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How to Tune a GM EFI System

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Published by CustomEFIS

Version 07.25.08

INTRODUCTION

This document describes how to tune (recalibrate) a GM Fuel Injection system. It only covers speed density (MAP sensor type) systems. MAF (Mass Air Flow) systems are less adaptable to other engines which among other reasons, is why I don't cover MAF systems. It assumes that your GM EFI system hardware is properly sized, installed, and functions properly and initial settings are correctly set. If these conditions are not met you must resolve any hardware issues before attempting to recalibrate the system software or you will be repeating your efforts. From my experience, there are four stages of calibration quality. Each stage is better than the previous stage with the final stage being a perfect calibration. The goal of this document is to explain how to arrive at a perfect calibration.

There are many different speed density GM ECMs but they all have a MAP (Manifold Absolute Pressure) sensor in common. They will also have a VE table(s) in common. The VE tables may vary in how they are presented and how much resolution they have, and what load ranges they cover, but the fundamental principal is the same; the VE table is the primary calibration feature affecting how a speed density ECM estimates ingested airflow. Many people mistakenly call them fuel tables, but they are really airflow estimation correction tables. For both MAF and MAP based EFI, the airflow is either measured (MAF) or estimated (MAP) and then an air fuel ratio is applied to arrive at the injected fuel quantity. So the VE tables do eventually affect fueling but you should know why in order to properly understand the recalibration process. This manual explains how the VE tables are adjusted for best engine operation. If I don't cover your specific ECM in this manual, and you know for a fact that the ECM is a speed density ECM (wiring diagram will have a terminal for a MAP sensor) then follow the fundamental principal of tuning a speed density system and look for VE tables (after setting up constants first). All this is explained in detail herein. Also follow the help guides that came with your tuning software such as Tunercat.

One of the common misconceptions is that just bolting GM EFI hardware on to any similar size engine will allow the system to work just as it did on the donor GM vehicle. This is far from the truth. The fact is that most GM EFI engines of the late 80s and early 90s were much improved engine designs over the 50's, 60's, and 70's engines on which GM systems are frequently retrofit. Modern engines have more efficient cylinder heads with higher volumetric efficiency. This means that for a given vacuum reading, a modern engine will take in more air than an older engine. Since the factory chip is programmed to deliver fuel to match the ingested air at that given vacuum reading, most factory GM calibration chips will run too rich on older engines. Also, since modern heads produce more turbulence for good mixing of the air and fuel, there is no need for large amounts of spark advance. This means that the spark advance tables from a GM calibration are typically way too late to run an early model engine. I typically have to lower the fuel tables and raise the spark timing on my EFI retrofit kits. The purpose of stating this in the introduction is to emphasize the importance of reprogramming the EPROM chip in the GM ECM. If you don't do that, you might as well keep a carburetor since it will run better. One of my biggest pet peeves is people who install a GM EFI system retrofit kit and then don't recalibrate the chip. They rave about how much better it runs but don't realize they aren't scratching the surface of how much better it will run if re-calibrated.

Re-calibrating a factory GM calibration is not hard but does involve a lot of tedious detail. It requires methodical procedures and lots of number crunching. If you decide that it's too difficult, I am available for re-calibration services at an hourly rate.

This manual covers GM EFI systems between the years 1985 and 1995. These systems are the easiest to retrofit onto older vehicles. This manual does not cover the LT-1 or later GM engines that used sequential EFI systems without distributors. The main reason is that all 1996 and later GM ECMs used onboard flash memory that is not removable from the ECM. Reprogramming is done through the diagnostic port inside the car which means if an ECM is damaged (corrupted chip) during reprogramming the ECM must be repaired or replaced at great expense. All systems I work with have removable chips which cost at most $25 if the chip must be replaced.

This tuning guide is a continuous work in progress. When you receive the booklet, email my site at John@customefis.com and ask for a Username and Password to gain access to updates to the guide. This is the second version of my DIY GM EFI manual and no longer includes hardware information. I moved all hardware information to www.customefis.com in the password protected section.

BINARY FILES AND CHIP REPROGRAMMING METHODS

All GM ECMs are microprocessor based digital control modules. As such they all use a binary data file for the instructions on how to run a particular engine. With early ECMs the binary files programmed on removable chips contain mostly calibration data and not processor code. The processor code was contained on a separate ROM (non-reprogrammable) chip inside the ECM. Processor code is binary machine language instructions that the microprocessor uses to run the engine and is mostly the same for all combustion engines. Only GM EFI experts should change processor code because the ECM can do something completely unexpected (if the engine runs at all) if the code is changed. Calibration data is engineering data specific to a particular type of engine and determines how well the engine runs. Degrees of spark advance at full throttle is an example of calibration data. Machine code instructions to check the current RPM against the RPM Upper Limit value in the calibration data is an example of code. Later model ECMs have all the processor code as well as the calibration data in the removable chip and the different types of data are usually clearly separated on the chip in low and high addressable areas of the binary file.

Some factory binary files for the same engine size and year are better than others. When GM had a drivability complaint they issued technical service bulletins (TSB) along with a new binary file to solve the drivability problem. When I choose a starting binary file I use Tunercat's CALDATA program to search all the available calibration files for a particular engine size closest to my application and use the latest dated calibration for the ECM I am using. I then search for the binary file on the internet if I don't already have it in my archives. The purpose of the calibration editing (tuning) software discussed in this manual is to change the calibration data to better suit a particular engine. The tuning software should never change the processor code and won't unless you set it up intentionally to do that, which I have done on occasion.

Factory binary files are identified by a four letter code called a BBC or Binary Broadcast Code. Having this code tells you everything about the file i.e. year, ECM model, engine size, transmission type, gear ratio, etc. One of the most useful software tools I have is Tunercat's CALDATA program. You can type in a BBC and the program will tell you everything about it. Even better, you can type in engine size, ECM model, and trans type and the program will tell you all BBC's that came out for that application. Another binary file identifier is the mask ID. The mask ID indicates the calibration format and is specific to a particular ECM model. For ex. Mask ID $42 is specific to a 1227747 ECM model and is for 6 and 8 cylinder TBI engines only. Mask ID $8D is for the 1227730 ECM model and runs a V8 speed density Tuned Port Injection or any V8 multiport system. Each of Tunercat's TDF files is for a specific mask ID. You can have many BBC's with the same mask ID through the years as GM issued drivability service updates.

CHIP REPROGRAMMING METHODS

When I first became involved with GM EFI the only way to change the calibration data was to purchase an EPROM eraser and EPROM programmer to erase and then reprogram the factory EPROM (calibration chip or PROM). EPROM stands for Electronically Programmable Read Only Memory. These type memory chips required an ultraviolet light source to erase them (usually for 15 minutes minimum) and a separate programmer plugged into a computer. Due to advances in technology, you can now change the calibration data with the ECM running the engine in real time with what is called an emulator. This is the ultimate way to tune a GM EFI system since you get immediate feedback on how well your changes make the engine run. Another improvement over the older technology EPROMs is EEPROMs. EEPROMs are Electronically Erasable Programmable Read Only Memory also called flash chips. These chips typically hold a lot more data than EPROMs (due to better technology) and are erasable by the same device that programs them. The erasing process for EEPROMs is usually a matter of seconds instead of minutes. Due to the cost savings of a single erasing and reprogramming device and the time savings of erasing and reprogramming EEPROMs, I always convert the ECM to use a flash chip at the very least. Depending on whether the customer wants to use an emulator, I either convert the flash chip to fit an unmodified ECM, or I convert the ECM to use an emulator. The method of erasing and reprogramming a factory EPROM, erasing and reprogramming a flash chip, or using an emulator is specific to that particular device and I will refer you to the instructions that came with the programming tool you purchase for its use. You can also email me for assistance or check my website for instructions. The bottom line is each time you re-calibrate a GM ECM, you will be programming a modified binary file back onto an erased chip or uploading the modified binary file to an emulator. The emulator combines the binary editing steps, erasing, and reprogramming into one device.

At current technology offerings, you have three choices for reprogramming the ECM:

1) factory EPROM programmer and eraser (not recommended due to high cost and slow speed)

2) EEPROM programmer (inexpensive programmer and eraser in one device but requires a specially modified flash chip; recommended if you want the least expensive path to reprogramming)

3) emulator (this device emulates a chip but can be uploaded with the engine running when connected to a laptop; this is the ultimate reprogramming method but costs the most)

I sell items 2 and 3 with the modified flash chip or ECM as needed. Consult with my website for more information and pricing.

CALIBRATION STAGES

In this section, I will discuss the different stages of calibration quality as I have qualified them from experience. The stages will be called stage 0 through stage 4.

Stage 0 - Although this isn't really a calibration stage I should mention it since some customers get confused about limp home mode. Limp home mode is an analog fuel only mode built into each GM ECM. It is "calibrated" with a chip called a NETRES that is usually plugged into the ECM very near the reprogrammable EPROM. The NETRES chip contains a network of resistors (hence NETRES) that allow the analog circuitry to run the engine in a safe manner. The NETRES chip is not re-programmable so limp home mode cannot be recalibrated per se. I suppose you could search far and wide and find a different NETRES chip that would run your modified engine better but its not worth the effort to me since its for emergency situations only. The ECM uses limp home mode when one of the following occurs:

1) ECM CPU crashes;

2) the CPU can't read the binary calibration file either because the programming process was improper, the chip is defective, or the chip was not inserted in the ECM correctly;

3) the wrong binary file (mismatched mask ID) was programmed on the chip and the ECM can't interpret the data.

If you are in limp home mode the ECM is using the NETRES chip to run the engine and is not in digital mode. Since it's not reading the digital chip, changes you make to the reprogrammable digital chip will have no effect. Basically this is not a calibration stage but a hardware defect that needs resolving before any tuning can take place.

Stage 1 – Stage 1 is using a factory binary file that is close to your engine specs without making a single change to the file. Within this stage I will group all BBC's with the same mask ID that might run your application and the "tuning" would consist of trying different BBC's to find one that runs your engine the best. For ex. when I first began CustomEFIS I tried many BBC's for an AMC 360 in a 1986 Jeep Grand Wagoneer, the first non-GM vehicle I ever converted to GM EFI. What I found was that BBC ASDU ran the engine the best compared to other BBC's with the same mask ID $42. ASDU is for a 1989 Chevy 350 V8 with automatic transmission. The manual BBC's that I tried caused the engine to idle too high at stop signs and I later found out that this is called throttle follower and requires a speed sensor to operate correctly. While Stage 1 is not technically a calibration stage to me since I know how to re-calibrate files to the extreme, there is a valuable point to make. You need to start with the best BBC for your application (closely match engine size, horsepower, transmission type, gear ratio, etc.). Once you have the best BBC you then tweak the calibration data to perfect how it runs your engine combination. There are only two ways to find the best BBC and they are to experiment with them like I did (and use Tunercat's CALDATA program) or ask me. You may or may not get the engine to run well with just Stage 1 level "tuning". You can play with distributor settings, fuel pressure, install a working EGR system etc. but the calibration will still more than likely be considerably rough. The only time Stage 1 would be acceptable to me is when you are running the exact same engine with all emissions devices connected that the calibration was designed for. If you swap an engine from a Chevrolet into some other vehicle and swap the ECM and calibration with it then this will be a satisfactory situation although there will probably be room for improvement. The problem with Stage 1 is that there are a lot of basic settings that should be done to make the system work reasonably well with your engine. This leads to Stage 2.

Stage 2 – Stage 2 is making basic settings to a factory calibration to better run your engine. This is the first level that requires you to erase and reprogram the binary calibration chip. You can use either the factory EPROM, a flash chip, or use an emulator. In this Stage you adjust parameters such as base pulse constant, initial distributor setting, turn off EGR, remove interlocks to speed sensor on BLM learning, etc. This stage, while still not real good at running your engine, will be better than the Stage 1 method. For ex. as you'll learn later, the Base Pulse Constant (early TBI ECMs only) is the single most important parameter in a TBI EFI system. It relates the engine size and injector size so that global fueling is accurate. A factory GM 350 BPC is 135. Installing the same system on an AMC 360 requires the BPC to be raised to 140 (360/350 * 135 = 140). While the AMC 360 will run with a BPC of 135, the O2 sensor will have to do its job to raise the fueling globally by 4% since 135 is a tad too low. Other important parameters to adjust are the EGR speed qualifiers. If EGR logic is enabled it will make the ECM lean out the mixture by 10% at part throttle operation. The O2 sensor will then have to correct for this with the result being sluggish throttle response. Setting the speed to 255 MPH for EGR to turn on and the speed to 254 MPH for EGR to turn off will insure that EGR logic never turns on. Setting parameters to unattainable values is a common way to disable certain features. These type settings are good for a beginner to make and experiment with. Making Stage 2 settings will at least get you on the way to a good tune but it's still a long way from being perfect. Many chips you might buy on the internet are no better than Stage 2. They can't be because stage 3 takes too much work.

