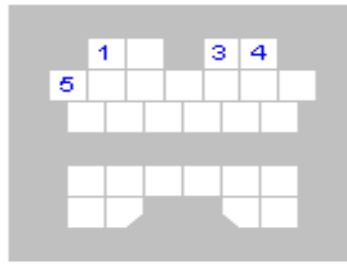


Error codes



Diagnostic plug

Diagnostic plug:

- 1 = Datalink LED tester (FEN)
- 3 = activation error codes (TEN)
- 4 = positive battery terminal (+B)
- 5 = ground

Read-out

- Connect LED tester to positive battery terminal and diagnostic-plug terminal 1.
- Connect diagnostic-plug terminal 3 to ground.
- Turn ignition on.
- Error codes will appear on LED tester.

Reset

- Turn ignition off.
- Disconnect negative terminal of the battery.
- Depress brake pedal for at least 5 seconds.
- Connect negative terminal of the battery.
- Verify that no error codes are displayed.

Signal

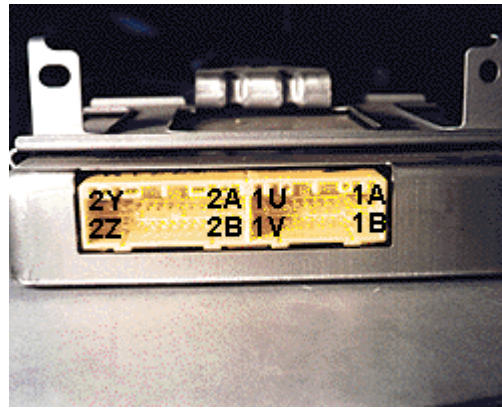
- Digit 1 (tens position): Light pulse 1.2 seconds long, 0.4 seconds pause in-between.
- Pause 1.6 seconds light-off.
- Digit 2 (units position): Light pulse 0.4 seconds long, 0.4 seconds pause in-between.
- Pause 4.0 seconds light-off.

Error codes

- 02 Opto-coupler no signal (Ne).
- 03 Opto-coupler no signal (G).
- 06 Vehicle speed sensor, no signal.
- 08 Mass airflow meter, open or short circuit.
- 09 Coolant temperature sensor, open or short circuit.
- 11 Air temperature sensor, open or short circuit.
- 12 Throttle position sensor, open or short circuit.
- 14 Absolute pressure sensor (inside ECU), open or short circuit.
- 15 Oxygen sensor, lean signal for longer than 75 seconds, engine speed is higher than 1500 rpm, warm engine.
- 17 Oxygen sensor signal does not change for 40 seconds, engine speed is higher than 1500 rpm.
- 25 Increased fuel pressure solenoid, open or short circuit.
- 26 Canister purge solenoid, open or short circuit.
- 28 EGR purge solenoid, open or short circuit.
- 34 Idle speed control valve (ISC) open or short circuit.
- 55 No ATX signal at 40 km/h or higher.
- 56 Thermosensor (ATX), open or short circuit.
- 60 Shift valve 1-2 (ATX), open or short circuit.
- 61 Shift valve 2-3 (ATX), open or short circuit.
- 62 Shift valve 3-4 (ATX), open or short circuit.

- 63 Lock-up solenoid (ATX), open or short circuit.
- 64 Shift timing valve 3-2 (ATX), open or short circuit.
- 65 Lock-up solenoid (ATX), open or short circuit.
- 66 Pressure switch (ATX), open or short circuit.
- 67 Fan relay (low temperature) open or short circuit.
- 68 Fan relay (high temperature) open or short circuit.
- 69 Coolant temperature sensor cooling fan, open or short circuit.

100. control unit



Function

The control unit receives signals from sensors that monitor various engine operating parameters. The control unit generates output signals to provide optimal air/fuel ratio, idle speed control and ignition timing.

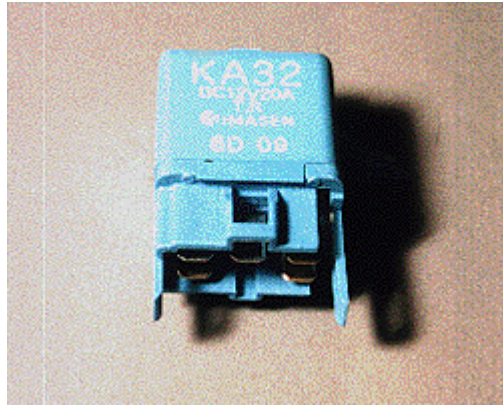
Diagnosis

Check connector(s): Inspect the connector(s) and if necessary clean or fix them to make sure the connection is good. When you suspect the control unit is faulty, make sure all sensors and actuators function properly, and that signals from other control unit(s) are received properly. Next check the supply voltage and ground connections of the control unit:

Turn ignition off. Remove ECU connector.

Locate the supply voltage connections. Turn ignition on. Measure voltage between corresponding connector terminal(s) and the negative terminal of the battery. They should equal battery voltage. If not check wiring and fuse. Turn ignition off. Locate the ground connections. Measure resistance between corresponding connector terminal(s) and the negative terminal of the battery. They should be < 1 ohm.

92. relay



Function

A relay is an electrically operated power supply switch, switching supply voltage to the component(s) of the engine management system.

Specifications

single normally opened relay.

Diagnosis

Check connector(s): Inspect the connector(s) and if necessary clean or fix them to make sure the connection is good.

Check relay:

Turn ignition off. Remove relay from relay box.

Connect the input of the coil to battery voltage and the output of the coil to ground. The relay should click. If not replace relay.

Check the switch of the relay. Measure the resistance between the input of the switch and the output. When switch is closed the resistance should be < 1 ohm. When switch is open, the resistance should be infinite. If not replace relay.

Check supply voltage:

Turn ignition off. Remove relay from relay box.

Turn ignition on. Connect a circuit tester between the input terminal of the coil or the input terminal of the switch in the relay box and the negative terminal of the battery. Both times the tester should light up. If not check wiring and if present fuse(s), second relay and inertia switch.

Check connection to ECU:

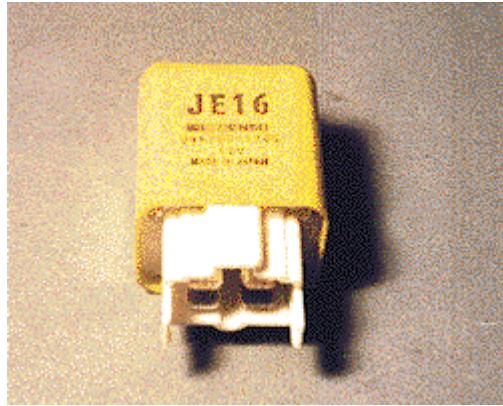
Turn ignition off. Remove relay from relay box and remove connector from ECU.

Measure the resistance between the output terminal of the coil in the relay box and the corresponding terminal in the ECU connector. It should be < 1 ohm. If not check wiring.

Check signal from ECU:

Measure voltage between the output terminal of the coil and the positive terminal of the battery. Crank the engine. It should equal battery voltage. If not check ECU.

90. main relay



Function

Switches power to sensors, actuators and / or control unit.

Specifications

single normally opened relay.
colour relay: yellow

Diagnosis

Check connector(s): Inspect the connector(s) and if necessary clean or fix them to make sure the connection is good.

Check relay:

Turn ignition off. Remove relay from relay box.

Connect the input of the coil to battery voltage and the output of the coil to ground. The relay should click. If not replace relay.

Check the switch of the relay. Measure the resistance between the input of the switch and the output(s). When coil connected the resistance should be < 1 ohm. When coil disconnected resistance should be infinite. If not replace relay.

Check supply voltage:

Turn ignition off. Remove relay from relay box.

Turn ignition on. Connect a circuit tester between the input terminal of the coil or between the input terminal of the switch in the relay box and the negative terminal of the battery. The tester should light up. If not check wiring and, if present, fuse(s) and second relay.

