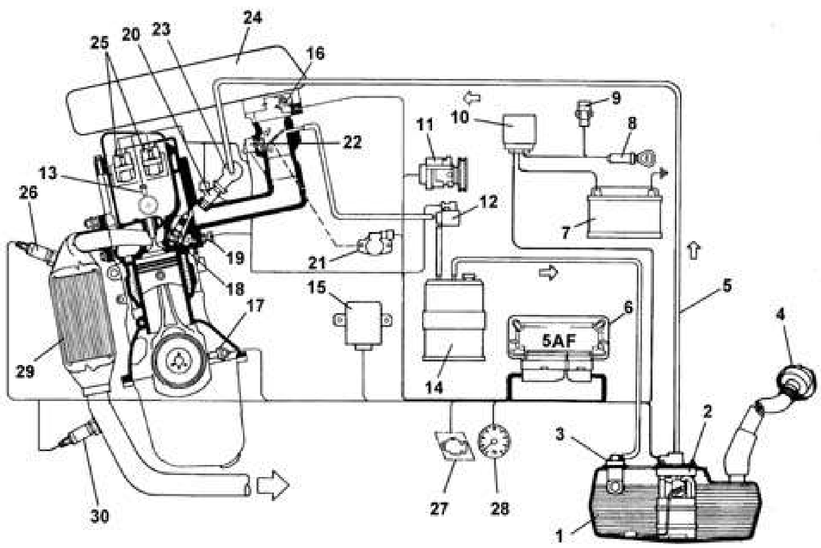
1.1 Introduction - PETROL INJECTION SYSTEM

The Marelli IAW 5AF system belongs to the category of systems integrated with:

- inductive discharge digital electronic ignition
- distributorless
- sequential, phased electronic injection (1-3-4-2).

The following figure shows the system in general.



1, Fuel tank
2, Electric fuel pump
3, Multi-purpose valve
4, Safety valve
5, Fuel delivery pipe
6, Injection-ignition ECU
7, Battery
8, Ignition switch
9, Inertia switch
10, Engine compartment junction unit
11, Climate control system
12, Fuel vapour cut-off valve
13, Injection timing sensor
14, Activated carbon filter
15, Body Computer (tester connection and Fiat CODE signal)
16, Absolute pressure and temperature sensor
17, Rpm and TDC sensor
18, Spark plugs
19, Coolant temperature sensor
20, Injectors
21, Throttle valve position sensor
22, Idle speed actuator
23, Fuel supply manifold
24, Air cleaner
25, Ignition coils
26, Lambda sensor (upstream)
27, System failure warning light
28, Rev counter
29, Catalytic converter
30, Lambda sensor (downstream)

MAIN FUNCTIONS

While the engine is idling, the control unit controls the following to keep the engine running smoothly as the ambient parameters and loads applied vary:

- the ignition instant
- air flow

The control unit controls and manages fuel injection so that the stoichiometric ratio (air/fuel) is always at the optimum value.

The system's functions are basically as follows:

- system self-adaptation
- self test
- recognition of FIAT CODE
- control of cold starting
- control of combustion - Lambda sensor
- control of detonation
- control of mixture enrichment during acceleration
- fuel cut-off during overrunning
- fuel vapour recovery
- limitation of the maximum rpm
- control of fuel-electric fuel pump supply
- connection to the climate control system
- recognition of cylinder position
- adjustment of injection times
- adjustment of ignition advance values
- control and management of the idle speed
- control of electric cooling fan.

FUEL INJECTION SYSTEM

The essential conditions that must always be met in the preparation of the air-fuel mixture for the correct operation of controlled-ignition engines are mainly:

- the 'metering' (air/fuel ratio) must constantly be kept as close as possible to the stoichiometric ratio, so as to ensure the necessary rapidity of combustion, avoiding unnecessary fuel consumption.
- the 'homogeneity' of the mixture, consisting of petrol vapours, diffused as finely and evenly as possible in the air.

The injection/ignition system uses an indirect measuring system known as the 'SPEED DENSITY LAMBDA' type.
In other words the angular rotation speed, density of the intake air and control of the mixture strength (retroactive control).
In practice the system uses data on the ENGINE SPEED (rpm) and AIR DENSITY (pressure and temperature) to measure the quantity of air drawn in by the engine.
The quantity of air drawn in by each cylinder, for each engine cycle depends not only on the density of the intake air, but also on the unit displacement and the volumetric efficiency.
The density of the air refers to that of the air drawn in by the engine and calculated according to the absolute pressure and the temperature, both detected in the inlet manifold.
Volumetric efficiency refers to the parameter relating to the coefficient for filling the cylinders measured on the basis of experimental tests carried out on the engine throughout the entire operating range and then stored in the electronic control unit memory.
Having established the quantity of intake air, the system has to provide the quantity of fuel according to the desired mixture strength.
The end of injection pulse or supply timing is contained in a map stored in the control unit memory and varies according to the engine speed and the pressure in the inlet manifold.
In practice, it involves processing which the electronic control unit carries out to command the sequential, phased opening of the four injectors, one per cylinder, for the length of time strictly necessary to form the air/petrol mixture which is closest to the stoichiometric ratio.
The fuel is injected directly into the manifold near the inlet valve at a pressure of around 3.5 bar.
Whilst the speed (rpm) and the density of the air (pressure and temperature) are used to measure the quantity of intake air, which when established allows the quantity of fuel to be metered according to the desired mixture strength, the other sensors in the system (coolant temperature, butterfly valve position, battery voltage, etc.) allow the electronic control unit to correct the basic strategy for all engine operating conditions.
It is vital for the air/fuel ratio to be around the stoichiometric value for the correct and prolonged operation of the catalytic silencer and for the reduction of pollutant emissions.

IGNITION SYSTEM

The ignition is of the inductive discharge type, breakerless with power modules located in the electronic injection/ignition control unit.
The system has two high tension twin outlet coils joined in a single container and connected directly to the spark plugs.
The primary winding for each coil is connected to the power relay (thereby receiving the battery voltage) and to the pins for the electronic control unit for connection to earth.

