Gasoline direct injection
Key technology for greater efficiency and dynamics

BOSCH
Invented for life

clean & economical

Gasoline direct injection: Using high pressure to drive down consumption and emissions

Gasoline direct injection

As demand for mobility continues to grow across the globe, so too does the market for cars and trucks. At the same time, the proliferation of statutory fuel-consumption requirements and ever more stringent emissions regulations are leading to rapid growth in vehicles featuring gasoline direct injection.

It is predicted that by 2020 a quarter of all vehicles will be equipped with this technology, which helps to achieve fuel economy targets in combination with downsizing and turbocharging.

Ideal for downsizing concepts with turbocharging

Gasoline direct injection is a process whereby fuel is injected straight into the combustion chamber at high pressure. This is an effective means of reducing fuel consumption and emissions on the one hand and greatly boosting driving dynamics on the other.

Combined with innovative downsizing concepts and turbocharging, reductions in fuel consumption and CO_2 emissions can be delivered in the region of 15 percent.

The high pressure injection system is especially suitable for engines with a power-to-weight ratio between around 60 and 100 kW/liter along with downsizing rates of up to 45 percent in future.

In case of "extreme downsizing" with reductions in engine displacement of up to 50 percent, it makes sense to combine the system with additional measures such as modifications to the gears or electrification of the powertrain in order to ensure an optimum driving experience.

No turbo lag, improved dynamics: scavenging

Turbochargers are able to reach their set boost pressure only beyond a certain engine speed. At low engine speeds, the exhaust gas flow inside the turbine is too weak, with the result that the air can not be compressed well enough. This produces a turbo lag.

Bosch's "scavenging" system approach solves this problem by briefly opening the intake and exhaust valves simultaneously, creating a dynamic head between the intake and exhaust sides of the engine and increasing the supply of fresh air in the combustion chamber. This generates up to 50 percent higher torque at low engine speeds.

Scavenging leverages the synergies from gasoline direct injection, variable camshaft adjustment, and turbocharging and supplies improved responsiveness on a par with that of high capacity engines.

Paving the way with gasoline direct injection system innovations

Bosch launched gasoline direct injection in 1951 and has remained at the cutting edge of the technology ever since. Today we provide technology for fuel supply, fuel injection, air management, ignition, engine control, and exhaust-gas treatment as well as end-to-end solutions for this drive system.

With system innovations such as "controlled valve operation", we are reinforcing our position as a pioneering force in this sector.

Controlled Valve Operation

From optimized injection to centralized control

In gasoline direct injection the air-fuel mixture is formed directly in the combustion chamber. While the high pressure pump brings the fuel pressure in the fuel rail up to the required level of around 200 bar, fresh air flows through the open intake valve into the intake port and finally into the combustion chamber.

High pressure injectors, which are fitted directly to the fuel rail, meter and vaporize the fuel at great speed, ensuring optimal fuel-air mixing. Innovative laser-drilled injection holes afford maximum spray design flexibilty and minimize wetting of the combustion chamber walls.

Motronic is an electronic control unit developed by Bosch. It groups together, prioritizes, and processes all demands made of the engine and converts them into control commands. The key criteria for this conversion is torque. In order to ensure that torque is delivered in a clean and economical fashion, Motronic regulates the air/fuel ratio accordingly.

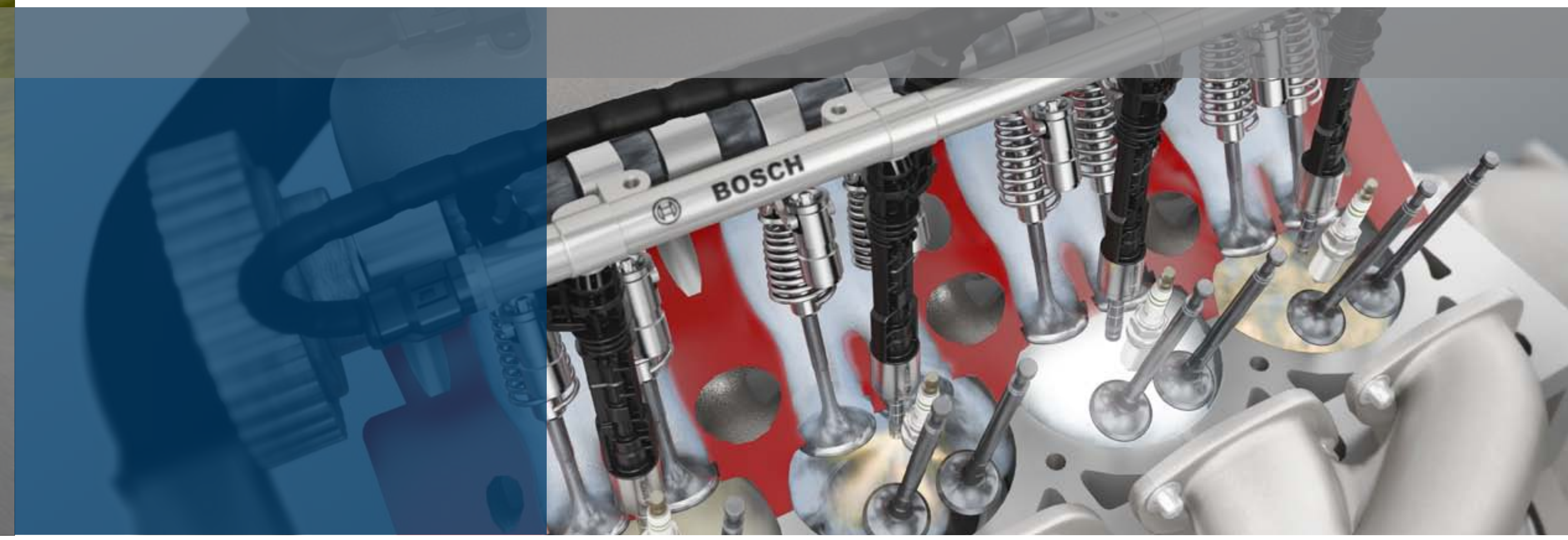
Reducing metering tolerances: controlled valve operation (CVO)

Future combustion processes will operate at high pressures even for small loads and with multiple injections to improve penetration control. Typically, this leads to very short injection times and increased metering tolerances.

With Bosch's CVO system innovation, these tolerances can be significantly reduced and can therefore be used for series application. This mechatronic solution involves actuating the high pressure injectors, which are fitted directly to the engine, for individual lengths of time. This individual setting for how long different valves are open reduces metering tolerances during injection over the entire lifetime of valves.

Further information:
www.bosch-di.com

Automotive competence from a single source: Bosch, your partner for gasoline direct injection



Comprehensive portfolio and extensive expertise
In close collaboration with automakers, Bosch brings to the table a comprehensive range of technologies as well as many years of experience and broad expertise. We have already celebrated two impressive milestones, with our global manufacturing network now having produced more than 50 million high-pressure pumps and over 10 million injection valves.

System and network competence
As a systems provider, we know the technical requirements for the different components and have a deep understanding of the complex relationships and interdependencies in the overall vehicle system. We apply and integrate drive technology according to the exact system requirements of our customers, helping them to reduce their development investment, attain series-production readiness sooner, and hence bring down costs.

Innovation driver and technology leader
We are continuously improving the gasoline direct injection technology and integrating technical innovations into series production. Innovations such as “Controlled Valve Operation” for reducing metering tolerances and high pressure injection valves with laser-drilled injection holes open up further potential for reductions in fuel consumption and CO_2 emissions while simultaneously optimizing engine performance.

Ensuring quality and reliability
Bosch technology is designed to have a service life of around 240,000 kilometers. Just as impressive as the technology’s reliability and quality are the details of its design and functionality. For example, the compact and light HDP5 high pressure pump helps to save space and weight. Like all products for gasoline direct injection, the pump is manufactured from stainless steel and therefore offers high fuel compatibility worldwide.

Global presence
Our global footprint, with production and R&D experts for gasoline direct injection, is unique in the automotive supply industry. We are close to our customers wherever they are and know their specific needs along with the regional requirements of the different markets.

Long-term partnership
Reliability and long-term partnerships are cornerstones of our work. We have expertise across the whole lifecycle of vehicles and offer our customers continuous support: from development to series maturity to maintenance and supplying spare parts.

Gasoline Systems

High-pressure solenoid injector HDEV5

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High-pressure injector HDEV5

Customer benefits

- Series experience: high number of customer applications worldwide, compliance to major global fuel specifications
- Individual sprays through laser-drilled spray holes for an optimal spray preparation
- Local supply of our customers in our internatio- nal production network
- Flow rate and spray angle are independent injector parameters
- High deposit robustness
- High evaporation rate
- High spray stability and accuracy – minor influence of back pressure and air movement on spray propagation
- Improved fuel evaporation by optimal inter- action of fuel and air
- Large metering range with system pressure modification

Engines with gasoline direct injection generate the air-fuel mixture directly in the combustion chamber. Only fresh air flows through the open intake valve.

The fuel is injected directly into the combustion chamber using high-pressure injectors. This improves combustion chamber cooling and enables higher engine efficiency due to higher compression, resulting in increased fuel efficiency and torque.

