

SE-EFI

Small Engine Electronic Control Unit
– for 1 or 2 cylinder engines

ECOTRONS

Tuning Guide

V1.4

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Note: this tuning guide will be under continuous improvements. Contact us for the latest version.

Note: only use this Tuning Guide after you finished the installation of the EFI Kit, by following the installation manual.



SE-EFI Kit

Quick Tips

Q: I finished the installation, My engine does not start, why?

A: Go back to your installation manual, in the last chapter, there are detailed procedures for you to trouble-shoot the starting problem.

Q: How do I log data and play back?

- 1) Run ProCAL (load the correct A2L and S19 file).
 - 1.1) Key on, and key on only for starting issues;
- 2) go to menu -> run -> connect
- 3) go to menu -> run -> start recording
- 4) Do your test, or start the engine;
- 5) when done the test, go to menu -> run -> stop recording
- 6) go to menu -> run -> data analyzer
- 7) A window pops-up , and click "load", it will tell you where are the logged files.
- 8) copy the logged files and send to us. (don't change file names)

Q: How do I change a calibration?

Assume you want to change the value of the calibration variable "VAL_XXXX" to "YYYY":

- 1) Key-ON, Use ProCAL and correct A2L/S19 files, talk to ECU;
- 2) In ProCAL menu, go to: "Advanced" -> "add advanced calibrations";
- 3) pop up a window, type in "VAL_XXXX", select it, and click "add to", and then click "OK".
- 4) back to ProCAL window, "VAL_XXXX" should be displayed in a small window. Change its value to "YYYY". Hit "Enter";
- 5) Go to menu, "run" -> "burn to ECU".
- 7) Download.....completed.
- 8) start the engine, see the effect.

1. Tuning fuel

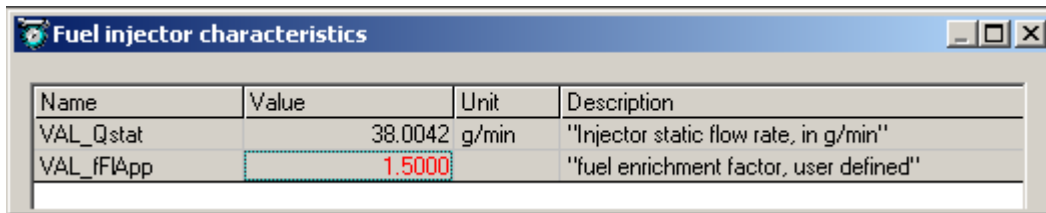
1.1 Global fuel tuning

VAL_fFIAPP – “fuel enrichment factor, user defined”

In ProCAL:

menu → calibrations → fuel system → injector characteristics →

VAL_fFIAPP = 1.0 (default).



Name	Value	Unit	Description
VAL_Qstat	38.0042	g/min	"Injector static flow rate, in g/min"
VAL_fFIApp	1.5000		"fuel enrichment factor, user defined"

It's a global enrichment factor multiplied on the base fuel, meaning, if you change it to 1.5, your fuel amount will be 1.5 times everywhere. And it applies to all operating conditions (start, warm-up, steady-state, transient). It has a range of 0-4.0.

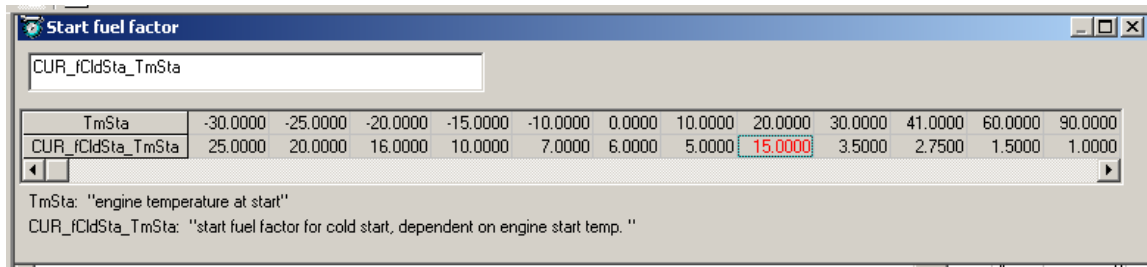
This factor is only supposed to be used temporarily. It's kind of “quick and dirty” fix just for you to fire the engine up and not to stall. The change should be removed once you know the system better, and tune the engine with appropriate parameters.

1.2 Start fuel tuning

CUR_fCIIdSta_TmSta – “start fuel factor for cold start, dependent on engine start temp.”

In ProCAL:

menu → calibrations → fuel system → start fuel factor →



TmSta	-30.0000	-25.0000	-20.0000	-15.0000	-10.0000	0.0000	10.0000	20.0000	30.0000	41.0000	60.0000	90.0000
CUR_fCIIdSta_TmSta	25.0000	20.0000	16.0000	10.0000	7.0000	6.0000	5.0000	15.0000	3.5000	2.7500	1.5000	1.0000

TmSta: "engine temperature at start"
CUR_fCIIdSta_TmSta: "start fuel factor for cold start, dependent on engine start temp."

This is probably the most important tuning parameter for most users. Because:

