Module 1
The PGMFI System Overview - Part 1

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1 The PGMFI System Overview - Part 1

1.1 The Formative Years

For many years, the primary goal in engine design was for power and driveability. The earlier engine control systems could reach these goals by using mechanical and vacuum controls. Carbureted engines with a traditional mechanical / vacuum distributor were used for over 15 years on most Hondas sold in the USA.

In the late 1970s legislation was passed that mandated a maximum tailpipe emissions standard. Fuel-efficient cars were in demand by consumers and there was also legislation that mandated minimum fuel economy standards. The tailpipe emissions standards got progressively lower and the demand for high efficient vehicles got higher. It was impossible to deliver the low emissions and high fuel economy without better fuel and ignition control. It could no longer be done using mechanical and vacuum controls. It was this demand for cleaner and more efficient engines that required the use of electronic engine control systems.

1.2 PGMFI as an Emission Control Device

Tailpipe emissions can be put into two main categories: pre-combustion and post-combustion. Pre-combustion emission controls are all the things that are done to reduce the emissions before the exhaust leaves the combustion chamber. Post-combustion controls are the systems that further reduce the emissions after the exhaust has left the combustion chamber.

1.2.1 Examples of pre-combustion emission controls

Some examples of pre-combustion emission controls are: engine design, EGR systems, fuel and ignition timing controls. It may seem a little odd to think of the fuel control system as an emission control device, buy that is a large part of what it is! The PGMFI fuel injection system is a major player in pre-combustion emissions. By designing a good fuel control system, many post-combustion systems can be down sized or, in some cases, eliminated.

Honda's approach from the very beginning was to control tailpipe emissions as much as possible at the pre-combustion stage. The Honda engineers control as much as possible from superior engine design, then by superior fuel and ignition controls, and lastly by post-combustion systems.

It was this approach that led to the Compound Vortex Controlled Combustion (CVCC) engine design that allowed Hondas to meet emission standards, until the early 1980s, without a catalytic converter (5 years later than most domestic cars). In this example, Honda was able to totally eliminate a post-combustion system by superior engine design.

Honda even offered to license the CVCC technology to General Motors so they too could eliminate the need for installing a catalytic converter, on their cars, in 1975. GM did not want to use the CVCC technology. Their engineers said it would not work on a larger displacement engine.

Honda engineers took a Chevy Impala to Japan and hand built a set of heads that used the CVCC technology and proved to GM that it would work. Even after it was proven that GM cars could meet the emission standards without using a catalytic converter, GM still did not change its mind. Apparently GM had committed to using converters in 1975, years before. It seems that GM had made heavy investments in platinum mines and the equipment to manufacture catalytic converters.

Some of the areas of engine design that effect pre-combustion emissions are:

- Valve timing (think of VTEC as an emission control device too)
- Number of valves and valve placement
- Combustion chamber design
- Intake manifold design

It has been Honda's attention to detail in the pre-combustion area that has placed it as a leader in producing vehicles with low emissions and good economy. For many years, car manufacturers struggled to keep up with the increasingly tougher emission standards. Honda is now producing cars that meet standards many years into the future. They are the industry leader in the low emission (LEV) and "Zero" emission technology today.

Post-combustion emission controls fall into three main categories: evaporative, crankcase, and tailpipe emissions. Tailpipe emissions are the most important and are comprised of catalytic converters and pulsed air injection (on some models). These systems further reduce the emissions after the exhaust has left the combustion chamber.

1.3 The Evolution of Fuel Control - From Carbs to PGMFI

1.3.1 Vacuum / Mechanical Systems

From 1973 to the early 1980s, Honda used traditional vacuum and mechanical systems to control ignition and fuel. They used a traditional carburetor and a mechanical / vacuum ignition distributor. The carburetors used on the CVCC engines are somewhat different than most since it is actually two carbs in one. It had a section that supplied a rich mixture to the pre-combustion chamber and a section that provided a lean mixture to the main combustion chamber. This technique allowed the engines to run on a much leaner mixture than was possible with a traditional combustion chamber.

These models had very basic timing and fuel controls. Most controls were mechanical or vacuum in nature. About the only unusual control found on these carbs was an altitude compensating device that seemed to be reserved for the Hi Altitude cars. It was a barometric pressure-sensing device that could add extra air to the air bleeds as needed.

