Module 21
Fuel Injectors - Dual Point Injection (DPI)

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21 **Fuel Injectors - Dual Point Injection**

21.1 General Overview

The fuel injector is a solenoid style output device that directly controls fuel delivery into the intake manifold. The injectors are operated by a duty cycle type ground signal from the engine control module (ECM).

The PGMFI system can be a multi-port injection (MPI) system or a dual-point injection (DPI) system. The MPI system is by far the more popular of the two systems. This chapter will describe the operation of the DPI injection system. For information on the MPI system see Chapter 20 - Fuel Injectors / Multi-Port Injection.

21.2 How Do They Work?

The fuel injector is the output device that is responsible for directly controlling fuel delivery. The fuel pump and regulator supply the inlet of the injectors with a constant regulated supply of fuel. The fuel is even adjusted for changes in the manifold pressure, so that the pressure differential between the fuel supply and the intake manifold is always constant. The amount of fuel injected is directly proportional to the amount of time the fuel injector is turned on. The injector "on time" is typically referred to as pulse width (PW) and is measured in milliseconds (ms).

The unit of measure for injector operation should always be time, not a duty cycle or dwell unit. When injector operation is measured as a duty cycle, the value becomes RPM dependant.

The injector's PW will vary depending on many inputs. The ECM turns the injector on the correct amount of time to deliver the optimum amount of fuel for the given conditions. In addition to delivering the correct amounts of fuel, there are two occasions when the injectors are turned off totally. This happens at a pre-programmed high rpm, and during deceleration periods.

Image 21-1

The DPI system is a throttle body version of the PGMFI. It uses two large injectors, mounted in the throttle body. These two injectors can be seen inside the circle in Image 21-1 and also in Image 21-2. The bottom injector injects fuel all the time below the throttle plate, and the top injector

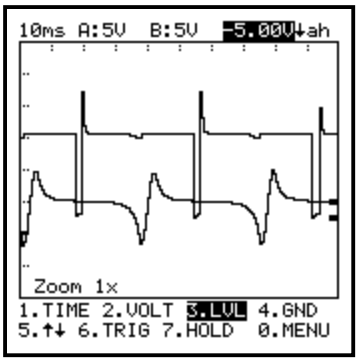
Image 21-2

is used during start-up, and under high fuel demands. This system was only used on Civic DX models from 1988-91.

The bottom injector (green) injects fuel all the time. In the Honda manuals it is called the auxiliary injector, even though it fires all the time. The top injector (brown) that only fires at start-up, and under load conditions is called the main injector.

The auxiliary injector (bottom) fires once per each cylinder's intake stroke. This can be seen in the Screen Capture 21-1. The top waveform is the firing of the auxiliary injector, and the bottom waveform is the firing of each cylinder's ignition (TDC sensor). The normal PW is close to 2ms at idle with no load.

Screen Capture 21-1



The main injector (top) is used to deliver fuel at start-up, and speeds above about 1100 RPM. This injector also fires once for every firing of a cylinder. The PW of the main injector varies widely since it is being driven by the load of the engine.

The bodies of the two injectors are shaped differently and cannot be interchanged. Due to the way the injectors are mounted in the throttle body assembly, if the back o-ring leaks, unmetered fuel could get into the intake manifold.

21.3 Fuel Delivery Strategy

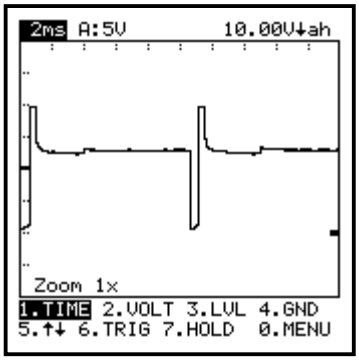
21.3.1 Auxiliary Injector

The DPI uses a somewhat different strategy to deliver fuel than the MPI. With the DPI system the bottom injector is opened each time a cylinder fires. The PW of the bottom injector does not widen under a load. The additional needed fuel is all delivered by the top injector. The bottom injector's current is controlled by the circuit's resistance just like the MPI system does.