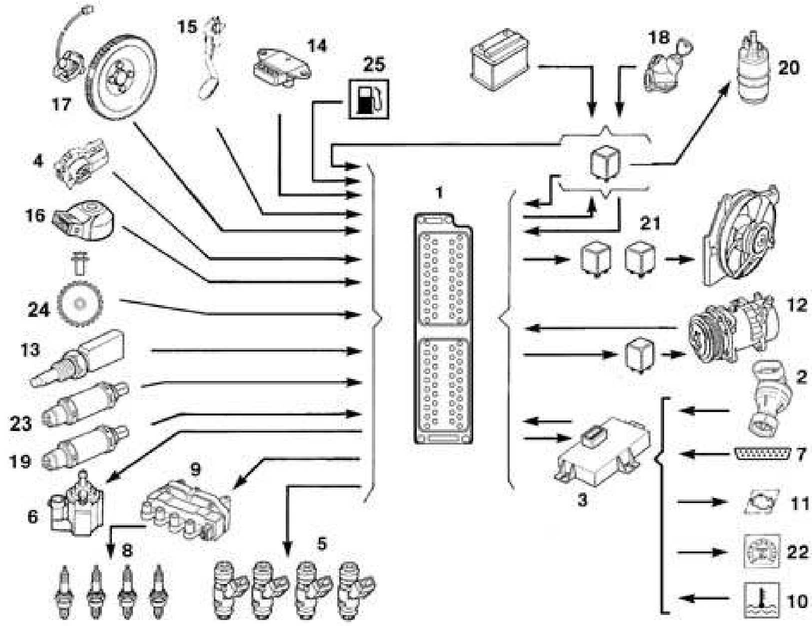
After the starting stage, the electronic unit manages the basic advance taken from a special map according to the:

- engine rpm
- absolute pressure value (mbar) measured in the inlet manifold.

This advance value is corrected according to the temperature of the engine coolant and the intake air.
The spark plugs for cylinder 1-4 and 2-3 are connected directly (two at a time) by means of high tension leads to the terminals of the coil secondary winding and their connection is in series because the cylinder head joins them.
This solution is also known as the 'lost spark' becuse the energy accumulated by the coil is almost exclusively discharged at the electrodes for the spark plug of the cylinder under compression allowing the ignition of the mixture.
The other spark is obviously not used, as no mixture is found in the cylinder to ignite, only exhaust gas.

DIAGRAM OF INPUT/OUTPUT INFO TO/FROM CONTROL UNIT

The diagram below illustrates the information entering/leaving the injection control unit.



1, Electronic control unit
2, Speedometer sensor
3, Body Computer
4, Engine idle speed actuator
5, Fuel injectors
6, Fuel vapour solenoid valve
7, Diagnostic socket
8, Spark plugs
9, Ignition coils
10, Engine coolant overheating warning light
11, Injection failure warning light
12, Climate control system
13, Engine coolant temperature sensor
14, Intke air temperature and pressure sensor
15, Butterfly valve position sensor
16, Detonation sensor
17, Rpm and TDC sensor
18, Ignition switch
19, Lamba sensor (pre-catalzer)
20, Electric fuel pump
21, Radiator fan high and low speed relay feeds
22, Speedometer / milometer
23, Lambda sensor (post-catalyzer)
24, Injection phase sensor
25, Fuel level sensor

SYSTEM SELF-ADAPTATION

The control unit has a self-adaption function which recognizes changes in the engine which occur as a result of bedding-in and ageing processes of both components and the engine itself.
These changes are stored in the form of modifications to the basic mapping, and their purpose is to adapt the operation of the system to the gradual alterations in the engine and components compared with their characteristics when new.
This self-adaptation function also makes it possible to even out inevitable differences (due to production tolerances) in any replaced components.
From the exhaust gas analysis, the control unit changes the basic mapping in relation to the original characteristics of the new engine.
The self-adaptation parameters are not cancelled if the battery is disconnected.

AUTODIAGNOSIS AND RECOVERY

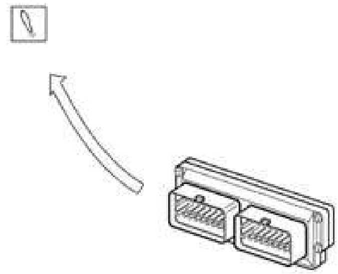
The control unit autodiagnostic system controls the correct operation of the system and signals any faults by means of an (MIL) warning light in the instrument panel which has a standardized European colour and ideogram.
This warning light signals both engine management faults and problems detected by the EOBD strategies.
The (MIL) warning light operating logic is as follows:
with the ignition key in the ON position, the warning light comes on and remains on until the engine has been started up.
The control unit's self-test checks the signals coming from the sensors, comparing them with the permitted limits:

Signalling of faults during engine starting:

- the failure of the warning light to go out once the engine has been started up means that there is an error memorized in the control unit.

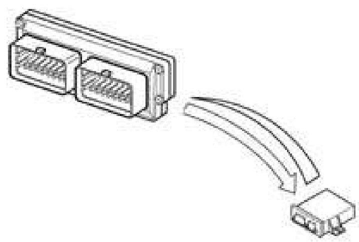
Fault indication during operation
the warning light flashing indicates possible damage to the catalyzer due to misfire.
- if the warning light comes on fixed, it indicates the presence of engine management errors or EOBD diagnosis errors.

From time to time, the control unit defines the type of recovery according to the components which are faulty.
The recovery parameters are managed by those components which are not faulty.



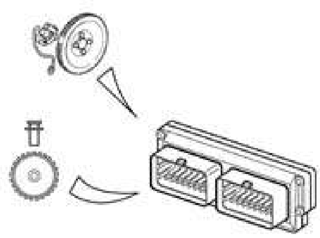
RECOGNITION OF FIAT CODE

When the control unit receives the ignition 'ON' signal, it dialogues with the Body Computer (Fiat CODE function) to obtain starting enablement.
Communication takes place via the CAN line which connects the two control units.



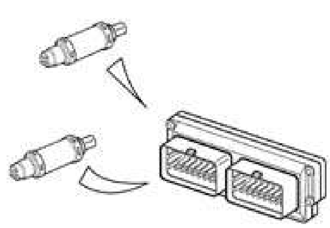
RECOGNITION OF CYLINDER POSITION

The engine timing signal, together with the engine rpm and top dead centre (TDC) signal, allows the control unit to recognize the succession of cylinders to implement phased injection.
This signal is generated by a Hall-effect sensor, positioned on the rocker cover near the phonic wheel formed on the camshaft pulley.



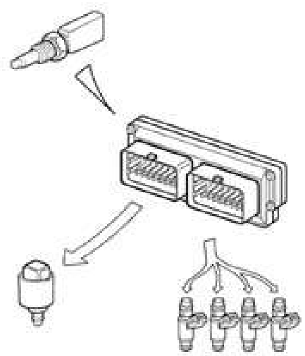
CONTROL OF COMBUSTION - LAMBDA SENSORS

In EOBD systems the Lambda sensors, which are all the same type but not interchangeable, are located one before (pre-catalyzer) and one after (post-catalyzer) the catalyzer system. The pre-catalyzer sensor carries out the check on the mixture strength known as the 1st loop (pre-catalyzer sensor closed loop).
The post-catalyzer sensor is used for the catalyzer diagnosis and for finely modulating the 1st loop control parameters.
With this in mind, the adjustment of the second loop is designed to recover both production differences and those in the response of the pre-catalyzer sensors which may occur as a result of ageing and pollution.
This control is known as the 2nd loop (post-catalyzer sensor closed loop).



