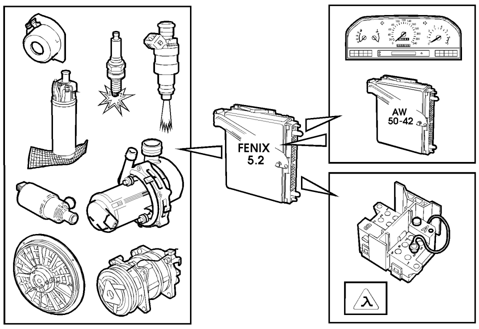
Introduction

Fenix 5.2



Fenix 5.2 is an integrated engine management system which not only controls fuel injection, ignition, FP and idling speed, but also the HO2S heating, the A/C compressor, engine coolant fan and the auxiliary air intake system, EGR system and control unit box fan. The control unit also communicates with the dashboard and automatic TCM.

The unique feature of Fenix 5.2 is that the injectors operate individually for each cylinder ('sequential injection'). The advantage of this is that fuel is injected at the optimum time for combustion and the injectors can be controlled individually.

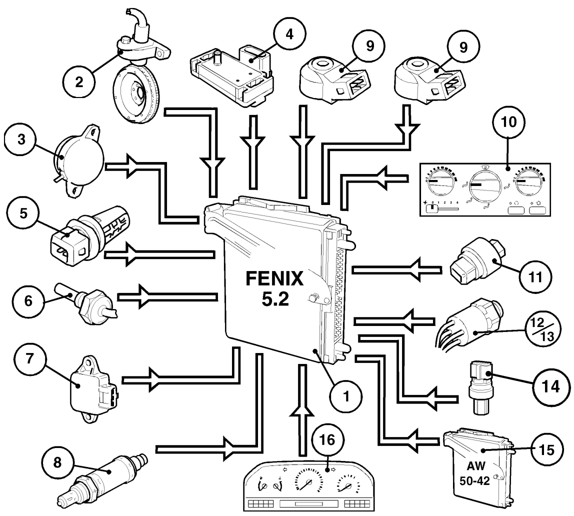
Fenix 5.2 includes facilities for long–term fuel trim, idle air trim and retarding ignition in the event of knocking. This keeps exhaust gas emissions to a minimum, and keeps service requirements low; neither CO adjustment or adjustments to the idling speed are necessary.

The control unit has a built–in diagnostic function which records any faults as they occur and stores them in memory for subsequent retrieval manually via the DLC or using the ST.

If there is a fault which affects exhaust gas emission levels, the MIL on the dashboard comes on.

System overview

Input signals



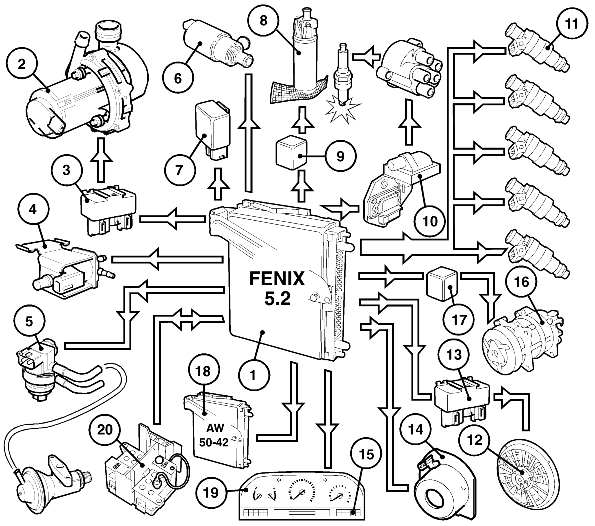
The Fenix 5.2 control module (1) receives input signals on the car operating conditions from the following components:

- Engine speed and camshaft position, from the RPM sensor (2).
- Cylinder working cycles from the CMP sensor (3).
- Vacuum in the intake manifold, from the pressure sensor (4).
- Intake air temperature from the IAT sensor (5).
- Engine temperature, from the ECT sensor (6).
- Throttle opening from the TP switch (7).
- Combustion in the cylinders, from the HO2S (8).
- If the engine starts knocking, from two knock sensors (KS) (9).
- If A/C has been selected, from the A/C unit control panel (10).
- Whether the A/C compressor is on, from the pressostat (11).
- Pressure in the A/C system from the combined high and low pressure sensors (12/13), 1993 models.
- Pressure in the A/C system, from a linear A/C pressure sensor (14), 1994 models onwards.
- Whether to change gear (automatic models only) from

the TCM (15).

- Whether the gearshift on automatic models is in P or N position, from the TCM (15).
- Vehicle speed, from the dashboard (16).

Output signals



Depending on the input signals, the control module (1) controls the:

- Air pump (2) via the air pump relay (3), (some markets only).
- Solenoid valve for the auxiliary air system (4), (some markets only).
- EGR converter (5) controlling the EGR valve (some markets only).
- Idling speed, by controlling the IAC valve (6).
- Main relay (7).
- FP (8) by operating the FP relay (9).
- Ignition, by sending signals to the output unit (10) integrated with the ignition coil.
- Fuel injection, by operating injectors individually (11).
- FC (12), by using the fan relay (13).
- Control box FC (14), (some markets only).
- The MIL on the dashboard (15).

