

FUEL INJECTION SYSTEM - BOSCH CIS

Article Text

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ARTICLE BEGINNING

1987 Fuel Injection

BOSCH CIS (LAMBDA) SYSTEM

Cabriolet, Jetta, Golf

DESCRIPTION

Bosch Continuous Injection System (CIS) is a mechanical fuel injection system which uses airflow sensor assembly connected to fuel distributor to control injection quantity.

Lambda is a feedback control system capable of continuously measuring and correcting air/fuel ratios. Combination of 2 systems allows for both economy and performance with minimal exhaust emissions. See Fig. 1.

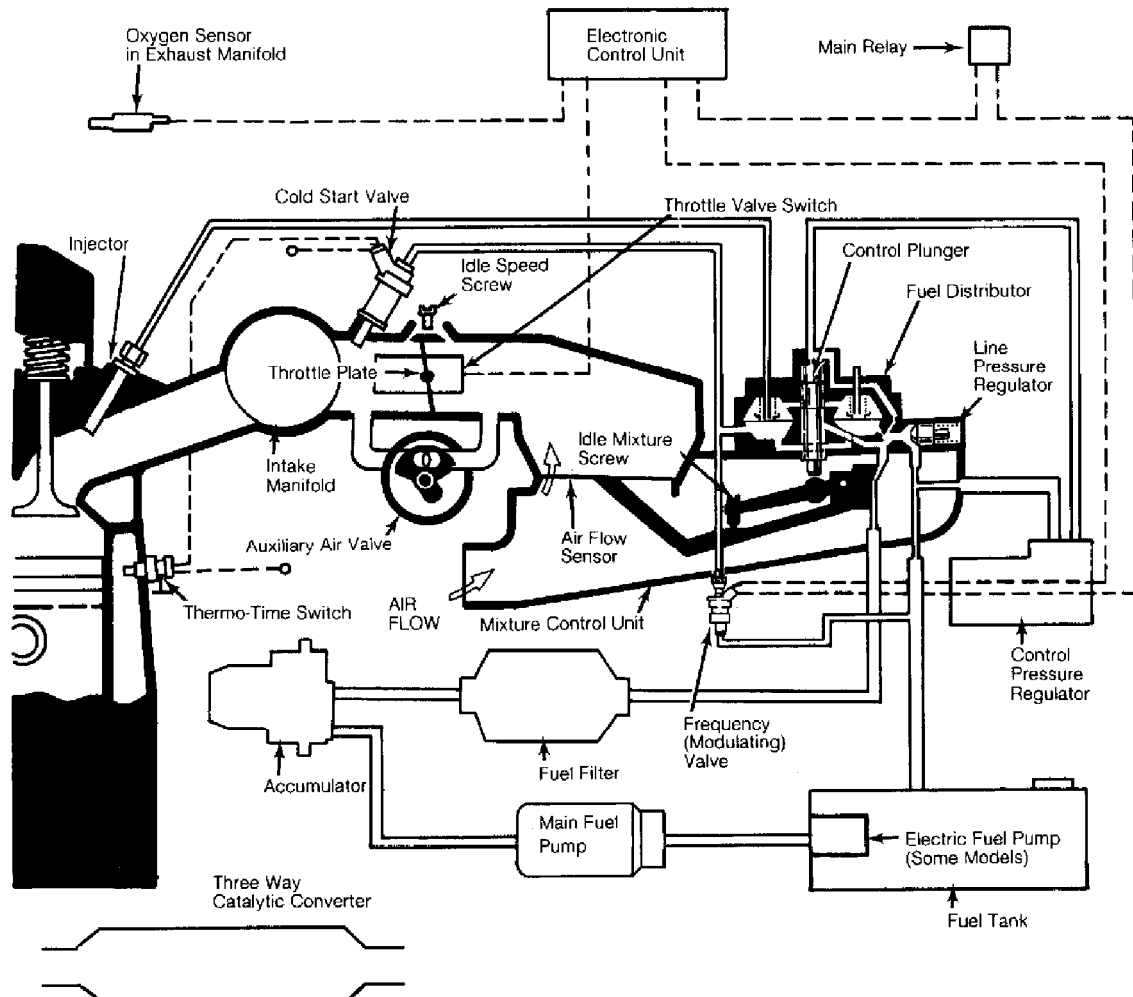


Fig. 1: Bosch CIS (Lambda) Fuel Injection System Diagram
This illustration is typical of all models.

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System consists of mixture control unit (airflow sensor and fuel distributor), control pressure (warm-up) regulator, auxiliary air regulator, cold start valve, thermo time switch, fuel injectors, fuel pump, filter, oxygen sensor, Electronic Control Unit (ECU), frequency valve and catalytic converter.

Some models use additional components, such as thermo vacuum valve, hot start pulse relay or constant idle speed control system.

OPERATION

MIXTURE CONTROL UNIT

Airflow sensor housing contains sensor plate which moves in cone-shaped venturi. All engine intake air is drawn past sensor plate.

Movement of sensor plate lever changes position of control plunger in fuel distributor. Control plunger is used to meter amount of fuel injected into each cylinder. Movement of plate is controlled by amount of air flowing through airflow sensor housing.

Fuel distribution pressure to each injector is equal. Pressure regulating valves in fuel distributor equalize system pressure. These valves are not adjustable.

CONTROL PRESSURE REGULATOR

Control pressure regulator (or warm-up regulator) modulates system fuel pressure before it goes to top of plunger in fuel distributor. See Fig. 2.

During cold start operation, reduced control pressure allows plate to open farther with same airflow. This supplies more fuel (richer mixture) to injectors until normal operating temperature is reached. As engine warms up, control pressure regulator increases control pressure, causing leaner air/fuel mixture.

