Module 4
Inputs / Outputs - Part 1

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4 Inputs / Outputs - Part 1

4.1 General Overview

The heart of the Honda PGMFI system is the engine control module (ECM). The ECM receives inputs from various sensors, processes the information, and produces an output. This concept is relatively simple, but so powerful if understood!

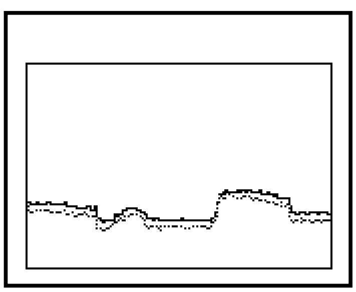
A technician's initial "interface" with the PGMFI system is usually with an output. For example, if a customer brings in a car that is running rich, the first thing most techs would do to confirm this would be to check O2 voltage and/ the injector pulse width (PW). They would be checking an output that is affected by many different inputs. If the O2 sensor voltage was stuck high, or the PW was too wide, they would then need to start checking the inputs that contributed to these outputs.

Output components directly control fuel, idle, timing, etc. and output components are directly controlled by their related inputs. Techs who master these following concepts will become very efficient at diagnosing driveability problems.

- ECMs very rarely fail
- Every output is controlled by specific inputs
- Abnormal outputs are almost always caused by an abnormal input
- Inputs have a very specific “window of authority” with respect to a given output
- An input’s “window of authority”, over a given output, can be different under different conditions.

4.2 Input / Output Relationship Example

Screen Capture 4-1



To better understand the input/output concept take a look at Screen Capture 4-1. This was taken from a 1997 Civic at cruise speed. The tester used was a Mastertech (with Honda software), operating in the line graph mode.

The two parameters that are being graphed are: manifold absolute pressure (MAP) sensor voltage (solid line) and fuel injector PW (dotted line).

The MAP sensor is a major input to the PW. On this one screen you are watching an input and its respective output graphed simultaneously. You can see that for every change in the MAP sensor voltage there was an equal change in the injector's PW.

4.3 Rapid Growth of Computer Control on Vehicles

1985 PGMFI INPUTS / OUTPUTS	
Inputs	**Outputs**
Crank Angle Sensor	Fuel Injector
MAP Sensor	Fuel Pump Relay
Vehicle Speed Sensor	Idle Control Valves
ECT Sensor	
IAT Sensor	
TP Sensor	
O2 Sensor	
Battery Voltage	
Starter Signal	
BARO Sensor	
A/T Shift Position Signal	
A/C Switch Signal	

The first PGMFI systems were a lot less sophisticated than the systems used today. The first systems only controlled fuel and some basic idle functions. As you can see from the table on the left, the 1985 system only had 12 inputs and 3 outputs. Compare that to a late model "drive by wire" Acura NSX which has 30 inputs and 16 outputs!

In 1988 the ECM took over idle control by adding an idle air control (IAC) valve. By 1990, all models were using the ECM to control all ignition functions.

The ECMs, on late model Hondas, control many systems that are not directly related to fuel or ignition control. Some of these systems include: air conditioning control, radiator cooling fan operation, etc.

4.4 Validation of Input Signals

The processor inside the ECM places conditions upon the input signals. The input components are continuously being checked for opens or shorts. The input signal also is tested for a high/low range and rationality. If an input signal does not pass these tests, the input is ignored and an internal stored value is used. When this occurs, it usually sets a diagnostic trouble code (DTC) and illuminates the malfunction indicator light (MIL). Lets take a closer look at these validation tests:

4.4.1 Open / Short Checks - High / Low Value Checks

All input signals on every PGMFI system have to pass these simple validity checks. This was the extent of input validity testing prior to OBD-II. With the OBD-II systems these checks are called “Comprehensive Component Monitoring”.

4.4.2 Rationality Check (OBD-II Systems Only)

Rationality of Parameter Relationships
OBD-II regulations state that vehicle inputs must also be checked for rationality. It is not enough that the input value passes a high/low test; the input must also be rational as it relates to other inputs.

While the OBD-II regulations called for the inputs to be tested for rationality, the amount of rationality testing used among the car manufacturers varies widely. Presently, the only rationality DTCs among Honda's DTC set are these four:

- P1121 Throttle Position Lower Than Expected
- P1122 Throttle Position Higher Than Expected
- P1128 Manifold Absolute Pressure Lower Than Expected
- P1129 Manifold Absolute Pressure Higher Than Expected

Rationality of Single Input
Individual inputs are tested for rationality. In addition to just having to pass a standard high / low threshold test like in OBD-I, the sensors input must also be rational. The signals are tested for rates of change, and variations that would not be rational.

One situation that would probably be caught by the stricter OBD-II input signal monitoring is a failing engine coolant temperature (ECT) sensor. The sensors tend to swing wildly from full hot to full cold when they fail. It is irrational that the engine coolant can change its temperature this fast, so this condition would probably set a DTC.

4.5 Windows of Authority for Input Signals

Even after an input signal makes it past all the validation checks, it still has its limitations. The processor has been programmed to give every input a "window of authority" over a specific output. This means that the input signal has been programmed to only have a specific maximum affect on a given output.

An input could also have different windows of authority over different outputs. For instance the ECT sensor is used to control the IAC valve and the injector PW. This sensor could have different windows of authority over each output.

