SE-EFI

Small Engine Electronic Fuel Injection
– for 1 or 2 cylinder engines

ECOTRONS

Tuning Guide

V2.4

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.


www.ecotrons.com
Harness
USB-RS232
ECU
Communication Cable
CDI
ECU controlled
Throttle body &
Intake Manifold
Software-CD
Temperature Sensors
Fuel injector
MAP Sensor
Fuel return
line
Fuel pressure
regulator
Fuel Pump
Fuel filter
Oxygen Sensor
High pressure fuel line
T-pipes

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_xxxxx” 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_xxxxx", select it, and click "add to", and then click "OK".
4) back to ProCAL window, "VAL_xxxxx" 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.

How to run ProCAL in Windows Vista or Win7?

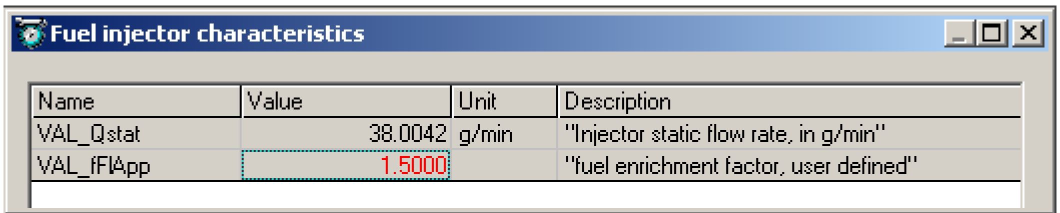
1. Right click on the ProCal icon
2. Choose properties
3. Click compatibility tab
4. Check: Run this program in compatibility mode
5. Choose XP service pack 2
6. Check: run this program as administrator
7. Apply

1. Tuning fuel

1.1 Global fuel tuning

VAL_fFlApp – "fuel enrichment factor, user defined"

In ProCAL:
menu → calibrations → fuel system → injector characteristics →
VAL_fFlApp = 1.0 (default).



Fuel injector characteristics

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

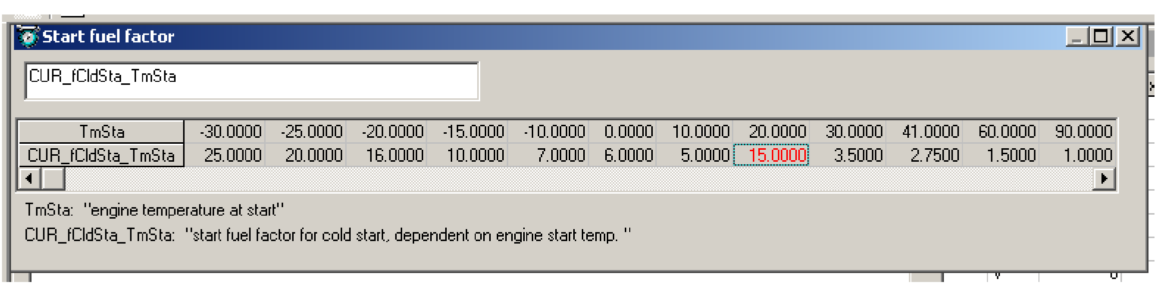
It's a global enrichment factor multiplied on the base fuel, meaning, if you change it to 1.5, your fuel amount will be 1.5 times everywhere. And it applies to all operating conditions (start, warm-up, steady-state, transient). It has a range of 0-4.0.

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_fCldSta_TmSta – "start fuel factor for cold start, dependent on engine start temp."

In ProCAL:
menu → calibrations → fuel system → start fuel factor →



Start fuel factor

CUR_fCldSta_TmSta

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_fCldSta_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_fCldSta_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.

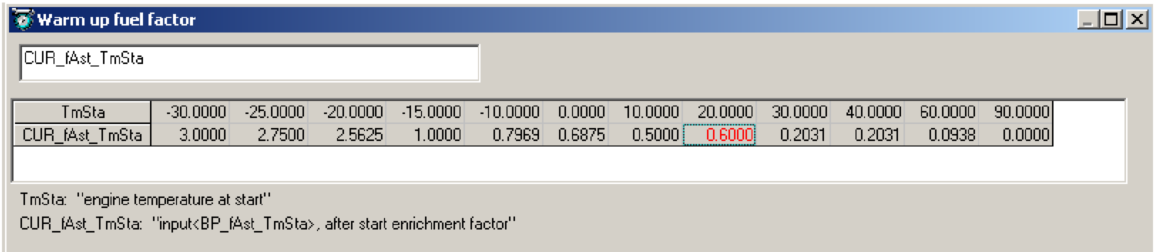
5) Start fuel only applies during start. Once the start of engine is ended, indicated by that the engine speed (N) is greater than 1000rpm; the start fuel will be inactive. The after-start fuel and warm-up fuel will take over.

Example:
Early in the morning, Key on, connect your laptop, read the Tm (or ECT), in ProCAL, say, it's 9C. Then find the celll in the table where the break point is the closest, 10C in this case; and the existing value is 5.0; meaning, 5 times enrichment is the pre-set.
Most likely you are starting a little leaner at that temperature; so you would increase the value to 5.5; and then "burn to ECU".
Then you start the engine, see if the starting is better. If not, you may have to wait for next day morning. and increase it to 6.0; and try it again.
You may end up over-enriching the start fuel, which causes black smokes, and strong smell, and even flooding. In that case, you may go to the other direction, reducing the enrichment factor.
The challenge is that there is no direct measure which tells you whether it's over-enriched or under-enriched. It's really based on your feeling and experiments.

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 →

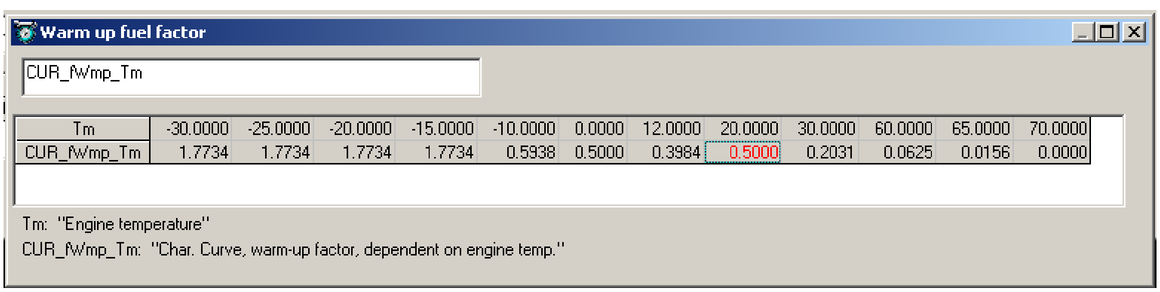


TmSta	-30.0000	-25.0000	-20.0000	-15.0000	-10.0000	0.0000	10.0000	20.0000	30.0000	40.0000	60.0000	90.0000
CUR_fAst_TmSta	3.0000	2.7500	2.5625	1.0000	0.7969	0.6875	0.5000	0.6000	0.2031	0.2031	0.0938	0.0000

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 →



Tm	-30.0000	-25.0000	-20.0000	-15.0000	-10.0000	0.0000	12.0000	20.0000	30.0000	60.0000	65.0000	70.0000
CUR_fWmp_Tm	1.7734	1.7734	1.7734	1.7734	0.5938	0.5000	0.3984	0.5000	0.2031	0.0625	0.0156	0.0000

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 takes into account of the impact of engine load and speed.

Q: Tips for after-start and warm-up fuel

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.
3) Exceptions #1: if you notice the engine clearly fires for the start (during first couple of revolutions), and the RPM rises quickly to more than 800rpm, but then stalls immediately; this tells you that the after-start fuel is not enough. You will need to increase the after-start fuel factor.
4) Exception #2: if you notice that the engine starts, and idles at relatively good rpm, like 1800rpm, but then slowly it dies. This tells you that you may need to enrich the warm-up fuel to keep engine running after the start-up and after-start fuel factors ramping out.

Q: Engine starts, and idling, and can stay running, but kind of rough. What's next?

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.

