XC90, 2005, B6294T, 4T65 AWD, L.H.D

14/11/2018

PRINT

Camshaft control (CVVT)

Cruise control

Fuel pressure regulation (only vehicles with demand controlled fuel pumps)

Fuel trim

Ignition control

Immobilizer

Knock control

Oil level monitoring (2004-, certain markets and models only)

Throttle control

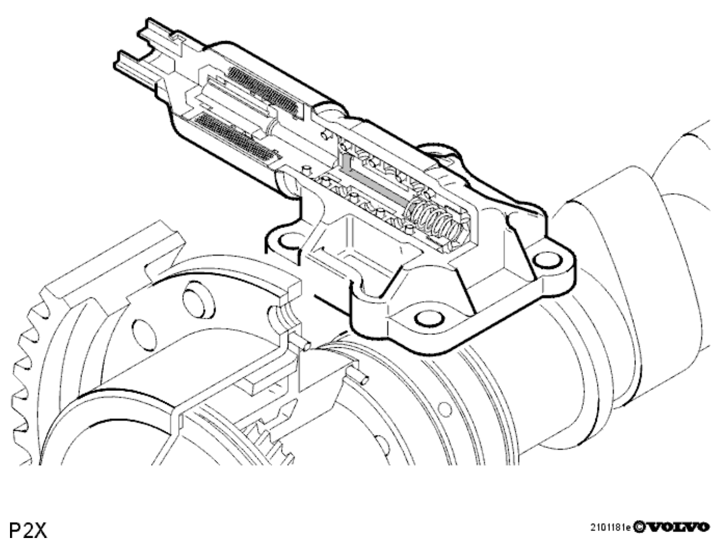
Turbocharger (TC) control system

Function

Immobilizer

See Design and Function, Immobilizer.

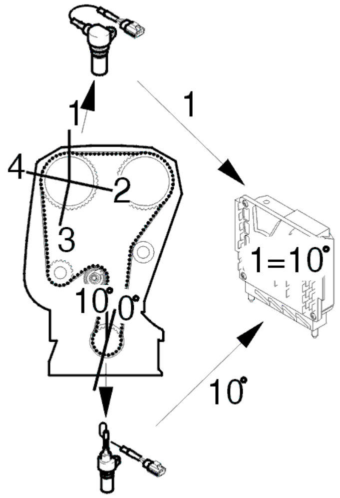
Camshaft control (CVVT)



When the camshaft is set at the factory, it is aligned with the position of the crankshaft. The position of the camshaft in relation to the crankshaft is designated the camshaft 0 position. During camshaft control (CVVT) the camshaft 0 position is offset. The value of the 0 position offset is called the cam timing. The cam timing is 0° if the camshaft is not being controlled. By controlling the cam timing (the camshaft is deployed from its 0 position) the performance of the engine is increased, the idle speed quality is improved and the emissions are reduced.

In order to detect the cam timing, the engine control module (ECM) uses the signals from the engine speed (RPM) sensor (the position of the crankshaft) and from the camshaft position (CMP) sensor (the position of the camshaft). By comparing these two signals, the control module is able to determine the cam timing (the number of degrees the camshaft is from its 0 position).

There are diagnostic for this function. See also Camshaft diagnostics (CVVT) .



Camshaft cam timing

The camshaft (A) is divided into four flanks per revolution of the camshaft (flanks 1-4). The angle between flanks 1-2 = 103°, flanks 2-3 = 90°, flanks 3-4 = 90° and flanks 4-1 = 77°. The angle between the flanks is different, allowing the control module to determine which flank it is detecting and therefore determine which combustion cycle the cylinders are in,

The crankshaft has four reference positions, one for each camshaft flank. The camshaft turns at half the speed of the crankshaft. This means that two reference positions are detected for each turn of the crankshaft. Therefore two engine revolutions are required to detect all flanks on the camshaft. For example (may vary between different engine variants): flank 1 at 0°, flank 2 at 206°, flank 3 at 386° and flank 4 at 576° (flanks 3 and 4 are detected during the second engine revolution).

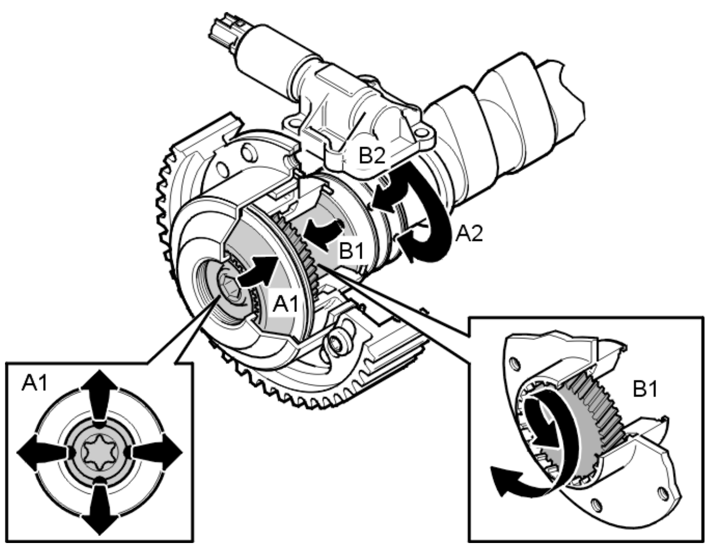
The reference positions of the crankshaft coincide exactly with each camshaft flank if the camshaft cam timing is 0°. If the cam timing deviates from 0°, i.e. the flanks deviate from the reference positions of the crankshaft, the control module calculates the number of crankshaft degrees by which the flank is deviating.
The control module detects the reference positions for the camshaft flanks using the signal from the engine speed (RPM) sensor.

