Gasoline Direct Injection
Engine Management System

This is an electronic control system for gasoline direct injection engines used by an increasing number of automakers to increase fuel efficiency. The system uses injectors that deliver fuel at pressures as high as 20 MPa, high-precision sensors, and other advanced devices to optimally control engine combustion. It increases both engine power and fuel efficiency.

Key Points

- Sophisticated air-fuel ratio feedback control to simplify the after-treatment of exhaust emissions.
- A variety of high-precision sensors to precisely detect engine operating conditions, including intake air quantity and air-fuel ratio.
- High-performance, high-pressure fuel injectors and pump to deliver atomized and optimally shaped fuel spray that can conform to a variety of combustion chamber configurations.
- A wide range of advanced actuators to best control exhaust gas recirculation (EGR), intake and exhaust valve timing, and other factors.

System Structure (a case of supercharged engine)
Gasoline Direct Injection Engine Management System

Press the button to see your selected product.

- Engine ECU
- Manifold Absolute Pressure Sensor
- Electric Variable Cam Timing (VCT)
- Air Flow Meter
- Electronic Throttle Body
- High Pressure Injector
- Turbo Pressure Sensor
- Accelerator Pedal Module
- High Pressure Pump
Gasoline Direct Injection Engine Management System

Press the button to see your selected product.

- Fuel Pump
- Spark Plug
- Knock sensor (non-resonance type)
- Fuel Pressure Sensor
- Crank Position Sensor (semiconductor type)
- Air-Fuel Ratio Sensor
- Stick Coil
- Cam Position Sensor (semiconductor type)
- Oxygen Sensor
Gasoline Direct Injection Engine Management System

Press the button to see your selected product.

- Exhaust Gas Temperature Sensor
- Exhaust Gas Recirculation (EGR) Cooler
- Coolant Temperature Sensor
- Catalytic Substrate (front and rear)
- Purge Valve
- Exhaust Gas Recirculation (EGR) Valve
- Evaporative Leak Check Module
Engine ECU

The engine ECU is designed to have total control of the actuators and run the engine under optimal conditions based on various sensor signals transmitted under the ever-changing driving conditions of a vehicle.

- High integration and compactness by in-vehicle custom IC.
- High-speed processing with high-performance 32-bit microcomputer.
- Waterproof structure to enable the engine room installation of the ECU
- Excellent heat radiation performance of the power ICs by means of a reverse heat sink package directly attached to the metal case
- Integrated with an injector driver unit.
Air Flow Meter

Meter to measure the amount of air taken into the engine in order to calculate the quantity for fuel injection.

- Air flow meter-specific IC for a smaller circuit chamber
- New air flow bypass with air intake apertures allowing for more precise measurements when a pulsating flow arises and for expanded measuring range

<table>
<thead>
<tr>
<th>Effects</th>
<th>Conventional product</th>
<th>This product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>52 (g)</td>
<td>31 (▲40%)</td>
</tr>
<tr>
<td>Measurement precision when a pulsating flow arises</td>
<td>±8.0 %</td>
<td>±5.0 (▲40%)</td>
</tr>
<tr>
<td>Measurement range (maximum air flow/minimum air flow)</td>
<td>106 times</td>
<td>140 times</td>
</tr>
</tbody>
</table>

Installed on the air cleaner; Durability: 10 years or 160,000 km
Turbo Pressure Sensor

Pressure sensor to measure the pressure of turbocharged intake air.

- Compact and highly mass-producible piezo resistance turbo pressure sensor
  Pressure detection with the piezo resistance effect of silicon: resistance value changes due to the distortion upon the application of a voltage
- Ultimately simplified structure using a bare chip mounting method
  Sensor and circuit chips are directly mounted on the resign case (PPS-G40) to reduce the number of components to its smallest possible limit
- DENSO's proprietary on-chip noise prevention technology
  On-chip noise cancellation circuit requires no noise prevention components
Turbo Pressure Sensor

- DENSO’s own impact absorbing surface structure can cope with an increasingly harsh environment in the intake manifold. A two-layer surface structure made of full gel and rubber allows the sensor to be used in harsh environments in the intake manifold.

