant flow through the compressor.

By matching the refrigerant flow to the thermal load of the evaporator, the variable compressor maintains a relatively constant evaporator temperature of approximately 3 to 4°C (37 to 39°F).

Condenser and Modulator



1 Modulator
2 Desiccant
3 Filter
4 Plug
5 Heat exchanger
6 Outlet connection
7 Inlet connection

The condenser transfers heat from the refrigerant to the surrounding air to convert the vapour from the compressor into a liquid. A modulator mounted on the side of the condenser performs the same basic function as a conventional receiver/drier, in that it incorporates a filter and a desiccant to remove moisture and solid impurities from the refrigerant. The modulator also functions as a reservoir for liquid refrigerant, to accommodate changes of heat load at the evaporator.

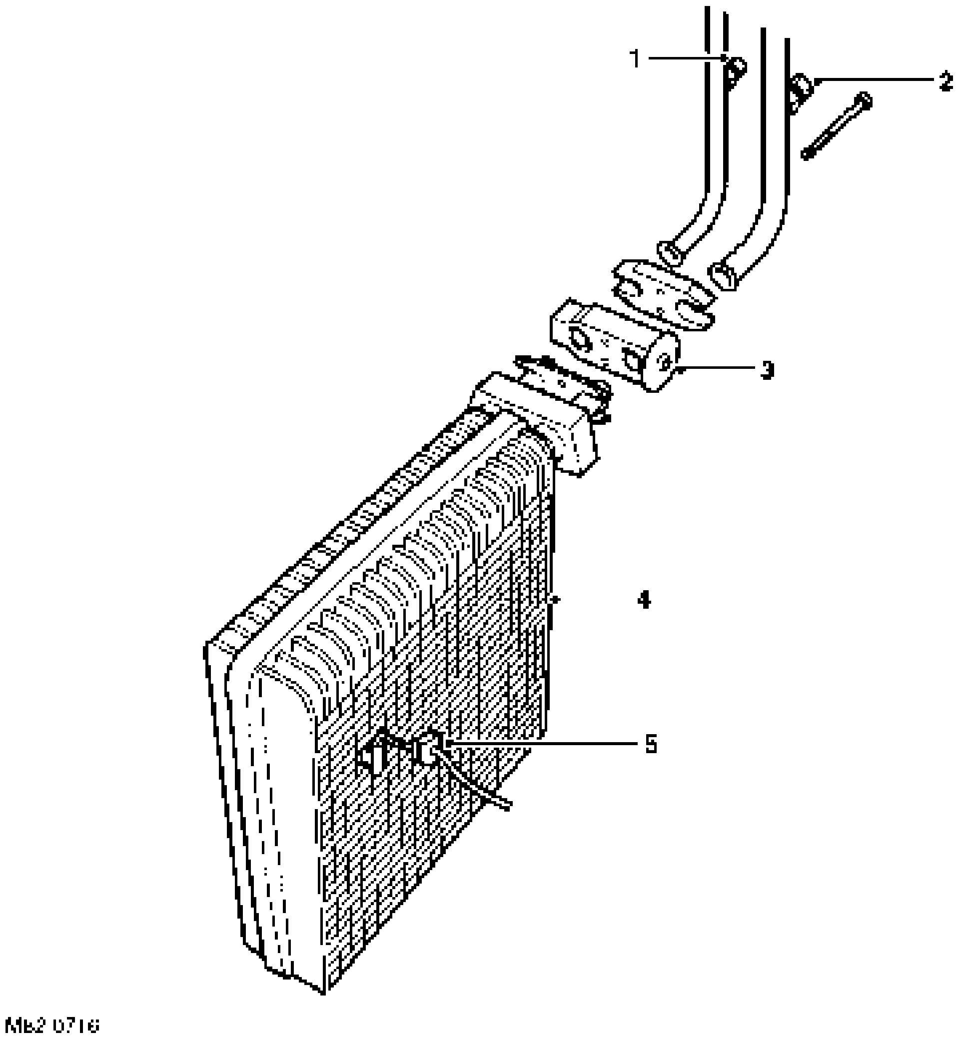
The condenser is installed immediately in front of the radiator. Side mounting brackets on the condenser end tanks locate to mounting points on the front of the radiator using bolts. The modulator on the LH end of the condenser is mounted in a dedicated bracket. Exact mounting position of the condenser unit is dependent on the engine variant for the particular vehicle.

The unit is classified as a sub-cooling condenser and consists of a fin and tube heat exchanger installed between two end tanks. Divisions in the end tanks separate the heat exchanger into a three pass upper (condenser) section and a single pass lower (sub-cooler) section, which are interconnected by the modulator on the LH end of the tank. The modulator is separately serviceable unit from the condenser, and it contains a serviceable desiccant pack and filter retained by a threaded plug.

Ambient air passing through the heat exchanger due to the ram air effect is supplemented by the two cooling fans, which combine to cool the refrigerant in the condenser sufficiently in order to form a high pressure slightly sub-cooled liquid.

The sub-cooled liquid is then passed to the modulator (which performs the same basic function as a standard receiver/drier) which is of a canister type construction located at the LH side of the condenser. In the modulator, most of the remaining gas in the refrigerant separates off and the refrigerant passes through the desiccant and filter, to remove moisture and solid impurities before the refrigerant enters the sub-cooled section of the condenser. The refrigerant is cooled even further as it passes through the sub-cooler section of the condenser, resulting in the refrigerant at the outlet to the condenser being almost 100% liquid.

Thermostatic Expansion Valve (TXV)



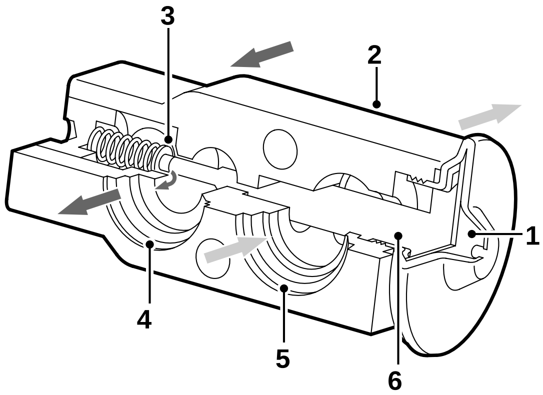
1 High pressure (evaporator inlet) servicing connection
2 Low pressure (evaporator outlet) servicing connection
3 Thermostatic expansion valve (TXV)
4 Evaporator matrix
5 Evaporator temperature sensor

The sub-cooled liquid refrigerant passes from the outlet of the condenser through a pipe to a thermostatic expansion valve (TXV) situated at the engine compartment bulkhead. The TXV connects to the evaporator unit mounted inside the air inlet and blower motor casing in the vehicle cabin.

The thermostatic expansion valve meters the flow of refrigerant into the evaporator, to match the refrigerant flow with the heat load of the air passing through the evaporator matrix.

The thermostatic expansion valve (block valve) incorporates a restrictor which converts the liquid refrigerant into a low temperature, low pressure liquid vapour mixture (fine spray). The valve has an internally located temperature sensing bulb for precise control of superheat. If high temperatures are sensed, the valve opens wider and vice versa.

The thermostatic expansion valve is attached to the inlet and outlet ports of the evaporator, in the cooling unit behind the passenger's side of the fascia. The valve is the parallel charge type, consisting of an aluminium housing containing inlet and outlet passages. A ball and spring metering valve is installed in the inlet passage and a temperature sensor is installed in the outlet passage. The temperature sensor consists of a push rod connected to a diaphragm. The bottom end of the push rod acts on the ball of the metering valve. Pressure on top of the diaphragm is controlled by evaporator outlet temperature conducted through the push rod. The bottom of the diaphragm senses evaporator outlet pressure via internal passages.



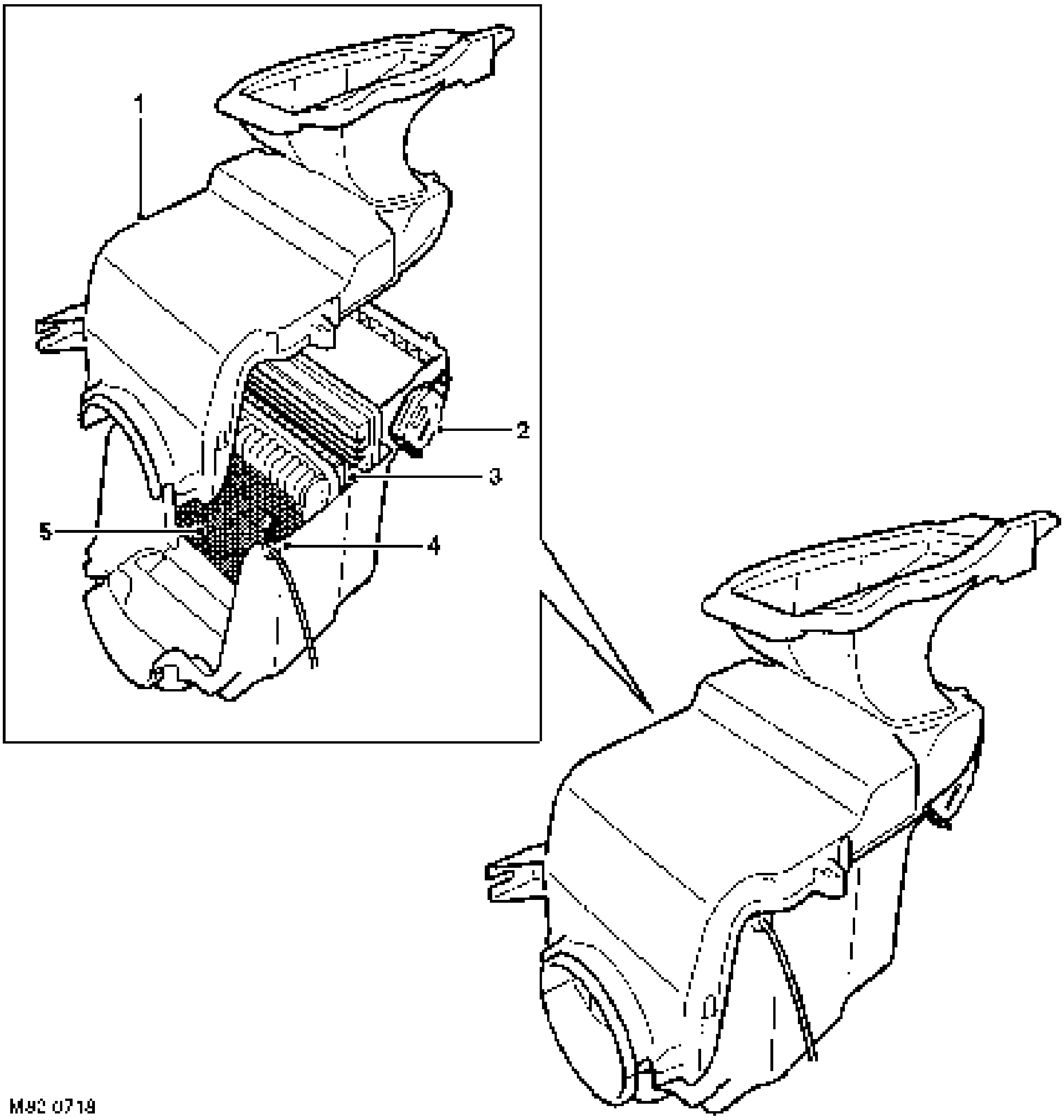
M82 0720

1 Diaphragm
2 Housing
3 Metering valve
4 Inlet passage to evaporator
5 Outlet passage from evaporator
6 Temperature sensitive tube

Liquid refrigerant flows through the metering valve into the evaporator. The restriction across the metering valve reduces the pressure and temperature of the refrigerant. The restriction also changes the solid stream of refrigerant into a fine spray, to improve the evaporation process. As the refrigerant passes through the evaporator, it absorbs heat from the air flowing through the evaporator matrix. The increase in temperature causes the refrigerant to vapourise and increase in pressure.

The temperature and pressure of the refrigerant leaving the evaporator act on the diaphragm and temperature sensitive tube, which move to regulate the metering valve opening and so control the volume of refrigerant flowing through the evaporator. The warmer the air flowing through the evaporator matrix, the more heat available to evaporate refrigerant and thus the greater the volume of refrigerant allowed through the metering valve.

Cooling Unit and Evaporator



1 Evaporator casing
2 Fresh/recirculated air flap motor
3 Pollen filter
4 Evaporator temperature sensor
5 Evaporator matrix

The cooling unit directs the flow of air, from the plenum or the vehicle interior, through the evaporator to the heater assembly.

The cooling unit is installed in place of the air inlet duct used for non air-conditioned vehicles, and contains the evaporator, inlet and outlet pipes connecting to the thermostatic expansion valve through the bulkhead and the evaporator temperature sensor. It also incorporates the water condensate drain and the fresh and recirculated air inlets.

A control flap, operated by a recirculated air motor, opens and closes the fresh and recirculated air inlets. On the downstream side of the evaporator, the casing is lined with polystyrene insulation.

The fin and plate, brazed aluminium evaporator is installed in the cooling unit behind the passenger's side of the fascia, to absorb heat from the exterior or recirculated inlet air. Low pressure, low temperature refrigerant changes from liquid to vapour in the evaporator, absorbing large quantities of heat as it changes state.

Most of the moisture in the air passing through the evaporator condenses into water, which is drained away from the air inlet casing via a drain tube routed to beneath the vehicle.

Refrigerant Lines

To maintain similar flow velocities around the system, the diameter of the refrigerant lines varies to suit the two pressure/temperature regimes. The larger diameters are installed in the low pressure/temperature regime and the smaller diameters are installed in the high pressure/temperature regime. Low and high pressure charging connections are incorporated into the refrigerant lines for system servicing.

Air Conditioning Control System

In conjunction with the Engine Control Module (ECM), the air conditioning control system operates the cooling/condenser fans and the compressor clutch to control the flow of refrigerant through the system.

The air conditioning control system comprises of a compressor clutch relay, an evaporator temperature sensor, a refrigerant pressure sensor, a cooling fan control module and control switches. These controls, in conjunction with the cooling fans, compressor clutch, blower and heater distribution and blend unit, maintain the required environment inside the vehicle with minimal input from the driver.

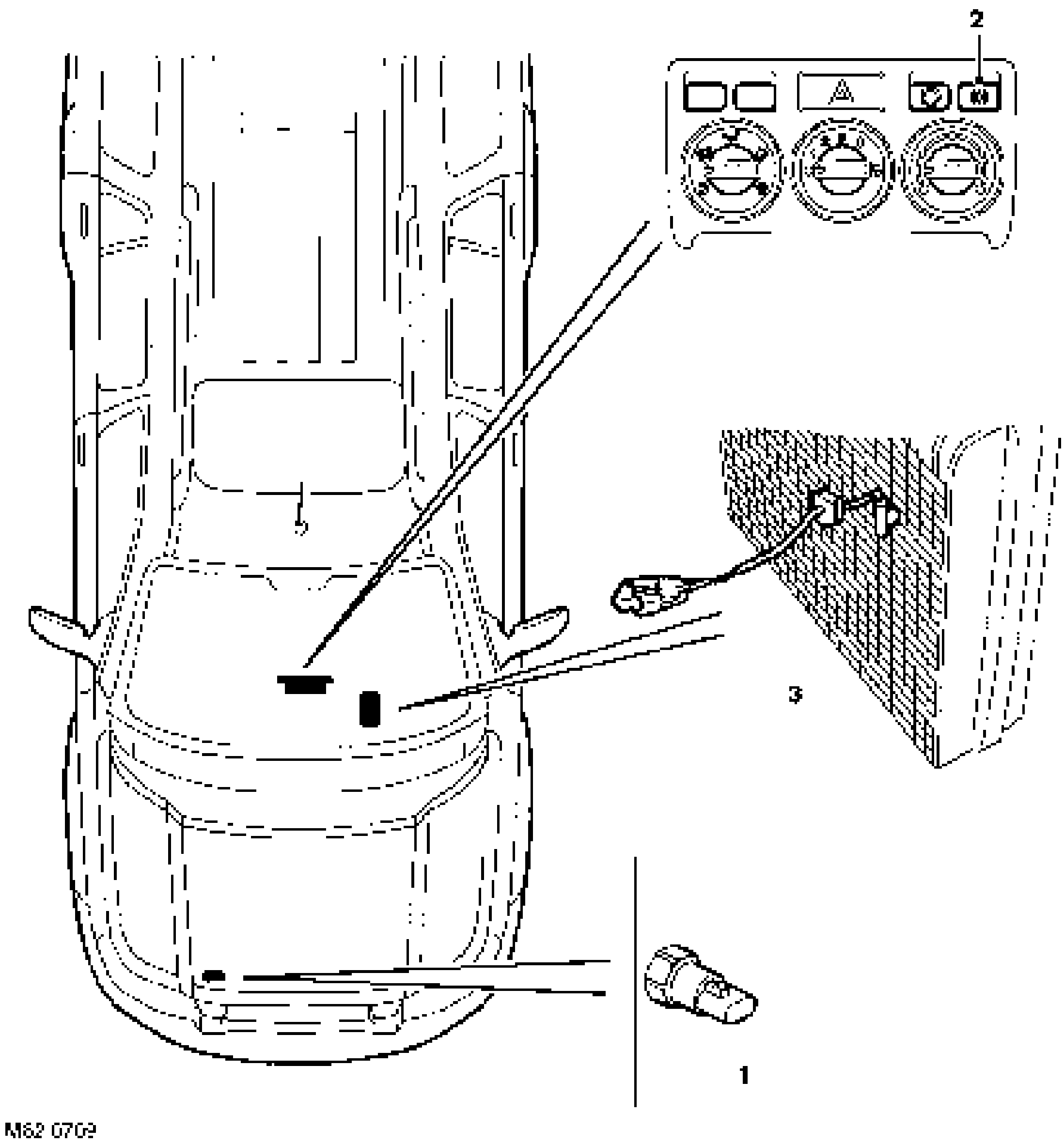
When air conditioning is not selected, air is supplied by ram effect or blower operation to the areas selected by the air distribution control. The air mix flap on the heater assembly blend unit controls the temperature of the air being delivered. No cooled air is available.

☞ **HEATING AND VENTILATION, DESCRIPTION AND OPERATION, Description.**

Selecting air conditioning provides the added facility of cooled air available to be mixed with heated air in the blend unit. When required, a fully cold condition can be selected by turning the temperature control selector to the cold position, this automatically closes the path of inlet air through the heater matrix.

Mixtures of cooled, fresh, and hot air can be selected to give the required interior environmental conditions by selection at the control panel.

Evaporator Temperature Sensor



1 Refrigerant pressure sensor
2 Air conditioning switch
3 Evaporator temperature sensor

The evaporator temperature sensor is a Negative Temperature Coefficient (NTC) encapsulated thermistor installed in the air outlet side of the evaporator. The evaporator temperature sensor is connected to the instrument pack, and the signal is relayed to the ECM from the instrument pack via the CAN Bus.

The temperature signal is used to prevent the air conditioning system from operating when the evaporator is frozen. Frosting of the evaporator cooling fins will cause a reduction in the effectiveness of the cooling system.

If the temperature at the evaporator falls low enough for ice to form on the fins, the ECM withholds or discontinues engagement of the compressor clutch. When the temperature at the evaporator rises sufficiently, the ECM engages the compressor clutch.

The evaporator temperature sensor is also used in conjunction with the refrigerant pressure sensor to facilitate compressor load prediction for optimum idle speed control and load management. The A/C system places an extra load on the engine when the compressor is operating, so the ECM automatically adjusts the idle speed to compensate for the additional load.

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

Refrigerant Pressure Sensor

The refrigerant pressure sensor is located in the refrigerant lines. On LHD vehicles with KV6 engines it is located at the RH side of the engine compartment close to the outlet from the condenser in the refrigerant line leading to the thermostatic expansion valve. On all other engine/vehicle derivatives the sensor is located in the same refrigerant line at the LH side of the engine compartment. The refrigerant pressure sensor provides the ECM with a pressure input from the high pressure side of the refrigerant system.

The ECM uses the signal from the refrigerant pressure sensor to protect the system from extremes of pressure, by disengaging the compressor clutch. The signal is also used for cooling fan control. The temperature sensor used has a low pressure range of 0 – 600 psi and provides the following functions:

- Provide a safety cut-out function if the refrigerant pressure goes either too high or too low.
- Indicate when the refrigerant pressure reaches such a point that additional cooling is required – if the pressure reaches the medium point, the cooling fans will be switched to high speed.
- The pressure sensor is used in conjunction with the evaporator temperature sensor to predict compressor load for load management at idle/part throttle.

The refrigerant pressure sensor is connected to the instrument pack, and the signal is relayed to the ECM from the instrument pack via the CAN Bus.

Because the compressor is lubricated by oil suspended in the refrigerant, a low pressure signal from the sensor is used by the ECM to prevent operation of the compressor unless there is a minimum refrigerant pressure, and thus refrigerant and oil in the system.

Control Switches

The control switches consist of two latching push switches installed in the centre console, an air conditioning switch and a fresh/recirculated air switch. Each switch contains an amber indicator lamp which illuminates when air conditioning or recirculated air is selected, as applicable.

The A/C switch is supplied with a positive feed through the blower motor switch when one of the four blower speeds is selected. When the A/C switch is selected, a signal is supplied to the instrument pack through a hard wire connection. The instrument pack interprets the A/C request signal and transfers the request to the ECM via the CAN bus.

☞ **INSTRUMENTS, DESCRIPTION AND OPERATION, Description.**

On vehicles from 2003 model year, an automatic A/C on feature is introduced. This feature automatically selects A/C on when the air distribution control is moved to the feet/screen or screen positions. A microswitch, which is operated by the distribution control knob, is wired in parallel with the A/C switch and has the same functionality. The automatic on function cannot be overridden and there is no indicator lamp to display when the A/C is active. The blower motor switch must be in positions 1 to 4 before the automatic on function will operate.

Compressor Clutch Relay

The compressor clutch relay switches power to the compressor clutch under the control of the ECM. The relay is located in the engine compartment fusebox. The compressor clutch is energized to engage and de-energized to disengage.

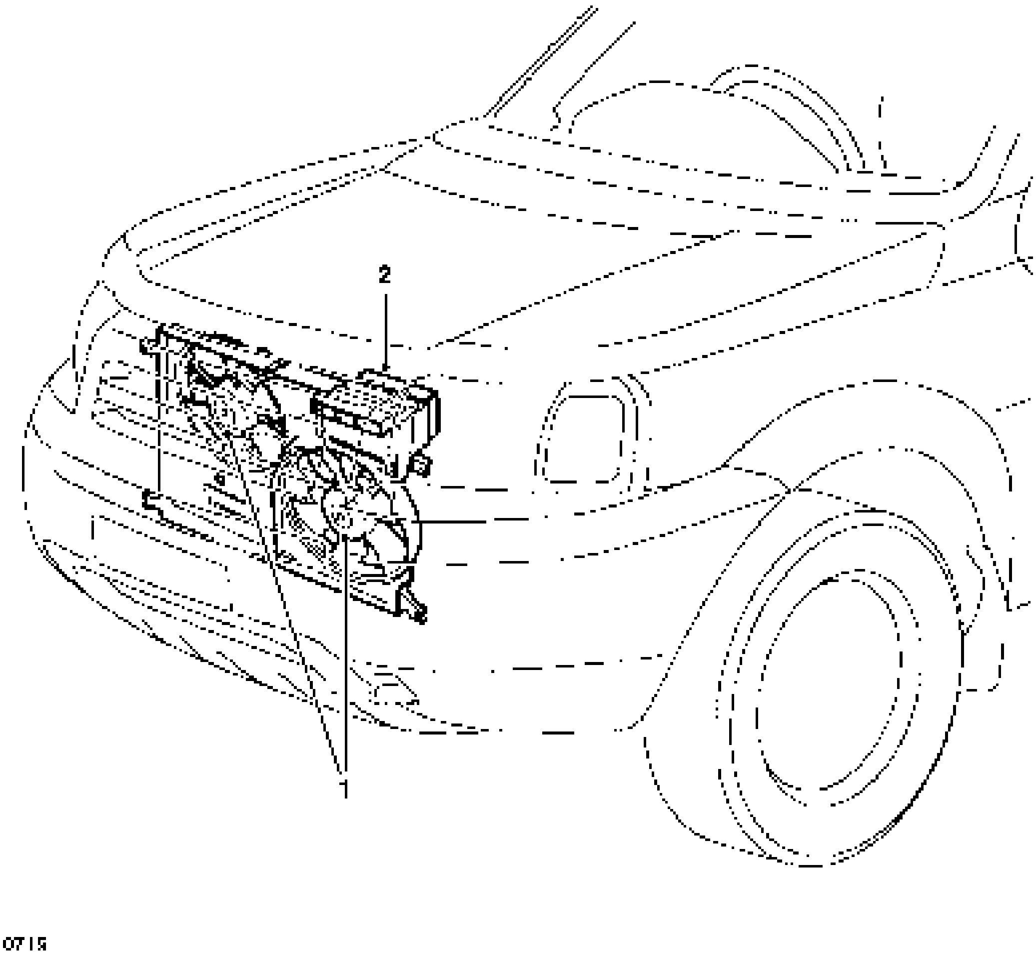
Compressor

Operation of the clutch is controlled by the engine control module (ECM). To protect the refrigerant system from unacceptably high pressure, a pressure relief valve is installed in the outlet side of the compressor. The pressure relief valve is set to operate at 3430 kPa (497.5 lbf.in) and vents excess pressure into the engine compartment.

The ECM controls the operation of the compressor via the compressor clutch relay in the engine compartment fuse box. When the A/C switch is used to request air conditioning, the ECM energises the compressor clutch relay to supply a power feed to the compressor clutch. Engagement of the compressor clutch is withheld, or discontinued, if refrigerant pressure exceeds upper or lower pressure limits:

- The upper pressure limit is 29 bar (421 lbf/in^2), e.g. due to a blockage. Compressor engagement is re-enabled when the pressure decreases to 23 bar (334 lbf.in^2).
- The lower pressure limit is 1.6 bar (23.2 lbf/in^2), e.g. due to a leak. Compressor engagement is re-enabled when the pressure increases to 2.0 bar (29.0 lbf/in^2).

Cooling and Condenser Fans



1 Cooling and condenser fans

2 Cooling/condenser fan controller

The cooling fans operate automatically whenever the air conditioning system is switched on, provided the system pressure is correct. The motors of the two fans are variable speed and are switched together in parallel.

The ECM controls the operation of the variable speed cooling fans via a cooling fan controller installed on the back of the cooling fan assembly. The control signal from the ECM to the fan controller is a pulse width modulated (PWM) signal. The output from the ECM runs from 10% to 90%, corresponding to 0% to 100% fan current output from the interface. PWM signals below 10% or greater than 90% correspond to open and closed loop circuit failures, which can be diagnosed using Testbook. The cooling fan controller receives the PWM signal and regulates the power feeds to the cooling fans accordingly to produce the required fan speed.

When air conditioning is selected, the cooling fans initially operate at minimum speed. If the pressure increases to 16 bar (232 lbf/in^2), the speed of the fans progressively increase up to a maximum speed at 27 bar (392 lbf/in^2). When the fans are at maximum speed, if the refrigerant pressure decreases, the speed of the fans progressively decrease down to a minimum speed at 15 bar (218 lbf/in^2). Operation of the cooling fans is also affected by coolant temperature.

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

Operation

General
Air conditioning operates only while the engine is running and the blower in the heater assembly is on (any speed). Fresh or recirculated air can be selected with or without the air conditioning being on, provided the ignition is on.

Air Conditioning
When the air conditioning switch is selected on, the indicator lamp in the switch illuminates and an air conditioning request signal is input to the ECM via the instrument pack and CAN Bus.

On vehicles from 2003 model year, when the automatic on function is selected on, an air conditioning request signal is input to the ECM via the instrument pack and the CAN bus.

The air conditioning request signal consists of a positive voltage supply via the blower switch and A/C switch, hard wired to the instrument pack. The instrument pack interprets the A/C request signal and informs the ECM of the condition using a message on the CAN Bus.

The signals from the refrigerant pressure sensor and the evaporator temperature sensor are supplied to the instrument pack, which calculates the additional engine load and the cooling fan speed and transmits them to the instrument pack on the CAN Bus.

On receipt of the air conditioning request signal, the ECM switches air conditioning on by signalling the compressor clutch relay module to engage the compressor clutch and the cooling fan controller to run the cooling fans at the appropriate speed using a PWM signal. The engine drives the compressor to circulate the refrigerant. The blower draws fresh or recirculated air through the evaporator. As the air flows through the evaporator, moisture condenses out from the relatively warm air onto the cold evaporator. The dehumidified air is then fed into the heater assembly, from where it is distributed to the vehicle interior.

When the air conditioning switch is selected off, or if the blower is selected off, the indicator lamp in the air conditioning switch extinguishes and the air conditioning request signal is removed from the ECM.

On vehicles from 2003 model year, when the automatic on function is selected off, or the blower is selected off, the air conditioning signal is removed from the ECM.

The ECM then switches air conditioning off by signalling the relay module to disengage the compressor clutch and cooling fan controller to terminate the operation of the cooling fans.

Blower Control
The blower can be operated at any one of four speeds by rotating the blower switch to the required position. When the blower is switched off the air conditioning system will not operate.

The fresh air/recirculation flap has two positions and is operated by pressing the button in the centre console. In the recirculation position, air is drawn into the heater from the vehicle by closing the exterior air inlet and opening the interior inlet. In the fresh air position, air is drawn into the heater from outside the vehicle by opening the exterior air inlet and closing the interior inlet.

Heater Distribution and Blend Unit Control

Blower unit air flow, having passed through the evaporator passes into the heater blend unit to be heated, if required. It is then directed into the vehicle interior in accordance with the flap positions, which are designated by the air distribution control on the fascia panel. A heater flap controls the amount of air flowing through the heater matrix, this flap is moved in response to temperature selection using the knob on the control panel.

The distribution control moves the flaps which control the direction of the air flow into the interior of the vehicle.

Compressor and Cooling Fan Operating Conditions

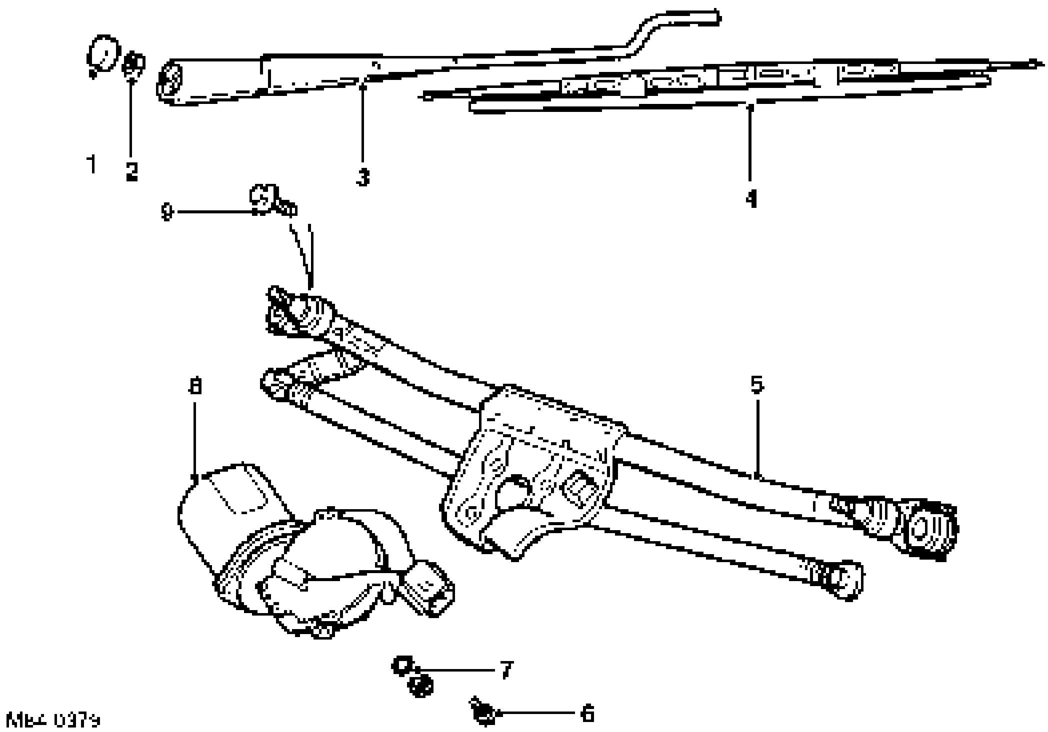
The Engine Control Module (ECM) controls the compressor and cooling fan operation in response to signals received from the refrigerant pressure sensor, evaporator temperature sensor and engine coolant temperature sensor, either directly or on the CAN Bus from the instrument pack. The refrigerant pressure can be low, medium or high, the system operating characteristics applicable for each condition is shown in the following table:

A/C Compressor On/ Off	Refrigerant Pressure Sensor Operating Range	Action
Off	MED range	Air Con MED limit reached, cooling fans switched to High speed.
Off	NORMAL range	Normal Condition, Low fan speed - no additional action
Off	HIGH range	COMPRESSOR NOT ALLOWED TO BE TURNED ON, cooling fans at high speed
Off	LOW range	COMPRESSOR NOT ALLOWED TO BE TURNED ON*
On	MED range	Air Con MED limit reached, cooling fans to High speed
On	NORMAL range	Standard condition, low fan speed - no additional action
On	HIGH range	AIR CON COMPRESSOR MUST BE DISENGAGED IMMEDIATELY, cooling fans set to High speed.
On	LOW range	AIR CON COMPRESSOR MUST BE DISENGAGED IMMEDIATELY*

* With pressure below the low pressure limit, the cooling fans will always be off unless air conditioning is running whilst evaporator temperature drops below minimum. If evaporator temperature drops below minimum, the cooling fans are required to prevent cabin temperature cycling.