Example:
If camshaft flank 1 is detected at 10° from the crankshaft reference position for flank 1 (0° +10°), the cam timing is 10°. If the cam timing is the same (10°), flank 2 is detected at 216° (206° + 10°), flank 3 at 396° (386° + 10°), and flank 4 at 586° (576° + 10°). The cam timing can be positive (+) or negative (-) depending on whether the flank is detected before or after the different

reference positions for the crankshaft.

The engine control module (ECM) controls the camshaft reset valve smoothly in order to regulate the camshaft cam timing. The valve controls the flow of engine oil to the continuous variable valve timing (CVVT) unit which is affected by the oil pressure that builds up.
Also see Design:Camshaft reset valve (Continuous variable valve timing (CVVT)) .

Control



Control takes place as follows when deploying the camshaft:

1. Oil is forced from the engine lubricating system to the intake port on the reset valve
2. The engine control module (ECM) grounds the valve, the position of the piston in the valve changes and the oil is guided to the continuous variable valve timing (CVVT) unit chamber (A1) via the duct (A2)

in the camshaft

3. The continuous variable valve timing (CVVT) unit hub is pressed backwards by the oil pressure. The continuous variable valve timing (CVVT) unit then rotates the hub and the carriers are joined by twisted splines
4. The oil flows to the engine oil pan via the outer ducts on the hub and the reset valve's return hose.

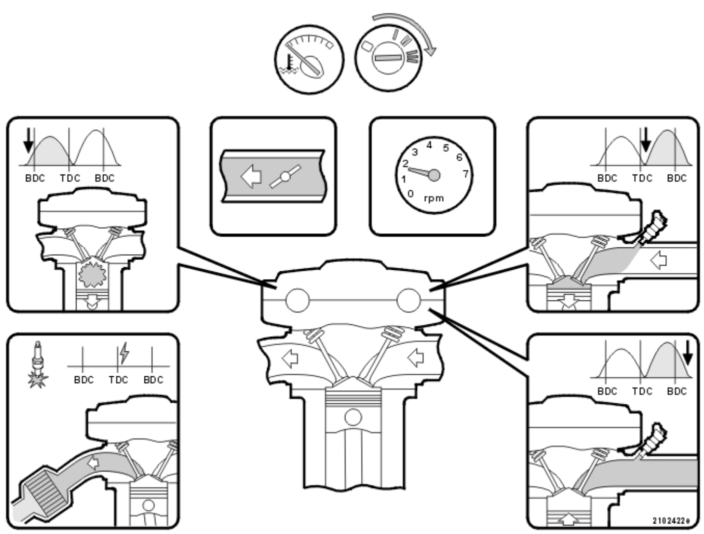
Control takes place as follows when returning the camshaft:

1. Oil is forced from the engine lubricating system to the intake port on the reset valve
2. The engine control module (ECM) breaks the ground connection for the valve. The piston in the valve is then pressed back by a spring. The oil flows to the continuous variable valve timing (CVVT) unit chamber (B1) via a duct (B2) in the camshaft
3. The hub of the continuous variable valve timing (CVVT) unit is forced forward by the oil pressure that is

created. The continuous variable valve timing (CVVT) unit will rotate back to the non-deployed position
4. The oil flows to the engine oil pan via the center duct on the hub and the reset valve's return duct.

The above takes place very quickly. The engine control module (ECM) controls the deployment and return of the reset valve continually at high frequency. This results in rapid and exact control. The extent of camshaft control (the change of cam timing) varies depending on the engine variant and the model year.

”Wide Range” concept



Ignition timing
The combustion of the fuel film on the cylinder walls is improved by

retarding the ignition. Retarded ignition reduces the efficiency of the engine and the heat energy which is generated is released with the exhaust gases. This is used to heat the three-way catalytic converters (TWC).

Exhaust camshaft (turbocharged engines)
By opening the exhaust valve late, combustion takes place over a relatively long period. The film of fuel on the cylinder walls combusts, reducing the exhaust emissions.

