



Tech Articles

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DIY Tuning, Part Two

In the last article, I discussed what hardware and software you needed to do your own ECM tuning. If you missed that article, I recommend you obtain it because it contains valuable information needed to understand and use this and the following parts of the series of Do-IT-Yourself Tuning articles I am writing for our friends at Fiero Focus. These articles should be considered to be basic instructions on how to perform the task of tuning. There are more advanced ways to tune, but in the interest of our general reader, I will try to keep things as simple to understand and follow as possible.

Before you dive into tuning, a few preliminary checks need to be done...

Make sure all fluids are full and the cooling system is operational. If you miss something here, the engine could easily be damaged, as your attention will be elsewhere.

Make sure you have no electrical or mechanical problems that could cause the engine to run erratically. Any existing problem here can throw off the tune, which could result in you wasting your time.

Make sure there are no exhaust leaks between the O2 sensor and the cylinder head exhaust ports. Any existing exhaust leak can result in fresh air entering the exhaust system which can cause the computer to "see" a false rich condition which will throw off the tune and can make the engine run poorly.

Make sure you are using a good quality, fresh fuel. Old or bad gas can negatively impact engine operation affecting the tune. Make sure you are using the octane of fuel you plan on running in the car once it is in normal service.

Scanning

First thing you need to do is to get your live data scan running. The goal here is to see what the ECM sees is going on. Verify all sensor readings (such as temperatures, pressures, etc.) are within spec. Check readings before starting the engine to ensure correct functionality of all sensors connected to the ECM. If any problems are detected, correct/repair them before working on the tune.

Step 1: Before You Get Started

Before getting started with your tuning, select a base-tuning file that is close to what you are working with. I have a great deal of stock GM tunes for various applications and I like to use the one that best matches what I am working with before attempting a custom tune. Many can be found on the Internet, or if you need one, feel free to email me and I will be happy to email one to you if I have what you need. If you have changed fuel injectors, the thermostat, etc. go into your starting tune file now and make the necessary adjustments to work with those new parts before you start the engine for the first time. Now also isn't a bad time to set your top speed/rev limiters and desired idle speeds where you want them before you get started.

Step 2: Cold Start & Idle Tuning

The best place to start is at the beginning. It won't do you much good to tune for part and full throttle if your engine is stalling at idle or if it doesn't run right when cold. Tuning for cold start is tricky because the O2 sensor isn't ready to start producing a signal while the engine is cold (unless you have a heated O2 sensor or WideBand setup). If you have a heated O2 sensor, you can key on the ignition and allow the O2 sensor to pre-heat before starting the engine. You will have a limited time to tune cold start and cold engine operation before the engine warms up to a point these tables are no longer being used by the ECM. So, you may need to come back to this a few times before you get it nailed down. Most of your cold start changes are going to be trial and error to see what works best. It is pretty easy to determine if the engine is running too rich, as would be indicated by a strong exhaust odor. If the engine seems to be struggling (loss of power or seems to want to stall), the cold operation fueling might be too lean. In most ECMs, there are separate tables for cold start, cold running (open loop) fuel delivery values. If these tables

are based on VE (volumetric efficiency) values, increasing the number adds fuel, decreasing it leans it out. If these tables are based on AFR (air/fuel ratio) values, decreasing the value adds fuel and increasing it leans it out. Depending on the system, there could also be separate cold engine ignition timing tables. Once you get the fuel dialed in, you can try different settings to see what works best for your engine. More ignition timing advance can allow the engine to digest and deal with more fuel but can also make operation “edgy”, possibly creating a stall. Less advance can help stabilize idle but may cause the engine to become lazy. The best thing to do is to try different settings to see what works.

Once the O2 sensor warms, it will start producing a signal. All stock GM systems operate on a narrow band O2 sensor that produces a voltage of higher than 0.500 volts when it detects a rich fuel mixture and less than 0.400 volts when it detects a lean fuel mixture. If your ECM is still operating in open loop when the O2 sensor voltage starts to move, you can tweak your fuel settings based on what you see the voltage doing. The best advice I can give is to try to keep the O2 voltage between 0.500 and 0.800 volts during open loop operation. This will ensure the engine is getting enough fuel and it will help signal the ECM that the O2 sensor is ready for closed loop operation. Once the ECM drops into closed loop, the O2 sensor output voltage signal should start to vary rapidly from high to low as the computer makes changes to the fuel delivery.