In addition, if required, the control module can also switch off the A/C compressor (16) via the compressor relay (17).
The control module (1) also sends signals to the following components:

- Confirmation of torque control by retarding ignition, to the TCM (18).
- Engine speed and load signals, to the TCM (18).
- Throttle opening, to the TCM (18).
- RPM signal to the tachometer on the dashboard (19).
- Engine temperature to the dashboard (19).
- Injected fuel amount to the on–board computer (optional extra) on the dashboard (19).

The control module is connected to the DLC (20), which is used to operate a number of DTMs and display DTCs.

Pressure sensor

Control function

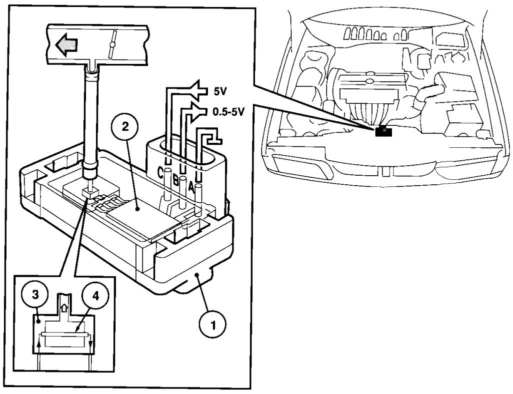
Electronic pressure and air temperature sensors measure the partial vacuum in the engine intake manifold and the intake air temperature.
The control module uses data from the sensors in calculating the engine load.

Pressure sensor components:

- Casing (1).
- PCB with electronic components (2).
- Pressure sensor (3) with piezo–electric membrane (4).

How it works:

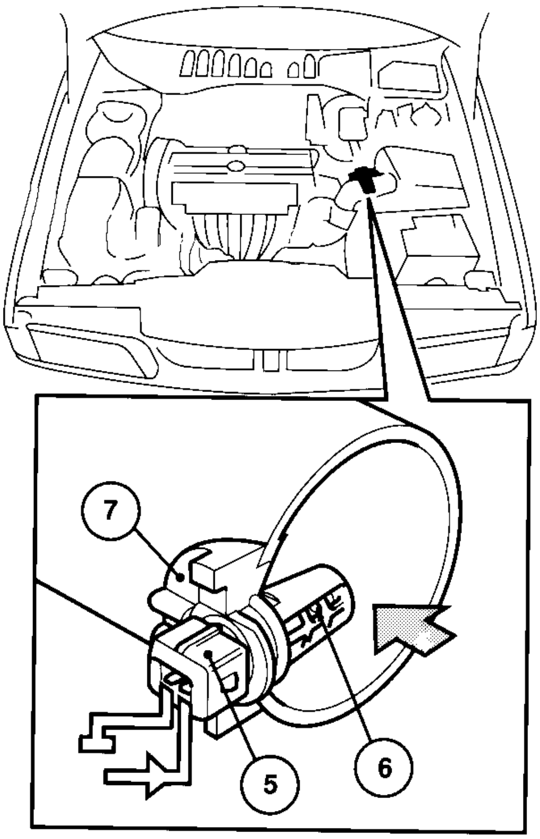
The control module supplies the pressure sensor with a



5 V voltage. Depending on the pressure in the intake pipe, the membrane bends to a varying extent and its resistance alters. The PCB notes this change, and adjusts and amplifies the signal so that the output signal from the pressure sensor varies between 0.5 and 5 V, depending on the pressure.

Air temperature sensor

Control function



Electronic pressure and air temperature sensors measure the partial vacuum in the engine intake manifold and the intake air temperature.
The control module uses data from the sensors in calculating the engine load.

Air temperature sensor components:

- Casing (5).
- NTC temperature–sensitive resistor (6).
- Seal (7).

How it works:
The control module supplies the air temperature sensor with a nominal (no load) voltage of 5 V. Changes in intake air temperature change the NTC resistor's resistance and hence the voltage.

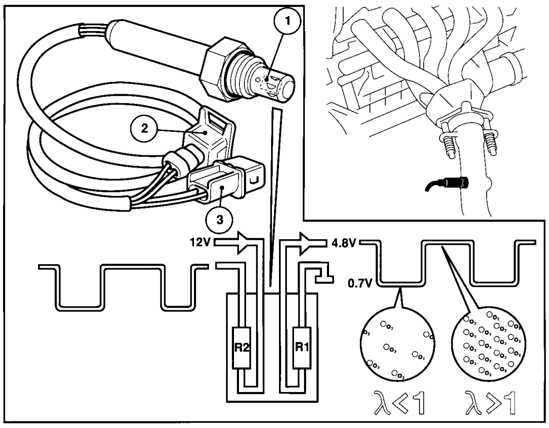
Heated oxygen sensor (HO2S)

Control function

The electrically–heated oxygen sensor (HO2S) is located in the exhaust, and records the acid levels in the exhaust gases. This tells the control module if the engine is running lean or rich.

HO2S components:
1993 models

- Sensor and preheat element (1).
- 2–pin connector (output signal and earth) (2).
- 2–pin connector (heating current and temperature control) (3).



1994 models onwards

- Sensor and preheat element (1).
- 4–pin connector (output signal, ground, heating current and temperature control) (4).

How it works:

The sensor panel has two resistors, R1 and R2: R2 is the preheat element and R1 the oxygen sensor (titanium dioxide type). One preheat element connection takes power from the system relay, and the other controls the control module temperature by grounding the preheat element at a given frequency, with the length of ground pulses governing heating. The control module is programmed to maintain the sensor panel temperature at around 700°C.