- Electrical connections without soldering. (wire bond connection) A wire bond electrical connection between devices and terminals provides higher reliability and requires no soldering. (no use of lead)

- The intake air pressure and temperature can be measured in real time. It is possible to detect them with high reliability even in a severe supercharging environment to return Exhaust Gas Recirculation (EGR).
Manifold Absolute Pressure Sensor

The sensor measures the manifold absolute pressure to provide accurate air-fuel ratio control in conjunction with the results of measurements from the air flow meter.

- Compact and highly mass-producible piezoresistance boost pressure sensor. Pressure detection by the piezoresistance effect of silicon: resistance value changes due to the distortion upon the application of a voltage.
- Ultimately simplified structure by a bare chip mounting method Sensor and circuit chips are directly mounted on the resin case (PPS-G40) to reduce the number of components to its smallest limit possible.
- DENSO’s proprietary on-chip noise prevention technology The on-chip noise cancellation circuit requires no noise prevention components.
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Electronic Throttle Body

Contrary to conventional throttle bodies, which are directly and mechanically connected to the accelerator pedal module, the electronic throttle body opens and closes the throttle valve electronically. Based on how far the driver depresses the accelerator pedal, the electronic throttle body precisely controls the valve timing for higher fuel efficiency and cleaner exhaust emissions.

● Use of a DIC motor for quick response and continuous air flow control

● Use of resin gears and a small motor for lighter weight and a lower cost

● Use of a contactless sensor for a longer life and high reliability
Accelerator Pedal Module

An accelerator pedal module detects the amount of pedal depression while providing good pedal operation feel. Pedal depression is the basic information necessary for electronic throttle control,

- Contactless Hall IC sensor for a longer life and higher reliability
- Swash-plate pedal pressure-induced hysteresis mechanism for good pedal operation feel
- Resin components for lighter weight and lower costs
Accelerator Pedal Module

- **Operating principle of a Hall IC sensor**
  - Hall IC sensor
  - Stator
  - Magnet
  - Fully closed (0°)
  - Rotation
  - The magnetic flux that changes according to the pedal position is converted into a voltage

- **Swash-plate pedal pressure-induced hysteresis mechanism**
  - Pedal depression
  - Pedal release
  - Pedal pressure hysteresis
  - Spring force
  - Pressing force
  - Friction plate
  - Rotor and pedal swash plates
  - Pedal pressure
  - Friction force
  - The swash plate generates a pressing force according to the spring force
  - The pressing force generated by the swash plates produces a friction force (pedal pressure hysteresis)
Electric Variable Cam Timing (VCT)

Continuous variable cam timing control combined with an electric motor contributes to low fuel consumption, low emissions, and high output of engines.

- This mechanism can operate at low engine speeds, including engine stops, and low temperatures because of the electric motor drive.
- This mechanism can set the camshaft in any phase when turning off or starting the engine by using the magnetic torque of the electric motor.
- Motor speed feedback control by an electronic driver unit (EDU) ensures accurate cam timing control.

※1: Variable Cam Timing  
※2: Electronic Control Unit
High Pressure Injector

The compact, lightweight, and high-response injector is designed for direct injection gasoline engines.

- Fuel is sprayed at high pressure (20MPa) through a nozzle with many tiny holes.
- Different spray patterns are available for different types of engines.
- Atomized fuel is sprayed to optimize combustion in the engine.
- A magnetic circuit is optimized to control fuel injection volume with high precision and achieve high response.
- The number of components is minimized to make the injector compact and lightweight.
High Pressure Pump

A high pressure pump is designed to pressurize, meter, and supply fuel with high efficiency. The pump is driven by the engine's camshaft.

