Toyota Gen 1 Calibration Logic Tuning Guide

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1. FUELING – ELECTRONIC

Fuel delivery on Toyota Generation 1 ECUs uses a static formula which follows these basic principles;

1.1. Closed Loop Control

The ECU requests a constant 14.6 "**Closed loop**" AFR at all times unless commanded conditions are met:

1.1.1. Condition 1: Power enrichment has been enabled.

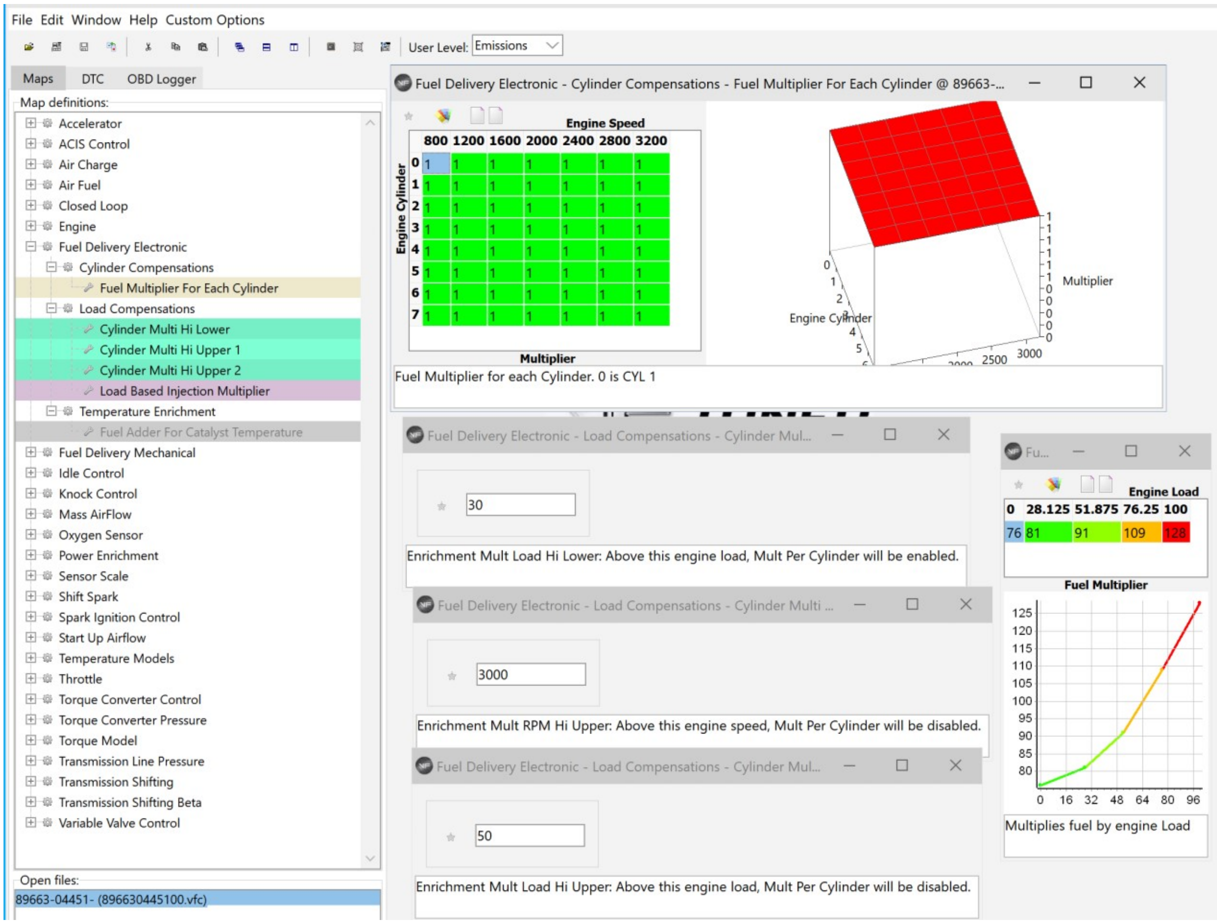
Conditions 1 is present once the thresholds (throttle, accelerator) have been met which causes the ECU to switch to Fuel trim corrected OPEN Loop and uses the target Power Enrichment (full throttle fuel target) Table for target fuel.

1.1.2. Condition 2: Catalyst over-temperature protection.

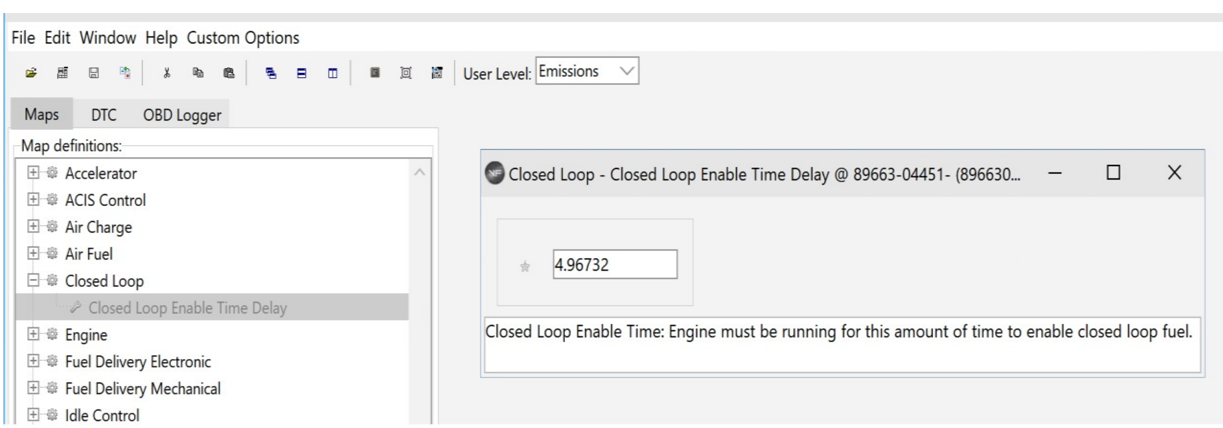
Condition 2 is present when the vehicle is not in 1st (first) gear, at high loads and high engine speeds for a preset amount of time. After this condition is met and condition 1 is NOT present, the ECU will enrich fueling based on the catalyst preservation fueling strategy (using the Fuel adder For Catalyst Temperature Table).

Note: Zeroing out the Fuel adder table DOES NOT disable Catalyst Temperature enrichment control. The ECU has additional logic strategies which provide additional enrichment. There are tables that normally do not need to be modified but under some conditions may need modified to trim for individual cylinders.

The tables Fuel multiplier for each cylinder multipliers (**1.0 = 100%, 1.1 = 110%**) for each cylinder 0 on the table = CYLINDER 1. There are breakpoints (load, RPM) that also disable or enable this table.

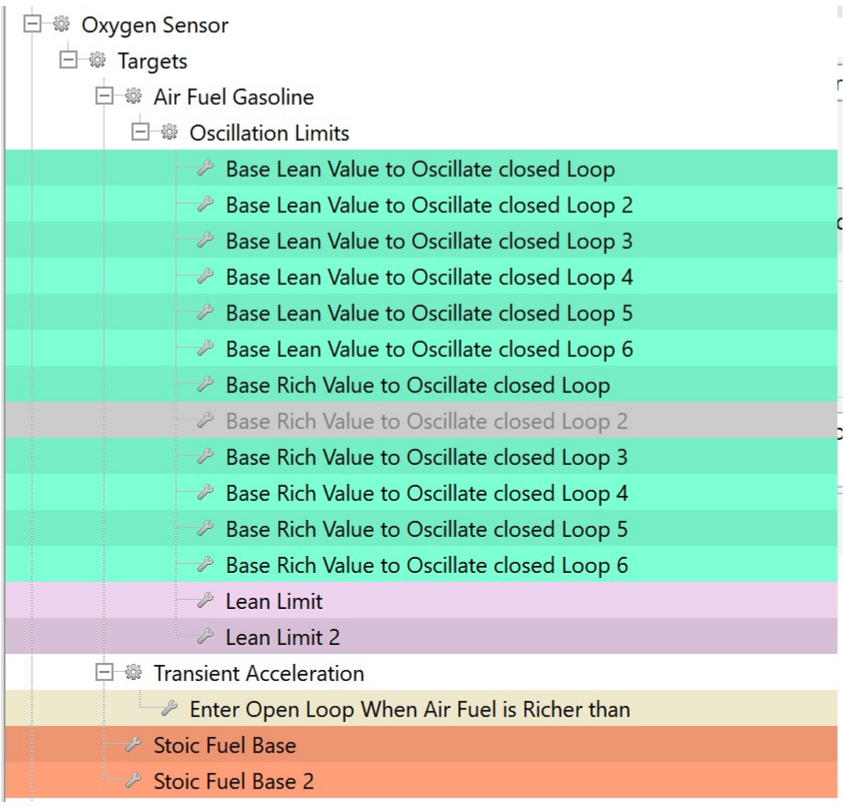


Controlling closed loop is a simple operation because the ECU will always be in closed loop as long as all conditions for fueling are met and there are no faults present. Because of this, the only table that can modify closed loop directly is available is the ***post start delay timer***. This table delays the amount of time (s) until closed loop becomes active.



