

Service Manual for Chery Fulwin 2 Hatchback
(Engine Management System (EMS))
from United Automotive Electronic Systems Co., Ltd. (UAES))

After-Service Department of Chery Automobile Sales Co., Ltd.

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Chapter I Engine Electronic Injection Part

Section 1 Introduction to UEAS (M780) Engine Electronic Injection System for Fulwin 2 Hatchback Model

I. System Introduction

This system adopts the M780 electronic fuel injection system from United Automotive Electronic Systems Co., Ltd. The Bosch Motronic system is one set of advanced engine management system. With one engine electronic unit (hereinafter referred to as ECU) as the control center and by means of the sensors installed on various portions of the engine, it measures various working parameters of the engine and, in accordance with the preset control programs in the ECU, precisely controls the fuel injection amount and ignition advance angle so that the engine can function at best state under various working conditions, namely the output at best state, most economic fuel consumption, and best exhaust emission. The Motronic system adopts the multi-point sequential fuel injection control, of which the control strategy includes the start control, the model-based torque indication control, idling closed-loop control, gas mixture closed-loop control and adaptive control, canister control, transient working condition control, ignition angle control, slave cylinder knock control, A/C control, fan control, vehicle speed and engine speed limitation, heating and protection control of three-way catalytic converter, and system self-diagnosis (OBD standard compliant). The CAN bus interface and the communication interface with ABS, automatic transmission, airbag, and anti-theft system are reserved in the system.

What is M7 system:

- Manifold injection system
- With air (idling), fuel, and ignition angle as the control objects
- Based on the physical model and oriented on the torque for control of parameters and interfaces
- Introduced the coordination mechanism of advanced torque and gas mixture
- SULEV and EVIV emission standard compliant
- Adopted the OBDII and EOBD fault diagnosis standard
- Modularized open system

Six advantages of introduction of M7 system:

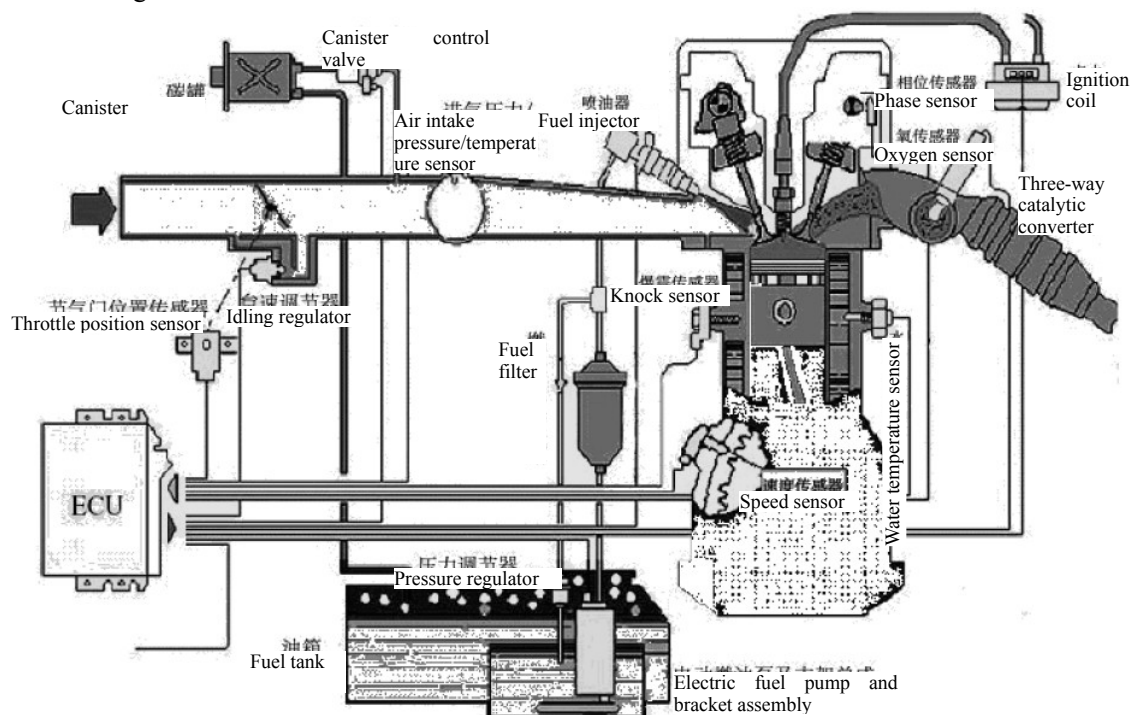
- Easy realization for modification of system configuration and adding of new subsystems
- Possibility of networking for control system of complete vehicle
- Greatly simplified data calibration, thanks to the decoupling of various subsystems.
- More precise realization of torque demands
- System integrated gas mixture coordination mechanism (by Lambda)
- Powerful system expandability thanks to open structure

Comparison against previous system:

- New engine functional structure as a function of torque variable enables easy compatibility with other systems
- New modularized software and hardware structures
- The model-based engine basic characteristic diagrams are independent with each other, simplifying the calibration process
- System integrated anti-theft function
- Improvement of driving performance by means of the centralized coordination of various torque demands
- 16-bit central processing unit, with 24MHz clock frequency and 512K cache
- System expandability against future demands, such as future emission regulations, OBDII, and electronic throttle.

II. Schematic Diagram of Engine Management System (EMS)

3.2 Schematic Diagram of EMS



1. Basic Parameter of Engine

Model	QR477F
Type	4-cylinder, inline, 4-stroke, water cooling
Cylinder bore	77.4mm
Stroke	85.5mm
Displacement	1497mL
Compression ratio	10.5
Ignition Order	1-3-4-2
Max. power output	80Kw/6000rpm
Max. torque output	140Nm/4500rpm
Idling	800±30rpm
Gasoline	93# and above
Emission	EUIV compliant
Cold start	-30°C

The components of the engine management system exert the important function to the performance of the complete vehicle and the damage of one component may severely impair the engine performance or even ignition failure. Therefore, the maintenance and repair of the engine management system components are of great importance.

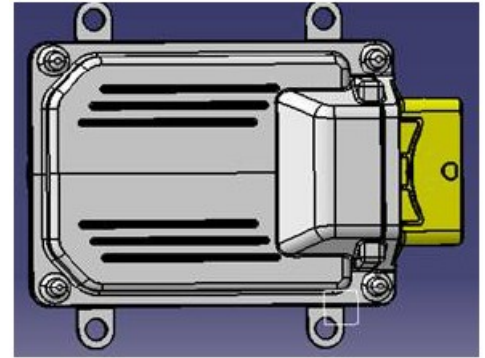
2. ECU

1) Installation Location:

Front passenger cabin

2) Function :

- Multi-point sequential injection
- Control of ignition
- Idling control
- Knock control, independent cylinder knock control (knock sensor KS-4)
- Power supply to sensors: 5V/100mA
- Adoption of cylinder judgment signal (phase sensor PG1)
- λ closed-loop control, with adaptive function
- Control of canister control valve
- A/C switch
- Engine malfunction indicator lamp
- Fuel quantitative correction
- Output of engine speed signal (TN signal)
- Input of vehicle speed signal
- Fault self-diagnosis, with flashing code function
- Receiving engine load signal, and so on.



(ECU profile)

3. Definition of ECU Pins:

Pin	Connecting point	Type	Pin	Connecting Point	Type
1	/		42	Cam position sensor 2#	Input
2	Upstream oxygen sensor heating plug-in unit 3#	Output	43	1# of earth P1, ECU connector 48#	Ground
3	Ignition coil 1#	Output	44	A/C pressure switch 2#	Input
4	Downstream oxygen sensor heating 3#	Output	45	Upstream oxygen sensor 2#	Input
5	Ignition ground	Ground	46	Engine speed sensor 2#	Input
6	/		47	Engine speed sensor 1#	Output
7	Ignition coil 2#	Output	48	1# of earth P1, ECU connector 43#	Ground
8	51# of ECU control plug-in unit, 2# of electric box C	Input	49	Fuel injector (3 rd cylinder) connector 2#	
9	/		50	Fuel injector (1 st cylinder) connector 2#	Output
10	A/C pressure switch 4#	Input	51	ECU connector 8#, 2# of electric box C	Input
11	/		52	Instrument harness connector 19#	Output
12	Instrument harness connector 20#	Input	53	/	Ground
13	/		54	/	
14	/		55	/	
15	Instrument harness connector 6#		56	/	
16	17# of electric box C	Input	57	/	
17	11# of electric box C	Ground	58	/	
18	Air intake temperature/pressure	Input	59	Air intake temperature/pressure	Input

	sensor 3#			sensor 4#	
19	Camshaft position sensor 3#, throttle position 1#	Input	60	7# of electric box C	Output
20	/		61	18# of electric box C	Output
21	Stepping motor 2#	Output	62	Instrument harness connector 18#	Output
22	Stepping motor 1#	Output	63	Fuel injector (2 nd cylinder) 2#	Input
23	/		64	Fuel injector (4 th cylinder) 2#	Output
24	/		65	/	
25	Air intake temperature/pressure sensor 2#	Input	66	/	
26	Throttle position sensor 3#	Input	67	/	
27	/		68	/	
28	/		69	/	
29	Downstream oxygen sensor 2#	Input	70	/	
30	Knock sensor 1#	Input	71	/	
31	Knock sensor 2#	Input	72	/	
32	4# of electric box C		73	/	
33	CAN-HLGH bus interface		74	/	
34	CAN-LOW bus interface		75	/	
35	Stepping motor 3#	Output	76	/	
36	Stepping motor 4#	Output	77	/	
37	Canister solenoid valve 2#	Input	78	/	
38	/		79	/	
39	Camshaft sensor 1#, throttle sensor 2#, front oxygen 1#, rear oxygen 1#	Ground	80	/	
40	Water temperature sensor 2#, air intake pressure/temperature sensor 1#	Ground	81	/	
41	Water temperature sensor 1#	Input		/	

4. Technical Characteristic Parameters

Limit Data		Value			Unit
		Min.	Typical	Max.	V
Battery voltage	Normal running	9.0		16.0	V
	Limited function	6.0~9.0		16.0~18.0	S
Limit and time for battery over-voltage resistance	26.0V	Some functions are maintained and fault diagnosis is executable.		60	S
	13.0V	The start function is guaranteed and fault diagnosis is executable.		60	°C
Working temperature		-40		+70	°C
Storage temperature		-40		+90	

5. Precautions

- 1) The waterproof shall be cautioned. Never contaminate the ECU with water nor immerse the ECU in the water, or it may burn out the ECU.
- 2) The static protection shall be cautioned during the installation.

- 3) Notice the protection of connector pins.
- 4) Before removing the ECU, disconnect the battery terminals and maintain for more than 1min.
- 5) it's prohibited to install additional circuits onto the connecting wires of the ECU.
- 6) No knocking is allowed for ECU. Handle with care during the replacement of ECU and do not drop carelessly.
- 7) it's prohibited to replace the ECU when the ignition switch is turned on.
- 8) The electronic control module is one high quality unit, with seldom faults. The special equipment shall be used for checking and generally the removal and repair at liberty is disallowed.
- 9) While replacing the ECU, upon the confirmation of the professionals from the service station, choose the ECU with same system and same version, or it may lead to damage of electronic control units, impaired engine performance, ignition failure and so on.

6. Fault Phenomenon and Judgment Method:

Fault phenomenon: Unstable idling, poor acceleration, stature failure, over-high idling speed, excessive exhaust emission, difficult start, failure of A/C, control failure of fuel injector, engine flameout, and so on.

General fault causes:

- 1) The electric overload of peripheral devices leads to burnout of ECU internal components and then leads to fault;
- 2) The water ingress into the ECU leads to rusting of circuit board.

Simple Measurement Method:

- 1) (connect the connector) Read the engine fault record by means of the engine data cable K;
- 2) (Remove the connector) Check the ECU connecting wires for intactness, mainly check the ECU power supply and grounding circuit for normal functioning;
- 3) Check whether the external sensors function normally, whether the signal output is credible, and whether the circuits are intact;
- 4) Check whether the actuators function normally and whether the circuits are intact;
- 5) Finally, replace the ECU for testing purpose.

III. Ignition System

1. Ignition Coil

1) Diagram and pins

2) Definition of pins:

Low voltage end:

- 1# coil primary winding is connected to 3# pin of ECU;
 2# coil primary winding is connected to 7# pin of ECU;
 3# pin is connected to 9# pin of electric box C and both pins are connected to positive pole of power supply.

High voltage end:

The 1#, 2#, 3#, and 4# pins are connected to engine spark plugs respectively via the cylinder distribution wire.

3) Installation location:

On the engine.

4) Working principle

The ignition coil ZS-K2×2 is composed of two primary windings, two secondary windings, iron core, and housing. One primary winding is charged once the grounding lead of such primary winding is connected. The charging is interrupted once the ECU cut off the primary winding circuit and at the same time the high voltage is generated in the secondary winding to drive the discharge of the spark plug. Differing from the ignition coil with distributor, one spark plug is connected on both sides of the secondary winding of ignition coil ZK-K2×2, in which case these two spark plugs fire at the same time. Two primary windings are powered on and off alternately and accordingly two secondary windings discharge alternately.



