

Small Engine Electronic Fuel Injection System Tuning Guide

V3.0.1



Copyright ECOTRONS LLC
All Rights Reserved

Note:

This tuning guide will be under continuous improvements. Contact us for the latest version.

Only use this Tuning Guide after you finished the installation of the EFI Kit, by following Ecotrons Installation Manual.

Contact us:

Website: <http://www.ecotrons.com>

Email: info@ecotrons.com
support@ecotrons.com

Date	Version	Editor	Comments
12/07/2018	3.0.0	Wasseem A.	Minor revision
12/13/2018	3.0.1	Zack L.	Format check

CONTENTS

FAQs	1
Chapter 1 System Requirements	5
1.1 Laptop tuning software EcoCAL	5
1.2 Smart Phone tuning software Ecotrons DroidCAL	5
1.3 Load the correct files by using EcoCAL	5
Chapter 2 Start the Engine	7
2.1 Start issue trouble-shooting	7
2.2 Global fuel enrichment	11
2.3 Start fuel factor	12
2.4 After-Start and Warm-up fuel factor	15
Chapter 3 Engine idle tuning	23
3.1 Target Idle Speed	23
3.2 Idle speed adjustment via Mechanical methods	25
3.3 Electronic Idle Air Control – IAC motor	34
3.4 Idle Controls via ignition timing	45
3.5 Idle fuel too rich because of minimum injector pulse width	49
Chapter 4 Open-loop and closed-loop fuel control	55
4.1 Open Loop Fuel Control	55
4.2 Closed Loop fuel control	56
Chapter 5 VE table and Load table tuning	61
Chapter 6 The Ignition System Calibration	80
6.1 The CKP calibration from single pickup signal	80
6.2 The CKP calibration from multi-tooth trigger-wheel signal	86

6.3 Calibration for ignition timing.....	92
Chapter 7 Advanced Tuning.....	96
7.1 Transient fuel	96
7.2 Decel-Fuel-Cut-Off	102
7.3 Driver’s desired lambda	103
7.4 Advanced Calibration for injection timing.....	106
7.5 Dual injectors advanced tuning	107
7.6 Altitude tuning	109
7.7 Convert PWM signal of servo motor to TPS.	112
7.8 Calibrate the TPS sensor without the adaptation.....	116
Chapter 8 Basic Parameters Calibration	119
8.1 Engine Displacement.....	119
8.2 Fuel Injector	120
8.3 MAP sensor	121
8.4 IAT sensor.....	123
8.5 ECT sensor.....	124
8.6 TPS sensor	126
Chapter 9 Advance functions of EFI.....	130
9.1 Fuel Dial Function	130
9.2 Oil pump control tuning.....	132
9.3 Fuel consumption calculation of EFI	133
9.4 The CAN Baud rate setting of ECU	135
Chapter 10 ALM-ECU integration for tuning	137
10.1 Connect the ALM to Small EFI kit.....	137
10.2 Connect the ALM to UAV EFI kit	140
10.2.1 Install the wideband O2 sensor	140
10.2.2 Connect the ALM to ECU via Performance switch.....	141

10.2.3 Connect ALM-CAN to ECU via CAN bus	143
Chapter 11 On-the-fly Calibration Data	144
Chapter 12 Broadcast protocol via serial cable	147
Chapter 13 Ecotrons software tools and ECU communications.....	149
13.1 Check A2I or CAL which should be matching ECU	149
13.2 Burn to ECU successfully.....	152
13.3 load configuration.....	152
Chapter 14 Fault Diagnosis and Heal	154
14.1 TPS sensor diagnostic.....	155
14.2 MAP sensor diagnostic.....	163
14.3 Temperature sensor (IAT & ECT) diagnostic	166
14.4 NB O2 sensor diagnostic	167
14.5 Trigger (VRS) signal diagnostic.....	169
14.6 Battery diagnostic	172
14.7 Actuator Diagnosis	172
14.8 How to check a non-working ECU.....	173
Appendix I: ECU main connector pin-out (24-pin).....	179
Appendix II: ECU main connector pin-out (20-pin).....	183

FAQs

Q: Is it easy to tune Ecotrons EFI?

This is depending on how much you know EFI and how much time you want to spend on learning. First of all, Ecotrons EFI is coming from an automotive professional engine control system. It is more sophisticated than most of the aftermarket EFI systems. Though we tried to make the tuning software simple and user friendly, it still requires some software skills and practice to get familiar with. We recommend the below:

- If you have done EFI conversions and used other EFI tuning software before, and if you are not shy to learn some new software user interface; or
- If you have a strong engineering background, like electrical engineering or computer science, you have a good base to learn our software; or
- If you are college students, and the purpose of the project is to learn and practice anyway;

You should be able to use/learn our tuning software to tune the EFI.

For most weekend racers, hobbyists or similar users, who are mechanical inclined, but shy of computer skills, we recommend you to just log data with our EFI, send data to us, and let us do the tuning for you.

You can always try to tune it by yourself. This is no reason you cannot learn the software. It is only matter of your willingness and time.

Ecotrons tech support team provides tuning help via Emails, not on the phone, because 1) we need data logs via Email first, 2) phone calls are often filled with basic questions on EFI and computer skills which are supposed to learn via reading manuals.

Note: Ecotrons EFI is meant to provide a complete EFI kit that includes almost all parts for you to convert a carburetor engine. It is not a Plug and Play, aka PNP, system. Tuning is required more or less. The benefit of Ecotrons EFI is that you get a complete kit, instead of an ECU with a harness. Plus you get tuning support from Ecotrons. With others, you may be left un-answered, or alone.

Q: I finished the EFI installation; but my engine does not start, why?

Go back to your installation manual, in the last chapter, there are detailed procedures for you to trouble-shoot the starting problem. If still cannot find answers there, you can jump to chapter 2 of this manual for further trouble shooting on engine start issues. The EFI installation manual can be downloaded here:

www.ecotrons.com/support

Q: How do I log data and send the data files?

Assuming you have installed the EcoCAL (default directory should be C:\EcoCAL or D:\EcoCAL). Otherwise, install the EcoCAL to your laptop. EcoCAL is coming in the CD with the EFI kit or you can download it from our website. Details on how to use EcoCAL can be found in our EcoCAL manual, also downloadable.

www.ecotrons.com/support

- 1) Run EcoCAL (load the correct A2L and CAL file);
- 2) Key on, and key on only;
- 3) Go to menu -> run -> connect;
- 4) Go to menu -> run -> start recording
- 5) Do your test, or start the engine;
- 6) When done the test, go to menu -> run -> stop recording
- 7) go to menu -> run -> Play back;
- 8) A window pops-up, and click "open", it will take you to where the logged files are. All files are in a folder called "**C:\EcoCAL\record**", assuming C:\EcoCAL is where you installed the EcoCAL.
All files are recorded in sub-folder names as "dd-mm-yyyy-hh-mm-ss".
- 9) You need to copy all 3 logged files and send to us. (Every time there are 3 CSV files logged); you can even zip the whole "record" folder and send to us, we can help you to analyze it. (Note: latest EcoCAL software starting v7.2.7 has only one CSV file)

Q: How do I change a calibration?

Assume you want to change the value of the calibration variable "VAL_XXXX" to "1234":

- 1) Key-ON, run EcoCAL with the correct A2L/CAL files, connect it to ECU;
- 2) In EcoCAL menu, go to: "Variables"-> "Calibration Selection";
- 3) Pop up a window, type in "VAL_XXXX", select it, and click "add to", and then click "OK".

- 4) Back to EcoCAL window, "VAL_xxxxx" should be displayed in a small window. Double click it and change its value to "1234". Hit "Enter";
- 5) Go to menu; "run" -> "Connect".
- 7) Download.....completed.
- 8) Start the engine, see the effect.

Chapter 1 System Requirements

1.1 Laptop tuning software EcoCAL

Ecotrons tuning software EcoCAL can be installed and run in the Microsoft Windows XP, Vista, Win7 or Win8.1.

Note: During the installation of the EcoCAL, it is automatically set as the compatibility mode for Windows XP.

1.2 Smart phone tuning software Ecotrons DroidCAL

DroidCAL is the version of EcoCAL that can be run on an Android based smart phones and tablets.

Note: On your phone, you can directly search “Ecotrons” in “Google Play Store” and it is free to download.

Note: EcoCAL and DroidCAL are free and you can always download them from our website:

www.ecotrons.com/support

1.3 Load the correct files by using EcoCAL

S19 file: this is a Motorola format microprocessor executable file; we call it “Firmware”.

A2L file: this is a description file that contains the ECU info for EcoCAL;

CAL file: this is a calibration data file that contains parameters users can tune. CAL file is one part of the S19 file.

Note: Most customers don't need the S19 file; unless an ECU firmware update is necessary;

It is enough to have the A2L file and CAL file to run EcoCAL and tune your engines.

If you have not got A2L file and CAL file in your CD coming with the EFI kit or the software package via Email, please contact us: info@ecotrons.com

Often the user will need to load different A2L file and CAL file than the default ones coming with the EcoCAL. For example, a software update or new calibration release will give you newer A2L file and CAL file.

To load the new A2L file and CAL file, in EcoCAL, go to "**File->Open**", and then go to the right folder and select the files.

For more details, please download the EcoCAL software Manual.

<http://www.ecotrons.com/support/>

Chapter 2 Start the Engine

2.1 Start issue trouble-shooting

After install the EFI system, the engine doesn't start, why?

There are some questions need to be answered first:

1 .which signal is used as the pick-up signal?

Is it the stock pickup (coil), or a Hall Effect Sensor? Or is it from the Kill switch wire?

If it is a stock pickup (coil) signal, connect the wire labeled as CKP from the ECU harness to the pick-up signal of your stock CDI ignition. The other wire of the pickup sensor usually is grounded in your stock system. Connect the green GND wire from the EFI harness to the pickup ground.

If it is a hall sensor, please check: is the hall sensor installed correctly? You need find out what polarity the magnet has. Usually our Hall sensor is triggered by the S polarity magnet; and the distance from the hall sensor to the magnet should be in the range from 2mm to 5mm,.

If it is the stock kill switch wire, you need connect the CKP wire to the kill wire, and connect the green wire from the ECU harness to the chassis or the ground of the stock system. If possible, use a scope to check if the kill wire signal is clean, meaning, only one pulse per revolution.

Make sure your engine block is connected to the 12V negative, so all grounds are common!

2. The pickup is correct, but the engine still doesn't start, why?

Do you have the MAP sensor connected to the intake manifold for 4 stroke engines? The Map sensor needs to measure the vacuum for 4 stroke engines to start.

For 2 stroke engines, MAP sensor can be hanged in the air and measure the ambient pressure only.

3. Does the fuel pump turn on for a few seconds when powering on the ECU?

If the fuel pump does not turn on after the ECU power is on, then check your wire connection. Or if the fuel pump does not turn on when the engine is spinning, you need to check the CKP wire connection.

4. Is there a RPM reading by ECU?

Start to use EcoCAL to read the RPM. Connect your laptop to the ECU. If there is no RPM reading when the engine is spinning; that means something wrong with the CKP signal, or the MAP sensor signal for 4 stroke engines.

5. Is there any fuel injection when cranking?

- 1) un-screw and pull out the injector,
- 2) Seal the hole of injector mount;
- 3) Hold the injector in air, point it to a safe direction, and use a container to receive the fuel jet!
- 4) crank the engine;

If there is no injection, please check the CKP wire connection, and/or MAP sensor connection

Have you connected the engine chassis to the negative of the battery?

Have you connected the green wire labeled GND to the negative of the battery or to the chassis?

6. No spark?

Do you use the stock ignition system or use Ecotrons ECU to control the ignition?

If stock ignition system, check your stock CDI, coil, and spark plug.

If use Ecotrons ECU to control the ignition, please check the installation of Ecotrons CDI and Coil, and make sure the high voltage cable is fully plugged to the spark plug. Please see the installation manual for details.

If you are using a multi-tooth trigger wheel, and an Ecotrons VRS sensor, please double check the installation, and the setting of the trigger wheel in the EcoCAL software. (Details are in the later chapter).

7. No fuel flow?

When the fuel pump is running, (with key on), do you see fuel flowing in the fuel line? Are there bubbles in the fuel hose?

Is the pressure regulator installed correctly?

Can you see the fuel flowing back to the tank in the return line after a couple of times of key-cycles?

One way to check fuel supply system is to unplug the high pressure fuel line to the fuel injector, point it to a fuel bottle, and turn on the power; you should see fuel sprout out of the high pressure line.

8. Is the fuel pressure enough?

This is a frequent issue mostly because of the low battery, or incorrect installation of the fuel supply system. A lot of installation problems end up as the low fuel pressure. The best way to trouble shooting the fuel supply system is to install a fuel pressure gauge, which can be bought in any auto parts store.

When the power is on, the fuel pressure should reach 3 bar or 43 psi normally. If the pressure is significantly low, then check your battery voltage, or fuel supply system.

9. Is the idle air enough?

You may not have enough idle air to start the engine. Try crack-opening throttle, like 2%-5% throttle, and then crank the engine. Does it fire?

10. Is there enough starting fuel?

The start fuel may not be enough, give a quick enrichment by using “VAL_fFIApp” (see Section 2.3 for details) ?

11. Log data and send us.

“I have checked all the above items, and I think they are all normal, but I still can’t start the engine”.

Please log some data with EcoCAL and send us; and we will help you to trouble shoot. Note, when logging data for start issue, follow these steps: Key on → connect EcoCAL to ECU → start recording → crank engine → engine not started → stop recording → find the data log files → send by email.

Some engines have 2 pulses per revolution, and some engines have some unique pulses like negative pulses only. All these need to be identified to have the correct CKP signal. One way is to log data with EcoCAL and send to us.

It is also helpful to send us some pictures of your EFI installation, especially on how you connect the loose end wires.

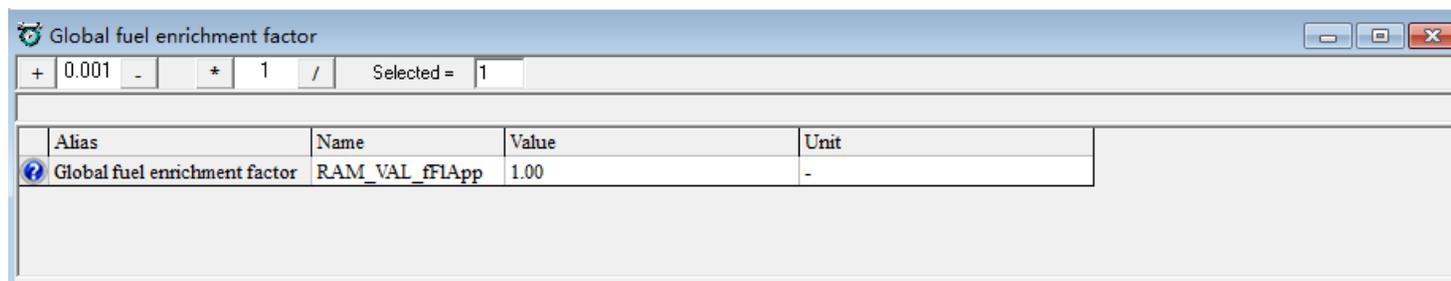
2.2 Global fuel enrichment

VAL_fFIApp (RAM_VAL_fFIApp) - "global fuel enrichment factor, user defined"

In EcoCAL:

Menu → Variables → Calibration Selection →

VAL_fFIApp = 1.0 (default).



It's a global enrichment factor multiplied on the base fuel, meaning, if you change it to 1.5, you'll get 1.5 times of the fuel everywhere. And it applies to all operating conditions (start, warm-up, and 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.

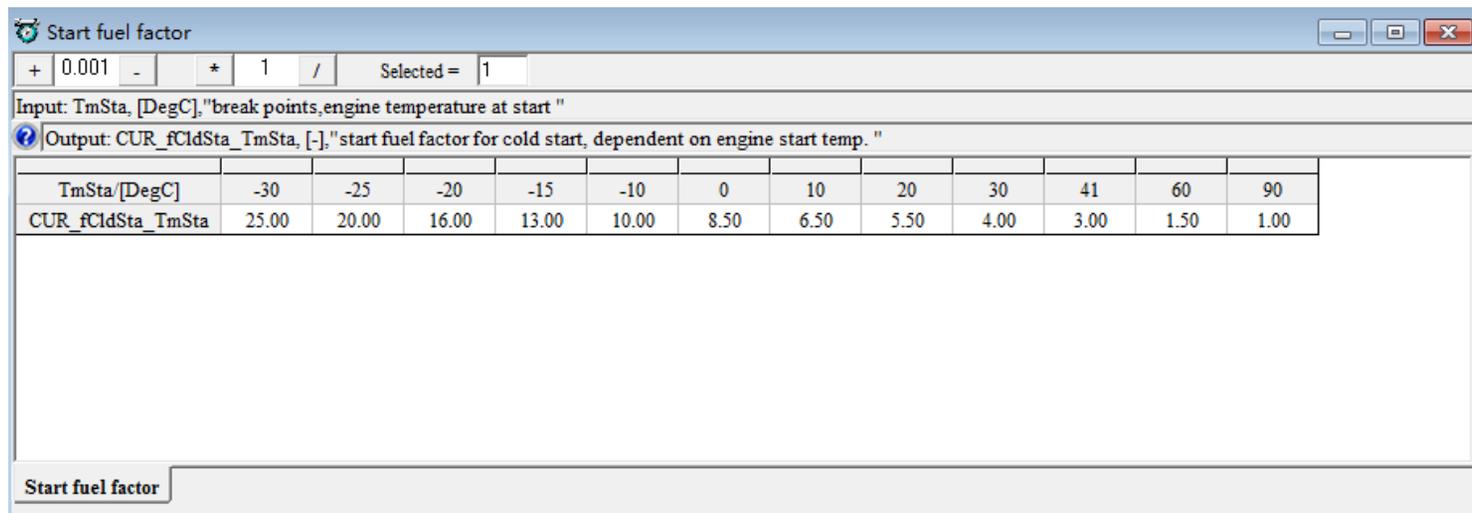
Certainly you can en-lean the fuel global-wise, by setting it to smaller than 1.0.

2.3 Start fuel factor

CUR_fCldSta_TmSta - "start fuel factor for cold start, dependent on engine start temperature."

In EcoCAL:

Menu → Variables → Calibration Selection →



TmSta/[DegC]	-30	-25	-20	-15	-10	0	10	20	30	41	60	90
CUR_fCldSta_TmSta	25.00	20.00	16.00	13.00	10.00	8.50	6.50	5.50	4.00	3.00	1.50	1.00

This is probably the most important tuning parameter for engine start.

- 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 cannot 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. 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 EcoCAL, locates 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: First start in the morning, key on, connect your laptop, and read the Tm (or ECT), in EcoCAL, say, it's 9 deg C. Then find the cell 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.

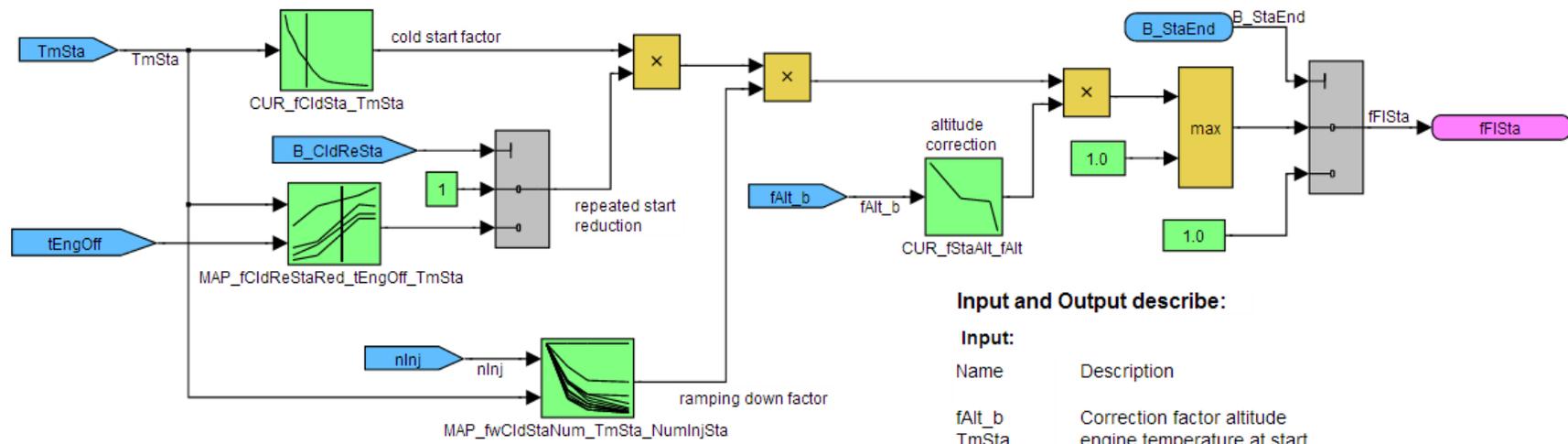
Most likely you are starting a little leaner at that temperature; so you would increase the value to 5.5; and then "burn to ECU".

Then you crank the engine again; 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 engine 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 too rich or too lean. It's really based on your feeling and experiments.

Start control strategy:



Input and Output describe:

Input:

Name	Description
fAlt_b	Correction factor altitude
TmSta	engine temperature at start
B_StaEnd	condition end of start
tEngOff	engine off time
nInj	injection counter

Output:

fFISa	start-injection factor
-------	------------------------

Note: If your are in the high altitude, there is also altitude correct factor $CUR_fStaAlt_fAlt$, needs be tuned to get a easy start.

2.4 After-Start and Warm-up fuel factor

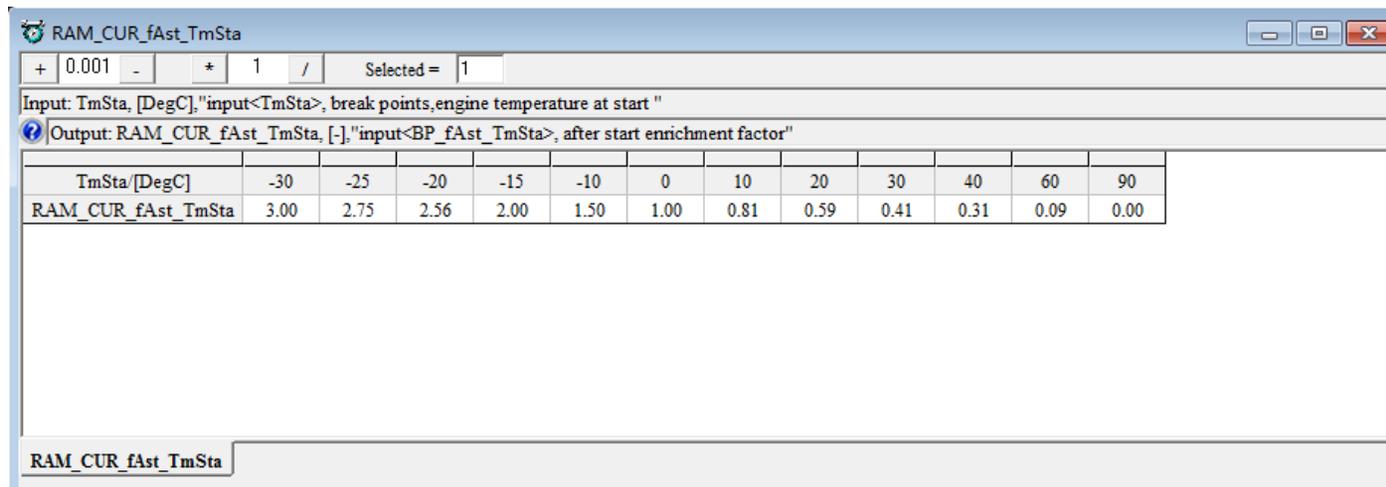
CUR_fAst_TmSta - "after-start fuel enrichment factor, dependent on engine start temp."

The output of this Curve will be added on top of 1.0 as the after-start factor.

It will be ramping down to 1.0 with the engine running time increased after start.

In EcoCAL:

Menu → Variables → Calibration Selection →



TmSta [DegC]	-30	-25	-20	-15	-10	0	10	20	30	40	60	90
RAM_CUR_fAst_TmSta	3.00	2.75	2.56	2.00	1.50	1.00	0.81	0.59	0.41	0.31	0.09	0.00

Note: After-start factor is actually = 1 + look-up table value.

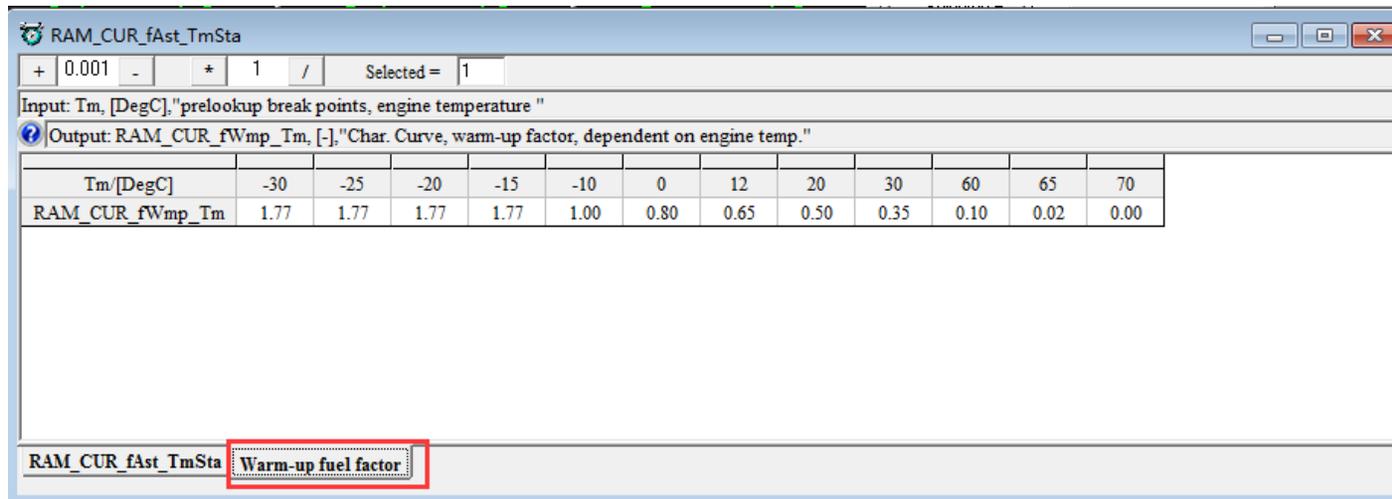
For example, if you set the table value as 0.6; the after-start factor is = 1.6

Why? It is easy for software implementation.

CUR_fWmp_Tm - "Warm-up fuel enrichment factor, dependent on engine temp."

In EcoCAL:

Menu → Variables → Calibration Selection →

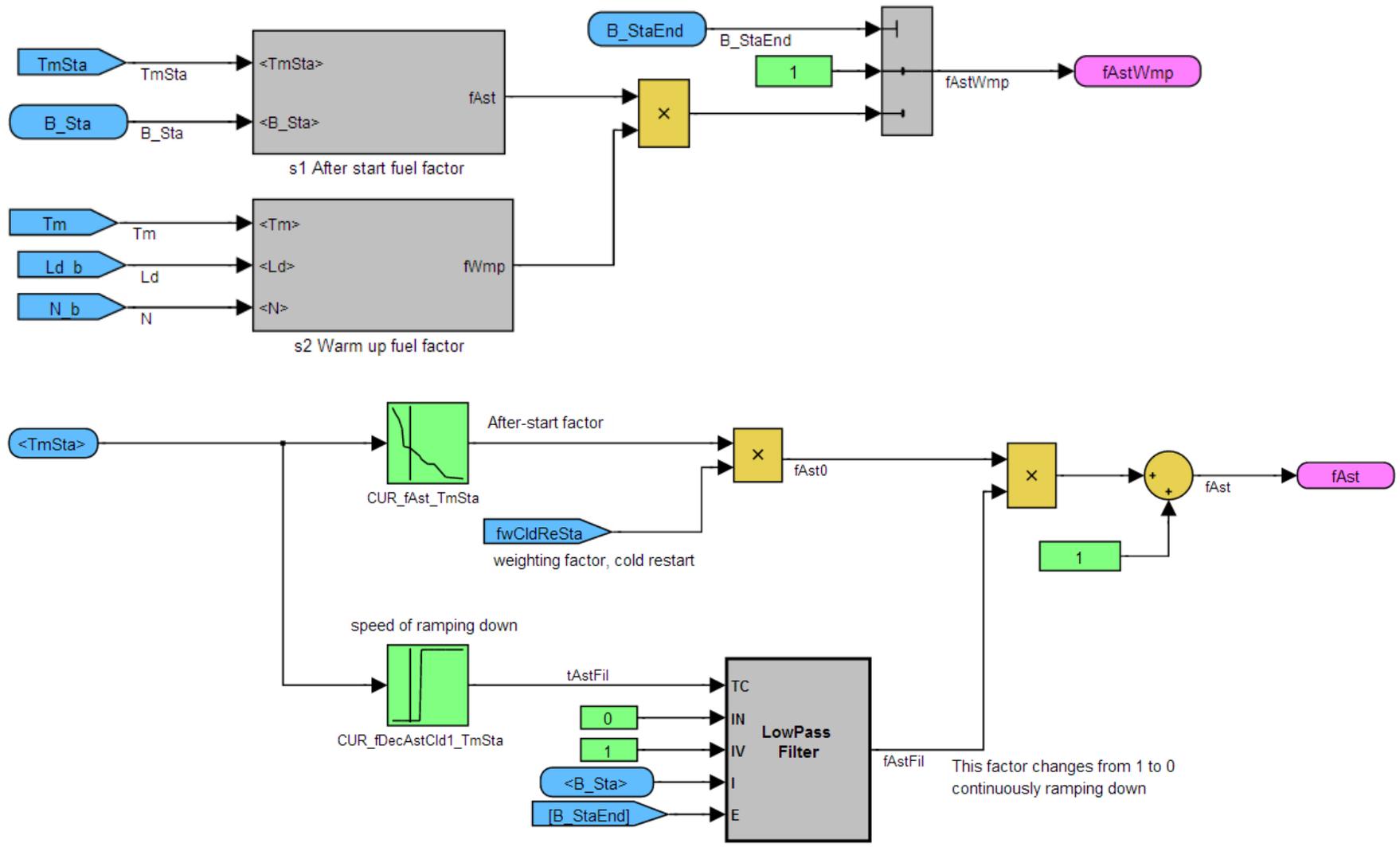


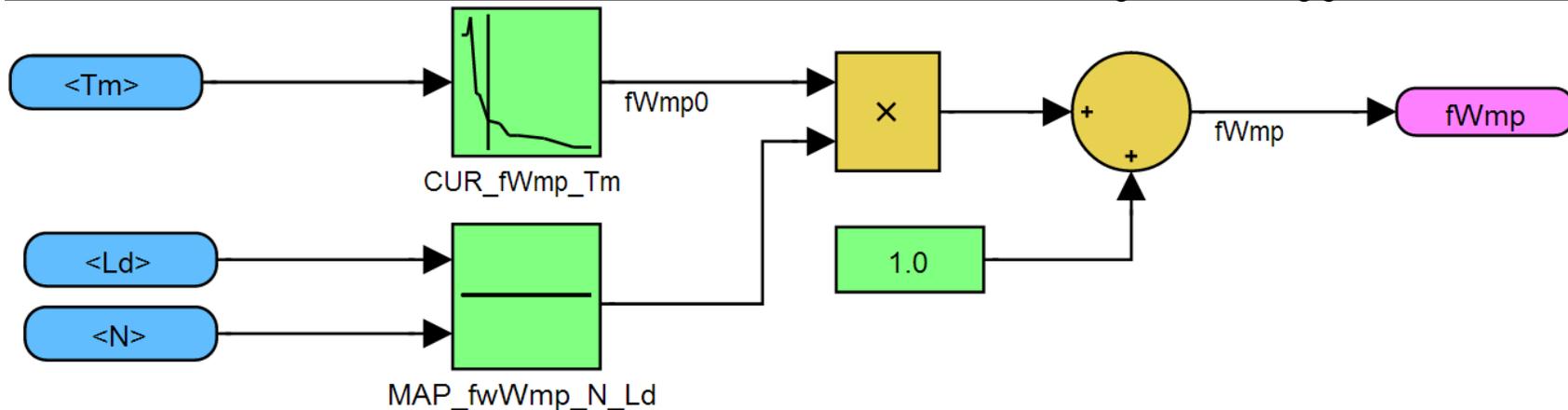
Same: warm-up factor is actually = 1 + look-up table value.

For example, if you set the table value as 0.6; the warm-up factor is = 1.6

Why? It is easy for software implementation.

After Start / warm-up control strategy:





Note: The final factor is $f_{AstWamp} = f_{Ast} * f_{Wmp}$, so you need to tune both variables after start.

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, close to good 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 with engine warms up. 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 is idling, 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 fine for now. 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.

Note: once engine can stay running, then wait for engine warmed up, and tune the base fuel mapping first (VE table, Load table, see later chapters). Don't do fine-tuning on the start fuel factor, after-start, and warm-up fuel factors before you have a good base fuel mapping, because these factors are nothing but a multiplicative factors on the base fuel.

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

See below the 2 graphs of start and warm-up process from a real scooter engine:

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 (fFISta), 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 (fFISta =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 = fFISta * VAL_FIApp (during start)

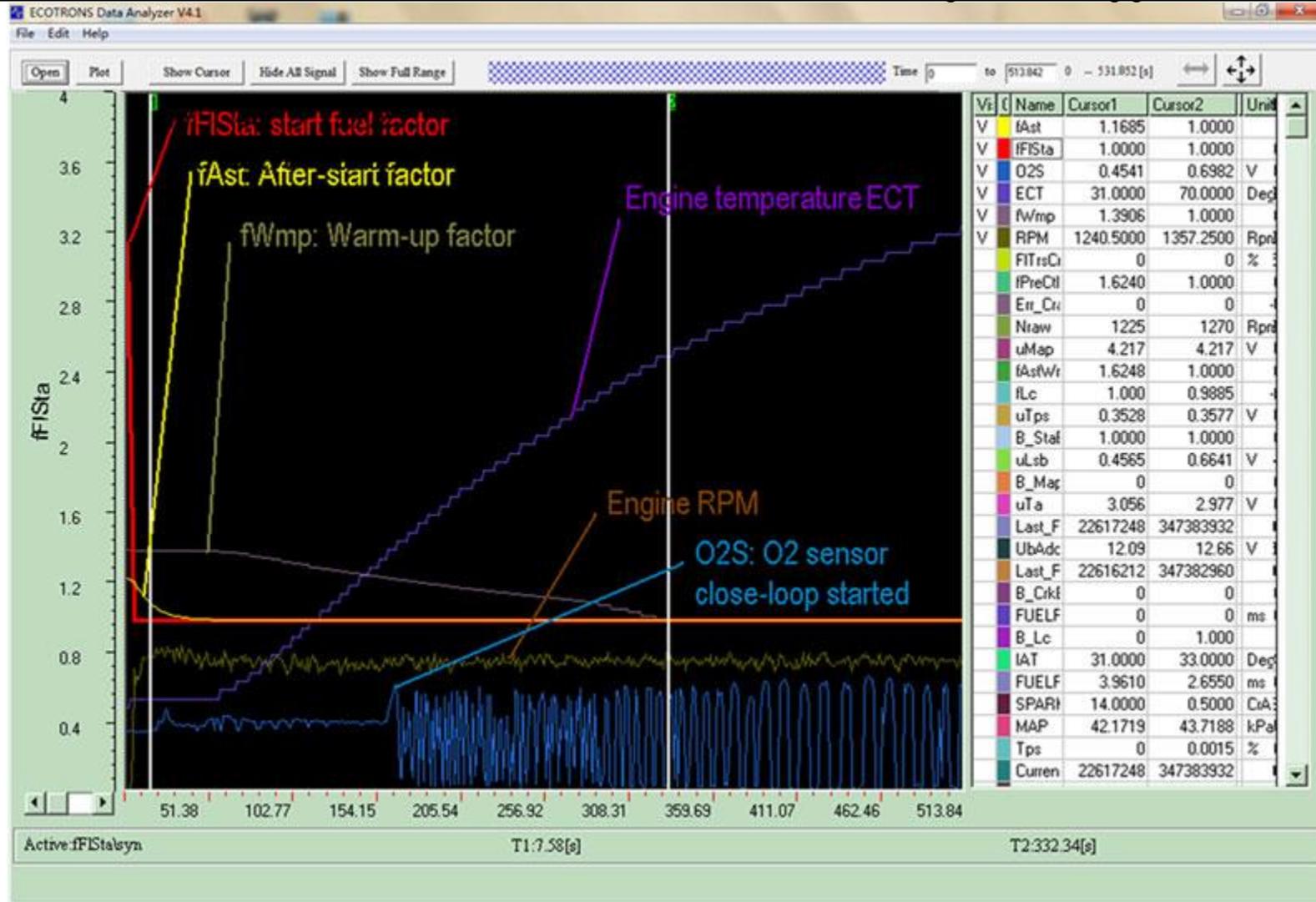
fPreCtl = fAst * fWmp* VAL_FIApp (during after-start, warm-up)

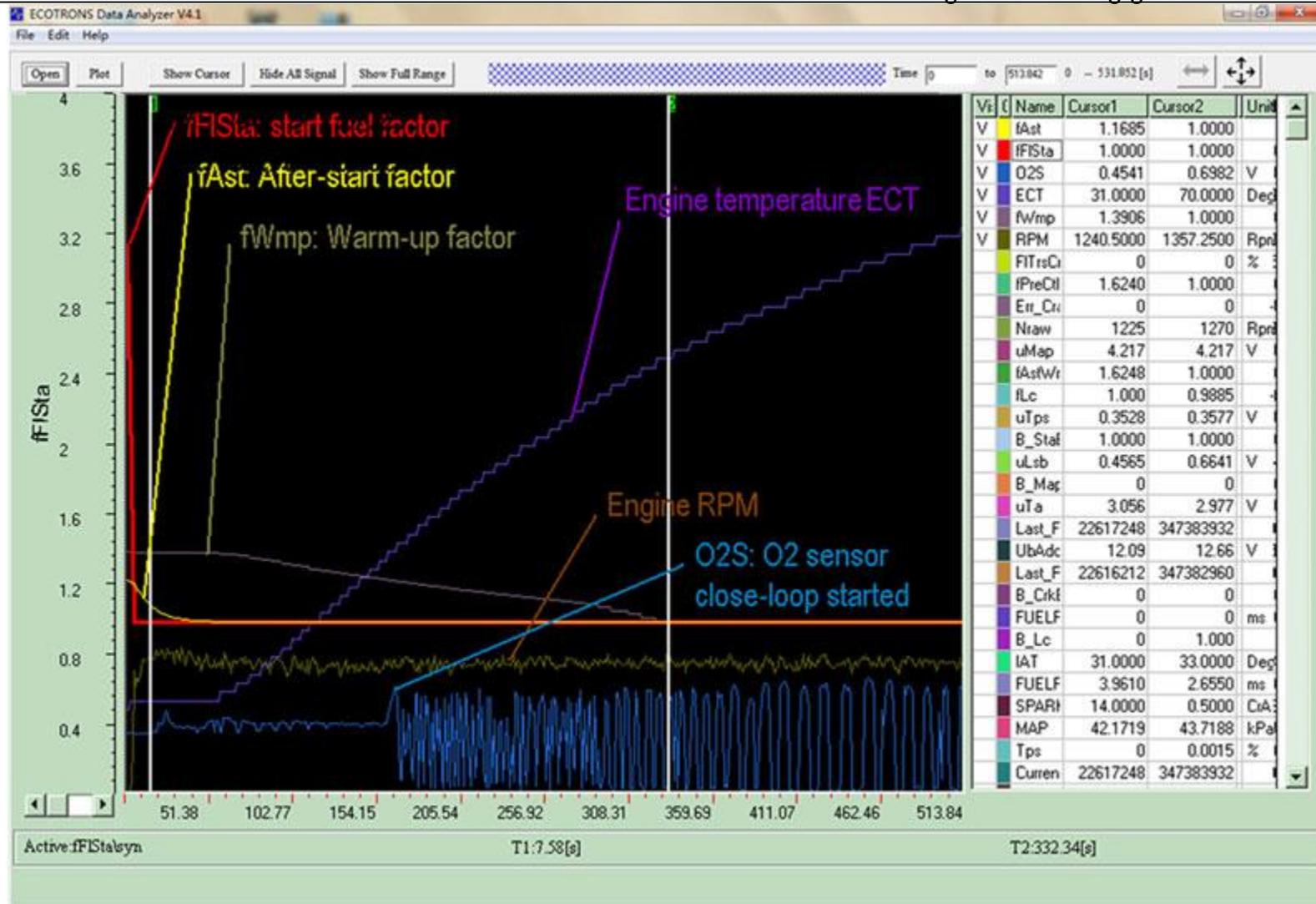
Note: During start, fAst and fWmp are not used; meaning they are equivalent to 1; VAL_FIApp is the global enrichment factor.

fPreCtl is the overall enrichment factor.

It is the green line in the second graph.

Note: In your logged data, you can see this variable plotted. It tells you how your starting-warm-up fuel is controlled.

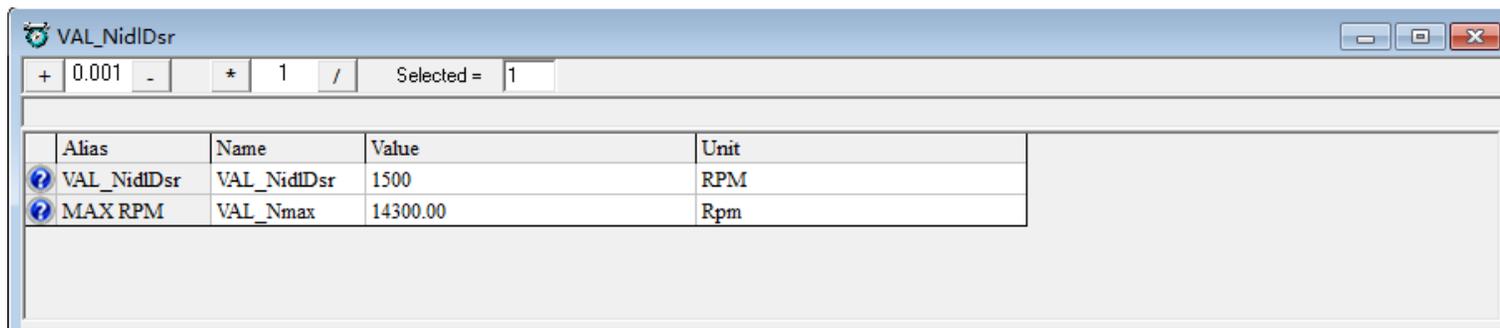




Chapter 3 Engine idle tuning

3.1 Target Idle Speed

How to set the target idle speed in EcoCAL?