The engine management system also drives fan speed based on engine temperature. A faster cooling fan request from either the engine cooling control or the A/C system will override another slow cooling fan speed request.

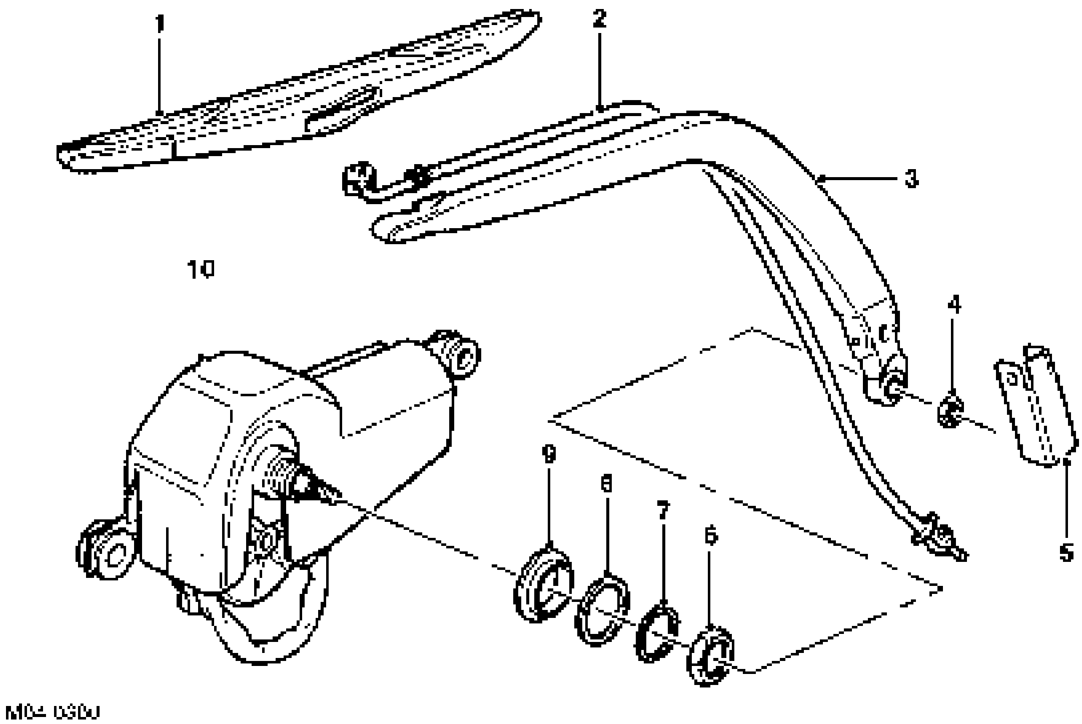
Windscreen Wiper Components



RHD shown, LHD mirror image

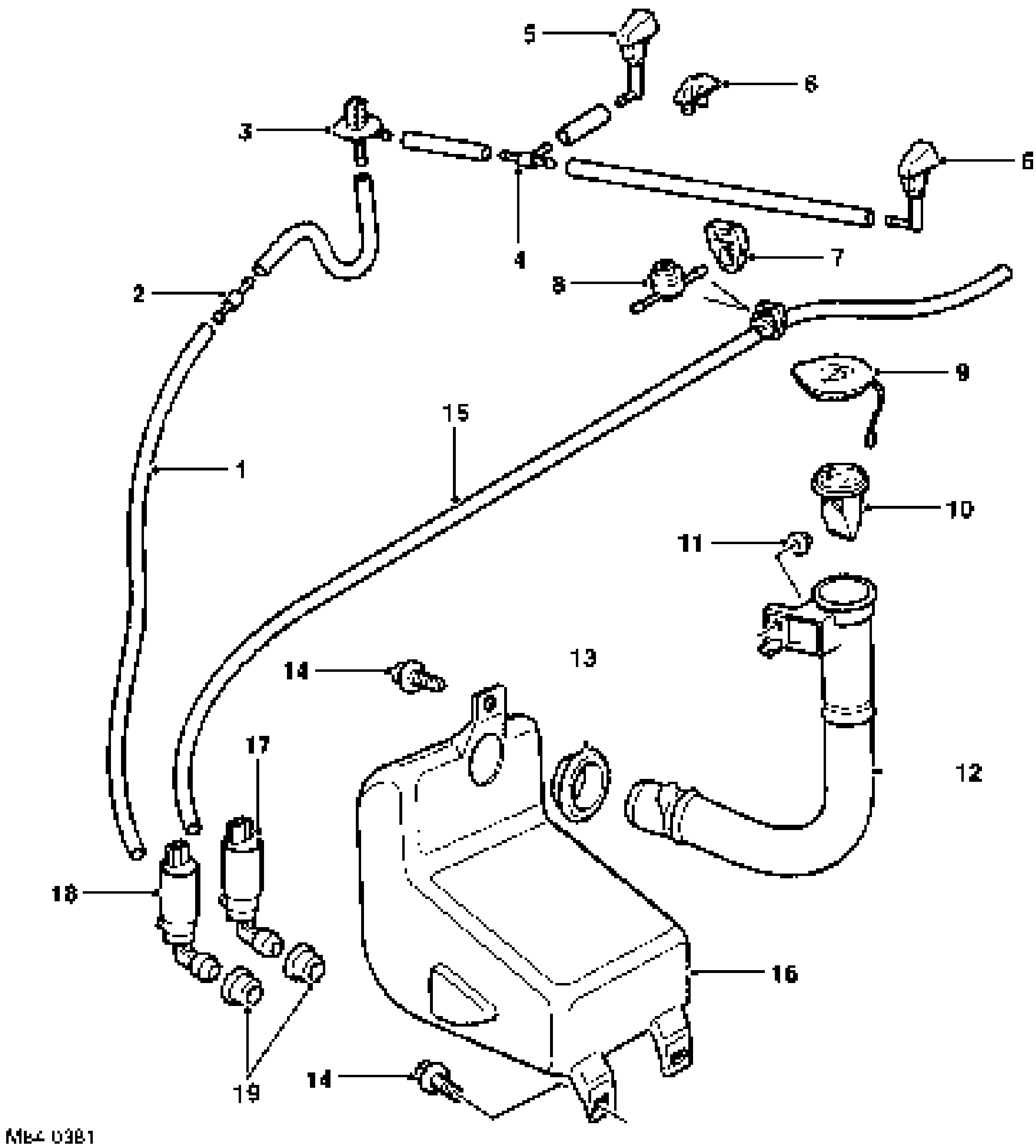
- **1** Cap, 2 off
- **2** Nut, 2 off
- **3** Wiper arm, 2 off
- **4** Wiper blade, 2 off
- **5** Wiper link assembly
- **6** Motor mounting bolt, 3 off
- **7** Nut and washer
- **8** Wiper motor
- **9** Mounting bolt, 3 off

Rear Screen Wiper Components



- **1** Wiper blade
- **2** Washer jet and hose
- **3** Wiper arm
- **4** Nut
- **5** Cover
- **6** Nut
- **7** Washer
- **8** Rubber washer
- **9** Rubber spacer
- **10** Wiper motor

Washer Components



1 Windscreen washer hose
2 Non return valve
3 Connector elbow
4 Connector 'T' piece
5 Washer jet, 2 off
6 Washer jet holder, 2 off
7 Hose clip
8 Non return valve
9 Filler cap
10 Filler filter
11 Mounting nut
12 Filler neck tube
13 Filler neck seal
14 Mounting bolt, 3 off
15 Rear screen washer hose
16 Washer reservoir
17 Rear screen washer pump
18 Windscreen washer pump
19 Grommet, 2 off

Description

Windscreen Wipers
Two front windscreen wipers are operated by a single electric motor. The motor and a link assembly are located below the plenum grill at the base of the windscreen.

The link assembly is handed for left and right hand drive vehicles. All other wiper components remain common to both versions. The component descriptions and operation are the same for both left and right hand drive.

The parallel coupled link assembly comprises a curved galvanized tube which has a cast wheel box pushed into each end of the tube and crimped for retention. A galvanized link arm is attached to a lever at the base of each wheel box.

Each link is attached by a spherical bearing which is permanently attached to the lever and the link. The opposite end of each link also has a spherical bearing, which are both attached to a spigot which in turn is attached to a lever. The lever has a splined bore and mates with a splined shaft from the motor. A spring washer and nut secure the lever to the shaft.

Each wheel box comprises a cast housing, through which a splined shaft is located on bearings. The outer end of each shaft has splines which provide positive location for the wiper arms. The link assembly is a sealed unit and is not serviceable. The motor is attached to the link assembly with three bolts. The motor can operate at two speeds for fast and slow wiper operation. The motor is a DC motor with permanent magnets. The central shaft of the motor is fitted with a worm drive which in turn rotates a gear connected to the splined drive shaft.

A wiper arm is located on the splined shaft of each wheel box and secured with a nut. The wiper arm attachment to the splined shaft has a pivot to which the remainder of the arm is attached. The two parts of the arm are connected by a spring which controls the pressure of the blade on the screen to a predetermined amount.

Each wiper blade is attached to its wiper arm with a clip that allows the blade to pivot. Each wiper blade comprises a number of levers and yokes to which the rubber wiper is fitted. The levers and yokes ensure that the pressure applied by the arm spring is distributed evenly along the full length of the blade. The rubber wiper is held in the yokes by a pair of stainless steel strips, which also distribute the spring pressure evenly. The driver's side wiper blade is fitted with an aerofoil, which presses the wiper blade onto the windscreen at high speed. This prevents the wiper blade from lifting off the screen and maintains the wiping performance.

Rear Screen Wiper
The rear screen wiper is attached to a splined shaft which is driven by an electric motor via an eccentric drive mechanism.

The motor is a single speed dc motor with permanent magnets. The motor shaft is fitted with a worm drive which rotates a gear wheel. The gear wheel has an offset spigot to which an eccentric cam is fitted which can rotate through 180° in each direction. A coil spring is located around the cam and operates as a simple friction clutch to enable the cam to be rotated when the motor is driven in reverse. A connecting link is attached to the cam and drives two gears located in a link. The connecting link converts the rotary motion of the gear wheel into linear movement of the link. The linear movement is converted back into rotary movement of the splined shaft which moves the wiper arm in an arc in two directions across the rear screen.

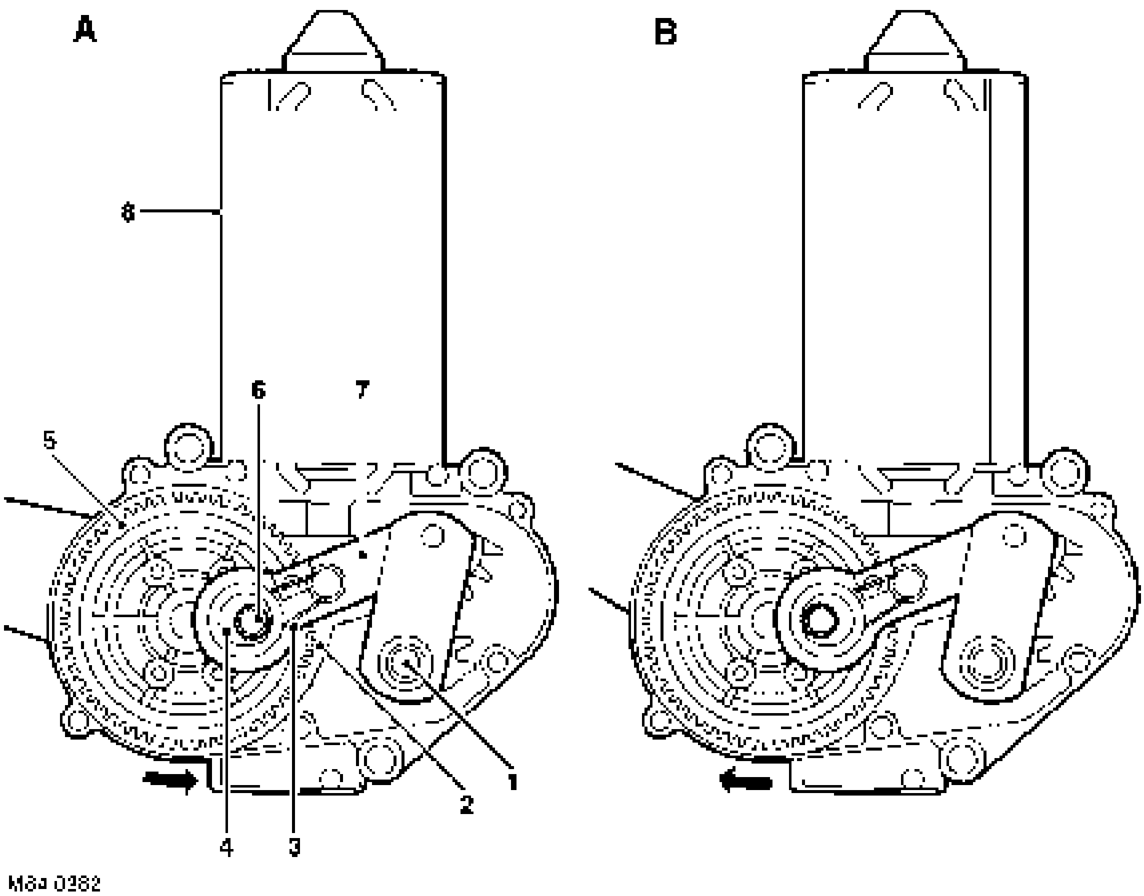
The wiper motor has the ability to park the wiper arm off the rear screen when the wiper is selected off. When the motor is operating to wipe the rear screen, the motor shaft is rotating in a clockwise direction. When the rear screen wiper is selected off, the Central Control Unit (CCU) allows the wiper arm to reach the vertical position on the screen. A microswitch, actuated by a slip ring on the underside of the gear wheel, signals that the wiper arm has reached this position. The CCU then reverses the polarity of the supply to the motor which causes the motor shaft to rotate in an anti-clockwise direction.

When the motor changes direction, the eccentric cam is rotated through 180° which effectively lengthens the linear movement of the connecting link. This causes the wiper arm to sweep across the screen to its park position. The longer linear movement of the connecting link, causes the wiper arm to rotate further than during normal wiping, parking the wiper arm and blade off screen. A second slip ring operated microswitch, on the underside of the gear wheel, signals the CCU that the wiper arm has reached the off screen position and the CCU removes the supply to the rear screen wiper motor.

The wiper arm is located on the splined shaft from the motor and secured with a nut. The wiper arm attachment to the splined shaft has a pivot to which the remainder of the arm is attached. The two parts of the arm are connected by a spring which controls the pressure of the blade on the screen to a predetermined amount.

The wiper blade is pushed onto the wiper arm which has a clip-on feature that allows the blade to pivot. The wiper blade comprises a lever, two yokes and a plastic strip. The rubber wiper is fitted to the plastic strip and held in the yokes. The lever, yokes and plastic strip ensure that pressure applied by the arm spring is distributed evenly along the length of the blade.

Rear Screen Wiper Operating Principle



A = Motor operating (forward operation - wiper at bottom of screen)
B = Park position (reverse operation - off-screen parked)

1 Splined shaft
2 Motor worm drive
3 Coil spring
4 Cam
5 Gear wheel
6 Spigot
7 Link
8 Motor

Windscreen Washers
The windscreen washers consist of two washer jets located on the top surface of the bonnet. Each washer jet contains two adjustable outlets which can be moved to obtain the correct coverage of the windscreen. The two washer jets are connected in series to a flexible pipe which is routed in the electrical harness to a washer reservoir. The reservoir is located inside the RH front wheel arch behind the wheel arch liner. A non-return valve is located in the feed pipe to the windscreen washer jets to prevent washer fluid siphoning back to the reservoir.

The reservoir is moulded from plastic and has a capacity of approximately 4.0 litres (1.0 US gallon). The reservoir has two ports which allow for the attachment of two washer pumps. The flexible pipe from the windscreen washer jets is connected to the forward of the two electric washer pumps. The reservoir has a filler tube which protrudes into the engine compartment. The tube is sealed by a removable cap. A filter is located in the neck of the filler tube and prevents the ingress of particulate matter when replenishing the reservoir. The filter can be removed for cleaning.

Rear Screen Washer
The rear washer uses the same reservoir as the windscreen washers. A second electric washer pump is fitted to the reservoir and supplies washer fluid, via a pipe located in the wiring harness, to a single washer jet which is fitted in the rear wiper arm. The washer jet has four outlets which direct washer fluid to each side of the wiper blade. A non-return valve is located in the feed pipe to the rear screen washer jet to prevent washer fluid siphoning back to the reservoir.

Operation

General
The wipers and washers operate only while the ignition switch is in position II. Operation of the rear screen wiper and washer is prevented or discontinued if the tail door opens, the tail door window is lowered or, on 3 door models, the roof is opened (soft back) or removed (hard back).

Windscreen Wipers
The wash/wipe stalk, located on the RH side of the steering column, and the CCU control the operation of the wipers. Intermittent wipe, slow speed and fast speed are selected using a rotary wiper control switch on the stalk. A flick wipe function can be selected using the stalk. The CCU is responsible for the operation of the intermittent wipe facility and the park facility when the wipers are turned off.

Intermittent Wipe
When intermittent wipe is selected, the wipers operate at slow speed with a delay between wipes. A five position rotary potentiometer, inboard of the wiper control switch, varies the time delay of the intermittent wipe function. The CCU monitors the resistance through the rotary potentiometer and adjusts the time delay to suit the position selected.

The following table details the resistance at each rotary potentiometer position and the corresponding time delays:

Switch Position	Switch Resistance, Ω	Delay, Seconds
1	0	3 ± 1
2	1600 ± 80	5 ± 1
3	3200 ± 160	8 ± 2
4	4800 ± 240	12 ± 2
5	6400 ± 320	17 ± 3
Default	Open circuit	8 ± 2

Slow and Fast Speeds
Slow and fast speed operation is achieved by three brushes in the motor. One brush is the common earth. The slow speed is initiated by a brush positioned 180° to the common brush. The fast speed is initiated by a brush positioned at approximately 45° to the common brush. The fast speed operates by the brushes transferring direct current to a smaller portion of the armature coils, which causes the armature to rotate faster, but with a lower torque than the slow speed.

Flick Wipe
The wipers perform a single wipe at fast speed if the wash/wipe stalk is momentarily moved down. If the stalk is held down the wipers operate at fast speed until the stalk is released.

Rear Screen Wiper
The rear screen wiper is controlled from a latching push switch, located on the RH side of the instrument pack cowl, and the CCU. The wiper operates only while the tail door window is closed and, on 3 door models, the roof is closed (soft back) or on (hard back).

The CCU operates the wiper motor via a dual, forward/reverse relay installed above the RH rear suspension turret. The forward relay is energised when the wiper is operating in intermittent and continuous modes. The reverse relay is energised to reverse the rotational direction of the motor to activate the off-screen park function.

Intermittent
When the rear window wiper switch is selected on, the CCU initially operates the wiper continuously for approximately 6 seconds (3 or 4 wipes) and then changes to intermittent operation with a fixed delay of five seconds between wipes.

Continuous
When reverse gear is engaged while the rear screen wiper is on, the CCU changes the wiper to continuous operation until reverse gear is disengaged, then reverts to intermittent operation again. If reverse gear is engaged while the rear screen wiper is off, but the windscreen wipers are on, the CCU also operates the rear screen wiper continuously, until reverse gear is disengaged or the windscreen wipers are selected off.

Off-screen Park
When the rear screen wiper is selected off, the CCU waits for the next signal from the wiper vertical microswitch in the wiper motor, then de-energises the forward relay and energises the reverse relay. The reverse relay operates the motor in the opposite direction, which lengthens the stroke of the wiper arm. When the wiper arm reaches the off-screen position, the CCU receives a signal from the off-screen park microswitch in the wiper motor and de-energises the reverse relay to stop the wiper.

Off-screen Park Monitoring
In order to monitor the off-screen park function, the CCU invokes a 10 second timer each time intermittent or continuous operation of the rear screen wiper is deselected (by either the control switch on the instrument pack cowl or the CCU). If, within the 10 seconds, a signal is received from both the vertical and the off-screen park microswitches in the wiper motor, the CCU determines that the system is serviceable and continues operation as normal. If, within the 10 seconds, a signal is not received from both microswitches, the CCU determines there is a fault with one of the microswitches or the motor circuit and de-energises the forward and reverse wiper relays to prevent further operation. Since a faulty wiper could stop at any position on the tail door window, to prevent damage to the wiper or window after a fault is detected, the CCU also inhibits operation of the tail door window, with the following exceptions:

- Clear of seal/seal engagement window movement when the tail door is opened/closed.
- Automatic window retraction when the roof is removed/opened.
- Window calibration using the vehicle key in the tail door lock.

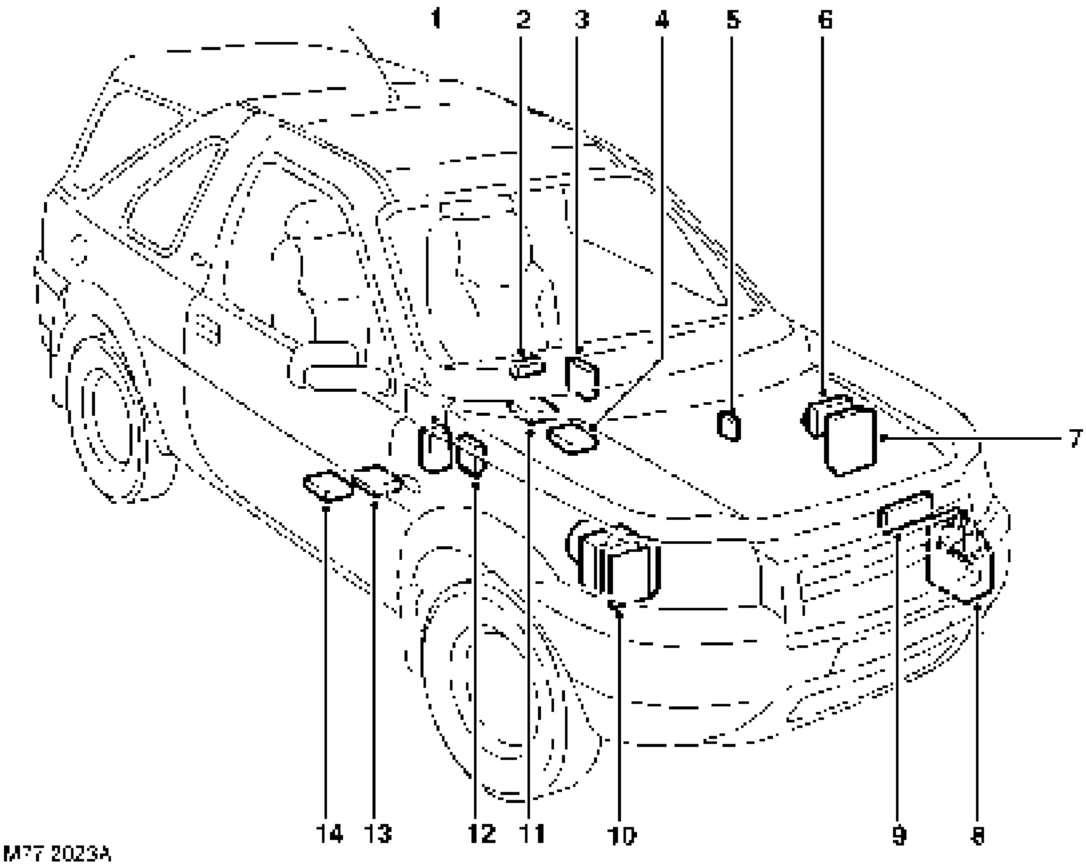
When the fault has been corrected, tail door window operation returns to normal after the CCU has detected the two microswitch inputs from the rear screen wiper motor again.

Windscreen Washers
The windscreen washers are operated by pulling on the wash/wipe stalk located on the RH side of the steering column. Operation of the windscreen washers can also operate the windscreen wipers in a programmed wash/wipe mode.

When the wash/wipe stalk is pulled, the washers operate immediately and stop immediately the stalk is released. When the stalk is held on for more than 0.6 second, the CCU enters the programmed wash/wipe mode and, if the windscreen wipers are selected to intermittent operation or off, operates them at slow speed. If the windscreen wipers are already selected to slow or fast speed, they remain at the selected speed. When the stalk is released with the CCU in the wash/wipe mode, if the windscreen wipers are selected to intermittent operation or off, the wipers operate at slow speed for a further 2 seconds (3 or 4 wipes) and then revert to intermittent operation or park, as applicable.

Rear Screen Washer
The rear washer is controlled by a non-latching push switch, located on the RH side of the instrument pack cowl, and the CCU. Pressing the rear washer switch operates the washer until the switch is released. When the washer switch is pressed, the CCU also operates the rear screen wiper in a programmed wash/wipe mode. While the switch is pressed, the CCU operates the wiper continuously. When the switch is released the CCU operates the wiper continuously for a further six seconds (3 or 4 wipes) and then parks the wiper or reverts to the previous operating mode.

Control Unit Locations



RHD shown, LHD similar

1 CCU
2 RF receiver
3 Immobilisation ECU
4 SRS DCU
5 Folding door mirror relay, from 2002 MY (where fitted)
6 EAT ECU (automatic gearbox models only)
7 ECM
8 Fuel burning heater ECU (some Td4 models)
9 Cooling fan ECU (all except K1.8 non A/C)
10 ABS modulator
11 Folding door mirror ECU, up to 2002 MY (where fitted)
12 Window lift ECU
13 Cruise control interface ECU (where fitted)
14 Cruise control ECU (where fitted)

Description

Central Control Unit (CCU)
The CCU is plugged into the back of the passenger compartment fusebox below the fascia. Two connectors provide the interface between the CCU and the passenger compartment fusebox and three connectors provide the interface between the main harness and the CCU. The CCU is responsible for controlling the following functions:

- Transit mode.
- Anti theft alarm.
- Windscreen wipers.
- Courtesy lamp delay.
- Door open warning lamp.
- Key in alarm.
- Rear fog guard lamps.
- Lights on alarm.
- Seat belt warning.
- Handbrake warning.
- Rear screen wiper.
- Tail door window.
- Heated rear window.
- Heated windscreen.
- Tail door latch.
- Window lift.
- Seat heating.
- Daytime running lamps.

Some of the features controlled by the CCU are market selectable and may not be operative or available in specific markets. TestBook can be used to configure the CCU to enable/disable market selectable features, tailor anti theft alarm features to customer requirements and can also interrogate the CCU for stored fault codes and alarm triggers. TestBook is connected to the CCU via the diagnostic socket which is located in the passenger footwell.

Transit Mode
The transit mode feature is to minimise battery usage when the vehicle is being stored or transported prior to sale. When the CCU is programmed in the transit mode, the following functions are disabled:

- RF receiver.
- Tail door actuator.
- Tail door window.
- Central Door Locking (CDL).
- Interior lamps.

If the ignition is switched to position II, the CCU buzzer will sound an alarm to warn that the vehicle is in transit mode. The dealer can remove the transit mode feature and programme the CCU to the applicable market specification at the Pre Delivery Inspection (PDI) using TestBook/T4.

Anti Theft Alarm System
The CCU controls the Central Door Locking (CDL) and the alarm system for the vehicle. These are integrated into the vehicle security system, which also includes engine immobilisation.

☞ **SECURITY, DESCRIPTION AND OPERATION, Description.**

Windscreen Wipers
The CCU controls the intermittent wipe and programmed wash/wipe of the windscreen wipers.
☞ **WIPERS AND WASHERS, DESCRIPTION AND OPERATION, Description.**

Courtesy Lamp Delay
The CCU controls the delay function of the interior courtesy lamp. The courtesy lamp can also be switched on using a manual switch on the lamp unit.

Door Open Warning Lamp
The CCU illuminates a warning lamp on the instrument pack if the driver's door, passenger door(s), tail door or bonnet is open while the ignition is on.

Key In Alarm
The CCU will sound a continuous warning on the integral sounder when the driver's door is open while the key is in the ignition switch at position 0 or I. This is to prevent the driver inadvertently leaving the vehicle with the key in the ignition switch.

Rear Fog Guard Lamps
The CCU controls the operation of the rear fog guard lamps via a rear fog guard lamp relay. The guard lamps operate only if the headlamps are on and the ignition switch is in position II. When the headlamps or the ignition are switched off the CCU automatically switches off the guard lamps.

Lights On Alarm
The CCU will sound a continuous warning on the integral sounder when the driver's door is open while the side lamps or headlamps are on and the ignition is off. This is to prevent the driver inadvertently leaving the vehicle with the side lamps or headlamps on.

Seat Belt Warning
When the ignition is switched on the CCU performs a bulb check of the seat belt warning lamp in the instrument pack for approximately 5 seconds, or until the ignition is switched off or the engine cranks. To prevent a driver inadvertently driving without fastening their seat belt, if the driver's seat belt is unfastened when the ignition is switched on the CCU sounds a warning on the integral sounder for approximately 5 seconds and keeps the seat belt warning lamp illuminated after the bulb check.

Handbrake Warning
A warning lamp to warn the driver that the handbrake is on is located in the instrument pack. The warning lamp illuminates when the ignition is on and the handbrake is applied. In some markets the CCU performs a bulb check of the warning lamp for approximately 5 seconds at the beginning of each ignition cycle.

Rear Screen Wiper
The CCU controls the rear screen wiper via a forward and a reverse relay. The wiper will not operate if the tail door window is lowered or not calibrated or, on 3 door models, if the roof is open (soft back) or removed (hard back).
☞ **WIPERS AND WASHERS, DESCRIPTION AND OPERATION, Description.**

Tail Door Window
The CCU controls the lowering and raising of the tail door window, which can be opened using a console switch or the remote handset. On 3 door models, opening/removal of the roof will automatically lower the window. The window can be raised using the console switch or the vehicle key in the tail door key barrel. When the tail door is opened, the tail door window lowers to a 'clear of seal' position. When the door is closed the window automatically rises to its fully up position.
☞ **WINDOWS, DESCRIPTION AND OPERATION, Description.**

Heated Rear Window (HRW)

The CCU controls the operation of the HRW. When the HRW switch, located on the centre of the fascia, is pressed and released a signal is sent to the CCU. With the ignition on, the oil pressure sense present (i.e. the engine running), the tail window not lower than the 'clear of seal' position and, on 3 door models the roof closed/on, the CCU will grant the HRW on. The CCU will energise the HRW relay for approximately 15 minutes after which the CCU will de-energise the HRW relay. A warning lamp in the HRW switch shows when the HRW is operating.

If the switch is pressed before the timed 15 minute period, the CCU will immediately switch off the HRW. Removal of any of the input signals to the CCU will also stop HRW operation. The HRW switch will require re-selection to operate again.

Heated Windscreen

Operation of the heated windscreen is controlled by the CCU and a non latching switch on the centre console. The switch contains a LED which illuminates while the heated windscreen is on. Power for the heater elements is supplied by a relay, on the inboard side of the E-box, controlled by the CCU. Two fuses next to the relay provide electrical protection for the heater elements.

