

# 2010

ChevyTycoon

**ODB I MAF TPI Guide**

**1985 – 1989 MAF**

**1990 – 1993 Speed Density**

**1994 – 1997 LT1 / LT4**

**1996 – 2001 Vortec/LS**

# **MASS AIR FLOW TUNED PORT INJECTION PROGRAMMING AND TUNING GUIDE**

Mostly MAF tuning based on personal experience, although through the lifecycle of this 2 yr project, it evolved from an original \$32 mask into \$6E. Also added some speed density and vortec tuning information. This is a compilation from hundreds of previously “published” articles, forums and selfless knowledge sharing among a few ‘trusted advisor’ web sites such as [thirdgen.org](http://thirdgen.org), [gearhead-efi](http://gearhead-efi), [diy-efi.org](http://diy-efi.org), [moates](http://moates), [TunerPro](http://TunerPro) and [fullsizechevy](http://fullsizechevy).

## Contents

Mass Air Flow Intro.....	3
<i>Block Learn Multiplier / Integrator [BLM / INT]</i> .....	3
<i>XDFs, BIN definitions and Masks</i> .....	4
<i>Considerations for changing from \$32 to \$6E with 1989 BINS</i> .....	5
Setting Injector Constants .....	5
BPW Tuning method in \$32, \$32b .....	6
<i>MAF Tables</i> .....	8
<i>MAF Scalars (\$32, \$32b, \$6e)</i> .....	13
<i>Setting Timing &amp; Spark</i> .....	14
WOT Tuning .....	16
<i>Scalar: Max Spark Advance</i> .....	16
Troubleshooting .....	20
<i>Changing Fuel Injector sizes</i> .....	20
<i>Field Service Mode</i> .....	21
<i>Converting \$32 or \$32b over to \$6E</i> .....	21
<i>Limp Home Mode</i> .....	21
<i>Lean 'POP' condition</i> .....	22
<i>Torque Converter Clutch (TCC) Info</i> .....	22
TRUSTED-ADVISOR TUNING SITES:.....	23
Abbreviations .....	23
ECM / PROM Reference Chart ODB I II.....	24
<i>Throttle Body</i> .....	24
<i>Tuned Port</i> .....	24
BINS .....	26
Speed Density programming: .....	27
History of Changes .....	29
<i>72 GMC K2500 '86 MAF TPI 700R4 NP205 4:10 31"</i> .....	29
July 12, 2010: Rick TPI Shop. Creates A, B, C.....	<b>Error! Bookmark not defined.</b>
Aug 30, 2010: Rick Chip B throws SES light: code 43 AND code 45 .....	<b>Error! Bookmark not defined.</b>
Sep 6, 2010 1PM: MemCal, Original Chip + adapter .....	29
Sep 6, 2010 2:30PM: MemCal only .....	29
Sep 6, 2010 2:50PM: MemCal, TPI chip B + adapter.....	<b>Error! Bookmark not defined.</b>
Sep 7, 2010 3:50PM: MemCal, Rick chip B + adapter ....	<b>Error! Bookmark not defined.</b>
Sep 8, 2010 8PM: MemCal, TPI chip B + adapter .....	<b>Error! Bookmark not defined.</b>
Next step is to modify AUJM rev2 D with D.1, D.2, D.3 and D.4 ....	<b>Error! Bookmark not defined.</b>

Using TunerPro RT V5 .....	31
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## Mass Air Flow Intro

The MAF based engine control systems utilize a Mass Air Flow sensor for its primary fueling routines. The ECM assumes that a mass of air will equate to a specific requirement of fuel, based on the ECMs programmed air/fuel ratio, combined with multiple terms and load conditions.

The Mass Air Flow device in our application utilizes a hot wire element to create a transfer function based upon the relationship of an electrical current flow through an element (temperature rise) to airflow (cooling effect of airflow). As the airflow increases, additional current flow through the element is required in order to maintain a set temperature. This current change is converted to a voltage range of ~0-5 Volts in this particular sensor. This relationship of heating to current flow is known as King's Law. The formula(s) is available on the internet if more technical detail is of interest.

One item to note is that since the MAF sensor measures effective cooling of a heated wire, in reality, humidity will also affect the MAF voltage reading. The tune should not vary greatly due to this (this depends on engine modifications, and how tightly the engine is tuned), but if you encounter weird engine operation, and can account for large changes in humidity, this may be responsible. This is one of the downfalls of this type of load measurement device.

### *Block Learn Multiplier / Integrator [BLM / INT]*

So, what are these values? The factory ECM has a learning ability to allow it to make corrections for minor and major variations in fueling to improve performance and drivability. There are two learning features: The Integrator (INT) and Block Learn Memory (BLM) functions, represented as values from 100 to 160. The INT is a short term corrective action while the BLM is a long term correction. The BLM value will change if the integrator has seen a condition which lasts for a longer period of time. There are from two to sixteen different "cells" which the ECM modifies, depending on RPM, airflow or manifold air pressure and other conditions such as AC on or off, etc. The ECM learns how much adjustment is required in each cell, retains it in memory, and applies these adjustments when the engine operates in that cell or RPM/Load Range. These features of the ECM allow the system to adjust itself constantly to your engine and driving conditions so as to assure peak performance efficiency for stock and other than stock engines.

The INT and BLM values are considered normal when the value is (around) 128 (the possible range being 100-160). The holy grail of MAF tuning is keeping the BLM value at a constant 128 throughout the entire driving experience! A value of 128 indicates the engine is running at its most peak efficiency, assuming a perfect stoichiometric air-fuel ratio (AFR) is 14.7:1. Don't get bogged down, at this moment, with understanding the myriad complexities involved with different AFR's – that comes later in your learning cycle. But the object of adjusting your tune to maintain a BLM value of 128 is also one of the harder concepts to understand when first starting out so take your time and really

understand the meaning of this variable. When the BLM value is **higher than 128**, it indicates that the ECM is **adding fuel** to the base fuel calculations because its responding to what it BELIEVES is **a lean condition**. When the BLM value is **lower than 128** it indicates that the ECM is **removing fuel** to the base fuel calculations because its responding to what it BELIEVES is **a rich condition**.

To repeat: When values are **above 128**, the ECM is adding fuel due to a perceived **lean condition**. When BLMs are **below 128**, the ECM is removing fuel because of a perceived **rich** condition.

So let's demonstrate this into some real world examples. A worn fuel pump isn't providing enough fuel pressure, so FP is low and now the injectors aren't providing the flow (amount) of fuel the ECM is expecting. This creates a lean condition. Now the Oxygen Sensor (O2), sensing more air than fuel in the exhaust stream, elevates (above 128) BLM values. Keep in mind that a lean condition means there isn't enough fuel to satisfy the 14.7:1 AFR baseline. Another common lean condition is a vacuum leak: the oxygen sensor reads that there is more air than fuel (because not all the air is being properly read by the MAF sensor) so it signals to the ECM to increase fueling in order to meet the 14.7:1 baseline AFR. Another: If you have a dirty MAF sensor its *reporting less air flow than is actually entering the engine*, it's a lean condition. If you have a speed-density setup, and have modified the intake and exhaust to improve the engine's breathing, but have not had the programming modified with changes to the volumetric efficiency (VE) tables, it would run lean. These are all "TRUE" lean conditions.

Rich conditions, indicated by lower BLM values, can be caused by fouled spark plugs (more fuel than air read by the O2 sensor), a timing "miss" from a worn cap/rotor/wire or leaking fuel injectors.

NOTE: When the vehicle power is disconnected for repair or to clear diagnostic codes, the BLM/INT learning process has to begin all over again. For the ECM to re-learn drive the vehicle at operating temperature with moderate acceleration and idle conditions for at least twenty minutes.

### ***XDFs, BIN definitions and Masks***

Tuning Programs (TunerPro, TunerCat, DynamicEFI, etc.) utilize a "mask" file (i.e. .xdf) that translates the binary machine language (BIN) of the ECM program into a Graphical User Interface program. This GUI allows us humans the ability to easily tune the BIN w/out having to know, and then manipulate, machine language (hex). *There is a chart in the latter half of this doc showing all the mask-to-bin relationships, by year.* For purposes of this project I started on a \$32 mask but eventually migrated up to the \$6E mask. There are different masks for different years, but they can be shared with only a small amount of BIN changes but it is important to note that 1986-1987 masks and BINs differ quite a bit from 89 masks and BINs since 89 cars didn't have a cold start injector (even the upper plenum and runners are different between those years). Before you use a 1989 BIN in an earlier MAF mask, you need to physically disable the CSI (see below), otherwise the engine won't start.

1986 and 1987-88 (all use a cold start injector) respectively use \$32, \$32b masks. 1989 calibrations (doesn't have the cold start injector) use a \$6E mask; however, \$6E doesn't use injector base pulse width table, which is a great tuning methodology. But since this mask was the "latest & greatest" offered by GM for MAF cars so it does contain many additional parameters that can be adjusted beyond the earlier \$32/\$32b masks. It is purely a personal preference, although many threads on thridgen.org forums have found improved tuning setups running \$6E

1990-1995 years utilized a Speed Density program, \$8D and \$EE

In recent years, TunerCat added **crank fuel pulse width vs. temp** and **crank fuel pulse width multiplier vs. reference pulses**, \$32B, so it closely resembles the same tuning parameters in \$6E: [http://diy-efi.org/gmecm/ecm\\_info/1227165/](http://diy-efi.org/gmecm/ecm_info/1227165/)

### *Considerations for changing from \$32 to \$6E with 1989 BINs*

My thread @ thridgen.org: <http://www.thridgen.org/techboard/dfi-ecm/636802-spark-adv-exceeding-table-2.html>

*Actual step by step how-to is found in the troubleshooting section below*

- **Analog MAF Meter in use (HLM) @ Loc 0x14:** \$6E is an analog MAF only mask. GM then used that same option flag location as the 4th gear Normally Closed or Normally Open (NC/ NO) selection. As long as the TCC looks up at a higher MPH when the transmission is actually in 4th gear (then 2nd or 3rd), then the option flag is set correctly.
- The PW based tuning tables went away in \$6E. Gone. \$6E uses the MAF airflow and calculates an injector PW.
- \$6E has a lean cruise mode for better mileage.

Based on my experience, you should keep the model-year masks and BINs matched. For example, a 1989 model-year BIN SHOULD USE \$6E mask, otherwise if an 89 BIN is used with a \$32b mask, graphs are all spiky, up and down, across all parameters.