Stage 3 – Once you have made all the Stage 2 parameter changes to get the basic settings correct, its then time to start adjusting the tables that will make the calibration more closely match your engine. This stage is where things begin to become what I call accurate. Accuracy is important as a tuner because it helps you relate one calibration to another. All settings in an ECM need to be accurate, even the basic settings, so that you get results that make engineering sense. For ex. say you've tuned one engine and it makes the most power at 5500RPM with 34 degrees timing BTDC. Then you tune an identical engine and it makes the most power at 5500 RPM with 24 degrees timing BTDC. As a tuner and engineer, this would alarm me and make me think something was not set correctly. What it would probably mean is the initial distributor setting is 10 degrees off on one engine vs. the other. The factory timing for an AMC 360 engine is 10 degrees BTDC so that is what I tell my Jeep customers to set the distributor at with a timing light. I then set the initial distributor parameter in my Jeep calibrations for 10 degrees BTDC. This means the calibration and the hardware are in agreement and the timing that I program in the calibration at all loads will then be accurate. If the customer sets the timing at say 20 degrees just because he wants to then the real world timing will be 10 degrees higher than what I see in the spark timing tables. If the customer asks me for help a year down the road and I look at his spark tables and see normal values, yet he tells me his engine is pinging like mad, I have no way of knowing why unless I happen to have him check his base timing again. This is one example of why all settings should be accurate. Troubleshooting an inaccurately programmed system is a nightmare.

Another example where accuracy is crucial is in the VE tables. VE (volumetric efficiency) tables are fudge factors to help the ECM estimate the air quantity flowing into the engine. Speed density systems estimate airflow using a chemical formula called the ideal gas law. It's beyond the scope of this document to explain but the ideal gas law assumes 100% volumetric efficiency of the incoming air's ability to fill the engine cylinder. By applying a factor that makes the estimate accurate at a given RPM and manifold pressure, the ECM has a good estimate of the airflow. It then applies a programmed air fuel ratio to arrive at the correct quantity of fuel to be injected. The signature tuning feature of a speed density system is adjusting VE tables to make them accurate. Since a factory narrow band oxygen sensor locks you in at 14.7 air fuel ratio, you use the O2 sensor to accurately program the VE tables using the Block Learn feature of a GM ECM. This is described in more detail herein but the point is that the accuracy of all other fueling modes is determined by the accuracy of the VE tables. The purpose of the BLM feature is to force accuracy of the fueling at all loads. This will become clearer later.

Once you've become proficient at this stage you should be able to set up a calibration accurately. But just because a calibration is accurate doesn't mean its right for the engine. I can set the timing table for 10 degrees across the board from idle to full throttle. As long as the distributor setting is correct, the engine will run with 10 degrees of timing at all loads. It won't have much power and will waste gas but it will run and it will be accurate.

Here is the most common trap that beginning tuners fall into. Many people will tune one parameter and the engine performance will improve and they will think that the calibration is perfect. The problem is that what has happened is there are two parameters that are not accurate and the combination of the two is offsetting allowing the engine to run well. For ex. say you are tuning on a dyno and you raise the wide open throttle AFR above 13.0 and the power improves. Say you keep going and the power gets even better. As an experienced tuner I would know to stop and check the accuracy of the VE tables. Most naturally aspirated engines make maximum power just below 13.0 AFR. If you set the AFR much higher than that you run the risk of damaging the engine. But if the VE table at the same RPM and MAP (MAP at WOT is only important at high altitudes) readings is incorrectly programmed with a high value, you are really running at a much lower AFR than 13.0. The high VE value and high AFR value are both inaccurate but together they result in a good mixture for the engine. Many beginning tuners get caught in this situation. They get the engine to run well and then stop, thinking the calibration is perfect when in reality the inaccuracies have complemented each other. Many professional tuning shops sell chips like this. They don't have the time to accurately tune your engine (they can't without proper tuning tools such as a wide band O2 sensor) so they just make a change that makes the engine run with more power. But who knows what the true AFR is coming out of the engine with an inaccurate calibration. When I sell a system for an engine in a passenger car such as a Jeep Wagoneer, I have to sell an inaccurate calibration. It's as accurate as my experience allows me to get it but unless the customer sends me ALDL data for dialing in the calibration it's not going to be accurate for that particular engine. And unless the customer installs a wide band O2 sensor so I can check the full throttle AFR, I have to guess at the WOT AFR table. If you are running out of time and the engine (passenger car) is operating well, you can stop here in the calibration process. But it wouldn't be wise to compare your calibration with someone else's for the same vehicle. I see people sending calibrations back and forth across the internet for similar vehicles but unless the accuracy is checked the comparisons are meaningless. That's why I never use a non-factory calibration that I find on the internet. You just don't know its accuracy. If you want to perfect your calibration then you proceed to Stage 4. Incidentally, if you buy a chip from me or anyone else on the internet, the best you'll get is a Stage 3 chip that had been set up based on experience with similar engines. Basic settings such as engine size, injector size, EGR disabling, and base timing are the easy part. Experience tells me to lower the VE tables 10-15% in the idle area of the VE tables, and raise the idle timing to about 25-27 degrees for engines with cams in the 225-230 @ 0.050 duration specs. If the engine has good breathing heads, intake, and exhaust, then I'll raise the VE table values in the high RPM, high MAP area of the table. Depending on the customer's desires, I'll also lean out the WOT AFR table which typically provides more power than leaving it stock.

Stage 4 – Stage 4 is taking a nearly accurate Stage 3 calibration and perfecting it. To perfect a calibration you need special tuning tools to check the accuracy of all the settings. The most important tool is a wide band O2 sensor. A factory type O2 sensor is called a narrow band O2 sensor. It is limited to telling you when you are running very near 14.7 AFR. The narrow band sensor is useful for accurately calibrating the VE tables at idle and moderate throttle openings. At wide open throttle (WOT), since most engines run best below 13.0 AFR, a wide band O2 sensor is needed. Lets use the example above of WOT tuning and how two inaccurate tables can offset each other and get them accurate again. Without a wide band O2 sensor you really don't know what the real AFR is coming out of the engine but with a WB O2 you can measure it. Lets say you have a WB O2 installed and you've calibrated it per the instructions that came with the sensor. Then you program the WOT AFR table in the calibration file for 12.0 at all RPM values. I chose 12.0 because that's a safe value to tune to. Then by logging data (hopefully you have configured the ECM to log WB O2 data with the rest of the sensor data; ask me how) you will now know the true AFR as you drive at the different RPM values. Its best to try and hold a steady RPM to get good readings. Now lets say at 4000 RPM the logged AFR was 11.0. According to the above example I would expect the AFR to be lower than programmed because the VE tables were too high adding too much fuel. So what I would do is lower the VE table at 4000 RPM by whatever percentage it takes to get the AFR to measure 12.0. I would check all RPM values in the WOT AFR table in the logged data and make corrections to the VE table at that RPM to get the AFR to measure 12.0. After repeating the driving sessions to check the calibration changes I should be able to get the logged AFR to measure 12.0 at all RPMs. Once I have this result I will know my VE table is now accurate not only at idle and part throttle but also at WOT. Now that the VE table is accurate up there, I can now program the WOT AFR table for leaner and leaner mixtures knowing that I should expect maximum power just below 13.0 AFR. If you have a dyno you can measure the power increases and program the WOT AFR table perfectly to maximize power. Without a dyno just knowing that your AFR is between 12.5 and 13.0 should be close enough to make you happy. One point to make is that having the WOT AFR anywhere from

11 to 13 is within 10% of the maximum power. This info came from one of my carburetor tuning manuals. So even if the calibration is not tuned to get the WOT AFR near 13.0, you'll still be within 10%. For this reason, I frequently choose 12.0 as a safe AFR to set the WOT AFR table on a passenger car. You'll also find that many factory calibrations are tuned rich with WOT values as low as 10.0. The reason is the factory wants the engines to last longer and tunes them conservatively. This is especially true on truck engines that are expected to see heavy duty use. If you want to see the opposite find a police car calibration and check the WOT AFR and spark timing tables. You will be amazed at the differences.

So far I've covered fuel tuning when perfecting a calibration. Tuning spark timing is more trial and error since without feedback you don't know whether to add timing or remove timing. Tuning spark timing requires that you read the plugs to do it right. There are tips from drag racing enthusiasts on how to read spark plugs for best timing settings but what I do is try and get a copy of the factory service manual for a particular engine and program the timing tables to match the service manual curves. I created an EXCEL spreadsheet that populates the spark timing tables if you know the RPM and vacuum advance curves for a particular engine. Email me if you would like a copy of that spreadsheet. Keep in mind that factory curves may have EGR factored in the settings. This means you should remove 3-4 degrees of timing from the curves at part throttle if programming a GM EFI timing table. EGR timing is handled by a separate EGR timing table that should be disabled unless you have a working EGR valve on your engine.

Hopefully by now you understand the different qualities of GM EFI calibrations and that at a minimum you should have reached Stage 3 before stopping your calibration process. Stage 3 is acceptable for a passenger car but I wouldn't stop there for a performance engine.

GM ECM BINARY FILE EDITING SOFTWARE

In this section, I will discuss why I choose particular ECMs and how to re-calibrate the EPROM in the ECM.

CHOOSING AN ECM

Choosing an ECM is a relatively simple decision for me. You have to choose one that is reprogrammable, bottom line. To help with this decision, I'll provide some background information first. The reason I am able to build GM EFI systems is that some really sharp computer guys have reverse engineered the code in some GM ECMs. This is called "hacking" or having a "hac" for an ECM. When the code is hacked, the locations and the meaning of the digital data on the EPROM (the calibration chip in the ECM) is understood. Since the data on the EPROM is binary data, locating it, understanding it, and reprogramming it is next to impossible without first hacking the ECM it came from. Once an ECM is hacked, a program can be written (called a Tuning Editor or Editor) that will edit the binary data on the ECM's EPROM so that you can recalibrate the data. The tuning editor "knows" where the data is located on the EPROM and what the purpose of that data is. However, the tuning editor program doesn't know what to change or why. That's what you as the tuner must learn and understand by knowing how engines work and what you want to accomplish. Typically, the data has to be converted from binary numbers to real world units like temperature, RPM, AFR, MPH, etc. The Tuning Editor performs these conversions on specific binary file locations. Once the binary file editing is complete, the file is then re-burned onto an erased EPROM. Typically, it takes many burns to get the calibration just right.

There are two different designations for GM engine computers. The early ones were called ECMs (Engine Control Module) since they only controlled the fuel and spark timing of the engine and sometimes the lockup torque converter in the transmission. In the early 90s, PCMs (Powertrain Control Modules) were introduced when the fully electronic transmissions became available. Between 1992 and 1995, both were used in the GM vehicle line. After 1995, all engine computers were PCMs, and flash to boot. Flash means the chips were no longer removable from the PCM and had to be reprogrammed thru the ALDL connector in the car. I don't like flash PCMs for a variety of reasons, but the main one is that they are very fickle. If a single glitch occurs when programming a flash PCM, the entire PCM is damaged and requires a $200 flash replacement repair. I don't want to pay $200 every time a PCM is killed because someone opened the car door and the drop in voltage caused a glitch. Flashing a PCM is a DIY operation only if you ask me. The flash PCMs were introduced with the 1992 LT-1 Corvette and the Camaro LT-1 in 1993. Fortunately, the truck PCMs kept MEMCALs thru 1995. These MEMCAL (removable chip) based truck PCMs are the ones I use nearly all my systems now since the code is almost universal. The data quantity and speed from these PCMs is top of the line, so they are a must for a critical application. The early TBI ECMs were about 50 times slower sending out data and included no spark timing information in the data frame. The later ECMs and PCMs sent all kinds of data about 6-7 times per second for a complete data frame. A data frame is a complete list of all the engine sensor information used by the ECM. If you can afford it, you want the fastest ECM/PCM you can get.

So, how do you find a hacked ECM? For me, I just look for the supported ECM list on www.Tunercat.com. These guys are professional GM ECM hackers. Tunercat consists of two parts, the main program and the TDF (Tuner Definition File). The main program runs all the TDF files and each TDF file is unique for a given ECM model number. Think of the main program as your brain and each TDF file as a road map of a particular city. When you travel to a foreign city, you use the same brain but a unique road map for that city to learn the addresses of where you want to go. The TDF files are the road maps to the information contained in each ECM, and each ECM model's tuning data locations are different from another.

The other source for hacked ECM information is www.diy-efi.org. There are four other tuning editor programs that I know of: Promedit, GMEPRO, WINBIN, and LT-1 Edit. Promedit is a freeware dos based tuning editor found on the diy-efi website. It is very primitive but works well. The capability of promedit is completely dependent on the ECU file that you use with the program. An ECU file is equivalent to the Tunercat TDF file. I'll refer you to www.diy-efi.org for more info on how to use Promedit, Winbin, GMEPRO, and LT-1 Edit. Since the first two of these are free, those on a budget may want to use these, but I like Tunercat for the technical support. WINBIN is nice because it is Windows based and free, but it is basically a Windows version of Promedit with no tech support.

Update: There is a new program called TunerPRO RT that has made Promedit, GMEPRO, and WINBIN obsolete. Search for it on Google. I still use Tunercat because it is less buggy and I get tech support.

For more info on choosing an ECM, go to the DIY-EFI website and look in the GMECM FAQ link. But for a quick run down on the most popular and least expensive ECMs, follow this guide:

TBI EFI - ECM model 1227747 is the most popular and best hacked; port EFI - ECM model 1227730 is the most popular, with 1227727 (Corvette version) being identical electronically but in a weather-resistant case. Turbo port EFI - ECM model 1227749 is from the Syclone/Typhoon turbo charged trucks (there is a separate Email list covering these trucks and ECMs; www.syty.org). This selection covers 99% of the GM custom EFI market.

