Module 7
Air Flow / MAP Sensor - Base Inj Pulse Width

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7 Air Flow / MAP Sensor – Base Inj Pulse Width

7.1 General Overview

Honda engineered the Honda PGMFI fuel injection system. The Honda engineers always look at different ways to approach a problem and many times come up some unconventional solutions. Honda's approach to monitoring airflow was a different approach than used by most Asian fuel injection (FI) systems in the 1980's, but I think it is a better way. The system is referred to as a speed / density system and is now used on many other cars. It is this "virtual" measurement of airflow combined with the manifold absolute pressure (MAP) sensor input voltage that determines the injector's initial pulse width (PW). Lets take a look at these two major inputs and see how they work together to determine the base PW.

7.2 The PGMFI Air Flow Measurement

The PGMFI system does not directly measure airflow, with a mass air flow (MAF) meter, like many other FI systems do. You will not find a traditional air flow meter in the intake air stream. There are a few new Acura models that use a "hot wire" system to measure the intake airflow, but these have not been used on Hondas. So how do they determine airflow? The system uses the engine RPM to determine the airflow.

Determining the airflow based from the engine RPM is rather cleaver and is much simpler than trying to measure it with an air flow meter. It is based on the fact that on a given engine, a given amount of air will be displaced on each intake stroke. As the engine RPM rises and falls this amount of air per cylinder, per cycle, does not change much. When an engine is revved up, the number of times the cylinder fires per second will increase, but the amount of air displaced per cycle will not change significantly (excluding the effects of volumetric efficiency (VE). This is why an injector PW being monitored on a digital storage oscilloscope (DSO) will stay virtually unchanged regardless of the RPM (with no change in load).

The engine control module (ECM) must determine how much air entered the combustion chamber and hold the pintle on the injector open just the right amount of time to give the engine the proper air / fuel mixture. Later in this module we will look at the major role the MAP sensor plays, but lets look at the airflow just a little deeper.

Does the engine always displace the same amount of air for each intake stroke? In a perfect world a 4-cyl 2.0 liter engine would displace 500cc per cylinder on every intake stroke. In the real world this never happens. It will always be some percentage of the 500cc. This percentage is called the VE of the engine. VE is defined as the amount that makes it into the engine divided by the displacement of the engine. An engine will achieve virtually 100% VE at low speeds but drop significantly at higher speeds. Engines of just 20 years ago could have VE low as

50% at high RPMs. New induction technology has improved the VE greatly with race engines approaching 95% at high RPMs. It is the loss of VE that causes an engine's torque curve to fall off. The engine effectively gets "smaller" as it gets into higher RPMs.

So what is the point in all this discussion about VE? The point is that the injector PW is not a set time for all intake strokes. The ECM determines the injector PW after "looking up" the value in a RPM table. The PW values for given RPMs was determined by research and testing.

7.3 The Map Sensor Input

The second key player in the injector base PW is the MAP sensor input voltage. The MAP sensor is monitoring the intake manifold vacuum. Manifold absolute pressure is just a high tech word for manifold vacuum. The concept of absolute pressure is that pressure starts at 0 pressure (no atmospheric pressure). That makes our environment a +15psi environment and the intake manifold is also a pressure, but less than atmospheric.

Many testers, such as the Mastertech by Vetronix, can read the MAP input as an absolute pressure. When you use this measurement remember that this is an absolute pressure reading, not a vacuum reading. The value will be in inches of HG, and you will need to subtract this value from the current barometric pressure (also available from the Mastertech's parameter list) to get the actual vacuum of the engine.

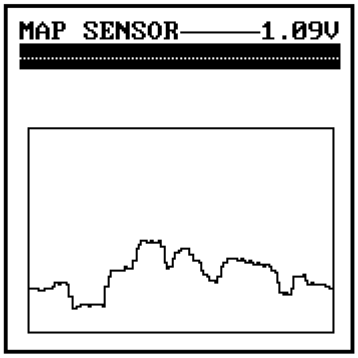
The ECM, to determine the amount of load an engine is experiencing, uses the MAP sensor input voltage. When the manifold pressure drops it is an indication that the engine is under a load. The normal cruising air/fuel ratios are so lean that more fuel has to be added when under a load or the engine will misfire. The carbureted car equivalent to this system would be a power valve.

The Map sensor is a standard 5-volt reference sensor that is supplied 5 volts over two wires and the third wire feeds back a voltage to the ECU that varies from about .6 volt to 2.7 volts. When the engine is running with no load the voltage will be low (usually less than 1 volt). When the engine is under a heavy load the voltage will go up to about 2.5-2.75 volts.

7.4 Putting It All Together

The ECU takes the engine RPM input and the MAP sensor input voltage input and "looks up" the injector PW time in an internal table. These two inputs determine the injector's base PW. All the other inputs have relatively small effects on the injector PW. Excluding the very rich PW (as high as 100ms) that occurs during cold cranking, most inputs will only cause an injector PW to vary about .25ms. For instance you can replace an engine coolant temperature (ECT) sensor with a variable resistor and with the engine running go from full cold to full hot with only about a .25ms difference in the injector PW.