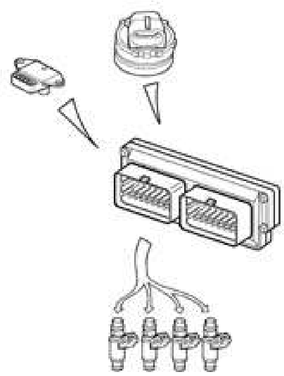
OPERATION WHEN COLD

Under these circumstances there is a natural weakening of the mixture because of the poor turbulence of the fuel particles at low temperatures, reduced evaporation and condensation on the inner walls of the inlet manifold, all of which is exacerbated by the increased viscosity of the lubricant oil which, as is well known, increases the rolling torque of the engine mechanical components at low temperatures.
The electronic control unit recognizes this condition on the basis of the coolant temperature signal, increasing the basic injection time.
Whilst the engine is warming up, the electronic control unit also operates the stepping motor which determines the quantity of air needed to ensure that the engine does not cut out.



OPERATION UNDER FULL LOAD

Operation in full load conditions is detected, by the control unit, through the values supplied by the butterfly position and absolute pressure sensors.
In full load conditions, the basic injection time must be increased to obtain the maximum power supplied by the engine.

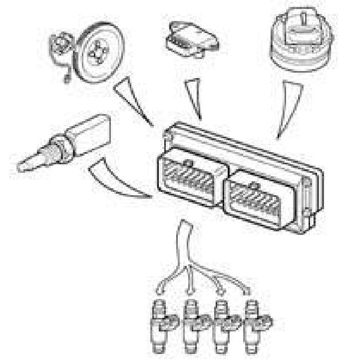


OPERATION DURING OVER-RUN

During this stage the engine has two strategies:

- A negative, transitory strategy to keep the quantity of fuel supplied to the engine at the stoichiometric value (less pollution). this stage is recognized by the control unit when the throttle potentiometer signal goes from a high voltage reading to a lower one.
- A soft accompaniment strategy at the lower speed (dash-pot) to lessen the variation in the torque supplied (reduced engine braking).

Barometric correction
Atmospheric pressure varies according to the altitude creating a variation in the volumetric efficiency which requires correction of the basic mixture strength (injection time).
The correction of the injection time depends on the variation in altitude and is automatically updated by the electronic control unit each time the engine is switched off and in certain butterfly position and rpm conditions (typically at low speeds and with the butterfly wide open) (dynamic adjustment of barometric correction).
Operation during cut-off
The cut-off strategy is implemented when the control unit recognizes the throttle valve in the idle position (throttle potentiometer signal) and the engine speed exceeds around 1350 rpm. (This figure is given by way of example and varies according to several parameters, the main ones being temperature and gear).
In the case of versions equipped with a motorized throttle, the cut-off strategy is implemented when the control unit recognizes the accelerator pedal released position: pedal percentage = 0%.
The control unit only enables the cut-off when the engine temperature exceeds 0° C.
The recognition of the throttle valve in a non closed position or the engine speed below 1270 rpm (variable indicative value for various models) re-enables the supply to the engine.
For very high speeds the cut-off is implemented even when the throttle is not completely closed, but when the pressure in the inlet manifold is particularly low (partial cut-off).

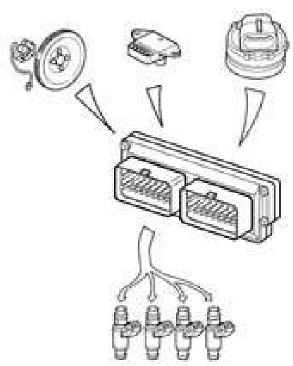


OPERATION DURING ACCELERATION

During this stage, the control unit increases the quantity of fuel requested by the engine as appropriate (to achieve maximum torque) according to the signals coming from the following components:

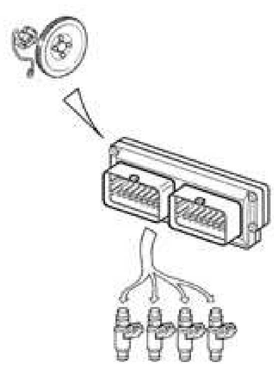
- throttle potentiometer;
- rpm and T.D.C. sensor.

The 'basic' injection time is multiplied by a coefficient which depends on the temperature of the engine coolant, the opening speed of the accelerator butterfly and the increase in pressure in the inlet manifold.
If the sharp variation in the injection time is calculated when the injector is already closed, the control unit reopens the injector (extra pulse) in order to compensate the mixture strength extremely quickly; the subsequent injections are already increased on the basis of the coefficients mentioned previously.



PROTECTION AGAINST EXCESS RPM

When the engine rotation speed exceeds 6530 rpm, the value set by the manufacturer, the engine finds itself in 'critical' operating conditions.
When the electronic control unit recognizes that the above speed has been exceeded, it prevents the operation of the injectors.
When the rotation speed returns to a non critical value (6500 rpm), the operation is resumed.

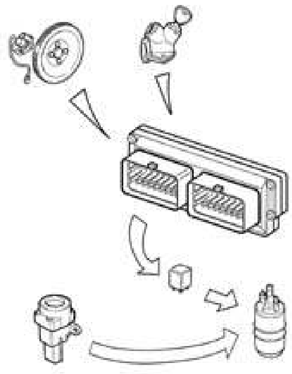


FUEL PUMP CONTROL

The electric fuel pump is controlled by the engine control unit by means of a relay.

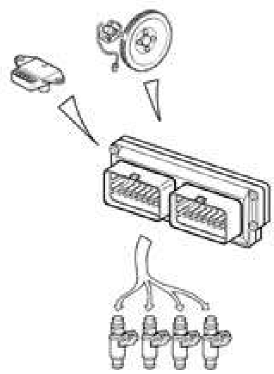
The pump cuts out:

- if the engine speed goes below around 40 rpm
- after a certain period (about 3 seconds) with the ignition switch in the ON position without the engine being started up (timed go ahead)
- if the inertia switch has operated.



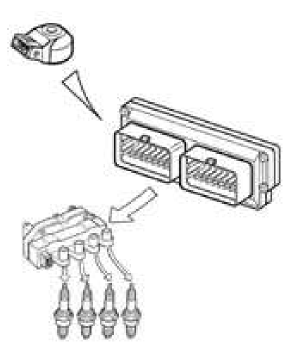
INJECTOR CONTROL

The operation of the injectors is the sequential, phased type.
However, during starting the injectors are operated once in parallel (full-group).
The timing of the injector operation varies according to the engine speed and pressure of the inlet air in order to improve the filling of the cylinders with advantages in terms of consumption, driveability and pollution.



