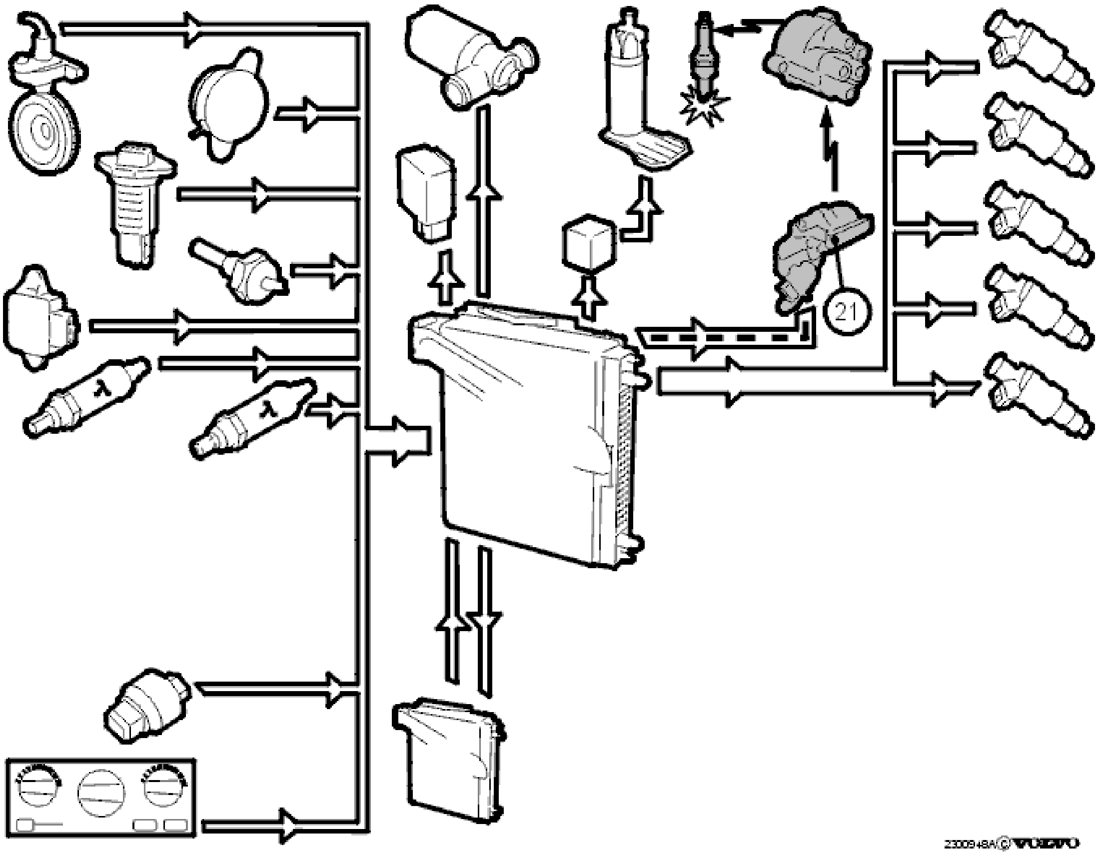
Ignition control



The ignition system tasks

To transform the system voltage (approximately 14 V) to a sufficiently high ignition voltage. In electronic systems this is normally above 30 kV (30 000 V).

Provide an ignition spark to the correct spark plug at the correct moment.

How is the ignition coil charge time and the ignition setting regulated?

There is an ignition discharge module (IDM) included in the ignition system. In principle the task of the ignition discharge module (IDM) is the same as points. In other words to open and close the current through the ignition coil.

Usually a separate ignition discharge module (IDM) outside the control module is used to avoid the high current and therefore the heat generated inside the control module.

The ignition discharge module (IDM) and the ignition coil (21) are supplied with voltage (15 +).

The control module controls the ignition by using signals to the ignition discharge module (IDM) to govern when the ignition coil ground terminal should be opened and closed.

- Charging begins when the ignition coil is connected to ground.

- The period in which the ground terminal is connected is identical with the ignition coil charging time.
- When the ignition coil ground terminal is opened the ignition coil discharges and a high voltage is generated.