1.3.2 Feedback Carb

A forerunner to the PGMFI system was the feedback carburetor system. It was used; beginning in 1984, on all models and was used until the carb was replaced by a PGMFI system. If PGMFI were one of Honda's brightest engineering moments, then the feedback carburetors would have to be one of Honda's darkest engineering moments (author's opinion only). The Honda feedback carburetor systems must hold the record for the most vacuum lines and air control valves ever put under one hood!

The feedback carb system utilized an O2 sensor to monitor the exhaust oxygen content. It also used an electronic control unit to monitor several inputs, including the oxygen sensor. When certain conditions were met the control unit would use the oxygen sensor input to adjust the air / fuel (A/F) ratio. This condition is called closed loop (CL) operation and works a lot like the CL operation of a PGMFI system.

To control the A/F ratio, the control unit used air valves to dump air into the intake manifold. The carb feedback systems could only lean the mixture by adding more air to the intake manifold. Two different air control systems were used by Honda, the "M" and "X" system. The “X” system was used for large air adjustments and the “M” system was used for finer air adjustments.

Since the carb feedback system did not operate in CL mode at idle speeds, the Honda carb feedback system should always be checked at 2000 RPM and up. The feedback carb systems used a ported vacuum switch (instead of a throttle position sensor) to confirm the engine was not at idle.

If this system was working correctly it was “OK”, but if it gave trouble it could get nasty! Tracking down vacuum leaks and diagnosing air valve malfunctions could easily turn into an afternoon project!

Most car manufacturers utilized feedback carburetor systems to help make the transition from carburetors to fuel injection systems. There were basically three approaches used to control the A/F ratio on carb feedback systems.

Control the Fuel
The controlling of the fuel was the most widely used system. Most manufacturers put a fuel mixture control solenoid inside the carb and it worked

well. Basically, this system only added a wire or two to the underhood of the car.

Control the Air Bleeds
Some manufacturers controlled the A/F ratio by controlling the air bleeds. This also worked well and only added a few small vacuum lines.

Control the Air
To my knowledge; Honda was the only major manufacturer that chose to control the A/F mixture by directly adding air to the intake manifold. To make a difference in the A/F ratio by changing air it took some significant volumes of air. This system turned the engine compartment into a vacuum line / air control valve smorgasbord.

1.3.3 PGMFI / Pre OBD-II

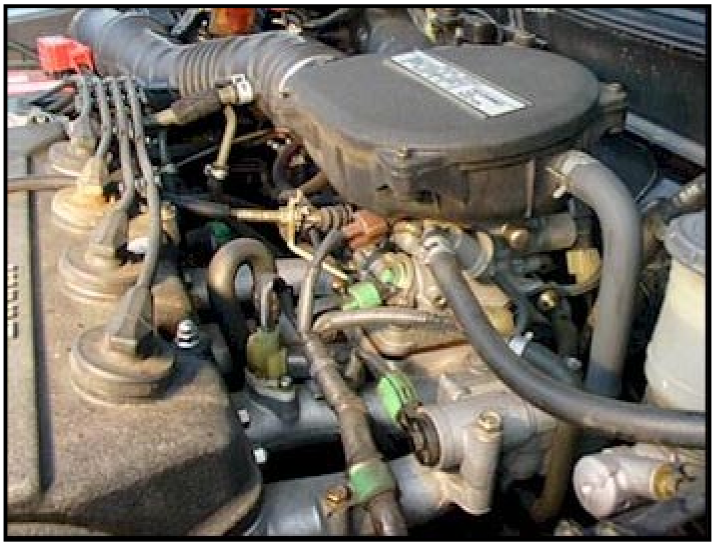
In 1985, Honda debuted its PGMFI system on certain models. In 1988 all Civic models used the PGMFI system. Accords went full injection in 1990 and Preludes went full injection in 1991. The PGMFI system is engineered by Honda and is used exclusively on all fuel injected Hondas (except Passports). It is a well-engineered system and its basic design has stayed relatively unchanged over the years. The newer PGMFI systems use more inputs, control more systems, and have more powerful processors than the earlier systems, but still are very similar to the first PGMFI system used in1985.