Double-spark ignition coil ZS-K2×2

5) Technical Characteristic Parameters

Limit Data

Measurement	Value			Unit
	Min.	Typical	Max.	
Allowable temperature at specified	-40		+120	°C
Max. temperature within 1hr			+140	°C

Characteristic Data

Measurement		Value			Unit
		Min.	Typical	Max.	
Voltage rating			14		V
Resistance (20~25°C)	Primary winding	0.42	0.5	0.58	Ω
	Secondary winding	11.2	13.0	14.8	kΩ
Inductance (20~25°C)	Primary winding	3.4	4.1	4.8	mH
	Secondary winding	26.5	32.0	37.5	H
Voltage generated	Under load 50pF	30			kV
	Under load 50pF//1MΩ	23			kV

6) Fault phenomenon and judgment method

Fault phenomenon: Start failure and so on.

Fault cause: Burnout due to excessive current, damage due to external force, and so on.

Precautions: During the repair, the “short-circuit ignition trial” for testing of ignition function is prohibited, in order to prevent damaging the electric controllers.

Simple measurement method:

(Remove the connector) Turn the digital multimeter to Ohm measurement scale and connect two probes to two pins of the primary winding respectively. Under 20°C, the resistance shall be 0.42~0.58Ω. The resistance measurement shall be 11.2~14.8kΩ for secondary winding.

2. Spark Plug

Due to the extremely harsh working conditions, the spark plug is subject to the high voltage and high temperature impact and to the harsh corrosion by combustion products and therefore the spark plug is classified as one wearing part.

1) Thermal characteristic

To guarantee the good working of spark plugs, ensure to maintain the spark plug at proper temperature. The practices prove that, when the insulator skirt of the spark plug is maintained at 500~700°C temperature, the oil drops falling onto the insulator can be burnt away immediately against forming the carbon deposit. This temperature is referred to as the self-cleaning temperature of the spark plug. When below this temperature scope, the carbon deposit will be formed on the spark plug to cause electric leakage and ignition failure. When above this temperature scope, the gas mixture will contact with the hot insulator to cause possible early combustion and knock or even cause combustion during air intake process, leading to backfire.

2) Possible faults arising from deteriorated ignition performance of spark plug

Difficult start, unstable vehicle speed, engine tremble, black smoke from exhaust pipe, high fuel consumption, and insufficient power output.

3) Judge from spark plug color the matching between vehicle condition and spark plug model

Yellow or tan	Normal	It indicates that the combustion status of gas mixture is normal
Black, with carbon deposit	Carbon deposit	Check if the spark plug model is matched and replace with spark plug with lower thermal value (slow heat radiation)
Black, with dirt	Blackened	If the fuel injector is dirty, clean it.
	If the gas mixture ratio is too dense, thin the gas mixture	
	If the high voltage is insufficient,	

	check ignition coil and so on	
Black, with oil dirt	Burnout of engine oil	Check sealing condition of seal ring and check cylinder wall for presence of scratches.
Gray	Overheating	Check if the spark plug model is matched and replace with spark plug with higher thermal value (fast heat radiation)

4) Periodical replacement and overtime service

The spark plug is one low-value wearing part, with relatively low price compared with other parts. However, the ignition performance of the spark plug directly influences the engine performance and therefore the spark plug shall be replaced periodically. For the spark plugs used in our engine, it's recommended to replace the single electrode spark plug for every 10,000~15,000km and to replace the multi-electrode spark plug for ever 15,000~25,000km.

The deteriorated ignition performance of the spark plug will lead to increased fuel consumption and lowered power output. The daily economic loss arising from the excessive fuel consumption unknowingly will be enough to buy hundreds of new spark plugs. The overtime service of the spark plug will cause the engine to work under poor condition for a long period and will cause certain damage to the engine.

5) Inspection and maintenance of spark plug

The checking of spark plug mainly includes the carbon deposit, electrode ablation, electrode gap, spark plug sealing performance, and arcing performance.

The **electrode gap** of the spark plug shall be **0.7~0.9mm**. The insufficient electrode gap will lower the puncture voltage and weaken the spark intensity. The excessive electrode gap will increase the required voltage of the spark plug and lead to misfire, especially in event of aged ignition coil and poor maintenance of ignition system, in which the misfire will more likely occur.

The common faults of spark plug include lowered sealing performance, presence of air leakage, and blackened trace at air leakage portion. Above faults may be checked and judged by means of sealing test and arcing test. The sealing test and the arcing test can be conducted on the spark plug cleaning tester.

Some drivers and repair personnel remove the spark plugs from the engine, place them on the cylinder hood, and inspect with onboard high voltage power. It shall be pointed out that this method is unscientific. This is because that, in this test, the spark plug electrode is tested under the atmospheric pressure. However, the spark plug is actually working under air pressure with above 800kPa. Therefore, the arcing of spark plug under atmospheric pressure doesn't equal to the reliable arcing under high pressure within the cylinder.

During the service of the spark plug, it's required to clean the carbon deposit and properly adjust the spark plug gap for every 10,000~15,000km. When the cylinder temperature is increased, the electrode gap shall be increased properly, namely the electrode gap shall be increased in summer and shall be reduced in winter. When the gas mixture is dense, the electrode gap shall be properly increased and on the contrary the electrode gap shall be reduced. The electrode gap shall be reduced in plains and shall be increased in highlands.

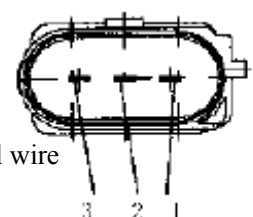
IV. Speed Sensor (Crankshaft Position Sensor)

1. Diagram and pins

2. Installation location



1# is connected to shield;
2# and 3# are connected to signal wire



3. Working principle

The inductive speed sensor is fitted with the pulse wheel to provide the engine speed information and crankshaft top dead point information in the ignition system without distributor. The inductive speed sensor is composed of on permanent magnet and the coil surrounding the magnet. The pulse wheel is one 60-tooth fluted disc, in which two teeth are missing. The pulse wheel is installed on the crankshaft and rotates along with the crankshaft. When the tooth tip passes closely through the end of inductive speed sensor, the pulse wheel made of ferromagnetic material cuts the magnetic lines of the permanent magnet within the inductive speed sensor so that the inductive voltage is generated in the coil as the speed signal output.

4. Technical Characteristic Parameters

Limit Data

Variable			Value			Unit
			Min.	Typical	Max.	
Tolerable temperature of PUR wire inductive speed sensor (see figure below)	Coil zone		-40		+150	°C
	Transitional zone		Mixed		Mixed	°C
	Wire zone		-40		+120	°C
	Storage temperature		-20		+50	°C
	Environment temperature during non-working		-40		+120	°C
	Long-term environment temperature during working		-40		+120	°C
	Short-term environment temperature during working	150hr			+150	°C
		380hr			+140	°C
	Within entire service life of wire zone	150hr			+150	°C
		380hr			+140	°C
1130hr				+130	°C	
Tolerable temperature of H&S wire inductive speed sensor (see figure below)	Coil zone		-40		+150	°C
	Transitional zone		Mixed		Mixed	°C
	Wire zone		-40		+130	°C
	Storage temperature		-20		+50	°C
	Environment temperature during non-working		-40		+130	°C
	Long-term environment temperature during working		-40		+130	°C
	Short-term environment temperature during working				+150	°C
	Within entire service life of wire zone	500hr			+150	°C
		200hr			+160	°C
168hr vibration resistance within each plane	20~71Hz		Acceleration ≥ 40			m/s ²
	71~220Hz		Amplitude ≥ 0.2			mm
Allowable magnetic field intensity of external magnetic field in opposite direction					≤2	kA/m
Insulation resistance (10s, with testing voltage at 100V)	New state		≥1			MΩ
	At end of service		≥100			kΩ
Voltage resistance (1~3s, under 1,200V AC)			No puncture			

Characteristic Parameters

Variable	Value			Unit
	Min.	Typical	Max.	
Resistance under 20° environment temperature	774	860	946	Ω
Inductance	310	370	430	mH
Voltage output at 416rpm of crankshaft	>1650			mV

5. Precautions

- It's only allowed to take the inductive speed sensor out of the packaging material right before the installation on the vehicle or on the tester.
- The inductive speed sensor shall be installed by means of press-in, instead of the hammering.
- It's recommended to adopt partially micro-sealed bolts M6×12 to fix the inductive speed sensor.
- Tightening torque: $8\pm 2\text{Nm}$.
- Air gap between inductive speed sensor and tooth tip of pulse wheel: 0.8~1.2mm

6. Fault phenomenon and judgment method

Fault phenomenon: Start failure and so on.

Precautions: During the repair, use the press-in instead of hammering for installation.

Simple measurement method:

- 1) (Remove the connector) Turn the digital multimeter to Ohm measurement scale and connect two probes to 2# and 3# pins of the sensor respectively. The rated resistance under 20°C shall be $860\Omega\pm 10\%$.
- 2) (Connect the connector) Turn the digital multimeter to AC Voltage measurement scale and connect two probes to 2# and 3# pins of the sensor respectively. When the engine is started, there shall be voltage output.

V. Phase Sensor (Camshaft Position Sensor)

1. Diagram and pins

Pins:

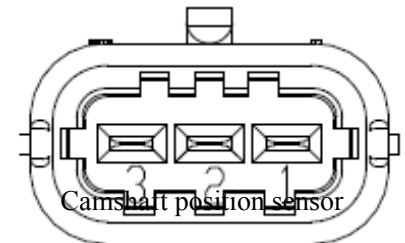
Marking "1" stands for ground;

Marking "2" stands for signal output;

Marking "3" stands for connection to positive pole of power supply.

2. Installation location:

End cap of camshaft.



3. Working Principle

Sensor function: Provide the crankshaft phase information to the ECU, namely differentiating the compression top dead point and the exhaust top dead point of the crankshaft.

Structure: Composed of one Hall sensor and one rotor made of steel plate. The Hall sensor is fixed and the rotor is installed on the camshaft. The rotor is one semi-cylindrical shaped steel blade. When the Hall sensor is covered by this blade, there is no signal output. Otherwise, there is signal output. As two semi-cycles of the camshaft will be equivalent to two complete turns of the crankshaft, the compression top dead point and the exhaust top dead point can be differentiated.

4. Characteristic parameters

Limit Data

Variable		Value			Unit
		Min.	Typical	Max.	
Environment temperature		-40		+130	°C
Space vibration acceleration	Environment temperature 130-5°C, 50hr	500			m/s ²
	Environment temperature 130-5°C, 25hr	600			m/s ²

Notice: There are two holes on the sensor housing for fixing purpose.

5. Fault phenomenon and judgment method

Fault phenomenon: Out-of-limit of emission, increased fuel consumption, and so on.

Simple measurement method:

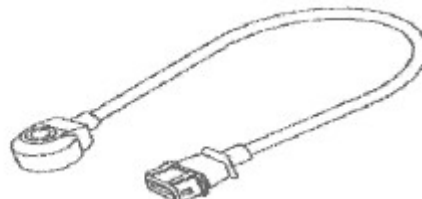
(Connect the connector) Turn on the ignition switch, but do not start the engine. Turn the digital multimeter to DC Voltage measurement scale and connector two probes to 1# and 3# pins of the sensor respectively. Ensure there is the presence of 12V reference voltage. When the engine is started, check with automotive oscilloscope whether the signal at 2# pin is normal.

VI. Knock Sensor

1. Diagram and pins



Knock sensor without cable



Knock sensor with cable

Pins: 1# and 2# are connected to ECU and 3# is connected to shield.

2. Installation location:

For 3-cylinder engine, it's installed in the middle of 2# cylinder. For 4-cylinder engine, it's installed between 2# and 3# cylinders.

3. Working Principle

The knock sensor is one kind of vibration acceleration sensor and is installed on the engine cylinder block. One or more sensor(s) can be installed. The sensing unit of the sensor is one piezoelectric unit. The vibration of the engine cylinder block is transmitted to the piezoelectric crystal via the mass block within the sensor. Under the pressure generated from the vibration of mass block, the piezoelectric crystal generates voltage between two electrode faces and converts the vibration signal to alternating voltage signal output. Its frequency response characteristic curve is shown in the figure below. As the frequency of the vibration signal arising from the engine knock is greatly higher than that of normal engine vibration signal, the ECU can differentiate the knock signal and non-knock signal after processing the signal of the knock sensor.

The knock sensor can be classified by structure as two types (with cable and without cable) at customers' choice.

4. Characteristic Parameters

Limit Data

Variable	Value			Unit
	Min.	Typical	Max.	
Working temperature	-40		+130	°C

Characteristic Data

Variable		Value	Unit
Sensitivity of new sensor towards 5kHz signal		26±8	mV/g
Linearity between 3kHz and 15kHz		±15% of 5kHz	
Linearity at resonance		15~39	mV/g
Variation during entire service life		-17% Max.	
Main resonance frequency		>20	kHz
Impedance	Resistance	>1	MΩ
	Capacity	1200±400	pF
	Cable capacity thereof	280±60	pF/m
Leak resistance (resistance between two output pins of sensor)		4.8±15%	MΩ
Sensitivity variation arising from temperature		≤-0.06	mV/g°K

5. Precautions

There is one hole in the middle of the knock sensor and one M8 bolt is used to fix the sensor onto the cylinder block. For aluminum alloy cylinder block, the bolt with 30mm length is adopted. For cast iron cylinder block, the bolt with 25mm length is adopted. The tightening torque shall be 20±5Nm. The installation location shall ensure that the sensor can easily receive the vibration signal from all cylinders. The best installation location of the knock sensor shall be determined by means of the model analysis of the engine block. Generally, the knock sensor is installed between 2# and 3# cylinders for 4-cylinder engines and in the middle of 2# cylinder for 3-cylinder engines. Notice to keep various fluids (such as engine oil, coolant, brake fluid, and water) away from long-term contact with the sensor. During the installation, the use of all kinds of gaskets is disallowed. The sensor shall cling with its metallic surface to the cylinder block. The wire arrangement for the signal cable of the sensor shall be cautioned to keep the signal cable from resonance, in order to prevent breakage. Make sure to prevent applying high voltage between 1# and 2# pins of the sensor, or it may damage the piezoelectric unit.