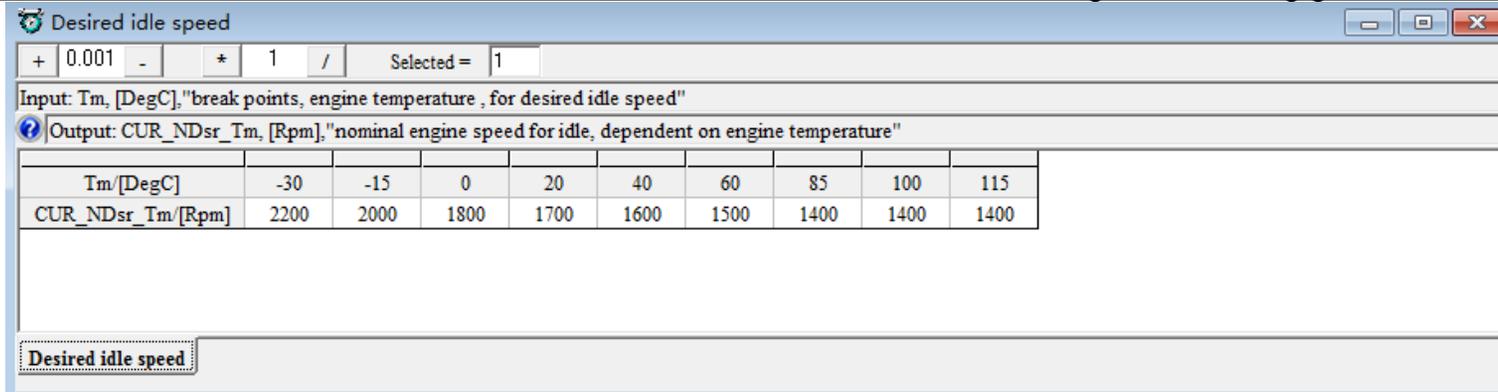


VAL_NidIDsr - "Desired idle speed"

In EcoCAL: Menu → Variables → Calibration Selection →

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

For newer software version, the desired idle speed is dependent on the engine temperature. You will need to calibrate the CURVE: **CUR_NDsr_Tm**



Tm/[DegC]	-30	-15	0	20	40	60	85	100	115
CUR_NDsr_Tm/[Rpm]	2200	2000	1800	1700	1600	1500	1400	1400	1400

In EcoCAL:

Menu → Variables → Calibration Selection → add this variable.

Note: If your engine's idle RPM is not stable, or too high, or too low, it may be because of the idle air, so you need to adjust the idle air first.

You must make sure the whole air intake system is air-tight first!

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 downs 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 leak!

Note: The idle speed with a cold engine could be lower than the warmed-up engine, especially if you do not use the EFI to control the idle speed.

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

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 for the small engines.

If you do not have our ECU-controlled ignition system, you will have comparatively low idle speed at cold start and higher idle speed after warm-up. This is normal.

How do you have a constant idle RPM, regardless of a cold or hot engine? You need to have our ECU-controlled ignition system.

See the chapter of "Ignition Angle Tuning".

3.2 Idle speed adjustment via Mechanical methods

Single cylinder idle air screw adjustment

Our 28mm throttle body comes with an idle screw; if your idle speed is too low, or too high, you can adjust the idle screw to get more or less idle air.

The idle screw from 28mm throttle body:



Picture1

Adjust the idle screw:



Picture 2

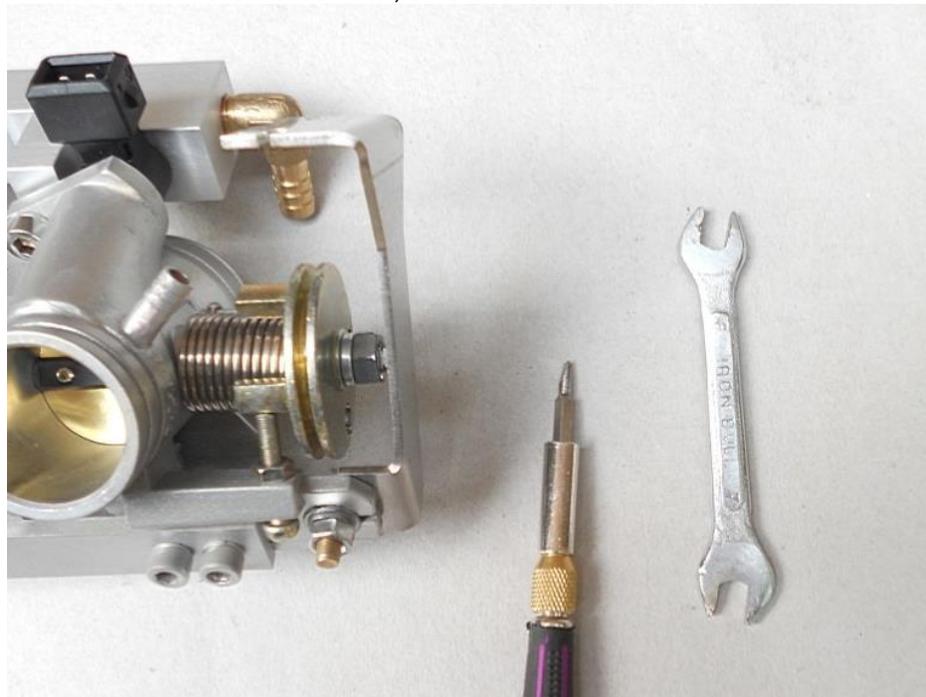
Further mechanical idle Air adjustment

If by only adjusting the idle air screws can't meet your idle air requirements, such as the idle RPM is still too low, you need adjust the mechanical stop position of the throttle valve (this is not preferred, unless you have no other options). The factory setting of the throttle plate is usually optimized. You need to be careful on this mechanical adjustment.

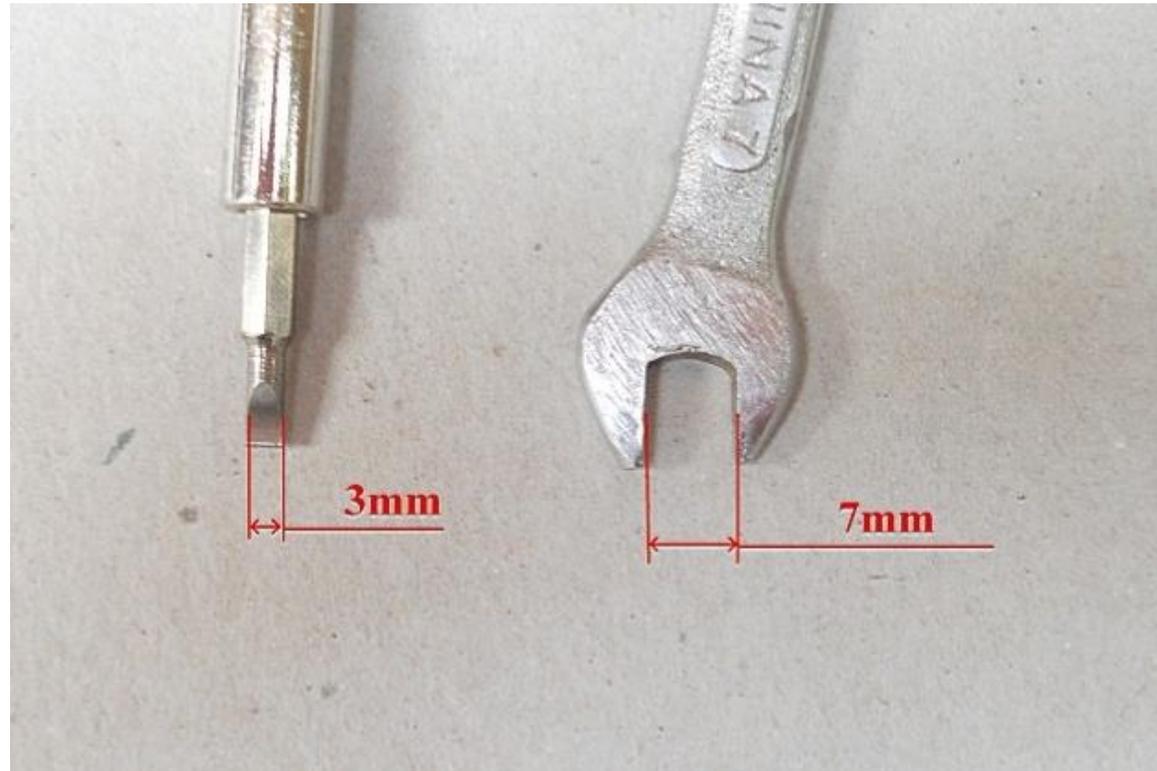
Basically the idea is to open the throttle plate a little tiny bit, so there is more idle leaking air.

The steps are below:

(1) Please prepare two tools: one is screwdriver, and the other one is wrench.

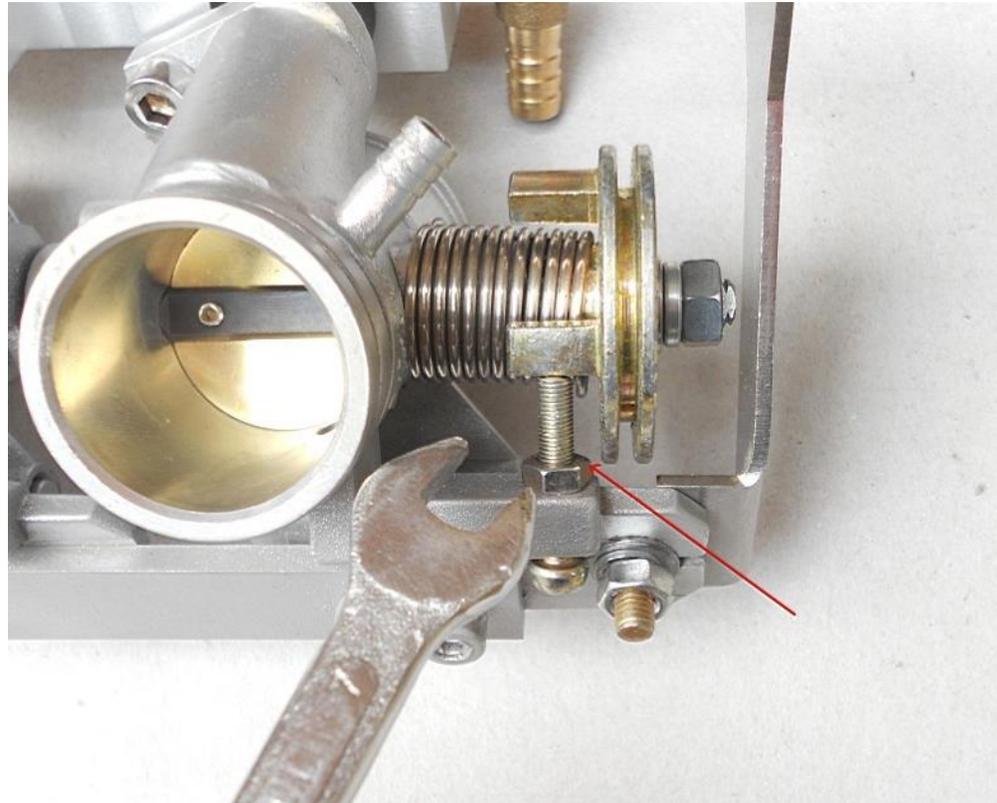


For the size of the each tool, you can see in the below picture.

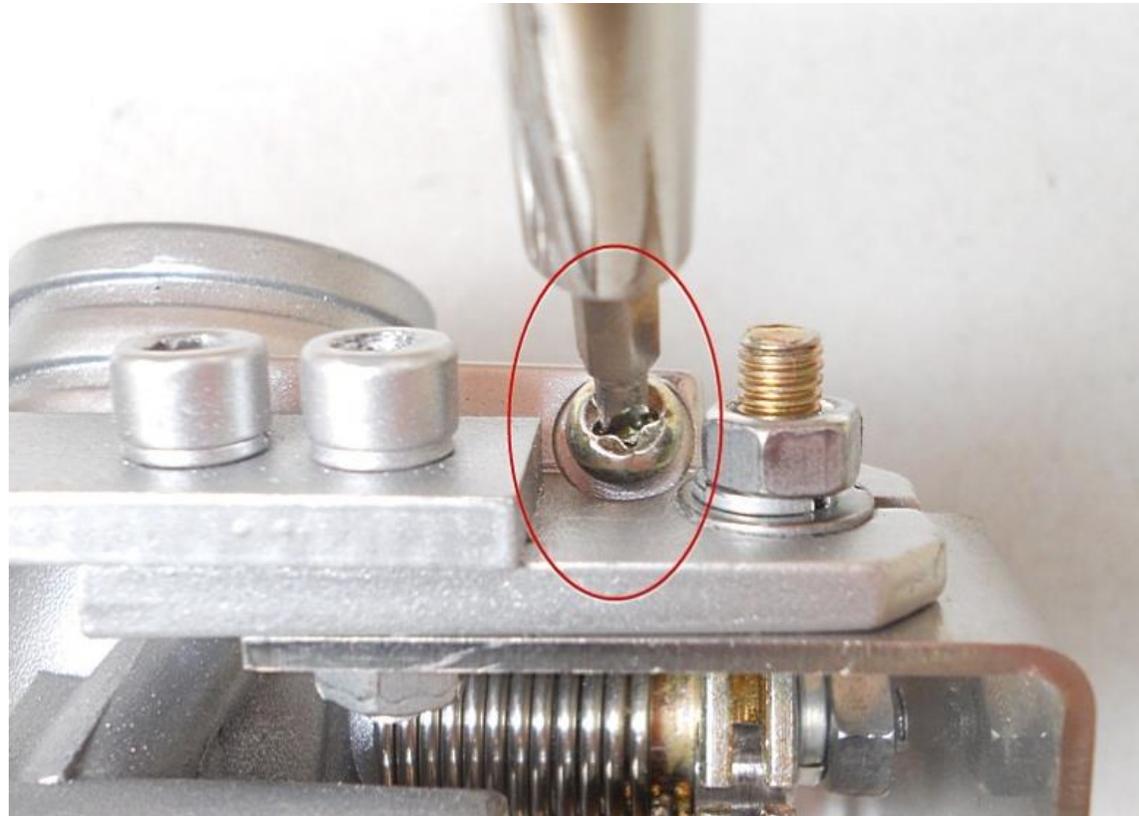


(2) Begin to adjust now, please see the below pictures.

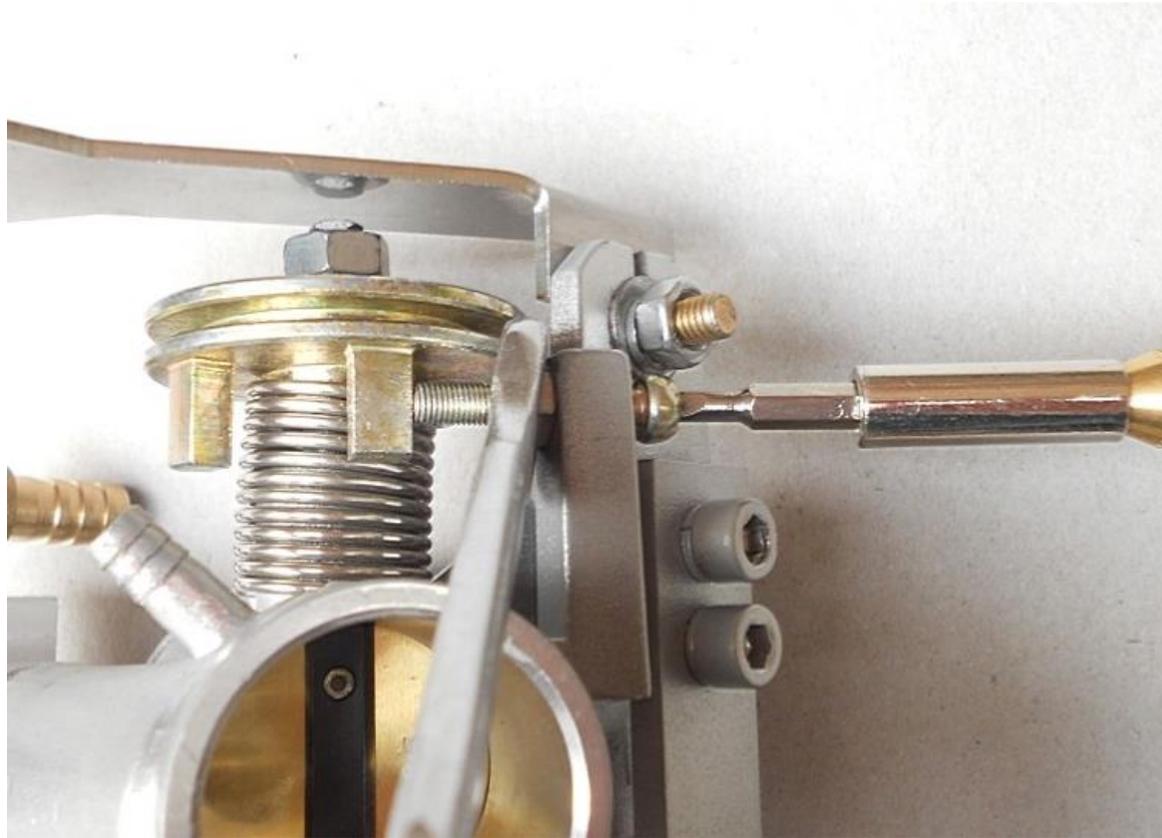
First, loose the nut:



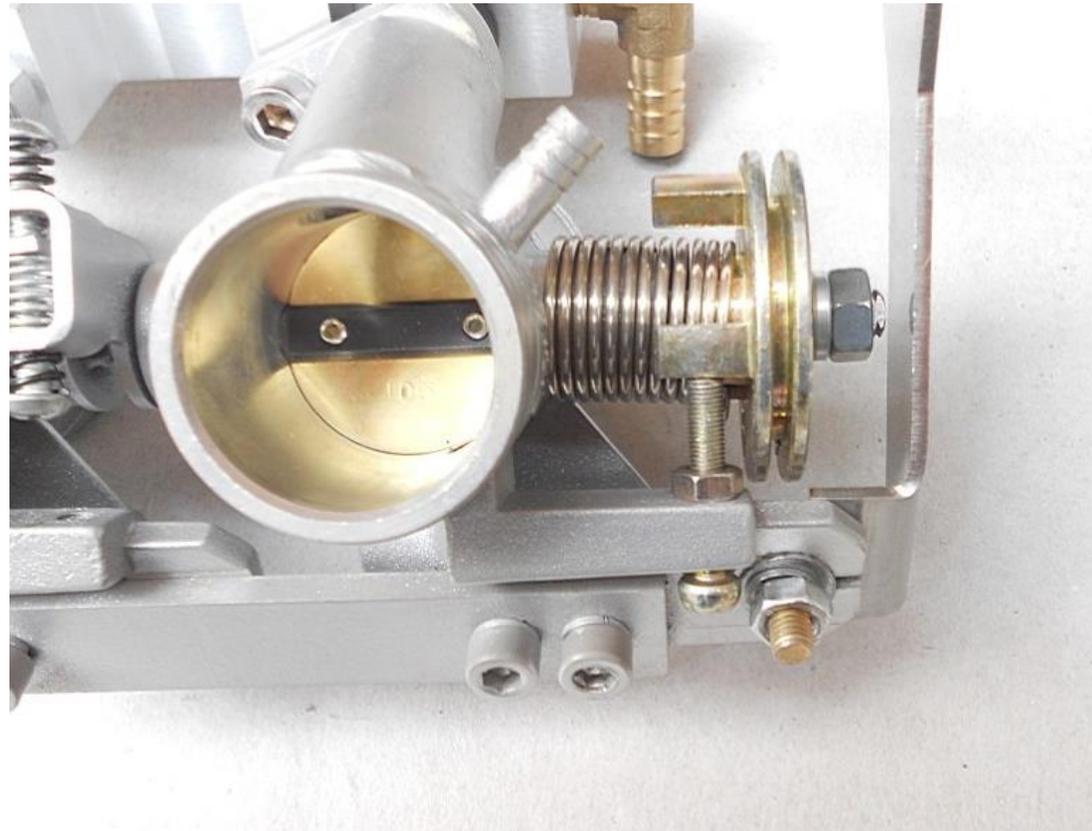
Then, use the screwdriver to turn the screw; if you want more idle air, you need turn the screw in clockwise, and if you want less idle air, you need turn the screw in counter-clockwise.



Last, when you are done adjusting the screw, please tight the nut by using the 2 tools.

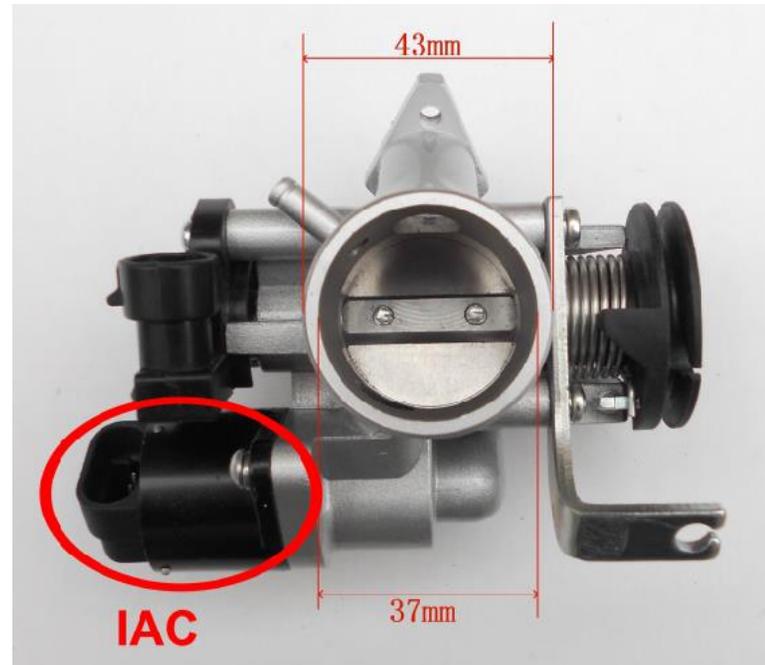


Finished:



3.3 Electronic Idle Air Control – IAC motor

Our 34mm size and bigger throttle bodies all 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.

Q: How to tune the idle RPM with an IAC motor?

If your engine idle RPM is too high, or too low, you need to adjust the desired stepper motor position (MAP_StepPrePos_Tm_N) according to the actual position “StepPos”; which can be logged via EcoCAL.

Note: The stepper motor position has an inverse logic to the idle RPM. By increasing the stepper motor position values in the table, you are reducing the idle air; and idle RPM will be lower.

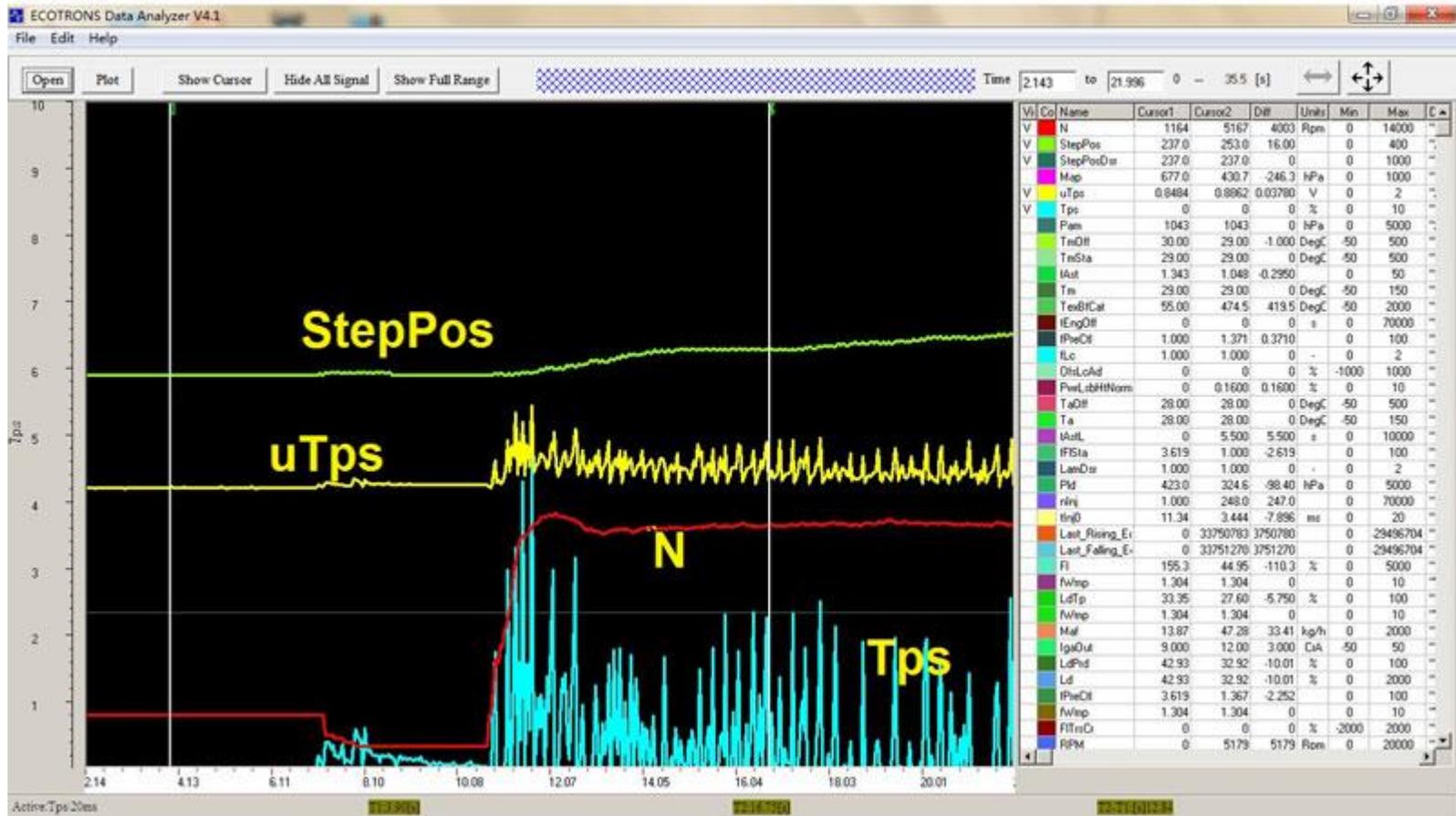
Note: If your engine idle speed stays higher than your target speed, and no matter what you do with an IAC system, you may have air leak in your intake air system.

The stepper motor comes with the throttle bodies are designed for certain range of engine displacements (engine cc sizes). If you use these throttle bodies (34mm or 42mm or 50mm or 55mm) on too big engines or too small engines, the idle motor may reach its physical max/min limits, and the idle air cannot be adjusted anymore by the IAC. You could also end up with too high or too low idle RPMs.

Note: IAC based idle controls only work if your TPS sensor reads 0%; meaning throttle body fully closed. Sometime your throttle cable is stuck and throttle plate is not fully closed.

If your engine idle RPM is not stable, or stays high for a long time, and it still can't go down to the desired RPM, then check your TPS signal. Maybe the TPS sensor signal is too noisy. Or the value of TPS is not 0 when engine runs in idle. TPS signal must have a stable value at 0 when engine is running in idle. If this is not the case, you better check the TPS sensor installation and also the throttle cable returning spring, etc.; make sure mechanically the TPS position is fixed at 0 when in idle. Also check the TPS connector and wire connections, make sure they are secured.

Below is a plot of noisy TPS signal example.



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 cannot be set too high or too low. For example, if your engine idle RPM (OEM setting) is 1500 RPM, and you change 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.

How to calibrate the stepper motor position to get a desired idle RPM? And how to fix the issue after the engine started, like, the idle RPM is too high or too low?

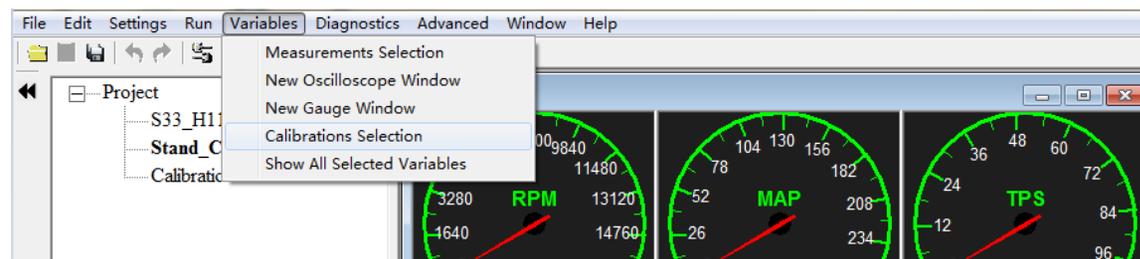
You need to tune the stepper motor position, MAP_StepPrePos_Tm_N, according to the following method.

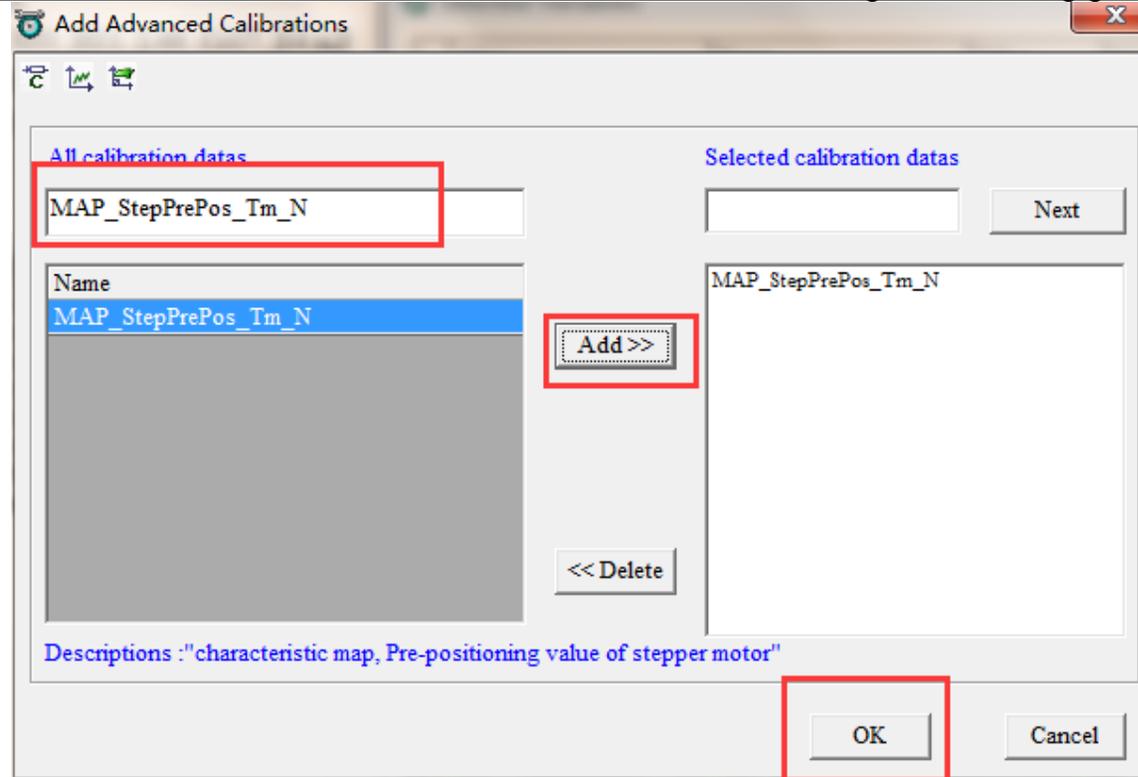
Note: the default stepper motor position is intentionally over- tuned, meaning, and more idle air than necessary. This is to make the initial start easier. If the idle RPM is too high after start, you need increase the stepper position value to reduce the idle air;

If the idle RPM is too low after start, you need reduce the stepper position value to get more idle air.

Adjust idle motor desired position; you need to do some advanced tuning, follow the below steps.

(1) Add advance calibration: Menu → Variables → Calibration Selection →





Find the variable: MAP_StepPrePos_Tm_N on the left side, then click “Add>>”. The variable appears on the right window. Click "OK"

Stepper motor pre-start position

+ 0.001 - * 1 / Selected = 1

Input-X: N, [Rpm], "break points, engine speed, for stepper motor control" Input-Y: Tm, [DegC], "break points, engine temperature, for stepper motor control"

Output: MAP_StepPrePos_Tm_N, [-], "characteristic map, Pre-positioning value of stepper motor"

X/Y	500.00	800.00
-30	110	110
-20	115	115
-10	120	120
0	125	125
10	130	130
20	140	140
30	150	150
40	160	160
50	170	170
60	180	180
70	190	190
90	190	190
99	190	190
110	190	190
125	190	190

Stepper motor pre-start position

(2) You can see the idle motor position when you finish adjusting.

Go to "Menu → Variables → Measurements Selection→"

The screenshot displays the EcoCAL V1.8.5.1 software interface. A 'Measurements Selection' menu is open, listing options: 'New Oscilloscope Window', 'New Gauge Window', 'Calibrations Selection', and 'Show All Selected Variables'. The main display features a 3x3 grid of gauges:

- Top Row:** RPM (0.00 Rpm), MAP (0.00 kPa), TPS (0.00 %)
- Middle Row:** ECT (-40 DegC), IAT (-40 DegC), LAMBDA (0.00)
- Bottom Row:** SPARK (-64.0 CrA), FUEL PW1 (0.00 ms), UbAdc (0.00 V)

On the left, a list of parameters is shown with their current values:

- RPM: 0 Rpm
- MAP: 0 kPa
- TPS: 0 %
- ECT: 0 DegC
- IAT: 0 DegC
- O2S: 0 V
- SPARK: 0 CrA
- FUEL PW1: 0 ms
- FUEL PW2: 0 ms
- LamWO2: 0

On the right, there are three tables for parameter settings:

Injector setting

Alias	Name	Value	Unit
?	Injector flow rate	VAL_Qstat	190.00 g/min
?	#2 injector flow rate	VAL_Qstat2	190.00 g/min

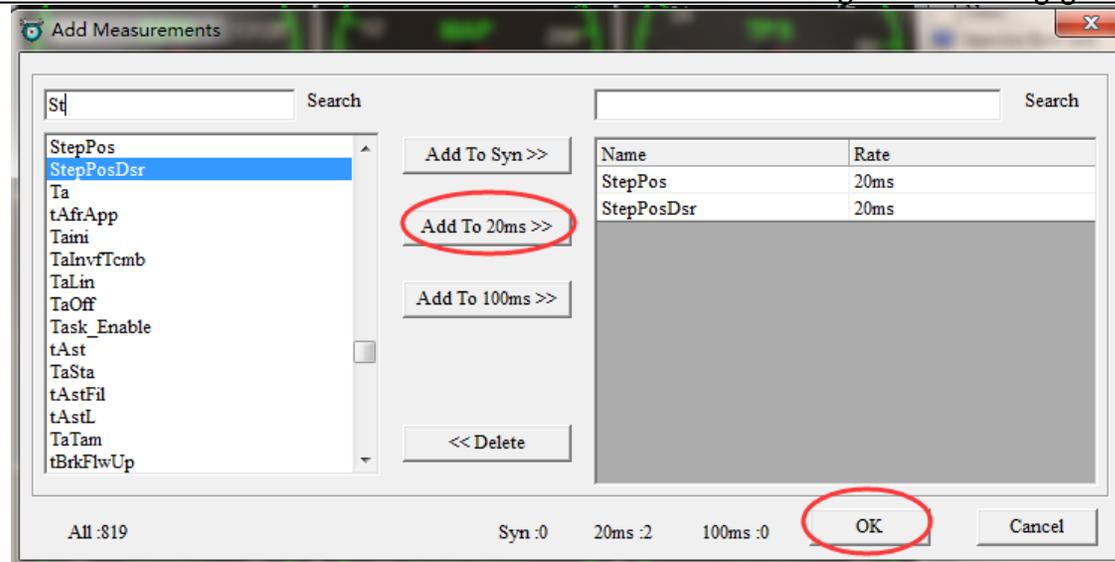
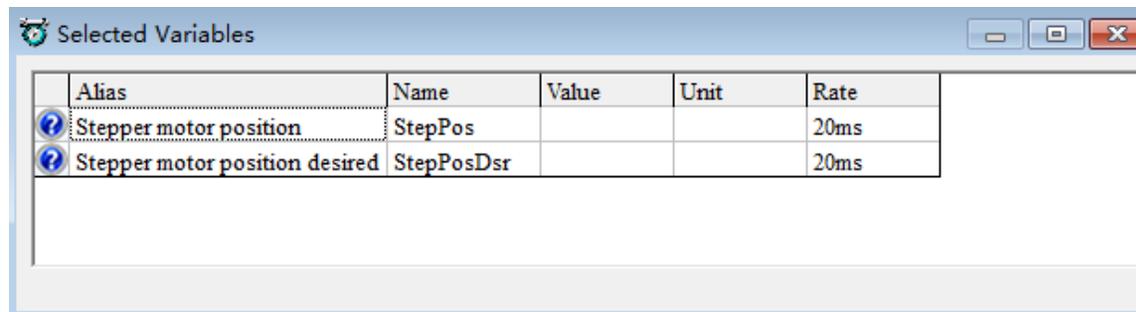
Engine parameter

Alias	Name	Value	Unit
?	# of cylinders	VAL_CyNum	1
?	MAX RPM	VAL_Nmax	12000.00 Rpm
?	Cylinder displacement	VAL_vEng	250.01 cc

Total number of teeth

Alias	Name	Value	Unit
?	Hall sensor active level	VAL_CKP_Pulse_Polarity	0
?	Pickup to TDC advance angle	VAL_dIgsGap2TdcAdj	29
?	Missing number of teeth	VAL_nTeethMiss	2
?	Total number of teeth	VAL_nTeethTot	1
?	TDC Tooth of #1 cylinder	VAL_ToothTDC	1
?	TDC Tooth for 2nd cylinder	VAL_ToothTDC2	2

At the bottom, a navigation bar includes tabs for: EFI basic setting, Servo Motor, Idle controls, Global fuel enrichment, Start fuel, After-start Warm-up Fuel, Steady-State, Acceleration, Deceleration, Performance WOT, Altitude Calibration, and Advanced Tuning f.

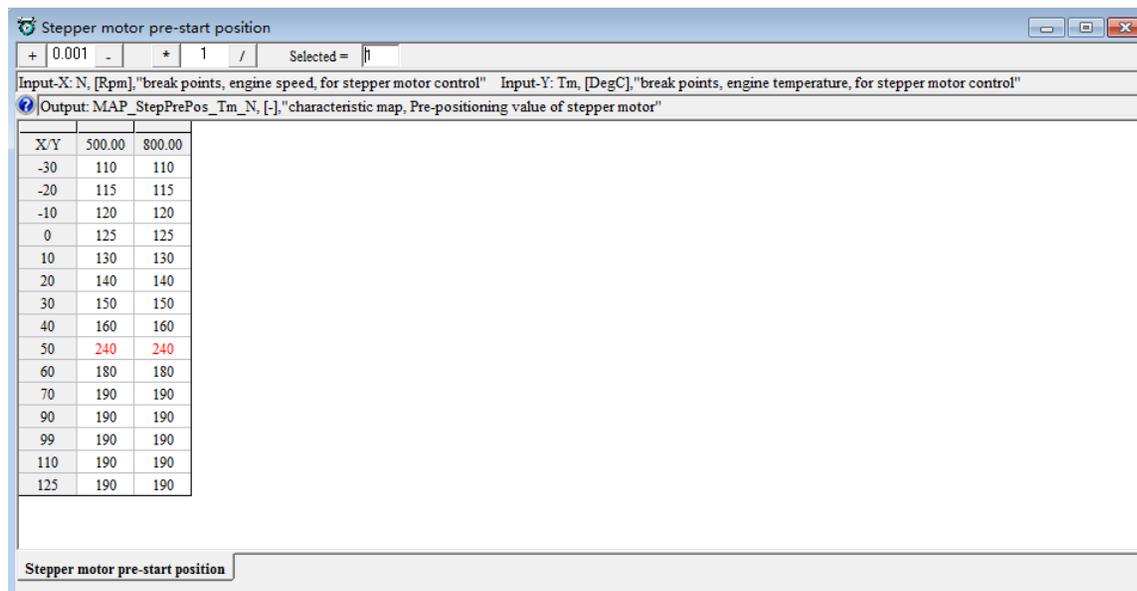
Alias	Name	Value	Unit	Rate
Stepper motor position	StepPos			20ms
Stepper motor position desired	StepPosDsr			20ms

Note: The value of "StepPosDsr" is the desired value from the table of "MAP_StepPrePos_Tm_N", based on the engine temperature "Tm". "StepPos" is the actually stepper motor position when engine is running at idle

with the desired RPM. You want to tune the “StepPosDsr” as close as possible to “StepPos” at certain engine temperatures.

For example:

If engine temperature is 50 C, and the "StepPosDsr" value is 170 from the table, when engine is at idle with the desired RPM; the "StepPos" value is 290. So you can change the cell value to 240 at 50 C (the value is smaller than 290, the difference is about 50 steps, to have some room, for better engine start).



The screenshot shows a software window titled "Stepper motor pre-start position". It contains a table with three columns: "X/Y", "500.00", and "800.00". The rows represent different engine speeds and temperatures. The value 240 is highlighted in red in the row where X/Y is 50.

