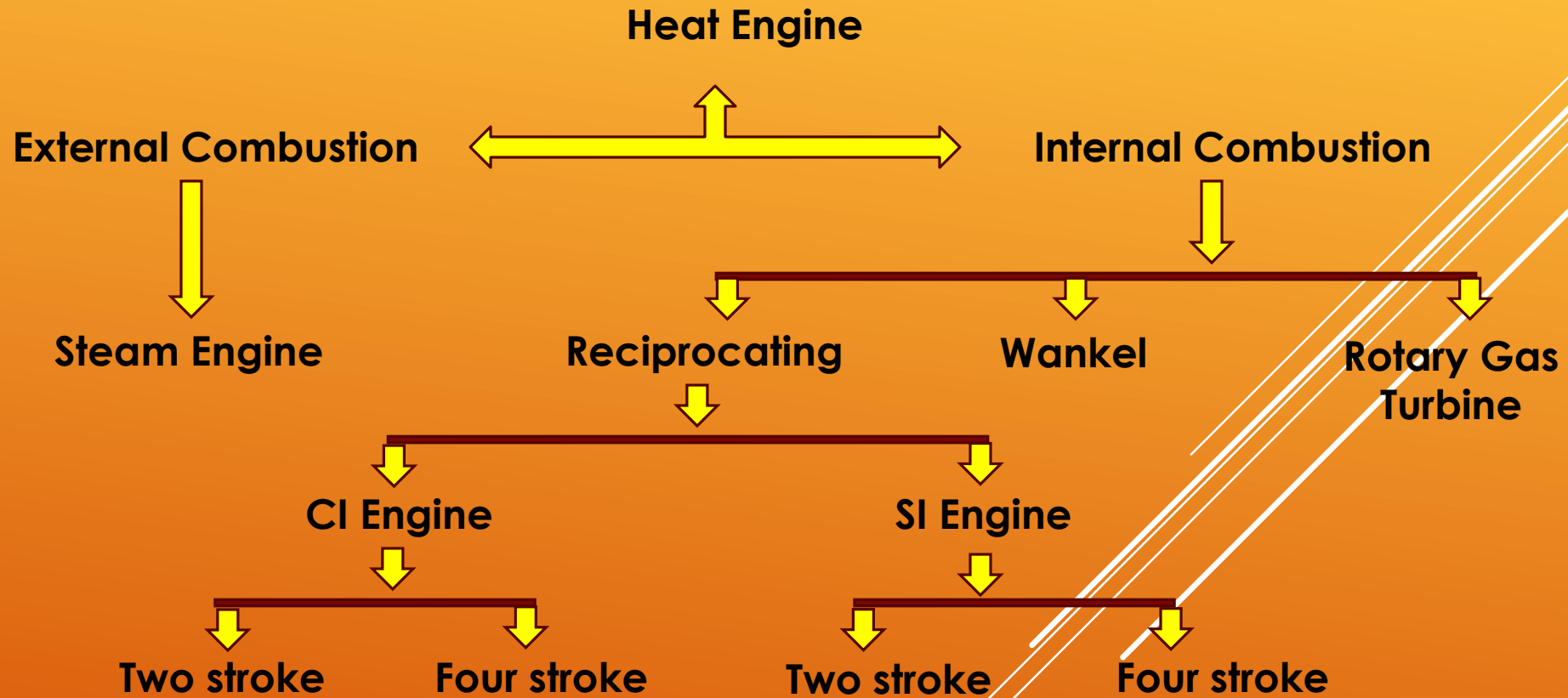


# DIAGNOSTIC OF VEHICLES M14



# TYPES OF ENGINES



# INTERNAL COMBUSTION ENGINE

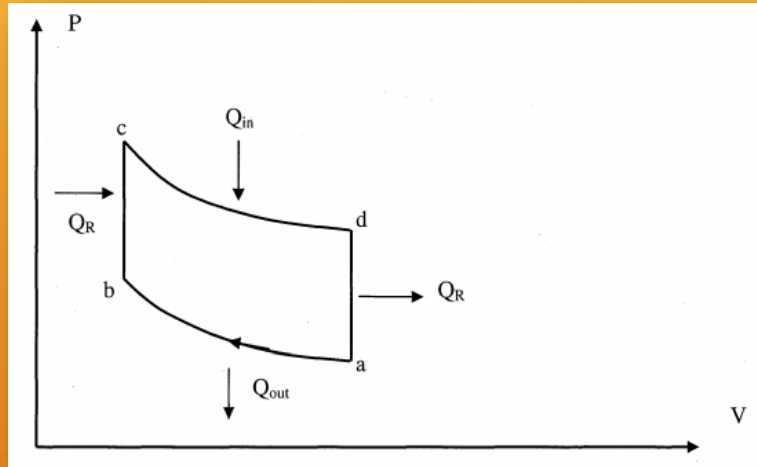
Combustion, also known as burning, is the basic chemical process of releasing energy from a fuel and air mixture. In an internal combustion engine (ICE), the ignition and combustion of the fuel occurs within the engine itself. The engine then partially converts the energy from the combustion to work. The engine consists of a fixed cylinder and a moving piston. The expanding combustion gases push the piston, which in turn rotates the crankshaft. Ultimately, through a system of gears in the powertrain, this motion drives the vehicle's wheels.

Internal combustion engines (ICE) are the most common form of heat engines, as they are used in vehicles, boats, ships, airplanes, and trains. They are named as such because the fuel is ignited in order to do work inside the engine. The same fuel and air mixture is then emitted as exhaust. This can be done using a piston (called a reciprocating engine), or with a turbine.

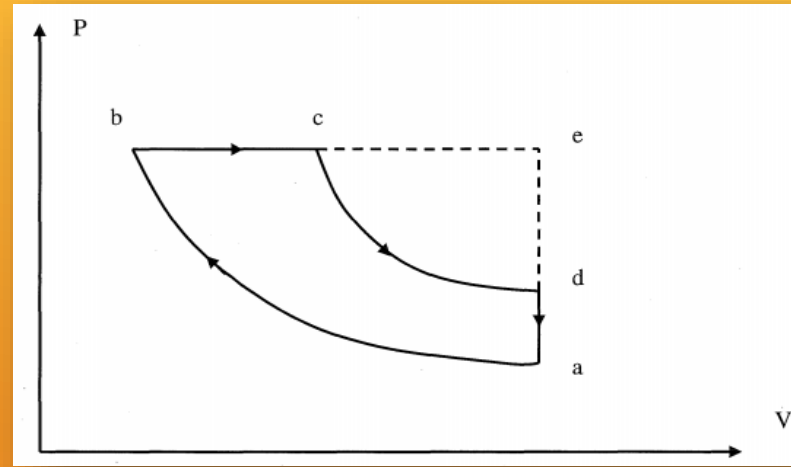
<https://www.energy.gov/eere/vehicles/articles/internal-combustion-engine-basics>  
[https://energyeducation.ca/encyclopedia/Internal\\_combustion\\_engine](https://energyeducation.ca/encyclopedia/Internal_combustion_engine)



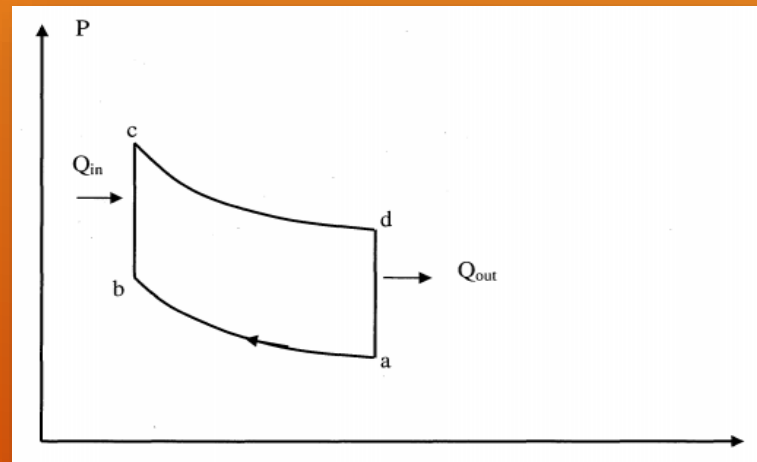
# INTERNAL COMBUSTION ENGINE



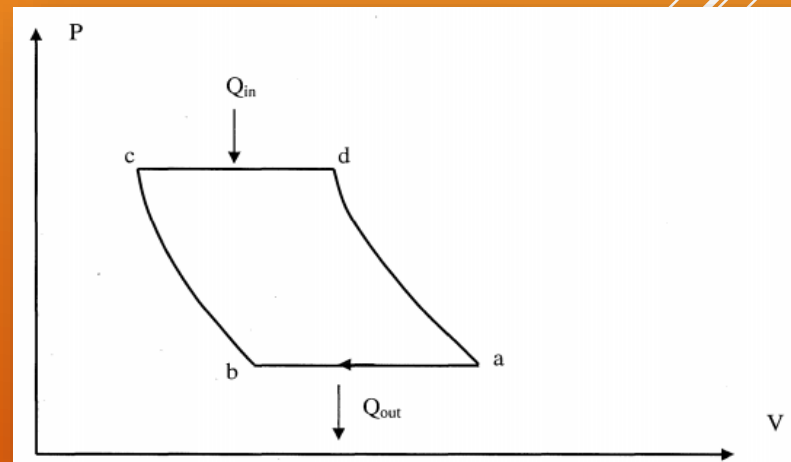
Stirling Cycle



Diesel Cycle



Otto Cycle



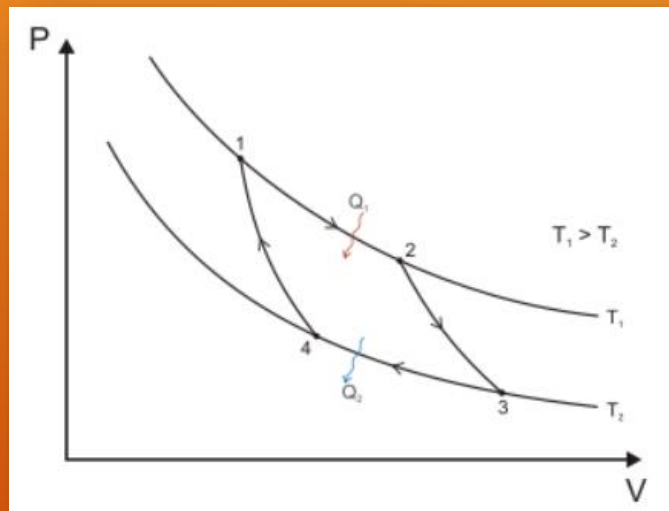
Brayton Cycle



# INTERNAL COMBUSTION ENGINE - cycles

	$a \rightarrow b$	$b \rightarrow c$	$c \rightarrow d$	$d \rightarrow a$
Carnot cycle	Isothermal compression	Adiabatic compression	Isothermal expansion	Adiabatic expansion
Stirling cycle	Isothermal compression	Isochoric process	Isothermal expansion	Isochoric process
Otto cycle	Adiabatic compression	Isochoric process	Adiabatic expansion	Isochoric process
Brayton cycle	Isobaric compression	Adiabatic compression	Isobaric expansion	Adiabatic expansion
Diesel cycle	Adiabatic compression	Isobaric expansion	Adiabatic expansion	Isochoric process

Thermodynamic processes for the Carnot, Stirling, Otto, Brayton and Diesel Cycles.



Carnot Cycle

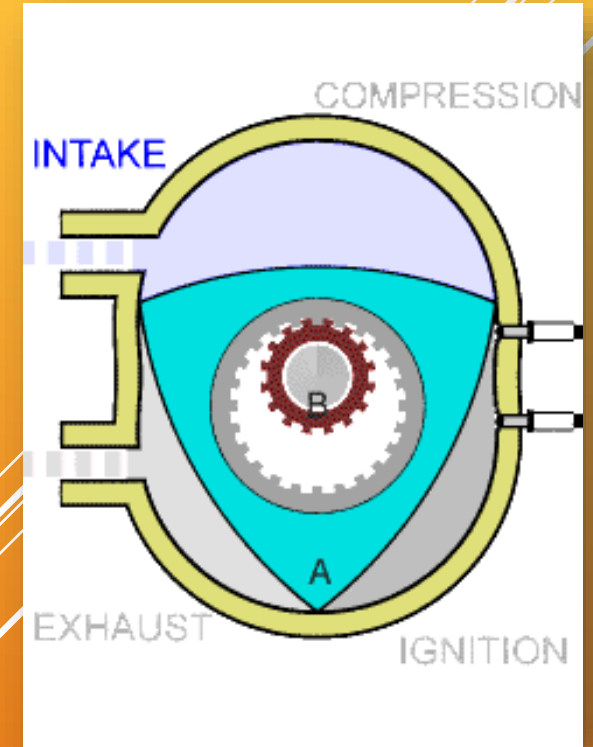
<https://mastransactions.org/doi/pdf/10.30956/0544-540X-42.2008.1>



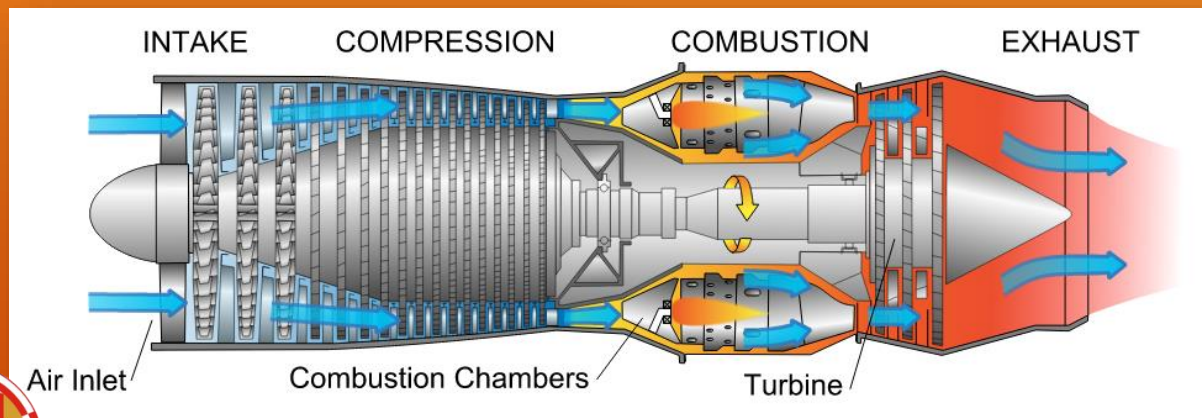
# INTERNAL COMBUSTION ENGINE

An engine that uses a piston is called an intermittent combustion engine, whereas one that uses a turbine is called a continuous combustion engine. The difference in mechanics is obvious due to the names, but difference in use is less obvious.

In this type of engine, there is a rotor which is contained in an oval shaped housing. It performs the common four-stroke cycle steps (intake, compression, ignition, exhaust) however, these steps occur 3 times per one spin of the rotor—creating three power strokes per rotation.



Rotary (Wankel) Engine



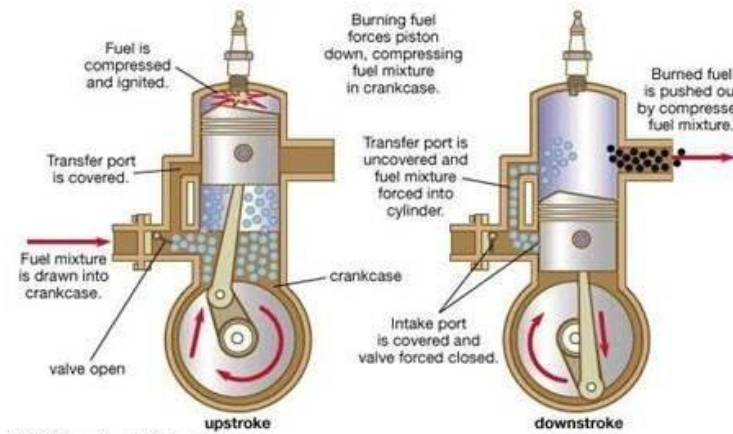
Gas turbine engine

[https://energyeducation.ca/encyclopedia/Internal\\_combustion\\_engine](https://energyeducation.ca/encyclopedia/Internal_combustion_engine)



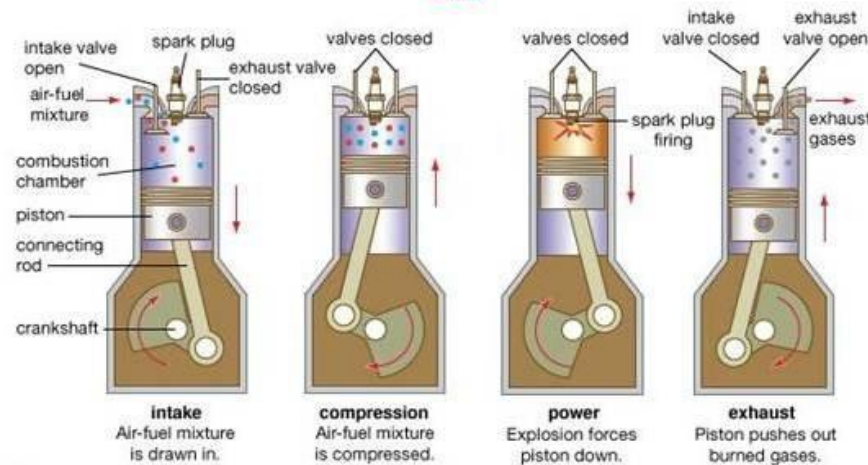


# TWO STROKE VS FOUR STROKE



## Two Stroke

VS



## Four Stroke

<http://oh.best-web.pw/2-stroke-vs-4-stroke-diesel-engines.html>



# TWO STROKE VS FOUR STROKE

## ADVANTAGES AND DISADVANTAGES OF TWO-STROKE CYCLE OVER FOUR-STROKE CYCLE ENGINES

### Advantages:

The two-stroke cycle engine gives one working stroke for each revolution of the crankshaft. Hence theoretically the power developed for the same engine speed and cylinder volume is twice that of the four-stroke cycle engine, which gives only one working stroke for every two revolutions of the crankshaft. However, in practice, because of poor scavenging, only 50-60% extra power is developed.