An electronic engine management system has many advantages over the earlier vacuum / mechanical systems and even the feedback carb systems. With the PGMFI system all the individual control systems could be brought under the control of one processor. Here are some more reasons why an integrated electronic control system such as the PGMFI system is so much better and effective than earlier control systems:

1. Electronic control can constantly adjust outputs based on changing inputs.
2. The system can produce the lowest emissions by keeping all the fuel and ignition controls close to the optimum setting.
3. If an input to the engine control module ECM is lost or become corrupt, the ECM can ignore that input and resort to an internal stored value.
4. Electronic controls can provide a certain level of self-diagnostics to the service tech.

The PGMFI systems were offered in a throttle body style system (called dual point injection - DPI, by Honda) and a multi-port fuel injection (MPI) system. The DPI system was only used on certain 1988-91 Civics. The performance and high fuel efficient models still used the MPI system. The DPI has two injectors, one below the throttle plate and one above the throttle plate. It also utilizes a flap

Image 1-1 The PGMFI DPI System



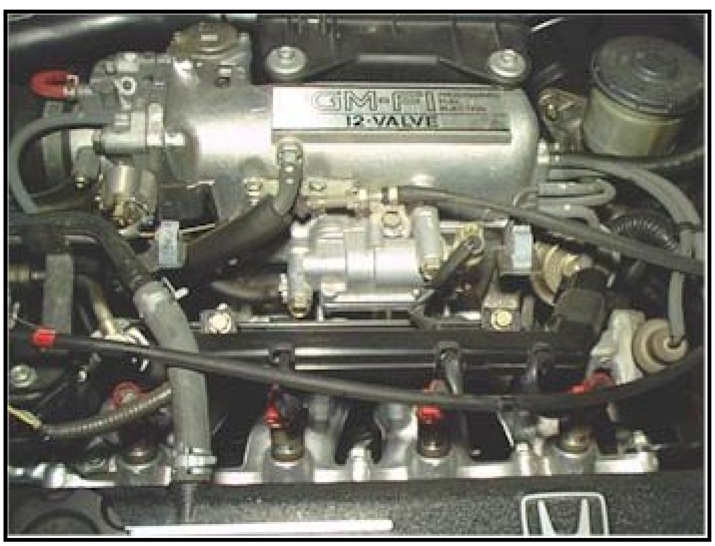
in the air horn that closes under low airflow to help speed up the air at the top injector.

Image 1-1 shows a PGMFI DPI system used on a 1991 Civic DX.

Image 1-2 shows a PGMFI MPI system used on a 1989 Accord. The MPI system was, by far, the most popular and widely used system. The bulk of the information in this manual is focused at the MPI system; however, most of the information applies to both systems.

The major operating conditions that the PGMFI system must recognize and control are: cold start, warm up, acceleration, deceleration, cruise, full load conditions, and idle. The PGMFI system accomplishes all these tasks by using information provided from inputs and internal tables programmed into the memory of the ECM.

Image 1-2 The PGMFI MPI System



For More Information About	Go To
The DPI Injection System	**Chapter 21**
The MPI Injection System	**Chapter 20**

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1.3.4 PGMFI With ECM Data Stream / OBD-II

The PGMFI systems, with the addition of a data link connector (DLC) for serial data stream retrieval, bring us up to the current systems. The basic PGMFI system did not change much, but the added ability to retrieve a live data stream takes this system to a higher level. The ability for a tech to pull diagnostic trouble code (DTCs) and view live engine parameters from a DLC added tremendous diagnostic capabilities.

A 3-pin DLC was added to 1992 Civics / Preludes and 1994 Accords. This DLC uses a proprietary protocol and is not OBD-II compliant. A 16-pin OBD-II DLC was added to 1995 V-6 Accords and all 1996 and up Hondas. The OBD-II equipped Hondas offer the most diagnostic information through the DLC.

For More Information About	Go To
Honda's Data Stream	**Chapter 26**

1.4 ECU, ECM, TCM, or a PCM?

Is it an ECU, a TCM, an ECM, or a PCM? Whew.... It depends on the year, model and whether you want to be OBD-II "politically correct". Let's take a look at the differences:

ECU
Honda, in the past, called all its PGMFI controllers an Electronic Control Unit (ECU). Since the standardization of terms under the OBD-II regulations J1930, the term ECU is no longer used.

ECM
Engine Control Module (ECM) is the "OBD-II correct" term for a processor that primarily controls the engine management systems. An ECM typically does not control any major transmission functions.

TCM
Transmission Control Module (TCM) is the "OBD-II correct" term for a processor that primarily controls transmission systems.