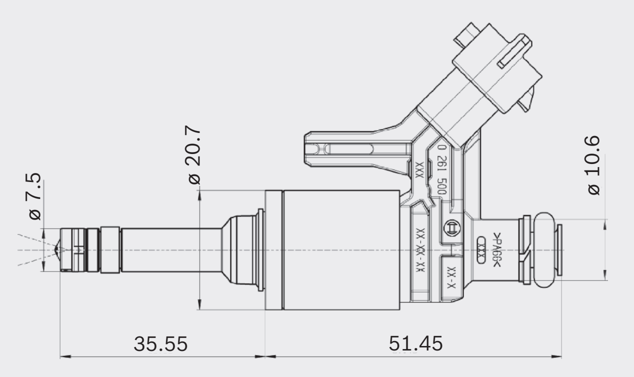
The high-pressure circuit is fed via the high-pressure pump. The high-pressure injectors, fitted to the fuel rail, meter and atomize the fuel at high pressure and extremely rapidly to provide optimum mixture prepa- ration directly in the combustion chamber.

As a result of increasingly strict emission laws and demand for low fuel consumption on one hand and the desire for more fun-to-drive at low cost on the other hand, the technical components require innovative concepts and ideas. Within this field the high-pressure injector (HDEV5) plays a major role.

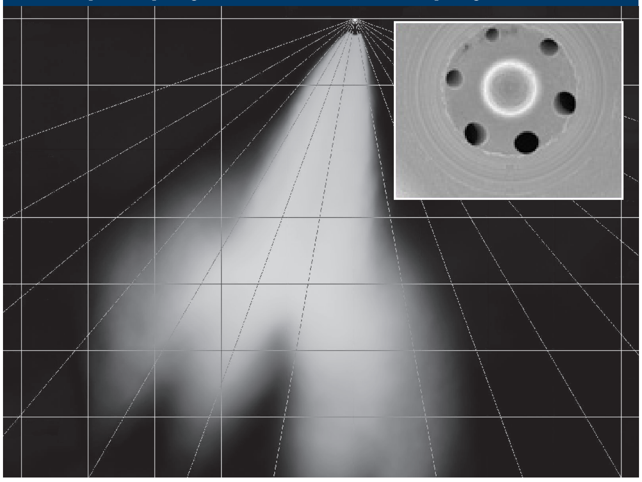
Task

The HDEV5 meters and atomizes the fuel equally (homogeneously) in the entire combustion chamber to achieve an optimal mixture of fuel and air.

Dimensions



Example: spray with laser-drilled spray holes



High-pressure injector HDEV5

Long version

Technical features

System pressure	≤ 20 MPa
Flow rate	≤ 22.5 cm³/s at 10 MPa
Leakage	< 2.5 mm³/min at 10 MPa
Fuels	Current worldwide qualities
Droplet size SMD (Sauter Mean Diameter)	15 μm
Spray form	Variable number and position of spray holes
Injector installation	Central or side installation at the cylinder head

Function

- Inward-opening solenoid injector
- Multihole injector (MHI) with high variability concerning spray angle and spray shape
- For variable system pressure up to 20 MPa nominal
- Suitable for highly integrated power stage (65 V booster voltage)
- Easy assembly and fixing for central or side installation at the cylinder head
- Option: variable lengths (for different installation requirements)

Application

By its flexibility regarding spray shape as well as flow rate the high-pressure injector is qualified for various engine types.

Today the injector is applied worldwide in a 1.0 l 3-cylinder as well as a V8 with turbocharging, both for consumption (e.g. downsizing) and fun-to-drive concepts (e.g. in combination with turbocharging).

Thereby the high-pressure injector supports different engine operating points – from high-pressure start with catalyst heating and multiple injection to homogeneous full load.

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Gasoline Systems
High-pressure pump HDP5

Invented for life

High-pressure pump HDP5

Customer benefits

- Series experience: high number of customer applications worldwide, compliance to major global fuel specifications
- Best in class concerning number of possible design variants
- Local supply of our customers in our international production network
- Optimized fuel economy due to demand controlled operation
- Zero evaporation (ZEVAP) capable
- Low weight (780 g)
- Easy application to engine packaging

- **HDP5 evo**
  - Significant noise improvement
  - Increased flow rate

Engines with gasoline direct injection generate the air-fuel mixture directly in the combustion chamber. Only fresh air flows through the open intake valve.

The fuel is injected directly into the combustion chamber using high-pressure injectors. This improves combustion chamber cooling and enables higher engine efficiency due to higher compression, resulting in increased fuel efficiency and torque.

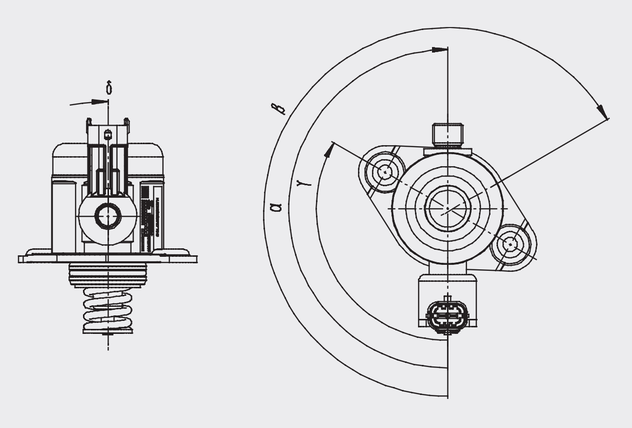
The high-pressure circuit is fed via the high-pressure pump. The high-pressure injectors fitted to the fuel rail meter and atomize the fuel at high pressure and extremely rapidly to provide optimum mixture preparation directly in the combustion chamber.

Task

The fuel is supplied by the electric fuel pump. The high-pressure pump generates the fuel pressure of up to 20 MPa (200 bar) required for high-pressure injection.

The unique pump design features an all stainless steel concept, using a minimum of material input and applying ambitious manufacturing processes for maximum customer benefits.

Design



Function

- Demand-controlled single piston plug-in pump
- High flow rate at high speeds
- Flexible integration concept, hydraulic/electric

Technical features

	HDP5	HDP5 evo
Max. system pressure	20 MPa	20 MPa
Max. delivery quantity	1.12 cm^3/r_{CAM}	1.2 cm^3/r_{CAM}
Min. volumetric efficiency	85%	90%
Max. number of strokes (3-way cam)	10,500 min^{-1}	10,500 min^{-1}
Pressure relief valve	Integrated	Integrated
Weight	780 g	780 g

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Gasoline Systems
High-pressure piezo injector HDEV4

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High-pressure injector HDEV4

Customer benefits
- Perfect for spray-guided combustion processes including concepts with stratified charge, turbo-charging, for Euro 6 and SULEV
- Improved cold start capability
- Optimal dynamic response
- High deposit robustness
- High evaporation rate
- Very large metering range and high precision

Engines with gasoline direct injection generate the air-fuel mixture directly in the combustion chamber. Only fresh air flows through the open intake valve.

The fuel is injected directly into the combustion chamber using high-pressure injectors. This improves combustion chamber cooling and enables higher engine efficiency due to higher compression, resulting in increased fuel efficiency and torque.

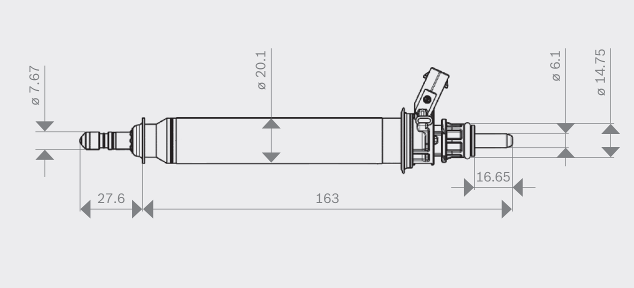
The high-pressure circuit is fed via the high-pressure pump. The high-pressure injectors, fitted to the fuel rail, meter and atomize the fuel at high pressure and extremely rapidly to provide optimum mixture preparation directly in the combustion chamber.

As a result of increasingly strict emission laws and demand for low fuel consumption on one hand and the desire for more fun-to-drive at low cost on the other hand, the technical components require innovative concepts and ideas. Within this field the high-pressure injector (HDEV4) plays a major role.

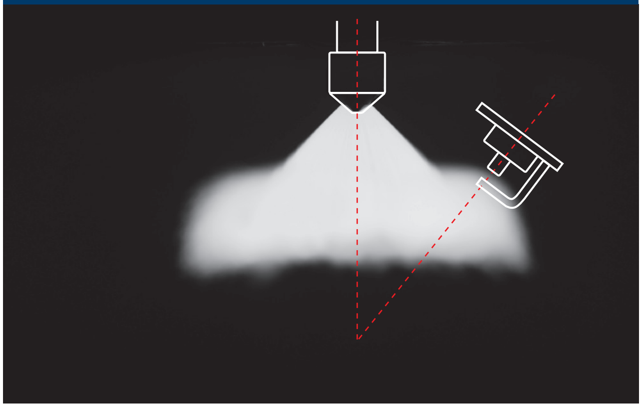
Task

The HDEV4 meters and atomizes the fuel so that fuel and air are specifically mixed in a defined area of the combustion chamber. Depending on the required operation mode the fuel is concentrated in the area around the spark plug (stratified charge).

Dimensions



Hollow-cone spray from outward-opening nozzle



Technical features

Needle actuation	Direct
Spray angle	85° ± 5°
Shot-to-shot scatter	± 1°
Back-pressure dependence	< 4 %
Resistance to carbon buildup	< 3°
Droplet size SMD (Sauter Mean Diameter)	10–15 µm
Penetration	< 30 mm
System pressure	20 MPa
Needle lift	≤ 35 µm
Dynamic flow range q_{dyn}	34.5 mg/lift @ t_i = 1 ms
Partial-lift capability	≥ 10–35 µm
Injection time	70–5,000 µs
Multiple injection	≤ 5 injections/cycle
Interval time	≥ 50 µs
Metering range	0.5–150 mg/injection

Function

- Outward-opening piezo injector with direct needle actuation
- Symmetrical hollow-cone spray for central mounting position
- For variable system pressure up to 20 MPa nominal
- Precise control with variable needle lift due to charge-controlled power stage for piezo actuator
- Hydraulic coupling module for compensation of different thermal expansion coefficients of metal and ceramic components
- High evaporation rate
- Low penetration
- Large metering range

Application

Due to its large metering range the HDEV4 is qualified for a wide range of engines.