Due to one working stroke for each revolution of the crankshaft, the turning moment on the crankshaft is more uniform. Therefore, a two-stroke engine requires a lighter flywheel.

The two-stroke engine is simpler in construction. The design of its ports is much simpler and their maintenance easier than that of the valve mechanism.

The power required to overcome frictional resistance of the suction and exhaust strokes is saved, resulting in some economy of fuel.

Owing to the absence of the cam, camshaft, rockers, etc. of the valve mechanism, the mechanical efficiency is higher.

The two-stroke engine gives fewer oscillations.

For the same power, a two-stroke engine is more compact and requires less space than a four-stroke cycle engine. This makes it more suitable for use in small machines and motorcycles.

A two-stroke engine is lighter in weight for the same power and speed especially when the crankcase compression is used.

Due to its simpler design, it requires fewer spare parts.

A two-stroke cycle engine can be easily reversed if it is of the valveless type.





# TWO STROKE VS FOUR STROKE

## Disadvantages:

The scavenging being not very efficient in a two-stroke engine, the dilution of the charges takes place which results in poor thermal efficiency.

The two-stroke spark ignition engines do not have a separate lubrication system and normally, lubricating oil is mixed with the fuel. This is not as effective as the lubrication of a four-stroke engine. Therefore, the parts of the two-stroke engine are subjected to greater wear and tear.

In a spark ignition two-stroke engine, some of the fuel passes directly to the exhaust. Hence, the fuel consumption per horsepower is comparatively higher.

With heavy loads a two-stroke engine gets heated up due to the excessive heat produced. At the same time the running of the engine is riot very smooth at light loads.

It consumes more lubricating oil because of the greater amount of heat generated.

Since the ports remain open during the upward stroke, the actual compression starts only after both the inlet and exhaust ports have been closed. Hence, the compression ratio of this engine is lower than that of a four-stroke engine of the same dimensions. As the efficiency of an engine is directly proportional to its compression ratio, the efficiency of a two-stroke cycle engine is lower than that of a four-stroke cycle engine of the same size.



# GASOLINE VS DIESEL ENGINES

## Diesel engine

Invented in the 1890's in Germany by Rudolf Diesel.

Invented because of the inefficiency of steam power (10% efficient)

## Gasoline vs Diesel

- No Carburetor or port injection in Diesels
- Uses direct injection into cylinder
- No spark plugs
- Glow plugs to heat engine
- Much more compression than gasoline engine (approx 2-3 times more)
- Highest thermal efficiency of all engine types
- Due to high compression and expansion ratio, diesels are 45% efficient compared to gasoline at 30%
- No high voltage electrical system needed
- Diesel engines usually last 2x longer than gasoline due to stronger parts and better lubrication

## Advantages

- Diesel fuel is safer than gasoline (not explosive)
- Fuel efficiency remains constant
- Much more torque than gas due to longer piston stroke (large diameter crankshaft needed)
- More potential for power due to adding of turbo or sometimes supercharger

## Disadvantages

- Louder engine due to large amount of rapidly expanding gas
- Diesel fuel is more expensive
- Higher initial cost
- Lower performance overall compared to gas in regular driving
- Problematic in cold weather
- Low sulfur fuel now used but exhaust can still smell and smoke



# GASOLINE VS DIESEL ENGINES

## COMPARISON OF CI AND SI ENGINES

The CI engine has the following advantages over the SI engine.

Reliability of the CI engine is much higher than that of the SI engine. This is because in case of the failure of the battery, ignition or carburetor system, the SI engine cannot operate, whereas the CI engine, with a separate fuel injector for each cylinder, has less risk of failure.

The distribution of fuel to each cylinder is uniform as each of them has a separate injector, whereas in the SI engine the distribution of fuel mixture is not uniform, owing to the design of the single carburetor and the intake manifold.

Since the servicing period of the fuel injection system of CI engine is longer, its maintenance cost is less than that of the SI engine.

The expansion ratio of the CI engine is higher than that of the SI engine; therefore, the heat loss to the cylinder walls is less in the CI engine than that of the SI engine. Consequently, the cooling system of the CI engine can be of smaller dimensions.

The torque characteristics of the CI engine are more uniform which results in better top gear performance.

The CI engine can be switched over from part load to full load soon after starting from cold, whereas the SI engine requires warming up.

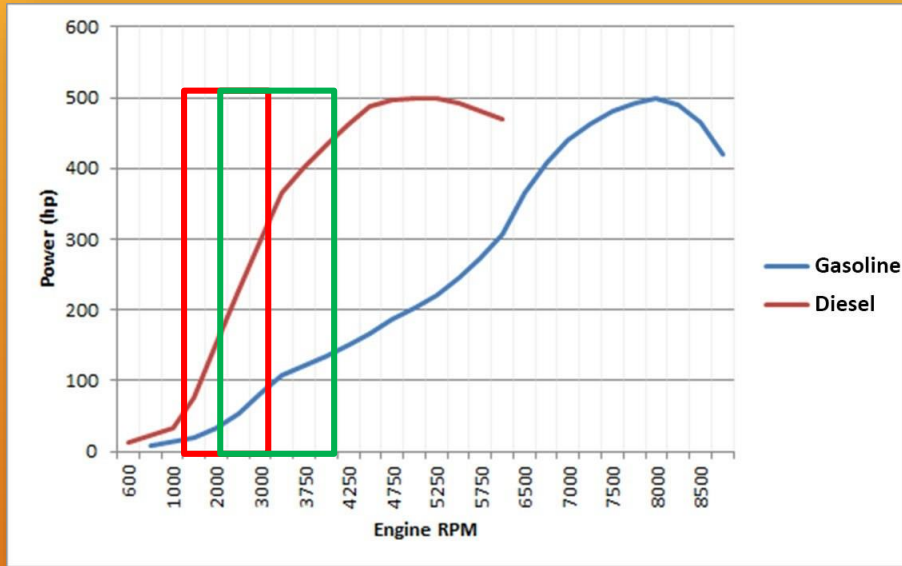
The fuel (diesel) for the CI engine is cheaper than the fuel (petrol) for SI engine.

The fire risk in the CI engine is minimized due to the absence of the ignition system.

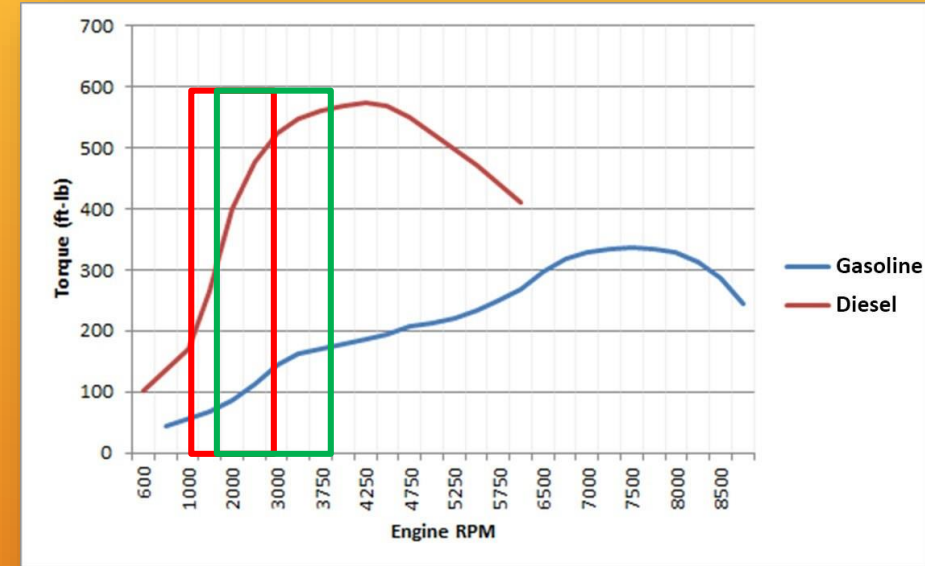
On part load, the specific fuel consumption of the CI engine is low.



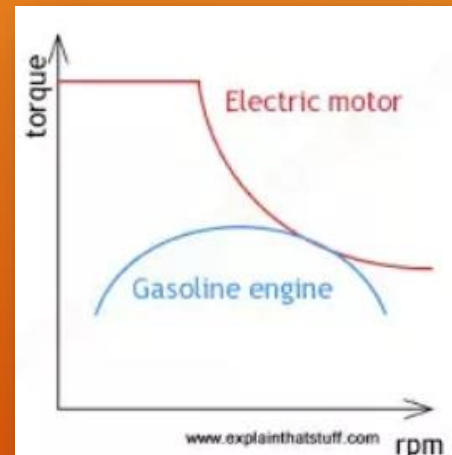
# GASOLINE VS DIESEL ENGINES



<https://www.electricbike.com/electric-vs-gas-vs-diesel-when-is-a-horsepower-not-really-a-horsepower/>



<https://www.quora.com/Why-do-petrol-engines-have-higher-horsepower-lower-torque-and-accelerate-faster-than-diesel-engines>



<https://riskandwellbeing.com/tag/ice-versus-ev/>



# GASOLINE FUEL INJECTION SYSTEM - TYPES

The fuel injection types used in newer cars include four basic types:

- Carburetor
  - Single-point or throttle body injection
  - Port or multipoint fuel injection
  - Sequential fuel injection
- } Indirect injection
- Direct injection

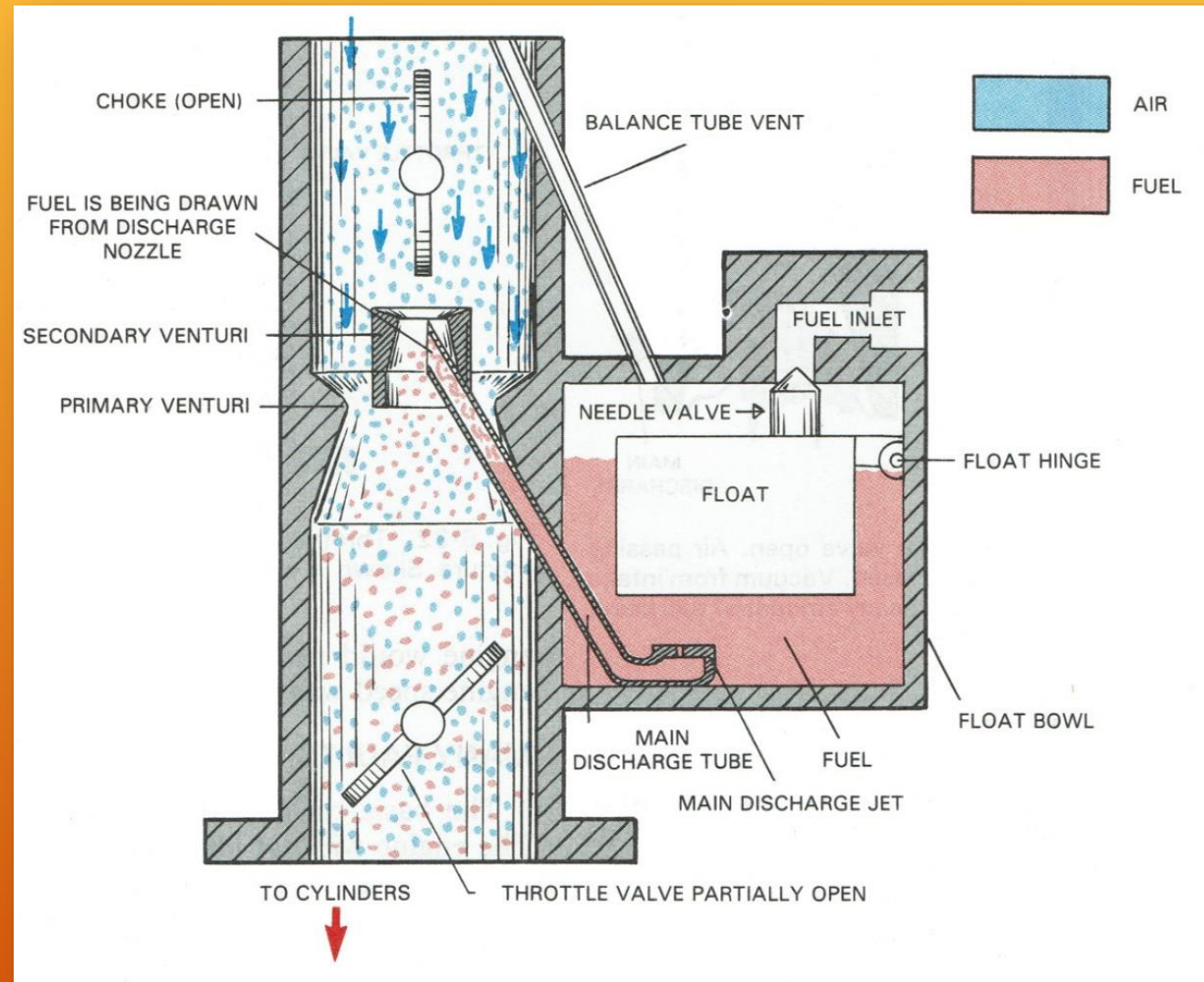




# GASOLINE FUEL INJECTION SYSTEM - TYPES

## Carburetor

Fuel enters the carburetor through a fuel inlet. The float regulates how much fuel to let in. When the float bowl has enough fuel the float moves up and shuts off the fuel via the needle valve. As the fuel level drops, the float drops down and allows the needle valve to open.



[https://www.carburetor-parts.com/How-a-Carburetor-Works\\_ep\\_1845.html](https://www.carburetor-parts.com/How-a-Carburetor-Works_ep_1845.html)

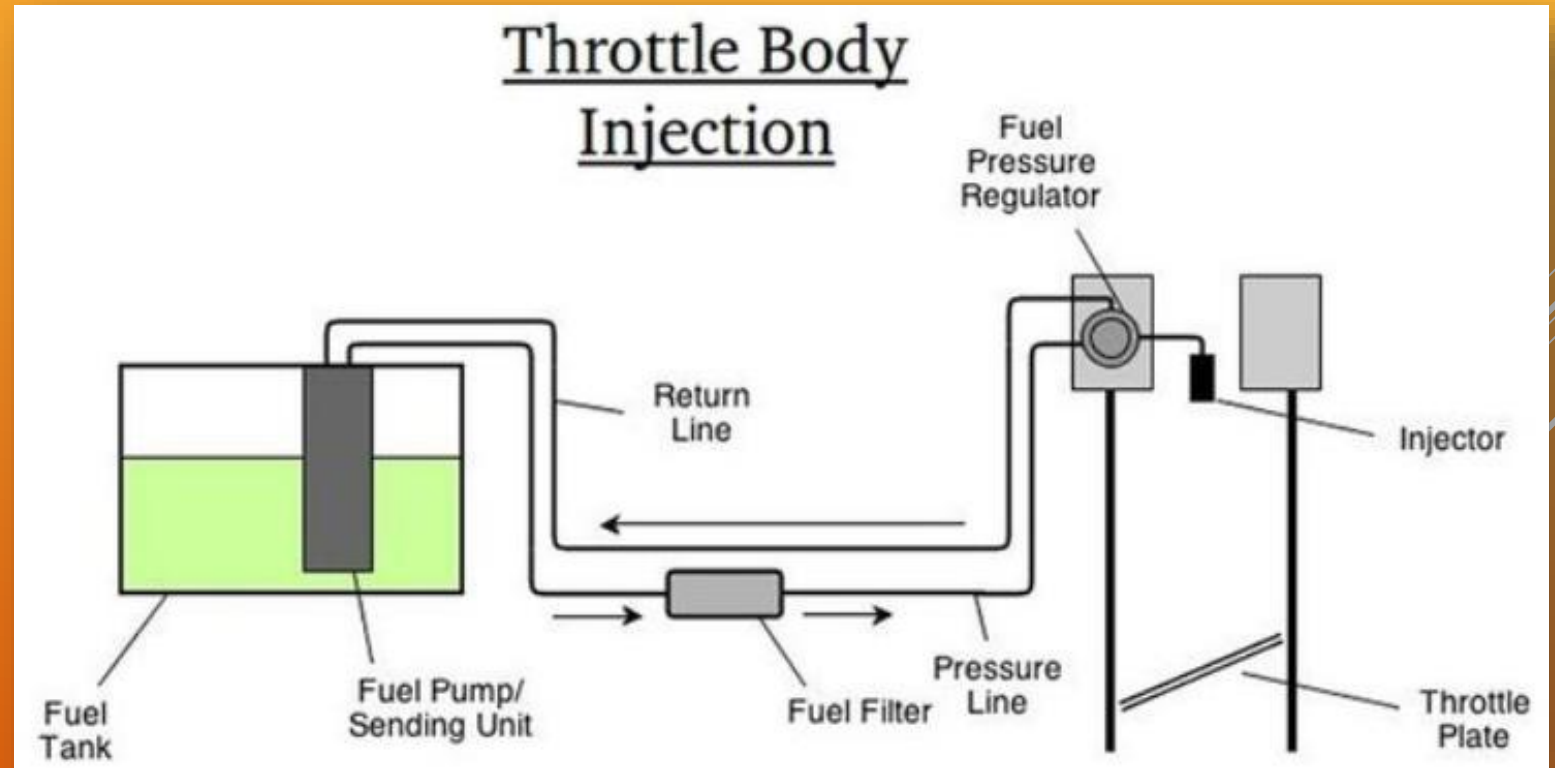




# GASOLINE FUEL INJECTION SYSTEM - TYPES

## Single-point or throttle body injection

The throttle body injection (TBI) system is one of the first types of injection systems ever used by vehicles. TBIs work in a manner very similar to a carburetor. The fuel is still sucked into the cylinders because of the suction created by the engine. However, TBIs are controlled by an electronic computer within the vehicle. The computer provides more accuracy by determining the amount of fuel that should be deposited into the engine.