X/Y	500.00	800.00
-30	110	110
-20	115	115
-10	120	120
0	125	125
10	130	130
20	140	140
30	150	150
40	160	160
50	240	240
60	180	180
70	190	190
90	190	190
99	190	190
110	190	190
125	190	190

You can also change the value in the table when "Tm" is higher than 50 degree.

Stepper motor pre-start position

+ 0.001 - * 1 / Selected = 1

Input-X: N, [Rpm], "break points, engine speed, for stepper motor control" Input-Y: Tm, [DegC], "break points, engine temperature, for stepper motor control"

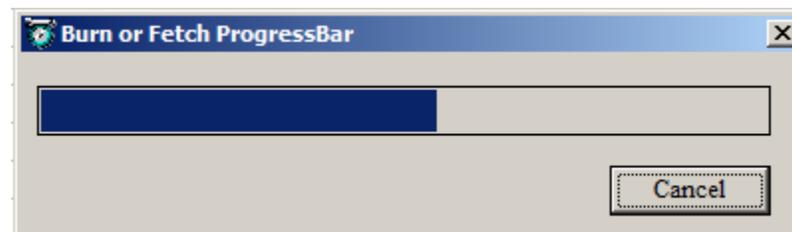
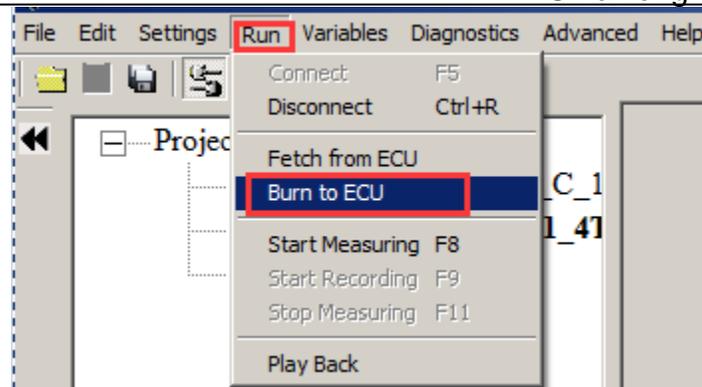
Output: MAP_StepPrePos_Tm_N, [-], "characteristic map, Pre-positioning value of stepper motor"

X\Y	500.00	800.00
-30	110	110
-20	115	115
-10	120	120
0	125	125
10	130	130
20	140	140
30	150	150
40	160	160
50	240	240
60	245	245
70	250	250
90	255	255
99	260	260
110	260	260
125	260	260

Stepper motor pre-start position

Note: Increase the cell values in the table; you will get lower RPM. This means the bigger the stepper motor position, the less idle air.

(1) After you change the value, then "Burn to ECU"



If the file downloaded successfully, lower left corner will pop up message "Burn to ECU Successfully"
When burn to ECU successfully, you will hear the noise of fuel pump working.

Note:

Make sure your 12V battery is healthy, before you do any "burn to ECU"!

During the upload or download, users are not allowed to do any operations to the EFI system.

Do not turn off the ECU power or disconnect the serial cable before the upload/download is finished.

Usually, the value of stepper motor position (StepPos) is 390, this means, the stepper motor has went to the largest position, if the idle RPM is still high, please check whether it has air leak, or the stepper motor connector is not connected well, or something wrong with the stepper motor.

The way to check stepper motor is take out it from throttle body, place a side, start to run engine, to see the stepper motor whether is working, and when key-off the ECU, the stepper motor will go to the smallest position and then go to the default position, if the stepper motor doesn't work, it means, the stepper motor is damaged or something wrong with the ECU.

3.4 Idle Controls via Ignition Timing

Note: If you do not have our ECU-controlled ignition, skip the rest of this part (ignition controls).

For throttle bodies (28mm for example) that do not have an IAC motor. The idle speed can be controlled by the ECU via ignition angle adjustment. This is only to adjust the small idle RPM deviation.

The mechanical idle air screw must be adjusted to a good position that your idle RPM is a little higher than you desired when the engine is warmed up.

Then the idle ignition angle can be retarded, and reduce the idle RPM at fully warmed up. At cold engine, idle ignition angle is likely at the optimum advanced angle, so that the idle RPM can be at your desired RPM even with a cold engine. For example, your idle ignition angle will be 9 degree CrA positive when it's cold. And it could be -7 degree CrA, a negative value, when it is fully warmed up.

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?

After you have a stable running engine with the fuel control only, 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 air to start in cold and stable idle in cold first. But that amount of air is a little more than necessary for the warm engine. (That's why you get a high idle rpm at hot but a low idle rpm at cold.)

Then the strategy is to retard 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 to reduce the emissions).

Furthermore, this gives some torque reserve for possible high idle requests (for example, to prevent undercharging).

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!

Pre-defined idle ignition angle map [MAP_Igaldc_N_Ld](#) : when engine runs in idle, (throttle body is fully closed).

Idle ignition angle pre-control

+ 0.001 - * 1 / Selected = 1

Input-X: N_b, [Rpm], "break points, engine speed, for ignition angle at idle" Input-Y: Ld_b, [%], "break points, load, for ignition angle at idle"

Output: MAP_Igaldc_N_Ld, [CrA], "characteristic map, ignition angle for idle, dependent on engine speed and load"

X/Y	1200	1320	1380	1500	1620	1800
18.00	9.75	9.75	9.75	9.75	9.75	9.75
24.75	9.75	9.75	9.75	9.75	9.75	9.75
30.00	9.75	9.75	9.75	9.75	9.75	9.75
35.25	9.75	9.75	9.75	9.75	9.75	9.75
40.50	9.75	9.75	9.75	9.75	9.75	9.75
45.00	9.75	9.75	9.75	9.75	9.75	9.75

Idle ignition angle pre-control

There are also two correct ignition factors based on battery voltage and engine temperature.
 CUR_dlgaldc_Tm, CUR_dlgaldc_Ub

Ignition angle correction based on Engine temperature

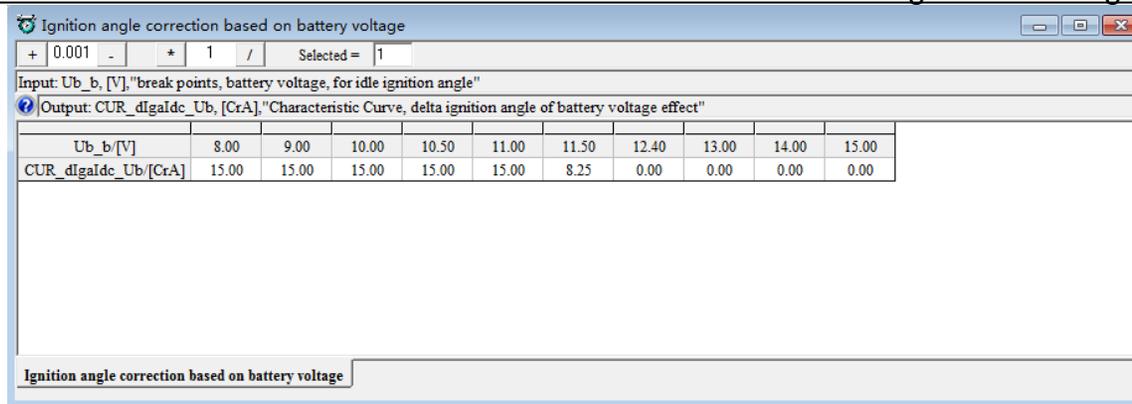
+ 0.001 - * 1 / Selected = 1

Input: Tm, [DegC], "break points, engine temperature, for idle ignition angle"

Output: CUR_dlgaldc_Tm, [CrA], "Characteristic Curve, delta ignition angle of engine temperature effect"

Tm [DegC]	-30	-25	-15	-10	0	10	20	45	80	90
CUR_dlgaldc_Tm [CrA]	30.00	24.75	24.75	24.75	24.75	9.75	0.00	0.00	0.00	0.00

Ignition angle correction based on Engine temperature



Ignition angle correction based on battery voltage

+ 0.001 - * 1 / Selected = 1

Input: Ub_b, [V], "break points, battery voltage, for idle ignition angle"

Output: CUR_dIgaIdc_Ub, [CrA], "Characteristic Curve, delta ignition angle of battery voltage effect"

Ub_b [V]	8.00	9.00	10.00	10.50	11.00	11.50	12.40	13.00	14.00	15.00
CUR_dIgaIdc_Ub [CrA]	15.00	15.00	15.00	15.00	15.00	8.25	0.00	0.00	0.00	0.00

Ignition angle correction based on battery voltage

The pre-defined idle ignition output angle = MAP_IgaIdc_N_Ld + CUR_dIgaIdc_Tm + CUR_dIgaIdc_Ub
 And the close loop ignition angle control for idle speed control is based on this pre-defined ignition angle.

EFI System without an IAC Motor, and without Ignition Control

If the idle air is too much or too less, it leads the Engine idle RPM too high or too low.

Because ECU has no way to control the idle RPM, in this case, you may have to start with a high idle RPM and later on, to fine tune the throttle mechanical stop position or idle air screw position to get a compromise of idle RPM.

If the engine idle RPM is super high, like 3000rpm, ECU will cut the fuel, and the RPM may go up and down.

3.5 Idle fuel too rich because of minimum injector pulse width

Q: why to adjust fuel injection time in idle?

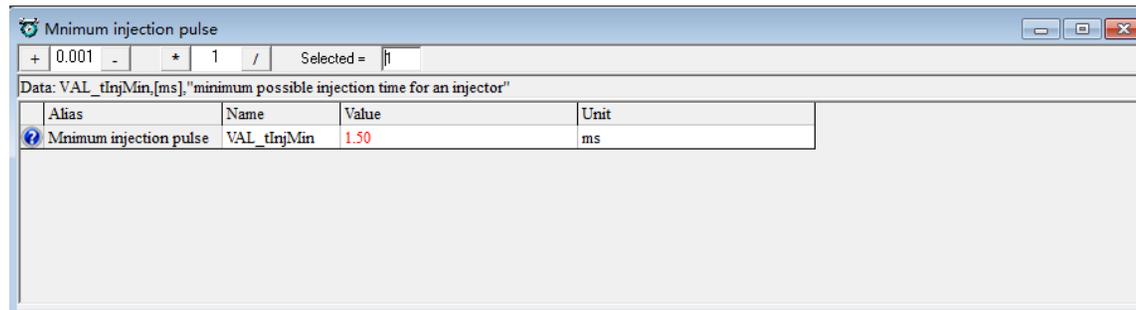
No matter how much you have changed the base fuel mapping for idle, (via VE table or TPS Load table), the engine still runs too rich. It seems no effect even you put the 0 fuel pulse in the table. It is because your fuel pulse width is clipped by the minimum fuel injection pulse width. You need to change that limit to lower, VAL_tInjMin.

This calibration basically defines the minimum pulse width that can open the injector. This is the physical limit of an injector, usually in 1ms to 2ms ranges.

Go to "Menu → Variables → Calibration Selection" to add the VAL_tInjMin. And decrease this value according to the actual engine running. This value by default is 2ms; or 2.2ms including the battery voltage compensation. The reason to have a 2ms min pulse width is because the injector has a better flow rate when it is bigger than 2ms. For many engines, the min pulse width could be smaller. Usually you can set it to 1.5ms or 1.0ms as the extreme minimum. Anything smaller than 1ms, you may not have fuel injection at all.

For example:





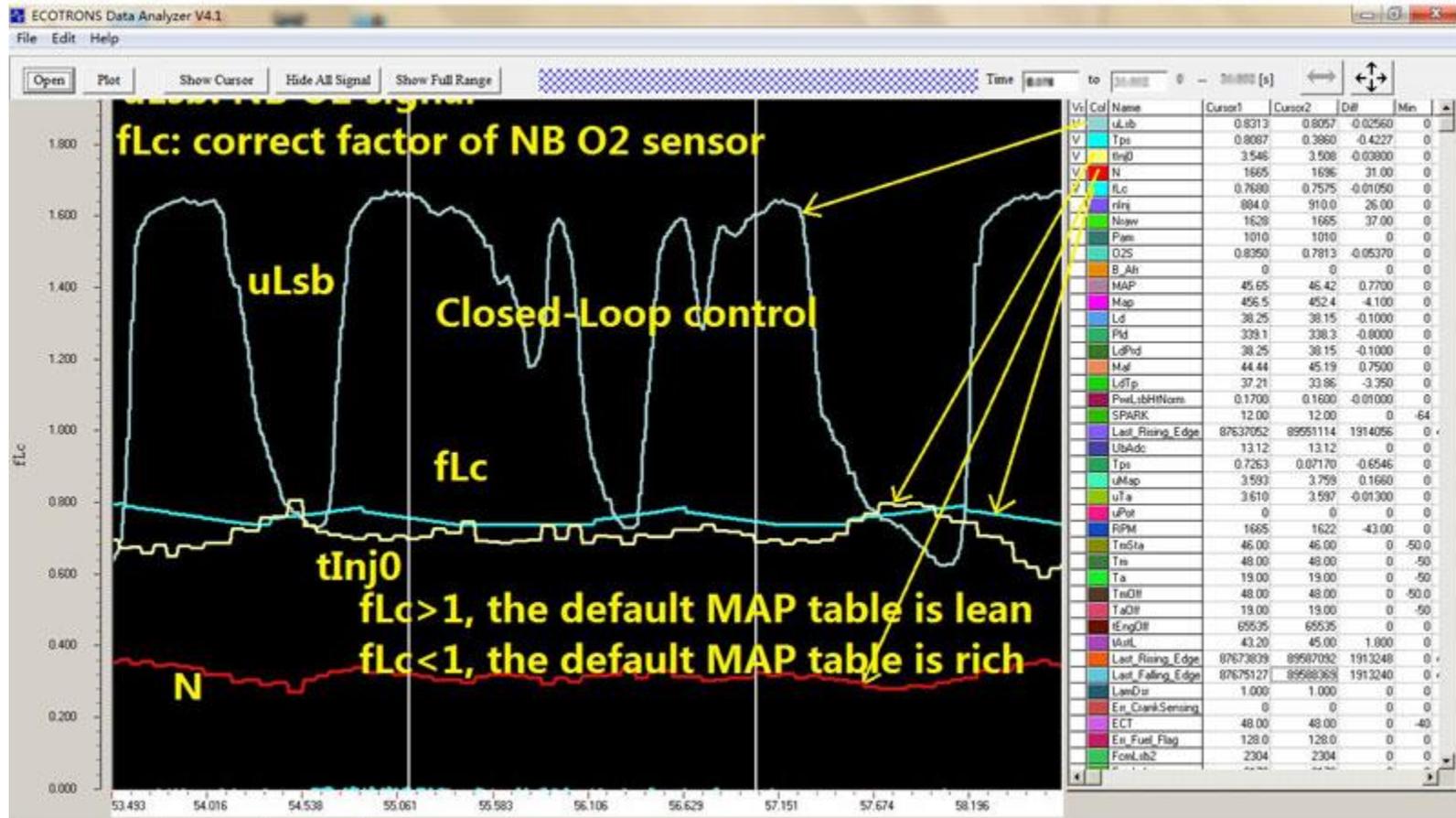
Q: How do I know whether it is rich or lean?

You can use the following method to know whether the engine runs too rich or too lean with a NB O2 sensor or a wideband ALM. Also you may know it by smelling the exhaust gas when it is too rich.

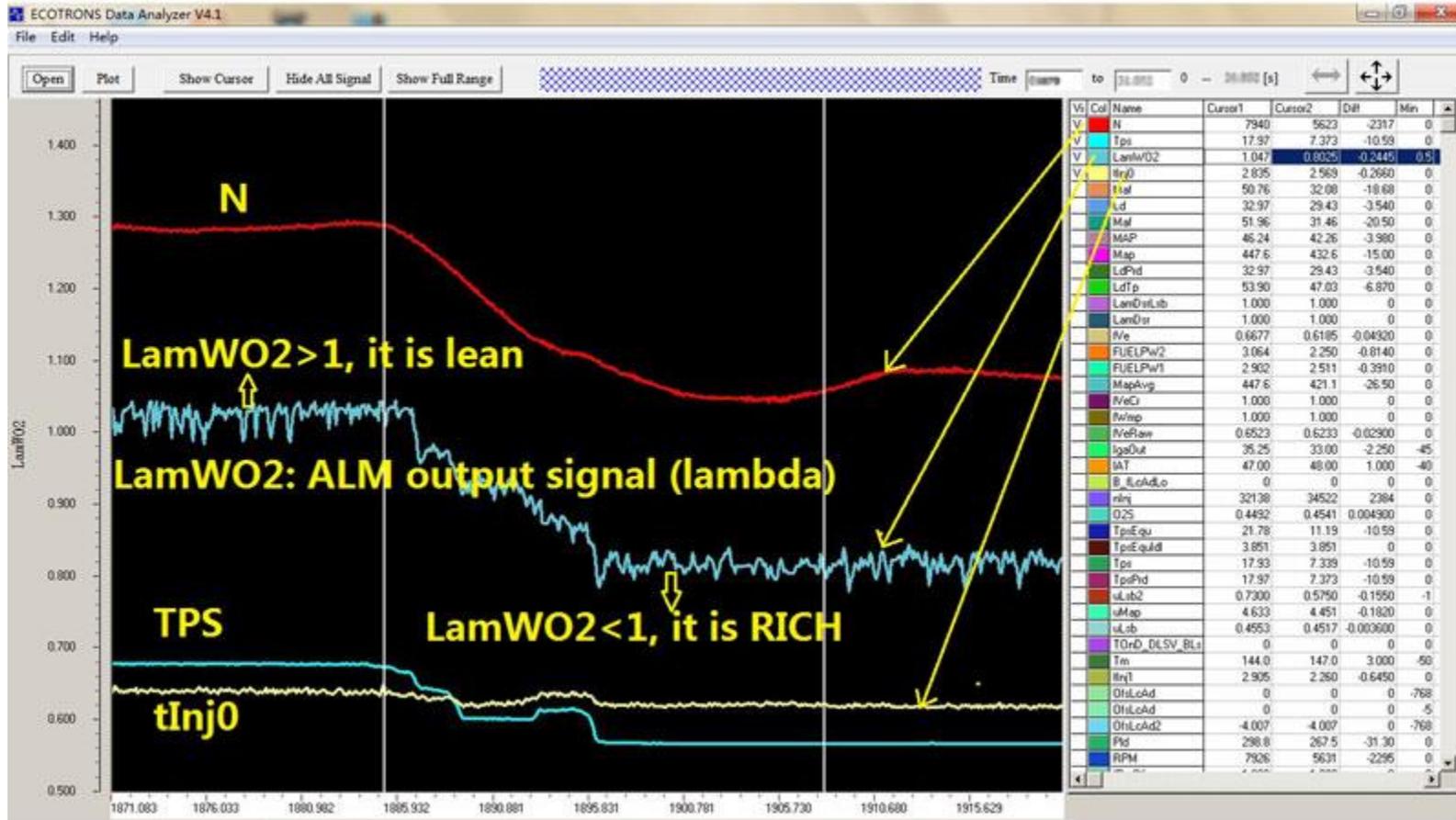
(1) With a NB O2 sensor. You can read the voltage of the NB O2 sensor in the EcoCAL gauge, O2S; to know whether it is rich or lean.

uLsb: signal of lambda sensor, in the List of variables.

If it is higher than 0.45V, the engine runs rich. If it is lower than 0.45V, it runs lean.



(2) Read the AFR by using an ALM gauge, which you can buy from ECOTRONS. You can also read the real time lambda (LamWO2) in EcoCAL, for which you need to connect the ALM to ECU through the EFI harness. With the ALM, the advantage is that you can read / log the real-time AFR or lambda value, then you do some tuning.



Chapter 4 Open-loop and closed-loop fuel control

4.1 Open Loop Fuel Control

What is open loop fuel control, 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 because it is a precautionary step 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 (like a scooter GY6 150cc, 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. 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 correct the small errors. The big difference cannot be learnt by the ECU and could lead to the oscillations, or unstable running.

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 cannot self-learn the engine for variations. The self-fine-tuning of the fuel is not happening.

Even in open loop mode, if tuned well, an EFI engine can run much better than a carb engine, NO QUESTION.

Many OEMs have open loop EFI engines certified with EPA / CARB emission regulations. The key is the tuning.

What if I cannot 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_fIApp**". And once you have a relative stable run, you can detune this factor by using other parameters.

If your idle speed is too low, and you cannot maintain the stable idle RPM, go to Chapter 3 (idle air adjustment).

For open loop tuning, you can find the details in Chapter 5. But you need to know what a close loop control system is first.

4.2 Closed Loop fuel control

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. We do have a wideband kit, ALM, for your tuning purpose.

When you see the O2 sensor voltage 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 EcoCAL, among a bunch of green/black gauges, there is an O2S gauge indicates the voltage.

Better 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 warm-up, 3 minutes later), what's wrong?

Possible reason #1: you don't have it connected;

Possible reason #2: the sensor is broken, or the wire is broken;

Read the diagnostic DTC in EcoCAL.

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

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.

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 VAL_FIApp; you fuel injector size, your engine displacement, etc, in EcoCAL.

Case 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. Read the later chapters.

Case 4: The sensor is broken, or the wire is shorted.

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

You are running lean all the time. It may happen if you have fuel supply issues. For example, your fuel pump is having air bubbles; or the fuel pressure is not enough; or the pressure regulator is malfunctioning; or the battery voltage is too low, etc.

You have wrong calibrations. Check you fuel injector size, your engine displacement, etc.

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. Read the later chapters.

The sensor is broken, or the wire is shorted.

Q: How long does the EFI need to run for the self-tuning?

ECU self-tuning is only possible if you have a stable engine running in active close-loop controls. (this means, 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) .

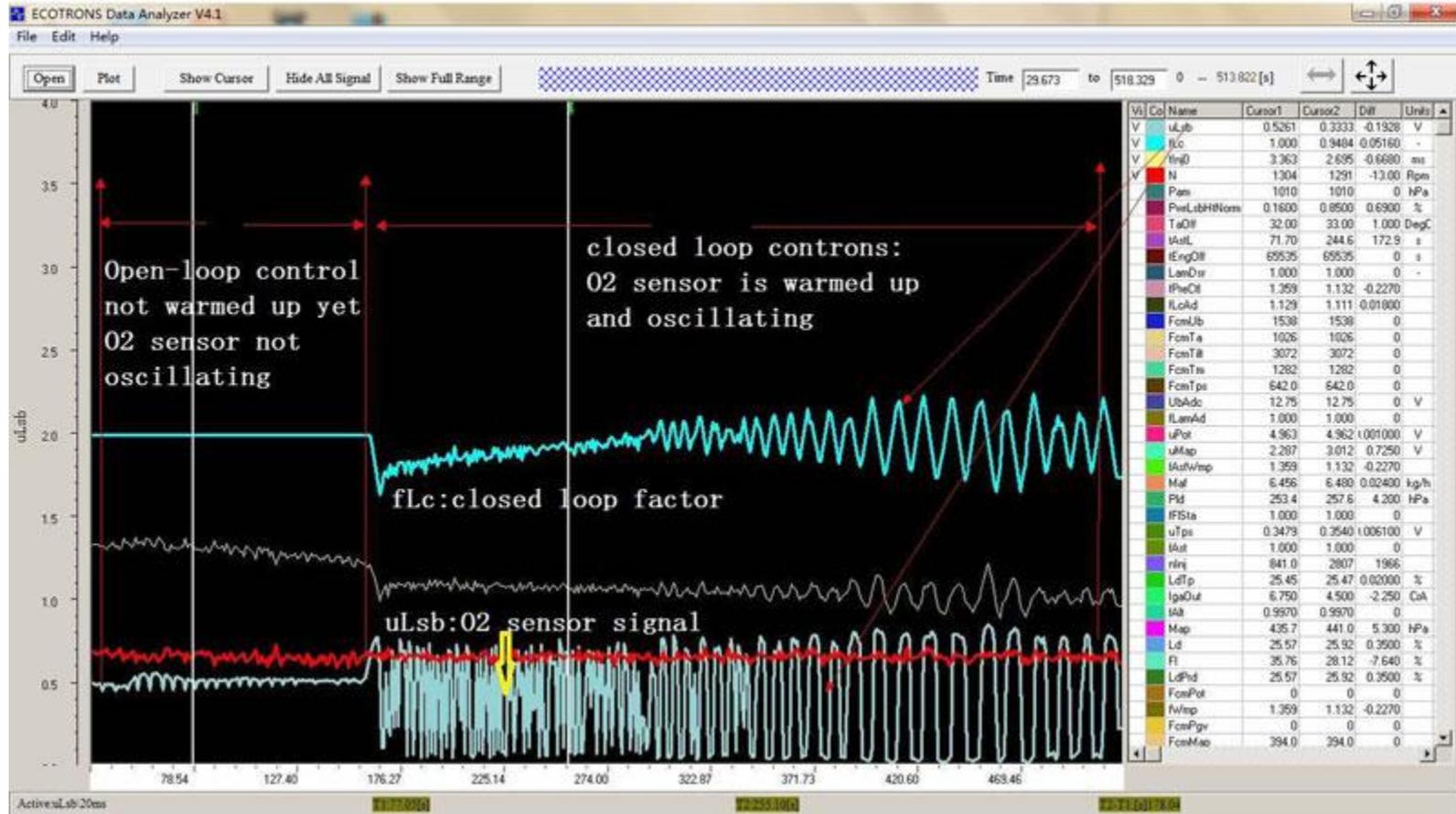
It does not take long for the self-tuning. It takes a few minutes for every different operating condition. The key is to run the engine in a steady-state and traverse through the common operating conditions (idle, part-load, high-load, WOT, etc.)

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.

Note: This self-tuning is based on the Narrow Band O2. It only adjusts small errors. It only works if the base fuel mapping is good.

Note: This self-tuning is a life-long continuous process. It changes very slow, and takes only effect of long term factors

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



Chapter 5 VE table and Load table tuning

Note: EFI is an advanced technology compare to the carbs. It requires a thorough understanding of the electronics and software strategy to be able to tune the system.

Please educate yourself on the basics of engines and electronic fuel injections. There are tons 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 the "Volumetric Efficiency".

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

Volumetric Efficiency – VE table

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 and the residual exhaust gas. To know exactly how much fuel you need to inject and to 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 you have to know the volumetric efficiency.

With a MAP sensor based system, you 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, you can calculate the air mass in the combustion chamber. This is called by the auto industry as “**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 you know the manifold air pressure, intake air temperature, and the volumetric efficiency, you can calculate the fresh air mass in the cylinder and therefore the fuel quantity that needs to be injected.

Unfortunately, volumetric efficiency is not able to be measured directly with any sensor. You'd have to calibrate it one operating-point (RPM vs MAP reading) 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 throttles and RPMs); at a certain MAP signal and RPM, you can tweak the volumetric efficiency table until you get the stoic AFR read 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 the 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: NB O2 based tuning is only possible if you have everything running normally and in close-loop control.

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 full cylinder.

What is the ideal air mass? When you have your cylinder fully filled with the 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. In other words, if your engine displacement is 150cc, the idea air mass is the 150cc fresh air mass at standard conditions (1 bar, 0 degree C).

"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".

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

"LOAD" based tuning makes most of our tuning data "portable" from one engine to another, with minimum changes. LOAD based tuning is the only professional way to tune.

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 may seem easier to map the engine in the coarse way, but it actually costs more time and efforts later on. You'll pay for that "short-cut" sooner or later.

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. This means, you base LOAD mapping is not affected by the altitude, temperature, density, etc. Those factors will be added in later. This is the fundamental of "model-based-design" , a modern method used by Ford and GM, etc. engineers.

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 called "**Alpha-N**" model by the auto industry.

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. Just 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 when 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.

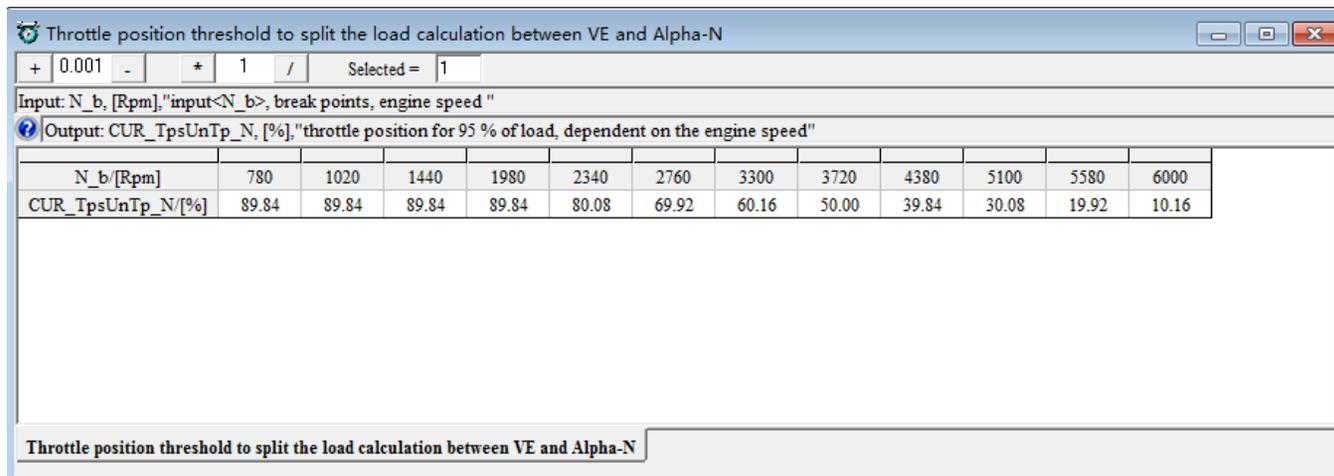
But as you may have noticed, small engines' manifold pressure is changing so dynamically, there is no "stable, constant" MAP signal; even you hold the throttle position unchanged. This becomes worse when you have large throttle opening, and you are running more than 6000 RPM. MAP sensor signal becomes 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 cannot 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 exactly 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 EcoCAL (this calibration is only available for certain users):

Menu → Variables → Calibration Selection → Add: **CUR_TpsUnTp_N** "Characteristic curve, TPS threshold, air flow is un-throttled and/or pressure change is insensitive."



Throttle position threshold to split the load calculation between VE and Alpha-N

Input: N_b, [Rpm], "input<N_b>, break points, engine speed "

Output: CUR_TpsUnTp_N, [%], "throttle position for 95 % of load, dependent on the engine speed"

N_b [Rpm]	780	1020	1440	1980	2340	2760	3300	3720	4380	5100	5580	6000
CUR_TpsUnTp_N [%]	89.84	89.84	89.84	89.84	80.08	69.92	60.16	50.00	39.84	30.08	19.92	10.16

Throttle position threshold to split the load calculation between VE and Alpha-N

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 of 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 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.

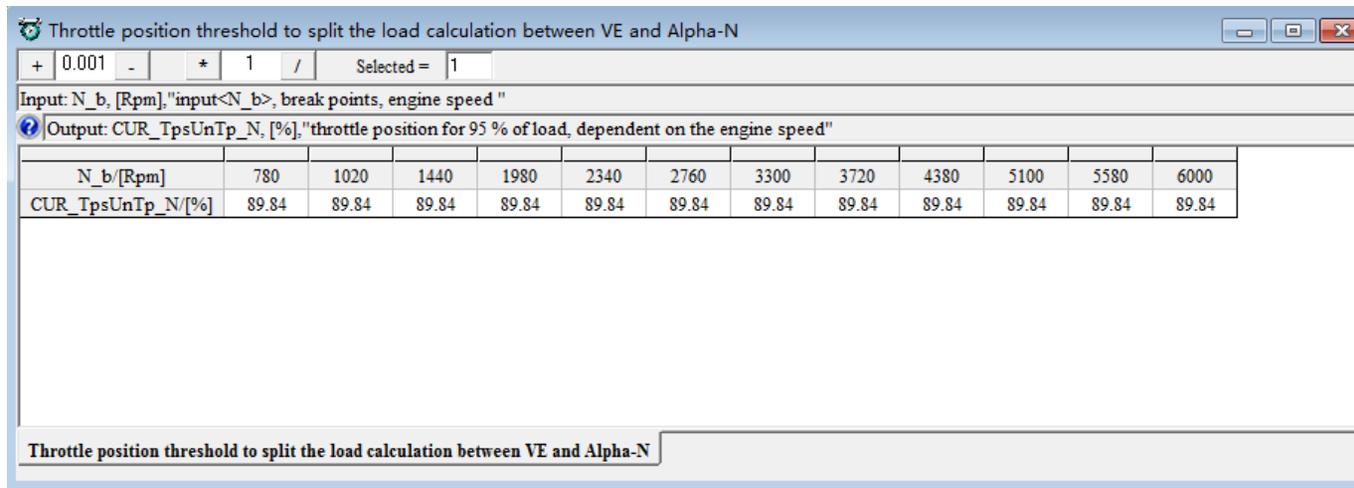
For a sporty, high RPM engine, like Kawasaki Ninja 250r, which has a RPM range of 1500rpm - 13000rpm, the blended "speed-density" and "alpha-N" is a must to have a good control over the wide range.

Specific examples:

Ok, you have read and known the above information, let's try to tune it.

If your engine is running rich or lean in different throttle positions, you need do some advanced calibrations. There are two fuel mapping tables, one is "RAM_MAP_fVe_Map_N" which is based on pressure signal "Map" and RPM, the other table is "RAM_MAP_LdTp_Tps_N" which is based on Tps and RPM.

For **four-stroke** engines, the default fuel mapping usually is volumetric efficiency table (MAP_fVe_Map_N), at least for all low RPM and mid-range RPM. For high RPM and WOT(wide open throttle), it is based on "MAP_LdTp_Tps_N". The split between the 2 tables is defined in "CUR_TpsUnTp_N" :



Throttle position threshold to split the load calculation between VE and Alpha-N

+ 0.001 - * 1 / Selected = 1

Input: N_b, [Rpm], "input<N_b>, break points, engine speed "

Output: CUR_TpsUnTp_N, [%], "throttle position for 95 % of load, dependent on the engine speed"

N_b/[Rpm]	780	1020	1440	1980	2340	2760	3300	3720	4380	5100	5580	6000
CUR_TpsUnTp_N[%]	89.84	89.84	89.84	89.84	89.84	89.84	89.84	89.84	89.84	89.84	89.84	89.84

Throttle position threshold to split the load calculation between VE and Alpha-N

If the throttle position (Tps) is bigger than the value of the table, it will be changed to use the Alpha/N model, otherwise it will use VE table.

Example:

(1) You can use NB O2 sensor voltage in the closed loop control to know whether it is rich or lean.



Figure 1

Note: fLc is the factor of lambda control, when closed-loop is active. It automatically changes based on the O2 sensor feedback. If it is smaller than 1 for a long time, it means the default VE table value is too bigger; you need change it to a smaller one to reduce the fuel quantity.

(2) Using the wideband ALM, you can read the AFR or lambda directly, and also log the real-time lambda (lamWO2) in EcoCAL.

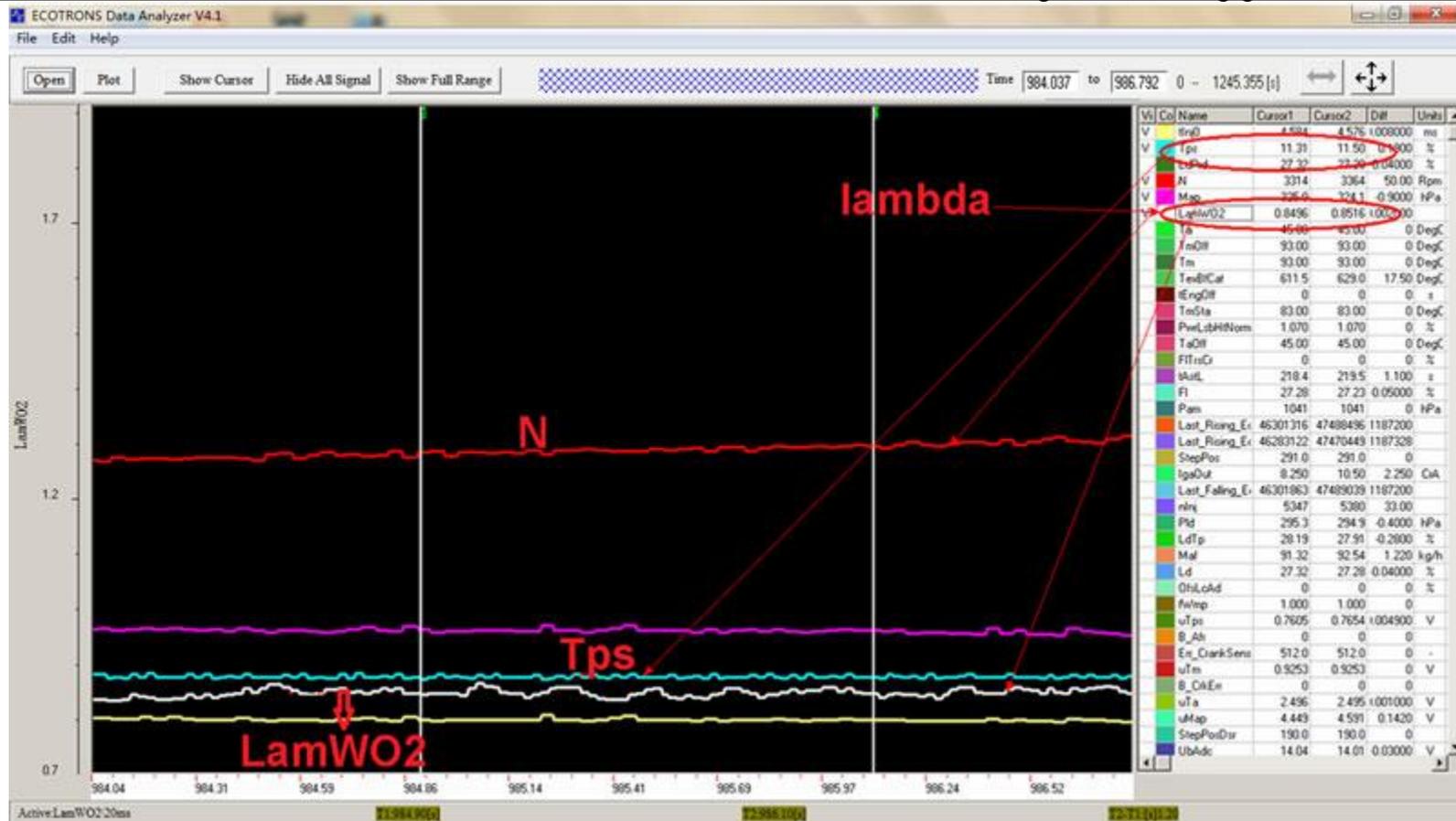
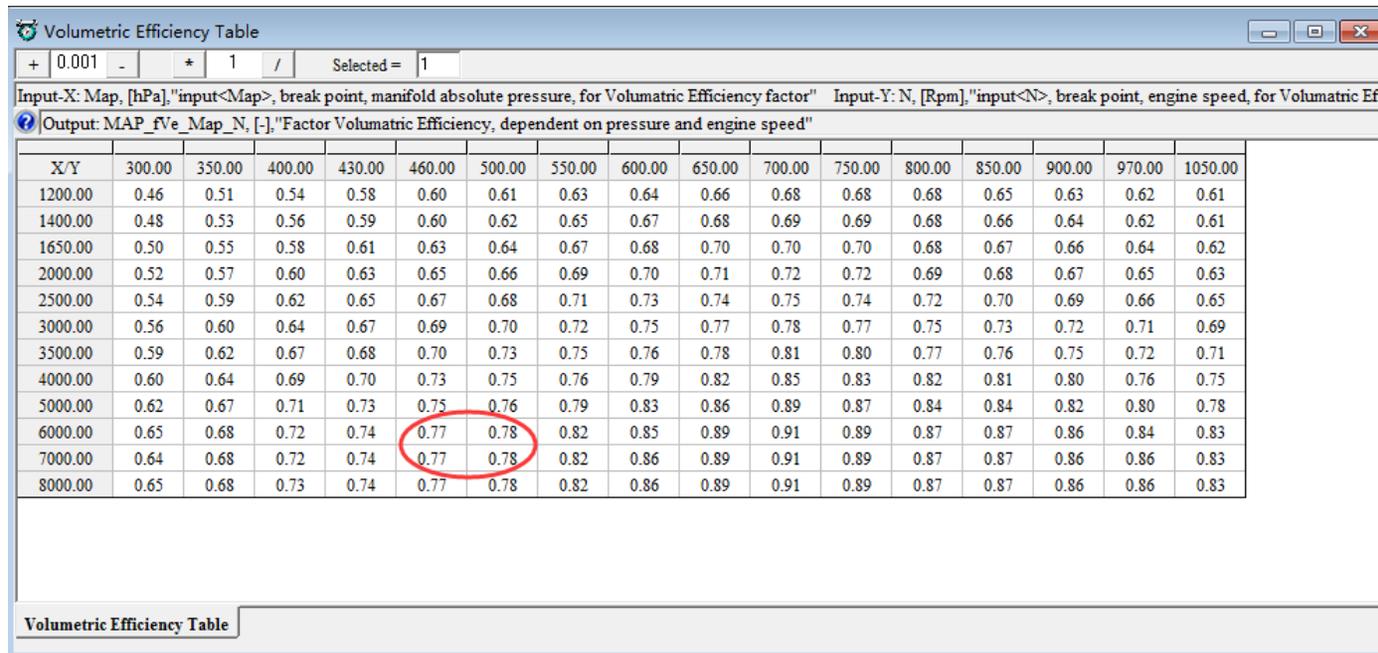


Figure 2

You can change the VE table value based on "Map" and "N", and adjust MAP_LdTp_Tps_N based on "Tps" and "N". You can read the value of "Map" and "N" in EcoCAL (Menu → Variables → Measurements Selection→).

NOTE: If you want to tune the value of VE table or Alpha/N table, the engine must be warmed up, there is no enrichment factor, and you set it to ECO mode with the NB O2 sensor.

