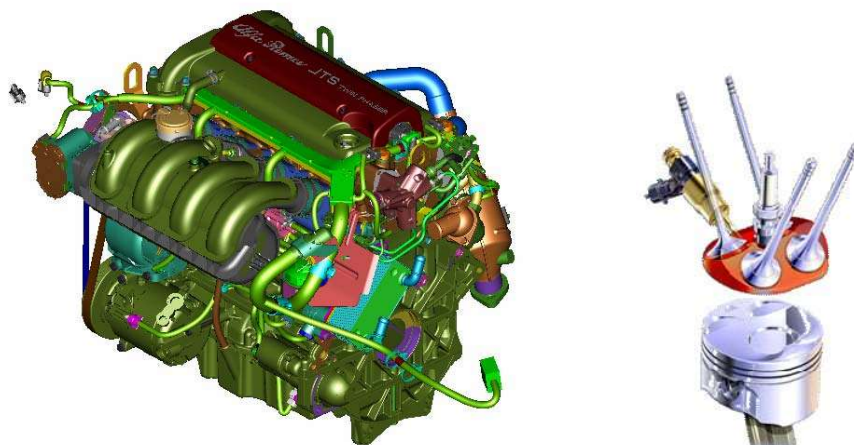


3. ENGINE

3.1 1.9 AND 2.2 LITRE DIRECT INJECTION PETROL ENGINES

3.1.1 Features



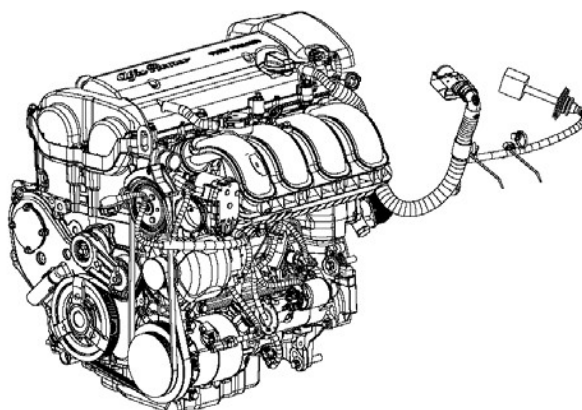
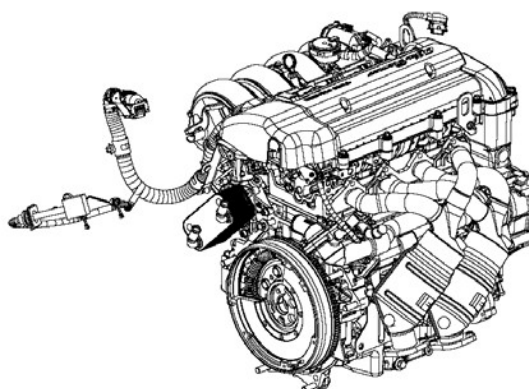
The 1.9 and 2.2 direct injection petrol engines are the first of a new generation of Alfa Romeo four-cylinder petrol engines created to replace the current 2.0 JTS petrol family. The main features of these powerful, sophisticated multivalve engines are their light weight (both the cylinder head and the crankcase are made of aluminium) and their performance (specific power out in excess of 60kW/l, output torque higher than 100Nm/l).

The main features of the new engines are:

- four-cylinder in-line arrangement
- twin overhead camshaft and 16 valve timing
- direct petrol injection
- continuous twin variable timing (on suction and exhaust side)
- aluminium alloy engine block, cylinder head, oil sump and timing cover
- dry insert cylinder liners in engine block
- hydraulic tappets
- two chain driven countershafts in engine block

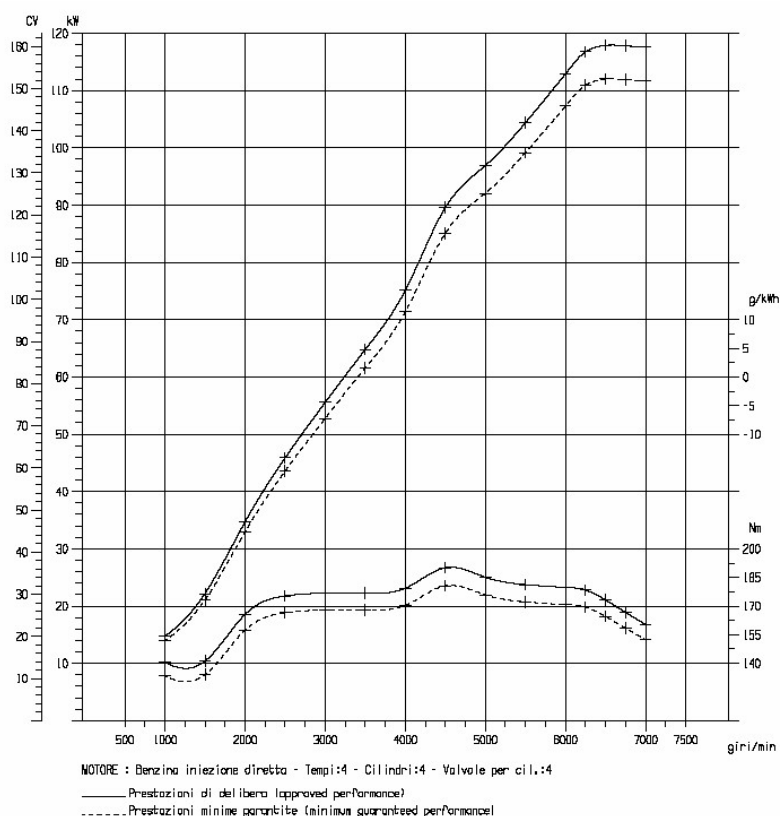
- internal water pump
- oil filter built into engine block
- chain driven timing
- light weight
- electronic accelerator and motorised throttle body
- pencil-coil ignition system with spark plug connectors integrated in a single module
- low consumption and emissions (Euro 4 compliant)
- four lambda sensors
- Type 4 2-in-1 exhaust manifold.



Engine (suction side)**Engine (exhaust side)****Specifications: 1.9 litre engine**

Type	1.9 XHR
Displacement	1859 cm ³
Bore	86 mm
Stroke	80 mm
Suction valve diameter	35.1 mm
Exhaust valve diameter	30.1 mm
Maximum power/speed	117.9 kW / 6500 rpm
Maximum torque/speed	190.1 Nm / 4500 rpm
Compression ratio	11.3 : 1
Engine ECU	Bosch MED 7.6.1
Pollution standard	Euro 4

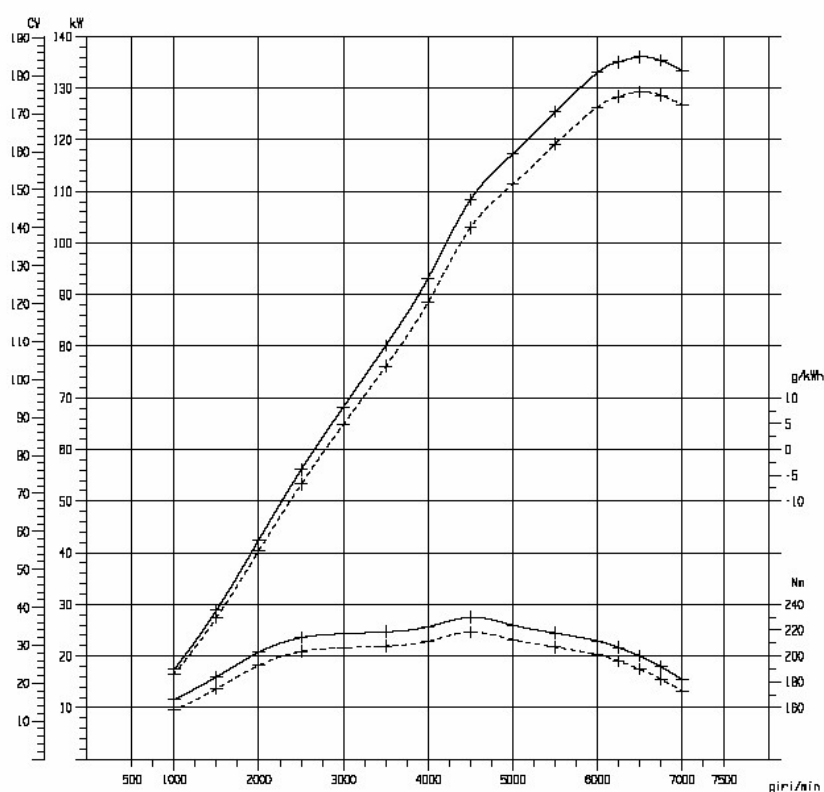




Specifications: 2.2 litre engine

Type	2.2 XHR
Displacement	2198 cm ³
Bore	86 mm
Stroke	94.6 mm
Suction valve diameter	35.1 mm
Exhaust valve diameter	30.1 mm
Maximum power/speed	136.1 kW / 6500 rpm
Maximum torque/speed	230 Nm / 4500 rpm
Compression ratio	11.3 : 1
Engine ECU	Bosch MED 7.6.1
Pollution standard	Euro 4





MOTORE : Benzina iniezione diretta - Tempi:4 - Cilindri:4 - Valvola per cil.:4

—— Prestazioni di delibera (approved performance)

----- Prestazioni minime garantite (minimum guaranteed performance)

Engine specifications compared

	1.9 litres	2.2 litres	
Bore	86	86	(mm)
Stroke	80	94.6	(mm)
Number of cylinders	4	4	
Displacement	1859	2198	(cc)
Bore x stroke ratio	0.93	1.10	
Connecting rod length	153	145.5	(mm)
Distance between cylinders	96	96	(mm)
Crankcase height	221	221	(mm)
Compression ratio	11.3	11.3	
Piston compression height	28	28	(mm)
Number of valves per cylinder	35.3	35.3	(mm)
Exhaust valve diameter	30.3	30.3	(mm)
Maximum valve lift (suction/exhaust)	10.3/10.1	10.3/10.3	(mm)
Variable timing stroke (suction/exhaust)	50/50	50/50	(g AM)
Engine weight	150	151	(kg)
Max. output	160	185	HP
Max rated power speed	6500	6500	(rpm)
Specific power	86.1	84.2	(HP/litre)
Area power	68.9	79.6	(HP/dm ²)
Average piston speed (at Pmax)	17.3	20.5	(m/s)
Maximum admitted rotating speed	7000	7000	(rev/ min)
Maximum torque	190	230	(Nm)
Maximum torque speed	4500	4500	(rpm)
Maximum PME	12.9	13.1	(bar)



Engine performance

These new engines with respect to their predecessors have more power and torque as shown in the following table.

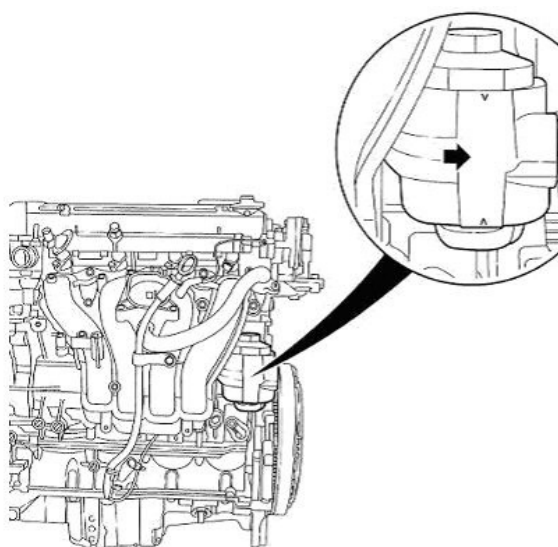
		B 1.8	L8501.9	2.0 JTS petrol	L8502.2
Displacement (cc)	1747	1858	1970	2198	
Maximum power (HP)	140	160	165	185	
Maximum torque (kgm)	16.7	19.4	21.0	23.4	

Specifically, the presence of double continuous variable timing, combined with the separate twin catalysing system exhaust, provides excellent torque output at only 2000 rpm at which speed both engines provide 90% of the maximum torque.

The double variable timing means that use of a two-way module suction system is no longer necessary.

Code location on engines

The engine identification codes are positioned vertically on the cylinder block, on the flat surface of the oil filter housing.



2.2 XHR
1.9 XHR

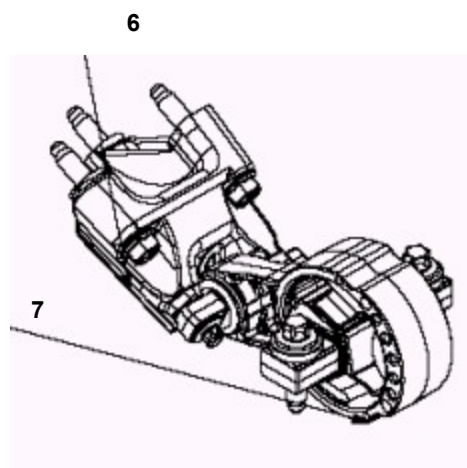
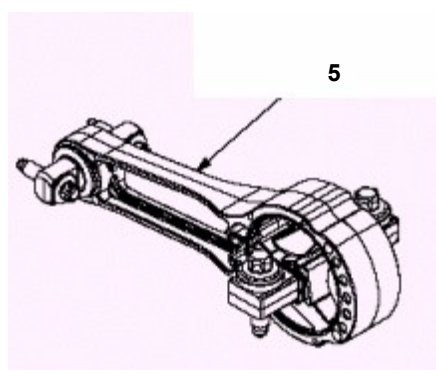
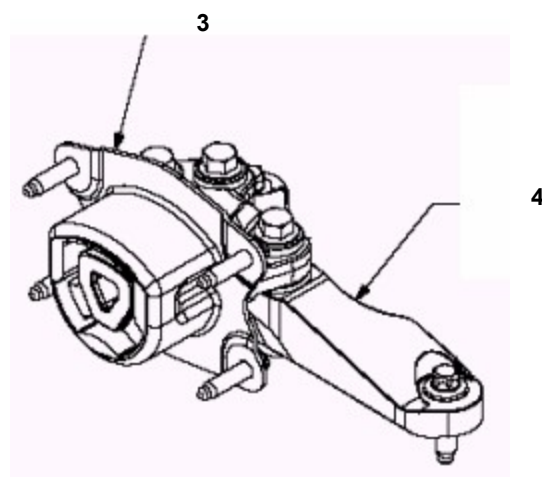
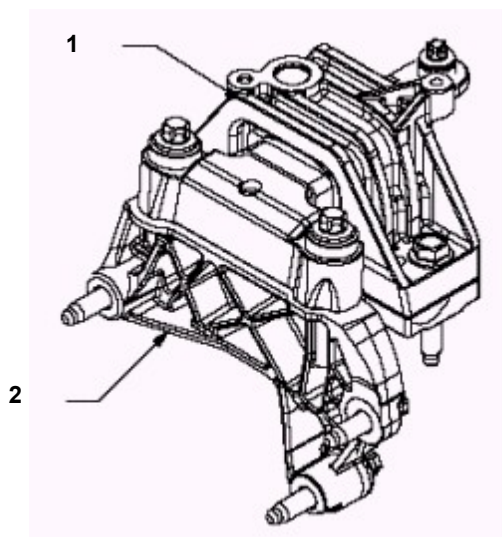
Old code
Z22XHR 11247400
Z19XHR 11247500

New code
939A5000-1247400
939A6000-1247500



3.1.2 Engine components

Engine mounts



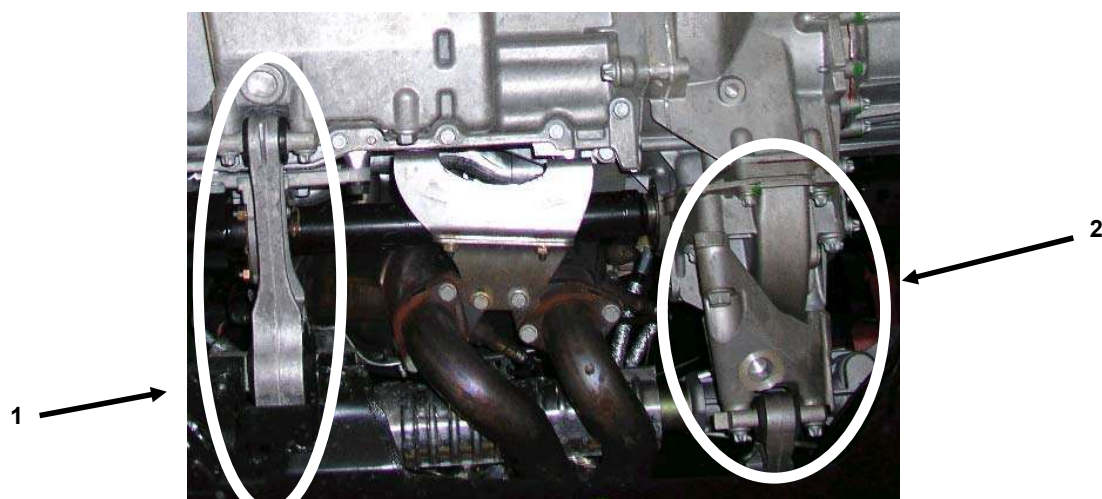
1. Engine pad engine side
2. Engine bracket engine side
3. Engine pad gearbox side
4. Engine bracket gearbox side
5. Engine rod engine side
6. Rod anchoring bracket gearbox side to gearbox
7. Engine rod gearbox side



FUNCTION: The engine mounts fasten the powerplant to the body (load-bearing structure). They are dimensioned to support the weight of the powerplant and the loads deriving from reaction torque transmitted by the engine. They also damper vibrations transmitted by the engine to the body and improve handling comfort.

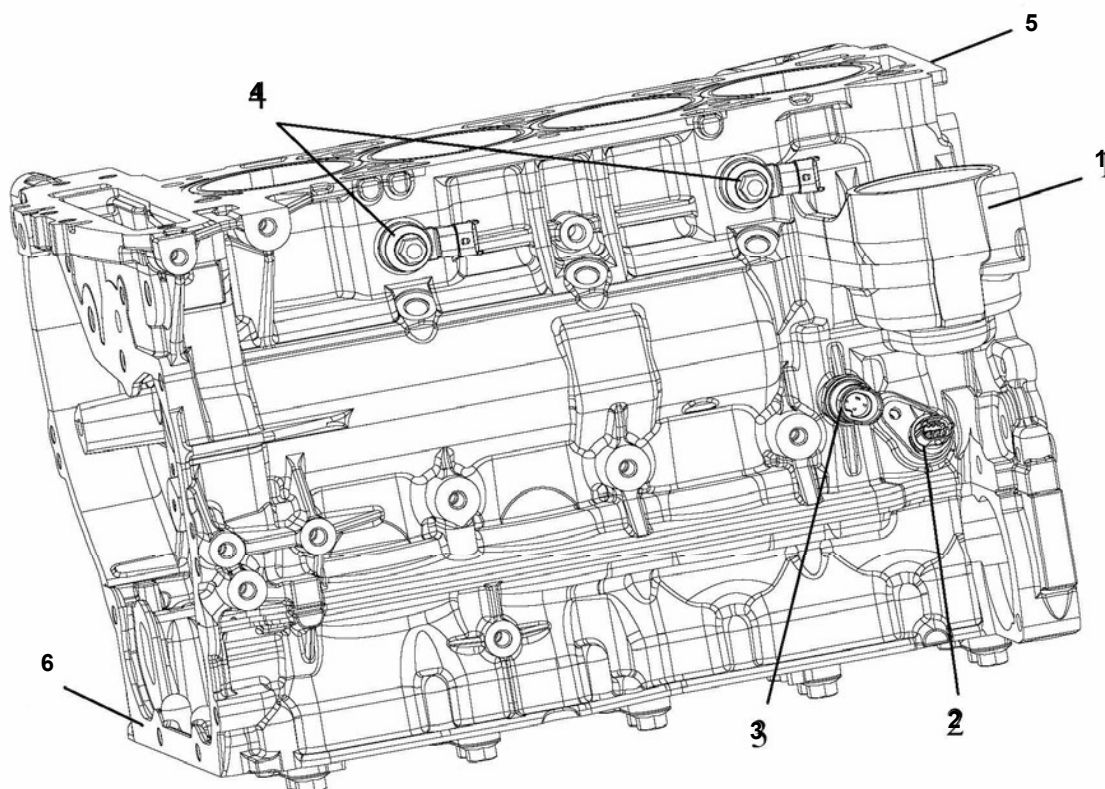
TYPE: Centre-of-gravity balanced engine mount system, with two pads and two reaction rods (5 and 7 in the figures above) which act as linkages. The mounts are aligned along an axis passing through the centre of gravity of the engine which eliminates reaction moments on the mounts.

CONSTRUCTION: Each support is provided with a vibrations damping rubber and metal pad.



1. Engine rod engine side
2. Engine rod gearbox side



Cylinder block

1. Oil filter housing
2. Crankshaft shaft speed sensor
3. Oil pressure switch
4. Knock sensors
5. Cylinder block
6. Bottom plate

FUNCTION: In addition to containing the cylinder liners, the cylinder block supports the mobile parts of the engine (pistons, connecting rods, crankshaft, camshaft, etc.), the inserted fixed elements (cylinder head, oil sump, timing box) and the auxiliary organs (alternator, starter motor, climate control compressor, etc.).

MATERIAL: Made entirely of aluminium alloy in two parts (the cylinder block itself and the bottom plate).

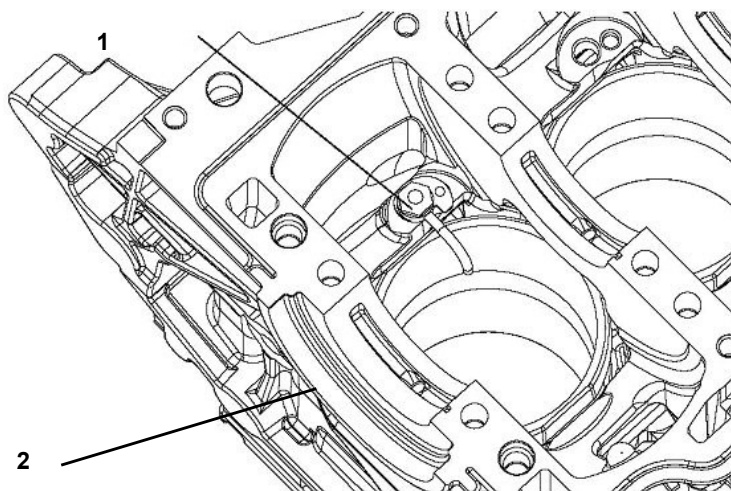
FEATURES:

- Dry inserted liners.
- Integrated balancing countershafts.
- Ventilation, lubrication and cooling conduits built into crankcase.
- Integrated oil filter housing.
- Main caps fully integrated in bottom plate to stiffen the crankshaft journal system.

MAINTENANCE: The cylinder block and bottom plate must be replaced at the same time. The liner inserts in the cylinder block cannot be replaced.

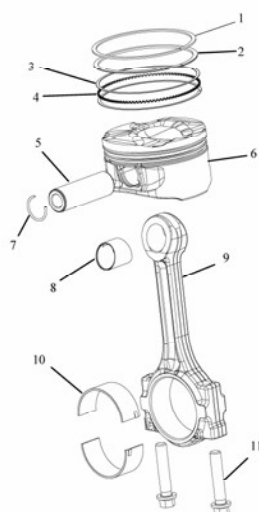


The figure below shows one of the four oil sprayers on the pistons.



Refer to the technical servicing manuals for tightening torques of screws fastening the bottom plate to the cylinder block.

Pistons and connecting rods



1. Upper gas ring
2. Secondary gas ring
3. First oil scraper
4. Second oil scraper
5. Pin
6. Piston
7. Snap ring
8. Bronze bearing
9. Connecting rod
10. Half bronze bearing
11. Connecting rod cap fastening screws

MATERIAL: The pistons are made of aluminium alloy casings. The connecting rods are made of high resistance cast iron.

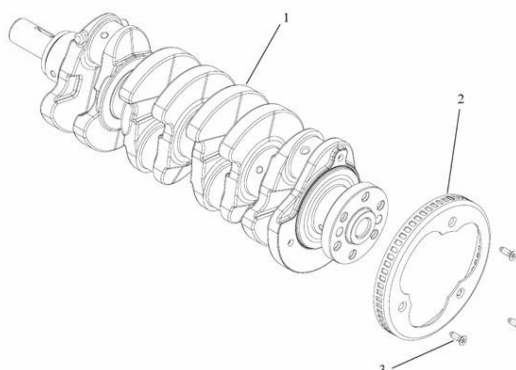


FEATURES: The pistons of both engine versions have indents for valves and a dish for the combustion chamber on the roof. The lower part is cooled by a jet of oil. The 2.2 litre engine piston has a seat on the skirt for avoiding interference with the sprayer nozzle. The connecting rod caps are fracture-split and joined by pressure with screws along with 1 mm thick half bronze bearings. Pistons and connecting rod small ends are connected by a bronze bearing and a gudgeon pin held in place by two snap rings.

The 2.2 engine connecting rods are 145.5 mm long; the 1.9 engine connecting rods are 153 mm long.

MAINTENANCE: Since connecting rod caps are fracture-split, each cap couples perfectly with its connecting rod. When refitting connecting rod caps, make sure that each cap is coupled with its connecting rod to prevent damage due to imperfect surface coupling.

Crankshaft



1. Crankshaft
2. Phonic wheel
3. Phonic wheel fastening screws

FUNCTION: The crankshaft transmits motion to the flywheel and therefore to the driveline by effect of the drive torque resulting from the thrust of the gasses. It drives the other turning parts of the engine and the various accessories.

MATERIAL: The crankshafts of both engine versions are made of cast iron.

FEATURES: The crankshaft is supported by five main bearings supported by the crankcase main bearings and eight counterweights. The steel phonic wheel is fitted on the eighth counterweight with three screws. Along with the speed sensor, the phonic wheel generates the crankshaft speed signal and determines top dead centre. The crankshaft ends on one side with a flange for fastening to the flywheel and with an engine pulley on the other end. The crankshafts of the two engine versions (1.9 and 2.2) are different.

Flywheel

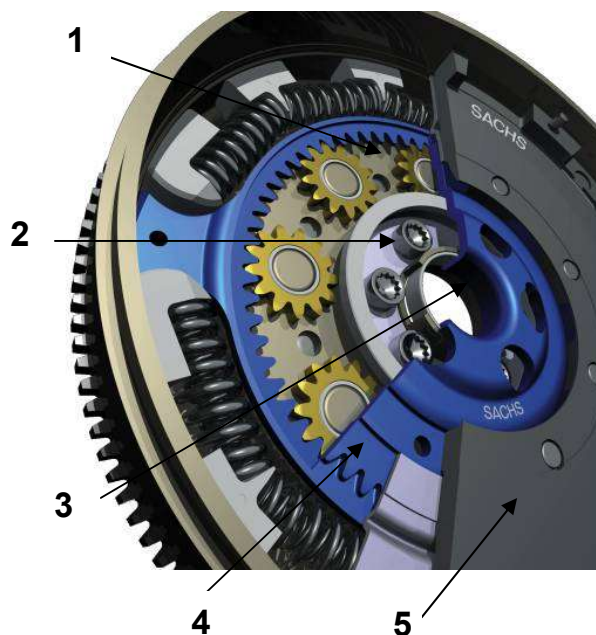
The Sachs flywheel is of the damped dual-mass type.



FUNCTION: The flywheel makes engine operation smooth by accumulating kinetic energy during the active stroke of the engine and letting it out during the three passive strokes; this ensures smoother engine running because the engine power output to the driveline is stabilised by the flywheel.

FEATURES: The engines dealt with here fit a dual-mass flywheel, one fastened to the crankshaft and the other connected to the primary gearbox shaft. An elastic double stiffness damping system is arranged between these two rotating masses with springs of different elastic stiffness and a planetary gear set with sun and planetary gears. Other advantage of this type of flywheel is the low vibrations of the crankshaft-flywheel system at slow engine speeds (engine cranking).

ADVANTAGES: The adoption of this type of flywheel better filters the vibrations induced by the engine to the transmission and to the rest of the driveline, improving driving comfort and reducing transmission of abnormal loads to the gearbox.



1. Shoe
2. Planetary gear
3. Sun gear
4. Primary flywheel (fastened to crankshaft)
5. Tangentially arranged helical springs

DMF (DUAL-MASS FLYWHEEL) OPERATION The two masses are connected together by springs to provide a high reduction of vibrations induced by the engine to the transmission especially at slower engine speed when the vibrations are higher. This increases driving comfort, especially at low engine speed.

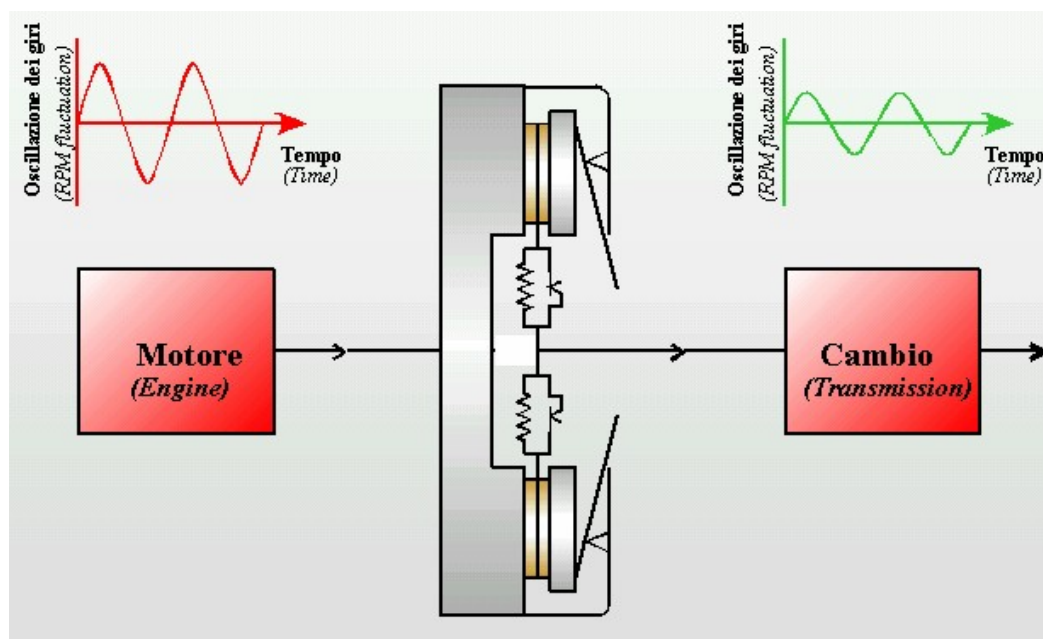
The features of the flywheel include:

- Variable damping
- Serial spring arrangement in guide shoe compartment
- Mechanical protection to prevent spring packing
- Combination of two damping principles:
 - Shoe friction on primary flywheel
 - Damping proportional to speed on planetary gears
- No additional damping element is required by the system
- Lubricated for life with grease
- Neutral performance during cranking and stopping of the engine.

With respect to a traditional driveline, this flywheel reduces oscillation of engine speed transmission taking the resonance amplitude (causing possible vibrations and roughness in transmission) at sufficiently low engine speed to prevent interference with the speed range usually employed for driving.

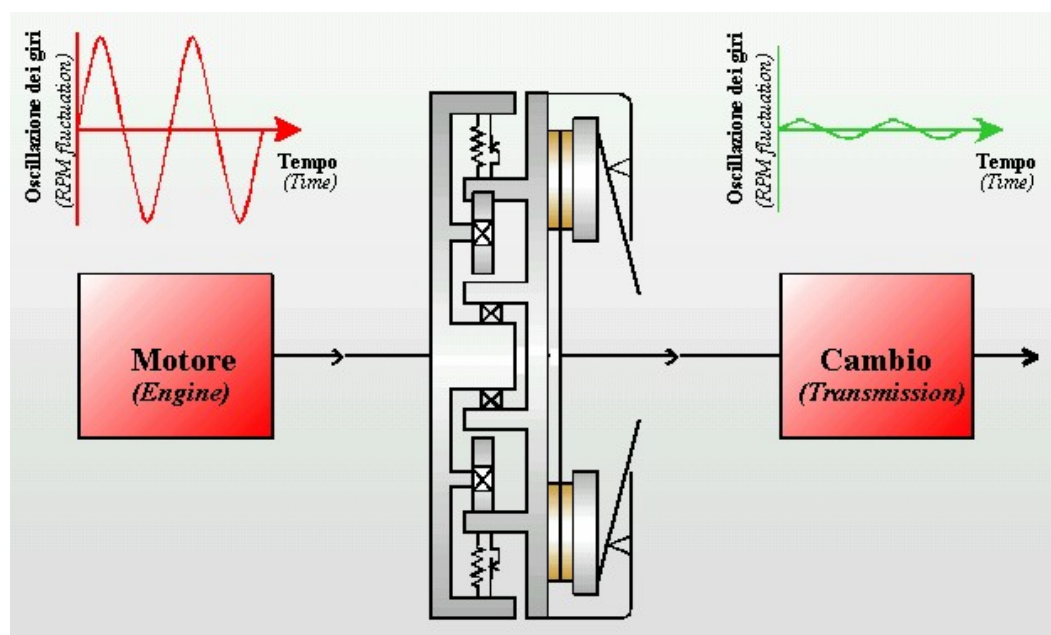


Transmission diagram of a traditional one-mass flywheel:



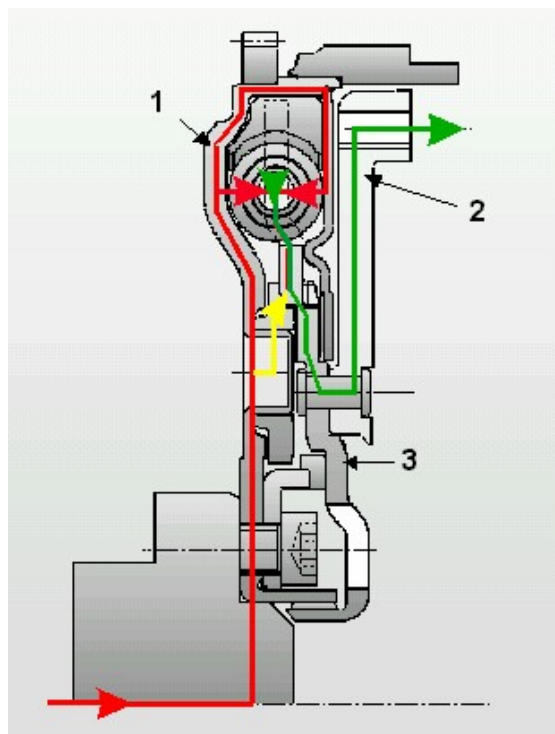
The diagram (engine-flywheel-clutch-transmission) shows the oscillation in time of the engine output speed and the transmission input speed.

Transmission diagram with Sachs dual-mass flywheel:



OPERATION DIAGRAM: The motion transmission course is shown below:





1. Primary flywheel
2. Secondary flywheel
3. Ring gear

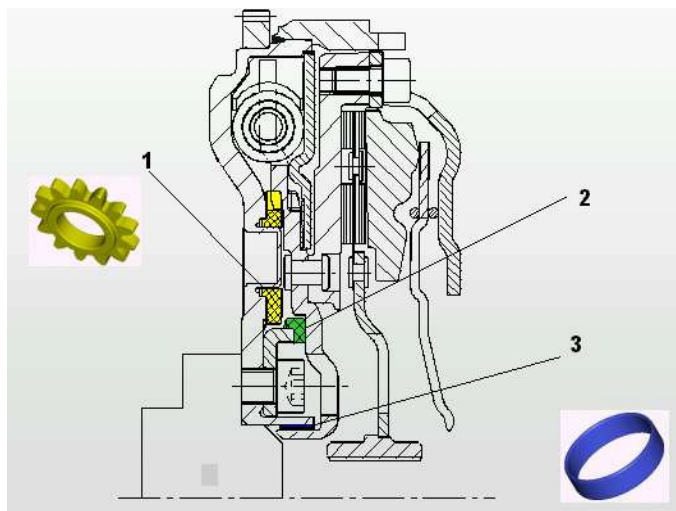
- The crankshaft transmits motion to the primary flywheel.
- The guide shoes receive motion from the primary flywheel and transfer it to the springs.
- The spring system damps the torque variations.
- The shoe-spring system transmits motion to the ring gear which in turn transmits it to the secondary flywheel.

The planetary gear set consists of a gear carrier (primary flywheel), a planetary ring gear and eight satellite gears. This gear set is submerged in grease and the satellite gears have rotation inertia. It therefore acts as a second damping element.

The guide shoes are provided with anti-packing caps. This means that in the presence of sudden torque variations, the springs are distorted until the shoes pack to prevent excessive spring distortion.

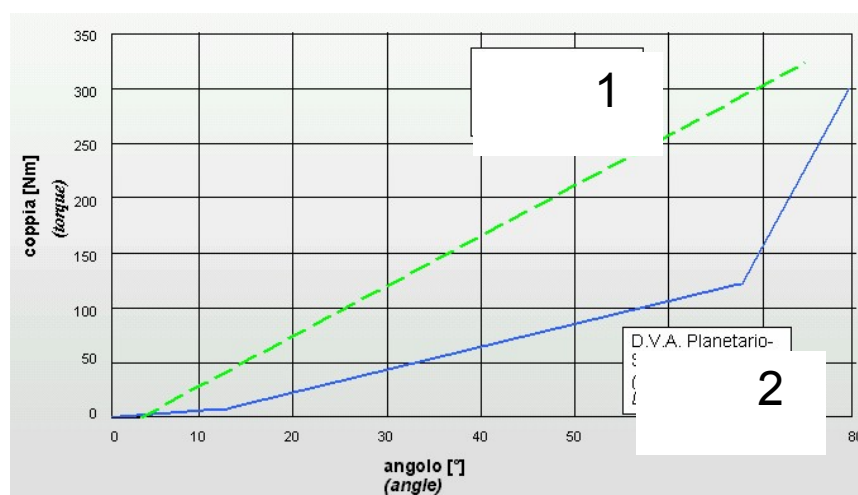
The primary flywheel arrangement of the planetary gear and the radial and axial bearings is shown in the figure:





1. Planetary gear
2. Axial bearing
3. Radial bearing

DMF TWO STAGE CHARACTERISTIC - A two-stage torque fluctuation damping curve can be expected from this type of flywheel for effective, targeted reduction of vibrations and transmission roughness. The figure below compares the performance of a traditional flywheel and a Sachs DMF:



1. Conventional flywheel
2. Sachs planetary flywheel



The configuration with planetary in home position without torque transmission.



Configuration with planetary at first stage end of stroke (first stiffness ramp).

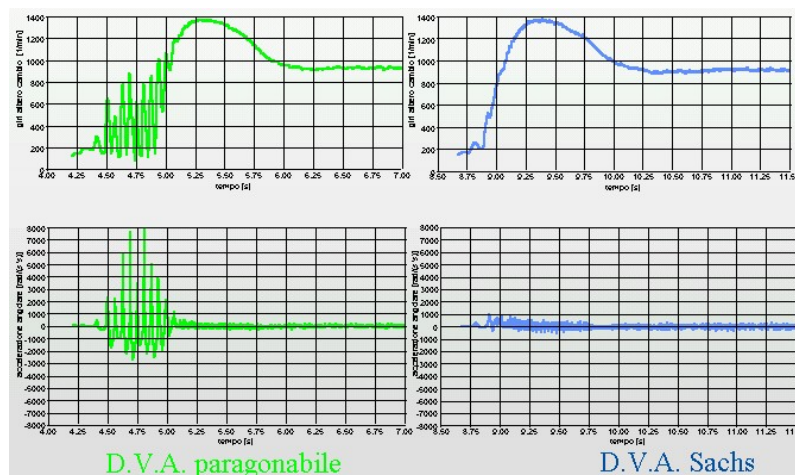


Configuration with planetary at second stage end of stroke (second stiffness ramp) with guide shoes packed.

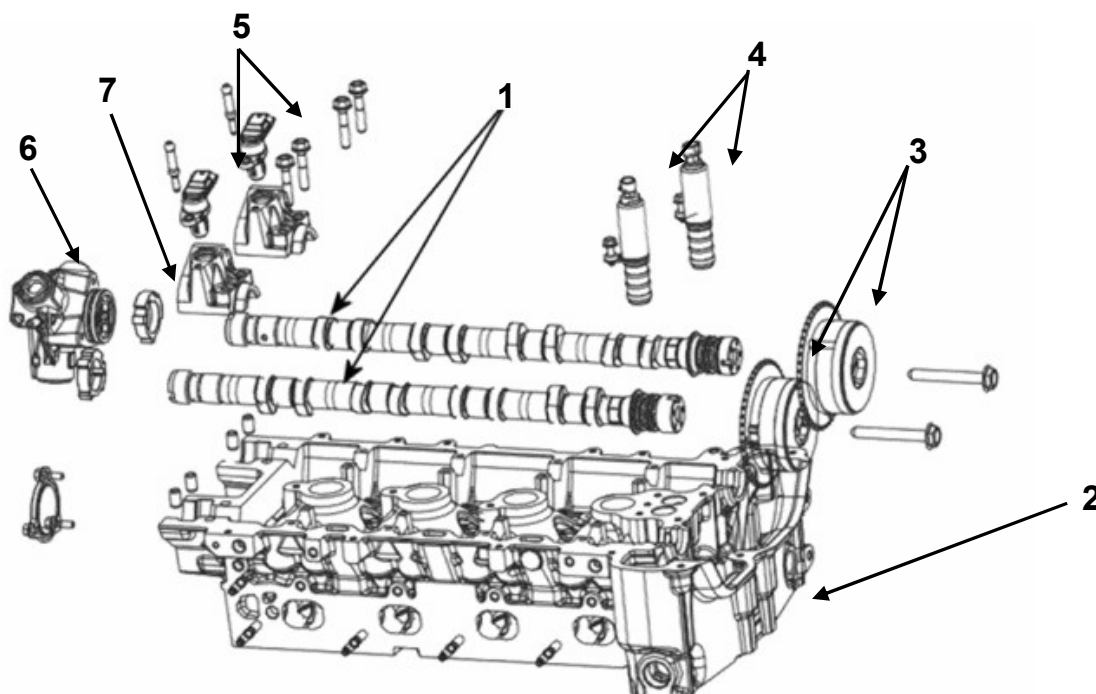


The following figures compare the performance of a traditional dual-mass flywheel and that of a Sachs dual-mass flywheel when the engine is cranked. Note the considerable reduction of oscillation of the gearbox shaft of the Sachs DMF.





The diagrams on the top show the gearbox shaft speed in rpm; the diagrams underneath show the gearbox shaft acceleration (vibrations).



1. Specific cam profiles
2. Cylinder head
3. Variable timing
4. Variable timing solenoid valves
5. Timing sensor
6. Fuel high pressure pump
7. Camshaft timing phonic wheel

FUNCTION: To contain and correctly support the various timing parts, suction and exhaust conduits, spark plug houses and injector housings. It determines the shape of the combustion chamber.

MATERIAL: The cylinder head for 1.9 and 2.2 litre engines is an aluminium alloy casting.

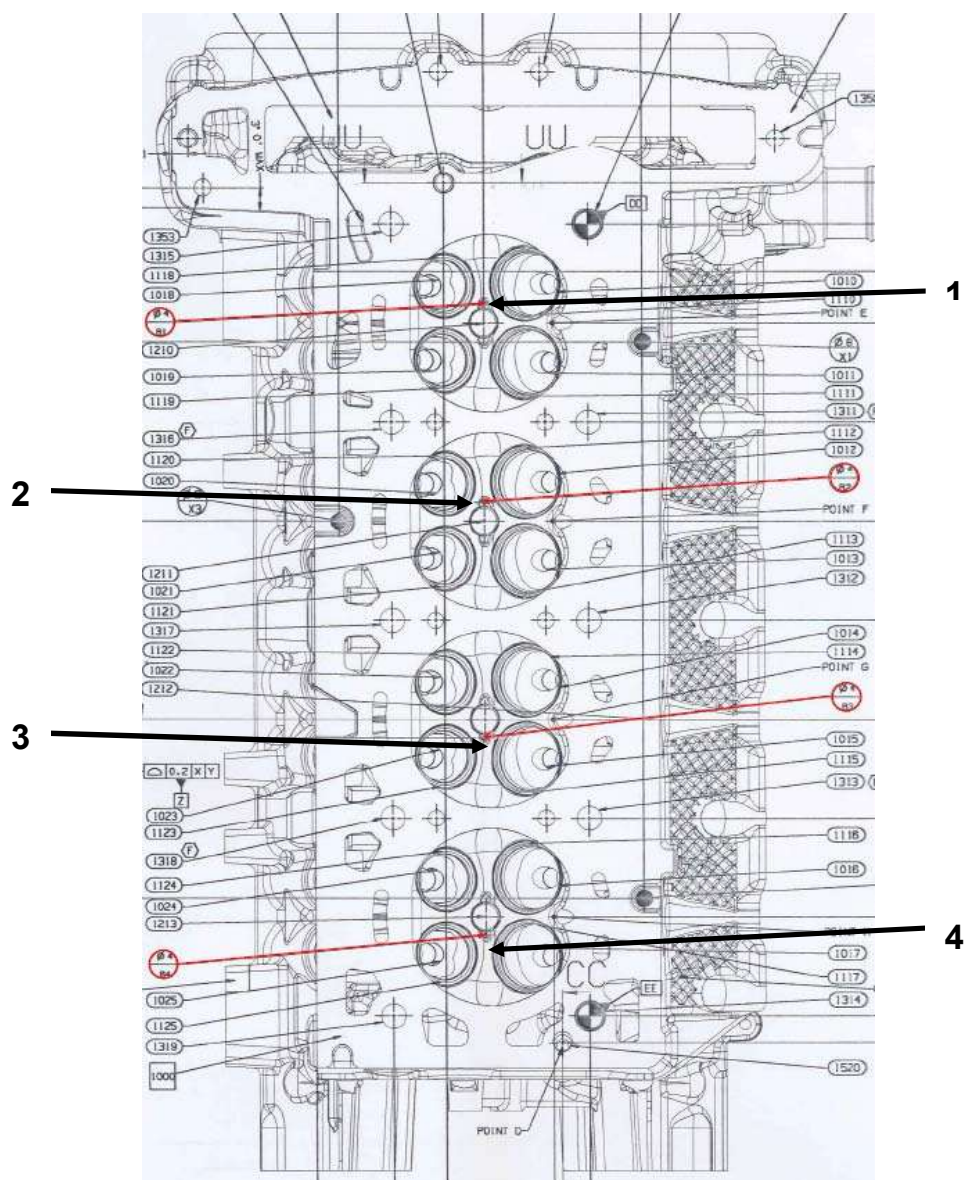
FEATURES:

- Plastic cylinder head cover.
- Spark plug holes slanted towards the exhaust conduits by 3 mm.



- Injectors positioned directly in the cylinder head spraying directly into the combustion chamber. The injectors are pre-assembled on an intermediate flange which houses the fuel rail.
- Valves actuated by rollers equipped with hydraulic tappets.
- Exhaust conduits directed towards the back of the engine.
- Presence of twin continuous variable timing.

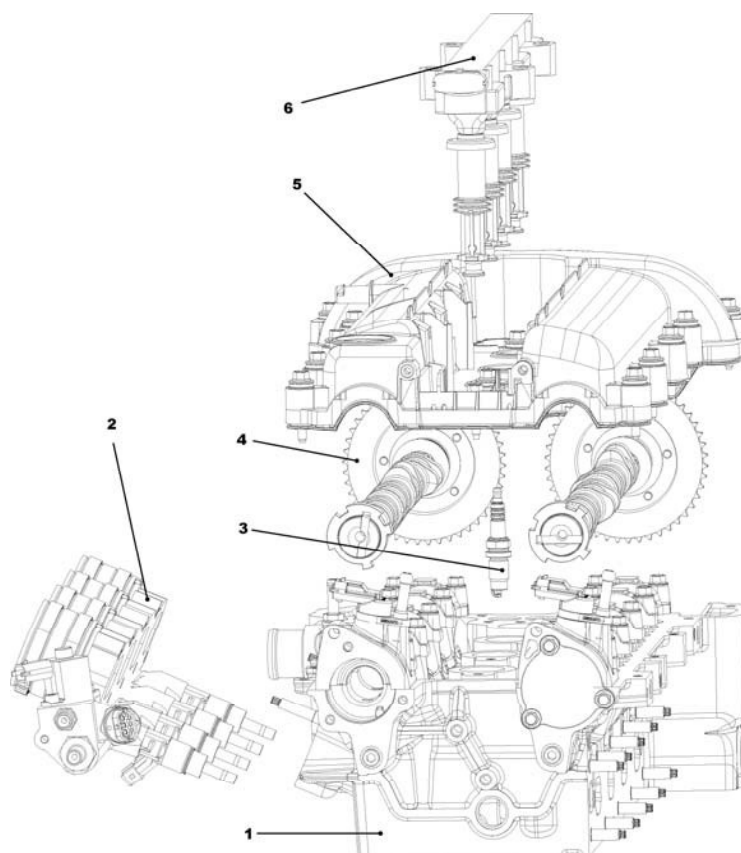
SERVICING OPERATIONS: Cylinder head flattening is allowed to correct errors of planarity in the range from 0.05 and 0.15 mm. Flattening is not necessary under this range and not allowed over the range (replace the part). Flattening must ensure a minimum depth of 12.75 mm measured in the points shown in the drawing (the minimum depth of the combustion chamber volume).



