MSnS_Extra code Manual

Only for use with the MSnS-Extra code (MS1 based microprocessors)

by Philip Ringwood and James Murrey

For Manuals on other Megasquirt products please see: www.megasquirt.info for the Megasquirt EFI Forum see: www.msefi.com

Before you start tuning please read this entire manual, we appreciate it's rather long but it is important to read it. Take a few days to digest it or read it in small sections if it gets boring, but it will aid your install.

For Hardware mod's e.g. Launch Control, etc, please see the main **MSnS-Extra website**

Fuel / General

Upgrading to the Extra code

The standard MS ECU from a B+G recommended supplier will most probably come with the standard V3.0 code unless you have specifically asked for an Extra code or if you bought an assembled ECU from me at **ExtraEFI.co.uk**

To upgrade to an Extra code start by downloading the latest stable release from the MSnS_Extra website **HERE**. Unzip the file and open the first dir (e.g. 029t) Now double click on the "download-firmware.bat" file.
Select your Comm port (e.g. 1) then select "N" if you have an Extra code already running and are upgrading to a later version or "Y" if you have a standard V3.0 B+G code.

If using the standard B+G code you will need to have the lid removed so you can short the 'Boot loader' terminals out when instructed.

After the counter has reached somewhere around 1400 -1700 depending on the code version, the display will show you the version you have burnt to the ECU and the battery voltage. Now your MS will run again.
You have now finished re programming the ECU. You now need to setup your configuration in Megatune or Megatunix before attempting to start the engine. Having a file ready to burn is very helpful, there are some basic files **HERE**, but these are to be used at your own risk, they are only to be used as a base configuration and should be checked that they are setup for your Spark configuration.

It is VERY important to remember to have any coil packs unplugged from the MS ECU during the download. Keep them unplugged untill you have set up your ECU with the relavent Spark settings in Megatune. See HERE for more details of the settings.

If you are upgrading due to using your original sensors or non-standard MS sensors see these instructions **HERE**
There are some sensor files from various vehicles **HERE,** again these are used at your own risk.

Tuning Your MegaSquirt

Now that you have installed your MegaSquirt, you need to get your engine started and tuned. This is not too difficult if you work methodically, and do not let your enthusiasm prod you into a premature full-throttle melt-down. It does help if the engine was running before the conversion, and does not need a pile of tune-up/rebuild parts.

Read this entire tuning section first, before attempting to start or tune your car. There may be some later passages that will help you in earlier steps, depending on your installation details. You will get the 'big picture', and the tuning process should make more sense to you. Reread this section if necessary.

When you do your conversion, it helps if you can hook the fuel injection up (sitting on the fender) except for the actual injectors, while still running the engine on its original fuel system. This allows you to start the engine and verify that the temperature sensors, TPS sensor, the O_2 sensor, fuel pump, etc., work as expected. It will ease your mind when you proceed to running on MegaSquirt. If you have a running engine, it is something you might consider.

Tuning Theory

Tuning involves setting all the parameters that MegaSquirt uses to be optimal for your engine, injection, and driving. These include things like cold start pulse widths and acceleration enrichments. The most fundamental parameters are in the 12×12 volumetric efficiency table.

In general, this is all much easier to understand when you are working on a running engine. Trying to estimate what your engine will specifically need beforehand can be more confusing than productive. It is worthwhile exercise to understand the requirements, but always remember that ultimately you will rely on your “seat of the pants” and O_2 sensor (as well as drag strip times, exhaust gas temperature sensors, etc. etc., if you have them available) to tune your engine.

Remember that people tuned engines for maximum performance and efficiency for many years with carburetors without any quantitative feedback at all. They often got very good results The O_2 sensor and MSTweak3000 make tuning much easier. By the time you have had a few sessions with MSTweak, you will have a better idea of how to tune the remaining areas.

When tuning:

- Read this entire section first before starting to tune, and be sure you understand what you read,
- Do not change more than one thing at a time and always be able to get back to where you started,
- Do not try to drive the car if you can not get it to idle properly, fix the idle first,
- Do not try to tune accel before you have tuned VE,
- If you report a problem to the list, please supply details, do not just say it does not work.

If you have a settings file from someone else's similar configuration, by all means use it as a start. Using other people's settings and tables is a reasonable starting point for tuning. However, no-one should ever assume another person's table is totally right for their engine, even if it is seemingly identical. The reason is that the tolerance build-up of variables makes things different. Small changes (within acceptable tolerances) in injector flow rates, regulated fuel pressure, MAP sensor output, etc., etc., etc., can add up to needing quite different settings and tables. This is especially true of the more subjective parameters, like accel enrichment, and those that interact, like afterstart enrichmnet and warm-up enrichment.

