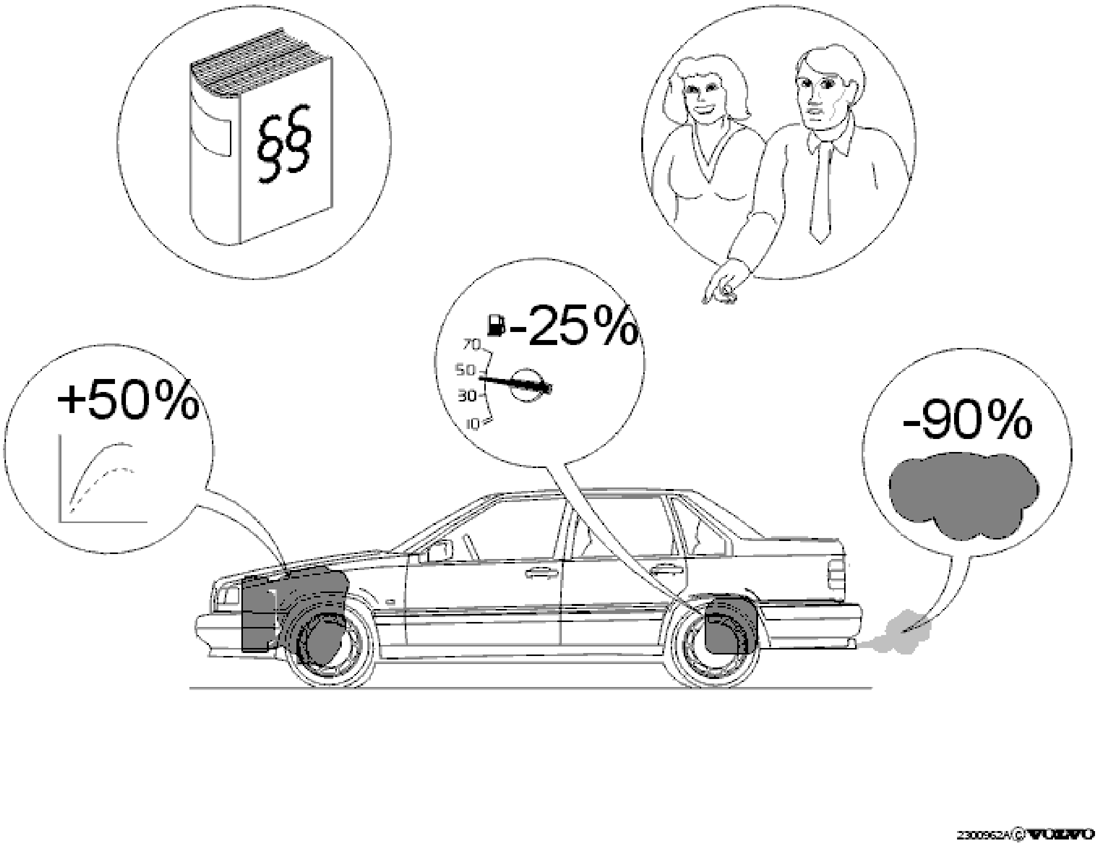
Electronic



Why use an electronic system?

Today the requirement are much higher than for a number of years ago. There are both legal requirements and the wishes of the customer about.

- As little harmful emission as possible.
- Low fuel consumption.
- Good performance.
- Long service intervals and high reliability. In some countries there are, for example, statutory requirements covering the distances a car should be able to cover before emission limits are exceeded. In addition this should be achieved without any service action being taken on the car.
- Quick diagnosis in the event of faults.

The only way to satisfy such requirements is to use electronic systems.