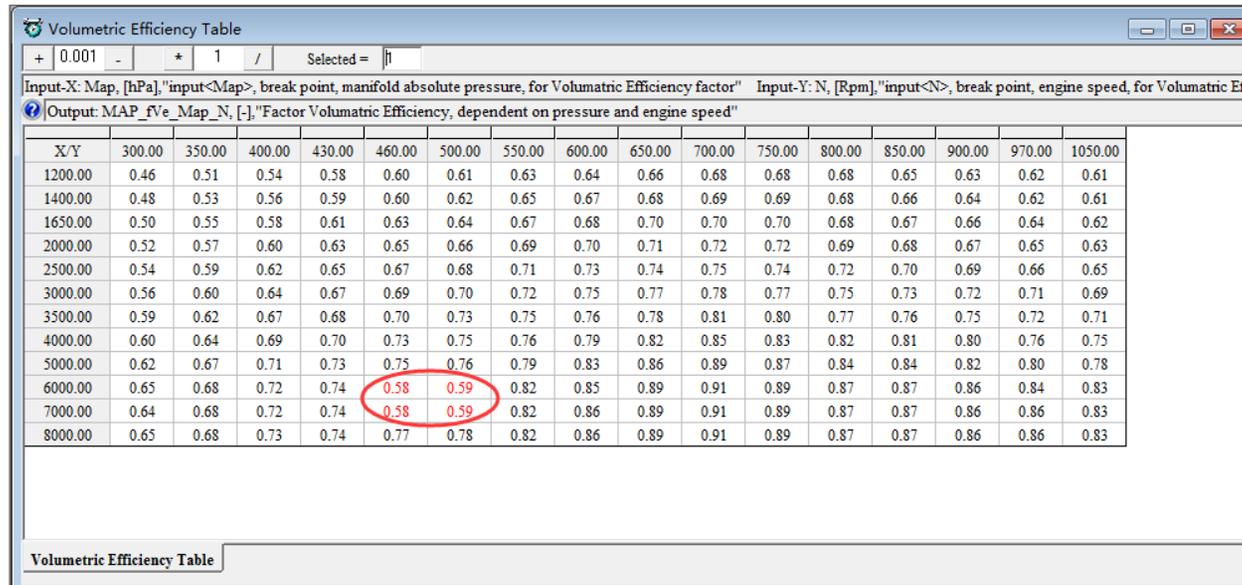
Try to calibrate one cell value now, N=6929, Map=475, fLc (Or lamWo2) =0.75



X/Y	300.00	350.00	400.00	430.00	460.00	500.00	550.00	600.00	650.00	700.00	750.00	800.00	850.00	900.00	970.00	1050.00
1200.00	0.46	0.51	0.54	0.58	0.60	0.61	0.63	0.64	0.66	0.68	0.68	0.68	0.65	0.63	0.62	0.61
1400.00	0.48	0.53	0.56	0.59	0.60	0.62	0.65	0.67	0.68	0.69	0.69	0.68	0.66	0.64	0.62	0.61
1650.00	0.50	0.55	0.58	0.61	0.63	0.64	0.67	0.68	0.70	0.70	0.70	0.68	0.67	0.66	0.64	0.62
2000.00	0.52	0.57	0.60	0.63	0.65	0.66	0.69	0.70	0.71	0.72	0.72	0.69	0.68	0.67	0.65	0.63
2500.00	0.54	0.59	0.62	0.65	0.67	0.68	0.71	0.73	0.74	0.75	0.74	0.72	0.70	0.69	0.66	0.65
3000.00	0.56	0.60	0.64	0.67	0.69	0.70	0.72	0.75	0.77	0.78	0.77	0.75	0.73	0.72	0.71	0.69
3500.00	0.59	0.62	0.67	0.68	0.70	0.73	0.75	0.76	0.78	0.81	0.80	0.77	0.76	0.75	0.72	0.71
4000.00	0.60	0.64	0.69	0.70	0.73	0.75	0.76	0.79	0.82	0.85	0.83	0.82	0.81	0.80	0.76	0.75
5000.00	0.62	0.67	0.71	0.73	0.75	0.76	0.79	0.83	0.86	0.89	0.87	0.84	0.84	0.82	0.80	0.78
6000.00	0.65	0.68	0.72	0.74	0.77	0.78	0.82	0.85	0.89	0.91	0.89	0.87	0.87	0.86	0.84	0.83
7000.00	0.64	0.68	0.72	0.74	0.77	0.78	0.82	0.86	0.89	0.91	0.89	0.87	0.87	0.86	0.86	0.83
8000.00	0.65	0.68	0.73	0.74	0.77	0.78	0.82	0.86	0.89	0.91	0.89	0.87	0.87	0.86	0.86	0.83

To calculate the fuel injection quantity within the red circular area, for example, at 6929 RPM and 475 Map, because it is rich, and needs to reduce the value of this area to get less fuel quantity, according to the O2 sensor factor; you can multiply the value of “fLc” or “LamWO2” to the cell value and hit “ENTER”. See below:

Note: the VE table and LOAD table can be calibrated “on-the-fly”, meaning, it takes effect immediately.



X\Y	300.00	350.00	400.00	430.00	460.00	500.00	550.00	600.00	650.00	700.00	750.00	800.00	850.00	900.00	970.00	1050.00
1200.00	0.46	0.51	0.54	0.58	0.60	0.61	0.63	0.64	0.66	0.68	0.68	0.68	0.65	0.63	0.62	0.61
1400.00	0.48	0.53	0.56	0.59	0.60	0.62	0.65	0.67	0.68	0.69	0.69	0.68	0.66	0.64	0.62	0.61
1650.00	0.50	0.55	0.58	0.61	0.63	0.64	0.67	0.68	0.70	0.70	0.70	0.68	0.67	0.66	0.64	0.62
2000.00	0.52	0.57	0.60	0.63	0.65	0.66	0.69	0.70	0.71	0.72	0.72	0.69	0.68	0.67	0.65	0.63
2500.00	0.54	0.59	0.62	0.65	0.67	0.68	0.71	0.73	0.74	0.75	0.74	0.72	0.70	0.69	0.66	0.65
3000.00	0.56	0.60	0.64	0.67	0.69	0.70	0.72	0.75	0.77	0.78	0.77	0.75	0.73	0.72	0.71	0.69
3500.00	0.59	0.62	0.67	0.68	0.70	0.73	0.75	0.76	0.78	0.81	0.80	0.77	0.76	0.75	0.72	0.71
4000.00	0.60	0.64	0.69	0.70	0.73	0.75	0.76	0.79	0.82	0.85	0.83	0.82	0.81	0.80	0.76	0.75
5000.00	0.62	0.67	0.71	0.73	0.75	0.76	0.79	0.83	0.86	0.89	0.87	0.84	0.84	0.82	0.80	0.78
6000.00	0.65	0.68	0.72	0.74	0.58	0.59	0.82	0.85	0.89	0.91	0.89	0.87	0.87	0.86	0.84	0.83
7000.00	0.64	0.68	0.72	0.74	0.58	0.59	0.82	0.86	0.89	0.91	0.89	0.87	0.87	0.86	0.86	0.83
8000.00	0.65	0.68	0.73	0.74	0.77	0.78	0.82	0.86	0.89	0.91	0.89	0.87	0.87	0.86	0.86	0.83

You can use the same method to calibrate all other cells of the table, when you have finished the calibration, the table must be manually made smooth and burn it to ECU. 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 3D surf, and manually smoothen out any spikes). Spikes are no good for engine controls.

You can also use the real-time lambda (ALM output) to calibrate the table. Make sure to use the engine steady-state running signals.

The method to calibrate the MAP_LdTp_Tps_N (Alpha/N model) is same as MAP_fVe_Map_N, only different in the dependency of "Tps" and "N", throttle position and RPM.

2-stroke and UAV engines EFI system tuning

For two stroke engine and UAV engine, the default fuel mapping is MAP_LdTp_Tps_N, so if you want to tune the mapping, you just need to tune the TPS based load mapping, MAP_LdTp_Tps_N.

And for 2-stroke and UAV EFI system, there is no narrow band sensor; you should install the wideband sensor for tuning.

Example:

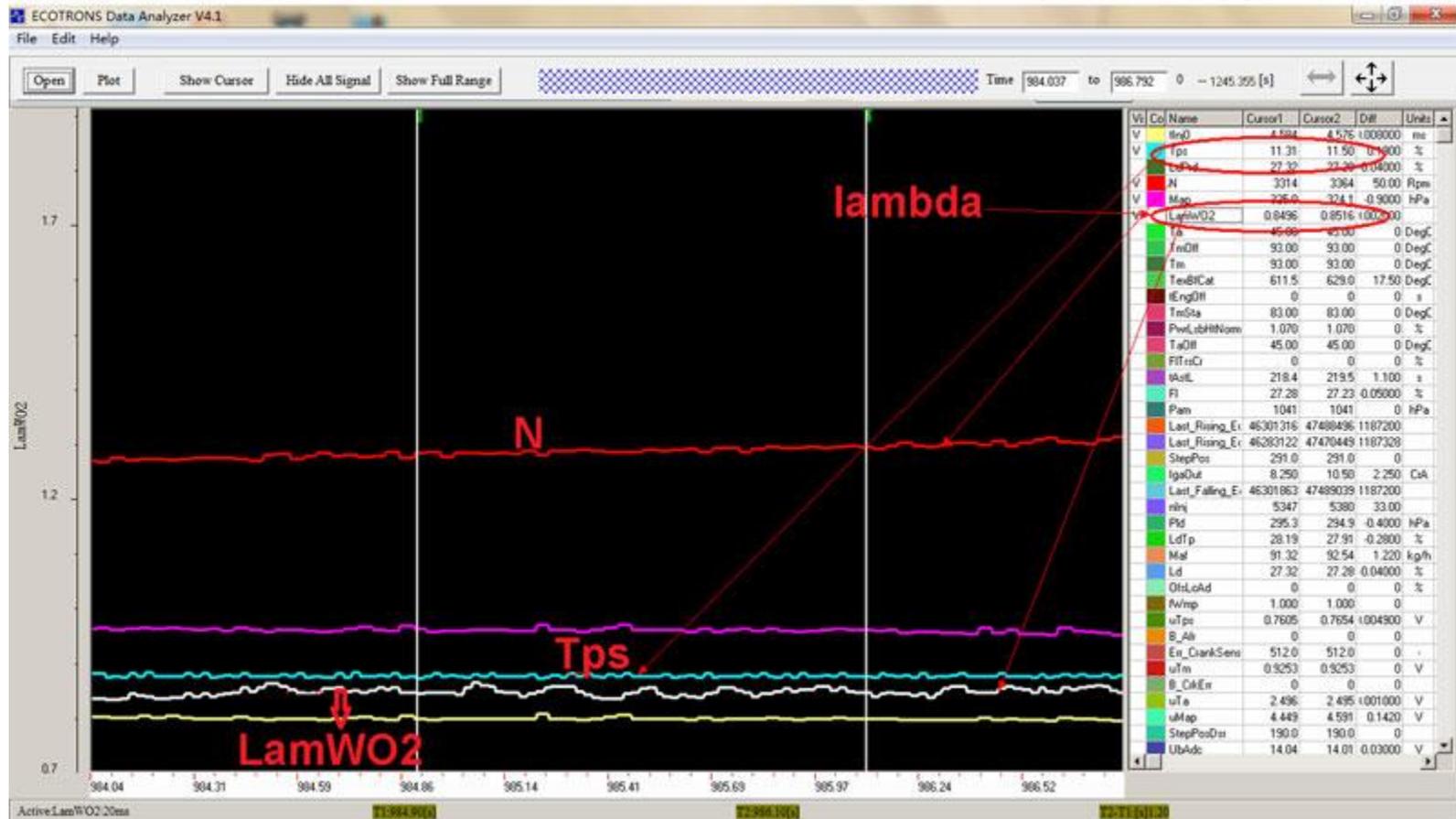
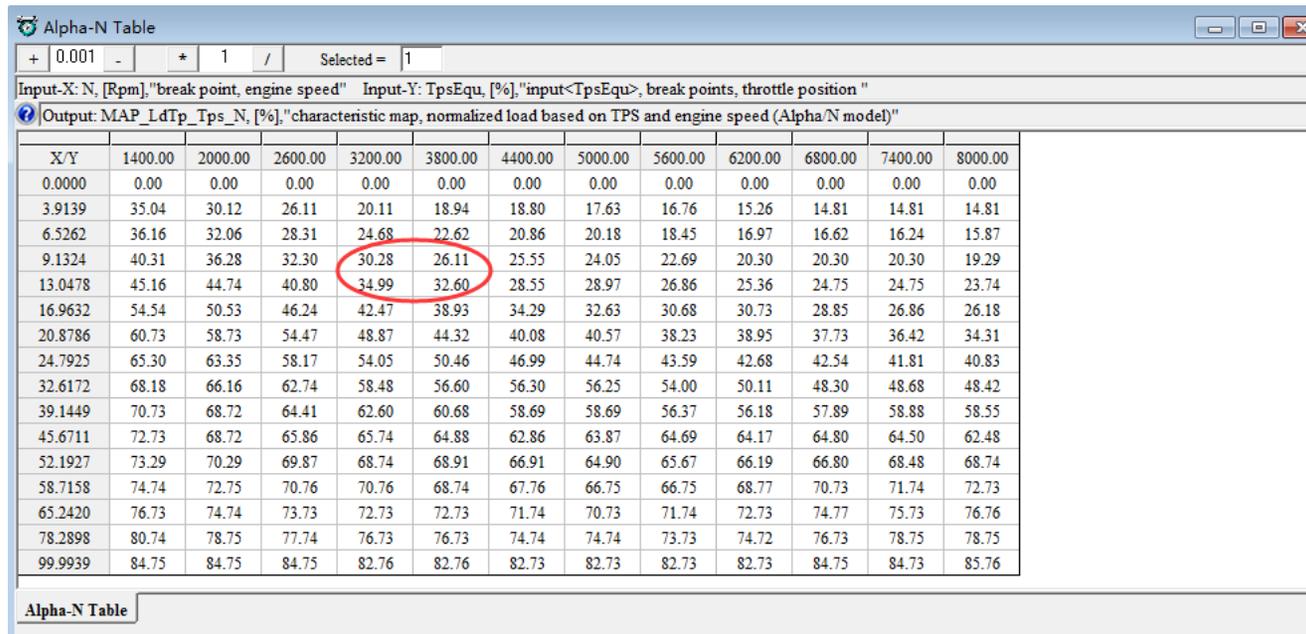


Figure 2

You can adjust MAP_LdTp_Tps_N based on "Tps" and "N". You can read the value of "TPS" and "N" in EcoCAL (Menu → Variables → Measurements Selection →).

NOTE: If you want to tune the value of Alpha/N table, the engine must be warmed up, there is no enrichment factor.

Try to calibrate one cell value now, N=3314, Tps=11.3, lamWO2 (Lambda) =0.85



X/Y	1400.00	2000.00	2600.00	3200.00	3800.00	4400.00	5000.00	5600.00	6200.00	6800.00	7400.00	8000.00
0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.9139	35.04	30.12	26.11	20.11	18.94	18.80	17.63	16.76	15.26	14.81	14.81	14.81
6.5262	36.16	32.06	28.31	24.68	22.62	20.86	20.18	18.45	16.97	16.62	16.24	15.87
9.1324	40.31	36.28	32.30	30.28	26.11	25.55	24.05	22.69	20.30	20.30	20.30	19.29
13.0478	45.16	44.74	40.80	34.99	32.60	28.55	28.97	26.86	25.36	24.75	24.75	23.74
16.9632	54.54	50.53	46.24	42.47	38.93	34.29	32.63	30.68	30.73	28.85	26.86	26.18
20.8786	60.73	58.73	54.47	48.87	44.32	40.08	40.57	38.23	38.95	37.73	36.42	34.31
24.7925	65.30	63.35	58.17	54.05	50.46	46.99	44.74	43.59	42.68	42.54	41.81	40.83
32.6172	68.18	66.16	62.74	58.48	56.60	56.30	56.25	54.00	50.11	48.30	48.68	48.42
39.1449	70.73	68.72	64.41	62.60	60.68	58.69	58.69	56.37	56.18	57.89	58.88	58.55
45.6711	72.73	68.72	65.86	65.74	64.88	62.86	63.87	64.69	64.17	64.80	64.50	62.48
52.1927	73.29	70.29	69.87	68.74	68.91	66.91	64.90	65.67	66.19	66.80	68.48	68.74
58.7158	74.74	72.75	70.76	70.76	68.74	67.76	66.75	66.75	68.77	70.73	71.74	72.73
65.2420	76.73	74.74	73.73	72.73	72.73	71.74	70.73	71.74	72.73	74.77	75.73	76.76
78.2898	80.74	78.75	77.74	76.73	76.73	74.74	74.74	73.73	74.72	76.73	78.75	78.75
99.9939	84.75	84.75	84.75	82.76	82.76	82.73	82.73	82.73	82.73	84.75	84.73	85.76

To calculate the fuel injection quantity within the red circular area, for example, at 3314 RPM and 11 TPS, the lambda is 0.85, because it is rich, and needs to reduce the value of this area to get less fuel quantity, you can multiply the value of “LamWO2” to the cell value and hit “ENTER”, to tune the desired lambda to be 1. See below:

Note: the LOAD table can be calibrated “on-the-fly”, meaning, it takes effect immediately.

Alpha-N Table

Input-X: N, [Rpm], "break point, engine speed" Input-Y: TpsEqu, [%], "input<TpsEqu>, break points, throttle position "

Output: MAP_LdTp_Tps_N, [%], "characteristic map, normalized load based on TPS and engine speed (Alpha/N model)"

X/Y	1400.00	2000.00	2600.00	3200.00	3800.00	4400.00	5000.00	5600.00	6200.00	6800.00	7400.00	8000.00
0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.9139	35.04	30.12	26.11	20.11	18.94	18.80	17.63	16.76	15.26	14.81	14.81	14.81
6.5262	36.16	32.06	28.31	24.68	22.62	20.86	20.18	18.45	16.97	16.62	16.24	15.87
9.1324	40.31	36.28	32.30	25.73	22.20	25.55	24.05	22.69	20.30	20.30	20.30	19.29
13.0478	45.16	44.74	40.80	29.74	27.70	28.55	28.97	26.86	25.36	24.75	24.75	23.74
16.9632	54.54	50.53	46.24	42.47	38.93	34.29	32.63	30.68	30.73	28.85	26.86	26.18
20.8786	60.73	58.73	54.47	48.87	44.32	40.08	40.57	38.23	38.95	37.73	36.42	34.31
24.7925	65.30	63.35	58.17	54.05	50.46	46.99	44.74	43.59	42.68	42.54	41.81	40.83
32.6172	68.18	66.16	62.74	58.48	56.60	56.30	56.25	54.00	50.11	48.30	48.68	48.42
39.1449	70.73	68.72	64.41	62.60	60.68	58.69	58.69	56.37	56.18	57.89	58.88	58.55
45.6711	72.73	68.72	65.86	65.74	64.88	62.86	63.87	64.69	64.17	64.80	64.50	62.48
52.1927	73.29	70.29	69.87	68.74	68.91	66.91	64.90	65.67	66.19	66.80	68.48	68.74
58.7158	74.74	72.75	70.76	70.76	68.74	67.76	66.75	66.75	68.77	70.73	71.74	72.73
65.2420	76.73	74.74	73.73	72.73	72.73	71.74	70.73	71.74	72.73	74.77	75.73	76.76
78.2898	80.74	78.75	77.74	76.73	76.73	74.74	74.74	73.73	74.72	76.73	78.75	78.75
99.9939	84.75	84.75	84.75	82.76	82.76	82.73	82.73	82.73	82.73	84.75	84.73	85.76

Alpha-N Table

You can use the same method to calibrate all other cells of the table, when you have finished the calibration, the table must be manually made smooth and burn it to ECU. It is critical to have a smooth transition from one operating point (one cell) 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 3D surf, and manually smoothen out any spikes). Spikes are no good for engine controls.

Note: For 2-stroke engines, the desired lambda is about 0.85-0.95 lambda, so when you tune the mapping, please make sure the desired lambda is about 0.9.

Note: To make it easy on 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 EcoCAL 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.

You can calibrate CUR_TpsUnTp_N to choose when to use Alpha/N model.

If you want us to help you to tune the EFI, Please log data at different conditions, and have comparatively steady state driving at different throttle positions.

For two-stroke engines, the default fuel mapping is Alpha/N method, "RAM_MAP_LdTp_Tps_N", so if you want to calibrate the fuel quantity for a 2-stroke engine, you just modify the LOAD table only. The procedure is same as the four-stroke system.

Some notes before tuning the fuel mapping tables:

- 1) The engine has finished warm-up, this means it doesn't have other enrichment factor. You can see the value of "fPreCtl", when the fPreCtl is 1, you can go to tune the tables.
- 2) The fuel pressure must be enough and stable, the fuel pressure is about 3Bar (43psi).
- 3) When you tune the value of the fuel tables, you need read the lambda (LamWO2) in the stable condition; stable throttle position and RPM, not use the lambda in accelerate and decelerate to tune the tables.

Chapter 6 The Ignition System Calibration

If the ECU to control ignition system, you need to do some advanced calibration on the ignition system to get a good performance. Please skip the chapter if you use the stock ignition system.

6.1 The CKP calibration from single pickup signal

If you are using our ECU and CDI to control the ignition timing (spark advance), based on a single pickup (sensor), you must identify the offset angle between the pickup pulse and the engine TDC.

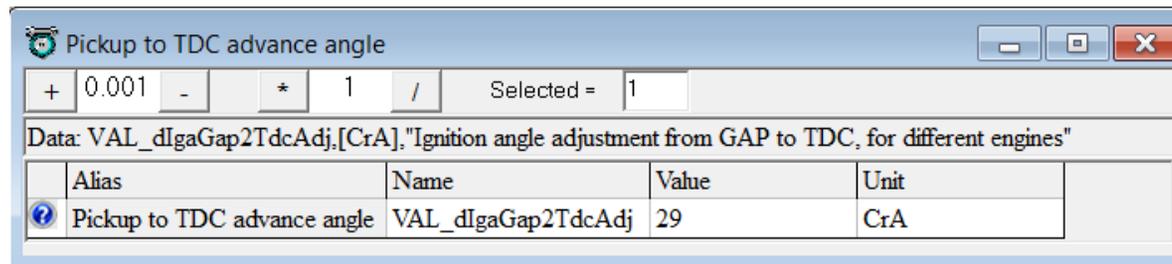
ECU controls the CDI to fire the ignition at the right timing only, so you need to get this offset angle.

If you don't know this offset, or if you have trouble to figure out this offset angle, you better keep the stock ignition system and use the EFI to control fuel only. Therefore, you can start the engine without worrying about the ignition system.

VAL_dIgaGap2TdcAdj: "Ignition angle adjustment from GAP to TDC, GAP is pickup pulse location."

Please set the offset angle in EcoCAL:

Menu → Variables → Calibration Selection →



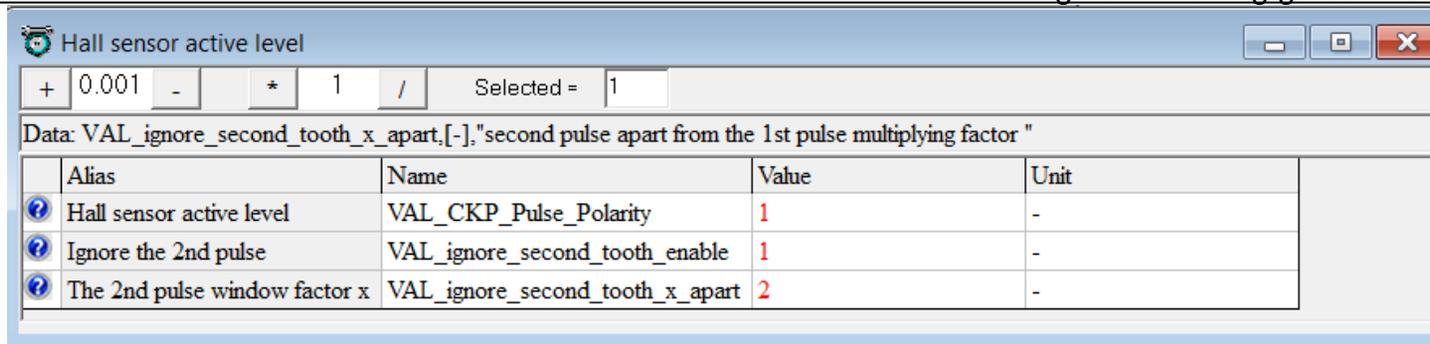
Note:

- 1) This is the first calibration you need to be sure. It determines the engine TDC position in regarding to the pulse generation.
- 2) The default is 29 CrA. That means 29 degrees in advance to the TDC. It is a positive value 29 degree of crankshaft angle (CrA).
- 3) VAL_dIgaGap2TdcAdj needs to be set in old software. The negative is corresponding for advance angle, the positive is corresponding for lag angle value. You can find out whether it should be a negative value with your A2L file, such as: "S33_H1_L48_Cr17_AT3.4_E4.a2l" if the number less than or equal to "Cr17", for example, "Cr17or Cr15...."

Parameters Settings for Special EFI system with Hall Effect sensor:

- 1) Some parameters need to be set to match the signal of Hall Effect sensor for EFI system with hall effect sensor (We have preset these calibration values for EFI system with hall effect sensor acquiescently)

VAL_CKP_Pulse_Polarity:	Hall sensor active level
VAL_ignore_second_tooth_enable:	Enable the function of ignoring the noise signal
VAL_ignore_second_tooth_x_apart:	The multiplying factor of pulse width for the noise pulse signal which is ignored to the correct pulse signal



2) We have optimized the signal of Hall Effect sensor in UAV EFI system, so you only need to set the below parameters to match the signal of Hall Effect sensor (We have preset this calibration values in UAV EFI system with Hall Effect sensor acquiescently)

VAL_CKP_Pulse_Polarity: Hall sensor active level

VAL_ignore_second_tooth_enable: Enable the function of ignoring the noise signal

VAL_ignore_second_tooth_x_apart : The multiplying factor of pulse width for the noise pulse signal which is ignored to the correct pulse signal

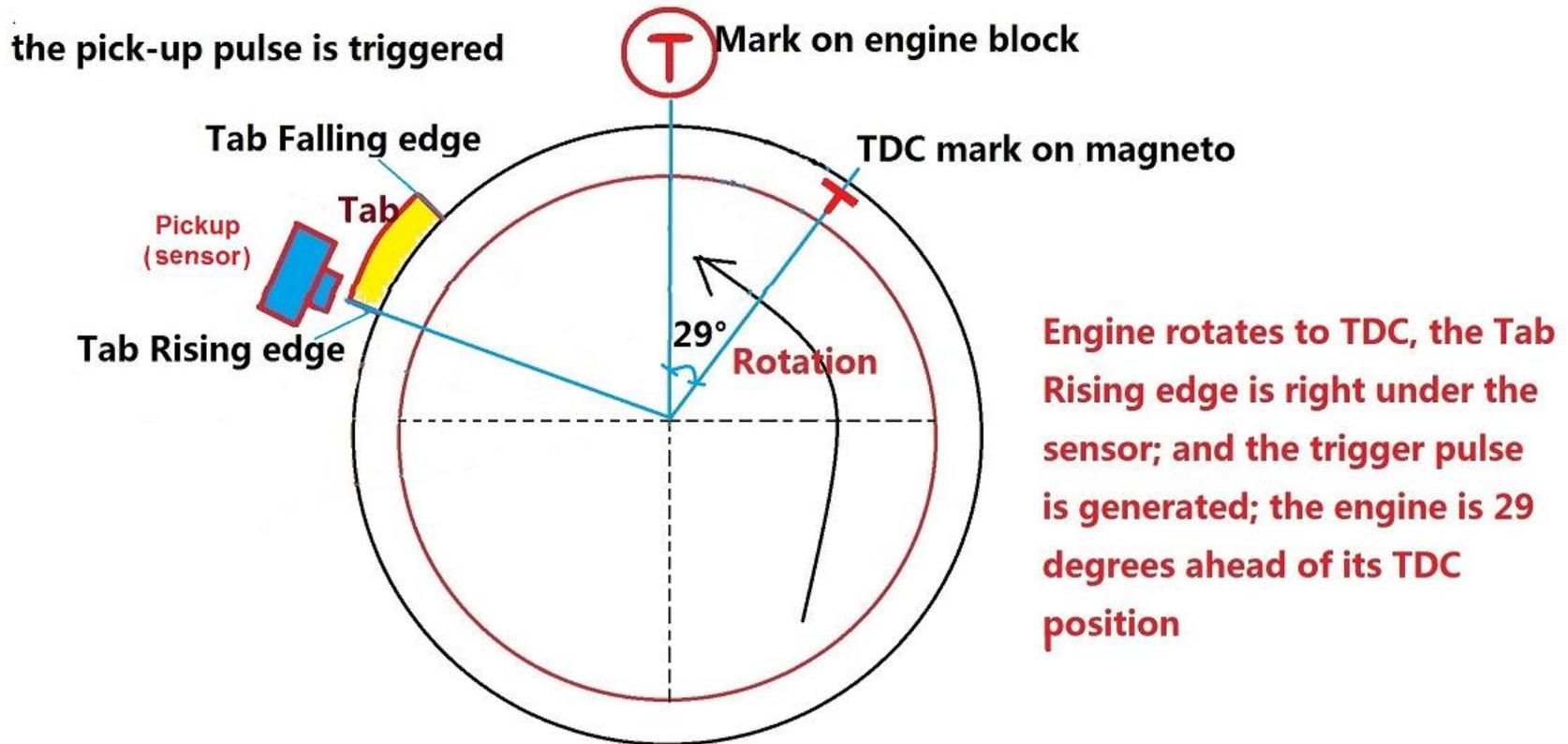
Hall sensor active level

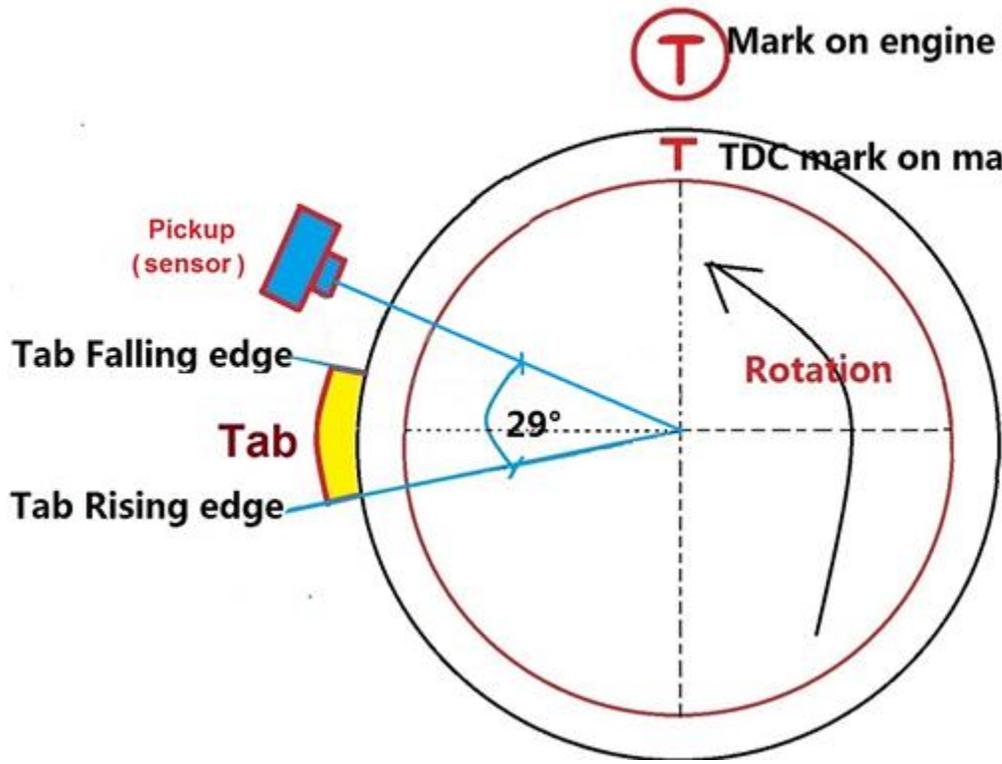
+ 0.001 - * 1 / Selected = | |

Data: VAL_ignore_second_tooth_x_apart,[-],"second pulse apart from the 1st pulse multiplying factor "

Alias	Name	Value	Unit
Hall sensor active level	VAL_CKP_Pulse_Polarity	0	-
Ignore the 2nd pulse	VAL_ignore_second_tooth_enable	1	-
The 2nd pulse window factor x	VAL_ignore_second_tooth_x_apart	1	-

How to find the offset angle:





Engine is at the TDC, the Tab Rising edge passed the sensor for 29 degrees.

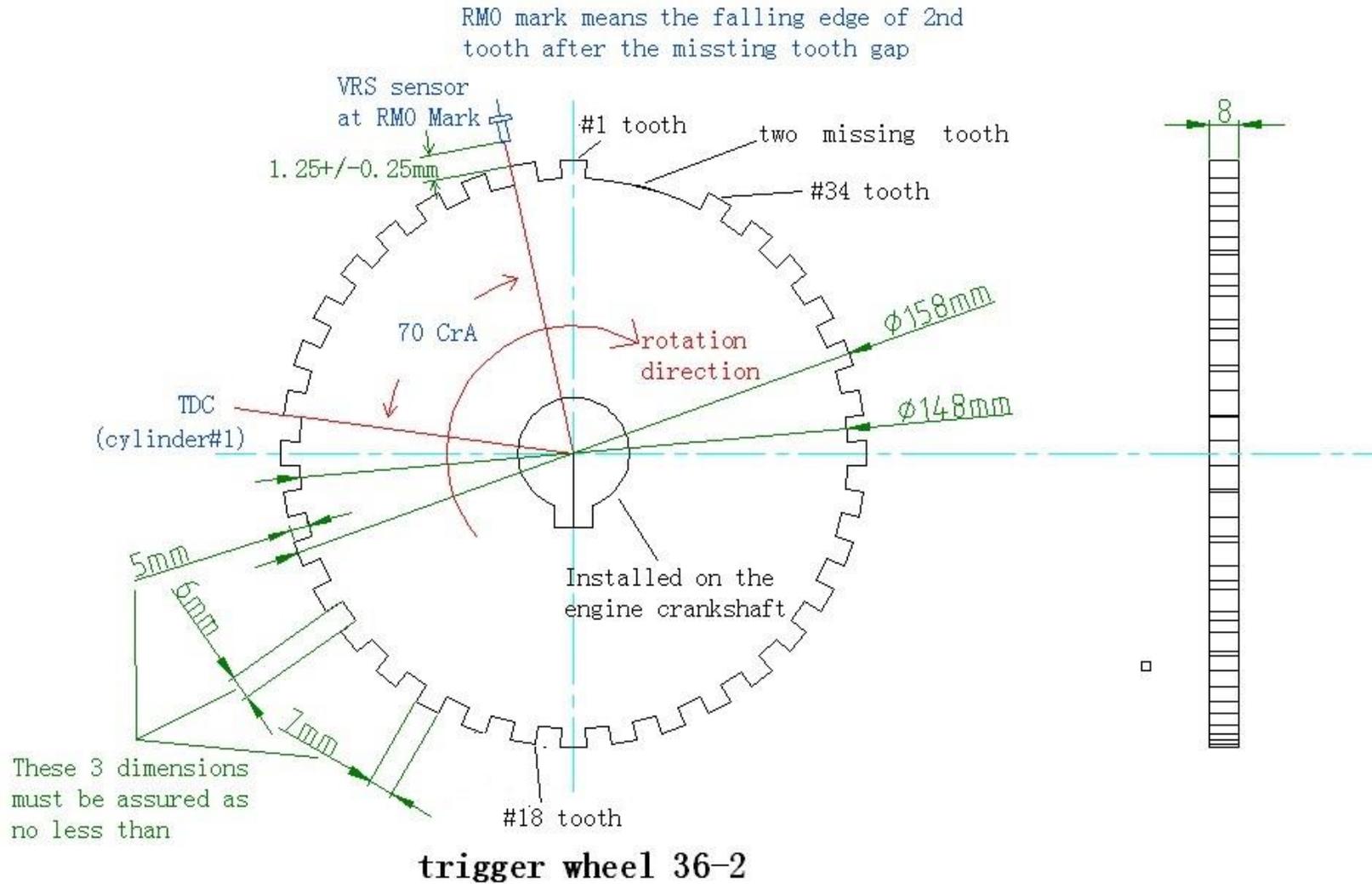
**Note:
VAL_dIgaGap2TdcAdj= 29**

6.2 The CKP calibration from multi-tooth trigger-wheel signal

The EFI works with a wide range of multi-tooth trigger wheels. The typical trigger wheels have 36-2 tooth-wheel, or 12-1, 24-1, 36-1 or 60-2 tooth wheels. For example, “36-2” tooth wheel means there are totally 36 teeth with 2 missing teeth. 12-1 means totally 12 teeth with 1 missing tooth, and so on. The ECU supports different combinations of total teeth and missing tooth setting. **The total number of teeth less than or equal to 60, the missing tooth can only be 1 or 2.**

The high speed engines install few teeth flywheel normally. The reason is that the tooth signal becomes smaller and smaller at higher speed, and eventually, the ECU cannot read it anymore. For most 2 stroke engines, 12-1 tooth wheel, or 24-1 tooth wheel is typical because 2 stroke engines are higher speed ones usually. For most 4 stroke engines, the tooth wheel is 36-2 usually.

Below is an illustration of the 36-2 trigger wheel and the engine positions. The first tooth after missing teeth is marked as the #1 tooth.



The following calibrations need to be defined:

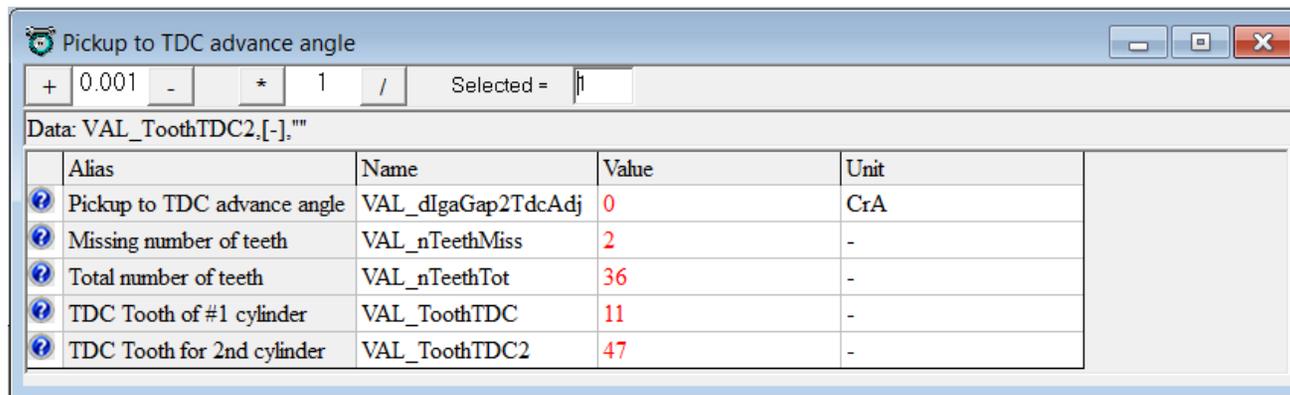
VAL_dIgaGap2TdcAdj: Ignition adjustment angle between VRS sensor and the falling edge of TDC tooth when the engine is at the TDC position.

VAL_nTeethTot: Total number of teeth on the tooth-wheel, including the missing tooth

VAL_nTeethMiss: Number of missing tooth on the tooth-wheel

VAL_ToothTDC: tooth number of TDC position

VAL_ToothTDC2: The tooth # of 2nd cylinder TDC for twin cylinder engines



The screenshot shows a software window titled "Pickup to TDC advance angle". At the top, there is a calculator-style interface with a display showing "0.001" and a "Selected =" field. Below this is a table with the following data:

Alias	Name	Value	Unit
Pickup to TDC advance angle	VAL_dIgaGap2TdcAdj	0	CrA
Missing number of teeth	VAL_nTeethMiss	2	-
Total number of teeth	VAL_nTeethTot	36	-
TDC Tooth of #1 cylinder	VAL_ToothTDC	11	-
TDC Tooth for 2nd cylinder	VAL_ToothTDC2	47	-

Note:

- 1) We suggest that the TDC from #1 cylinder should be mounted about 100-120 degrees after the missing tooth.
- 2) The "VAL_ToothTDC2" need to be set only for twin cylinders engine.