1.2. Air Fuel Control / Oxygen sensor and oscillation considerations

Modifying closed loop target AFR IS POSSIBLE, with certain considerations. VF Tuner has made available the oscillation and target requests for multiple conditions in closed loop. Modifying these tables **CAN** and **WILL** directly result in changes to TARGET AFR during CLOSED LOOP (corrected) operation. **This is not recommended for normal use or driving and may cause a decrease in MPG**. You can target RICHER than stoic AFR but cannot target LEANER than stoic AFR. Stoic AFR targets are HARD CODE corrected in the ECU.



1.3. Power Enrichment

Power enrichment is a critical part of tuning that can result in drastic power increases or power losses. Understanding power enrichment operation is VERY SIMPLE, and goes back to Fueling: Condition 1 - Power Enrichment. The strategy follows these simple rules.

1. **Table power Enrich Speed Bypass Delay** (This is the amount time to delay before enrichment begins ONCE Condition 1 is active.) stock should be **0**, which means there is no delay

There are 2 tables for Throttle Thresholds; In stock form, above 79% , Throttle Condition 1 is ACTIVE and below 71% , Condition 1 is INACTIVE.

Modifying these by lowering the values can bring power enrichment (Condition 1) active sooner.

Note: It is important to understand the ECU can have CONDITION 1 and CONDITION 2 Active AT THE SAME TIME!

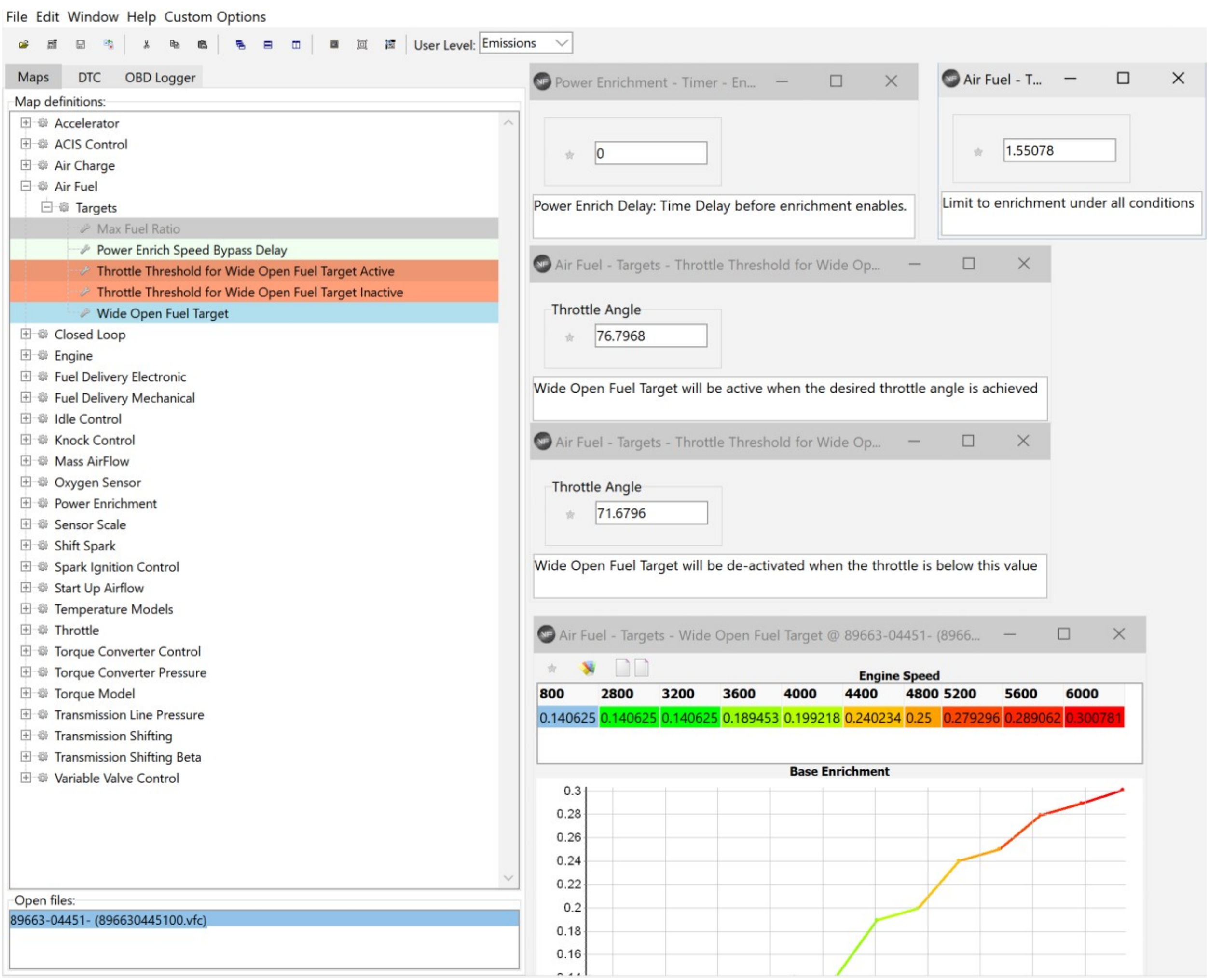


Image 4 showing power Enrich Speed Bypass Delay table

2. **Wide Open Fuel Target Tuning: -** This table directly controls CONDITION 1 Fuel request. *Smaller values* = **LESS** fuel and *larger values* = **MORE FUEL**

You can see the stock table enriches progressively and provides a lot of additional enrichment (very rich when read with a wideband) above 5200 RPM. Leaning these values out can produce more power. Data logging AFR is required for accurate open loop tuning.

You can use the stock O2 sensors to data log for N/A Applications where target AFR would be around 13.1-13.2 AFR (premium octane) for the best power.