1. Depth measuring point
2. Depth measuring point
3. Depth measuring point
4. Depth measuring point

After flattening the cylinder head, measure that the minimum depth of 12.75 mm is obtained in measuring points 1, 2, 3, 4.



Timing

1. Cylinder head
2. Fuel high pressure rail
3. Spark plug
4. Camshaft and pulley
5. Head cover
6. Ignition coil module

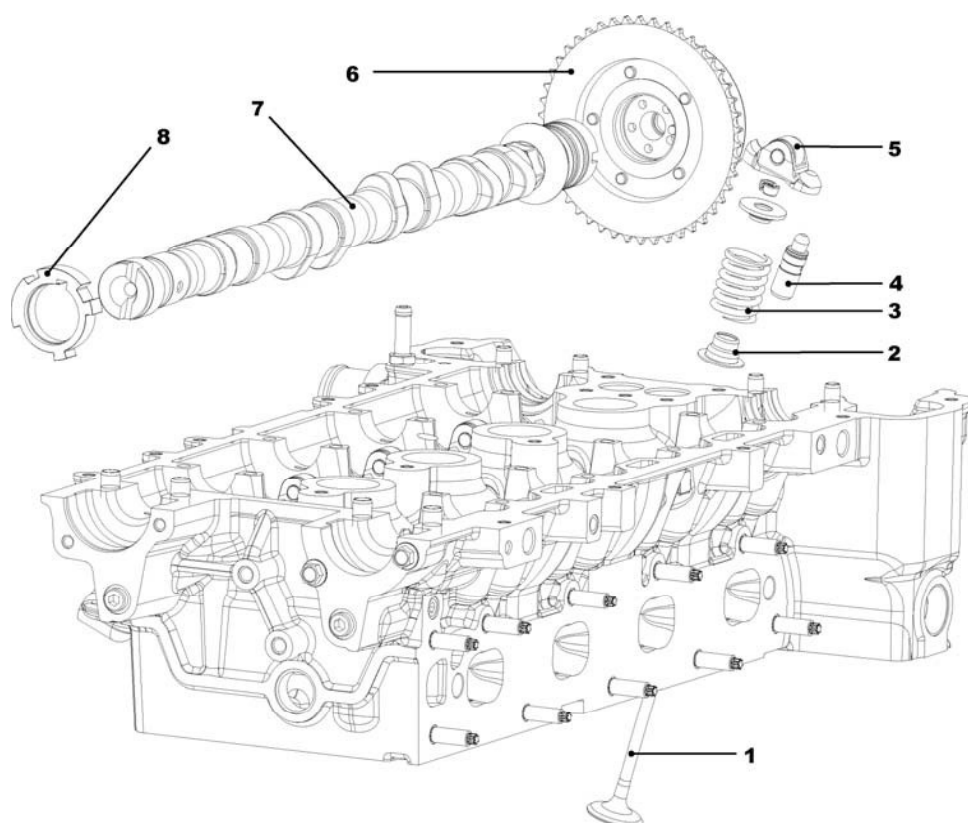
FUNCTION: The timing components open and close the suction and exhaust valves to provide the engine's timing diagram.

DESCRIPTION: These engines are characterised by the new timing system, consisting of a roller rocker arm system (clearance is recovered hydraulically) which considerably reduces loss due to friction and continuous variable timing on the suction line and the exhaust line obtained by means of 'compartments'.

The variable timing constantly adjusts the timing angles on both lines (suction and exhaust) to maximise performance (by providing the appropriate timing for all engine speeds) and to reduce consumption and emissions at partial loads. Continuous suction and exhaust valve variable timing acts on the exhaust valve to extend expansion (by converting more heat into work) and provide internal EGR functions (by avoiding the leakage of the last exhaust gas which is rich in unburnt components) and on the suction valve to improve cylinder mixture filling at the various speeds.

The cam profile which determines the valve opening and closing method has been revised to provide the performance required by Alfa Romeo. The maximum power is reached at 6500 rpm thanks to the use of wider profiles, while allowing to run without problems at 7000 rpm (which the maximum engine speed allowed by the electronic limiter).



Camshaft

1. Valve
2. Valve stem cap
3. Spring
4. Hydraulic tappets
5. Roller rocker arm
6. Continuous variable timing
7. Camshaft
8. Timing sensor phonic wheel

MATERIAL: The camshafts are made of cast iron. Cams are tempered and hardened. The surface treatment increases surface hardness of the cams and increases resistance to wear.

FEATURES: The camshaft is driven by a chain whose main advantage, with respect to a belt system, is that it does not need to be replaced for the entire life of the engine. There are two suction valves and two exhaust valves for each cylinder. The spark plugs are positioned vertically between the two valves. The hydraulic tappets used in these engines automatically cancel valve backlash while the engine is running: this reduces the need for interventions on the engine and engine noise.

The high area power (the specific power released on the piston) of the engine (80 HP/dm² for the 2.2 litre) called for the adoption of sodium cooled exhaust valves to reach high volumetric yield. The maximum suction valve lift is 10.3 mm for both engine versions.

The roof-shaped combustion chamber has four valves per cylinder with valve valves with respect to a 86 mm bore (35.3 mm suction and 30.3 mm exhaust) for easy air flow to favour engine performance.

Attention in designed focused greatly on the piston height to contain the total height of the engine despite the 94.6 mm stroke to provide a compression height of only 28 mm; this result is excellent considering the high area power reached.

Drive chains

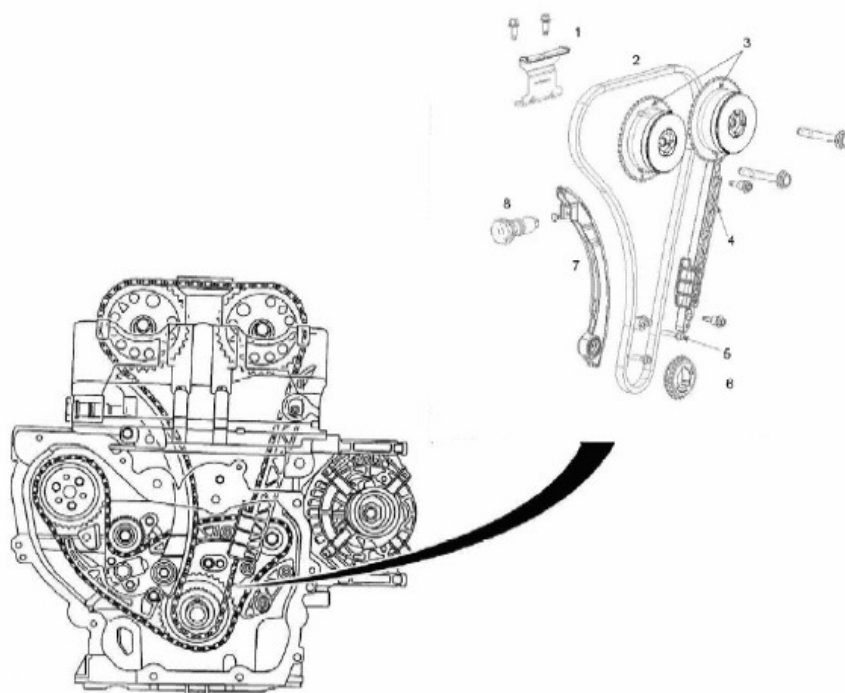
FEATURES: One chain drives the camshaft and another drives the balancing countershafts and the coolant pump. Two maintenance-free hydraulic tensioners ensure that the chains are correctly pulled. The timing chains cross two



centrally fitted conduits and guides fastened on the tensioner side of the timing box. A sliding conduit guides the chain between the camshaft pulleys. The oil nozzle in the middle ensures correct lubrication. Specific chain lubrication is allowed by the oil returning from the head.

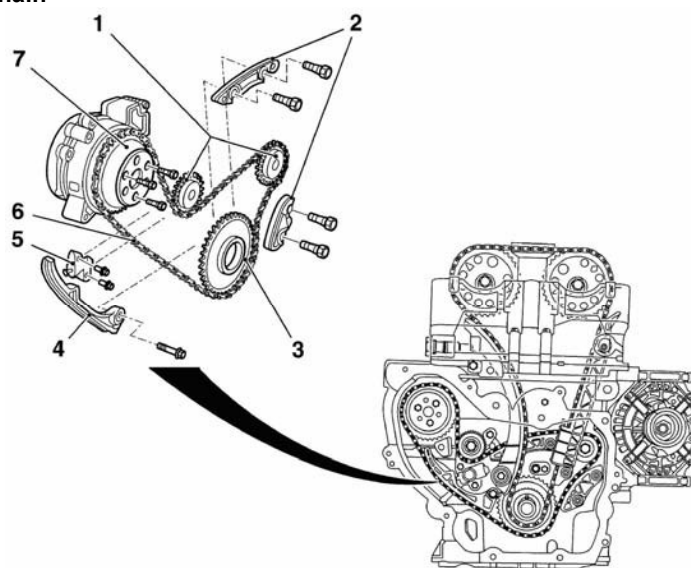
MAINTENANCE: The chains last for the entire life of the engine and must not be opened.

Camshaft drive chain

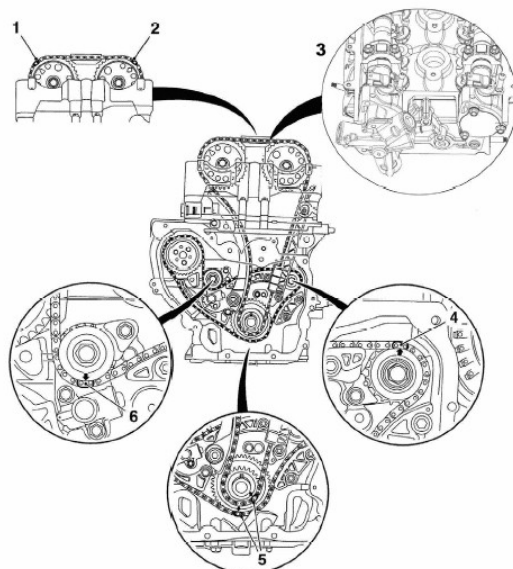


1. Sliding conduit
2. Camshaft drive chain
3. Camshaft pulleys
4. Guide conduit
5. Oil nozzle
6. Crankshaft pulley
7. Tensioning conduit
8. Chain tensioner



Countershaft drive chain

1. Countershaft drive pulleys
2. Guide conduits
3. Crankshaft pulley
4. Tensioner unit
5. Tensioner
6. Countershaft drive chain
7. Coolant pump drive gear

Timing system

1. Output marking ▷ on camshaft actuator pulley drive chain
2. Input marking ◁ on camshaft actuator pulley drive chain
3. Fourth cylinder cam position
4. Marking on countershaft drive chain, input side (brass colour)
5. Marking on crankshaft pulley drive chain (silver colour)
6. Marking on countershaft drive chain (silver colour)

Timing is adjusted using the fourth cylinder TDC as reference. The TDC points on the chain are marked by coloured links. These must correspond to the markings on the drive gear teeth.



Important:

Timing cannot be checked during the references once the engine has been timed after the crankshaft has turned once.

TIMING INSPECTION: with fourth cylinder at TDC. The camshaft pulleys must be positioned with a specific tool. The markings on the torsional vibration damper and the timing box must be aligned in this position.

Camshaft tensioners

LOCATION: The two hydraulic chain tensioners are arranged:

- in the head (crankshaft drive chain)
- timing box (countershaft drive chain).

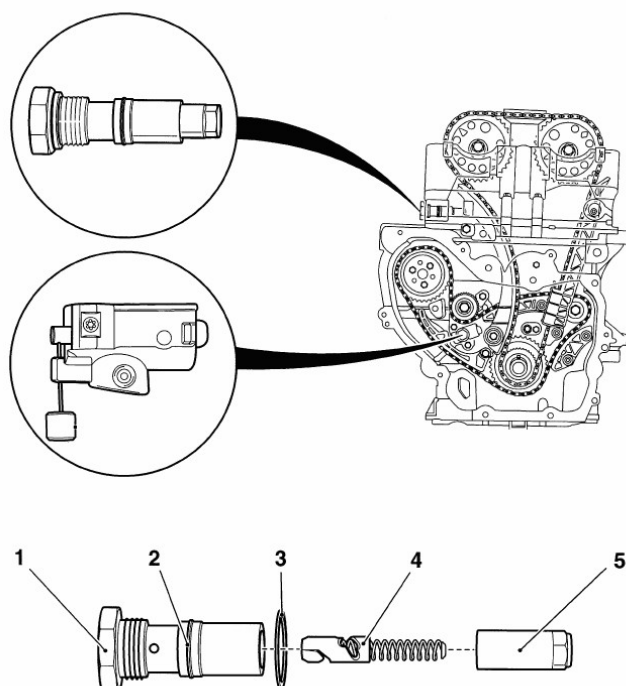
MAINTENANCE: Remove the concerned tensioner before starting any job on the chain.

Crankshaft drive chain tensioner: turn the piston by 90°, press back and lock in this position with the specific tool.

Camshaft drive chain tensioner: remove the tensioner. Before installing the camshaft drive chain tensioner, the internal piston must be pressed against the spring and locked against the last tooth of the piston by turning it rightwards. The lock is automatically released when the engine is cranked.

Important:

Disrespect of these precautions can cause excessive chain tensioning which could damage the tensioning conduits and the chain.



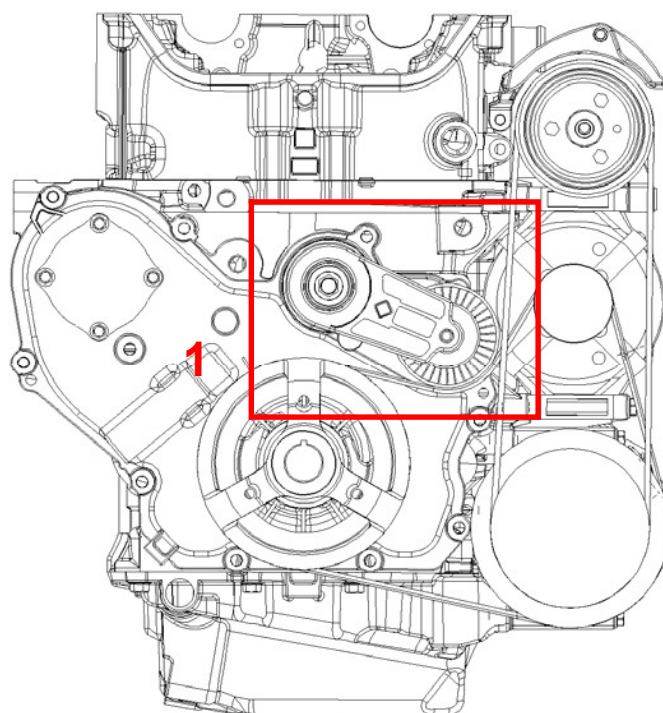
1. Camshaft chain tensioner
2. Countershaft chain tensioner locked with specific tool
3. Chain tensioner
4. O-ring
5. Seal
6. Internal piston with spring
7. Thrust piston



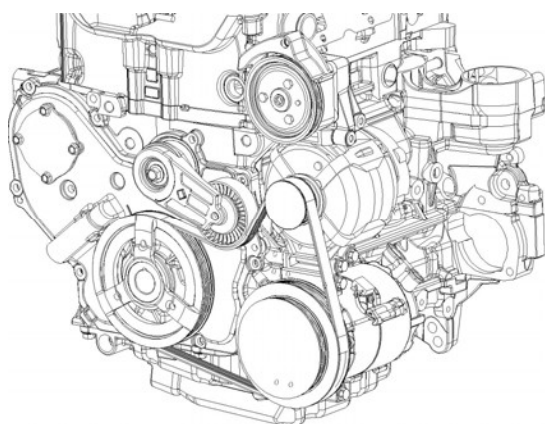
Utility drive belt

FEATURES: The alternator and A/C compressor drive belt is maintenance-free. The belt is pulled by an automatic tensioner. The power steering pump is controlled by a second, narrower belt.

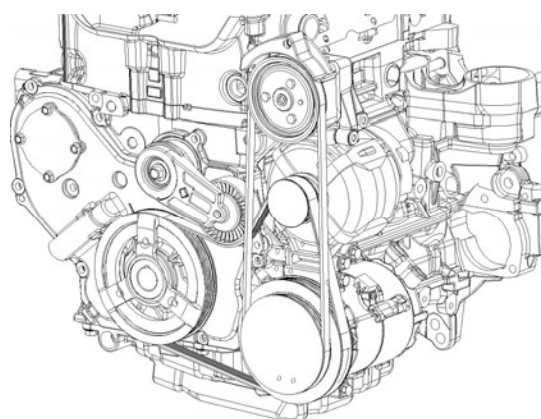
MAINTENANCE: The belt tensioner must be loaded against the pressure of the spring with a specific tool. This releases tension from the belt which can therefore be removed. The power steering drive belt must be removed using the specific tool.



1. Utility belt tensioner



1



2

1. Course of the belt with A/C compressor
2. Height of belt with A/C compressor and second power steering pump belt

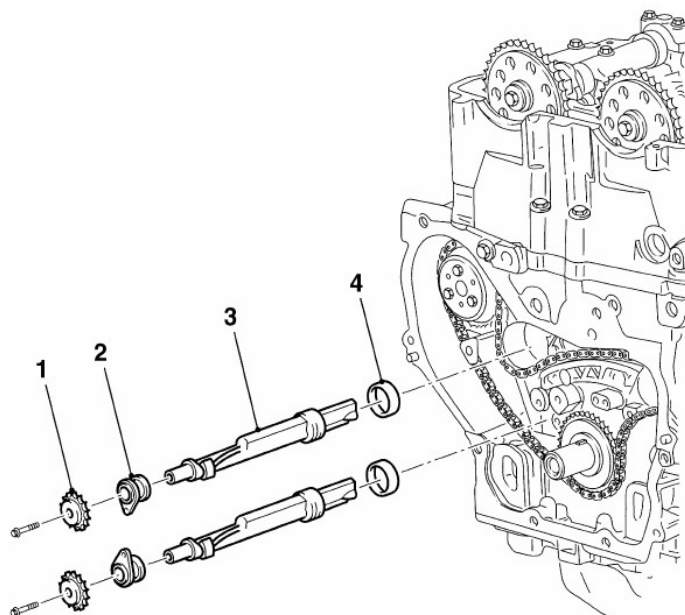


Balancing countershafts

FUNCTION: The engine is equipped with two balancing countershafts to improving riding comfort in terms of noise and vibrations. These eliminate the reciprocating forces typical of four cylinder in-line engines that the crankshaft counterweights cannot balance.

MATERIAL: The rotating countershafts are made of cast iron.

FEATURES: The two countershafts with cast iron balancing counterweights ensure high performance in terms of noise and vibration containment. They are located inside the crankcase and controlled by the countershaft chain. The countershaft gear teeth are provided with damper rings which additionally reduce the noise from the chain. The coolant pump is part of this chain driving system. The countershafts run at double speed in the opposite direction. These ensure regular and smooth engine rotation.



1. Countershaft gear
2. Countershaft retainer bearing
3. Countershaft
4. Countershaft bearing

Continuous cam variable timing system

Variable timing control valve



Variable timing system



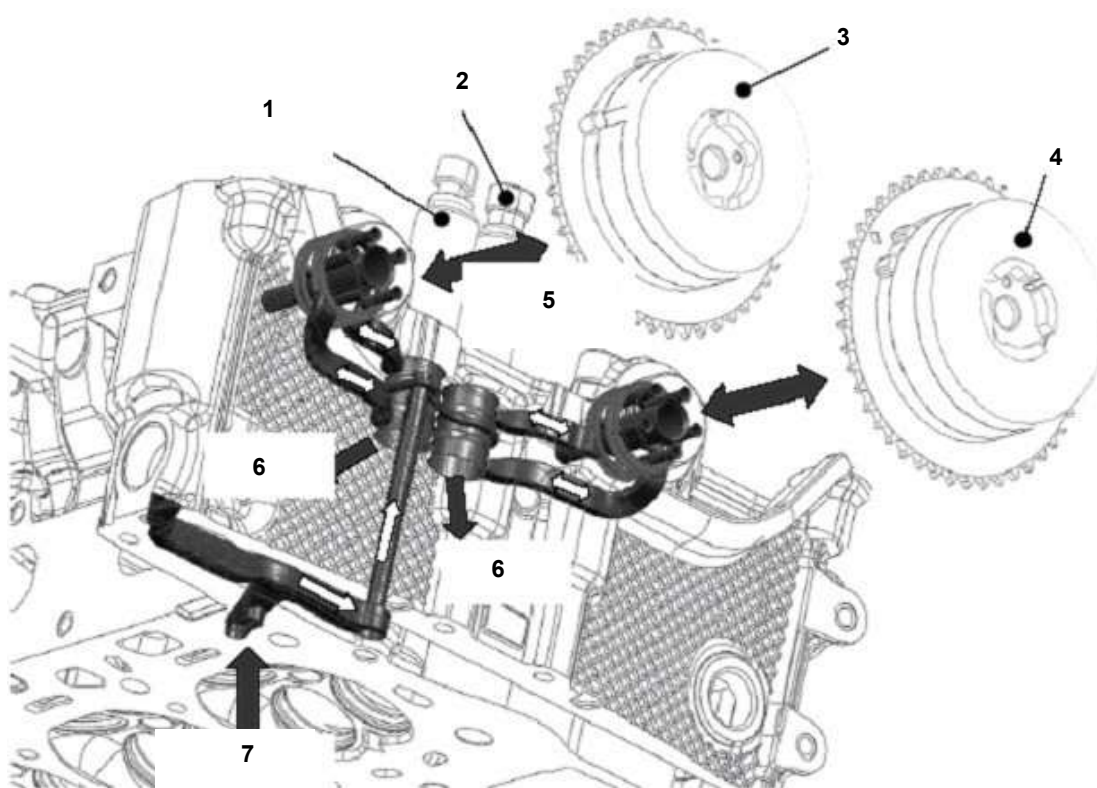
FUNCTION: The electro-hydraulic variable timing replaces the standard camshaft control system. It controls and varies the timing diagram according to the engine conditions to increase the power peak at high speed and decrease HC, NOx emissions and fuel consumption at the same time.

FEATURES: These engine fit two variable timing systems, one on each camshaft. They are capable of varying the cam angle during engine operation according to conditions of use. The variable timing on suction side provides continuous variation of camshaft slant by even 30°. The variable timing on exhaust side allows a rotation of 25°. The engine ECU determines the position of the cam through the sensors arranged on the camshaft and the crankshaft and sets the position of the control valve fitted on the head which controls the oil flow into the variable timing system.

ADVANTAGES:

- Optimal dimensions (minimum length, minimum diameter).
- Capacity of reaching high torque values.
- Low weight due to small dimensions and use of alternative materials.
- Simple assembly (single central bolt and fastening pin).

System operation

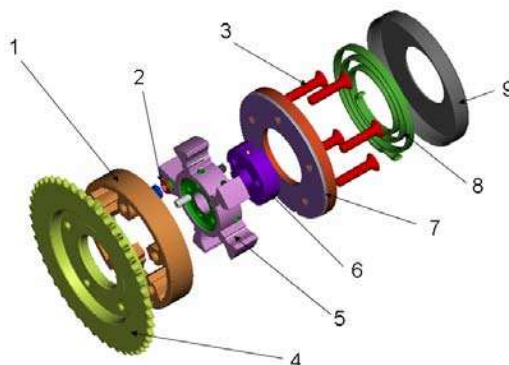


1. Control valve, exhaust side
2. Control valve, suction side
3. Variable timing, exhaust side
4. Variable timing, suction side
5. Reversible oil duct
6. Oil return duct
7. Oil delivery duct

OPERATION: The hydraulic variable timing system is shown in the figure. Duct (7) supplies the 4/3 distributor hydraulic solenoid valves (four ports, three positions) each of which is connected to its own rotating actuator (variable timing) via two ducts. The variable timing compartments between the rotor (fixed to camshaft) and the stator (fixed to pulley) can be filled with oil or emptied. The rotor is turned by the filling and emptying of the conduits. The rotor can turn with respect to the stator in either direction.

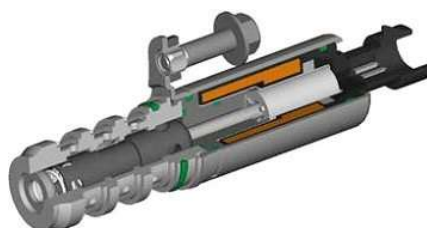


Variable timing exploded view



1. Stator
2. Block system
3. Screws
4. Pulley
5. Rotor
6. Adapter
7. Plate
8. Return spring
9. Cover

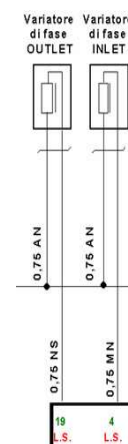
Variable timing control valves

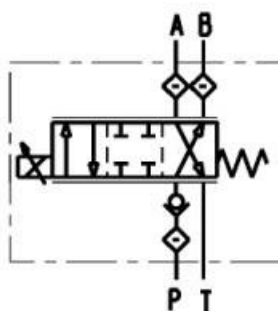


FEATURES: The proportioning hydraulic valve is part of the variable timing hydraulic system. Actuation is electromagnetic with return spring. It is provided with a fastening support, assembly screw and 2-pin integrated connector. The connection to the engine ECU is:

CONNECTION TO ECU

- Camshaft variable timing valve, suction side
- connector pin 1 to ECU connector A pin 4
- connector pin 2 to power wire
- Camshaft variable timing valve, exhaust side
- connector pin 1 to ECU connector A pin 19
- connector pin 2 to power wire

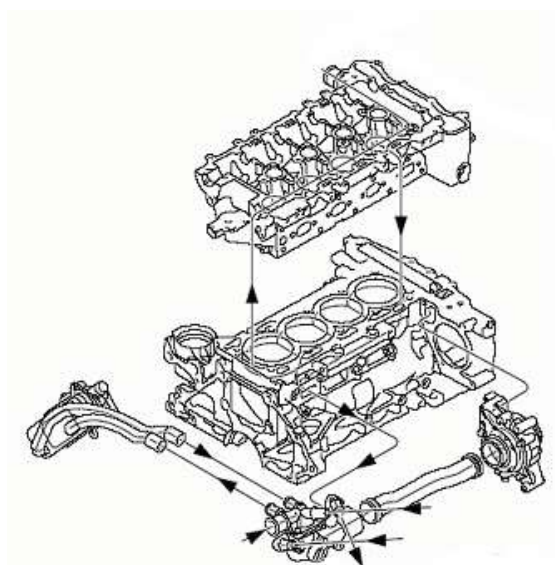
CONNECTOR**DRAWING**

Hydraulic features

Working using engine oil
Flow > 3.8 l/min
Working pressure < 10 bars
Filters integrated on valves (fine mesh 300 µm).

Electrical characteristics:

Frequency signal in range from 200 to 250 Hz.

Cooling system

FUNCTION: To cool the various parts of the engine, warm the air for the climate control system and cool engine oil.

FEATURES: This is a total flow bypass cooling system: in other words, the coolant can be entirely recirculated by the pump suction if it is too cold at engine outlet.

The coolant pump is built into the engine block on timing side and is driven by the balancing shaft drive chain.

An o-ring is arranged between the cylinder block and the coolant pump. Both engine versions fit a heat exchanger for the engine oil.

This is positioned outside the engine block and is positioned on the oil filter side.

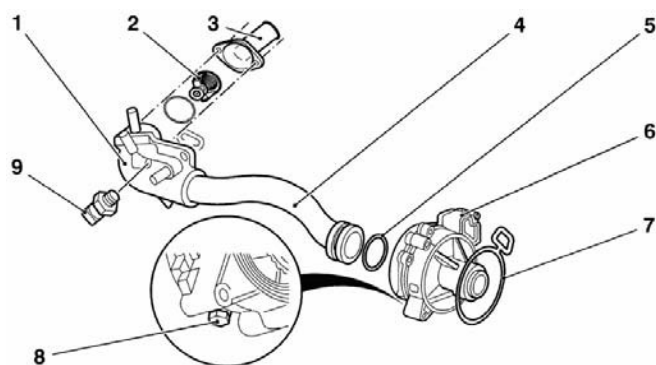
The coolant may penetrate inside the lubrication circuit if an o-ring or the drive shaft gasket is not tight.

MAINTENANCE: The cooling circuit must be emptied through the drain holes on the radiator and pump before removing the coolant pump.

Before removing the pump, the coolant chain gear must be blocked with respect to the timing chain cover using a specific tool.

The balancing shaft chain and the timing chain housing do not need to be removed.

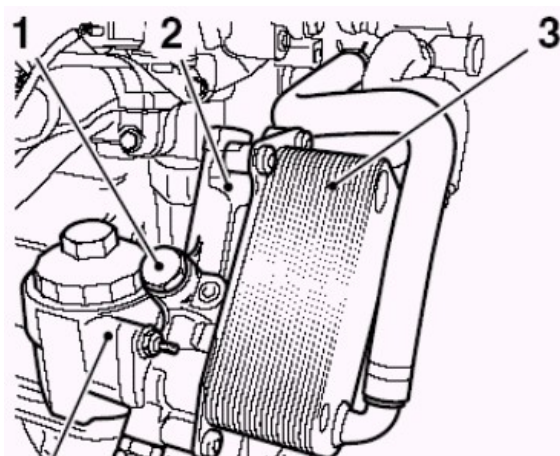
Cooling circuit components



1. Thermostat housing
2. Thermostat
3. Thermostat cover
4. Pipe
5. O-ring (pipe)
6. Coolant pump
7. O-ring (pump)
8. Pump draining nut
9. Coolant temperature sensor

The thermostat unit is connected to the crankcase with screws. The temperature sensor is fastened to the unit with a threaded connection.

Oil-water heat exchanger



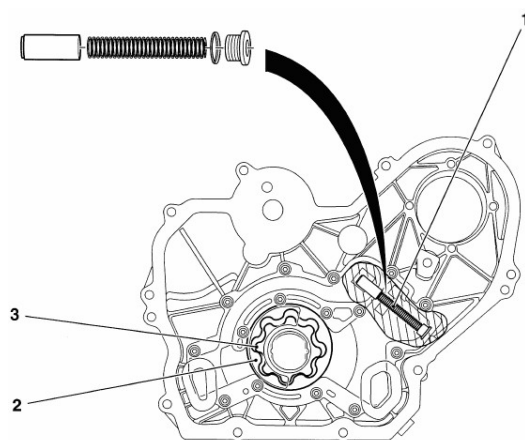
1. Engine oil thermostat
2. Oil filter adapter housing
3. Engine oil cooler
4. Oil filter housing

FUNCTION: Effective oil cooling is needed to maintain the chemical, physical and viscous properties of oil. This function is ensured by a water-oil heat exchanger.

MATERIAL: The heat exchanger consists of a pack of aluminium plates crossed on one side by a flow of coolant and on the other by a flow of engine oil.

LOCATION: The heat exchanger is fastened to the cylinder block on flywheel side, on the upper part.



Lubrication system**Oil pump**

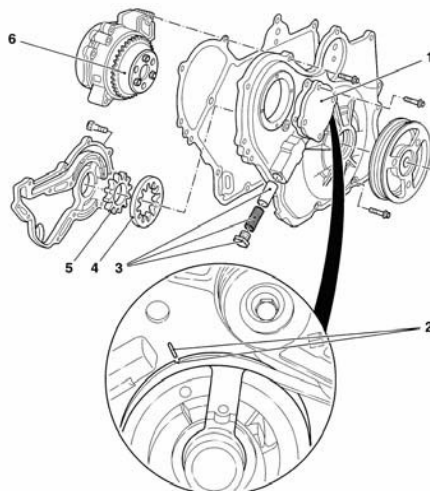
1. Pressure regulator valve
2. Stator
3. Rotor

FUNCTION: The oil pump circulates the flow needed for forced lubrication of the various engine parts.

LOCATION: The oil pump is built into the timing chain box.

FEATURES: It is operated by the crankcase by damping torsional vibrations. The pressure regulating valve can be accessed from the outside and opens a range of pressures from 4 to 6 bars. The two main lubrication channels are supplied by the channels in the cylinder block casting. These two main channels supply the entire engine lubrication system, the bearings, cylinder head, balancing shaft and chains.

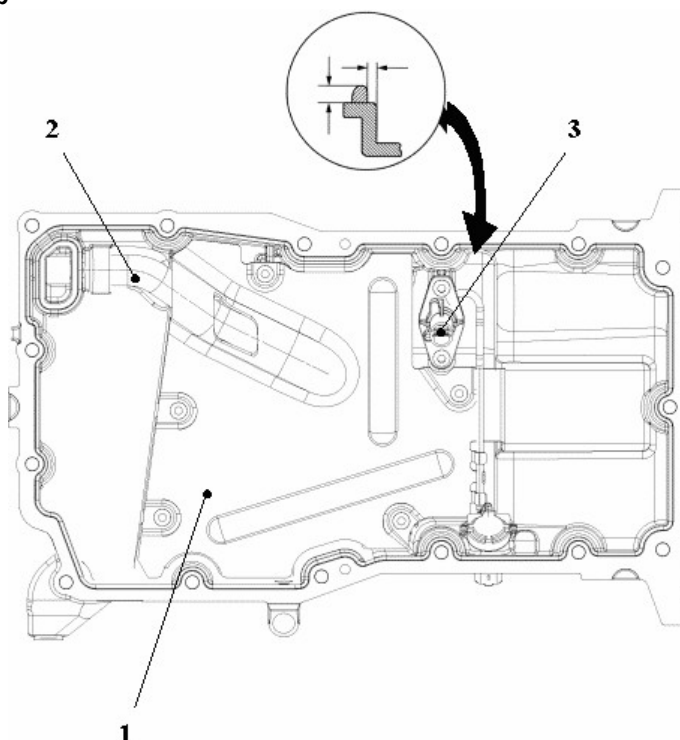
The oil pump is built into the timing chain gear assembly. The pump gears (one internal and one external) are fitted on cams. Displacement is variable according to engine speed.



1. Pump service opening cover
2. TDC piston signal for timing
3. Oil pressure regulating valve
4. Stator
5. Rotor
6. Oil pump drive gear



Oil sump



1. Dimension 1: 1.75 - 2.75 mm
2. Dimension 2: 0.5 - 1.5 mm
3. Oil baffle
4. Oil suction pipe
5. Oil level sensor

FUNCTION: To contain lubrication oil and cool it by effect of air while the vehicle is travelling.

MATERIAL: The oil sump is made of aluminium alloy with evident advantages in terms of weight reduction and heat exchange features.

FEATURES: A baffle is riveted to the oil sump for integrating the oil suction pipe. The baffle avoids excess splashing of the oil while the vehicle is travelling and prevents no-load priming of the pump. It reduces noise and prevent mixing of residues from the bottom of the sump.

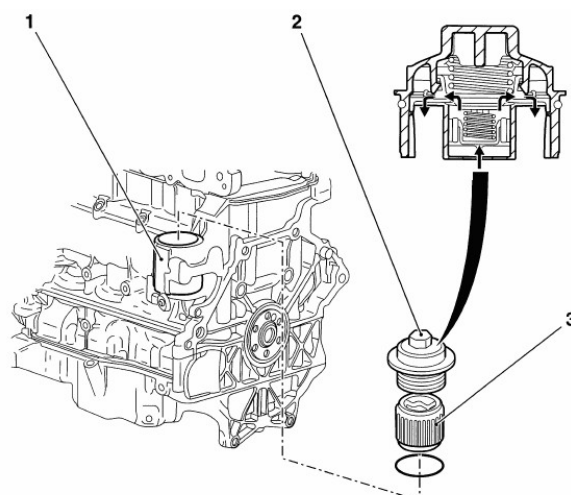
MAINTENANCE: Residues of sealant, grease and dirt must be removed from the coupling surfaces of the oil sump before refitting the oil sump. Remove sealant residues with a plastic chisel.

The oil sump must be sealed with silicon sealant (grey) as follows:

- Apply a bead of silicon sealant width 1.75 - 2.75 mm (dimension 1) on the surface of the oil sump at a distance of 0.5 - 1.5 mm (dimension 2) from the internal edge of each coupling surface.
- Apply a bead of sealant width 1.75 - 2.75 mm on the oil suction pipe union.

NOTE: The silicon sealant may get into the lubrication circuit and from there into the oil pump if it is not applied correctly on the oil suction pipe union. Fit the oil sump within 10 minutes from application of sealant. The dipstick guide pipe is designed to be used to drain the engine oil for replacement.



Oil filter

1. Oil filter housing
2. Oil filter cover
3. Filtering cartridge

LOCATION: The oil filter housing is made in the cylinder block casting.

FEATURES: The oil filter consists of a paper cartridge. The screw-on filter cartridge contains the bypass filter.

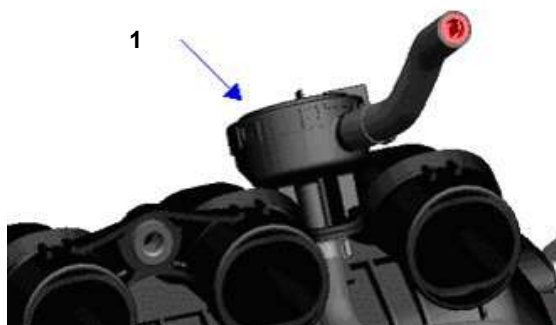
MAINTENANCE: Use the specific tool to remove the oil filter cover. Change the engine oil regularly as shown in the Owner's Handbook.

Blow-by system

FUNCTION: To collect the oil vapours developed in the crankcase and cylinder head to prevent dispersion outside the engine, to condense them and send them back to the sump.

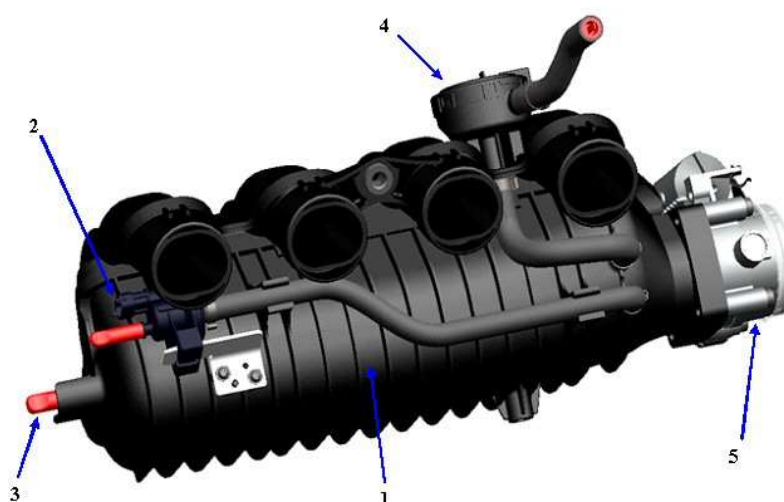
FEATURES: Vapour emissions are controlled by an oil separator which collects the vapours from the crankcase and the tappet cover. The condensed vapours return to the sump through a pipe. The uncondensed vapours are conveyed by a pipe to the suction air sleeve.

BLOW-BY VALVE: A regulating valve is arranged on the vapour conveying pipe. In normal conditions, the valve spring presses a membrane keeping it open and letting oil vapours from the oil separator through. When the vacuum inside the pipe exceeds its calibration, the spring moves the membrane and closes the conduit from the oil separator consequently preventing the access of oil into the sump.



1. Blow-by valve



Air intake system

1. Intake plenum
2. Canister bleeder valve
3. Brake booster vacuum port
4. Blow-by valve
5. Electronic throttle
6. Supporting bracket fastening

FUNCTION: The plenum contains the air that is taken in by the cylinders and conduits that convey the air evenly to the various cylinders.

MATERIAL: The intake plenum is made of composite material with three layers of nylon filled with 30% glass fibres and friction welded.

FEATURES: It distributes intake air to each cylinder. The air flows from the throttle body inside the plenum and is distributed evenly through the single conduits and then into the cylinder volume. The plenum volume and shape must stabilise the pulses created by intermittent suction of the various cylinders.

Air course length	255 mm
Air course diameter	48/45 mm
Capacity	3.55 dm ³
Plenum weight	1900 g
Complete module weight	3100 g
Range of operation	from -30°C to 120°C

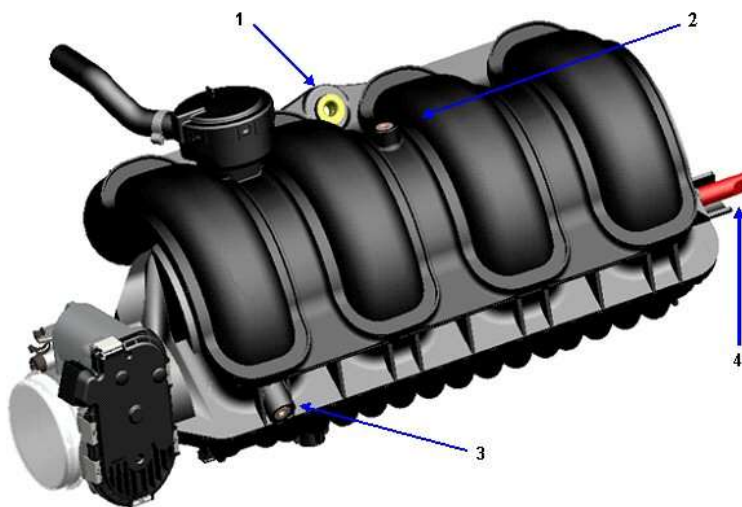
ASSEMBLY CONDITIONS: The following elements must be taken into consideration when fitting the module:

INTAKE PLENUM SUPPORTING BRACKET: The plenum is fastened to the bracket by a bolt.

AIR CONDUIT: The plenum is joined to the injection conduit by means of 4 sleeves and 8 terminals.

COUPLING ELEMENT: The additional plenum-injection conduit fastening is obtained by means of a coupling element fastened with a screw and bolt.



Additional component fastening

1. Coupling element
2. Oil indicator tube housing
3. Water pipe housing
4. Brake booster vacuum port

OIL LEVEL GAUGE PIPE HOUSING: The oil gauge pipe is fastened to the plenum by a screw.

WATER PIPE HOUSING: The water pipe is fastened to the plenum by a screw.

BRAKE BOOSTER VACUUM PORT: The brake booster pipe is fastened to the plenum by a pipe clamp. A specific tool is needed for fastening.

THROTTLE BODY: The throttle body is fastened to the plenum bracket by bolts. Fasten the four bolts in alternating pattern. The air pipe is fastened to the body by means of a clamp.

BLOW-BY VALVE: The blow-by valve welded to the plenum. The valve consists of a body, a spring and a diaphragm. The valve assembly can be disassembled.

CANISTER BLEEDER VALVE: The canister bleeder valve is clipped onto the plenum. The valve fastening support is fastened to the plenum by means of two screws.

Electronic accelerator throttle

FEATURES: The ETC (Electronic Throttle Control) system is designed for spark ignition engines. It consists of a throttle body, a potentiometer on the accelerator pedal and an ECU. The throttle body includes an actuator, a throttle valve and a valve position sensor (potentiometer) integrated in a single unit. The actuator is a direct current, dual stage motor. The working life of the throttle body is 15 years with a minimum kilometrage of 250,000 km. The connections to the engine ECU are:

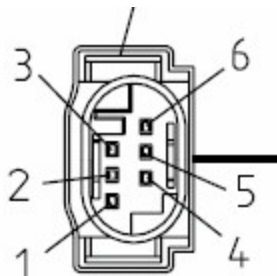


CONNECTION TO ECU

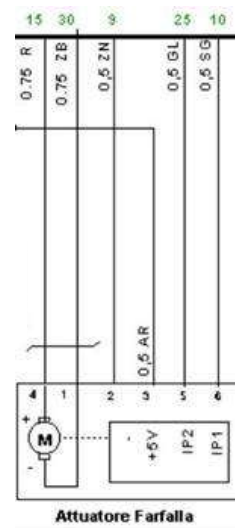
- connector pin 1 to ECU pin 30 side A (DC electrical motor ground)
- connector pin 2 to ECU pin 9 side A (actuator ground)
- connector pin 3 to ECU pin 24 side A (sensor power)
- connector pin 4 to ECU pin 15 side A (DC motor power)
- connector pin 5 to ECU pin 25 side A (IP2 signal from actuator to throttle)
- connector pin 6 to ECU pin 10 side A (IP1 signal from actuator to throttle)

CONNECTOR

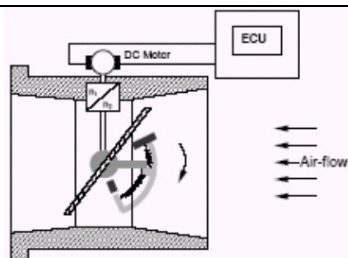
6 pins, two rows



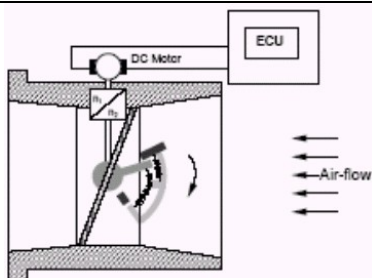
DRAWING



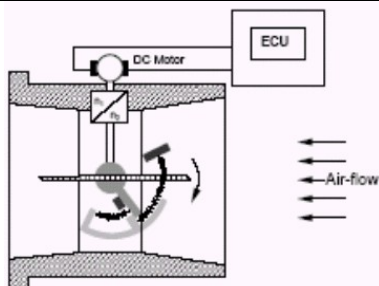
CONNECTION ROUTE: The maximum slant of the wiring route with respect to the direction of the pins must not exceed 45°. The wires fastened to the intake plenum must be shorter than 100 mm.



NLP Failure position



UEA Home position



OEA Maximum opening position



OPERATING PRINCIPLE: The air flow is controlled by the position of the throttle valve inside the cylindrical conduit. The valve is controlled by an actuator that works in a range from UEA (lowest electrical stop point) to OEA (highest electrical stop point). The actuator is a dual stage mechanism controlled by a direct current motor. The valve returns to the lowest of the mechanical positions (NLP) controlled by double spring system in the event of a failure.

INSTALLATION PREFERENCES: The throttle body should be installed with the valve axis horizontal and by slanting the conduit $>15^\circ$ with respect to the horizontal line to eliminate possible accumulations of water.

ELECTRICAL FEATURES: All technical data refer to an ambient temperature of $23^\circ\text{C} \pm 5^\circ\text{C}$ and ECU nominal voltage of $13.5\text{ V} \pm 0.5\text{ V}$.

DC MOTOR ACTUATOR

resistance	$1.5\ \Omega \pm 0.3\ \Omega$
no-load current	$< 0.8\text{ A}$
no-load speed	4500 rpm
closing current (typical)	9.5 A
maximum constant current at 100°C	2.5 A
nominal current (engine idling)	$< 1.5\text{ A}$
maximum admitted generator current	$< 10.0\text{ A}$

POTENTIOMETER

potentiometer voltage power	$5\text{ V} \pm 0.2\text{ V}$
resistance	$1.25\text{ k}\Omega \pm 30\%$
(IP1 / IP2 parallel connection)	
typical cursor current	$10\ \mu\text{A}$

Accelerator pedal potentiometer



FEATURES: The sensor consists of a body fastened to the accelerator pedal inside which a shaft connected to the two potentiometers (one main potentiometer and one safety potentiometer) are axially arranged. A coil spring on the shaft ensures the correct resistance to pressure while a second spring ensure return when the pedal is released.

OPERATION: The position of the accelerator pedal is transformed into an electrical voltage signal and sent to the potentiometer ECU connected to the pedal. The accelerator pedal position signal is processed along with the engine speed information to define throttle body position, injection times and respective fuel pressure.



The sensor connections to the engine ECU are:

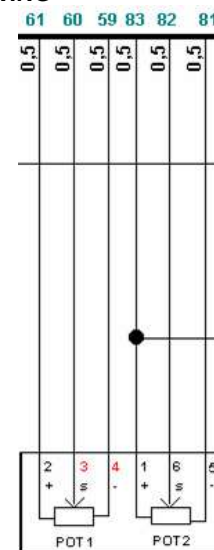
CONNECTION TO ECU

- connector pin 1 to ECU pin 83 side K
- connector pin 2 to ECU pin 61 side K
- connector pin 3 to ECU pin 60 side K
- connector pin 4 to ECU pin 59 side K
- connector pin 5 to ECU pin 81 side K
- connector pin 6 to ECU pin 82 side K

CONNECTOR



DRAWING



Potenzimetro su pedale acceleratore

Electrical specifications:

SENSOR FEATURES

Double resistance sensor
Power voltage: 5 V

OUTPUT SIGNAL TYPE

Electrical voltage signal
Variable resistance according to accelerator pedal position
Resistance track 1: 1.2 kOhm
1.5 kOhm (pedal 50%)
1.9 kOhm (pedal 100%)

Fuel injection system

FEATURES: The direct injection system injects fuel directly inside the cylinder. The main advantages are better fuel evaporation and increased engine volumetric yield because evaporation heat is subtracted from the suction air instead of from the intake manifold walls. The air and petrol load therefore has a higher density and is cooler: this reduces the compression ratio which has been set to a high value (11.3) despite the use of Euro Super petrol with a relatively low octane rating of 95. The high compression ratio is useful to increase performance and increase engine energy efficiency.