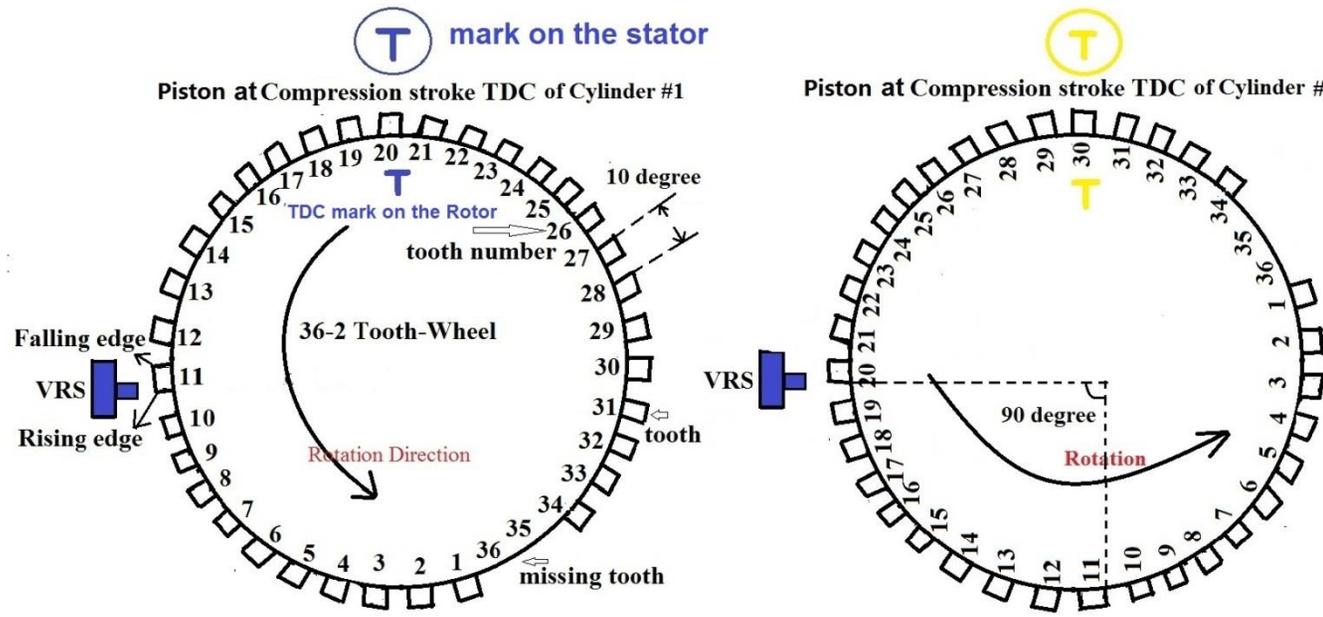
- 3) The “VAL_dIgaGap2TdcAdj” is set 0 acquiescently. The angle needs to be set again only when VRS sensor does not align well with the falling edge of the tooth. For example, VRS sensor does align well with the rising edge of the tooth, or interval of tooth. And the angle is smaller than crankshaft angle of a tooth.
- 4) VAL_dIgaGap2TdcAdj needs to be set in old software. The negative is corresponding for advance angle, the positive is corresponding for lag angle value. You can find out whether it should be a negative value with your A2L file, such as:”S33_H1_L48_Cr17_AT3.4_E4.a2l” if the number less than or equal to “Cr17”, for example, “Cr17or Cr15...”

The calibration for 4 stroke twin cylinders engine

Calculate the TDC tooth of #2 cylinder:

With a V-twin engine as an example, the two cylinders are separated by 90 degrees.

For 36-2 tooth-wheel, V-twin cylinders engine, the TDC tooth of #1 cylinder is 11, and the two cylinders are 90 degree apart, so the TDC of #2 cylinder is 450 (360+90) degrees after the # 1 cylinder. So the TDC tooth of #2 cylinder is 56(450/10+11). VAL_ToothTDC=11, VAL_ToothTDC2=56.



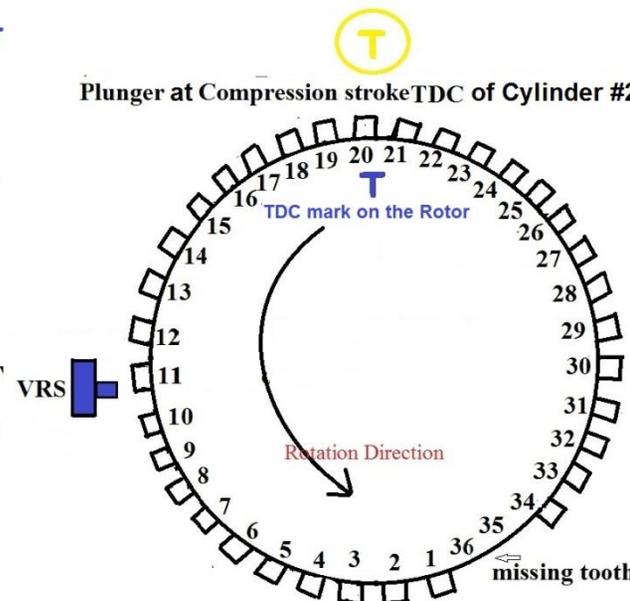
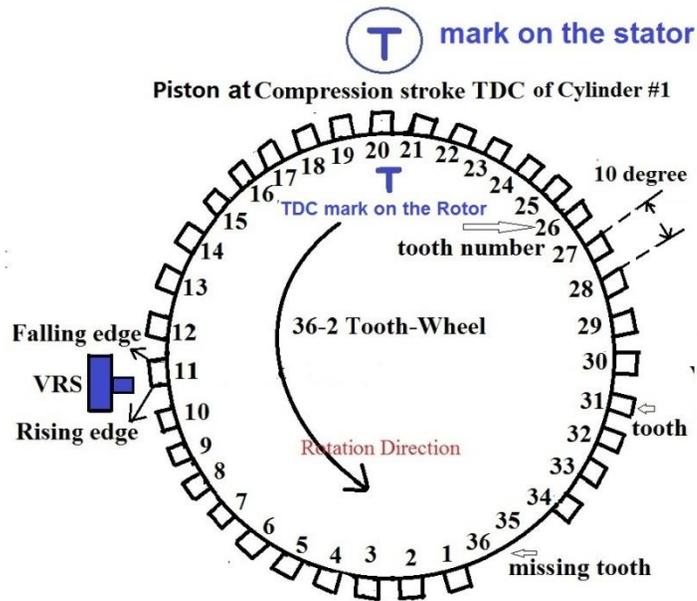
V-twin, two-cylinder engine, the two cylinders' ignition timing is 450 degrees separated

VAL_nTeethTot=36
VAL_nTeethMiss=2

#11 tooth is the Cyl-1 TDC
#56 tooth is the Cyl-2 TDC

VAL_ToothTDC=11
VAL_ToothTDC2=56

If the two cylinders are separate from 360 degrees, like a boxer twin engine, so the ignition TDC tooth of #2 cylinder is 47 if the ignition TDC tooth of #1 cylinder is 11. VAL_ToothTDC=11, VAL_ToothTDC2=47.



Parallel or boxer, two-cylinder engine, the two cylinders' ignition timing is 360 degrees separated

VAL_nTeethTot=36
VAL_nTeethMiss=2

#11 tooth is the Cyl-1 TDC
#47 tooth is the Cyl-2 TDC

VAL_ToothTDC=11
VAL_ToothTDC2=47

Note:

- 1) The value of the tooth number for 4 stroke engines is from 1 to 72, because 2 revolutions are one full engine cycle. The tooth number will increment by 1 into the next revolution, until 72. After number 72, the tooth number reset to 1.
- 2) The method to calibrate 12-1, 24-1, 60-2, and etc. tooth wheels is same as to the 36-2 tooth-wheel.

The calibration for 2 stroke twin cylinders engine

Calculate the ignition TDC tooth of #2 cylinder:

For 36-2 tooth-wheel, a two-cylinder engine, the ignition TDC tooth of #1 cylinder is 11, if the two cylinders are 180 degree apart, So the ignition TDC tooth of #2 cylinder is 29 ($180/10+11$), VAL_ToothTDC=11, VAL_ToothTDC2=29. The TDC is same if the two cylinders are 0 degree apart.

Note:

- 1) The value of the tooth number is from 1 to 36 for 2 stroke engines, because 1 revolution is one full engine cycle. The tooth number will be reset to 1 in the next cycle.
- 2) The method to calibrate 12-1, 24-1, 60-2, and etc. tooth wheels is same as to the 36-2 tooth-wheel.

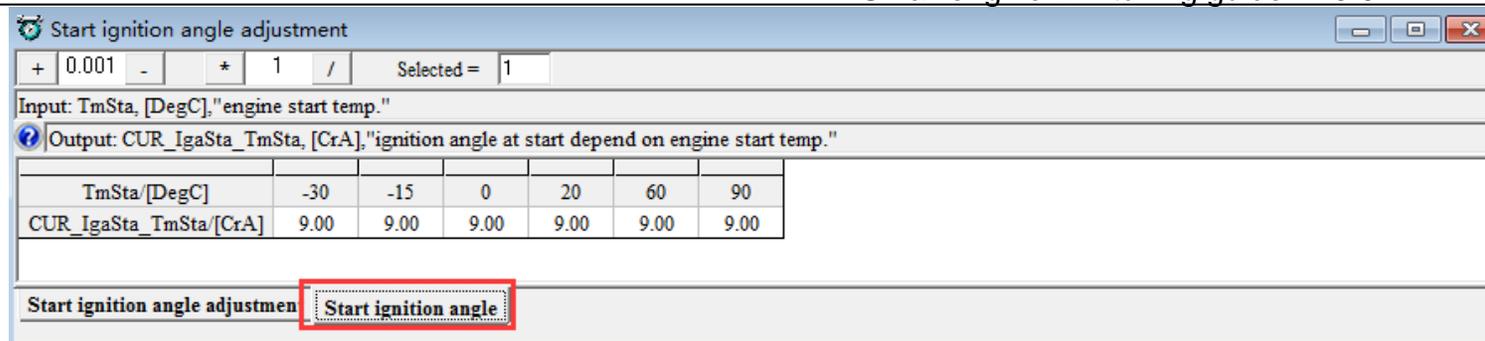
6.3 Calibration for ignition timing

Start ignition angle

If you use Ecotrons' CDI to control ignition, the default start ignition angle may be not suitable, if it has start ignition issue, you can try to modify the start ignition angle table Ignition; it is based on the engine temperature at start.

Please add this advanced calibration variable in EcoCAL:

Menu → Variables → Calibration Selection →



Angle in start: CUR_IgaSta_TmSta

When engine go to start, the ignition angle is the value of CUR_IgaSta_TmSta

Basic Ignition Angle mapping

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 cannot run 100% optimized spark advance unless you have a good knock control systems (with 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.

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

Please add this advanced calibration variable in EcoCAL:

Base ignition angle

+ 0.001 - * 1 / Selected = 1

Input-X: Ld_b, [%], "load" Input-Y: N_b, [Rpm], "engine speed"

Output: MAP_Iga_N_Ld, [CrA], "characteristic map, basic ignition angle, dependent on engine speed and load"

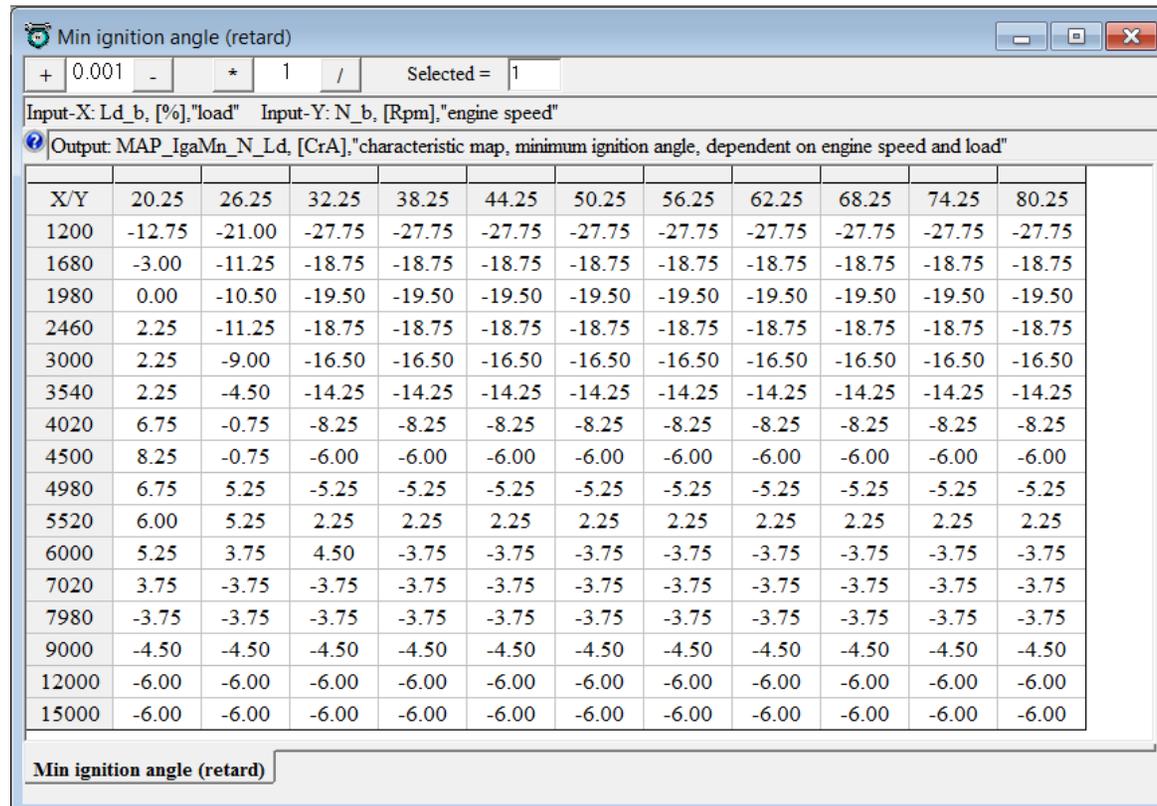
X/Y	20.25	26.25	32.25	38.25	44.25	50.25	56.25	62.25	68.25	74.25	80.25
1200	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75	9.75
1680	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
1980	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
2460	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00
3000	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25	20.25
3540	21.75	21.75	21.75	21.75	21.75	21.75	21.75	21.75	21.75	21.75	21.75
4020	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00
4500	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25
4980	27.75	27.75	27.75	27.75	27.75	27.75	27.75	27.75	27.75	27.75	27.75
5520	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
6000	32.25	32.25	32.25	32.25	32.25	32.25	32.25	32.25	32.25	32.25	32.25
7020	33.75	33.75	33.75	33.75	33.75	33.75	33.75	33.75	33.75	33.75	33.75
7980	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00
9000	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00
12000	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00
15000	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00	36.00

Base ignition angle

Note: The default ignition table is very close to the best ignition angle, so if you want to change it, please adjust it in a small step and range, such as 1 degree or 3 degrees (For example, if the default value is 36, you can change it to 38). It protects the engine from too aggressive ignition angle, which can damage the engine.

Minimum Ignition Angle

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



Min ignition angle (retard)

+ 0.001 - * 1 / Selected = 1

Input-X: Ld_b, [%], "load" Input-Y: N_b, [Rpm], "engine speed"

Output: MAP_IgaMn_N_Ld, [CrA], "characteristic map, minimum ignition angle, dependent on engine speed and load"

X/Y	20.25	26.25	32.25	38.25	44.25	50.25	56.25	62.25	68.25	74.25	80.25
1200	-12.75	-21.00	-27.75	-27.75	-27.75	-27.75	-27.75	-27.75	-27.75	-27.75	-27.75
1680	-3.00	-11.25	-18.75	-18.75	-18.75	-18.75	-18.75	-18.75	-18.75	-18.75	-18.75
1980	0.00	-10.50	-19.50	-19.50	-19.50	-19.50	-19.50	-19.50	-19.50	-19.50	-19.50
2460	2.25	-11.25	-18.75	-18.75	-18.75	-18.75	-18.75	-18.75	-18.75	-18.75	-18.75
3000	2.25	-9.00	-16.50	-16.50	-16.50	-16.50	-16.50	-16.50	-16.50	-16.50	-16.50
3540	2.25	-4.50	-14.25	-14.25	-14.25	-14.25	-14.25	-14.25	-14.25	-14.25	-14.25
4020	6.75	-0.75	-8.25	-8.25	-8.25	-8.25	-8.25	-8.25	-8.25	-8.25	-8.25
4500	8.25	-0.75	-6.00	-6.00	-6.00	-6.00	-6.00	-6.00	-6.00	-6.00	-6.00
4980	6.75	5.25	-5.25	-5.25	-5.25	-5.25	-5.25	-5.25	-5.25	-5.25	-5.25
5520	6.00	5.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
6000	5.25	3.75	4.50	-3.75	-3.75	-3.75	-3.75	-3.75	-3.75	-3.75	-3.75
7020	3.75	-3.75	-3.75	-3.75	-3.75	-3.75	-3.75	-3.75	-3.75	-3.75	-3.75
7980	-3.75	-3.75	-3.75	-3.75	-3.75	-3.75	-3.75	-3.75	-3.75	-3.75	-3.75
9000	-4.50	-4.50	-4.50	-4.50	-4.50	-4.50	-4.50	-4.50	-4.50	-4.50	-4.50
12000	-6.00	-6.00	-6.00	-6.00	-6.00	-6.00	-6.00	-6.00	-6.00	-6.00	-6.00
15000	-6.00	-6.00	-6.00	-6.00	-6.00	-6.00	-6.00	-6.00	-6.00	-6.00	-6.00

Min ignition angle (retard)

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.

Chapter 7 Advanced Tuning

7.1 Transient fuel

To improve the performance of the throttle response, you need to change the transient fuel.

When you open the throttle, if you feel the bike bogs or pops or doesn't have much power, it may be too rich or too lean, you can read the AFR/lambda by using the ALM wideband sensor. Then do some advance tuning according to the below instructions. Add two calibration variables by using the advanced calibration menu, "CUR_Wf_Ldp" and "VAL_fTrsRedS"

"CUR_Wf_Ldp": the wall film fuel quantity during the transient, depend on the predicted LOAD.

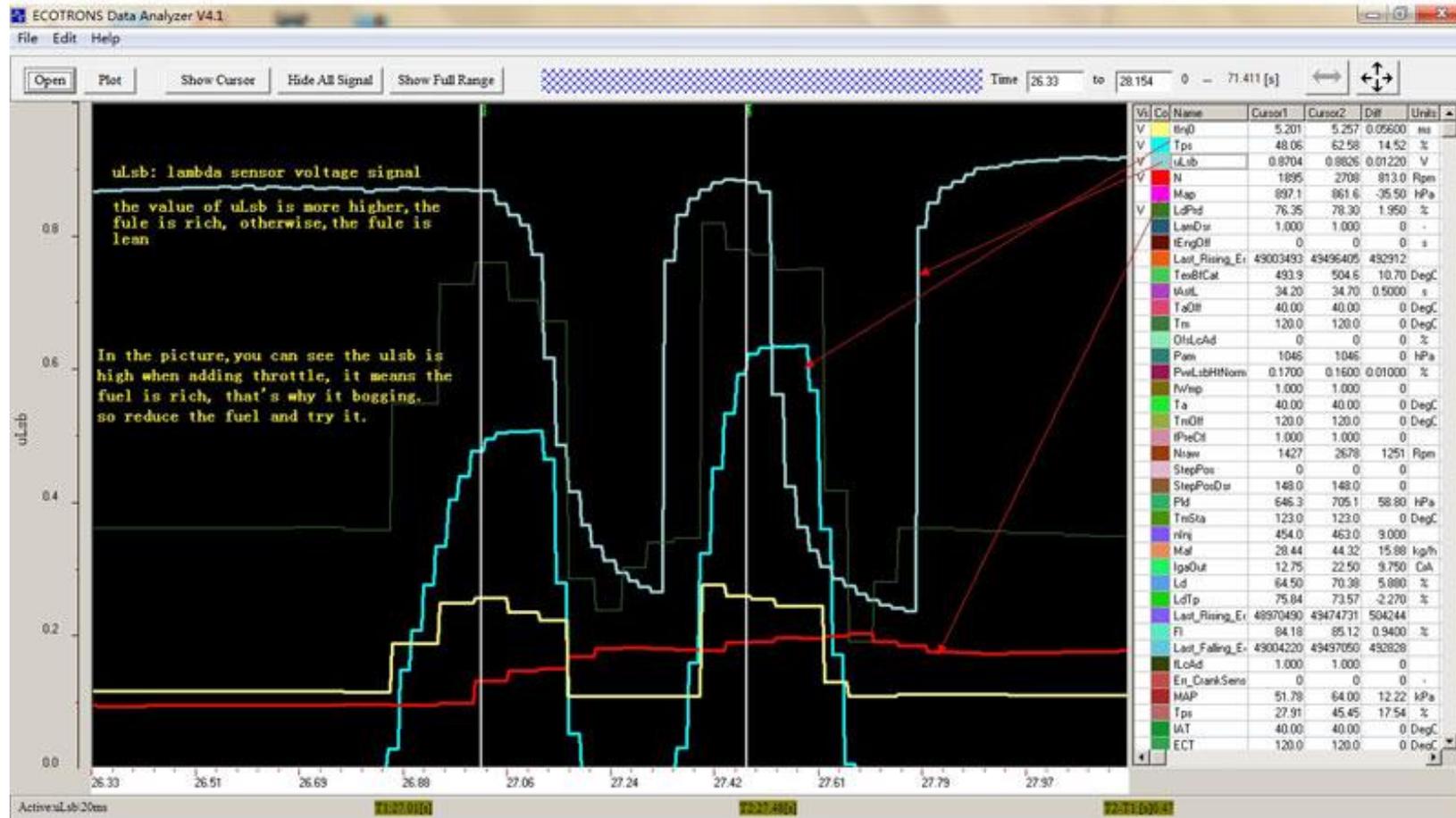
"VAL_fTrsRedS": reduction factor of the short-term transient fuel

Our transient fuel tuning, is based on the Wall film model. Wall film fuel is the fuel stuck on the intake manifold wall or combustion chamber corner, clearance, which is not participating in the combustion. Then you open the throttle or close the throttle, the wall film fuel will increase or decrease, and therefore change your desired AFR.

The transient fuel tuning is to model this wall film at different Load conditions, and then compensate the fuel that is caused by the wall film fuel changing.

The wall film fuel is modeled based on the "**Predicted LOAD**". Predicted load is the engine load of the next combustion cycle. You must use predicted load, not the current load, for the next cycle's fuel calculation. This is a whole advanced engine control theory, if you are interested.

Below are a couple of examples of transient fuel tuning.





You can calibrate the "CUR_Wf_Ldp" value based on the LdPrd, you can read the value of LdPrd in EcoCAL.

Calibrate the "CUR_Wf_Ldp" value in EcoCAL: Go to "Menu → Variables → Calibration Selection" to add the "CUR_Wf_Ldp".

Wall film fuel depending on the predicted load

+ 0.001 - * 1 / Selected = 1

Input: LdPrd, [%], "break points, fuel wall film, dependent on Load predicted"

Output: CUR_Wf_Ldp, [%], "characteristic curve: fuel wall film, dependent on Load predicted"

LdPrd [%]	0.00	6.00	12.00	18.00	24.00	30.00	36.00	42.00	48.00	54.00	60.00	66.00	72.00	78.00	84.00	90.00	96.00
CUR_Wf_Ldp [%]	0.00	1.50	4.69	12.00	41.06	65.06	90.00	117.00	150.00	171.00	189.94	207.00	222.94	231.94	245.06	257.06	261.94

Wall film fuel depending on the predicted load

Read the value of LdPrd in EcoCAL:

Go to "Menu → Variables → Measurements Selection→" to add the " LdPrd".

Selected Variables

Alias	Name	Value	Unit	Rate
Predicted Load	LdPrd	41.25	%	Syn

You can change the wall film quantity according to LdPrd before increasing the throttle and after increasing the throttle. The delta of the wall film quantity at different LdPrd is the base transient fuel. If you see lean conditions at the throttle opening, that means you need to add more wall film at high Load conditions (big LdPrd).

You can also try to adjust the value of "VAL_fTrsRedS" to get different effects of the throttle opening conditions.

"CUR_fwLdpMapTps_N" is a weight factor for PN model and Alpha/N model in transient conditions.

Raise the value of CUR_fwLdpMapTps_N will make TPS-based prediction more weighting, when you increase throttle in acceleration condition.

When you begin to calibrate the transient fuel, the basic injection table must be stable, the engine must run normally. And to calibrate it, you need to repeat the test to get a better performance.

Advanced tuning for throttle blips

If the response of throttle blip is not in favor, and you have the right software version from us for this issue, you can calibrate it by yourself, and find a suitable value to improve the response (usually for the big displacement engine).

Injection compensation variables for throttle blips:

VAL_dtlnjTpBlip_Max --- max delta injection pulse width in ms when throttle blip happens.

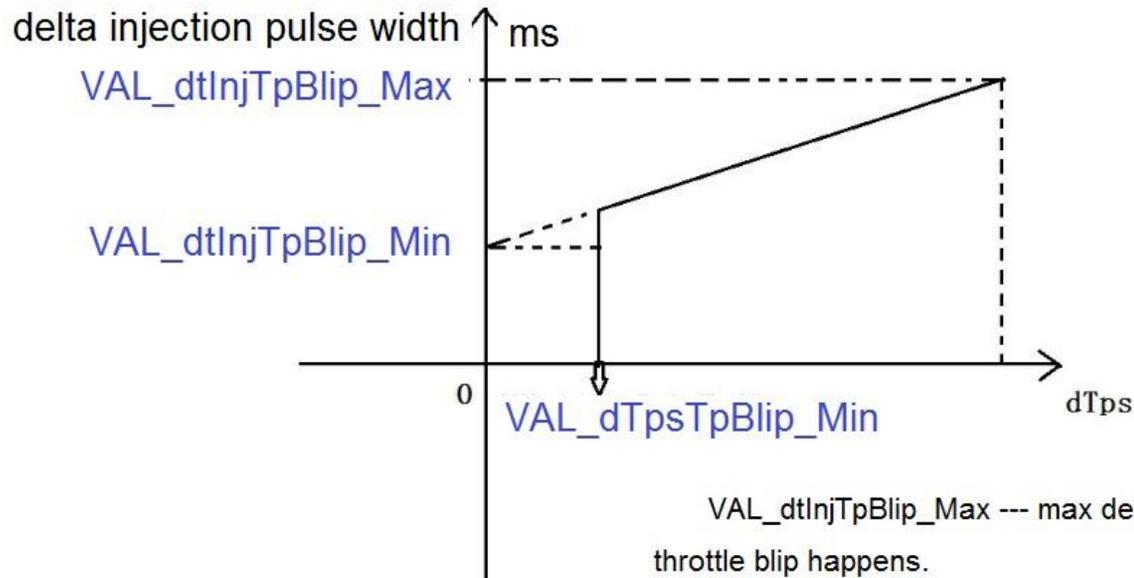
VAL_dtlnjTpBlip_Min --- min delta injection pulse width in ms when throttle blip happens.

VAL_dTpsTpBlip_Min --- min delta Tps change in 20ms to recognize the throttle blip.

(If the Tps change is bigger than VAL_dTpsTpBlip_Min, it will enable the function to add fuel.)

VAL_NTpBlip_Max --- max RPM limited when throttle blip

(If the RPM is higher than VAL_NTpBlip_Max when the throttle blips, there is no additional fuel)



VAL_dtInjTpBlip_Max --- max delta injection pulse width in ms when throttle blip happens.

VAL_dtInjTpBlip_Min --- min delta injection pulse width in ms when throttle blip happens.

VAL_dTpsTpBlip_Min --- min delta Tps change in 20ms to recognize the throttle blip.

Example:

VAL_dTpsTpBlip_Min =10 (%)

VAL_dtInjTpBlip_Min =4 (ms)

VAL_dtInjTpBlip_Max =8 (ms)

If the TPS is changed less than 10%, the fuel injector will not inject extra fuel.

If the TPS is changed 10% in 20ms, the fuel injector will inject 4ms width extra fuel at the 20ms time.

And if the TPS is changed 20% in 20ms, the fuel injector will inject $4 + 4 * (20\% - 10\%) / (100\% - 10\%) = 4.45$ (ms) extra fuel.

If the TPS is changed 100% in 20ms, the fuel injector will inject 8mm width extra fuel at the 20ms time

Now, is it clear?

So different TPS changed, the ECU will inject the different fuel.

Dashpot functions for deceleration:

And if you have the software for deceleration to avoid a stall issue with the stepper motor control system, you also can calibrate the below variables.

VAL_McDashpot_DeltaDecrements: the step size of IAC ramp-down, range: 12-24; the bigger the value, the faster the ramp, but more likely to stall.

VAL_McDashpotInitValue: initial position of the IAC motor for dashpot, range 640-320;

Note: You can find the variables in EcoCAL if you have the correct A2L file, go to menu->Variables-> Calibrations

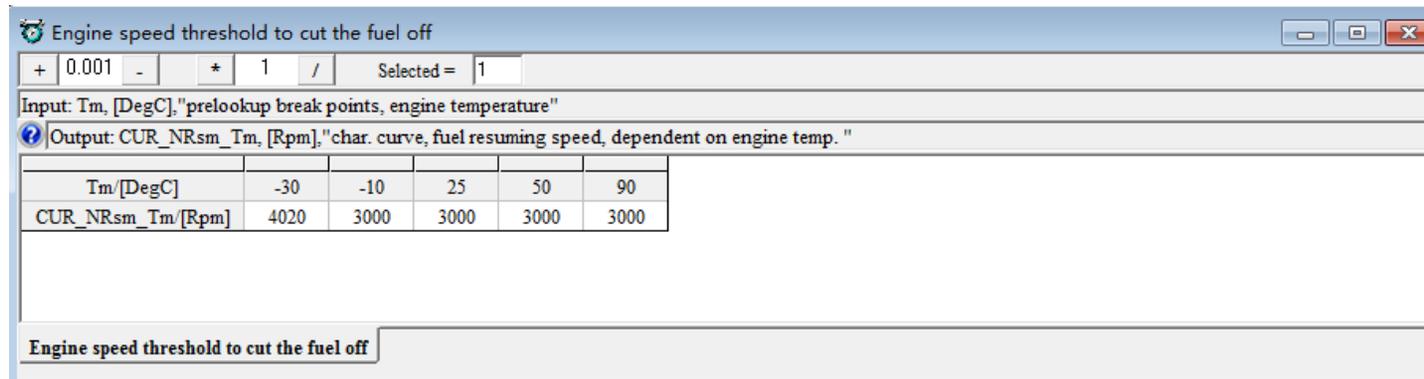
Selection. You need to repeat the attempts to tune it.

7.2 Decel-Fuel-Cut-Off

Our EFI system by default has enabled the decel-fuel-cut-off function. It is RPM dependent, when you release the throttle to idle and RPM is higher than the table value, it will cut the fuel injection.

And you can adjust the table value to decide at what RPM to resume fuel.

Menu->Variables-> Calibration Selection



Engine speed threshold to cut the fuel off

+ 0.001 - * 1 / Selected = 1

Input: Tm, [DegC], "prelookup break points, engine temperature"

Output: CUR_NRsm_Tm, [Rpm], "char. curve, fuel resuming speed, dependent on engine temp. "

Tm [DegC]	-30	-10	25	50	90
CUR_NRsm_Tm [Rpm]	4020	3000	3000	3000	3000

Engine speed threshold to cut the fuel off

Note: So if you want to disable decal-fuel-cut-off, you can adjust the table value to a bigger one.

But don't disable the decal-fuel-cut-off, if you are running in a mountain area, and it may damage the engine in downhill driving because a lot of un-burnt fuel getting into the exhaust system.

7.3 Driver's desired lambda

- 1) Driver desired lambda is only feasible 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.

- 2) 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.
- 3) Default value of desired lambda is as below table. It is enriched at high end. 1 means stoic AFR (14.7 for gasoline).
- 4) Desired lambda table can be activated by turning on the "RICH" mode, by switching the "Performance switch" to ON position. By default, the engine is running in "ECO" mode; and the desired lambda table is not used.

Some more comments on RICH mode: Rich mode only works well after ECO mode is tuned.

RICH mode is actually an open loop mode, meaning, ECU will command the "desired Lambda" based on the ECO mode tuning. It assumes you have tuned the base mapping like VE table and TPS Load table close to Stoic AFR at all conditions. It then divides the desired lambda on the top of the base fuel quantity.

In RICH mode, you only tune the "desired lambda table", which should between 0.8 to 1.2 ranges. This is nothing but a dividing factor on top of the base fuel mapping.

For example, you base fuel mapping outputs a fuel quantity of 3ms pulse width, and your desired lambda is 0.9; then your final fuel pulse output is $3 / 0.9 = 3.33\text{ms}$.

Menu->Variables-> Calibration Selection

Driver desired lambda

+ 0.001 - * 1 / Selected = 1

Input-X: N, [Rpm],"break point, engine speed" Input-Y: TpsEqu, [%],"input<TpsEqu>, break points, throttle position "

Output: MAP_LamDrv_Tps_N, [-],"characteristic map, Driver desired lambda, dependent on TPS and N"

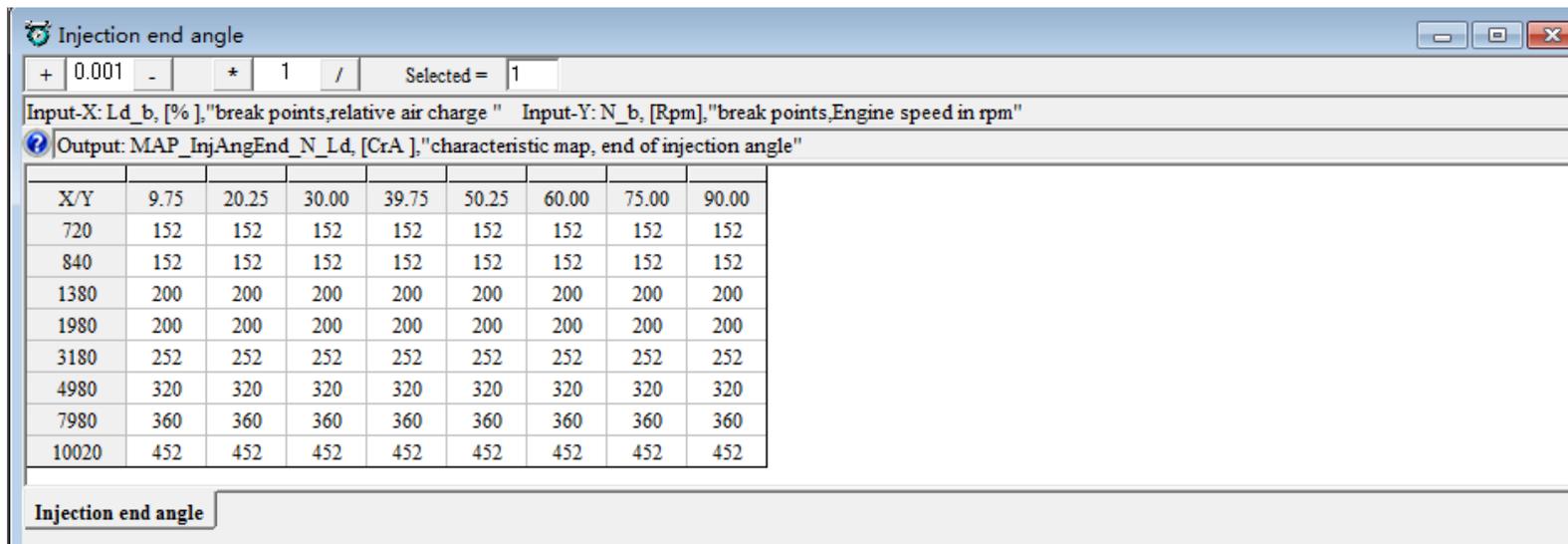
X/Y	1400.00	2000.00	2600.00	3200.00	3800.00	4400.00	5000.00	5600.00	6200.00	6800.00	7400.00	8000.00
0.0000	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3.9139	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99	0.99
6.5262	1.00	1.00	0.99	0.99	0.99	0.99	0.99	0.99	0.95	0.95	0.95	0.95
9.1324	1.00	0.99	0.95	0.95	0.95	0.95	0.95	0.95	0.92	0.92	0.92	0.92
13.0478	0.99	0.99	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.88	0.88	0.88
16.9632	0.99	0.99	0.92	0.88	0.88	0.88	0.88	0.88	0.88	0.85	0.85	0.85
20.8786	0.88	0.95	0.89	0.88	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
24.7925	0.88	0.95	0.89	0.88	0.85	0.85	0.85	0.85	0.85	0.84	0.84	0.84
32.6172	0.88	0.88	0.88	0.87	0.85	0.84	0.84	0.84	0.84	0.84	0.84	0.84
39.1449	0.88	0.88	0.88	0.87	0.85	0.84	0.84	0.84	0.84	0.84	0.84	0.84
45.6711	0.88	0.88	0.88	0.86	0.85	0.84	0.84	0.84	0.84	0.83	0.83	0.83
52.1927	0.88	0.88	0.88	0.86	0.85	0.83	0.83	0.83	0.83	0.83	0.83	0.83
58.7158	0.88	0.88	0.88	0.86	0.85	0.83	0.83	0.83	0.83	0.83	0.83	0.83
65.2420	0.88	0.88	0.88	0.86	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
78.2898	0.88	0.88	0.88	0.86	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83
99.9939	0.88	0.88	0.88	0.86	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.83

Driver desired lambda

7.4 Advanced Calibration for injection timing

VAL_InjAngEndSta--- the end angle of injection when engine starts.

MAP_InjAngEnd_N_Ld--- the end angle of injection referring to TDC; it means the angle from injection end to the ignition TDC position.



X/Y	9.75	20.25	30.00	39.75	50.25	60.00	75.00	90.00
720	152	152	152	152	152	152	152	152
840	152	152	152	152	152	152	152	152
1380	200	200	200	200	200	200	200	200
1980	200	200	200	200	200	200	200	200
3180	252	252	252	252	252	252	252	252
4980	320	320	320	320	320	320	320	320
7980	360	360	360	360	360	360	360	360
10020	452	452	452	452	452	452	452	452

Both of them can be calibrated in the engine dyno or chassis dyno.

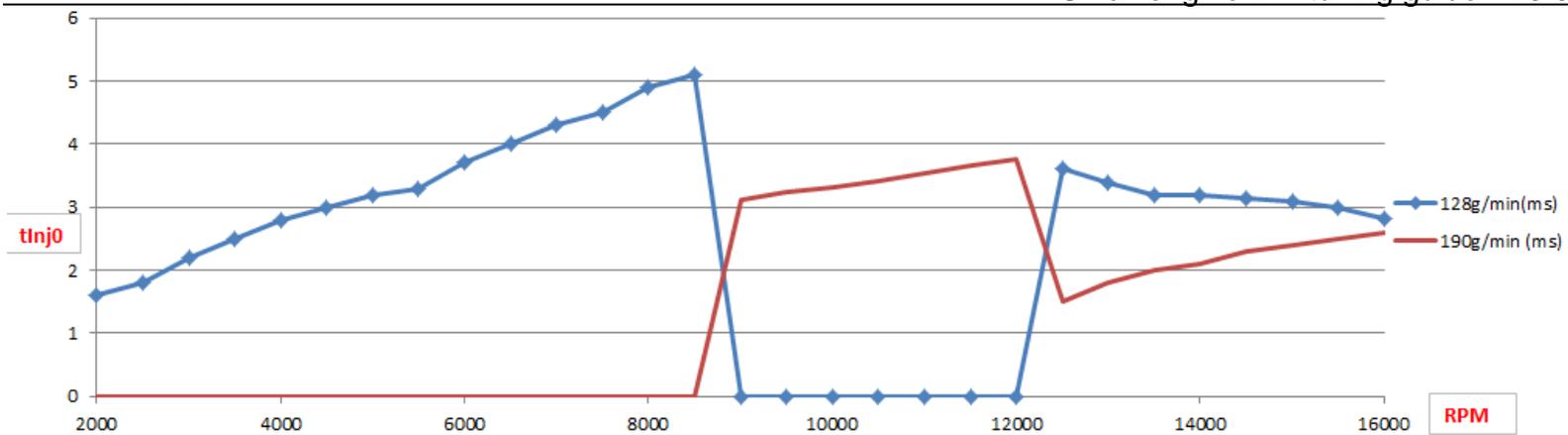
7.5 Dual injectors advanced tuning

Why 2 injectors it need for 2-strokes and high RPM engine?

The whole idea of 2 injectors (one small, one big) is based on the need: 2-stroke engines have only half the time to inject fuel compared to 4-stroke (360 vs 720 degrees), and the 2-strokes usually (esp. high-end engines) have such a wide range of RPM (2000 - 16000rpm, for example). One injector is not able to cover the whole RPM range, simply because every injector has its physical limit: the fixed flow rate. If you use a big injector to cover the high end, then you will have too-rich idle. If you use a small injector, to have a good idle, then you don't have enough fuel for WOT. Given a certain inject flow rate, you can only run an engine either at low RPM range or high RPM range, but not both (from 2000 to 16000rpm).

So, for 2-stroke engines with 10k-16k RPM, usually, we provide EFI system with dual fuel injectors, one smaller and one larger, the smaller injector is used start, idle, low RPM, and the larger one is used high RPM, and in WOT condition, the 2x injectors work together.

The following is the working example, 1 cylinder, 2-stroke engine with 16000 RPM (128g/min and 190g/min).



Control strategy:

There is one important thing you need understand for two injectors system.

For example, for a 2 stroke engine, if the RPM is 10k, the time of 1 revolution is 6ms. ($1 \text{ min} = 60\text{s} = 60000\text{ms}$, $60000\text{ms}/10000\text{RPM} = 6\text{ms}/\text{RPM}$)

If the first injector pulse width (t_{Inj0}) is bigger than 4ms ($= 6\text{ms} - 2\text{ms}$, min break time), this injector cannot meet the need of fuel for this high RPM. EFI will switch to the second injector (larger one) to inject fuel. The larger injector will only need to open for shorter time (t_{Inj2}), for 10k RPM.

If the larger injector cannot inject enough fuel for the higher engine RPM, then both injectors will work together.

Note: all these switching between small to large injector, or to both injectors are automatically done by ECU, it is transparent to the user. The use just take it as ONE big injector that covers a wide range of RPM.

You only need to tune the total fuel injection quantity. The ECU will decide how to split between 2 injectors.

You can adjust the fuel injection MAP table “RAM_MAP_LdTp_Tps_N” based on your engine running, the bigger the value of this table is, the more the fuel will be injected. .

Default setting: VAL_tInjBrkMin=2000 us=2ms

The break time is between the 2 consecutive pulses of the same injector. You can change it a little bigger or a little small, to fine-tune in which condition to switch to the #2 injector

(Go to “Menu → Variables → Calibration Selection→” to add the "VAL_tInjBrkMin ").

7.6 Altitude tuning

Ecotrons EFI can compensate the altitude changes automatically.