Check connection to ECU:

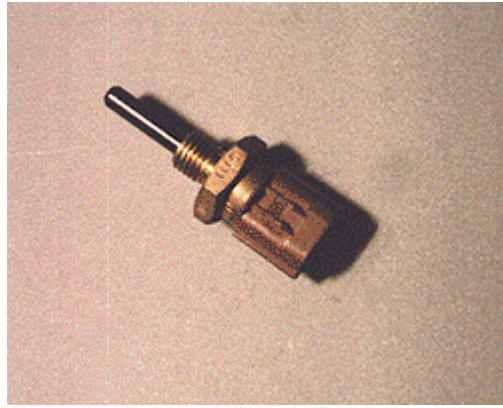
Turn ignition off. Remove relay from relay box and remove connector from ECU.

Measure the resistance between the output terminal(s) of the switch in the relay box and the corresponding terminal(s) in the ECU connector. It should be < 1 ohm. If not check wiring.

Check connection to ground:

Turn ignition off. Remove relay from relay box. Measure the resistance between the output terminal of the coil and the negative battery terminal. It should be < 1 ohm. If not check wiring.

43. air temperature sensor



Function

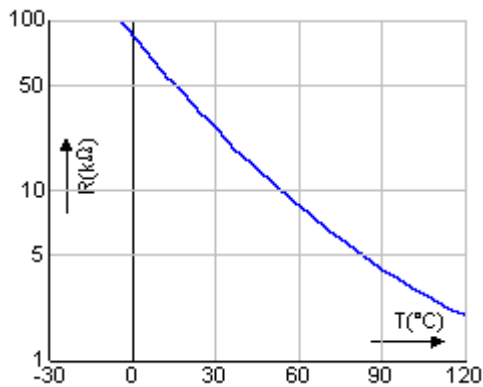
The air temperature sensor is a temperature-sensitive resistor. Low temperature causes high resistance while high temperature causes low resistance. The control unit determines the temperature by monitoring the voltage across the sensor.

Specifications

supply voltage: 5 V

resistance: 35,000 - 40,000 ohms / 20°C

resistance: 1,900 - 2,500 ohms / 100°C



CANISTER PURGE SOLENOID

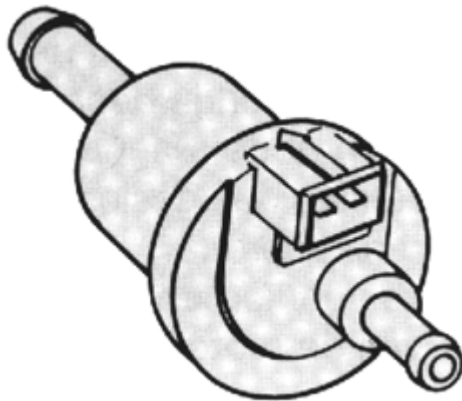
Function

The evaporative gases produced in the fuel tank are absorbed by the activated charcoal in the carbon canister. As the purge control solenoid valve opens these gases are delivered to the intake manifold for combustion purposes. The purge control solenoid valve is controlled by the control unit. The control unit operates this valve during the time the lambda control loop is active.

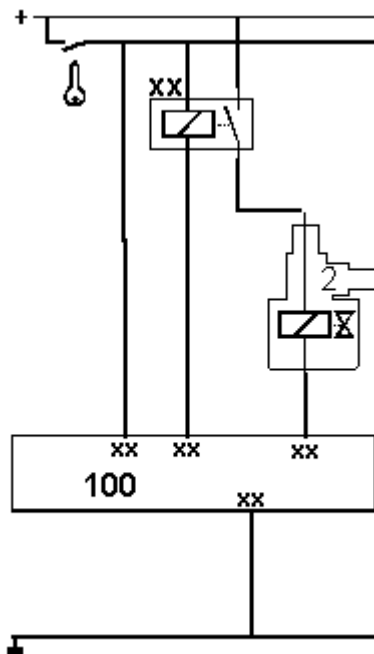
Specifications

RESISTANCE:

resistance:	± 50 ohms
supply voltage:	12 Volts
current:	± 250 mA



Electrical control



Most solenoids are normally closed. This means that the connection between the canister and the intake manifold is closed. The solenoid has a connector with two terminals. On one of those terminals is connected to the battery voltage. This supply-voltage is often switched with a relay. The other terminal leads directly to the control unit. The current through the solenoid is switched on during the time the control unit connects this terminal to ground. The voltage on this terminal is during this time 0 Volts. During the time the solenoid is switched off, the voltage on this terminal is 12 Volts. Some motormanagement systems control the amount gases delivered to the intake manifold switching the solenoid on and of with a certain duty cycle. In this case the duty-cycle depends on engine RPM and engine load.

Electrical diagnosis

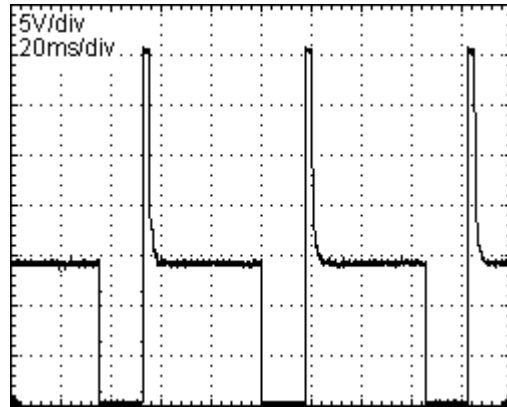
STATIC

General

- To perform this measurements the relay switching the power to the solenoid should be closed. Short circuit the switch in the relay if necessary.

Measurements

- Measure the voltage on the control unit. Use the pin which switches the solenoid.



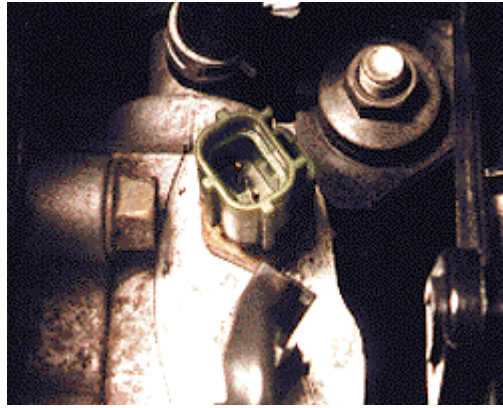
result: **12 V**

- solenoid and wiring are electrically OK

0 V

- check the relay switching the power to the solenoid
- check the wiring between the relay and the solenoid
- check the solenoid resistance
- check the wiring between the solenoid and the control unit
- check the control unit

42. coolant temperature sensor

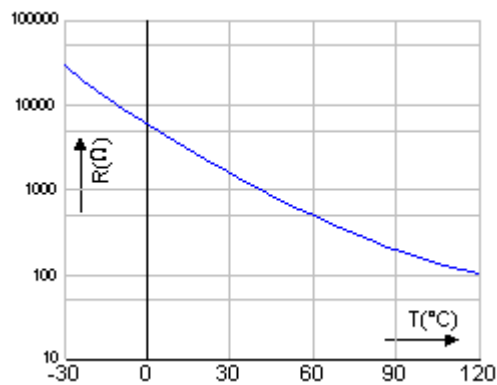


Function

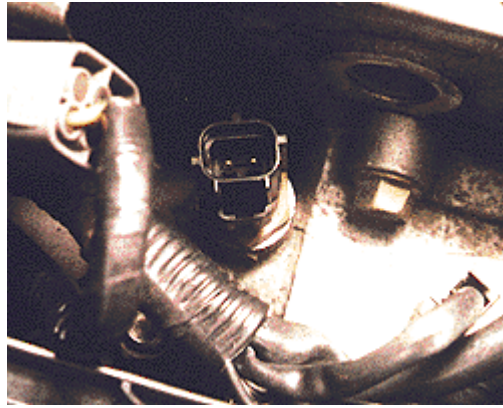
The coolant temperature sensor is a temperature-sensitive resistor. Low temperature causes high resistance while high temperature causes low resistance. The control unit determines the temperature by monitoring the voltage across the sensor.