Also when transferring configuration files (msq files) from others or from the Internet or simply changing settings in Megatune please ensure that the Outputs are setup for your ECU before downloading it to your MS ECU.
To check this open Megatune (MT) open the msq file and when asked whether to burn click "N".
Then go to Code Config - Codebase and Output Functions:

Single Spark output MS ECU (MSD or Distributor or EDIS module, TFI, etc)
LED17 (D14) = SparkA

LED18, LED19 and Output3/SparkD must NOT be a Spark output

Two Spark output MS ECU (4 cylinder wasted spark)
LED17 (D14) = SparkA
LED18 (D15) and Output3/SparkD must NOT be a Spark output
LED19 (D16) = SparkB

Three Spark output MS ECU (6 cylinder wasted spark)
LED17 (D14) = SparkA
LED18 (D15) = SparkC
LED19 (D16) = SparkB
Output3/SparkD must NOT be a Spark output

Four Spark output MS ECU (8 cylinder wasted spark)
LED17 (D14) = SparkA
LED18 (D15) = SparkC
LED19 (D16) = SparkB
Output3/SparkD = SparkD

Note that in this manual we assume you are running gasoline. However, other fuels have different Air/Fuel Ratio (AFR) requirements. Below is a chart of the equivalent air/fuel ratios for several popular fuels:

Air/Fuel Ratio Equivalents					
Lambda	**Gasoline**	**Propane**	**Methanol**	**Ethanol**	**Diesel**
0.70	10.3	11.0	4.5	6.3	10.2
0.75	11.0	11.8	4.9	6.8	10.9
0.80	11.8	12.5	5.2	7.2	11.6
0.85	12.5	13.3	5.5	7.7	12.3
0.90	13.2	14.1	5.8	8.1	13.1
0.95	14.0	14.9	6.1	8.6	13.8
1.00	14.7	15.7	6.5	9.0	14.5
1.05	15.4	16.5	6.8	9.5	15.2
1.10	16.2	17.2	7.1	9.9	16.0
1.15	16.9	18.0	7.4	10.4	16.7
1.20	17.6	18.8	7.8	10.8	17.4
1.25	18.4	19.6	8.1	11.3	18.1
1.30	19.1	20.4	8.4	11.7	18.9

Lambda is the ratio of a given AFR (air/fuel ratio) to the stoichiometric AFR for that fuel. So if a gasoline engine is rich, say 12.5:1, lambda is:

$$12.5:1 \div 14.7:1 = 0.85$$

Tuning Software

There are a few software applications to help you tune and configure your MegaSquirt.

- **MegaTune** - for tuning and data logging MegaSquirt with a laptop computer running Windows 9x/ME/XP. (Eric Fahlgren)
- **MegaTunix** - for tuning/datalogging/datalog playback Megasquirt with Linux, Mac OS-X and Windows. (David J. Andruczyk) Screen shots of Megatunix are available **HERE** In order to run this on a windows machine you'll need GTK+ Runtime from **HERE**

- **MegaTweak3000** - for refining your volumetric efficiency table from datalogged data, (Darren Clark),
- **EasyTherm** - to simplify configuring your MegaSquirt to accept the substitution of non-standard temperature sensors and to upload software revisions. (Roger Enns) See the **help files HERE** for more information on this and how to change the sensors in the MSnS_Extra code
- **MS Palm** - to tune and datalog with a Palm (Roger Enns)
- **MegaLogViewer** - A very good log veiwer which is configurable making it suitable for MSnS_Extra's extra features.Download these programs by clicking on their links above.

Note: If you get a pop-up message stating,

Component 'COMDLG32.OCX' or one of its dependencies is not correctly registered: a file is missing or invalid.

you need to download this file and/or register it.

To fix this error,

- download **COMDLG32.OCX** You can download COMDLG32.OCX from:

  http://www.ascentive.com/support/new/support_dll.phtml?dllname=COMDLG32.OCX

  or

  http://www.snapfiles.com/help/missingfiles.html

- copy it into the **\Windows\System** directory (Win 9x/Me) or **\Windows\System32** (WinXP) directory.
- open the run dialog box using "Start Run..." and enter:

  Regsvr32 c:\windows*SystemXX*\comdlg32.ocx

  to register the file. (*SystemXX* should match the directory to which you saved the file)

To tune all the parameters of MegaSquirt so that your engine runs the best it can, you will need to do the following:

1. First, learn to use MegaTune (*or MegaTunix*),
2. Next, set the constants, (these should be set if you bought through **www.ExtraEFI.co.uk**)
3. Set the codebase and output functions (again these should be be set if you bought through **www.ExtraEFI.co.uk**)
4. Get the engine started and idling,
5. Then set the PWM criteria,
6. Then set the cold start and warm-up enrichments,
7. Then set the VE table,
8. Set the acceleration enrichments,
9. Check that certain resistors are not getting too hot while driving.

We will go through each of these steps in turn.

Using MegaTune

MegaTune is the Windows 95 and later configuration editor for the MegaSquirt EFI controller. You can download the latest version from the MS Forums file download section at:

http://www.msefi.com/dload.php?action=category&cat_id=26.