How is the ignition coil charge time calculated?

When the control module generates the charge time, it also takes into account the system voltage and engine speed (RPM) (≈ cam angle control).

For example, if the system voltage is low or the engine speed (RPM) high, the charging of the ignition coil begins earlier than normal. The charge time is always extended under such conditions. Therefore modern ignition systems always provide a high ignition voltage independent of engine speed (RPM) and system voltage.

What is the correct ignition time?

Signals from a number of sensors are required in order for the control module to be able to calculate this.

Which are the most important sensors?

Basic position, ignition

The two most important sensors are the engine speed (RPM) sensor (2) and the volume air flow (VAF) sensor (4). All engines use the information from these sensors to calculate the ignition setting.

The control module reads off the signals from the sensors. It then checks its memory to determine what the ignition setting should be.

4 cylinder engines

On 4 cylinder engines there is usually a special signal from the engine speed (RPM) sensor 90° before top dead center (TDC) for cylinder 1. The control module is then able to calculate when the ignition coil should be grounded in order to have enough time to charge, and when the ground connection should be broken (ie the spark is produced).

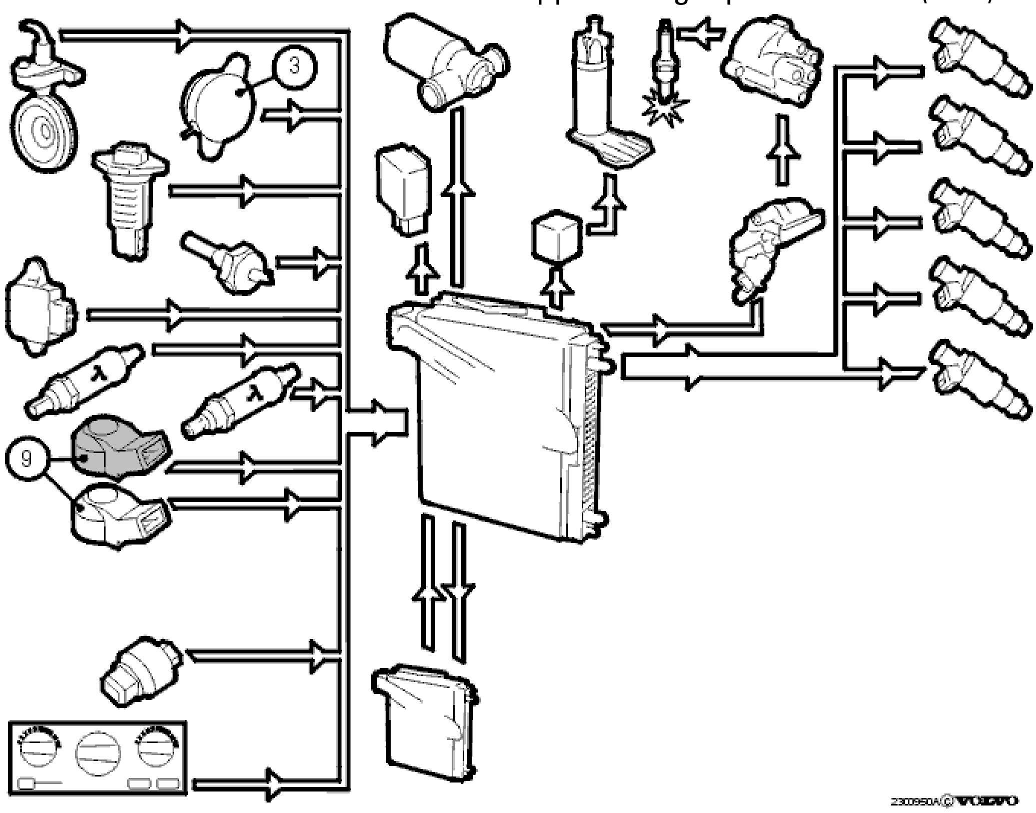
5 cylinder engines

On 5 cylinder engines the amount of time before each cylinder reaches top dead center (TDC) varies when the engine speed (RPM) sensor transmits its reference signal for the crankshaft position.