PCM
Powertrain Control Module (PCM) is the "OBD-II correct" term for a processor that controls both engine and transmission systems.

Automatic transmission equipped Accords, from 1990 to 1995, used a separate TCM and combined the ECM and TCM into a PCM on 1996 and newer models. Civics never used a separate TCM. On 1996 and newer Civics, the ECM did take on significant transmission functions and therefore is called a PCM. The 1995 Odyssey had a separate TCM and a ECM. They were combined in 1996 to one unit, a PCM. Preludes have maintained a separate TCM for A/T equipped models from 1988 to present.

It is important to understand that Honda automatic transmissions either had their own controller (a TCM) or a specific, dedicated section within the PCM controller. The automatic transmission controller maintains its own DTC set and will illuminate either the "S" "S3" or the "D4" dash light. The MIL is only illuminated if the transmission malfunction would affect tail-pipe emissions.

If you are using a scan tool to retrieve automatic transmission DTCs from a Honda, be sure you are polling the transmission processor. You can specify the fuel delivery controller or the transmission controller (even if they are combined into a PCM) from your scan tool.

For simplicity, within this training module, “ECM” will be used to mean the processor that controls the PGMFI system, even though it may technically be a PCM.

1.4.1 ECM Location

The Honda ECM has been stuck in a lot of different places. The earlier systems had them under either the left or right front seat. The early Preludes stuck them behind the interior panel at the left of the back seat and you read the DTC flashes by removing the ashtray. All the later systems have moved the ECM and the TCM (if equipped) to the right front floorboard / firewall area. Some are mounted vertical in the right front kick panel area. The units that mounted flat on the floorboard were susceptible to water damage from even minor flooding.

1.4.2 ECM Construction

All Honda ECMs are programmed with the correct engine parameters at the factory and are not field reprogramable. Each ECM is programmed with information that is specific to the vehicle it will be installed in. Some of the information added to the ECM memory is engine displacement, compression ratio, and various other engine and drivetrain parameters. In addition to not being reprogramable in the field, the Honda ECMs have no removable chips. You cannot use a scan tool to change any of the engine parameters. Some scan tools will allow you to use a bidirectional mode to test transmission solenoids by activating them.

A Honda ECM very rarely gives trouble. They are very durable and usually is the last item to suspect when diagnosing a problem. Most abnormal output readings can be traced back to a bad input signal. There has only been one ECU recall, which only affected a small number of Honda Civics.

For More Information About	Go To
ECM Construction & Theory	**Chapter 6**

1.5 Adaptive Learning

Screen Capture 1-1

```
ENGINE SPD........997RPM
VSS..................0MPH
ECT SENSOR.........1.52V
IAT SENSOR.........3.32V
MAP SENSOR.........1.05V
CLV...................32%
BARO S.............2.77V
TP SENSOR..........0.49V
HO2S S1............0.39V
ST FUEL TRIM........1.02
LT FUEL TRIM........0.97
O2 FB COND........CLOSED
```

Beginning with the OBD-II equipped Hondas (95 V-6 Accords and all 96 and newer models) the ECM will "learn" the fuel requirement characteristics of each car. The concept of adaptive learning is similar to "block learning" used by many domestic car manufacturers. Honda uses adaptive learning to learn a car's fuel trim requirements and apply it to the base pulse width (PW).

One of the parameters the ECM monitors is long term fuel trim (LT FT). Screen Capture 1-1 shows the LT FT at .97. This means that this vehicle runs a 3% narrower PW than the factory default base pulse width.

This parameter indicates if the ECM must run the PW wider or narrower than the factory default base pulse width to maintain proper fuel control. The LT FT begins at 1. If the ECM has to consistently widen the PW to keep the fuel mixture correct, the number will increase by that percentage. For example, if the ECM has to consistently increase the PW by 10% to keep the A/F ratio correct, the Lt FT will be 1.1

Also note that a generic scan tool and the Honda OEM scan tool report the LT FT parameter differently. A generic scan tool always reports the deviation from the default PW as a percentage. The Honda OEM scan tool uses the index of "1" as the factory default PW. For example a Honda with a 3% wider PW would be reported as +3% by a generic scan tool, but reported as 1.03 by the Honda OEM scan tool.

It needs to be understood that the LT FT parameter is reflecting the variance in the PW from the factory default base PW and is not necessarily reflecting a change in the actual amount of fuel being delivered. Take this scenario as an example.