When the heated windscreen switch is pressed, the CCU energises the heated windscreen relay, provided the engine is running, to connect a battery power feed to each of the heater elements. The feed to the RH heater element also provides the power feed to illuminate the LED in the heated windscreen switch.

The CCU de-energises the heated windscreen relay after approximately 5 minutes, when the switch is pressed again, or if the engine stops.

Tail Door Latch

The tail door latch is operated by a tail door lock motor controlled by the CCU. When the CCU receives an open request from the tail door handle switch, it energises the tail door lock motor for 440 ± 40 milliseconds provided the vehicle is in the following configuration:

- The door locking system is in the unlocked state.
- The alarm system is disarmed.
- Road speed is less than 3 ± 1 mph (5 ± 1.5 km/h).

The position of the ignition switch has no effect on the operation of the tail door lock motor.

Window Lift

Power for side door window operation is supplied from the window lift relay and, on 5 door models, the auxiliary relay, both located in the passenger compartment fusebox. The CCU controls the relays, which are energised while the ignition switch is in position II and for approximately 40 seconds after the ignition is turned off.

☞ **WINDOWS, DESCRIPTION AND OPERATION, Description.**

Seat Heating

Power for the seat heaters is supplied from the auxiliary relay in the passenger compartment fusebox. The CCU controls the auxiliary relay, which is energised while the ignition switch is in position II and for approximately 40 seconds after the ignition is turned off.

Daytime Running Lamps

The daylight running feature is controlled by the CCU via two daylight running relays located inboard of the passenger compartment fusebox. The CCU switches the relays, to illuminate the dipped beams, side lamps, tail lamps, rear number plate lamp and side marker lamps, when the following conditions are met:

- The engine is running.
- Gearbox selector lever not in Park.
- Headlamps not selected on.

The CCU and the daylight running relays are also used to operate the head/side lamps when they are selected on using the lighting switch on the LH column stalk. The lamps then operate as on non daylight running vehicles, and remain on when the gearbox is in Park and when the engine is switched off.

Self Test Mode

The CCU can be put into a self test mode to enable the inputs and outputs to be tested for correct functionality without the need for TestBook/T4. To put the CCU into the self test mode the vehicle must be unlocked and disarmed, then the ignition turned on and the following sequence completed within 4 seconds:

- Hold the rear fog guard lamp switch on.
- Turn the ignition off.
- Turn the ignition on.
- Release the rear fog guard lamp switch.

On successful entry to the self test mode the CCU simultaneously operates the sounder and illuminates the courtesy lamps for 0.8 second.

When testing an input, e.g. a door open switch, on successful receipt of the input the CCU also simultaneously operates the sounder and illuminates the courtesy lamps for 0.8 second.

Outputs are tested in sequence using the CDL lock switch to progress through the outputs. A CDL unlock request repeats the last test. Outputs are either operated continuously until the CDL lock switch is released, or operated with a pulse.

Self Test Outputs Sequence

Output	Test Type
Rear fog lamps	Continuous
Lock	Pulsed for 0.76 second
Superlock	Pulsed for 0.76 second
Unlock	Pulsed for 0.76 second
Front wiper	Continuous, then self parks
Alarm LED	Continuous
Volumetrics	Continuous
Horn	Pulsed for 0.8 second
Heated windscreen	Pulsed for 0.8 second
Heated rear window	Pulsed for 0.8 second
Tail window down	Pulsed, drives fully down
Tail door actuator	Pulsed for 0.44 second
Tail window up	Pulsed, drives fully up
Rear wiper	Continuous
Hazard lamps	Continuous
Door open warning	Continuous
Seat belt warning lamp	Continuous
Handbrake/Brake warning lamp	Continuous
Daytime running lamps	Continuous

Self test mode is cancelled when the ignition is turned off, if oil pressure is sensed (i.e. engine running) or if the vehicle speed exceeds 0.6 mph (1 km/h).

Radio Frequency (RF) Receiver
The RF receiver is part of the security system and relays data from the remote transmitter (plip) to the CCU. The RF receiver is located on top of the instrument pack, between the housing and the face plate.
☞ **SECURITY, DESCRIPTION AND OPERATION, Description.**

Immobilisation ECU
The immobilisation ECU controls operation of the starter motor to provide the engine immobilisation function of the security system. The immobilisation ECU is secured to the rear of the fascia near the vehicle centre-line.
☞ **SECURITY, DESCRIPTION AND OPERATION, Description.**

Supplementary Restraint System (SRS) Diagnostic Control Unit (DCU)
The SRS DCU controls the operation of the vehicle's airbags and seat belt pretensioners. The SRS DCU is attached to the transmission tunnel below the heater assembly.
☞ **RESTRAINT SYSTEMS, DESCRIPTION AND OPERATION, Description.**

Electronic Automatic Transmission (EAT) ECU
The EAT ECU controls gear changing and torque converter lockup. The EAT ECU is installed in the Environmental (E) box in the engine compartment.
☞ **AUTOMATIC GEARBOX - JATCO, DESCRIPTION AND OPERATION, Description.**

Engine Control Module (ECM)
The ECM controls all aspects of engine operation and interfaces with the security system during engine starting. The ECM is installed in the E-box in the engine compartment.
☞ **ENGINE MANAGEMENT SYSTEM - SIEMENS, DESCRIPTION AND OPERATION, Description.**

Cooling Fan ECU
The cooling fan ECU controls the speed of the two cooling fans. The cooling fan ECU is installed in the rear upper left corner of the cooling fan housing.
☞ **COOLING SYSTEM - K SERIES KV6, DESCRIPTION AND OPERATION, Description.**

Anti-lock Braking System (ABS) Modulator
The brake system incorporates an ABS ECU that controls the operation of the hydraulic modulator to provide the ABS, electronic brake force distribution, traction control and hill descent control functions. The ABS ECU is attached to the hydraulic modulator, which is installed in the front right corner of the engine compartment.
☞ **BRAKES, DESCRIPTION AND OPERATION, Description.**

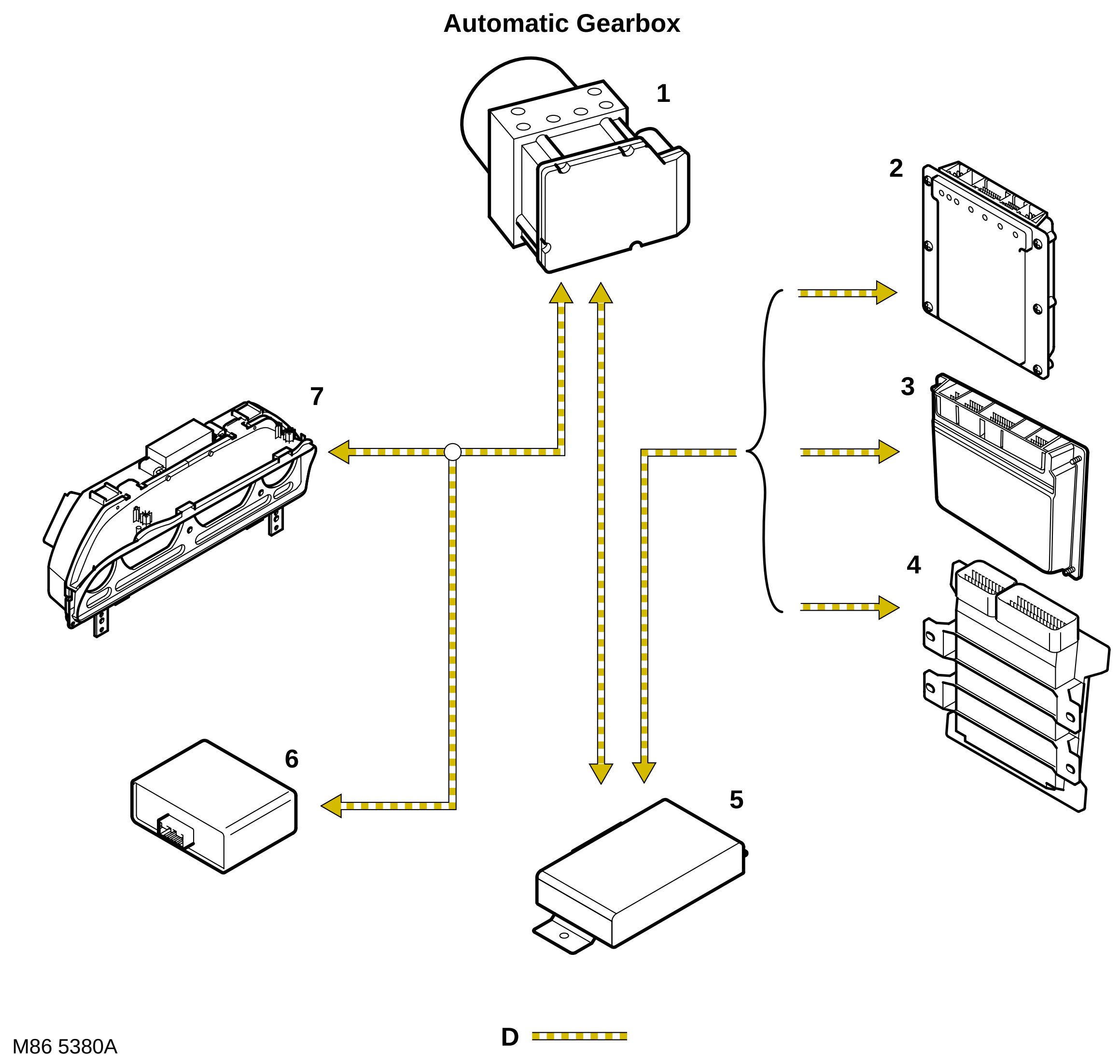
Folding Door Mirror ECU (Some Markets)
In some markets folding door mirrors are installed and these are controlled by the folding door mirror ECU on vehicles up to 2002 MY. The folding door mirror ECU is installed on the transmission tunnel, below the centre console.

On vehicles from 2002 MY, the folding door mirror ECU was replaced by a relay. The folding door mirror relay is located on the front passenger side 'A' post.

Window Lift ECU
The window lift ECU is installed to provide one shot opening of the driver's door window. The window lift ECU is installed on the driver's side A post, level with the lower edge of the fascia.
☞ **WINDOWS, DESCRIPTION AND OPERATION, Description.**

Cruise Control Interface ECU
Where fitted, the cruise control interface ECU provides the interface between the cruise control operating system and the cruise control switches on the steering wheel. The interface ECU is installed under the RH front seat.
☞ **ENGINE MANAGEMENT SYSTEM - SIEMENS, DESCRIPTION AND OPERATION, Cruise Control Description.**

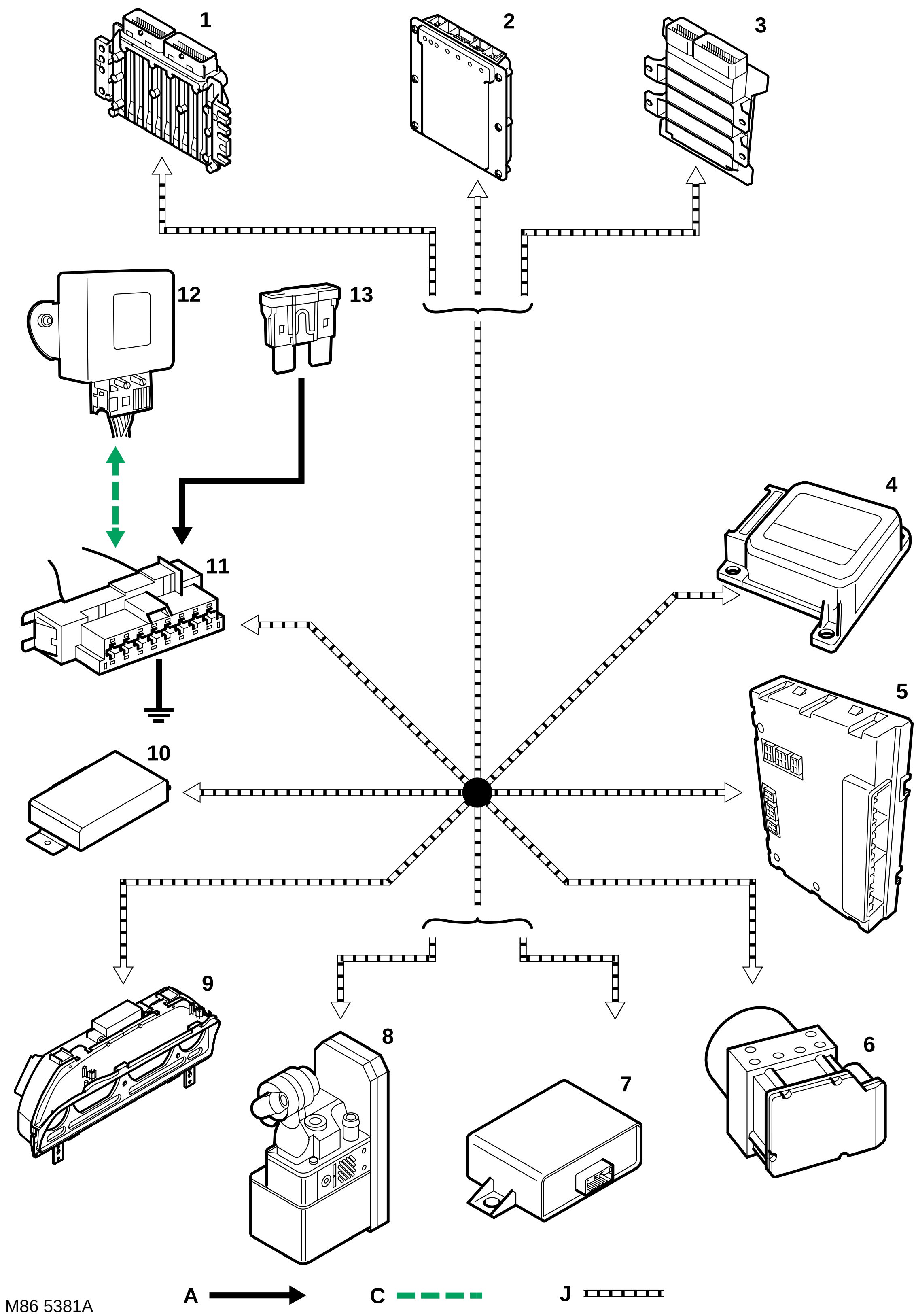
CAN Bus Control Diagram



D = CAN bus

1. **1** Antilock brake system ECU
2. **2** Engine control module (Td4)
3. **3** Engine control module (non NAS KV6)
4. **4** Engine control module (NAS KV6)
5. **5** Electronic automatic transmission ECU
6. **6** Cruise control interface unit
7. **7** Instrument pack

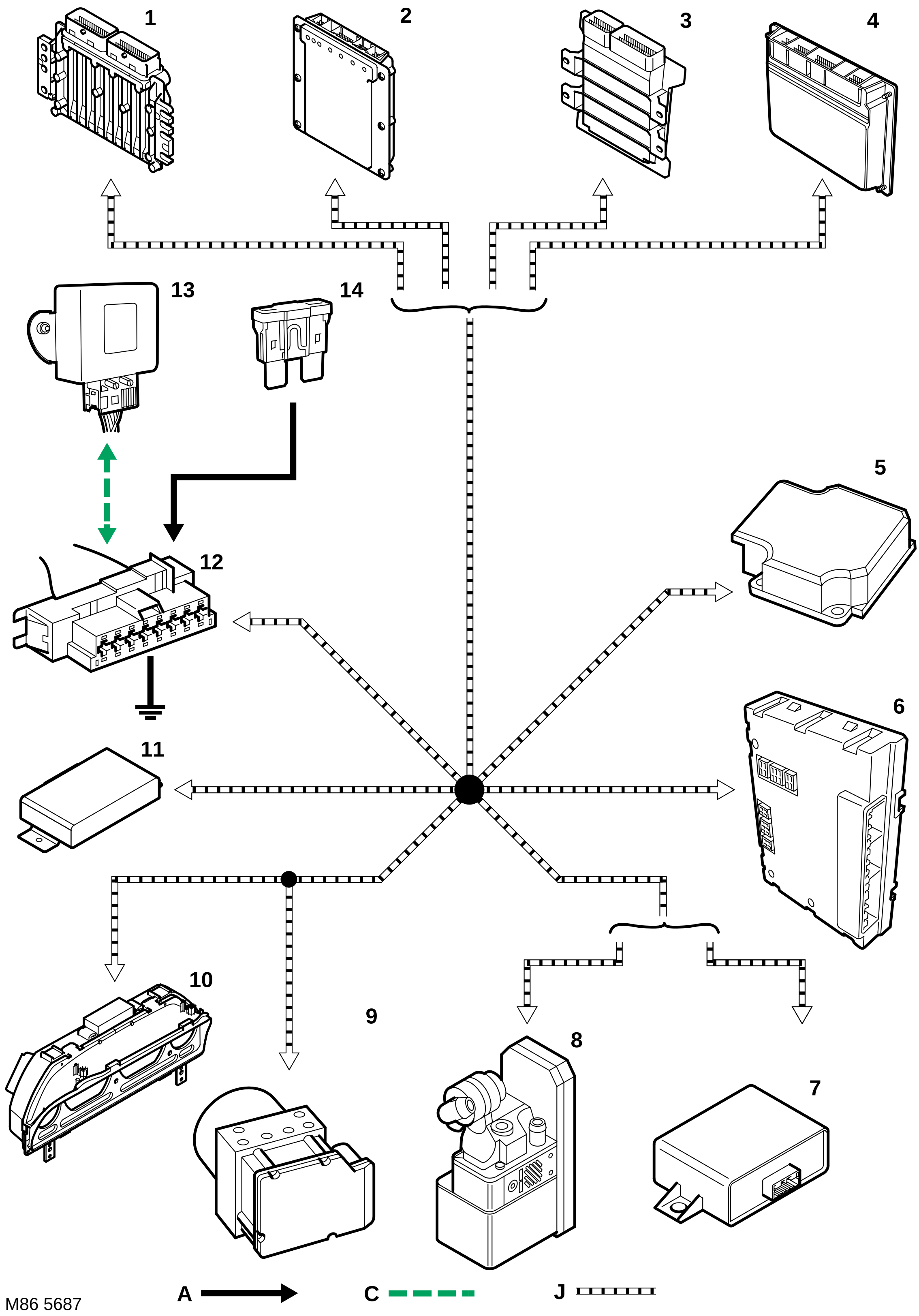
Diagnostic Buses (Up To 2002 Model Year)



A = Hardwired connection; C = Diagnostic DS2 bus; J = Diagnostic ISO 9141 K line bus

1 Engine control module (KV6)
2 Engine control module (Td4)
3 Engine control module (K1.8)
4 SRS diagnostic and control unit
5 Central control unit
6 ABS ECU
7 Cruise control ECU (KV6, where fitted)
8 Fuel burning heater (where fitted)
9 Instrument pack
10 EAT ECU (where fitted)
11 Diagnostic socket
12 Immobilisation ECU
13 Fuse 14 battery power supply, passenger compartment fusebox

Diagnostic Buses (From 2002 Model Year)



A = Hardwired connection; C = Diagnostic DS2 bus; J = Diagnostic ISO 9141 K line bus

1. Engine control module (KV6, all except NAS)
2. Engine control module (Td4)
3. Engine control module (K1.8)
4. Engine control module (NAS)
5. SRS diagnostic and control unit
6. Central control unit
7. Cruise control ECU (non NAS KV6, where fitted)
8. Fuel burning heater (where fitted)
9. Instrument pack
10. EAT ECU (where fitted)
11. Diagnostic socket
12. ABS ECU
13. Immobilisation ECU
14. Fuse 14 battery power supply, passenger compartment fusebox

Description

General
A number of different types of data bus can be incorporated into vehicle wiring harnesses for the transmission of commands and information between ECU's. Some of the buses are installed as a network connecting several ECU's together and some are installed as dedicated links between pairs of ECU's. The bus configuration installed on a particular vehicle depends on the model and equipment level.

Freelander incorporates the following data bus systems:

- Controller Area Network (CAN) bus. A network connected between the instrument pack, the ABS and powertrain related ECU's
- Diagnostic DS2 bus
- ISO 9141 K line

Serial interface circuits in the ECU's transmit and receive commands and information on the buses as digital messages. ECU's connected to the same bus use a common protocol (format) and baud rate (transmission speed) for the messages they transmit. The protocol and baud rate vary from bus to bus.

Not all system ECU's are connected to the CAN bus system but they may require information that is being transmitted on the CAN bus system. The instrument pack acts as a gateway translating CAN bus signals into a format compatible with non CAN ECU's. Some signals are also converted from their existing state into the CAN format and transmitted on the CAN bus system for use by CAN based ECU's, for example the air conditioning pressure sensor reading is converted by the instrument pack and sent via CAN to the respective engine management system.

A twisted pair of wires are used for the CAN bus and single wires are used for the diagnostic buses. Bus wires can be repaired using the recommended connectors and the recommended procedure. The unwound length of CAN bus wires must not exceed 40 mm (1.6 in). If a fault is suspected on the CAN bus system it must be diagnosed and rectified using TestBook/T4.

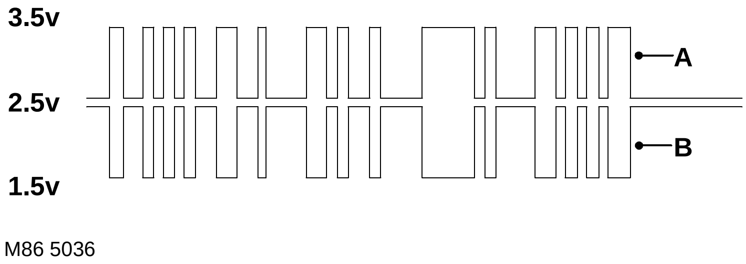
Data Bus Types

Bus	Baud Rate (kbits/s)	Protocol
CAN	500	ISO 11898
ISO 9141 K line	10.4	ISO keyword 2000
Diagnostic DS2	9.6	Corporate for diagnostics

CAN Bus
The CAN bus is a high speed broadcast network where the ECU's automatically transmit information on the bus every few microseconds. The two wires of the bus are identified as CAN Low (L) and CAN High (H), and are twisted together to minimise the electromagnetic interference (noise) produced by the CAN messages. To prevent message errors from electrical reflections, 120 ohm resistors are incorporated into the CAN wire terminals of the instrument pack and the Engine Control Module (ECM).

Messages consist of a signal which is simultaneously transmitted, in opposite phase, on both wires. CAN L switches between 2.5 and 1.5 volts while CAN H switches between 2.5 and 3.5 volts, which causes the potential difference between the two lines to switch between 0 volt (logic 1) and 2 volts (logic 0) to produce the digital signal message.

CAN Bus Switching



A = CAN H; B = CAN L

CAN Message Transmission

Messages transmitted via the CAN system are made up of eight data bytes and transmitted using a baud rate of 5,000 kbits per second. The twisted pair of wires used are coloured yellow and black (CAN_H) and yellow and brown (CAN_L).

The following table lists the signals transmitted via the CAN system illustrating the system originating the message and the message recipient:

CAN Message Transmission

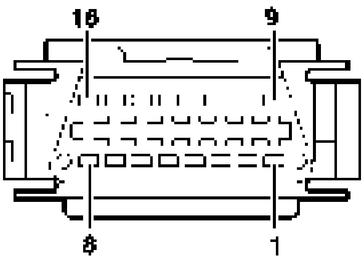
Message	Source	Destination
Brake pedal application status	ABS ECU	EAT ECU
Electronic brake distribution	ABS ECU	Instrument pack
ABS lamp status	ABS ECU	Instrument pack
Traction control lamp status	ABS ECU	Instrument pack
Brake intervention status	ABS ECU	EAT ECU
Vehicle speed error status	ABS ECU	ECM
Vehicle speed	ABS ECU	ECM, Instrument pack
Road surface status (roughness)	ABS ECU	ECM (petrol only)
Hill Descent Control (HDC) activity status	ABS ECU	EAT ECU, ECM
Hill Descent Control (HDC) fault status	ABS ECU	EAT ECU, ECM
Ignition switch status	ECM	ABS ECU, EAT ECU
Engine speed error status	ECM	ABS ECU, EAT ECU
Torque reduction status	ECM	EAT ECU
Torque measurement error status	ECM	ABS ECU, EAT ECU
Actual engine torque	ECM	ABS ECU, EAT ECU
Engine speed	ECM	ABS ECU, EAT ECU, instrument pack
Maximum engine torque	ECM	ABS ECU, EAT ECU
Friction torque loss	ECM	ABS ECU, EAT ECU
Multiplexed information (CAN specification version, engine type identifier, scaling factor for torque values)	ECM	ABS ECU, EAT ECU, instrument pack
Coolant temperature	ECM	EAT ECU, instrument pack
Driver demand/throttle angle	ECM	ABS ECU, EAT ECU
Cruise active	ECM	Cruise control interface unit, EAT ECU, instrument pack
Engine MIL status	ECM	EAT ECU, instrument pack
Engine status (non emissions related faults)	ECM	Instrument pack
Fuel consumption	ECM	Instrument pack
Throttle pedal switch status	ECM	ABS ECU
Throttle pedal fault	ECM	ABS ECU

Message	Source	Destination
Target gear (actual gear unless changing, then target gear)	EAT ECU	ABS ECU, ECM, instrument pack
Shift in progress	EAT ECU	ABS ECU, ECM
Gearbox MIL status	EAT ECU	ECM (KV6)
Selector lever position	EAT ECU	ABS ECU, ECM, instrument pack
Gear shift mode	EAT ECU	Instrument pack
Torque level required	EAT ECU	ECM
Transmission fault status	EAT ECU	Instrument pack
Gearbox cooling request	EAT ECU	ECM
Fuel level	Instrument pack	ECM
A/C request	Instrument pack	ECM
A/C switch status	Instrument pack	ECM
A/C compressor load	Instrument pack	ECM
Engine cooling fan speed	Instrument pack	ECM
Vehicle reference speed	Instrument pack	EAT ECU, ECM
Gear selected (manual gearbox)	Instrument pack	ABS ECU

Diagnostic Buses

The diagnostic buses connect the diagnostic socket to the ECU's on the CAN bus and to individual system ECU's. The diagnostic buses enable fault diagnosis, system testing and vehicle configuration.

Diagnostic Socket (C0040)



Diagnostic Socket (C0040)

Pin No.	Description	Input/output
1 to 3	Not used	–
4	Chassis earth	Output
5	Signal earth (From 2002.5 model year)	Output
6	Not used	–
7	ISO 9141 K line	Input/Output
8 to 12	Not used	–
13	DS2 bus	Input/Output
14 and 15	Not used	–
16	Battery power supply	Input

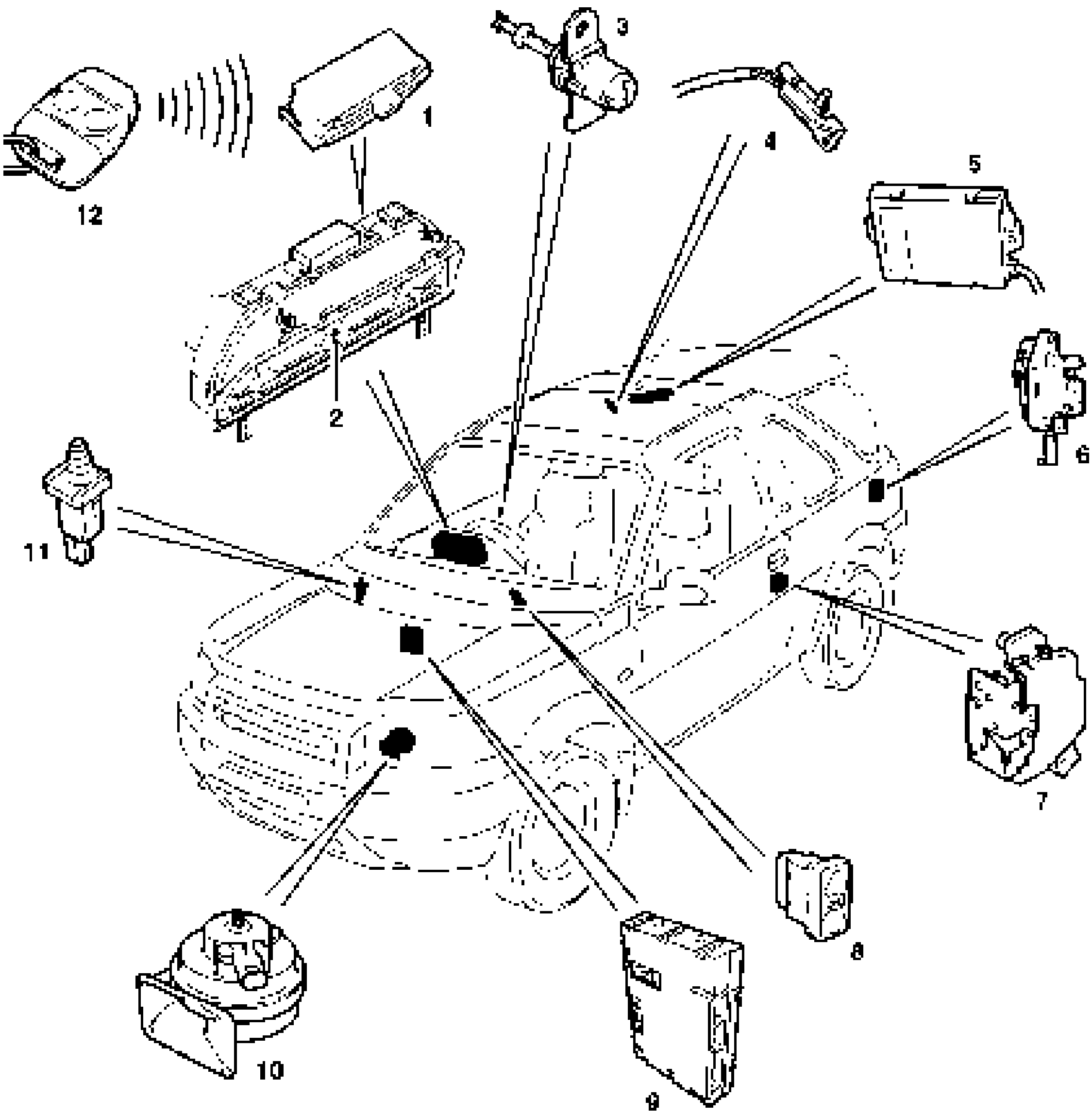
ISO 9141 K Line

The ISO 9141 K line connects the diagnostic socket to the majority of the ECU's fitted to the vehicle. The protocol used means that non TestBook/T4 diagnostic equipment, such as scan tools, can be used to access SRS and emission related faults stored in the ECU memories.

DS2 Bus

The DS2 bus connects the diagnostic socket to the immobilisation ECU. The protocol used means that only TestBook/T4 can communicate with the immobilisation system and the ABS ECU.