Intake camshaft
By opening/closing the intake valve late:

- so that there is little or no overlap, a predetermined pressure difference is maintained between the intake manifold and the combustion chamber/cylinder. The lower pressure in the cylinder ensures that all the injected fuel reaches the cylinder. This allows the Engine Control Module (ECM) to calculate and control the fuel quantity required in the

combustion phase in advance
- maintains a high and stable pressure in the intake manifold (due to the upwards movement of the piston). Stable high pressure means that the vaporization of the fuel which has condensed on the walls of the intake manifold can be predicted.

Double continuous variable valve timing (CVVT)

CVVT on both the intake camshaft and the exhaust camshaft means that the valve overlap can be changed to a greater degree than on engines where only one of the camshafts is controlled. Valve overlap is the extent to which the intake and exhaust valves (on the same cylinder) are open at the same time.

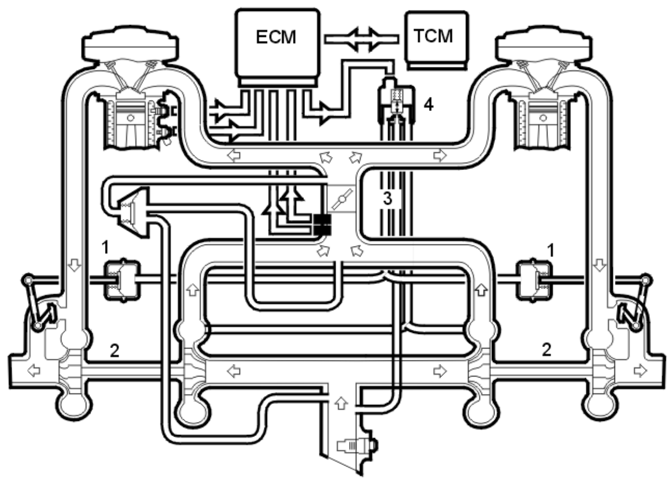
The advantages of continuous variable valve timing (CVVT) are used in different operating conditions:

- *during cold starting and during the warm-up phases* when the intake camshaft and exhaust camshaft are set late. This reduces the emissions
- *during idle and*

when the engine is at operating temperature when the exhaust camshaft is set to early and the intake camshaft is set to late. This results in small valve overlap, reducing exhaust gas recirculation (EGR) and ensuring stable idling

- *at part load* when both the exhaust and intake camshaft are set to relatively late, with greater valve overlap. Greater valve overlap results in internal exhaust gas recirculation (EGR) which reduces the release of nitrous oxide. This also limits the incoming fuel/air mixture to the cylinder. As a result, the throttle does not need to reduce the supply of air, thereby reducing ”pump losses” and lowering the fuel consumption. At higher engine speeds (RPM), the camshafts are set for a smaller valve overlap. The exhaust camshaft is set earlier, the intake camshaft later. This provides an optimum fuel/air mixture to the cylinder. Reduces internal exhaust gas recirculation (EGR).

Turbocharger (TC) control system



Hint:
The above illustration is for a 6 cylinder engine. However the principle is the same for 5 cylinder engines.

The boost pressure in the intake manifold is controlled by the boost pressure control (BPC) valves, whose pressure regulators (1) are affected by the pressure from the turbocharger (TC) (2).

The Engine Control Module (ECM) receives information about the actual throttle position via the throttle position sensor (TP) for the throttle unit (3), engine load, knocking etc. This affects the boost pressure that is permitted. The boost pressure is measured

by the boost pressure sensor.
The control module controls the control pressure using the turbocharger (TC) control valve (4) (also see Design:Turbocharger (TC) control valve), which controls the pressure to the boost pressure control (BPC) valves so that the control is adapted to the required pressure.

The pressure regulators in the boost pressure control (BPC) valves are affected when the pressure rises. When the boost pressure has increased to the maximum permissible value, the boost pressure control (BPC) valves open. Some of the exhaust gases pass the turbine in the turbocharger (TC), limiting the boost pressure.

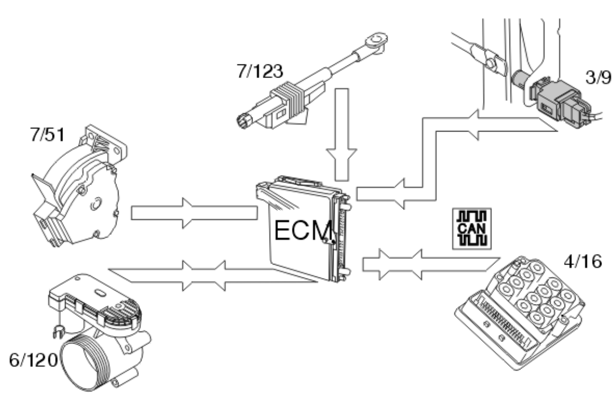
Turbocharger (TC) control is governed continually by the engine control module (ECM).