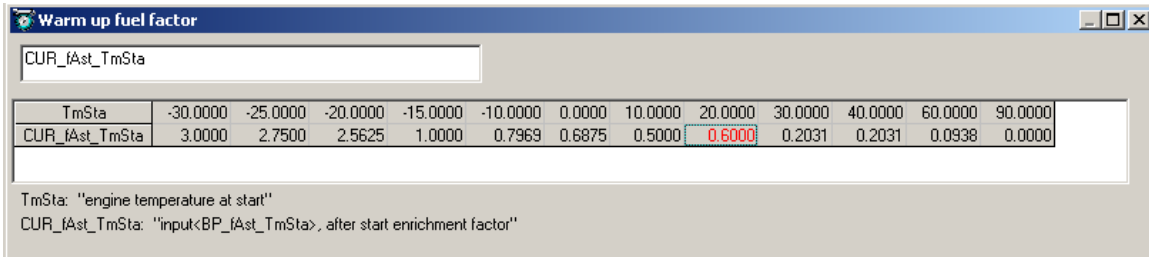
- 1) Start fuel can NOT be self-tuned by the ECU. Self-tuning is only possible in the “close-loop” control, which is only active after the engine is fully warmed up. ECU can not learn the engine during the start.
- 2) Every engine can be different. The start fuel could be different from one to the other. Especially if you have modified the intake manifold or added an adaptor for the throttle, or simply because your engine is different than ours, the base calibration engine, which is a 125cc GY6 engine. The initial wall wetting and the amount of lost fuel during start could be significantly different from engine to engine.
- 3) Good news, we tried to calibrate the start fuel to be a little rich, and to cover more engines, and to make your initial fire-up successful. So most likely, you can start your engine after a few tries, if your intake air system is not modified significantly. Yet, you could end up tune your start fuel by your-self. Because this part can only be done via trials.
- 4) Tuning tips: read your engine temperature before start, “Tm”, in ProCAL, locate the closest break point of “TmSta” in the table, and change the associated start fuel factor value. Try to start the engine, after a few trials, you identify the best value for that temperature. Then you can apply the similar changes to the neighbor points.
- 5) Start fuel only applies during start. Once the start of engine is ended, indicated by that the engine speed (N) is greater than 1000rpm; the start fuel will be inactive. The after-start fuel and warm-up fuel will take over.

1.3 After-Start fuel and Warm-up fuel

CUR_fAst_TmSta – “after-start fuel enrichment factor, dependent on engine start temp.”

In ProCAL:

menu → calibrations → fuel system → warm-up fuel factor →



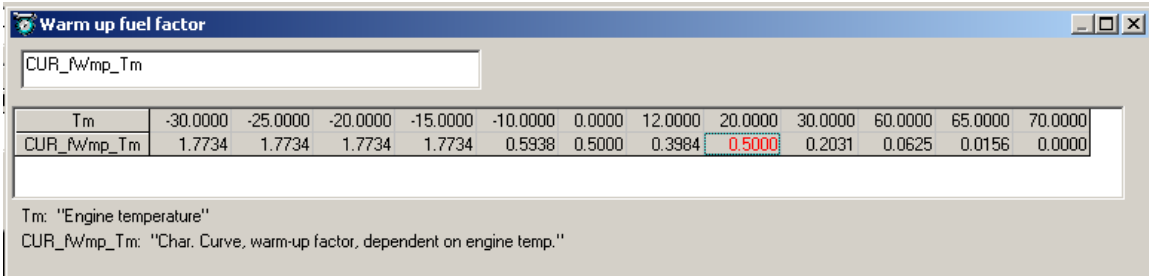
Note: after-start factor is actually = 1 + look-up table output.

For example, if you set the table value as: 0.6; the after-start factor is = 1.6; why? Easy for software implementation.

CUR_fWmp_Tm – “Warm-up fuel enrichment factor, dependent on engine temp.”

In ProCAL:

menu → calibrations → fuel system → warm-up fuel factor →



Same: warm-up factor is actually = 1 + look-up table output.

Q: What is the difference between after-start fuel and warm-up fuel?

After-start fuel is carrying over the start-fuel enrichment, and quickly ramping down to 1.0. It is dependent on the engine start temperature only.

Warm-up fuel is dynamically adjusting the fuel dependent on how fast the engine temperature warms up. It also includes the impact to engine load and speed.

Q: Too complicated?

Good news! You do NOT have to tune these 2 factors in most cases, because:

- 1) They are normalized for most engines, work very well for most engines.
- 2) They are designed for emission reduction purposes. For after-market conversions, pre-set data are often good enough.

Q: Do nothing? What happens next?

That's right, do nothing for these 2 factors. As long as you can start the engine and let the engine running and not stalling. You are good. Engine will warm itself up, and quickly the warm-up fuel factor will ramp down to 1.0 (neutral). Next we will make sure the engine can be run in open-loop mode comparatively stable.

Open Loop Fuel Controls

What is open loop fuel controls, why do we need it?

Open loop fuel control is to run the engine without installing the O2 sensor. The reason we need to run it is to protect the O2 sensor; to have a stable engine running before plugging in the O2 sensor.

A good practice is to start and run the engine in the open loop mode, especially if your engine is very different than our base calibration engines (scooter GY6 125cc, which is the mostly tested engine). Or you have modified your engine significantly, like a big bore kit, a high cam, or a bigger intake manifold, or an adaptor between the throttle and the manifold. All these difference will cause the big deviations in the air charge model pre-loaded in the ECU. Close-loop fuel control and self-learning is only supposed to learn the small errors from engine to engines. These big difference can not be learnt thoroughly by the ECU and could lead to the oscillations, or hitting the limitations.

Without a comparatively stable engine running in open-loop, the exhaust from the engine could be erratically rich or lean or fuel flooding, random moistures in the exhaust, etc. These could damage the O2 sensor before you even have a chance to run close loop controls.

In open loop mode, ECU is reading the MAP sensor signal, TPS signal, and temperature signals to calculate the fuel, and control the fuel comparatively precisely.

In open loop mode, you can drive the vehicle around, and tip-in, tip-out, and you can do almost everything, except that the ECU does not really know whether you are running rich or lean. And the ECU can not self-learn the engine for variations. The self-fine-tuning of the fuel is not happening.

What if I can not get a stable engine running in the open loop mode?

If you “smell” it lean, a quick and dirty fix is to enrich the fuel with the global factor: “**VAL_fFIAPP**”. And once you have a stable run, you can detune this factor by using other parameters.

If your idle speed is too low, and you can not maintain the stable idle RPM, go to next chapter.

Idle Speed

Air Path

Adjust idle speed by adjusting idle by-pass air via the idle screw.

Every throttle of our EFI kit comes with an idle by-pass air screw. If you noticed that your engine is idling, but the idle speed is too low or too high, you can adjust this screw, to give the engine a little more / less air.

Note, the idle speed with a cold engine could be lower than the warmed-up engine. Especially if you do not use our ECU-controlled-CDI to control the ignition angles.

If your engine idle speed is already high after warmed up, do not adjust idle air too high in the cold.



Note, if you notice that you have to hold the throttle to open a little to start the engine and keep the engine running, and as soon as you let the throttle go, the engine stalls. This means you may have too less idle by-pass air. This could be the case especially for the big engines, where more idle air is needed than the small engines.