Fuel consumption is reduced by up to 20% with respect to similar traditional injection spark ignition engines thanks to direct injection. CO₂ emissions are reduced on the road.

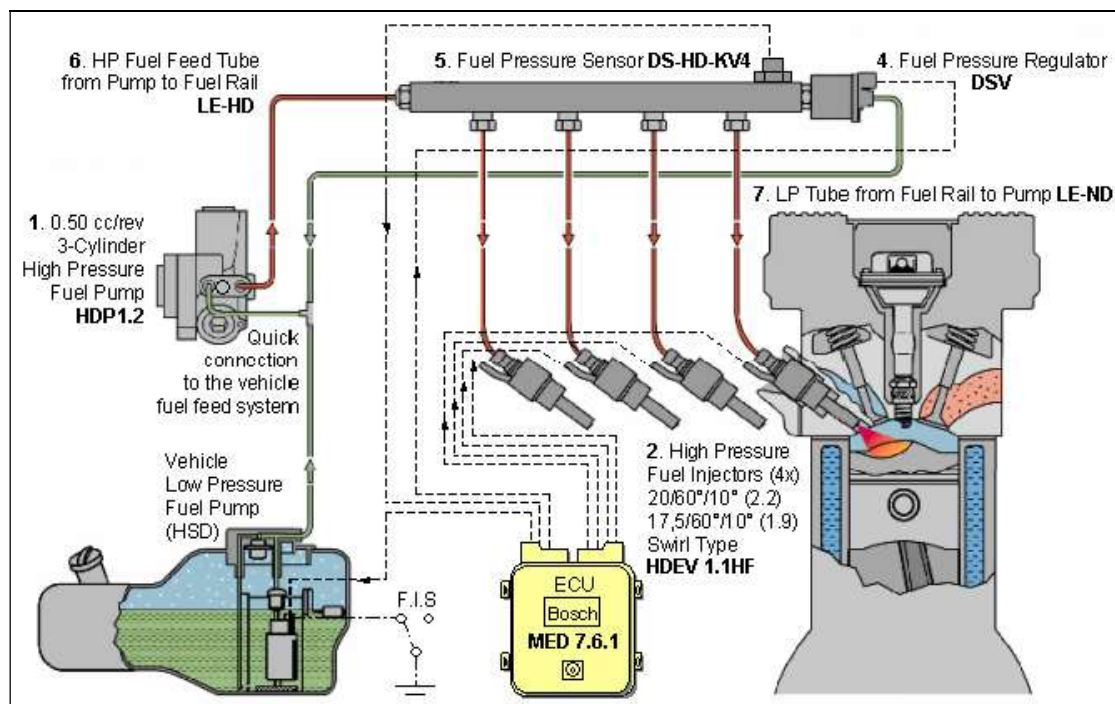
Consumption reduction is possible with direct fuel injection when the engine can switch from stratified (partial load) to homogenous (full load).

Injection system requirements include:

- extreme precision of the injected fuel quantity
- generation of the necessary injection pressure
- definition of precise instant of ignition of the mixture according to the operating mode of the engine
- fuel introduction directly and accurately into the engine combustion chamber.



Injection system architecture



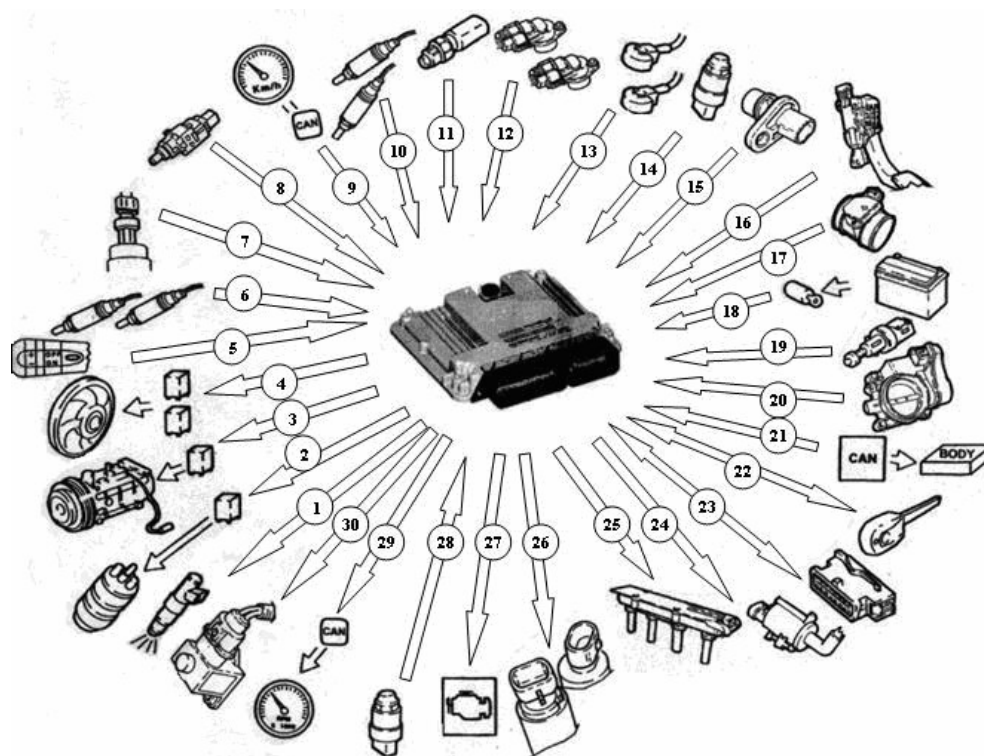
1. Fuel high pressure three cylinder pump
2. Fuel high pressure injectors
3. Connection to fuel rail
4. Fuel pressure regulator valve
5. Fuel pressure sensor
6. High pressure pipe from pump to fuel rail
7. Low pressure pipe from fuel rail to pump
8. Tank with low pressure pump

FEATURES: The fuel injection system consists mainly of a fuel rail to which the injectors are connected. With this system, the fuel can be directly injected into the cylinders via high pressure injectors.

The intake air flow is freely controlled by the electronic throttle control. A hot film air flow meter is used to measure air accurately. The air-fuel mixture is monitored directly by the universal lambda sensors placed in the exhaust gas flow before and after the catalytic converter. They guarantee that λ is equal to 1 and that the engine is running on a lean mixture. They are also responsible for precise control of catalytic converter regeneration.



Input/output diagram



1. Injectors
2. Fuel pump
3. A/C compressor
4. Engine coolant fan
5. Cruise control (4 digital inputs)
6. Post-cat lambda sensor
7. A/C gas pressure linear sensor
8. Brake pedal switch
9. Speedometer signal from CAN
10. Pre-cat lambda sensor
11. Coolant temperature sensor
12. Timing sensors
13. Knock sensors
14. Fuel pressure sensor
15. Engine speed sensor
16. Accelerator pedal potentiometer
17. Air flow meter with built-in temperature sensor
18. Battery (in addition to permanent power, the ECU receives key-on signal and power after main relay)
19. Brake pedal switch
20. Driven throttle body
21. CAN (for communicating with Body Computer for the following signals: engine speed, engine coolant temperature, coolant overheat warning light, fuel gauge, ABS/ASR-VDC and automatic transmission signals, where fitted)
22. Fiat CODE (on CAN and redundant W line)
23. Diagnostic socket
24. Fuel vapour recirculation solenoid valve
25. Ignition coils
26. Variable timing control valves
27. Injection warning lights (amber MIL EOBD)
28. Oil pressure switch
29. Engine speed signal from CAN
30. Fuel pressure regulator valve



Bosch MED 7.6.1 ECU

FEATURES: The electronic control unit governs the engine system. It has two connections:

- one for the wiring on vehicle side ("K")
- one for the wiring on engine side ("A")

It is fastened with mounts inside the engine compartment.

Identification numbers:

ALFA 939	Transmission	Series-No.	Homologation-No.	
2,2l	M/T	0 261 S01 034	MED761A003	
1,9l	M/T	0 261 S01 041	MED761A002	2
1,9l	Selespeed	0 261 S01 042	MED761A001	1

**ECU CONNECTOR ON ENGINE SIDE (A)**

PIN	PIN FUNCTION (60 pin connector)
1	Cylinder coil 3 (pin 4)
2	Not connected
3	Not connected
4	Inlet variable timing LS signal
5	Not connected
6	Not connected
7	Fuel pressure sensor and timing sensor 1 and 2 negative (pin 1)
8	Fuel pressure sensor signal (pin 2)
9	Throttle actuator negative (pin 2)
10	Throttle actuator IP1 signal (pin 6)
11	Flow meter (pin 3)
12	Flow meter (pin 5)
13	Not connected
14	Not connected
15	Throttle actuator motor positive power (pin 4)
16	Cylinder coil 4 (pin 3)
17	Not connected
18	Canister solenoid valve LS signal
19	Outlet variable timing LS signal
20	Pressure control valve
21	Not connected
22	Engine coolant temperature sensor signal
23	Not connected
24	Fuel pressure sensor and timing sensor 1 and 2 power (pin 3)
25	Throttle actuator IP2 signal (pin 5)
26	Flow meter (pin 4)
27	Flow meter (pin 1)
28	Signal from low engine oil pressure switch
29	Not connected
30	Throttle actuator motor negative power (pin 1)
31	Cylinder coil 2 (pin 5)
32	High pressure injector cylinder 3 + (pin 1)
33	High pressure injector cylinder 3 - (pin 2)
34	High pressure injector cylinder 4 - (pin 2)
35	High pressure injector cylinder 4 + (pin 1)
36	Not connected
37	Not connected
38	Not connected
39	Not connected
40	Engine speed sensor signal (pin 2)
41	Timing sensor signal 1 (pin 2)
42	Not connected



43	Knock sensor signal 2 (pin 1)
44	Knock sensor signal 1 (pin 2)
45	Not connected
46	Cylinder coil 1 (pin 6)
47	High pressure injector cylinder 2 + (pin 1)
48	High pressure injector cylinder 2 - (pin 2)
49	High pressure injector cylinder 1 - (pin 2)
50	High pressure injector cylinder 1 + (pin 1)
51	Not connected
52	Not connected
53	Not connected
54	Not connected
55	Engine speed sensor signal (pin 1)
56	Timing sensor signal 2 (pin 2)
57	Not connected
58	Knock sensor 2 (pin 2)
59	Knock sensor 1 (pin 1)
60	Not connected

ECU CONNECTOR ON VEHICLE SIDE (K)

PIN	PIN FUNCTION (94 pin connector)
1	Ground
2	Ground
3	Primary load power
4	Ground
5	Primary load power
6	Primary load power
7	Not connected
8	Petrol pump relay positive
9	Not connected
10	Not connected
11	HS A/C Req signal from NCL
12	LS compressor relay negative to CVM
13	Not connected
14	Stop light signal (NO)
15	Not connected
16	A/C linear pressure sensor negative
17	Not connected
18	Not connected
19	Not connected
20	Stop light signal (NC)
21	Not connected
22	Not connected
23	Not connected
24	Not connected
25	Main relay LS to CVM negative
26	Not connected
27	Not connected
28	Not connected
29	Not connected
30	Not connected
31	Not connected
32	Clutch pedal switch negative (NO)
33	Cruise control resume signal from stalk
34	Cruise control +/-set signal from stalk
35	Cruise control on signal from stalk
36	Not connected
37	Not connected
38	A/C linear pressure sensor signal



39	Not connected
40	Not connected
41	Not connected
42	Not connected
43	Cruise control signal from stalk
44	Not connected
45	Not connected
46	Not connected
47	Not connected
48	Not connected
49	Not connected
50	Planar λ sensor 1 (post-cat) (pin 3)
51	Linear λ sensor 2 (pre-cat) (pin 3)
52	Planar λ sensor 2 (post-cat) (pin 2)
53	Planar λ sensor 2 (post-cat) (pin 1)
54	Not connected
55	Linear λ sensor 1 (pre-cat) (pin 2)
56	Linear λ sensor 1 (pre-cat) (pin 1)
57	Linear λ sensor 2 (pre-cat) (pin 2)
58	Linear λ sensor 2 (pre-cat) (pin 1)
59	Accelerator pedal potentiometer negative
60	Accelerator pedal potentiometer signal
61	Accelerator pedal potentiometer power
62	Not connected
63	C-CAN H
64	C-CAN H
65	Not connected
66	Not connected
67	INT/1 from F-16 CVM 7.5A
68	LS command for M.I. warning light to NQS
69	Not connected
70	LS relay negative to CVM for engine cooling fan high speed
71	Not connected
72	Not connected
73	Linear λ sensor 1 (pre-cat) (pin 3)
74	Planar λ sensor 1 (post-cat) (pin 2)
75	Planar λ sensor 1 (post-cat) (pin 1)
76	Not connected
77	Linear λ sensor 1 (pre-cat) (pin 6)
78	Linear λ sensor 1 (pre-cat) (pin 5)
79	Linear λ sensor 2 (pre-cat) (pin 6)
80	Linear λ sensor 2 (pre-cat) (pin 5)
81	Accelerator pedal potentiometer negative
82	Accelerator pedal potentiometer signal
83	Accelerator pedal potentiometer power
84	Not connected
85	C-CAN L
86	C-CAN L
87	K line
88	Not connected
89	LS relay negative to CVM for engine cooling fan low speed
90	Not connected
91	Not connected
92	+30 from F-18 CVM 7.5A
93	W line
94	Planar λ sensor 2 (post-cat) (pin 3)



Low pressure fuel circuit

A low pressure pump with parallel mechanical pressure regulator is fitted inside the fuel tank. The tank supplies the high pressure pump via a pipe. Delivery pressure of the low pressure pump is 3.5 bars.

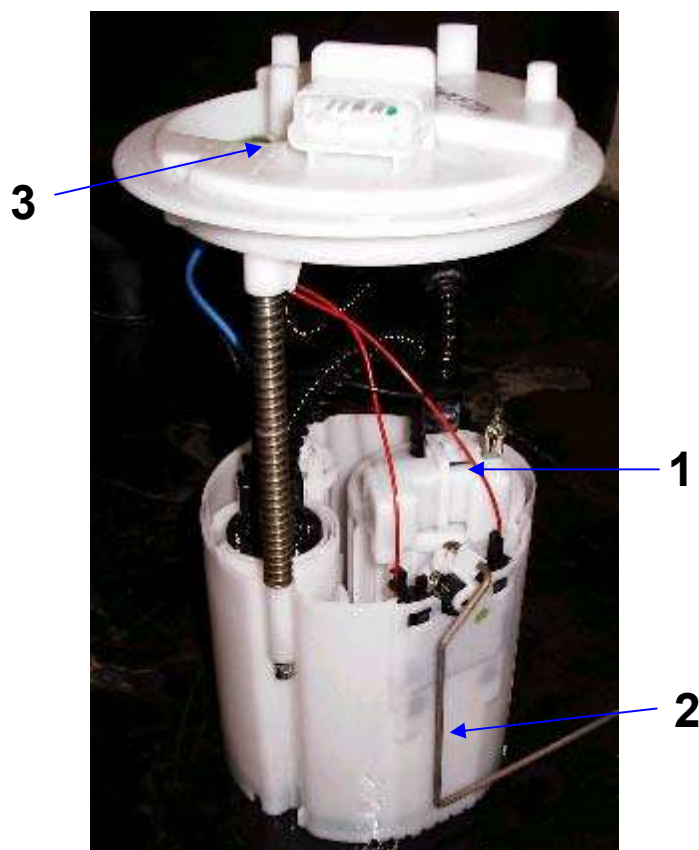
Fuel tank



1. Fuel tank
2. Pump housing
3. Petrol vapour floating valves
4. Overflow-proof fuel filler

FEATURES: The pump supplies the lower pressure fuel circuit and two floating valves are fitted in the fuel tank. These send fuel vapours to the separator where they condense and drip back into the tank. Uncondensed vapours are sent back to the canister valve.



Fuel pump in tank

1. Fuel pump
2. Float level gauge arm
3. Wiring harness connector

FEATURES: The fuel pump is provided with a permanent magnet electrical motor which controls the pump impeller and a terminal support cover which contains the electrical and hydraulic connections. A single stage, peripheral flow pump is fitted providing high performance in low voltage and temperature conditions. The advantages with respect to positive-displacement pumps are light weight and compact dimensions.

Low pressure fuel line

FUNCTION: This line is found in direct injection petrol systems to connect the fuel tank to the high pressure pump and forms the low pressure fuel supply system.



FEATURES:

Working pressure up to 0.7 MPa
 Pipe system tightness up to working pressure

System lifespan: specific tolerances are valid for up to 10 years or 150,000 km.

WORKING CONDITIONS:

Storage temperature from -40°C to +70°C
 Component temperature from -30°C to +110°C
 maximum 115°C
 Dynamic resistance admissible vibration level
 600 m/s² peak

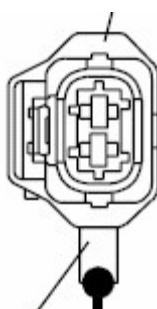
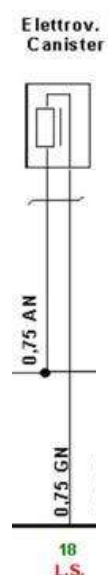
Canister bleeder valve

OBJECTIVE: The valve is used to bleed the flow from the activated carbon filter.

FEATURES: It is provided with a fastening support and 2-pin integrated connector. The connection to the engine ECU is:

CONNECTION TO ECU

- connector pin 1 to ECU pin 18 side A
- connector pin 2 to power wire

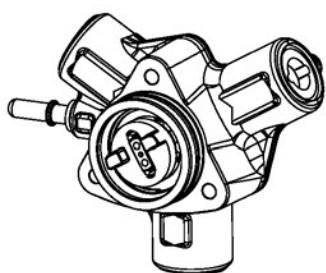
CONNECTOR**DRAWING**

REMOVAL/REFITTING: When lubricants are used (e.g. to connect pipes), the utmost care must be devoted to prevent blocking the flow and being sucked into the internal parts of the valve. An arrow on the seat shows the direction of flow. Make sure that the valve is not subjected to mechanical stress during removal. The valve cannot be reused if it is dropped or if visible damage is apparent.



High pressure fuel circuit**SYSTEM ACTUATORS:**

- High pressure fuel pump
- Injection piping
- High pressure injector
- Pressure regulator valve
- Fuel high and low pressure line
- Ignition coil module

High pressure fuel pump

OBJECTIVE: The high pressure fuel pump increases input fuel pressure (equal to 3.5 bars) to 120 bars for supplying the rail. This pressure reduces pressure fluctuations inside the rail.

TECHNICAL SPECIFICATIONS:

Three cylinder, radial piston pump

Displacement 0.5 cm³/rev

Pressure range 2 - 12 MPa, 0.4 MPa at start-up

Speed range 40 - 3500 rpm.

LIFESPAN OF COMPONENT: The specific tolerances of the component are designed to last for 10 years or 150,000 km.

WORKING CONDITIONS:

Fuel temperature during normal use maximum 80°C, not in use 100°C, maximum temperature of 130°C can be held for 30 minutes.

Fuel vapours must not penetrate inside inlet area.

Two filters: main filter on supply line with 5 µm fine mesh and filter on connection with 30 µm fine mesh.

Admissible dynamic load $\leq 600 \text{ m/s}^2$.

REMOVAL/REFITTING: The pump is fitted on the head axially with respect to the camshaft with an Oldham clutch. It is essential to lubricate the o-ring with engine oil (clean, no silicon). The Oldham clutch is joined without applying force. Union with the head is obtained by applying a force not exceeding 200 N.

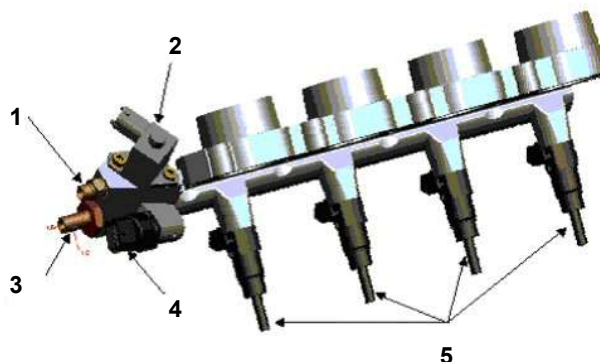
ADDITIONAL INDICATIONS: The pressure of the screws on the head must not exceed 360 N/mm². The Oldham clutch and the bearing required continuous lubrication during operation. Replace the o-ring after each removal. Handle the pump with care.

Injection piping

FUNCTION: To ensure supply of fuel in direct injection petrol systems.

FEATURES: Four fuel injectors, a pressure regulating valve and the pressure sensor are fitted on the fuel rail. The rail is also fitted with a high pressure and a low pressure connector. The rail must be adequately flexible to dampen pressure oscillations generated by the fuel injections and by the high pressure pump operation. At the same time, it must be stiff enough to rapidly respond to pressure variations during engine operation.





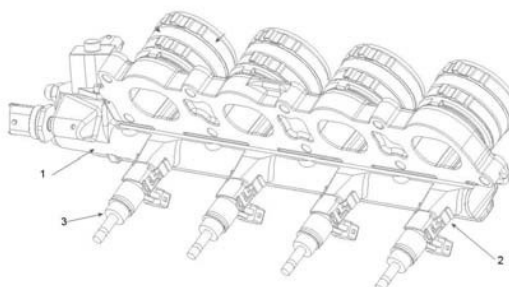
1. Low pressure tube fitting
2. Pressure regulator valve
3. High pressure tube fitting
4. Pressure sensor
5. High pressure injectors

REMOVAL/REFITTING: Two versions of the injection rail are available: code AA for 1.9 litre engines and code BC for 2.2 litre engines. The injectors are fixed with o-rings only. The assembly is directly mounted on the head. A specific tool is needed to fit the clamps on the sleeves. Simply press the injectors in their housings to assemble the rail. Then fit the fastening screws at the same time with the correct tightening torque.

High pressure injectors



FEATURES: These electromagnetic high pressure injectors with compact 2-pin connector are connected directly to the fuel rail and spray directly into the combustion chamber. The instant of opening of the injectors and the amount of injected fuel are managed by the electrical control signal of the injectors. The injectors are fastened in their housings with devices to prevent loosening into the fuel rail. This ensures correct positioning of the injectors on the head. Replace the clamps after removal with the injector maintenance to ensure perfect tightness.



1. Fuel rail
2. Injector clamps
3. Injectors



The connections to the engine ECU of each injector are:

CONNECTION TO ECU

High pressure injector cylinder 1

- connector pin 1 to ECU pin 50 side A (pole +)
- connector pin 2 to ECU pin 49 side A (pole -)

High pressure injector cylinder 2

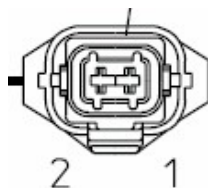
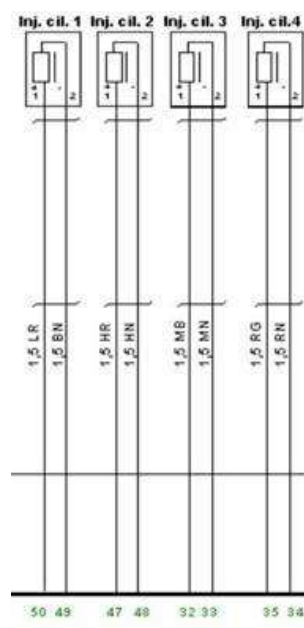
- connector pin 1 to ECU pin 47 side A (pole +)
- connector pin 2 to ECU pin 48 side A (pole -)

High pressure injector cylinder 3

- connector pin 1 to ECU pin 32 side A (pole +)
- connector pin 2 to ECU pin 33 side A (pole -)

High pressure injector cylinder 4

- connector pin 1 to ECU pin 35 side A (pole +)
- connector pin 2 to ECU pin 34 side A (pole -)

CONNECTOR**DRAWING****TECHNICAL SPECIFICATIONS:**

Working pressure

At start-up

0.4 MPa

Reference

10 MPa $\pm$ 25 kPa

Maximum admitted

14 MPa

Maximum temperature of injector nozzle

< 170°C

Tightness and flow are ensured by the system up to 1 milligram of impurity for the entire life of the product.

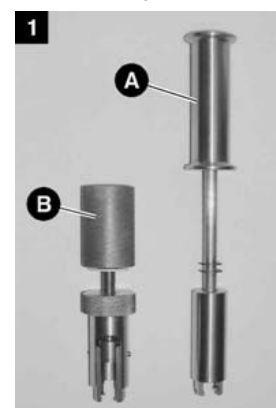
REMOVAL/REFITTING: The injector is fitted on the fuel rail. The combustion chamber o-ring must not be lubricated. A maximum force of 200 N can be applied to fasten the injector to the head. A specific tool is needed to remove the injector. When refitting, replace the teflon ring, the guide plate and the o-ring. Calibrate the teflon ring with a specific tool.

Injector removal tools:

A: (0 986 616 100)

B: (0 986 616 101)

Slant the tool to remove the injector along the installation axis of the valve.



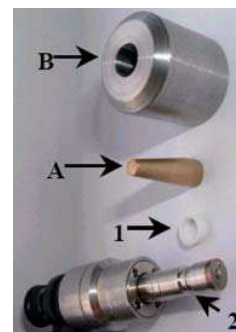
Teflon ring calibration tool (combustion chamber seal):

Two tools are needed to remove the combustion chamber seal (1) from the injector stem (2):

A: (0 986 616 098)

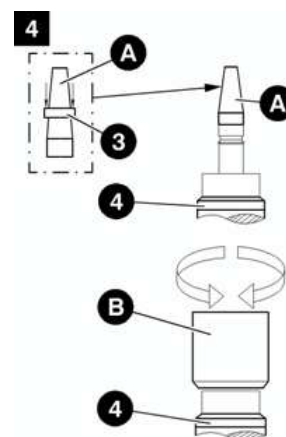
B: (0 986 616 099)

Tool A holds the seal 1; tool B is used to position it 2 after fitting.



To refit the seal 1: Position tool A on injector 4.

Pull the new seal 1 up combining tool A on the valve body stem. Do not use lubricant. To calibrate the seal, push tool B on the chamfered side, turn it by half a turn on one side and then back to the starting point.



Pressure regulator valve

FUNCTION: The pressure regulator valve controls the fuel pressure inside the rail according to the ECU mapping independently from the amount of injected fuel and from the pulses caused by the high pressure pump. Excess flow is sent back to the high pressure pump suction.

FEATURES: Electronic pressure control valve with compact 2-pin connector.

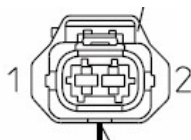


The connection to the engine ECU is:

CONNECTION TO ECU

- connector pin 1 to ECU pin 20 side A
- connector pin 2 to power wire

CONNECTOR



DRAWING



TECHNICAL SPECIFICATIONS: All data refer to a temperature of 23°C and control voltage of 14 V $\pm$ 0.02 V.

Pressure range	from 0.4 to 12 MPa
Return pressure	0.4 MPa;
Operating principle	proportioning valve, closed without current
Working pressure	11 MPa at 600 rpm
Maximum flow	100 l/h
50 μ m fine mesh input filter	

LIFESPAN OF COMPONENT: The specific tolerances of the component are designed to last for 10 years or 150,000 km.

REMOVAL/REFITTING: Make sure that the housing is intact and clean before fitting the valve. Lubricate the o-rings with clean, non silicon-based engine oil. Insert the valve to the end of the collar. The fasten the M6 aluminium screws, tightening torque of 6 ± 1 Nm. Replace the o-ring and the filter when refitting the valve.

ELECTRICAL SPECIFICATIONS:

ELECTRICAL SPECIFICATIONS OF ACTUATOR

Solenoid valve:
Working current 1.8 A.

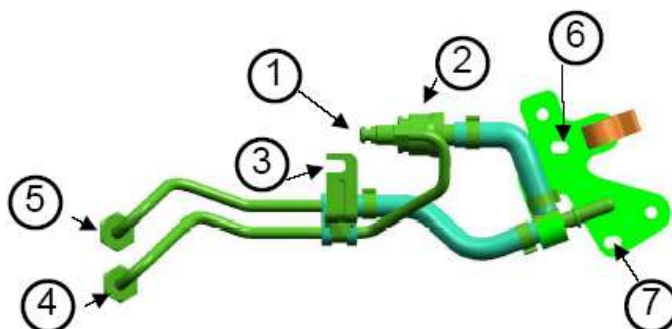
COMMAND TYPE

PWM signal; maximum voltage 12V (frequency 500 Hz).

MEASURING METHOD

The ECU must be powered to pick up the output signal. An oscilloscope or Examiner with SAM (Examiner Smart) module is needed to view the signal, considering its type. Set Examiner as a voltmeter and acquire the signal for approximately 5 seconds.



Fuel high and low pressure line

1. High pressure connection
2. Fuel pump fastening element
3. Fuel pump fastening shelf
4. High pressure fuel rail fastening element
5. Low pressure fuel rail fastening element
6. Mount fastening bracket
7. Mount fastening holes

FEATURES: The line joins the low pressure fuel line (fuel pressure up to 0.6 MPa) to the high pressure line (fuel pressure 10 MPa) to the fuel injection rail.

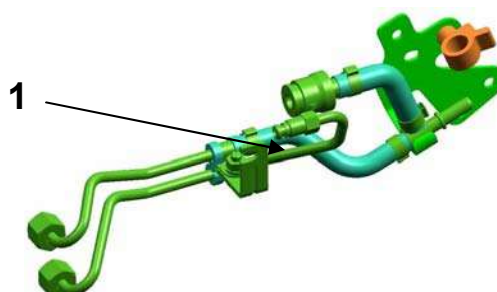
ASSEMBLY

- Position elements 1, 2 and 3 at the same time (high pressure pump connection and shelf).
- Fit connector 2 to the high pressure pump.
- Fit high pressure connections 1 and 4 by hand on both ends.
- Fasten connection 1 to the pump at the necessary torque.
- Fasten connection 4 to the rail at the necessary torque.
- Fit connection 5 to the low pressure line at the necessary torque.
- Position the shelf on mounts 6 and 7.
- Fasten onto mounts 6 and 7 and onto the shelf 3.

REMOVAL

- Loosen connections 1, 3, 4, 5, 6, 7.
- Move the T fasteners from the mounts 6 and 7.
- Release connector 2 from the high pressure pump.

ADDITIONAL INFORMATION The high pressure pump connection screw is coated with wax to provide the right torque during assembly. Repeat the procedure when refitting.



1. Wax-coated screw



Ignition coil line

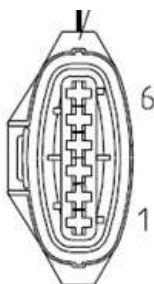
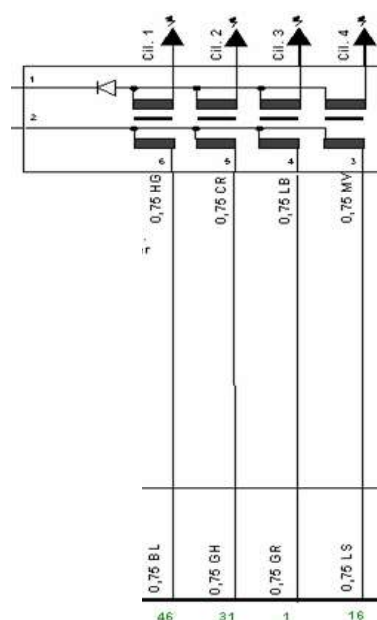
FEATURES: The ignition system features a unique single spark box for all four cylinder spark plug coils. Ignition is electrically controlled. The spark instant and time is determined for each spark plug in the cylinder. Direct injection tends to create a more concentrated mixture in the middle of the chamber. For this reason, and thanks to the four-valve per cylinder geometry, having a second spark plug in the peripheral area of the chamber would not be advantageous.



The connections to the engine ECU are:

CONNECTION TO ECU

- engine ground pin 1 for coil ignition
- power pin 2 to rail
- connector pin 3 to ECU pin 16 side A
- connector pin 4 to ECU pin 1 side A
- connector pin 5 to ECU pin 31 side A
- connector pin 6 to ECU pin 46 side A

CONNECTOR**DRAWING**

ASSEMBLY: The ignition module is fastened with 4 screws to the head cover.

REMOVAL: A specific tool is needed.

ELECTRICAL SPECIFICATIONS:**ELECTRICAL SPECIFICATIONS OF ACTUATOR****COMMAND TYPE**

Nominal current 7A
 Nominal voltage 14V
 Coil resistance 1.3Ohm
 Signal from spark box



Sensors

Engine speed sensor
Camshaft timing sensor
High pressure fuel sensor
Knock sensor
Temperature sensor
Oil pressure on/off sensor
Oil level and temperature sensor
Air mass meter
Linear lambda sensor (post-cat)
Planar lambda sensor (pre-cat)

Engine speed sensor

FUNCTION: The sensor sends an electrical signal to the engine ECU used to compute the speed and angular position of the engine.

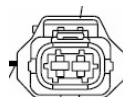
FEATURES: The sensor consists of a body and metallic coil and a 2-pin connector.

OPERATION: The switch from empty to full due to the presence or absence of a tooth on the phonic wheel determines variations in magnetic flow capable of generating induced alternating voltage which is used to count the teeth on a ring (or phonic wheel). The frequency of the voltage sent to the ECU varies according to the angular speed of the crankshaft.

The sensor connections to the engine ECU are:

CONNECTION TO ECU

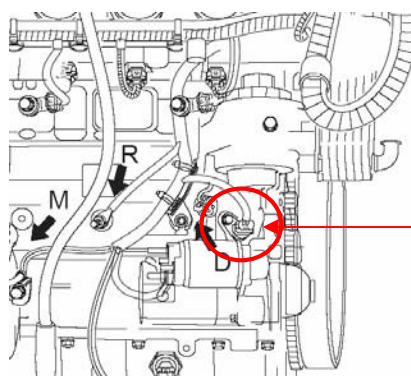
- connector pin 1 to ECU pin 55 side A
- connector pin 2 to ECU pin 40 side A

CONNECTOR**DRAWING**

REMOVAL/REFITTING: Fit the sensor by pressing it in the housing and fasten with a screw. Replace the sensor if it is accidentally dropped.

POSITION: The crankcase sensor is positioned on the front side of the engine, in the bottom right: it faces the phonic wheel positioned on the crankshaft.

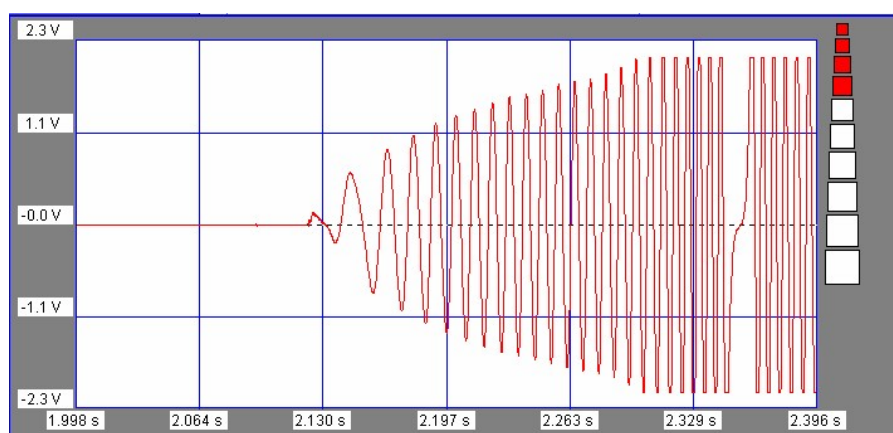




1

1. Engine speed sensor

ELECTRICAL SPECIFICATIONS:



SENSOR FEATURES

Electrical resistance equal to approximately 1 kOhm.

OUTPUT SIGNAL TYPE

Variable alternating voltage, maximum value and frequency proportional to flywheel speed

Examiner with SAM (Examiner Smart) module is needed to view the signal, considering its type. Set Examiner as a voltmeter and acquire the signal for approximately 5 seconds.

MEASURING METHOD

The graph must show the following characteristics:

- wave amplitude and frequency proportional to each other and to the flywheel speed
- signal changes when sensor picks up missing tooth.

Camshaft timing sensor

FUNCTION: For the engine ECU to acknowledge which cylinder is at compression stroke.

FEATURES: The Hall effect timing sensor consists of a body which integrates a coupling element and a 3-pin connector, a magnet and a signal acquisition circuit. Two sensors are fitted (one on each camshaft).

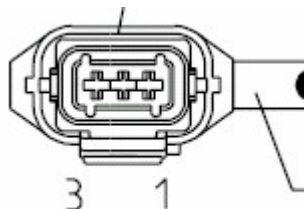


The sensor connections to the engine ECU are:

CONNECTION TO ECU**CONNECTOR****DRAWING**

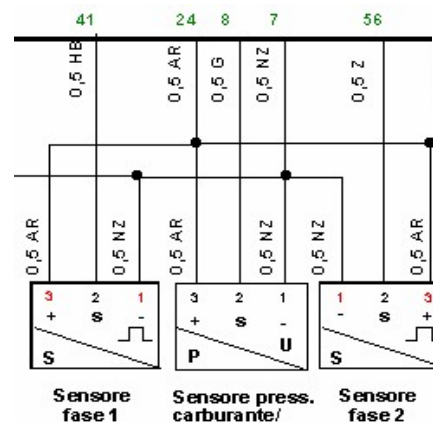
Timing sensor 1

- connector pin 1 to ECU pin 7 side A (ground)
- connector pin 2 to ECU pin 41 side A
- connector pin 3 to ECU pin 24 side A (power)



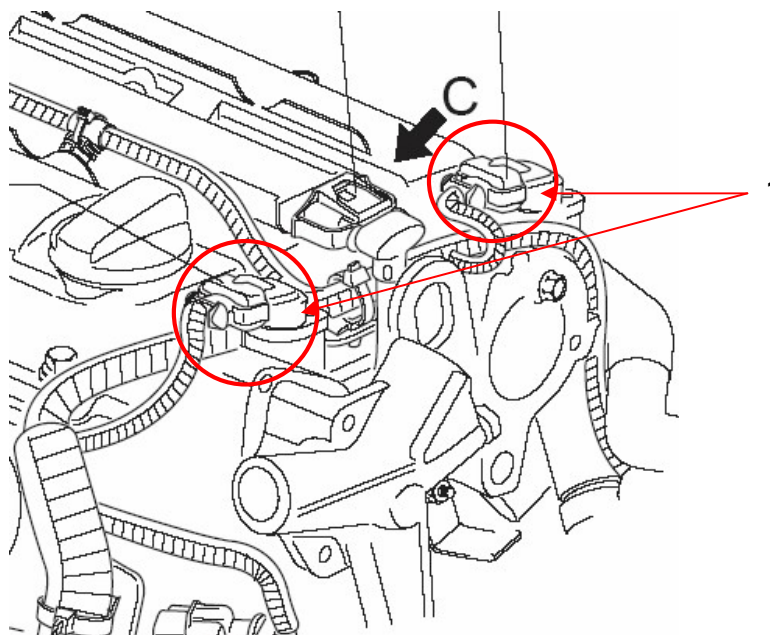
Timing sensor 2

- connector pin 1 to ECU pin 7 side A (ground)
- connector pin 2 to ECU pin 56 side A
- connector pin 3 to ECU pin 24 side A (power)



REMOVAL/REFITTING: The sensor is fitted by being pressed into its housing. Lubricate the seal with mineral oil. It is fastened with a screw.

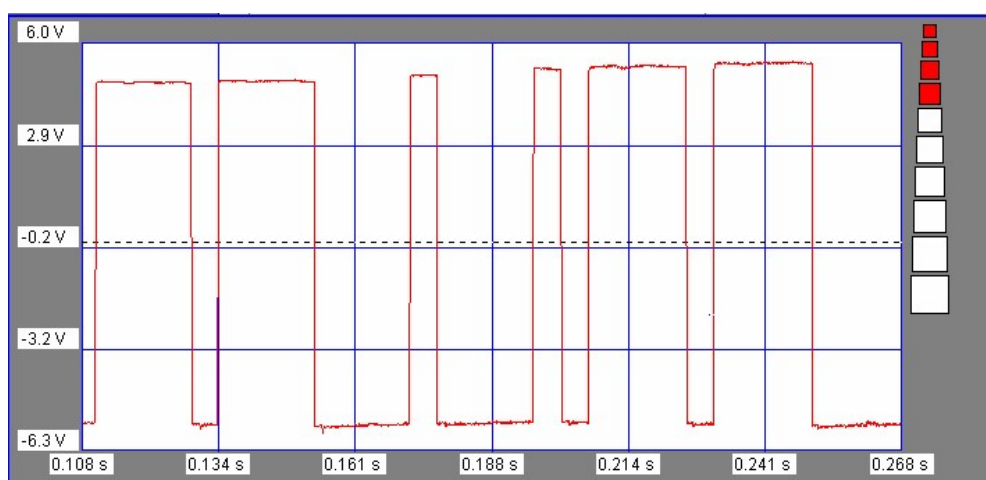
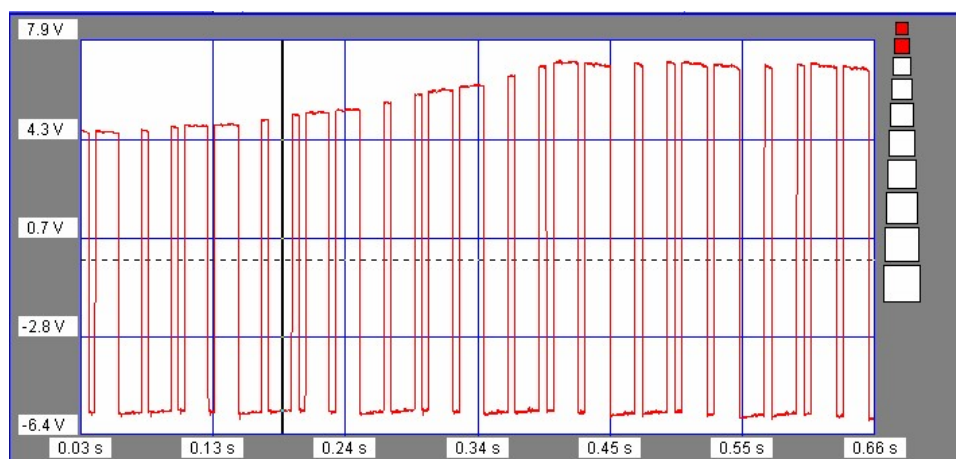
POSITION: The timing sensors are positioned on the right-hand side of the camshafts.



1. Camshaft timing sensors



ELECTRICAL SPECIFICATIONS:



SENSOR FEATURES

5V power from the ECU

OUTPUT SIGNAL TYPE

Variable voltage signal in time, maximum value and frequency according to pulse waveform (square wave) when sensor meets phonic wheel teeth. Two long teeth are followed by two short teeth.

MEASURING METHOD

The ECU must be powered to pick up the output signal. Examiner with SAM (Examiner Smart) module is needed to view the signal, considering its type. Set Examiner as a voltmeter and acquire the signal for approximately 5 seconds.

High pressure fuel sensor

FUNCTION: To measure the fuel pressure in the rail by sending a feedback signal to the injection ECU to control injection pressure and duration.

FEATURES: This is piezoelectric pressure sensor consists of a mixed metal and plastic body. The metal part comprises a diaphragm pressure gauge, a plastic part and a 3-pin connector (one for power, one for signal to ECU and one for ground).

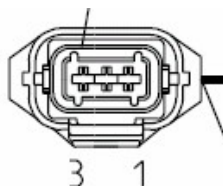
The sensor connections to the engine ECU are:



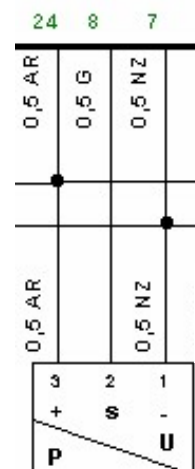
CONNECTION TO ECU

- connector pin 1 to ECU pin 7 side A (ground)
- connector pin 2 to ECU pin 8 side A
- connector pin 3 to ECU pin 24 side A (power)

CONNECTOR



DRAWING



Sensore press.
carburante/

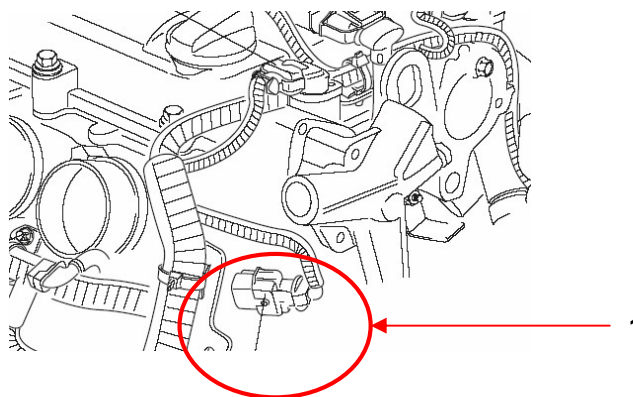
REMOVAL/REFITTING: The sensor is part of the injection rail and is fastened onto the rail. It is fastened by turning the hexagonal metallic part.

ADDITIONAL INFORMATION The recommended assembly position is with the sensor hexagon facing downwards, at a 0° to 90° slant with respect to the vertical line and minimum space between the sensor and the rail.

WORKING DATA:

- Pressure range from 0 to 14 MPa
- Response time 2.0 ms

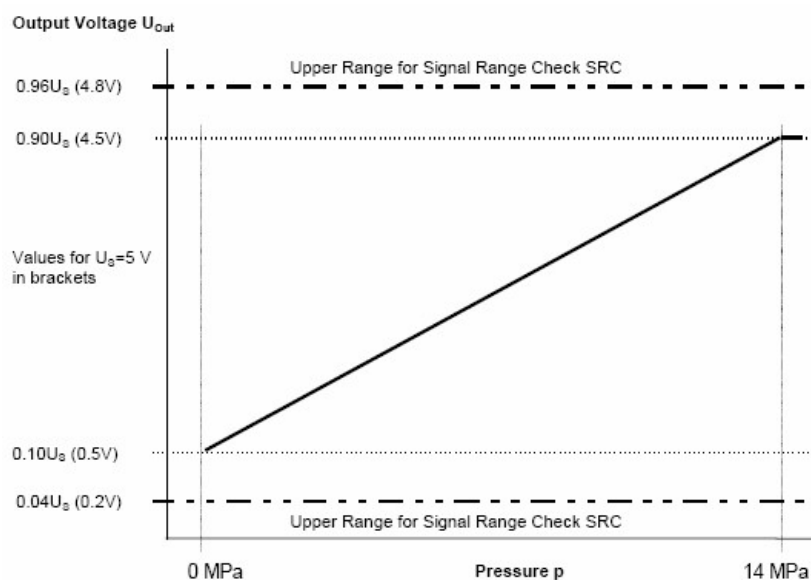
POSITION: The pressure sensor is positioned on the front side of the engine on the right on the intake plenum by the side of the pressure regulator valve.



1. Fuel pressure sensor



ELECTRICAL SPECIFICATIONS:



SENSOR FEATURES

Nominal specifications:

- Power voltage: 5 V
- Power current 12 mA

OUTPUT SIGNAL TYPE

Variable voltage according to measured pressure.

Linear characteristic from 0.5 V (0 MPa) to 4.5 V (14 MPa).

MEASURING METHOD

The ECU must be powered to pick up the output signal. Examiner with SAM (Examiner Smart) module is needed to view the signal, considering its type. Set Examiner as a voltmeter and acquire the signal for approximately 5 seconds.

Knock sensor

FEATURES: This is a directly fitted piezoelectric knock sensor with compact connector. Two sensors are fitted (one between cylinders 1 and 2 and the other between cylinders 3 and 4). The sensor detects vibrations caused by mechanical pressure in the combustion chambers.



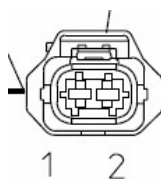
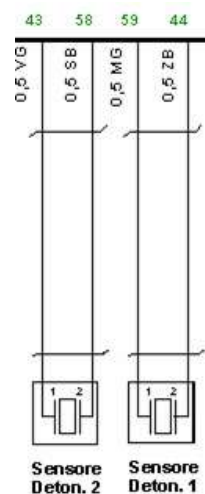
The connections to the engine ECU are:

CONNECTION TO ECU**Knock sensor 1**

- connector pin 1 to ECU pin 59 side A
- connector pin 2 to ECU pin 44 side A

Knock sensor 2

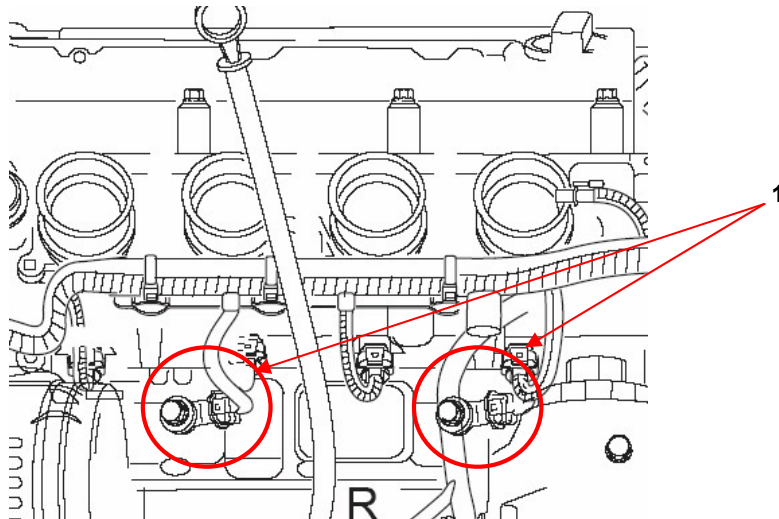
- connector pin 1 to ECU pin 43 side A
- connector pin 2 to ECU pin 58 side A

CONNECTOR**DRAWING**

REMOVAL/REFITTING: The sensor is fastened on the cylinder block with a screw.