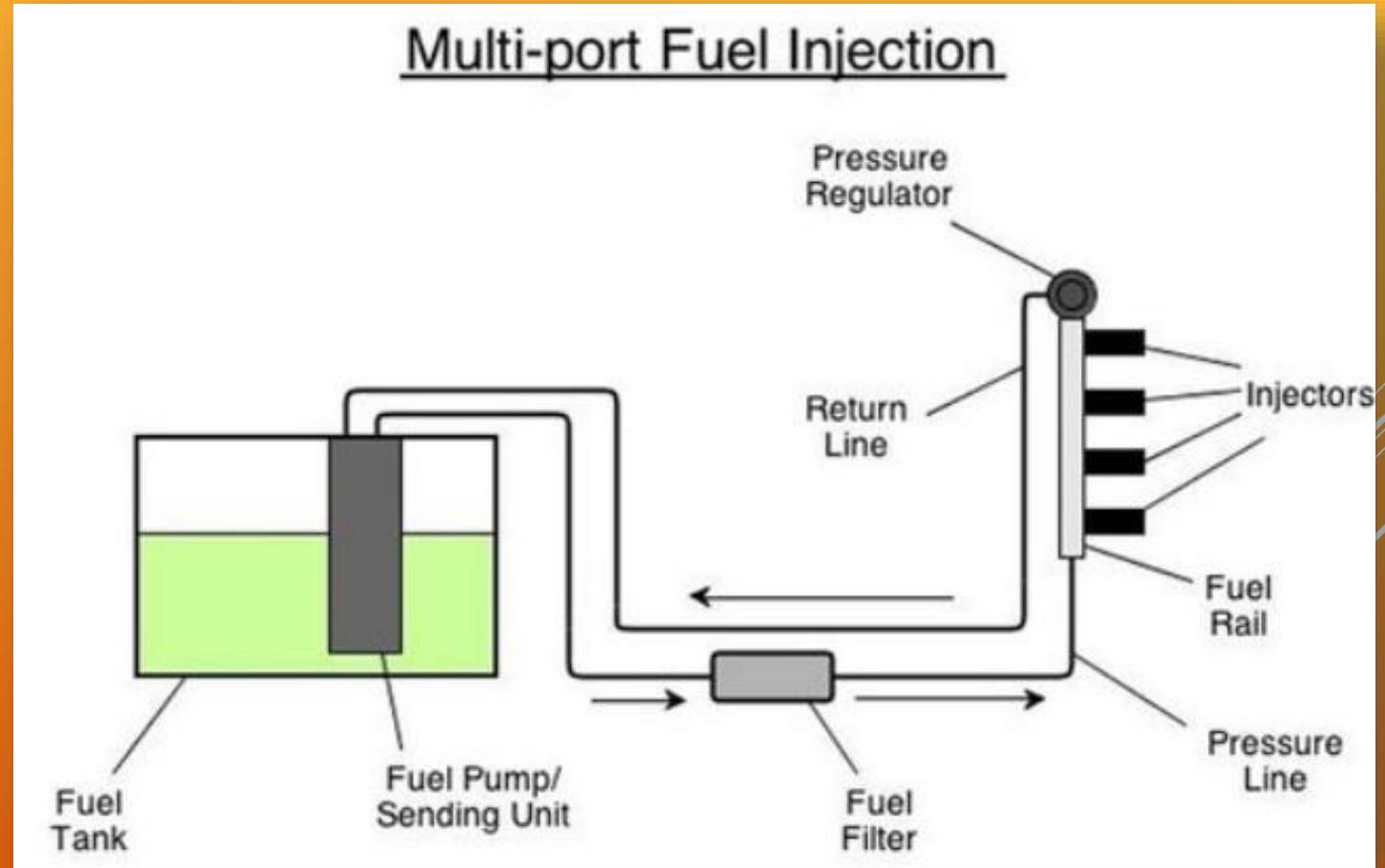
<http://jamesduncanfyp.weebly.com/mpi.html>



# GASOLINE FUEL INJECTION SYSTEM - TYPES

## Port or multipoint fuel injection

Multipoint fuel injection devotes a separate injector nozzle to each cylinder, right outside its intake port, which is why the system is sometimes called port injection. Shooting the fuel vapor this close to the intake port almost ensures that it will be drawn completely into the cylinder. The main advantage is that MPFI meters fuel more precisely than do TBI designs, better achieving the desired air-fuel ratio and improving all related aspects.



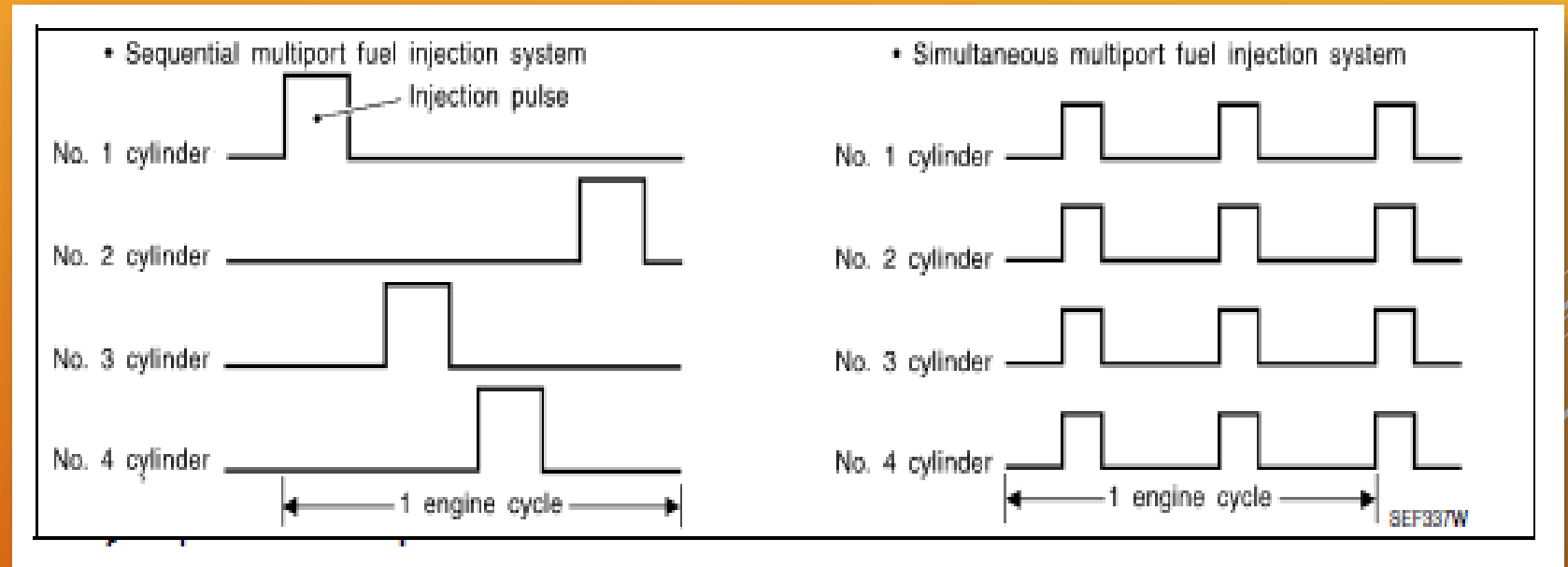
<http://jamesduncanfyp.weebly.com/mpi.html>



# GASOLINE FUEL INJECTION SYSTEM - TYPES

## Sequential fuel injection

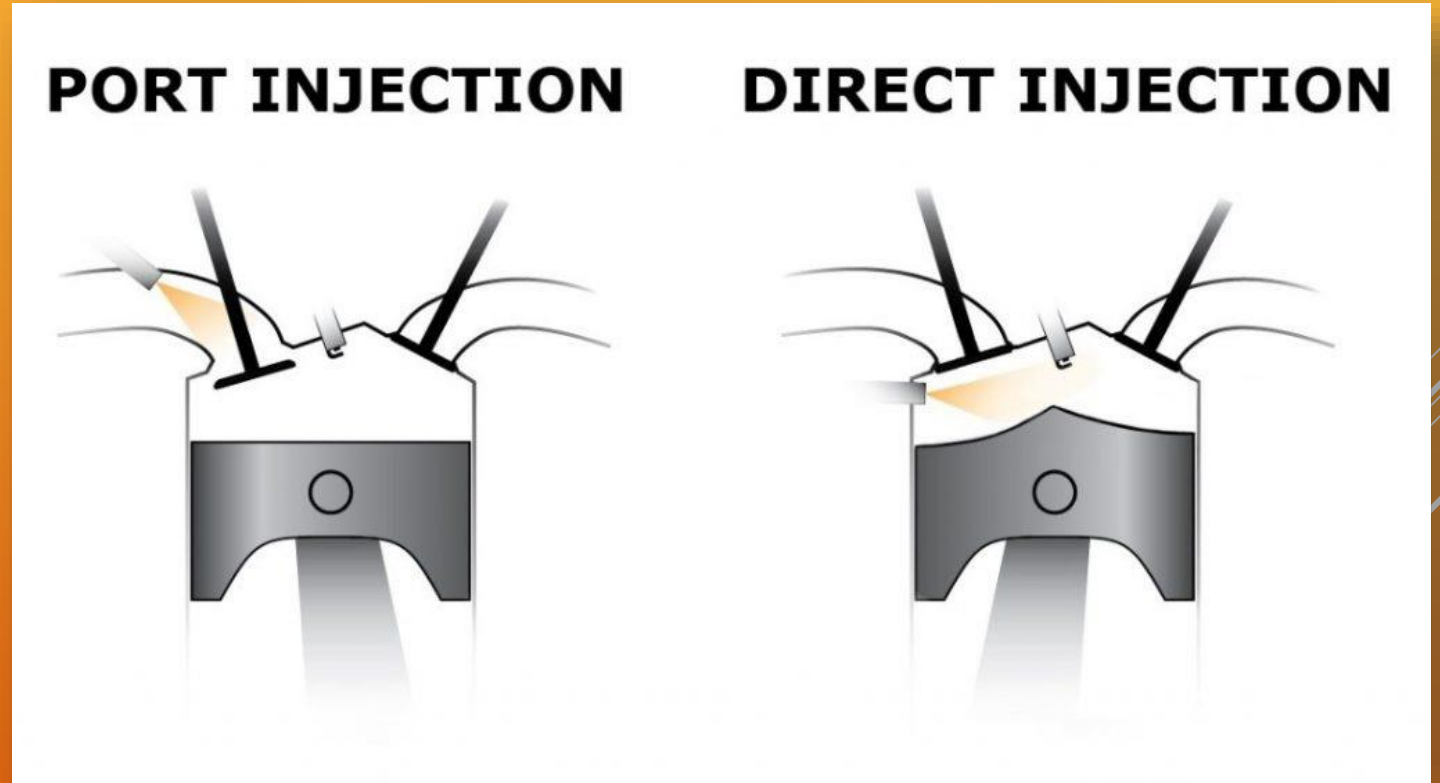
Sequential fuel injection, also called sequential port fuel injection (SPFI) or timed injection, is a type of multiport injection. Though basic MPFI employs multiple injectors, they all spray their fuel at the same time or in groups. As a result, the fuel may “hang around” a port for as long as 150 milliseconds when the engine is idling.



# GASOLINE FUEL INJECTION SYSTEM - TYPES

## Direct injection

Direct injection takes the fuel injection concept about as far as it can go, injecting fuel directly into the combustion chambers, past the valves. More common in diesel engines, direct injection is starting to pop up in gasoline engine designs, sometimes called DIG for direct-injection gasoline. Again, fuel metering is even more precise than in the other injection schemes, and the direct injection gives engineers yet another variable to influence precisely how combustion occurs in the cylinders.

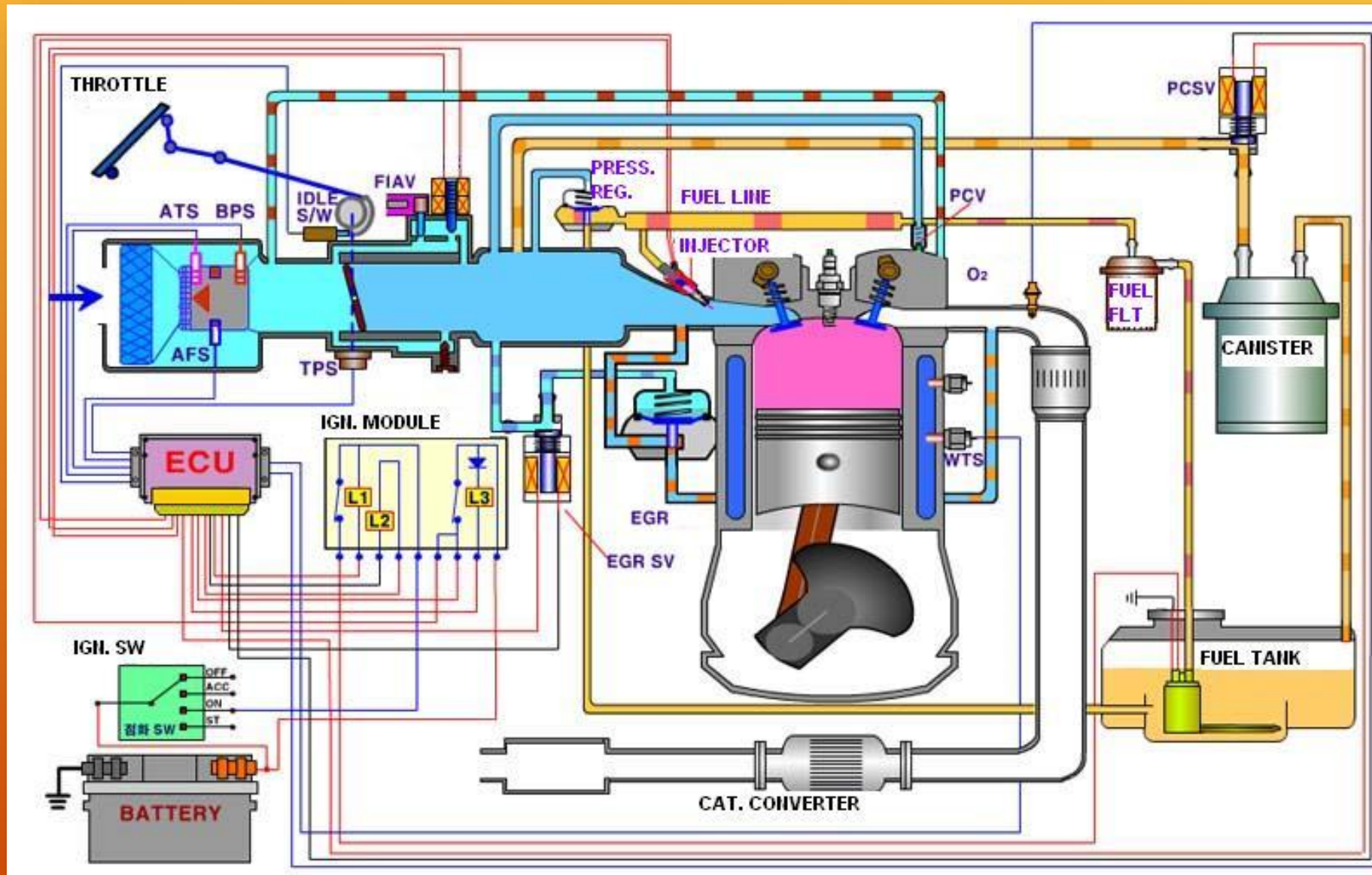


<https://stillrunningstrong.com/car-technology/gasoline-direct-injection/>





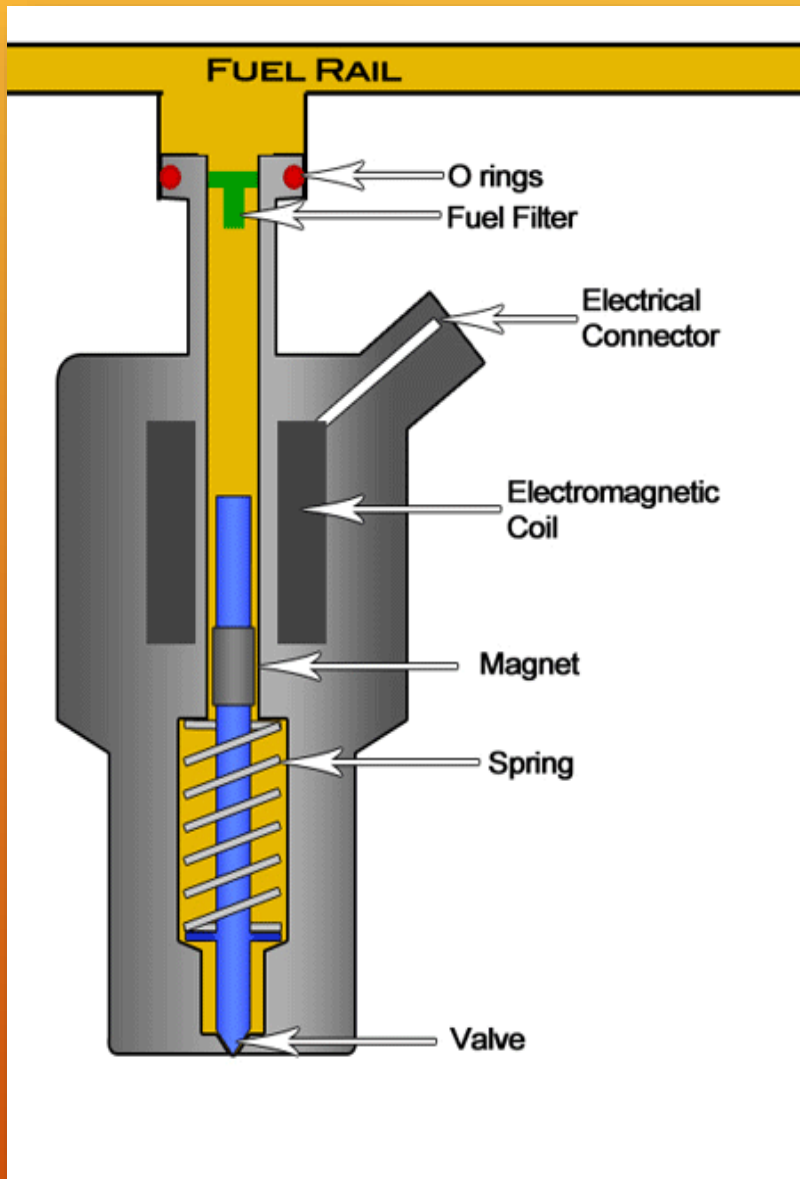
# GASOLINE FUEL INJECTION SYSTEM - TYPES



<https://www.chap.sch.ir>



# INJECTORS



Fuel Injector is simply a coil or solenoid operated valve.