The HDEV4 can be used to realize any conceivable operation modes, including concepts with stratified charge and turbocharging as well as Euro 6 and SULEV concepts.

With its narrow spray tolerances and its large metering range the HDEV4 has been specifically developed for spray-guided stratified combustion systems. It improves the cold-start capability of the engine and features optimal dynamic response.

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Gasoline Systems
High-pressure sensor

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High-pressure sensor

Customer benefits

- Bosch system competence in fuel injection and engine management
- High measuring precision and reliability
- Resistant to media, hermetic sealing of measured media
- Variation of plug connection and hydraulic connection and mounting position possible
- Low signal sensitivity to mounting torque
- Fault diagnostics using signal-range check
- Compact design, low height

The air-fuel mixture for gasoline engines is expected to facilitate maximal engine power with maximal fuel efficiency; on the other hand its composition must also support optimal exhaust-gas treatment. This is achieved by precisely adapting the amount of fuel injected to the intake air mass.

Task

The high-pressure sensor measures the fuel pressure in the high-pressure fuel rail of engines with gasoline direct injection. This information is required by the engine control unit for exactly metering the injected fuel mass. The CNG high-pressure sensor measures the pressure in the pressure control module.

Function

The sensing element consists of a metal membrane onto which strain gauges are mounted. When pressure is applied the gauges are detuned and generate an electric voltage. This voltage changes proportionately with pressure. It is amplified and digitized by an electronic evaluation circuit.

Technical features

	HD-KV4.2 (gasoline)	**PS-HPS5 (gasoline)**	**HD-KV4.2 (CNG)**
Measuring location	DI fuel rail	DI fuel rail	CNG pressure-control module
Technology	Steel membrane with metal thin-film strain gauges on top		
Circuit Output signal	Digital Analog	Digital Digital (SENT)	Digital Analog
Connector		3 pin also with temp. signal (ASIC Temp.)	
Characteristic	5 V, 3.3 V (optional)		5 V, 3.3 V (optional)
Pressure range	14, 20, 26, 28 MPa, 40 MPa from 2014	14, 20, 26, 28, 40 MPa	26, 28 MPa
Specific	Integrated NTC for fuel temperature		CNG type approval KBA Kraftfahrt-Bundesamt

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Gasoline Systems
Scavenging with gasoline direct injection

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Scavenging

Customer benefits
- Reduction of fuel consumption/CO_2 output by up to 15%: scavenging facilitates a reduction of engine displacement (Extreme Downsizing)
- Fun-to-drive by eliminating the turbo lag
- Quick response due to high low-end torque
- Comprehensive Bosch expertise in systems with scavenging

Gasoline direct injection contributes to the further reduction of fuel consumption and emission. Engines with gasoline direct injection generate the air-fuel mixture directly in the combustion chamber. Only fresh air flows through the open intake valve. The fuel is injected directly into the combustion chamber using high-pressure injectors.

Task
Bosch has developed a system approach that eliminates the turbo lag and offers dynamic driving with high torque even at low engine speeds. Scavenging leverages the synergies from gasoline direct injection, variable camshaft adjustment and turbocharging.

Function
Scavenging controls the valves so that at low engine speed they are opened simultaneously for a moment. This creates a strong dynamic pressure differential between the engine's intake and exhaust sides, which draws large amounts of fresh air into the combustion chamber and purges the residual gases more efficiently. The electronic engine control Motronic utilizes this effect by optimally adjusting the charging and combustion control process.

Closing the intake valve early at low engine speed with later injection leads to a substantial increase in charging since less air is pushed back into the intake port. This effect is made possible thanks to camshaft adjustment wich is controlled by Motronic.

The higher mass throughput increases the efficiency of the exhaust-gas turbocharger. Its operating point is shifted to a higher charge speed level with much higher charge pressure. Below 2,000 rpm, the torque increase at full load can be increased so much that the responsiveness is on par with larger-displacement engines. Compared with port-fuel injection engines with the same power output, fuel consumption can be reduced by up to 15%.

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Gasoline Systems

Controlled valve operation CVO

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Controlled valve operation CVO

Customer benefits

- Worldwide manufacturing available
- Improved functionality of the injection system
- Improved injection accuracy over lifetime, specifically for small amounts (> 1.5 mg/injection)
- Extended usable quantity range with larger DFR (dynamic flow range) supports turbocharging, downsizing, high boost, and flex fuel operation
- New possibilities for the development of combustion processes
- Stabilization of metering; “allowances” can be reduced
- No additional sensors required for analyzing valve opening times

Task

Future combustion processes (e.g. for Euro 6) call for the use of high pressure even with small loads and multiple injections. These help to avoid soot generation which is caused by wall and piston wetting. These processes require very short injection times and minimized metering tolerances over the vehicle’s lifetime.

Function

Bosch has developed a mechatronic approach for controlling the high-pressure injection valve which substantially reduces these metering tolerances and thus enables series application: CVO (controlled valve operation). CVO determines the actual opening time of the injector and compares it with the set value. As soon as a deviation is detected, an adjustment function sets in to minimize fuel metering tolerances.

Each valve behaves differently over its lifetime. Adjusting the individual control speed enables metering tolerances to be substantially reduced, especially with small amounts. The change in metering tolerances caused by aging can also be limited since CVO adapts to constant usage drift. Therefore the quantity of fuel injected can be maintained stable to a large extent over the valve’s lifetime.

Engines with gasoline direct injection generate the air-fuel mixture directly in the combustion chamber. Only fresh air flows through the open intake valve. The fuel is injected directly into the combustion chamber using high-pressure injectors. This improves combustion chamber cooling and enables higher engine efficiency due to higher compression, resulting in increased fuel efficiency and torque.

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Gasoline Systems

Extreme Downsizing with direct gasoline injection

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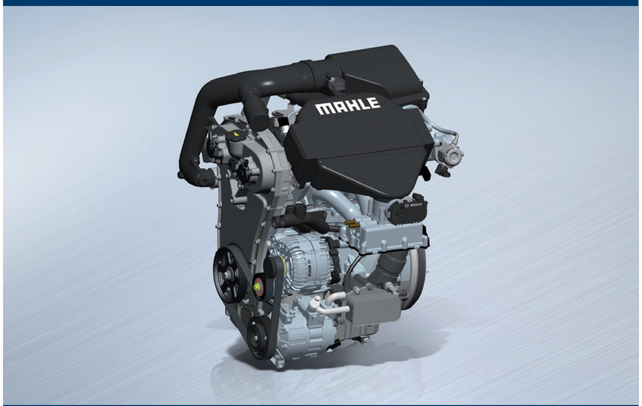
Extreme Downsizing engine



Customer benefits

- Fuel consumption reduced by about 30% and accordingly lower CO_2 output
- Optimum cost-benefit relation for maximum CO_2 reduction
- Consumption concept suitable for mass markets with attractive driving performance and driving characteristics

Future vehicle engines will have to meet high demands concerning fuel economy and low CO_2 output. Extreme Downsizing is one specific method of utilizing the potentials of gasoline engines.

Task

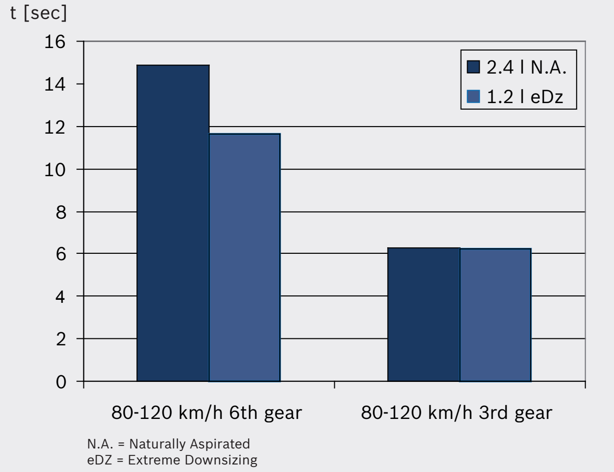
With Extreme Downsizing, engine displacement is radically reduced, while driveability and engine performance are kept unchanged.

For realizing Extreme Downsizing Bosch is combining several of its competences:

- the engine control unit with sensors and application
- the development of the combustion process
- the design of fuel injection and ignition
- the development and design of the turbocharger and its peripheral devices

Bosch also contributes its expertise in construction and design of the engine and its main components as well as the basic development of engine thermo-dynamics and mechanics.

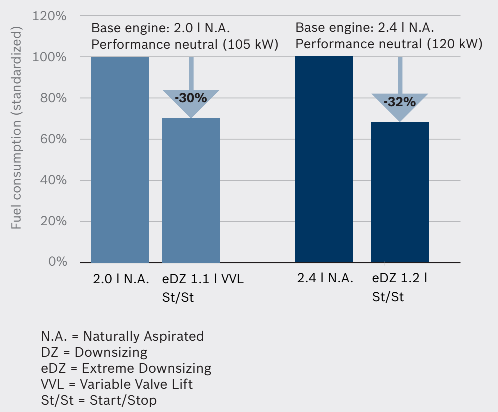
Comparison of driving performances (example)



Technical features

	Example (demonstrator)
Engine displacement	1.2 l
No. of cylinders	3
Bore/stroke	83.0/73.9 mm
Compression ratio	9.3
Fuel injection	Multihole DI 200 bar (Bosch)
Sparkplug ø thread	Bosch M10
Engine control	Bosch Motronic MED17
Turbocharger	BMTS single stage
Power @ at rpm	120 kW 5,000–6,000 min^{-1}
Max. torque @ rpm	286 Nm 1,600–3,500 min^{-1}
Torque @ 1,200 min^{-1}	161 Nm
Engine weight	125 kg
Fuel consumption NEDC equals CO_2 output	5.8 l/100 km (40 mpg) 139 g/km
80–120 km/5th gear	8.1 s
Emission target	Euro 6

Reduction of fuel consumption (example)



Function

With single-stage turbocharging, the engine displacement can be reduced by 50%. This enables a fuel consumption benefit of more than 30%.