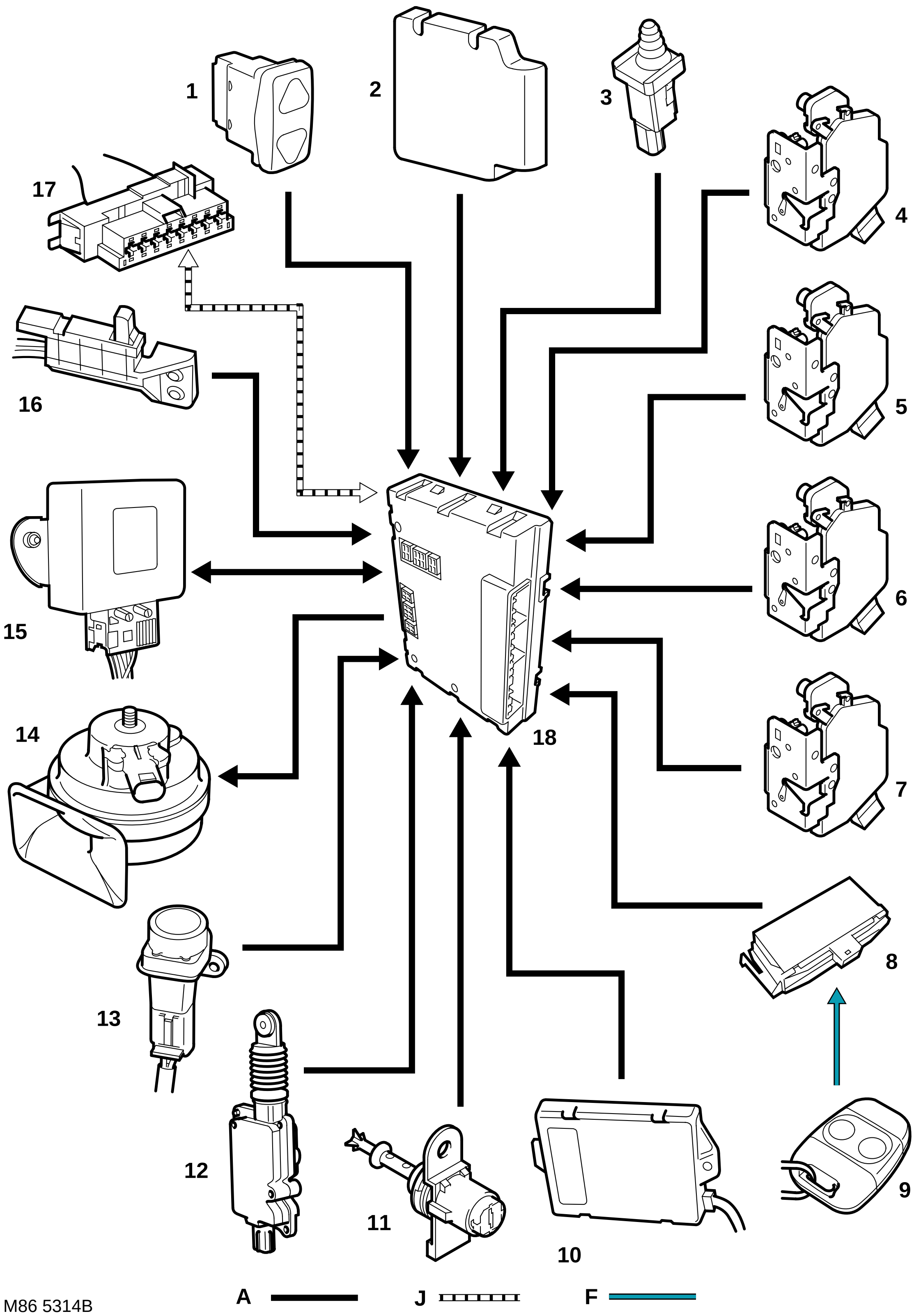
Locking and Alarm System Component Layout



M86 5313C

1	RF receiver	**7**	Door latch
2	Alarm LED	**8**	CDL switch
3	Driver's door key barrel switch	**9**	CCU
4	Roof switch (3 door only)	**10**	Horn
5	Volumetric sensor	**11**	Bonnet switch
6	Tail door latch	**12**	Remote handset

Locking and Alarm System Control Diagram



A = Hardwired connection; F = RF transmission; J = Diagnostic ISO 9141 K line bus

1 CDL switch
2 ABS ECU
3 Bonnet switch
4 Driver's door actuator and switch
5 Front passenger door actuator and switch
6 Left hand rear door actuator and switch
7 Right hand rear door actuator and switch
8 RF receiver
9 Remote handset
10 Volumetric sensor
11 Driver's door key barrel switch
12 Tail door switch and actuator
13 Inertia switch
14 Horn or BBUS
15 Immobilisation ECU
16 Roof switch (3 door only)
17 Diagnostic socket
18 Central control unit

Description

General
This description covers all aspects of the vehicle locking and alarm system.

The vehicle locking and alarm system is controlled by the central control unit (27VT) located on the back of the passenger compartment fusebox below the fascia.

Locking and Alarm System
The locking and alarm system comprises:
- Central door locking master switch
- Door switches
- Roof switch (3 door only)
- Remote handset (RF transmitter)
- RF receiver
- Driver's door key barrel
- Door lock actuators
- Tail door switch
- Tail door release actuator
- Bonnet switch
- Inertia switch
- Horn or BBUS
- Alarm LED
- Immobilisation ECU
- ABS ECU Speed input
- Volumetric sensor

Central Locking
The vehicle can be locked and unlocked by three methods; CDL switch, vehicle key or remote handset.

CDL Switch
The CDL switch is located in the centre console. The CDL switch allows the occupants to CDL lock the vehicle from inside without arming the alarm. The CDL switch is inoperative if the inertia switch is tripped. The CDL locked state can be removed by operation of the CDL switch, remote handset or by a key unlock operation in the driver's door key barrel.

If the inertia switch is tripped while the doors are CDL locked and the ignition is on, all doors will automatically unlock.

Key Locking
The vehicle can be CDL locked using the vehicle key in the driver's door key barrel. Turning the top of the key to the rear of the vehicle will CDL lock all doors. Turning the key a second time, within one second of the first turn, will superlock all doors.

Key Unlocking
Single point entry is a programmable feature and its selection affects how the vehicle responds to key unlock requests:

- Turning the top of the key once towards the front of a vehicle which is in a CDL state, with the alarm disarmed, will unlock all the doors irrespective of their existing lock status
- Turning the top of the key once towards the front of a vehicle in a superlocked state without SPE selected and the alarm armed, will unlock all the doors irrespective of their existing lock status
- Turning the top of the key once towards the front of a vehicle in a superlocked state with SPE selected and the alarm armed, will unlock the driver's door. The remaining doors will unlock to the CDL state and can be unlocked with a further key unlock operation

Remote Locking
On vehicles with superlocking selected the vehicle can be superlocked by pressing the lock button on the remote handset once. On vehicles with superlocking not selected (market option) the vehicle can be CDL locked by pressing the lock button on the remote handset once.

Remote Unlocking
With the vehicle CDL locked, pressing the unlock button on the remote handset once will unlock all doors.

If the vehicle is superlocked, pressing the unlock button once on the remote handset will only unlock the drivers door for SPE. The remaining door(s) will unlock to the CDL state. If the button is pressed a second time, the remaining door(s) will unlock.

NOTE: If the vehicle is superlocked and SPE has not been selected in the CCU, pressing the unlock button once on the remote handset will unlock all the doors.

Central Locking Notes
Locking or unlocking using the vehicle key or remote handset is prevented if the CCU senses that the ignition is 'on'. Using the key to lock the vehicle via the driver's key lock with the ignition 'on' will mechanically lock the driver's door.

Superlocking is prevented if the CCU senses that one or more doors are open. In this instance the CCU will attempt to CDL lock all doors.

Inertia Switch
The inertia switch is located on the bulkhead in the engine compartment. The switch is mounted vertically and has a reset button on its top surface, covered by a rubber boot.

If the inertia switch is tripped, with the ignition 'on' and the alarm disarmed, all the doors will be unlocked regardless of their locked state at that time. Further locking is disabled unless:

1. the ignition is switched off and the driver's door is opened and closed
2. the driver's door is opened and closed and the inertia switch is manually reset

The inertia switch can be reset by depressing the button on the top of the switch.

Tail Door
The CCU also controls the tail door release. The tail door can only be opened if the vehicle is unlocked, the alarm is not armed and the vehicle is travelling at not more than 3 mph (5 km/h).

Slam Locking
The driver's door is designed to prevent slam locking. The remaining door(s) can be slam locked.

Latch Motor Protection

To protect the door lock latches from damage, the CCU will only allow eight changes of state of the locks in any sixteen second period or less. If eight changes of state occurs within the sixteen second period, the CCU will prevent further operation of the latch motors for a further sixteen second period. The CCU will always prevent further operation only when the latch motors are in an unlocked condition. If SPE is operational, the CCU will override the SPE function and all doors will unlock if eight operations is exceeded in the sixteen second period.

The alarm system will continue to operate during the latch motor protection period.

Alarm System

The alarm system can be armed and disarmed using the vehicle key or the remote handset. The alarm system monitors the driver's door, passenger door(s), tail door, bonnet and roof (3 door models only) using perimetric sensing. It also monitors movement within the passenger compartment using volumetric sensing.

In certain countries, the alarm system is programmed not to arm under any circumstances.

NOTE: Hazard warning light confirmation of alarm arm or disarm is market programmable and therefore may not be operative on certain market variants.

Perimetric Sensing

Perimetric sensing is invoked by the CCU to monitor entry to the vehicle after the alarm has been set. The panel open switches on the driver's door, passenger door(s), tail door, bonnet and roof (3 door only) are all monitored by the CCU.

If a panel is opened after the alarm has been set, the alarm will be triggered. The horn or BBUS will sound and the hazard warning lights will operate. On 3 door models, if the roof is off when the alarm is armed, further operation of the roof off switch will not trigger the alarm.

Volumetric Sensing

The volumetric sensor is located in a central position on the roof panel, behind the headlining. The volumetric sensor is a microwave sensor which monitors movement inside the vehicle to detect any possible intrusion. The vehicle can be armed with the volumetric sensor disabled to avoid accidental triggering of the alarm if a pet is in the vehicle for instance. The volumetric sensor is also inoperative if the CCU senses that a panel has been left open, with the exception of the bonnet.

A fifteen second delay is initiated after arming of the alarm before signals from the volumetric sensor are interpreted as an intrusion. This precaution is included in the CCU software to avoid accidental or nuisance triggering of the alarm.

If the alarm has been triggered, the CCU will ignore further volumetric sensor signals for the duration of the alarm sounding. The CCU will delay volumetric sensing for a further 15 seconds after the alarm has stopped sounding, unless ten triggers have been sensed by the volumetric sensor since the alarm was last armed.

The volumetric gain setting is controlled by the VIN stored in the CCU. The VIN informs the CCU of the vehicle body and roof type to avoid under or over sensitivity.

If battery supply voltage falls to below 9 Volts, the CCU will ignore inputs from the volumetric sensor.

Alarm - Key Operation

Arming and disarming using the vehicle key in the driver's door key barrel will be ignored if the CCU senses that the ignition is 'on'. In certain markets the alarm system is programmed not to arm under any circumstances, in these cases key operation will only operate the door locking facility as described in Key Locking/Unlocking.

NOTE: Using the vehicle key in the driver door key barrel will not enable volumetric sensing.

Key Arm
The vehicle alarm can be fully armed by turning the top of the key to the rear of the vehicle once with all panels closed. The Vehicle will be CDL locked, the hazard warning lights will flash three times. The alarm LED will fast flash for ten seconds and then change to slow flash. Perimetric sensing will be activated.

The vehicle alarm can also be fully armed by turning the top of the key to the rear of the vehicle a second time, within one second of the first turn, with all the panels closed. The vehicle will be superlocked, the hazard warning lights will flash three times. The alarm LED will fast flash for ten seconds and then change to slow flash. Perimetric sensing will be activated.

Key Disarm
The vehicle can be disarmed by turning the top of the key towards the front of the vehicle. The vehicle will unlock all the doors, if the vehicle is being unlocked from the superlock state with SPE active, the driver's door will unlock, the remaining doors will enter the CDL state. Also the hazards will flash once and the alarm LED will extinguish.

Alarm Remote Handset Operation
In certain markets, the alarm system is programmed not to arm under any circumstances. In these cases the remote handset will only operate the door locking facility as described in remote handset lock/unlock.

Remote Handset Arm
The vehicle alarm can be fully armed by pressing the lock button on the remote handset once with all panels closed. The Vehicle will be superlocked, the hazard warning lights will flash three times. The alarm LED will fast flash for ten seconds and then change to slow flash. Perimetric and volumetric sensing will be activated.

Remote Handset Disarm
The vehicle can be fully disarmed by pressing the unlock button once on the remote handset. The hazard warning lights will flash once and the alarm LED will go off. Perimetric and volumetric sensing will be disabled.

Partial Arming
If one or more of the panels is left open, the CCU will attempt to partially arm as much of the vehicle as possible. If a failure of a panel open switch or wiring occurs, the CCU will partially arm the alarm in the same manner as if a panel is left open.

When the alarm is armed with one or more panels open, the CCU will sound a mislock warning from the horn or BBUS to tell the driver that a panel is open.

The mis-lock warning sound is market selectable and therefore may not be operative in specific markets. When the CCU enters a partially armed state, there is no hazard warning flasher operation, the alarm LED will be extinguished for 10 seconds and will then slow flash.

The CCU will partially alarm the vehicle according the priority of the panel left open. The panel priority is driver's door, passenger door(s), tail door and bonnet with the driver's door being the highest priority and the bonnet being the lowest.

Drivers Door
If the driver's door is open and a lock request is made, the CCU will CDL lock the closed doors, give a mislock sound, suspend superlocking and volumetric sensing and monitor the panel(s) left open. With the driver's door open CDL centre console switch lock requests are ignored.

Vehicle state changes:
- If the driver's door is open and a lower priority panel closes, the CCU will give a mis-lock sound and remain in the driver's door partial arm condition
- If the driver's door closes, the CCU will sound a mis-lock warning and remain in the driver's door partial arm condition. If the driver's door is opened, the alarm will be triggered
- If the driver's door closes and one or more lower priority panels are open and a lock request is made, the CCU will CDL lock the closed door(s) and enter the partial arm state of the panel open with the next highest priority
- If the driver's door closes and all other panels are closed and a lock request is made, the CCU will lock the doors and arm the alarm

Passenger Door(s)
If one or more of the passenger doors are open and the driver's door is closed and a lock request is made, the CCU will CDL lock the closed door(s), suspend superlocking and volumetric sensing and monitor the panel(s) left open.

Vehicle state changes:
- If one or more passenger door(s) are open and a lower priority panel closes, the CCU will sound a mis-lock warning and remain in the passenger door partial arm condition
- If the passenger door(s) close(s) and one or more lower priority panels remain open, the CCU will sound a mis-lock warning and enter the partial arm condition of the panel with the next highest priority
- If the passenger door(s) close(s) and all other panels are closed, the CCU will arm the alarm door sense switches for the closed door(s)

Tail Door
If the tail door is open and all higher priority panels are closed and a lock request is made, the CCU will allow superlocking of the passenger and driver's doors, suspend volumetric sensing and monitor the panel(s) left open.

Vehicle state changes:
- If the tail door is open and the bonnet closes, the CCU will sound a mis-lock warning and remain in the tail door partial arm condition
- If the tail door closes and the bonnet remains open, the CCU will suspend operation of the tail door open actuator until the next unlock request is made and enter the bonnet partial arm condition
- If the tail door closes and the bonnet and all other panels are closed, the CCU will lock the doors and arm the alarm

Bonnet
If the bonnet is open and all higher priority panels are closed and a lock request is made, the CCU will allow superlocking of the passenger and driver's doors and volumetric sensing and monitor the panel left open.

Vehicle state changes:
- If the bonnet closes and all other panels are closed, the CCU will enter the locked and armed condition

Mislock Warning
When the CCU enters a partial armed condition or the alarm is armed with the tail door window down, the CCU will sound a mis-lock warning. The mis-lock warning is market selectable. The mis-lock warning is sounded from either the vehicle horn for a period of 0.02 seconds or from the BBUS for a period of 0.1 seconds.

Alarm Activated

The audible and visual warnings are activated by the CCU when an alarm trigger is received by the CCU, is market selectable. The audible warning can be a constant tone from the horn for a period of 30 seconds or an intermittent tone from the horn for 30 seconds, with the horn sounding for 0.5 seconds and off for 0.5 seconds. The visual warning is flashing of the hazard warning lights for 30 seconds.

When a BBUS is fitted, all alarm and miss-lock warnings will be sounded via the BBUS.

Alarm Reset

When the alarm has been activated, it can be silenced, with the ignition 'off', by either disarming or repeat arming using the vehicle key or the remote handset.

Battery Backed Up Sounder

The BBUS is market programmable and when fitted will provide security warnings: alarm sounder and mislock.

In the event of a tamper detection i.e. power loss to the BBUS, the sounder can only be silenced with reconnection of power to the BBUS and a disarm request followed by an arm request.

In the alarm armed condition the BBUS will sound if it detects a power supply/battery disconnection. If the alarm is not armed the BBUS can be disconnected without the device sounding. Therefore, to prevent the BBUS sounding inadvertently, before any work on the vehicle which requires battery disconnection is carried out, ensure the alarm is not armed.

It is recommended that the BBUS is changed after three years due to limits of battery life.

Remote Handset (RF Transmitter)

Two remote handsets are supplied with each vehicle. Two buttons on the handset control the locking and unlocking and alarm arm and disarm functions remotely. The remote handset transmits a coded signal which is recognized by the RF receiver. If the handset battery is removed or changed, or the vehicle battery is disconnected, the synchronization of the handset and the RF receiver will be lost.

Remote Handset Re-synchronization

Re-synchronization can be achieved using the handset by operating either handset button five times in quick succession with the ignition off.

Remote Handset Battery Low Warning

If the remote handset battery voltage becomes low, when the handset transmits a signal to the CCU, it also transmits a low battery signal when the driver's door is opened. The CCU buzzer sounds a 10 second warning and the alarm LED flashes for 10 seconds to signify to the driver that the handset battery requires replacement. When the battery is replaced, the remote handset will require re-synchronization with the CCU.

Replacement Handset Programming

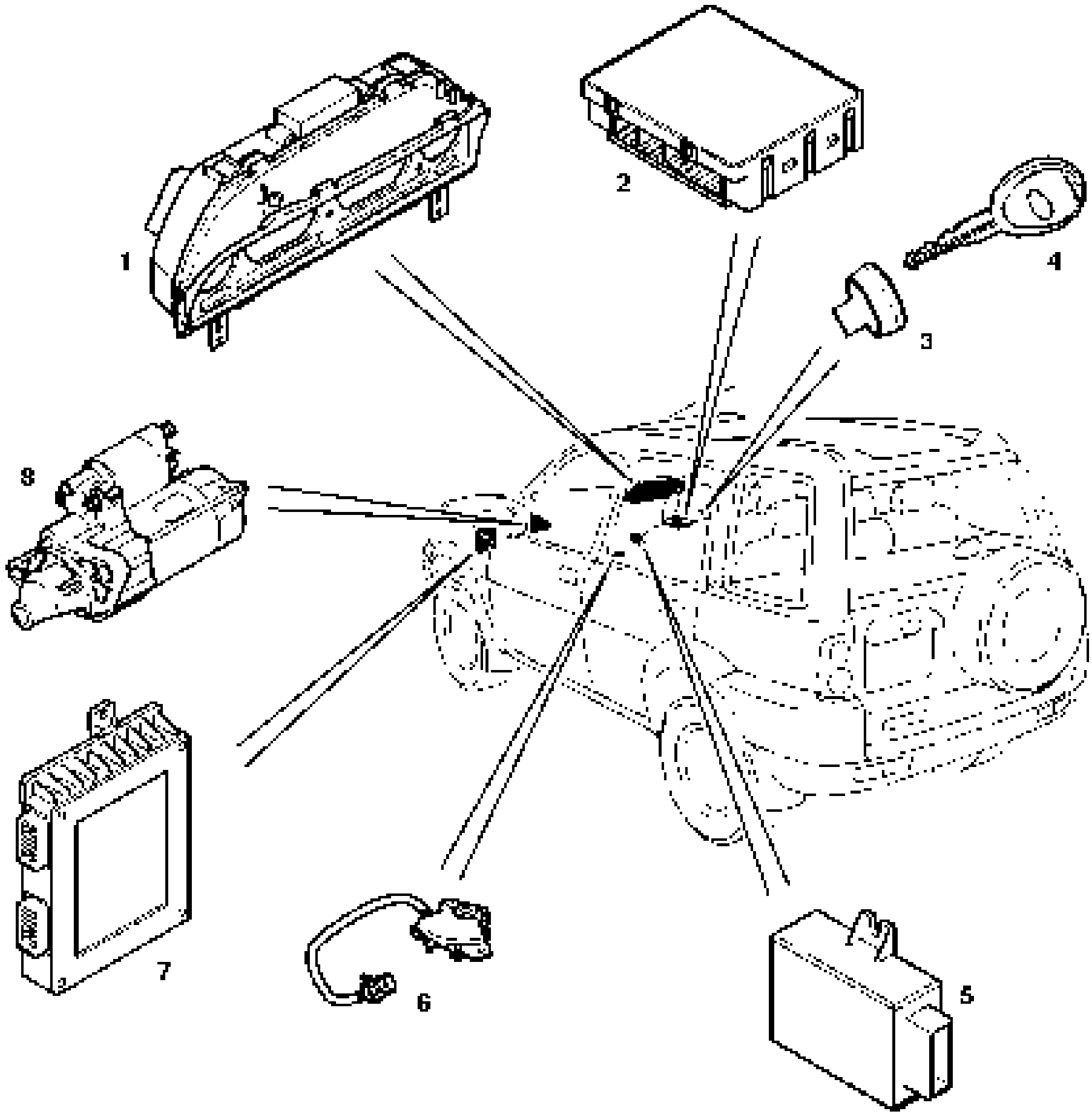
Remote handset replacements will require synchronising. This is achieved using TestBook/T4 (security diagnostics) to enter two bar code serial numbers, supplied on a label with the handset, into one of four code positions in the CCU.

Diagnostics

A diagnostic socket allows the exchange of information between the CCU and TestBook/T4. The diagnostic socket is located in the driver's footwell and is constructed to ISO standard. A dedicated diagnostic bus is connected between the socket and the CCU and allows the retrieval of diagnostic information and programming of certain functions to be performed using TestBook/T4.

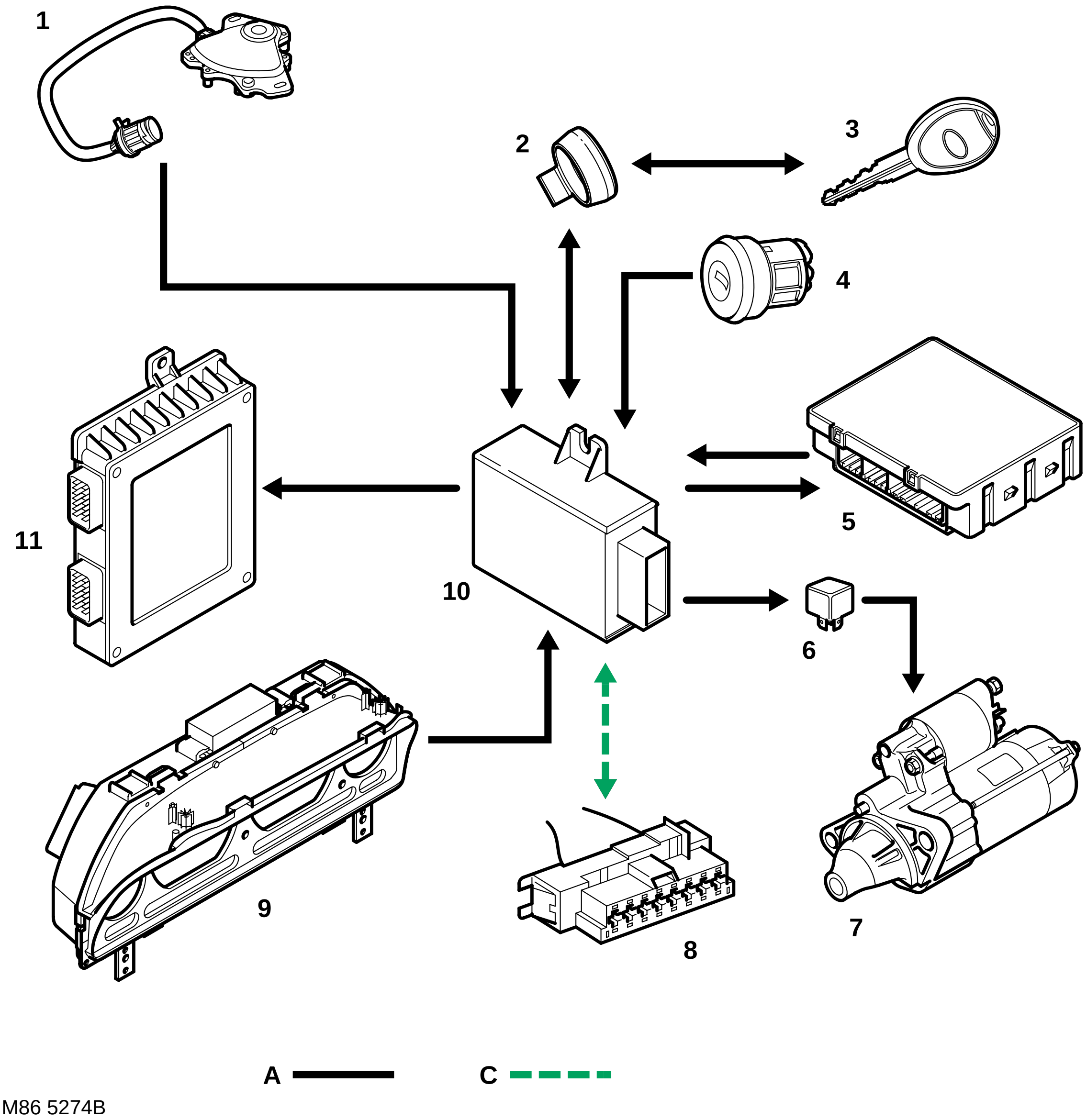
The CCU monitors all inputs and outputs and if a fault is detected a code for that fault is stored in a fault log. The CCU has two fault logs for internal and external faults. The CCU is capable of detecting short or open circuits. The CCU will disable certain functions when faults are detected and reinstate functions when faults are corrected and the function is again requested.

Immobilisation System Component Layout



1 Instrument pack
2 Central control unit
3 Transponder coil (ring antenna)
4 Key transponder
5 Immobilisation ECU (up to VIN 242163 shown)
6 Automatic transmission selector and inhibitor switch
7 Engine Control Module (ECM)
8 Starter motor

Immobilisation System Control Diagram



A = Hardwired connection; C = Diagnostic DS2 bus (EWS3–D system up to VIN 242163) or Keyword 2000 bus (from VIN 242164)*

1. Automatic transmission position switch
2. Transponder coil (ring antenna)
3. Key transponder
4. Ignition switch
5. Central control unit
6. Starter relay
7. Starter motor
8. Diagnostic socket
9. Instrument pack
10. Immobilisation ECU (up to VIN 242163 shown)
11. Engine control module

Description

General
The immobilisation system is essentially a stand alone system with its own controlling ECU located centrally behind the fascia.

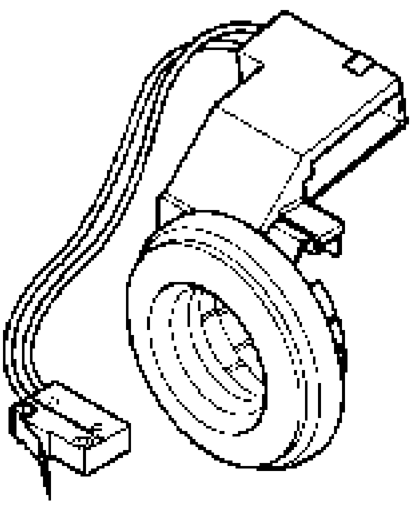
On late 2003 model year vehicles (from VIN 242164 onwards), the EWS3-D immobilisation system was replaced. A new system was introduced which improved the process for adding or replacing keys, allowing the dealer to enable new keys using TestBook/T4. Apart from the immobilisation ECU, the system retains similar components and functionality of the previous immobilisation system. The system is not available as a replacement for vehicles fitted with an EWS3–D system.

Immobilisation System
The immobilisation system comprises:

- Immobilisation ECU
- Ignition switch transponder coil (Ring antenna)
- Key transponder
- Ignition switch
- Instrument pack
- Engine Control Module (ECM)
- Central Control Unit (CCU)
- Park/neutral switch
- Starter motor

Immobilisation System - General
The function of the immobilisation system is to prevent unauthorised starting of the vehicle. The ECU operates in a secure interface which cannot be by-passed or copied. Re-mobilisation is achieved through a transponder in the vehicle key which is energised by a transponder coil surrounding the ignition switch when the ignition is turned to 'AUX' position I. When energised, the transponder data is read by the immobilisation ECU which will confirm the validity of the start request.

Ignition Switch Transponder Coil



M86 5906

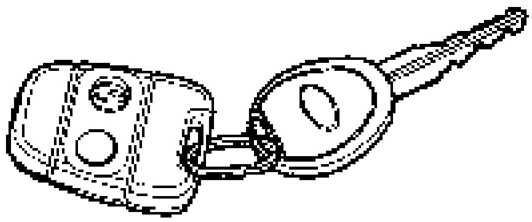
The transponder coil is located in a black plastic housing which is located around the ignition key barrel. The coil is connected by two wires to the immobilisation ECU.

The transponder coil passes electrical energy and data at a frequency of 125 kHz to a transponder in the vehicle key, up to a range of 20 mm (0.78 in) from the coil.

Key Transponder

Each vehicle is supplied with two vehicle keys and two separate RF transmitters. The RF transmitters are used to lock and arm the vehicle, and for the tail door window drop function. The key head contains the transponder used by the immobilisation system.

Key and Remote Handset



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On vehicles up to VIN 242163 (EWS-3D System), each keyblade has an external waveform profile which is coded and recorded in a BMW Group database, therefore replacement keys are only available from franchised dealers/ suppliers. The transponder contains a 128 byte EEPROM which is programmed with vehicle identification data which is checked by the immobilisation ECU before re-mobilisation is activated. The information programmed into the EEPROM cannot be overwritten.

On vehicles from VIN 242164, each keyblade has an external waveform profile which is coded and recorded in a Land Rover database. Replacement keys are supplied to the dealer with the correct keyblade waveform profile cut and the transponder programmed by Land Rover. The transponder contains a 256 byte EEPROM which is programmed with vehicle identification data which is checked by the immobilisation ECU before re-mobilisation is activated. The information programmed into the EEPROM cannot be overwritten.

Immobilisation ECU

The immobilisation ECU is the central component in the immobilisation system and is located behind the fascia in a central position.

The immobilisation ECU communicates with the CCU and is connected to the diagnostic socket enabling diagnostic procedures to be carried out.

There is no audible or visual indication to the driver of the condition of the immobilisation system.

The immobilisation ECU receives information from related systems on the vehicle and passes a coded signal to the ECM to allow starting if all starting parameters have been met. The information is decoded by the ECM which will allow the engine run if the information is correct. The information is on a rolling code system and both the ECU and the ECM will require synchronisation if either component is renewed.

Depending on engine fitment, four different ECM's can be used on the vehicle. Each ECM communicates with the immobilisation ECU using the same protocol .

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

Immobilisation ECU and Key Ordering Procedure – EWS-3D System – Up to VIN 242163 Only

The immobilisation system is a highly secure system and to maintain security, the supply of spare/replacement keys and immobilisation ECU's is restricted to BMW Group dealers only. Keys can be disabled to prevent use of an unauthorised key using TestBook/T4 (immobilisation diagnostic).

Key and ECU Ordering Procedure (Except Japan)

Each dealer must adhere to the following procedure when ordering keys and/or immobilisation ECU's.

1. The dealer receives a request from the customer for a spare/replacement key or a replacement immobilisation ECU and key set
2. The dealer must request from the customer proof of ownership and Vehicle Identification Number (VIN). This may be in the form of a registration document for example. If proof of ownership cannot be supplied, the dealer must not proceed with ordering keys
3. The dealer must raise a Vehicle Off Road (VOR) order quoting the VIN and the part number of the part(s) required
4. The dealer must pass the VOR order to the corporate wholesaler, European distribution centre or importer on the Unipart parts ordering system before 12:45 pm for next day delivery
5. Unipart will validate the VIN and, if correct, will send an order to BMW GB on the Direct Factory Supplier (DFS) system before 1:00 pm for the same day delivery to Unipart. If Unipart find the VIN to be incorrect, they will contact the dealer to revalidate the VIN
6. BMW GB record the order and pass it to BMW AG in Dingolfing, Germany who interrogate their database to establish that the VIN is valid. From the database, BMW AG confirm that immobilisation codes remain available
7. If no codes are available, the order is returned to BMW GB who inform Unipart that all available codes have been used and that a new immobilisation ECU and key set is required. Unipart inform the corporate wholesaler, European distribution centre or importer on a parts information sheet that order has been rejected and reason for rejection. The corporate wholesaler, European distribution centre or importer inform the dealer who will advise the customer that a new immobilisation ECU and key set is required. If customer agrees, then the ordering procedure is repeated from step 3
8. BMW AG will establish mechanical and electrical key configuration, update the database and create a bar code order form from which the spare/replacement key or immobilisation ECU and key set is made
9. BMW AG will pass the completed order form to the BMW GB key cutting centre who use the bar code to produce the new keys or new immobilisation ECU and key sets
10. BMW GB will despatch the part(s) to Unipart at circa 3:30 pm on the same day in order to get the parts on the Unipart overnight VOR delivery
11. In the UK market, Unipart will despatch the part(s) to the corporate wholesaler overnight to arrive circa 8:30 am next day. The corporate wholesaler will deliver the part(s) to the dealer at circa 12:00 pm on the same day
12. In ROW markets, Unipart will despatch the part(s) to the European distribution centre or importer next day to arrive by 12:00 pm the following day. The European distribution centre will deliver the part(s) overnight to arrive at the dealer at circa 8:30 am the following day. In importer markets, courier delivery times to the dealer can be typically 5/6 days for South America/Asia and 8/12 days for Australia

Replacement Key CCU Programming

A replacement key will arrive ready for use. The EWS-3D will recognise the first use of the key and will initiate the random rolling code from then on. TestBook/T4 can also be used to enable or disable keys, if a key is lost for example.