Screen Capture 7-1

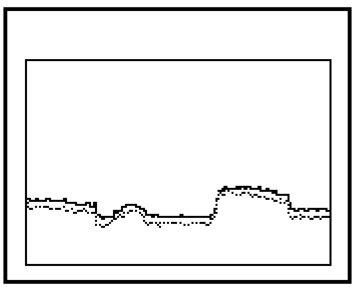


Screen Capture 7-1 shows the MAP Sensor input voltage as a Honda is driven in normal highway traffic. The slightest change of vehicle load causes the MAP input voltage to change.

This is a screen captured from a Vetronix Mastertech tester, operating in the line graph mode. The screen was captured and stored using AES Wave software.

The vehicle used was a 1997 Civic 1600 with 12,000 miles.

Screen Capture 7-2



Screen Capture 7-2 shows the control that the MAP Sensor input voltage has over injector PW. The MAP Sensor input voltage is shown as a solid line and the PW as a dotted line. The MAP Sensor input voltage and injector PW change as though they are one. Any change in the MAP Sensor input voltage makes an equal change in the PW!

This is a screen captured from a Vetronix Mastertech tester, operating in the line graph mode. The screen was captured and stored using AES Wave software.

The vehicle used was a 1997 Civic 1600 with 12,000 miles.

7.5 Using This Information While Diagnosing

So how do I use this information in the real world to help diagnose the Honda PGMFI? Now that you know that the engine RPM and MAP sensor are the two key inputs that make big changes to the injector PW, you can save yourself a lot of time.

Remember this, it will save you plenty of time in rich situations! If a Honda comes into the shop and it is carbon monoxide (CO) meter pegging RICH don't waste time checking out any other inputs until you have checked the RPM and MAP sensor inputs. None of the other sensors can cause this problem. Sure there can be some unusual problems like a stuck injector pintle, or a grounded injector wire, but the other input sensors just do not have that much control over injector PW.

A typical Honda MAP will run 1 volt or slightly lower when warm and idling. This voltage is critical! If the voltage goes much over 1 volt, the Honda will run rich. To get a better understanding of how important this voltage is, look at these readings taken from a 1992 Civic 1600:

Condition	MAP Volts	Inj PW	Exhaust CO
Normal	.94	2.0 ms	.3 %
Vacuum Leak Created on MAP Hose	1.13	2.3 ms	6.5 %
Bigger Vacuum Leak Created on Map Hose	1.25	2.7 ms	9.9 %

As can be seen from this chart, a slight increase in the MAP sensor input voltage makes big changes in the PW. When a leak was created that caused the MAP sensor input voltage to increase approximately.3 volt, the CO meter pegged on the exhaust analyzer.

Honda MAP sensors themselves are very durable. The biggest problem is on the remotely mounted Maps that use a rubber hose to connect to the intake manifold. The slightest of leaks in this hose will cause havoc on a Honda PGMFI systems. Also keep in mind any other situation that will cause a drop in intake manifold vacuum will cause the system to go rich. The most common cause of this is when the camshafts are not timed properly. A Honda with a camshaft out of time will drop the intake vacuum significantly (to about 15 " HG) and the car will run RICH. For more specific information on how to diagnose a Honda MAP sensor refer to the Map sensor module (due out in April 1998).

7.6 Service Issues

7.6.1 Vacuum leaks just cause the engine RPM to increase

Since a Honda does not directly monitor intake airflow, but injects a set amount of fuel for a given RPM, a vacuum leak will only cause the engine to rev up. A vacuum leak will not cause a lean condition! If you have a Honda running lean you will not fix that condition by fixing intake manifold vacuum leaks. Conversely, if you have a Honda that is idling to high, and the idle control systems check out, look for a leak!

So how can you create a temporary lean condition, for testing an oxygen sensor response? You can't pull a hose off. A vacuum leak on a speed/density system will not create a lean condition. The best way is to temporarily unplug an injector. With the injector unplugged that cylinder will only be displacing air and will instantly create a very lean condition!

By the way the best way to create a temporary rich condition is to give the intake a shot of propane. Propane is safe on the oxygen sensors and exhaust analyzer equipment. If propane is not handy you can richen up the system by pulling the vacuum hose off the fuel regulator.

7.6.2 Low vacuum causes the car to run rich

The MAP sensor has such a huge effect on injector PW and its input is directly related to the engine vacuum. If there is a mechanical reason that is causing the manifold vacuum to decrease, it will cause the car to run rich. Some of the more common things you might find are camshafts out of time, valves adjusted too tight, and restricted exhausts. If a car comes in running rich and it has just had a timing belt, check the cam timing! Especially on twin cam Hondas, since a shop has twice as many chances to get the cams out of time.

7.6.3 False ignition firings will cause the car to run rich

A speed / density fuel injection system fires an injector for every cycle of the engine. It fires the injector during the intake stroke, but gets its information about when to fire from the ignition system. If a condition is creating extra "false firings" (extra firing lines) the PGMFI system will fire the injectors extra times.