Specifications

supply voltage: 5 V (connector disconnected)
resistance: 2,000 - 3,000 ohms / 20°C
resistance: 200 - 300 ohms / 90°C



186. coolant temperature sensor fan



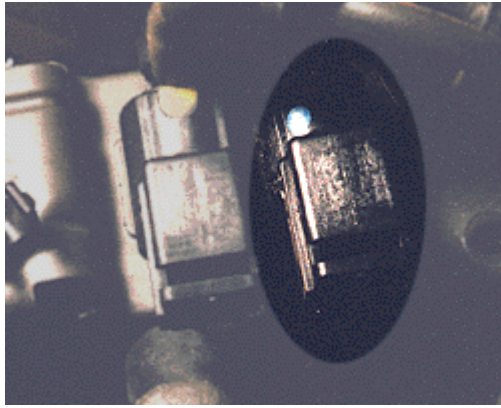
Function

The coolant temperature sensor is a temperature-sensitive resistor. Low temperature causes high resistance while high temperature causes low resistance. The control unit determines the temperature by monitoring the voltage across the sensor and switches the cooling fan on or off.

Specifications

supply voltage: 5 V
resistance: 1,700 - 1,840 ohms / 91°C
1,420 - 1,530 ohms / 97°C
1,030 - 1,110 ohms / 108°C

23. EGR purge solenoid



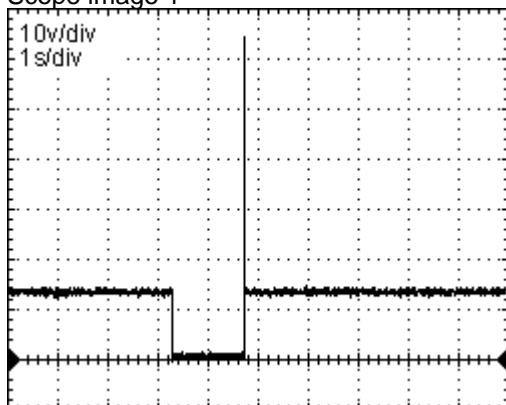
Function

The EGR purge solenoid controls the vacuum at the EGR valve. The EGR purge solenoid is controlled by the control unit.

Specifications

supply voltage: 12 V
resistance: 35 - 45 ohms

Scope image 1



Pins to ground: 2S

Diagnosis

Check connector(s): Inspect the connector(s) and if necessary clean or fix them to make sure the connection is good.

Check resistance:

Turn ignition off. Remove connector from solenoid.

Measure resistance between the two pins of the solenoid. Compare with specified resistance. Alternatively, check solenoid function by applying battery voltage to its pins. The solenoid should "click".

Check supply voltage:

Turn ignition off. Remove connector from solenoid.

Turn ignition on, start or crank the engine and measure voltage between one connector terminal and the negative terminal of the battery. Check the second terminal. One of the two should equal battery voltage. If not check wiring and, if present, relay or power supply unit and fuse(s).

Check connection to ECU:

Turn ignition off. Remove connectors from solenoid and ECU.

Measure the resistance between one of the two connector terminals and the corresponding terminal in the ECU connector. Check the other terminal. One of the two should be < 1 ohm. If not check wiring.

Check solenoid activation:

Connect oscilloscope to signal pin of the ECU and ground. Start the engine and compare to the scope image shown.

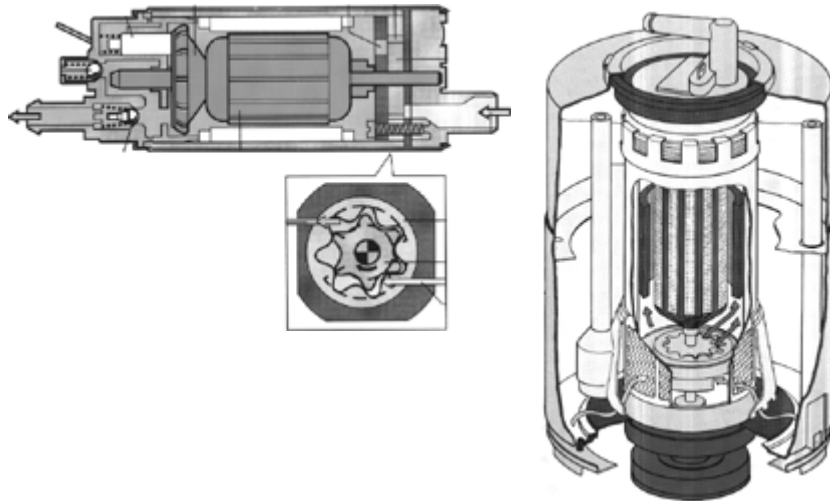
FUEL PUMP

Function

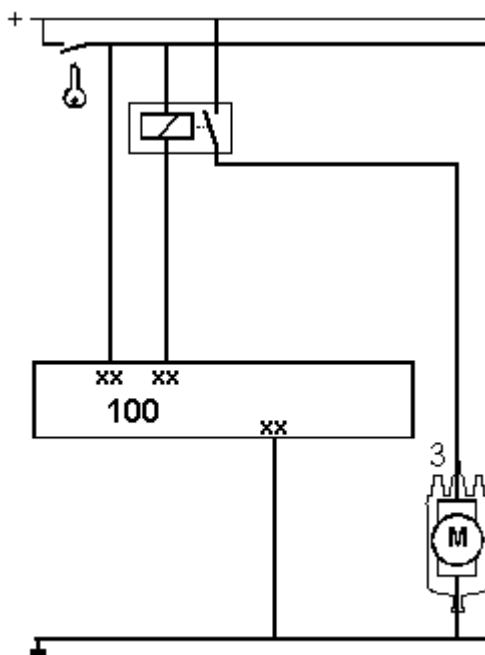
The fuel pump is an electrically operated pump which lifts the fuel from the fuel tank and pumps it under pressure through a filter to the fuel rail or throttle body. The fuel runs along the injector(s) and returns to the tank via the fuel pressure regulator. Some systems use two pumps. The fuel lift pump inside the tank and the fuel pressure pump outside the tank.

Specifications

pump pressure:	$\pm 0,25 - 6$ bars
system pressure:	$\pm 0,6 - 1,1$ bar (single-point) $\pm 2 - 3,5$ bar (multi-point)
flow:	$\pm 50 - 100$ l/h
supply voltage:	12 Volts
current:	$\pm 5A$



Electrical control



The fuel pump is operated by a relay. The conditions the relay is closed are.

- during several seconds after switching on the ignition
- during the time the system receives RPM pulses.

The fuel pump relay is often controlled by the control unit.

The relay coil has two terminals. On one of those terminals is connected with the battery voltage. The other terminal leads directly to the control unit.

The current through the relay coil is switched on during the time the control unit connects this pin to ground. The voltage on this pin is during this time 0 Volts. During the time the relay is not switched on, the voltage on the pin is 12 Volts.

Electrical diagnosis

STATIC

General

- Turn the ignition switch "on"
- Listen to the fuel pump operating sound. The fuel pump should operate for several seconds after the ignition switch is turned "on"

Power supply

- To perform this measurements the relay switching the power to the fuel-pump should be closed. Short circuit the switch in the relay if necessary.