21.3.2 Main Injector

The top injector operates differently. It opens above 1100 RPM and during cranking to deliver extra fuel. It also opens each time a cylinder fires when it is acti-

Screen Capture 21-2

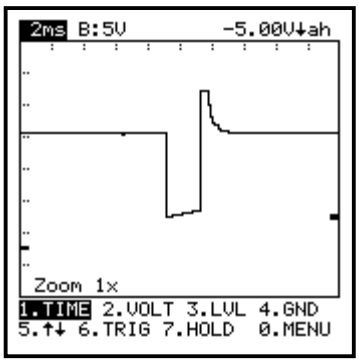


vated. Since the top injector has to deliver all the extra fuel used while under load conditions, the PWs can get long. On this injector the injector current is controlled by a current limiting transistor when the PW exceeds about 2ms.

Screen Capture 21-2 is a main injector at just above 1100 RPM. You can see that the main injector uses circuit saturation to control the current flow at this point.

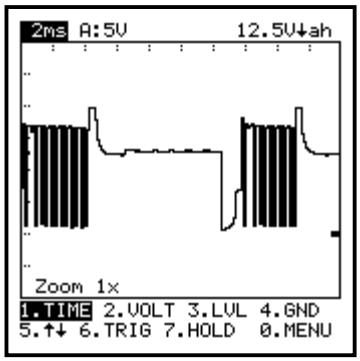
Screen Capture 21-3 is the main injector while under a moderate load. The injector current is still being controlled by the circuit's resistance.

Screen Capture 21-3



Screen Capture 21-4 is the main injector under a heavy load. Notice the current limiting technique used by the driver. When the PW of the main injector exceeds about 2 ms, the driver starts quickly switching the circuit on and off. This is done to control the current. The injector on-time is from the initial drop to 0 volts to the final upward rise.

Screen Capture 21-4



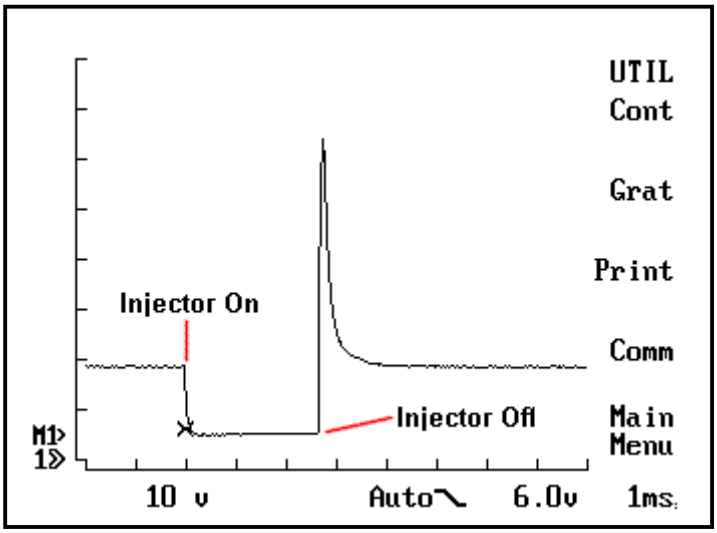
21.4 How Do You Test Them?

Just like most other Honda fuel injection components, the fuel injectors are fairly fool proof. An electrical failure is somewhat uncommon. As far as testing the injectors (on the car) you have three choices, checking the injector's PW, the injector's winding resistance, and monitoring the injector's current flow.

21.4.1 Injector Pulse Width

You can actually measure voltage at the ground side of the injector and determine the injector's PW. While this is a very useful test for diagnosing fuel delivery problems, it is not real effective in finding injectors with stuck pintles. The best way to confirm an injector's pintle is opening and closing is to monitor the injector's current with a DSO. The PW can be measured with a digital storage oscilloscope (DSO) as shown on Screen Capture 21-5, on the left.

Screen Capture 21-5



Battery voltage is present on the ground side of the injector when it is turned off since there is no ground and subsequently no current is flowing in the injector circuit. When the injector is turned on, the voltage is pulled close to 0 volts, as the driver transistor provides a ground. The length of time the pintle is held open by the continued current in the injector winding can be measured by looking at the bottom time line. The time between the injector on time and the injector off time is the PW. The injector off time is indicated by the voltage returning to battery voltage. When the ground is released there is an inductive spike produced by the collapsing electromagnetic field, this is normal.

The PW Screen Capture 21-5, is 2.75ms. You can see that the time division is set up for 1ms per division. The injector is grounded for 2.75 divisions.

Note that the top injector's voltage waveform will look different than Screen Capture 21-5 while in current limiting mode. Screen Capture 21-4 is the waveform of the main injector while in the current limiting mode.

