Part 2

INTRODUCTION: If you've implemented the various sensor mods outlined in part 1 of this guide to execute your own control of the various data streams to the ECU you are well on your way to experiencing better performance, emissions, and fuel economy by using supplemental hydroxy injection. Now the key is to learn how to adjust the mods you've made to extract the performance you want from the ECU.

Scan Tools- There are various OBD1 and OBDII interfaces that will allow you to see the data streams being sent to the ECU from the sensors. This is a must to know what your modifications are "telling" the ECU, and what the ECU is doing in response to your sensor stream modifications. Scan tools can vary greatly in complexity from tools that allow partial re-mapping of the actual ECU tables, to OBD "code readers" that simply report numbered fault events that tell you when something is wrong. A scan tool for this type of tuning MUST have the ability to view sensor data streams, so keep that in mind when purchasing a scan tool. A ScangaugeII by Linear Logic ($150) is a basic and very useful scan tool that will work on OBDII sensor streams. Mainstream auto parts stores like NAPA and Autozone also have basic scan tools that offer a sensor stream data readout. There's also laptop based scanners such as Auto Enginuity ($200) that offer a nice graphical user interface to ease such tuning. Find a scan tool that best suits your skill level and purpose. For a single vehicle install you really don't need much beyond the Scangauge, but for a technician that does multiple installs a week the greater investment in a more complex scan tool might be justified. Basically, your scan tool needs to have the ability to display:

Short and long term fuel trims (can be added to ScangaugeII as an "Xgauge")

IAT temp Coolant Temp

MAP/MAF measurement

O2 sensor/AFR sensor readings

Loop Status (open or closed loop)

Optional, but useful items for display include:

Horsepower

MPG

MPT (miles per tank average economy)

GPH (gallons per hour of fuel being used)

Fuel injector pulse width

Using the scantool to read the ECU and data- Once you have purchased and learned how to operate your scan tool to display the above, it's time to proceed to step 1 in the beginning of this guide and log a baseline for your vehicle. After you establish your baseline, perform the mods described and verify your adjustment knobs for the IAT, CTS, MAP/MAF and EFIE are all effecting the sensor streams properly. When you have verified you have control of them but also can revert back to factory data streams you are ready to begin the tuning procedure.

Sensor Stream/Hydroxy Gas Injection Order and Delay There is a specific order in which you

must switch in your mods and intercept the data streams. Some newer cars also require no hydroxy gas to be injected for the first few minutes after start up. Failure to follow the sensor modification order or delays might result in a check engine light and various poor running conditions such as stalling, bucking, rough idle, etc… You can choose to switch in your sensor mods/HHO manually every time you drive, or you can use timer activated electronic relays to switch the various mods/HHO in automatically. My recommendation is to use manual toggle switches first to figure out what time delays are best for your vehicle and then convert them over to time delayed automatic relays. Generally speaking, the order that works best is as follows:

1. MAP/MAF offset should be switched in before you start the car, or always connected.

2. Start engine and allow it to warm up. (depending on climate this could be 2 mins to 10 mins) 2b. (optional) Switch on HHO generator. (some newer cars require a delay in hydroxy injection to pass self-tests)

3. Switch in the IAT/CTS temp offsets. (it's best if these offset values ramp up slowly instead of being switched in at full offset. You can use digitally controlled potentiometers to accomplish this. If you don't have that ability just switch in the higher temp values)

4. Switch in the EFIE O2 switch point offset, after IAT/CTS reach offset and set the stage for leaner tables.

Explanation of The Above Steps: 1.With the vehicle not running first adjust your MAP/MAF offset down slightly from the factory VRef or air reading. For example, use your MAP/MAF enhancer to send 4.875 volts to the MAP/MAF instead of the normal 5 volts. It's important to not do this while the car is running because these sensors tell the ECU what the barometric pressure is on start up. The ECU then uses the baro reading to project what tables and ignition timing it will use after the engine starts. By lowering the reading on the MAP/MAF the ECU will believe you are operating your vehicle at higher altitudes, which will enable a leaner table and advanced ignition timing.

2.Start the engine and let it reach operating temps from driving or idling. Providing time here also allows the ECU to go through its self-test mode of all the various sensors and read them as normal before you modify the stream data. Modifying the stream data too early can sometimes trip codes.

2b. Start HHO injection. Depending on the system you run HHO injection could effect O2 data streams, which should not be changed during the vehicle start up and self-test mode the ECU performs. Older vehicles can run HHO from the start.

3.IAT/CTS temp offsets are ramped up or switched in. This gives the ECU the "green flag" that leaner fuel tables and retarded ignition timing to optimize HHO injection are justified. It adjusts accordingly.