ADDITIONAL INFORMATION The entire surface of the sensor/crankcase must be in contact to ensure correct transmission of the signal.

POSITION: The knock sensors are positioned on the front side of the engine underneath the intake plenum.



1. Knock sensors

ELECTRICAL SPECIFICATIONS:**SENSOR FEATURES**

Piezoelectric knock sensor

OUTPUT SIGNAL TYPE

Electrical pulse signal



Temperature sensor

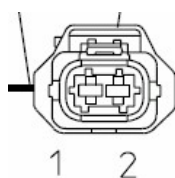
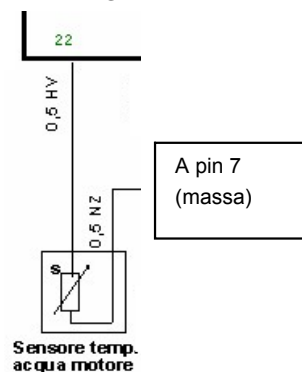
FEATURES: Sensor for measuring engine coolant temperature, with 2 pins, working range from -40°C to 130°C, fitted in crankcase.



The connection to the engine ECU is:

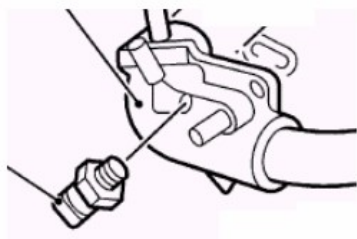
CONNECTION TO ECU

- connector pin 1 to ECU pin 7 side A (ground)
- connector pin 2 to ECU pin 22 side A

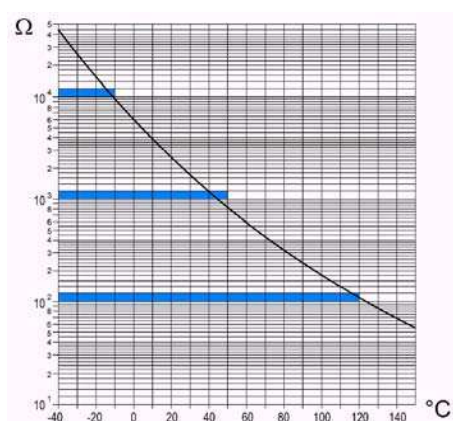
CONNECTOR**DRAWING**

REMOVAL/REFITTING: The tightening torque must be in the range from 18 to 25 Nm.

POSITION: The sensor is positioned on the cooling circuit thermostat housing.



1. Temperature sensor
2. Coolant circuit thermostat housing

ELECTRICAL SPECIFICATIONS:

SENSOR FEATURES

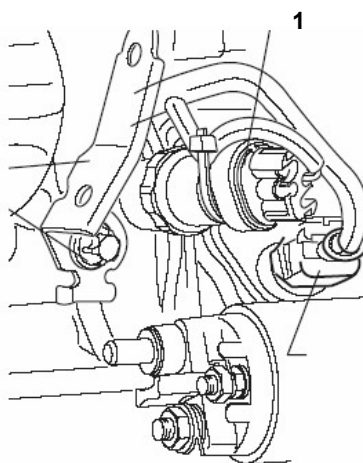
NTC thermistor sensor

OUTPUT SIGNAL TYPE

Variable resistance from a maximum of 45kOhm to -40°C (60 Ohm) to 150°C.

MEASURING METHOD

The ECU must be powered to pick up the output signal. Examiner with SAM (Examiner Smart) module is needed to view the signal, considering its type. Set to resistance mode (ohmmeter).

Oil pressure on/off sensor

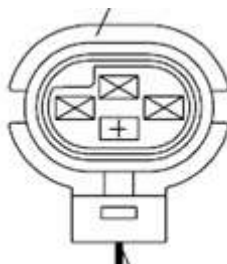
1. Oil pressure indicator switch
2. Engine speed sensor

2

FEATURES: The oil pressure indicator on/off sensor is fitted on the crankcase, on the left of the oil filter, and is connected to the engine ECU.

CONNECTION TO ECU

- connector pin 1 to ECU pin 28 side A

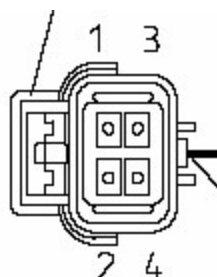
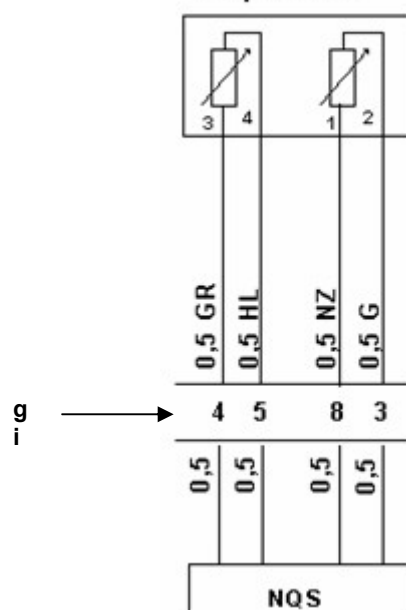
CONNECTOR**DRAWING**

Oil level and temperature sensor

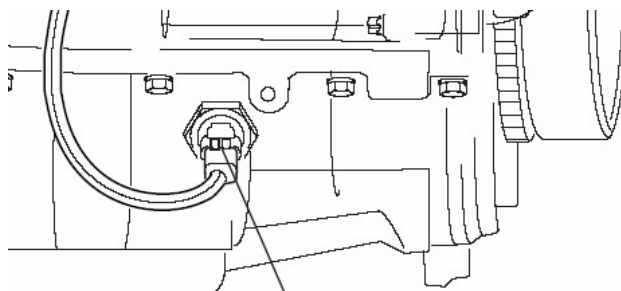
FEATURES: The sensor monitors lubricant oil level and temperature inside the oil sump fitted underneath the engine block. This sensor is not connected to the engine ECU: it interfaces with the instrument panel node (NQS) instead. The diagram connection is:

SPLICE CONNECTION A

- connector pin 1 to splice pin 8
- connector pin 2 to splice pin 3
- connector pin 3 to splice pin 4
- connector pin 4 to splice pin 5

CONNECTOR**DRAWING****Sensore livello
temper. OLIO**

POSITION: The minimum oil level sensor connection is positioned on the front side of the engine, on the bottom right.



1. Oil level and temperature sensor fitting

1

Air mass meter

FEATURES: The air mass meter essentially consists of a heated film arranged in a measuring channel through which engine intake air flows.

The hot film is kept at a constant temperature of 120°C (this is why a temperature sensor is present) by a heating resistor.

The flow of intake air takes heat from the hot film causing a potential lowering of temperature: the heat given up by the film is proportional to the intake air mass. A certain current is circulated in the resistor to keep the film temperature constant: this current is proportional to the given up heat.



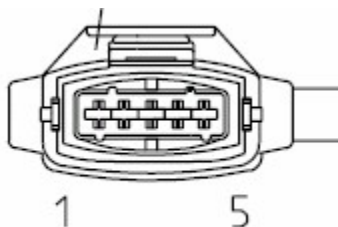
The current crosses a Wheatstone bridge which imbalances it and determines a potential difference which is detected. The analogue flow meter has a 5 pin connector.

The connections to the engine ECU are:

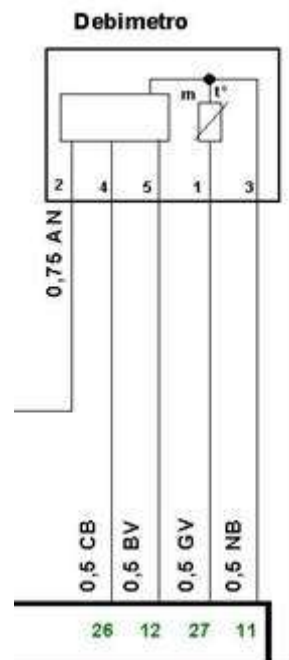
CONNECTION TO ECU

- connector pin 1 to ECU pin 27 side A
- pin 2 power from ECU (used to guarantee air flow signal output independent from battery voltage variations)
- connector pin 3 to ECU pin 11 side A
- connector pin 4 to ECU pin 26 side A
- connector pin 5 to ECU pin 12 side A

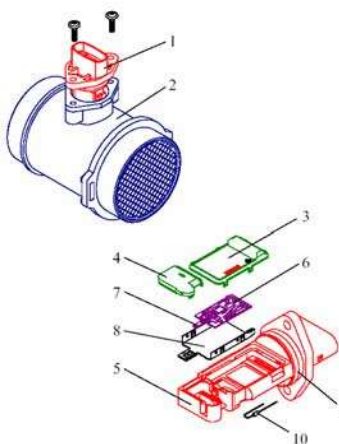
CONNECTOR



DRAWING



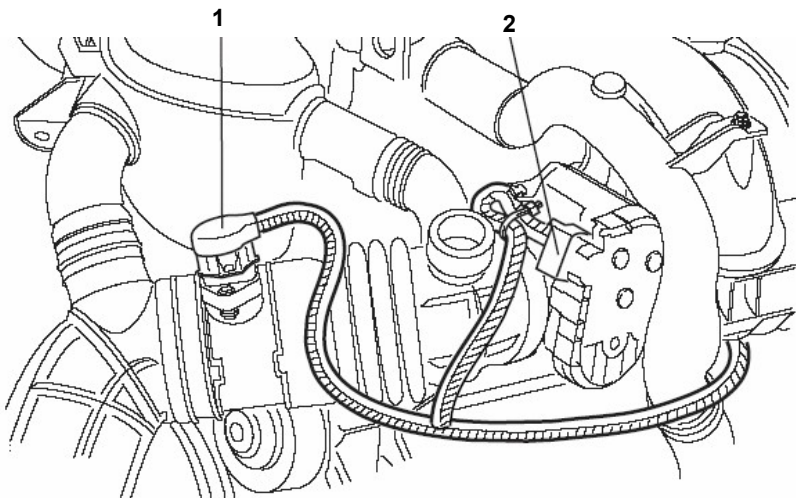
STRUCTURE



1. Female connector
2. Cylindrical body
3. Circuit cover
4. Measuring conduit cover
5. Measuring conduit
6. Circuit
7. Sensor
8. Circuit assembly plate
9. O-ring
10. Temperature sensor



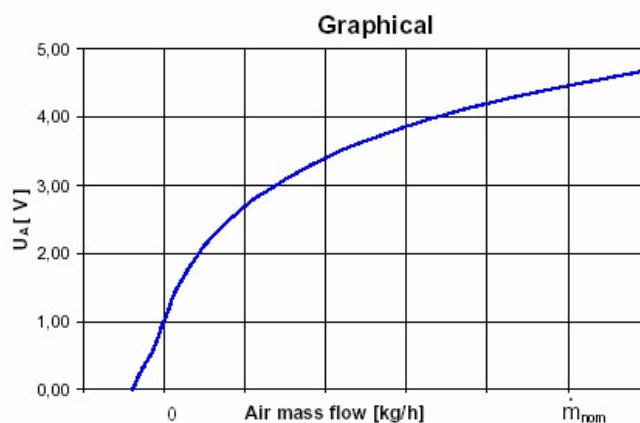
POSITION: The flow meter is arranged along with intake air conduit upstream of the throttle body and the intake plenum.



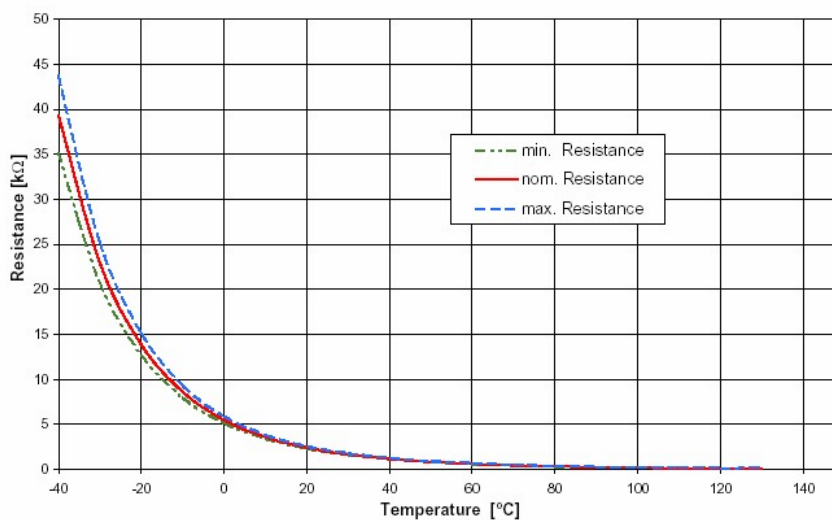
1. Air mass meter
2. Throttle body

ELECTRICAL SPECIFICATIONS:

Air flow characteristic:



Temperature characteristic:



SENSOR FEATURES

14V power

OUTPUT SIGNAL TYPE

Refer to the air flow voltage characteristic and resistance to the temperature characteristic.

Temperature sensor

Set multimeter to resistance mode (ohmmeter).

MEASURING METHOD

Ground sensor

Arrange multimeter for measuring voltage with sensor powered by ECU

Pre-cat exhaust gas sensor

FEATURES: The linear wide band sensor with integrated heater works at $\lambda=0.65$ in air. The sensor must be used in connection with an ECU. Two sensors with 6-pin electrical connectors are provided because the exhaust system is split.



The connections to the engine ECU are:

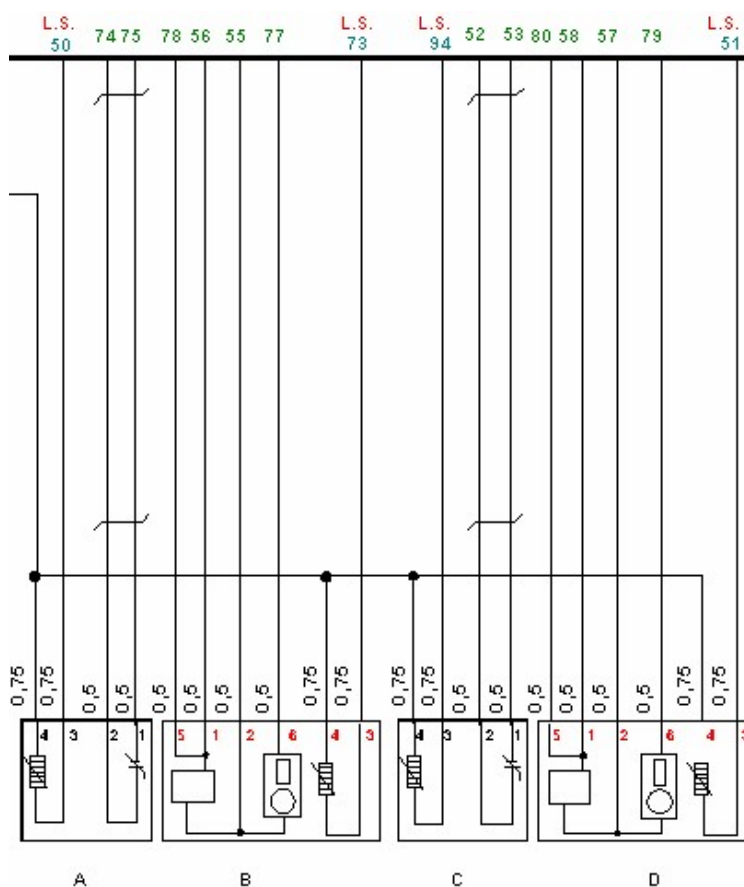
CONNECTION TO ECU

Linear sensor 1

- connector pin 1 to ECU pin 56 side K
- connector pin 2 to ECU pin 55 side K
- connector pin 3 to ECU pin 73 side K
- pin 4 power from ECU
- connector pin 5 to ECU pin 78 side K
- connector pin 6 to ECU pin 77 side K

DRAWING

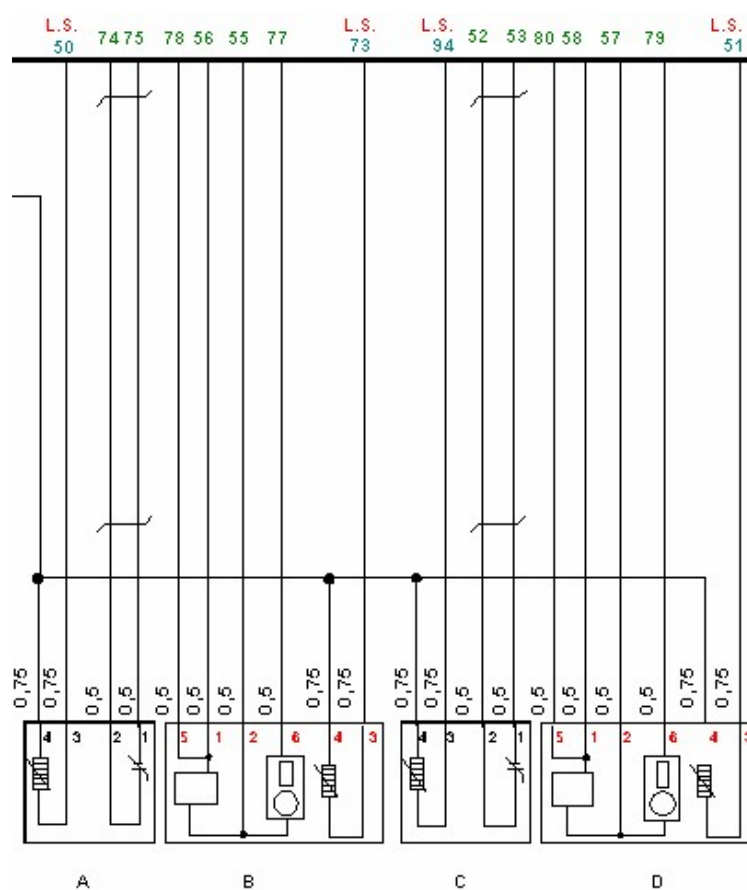
- A: Sonda Lambda planare 1 (a valle catalizzatore)**
B: Sonda Lambda lineare 1 (a monte catalizzatore)
C: Sonda Lambda planare 2 (a valle catalizzatore)
D: Sonda Lambda lineare 2 (a monte catalizzatore)



Linear sensor 2

- connector pin 1 to ECU pin 58 side K
- connector pin 2 to ECU pin 57 side K
- connector pin 3 to ECU pin 51 side K
- pin 4 power from ECU
- connector pin 5 to ECU pin 80 side K
- connector pin 6 to ECU pin 79 side K

- A: Sonda Lambda planare 1 (a valle catalizzatore)**
B: Sonda Lambda lineare 1 (a monte catalizzatore)
C: Sonda Lambda planare 2 (a valle catalizzatore)
D: Sonda Lambda lineare 2 (a monte catalizzatore)



REMOVAL/REFITTING: The sensor is part of the exhaust system and is fastened to the exhaust pipe over the catalyzer. The connector with seal is connected to the ECU and protected from water. The wire layout prevents possible stress due to contact. Replace the sensor if it is accidentally dropped.

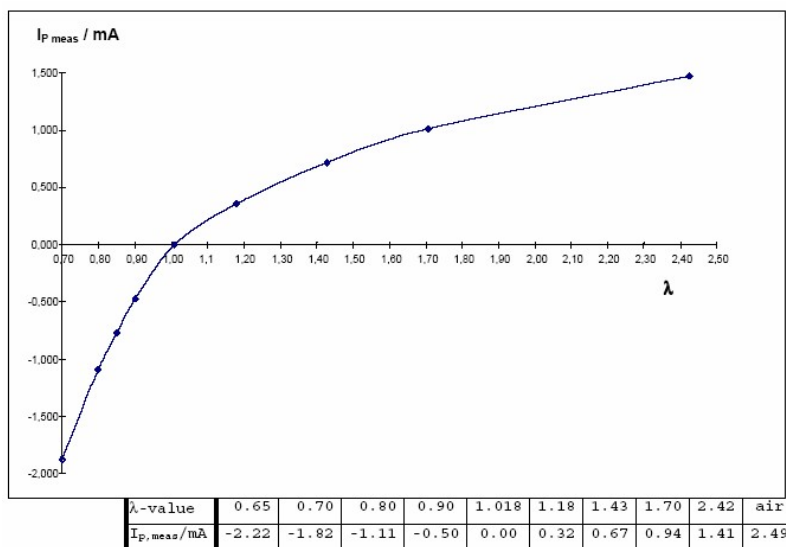
SPECIFICATIONS:

- Exhaust gas temperature <930°C
- Temperature outside sensor <570°C
- Connector temperature <120°C
- Maximum exhaust gas pressure 2.5 bar

ELECTRICAL SPECIFICATIONS:

The graph indicates the measuring current variations according to lambda values and indicates the presence of rich or lean mixture to the ECU (optimal lambda = 1).



**SENSOR FEATURES**

12/14V power

OUTPUT SIGNAL TYPE

Variable voltage signal according to characteristics of the exhaust gas and engine speed increases and decreases. Signal peaks are interference.

MEASURING METHOD

The ECU must be powered to pick up the output signal. Examiner with SAM (Examiner Smart) module is needed to view the signal, considering its type. Set Examiner as a voltmeter and acquire the signal for approximately 30 seconds.

Post-cat exhaust gas sensor

FEATURES: The planar oxygen sensor works at $\lambda=1$. The sensor must be used in connection with an ECU. Two sensors with 4-pin connectors are provided because the exhaust system is split.



The connections to the engine ECU are:

CONNECTION TO ECU

Planar sensor 1

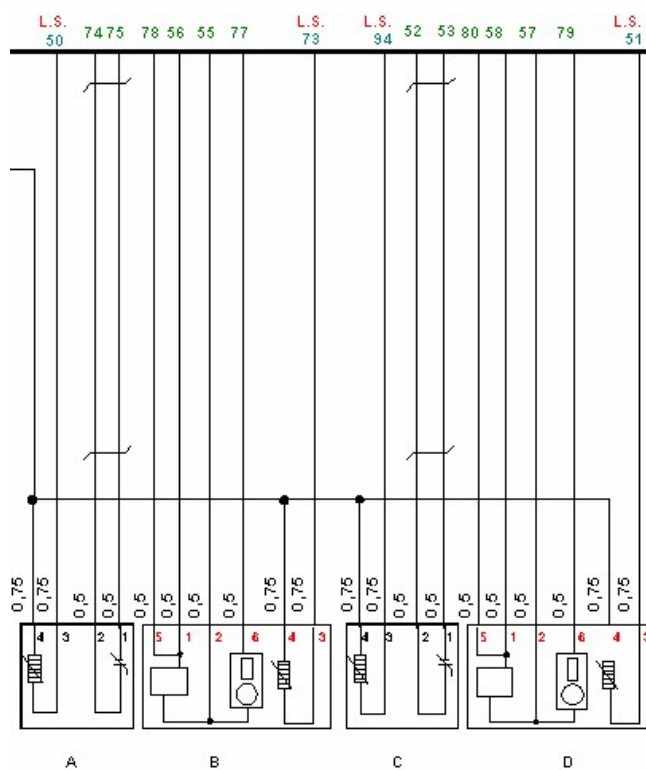
- connector pin 1 to ECU pin 75 side K
- connector pin 2 to ECU pin 74 side K
- connector pin 3 to ECU pin 50 side K
- pin 4 power from ECU

Planar sensor 2

- connector pin 1 to ECU pin 53 side K
- connector pin 2 to ECU pin 52 side K
- connector pin 3 to ECU pin 94 side K
- pin 4 power from ECU

DRAWING

- A: Sonda Lambda planare 1 (a valle catalizzatore)**
B: Sonda Lambda lineare 1 (a monte catalizzatore)
C: Sonda Lambda planare 2 (a valle catalizzatore)
D: Sonda Lambda lineare 2 (a monte catalizzatore)



REMOVAL/REFITTING: The sensor is part of the exhaust system and is fasten to the exhaust pipe under the catalyzer. The connector with seal is connected to the ECU and protected from water. The wire layout prevents possible stress due to contact.

SPECIFICATIONS:

- Exhaust gas temperature <930°C
- Temperature outside sensor <570°C
- Connector temperature <120°C

ELECTRICAL SPECIFICATIONS:**OUTPUT SIGNAL TYPE**

Variable voltage signal according to characteristics of exhaust gas.

MEASURING METHOD

The ECU must be powered to pick up the output signal. Examiner with SAM (Examiner Smart) module is needed to view the signal, considering its type. Set Examiner as a voltmeter and acquire the signal for approximately 5 seconds.

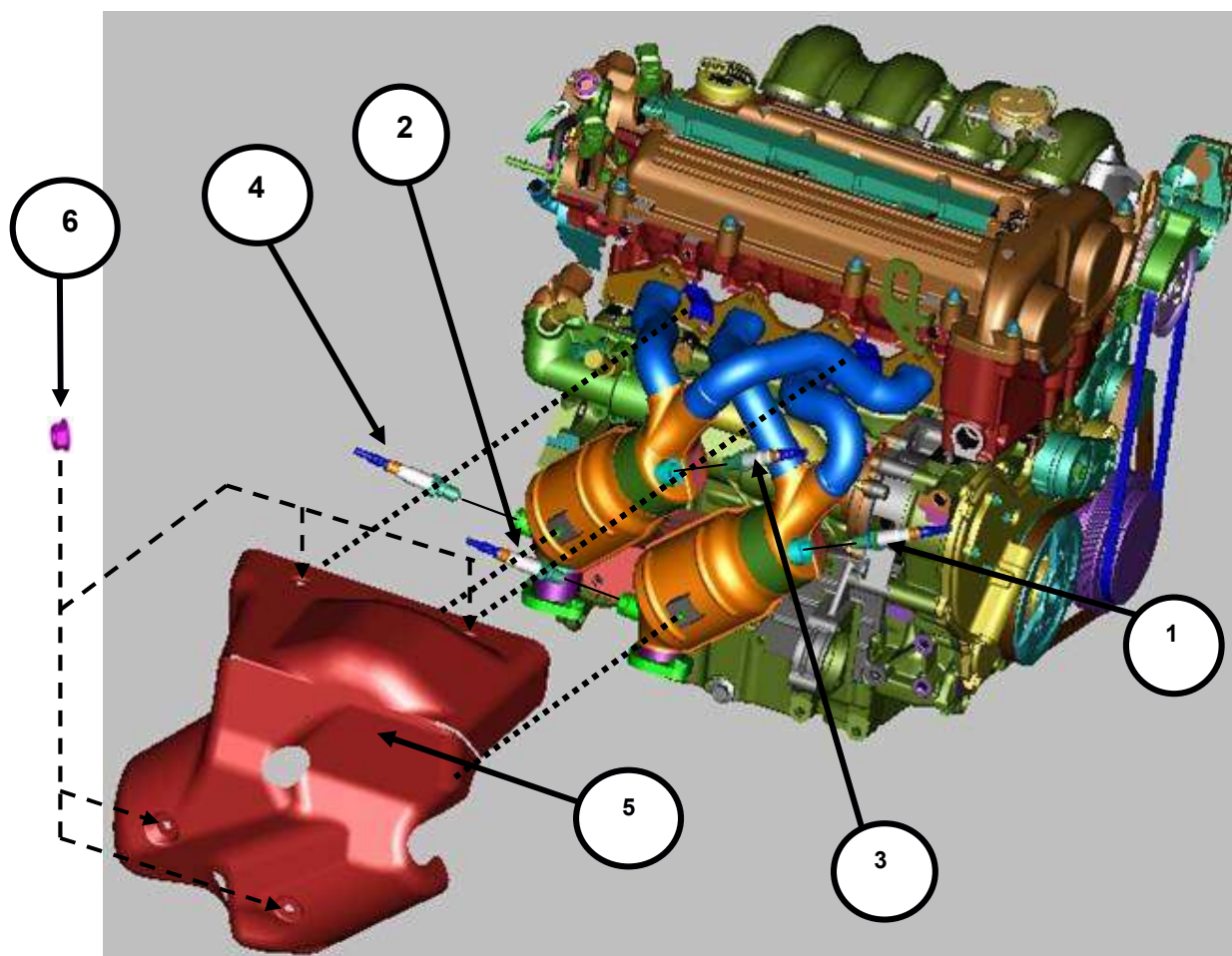


Exhaust system

FEATURES: The engine has a 4-in-2-in-1 exhaust system with two three-way CCC ('Close Coupled Converter') catalysers built into one. The catalysing elements are relatively close to the engine. This means that Euro 4 specifications on the emission of pollutants can be reached without adopting particular systems, such as secondary air or electrical heating.

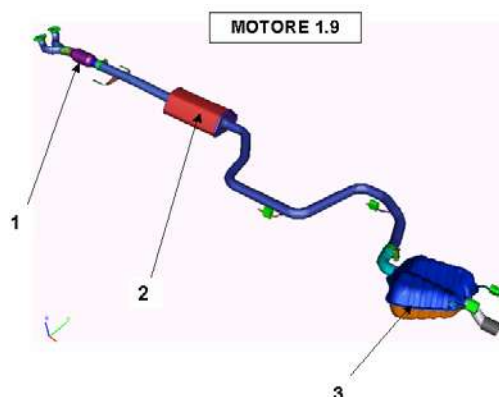
Double injection (lasting for approximately 50 seconds) is exploited to significantly reduce emissions thanks to the possibility of injecting petrol directly into the chamber. Double injection is exploited to make the charge richer near the spark plug so that the better fuel ignition quality will provide a longer ignition delay. This has two advantages: firstly gases are hotter and therefore the catalyser warms up faster; secondly, due to the gases being hotter during expansion and exhaust, a significant fraction of the unburnt hydrocarbons is converted before reaching the catalyser. The content of these components is approximately 5 times lower than that of a traditional engine.

To decrease heating time and improve catalyser performance, the exhaust plenum is not exposed to the current of air hitting the vehicle, being positioned so that the engine shields it from the wind instead.



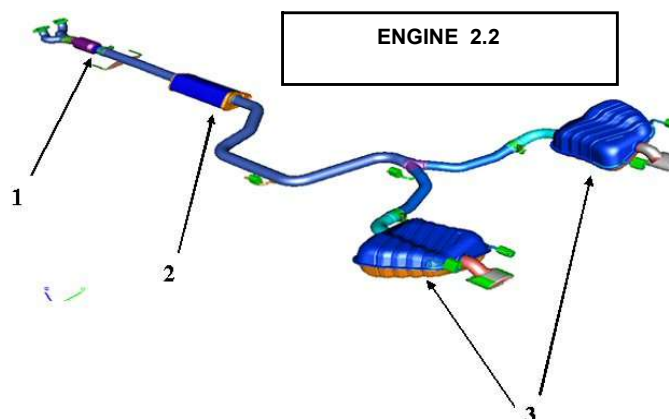
1. Pre-cat lambda sensor
2. Post-cat lambda sensor
3. Pre-cat lambda sensor
4. Post-cat lambda sensor
5. Heat shield
6. Nut



Exhaust diagram - cold part

1. Flexible coupling
2. Central muffler
3. Rear muffler

The 1.9 litre version has a single rear muffler configuration with one tailpipe.



1. Flexible coupling
2. Central muffler
3. Rear mufflers

The 2.2 litre version has a rear double rear muffler configuration with one tailpipe.

3.1.3 Bosch MED 7.6.1 ECU operating logic

The 1.9 and 2.2 JTS engines are characterised by a fuel feed system with high pressure direction injection pump. The electronic control system governs and controls all engine parameters, optimising performance and consumption by providing real time response in various operating modes.

The system is managed by a single Bosch Motronic MED7.6.1 driven throttle ECU that controls sequential and timed ignition and injection.

The ECU controls the actuators on the basis of the signals received from numerous sensors and governs the following systems:

- fuel system
- high pressure fuel pump
- air supply
- accelerator pedal
- engine cooling
- exhaust with catalytic converters controlled by four lambda sensors
- fuel vapour recirculation.



The JTS engine ECU manages the high pressure fuel pump by controlling a pressure regulator and the respective pressure sensor.

Also the throttle is electronically controlled by the ECU: opening of the throttle is controlled according to a specific engine ECU logic called 'torque control'; in this way, in addition to eliminating the mechanical connection between the accelerator pedal and the throttle, the ECU can very accurately monitor the real amount of fuel needed in each instant of operation, manage the power pressure most suitable to for each cycle and define the fuel injection start point to introduce the perfect amount of fuel into the combustion chamber in the best instant.

The ECU also controls the variable timing, as described more in detail below.

Thanks to a specific sensor, the ECU also detects drops of vacuum in the brake booster and intervenes by appropriately reducing the load to restore more efficient braking.

The main functional characteristics of the system are:

- self-learning
- system self-adaptation
- Alfa Romeo Code (Immobilizer) recognition
- cold start-up control
- combustion control - lambda sensors
- knock control
- acceleration mixture enrichment control
- accelerator pedal fuel cut-off
- fuel vapour recovery
- maximum engine speed control
- fuel temperature control
- climate control system connection
- cylinder position acknowledgment
- optimal injection time for each cylinder
- ignition advance regulation
- idling speed management (also according to battery voltage)
- fan control
- ABS/ASR ECU connection
- fuel system diagnostics
- variable timing management.

Continuous variable timing management

The variable timing system of 1.9 and 2.2 JTS engines, unlike the previous versions with on/off variable timing on intake only, is continuous and applied to both intake and exhaust. It has a 50 degree adjustment range.

The controls on intake and exhaust side are completely independent.

The following table illustrates the effects of variable timing on engine operation by the way of example.

Settings are the result of a compromise between opening advance and closure delay to optimise consumption, performance and emissions.

There is no clear application principle; reference is made to the experience of motor engineers at the test bench.



The main reasons for adjustments are explained below.

INTAKE:

OPENING ADVANCE	The exhaust gas inertia combined at the same time with valve opening lets more fresh air into the cylinder.
CLOSING DELAY	At high speeds, the output air acquires a good inertia which allows delayed closing of the valve and air flow also after BDC.

EXHAUST:

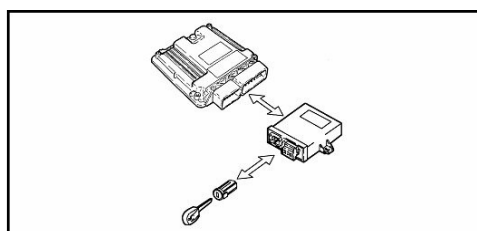
OPENING ADVANCE	This expels burnt gas favoured by the higher pressure in the chamber and decreases the ejection work.
CLOSING DELAY	This exploits all the kinetic energy deriving from combustion/expansion of the mixture.

RECIPROCAL CROSSING MAY PROVIDE:

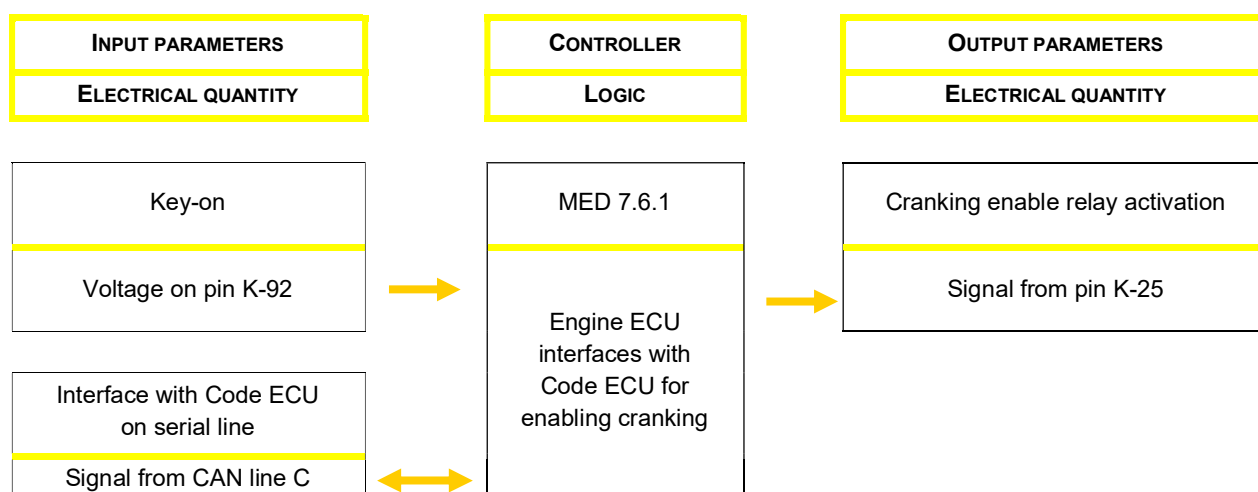
HIGH LOAD	More input of fresh air due to vacuum caused by flow of burnt gases.
PARTIAL LOAD	Recall of burnt gas into the chamber with a beneficial effect on emissions (virtual displacement reduction).
LOW LOAD	Decay in combustion quality with problems of regularity.

3.1.4 Operating strategies

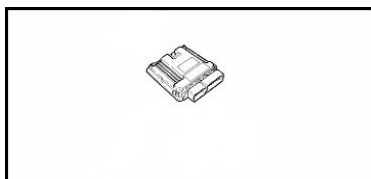
Alfa Code recognition



The ECU interfaces with the body computer at key-on to implement the Alfa Code function and enable cranking.



Self-learning

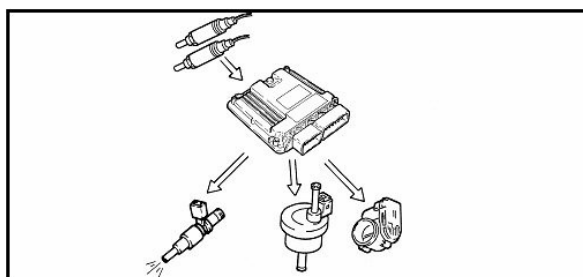


The ECU implements self-learning logic in the following conditions:

- installation of a new injection ECU
- installation of a new throttle actuator
- removal/refitting of engine speed sensor or phonic wheel for misfire acknowledgment.

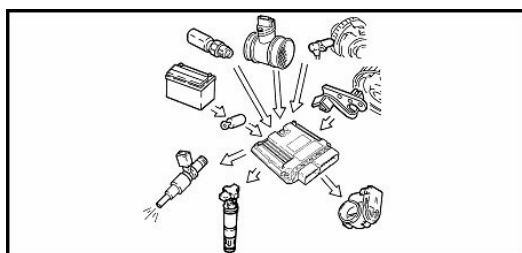
The throttle learning settings are maintained also when the battery is disconnected. The misfire acknowledgement phonic wheel settings on the other hand are lost.

System self-adaptation



The ECU is provided with a self-adaptive function which acknowledges changes in the engine due to settling in time and ageing of components and the engine itself. There are two adaptation functions for two intervention plans: minimum and user.

Cold start-up control



Mixture is naturally leaner during cold starts due to low fuel evaporation at low temperatures and higher engine oil viscosity. The engine ECU acknowledges this condition and corrects the injection time according to:

- coolant temperature
- intake air temperature
- battery voltage
- engine speed.

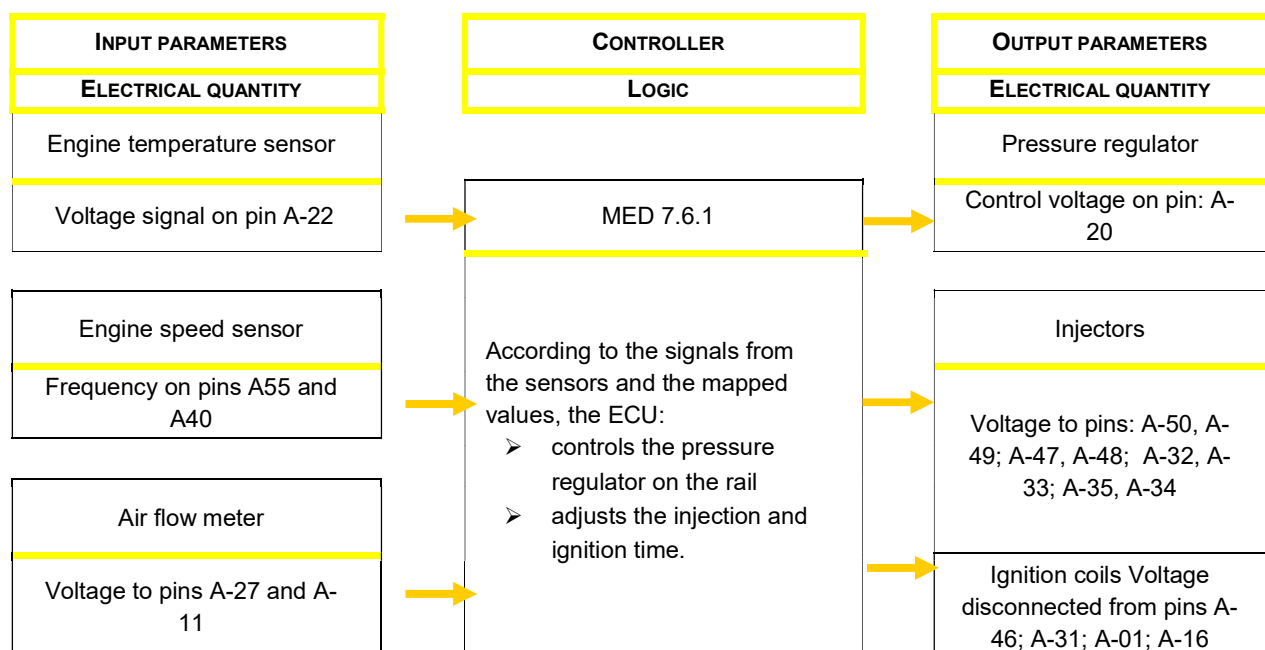
Spark advance is controlled according to the engine speed and engine coolant temperature only.

While cranking, the ECU controls a first simultaneous injection for all injectors (full-group injection) and after starts normal sequential, timed operation after acknowledging the cylinder stroke.

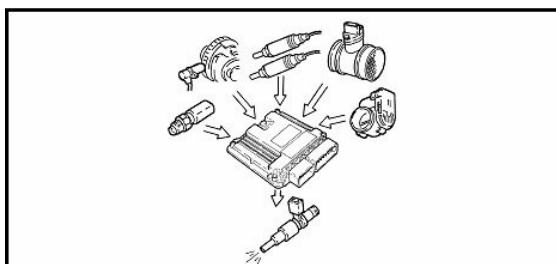
When the engine is warm, the ECU governs the throttle to control the amount of air needed to keep the engine running.

The engine speed is decreased as the engine temperature increases to obtain nominal values when the engine is warm.



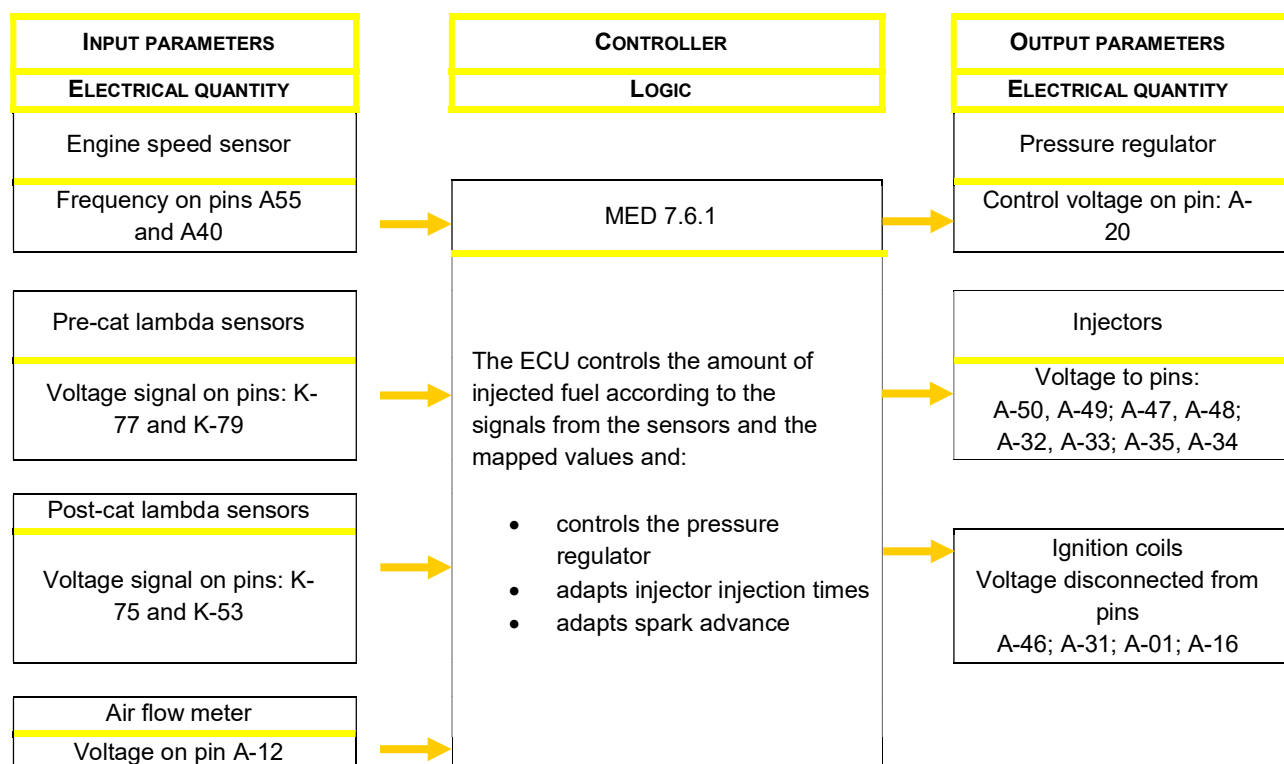


Combustion control - lambda sensors

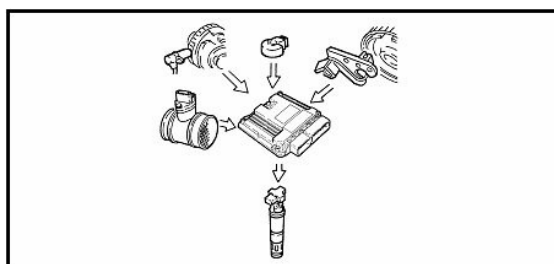


In EOBD systems, the lambda sensors are arranged before and after the catalyser system. The pre-cat sensors control the "first loop" strength (closed loop). The post-cat sensors are used to diagnose the catalyser and fine tune the first loop parameters. In this perspective, the second loop adaptation is used to recover production dispersions and slow deviations of the pre-cat sensors caused by ageing and poisoning. This is called the "second loop" control (closed loop).





Knock control



The ECU can delay ignition selectively on the cylinder where this is required according to the combination of values received by the knock and timing sensors and:

- reduces ignition advance in 3° steps to a maximum of 9°;
- updates the threshold to account for background noise and engine ageing.

The ECU during acceleration uses a higher threshold to increase engine noise.

When knock disappears, the ECU will increase ignition advance in 0.75° steps to total recovery.

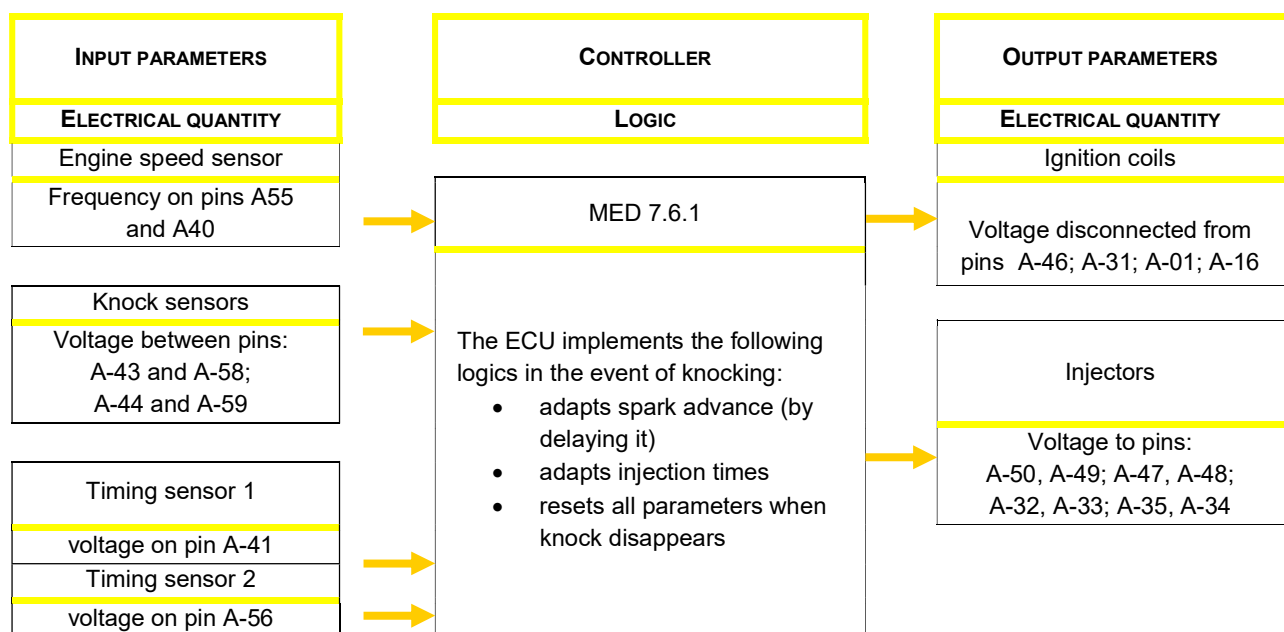
The ECU self-adaptive function:

- stores the continuously repeated advance reductions
- updates mapping to the various conditions in which the engine operated.