- A Honda has a fuel filter that has become partially clogged with trash.
- This situation ends up dropping the fuel pressure at the injector rail by 5 pounds
- With the lower fuel pressure, less fuel is delivered for the same injector PW
- The oxygen sensor reports a lean condition and calls for more fuel from the ECM
- The ECM widens the PW to deliver the correct amount of fuel to satisfy the oxygen sensor

In this scenario the increase in the PW was to compensate for the drop in fuel pressure. In this case, the same amount of fuel was delivered to the engine even though the PW was widened. This shows how the LT FT parameter can often be used to indicate a problem that is developing within the fuel delivery system.

This variance from normal is learned by the ECM and reflected by the LT FT parameter. This learned parameter is also used to change the fuel mixture while the car is operating in open loop (OL). When a Honda is in OL operation, it must rely on internal tables to determine the base PW. If during CL operation, it is "learned" that the engine needs a 10% wider PW than the ECM expected, then it is logical that it should need a 10% wider PW when operating in OL. If power is lost to the ECM, the learned LT FT parameter will be set back to 1. It may take several trips for the ECM to relearn any fuel delivery abnormalities.

It is possible to have an OL driveability problem develop from just replacing a battery and loosing the learned LT FT parameter. It is better to reset a DTC using a scan tool (instead of pulling the ECM fuse) so that the adaptive learning will not be lost. It may be a good idea to mention to customers that after a battery change it is possible for the initial cranking and warm up period to seem different until the ECM has relearned the characteristics of the car's fuel requirements again.

Slight deviations from the standard of “1” are normal. A major deviation, like ± 5%, may be an indication of a problem developing with the fuel system. The ECM will set a code and illuminate the MIL if the LT FT parameter exceeds ± 20%.

1.6 Fail Safe

The Honda engineers have done a good job of designing the PGMFI system to be fail-safe. It is very rare that a car is rendered undriveable by the PGMFI system. For beginners, all the outputs that the ECM has to activate are usually supplied with power and the ECM completes the circuit by providing a ground. This means that if the wire from the output device to the ECM gets shorted to ground, it will not cause any damage to the ECM, since it was a ground to start with.

If the input signal is lost or becomes corrupt, the ECM will go into a fail-safe mode. It will ignore the input and use an internal standard that is pre-programmed into the ECM. It will also illuminate the MIL and store a DTC. The DTC will remain in the ECM until it is cleared from the memory, or power is lost to the ECM. The next time the car is started, the ECM will try to use the input again. If the input is missing or corrupt, the ECM will repeat the process of ignoring the input, resorting to an internal standard, and illuminating the MIL, again.

Note that OBD-II equipped Hondas have a different MIL illuminating and DTC storing strategy. These are covered in depth in Chapter 24.

The ability of the ECM to ignore bad inputs and run the car on an internal ECM standard makes the system almost fail proof. You can unplug virtually all inputs except the ignition and manifold absolute pressure (MAP) Sensor inputs and a Honda will run remarkably well.

1.7 Back-Up Mode

If a major malfunction is detected in the controller part of the ECM, the ECM can switch over to a "limp home" section. This is referred to as going into Back-Up mode. When the vehicle is in back up mode the car should be driven as little as possible till the vehicle can be checked out. The MIL will usually come on and flash even when the service check connector is shorted if the car is operating in the back-up mode.

1.8 Self Diagnostics

Each input has specific operating parameters. When an input operates outside these values, the ECM will ignore the input. It then relies on an internal standard and illuminates the MIL. You can retrieve the stored DTCs by either reading the code from the ECM or by shorting a service check connector and counting the flashes of the MIL.

While this self-diagnostic feature is usually helpful, it will not catch all problems. The OBD-I systems only compares most inputs to a high / low range. The OBD-II systems did add rationality and functionality checks to most input and output signals. Technicians should not rely on the self-diagnostics of the ECM to identify all problems. In many cases there is a legitimate problem that can be effectively diagnosed with proper equipment, yet the car will have no stored DTC.

On Hondas equipped with a DLC, a scan tool can be used to retrieve codes. The three pin DLCs used on Hondas prior to OBD-II produce a numeric code similar to the one displayed by the flashing MIL, but it is more detailed. On OBD-II equipped Hondas a scan tool can be used to pull the standard OBD-II "P" codes

This PGMFI system overview is continued in Chapter 2!