Operation

Immobilisation System
The immobilisation system prevents unauthorised starting of the vehicle. The immobilisation ECU is a secure interface between the ECM which cannot be copied or by-passed.

Immobilisation ECU
The ECU ensures that the vehicle is in a safe condition to start the engine. The ECU prevents starter operation if the transmission selector lever is not in park or neutral. A feed from the automatic transmission solenoid (C0024) is connected to pin 3 on the immobilisation ECU. The feed is only present when the selector lever is in either park/ neutral. If the selector lever is moved to any other position the feed to the immobilisation ECU is removed and engine cranking will be disabled.

When the ignition is switched to position 0 (off) and the key is removed from the switch, the immobilisation ECU becomes active and prevents unauthorised starter operation. Re-mobilisation is achieved only by insertion of a valid vehicle key into the ignition switch and turning the switch to position I (AUX).

Ignition Switch Transponder Coil and Key Transponder
The transponder coil is supplied with a modulated electric current from the immobilisation ECU. When the key transponder is within 2 cm (0.78 in) from the coil, with the ignition switch in the position I (AUX), an energy transfer from the coil to the transponder takes place, similar to the transformer principle, at a frequency of 125 kHz. The ECU de-modulates and decodes the received data and compares this with identification code data from the ECM. If the data is correct the ECU allows starter operation.

When the key is inserted in the ignition switch, communications between the transponder and the immobilisation ECU, via the transponder coil, occur as follows:

- A unique key identification number is passed to the ECU
- A random code is transmitted by the ECU to communicate with the key transponder
- An encrypted response to the random code is transmitted from the key transponder to the ECU.

Programming – Vehicles Up to VIN 242163
The immobilisation ECU is programmed with vehicle specific data during manufacture. The key transponders are supplied with the specific vehicle pre-programmed with the mechanical code for that vehicle's lockset. The mechanical code is read at the factory before the keys are programmed and the information is stored in a central database. The data is required to cut spare or replacement keys.

The ECU is programmed during manufacture with data to support up to ten keys. The programmed information is recorded against the VIN for that vehicle and stored in a central database.

Replacement or spare keys will be ordered and delivered to the dealer already programmed with the correct information specific to the particular vehicle and ready for use.

If a replacement immobilisation ECU is required it will be ordered and delivered to the dealer programmed with the original information stored during manufacture. The ECM will not require reprogramming because the replacement ECU will have the same identification code as before. The ECM and the EWS-3D immobilisation ECU will however need have their rolling code synchronised using TestBook/T4.

If the ECM is replaced, the ECM will have to learn the identification code. This is achieved using TestBook/T4. When the immobilisation ECU receives the correct diagnostic message it will transmit the identification code on a continual basis until the ignition is switched off. Simultaneously, the ECM also receives a diagnostic command to learn the new code.

Programming – Vehicles From VIN 242164

The immobilisation ECU is programmed with vehicle specific data by Land Rover during vehicle manufacture. This data is also stored in other ECU's on the vehicle. Non-sensitive data stored in the immobilisation ECU can be retrieved using TestBook/T4.

The ECU is programmed during manufacture with data to support up to 30 keys which can be enabled with TestBook/T4. Replacement or spare keys will be ordered and delivered to the dealer as a disabled key. The dealer will use the previously described 'Learn Blank/New Keys' procedure for enabling the new key. The key will be supplied with the correct key blade profile for the applicable vehicle lockset.

If a replacement immobilisation ECU is required it will be ordered and delivered to the dealer as a pre-programmed ECU. The ECM and the new immobilisation ECU will however need have their rolling code synchronised using TestBook/T4.

If the ECM is replaced, the new ECM will have to learn the identification code. This is achieved using TestBook/T4. When the immobilisation ECU receives the correct diagnostic message it will transmit the identification code on a continual basis until the ignition is switched to position 0 (off). Simultaneously, the ECM also receives a diagnostic command to learn the new code.

Starter Motor Protection

The immobilisation system incorporates a starter motor protection function. When the engine speed exceeds a predetermined value, a starter relay inside the immobilisation ECU is disabled. This relay is wired in series with the main starter motor solenoid and therefore when disabled it cuts off the power supply to the starter motor. This prevents damage to the starter motor being caused by a sticking ignition switch. The engine speed is derived from the instrument pack which converts the speed from a CAN bus signal into a pulsed signal compatible with the immobilisation ECU.

Diagnostics

A diagnostic socket allows the exchange of information between the immobilisation ECU and TestBook/T4. The diagnostic socket is located in the driver's footwell and is constructed to ISO standard. A dedicated diagnostic bus is connected between the socket and the immobilisation ECU. The bus allows the retrieval of diagnostic information and programming of certain functions to be performed using TestBook/T4.

The diagnostic bus protocol differs depending on the immobilisation system fitted to the vehicle as follows:

- for vehicles up to VIN 242163 (EWS3-D system) the immobilisation ECU uses DS2 protocol
- for vehicles from VIN 242164 the immobilisation ECU uses Keyword 2000* protocol.

The immobilisation ECU monitors all inputs and outputs and if a fault is detected, a code for that fault is stored in a fault log which can be retrieved using TestBook/T4. The diagnostic interface is also used for synchronising a replacement ECM to the existing immobilisation ECU and for enabling or disabling new or current keys.

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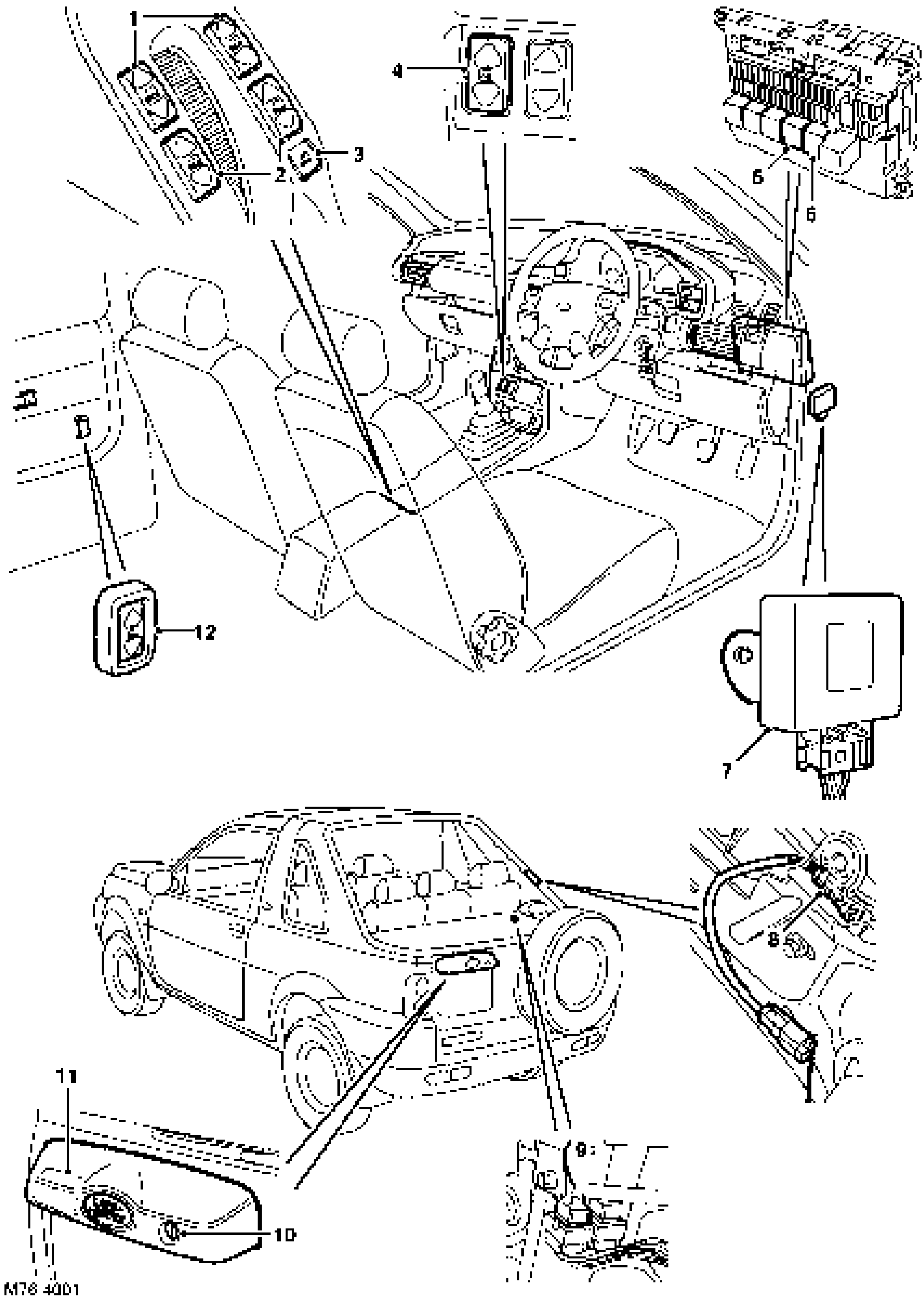
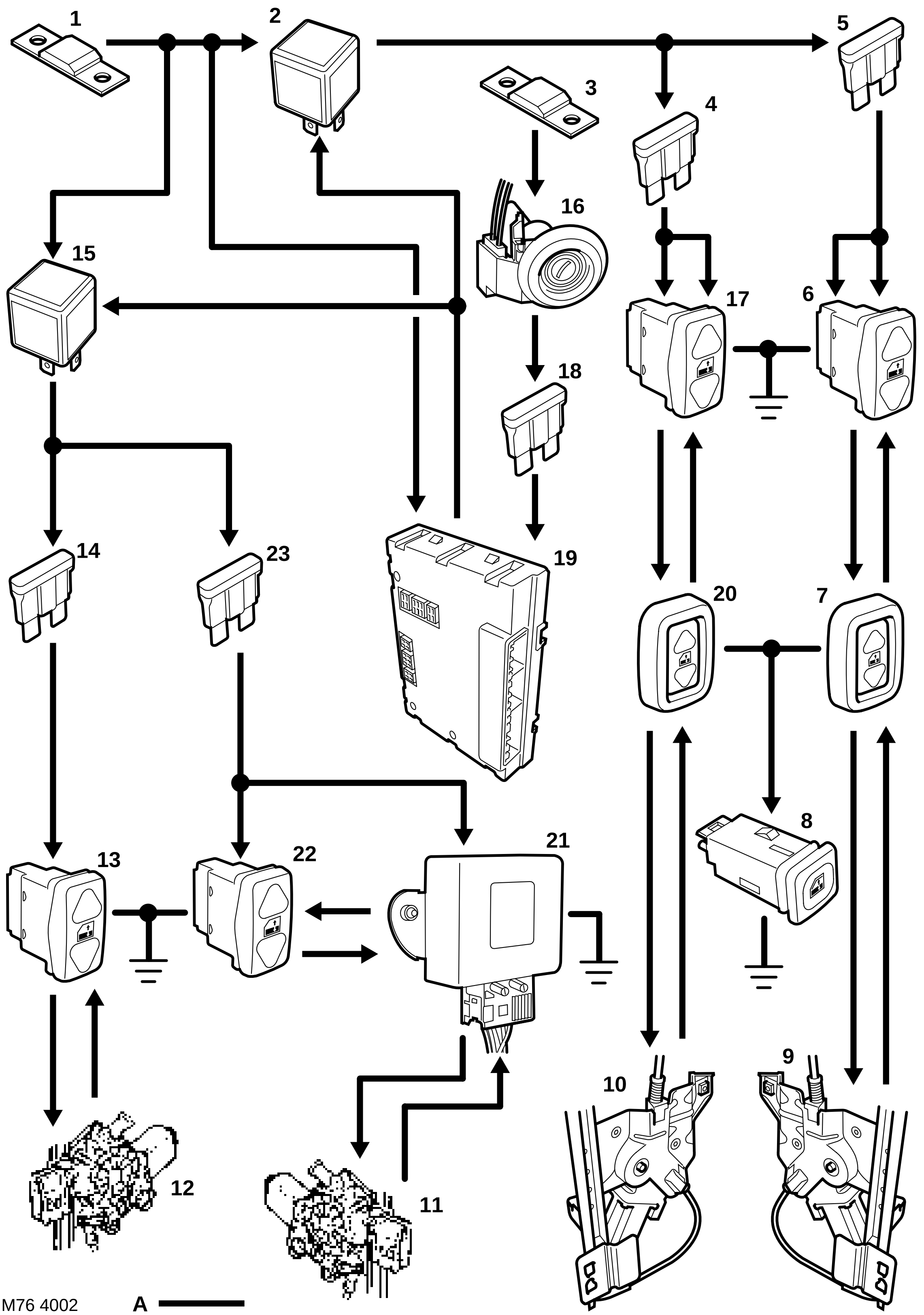
Window Component Layout



1 Front side door window switches
2 Rear side door window switches (5 door only)
3 Isolator switch (5 door only)
4 Tail door window switch
5 Sunroof relay (5 door only)
6 Window lift relay
7 Window lift ECU
8 Roof sensing switch (3 door only)
9 Tail door window relay
10 Tail door lock
11 Tail door handle
12 Rear side door window switch (5 door only)

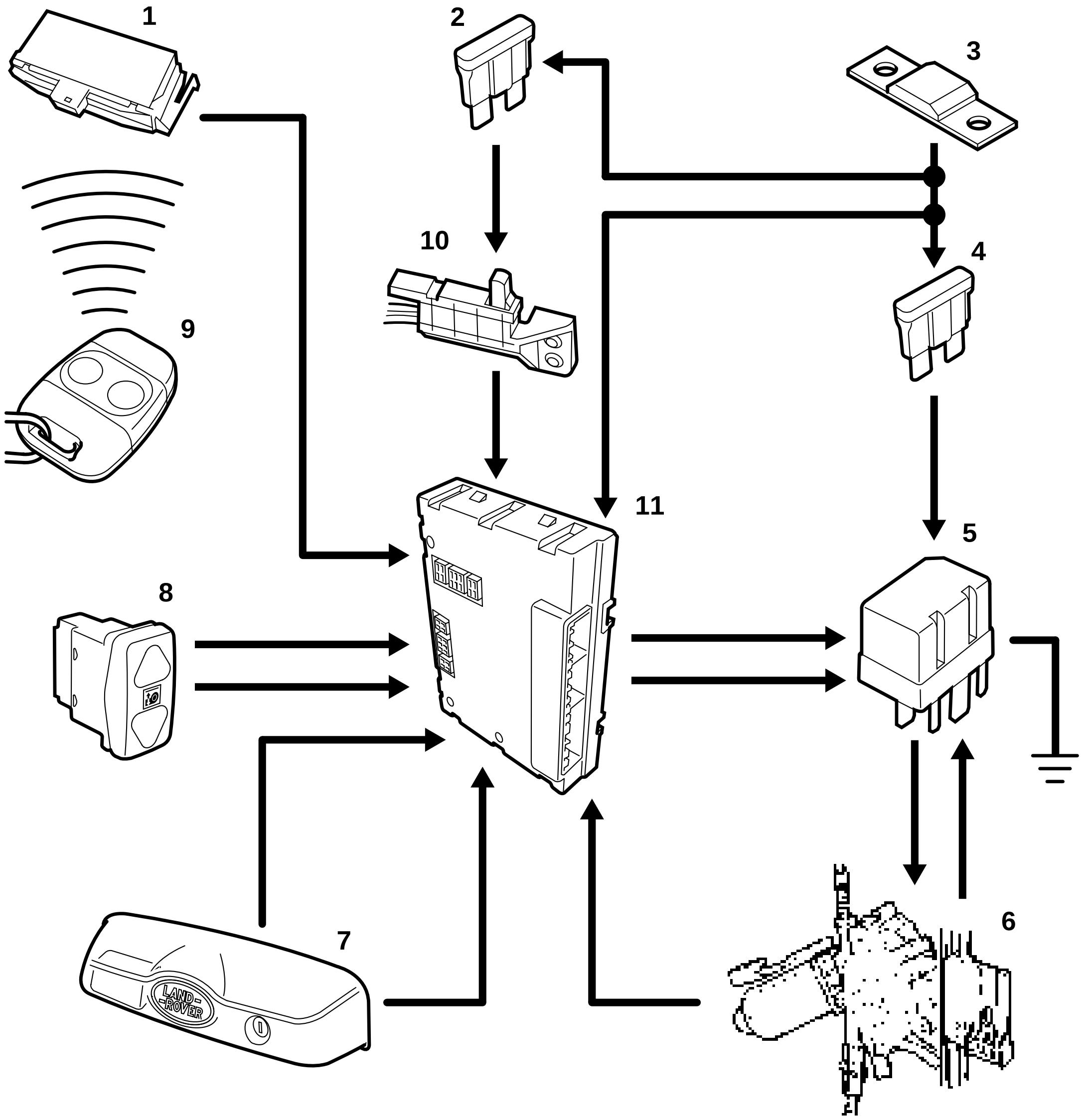
Side Door Window Control Diagram



A = Hardwired connections

1 Fusible link 4, engine compartment fusebox
2 Sunroof relay
3 Fusible link 3, engine compartment fusebox
4 Fuse 26, passenger compartment fusebox
5 Fuse 27, passenger compartment fusebox
6 Centre console RH rear window switch (5 door only)
7 Door trim RH rear window switch (5 door only)
8 Isolator switch (5 door only)
9 RH rear window motor (5 door only)
10 LH rear window motor (5 door only)
11 Driver's window motor
12 Front passenger's window motor
13 Front passenger's window switch
14 Fuse 34, passenger compartment fusebox
15 Window lift relay
16 Ignition switch
17 Centre console LH rear window switch (5 door only)
18 Fuse 8, passenger compartment fusebox
19 CCU
20 Door trim LH rear window switch (5 door only)
21 Window lift ECU
22 Driver's window switch
23 Fuse 33, passenger compartment fusebox

Tail Door Window Control Diagram



1 RF receiver
2 Fuse 14, passenger compartment fusebox
3 Fusible link 4, engine compartment fusebox
4 Fuse 31, passenger compartment fusebox
5 Tail door window lift relay
6 Tail door window motor
7 Tail door handle and lock
8 Tail door window switch
9 Remote transmitter (plip)
10 Roof sensing switch (3 door models only)
11 CCU

Description

General
All models feature electrically operated windows on the side doors and the tail door.

The side door windows are controlled by a window lift ECU and individual rocker switches located in the centre console and, on 5 door models, in the rear door trim casings. 5 door models also incorporate an isolator switch, in the centre console, for the rear side door windows.

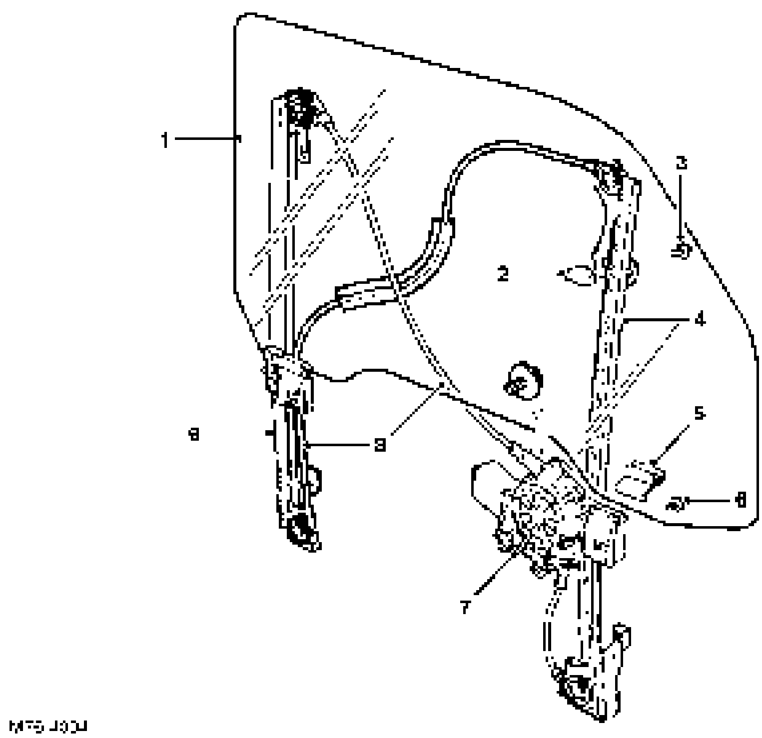
The tail door window is controlled by the Central Control Unit (CCU), a rocker switch on the fascia, the remote handset and the tail door handle and lock. The CCU also uses inputs from the rear screen wiper system and, on 3 door models, a roof switch, to inhibit window operation while the rear screen wiper is operating or the roof is open (soft back) or removed (hard back).

Front Door Windows
The front window regulator and motor is supplied as an assembly and is handed. Each assembly comprises a front and rear runner, a continuous cable and a motor.

The runners are secured in the door frame with four screws. The door glass is located in two carriers which are located in tracks in the runners. The glass is retained in friction pads in each carrier and secured with clamp screws.

Each carrier is attached to the cable which, in turn, is attached to a drum driven by the motor. When the motor is operated the drum pulls the cable in the required direction to raise or lower the glass.

Front Door Window Regulator



LH regulator shown, RH similar

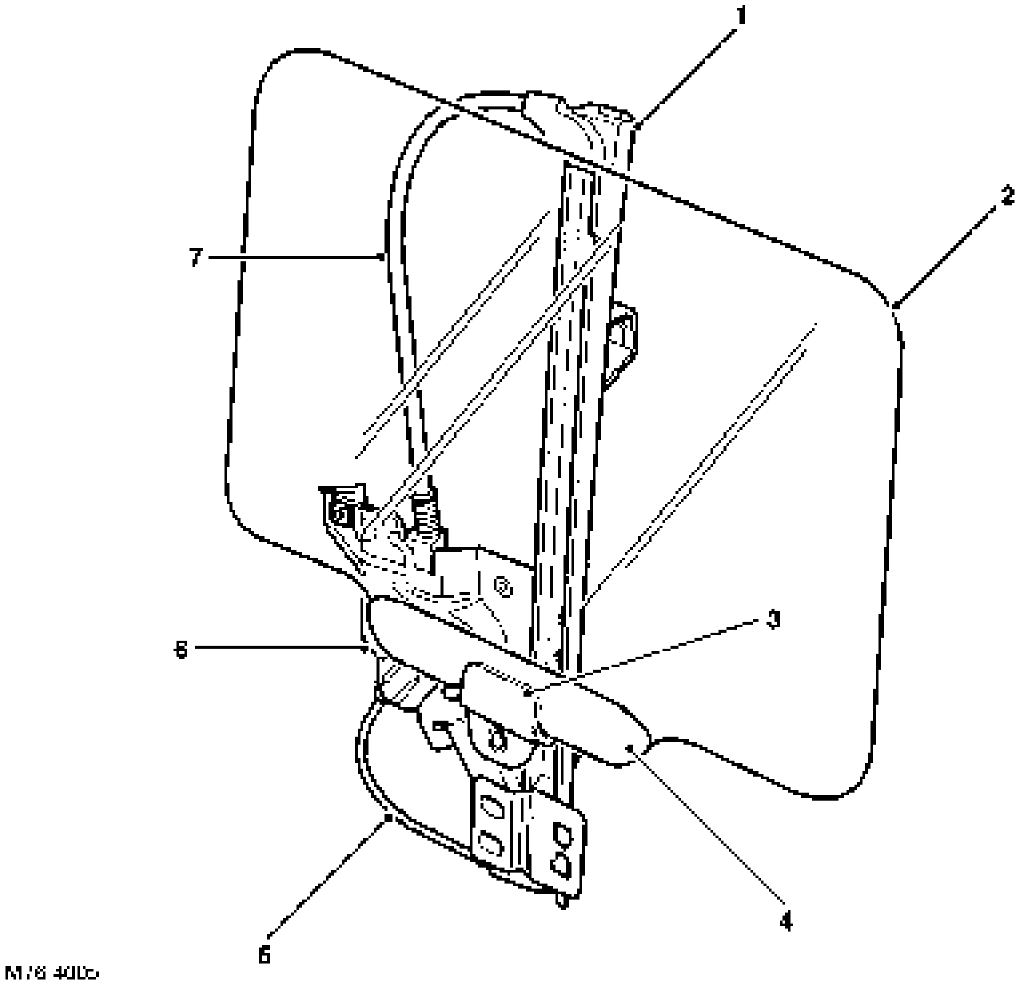
1 Window glass
2 Glass stop damper
3 Mounting screw (4 off)
4 Forward runner
5 Friction pad
6 Glass clamp screw
7 Motor assembly
8 Cable
9 Rear runner

Rear Door Windows
The rear window regulator and motor is supplied as an assembly and is handed. Each assembly comprises a runner, a continuous cable and a motor.

The runner is secured in the door frame with four bolts. The door glass is located in a carrier located in a track in the runner. The glass is retained in friction pads in the carrier and secured with a clamp screw.

The carrier is attached to the cable which, in turn, is attached to a drum driven by the motor. When the motor is operated, the drum pulls the cable in the required direction to raise or lower the glass.

Rear Door Window Regulator



RH regulator shown, LH similar

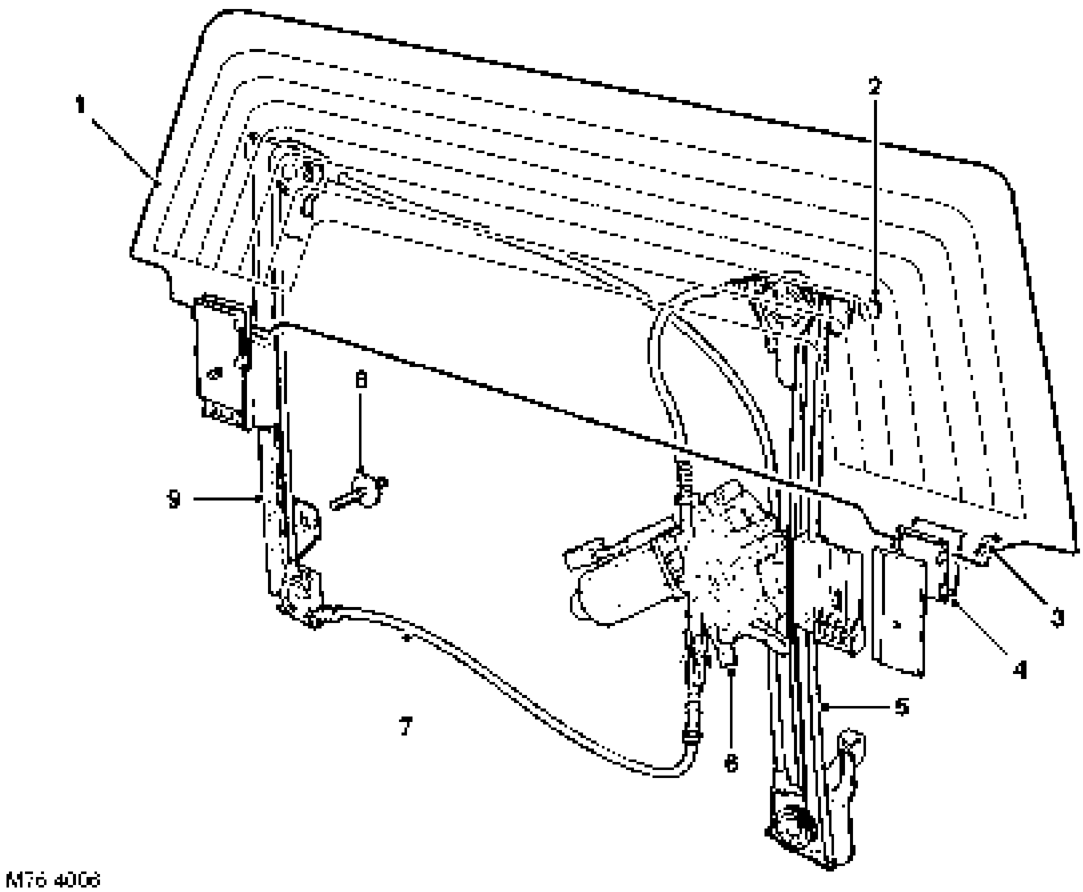
- **1** Runner
- **2** Window glass
- **3** Friction pad
- **4** Carrier
- **5** Cable
- **6** Motor and regulator
- **7** Cable

Tail Door Window
The tail door window regulator comprises left and right hand runners, a continuous cable and a motor. The runners are secured in the tail door frame with four screws. The glass is located in two carriers which are located in tracks in the runners. The glass is retained in friction pads in each carrier and secured with clamp screws.

Each carrier is attached to the cable which, in turn, is attached to a drum driven by the motor. When the motor is operated, the drum pulls the cable in the required direction to raise or lower the glass.

The motor incorporates a movement sensor that supplies a position feedback signal to the CCU.

Tail Door Window Regulator



1 Tail door glass
2 Nut (3 off)
3 Clamp screw (2 off)
4 Friction pad (2 off)
5 RH runner
6 Motor
7 Cable
8 Mounting screw (4 off)
9 LH runner

Window Lift ECU
The window lift ECU provides 'one shot' opening of the driver's door window. Instead of the window switch being connected direct to the window motor, as on the other side door(s), the driver's door window switch is connected to the window motor via the window lift ECU. The window lift ECU is installed on the driver's side A post, level with the lower edge of the fascia.

Operation

Side Door Windows

Power for side door window operation is supplied from the window lift relay and, on 5 door models, the sunroof relay, both located in the passenger compartment fusebox. The CCU controls the relays, which are energised while the ignition switch is in position II and for 40 seconds after the ignition is turned off.

When an up or down selection is made on one of the side door window switches, the switch simultaneously connects a power supply and an earth to the related door window motor to drive the window in the required direction. When the opposite selection is made, the switch changes the polarity of the connections to drive the window in the opposite direction. The window stops moving immediately the switch is released, except when a momentary down selection is made on the driver's door switch.

The driver's door window switch is connected to the window motor via the window lift ECU. When the window lift ECU senses a momentary (0.2 second or less) down selection on the driver's door switch, it connects the driver's door window motor to a power supply direct from the window lift relay and to an ECU earth. The window lift ECU maintains these connections until the door window motor stalls, after driving the window fully down, or an up selection is made on the window switch.

On 5 door models, each rear window switch on the centre console is connected to the window motor via the related rear door mounted window switch. When the isolator switch is pressed, the earth path for the two rear door mounted window switches is disconnected. With the isolator switch pressed, only the rear window switches in the centre console will operate the rear door window motors.

Tail Door Window

The CCU controls the tail door window via the tail door window relay located above the RH rear suspension turret. The tail door window relay is a dual relay that incorporates separate 'up' and 'down' contacts. When the CCU wants to operate the window, it switches the appropriate contacts in the tail door window relay to connect a power supply and an earth to drive the window motor in the required direction. The contacts change the polarity of the motor to change the direction of drive.

The tail door window can be lowered using the console switch or the remote handset. On 3 door models, opening/ removal of the roof will automatically lower the window. The window can be raised using the console switch or the vehicle key in the tail door key barrel. When the tail door is opened, the tail door window lowers to a 'clear of seal' position and, when the door is closed, the window automatically rises to its fully up position in the window seal.

Tail Door Window Lower

The rear screen wiper must be parked off-screen before the CCU will allow the tail door window to lower. If the rear screen wiper is operating when a window down request is made, the CCU will automatically park the wiper off-screen before lowering the window. If the Heated Rear Window (HRW) is operating, the CCU will turn off the HRW when the window is lowered.

Remote Handset Lower: With the ignition off and the tail door closed, if the unlock button on the remote handset is pressed for a minimum of 1 second the CCU will unlock the doors and energise the tail door window down relay to fully lower the window.