- This works: opening 89 bin in \$32b, then saving it as \$32b
- Opening 89 bin in \$32b, converting the file to \$6E and saving, will NOT work. You must open the bin, select the XDF, THEN MAKE CHANGES and save as that XDF file. You must always open and save in that same XDF. You CANNOT open in one XDF, open a different XDF and then save it – it WILL NOT WORK

## **Setting Injector Constants**

This is an important Scalar to verify. From the factory, MAF BINs expect the fuel pressure @ 43 PSI. We often change and swap injectors so be extra careful when adjusting this scalar since some injectors are not rated at 43 PSI, but at higher or lower

pressures. You will need to convert your injectors flow rate if they are not rated at 43PSI. That being said, you can adjust this value (scalar) to affect global fueling calculations. For example, if the BLM values are way off across your entire logging, adjust these accordingly to center your BLM values. When just starting out as a newbie, leave this set at the BIN default until your more comfortable understanding some of the other basic concepts contained herein. Furthermore, there is a more detail on this concept in Changing Injector Sizes in the Troubleshooting section.

**Injector Flow Rate, (Single Fire)**

**Injector Flow Rate, (Double Fire)**

These two Injector flow rates should be set to the same value, in Lbs/Hr, at 43 PSI. For example, if you are using 24lb Ford SVO injectors, they are rated at a lower pressure for this flow rate and you will find that your average BLM values are low when using a value of 24 lbs. The ECM is compensating for the error in flow rate by using less fuel, since the injectors are actually bigger than the ECM thinks. By adjusting the constants to 25.6lbs, your BLM values increase to give you an average of 128.

Also, there appears to be a difference of how the BIN reports this value between using \$32/\$32b and \$6E masks so use the correct mask for your BIN. i.e. .17 verse 17

### **BPW Tuning method in \$32, \$32b**

Now on to the good stuff!! If you have modified your MAF engine and find yourself lean or rich then its time to start working here. This is the **BPW FUEL vs. LOAD**, msec (of Inj PW.)

In the ECM switches table, \$32B, uncheck **Base P.W. Calibration Method (X=Calc.)**, to use the MAF injector pulse width table. Make sure to unswitch it or this method will never work.



<http://www.thirdgen.org/techboard/diy-prom/133967-definitive-32-32b-tunning.html>

### *Base Pulse Width calculations*

This is where the magic of tuning for drivability come into play. This table is the whole key to tuning your MAF car. I find the best tuning method to do this is note various BLM (block learn multipliers) and INT (integrators) readings at all load levels and RPM's and make percentage based changes. For example:

INT of 108 and a BLM of 100 = roughly 5% rich. It will need a lot of work for a modded car.

Ultimately, these variables are needed to determine the amount of fuel required to maintain 14.7:1 AFR (Air Fuel Ratio).

The ECM determines this based on calculations below:

$$PW = ((((((DRP * \text{gms/sec}) / 512) * AFR) / 256) * \text{InjFlwRate} / 128) * 0.01526$$

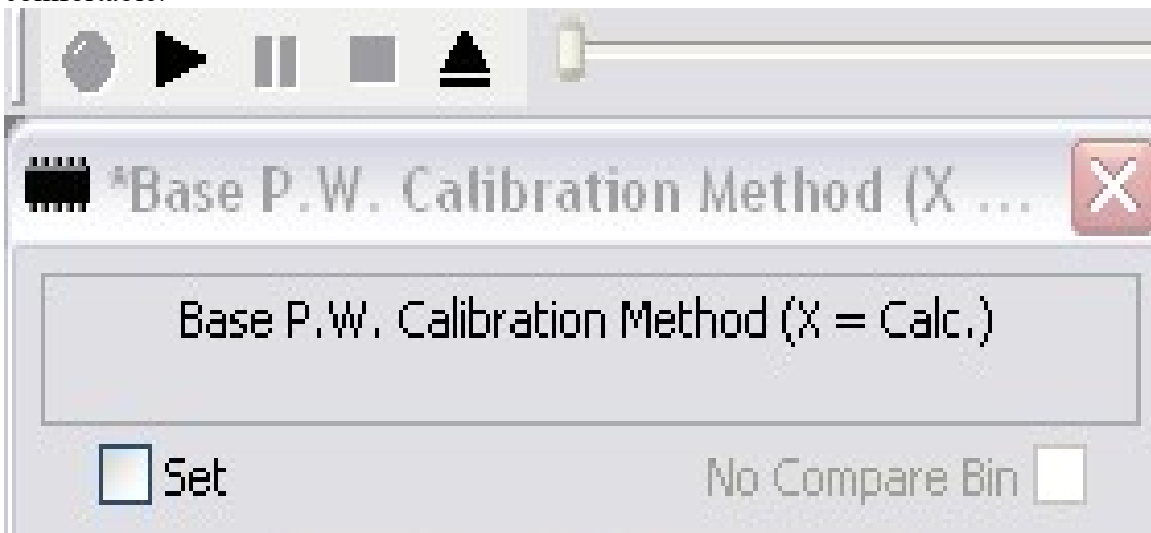
As an example:

2000 RPM, 20 gms/sec., 445 AFR, 441 secs/gms Inj:

$$PW = ((((((492 * 20) / 512) * 445) / 256) * 441) / 128) * 0.01526$$

= 1.76 msec.

It's important to understand the relationship between all of these variables as changing the BPW table will ultimately affect a lot of operating parameters, so subtle tweaks to improve your fueling is recommended, but avoid large changes until your more comfortable.



The **BPW Fuel Vs. Load, (msec)** is the table that takes place of ECM-calculated Injector Base Pulse Width when the BPW flag is not set (unchecked). Fueling will then be directly related to the pulse widths you define. If you look at the table, you will see the same values repeated in all RPM columns. The factory map (akfm2174.bin,



89FBA35032.bin) is flat and straight and not the best to start with as these are obviously just placeholder values.

It is best to Datalog carefully for a baseline fuel curve then change the values to reflect what the logs show for various load/rpm points **before the flag is switched**. Fill the table with the values that closest match the cells, then smooth in the rest. From that point, datalog and see how the BLM and INT values have changed, and correct in the proper cells. To truly achieve 128 (no corrections) with a \$32/\$32B MAF system, this method of fuel tuning is useful.

Now that we've adjusted fueling to narrow in on 128 BLMs, you may need not have to go any further. But for a heavily modified setup where the intake, runners, cam, headers, etc. have been changed, then you may need to look at aligning the MAF tables as well. Keep in mind that GM Engineers spent considerable time developing the proper MAF values based on factory intake-plumbing setups and that if using a stock setup, these are probably sufficiently defined as they are in their respective stock BINs.

I highly recommend that this be an iterative approach: Adjust BPW table, then follow up with MAF table; return to BPW and follow up with MAF, etc. Again, you want to always maintain (at part-throttle and cruising) a BLM of 128.

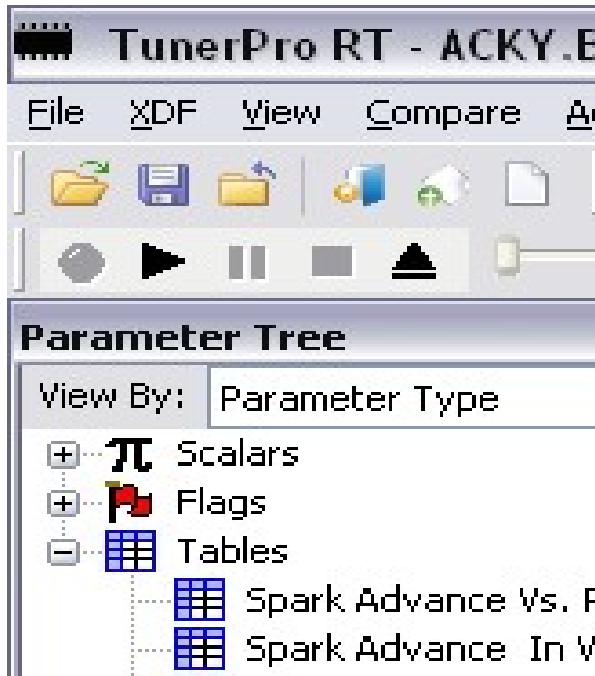
### **MAF Tables**

The MAF system is effective in its simple relationship between airflow to required fuel. If X amount of air is flowing, Y amount of fuel is needed. Because of this, you will not see any parameters dealing with engine displacement, since it will always try to maintain 14.7:1 AFR in closed loop (Non Power Enrichment) based solely on airflow.

There are 6 tables. Higher ones 5-6 usually only hit with WOT and 6 is mostly 254 g/s which is the max allowable value. The differences between each cell in the higher tables can be 7-11 g/s while in table 1, the difference between each cell can be 2-5. So a change of 1 g/s in table 1 can have a larger impact on air fuel ratio than a change of 1 g/s in table 5. More fuel is needed at higher g/s flows than low idle speeds.

#### **Mass Air Flow table 1,**

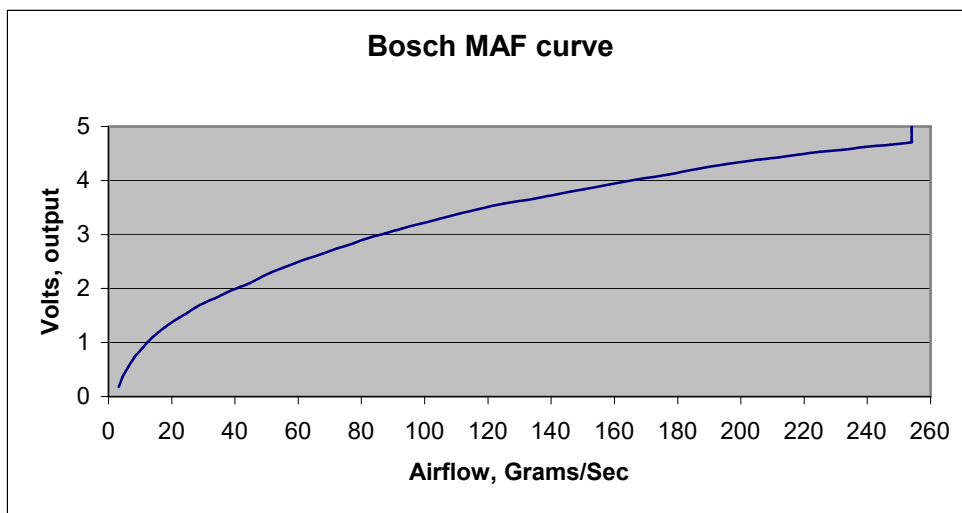
MAF input FQ in MGHZ = grams of air per second.



As you go higher in the tables up to table 4-6, it takes a bit more change to the grams/sec values to see a change in air fuel or BLM's when in closed loop.

**Important Note:** You'll notice that the last value in each column and the first value of the next column match very closely. This relationship must be maintained if modifying these tables

Additionally, in the Bosch MAF curve chart, you can see how the curve is nice and smooth. This is because the tables are carefully calculated to provide seamless transitions from one table to the next. Since the tables are made using a scalar multiplier, it is important to realize that if you need to tweak a table at the last entry, that you affect both the table, the scalar, and the next table and its scalar.