At the same time, after undergoing Extreme Downsizing, engines feature impressive driving performance with very high torque over a wide rpm range, even at low engine speed, e.g. when driving off. Even after Extreme Downsizing, the engine's driving performance is comparable to that of a corresponding naturally aspirated engine.

Outlook

With further evolutionary steps and additions to the technology packages new potentials in fuel consumption will be made available. One example is variable valve lift. Hybridization or the combination with specifically adapted transmissions, in addition to downsizing, can contribute to further increasing the consumption benefits.

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Gasoline Systems
Turbocharger with wastegate

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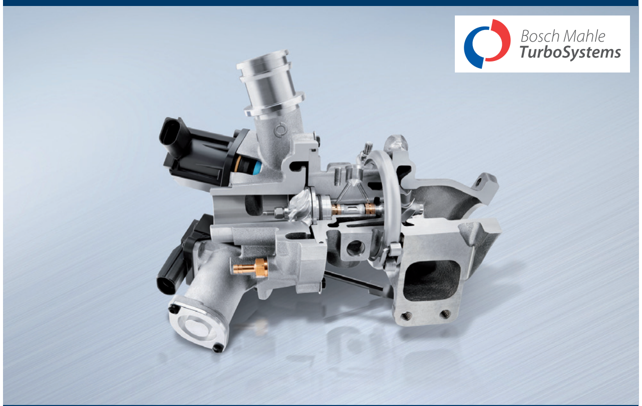
Exhaust-gas turbocharger with wastegate



Customer benefits

- Reduction of CO_2 output
- Reduction of fuel consumption
- Improved transient response
- Improved response characteristic
- Increased map utilization

Technical features	
Decoupling	Thermal
Compressor wheel	Milled
Wastegate actuator	Electrical

Turbocharging delivers a greater mass of air into the combustion chamber so that more air-fuel mixture can be burnt. This generates a higher power and torque yield. Conversely, a specific engine output power can be generated with a smaller engine (downsizing). Bosch Mahle Turbo Systems combines the expertise of Bosch and Mahle in developing and manufacturing turbochargers.

Task

The exhaust-gas turbocharger uses the kinetic energy from the exhaust-gas stream to turbocharge the internal combustion engine. Unlike mechanical charging (compressor) the exhaust-gas turbocharger does not require additional power input. This results in higher fuel efficiency.

Function

The exhaust-gas turbocharger consists of two turbo elements: an exhaust-gas turbine wich is driven by the exhaust-gas stream, and a compressor which compresses the intake air.

At high engine speeds the wastegate diverts a part of the exhaust gas. This reduces the exhaust-gas flow through the turbine and the exhaust back pressure. At low engine speeds the wastegate is closed so that the entire exhaust-gas flow drives the turbine which in turn drives the compressor.

The product portfolio comprises the wastegate charge pressure control for all diesel and gasoline engines up to 560 kW. The wastegate charge pressure control boasts a combination of excellent durability and good functionality. This is why Bosch Mahle Turbo Systems is using this technology when extended service life and resistance against extreme thermal loads are required.

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Gasoline Systems
Electronic control unit Motronic

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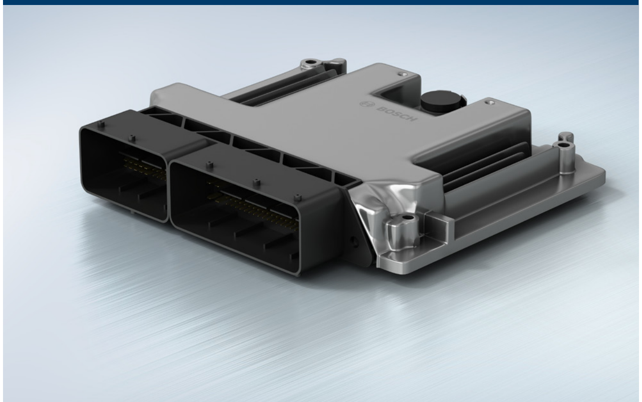
Electronic control unit Motronic



Customer benefits
- Full-line product portfolio for all markets and segments
- Global presence with worldwide local support
- One single, scalable ECU family for different markets and vehicle segments
- Potential for extended functionality
- Flexible integration of customer software

The electronic engine management enables precise, central control of all relevant functions for engine operation. The target is to warrant constant driving behavior and emissions over the engine's useful life.

Task
The electronic control unit collates all requirements on the engine, prioritizes and then implements them. These requirements include, for example, the accelerator pedal position and requirements of the exhaust system on mixture formation.

Function
Torque is used as the key criterion for implementing all requirements. According to this criterion, the air-fuel ratio is adjusted in such a way that the demanded torque is provided as economically and cleanly as possible. It also allows active driving safety systems such as traction control and ESP® to intervene in the engine torque.

Motronic can be used to control internal-combustion engines running on gasoline (port fuel or direct injection), diesel, natural gas (CNG, liquid gas) or ethanol as well as hybrid drives. Standardized communication interfaces and data formats support networking with all vehicle systems which influence the drivetrain.

The electronic control unit variants feature:
- A common platform for gasoline, flex fuel, CNG and diesel applications
- Printed circuit board design
- Diagnostics functions, e.g. for compliance with emission legislation
- Infineon 32 bit microcontroller
- Standardized communication interfaces (CAN, FlexRay, SENT, LIN, K-LINE)
- Highly scalable software and hardware, 4-fold computing power from basic segment to high-end
- Standardized formats to support software sharing and global development (AUTOSAR, MSR)

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Gasoline Systems

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Gasoline Systems
Ignition coil

BOSCH
Invented for life

Ignition coil

Customer benefits
- Compact, lightweight and robust
- Scalable spark energy
  - High efficiency
  - Can be used for all combustion processes
- Customization
  - Installation point, primary connector, jacket, spark energy and characteristic
- Flexible jacket makes it also suitable for difficult installation conditions

Gasoline engines require an ignition spark to start the combustion of the air-fuel mixture in the combustion chamber. This spark is generated at the spark plug. The ignition coil transforms energy from the vehicle electric system into the required high voltage and provides it to the spark plug.

Task

The air-fuel mixture in the combustion chamber is ignited by means of an ignition spark. The spark plug requires an ignition voltage of up to 30,000 Volts to generate the spark. The ignition coil generates this voltage from the 12 V vehicle electrical system and delivers it to the spark plug at the time of ignition.

Function

The ignition coil works like a transformer. Using two concentric coils it transforms the electric energy from the vehicle battery into high voltage, stores it temporarily and then delivers it to the spark plug as a high-voltage current surge.

Technical features

	Power Mini ignition coil
Ignition energy	50–90 mJ
Secondary voltage (35 pF/10 MΩ)	> 32 kV
Option	Integrated electronics
Application with	Gasoline, CNG, flex fuel

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Gasoline Systems
Fuel supply for gasoline engines

BOSCH
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Fuel-supply module FSM

Customer benefits
FSM standard segment
- Increased efficiency: 28% higher than EKPT13/14 electric fuel pump
- Improved radio frequency interference
- Excellent cold start flow rate and optimized performance at hot fuel conditions

FSM Premium
- Highest pressure and flow rate in the portfolio
- Improved fuel resistance for E85 and for emerging markets
- Extended lifetime

FSM Emerging Markets
- Exchangeable components, e.g. fine filter
- Global platform with worldwide availability of components
- R&D minimization due to global development and validation concept
- Lower overall costs for OEMs and vehicle owners

The air-fuel mixture for gasoline engines is expected to facilitate maximal engine power with maximal fuel efficiency; on the other hand its composition must also support optimal exhaust-gas treatment. Fuel supply with the fuel-supply module (FSM) significantly contributes to mixture formation.

Task
The fuel-supply system provides the necessary amount of fuel from the tank to the injection system (port fuel injection or direct injection) at a specific pressure. It consists of the fuel-supply module with integrated electric fuel pump, fuel reservoir, level sensor, an optional fuel filter as well as a pressure regulator.

Function
The fuel-supply module is integrated into the fuel tank. It always supplies the right amount of fuel from the tank to the fuel rail. An electric fuel-supply pump with a demand-driven or constant delivery rate is used to deliver the fuel. The fuel reservoir ensures an uninterrupted fuel supply of the integrated pump when cornering.

An optional integrated fuel filter prevents contaminants from reaching the injectors or the engine. The lifetime filter is used in “good fuel” markets.

The fuel level sensor is an angular-position sensor with float. An additional pressure control valve can be integrated.

In flex fuel systems with Flexstart system, at temperatures below 20°C and an ethanol content above 85% (E85) the quantity of fuel injected is increased during the cold start phase.