One oxygen sensor connector is grounded to the control module, the other has a nominal 5 V voltage.

If the engine is running lean (λ>1), there will be an excess of oxygen in the exhaust gases, the oxygen sensor resistance is high and the input voltage will also be high (approx. 4.8 V), because of the high resistance between the input voltage and ground.

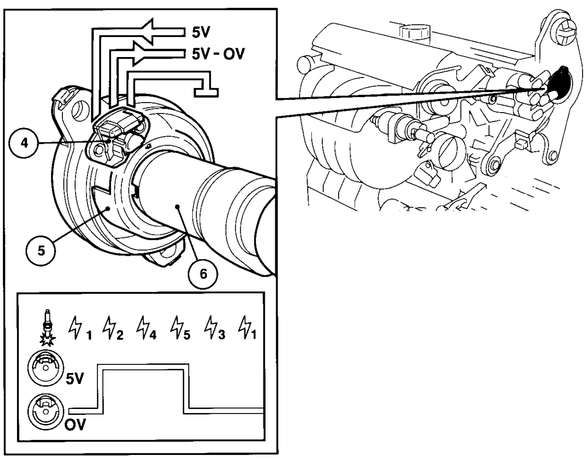
If the engine is running rich (λ<1), there will be little or no oxygen in the exhaust gases, the oxygen sensor resistance will be low and the input voltage will drop to approx. 0.7 V.

As the oxygen sensor signal varies slightly with sensor panel temperature, the control module also uses the signal to control the sensor panel temperature.

Using the signal from the HO2S, the control module can adjust the fuel injection to give the engine the optimum amount of fuel at all times (λ=1).

Camshaft position (CMP) sensor

Control function



The CMP sensor has a Hall generator which helps the control module decide the different cylinders' working cycle.

Components:

- Hall generator (4).
- Trigger rotor (5).
- Camshaft (6).

How it works:

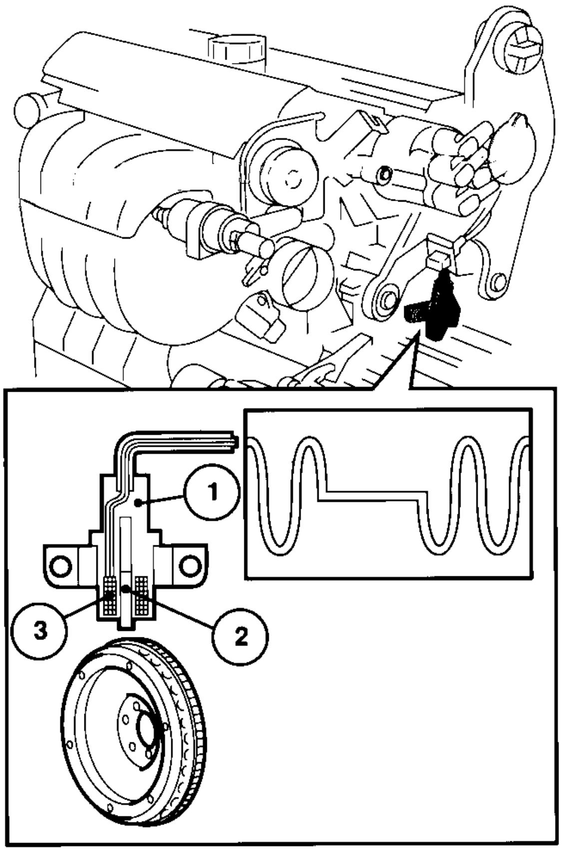
The split rotor rotates at the same speed as the camshaft. The control module sends a 5 V supply to the Hall generator; when the gap in the split rotor is central to the Hall generator, the voltage is earthed. The output signal is now 0 V. With the Hall generator screened by the rotor, the voltage is unaffected and remains at 5 V.

As the camshafts rotate at half the crankshaft speed, the output signal will be high once and low once for every other turn of the crankshaft, which is in line with the respective cylinder's working cycle.

The CMP sensor tells the control module which cylinder to fire, and also which cylinder to look for knocking in using the knock sensors (KS).
The control module fires cylinders 1 and 3 when the signal is low and 2, 4 and 5 when the signal is high.

RPM sensor

Control function



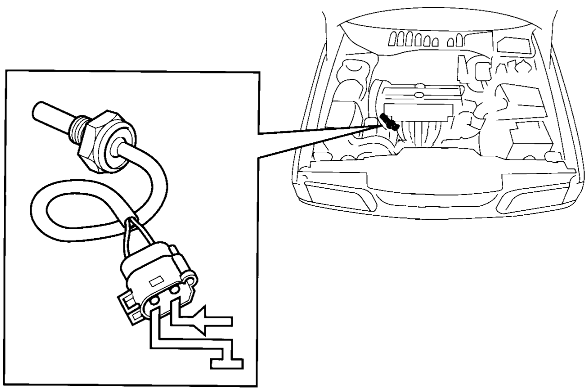
The RPM sensor is of the inductive type: it counts the holes in the flywheel and provides the control module with information on engine speed and CKP.

Components:
- Casing (1).
- Permanent magnet (2).
- Coil (3).