When a higher boost pressure is permitted, the control module opens the turbocharger (TC) control valve further. Some of the boost pressure which affects the pressure regulators for the boost pressure control (BPC) valves is released back into the turbocharger (TC) intake. This lowers the control pressure, the boost pressure control (BPC) valves open later and the boost pressure increases.

Because the control module calculates the boost pressure using the signal from the boost pressure sensor and the intake temperature sensor, there is automatic compensation of boost pressure control when driving at altitude and at different temperatures. As a result engine power will not be noticeably affected by the air density or temperature.

The engine control module (ECM) can diagnose the turbocharger (TC) control function.

Throttle control



To ensure that the correct throttle angle is reached, the engine control module (ECM) controls the throttle shutter in the throttle unit (6/120), mainly using the signal from:

- accelerator pedal (AP) position sensor (7/51)
- clutch pedal sensor (7/123)
- stop lamp switch (3/9)
- the throttle position (TP) sensor on the electronic throttle unit (6/120)
- brake control module (BCM) (4/16), signal for the brake pedal sensor.

Additional signals and parameters are used to ensure optimum throttle control. For example there is compensation for the load from the air conditioning (A/C) compressor, load from the transmission depending on the gear selected (automatic), engine temperature etc. In cars with Four-C (Continuously Controlled Chassis Concept), the throttle characteristic changes depending on the driving mode selected.

The position of the throttle is measured by two potentiometers, in the throttle position (TP) sensor, which are on the throttle unit. These are connected, so that potentiometer 1 produces a higher voltage as the throttle angle increases, while potentiometer 2 does the opposite.

In a combustion engine, the difference between the minimum and maximum airflow is considerable. The smaller air flows need more thorough regulation, so the potentiometer signal from potentiometer 1 is amplified approximately 4 times in the engine control module (ECM) before it reaches the Analog/Digital converter in the engine control module (ECM). This means that there are three, two real and one fictitious, input signals available to the engine control module (ECM). These signals are used to determine the position of the throttle and to deploy the damper motor to the correct position. In general the amplified signal is primarily used for small throttle angles (small air flows), which are desirable when a high degree of accuracy is required, for idle air trim for example.

Because the signal is amplified, it reaches its maximum value as early as approximately a quarter of maximum deployment.

The engine control module (ECM) first uses the signal from potentiometer 1 to measure the throttle opening. The signal from potentiometer 2 is mainly used to check that potentiometer 1 is functioning correctly. The engine control module (ECM) then uses the signal to calculate a throttle angle (actual value). This is the actual throttle angle. The value for the actual throttle angle is used by those functions in the engine control module (ECM) which depend on this information so that the throttle can be correctly regulated.

There is an adaptation (learning) in the engine control module (ECM) so that the control module can calculate how the damper motor needs to be controlled. See "Adaptation of the throttle unit" below. This adaptation is carried out during manufacture of the car, when the engine control module (ECM) deploys the throttle disc to the different positions and reads off and registers the actual values from the potentiometers.

The throttle angle is regulated so that the actual angle (actual value) is the same as the angle calculated by the engine control module (ECM) (desired value). The engine control module (ECM) also uses the values that were stored during adaptation of the throttle angle, and the actual signals from the potentiometers.

The damper motor is controlled by a power stage integrated in the engine control module (ECM) using a pulse width modulation (PWM) signal. The torsion from the opening and return springs in the throttle unit is also used. If there is a fault in the engine control module (ECM) so that the throttle unit cannot be operated or supplied with power, the springs in the throttle unit will turn the throttle disc to the limp home position (return position). This return position gives a throttle angle large enough to allow the car to be driven to a workshop, although with considerably reduced drivability.

Throttle angle

The throttle angle is usually gauged by potentiometer 1. For small angles the amplified signal is used to obtain a clearer signal. The engine control module (ECM) also monitors the throttle unit signals from the potentiometers to check

that they are plausible, that they are within the minimum and maximum limits and that the signals correspond to the same throttle angle. If there is a difference in the signals, a fictitious throttle signal is calculated from the load signal, the engine speed (rpm) and the prevailing conditions, particularly pressure and temperature.
The potentiometer whose signal is closest to the calculated throttle angle will then be assumed to be correct. The other potentiometer is then classified as not functioning and a diagnostic trouble code (DTC) is stored. The system then constantly monitors the throttle angle of the remaining potentiometer in comparison to the calculated throttle angle. If there is a difference between these values, the engine control module (ECM) will not rely on any of the throttle unit potentiometers. The power stage in the throttle unit is then disengaged, and the throttle switches to limp home mode (return position).