More on Start, After-Start, Warm-up process:

See below the 2 graphs of start and warm-up process from a real scooter engine (please rotate 90 degree for view):

Descriptions:

1) The engine starts at 30C degree; and idles up to 70C degree (where the warm-up process is ended);
2) Start fuel factor starts at 3.2 (fFlSta), for example; and drops to 1 as soon as the RPM > 1000rpm (start ended); this only takes a few seconds;
3) After-start fuel factor starts to take over when start is ended (fFlSta =1); and for example, it starts at 1.23; and quickly ramps down to 1; and this takes about 1 minute (or 60s); This factor is dependent on the engine start temperature only (30C);
4) Warm-up fuel factor happens simultaneously with the after-start factor, but it ramps down very slowly; it starts at 1.4; and takes about 6 minutes (360s) to ramp down to 1, when ECT is 70C deg. This factor depends on real-time engine temperature (changing from 30C to 70C).
5) The close-loop fuel only happens 3 minutes after start, where the O2S signal starts to oscillate.
6) Overall fuel enrichment factor, fPreCtl, is the results of all 3 factors, start factor, after-start factor, warm-up factor:

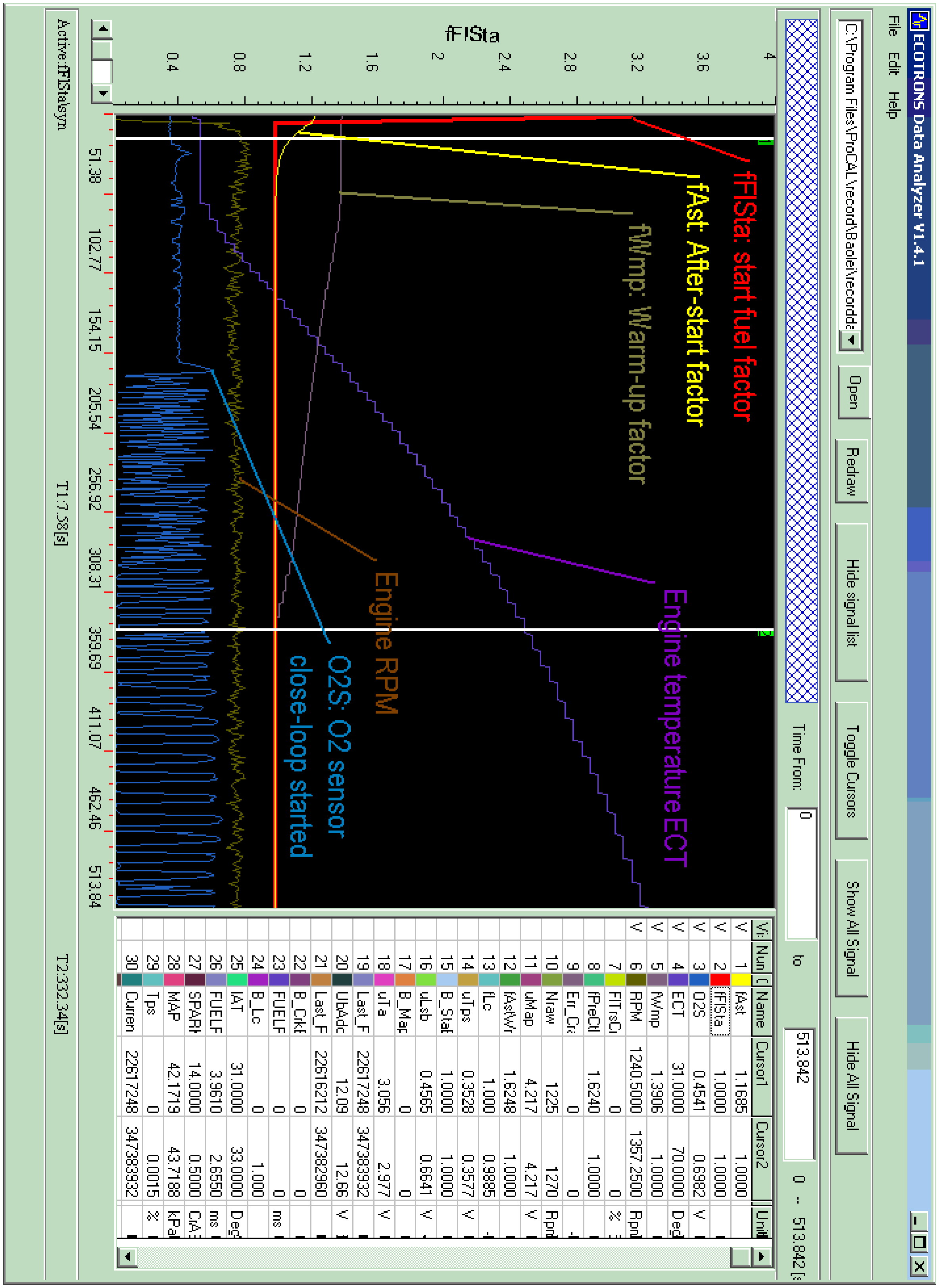
   fPreCtl = fFlSta * VAL_FlApp (during start)

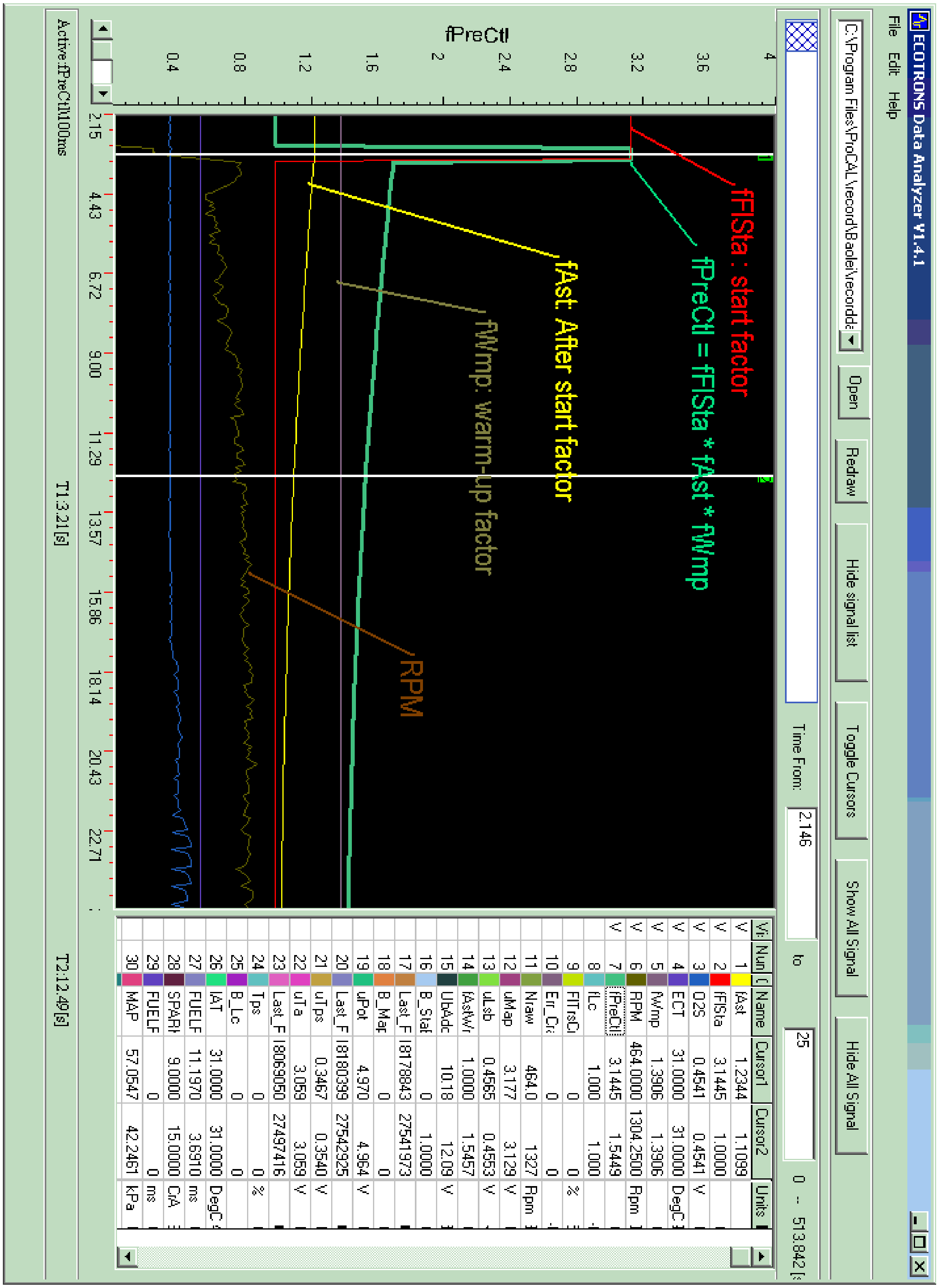
   fPreCtl = fAst * fWmp* VAL_FlApp (during after-start, warm-up)

   Note: During start, fAst and fWmp are not used; meaning they are equivalent to 1; VAL_FlApp is the global enrichment factor.

   fPreCtl is the overall enrichment factor.

   It is the green line in the second graph. Note, in your logged data, you can only see this variable plotted. It tells you how your starting-warm-up fuel is controlled.