NOTE: The tail door window cannot be raised using the remote handset. To raise the tail door window use the Tail Door Key Barrel Raise procedure.

Console Switch Lower - Inch Down: With the ignition on, pressing the console switch in the down position will signal the CCU to lower the tail door window for as long as the switch is held. The window will stop at the chosen position when the switch is released. When the window is almost fully down, the CCU will continue to lower the window irrespective of whether the switch is pressed or not.

Console Switch Lower - One Shot: With the ignition on, pressing the console switch in the down position, for approximately 0.2 second or less, will signal the CCU to lower the tail door window until it is fully down or an up request is received. This feature is market programmable.

Roof Removal (3 Door Models Only): Opening/ removal of the roof will trip the roof off switch. This signals the CCU which, if the alarm is not armed, automatically lowers the tail door window even if the tail door is open. If the roof is opened/ removed while the alarm is armed, the roof off switch triggers the alarm and the CCU will not lower the tail door window.

Tail Door Window Raise

If the rear screen wiper is selected on when the tail door window is raised, the CCU will start/ resume operation of the wiper once the window is closed.

Tail Door Key Barrel Raise: With the tail door closed and, on 3 door models the roof closed/on, turning and holding the key in the tail door key barrel will signal the CCU to raise the tail door window. The key must be held until the window is fully raised (stalled position). If the key is released before the window is fully raised, the raise signal is removed from the CCU and the window will be fully lowered.

Console Switch Raise: With the ignition on, the tail door closed and, on 3 door models the roof closed/on, pressing the console switch in the up position will signal the CCU to raise the tail door window. The switch must be pressed until the window is fully raised (stalled position). If the switch is released before the window is fully raised, the raise signal is removed from the CCU and the window will be fully lowered.

Motor Timeout

To protect the tail door window motor from damage, the motor outputs have a fail-safe inhibit relative to the window height. This prevents the motor from being overdriven. If the fail-safe limit is reached, the CCU will energise the tail window down relay, to fully lower the window, and change the window position setting to uncalibrated. The calibration procedure will need to be performed to restore normal tail door window operation.

Tail Door Window Open Warning

If the tail door window is calibrated and open and, on 3 door models the roof is closed/on, and a lock request is made from the remote handset or the driver's door key barrel, the CCU will sound an audible miss-lock warning to advise that the window is open. The window can be closed using either the console switch or the tail door key barrel.

Calibration

When the CCU is changed from transit mode to a valid market mode, and/or after the vehicle battery has been disconnected, the tail door window must be calibrated to provide the CCU with a window position datum. When the CCU mode is changed to a valid market, or the battery reconnected, the CCU automatically begins the calibration process by energising the down contacts in the tail window lift relay until the window motor stalls, to ensure the window is fully down. The calibration procedure is completed as follows:

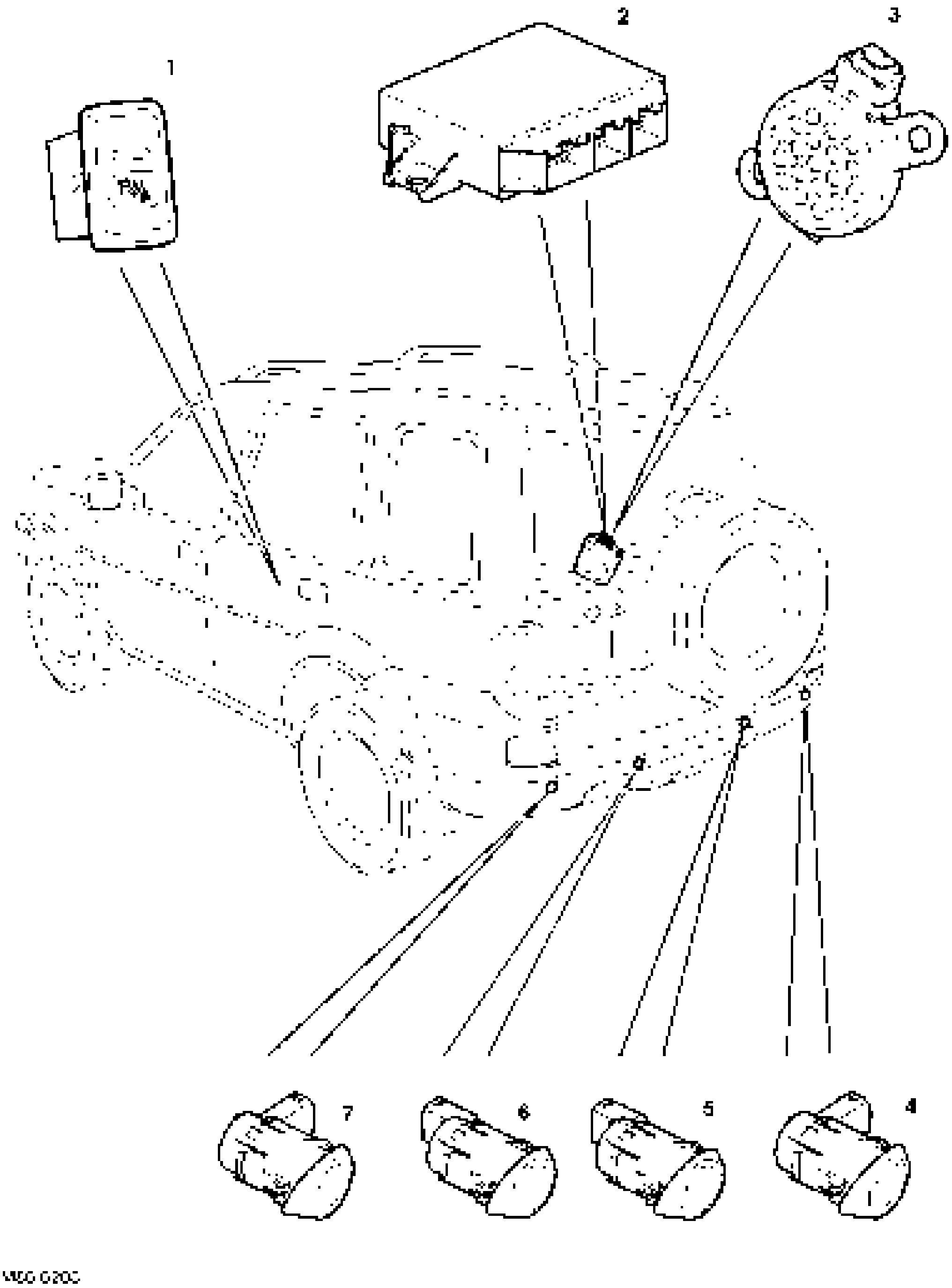
1. Ensure the tail door is closed, the vehicle unlocked and the alarm disarmed.
2. On 3 door models, ensure the roof is on (hard back) or lowered and secured (soft back).
3. Disconnect the battery earth lead, observing battery disconnection electrical precautions detailed in the Workshop Manual Service Repairs.
4. Allow at least 10 seconds to elapse before reconnecting the battery earth lead. The tail door glass will fully lower approximately 2 seconds after the battery is reconnected.
5. Start the engine. Ensure that all electrical loads, i.e. lights etc. are switched off. Increase the engine speed to 1500 rev/min. for 10 seconds.
6. After 10 seconds and whilst maintaining the engine speed at 1500 rev/min., carry out the following:
   - **a** Close the tail door window fully to start the calibration procedure.
   - **b** Fully open the tail door window.
   - **c** Fully close the tail door window.
   - **d** If the tail door window remains closed, the calibration procedure is complete.
7. If the calibration procedure is unsuccessful, the CCU will sound a warning for approximately 0.8 second and fully lower the window. Repeat the calibration procedure from step 1.
8. Allow the engine to idle and then switch off the engine.

Tail door window calibration can fail for the following reasons:

- Window stops before minimum travel is achieved.
- Window does not achieve a stall.
- Window request removed before stall is achieved.
- Tail door opened while driving window up.

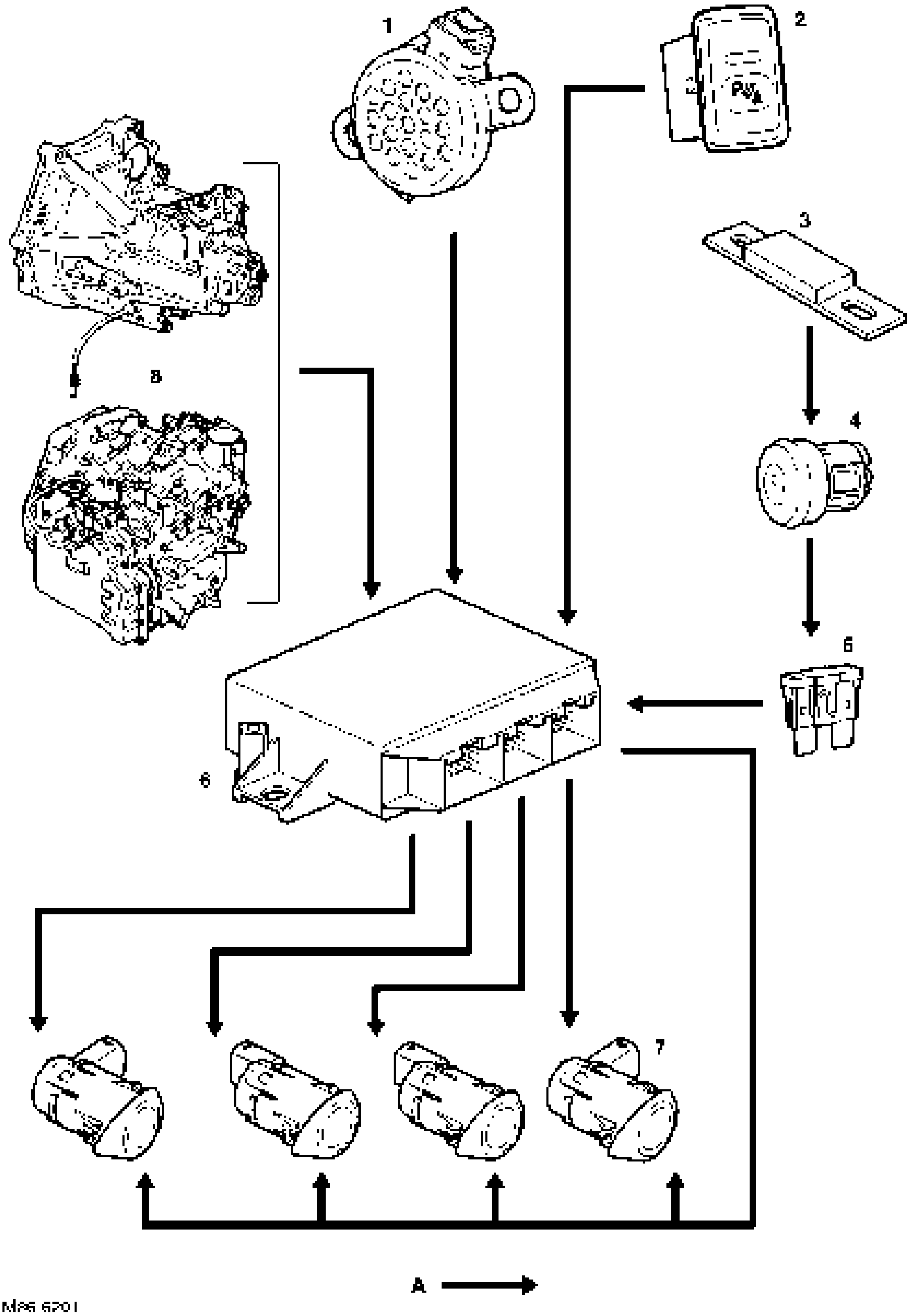
Park Distance Control

Park Distance Control Component Location



1. Park Distance Control (PDC) switch
2. PDC ECU
3. PDC sounder
4. RH outer PDC sensor
5. RH inner PDC sensor
6. LH inner PDC sensor
7. LH outer PDC sensor

Park Distance Control Control Diagram



1 PDC sounder
2 PDC switch
3 Fusible link
4 Ignition switch
5 Fuse
6 PDC ECU
7 PDC sensors
8 Transmission (reverse gear input)

Description

General
PDC provides an audible warning to the driver when any obstacles are in the path of the vehicle during a reversing manoeuvre. The purpose of the system is to assist the driver when parking or manoeuvring in restricted space. It is not designed as a crash avoidance system or a replacement for visual interpretation for the driver.

The system comprises four ultrasonic sensors in the rear bumper, a control module, a fascia mounted control switch and a rear sounder unit.

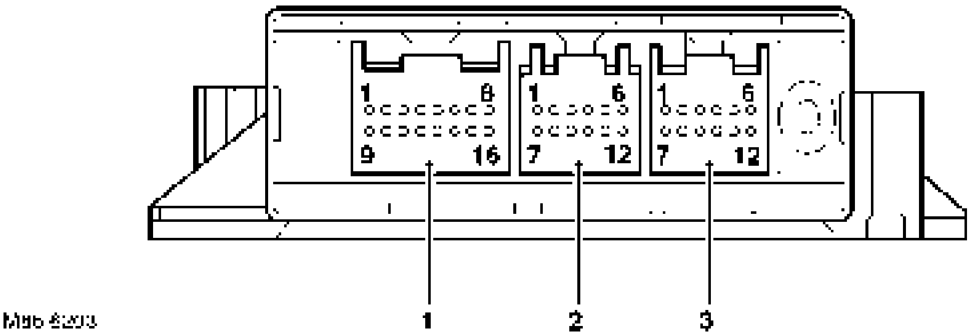
The system operates using ultrasonic signals which are transmitted by the sensors. The reflected echo from this output is received by the sensors and used by the PDC ECU to calculate the distance from an object.

The fascia mounted switch allows the driver to deactivate the PDC system, if operation is not required.

PDC ECU
The PDC ECU is located in the rear right hand side of the luggage compartment, behind the side trim panel.

The PDC ECU uses a single microprocessor to perform the following tasks:
- Control of the ultrasonic sensors
- Monitoring of the sensors
- Evaluation of received echo signals from the sensors
- Noise and disturbance suppression
- Control of the PDC sounder
- Monitoring of the sounder and lead
- Control and monitoring of the switch status LED and lead
- Evaluation and monitoring of the control inputs
- Management of diagnostic and test functions
- Monitoring of power supply
- Communication via diagnostic link.

PDC Connector Pin Details



1 Connector C0958
2 Not used
3 Connector C0957

The following tables give input/output information for the two harness connectors used on the PDC ECU.

Connector C0958

Pin No.	Description	Input/Output
1	Ignition switch power supply	Input
2	Sounder - Negative	Input
3	Not used	–
4	PDC switch	Input
5	Not used	–
6	Reverse gear signal	Input
7, 8 and 9	Not used	–
10	Sounder - Positive 12V supply	Output
11 and 12	Not used	–
13	PDC switch	Output
14 and 15	Not used	–
16	Ground	–

Connector C0957

Pin No.	Description	Input/Output
1	Not used	–
2	Sensor - RH Inner - Signal	Input
3	Sensor - LH Inner - Signal	Input
4	Sensor - RH Outer - Signal	Input
5	Sensor - LH Outer - Signal	Input
6 and 7	Not used	–
8	Ground - All sensors	Input
9	Not used	–
10	Power supply - All sensors	Output
11 and 12	Not used	–

Inputs and outputs

Two connectors provide the interface between the PDC ECU and the external PDC components.

The ECU receives inputs from the following:

- Reverse lamp circuit - for system activation when reverse gear is selected
- PDC switch - fro activation and de-activation of the system
- Ignition switch - power supply for system operation.

The ECU outputs to the following:

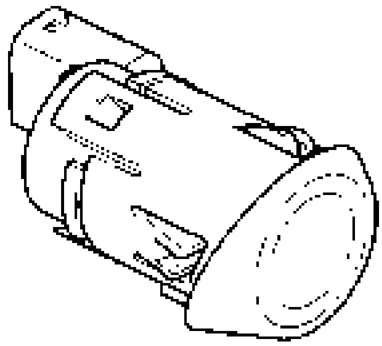
- Sensors - power and ground connections
- Sensors - digital signal transmit and receive signals
- Sounder - signal for sounder operation
- PDC switch - power supply for switch LED operation.

Diagnostics

The PDC ECU has no diagnostic connection to enable faults to be retrieved using TestBook/T4. An on-board diagnostic routine monitors the system and alerts the driver to a system fault by emitting a tone from the sounder.

If a PDC system fault has occurred, the sounder will emit a continuous tone for 3 seconds and the PDC switch LED will flash continuously when reverse gear is selected.

Sensors



M86 6204

Four sensors are positioned in the rear bumper. Each sensor comprises an outer housing with an angled rubber trim which differs between the inner and outer sensors and the sensor body. The outer housing has a slot which engages with a pin on the sensor body and is locked by rotating the sensor. A coil spring around the sensor is compressed when the sensor is installed in the bumper and maintains the sensor housing engaged on the pin. The sensor housing has a raised lip at the top which locates in a corresponding groove in the bumper mounting hole and sets the correct orientation for the sensor body.

Each sensor has a three pin connector which connects into a common harness linking all four sensors. This harness is connected to the main vehicle body harness. The three pins are for sensor negative and positive feeds and a signal line.

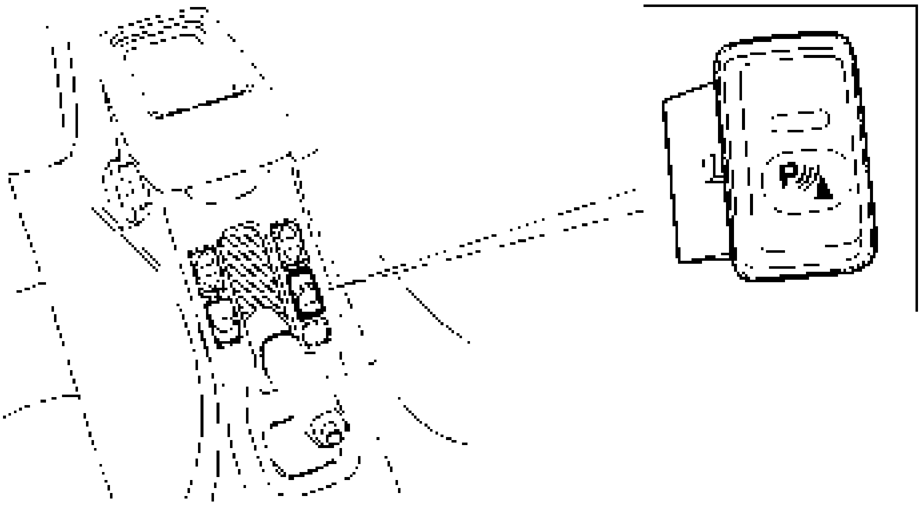
Each sensor comprises a plastic housing which contains a piezoelectric disc. The disc resonates at a frequency of 38.4kHz, producing an ultrasonic signal output. The disc also receives the reflected echo signal.

The PDC ECU controls the operating mode of each sensor by output of a digital signal on the signal line. Each sensor has two modes of operation; combined transmitter and receiver mode or receiver mode only.

In the combined mode, the sensor emits a series of ultrasonic impulses and then switches to receiver mode to receive the echo reflected by an obstacle in the detection range. These echo signals are amplified and converted from an analogue signal to a digital signal by the sensor. The digital signal is then transmitted to the PDC ECU and compared with preprogrammed data stored in an EEPROM within the ECU. The ECU receives this data via the signal line from the sensor and calculates the distance to the obstacle according to the elapsed time between the transmitted and received impulse. The duration of the impulse transmission is determined by the module. The sensor determines the frequency of the impulse.

In the receiver mode, the sensor will receive impulses that were emitted by adjacent sensors. The ECU uses this information to precisely determine position and distance of the obstacle.

PDC Switch


M86 8205

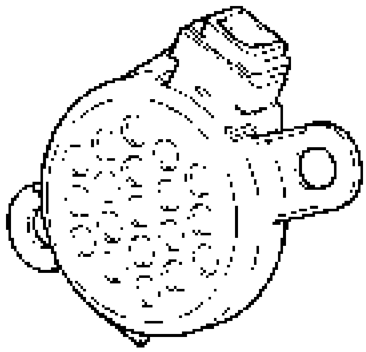
The PDC switch is located in the rear of the centre console. The switch has a momentary, non-latching action, which switches a positive output from the PDC ECU to ground when pressed. This signal is used by the ECU to switch the PDC between the activated and de-activated conditions. The switch is connected to the PDC ECU via a harness connector which is integrated into the vehicle body harness.

The switch contains an LED. When the system is active (i.e. an obstacle is detected) the LED illuminates to show the active condition.

When the PDC is switched from the off condition to the active condition, the LED is illuminated, along with a chime from the sounder, to signal that the system has been activated.

If a fault exists in the PDC system, the ECU flashes the LED continuously, when the switch is pressed to activate the system.

PDC Sounder



M82 6236

The PDC sounder is controlled by the PDC ECU and emits a series of tones of varying frequency to inform the driver of the distance between the vehicle and a detected object.

The PDC sounder is located in the RH side of the rear luggage compartment. A bracket is attached to the 'E' post, behind the trim panel and provides for the attachment of the PDC sounder and the PDC ECU. The sounder is connected to the PDC ECU via a harness connector.

PDC System Operation
When the ignition switch is in position II and reverse gear is selected, the PDC sensors are automatically activated. The PDC ECU only activates the system if reverse is selected for more than 1 second. This avoids nuisance audible warnings when the gear selector lever is being moved between Drive and Park.

When the system is activated, the PDC ECU illuminates the indicator LED in the PDC switch, switches on the ultrasonic sensors and generates a single chime on the PDC sounder to indicate the system is active. If an object is range of the sensors when the system is activated, a series of audible warnings are emitted by the PDC sounder immediately.

If PDC operation is not required, it can be suspended temporarily by pressing the PDC switch. When reverse is deselected and subsequently reselected, PDC will automatically become active again.

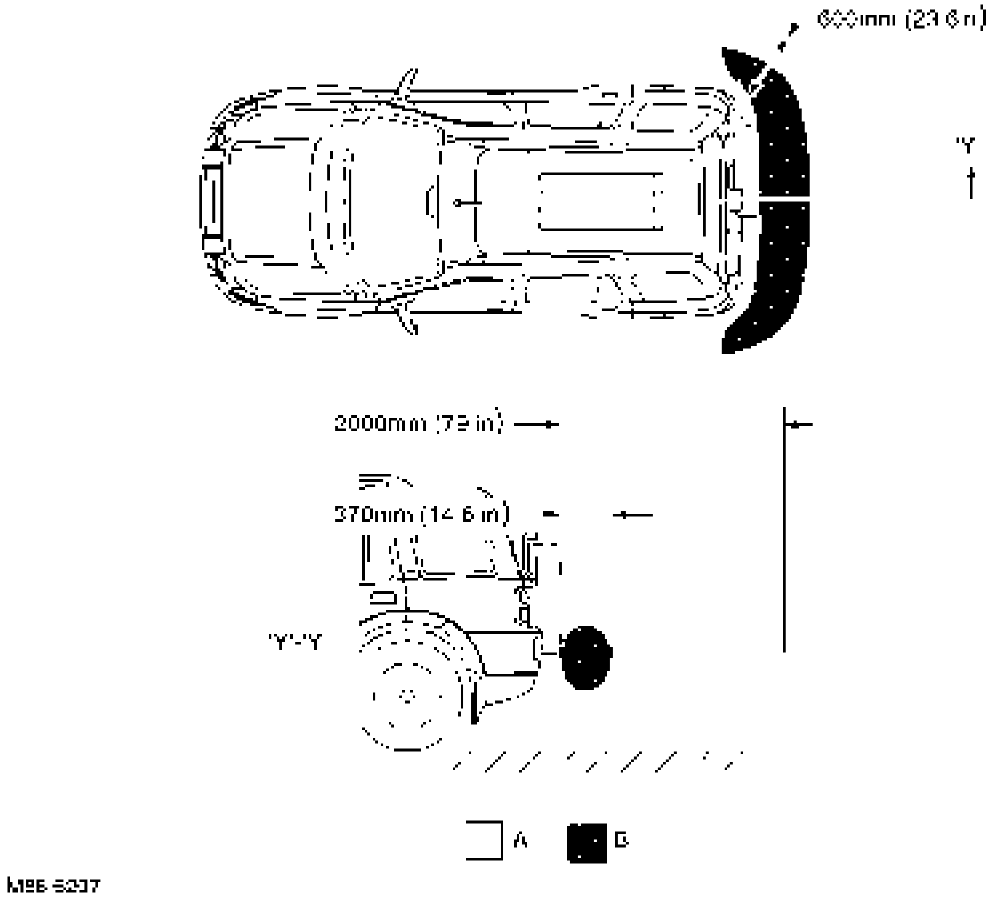
A second press of the switch is required to turn off the PDC or the PDC will be deactivated if reverse is selected and then deselected.

Sensor Operation
The PDC ECU processes the distance readings from the ultrasonic sensors to determine if there are any objects within the detection areas. If there are no objects in the detection areas, there are no further audible warnings. If an object is detected, repeated audible warnings are produced on the PDC sounder.

The maximum detection range is 2000 mm (78.7 in). When an object is detected, the time delay between the audible warning tones decreases as the distance between the detected object and the vehicle decreases until, at approximately 370 mm (14.5 in), the audible warning tone is continuous.

After the initial detection of an object, if there is no decrease in the distance between an object and the central sensors, the time delay between the audible warnings remains constant. If an object is detected by one of the corner sensors only, the audible warnings stop after about 5 seconds if there is no change in the distance between the object and the corner sensor.

Park Distance Control Detection Area



A Intermittent Warning Tone

B Continuous Warning Tone

Detection Calculation

When operating in the combined transmitter and receiver mode, the sensor outputs a number ultrasonic pulses and receives the reflected echo signal. The ECU amplifies the received echo signals and compares them with a preprogrammed threshold to calculate the distance to the object. This is achieved by determining the elapsed time between the transmission and reception of the ultrasonic signal.

When operating in receiver mode, the sensor receives echo signals transmitted by an adjacent sensor. This mode is used to improve the accuracy of the system.

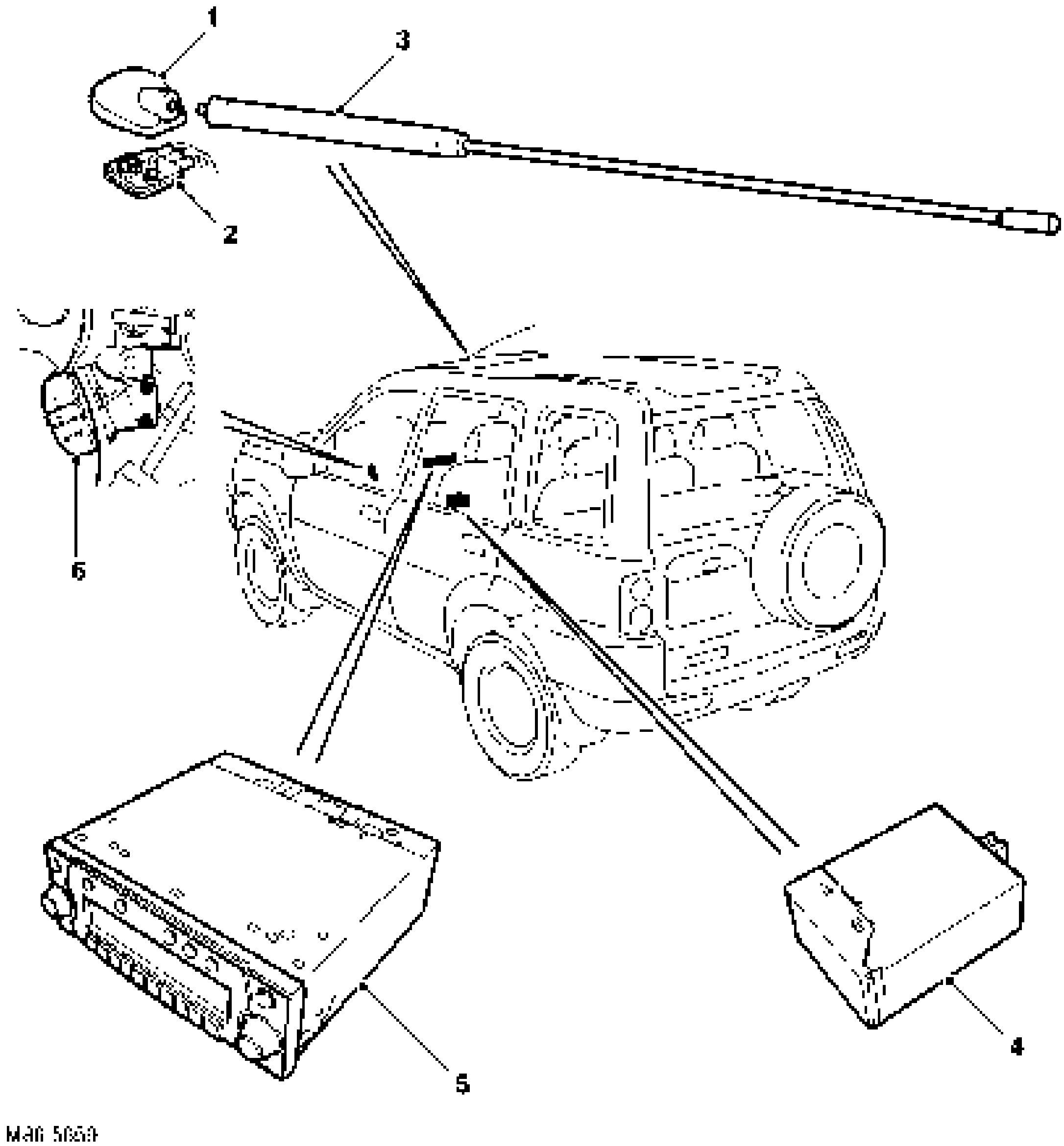
The detection cycle consists of the ECU operating one sensor in the combined transmitter and receiver mode and transmitting a number of ultrasonic pulses. The ECU then switches the transmitting sensor and the adjacent sensor(s) to receiver mode. After a short time delay, this sequence is repeated using a different sensor to transmit the ultrasonic pulse and continues until all four sensors have output an ultrasonic signal. This sequence is completed in 100ms. The ECU uses several measurements of the same sensors to remove errors from the calculation.

If the object is directly behind a sensor, the distance is calculated using the time between the transmission and reception of the signal. If the object is positioned between two sensors, the ECU uses both signals to determine the correct distance using triangulation.

To perform the triangulation calculation, the ECU must know the distance between the individual sensors in the bumper. This information is stored in the ECU memory. From the received distance from each sensor and using the known distance between adjacent sensors, the ECU can calculate the minimum distance from the vehicle to the object.

When approaching several objects, the ECU recognises the distance from the vehicle to the nearest object.

Navigation System Component Location



1 GPS antenna
2 Diplexer unit
3 FM antenna
4 Remote control interface unit
5 Navigation computer
6 Steering wheel switches

Description

General

The navigation system provides audio and visual route guidance to help the driver reach a selected destination. The system is an optional fit consisting of a Traffic Pro navigation computer and antenna, manufactured by Harman/ Becker Automotive Systems, which are fitted in place of the In Car Entertainment (ICE) head unit and antenna. Compact Disc (CD) and radio functions are incorporated into the navigation computer.

The navigation system allows the driver to choose between the shortest and fastest routes between the vehicle's current position and a selected destination, and to select a stopover point in the journey and a route that avoids motorways, ferries and toll roads. Directions to Points Of Interest (POI) e.g. airports, hospitals, petrol stations etc, either local, national or in another country, can also be selected. A traffic jam function enables the driver to request diversion instructions, around an obstructed part of the selected route, during the journey. A Traffic Management Control (TMC) function, currently only available in some European countries, monitors traffic broadcasts and automatically selects an alternative route during the journey if the original route is effected by a traffic jam, accident or road works etc.

The position of the vehicle is determined by the navigation computer using a combination of vehicle sensor inputs and radio signals from the 24 Global Positioning System (GPS) satellites orbiting the earth. The position of the vehicle is then plotted on a digitised map, loaded into the navigation computer from a CD-ROM, to determine the journey route and provide the route guidance.