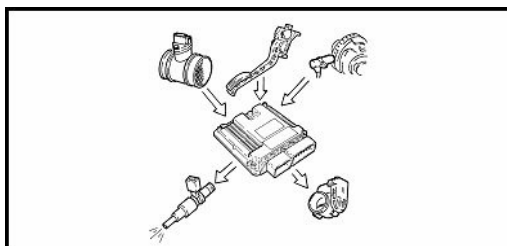
RECOVERY PROCEDURE

A variable spark delay is implemented according to the engine speed and temperature in the event of failure to the timing sensor or knock sensor. The maximum ignition delay is always less than 9° of the engine.





Acceleration mixture enrichment control

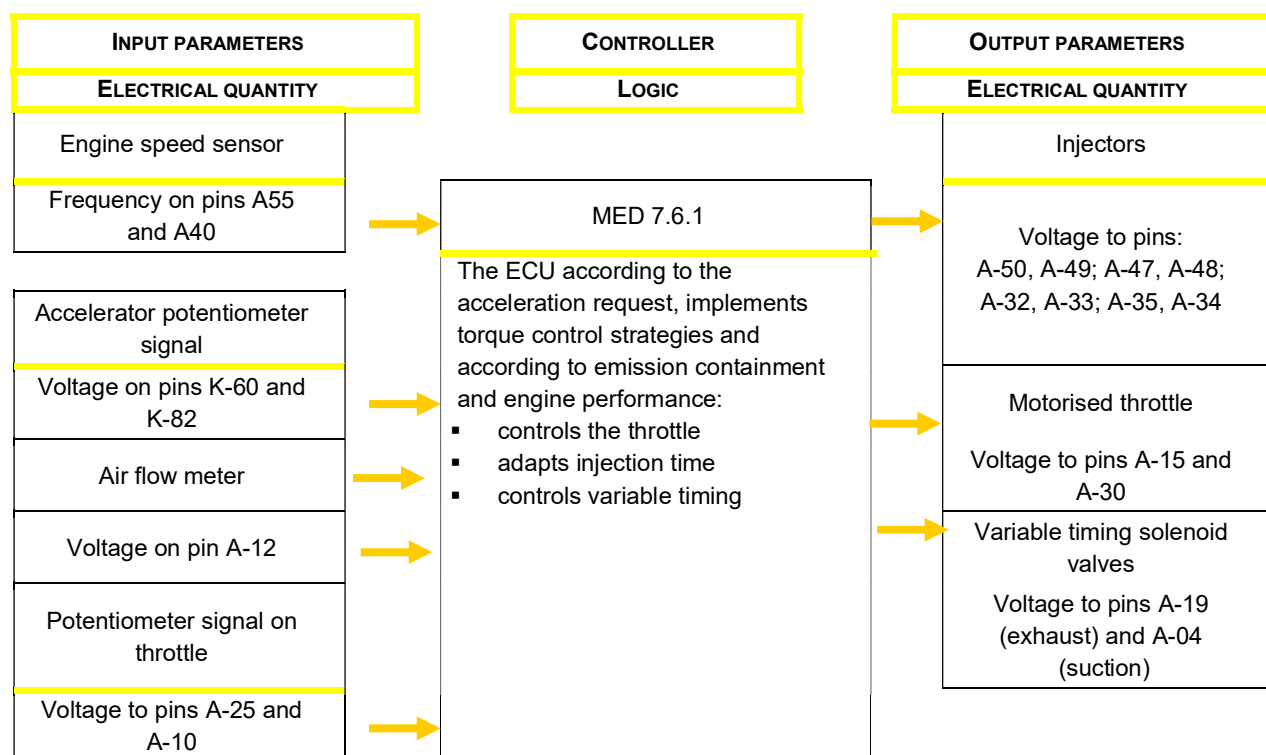


The ECU in event of high acceleration demand, modifies the injection time and position of the throttle.

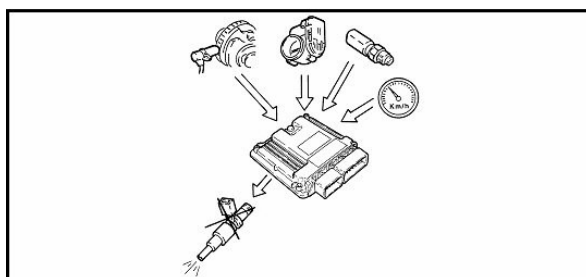
RECOVERY PROCEDURE

The ECU replaces the signal from the faulty air mass meter with the signal from the potentiometer integrated in the throttle actuator.





Accelerator pedal fuel cut-off



ECU functions include:

- idling acknowledgement
- rpm number over a certain threshold

It stops fuel injection according to:

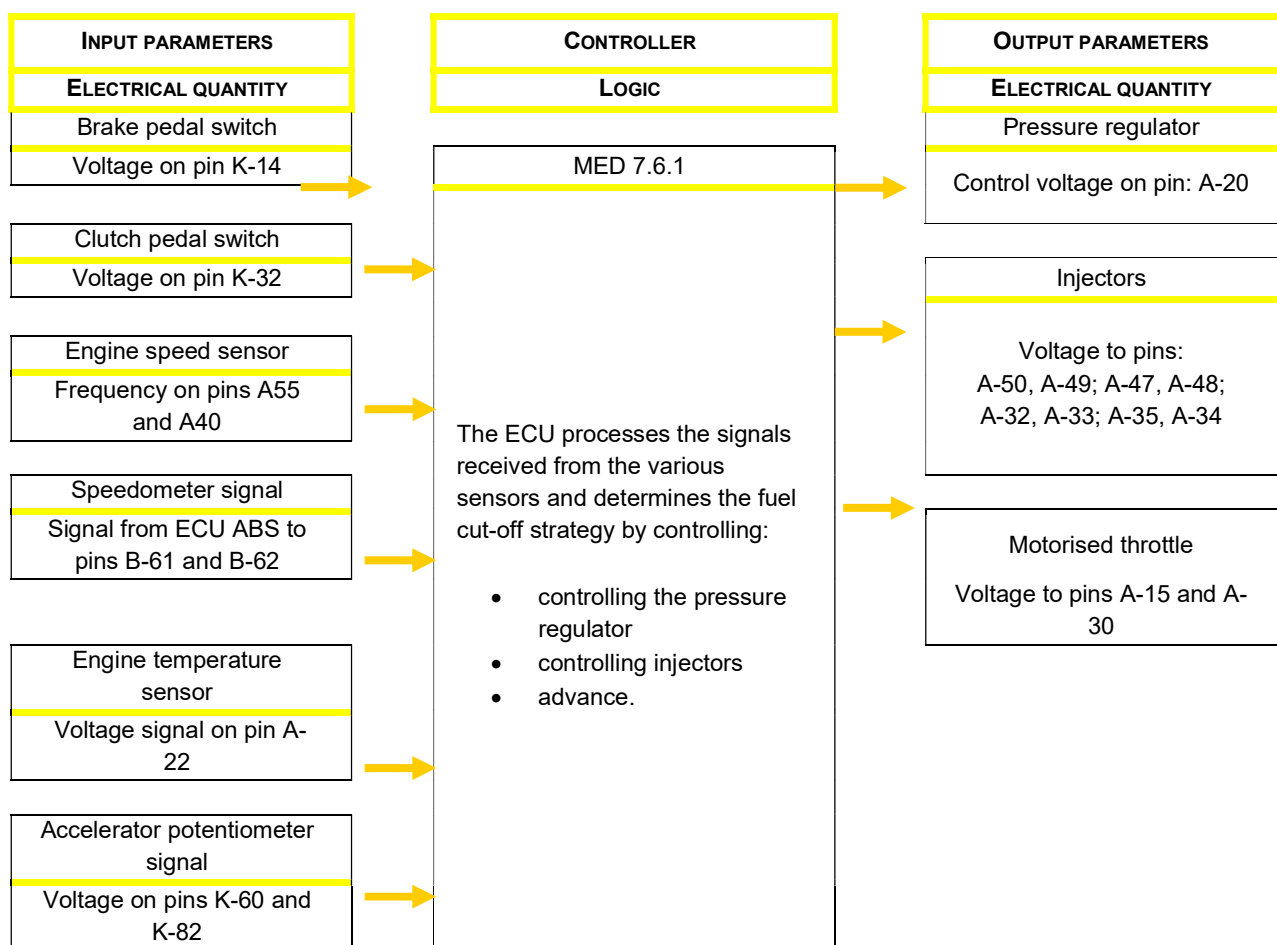
- engine speed
- engine temperature
- vehicle speed.

Dynamic decrease of engine speed is checked before reaching idling conditions.

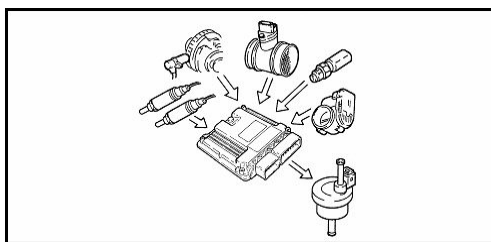
Fuel injection is partially reactivated according to a logic for smoothly taking the engine speed to idling ratio.

Normal functions are reactivated when idling speed is reached.





Fuel vapour recovery

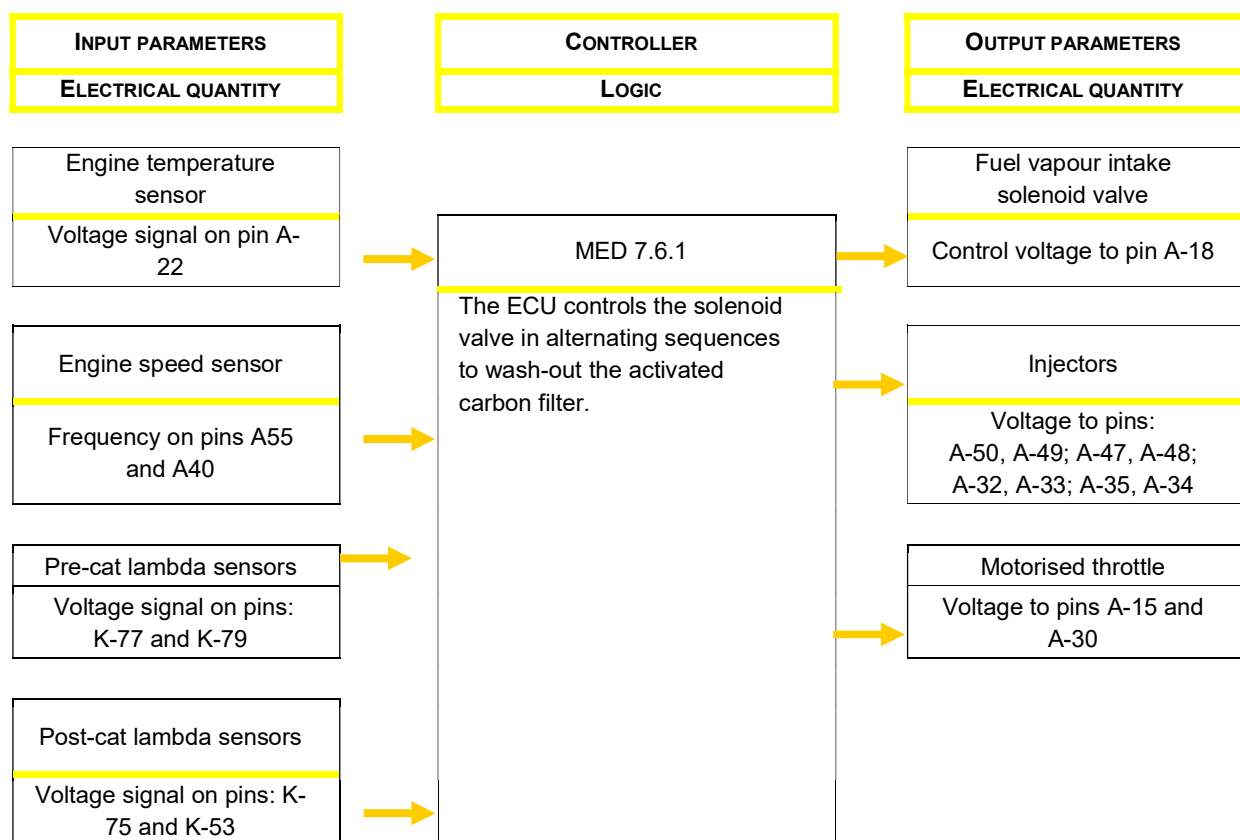


The polluting fuel vapours are collected in an activated carbon canister and are sent to the intake manifold to be burnt.

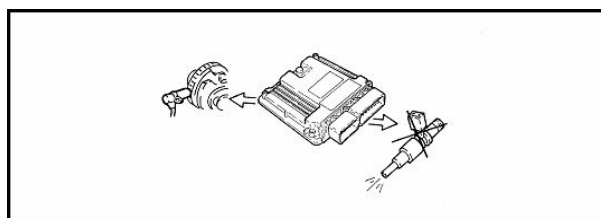
This occurs by means of a solenoid valve controlled by the ECU which alternates open stages (canister wash-out) and closed stages (fuel factor learning stage).

When opened, the solenoid valve opening duty cycle is controlled by the ECU to eliminate fuel vapours without changing engine carburetion.





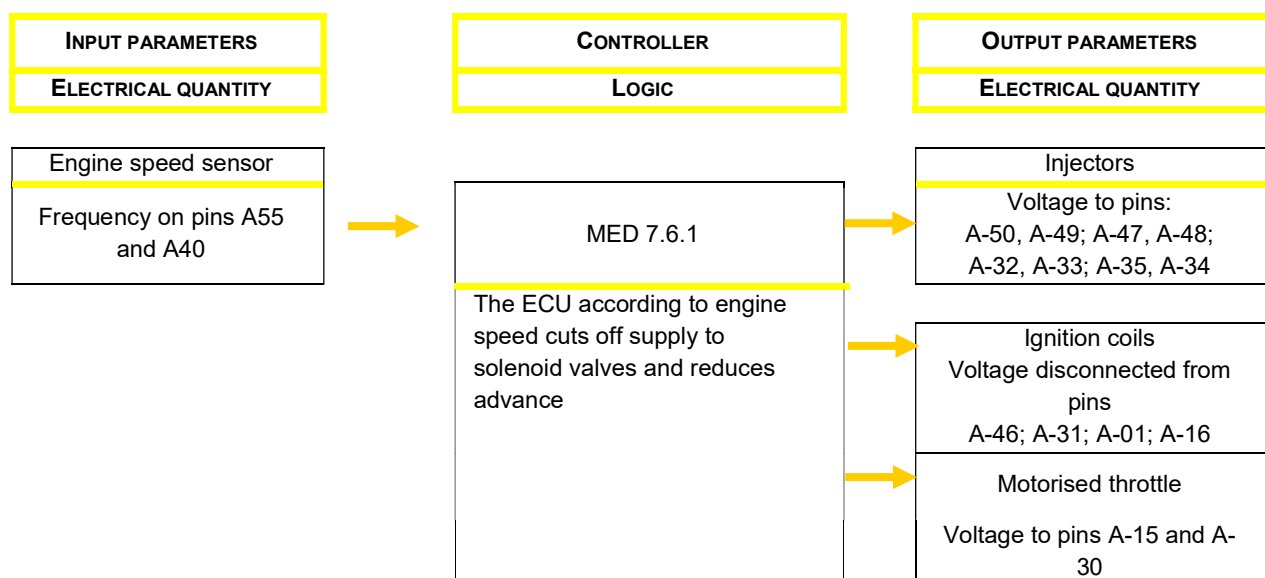
Maximum engine speed control



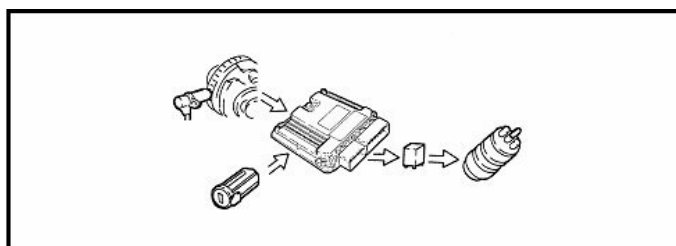
The ECU according to the engine speed:

- over 6800 rpm, cuts off supply to the injectors (the maximum limit of 7000 rpm can be held for no longer than 5 seconds)
- resumes injector control under 6600 rpm.



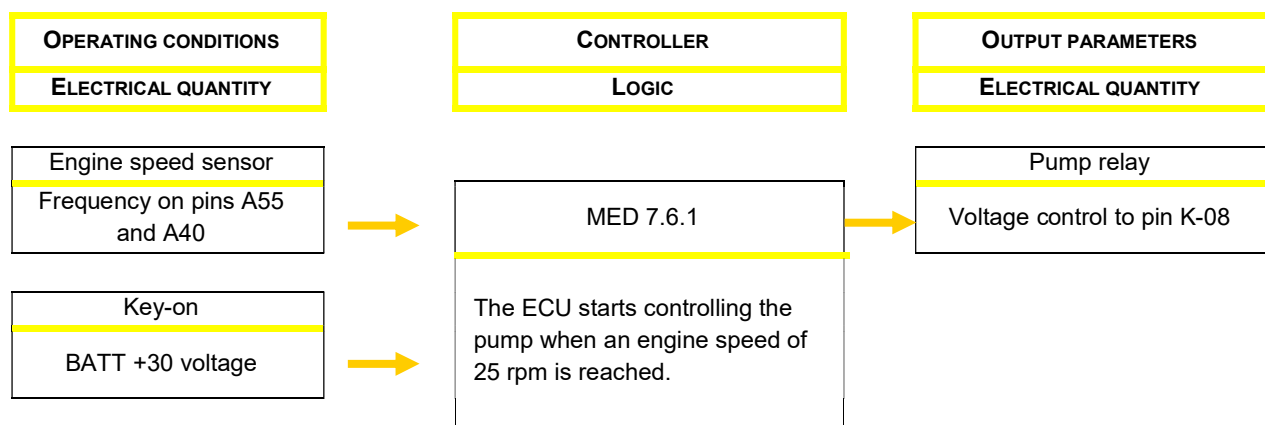


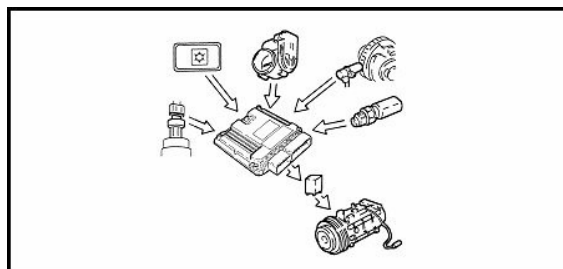
Fuel pump control



The ECU:

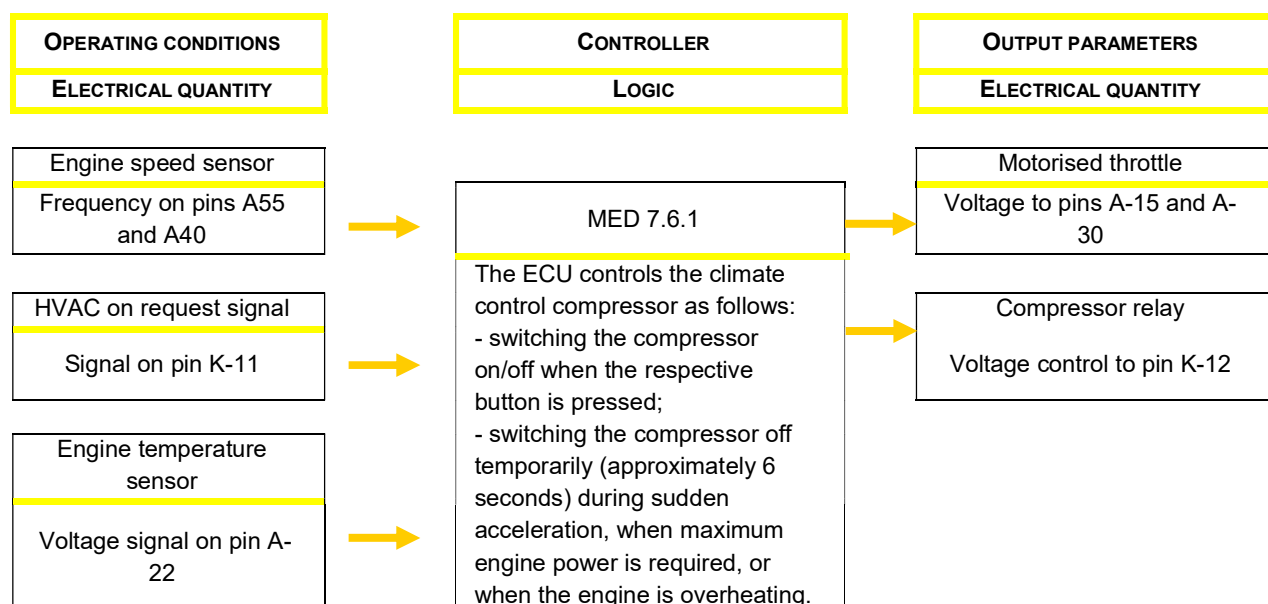
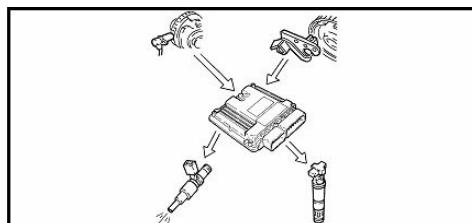
- powers the fuel pump at key-on (for 5 seconds) with engine speed > 25 rpm;
- cuts off power to pump at key-off with engine speed < 25 rpm.



Climate control system connection

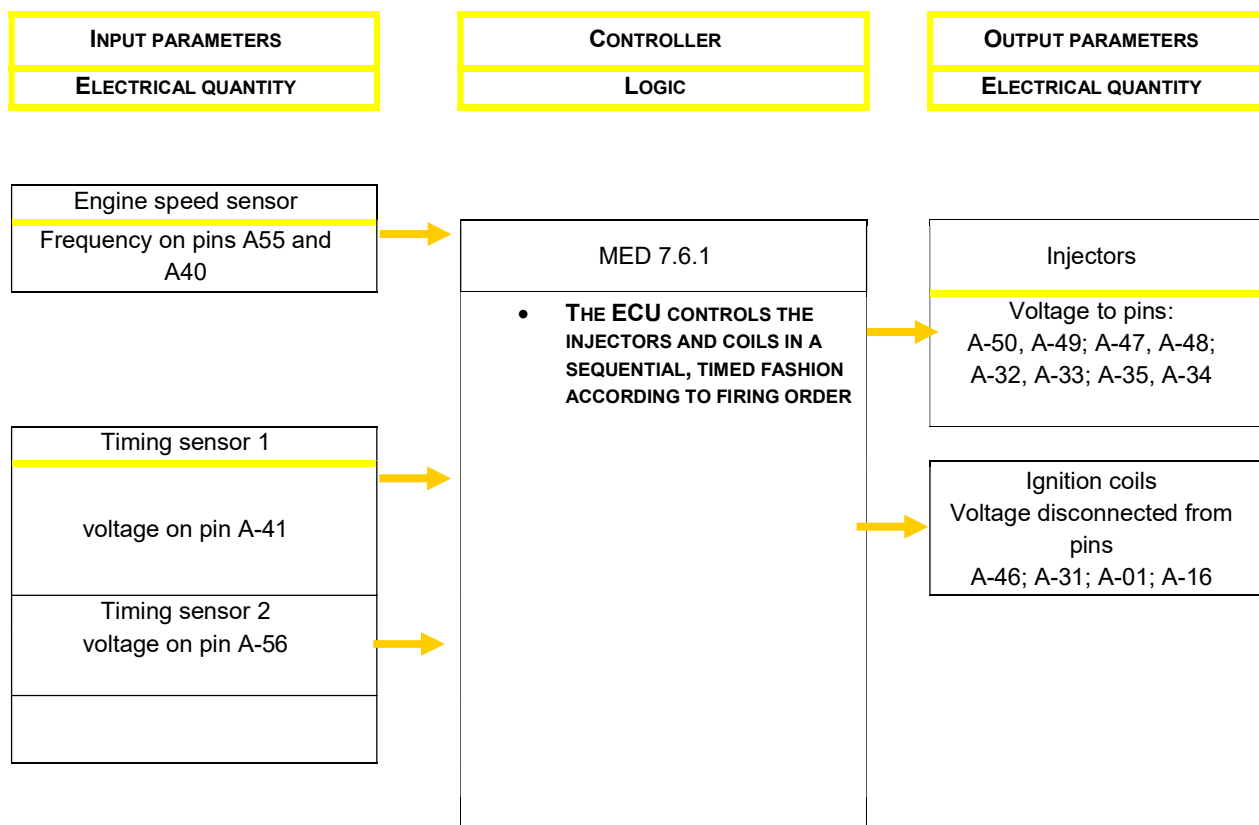
The compressor draws engine power when the climate control system is started.
When idling, the ECU adapts the air flow to the new power request with the advantage for ensuring optimal drivability.
The ECU cuts out the compressor:

- over 6500 rpm
- over a certain engine coolant temperature threshold (117°C)
- when cranking.

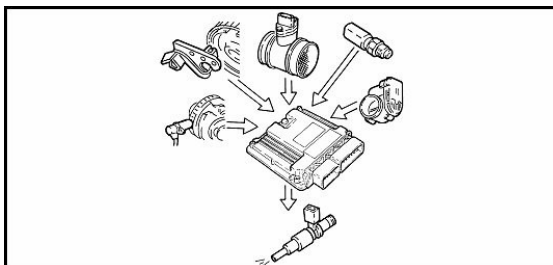
**Cylinder position acknowledgment**

The ECU acknowledges which cylinder is firing at each engine revolution: it controls the injection and ignition sequence of the cylinder in a sequential and timed fashion.



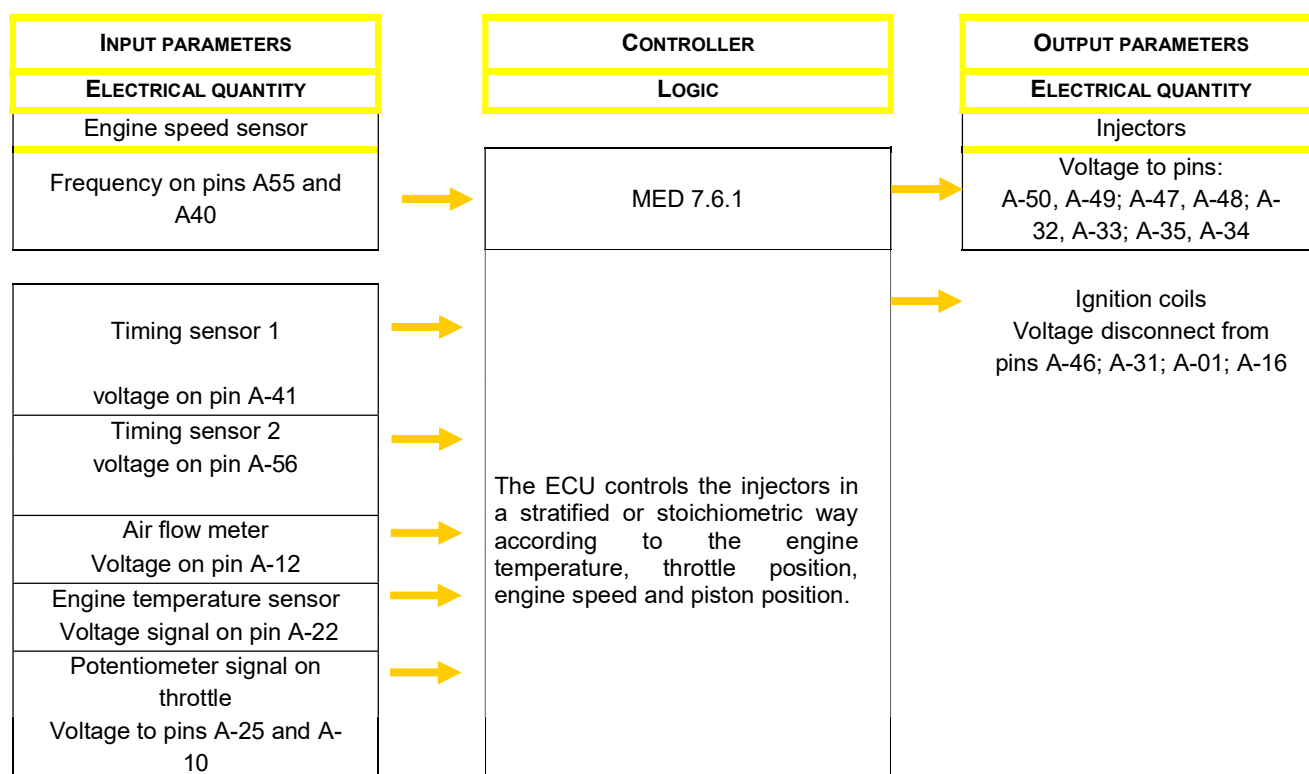


Optimal injection time for each cylinder

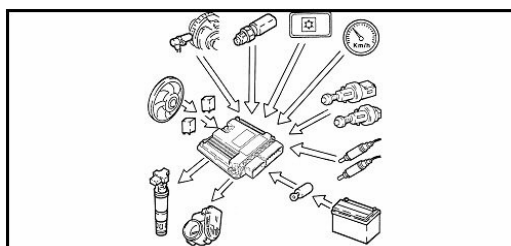


- When idling and up to 1200 rpm, the charge is stratified with lambda of 1.3-1.4.
- Idling injection start angle is approximately -45°.
- The mixture is homogenous and lambda is 1 when no idling.
- The injection starting angle varies from -310° to -370° to ensure homogenous mixture.



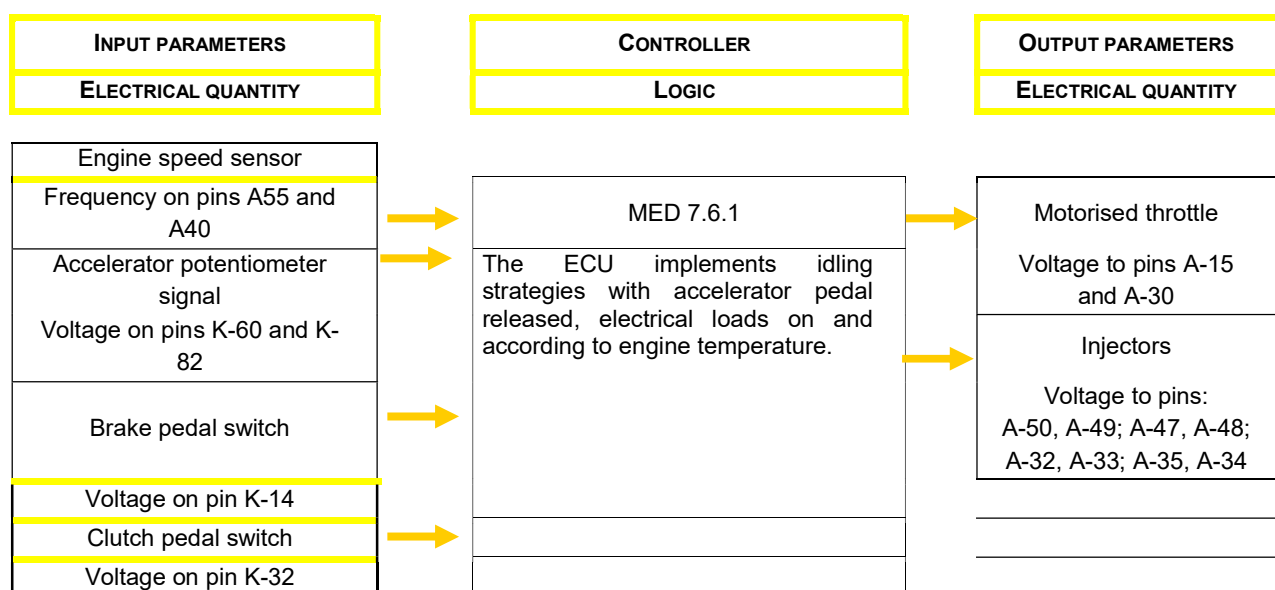
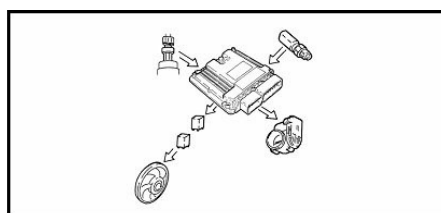


Idling speed management (also according to battery voltage)



The ECU acknowledges idling when the accelerator pedal is released. The ECU controls idling speed according to the utilities which are running and the brake-clutch pedal signals. It controls the position of the driven throttle and the injection time.

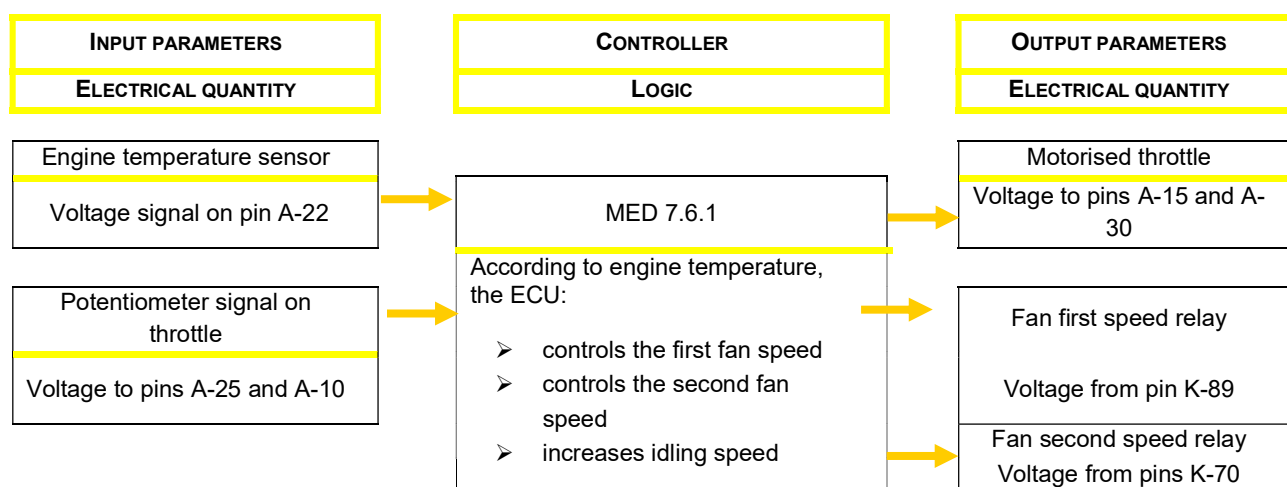


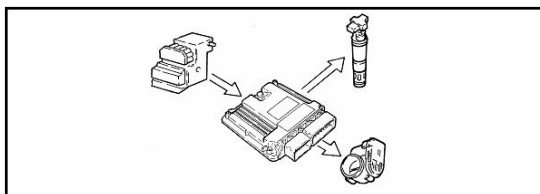
**Fan control**

The ECU operates the fan according to the coolant temperature:

- temperature when first fan speed is switched on: 97°C
- temperature when second fan speed is switched on: 102°C

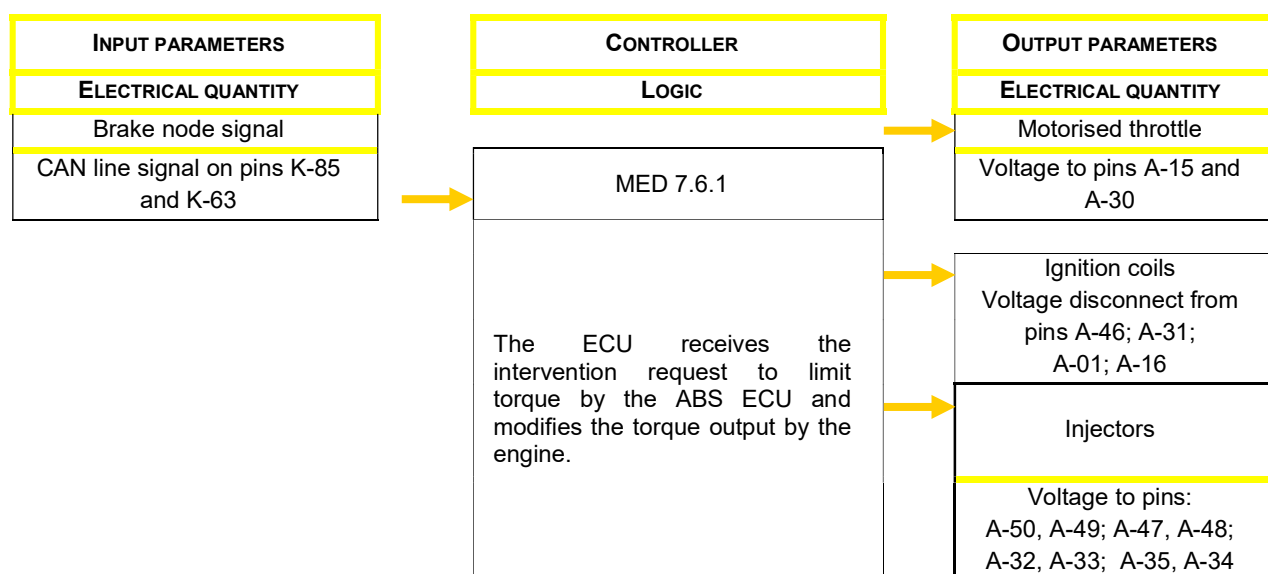
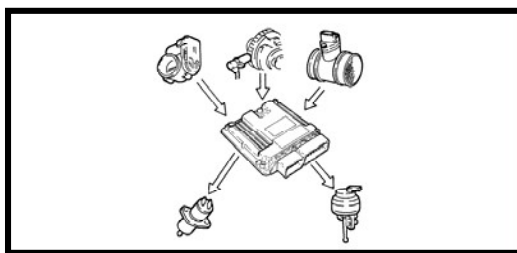
The ECU runs the fan at first speed when the A/C system is on. If the coolant temperature signal is absent, the ECU implements recovery mode by running the fan at second speed until the error is removed. The throttle is opened before starting the fans to prevent drops of engine speed.



ABS/ASR ECU connection

The interface between the engine control ECU and the ABS/ASR ECU via the CAN line between the two ECUs. The engine ECU if the wheels slip (indicated by the ABS/ASR ECU) to reduce drive torque by:

- reducing ignition advance
- reducing throttle opening angle
- reducing injection time

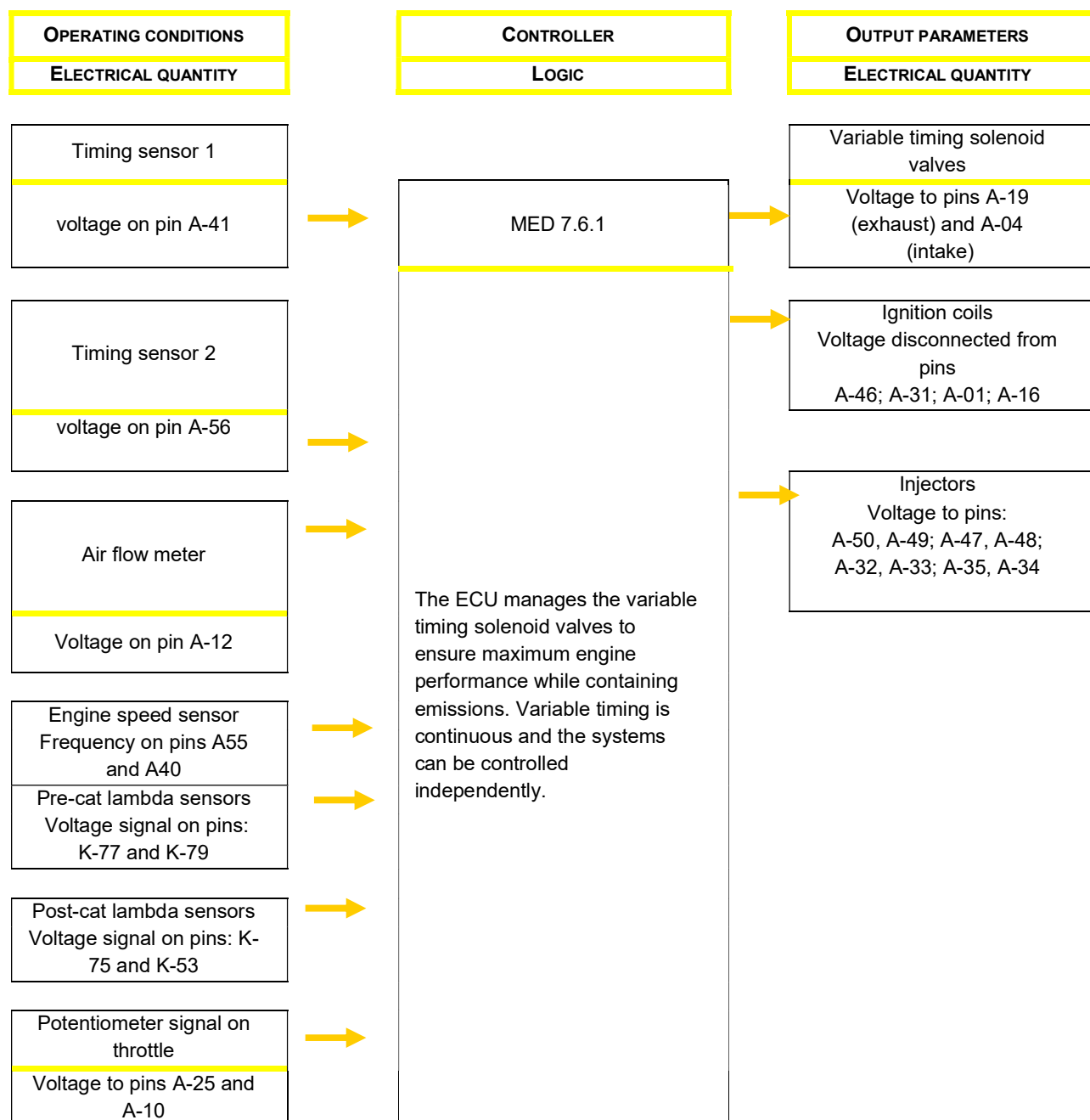
**Variable timing management**

The ECU according to the following information:

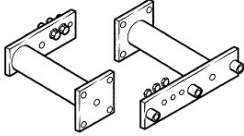
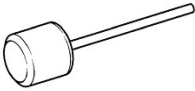
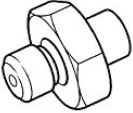
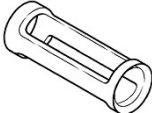
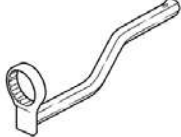
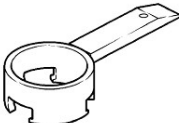
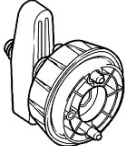
- engine temperature
- engine speed
- engine oil
- accelerator pedal position
- lambda sensor signals



independently manages two variable timing systems continuously with timing angles in the range from 0 to 50 degrees, controls the two proportioning solenoid valves to ensure careful timing management and better control over emissions and engine output torque.



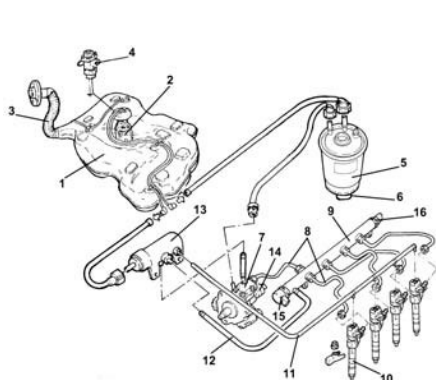
3.1.5 Engine maintenance special tools

	Engine assembly adapter
	Pin for blocking balancing countershaft chain tensioner USE EQUIVALENT FIAT TOOL
	Bushing for fitting crankshaft gasket (timing side) USE EQUIVALENT FIAT TOOL
	Adapter for measuring engine oil pressure USE EQUIVALENT FIAT TOOL
	Adapter for removing and installing valve springs USE EQUIVALENT FIAT TOOL
	Oil filter wrench FOR ON-VEHICLE FITTING/REMOVAL ONLY
	Tool for loosening utility belt tensioner
	Support for blocking torsional vibration damper
	Bushing for installing crankshaft gasket (transmission side) USE EQUIVALENT FIAT TOOL
	Support for fastening coolant pump drive pulley TO REMOVE COOLANT PUMP WITHOUT DISCONNECTING TIMING CHAIN

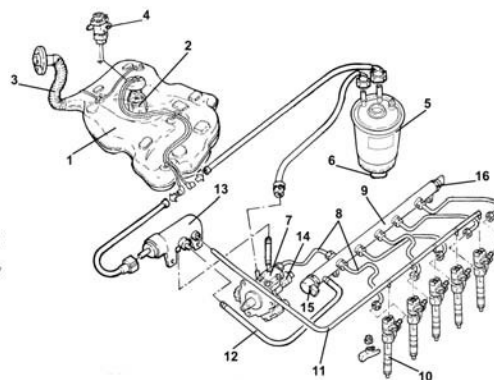


3.2 1.9 / 2.4 MJET DPF ENGINE

3.2.1 Fuel feed rail (common rail)



1.9 16v 150cv



2.4 20v 200cv

1. Fuel tank
2. Submerged pump assembly
3. Fuel filler tube
4. Inertia switch
5. Filter
6. Water in fuel sensor
7. High pressure pump
8. High pressure lines
9. Common rail
10. Injectors
11. Return line from injectors
12. Return line from rail
13. Fuel return manifold
14. Pump pressure regulator
15. Rail pressure regulator
16. Fuel pressure sensor

Features

- High injection pressure (up to 1600 bar).
- Modulated injection pressure from 150 to 1600 bar in all engine conditions.
- Fuel supply up to 100 mm³/stroke at engine speed in the range from 100 to 6000 rpm.
- Accurate injection control in terms of both advance and duration.
- One or more pilot injections controlled before TDC according to engine speed and engine load.

Construction

The fuel feed system consists of a low pressure circuit and a high pressure circuit.

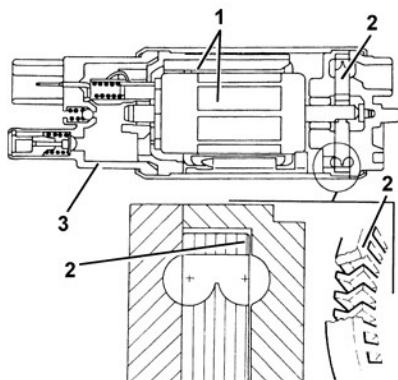
The low pressure circuit consists of:

- auxiliary pump
- fuel filter
- fuel return manifold
- connection lines.

The high pressure circuit consists of:

- fuel pressure pump
- common rail.



Fuel pump

1. Electrical motor
2. Pump impeller
3. Terminal cover

Function: To take fuel from the tank and send it to the high pressure pump at a pressure of 3.5 bars to ensure correct operation of the high pressure pump.

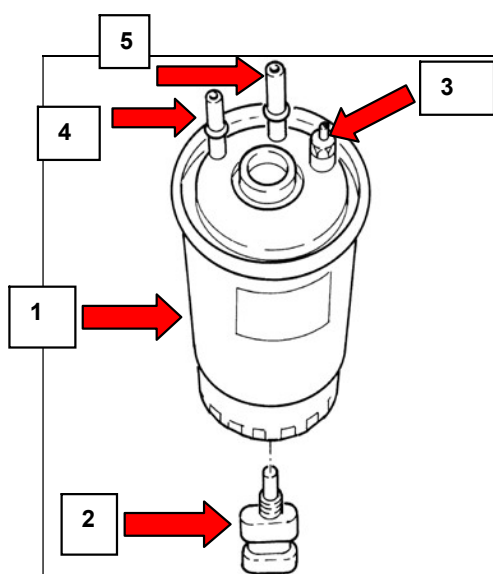
Location: Inside the fuel tank.

Features: The fuel pump is integral with the level gauge in the tank and the fuel filter. These components cannot be replaced individually.

Operation: The pump consists of a permanent magnet electrical motor which directly controls the pump impeller. This is a centrifuge (not positive displacement) pump. The impeller transfers a certain kinetic energy to the diesel which in the stator is transformed into pressure.