There is a minimum gms/sec limit which the ECM uses for fueling: 3 gms/sec. If it calculates something less than this, it uses this value. Ordinarily, this is not an issue.

There is a table of **Maximum Airflow VS RPM**. This table will become apparent when you are running a MAF system with large displacement engine, which will use large amounts of air at lower RPM than anticipated. You will find that the engine will always scan and show a specific gms/sec even if you determine that you should be using more. If you find yourself in this case, you can increase the entries (usually the upper entries) to avoid 'pegging the needle'. It's not commonly known exactly what purpose this table serves (the development engineers obviously know); there are theories that it prevents large engine modifications; or that it serves to help prevent false air readings/fueling calcs based on throttle transients/plenum filling.

So how does this airflow math work? The ECM works within an 8 bit word limit (in most cases), and as such, you can see that the airflow in grams per second conveniently ends at 254 for the last few entries in the curve.  $2^8=256$ : Using a 0 based numbering system, the max number is 255, and the above table ends at 254 due to the conversion math. This happened to be a matter of convenience, and it should be reinforced that these tables are merely a transfer function, or, more plainly put, there is nothing written in stone that this system is limited to 255 grams per sec. It could easily have been written to be 255 units per second, where each unit was 2 grams, but resolution is then lost.

In order to gain even better resolution, this coding scheme utilizes 2 dimensional tables along with scalar multipliers to efficiently model this curve while minimizing code space.

The math works as follows.

There are 6 MAF tables. Each MAF table has an associated Scalar. This value is multiplied by the table values to determine the conversion from volts to grams/sec.

$$(\text{MAF Table Value} * \text{Scalar for table}) / 255 = \text{Grams/Sec airflow}$$

Example, MAF table 2, value 4 = 163. Multiply by scalar (48) = 7824. Divide by 255 = 30.6 gms/s

This grams/sec value is then used to determine the load, based on RPM, called LV8: Load Variable (8 bit).

$$\text{Load Variable (8 Bit)} = \text{airflow} * \text{scale factor} * \text{inverse RPM factor}$$

$$\text{LV8} = (\text{gms/sec} / 256) * (\text{Scale factor} / 64) * (\text{Distributor Ref Pulse Count})$$

For an engine at 3000 RPM and an airflow of 90 gms/sec with a scalar of 80:

$$\text{LV8} = (90 / 256) * (80 / 64) * (328)$$

$$\text{LV8} = 144$$

The Distributor Reference Pulse Count value is determined by the internal 16 bit pulse counter.  $2^{16}=65536$  bit counts per second. 65536 multiplied by some time/4 stroke conversions gives you the formula for an 8 cylinder application:

$$\text{DRP}=983040/\text{rpm}$$

This is the term used the equation above (328).

The Scale factor of 80 is hard coded in the firmware, and could be calibration specific. For 32, a 32B and 6E mask, the factor is 80.

This LV8 term is then used for all load calculations.

#### To Adjust MAF tables:

First, find the gm/sec airflow reading corresponding to idle in your logs. Then, find the closest value(s) in the MAF sensor tables; you will sometimes have to alter two cells to affect one airflow range.

To **richen** your fuel mixture (BLMs > 128), **increase** the value(s) you found as mentioned above.

To **lean** the fuel mixture (BLMs < 128), simply **decrease** the appropriate MAF cells as mentioned above.

Idle table is table 1; smaller changes here make much bigger changes to the air fuel ratio. I try to start with .5's or so in table 1. Closer you get to where you want to be, make smaller changes.

While table's 3-4 are for heavier throttle, with more engine load you may need increases of 2-3 at a time to see a change. I don't touch table 5 and 6 since that's usually only WOT and I tune that by PE mode (Power Enrichment).

@ Idle, monitor the MAF output for grams/sec. IF it idles around 9 grams a second, and wideband shows rather lean say 16 to 1 air fuel, then you may want to increase fuel. If the idle is stable and "happy" then it may be ok there. If it's dying out due to being too lean, then may want to increase fuel there.

Do that by looking in MAF table 1, look in the g/s column where 9 would be. It may lie between 2 values say 10.87 and 8.36 which is what stock ARAP bin is. You will want to increase 8.36 and 10.87 to richen. Try 8.9 and 11.2 and see what happens. Take it slow with smaller changes and see what the motor does.

@ Cruise. If you are at 45mph and notice MAF gram sec is 45 g/s and wideband is showing too rich, go to your table that has 45 g/s in it. That's top of table 2 in ARAP bins, between 44.44 and 47.63. So change the 44.44 to 43.4 and 47.63 to 46.6. That will lean it out. A change of 1 there may be too much but won't know till you try it.

That's basically how I attack MAF tables. Works the same way if in CLOSED loop and watching BLM's instead of wideband AIR FUEL ratios. Datalogs with BLM and INT's

can be used. Compare g/s in the logs to the BLM's and INT's. If you are below 128 BLM you will want to lean out the motor so you need to decrease the grams/sec in the MAF tables. If above 128 BLM, need to richen it.

A BLM of 128 is targeting 14.7 to 1 air fuel or stoich. Good place to be for cruise and idle but not all motors want to idle there. You will see on a lot of cammed motors a blm of 128 doesn't always mean 14.7 to 1 air fuel at idle. As long as the motor is happy there it's ok. Lot of motors can be leaner there and still be ok.

Here is the worksheet, and the formulas I used to adjust:

			160	=128/ D1	=C1*E1	=C1+((1- E1)*C1)	=(C1*((D 1- 128)/2)/1 00)+C1
		R70			R71	R71 Ver2	R71 Ver3
		Orig	BLM reading	% from 128	Adj MAF	Adj MAF	Adj MAF
MAF 1	0	6.25				% of BLM	1% per 2
	0.18	3.52	160	0.80	2.82	4.22	4.08
	0.37	4.59	158	0.81	3.72	5.46	5.28
	0.55	6.15	160	0.80	4.92	7.38	7.13
	0.73	8.4	160	0.80	6.72	10.08	9.74
	0.91	10.84	141	0.91	9.84	11.84	11.54
	1.1	14.06	139	0.92	12.95	15.17	14.83
	1.28	17.77	139	0.92	16.36	19.18	18.75
	1.46	22.36	137	0.93	20.89	23.83	23.37
MAF 2	1.46	21.82	137	0.93	21.39	24.25	22.80
	1.55	23.93	135	0.95	22.69	25.17	24.77
	1.65	26.41	139	0.92	24.32	28.50	27.86
	1.74	29.29	137	0.93	27.37	31.21	30.61
	1.83	32.35	139	0.92	29.79	34.91	34.13
	1.92	35.6	130	0.98	35.05	36.15	35.96
	2.01	39.05	131	0.98	38.16	39.94	39.64
	2.2	42.68	133	0.96	41.08	44.28	43.75
	2.19	45.75	127	1.01	46.11	45.39	45.52
MAF 3	2.19	47.66	127	1.01	47.04	46.28	47.42
	2.29	51.23	133	0.96	49.30	53.16	52.51
	2.38	55.12	126	1.02	55.99	54.25	54.57
	2.47	59.01	132	0.97	57.22	60.80	60.19
	2.56	63.22	132	0.97	61.30	65.14	64.48
	2.65	67.76	132	0.97	65.71	69.81	69.12
	2.74	72.3	132	0.97	70.11	74.49	73.75

These values are also efficiently modified using percentages (%), or multiplying the values (1.xx to richen, 0.xx to lean). Start with 1%

(1.01/0.99) changes for every 2 BLMs off; so, a BLM of 118 would require a 5% decrease ( $128 - 118 = 10 / 2 = 5$ ), or multiplying the MAF airflow value(s) by 0.95. Again, trial and error will be needed to see if you have overshot a BLM of 128 with your changes

### MAF Scalars (\$32, \$32b, \$6e)

Scalar = MAF table maximum value in grm/sec. table value divided by 256 x scalar equals table entry value. For example:

Scalar is 120

counts	table value	grams/second
1	20	$20/256 \times 120 = 9.375$
2	30	$30/256 \times 120 = 14.0625$
3	40	$40/256 \times 120 = 18.75$
4	50	$50/256 \times 120 = 23.75$
5	255	$255/256 \times 120 = 119.256$

- scalars adjust fuel globally over the entire range of that particular table
- **raise** it to **richen** and lower to lean it out (pretty obvious)
- Scalar tables 1-6 affect MAF tables 1-6 respectfully to their numbers. Changes to scalar 1 will adjust fuel globally for MAF table 1 etc...
- The MAF tables tell you where the computer is looking at different flow rates (grams a second). MAF table 1 flows from 1 to 23 grams, MAF table 2 flows from 23 to 47 grams etc.....watch the grams/ second on your scanner at different throttle openings and load drops and you can figure out which MAF table you are in.
  - MAF table 1 is your idle and minimal throttle table
  - MAF table 2 & 3 are your part throttle cruising as well as slight tip in
  - MAF table 4 is 1/2 to 3/4 throttle opening
  - MAF 5 & 6 are PE and full throttle
  - watch the scanner to see what grams a sec. you are flowing, check your BLM's at that flow rate, find the table that flows that gram a sec. then adjust the scalar accordingly.
  - The first 3 to 4 entries on MAF table 1 will have to be raised or lowered (most likely lowered) on a cammed **car**. The scalar might be correct for minimal throttle, but the idle is most likely rich because of it. Use the sniff test to verify changes.
- Adjust certain points on MAF tables if you see a mysterious lean or rich point at a certain throttle position.