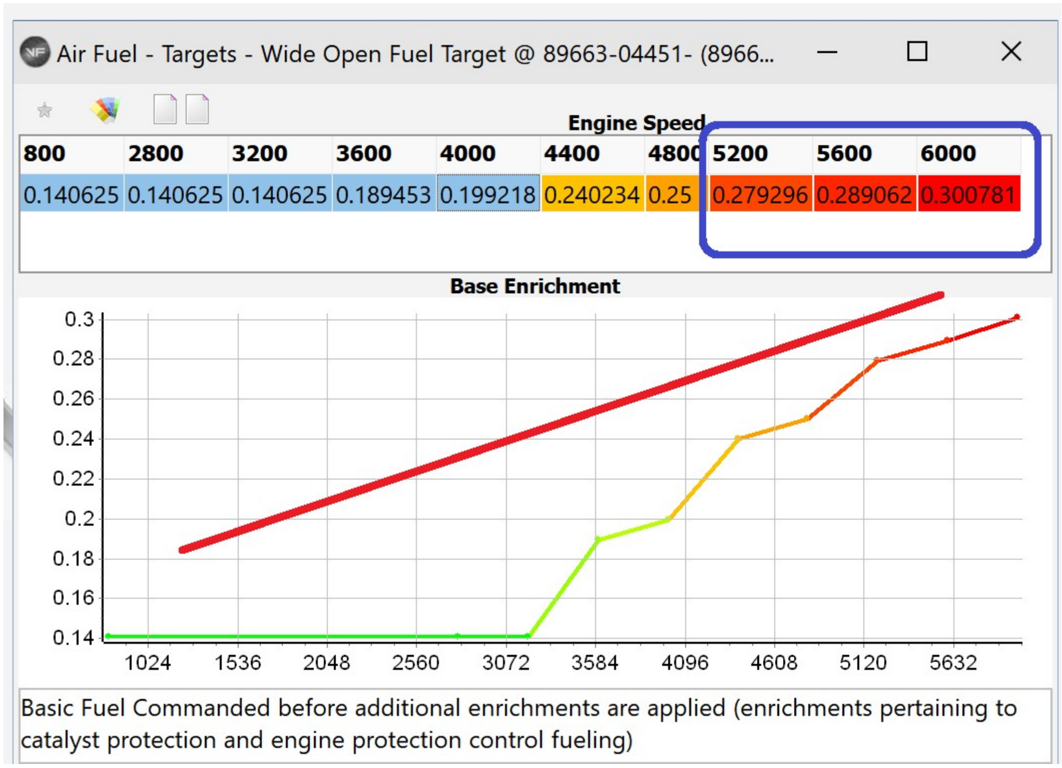
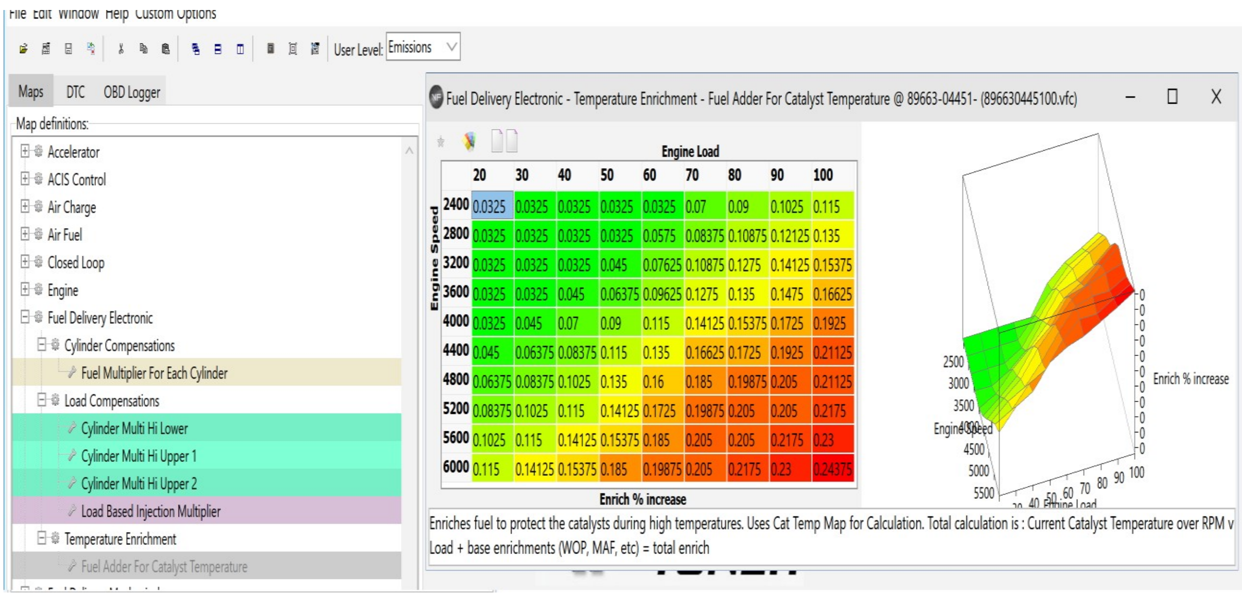


Image 5 showing Wide Open Fuel Target Tuning

1.4. Catalyst Protection Compensations

Catalyst Protection Compensations are CONDITION 2 for fueling. When the ECU has calculated (only calculated, as there are no cat temp sensor probes) that the catalyst has or will become too hot, it will enrich fueling using the Fuel adder table + logical adders (in code only) Zeroing this table **WILL NOT STOP CONDITION 2**.



1.5. Tuning Catalyst protection systems

Tuning CONDITION 2 is critically important to overall fuel control and disabling fuel enrichment where it is not needed. As previously stated, zeroing the fuel adder table **DOES NOT** disable CONDITION 2. But there are a few methods to disable condition 2.

1.6. Delay Timers and other considerations

There are multiple tables that affect CONDITION 2. These tables are ***Delay timers for load***, and ***Thresholds for load*** (CONDITION 2 will only be active when these conditions are met) along with some spark modifications.

There is a global (1D) byte table that can effectively disable CONDITION 2 entirely.

VF TUNER DOES NOT RECOMMEND THIS ON MOST VEHICLES! Disabling CONDITION 2 disables ALL logic and ALL compensations (including spark) for CONDITION 2. This can present a dangerous situation under sustained high stress high temperature conditions (Think > Towing up a mountain). There is a better method to disabling the FUELING feature while RETAINING other components of CONDITION 2. Going back to what was previously stated, the ECU only CALCULATES temperature. It does not know true temperature.

To **disable** the **FUELING ONLY** (primary fueling NOT logical fueling) you can perform a simple calibration procedure.

- Open the Fuel Adder table (or EQ comp protection) table and open ALL Catalyst temperature tables (only 1 shown in image example)

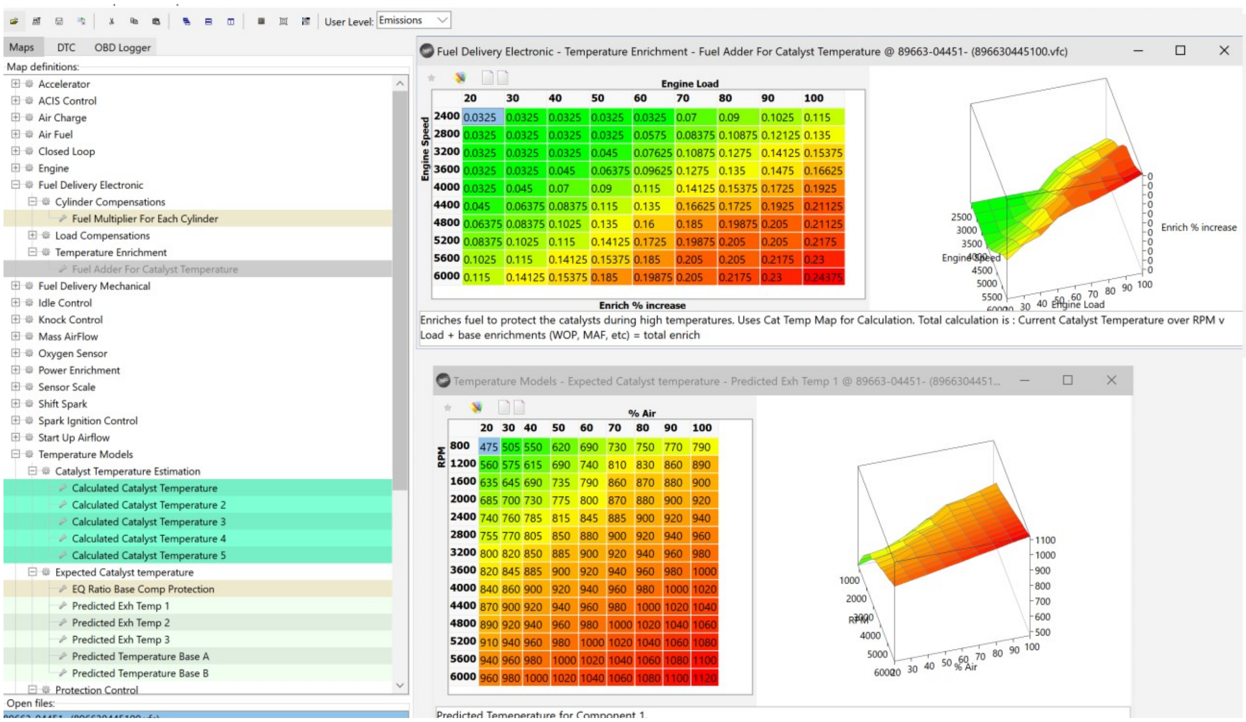
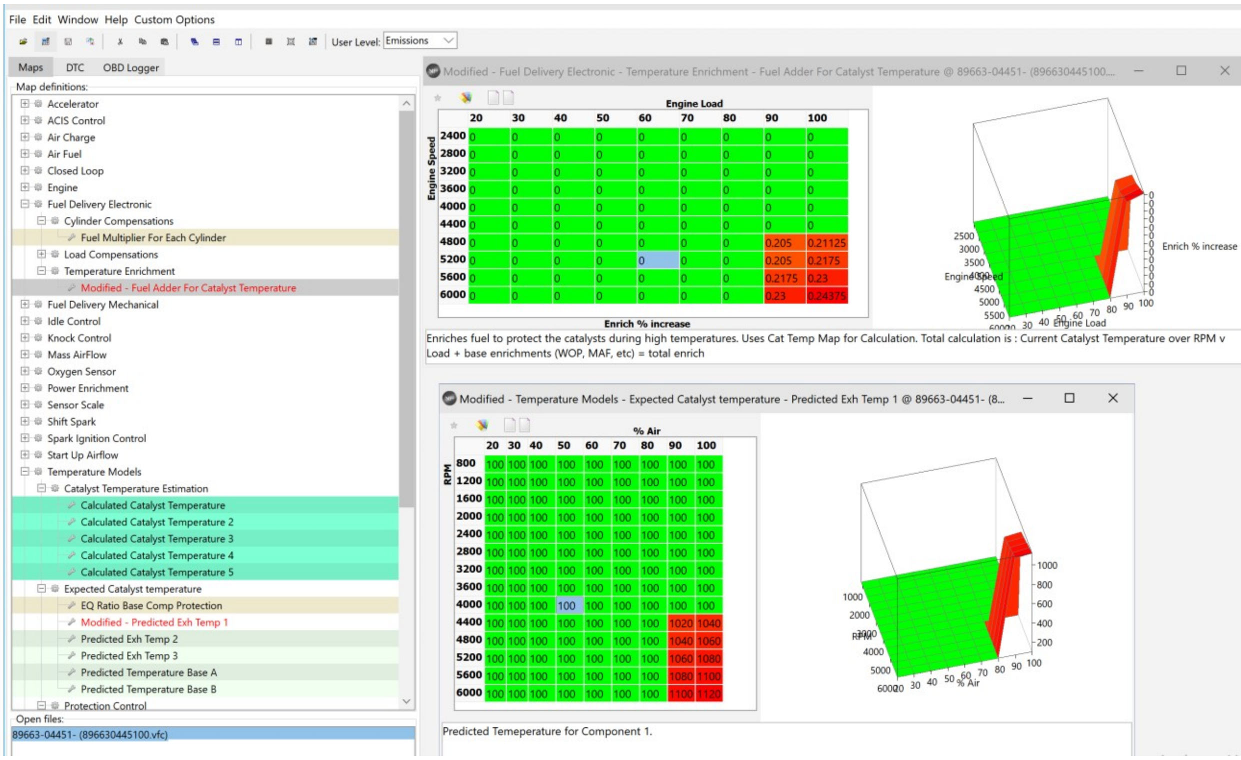