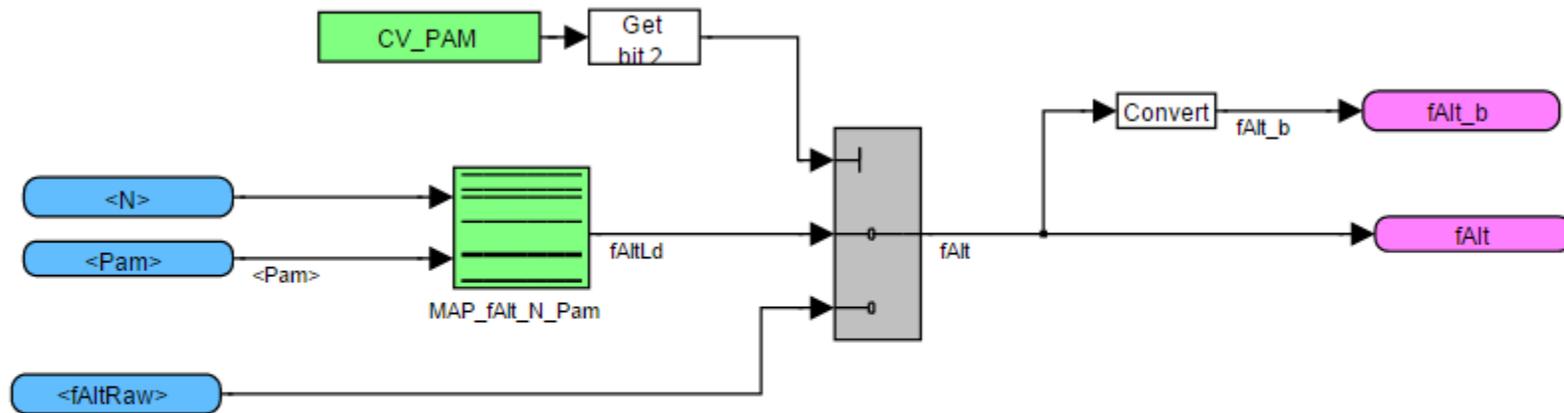
Fine tuning is required for different Altitudes. Once tuned, the tuning can be copied to every EFI system.

There are 2 ways for Ecotrons EFI to measure the altitudes:

- 1) Baro-pressure sensor
- 2) MAP sensor

Baro pressure sensor is installed either inside the ECU which has a channel to connect the surrounding air; or it could be a standalone pressure sensor installed on the harness. It measures baro pressure directly.

MAP sensor measures the manifold pressure, and when the engine is not running, the manifold fold pressure is same as the baro pressure. The disadvantage is using MAP sensor for baro pressure is that it can not measure the baro pressure directly once the engine is running.



Altitude factor can be directly from raw value, $fAltRaw$, which is simply a dividing of Baro pressure to sea level pressure.
 Or more flexibly, use the 2-D lookup table to calculate the altitude factor, then it is dependent on ambient pressure and engine speed.
 The altitude factor will be multiplied on Load or VE calculation.

Once the ECU knows the baro pressure, it will convert it to a fuel adjustment factor, “ $fAlt$ ” or altitude factor.

There is a multiplicative factor to correct the fuel quantity. $fAlt$, it is a global fuel factor, and it is multiplied on the base fuel mapping globally.

$fAltRaw = Pam/1013$ (hPa),

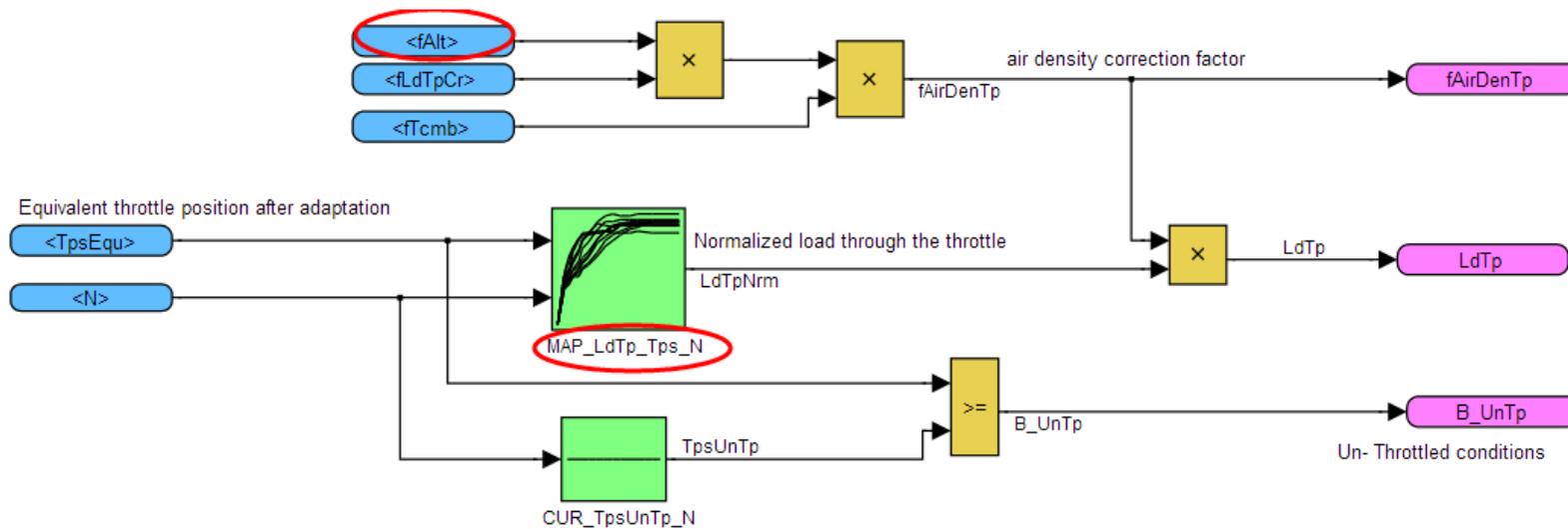
Pam is the ambient pressure in “hPa”. $1hPa = 100Pa$.

If you are at sea level, $Pam = 1013$ (hPa). So $fAlt = 1$ at sea level.

For example, at 5000 feet altitude, if $Pam = 850$ hPa, $fAlt = 850/1013 = 0.83$.

For example, at sea level, if the fuel injection is 5ms @ 2000RPM; then it will be 5×0.83 (fAlt) = 4.2ms @ 2000RPM at 5000 feet altitude.

The fAlt is not used to correct fuel injection directly, it is used to correct the fVe and Tps based Load, then to correct the fuel injection.



7.7 Convert PWM signal of servo motor to TPS.

For an UAV EFI system, we use the servo PWM signal as an equivalent TPS (throttle position sensor) signal to the ECU. ECU uses this signal input to calculate the fuel mass. So, the correct calibration of servo PWM signal is very important for engine running.

The servo PWM duty cycle is proportional to the throttle opening. The duty cycle is in linear relation with the throttle position. The calibration is to find out the slope and offset of the linear relation.

Note: the duty cycle could be **inversely** proportional, depending on the servo brand.

Step 1:

Load the correct A2I and CAL file by using EcoCAL tuning software.

Step 2:

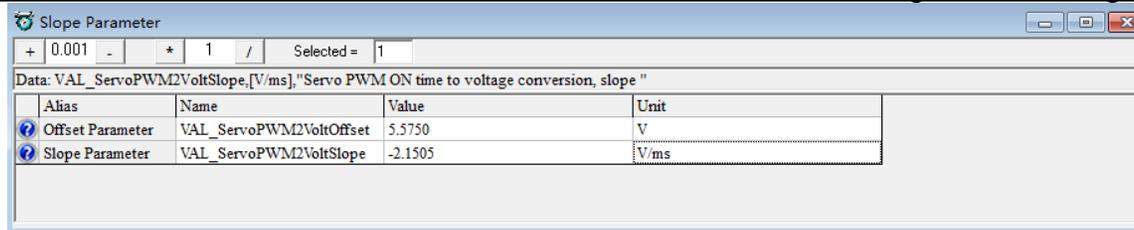
There are two calibration variables and one measured variable that you need to add.

Calibration variables:

Go to menu->Variables->Calibrations Selection, to find the two variables and add them.

VAL_ServoPWM2VoltSlope: slope parameter

VAL_ServoPWM2VoltOffset: offset parameter

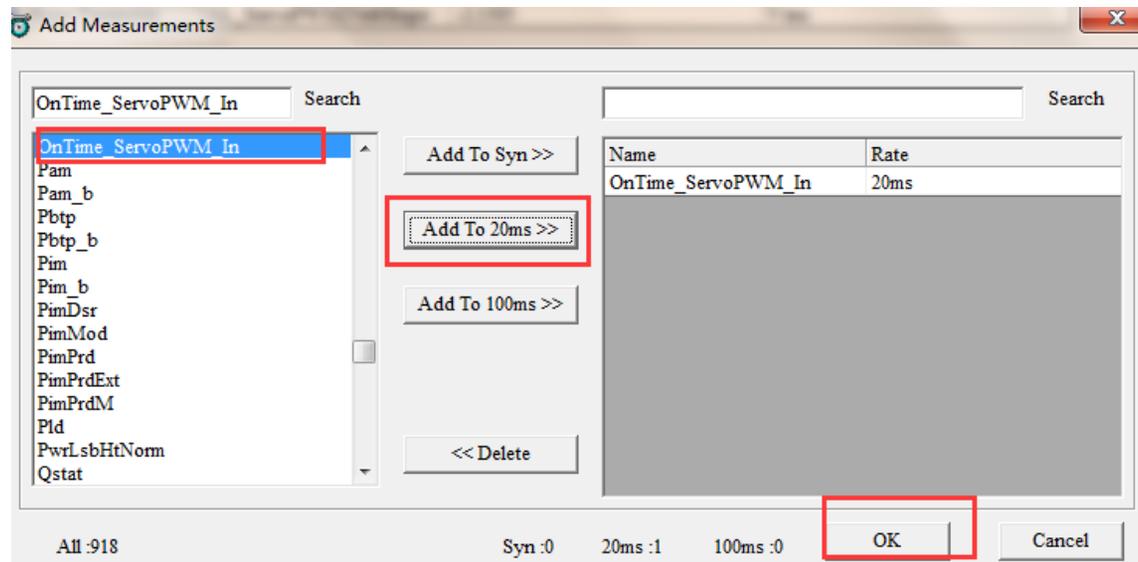


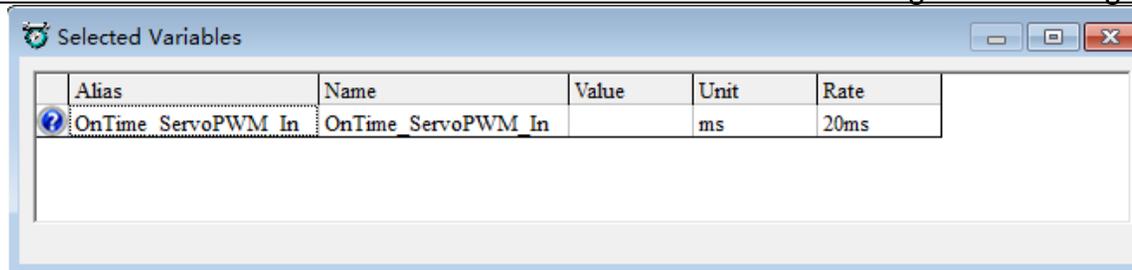
Measured Variable:

OnTime_ServoPWM_In – “Servo PWM signal ON time in milli-second, meaning, in the duty cycle signal, the high-level time.”

Go to Menu → Variables → Measurements Selection→. It will pop up a window, Selected Variables.

OnTime_ServoPWM_In “, and add it to 20ms, then click “OK”, you can see the variable on the list window.





Alias	Name	Value	Unit	Rate
OnTime_ServoPWM_In	OnTime_ServoPWM_In		ms	20ms

Step 3:

Connect the ECU to laptop via EcoCAL.

Use the remoter / auto-pilot to control the servo motor, move the throttle to the idle position. Read and record the “**OnTime_ServoPWM_In**” value, **marked PWM1**.

Then adjust the servo motor to move the throttle wide-open, read and record the “**OnTime_ServoPWM_In**” value, **marked PWM1**.

Step 4:

Calculate the offset and slope, to convert the signal of servo PWM to throttle position.

Use the following equations to calculate them:

$$0.5 = \text{PWM1} * \text{VAL_ServoPWM2VoltSlope} + \text{VAL_ServoPWM2VoltOffset (idle)}$$

$$4.5 = \text{PWM2} * \text{VAL_ServoPWM2VoltSlope} + \text{VAL_ServoPWM2VoltOffset (Wot)}$$

Basically, assume the 0.5V is the idle position, and 4.5V represents WOT position, which is typically a conventional TPS sensor signal range.

For example:

At idle: PWM1 (OnTime_ServoPWM_In) =2.02 ms

At Wot: PWM2 (OnTime_ServoPWM_In) =1.31 ms

0.5= 2.02 * VAL_ServoPWM2VoltSlope + VAL_ServoPWM2VoltOffset

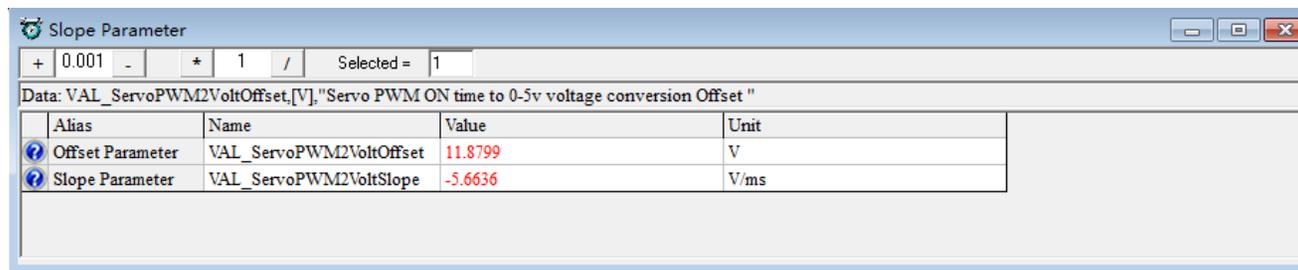
4.5= 1.31 * VAL_ServoPWM2VoltSlope + VAL_ServoPWM2VoltOffset

So,

VAL_ServoPWM2VoltSlope = -5.6336

VAL_ServoPWM2VoltOffset = 11.8799

Fill in the calibration data and burn to ECU, and then you can read the TPS signal: changing from 0-100%.



Alias	Name	Value	Unit
Offset Parameter	VAL_ServoPWM2VoltOffset	11.8799	V
Slope Parameter	VAL_ServoPWM2VoltSlope	-5.6636	V/ms

Verify the TPS signal is changing from 0 to 100% by control the servo from idle to WOT position.

Warning: The reading of OnTime_ServoPWM_In should be from 0.6 to 2.3ms for the Futaba S3016 which comes from Ecotros' EFI.

If the reading is lower than 0.6, and higher than 2.3, please reinstall the servo motor. Because of the reasonable control range is 0.6-2.3ms, if it is out of this range the servo motor will not work correctly.

Note: About the installation of servo motor, please read the manual for UAV engines.

7.8 Calibrate the TPS sensor without the adaptation

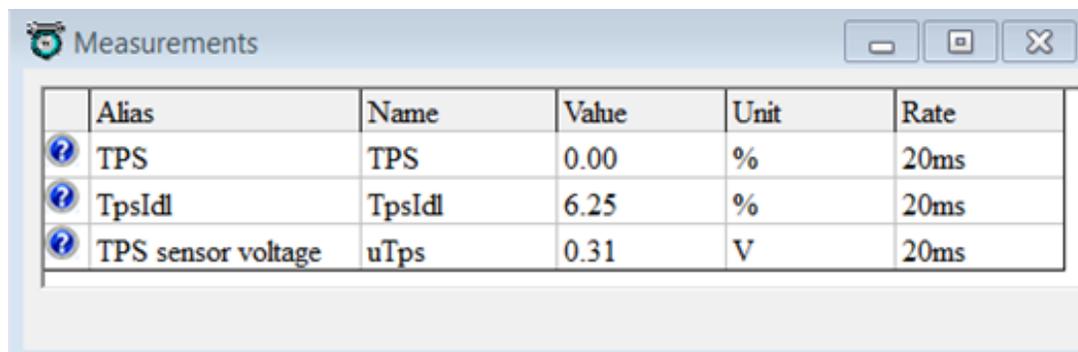
This function will disable the Tps adaptation and fixed the TPS max and min position.

1. Keep the throttle at idle position, and check the voltage of TPS sensor, **uTps** variable (TSP sensor voltage). Then calibrate these calibrations.

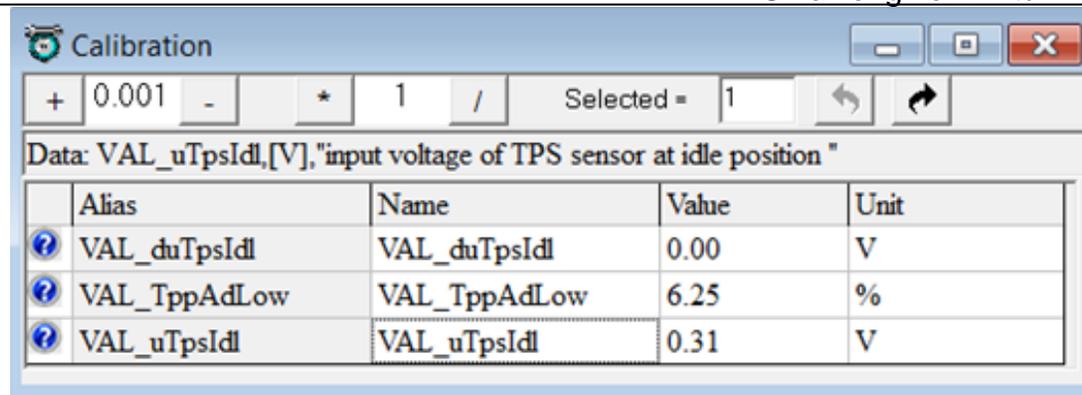
$VAL_uTpsIdl = uTps$

$VAL_duTpsIdl = 0$

$VAL_TppAdLow = uTps \times 20$



Alias	Name	Value	Unit	Rate
TPS	TPS	0.00	%	20ms
TpsIdl	TpsIdl	6.25	%	20ms
TPS sensor voltage	uTps	0.31	V	20ms



Calibration window showing a table of calibration data. The table has columns for Alias, Name, Value, and Unit. The data is as follows:

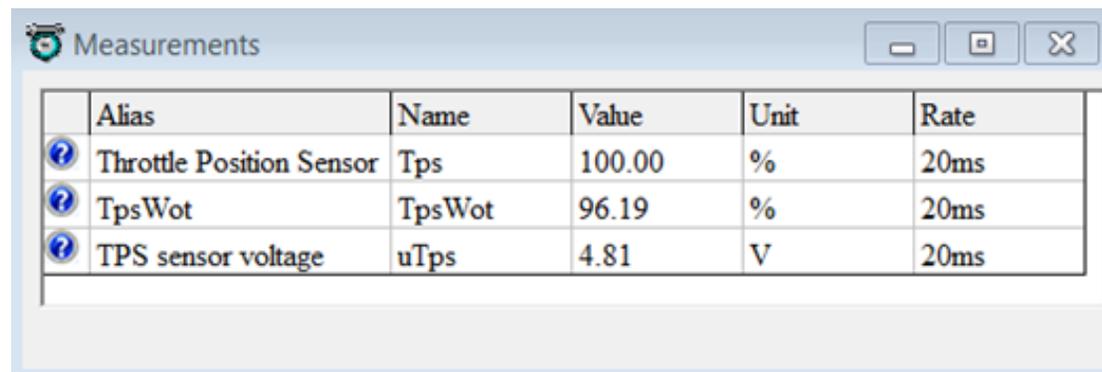
Alias	Name	Value	Unit
VAL_duTpsIdl	VAL_duTpsIdl	0.00	V
VAL_TppAdLow	VAL_TppAdLow	6.25	%
VAL_uTpsIdl	VAL_uTpsIdl	0.31	V

2. Open the throttle to max position, and check the voltage of TPS sensor, uTps variable. Then calibrate these calibrations.

$VAL_uTpsWot = uTps$

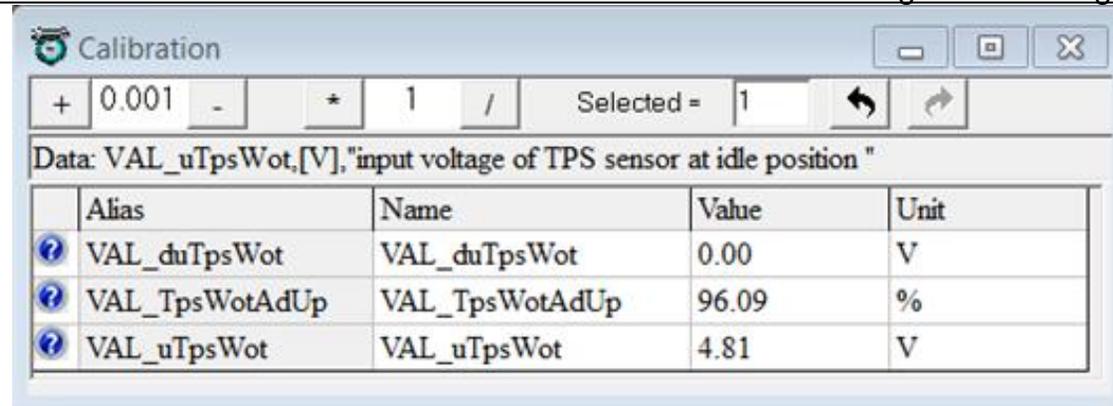
$VAL_duTpsWot = 0$

$VAL_TpsWotAdUp = uTps \times 20$



Measurements window showing a table of real-time measurements. The table has columns for Alias, Name, Value, Unit, and Rate. The data is as follows:

Alias	Name	Value	Unit	Rate
Throttle Position Sensor	Tps	100.00	%	20ms
TpsWot	TpsWot	96.19	%	20ms
TPS sensor voltage	uTps	4.81	V	20ms



3. Please click the “Burn to ECU” button. Finally, calibrate the TPS sensor without the adaptation function is finished. Different engines have different positions. So, you need to calibrate separately.

Chapter 8 Basic Parameters Calibration

Please skip this chapter if you use our entire EFI kits.

Usually, you don't need to change the basic parameters in .CAL file because we have calibrated these basic parameters for your engine.

You only need to calibrate these basic parameters if you are using the ones from the third party.

(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 only use Ecotrons ECU to replace the stock ECU of an EFI engine.

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

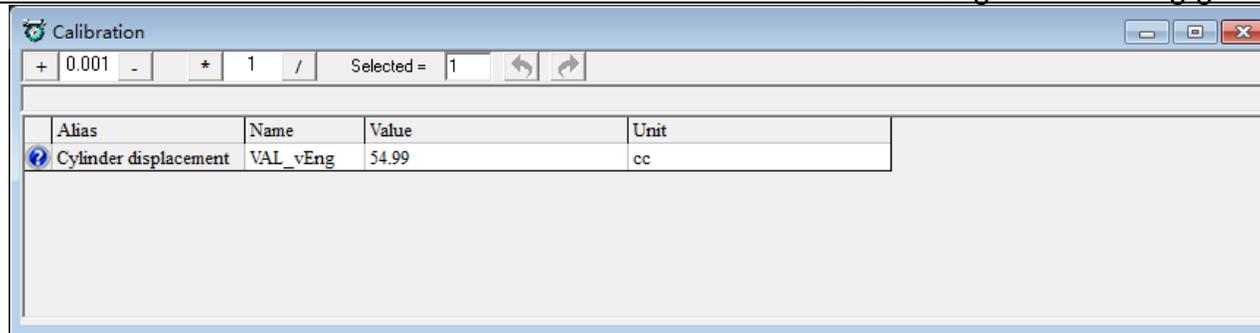
8.1 Engine Displacement

Cylinder displacement:

VAL_vEng: volume of engine displacement in cc or mL.

You can this variable in EcoCAL.

Go to Menu->Variables-> Calibration Selection



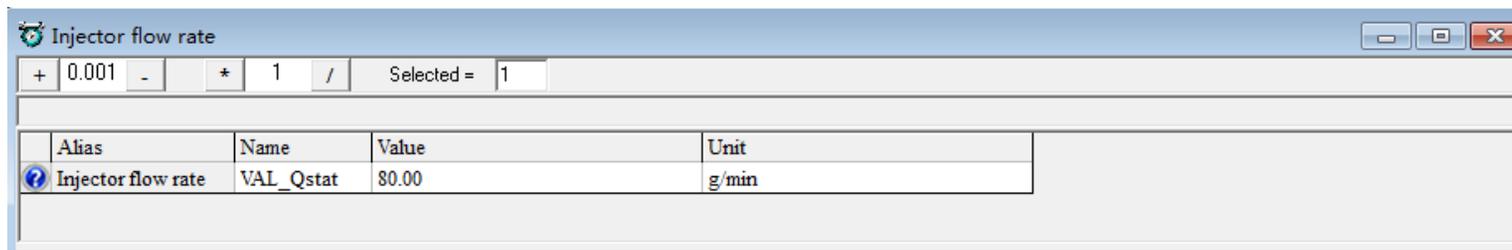
8.2 Fuel Injector

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.

Go to Menu->Variables-> Calibration Selection



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 be adjusted.

8.3 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:

Get it from the manufacturer, either from the vehicle manufacturer, or component manufacturer.

Measure it yourself, and you need 2 pairs of (pressure vs voltage) data points:

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;

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.

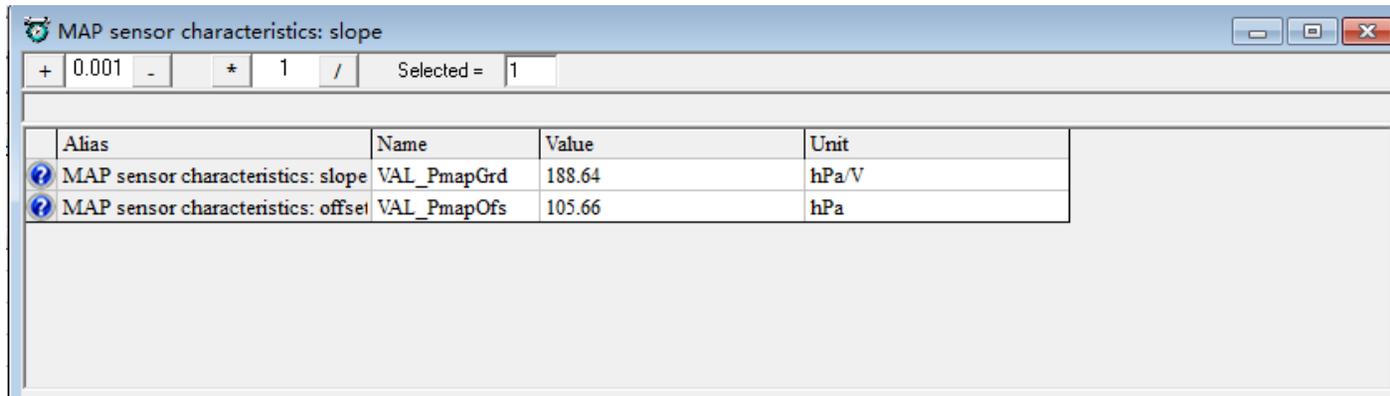
P2 can be the barometric pressure: 1013 hPa at sea level.

Then

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

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

Go to Menu->Variables-> Calibration Selection



Alias	Name	Value	Unit
MAP sensor characteristics: slope	VAL_PmapGrd	188.64	hPa/V
MAP sensor characteristics: offset	VAL_PmapOfs	105.66	hPa

8.4 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

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

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

Go to Menu->Variables-> Calibration Selection

Intake air temperature sensor characteristics: NTC type

+ 0.001 - * 1 / Selected = 1

Input: uTa, [V], "voltage signal of intake air temperature sensor"

Output: CUR_Ta_uTa, [DegC], "Characteristic curve, intake air temperature sensor"

uTa/[V]	0.30	0.37	0.46	0.59	0.75	0.97	1.32	1.77	2.54	3.74	4.24	4.49	4.68	4.80
CUR_Ta_uTa/[DegC]	150	135	125	113	102	90	76	62	43	15	0	-10	-20	-30

Intake air temperature sensor characteristics: NTC type

8.5 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

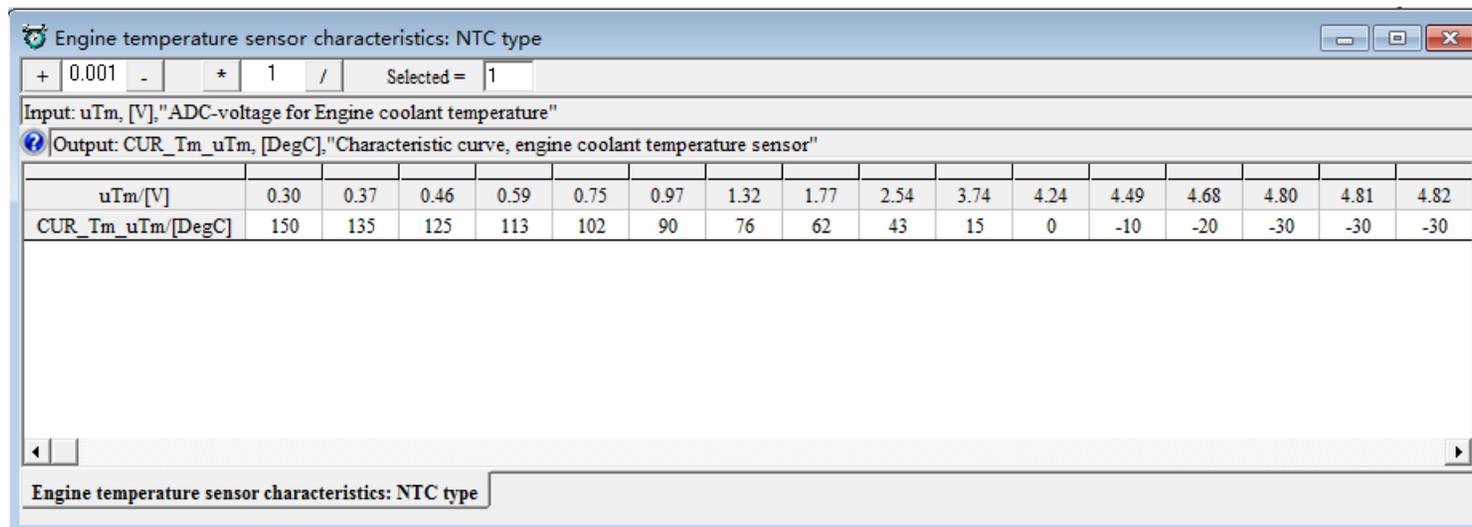
ΔT = change in temperature

k = first-order temperature coefficient of resistance

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

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

Go to Menu->Variables-> Calibration Selection



uTm/[V]	0.30	0.37	0.46	0.59	0.75	0.97	1.32	1.77	2.54	3.74	4.24	4.49	4.68	4.80	4.81	4.82
CUR_Tm_uTm/[DegC]	150	135	125	113	102	90	76	62	43	15	0	-10	-20	-30	-30	-30

Calibration for your own temperature sensor (IAT or ECT):

If you have the characteristic from the manufacturer, you can fill the table directly.

If not, you need measure it by yourself.

A rough but working one: put your temperature sensor into some coolant, which you can heat it up at different temp., and use a thermo-stat measure the coolant temp, and also measure the voltage with our software EcoCAL, and fill in the CUR_Tm_uTm or CUR-Ta_uTa.

8.6 TPS sensor

Tps: throttle position sensor (%)

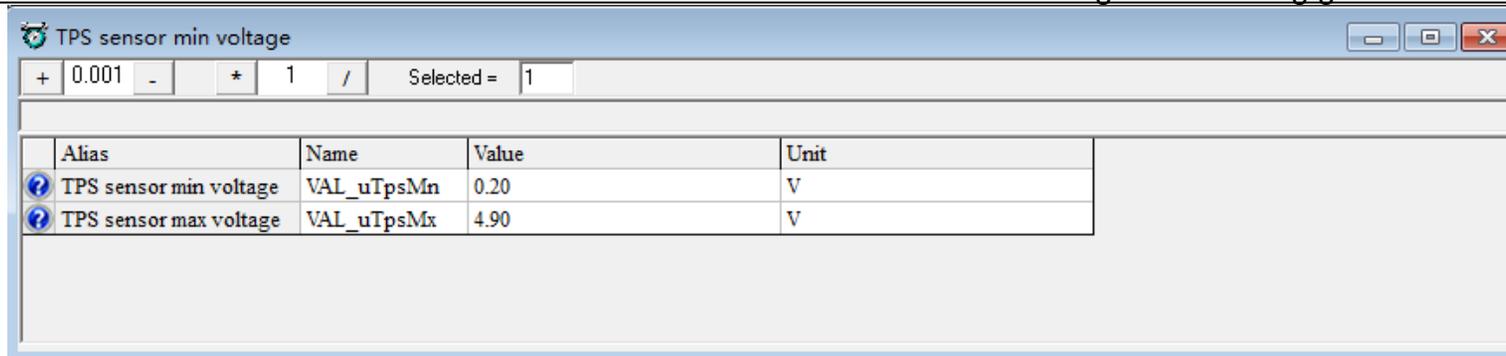
uTps: voltage of TPS sensor signal (V)

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:

$$+5V > VAL_uTpsMx > (uTps2 + 0.1v)$$

$$(uTps1 - 0.1v) > VAL_uTpsMn > 0$$



TPS self-adaptation :

When will the ECU run the TPS self-adaptation?

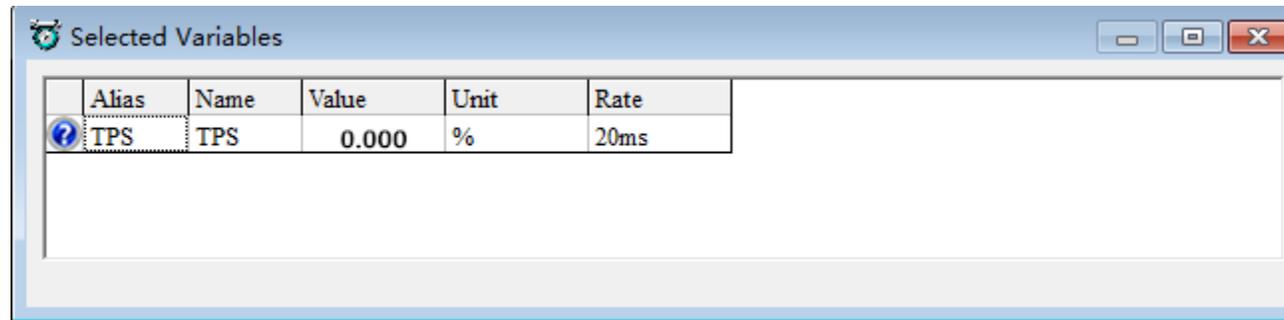
1. When a new ECU is installed;
2. When either the TPS or the throttle body is replaced;
3. Your ECU cannot reach 100% TPS.
4. When ECU is first on after the TPS is mechanically adjusted.

How to do TPS self-adaptation?

1. Power on, and disconnect the ECU (power-fail) to reset the self-adaptation;
For example, disconnect the ECU from the connector with key on.
2. Power off, re-connect the ECU, and power on again.
3. Keep the throttle at “idle position” for more than 5s.

If you look closely in EcoCAL, you can see the TPS reading is changing from a small value to 0% by itself.

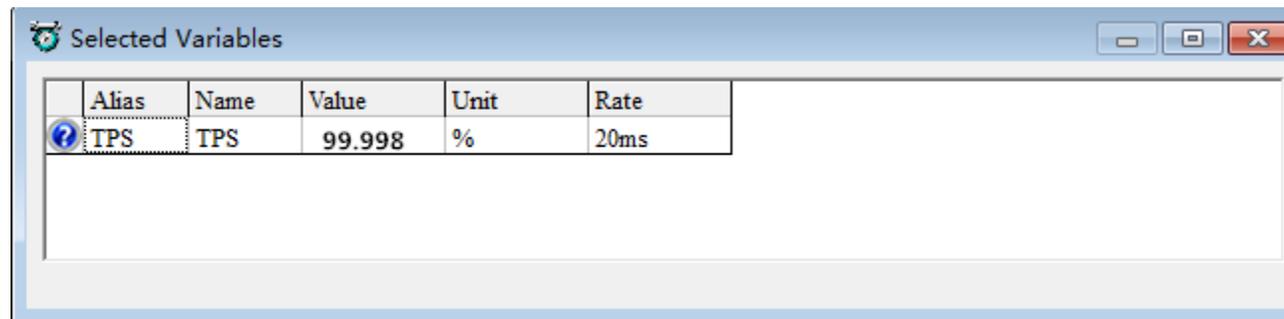
Now you can read the “TPS” is 0% in EcoCAL.



Alias	Name	Value	Unit	Rate
TPS	TPS	0.000	%	20ms

4. Keep the throttle at “WOT” (wide open throttle) for more than 5S.

Now you can read the “TPS” is almost 100% or 99.99% in EcoCAL.



Alias	Name	Value	Unit	Rate
TPS	TPS	99.998	%	20ms

5. Double check TPS in “EcoCAL”.

It is 0% when the throttle is at “idle position”, and it is 100% when the throttle is at “WOT” position.

Chapter 9 Advanced functions of EFI

9.1 Fuel Dial Function

Fuel Dial means input an analog voltage signal to ECU, and use this signal to adjust the desired lambda (LamDsr) to modify the real-time lambda (AFR).

We use the "Perf-SW", or performance switch, wire to connect the external signal input, such as a potentiometer.

LamDsr = 1/ (uPot * VAL_uPot2Fct+VAL_fLamDrvBas);

VAL_ LamLeanLim and VAL_ LamRichLim are the limitation of LamDsr Max and Min value.

VAL_ LamLeanLim < LamDsr < VAL_ LamRichLim;

lamDsr: desired lambda which you want

uPot: The voltage signal of potentiometer input to ECU

VAL_fLamDrvBas: Basic factor to calculate the lamDsr

VAL_uPot2Fct: Change the input voltage signal to actual factor.

VAL_ LamLeanLim: lambda lean condition limited

VAL_ LamRichLim: lambda rich condition limited

Default settings in CAL:

VAL_fLamDrvBas=0.5;

VAL_uPot2Fct=0.2;

VAL_LamLeanLim=2;

VAL_LamRichLim=0.5;

So, if uPot=0V, then LamDsr=2; and If uPot=5V, LamDsr=0.67.

You also can change the limitation value to limit the Max and Min value of lamDsr.

Example:

If you want the value of LamDsr is 1, then

$uPot = (1/\text{LamDsr} - \text{VAL_fLamDrvBas}) / \text{VAL_uPot2Fct}$; so uPot=2.5V.

So if you have not changed the default settings, the output voltage of your potentiometer should be 2.5V.

If you want to adjust the AFR (Lambda), you can pre-adjust the uPot to 2.5V (LamDsr=1) first, then you can change the potentiometer output to be bigger or smaller to get a rich or lean desired lambda, basing on the actual lambda.

9.2 Oil pump control tuning

The oil pump control tuning is only supporting for the custom EFI system. For some 2 stroke engines, maybe there needs extra oil pump for lubrication or mixture with fuel, our EFI can use PWM signal to control the oil pump. This is also suitable for 4 stroke engines.

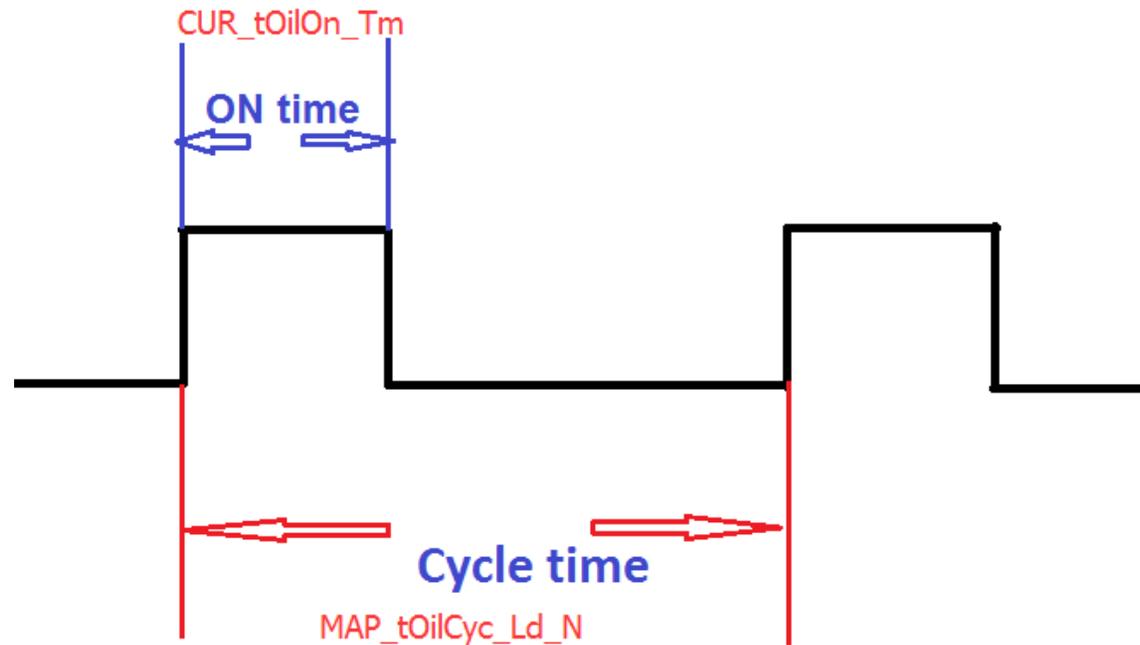
There are two control strategies to control the oil pump to work

1) When Key on, the oil pump will work some seconds, just like fuel pump control. The working time can be tuned, VAL_tOilPrimMx (s).

You can set VAL_tOilPrimMx to be 5, the oil pump will work 5 seconds after Key on.

2) When you crank to start, there is another MAP table to control the oil pump, MAP_tOilCyc_Ld_N, this table is based on engine temperature (Tm) and engine Load (Ld), and it is cycle time. VAL_tOilCycMx and VAL_tOilCycMn are the Max and Min value of on time limitation.

And there is also an on time table, CUR_tOilOn_Tm, based on engine temperature (Tm).