### *Setting Timing & Spark*

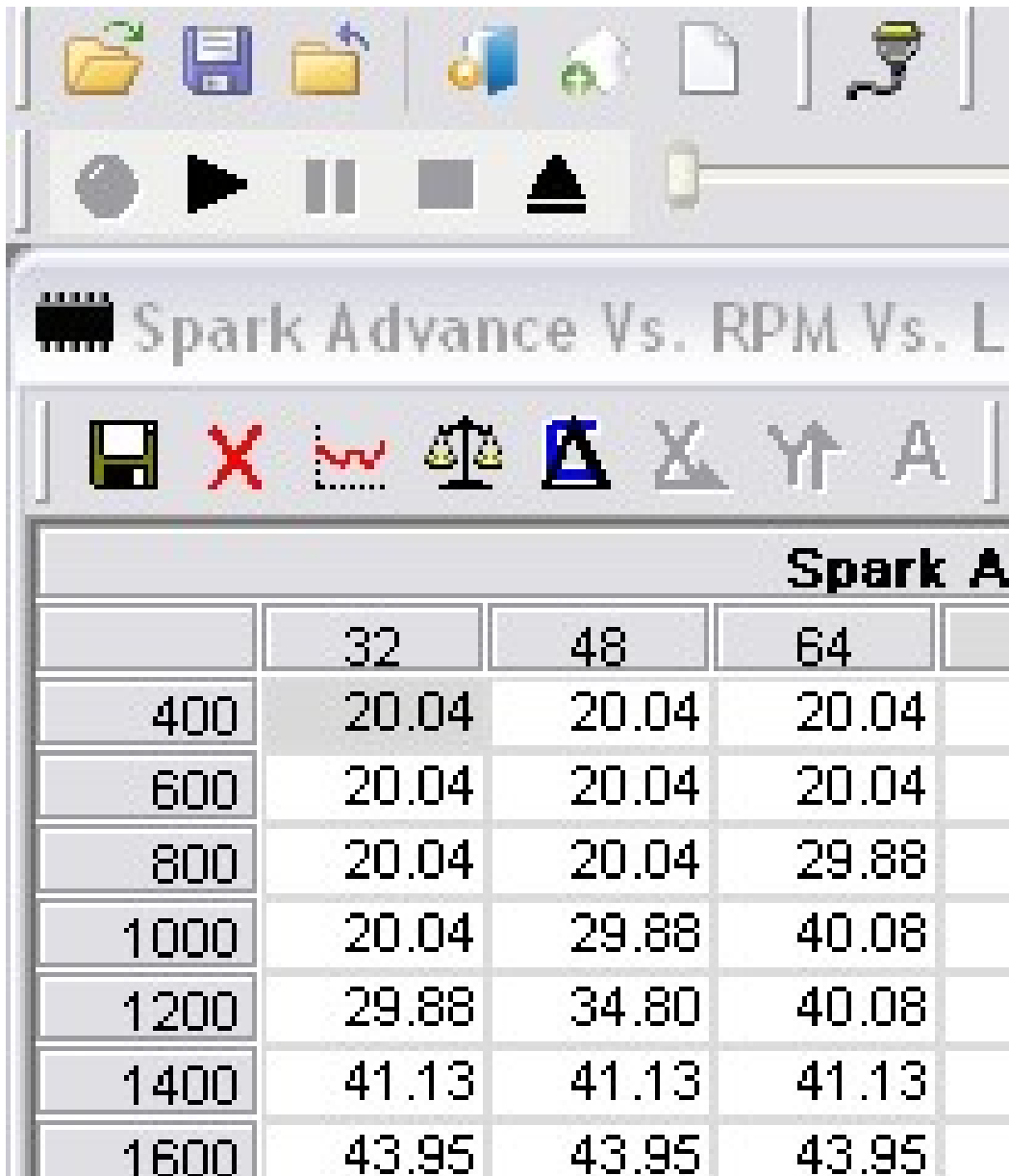
Now that we understand how the MAF tables function and how the ECM determines fueling at given load it time to discuss **timing**. This table is the complete spark advance table for the engine, while in normal operation (not PE). Keep in mind that, again, you want an iterative approach whereby you adjust, by a small amount, BPW fueling, then return to spark advance. Keep approaching each variable by alternating between them.

**Spark Advance vs. RPM vs. Load.** This is your part throttle table and it's even referenced for WOT. Just like the BPW fueling table this table is the basis for all WOT actions.

This table is a what-you-see-is-what-you-get. Meaning, whatever timing you want for your engine, set it in the appropriate cell. There is advice out in the world that says to just increase your timing until it knocks, then back it off a few degrees. For some, this is fine. But again you are trying to optimize efficiency and power by striving for a BLM value of 128 and this will require iterative exercises of altering, driving and data logging, adjusting and then repeating. You truly need enough logging to cover most of the load and rpm combinations that you encounter in your daily part-throttle driving to have enough data to make the right changes. Different engine combinations (cam, heads, compression, etc.) require huge differences in how much timing an engine likes, how fast that timing comes in, how much load the vehicle typically encounter and so on. Again, find what the engine "likes" – don't aim for what some other combination is running.

Read you plugs as well! This is a trusted way of truly seeing what is going on inside the combustion chamber.

*Spark advance table is based on LV8 instead of airflow*



There are a few basic things to remember when tuning more radical combinations

- Better breathing cylinder heads with efficient combustion chambers may require less total timing overall, but full timing ramped up more quickly, with higher initial timing than a stock motor.
- Camshafts with higher duration will require more initial timing, also ramped in quickly to max total timing over RPM.
- Supercharging and turbocharging will require less total advance as boost increases.
- Flattening out the shape of the timing area around idle can provide smoother idle, and make fueling a little easier



## WOT Tuning

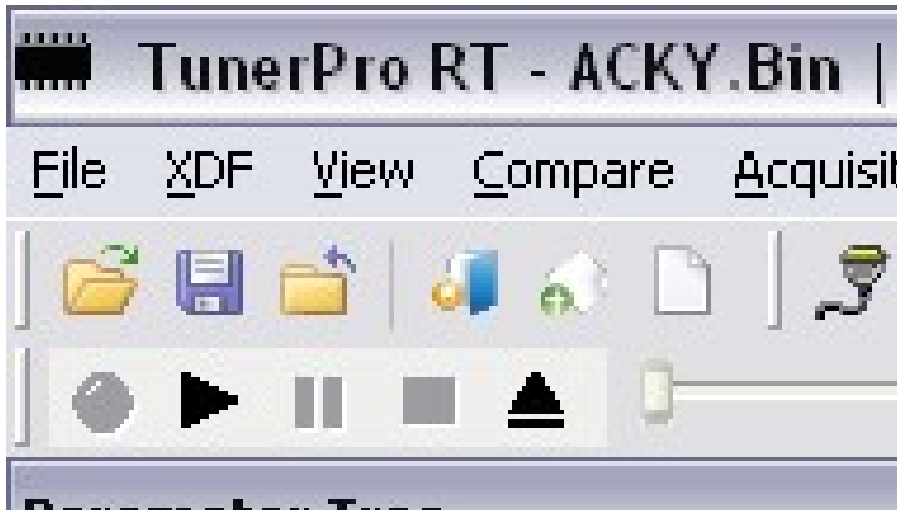
Now that we've covered tuning for part throttle drivability, we now switch to WOT and Acceleration tuning!! Again, the goal is to keep the BLM's and INT's at 128; but I have also come to the realization that given weather loads and a changing barometer that getting a perfect 128/128 tune from MAF is very time consuming. Even the factory calibrations will wander some from the 128/128 model. So if, after quite a while, you find your BLM's in a certain range of 123-132, you've done very well for yourself.

Wide Open Throttle tuning (stomping the gas pedal) is referred to as Acceleration Enrichment (AE) and Power Enrichment (PE). MAF BIN's use AE, PE and Wide Open Throttle (WOT) tables in which to make adjustments under heavy throttle conditions.

And now that we've completed part throttle tuning, we begin WOT tuning with:

### Spark Advance In WOT Vs. RPM

This Table will add or subtract timing when in PE mode, to achieve maximum power without detonation. Be cautious when adding SA to this table as it adds this amount to your main SA advance table. Summing these up is limited to the available mechanical advance that a V8 engine is allowed. Further, when in WOT, engines typically like extra fuel so be sure to "marry" this with the next table as well.



### *Scalar: Max Spark Advance*

Important Note: This value is the limit that the code will allow for advance. For a V-8 engine, maximum timing advance possible mechanically will be 45 degrees (360 degrees/8cylinders). This value should be set slightly less than maximum mechanical.

DIS ignition and Coil on Plug are not limited in this respect, and will vary.

**Power Enrichment: Stepping on the Throttle**

We now need to move onto AE (Acceleration Enrichment) and PE (Power Enrichment) Fueling. We begin at this table:

**WOT % change to AF ratio at WOT vs. RPM.**



RPM
0
400
800
1200

This table shows the amount of calculated change to the AFR at WOT. This table works in percentages so there a bit of a fudge factor based on injector size and airflow of the engine. The actual delivered % of extra fuel in term of AFR will be different car-to-car.

Another table similar is **WOT % change to AF versus COOLANT temp.** Now this is a wonderful table for people who don't let there cars warm up or run at the drag strip at lower engine temps

The next AE table is the **ACCEL enrich %BPW vs. Async pulse.** Now that you've got the WOT AF ratio where you want it and the PT cruising is great its time to fix that BOG when you nail the throttle.



Pulse
0
100
200
300

Increasing this will add a bigger pump shot (think of this is a carburetor accelerator pump-shot).

Now that we have a good bit of injector BPW added for smacking the loud pedal open we need to figure out for *how long to add* the extra fuel. This is critical in cars with big cams

that need to build engine speed to gain air flow velocity to help atomize fuel.  
**No. of Accel Enrich Async Pulses vs. engine Coolant Temp, \$32b**



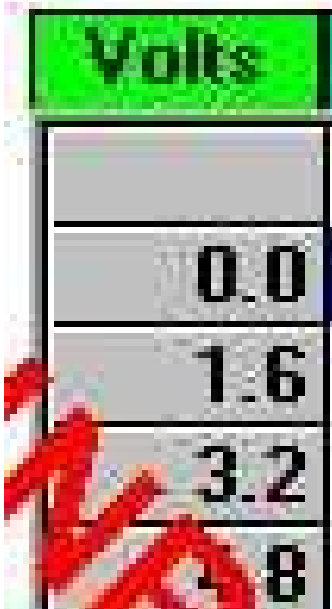
Deg. E
-4

Increasing will make the pump shot longer. This table provides the necessary acceleration enrichment (with additional asynchronous pulses) to **prevent lean popping** as the accelerator is pressed, based on the engine temperature. Colder engines may require more pulses than ones that are up to temperature. This table also plays a role in systems that require more fuel due to intake design (large plenum/runner geometry).

This table simply tells the ECM to go ahead and add 12, 13, 28 pulse of AE fuel for each injector PW event. So if you need a longer AE event to keep the engine happy add a few pulses.

This would be the step in tuning where the AE fueling is good but it's just not long enough to keep the engine in its sweet spot until things get going. For example: you've hit the stall on the converter and now the engine is laying down a bit.

Side note: must have enough voltage to sustain the extra pulsewidth. This is a warning to all those who are fighting a lean idle. This table is the **Injector PW correction vs. battery voltage, \$32b**



Volts
0.0
1.6
3.2
4.8

**LV8 Accel. Enrich. Factor vs. Delta LV8,**

From what I gather it starts from a static LV8 reading. If the lv8 is 8 then it will keep lv8 as a delta. If the lv8 changes IE increase due to increased airflow then it will use the factor as a divisor on BPW to add AE fueling.

LV8 Counts -----	Multiplier-----	change in PW added to current PW
0-----	0.10 x current PW + PW =	new AE PW
28-----	0.10 x 2.0msec = .2 + 2.0=	2.2 new AE PW
128-----	0.20 x 2.0 = .4 + 2.0 =	2.4

In short: the smaller the factor the less amplitude of change for AE mode to BPW as an adder to actual current PW.