If you do not have our ECU-controlled CDI to control the ignition angles, you will have comparatively low idle speed at cold start, and then idle speed will rise up a little after warm-up. This is normal. How do you have a stable idle RPM, regardless of a cold or hot engine? You need to have our ECU-controlled CDI. See the chapter of "Ignition Angle Tuning".

Dual Throttle Idle Air Adjustment

If you have our dual throttle for a parallel twin cylinder engine, and you want to adjust idle speed by adjusting the screws, **you must make sure the adjustment of both idle screws are same.** Otherwise, you could have unbalanced idle air between 2 cylinders.

The dual throttle comes with 2 idle screws pre-balanced. It is recommended not to adjust the idle screw for a known engine, (for example, Ninja 250r), which we tuned the throttle already.

If you really think you should adjust the idle screws, you must make sure the adjustment to both screws are same.



Idle screws for the dual throttle

Close-loop fuel

Q: How to tune the close-loop fuel?

A: You do NOT need to tune it. You only need to make sure it's happening. ECU will automatically tune it (with the O2 sensor).

Q: How do I know it's in close-loop controls?

First, you need to know a little bit of the O2 sensor.
The O2 sensor indicates lean or rich by a voltage signal.

When the O2 sensor is not active, the voltage should be about 450mV (or 0.45V);
When the O2 sensor indicates **rich**, the voltage should be **> 450mV**;
When the O2 sensor indicates **lean**, the voltage should be **< 450mV**;

That's right! it's a narrow band O2 sensor. The wideband O2 sensor is too expensive to be included with the base price.

When you see the O2 sensor voltage is oscillating up and down around 450mV, that means the close-loop tuning is active.

Q: How do I see the O2 sensor voltage?

Easy way: in ProCAL, among the bunch of black gauges, there is an O2S gauge indicates the voltage.

Professional way: You need to log the data and play it back to see what's going on.

In Data Analyzer, check the signal "uLsb", which is "voltage of lambda sensor (O2)".

Q: My O2 sensor voltage is always 450mV (even after warmup), what's wrong?

- 1) Possible reason #1: you don't have it connected;
- 2) Possible reason #2: the sensor is broken, or the wire is broken;
Read the diagnostic DTC in ProCAL.

Q: My O2 sensor voltage is always greater than 450mV, why?

- 1) You are running rich all the time. Case 1: for many engines, during idle, it has to run a little rich, just because the injector size is not small enough. You are running in the minimum pulse width (calibrated as 2ms). This is OK.
- 2) Case 2: you are running rich at all operating conditions, idle, part-load, WOT, etc. This could be cause by: you have enriched too much or you have some wrong calibrations. Check your enrichment factors, you fuel injector size, your engine displacement, etc, in ProCAL.
- 3) The base engine calibration is way-off for your engine. The ECU self-tuning is only capable of fine-tuning. You need to do some advanced tuning. Ask us how.
- 4) The sensor is broken, or the wire is shorted;

Q: My O2 sensor voltage is always smaller than 450mV, why?

- 1) You are running lean all the time. It may happen if you have fuel supply issues. For example, your injector is clogged. You fuel pump is having air bubbles. Fuel pressure is not maintained, or the battery voltage is low, etc.
- 2) You have wrong calibrations. Check your enrichment factors, you fuel injector size, your engine displacement, etc.
- 3) The base engine calibration is way-off for your engine. The ECU self-tuning is only capable of fine-tuning. You need to do some advanced tuning. Ask us how.
- 4) The sensor is broken, or the wire is shorted;

Q: How long does the ECU need to do the self-tuning?

- 1) ECU self-tuning is only possible if you have a stable engine running in active close-loop controls. (meaning, engine has warmed up, O2 sensor is working, system is fault free, open-loop control is in the ball-park of the stoic AFR; close-loop is active, etc) .
- 2) It does not take long for the self-tuning. It takes 3-5 minutes for every different operating condition. The key is to run the engine in a steady-state

- and traverse the common operating conditions (idle, part-load, high-load, WOT, etc.)
- 3) There are 2 key signals for you to check the self-tuning progress: "fLcAd" and "OfsLcAd". When you see they are slowly changing, the self-tuning is in progress; when they settle down at some non-1 value, the self-tuning is kind of done for now. Note, this self-tuning is a life-long continuous process. It changes very slow, and takes only effect of long term factors.

Q: How do I tune the "driver desired lambda" table?

- 4) Driver desired lambda is only effective after you have the system running stably in close loop controls and the ECU has done the self-tuning. That means, the ECU can control the AFR in the vicinity of stoic AFR (14.7 for gasoline). Only after that ECU can command a meaningful AFR other than the stoic. Otherwise, the driver desired lambda could have a big deviation from the actual lambda value.
- 5) Driver desired lambda is meant to give the user a way to command the AFR other than Stoic, either for performance purpose (more likely) or fuel saving purpose.

Some Advanced Tuning

**If you don't have a thorough understanding of EFI system, or if you've already felt confusing so far by reading this tuning guide, or if you start to feel confusing on the below sections, STOP!
Skip this chapter and leave it to us to help you.**

Warning: some users tried to tune the volumetric efficiency or throttle based fuel mappings, without fully understand the system, and ended up with the worse-running engine.

Volumetric Efficiency

Volumetric efficiency is probably the most important characteristics of an engine. It determines how efficient the engine is sucking the air into the cylinder, and therefore, how much torque it can generate, given the certain spark advance and air-fuel ratio.

It is the fundamental calibration of the engine tuning.

By definition, volumetric efficiency is the fresh air mass in the combustion chamber divided by the total air mass in it. Basically there is always some residual combustion gas trapped in the combustion chamber during the engine intake stroke. To know exactly how much fuel you need to inject and mix with the air in the combustion chamber, you have to know this volumetric efficiency.

With a MAP sensor based system, we can measure the pressure in the intake manifold, and use that as the pressure in the combustion chamber, and together with the intake air temperature, and engine displacement, we can calculate the air mass in the combustion chamber. This is what the auto industry calls "Speed Density" method. Following the ideal gas law:

$$m = PV/RT$$

m – air mass

P – pressure

V – volume or engine displacement

T – air temperature

R – gas constant

Once we know the manifold air pressure, intake air temperature, and the volumetric efficiency, we can calculate the air mass in the cylinder and therefore the fuel amount that it needs.