Bi-metallic strip in control pressure regulator changes spring pressure on control diaphragm. As strip heats up, it will bend and increase spring pressure on control diaphragm. This will increase control pressure. Some regulators have altitude compensation function that changes with barometric pressure.

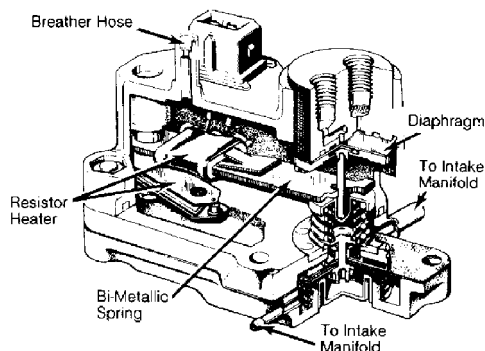


Fig. 2: Control Pressure Regulator
Pressure-compensated type is shown; all types are similar.

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AUXILIARY AIR REGULATOR

During cold start operation, auxiliary air regulator provides additional air to engine to increase idle speed. It allows intake air to by-pass throttle plates which are closed at idle.

Heating coil in regulator is connected to fuel pump circuit. As coil warms up, air passage gradually closes.

COLD START VALVE

Cold start valve is mounted on intake manifold and sprays fuel during starting. It provides additional enrichment so engine will start easily. Valve is powered through starter circuit and grounded through thermo time switch. It operates only while cold engine is being cranked.

THERMO TIME SWITCH & HOT START PULSE RELAY

Thermo time switch provides ground for cold start valve. It is affected by engine temperature and starter current. Depending on engine coolant temperature, switch will take from 3-10 seconds to open. Injection through cold start valve will stop when thermo time switch opens.

Some models use hot start pulse relay to improve hot starting. While starter is being operated on cold engine, pulse relay allows cold start valve to spray small amounts of fuel at regular intervals after thermo time switch opens. On hot engines, pulse relay allows cold start valve to spray fuel after 2 seconds of starter operation. It then shuts off and sprays periodically until engine starts.

FUEL INJECTORS

Fuel injectors in CIS system open at a pre-set pressure. Fuel is always present in lines between fuel distributor and injectors to ensure good starting. As pressure from fuel distributor increases (when engine is started), valves open and spray constantly. Amount of fuel injected will be determined by position of control plunger in fuel distributor. See Fig. 3.

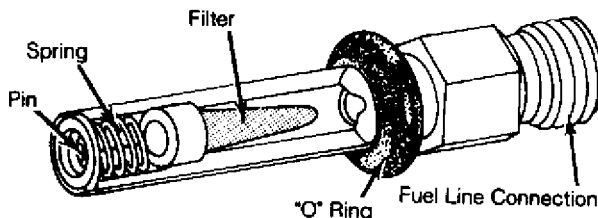


Fig. 3: Bosch CIS (Lambda) Fuel Injector
Pin in injector vibrates to atomize fuel.

FUEL PUMP

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Electric fuel pump is used to provide fuel pressure of 60-80 psi (4.2-5.6 kg/cm²). To aid in starting, check valve in pump maintains pressure in lines when engine is not running. Fuel accumulator and line pressure regulator "O" ring also act to hold pressure in system.

Fuel pump is controlled by relay to prevent it from continuing to operate if engine stalls. It can be wired in several ways. There are 2 common circuits that are used to switch on the airflow sensor or coil. These components are energized by ignition system. When testing system, fuel pump relay must be by-passed.

OXYGEN SENSOR

Oxygen sensor is located in exhaust manifold and measures amount of unburned oxygen in exhaust gas. If oxygen is low (rich mixture), higher voltage will be generated by sensor. If oxygen is high (lean mixture), lower voltage will be generated. Voltage signal from oxygen sensor is sent to ECU which controls fuel mixture through frequency valve.

ECU & FREQUENCY VALVE

ECU continually corrects air/fuel mixture, based on signals from oxygen sensor. ECU sends signals to frequency valve, which is located in fuel line between upper and lower halves of fuel distributor. Frequency valve operates at constant frequency (70 Hz) as soon as engine is running.

When frequency valve is closed, fuel pressure to injectors is determined by spring in each pressure regulating valve. When frequency valve is open, fuel pressure decreases in lower half of fuel distributor, tension on spring is relieved, and more fuel is directed to cylinders. See Fig. 4.

ECU grounds connection for frequency valve in different length pulses. This will open and close valve to ensure continuous regulation of fuel mixture. When engine is cold, ratio of valve open to valve closed is about 60/40.

After engine warms up, voltage produced by oxygen sensor determines amount of time frequency valve must be open or closed. This ratio can be read with special tester or with dwell meter (on most models). Dwell reading of 45 degrees indicates ratio of 50% open, 50% closed.