Image 7 showing table values on how to disable the FUELING ONLY

- Modify these tables by setting the Fuel adder where you do NOT want fuel, to 0.
- Then, modify the Catalyst control tables by setting the temperature very low (0 - 100) only in the ranges you want the FUELING to be disabled.

By doing this you have **disabled** Catalyst FUEL **but** have **NOT** disabled other catalyst and temperature safety features



2. FUELING – MECHANICAL

Mechanical fuel delivery consists of all calibratable parameters for the port injectors

2.1. Port Injectors

Toyota uses an injector constant and inverse to constant for calculating injection. This is done by calculating the amount of fuel the injector provides per 1ms open time in (*uL*) and the amount of fuel needed (*uL*) per mass air (*1g*) for stoic operation.

This is a similar strategy to Hyundai Siemens / Bosch / and other engine calibrations.

2.2. Cranking

Cranking tables are in millisecond, along with dwell / latency and minimum times.

These tables rarely need modified for a stock vehicle but MUST be tuned when switching injectors.

2.3. Injector Constant

We have also provided a table that converts the values to a easier to use value that you can modify, with some CC injector examples

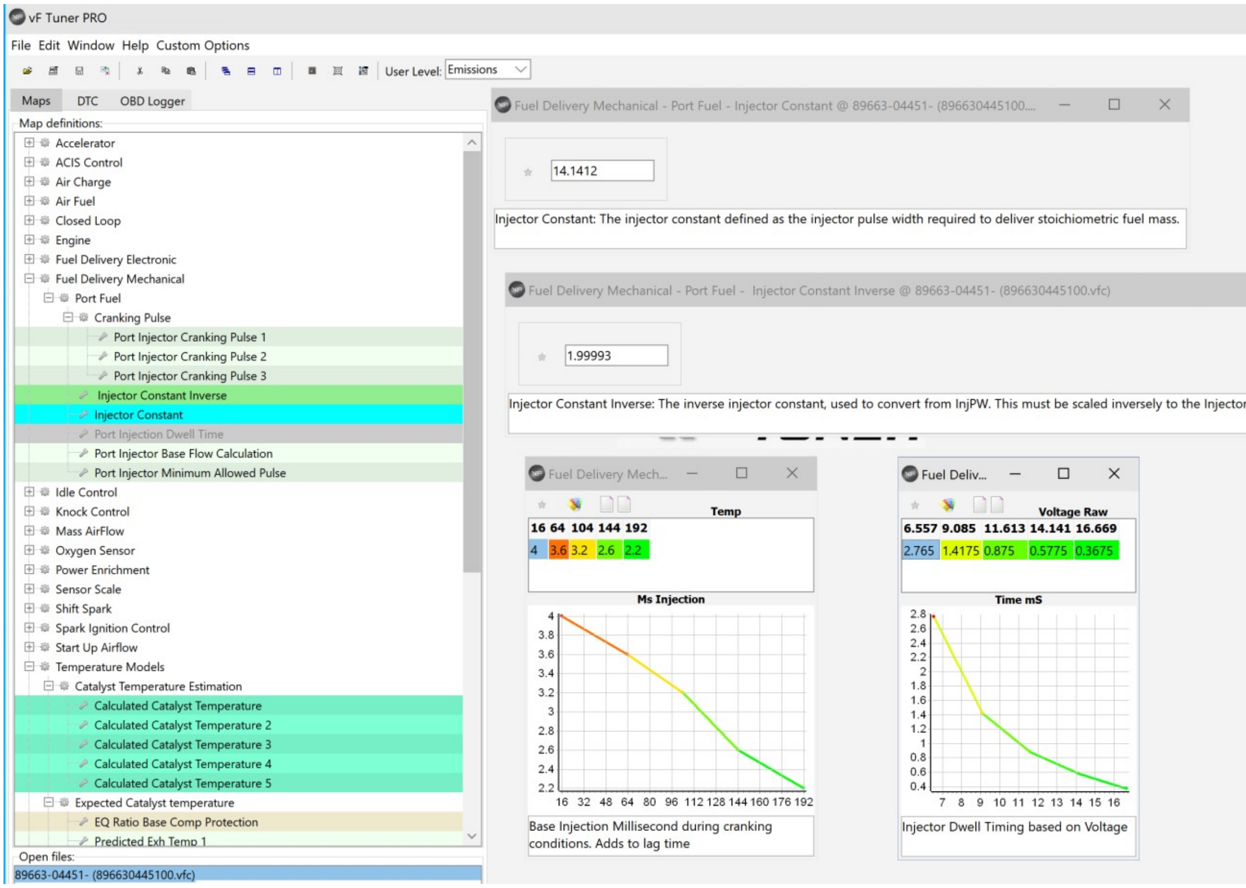


Image 9 showing a table that converts the injector values

3. LIMITERS

3.1. Engine and Speed Limiter

Engine RPM limits and speed limiters are very simple tables with easy to change values. Simply input the value you want for speed (KPH) and RPM

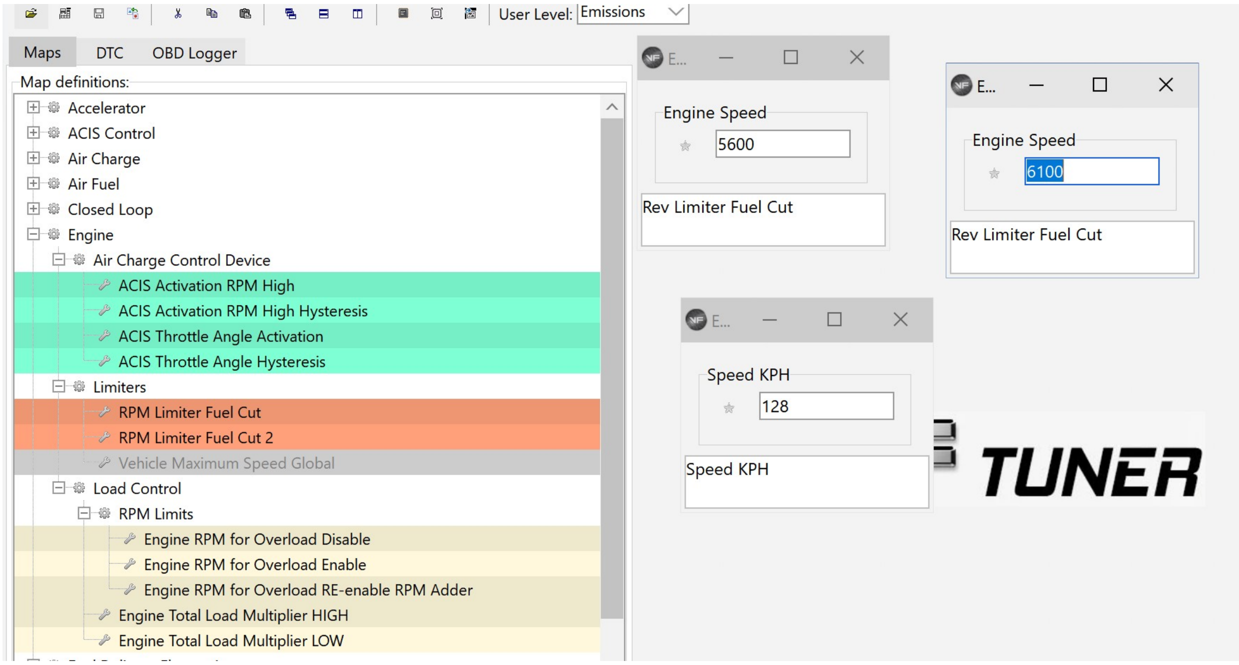


Image 10 showing Engine RPM limits and speed limiters tables

4. IGNITION

4.1. Knock Control Basics

Toyotas knock control scheme is pretty simple to understand and calibrate. Until certain conditions are met the knock sensor is effectively DISABLED, along with this so is Knock LEARNING.