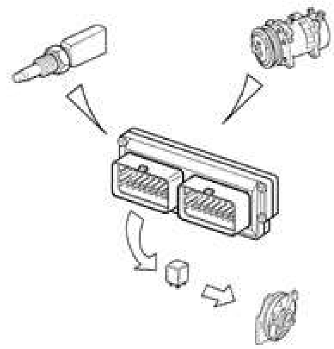
CHECK ON KNOCKING

The control unit detects the presence of knocking by processing the signal coming from the relevant sensor.
The strategy continuously compares the signal coming from the sensor with a threshold value, which, in turn, is continuously updated to take account of background noise and ageing of the engine.
If the system recognizes the presence of detonation, the strategy reduces the ignition advance until the phenomenon disappears. Later, the advance is gradually restored to the basic value or until the phenomenon occurs again.
In particular, advance increases are implemented gradually, whilst reductions are implemented immediately.
Under acceleration conditions, a higher threshold is used to take account of the increased engine noise under such conditions.
The strategy also features a self-adaptation function which temporarily memorizes the reductions in the advance that may be continuously repeated, in order to adjust the advance to the different engine operating conditions (for example, the use of a low octane rating fuel). The strategy is capable of restoring the advance to the threshold value memorized when the conditions which have caused the reduction no longer exist.



MANAGEMENT OF RADIATOR FAN

The control unit directly controls the operation of the radiator fan according to the temperature of the engine coolant and the engagement of the climate control system.
The fan is switched on when the temperature exceeds 95°C (1st speed) and 105°C (2nd speed).
The fan is switched off with a hysteresis of 3°C below the engagement threshold (indicative values which vary for the various models and on the basis of experimental tests).
The high and low speed functions are managed by the intervention of special relays in the climate control system control unit and are operated by the injection control unit.



ENGINE IDLE MANAGEMENT

The general aim of this strategy is to keep the engine idling at around the value memorized (engine warm without loads applied: 820 rpm); there is a series of values mapped in the control unit which depend on the various parameters including the loads applied.
The position of the actuator depends on the following engine conditions:

Starting stage:

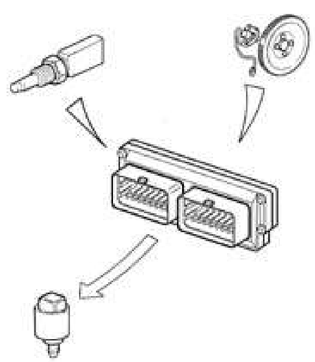
- When the key is inserted, the position of the actuator depends on the temperature of the engine coolant and the voltage of the battery (open-loop position).

Warming up stage:

- The engine speed is corrected, particularly on the basis of the engine coolant temperature.
- With the engine at operating temperature, the management of the idle depends on the signal coming from the rpm sensor; when external loads are switched on, the control unit manages the supported idle.

Deceleration stage:

- In deceleration conditions outside of idling, the control unit controls the position of the engine idle speed actuator by means of a special flow rate curve (dash-pot curve), in other words it slows down the return of the shutter towards its seating, improving the engine braking effect (fast idle).



MANAGEMENT OF FUEL VAPOUR RECIRCULATION

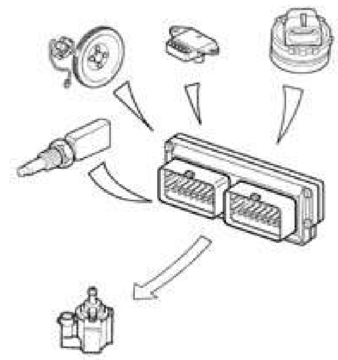
This strategy controls the position of the vapour cut out solenoid valve in the following way:

- during starting the solenoid remains closed, preventing the fuel vapours from enriching the mixture too much; this conditioner persists until the temperature of the coolant temperature reaches 65° C.
- with the engine at operating temperature, the electronic control unit sends the solenoid valve a square wave signal (duty-cycle operation) and the opening is modulated.

In this way the control unit controls the quantity of fuel vapours sent to the inlet, preventing considerable variations in the mixture strength.

To improve the operation of the engine, the operation of the solenoid valve is inhibitied, maintaining the same closed position, in the operating conditions listed below:

- throttle valve in closed position
- engine speed below 1500 rpm
- inlet manifold pressure below the limit calculated by the control unit depending on the number of revs.



CLIMATE CONTROL SYSTEM MANAGEMENT

The injection/ignition control unit is connected to the climate control system in that:

- it receives the request to switch on the compressor and make the related interventions (additional air);
- it gives the go ahead to switch on the compressor, when the conditions covered by the strategies have arisen;
- it receives information on the state of the four-stage pressure switch and makes the appropriate interventions (radiator fan operation).

If the engine is idling, the control unit increases the flow rate of the air passing from the idle actuator before the compressor is switched on and, viceversa, it returns the actuator to the normal position after the compressor is switched off.

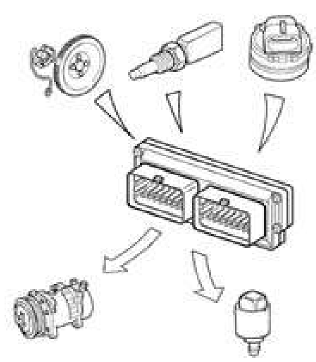
The control unit automatically controls the disengagement of the compressor:

- at engine coolant temperatures above 114° C
- at engine speeds below 650 rpm.

The compressor automatically switches back on when the engine speed rises once more to 750 rpm.

The control unit temporarily controls the disengagement of the compressor (for a few seconds):

- during high power requests from the engine (strong acceleration)
- during engine pickup.



AIR TEMPERATURE SENSOR

If the error is present during starting:

- it assumes a value of 50 °C
- self-adjustment of the mixture strength is inhibited.

If the error is present in other conditions:

- the last valid value is memorized and updated according to the coolant temperature.

KNOCK SENSOR

If the sensor is faulty, the engine control unit implements more conservative ignition advance 'maps' to safeguard the engine

PRESSURE SENSOR

If the failure is present during starting, it uses a value of 1024 mbar.
During operation the value used is calculated on the basis of parameters supplied by the throttle valve position sensor and the rpm sensor.
Self-adjustment of the mixture strength is inhibited.

THROTTLE VALVE POSITION SENSOR

In the case of a fault, a value calculated from the absolute pressure sensor readings is set, and if this sensor is broken, a fixed value equal to a throttle opening of 50 degrees is set.
The mixture strength and idle self-adjustment dash-pot strategies are suspended.

VEHICLE SPEED SENSOR

The control unit uses the last vehicle speed value memorized when there was no error.