**LV8 Accel. Enrich. Coolant Factor delta vs. Coolant Temp.**

Basically this will change how much additional AE is added due to cooler engine temps. Same operating formula as above.

**LV8 Accel Enrich Decay Rate vs. Coolant Temp.**

This table simply cuts down on the amount of additional AE added per AE pulse event based on coolant temp. The colder the engine the longer the domain time needed to keep AE fuel in there. So if you lower these values it will hold the original AE values longer giving you a longer AE PW.

**Accel. Enrich. Async Factor vs. Coolant Temp.**

This is just another way to reduce overall AE fueling based on coolant temp. The factor is really a slick divisor and works like so.

Coolant temp-----	factor-----	affect
10-----	AE PW x factor=	affect
20-----	2.0msec x 1.00 =	2.0msec
180 -----	2.0msec x 0.90 =	1.8msec

also from what I've seen the tables are additive. I.e. they add together for the total AE Pulse width change.

Now, let's move over to Constants.

**Minimum Delta TPS for accel enrich.**

Basically if throttle is closed and you open it will start the AE mode at 3.9% difference if it occurs in less than 12.5 msec. or something like that. I'm not too sure about the time domain.

**Minimum Delta LV8 for accel enrich.**

This works like the TPS but could come on going up a hill. Being as all these Accel enriches factors and multiplier are based on LV8 this table has a lot more affect. However

I strongly caution against lowering this variable too much. If you hold a steady pedal and drive up a small hill you could enter the AE mode. Thereby destroying your gas mileage.

The same goes for the TPS. Set it to low it and it'll be constantly entering the enrich mode if even for a millisecond that'll add up over time.

## Troubleshooting

### *Changing Fuel Injector sizes*

If you physically swap out the Injector size or physically alter from the standard fuel pressure of 43 PSI you MUST change the Injector Size constant. The Injector Size Constant is in the BIN for a reason...and it is to properly size your injectors. The ECM calculates the injector pulse width (how long the injector stays opens), sometimes called PW or IPW, on the assumption that it knows all about your engine... displacement, injector size, mass air flow, etc. It uses an equation that includes the terms:

..... x (BLM/128) x (INT/128).....

The injector constant affects **all** areas of rpm/load, a.k.a., global changes. First step is to verify the injector constant. Again, make sure that you find the proper flow rating of your injectors at 43 PSI. Then, you can begin altering this constant to affect global changes in fueling in order to tighten the BLMs into the 128 range.

How to Modify: If BLMs are less than 128, (which is a richer engine) increase the injector constant. This will decrease the commanded PW from the ECM thereby removing fuel from the system. Drive it for 20 minutes (warmed up, up to temperature, normal driving), log the readings against various part-throttle conditions and then adjust the injector flow rate until the BLMs are 128.

To repeat another way, a Lean Engine = higher than 128 = so lower the injector flow constant; conversely, Rich Engine = less than 128 = so increase the injector constant.

The MAF Tables (\$32B/\$6E) or VE Tables (\$8D) are the tables in which to make minor, “targeted” modifications specific to a specific part-throttle condition while global changes can be made with the changing of the Injector Size Constant. If using them together to make changes, a rich engine = less than 128 = lowering the values in the MAF tables (which removes air).

### Relationship of Fuel Pressure

The Injector Size Constant is definitely affected by Fuel Pressure. If you run higher than stock (43PSI) fuel pressure, it is effectively the same as increasing your injector size (but not really). Most injectors are rated at 3 bars which is 43.5 psi.

Set the Fuel Pressure to 43 with vacuum unplugged.

If FP is higher than stock, compensate with this formula:

$\sqrt{\text{new pressure/old pressure}} * \text{rated flow rate at old pressure} = \text{new flow rate at new pressure.}$

For example: 22 lb injectors rated at 43.5 psi but running FP @ 48PSI...  
 $\text{Sqrt}(48/43.5) * 22\text{lb} = 23.11 \text{ lbs/hr}$  as your new constant

Another example: 30 Lb injectors rated at 43 PSI but running FP @ 58PSI...  
 $\text{sqrt}(58/43.5) * 30\text{lb} = 34.6 \text{ lbs/hr.}$

Ford injectors, I believe, are rated at 39psi pressure instead of 43.5.

### ***Field Service Mode***

On the OBDI ECMs, you can jump 'A' and 'B' terminals on the ALDL while the engine is running.

WARNING! This must be done after the engine is running. This is called "Field Service Mode" and will not harm the ECM

If the ECM is in Open-Loop mode, the SES light will flash rapidly, about 2½ times per second. If it's in Closed-Loop mode, it will flash about once per second. When in Closed Loop mode, flashing less than once per second indicates the ECM is enriching the mixture above the 128 count base line. Flashing more than once per second indicates the ECM is leaning the mixture below the 128 base line.

### ***Converting \$32 or \$32b over to \$6E***

\$32, \$32b are completely interchangeable; \$6e is interchangeable IF you remove cold-start injector (operates off of a thermal switch, so the ECM doesn't have independent control of it.).

As simple as this for loading \$6E:

- 1) Select your bin (ARAP/APYP/ANZA [5spd LB9])
- 2) Reverse the Fan N/O switch in the switches list if necessary (ARAP/APYP)
- 3) Disable your cold start injector by physically unplugging the harness
- 4) Disable the VATS switch in the switches list if your car doesn't have it
- 5) Burn PROM
- 6) Drive Vehicle

### ***Limp Home Mode***

A 3.9K resistor installed between ALDL terminals 'A' and 'B' forces the ECM into Backup Fuel mode. This mode forces the ECM to use predetermined fuel calculations in the ECM PROM instead of the learned inputs in active RAM. This is more commonly referred to as the "Limp Home" mode of operation. Backup fuel is usually around 12:1 or richer from the factory.

Limp home mode is the mode you are in if the Service Engine Soon light stays on due to a code being encountered by the ECM (see the codes down below)

### *Lean 'POP' condition*

A lean pop when it's bad sounds like a big thud in the engine or intake system, not so much in the exhaust. A lean pop is not while you are **driving** around and let off the gas quick, then hear a "gunshot" from the exhaust, because the ECM hasn't shut off enough fuel (DFCO and Deceleration Enlean) when the throttle suddenly closes.

A lean pop when you get on it means too small a pump shot, not long enough, decays too quickly or doesn't come in quick enough.

Get the BLMs in order first. I started with an ARAP bin, and made my own ramped timing table having all 34 deg in by 3000rpm and I idle at 19 deg.

AE tables and the AE constants are what you need to adjust, and add more fuel. Take it slow. Start with the Constants, and the size of the AE.

Tables contributing to lean-pop:

**LV8 Accel. Enrich. decay rate vs. coolant temp.** Lower the values and the pumpshot won't go away as fast. At operating temp I lowered the values from 39 to 26.

**Accel Enrich%BPW Factor vs. Async Pulse:** Pulse 1 is 3.59, 3.30, 3.20, and 3 for pulse 4-8. Adding #s increases pump shot.

The big change happened here: **LV8 Accel Enrichment Coolant factor vs. coolant temp.**

Stock ARAP: 306F(0), 262F(.05), .05, .05, .15, .35, .43, .43, .43

Modified: 306F(.3), 262F(.03), .35, .35, .35, .35, .35, .40, .40

And my Min Delta %TPS for AE Constant is at 3.13,  
and the Min Delta LV8 for AE is at 18.

These fueling changes, along with the timing at 20 idle up to 34deg by 3000 gives me excellent throttle response, no stumble, and NO MORE LEAN POP.

### *Torque Converter Clutch (TCC) Info*

An important aspect of TCC control is that the ECM does **not** check to see when the TCC should be locked. It does the opposite: **it checks to see when the TCC is to be unlocked.** The TCC logic goes through a series of checks to see if there is a reason to unlock the TCC. **If there is no reason for it to be unlocked, it will then be locked.**

The only deviation to this logic is a mandatory lock above a particular vehicle road speed.

Operation:

A minimum road speed is required before the TCC will lock. The actual speed threshold can vary depending upon which gear the transmission is in. To keep the TCC from chattering the required road speed will use two values. If the TCC is currently locked the

unlock road speed threshold will be a value lower than if the TCC is not currently locked. This action is called hysteresis. These values are typically a couple of MPH apart.

An example would be the road speed values of 38 mph & 36 mph. If the TCC is unlocked it will stay unlocked as long as the road speed is below 38 mph.

Once the TCC locks the unlock road speed will be the 36 mph threshold. In this manner if the vehicle speed is held at 38 mph the TCC will not continuously lock/unlock causing chatter. If vehicle road speed falls below 36 mph the TCC will be unlocked.

f) The TCC unlock parameter most commonly known is the **TPS% required to unlock vs. vehicle road speed**. There may be one or more of these tables dependent upon the current gear in use. A table consists of two sets of values. One set is used when the TCC is unlocked. The other set is used when the TCC is locked.

The table values are typically based on vehicle road speed. Many ECMs have an option to allow these tables to be vehicle engine speed based.

The sets of values may have 12 entries ranging from 20 MPH to 60 MPH. This allows the amount of TPS% required to unlock to vary according to vehicle road speed.

### **TRUSTED-ADVISOR TUNING SITES:**

<http://diy-efi.org/gmecm/papers/tunetip.html>

<http://www.gearhead-efi.com/Fuel-Injection/forumdisplay.php?10-GM-EFI-Systems>

<http://www.thirdgen.org/techboard/dfi-ecm/>

<http://www.edgesz28.com/edgesz28/suburban/suburban-home.htm>

### **Abbreviations:**

<http://diy-efi.org/gmecm/fag/biglist.txt>

AFR Air Fuel Ratio

AE Acceleration Enrichment

BPW base pulse width

BLM Block Learn Multiplier: Block learn multiplier. Part of the self tuning capability of the ECM. An ECM typically has a table of BLM values, indexed by MAP and RPM. When the engine is in closed loop mode, the O2 sensor is monitored and fuel is either added or subtracted to maintain 14.7:1. Over time these changes accumulate in the BLM table.