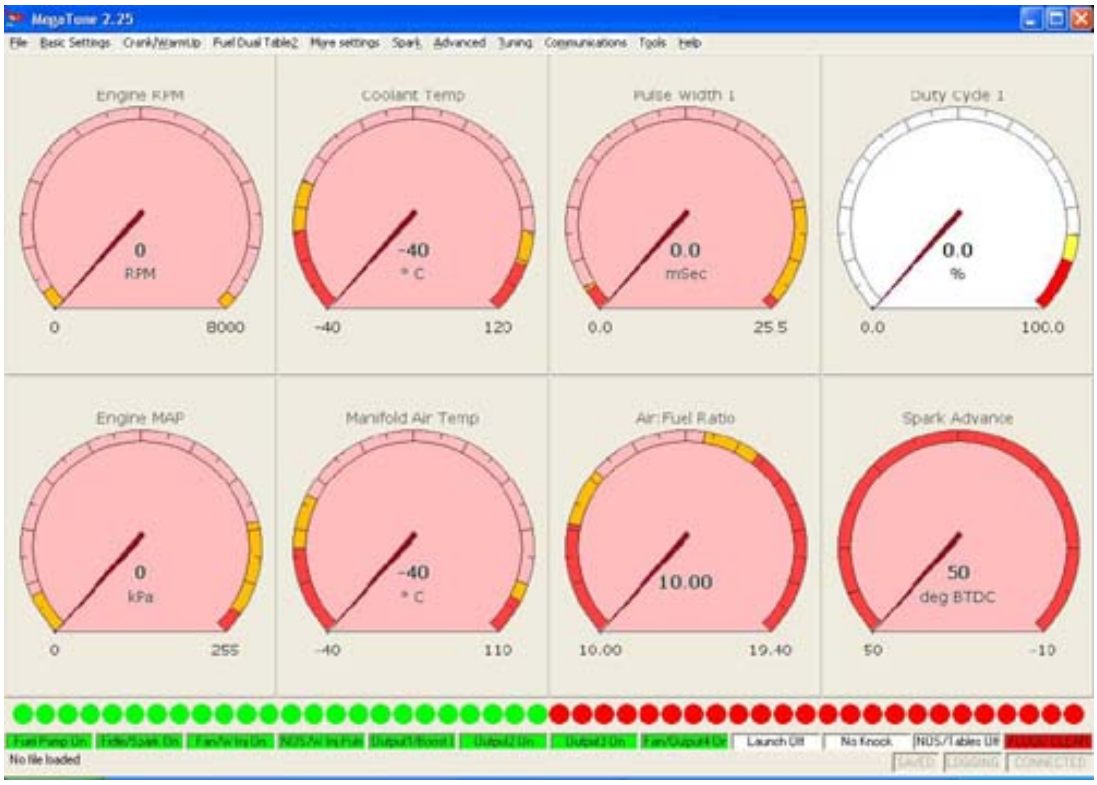
In order to get Megatune to run on the Extra code youll need to do this:

Open the Firmware directory downloadable from **HERE** (e.g. 029t) Double click on "**copyini.bat**" This loads the msns-extra.ini file from the code's directory into
c:\program files\megasquirt\megatune2.25\mtcfg
it will overwrite the one thats in there.

Next we need to load in the correct settings.ini file for MegaTune to use the "Extra" code. This is done by double clicking on the "**Copy_settings.bat**" This copies the settings.ini file from the code's directory into
c:\program files\megasquirt\Car1\mtcfg
it will overwrite the one thats in there.

MegaTune allows all of the parameters to be modified and has a real-time VE table editor, which allows a vehicle passenger to tune the engine while driving.

*Note that instead of MegaTune, you can use **MegaTunix** tuning/datalogging software which is setup for Extra code 029t for Linux, Unix and Mac OS-X (and now cross-compiled for Windows) for tuning your MegaSquirt.*



Pulse width is the measure in milliseconds ($^1/_{1000}$ of a second) of how long the injector is opened for each pulse, regardless of how many times it is opened in a cycle. Duty cycle gives the percentage of time the injector is open irrespective of individual pulse duration.

The bar gauge across the bottom of the window shows the oxygen sensor reading. The scale is determined by egoGauge value in the Tuning section of the megatune.ini file. This same setting controls the analog and bar gauges on the tuning page. The first value of this setting controls the lowest voltage displayed on the gauges, the second number controls the highest and the optional third value specifies the "alert" value, above which the LEDs are red. The bottom of the front page contains a status bar. The current file name (used for Save operations) is displayed in the left part of the status bar, followed by "saved" status. When the memory image has been modified since the last Open or Save operation, this entry shows "**SAVED**" in bold face.

MegaTune allows you to save and restore configurations as files. Use the "Open", "Save" and "Save As" menu items to do this.

Pressing *'F1'* in any of the setting boxes will show some Help files and some suggested values.

You should check that MegaTune reads approximately the correct barometric pressure when no vacuum is applied (i.e. the engine isn't running). Below is a chart of the 'normal' barometric pressures for various geographic elevations. MegaSquirt should generally be within 4 or 5 kPa of the value below for your elevation. If it is significantly different, check that you have the correct ".inc" files loaded for MegaTune. See the MegaTune help file for more details.