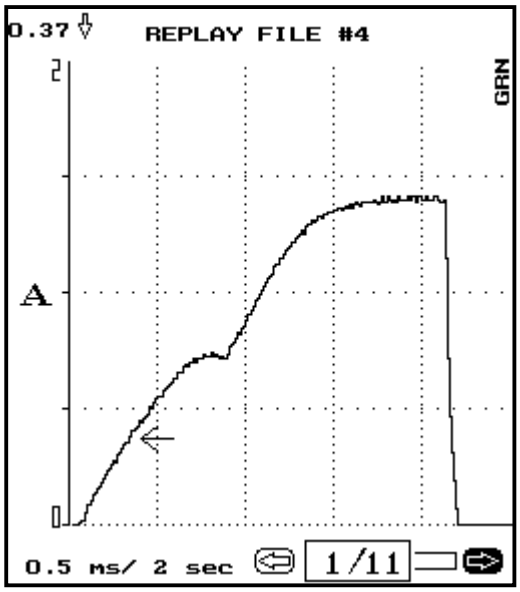
21.4.2 Injector Resistance Test

The normal resistance of the injectors are:

Main Injector (Top): .6-1.6 ohms
Auxiliary Injector (Bottom): 6-10 ohms

21.4.3 Auxiliary Injector Current Waveform

Screen Capture 21-6

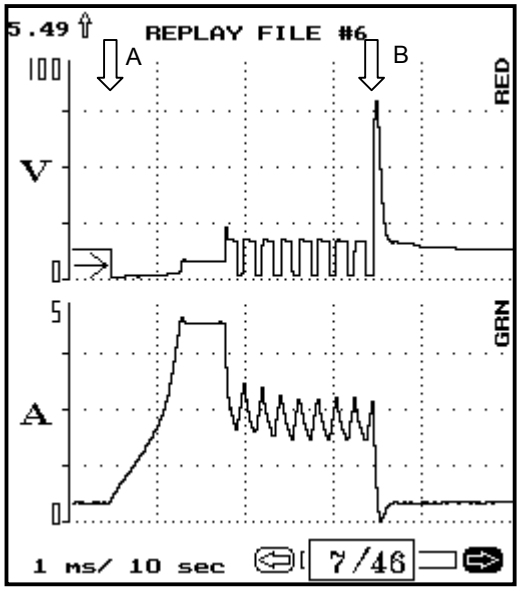


The test that gives you the most information about the operation and condition of a fuel injector is the current test. Just within the last few years current probes have become commercially available that will allow a tech to observe the current flow in small time units. Current probes are presently available for under $300 that will measure current accurately in time units as small as 1ms.

Screen Capture 21-6 is the current waveform of the auxiliary injector from a DPI equipped Civic. From this waveform you can establish the PW, the total current draw, and the point at which the pintle opened. For a detailed explanation of how to "read" this waveform, refer to section 20.5.3.

21.4.4 Main Injector Current Waveform

Screen Capture 21-7



Screen Capture 21-7 shows both the voltage and current waveform of the main injector. At point A the injector is gounded as seen by the voltage being pulled to ground in the top waveform. You can see that this is the same instant that the current starts climbing.

The ramp of the current waveform (on the bottom) can be analyzed by the procedure explained at section 20.5.3.

The additional voltage and current oscillations at the end of the waveforms indicate the ECM/PCM driver is in the current limiting mode.

21.5 Service Tips

Honda fuel injectors are reasonably durable. Many Hondas go a lifetime on the original set. There are a few service related situations related to fuel injectors and I have included them here. Some are somewhat common and some are rare, but you need to know about them !

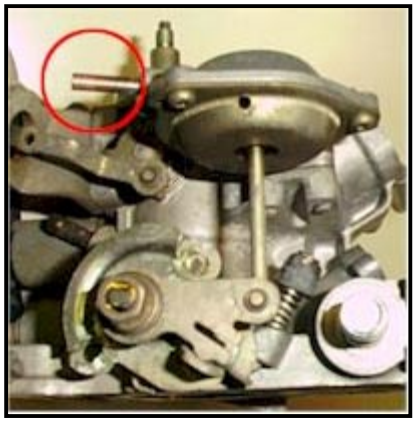
21.5.1 Poor Spray Pattern

From time to time you may experience a Honda that has a driveability problem or poor cold running problems. This could be caused by an injector that has a poor spray pattern. A poor spray pattern could be cause by partially clogged or dirty injectors. Poor injector spray patterns typically tend to cause more driveability problems on cold starts.