6. Fault phenomenon and judgment method

Fault phenomenon: Poor acceleration and so on.

General fault causes: The sensor is corroded due to long-term contact with various fluids (such as engine oil, coolant, brake fluid, and water).

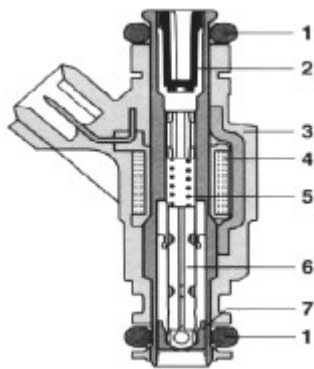
Simple measurement method:

(Remove the connector) Turn the digital multimeter to Ohm measurement scale and connect two probes to 1# and 2# pins and 1# and 3# pins of the sensor respectively. The resistance under atmosphere temperature shall be above $1M\Omega$. Turn the digital multimeter to mV measurement scale and knock lightly the vicinity of the knock sensor with small hammer. In such case, there shall be the presence of voltage signal output.

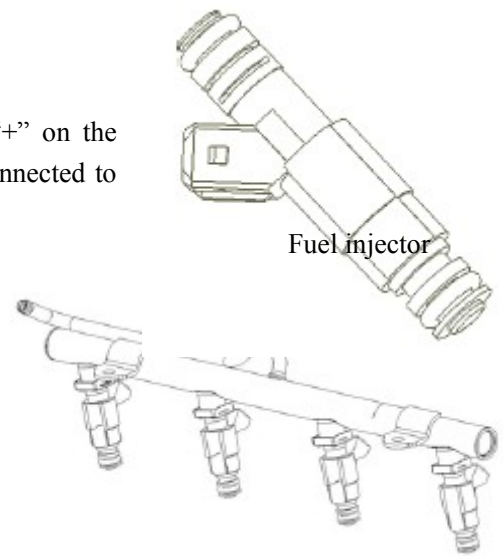
VII. Fuel Injector

1. Diagram and pins

Pins: Each fuel injector has two pins, of which the pin marked with “+” on the housing side is connected to main relay output end and another pin is connected to the ECU end.



1. O-ring
2. Strainer
3. Fuel injector body with electric plug
4. Coil
5. Spring
6. Valve needle with coil armature
7. Valve seat with orifice plate



Sectional view of fuel injector

2. Installation location:

On the air intake manifold, closing to the air intake valve.

3. Working principle

The ECU issues the electric pulse to the coil of fuel injector to form the magnetic field force. When the magnetic field force is increased to overcome the resultant force from return spring pressure, needle valve gravity force, and friction force, the needle valve starts to lift and the fuel injection process begins. When the fuel injection pulse is ended, the pressure of the return spring will re-close the needle valve.

4. Technical characteristic parameters

Limit Data

Variable	Value			Unit
	Min.	Typical	Max.	
Storage temperature (as supplied package)	-40		+70	°C
Allowable temperature of fuel injector within vehicle (non-working)			+140	°C
Working temperature of fuel injector	Continuously	-40	+110	°C
	Short-term after hot start (approximate 3min)		+130	°C
Allowable temperature of fuel at inlet of fuel injector	Continuously		+70	°C
	Short-term (approximate 3min)		+130	°C
Temperature on which the variation of fuel flow reaches 5% against fuel flow at 20°C	-40		+45	°C
Allowable leakage of O-ring within -35~-40°C	Within the O-ring area, the fuel moisture is allowed, but the fuel drops are prohibited.			
Max. allowable vibration acceleration (peak)			400	m/s ²
Power supply voltage	6		16	V
Insulation resistance	1			MΩ
Tolerable internal fuel pressure			1100	kPa
Tolerable bending stress			6	Nm
Tolerable axial stress			600	N

Characteristic Data

Variable	Value			Unit
	Min.	Typical	Max.	
Working pressure (pressure difference)		400		kPa
Resistance of fuel injector at 20°C	11		16	Ω

Allowable Fuel Grades

The fuel injector shall only use the fuels specified in the national standard GB 17930-1999 “Automotive Unleaded Gasoline” and the national environment protection standard GWKB1-1999 “Standard on Control of Hazardous Substances in Automotive Gasoline” of the People’s Republic of China, with added detergent additives. It shall be specially pointed out that the gasoline will deteriorate after excessively long storage period. Especially for the dual-fuel taxis (LPG + gasoline), which take the LPG as long-term fuel and take the gasoline for start only, though the daily gasoline consumption is really low, the fuel pump runs continuously and the temperature of fuel tank is very high. Within the fuel tank of such vehicles, the gasoline will easily get oxidized and deteriorated and may lead to blockage or damage of fuel injector.

5. Precautions

- 1) Confirm the BOSCH trademark and product number.
- 2) For certain fuel injector, make sure to use corresponding plug and never mix with other plugs.
- 3) To facilitate the installation, it’s recommended to apply silicon-free clean engine oil on the surface of upper O-ring connecting to the fuel distributor pipe. Notice not to contaminate the inside and injection hole of the fuel injector with engine oil.
- 4) Install the fuel injector into the fuel injector seat along the direction perpendicular to the fuel injector seat and then fix the fuel injector onto the fuel injector seat with clip.

Notices:

- (1) The fuel injector clips can be classified by position method into axial positioning clip and the axial/radial positioning clip. Prevent the use error.
 - (2) For the installation of axial positioning fuel injector, make sure that the socket in the middle of the clip fully engages with the groove of the fuel injector and the groove on both sides of clip fully engages with the flange of the fuel injector seat.
 - (3) For the installation of fuel injector with both axial and radial positioning requirements, use the axial/radial positioning clip and ensure that the positioning block of the fuel injector and the positioning pin of the fuel injector seat engage with corresponding grooves on the positioning clip.
 - (4) If there are two grooves on the fuel injector, notice to prevent the wrong engagement, with reference to the installation position of the original part.
- The installation of the fuel injector shall be fulfilled by hand and it's prohibited to knock the fuel injector with tools such as hammer.
 - During the removal and reinstallation of fuel injector, make sure to replace the O-ring. In such case, do not damage the sealing face of the fuel injector.
 - Do not pull out the supporting ring of O-ring from the fuel injector. During the installation, avoid damaging the inlet end, O-ring, supporting ring, orifice plate, and electric plug of fuel injector. Any damaged part is prohibited for use.
 - After the installation of fuel injector, test the sealing performance of the fuel distributor pipe assembly and only the one without leakage is qualified.
 - The failed parts shall be removed manually. Remove the clip from the fuel injector and pull out the fuel injector from the fuel injector seat.
 - After the removal, ensure the cleanliness of the fuel injector seat and avoid the contamination.

6. Fault phenomenon and judgment method

Fault phenomenon: Poor idling, poor acceleration, start failure (difficult start) and so on.

General fault causes: The lack of maintenance leads to accumulation of colloid within the fuel injector and thus leads to failure.

Simple measurement method:

(Remove the connector) Turn the digital multimeter to Ohm measurement scale and connect two probes to two pins of fuel injector respectively. The rated resistance under 20°C shall be 11~16Ω.

Recommendation: Use the fuel injector special cleaning analyzer to conduct periodical cleaning analysis for the fuel injector.

VIII. Canister Control Valve

1. Diagram and pins

Definition of canister control valve pins:

Pins: The canister control valve contains two pins, of which one is connected to main relay and another is connected to ECU pin.



Carbon canister control valve TEV-2

炭罐控制阀 TEV-2

2. Installation location

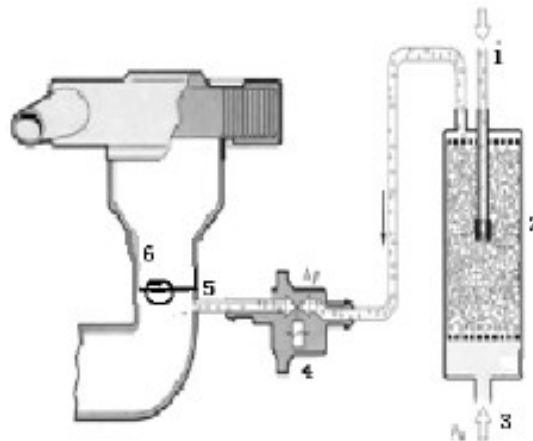
On vacuum pipeline between canister and air intake manifold.



3. Working Principle



Sectional view of
canister control valve



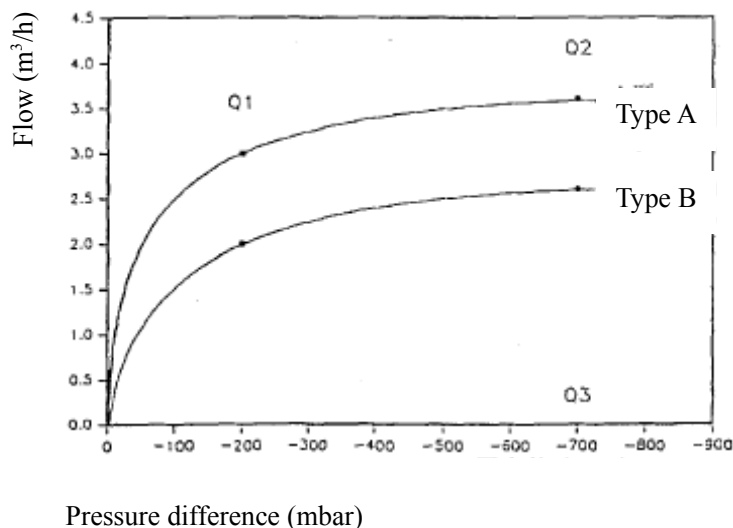
ΔP is difference between environment pressure P_u
and air intake manifold pressure P_s

Installation diagram of canister
control valve

1. From oil tank
2. canister
3. Atmosphere air
4. Canister control valve
5. To air intake manifold
6. Throttle

The canister control valve is composed of the solenoid coil, armature, and valve. The strainer is set at the inlet. The air flow flowing through the canister control valve is on one hand related to the pulse duty ratio of the canister control valve and on another hand is related to the pressure difference between inlet and outlet of the canister control valve. The canister control valve is closed when there is no pulse.

Different types of canister control valve have different flow under 100% duty ratio, namely the valves are thoroughly opened. The figure below gives two typical flow curves. It can be read from this figure that, under the 200mbar pressure difference, the flow at thoroughly open state is 3.0m³/h for type A canister control valve and is 2.0m³/h for type B canister control valve.



(This vehicle model is type A) Canister control valve flow diagram

4. Technical Characteristic Parameters

Limit Data

Variable	Value			Unit
	Min.	Typical	Max.	
Working voltage	9		16	V
1min over-voltage		22		V
Min. start voltage	7			V
Min. voltage drop	1.0			V
Allowable working temperature	-30		+120	°C
Short-term allowable working temperature			+130	°C
Allowable storage temperature	-40		+130	°C
Tolerable pressure difference between inlet and outlet			800	mbar
Allowable switching cycle		10 ⁸		
Allowable vibration acceleration on product			300	m/s ²
Leakage at 400mbar pressure difference			0.002	m ³ /h

Characteristic Data

Variable		Value			Unit
		Min.	Typical	Max.	
Rated voltage			13.5		V
Resistance under +20°C			26		Ω
Current under rated voltage			0.5		A
Frequency of control pulse				30	Hz
Typical control pulse width	Type A		7		ms
	Type B		6		ms
Flow under 200mbar pressure difference and 100% duty ratio	Type A	2.7	3.0	3.3	m³/h
	Type B	1.7	2.0	2.3	m³/h

5. Precautions

- To avoid the transmission of solid-borne noise, it's recommended to install the canister control valve on the hose in such manner that the control valve hangs in the air.
- During the installation, ensure that the air flow direction complies with the requirement.
- Make sure to adopt proper measures (such as filtration, purification) to prevent the ingress of foreign matters (such as particles) into the canister control valve via canister or hose. It's recommended to install one corresponding protective filter on the outlet of the canister.

6. Fault phenomenon and judgment method

Fault phenomenon: Function failure and so on.

General fault causes: The ingress of foreign matters into the valve leads to rusting or poor sealing performance.

Precautions:

1. During the installation, ensure that the air flow direction complies with the requirement.

2. Upon the detection that the black particles within the valve lead to the failure of control valve and it's necessary to replace the control valve, check the condition of the canister.
3. During the repair, prevent the ingress of fluids (such as water and oil) into the valve as far as possible.
4. To avoid the transmission of solid-borne noise, it's recommended to install the canister control valve on the hose in such manner that the control valve hangs in the air.

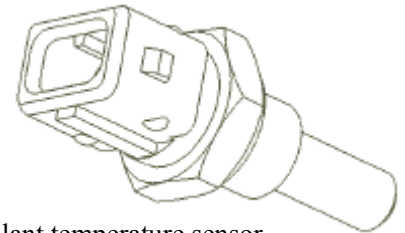
Simple measurement method:

Turn the digital multimeter to Ohm measurement scale and connect two probes to two pins of canister control valve. The rated resistance under 20°C shall be $26\pm 4\Omega$.