Measurements

- Disconnect the fuel pump connector. Measure the voltage over the fuel pump terminals in the connector. The voltage should be 12 Volts.

result: **12 V**

- replace the fuel pump

0 V

- check ground circuit
- check the wiring between the relay and the pump
- check the relay switching the power to the pump

Mechanical diagnosis

Measurements

- To perform this measurements the relay switching the power to the fuel-pump should be closed. Short circuit the switch in the relay if necessary.
- check the fuel system pressure

result:

- check the fuel level in the tank
- check the fuel pressure regulator
- check the fuel filters
- check the fuel pump
- check the fuel return circuit to the tank

IDLE SPEED CONTROL VALVE

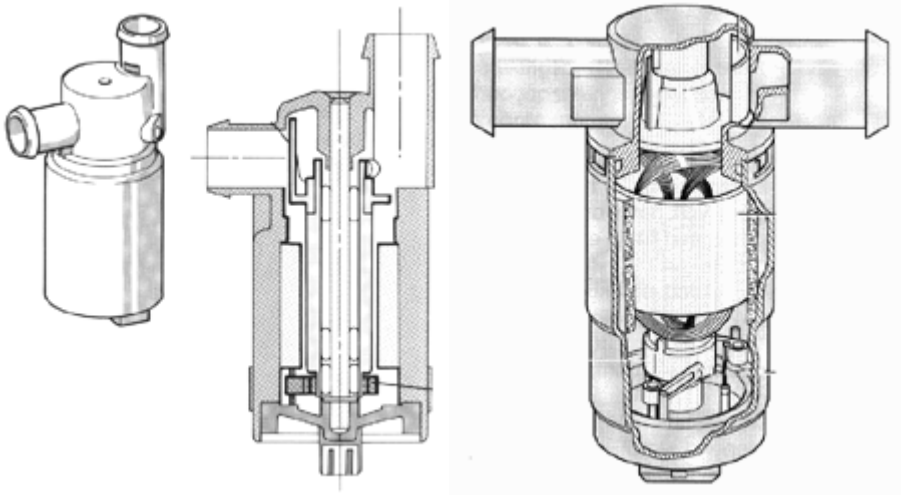
Function

The idle control valve is located in a tube bypassing the throttle. The control unit controls this device to ensure stable idling in all operating conditions.

Specifications

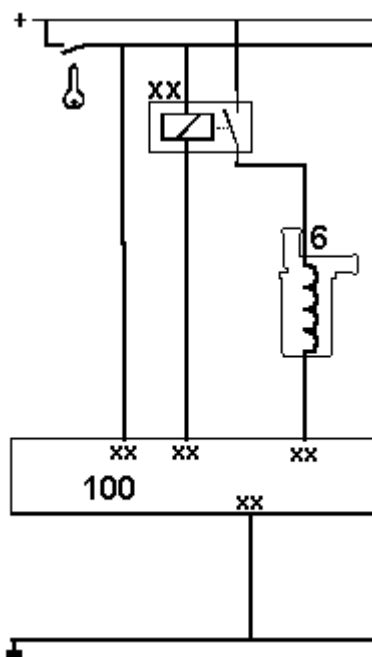
resistance coil(s):	± 20 ohms
supply voltage:	12 Volts

A rotary slide valve attached to the armature is turned to open the air bypass until the desired idle speed is obtained. The position of the armature is controlled by the force of an internal spring opposing the force of a solenoid (types with two terminals) or controlled by two solenoids energised alternately which exerts opposing forces on the armature (types with three terminals).



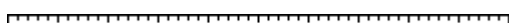
Electrical control

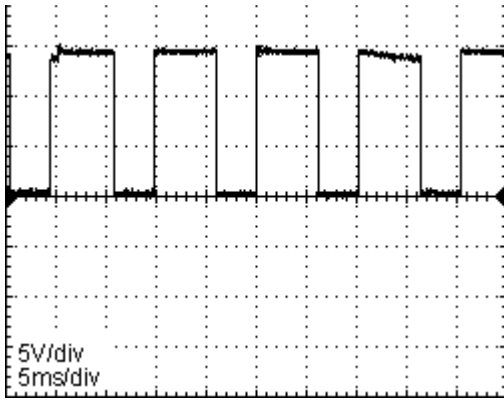
Types with two terminals



As a current flows through the coil the armature is turned against the spring force. As the current increases the airflow and the idle speed increases. If the current through the coil is switched off due to a malfunctioning system, the valve is forced into a position which results in a (too) high idle speed.

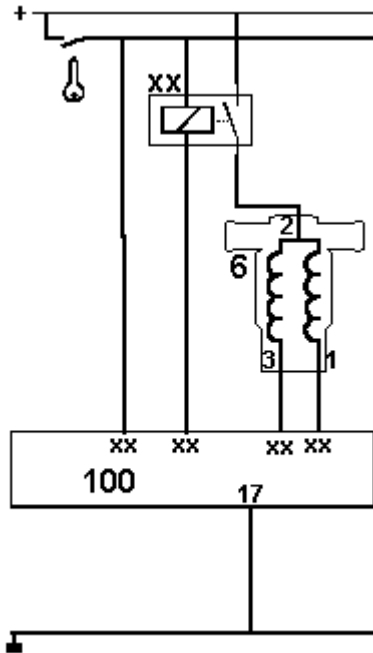
The idle control valve has a connector with two terminals. On one of those terminals is connected to the battery voltage. This supply-voltage is often switched with a relay. The other terminal leads directly to the control unit. The current through the coil is switched on during the time the control unit connects this terminal to ground. The voltage on this terminal is during this time 0 Volts. During the time the current through the coil is switched off, the voltage on this terminal is 12 Volts.



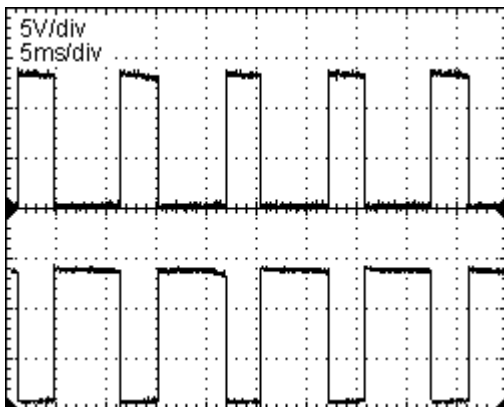


The control unit controls the current through the coil switching the current on and off with a certain duty cycle. The current increases as the duty-cycle increases. The duty cycle varies between approx. 35% (valve closed) and 85% (valve opened). Nominal idle speed is obtained when slightly open.

Three terminal types



The two coils inside this type of idle speed control valve are connected with the supply voltage using one common terminal. The other two terminals lead directly to the control unit. The control unit switches the current through the solenoid on and off alternately with a duty cycle between 35 and 85%.



Electrical diagnosis

STATIC

- To perform this measurements the relay switching the power to the idle control valve should be closed. Short circuit the switch in the relay if necessary.

Measurements:

Disconnect the connector and

DYNAMIC TESTS THREE TERMINAL TYPES

- Remove the idle control valve but leave the electrical connections in place. Fully open or close the rotating plunger. Switch on the ignition.

measure the resistance of the coil(s). The nominal value is app. 20 ohms.

- Check the relay switching the power to the idle control valve
 - Check the wiring between the relay and the idle control valve
 - Check the wiring between the idle control valve and the control unit
 - Check the control unit
- result:
- Switch on the ignition. The rotating plunger must move to a position equivalent to app. 50% opening, and remain there.

Mechanical diagnosis

- Check the air chamber on air leakage.
- Check engine on air leaks into the intake system.
- Remove the idle control valve. The plunger should rotate or move easily. Clean if necessary.

IGNITION COIL

Function

The ignition coil transforms the battery voltage into the high voltage needed to create a spark.

The ignition coil consists of an electromagnet (the primary coil) and a high voltage coil (secondary coil).

By switching the current through the primary coil on, a magnetic field is induced. The moment the current is switched off, the magnetic field suddenly disappears.

This change of magnetic field creates an induction voltage in the secondary coil, high enough to ionise the mixture. The ionised mixture is a conductor and a current flows through the spark plug.