How it works:
The flywheel in manual cars has 58 holes (automatic models have 57). The distance between holes is greater at 90° before TDC for cylinder 1.
Each time a hole passes, it induces a voltage in the coil; by noting the voltage pulses, the control module can establish the crankshaft speed and position.

Engine coolant temperature (ECT) sensor

Control function



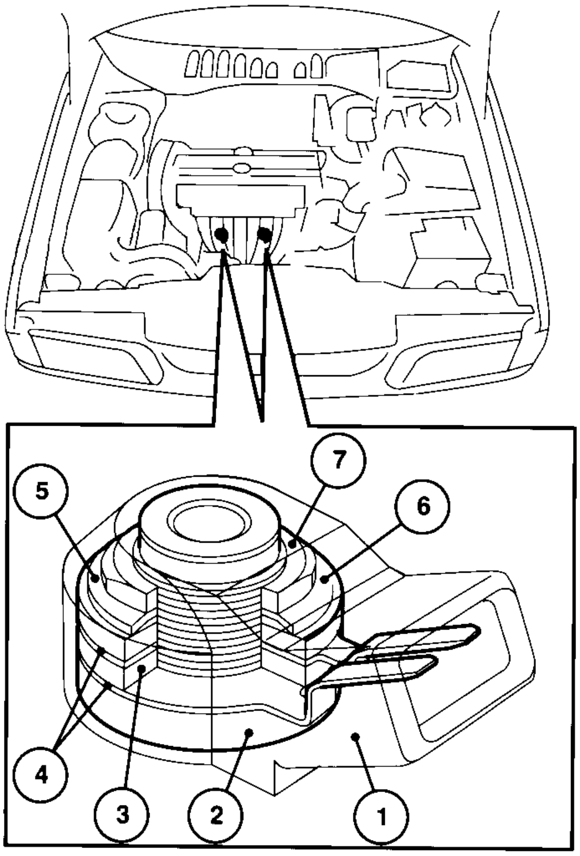
The ECT sensor on the thermostat casing provides the control module with information on the ECT. The ECT sensor has a temperature–sensitive resistor with a NTC. The control module sends a nominal (no–load) 5 V voltage to one of the sensor connections, while the other is connected to ground. Depending on the ECT and hence the sensor's resistance, the voltage from the control module varies. The voltage is high when the engine is cold and low when it is hot.

Knock sensor (KS)

Control function

The two KS are mounted on the engine block, and transmit signals to the control module if any of the cylinders starts knocking.

Components:

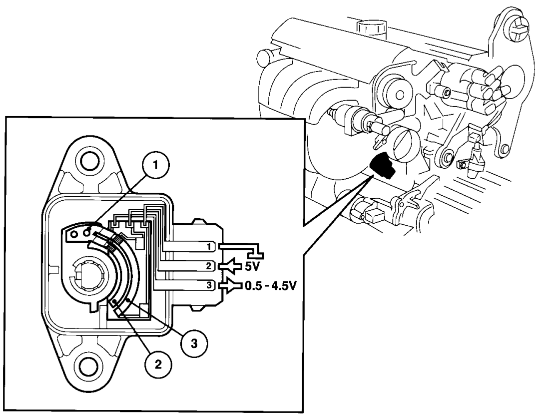


- Casing (1).
- Sleeve (2).
- Piezo–electric crystal (3).
- Contact strips (4).
- Damping weight (5).
- Washer (6).
- Nut (7).

How it works:
If any of the cylinders starts knocking, this produces a certain type of vibration in the engine block. This produces a mechanical effect in the KS piezo–electric crystals, causing them to emit a voltage. By comparing this with the CMP and ECT sensors, the control module can tell which cylinder is knocking.

Throttle position (TP) switch

Control functions



The TP switch is mounted on the throttle casing, and tells the control module how wide the throttle is open. This information is used to determine acceleration and engine load.

Components:
- Hub and wiper contacts (1).
- Wiper track (2).
- Resistance track (3).

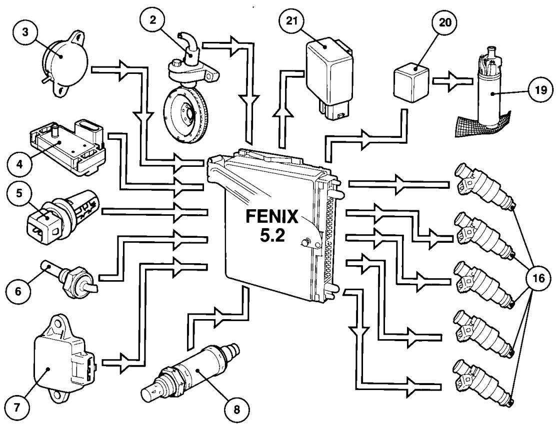
How it works:
The throttle spindle rotates the hub and wiper contacts, varying the sensor resistance. The control module sends a 5 V supply to the TP switch terminal (2). Terminal (1) is grounded, and the output signal from terminal (3) varies between 0.5 V with the throttle closed to 4.5 V at WOT.

Control, fuel system

Control function

The control module controls the main relay (1), the FP relay (2) and injectors (3) on the basis of information from the following sensors:

Sensors:
- RPM sensor (4).
- CMP sensor (5).
- Pressure sensor (6).
- Air temperature sensor (7).



- ECT sensor (8).
- TP sensor (9).
- Heated oxygen sensor (HO2S) (10).