There are a few tables you want to pay attention to, and modify, if you want more accurate and finer knock tuning control

The maximum RPM knock is enabled (this means any RPM above that value KNOCK IS IGNORED!) in our example file that means any RPM above 5600, the Knock sensor is IGNORED. **Not good!** You want to set this value **AT LEAST 100 RPM** above your RPM limit

Knock enable temp 1. This table sets the minimum ECT (engine coolant temp) to enable the knock sensor.

Stock is 60* C. So any time the engine is below 60* C, the knock sensor is DISABLED.

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You definitely want to consider setting this temperature lower. Knock learning is disabled until the engine is at least 83*. *full operating temperature*

Lowering this value can start the knock learning operation sooner.

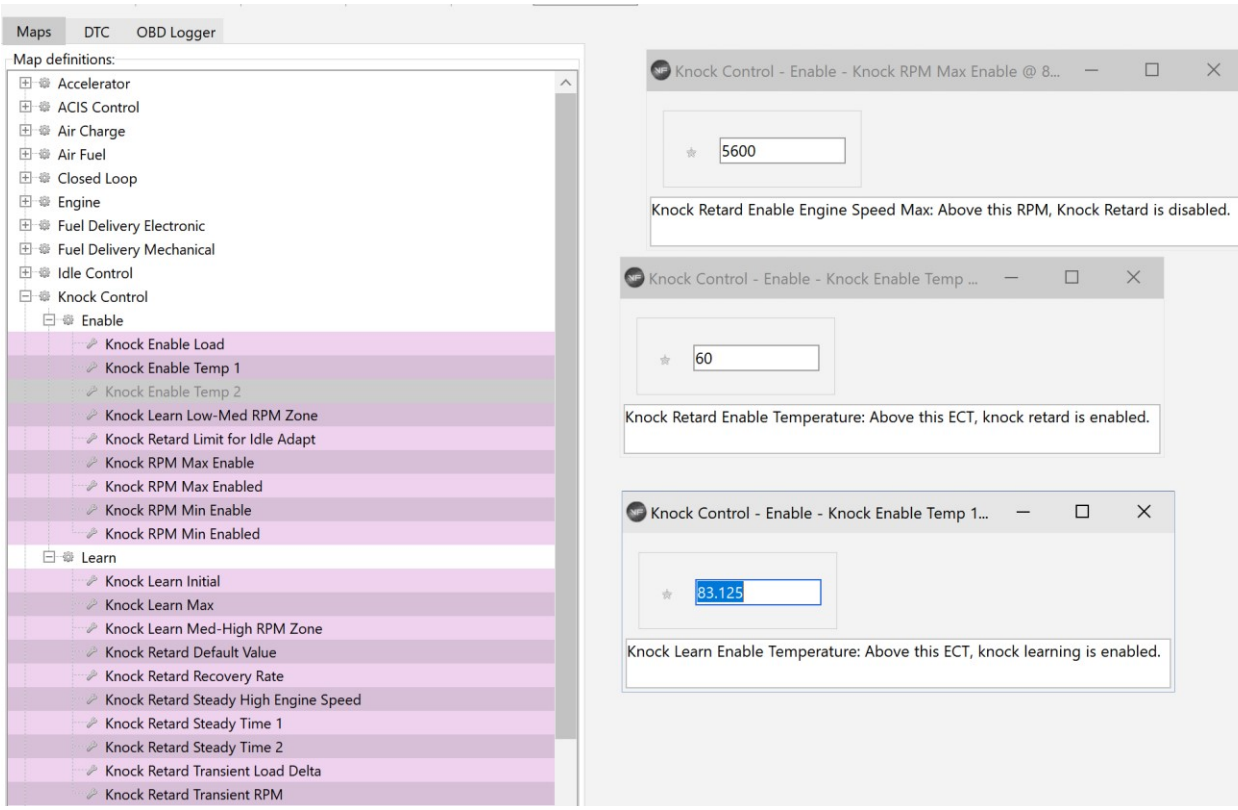


Image 11showing knock control basic tables

4.2. Ignition Control Basics

Toyota Gen 1 Ignition control has many aspects. The Formula is as follows:

Ignition Timing Calculation is

*Most retarded Timing value *1 + Knock Correct Learn Value *2 + Knock F/B Value *3 + Each compensation table applied*

For example from our fully reversed C code example:

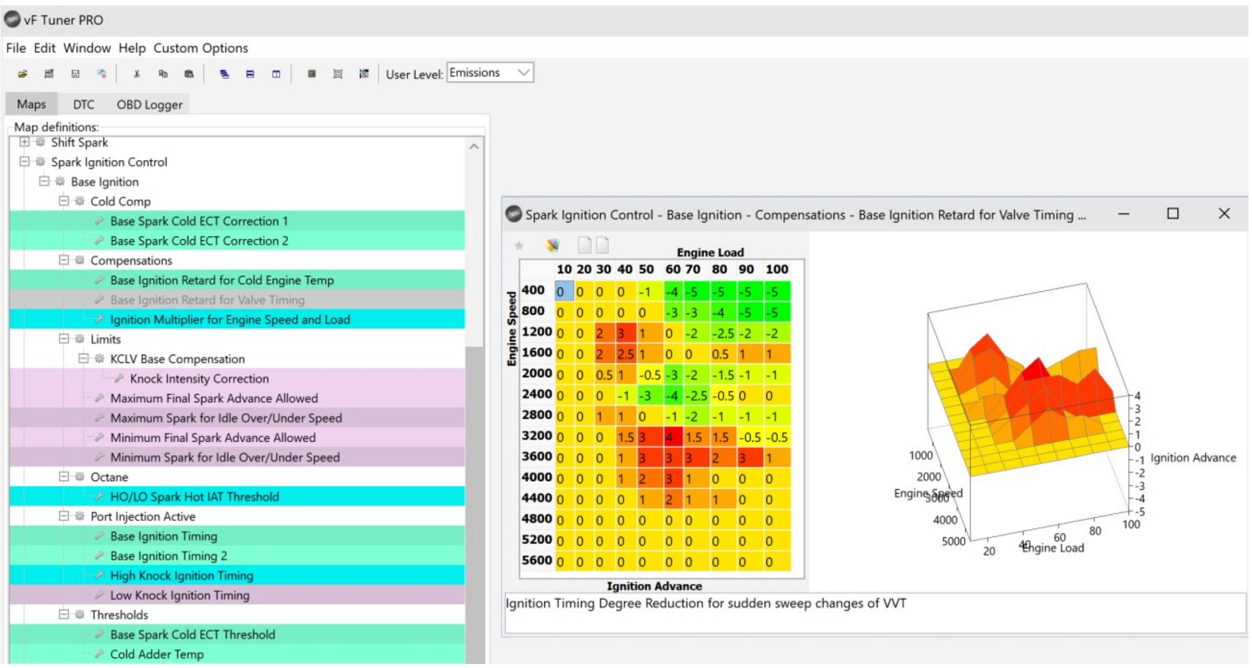
rxx_RESULT_val = ((((*int*) *short_at* (0xfedexxx) + *short_at* (0xfedexxx) + *lookup_fixed_table2_*) - *limited_val2*) - *zero*) + *sum_of_two_globals*

4.3. Compensations

4.3.1. Ignition Timing Compensation for VVT

This table reduces (or advances) the ignition timing during VVT transitional phases (when VVT is active and the angle is being changed). **Example**;

- When VVT is at 0*, this table does nothing
- When VVT changes from 0-10*, this table is referenced, and ignition is added or reduced, depending on engine load and RPM and what is being requested from this table.



4.3.2. Ignition multiplier

Another type of compensation is an ignition multiplier for high speed and high load (CONDITION 2 FUELING ACTIVE). This table multiplies (stock table reduces) ignition when catalyst *overtemp* (CONDITION 2) is active.