IX. Coolant Temperature Sensor

1. Diagram and pins

Pins: This sensor contains two pins, which are interchangeable.



Coolant temperature sensor

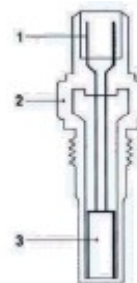
2. Installation location:

Installed on the outlet of engine.

3. Working Principle

This sensor is one negative temperature coefficient (NTC) thermal-sensitive resistor, of which the resistance reduces following the increasing of coolant temperature, but not in linear relationship. The NTC thermal-sensitive resistor is installed on one copper surface, as shown in the figure below.

Structural diagram



1. Electric plug
2. Housing
3. NTC resistor

Sectional view of coolant temperature sensor

4. Technical Characteristic Parameters

Variable	Value	Unit
Rated voltage	Functional only by ECU	
Rated resistance under 20°C	$2.5\pm 5\%$	$k\Omega$
Working temperature range	-30~+130	°C
Max. measurement current through sensor	1	mA
Allowable vibration acceleration	600	m/s^2

Characteristic Data

No.	Resistance (kΩ)				Temperature (°C)
	Temperature tolerance ±1°C		Temperature tolerance ±0°C		
	Min.	Max.	Min.	Max.	
1	8.16	10.74	8.62	10.28	-10
2	2.27	2.73	2.37	2.63	+20
3	0.290	0.354	0.299	0.345	+80

5. Precautions

The coolant temperature sensor is installed on the cylinder block and the copper heat conduction sleeve shall be inserted into the coolant. The sleeve contains thread. By means of the hexagon head on the sleeve, the coolant temperature sensor can be easily screwed into the threaded hole of the cylinder block. Max. allowable tightening torque shall be 15Nm.

6. Fault phenomenon and judgment method

Fault phenomenon: Difficult start and so on.

Simple measurement method:

(Remove the connector) Turn the digital multimeter to Ohm measurement scale and connect two probes to 1# and 2# pins of sensor respectively. The rated resistance under 20°C shall be 2.5k Ω $\pm$ 5%. The simulation method can be used for measurement, namely immerse the working area of the sensor into the boiling water (notice that the immersion time shall be sufficient) and observe the variation of sensor resistance. In such case, the resistance shall drop to 300 Ω ~400 Ω (Depending on the temperature of the boiling water).

X. Idling Stepping Motor

1. Diagram and pins

The pin A is connected to 22# pin of ECU

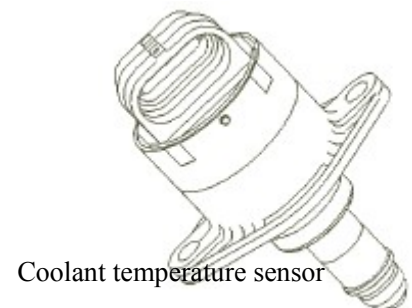
The pin B is connected to 21# pin of ECU

The pin C is connected to 35# pin of ECU

The pin D is connected to 36# pin of ECU

2. Installation Location:

On the throttle body.

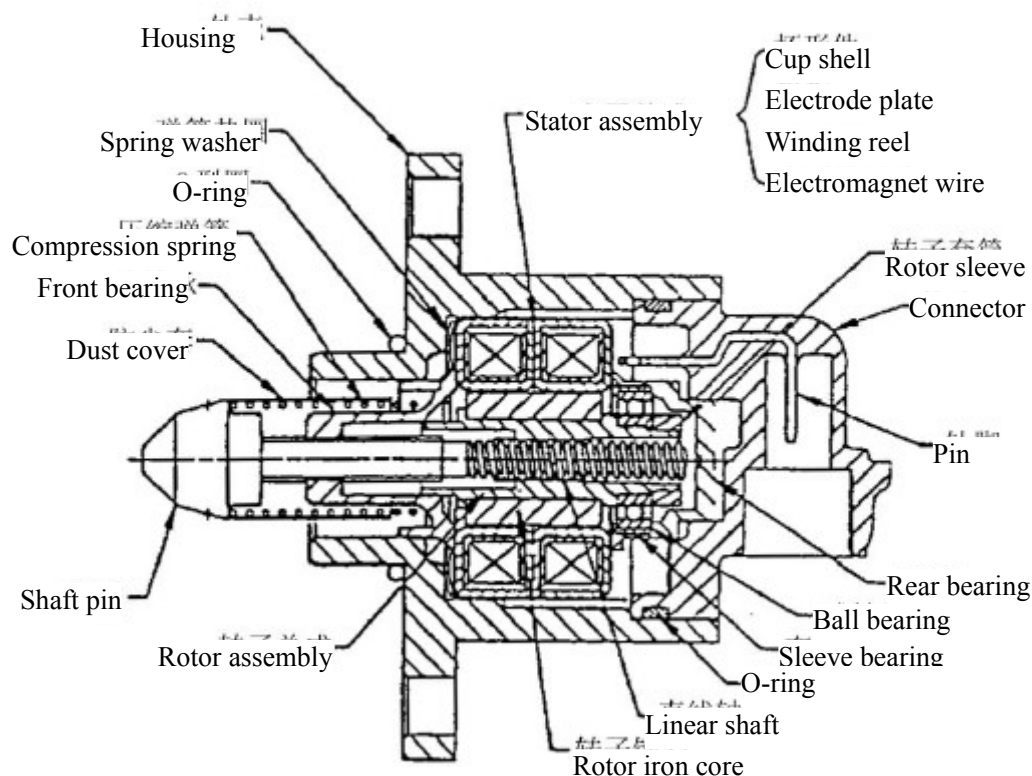


Coolant temperature sensor

3. Working Principle

The stepping motor is one miniature motor composed of multiple steel stators that form one circle and one rotor, as shown in the figure below. Each steel stator is wound with one coil. The rotor is one permanent magnet, of which the center is one nut. All stator coils are constantly electrified. The rotor turns for one certain angle once the current direction of any coil is changed. When the current direction of various stator coils is changed as per the appropriate order, one rotating magnetic field is formed so that the rotor made of permanent magnet rotates in certain direction. If the order for change of current direction is reversed, the rotation direction of the rotor is also reversed. The nut connected to the rotor center drives one screw. The screw is designed in such manner that it can't be rotated, therefore it can move axially, which is referred to as linear shaft. The end of the screw is one plug so that the plug can retract or extend accordingly to increase or reduce the sectional area of by-intake passage of idling actuator, till the by-intake passage is thoroughly blocked. Once the current direction of certain coil is changed, the rotor turns for one fixed angle, which is referred to as one step and equal to 360° divided by the number of the stators or coils. The step of this stepping motor rotor is 15° Accordingly, the distance for each movement of the screw is also fixed. By controlling the change times of the coil current direction, the ECU controls the number of the movement steps of the stepping motor to adjust the sectional area

of the bypass passage and the air flow passing through. Generally, the air flow is in linear relationship with the step. There is one spring behind the plug of the screw end, as shown in figure below. The force available in the extension direction of the plug is equal to the force of the stepping motor plus the spring force and the force available in the retraction direction of the plug is equal to the force of the stepping motor subtracted by the spring force.



4. Technical Characteristic Parameters

Limit Data

Variable	Value			Unit
	Min.	Typical	Max.	
Working voltage	-40		+125	°C
Max. allowable cycles for contact seat of stepping motor plug			2.0×10^6	Cycle

Characteristic Data

Variable	Value			Unit
	Min.	Typical	Max.	
Resistance of each coil under 25°C	47.7	53	58.3	Ω
Resistance of each coil within working temperature range	35 (-40°C)		95 (+125°C)	Ω
Inductance of each coil against 1000Hz under 25°C	26.8	33.5	40.2	mH
Normal working voltage	7.5		12.0	V
Possible working voltage	3.5		14.0	V
Step of stepping motor rotor		15		Degree
Pressure drop between two ends when bypass passage is opened		60		kPa
Max. axial force arising from air pressure difference		6.28		N

5. Precautions

The stepping motor idling actuator is installed on the throttle body casting, forming bypass passage between two ends of throttle.

- 1) The tightening torque for bolts shall be $4.0 \pm 0.4 \text{ Nm}$. Use 8×14 bolts.
- 2) During installation, use the spring washers and apply sealant.
- 3) The shaft with stepping motor idling actuator shall not be installed at horizontal status or below the horizontal status, in order to prevent the ingress of condensate water.
- 4) Do not apply any kind of axial force to press in or pull out the shaft.
- 5) Before installing the idling actuator with stepping motor into the throttle body, its shaft must be thoroughly retracted.

6. Fault phenomenon and judgment method

Fault phenomenon: Over-high idling speed, engine flameout during idling, and so on.

General fault causes: The accumulation of dust or oil gas causes the partial blockage of bypass air passage, leading to abnormal idling adjustment of stepping motor.

Precautions:

- 1) Do not apply any kind of axial force to press in or pull out the shaft.
- 2) Before installing the idling actuator with stepping motor into the throttle body, its shaft must be thoroughly retracted.
- 3) Pay attention to the cleaning and maintenance of bypass air passage.
- 4) After removing the battery or ECU, notice to conduct the self-learning of stepping motor timely.

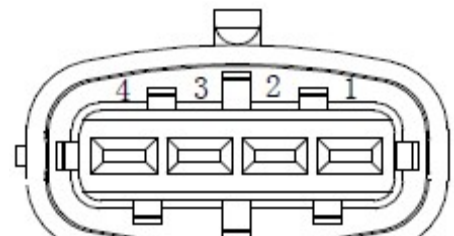
Self-learning method of M780 system: Turn on the ignition switch, but do not start the engine immediately. After waiting for 5s, start the engine. In such case, upon the detection of poor idling of the engine, repeat above step.

Simple measurement method:

(Remove the connector) Turn the digital multimeter to Ohm measurement scale and connect two probes to AD and BC pins of the regulator. The rated resistance under 25°C shall be $53 \pm 5.3 \Omega$.

XI. Air Intake Pressure and Temperature Sensor

1. Diagram and pins



Definition of pins for air intake pressure and temperature sensor



Air intake pressure and temperature sensor

进气压力温度传感器

Pins: 1# is grounded;
 2# outputs the temperature signal;
 3# is powered by 5V;
 4# outputs the pressure signal.

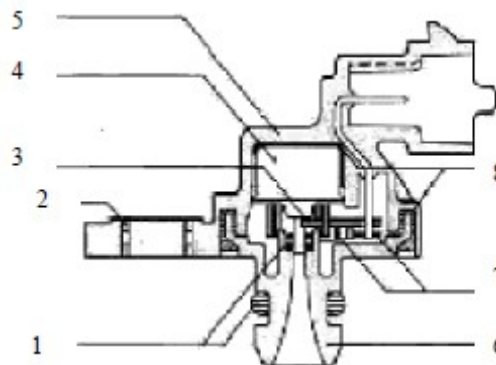
2. Installation location:

This sensor is composed of two sensor, namely air intake manifold absolute pressure sensor and air intake temperature sensor and is installed on the air intake manifold.

3. Working Principle

The air intake manifold absolute pressure sensing unit is composed of one silicone chip. One pressure diaphragm is etched on this silicone chip. There are four piezoelectric resistors on the pressure diaphragm. Being the strain units, four piezoelectric resistors form one Wheatstone bridge. In addition to this pressure diaphragm, the silicone chip integrates the signal processing circuit. The silicone chip works with one metallic housing to form one enclosed reference room, in which the absolute air pressure closes to zero. In such case, one micro-electronic mechanical system is formed. The active surface of the silicone chip is subject to a near-zero pressure and its back surface is subject to the air intake manifold absolute pressure introduced by one connecting pipe for measurement. The thickness of the silicone chip is only several micrometers (μm) so that the variation of air intake manifold absolute pressure will result in the mechanical deformation of the silicone chip and four piezoelectric resistors will deform accordingly, in which their resistances are altered. After being processed by the signal processing circuit of the silicone chip, it forms the voltage signal in linear relationship with the pressure.

The air intake temperature sensing unit is one negative temperature coefficient (NTC) resistor, of which the resistance varies following the air intake temperature. This sensor provides the controller with one voltage indicating the variation of air intake temperature.



Sectional view of air intake manifold absolute pressure and air intake temperature sensor

1. Seal ring 2. Stainless steel bush 3. PCB board 4. Sensing unit 5. Housing
 6. Pressure bracket 7. Welded connection 8. Adhesion connection

4. Technical characteristic parameters

Limit Data

Variable	Value			Unit
	Min.	Typical	Max.	
Power voltage resistance			16	V
Pressure resistance			500	kPa
Storage temperature resistance	-40		+130	°C

Characteristic Data

Variable	Value			Unit
	Min.	Typical	Max.	
Pressure measurement range	20		115	kPa
Working temperature	-40		125	°C
Working power voltage	4.5	5.0	5.5	V
Current under $U_s=5.0V$	6.0	9.0	12.5	mA
Load current of output circuit	-0.1		0.1	mA
Load resistance against ground or battery	50			kΩ
Response time		0.2		ms
Mass		27		g

(1) Transfer function of pressure sensor

$$U_A = (c_1 p_{abs} + C_0) U_s$$

Of which, U_A = Signal output voltage (V)

U_s = Power voltage (V)

C_0 = Absolute pressure (kPa)

$p_{abs} = -9.4/95$

$c_1=0.85/95$ (1/kPa)

It can be seen from above equation that the signal output voltage of the pressure sensor equals to the power voltage under atmosphere pressure.