Closed Loop: Integrator & Block Learn

When the ECM goes into closed loop mode, it will start making adjustments to the fuel delivery using the integrator and block learn functions. The integrator is the computer’s short term (or instant) fuel adjustment, and the block learn is the computer’s long term (or stored in memory) fuel adjustment. In most OBD-1 systems, these numbers start at 128; which is 0% adjust. Any number higher than 128 = the ECM adding fuel. Any number lower is the computer subtracting fuel. You can do some simple math to change the 128-based number over to a percentage. If you see 120, then divide 120 by 128 = 0.9375 which means the computer is subtracting about 6% from the stored fuel tables (in the tuning) to satisfy the engine’s fuel needs. You must take both integrator and block learn trim numbers into account when calculating the total adjustment the ECM is making to the fuel delivery. So if your integrator is at 120 and your block learn is at 118, you really have a total trim number of 110 which equals 14% the computer is removing.

As you progress thru the tuning process, you may notice the integrator number moves around more quickly and more often than the block learn number. This is normal. The block learn number is going to “chase” the integrator number as the computer decides to “learn” what that value is. The ECM will adjust the block learn number in an attempt to get the integrator number back to 128. During this process, the block learn number is “learned” and the value is stored in a pre-determined cell stored in the computer’s keep-alive memory. This memory does not clear when you turn off the key but will be cleared if battery power is removed from the computer. These stored values can also be replaced if the computer finds a new value to replace it with. The BLM cell table is determined by engine speed and load; some applications can have more than 10 cells. Some can have as little as 3.

In any case, once you see a high or low fuel trim number, you can correct for it by changing the value in the appropriate fuel table in the programming. In ECMs that do not use a Mass Air Flow (MAF) sensor, these values are stored in VE tables that are based on RPM and MAP (manifold absolute pressure). So let’s say you are watching your scan tool and in one frame with the RPM at 1000 and the MAP at 42kpa you see the integrator at 138 and the block learn at 132. Doing the math we determine the computer is adding about 11% to the current tune to satisfy the engine’s needs. So we simply open up the appropriate VE table in the tuning software and find the value closest to 1000rpm and 42kpa MAP (closest may be 1200rpm and 40kpa MAP depending on how the tables are laid out). Next we add about 11% to that value and retest. After doing this you should see the INT/BLM counts come back closer if not right onto 128 at that same RPM and MAP. Repeat this process at different MAP and RPM values and make changes to the VE table values as necessary.

If your computer uses a MAF sensor, then there will be tables in the ECM programming where the computer will assign an airflow value to a specific frequency it sees coming from the MAF sensor. The scan data should show either this frequency or a MAF sensor flow rate (in grams per second or gm/sec). Increasing this number richens fuel, decreasing it leans fuel.

As a general rule of thumb, I allow for an operational window of about +/- 6% in the fuel trims before I attempt to make any changes in the tune. Within this window, the computer is plenty capable of self-correcting for what it sees and I instead focus my attention to other aspects of the tune. You can be more exact if you wish, but you will find that changing weather conditions will influence the tune so you may never be able to maintain a “perfect” fuel trim number. Keep in mind you can always come back and make these “fine” adjustments when you are done doing the rest of the tune. Also keep in mind that changes you make later to the ignition timing tables could impact the fuel trims as well so I don’t recommend spending a lot of time on trying to make these perfect right now. Your goal should be to just get it close so the engine is getting the fuel it needs.

If by chance during your scanning you notice the fuel trims are always trending lean or rich no matter the RPM or load, you can make a “gross” change to the programming that can save you from needing to go into the VE tables to make lots of individual changes. If your ECM uses the Base Pulse Constant (BPC) to calculate injector size, you can

simply lower this number to lean out the overall fuel delivery or you can increase it to richen. If your ECM uses the Injector Flow Rate constant to tell it what size the injectors are, you can increase this number to lean out overall fuel delivery or decrease it to richen. BE AWARE that any changes you make to this constant will affect overall fuel delivery, cold or hot engine, regardless of RPM or load. So everything will be affected.

In the next issue of Fiero Focus, we will continue our discussion on tuning.

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