Changing the values back to 1.0 (100%) removes the reduction (values under 1.0 = less than)

Engine Speed \ Engine Load	10	20	30	40	50	60	70	80	90	100
600	1	1	1	1	1	1	1	1	1	1
800	1	1	1	1	1	1	1	1	1	1
1600	1	1	1	1	1	1	1	1	1	1
2400	1	1	1	1	1	1	1	1	1	1
3200	1	1	1	1	1	1	1	1	1	1
4000	1	1	1	1	1	1	1	1	1	1
4400	1	1	1	1	1	1	1	1	1	1
4800	1	1	1	1	1	1	0.875	0.765625	0.765625	0.765625
5000	1	1	1	1	1	1	0.84375	0.6875	0.6875	0.6875
5200	1	1	1	1	1	1	0.84375	0.6875	0.6875	0.6875
5600	1	1	1	1	1	1	0.84375	0.6875	0.6875	0.6875

Image 13 showing ignition multiplier for high speed and high load where condition 2fueling is active

4.3.3. Base timing, high and Low ignition timing

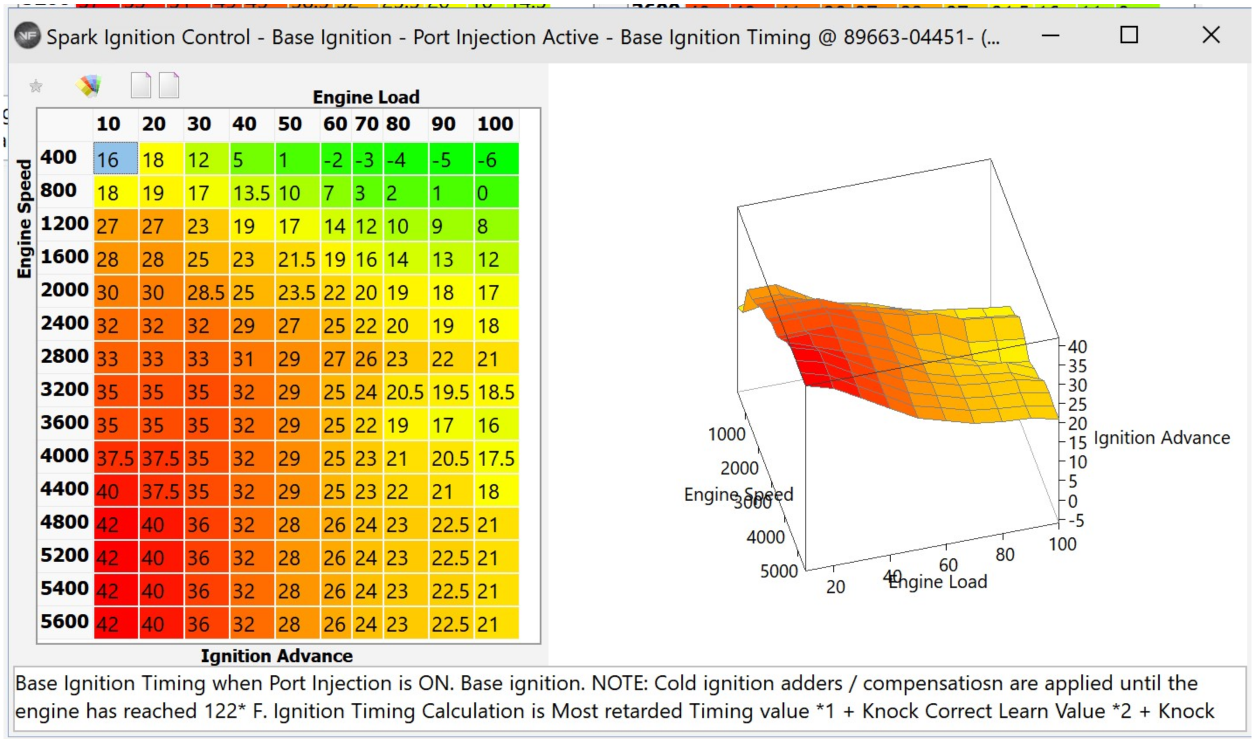
Primary ignition tables are simple to tune. There are Base tables, low and high knock tables.

During **FIRST START BEFORE ANY KNOCK LEARNING HAS EVER OCCURED** (LIKE RIGHT AFTER A FLASH), the ECU will use the MOST RETARDED (least) table. This is the Low knock table. On some ECUs, the low and high knock tables are the same, this is normal. You can modify these tables to set your own high and low options.

How it works, simplified

- The ECU will use the least table first (low knock) and as knock learning occurs, it can ADD ignition.
- Once it has added ignition; enough ignition to be at or above the base table, it will then use the BASE table + compensations (or high knock + compensations).

For tuning, to ensure the knock strategy remains in effect BASE table should **ALWAYS BE HIGHER THAN LOW IGNITION**.



Engine Speed \ Engine Load	10	20	30	40	50	60	70	80	90	100
400	16	18	12	5	1	-2	-3	-4	-5	-6
800	18	19	17	13.5	10	7	3	2	1	0
1200	27	27	23	19	17	14	12	10	9	8
1600	28	28	25	23	21.5	19	16	14	13	12
2000	30	30	28.5	25	23.5	22	20	19	18	17
2400	32	32	32	29	27	25	22	20	19	18
2800	33	33	33	31	29	27	26	23	22	21
3200	35	35	35	32	29	25	24	20.5	19.5	18.5
3600	35	35	35	32	29	25	22	19	17	16
4000	37.5	37.5	35	32	29	25	23	21	20.5	17.5
4400	40	37.5	35	32	29	25	23	22	21	18
4800	42	40	36	32	28	26	24	23	22.5	21
5200	42	40	36	32	28	26	24	23	22.5	21
5400	42	40	36	32	28	26	24	23	22.5	21
5600	42	40	36	32	28	26	24	23	22.5	21

Image 14 showing base ignition tables

The stock values are tuned for regular octane gasoline (85-87octane). Significantly, more advancement is possible with premium fuel.

5. AIR CHARGE AND LOAD

Controlling the Air charge and Load can be done through throttle and auxiliary system tuning (ACIS). Reference: https://www.toyotaguru.us/sequoia-2001-repair/note-acoustic-control-induction-system-acis-may-also-be-referred-to-as-intake-air-control-valve-system.html

ACIS is a variable induction system that improves engine performance by increasing the length of intake runners in the air intake chamber. In accordance with engine speed and throttle opening angle, ACIS controls the length of intake runners in air intake chamber in 2 stages. This is accomplished by opening and closing the intake air control valve located on end of air intake chamber. See *Image 15 below*. ACIS is controlled by Engine Control Module (ECM). ECM controls ACIS Vacuum Switching Valve (VSV) which controls vacuum supply from vacuum tank to the actuator. Actuator operates intake air control valve in air intake chamber. ECM uses engine RPM input signal and throttle position sensor input signal for determining ACIS operation. Engine RPM input signal is provided by camshaft and crankshaft position sensors.