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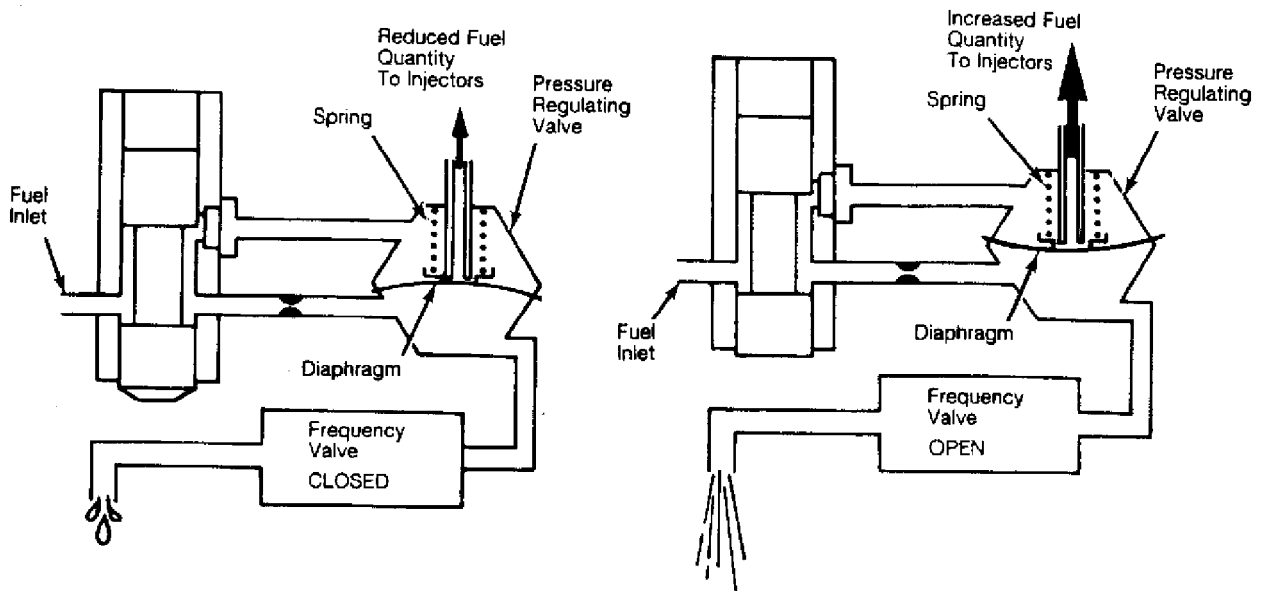


Fig. 4: Effect Of Frequency Valve On Fuel Distributor

ELECTRONIC IDLE SPEED CONTROL SYSTEMS

This system maintains constant idle speed by varying amount of air by-passing throttle valve through air control valve. Air control valve is operated by idle speed ECU which receives engine information from throttle switch, coolant temperature sensor, and ignition coil.

TESTING

* PLEASE READ THIS FIRST *

NOTE: Testing procedures described below will apply to all models using CIS (Lambda) system unless otherwise noted. Not all models will use all components.

PREPARATION FOR TESTING

1) All CIS systems are very sensitive to air leaks. Check condition of rubber boots, hoses and gaskets. Other areas of air leakage are injector "O" rings, cold start valve, oil filler cap and dipstick.

2) Install pressure gauge to perform fuel pressure tests. On all models, pressure gauge is installed in line between control pressure regulator and fuel distributor. See Fig. 5.

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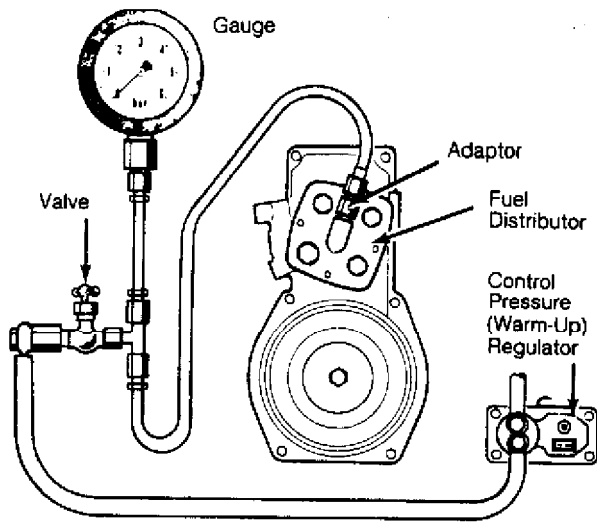


Fig. 5: Pressure Gauge Installation

After installation, bleed pressure gauge by opening and closing valve several times.

3) To operate fuel pump with engine not running, disconnect safety contact switch connector on airflow sensor. Turn ignition on. Place pressure gauge as low as possible in engine compartment. Open and close valve 5 times to bleed gauge. Place valve in open position and hang out of the way. Turn pump off.

AIRFLOW SENSOR

1) Remove rubber bellows above airflow sensor plate. Unplug electrical connectors on auxiliary air regulator and control pressure regulator. Operate fuel pump for 10 seconds to build up control pressure.

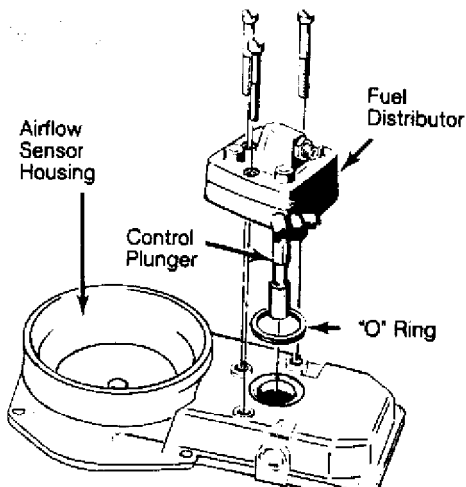


Fig. 6: Removing Fuel Distributor Control Plunger

DO NOT allow control plunger to drop from fuel distributor.

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2) Lift sensor plate slowly with magnet or pliers. Use care to avoid damage to sensor plate or venturi surfaces. Resistance due to control plunger pressure should be felt through entire lift. Release plate and allow it to return to rest position slowly. Lever and control plunger should follow. See Fig. 7.

3) Lift plate and return it rapidly to rest position. Plunger should be heard hitting lever as it moves slowly to rest position. If not, control plunger is sticking. Remove 3 screws from fuel distributor and lift off of airflow sensor housing. Be careful not to drop control plunger. See Fig. 6.