Specifications

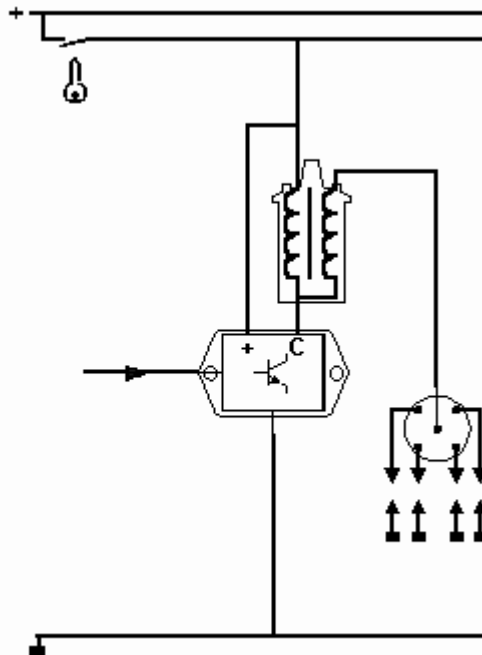
RESISTANCE:

primary:	$\pm 0,3 - 2$ ohms
secondary	$\pm 5k - 20k$ ohms
supply voltage:	12 V
current limited at:	$\pm 7A$

Systems with a distributor

Ignition coils used in combination with a distributor consists of one primary and one secondary coil.

The high voltage, induced in the secondary coil is connected to one of the spark plugs



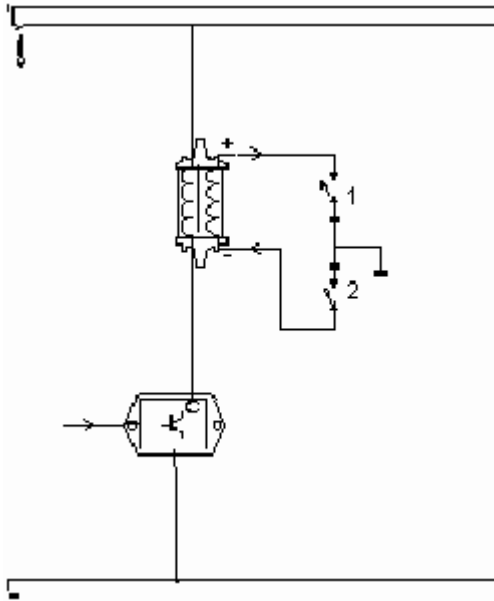
selected by the distributor.



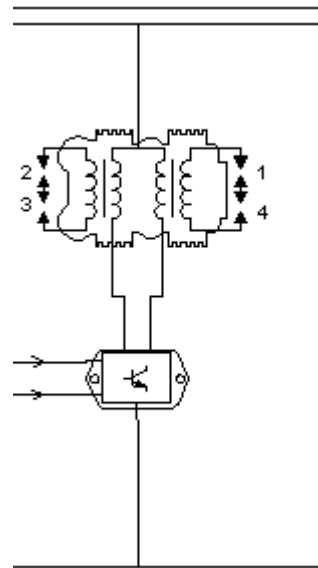


Wasted spark ignition coils

The secondary coil has two ends. In a normal ignition coil one of those ends delivers the high voltage to a spark plug. The other end is connected to either the positive (+) or the negative (-) terminal of the primary coil. In a wasted spark ignition coil both ends are connected to a spark plug. Therefore both spark plugs will spark at the same time.

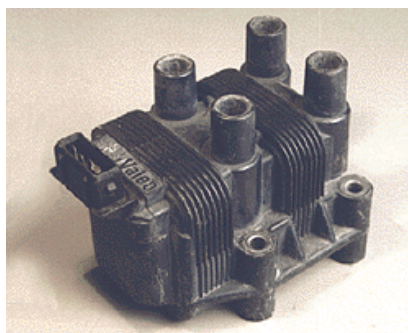
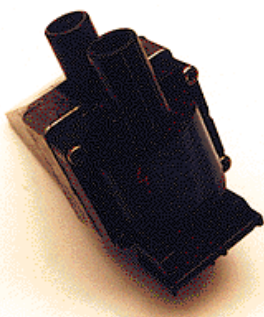


wasted spark ignition coil on 2- cylinder 4-stroke engine



a wasted spark ignition coil on a 4- cylinder 4-stroke engine

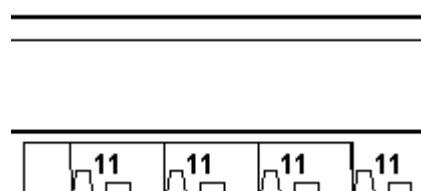
To supply the four spark plugs of a 4 cylinder engine, two ignition coils are needed. The picture below (left) shows an ignition coil for two spark plugs. The ignition coil in the right picture incorporates two of those. This ignition coil supplies four spark plugs.

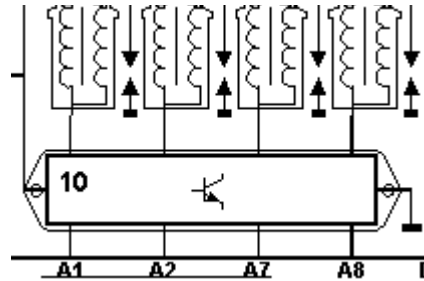


Sequential ignition

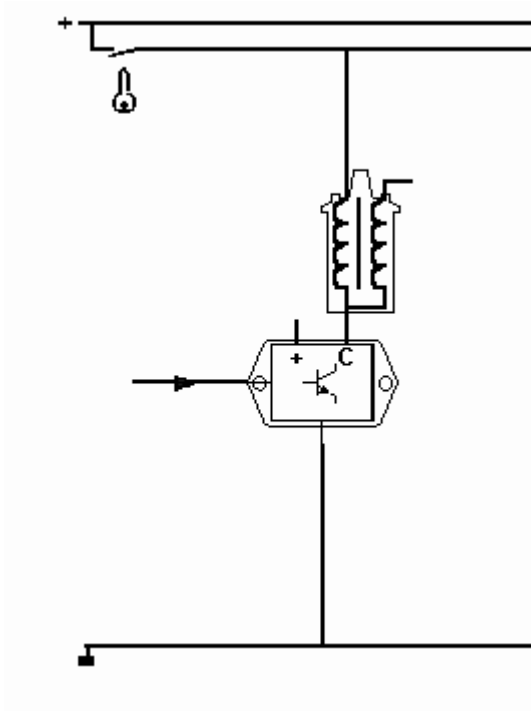
Sequential ignition systems are distributor less ignition systems using one ignition coil per cylinder.

Each ignition coil is controlled by the control unit individually.





Electrical control



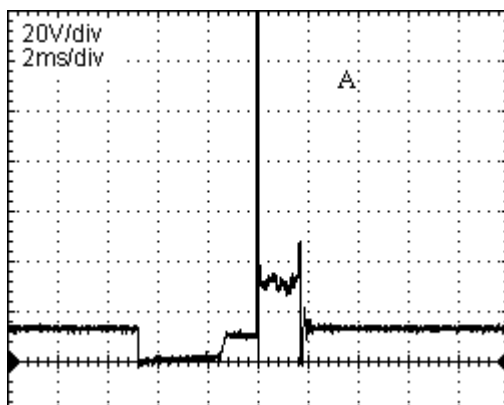
A current through the primary coil induces a magnetic field. The moment the current is switched off, the magnetic field suddenly disappears. This change of magnetic field induces an induction voltage and causes a spark.

The amperage before switching the current off should be high enough to create a high change of magnetic field the moment the current is switched off.

Therefore the current through the primary coil is controlled electronically.

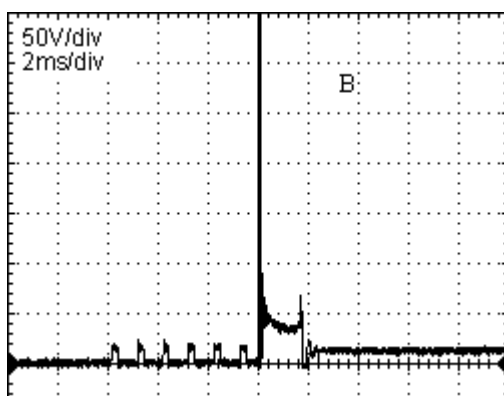
The ignition module is supplied with a current limited circuit. Using this in combination with a low resistance ignition coil the amperage does not depend on the battery voltage.