ECOTRONS Data Analyzer V1.4.1
fFISta: start fuel factor
fAst: After-start factor
fWmp: Warm-up factor
Engine temperature ECT
Engine RPM
O2S: O2 sensor
close-loop started


ECOTRONS Data Analyzer V1.4.1
fFlSta : start factor
fPreCtl = fFlSta * fAst * fWmp
fAst: After start factor
fWmp: warm-up factor
RPM

Open Loop Fuel Controls

What is open loop fuel controls, why do we have 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. The big difference can not be learnt thoroughly by the ECU and could lead to the oscillations, or hit the limitations.

Without a comparatively stable engine running in open-loop, the exhaust from the engine could be erratically rich or lean or have fuel flooding, and 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.

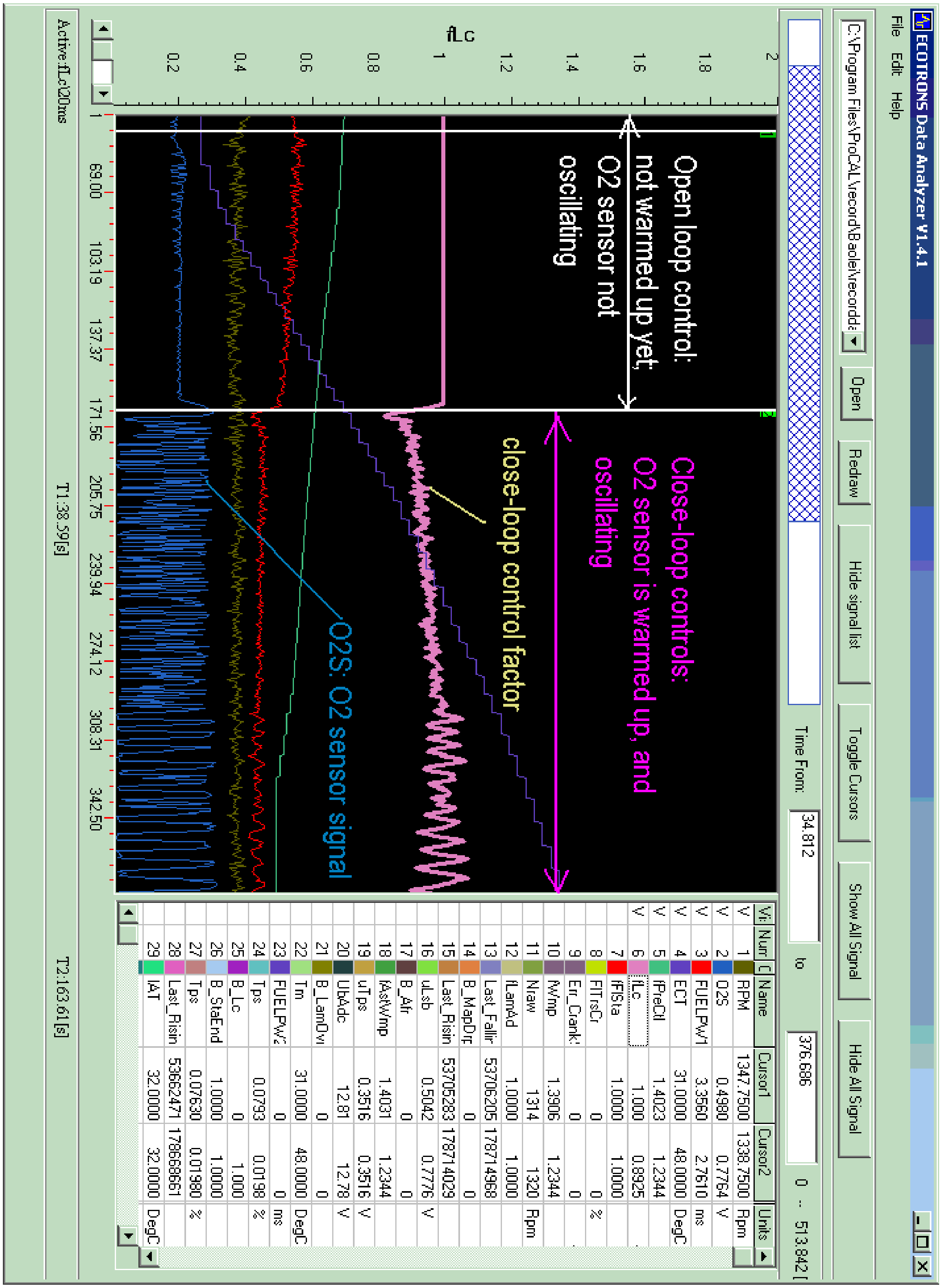
Open-loop tuning is actually advanced tuning, we talk about it later.

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 air adjustment).

Note: during start and warm-up process, the engine is running in open-loop mode; it only starts to run close-loop mode after the O2 sensor is warmed up (see graph below) :

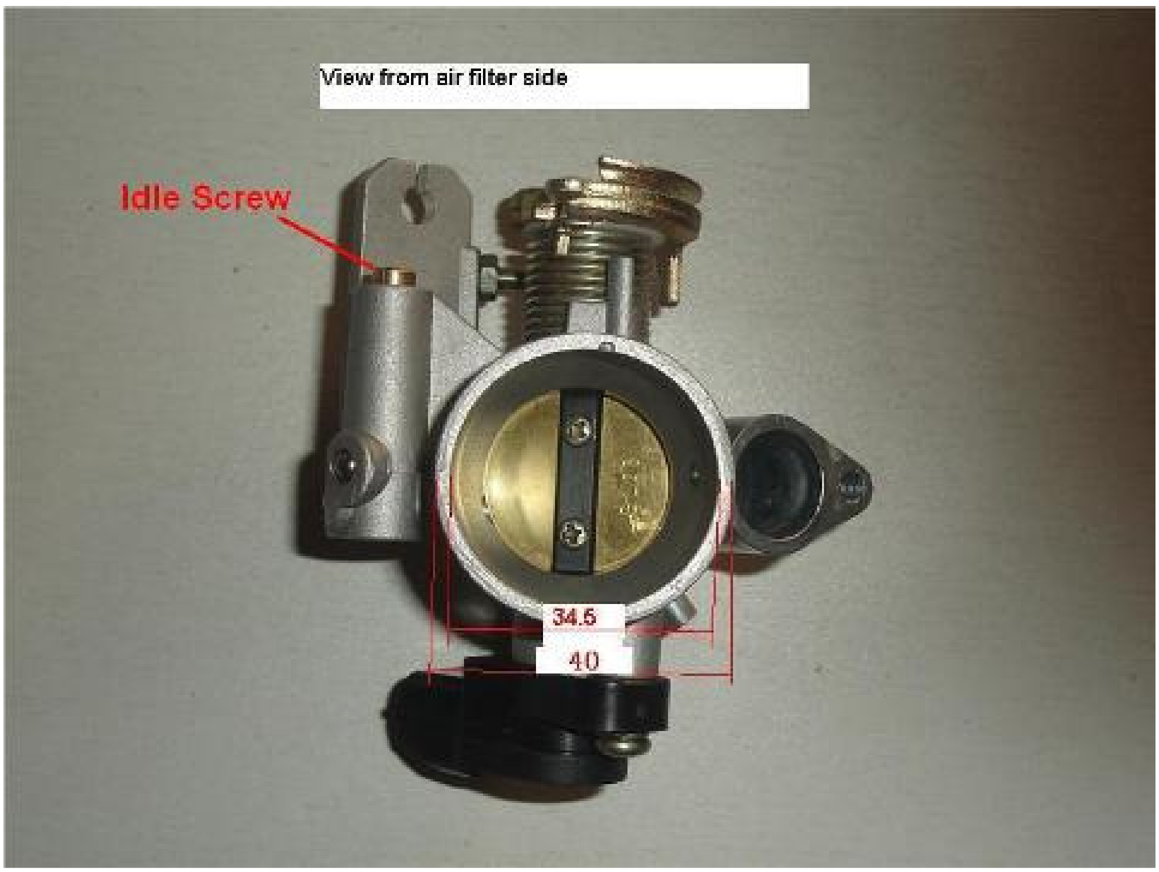

ECOTRONS Data Analyzer V1.4.1
Open loop control: not warmed up yet, O2 sensor not oscillating
Close-loop controls: O2 sensor is warmed up, and oscillating
close-loop control factor
O2S: O2 sensor signal

Idle Speed

Air Path

Adjust idle speed by adjusting idle by-pass air screw. (our 28mm Throttle body and 24mm throttle body)

Our 24mm/28mm throttle body 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.



Usually the idle speed for 1 or 2 cylinder engines is around 1500rpm. (obviously there are so many different engines, this number is only just an example.)

Certainly, you must make sure the whole intake air system is air-tight!