Spring pressure holds the injector closed.

When engaged, the injector sprays fuel into the engine.

Injector Pulse Width indicates the time each Injector is energized (*Kept Open*).



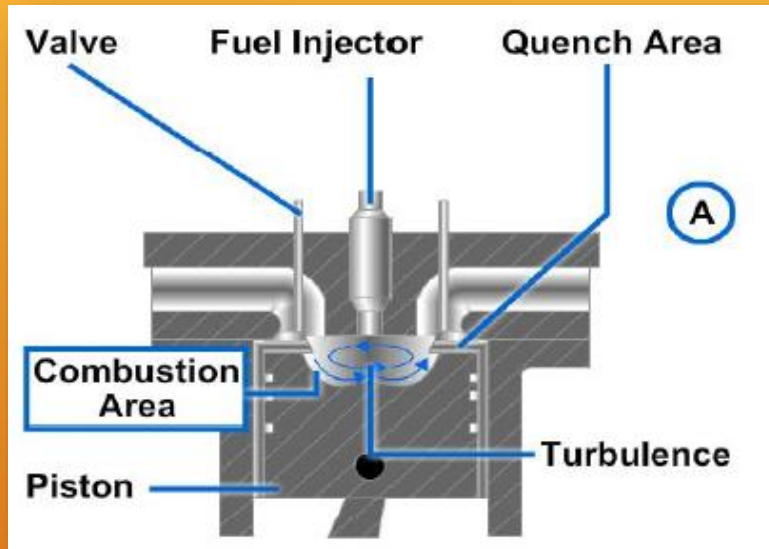
<http://premierautotrade.com.au/news/injector-service-components.php>



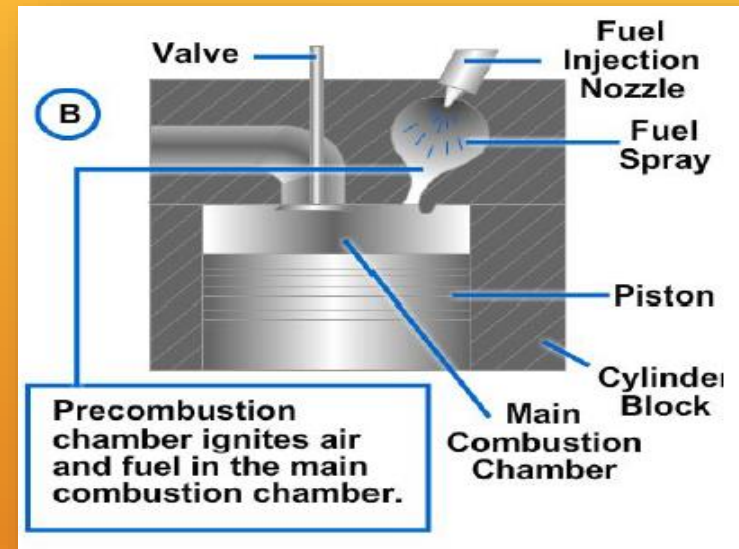
<http://saper96.ru/?k=How+Fuel+Injection+Systems+Work++HowStuffWorks>



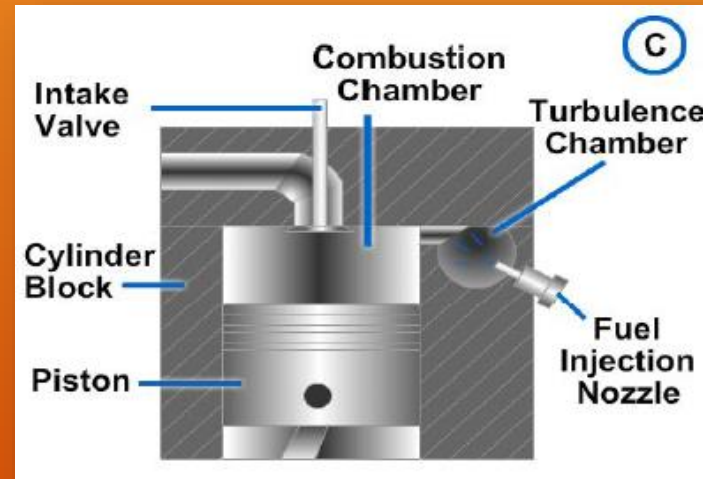
# DIESEL FUEL SYSTEM - TYPES



Direct Injection Combustion Chamber



Pre-combustion Chamber



Swirl Combustion Chamber



# DIESEL FUEL SYSTEM - TYPES

## 1. Inline injection pumps

- Standard PE injection in line pumps
- Inline slide injection pumps

## 2. Distributor injection pumps

- Axial distributor injection pumps
- Radial distributor injection pumps
- Distributor injection pumps controlled by an electromagnetic valve

## 3. Systems with individual injection units

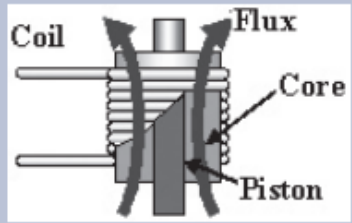

- Systems with PF injection units
- UIS Unit Injector System
- UPS Unit Pump System

## 4. Common Rail CR systems



# DIESEL INJECTORS

1. Electromagnetic injector
2. Piezoelectric injector

	Electromagnetic		Piezoelectric	
				
Drive system	Indirect drive by electromagnetic force		Solid deformation by inverse piezoelectric effect	
Displacement amount	○		×	1/10 to 1/100
Force generation	×		○	Utilization of solid rigidity
Displacement accuracy	×	> 0.1mm	○	0.01mm to 0.1mm
Response speed	×	> 1msec.	○	0.1 to 1 msec.
Energy efficiency	×	Coil winding loss	○	No coil
Noise	×	Piston sliding reciprocation noise	○	No piston
Proportional control	×	ON/OFF control	○	Voltage-proportional
Drive voltage	○		×	Hundreds of V/mm

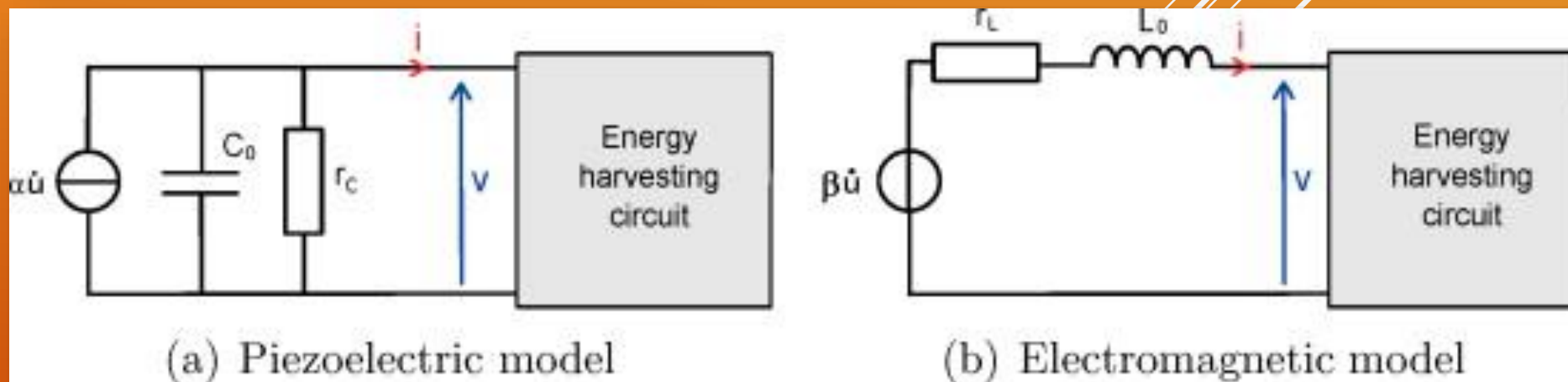
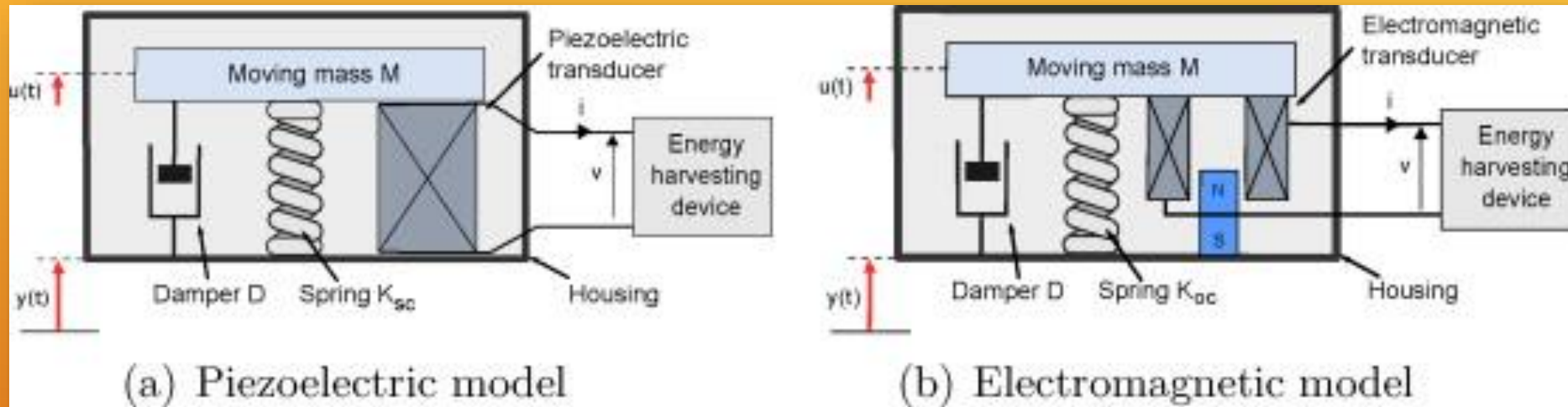
○: Advantageous ×: Disadvantageous



<https://www.dynamic-structures.com/articles/advantages-of-piezoelectric-actuators>  
<https://www.swiat-diesla.pl/Wtryskiwacze-elektromagnetyczne-i-piezoelektryczne-roznicze-w-rozwiazaniach-i-osiagach-news-pol-1528379021.html>



# DIESEL INJECTORS





# DIESEL FUEL SYSTEM

The fuel spray serves multiple purposes:

- Atomization
- Fuel distribution
- Fuel/air mixing

Typical Diesel fuel injector

Injection pressure: 1000 to 2200 bar

5 to 20 holes at ~ 0.12 - 0.2 mm diameter

Drop size 0.1 to 10  $\mu\text{m}$

For best torque, injection starts at about 20° BTDC

Injection strategies for NO<sub>x</sub> control

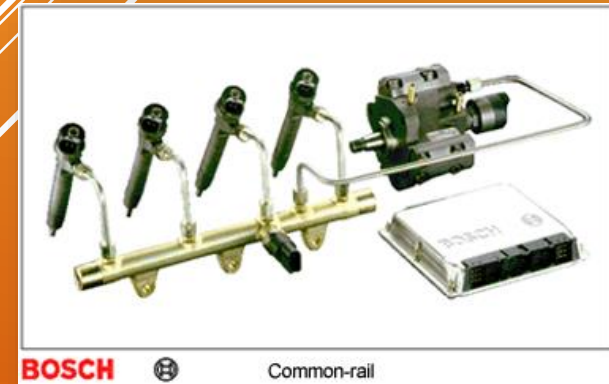
Late injection (inj. starts at around TDC)

Other control strategies:

Pilot and multiple injections, rate shaping, water emulsion



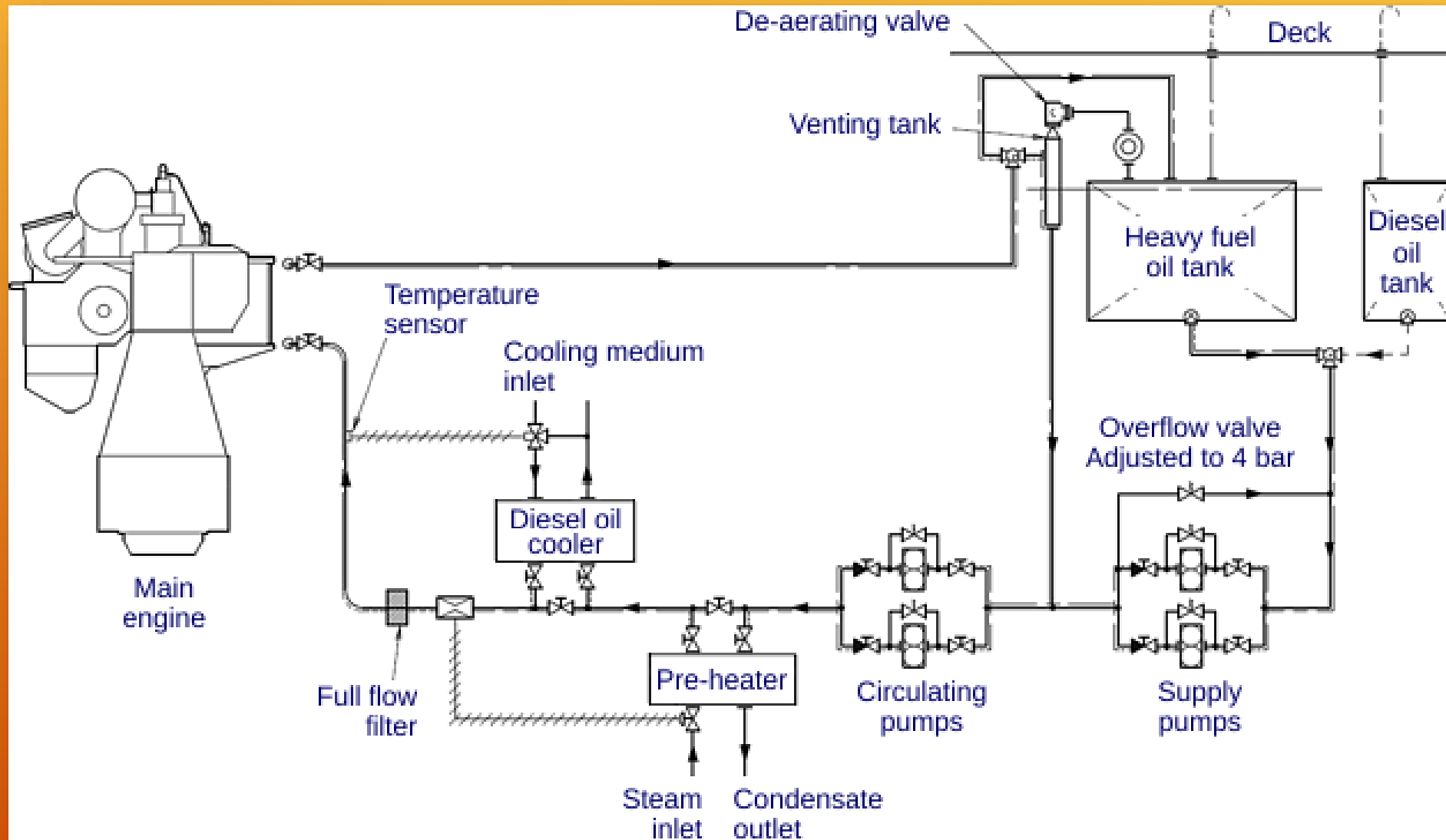
<https://www.indiamart.com/proddetail/diesel-fuel-injection-system-13911973497.html>



<https://www.wtryskiwacz.com/aktualnosci/comm-on-rail-regeneracja-wtryskiwaczy-i-pomp>



# DIESEL FUEL SYSTEM CR



[https://dieselnet.com/tech/diesel\\_fi\\_comp.php](https://dieselnet.com/tech/diesel_fi_comp.php)





# AIR INDUCTION SYSTEM



▲ Air Cleaner



Air Cleaner Element



▲ Air Cleaner Hose

Air Cleaner  
Air Cleaner Element  
Cooling Guide  
Air Inlet Duct  
Air Cleaner Hose  
Resonator Chamber



▲ Cooling Guide



▲ Air Inlet Duct



▲ Resonator Chamber



▲ Air Intake



<https://www.tiger-poly.com/product/car/c01.php>

# ENGINE THROTTLE VALVE

Controls air flow and gasoline to power engine.

When butterfly valve is closed it restricts air-flow and the resulting flow of fuel into the engine.

When accelerator is pressed, the air-flow is increased in the intake manifold.

Engine sensors detect the resulting changes and increase fuel flow through the injectors.