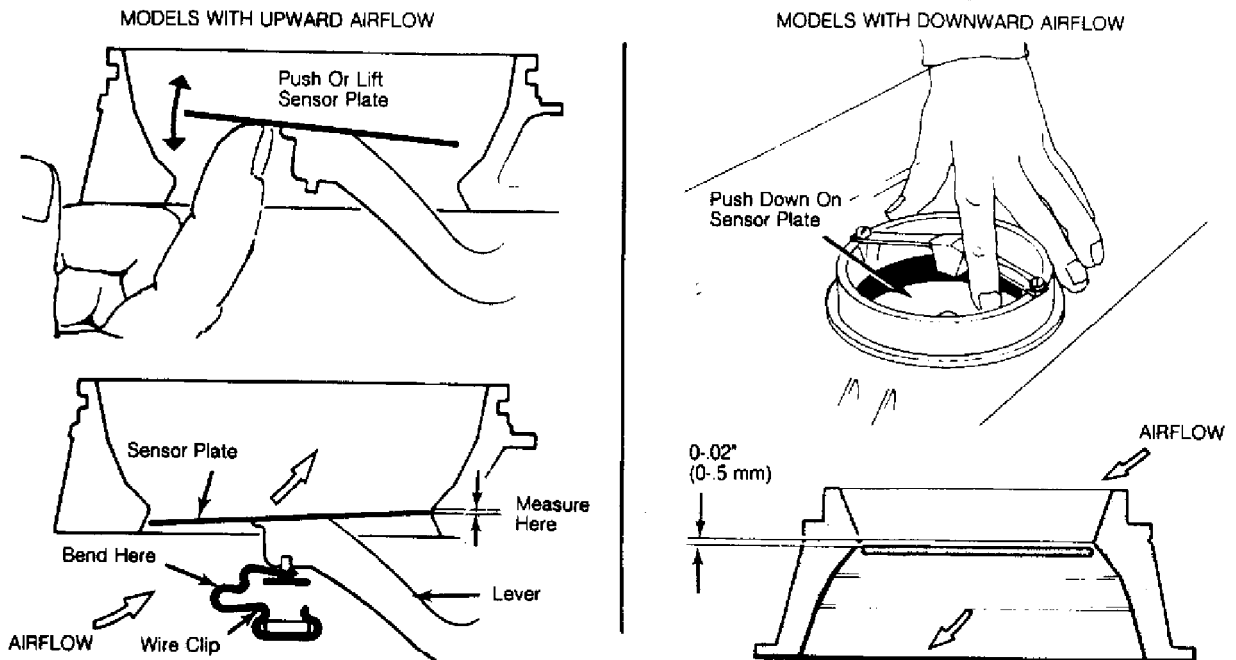


Fig. 7: Checking Sensor Plate Operation & Adjustment

4) Clean plunger in gasoline. Remove any deposits with finger nail. DO NOT use tools. Slide plunger in and out while turning it. If any sticking or binding is felt, replace fuel distributor.

5) Reinstall fuel distributor. Plate should be centered in housing. If not, loosen center bolt and align plate with .004" (.10 mm) feeler gauge at 4 points around rim. Using Loctite, install and tighten bolt.

6) Check airflow sensor plate height adjustment. Plate should be even with bottom rim or .02" (.5 mm) lower. If not, bend spring clip or reposition stop pin (tap lightly with punch) to set plate height. See Fig. 7.

CONTROL PRESSURE TEST (COLD ENGINE)

1) Testing must be done on cold engine. Unplug electrical connectors at auxiliary air valve and control pressure regulator. Place valve on pressure gauge in open position and operate fuel pump. Check control pressure.

2) Reading should fall in shaded area of graph. Check

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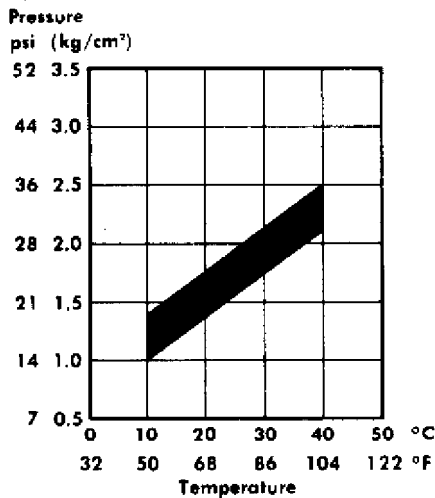
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ambient air temperature and read correct area of graph. See Fig. 8.
If control pressure is not correct, retest with new control pressure
regulator. Control pressure regulator cannot be adjusted.

NOTE: Some control pressure regulators have atmospheric pressure
compensation. If so, fuel pressures will vary depending upon
barometric pressure.



VW

Fig. 8: Control Pressure Test (Cold Engine) Graphs

CONTROL PRESSURE TEST (WARM ENGINE)

1) Connect plug to control pressure regulator. Leave
auxiliary air valve and airflow sensor (if equipped) plugs
disconnected. Place valve for pressure gauge in open position and
operate fuel pump.

2) After about 5 minutes, control pressure should rise to
specified level. See CIS (LAMBDA) FUEL PRESSURES table. On models
with vacuum hose connected to control pressure regulator, leave hose
connected to read pressure.

3) Start engine and allow to idle. Pressure should remain
same or rise slightly. On models with control pressure regulator
vacuum line, remove and plug hose. Pressure should drop.

4) If pressure does not reach level specified, disconnect
plug at control pressure regulator. Check for voltage across
terminals with test lamp or voltmeter. At least 11.5 volts should be
present. If not, check wiring. If voltage is present and pressure is
not correct, replace control pressure regulator.

CIS (LAMBDA) FUEL PRESSURES

AA

Application

Volkswagen

System Pressure psi (kg/cm²)..... 68-78 (4.7-5.4)

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Control Pressure (Warm)(1) psi (kg/cm²)..... 50-53 (3.4-3.7)
Residual Pressure psi (kg/cm²).....(2) 35 (2.4)
Injector Opening Pressure psi (kg/cm²)..... 50-58 (3.4-4.0)

(1) - Engine oil temperature 122-158°F (50-70°C).

(2) - After 20 minutes.