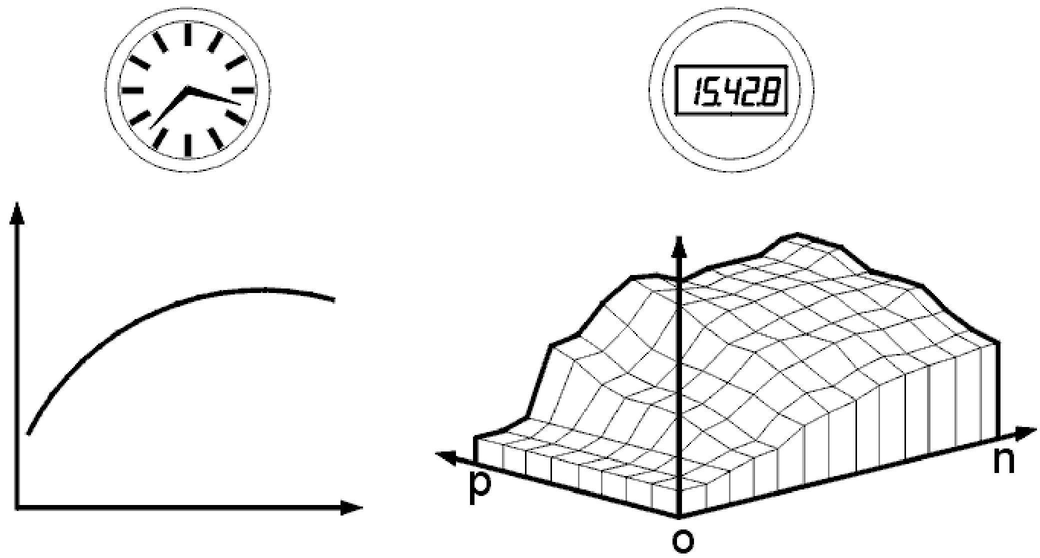
It is largely due to the electronic systems that it is now possible to construct cars which have, in comparison to cars from the early 1970s:

- ⇒ 90% cleaner exhaust gases
- ⇒ 50% higher power (calculated using the same engine volume)
- ⇒ 25% lower fuel consumption

- ⇒ three times as long between service intervals

Some advantages of electronic systems compared with earlier solutions

1. Can be more carefully adapted to the engine. This is because their operational function is digital rather that analogous.
2. Can provide more precise control. For example the ignition can be controlled to fractions of a degree.
3. Can provide control more suited to the operating conditions. This is because they have more sensors which affect the control.
4. Can provide quicker control. The engine speed (RPM) sensor is read off approximately 50 times per engine revolution. In other words 5000 times a second at 6000 rpm. Other sensors usually read off the engine speed (RPM) once per engine revolution. In other words 100 times a second at 6000 rpm.
5. Can interact between different systems. For example the ignition system can in some cases affect the quantity of fuel.
6. Has few components with mechanical wear. This reduces the requirement for maintenance and increases both reliability and service life.
7. Can adapt themselves when the engine wears and the conditions change. The majority of modern systems have so called adaptive functions. This reduces maintenance requirements.
8. Can carry out self diagnostics and warn in the event of certain faults which may result in, for example, emissions exceeding certain limits.