Adaptation of the throttle unit
Normally the engine control module (ECM) adapts the throttle unit during manufacture of the car. There are a

number of other occasions when the throttle unit must be adapted. A new adaptation is obviously required if the throttle unit or the engine control module (ECM) is replaced, but also if the software in the engine control module (ECM) is replaced. This is because the adaptation values are stored in the EEPROM memory in the control module, at a predetermined location in the memory for each software. These storage locations may vary between different software, in which case a new adaptation will be required. The final reason for adaptation is that the values for the throttle unit may have changed during its service life. Therefore there is a routine which begins adaptation of the throttle unit if the car is left with the engine off and the throttle on for 30 seconds (and other basic conditions for adaptation of the throttle unit are met). A new adaptation is then carried out. If the ”new” values are different from the ”old” values, the new values are used. Adaptation usually takes place automatically when the engine control module (ECM) detects that the adaptation has not been run or that the values from a previous adaptation are outside certain tolerances. However a number of basic conditions must be met to ensure that the adaptation is carried out correctly:

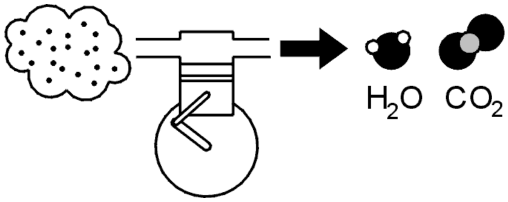
Basic conditions for adaptation of the throttle unit:

- ignition on / engine off
- battery voltage above 10 V
- accelerator pedal (AP) released (unaffected)
- the car must be stationary (no speed signal)
- engine coolant temperature (ECT) between 5 and 100 °C
- intake air temperature (IAT) above 5 °C.

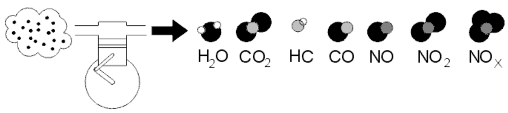
During adaptation, the engine control module (ECM) checks that the values obtained are within reasonable limits. This helps to determine whether the throttle unit is functioning correctly or not. When the adaptation has been carried out, all relevant values are stored in the EEPROM memory in the control module so that they can be retrieved if the power supply is broken. This means that if the battery is replaced for example, a new adaptation is not necessary.

Fuel trim

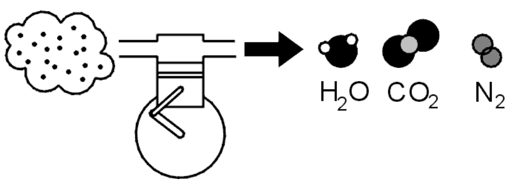
Overview



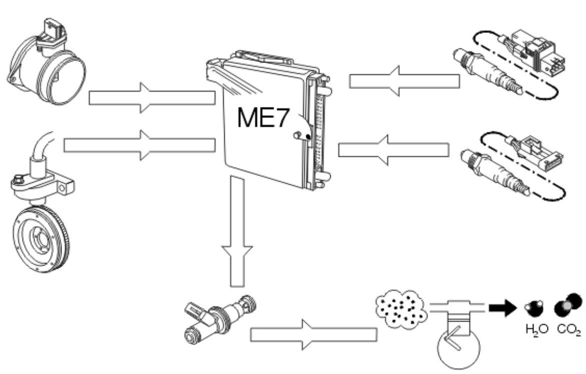
Fuel trim reduces exhaust emissions. Fuel trim reduces nitrous oxide (NO_x), carbon monoxide (CO) and hydrocarbon (HC) emissions. Theoretically, if the correct amount of oxygen is added during combustion, fuel can be converted to water (H_2O) and carbon dioxide (CO_2). Emissions would then be completely safe.
In practice considerable amounts of hydro-carbons (HC) and varying amounts of carbon monoxide (CO) and carbon dioxide (CO_2) remain.



Due to the high temperature and pressure, nitrous oxides such as NO and NO_2 are also formed. The common designation for these gases is nitrous oxides NO_x.



By speeding up the reaction between the remaining reactive components using a catalytic converter, these can be converted to water (H_2O), carbon dioxide (CO_2) and nitrogen (N_2).
However this can only happen if the balance of hydro-carbons (HC), carbon monoxide (CO), oxygen (O_2) and nitrous oxides (NO_x) is exactly right in the exhaust. This happens when the fuel air mixture before combustion is 14.7 kg of air per kg of fuel. The Lambda value is then said to be one, (λ=1).

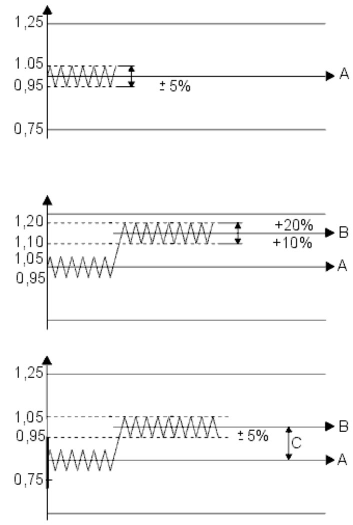


A base program in the

engine control module (ECM) calculates the injection period based on data about load, i.e. the measured air mass and engine speed (rpm). The calculated injection time (from the base program) is then modified by a circuit (short-term fuel trim). The signal from the heated oxygen sensor (HO2S) is used to finely adjust the injection period so that λ=1 is reached. The short-term fuel trim is also a circuit that finely adjusts the injection period so that the fuel air mixture is optimized (λ=1). The control module also used the signals from the front and rear heated oxygen sensors (HO2S) to correct the front heated oxygen sensor (HO2S) (offset adjustment) and thereby the injection period. This gives a higher degree of accuracy during fuel trim. Fuel trim is a rapid process which may take place several times a second. Adjustment of the calculated injection period calculated in the base program is limited.