For example, the signal from the engine speed (RPM) sensor is transmitted 84° before top dead center (TDC) when cylinder 1 reaches TDC and 12° before TDC when cylinder 4 reaches TDC. The control module therefore also requires a signal about which cylinder should be ignited.
This is so that it can calculate when the ignition coil should be connected to ground and when the ground connection should be interrupted (a spark is produced). By using the signals from the camshaft position (CMP) sensor (3) the control module is able to determine whether the crankshaft is in the first or second revolution of the operating cycle. In other words, in this example, cylinder 1 or 4 is in the compression phase.

6 cylinder engines

The signal from the camshaft position (CMP) sensor is also required for engines without a distributor and which have separate ignition coils for each spark plug. Some Volvo 6 cylinder engines have this system. This is so that the control module knows which if the cylinders should be ignited. In other words which ignition coil must be connected when the cylinder pairs (1 - 6, 2 -5 or 3 -4) are approaching top dead center (TDC).



Correcting the ignition setting

With an electronic ignition system it is possible to program the ignition setting irrespective of whether the load etc. is close to the knocking limit.

The closer the ignition setting is to the knocking limit, the better the use of the energy content in the fuel. The system attempts to raise the ignition as much as possible without the engine knocking.

In the event of interference, for example carbon deposits or poor quality fuel, the engine may start to knock. This results in vibrations in the cylinder block.

Knock sensor (KS)

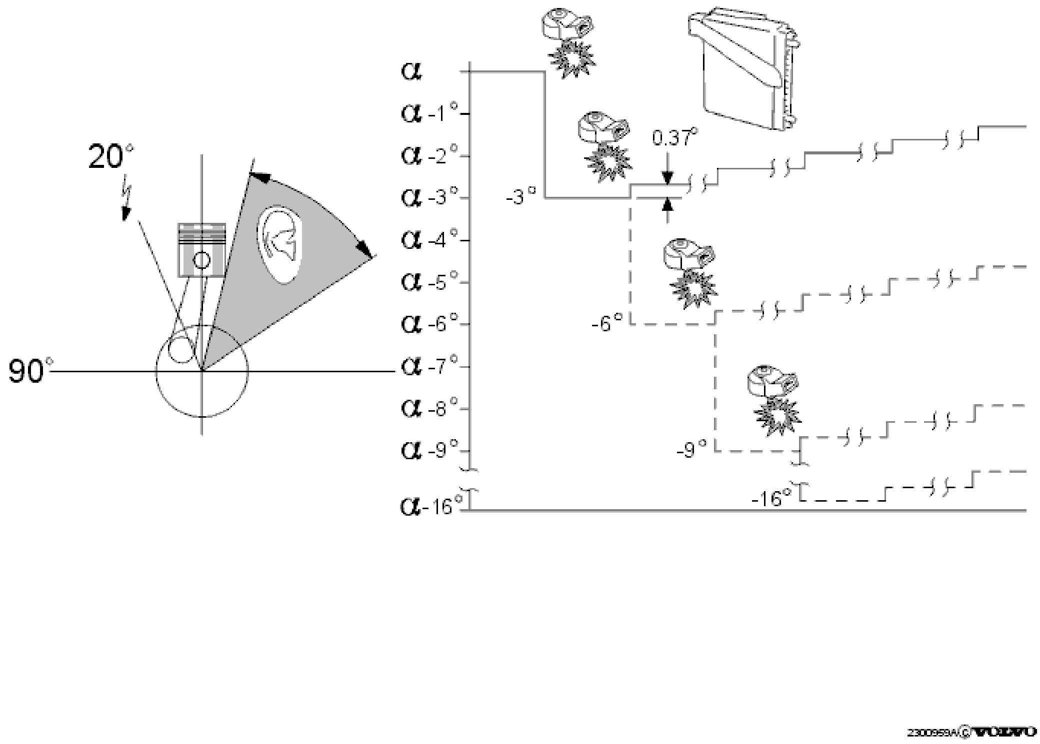
The knock sensor (KS) (9) senses vibrations in the cylinder block and supplies the control module with signals about them.