Past experience shows that during initial installations, some users forgot to make sure the air-tight of the system, and end up high “idle” RPM, like 4000rpm; and which actually leads to RPM oscillations! Because our ECU is trying to cut the fuel to lower down the idle RPM.

So if you see an oscillating idle RPM from 4000rpm to 1000rpm, that tells you that you should check your intake air system, and find out air leakage!

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.

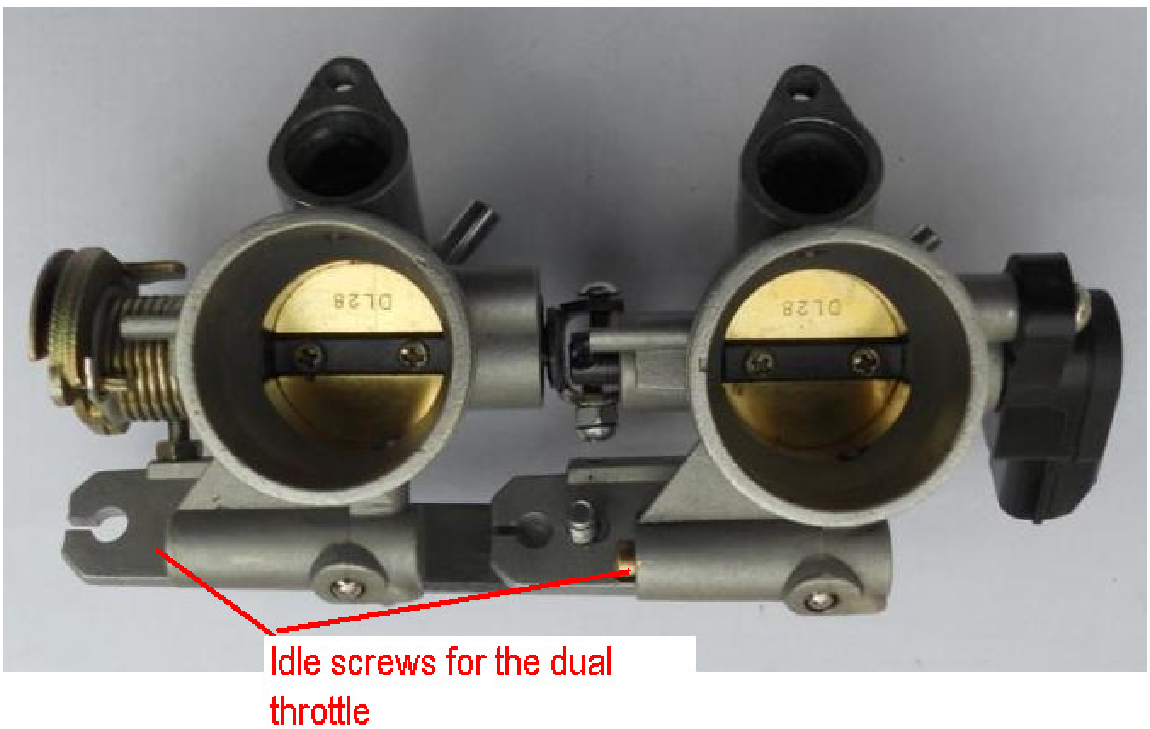
Note, if you notice that you have to hold the throttle to open a little to start the engine and keep the engine running, and as soon as you let the throttle go, the engine stalls. This means you may have too less idle air. This could be the case especially for the big engines, where more idle air is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

If you have our dual throttle body for a parallel twin engine (Ninja 250r), 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 adjustments to both screws are same.



Idle Speed controls via IAC motor

Our 34mm, 38mm or 42mm throttle bodies come with an Idle Air Control (IAC) motor, which is a stepper motor, with 4 wires.

With these throttle bodies, you can set the target idle speed, and ECU will control the stepper motor to reach that speed.

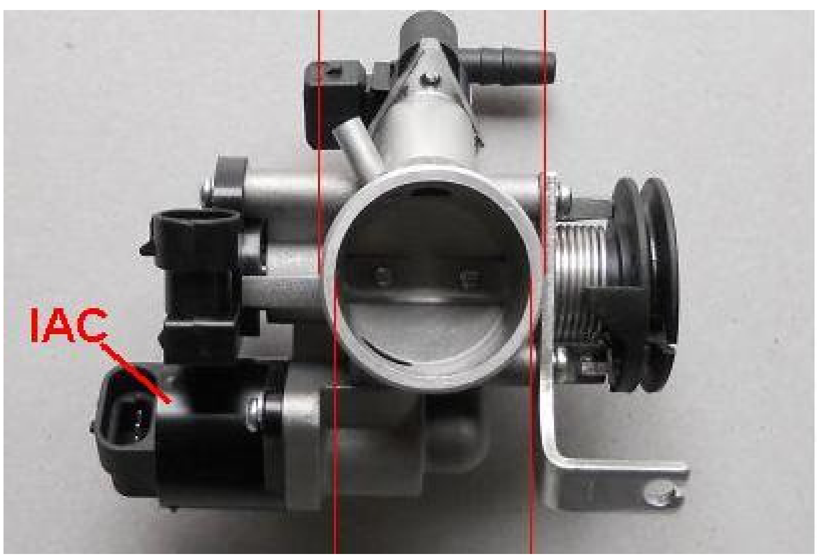
Desired Idle Speed

Name	Value	Unit	Description
VAL_NidlDsr	1200.0000	RPM	"desired idle speed, LLD"

VAL_NidlDsr – "Desired idle speed"

In ProCAL:
menu → calibrations → Air system → Desired idle speed

By default, it is set as 1500 RPM, if your engine has a different idle RPM, you need to change it.



Our idle speed controls via IAC motor is a close-loop control. It reads the actually engine RPM and compares it to the target idle speed, and adjust the idle air correspondingly, and maintain the target the idle speed.

Note: the idle speed certainly can not be set too high or too low. For example, if your engine idle RPM (OEM setting) is 1500 RPM, and you set it to 3000RPM, it will not work, and you may have an oscillating RPM.
If you set the idle RPM too low, like 1000rpm, it may end up stall frequently.

Also the stepper motor comes with the throttle bodies are designed for certain range of displacements (engine cc sizes). If you use these throttle bodies on too big engines or too small engines, the idle motor may reach its physical max/min limits, and the idle air can not be increase more, or reduced to less. You could also end up with too high or too low idle RPMs.

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 in the base kit. You can certainly install your own wideband sensor (must come with a wideband controller). We do carry our own wideband controller, ALM, though.

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

Q: How do I see the O2 sensor voltage?

Easy way: in ProCAL, among the bunch of green/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 caused 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.
6) Default value of Desired lambda is as below table. It is enriched at high end. It is lambda value, and 1 means stoic AFR (14.7 for gasoline).
7) Desired lambda table is only active if you turn on the "RICH" mode, by switching the "Performance switch" to ON position. By default, the engine is running in "ECO" mode; and this table is not used.

Desired lambda

MAP_LamDrv_Tps_N

Y/X	700	1400	2000	3000	4000	5000	6000	7000	7500	9000	11000	14000
0.00	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5.00	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9863	0.9863	0.9863	0.9863
10.00	1.0000	1.0000	0.9932	0.9863	0.9863	0.9863	0.9863	0.9863	0.9524	0.9524	0.9524	0.9524
13.16	1.0000	0.9932	0.9524	0.9524	0.9524	0.9524	0.9524	0.9524	0.9185	0.9185	0.9185	0.9185
17.11	0.9863	0.9863	0.9185	0.9185	0.9185	0.9185	0.9185	0.9185	0.9185	0.8845	0.8845	0.8845
21.05	0.9863	0.9863	0.9185	0.8845	0.8845	0.8845	0.8845	0.8845	0.8845	0.8503	0.8503	0.8503
25.00	0.8845	0.9524	0.8911	0.8845	0.8503	0.8503	0.8503	0.8503	0.8503	0.8503	0.8503	0.8503
32.89	0.8845	0.9524	0.8911	0.8777	0.8503	0.8503	0.8503	0.8503	0.8503	0.8435	0.8435	0.8435
39.47	0.8777	0.8845	0.8845	0.8706	0.8503	0.8435	0.8435	0.8435	0.8435	0.8367	0.8367	0.8367
46.05	0.8777	0.8845	0.8845	0.8706	0.8503	0.8367	0.8367	0.8367	0.8367	0.8367	0.8367	0.8367
52.63	0.8777	0.8845	0.8845	0.8640	0.8503	0.8367	0.8367	0.8367	0.8367	0.8298	0.8298	0.8298
59.20	0.8777	0.8845	0.8777	0.8640	0.8503	0.8298	0.8298	0.8298	0.8298	0.8298	0.8298	0.8298
65.78	0.8777	0.8845	0.8777	0.8640	0.8503	0.8298	0.8298	0.8298	0.8298	0.8298	0.8298	0.8298
73.00	0.8777	0.8845	0.8777	0.8640	0.8298	0.8298	0.8298	0.8298	0.8298	0.8298	0.8298	0.8298
82.00	0.8777	0.8845	0.8777	0.8640	0.8298	0.8298	0.8298	0.8298	0.8298	0.8298	0.8298	0.8298
99.99	0.8777	0.8845	0.8777	0.8640	0.8298	0.8298	0.8298	0.8298	0.8298	0.8298	0.8298	0.8298

X: N, [Rpm] "Engine speed in Rpm"
Y: NO_INPUT_QUANTITY, [%] "input<TpsEqu>, break points, throttle position "
MAP_LamDrv_Tps_N: [-] "characteristic map, Driver desired lambda, dependent on TPS and N"

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!
Please educate yourself on the basics of engines and electronic fuel injections. There are tons of this kind of info on the internet, and all you need to do is find appropriate levels of materials and read them.