<https://auto.howstuffworks.com/fuel-injection2.htm>



<http://206gti.net/intakemod/>



# THROTTLE BODY INJECTION

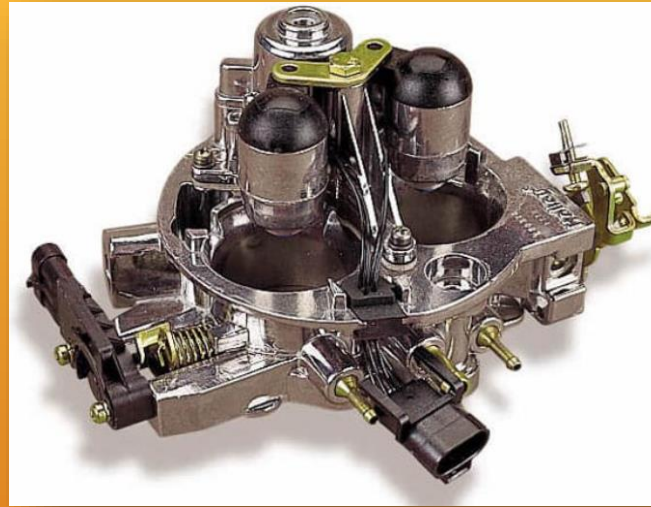
Uses one or two injectors.

Injectors (*pulse*) spray fuel into the top of throttle body air horn.

Atomized fuel mixes with air and drawn into the engine.

Fuel pressure regulator is spring loaded and is part of the housing.

Fuel is being injected whenever the engine is running, also called CIS: Continuous Injection System.



[https://www.holley.com/products/fuel\\_systems/fuel\\_injection/throttle\\_bodies/throttle\\_body\\_components/parts/500-6S](https://www.holley.com/products/fuel_systems/fuel_injection/throttle_bodies/throttle_body_components/parts/500-6S)



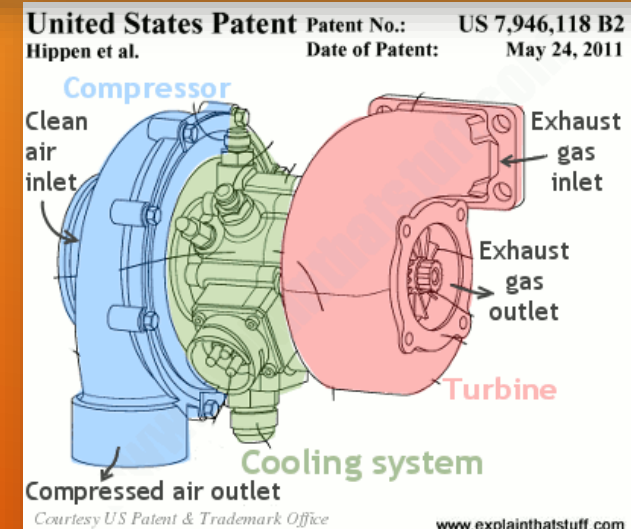
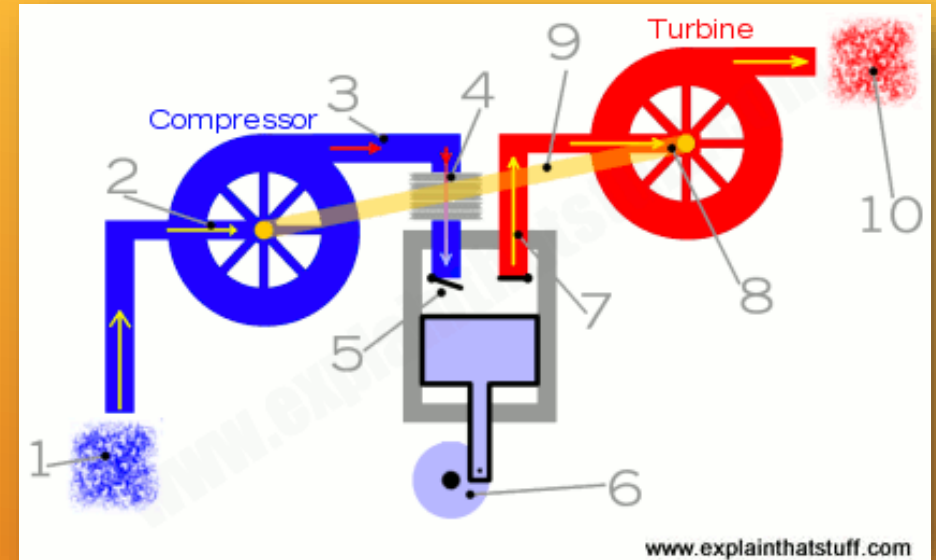
<https://www.homedepot.com/p/ACDelco-Fuel-Injection-Throttle-Body-12670981/308433891>



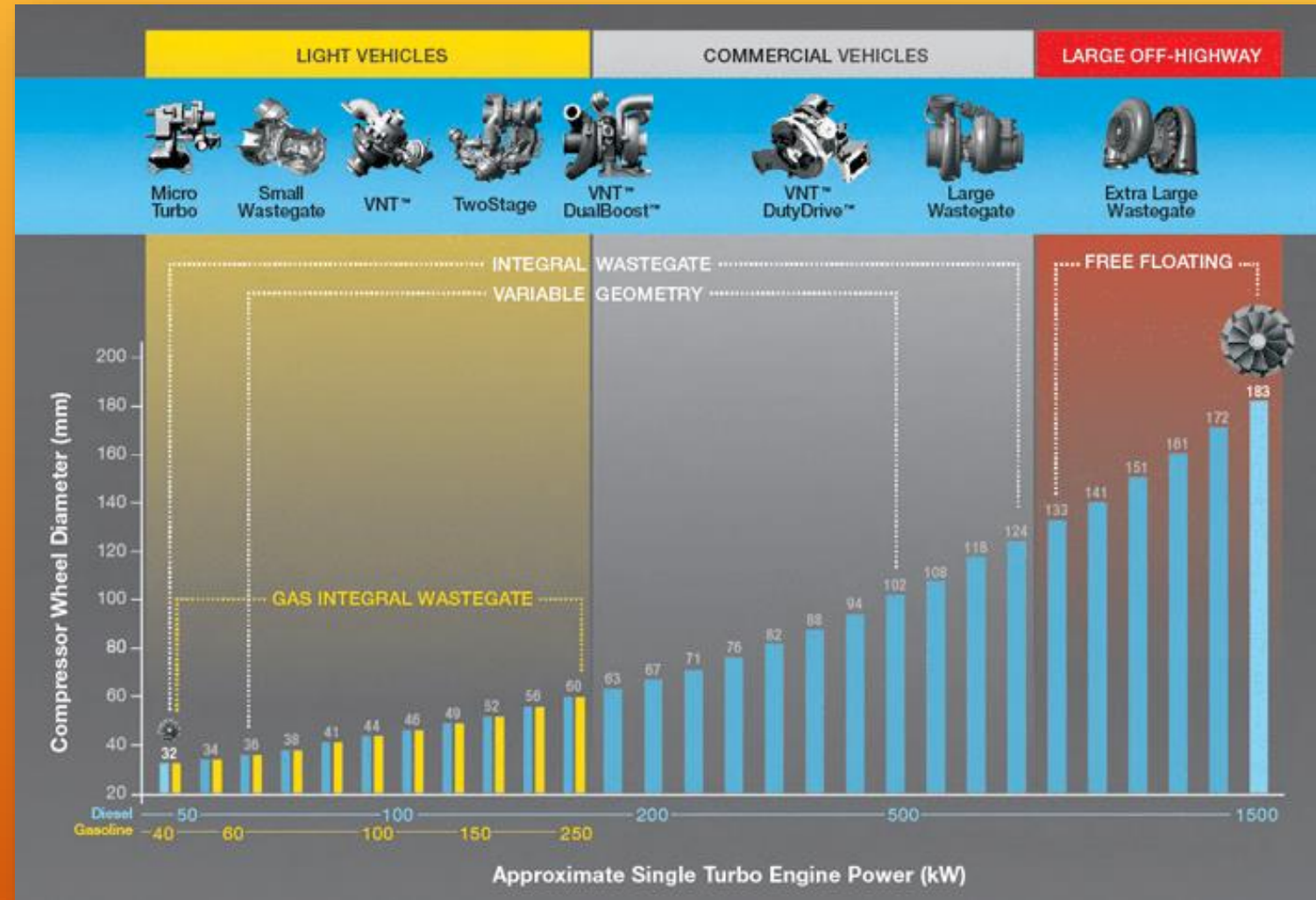


# TURBOCHARGER

1. Cool air enters the engine's air intake and heads toward the compressor.
2. The compressor fan helps to suck air in.
3. The compressor squeezes and heats up the incoming air and blows it out again.
4. Hot, compressed air from the compressor passes through the heat exchanger, which cools it down.
5. Cooled, compressed air enters the cylinder's air intake. The extra oxygen helps to burn fuel in the cylinder at a faster rate.
6. Since the cylinder burns more fuel, it produces energy more quickly and can send more power to the wheels via the piston, shafts, and gears.
7. Waste gas from the cylinder exits through the exhaust outlet.
8. The hot exhaust gases blowing past the turbine fan make it rotate at high speed.
9. The spinning turbine is mounted on the same shaft as the compressor (shown here as a pale orange line). So, as the turbine spins, the compressor spins too.
10. The exhaust gas leaves the car, wasting less energy than it would otherwise.



# TURBOCHARGER - types



- Single turbo
- Sequential turbos
- Twin-scroll turbo
  
- VGT turbo
- Variable twin-scroll turbo
- Electric turbo

[https://commons.wikimedia.org/wiki/File:Honeywell\\_Turbo\\_Product\\_range.gif](https://commons.wikimedia.org/wiki/File:Honeywell_Turbo_Product_range.gif)



Therefore, you would expect to get 50 percent more power. It's not perfectly efficient, so you might get a 30- to 40-percent improvement instead.

In order to handle speeds of up to 150,000 rpm, the turbine shaft has to be supported very carefully. Most bearings would explode at speeds like this, so most turbochargers use a fluid bearing.

In recent years many advancements in this area have been observed, to name a few:

Variable geometry turbocharger or popularly known as VGT.

Multi stage turbochargers.

Twin scroll turbochargers.

Electric motor driven turbo chargers.

The first turbo was made in 1905.





# ENGINE SENSORS LISTS

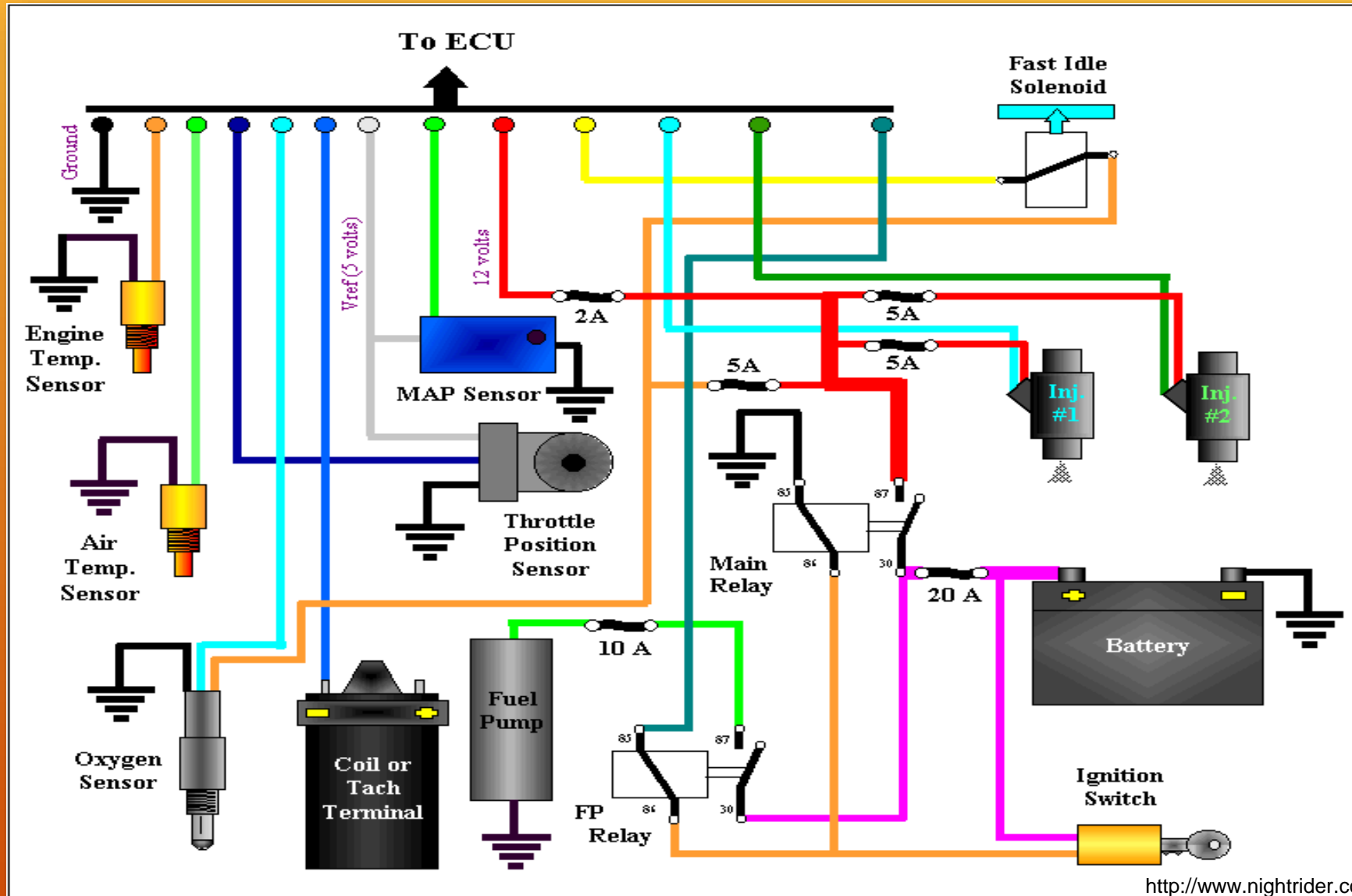
1. Engine speed sensor
2. Camshaft position sensor
3. Intake manifold pressure sensor
4. Air flow meters
5. Coolant temperature sensor
6. Throttle position sensor
7. Accelerator pedal position sensor
8. Knock sensor
9. Oxygen sensor



<https://warsztatowiec.info/czujniki-zrodlo-wszelkich-informacji/>



# ENGINE SENSORS



[http://www.nightrider.com/biketech/motorcycle\\_efi\\_basics.htm](http://www.nightrider.com/biketech/motorcycle_efi_basics.htm)



# ENGINE SENSORS

Oxygen Sensor measures the oxygen content in engine exhaust.

Mounted on the exhaust system before the catalytic converter.

Voltage out-put of O<sub>2</sub> sensor changes with the change in oxygen content of exhaust.

Lean mixture decreases the voltage. Rich mixture increases the voltage.

Signal is sent to ECM and the ECM changes the time that an injector is open or close.



<https://warsztat.pl/artykuly/sondy-lambda-rodzaje-przyczyny-i-skutki-awarii,65169>



# ENGINE SENSORS

## Construction of a binary probe – narrow band

Electrolytic resistance sensors are used to detect oxygen in the exhaust gas. A method of measuring voltage drop is used on a converter made of a ceramic DC power supply, as well as a method of direct measurement of the electromotive force of a galvanic cell with a solid electrolyte.

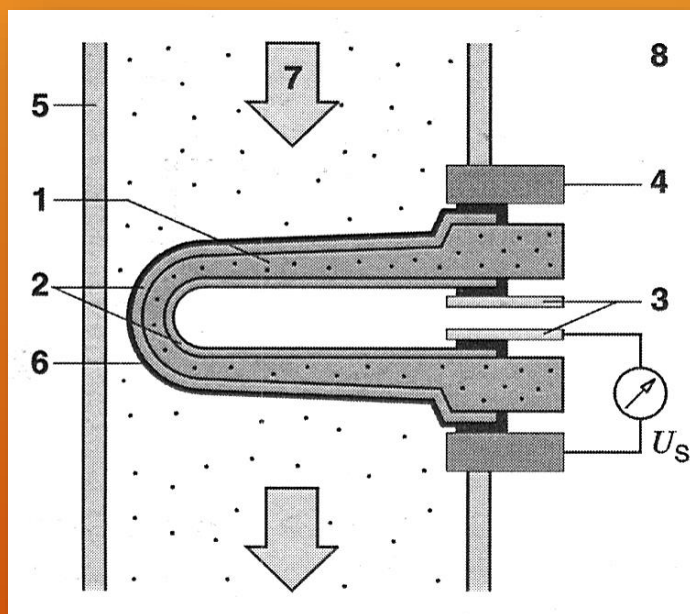
The solid electrolyte is a one-sided, gas impermeable zirconia ceramic liner stabilized with yttrium oxide. The outer electrolyte surfaces on both sides are equipped with electrodes made of a porous, thin layer of platinum. The platinum electrode on the outside is in contact with the exhaust gas in the exhaust pipe acts as a small catalyst; the exhaust gases encountered are catalytically brought to a stoichiometric equilibrium state ( $\lambda = 1$ ). In addition, the platinum electrode on the exposed side of the flue was covered with a porous ceramic layer of magnesium silicon oxides to protect it from pollution. A metal tube cover with multiple gaps protects the ceramic insert against mechanical and thermal loads. Shielded against exhaust fumes, the open internal space of the court is connected with air, which is the role of comparative gas. The probes are equipped with a heating element to heat the probe faster to its operating temperature (approx. 600 °C).