Unfortunately, volumetric efficiency is not able to be measured directly with any sensor. You'd have to tune the engine and tweak it one point at a time.

The best way to tune volumetric efficiency is to put your engine on a dyno and use an accurate wideband air-fuel-ratio (lambda) meter to measure the mixture, and back-ward calculate the volumetric efficiency.

However, knowing most people don't have access to a dyno, we can propose a coarse way to tune the volumetric efficiency.

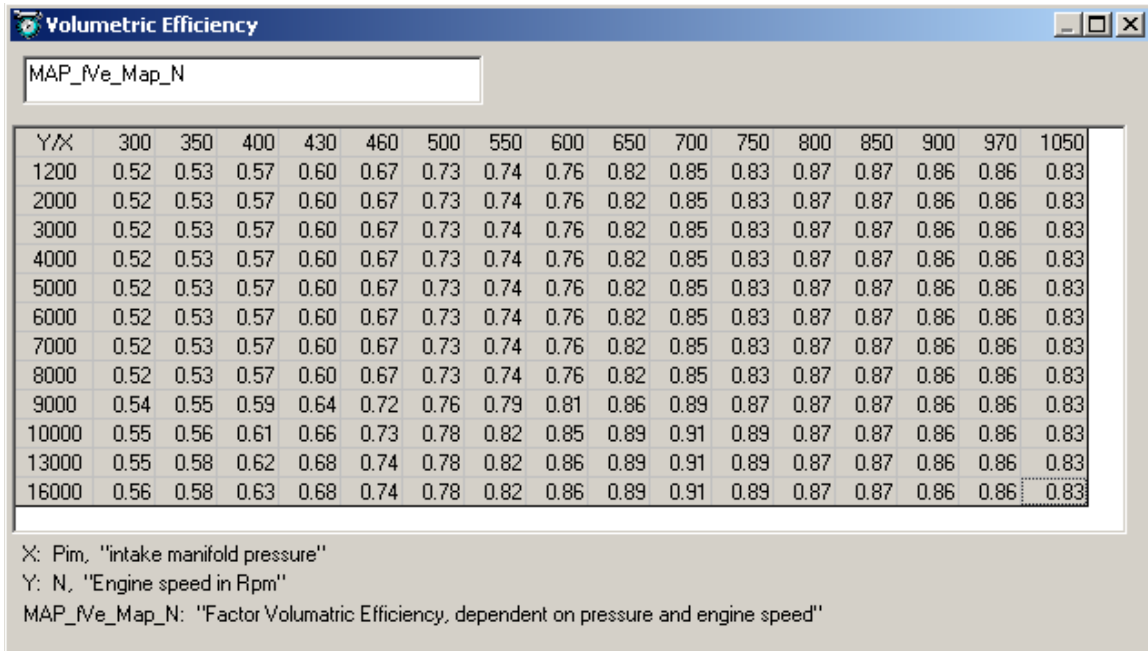
If you have a wideband controller, you can run the engine with the wideband controller together, at certain MAP signal and RPM, you can tweak the volumetric efficiency until you get the stoic AFR from your wideband controller.

Make sure you have an accurate and reliable wideband controller, or you could end up with wasting your time.

If you don't even have a wideband controller, then you can use an ever coarser way to tune it. Use your narrow band O2 sensor, which comes with the kit, and read the O2S gauge, lean or rich, at certain MAP signal and RPM, tweak the volumetric efficiency until O2S gauge indicates an oscillating voltages, up and down around the 450mV. (note, this only possible if you have everything running normally and in close-loop control).

In ProCAL:

menu → calibrations → air system → volumetric efficiency →



The screenshot shows a software window titled "Volumetric Efficiency". It contains a text input field labeled "MAP_fVe_Map_N". Below this is a table with 17 columns and 12 rows of numerical data. The columns are labeled with RPM values (300, 350, 400, 430, 460, 500, 550, 600, 650, 700, 750, 800, 850, 900, 970, 1050) and the rows are labeled with MAP values (1200, 2000, 3000, 4000, 5000, 6000, 7000, 8000, 9000, 10000, 13000, 16000). Below the table, there are three lines of text defining the axes: X: Pim, "intake manifold pressure"; Y: N, "Engine speed in Rpm"; and MAP_fVe_Map_N: "Factor Volumetric Efficiency, dependent on pressure and engine speed".

Y/X	300	350	400	430	460	500	550	600	650	700	750	800	850	900	970	1050
1200	0.52	0.53	0.57	0.60	0.67	0.73	0.74	0.76	0.82	0.85	0.83	0.87	0.87	0.86	0.86	0.83
2000	0.52	0.53	0.57	0.60	0.67	0.73	0.74	0.76	0.82	0.85	0.83	0.87	0.87	0.86	0.86	0.83
3000	0.52	0.53	0.57	0.60	0.67	0.73	0.74	0.76	0.82	0.85	0.83	0.87	0.87	0.86	0.86	0.83
4000	0.52	0.53	0.57	0.60	0.67	0.73	0.74	0.76	0.82	0.85	0.83	0.87	0.87	0.86	0.86	0.83
5000	0.52	0.53	0.57	0.60	0.67	0.73	0.74	0.76	0.82	0.85	0.83	0.87	0.87	0.86	0.86	0.83
6000	0.52	0.53	0.57	0.60	0.67	0.73	0.74	0.76	0.82	0.85	0.83	0.87	0.87	0.86	0.86	0.83
7000	0.52	0.53	0.57	0.60	0.67	0.73	0.74	0.76	0.82	0.85	0.83	0.87	0.87	0.86	0.86	0.83
8000	0.52	0.53	0.57	0.60	0.67	0.73	0.74	0.76	0.82	0.85	0.83	0.87	0.87	0.86	0.86	0.83
9000	0.54	0.55	0.59	0.64	0.72	0.76	0.79	0.81	0.86	0.89	0.87	0.87	0.87	0.86	0.86	0.83
10000	0.55	0.56	0.61	0.66	0.73	0.78	0.82	0.85	0.89	0.91	0.89	0.87	0.87	0.86	0.86	0.83
13000	0.55	0.58	0.62	0.68	0.74	0.78	0.82	0.86	0.89	0.91	0.89	0.87	0.87	0.86	0.86	0.83
16000	0.56	0.58	0.63	0.68	0.74	0.78	0.82	0.86	0.89	0.91	0.89	0.87	0.87	0.86	0.86	0.83

X: Pim, "intake manifold pressure"
Y: N, "Engine speed in Rpm"
MAP_fVe_Map_N: "Factor Volumetric Efficiency, dependent on pressure and engine speed"

LOAD based system

To know more about the advance tuning with our EFI kit, you need to understand what the “LOAD” is.