Update: I now use 1995 16197427 PCMs for nearly all GM EFI systems that I build. This PCM covers 6 and 8 cylinder TBI systems for all engines, and 4, 6, and 8 cylinder MPFI systems. 8 cylinder MPFI systems require a change to the motherboard so that the PCM can run 4 MPFI injectors on each output. Unstable injector operation will occur if the change is not made to the motherboard. Also, stay away from the 1227749 Syclone ECMs. My experience with them is the code is buggy and does strange things. A better ECM for boosted applications is from this site:

www.dynamicefi.com

This guy took a standard TBI ECM and changed the code to run just about any engine you can dream up, boosted or not.

Note that the above ECMs all have removable EPROMs or MEMCALs of some fashion or another. There is a reason I only mention these. I like to be able to remove the EPROM but leave the ECM in the car. This way, all you need is a backup EPROM or MEMCAL and you can keep driving the car while your primary one is being reprogrammed. On the later (1993 and up Vette LT-1) PCMs, there is no removable chip. The entire PCM has to be removed from the car and shipped to a reprogrammer for any changes. This means you would have to keep a spare $200 PCM around to continue driving the car, and you would have to pay for more expensive shipping of a huge (comparatively speaking) PCM back and forth to your reprogrammer.

One more comment. Many people ask if a port ECM can be used to run a throttle body system. The answer is typically no, although some DIY er's have tried it. The reason is the timing of the fuel injector pulses and the injector drivers inside the ECM. GM port EFI ECMs are batch fire ECMs that fire all 8 injectors once every revolution (usually), but TBI ECMs fire each injector every other ignition event. So this is what happens. If you are using a port batch ECM with TBI, you will be starving 2 out of 4 cylinders of fuel because only the cylinder on the intake stroke gets fuel. The other two in the firing order on that manifold plane miss out because their intake valve closes before the ECM fires the injector again. This is kind of hard to explain. Another reason that you don't use port ECMs on TBI is that TBI injectors are what's called peak and hold injectors. Because of their size and flow rate, it takes a good jolt of current to quickly open a TBI injector. Port ECMs use saturated injectors, or high impedance injectors. These injectors use the same current pretty much whenever they are open, and don't need the current jolt. The ECM will limit current with MPFI injectors and this will cause erratic operation. On the other hand, you run into problems using a TBI ECM with port injectors too. Since a TBI ECM fires its injectors twice as much as port ECMs, you end up spraying too much fuel with port injectors. You might could compensate in the EPROM for this, but I think you'd also run out of time for an adequate duty cycle at higher RPM. For me, bottom line is stick with what works. GM EFI is hard enough without trying to do circus tricks with this stuff.

PROGRAMMING A GM ECM EPROM

A quick and dirty overview of the tuning process is as follows. I will describe each tool in the order that you will use them. First, you will have to gather diagnostic data from your vehicle's ECM while driving. For this, you will need an ALDL cable (I sell them for $35 for 9 pin serial ports only) and a diagnostic software program. The free programs are WINALDL for TBI ECMs and Craig Moate's GM ECM for TPI ECMs. There are links to free and not so free diagnostic programs in my EFI links section on my homepage. These programs do nothing but gather ECM sensor info and store it in a file on your laptop computer's hard drive. You then analyze the data with Microsoft Excel's data sort function to find where you need to make changes to the chip. Learning how to analyze the data is the big enchalada and is covered in the software section. After you analyze the data, you will then need a Tuning Editor program. The free ones are Promedit and WINBIN. Others are Tunercat, GMEPRO, and LT-1 Edit for LT-1 engines only. You will need an EPROM programmer to read the data from your chip. Then, change the data with the tuning editor program above, and burn the edited file back on an erased chip (EPROM). You'll need an EPROM eraser to erase the EPROM before you burn the new file onto it. However, if you are using a new flash chip, you don't need the eraser. Links to purchase all the least expensive tools above are found in my EFI links section. If you are still confused about what to buy to reprogram a GM EPROM, check out the following link. It goes into great detail on the technique of how to reprogram your own EPROMs. Keep in mind that this link only discusses the method of reprogramming EPROMs. It doesn't tell you what to change on the chip or why in any detail. The site is:
http://www.thirdgen.org/newdesign/tech/promintro.shtml
As you probably read in the above link, there is no one book or document that explains how to recalibrate a chip. My ultimate goal is to provide that document herein.

GM ECM SOFTWARE AND CHIP RE-CALIBRATION

BACKGROUND

Before reading this section, you should read Appendix A - "Why GM EFI Needs Reprogramming". I discuss the basics of GM EFI and the terminology there. Keep in mind that all GM EFI reprogramming is only possible due to the reverse engineering efforts of some sharp computer types. GM doesn't condone or assist with this effort. I will assume that you have purchased Tunercat (www.tunercat.com) in order to retune your GM ECM and that you have an EPROM programmer and eraser, flash chip programmer, or emulator. I will discuss the programming in the order of Tunercat's $42 TDF file for the 1227747 TBI ECM. There are three data types in a GM ECM calibration file. They are switches, constants, and tables.

SWITCHES

Switches are single bit data that represent a two position parameter that can only be on or off, hi or lo, enabled or disabled, etc. They have no value other than one of two positions. A single 8 bit byte in the EPROM can store 8 separate switches. Most of the time the switches are for error code enabling or disabling. For ex. if you don't have a speed sensor and don't want a speed sensor nuisance error code, you can turn off the speed sensor error code so that you will not get a check engine light when the speed sensor diagnostic test is run. This does not mean the test itself is disabled, just that the ECM won't turn on the Check Engine light. An example of another switch is whether the VATS (Vehicle Anti-Theft System) is enabled or disabled. I won't individually discuss the switches in the $42 TDF since they should be self-explanatory now.

CONSTANTS

Constants are non-varying values that don't change based on some other parameter. Examples are the size of one cylinder of your engine in liters, the flow rate of one injector in #/hr at 100% duty cycle, the static setting of the distributor in your engine, the maximum speed before fuel shutoff on a speed limiter, etc. The constants in Tunercat are as follows:

Main Spark Bias

This is hard for most beginners to understand but it allows negative spark advance amounts to be programmed. The spark table itself can't hold negative numbers, but if you subtract 10 degrees from every single value in the main spark table, you can get a net negative advance. For ex. if the main spark table has a value of 6 degrees, subtracting 10 degrees makes the net advance -4 degrees, or 4 degrees retarded. Most of the time, the main spark bias will be 10 degrees. I have seen values of 20 degrees though. Best advice here is to leave this value unchanged. Tunercat automatically subtracts the main spark bias from the main table value so that net spark advance is displayed. Likewise, when you change a value in the main table with Tunercat, Tunercat adds the bias to it before saving the change in the main table. I don't think WINBIN does this. WINBIN and promedit are more primitive than Tunercat so you have to be careful when applying this discussion to programs other than Tunercat.

Initial Spark Advance

This is the amount of degrees BTDC that your distributor is physically set to. On most GM trucks, this value is zero. The purpose of this value is so that the spark table can be programmed to represent the real spark advance from zero degrees BTDC. For ex., say that the value in the chip is 0 degrees. If you have the distributor set at 10 BTDC, and the spark table says 10 degrees in some places in the table, your true timing will be 20 degrees because the distributor is adding an extra 10 degrees on top of the 10 that the table contains. If you set the distributor to 10 BTDC, and then change the initial spark advance setting to 10 degrees in the chip, where ever the table says 10 degrees means the true timing will be 10 degrees BTDC. The table says 10, then the inital setting value is subtracted, which would leave a net value of zero degrees coming from the ECM, but since the distributor is set at 10 BTDC, the true timing will be 10 BTDC.

Extended Spark RPM Slope

The purpose of this table is to determine how much spark advance occurs above the main spark table range. As you will see later, the main spark table stops at 3600 RPM in the 1227747 ECM. Any spark above this RPM is determined by multiplying the Extended Spark RPM Slope by the current RPM minus 3600 RPM. For ex., say your slope is 5 degrees/1000 RPM. If the current RPM is 4000 RPM, you are 400 RPM over 3600. 400 X 5/1000 = 2 degrees. So you will have 2 more degrees than the value in the main table at 3600 RPM. The maximum advance is limited by another EPROM parameter called max RPM for spark slope. The $42 TDF file doesn't show this value, but it does exist and is usually around 4800 RPM. This means once you reach 4800 RPM, the spark advance is maxed out and will not increase.

Min. Speed to Enable Hiway Mode Spark

This parameter is the minimum speed to maintain before hiway spark mode will be enabled. Hiway mode is a special open loop mode in which the ECM runs leaner than 14.7 AFR. There are two functions that occur in hiway mode. They are hiway spark mode and hiway fuel mode. In order to enter hiway mode, certain conditions have to be met; ECM has to be in closed loop for a certain amount of time, the speed has to be higher than a programmed speed and the engine load (MAP) has to be less than a programmed amount. A certain amount of time also has to lapse since the hiway mode conditions have been met, but the other criteria have to be met before hiway spark will occur. I don't recommend hiway mode for beginners. Wait until you have a lot of experience with GM EFI before trying to engage hiway mode. If you have the experience, then you won't need me to explain how to set this up. There is documentation (hiway747.zip) and a code patch that allows hiway mode on the 1227747 ECM. It is located in the incoming directory of www.diy-efi.org.

Time Delay to Enable Hiway Mode Spark

See above description.

Bypass Power Enrichment Delay

Power Enrichment (PE) mode is the full throttle mode when maximum power is needed. The ECM uses only coolant temperature and the throttle position sensor (TPS) for determining when to enter PE mode. However, in some calibrations, the ECM will delay PE mode when the engine RPM is less than this value. This is an economy feature that prevents PE mode from quick stabs at the throttle. Below this RPM, the throttle has to maintained above the PE mode threshold for a programmed time before PE mode will be in effect. But above this RPM, the delay is ignored and PE mode takes effect immediately.

Power Enrichment Mode Delay

This is the programmed amount of time that PE mode is delayed when the RPM is below the Bypass Power Enrichment Delay RPM. See above description.

BPW Constant

THIS IS THE MOST IMPORTANT PARAMETER that you can adjust in a $42 GM TBI EFI system. If you read nothing else in this entire manual, read this paragraph. This number is a universal fuel rate number. Raising this number increases the fuel delivery across the board and lowering it does the opposite. It has the same effect as changing the fuel pressure. Ideally you want to calculate this number based on the measured flow rate of your injectors and your actual engine displacement and not use this parameter to fine tune a calibration. Without going into the details, this constant is determined by the size of one engine cylinder in liters and the flow rate of one injector in grams/sec. The equation is:

BPW = 1461.5 X engine size in liters/# of cylinders / injector flow rate in gms/sec

Lets do an example of this. Say you have a 5.7L V8 and you have a twin injector TBI with 66 lb/hr injectors. First convert 66 lbs/hr to gms/sec. 66lbs/hr X 453.6 gms/lb. X 1hr/3600 sec = 8.316 gms/sec. Then 1461.5 X (5.7/8) / 8.316 = 125. So 125 would be the BPW for this calibration. Some people will raise or lower this number to get the fuel delivery in line using the BLM fuel trim number. This is acceptable as long as you don't vary this number too far. When you measure an injector, you can have errors due to evaporation, spills, gasoline film left in the measuring flask, etc. Since the BPW is based on this measurement, there is more than likely some error in the exact number, so changing it a little doesn't hurt. As you will see later, any changes to the BPW constant can be offset in the VE tables. If you don't have a way to measure the flow rate of your injectors, take the stock flow rate listed in my site, correct the flow rate for your fuel pressure, and use that flow rate in this equation and you will be close enough. The only reason you might be off is if your injectors are dirty or defective and don't flow at their rating.

EGR On / Off (%TPS)

These are EGR qualifiers that turn EGR on above a programmed TPS % and off below another TPS %.

EGR On / Off (Speed)

These are EGR qualifiers that turn EGR on above a programmed MPH and off below another MPH. I use these parameters to disable EGR on my calibrations. If you set the EGR on speed at 255 MPH and the EGR off speed at 254 MPH, EGR will never be enabled because you can't reach these speeds. Setting the parameters at an unrealistically high (or low) value is a common way of disabling a feature.

Low MAP EGR On / Off

Again, these are EGR qualifiers that turn EGR on above a programmed MAP and off below another MAP. All the qualifiers have to be met for EGR to be enabled and there are others that are not even shown in Tunercat's $42 TDF file. I have added the EGR enable temp to my $42 TDF file myself with Tunercat's TDF Editor software.

Minimum/Maximum MAP for BLM

These qualifiers determine the range that the BLM function is allowed to operate between. I have not seen a calibration that reduced the MAP range from 10 to 100 MAP.

Maximum RPM for BLM

This parameter prevents BLM operation above the programmed value. Typically, this value is 3000-3500 RPM.

Speed To Enable Open Loop Idle

Describing the purpose of this parameter is going to be difficult. I will have to go into detail about all the different open loop situations. The way I see it, there are 3 different ways you can be in open loop. There is normal open loop, abnormal open loop, and forced open loop. Normal open loop is when the ECM is in open loop because one of the normal qualifiers to enter closed loop has not been satisifed. It could be that the O2 sensor is not hot enough or that the coolant is still too cold to enter closed loop. This is considered normal operation. Abnormal open loop is when all the closed loop qualifiers should have been met, but something is keeping the ECM in open loop. This could be a broken O2 sensor wire, or a defective coolant sensor, or any number of faults that will prevent the ECM from entering closed loop mode. Technically, normal and abnormal open loop are the same thing, but usually an error code will set if you remain in abnormal open loop. Forced open loop is when a special programming feature of the ECM is used to force the ECM out of closed loop and into open loop as a normal part of system operation. Open loop idle is one of those features. Power Enrichment (PE) mode and Hi-way modes are two others.