COOLANT TEMPERATURE SENSOR

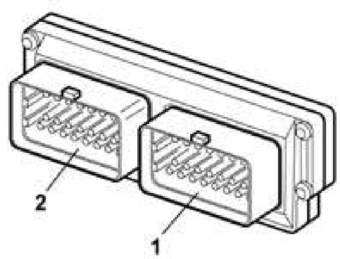
In the case of a failure the ECU inhibits the self-adjustment of the mixture strength and idle.
It sets the last temperature value measured; If this does not correspond to the normal working value, the ECU increases it gradually according to the time since the engine was started up until it reaches 80 °C.
The radiator cooling fan is operated.

ENGINE IDLE SPEED ACTUATOR

In the event of a fault, the operation of the actuator is disabled and self-adjustment of the idle mixture strength is stopped.

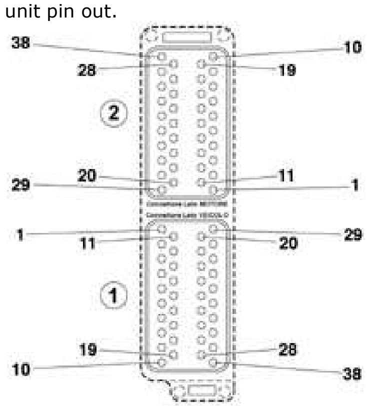
GENERAL CHARACTERISTICS

The engine unit is fitted in the engine compartment and is capable of withstanding high temperatures.
It is a digital type with a microprocessor, featuring a high calculation capacity, precision, reliability, versatility and low energy consumption and is maintenance-free.
The task of the electronic control unit is to process the signals coming from the various sensors through the application of software algorithms and control the operation of the actuators (in particular the injectors, ignition coils and idle actuator) in order to ensure optimum engine operation.
The adoption of the Fiat CODE does not allow control units to be exchanged between cars.



PIN-OUT

The diagram below illustrates the electronic control unit pin out.



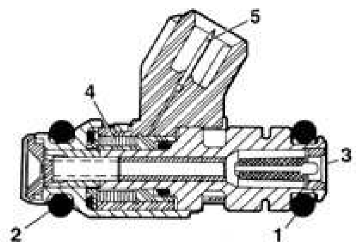
Vehicle side connector (1)
1, Post-catalyzer Lambda sensor heater (-)
2, Not connected
3, Not connected
4, Control unit supply (+30)
5, Not connected
6, Pump relay control
7, Not connected
8, Radiator fan 1st speed relay feed
9, Not connected
10, Not connected
11, Pre-catalyzer Lambda sensor heater (-)
12, Air conditioner compressor relay control
13, Not connected
14, Not connected
15, Not connected
16, Serial line K
17, Key signal (+15/54)
18, Radiator fan 2 speed relay control
19, Not connected
20, CAN line (HIGH)

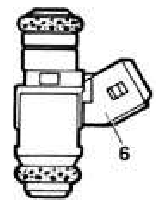
21, Post-catalyzer Lambda sensor signal (-)
22, Pre-catalyzer Lambda sensor signal (+)
23, Linear pressure sensor signal
24, Not connected
25, Not connected
26, Not connected
27, Air conditioning engagement request
28, Not connected
29, CAN line (LOW)
30, Not connected
31, Post-catalyzer Lambda sensor signal (+)
32, Pre-catalyzer Lambda sensor signal (-)
33, Not connected
34, Lambda sensor shielding
35, Not connected
36, Not connected
37, Not connected
38, Not connected
Engine side connector (2)
1, Not connected
2, Not connected
3, Throttle position sensor signal
4, Not connected
5, Coolant temperature sensor
6, Knock sensor (+)
7, Not connected
8, Knock sensor shielding
9, Idle actuator control
10, Ignition coil control (cylinders 2-3)
11, Not connected
12, Not connected
13, Air temperature and absolute pressure sensor
14, Absolute pressure and air temperature sensors
15, Knock sensor (-)
16, Not connected
17, Idle actuator control
18, Idle actuator control
19, Idle actuator control
20, Earth reference
21, Not connected
22, Power supply for absolute pressure and air temperature sensor
23, Engine oil pressure switch
24, Engine timing sensor
25, Rpm sensor (+)
26, Canister solenoid control
27, Cylinder 4 injector control
28, Cylinder 1 injector control
29, Sensor earth reference
30, Not connected
31, Not connected
32, Throttle position sensor supply
33, Not connected
34, Rpm sensor screening
35, Rpm sensor (-)
36, Cylinder 2 injector control
37, Cylinder 3 injector control
38, Ignition coil control (cylinders 1 - 4)

SPECIFICATIONS

The injectors are the (peak) miniature type with a supply of 12 V and an internal resistance of 13.8 - 15.2 ohm at 20°C.
The injectors are fixed by the manifold which presses them into their housings in the inlet manifold ducts, whilst two rubber seals (1) and (2) seal the inlet manifold and the fuel manifold.
The fuel is supplied from above (3) the injector, which contains the winding (4) connected to the terminals (5) of the electrical connector (6).

During the removing-refitting operations, do not exert forces greater than 120 Nm on the injector connector as this could adversely effect its operation.



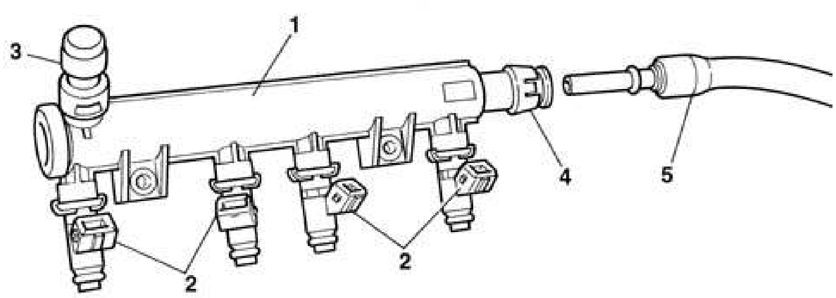


OPERATION

The fuel jet at the absolute pressure of 3.5 bar, by means of the returnless system, emerges from the injector and is instantly atomized.
The control logic for the injectors is the sequential, phased type, in other words the four injectors are operated according to the inlet sequences.

SPECIFCATIONS

The fuel manifold is fixed to the inner part of the inlet manifold and its function is to send the fuel to the injectors.
In addition to the injector seats, there is a rapid attachment on the manifold for connection with the fuel supply pipe and an attachment for checking the fuel supply pressure.



