Module 10
Closed Loop Strategies - Case Studies

Author: Grant Swaim

E-mail: sureseal@nr.infi.net

URL: www.tech2tech.net

Phone: (336) 632-9882

Fax: (336) 632-9688

Postal Address: Tech-2-Tech Website
PO Box 18443
Greensboro, NC 27419

Physical Address: 220-4 Swing Rd
Greensboro, NC 27409

Last Update: April 2000

Tech-2-Tech offers the following training modules in printed manual, CD-ROM, and on-line formats.

PGMFI Training Modules

- The PGMFI System Overview—Part 1
- The PGMFI System Overview—Part 2
- PGMFI Flash Type DTCs
- Inputs / Outputs—Part 1
- Inputs / Outputs—Part 2
- Engine Control Module
- Air Flow / MAP Sensor—Base Inj Pulse Width
- Fuel Delivery System
- Closed Loop Strategies—Theory
- Closed Loop Strategies—Case Studies
- Thermistor Inputs
- Throttle Position Sensor
- EGR Valve Lift Sensor
- MAP / BARO Sensor
- Ignition Inputs
- Vehicle Speed Sensor
- Oxygen Sensor
- Lean Air Fuel Sensor
- Miscellaneous Input Signals
- Fuel Injectors—Multi-Port Injection
- Fuel Injectors—Dual Point Injection
- Ignition System—Outputs
- Idle Air Control Valve

OBD-II Training Modules

- On Board Diagnostics—General Overview
- Diagnostic Trouble Codes
- MIL / Freeze Frame
- Scan Tool
- Scan Tool—Advanced
- Monitor Tests—Overview
- Comprehensive Component Monitor
- Catalyst Monitor
- EGR Monitor
- Evaporative Monitor
- Fuel System Monitor
- Misfire Monitor
- Oxygen Sensor Monitor
- Oxygen Sensor Heater Monitor
- "P" Codes

Miscellaneous Training Material

- Glossary of Terms

10 Closed Loop - Case Studies

10.1 Closed Loop Scenarios

We have looked at all the theory behind CL operation and CL strategies. Now lets start putting it all together and try to look at some "real world" situations. The following "case studies" are situations that you may very well see in the field. Some are fairly common and some fairly rare. These situations assume you have at least a DVOM / DSO / and an exhaust analyzer.

The exhaust analyzer is basically used to determine if the O2 sensor is accurately reflecting the exhaust A/F ratio. If you do not have an exhaust analyzer you can feed the sensor a rich and a lean mixture to the see how it responds. If the sensor responds correctly to a rich and a lean mixture it can be assumed that the O2 sensor is capable of accurately indicating the exhaust A/F ratio. Having an exhaust analyzer to measure the exhaust as you are diagnosing makes for a quicker and more accurate diagnosis.

The scenarios are sorted into two main categories - a lean exhaust condition and a rich exhaust condition. Within each category the possible causes for these scenarios are listed from the most probable to the least probable. Virtually all the following scenarios assume that the car is in the CL mode.

10.2 Lean Exhaust Conditions

10.2.1 O2 Low / Injector PW Wide / CO Low Scenario

O2 sensor Voltage	Injector PW	Exhaust Analyzer
Lean (Low)	Rich (Wide)	Lean (Low CO)

In this case we have O2 sensor voltage and injector PW opposite, so the system should be operating in CL mode. What should be apparent is that the O2 sensor is calling for more fuel and the injector cannot deliver it! In this case you should expect a fuel delivery or injector problem. This scenario is somewhat common.

Possible Causes:

Low Fuel Pressure
The injector is turned on by the ECM for a set amount of time to inject a certain amount of fuel at a certain pressure. When the fuel pressure is below the design standards the injector will not inject enough fuel. This lean condition is sensed by the O2 sensor and feedback to the ECM.

The ECM will widen the PW to try to richen up the exhaust. The wider PW would show up as a high LT FT number on OBD-II models. This will

work for small deviations from the correct fuel pressure, but there are limitations. The O2 sensor input has a limited authority over the PW. Actually the O2 sensor has less authority than many other sensors. The ECM will only widen the injector PW a certain amount based on many different factors. If enough fuel is not delivered at this maximum PW, then the mixture will be lean.

For more information about the fuel delivery system see Chapter 8 - Fuel Delivery.

Restricted Injectors
If the correct fuel pressure is available at the injectors, the PW is wide, and the mixture is still lean - it should indicate a problem with the injectors. As injectors age they can become restricted and not flow as much fuel as they were initially designed to do. You can substitute a known good set of injectors to confirm this.