If the power voltage is 5v, the signal output voltage of the pressure sensor is approximate 4.5V when the throttle is thoroughly open.

(2) Limit data of temperature sensor

Storage temperature: -40/+130°C

Bearing capacity under 25°C: 100mW

(3) Characteristic data of temperature sensor

Working temperature: -40/+125°C

Voltage rating: Work under 5V with 1kΩ pre-resistor or work with ≤1mA testing current.

Rated resistance under 20°C: 2.5kΩ ± 5%

Temperature-time coefficient in air τ_{63} , $v=6m/s$: ≤45ss

5. Precautions

This sensor is designed to be installed on the plane of the automotive engine air intake manifold. Both the pressure connecting pipe and the temperature sensor protrude in the air intake manifold and adopt one O-ring to realize the air-tightness against the air.

If appropriate mode is adopted to install this sensor onto the vehicle (such as take the pressure from air intake manifold or incline downward the pressure connecting pipe), it can be guaranteed that the condensate water will not form on the pressure sensitive unit.

The drilling and fixing on the air intake manifold must be conducted as per the supply diagram, in order to guarantee the long-term sealing and resistance against the corrosion of media.

The reliability of the electric connections is mainly subject to the influence of the connectors of the parts and also is related to the material quality and the size precision of the fitting connectors on the harness.

6. Fault phenomenon and judgment method

Fault phenomenon: Engine flameout, poor idling, and so on.

General fault causes:

1. Abnormal high voltage or high reverse current during working.
2. Damage of vacuum units during repair.

Precautions: During the repair, it's prohibited to blow the vacuum units with high pressure air. When it's necessary to replace the fault sensor, check whether the alternator output voltage and current are normal.

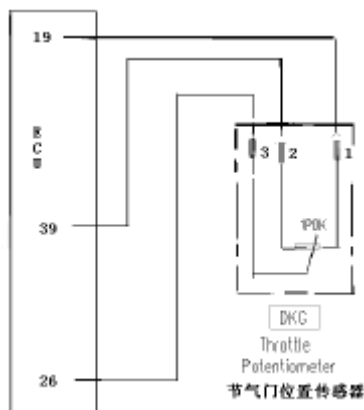
Simple measurement method:

Temperature sensor part: (Remove the connector) Turn the digital multimeter to Ohm measurement scale and connect two probes to 1# and 2# pins of the sensor. The rated resistance under 20°C shall be $2.5k\Omega \pm 5\%$. Also, the simulation method may be used for measurement. Use the blow driver to blow the sensor (Pay attention not to close too much) and observe the resistance variation of the sensor. In such case, the resistance shall drop.

Pressure sensor part: (Connect the connector) Turn the digital multimeter to DC Voltage measurement scale and connect the black probe to ground and connect the red probe to 3# and 4# pins respectively. Under the idling, there shall be 5V reference voltage at 3# pin and approximate 1.3V voltage at 4# pin (depending on the specific vehicle model). When slowly opening the throttle under unloaded status, the voltage variation is not much at 4# pin. When rapidly opening the throttle, the voltage at 4# pin can instantaneously reach approximate 4V (depending on the specific vehicle model) and then lower to approximate 1.5V (depending on the specific vehicle model).

XII. Throttle Position Sensor

1. Diagram and pins



Circuit diagram of throttle position sensor

Pins:

For those rotating the throttle counter-clockwise (when observed from sensor side to throttle along the throttle axis) to increase open extent: 1# pin is grounded and 2# pin is connected to 5V power supply;

For those rotating the throttle clockwise (when observed from sensor side to throttle along the throttle axis) to increase open extent: 1# pin is connected to 5V power supply, 2# pin is grounded, and 3# pin outputs the signal.

2. Installation location

Installed on the throttle body.

3. Working principle

This sensor is one angle sensor with linear output and is composed of two arc slide resistors and two sliders. The rotating shafts of the sliders are connected to one same axis along with the throttle shaft. Two ends of the slide resistors are charged with 5V power voltage U_s . When the throttle rotates, the slider rotates accordingly and at the same time moves on the slide resistor and imports the potential at the contact U_p as the voltage output. Therefore, it's actually one angle potentiometer, which outputs the voltage signal in proportion to the throttle position.

4. Technical characteristic parameters

Limit Data

Variable	Value	Unit
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Mechanical angle between two limit positions	≥ 95	Degree
Available electric angle between two limit positions	≤ 86	Degree
Allowable slider current	≤ 18	μA
Storage temperature	$-40/+130$	$^{\circ}\text{C}$
Allowable vibration acceleration	≤ 700	m/s^2

Characteristic Data

Variable	Value			Unit
	Min.	Typical	Max.	
Total resistance (between 1# and 2# pins)	1.6	2.0	2.4	$\text{k}\Omega$
Slider protection resistance (between 2# and 3# pins, with slider at zero position)	710		1380	Ω
Working temperature	-40		130	$^{\circ}\text{C}$
Power voltage		5		V
Voltage ratio at right limit position	0.04		0.093	
Voltage ratio at left limit position	0.873		0.960	
Increment following throttle rotation angle U_p/U_s		0.00927		1/dgree
Mass	22	25	28	g

5. Precautions

In consideration of the leakage at shaft sealed portion of throttle after long-term service, it's recommended to deflect the throttle shaft by at least 30° with respect to the vertical direction for installation. The allowable tightening torque for fixing screws shall be 1.5Nm~2.5Nm.

6. Fault phenomenon and judgment method

Fault phenomenon: Poor acceleration and so on.

Precautions: Notice the installation position.

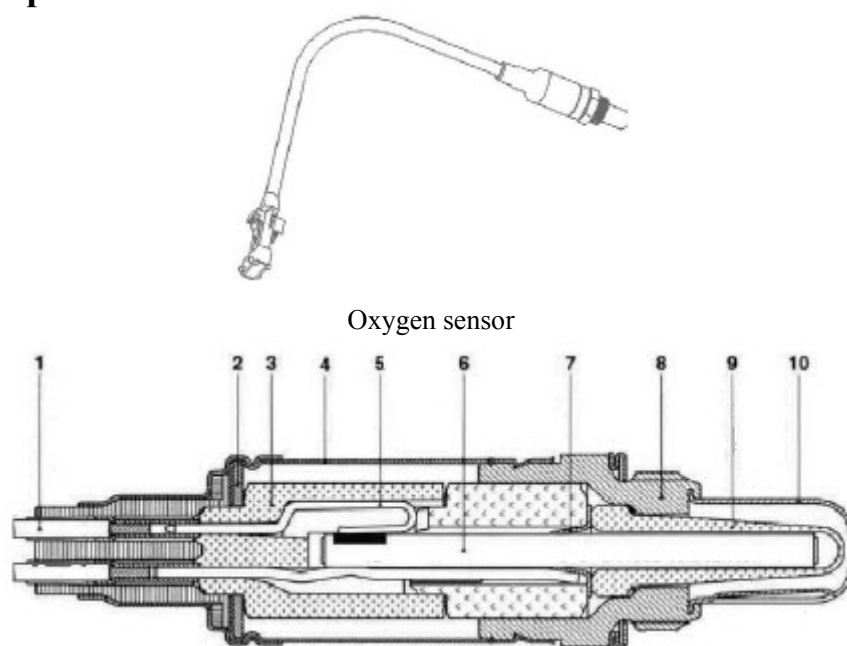
Simple measurement method:

- (Remove the connector) Turn the digital multimeter to Ohm measurement scale and connect two probes to 1# and 2# pins of the sensor respectively. The resistance under ambient temperature is $2\text{k}\Omega \pm 20\%$. Connect two probes to 1# and 3# pins respectively and rotate the throttle. Its resistance shall vary linearly following the opening of the throttle. The measurement between 2# and 3# pins shall be on the contrary.
- (Connect the connector) Turn on the ignition switch, but do not start the engine. Turn the digital multimeter to DC Voltage measurement scale and connect the black probe to ground and connect the red probe to 2# pin. In such case, there shall be the presence of 5V reference voltage. When connecting the red probe to 3# pin, the voltage measurement shall be approximate 0.3V when the throttle is thoroughly closed (depending on the specific vehicle model) and shall be approximate 3V when the throttle is thoroughly opened (depending on the specific vehicle model).

Note: When observing the resistance variation, pay attention to observe whether there is any resistance jump.

XIII. Oxygen Sensor

1. Diagram and pins



1. Cable 2. Disc washer 3. Insulation bush 4. Protective sleeve 5. Heating unit gripping connector
6. Heating rod 7. Contact gasket 8. Sensor seat 9. Ceramic probe 10. Protection tube

Sectional view of oxygen sensor

The oxygen sensor is equipped with one cable, of which one end is one electric connector. The electric connector of the oxygen sensor manufactured by our company includes four pins:

1# = Sensor ground 2# = Sensor signal 3# = Sensor + 4# = Main relay

2. Installation location:

The front of the exhaust pipe.

3. Working principle

The sensing unit of the oxygen sensor is one ceramic tube with porosity, of which the outside is surrounded by the engine emission and the inside is connected to the atmosphere air. The sensing ceramic tube wall is one kind of solid electrolyte and the ceramic tube contains the built-in electric heating tube, as shown in figure 3-17.

The oxygen sensor is functioned to convert the oxygen ion concentration difference between inside and outside of the sensing ceramic tube to voltage signal output. When the temperature of the sensing ceramic tube reaches 400°C, embodying the characteristic of the solid electrolyte, the special material enables the oxygen ion to pass through the ceramic tube freely. By utilizing this characteristic, the concentration difference is converted to potential difference to form the electric signal output. If the gas mixture is too dense, the oxygen ion concentration difference between inside and outside of ceramic tube will be high and the potential difference will be high so that a large amount of oxygen ion transfers from inside to outside of the ceramic tube and thus the voltage output is high (closing to 800mV~1000mV). If the gas mixture is too thin, the oxygen ion concentration difference between inside and outside of ceramic tube will be lower and the potential difference will be lower so that only a small amount of oxygen ion transfers from inside to outside of the ceramic tube and thus the voltage output is low (closing to 100mV). The signal voltage changes abruptly in the vicinity of the theoretical equivalent air-fuel ratio ($\lambda=1$), as shown in the figure above.

4. Technical characteristic parameters

Limit Data

Variable	Value	Unit
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		Min.	Typical	Max.	
Storage temperature		-40		+100	°C
Working temperature	Ceramic tube end	200		850	°C
	Housing hexagon head			≤570	°C
	Cable metallic retainer ring and connecting cable			≤250	°C
	Connector			≤120	°C

Max. allowable temperature when heating unit is electrified (Max. 10min for each cycle, Max. 40hr in total)	Emission at ceramic tube end			930	°C
	Housing hexagon head			630	°C
	Cable metallic retainer ring and connecting cable			280	°C
Allowable temperature variation ratio at ceramic tube end				≤100	K/s
Allowable temperature of ceramic unit when there is condensate water at exhaust side				≤400	°C
Allowable vibration of housing	Random vibration (peak)			≤800	m/s ²
	Simple harmonic vibration (vibration displacement)			≤0.3	mm
	Simple harmonic vibration (vibration acceleration)			≤300	m/s ²
Continuous DC current under 400°C				Absolute value≤10	μA
Max. continuous AC current under ≥400°C exhaust temperature and f≥1Hz				±20	μA
Allowable fuel additive		Unleaded gasoline, or allowable lead content up to 0.15g/L			
Consumption and combustion of engine oil		The allowable value and data must be determined by customers as per proper scale of tests. Guidance value: ≤0.7L/1000km			

Characteristic Data

Variable	New		After 250hr stand test	
Exhaust temperature established by characteristic data	400°C	850°C	400°C	850°C
Sensing unit voltage under λ=0.97 (CO=1%) (mV)	840±70	710±70	840±70	710±70
Sensing unit voltage under λ=1.10 (mV)	20±50	50±30	20±50	40±40
Internal resistance of sensing unit (kΩ)	≤1.0	≤0.1	≤1.5	≤0.3
Response time (ms) (600mV~300mV)	<200	<200	<400	<400
Response time (ms) (300mV~600mV)	<200	<200	<400	<400

Electric Data of Sensor

Variable		Value	Unit
Insulation resistance between new sensor heating unit and sensor connector	Ambient temperature, with heating unit powered off	≥ 30	M Ω
	Exhaust temperature at 400°C	≥ 10	M Ω
	Exhaust temperature at 850°C	≥ 100	k Ω
Power voltage on connector	Rated voltage	12	V
	Continuous working voltage	12~14	V
	Working voltage maintaining up to 1% overall life (exhaust temperature $\leq 850^{\circ}\text{C}$)	15	V
	Working voltage maintaining up to 75s (exhaust temperature $\leq 400^{\circ}\text{C}$)	24	V
	Testing voltage	13	V
Heating power when the thermal equilibrium is reached, with working voltage at 13V (exhaust temperature at 400°C and exhaust flow at approximate 0.7m/s)		12	W
Heating current when the thermal equilibrium is reached, with working voltage at 13V (exhaust temperature at 400°C and exhaust flow at approximate 0.7m/s)		5	A
Fuse of heating circuit		8	A

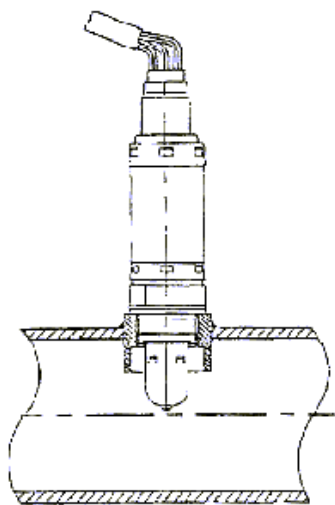
Service Life

The service life of the oxygen sensor is related to the lead content in the gasoline, as shown in the table below.