INT Integrator

IPW Injector Pulse Width

IS Idle Speed

ISC Idle Speed Control

LV8 load variable



## ECM / PROM Reference Chart ODB I II

[http://www.gmhightechperformance.com/tech/0704gm\\_factory\\_pcms/viewall.html](http://www.gmhightechperformance.com/tech/0704gm_factory_pcms/viewall.html)

### Throttle Body

Year (TBI eng.)	1988	1989-1992	1994-1997	1997-1998	1999-2000	2001-2002	2003-2007
ECM Type	C3	C3	Gen 2LT1 /LT4	Gen 3 L31	LS1	'blue'	'Green'
ECM ID	1228063 1227747	1228746 1227747	94 Trk: 16196395 Trk 96-99: 16197427	Trk 96-99: 16197427	Trk 96-99: 16197427	1220041 1	12576106 12586243 12586242 12583560 12583561 12589463
EPROM Type	2732A	2732A					
BIN Size	4Kb	4Kb	128Kb	512Kb		512Kb	1Gb
Mask Program ID Calibration	\$4D \$42	Trk: \$85 \$61 \$42	Trk: \$0D, \$31, \$E6 HD:\$0E	Van: \$63/\$0D			
Baud Rate	160	160					
MemCal	No	No					
Bare EPROM	Yes	Yes					

Year (TPI eng.)	1985	1986	1987	1988	1989	1990-1993	1994-1997	1997-1998	1999-2000	2001-2002	2003-2007
ECM Type	C3	P4	P4	P4	P4	P4	Gen 2 LT1 /LT4	Gen 3 LS1	LS1	'blue'	'Green'
ECM ID	1226870	1227165	1227165	1227165	1227165	1227730	96: 16214399 97: 16242921 F: 16188051 Y: 16181333	16238212	09354896  Trk 96-99: 16197427	12200411	12576106 12586243 12586242 12583560 12583561 12589463
EPROM Type	2732	27C128	27C128	27C128	27C128	27C256					
BIN Size	4Kb	16Kb	16Kb	16Kb	16Kb	32Kb	128Kb	512Kb		512Kb	1Gb
Mask Program ID (Calibration)	\$1F	\$32	\$32B	\$32B	\$6E	\$8D	LT5: \$F0 \$EE				
Engine Management	MAF	MAF	MAF	MAF	MAF	Speed Density					
Baud Rate	160	8192	8192	8192	8192	8192					
MemCal	No	Yes	Yes	Yes	Yes	Yes			.		.
Bare EPROM	Yes	No	No	No	No	No					

## BINS

<http://www.gearhead-efi.com/BCCFind/>

ARAP: Stock '89 Vette Alum heads 350 w 700R4 (Arap 6E)

APYP: APYP is the manual equiv of ARAP; 6spd, 3.33/3.54 Y car

Abtm\_32: ??

Abtz\_32: ??

85TAtpi305A: Stock '85 T/A TPI305 w 700R4

85tpi1.bin: Stock '85 Z28 TPI; (Feb85 Delivery -305,TPI,700R4,AC,Z28 - "Buggy?")

85vette2.bin: Stock '85 Vette; (Later ECM - 350, TPI, 700R4, AC - 22 lb injectors)

Aum0122.bin: 1986 F-body 5.0 TPI (Personally Read from chip)

86TPI\_32: VERY similar to AUM (only 4 bytes different)

86z28stk: very similar to AUM0122 (10 bytes different: prom, checksum, fuel limiter)

86-88FBA350: MAJOR difference to AUM0122. Close to 87z28stk, 87Z\_TPI\_, akfm2174

AUM 3236: 1986 TPI 5.0 F-Body, Auto, AC, Fed+CA emmis,

87z28stk: (87Z\_TPI\_305\_auto\_stock\_16k). Stock '87 Z28TPI305 w 700R4, 3.42.

Similar to akfm2174

87Ztpi305A342.bin: (87Z\_TPI\_305\_auto\_stock\_16k) Stock '87 Z28TPI305 w 700R4, 3.42

ACXX: 1987 305 F Body Auto 3.23/3.27

akfm2174: Stock '88 Z 305 w A4, 2.73 (fed)

88CORV\_32: Same as 88corv\_6e:

ANPK 6427...1988 5.0 F Body, TPI, 5spd, 3:45, Fed emmis.

89corv\_6e: Similar to Arap 6E

89f305a4: Duplicate of 89FBA305a4

89FBA305a4: '86-'89 F-body with 305/TPI/A4 No VATS (Built from M5 stock image)

89FBA35032: (89FBA350\_32)

89Z\_TPI\_350\_Auto\_327\_stk

AUJM: 89 F body...5.7L....auto....3:27... FED

APYN/APYN3496 (4bytes off): 89 F body....5.7L...auto....2:77...FED

Apyn3496 6E: Duplicate of APYN 3496

APYU 3516: 89 F body....5.7L...700R4....3.27 (GW6) FED

APYU3516\_\_89Z\_TPI\_350\_auto\_327\_stk: heavily changed

Arap 6e: Stock '89 Vette Alum heads 350 w 700R4...3:07

ARAPZZ4: minor variation of Arap 6e: 86-89Z 24lbs, 160Therm

## Speed Density programming:

ANHT is a aluminum head 'Vette calibration for the 1227727 (1227730 under hood package)

AUJP is a common F-body TPI auto trans calibration for the 1227730 ECM.

Where to start:

For SD systems, you should start with your VE tables as this is what controls your mixture.

Go with the AT29C256 Flash Prom.

Second, start with the 90-91 Corvette ANHT BIN. The Corvette BIN, while VERY CLOSE to an F-body BIN, also is different. The Corvette BIN has code to work with the oil temp sensor which the F-body version does not. Also, choose the proper BIN for your transmission i.e. ANHT with a 6-speed for the Corvette if you have a manual tranny. The best place to start is, typically, your own Memcal.

Changes to make BEFORE even touching the VE Tables:

1) set your Cylinder Volume in the constant table to 784cc. This will tell the ECM what size of motor you have to calculate the proper amount of fuel.

2) Set your Injector Flow constant to the "rated flow" of the injector. If you know the "correction factor" for the particular fuel pressure you are running (I recommend around 46-48 psi), use that. But don't get too hung up as whatever you put in here is going to be changed.

3) Set your "Desired Idle Speed Vs. Coolant Table". This is assuming you have set your IAC and TPS. If you have not reset your IAC or TPS, go to the "Tech Articles" on this web site and read up on how to adjust the IAC, it is VERY SIMPLE but needs to be adjusted properly before you even begin to tune your EPROM.

If your IAC/TPS are adjusted properly, then go into the "Desired Idle Speed vs. Coolant Temp" to make the adjustment for the idle speed you want. With your LT-4 Cam, you probably want a higher idle than the stock BIN of 600-650 RPM. Probably more like 750ish at proper operating temp.

4) Now start taking your car for a "little drive" and drive at reasonably light throttle. An interesting observation that I have made is the lower VE Table for low-mid Load (kpa) and low-mid RPM is actually very similar for ALL SD engines, if the Cylinder Constant and Injector Constant are reasonably correct.

If at part throttle (1200-1600 rpm/40-60 Kpa) the BLMs are all way below 128, then **increase** the Injector Constant to lean the engine which will raise the BLM value.

Conversely, if the BLMs are all way **above 128**, then **decrease** the Injector Constant to richen the engine and lower the BLM value. Do this adjustment until you notice that half of your BLMS are above 128 and half are below 128 (best scenario) or reasonably close to a range of 120-135. But the closer you can get most of the readings on the 1200-1600 rpm/40-60 Kpa to 128ish, the better.

5) Now you are ready to begin tuning your VE table. In fact, you may find your car is even running reasonably well and fairly close...now you have a BIN close to what someone else would probably have e-mailed you or would have bought from a custom prom writer. Follow the "P730: Part throttle tuning VE (no PE)" and begin tweaking your VE tables. This will get your fuel mixture correct and once done, you will be ready to start tweaking the spark.

# Tuning Diary: History of Changes

## 72 GMC K2500 '86 MAF TPI 700R4 NP205 4:10 31" 4800Lbs

86 305 TPI MAF, 700R4+2600, NP205, 4:11, 31" tires, Vortec heads/baseplate

86 1227165 + Stock MemCal + TPIParts 'original' chip (w/ adaptor), \$32:

- No Vats, No oil switch
- Venom 24Lbs injectors
- Fan 205/190
- 6000 limiter

Sep 3, 2010: driving results:

- TPI chip A: good Part-Throttle response. WOT = SES code 43
- TPI chip B: PT = SES 43
- Rick chip B: 6Miles PT very good. Hwy AW/PE = SES 43
- TPI chip C: 3M of PT then 1M of hwy. SES 43 on hwy
- Return to Original chip: no codes, sluggish, no power, no PT response 'blatty' sounding, wrong TCC
- Back to stock MemCal and no chip/adaptor:
  - No codes, 'slow' low-end but great hwy, good TR, 'smooth' sounding
  - Best so far. Head to Mountains: under load = SES 43

\*\*\*\*\*Sep 6, 2010 9AM: start with basics again:\*\*\*\*\*

- Check Timing at 8 deg mechanical
- Check Fuel Pressure: 60 PSI DOH!!!!!!!
- Reset FP to 39 (vacuum removed)
- Fixed vacuum leak at throttle body:
  - Tightened up EGR vacuum line as well at plenum

Sep 6, 2010 11AM: Start with MemCal, Original Chip + adapter:

- Remove 2 deg directly from distributor
- Crappy. Even worse than before

Sep 6, 2010 1PM: MemCal, Original Chip + adapter

- **Set timing back to 8 + add 2 deg mechanical advanced**
- Better; off-idle 'POP' now
- Idle stumbles a bit; isn't smooth - jumps around

Sep 6, 2010 2:30PM: MemCal only

- Keep timing 2 deg mech advanced (10 deg total)
- 15M PT and FT hwy w/ no codes
- Better response across rpm range

Sep 8, 2010

### 1. AUJM stock E

- a. Disable VATS, EGR
- b. Change Fan to 86C off, 94C on

### 2. AUJM F (includes all changes from E)

- a. From E: Disable VATS, EGR, Change Fan to 86C off, 94C on
- b. Change TCC Unlock Speed Vs. %TPS (In 4th)
- c. TCC Unlock Speed Vs. %TPS (Not In 4th)

- d. TCC Lock Speed Vs. %TPS (In 4th)
  - **The best so far**
  - Great power
  - Great TCC operation
- 3. **ARAP stock**
  - a. Disable VATS, EGR
    - **Pretty good.** Good power, hwy was alright, but lacked power in 4<sup>th</sup>
    - **Wasn't entirely happy with TCC settings**
- 4. **APYU\_base\_TCC\_Fan\_VATS**
  - a. Disable VATS/VATS diag, EGR/EGR Diagnostics
  - b. EGR Off 0%; EGR On 100%
  - c. Change Fan to 86C Off, 94.25C on
  - d. TCC unlock low 14, lock low 38, unlock high 35, lock high 44
- 5. **APYU\_base\_TCC\_Fan\_VATS\_Inj\_**