Wrong Injectors - Too Small
I have seen at least three cases of wrong injectors that can create this exact scenario. It seems that all the Honda / Acura injectors have virtually the same external dimensions and can be installed in just about any Honda / Acura engine. It is not unusual to see a wrong set of injectors in a Honda. Apparently to keep the PW close to the same on all the models the injector pintle size varies with the engine size. Always look for evidence that the injectors have been recently changed!

Just recently I was helping a garage owner with a Civic that kept setting a diagnostic trouble code (DTC) 1. We found the O2 sensor was fixed at about .1 volt and the PW was on the wide side. The car was also running lean. We noticed the injectors looked fairly new and called the owner. The owner had replaced them earlier and had the part number. After further investigation we found that he had installed a set of 1500 HF injectors into a 1600 engine. BINGO!

10.2.2 O2 High / Injector PW Narrow / CO Low Scenario

O2 sensor Voltage	Injector PW	Exhaust Analyzer
Rich (High)	Lean (Narrow)	Lean (Low CO)

Lets take a look at what is going on here. The O2 signal and the injector PW are opposite, so this car is probably in CL. The real strange part of this is that the O2 sensor is not matching the actual exhaust readings. This type of situation should make us suspect problems with the O2 sensor input! These types of failures are not too common, and can be very hard to diagnose.

Possible Causes:

O2 sensor Input Voltage Bleedover
The O2 sensor is a voltage producing sensor. If any other wire with voltage were to come in contact with the O2 sensor input wire, that voltage would be sensed by the ECM. This is a rare circumstance, but there have been a few cases with this happening with heated O2 sensors. The O2 sensor heater voltage wire somehow ends up bleeding over to the O2 sensor input wire.

If this were to happen it should be obvious since the normal highest voltage produced by the O2 sensor is about 1 volt. Most any wire with voltage in the wiring harness is significantly higher than 1 volt. Also a DTC would probably be set if a voltage that significantly exceeded 1 volt was sensed by the ECM.

10.3 Rich Exhaust Conditions

10.3.1 O2 High / Injector PW Narrow / CO High Scenario

O2 Sensor Voltage	Injector PW	Exhaust Analyzer
Rich (High)	Lean (Narrow)	Rich (High CO)

In this case we have O2 sensor and injector PW opposite, so it should be in CL. What should be apparent is that the O2 sensor is calling for less fuel and the injector cannot deliver less fuel! In this case we should expect a fuel delivery / injector problem.

Possible Causes:

High Fuel Pressure
The injector is turned on by the ECM for a set amount of time to inject a certain amount of fuel at a certain pressure. When the fuel pressure is above the design standards the injector will inject too much fuel. This rich condition is sensed by the O2 sensor and feedback to the ECM.

The ECM will narrow the PW to try to lean up the exhaust. The narrower PW would show up as a low LT FT number on OBD-II models. This will work for small deviations from the correct fuel pressure, but there are limitations. The O2 sensor input has a limited authority over the PW. Actually the O2 sensor has less authority than many other sensors. The ECM will only narrow or widen the injector PW a certain amount based on many different factors. If too much fuel is being delivered at this minimum PW, then the mixture will be rich.

For more information about the fuel delivery system see the: Fuel Delivery Training Module.

Wrong Injectors - Too Big
I have seen several cases of wrong injectors that can create this exact scenario. It seems that all the Honda / Acura injectors have virtually the same external dimensions and can be installed in any Honda / Acura engine. It is not unusual to see a wrong set of injectors in a Honda. Apparently to keep the PW close to the same on all the models the injector pintle size varies with the engine size. Always look for evidence that the injectors have been recently changed!

I saw this happen when a set of Legend injectors were stuck in an Integra by mistake. The initial symptom was the catalytic converter was getting hot. The car was running rich all the time and the catalytic converter was working overtime. After the wrong injectors were discovered and changed the catalyst also had to be changed.

Unmetered Fuel Entering the Engine
Any fuel entering the engine other than through the injectors could also create this situation. A leaking injector o-ring on a dual point injection (DPI) type system can leak unmetered fuel into the engine.

The only other possible source of unmetered fuel would be from a defective pressure regulator diaphragm. If the diaphragm were to leak, it would allow fuel from the fuel rail to be drawn into the intake manifold. The check here is to pull the pressure regulator vacuum hose and look for fuel.

Injector Ground Wire Grounded
This may sound like a bizarre one, but I saw it and I wanted to pass it on. The injectors are delivered +12 volts by the main relay. The ECM opens the injectors by providing a ground and completing the circuit. If the wire leaving the injector and going to the ECM comes in contact with a ground, the injector will be opened as long as the wire is grounded.