The first concept you need to understand is "Volumetric Efficiency".

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 at the end of the engine exhaust stroke. The total air mass in the cylinder is the sum of the fresh air sucked in and the residual exhaust gas. To know exactly how much fuel you need to inject and mix with the air in the combustion chamber, you have to know how much fresh air is in there instead of the total air mass, and that is why we have to know the 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 fresh air mass in the cylinder and therefore the fuel amount that needs to be injected.

Unfortunately, volumetric efficiency is not able to be measured directly with any sensor. You'd have to tune the engine and calibrate it one operating-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.

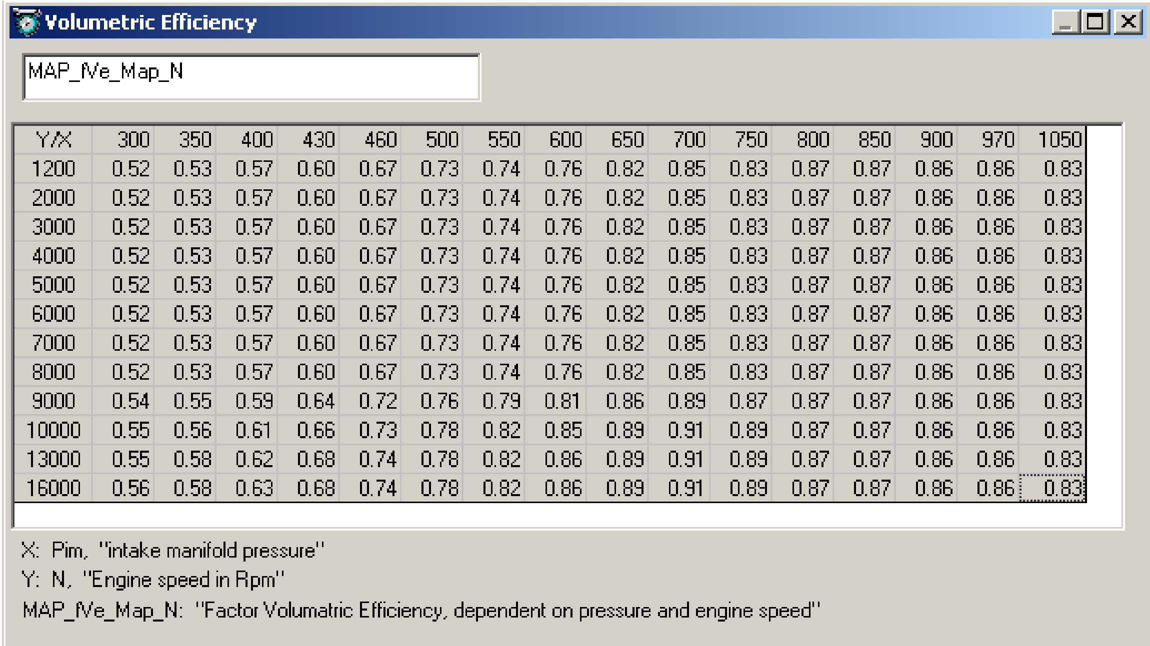
If you have a wideband controller, you can run the engine with the wideband controller together, or ride the bike in a steady state (comparatively constant throttle and RPM); at certain MAP signal and RPM, you can tweak the volumetric efficiency table until you get the stoic AFR indication from your 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, you can use an even 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).

Note: do NOT tune your VE table when engine has not been warmed up! Only do that after the engine is fully warmed up (example, ECT >= 50C).

In ProCAL:
menu → calibrations → air system → volumetric efficiency →



Volumetric Efficiency

MAP_fVe_Map_N

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 Volumatric Efficiency, dependent on pressure and engine speed"

Note: it is critical to have a smooth transition from one operating point (one cell) to the next in the VE table. Never ever leave a spike in the table (a good way is to export the table to EXCEL and plot a 3D Surf, and manually smoothen out any spikes). Spikes are no good for engine controls.

Note: To ease the time-consuming tuning, understand you don't want to tune each cell, we developed the "EXPORT" functions of the tables. You can modify the whole table in MicroSoft EXCEL!

Right click the table, select "export", it will save the table in the CSV format. And you can do the editing in Excel, which most users are very familiar. After you done the editing in EXCEL, you right click the table in ProCAL again, and select "import", select the CSV file you saved, and it will import the whole table back in.

It is so easy to edit the table in EXCEL, that it has become a must to use this feature to do the tuning. You can also do the 3D plots, and use EXCEL math functions to tweak the cell values, and smooth out the spikes.

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 could 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), the mass of the air in the cylinder is the ideal air mass.

“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 desired air-fuel-ratio. Because you can only calculate the fuel quantity, 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 big or how small your 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 pulse width on the dyno……”.
While, you will end up re-tune all your mapping for some small things 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 has a 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.

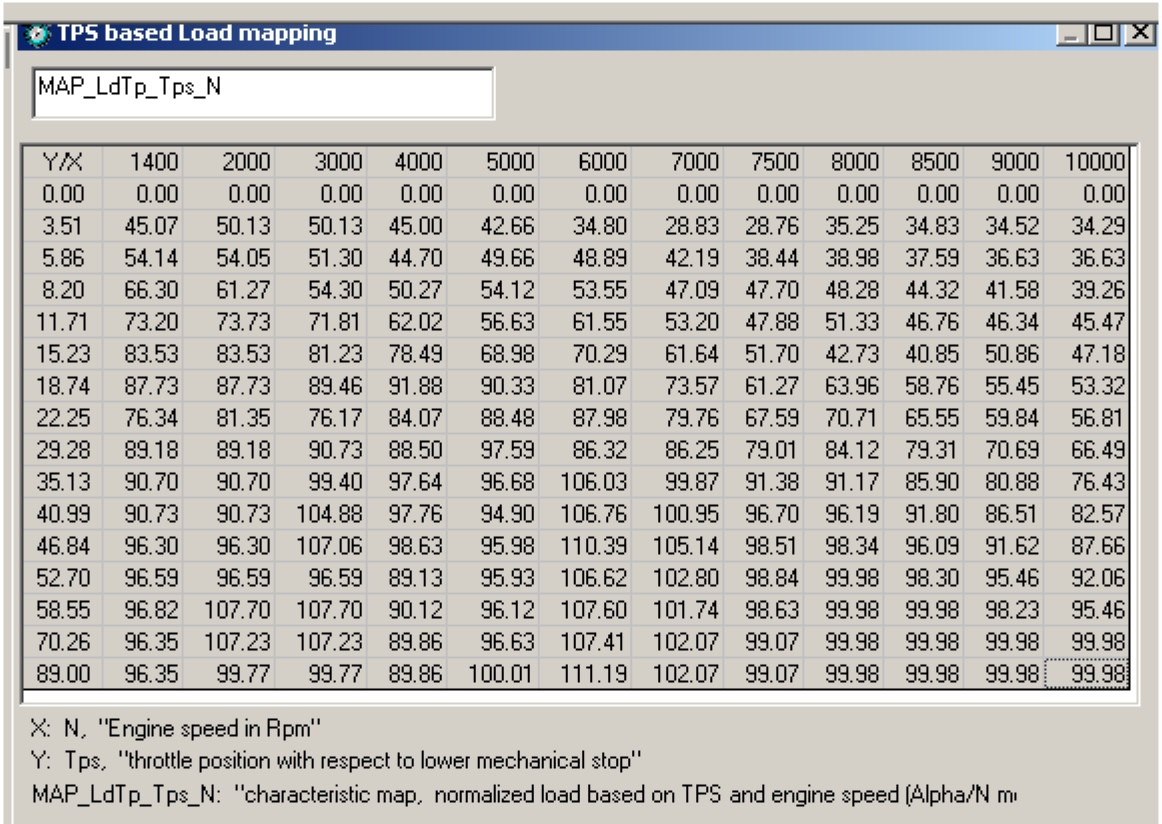
The way to calibrate the LOAD mapping is similar to the "volumetric efficiency" table. The best way is to use an engine dyno. If not, use a wideband controller, and if not, use the narrow band O2 sensor to do "estimations".