How it works:

When the ignition is switched on, the control module activates the system relay. The FP relay also operates for about 1 second to enable the FP (11) to build up the fuel pressure.

When the starter motor turns the engine over, the RPM sensor and CMP sensor send information on engine speed and position to the control module, which then operates the FP relay and opens all the injectors at once, injecting fuel in when the RPM sensor indicates TDC.

When starting the engine, the control module calculates the injection time on the basis of engine temperature, air pressure and engine speed.

Once the engine is running, injection times are based on engine speed, battery voltage, temperature and load data, which are calculated using the pressure in the intake pipe, air temperature and TP.

At the same time, the control module switches to sequential injection once per working cycle when the intake valve is open.

Once the HO2S has reached its working temperature, the signal from it is also used in working out how much fuel to inject.

The control module has built–in programs which compensate for variations in battery voltage, acceleration, full load and shutting off fuel during engine braking. There are also long–term functions which store information on optimum fuel supply under different driving conditions. The control module uses this information to make up for wear and tolerances on components used. This minimises exhaust gas emission levels, maintenance and adjustments.

If the engine starts knocking over a given level, the system injects more fuel to cool the combustion process.

If the engine overspeeds, the control module shuts off the fuel injection to prevent damage to the engine.

If the A/C compressor or a drive position is selected, the control module temporarily increases the amount of fuel injected to make up for the increase in load and to help keep the engine speed more or less constant.

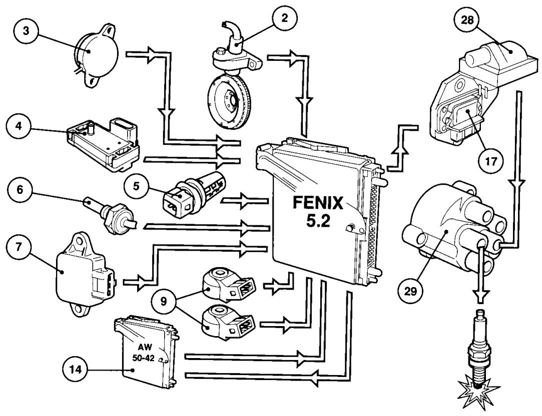
Control, ignition system

Control function

On the basis of information from the following sensors, the control module calculates the timing and activates the power stage (1), which cuts the current to the ignition coil (2). The distributor (3) sends the high voltage this produces to the spark plugs.

Sensors:

- RPM sensor (4).



- CMP sensor (5).
- Pressure sensor (6).
- Air temperature sensor (7).
- ECT sensor (8).
- TP sensor (9).
- KS (10).
- TCM (11).

How it works:

When starting the engine, the control module uses a fixed timing. Once the engine is running and the car is moving, the control module calculates the optimum timing for the engine speed, load and temperature at any time.

The control module only starts checking the knock sensors once the engine has warmed up; if any of the cylinders starts knocking, it retards the ignition in that cylinder until the knocking stops.

Timing then returns to its normal position or until knocking starts once more. If this does not work, and the engine continues to knock, the system injects more fuel and reduces the combustion temperature.

With automatic transmissions, the gearshift sends a request to the control module to limit the torque, and the control module then retards the ignition temporarily. At the same time, it sends an acknowledgement signal to the TCM, which then changes gear. Timing may be retarded between 3° and 27°, depending on engine load.

Together with the power stage, the control module has a built–in function which controls the current to the coil so that it is always optimally charged, irrespective of engine speed.

Control, idle air control (IAC) valve

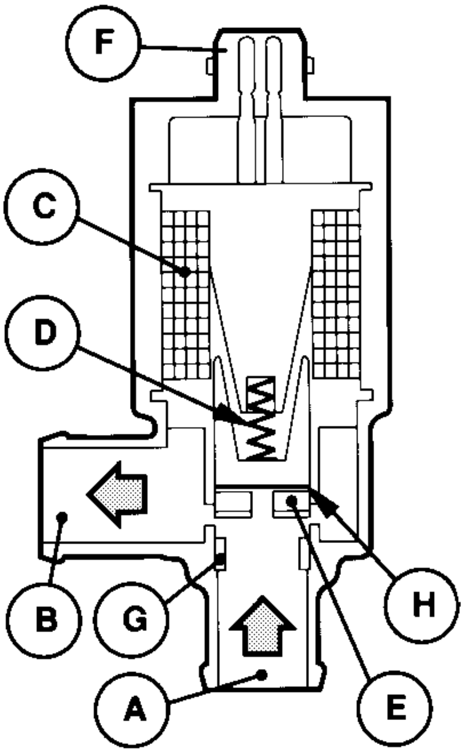
Control function

Using information from the sensors, the control module calculates the idling speed and controls the linear IAC valve (1) to keep the idling speed constant at all times.