I saw this on a Honda that had an aftermarket radio amplifier mounted under the right dash. One of the mounting screws was screwed right through an injector ground wire, grounding the wire. When the car was cranked up that one injector was on continuously. The O2 was sensing rich and the PW was commanded as narrow as possible. This one injector that was spraying all the time could not be compensated by the narrow PW. It was just too much fuel!

In a case like this, you would have to use a DSO to check each injector until you found it, unless you were lucky enough to have scoped the shorted injector first. The grounded injector would have shown a flat line (0 volts)

all the time on a DSO. The other injectors would have a normal waveform, but a narrow PW. A scan tool that could read PW from the DLC would not have picked this up either, other than to show the PW as being narrow.

10.3.2 O2 High / Injector PW Wide / CO High

O2 Sensor Voltage	Injector PW	Exhaust Analyzer
Rich (High)	Rich (Wide)	Rich (High CO)

This particular scenario is somewhat common. Note that the O2 sensor and the injector PW are not opposite, but this car could still be in CL mode.

Possible Causes:

Car in Open Loop
It is possible that the car is in OL mode. Vehicles run slightly rich while in OL and a Rich - O2 / Rich - PW / Rich - Exhaust condition is classic readings for a car that is warmed up but has not entered CL. A vehicle that has warmed up enough for the O2 sensor to start working (evident by the high voltage) should be in CL. You will need to check all the inputs and find out why this car is not in CL.

A sensor With More Authority Over The PW Than The O2 sensor is in Control
Most all the sensors used by the PGMFI system to determine injector PW, have more authority than the O2 sensor does. If certain sensors were to command the PW rich, the PW would go rich, along with the O2 sensor and the exhaust. Most of the inputs that could do this tend to richen the mixture if there is a failure. It is more common to see a Rich / Rich / Rich situation occur than a Lean / Lean / Lean.

Here is an example of this situation that happens very often. The (MAP) sensor has much more authority over the PW than the O2 sensor has. If a condition is present that is causing the manifold vacuum to decrease, the MAP sensor input will "overpower" the O2 sensor input and cause the car to run rich. Some of the more common things that could create low manifold vacuum are camshafts out of time, performance camshafts, valves adjusted too tight, and restricted exhausts.

It is very common to have a Honda come in with the cam(s) out of time. If you see Rich / Rich / 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.

10.3.3 O2 Low / Injector PW Wide / CO High Scenario

O2 sensor Voltage	Injector PW	Exhaust Analyzer
Lean (Low)	Rich (Wide)	Rich (High CO)

Lets take a look at what is going on here. The O2 signal and the injector PW are opposite, so this car is probably in CL. The real strange part of this is that the O2 sensor is not matching the actual exhaust readings. This type of situation should make us suspect problems with the O2 sensor input!

Possible Causes:

A Dead O2 sensor
When an O2 sensor fails it typically produces no or low voltage. A car in CL and using a dead O2 sensor input will drive the PW rich and the exhaust will also be rich. Test the O2 sensor by giving it a shot of propane and see if the voltage will quickly increase. If the O2 sensor does not respond to propane replace it.

When you place a defective O2 sensor (especially on a low mileage car) try to look for a reason. Most O2 sensors have a long life and when they fail it could be due to reason other than "old age". The O2 sensors can be damaged due to anything going through the engine other than fuel and air. Look for excessive oil consumption or antifreeze / brake fluid leaking into the engine. Also many chemicals that people spray into the intake and add to the gas are capable of clogging the pores of the O2 sensor.

When creating temporary rich conditions always use propane, it is safe! Don't forget the external vents on an O2 sensor. Anything leaking onto the sensor from the outside can get into the external vents and damage the O2 sensor.

O2 sensor Wire Shorted to Ground or Open
If the O2 sensor wire gets shorted to ground the input voltage will be 0 volts. This in turn drives the PW and exhaust rich. This could be due to the wire getting pinched under a head or valve cover gasket. This could also be more probable on a wreck-damaged car.

If the O2 sensor wire is open somewhere between the sensor and the ECM again the ECM sees an input of 0 volts. This too would drive the PW and exhaust rich. Double-check all connectors for bad connections. To absolutely eliminate this possibility you would need to check the O2 sensor voltage at the ECM.

False Air at the O2 sensor
Any air that leaks into the exhaust upstream of the O2 sensor could cause the sensor to read a high O2 content (lean). The lean O2 reading would then drive the PW rich and the exhaust rich. Confirm there are no exhaust leaks that could supply false air to the O2 sensor.

Another source of false air could be a misfire. Remember that an O2 sensor does not monitor fuel in the exhaust, but monitors O2 in the exhaust. If a cylinder were misfiring the unburned oxygen would create a low O2 sensor voltage reading even though the A/F mixture was rich.