1, Fuel manifold
2, Injector
3, Attachment for fuel drainage pressure
4, Rapid attachment
5, Fuel delivery pipe

SPECIFICATIONS

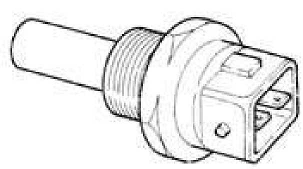
It is fitted on the thermostatic cup and measures the temperature of the coolant by means of an NTC thermistor which has a negative resistance coefficient.
Electrical characteristics

°C	O
-20	15971
-10	9620
0	5975
10	3816
20	2502

25	2044
30	1679
40	1152
50	807
60	576
70	418
80	309
90	231
100	176

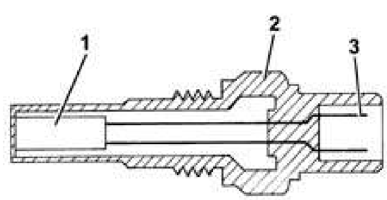
OPERATION

The reference voltage for the NTC element for the injection system is 5 Volt; As the input circuit into the control unit is designed as a voltage divider, this voltage is divided between a resistor located in the control unit and the sensor's NTC resistor.
The control unit is thus able to assess the changes in the sensor's resistance via the changes in voltage, and thus obtain the temperature information.



COMPONENTS

The diagram illustrates the composition of the sensor.



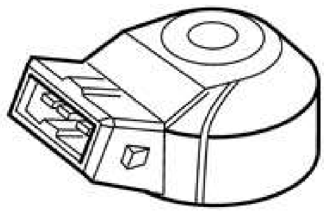
1, NTC resistor
2, Sensor body
3, Electrical connector

SPECIFICATIONS

The piezoelectric type detonation sensor is fitted on the cylinder block/crankcase and detects the intensity of the vibrations caused by the detonation in the combustion chambers.
This phenomenon produces a mechanical repercussion on a piezoelectric crystal which sends a signal to the control unit; on the basis of this signal, the control unit reduces the ignition advance until the phenomenon has disappeared. The advance is then gradually restored to the basic value.

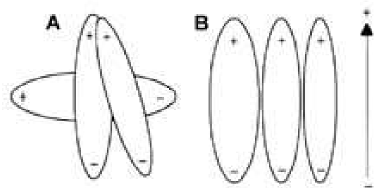
Electrical characteristics

- resistance: 532-588 ohm at 20°C.



OPERATION

The molecules of a quartz crystal feature electrical polarization.
In rest conditions (A) the molecules do not have a particular direction.
When the crystal is subjected to pressure or an impact (B), they are directed - the higher the pressure to which the crystal is subjected, the more marked their direction.
This direction produces a voltage at the ends of the crystal.



A. Rest position
B. Under pressure position

SPECIFICATIONS

It is mounted on the engine block and 'faces' the phonic wheel located on the crankshaft.
It is of the inductive type, i.e. it functions by means of the variation in the magnetic field generated by the passage of the teeth of the flywheel (60-2 teeth).

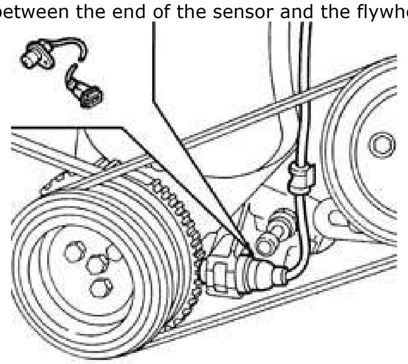
The fuel injection control unit uses the rpm sensor to:

- determine the speed of rotation
- determine the angle of the crankshaft.

Electrical characteristics

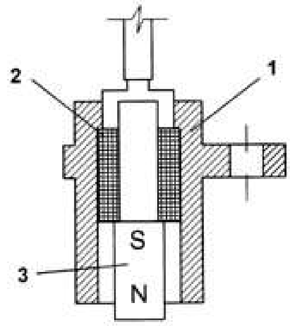
- resistance = 1134-1386 ohm at 20°C.

The distance (gap) for obtaining correct signals, between the end of the sensor and the flywheel, should be between 0.5 and 1.5 mm.



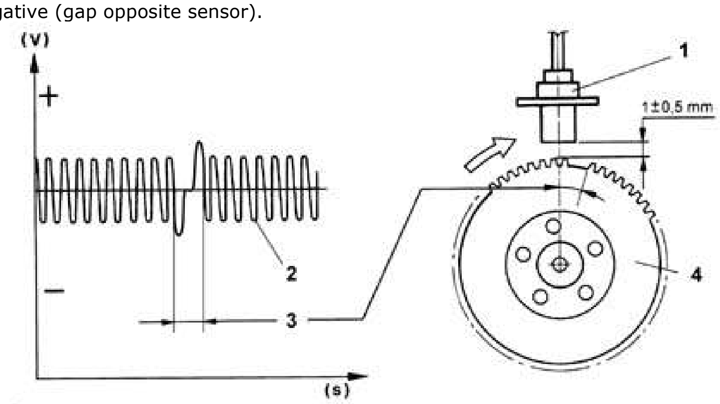
COMPONENTS

The sensor consits of a tubular casing (1) which contains a permanent magnet (3) and an electrical winding (2).



OPERATION

As the flywheel teeth go past, the magnetic flow produced by the magnet (3) undergoes fluctuations due to the change in the gap.
These fluctuations induce an electromotive force in the winding (2), at the ends of which there is a voltage which alternates between positive (tooth opposite sensor) and negative (gap opposite sensor).



1, Sensor
2, Output signal
3, Signal corresponding to the two missing teeth
4, Crankshaft pulley with flywheel

OPERATION

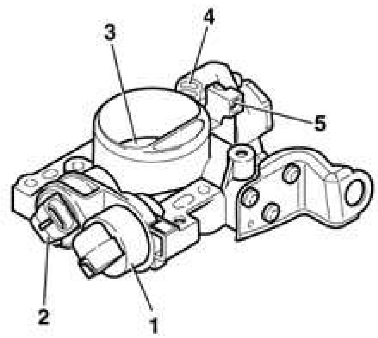
The peak value of the output voltage from the sensor, provided other factors remain the same, depends on the distance between the sensor and tooth (gap).
The phonic wheel comprises sixty teeth, two of which have been removed to create a reference: the pitch of the wheel thus corresponds to an angle of 6° (360° divided by 60 teeth).
The synchronization point is recognized at the end of the first tooth after the space created by the two missing teeth: when this passes under the sensor, the pair of pistons 1-4 of the engine are at 114 degrees before TDC.

SPECIFICATIONS

This has the task of metering the amount of air supplied to the engine (and consequently the power developed) according to the request from the driver via the accelerator.
The butterfly casing is fixed to the intake manifold; the butterfly is opened by means of a non linear linkage which, depending on the pedal travel, produces small butterfly opening angles in the first section of the accelerator pedal travel and, conversely, greater angles with the pedal very depressed.
With the pedal completely released (engine decelerating or idling) the additional air required is supplied by the engine idle speed actuator; under these circumstances, the throttle opening lever comes up against an anti-tamper screw which prevents the throttle from getting stuck in the closed position.
The butterfly valve position sensor and the engine idle speed actuator are also fitted on the throttle body.