There is a filter in the control module which only allows through signals from the knock sensor (KS) which have the special frequencies that occur in the event of knocking. In other words the control module will not to react to the normal vibrations in the engine. The normal vibrations change as the engine wears. However the control module continuously updates its memory so that it can tell which are normal at any given time.

If the signal has the correct frequency and is above a certain level, the control module lowers the ignition on the cylinder that has knocked. On certain older systems the ignition is lowered on all cylinders in the event of knocking.

Two knock sensors (KS)

On 5 and 6 cylinder engines with a relatively long stroke and on V engines, two knock sensors (KS) are used. This is because the vibrations in the event of knocking do not always spread throughout the entire cylinder block. On engines with a camshaft position (CMP) sensor, its signals are used so that the control module only listens to the knock sensor (KS) located closest to the cylinder that is igniting.



Knock control

Knock control works in approximately the same way as fuel trim using the oxygen sensor (HO2S). The control module allows something to happen, then it checks what happened and then a correction is carried out. It is quite normal to hear an occasional single knock from the engine with this kind of control process.

Knock control functions in the following manner:

1. The control module reads off the sensor and calculates the correct ignition setting, for example 20° before top dead center (BTDC).
2. The control module ensures that the spark is delivered to the correct cylinder at the correct time.
3. Immediately after top dead center (TDC) (between approximately 15-55°) the control module connects the knock sensor and listens to see if that cylinder is knocking.
4. If the control module hears a knock it is remembered and the cylinder which knocked is also registered.
5. The next time that cylinder should fire the ignition is retarded slightly.
6. If the knocking continues despite retardation the ignition is retarded further the next time the cylinder fires.
7. If there is no knocking after retardation, the control module waits a short time and then

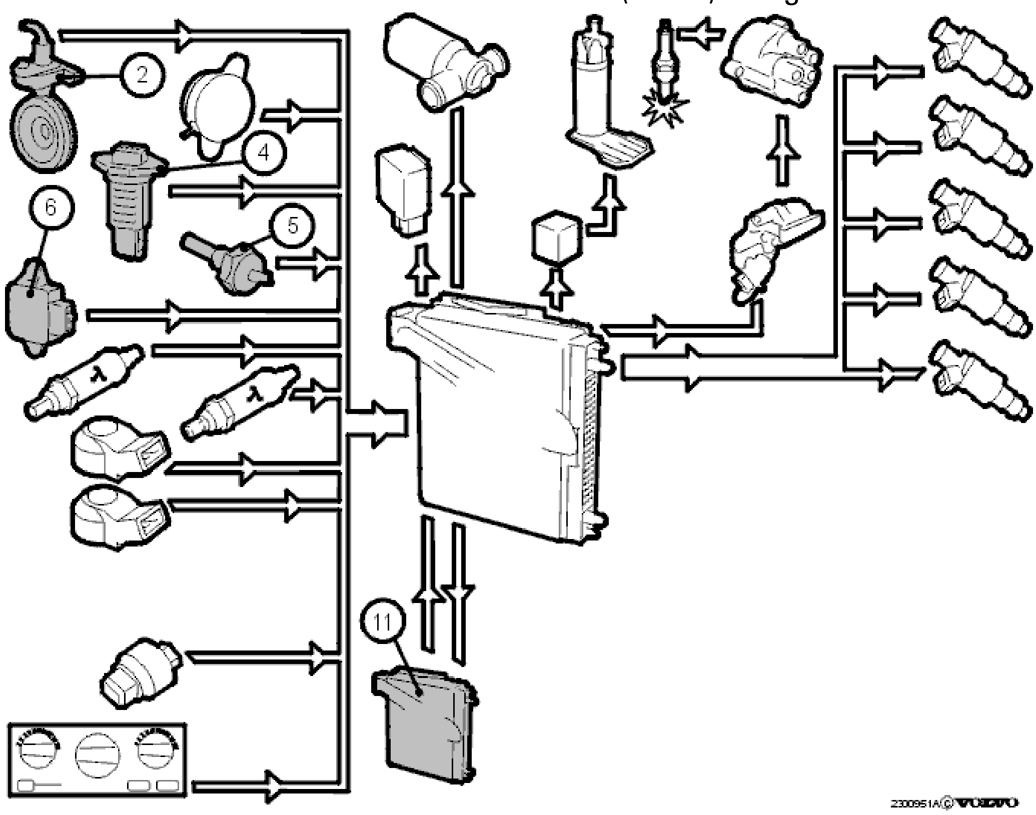
advances the ignition gradually.