Sep 15, 2010

- 1. **AUJM F rev2**
  - a. Includes all TCC\_FAN\_VATS from AUJM E + AUJM F
  - b. LV8 Accel. Enrich. Decay Rate Vs. Coolant Temp
  - c. LV8 Accel Enrich Coolant Factor Vs. Coolant Temp.
    - 'morning' pop and stumble improved
    - Ran great once warm
- 2. **AUJM F rev3**
  - a. Normally Open Fan Request Input no NOT SET
  - b. Fan On Coolant Temp Threshold up to 96.5C
  - c. Minimum Delta LV8 For Accel. Enrich. From 128 to 80
  - d. Minimum Delta TPS For Accel. Enrich from 99.61% to 48.05%
  - e. Accel. Enrich %BPW Factor Vs Async Pulse
  - f. LV8 Accel. Enrich. Decay Rate Vs. Coolant Temp
  - g. LV8 Accel Enrich Coolant Factor Vs. Coolant Temp.
    - Don't recall how it ran, but went back to ver2 from here
- 3. **AUJM F rev3\_Inj\_G**
  - a. Changed injector flow rates (I think incorrectly)
    - **Wouldn't Start**
- 4. **AUJM F rev3\_Timing\_H**
  - a. Spark Advance vs. RPM vs. Load
  - b. Spark Advance In WOT Vs. RPM
  - c. Maximum Knock Retard, (In WOT)
    - Don't recall what happened

Round 4 Sep 16, 2010

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- 1. **AUJM F rev4**
  - a. No. of Accel Enrich Async Pulses Vs. Coolant Temp.
  - b. Accel. Enrich %BPW Factor Vs Async Pulse
  - c. LV8 Accel. Enrich. Decay Rate Vs. Coolant Temp.
  - d. LV8 Accel Enrich Coolant Factor Vs. Coolant Temp.
    - **Threw Code**
    - **Wouldn't Run**

Round 5 October 9, 2010

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- 1. **AUJM F rev5**
  - a. Changed Fan on/off slightly

- b. Normally Open Fan Request to NOT SET
- c. Injector Flow Rate from .21 to .24
- **Wouldn't start**

## 2. AUJM F rev2 A

- a. copied ARAP timing table exactly
  - i. Spark Advance Vs. RPM Vs. Load

## 3. AUJM F rev2 D

- a. copied 87Z\_TPI\_305\_auto\_stk\_16K tables exactly
  - i. Spark Advance Vs. RPM Vs. Load
  - ii. Spark Advance In WOT Vs. RPM
  - iii. WOT %Change To Fuel/Air Ratio Vs. RPM
  - iv. WOT %Change To Fuel/Air Ratio Vs. Coolant Temp changed.
  - v. %TPS To Enable WOT vs. RPM
  - vi. Maximum Knock Retard, (In WOT)
    - Really like!!!
    - Very small hesitation off idle
    - No more pop/sputter

Round 6 October 17, 2010

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## 1. AUJM F rev2 A.1

- a. copied ARAP timing table exactly
  - i. Spark Advance Vs. RPM Vs. Load
  - ii. Max knock retard
  - iii. WOT %Change To Fuel/Air Ratio Vs. Coolant Temp
  - iv. Open Loop Fuel/Air Ratio %Change vs. Load
  - v. BPW Fuel vs. Load, (msec)
    - Ran good at cool temperatures
    - **Just wouldn't climb any hills—plain flat, no pull**
    - **Did get 12 mpg once**

June 27, 2011

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To recap notes so far:

- have been running AUJM F A.4 for 6 months averaging 10.1 MPG. Still doesn't climb hills under load (ARAP timing tables, mostly).
- Did return to AUJM F A.1 in late April, 2010. Did get 12 MPG once....but doesn't climb hills under load as well.
- Ordered a Data Logger from Moates today after putting up with this enough!!!!

Going to create a few chips based solely on stock settings to get a feel as to how far off from stock we really are. I still don't know if the 'blatty' sound is exhaust or crappy timing. But it's (currently) loud and very noticeable.

Using TunerPro RT V5

Round 8 July 3, 2011

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TunerPro RT V5.7686, \$32B XDF, 1227165\_6E ADX (upgraded this morning)

- 1. **89Z\_VATS\_EGR disable T1** (T for Timing...made my own table)
  - a. Spark Advance Vs. RPM Vs. Load changed/created
    - i. Made my **own entire table** from scratch
    - ii. Added timing based on RPM AND load...



- iii. Assumed that the **10degree base** was the starting point for this table and that the values in this table are added to base to get overall timing...need to verify when data logging???????

RPM	Load Value (LV8)												
	32	48	64	80	96	112	128	144	160	176	192	208	
4800	24.26	27.42	29.88	32.70	34.10	35.16	35.51	35.86	36.21	36.21	31.99	29.88	
4400	18.63	24.26	26.37	28.48	31.29	34.10	35.16	33.75	35.51	36.21	31.99	30.59	
4000	17.58	21.09	22.85	25.31	27.42	30.94	32.70	35.16	34.80	35.16	31.99	30.59	
3600	15.82	17.93	20.39	22.50	24.26	29.18	31.99	33.75	33.75	35.16	31.64	29.88	
3200	13.01	13.71	17.23	19.69	22.50	27.07	30.94	33.40	33.40	33.75	30.23	29.18	
2800	9.84	11.95	14.06	17.23	20.74	26.02	29.88	31.64	30.94	30.94	29.18	28.48	
2400	8.44	8.79	9.84	15.82	19.69	24.61	28.13	31.29	29.53	29.53	28.83	27.07	
2200	7.73	7.73	8.79	14.06	17.93	22.50	26.37	29.53	28.13	28.13	27.77	26.37	
2000	5.98	6.68	7.38	12.30	16.52	20.74	24.61	28.83	26.72	27.07	26.02	25.66	
1800	3.87	4.92	5.63	10.55	13.36	17.23	22.85	24.26	24.96	24.96	24.61	24.96	
1600	3.16	3.87	4.22	8.44	11.95	15.12	19.34	21.80	23.20	22.15	22.15	22.15	
1400	2.11	2.81	3.87	7.73	10.20	10.55	15.47	17.58	18.28	18.98	18.98	18.98	
1200	2.11	2.11	3.16	5.98	7.03	8.44	10.55	11.25	11.60	13.36	13.71	16.17	
1000	2.11	1.41	1.41	2.46	3.16	4.92	5.27	5.63	5.27	4.92	5.63	6.33	
800	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.11	2.11	2.11	2.11	
600	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.11	2.11	2.11	2.11	
400	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.11	2.11	2.11	2.11	

**2. 89Z\_VATS\_EGR disable T4**

- a. used T1 Spark Advance Vs. RPM Vs. Load table
- b. used T2 Spark Advance in WOT Vs. RPM
- c. %TPS To Enable WOT vs. RPM
- d. Changed all TCC variables to mirror AUJM F (Sep 8, 2010)
  - i. TCC Lock Speed (Low Gears) changed from 255.00 MPH (0xFF) to 40.00 MPH (0x28).
  - ii. Table: TCC Unlock Speed Vs. %TPS (Not In 4th) changed.
  - iii. Table: TCC Lock Speed Vs. %TPS (In 4th) changed.
  - iv. Table: TCC Unlock Speed Vs. %TPS (In 4th) changed.
  - v. Scalar: TCC Unlock Speed (Low Gears) changed from 29.00 MPH (0x1D) to 29.00 MPH (0x1D).

**Round 9 July 6, 2011**

TunerPro RT V5.7686, TunerPro RT\Bins\Bentley Bins\Round 9: \$32B XDF, 1227165\_6E ADX.

**Using logging, ECM gives the total timing (relative to TDC) in the spark table – does not add in base mechanical.** So I am changing the 'idle' timing to 10 degrees. This is going to uplift all other values, but will smooth them out (using the graph) so as not to exceed my max of 36.21

Doesn't seem like the TCC clutch is actually engaging in 4<sup>th</sup> gear...logging says overdrive engaged, but unsure if this reading is accurate.

Also, researching Fan settings – if using a 6E, you must change fan N/O from 32/32B...since I found a new 6E mask (6e\_extended) from thirdgen.org web site that has MUCH more variables than standard 6e

Going to create a different chip that changes idle timing (leaving the rest alone) and changing TCC settings to see why 4<sup>th</sup> isn't locking up.

Then going to create this new chip program in both a 32B and a 6E to see if there is a difference.

- **89Z\_VATS\_EGR disable T5 (T for Timing...made my own table)**

- e. adding 10 to the 'lower' areas
- f. raising middle a few points
- g. raising mid to high a just a little
  - AWESOME---best so far---pulls in all RPMS
  - Climbs hills FOR THE FIRST TIME
  - 11.1 MPG (solidly in the 11's)
  - doesn't appear that the TCC engages in 4<sup>th</sup> gear though
  - and it probably could use a tad more timing at top end since I never hit the knock sensor

Round 10 July 7, 2011

Wanted to try the difference in XDF (data definitions) to see if anything changes just using them. I didn't, however, disconnect the cold start injector before trying these. That is an action item *left to do: dis'c cold-start injector THEN try \$6E formats*

- **89Z\_VATS\_EGR disable\_T7**

- h. saved as a \$32b (did increase all timing by 5 degrees to see if I could raise the top end but also raised the 'initial' into the 10+ range) – **didn't start**
- i. saved as a \$6E: **Didn't Start**
- j. saved as a \$6Eextended (the new format from thirdgen.org website
  - **NONE WORKED**.....Will need to retest at some point in time

## **T12 TCC2**

Created a XLS graph and burned this homemade program.  
**Still didn't lock up**

### **1. T12 TCC3**

Created a XLS graph and burned this homemade program.

**Used all AUJM F TCC settings (Sep 8, 2010)**

- Locks up good in 4<sup>th</sup> but doesn't stay locked up with much throttle pressure.
- All the way up to 75-80 MPH still unlocked
- **Absolutely no power in 4<sup>th</sup> gear climbing any slight incline – just flat**

### **2. T12 TCC4 – still based on AUJM F Rev 2 D**

Created my own tables in XLS and copied them over (TCC4)

Changed TCC lock/unlock scalars closer to 87Z\_TPI\_305\_auto\_stock\_16k

Changed startup fuel/air ratio to 87Z\_xxxxxxxx

Changed spark tables slightly in the low rpm/LV8 boxes

1. BEST TCC operation EVER.
2. Love the lockup – happens immediately when shifting into 4<sup>th</sup> gear
3. Not sure, though, if it locks up in 3<sup>rd</sup> gear or not
4. **Locked up in 4<sup>th</sup> would actually accelerate up an incline w/out downshifting – meaning it actually stays in O/D under Hwy Acceleration!!!**  
**YEAH**
5. Good mid range power
6. **Wont stay running VERY first thing in the morning – stumbles then dies. Pops and misses until warmed up**

**NEW CONCLUSION:** Any 1989 BIN MUST USE 6e mask otherwise the graphs are all spiky, up and down, across all ranges if you use 89 BIN with a 32b mask.