The GPS satellite signals are used for initial determination of the vehicle's position and periodic position updates. The vehicle sensor inputs are used to monitor the vehicle's direction of travel and distance travelled between position updates from the GPS satellite signals. The vehicle sensor inputs consist of:

- A vehicle speed signal from the ABS ECU, to monitor the distance travelled and for automatic volume control.
- A reverse gear signal from the selector and inhibitor switch, to enable the navigation computer to differentiate between forward and rearward movement of the vehicle.
- A gyro in the navigation computer, to monitor changes of direction, i.e. steering inputs.

The signal from each GPS satellite contains information about satellite position, almanac data and time (almanac data is the current status of the satellite). Signals from between five and 11 of the GPS satellites can be received at a given point on the earth's surface at any one time. The number and quality of separate GPS satellite signals received also varies with vehicle location. In hilly or tree lined areas, built up areas with tall buildings, multi-storey car parks, garages, tunnels, bridges and during heavy rain/thunderstorms, signal reception of some or all of the GPS satellites will be poor or non existent.

A minimum of three separate GPS satellite signals are required for the navigation computer to calculate a three dimensional (3D) positional fix. When only two signals are being received, the navigation computer will calculate a less accurate two dimensional (2D) positional fix. The more widely dispersed that the GPS satellites are, the more accurate the positional fix. The navigation computer can store information from a maximum of 12 GPS satellites at any one time. When more than three signals are stored, the navigation computer selects the three most widely dispersed signals for the position calculation.

Antenna Assembly

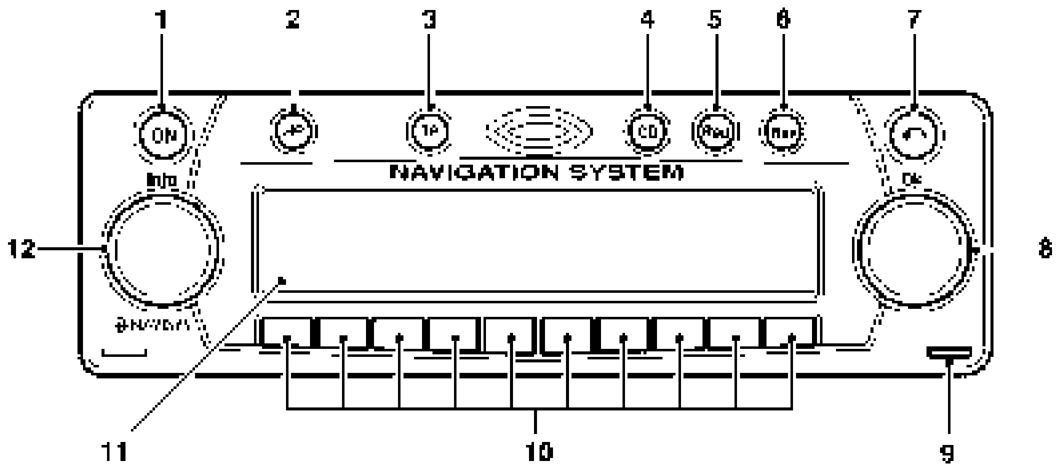
The antenna assembly consists of a GPS antenna, installed at the front of the roof centreline, and an FM radio antenna which screws into the GPS antenna. A diplexer unit on the underside of the GPS antenna amplifies the radio signals received from the GPS satellites and radio stations and transmits them through separate co-axial cables to the navigation computer for processing.

Navigation Computer
The navigation computer is installed in the DIN radio slot in the fascia. A spring loaded catch on each side of the navigation computer secures it in position. Slide tools, installed in slots at the bottom front corners of the navigation computer, are required to unlock the catches during removal.

The navigation computer contains all the hardware and software required for control of the navigation, radio and CD systems, including the GPS receiver and a solid state piezo gyro for the navigation system. The piezo gyro measures the motion of the vehicle around its vertical axis.

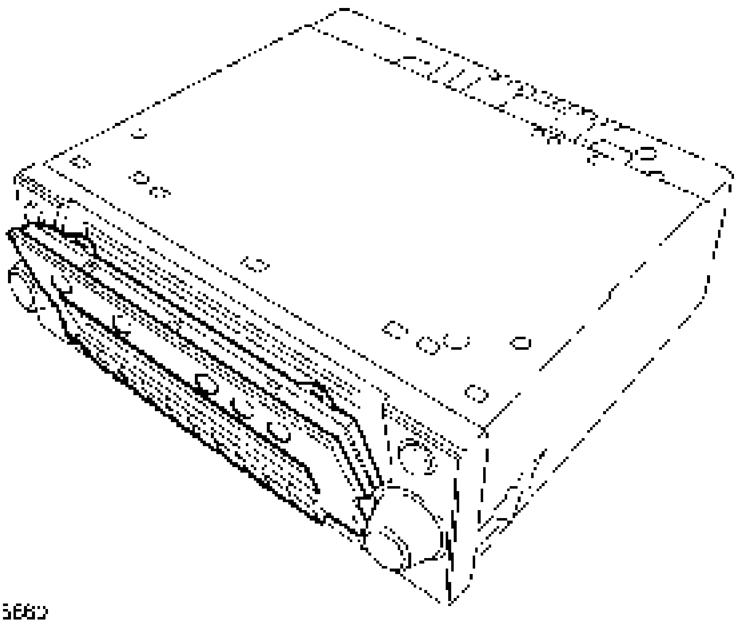
The controls for the navigation computer are all located on the front panel of the unit. The centre section of the front panel hinges to allow access to the CD player and, for security purposes, can be removed from the unit. The controls perform the following functions:

- On/Off (ON) button, for switching the unit on and off.
- Tone button, for activating the tone menu to adjust bass, treble, balance, fade and loudness functions.
- Traffic Programme (TP) button, for activating the traffic information programme menu (Europe only).
- Compact Disc (CD) mode button, for selecting CD operation.
- Radio (Rad) mode button, for selecting radio operation and tuning menus.
- Navigation (Nav) mode button, for entry and exit of the navigation menu and service mode.
- CD eject button, opens the removable panel and ejects the CD.
- RH rotary control, scrolls through menus when turned and enters a selection when pressed. Also mutes audio navigation instructions when pressed in navigation mode.
- Multifunction buttons, for entering the security code and menu selections.
- Liquid Crystal Display (LCD), green screen that displays navigation, radio and CD information.
- LH rotary control, adjusts volume when turned. When pressed, restores, repeats or interrupts audio navigation instructions or provides destination details.



M86 5652

1	On/Off button	**7**	CD eject button
2	Tone button	**8**	RH rotary control
3	Traffic programme button (Europe only)	**9**	Release tool slot
4	CD mode button	**10**	Multifunction buttons
5	Radio mode button	**11**	LCD
6	Navigation mode button	**12**	LH rotary control



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Inputs and Outputs

In addition to the vehicle sensor and the antenna inputs, the navigation computer also receives the following:

- A permanent battery feed from the passenger compartment fusebox, to power the navigation function.
- An ignition switched battery feed from the passenger compartment fusebox, to power the navigation, radio and CD functions when the ignition switch is in positions I and II.
- An illumination power feed for switch illumination and LCD backlighting when the exterior lights are on.

Navigation computer outputs consist of those for the ICE system speakers and to the auxiliary CD autochanger, where fitted.

Security Code

The navigation computer is programmed with a five digit security code selected from numbers 1 to 7. If the battery or the navigation computer are disconnected, the code is requested on the LCD the first time the navigation computer is switched on after reconnection; this also occurs if a different removable panel is fitted.

The code is entered using the appropriate multifunction buttons. The navigation computer automatically starts to operate when the fifth digit of the correct code is entered. If an incorrect code is entered, CODE is displayed on the LCD to prompt another entry attempt. If an incorrect code is entered three times in succession, WAIT is displayed on the LCD and the unit is disabled for approximately 60 minutes. If the navigation computer is switched off, the remaining disabled time will resume when the power is restored.

Automatic Volume Control (AVC)

The AVC feature automatically increases and decreases the audio volume with increases and decreases of vehicle road speed. The AVC feature, also known as the GAL setting, uses the vehicle speed signal from the ABS ECU and can be turned off or adjusted to start at a different vehicle speed. The GAL setting is accessed through the User Menu and can be set to between 0 and +15, where 0 is off and +1 to +15 progressively increase the vehicle speed at which AVC starts to operate.

System Settings Menu

The system settings menu provides access to features that can be changed to suit market and personal preferences and to navigation system operating features. On European systems, the system settings menu also includes computer games and a currency converter. While the navigation computer is in the navigation mode, the system settings menu can be accessed by pressing the Nav button. Using the RH rotary control, the following features can be selected and adjusted:

- *TIME* – Allows the navigation system clock to be set to local time as opposed to the Greenwich Mean Time (GMT) transmitted from the GPS satellites. The local time setting is necessary for correct navigation on routes with time restrictions and for Estimated Time of Arrival (ETA) calculations. The time can only be adjusted in 30 minute steps.
- *SAVE POSITION* – Allows the current vehicle position to be saved and allocated a name in the navigation destination memory.
- *GAMES* – Provides access to a selection of computer games.
- *LANGUAGE* – Allows the navigation system language and voice (where applicable) to be changed.
- *ANIMATIONS* – Allows the LCD animations to be switched on and off.
- *MEASURING UNIT* – Allows the route guidance distances displayed on the LCD to be switched between metric and Imperial units.
- *ANNOUNCEMENT ETA* – Allows the route guidance ETA announcement to be switched on and off.
- *CALCULATE EURO* – Provides access to a currency converter.

User Menu

The user menu provides access to further features that can be changed to suit personal preferences. While the navigation computer is in navigation, radio or CD modes, the user menu can be accessed by pressing and holding the tone button for more than 2 seconds. The user menu is displayed over two screens, which can be toggled between using the ⇒ multifunction button. Using the appropriate multifunction button or the RH rotary control, the following settings can be selected and adjusted:

Screen 1

- *Gal* – Automatic volume control setting (see above).
- *Tel* – If a handsfree telephone system is connected to the navigation computer, allows either *mute* (telephone mute mode) or *audio signal* (telephone conversation via the ICE speakers) to be selected.
- *Lcd* – The LCD can be set to appear *negative, positive* or *automatic*. In *automatic*, the display will be positive or negative, depending on the setting of the exterior lamps.
- *Led* – A Light Emitting Diode (LED) in the display can be set to *off* or *blinking*. When set to *blinking*, the LED flashes when the navigation computer is switched off.
- *M/S* – Radio reception can be set to *Stereo, Mono* or *Auto*, to suppress interference and reflections and so optimise reception. *Stereo* is for exceptionally good reception conditions. *Mono* is for poor reception conditions. In *auto*, the normal setting, the navigation computer automatically switches between stereo and mono depending on reception conditions.

Screen 2

- *Nav* – Sets how audio navigation instructions are delivered. In *onl*, other audio sources are suppressed and only the navigation instruction is output to the speakers. In *mixed*, the volume of any other audio source is reduced and the volume of the navigation announcement is the same as the original audio source +/– 6 dB (adjustable). In *independ*, the audio source and navigation announcement can be set to independent volume levels.
- *Aux* – Used to switch auxiliary CD AF connections between *Aux mode on* and *Aux mode off*. If no CD autochanger is installed, an external cassette or CD player can be connected to the navigation computer and powered by switching on the auxiliary CD AF connections.
- *Cmp* – Allows a compass to be shown on the LCD when route guidance is not active.
- *BeV* – Used to adjust the signal tone volume. Signal tones sound to confirm storage confirmation etc. and can be set between 0 (quiet) and +5 (loud).

Service Menu
The service menu provides access to details of the navigation computer hardware and software, and can be accessed when the navigation computer is in radio mode, by simultaneously pressing the *NAV* button and the 10 multifunction buttons. The following items can then be scrolled through by pressing the *Nxt* (next) and *Prv* (previous) multifunction buttons, or turning the RH rotary control:

- *Model No.*
- *Serial No.*
- *Changer Reset*
- *GAL*
- *Radio Software*
- *Radio Bolo*
- *Navi Rom*
- *Navi Flash*
- *RTC Value*

When Changer Reset is displayed, the CD autochanger (where fitted) can be reset by pressing the appropriate multifunction button.

When the End multifunction button is pressed, the navigation computer quits the service menu and returns to radio mode.

Garage Menu
Garage menu enables the navigation system to be tested and calibrated, and also contains a route navigation demonstration. The garage menu is entered from the main navigation menu, as follows:

1. Press the Nav button to access the system settings.
2. Press and hold multifunction button 3, then press multifunction button 5 to display the garage menu.

The garage menu contains the following, which can be accessed using the RH rotary control:

- *CALIBRATION RIDE* – Used to calibrate the navigation computer, to enable route navigation.
- *GPS INFO*– Provides functional test of antenna by checking GPS reception. If functioning correctly, displays the number of satellites being received, the date, time (Greenwich Mean Time) and the type of positional fix currently possible.
- *CALIBRATION*– Allows vehicle specific calibration data to be entered, e.g. tyre size. Also allows current calibration to be deleted prior to re-calibrating.

NOTE: Only known calibration data should be entered. The navigation computer cannot make route calculations if incorrect data is entered.

- *SENSORS*– Allows wheel speed, reverse gear and gyro sensor inputs to be checked.
- *VERSION*– Displays navigation computer hardware and software details.
- *SPEECH TEST*– Performs a test of the navigation computer audio output.
- *MODULE TEST*– Performs a test routine on the internal components of the navigation computer.
- *DEMO* – Allows a route navigation demonstration to be run.

To quit the garage menu, press the Nav button.

Calibration

Calibration is required after initial installation or replacement of the navigation computer. It may also be necessary after repairs to system wiring and if route navigation becomes inaccurate or fails to operate. If the navigation computer contains an existing calibration, this must be deleted, using the garage menu, prior to running the new calibration routine. The sensor inputs should also be checked before running the calibration routine.

Sensor Check

1 Call up the SENSORS screen on the LCD:

- If the navigation CD-ROM has not been installed before, press and hold multifunction button 1 then press multifunction button 10.
- If the navigation CD-ROM has been installed before, use the garage menu as detailed above.

2 Drive the vehicle forwards a short distance at a speed greater than 2.5 mph (4 km/h) and ensure the road speed counter on the SENSORS screen starts to increment.

3 Select reverse gear and ensure the direction arrows on the SENSORS screen point rearwards.

4 Ensure the GPS data on the SENSORS screen is displayed and updated.

NOTE: The GPS data will randomly display a GPS MODULE FAILURE message. This is not a fault condition, and no action need be taken, provided the GPS data switches between the GPS MODULE FAILURE message and actual GPS data.

5 Exit the SENSORS screen:

- If the navigation CD-ROM has not been installed before, press and hold multifunction button 1 then press multifunction button 10.
- If the navigation CD-ROM has been installed before, press the Nav button.

Calibration Routine

1 Park the vehicle outside in an area clear of high buildings, trees etc.

NOTE: The more open the surrounding area is, the faster the system will acquire sufficient GPS satellite signals to begin calibration. To minimise the calibration time, the vehicle should not be moved again until the calibration ride.

NOTE: On NAS Freelanders, when the security system RF receiver is active it disrupts the GPS satellite signals. To allow the navigation system to operate, the RF receiver is deactivated when the ignition is on. During calibration, ensure the ignition remains on and that the vehicle is not parked next to a Freelander with an active RF receiver.

2 Turn the ignition switch to position II. If the navigation computer does not come on, press the navigation computer ON button.

3 If necessary, use the navigation computer multifunction buttons to enter the security code.

4 Call up the SENSORS screen on the LCD:

- If the navigation CD-ROM has not been installed before, press and hold multifunction button 1 then press multifunction button 10.
- If the navigation CD-ROM has been installed before, use the garage menu as detailed above.

5 Turn the LH rotary control to minimum volume.

6 Wait for 30 minutes. If necessary the engine can be started.

NOTE: Land Rover recommend a minimum of 30 minutes be allowed to elapse in order to ensure that only a short distance need be driven to achieve calibration.

7 After the 30 minutes have elapsed, ensure the navigation computer LCD shows a GPS almanac figure of 27 or higher.

8 Start the vehicle engine and allow to idle.

9 Install the navigation CD-ROM.

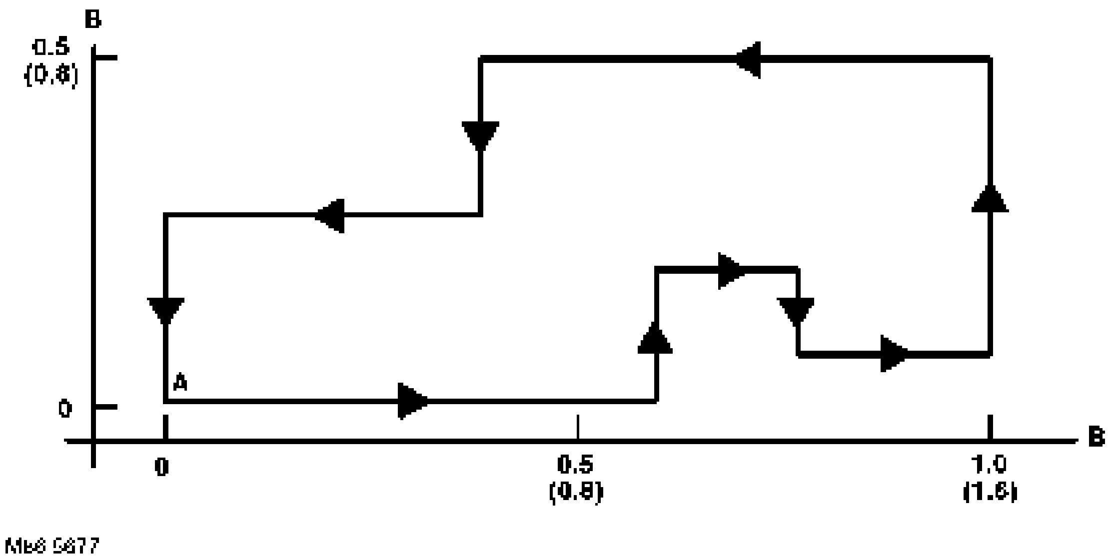
10 Wait until the navigation computer LCD prompts for a language to be selected. Turn the RH rotary control to scroll through the options, highlight the required language and press the RH rotary control to select.

11 The navigation computer LCD will prompt for a voice to be selected. Turn the RH rotary control to scroll through the options, highlight the required voice and press the RH rotary control to select.
12 Wait until the navigation computer LCD advises "language has been loaded OK". Press the RH rotary control to confirm the language and voice selections.
13 The navigation computer LCD will default to the CALIBRATION RIDE screen and should show the CALIBRATION RIDE CAN START message. The GPS data and the road speed counter will also be shown.
14 Drive the vehicle over a road route approximating that shown below (it is not necessary to copy the route exactly). Calibration is complete when the navigation computer LCD switches to show DESTINATION & POI and the satellite graphic. If all the pre calibration ride conditions were complied with, calibration is typically achieved within 3 miles (5 km) and usually occurs when the vehicle returns to the start point. However, calibration may be achieved earlier in the journey and, if it is, there is no need to complete the remainder of the calibration route.
15 After calibration is achieved, return to the dealership, park the vehicle and stop the engine.
16 Turn the ignition switch to position I.
17 Use the system settings menu to set the navigation computer to local time and the required units of measure:
- **a** Press the Nav button.
- **b** Turn the RH rotary control to scroll through the displayed menu, highlight TIME and press the RH rotary control to select. Press the + or – multifunction button to adjust the time in 30 minute steps. Select the 24 hour clock and confirm by pressing the OK multifunction button.
- **c** If metric units of measure are required, go to step e. (the navigation computer defaults to metric units of measure).
- **d** If Imperial units of measure are required, turn the RH rotary control to scroll through the displayed menu, highlight MEASURING UNIT and press the RH rotary control to select. Turn the RH rotary control to highlight IMPERIAL and press the RH rotary control to select.
- **e** Press the Nav button to return to the destination menu.

18 Calibration is complete. The navigation system is ready for use.

NOTE: The accuracy of the system will automatically be fine tuned when a further journey is made, but this is not required as part of the calibration procedure.

NOTE: In European countries, the territory will have to be set the first time the navigation system is used, and the first time a destination in another country is selected. The first time the navigation system is used or a destination in another country is selected, a map is displayed with the default/current territory highlighted. To change the territory: Press the RH rotary control to display the territory list; turn the RH rotary control to scroll through the list and highlight the required territory; press the RH rotary control to confirm the selection.



A = Start/Finish point; B = Distance, miles (km)

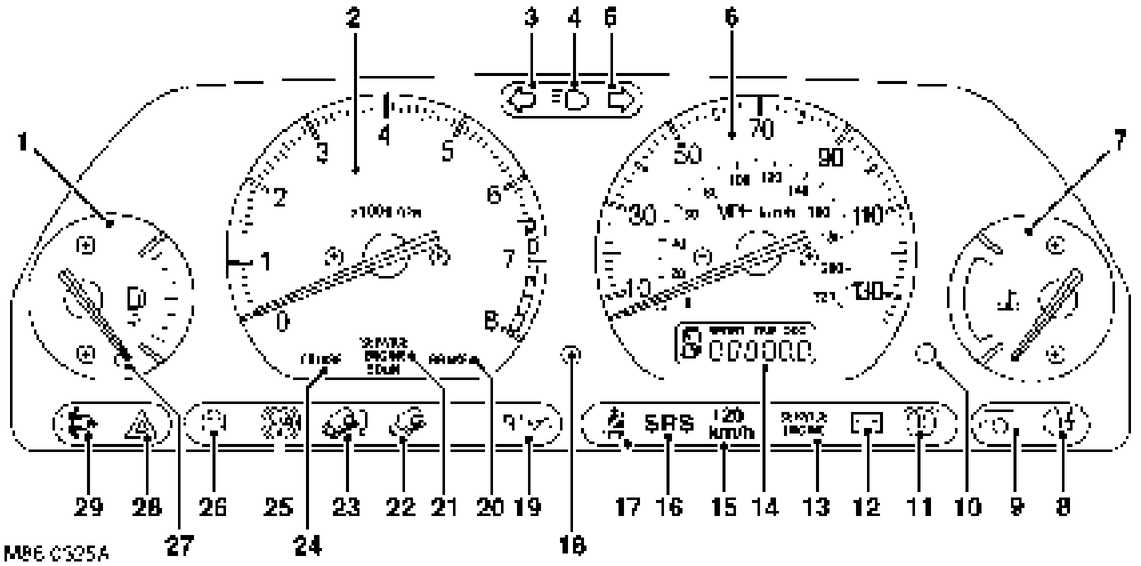
Reset
If the navigation system malfunctions, a system reset can be triggered by simultaneously pressing the TP button and multifunction button 1 or 3. The navigation CD will need to be installed after the system reset.

Steering Wheel Switches
The steering wheel switches provide remote control operation for some of the navigation computer functions. The switches can be used to select between the radio/CD/navigation modes, to adjust the volume (in all modes) and to select search/preset up/down for radio and CD operation.

Remote Control Interface Unit
The remote control interface unit converts the analogue signals from the steering wheel switches into digital signals for use by the navigation computer. The remote control interface unit is installed in a plastic bracket immediately in front of the gear selector lever.

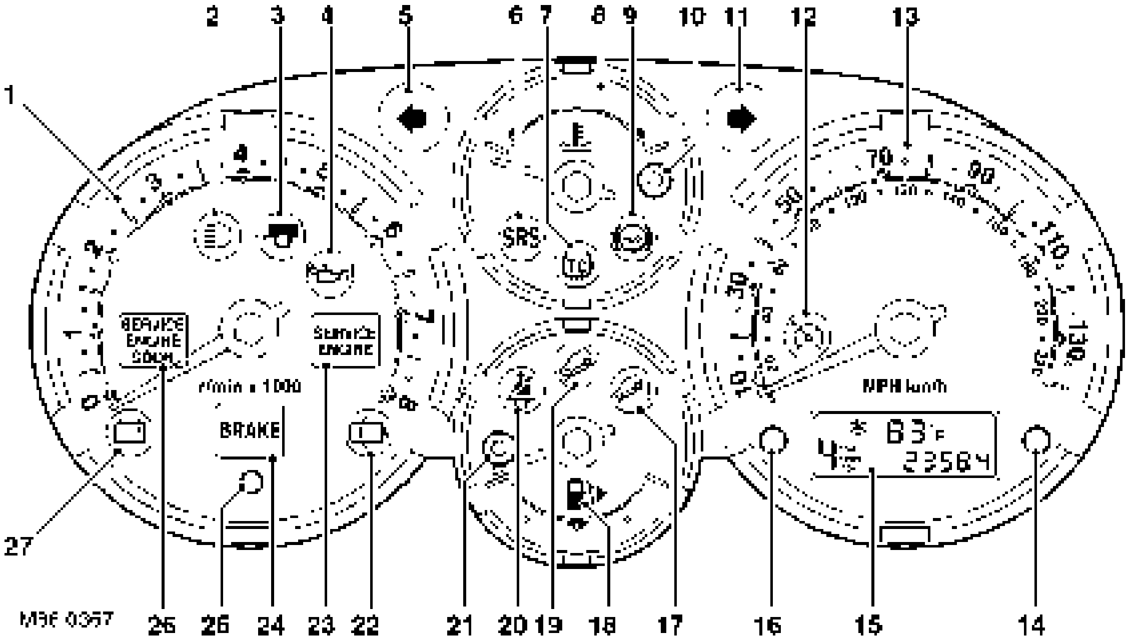
The radio remote switches form a resistance ladder between two wires with the resistance across wires dependent on which switch is pressed. The remote control interface unit monitors the two wires and converts their input into Instrument (I) bus protocol messages, which it outputs on a dedicated serial link to the navigation computer.

Instrument Pack Component Location - Front View



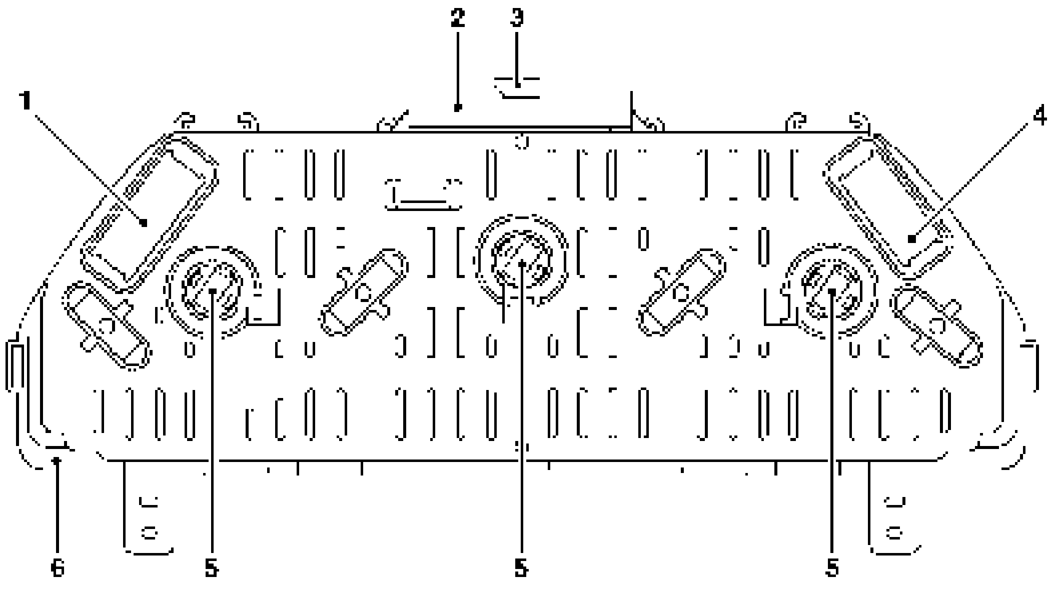
1. Fuel level gauge
2. Tachometer
3. LH direction indicator warning lamp
4. Headlamp main beam warning lamp
5. RH direction indicator warning lamp
6. Speedometer (USA version shown)
7. Engine coolant temperature gauge
8. Rear fog lamp warning lamp
9. Trailer direction indicator/hazard failure warning lamp
10. Trip counter reset button
11. Not used
12. Ignition/No charge warning lamp
13. Engine malfunction warning lamp (Service Engine)
14. Liquid Crystal Display (LCD)
15. Not used
16. Supplementary Restraint System (SRS) warning lamp
17. Not used
18. Alarm LED
19. Low oil pressure warning lamp
20. Handbrake and brake system warning lamp
21. Malfunction Indicator Lamp (MIL) (Service Engine Soon)
22. Hill Descent Control (HDC) active warning lamp
23. HDC failure warning lamp
24. Cruise control active warning lamp (if fitted)
25. Anti-lock Braking System (ABS) warning lamp
26. Traction Control (TC) active warning lamp
27. Low fuel level warning lamp
28. Hazard flasher warning lamp
29. Door open warning lamp

Instrument Pack Component Location - Front View (2004MY Only)



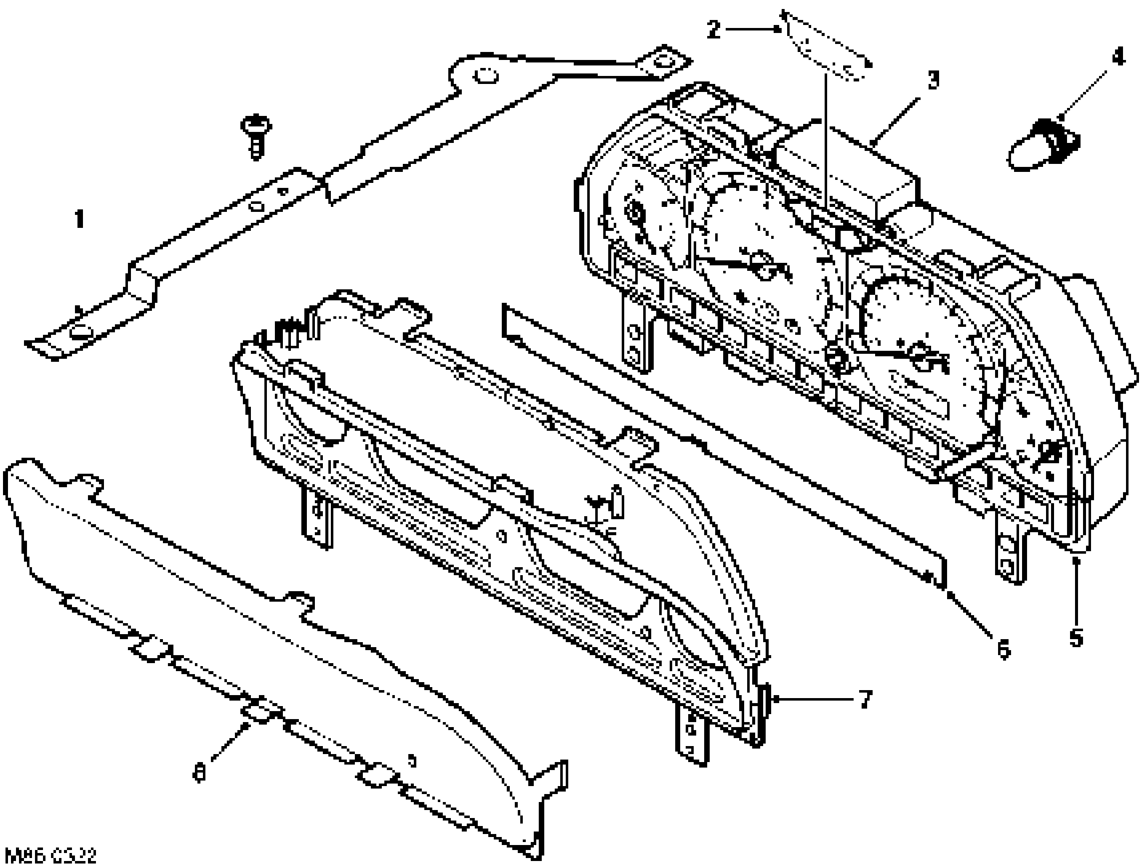
1 Tachometer
2 Headlamp main beam warning lamp
3 Trailer direction indicator/hazard failure warning lamp
4 Low oil pressure warning lamp
5 LH direction indicator warning lamp
6 Supplementary Restraint System (SRS) warning lamp
7 Traction Control (TC) active warning lamp
8 Engine coolant temperature gauge
9 Anti-lock Braking System (ABS) warning lamp
10 High engine coolant temperature warning lamp
11 RH direction indicator warning lamp
12 Cruise control active warning lamp (if fitted)
13 Speedometer
14 Trip counter reset button
15 Liquid Crystal Display (LCD)
16 Not used
17 Hill descent control (HDC) failure warning lamp
18 Fuel level gauge
19 Hill Descent Control (HDC) active warning lamp
20 Seat belt warning lamp
21 Low fuel level warning lamp
22 Door open warning lamp
23 Engine malfunction warning lamp (Service Engine)
24 Handbrake and brake system warning lamp
25 Alarm LED
26 Malfunction Indicator Lamp (MIL) (Service Engine Soon)
27 Ignition/No charge warning lamp

Instrument Pack Component Layout - Rear View



1 Connector C0230
2 RF receiver (Ref. only)
3 RF Receiver connector (Ref. only)
4 Connector C0233
5 Panel illumination bulb (3 off)
6 Instrument pack rear housing

Instrument Pack Components - Exploded View



1 Support bracket (2 off)
2 Warning lamp filter
3 RF receiver (Ref. only)
4 Panel illumination bulb (3 off)
5 Instrument pack housing assembly
6 Warning lamp filter
7 Instrument pack face plate
8 Instrument lens

Description

General

The instrument packs fitted to all Freelander models are similar, with the only differences being the mph or km/h speedometer, odometer readings, tachometer maximum rev/min band and certain warning lamps.

