Common Rail (Bosch)

Chonan Technical Service Training Center
System Overview
System Overview

- ECM
- Rail Pressure Sensor
- Common Rail
- High Pressure Pump
- Injectors
## Comparison

<table>
<thead>
<tr>
<th></th>
<th>Common Rail</th>
<th>Injection Pump</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Engine Speed</strong></td>
<td>Independance</td>
<td>Dependance</td>
</tr>
<tr>
<td><strong>Pilot Injection</strong></td>
<td>Possible</td>
<td>Impossible</td>
</tr>
<tr>
<td><strong>Injection</strong></td>
<td>Electrical</td>
<td>Mechanical</td>
</tr>
</tbody>
</table>
Common Rail System

ECM

Injector

Cylinder
Advantages

- **High Performance and Fuel Efficiency**
  - Electronically Controlled Common Rail Fuel Injection System to meet optimum combustion

- **Low Emission & Low Noise**
  - Environment-friendly to Meet All The Emission Regulations of The World
  - Central-vertically Located Injectors
  - Pilot Injection of Common Rail Fuel Injection System
Low Pressure Circuit

Fuel system for a Common Rail fuel-injection system

1. Fuel tank,
2. Pre-filter,
3. Presuply pump,
4. Fuel filter,
5. Low-pressure fuel lines,
6. High-pressure pump,
7. High-pressure fuel lines,
8. Rail,
9. Injector,
10. Fuel-return line,
11. ECU.
High Pressure Circuit
High Pressure Circuit

- Generate and store high pressure
- Closed-loop control of rail pressure
- Fuel Injection
High Pressure Pump

CP1

CP3

MPROP: (Magnetic Proportion Valve)

KUV: (Kraftstoff uber druck ventil......Over pressure safety valve)
High Pressure Pump Operation

Fuel Feed

Pressure Control valve

Fuel Feed
Common Rail
Injector Operation

1 = Capacitor disharge
2 = Injector pull in current
3 = Capacitor charge
4 = Injector holding current
5 = Capacitor charge (PST off)
6 = Regulated holding current (free-wheeling)
7 = Regulated holding current (power stage on)
### Pilot Injection

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>OT</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pre-injection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Main injection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1a</td>
<td>Combustion pressure with pre-injection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2a</td>
<td>Combustion pressure without pre-injection</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 = Pre-injection  
1a = Combustion pressure with pre-injection  
2 = Main injection  
2a = Combustion pressure without pre-injection
SENSORS
Electronic Fuel Injection Control
Accelerator-Pedal Sensor (Module)

Module Assembly

Sensor Assembly

APM (Module, pedal/sensor, 1 unit)
LC, FC, SM (LHD)

APS (Pedal + sensor)
XD, FO, SM (RHD/LHD)
Accelerator-Pedal Sensor (Module)

<table>
<thead>
<tr>
<th></th>
<th>Potentiometer 1</th>
<th>Potentiometer 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>IDLE</td>
<td>0.6 ~ 0.9V</td>
<td>0.25 ~ 0.6V</td>
</tr>
<tr>
<td>WOT</td>
<td>3.6 ~ 4.6V</td>
<td>1.6 ~ 2.5V</td>
</tr>
</tbody>
</table>
Accelerator-Pedal Sensor (Module)

[Idle]
Average output signal in idle condition becomes 0.6~0.8V in APS 1.
(It depends on the vehicle)

[Load]
Average output signal in load condition becomes 3.9V in APS 1.
(It depends on the vehicle)
Rail Pressure Sensor

1 Electrical connections
2 Evaluation circuit
3 Diaphragm with sensor element
4 High-pressure connection
5 Mounting thread
Rail Pressure Sensor

Output voltage $U$

5.00 V

4.80 V

4.65 V

4.50 V

0.50 V

0.30 V

0.20 V

100 bar

1500 bar

pressure
Rail Pressure Sensor

[Diagram showing connections and signal flow]

[Graph showing data with labels: CH B: 4.1 V DT: 2.63 S FREQ: 0.38 Hz]
Air Flow Sensor (Hot Film Type)