If you suspect a problem with a fuel injector, there is no real easy way to test one other than to replace it with a known good injector. Fortunately, changing out a set of injectors on a Honda is very easy (15-30 minutes).

21.5.2 Procedure For Checking TP Sensor Idle Voltage

Image 21-3



When testing the throttle position (TP) Sensor idle voltage, on the DPI models, you must add an extra step in the procedure. On the DPI throttle body, an extra vacuum diaphragm is added to open the throttle blade slightly when the engine is turned off. This will not give you an accurate idle TP Sensor voltage.

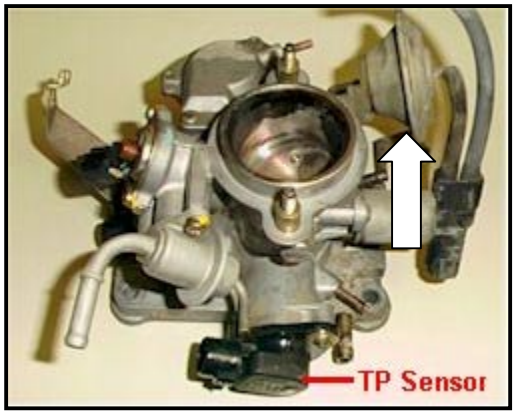
Before checking idle TP voltage on a DPI system, apply vacuum to the idle diaphragm (indicated by a circle in Image 21.3.). This will let the throttle shaft go fully closed and rest on the factory set throttle shaft stop.

It is especially critical that the throttle returns to full closed at idle with the DPI system. If the throttle is held just slightly open, the main (top) injector may start delivering fuel. The throttle cable should be checked for proper play to assure that the throttle can go fully closed.

21.5.3 In-Operative Tandem Air Valve

The DPI throttle body uses a tandem valve to help keep air speed high in the air horn. The tandem valve looks similar to a choke and is operated by a vacuum diaphragm (located at the right rear corner of the throttle body) that is operated by venturi vacuum. The valve is shown by the arrow in Image 21-4.

Image 21-4



As the engine RPMs rise the rising venturi vacuum slowly opens the air valve in the top of the throttle body. The valve does not open until the engine coolant has reached 160 degree and the RPM is above 1500 RPM on automatics and 2000 RPM on straight drives.

When the tandem valve is operating properly, it will open up nice an smooth as the engine is revved up. On high mileage Civics it is not uncommon to find a failed vacuum diaphragm. When this happens the air valve will not open adequately and the car will have a marked reduction in power. The symptoms can be similar to that of a restricted exhaust. The vacuum diaphragm can be checked using a traditional vacuum pump.

21.5.4 DPI - Running Rich

The DPI system used on some 1988-92 Civics can have a rich condition due to defective injectors. Here are the symptoms:

The car is running at a high reading on both carbon monoxide (CO) and hydrocarbons (HC). The readings are high at low RPM and high RPM. The readings may even be higher at high RPMs. Normally all the other engine parameters are pretty normal such as:

Input / Output Parameter	**Approx. Reading**
Manifold Absolute Pressure (MAP) Sensor Voltage	.9 Volts
Auxiliary Fuel Injector (below throttle plate injector)	2 ms
O2 Sensor Voltage	.8-.9 Volts
Fuel Pressure	36-40 PSI
Engine Vacuum	20" +
TP Sensor Sweep	.45 - 4.5 Volts

Under these conditions the car should not be running rich ! The MAP sensor voltage is nice and low. The injector should not be delivering too much fuel at a PW of 2ms, yet too much fuel is being delivered to the engine. If you disconnect the main injector, located at the top of the throttle body, it will still run rich.

The Cause
Apparently the injectors start leaking in the throttle body and let unmetered fuel

come in around the injector base o-rings. The key here is that the car is getting way too much fuel yet the PW is normal. When this happens the car will run rich most of the time. The ECM tries to maintain control by cutting the PW back, but it still runs way too rich.

The Fix

The fix for this car is to replace the injectors. There is actually a technical service bulletin that covers this problem. The TSB 93-009 is available in PDF format from this site. When you read the bulletin you would think the only thing that the repair kit contains is a new purge line; however, the kit also has both injectors in it for a reasonable price. The repair kit is part number 04103-SH3-K30, and it includes both new injectors.