Open loop idle is a feature that allows the ECM to leave closed loop mode when the engine is idling. Typically, the AFR is programmed richer than 14.7 in open loop idle mode to help the engine have a more stable idle. I have found that engines with significantly non-stock cams will idle better with an AFR around 13.5. The ECM will go into open loop idle mode when certain criteria are met, one of those being the speed is less than this programmed value. 2-4 MPH is a good value for this parameter.

%TPS to Enable Open Loop Idle Mode

This is another open loop idle mode qualifying parameter. The TPS has to be less than this amount (i.e. foot off the gas) before the ECM will engage open loop idle mode.

Maximum AFR At Open Loop Idle

This is the AFR that the ECM uses when in open loop idle mode. It is an upper limit to the AFR that the ECM will use in open loop idle mode. I suppose the AFR could be less than this, but I don't know of any conditions that would allow this to happen, as you will see later. I typically use values of 13.5 to 12.5 here. You have to experiment with your engine to determine the best value. However, don't forget that the VE tables (or the BLM has had time to adjust) must be accurate or this AFR value will have no meaning.

Lean Idle AFR at Open Loop

This parameter's name is misleading and Tunercat's explanation in their help file is also questionable about this parameter. By my own experimenting, I have found that this parameter is the lean AFR limit when the ECM is in normal open loop mode, but idling. This is not the same as the forced open loop idle mode above and has nothing to do with it. As you will read later, the AFR can be much leaner than 14.7 (as lean as 17 AFR) in normal open loop mode. But the engine will have a hard time idling at 17 AFR, so when the engine is idling in normal open loop, this value caps the AFR, so it is a lean AFR limit. This is completely different than the AFR in open loop idle mode. Open loop idle mode is forced, whereas open loop idling is just idling, but in open loop. The criteria that determine idling in open loop are not the same as the ones that force open loop idle mode. They are adjustable, but are not a part of the standard $42 TDF file.

Maximum AFR In Open Loop (Non-idle)

As the name states, this parameter is an upper limit on the AFR when the ECM is in normal open loop mode, but not idling. This value can be as high as 20 AFR without any problems, which is where I program mine. I am not really sure why this parameter is even needed, but GM put it in there.

Warm Closed Loop Delay Timer

This value is the amount of time that the ECM waits before entering closed loop mode after cranking, but with a warm engine. How warm? Thats another value in the calibration that's not in the $42 TDF.

Cold Closed Loop Timer

Same as above, but for a cold engine.

Minimum Coolant Temp for Closed Loop Fuel

This value is the lowest temperature that the ECM will attempt to enter closed loop mode. This and other qualifiers must be met before the ECM will enter closed loop. I set this value to 150 Deg C. often to keep the ECM in normal open loop mode. If my VE tables are adjusted correctly, I can get better mileage this way, as you will read later.

Open Loop Idle AFR Enable RPM Threshold

This is the engine RPM below which the ECM will enter open loop idle mode, provided the other qualifiers have also been met, such as the speed and %TPS parameters. I typically set this value at 900 RPM when I want to use open loop idle mode.

Open Loop Idle AFR Disable RPM Threshold

This is the engine RPM above which the ECM will leave open loop idle mode and re-enter closed loop mode. By having a separate disable value, the ECM is prevented from rapidly going in and out of open loop idle mode. I typically set this value at 1100 RPM when I set up open loop idle mode.

Open Loop Idle AFR Enable Delay

This is the amount of time in seconds that all Open Loop Idle qualifiers must be satisfied before the ECM will attempt to enter open loop idle mode. Once this time has been reached, another timer is started before the ECM will go into open loop idle mode. The factory setting for this value is about 8 seconds.

Open Loop Idle AFR Time Delay

This is a timer that starts once the Open Loop Idle mode Enable delay has completed. The factory setting for this value is about 5 seconds. The ECM will enter open loop idle mode when this timer times out.

TCC Lock Speeds

These parameters determine when the lock up torque convertor in a GM 700R4 transmission locks up, with different values used depending on whether the transmission is in high gear or the lower gears. The earlier GM ECMs did not control any other function of the transmission. I will not address these values since most of my projects do not involve a GM transmission.

IAC (Idle Air Control motor) Park Position

This is the number of IAC counts (steps) that the IAC motor moves when the engine is shut off. The IAC counts are an indication of the IAC motor's position. Zero IAC counts means the IAC is completely closed, whereas 256 counts means the IAC is wide open.

IAC Park or Neutral Offset

This is the relative number of IAC counts that the IAC motor will move when the transmission is shifted from Park to Drive or vice versa. For ex., say this parameter is 25 counts. If the engine is idling at 600 RPM in park, and the IAC counts are 30, the IAC counts will imediately jump to 55 counts when the transmission is shifted to drive. The purpose of this parameter is to prevent the engine idle speed from suddenly dropping or rising when shifting in and out of gear. I have found a good value to use on my AMC 360 chips is 25 counts.

Idle RPM Adder A/C On

This value is the amount of engine RPM added to the idle speed when the air conditioner is switched on. This allows the A/C to cool better.

Maximum/Minimum BLM/INT Values

These are the maximum and minimum BLM values and INTEGRATOR values that the ECM uses when in closed loop to maintain a 14.7 AFR. Narrowing the range covered by these values will hinder the ability of the ECM to control the AFR when in closed loop. I rarely change these values.

PROM ID

This is a code used by GM to identify the exact calibration in this particular file. Some tuners use it to keep track of the changes they have made to their calibrations. This value has no effect on the system tune.

This concludes the discussion of the constants in the Tunercat $42 TDF. Keep in mind that there are many more constants in the $42 calibration that Tunercat elected not to include. I have Tunercat's TDF editor program so I added some more constants to my $42 TDF that I considered important. For those using WINBIN instead of Tunercat, a registered member sent me one of the most complete $42 ECU files that I have ever seen. Email me if you want a copy.

TABLES

Tables can be either 2 dimensional or 3 dimensional. 2D tables have a parameter that varies as one other item varies. For ex., the target idle RPM vs. Coolant Temperature is a 2D table, whereas the Main Spark Advance vs. RPM vs. MAP is a 3D table since the spark advance varies as two other items change. The tables in Tunercat's $42 TDF are as follows:

Main Spark Table

This 3D table displays the spark timing from TDC in degrees at the crankshaft. Next to the main VE table, this table is the most important for optimizing your GM EFI system. Looking at the Tunercat display screen, you have MAP (in Kpa) increasing across the top and RPM increasing along the left side. This means that spark timing is dependent on both RPM and engine vacuum (MAP is the opposite of vacuum, but both indicate engine load; 100 MAP is zero vacuum). Now, from the carburetor days, we know that the spark advance increased as engine RPM increased. So to isolate the RPM only effect, look at the right most column and you will see the 100 MAP column. This column is the spark advance when the throttle is to the floor, or WOT. It changes only as the RPM climbs. So you can derive the RPM only contribution from this column. But remember that the entire table shows spark advance relative to zero BTDC. So the lowest value here is probably the distributor timing setting. For ex. in my spark table of my AMC 360 chip, the lowest value is 10 degrees, which corresponds to the distributor setting on a stock AMC 360. So to get the RPM only curve, subtract the lowest value from all the other values in the 100 MAP column, and this is your RPM only contribution to spark timing. Now, look on the 400-600 RPM row of the table. The RPM stays constant as you move along this row from 30 all the way to 100 MAP. This row is the vacuum only contribution to the spark table, but again, the static distributor timing setting must be subtracted from all values to get the vacuum only contribution. What does this mean when retrofitting GM EFI to any other engine? Well, if you have the RPM advance curve and vacuum advance curve from the distributor in your carbureted engine, you can transfer those curves to the chip. I wrote an Excel spreadsheet that does this. If you know the RPM advance curve and the vacuum advance curve, and the distributor setting, you put that info in the spreadsheet and it will calculate the spark timing at each location in the table. Then all you do is cut and paste from Excel into Tunercat and you have your spark table. (WARNING - Most centrifugal and vacuum advance factory spark curves are setup for EGR operation at all part throttle conditions; you must subtract out 3-6 degrees from the factory curves at part throttle before plugging the numbers into my Excel spreadsheet; The sheet is only for the non-EGR main timing table; EGR timing is applied in another table in the EPROM) Keep in mind that this is to be considered as a starting point for your spark table and that more than likely, tweaking it here and there can gain you some power or efficiency. If you want a copy of my spark table spreadsheet, just Email me. I will discuss some spark table tweaking tips later in this section.

Coolant Compensation Spark Table

This table is an adjustment to the main spark table based on coolant temperature. Typically, the timing is advanced considerably when the engine is cold for more power and retarded when the engine is very hot to reduce detonation under load. I experimented with the CTOs of my Jeep AMC 360 engine and figured out the temperatures at which the CTOs and the non-linear valve effected the spark timing. I then used this table to perform the same functions as these emissions devices on an AMC 360 engine. For an understanding of what the CTOs do, read my "Understanding Emissions Controls And How To Reconnect Them" link on my home page. For better understanding of what this table does, use Tunercat and study some factory EPROM files from the www.diy-efi.org site. The most important comment about this table is that the MAP values are vacuum, and they stop at 40 MAP vacuum (60 MAP absolute). But the timing corrections in the 40 MAP vacuum column apply to all vacuum values less than 40, which means that all absolute MAP less than 60 has the 40 MAP vacuum column corrections applied.

Power Enrichment Spark Table

This table contains spark advance that is added to the main table values when the ECM is in Power Enrichment (PE) mode. This allows the main table to be conservative while the PE table adds aggressive timing. However, from what I have heard, the PE table will not be activated unless the knock sensor system passes its diagnostic test, and since most of my EFI kits do not have a knock sensor, I don't use the PE table. I just zero it out. You can compensate in the main table by just raising the 90-100 Kpa MAP timing.

Hiway Mode Spark Advance vs. Vacuum

This table contains spark advance that is added to the main table values when the ECM is in Hiway mode. The purpose of this added timing is to make the engine more efficient when running at lean AFR values. Lean mixtures burn slower and this allows the timing to be advanced slightly to get a little more efficiency. I do not know of any factory calibrations that enabled hiway mode. The values I have seen in hiway mode tables in other ECMs are at most 2-3 degrees advance. As I have explained before, hiway mode is an advanced topic that I would rather not elaborate on in this manual. Once you have enough experience to be able to retune your ECM adequately in all other modes, then you will have enough knowledge to figure out hiway mode for yourself. IOW, don't melt your engine unless you are sure you want to.

Max. Knock Retard vs. RPM (in PE)

This table contains spark timing that is subtracted from the main table values when the ECM is in PE mode and knock is detected. The table is the maximum amount of timing that will be pulled out when the ECM gets a signal that knock is present. This does not mean that the maximum will always be pulled out. Knock retard is accumulated over time. The longer the ECM gets a signal that knock is present, the timing will be reduced by a certain rate. This rate is programmable in degrees per millisecond, but is not part of the Tunercat TDF. However, this table limits the amount of timing that will be pulled out. Once the knock signal goes away, the ECM will put timing back in at another prescribed rate until the engine either begins to knock again, or you let off the gas and reduce the load. As a tuning issue, it is much better not to ever have knock, because once knock starts, it takes a disproportionate amount of knock retard to get rid of it, and pulling timing kills power. So most tuners start conservative on the low side, and gradually increase timing until knock is detected, then they take out 1-2 degrees at a time until the knock no longer occurs. This is far better than leaving the timing over advanced in the chip and letting the knock sensor get rid of the knock. Keep in mind that lean mixtures can promote knock even when the timing is OK, so if you have knock, increase the fueling a little at that load condition first to see if the knock goes away. I once had WOT knock with my PE fuel table set for 13 AFR everywhere. I lowered the PE fuel table to 12.5 and the knock went away and the engine had more power. 13 AFR was pushing it too close, esp. with a chip that wasn't fine tuned on a dyno.

Max. Knock Retard vs. MAP

This table contains the maximum spark timing that is subtracted from the main table values when the ECM is not in PE mode and knock is detected. The table is based on MAP (engine load) instead of RPM. All comments from the PE Mode Knock Retard table above apply here as well.