- A single plunger is used to achieve high discharge efficiency
- A solenoid metering valve is used to meter the fuel discharge volume with high precision
- Less energy is required to operate the pump by metering the discharge volume
- A lip seal prevents contamination of engine oil with fuel
Fuel Pump

Highly efficient, compact and low-noise fuel pump to meet the needs for lower vehicle electric power consumption and larger vehicle cabin.

- 3D impeller that allows the pump itself to improve its efficiency
- Variable pitch impeller for reduced noise
- High-performance honeycomb filter for a smaller size and a longer life
- Reservoir chamber for stable fuel delivery during cornering
- Integration of components for the fuel supply system, which allows for space-saving around the fuel tank
Fuel Pressure Sensor

A fuel pressure sensor is designed to measure and optimize the pressure of fuel supplied to the high pressure injector. The sensor is compact and lightweight.

- The piezo resistance type sensor is compact and well suited for mass production.
- The structure is extremely simple. The integrated pressure sensor chip has a built-in pressure detection mechanism in the IC chip.
- The sensor incorporates DENSO's unique on-chip noise protection technologies.
- The integrated sensor chip is protected with a metal diaphragm.
- Solderless electric connection (wire bonding)
Stick Coil

The compact ignition coil can be mounted directly in a plug hole.

- The coil has a small built-in molded igniter.
- The coil is compact thanks to the technology for diagonal winding in the secondary coil.
- The coil’s diameter has been reduced with a cylindrically laminated core.
Spark Plug

With a twin-needle electrode configuration, which uses a thin column-shaped ground electrode, this spark plug achieves high ignition performance and contributes to higher fuel economy.

- The twin-needle electrode configuration offers a reduced flame-out action against the flame kernel and improved ignition performance.
Spark Plug

- Ignition performance is determined by the flame-out action (action in which the electrodes sap the thermal energy of the flame kernel).
- The smaller the contact area between the flame kernel and the electrodes, the smaller the flame-out action and the higher the ignition performance.

<Flame-out action>

![Diagram showing flame-out action between flame kernel and electrodes of different types.](image)
Crank Position Sensor (semiconductor type)

Compact and high-performance cam position sensor to meet the needs for cleaner vehicle emissions and higher fuel efficiency (reduced CO₂ emissions).

- Smaller size by integrating a detection element and a processing circuit on one chip
- Higher position detection accuracy by using a highly sensitive magnetoresistive element with a high signal-to-noise ratio
- Greater reliability for use at high temperatures by employing a single-layer thin metal film magnetoresistive element
- DENSO’s own magnetic circuit design allows for the detection of the camshaft stop position
- Seamless packaging and soldering-free electric connection create an extremely reliable structure
Cam Position Sensor (semiconductor type)

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Knock sensor (non-resonance type)

Detects vibration (engine knock) caused by abnormal engine combustion and controls the ignition timing to keep it as close to the knock limit as possible.

The sensor is a non-resonant type that features an almost flat response over a wide range of engine vibration frequencies, using the piezoelectric effect of a PZT element (the voltage produced by a PZT element changes according to the magnitude of applied compressive stress) to detect engine knock.

Function: The deformation of the PZT element caused by the engine block vibration is output as a voltage.
Air-Fuel Ratio Sensor

This is a high response type air-fuel ratio sensor, which helps reduce exhaust emissions from vehicles.

Structure

- Waterproof filter
- Airtight seal
- Sensing element with a built-in heater
- Element protection cover

Air-fuel ratio: Mass ratio between air and fuel
Air-Fuel Ratio Sensor

**Features**

- High response makes it possible to control the air-fuel ratio of each cylinder.
- An element protective layer provides the sensor with high water resistance.
- Quick activation is achieved by a compact sensing element with a built-in heater.

**Structure**

- Waterproof filter
- Airtight seal
- Sensing element with a built-in heater
- Element protection cover

Air-fuel ratio: Mass ratio between air and fuel
Oxygen Sensor

This oxygen concentration sensor can exploit the full purification performance of the catalyst.
Oxygen Sensor

Features

- By means of the high-quality sensor signal through the combination of stabilized electrode reactions and an optimum cover design, the air-fuel ratio is optimally controlled at which the catalyst delivers best performance.