2300957 A © VOLVO

Analogous compared to digital

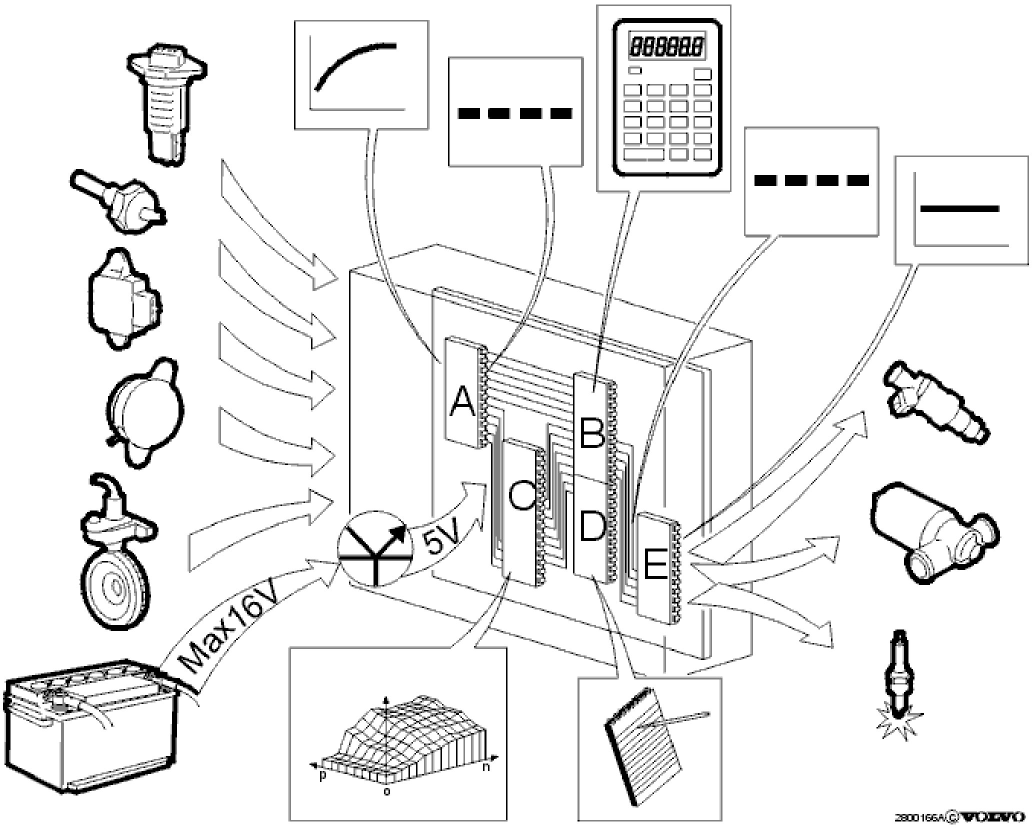
Analogous

Older systems (such as carburetors and breaker controlled ignition systems) function analogously (analog ≈ uniform). This means that the systems can only govern according to set curves with a quite limited control range.

Digital

Electronic systems operate digitally (digit = number). This means that only the digit values are stored in the control module memory. The number of digits or values is extremely high. The illustration shows an example of how this may look. Each point of intersection between the lines corresponds to a stored value.

The control module reads off the engine operating conditions, for example engine speed (RPM) and air flow. It then checks its memory for the correct numerical value for, for example, the quantity of fuel. If there is no value which exactly corresponds to the engine operating conditions, the control module calculates a reasonable value itself.
In principle, the number of possible values is infinite and the control range is very large.



How does an electronic module operate?

Voltage regulator

The control module operates internally with a low voltage, usually 5V. This is partly to limit the current and therefore heat generation in the control module. Too much heat can damage the electronics. This is also why all the functions that require high currents, such as ignition coils, are governed by external amplifiers.

The voltage regulator reduces the system voltage to 5V.

If the system voltage should increase above approximately 16V the regulator will no longer be able to fulfill its function. This results in incorrect signals and incorrect control.

A. Analog-digital converter (A/D converter)

The control module operates digitally (pulses, 1s and 0s) while the signals from the signals are analogous.

The A/D converter converts the analog signals to digital (pulses) which the control module is then able to work with. The digital signals are then transferred to the central processing unit (CPU).

B. The Central Processing Unit (CPU)

The CPU is independent and can be compared to a calculator and carries out all mathematical calculations. It works extremely quickly but can only perform one task at a time.

When calculating for example the quantity of fuel, the CPU carries out the following operations

- It "reads" the input signals for engine speed (RPM) and air flow (one at a time)
- Searches for the correct fuel quantity value in the program memory (C). If there is no value which is correct, the CPU calculates a reasonable value itself.
- Registers the fuel quantity value in the internal memory (D).
- Reads the next value, for example the temperature sensor.
- Checks in the program to determine whether the quantity of fuel needs to be adapted for a cold engine.
- Collects the noted values from the internal memory and calculates a new value depending on how much the value needs to be adapted.
- Notes the new value in the internal memory.
- Reads off the other sensors one at a time and calculates a new values if necessary.
- When all operations are complete, the CPU transmits the final value to the D/A converter (E) for control of the quantity of fuel.

C. Program memory (ROM = Read Only Memory)

The CPU can only read but cannot change something in the ROM.

In the ROM all the numerical values are programmed, for example the quantity of fuel, the idling speed and the correct ignition time.

There are different ROM versions depending on how it is manufactured and whether it is possible to make changes to the program.

ROM —The different values are programmed during manufacture.

PROM — The P is short for programmable The memory is manufactured empty and can be programmed later.

EPROM — The E is short for Erasable The memory can be erased and reprogrammed. This is usually done using ultra violet light.

EEPROM — The E is short for electrical. The memory can be erased and reprogrammed using electrical impulses.