Technical features

	FSM standard segment
Design	Flexible submodule architecture with various pressure regulators and level sensors
Set-up height	≥ 150 mm
Fuel pump	Optimized electric motor, channel and impeller geometry, hydraulic circuit and jet pump
Fuel resistance	Gasoline, E0–E100 (0%–100% ethanol) M15 (15% methanol)
Application	Systems with or without demand control
Reduced power consumption	Up to 4 W less than EKPT13/14
	FSM Premium & High End
High pump flow rates	≤ 245 l/h at 600 kPa, 12 V
Increased pressure	≤ 600 kPa
	FSM Emerging Markets
Exchangeable components	Fuel pump, level sensor, suction filter, fine filter

Components

1

2

1 Electronically commutated fuel pump FP

2 Pump controller EPC

Variants

The modular design facilitates providing an entire range of basic modules which can easily be adapted to the individual vehicle.

Variants of the fuel-supply module are available for:

- Standard segment
- Premium and high-end segment: with the highest pump flow rates and pressure as well as extended lifetime, improved fuel resistance and excellent hot-gasoline behavior
- Applications in emerging markets: with exchangeable components, low cost, high flexibility and extended fuel resistance

Electric fuel pump FP

The fuel-supply module is available with a mechanically commutated pump or a brushless direct current pump (BLDC).

The BLDC pump controls pump speed according to demand. This pump features extended lifetime and robustness against flex fuel and bad fuel. The pump is shorter, more lightweight, and up to 10% more efficient than the mechanically commutated pump. The pump and the electronic pump controller can be diagnosed.

Pump controller EPC

The pump controller is applied with a BLDC fuel pump and enables direct control of the flow rate according to demand (demand-controlled fuel supply, DECOS). The BLDC fuel pump is more efficient than conventional DC pumps and thus contributes to the reduction of CO_2 output due to its lower current consumption.

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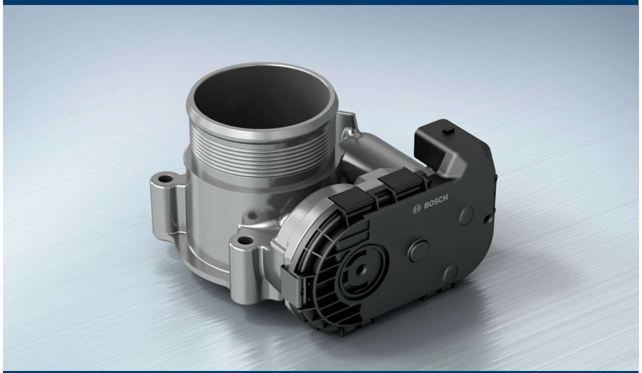
Gasoline Systems
Electronic throttle body

BOSCH
Invented for life

Electronic throttle body DV-E



Customer benefits

- ▶ Engineering and large scale manufacturing lines are available worldwide
- ▶ Cost optimized solution due to modular design
- ▶ Best in class Hall IMC (delay time, temperature independent characteristic)
- ▶ Smooth engine shutdown and minimized NVH (noise, vibration and harshness)
- ▶ DV-E5.9: optimized for small-volume projects
- ▶ RKL-E: robust against corrosive media

The air supply to the engine is as important as the fuel supply for the combustion of the air-fuel mixture. The air-to-fuel ratio, the air movement and the composition of the intake air contribute to clean, economical and dynamic engine operation. This is why the air supply is regulated with the help of flaps and valves.

Task

Electronic actuators enable high-precision air supply. With gasoline engines, the air supply to the combustion chamber is controlled by means of a throttle valve which reduces or enlarges the available intake manifold cross-section.

Function

The electronic throttle body comprises an electrically driven throttle valve and an angular-position sensor for position feedback.

The electronic engine management triggers the throttle valve electrically. The trigger input variables include the accelerator pedal position and the requirements of systems which can influence the engine torque (cruise control, Adaptive Cruise Control ACC, or the Electronic Stability Program ESP®).

Technical features

	DV-E 5.2/ RKL-E 5.2	DV-E 5.9 RKL-E 5.9
Throttle diameter	38–82 mm	32–60 mm
Ambient temperature	-40–180°C	-40–140°C
Actuation time t_{90}	< 100 ms	< 120 ms
Excess torque (ice breaking)	> 1.6 Nm	
Idle air leakage (ø 57 mm)	< 2.5 kg/h	< 3.5 kg/h
Interfaces	Analog and SENT	Analog or SENT
Optional	NiRo bearing, EMC package, DVE: water heating pipes	EMC package

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Gasoline Systems
General-purpose actuator

BOSCH
Invented for life

General-purpose actuator GPA

Customer benefits
- All-in-one component instead of several parts (vacuum cell, switching valve, lever arrangement)
- Overall system know-how

GPA-1CM at the intake manifold
- Flexibility regarding design adaption
- Packaging
- Continuous position control
- Independent from onboard vacuum systems
- Improved diagnosis

GPA-VTG for variable turbine geometry
- Flexibility regarding design adaption
- Improved drivability of high-end engines with high current forces, due to better actuating forces at all operating points
- Higher engine efficiency due to fast actuation, precise control and less hysteresis

GPA-WG for the wastegate valve
- Competitive scalability
- Modular portfolio covering the entire market
- Rapid torque build in downsized engines
- High permanent force for closed and open position
- Increased fuel economy and CO_2 reduction

The air supply to the engine is as important as the fuel supply for the combustion of the air-fuel mixture. The air-to-fuel ratio, the air movement and the composition of the intake air contribute to clean, economical and dynamic engine operation. This is why the air supply is regulated with the help of flaps and valves.

Task

Electronic actuators such as the general-purpose actuator (GPA) enable high-precision air supply. This actuator is used for adjusting flaps and valves in the intake tract. The precise control of the actuator allows to reduce fuel consumption, CO_2 output and other emissions by means of cylinder-charge control.

Function

The GPA is an electric motor with a transmission. It allows components in the intake tract to be adjusted by rotating its drive shaft, for instance rotating flaps or lifting and lowering valves. A position feedback sensor is included. Each GPA is individually adjusted to the zero position in order to ensure high accuracy. The GPA fulfills the specifications for OBD2 on-board diagnosis.

Technical features

	GPA-1CM	GPA-VTG	GPA-WG
Excess torque			
with failsafe	≥ 0.8 Nm		
w/o failsafe		≥ 1.2 Nm	
Continuous torque			
with failsafe	≥ 0.2 Nm		
w/o failsafe		≥ 0.5 Nm	2.51 Nm
Detent torque			
with failsafe			
w/o failsafe			4.0 Nm
Actuating time	< 120 ms	< 140 ms	< 250 ms
Actuating angle	0–130°	0–130°	
Temperature range	-40–130°C	-40–160°C	-40–160°C
Weight	< 300 g	< 400 g	< 650 g

Variants

The GPA is available in three variants for different applications and functions:

- GPA-1CM at the intake manifold, for swirl, tumble, and intake-tube flaps
- GPA-VTG at the turbocharger for variable turbine geometry (VTG)
- GPA-WG at the turbocharger for the wastegate valve

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Gasoline Systems
Hot-film mass air-flow sensor

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Invented for life

Hot-film mass air-flow sensor HFM

Customer benefits

- Precise and reliable determination of mass air flow
- Additional sensors can be integrated
- Optional chip heating avoids sensor contamination
- Robust sensor design (oil, water, dust)
- Reduced power consumption
- Rapid response
- Customer specific design
- Modular system with common sensor interface
- Highest accuracy: ready for future emission legislation

- **HFM-8**
  – reduced wiring and additional information available due to SENT interface

The air management ensures that the engine has the right air intake at any operating point. For this purpose the engine control unit requires precise ongoing information about the mass and other characteristics of the intake air. This information is supplied by the air management sensors.

Task

The HFM directly measures the engine's air intake. This input variable is used to calculate the required amount of fuel injected and to control the exhaust-gas recirculation, if applicable. Future, even more rigid emission and fuel-consumption legislation will require further increased signal precision and diagnostic capabilities. Additional temperature, humidity and pressure sensors can also be integrated.

Function

The HFM measures the air mass in the air intake tract. The sensor element consists of a heated sensor membrane over which the intake air flows. The temperature of two defined areas on the membrane is measured. The more air is flowing over the membrane, the higher the temperature difference between both measuring areas is rising.

Technical features

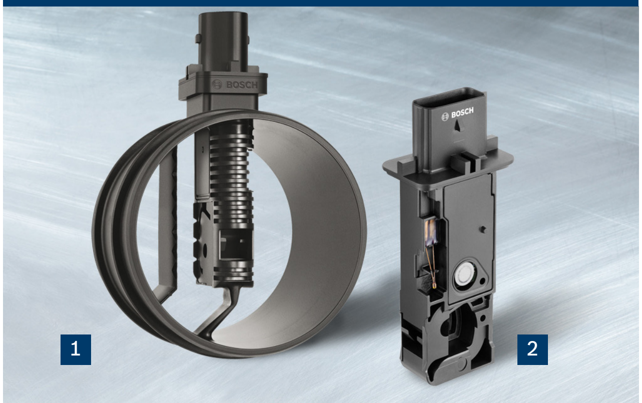
	HFM-7	HFM-8
New part tolerance	±2%	±1.5%
Lifetime tolerance	±5%	±3.5%
Pulsation error	±10%	±6%
Sensor interface	Analog and FAS	SENT or FAS
Supply voltage	12 V	5 V / 12 V
Power consumption basic sensor	< 100 mA	< 20 mA
Optional	Temperature, humidity, pressure sensor	Temperature, humidity, pressure sensor, applicable digital signal filter

Variants

The HFM-7 is available as a plug-in sensor or integrated into a cylinder tube. There are various housing designs (HFM-7-ID, HFM-7-IP) and versions with an integrated pressure and humidity sensor.