IAC valve

Components:

- Inlet (A).
- Outlet (B).
- Solenoid (C).
- Return spring (D).
- Valve (E).
- Connector (F)



Operation:

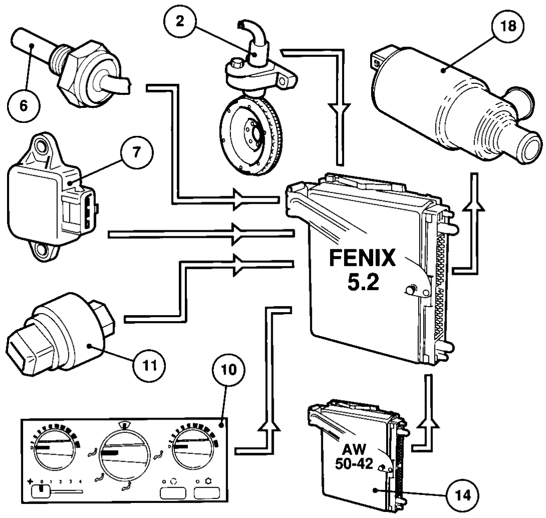
One of the connector (F) terminals is connected to the battery voltage via the system relay. The other connection is connected to the control module. To control the air flow, the control module grounds the solenoid (C) at a set frequency. Depending on the length of the ground pulses, the magnetic field strength varies and controls the return spring pressure on valve (E) and hence controls the opening between input (A) and output (B).

If the IAC valve control is faulty, the return spring presses the valve against stop (G) and exposes hole (H). This allows a limited amount of air through the hole, which increases the idling speed slightly.

Sensors

Components

- RPM sensor (2).
- ECT sensor (3).
- TP sensor (4).
- A/C system control panel (5).
- Pressostat (6).
- TCM (7).



Idle air trim, operation:

If the TP sensor indicates that the throttle is closed and the engine idles, the control module adjusts the IAC valve to make the engine idle at the right speed for the current engine temperature and load.

The control module receives information from the pressostat and transmission control module when the A/C compressor cuts in and/or the driver selects a drive position, increasing the airflow temporarily to boost idle air trim. The same thing happens if the control module operates the engine coolant fan.

The idle air trim is a `learning' system: the control module learns how far to open the IAC valve under different conditions. It stores this information and uses it the next time the engine starts. For this reason, there is no idling speed adjustment screw.

If the IAC valve control malfunctions, it assumes a set position with a higher than normal idling speed.

As the TP sensor has no set idling position, the control module has a long–term function which stores the lowest value read and takes that as equivalent to the throttle being closed. WOT is taken at a set angle from throttle closed.

Fan control (FC)

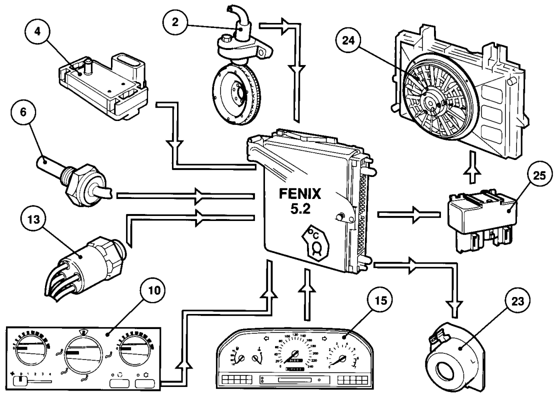
Control function

If the sensors indicate that more cooling is needed, the control module operates the engine coolant fan (1) via fan relay (2).

Vehicles with A/C have two–speed engine coolant fans.

Some 1993 models for tropical markets also have a separate FC (3) to cool the ICM box: this comes on at the same time as the engine coolant fan.

Vehicles without A/C have one-speed engine coolant fans, except for some 1994 models that were equipped with two-speed engine coolant fans.



Sensors:

- RPM sensor (4).
- Pressure sensor (5).
- ECT sensor (6).
- A/C system control panel (7).
- VSS (8).
- A/C pressure switch (9), 1993 models.
- Linear A/C pressure sensor (10), 1994 models onwards.

Operation:

The control module operates the engine coolant fan via fan relay (2). The fan runs at half speed at:

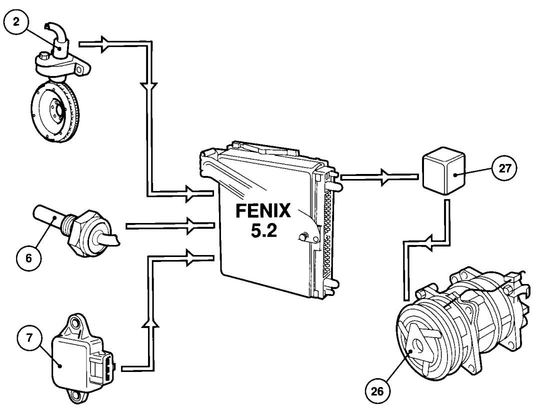
- High engine temperature. **or**
- A/C on, low engine speed and A/C pressure high at some point since engine started. **or**
- Temperature in control module box too high (noted by a built–in temperature sensor in the control module).

The control module always switches the engine coolant fan on at full load if there is a risk of the engine overheating.
Once the engine is switched off, the control module may keep the engine coolant fan going if:

- The engine was running under high load and temperature just before it was switched off.
- If the fan was running at full speed just before the engine was switched off, i.e. if there was a risk of overheating.

Control, A/C compressor

Control function



If A/C is selected, switching the A/C compressor (1) on and off is normally under the control of the pressostat and A/C system. Under certain conditions, the control module may cut the compressor out via A/C relay (2).

Sensors:

- RPM sensor (3).
- ECT sensor (4).
- TP sensor (5).