AA

SYSTEM (LINE) PRESSURE TEST

1) Close valve on pressure gauge. With engine off, operate fuel pump. Pressure should rise to level specified. See CIS (LAMBDA) FUEL PRESSURES table. If pressure is too low, check fuel pump output.

2) Disconnect fuel return line from fuel distributor and run hose from fuel distributor to container. Operate fuel pump and measure output after 30 seconds. See FUEL PUMP OUTPUT SPECIFICATIONS table. If not as specified, check fuel lines, filter, accumulator and pump.

FUEL PUMP OUTPUT SPECIFICATIONS

AA

Application	30 Sec. Flow Rate Qts. (L)
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Volkswagen80 (.76)
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AA

3) If pressure is too high, check for kinked or blocked fuel return line. If lines are clear, system pressure regulator must be adjusted. Turn pump off, loosen return line fitting, and relieve pressure.

4) Loosen line pressure regulator nut. Remove shims, spring(s) and plunger. Raise system pressure by adding shims; lower pressure by removing shims. Be sure "O" rings are in good condition. If piston is scored or damaged, complete fuel distributor must be replaced. See Fig. 9.

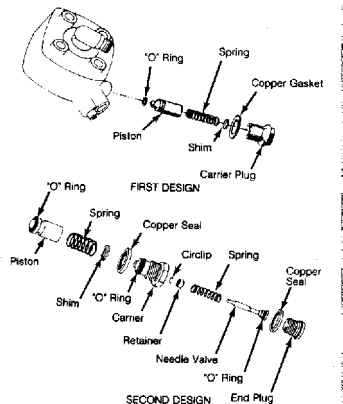


Fig. 9: Line Pressure Regulator
Replace complete fuel distributor if piston is damaged.

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RESIDUAL PRESSURE & INTERNAL LEAK TESTS

1) After correct warm engine control pressure has been obtained, stop fuel pump and note pressure drop. Pressure gauge valve should be in open position. Minimum pressure after 20 minutes must be as specified. See CIS (LAMBDA) FUEL PRESSURES table.

2) If pressure drops too rapidly, run pump again and close valve. Stop pump and observe pressure. If values are now correct, control pressure regulator is faulty and must be replaced.

3) If pressure still drops, check all connections, fuel pump check valve, cold start valve and fuel injectors.

COLD START VALVE, THERMO TIME SWITCH & PULSE RELAY

CAUTION: DO NOT connect jumper wire directly to battery during testing procedure. Sparks may occur when wire is touched to battery and create a FIRE danger.

1) If engine coolant is below 85°F (30°C), disconnect plug on cold start valve and connect test lamp across terminals. Remove coil high tension wire to prevent starting. Operate starter.

2) On models without pulse relay, test lamp will light for several seconds, then go out. On models with pulse relay, lamp will continue to flash off and on. If lamp does not light, test thermo time switch for continuity below opening temperature. If good, check wiring to starter terminal.

3) Remove cold start valve from manifold but leave fuel line connected. Place valve in container. See Fig. 10. Connect jumper wire from one terminal to ground, and from other terminal of cold start valve to switch. Other side of switch should be connected to source of battery voltage. Operate fuel pump.

4) Turn ignition on. Cold start injector should spray. Turn switch off, but leave fuel pump running. Injector should stop spraying. Wipe off nozzle. No drops should form within one minute with pump running. Replace cold start valve that is faulty. Install original valve if good, ensure that "O" ring is properly positioned.

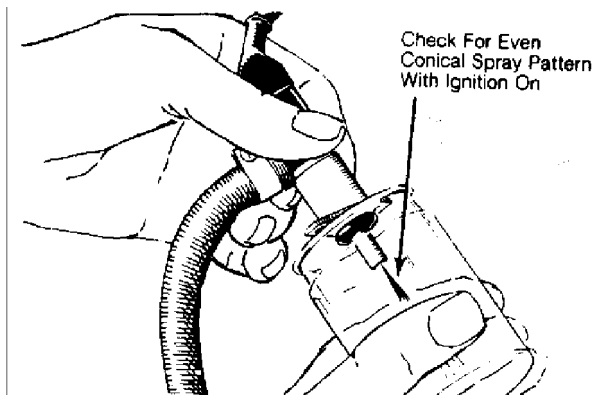


Fig. 10: Testing Cold Start Injector Valve
Valve should not drip after shutting off.

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FUEL INJECTORS

1) Remove injectors but leave hoses connected. Place injectors in individual measuring containers. Operate fuel pump to build up pressure, then turn pump off.

2) Lift airflow sensor plate half-way to operate injectors until one container has filled to 3.4 oz. (.10L). Volume of fuel in other containers should not vary more than 10-20%. Spray pattern must be even and cone-shaped.

3) If one injector does not conform to specifications, switch hoses between it and another (good) injector at fuel distributor and retest. If problem remains with injector, injector is faulty or fuel line is restricted. If problem goes to other (good) injector, fuel distributor must be replaced.

4) Relieve system pressure and remove gauge. Reconnect fuel lines and turn on pump to build up pressure. Injectors may leak slightly, but should stop leaking within 15 seconds. If fuel drops form, check airflow sensor plate height, sticking control plunger or incorrect injector opening pressure.

5) Remove injectors from vehicle and use injector tester to determine opening pressure. See Fig. 11. Check readings against specifications. See CIS (LAMBDA) FUEL PRESSURES table. Replace injectors if faulty.

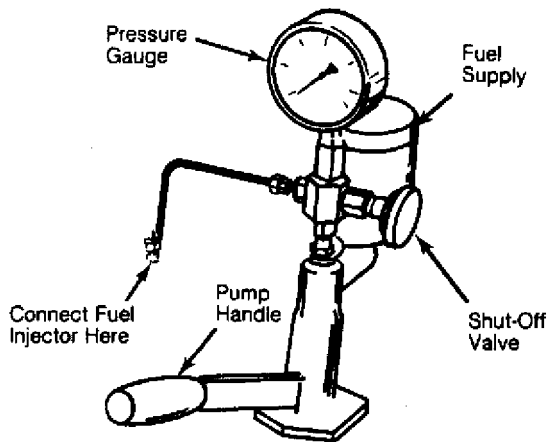


Fig. 11: Testing Fuel Injectors

Replace injectors if opening pressure is not in limits.