During the time the current is switched off, the voltage over the ignition module is 12 Volts. The moment the current is switched on, the voltage drops to 0 Volts. From this moment on the current increases until the limiting value is reached.

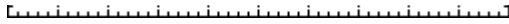


The oscilloscope images A and B gives you an example of the primary voltage measured on two different current limiting circuits.

By increasing the voltage over the ignition module, the voltage over the primary coil decreases. This causes a limited current in oscilloscope image A.



The ignition module in oscilloscope image B switches the current on and off to limit the current.



Electrical diagnosis

STATIC

To perform this measurements the ignition should be switched on.

Measurements:

- Measure the primary and secondary resistance of the ignition coil.
- Measure the voltage on the positive terminal of the ignition module.

The voltage should be equal to the battery voltage.

result: **Voltage is lower than battery voltage.**

- disconnect positive terminal and repeat measurement

result: **Voltage is equal to battery voltage.**

- check primary resistance of the ignition coil
- check ignition module
- check wiring between ignition module and ignition module.

result **Voltage is still lower than battery voltage.**

- check ignition lock
- check wiring between ignition lock and ignition coil

DYNAMIC

Start the engine and measure the primary voltage using an oscilloscope.

result: **0 V**

- check power supply.

12 V

- check ignition module

Mechanical diagnosis

Not available for this subject !

IGNITION MODULE

Function

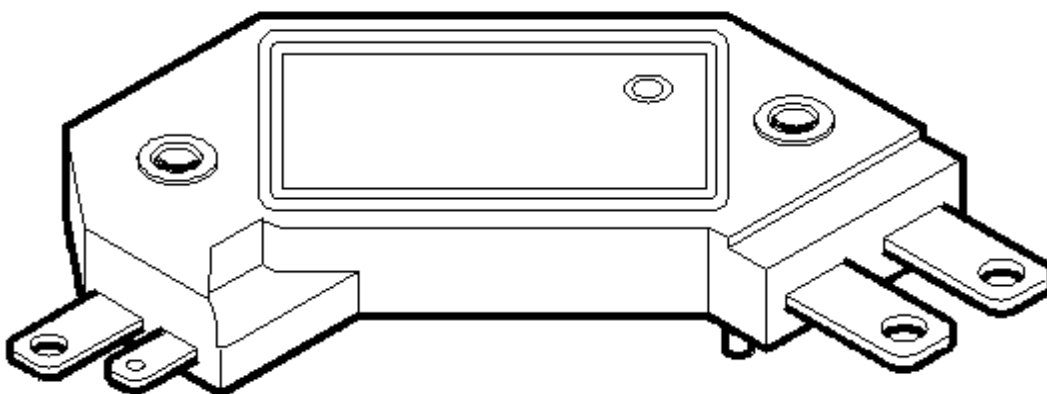
The ignition module switches the current through the primary ignition coil on and off. The ignition module charges the ignition coil during the time the current is switched on. The moment the ignition module switches the current 'off' the ignition coil induces an induction voltage which causes the spark.

An ignition module switches the current on and off according to an input signal. This input is delivered by the control unit. On older systems the input signal is delivered by an inductive, Hall or opto-coupled sensor mounted in the distributor.

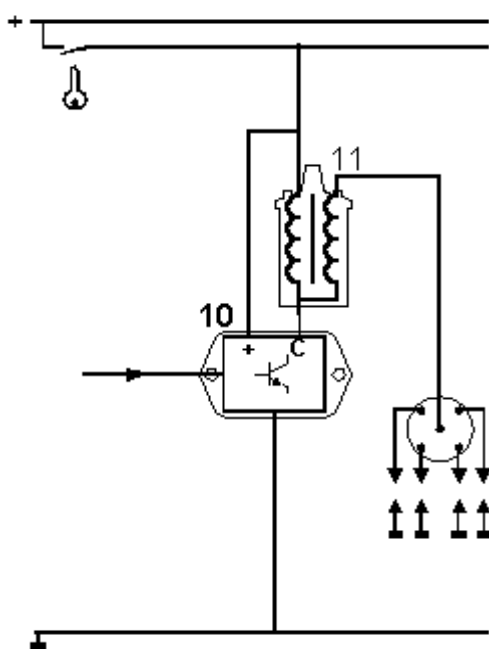
Specifications

resistance -

supply voltage -



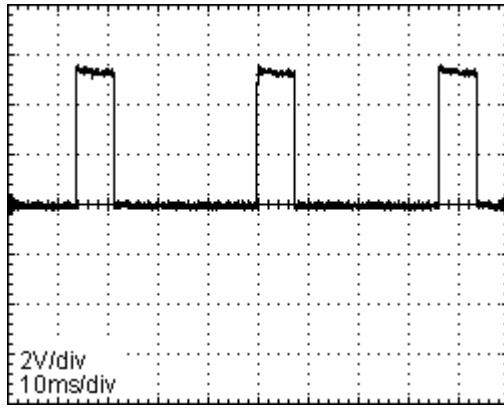
Electrical control



The connector of the ignition module has several terminals. The following terminals are used on common ignition modules.

- a terminal connected with the ignition coil. By this terminal the current through the ignition coil is switched on and of.
- a terminal connected with the supply voltage (12 Volts)
- a terminal connected with ground.
- terminal(s) to receive the input signal. If the input signal is delivered by an inductive sensor two terminals are needed.

The output voltage of an inductive sensor is delivered by an internal coil. This coil induces an almost sine wave output voltage. If the input signal is delivered by an Hall-sensor or opto-coupler three terminals are needed. Two of those three terminals are used to supply the sensor. The supply voltage is either 5 or 12 Volts. The third terminal receives the output signal from the sensor. The output voltage of these sensors is a square wave signal.



Addition terminals are possible. For example to send out a RPM signal to the revolution counter. Sometimes the input signal is delivered by a sensor while the ignition timing is controlled by the control unit. In this case the received input signal from the sensor is converted into a square wave signal by the ignition module and send out to the control unit. The control unit receiving this signal computes this input information and other input information from various engine parameters and sends out a new square wave signal to the ignition module. This signal is used by the ignition module to switch the current through the primary ignition coil on and off.

During the time the input signal for the ignition module is 'high' the current is switched 'on'. The moments this input signals falls to 'low' the current is switched 'off'. This moment the spark will appear

Electrical diagnosis

- Start the engine and measure (using an oscilloscope) the input signal delivered by the control unit or input sensor. The square wave signal or sine wave signal from a inductive sensor should be visible.
- signal not OK:
- Disconnect the ignition module's connector and check the wiring between the ignition module and the control unit or input sensor.
 - replace the ignition module if the signal appears on the disconnected connector and disappears on the connected connector.

If the output signal remains invisible the failure is not in the component.

- signal OK:
- check the power supply of the ignition module.
 - check the primary voltage using an ignition oscilloscope or normal oscilloscope with a suitable probe.
 - check the wiring between the ignition module and the ignition coil.

The voltage should be nearly 0 Volt during the period the ignition module receives an 'high' input voltage from the sensor or control unit.

Mechanical diagnosis

- Remove the auxiliary air valve without disconnecting the connector.
- Turn the ignition on and make sure that the valve closes as the heating element heats-up the bi-metallic strip.

167. increased fuel pressure solenoid



Function

The vacuum solenoid (P.R.C.) regulates the connection between the fuel pressure regulator and the inlet manifold vacuum. The vacuum solenoid is activated by the control unit at air temperatures above 20°C, at engine speeds below 1500 rpm, and with the idle switch closed.