Main Fuel Table #1 (% Volumetric Efficiency)

(The first thing I should mention is that the Main Fuel Table #2 below is added to table #1 to arrive at the total VE value, so you must include table #2 when making changes to table #1). The VE table contains values ranging from 0 to 100% that correct the air estimation equation for the engine's air pumping efficiency. This is the second most important fuel adjustment function in any speed density calibration, with the base pulse width constant being the first. This table, when adjusted properly, corrects the ingested air calculation so that the target AFR is achieved with no closed loop fueling correction. For ex., if the ECM is programmed to maintain a 14.7 AFR at all load conditions, you will get a 14.7 AFR going into the engine if this table is correct at all load conditions. Due to emissions control reasons, the majority of the time the ECM is trying to maintain a 14.7 AFR, and if this table is adjusted correctly, there will be no need for closed loop corrections. However, since engines wear causing compression changes and valves to gradually lose lift, the VE table programmed at the factory gradually gets out of tune. This is where the closed loop logic kicks in and the BLM function corrects the operating VE to achieve the target AFR when the calibrated VE table is no longer accurate. Don't think of this table as fuel efficiency or a fuel table because it is not. This table is the efficiency of the engine to suck in air, and to maintain a given AFR, a higher VE value means the engine needs more air to mix with the fuel at that load condition. So for tuning purposes, what this table really does is increase the amount of fuel needed to maintain a 14.7 AFR at a given load when the ECM is in closed loop, but the BLM function is not making any corrections. To tune this table, you try to reduce or eliminate any closed loop correction. From another link in my site you should understand by now how the BLM corrects the VE table to maintain a 14.7 AFR in closed loop. What you do is drive the vehicle in closed loop and record the BLM values at different load conditions. If you have Tunercat, open a $42 file and look at VE table #1. Note that the axes of RPM and MAP intersect at convenient values, say for ex. 1200 RPM and 50 MAP. This intersection represents a load condition that might for ex. have a BLM value of 135 associated with it. This means the closed loop logic is adding (135/128= 1.05) 5% to the air quantity calculation to maintain a 14.7 AFR. This means VE table #1(summed with table #2) is deficient by 5% at 1200 RPM and 50 MAP. WINALDL will record an average BLM at this load point if you happen to drive at this load condition for very long. The longer you drive at this condition, the better the average will be since it will have more samples to include in the average. There are two averages that WINALDL will save, narrow average and wide average. Narrow is better for tuning because only BLM values associated with a narrow band around the load intersection point is considered in the average. Wide average uses any BLM value associated with a range halfway between the adjacent load intersections. It's ok to use wide average when tuning, but the accuracy of the BLM will not be as good as the narrow average BLM. Once you have decided which BLM average value to use at a given load condition, divide the avg. BLM by 128 and multiply the VE value at that load condition by the result. The equation is (new VE table entry = old VE table entry x BLM avg./128). Repeat this equation for each load condition that you have an avg. BLM for. Lets run thru an example. Lets say at 2000 RPM and 60 MAP, you have a narrow BLM of 135, but there is only one sample. You also have a wide BLM avg. of 134 with 15 samples. I would use the wide average since there are not enough samples in the narrow average for it to have much accuracy. Now lets say the VE value (sum of table #1 and #2) at 2000 RPM and 60 MAP is 85%. So the correction at this load condition is 134/128 X 85% = 89%. So you would replace the 85% VE entry with 89% in that load condition only. You would then move on to another intersection of RPM and MAP and run through the same procedure of choosing an average BLM and correcting the VE table at that load condition. Now, obviously, to make as many VE table corrections as possible at each chip tuning session, you need to drive in a way that populates the entire BLM tab in WINALDL so that you will have an average BLM value for every intersection of the RPM and MAP axes. This is impossible to do since it is very hard to populate the extreme edges of the BLM tab table. As long as you populate as much of the BLM tab as you can, it will suffice. If you set WINALDL up to display the BLM tab on narrow average, you can see where the engine is running based on the green cursor on the computer screen. If there are any blank spaces, slow down until the engine RPM is about 100 RPM less than the RPM of the blank space you want to fill. Then feather the gas to make the green cursor jump into the blank space. Its easier to manipulate the MAP than it is the RPM. By slowing down and then speeding up to come into the blank space from the low RPM side, you can make the MAP vary widely with small changes in throttle application. Since the engine has a lot of intertia to overcome, you can't make the RPM change drastically without a lot of throttle input, which would send the MAP to 100 MAP instantly. One final thing to mention is that the VE table values should change smoothly from one load condition to the next. Drastic jumps in the VE table usually mean something is wrong. I have found the usual problem is that a customer has not disabled the EGR valve operation, and this really messes up the closed loop tuning process. The BLM function tries to correct for a rich mixture caused by the EGR valve reducing the oxygen pulled into the engine. You will end up with a VE table way off at part throttle. To properly tune the VE table, you should disconnect the EGR valve in the engine bay, and you should disable the EGR logic in the ECM EPROM.

Main Fuel Table #2 (% Volumetric Efficiency Adder)

The Main Fuel Table #2 VE values are added to the Table #1 values to arrive at the total engine VE. It's not clear to me why GM split the VE table into two tables, but my theory is that it improves the resolution of the table allowing finer adjustments. The gist of this table is that it must be added to the main fuel table #1 before you make any percent corrections. In other words, the equation really should be (new VE table #1 entry + table #2 entry) = (old VE #1 table entry + table #2 entry) x BLM avg./128. BTW, it's incorrect to name these tables Main Fuel Tables, but that's what Tunercat calls them and I didn't want to confuse things more than necessary.

%TPS Threshold Vs. RPM for PE Mode

This table determines when the ECM enters PE mode based on throttle position. When the throttle is opened above the values in this table, the ECM will leave closed loop mode and use a different target AFR to increase power output. Exactly how to adjust this table is not clear, but I believe it has a lot to do with the size of the throttle body. If you install a much larger throttle body than the engine really needs, the engine will get all the air it can pull in at much smaller throttle openings. So you should lower the %TPS to bring on PE mode when you change to a larger throttle body. On the other hand, if you install a much larger engine keeping the throttle body size the same, you should raise the %TPS so that the engine doesn't enter PE mode all the time.

Power Enrichment Air Fuel Ratio vs. RPM

Remember when I said the ECM is in closed loop most of the time and tries to maintain a 14.7 AFR? When the %TPS for PE mode table value is exceeded, the ECM uses the values in this table as the target AFR, however, the actual AFR may or may not match the target AFR. Since a standard O2 sensor can only detect a 14.7 AFR, the ECM can't use the O2 sensor to check the AFR in PE mode, so it just assumes the BLM has done its job and the target AFR is being maintained in open loop. For most stock engines, this table should have values between 12.5 to 13 AFR. Performance engines can range from 10 to 13. This table and the 90-100 Kpa MAP columns (non-turbo) of the Main VE table and the Main Spark table are where hotrodders spend all of their tuning time on a dyno. I will explain how to tune on a dyno in a later advanced tuning section.

Accel. Enrichment vs. Differential TPS

This table is similar to the pump shot of a carburetor. When the throttle is pressed quickly, the % change in the TPS causes extra fuel delivery above what would normally be called for to cover the sudden power demand. I normally leave this table alone if my factory binary file closely matches the engine size that I am tuning. If you do adjust this table, get everything else done first. You don't want to cover problems with the tune elsewhere with this table since it would just be a band aid fix. If you do change it, change it by factors of 2. Either double all the numbers or halve them with each change.

Accel. Enrichment vs. Differential MAP

This table has no similar function in a carburetor that I know of. It adds extra fuel when there is a sudden change in MAP signal. But to me, it would seem improbable that the MAP could suddenly change without the TPS changing drastically also. So I don't know exactly when this table would be applicable all by itself. Again, as long as my starting factory binary closely matches my application, I never change it.

Open Loop AFR vs. Coolant Temp

This table determines the target AFR when not in closed loop, whether as a normal condition or abnormal condition. But in order for this discussion to make sense, I have to include the Open Loop vs. MAP table in this paragraph. The Open Loop AFR vs. Coolant Temp table changes only with coolant temp and generally max's out at 13.0 AFR when the engine is fully warm. But at cruising loads and idling, you don't need as much fuel as you would at full power. So the Open Loop AFR vs. MAP table modifies the Open Loop AFR vs. Coolant Temp table to lean out the AFR when the MAP decreases. For ex. look at just about any factory $42 calibration and notice that the AFR at 92 degrees C is about 13.0. This is the AFR at 100 MAP. But as the MAP decreases, the Open Loop AFR vs. MAP table adds up to 4 AFR points to this 13.0 AFR. So your total AFR at 20 MAP on some calibrations is 17.0 AFR. This is very lean and will barely run on most engines. If you look at the ASDU factory binary for a 5.7L engine, the Open Loop AFR vs. MAP table shows a 3.2 AFR at 40 MAP and 3.0 AFR at 50 MAP. Since 40 to 50 MAP is the MAP at hiway cruise speeds, the total AFR is 16.2 to 16.0 AFR on the hiway. Well, guess what. This means your gas mileage will actually be better by (16.2/14.7=1.102) 10% in open loop than it would be in closed loop where you would be running with a 14.7 AFR. This probably goes against what you've been told about running in open loop. As long as the VE table and/or the BLM function has done its thing, you will get better mileage in open loop. So get on the hiway, drive for a while in closed loop, and then throw a switch disconnecting your O2 sensor. This will get you 10% better mileage. This is exactly what hiway mode does, but instead of disconnecting the O2 sensor, hiway mode re-enters closed loop mode every 300 seconds to recheck the AFR and adjust the BLM to make sure the AFR is still under control. Of course your emissions will go up and it is against the law, but it won't hurt the engine. Running leaner than 16.0 doesn't do much good though. There is a chart in the WINALDL site that shows the fuel economy vs. AFR. Above 15.4 there are diminishing returns.

Having said all this, running in open loop on an untested and untuned system could be dangerous to your engine. Remember that outside of closed loop, any programmed AFR is a target AFR, and it may or may not be achieved. If the VE table is not accurately tuned and the BLM function hasn't had time to correct for these inaccuracies, the open loop AFR could be way off, and instead of running at a cruise AFR of 16.2, you could be up in the 17 and higher AFR range if the tune is initially lean. This could possibly damage your engine. I hope by now you can understand the importance of tuning the Base Pulse Width Constant and VE tables first in closed loop before making any other adjustments to fuel tuning. Only in closed loop when the O2 sensor can verify the target AFR will you really know the actual AFR entering the engine. And since all other target AFR values are dependent on closed loop tuning, it only makes sense to do that first.

Air Fuel Ratio at Startup vs. Coolant Temp (choke)

One of the main benefits of EFI is improved cold weather drivability. This table is responsible for that. This table is subtracted from the sum of the open loop AFR vs. coolant and MAP tables. At any given temperature, the value in this table is subtracted from the other open loop tables to make the target AFR richer when cold. However, as time progresses after an engine start, the values in this table are gradually lowered until they completely disappear by the time the engine is warm. I will explain how in the next paragraph. For now, I find that most retrofitted engines need this table increased by 1 to 2 AFR points across the board. By increasing this table, the cold engine AFR is made lower (richer). This table is similar to how tight you have a choke adjusted on a carb.

Open Loop AFR vs. MAP

I discussed this table's function above so I will skip to the next one.

Choke AFR Multiplier vs. Coolant Temp

This table determines how fast the AFR startup vs. coolant temp table times out and is similar to a choke heat pull-off on a carb. There is a time interval at which the AFR startup value above is calculated. It is programmable, but I leave it at the 2 second stock value. Every 2 seconds, the startup AFR is reduced by the value in this table. For ex., if the value here is 95%, the next 2 second interval, the startup AFR correction will be 95% of what it was before, and the next interval it will be 95% of 95%. So each calculation interval, it is reduced by 95% of its previous value. In time, it is reduced to zero. Obviously, the higher the value in this table, the longer the startup AFR will be applied. Unless you have problems keeping the engine running after it is lukewarm, I wouldn't adjust this table. But if you lower this table, you might save gas by having the choke "pulloff" operate sooner.

Crank AFR vs. Coolant Temp

This table is not a modifier of other tables but a standalone table. The AFR values in this table are what the ECM uses during cranking. Cranking is when there is 12 volts on pin C9. Immediately after cranking, the ECM switches to the other open loop tables. I don't use this table on my systems unless hooking it up is easy, like on Jeeps. But even on those, I end up having customers disconnect them. The engine tends to flood out using this table i.e. having a wire hooked up on pin C9. More in depth hacking is needed to refine the purpose of this table. In my experience, leaving it disconnected has caused no problems, but I am in a mild climate.

IAC Steps vs. Coolant Temp

This table determines the IAC counts when the engine is cold and warming up. The IAC motor is driven to these values when the engine is just started and the IAC drops as the engine warms. But at a certain coolant temp and time lapse, the IAC counts are no longer used and the ECM goes into closed loop idle control (don't confuse this with closed loop fuel control) where it tries to maintain the idle speed at a certain RPM. The RPM in closed loop idle speed control is found in the next table. As for this table, raise it if the engine tends to die at idle when cold, or if you want a higher cold fast idle speed.

Target Idle RPM vs. Coolant Temp

This table is used to set the idle RPM after the ECM has timed out from a start condition and the coolant temp is above a certain threshold. It's the same as your curb idle speed adjustment on a carb, with the exception that the ECM can

maintain the idle RPM even if devices load the engine. On most stock automatic engines, 600 RPM is good for most of this table. On engines with mild to wild cams, you will want to raise the values in this table to get a smoother idle.
The rest of the tables deal with either EGR or transmission torque converter lockup speeds. I will cover these tables in future updates since they are minor issues in retrofits. This completes the software section of the $42 ECM calibration template. It's not that difficult to apply the principles discussed herein to other more complicated ECMs.

APPENDIX A – WHY GM EFI NEEDS REPROGRAMMING

This document describes how GM Fuel Injection manages fuel and spark in gasoline engines from a novice's point of view. There are three basic functions of GM fuel injection; fuel management, spark control, and transmission control. I will discuss fuel management first since that is the most important.

FUEL MANAGEMENT

EFI systems have different operating modes depending on the power output needed from the engine and operating conditions. The modes are open loop, closed loop, power enrichment and lean cruise modes. I will describe closed loop first since it is the predominant operating mode.