“LOAD” by definition is the actual air mass charged into the cylinder divided by the ideal air mass that can be filled into the cylinder.

What is the ideal air mass? When you have your cylinder full-filled with fresh air at sea level (barometric pressure = 1 bar), and at the temperature of zero degree C (air temperature = 32 F).

“LOAD” is a relative value, in percentage, unit-less.

“LOAD” is not the throttle position, because you can have different air mass in the cylinder at the same throttle position.

Why making it so complicated? Because it is the only way, the RIGHT way, to control the engine.

“LOAD” tells the ECU how much fuel is exactly needed for the given air-fuel-ratio. Because you can only calculate the fuel pulse width, if you know how much air is in the cylinder.

“LOAD” based system makes the tuning process universal for all engines! It does not matter how different you engine is.

“LOAD” based system makes the EFI system modularized. The subsystems can be tuned independently (namely air sub-system, fuel-subsystem, ignition-subsystem, etc.)

You may say: “Hey, I can just use the throttle position and RPM, to map the fuel on the dyno.....”.

While, you will end up re-tune all your mapping for some small thing that you overlooked, or any small changes of the engine; or you will have to start the tuning for a new engine from the scratch every time.

TPS based load mapping

Once you know what the “LOAD” is, you can tune the TPS based load mapping. Our system do not let you map the fuel pulse width directly out of the TPS / RPM table, because it is too coarse, and it is affected by too many factors

(temperatures, altitude, speed, AFR, etc.). It seems easier to map the engine this way, but it actually costs more time and efforts later on. It simply is not the professional way.

Our system let you map the "LOAD" out of TPS/RPM table, and then the load is used everywhere else as the base inputs (fuel, ignition, lambda, etc). Why?

Because LOAD is the most representative physical variable for air charge in the cylinder. Throttle position is not even proportional to the air mass. It is non-linear relation to the air mass (if you know some math ☺).

LOAD is normalized against the air temperature, and altitude, and pressure. It is then multiplied by those factors with correct physical models.

The way to calibrate the LOAD mapping is similar to the "volumetric efficiency" table. The best way is to use an engine dyno. If not, use a wideband controller, and if not, use the narrow band O2 sensor to do "estimations".

At certain throttle position, and RPM, tweak your LOAD output, until you have a good AFR.

In ProCAL:

menu → calibrations → air system → TPS based load mapping →

Y/X	1400	2000	3000	4000	5000	6000	7000	7500	8000	8500	9000	10000
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.51	45.07	50.13	50.13	45.00	42.66	34.80	28.83	28.76	35.25	34.83	34.52	34.29
5.86	54.14	54.05	51.30	44.70	49.66	48.89	42.19	38.44	38.98	37.59	36.63	36.63
8.20	66.30	61.27	54.30	50.27	54.12	53.55	47.09	47.70	48.28	44.32	41.58	39.26
11.71	73.20	73.73	71.81	62.02	56.63	61.55	53.20	47.88	51.33	46.76	46.34	45.47
15.23	83.53	83.53	81.23	78.49	68.98	70.29	61.64	51.70	42.73	40.85	50.86	47.18
18.74	87.73	87.73	89.46	91.88	90.33	81.07	73.57	61.27	63.96	58.76	55.45	53.32
22.25	76.34	81.35	76.17	84.07	88.48	87.98	79.76	67.59	70.71	65.55	59.84	56.81
29.28	89.18	89.18	90.73	88.50	97.59	86.32	86.25	79.01	84.12	79.31	70.69	66.49
35.13	90.70	90.70	99.40	97.64	96.68	106.03	99.87	91.38	91.17	85.90	80.88	76.43
40.99	90.73	90.73	104.88	97.76	94.90	106.76	100.95	96.70	96.19	91.80	86.51	82.57
46.84	96.30	96.30	107.06	98.63	95.98	110.39	105.14	98.51	98.34	96.09	91.62	87.66
52.70	96.59	96.59	96.59	89.13	95.93	106.62	102.80	98.84	99.98	98.30	95.46	92.06
58.55	96.82	107.70	107.70	90.12	96.12	107.60	101.74	98.63	99.98	99.98	98.23	95.46
70.26	96.35	107.23	107.23	89.86	96.63	107.41	102.07	99.07	99.98	99.98	99.98	99.98
89.00	96.35	99.77	99.77	89.86	100.01	111.19	102.07	99.07	99.98	99.98	99.98	99.98

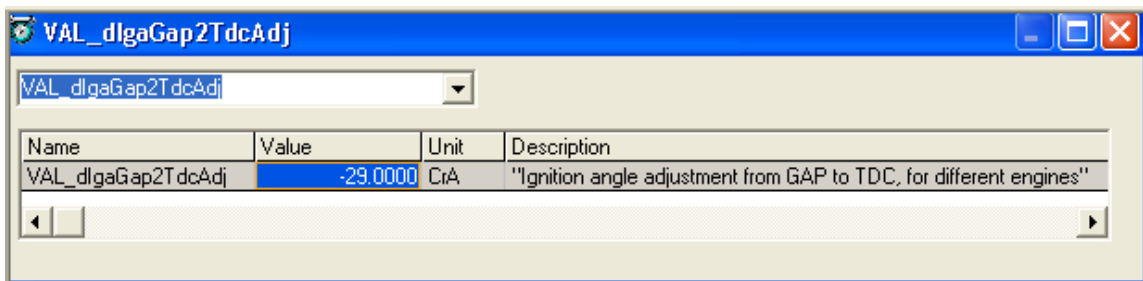
X: N, "Engine speed in Rpm"
 Y: Tps, "throttle position with respect to lower mechanical stop"
 MAP_LdTp_Tps_N: "characteristic map, normalized load based on TPS and engine speed (Alpha/N m"

Ignition Angle Tuning

How do I set the offset angle between the pickup trigger to TDC?