1. Plug-in sensor
2. Cylinder housing
3. Cover of hybrid
4. Cover of measuring duct
5. Housing
6. Hybrid
7. Sensor
8. Mounting plate
9. O-ring
10. Temperature sensor
Air Flow Sensor (Hot Film Type)

![Graph with waveforms and measurements](image)

<table>
<thead>
<tr>
<th>Code</th>
<th>Detail Description</th>
<th>Symptoms</th>
<th>Check Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>C001</td>
<td>Signal below lower limit (Air mass &lt; -20kg/h)</td>
<td></td>
<td>Eng. Run</td>
</tr>
<tr>
<td>C002</td>
<td>Signal above upper limit (Air mass &gt; 800kg/h)</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>C003</td>
<td>General Error (Reference Volt &gt; 4.7~5.1)</td>
<td>Y</td>
<td></td>
</tr>
</tbody>
</table>
Camshaft position sensor

ECM
104
103

Ground
Sensor signal

VM1

CAMSHAFT POSITION SENSOR

CMP Sensor
# Camshaft position sensor

![Waveform diagram](image)

<table>
<thead>
<tr>
<th>Code</th>
<th>DTC</th>
<th>CC</th>
<th>Detail Description</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>0340</td>
<td>C001</td>
<td>CM0</td>
<td>CMP signal below lower limit (No signal)</td>
<td>Fuel = 0, EGR off, Fuel Limit, MIL On</td>
</tr>
<tr>
<td></td>
<td>C002</td>
<td>CM0</td>
<td>CMP Signal above upper limit</td>
<td>No START, MIL On</td>
</tr>
<tr>
<td></td>
<td>C003</td>
<td>CM0</td>
<td>CKP &amp; CMP General error (Rationality check)</td>
<td>MIL On</td>
</tr>
<tr>
<td></td>
<td>C004</td>
<td>CM0</td>
<td>CKP Plausibility error</td>
<td>MIL On</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Eng. Run</td>
</tr>
</tbody>
</table>

![KIA Motors logo](image)
Crankshaft Position Sensor Operation

- Sensor motion direction
- Air gap = 1 ± 0.5mm
- Reference point of the target used by EMS to synchronize the engine
- Crankshaft Mechanical Target Wheel
- 1 tooth = 6°
- Output sensor Electrical signal
  - ON = 0V
  - OFF = 5V
  - Above 4.7V
  - Below 0.8V
- ECM
  - ON ≤ 1.8
  - OFF ≥ 4.2V
- Tolerance = ±0.45° crankshaft
Fuel Temperature Sensor
Coolant Temperature Sensor

D-engine

A-engine
# Coolant Temperature Sensor

![Diagram of Coolant Temperature Sensor](image)

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<tr>
<th>Code</th>
<th>Detail Description</th>
<th>Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>DTC</td>
<td>CC</td>
<td>Fuel = 0</td>
</tr>
<tr>
<td>C0115</td>
<td>C001 Signal below lower limit (Signal &lt; 225 mV)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C002 Signal above upper limit (Signal &gt; 4.9 V)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Check Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>IG. On</td>
</tr>
</tbody>
</table>
Clutch Switch

- Cancellation of cruise control
- Impending engine load signal (de-clutch, engage first gear, move off)
- To prevent engine RPM surging when de-clutching during gear changes, ECM adjusts injector operation.
Brake Switch

Battery +
Control Relay
Brake Switch

ECM

Stop Lamp
ACTUATORS
Injector
Rail Pressure Control Valve

CP1
Rail Pressure Control Valve Operation
Pre-Supply Pump (low pressure pump)

Located next to the fuel tank

Electrical Pump

CP1
Pre-Supply Pump (low pressure pump)

Low Pressure Pump
Located rear side of High Pressure Pump
Mechanical Gear Pump

CP3

Gear-type fuel pump (schematic)
Pre-Supply Pump (low pressure pump) Operation
Exhaust Gas Re-circulation (EGR)
EGR Operation Condition

EGR OFF Condition

- Less than 650 RPM
- Pressure sensor malfunction
- Air flow sensor malfunction
- EGR malfunction
- Battery below 9V
- Injection Quantity over 42 mm³
- Engine over 3050 RPM
- Idle condition (below 1000 RPM for 52 seconds)