Advantages: The use of a centrifuge pump (instead of a positive displacement pump) offers the following advantages:

- high performance also at low electrical motor power and low fluid temperatures
- light weight
- smaller size.

Fuel filter

1. metal filtering element cartridge
2. water in fuel filter sensor
3. bleeder
4. from fuel pump to high pressure pump
5. to high pressure pump

FUNCTION:

To filter the fuel before it is sent to the high pressure pump.

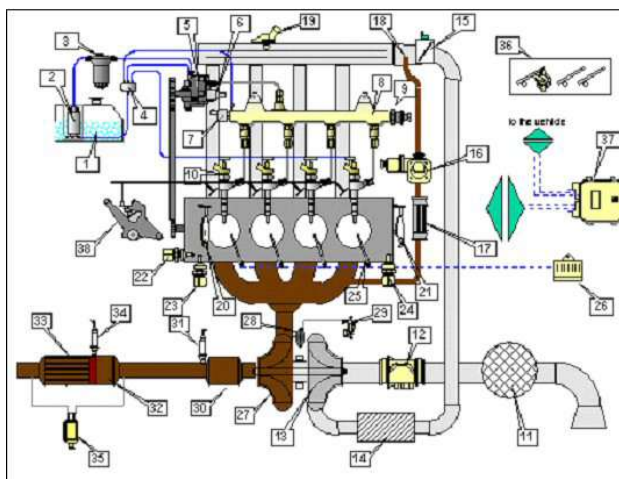
LOCATION: The fuel filter is fitted on the firewall in the engine compartment.

FEATURES: The metal grafted cartridge fuel filter consists of a pack of paper disks with a filtering surface of 5300 cm² and 4-5µm filtering capacity.

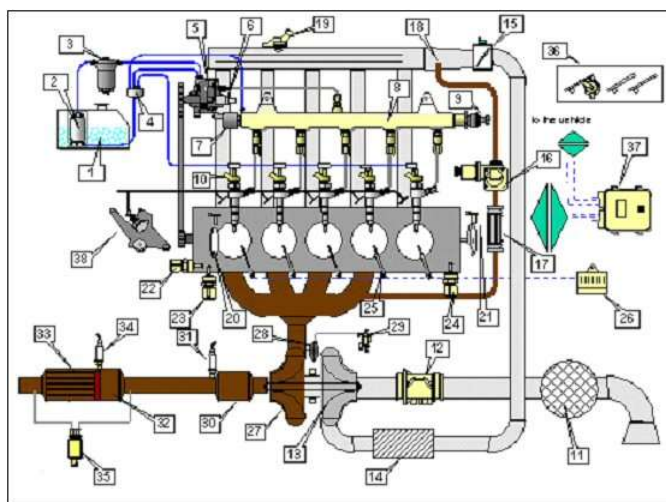
COMPONENTS: The fuel filter is provided with the following components, in addition to the filtering cartridge:

- water in fuel filter sensor.

3.2.2 Bosch EDC-16C39 electronic control system



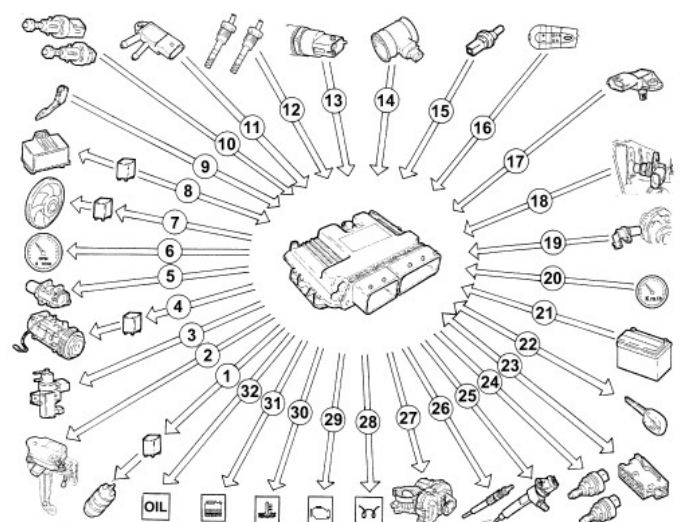
1.9 16v 150 HP



2.4 20v 200 HP

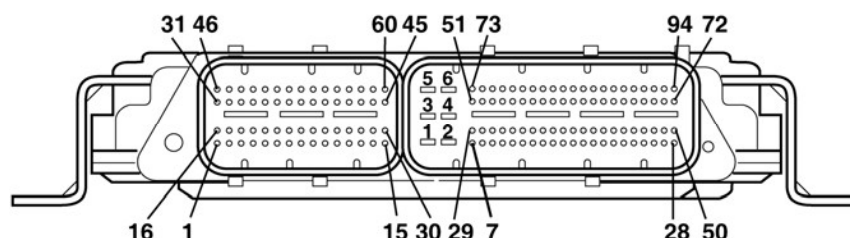


1. Tank
2. Fuel pump
3. Fuel filter
4. Damper
5. Radial jet
6. M - PROP regulator
7. Pressure regulator
8. Rail
9. Rail pressure sensor
10. Injectors
11. Air cleaner
12. Air mass meter
13. Compressor
14. Intercooler
15. Throttle
16. EGR
17. EGR cooler
18. Gas recirculation input
19. Supercharger sensor
20. Engine speed sensor
21. Timing sensor
22. Coolant temperature sensor
23. Oil pressure sensor
24. Oil level sensor
25. Glow plugs
26. Glow plug ECU
27. Variable geometry turbine
28. Turbo actuator
29. Turbo control solenoid valve
30. Pre-catalyser
31. Pre-cat output temperature sensor
32. Catalyser
33. DPF particulate trap
34. DPF input temperature sensor
35. DPF differential pressure sensor
36. Pedal board
37. Engine ECU
38. Swirl actuator



- | | |
|--|---|
| 1. Auxiliary fuel pump | 17. Air pressure and temperature signal |
| 2. Swirl mechanism | 18. Timing sensor |
| 3. VGT solenoid valve | 19. Engine speed sensor |
| 4. A/C compressor | 20. Speedometer |
| 5. EGR solenoid valve | 21. Battery |
| 6. Tachometer | 22. Alfa Code |
| 7. Cooling fan | 23. Diagnostic socket |
| 8. Glow plug pre-heater ECU | 24. Pressure regulator |
| 9. Accelerator pedal with built-in potentiometer | 25. Injectors |
| 10. Brake-clutch pedal switch | 26. Glow plugs |
| 11. Differential pressure sensor | 27. Throttle solenoid valve |
| 12. Thermocouples | 28. Glow plug pre-heater warning light |
| 13. Fuel pressure sensor | 29. Injection warning light |
| 14. Air mass meter | 30. Coolant overheat warning light |
| 15. Coolant temperature sensor | 31. Water in fuel warning light |
| 16. Cruise control | 32. Oil warning light |

Bosch EDC16C39 ECU pinout



Connector K (engine utilities wire, vehicle side)

PIN	FUNCTION
1	Injection primary utility power from B001 F17
2	Ground
3	Not connected
4	Ground
5	Injection primary utility power from B001 F22
6	Ground
7	Variable geometry turbine solenoid valve signal
8	Accelerator pedal potentiometer 2 -
9	Accelerator pedal potentiometer 1
10	Fuel temperature sensor -
11	Fuel temperature sensor signal
12	A/C linear pressure sensor -
13	A/C linear pressure sensor signal
14	Not connected
15	Not connected
16	Not connected
17	Brake pedal contact signal + (NO)
18	Not connected
19	Not connected
20	Not connected
21	Not connected
22	A/C linear pressure sensor -
23	Not connected
24	Not connected
25	K line
26	Not connected
27	Not connected
28	15/54 power from B001 F16



29	Compressor relay control negative signal (T5)
30	Accelerator pedal potentiometer 1 -
31	Accelerator pedal potentiometer 2
32	Post particulate trap (DPF) temperature sensor signal
33	Post particulate trap (DPF) temperature sensor -
34	Pre particulate trap (DPF) temperature sensor signal
35	Pre particulate trap (DPF) temperature sensor -
36	Differential pressure sensor signal (DPF)
37	Differential pressure sensor (DPF) -
38	Resume Cruise Control
39	Not connected
40	Not connected
41	Not connected
42	Not connected
43	Not connected
44	Differential pressure sensor (DPF) +
45	Accelerator pedal potentiometer 1 +
46	Accelerator pedal potentiometer 2 +
47	W line (immobilizer)
48	Not connected
49	Not connected
50	Not connected
51	Not connected
52	Glow plug pre-heat ECU diagnostics
53	Not connected
54	A/C request from HVAC node
55	Not connected
56	SET + Cruise Control
57	Not connected
58	Not connected
59	Not connected
60	Not connected
61	C-CAN L
62	C-CAN H
63	Not connected
64	Not connected
65	Not connected
66	Not connected
67	Not connected
68	Not connected
69	Engine cooling fan second level
70	Not connected
71	EOBD failure warning light
72	Main relay negative signal (T19)
73	Not connected



74	Water in fuel filter sensor signal
75	Not connected
76	Not connected
77	ON Cruise Control
78	SET + Cruise Control
79 (*)	Clutch pedal contact signal -
80	Brake pedal contact signal + (NC)
81	Not connected
82	Not connected
83	C-CAN L
84	C-CAN H
85	Not connected
86	Not connected
87	Not connected
88	Not connected
89	Not connected
90	Engine cooling fan first level
91	Fuel pump relay negative signal (T9)
92	Not connected
93	Glow plug pre-heater on
94	Not connected

(*): Not fitted in versions with automatic transmission

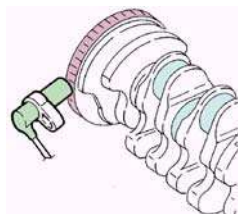
Connector A (engine pre-wired harness)

PIN	FUNCTION
1	Cylinder 3 injector +
2	Cylinder 2 injector +
3	Not connected
4	Fuel pressure regulator on rail +
5	Not connected
6	Swirl solenoid valve ground
7	Not connected
8	Fuel pressure sensor -
9	Not connected
10	Not connected
11	Timing sensor +
12	Engine speed sensor -
13	Air pressure/temperature sensor +
14	Not connected
15	Not connected
16	Cylinder 1 injector +
17	Cylinder 4 injector +
18	Not connected/ Cylinder 5 injector + (for 2.4)
19	Fuel pressure regulator +
20	Timing sensor -
21	Engine oil level
22	Not connected
23	Air pressure/temperature sensor -
24	Not connected
25	Not connected
26	Not connected
27	Engine speed sensor +
28	Fuel pressure sensor +
29	Not connected
30	Not connected
31	Cylinder 2 injector -
32	Not connected



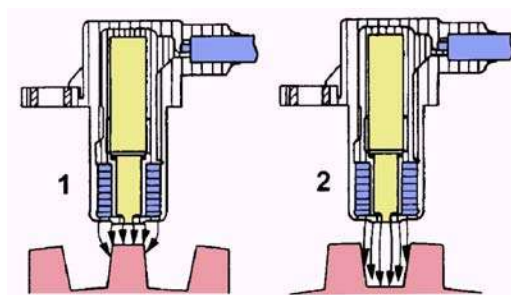
33	Cylinder 4 injector -
34	Fuel pressure regulator on rail +
35	Diagnostic feedback (swirl)
36	Not connected
37	Air temperature sensor (air mass meter)
38	Not connected
39	Driven throttle ground
40	Pressure signal from air pressure/temperature sensor
41	Engine coolant temperature sensor -
42	Output signal + (air mass meter)
43	Fuel pressure sensor signal
44	Ground (air mass meter)
45	Swirl solenoid valve command
46	Cylinder 4 injector -
47	Cylinder 1 injector -
48	Not connected/ Cylinder 5 injector - (for 2.4)
49	Fuel pressure regulator -
50	Timing sensor signal
51	Not connected
52	Throttle body feedback
53	Temperature signal from air pressure/temperature sensor
54	Not connected
55	Not connected
56	Low engine oil pressure
57	Not connected
58	Engine coolant temperature sensor signal
59	Throttle solenoid valve command
60	EGR solenoid valve

Engine speed sensor



FUNCTION: The sensor provides an electrical signal to the engine ECU used to compute the speed and angular position of the engine.

LOCATION: The sensor is fitted on the crankcase facing the phonic wheel on the crankshaft.



1. maximum magnetic flow
2. minimum magnetic flow

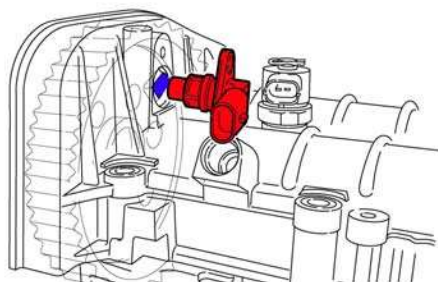


OPERATION: The switch from empty to full due to the presence or absence of a tooth determines variations in magnetic flow capable of generating induced alternating voltage which is used to count the teeth on the phonic wheel.

The frequency and amplitude of the voltage sent to the ECU varies according to the angular speed of the crankshaft. The sensor is connected to ECU pins 27 and 21 via the shielded wire to connector A.

INSTALLATION REQUIREMENTS: The distance between end of sensor and phonic wheel must be in the range from 0.8 to 1.5 mm for the signals to be correct.

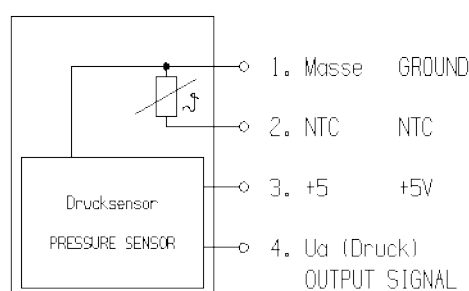
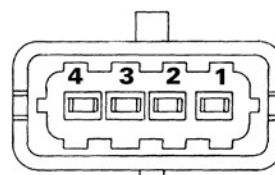
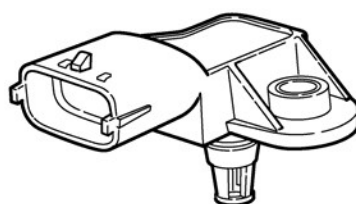
Cam angle (timing) sensor



LOCATION: The sensor is located on the cylinder head facing the camshaft drive pulley. A tooth on the pulley is used by the timing sensor to acknowledge the engine timing position.

FUNCTION: For the engine ECU to acknowledge which cylinder is at compression stroke. The sensor is connected to ECU pins 11, 50 and 20 via the shielded wire to connector A.

Intake air pressure and temperature signal



1. ground
2. NTC (air temperature signal)
3. 5V power
4. supercharger pressure signal

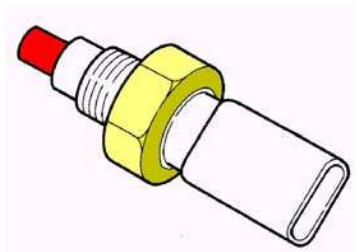


LOCATION: The intake air temperature and pressure sensor is fitted on the intake manifold.

FUNCTION: The sensor provides information on air temperature and pressure in the intake manifold to the engine ECU. This information is used by the ECU to adjust the position of the VGT actuator (and therefore supercharger pressure) to optimise engine operation and to adjust injection time.

FEATURES: This double sensor is used to read the air temperature via a NTC (Negative Temperature Coefficient) measuring element and the pressure inside the manifold via a piezoelectric measuring element. The sensor is connected to ECU pins 23, 53, 13 and 40 via connector A pins 1, 2, 3, 4 respectively.

Engine coolant temperature sensor



LOCATION: This sensor is fitted on the thermostat cup (where the thermostat valve is fitted).

FUNCTION: The sensor detects the engine coolant temperature.

FEATURES: This NTC (Negative Temperature Coefficient) sensor sends the coolant temperature signal to the engine ECU. The sensor is connected to ECU pins 41 and 58 via connector A.

HFM 6 digital air mass meter



The advantages of the new air mass meter are:

1. Better protection of the sensitive of the element from impurities in the air (particles, water, oil vapours, etc.).
2. Better measuring accuracy.

The differences between the HFM6 and previous air mass meters are:

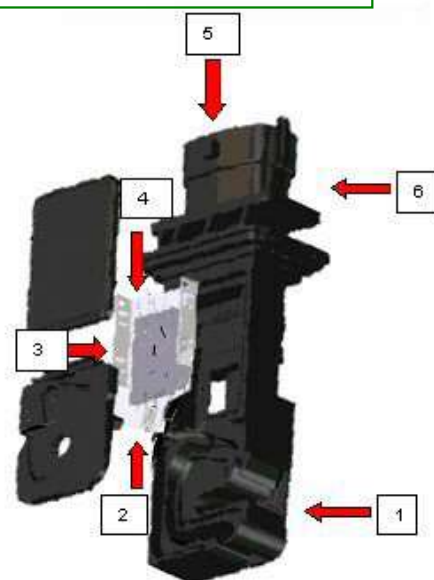
1. Digital air temperature and flow rate signals.
2. Four wire electrical connection.
3. New bypass arrangement of air flow onto sensitive element.
4. Turret welded to air flow conduit.
5. Protection grid on air flow outlet (to condense oil vapours).



Analogue air mass meter



Digital air mass meter



1. Air flow inlet proportional to total flow
2. Resistive sensitive element
3. Signal detection and amplification circuit
4. Interference shielding
5. Connector
6. Body

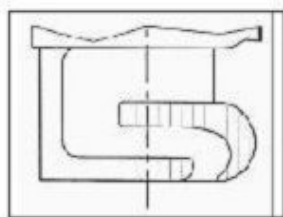
The HFM6 air mass meter sensor exploits the same operating principles of the previous hot film air mass meters with a new path of the air flow onto the sensitive element.



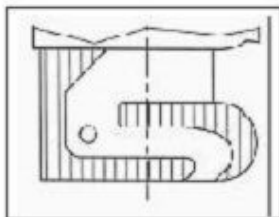
HFM6

The evolution of air flow conduits in analogue air mass meters.

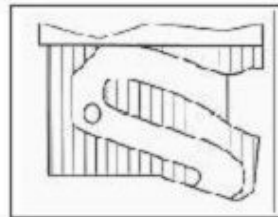




HFM5



HFM5 -C



HFM5 -CL

One of the advantages of digital air mass meters with respect to analogue meters is that the sensitive element of the sensor is more protected from impurities in the air.



Sensitive element
measuring point

Measuring flow

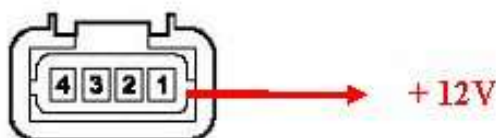
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Main flow

————

The measuring flow is taken from the main flow through a secondary bypass. This conduit has a smaller section and is longer than the main conduit. It houses the sensitive element. The new bypass design lets pollutants in the main flow out towards the outlet by kinetic energy without entering the measuring conduit. The measuring flow is designed so that the amount of air is proportional to that in the main conduit.

Air mass meter to ECU connection



Engine ECU pins (Connector A)

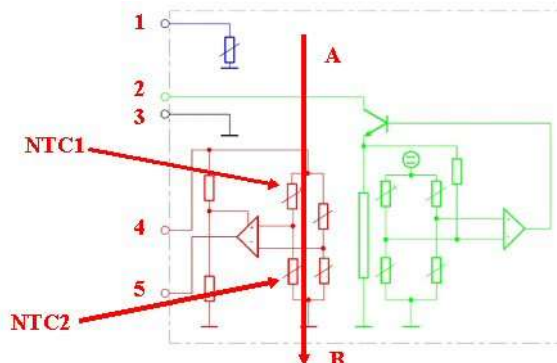
44
37
42

Connector pins

2. Ground
3. Temperature signal output
4. Air flow rate signal output

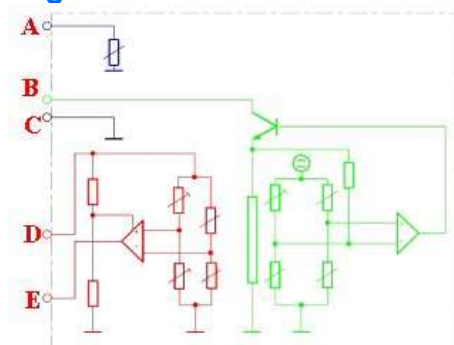


OPERATION: The flow of air normally invests the sensor (kept at constant temperature) from A to B. The temperature drop caused by the air on the thermo resistors (NTC1, NTC2) causes a variation of resistance which is proportional to the amount of measured air and imbalances the bridge. Two thermo resistors are used to determine the direction of the air flow (reversed flows or pulses are possible in certain conditions of the use of the engine). The ECU measures the temperature used to integrated the air flow output by the air mass meter on ECU pin 1.

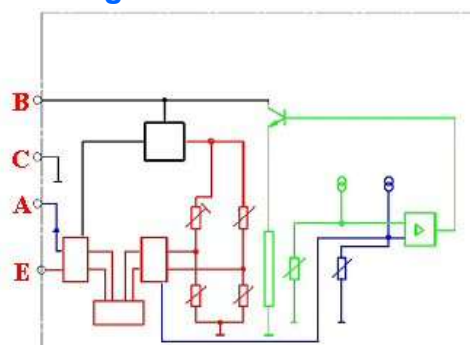


Also if the flow of air goes from B to A (backflow) the engine ECU is informed and can implement the appropriate strategies.

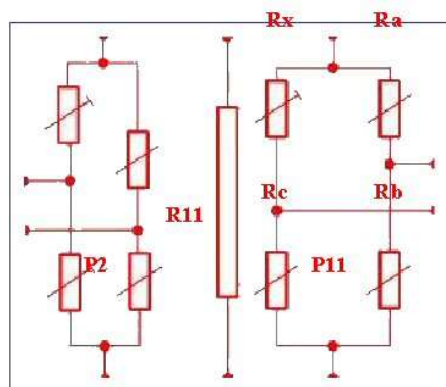
Analogue air mass meter



Digital air mass meter



The HFM6 air mass meter has a four pin connector while the analogue meter has a five pin connector. The extra wire (D) is used for the 5V voltage provided by the ECU and used to ensure that the air flow rate signal is independent from battery voltage variations.



The operating principle of the active part of the flow meter is based on the application of a double resistance bridge, also called a "Wheatstone bridge", consisting of Ra, Rb, Rc and Rx. The double bridge, plus heating resistor (R1), is made on the support (hot film) by applying epitaxial technology.



The Wheatstone bridge in addition to being used to measure resistance is specifically employed as a measuring circuit for resistive sensors.

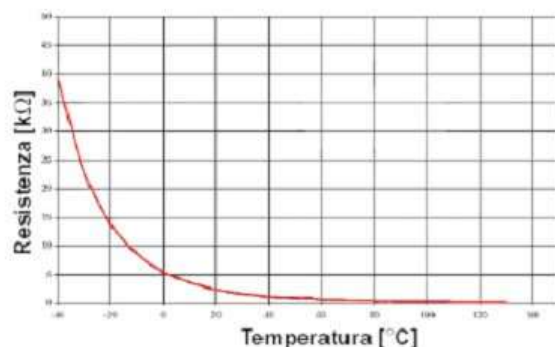
A thermo resistor whose values are known is employed instead of an unknown resistance (R_x). The resistance of the thermo resistor varies with the temperature and causes imbalance of the bridge.

There is therefore a proportional link between voltage imbalance, unknown resistance and temperature.

The first resistive bridge (P1), with a thermo resistor, controls and stabilises the heater temperature (R_1) of the sensor (hot film heating).

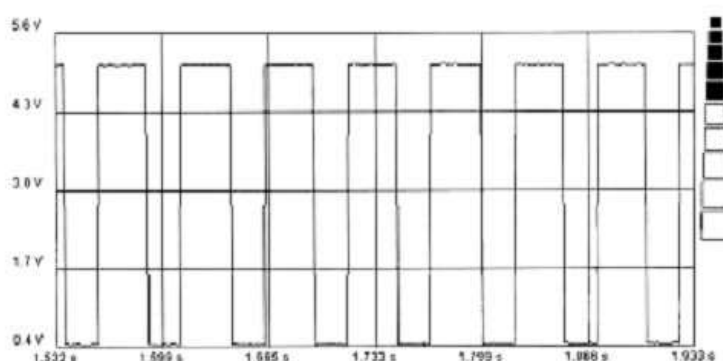
The second resistive bridge (P2), with two thermo resistors exposed to the air flow, detects and converts the voltage air flow variation also defining the direction of flow.

TEMPERATURE SIGNAL

**HFM5**

The temperature is measured by a NTC in analogue air mass flow meters. The characteristic is shown above.

The measurement of a digital air mass meter is a constant frequency duty cycle modified PWM signal.

**HFM6**

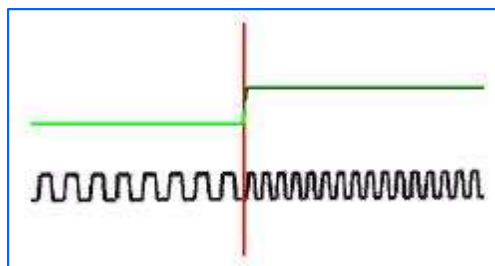
The working voltage is 5 volts. The measuring range is from -50 °C to +150 °C. The duty cycle is from 10% to 90%.

AIR FLOW RATE SIGNAL

**HFM5**

In analogue air mass meters, the air flow rate signal has the pattern shown in the graph.

In digital air mass meters, the signal sent to the engine ECU is equal to 5 volts and has variable frequency (from 1.4 kHz to 12 kHz).



HFM6

Air flow rate

Output frequency

The frequency of the signal output by the meter increases along with the input air flow rate (this consequently decrease the period).

A graphic voltmeter (Examiner) is needed to measure and test the signal amplitude (5 volts). To measure the frequency, simply use a multimeter selected to measure frequency and connect the probes to one of the air mass meter ground pins and to the air flow signal pin.

Motorised throttle



FUNCTION: To limit engine shaking while stopping. For this function, an electronically controlled throttle is fitted before the air plenum.

OPERATION: The motorised throttle at rest is open. When it is controlled by the engine ECU, it closes and shuts off air flow to the engine.

ENGINE OFF: the throttle remains open.

ENGINE RUNNING: the throttle remains open during normal operation of the engine.

ENGINE STOPPING: while stopping the engine, the ECU powers the motorised throttle with a PWM signal and closes it.

SPECIAL THROTTLE MANAGEMENT STRATEGIES

In addition to preventing shaking when the engine is stopped, the throttle is used for the DPF regeneration strategies. During this function, the throttle is controlled using a PWM signal for constant opening control and manage the temperatures needed to regenerate the trap.

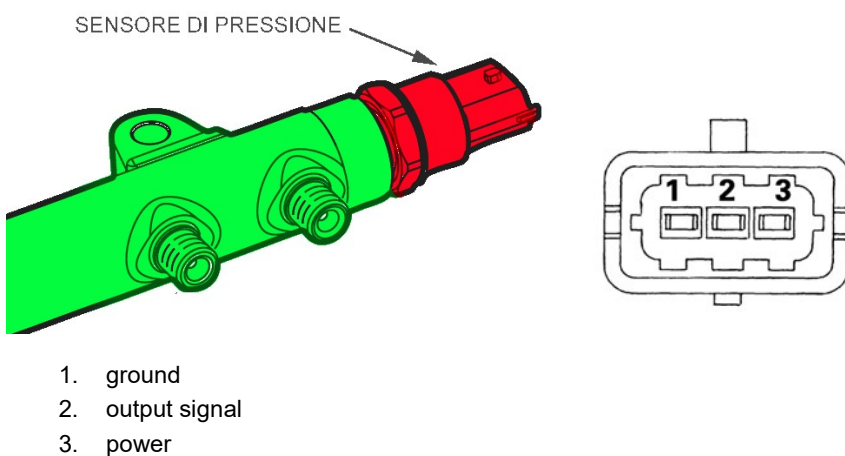
Engine ECU pins (Connector A)

Connector pins

Pin 1
Pin 2
Pin 4
Pin 6

39
+ 12V
52
59



Fuel pressure sensor

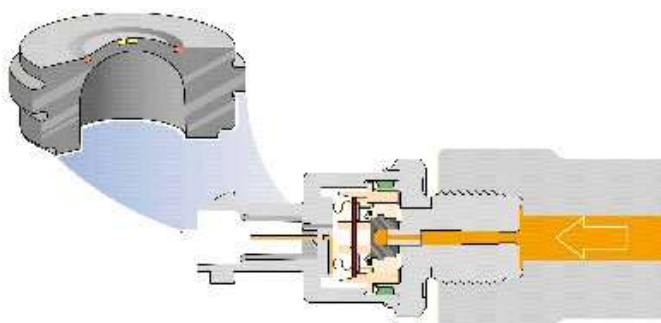
Engine ECU pins (connector A)

Pin 8
Pin 43
Pin 28

Connector pins

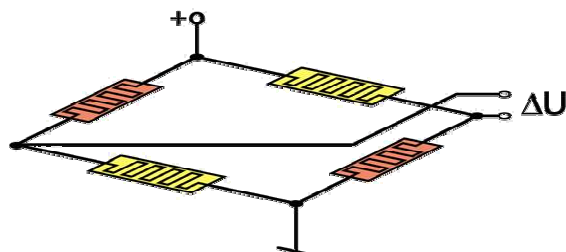
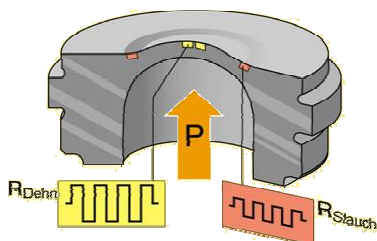
1
2
3

LOCATION: The sensor is fastened directly onto the end of the fuel rail as shown in the figure.

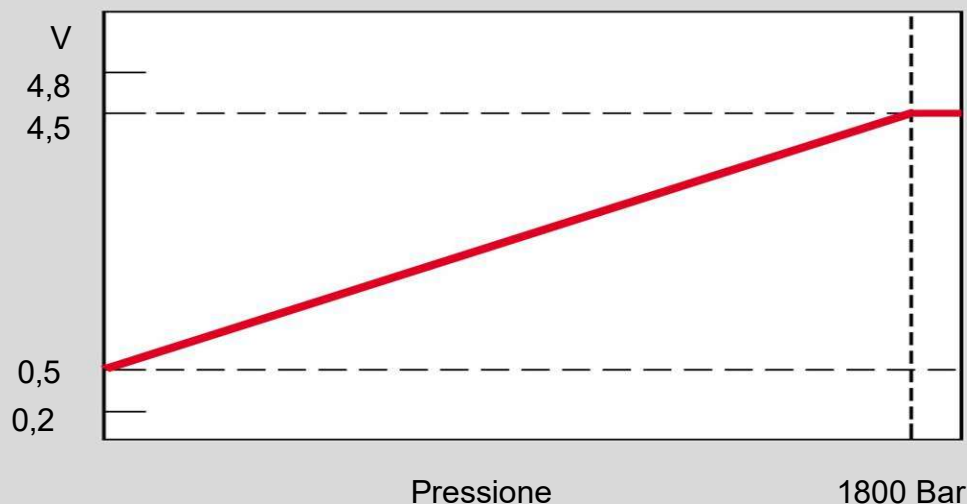


OPERATION: The piezoresistive sensor output increases in a linear fashion as the voltage signal pressure increases.

The internal bridge of the sensor and the linear response curve are shown in the voltage and pressure graph below.



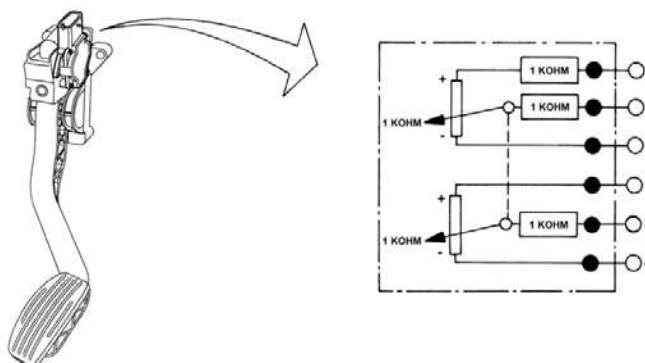
**Tensione
segnale**



FUNCTION: This sensor provides a feedback signal to the injection ECU to:

- adjust pressure inside the fuel rail
- adjust injection time.

Accelerator pedal potentiometer



LOCATION: The accelerator pedal potentiometer consists of an armature fastened to the accelerator pedal.

FUNCTION: It provides information to the engine ECU on the position of the accelerator pedal which is integral with the potentiometer itself.

OPERATION: Mechanically, the potentiometer consists of an armature inside which a spindle turns (the spindle is integral with the accelerator pedal). A helical spring ensures return to home position when the pedal is not pressed. Two potentiometers are fitted inside the armature (one main potentiometer and one backup). Their resistance varies according to the angle of rotation of the spindle (i.e. the angular position of the accelerator pedal) with which they are integral.

The changes in resistance offered by the potentiometer is read by the ECU.

Two potentiometers are provided for safety reasons.

A coil spring on the shaft ensures the correct resistance to pressure of the pedal while a second spring ensure return when the pedal is released.



Engine ECU pins (connector B)

46
45
9
30
8
31

Connector pins

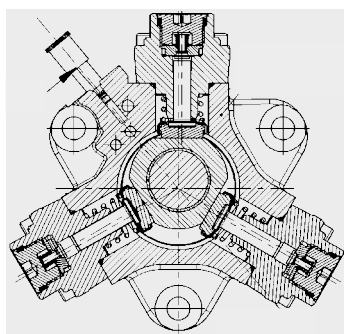
1. Potentiometer positive 2
2. Potentiometer positive 1
3. Potentiometer signal 1
4. Potentiometer negative 1
5. Potentiometer negative 2
6. Potentiometer signal 2

Bosch CP1H high pressure pump

INTRODUCTION: The pumping effect of the *Radialjet* common rail fuel supply pump is obtained by three pistons in a radial arrangement with respect to the pump shaft. The angular distance between two pumping elements is 120°.

FUNCTION: The pump is turned by the engine at a speed equal to 2/3 (4v) and 25/43 (2v) of that of the engine via a timing belt. Timing and injection are controlled by the ECU in injection systems of this kind. The pump only maintains the fuel permanently in the rail at the required pressure.

REQUIREMENTS: The pump must receive low pressure fuel (at least 3.5 relative bars) and minimum flow rate is 160 litres/hour for correct operation. This is provided by a low pressure electrical pump.

High pressure pump operation

Piston movement is determined by the rotation of a triangular cam integral with the pump shaft. This cam determines the movement in sequence of the three pistons by shifting a mechanical interface (tappets) between the cam and the foot of the piston. The contact between the cam and each tappet is ensured by a spring.

Each pumping unit is equipped with a plate suction valve and a ball delivery valve. All three flows from the pumping elements are internally joined to the pump and convey the fuel to the common rail via a single conduit. A particular feature of this pump is that it is lubricated and cooled at the same time by the fuel circulating inside it through specific gaps.

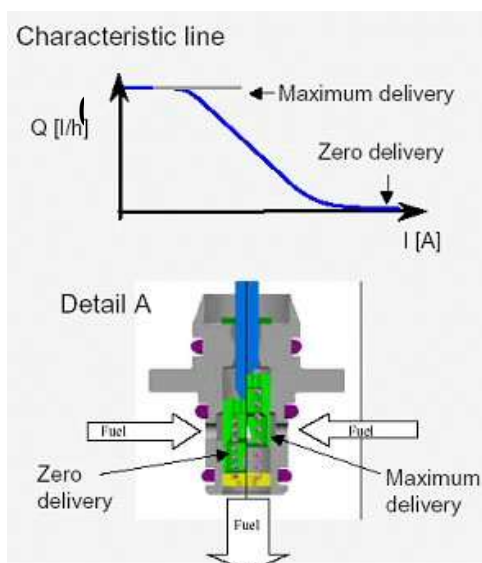
A low pressure regulating solenoid valve is fitted on the pump inlet to adjust delivery pressure and compress only the fuel needed to each the pressure mapped in the ECU.

The main features of the Radialjet pump are shown in the table on the following page.



Radialjet pump specifications

Type	Radialjet radial pumps
Number of pumps	3
Total displacement	0,697 cm ³ /rev. (4 cylinders) 0.794 cm ³ /rev. (5 cylinders)
Volumetric efficiency	>76% at 1600 bars 1000 pump rpm 40°C fuel
Maximum working pressure	1600 bars
Drawn power	1.6k W at 1600 bars, 3450 rpm (4 cylinders) 3.2 kW at 1600 bars, 2800 rpm (5 cylinders)
Top speed	See following page
Fuel feed	Fuel pressure 3.5 bars, minimum flow rate equal to 160 litres/hour
Lubrication	By fuel
Cooling	By fuel

Low pressure regulator solenoid valve

FEATURES: The pressure regulator is used to control the amount of fuel let into the pump.

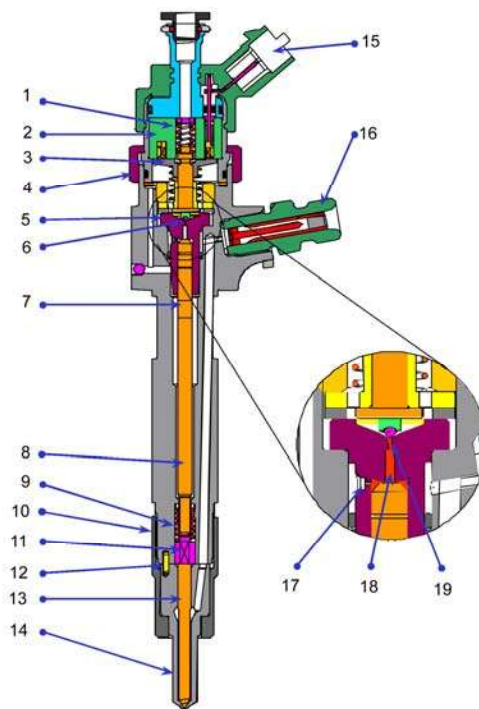
OPERATION: Flow into the pump is maximum when the solenoid is de-energised, i.e. the regulator is fully open and is a simply passage for the fuel conveyed from the submerged electrical pump at a pressure of 3.5 bars and flow rate of 160 l/h.

The ECU powers the regulator in PWM to limit the flow rate and let in only the amount of fuel to be compressed and sent to the rail. The graph clearly shows that the flow rate decreases when the control current increases.

The safety function is no longer present. This function is preformed by the regulator on the rail.



Injectors



1. spring
2. electromagnet
3. anchor
4. ring
5. valve
6. ball pintle
7. pressure rod
8. body
9. spring
10. nut

11. calibrated shim
12. reference dowel
13. atomiser
14. nozzle
15. electrical connector
16. fitting
17. "Z"
18. Vc control port
19. "A"

FEATURES: The solenoid valve is supplied at high pressure only. The fuel flow in the injector is split into two parts, one to supply the atomiser and the other to the pressure control rod. Both parts of the flow lubricate the moving parts of the injector thanks to the considerable leakage in the injection system that works at such high pressure. An atmospheric pressure circulation is also present. This is needed to dump the diesel used to operate the pilot valve and convey the leakage mentioned above.

The temperature of the fuel recirculated by the injector can be very hot (100°C) therefore the recirculation system must be equipped with pipes suited to withstand such temperatures.

Injector structure

CONSTRUCTION: The injector can be split into two parts to better understanding how it works (see figure above):

1. actuator/atomiser consisting of the nozzle and the pressure rod-pin assembly
2. control solenoid valve consisting of the solenoid and the valve.

CHECK PORT: The space inside the pilot valve immediately over the actuator is called the *check port* and is essential for injector operation. It is permanently supplied by fuel via "Z" (from German Zufluss = inlet). This volume is emptied through "A" (from German Abfluss = outlet) whose opening is controlled by the solenoid valve.

The fuel contained in the check port exerts a modular intensity pressure which acts on the upper surface of the pressure rod, whose area is A_c . The force on this area therefore depends on the pressure inside the check port.



ATOMISER ACTUATOR: The actuator/atomiser consists of the nozzle and the pressure rod-pin assembly. The nozzle is supplied with pressurised fuel when the pressure rod-pin assembly is raised. The latter is lifted by the imbalance of counterpoised forces on the assembly. Three forces act on the pressure rod-pin system:

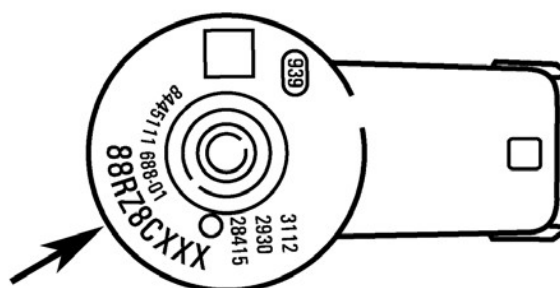
Elastic force F_e , in the direction of closure due to the spring on the pin. This force ensures tightness of the nozzle when the line pressure drops to zero and avoids dripping of fuel into the cylinder.

Force F_c also in the direction of closure due to the pressure of the fuel in the check port. This pressure acts on the upper area of the pressure rod.

Force F_a , in the direction of opening is due to the pressure of the fuel in the feeding port and acts on the circular crown area delimited on the outside by the sliding diameter of the pin in the nozzle and the seal diameter of the tapered seat.

The balance of the pressure rod-pin assembly depends on the balance of these three forces. The pressure in the feeding port and in the check port are identical and equal to the line pressure provided by the rail when the injector is not energised. In these conditions: $F_c + F_e > F_a$

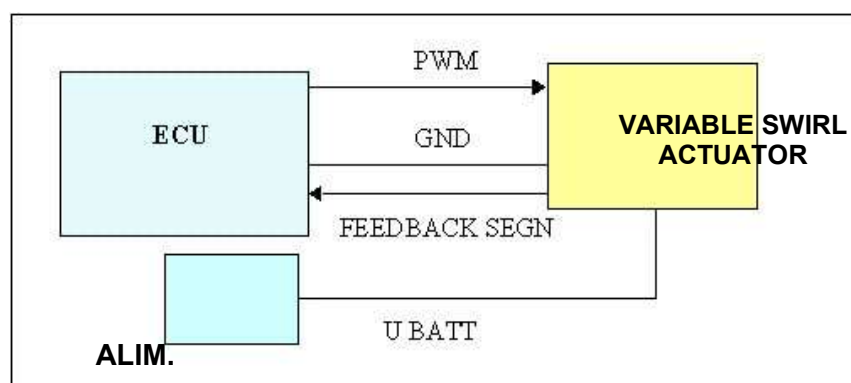
IMA injector classification



Injectors are inspected and the characteristics in various conditions of pressure/flow rate are tested. Any injectors which are not up to standards are eliminated. The injectors that pass the tests are classified with a 9-character alphanumeric code, called IMA code (see arrow in figure above). The code is laser engraved on the top of the injector magnet.

The IMA code of the injectors must be stored in the ECU (using Examiner) after replacing one or more injectors.

Variable geometry intake actuator



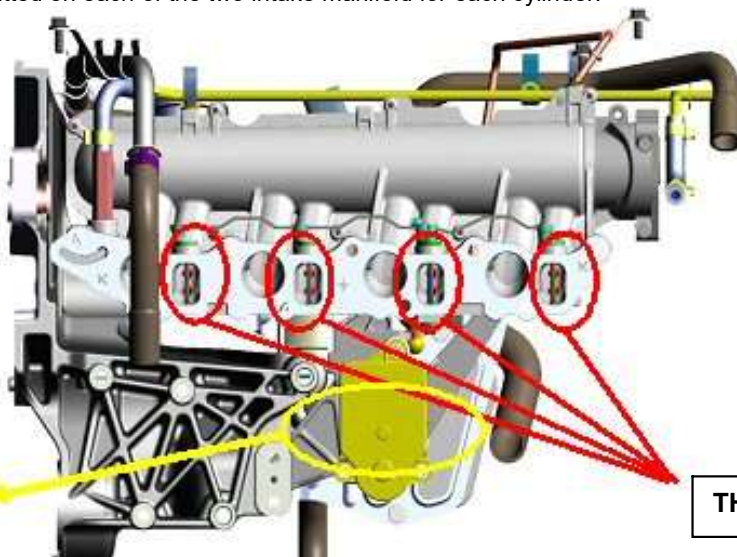
LOCATION: In the engine compartment, connected to the intake manifold.

FUNCTION: To control throttle operation and optimise swirl in the combustion chamber.

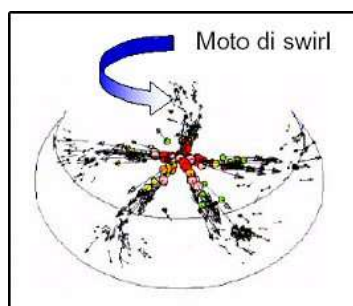
CONSTRUCTION: The variable swirl system essentially consists of:



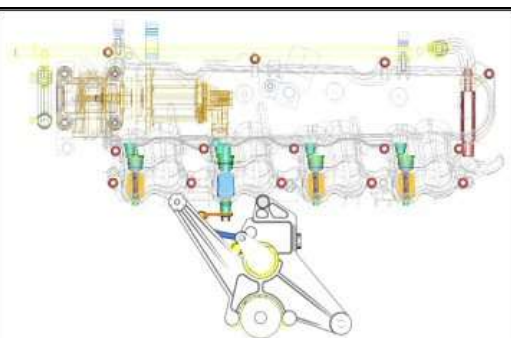
- an electrical actuator controlling the angular position of the throttles on the intake manifold
- a double conduit intake manifold for each cylinder
- a set of throttles fitted on each of the two intake manifold for each cylinder.



What is swirl?



It is the twisting motion of intake air (or air-fuel mixture in Otto cycle engines) around the cylinder axis. Swirl is obtained by appropriate shaping the intake conduits, the valves and the combustion chamber. It is exploited to optimise air mixing with fuel inside the combustion chamber to provide more efficient combustion and consequent reduction of polluting emissions.

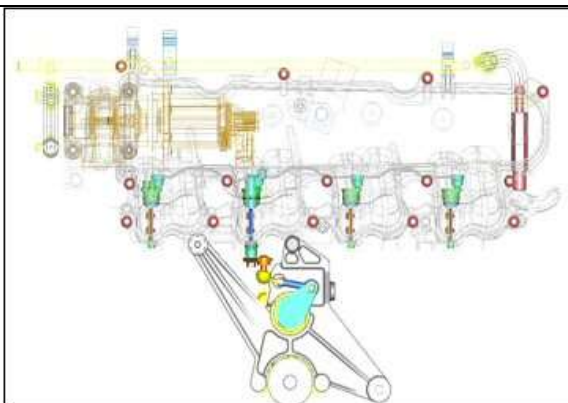


CLOSED THROTTLE

The throttles are closed when idling and at medium engine speeds. The powerplant runs a two-valve per cylinder engine with considerable benefits in terms of volumetric filling and torque at low speeds.

In this condition, the air column has a considerable swirl exploited to optimise mixing with fuel and considerably improve combustion efficiency.



**OPEN THROTTLE**

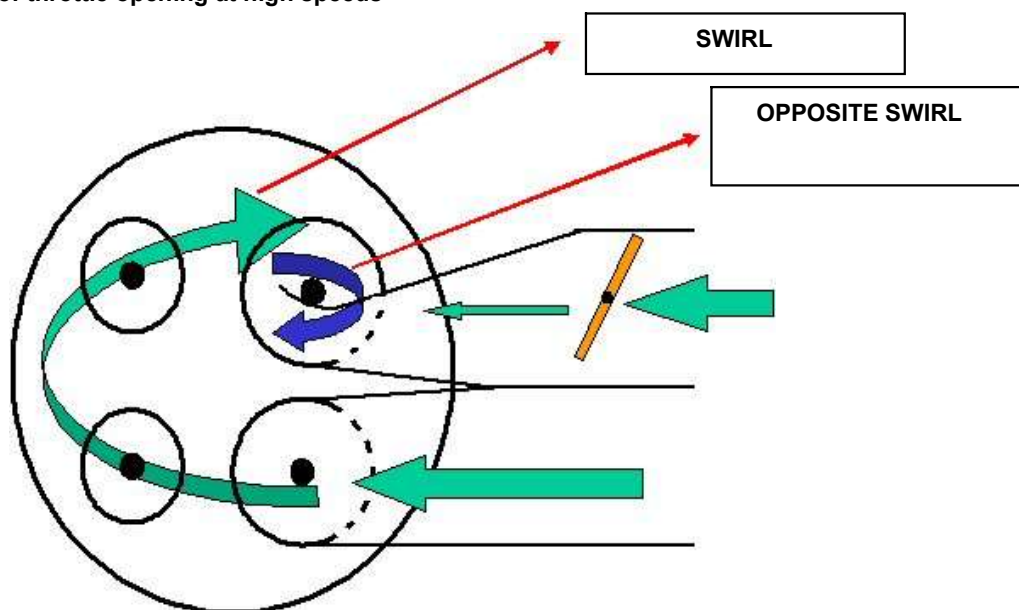
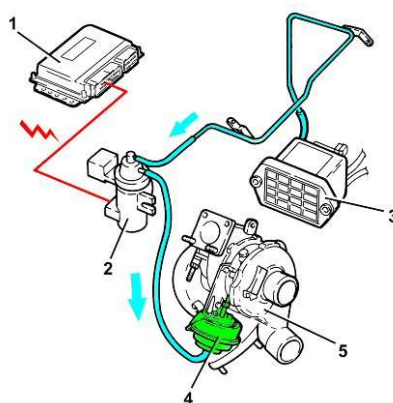
At full load, the engine needs more air flow. The throttles are opened and the powerplant works as a normal four-valve per cylinder engine.