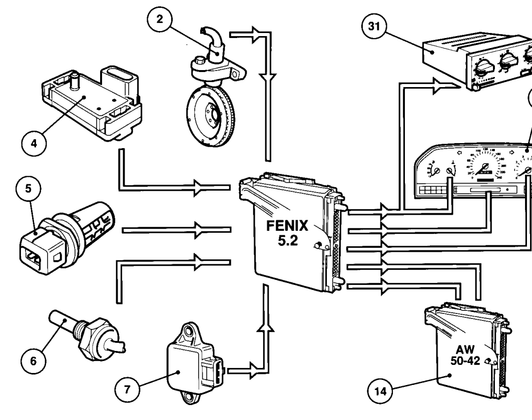
Operation:

To reduce the load on the engine, the control module may cut the A/C compressor out via the A/C relay under the following conditions:

- When accelerating under full load, it cuts out the compressor for between 5 and 15 seconds.
- When the engine temperature is high.
- When starting the engine.

Output signals

Control function



The control module supplies some other systems in the car with data it takes from the sensors.

Sensors:

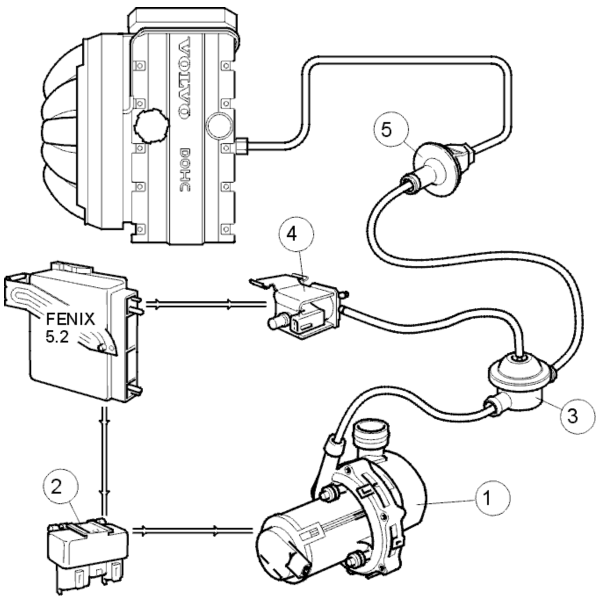
- RPM sensor (1).
- Pressure sensor (2).
- Air temperature sensor (3)
- ECT sensor (4).
- TP sensor (5).

Control module output signals:

- RPM signal to dashboard (6) tachometer.
- Fuel injected to dashboard on–board computer (optional extra).
- ECT to dashboard temperature gauge and ECC system (7).
- Engine load to TCM (8).
- TP to TCM.

Auxiliary air system

Control function



The auxiliary air system is designed to minimize hydrocarbon and carbon dioxide emissions when starting from cold and to heat the catalyser up faster. By adding fresh air to the exhaust ports when starting the engine from cold, the air pump helps burn off uncombusted hydrocarbons. This enables the system to increase the injection time and retard the timing, increasing the exhaust gas temperature and activating the catalyser faster.
The system consists of:

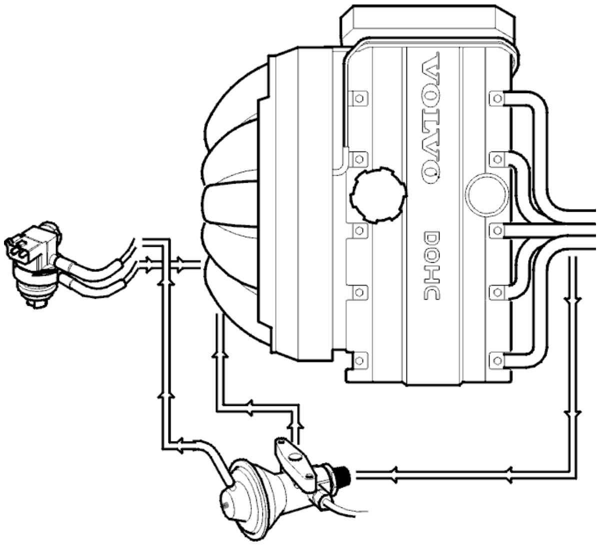
- The air pump (1) operated via the air pump relay (2). The air pump is fitted with a filter and an intake pipe pointed towards the side member to prevent it drawing in dirt and water. The pump and relay are protected by a 40 A fuse in the electrical control unit. A resettable bimetallic fuse in the pump trips in the event of overheating, which may occur after repeated cold starts.
- The shutoff valve (3) which controls the air supply to the exhaust gas ports.
- Solenoid valve (4) which controls the shutoff valve via the partial vacuum in the intake pipe.
- Non–return valve (5) preventing exhaust gases escaping out the back way if the system is not working.

Fenix 5.2 controls the air pump relay and solenoid valve which starts the air pump and opens the shutoff valve when the system starts up. Air then passes from the pump via the shutoff valve and non–return valve to the exhaust ports.
The supplementary air system operates 20 seconds after starting the engine if the ECT is less than 30 °C and the car is not idling. Once the system switches on, it works

for 45 seconds and then switches off automatically.