Please add this advanced calibrations in ProCAL:

VAL_dlgaGap2TdcAdj = -29 CrA (crank-shaft angle)



This defines the offset between your trigger pulse to TDC. The default is -29 CrA. that means 29 degrees in advance than the TDC. This is OK for most scooter/bike engines, that you don't have to change.

For example, when you command 0 degree ignition angle, you should see the 29 degree between the trigger pulse and the ignition pulse.

If you do not have our ECU-controlled CDI, or if your engine is not recommended for ECU-controlled CDI (2-stroke engines, for example). Or our ECU does not support CDI controls for your engine, skip the rest of this chapter.

Idle speed controls via ignition angle controls (only possible if you have ECU-controlled ignition system).

Why do you need the ECU-controlled CDI for idle speed control?

Now it's time for you to add our CDI box. Because it will help to lower down the idle RPM after engine warm-up. The strategy is to have enough idle to start in cold and stable idle in cold. But that amount of air is a little more than necessary for the warmed up engine. (that's why you get high idle rpm at hot but low idle rpm at cold.)

The strategy is to postpone the spark advance to lower down the idle rpm once the engine is warmed up. It reduces the engine torque because of later sparks. (This also indirectly helps the emissions to be less).

Further more, this gives some torque reserve for possible high idle requests (for undercharging, for example).

And this also helps the launch, because once you open the throttle, the spark advance can be immediately goes to the optimum, and you get big torque increase!

What else can I benefit from ECU-controlled CDI?

Basic Ignition Angle

Basic ignition angle is the spark advance that you can run the engine at the max torque (at given LOAD and RPM), but not causing the knock.

Actually it is not 100% optimized. There are 2-5 degrees of buffer reserved to protect the engine. You can not run 100% optimized spark advance unless you have a good knock control systems (knock sensors, for additional cost, etc).

A 16x12 ignition angle table for you to tune the ignition angle at different operating conditions, instead of pre-set factory ignition curve only dependent on the RPM.

This 16x12 basic ignition table is dependent on RPM and Load, and you can tune it to whatever curve, or actually “surf” as you want. Factory CDI timing is usually a fixed curve – more advance at higher RPM. That’s it.

ECU controlled ignition angle has much more flexibility: it also takes into account of AFR (rich or lean), temperatures (cold or hot), altitude, etc, as the input to adjust the ignition angles. You need to read through the strategy book to understand how these factors affect the final ignition angle output.

In ProCAL:

menu → calibrations → ignition system → basic ignition angle →

The screenshot shows a software window titled "Volumetric Efficiency" with a text input field containing "MAP_Iga_N_Ld". Below the input field is a table with 12 columns and 18 rows. The first column is labeled "Y/X" and lists engine speeds from 1200 to 10200. The subsequent 11 columns list values for different load conditions (X). The values in the table are as follows:

Y/X	20.25	26.25	32.25	38.25	44.25	50.25	56.25	62.25	68.25	74.25	80.25
1200	24.75	24.75	24.75	24.75	24.75	24.75	24.75	24.75	24.75	24.75	24.75
1680	24.75	24.75	24.75	24.75	24.75	24.75	24.75	24.75	24.75	24.75	24.75
2000	24.75	24.75	24.75	24.75	24.75	24.75	24.75	24.75	24.75	24.75	24.75
2480	24.75	24.75	24.75	24.75	24.75	24.75	24.75	24.75	24.75	24.75	24.75
3000	24.75	24.75	24.75	24.75	24.75	24.75	24.75	24.75	24.75	24.75	24.75
3520	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
4000	30.75	30.75	30.75	30.75	30.75	30.75	30.75	30.75	30.75	30.75	30.75
4480	32.25	32.25	32.25	32.25	32.25	32.25	32.25	32.25	32.25	32.25	32.25
5000	32.25	32.25	32.25	32.25	32.25	32.25	32.25	32.25	32.25	32.25	32.25
5520	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00	33.00
6000	35.25	35.25	35.25	35.25	35.25	35.25	35.25	35.25	35.25	35.25	35.25
7000	35.25	35.25	35.25	35.25	35.25	35.25	35.25	35.25	35.25	35.25	35.25
8000	35.25	35.25	35.25	35.25	35.25	35.25	35.25	35.25	35.25	35.25	35.25
9000	35.25	35.25	35.25	35.25	35.25	35.25	35.25	35.25	35.25	35.25	35.25
10000	35.25	35.25	35.25	35.25	35.25	35.25	35.25	35.25	35.25	35.25	35.25
10200	35.25	35.25	35.25	35.25	35.25	35.25	35.25	35.25	35.25	35.25	35.25

Below the table, there are three explanatory lines:

- X: Ld_b, "Load, or relative air charge (byte)"
- Y: N_b, "engine speed, byte value"
- MAP_Iga_N_Ld: "characteristic map, basic ignition angle, dependent on engine speed and load"

Minimum Ignition Angle

Minimum ignition angle is the latest spark retard angle (refer to TDC) that you can still run the engine without misfiring.

Other Ignition Angle Adjustment

Basic ignition angle will be adjusted according to temperature, altitude, lambda, knock limit, etc. That's probably why sometime you see the actual ignition angle is not the one you filled in the basic ignition angle. It can be something in the middle of basic angle and minimum angle.

Sensor and Actuator Calibrations

You only need to tune with this chapter if you are using sensors or actuators other than the ones provided by us. (For example, you installed a throttle from a savaged FI engine, which comes with the OEM's TPS, MAP sensors, and injector); Or if you use our ECU only to replace the stock ECU on a FI engine.