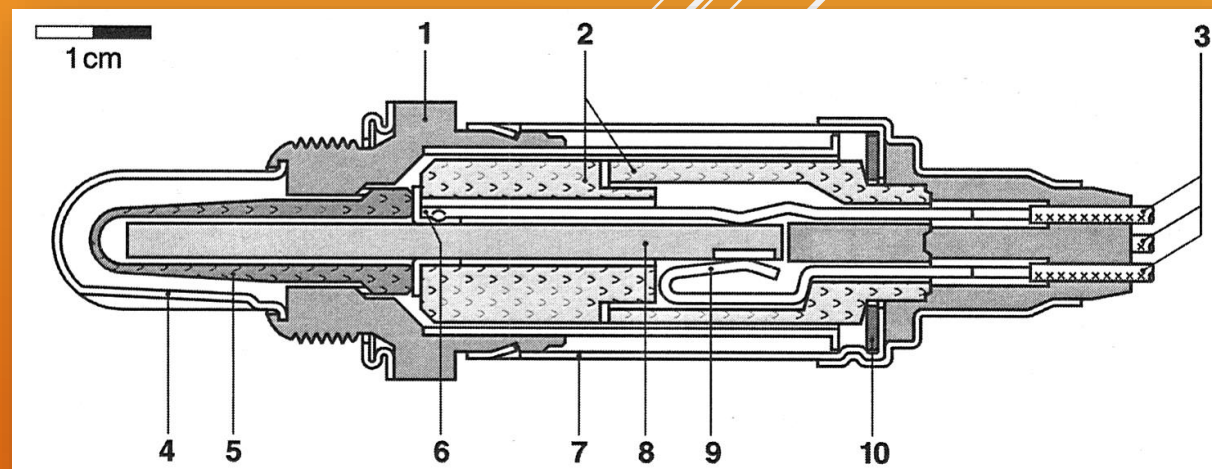
# ENGINE SENSORS

- 1 - solid electrolyte (ceramics),
- 2 - electrodes,
- 3 - electrical contacts,
- 4 - housing,
- 5 - exhaust outlet pipe,
- 6 - porous ceramic protective coating
- 7 - flue gas stream,
- US - probe voltage



[https://www.skola-auto.cz/wp-content/uploads/2017/09/Vstrikovaci\\_systemy\\_zaz\\_motoru\\_II.pdf](https://www.skola-auto.cz/wp-content/uploads/2017/09/Vstrikovaci_systemy_zaz_motoru_II.pdf)

- 1 - housing, 2 - ceramic tubular insert,
- 3 - electric wires, 4 - pipe cover with slots,
- 5 - active shaft (probe electrode), 6 - electric contact,
- 7 - protective sleeve, 8 - heating element,
- 9 - electric contact of the heating element, 10 - disc spring



<http://otomotivlab.net/wp-content/uploads/2015/07/?MA>





# OXYGEN SENSOR

## Construction of a binary probe – narrow band

A platinum electrode catalytically affects the exhaust gas flowing through its pores. This causes CO and HC combustion and reduction of NOX nitrogen oxides contained in the exhaust gas. As a result, oxygen reaches the probe's measuring element, which remains in the flue gas after catalytic oxidation and after reduction, as well as free oxygen. The difference in oxygen concentration on both sides of the galvanic cell causes the flow of oxygen ions without applying external voltage. Since the oxygen content in the air is constant, the oxygen content in the exhaust gas can be determined based on the potential of such a cell.

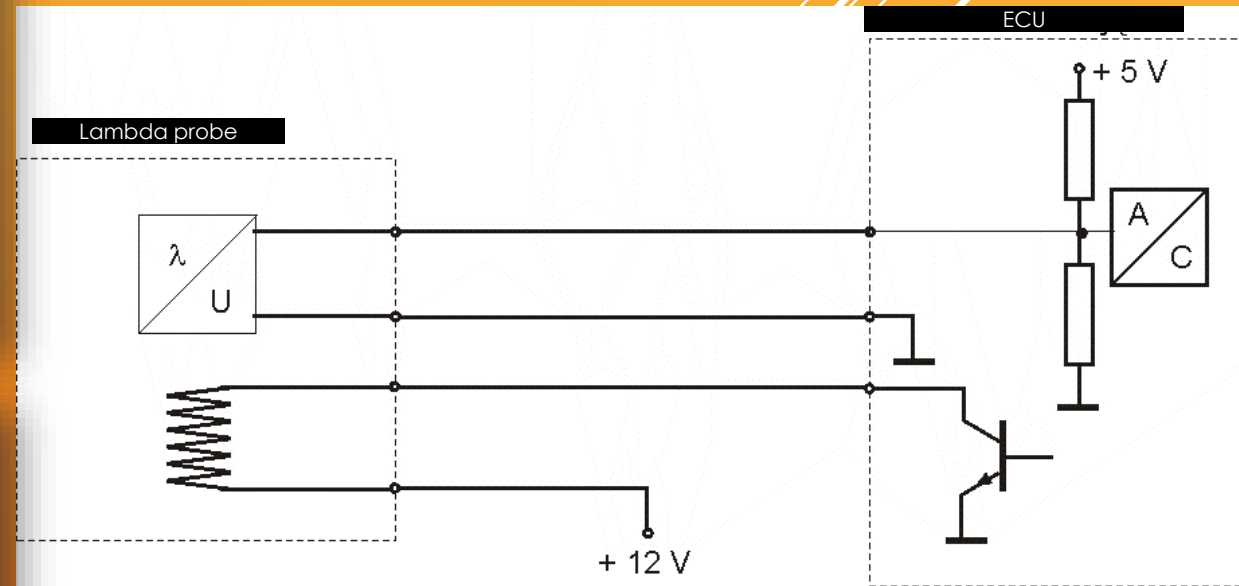
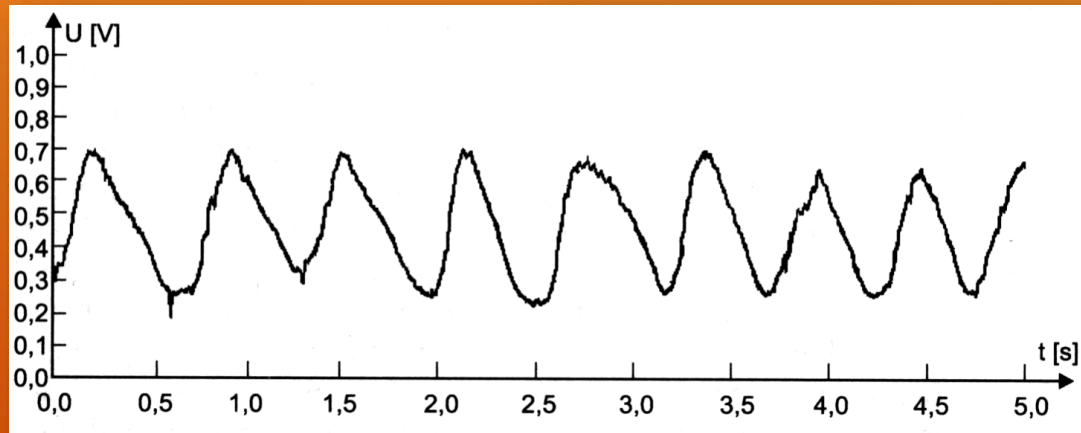
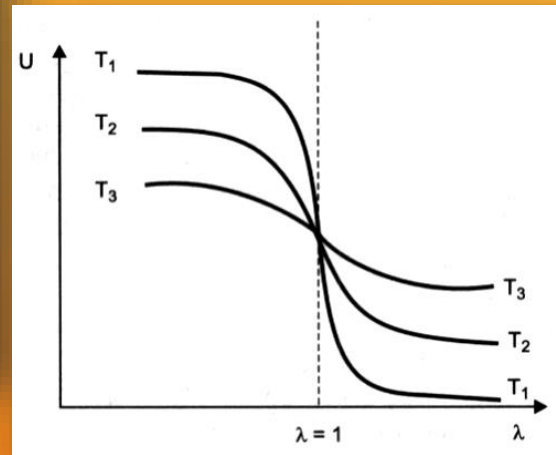
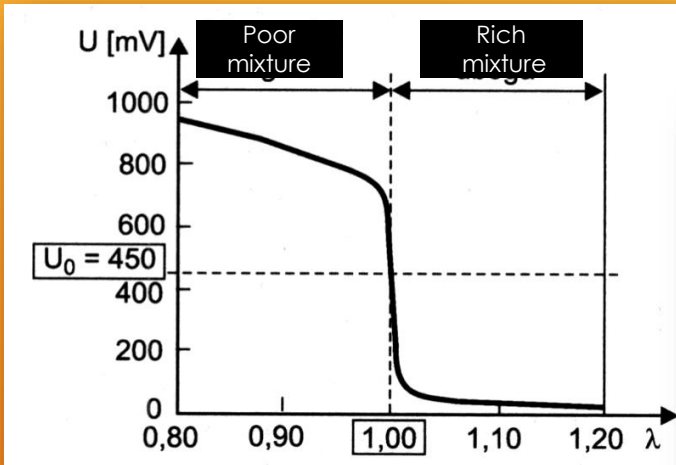
These processes mean that the ratio of the amount of oxygen remaining after combustion of the lean mixture to the amount of oxygen remaining after the combustion of the rich mixture is several orders higher than if this interaction had not been. Thanks to this, a large voltage surge occurs on the measuring element at the stoichiometric point.



<https://www.dalesautomotive.co.uk/pages/repairs>

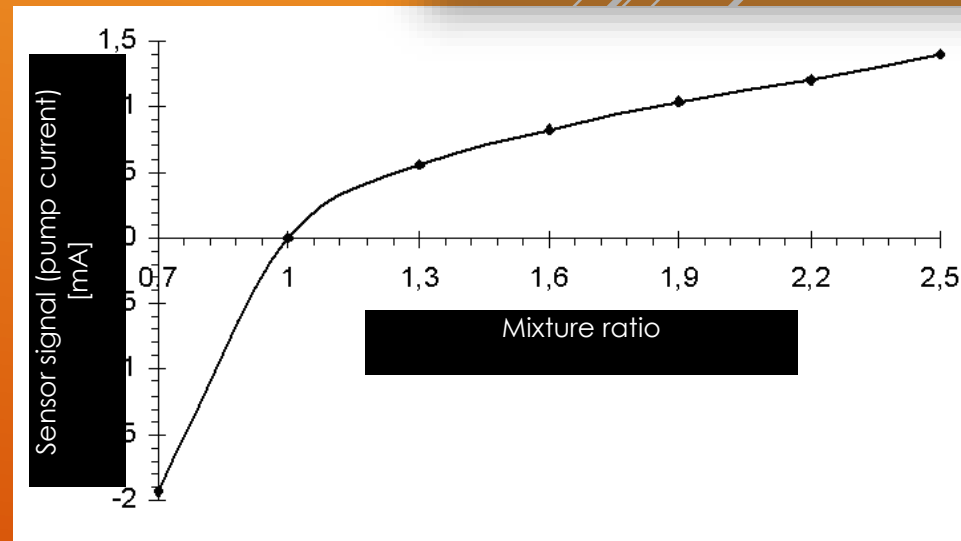
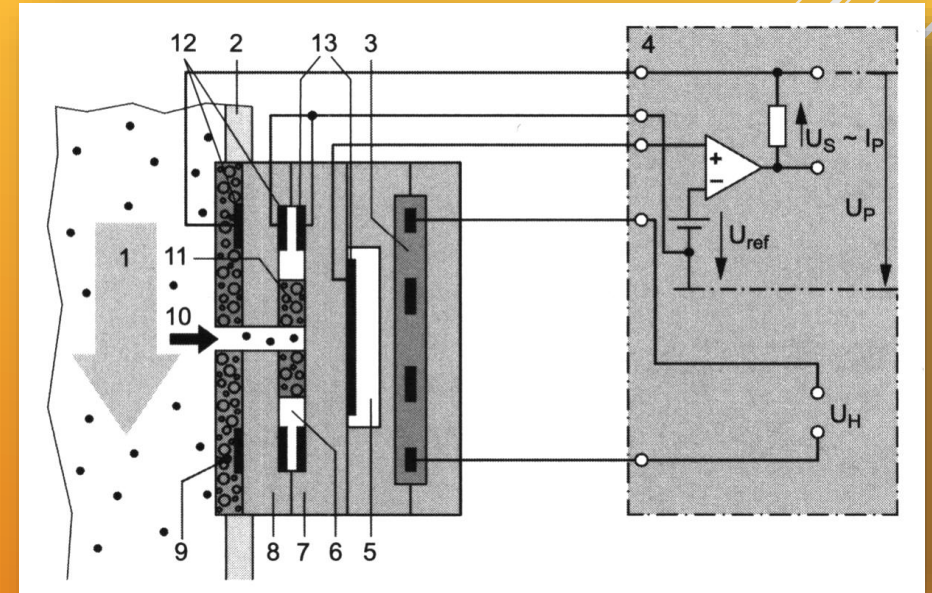


# OXYGEN SENSOR



# WIDE RANGE LAMBDA PROBE

- 1 - exhaust gases,
- 2 - exhaust system,
- 3 - probe heater with temperature stabilization system,
- 4 - electronic power supply and signal measurement system,
- 5 - air chamber,
- 6 - diffusion space,
- 7 - Nernst concentration cell, 8 - oxygen "pump",
- 9 - porous protective layer,
- 10 - flue gas inlet channel to the diffusion barrier,
- 11 - porous diffusion barrier,
- 12 - oxygen pump electrodes, 13 - Nernst cell electrodes,
- IP - current flowing through the pump,
- UH - voltage supplying the heating winding,
- UREF - reference voltage source.



# ENGINE SENSORS

Manifold Absolute Pressure Sensor (MAP)

Signs of a map sensor:

Fuel ratio of lean air and rich air

Surging

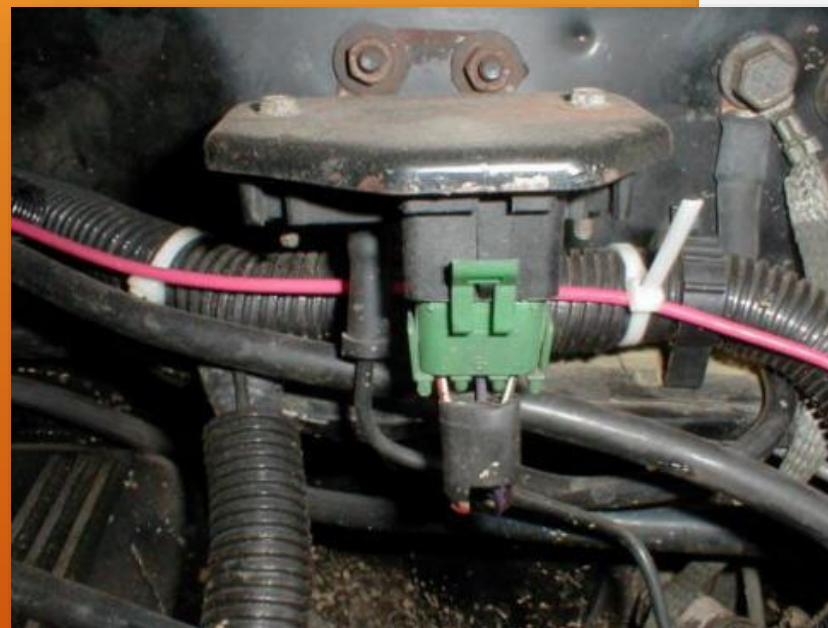
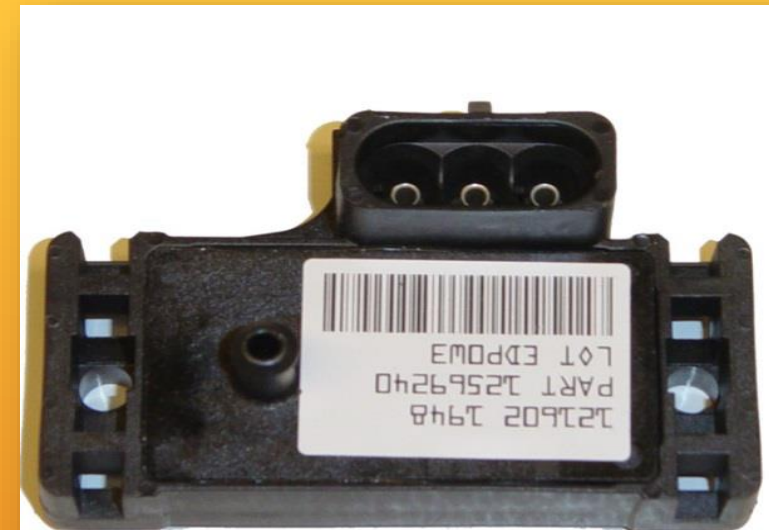
The economy of Poor fuel

It cannot work

Engine power problem

Stalling

Misfire & Detonation



<http://blog.naver.com/PostView.nhn?blogId=ofu09&logNo=110015621271>

<https://www.cherokeeforum.com/f2/map-sensor-location-57912/>





# MANIFOLD ABSOLUTE PRESSURE SENSOR (MAP)

Measurement of air pressure in the engine intake system

Measurement of ambient pressure

Fuel tank pressure measurement

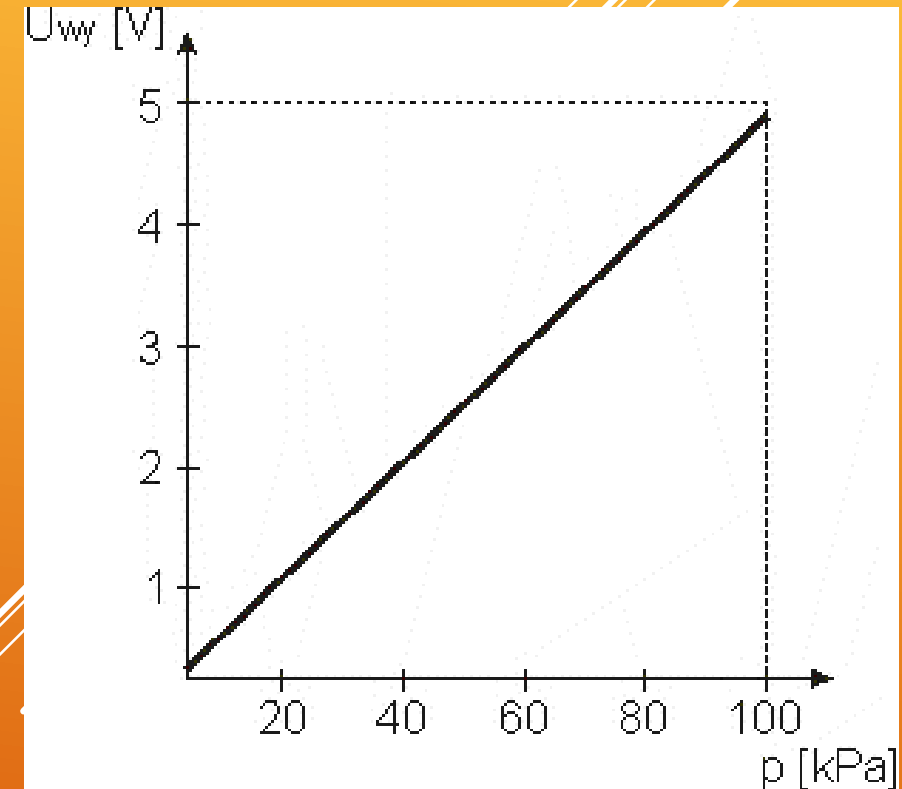
Pressure sensors use a resistive element (strain gauge) in the form of thin wires, mesh or foil made of metal or semiconductor. Strain gauges are resistance sensors in which the resistance changes proportionally to their deformation.