COMPOSITION

The diagram shows the composition of the throttle casing.



1, Engine idle speed actuator
2, Butterfly valve position sensor
3, Butterfly valve
4, Butterfly opening linkage
5, Butterfly valve anti-tamper and adjustment screw

COMPOSITION

The anti-tamper screw (5) is regulated during the fluxing operation in the factory and should never be tampered with.

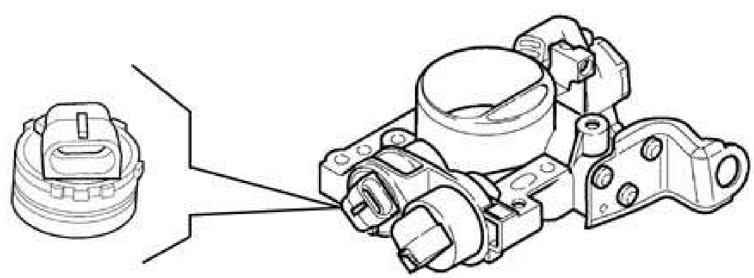
SPECIFICATIONS

This sensor consists of a potentiometer where the moving part is controlled by the butterfly valve shaft.
The potentiometer is in a plastic container which is designed to guarantee the mounting and the correct positioning of the sensor in relation to the throttle.

Electrical characteristics

- Fixed resistance (between pins A and B) = 1200 ohm
- Variable resistance (between pins A and C) = 0 - 1200 ohm ± 20%.

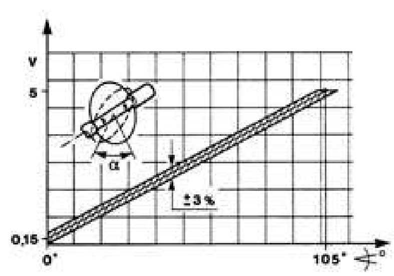
Note: The sensor cannot be replaced by itself; it forms a single unit with the butterfly casing.



COMPONENTS

The potentiometer is of linear type (single ramp); its main characteristics are:

- Total mechanical travel of the potentiometer: 110° ± 8°
- Operating range: 90° ± 2°
- Temperature operating range: -30°C - +125°C



OPERATION

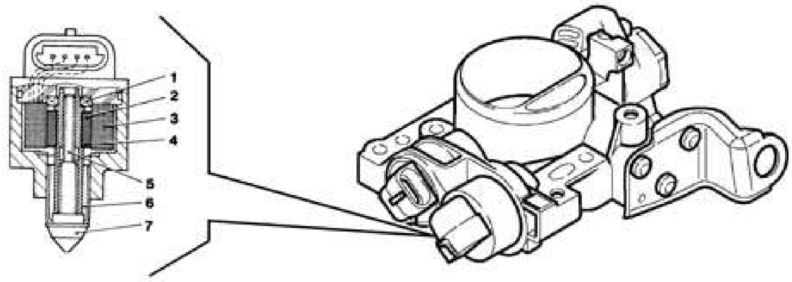
During operation, the control unit provides the potentiometer with a 5 Volt supply.
The parameter measured is the butterfly position from minimum to full opening for the management of the injection.
On the basis of the output voltage, the control unit recognizes the throttle valve opening condition and suitably corrects the mixture strength.
With the butterfly closed, an electrical voltage signal is sent to the control unit which recognizes the idle and cut-off conditions (distinguishing

between them on the basis of the engine speed).

SPECIFICATIONS

The actuator, fixed to the throttle body, consists of:

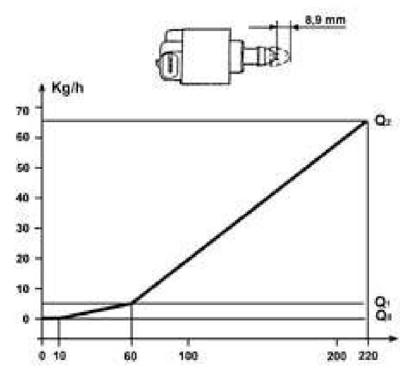
- An electrical stepper motor with two windings in the stator and a rotor composed of pairs of permanent magnet poles.
- A worm and nutscrew type reduction gear which converts rotary motion into rectilinear motion.



1, Bearing
2, Female screw
3, Coils
4, Magnet
5, Screw
6, Anti-rotation splining
7, Shutter

SPECIFICATIONS

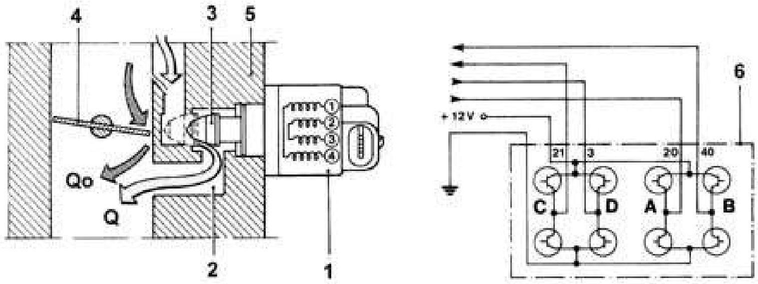
The electrical stepper motor features a high degree of precision and rapid resolution (about 220 steps per second).
The impulses sent by the electronic control unit to the engine are transformed from a rotary motion into a linear motion (about 0.04 mm/step) by means of a screw-female screw type mechanism, operating the shutter whose movements alter the section of the by-pass duct.
The constant value of the minimum air flow rate (Qo) is due o the flow under the butterfly valve which is regulated in production and guranteed by an anti-tamper plug.
The maximum flow rate (Q2) is guaranteed by the shutter in the fully retracted position (about 220 steps corresponding to 8.9 mm).
The law shown in the graph below applies between these two air flow rate values:



OPERATION

In order to idle, i.e. with the butterfly (4) completely closed, the engine requires a certain amount of air (Qo) and fuel to overcome the internal friction and sustain its rotation speed.
To the quantity of air (Qo) arriving from the filter which, during idling, flows through the butterfly valve (4) in a closed position, it is necessary to add, when the engine is warming up or when electrical consumers are switched on or outside loads applied (air conditioning etc.), a further quantity of air (Q) to allow the engine to keep the rotation speed constant.
To achieve this result the system uses a stepping motor (1) operated by a circuit (6) inside the injection/ignition electronic control unit which, when operating, moves stem with a shutter (3) which alters the section of the by-pass duct (2) and, consequently, the quantity of air (Qo + Q) drawn in by the engine.
To adjust this type of action, the electronic unit uses the engine angular speed and coolant temperature parameters, coming from the respective sensors.