- An element protective layer provides the sensor with high water resistance.

Structure

- Waterproof filter
- Airtight seal
- Heater
- Detection element
- Element protection cover

Diagram:

- Highest purification point of catalyst
- Purification rate of catalyst
- NOx
- Control voltage
- Sensor output voltage
- Air-fuel ratio: Mass ratio between air and fuel
- 14.5
Exhaust Gas Temperature Sensor

This thermistor type temperature sensor can detect the exhaust gas temperature of automobiles accurately.

- Simple in shape and easy to mount.
- Highly resistant to vibration and heat to withstand the harsh working environment of automobiles.
- High temperature detection accuracy achieved by the blending of optimum thermistor material, ultra-precision trimming, and glass molding of high heat resistance.
- High sensing response because of the small sensor diameter by means of the downsized thermistor element.
Catalytic Substrate (front and rear)

The lightweight and highly reliable catalytic substrate meets the needs of higher engine output and cleaner emissions.

- A highly porous ceramic substrate has led to a reduction in weight
- The thin wall structure and highly meshed configuration have reduced the time required to warm the catalyst, increased the surface area of the catalyst, and thereby improved the performance of converting harmful combustion byproducts into harmless compounds
- DENSO’s unique reinforced structure has achieved improved reliability
Catalytic Substrate (front and rear)

- DENSO's unique hexagonal cell structure has achieved even thickness for the supported catalysts (platinum, rhodium, palladium, and other precious metals), and reduced pressure loss and volume of supported catalysts. Both better engine output and greater purification performance have been achieved, and the system cost has been reduced.

- The hexagonal cell configuration is used primarily for the three-way catalyst in the front and for the NOx catalyst in the rear to reduce pressure loss and enhance purification performance.
Exhaust Gas Recirculation (EGR) Valve

Large-volume LPL (Low Pressure Loop) EGR under low differential pressure is effective in improving fuel economy. This EGR valve provides accurate control of LPL EGR flow.

● Compactness and a large flow volume by means of a butterfly valve with low pressure loss

● Improved flow rate controllability by a high-accuracy angle sensor backed by multipoint correction

● Greatly reduced valve sticking caused by deposit by means of both a cleaning action of a overturn mechanism of the butterfly valve and a high torque DC motor
Exhaust Gas Recirculation (EGR) Cooler

Intended for large-volume EGR, this EGR cooler offers excellent performance, compactness, and high heat resistance.

- Features
  - High performance and low pressure loss by means of fine offset fins
  - Thermal strain resistance by means of local temperature difference reduction structure
  - Boiling prevention by means of heat transfer control dimples and stagnation prevention ribs
Purge Valve

Compact and low-noise gasoline vapor flow control valve to prevent the leak of gasoline vapor from contributing to air pollution

- Smaller size by incorporating a chamber
- Magnetic circuit with a magnetic constriction mechanism to provide a larger valve opening force
- Smaller size by incorporating a magnetic circuit
- Improved hermetic sealing with laser welding
Evaporative Leak Check Module

To prevent fuel vapor from leaking to the outside air and contributing to air pollution, the total emission volume of fuel vapor is regulated. This product precisely measures the size of a pore in the fuel system from which the leakage of fuel vapor may occur to check if it is within the specified limits.

- Modular unit consisting of a brush-less motor, a pump, a pressure sensor, a changeover valve, and an opening
- Reference opening for more precise detection
- Built-in vacuum pump that allows for detection during the engine stop
- Brush-less motor for a longer life and safer operation
Coolant Temperature Sensor

Sensor that measures engine coolant temperature

- Output variation reduction by using a high accuracy thermistor
- High response by smaller elements and case
- High reliability for use in harsh operating environments conditions

Response comparison