The fuel trim can be read off using VIDA.

Adaptive functions

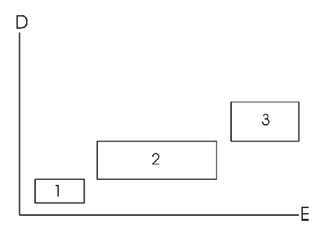


Certain factors, such as deviations in tolerance for certain components such as the mass air flow (MAF) sensor and injectors, intake air leakage, fuel pressure etc, will affect the composition of the fuel air mixture. To compensate for this, the engine control module (ECM) has adaptive (self learning) functions. When the engine is new, the short-term fuel trim is assumed to vary cyclically around a nominal center line (A) 1.00 with, for example, a ± 5% change in the injection period when fuel trim is active.

If there is air leakage for example, the short-term fuel trim will quickly be offset to a new position (B) and will then work for example between 1.10 (+10%) and 1.20 (+20%), although still at an amplitude of 5%, but with an offset in relation to the original center line (A). The injection period has then been increased to compensate the increase in the amount of air.

The adaptive functions will correct the change, so that the short-term fuel trim will work around the new center line (B) where it will again have its full range of control available.

Put simply, fuel trim is a measurement of the difference (C) between the original short-term fuel trim center line (A) and the new center line (B).



The adaptive functions consist of three sections and correspond to the different operating ranges of the engine; load (D) and engine speed (E):

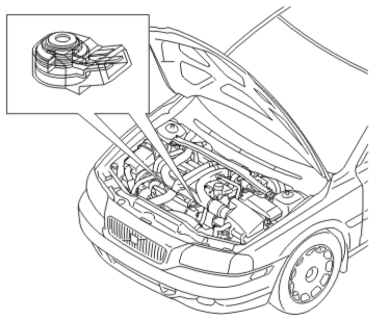
- Additive adaptation (1) is when the engine is idling. This is how the control module adjusts the CO content at idle speed. Long-

term fuel trim, idling can be read off using VIDA
- Multiplicative adaptation, lower part load (2), carried out in the lower part load range. Lower part load range is reached when driving at low load. Long-term fuel trim, lower part load can be read off using VIDA
- Multiplicative adaptation, upper part load (3). Carried out in the upper part load range. The upper part load range is reached when driving under high load and at high engine speed (rpm). Long-term fuel trim, upper part load can be read off using VIDA.

The adaptive adjustments of the injection period are stored continuously in the control module. This means that under different operating conditions the fuel air mixture is obtained before the heated oxygen sensor (HO2S) is warm enough to function.

A diagnostic trouble code (DTC) will be stored in the control module if any adaptation value is too high or too low. For further information, also see Heated oxygen sensor (HO2S) diagnostic .

Knock control



Knocking occurs in the combustion chamber when the fuel and air mixture self ignites. This can occur either before or after the spark plug has produced an ignition spark. In both cases the gas in two or more places ignites in the combustion chamber.

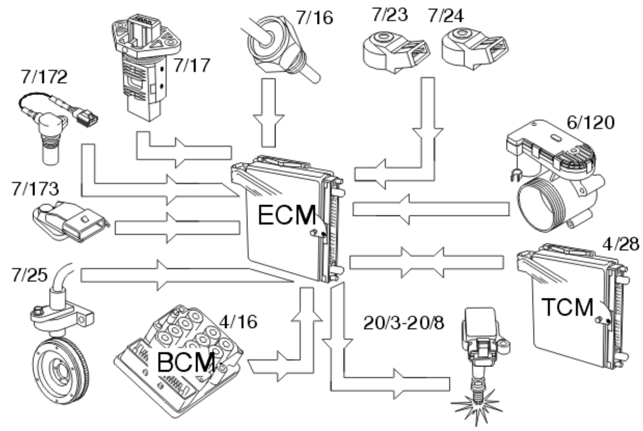
This results in an extremely fast combustion process with flames from several directions. When these flames collide, the pressure in the cylinder increases rapidly and there is a mechanical knocking sound.

If any of the cylinders knock there is a specific type of vibration in the cylinder block. These vibrations are transferred to the knock sensors (KS) which are screwed into place in the cylinder block. The resultant mechanical stress in the piezo electrical material in the knock sensors generates a voltage. The engine control module (ECM) can then determine which cylinder is knocking with the help of the camshaft position (CMP) sensor and the engine speed (RPM) sensor.