The instrument pack is a totally electronic controlled device receiving electrical signals from sender units and CAN messages from the Engine Control Module (ECM), ABS ECU and the Electronic Automatic Transmission (EAT) ECU and transposing them via a microprocessor into analogue gauge readouts and warning lamp illumination.

The instrument pack is connected to the fascia harness by connectors C0230 and C0233 which provide all input and output connections for instrument pack operation.

A Printed Circuit Board (PCB) is located on the rear of the pack. The analogue displays, warning lamps and the LCD are integral with the PCB. No internal components are serviceable.

The instrument pack contains a non-volatile EEPROM memory which records the vehicle identification number (VIN), engine type and odometer reading. The stored odometer value cannot be changed. The EEPROM is protected by a security code to prevent unauthorised access. TestBook/T4 CD DRG?L24 (where ? represents the language) allows the data stored in the instrument pack to be downloaded and saved to the new replacement instrument pack.

A flash memory stores software and hardware identifiers which are accessible via diagnostics.

The main function of the instrument pack is to provide information to the driver of the vehicle status. The instrument pack features the following displays:

- Tachometer - large analogue display
- Speedometer - large analogue display
- Fuel gauge - small analogue display
- Engine coolant temperature gauge - small analogue display
- Odometer, trip meter - Liquid Crystal Display (LCD)
- Gearbox status - LCD.

The instrument pack also features a number of warning lamps. The warning lamps illuminate in one of four colours which indicate the level of importance of the warning as follows:

- Red = Warning
- Amber = Caution
- Green = System operative
- Blue = Headlamp main beam operative.

The warning lamps are located in various positions around the periphery of the analogue gauges in the instrument pack display and in the lower half of the tachometer. The direction indicators and main beam warning lamps are located at the top of the display.

The following warning lamps are available:
- Left and right hand indicators (Green)
- Headlamp main beam (Blue)
- Glow plug (Amber) - Diesel models only
- Seat belt (Red) - Selective markets only
- SRS (Red)
- Engine Malfunction Indicator Lamp (MIL) (Amber) - All markets except NAS
- Service Engine Soon (MIL) (Amber) – NAS only
- Anti-lock Braking System (ABS) (Amber)
- Door open (Red)
- Hazard warning (Red)
- Hill descent control information (Green)
- Hill descent control fault (Amber)
- Handbrake and brake system (Red)
- Low oil pressure (Red)
- Ignition/No charge (Red)
- Engine malfunction (Amber) - Diesel models only
- Service Engine (Engine malfunction) (Amber) - NAS only
- Overspeed (Red) - Selective markets only
- Cruise control (Amber)
- Low fuel level (Amber)
- Trailer lamp failure warning lamp (Red)
- Electronic Traction Control (TC) fault (Amber)
- Rear fog guard lamp (Red)

Operating Modes

The instrument pack will function in seven modes:
- Shut down
- Normal
- Powered/Unpowered
- Diagnostic
- Crank
- Standby normal
- Low battery voltage.

Shut Down Mode

The instrument pack enters shut down mode when the ignition is moved from position II to the off position (O). Ignition voltage is removed and only the permanent battery feed is available. All CAN gateway, diagnostic, instrument pack and warning lamp functions are suspended. Some conventionally wired warning lamps can still function in shut down mode, i.e.; hazard warning lamp.

When the instrument pack senses that the ignition supply has been removed, it can remain in normal mode for up to fifteen seconds to allow the microprocessor to power down. In shut down mode the total current draw for the instrument pack does not exceed 1mA.

Normal Mode

The instrument pack enters normal mode when battery voltage from ignition switch position II is received. The ECM transmits a message for the CAN standard. If this message is correct or not received, the instrument pack remains in normal mode. If an incorrect CAN standard message is received, the instrument pack will enter standby normal mode.

Powered/Unpowered Modes

Powered mode is the standard operational condition for the instrument pack. In this condition the pack receives a permanent 12V battery supply, no ignition supply or CAN messages. The microprocessor is also off but the real time clock will remain powered.

Unpowered mode is entered when the vehicle battery is disconnected. When the power supply is restored, the pack will resume powered mode.

Diagnostic Mode

To enter diagnostic mode, the instrument pack must first be in normal or standby normal mode and TestBook or another diagnostic tool must be connected to the diagnostic socket. The instrument pack will enter diagnostic mode when it receives a valid message on the ISO 9141 K Line. Confirmation of access to this mode is given by a 'dIAg' message in the LCD.

Diagnostic mode is exited by receipt of a message from the diagnostic tool to terminate diagnostics. Removal of the ignition switch position II battery supply or disconnection of the diagnostic communication to the socket will also terminate the diagnostic mode.

Crank Mode

When the starter motor is cranking the engine, the current drain may cause the values of inputs and CAN messages to become corrupted or invalid. The instrument pack senses that cranking is operative when ignition switch positions II and III are active and the ignition feed from switch position II falls to approximately 3V.

During cranking, all inputs to gauges are suspended and the gauges will remain in their pre-crank state. The odometer display is not affected.

Standby Normal Mode

Standby normal mode is used if an incorrect CAN standard message is received and also allows access to diagnostics. In this mode all CAN transmissions are terminated and the pack will not respond to any CAN messages received. All conventionally wired warning lamps will function normally and the pack can enter diagnostic mode if required. A fault flag is recorded in the EEPROM for the CAN standard message fault.

Low Battery Operation

If the permanent battery supply voltage falls to below 8V, CAN message transmissions will be suspended and received CAN messages will be ignored, analogue gauges will read zero and warning lamp operation is suspended. When the voltage rises above 8V, normal instrument pack operation is resumed.

Speedometer

The speedometer is electronically operated and contains an LCD. Each model has a maximum scale indication of 136 mph (220 km/h).

The speedometer is driven by CAN messages from the ABS ECU. The messages are generated by an ABS wheel speed sensor which produces pulses as the reluctor rotates. The instrument pack microprocessor processes the incoming CAN message from the ABS ECU and converts it into electrical signals for speedometer operation.

If the CAN message fails for more than 64ms the microprocessor will terminate speedometer operation and record a fault flag. The recorded fault can be accessed using TestBook.

Liquid Crystal Display (LCD)
The LCD shows odometer readings up to 99999.9 miles or kilometres and trip computer readings up to 999.9 miles or kilometres. A trip counter reset button is located at the bottom of the speedometer and resets the counter to zero when pressed for more than two seconds. A short press will change the LCD display from odometer to trip.

The odometer uses the same CAN messages as the speedometer to calculate the distance travelled. If the CAN message fails, the LCD will display the odometer distance and 'Error' alternately for one second each.

The LCD also displays gearbox status information as shown in the following table:

LCD Character	Description
P	Park
R	Reverse
N	Neutral
D	Drive
Sport	Sport mode
4	Automatic gearbox operation up to 4th ratio
2	Automatic gearbox operation up to 2nd ratio
1	Automatic gearbox operation in 1st gear ratio
1	Manual mode 1st ratio
2	Manual mode 2nd ratio
3	Manual mode 3rd ratio
4	Manual mode 4th ratio
5	Manual mode 5th ratio
F and 4 (Flashing alternately)	Gearbox fault has occurred. Gearbox remains in fourth gear.

Tachometer
The tachometer is electronically operated and is driven by CAN messages from the ECM. The ECM output is derived from the crankshaft position (CKP) sensor. Loss of the CAN message will cause the tachometer to read zero until the engine speed message is restored.

Petrol models have a maximum tachometer scale reading of 8000 rev/min.

The tachometer scale has a red segment which denotes the maximum engine speed for the model. The engine must not be operated beyond the start of the red segment. The maximum engine speed for the KV6 is 6500 rev/min.

Three warning lamps are located in the lower part of the tachometer face; Cruise control, Malfunction Indicator Lamp (MIL) and handbrake and brake warning lamp.

Fuel Level Gauge

The fuel level gauge pointer indicates the current fuel level in the fuel tank and returns to the empty position when the ignition is switched off. The gauge is operated by an output from the fuel gauge to the fuel tank sender which is integral with the fuel pump.

Fuel Level Gauge – Up to 2002.5 Model Year

The sender is a float operated rotary potentiometer which provides a variable resistance to earth for the output from the gauge. Movement of the sender unit float arm varies the electrical resistance across the sender unit, so the voltage of the control signal and the resultant deflection of the gauge pointer are directly related to the level of fuel in the tank. When the sender float is at its lowest point, indicating an empty fuel tank, the resistance to earth is at its greatest.

The measured resistance is processed by the instrument pack to implement an anti-slosh function. This monitors the signal and updates the fuel gauge pointer position at regular intervals. This prevents constant needle movement caused by fuel movement in the tank due to cornering or braking.

A warning lamp is located in the face of the fuel gauge and illuminates when the fuel level is at or below 2.2 gallons (10 litres).

The fuel level sender signal is converted into a CAN message by the instrument pack as a direct interpretation of the fuel tank contents in litres. The ECM uses the CAN message to suspend OBD misfire detection when the fuel level is below 15% capacity.

Fuel Gauge Resistance/Read out Table – Up to 2002.5 Model Year

Sender Unit Resistance, Ohms	Nominal Gauge Reading
503	Empty
413	Low fuel level illumination
302	Half full
135	Full

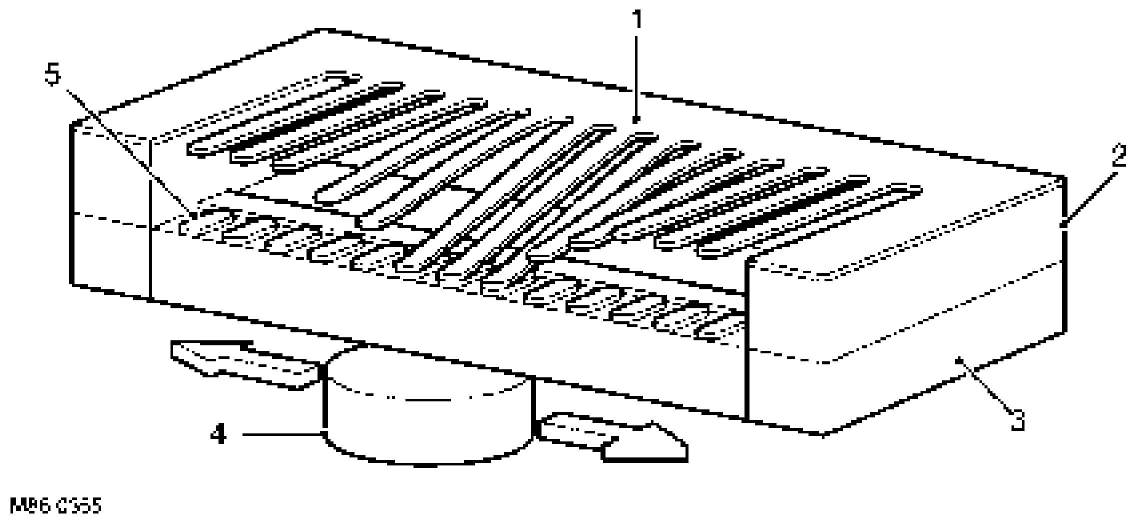
Fuel Level Gauge – From 2002.5 Model Year

A new design fuel level sensor is introduced from 2002.5 model year. Unlike the previous sensor, this sensor is sealed from the fuel preventing contamination of the contacts.

The new sensor requires modifications to the instrument pack fuel gauge calibration, therefore, the new sensor cannot be fitted to a pre 2005.5 model year vehicle.

The sensor is a MAgnetic Passive Position Sensor (MAPPS) which provides a variable resistance to earth for the output from the fuel gauge. The gauge comprises a series of 51 film resistors mounted in an arc on a ceramic surface. The resistors are wired in series with individual contacts. A soft magnetic foil with 51 flexible contacts is mounted a small distance above the film resistors. A magnet, located below the ceramic surface, is attached to the sender unit float arm. As the float arm moves the magnet follows the same arc as the film resistors. The magnet pulls the flexible contacts onto the opposite film resistor contacts forming an electrical circuit.

Sensor Operating Principle



1 Magnetic foil
2 Spacer
3 Ceramic surface
4 Magnet
5 Resistance film

The film resistors are arranged in a linear arc with resistance ranging from 50 to 1000Ω. The electrical output signal is output proportional to the amount of fuel in the tank and the position of the float arm. The measured resistance is processed by the instrument pack to implement an anti-slosh function. This monitors the signal and updates the fuel gauge pointer position at regular intervals, preventing constant pointer movement caused by fuel movement in the tank due to cornering or braking.

A warning lamp is incorporated into the face of the fuel gauge and illuminates when the fuel level is at or below 1.5 gallons (7 litres).

The fuel level sender signal is converted into a CAN message by the instrument pack as a direct interpretation of the fuel tank contents in litres. The ECM uses the CAN message to suspend OBD misfire detection when the fuel level is below 15% capacity.

Fuel Gauge Resistance/Read out Table – From 2002.5 Model Year

Petrol Engines – Sender Unit Resistance, Ohms	Nominal Gauge Reading
101 - 106	Empty
176	Low fuel level illumination
340	Half full
549 - 554	Full

Engine Coolant Temperature Gauge
The coolant temperature gauge indicates the temperature of the engine coolant. When the engine reaches normal operating temperature, the gauge rests at the mid-point of the temperature scale.

If the engine coolant temperature becomes too high, the pointer will rise to the red segment of the scale to warn of an engine cooling fault. At this position the engine coolant temperature is too high and continued operation could result in engine damage; the vehicle should be stopped as soon as possible.

The engine coolant temperature gauge is driven by a CAN message from the ECM. The ECM derives the engine coolant temperature from an engine coolant temperature (ECT) sensor. Refer to the applicable Engine Management System section for ECT location and description.

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

The temperature gauge is fitted with a return magnet causing the gauge to return to zero when the ignition is switched off. The coolant temperature gauge is only operative when the ignition switch is in position II or when diagnostics are selected.

When the engine is hot, the gauge will display normal temperature until the engine has been running for more than 15 seconds. This prevents the gauge moving to the red sector of the gauge if the ignition is turned off and then on after a journey. If the engine is not started, the coolant pump will not circulate coolant and local hot spots occur in the engine and give an incorrect temperature reading. The 15 second delay allows for the engine to be started and coolant circulated, allowing the gauge to display the true average temperature.

Coolant Temperature Gauge Needle Position	Engine Coolant Temperature °C (°F)
Cold	40 (104)
Normal	75 - 115(167 - 239)
Hot (Red zone)	120 (248)

Instrument Illumination
The instrument pack backlighting illumination is provided by three, T10 single filament 3.4W 14V bulbs. The bulbs are rated at 14V to improve their resistance to failure and are fitted with a coloured shroud to give the required backlight illumination colour.

The lamps illuminate when the side lamps or headlamps are switched on. In selected markets the instrument panel, radio and switch illumination is also controlled by an instrument illumination dimmer control.

Warning Lamps
The following warning lamp descriptions cover all model and market variants. Therefore, some warning lamps may not be present on specific models.

Left and Right Hand Indicators
The LH and RH indicator warning lamps flash in time with the exterior direction indicators when they are operated. If either warning lamp flashes very rapidly, this indicates that one of the front or rear exterior indicator bulbs has failed.

When hazard warning lamps are operative, both direction indicator warning lamps flash simultaneously with the exterior indicators.

Headlamp Main Beam
The headlamp main beam warning lamp illuminates when the headlamps are switched to main beam or the headlamp flash is operated.

Seat Belt (Selective Markets Only)
The lamp illuminates when the ignition is switched to position II. When the seat belt buckle is secured in the stalk, a switch in the stalk extinguishes the lamp.

SRS
The SRS lamp illuminates for approximately 5 seconds when the ignition is switched to position II for a bulb check. If the lamp remains illuminated or illuminates when the engine is running, the SRS has a fault which must be rectified as soon as possible.

Malfunction Indicator Lamp (Service Engine Soon)
The MIL illuminates at all times when the ignition is in position II and the engine is not running. If the lamp remains illuminated or illuminates when the engine is running, a fault has occurred in the engine emission control system or an emission related automatic gearbox fault has occurred. Stop the vehicle and switch off the ignition for at least 30 seconds. If the lamp illuminates after the engine is restarted, rectification must be sought as soon as possible to avoid potential engine or gearbox damage and excessive exhaust emissions.

Anti-Lock Braking System (ABS)
The ABS lamp illuminates when the ignition is switched to position II and extinguishes after the engine is started. If the lamp illuminates at any other time, a fault has occurred in the ABS and should be rectified at the earliest opportunity.

Door Open
The lamp illuminates if any side door, the tail door or the bonnet is open and the ignition switch is in position II.

Hazard Warning
The lamp illuminates alternately with the direction indicators and direction indicator warning lamps when the hazard warning switch is operated.

Hill Descent Control Information
The lamp illuminates for approximately 2 seconds when the ignition is switched to position II for a bulb check. The lamp illuminates when the driver selects Hill Descent Control (HDC), to inform the driver that the system is enabled. If the lamp flashes, the system cannot enable HDC due to excessive speed or incorrect gear selection.

Hill Descent Control Fault
The lamp illuminates for approximately 2 seconds when the ignition is switched to position II for a bulb check. The lamp illuminates if a fault is detected within the HDC system, providing the driver with a visible warning. The lamp is illuminated for a short period when the ignition is switched to position II.

Handbrake and Brake System
In some markets, the lamp illuminates for approximately 2 seconds when the ignition is switched to position II for a bulb check. The lamp illuminates when the handbrake is applied. If the lamp illuminates when the handbrake is released, urgent attention is required to the braking system.

Low Oil Pressure
The low oil pressure lamp illuminates at all times when the ignition switch is in position II and the engine is not running. If the lamp remains on, flashes on and off or illuminates at any time when the engine is running, the engine must be stopped at the earliest opportunity or serious engine damage could occur.

Ignition/No Charge
The ignition/no charge lamp illuminates at all times when the ignition switch is in position II and the engine is not running. If the lamp remains illuminated or illuminates when the engine is running, a fault has occurred with the battery charging system and should be rectified at the earliest opportunity. On petrol models the lamp is controlled by an output direct from the alternator.

Service Engine
The service engine warning lamp illuminates for approximately 2 seconds when the ignition is switched to position II for a bulb check. If the lamp remains illuminated or illuminates during driving, an engine management fault has occurred. If the lamp is permanently illuminated, the vehicle may still be driven but rectification of the fault should be sought at the earliest opportunity. If the lamp flashes, the fault must be rectified immediately.

Overspeed Warning (Selected Markets Only)
The overspeed lamp is illuminated for approximately 2 seconds when the ignition is switched to position II for a bulb check. The lamp will only illuminate when the engine is running if the vehicle speed exceeds 120 km/h, and will extinguish when the speed drops below this value.

Cruise Control (If Fitted)
The cruise control lamp illuminates when the cruise control switch in the centre console is selected on and the cruise control is active. The lamp remains illuminated until the cruise control switch is selected off or cruise control is deactivated.

Low Fuel Level
The low fuel level lamp is located in the fuel gauge dial face. The lamp is illuminated for 2 seconds when the ignition is switched to position II for a bulb check. The lamp illuminates when the fuel level drops to approximately 10 litres (2.65 US gallons).

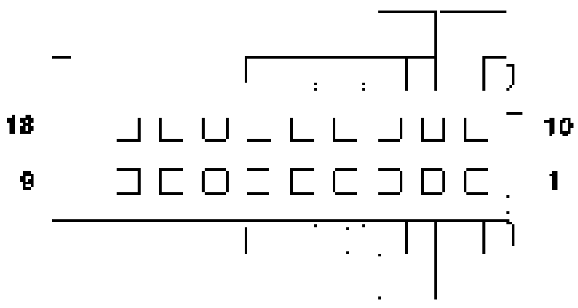
Trailer Lamp Failure
The trailer lamp failure warning lamp illuminates to show failure of one or more of the trailer indicator or tail lamps.

Rear Fog Lamp
The rear fog lamp warning lamp illuminates when the headlamps are switched on and the rear fog lamp switch is operated. The lamp is extinguished when the fog lamp switch is operated to turn off the fog lamps or the headlamps are switched off.

Electronic Traction Control (TC)
The TC warning lamp is illuminated for approximately 4 seconds when the ignition is switched to position II for a bulb check. When traction control is operating, the TC warning lamp will be illuminated for a minimum of 2 seconds or for as long as the traction control system is active. The TC warning lamp also illuminates when the ABS ECU detects a brake system fault which affects traction control. If a fault is detected the lamp will remain permanently illuminated. The vehicle may still be driven but rectification of the fault should be sought at the earliest opportunity.

Instrument Pack Connector Details
The following tables shows the harness connector face views, pin numbers and input/output information for connectors C0230 and C0233.

Connector C0233

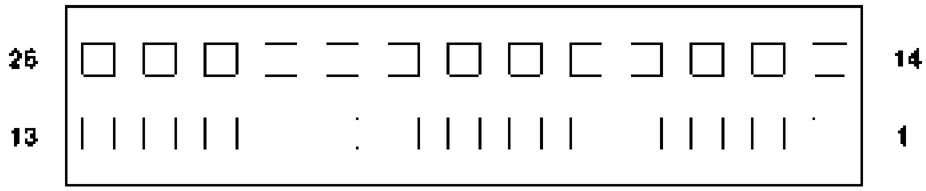


M88 0335

The following table shows pin inputs/outputs for connector C0233.

Pin No.	Description	Input/Output
1	Door open signal	Input
2	Hazard warning lamps active signal	Input
3	Not used	-
4	Brake warning signal	Input
5	Panel illumination –	Output
6	Panel illumination +	Input
7	Earth	Input
8	Ignition switch position II (ignition) signal	Input
9	Ignition switch position III (crank) signal	Input
10	Ignition charge signal	Input
11	SRS warning signal	Input
12	Oil pressure low signal	Input
13	Air Conditioning request signal	Input
14	Reverse switch signal	Input
15	Alarm active signal	Input
16	LH direction indicator active signal	Input
17	Main beam active signal	Input
18	RH direction indicator active signal	Input

Connector C0230



M88 0334

The following table shows pin inputs/outputs for connector C0230.

Pin No.	Description	Input/Output
1	Seat belt warning signal	Input
2	Not used	-
3	Not used	-
4	Engine speed signal	Input (PWM)
5	Cruise active signal	Input (digital)
6	Not used	-
7	1st gear input (manual gearbox only)	Input (digital)
8	A/C pressure sensor (power supply)	Output
9	A/C pressure sensor signal (System pressure)	Input (analogue)
10	A/C pressure sensor earth	Output
11	Diagnostic ISO 9141 K Bus (serial)	Input/Output
12	CAN + (serial)	Input/Output
13	CAN + (serial)	Input/Output
14	Rear fog lamp active signal	Input
15	Trailer lamp failure signal	Input
16	Not used	-
17	Not used	-
18	Not used	-
19	Not used	-
20	A/C evaporator temperature signal	Input (analogue)
21	Fuel level sender signal	Input (analogue)
22	Not used	-
23	Permanent battery supply (13.4 V nominal)	Input
24	Earth	Input
25	CAN – (serial)	Input/Output
26	CAN – (serial)	Input/Output

Diagnostics
A diagnostic socket allows the exchange of information between the instrument pack and TestBook or other diagnostic tool. The diagnostic socket is located behind the centre console, in the passenger footwell.

The diagnostic socket is connected to the instrument pack on an ISO 9141 K Line. When the diagnostic mode is accessed the LCD displays 'dIAg, which remains until the diagnostic mode is exited.

The instrument pack stores fault flags which can be retrieved using TestBook or any diagnostic tool using Keyword 2000 protocol.

Each fault stores two flags. The first flag (fault log) indicates that a fault has occurred with that function. This flag can only be removed using a diagnostic tool.

The second flag (active fault) indicates that there is currently a fault with that function. This flag is only active while the fault condition exists. Removal of the fault condition will clear the active fault flag.

Controller Area Network (CAN)
The CAN bus is a high speed broadcast network between the instrument pack, the ECM, the EAT ECU and the ABS ECU, allowing fast exchange of data between the components every few microseconds.

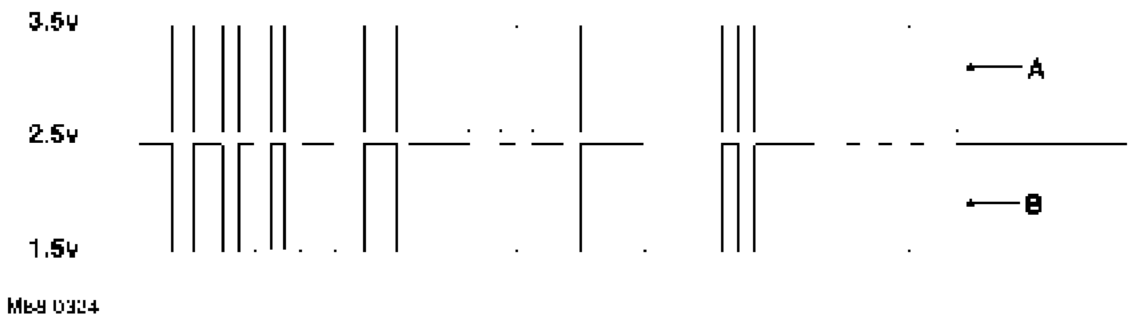
The bus comprises two wires which are identified as CAN Low (L) and CAN High (H). The wires are twisted together to minimise the electromagnetic interference (noise) produced from the CAN messages.

To prevent message errors from electrical reflections, 120Ω resistors are incorporated into the CAN wire terminals of the ECM, ABS ECU, EAT ECU and the instrument pack.

CAN messages consist of a signal which is simultaneously transmitted, in opposite phase, on both wires. CAN L switches between 2.5 and 1.5 volts, while CAN H switches between 2.5 and 3.5 volts. This causes a potential difference between the two lines to switch between 0 volt (logic 1) and 2 volts (logic 0) to produce the digital signal message.

In the event of CAN bus failure, any of the following symptoms may be observed:
- Tachometer, speedometer and temperature gauge will fail to operate
- CAN controlled warning lamps will be inoperative.

CAN Bus Switching



A = CAN High
B = CAN Low

Instrument Pack CAN Messages
The instrument pack acts as a CAN gateway to other CAN controlled functions on the vehicle. The following table lists signals which are routed through the gateway and translated to or from CAN as applicable. For further details about the origins of these messages refer to the relevant section.
☞ **BRAKES, DESCRIPTION AND OPERATION, Description.**
☞ **ENGINE MANAGEMENT SYSTEM - SIEMENS, DESCRIPTION AND OPERATION, Description.**
☞ **AUTOMATIC GEARBOX - JATCO, DESCRIPTION AND OPERATION, Description.**

Signal	Source	Destination
Air conditioning on request	Air conditioning switch	ECM
Road speed	ABS ECU	ECM and EAT ECU (Petrol engines only) and instrument pack
Current gear (vehicles with manual gearbox only)	Gearbox switches	ABS ECU
Fuel level (Petrol engines only)	Fuel level sender	ECM and instrument pack
Engine speed (pulse train)	ECM	EWS3D immobilisation ECU and instrument pack
Evaporator temperature	Evaporator temperature sensor	ECM
Air conditioning pressure	Air conditioning pressure sensor	ECM
Electric cooling fan speed	Air conditioning pressure signal	ECM

CAN Inputs

The following CAN inputs are received by the instrument pack:

Inputs	
Electronic Brake Distribution (EBD)	Engine MIL status
ABS lamp status	Engine status
Traction control lamp status	Fuel consumption
Vehicle speed	Target gear
HDC activity status	Selector position
HDC fault status	Gear shift mode
Engine speed	Gearbox fault status
Engine coolant temperature	
Glow plug lamp status	

- *Electronic Brake Distribution (EBD):* This signal represents the electronic brake proportioning status. This signal is used to indicate a fault with either the brake proportioning system or low brake lamp fluid and illuminate the brake system warning lamp. The signal is originated from the ABS ECU.
- *ABS Lamp Status:* This signal is used to illuminate the ABS warning lamp when an ABS fault occurs. The ABS system will illuminate the lamp when the engine is not running and extinguish it when the engine starts. Further illumination indicates an ABS fault. The signal is originated from the ABS ECU.
- *Traction Control (TC) Lamp Status:* This signal is used to illuminate the TC warning lamp for a bulb check when the ignition is first switched on and also for when TC is active. The signal is also used to illuminate the TC warning lamp when the ABS ECU detects a fault in the brake system for traction control. The signals are originated from the ABS ECU.
- *Vehicle Speed:* This signal is used to operate the speedometer and the odometer and trip functions. The signal is originated from the ABS ECU.
- *HDC Activity Status:* This signal is used to illuminate the HDC active lamp. The signal informs the instrument pack if the HDC function is enabled or disabled. If the HDC function is disabled, the HDC lamp will flash to indicate that the incorrect gear is selected or the vehicle is travelling at excessive speed for HDC operation. The signal is originated from the ABS ECU.
- *HDC Fault Status:* This signal is used to illuminate the HDC fault lamp. The signal is a combination of the HDC activity and fault messages and is only illuminated when the ABS system detects a HDC function fault. The signal is originated from the ABS ECU.
- *Engine Speed:* This signal is used to operate the tachometer. The signal is unfiltered with any damping performed by the instrument pack. The ECM also issues an engine speed error signal which is ignored by the instrument pack. Both signals are also used by the EAT ECU to assist shift timing and fluid pressure calculations and by the ABS ECU for traction control. The signal is originated from the ECM .
- *Engine Coolant Temperature:* This signal is used to operate the coolant temperature gauge. The signal is unfiltered with any damping performed by the instrument pack. The signal is also used by the EAT ECU for warm up cycle detection. The signal is originated from the ECM.
- *Engine MIL Status (Service Engine Soon):* This signal is used to illuminate the MIL. The signal is originated from the ECM if an OBD related engine management fault occurs or on KV6 vehicles from the EAT ECU, via the ECM, if an OBD related gearbox fault occurs. The signal is also used by the EAT ECU to disable OBD fault monitoring in the event of an ECM fault.
- *Engine Status:* This signal is used to illuminate the engine malfunction (service engine) lamp. This lamp is illuminated for non OBD related faults which would not illuminate the MIL. The signal is originated from the ECM.
- *Fuel Consumption:* This signal is used to calculate the service interval announcement in the LCD. The signal is the sum of the volume of injected fuel, calculated from the injection periods minus the valve delay times, and the pitch of the corresponding injector. The injected volumes are calculated as they occur and transmitted on the CAN every 10ms. The signal is originated from the ECM.
- *Target Gear:* This signal is used in conjunction with the selector position signal to display the current gear selection in the LCD. The signal is the actual gear or target gear if gearbox is changing ratios. The signal is also used by the ECM to assist in engine load change prediction. The signal is originated from the EAT ECU.
- *Selector Position:* This signal is used in conjunction with the target gear signal to display the current gear selection in the LCD. The signal represents the actual selected gear position. The signal is also used by the ECM to assist in idle speed control. The signal is originated from the ECM.
- *Gear Shift Mode:* This signal is used to display the currently selected gearshift mode; drive, sport or manual in the LCD. The signal is originated from the EAT ECU.
- *Gearbox Fault Status:* This signal is used to display the status of the EAT ECU. If a gearbox fault occurs the EAT ECU will generate this message to alternately display 'F' and '4' in the LCD and initiate the default strategy for gearbox control.