Specifications

supply voltage: 12 V
resistance: 35 - 45 ohms

INJECTOR

Function

Injectors are electronically operated electromagnetic valves. Using the injectors the control unit is able to inject an exact quantity of fuel. Adding this quantity of fuel to the air, a mixture with the demanded air/fuel ratio is created. Depending on the kind of motormanagement system either one injector per cylinder (multipoint systems) or one injector for all cylinders (singlepoint systems) are used.

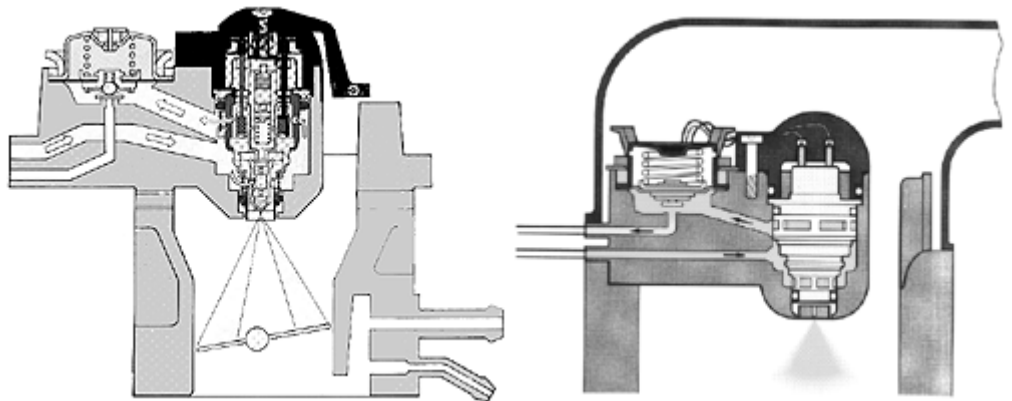
Specifications

RESISTANCE:

high impedance:	± 15 ohms
low impedance:	± 0,5 - 2,5 ohm
flow:	± 50 - 200
gr/minsupply voltage:	1- 12 Volts
current:	± 0,75Amps

Single-point systems

Single-point fuel injection systems use one central placed injector to create the required air/fuel ratio. The injector is mounted in the throttle-body and injects the fuel on top of the throttle. The fuel is delivered by a fuel pump and kept at a constant level by the fuel pressure regulator mounted on the throttle body. The fuel pressure on single-point systems is usually between 0,6 and 1,2 bars .



Multipoint systems

Multipoint fuel injection systems use one injector for each cylinder. The injectors are mounted in the intake manifold. The fuel is injected in the direction of the inlet valves. The fuel is delivered by a fuel pump. The pressure difference between the air pressure in the intake manifold and the fuel pressure is kept at a constant level by the fuel pressure regulator. Therefore the fuel pressure regulator increases the fuel pressure as the intake manifold pressure increases. The fuel pressure on multipoint systems is usually between 2 and 3 bars. The fuel pressure regulator is mounted on the fuel rail.

Sequential fuel injection

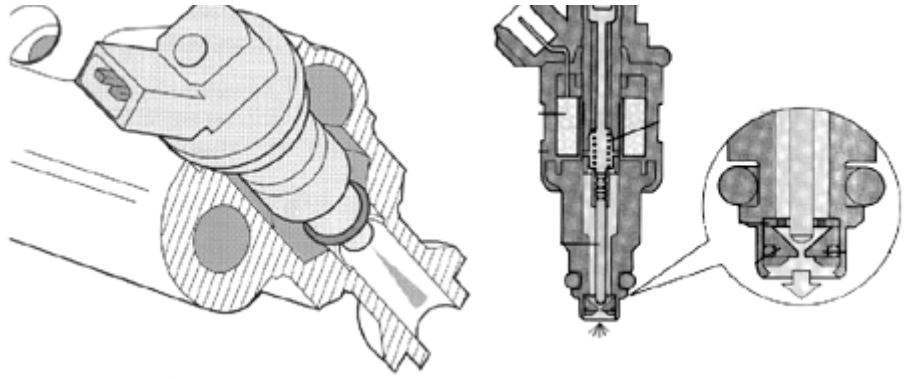
Sequential fuel injection is a method used by multipoint systems to control the air/fuel ratio and the injection timing per cylinder. Each injector of a sequential injection system is controlled by the control unit individually..

Bottom- and top-feed injectors

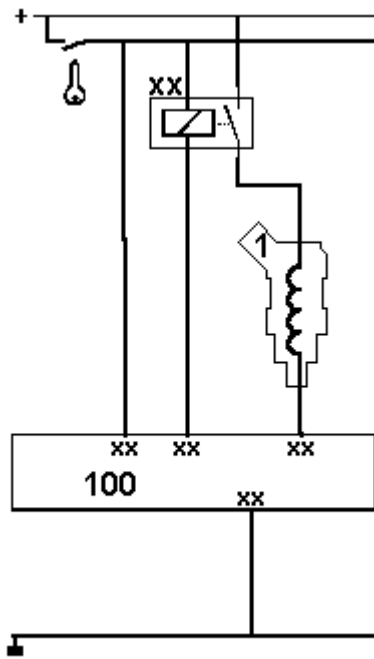
The injector fuel inlet can be at the



top or at the bottom. Bottom-feed injectors are often used on singlepoint injection systems while top-feed injectors more often are used as multipoint injectors.



Electrical control

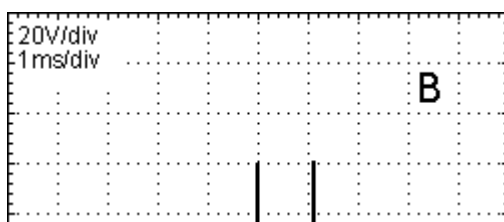
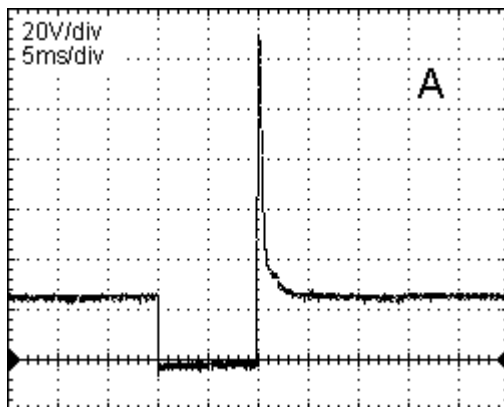


The electrical behaviour of an injector is determined by the coil inside. As a current flows through the coil the injector needle is pulled up against the spring force which causes the fuel to be injected. Two types of injector coils are used. The resistance of a normal coil is approximate 15 ohms. Other injection systems use low resistance coils (approximate 1-2,5 ohms).

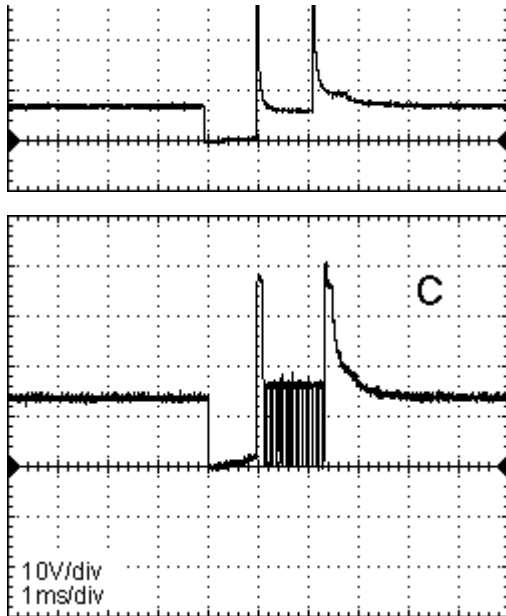
Low impedance injector can be switched on in two different ways:

- using an extra external resistance to limit the current
- using a current limiting circuit inside the control unit.