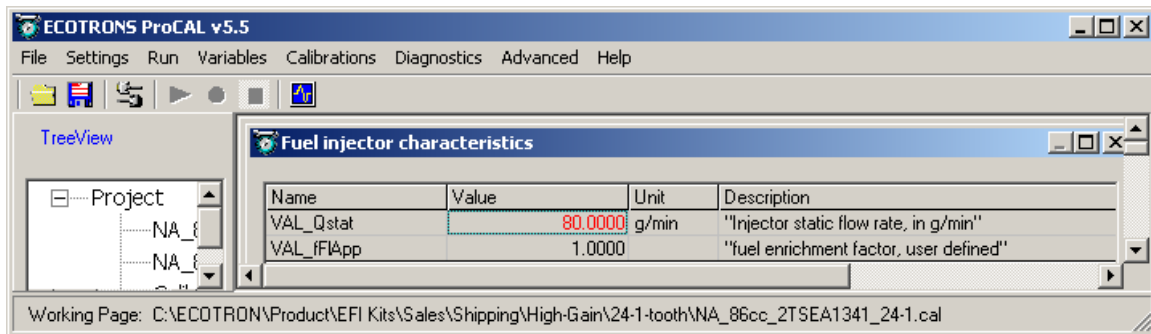
The best way to tune the sensor and actuator's characteristics is to find out from the manufacturer's data sheets. If you can not get them, here are the ways to get coarse data of them.

Injector characteristics

1. static flow rate

VAL_Qstat: injector static flow rate (g/min, or gram per minute)

This must be found out from the manufacturer's datasheet or manual.



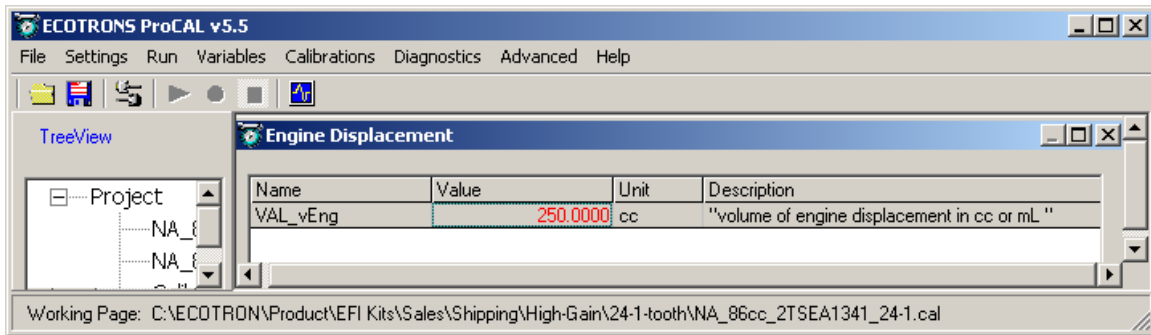
Together, it may be necessary to find out what is the fuel pressure in the fuel rail, or high pressure line. Make sure the VAL_Qstat has the value which is associated with this fuel pressure. Otherwise it may need adjusted. Ask us how to.

Engine displacement

VAL_vEng: volume of engine displacement (cc or milliliter)

This might be the easiest one to figure out.

Note, if it's a 2 cylinder engine, this value needs to be divided by 2. meaning this is the single-cylinder displacement.



MAP sensor

Map: manifold absolute pressure (hPa)

uMap: voltage of MAP sensor signal (V)

$$\text{Map} = \text{uMap} * \text{VAL_PmapGrd} + \text{VAL_PmapOfs}$$

analog signal from the MAP sensor, uMap, is converted into absolute pressure in hPa. the conversion is linear, with slope of VAL_PmapGrd, and offset of VAL_PmapOfs.

“VAL_PmapGrd” and “VAL_PmapOfs” are calibrate-able variables in the ECU.

To find out these 2 values, you have below options:

1. Get it from the manufacturer, either from the vehicle manufacturer, or component manufacturer.
2. Measure it your self, and you need 2 pairs of (pressure vs voltage) data points:
 - 1) Use an accurate pressure gauge, measure the pressure point #1, P1, and at the same time use a multi-meter, measure the voltage of the MAP sensor signal wire, u1;
 - 2) measure the pressure point #2, P2, and at the same time use a multi-meter, measure the voltage of the MAP sensor signal wire, u2;

These 2 data points are preferred to be representative to the range of MAP sensor. for example;

P1 can be the idle air pressure: 500hPa (note, when measuring the pressure, create a stable vacuum. Small engine manifold pressure is too dynamic for this measurement.)

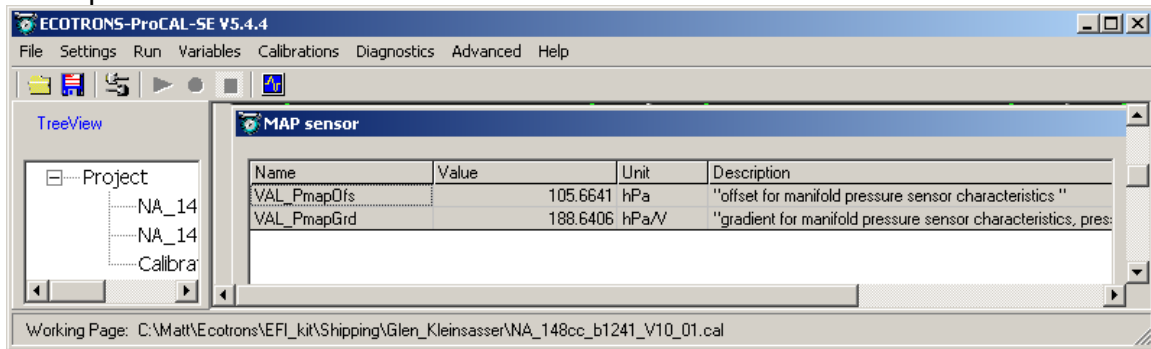
P2 can be the barometric pressure: 1013 hPa at sea level.

Then

$$\text{VAL_PmapGrd} = (\text{P2} - \text{P1}) / (\text{u2} - \text{u1})$$

$$\text{VAL_PmapOfs} = \text{P2} - \text{u2} * \text{VAL_PmapGrd}$$

Example:



IAT sensor

IAT: intake air temperature sensor

Ta: Temperature of intake air (°C)

uTa: voltage of air temperature sensor signal (V)

Usually temperature sensors are NTC type : negative temp characteristics:

Assuming, as a first-order approximation, that the relationship between resistance and temperature is linear, then:

$$\Delta R = k * \Delta T$$

where

ΔR = change in resistance

ΔT = change in temperature

k = first-order temperature coefficient of resistance

You need find out what is the "k" value by measuring 2 pair of (resistance , temperatures): (T2, R2), (T1, R1).