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

This is what auto industry called "**Alpha-N**" method.

Note: again, do NOT tune your LOAD table when engine has not been warmed up! Only do that after the engine is fully warmed up (example, ECT >= 50C).

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

Note: the same rule applies here too: it is critical to have a smooth transition from one operating point (cell value) to the next, in the Load table. Never ever leave a spike in the table (a good way is to export the table to EXCEL and plot a 3D Surf, and manually smoothen out any spikes). Spikes are no good for engine controls.

Again, you can use "export / import" feature to use EXCEL to edit the whole table. Right click the table, select "export", to go to EXCEL.

Blended Speed-Density and Alpha-N methods

So, “Speed-Density”, or “Alpha-N”, which method is better for engine controls? There have been too many debates on this. Google it.

But the truth is: neither is perfect. You need both. You need blend them together to have the best engine controls, especially for high RPM, sporty motorcycle engines.

As common sense, MAP sensor is a direct measure of air mass into the cylinder, while TPS sensor is an indirect measure of the air mass. It seems MAP sensor based “speed-density” is better than TPS based “Alpha-N” method for air charge detection. This is true at low RPM, and small loads. Because then the MAP sensor signal has enough resolutions and the air mass calculated based on the instant manifold pressure is more accurate than the estimated by TPS position. TPS based air mass estimation has very poor resolution at low throttle opening. A small throttle position change at low throttle can cause big air mass change.

But as you may have noticed, small engines’ manifold pressure is changing so dynamically, there is no “stable, constant” MAP signal, even you hold the throttle position unchanged. This becomes worse when you have large throttle opening, and you are running more than 6000 RPM. MAP sensor signal becomes un-stable and even not usable. For motorcycle sporty engines, at large throttle opening, which is usually accompanied by high RPMs, the air flow in the manifold is so fast, that the pressure change can not be detected by MAP sensor any more. The result: you open the throttle more, but your MAP sensor gives you the same pressure reading, which is certainly wrong, because you have more air flow into the cylinder. In this situation, you must use “Alpha-N” method to calculate the air charge.

So, in short, you should use “Speed-density” for low RPM, low loads; but use “Alpha-N” method for high RPM, high loads.

This is how our system works.

We have a TPS characteristic curve that is based on RPM to split the fuel mapping between the “speed-density” and “alpha-N” methods. This curve is the threshold of TPS, that below it, you use “speed-density”, and above it, you use “alpha-N”. The curve is dependent on RPM.

You can find this curve in the advanced calibrations in ProCAL (this calibration is only available for certain users):

ProCAL → advanced → add advanced calibrations; Add:
CUR_TpsUnTp_N “Characteristic curve, TPS threshold, air flow is un-throttled and/or pressure change is insensitive.”

CUR_TpsUnTp_N

N_b	780.0000	3000.0000	3480.0000	4020.0000	4980.0000	6000.0000	7020.0000	7980.0000	9000.0000	10020.0000	10980.0000	12000.0000
CUR_TpsUnTp_N	98.0469	98.0469	46.0938	35.9375	32.0313	25.0000	17.9688	10.1563	10.1563	10.1563	10.1563	10.1563

N_b: [Rpm] "engine speed, byte value"
CUR_TpsUnTp_N: [%] "throttle position for 95 % of load, dependent on the engine speed"

Too complicated? I don't want to tune both tables… How about just one table?

Of course, you can just use one method: "Speed-Density", or "Alpha-N". Only you don't have as much accuracy as the blended method. But most users do not really need that much of accuracy. Using one method is often good enough.

If you engine max RPM is less than **8000RPM**, "speed-density" method often gives good enough controls without using "alpha-N". Actually most our base engine calibrations use the "speed-density" over the whole load / speed range. This means you only need to tune the VE table.

Some other users prefer to using TPS based fuel mapping. And use MAP sensor only for Baro pressure reading (therefore adjust fuel for different altitude). This is especially true for 2-stroke engine tuning. As you know, 2-stroke engine does not have much meaningful manifold pressure to be used as air charge detection. In this case, you only need to tune the "TPS based Load Mapping" table.

The disadvantage of "Alpha-N" method only is that it does not adapt to the small changes in the intake air systems. Say, a small air leak will cause your idle AFR deviated.

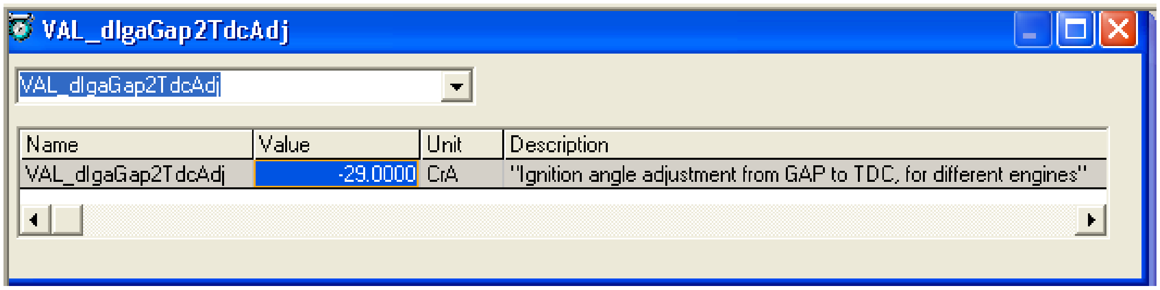
For a sporty, high RPM engine, like Kawasaki Ninja 250r, which has a RPM range of 1500rpm – 13000rpm, the blended "speed-density" and "alpha-N" is a must to have a good control over the wide range.

Ignition Angle Tuning

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

Please add this advanced calibrations in ProCAL:
ProCAL → advanced → add advanced calibrations :

VAL_dIgaGap2TdcAdj = -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 (note it is a negative value. It is different than the ignition angle table, where the negative means after TDC.).
This number (-29) 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 get 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), without 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).

There is a 16x12 ignition angle table (based on RPM and Load) for you to tune at different operating conditions. There are other tables, curves to tune to adjust ignition angles dependent on temperatures, AFR, altitude, etc. It is fully programmable ignition systems, instead of pre-set factory ignition curve only dependent on the RPM.

The 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 →

Volumetric Efficiency

MAP_Iga_N_Ld

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

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 able. It can be something in the middle of basic angle and minimum angle.

Sensor and Actuator Calibrations

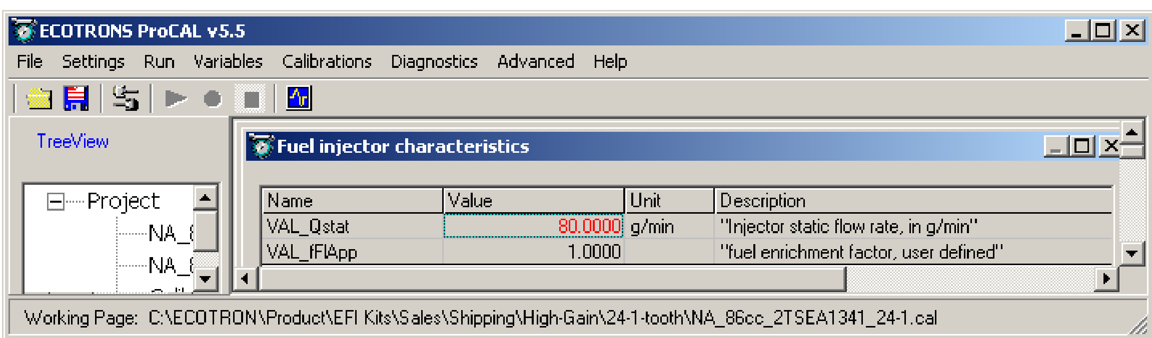
You only need to tune with this chapter if you are using sensors or actuators other than the ones provided by us.
(For example, you installed a throttle body from after-market or from another FI engine, which comes with the OEM's TPS, MAP sensors, and injector); Or if you use our ECU only to replace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

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

Injector characteristics

1. static flow rate

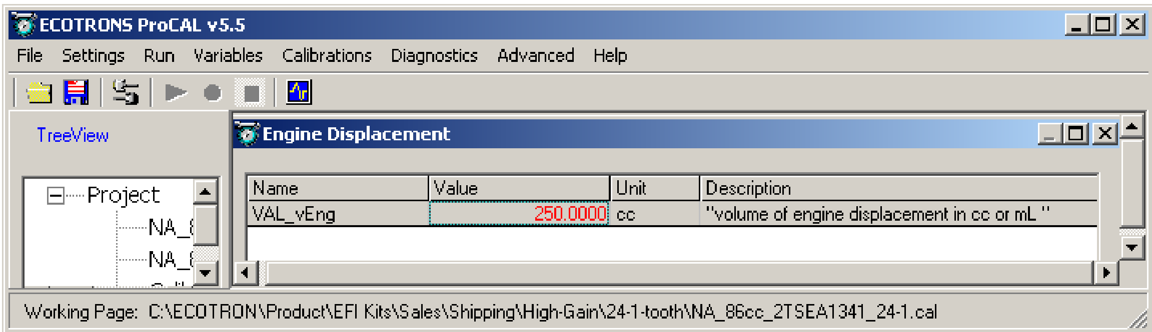
VAL_Qstat: injector static flow rate (g/min, or gram per minute)
This must be found out from the manufacturer's datasheet. Or you have to hire a professional company to measure it.