An injector has an electrical connector with two pins. On one of those pins is connected with the battery voltage. This supply-voltage is often switched to the injector using a relay. The other pin leads directly to the control unit. The current through the injector is switched on during the period the control unit connects this pin to ground. The voltage on this pin is during this time 0 Volts. During the period the injector is not switched on, the voltage on the pin is 12 Volts



Oscilloscope image A shows the voltage signal measured on an high impedance injector or low impedance injector with external resistance.



Oscilloscope images B and C show two different current limiting circuits used on low impedance injectors.

Electrical diagnosis

STATIC

- To perform this measurements the relay switching the power to the injector(s) should be closed. Short circuit the switch in the relay if necessary. Perform the tests on one injector at the time. Disconnect parallel switched injectors.

Measurements

Measure the voltage on the control unit. Use the pin which switches the injector current.

result: **12 V**

- injector and wiring are electrically OK

0 V

- check the relay switching the power to the injector(s)
- check the wiring between the relay and the injector
- check the injector resistance
- check the wiring between the injector and the control unit
- check the control unit

DYNAMIC

- Connect all injectors. Start the engine and measure using an oscilloscope the voltage on the control unit's pin switching the injector current.

result: **0 V**

- perform static tests.

12 V

- control unit does not switch the injector(s).

Mechanical diagnosis

- check fuel system pressure
- check injectors on leakage and pollution
- bottom-feed injectors: check the seal between the injector and the throttle body
- multipoint systems: disconnect the hose between the fuel pressure regulator and the intake manifold. No fuel should leak out of the fuel pressure regulator.

31. mass airflow meter



Function

The mass airflow meter uses a wire filament kept at constant temperature to measure the air mass entering the engine inlet system.

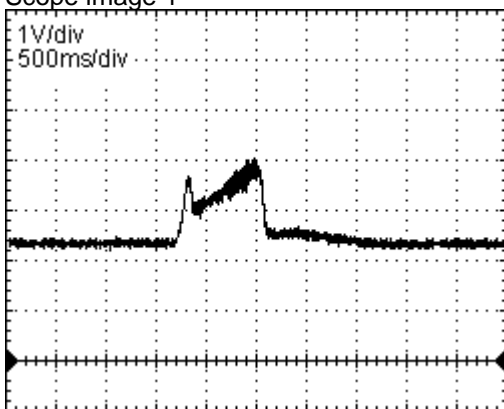
Specifications

supply voltage: 12 V

output voltage: 0 - 5 V

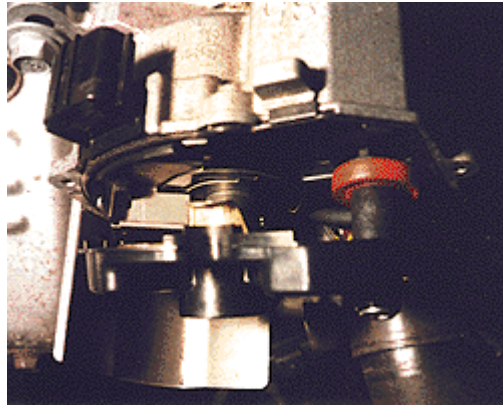
waveform information: during acceleration

Scope image 1



Pins to ground: 20

178. opto-coupler



Function

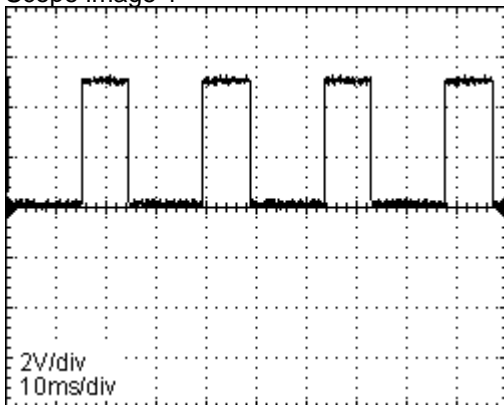
The disc mounted on the rotor passes through the opto-coupler, which sends a signal to the control unit to determine TDC.

Specifications

supply voltage: 12 V

waveform information: engine running at idle

Scope image 1



Pins to ground: 2E

37. oxygen sensor

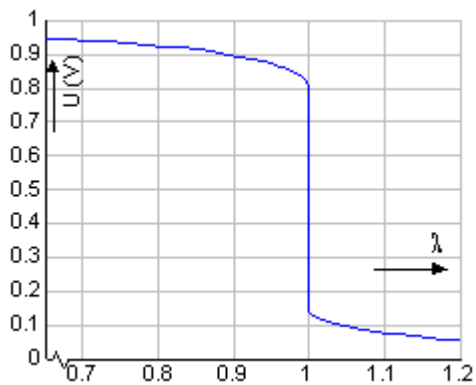


Function

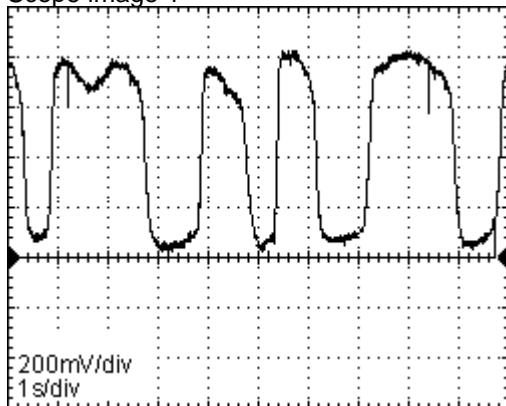
The oxygen sensor is exposed to exhaust gas flow and returns an output signal proportional to the oxygen content of the exhaust gases. A heating element maintains the sensor at constant operating temperature.

Specifications

supply voltage heating element: 12 V
resistance heating element: 4 - 40 ohms (20°C)
output voltage: 200 - 850 mV
waveform information: hot engine running at idle

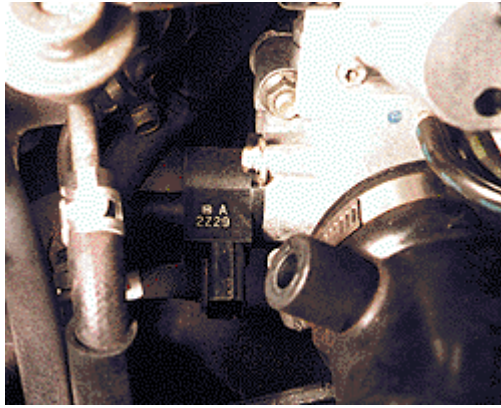


Scope image 1



Pins to ground: 2N

33. throttle position sensor



Function

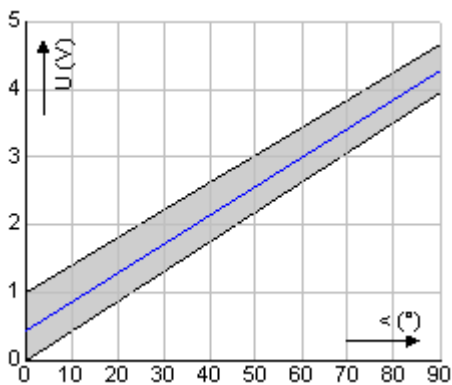
The throttle position sensor measures the angle of the throttle shaft using a potentiometer. The sensor returns a signal proportional to the throttle shaft angle.

Specifications

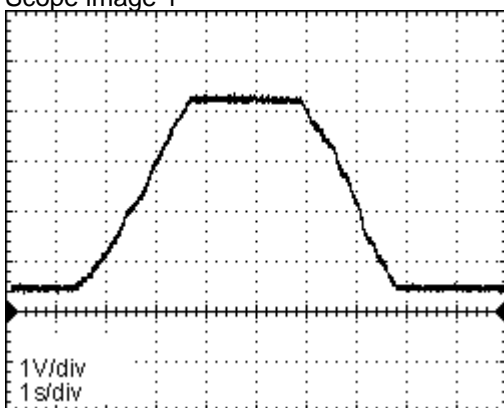
supply voltage: 5 V

output voltage: 0 - 5 V

waveform information: output signal while opening throttle.



Scope image 1



Pins to ground: 2M