Barometric Pressure vs. Elevation

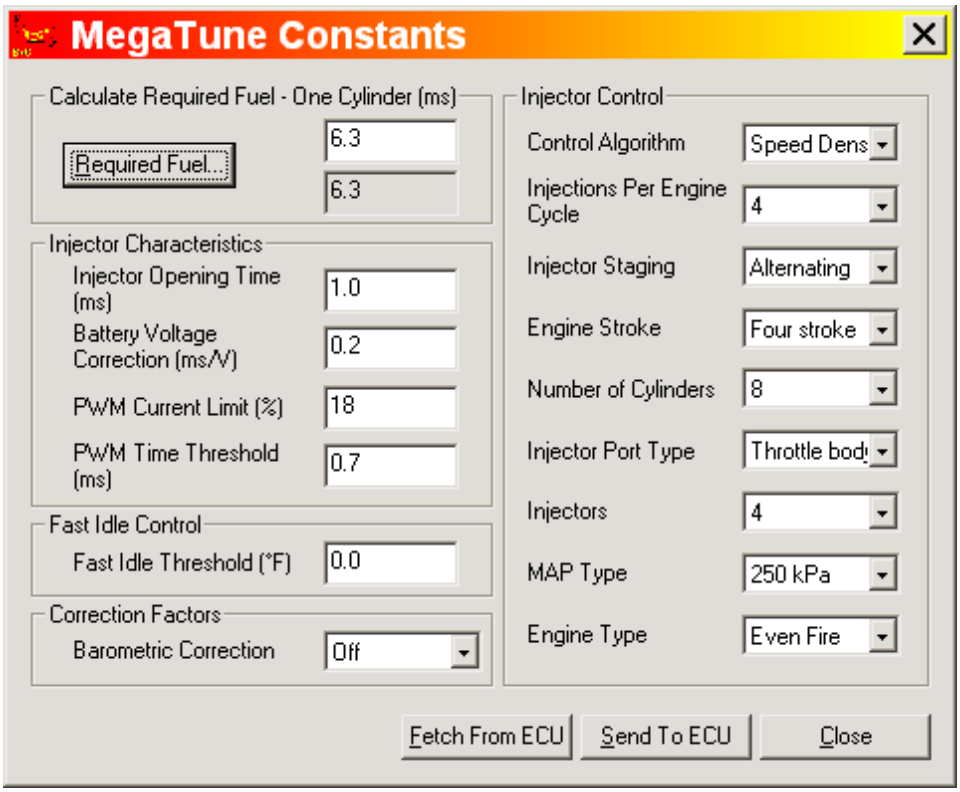
Elevation Above Sea Level		**Atmospheric Pressure**	
Feet	**Meters**	**kiloPascals (kPa)**	***example***
0	0	101.33	New York, Vancouver, Washington
500	153	99.49	Dallas (435 feet), Detroit (585 feet)
1000	305	97.63	Geneva (1230 feet), Kelowna (1129 feet)
1500	458	95.91	Helena (1404 feet), Wichita (1290 feet),
2000	610	94.19	Canberra (1886 feet), Las Vegas (2030 feet), Regina (1893 feet)
2500	763	92.46	
3000	915	90.81	Red Deer (2968 feet)
3500	1068	89.15	Brasilia (3480 feet), Calgary (3750 feet)
4000	1220	87.49	
4500	1373	85.91	Banff (4500 feet)
5000	1526	84.33	Albuquerque (4945 feet), Denver (5280 feet)
6000	1831	81.22	Colorado Springs (5890 feet)
7000	2136	78.19	Mexico City (~7200 feet)
8000	2441	75.22	
9000	2746	72.40	
10,000	3050	69.64	
15,000	4577	57.16	La Paz (13,169 feet), Mauna Kea (~14,000 feet)

Note that weather reports usually report the barometric pressure 'corrected' to read as if 101.3 kPa was the 'normal' for your elevation. Do not expect these reports to correspond to what you get on MegaSquirt unless you are at sea level.

Setting the Constants

Before attempting to start your MegaSquirt equipped engine, you will need to set a number of parameters that determine how MegaSquirt injects fuel. These include the injector open time, Req_Fuel, injector control criteria, PWM criteria, EGO characteristics, etc. These constants are either calculated, or based on the configuration of your system.

Note that for a Wankel rotary engine (Mazda 13B, etc.), see the MegaSquirt & Rotary Engines document for settings and other advice.



On the Settings/Constants page:

If you are running **high-impedance injectors** (greater than 10 Ohms), then set the:

- **PWM Time Threshold** to **25.4 msec**, and the
- **PWM Current Limit (%)** to **100%**.

If you have **low impedance injectors** (less than 4 Ohms), set the:

- **PWM Time Threshold** to **1.0 msec**, and
- **PWM Current Limit** to **75%**(30% if you have installed the 'Flyback Board' daughter card).

You will tune these after getting the engine running. See “Setting the PWM Criteria” in this section. **Failure to perform these steps can result in damage to your injectors**. If you have high-impedance injectors, set these values to 25.4 ms and 100%, and you do not need to tune them further.

“**Control Algorithm**” lets you choose between Speed Density and Alpha-N. In all cases, you should choose speed density unless you have a good reason to do otherwise, and understand how this will change your tuning efforts. All tuning advice in this manual is based on the speed-density algorithm. Alpha-N uses the throttle position (alpha) and RPM (N) to calculate the amount of fuel to inject as opposed to using the manifold absolute pressure (MAP) and RPM to calculate the amount of fuel to inject. Alpha-N is useful for long duration cams where the resolution of manifold air pressure (map) would be small. It is also useful to get smoother idle on engines that have erratic map values. MegaSquirt be converted from its default **speed-density** calculations to **Alpha-N** which uses RPM, temperature and TPS only. Start up the tuning software, go to the Constants dialog and change speed density to Alpha-N. Re-map your VE table. You will no longer use the MAP sensor for estimating the load on the engine -- the throttle position and rpm are used instead. This can help with cams with long duration and/or a lot of overlap, as they have low and variable vacuum at idle, making tuning very difficult. You will need to change the "Settings.ini" file in Megatune before you can proceed. Find "settings.ini" in c:/programfiles/megasquirt/Car1/mtCfg/ and open it in a text editor. Then find this text:

#group Fueling_Algorithm "Fueling Algorithms (Speed Density DEFAULT)"
; Some code variants have been modified to allow alpha-N, almost
; none have MAF support, so beware of partial implementations in
; ini files.

set SPEED_DENSITY "Speed Density Fueling Algorithm (Off=Alpha-N)"

unset ALPHA_N "Alpha-N fueling Algorithm"
unset AIR_FLOW_METER "Use an Air Flow Meter rather than a MAP sensor for fueling algorithm"

change this to:

#group Fueling_Algorithm "Fueling Algorithms (Speed Density DEFAULT)"
; Some code variants have been modified to allow alpha-N, almost
; none have MAF support, so beware of partial implementations in
; ini files.

unset SPEED_DENSITY "Speed Density Fueling Algorithm (Off=Alpha-N)"
set ALPHA_N "Alpha-N fueling Algorithm"
unset AIR_FLOW_METER "Use an Air Flow Meter rather than a MAP sensor for fueling algorithm"

save the file, now your load scale in Megatune's VE Tables should have TPS.