D. Internal memory or RAM (RAM= Random Access Memory)

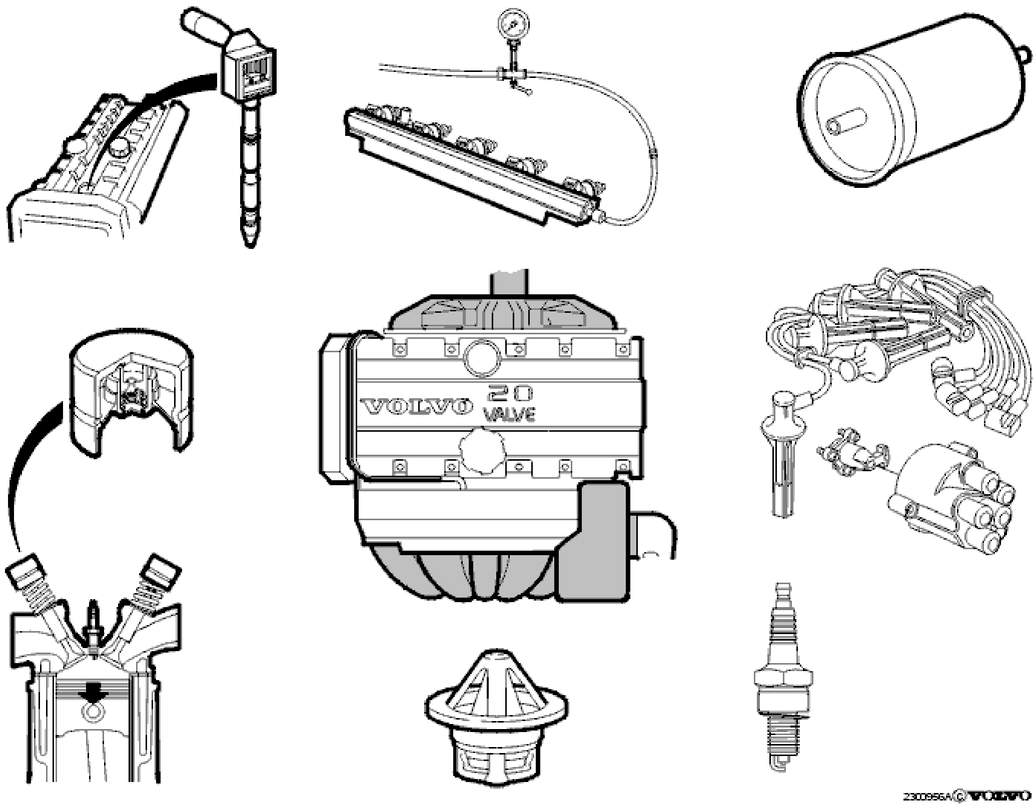
This is used by the CPU to temporarily store calculated values. Can be compared to a notepad.

E. Digital and analogous converter (D/A converter)

The values calculated and sent to the D/A converter by the CPU are digital (pulses).

The D/A converter converts the signals to analog signals, for example a current or voltage with a set strength and time span.

The signals usually pass through an amplifier in the control module because they are quite weak. These are then used to govern the functions controlled by the control module, for example the quantity of fuel, idling speed and ignition time.



What the control module does not know but assumes is correct!

There is not a sensor for everything. Therefore the control module assumes that certain things are correct. Examples of this are:

- The engine is in good mechanical condition, for example the valve clearance, camshaft adjustment and compression etc are correct.

- The air intake, for example the air preheating and air cleaner (ACL) function correctly and that the throttle disc setting is correct.
- There is no air leakage in either the intake or exhaust side.
- The fuel pressure and fuel flow are correct. In other words that the fuel pump (FP), fuel filter and injectors are fault free.
- The cooling system functions as normal, for example the thermostat opens at the correct temperature.
- The components in the ignition system, for example the ignition discharge module (IDM), ignition cables, distributor cap, rotor and spark plugs are not damaged or worn.
- The generator (GEN) charges correctly, for example that the charge voltage is not above 16V or that the battery voltage is below 10.5V.

If the above are not correct the combustion process will be affected.

In the event of a fault, the engine operation, fuel consumption and emissions can be affected. This can in turn result in abnormal signals from the oxygen sensor (HO2S) for example. The electronic systems are often blamed for this and attempts are made to replace components that are not faulty for example.

In systems with adaptive (self learning) function, an automatic adjustment takes place. However the fault may be so large that the adaptive adjustment is overloaded and is unable to compensate for the entire fault.

Worth bearing in mind when fault-tracing

There are many electronic systems in modern cars. Therefore it is easy to simply blame the "complicated" electronics and overlook the normal basics of engine operation. These basic principles are just important today as with carburetor engines!

A common mistake when fault-tracing is to limit oneself too hastily to a certain area without having checked the ignition system and that the engine is in good mechanical condition for example.

Modern Service Manuals can seem intimidating given that the number of pages is often in excess of 350 for an engine management system. However it is an extremely good guide when fault-tracing, which is almost impossible without it. By using the table of contents at the beginning it is easy to find the correct method for localizing the fault.

The electronic components in the management systems are extremely reliable and rarely cause any faults!