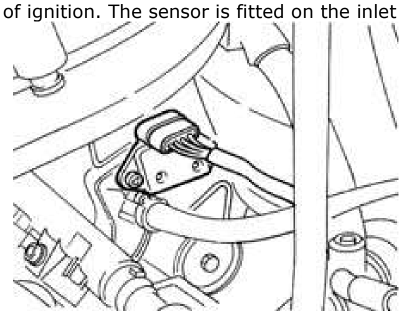
The actuator cannot be replaced by itself; it forms a single unit with the butterfly casing.



Q, Air flow rate regulated by the actuator (variable)
Q0, Air flow rate escaping from the butterfly (constant)

SPECIFICATIONS

The intake air temperature and pressure sensor is a component which is designed to measure the pressure and the temperature of the air inside the inlet manifold.
Both pieces of information are used by the injection control unit to define the quantity of air drawn in by the engine; this information is then used to calculate the injection time and the point of ignition. The sensor is fitted on the inlet manifold.



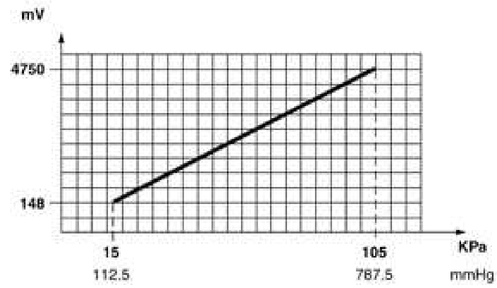
SPECIFICATIONS

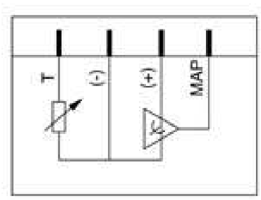
The air temperature sensor consists of an NTC thermistor (Negative Temperature Coefficient).
The resistance of the sensor decreases as the temperature increases.
The control unit input circuit divides the 5 Volt reference voltage between the sensor resistance and a fixed reference value, obtaining a voltage which is proportional to the resistance and therefore to the temperature.
The sensitive element of the pressure sensor consits of a Wheatstone bridge on a cermamic diaphragm.
On one side of the diaphragm is the absolute reference vacuum, whilst on the other side there is the vacuum from the inlet manifold.
The (piezoresistive) signal from the distortion suffered by the diaphragm, before being sent to the engine control unit, is amplified by an electronic circuit in the support which also houses the ceramic diaphragm.
When the engine is off, the diaphragm bends in accordance with the atmospheric pressure; the altitude information is thus obtained.
When the engine is running, the effect of the vacuum produces a mechanical action on the sensor diaphgram, which bends, altering the resistance value.
Since the supply is kept rigorously constant (5V) by the control unit, altering the resistance alters the voltage output value.

ELECTRICAL CHARACTERISTICS

The diagram below illustrates the electrical specifications of the sensor.

T °C	Ω	± Ω %
-40*	49.933	13.6
-30	26.628	12.1
-20	15.701	10.8
-10	9.539	9.6
0	5.959	8.5
+10*	3.820	7.4
+20	2.509	6.5
+25	2.051	6.0
+30	1.686	6.0
+40	1.157	5.9
+50	0.810	5.8
+60	0.578	5.7
+70	0.419	5.6
+80	0.309	5.5
+85	0.263	5.5
+90	0.231	5.5
+100	0.176	5.4
+110	0.135	6.0
+120	0.105	6.5
+125	0.092	6.7
+130	0.083	7.0



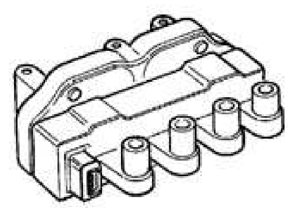


SPECIFCATIONS

The coils are fixed, by a bracket, to the camshaft covers and are the closed magnetic circuit type with a core made from silicon steel with a thin gap containing both windings.

Electrical characteristics

- Primary circuit resistance: 0.52-0.62 ohm at 23°C
- Secondary circuit resistance: 0.52-0.62 ohm at 23°C

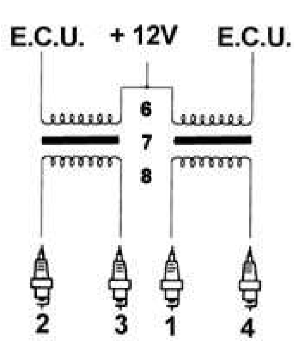


SPECIFCATIONS

The windings are covered by a pressed plastic container and are insulated through immersion in an epoxide resin and quartz compound which gives hem exceptional dielectric, mechanical and thermal properties enabling them to withstand high temperatures.
The proximity of the primary winding to the magnetic core reduces the magnetic flow losses optimizing the coupling with the secondary winding.

COMPOSITION

The diagram below illustrates the composition of the coils.



1, H.T. socket for spark plug for cylinder 1
2, H.T. socket for spark plug for cylinder 2
3, H.T. socket for spark plug for cylinder 3

4, H.T. socket for spark plug for cylinder 4
5, L.T. socket for control unit connection
6, Primary circuit
7, Gap
8, Secondary circuit

SPECIFCATIONS

This sensor is located at the differential output, by the left driveshaft joint and transmits the vehicle speed to the body computer, which forwards it to the control unit: the signal is also used for the operation of the speedometer.
The Hall effect sensor transmits 16 impulses/rev; according to the frequency of the impulses it is possible to ascertain the speed of the vehicle.

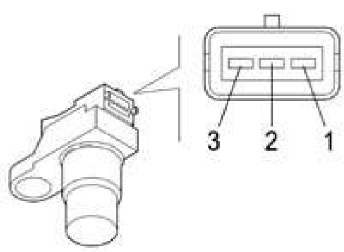

on versions with ABS, the vehicle speed signal is generated by the ABS control unit. On the Punto the sensor transmits information to the body computer which makes it available to the injection control unit.

COMPOSITION

The sensor is of the Hall-effect type. A semiconducting layer, through which current passes, immersed in a perpendicular magnetic field, generates at its ends a difference in potential known as Hall voltage.

OPERATING

The force lines perpendicular to the current direction generate at the ends a different in potential (called Hall voltage).
If the integrity of the current remains constant, the voltage generated depends only on the intensity of the magnetic field; the intensity of the field simply has to vary perpendicularly to produce a modulated electrical signal, whose frequency is proportional to the speed with which it changes magnetic field.
To obtain this change, the distance between the sensor and the pulley on the camshaft varies, as it has four references.
In the rotation of the pulley, the distance varies and a low voltage signal is generated, corresponding to each mark.
Vice versa, where these three marks are not present, the sensor generates a higher voltage signal.
Consequently the high signal alternates with the low signal, four times for each engine cycle.
This signal, together with the rpm and TDC signal, allows the control unit to recognize the cylinders and determine the injection and ignition point.



1, Earth
2, Output or signal
3, Supply voltage