Lead content in gasoline (g/L)	Life (km)
≤ 0.6	30,000
≤ 0.4	50,000
≤ 0.15	80,000
≤ 0.005 (unleaded gasoline)	160,000

5. Precautions

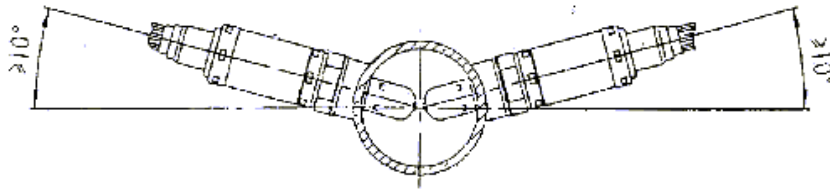
The oxygen sensor is installed on the exhaust pipe in such manner that the installation location can stand for the emission contents and meet the specified temperature limit. The installation location shall close to the engine as far as possible. The exhaust pipe contains the thread for engagement with the oxygen sensor, as shown in the figure below.



Installation location of oxygen sensor

Installation gesture of oxygen sensor

The oxygen sensor shall be installed to form $\geq 10^{\circ}$ angle with the horizontal surface, with the sensor tip facing downward, in order to prevent the accumulation of condensate water between the sensor housing and the sensing ceramic tube during the cold start, as shown in the figure below.



Installation gesture of oxygen sensor

- Requirement of exhaust pipe: To enable the rapid radiation of exhaust pipe part in front of the oxygen sensor. If possible, the exhaust pipe shall be designed to incline downward, in order to prevent the accumulation of condensate water in front of the sensor.
- Do not expose the cable metallic retainer ring on oxygen sensor side to inappropriate heating, especially when the engine is stopped.
- Do not use the detergent, oily fluid or volatile solid on the connector of oxygen sensor.
- The thread of oxygen sensor is M18×1.5.
- The hexagon head wrench for oxygen sensor is 22-0.33.
- The tightening torque for oxygen sensor shall be 40~60Nm.

6. Fault phenomenon and judgment method

Fault phenomenon: Poor idling, poor acceleration, out-of-limit of exhaust emission, excessive fuel consumption, and so on.

General fault causes:

1. The moisture vapor enters into the sensor, resulting in sudden change of temperature and breakage of probe.
2. “Intoxication” of oxygen sensor. (Pb, S, Br, Si)

Precautions: During the repair, it’s prohibited to use the detergent, oily fluid or volatile solid on the oxygen sensor.

Simple measurement method:

1. (Remove the connector) Turn the digital multimeter to Ohm measurement scale and connect two probes to 1# (white) and 2# (white) pins of the sensor respectively. The resistance under ambient temperature shall be 1~6Ω.
2. (Connect the connector) Under the idling, after waiting for the oxygen sensor to reach the working temperature 400°C, turn the digital multimeter to DC Voltage measurement scale and connect two probes to 3# (gray) and 4# (black) pins of the sensor respectively. In such case, the voltage measurement shall fluctuate rapidly between 0.1V and 0.9V.

Section II. Common Faults and Diagnosis Flow for M780 UAES System

1. Fault Diagnosis Procedure

(1) Before conducting the fault diagnosis procedure as per the engine fault phenomenon, firstly conduct the initial checking:

- 1) Confirm whether the engine malfunction indicator lamp functions normally.
- 2) Check with fault diagnosis unit and confirm there is no fault information recorded.
- 3) Conform the presence of fault phenomenon the owner claimed and confirm the conditions when such fault occurred.

(2) Then conduct the appearance checking:

- 1) Check the fuel pipeline for presence of leakage;

- 2) Check the vacuum pipeline for rupture and twist and check whether the connections are correct;
- 3) Check the air intake pipeline for blockage, air leakage, being flattened, and damage.
- 4) Check the high voltage wire of ignition system for breakage and aging and check whether the ignition order is correct.
- 5) Check whether the grounding point of the harness is clean and secure;
 - (1) Check the connectors of various sensors and actuators for looseness or poor contact.

In event of any of above phenomena, firstly conduct the repair in response to such fault phenomenon, or it will influence the afterwards fault diagnosis and repair.

Diagnosis assistance:

1. Confirm that the engine is free of any fault record.
2. Confirm that the fault phenomenon claimed does exist.
3. The checking as per above procedure is completed and no abnormal condition is detected.
4. During the repair, do not neglect the system influences by vehicle maintenance, cylinder pressure, mechanical ignition timing, and fuel condition.
5. Replace the ECU for testing.

In such case, if the fault phenomenon disappears, it indicates that the fault lies in ECU. If the fault phenomenon still exists, replace with original ECU and repeat above procedure for re-checking.

2. Common Fault Phenomena and Diagnosis Flow

1. No rotation or slow rotation of engine during start
2. The engine can rotate with dragging, but can't start successfully during start.
3. Difficult hot start
4. Difficult cold start
5. The engine speed is normal, but the start is difficult at all times.
6. The start is normal, but the idling is unstable at all times.
7. The start is normal, but the idling is unstable during engine warm-up.
8. The start is normal, but the idling is unstable after engine warm-up.
9. The start is normal, but the idling is unstable or engine is stopped under partial load (such as the A/C is turned on).
10. The start is normal, but the idling is too high.
11. The engine speed can't increase or the engine is stopped during acceleration.
12. Slow response during acceleration.
13. Weak acceleration and poor performance.

2.1 No rotation or slow rotation of engine during start

Fault portions:

1. Battery;
2. Starter motor;
3. Harness or ignition switch;
4. Engine mechanical part

Diagnosis flow:

No.	Operation Procedure	Checking result	Subsequent Step
1	Use the multimeter to check whether the voltage between two wiring posts of the battery is approximate 8~12V during the engine start.	Yes	Next
		No	Replace battery
2	Maintain the ignition switch at Start position and use multimeter to check whether there is above 8V voltage at the positive post of starter motor.	Yes	Next
		No	Repair or replace harness
3	Disassemble the starter motor and check working condition of starter motor. Mainly check whether there is open-circuit or blockage due to poor	Yes	Repair or replace starter motor

	lubrication.	No	Next
4	If the fault only occurs in winter, check whether this fault is caused by excessive resistance of starter motor due to improper choice of engine lubricating oil and gearbox oil.	Yes	Replace with lubricating oil with appropriate trademark.
		No	Next
5	Check whether the internal mechanical resistance of the engine is too high, leading to non-rotation or slow rotation of starter motor.	Yes	Check and repair internal resistance of engine.
		No	Repeat above step

2.2 The engine can rotate with dragging, but can't start successfully during start.

Fault portions:

1. No fuel in fuel tank; 2. Fuel pump; 3. Speed sensor; 4. Ignition coil; 5. Engine mechanical part.

Diagnosis flow:

No.	Operation Procedure	Checking result	Subsequent Step
1	Connect the fuel pressure gauge (The connection point shall be the front end of inlet pipe of fuel distributor pipe assembly), start the engine, and check whether the fuel pressure of engine under all condition is approximate 400kPa.	Yes	Next
		No	Check and repair fuel supply system
2	Connect the electronic injection system diagnosis unit, observe the "engine speed" data item, start the engine, and observe whether there is speed signal output.	Yes	Next
		No	Check and repair speed sensor circuit
3	Unplug one cylinder distribution wire, connect the spark plug, position the spark plug electrode to 5mm away from engine block, start the engine, and observe whether there is blue-white high voltage fire.	Yes	Next
		No	Check and repair ignition system
4	Check the pressure condition for each cylinder of engine and observe whether there is insufficient pressure in the engine cylinders.	Yes	Resolve engine mechanical fault
		No	Next
5	Connect electronic injection system adapter, turn on the ignition switch, and check whether the power supply at 12#, 13#, 44#, 45#, and 63# pins is normal and whether the earthing at 3#, 51#, 53#, 61#, and 80# pins is normal.	Yes	Diagnosis help
		No	Check and repair corresponding circuit

2.3 Difficult hot start

Fault portions:

1. Water content in fuel; 2. Fuel pump; 3. Coolant temperature sensor; 4. Fuel pressure regulator vacuum pipe; 5. Ignition coil

Diagnosis flow:

No.	Operation Procedure	Checking result	Subsequent Step
1	Connect the fuel pressure gauge (The connection point shall be the front end of inlet pipe of fuel distributor pipe assembly), start the engine, and check whether the fuel pressure of engine under all condition is approximate 400kPa.	Yes	Next
		No	Check and repair fuel supply system
2	Unplug one cylinder distribution wire, connect the spark plug, position the spark plug electrode to 5mm away from engine block, start the engine, and observe whether there is blue-white high voltage fire.	Yes	Next
		No	Check and repair ignition system
3	Unplug the coolant temperature sensor connector and try to start the engine. Observe whether the engine can start successfully. (Or series connect one 300Ω resistor at the coolant temperature sensor to replace the coolant temperature sensor and observe whether the engine can start successfully.)	Yes	Check and repair circuit or replace sensor
		No	Next
4	Check whether there is looseness or air leakage at the fuel pressure regulator vacuum pipe.	Yes	Check and repair or replace
		No	Next
5	Check the fuel condition and observe whether the fault phenomenon occurs right after the refueling.	Yes	Replace fuel
		No	Next
6	Connect electronic injection system adapter, turn on the ignition switch, and check whether the power supply at 12#, 13#, 44#, 45#, and 63# pins is normal and whether the earthing at 3#, 51#, 53#, 61#, and 80# pins is normal.	Yes	Diagnosis help
		No	Check and repair corresponding circuit

2.4 Difficult cold start

Fault portions:

1. Water content in fuel; 2. Fuel pump; 3. Coolant temperature sensor; 4. Fuel injector; 5. Ignition coil;
6. Throttle body and idling bypass air passage 7. Engine mechanical part

Diagnosis flow:

No.	Operation Procedure	Checking result	Subsequent Step
1	Connect the fuel pressure gauge (The connection point shall be the front end of inlet pipe of fuel distributor pipe assembly), start the engine, and check whether the fuel pressure of engine under all condition is approximate 400kPa.	Yes	Next
		No	Check and repair fuel supply system
2	Unplug one cylinder distribution wire, connect the spark plug, position the spark plug electrode to 5mm away from engine block, start the engine, and observe whether there is blue-white high voltage fire.	Yes	Next
		No	Check and repair ignition system
3	Unplug the coolant temperature sensor connector and try to start the engine. Observe whether the engine can start successfully. (Or series connect one 2500Ω resistor at the coolant temperature sensor to replace the coolant temperature sensor and observe whether the engine can start successfully.)	Yes	Check and repair circuit or replace sensor
		No	Next
4	Step down the accelerator pedal lightly and observe whether the engine can start easier.	Yes	Clean throttle and idling air passage
		No	Next
5	Remove fuel injector and use the fuel injector special cleaning analyzer to	Yes	Replace fault part

	check whether there is leakage or blockage in fuel injector.	No	Next
6	Check the fuel condition and observe whether the fault phenomenon occurs right after the refueling.	Yes	Replace fuel
		No	Next
7	Check the pressure of various cylinders of the engine and observe whether there is insufficient pressure in engine cylinder.	Yes	Resolve engine mechanical fault
		No	Next
8	Connect electronic injection system adapter, turn on the ignition switch, and check whether the power supply at 12#, 13#, 44#, 45#, and 63# pins is normal and whether the earthing at 3#, 51#, 53#, 61#, and 80# pins is normal.	Yes	Diagnosis help
		No	Check and repair corresponding circuit

2.5 The engine speed is normal, but the start is difficult at all times.

Fault portions:

1. Water content in fuel; 2. Fuel pump; 3. Coolant temperature sensor; 4. Fuel injector; 5. Ignition coil;
6. Throttle body and idling bypass air passage; 7. Air intake passage; 8. Ignition timing; 9. Spark plug;
10. Engine mechanical part.

Diagnosis flow:

No.	Operation Procedure	Checking result	Subsequent Step
1	Check whether the air cleaner is blocked and whether there is air leakage in air intake passage.	Yes	Check and repair air intake system
		No	Next
2	Connect the fuel pressure gauge (The connection point shall be the front end of inlet pipe of fuel distributor pipe assembly), start the engine, and check whether the fuel pressure of engine under all condition is approximate 400kPa.	Yes	Next
		No	Check and repair fuel supply system
3	Unplug one cylinder distribution wire, connect the spark plug, position the spark plug electrode to 5mm away from engine block, start the engine, and observe whether there is blue-white high voltage fire.	Yes	Next
		No	Check and repair ignition system
4	Check the spark plug for various cylinders and observe whether the model and gap comply with the specification.	Yes	Next
		No	Adjust or replace
5	Unplug the coolant temperature sensor connector and try to start the engine. Observe whether the engine can start successfully.	Yes	Check and repair circuit or replace sensor
		No	Next
6	Step down the accelerator pedal lightly and observe whether the engine can start easier.	Yes	Clean throttle and idling air passage
		No	Next
7	Remove fuel injector and use the fuel injector special cleaning analyzer to check whether there is leakage or blockage in fuel injector.	Yes	Replace fault part
		No	Next
8	Check the fuel condition and observe whether the fault phenomenon occurs right after the refueling.	Yes	Replace fuel
		No	Next
9	Check the pressure of various cylinders of the engine and observe whether there is insufficient pressure in engine cylinder.	Yes	Resolve engine mechanical fault
		No	Next
10	Check whether the ignition order and ignition timing of the engine comply with the specification.	Yes	Next
		No	Check and repair

			ignition timing
11	Connect electronic injection system adapter, turn on the ignition switch, and check whether the power supply at 12#, 13#, 44#, 45#, and 63# pins is normal and whether the earthing at 3#, 51#, 53#, 61#, and 80# pins is normal.	Yes	Diagnosis help
		No	Check and repair corresponding circuit

2.6 The start is normal, but the idling is unstable at all times.

Fault portions:

1. Water content in fuel; 2. Fuel injector; 3. Spark plug; 4. Throttle body and idling bypass air passage; 5. Air intake passage; 6. Idling regulator; 7. Ignition timing; 8. Spark plug; 10. Engine mechanical part.