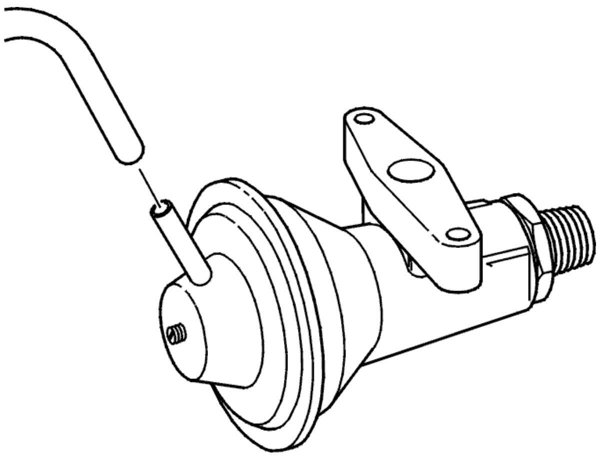
Exhaust Gas Recirculation (EGR)

Control function



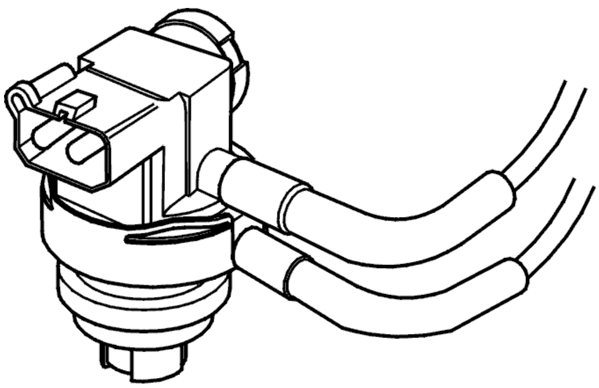
A proportion of the exhaust gases is recirculated to the intake manifold to reduce emissions of nitrogen oxides (NOx) in the exhaust gases. NOx gases form at the high temperatures which occur in engine combustion at high loads.
Recirculating some of the exhaust gases at high loads lowers the combustion temperature and helps reduce nitrogen oxide levels in the exhaust gases.
The system is not operative when the engine is cold or idling, to avoid affecting the engine idling characteristics.
Exhaust gas recirculation is controlled by the EGR valve, which the control unit controls via the EGR controller.
The EGR controller receives a signal from the control unit which depends amongst other things on engine speed, load and temperature. The signal from the control unit, ambient pressure and pressure in the intake manifold is converted to a modified vacuum signal which operates the EGR valve via the vacuum hose.

EGR valve



The EGR valve controls the flow of gas from the exhaust manifold to the inlet manifold. The valve is controlled by the vacuum in the line connected to the EGR controller.
The EGR valve is located underneath the inlet manifold.

EGR controller



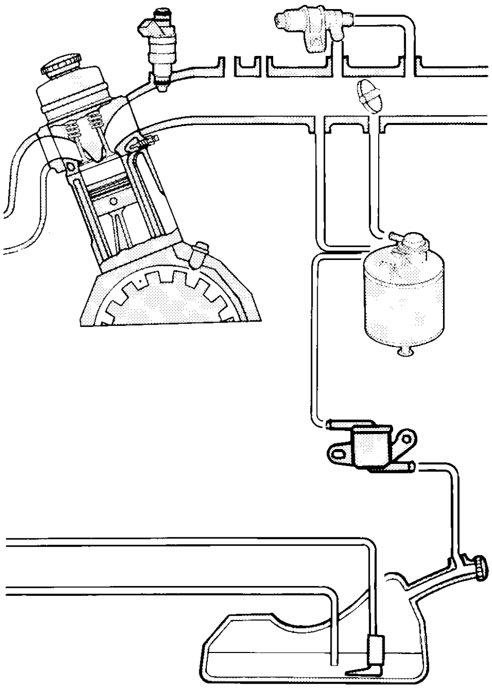
The EGR controller regulates the vacuum pressure to the EGR valve from the outlet on the top of the EGR controller. The vacuum from the intake manifold is supplied to the underside of the EGR controller. The controller stabilises the vacuum from the intake manifold and converts the electrical signal from the control unit to a vacuum signal for controlling the EGR valve.
The EGR controller is mounted on the underside of the relay shelf, above the engine coolant fan.

EGR pipe

The EGR pipe conveys the recirculated gases from the exhaust manifold to the EGR valve.

EVAP-system

Control function



EVAP stands for Evaporative Control System, and is a system which recovers the fuel which evaporates in the fuel tank and prevents it escaping into the atmosphere. The fuel vapor passes through a system of hoses from the fuel tank filler pipe through a roll–over valve to a filter (or canister) of activated charcoal. This absorbs fuel vapors and prevents them escaping into the atmosphere.

EVAP canister

Fuel vapor from the tank enters the top of the filter, where it binds to the activated charcoal. Air is discharged through a passage in the bottom of the filter. The filter holds approximately 90 grams of fuel, depending on the temperature and other conditions.

Roll–over valve

The roll–over valve closes if the car tilts sideways by more than 45{SONDZEICHEN 176 \f "Symbol"}, helping to prevent fuel leaking in the event of an accident.

EVAP valve

The EVAP valve is mounted in the top of the EVAP canister and is closed when the engine is off. It is also closed when idling so as not to affect the engine idling characteristics. This is achieved by using the vacuum in the intake manifold to control the valve and the fact that this is connected to the positive side of the throttle.
If the load on the engine increases, the EVAP valve opens and allows fuel vapor from the EVAP canister to enter the engine intake manifold. At the same time, air is drawn in through the opening in the bottom of the filter. Under normal conditions, the filter is emptied in about 15–20 minutes.