Required Fuel – (Req_Fuel) this is top field of the Constants window. It has a calculation dialog to help you find an appropriate value. It should contain the injector pulse width, in milliseconds, required to supply the fuel for a single injection event at stoichiometric combustion and 100% volumetric efficiency.

In order to come up with this value, MegaTune provides a calculator that will suffice for 99% of applications (those for which it will not work generally require changes to the MegaSquirt controller code itself, and that is beyond the scope of this manual). To use the calculator, click on the Required Fuel button, and fill in the fields (*Engine Displacement, Number of cylinders, Injector flow,* and *Air:Fuel ratio*, then click 'Okay').

For a 4-stroke, a complete stroke cycle is 720 degrees of crankshaft rotation (i.e. two revolutions); for a 2-stroke, it is 360 degrees (this is also factored in the REQ_FUEL value down loaded to MegaSquirt).

In the tuning software, the **upper REQ_FUEL box** is the amount per cylinder, as noted above. The **lower REQ_FUEL box** is the value down loaded to MegaSquirt. It is the REQ_FUEL number on top, but scaled by your selected injection mode (number of squirts and alternate/simultaneous).

For example, if you inject simultaneous and one injection, and have the same number of injectors as cylinders [i.e. port injection], then REQ_FUEL on the bottom is the same as REQ_FUEL on top. Same with alternate and two squirts. If you put in simultaneous and two squirts, then REQ_FUEL is divided in half - because you squirt twice, you need to inject 1/2 the fuel on each shot.

Note: if you choose alternating for port injection, make sure your number of squirts is an even number (2,4,...) and evenly divisible into the number of cylinders. For example, with an eight cylinder engine, you could use alternating and 2, 4, or 8 squirts/cycle. With a six cylinder, if you choose alternating, you MUST use 2 or 6 squirts/cycle. Also, the only possible combinations for an odd-cylinder count engine are either 1 squirt/simultaneous or N squirt/simultaneous combination, where N is the number of cylinders."

Permissable Combinations:

Number of Cylinders

	1	2	3	4	5	6	8	10	12
1	OK	*simultaneous only*	*simultaneous only*	*simultaneous only*	*simultaneous only*	*simultaneous only*	*simultaneous only*	*simultaneous only*	*simultaneous only*
2	no	OK	no	OK	no	OK	OK	OK	OK
3	no	no	*simultaneous only*	no	no	*simultaneous only*	no	no	*simultaneous only*
4	no	no	no	OK	no	no	OK	no	OK
5	no	no	no	no	*simultaneous only*	no	no	*simultaneous only*	no

Number	6	no	no	no	no	no	OK	no	no	OK
of	7	no	no	no	no	no	no	no	no	no
squirts	8	no	no	no	no	no	no	OK	no	no
	9	no	no	no	no	no	no	no	no	no
	10	no	no	no	no	no	no	no	OK	no
	11	no	no	no	no	no	no	no	no	no
	12	no	no	no	no	no	no	no	no	OK

*"**OK**" means the combination will work with either simultaneous or alternating. "no" means it will not work with either, i.e., not at all.*

Injector Opening Time (ms) is the amount of time required for the injector to go from a fully closed state to a fully opened state when a 13.2 volt signal is applied. Since fuel injectors are electro-mechanical devices with mass, they have latency between the time a signal is applied and the time they are in steady-state spraying mode. Typically, this value is very close to 1.0 milliseconds.

The current MegaSquirt controller code assumes that NO fuel is injected during the opening (and closing) phases. However, it is very likely that a small amount actually is injected. Thus making this value larger will enrich the mix and will have a much greater effect at low pulse widths. MegaSquirt also uses this value as an additive constant in pulse width calculation, thus making this the lower limit for pulse width.

Injections per Engine Cycle is set the number of squirts you want per engine cycle. You want this to be set so that your idle pulse width is no less than 2.0 ms, if possible, and your Req_Fuel is less than 12-15 milliseconds, but more than 8 milliseconds. These values allow proper tuning of the idle mixture while maintaining the ability to apply enrichments (acceleration, warm-up, etc.) under full throttle. This is the total injector events that you wish to occur for every engine cycle (360 degrees for two stroke engines and 720° for four strokes).

Injector Staging values for injector staging are simultaneous or alternating. If you want all your injectors to fire at once, select simultaneous. If you want half your injectors to fire at each injection event, and the other half on the next event, select alternating.

Note that with port injection, you must choose at at least 2 squirts per cycle with alternating injection, otherwise every other cycle for each cylinder will get NO fuel! The engine will run very badly.

There is some benefit to choosing 2 squirts/alternating for port injection, since only half of the injectors fire at once, the pressure drop in the fuel rails is reduced and the fuelling is more consistent.