Diagnosis flow:

No.	Operation Procedure	Checking result	Subsequent Step
1	Check whether the air cleaner is blocked and whether there is air leakage in air intake passage.	Yes	Check and repair air intake system
		No	Next
2	Check the idling regulator for clamping stagnation	Yes	Clean or replace
		No	Next
3	Check the spark plug for various cylinders and observe whether the model and gap comply with the specification.	Yes	Next
		No	Adjust or replace
4	Check the throttle body and idling bypass air passage for presence of carbon deposit	Yes	Clean
		No	Next
5	Remove fuel injector and use the fuel injector special cleaning analyzer to check whether there is leakage or blockage in fuel injector.	Yes	Replace fault part
		No	Next
6	Check the fuel condition and observe whether the fault phenomenon occurs right after the refueling.	Yes	Replace fuel
		No	Next
7	Check the pressure of various cylinders of the engine and observe whether there is high difference among engine cylinders.	Yes	Resolve engine mechanical fault
		No	Next
8	Check whether the ignition order and ignition timing of the engine comply with the specification.	Yes	Next
		No	Check and repair ignition timing
9	Connect electronic injection system adapter, turn on the ignition switch, and check whether the power supply at 12#, 13#, 44#, 45#, and 63# pins is normal and whether the earthing at 3#, 51#, 53#, 61#, and 80# pins is normal.	Yes	Diagnosis help
		No	Check and repair corresponding circuit

2.7 The start is normal, but the idling is unstable during engine warm-up.

Fault portions:

1. Water content in fuel; 2. Coolant temperature sensor; 3. Spark plug; 4. Throttle body and idling bypass air passage; 5 Air intake passage; 6. Idling regulator; 7. Engine mechanical part.

Diagnosis flow:

No.	Operation Procedure	Checking result	Subsequent Step
1	Check whether the air cleaner is blocked and whether there is air leakage in air intake passage.	Yes	Check and repair air intake system
		No	Next

2	Check the spark plug for various cylinders and observe whether the model and gap comply with the specification.	Yes	Next
		No	Adjust or replace
3	Remove the idling regulator and check the throttle body, idling regulator, and idling bypass air passage for the presence of carbon deposit.	Yes	Clean relevant parts
		No	Next
4	Unplug the coolant temperature sensor connector, start the engine, and observe whether there is unstable idling during the engine warm-up.	Yes	Check and repair circuits or replace sensor
		No	Next
5	Remove fuel injector and use the fuel injector special cleaning analyzer to check whether there is leakage or blockage in fuel injector.	Yes	Replace fault part
		No	Next
6	Check the fuel condition and observe whether the fault phenomenon occurs right after the refueling.	Yes	Replace fuel
		No	Next
7	Check the pressure of various cylinders of the engine and observe whether there is high difference among engine cylinders.	Yes	Resolve engine mechanical fault
		No	Next
8	Connect electronic injection system adapter, turn on the ignition switch, and check whether the power supply at 12#, 13#, 44#, 45#, and 63# pins is normal and whether the earthing at 3#, 51#, 53#, 61#, and 80# pins is normal.	Yes	Diagnosis help
		No	Check and repair corresponding circuit

2.8 The start is normal, but the idling is unstable after engine warm-up.

Fault portions:

1. Water content in fuel; 2. Coolant temperature sensor; 3. Spark plug; 4. Throttle body and idling bypass air passage; 5 Air intake passage; 6. Idling regulator; 7. Engine mechanical part.

Diagnosis flow:

No.	Operation Procedure	Checking result	Subsequent Step
1	Check whether the air cleaner is blocked and whether there is air leakage in air intake passage.	Yes	Check and repair air intake system
		No	Next
2	Check the spark plug for various cylinders and observe whether the model and gap comply with the specification.	Yes	Next
		No	Adjust or replace
3	Remove the idling regulator and check the throttle body, idling regulator, and idling bypass air passage for the presence of carbon deposit.	Yes	Clean relevant parts
		No	Next
4	Unplug the coolant temperature sensor connector, start the engine, and observe whether there is unstable idling during the engine warm-up.	Yes	Check and repair circuits or replace sensor
		No	Next
5	Remove fuel injector and use the fuel injector special cleaning analyzer to check whether there is leakage or blockage in fuel injector.	Yes	Replace fault part
		No	Next
6	Check the fuel condition and observe whether the fault phenomenon occurs right after the refueling.	Yes	Replace fuel
		No	Next
7	Check the pressure of various cylinders of the engine and observe whether there is high difference among engine cylinders.	Yes	Resolve engine mechanical fault
		No	Next
8	Connect electronic injection system adapter, turn on the ignition switch, and check whether the power supply at 12#, 13#, 44#, 45#, and 63# pins	Yes	Diagnosis help
		No	Check and repair

	is normal and whether the earthing at 3#, 51#, 53#, 61#, and 80# pins is		corresponding circuit
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2.9 The start is normal, but the idling is unstable or engine is stopped under partial load (such as the A/C is turned on).

Fault portions:

1. Air conditioning system; 2. Idling regulator; 3. Fuel injector.

Diagnosis flow:

No.	Operation Procedure	Checking result	Subsequent Step
1	Remove the idling regulator and check the throttle body, idling regulator, and idling bypass air passage for the presence of carbon deposit.	Yes	Clean relevant parts
		No	Next
2	Observe whether the engine power output is increased when the A/C is turned on, namely use the electronic injection system diagnosis unit to observe the variation of ignition advance angle, fuel injection pulse width, and air intake amount.	Yes	Turn to step 4
		No	Next
3	Connect the electronic injection system adapter and disconnect the connecting wire of ECU 75# pin. Check whether there is high level signal at harness end when the A/C is turned on.	Yes	Next
		No	Check and repair air conditioning system
4	Check whether the pressure of air conditioning system, electromagnetic clutch of compressor, and the A/C compressor pump are normal.	Yes	Next
		No	Check and repair air conditioning system
5	Remove fuel injector and use the fuel injector special cleaning analyzer to check whether there is leakage, blockage or excessive flow in fuel injector.	Yes	Replace fault part
		No	Next
6	Connect electronic injection system adapter, turn on the ignition switch, and check whether the power supply at 12#, 13#, 44#, 45#, and 63# pins is normal and whether the earthing at 3#, 51#, 53#, 61#, and 80# pins is normal.	Yes	Diagnosis help
		No	Check and repair corresponding circuit

2.10 The start is normal, but the idling is too high.

Fault portions:

1. Throttle body and idling bypass air passage; 2. Vacuum pipe; 3. Idling regulator; 4. Coolant temperature sensor; 5. Ignition timing.

Diagnosis flow:

No.	Operation Procedure	Checking result	Subsequent Step
1	Check whether the accelerator cable is blocked or is too tight.	Yes	Adjust
		No	Next
2	Check whether there is air leakage in the air intake system and its connecting vacuum pipes.	Yes	Check and repair air intake system
		No	Next
3	Remove the idling regulator and check the throttle body, idling regulator, and idling bypass air passage for the presence of carbon deposit.	Yes	Clean relevant parts
		No	Next
4	Unplug the coolant temperature sensor connector and start the engine. Observe whether the engine idling speed is too high.	Yes	Check and repair circuit or replace sensor

		No	Next
5	Check whether the ignition timing of the engine complies with the specification.	Yes	Next
		No	Check and repair ignition timing
6	Connect electronic injection system adapter, turn on the ignition switch, and check whether the power supply at 12#, 13#, 44#, 45#, and 63# pins is normal and whether the earthing at 3#, 51#, 53#, 61#, and 80# pins is normal.	Yes	Diagnosis help
		No	Check and repair corresponding circuit

2.11 The engine speed can't increase or the engine is stopped during acceleration

Fault portions:

1. Water content in fuel; 2. Air intake pressure sensor and throttle position sensor; 3. Spark plug;
4. Throttle body and idling bypass air passage; 5. Air intake passage; 6. Idling regulator; 7. Fuel injector;
8. Ignition timing; 10. Exhaust pipe.

Diagnosis flow:

No.	Operation Procedure	Checking result	Subsequent Step
1	Check whether the air cleaner is blocked.	Yes	Check and repair air intake system
		No	Next
2	Connect the fuel pressure gauge (The connection point shall be the front end of inlet pipe of fuel distributor pipe assembly), start the engine, and check whether the fuel pressure of engine under all condition is approximate 400kPa.	Yes	Next
		No	Check and repair fuel supply system
3	Check the spark plug for various cylinders and observe whether the model and gap comply with the specification.	Yes	Next
		No	Adjust or replace
4	Remove the idling regulator and check the throttle body, idling regulator, and idling bypass air passage for the presence of carbon deposit.	Yes	Clean relevant parts
		No	Next
5	Check whether the air intake pressure sensor, throttle position sensor and its circuit are normal.	Yes	Next
		No	Check and repair circuit or replace sensor
6	Remove fuel injector and use the fuel injector special cleaning analyzer to check whether there is leakage or blockage in fuel injector.	Yes	Replace fault part
		No	Next
7	Check the fuel condition and observe whether the fault phenomenon occurs right after the refueling.	Yes	Replace fuel
		No	Next
8	Check whether the ignition order and the ignition timing of the engine comply with the specification.	Yes	Next
		No	Check and repair ignition timing
9	Check whether the exhaust is unhindered from the exhaust pipe.	Yes	Next
		No	Repair or replace exhaust pipe
10	Connect electronic injection system adapter, turn on the ignition switch, and check whether the power supply at 12#, 13#, 44#, 45#, and 63# pins is normal and whether the earthing at 3#, 51#, 53#, 61#, and 80# pins is normal.	Yes	Diagnosis help
		No	Check and repair corresponding circuit

2.12 Slow response during acceleration.

Fault portions:

1. Water content in fuel; 2. Air intake pressure sensor and throttle position sensor; 3. Spark plug;
4. Throttle body and idling bypass air passage; 5. Air intake passage; 6. Idling regulator; 7. Fuel injector;
8. Ignition timing; 9. Exhaust pipe.

Diagnosis flow:

No.	Operation Procedure	Checking result	Subsequent Step
1	Check whether the air cleaner is blocked.	Yes	Check and repair air intake system
		No	Next
2	Connect the fuel pressure gauge (The connection point shall be the front end of inlet pipe of fuel distributor pipe assembly), start the engine, and check whether the fuel pressure of engine under all condition is approximate 400kPa.	Yes	Next
		No	Check and repair fuel supply system
3	Check the spark plug for various cylinders and observe whether the model and gap comply with the specification.	Yes	Next
		No	Adjust or replace
4	Remove the idling regulator and check the throttle body, idling regulator, and idling bypass air passage for the presence of carbon deposit.	Yes	Clean relevant parts
		No	Next
5	Check whether the air intake pressure sensor, throttle position sensor and its circuit are normal.	Yes	Next
		No	Check and repair circuit or replace sensor
6	Remove fuel injector and use the fuel injector special cleaning analyzer to check whether there is leakage or blockage in fuel injector.	Yes	Replace fault part
		No	Next
7	Check the fuel condition and observe whether the fault phenomenon occurs right after the refueling.	Yes	Replace fuel
		No	Next
8	Check whether the ignition order and the ignition timing of the engine comply with the specification.	Yes	Next
		No	Check and repair ignition timing
9	Check whether the exhaust is unhindered from the exhaust pipe.	Yes	Next
		No	Repair or replace exhaust pipe
10	Connect electronic injection system adapter, turn on the ignition switch, and check whether the power supply at 12#, 13#, 44#, 45#, and 63# pins is normal and whether the earthing at 3#, 51#, 53#, 61#, and 80# pins is normal.	Yes	Diagnosis help
		No	Check and repair corresponding circuit

2.13 Weak acceleration and poor performance

Fault portions:

1. Water content in fuel; 2. Air intake pressure sensor and throttle position sensor; 3. Spark plug;
 4. Ignition coil; 5. Throttle body and idling bypass air passage; 6. Air intake passage; 7. Idling regulator;
 8. Fuel injector; 9. Ignition timing; 10. Exhaust pipe.