Closed loop mode means the engine control module (ECM) measures the A/F (air/fuel) ratio and uses this information to maintain the A/F ratio at a certain constant value. This mode uses feedback from an (oxygen) O2 sensor to close the loop. The A/F that the system tries to maintain is 14.7 to 1. The reason is that a 14.7 A/F ratio allows a catalytic converter to reduce exhaust emissions most efficiently. Engines don't necessarily run the best at 14.7 at all times, but they produce the least emissions with a catalytic converter at this ratio. Also, it just so happens that the standard O2 sensor is most accurate at 14.7 A/F ratio, which gives a good feedback signal.
The bottom line is that the ECM control logic tries to maintain a 14.7 A/F ratio during normal conditions. Normal conditions are a fully warmed engine and other than full throttle. Because of closed loop, engines can run for thousands of miles and the EFI system will compensate as the engine wears to keep fuel delivery consistent.

Open loop mode differs from closed loop in that the O2 sensor is ignored and the engine can be managed to run at A/F ratios other than 14.7, usually richer or lower than 14.7. The ECM controls the fuel injectors without getting any feedback that the calculated fuel delivery rate actually matches what the engine received. Without feedback, the loop is open, hence the term "open loop". A good example of open loop is when the engine is first started on a cold day. It requires a rich mixture to start a cold engine since a lot of the fuel doesn't reach the combustion chamber. This is because a portion of the gasoline doesn't vaporize and pools inside the manifold until engine heat vaporizes the fuel. Another reason that engines run in open loop when cold is that O2 sensors don't work until they reach about 600° F, so it takes a few minutes in cold weather for them to begin functioning. Open loop is sometimes used at idle conditions since some engines idle better with a rich mixture. In open loop, the ECM commands an A/F ratio that is determined from a table of A/F vs. engine coolant temperature. The open loop A/F is also adjusted to run richer as engine load increases.

Another mode is **power enrichment mode**. This mode only occurs under wide open throttle conditions and is solely determined by the throttle position sensor (i.e. above say 60% throttle opening.) In this mode, the ECM ignores the O2 sensor and commands a richer than 14.7 A/F ratio. This is because engines develop more power with a slightly richer mixture but not too rich. This is the area of tuning that interests hot rodders the most since PE mode is where the fuel delivery for all out power is determined.

Finally there is **lean cruise mode**. In this mode the ECM commands a leaner than 14.7 A/F ratio or less fuel. This mode can only used be used at light loads when the vehicle speed is above a certain value, in other words, hiway cruise. In this mode, the ECM commands the leaner A/F ratio, increases spark advance, and occasionally returns to closed loop mode to double check itself. There is one problem with this mode. GM ultimately did not enable this mode since it allowed them to circumvent the emissions laws to achieve better gas mileage. This mode is only used by GM EFI tuning experts with enough knowledge to make it work without damaging their engine. If the engine is run too lean, spark plugs, valves, and pistons can be damaged. However, when done correctly, up to 10% in mileage gains are possible above the already excellent mileage from closed loop mode.

In summary, GM EFI controls fuel to maintain a 14.7 A/F ratio at all times under normal conditions. During other than normal conditions, open loop mode is used so that A/F ratios other than 14.7 can be commanded.

How to Tune a GM EFI System

From this point on, this document will go into greater detail about how the ECM implements the different modes and how the system can be retuned to control modified engines.

The best way to organize the rest of this document is to explain each term in the fuel delivery calculation individually. The pulse width of an injector determines the amount of fuel delivered to the engine. A pulse width is the amount of time an injector is turned on over a fixed time interval. If the injector is turned on longer, more fuel is injected. If the injector is turned off sooner, less fuel is injected. The equation that determines the injector pulse width is this:

BPW = BPC * MAP * T * A/F * VE * BVC * BLM * DFCO * DE * CLT * TBM

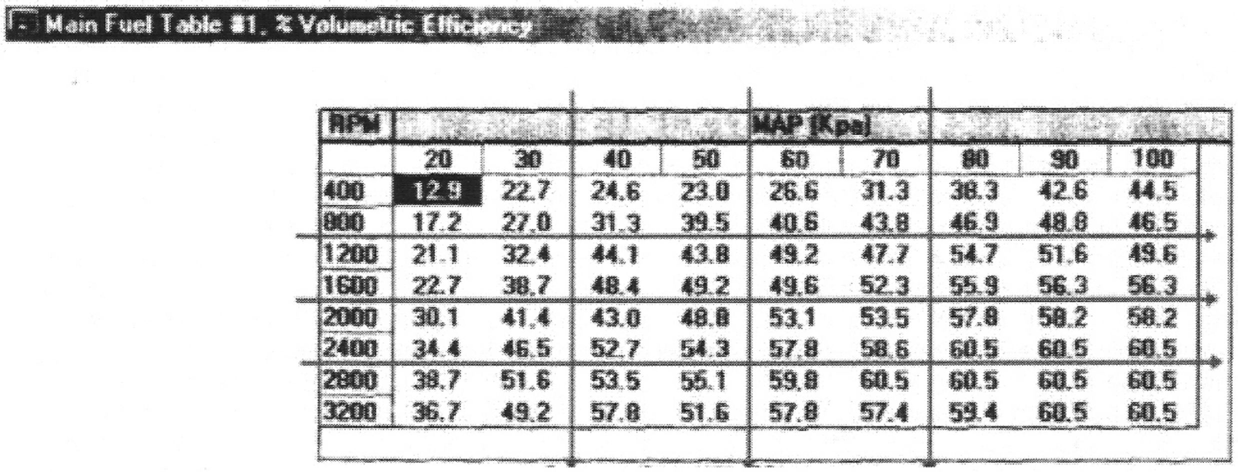
Where

BPW - Base Pulse Width
BPC - Base Pulse Constant
MAP - Manifold Absolute Pressure
T - Temperature
A/F - Air Fuel Ratio
VE - Volumetric Efficiency
BVC - Battery Voltage Correction
BLM - Block Learn
DFCO - Decel Fuel Cutoff
DE - Decel Enleanment
CLT - Closed Loop
TBM - Turbo Boost Multiplier

In the above equation, any term that has a value of 1 is essentially not contributing to fuel delivery or neutral. It is not taking away or adding to the fuel quantity.

BPW - Base Pulse Width means the pulse width under steady state engine conditions. Extra fuel is added when the throttle is juiced for acceleration. This is called asynchronous mode and will be discussed later. The above equation only consists of the synchronous mode contribution.
BPC - Base Pulse Constant is a term that is calculated from the volume of one cylinder, the flow rate of one injector, and a constant that converts the units to match other terms in the equation. For more on this term, see www.tunercat.com and the 1227747 ECM calibration help file.
MAP – Manifold Absolute Pressure is a measure of the load on the engine. It is the pressure inside the intake manifold in KiloPascals above absolute zero pressure. It is the opposite of engine vacuum meaning that a high vacuum reading is a low MAP value. Zero vacuum (full throttle) is 100 Kpa MAP. Although I don't fully understand the inclusion of this term in the equation, it is used extensively in all areas of engine control.
T – Temperature is actually the inverse of the absolute temperature. Once again, I don't fully understand the inclusion of this term in the equation, but as you will see later, I don't need to for the purpose of this document. It probably adjusts for the density of the air in calculating the fuel delivery.
A/F – Air Fuel Ratio is a term that I do understand. In closed loop mode, this term remains 1 and does not contribute to the equation. In open loop mode, this term takes on different values depending on coolant temperature, MAP, cranking status, clear flood condition, throttle position sensor, etc. When this term is other than 1, the closed loop term is held to 1 so that the two terms will not be fighting one another. This term is also where PE mode is implemented. In other words, this term is the controlling term when other than a 14.7 A/F is desired.
VE – Volumetric Efficiency is a term that corrects for different engine efficiencies. An engine is basically an air pump and the better the pump, the more power it can generate. Some engines are better pumps than others at a given RPM and MAP condition, so this term allows the equation to be calibrated for different engines. This is the single most important term that a speed density EFI system is famous for. There is a table in the ECM EPROM (chip) that gives VE for a given RPM and MAP condition. The important concept to grasp here is that the VE table is used in both open and closed loop modes, and essentially all modes. What is not so obvious to a novice is that this table, when programmed correctly, will result in a 14.7 A/F ratio with no closed loop or open loop correction taking place. In other words, this table provides a baseline that tells the ECM where 14.7 A/F ratio is so that other A/F ratios can be commanded and the ECM will be at the desired AFR. When this table is adjusted correctly, the engine runs the smoothest, not because

the engine is running at 14.7 necessarily, but because all other ratios depend on this table being accurate. If this table is off, the closed loop term will correct the A/F ratio back to 14.7 to a degree. If this table is way off, the closed loop term can't compensate and the engine may not run period. A good example of when this table needs adjusting is when a hot cam is installed. A stock cam typically idles at 17 inches vacuum. But a hot cam might idle at 15 inches or less of vacuum. The VE table will be calling for more fuel at a lower vacuum reading (higher MAP), but the engine doesn't need the extra fuel because its still idling. In this case, the calibration doesn't match the engine's airflow characteristics. Unless the VE table is changed to lower the efficiency at this MAP and RPM, the engine will run very rich and probably stumble and blow black smoke. The majority of retuning a GM EFI system for non-GM and non-stock engines is done in the VE table since this is the baseline of the entire system. See Figure 12 for a sample of this table.



RPM	MAP (Kpa)								
	20	30	40	50	60	70	80	90	100
400	12.9	22.7	24.6	23.0	26.6	31.3	38.3	42.6	44.5
800	17.2	27.0	31.3	39.5	40.6	43.8	46.9	48.8	46.5
1200	21.1	32.4	44.1	43.8	49.2	47.7	54.7	51.6	49.6
1600	22.7	38.7	48.4	49.2	49.6	52.3	55.9	56.3	56.3
2000	30.1	41.4	43.0	48.8	53.1	53.5	57.8	58.2	58.2
2400	34.4	46.5	52.7	54.3	57.8	58.6	60.5	60.5	60.5
2800	38.7	51.6	53.5	55.1	59.8	60.5	60.5	60.5	60.5
3200	36.7	49.2	57.8	51.6	57.8	57.4	59.4	60.5	60.5

Figure 1

BVC – Battery Voltage Correction is a term that corrects the fuel delivery rate for different battery voltages. The injector response is enhanced at higher voltages and is a bit sluggish by comparison at lower voltages. This term is a correction to offset the change in injector response due to battery voltage fluctuations. I suppose in time the closed loop term would correct the A/F ratio anyway, but this term catches it first. I see no reason to change this table since GM set it up based on their injectors' characteristics.

Block Learn – Block Learn is a term that is related to closed loop mode, but continues its influence during all modes. To make the block learn term easier to understand I will ask you to jump to the closed loop term discussion and then come back to this section. Now that you understand the closed loop term, I'll continue. The BLOCK LEARN term can be viewed as a semi-permanent automatic adjustment of the VE tables. I say semi-permanent because if you disconnect the battery, the BLM adjustments revert back to 128 or neutral (the neutral value for a BLM value is 128). Another name for the BLOCK LEARN term is long term fuel trim. Over time, the BLM numbers will settle at a value that gives a 14.7 A/F ratio with no closed loop term correction. I say values because there are more than one BLM value, unlike the single Integrator. The BLM can be up to 32 different numbers depending on the ECM model. The Block Learn term derives its name from the way the VE table is divided into blocks for the corrections to take place. To illustrate this better, see figure 1. I have drawn a grid over the VE table. The grid in the figure is for illustration purposes only. The actual BLM boundaries are decided by the ECM and the EPROM settings. Each division of the grid is called a Block Learn cell and each cell has its own BLOCK LEARN value. Each cell is associated with certain ranges of RPM and MAP in the VE table, so the BLM value in a given cell affects all the VE values in that cell. For ex., say cell 4 has a BLM value of 140. Every VE value in cell 4 will be increased by 140/128, or about 9 percent. In an adjacent cell, the BLM might be 110, which will decrease all VE values in that cell by 110/128, or 14 percent.