Then:

$$k = (R2-R1) / (T2-T1)$$

Once you get the value of "k", you can calculate any pair of (T, R):

$$T = T1 + (R - R1) / k$$

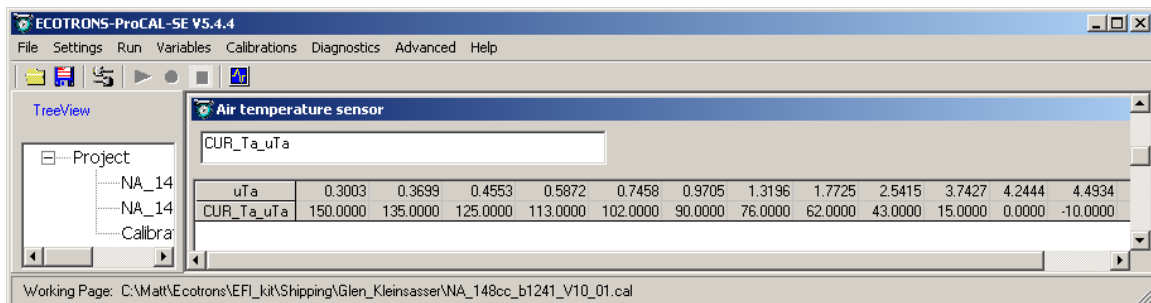
Where: T is the any temperature, and R is the corresponding Resistance.

$$R = R0 * [uTa / (5 - uTa)]$$

R0 is provided by ECU manufacturer. It is a constant resistor. . It is **1k Ω** unless otherwise specified.

uTa is the voltage That ECU reads from the IAT sensor. 5 is the +5V sensor power supply.

By these relations, you can calculate the below table and fill in ProCAL:



Examples on how to measure the temperature sensors:

1. Soak the vehicle in over-night, get up earlier in the morning, when the ambient temperature is comparatively low, use a thermostat, read the ambient temperature, T1, like 10 deg C; for example. And use a multi-meter, measure the resistance between the sensor signal wire and chassis, R1.
2. Soak the vehicle in the sun-shine area during a hot day, wait for the hottest time in the afternoon, when the ambient temperature is comparatively high, use the thermostat, read the ambient temperature, T2, like 35 deg C; for example. And use the multi-meter, measure the resistance between the sensor signal wire and chassis, R2.
3. Use these 2 pair of data (T1, R1) and (T2, R2) do the calculations as the above.

ECT sensor

ECT: engine coolant temperature sensor

Tm: Engine (motor)Temperature (°C)

uTm: voltage of engine temperature sensor signal (V)

Usually temperature sensors are NTC type : negative temp characteristics:

Assuming, as a first-order approximation, that the relationship between resistance and temperature is linear, then:

$$\Delta R = k * \Delta T$$

where

ΔR = change in resistance

ΔT = change in temperature

k = first-order temperature coefficient of resistance

You need find out what is the "k" value by measuring 2 pair of (resistance , temperatures): (T2, R2), (T1, R1).

Then:

$$k = (R2-R1) / (T2-T1)$$

Once you get the value of "k", you can calculate any pair of (T, R):

$$T = T1 + (R - R1) / k$$

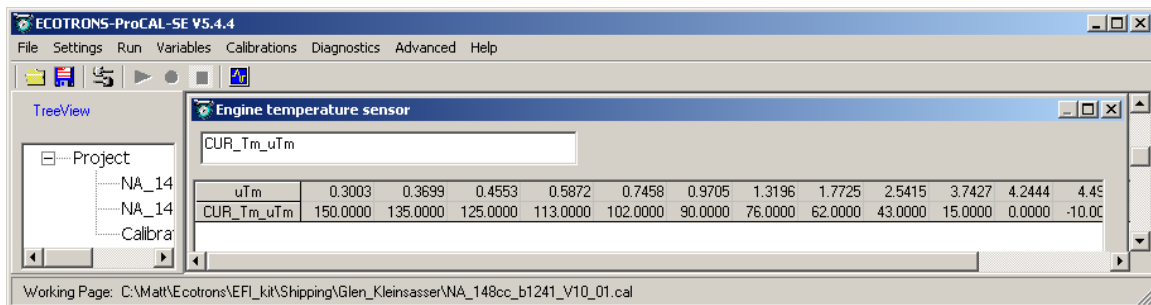
Where: T is the any temperature, and R is the corresponding Resistance.

$$R = R0 * [uTm / (5 - uTm)]$$

R0 is provided by ECU manufacturer. It is a constant resistor. It is **1k Ω** unless otherwise specified.

uTm is the voltage That ECU reads from the ECT sensor. 5 is the +5V sensor power supply.

By this relations, you can calculate the below table and fill in ProCAL:



The screenshot shows the ECOTRONS-ProCAL-SE V5.4.4 software interface. The main window displays a table for 'Engine temperature sensor' calibration data. The table has two rows: 'uTm' and 'CUR_Tm_uTm'. The 'uTm' row contains 11 numerical values ranging from 0.3003 to 4.45. The 'CUR_Tm_uTm' row contains 11 numerical values ranging from 150.0000 to -10.00. The software interface includes a menu bar (File, Settings, Run, Variables, Calibrations, Diagnostics, Advanced, Help) and a TreeView on the left side.

uTm	0.3003	0.3699	0.4553	0.5872	0.7458	0.9705	1.3196	1.7725	2.5415	3.7427	4.2444	4.45
CUR_Tm_uTm	150.0000	135.0000	125.0000	113.0000	102.0000	90.0000	76.0000	62.0000	43.0000	15.0000	0.0000	-10.00

Examples on how to measure the temperature sensors:

Same as the IAT sensor.

TPS sensor

Tps: throttle position sensor (hPa)

uTps: voltage of TPS sensor signal (V)

For throttle position sensors, you need to measure the idle position “uTps1”, and WOT position “uTps2”.

Then find the values for VAL_uTpsMx and VAL_uTpsMn, to make sure that:

$$+5V > VAL_uTpsMx > (uTps2 + 0.1v)$$
$$(uTps1 - 0.1v) > VAL_uTpsMn > 0$$