Diagnosis flow:

No.	Operation Procedure	Checking result	Subsequent Step
1	Check whether there is the presence of clutch skid, low tire pressure, braking stagnation, incorrect tire size, and incorrect wheel alignment.	Yes	Repair
		No	Next
2	Check whether the air cleaner is blocked.	Yes	Check and repair air intake system
		No	Next
3	Connect the fuel pressure gauge (The connection point shall be the front	Yes	Next

	end of inlet pipe of fuel distributor pipe assembly), start the engine, and check whether the fuel pressure of engine under all condition is approximate 400kPa.	No	Check and repair fuel supply system
4	Unplug one cylinder distribution wire, connect the spark plug, position the spark plug electrode to 5mm away from engine block, start the engine, and observe whether the high voltage fire strength is normal.	Yes	Next
		No	Check and repair ignition system
5	Check the spark plug for various cylinders and observe whether the model and gap comply with the specification.	Yes	Next
		No	Adjust or replace
6	Remove the idling regulator and check the throttle body, idling regulator, and idling bypass air passage for the presence of carbon deposit.	Yes	Clean relevant parts
		No	Next
7	Check whether the air intake pressure sensor, throttle position sensor and its circuit are normal.	Yes	Next
		No	Check and repair circuit or replace sensor
8	Remove fuel injector and use the fuel injector special cleaning analyzer to check whether there is leakage or blockage in fuel injector.	Yes	Replace fault part
		No	Next
9	Check the fuel condition and observe whether the fault phenomenon occurs right after the refueling.	Yes	Replace fuel
		No	Next
10	Check whether the ignition order and the ignition timing of the engine comply with the specification.	Yes	Next
		No	Check and repair ignition timing
11	Check whether the exhaust is unhindered from the exhaust pipe.	Yes	Next
		No	Repair or replace exhaust pipe
12	Connect electronic injection system adapter, turn on the ignition switch, and check whether the power supply at 12#, 13#, 44#, 45#, and 63# pins is normal and whether the earthing at 3#, 51#, 53#, 61#, and 80# pins is normal.	Yes	Diagnosis help
		No	Check and repair corresponding circuit

3. List of Common Fault Codes (PCODE)

1	P0016	Crankshaft Position-Camshaft Position Correlation Bank 1 Sensor A	Inappropriate relative installation location between camshaft and crankshaft
2	P0030	O2 Sensor Heater Contr. Circ.(Bank1(1)Sensor 1)	Open-circuit of upstream oxygen sensor heating control circuit
3	P0031	O2 Sensor Heater Contr. Circ.(Bank1(1)Sensor 1) Low	Short-circuit of upstream oxygen sensor heating control circuit to ground
4	P0032	O2 Sensor Heater Contr. Circ.(Bank1(1)Sensor 1) High	Short-circuit of upstream oxygen sensor heating control circuit to power supply
5	P0036	O2 Sensor Heater Contr. Circ.(Bank1(1)Sensor 2)	Open-circuit of downstream oxygen sensor heating control circuit
6	P0037	O2 Sensor Heater Contr. Circ.(Bank1(1)Sensor 2) Low	Short-circuit of downstream oxygen sensor heating control circuit to ground
7	P0038	O2 Sensor Heater Contr. Circ.(Bank1(1)Sensor 2) High	Short-circuit of downstream oxygen sensor heating control circuit to power supply

8	P0053	O2 Sensor Heater Resistance(Bank1(1)Sensor 1)	Inappropriate heating internal resistance of upstream oxygen sensor
9	P0054	O2 Sensor Heater Resistance(Bank1(1)Sensor 2)	Inappropriate heating internal resistance of downstream oxygen sensor
10	P0105	Manifold Absolute Pressure/Barometric Pressure Circuit	No signal variation of air intake pressure sensor (Frozen)
11	P0106	Manifold Abs. Pressure or Bar. Pressure Range/Performance	Inappropriate air intake pressure sensor
12	P0107	Manifold Abs. Pressure or Bar. Pressure Low Input	Short-circuit of air intake pressure sensor to ground
13	P0108	Manifold Abs. Pressure or Bar. Pressure High Input	Short-circuit of air intake pressure sensor to power supply
14	P0112	Intake Air Temp. Circ. Low Input	Low signal voltage of air intake pressure sensor
15	P0113	Intake Air Temp. Circ. High Input	High signal voltage of air intake pressure sensor
16	P0116	Engine Coolant Temp. Circ. Range/Performance	Inappropriate engine coolant temperature sensor
17	P0117	Engine Coolant Temp. Circ. Low Input	Low voltage of engine coolant temperature sensor circuit
18	P0118	Engine Coolant Temp. Circ. High Input	High voltage of engine coolant temperature sensor circuit
19	P0122	Throttle/Pedal Pos.Sensor A Circ. Low Input	Out-of-lower-limit of throttle position sensor circuit voltage
20	P0123	Throttle/Pedal Pos.Sensor A Circ. High Input	Out-of-upper-limit of throttle position sensor circuit voltage
21	P0130	O2 Sensor Circ.,Bank1-Sensor1 Malfunction	Inappropriate upstream oxygen sensor signal
22	P0131	O2 Sensor Circ.,Bank1-Sensor1 Low Voltage	Low upstream oxygen sensor signal voltage
23	P0132	O2 Sensor Circ.,Bank1-Sensor1 High Voltage	High upstream oxygen sensor signal circuit voltage
24	P0133	O2 Sensor Circ.,Bank1-Sensor1 Slow Response	Aging of upstream oxygen sensor
25	P0134	O2 Sensor Circ.,Bank1-Sensor1 No Activity Detected	Fault of upstream oxygen sensor circuit signal
26	P0136	O2 Sensor Circ.,Bank1-Sensor2 Malfunction	Inappropriate downstream oxygen sensor signal
27	P0137	O2 Sensor Circ.,Bank1-Sensor2 Low Voltage	Low downstream oxygen sensor signal voltage
28	P0138	O2 Sensor Circ.,Bank1-Sensor2 High Voltage	High downstream oxygen sensor signal circuit voltage
29	P0140	O2 Sensor Circ.,Bank1-Sensor2 No Activity Detected	Fault of downstream oxygen sensor circuit signal
30	P0170	Fuel Trim,Bank1 Malfunction	Inappropriate closed-loop control self-learning of off-line testing air-fuel ratio
31	P0171	Fuel Trim,Bank1 System too Lean	Thin closed-loop control self-learning of off-line

			testing air-fuel ratio
32	P0172	Fuel Trim,Bank1 System too Rich	Dense closed-loop control self-learning of off-line testing air-fuel ratio
33	P0201	Cylinder 1- Injector Circuit	Open-circuit of 1# fuel injector control circuit
34	P0202	Cylinder 2- Injector Circuit	Open-circuit of 2# fuel injector control circuit
35	P0203	Cylinder 3- Injector Circuit	Open-circuit of 3# fuel injector control circuit
36	P0204	Cylinder 4- Injector Circuit	Open-circuit of 4# fuel injector control circuit
37	P0261	Cylinder 1- Injector Circuit Low	Short-circuit of 1# cylinder fuel injector control circuit to ground
38	P0262	Cylinder 1- Injector Circuit High	Short-circuit of 1# cylinder fuel injector control circuit to power supply
39	P0264	Cylinder 2- Injector Circuit Low	Short-circuit of 2# cylinder fuel injector control circuit to ground
40	P0265	Cylinder 2- Injector Circuit High	Short-circuit of 2# cylinder fuel injector control circuit to power supply
41	P0267	Cylinder 3- Injector Circuit Low	Short-circuit of 3# cylinder fuel injector control circuit to ground
42	P0268	Cylinder 3- Injector Circuit High	Short-circuit of 3# cylinder fuel injector control circuit to power supply
43	P0270	Cylinder 4- Injector Circuit Low	Short-circuit of 4# cylinder fuel injector control circuit to ground
44	P0271	Cylinder 4- Injector Circuit High	Short-circuit of 4# cylinder fuel injector control circuit to power supply
45	P0300	Random/Multiple Cylinder Misfire Detected	Detection of misfire in various cylinders
46	P0301	Cyl.1 Misfire Detected	Detection of misfire in 1# cylinder
47	P0302	Cyl.2 Misfire Detected	Detection of misfire in 2# cylinder
48	P0303	Cyl.3 Misfire Detected	Detection of misfire in 3# cylinder
49	P0304	Cyl.4 Misfire Detected	Detection of misfire in 4# cylinder
50	P0317	Rough Road Sensor "A" Not present	ABS loss of rough road detection signal
51	P0321	Ign./Distributor Eng. Speed Inp. Circ. Range/Performance	Fault of crankshaft upper dead point signal
52	P0322	Ign./Distributor Eng. Speed Inp. Circ. No Signal	Fault of engine speed sensor signal
53	P0327	Knock Sensor 1 Circ. Low Input	Low voltage of knock sensor signal circuit
54	P0328	Knock Sensor 1 Circ. High Input	High voltage of knock sensor signal circuit
55	P0340	Camshaft Position Sensor Circuit	Inappropriate installation location of phase sensor
56	P0341	Camshaft Pos. Sensor Circ. Range/Performance	Poor contact of phase sensor
57	P0342	Camshaft Pos. Sensor Circ. Low Input	Short-circuit of phase sensor to ground
58	P0343	Camshaft Pos. Sensor Circ. High Input	Short-circuit of phase sensor to power supply
59	P0420	Catalyst System,Bank1 Efficiency Below	Aged oxygen storage capacity of three-way

		Threshold	catalytic converter (out-of-limit of emission)
60	P0444	Evaporative Emiss. System Purge Control Valve Circ. Open	Open-circuit of canister control valve control circuit
61	P0458	Evaporative Emission System Purge Control Valve Circuit Low	Low voltage of canister control valve control circuit
62	P0459	Evaporative Emission System Purge Control Valve Circuit High	High voltage of canister control valve control circuit
63	P0480	Cooling Fan 1 Control Circuit	Fault of cooling fan relay control circuit (low speed)
64	P0481	Cooling Fan 2 Control Circuit	Fault of cooling fan relay control circuit (high speed)
65	P0501	Vehicle Speed Sensor Range/Performance	Inappropriate vehicle speed sensor signal
66	P0506	Idle Control System RPM Lower than Expected	Idling control speed lower than target idling speed
67	P0507	Idle Control System RPM Higher than Expected	Idling control speed higher than target idling speed
68	P0508	Idle Air Control System Circuit Low	Short-circuit of stepping motor drive pin to ground
69	P0509	Idle Air Control System Circuit High	Short-circuit of stepping motor drive pin to power supply
70	P0511	Idle Air Control Circuit	More than one fault at stepping motor drive pin
71	P0560	System Voltage Malfunction	Inappropriate system battery voltage signal
72	P0562	System Voltage Low Voltage	Low system battery voltage
73	P0563	System Voltage High Voltage	High system battery voltage
74	P0602	Control Module Programming Error	Programming error of electronic control unit
75	P0627	Fuel Pump "A" Control Circuit /Open	Open-circuit of fuel pump relay control circuit
76	P0628	Fuel Pump "A" Control Circuit Low	Short-circuit of fuel pump relay control circuit to ground
77	P0629	Fuel Pump "A" Control Circuit High	Short-circuit of fuel pump relay control circuit to power supply
78	P0645	AC clutch relay circuit	Open-circuit of A/C compressor relay control circuit
79	P0646	A/C Clutch Relay Control Circuit Low	Short-circuit of A/C compressor relay control circuit to ground
80	P0647	A/C Clutch Relay Control Circuit High	Short-circuit of A/C compressor relay control circuit to power supply
81	P0691	Cooling Fan 1 Control Circuit Low	Short-circuit of cooling fan relay control circuit to ground (low speed)
82	P0692	Cooling Fan 1 Control Circuit High	Short-circuit of cooling fan relay control circuit to power supply (low speed)
83	P0693	Cooling Fan 2 Control Circuit Low	Short-circuit of cooling fan relay control circuit to

			ground (high speed)
84	P0694	Cooling Fan 2 Control Circuit High	Short-circuit of cooling fan relay control circuit to power supply (high speed)
85	P1610	ECU defective	Non-programming error of Secret Key and Security Code
86	P1611	MIL Call-up Circ./Transm. Contr. Module Short to Ground	Receipt error of Security Code
87	P1612	Electronic Control Module Incorrect Coding	Failure of Challenge request
88	P1613	MIL Call-up Circ. Open/Short to B+	Failure of IMMO Code request
89	P1614	MIL Call-up Circ./Transm. Contr. Module Range/Performance	Transponder verification error
90	P2177	System Too Lean Off Idle	Out-of-upper-limit of air-fuel ratio closed-loop control self-learning (Medium load zone)
91	P2178	System Too Rich Off Idle	Out-of-lower-limit of air-fuel ratio closed-loop control self-learning (Medium load zone)
92	P2195	O2 Sensor Signal Stuck Lean; Bank 1 Sensor 1	Aged upstream oxygen sensor
93	P2196	O2 Sensor Signal Stuck Rich; Bank 1 Sensor 1	Aged upstream oxygen sensor
94	P2270	O2 Sensor Signal Stuck Lean; Bank 1 Sensor 2	Aged downstream oxygen sensor
95	P2271	O2 Sensor Signal Stuck Rich; Bank 1 Sensor 2	Aged downstream oxygen sensor
96	U0001	High Speed CAN defective	CAN communication related diagnosis
97	U0101	Lost Communication with TCM	Communication loss between ECU and TCU control module
98	U0121	Lost Communication With Instrument Panel Cluster (IPC) Control Module	Communication loss between ECU and ABS control module
99	U0140	Lost Communication with Body Control Module	Communication loss between ECU and BCM body control module
100	U0155	Lost communication with Instrument Panel Cluster control module	Abnormal communication between ECU and IPC (Instrument panel controller)

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