AUXILIARY AIR REGULATOR

1) Disconnect hoses from auxiliary air regulator. Use mirror and small flashlight to inspect valve opening. See Fig. 12. At room temperature, valve should be slightly open. Valve should close within 5 minutes after cold engine starts.

2) If valve does not operate properly, check for power at connector with engine running. Connect test lamp across connector terminals. If lamp does not light, check fuse and wiring.

3) If lamp lights, check resistance of auxiliary air regulator. If no resistance is measured, regulator is defective. Ensure electrical connections are tight and terminals are clean,

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prior to measuring resistance.

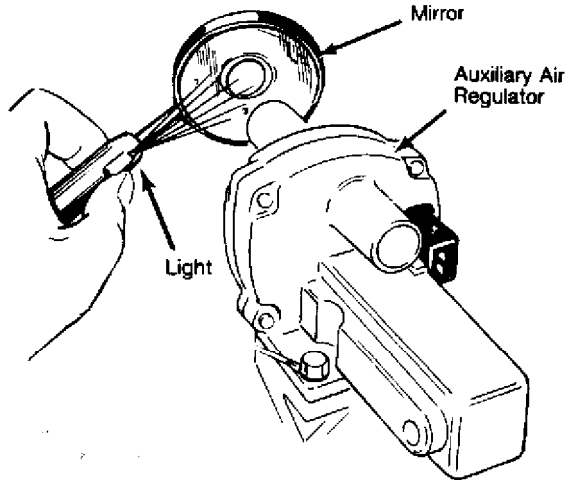


Fig. 12: Checking Auxiliary Air Regulator Operation
Valve should close after engine is running for 5 minutes.

LAMBDA SYSTEM CHECKS

PREPARATION FOR CHECKS

1) Frequency valve is operated by pulsating voltage from ECU. By measuring this signal, mixture function of system can be tested and changed. A high-quality dwell meter is used to check and adjust frequency valve control and duty cycle.

2) Connect tachometer and oil temperature gauge. Ensure A/C is off and transmission lever is in Park. Throttle valve lever must be against idle stop. Accelerator Bowden cable must be tension free at throttle lever. Adjust if necessary. Engine oil must be at operating temperature of 176°F (80°C). Check and adjust idle speed if necessary.

3) Connect dwell meter to 2-wire testing connector. Connector (Blue/White wire) is behind throttle valve housing.

4) The color-coded wire should be connected to positive (+) lead of dwell meter. Other wire in connector is ground and should be connected to negative (-) lead of dwell meter. Set dwell meter on 4-cylinder scale. Start engine and run until warm.

OPERATION CHECK & ADJUSTMENT

1) Remove fuel pump relay and connect jumper wire across sockets corresponding to terminals No. 30 and 87. Remove plug at airflow sensor (if equipped). Turn ignition on.

2) Frequency valve should operate, making buzzing noise. Dwell meter should indicate 45-65 degrees. Disconnect wire from oxygen sensor and touch wire end to ground. Readings on dwell meter should rise. Ground one end of 1.5-volt flashlight battery, and touch positive end to sensor wire. Readings should drop to less than 15 degrees.

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3) On models with throttle enrichment switch, operate throttle. Readings should be higher at idle or wide open throttle.

4) If engine is cold, enrichment switches will be closed. Disconnect lead at temperature sender. Readings should drop slightly. If engine is hot, connect temperature sender lead to ground. Reading should rise.

5) If starter enrichment relay is used, disconnect high tension lead at coil and crank engine. Readings should rise above normal level. If vacuum switches are used, apply vacuum to switch and note readings. Level should be higher with switch closed, and lower with switch open.

6) Connect oxygen sensor and start engine. With cold engine, dwell reading should be stable. When engine warms up, meter needle should fluctuate 10-20 degrees. It may be necessary to run engine faster than idle to heat oxygen sensor to create needle fluctuation.

7) Connect CO meter to exhaust test point. With oxygen sensor disconnected, reading should be stable on dwell meter. Note CO reading. With sensor lead grounded, reading should rise and CO increase. With lead connected to flashlight battery, reading and CO should decrease.

8) If dwell reading does not rise with sensor grounded, check sensor wiring. See ELECTRICAL TESTING in this article. If wiring is good, replace control unit. If dwell rises, but CO does not, check frequency valve and wiring. See ELECTRICAL TESTING. Replace if necessary.

9) If dwell does not decrease with battery connected to sensor lead, check sensor wiring and replace control unit if wires are good. If dwell decreases but CO does not, check frequency valve wiring and replace valve if wiring is good.

10) Adjust CO to rich level (3%) with oxygen sensor still disconnected. Reconnect sensor. Reading should drop at least 1%. If not, replace oxygen sensor.

ELECTRICAL TESTING

NOTE: ECU is located near glove box.

1) Locate ECU and press locking tabs back to disconnect connector. All connectors are wired with pin numbers in same location. Use volt-ohmmeter for testing.

2) Refer to wiring diagram for pin locations. With fuel pump relay jumper wire in place, turn ignition on and check for battery voltage at terminals No. 8 and 15 (18 and 1 on Jetta). Connect ground lead of voltmeter to terminals No. 5 and 16 (2, 10 and 22 on Jetta) while checking for battery voltage to ensure these wires make good ground connection.

3) If battery voltage is not available at terminal No. 8 or 18, check Lambda and fuel pump relays. If there is no voltage at terminal No. 15 or 1, check frequency valve connector. One wire should have battery voltage and other wire should have continuity to terminal No. 15 or 1. Frequency valve should have 2-3 ohms resistance. Repair or replace as necessary.