With throttle body injection, the number of injection/cycle you can will depend on your number of cylinders, plenum size, Req_Fuel, etc. You have to experiment to see what works best for your combination.

Engine Stroke values for engine stroke type are two-stroke or four-stroke. MegaSquirt uses engine stroke to determine how many degrees are in an engine cycle.

Number of Cylinders is the count of the cylinders on your engine. If you are unsure how many cylinders your engine has, you should not be installing MegaSquirt on it. This value is actually the number if ignition events per cycle sent to the ignition input on the controller.

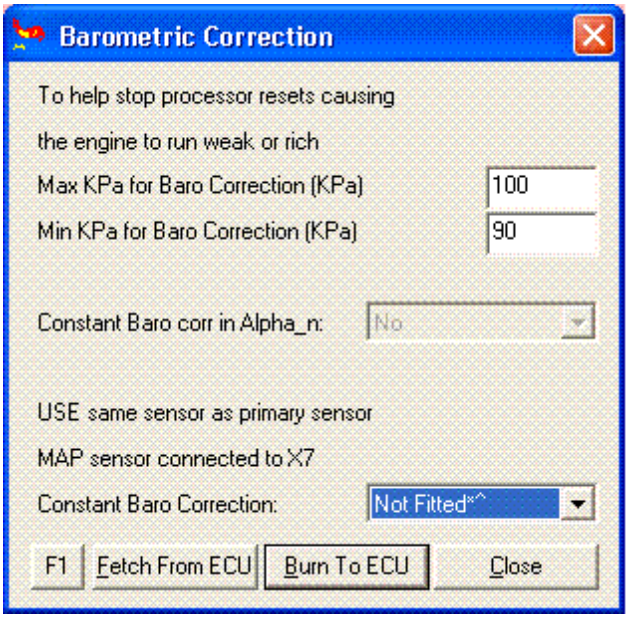
Injector Port Type This is not used in MSnS_Extra, so no settings needed for this, it should be greyed out.

Number of Injectors is the total number of injectors MegaSquirt is controlling, whether port or throttle body injection.

MAP Type this should be set to 250KPa type even if you have a 300 or 400Kpa sensor, unless you have an older V1 pcb that could have a 110KPa sensor

Barometric Correction On start-up MegaSquirt can record the ambient barometric pressure if set to ON in the Constants page. The barometer correction multiplier to VE increases as pressure decreases. If it the ambient baro pressure is low (high altitude) the algorithm adds fuel. This is mostly because at a given MAP, the engine will flow more air with less exhaust back pressure and therefore needs more fuel at higher altitudes. Once running the MAP sensor determines fuel based on you VE table entries which are then scaled by the baro correction

recorded at start-up. The correction values used by MegaSquirt came from a code disassembly of a 1990 Corvette ECU. As the barometric correction is determined when the ECU powers up if it resets during running the current MAP value is taken in, the chances are the engine will be creating a vacuum so the value would be incorrect. You can set up limits so the correction is not so far out if the ECU resets. See "Barro Corrections" If you are unsure set the minimum to 10 and the max to 110 KPa and it will have no real effects.



If using Alpha-n mode then you can use the MAP sensor thats on the MS board as a constant barometric correction sensor, but dont connect it to the manifold, simply leave it vented to atmosphere. .
A way to gain Constant Baro Correction when in normal speed density mode is by fitting an extra MAP sensor to input X7 (JS5 V3.0) The MAP sensor MUST be the same type as fitted to your MS.

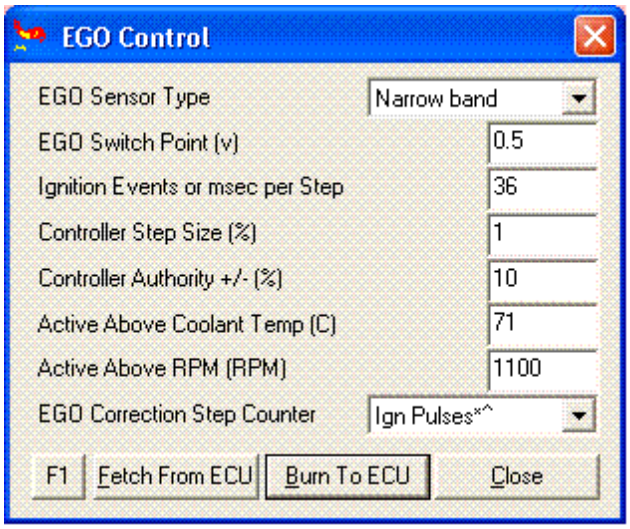
Engine Type has the options of Odd fire or even fire. Odd-fire or even fire does not refer to the firing order, but rather the interval between successive firings.

So if you have a 4 cylinder, and a spark every 180 degrees, you have an even fire. Almost all 4 cylinder engines are even fire.

However some 90 degree V6s, some V4s, and most V-Twins (usually motorcycle engines), as well as a few others, have 'odd-fire' arrangements.

For example, from 1978 to 1984, the GM V6 (200 and 229 cid) had a semi-even fire sequence, with firing intervals of 132°/108°. It is "semi" because the rod journals are offset, but not quite enough to make for even firing intervals. In MegaSquirt terms, this is an 'odd-fire' engine, because the interval between firing can be either 132° OR 108° degrees.