9.3 Fuel consumption calculation of EFI

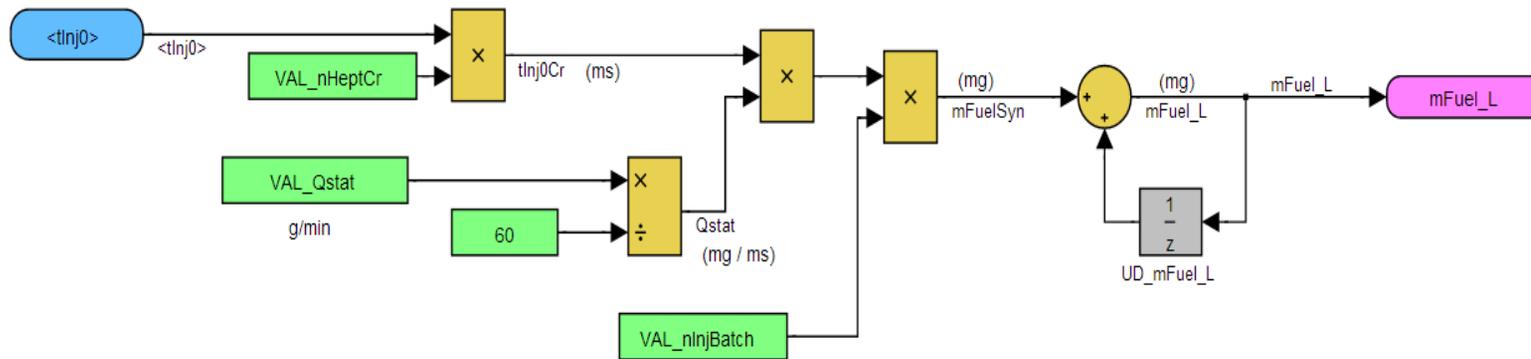
For our newest software, we add the function of the fuel consumption calculation, the result is in theory.

Calculate the total fuel mass

It is to calculate the total fuel from engine running to stop, t_{inj0} is the injection time of #1 fuel injection, the ECU will record the injection time and converts it to fuel mass of every injecting, then ECU will plus the fuel mass, and calculate the total fuel mass.

The variable of fuel mass in ECU is "mFuel_L", if you have two fuel injectors; "mFuel2_L" is the fuel mass of #2 injector.

Unit: mg



$$m_f1 = Qstat \text{ (g/min)} * 1000 \text{ (mg/g)} * t \text{ (ms)} / 60000 \text{ (ms/min)} * 1.05$$

Qstat mFuel_mx830mg

is the static n-heptane-fuel flow rate of the injector in (g/min), t is injection time in ms. 60000 is milliseconds per minute. VAL_nHeptCr (default 1.05) is the correction if fuel is regular gasoline.

VAL_nInjBatch is the # of injectors fires together, or batch mode.

$$m_f1 = Qstat * t * 1.05 / 60 \text{ (mg)}$$

For Qstat = 80(g/min), 5ms pulse width, fuel mass is 7mg .

mFuelSyn: 0~830mg ; 16-bit

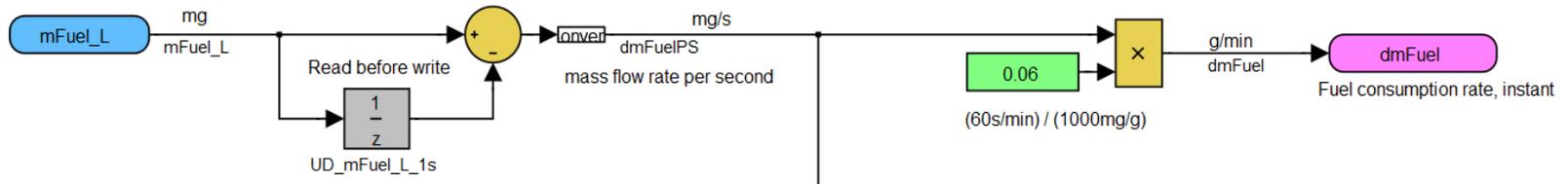
mFuel_32: 0~54389000mg or 0~ 54kg 32-bit

Calculate the Instant fuel consumption

The ECU also can calculate the instant fuel consumption in stable RPM.

For example, keep engine running in stable 5000RPM, hold on about 5 seconds, the ECU will calculate the fuel consumption at 5000RPM, the variable is dmFuel, the unit is g/min.

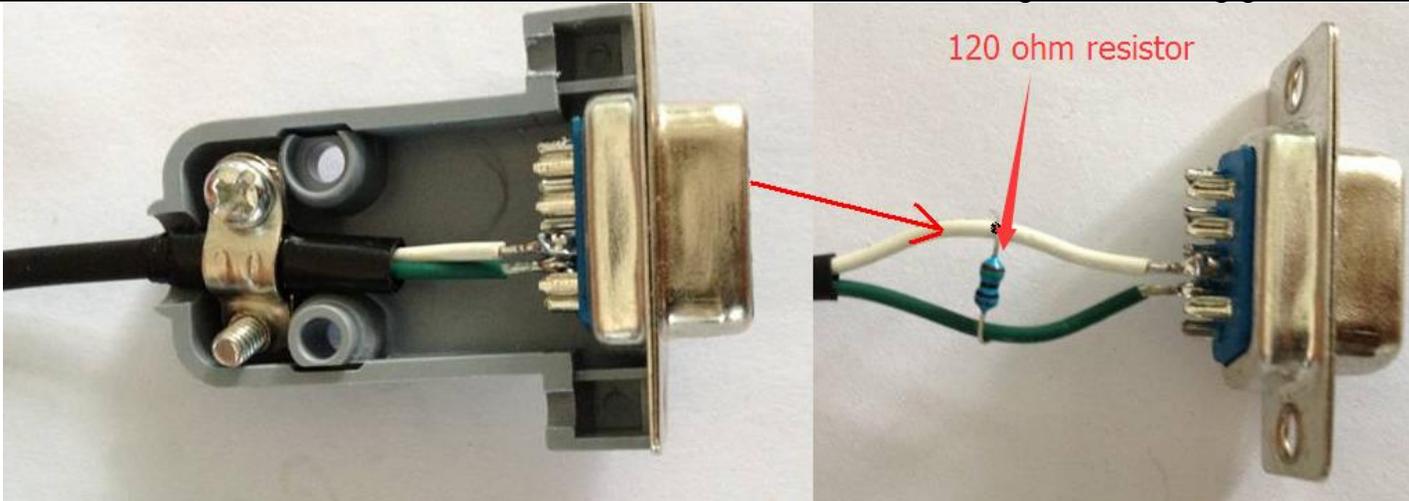
Fuel consumption since engine started



9.4 The CAN Baud rate setting of ECU

Our ECU and tuning software (EcoCAL) support the CAN communication, you can change the baud rate by yourself.

Note: There should be a 120 ohm resistor between the CAN wires, and our ECU doesn't have the 120 ohm termination resistor, so you need add it by yourself in the CAN connector, see below picture:



The calibration variable is “VAL_CAN0_BaudRate”, you can find this variable in Advanced.
The default is 250k, so VAL_CAN0_BaudRate = 4.

VAL_CAN0_BaudRate

/ CAN bus baud rate 1--1000k, 2--800k, 3--500k, 4--250k, 5--125k, 6--100k, 7--50k, 8--20k, 9--10k, 10--5k */*

Chapter 10 ALM-ECU integration for tuning

ALM and ECU work together if you want to tune the AFR accurately. In ECU, AFR is represented by Lambda (equivalent AFR). Lambda = 1 means AFR 14.7 for gasoline.

The default target Lambda is 1.0 across the board. You can define your own desired Lambda dependent on the RPM and TPS. Usually, a little rich AFR at high RPM / high TPS is preferred to have a better performance as well as engine cooling effect. A typical desired Lambda table could be 0.85 at high RPM and high TPS (>90%); and 1.0 everywhere else. The desired Lambda table should be engine specific. Some engines don't like 14.7 AFR at idle, and can only be stable if it is a little rich. In that case, you should define the desired Lambda to match the engine characteristics.

ECU will read the ALM's real-time lambda input, and you can adjust the fuel towards the desired Lambda at that RPM and TPS status.

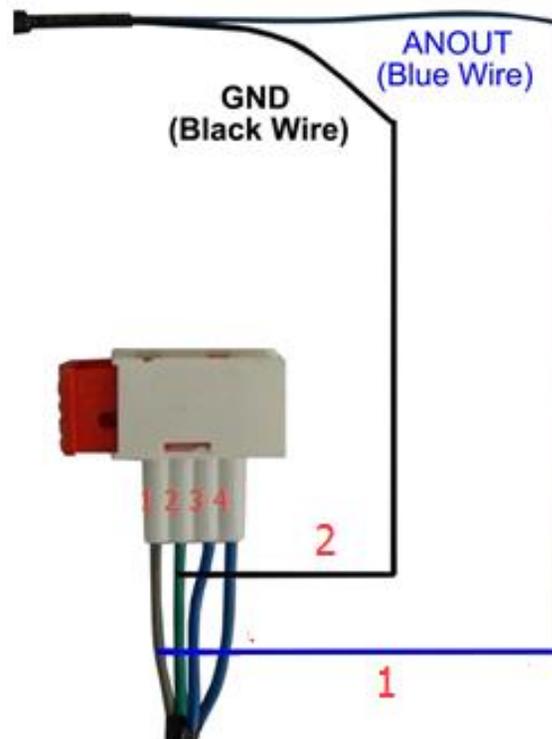
10.1 Connect the ALM to Small EFI kit

If you have a Small EFI kit from Ecotrons, please use the Narrow-band (NB) O2 input wire to connect the ALM analog voltage input, which allows for real-time lambda.

This means our ECU is actually hardware-compatible to both NB O2 and wideband (WB) O2 with the same input wire. The only difference is to download a different CAL file into ECU. This simplifies a lot of wire work.

Please use the wideband O2 sensor to replace the stock narrowband O2 sensor in the exhaust if you purchase the 4 stroke EFI kit from Ecotrons. You need to drill the hole and weld the bung in the exhaust and to install the wideband O2 sensor if you order the 2 stroke EFI kit from Ecotrons.

If you have one of our ALM kits, you shall connect the ALM to ECU. You need to connect the ANOUT (Blue) to O2in (1) and GND (Black) to Ground (2). As in the below picture:



Most of our Small EFI harness comes with a NB O2 sensor connector (white/red) which has 4 wires. [From right to left in the picture:](#)

- Heater circuit - (4)
- Heater circuit + (3)
- Reference Ground (2)
- O2in - O2 sensor input (1)

You can find two wires from our ALM harness:

- ANOUT (Blue) - analog output representing the lambda
- GND (Black) - reference ground

Burn the correct CAL file:

After you connect the ALM to ECU as the previous section, you need to burn the correct CAL file into ECU.

When you buy our ALM and ECU combo setup, please contact us to get a special CAL file.

You also can do some modifications of CAL file to match ALM by yourself.

Please set the following variables in CAL file if you order the 4 stroke EFI kit:

CV_DLSB = 0

CV_LSB = 0

CV_SSWO2 = 1

Please set the following variables in CAL file if you order the 2 stroke EFI kit:

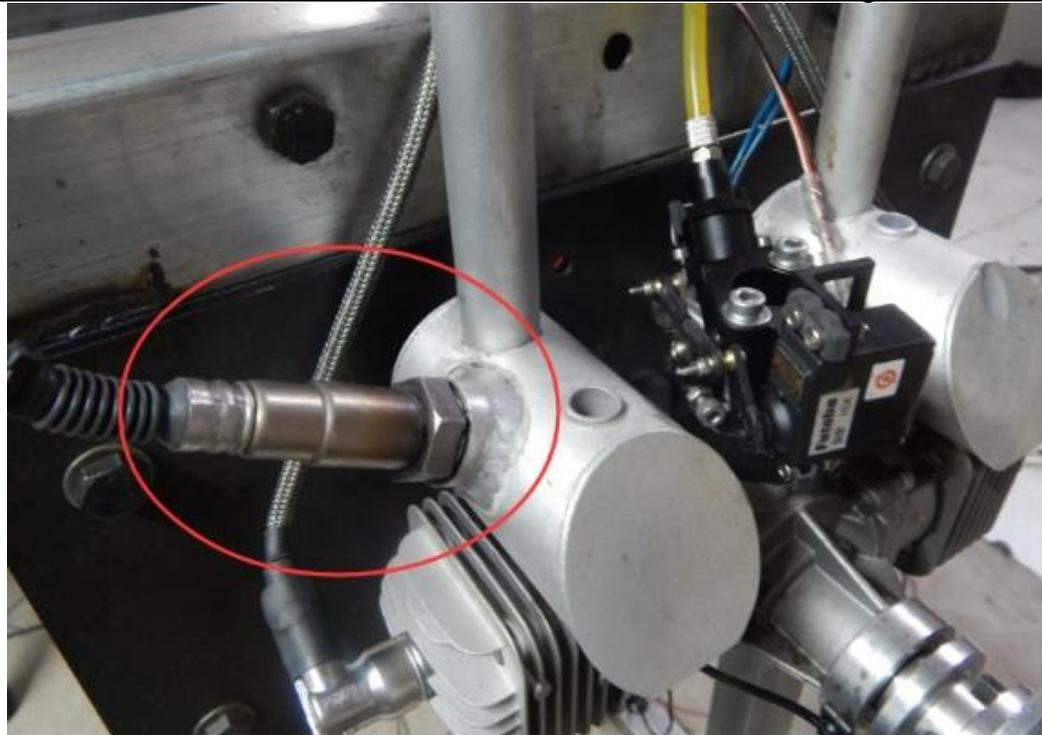
CV_SSWO2 = 1

10.2 Connect the ALM to UAV EFI kit

If you order the UAV EFI kit from Ecotrons, you can choose the "Perf-SW"(performance switch) or CAN channel, wire to connect the ALM input. That causes the loss of dual fuel map feature if you use the "Perf-SW".

10.2.1 Install the wideband O2 sensor

You need drill the hole and weld the bung in the exhaust and to install the wideband O2 sensor.

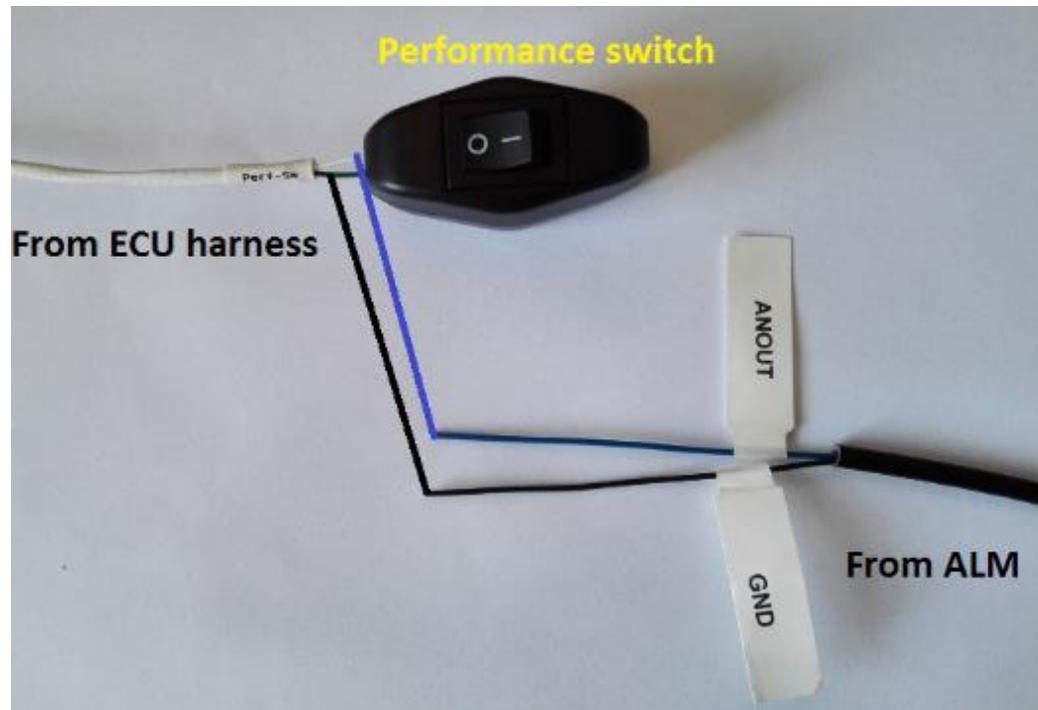


10.2.2 Connect the ALM to ECU via Performance switch

ECU can read the Lambda (AFR) from the wideband controller with LSU4.9/ADV sensor, you need connect the linear analog output of wideband controller to the ECU, then ECU can read the real-time lambda, and you can use the lambda to tune the fuel mapping of EFI.

We use the "Perf-SW", performance switch, wire to connect the ALM input. Most of EFI has this "Perf-SW" switch, you need to tap the linear output of wideband controller to the wires of performance switch.

Please connect it by using following pictures.



Connection

Connect the ANOUT to the white wire of performance switch

Connect the GND to the green wire of performance switch.

Warning: You need set the performance switch be “O” side, if not; it will not read the real-time lambda correctly

Please do a modification to match the ALM in CAL file.

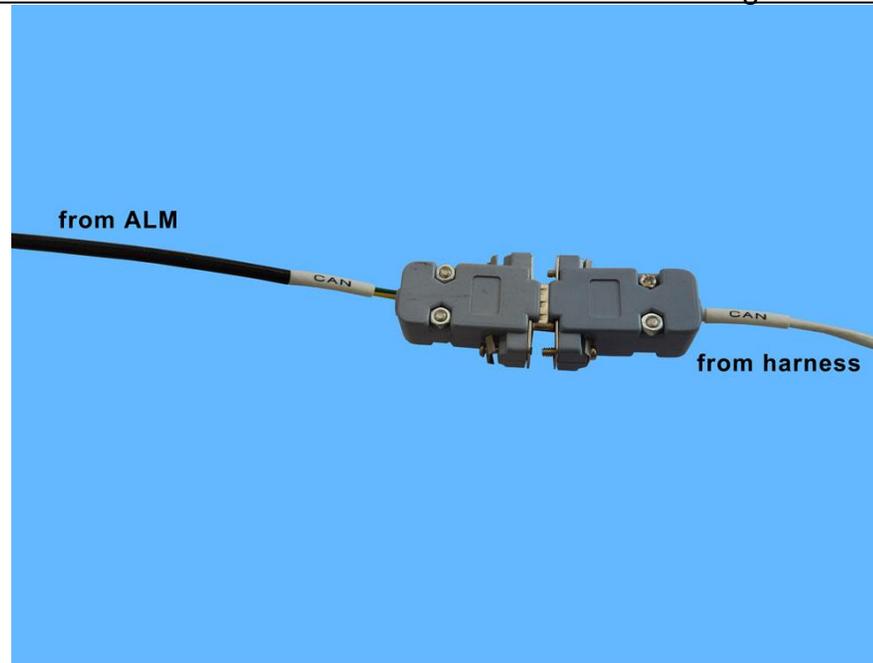
Please set the variable: **CV_SSWO2 = 1**

10.2.3 Connect ALM-CAN to ECU via CAN bus

If you order the ALM-CAN units from Ecotrons, which can be connected to ECU directly. ECU can receive the data from ALM-CAN by broadcasting and analyze the data to get the value about Lambda, AFR and O2%.

You need to modify the following calibration variable to match the ALM-CAN in CAL file.

Please set the variable: **CV_SSWO2 = 3**



Chapter 11 On-the-fly Calibration Data

On-the-fly calibrations are something must to have when tuning the engine on the dyno, so that you can make calibration changes taking effect immediately by hitting the "ENTER" key. No need to "Burn to ECU" or reprogram the ECU. Only by this way, you can keep the engine running without interrupted and at the same time find the sweet spots of the certain operating conditions. And you can tune your fuel / spark maps very quickly.

But the drawback of the "on-the-fly" calibrations is to use a lot of memory of ECU. Basically any calibration data you want to do "on-the-fly" changes, you must double or even triple the size of the memory for that set of data. That would significantly increase the ECU cost.

We have a compromise to do this: only make certain critical calibration maps as "on-the-fly" capable. And most other non-critical calibrations, which are seldom changed by customers, stay the old way.

Mainly for most customers, the calibrations that need to be tuned for their engines are basic Fuel maps (VE table, TPS-load table), Spark maps, and some supplemental fuel/spark characteristic curves.

You can also use "**Save as**" feature at "File" menu to save your new calibrations to a new CAL file. And later on load it into EcoCAL.

At this moment the below calibration maps, curves, and values are made "on-the-fly" capable:

RAM_MAP_LdTp_N_Tps:

"Tps based Load mapping" ; this is the most important one for dyno tuning. It determines the commanded fuel at different throttle position and RPM. Especially at WOT condition, fuel is solely determined by this table. Because on the dyno, the first thing to tune is the max power of the engine, and the max power is realized to optimize the AFR at the 100% TPS and max RPM. And the AFR at max RPM and 100%TPS is determined by this table.

RAM_MAP_fVe_Map_N:

"Volumetric efficiency, dependent on MAP sensor and RPM" ; this is the fundamental calibration map of an engine, also called "speed-density" method.

It determines the commanded fuel at different manifold pressure and RPM. Basically, the volumetric efficiency determines the fresh air amount in the cylinder, and therefore the fuel needed for optimized AFR.

Our ECU software use the blended "speed-density" and "Alpha-N" methods, and at most RPM ranges and part loads, speed-density is primary method to calculate Fuel. Actually Alpha-N is only used at WOT and high RPM. So for most operating conditions, you should tune the VE table for optimized AFR.

Other on-the-fly calibrations:

Basic Ignition angel table: **RAM_MAP_Iga_N_Ld**

After start and warm up factor: **RAM_CUR_fAst_TmSta, RAM_CUR_fWmp_Tm**

Globe enrichment factor: **RAM_VAL_fFIApp**

Note: when you tune the data on-the-fly, please “Stop Measuring”. Otherwise it will not take effect.

And if the ECU power off, the data will be lost, so you need save the data and burn to ECU after you think the data is OK.

Chapter 12 Broadcast protocol via serial cable

You can read some parameters of engine from the RS232 serial cable by using your equipment.

So we provide the protocol to you for using this function.

Variables: RPM, MAP, TPS, ECT, IAT, O2S, SPARK, FUELPW1, FUELPW1, UbAdc.

Note: Enable the broadcast data function; please tune the CV_APP to be 128, then burn to ECU.

Calibration: CV_APP=128

If you don't have this variable, please connect us.

The data format is hex, the baud rate is 115200, no parity bit, 8 data bits, 1 stop bit, time interval 100ms.

The data packages is (Buf[27]):

80 8F EA 16 50 08 00 00 6D 90 0F 00 0A 00 0A C0 00 5C 00 28 00 00 00 00 08 6F 42

Red: the header	80 8F EA 16 50 08(Buf[0]--Buf[5])
Blue: the data (word) high byte first	<p>00 00 (RPM) Buf[6] Buf[7] Physical value = ((high byte)*256 + low byte)/4</p> <p>6D 90 (MAP) Buf[8] Buf[9] Physical value = ((high byte)*256 + low byte)/256</p> <p>0F 00 (TPS) Buf[10] Buf[11] Physical value = ((high byte)*256 + low byte)/655.36</p> <p>0A 00 (ECT) Buf[12] Buf[13] Physical value = ((high byte)*256 + low byte) - 40</p> <p>0A C0 (IAT) Buf[14] Buf[15] Physical value = ((high byte)*256 + low byte) - 40</p> <p>00 5C (O2S) Buf[16] Buf[17] Physical value = ((high byte)*256 + low byte)/204.8</p> <p>00 28 (SPARK) Buf[18] Buf[19] Physical value = ((high byte)*256 + low byte)/2</p> <p>00 00 (FUELPW1) Buf[20] Buf[21] Physical value = ((high byte)*256 + low byte)/1000</p> <p>00 00 (FUELPW2) Buf[22] Buf[23] Physical value = ((high byte)*256 + low byte)/1000</p> <p>08 6F (UbAdc) Buf[24] Buf[25] Physical value = ((high byte)*256 + low byte)/160</p> <p>(Buf[6]--Buf[25])</p>
Green: the checksum	Checksum = Buf[26] =Buf[0]+Buf[1]+...+Buf[25]

Chapter 13 Ecotrons software tools and ECU communications

Note: We do not support the 3rd party USB-RS232 adapters, even though they might work sometime. The problem is that those consumer electronics rated USB adapters only works in a noise-free environments. This means, once the engine is running, it generates a lot of ~~electronic magnetic~~ electromagnetic noises. And those USB adapters, though looking pretty, will not stay working when you are driving. That's why we developed our own.

Recommend you to buy a new USB adapter from us and we can help you from there.

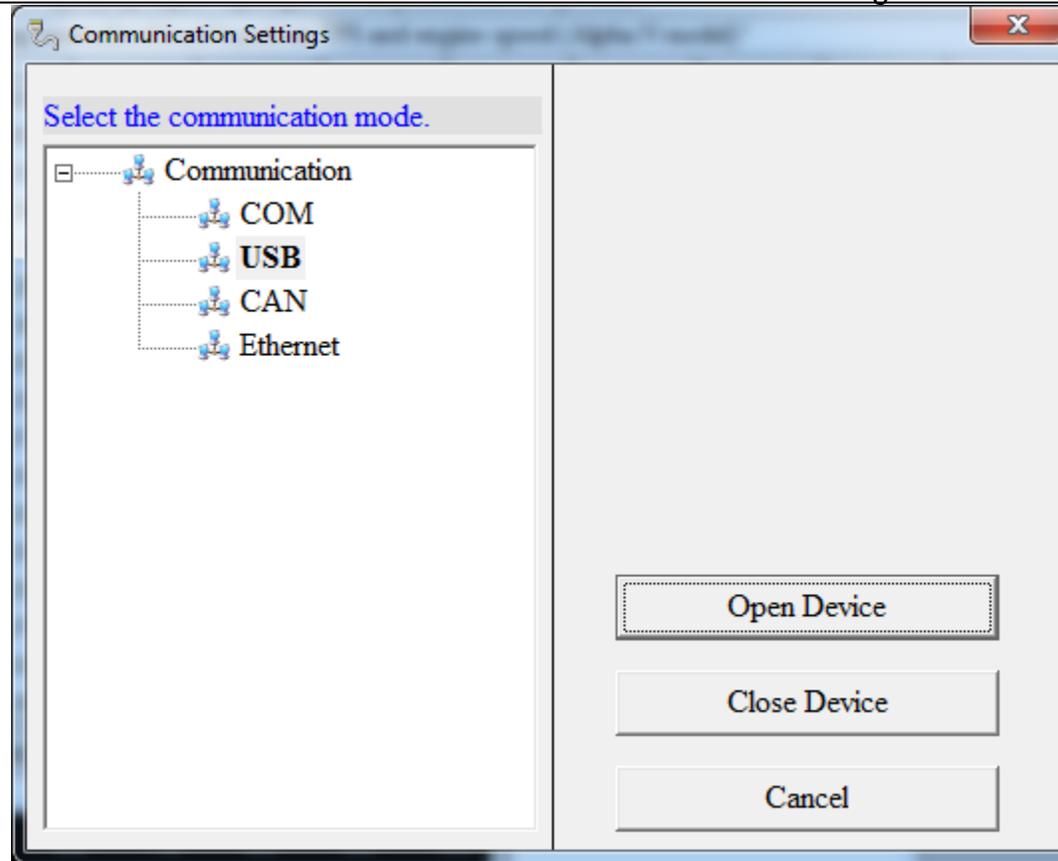
13.1 Check A2I or CAL which should be matching ECU

How to find the A2L or CAL files is matching with ECU?

You should select the communication mode first based on which way you use, COM or USB or CAN or Ethernet. In default, we provide the COM RS232 cable and USB adapter, so you can use the COM or USB for communication. Connect your laptop with a USB or RS232 to ECU harness. First do some communications settings in EcoCAL.

Go to menu->Settings->Communication Settings:

Select to the USB or COM or other according which you use.

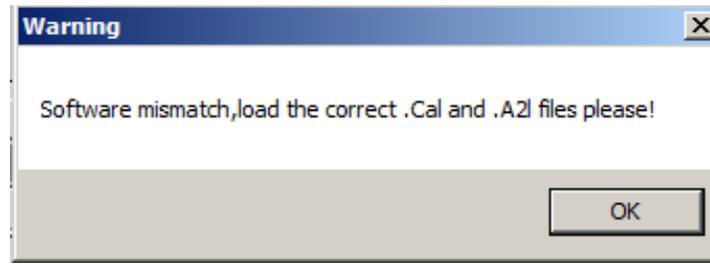


If you choose CAN or Ethernet communications settings, **please download the EcoCAL User Manual.**

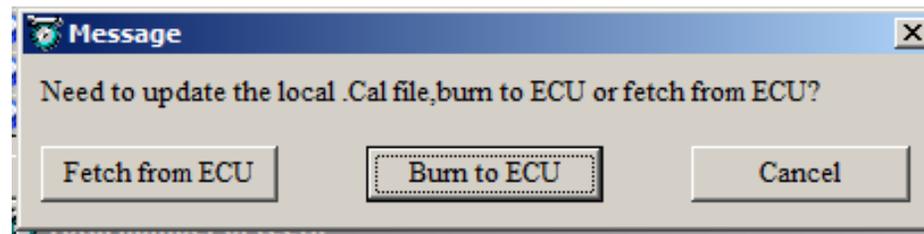
<http://www.ecotrons.com/support/>

Connect to ECU: "Run->Connect"

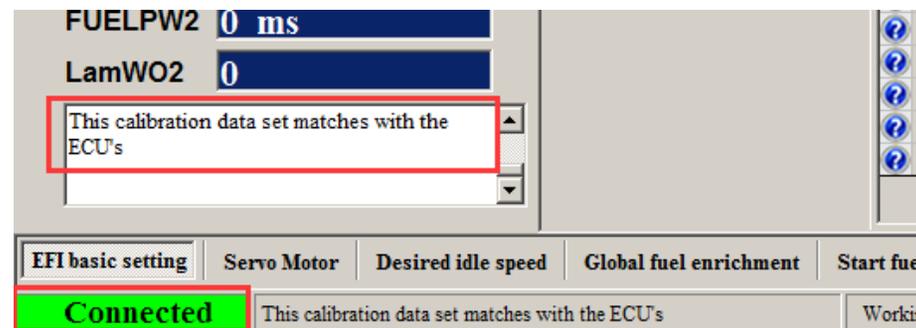
If it pop-up a warning box, so it is mismatching with your ECU. **Please contact us to get the right file.**



If it pop-up a message box, it means the settings of CAL is different from the ECU, you need to "Burn to ECU".



On the other hand, it will pop up a message "This calibration data set matches with the ECU's". It is right.



13.2 Burn to ECU successfully

How to make sure the "burn to ECU" is successful?

First, make sure the ECU is power on, and connect your laptop with a USB or RS232 or CAN or Ethernet to ECU harness.

When to burn to ECU, the power is still on and don't put the power switch off.

And if burn to ECU successfully, you will hear fuel pump running for a couple seconds. If not, please do again and check all of connection is right.

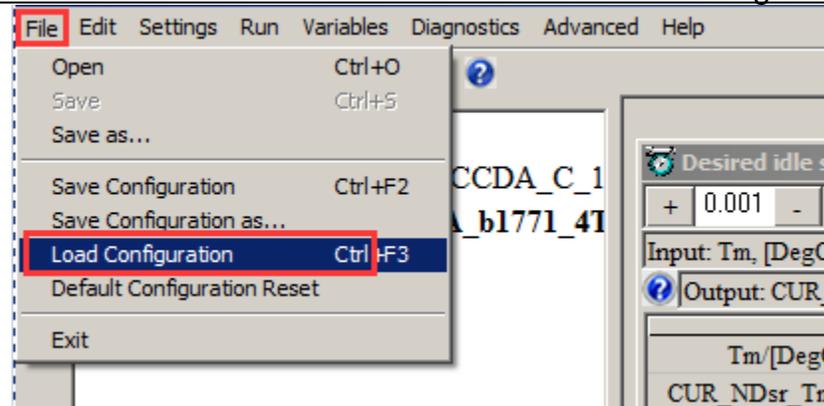
13.3 load configuration

For diagnosis and analyze the engine issue, sometime you need load the ".ini" file which we send you, in EcoCAL, and log data. You can do this by following example operation.

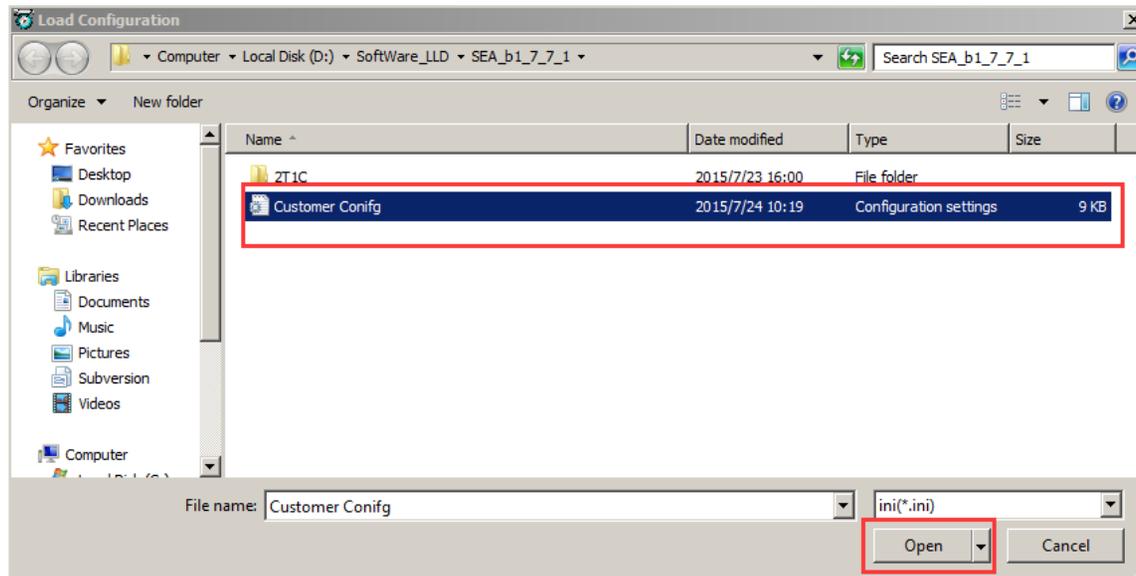
Sometimes, we will send the page configuration based on your custom EFI system for your tuning purpose. So you can load the configuration.

You also can load the configuration that you saved.

Go to menu->File->Load configuration



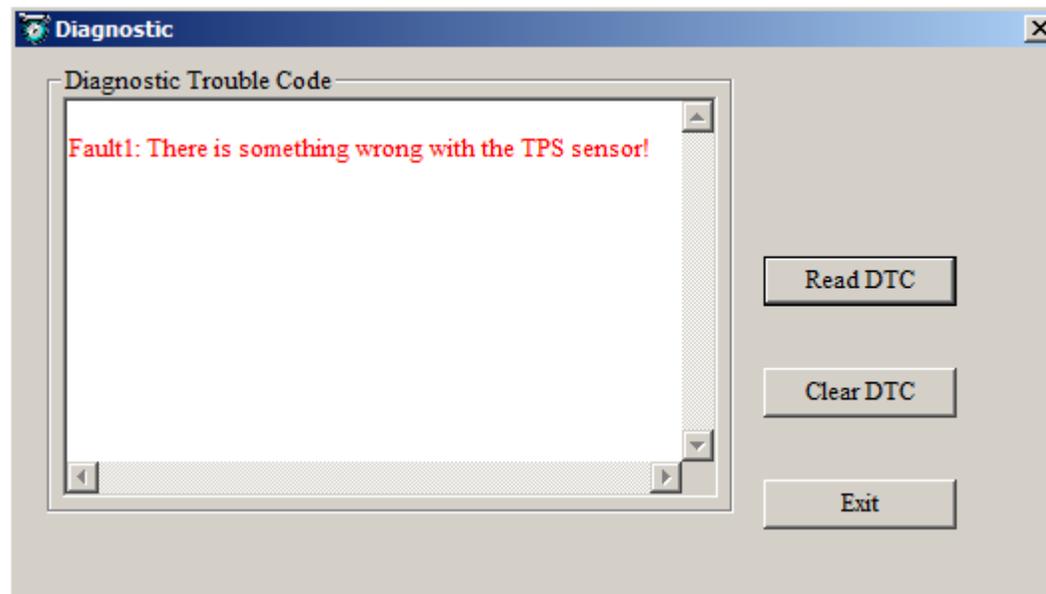
Choose the configuration file then click “Open”.



Chapter 14 Fault Diagnosis and Heal

Power on the EFI system, and if the MIL lamp (LED) is on, it means there is an error in the system. Please use EcoCAL to read DTC.

For example



Diagnostic Trouble Code:

Fault1: There is something wrong with the TPS sensor!

Throttle body position sensor error, please check the TPS connection, and see the sensor voltage of fully closed and wide opened ($4.8V > uTps > 0.2V$)

Fault2: There is something wrong with the MAP sensor!

Map sensor report error, please check the connection.

Fault3: There is something wrong with the O2 sensor!

Narrow band O2 sensor error, please check the installation and connection, and see the voltage of O2S is range from 0 to 1V

Fault4: There is something wrong with the CKP sensor!

Pick-up signal error, check the connection

Fault5: There is something wrong with the IAT sensor!

Intake air temperature sensor error, check the harness connection

Fault6: There is something wrong with the ECT sensor!

Engine temperature sensor error, check the harness connection

Fault7: There is something wrong with the VPWR!

Battery voltage error, if the voltage of battery is low to 10V and high to 16V, it will report error.

14.1 TPS sensor diagnostic

ECU reports TPS error

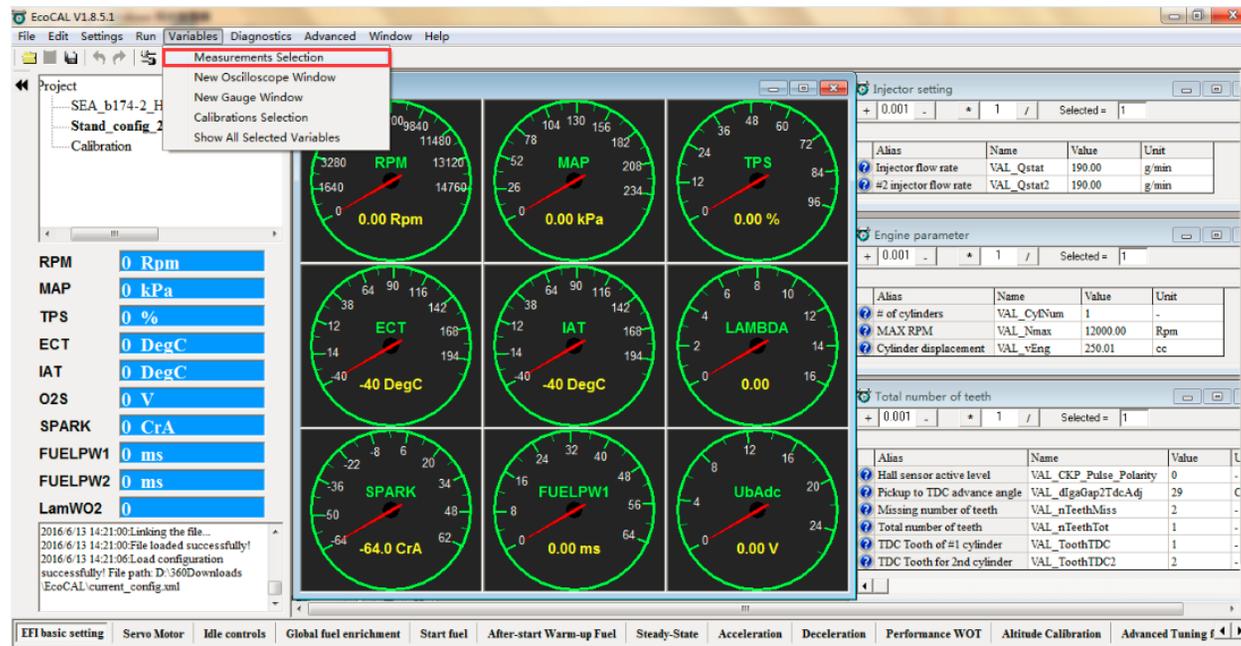
1) Connection problem

The Throttle position sensor is not connected well, please check the wire and reconnect it.