The HFM-8 is the latest-generation sensor. Its housing has been aerodynamically optimized due to a new, minimized sensor element, to improve pulsation behavior over the sensor's useful life. The HFM-8 covers broad customer requests. A flexible modular system setup enables the integration of additional sensors into a multifunctional sensor with one common interface and highest measuring accuracy.

HFM-7 variants (examples)



1 HFM-7-IPH with pressure and humidity sensor in a sensor tube

2 HFM-7-IPH plug-in sensor

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Gasoline Systems
Knock sensor

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Knock sensor

Customer benefits

- Fuel savings up to 9% due to increased engine efficiency with knock control
- Subsequent reduction of CO_2 output
- Linear characteristics also at high frequencies
- Maximum engine performance can be used
- Torque increase of up to 5%
- Engine protection from uncontrolled combustion
- Permits using various different fuel qualities

Technical features

Characteristics	Linear over a large frequency range
Temperature range Standard Optional	 -40°C–130°C ≤ 150°C
Technology	Piezo ceramic ring
Types	Plug-in or cable type

The electronic engine management enables precise, central control of all functions relevant for engine operation. This control is based on ongoing, exact information from the powertrain. This information is provided by sensors.

Task

"Knocking" occurs when the air-fuel mixture self-ignites prematurely. Sustained knocking combustion causes damage primarily to the cylinder head gasket and cylinder head. The risk of knocking can be reduced by moving the ignition point toward "late". The aim is to obtain the maximum energy yield from any fuel quality by starting ignition as early as possible.

Function

The knock sensor is mounted on the crankcase and measures the structure-borne noise using a piezoelectric measuring element. Knocking is discernible by its higher sound frequencies.

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Gasoline Systems
Lambda sensor

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Invented for life

Lambda sensor

Customer benefits
- ▶ Reduced emissions due to improved signal accuracy
- ▶ Long lasting experience in system integration
- ▶ Long lifetime (150,000 miles, 15 years)

▶ Switching-type lambda sensor
- – High characteristic curve accuracy due to controlled heater
- – Increased flexibility of application
- – Reduced emissions for cold and warm engine starts due to fast sensor readiness

▶ Wideband lambda sensor
- – Enhanced mounting options due to temperature robustness (exhaust, housing) and preformed hose
- – Improved signal readiness also at $\lambda \neq 1$ enables lower emissions during cold start and SLP-diagnoses ability
- – LSU-ADV: suitable for pre-turbo application due to high permanent-temperature and temperature cycling robustness

The first lambda sensor was applied in the exhaust tract of gasoline port fuel injection engines. Since then, Bosch has applied new technology concepts to develop a versatile program of sensors. With these sensors, engine manufacturers can customize lambda control exactly to their requirements. Our lambda sensors enable compliance with all international emission regulations with gasoline port fuel and direct injection.

Task

At the stoichiometric point (λ = 1: one part of fuel in 14.7 parts of air) the oxygen content of the exhaust gas is ideal for the conversion of the noxious substances in the catalytic converter. The lambda sensor provides the engine control unit with the basis for appropriate mixture formation. There are two sensor types: switching-type and wideband lambda sensors.

Function

The planar switching-type lambda sensor generates a switching signal during the transition from lean to rich operation. Thus the stoichiometric point is identified precisely: when there is neither an excess of fuel or air, the catalytic converter works most effectively.

The wideband lambda sensor provides a continuous measurement signal from lambda = 0.65 (rich mixture) to air. It allows for more precise control arrangements not just with λ = 1, but over a wide range of air-fuel ratios.

Technical features

	LSF Xfour	LSF 4.2	LSU 4.9
Sensor type	Switching-type	Switching-type	Wideband
Measurement range			λ = 0.65–air
Lambda control for	Gasoline engines	Gasoline engines	Gasoline engines, diesel engines
Sensor element	Planar, integrated central heater	Planar, integrated central heater	Planar, integrated central heater
Reference	Pumped	Air reference	Pumped
Sensor readiness (Fast Light-Off FLO)	FLO < 7 s @ 10.5 V	FLO ≤ 12 s	FLO ≤ 10 s
Heater power	7 W	7 W @ 350 °C	7.5 W
Permanent temperature exhaust gas	≤ 980°C	≤ 930°C	≤ 930°C
Peak temperature exhaust gas (max. hours)	1,030°C (300 h)	1,030°C (250 h)	1,030°C (250 h)
Thermo shock protection (TSP)	Optional	Optional	
Lifetime	150,000 miles 15 years	150,000 miles 15 years	150,000 miles 15 years
Control of sensor element temperature	Yes		Yes
Sensor trimming			Trim resistor in connector housing

Technical features

	LSU 4.9 TSP	LSU ADV	LSU 5.2
Sensor type	Wideband	Wideband	Wideband
Measurement range	λ = 0.65–air	λ = 0.65–air	λ = 0.65–air
Lambda control for	Gasoline engines	Gasoline engines, diesel engines	Gasoline engines
Sensor element	Planar, integrated central heater	Planar, integrated central heater	Planar, integrated central heater
Reference	Pumped	Pumped	Pumped
Sensor readiness (Fast Light-off FLO)	FLO ≤ 12 s	FLO ≤ 5 s	FLO ≤ 7 s
Heater power	8.4 W	8.7 W	~10 W
Permanent temperature exhaust gas	≤ 930°C	≤ 980°C*	≤ 980°C
Pre-turbo application		Yes	
Peak temperature exhaust gas (max. hours)	1,030°C (250 h)	1,030°C (250 h)	1,030°C (300 h)
Sensor element temperature control	Yes	Yes	Yes
Thermo shock protection (TSP)	Yes		Yes
Lifetime	150,000 miles 15 years	150,000 miles 15 years	150,000 miles 15 years
Sensor trimming	Trim resistor in connector housing	Trimming of sensor element	Trim resistor in connector housing

* Pre-turbo variant

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Gasoline Systems

Medium-pressure sensor

BOSCH
Invented for life

Medium-pressure sensor

Customer benefits

- Hermetic metal sealing, no o-ring required
- Compact, robust design on platform basis
- Flexible use for different applications and media (oil, fuel, gas)
- High measurement accuracy
- High electromagnetic compatibility (EMC)
- Customizable: characteristic curve, connector, mechanical interface, label, etc.
- Variant: medium-pressure sensor for CNG with fast responding temperature sensor

Saving CO_2 is one of the most important targets of modern combustion engine development. One way to achieve this target is the introduction of demand-controlled fuel and oil pressure.

Task

Demand-controlled oil and fuel systems continuously adapt the pump output to the requirements. The medium-pressure sensor contributes by monitoring the fuel pressure in the low-pressure circuit. The target is to reduce the pump performance in order to minimize the CO_2 output.

The medium-pressure sensor is also used for controlling CNG and LPG systems and for measuring the transmission oil pressure. The Bosch portfolio comprises sensors with or without integrated NTC resistor.

For example, in CNG systems a defined CNG pressure is required at the injector to ensure precise metering. The pressure is influenced by temperature, among others. Consequently, the CNG medium-pressure sensor monitors pressure and temperature of the gas directly upstream of the injector.

Function

The sensor contains a piezoresistive sensor element which generates a measurable electrical voltage when pressure is applied. The voltage increases with pressure so that the actual pressure can be calculated.

Technical features	
Media	Engine and transmission oil, diesel, gasoline, CNG, LPG
Measurement of	Absolute or relative pressure
Technology	Silicon single chip technology
Mechanical interface	Metal thread with hermetic metal sealing
Max. pressure	7 MPa
Temperature range	-40°C–140°C
Lifetime accuracy	2% full scale (3 sigma value)
Optional	Integrated temperature sensor (encapsulated NTC)

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Gasoline Systems
Crankshaft speed sensor

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Crankshaft speed sensor

Customer benefits
- High accuracy
- Robust design for long lifetime
- Wide air gap range
- Non-contacting measurement
- Large temperature range
- Helps to reduce emissions and to increase fuel efficiency

- **Active crankshaft speed sensor**
  - High EMC/ESD protection
  - Small packaging
  - Lightweight sensor
  - Rotation direction detection for start/stop
  - Flexible design

- **Inductive crankshaft speed sensor**
  - Strong output signal at low engine speed
  - Twist insensitive mounting (TIM)

The electronic engine management enables precise, central control of all functions relevant for engine operation. This control is based on ongoing, exact information from the drivetrain. This information is provided by sensors.

Task
The crankshaft speed sensor measures the speed, position and, optionally, the rotational direction of the crankshaft. This data is used by engine management systems for controlling injection and/or ignition timing. The crankshaft speed sensor supports compliance with emission regulations as well as increased driving comfort due to smoother engine operation.

Function
The sensor is a Hall or inductive sensor. The crankshaft is fitted with a target wheel which the sensor scans using a non-contacting method. The reference point is determined by a missing element in the target wheel.

Technical features	
Technology	
Active	Differential-Hall with/without rotational direction detection
Inductive	Inductive
Temperature range	
Active	-40°C–150°C
Inductive	-40°C–130°C
Air gap range	
Active	0.1–1.8 mm
Inductive	0.3–1.8 mm
Target wheel	
Active	Steel or multipole
Inductive	Steel

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Gasoline Systems
Camshaft speed sensor

BOSCH
Invented for life

Camshaft speed sensor

Customer benefits

- High accuracy
- Robust design for long lifetime
- High EMC/ESD protection
- Wide air gap range
- Non-contacting measurement
- Large temperature range
- Small packaging
- Lightweight sensor
- Twist insensitive mounting (TIM)
- Helps to reduce emissions and to increase fuel efficiency

The electronic engine management enables precise, central control of all functions relevant for engine operation. This control is based on ongoing, exact information from the drivetrain. This information is provided by sensors.