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)

Map = uMap * VAL_PmapGrd + 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.

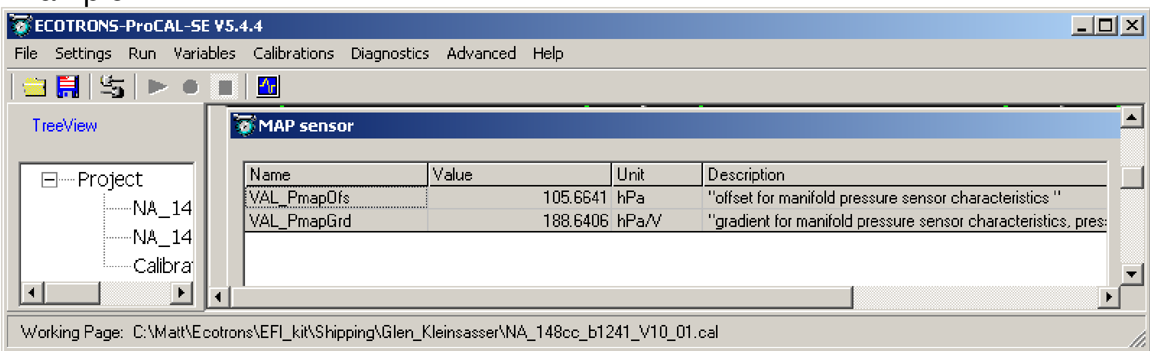
To find out these 2 values, you have below options:

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
VAL_PmapGrd = (P2 - P1) / (u2 - u1)
VAL_PmapOfs = P2 – u2* VAL_PmapGrd

Example:



IAT sensor

IAT: intake air temperature sensor
Ta: Tempearature of intake air (°C)
uTa: voltage of air temperature sensor signal (V)

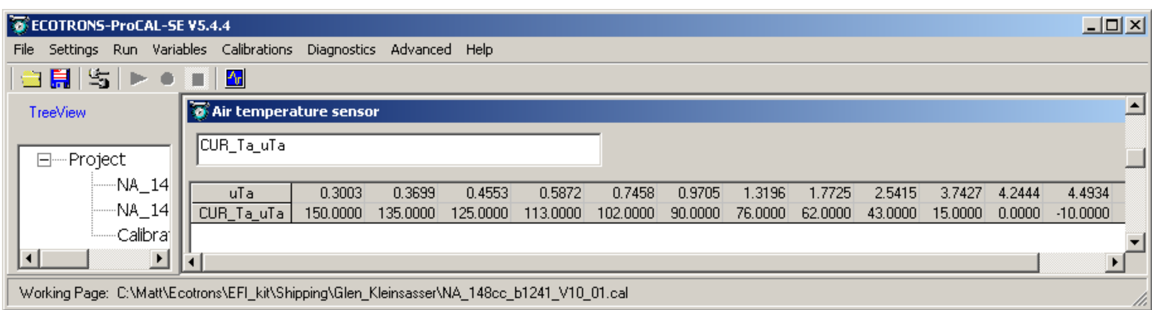
Usually temperature sensors are NTC type : negative temp characteristics:
Assuming, as a first-order approximation, that the relationship between resistance and temperature is linear, then:

$\Delta R = k * \Delta T$

where
ΔR = change in resistance
ΔT = change in temperature
k = first-order temperature coefficient of resistance

Contact us if you do not have sensor manufacturer's data.

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



uTa	0.3003	0.3699	0.4553	0.5872	0.7458	0.9705	1.3196	1.7725	2.5415	3.7427	4.2444	4.4934
CUR_Ta_uTa	150.0000	135.0000	125.0000	113.0000	102.0000	90.0000	76.0000	62.0000	43.0000	15.0000	0.0000	-10.0000

ECT sensor

ECT: engine coolant temperature sensor
Tm: Engine (motor)Tempearature (°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

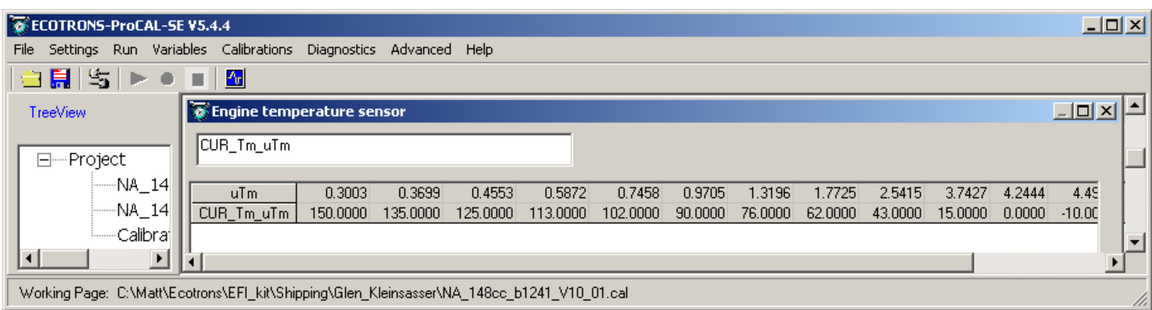
ΔR = change in resistance

ΔT = change in temperature

k = first-order temperature coefficient of resistance

Contact us if you do not have sensor manufacturer's data.

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



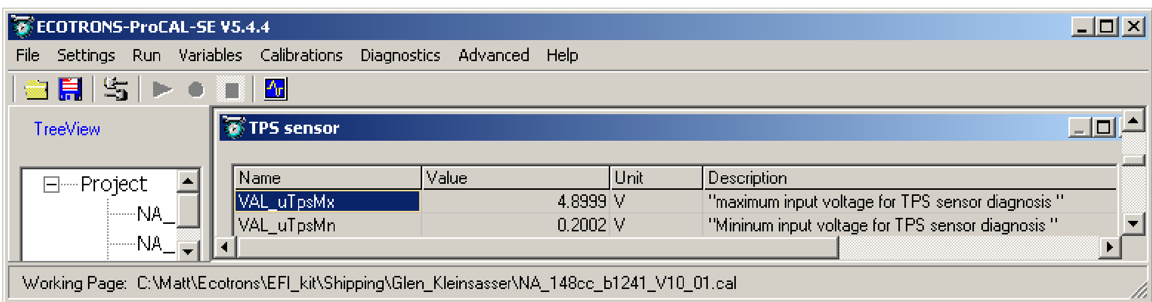
TPS sensor

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”.