Now that you know how the BLM value affects the VE table, we can explain how the BLM itself is changed. In closed loop, it is discussed how the Integrator increases or decreases as the ECM gets feedback from the O2 sensor. The BLM value tracks the Integrator but has a delay. If the Integrator increases, so does the BLM, but the BLM lags behind the Integrator. The higher the Integrator climbs above 128, the faster the BLM rises. As the BLM rises, it begins to effect the AFR because remember, the VE table is being increased. As the AFR drops (gets richer) in response to the increased VE table, the Integrator will stop rising and begin to fall. Once the Integrator returns to a value of 128, the BLM will stop moving. Not only will the BLM stop moving, it will remain at that value permanently, essentially retuning the VE table at this engine operating condition. The only thing that will send the BLM back to 128 is removing power from the ECMs memory (or retuning the VE table manually with an EPROM burner). In reality, the BLM values never stay in one spot. They constantly jump around a bit near the 14.7 AFR. The tuning implications of this are as follows. Remember that the Integrator value can't be used to determine how far away from 14.7 you are. However, the BLM value can. Since the BLM settles at a value indicating how much more fuel is needed beyond what the VE table is delivering, you can use the BLM value to adjust the VE tables manually, i.e. with an EPROM burner. If your scantool shows a BLM of 150 at 2000 RPM and 50 KPa MAP, then you know that the VE table value at 2000 RPM and 50 KPa MAP needs to be raised by (150/128) 17 percent. The problem is that the ECM doesn't tell you where the cell boundaries are through a scantool, so you need a great deal of data to discover where the VE tables are off. This is where a datalogging program such as Datamaster or WINALDL come in handy. They allow you to drive for up to 25 minutes (longer with WINALDL) and record on your laptop hard drive every sensor and internal value in the ECM up to 7 times per second. Obviously, with this much data, you need a good analysis tool like Datamaster and a statistical analysis program. I take the Datamaster file and export it into Excel so that I can use the data sort functions to group the data into useful information. Once you get the VE table close, one trick is to reprogram the BLM upper and lower limits to 128 so that the BLM feature is disabled. Then, you can use just the Integrator to do the fine tuning. You can immediately see where the AFR is rich or lean at any location in the VE table. But you have to guess at how much to add or remove from the VE table since the Integrator value is not scalable like the BLM values. You can't use just the O2 sensor voltage though. If you are not in closed loop, the ECM will be trying to control to all kinds of A/F ratios, so the O2 sensor voltage will be meaningless. Unless you know all the factors affecting the AFR that the ECM is trying to control to, you have to do your VE table tuning in closed loop. The reason is that the ECM is definitely trying to maintain a 14.7 AFR by definition in closed loop. In general, if your BLM values are all significantly low, then you probably have your BPC set too high. If your BLMs are all too high, set the BPC a little higher. If the BLMs are both above and below 128, but not too far above (135) and below (120), your VE table is probably reasonably close. If your BLMs are way above and below 128 all over the VE tables, the calibration is probably significantly off and needs to be manually corrected in the chip with an EPROM burner.

Decel Fuel Cutoff – Decel fuel cutoff means exactly that. When you take your foot off the gas pedal going downhill or decelerating quickly, the ECM will cut off the fuel entirely. The difference between this term and the next one, DECEL FUEL ENLEANMENT, is that some fuel is allowed to reach the engine during DECEL Enleanment. As to when one or the other occurs, I don't know. I do know that on my TPI system, I noticed a lunge from the engine right around 1500 RPM, so I think this is where the DECEL fuel enleanment takes over from the DECEL FUEL CUTOFF. The lunge was significant and could easily cause you to run into the something if you weren't expecting it. I also believe a speed sensor is required for these two modes to operate period. So this is another reason to have a speed sensor.

Decel Fuel Enleanment – See Decel Fuel Cutoff above.

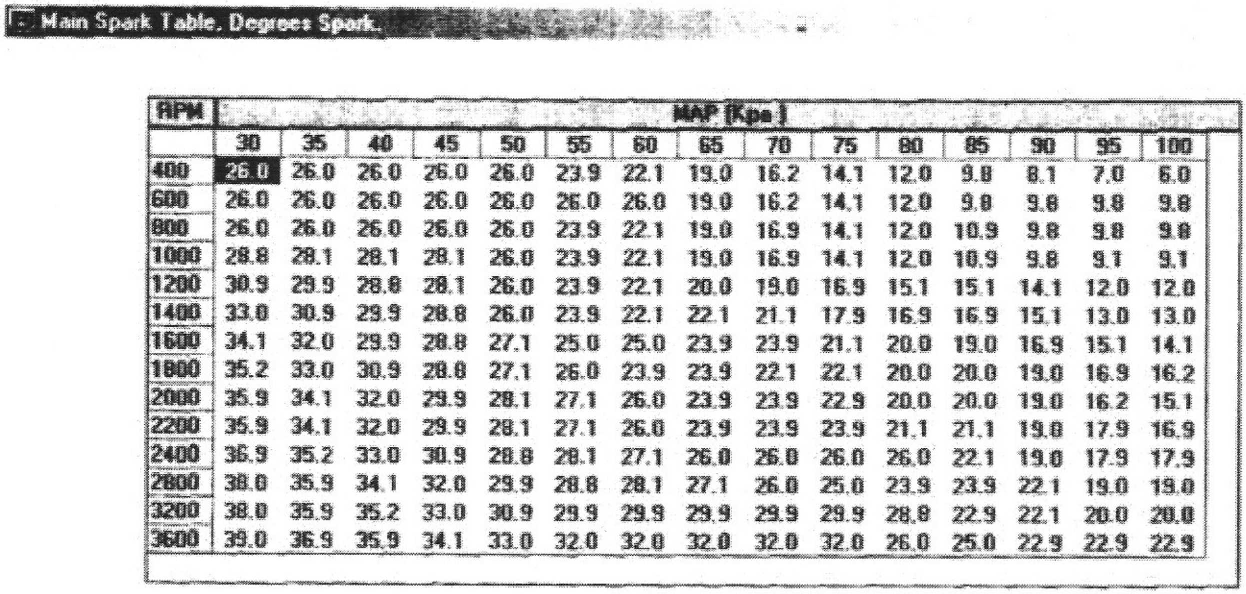
Closed Loop – Closed Loop is a term in which the ECM uses feedback from the O2 sensor to make corrections to the air fuel ratio. Another name for this term is short term fuel trim. The ECM makes immediate but temporary corrections to the fuel delivery to maintain the AFR at 14.7. The only ratio that can be maintained in closed loop is 14.7. This is due to the nature of the type oxygen sensor used on most passenger cars. There are other types of O2 sensors called wide band sensors, but they are expensive. They can be used to monitor the AFR at other than 14.7 AFR. The short term fuel trim value is called the Integrator in most early scan tools. The value of the integrator varies above and below 128 with 128 being no correction. For ex., if the Integrator is 140, the ECM is adding fuel because the O2 sensor is reading a lean mixture. If the Integrator is 115, the ECM is removing fuel because the O2 sensor is reading a rich mixture. Anytime the system is not in closed loop, the Integrator will immediately return to a value of 128 and stay there. There is only one Integrator and its value is solely dependent on the O2 sensor. When the engine is started, the ECM will keep the Integrator at 128 until the ECM determines that the O2 sensor is working correctly and that the engine temperature and time delay constraints before entering closed loop have been satisfied. Once the ECM goes into closed loop, the Integrator begins to adjust the fuel delivery to maintain a 14.7 A/F ratio, however, the Integrator term is only weighted half as much as the Block Learn term. The Integrator and BLOCK LEARN work together to re-tune the system to match any engine's charactersitics, up to a practical limit.

Turbo Boost Multiplier – This term adds extra fuel during boost conditions on turbo charged engines. Discussion of this term is beyond the scope of this document. It is recommended that you purchase Tunercat's SYTY TDF file if you want more information on this term.

Asynchronous Fuel Mode – This is not a term in the equation above but rather a temporary mode in which the injectors are commanded on longer for transient conditions. The accelerator pump shot is an asynchronous mode function in which extra milliseconds are added to the injector pulse width when the throttle postion sensor rapidly changes state. This will be illustrated later in other sections of this site.

SPARK MANAGEMENT

Unlike fuel management, spark management is an open loop only system. What you program in the chip is what the ECM uses with no automatic adjustment to improve performance or drivability. The exception to this statement is the knock sensor function of retarding timing to eliminate engine detonation, but this function does not advance the timing if the engine is running at less than optimum. The fact that spark timing is not automatically improved means that its up to you, the programmer, to optimize the spark timing tables, and herein lies the secret to tweaking more power from your vehicle. An engine operates at its best power level when the spark is timed to start combustion to give the maximum torque at that RPM and engine load. And getting spark timing this perfect requires extensive dyno testing or road testing. One fellow claims to have reprogrammed his chip 400 times to get it right on. The criteria for a good part throttle spark table is to be able to maintain a given speed and engine load (MAP) with a minimum amount of throttle input. I have found that a reasonably good spark table can be generated by duplicating the spark curves from a factory service manual for a particular non-GM engine or using the spark table from a stock GM binary file for a GM engine of similar size and specs. Beyond these methods, tuning a spark table is mostly trial and error by seeing what works the best and what doesn't. Figure 13 is the spark table I am running in my GMC 350 truck.



Main Spark Table, Degrees Spark

RPM	MAP (Kpa)														
	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
400	26.0	26.0	26.0	26.0	26.0	23.9	22.1	19.0	16.2	14.1	12.0	9.8	8.1	7.0	6.0
600	26.0	26.0	26.0	26.0	26.0	26.0	26.0	19.0	16.2	14.1	12.0	9.8	9.8	9.8	9.8
800	26.0	26.0	26.0	26.0	26.0	23.9	22.1	19.0	16.9	14.1	12.0	10.9	9.8	9.8	9.8
1000	28.8	28.1	28.1	28.1	26.0	23.9	22.1	19.0	16.9	14.1	12.0	10.9	9.8	9.1	9.1
1200	30.9	29.9	28.8	28.1	26.0	23.9	22.1	20.0	19.0	16.9	15.1	15.1	14.1	12.0	12.0
1400	33.0	30.9	29.9	28.8	26.0	23.9	22.1	22.1	21.1	17.9	16.9	16.9	15.1	13.0	13.0
1600	34.1	32.0	29.9	28.8	27.1	25.0	25.0	23.9	23.9	21.1	20.0	19.0	16.9	15.1	14.1
1800	35.2	33.0	30.9	28.8	27.1	26.0	23.9	23.9	22.1	22.1	20.0	20.0	19.0	16.9	16.2
2000	35.9	34.1	32.0	29.9	28.1	27.1	26.0	23.9	23.9	22.9	20.0	20.0	19.0	16.2	15.1
2200	35.9	34.1	32.0	29.9	28.1	27.1	26.0	23.9	23.9	23.9	21.1	21.1	19.0	17.9	16.9
2400	36.9	35.2	33.0	30.9	28.8	28.1	27.1	26.0	26.0	26.0	26.0	22.1	19.0	17.9	17.9
2800	38.0	35.9	34.1	32.0	29.9	28.8	28.1	27.1	26.0	25.0	23.9	23.9	22.1	19.0	19.0
3200	38.0	35.9	35.2	33.0	30.9	29.9	29.9	29.9	29.9	29.9	28.8	22.9	22.1	20.0	20.0
3600	39.0	36.9	35.9	34.1	33.0	32.0	32.0	32.0	32.0	32.0	26.0	25.0	22.9	22.9	22.9

Figure 2

Update:

Many have asked me why the chip needs reprogramming if the fuel tuning is self adjusting. Well, its kind of like the difference between a cheap $200 paint job and a nice shiny $2000 paint job. If the ECM has to do a lot of self-tuning, there are some situations where although the car will be drivable, it will not be smooth and steady, but hesitant and sluggish. The best way to explain why this happens is to look at Figure 1 above once more. Look at the 2000 RPM row and the 40 - 70 range of MAP. Say you have been steadily cruising along at 2000 RPM and 70 MAP (up a significant hill). Also say the BLM at this load point settled at around 118, so the VE table at 2000 RPM and 70 MAP is too rich, requiring the subtraction of 8% (118/128) less fuel. Also say earlier in the day you were cruising at 2000 RPM and 60 MAP on a flatter road. Say that at this load point the BLM settled at 138. This would mean that the VE table value at 2000 RPM and 60 MAP is too lean by 8% (138/128). If we assume that the lines I drew on the chart are the BLM cell boundaries, then we have established that within the same cell, you can have drastically different BLMs. When this happens, your engine will surge, hesitate, and in general feel like it may run out of gas at any moment. It won't, it just feels that way. The reason is this. Say you were cruising at the 2000 RPM and 70 MAP load point for quite some time resulting in the same 118 BLM. Then you quickly peaked a hill and were going down the other side at 2000 RPM at 40 MAP. Now you have jumped from one cell to a lower one. Once you get to the bottom of the hill, you start back up a flatter hill at 2000 RPM and 60 MAP. You would feel a sluggishness and reluctance to go for a few seconds until the integrator and BLM could correct the mixture. What happened is that at 2000 RPM and 60 MAP, the VE table is too lean (138 BLM), but the last time you were in this cell, your BLM was 118 and it stayed there when you left the cell. So now, you are 17% too lean because you are running a 118 BLM where it needs to be 138. This is 16% (118/138) too little fuel. The engine would feel sluggish here for a few seconds until closed loop could correct it. In a very short time of probably less than 10 seconds, the 118 BLM will rise up to 138 BLM, so once you reach a steady unchanging load, the engine will smooth out. In the situation I have just described, the calibration is marginally matched to the engine, although it will run the engine and you can live with the car. But when you adjust the VE tables such that all VE table values in the same cell yield the same BLM, the engine will run much smoother. It doesn't mean the calibration is right, but better suited for the engine. What this means is that a well tuned chip smooths out the transitions from one load point to another so that you can't tell when you've crossed into another cell. Ideally, each load point in the VE table should have had its own floating BLM value, but I imagine that the processor memory and speed were insufficient to handle this complex of a task in the early to mid 1980s when this stuff was created. So, the goal of tuning using the WINALDL program on my site is to get all the BLM values to remain at 128 throughout all the different load points on the BLM chart above.

APPENDIX B – ECMS COVERED BY THIS MANUAL

To simplify operating my business I decided to stick with a couple of ECM models rather than use whatever I could find or whatever was the cheapest. I found that the least expensive ECM usually ended up costing me a lot of time trying to figure out how to re-calibrate it correctly. But since you may already have a particular ECM I have provided this compatibility list to help you decide to either keep the ECM you have or switch to one that may be much easier to re-calibrate. Most of the early TBI ECMs had the same wiring pinout so they are interchangeable with the harness. If there were differences they were slight and could usually be taken care of by moving a few harness pins around.