Advantages of the sensor:

high sensitivity and measurement accuracy,  
high reliability, small dimensions, low weight,  
insensitivity to shocks, measurement of fast-changing deformations.

Disadvantages of the sensor:

small output signal.





# MANIFOLD ABSOLUTE PRESSURE SENSOR (MAP)

## Construction of a strain sensor

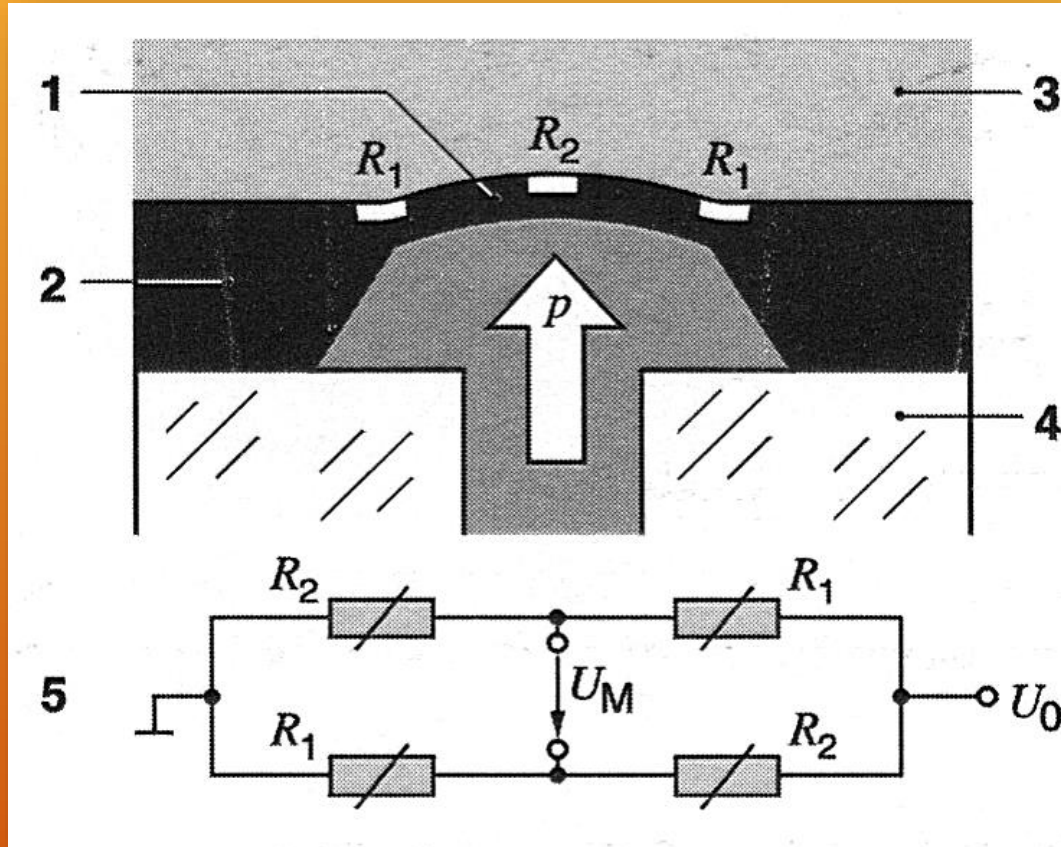
The measuring element consists of a silicon chip in which the diaphragm is micromechanically etched. Four strain gauges are applied on the diaphragm, whose resistance changes under the influence of mechanical load. The diaphragm is placed on a glass pedestal. All elements are located under a hermetic cover that creates a vacuum chamber.

The transducer diaphragm bends (10 - 1000  $\mu\text{m}$ ) depending on the pressure measured. The resistors are located in such a way that when the diaphragm is deformed, two of them increase the resistance, while the other two - decrease. As a result of the change in resistance, the voltage relationship across the Wheatstone bridge measuring resistors - UM voltage also changes. This voltage is a measure of pressure. The output voltage of the measuring bridge is transmitted via connecting cables to the signal processing circuit (signal bridge gain to 0-5V and temperature compensation) and then to the motor controller. The vacuum chamber is a reference so that the sensor measures absolute pressure.



# MANIFOLD ABSOLUTE PRESSURE SENSOR (MAP)

Bosch: Czujniki w pojazdach samochodowych



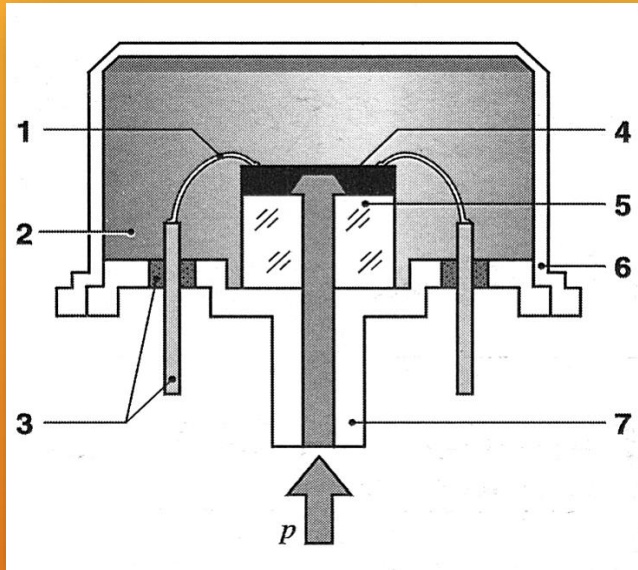
- 1 - diaphragm,
- 2 - silicon chip,
- 3 - reference vacuum,
- 4 - pyrex glass,
- 5 - bridge system of strain gauge connections



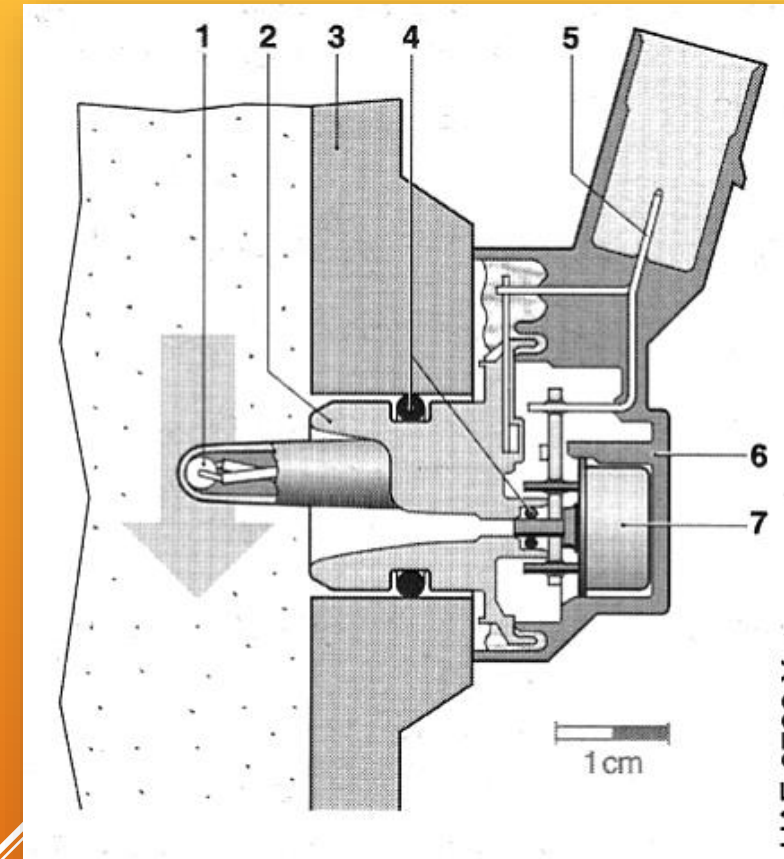
<http://www.fullmecnica.com/definiciones/s/872-sensor-de-presion>



# MANIFOLD ABSOLUTE PRESSURE SENSOR (MAP)



- 1,3 - electrical connectors,
- 2 - base vacuum chamber,
- 4 - element chip measuring
- 5 - glass plinth,
- 6 - cover,
- 7 - bringing measured pressure



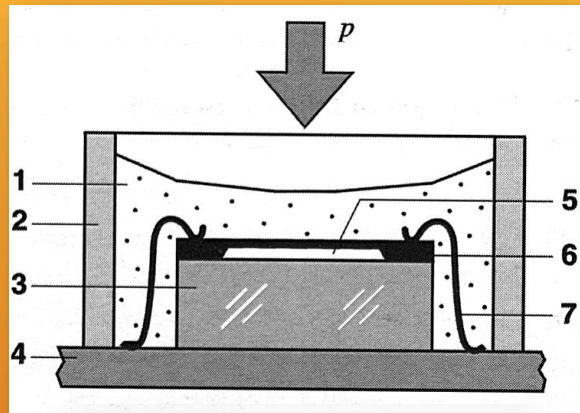
- 1 - temperature sensor,
- 2 - bottom part of the housing,
- 3 - intake manifold wall,
- 4 - sealing ring,
- 5 - plug connector,
- 6 - housing cover,
- 7 - measuring element



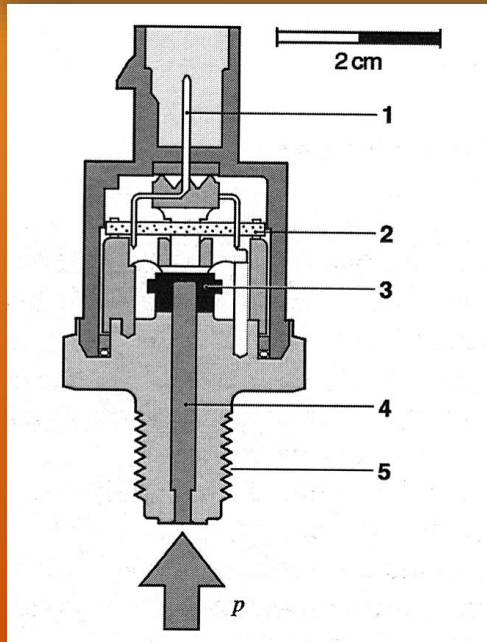
źródło: Bosch: Czujniki w pojazdach samochodowych



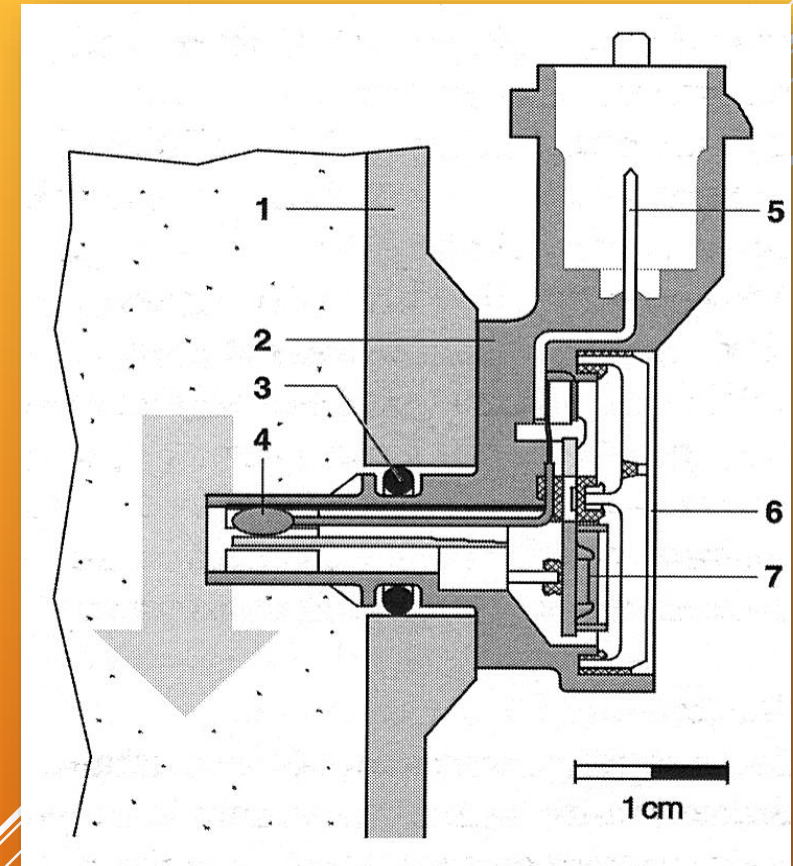
# MANIFOLD ABSOLUTE PRESSURE SENSOR (MAP)



- 1 - intake manifold wall,
- 2 - housing,
- 3 - sealing ring,
- 4 - temperature sensor
- 5 - plug connector,
- 6 - housing cover,
- 7 - measuring element



- 1 - electrical connector,
- 2 - electric circuit,
- 3 - steel diaphragm with strain gauges,
- 4 - pressure supply,
- 5 - threaded fastening connector



- 1 - protective gel,
- 2 - gel chamber cover,
- 3 - glass plinth,
- 4 - ceramic composite substrate,
- 5 - vacuum chamber,
- 6 - measuring element chip,
- 7 - micro-assembly connection

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Bosch: Czujniki w pojazdach samochodowych



# ENGINE SENSORS

## Throttle Position Sensor (TPS)

This sensor is usually mounted on the throttle body. It senses the position of the throttle valve or butterfly valve and transmits the information to the Engine control unit. This sensor monitors how far down the accelerator pedal is pushed and gives the output current determining the position of the pedal. The position of the pedal controls the airflow of the engine. If the valve is wide opened, a large amount of air is supplied to the engine and vice-versa. The output given by this sensor, along with other sensors is transmitted to the engine control unit, which decides the amount of fuel to be injected into the engine accordingly.

This sensor is a three wired potentiometer. Through the first wire, a 5V power is supplied to the sensors resistive layer. The second wire is used as ground whereas the third wire is connected to the potentiometer wiper and provides input to the Engine control system.

Based on its construction, there are three types of throttle position sensors. They are the throttle position sensors with built-in end switches also known as Closed Throttle Position Sensor, the potentiometer type and the combination of both these types.



<https://superparts.pl/czujnik-polozenia-przepustnicy-hella-6px-008-476-131-825484-opel/431889>



<https://www.yourmechanic.com/article/symptoms-of-a-bad-or-failing-throttle-position-sensor>



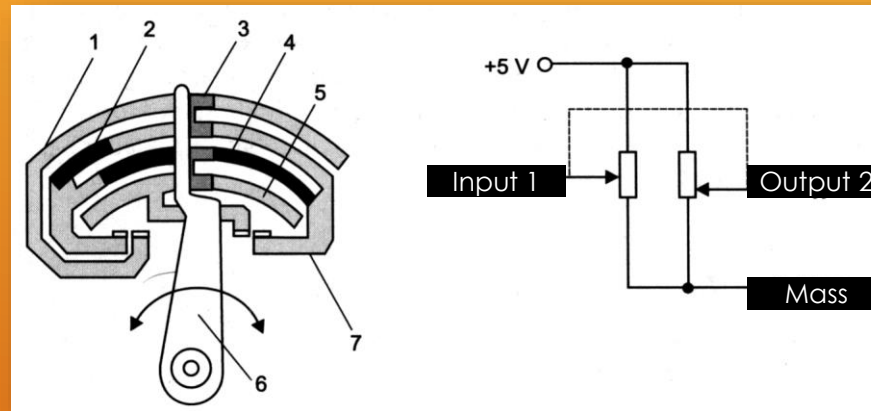


# THROTTLE POSITION SENSOR (TPS)

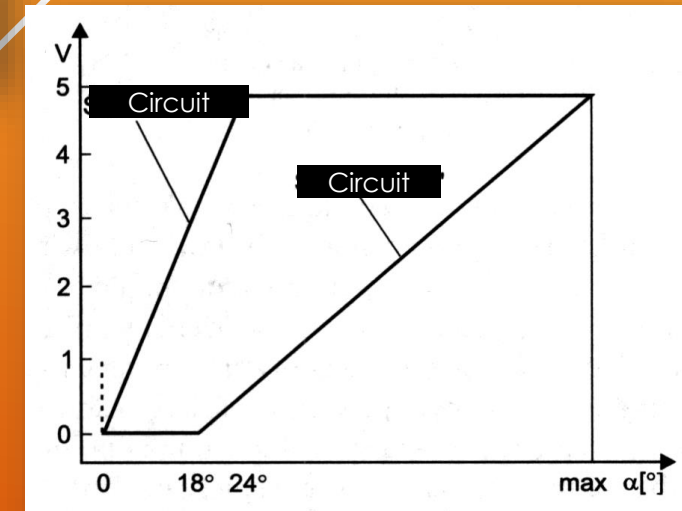
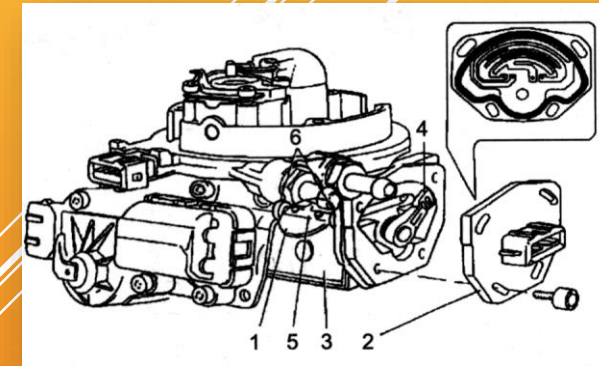
- 1 - throttle plate,
- 2 - sensor cover,
- 3 - injection unit,
- 4 - glider,
- 5 - throttle axis,
- 6 - damper axle bearings

## Construction of a potentiometer sensor

The throttle position sensor is a potentiometric angle position transducer with one or two linear characteristics. The slider arm slide, connected to the damper axis, moves along the resistive path, determining the angle of rotation of the damper as proportional to the quotient of the UA / UV voltage with the operating voltage of 5V. The slider joint is a second track with the same surface, lined with low-resistance conductive material. Changing the width of the measuring path affects the shape of the sensor characteristics.