Coolant Temperature

ON

OFF

20 25 100 105

(Slight differences between models)

- Atmospheric pressure (high altitude)
  Lower 920 mbar OFF
  Over 930 mbar ON
(EGR) Throttle valve control

Throttle Valve and Actuator
Glow Plug

Checking operation

Connect battery power to glow plug directly
## Glow Plug

**Pre glow**

<table>
<thead>
<tr>
<th>Coolant Temp. (°C)</th>
<th>-20°C</th>
<th>-10°C</th>
<th>20°C</th>
<th>50°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glow time (Sec.)</td>
<td>12</td>
<td>8</td>
<td>3</td>
<td>0.7</td>
</tr>
</tbody>
</table>

**Post glow**

<table>
<thead>
<tr>
<th>Coolant Temp. (°C)</th>
<th>-20°C</th>
<th>-10°C</th>
<th>20°C</th>
<th>40°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glow time (Sec.)</td>
<td>40</td>
<td>25</td>
<td>10</td>
<td>0</td>
</tr>
</tbody>
</table>
The ECM is controlling a solenoid valve (duty ratio) to effect a vacuum on the actuator which in turn is connected to a linkage which pulls a rotating base plate. Inside the base plate are connected the vanes using a cam mechanism to determine the angle of vane pitch.
VGT (Variable Geometry Turbocharger)
VGT (Variable Geometry Turbocharger)

BPS (Boost Pressure Sensor) for VGT

It monitors the boost pressure to control the vane of VGT.
Auxiliary parts
&
Handling caution
Pre-Heater

Three heating plugs
Fuel Filter Assembly

- Pressure release valve
- Thermo switch
- Heater element
- Connector
- Filter

IN -> OUT
RETURN
IN
Removing High Pressure Pipe

Never release high pressure pipes with running engine
Checking fuel pressure & checking injector operation

High pressure can be checked only via the Rail Pressure Sensor Voltage Reading.

High pressure can be checked only via the Rail Pressure Sensor Voltage Reading.
Removing and Installing Injectors

T40 Torx (torque: 2.7±0.2 kgm)
Removing and Installing Injectors
Removing and Installing Injectors

Before re-installing injector, clean cylinder head bore and sealing surface.
1) insert brush.
2) clean sealing surface and blow out.

Installing
1) Insert new copper seal ring (apply small quantity of grease to bond it to injector).
2) Insert injector (do not touch the nozzle tip) and sliding clamp with clamp bolt.
3) Fit Injector pipe (Nuts finger tight only)
4) Injector clamp bolt (torque: 2.7±0.2 kgm)
   * If injector too loose, cylinder may loose pressure,
   * If Injector too tight, may result in pinching of the needle, resulting in knocking or misfire.
5) Install high-pressure pipes
   (3.3±0.2 kgm - Newly revised on June 11, 2002)
   (Old specification : torque : 2.7±0.2 kgm)
   * high-pressure pipes must be installed without tension
6) Attach return leak rail. Never fit without clip.
7) Check installation by tugging it.
8) Attach elec. Connector.
9) Start engine and check leaks. Read out fault memory and cancel
Injector Handling

The injectors have 5 hole mini-sac spray nozzles, the bore is so small it is achieved using EDM (electrical discharge machining).

Checking of injector nozzles for spray pattern and fuel delivery quantity must be carried out by a Bosch workshop.

Do Not Dismantel Injector nozzle and needle shaft
Risk of damage
Bosch agent only
DOC (Diesel Oxidation Catalyst)

Similar to the petrol version in design, ie. The Monolith is supported by a matting, to prevent cracking by shocks etc.

The Oxidisation catalyst has no oxygen sensor, and the precious metals are different.

In this type of catalyst approximately 4.5 – 5.0 Gramms of Platinum is used to change the state of Hydrocarbons (HC) and Carbonmonoxide (CO) to water and carbon dioxide. In addition a certain amount of Nitrogen Oxide (NO$_X$) is reduced.

As a result the level of soot particles are also reduced.