On an output that uses many inputs, certain inputs will have a big affect on the output and some will have a small affect. Also, the window of authority of a given sensor can be different under different speeds and loads. A sensor can also have different windows of authority if in closed loop (CL) or open loop (OL) operation. For instance, a cold ECT sensor reading, in open loop, can increase the PW as much as 4ms. After the ECM has switched to CL operation the ECT is ignored.

4.6 Adaptive Learning

While the window of authority stays fixed, the base line may not. Under certain conditions the base line could change, based on the ECM's ability to learn fuel requirements of an individual car. The ability of the ECM to change the baseline is called adaptive learning.

The ECM is continuously comparing the actual fuel injector PW, while in the closed loop (CL) mode; to the factory default base PW. If the PW is wider than the factory default PW for a significant amount of time, the wider PW will become the "standard". This process is similar to the "block learning" concept used by many other manufacturers. All the inputs maintain their same window of authority on the output, but the baseline was moved based on adaptive learning.

On OBD-II equipped Hondas the deviation from the default PW can actually be checked. The deviation of the actual injector PW from the default PW is stored in the ECM as the parameter long term fuel trim (LT FT).

Screen Capture 4-2

```
ENGINE SPD........703RPM
VSS.....................0MPH
ECT SENSOR..........0.84V
IAT SENSOR..........3.08V
MAP SENSOR..........0.94V
CLV......................29%
BARO S...............2.77V
TP SENSOR...........0.49V
HO2S S1..............0.68V
ST FUEL TRIM........1.03
LT FUEL TRIM........0.97
 WAITING FOR TRIGGER
```

LT FT is given as a number with 1 being no fuel trim. When the PW is wider than the factory default the number of 1 is increased by that percentage. When the PW is narrower than the factory default the number of 1 is reduced by that percentage. For example, a Honda whose PW was 10% wider than the factory default would have a LT FT of 1.1 and a Honda whose PW is 10% narrower than the factory default would be .9. Screen Capture 4-2 is showing a Honda with a LT FT of .97, which means the PW is 3% narrower than the factory default.

Note: Since LT FT is an OBD-II defined parameter; it can be read using an OBD-II compliant Generic Scan Tool (GST). When using a GST the LT FT is read out as actual percentage, not as an index of 1.

4.7 Artificial Intelligence Does Not Exist!

In years past, the engine analyzer manufacturers have tried to build machines that would diagnose a car. You would hook up a "Volkswagen sized" analyzer and it would walk you through a series of steps. It would then spit out a report with the probable problems. It is interesting that now, many years later, the current analyzers are mainly used for data acquisition. The diagnosing is left up to the tech.

All the analyzers used today such as, scan tools, digital storage oscilloscopes (DSO), and graphing multi meters (GMM) are used for data acquisition. You, the technician, must use this data to diagnose the problem. The analyzers, even the

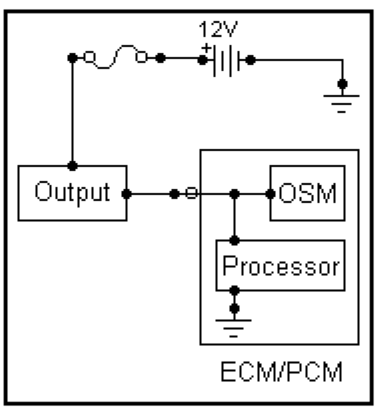
Honda PGM tester, have very limited built in diagnostics. The fact is that there has never been a practical way to build a machine to diagnose cars! You, the technician, have to apply the intelligence after acquiring data from an analyzer.

If a tech understands which inputs affect which outputs, and to what degree they do you will be able to take data from a piece of test equipment and fairly quickly diagnose PGMFI problems! If you get good at it you will be able to see input "signatures" in outputs. On certain readings you will know exactly which sensors control it and in some cases you will know that only one input could cause a certain output. This approach is a lot better than testing every sensor on the car for every driveability problem!

4.8 Output Information

While most of the discussion in this module has been about inputs, there are a few points that need to be made about outputs. Most outputs are devices that are activated by flowing current through a winding. Let's take a look at a couple of design features of a typical output.

Illustration 4-1



As shown in Illustration 4-1, most outputs are supplied fused battery voltage directly to the device. The ECM is controlling the ground of the output. This is done to help protect the ECM in case of a short in the circuit. If a short to ground occurs anywhere in the circuit, the current will be flowing from the battery and not through the ECM.

Beginning with OBD-II equipped cars, the output circuits are also checked for functionality. The ECM has special circuitry called an output state monitor (OSM). The OSM is confirming that the output is functioning by monitoring the current. When an output has been determined to not be functioning properly, a DTC is set.

4.9 Input / Output Relationships

With the number of inputs approaching 30 and the number of outputs approaching 20, it is virtually impossible to know all the relationships. If I were able to describe in detail all the relationships and strategies between all the inputs and outputs my life would probably be in danger! Hey...It's just a joke. The exact strategies used by the PGMFI system are a closely guarded secret. Some of the information in this chapter came from Honda service manuals, but most was learned from field studies and years of involvement in the Honda service industry.

In the next chapter (Inputs/Outputs Part 2), the fuel control and idle control input/output relationships are studied in depth. Most driveability problems are affected by these two subsystems.

If you spend much diagnostic time in other areas, I would encourage you do study those relationships both in the manuals and in the field. For example, if you do a lot of air conditioning work, study how the ECM controls the A/C. If you do a lot of emissions diagnostics, study the control the ECM has over those subsystems. A little learning time now will save you a lot of diagnosing time in the future.