The knock sensors (KS) also interpret a proportion of normal engine sound. The control module is able to recognize the vibrations which correspond to knocking by filtering, amplifying and using software to evaluate the signal.

If the knock sensors (KS) detect knocking in the engine over a certain threshold value, the ignition timing is first retarded and then the fuel / air mixture is enriched to eliminate knocking.

Ignition control



The following components are used for ignition control:

- engine speed (RPM) sensor (7/25)
- camshaft position (CMP) sensor (7/172-7/173)
- mass air flow (MAF) sensor (7/17)
- engine coolant temperature (ECT) sensor (7/16)
- throttle position (TP) sensor on the electronic throttle unit (6/120)
- knock sensor (KS) (7/23-7/24)
- transmission control module (TCM) (4/28)
- spark plugs with ignition coils (20/3-20/8)
- brake control module (BCM) (4/16).

The engine control module (ECM) calculates the optimum ignition advance based on the software and information from the sensors. The engine control module (ECM) cuts the current to the ignition coil mounted on the cylinder to be ignited and produces a spark.

During the starting phase the engine control module (ECM) produces a fixed ignition setting. When the engine starts and the car is driven the engine control module (ECM) calculates the optimum ignition setting according to the engine speed (RPM), load, temperature etc.

The engine control module (ECM) analyses the signal from the knock sensors (KS) when the engine reaches operating temperature. If any of the cylinders knock, the ignition is retarded for that specific cylinder until the knocking ceases.
The ignition then advanced to the normal position or until the knock recurs.

Before the transmission control module (TCM) changes gear, it sometimes transmits a torque limiting request to the engine control module (ECM). The engine control module (ECM) then retards the ignition momentarily to reduce the torque, resulting in smoother gear changes and reducing the load on the transmission. There are different ignition retardation levels depending on the signals from the transmission control module (TCM). The return signal from the engine control module (ECM) to the transmission control module (TCM) confirms that the signal reached the engine control module (ECM). The Brake Control Module (BCM) transmits information to the engine control module (ECM) about deviations in the drive line. The signal is used to stop the diagnosis. For further information, also see Misfire diagnostics .

The engine misfires if the fuel does not ignite correctly. For further information, also see Misfire diagnostics .

Cruise control

The cruise control function is an example of distributed functionality.

The following components are used when driving using cruise control:

- engine control module (ECM)
- electronic throttle unit
- brake control module (BCM)
- accelerator pedal (AP) position sensor
- clutch pedal sensor
- brake pedal sensor
- control unit cruise control
- steering wheel module (SWM)
- central electronic module (CEM)
- transmission control module (TCM)
- driver information module (DIM).

To activate cruise control the function must be switched on using the ”CRUISE” button. A lamp lights up in the driver information module (DIM).

The driver activates the function by pressing the SET+ or SET- button. A message is then transmitted via the low speed side of the Controller area network (CAN) to the central electronic module (CEM) which then transmits the message on via the high speed side of the Controller area network (CAN) to the engine control module (ECM).

The engine control module (ECM) controls the throttle angle so that a constant speed is maintained using the vehicle speed signal from the Brake Control Module (BCM). The transmission control module (TCM) also receives a message indicating that cruise control is active via the Controller area network (CAN), so that the transmission follows certain shifting patterns when the cruise control is active.

If the accelerator pedal (AP) is depressed the speed increases as normal and then resumes to the stored value when the driver releases the accelerator pedal (AP) again.

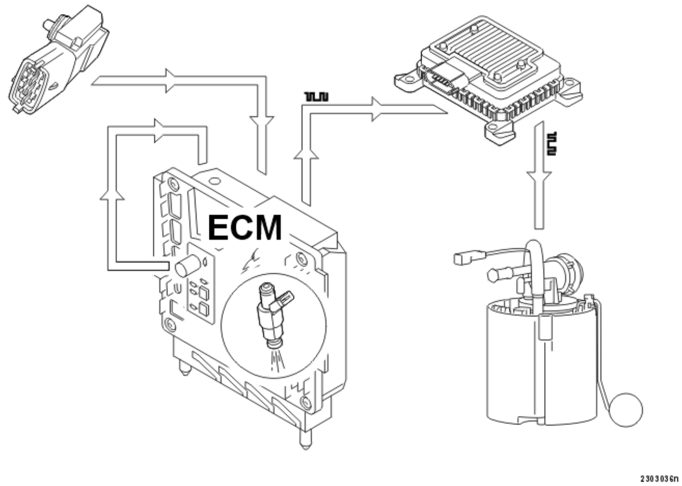
The engine control module (ECM) continually stores the speed. If the cruise control is disengaged, if for example the driver presses the brake pedal, the previous stored speed can be used by pressing the ”RESUME” button.

Cruise control cannot be activated at speeds below 35 km/h.