Task

The engine control unit uses the camshaft speed sensor to record the position of the camshaft. The sensor's high precision enables a precise variable camshaft phasing, which increases power while reducing emissions.

Function

The camshaft speed sensor is designed as a non-contacting Hall sensor. Due to the true power on function (TPO) the sensor is quick start capable: It provides a position information immediately after engine start.

Technical features

Technology	Single-Hall
Power-on function	True power on (TPO)
Mounting	Independent of mounting position (TIM)
Temperature range	-40°C–150°C (max. 250 h at 160°C)
Air gap	0.1–1.8 mm

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Low-pressure sensor for tank pressure

BOSCH
Invented for life

Low-pressure sensor for tank pressure

Customer benefits

- Compact, lightweight sensor
- Robust design
- Integrated evaluation circuit
- Easy handling and fitting
- Customer specific design of connector, pressure and reference pressure ports
- High accuracy, long-term stability and EMC
- Fast response
- Various mounting positions

When fuel evaporates from the fuel system of a gasoline engine, noxious hydrocarbons are released into the environment. The permitted level of these hydrocarbon emissions is limited by emissions legislation.

Task

Environmental legislation is increasingly regulating hydrocarbon emission (HC). Tank leakage can allow the HC contained in the gasoline to evaporate into the environment. The low-pressure sensor for tank pressure monitors the fuel tank seal.

Function

The micromechanical sensor contains a piezoresistive sensor element which generates an electrical voltage when pressure is applied. For the purpose of tank-leak diagnosis, following a reference measurement the tank system is evacuated while idling using the vacuum in the intake manifold. A leak will cause the pressure in the tank system to fall more slowly and to return faster to the ambient pressure once the air valve is closed.

Technical features

Application	Tank leakage detection
Signal	Analog
Pressure range	-3.75–3.5 kPa relative pressure
Burst pressure	> 150 kPa
Temperature range	-40–115°C

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Gasoline Systems

Manifold air-pressure and boost-pressure sensor

BOSCH
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Air-pressure and boost-pressure sensor

DS-S3

Customer benefits

- Compact, lightweight sensor
- Robust design
- Integrated evaluation circuit
- Easy handling and fitting
- Customer specific connector and mounting
- Flexible mounting position
- High accuracy and EMC, long term stability
- Fast response
- Cost-optimized design

The air management ensures that the engine has the right air intake at any operating point. For this purpose the engine control unit requires precise ongoing information about the mass and other characteristics of the intake air. This information is supplied by the air-management sensors.

Task

The low-pressure sensor measures the air pressure in the intake manifold. The volume of air that reaches the combustion chamber can be calculated from the measured air pressure and the engine speed. This input variable is required for calculating the amount of fuel injected.

Function

The micromechanical sensor contains a piezoresistive sensor element which generates a measurable voltage when pressure is applied. This voltage is used to measure the air pressure. The sensor is cost-optimized by using a preassembled electronic module.

Technical features

	DS-S3
Measurement of	intake air pressure, boost pressure
Pressure ranges	115, 250, 300, and 400 kPa
Technology	Silicon single chip technology
Connector	Bolted connection with o-ring sealing
Optional	Integrated temperature sensor (encapsulated)

Air-pressure and boost-pressure sensor

PS-4 TMAP

Customer benefits

- Increased accuracy (up to 0.5% FSS)
- High level of media resistance
- Large temperature range: up to 150°C with high-feature variant
- Fast temperature sensor
- Output of pressure and temperature signals via one wire (SENT interface)
- Improved diagnostic

Variant

The PS-4 sensor type features an extended pressure range, improved accuracy and a digital interface.

Technical features

	PS-4 TMAP
Measurement of	Intake air pressure, boost pressure, temperature (optional)
Pressure range	100–600 kPa
Technology	2-chip concept, separation of ASIC and membrane
Signal processing/calibration	Digital
Interface	Digital (SENT) for p and T
Optional	Integrated temperature sensor (NTC)

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Gasoline Systems

Canister purge valve

BOSCH
Invented for life

Canister purge valve TEV

Customer benefits

- Manufacture in Europe, America and Asia
- Maximum flow rates at relatively low differential pressure
- Stable air flow performance
- Precise air flow control
- Suitable for turbocharged engines (with external check valve)
- Compact and lightweight

Technical features

	TEV 5
Weight (base design)	55 g
Max. air flow rate	10 m³/h
Max. flow tolerance	± 0.3 m³/h (after lifetime)
Connector outlet	Radial/axial
Optional	Noise optimized variant, filter, direct mount

When fuel evaporates from the fuel system of a gasoline engine, noxious hydrocarbons are released into the environment. The permitted level of these hydrocarbon emissions is limited by emissions legislation.

Task

In order to minimize evaporative hydrocarbon emission, an activated charcoal filter traps the hydrocarbon vapors from the tank. Part of the intake air is routed through this filter and carries the hydrocarbon vapors into the combustion chamber where they are burned as part of the air-fuel mixture. The canister purge valve meters this air flow in accordance with the engine's operating state.

Function

The canister purge valve is a solenoid in a plastic housing which is controlled by the engine control unit. The TEV is characterized by:

- Modular design (connectors, in- and outlet arrangement, connector outlet)
- Compact design, low weight
- Variable air flow rates (3.5–10 m³/h)

It only takes a relatively low differential pressure to reach the maximum air flow. The TEV is suitable for direct mounting on the intake module. Bosch also supplies accessories such as mounting caps, etc.

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Gasoline Systems
Accelerator-pedal module

BOSCH
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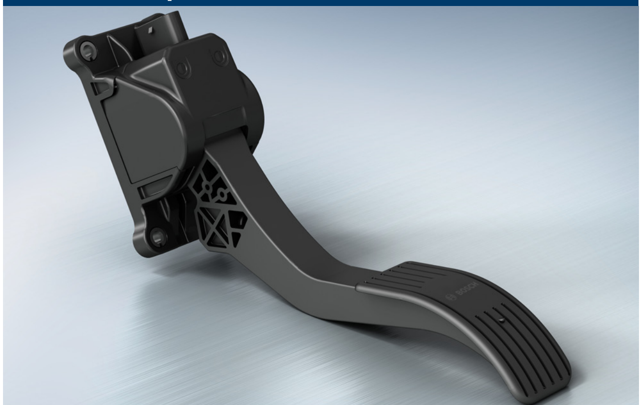
Accelerator-pedal module APM



Customer benefits
- ▶ Comprehensive system expertise: hardware (pedal), software and system know-how from a single source
- ▶ Designed for worldwide application
- ▶ Easy switch from contacting to non-contacting sensor due to modular concept
- ▶ Packaging advantage based on compact design
- ▶ Lightweight module
- ▶ Low application effort

▶ APM 3.0
- – Best price-performance ratio
- – Active feedback for the driver: several different feedback types for different functions
  - • fuel economy: e.g. coasting assistant, gear change assist
  - • safety: e.g. distance warning, speed warning

The air and fuel systems of gasoline engines prepare an air-fuel mixture which allows the engine to generate the required torque. Simultaneously, this mixture also fulfills further requirements, for example from the exhaust system. The electronic engine control adjusts the ideal air-fuel ratio and the optimal injection timing. The engine control evaluates sensor signals from the entire drivetrain and the exhaust system, prioritizes them and converts them into control commands.

Task
The driver's requirement for more or less torque is a key input variable for controlling the air charge electronically. The accelerator-pedal module provides this variable as a sensor signal.

Function
The accelerator-pedal module (APM) comprises an accelerator pedal and a potentiometer or a non-contacting Hall sensor as angular-position sensor. This sensor registers the movement and the position of the accelerator pedal. From this information, the engine management calculates the required torque and accordingly addresses the throttle device and the injection system. The accelerator-pedal module can output analog or digital signals.

Technical features

	APM1.2S C/NC
Idle voltage tolerance	±1%
Sensor synchronicity	±1.4%
Housing width	≤ 44 mm
Weight	250 g
Direct burst force	≤ 1,500 N
Returning force	≤ 10 N
Proven lifetime cycles	2,200,000
Interfaces	Analog and digital

Technical features

	APM3.0
Force tolerance	5–10%
Force	≤ 25 N
Response time	86–146 ms
Feedback types	Vibration, force feedback, knocking
Gear	2-stage including security system
Optional	Electronic on board

The accelerator pedal is made from plastic. It is available as a floor mounted or suspended pedal. A new topology-optimized design helps to reduce weight by up to 25% compared with the previous designs while maintaining the same strength.

The design of the Bosch accelerator-pedal modules is based on our field experience with over 25 million units supplied. The pedals fulfill all international requirements such as reliability, measuring precision, service life and crash behavior.

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Gasoline Systems
Connectors

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Connectors

Customer benefits

- **Low pole compact connectors**
  - High vibration and temperature resistance
  - High degree of protection (tightness)
  - Compact design
  - Suitable for engine mounting
- **Low pole Trapez connectors**
  - Particularly high vibration resistance and high temperature resistance
  - Compact and robust design
  - Suitable for engine and transmission mounting
  - Miniaturized 2-pole connector
- **High pole ABS/ESP connectors (EuCon family)**
  - Compact design
  - Easy assembly
  - High degree of protection (tightness)
- **High pole connectors for engine control units**
  - High vibration and temperature resistance
  - High media resistance
  - Design flexibility due to modular construction (2xxp)
  - High contact density due to miniaturization (156p/2xxp)
- **High current connector systems (VHC)**
  - High vibration resistance
  - Low contact resistance

The reliable function of the electric and electronically controlled vehicle systems requires a safe electric connection of the system components. These connections are provided by wire harnesses assembled with connectors which have been designed for specific requirements.