On the Exhaust Gas Settings page:



Set the **EGO switch point** to a value between 0.45-0.50 volts with a narrow band O_2 sensor. With a wide-band sensor, set it at 2.50 volts (DIY-WB, others may differ). These values will attempt to give stoichiometric mixtures under closed loop operation. Note that MegaSquirt will convert these values to binary numbers, so when you "fetch" the values back from MegaSquirt, they are converted back and may change slightly.

Again in Megatune you will need to change the "settings.ini" file if you have a wideband sensor. Find the "settings.ini" file in : c:/programfiles/megasquirt/Car1/mtCfg/ and open it in a text editor. Then find this text:

#group LAMBDA_SENSOR "Lambda Sensor Type"
 # set NARROW_BAND_EGO "Narrowband Sensor"
#unset WB_1_0_LINEAR "Wideband in NB Emulator Mode, 0-1v 1.5:0.5 Lambda"
#unset AEM_LINEAR "AEM Gauge AEM-30-42xx"
#unset AEM_NON_LINEAR "AEM UEGO Controller AEM-30-230x"
#unset DIYWB_NON_LINEAR "DIY-WB or Tech Edge non-linear output"
#unset DYNOJET_LINEAR "DynoJet Wideband Commander"
#unset TECHEDGE_LINEAR "Tech Edge sensor giving 0-5V 9-19:1 AFR"
#unset INNOVATE_1_2_LINEAR "Innovate sensor giving 1-2V 10-20:1 AFR"
#unset INNOVATE_0_5_LINEAR "Innovate, PLX 0-5V 10-20:1 AFR"
#unset INNOVATE_LC1_DEFAULT "Innovate LC-1 default, 0-5v = 0.5-1.5 lambda"
#unset ZEITRONIX_NON_LINEAR "Zeitronix Non-linear WB"
#unset WB_UNKNOWN "Wideband sensor but none of the above types"
#endgroup

change the NARROW_BAND_EGO to **#unset** then change your sensor to **#set** xxxxxxxxx

Note: If you do not have an oxygen sensor, be sure to set the EGO Step (%) on the enrichments page to zero, so that MegaSquirt will not try to use any stray signal from the O_2 sensor input pin.

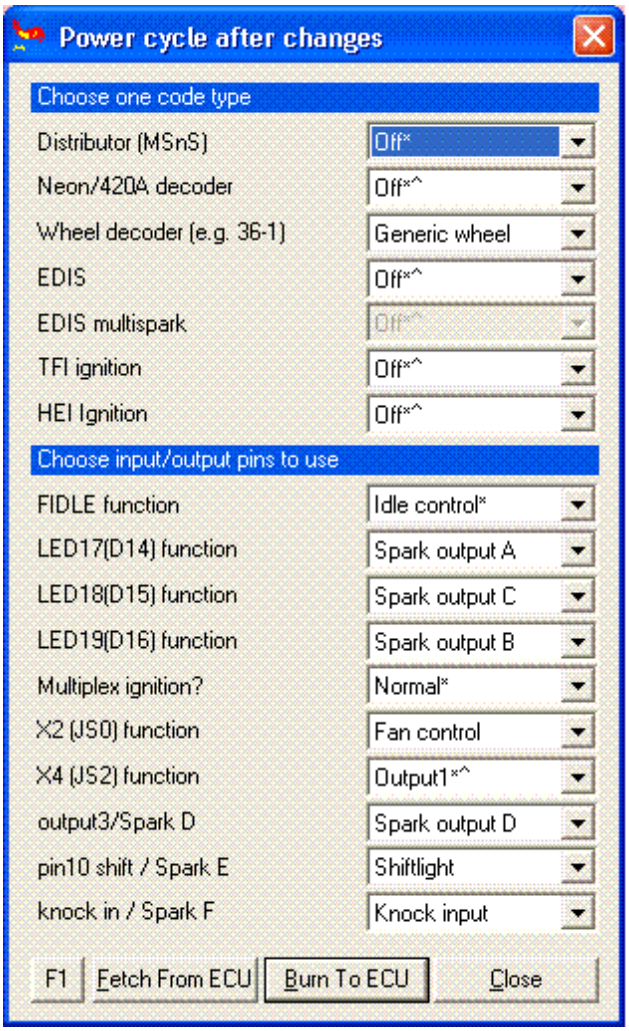
On the Communications/Settings page:

Port - The communications port number should correspond to the port to which the MegaSquirt controller is attached.

Timer Interval (ms) - The timer interval dictates how frequently the runtime and tuning displays are updated. An interrupt is generated at the specified interval, and the real time data is pulled down from the MegaSquirt controller. Use 100-200 ms to start; you can try to smaller values (ex. 50 ms) if your computer is fast enough.

Verify ECU Communications - Click this button to attempt communications with the MegaSquirt controller. Success will be reported.

Codebase and output Functions



When running ignition you must choose **ONLY ONE** code type and select as many spark outputs as you have coils
A **distributor** based setup must have **SparkA ONLY**;

A 4cyl wasted spark setup must have **SparkA, SparkB ONLY**, so **LED18 MUST** be set to anything other than a **Spark output, e.g. Warmup. Output3/SparkD** MUST be set to **output3, pin10 shift / Spark E** MUST be set to **Shiftlight** and **Knockin / Spark F** MUST be set to **Knockinput** even if they are not going to be used for those functions.

A 8cy wasted spark would be like this example, **ABCD spark** outputs set **ONLY,** so **pin10 shift / Spark E MUST** be set to **Shiftlight** and **Knockin / Spark F** MUST be set to **Knockinput** even if they are not going to be used for those functions.