- 1 - small swing contact path,
- 2 - small swing resistance path,
- 3 - slider contact,
- 4 - high tilt resistance path,
- 5 - high tilt contact path,
- 6 - glider arm,
- 7 - UV power supply



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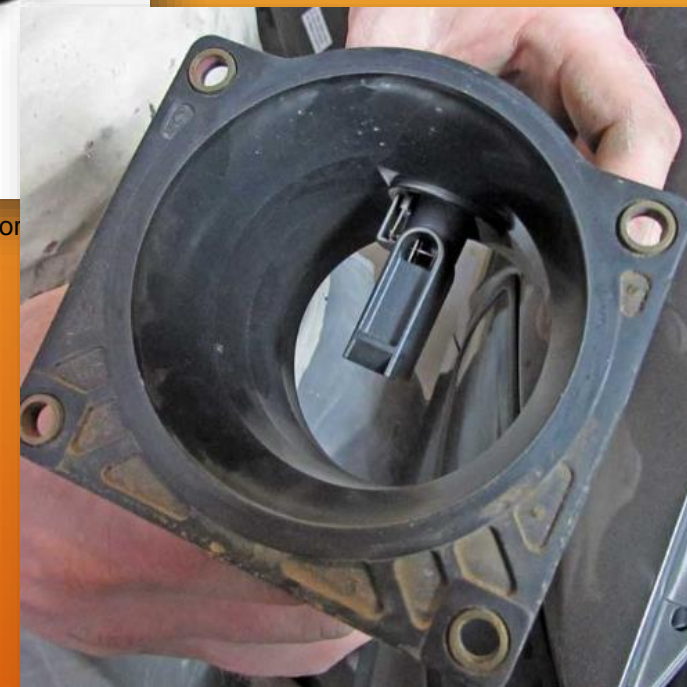
# ENGINE SENSORS

## Mass Air Flow Sensor (MAF)

Hot wire sensor (MAF) A hot wire mass airflow sensor determines the mass of air flowing into the engine's air intake system. ... When air flows past the wire, the wire cools, decreasing its resistance, which in turn allows more current to flow through the circuit, since the supply voltage is a constant.



<http://polish.carmafsensor.com/supplier-279538-bmw-maf-sensor/>



<http://knowhow.napaonline.com/know-how-notes-how-to-clean-your-maf-sensor/>

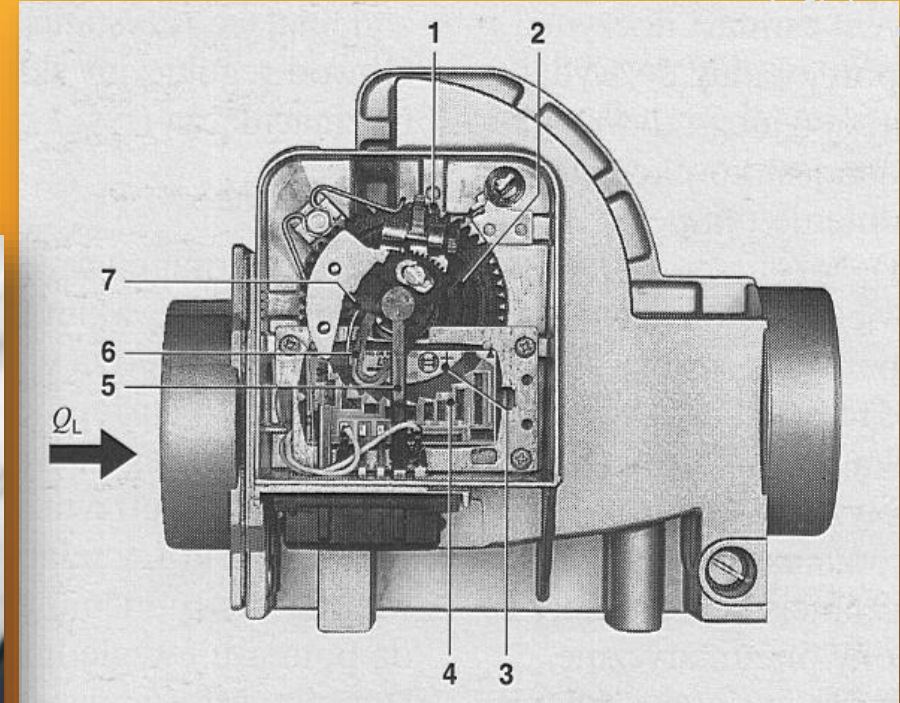


# MASS AIR FLOW SENSOR (MAF)

Flow meters are used to measure the mass or volume of air flowing to estimate the mass of air delivered to the engine cylinder.

Thermoanemometers - air mass measurement

Flap - measuring air volume



<https://mlfree.com/en/jetronic-fuel-injection/>

<https://volvoforums.com/forum/volvo-s60-v60-10/cleing-mass-air-flow-sensor-right-way-56121/>

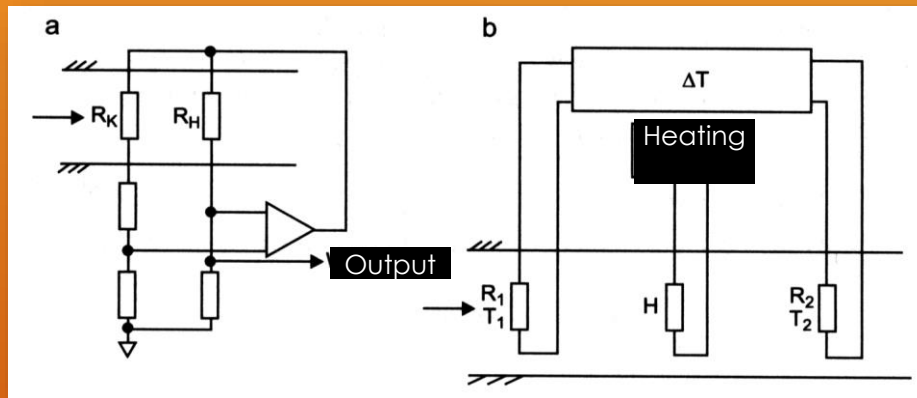




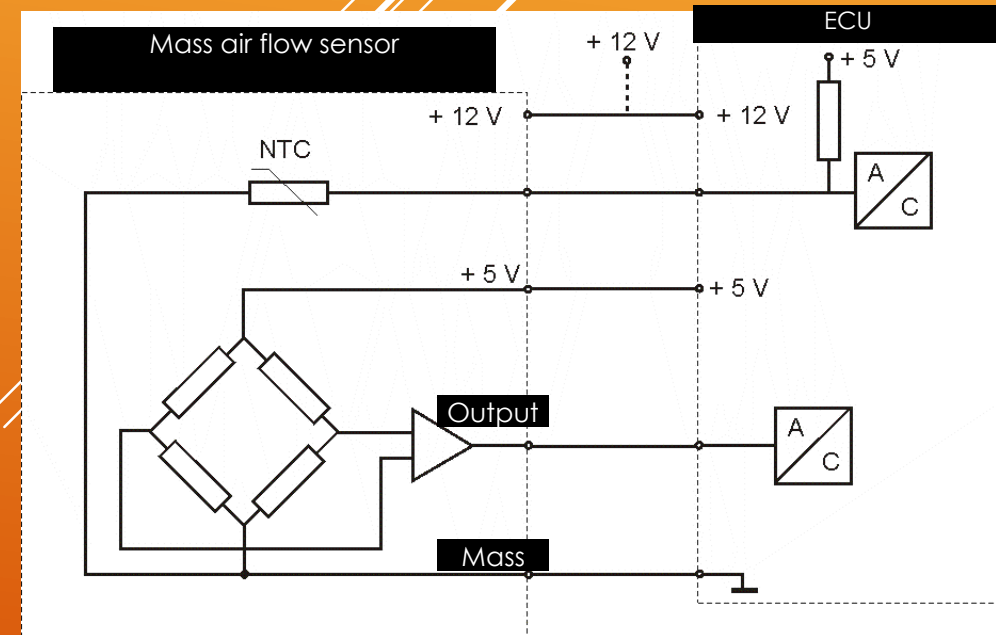
# MASS AIR FLOW SENSOR (MAF)

## Hot-wire anemometers

Thermoanemometers are sensors for the mass flow of medium. Their principle of operation is to measure the current needed to maintain a constant temperature of the heating element, washed by the stream of flowing medium, or to measure the temperature difference of resistors placed in the air stream and heated by a separate heater.



a - hot wire thermoanemometer,  
b - calorimetric thermoanemometer,  
 $R_H$  - heated resistor - measuring,  
 $R_K$  - compensation resistor,  
 $R_1, R_2$  - measuring resistors

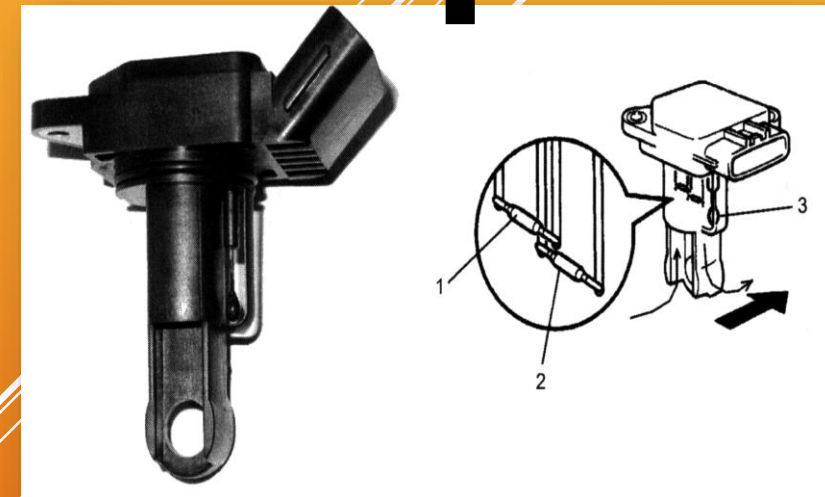
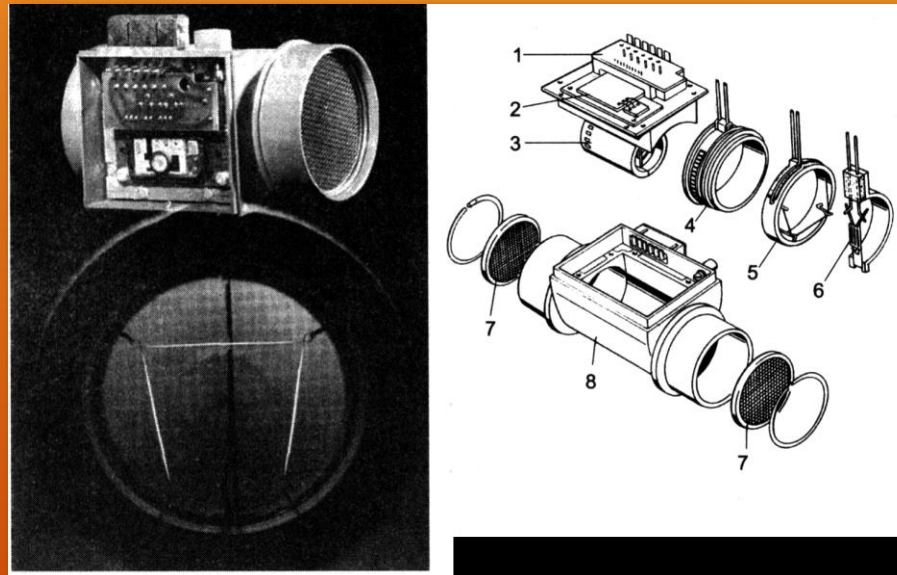


# MASS AIR FLOW SENSOR (MAF)

## Wire thermoanemometer - construction

The flow meter consists of a tubular housing mesh protected on both sides through which the intake air stream flows. Through the cross-section of the measuring pipe, a trapezoidal heated platinum wire with a diameter of 0.07 mm is spread. A temperature compensation resistor is placed in the stream ahead of it. Both components are components of the control circuit and act as resistors that change resistance with temperature. The control circuit consists of a bridge and an amplifier.

- 1 - electrical connection plate,
- 2 - bridge electrical system, temperature compensation, temperature compensation system,
- 3 - pipe internal,
- 4 - precision resistor,
- 5 - hot element wire,
- 6 - temperature compensation resistors,
- 7 - protective mesh,
- 8 - housing



- 1 - compensation resistor,
- 2 - platinum heated resistor,
- 3 - temperature sensor

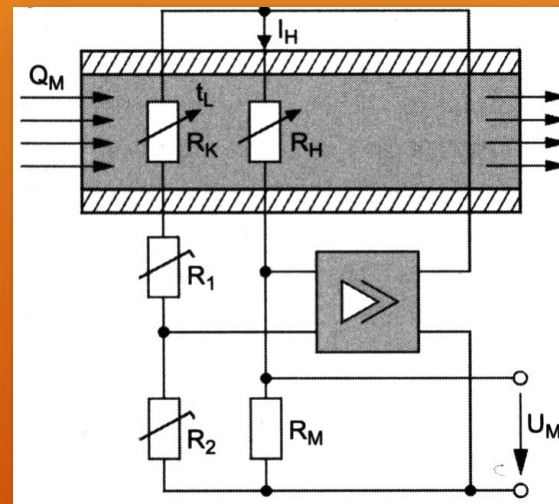
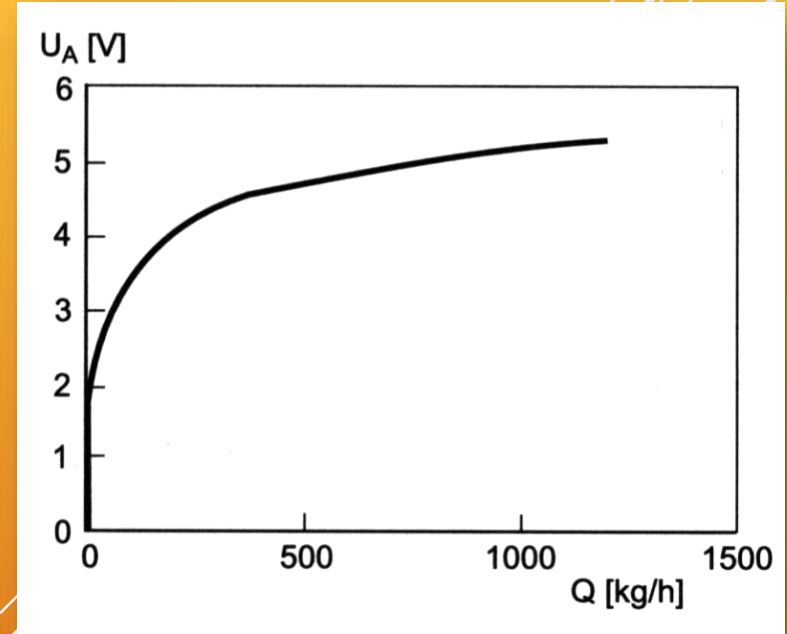




# MASS AIR FLOW SENSOR (MAF)

## Wire thermoanemometer - construction

The temperature compensation resistor measures the air temperature in the intake system, which then cools the hot wire. The control circuit doses the heating current so that it maintains a constant excess temperature of the wire (approx. 130°C) in relation to the temperature of the intake air. This measuring principle takes into account air density. The value of the heating current is a suitable measure of air flow. The heating current generates a UM voltage signal on a precision resistor (with RM measurement resistance) proportional to mass air flow. This signal is transmitted to the controller.



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# DZIĘKUJĘ ZA UWAGĘ !!!

## Diagnostic of Vehicles M14

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dr inż. Grzegorz Barański  
mgr inż. Paweł Magryta

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Projekt „Politechnika Lubelska – Regionalna Inicjatywa Doskonałości”  
– finansowany ze środków Ministerstwa Nauki i Szkolnictwa Wyższego



Ministerstwo  
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