Task

Connectors establish the contact between control units, sensors and actuators and the wires of the vehicle network. Connectors provide connections between the system components; these connections are detachable and easy-to-handle in vehicle production.

Function

Connectors safely transmit electric signals and electric power. They are subject to heavy stress by vibration, termperature changes, humidity and aggressive media. Under these circumstances they meet the specified tolerances over their lifetime. The layout design of the connector ensures the optimal interaction of the components (interface, wire-harness plug, contacts and wire connection).

The Bosch range comprises low pole connectors for actuators and sensors, high pole connectors for engine and ABS/ESP control units as well as the appropriate contacts. Bosch also offers connector systems for high current applications in hybrid and electrical vehicles.

Bosch connectors can be applied for passenger cars, commercial vehicles, and motorcycles.

Technical features

Low pole connectors	**Kompakt 1**	**Kompakt 4**	**BAK 6**
Number of terminals variants	2–7	2–4	5–6
Degree of protection: IP...	X6K, X9K	X6K, X7, X9K	X4K, X7, X9K, 6KX
Sealing Plug Wire	 Radial Single wire	 Radial Single wire	 Radial Single wire
Vibration resistance	20–30g	20g	40g
Temperature range	-40–150°C (Au)	-40–150°C (Au)	-40–150°C (Au)
Raster unit	4.5 mm	5 mm	4 mm
Connection cross-sections	0.5–2.5 mm²	0.5–2.5 mm²	0.5–1.0 mm²
Usable terminals	BSK 2.8/BDK 2.8	BDK 2.8	MCP 1.5K
Locking	Snap-fit	Snap-fit CPA (optional)	Snap-fit CPA (optional)
Secondary locking	No	Yes	Yes

Technical features

Low pole connectors	**GSK** **45°/90° cable outlet**	**Trapez**	**Trapez Slim Line** **(mini)**
Number of terminals variants	1	2–7	2
Degree of protection: IP...	Permeable	X6K, X7, X9K	X4K, X6K, X7, X9K
Sealing Plug Wire		 Radial Single wire	 Radial Single wire
Vibration resistance	30g	20g, 45g	45g
Temperature range	-40–150°C	-40–150°C (Au)	-40–150°C (Au)
Raster unit		3.75 mm/4 mm	
Connection cross-sections	1.5 mm² 2.5 mm²	0.35–1.0 mm²	0.35–1.0 mm²
Usable contacts	Sleeve contact 4.0	Matrix 1.2, MT2	Matrix 1.2 Lance (HV)
Locking	Snap ring groove at the glow plug	Snap-fit/Locking slide CPA (optional)	Locking hatch
Secondary locking	No	Yes	No*

*A push-back test ensures the correct assembly of contacts

Technical features

High pole connectors **ABS/ESP**	**26-pole EuCon**	**38-pole EuCon**	**46-pole EuCon**
Degree of protection: IP...	X6K, X7, X9K	X6K, X7, X9K	X6K, X7, X9K
Sealing Plug Wire	 Radial Single wire	 Radial Single wire	 Radial Single wire
Vibration resistance	5.1g	3.4g	4.3g
Temperature range	-40–125°C	-40–125°C	-40–125°C
Connection cross-sections	0.3–4.0 mm²	0.5–4.0 mm²	0.3–4.0 mm²
Usable contacts	BTC 1.5/2.8/4.8	BTC 1.5/2.8/4.8 BTL 1.5/2.8/4.8	Matrix 1.2 cb EAD BTC 2.8/4.8
Locking	Lever	Lever optional with CPA	Lever optional with CPA
Secondary locking	Yes	Yes	Yes

Technical features

High pole connectors for engine control units	**112-pole (2 x 56-pole)**	**154-pole engine oriented**	**154-pole vehicle oriented**	**196-pole**
Degree of protection: IP...	X6K, X9K	X6K, X8, X9K	X6K, X9K	X6K, X8, X9K
Sealing Plug Wire	 Radial Mat seal	 Radial Single wire Silicone gel	 Radial Single wire Mat seal	 Radial Single wire Mat seal
Vibration resistance	2.9g	4.2g	5.8g	3.4g
Temperature range	-40–105°C	-40–125°C	-40–105°C	-40–120°C
Connection cross-sections	0.5–4.0 mm²	0.35–2.5 mm²	0.35–2.5 mm²	0.35–2.5 mm²
Usable contacts	MQS 1.5 BCB 0.6	Matrix 1.2 BDK 2.8	BCB 0.6 MQS 1.5 BDK 2.8	Matrix 1.2 BTL 2.8
Locking	Lever	Lever/Slider	Lever/Slider	Lever/Slider
Secondary locking	Yes	Yes	Yes	Yes

Technical features

High pole connectors for engine control units	**156-pole miniature**	**254-/284-pole miniaturized**	**141-pole for CV**	**192-/228-pole for CV**
Degree of protection: IP...	X6K, X7, X9K	X6K, X9K	X6K, X9K	X6K, X8, X9K
Sealing Plug Wire	 Radial Mat seal	 Radial Mat seal	 Radial Single wire Silicone gel	 Radial Single wire Silicone gel
Vibration resistance	5g	11.9g	approx. 8g	3.7g
Temperature range	-40–125°C	-40–130°C	-40–105°C	-40–130°C
Connection cross-sections	0.22–1.5 mm²	0.35–2.5 mm²	0.5–2.5 mm²	0.5–2.5 mm²
Usable contacts	BMT 0.5 L Matrix 1.2 cb	BMT 0.5 L BTL 2.8 Matrix 1.2 cb	BSK 2.8 BMK 0.6	Matrix 1.2 cb EAD, BDK 2.8
Locking	Lever	Lever	Lever/Slider	Lever
Secondary locking	Yes	Yes	Yes	Yes

Technical features

Terminals	**Bosch Micro Terminal BMT0.5**	**Bosch Mikro Kontakt BMK0.6**	**Bosch Clean Body BCB0.6**	**Matrix 1.2 Lance**
Primary locking	Lance	Lance	Clean-Body terminal	Lance
Tab contacts	0.4 x 0.5 mm	0.6 x 0.6 mm	0.63 x 0.63 mm	1.2 x 0.63 mm
Secondary locking possible	Yes	Yes	Yes	Yes
Plating	Sn, Ag	Au, Sn	Sn, Ag	Sn, Ag, Au
Temperature range	-40–150°C (Ag)	-40–150°C (Au)	-40–150°C (Ag)	-40–150°C (Ag. Au)
Connection cross-sections	0.13–0.35 mm²	0.35–0.75 mm²	0.35–0.5 / 0.75 / 0.85 mm²	0.35–0.5 mm² 0.75–1.0 mm²
Current rating	≤ 3 A (0.35 mm²)	12 A	7 A	19 A
Insertion force	≤ 4 N	≤ 4.5 N	≤ 5 N	≤ 3 N
Wire sealing	Mat seal	Silicone gel	Silicone gel	Single wire Mat seal
Compatible with	Tyco nano MQS	Molex CP0.6	Tyco MQS0.6	Tyco MCON1.2-LL

Technical features

Terminals	**Matrix 1.2 cb**	**Bosch Terminal Lance BTL1.5**	**Bosch Terminal Clean Body BTC1.5**	**Bosch Terminal Lance BTL2.8**
Primary locking	Clean-Body terminal	Lance	Clean-Body terminal	Lance
Tab contacts	1.2 x 0.5 mm	1.5 x 0.6	1.5 x 0.6 mm	2.8 x 0.8 mm
Secondary locking possible	Yes	Yes	Yes	Yes
Plating	Sn	Sn	Sn	Sn
Temperature range	-40–130°C	-40–130°C	-40–130°C	-40–150°C
Connection cross-sections	0.35–0.5 mm^2 0.5–1.0 mm^2	0.35–0.5 mm^2 0.5–1.0 mm^2	0.35–0.5 mm^2 0.5–1.0 mm^2	0.5–1.0 mm^2
Current rating	19 A	19 A	19 A	28.5 A
Insertion force	≤ 3 N	≤ 6 N	≤ 16 N	≤ 13 N
Wire sealing	Single wire	Single wire	Single wire	Single wire
Compatible with	MCON1.2-CB	MCP1.5K		Tyco MCP2.8K

Technical features

Terminals	**Bosch Terminal Clean Body BTC2.8**	**Bosch Damping Terminal BDK2.8**	**Bosch Terminal Lance BTL4.8**	**Bosch Terminal Clean Body BTC4.8**
Primary locking	Clean-Body terminal	Lance	Lance	Clean-Body terminal
Tab contacts	2.8 x 0.8 mm	2.8 x 0.8 mm	4.8 x 0.8 mm 6.3 x 0.8 mm	4.8 x 0.8 mm 6.3 x 0.8 mm
Secondary locking possible	Yes	Yes	Yes	Yes
Plating	Sn	Sn, Ag, Au	Sn	Sn
Temperature range	-40–130°C	-40–150°C (Ag. Au)	-40–130°C	-40–130°C
Connection cross-sections	1.5–2.5 mm^2	0.5–1.0 mm^2	2.5–4.0 mm^2	2.5–4.0 mm^2
Current rating	28.5 A	25 A (Au. Ag)	42 A	42 A
Insertion force	≤ 13 N	≤ 8 N	≤ 16 N	≤ 16 N
Wire sealing	Single wire	Single wire	Single wire	Single wire
Compatible with			Tyco MCP4.8K	

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