1. OK: opening 89 bin in 32b, then saving it as 32b **WILL** work
2. Opening 89 bin 32b, converting to 6e and saving, will NOT work
3. **You must open the bin, select the XDF, THEN MAKE CHANGES and save as that XDF file. You must always open and save in that same XDF. You CANNOT open in one XDF, open a different XDF and then save it – it WILL NOT WORK**

\*\*\*\*\*

**Interesting note is that the chip I was using wouldn't data-log. But soon as I swapped back to the TCC12 T4 chip, would data log just fine. Maybe there is a batch of chips that won't work right???????**

Round 18: September 4, 2011

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There are 4 really good tunes, all with their own good traits:

1. T12 TCC4, which is based on a combination of AUJM F Rev2 D(89 F 350 Auto w 87 timing tables) and T5v4
  2. T17.8, which is bone stock for AKFM2174 (88 F 305 Auto)
  3. ACXX (87 305 F Body Auto) – stock MEMCAL, not in tunerpro
  4. AUJM F rev2 D
    - a. Probably in that order.
- Next steps are to compare all the differences from these four, plus data logs from each of the four.
  - Will need to continue using the 32B XDF since I've proven that 6E will NOT work unless the cold start injector is unplugged.
  - Will also need to compare fuel mileage and mountain driving between these four.

BIN	T12 TCC4	T5v4	T17.8	AUJM F r2 D
T12 TCC4	X	timing, TCC, Startup A/F, WOT A/F, Idle speed	timing, highway mode, spark WOT, TCC,Fan, Accel Enrich,crank PW, inj PW, A/F ratios, BPW, MAF, WOT, Idle, etc	spark, TCC, WOT, Idle,
T5v4			timing, highway mode, spark WOT, TCC,Fan, Accel Enrich,crank PW, inj PW, A/F ratios, BPW, MAF, WOT, Idle, etc	spark, TCC, WOT
T17.8	avail	X	x	avail
AUJM F r2 D	avail	avail	avail	x

Narrowing this down, based on the comparison of my "favorite four", shows that only two of the BINS are that dissimilar:

1. **T12 TCC4** (evolution of T5v4, evolution of AUJM F r2 D)

2. **T17.8** (going to be the Round 18 baseline since .1 thru .6 failed)
3. Need to evaluate the stock ACXX MemCal (cannot read into Tunerpro)

T12 TCC4 uses BPW table, while T17.8 calculates on the fly (doesn't use table)

T12 TCC4 MAF tables very spiky, while T17.8 is smooth and gently increasing

T12 TCC4 timing table is higher at high RPMs, while T17.8 is higher at low RPMs

Conclusion: drive with each chip up into mountains and record fuel mileage for each.

T12 TCC4 just averaged 10.2 MPG (Sep 4 filled up)

Also yet to test:

- ~~Can a 6E with cranking PW set to nil/zero allow the truck to start? NO (CSI 1)~~
- Smooth out MAF tables on T12 TCC4
- Smooth out BPW tables on T12 TCC4
- Smooth out Max Airflow tables on T12 TCC4
- ~~Change T17.8 to larger injectors = R18.1~~
- Change T17.8 timing tables to match my own custom tables from T12 TCC4
- Change T17.8 to use BPW table

**R18.2: Used R18 then lowered Injector Flow Rate from 20.82 to 19.00**

- Started right up; data logged just fine
- Fans on at 150 F; got up to 210 F during test drive
- TCC operation is WAY too early for me – need to fix
- **Great BLMs:** half below 128, half above 128; cruise = 128
- Seemed "dead" at low rpm, slight incline but revved quickly after 1700 RPMs
- Medium throttle really pulled hard – awesome shift into 2<sup>nd</sup> gear!!!!
- Full tank of fuel.

Therefore. Going to fix the TCC operation first, get through a tank of fuel, then try either MAF table alteration, or switching over to BPW table method. (still have T12 TCC4 ideas to play with as well)

Round 19 September 5, 2011

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**R19.1: base is R18.2** but altering for open loop changes, fan changes, TCC changes

- Fan N/O request Input changed to NOT SET (unchecked)
- Open loop A/F ratio %change vs. temp
- Open loop A/f ration %change vs. load
- Startup A/F ration %change vs. temp
- TCC scalars: ½ way between 18.3 (no 3<sup>rd</sup> l/u) and 18.2 (way too early/often)
- **FIXED OPEN LOOP**
- **Transition from O/L to Closed Loop was a bit 'rough' (smooth to choppy)**
- **Fans NEVER came on – cannot do N/O to not set – MUST BE SET**
- **THREW CODE FOR Knock Retard: hit 50 Deg spark advance**
- **TCC operation was VERY VERY good ☺**

**R19.2: keep N/O to NOT SET, but change Fan On/Off...A/C settings both match**

- On from 107C(225F) to 104C(219F)
- Off from 104C(219F) down to 95C (201F)
- SUCCESS!!!!!! Fans startup at 225F then shut off at 201F

**R30, Dec 25, 2011: \*\*\*\*NEW BASELINE for Timing+Initial Timing\*\*\*\*\***

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- Used 27.1 as TCC Fan baseline
- **Reset initial mechanical at 8 deg**
- Disc battery to clear all codes
- Used essentially akfm2174 STOCK 1988 Bin but disabled Vats, EGR etc.
- Pure stock Bin did GREAT (once set mechanical back to 8)
  - Left initial programming at 10.55 and did test drive = NO CODES
  - Created new R30 Base that alters Open Loop, Startup factors since very first startup had a bit of a cough before it smoothed out.
  - Set initial timing programming to 7.38 (close to 8 as can get)

Results:

\*\*\*\*\*CHANGED OVER TO \$6E – 1989 BINS\*\*\*\*\*

My thread @ thirdgen.org: <http://www.thirdgen.org/techboard/dfi-ecm/636802-spark-adv-exceeding-table-2.html>

Notes: Analog MAF Meter in use (HLM) @ Loc 0x14: \$6E is an analog MAF only mask. GM then used that same option flag location as the 4th gear NC or NO selection. As long as the TCC looks up at a higher MPH when the transmission is actually in 4th gear (then 2nd or 3rd), then the option flag is set correctly.

The **PW based tuning tables went away in \$6E**. Gone. \$6E uses the MAF airflow and calculates an injector PW.

Note that \$6E has a lean cruise mode for better mileage.

**R60, April 2, 2012: \*\*\*\*NEW FACTORY BINS FROM THIRDGEN.ORG\*\*\*\*\***

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- Finally perfected TCC operation after going through many factory BINS
- Settled on an 89 Vette 5.7 Auto ASXB as the baseline bin but altered the TCC stuff to get exactly what I want
  - Did, however, loose lockup in 3<sup>rd</sup> gear (*unlike akfm2174*)
  - This may be the Flag: Analog MAF Meter in use (HLM)
    - This is leftover from older stuff and mislabeled per <http://www.thirdgen.org/techboard/diy-prom/625682-flag-6e-switch-nc.html>
- OCT 12, 2012: ASXB\_R6\_ver\_6: perfect TCC (although lost lockup in 3<sup>rd</sup>)
- Fiddled a bit more: ASXB\_R6\_base\_ver3: PERFECTED
- PROBLEM Dec 2012: wouldn't start in single-digit cold weather!!!!...cranked and cranked.

**R61, Dec 27, 2012: \*\*\*\*Using asxb\_R6\_NewBase\_ver3 as new baseline\*\*\*\*\***

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- New Cold Weather (\_cw\_) tuning since mornings have been in low single digits
- **ASXB\_R6\_NewBase\_ver 4\_cw**
  - Started at 6Deg F this morning
  - But did crank about 8 times, instead of its normal 4 times

- Did logging back and forth to work: Dec 28
- **ASXB\_R6\_NewBase\_ver 5\_cw**
  - Started great this morning: 14 Deg F
  - Based on new learning's on thirdgen.org:
  - Removed the additional 2.96 degrees from Scalar: ALDL Spark ADDER
  - Did logging back and forth to work: Dec 29
- **ASXB\_R6\_NewBase\_ver 6\_cw**
  - Very small tweaks to hopefully shorten the cranking time to start
  - <http://www.thirdgen.org/techboard/diy-prom/458573-crank-bpw-too-high.html>

**R70, Dec 29, 2012: \*\*\*\*TRYING A VORTEC TUNE FROM 95 TRUCK\*\*\*\*\***

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1994-1995 TUNES USE Kpa, not LV8 – here is the conversion

$$80 - (5/16)*LV8$$

LV8=	32	48	64	80	96	112	128	144	160	176	192	208
Kpa=	70	65	60	55	50	45	40	35	30	25	20	15

- base was ASXB\_R6\_NewBase\_ver 6\_cw
- Created **asxb\_R6\_R70\_Vortec SA\_ver1.bin**
  - 1994 L31 (Vortec) truck motor
  - converted LV8 to Kpa using table above.
- Ran great! Good acceleration, rev'd very quickly.
- Did appear that it entered PE at a really low throttle input

Good info on a Vortec TPI build

<http://www.hotrodders.com/forum/350-vortec-tpi-build-need-some-help-advice-suggestions-204300.html>

**Jan 2013:**

**Feb 17, 2013:** still not very smooth in cold weather startup. Also, based on further research, returning to factory 1989 BINs. Plus, purchased two more TPI setups from craigslist that included factory EPROMS. **Delco APYM 3493** = 1989 5.0 Camaro Auto.

- This BIN starts awesome in cold weather
- Startup follows Idle Speed Table
- But has some sort of "ghost spark" that enters the ECM around the 200 Deg mark
- SES light at SA climbs to 50 Deg
- WTF?? Where is this extra 20 Deg coming from?
- At this 200-deg mark, it ignores AE/PE settings and adds fuel and spark MUCH earlier.
- According to thirdgen.org: another member had problems with this BIN...switched over to AUJM

Feb 17, 2013: I have been using asxb as the baseline for so long while working on timing tables. But found another thread that had better experience with vortec timing following more like the LT1/LT4 tables. So I need to try that.

But I also need incorporate the cold weather settings from apym into my baseline asxb chip.

Trying to inversely incorporate my asxb timing, fan, tcc into apym (which kept introducing ghost spark) kept throwing codes so I need to go the other way around: start with asxb and incorporate apym cold weather settings.....

The other option is to return to AUJM from Round 5 through X knowing what I know now...

ASXB is a 1989 5.7 Vette/ZR1 with 2.73 gears while AUJM is 1989 F-body 5.7 with 3.21.

Going to AUJM and adding APYM startup settings.

**Feb 17, 2013: Round 74\_AUJM Base: AUJM\_Ver 1**

- Good start! Seems like the AFR is too low (9-ish) and therefore the engine is too rich. Once AFR gets to 11-ish, idle picks up and follows the Idle Speed Table.

**Feb 18, 2013: Round74\_AUJM Base: AUJM Ver 2**

- Lessened OL AFR
- Incr Crank PW
- Changed Startup Timing
- Used LT4 SA table.
- ABSOLULETLY PERFECT!!!!!!!!!!!!!!!