One other criteria for choosing an ECM is the availability of an ALDL scanning program for a laptop. When I first learned GM ECM tuning there were very few ALDL programs available. Then in 2003 WINALDL came out and revolutionized ALDL scanning for the early C3 ECMs. WINALDL was and still is an awesome program but it only works with the early slower speed ECMs. If you check the site you'll see that I was either the first or one of the first user's to donate money to the creator of the program. It was so good for my business that I donated some more later since I wanted the author to keep improving the software and he did. I will state the ALDL scanning program needed with the below ECM lists since scanning is just as important as the ability to recalibrate. You really can't do one without the other.

EARLY V6 and V8 TBI ECMs – I will start with the early C3 TBI ECMs. C3 stands for Computer Command Control and was just a cute designation by GM of these ECMs. There is no particular importance to the designation other than all used relatively slow processors. The most popular GM ECM used in the DIY EFI arena is the 1227747 which is what the detailed software programming guide herein is based on. This ECM is found in many late 80s and early 90s trucks. All ECMs in this group are very similar to the 1227747 so you should have no problems applying the concepts from the 1227747 to other ECMs in this group. Some of them use an Intake Air Temp (IAT) sensor on pin C12. The following ECMs can be re-calibrated with a Tunercat TDF file:

1227137 – Mask ID $27 – early Astro vans
1227747 – Mask ID $42 – many late 80s trucks and vans
1228062 – Mask ID $4E – 89-90 4.3L S-10 and Blazers
16144288 – Mask ID $A0 – 91-92 4.3L Astro vans and trucks
1228063 – Mask ID $4D – 88 Camaro 5.0L only
1228746 – Mask ID $61 – 89-92 Camaro, Caprice 5.0 & 5.7L; requires IAT sensor; has rev limiter
16136965 – Mask ID $62 – 91-92 Caprice 5.0 & 5.7L ; requires IAT sensor

All of the above ECMs can be scanned for ALDL data with WINALDL. You can search for it on Google or check my website for a link.

FOUR CYLINDER TBI – While there were several 4 cylinder TBI ECMs I've focused all my attention on one model with one Mask ID. This ECM was also used in MAF based Tuned Port Injection vehicles which makes it more expensive than it otherwise would be. You'll need a 4 cylinder TBI MEMCAL instead of the V8 TPI MEMCAL. Its wiring is almost the same as the above C3 TBI ECMs with just 3 differences. I'll refer you to a factory wiring diagram for the differences.

1227165 – Mask ID $94 – 91-93 S-10 truck 2.5L TBI

This mask ID was impossible to scan until Tunerpro RT came out in 2005. Tunerpro RT can be customized to scan any pre-1995 GM ECM provided you have a copy of the ALDL datastream definition file. With that said, its still a hit or miss scan process due to the buggy nature of Tunerpro RT.

LATE P4 PCMs – The following PCMs were used in 93-95 trucks with electronically controlled transmissions, not just the lockup convertor but all transmission control such as shift points and shift hardness. I use these for 4, 6, and 8 cylinder MPFI (CPI mode) and for 6 and 8 cylinder TBI (TBI mode). These have a fast processor and therefore are more powerful and run smoother. 8 cylinder MPFI mode requires physically modifying the PCM circuit board to replace two resistors to allow the PCM to run 8 injectors. The PCM will cause 8 injectors to run in an unstable manner if the modification is not made. Since this is a hardware change I will post the instructions on my website. CPI stands for Central Port Injection. It was a hybrid between TBI and MPFI. It used two TBI injectors that injected fuel into a distribution header which then used plastic tubes to send the fuel to each individual cylinder. It was only used on 4.3L V6 Vortec engines. Since it injected fuel into separate cylinders it behaved similarly to any other batch fired MPFI system so it can be used for that type system if the calibration is placed in CPI mode with the software. It's best to start with a CPI BBC if you are using the PCM in a MPFI application. There were no V8 CPI engines so you have to use a V6 CPI BBC and re-calibrate it to run a V8 MPFI. If you are running a 4 cylinder MPFI system its best to start with a BBC from the 2.2L S-10 truck and modify it accordingly. This system was a DIS (Distributorless Ignition System) ignition so the ignition parameters will take some playing with to run a distributor based engine. Since I use these PCMs exclusively on my MPFI kits I will cover re-calibration inside this guide.

16168625 - Mask ID $0D – 93 trucks and vans 4.3, 5.0 & 5.7L TBI
16169982 – Mask ID $0D – 93-95 S-10 trucks 2.2L MPFI
16196395 – Mask ID $0D – 94-95 trucks 4.3, 5.7 & 7.4L TBI & CPI
16197427 – Mask ID $0D – 94-95 trucks 4.3, 5.7 & 7.4L TBI & CPI

All of the Mask ID $0D PCMs are best scanned with a program called Datamaster. Its available from www.ttspowersystems.com. You get 20 free uses and then you have to pay for the program. Download the $0D version only. You can also scan the $0D PCMs with Tunerpro RT if you have the time to create an ALDL definition file in Tunerpro. I prefer Datamaster since I paid for it long before Tunerpro RT came on the scene.

The above ECMs and PCMs are the only ones I use with concentration on 1227747, 16144288, and 16197427.

TUNED PORT INJECTION ECMs – I have deliberately skipped over the 1227730 and 1227727 ECMs (Mask ID $8D) used in Tuned Port Injection Camaros and Corvettes from 1990-1992. These ECMs use some non-intuitive calibration tables for many functions such as PE mode fueling and acceleration pump shot tables. You should be able to use the fundamentals of MAP ECMs to re-calibrate them but I won't cover them in this guide for the above reasons. Tunercat also has a detailed tuning guide for the Mask ID $8D on their website.

APPENDIX C – RE-CALIBRATING THE $0D MASK ID PCMS

As explained in Appendix B the 16197427 PCM (and others) running Mask ID $0D is very flexible so I use it on almost all MPFI systems as well as on high end TBI systems. The only type EFI system this PCM won't run is a 4 cylinder TBI system and I listed another high speed ECM for that application. Below I will list the most widely used calibration parameters (switches, constants, and tables) that are used in this PCM. All other parameters should be left alone provided you've started with a BBC very close to your application. Since a great many of my kits use this PCM this Appendix will become the primary source of information for re-calibrating my kits, however you should read the rest of this guide first since I will cover these parameters in a quick overview type manner. Some parameters that I mention below are not included in Tunercat's standard $0D TDF file. Using Tunercat's TDF editor program, I added extra parameters to Tunercat's TDF file as well as created a new one with extra switches, constants, and tables for setting up electric fan control and datalogging a wide band O2 sensor as well as setting up MPFI from CPI BBC binary files. I also make changes to the processor code with my TDF file so you should be careful and know what you are changing when using my TDF file. I will provide these TDF files with my EFI kit purchases. To aid my customers with tuning I have placed the switches, constants, and tables in my TDF files in a top to bottom priority order. The parameters at the top of the list are of high importance and will likely require changing. The parameters at the bottom may or may not need to be changed.

SWITCHES – (See notes at the end of this Appendix)

AUTO/Manual transmission (x=manual) ; leave in the automatic state (see note 1)
VATS select (x=enabled) ; Vehicle Antitheft System ; leave disabled
Speed Sensor Fail (code 16) (x=enabled) ; leave disabled if not using speed sensor
MAT Sensor Low (code 23) (x=enabled) ; leave disabled if not using MAT sensor
EGR diagnostic (code 32) (x=enabled) ; leave disabled if not using EGR valve
EST (timing error code 42) (x=enabled) ; leave enabled unless you are running a fuel only system
ESC Diagnostic (error code 43) (x=enabled) ; turn off if not using a knock sensor, leave on if using knock sensor
Open Loop AFR Enable (x=enable); this is an EGR parameter and should not be changed
EGR system type (x=backpressure); this is an EGR parameter and should not be changed
EGR system type (x=linear; 0=EVRV); this is an EGR parameter and should not be changed
Trans speed low (x=enabled) ; turn off if not using an electronic transmission
Trans Press (x=enabled) ; turn off if not using an electronic transmission
Governor Fail (x=enabled) ; turn off if not using an electronic transmission
VATS code 46 (x=enabled) ; turn off if not using VATS

The following switches are included in my own TDF file called PCM_$0D Switches –

MAT Sensor (x=yes;0=no) ; turn off if not using a MAT sensor (see note 2)
Asynchronous Double Fire (ASDF) crank ; leave in factory state for your application (see note 3)
Synchronous fuel at idle (TBI) (x=enabled) ; leave in factory state for your application
EFI system mode (x=CPI/MPFI ; 0=TBI) ; leave in factory state (see note 4)
ASDF (Asynchronous Double Fire) ; Asynchronous Double Fire mode ; leave in factory state (see note 3)
180 degree offset ; (see note 3)
VATS (Vehicle Antitheft System) (x=yes); leave disabled
EGR 400Db1 (x= WBO2) ; when logging wide band O2 on EGR position pin B16
EGR 400Db3 (0=WBO2) ; when logging wide band O2 on EGR position pin B16
EGR 400Db5 (x= WBO2) ; when logging wide band O2 on EGR position pin B16
ECM fan control on pin E3 (x=yes) ; when altering logic to control electric cooling fan set this bit to on
Cat. Overtemp Protection (x=enabled) ; leave in factory state
Knock Retard (x=enabled) ; enable when using knock sensor
ECM fan control on pin E3 (0=yes) ; when altering logic to control electric cooling fan set this bit to off

Rev Limiter (x=enabled)
TCC Only Non CC Transmission (x= TCC only)
TCC Option (x= man; 0=TCC)

CONSTANTS – (See notes at the end of this Appendix)

Number of cylinders ; 4, 6, or 8 (self explanatory)
Initial Spark Advance ; distributor base timing setting (usually zero for trucks; 6 BTDC for cars)
Max. Spark Advance ; upper limit to spark timing regardless of table value
Main Spark Bias ; allows negative spark advance without negative table values
Injector Flow Rate (per bank) ; very important parameter; total flow rate in #/hr for 2 injectors on 4 cylinder, 3 injectors on 6 cylinder, 4 on V8
Cylinder Volume (per cylinder); very important parameter; size of 1 cylinder in cubic inches
Fuel Cutoff/Resume Engine RPM ; RPM limiter settings high and low
Fuel Cutoff/Resume RPM (trans error) ; RPM limiter when trans trouble codes are present
Fuel Cutoff/Resume Speed ; speed limiter (must have speed sensor connected for this to function)
Min. Coolant for Closed Loop ; Coolant must be above this setting before ECM will enter closed loop
Min. Coolant for BLM enable; Coolant must be above this setting before ECM will move BLM
Max. Speed for Idle Fuel table; Use Idle Fuel table below this speed
Max. Speed for Idle Spark table; Use Idle Spark table below this speed
Max. %TPS for Idle Fuel table; Use Idle Fuel table below this TPS%
RPM to Bypass WOT delay ; Bypass WOT delay if RPM higher than this value
EGR Off/On (TPS) ; TPS settings for EGR to come on and go off
EGR Off/On (Engine RPM) ; engine RPM for EGR to come on and go off
EGR Off/On (Low Map Window) ; engine low MAP levels to enable EGR (see note 5)
EGR Off/On (High Map Window) ; engine high MAP levels to enable EGR (see note 5)
Minimum MPH to Enable EGR ; minimum vehicle speed to allow EGR
Normal Kick Down (speed and RPM) ; (see note 6)
Kick Down Upper/Lower Qualifier (TPS) ; (see note 6)
Minimum/Maximum BLM Value ; Limits on BLM correction range ; rarely change from factory setting
Minimum/Maximum INT Value ; Limits on INT correction range ; rarely change from factory setting
Maximum RPM to Enable BLM ; highest engine RPM that BLM learning will take place
Min/Max Map For BLM Enable ; MAP Window to allow BLM learning
Asynch to Synch Thresholds ; these settings change the injector firing frequency and should be left at factory settings
Trans Error Codes ; leave these at factory settings if an electronic transmission is used; set to zero if non-electronic trans is used (you will get nuisance codes if not using an electronic trans. and these are not set to zero)
CCP On/Off TPS threshold ; Charcoal Canister Purge solenoid on/off TPS settings ; leave at factory settings
Platform ID ; calibration identifier used by GM ; leave at factory value
PROM ID ; calibration identifier used by GM ; leave at factory value
Open Loop Idle Parameters ; used to run engine in open loop idle while sitting; leave at factory settings
DFCO Parameters ; Decel Fuel Cut-Off settings ; leave at factory settings

The following constants are included in my own TDF file called PCM_$0D Switches –

Fan RPM Control RPM 1, 2 ; if controlling electric fan set to zero; otherwise leave at factory values
Fan RPM Control RPM 3, 4 ; if controlling electric fan set to 6375; otherwise leave at factory values
Fan Control Coolant Temp On → Off ; this is the temperature that the fan will shut off if already on ; leave alone if no fan control
Fan Control Coolant Temp Off → On ; this is the temperature that the fan will turn on if currently off ; leave alone if no fan control
Fan Control CTS to Lockout ; coolant temp to lockout fan control ; set at -40 or leave at factory if no fan control
Fan Control Code $D3BB → CTS ($00A2 → 162) ; this line changes the processor code to allow fan control using coolant temp (see note 7)

TABLES – (See notes at the end of this Appendix)