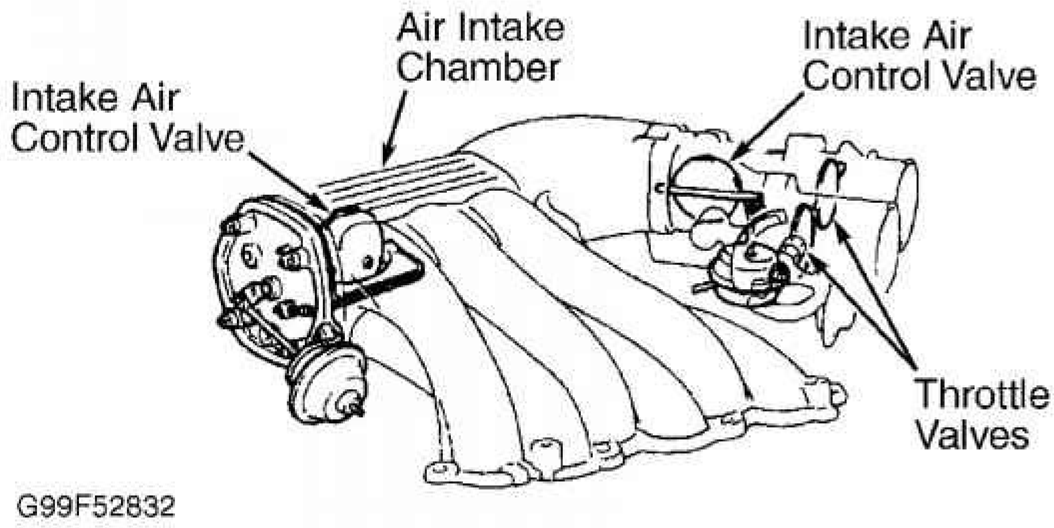


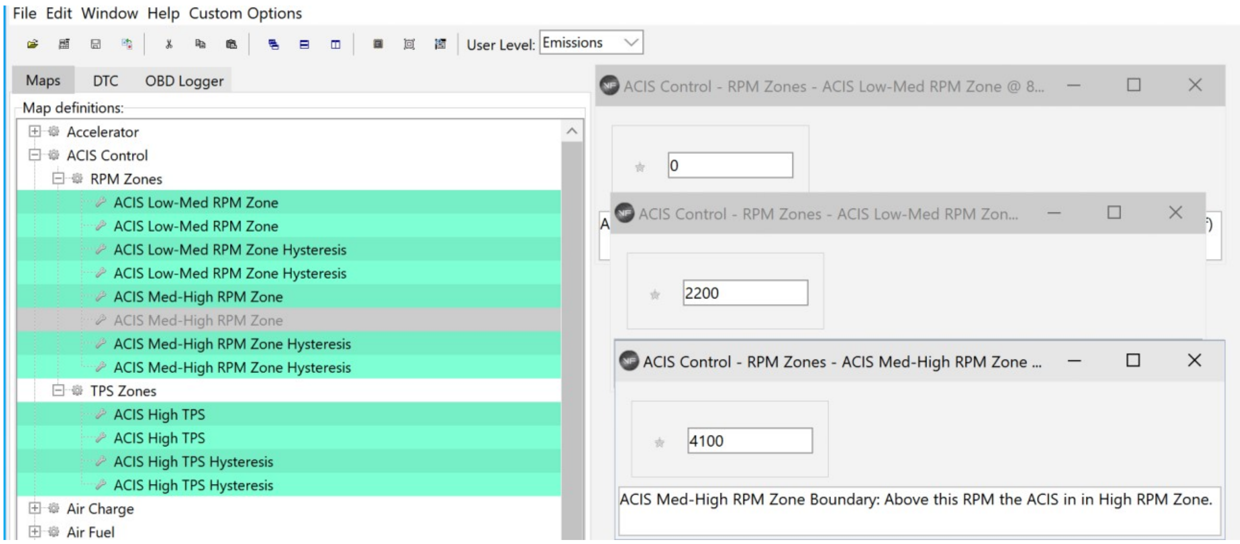
Image 15 showing intake air control valve

5.1. ACIS Tuning basics

The intake acoustic system is controlled by MANY thresholds / triggers. There are RPM triggers and Throttle (TPS) triggers.

To activate or deactivate the system ALL triggers must be met. This means that at TPS of X % the RPM must ALSO be at or above one of the RPM triggers. The system is simple to understand by following the basic logic:

- TPS trigger of 60%
- RPM trigger of 2200 for Low-Med Zone.
- Is the throttle at or above 60% AND the RPM is above 2200? If yes, activate ACIS. If either is NOT then, DO NOT ACTIVATE ACIS.



5.2. Accelerator and Throttle limits

Throttle limitations can occur on GEN 1 ECUs. Depending on the calibration there are 1 or 2 tables for accelerator to airload request (throttle limiters). Increasing the values in these tables can directly result in more throttle or relieving any throttle limits.

NOTE: Too high values in these tables can cause **THROTTLE LIMP MODE!**

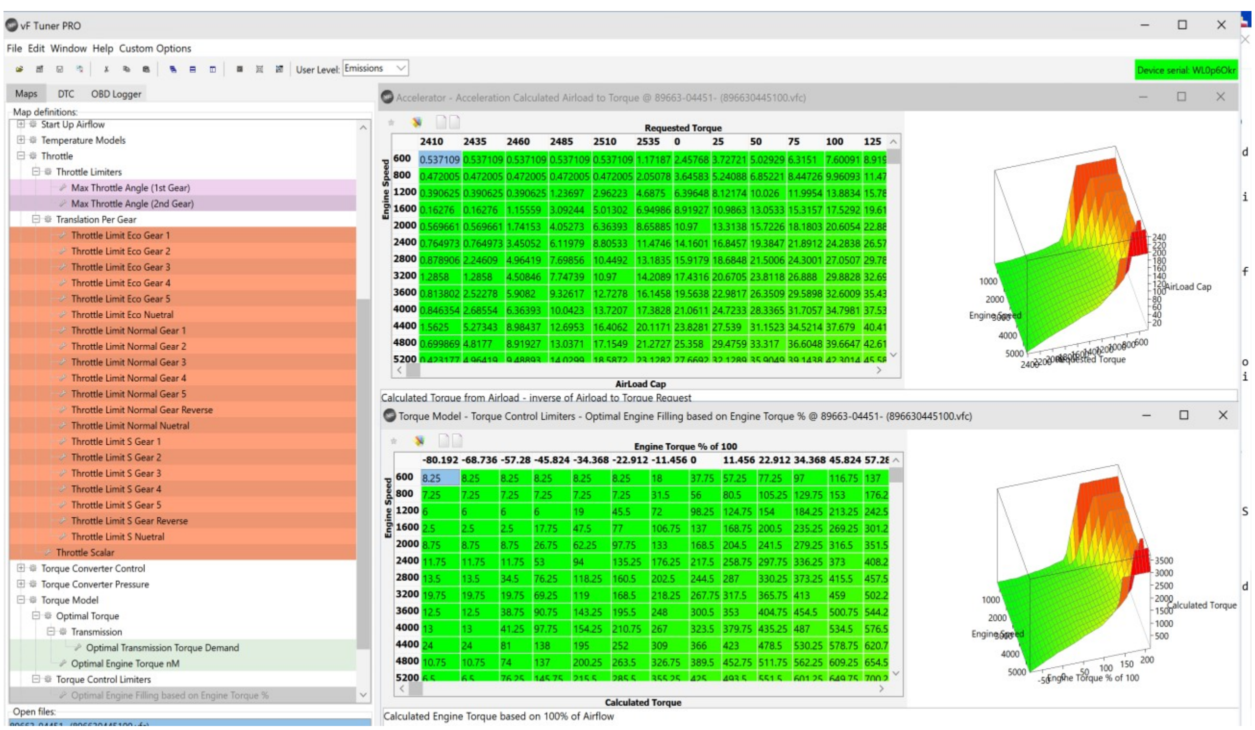


Image 17 showing accelerator limits tables

There are other per gear throttle limiters that may need attention. Normally these do NOT limit total throttle at WOT, but they can limit the throttle depending on the accelerator (gas pedal angle).

Modifying these tables can greatly increase "throttle sensitivity" for each gear. Some ECUs also have limiters for each gear under certain operation (1rst gear only, or 4WD). These can be modified to remove those limiters