At high speed, the very high speed may create over-swirl: the overlapping of flows generated by the swirl may worsen or even cancel the advantages of swirl.

The column of air introduced by the second conduit (the one with the throttles) has an opposite swirl with respect to that of the primary conduit.

In this way, an opposite air flow is let to the chamber to slow down the swirl in the combustion chamber.

This phenomenon is shown in below.

Effects of throttle opening at high speeds**GARRETT VGT 17 turbo charger**

1. engine ECU
2. VGT solenoid valve
3. vacuum reservoir
4. mobile impeller actuator
5. turbo charger



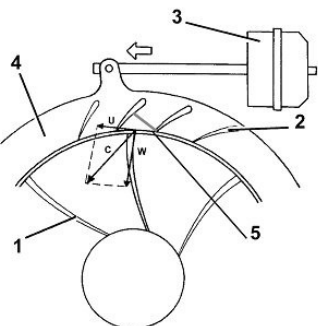
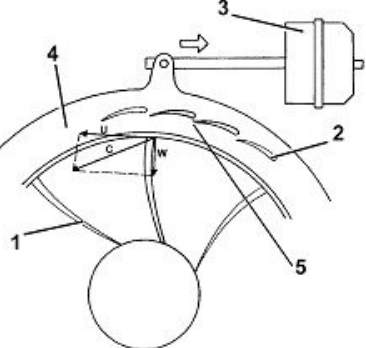
LOCATION: In the engine compartment, connected to the exhaust manifold (turbine side) and to the intake manifold (turbo charger side).

FUNCTION: To increase cylinder filling by providing more air mass given equivalent volume available in the combustion chamber. This is obtained by compressing the air to a pressure higher than atmospheric pressure before it reaches the combustion chamber.

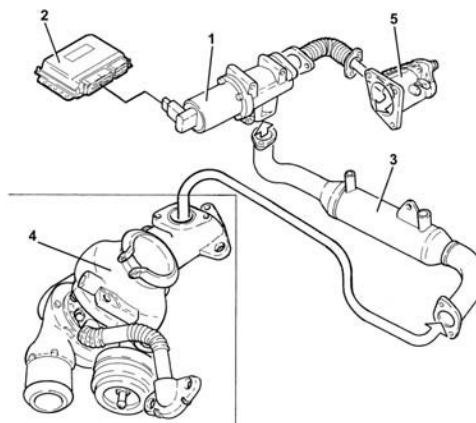
CONSTRUCTION: The variable geometry turbo charger essentially consists of the following parts:

- a turbine driven by exhaust gas appropriately deviated by the mobile distributor vanes
- a centrifuge compressor integral with the turbine that takes air from the intake manifold and accelerates it by impressing a certain kinetic energy that in the scroll is transformed into pressure energy
- a set of mobile vanes that form the turbine distributor
- a pneumatic actuator that controls the angular position of the distributor vanes.

VGT operation

	The exhaust gas kinetic energy progressively increases along with the engine speed. This would increase turbine speed and therefore that of the compressor given equivalent distributor passage proving more supercharging. The vane control actuator intervenes in these conditions (controlled by the ECU that detects increase of supercharger pressure over the allowed limit) to increase the exhaust gas passage than therefore slow them down.
	At slower speeds, the gas has a low kinetic energy which is not sufficient to ensure optimal supercharging pressure. In these conditions, the pallet actuator reduces the exhaust gas passage section and accelerates the gas speed. Higher entrance speed into the turbine cause higher peripheral speeds of the turbine and therefore of the centrifuge compressor.
1. Turbine 2. Vanes 3. Pneumatic actuator	4. Rotating ring 5. Passage section



Exhaust gas recirculation system

1. EGR solenoid valve
2. injection ECU
3. heat exchanger
4. exhaust manifold
5. throttle body

FUNCTION: The EGR system aspirates a variable part (from 5 to 15%) of the exhaust gas in certain conditions of operation. This lowers the maximum combustion temperature to under 1800°C when NO_x is formed in lean mixture conditions. The EGR solenoid valve controlled by the ECU lets some exhaust gas from the exhaust manifold back into intake. A heat exchanger partially cools the exhaust gas and additionally lowers the temperature in the combustion chamber.

OPERATION: The engine ECU controls the EGR solenoid valve with a PWM signal when the coolant temperature is > 20°C and the engine speed is in the range from 800 and 3000 rpm. The changes in the duty cycle of the signal moves the actuator to control the burnt gas flow from the exhaust manifold to the intake manifold. The result is two-fold:

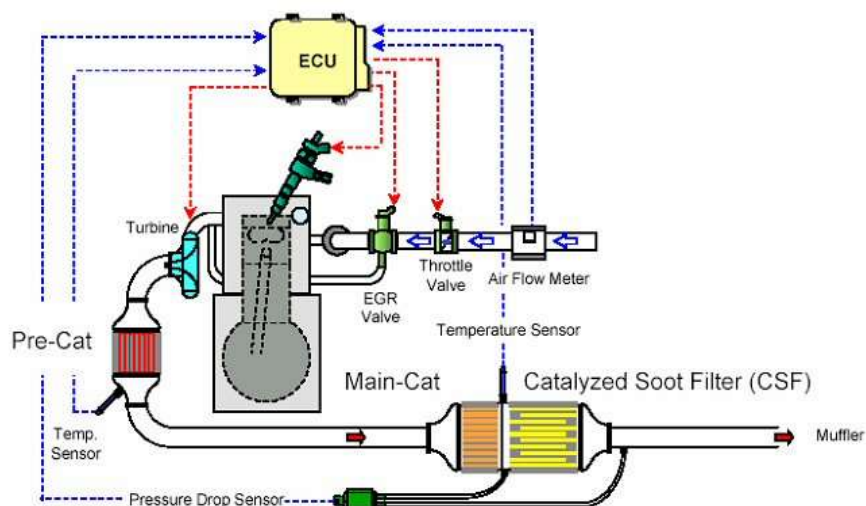
- less air is let into the engine;
- the firing temperature is lowered due to the presence of inert gas consequently reducing the formation of NO_x.

The ECU can calculate the amount of air recirculated to compare the theoretical intake mass for the various engine running conditions (value stored in mapping) and the real intake mass that crosses the air mass meter (and is therefore measured).

DPF particulate trap

The DPF (Diesel Particulate Filter) is a particulate abatement system fitted aboard Fiat Group diesel engines.



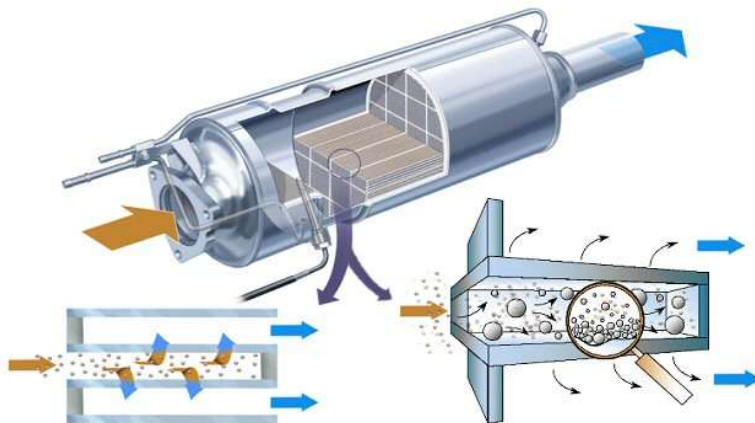


The DPF system consists of:

- DPF
- sensor and actuators
- specific engine ECU strategies.

The trap is an accumulation system that must be regularly regenerated (cleaned) by burning the particles of particulate in the filter whose quantity is calculated by the ECU by applying an algorithm. The ECU uses multiple injection to increase the exhaust gas temperature to $\sim 600^{\circ}\text{C}$ and burn the particulate.

The DPF abates emissions of particulate to 90% during NEDC test cycle (from 0.025 g/km to 0.001 g/km in compliance with Euro 4 limits).



The trap is an accumulation system that must be regularly regenerated (cleaned) by burning the particulate in the filter. There are essentially two regeneration technologies:

With additive

The additive technology is patented by PSA under the name FAP ('Filtre A Particules').

The additive is a catalyser liquid which is used to burn the particulate in the trap at lower temperatures $\sim 500^{\circ}\text{C}$.

Advantages

Lower regeneration temperature
Shorter regeneration time

Disadvantages

More complex architecture



Need to replace the trap and top up additive every 120 thousand kilometres.

Without additive

FA has developed a proprieter technology employing multiple injections to sufficiently increase gas temperature to $\sim 600^{\circ}\text{C}$ and burn the particulate.

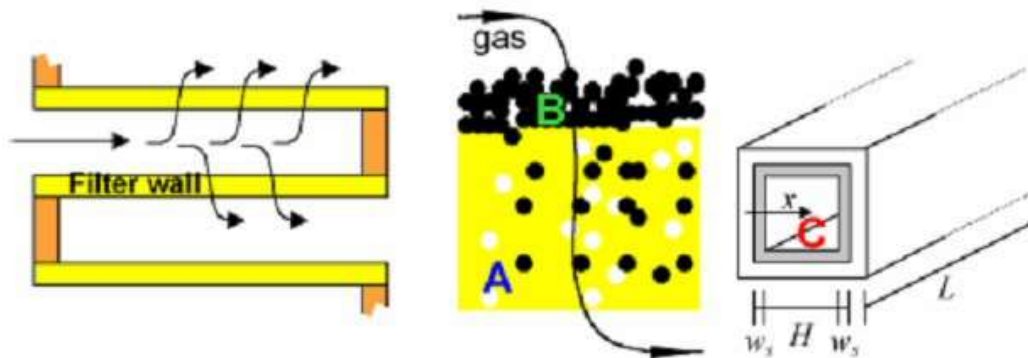
Advantages

More simple architecture
More reliability due to lower thermal gradients
Lower maintenance costs

Disadvantages

Higher regeneration temperature
More oil dilution

Operation



When exhaust gas enters the DPF trap, the internal channel in the element closes and the gas crosses section A accumulating in the filtering element. After this, the particulate accumulates and a substrate starts forming in section B dividing the gas passage from the filtering element.

The accumulation of particulate obstructs the passage of exhaust gas (section C) to raise the pressure detected by the respective differential pressure sensor by reading the DPF input and output pressure and measuring the exact absolute difference between the two values.

The particulate accumulation process and respective increase of exhaust gas pressure inside the DPF depends directly on:

- vehicle weight
- engine displacement and power
- engine emission profile.

Regeneration process

The filter is regenerated by taking the exhaust gas at DPF input to $>580^{\circ}\text{C}$ with an O_2 content of $> 5\%$.

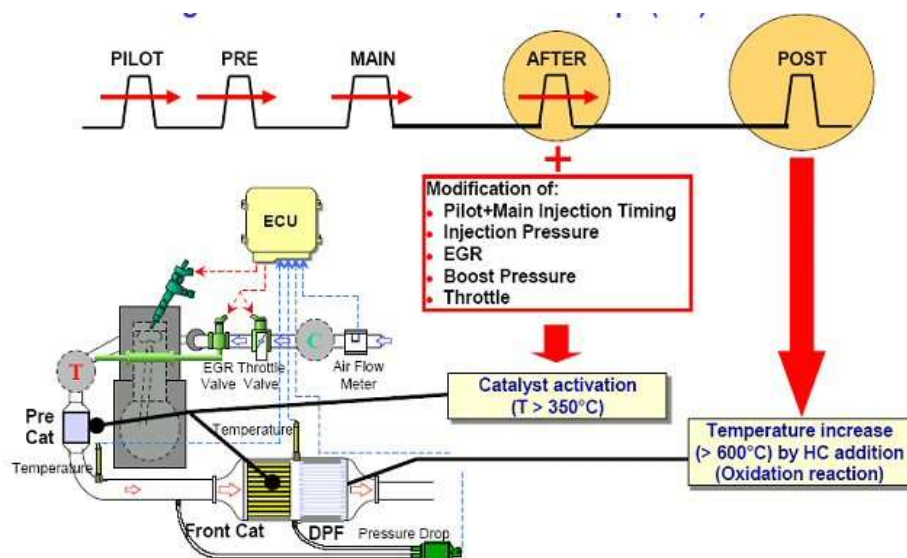
The engine ECU controls the process by:

- metering diesel (up to 5 injections in the cycle per cylinder)
- controlling air (EGR, supercharger pressure).

The generation pressure can last from 8 to 12 minutes according to the vehicle type and level of obstruction. During this phase, the specific calibration of the engine ensures that there is no disruption of output torque with respect to normal operation. The driver will not be aware of the process and regeneration will be maintained active in all engine running conditions.



The process is explained in the following graph:



Instrument panel:

The MIL and DPF warning lights are present on the instrument panel.

The MIL is fitted in all outfits; the DPF can be replaced by a message on the display according to the versions.

The warning light (where fitted) is activated for approximately 20 seconds to indicate that the trap is full. MIL and DPF warning light (or message) management is governed by the engine ECU.

DPF warning light/message management:

The DPF warning lights and/or message informs the driver that a certain drive cycle (speed > 40 km/h for at least 15 consecutive minutes, as shown in the Owner's Handbook) is required for the regeneration system to work. The DPF will continue to accumulate particulate if the spontaneous regeneration conditions are not reached and the warning light and/or message will stay on.

The DPF warning light is managed according to the number of interrupted regenerations (this threshold can be calibrated by the ECU) and will inform the driver that spontaneous regeneration is either needed or not possible. In the latter case, forced regeneration according to the respective procedure at a workshop is required. No performance limiting recovery mode is envisaged. The error codes are not stored in the ECU memory.

MIL management:

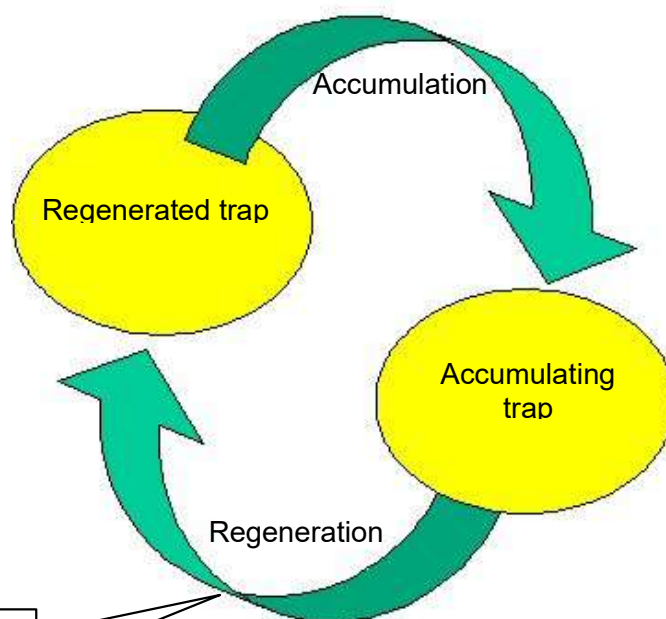
The MIL will light up when the 250% threshold is reached to indicate the need to have the trap regenerated at a workshop by applying the forced regeneration procedure. In this case, error code P1206 will be stored in memory and slight limitation of performance will be implemented by the recovery system. In these conditions, the system manages normal regenerations according to conditions. After exceeding the 250% threshold and reaching 300% of particulate accumulation, code P2002 is stored in the memory to indicate that the particulate trap, exhaust system and engine are at risk. Performance is dramatically limited to prevent damage to the system. In such conditions, the only option is to attempt to regenerate the trap by means of the forced regeneration procedure. The possibility of regenerating during vehicle use is factually eliminated.

Regeneration process flow

The system will work on two permanent working stages:

- Accumulation
- Regeneration





Spontaneous regeneration occurs when:
[Vehicle speed > 40km/h for at least 15 minutes;
Particulate mass charge < 200%]

Regeneration is managed fully autonomously by the engine ECU according to:

- **regeneration needs**
- **enabling conditions**

Oil

The use of delayed oil injections to regenerate the trap decreases the oil level in the sump. The oil replacement frequency therefore differs from that shown on the service schedule and becomes flexible (15 thousand - 50 thousand km).

- The driver is informed of the need to change the oil and given a 1000 km notice.
The quality parameter must be reset after changing the oil. This is only possible at dealer workshops.

Force regeneration at dealer workshop

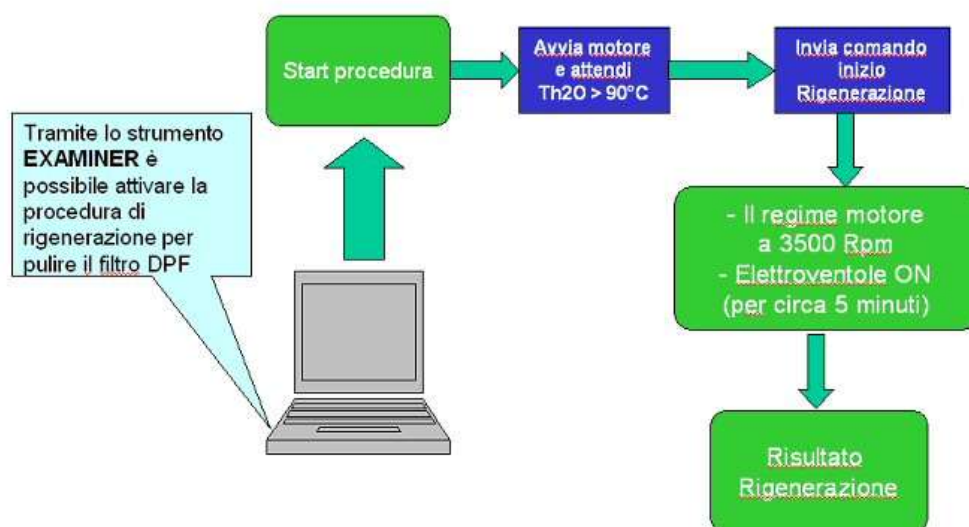
The DPF must be regenerated by a dealer workshop by means of the "forced regeneration" procedure when obstruction exceeds 250% (MIL on). This procedure must be run that the workshop by trained personnel in a controlled fashion because:

- it must not be interrupted once started to prevent damage to the internal parts of the filter
- it causes a considerable generation of heat and possible emission of smoke which could concern the customer who may stop the regeneration procedure before it is completed.

Examiner is needed for forced regeneration.

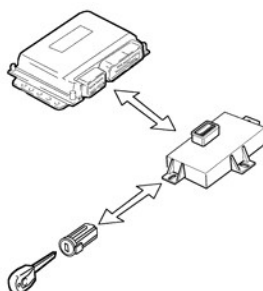


Rigenerazione forzata con l' EXAMINER

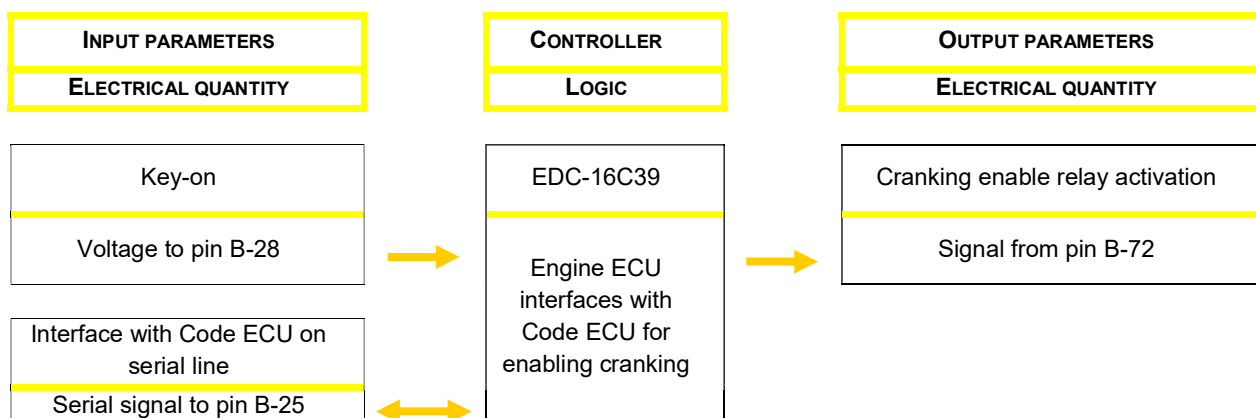


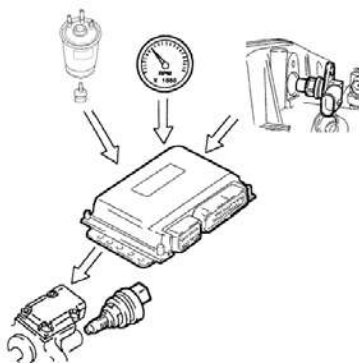
Bosch EDC-16C39 ECU logic

Alfa Code recognition

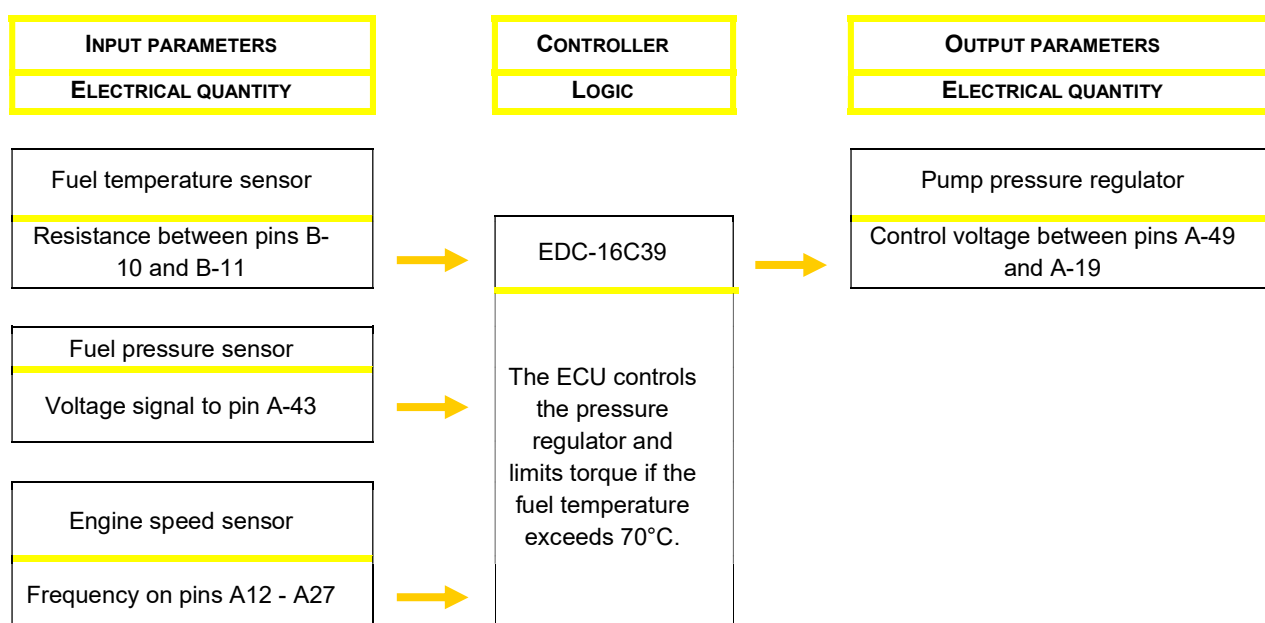
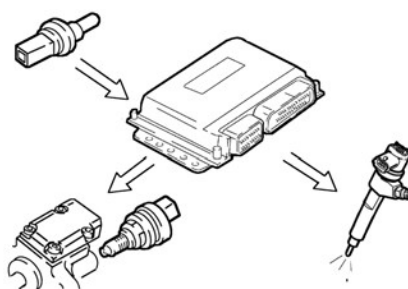


The ECU interfaces with the body computer at key-on to implement the Fiat Code function and enable cranking.



Fuel temperature control

The ECU controls the pressure regulator to reduce line pressure (without changing the injection times) if the fuel temperature reaches 80°C (measured by the sensor in the recirculation manifold).

**Engine coolant temperature control**

The ECU implements the following procedure when the engine coolant temperature exceeds 105°C:

- injected fuel amount is reduced (engine power is reduced);
- cooling fans are operated;
- coolant temperature warning light is switched on.



INPUT PARAMETERS

ELECTRICAL QUANTITY

CONTROLLER

LOGIC

OUTPUT PARAMETERS

ELECTRICAL QUANTITY

Engine coolant temperature
sensorResistance between pins A-41
and A-58

EDC-16C39

The ECU controls the
pressure regulator,
fans and warning light
if the coolant
temperature exceeds
105°C.

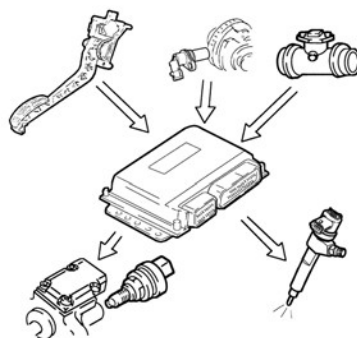
Pressure regulator

Control voltage between pins: A-
49 and A-19

Cooling fans

Voltage to pins:
B-69 and B-90

Injected fuel amount control



According to the signals from the sensors and the mapped values, the ECU:

- controls the pressure regulator;
- adapts the pilot injection times for all engine speed ranges;
- adapts the main injection time.

INPUT PARAMETERS

ELECTRICAL QUANTITY

Accelerator pedal sensor

Voltage signal to pins:
B-31 and B-9

CONTROLLER

LOGIC

EDC-16C39

According to the signals from the
sensors and the mapped values,
the ECU:

- controls the pressure
regulator
- varies injection time by
controlling four different
pilot and main injections.

OUTPUT PARAMETERS

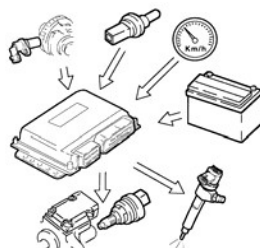
ELECTRICAL QUANTITY

Pump pressure regulator

Control voltage between
pins: A-49 and A-19

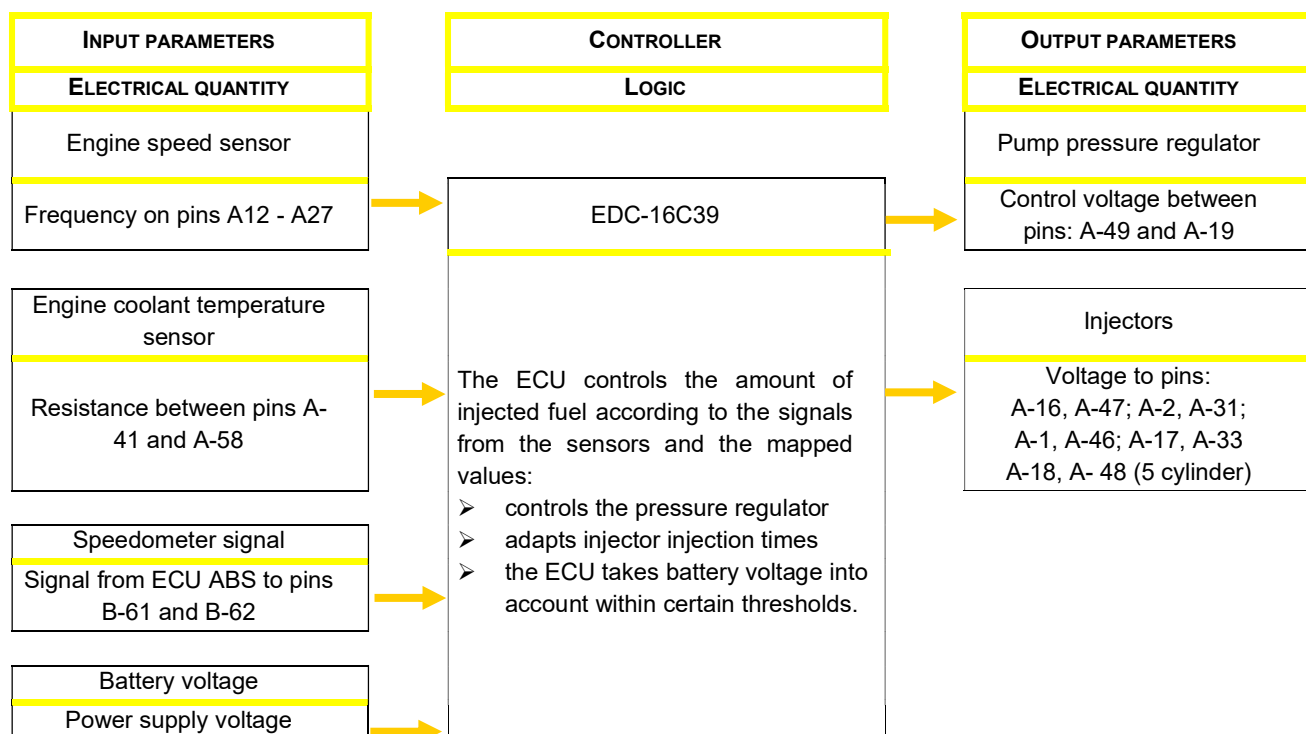
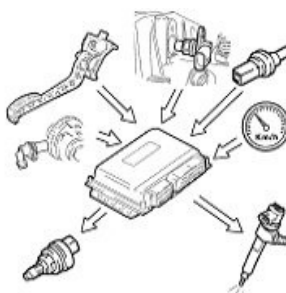
Injectors

Voltage to pins:
A-16, A-47; A-2, A-31;
A-1, A-46; A-17, A-33
A-18, A- 48 (5 cylinder)

Idling speed control

The ECU process the signals from the various sensors and adjusts the amount of injected fuel and:

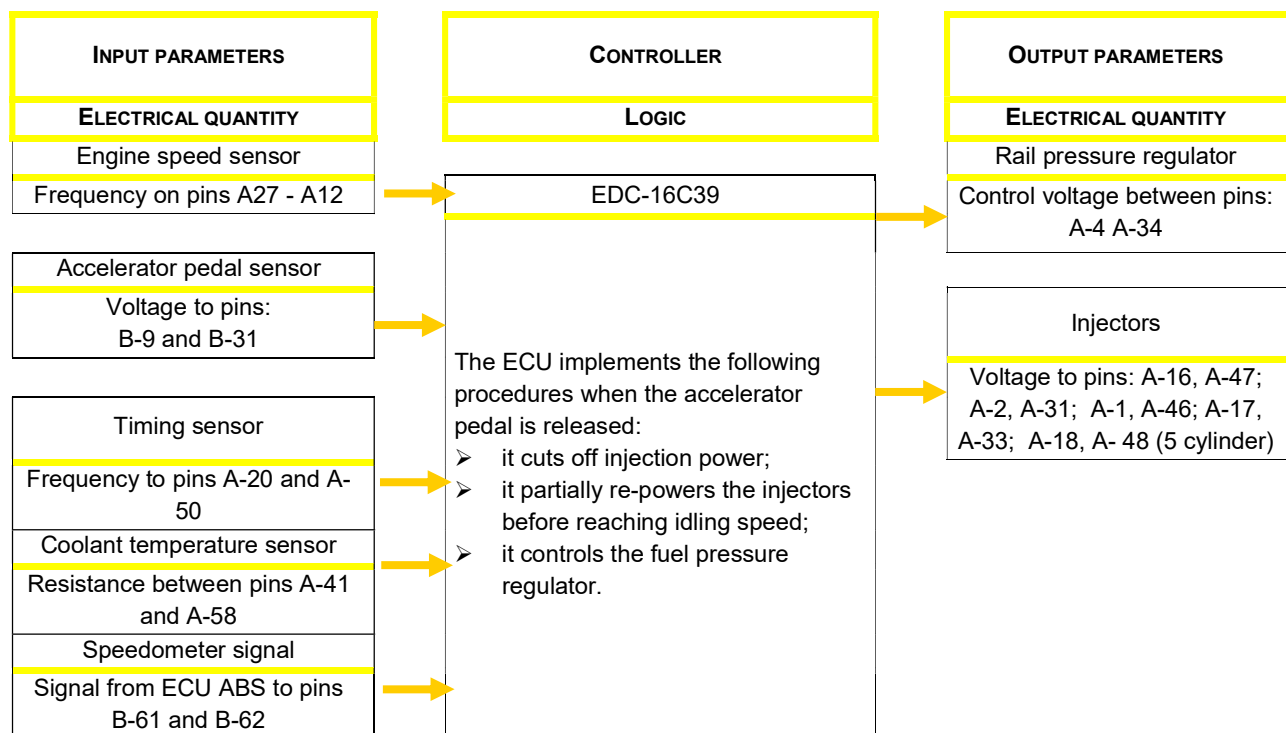
- controls the pressure regulator;
- adapts injector injection times.

**Fuel cut-off**

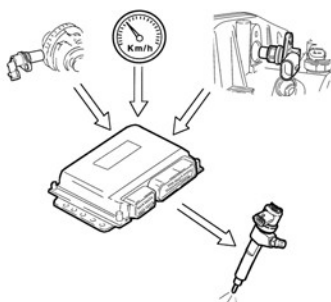
The ECU implements the following procedures when the accelerator pedal is released:

- it stops supplying the injectors and partially resumes supply before reaching idling speed;
- controls the fuel pressure regulator on the rail.

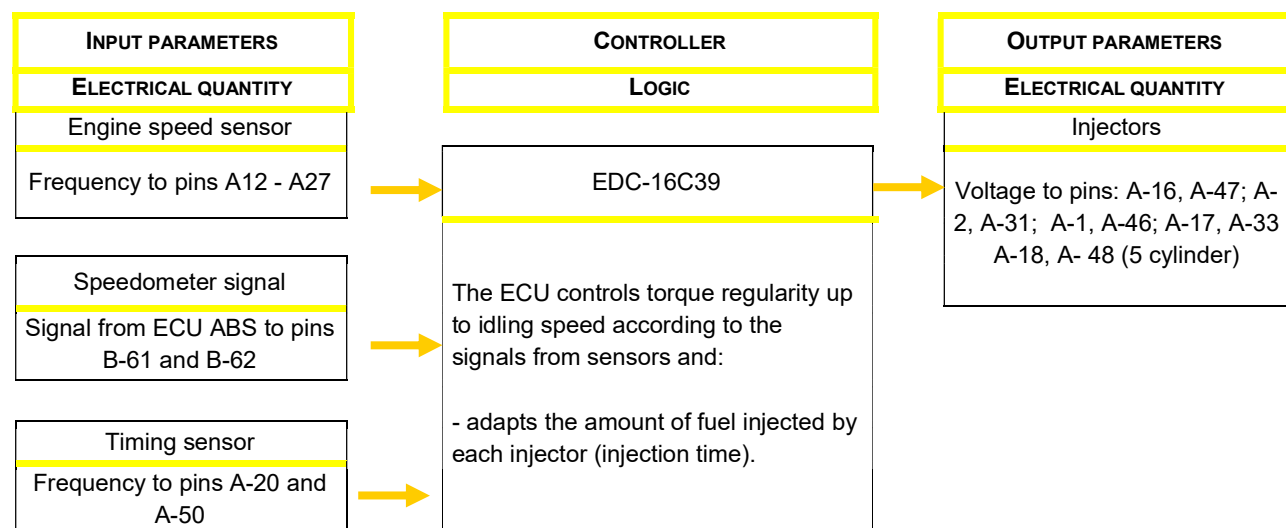


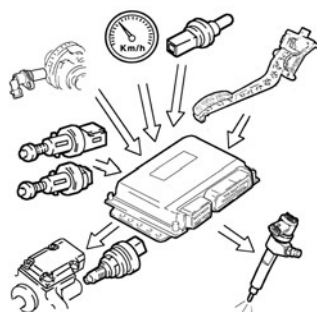


Cylinder balance control up to 3500 rpm

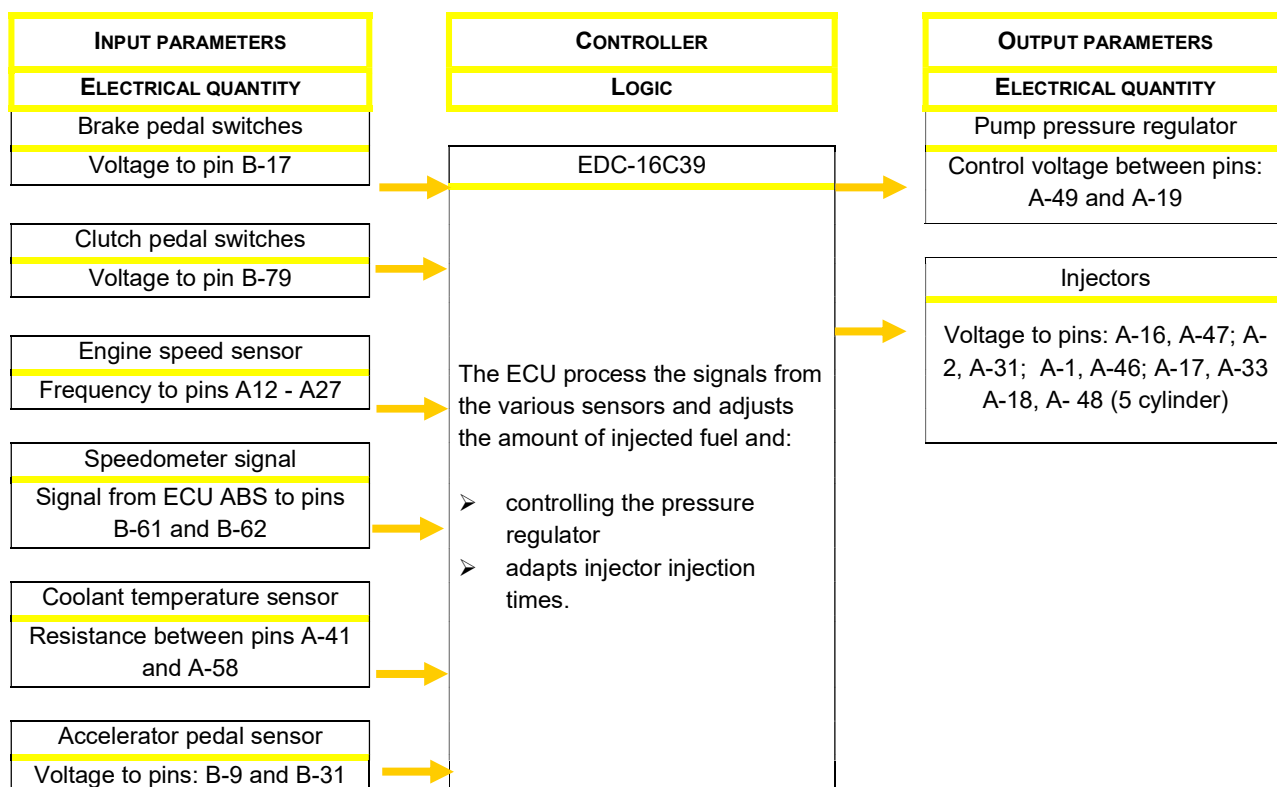
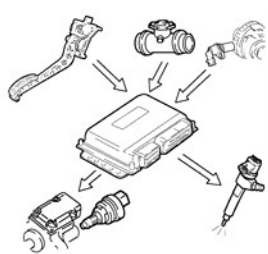


The ECU according to the signals received from the signals controls torque to 3500 rpm and varies the amount of fuel injected into the injectors (injection time).



Anti-sawing control

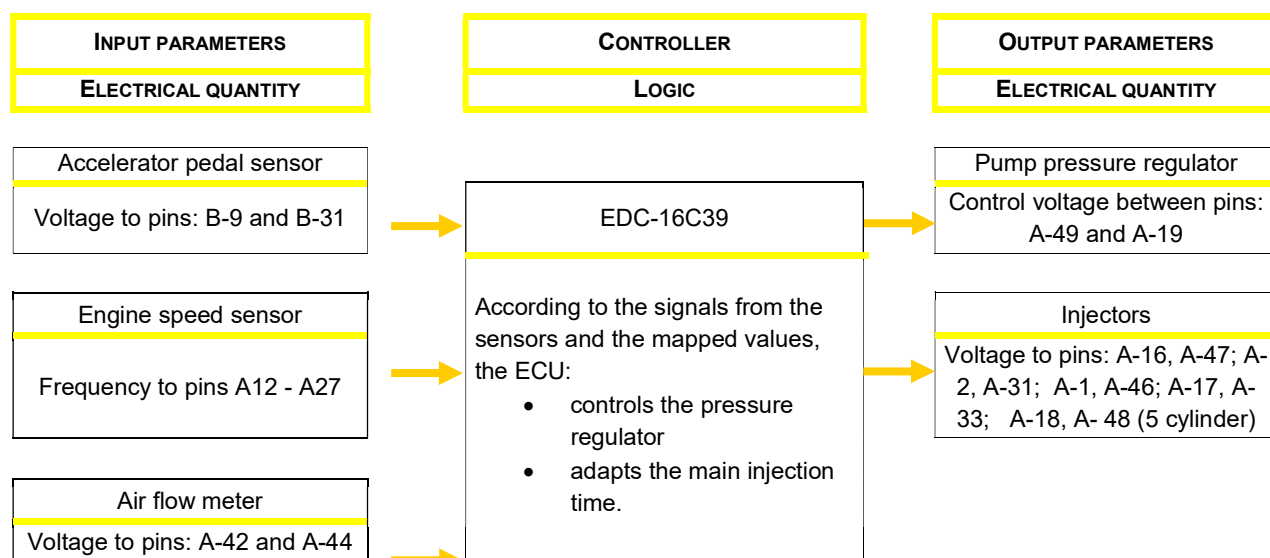
The ECU processes the signals from the various sensors and corrects the amount of fuel to be injected to improve handling and reduce jerking by adapting the injector operating time.

**Exhaust smokiness control during acceleration**

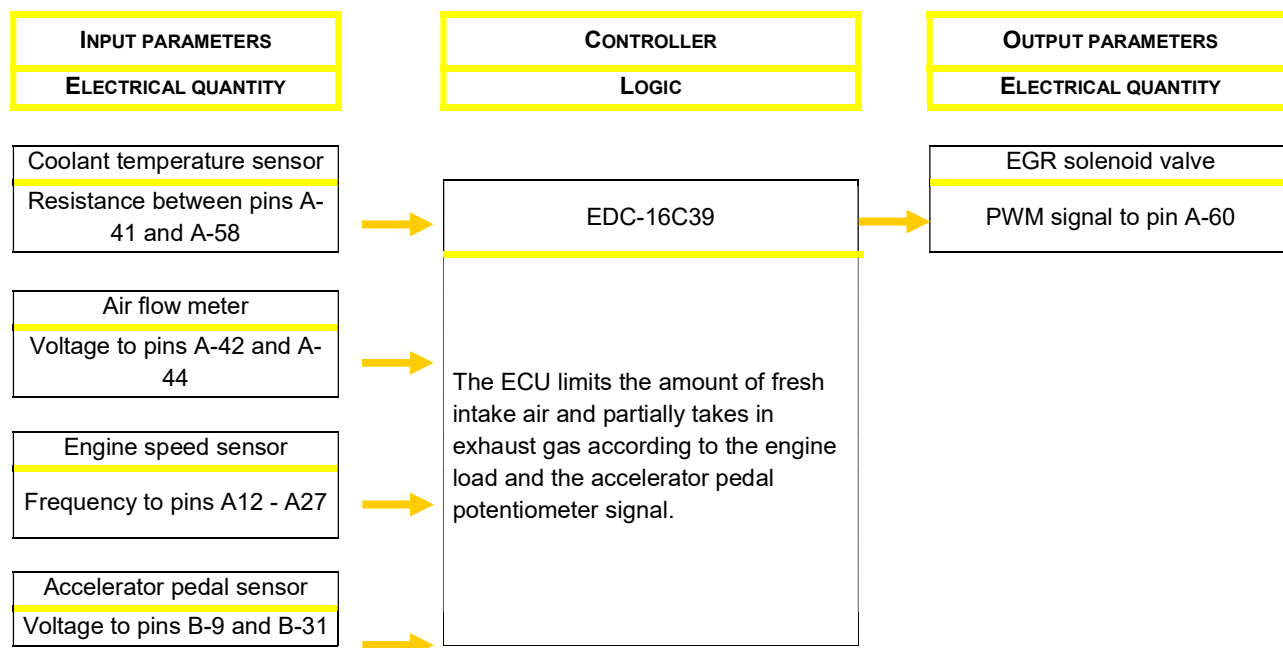
The ECU limits the amount of fuel to be injected to limit smokiness in exhaust during fast changes according to the signals received by the accelerator potentiometer, air flow meter and rpm sensor; specifically, the ECU:

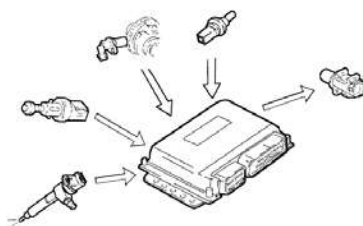
- controls the pressure regulator
- adapts injector injection times.



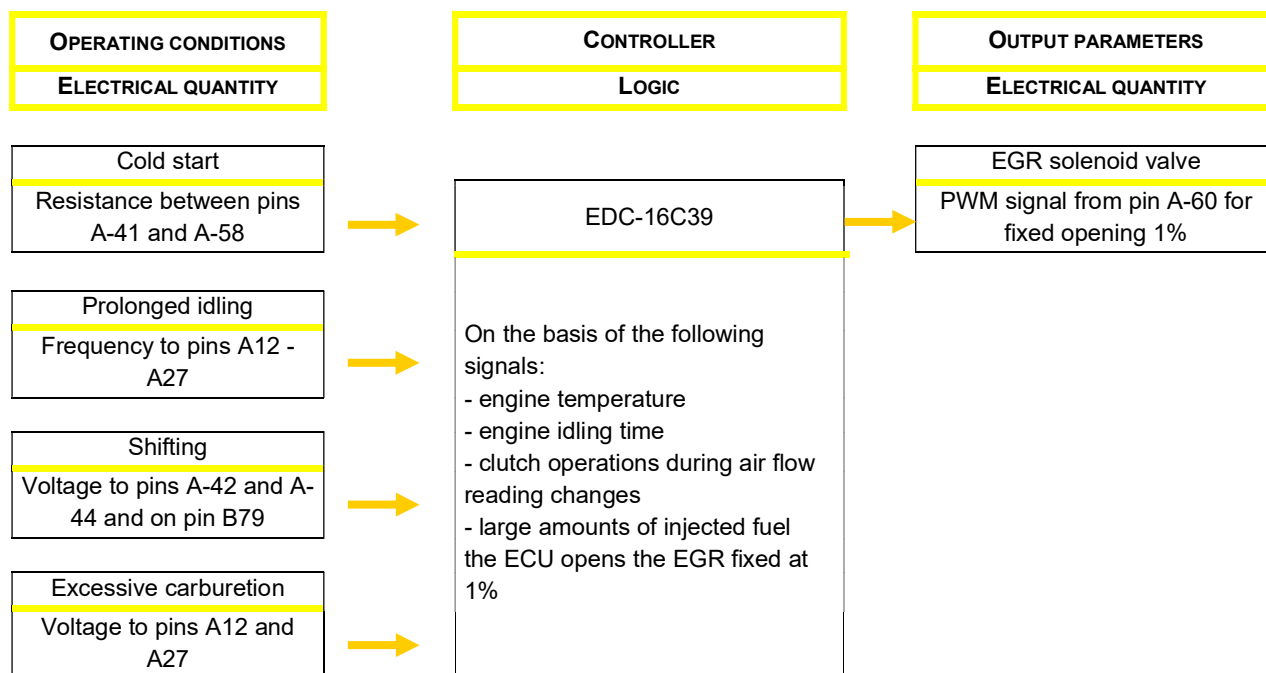
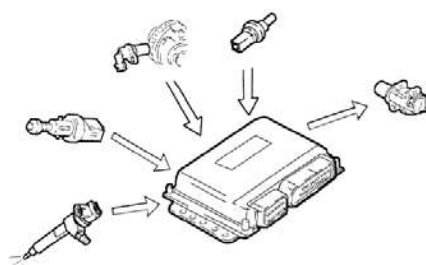
**Exhaust gas recirculation (EGR) control**

Implementing EURO 4 anti-pollution standard, the ECU limits the amount of fresh intake air and partially takes in exhaust gas according to the engine load and the accelerator pedal potentiometer signal; specifically the ECU:



Air control cut-off

The EGR valve is opened by 1% in the following cases for this strategy:

**Air control cut-off**

The EGR valve is opened by 1% in the following cases for this strategy:



OPERATING CONDITIONS

ELECTRICAL QUANTITY

Cut-off

Voltage to pins:
B-9 and B-31
Frequency to pins A12 - A27

Key-off

No voltage from + 15 and
frequency to pins A12 - A27

Cold start

Voltage on + 15 and
resistance between pins A-
41 and A-58

Air mass meter deviation

Voltage to pins A12 and A27

CONTROLLER

LOGIC

EDC-16C39

On the basis of the following
signals:
- cut-off input
- engine stopping
- cold cranking
- air mass meter deviation
the ECU opens the EGR fixed at
1%

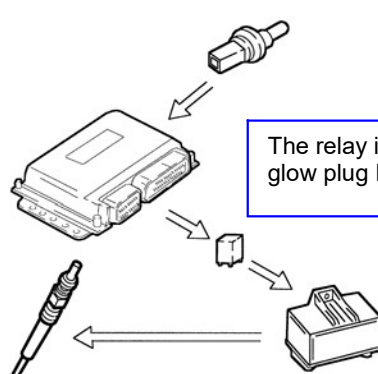
OUTPUT PARAMETERS

ELECTRICAL QUANTITY

EGR solenoid valve

PWM signal from pin A-60 for
fixed opening 1%

Glow plug control



The relay is built into the
glow plug ECU

The injection, ECU during cranking and post-cranking phases, times operation of the glow plug ECU according to engine temperature **if $T < 0$ degrees**.