Cruise control is disengaged:

- when the driver presses the clutch pedal or brake pedal
- when the driver presses the ”CRUISE” button on the steering wheel
- when the driver depresses the “0” button on the steering wheel
- if the ”P” or ”N” positions are transmitted on the controller area network (CAN) (applies to automatic transmissions)
- if the speed deviates too much from the set value
- when certain diagnostic trouble codes (DTCs) are stored which do not allow continued activation (For further information see diagnostic trouble code (DTC) information).

Fuel pressure regulation (only vehicles with demand controlled fuel pumps)



General

Fuel pressure regulation for demand controlled fuel pumps (DECOS - DEmand COntrolled fuel Supply) means that the fuel pressure is controlled steplessly by varying the output of the fuel pump. The design of the system allows a greater maximum pressure (approximately 6.5 bar) in the fuel pump. This pressure is used in extreme situations, such as heavy engine load for example.

The following components are used for fuel pressure regulation:

- engine control module (ECM)
- the fuel pump control module
- a fuel pressure sensor with a fuel temperature sensor
- a fuel pump (FP) with a by-pass

valve.

The time taken for the engine start procedure can be reduced by rapidly increasing the pressure in the fuel rail when the engine control module (ECM) receives a signal about the position of the ignition switch from the central electronic module (CEM).
The engine control module (ECM) is better able to calculate the injection period because the signal from the fuel pressure sensor gives information about the fuel pressure. This particular improves the cold starting characteristics of the engine.

The advantages of varying the output of the fuel pump so that it is not always at full power are:

- the total power consumption of the fuel pump (FP) is reduced, reducing the load on the power supply system
- the service life of the fuel pump (FP) is increased
- fuel pump noise is reduced.

Control
The engine control module (ECM) calculates the desired fuel pressure. A signal is then transmitted to

the fuel pump control module indicating the desired fuel pressure. Serial communication between the engine control module (ECM) and the fuel pump control module is used to carry the signal. The fuel pump control module then operates the fuel pump unit to obtain the desired pressure using a pulse width modulation voltage on the ground lead. The fuel pump (FP) can be controlled steplessly by changing the pulse width modulation (PWM) signal. Only that pressure which is required at that specific time will then be released to the fuel rail/injectors. The value of the pulse width modulation (PWM) signal is a measurement of the operational load of the fuel pump (FP) (% duty, 100% = maximum pressure).

The engine control module (ECM) continuously monitors the fuel pressure using the signal from the fuel pressure sensor. This allows the desired fuel pressure to be reached, and if necessary a signal is transmitted to the fuel pump control module requesting that the fuel pressure is adjusted.

By-pass valve

When the injectors are closed because of too high pressure (during engine braking for example) there is a pressure peak. The by-pass valve in the fuel pump (FP) is used to even out the pressure peak. The opening pressure of the valve is approximately 6.5 bar. The by-pass valve also functions as a non-return valve, ensuring that the fuel pressure in the system is maintained when the engine is switched off.

There is high pressure before the engine is started. This high pressure means that the valve in the by-pass valve opens and the system is "flushed".

Passive safety
For safety reasons, the engine control module (ECM) shuts off the fuel pump (FP) if the supplemental restraint system module (SRS) detects a collision.

Oil level monitoring (2004-, certain markets and models only)

General
The following components are used for oil monitoring:

- the oil level sensor
- engine control module (ECM)

- driver information module (DIM).

One of the advantage of always monitoring the oil level is that the driver can then be informed, via the driver information module (DIM), if the oil needs topping up.

Oil quality detection
To calculate the quality of the oil, the capacitance of the oil is gauged and then compared with the capacitance of the air. (Capacitance is the ability to store an electrical charge).
The capacitance of the oil and air is measured using both the capacitive gauge elements. The volume of contaminants in the oil increases the capacitance. This provides the electronics integrated in the oil level sensor with an oil quality dependent input signal.

Oil temperature detection
The PTC resistor integrated in the oil level sensor is used to calculate the oil temperature. The resistance of the PTC resistor changes, depending on the oil temperature. The resistance increases as the oil temperature rises. This provides the electronics integrated in the oil level sensor with

a temperature dependent input signal.

Oil level detection

The electronics integrated in the sensor calculate the oil level using the obtained values for oil temperature and quality.
Temporary changes in the oil level in the oil trough must be taken into account to correctly calculate the oil level. This happens when cornering and taking hills for example. The engine control module (ECM) makes these calculations using the oil level sensor signal and a number of other parameters. These other parameters include the vehicle speed signal and the load signal.

Oil level sensor signal

The oil level sensor internally calculates the parameters for oil level, quality and temperature. A PWM signal is then generated and transmitted on a cable to the engine control module (ECM). The PWM signal consists of a pulse train. The first pulse in the pulse train represents the oil temperature. The second pulse represents the oil level. The third pulse represents the oil quality. A change in oil level, quality or oil temperature affects the pulse ratio of the relevant pulse.

14/11/2018 **PRINT**