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4) Disconnect oxygen sensor and check for continuity between sensor lead and terminal No. 2 (11 on Jetta). No continuity should exist between ground and lead wire.

5) All models use switches for enrichment signal. All switches provide continuity to ground when switch is closed. Actuate throttle to test throttle valve switches.

6) Thermal switches can be checked by removing switch and heating in water. Repair wiring or replace switches as necessary.

7) After testing is completed, reconnect ECU, oxygen sensor and all switches. Remove fuel pump relay jumper wire and testing equipment.

REMOVAL & INSTALLATION

*** PLEASE READ THIS FIRST ***

CAUTION: Always disconnect battery and relieve fuel pressure before removing component parts.

MIXTURE CONTROL UNIT

1) On most models, top of mixture control unit must be removed to extract mixture screw plug or steel ball which blocks access opening. Tap plug or ball out with pin punch.

2) Clean around all fuel line connections. Remove fuel lines and wipe up any spilled fuel. Disconnect electrical wiring and remove rubber boot to manifold. Remove Allen screws and lift off mixture control unit.

3) To install, reverse removal procedure. Replace gaskets and seals. Check for leaks after installation.

FUEL DISTRIBUTOR

1) Remove mixture control unit. Remove 3 screws from top of fuel distributor. Lift fuel distributor carefully to ensure that plunger does not fall out.

2) Only line pressure regulator shims may be replaced. If either control plunger or regulator piston is scored, replace fuel distributor. Be sure new "O" ring is in place when installing fuel distributor.

CONTROL PRESSURE REGULATOR

Disconnect electrical plug and vacuum lines (if equipped). Remove fuel lines and wipe up any spilled fuel. Remove bolts and regulator. To install, reverse removal procedure.

AUXILIARY AIR REGULATOR

Remove and plug hoses. Disconnect electrical plug. Remove regulator and mounting bolts. Reverse removal procedure to install.

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COLD START VALVE

Remove electrical connector and fuel line. Loosen mounting bolts and remove cold start valve. Check "O" ring or gasket. Replace if necessary. Install valve.

FUEL INJECTORS

1) Clean area around valves. Hold valve securely and remove fuel line fitting. DO NOT allow valve to turn as damage may result.

2) Remove retaining plate if present, and pull valves out carefully. DO NOT remove insulator sleeve.

3) To install, reverse removal procedure. Replace "O" rings and lubricate with a drop of oil. Place injectors in sleeve and press until seated. Tighten fuel lines and check for leaks.

THERMO TIME SWITCH

Drain coolant below level of switch. Be careful not to damage connectors on switch while removing. Coat threads of sensor with sealant and reinstall.

FREQUENCY VALVE

1) Disconnect electrical connector. Hold small nut at hose and loosen larger valve nut. DO NOT spill gasoline on rubber mounting insulator as it will cause rubber to swell.

2) Remove return lines at fuel distributor and/or control pressure regulator. To install, reverse removal procedure. Use new gaskets. Check for leaks after installation.

ECU

Disconnect multi-plug connector from ECU behind glove box. Remove mounting bolts and ECU. To install, reverse removal procedure.

OXYGEN SENSOR

1) Disconnect wiring from sensor. Remove shield from sensor (if equipped). Remove sensor. Coat threads of new sensor with anti-seize compound. Take care not to get compound into slots on end of sensor.

2) Install sensor and tighten to 25-30 ft. lbs. (35-41 N.m) on all other models. Refit shield and connect sensor wire.