INPUT PARAMETERS

ELECTRICAL QUANTITY

Coolant temperature sensor

Voltage between pins:
A-41 and A-58

CONTROLLER

LOGIC

EDC-16C39

During the following phases:

- cranking
- post cranking

the ECU times the operation of the
glow plug ECU according to
engine temperature.

OUTPUT PARAMETERS

ELECTRICAL QUANTITY

Pre-heater ECU

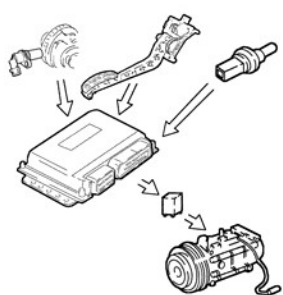
Signal from pins B-72
B-93 and B-52

Glow plugs

Voltage from pins 1-2-3-4 (5
for 5 cylinder) of the pre-
heater ECU

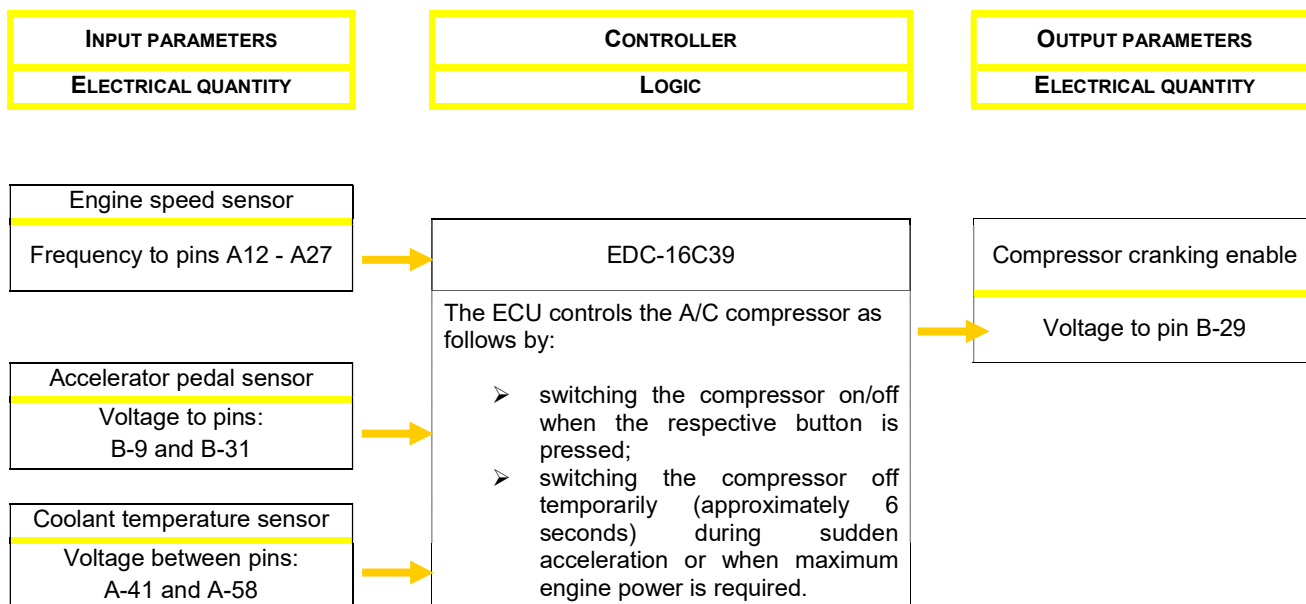
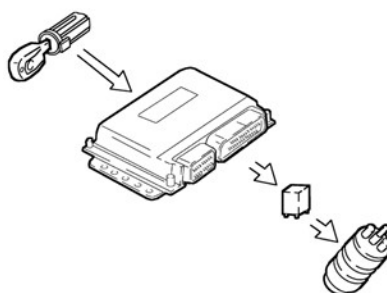




Intake control according to climate control system

The ECU controls the A/C compressor as follows by:

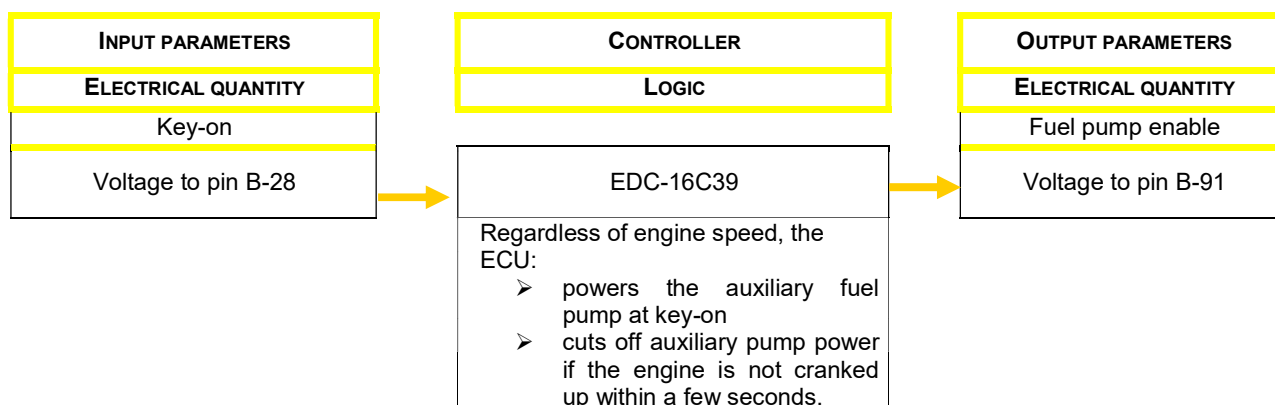
- switching the compressor on/off when the respective button is pressed;
- switching the compressor off temporarily (approximately 6 seconds) during sudden acceleration or when maximum engine power is required.

**Fuel pump control**

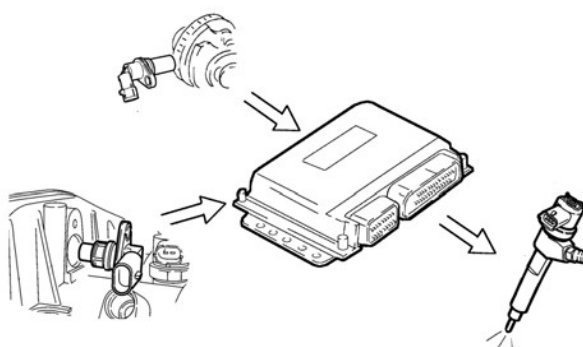
Regardless of engine speed, the ECU:

- powers the auxiliary fuel pump at key-on;
- cuts off auxiliary pump power if the engine is not cranked up within a few seconds.

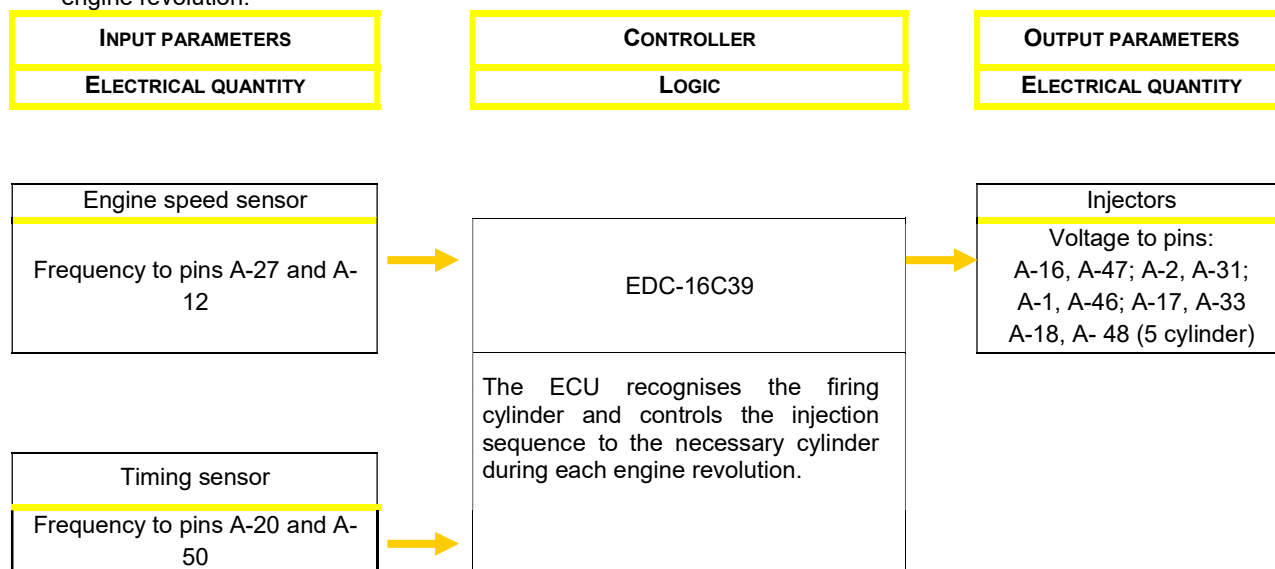


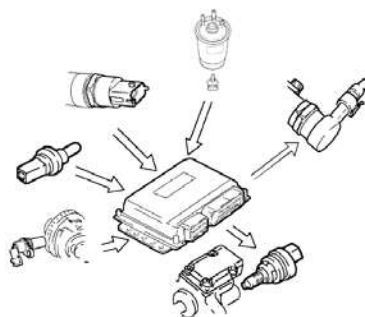


Cylinder position check

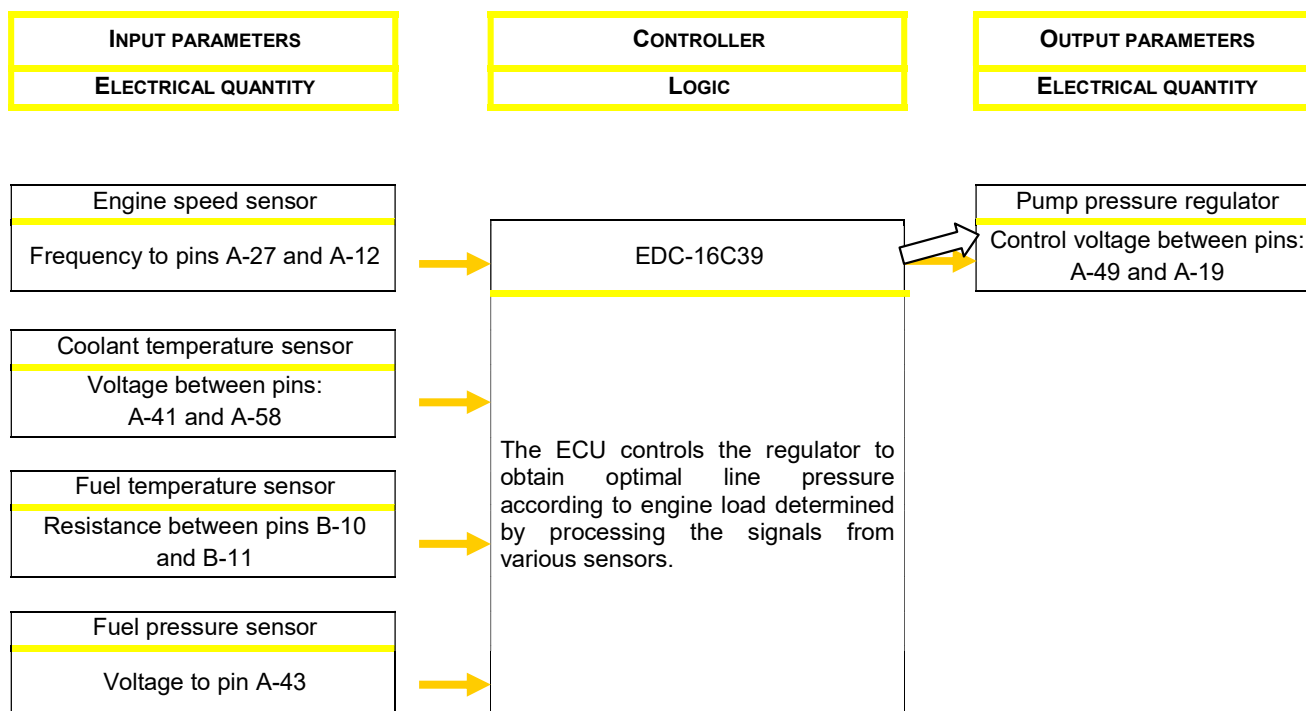
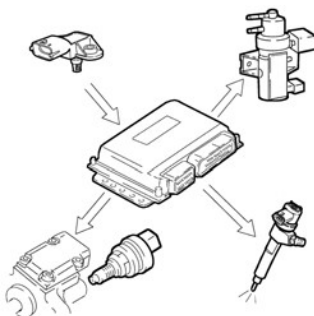


The ECU recognises the firing cylinder and controls the injection sequence to the necessary cylinder during each engine revolution.



Injection pressure closed cycle control

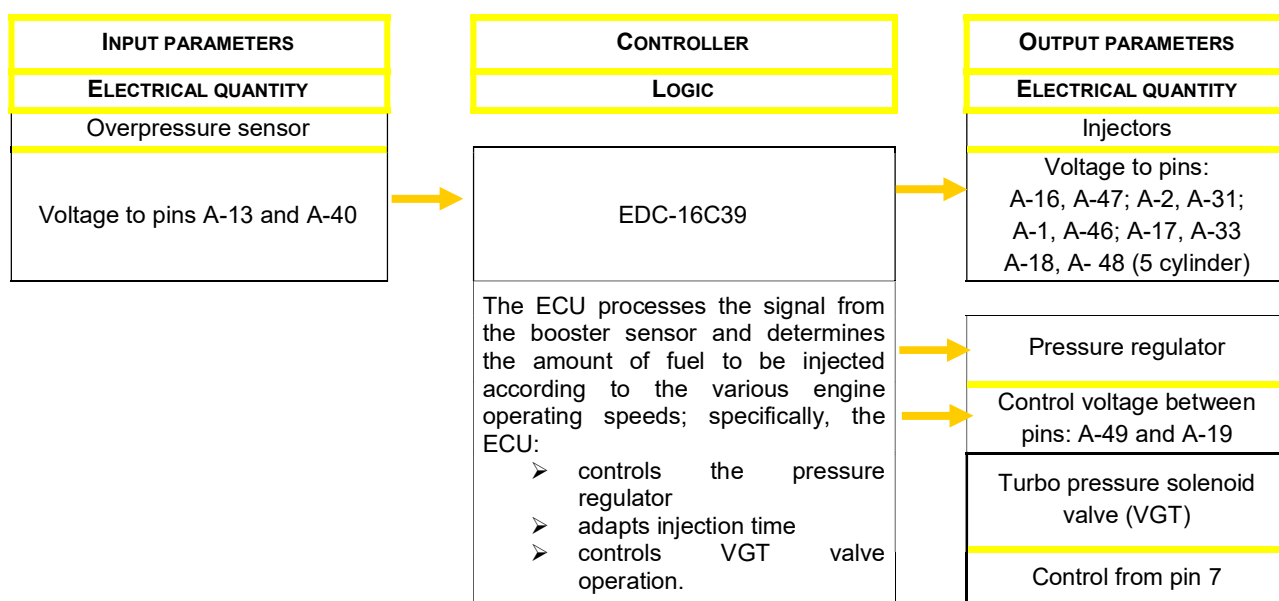
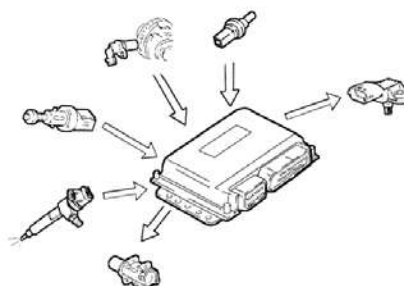
The ECU according to engine load controls the pressure regulator to obtain optimal line pressure.

**VGT variable geometry turbine control**

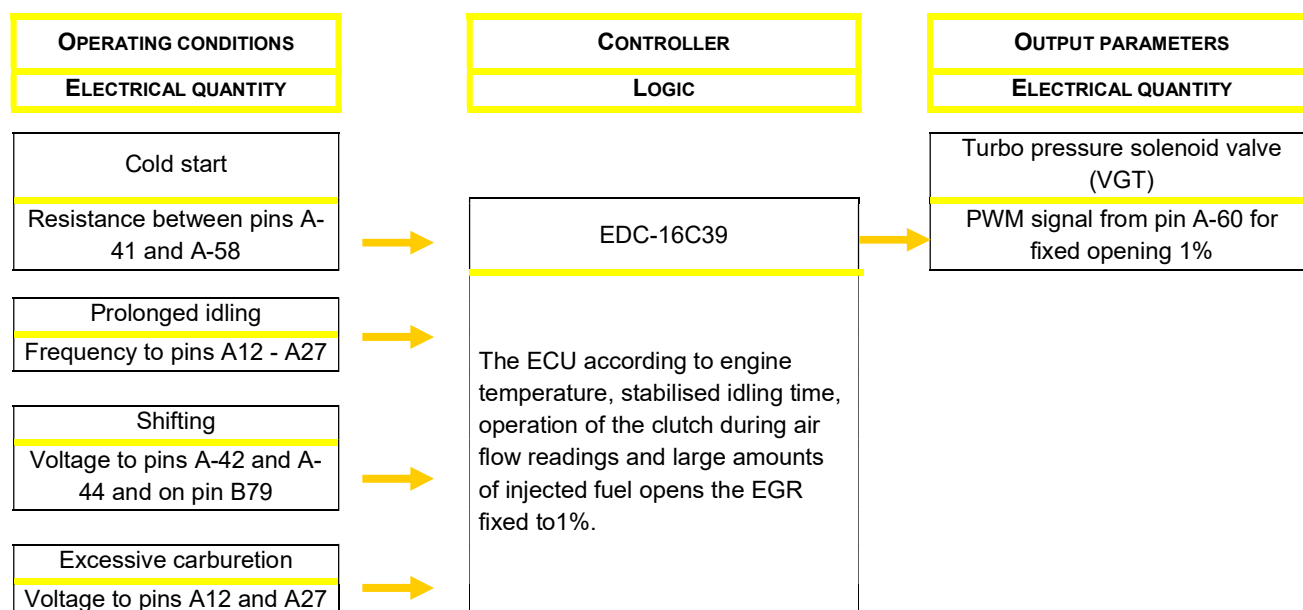
The ECU processes the signal from the booster sensor and determines the amount of fuel to be injected according to the various engine operating speeds; specifically, the ECU:

- injection time signal;
- adjusts turbine geometry to optimise performance in all working conditions.



**Supercharger cut-off**

According to this strategy, the supercharger control in certain engine running conditions is inhibited by setting the allowed supercharger percentage to a preset value.



According to this strategy, the supercharger control in certain engine running conditions is inhibited by setting the allowed supercharger percentage to a preset value.

RECOVERY AND FAILURE CONTROL SYSTEM:

In recovery conditions, can be set to 30%, 40%, 75% (supercharger off).

COLD START:

In this condition, a fixed value is held (supercharger off) for a time calculated according to start-up conditions.

The engine must not reach maximum value.

The calculated time can be very short to the extent that the parameter cannot be visualised with the diagnostic tool.

CLUTCH PEDAL PRESSED:

A fixed value (supercharger off) is set when the clutch pedal is pressed.

VERY LOW ENGINE SPEED:

In this condition, the presence of the turbo charger generates oscillations in the intake air column. This causes turbo charger noise.

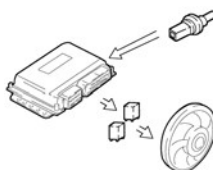
SUDDEN CHANGES FROM HIGH TO LOW ENGINE SPEED:

In this condition, the presence of the turbo charger generates oscillations in the intake air column. This causes turbo charger noise. Note the setting to 30% and then straight back to 75% before being activated again.

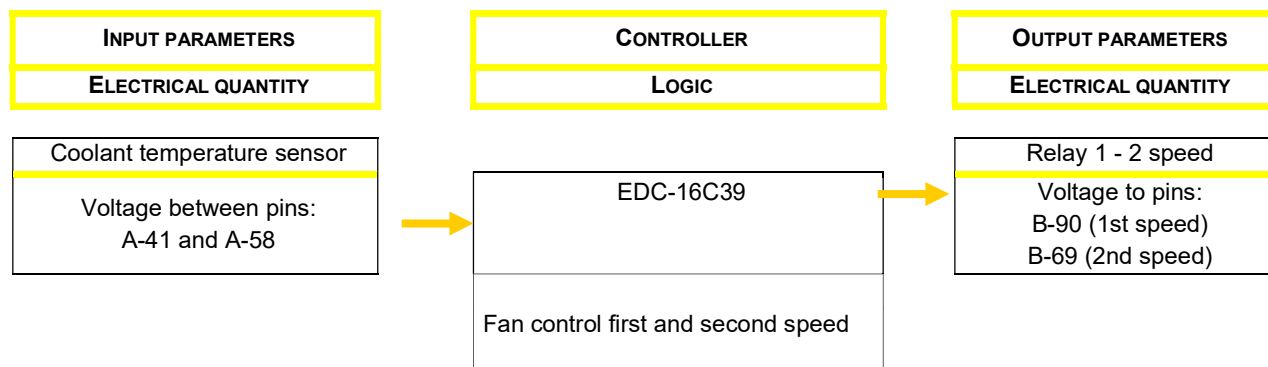
SUDDEN CHANGES FROM HIGH LOAD TO LOW LOAD:

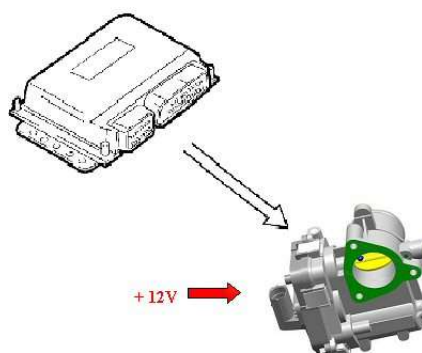
In this condition, the presence of the turbo charger generates oscillations in the intake air column. This causes turbo charger noise.

Fan control

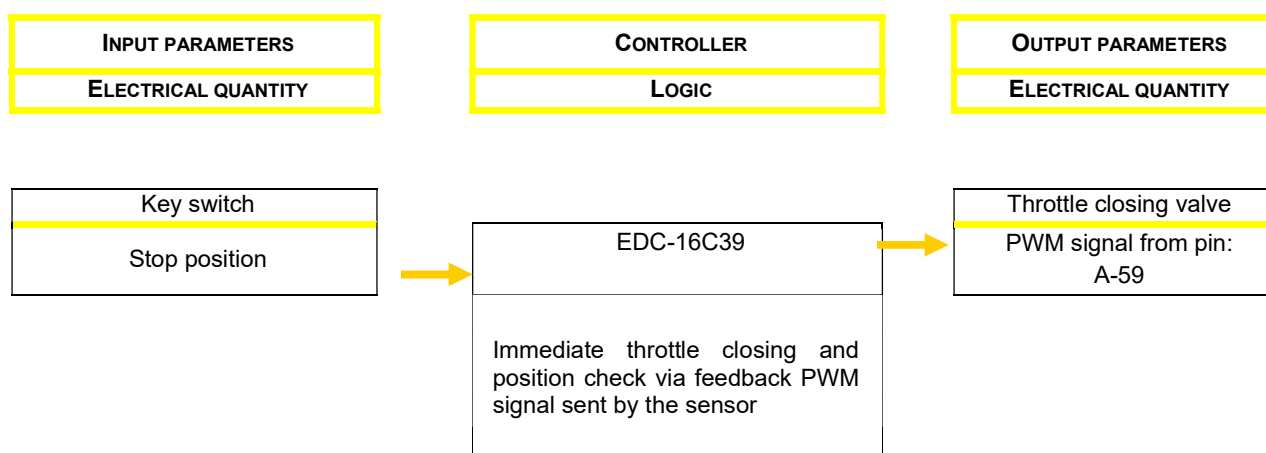
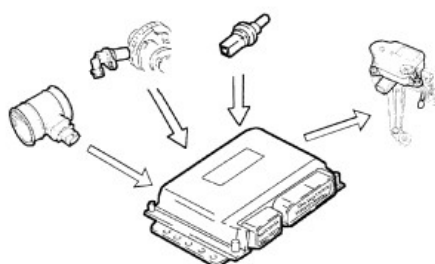


The ECU according to coolant temperature and coolant pressure in the climate control system operates the fans at first and second speed.



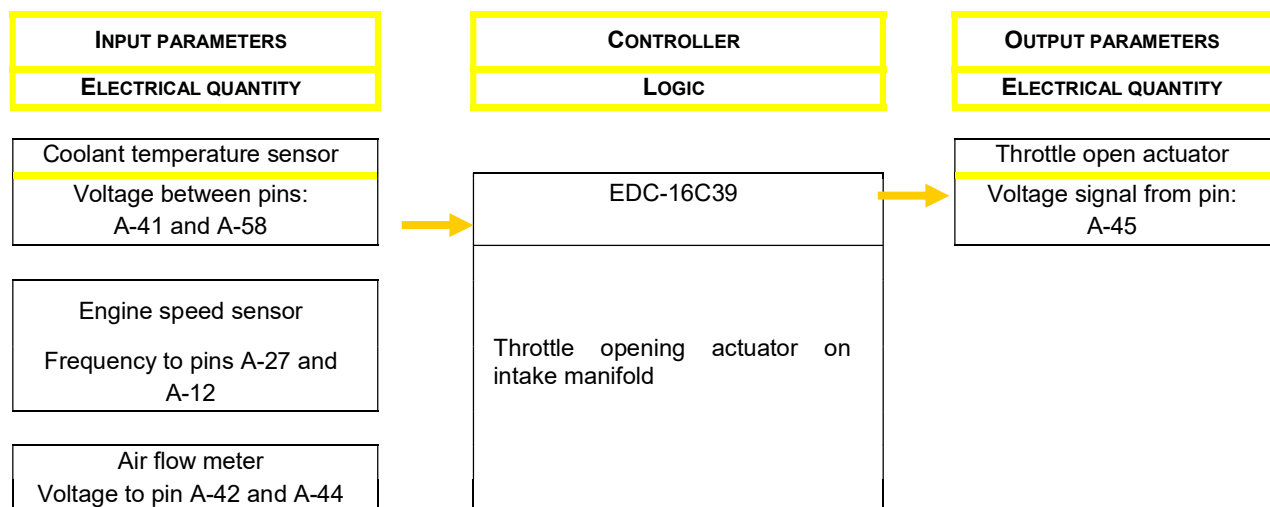
Throttle closing control while stopping

The injection ECU immediately closes the throttle to intake to limit shaking when the engine is stopped. The throttle is in all other conditions.

**Variable swirl actuator control**

To improve volumetric filling and emission control, the ECU manages an electrical actuator that controls the angular position of the throttles on the intake manifold according to engine temperature, engine speed and engine load.





'Oil Life' function

'Oil Life' is a software only function. No specific sensor is used. This strategy informs the driver that engine oil must be replaced.

The kilometrage threshold stored in the ECU is 50,000 kilometres. This function can vary according to use and above all according to DPF regeneration procedures.

During regeneration, post-injections occur during piston downstroke. In this way, the injected fuel reaches the cylinder walls, washing the liner and consequently diluting lubricant. Oil dilution reduces its lubricating power according to the number of regenerations.

The ECU uses software counters to count the distance driven and the number of regenerations. The starting threshold of new oil is set to 50,000 kilometres for distance and 100% for number of regenerations. The oil change warning light will come on when the first of the two counters reaches zero.

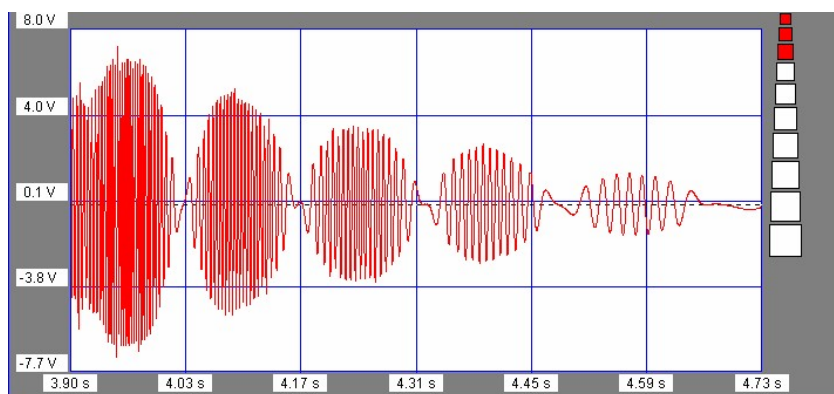
Care is required when replacing or re-flashing the ECU. Oil must be replaced in such cases otherwise the new ECU counters (starting from zero) will not be able to provide the necessary indications for operating the warning light.

The counter parameters must be reset when the oil is changed.

3.2.3 Electrical features of sensor

THE FOLLOWING FEATURES ARE PROVIDED BY THE WAY OF EXAMPLE

Tachometer sensor electrical features



SENSOR FEATURES

Electrical resistance equal to approximately 1 kOhm.

OUTPUT SIGNAL TYPE

Variable alternating voltage, maximum value and frequency proportional to flywheel speed

An oscilloscope or Examiner with SMA (Examiner Smart) module is needed to view the signal, considering its type. Set Examiner as a voltmeter and acquire the signal for approximately 2-5 seconds.

MEASURING METHOD

The graph must show the following characteristics:

- wave amplitude and frequency proportional to each other and to the flywheel speed
- signal modified when sensor reads the missing tooth (every 58 signal peaks).

Timing sensor electrical features

1. ground
2. signal
3. power

SENSOR FEATURES

Hall effect sensor; 5V power from ECU

OUTPUT SIGNAL TYPE

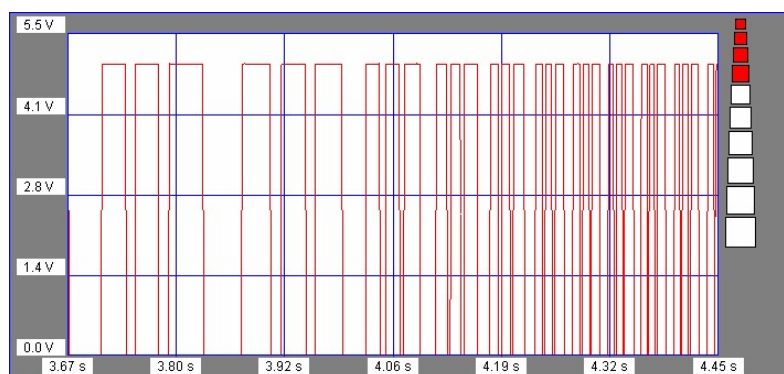
Variable voltage signal in time according to pulse square wave (when sensor meets tooth on pulley);

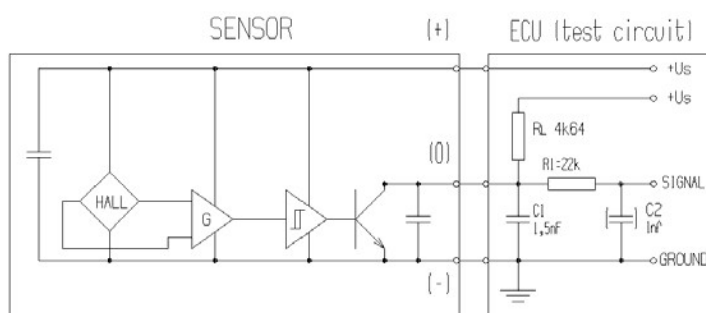
output signal: $0 < V_{out} < 4.5 \text{ V}$

MEASURING METHOD

Given the features of the sensor, the ECU must be powered to pick up the output signal.

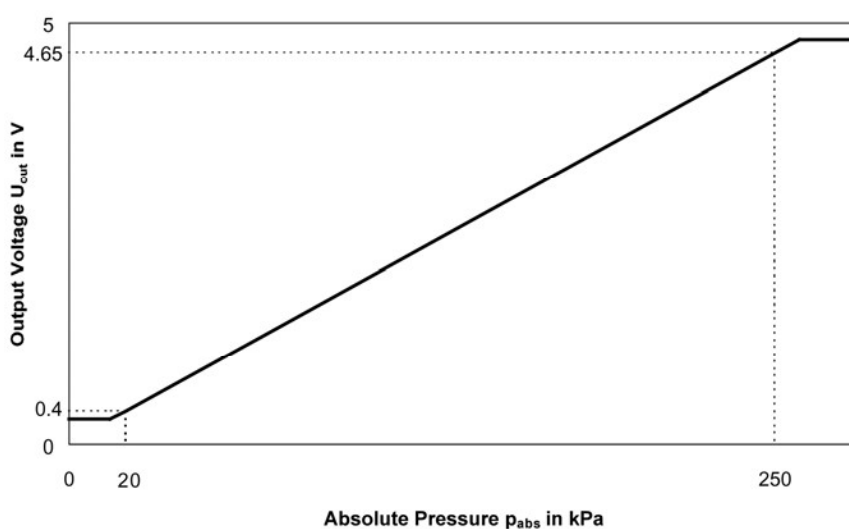
An oscilloscope or Examiner with signal acquisition module is needed to view the signal.

Timing sensor electrical features



PARTICULARITIES: The sensor is provided in electronic circuitry for squaring the Hall effect sensor signal. The connection to the ECU must be maintained to power the sensor correctly. The output signal pattern is that of a square wave.

Supercharger sensor features



SENSOR FEATURES

Double sensor consisting of NTC temperature sensor and piezoelectric pressure sensor.

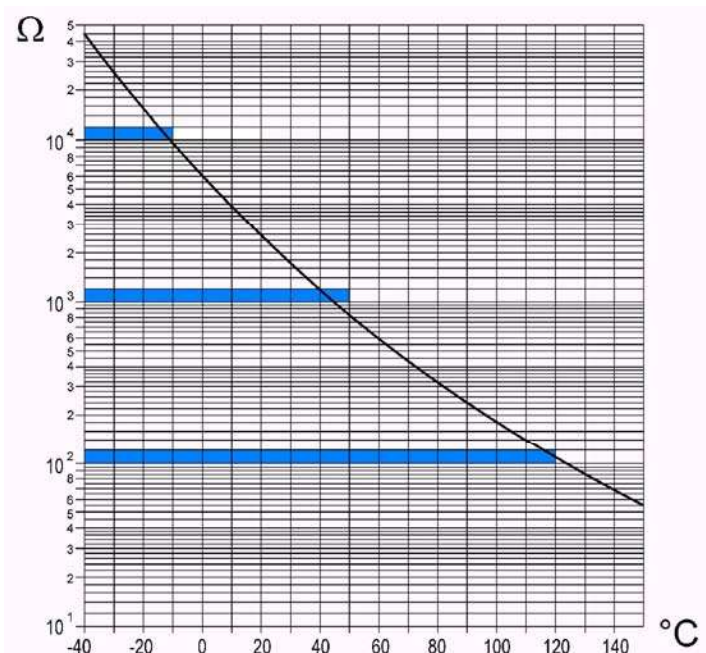
OUTPUT SIGNAL TYPE

Temperature sensor:
variable resistance from ... to ...
Pressure sensor:
variable voltage from ... to ...

MEASURING METHOD

Temperature sensor:
Set multimeter to resistance mode (ohmmeter).
Pressure sensor:
The ECU must remain powered for correct measurement. Set multimeter to voltmeter mode.



Coolant temperature sensor electrical features**SENSOR FEATURES**

NTC thermistor sensor

OUTPUT SIGNAL TYPE

Variable resistance from a maximum of 45kOhm to -40°C (60 Ohm) to 150°C.

MEASURING METHOD

Set multimeter to resistance mode (ohmmeter).

Air mass meter**SENSOR FEATURES**

Double sensor consisting of NTC and hot film sensitive element

OUTPUT SIGNAL TYPE

See tables below

Temperature sensor

Set multimeter to resistance mode (ohmmeter).

MEASURING METHOD

Ground sensor

Arrange multimeter for measuring voltage with sensor powered by ECU



CARATTERISTICA SENSORE
PORTATA ARIA

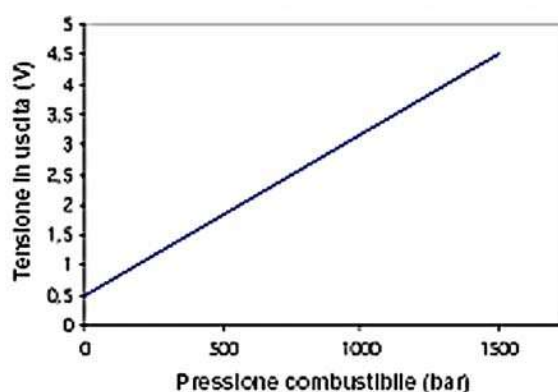
m (Kg/h)	Ua (V)
8	1.2899
10	1.3647
15	1.5271
30	1.9026
60	2.4150
120	3.0384
250	3.7877
370	4.2076
480	4.4962

A T= 20°C ±1°C
Vbatt= 14V ±0.1V
precisione: ±3%

CARATTERISTICA SENSORE TEMPERATURA

Temperatura °C	Resistenza (KΩ)		
	min	nom	max
-40	35.140	39.260	43.760
-30	20.770	22.960	25.310
-20	12.660	13.850	15.120
-10	7.943	8.609	9.307
0	5.119	5.499	5.892
+10	3.384	3.604	3.829
+20	2.290	2.420	2.551
+30	1.573	1.662	1.752
+40	1.096	1.166	1.238
+50	0.779	0.835	0.892
+60	0.565	0.609	0.654
+70	0.416	0.452	0.488
+80	0.312	0.340	0.370
+90	0.238	0.261	0.285
+100	0.184	0.202	0.222
+110	0.144	0.159	0.176
+120	0.114	0.127	0.141
+130	0.091	0.102	0.114

Fuel pressure sensor



SENSOR FEATURES

Piezoelectric pressure sensor

Variable voltage according to measured pressure.

Nominal specifications:

OUTPUT SIGNAL TYPE

Fuel feed: +5V

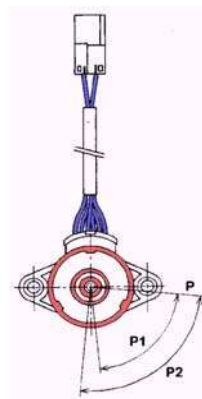
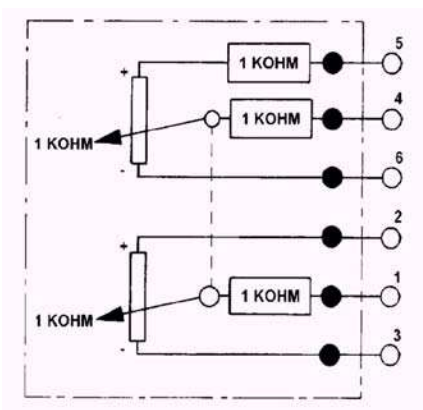
Working range: 0 -1800 bars

Linear characteristic: 500mV (0 bar) - 4500mV (1500 bar)

MEASURING METHOD

With sensor powered by ECU, use multimeter set to read voltage



Accelerator pedal potentiometer**SENSOR FEATURES**

Double resistance sensor

Variable resistance according to angle

Nominal values:

Mechanical

Idling position: $P = 0^\circ$

Working range: $P1 = 0^\circ - 70^\circ$

Mechanical stop range: $P2 = 0^\circ - 88^\circ$

Electrical:

Power voltage: $5V \pm 0.3V$

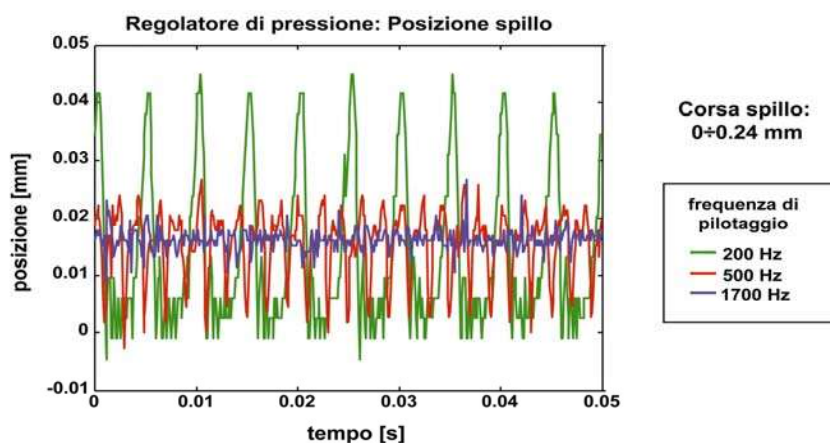
Potentiometer cursor terminal resistor: $1 \text{ Kohm} \pm 0.4 \text{ Kohm}$

Resistance track 1: $1.2 \text{ Kohm} \pm 0.4 \text{ Kohm}$

Resistance track 2: $1.7 \text{ Kohm} \pm 0.8 \text{ Kohm}$

OUTPUT SIGNAL TYPE**MEASURING METHOD**

Multimeter set to ohmmeter mode.

Electrical features of actuators**Pressure regulator**

ELECTRICAL SPECIFICATIONS OF ACTUATOR**COMMAND TYPE****MEASURING METHOD**

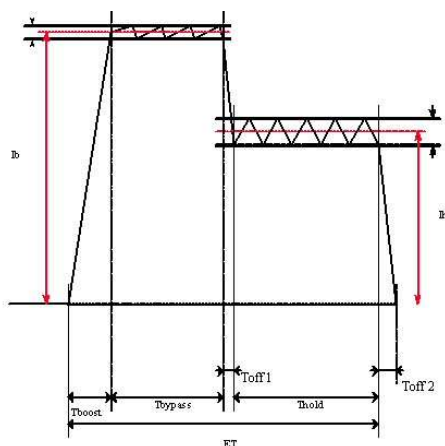
Solenoid valve:

Resistance: 2.07-2.53 [Ω] @ 20°C

Maximum current 2.5A

Control with PWM signal; maximum voltage 12V (carrier 360Hz)

Oscilloscope or analogue tool (Examiner with SMA)

3.2.4 Injector**ELECTRICAL SPECIFICATIONS OF ACTUATOR**

Typical current levels:

Average peak current (bypass): $I_b = 20A$ Peak current ripple (bypass): $\Delta I_b = 3A$ Average hold current: $I_h = 13A$ Hold current ripple (bypass): $\Delta I_h = 4^\circ$

Typical actuating times:

Energizing Time: ET = 160ms - 2ms

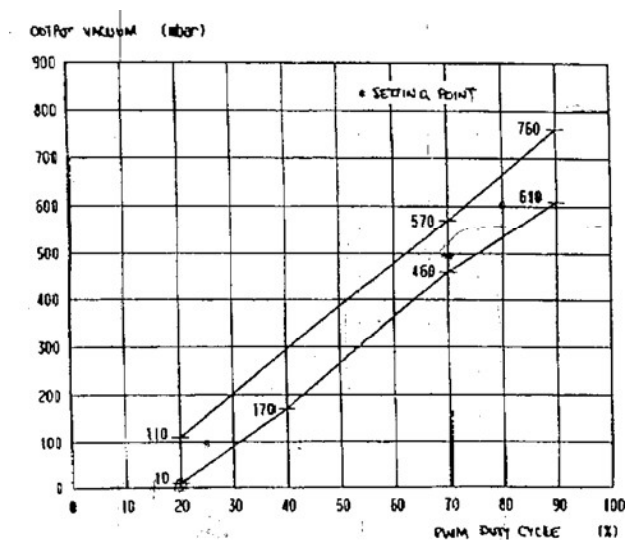
Boost time: $T_{boost} = 82ms$ Peak time (bypass): $T_{bypass} = 80ms - 350ms$ Peak/hold current decay time: $T_{off1} = 11ms$ Average hold time: $T_{hold} = ET - T_{boost} - T_{bypass} - T_{off1}$ Current decay time from hold: T_{off2} approximately 45ms**COMMAND TYPE****MEASURING METHOD**

Maximum voltage 12V

Oscilloscope or analogue tool (Examiner with SMA)



VGT solenoid valve

ELECTRICAL SPECIFICATIONS OF
ACTUATOR

COMMAND TYPE

MEASURING METHOD

Solenoid valve

Working range: 13 - 16V;

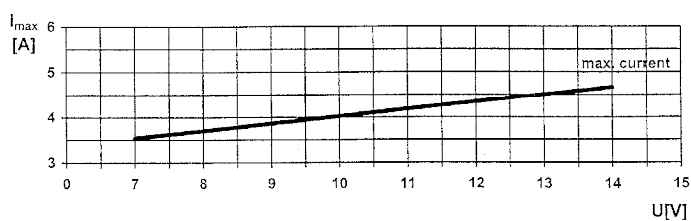
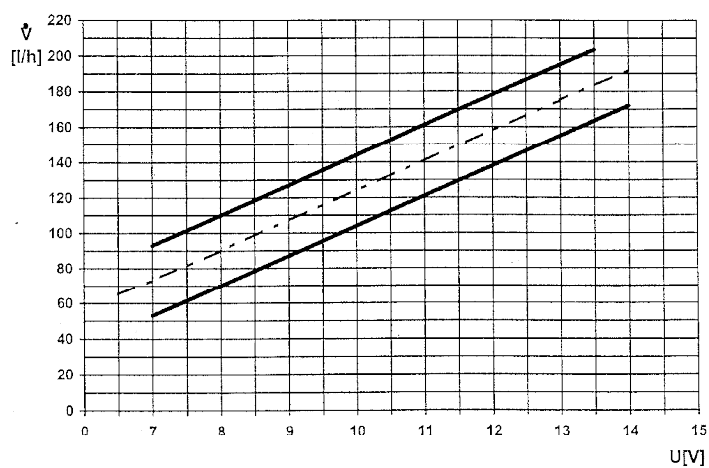
Winding resistance: $7.8 \pm 0.3 \text{ Ohm}$ (@ 20° C);

PWM carrier frequency: 100 -150 Hz

Solenoid valve: PWM modulated square wave voltage

Oscilloscope or analogue tool (Examiner with SMA)

Fuel pump



**ELECTRICAL SPECIFICATIONS
OF ACTUATOR**

See graph above

Operative voltage from 6 - 16V;

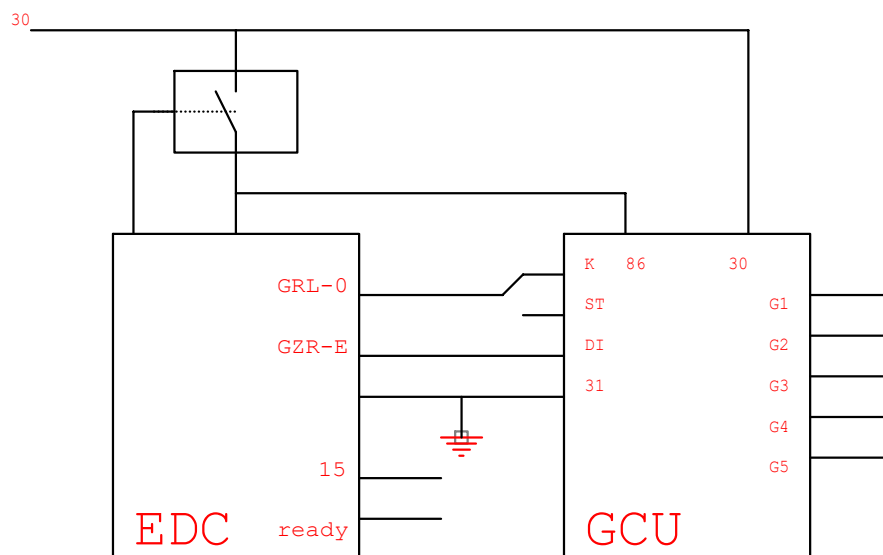
Working pressure 150 - 350 kPa (1.5 - 3.5 bar)

COMMAND TYPE

Battery voltage via relay controlled by ECU

MEASURING METHOD

Multimeter

Glow plug pre-heater ECU

EDC

Engine ECU

GCU

Glow plug ECU

30 terminal

Battery positive connection (+Ubat) for powering glow plugs

G1, G2, G3, G4, G5
terminal

Glow plug connection output

86 terminal

Power from EDC

31 terminal

Ground

ST terminal

Start input to control from EDC

K terminal

Start input to control from EDC

DI terminal

Output for direct diagnostic to EDC