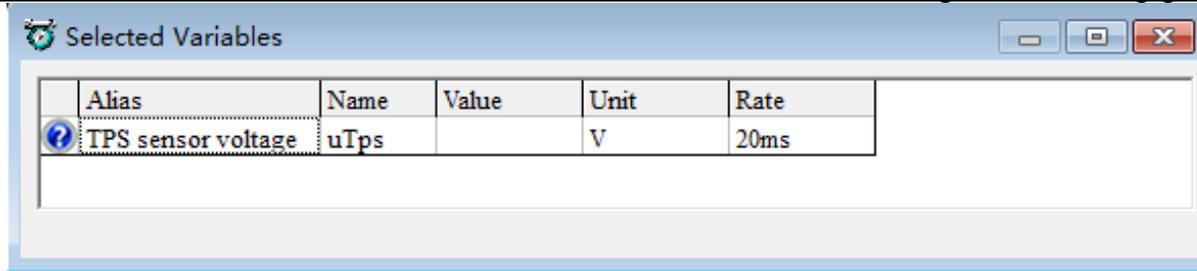
2) The voltage of TPS is out of measuring range

If the signal of TPS is out of range, you need to adjust it by using the following method

(1) Open EcoCAL, then go to " Menu → Variables → Measurements Selection →"



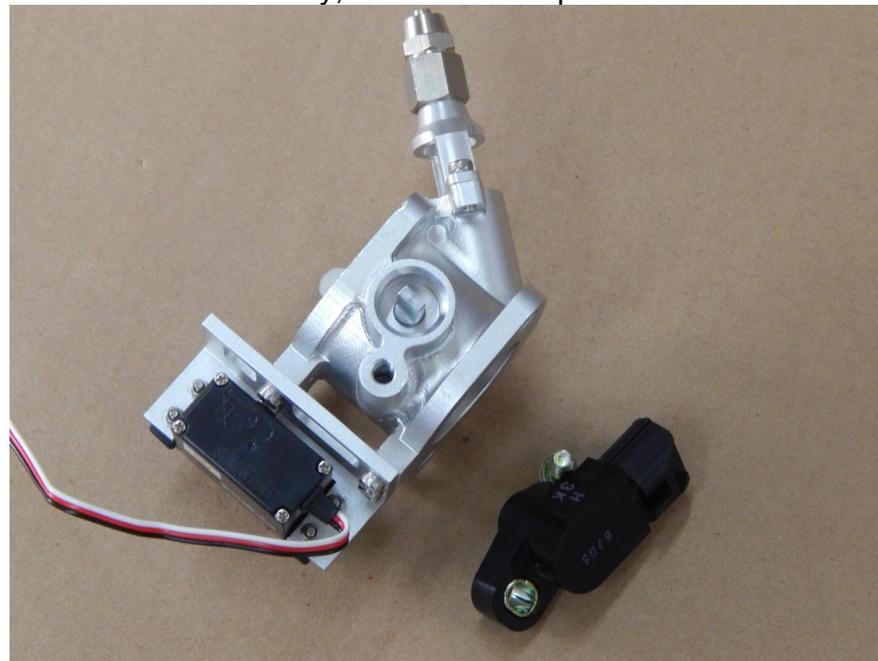
(2) Read the voltage of throttle position Sensor : " uTps"



Alias	Name	Value	Unit	Rate
TPS sensor voltage	uTps		V	20ms

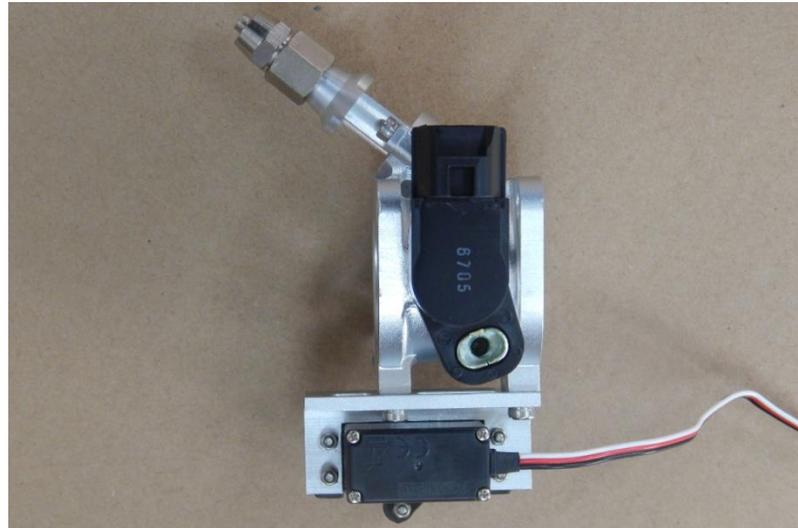
(3) Connect to ECU, to click "Run→Start Measuring"

(4) Remove the Tps sensor form the throttle body, see the below picture.

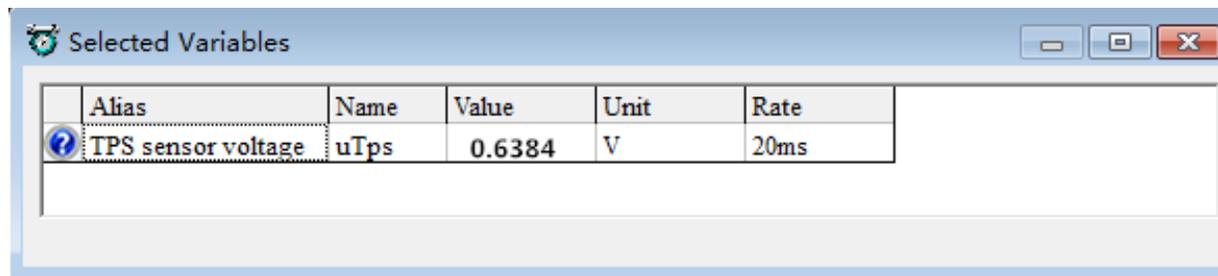


(5) Reinstall the throttle sensor.

(6) After installed, to mount the screw, it is better not to tight completely so you can adjust it conveniently.

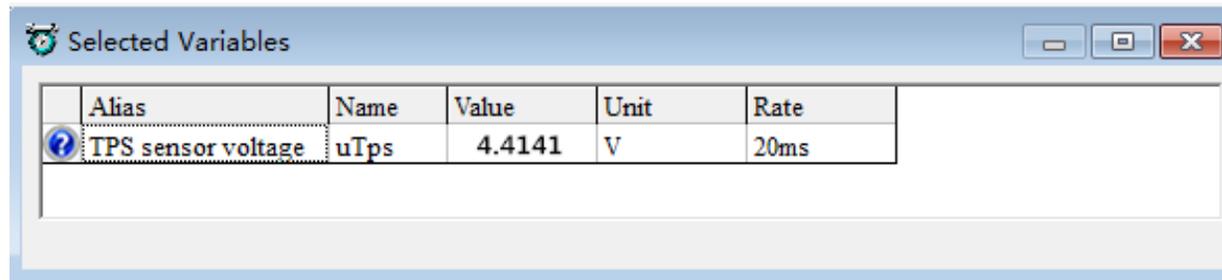


(7) When the throttle fully closed, to see the value of voltage of TPS by EcoCAL. (uTps > 0.3V)



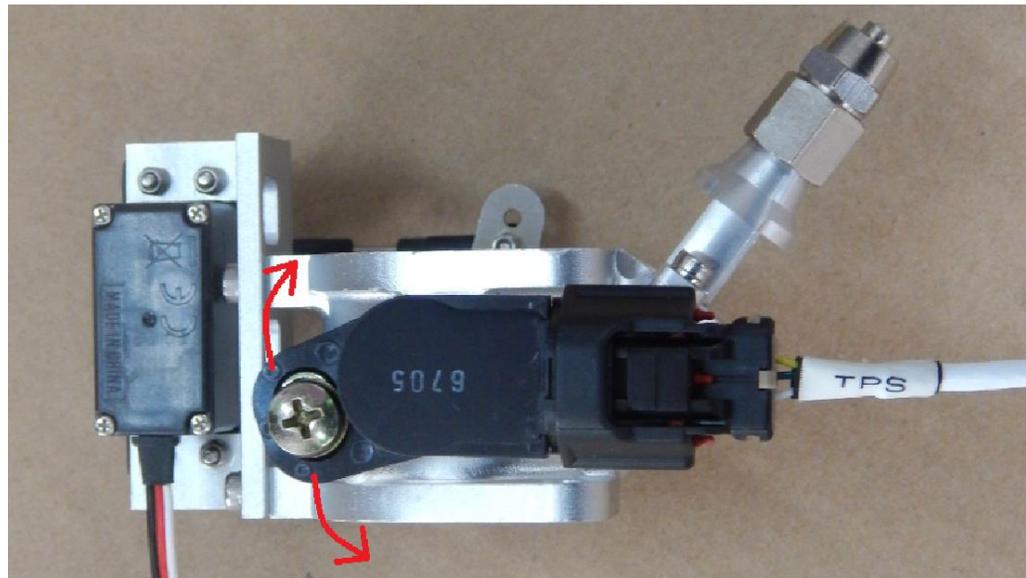
Alias	Name	Value	Unit	Rate
TPS sensor voltage	uTps	0.6384	V	20ms

(8) When the throttle is widely open, to see the voltage. (uTps<4.8V)



Alias	Name	Value	Unit	Rate
TPS sensor voltage	uTps	4.4141	V	20ms

(9) If the voltage of throttle sensor is not from 0.3V to 4.8V, you can rotate the sensor to adjust the voltage.



Note: The voltage of throttle sensor is normal in the range from 0.3 to 4.8V

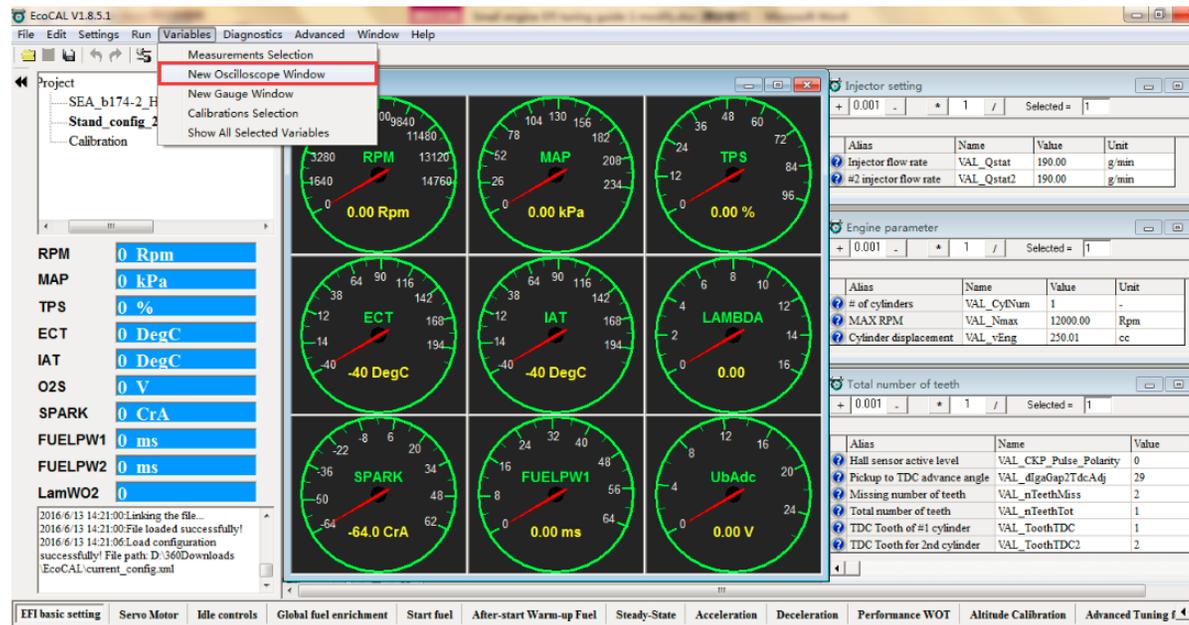
3) Reset the TPS position if Tps is not 0 when idle

Key on the system and key on only, disconnect the ECU from the main harness and reconnect it with keeping power on. Then you can see the Tps is changed to 0 when throttle is fully closed.

4) How to check the TPS signal rationality?

With the TPS is installed, the output voltage should be 0.3~4.8V DC. You can tell whether the TPS is broken by reading the virtual scope of the EcoCAL

(1) Show the “uTps” in the oscilloscope (Menu → Variables → New Oscilloscope Window →).





(2) Connect to ECU, to click “Run—Start Measuring”

(3) Slowly open and close the throttle, and you can get a symmetrical curve on the virtual oscilloscope, which is between 0.3V~4.8V, like picture 1. If the line is not consecutive, like picture 2, you should replace it with a new TPS sensor.



Picture 1



The signal is not consecutive.

Picture 2

14.2 MAP sensor diagnostic

If you have installed the EFI system and key on the bike, engine is not starting, the ECU reports Map error, and there are two possible causes.

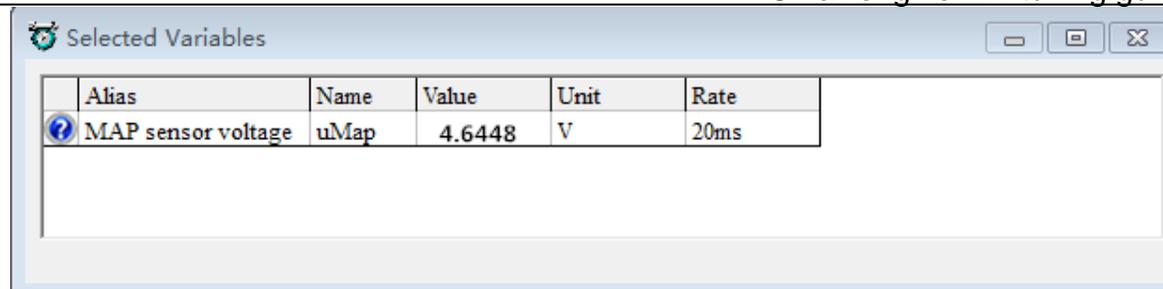
1) Connection error

The Map sensor is not connected intact. Please check it and reconnect it to ECU harness.

2) A bad sensor

The Map sensor is broken. Read the signal in EcoCAL to check it.

Power on ECU and connect to ECU. Go to menu "Menu → Variables → Measurements Selection →". Then "Run->Start measuring"



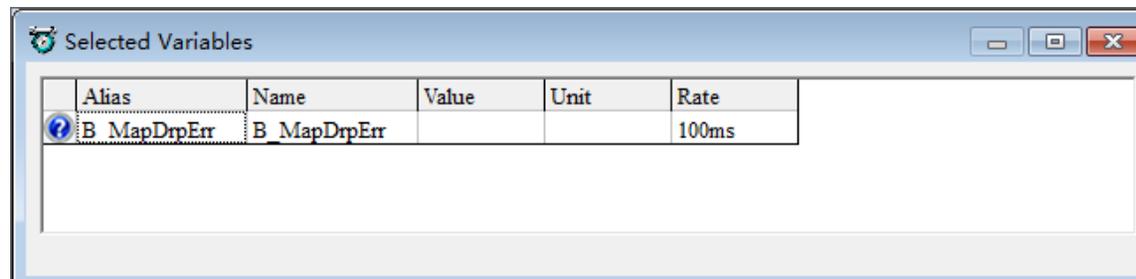
Alias	Name	Value	Unit	Rate
MAP sensor voltage	uMap	4.6448	V	20ms

If the voltage of Map sensor (uMap) is 0V or 4.99V, it shows that the Map sensor is broken, but makes sure the Map sensor is connected well at first.

If the Map sensor is broken, contact us to get a good one. The normal voltage (uMap) is about 4.7V (1 Bar sensor); and about 1.8V (2.5Bar sensor) when system is just powered on and engine doesn't start.

3) Fault indication when cranking engine

If ECU reports MAP error (B_MapDrpErr=1) when the engine starts or is running. The possible reason is the intake air vacuum is too less or there is some leaking air.



Alias	Name	Value	Unit	Rate
B_MapDrpErr	B_MapDrpErr			100ms

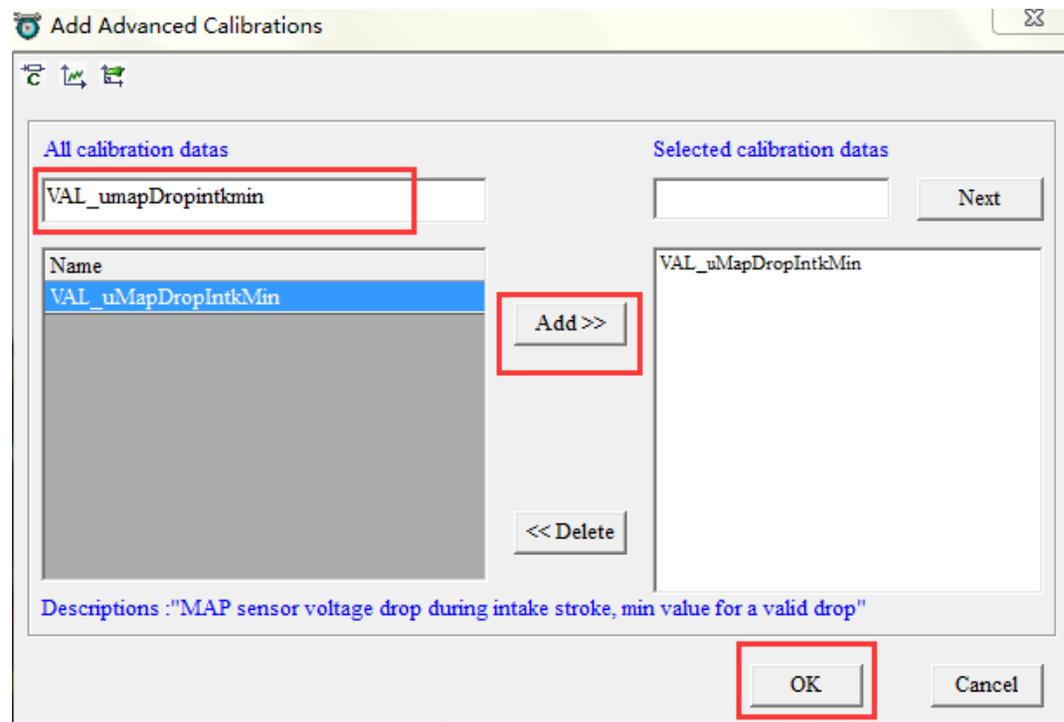
(3) First, check the Map sensor location, and connect the Map sensor to throttle body by a using a short hose.

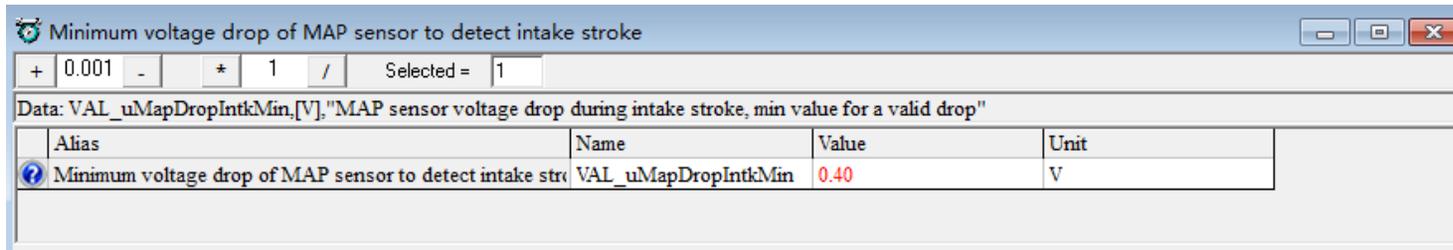
Check it for air leaks and make sure that it is sealed properly.

Turn the idle air screw or stepper motor position to get more idle air.

Change the value of minimum Map voltage drop "VAL_uMapDropIntkMin" during cranking.

In EcoCAL, go to "Go to Menu->Variables-> Calibration Selection"





Note: The value of "VAL_uMapDropIntkMin" cannot be smaller than 0.3V.

14.3 Temperature sensor (IAT & ECT) diagnostic

IAT: Intake air temperature sensor

ECT: Engine temperature sensor

If ECU reports IAT or ECT error, there are two possible reasons for this

Possible reason #1: the connect wire break off

Possible reason #2: the temperature sensor is broken

Note: If there is an error about the temperature sensor, please repair it or replace it as soon as possible, because it will affect the fuel injection, it may be too rich or too lean, and the engine can't run normally.

14.4 NB O2 sensor diagnostic

If you have installed an O2 sensor and the O2 sensor signal is not changed, it still 450mv or bigger than 1V when engine is finished warmed up (engine is running about 3 minutes) and anything is connected well. It shows the O2 sensor is broken, please change another good O2 sensor. And if the system reports O2S error, ~~and~~ you will also need to check the connection whether it is short or broken circuit.

How to check NB O2 sensor damaged?

When you finish installing the NB O2 sensor and the engine runs about 20 minutes, if the signal of NB O2 sensor (uLsb) is not changed, and the closed-loop control doesn't work, maybe there is something wrong with the NB O2 sensor, so you need check it by using a multi-meter, and measure the resistance between the two heat wires.

- 1) Select the 200ohm, to test the resistance between the two white wires. If the resistance is not ranged from 8 to 11 ohms, it means there is something wrong with the NB O2 sensor.



- 2) Select the 200M ohm to test the two wires except the two white wires, if the resistance is less than 200M ohm, it means there is something wrong with the NB O2 sensor.



Note: The multi-meter displays “1”, means that the resistor is larger than 200M ohm.

NOTE: Double check and make sure all wires are connected as they should be.

14.5 Trigger (VRS) signal diagnostic

No matter which pick-up sensor you used, crankshaft sensor or hall sensor, you must make sure there is a clean signal to input ECU, otherwise, the EFI system will not work. The installation and connection are very important. Check previous chapter on how to install the VRS sensor.

If The MIL-LAMP light is ON, and you read the error code in EcoCAL is” There is something wrong with CKP signal”, this means, ECU can’t read the trigger signal.

You can get the variable B_CrkErr=1, so you need to check the trigger signal wires connector.

There are **three** possible reasons: 1) The trigger wires are not connected well, so please reconnect it and connect the right trigger signal wires; 2) The voltage of trigger signal is too low, our ECU only can read the higher voltage of signal than 2V. 3) There is something wrong with ECU, maybe the ECU is damaged, and you can connect us for checking it.

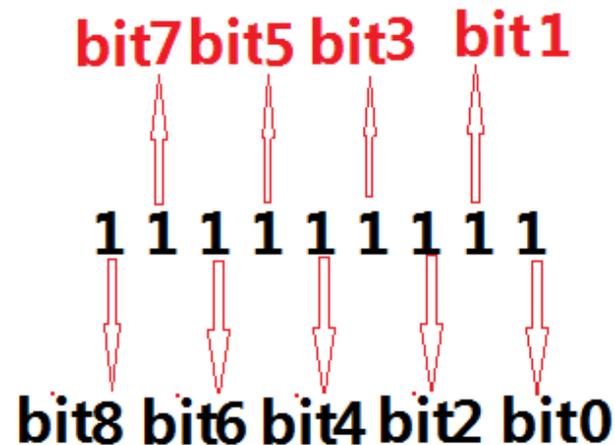
How to check the trigger signal whether is suitable when ECU reads the trigger signal?

There is an error flag of trigger signal, Err_CrankSensing_Flag. You can know whether the trigger signal whether is suitable from the value of Err_CrankSensing_Flag.

You can read its value on EcoCAL when start the engine, Go to "Menu → Variables → Measurements Selection→", then you can find the variable.

Alias	Name	Value	Unit	Rate
Err_CrankSensing_Flag	Err_CrankSensing_Flag		-	20ms

Note: When you read the value of Err_CrankSensing_Flag, you need to convert it to be binary.
 For example, the value of Err_CrankSensing_Flag is “511”, convert it to be binary, it is “11111111”.
 From right to left, it is marked by bit0, bit1, bit2, ..., bit 15,



Different byte has different meaning.

1) For single pulse pre REV

If bit0=1, this means the pulse of first trigger signal is too long or too short.

If bit4=1, this means, ECU reads the noise signal, please check all ground wires whether are connected to negative of battery.

2) For multi-tooth trigger wheel

If bit2=1, this means, ECU reads incorrect signal when the missing tooth passes through the trigger sensor.

If bit3=1, this means, ECU reads incorrect signal when the missing tooth passes through the trigger sensor.

The best way is to use oscilloscope to measure the trigger signal, and then send to us, we can help you to check it.

14.6 Battery diagnostic

If the system reports "VPWR" error, please check the health of battery or the 12V charging system integrity.

14.7 Actuator Diagnosis

EFI system has some Actuators, such as Relay, fuel pump, injector, CDI.

If one of actuators doesn't work, the EFI system will not run, so make sure all of these in good shape.

14.8 How to check a non-working ECU

How to find the ECU damaged?

If you have 20pin ECU, please remove the ECU from harness, and measure the resistance of ECU between pin15 and pin20. The normal value should be about 1K ohm.



If you have 24pin ECU, please remove the ECU from harness, and measure the resistance of ECU between pin4 and pin8. The normal value should be about 1K ohm.



When the ECU is broken, and you need to replace one new, please check the actuator and sensor of system as follows:

- 1) Check the voltage of the battery. It should be lower than 16V, it usually is about 12V.
- 2) Check the connection according to the installation manual. And notice whether the wire of harness is damaged.
- 3) Check the other parts of the system.
 - 3.1) Test the resistance of the fuel injector. It is more than 3 ohm, normally 12~15 ohm.



Picture 1

Picture 2

3.2) Test the resistance of the fuel pump relay. It is more than 60 ohm.



Picture 3

3.3) Test the resistance of the oxygen sensor at room temperature. It is more than 6 ohm, range is about 8~12ohm.



Picture 4

3.4) Test the resistance of the stepper motor which is mount on the throttle. It is about 45~55 ohm.
The below picture 5 and 6 are testing for stepper motor from **34mm throttle body**.



Picture 5



Picture 6

The below picture 7 and 8 are testing for stepper motor from **other throttle body**, 42mm, or 50mm TB.



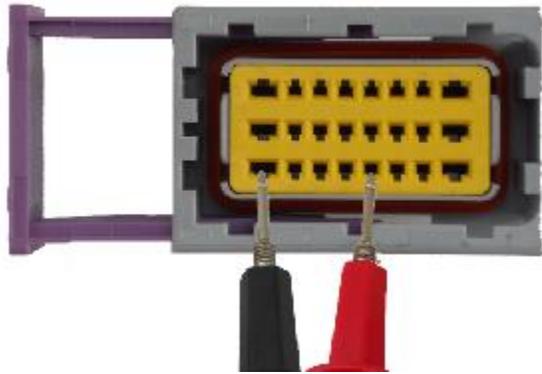
Picture 7



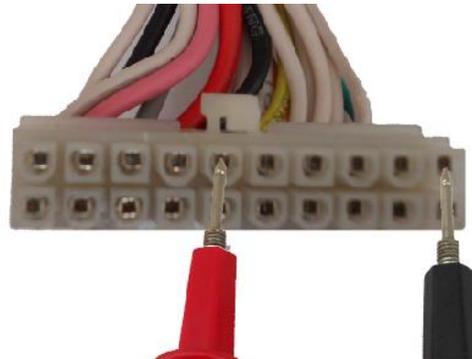
Picture 8



With the MAP and TPS sensor, oxygen sensor, IAT, ECT on the harness, please test the resistance of the harness. It should be more than **1000 ohm**.



Picture 9



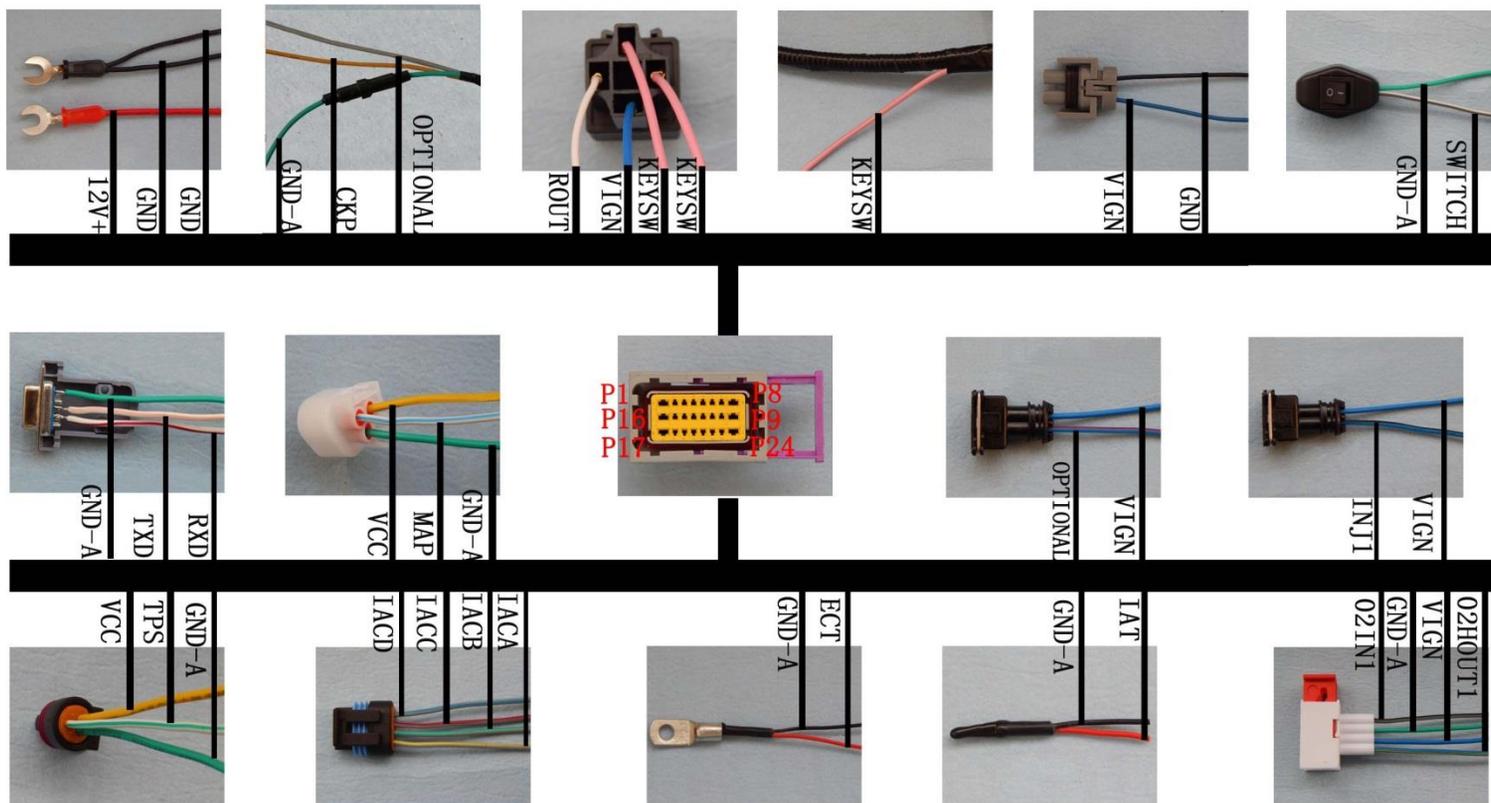
Picture 10

Test the max voltage with an oscilloscope if necessary.

	MAX voltage	Min voltage
Battery	16V	6V
Injector	40V	12V
Ignition coil (not CDI system)	400V	250V
Crank position sensor	150V	2V
VCC	5.1V	4.9V

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

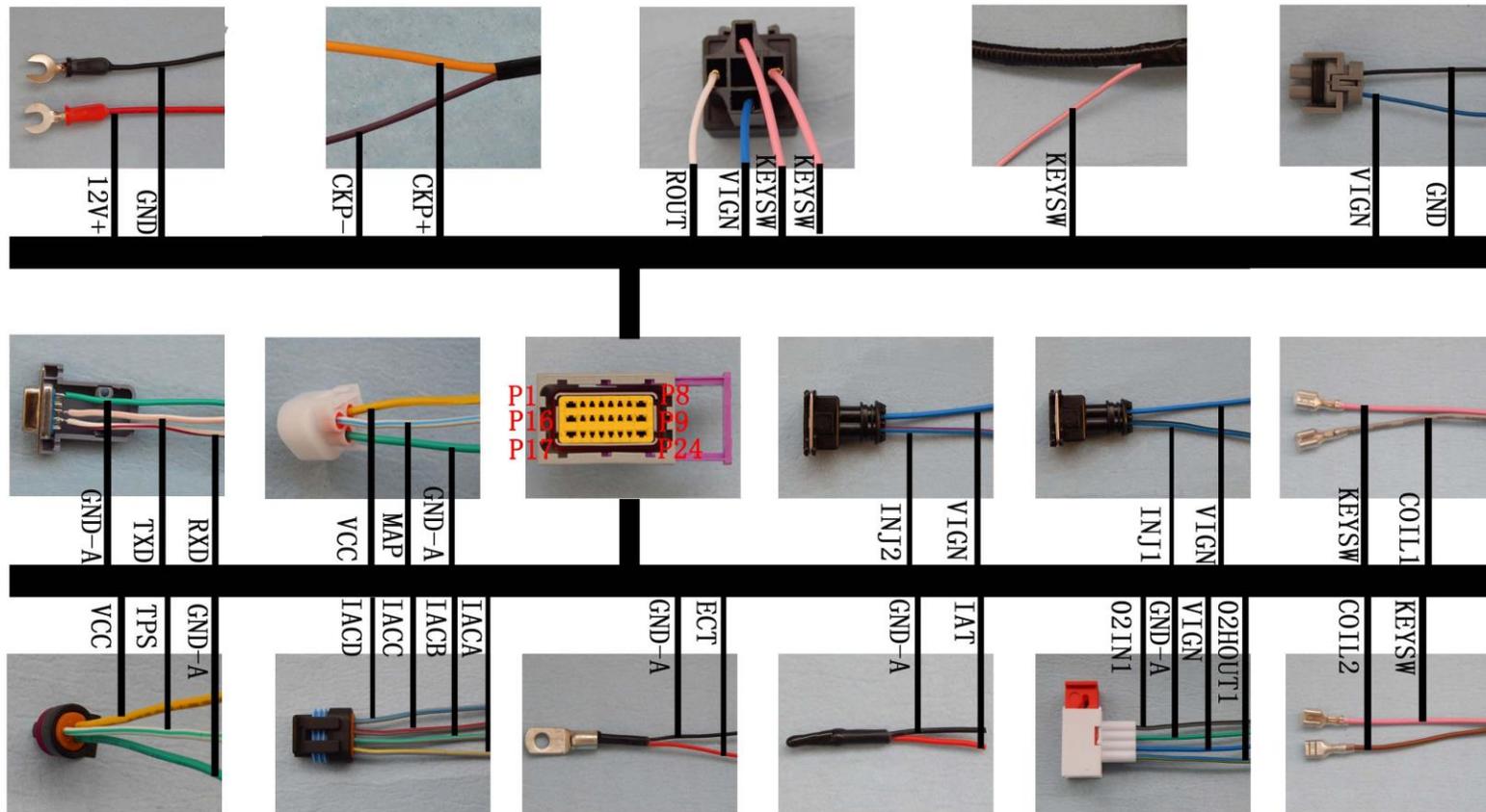
The wiring schematic is for **4-stroke 1 cylinder engine** (1 injector, 1 O2 sensors) with idle control motor (4 wires) and CDI ignition control. It is also compatible for two fuel injectors system. For different engines, like 2-stroke, 2 cylinders, w/ 2 injectors, some pin-out definitions or connector types are different.



Pin NO.	Component	Color	Description
P1	O2HOUT1	Blue/Yellow	O2 Sensor #1 Heater LS Driver output
P2	12V+	Red	Reverse Battery Protected Supply
P3	GND	Black	Power Ground
P4	VCC	Yellow	+5V Volt Supply Output
P5	RXD	White/Red	Sent Data to RS232
P6	SWITCH	Gray/White	Performance Switch
P7	TPS	White/Green	Throttle Position Sensor input
P8	GND-A	Green	Analog Ground
P9	IACA	Gray/Yellow	Idle Air Controller A
P10	MAP	White/Blue	Manifold Air Pressure Sensor Input
P11	IACD	Gray/Blue	Idle Air Controller D
P12	TXD	White/Pink	Receive data from RS232
P13	IAT	White/Yellow	Intake Air Temperature Sensor
P14	KEYSW	Pink	Key On Switch
P15	OPTIONAL	Blue/Red	Optional
P16	INJ1	Blue/Black	Injector #1 LS Driver Output
P17	GND	Black	Power Ground
P18	OPTIONAL	Gray	Optional
P19	IACC	Gray/Red	Idle Air Controller C
P20	ROUT	White	Power relay LS Driver output
P21	ECT	White/Brown	Engine (coolant) Temperature sensor
P22	IACB	Gray/Green	Idle Air Controller B
P23	O2IN1	Gray/Black	Oxygen Sensor #1 input
P24	CKP	Orange	Crank Position Sensor (connect igniting pickup sensor signal)

The wiring schematic is for **4-stroke 2 cylinders engine** (2 injector, 1 O2 sensors) with idle control motor (4 wires) and inductive Coil control. It can support multi-tooth trigger wheel, such as 12-1, 24-1, 36-2, etc.

It is also compatible for two-stroke with two fuel injectors or one fuel injector.

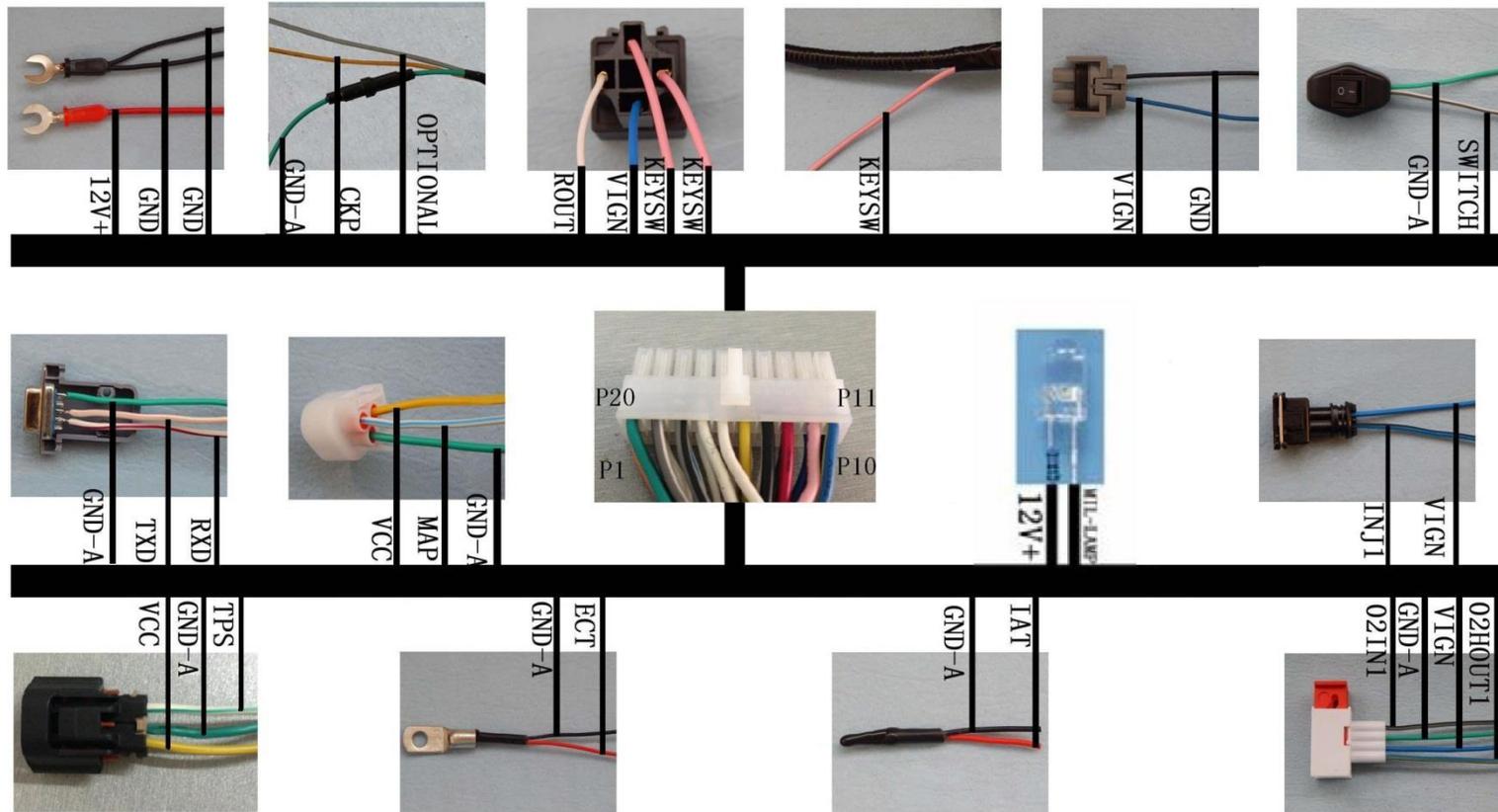


Pin NO.	Component	Color	Description
P1	O2HOUT1	Blue/Yellow	O2 Sensor #1 Heater LS Driver output
P2	12V+	Red	Reverse Battery Protected Supply
P3	IACC	Gray/Red	Idle Air Controller C
P4	VCC	Yellow	+5V Volt Supply Output
P5	RXD	White/Red	Sent Data to RS232
P6	IACA	Gray/Yellow	Idle Air Controller A
P7	TPS	White/Blue	Throttle Position Sensor input
P8	GND-A	Green	Analog Ground
P9	CKP-	Purple	Crank Position Sensor Negative
P10	MAP	White/Blue	Manifold Air Pressure Sensor Input
P11	IACD	Gray/Blue	Idle Air Controller D
P12	TXD	White/Pink	Receive data from RS232
P13	IAT	White/Yellow	Intake Air Temperature Sensor
P14	KEYSW	Pink	Key On Switch
P15	INJ2	Blue/Red	Injector #2 LS Driver Output
P16	INJ1	Blue/Black	Injector #1 LS Driver Output
P17	GND	Black	Power Ground
P18	COIL1	Gray	Ignition Coil #1 LS Driver output
P19	COIL2	Brown	Ignition Coil #2 LS Driver output
P20	ROUT	White	Power relay LS Driver output
P21	ECT	White/Brown	Engine (coolant) Temperature sensor
P22	IACB	Gray/Green	Idle Air Controller B
P23	O2IN1	Gray/Black	Oxygen Sensor #1 input
P24	CKP+	Orange	Crank Position Sensor Positive

Appendix II: ECU main connector pin-out (20-pin)

This wiring schematic 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.



Pin NO.	Component	Description
P1	CKP	Crank Position Sensor (connect igniting pickup sensor signal)
P2	Optional	Mil-lamp (Optional, Inj2: Blue/Red)
P3	MAP	Manifold Air Pressure Sensor Input
P4	IAT	Intake Air Temperature Sensor
P5	RXD	Sent Data to RS232
P6	TXD	Receive data from RS232
P7	ROUT	Power relay LS Driver output
P8	CDI-CTRL	CDI control signal
P9	INJ1	Injector #1 LS Driver Output
P10	GND	Power Ground
P11	O2HOUT1	O2 Sensor #1 Heater LS Driver output
P12	KEYSW	Key On Switch
P13	12V+	Reverse Battery Protected Supply
P14	GND	Power Ground
P15	VCC	+5V Volt Supply Output
P16	ECT	Engine (coolant) Temperature sensor
P17	TPS	Throttle Position Sensor input
P18	O2in	Oxygen Sensor signal input
P19	Per-SW	Performance Switch
P20	GND-A	Analog Ground