WIRING DIAGRAMS

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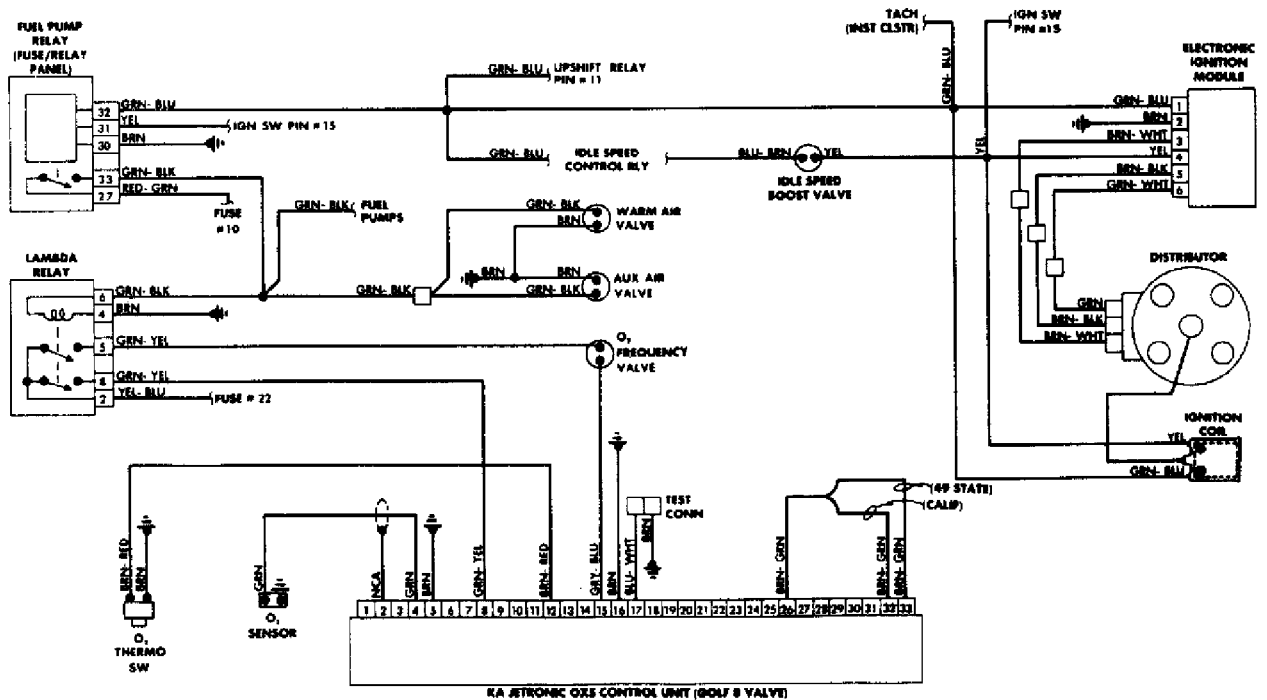
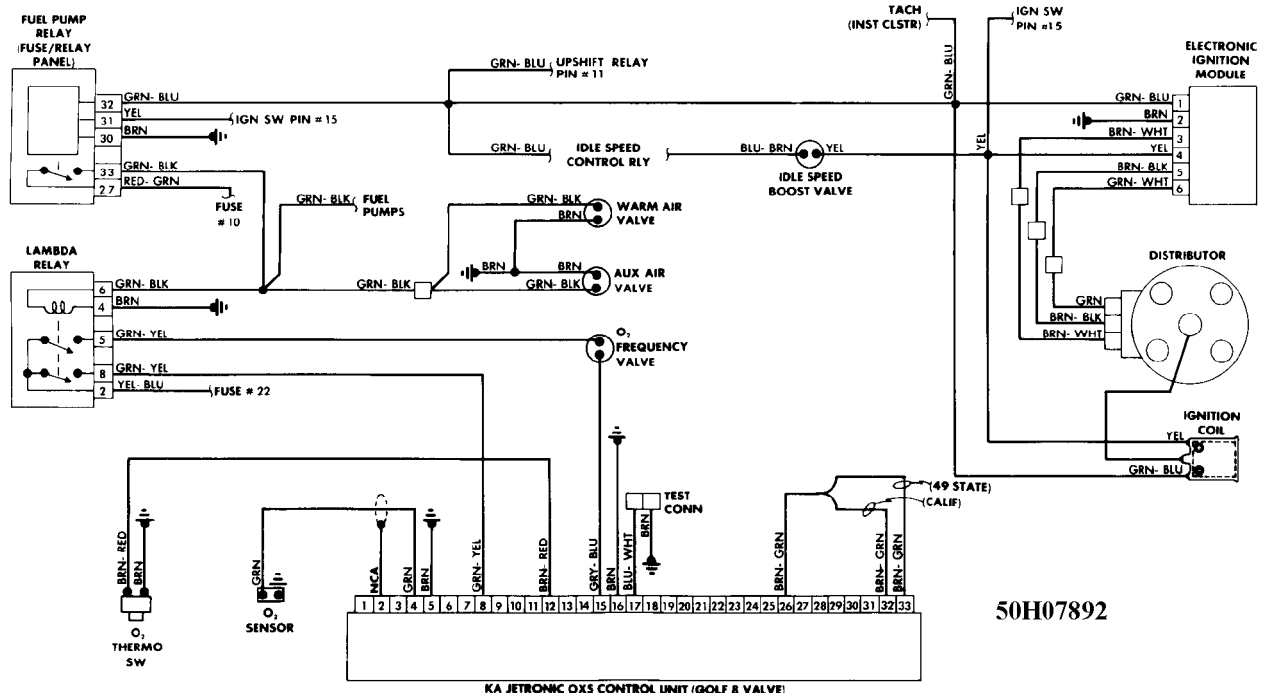


Fig. 13: CIS (Lambda) Wiring Diagram for Volkswagen Cabriolet



50H07892

Fig. 14: CIS (Lambda) Wiring Diagram for Volkswagen Golf

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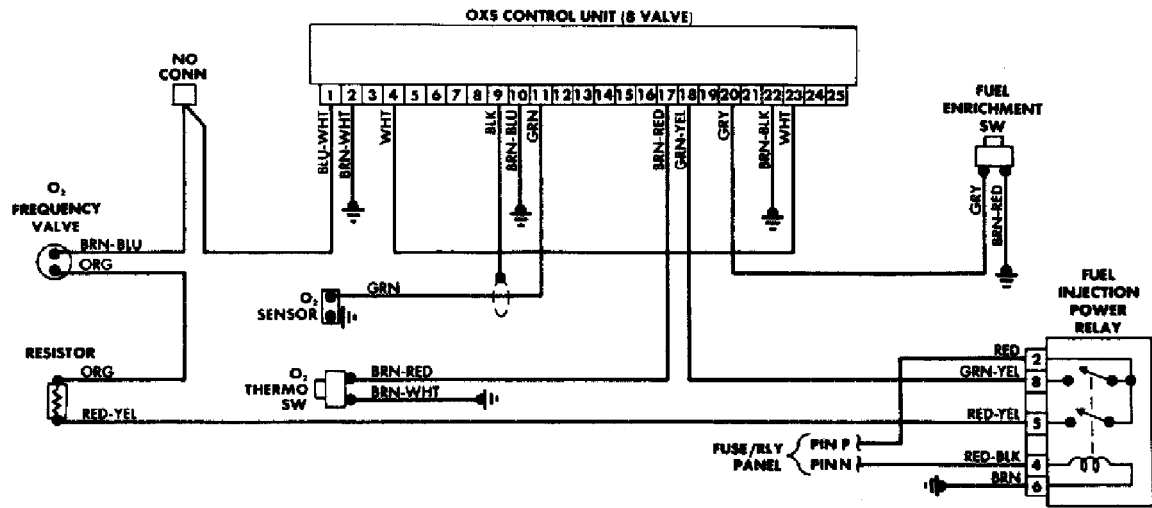


Fig. 15: CIS (Lambda) Wiring Diagram for Volkswagen Jetta

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