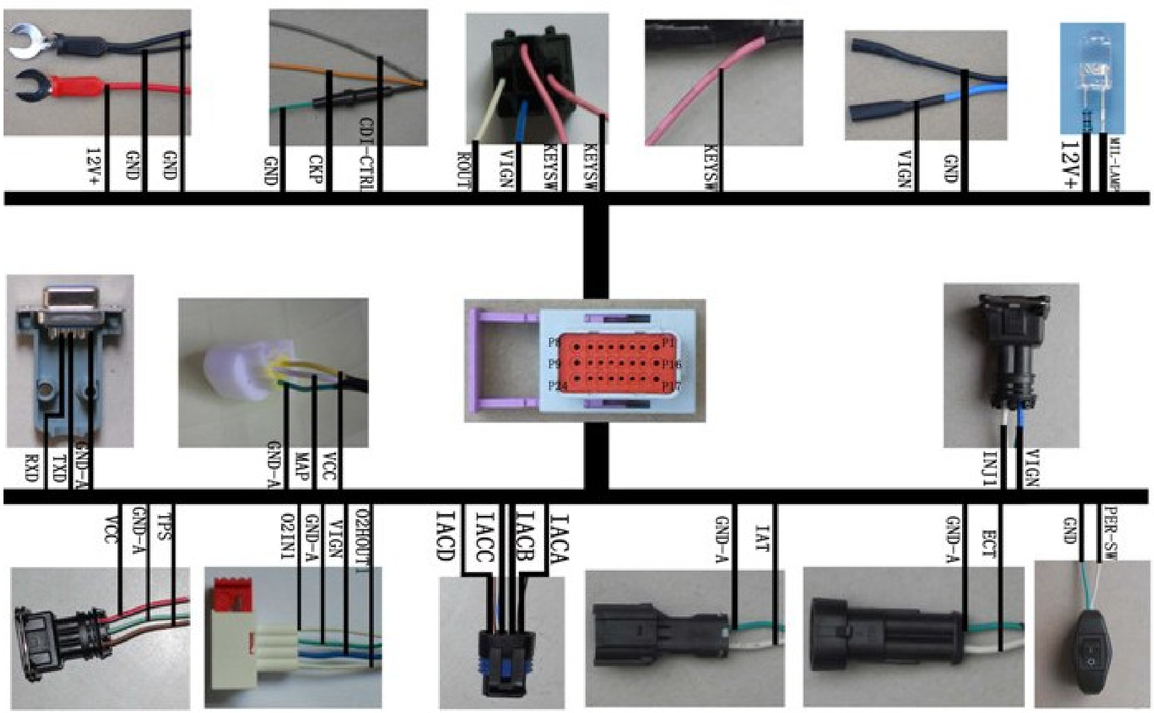
Then find the values for VAL_uTpsMx and VAL_uTpsMn, to make sure that:

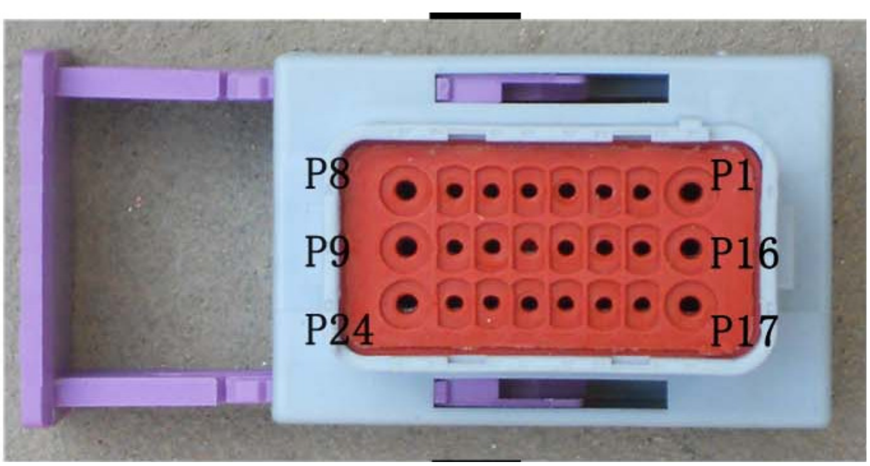
+5V > VAL_uTpsMx > (uTps2 + 0.1v)
(uTps1 - 0.1v) > VAL_uTpsMn > 0



Appendix: ECU main connector pin-out (24-pin)

This wiring schematics is for 4-stroke 1 cylinder engine (1 injector, 1 O2 sensors) with idle control motor (4 wires) settings.
For different engines, like 2-stroke, 2 cylinders, w/ 2 injectors, some pin-out definitions are different.





P1 O2HOUT1
--O2 Sensor 1 Heater LS Driver output

P2 12V+
--Reverse Battery Protected Supply

P3 GND
--Power Ground

P4 VCC
-- +5 Volt supply output

P5 RXD
--Send Data to RS232

P6 PER-SW
-- Performance Swith

P7 TPS
--Throttle Position Sensor input

P8 GND-A
-- Analog Ground

P9 IACA
--Idle Air Controller A

P10 MAP
-- Manifold Air Pressure Sensor input

P11 IACD
--Idle Air Controller D

P12 TXD
--Receive Data from RS232

P13 IAT
--intake air temp

P14 KEYSW
--Key On Swith

P15 MIL-LAMP
--Malfunction Indicator Lamp

P16 INJ1
--Injector 1 LS Driver output

P17 GND
--Power Ground

P18 CDI-CTRL
--CDI control output from ECU

P19 IACC
--Idle Air Controller C

P20 ROUT
--Power Relay LS Driver output

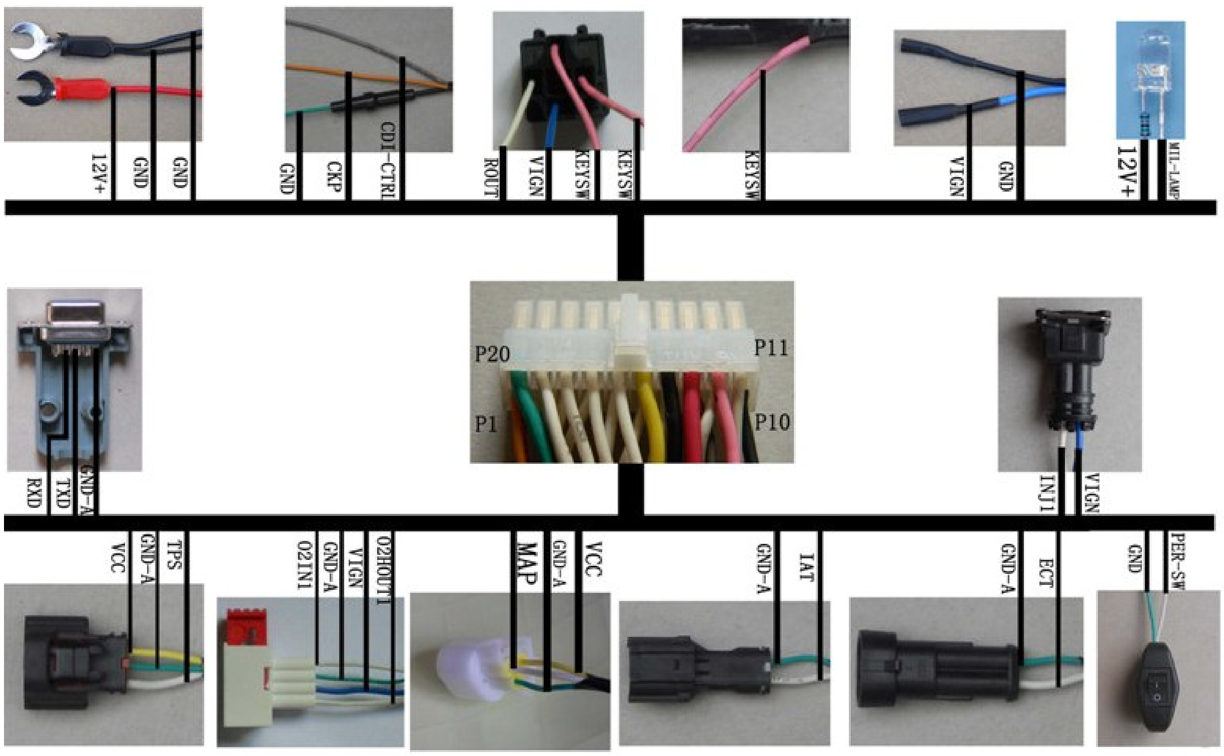
P21 ECT
-- engine (coolant) temp

P22 IACB
--Idle Air Controller B

P23 O2IN1
-- Oxygen Sensor 1 input

P24 CKP
-- Crank Position Sensor, connect to ignition pickup sensor signal

ECU main connector pin-out (20-pin)



This wiring schematics is for 4-stroke 1 cylinder engine (1 injector, 1 O2 sensor) settings. For different engines, like 2-stroke, 1 cylinder, w/ 2 injectors, some pin-out definitions are different.

P1 CKP
-- Crank Position Sensor, connect to ignition pickup sensor signal

P2 MIL-LAMP
--Malfunction Indicator Lamp

P3 MAP
-- Manifold Air Pressure Sensor input

P4 IAT
--intake air temp

P5 RXD
--Send Data to RS232

P6 TXD
--Receive Data from RS232

P7 ROUT
--Power Relay LS Driver output

P8 CDI-CTRL
--CDI control output from ECU

P9 INJ1
--Injector 1 LS Driver output

P10 GND
--Power Ground

P11 O2HOUT1
--O2 Sensor Heater LS Driver output

P12 KEYSW
--Key On Switch

P13 12V+
--Reverse Battery Protected Supply

P14 GND
--Power Ground

P15 VCC
-- +5 Volt supply output

P16 ECT
-- engine (coolant) temp

P17 TPS
--Throttle Position Sensor input

P18 O2IN
-- Oxygen Sensor input

P19 PER-SW
-- Performance Switch

P20 GND-A
-- Analog Ground