How much the ignition is retarded, how long the delay before advancing begins is, and how large the steps when adjusting the ignition are varies depending slightly depending on what system and version the car has (the illustration above is just an example).

Knock controlled fuel enrichment

Is only available on certain systems and engine versions, normally turbocharged engines and other powerful engines.

If all cylinders knock sufficiently the ignition system sends a signal to the fuel injection system. The fuel injection system replies by increasing the quantity of fuel. This cools combustion and reduces the risk of knocking. While the fuel injection system injects more fuel in this way the signals from the oxygen sensor (HO2S) are ignored.



Compensating the ignition position

Under certain circumstances the ignition position must be compensated, that is deviate from what is "normal" for the engine speed (RPM) and load.

The control module reads off these conditions via a number of sensors and compensates the quantity of fuel as necessary.

Idling speed, engine braking

When idling there are no great requirements of output power, but at the same time it is important that the engine runs smoothly and comfortably.

To give a good idle quality the top pressure (maximum combustion pressure) is reduced during combustion so that ignition is retarded.

On many systems the ignition position is more or less fixed while idling. The ignition position is only adjusted to prevent the ignition position from being further reduced if the engine speed (RPM) is below a certain value.

When engine braking the control module selects a compromise between the cleanest possible exhaust and low fuel consumption. On later systems it is only relevant at relatively low speeds, because a complete fuel shut off occurs when engine braking at higher engine speeds (RPM).

The signal that the throttle is closed comes from the throttle position (TP) sensor (6). The control module determines whether it is idling or engine braking by reading the signals from the engine speed (RPM) sensor (2).

Cold engine

During the warming up process the engine usually moves the ignition position from the normal setting. This can either be a question of a altitude increase or reduction depending on what operation is required from the engine.

Ignition advance is used to shorten the warming up time of the moving parts in the engine. A higher ignition gives higher combustion pressure and therefore higher engine coolant temperature (ECT).

Ignition retardation is used to shorten the three-way catalytic converter (TWC) warming up time and therefore reduce exhaust emissions. With late ignition the exhaust gases are withdrawn from the cylinder quickly in relation to the combustion finishing. This gives a higher exhaust temperature. More energy is converted to heat which is transferred to the exhausts.

The engine temperature signal comes from the engine coolant temperature (ECT) sensor (5).

Idling, engine at operating temperature

If the engine is very hot (coolant exceeds 105 °

C (221°F)) while idling the ignition is normally advanced. This is to help prevent the engine coolant from boiling (because of the pressure in the system the engine coolant temperature (ECT) must reach a value of approximately 125 °C (257°F) to boil).

The ignition advance in this case is because ignition is retarded while idling so that the engine runs evenly. By advancing the ignition more energy is introduced in the fuel which is transferred to mechanical operation and less energy is transferred to coolant in the form of heat.

Rapid acceleration

Because the ignition system works near the knock limits there is a risk of transitional knock when there is a sudden increase in load.
This is due to two things

- Air accelerates faster than fuel. It is not guaranteed that the fuel injection system will be able to supply more fuel and the mixture will be temporarily lean.
- The amount of fuel/air mixture increases rapidly and the ignition system does not have time to retard ignition with the normal controls.

Therefore the control module retards the ignition a number of degrees during hard acceleration. The information that it is hard acceleration is received by the control module either from the air flow (4) or throttle position (TP) sensor (6).

Shifting (cars with electronically controlled automatic transmission)

Just before shifting a signal comes from automatic transmission control module (TCM) (11). The engine control module (ECM) replies by retarding ignition for a short time. This gives a temporary reduction of engine torque and the shift is smoother. This function is normally only connected when the driving program selector for the automatic transmission is in economy position.

We now have a fuel system which adapts the ignition setting to the different driving conditions.