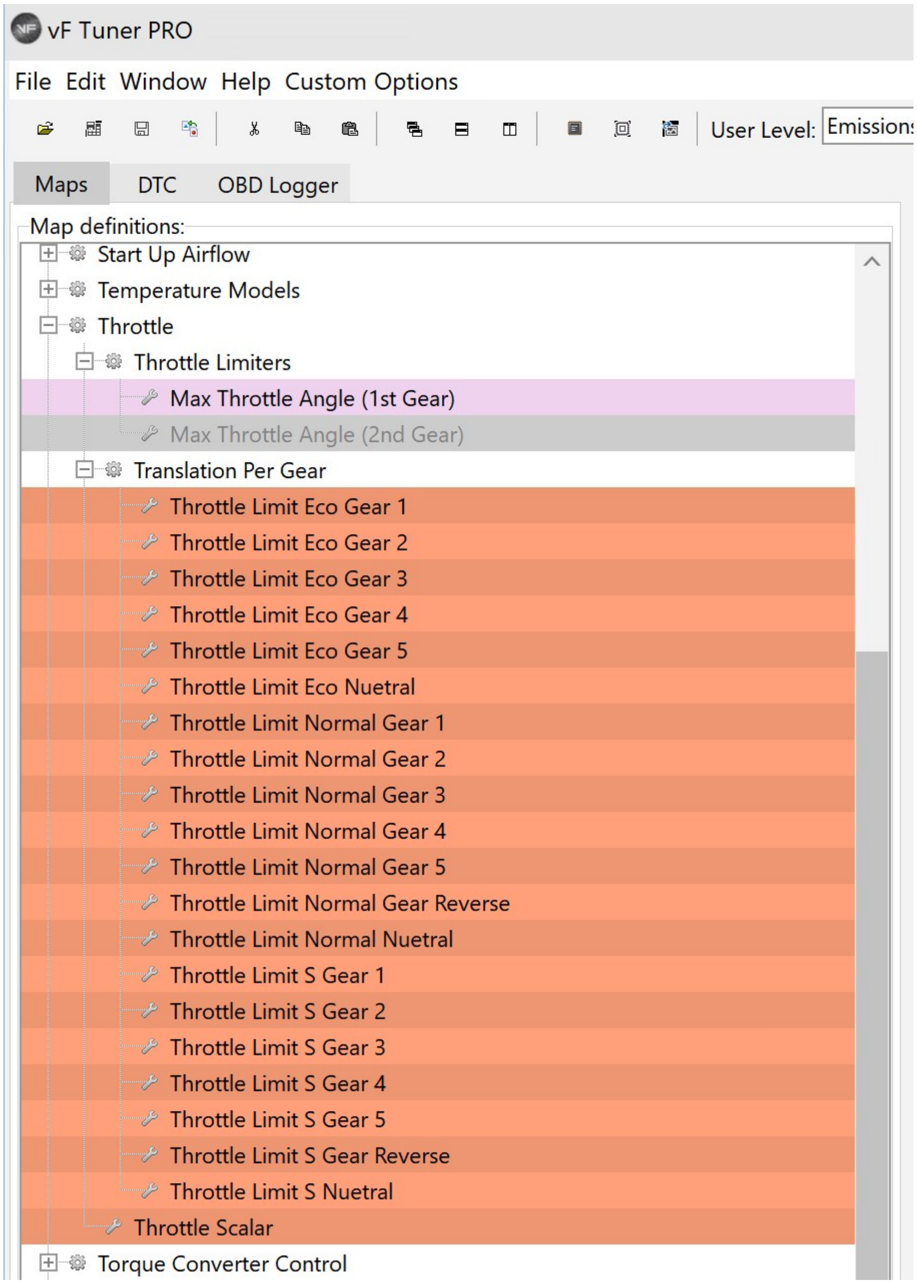


Image 18 showing throttle limit tables

5.3. Load Control and AirFlow / Load Multipliers

Engine Load (Absolute %) is calculated through a static algorithm. This algorithm uses 2 different controls; depending on engine speed (ONLY ENGINE SPEED is referenced). These are the Engine RPM overload disable and enable RPM triggers.

When OVERLOAD is enabled, the algorithm uses the multiplier HIGH, when disabled, the multiplier LOW.

Modifying these multipliers directly results in higher absolute load calculations, which in turn, provides more fuel.

These can be used to trim load in high flow situations, or increase load when necessary for boosted applications. In this example; overload DISABLE occurs at 2800 RPM (and the ECU will use the lower multiplier)

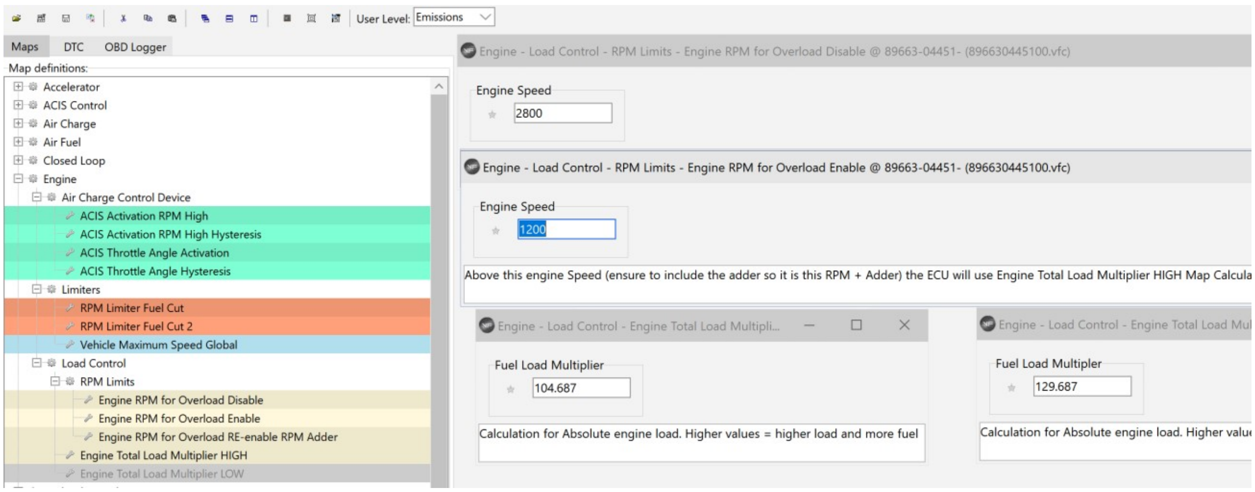


Image 19 showing Load Control and AirFlow / Load Multipliers

6. VALVE TIMING CONTROL

Toyotas Gen 1 ECUs use a combination of Intake and Exhaust valve timing, or on some engines, just intake Valve timing. For example, this example is for intake valve timing only.

NOTE: This is valve timing advance (when the valve opens) this is NOT and DOES NOT affect Valve LIFT (like VTEC)

6.1. Tuning VVTi

Tuning VVT is best done on a dyno. However, without a dyno you can still tune VVT by watching changes to airflow and load.

If you modify nothing except VVT and you see load INCREASE, this means the engine is getting more AIR (**GOOD**) and you are increasing in power potential (potential, as all must be accounted for, like ignition, AFR, etc).

If you modify nothing except VVT and you see load DECREASE, this means the engine is getting less AIR (**BAD**). And you are causing a restriction (bad).

A post provided online that has been shared everywhere, gives some basics to VVT tuning. We will also share that information here:

Simple cam tuning rules for NATURALLY ASPIRATED engines:

- Advancing both cams → more low-RPM power, less high-RPM power
- Retarding both cams → more high-RPM power, less low-RPM power
- Less overlap → more low-RPM power, less high-RPM power
- More overlap → more high-RPM power, less low-RPM power

In a naturally aspirated engine, the extra overlap is called "***scavenging***". **Scavenging** is using the out-flowing exhaust to help draw in the next intake charge (partially causing lumpy idle).

Simple cam tuning rules for BOOSTED engines:

- Advance intake and exhaust → more low-RPM power, less high-RPM power
- Retard intake and exhaust →more high-RPM power, less low-RPM power
- Less overlap →lower EGTs, faster turbo spool, less fuel
- More overlap → higher EGTs, slower turbo spool, more fuel

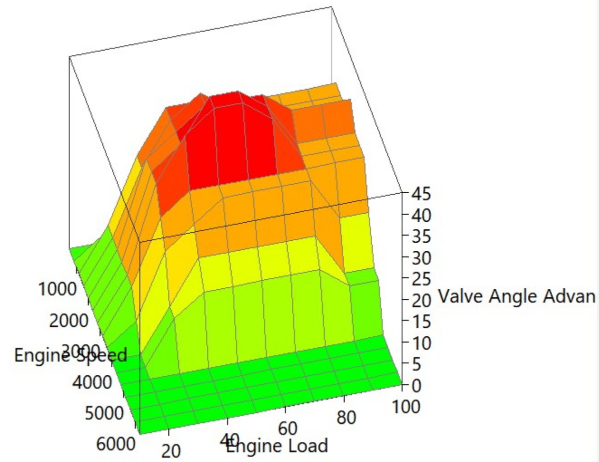
The stock calibration in this example has ZERO advances after a certain RPM (*see highlighted section in the image below*). Focusing on and calibrating VVT in this range and all other ranges can greatly increase horsepower.

Variable Valve Control - Intake Camshaft - Base Intake Valve Angle Target @ 89663-04451- (8...

Engine Load / Engine Speed

Engine Speed	10	20	30	40	50	60	70	80	90	100
400	0	0	0	0	0	5	5	5	5	5
800	0	5	5	5	30	30	30	30	30	30
1200	0	10	25	35	35	30	30	30	30	30
1600	0	10	25	35	40	35	30	30	30	30
2000	0	10	30	35	40	40	40	35	35	35
2400	0	10	30	35	45	45	40	30	30	30
2800	0	10	30	40	45	45	40	30	30	30
3200	0	10	25	30	30	30	30	30	30	30
3600	0	5	20	25	30	30	30	30	20	20
4000	0	0	10	20	20	20	20	20	10	10
4400	0	0	10	15	15	15	15	15	10	10
4800	0	0	0	0	0	0	0	0	0	0
5200	0	0	0	0	0	0	0	0	0	0
5600	0	0	0	0	0	0	0	0	0	0
6000	0	0	0	0	0	0	0	0	0	0
6400	0	0	0	0	0	0	0	0	0	0

Valve Angle Advanced



Base Valve Angle Target

Image 20 showing stock calibration for VVi tuning