4. The EFIE O2 sensor switch point is switched in to produce more frequent "rich" pulses, thus having the ECU lean the fuel trim out. The MAP/MAF, CTS, and IAT are all in agreement about the leaner table conditions needed from the ECU. It will comply with the request to lean the fuel mixture.

Tuning Your Sensor Mods to Start- Now that you know theproper order in which to use your mods it's time to begin to tune them. Always start out with your mods set very conservatively. Lower your MAP/MAF reading by 5-10%. Raise the IAT temp by about 30 degrees and the CTS temp by about 5-10 degrees. Set your EFIE switch point fairly high (rich), in the 380-400mv Range.

ECU Chain of Command- Just like on a ship or in the military, your ECU has a "chain of

command” when it comes to its sensors and their streams, and unlocking the various tables the ECU follows under different conditions . Generally the O2 sensors are the captain, or at the top of the command order. They have the first and the last “say” on what the ECU is to do in regard to fuel tables. Next,the MAP/MAF or “load” sensors come into play. The ECU checks several times a second to see if the load sensors and the O2 sensors are in agreement about conditions. Finally all other sensors, including the very important IAT and CTS streams are considered in the ECU selection of fuel tables and ignition timing curves that coincide. Loop status is very important. In "closed loop" the ECU is using the O2 sensors to make decisions about the fuel trims. In "open loop" the ECU is ignoring the O2 sensor streams. It is normal for the ECU to switch to open loop at WOT (wide open throttle) and when coasting with no throttle. If you see open loop status frequently outside of that it could mean your mods and settings could be too extreme (outside tolerances) for the ECU to accept.

Fuel Trims: Understanding what they mean- Earlier in this article I mentioned that your scan tool needs the ability to view Short and Long-Term Fuel Trims. I will now try to explain what these numbers mean and how to use them to know if you are tuning correctly. trim numbers actually give us the ability to see what the ECU is “thinking” in regard to its chain of command and what the sensors are “telling” it. The random numbers you will see flashing up on your scan tool are actually percentages of fuel being added and taken away from the injectors, so if you see +10 the computer is adding, or considering adding 10% more fuel to the injectors. Its not quite that simple though. First, lets go over the difference between Short-Term and Long-Term fuel trims and why you might see as many as 8 different selectable Short and Long term streams to look at on your scan tool.

Fuel trim numbers are all based on the O2/AFR sensor data streams, and most importantly, the ECU’s *reaction* to them. For each O2/AFR sensor on your vehicle, you will have a short-term and long-term data stream. For dual exhaust cars you will have a “left bank” and a “right bank” or banks 1-4, with both short and long term trim streams you can look at. The banks are referring to the O2/AFR sensors on each side of the exhaust. For example, a “right bank 1” would be an upstream O2 sensor on the right side of the engine. A “left bank 3” would be a down stream sensor on the left side. The older your vehicle is, (pre-2000), the less concerned with the downstream banks you need to be. For example, with my 1996 Bravada I just monitor the short and long term trims on bank 1, the upstream sensor. Bank 2 would be my downstream since I only have 2 O2 sensors but the downstreams on my Bravada make very little difference in the fuel trim regardless of what they read to the ECU.

Set your scan tool up accordingly to monitor the various short and long term trims of your O2/AFR sensors. On some scan tools that can only display a certain amount of streams at once, such as the Scangauge, you must prioritize and put the upstream(s) short and long term readings on display, while looking at your various other mods in the rest of the open display area. Once you are ready to monitor the banks, here’s a better understanding of what they are telling you:

Short Term Bank __%: This is how much fuel the ECU is adding/taking away at that very moment, based on conditions and this O2 stream. You can expect this number to jump all over the place, but usually not in excess of 15-20%. You’ll see positive numbers if fuel is being added and negative numbers if fuel is taken away. Long Term Bank __ %: This is how much fuel the ECU is *expecting* to add based on current conditions and this O2 stream. The numbers here are based on trends or averages from the short-term trim calculations

Zero is the goal- Short and long term numbers of zero represent that all your sensor streams are in agreement, and that fuel neither has to be added or taken away to maintain the current target AFR (Air to Fuel ratio). Keep in mind that the factory tuned target AFR is normally about 14.7:1,

which is very wasteful with an HHO system. Your optimal AFR will be somewhat higher than that. Also realize that you will never be driving around with 0's on both the short and long term trims all the time no matter what you do. It is normal for these numbers to move around a bit, but staying as close to zero while your mods are switched in and working is what you are trying to achieve. Staying under 10% on the long term fuel trims after your mods are in place and functioning is key to getting and maintaining your mileage gains while using an HHO system.

Part 3. Is available upon request after you have completed all of part 2.