For a **FUEL ONLY** setup with a simple tach input signal (i.e. not a 60-2 wheel) turn **OFF** all ignition types and spark outputs **(Ensure Spark A,B,C,D,E or F are NOT selected)**

If you are running a multi-toothed wheel like 36-1, 60-2, 24/2 etc. you have to configure the wheel decoder as if you were running spark and set a minimum of **SparkA**
Choose I/O pin usage.
FIdle = usually idle control, see Idle valve control, previously it has been used as sparkA output but we use **LED17/D14** now.

LED17/D14 is prefferred **SparkA** output for ignition setups.
Spark outputs must be used in sequence, i.e. for two outputs (4cy wasted) you must use A,B
X2 (JS0) output = Water Inj or Cooling Fan Control, if your not using either of these then it makes no difference what you select.
X4 (JS2) output = Output1 or Boost Control, if your not using either of these then it makes no difference what you select.

Please see the Ignition selection section for more info on these settings.

Pulsing Fuel Pump

The Extra code shows that there is a setting conflict by pulsing the fuel pump on and off constantly, this is used to protect the ECU and your setup from incorrectly set outputs, etc. The conflict can be found by using Megatune or Megatunix's "Mini Terminal", this can be found in the "Communications" sub heading. Simply re-start the MS with the mini terminal running and connected to the MS and it will tell you the error that must be rectified.

Before Starting Your Engine

If your engine is newly assembled, consider running it on a known good carburetor before attempting to run it on MegaSquirt. This way you wont have to worry about proper run-in for the cam shaft, proper ignition timing, etc., while trying to get a reasonable initial tune into MegaSquirt.

The cranking pulse width at -40°F should be about 3 to 5 times the 170°F value. To begin, set the -40°F cranking pulse width to about 88% of your "upper" req_fuel value, and the 170°F cranking pulse width to about 23% of your req_fuel. Those should get you 'in the ball park' for starting. (Once you have the engine running, you can tune the cranking pulse widths with small changes, moving them up or down together, and check it over a few days worth of starts before deciding which direction to go next.

Before starting, make sure to:

- Have two fully charged fire extinguishers on hand,
- Check the entire fuel system, from the tank to the injectors and back, for leaks while running the fuel pump. DO NOT attempt to start the engine if there are ANY leaks whatsoever. **Fix any leaks before proceeding**.
- Check that the fuel pressure is appropriate for your system (usually about 42-45 psi for port injection when not running, usually around 12-15 psi for throttle body systems).
- Verify that you have powered your MegaSquirt form a +12V source that will supply current **while cranking**. Many reported problems with MegaSquirt have been traced to power sources that are connected in “run” but not while cranking. Check your vehicle wiring diagrams if you are not sure. Some basic drawings for MSnS_Extra codes can be found here

> If you find that MegaSquirt is resetting while cranking, and you have verified that you have 12 volts to MegaSquirt while cranking, this is probably due to a 'noisy' alternator. To check, try disconnecting your alternating with the engine off (**do NOT disconnect it with the engine running or cranking!**), then crank the engine. If the resets stop, you've found your problem. Replacing the alternator connector only with the engine off. To fix the 'noisy' alternator, you can make a few modifications; using the MegaSquirt schematic (V2.2) for reference, try the following:
>
> **NOTE: First, be sure that all the grounds from your engine, alternator, and frame are in good shape and tight. And you may find that simply replacing the diode trio and the brushes in the alternator would be a cheaper and easier fix than doing the below.**
>
> If you have **coil packs** driven directly from the MS ECU then you should try fitting resistive plugs and plug leads. If this still doesn't fix it fit a 20-25uF capacitor between the +12V feed that's on the coil pack and a good chassis ground. Get the capacitor as close to the coil pack as possible. These are fitted to Ford coil packs in the engine bay and should be easy to get from a scrap yard.

- If you have a throttle body injection (TBI) system, verify that there is a small squirt of fuel (equal to the “prime pulse”) when MegaSquirt is powered up (by turning the ignition key to run), and that no more fuel is injected until cranking starts. If this is not the case for your system, find out what is wrong and correct it.
- Connect your laptop to your MegaSquirt using a DB-9 cable, turn the ignition to run (do not start it), and verify that all the sensors give reasonable values. The MAP should be about 100 kPa, the coolant and intake air temperatures should be approximately the same as the outside air, and the TPS should read from 0 to 100% as you open the throttle. Note that MegaTune has a two-step calibrating function for the TPS. Read about it in the MegaTune help file, and use it. The throttle position sensor is used for accel enrichment, and also for flood clear mode, and EGO enrichment:
    - **Flood clear mode** this can be set in "More Cranking Stuff" Sometimes you might want to temporarily stop the injectors from

injecting fuel during cranking to clear a flooded engine. This is achieved by holding down the gas pedal during cranking. The MegaSquirt needs to know at what point of gas pedal deflection it should turn off the injectors and a good starting point would be just before floored.
To get this value, go to Tools, Calibrate TPS, and push the gas pedal almost all the way to the floor - about where you think the fuel should be cut off and hit Get Current. Remember this value and hit CANCEL on the Calibrate TPS dialog. Insert this value for the TPS Flood Clear. If this value is set too low then you will not get any fuel during cranking. If you set this value too high, then you won't be able to press the pedal enough to trigger the Flood Clear.
    - **EGO feedback** In "Open Loop Mode" you can turn off closed loop oxygen sensor monitoring above a TPS position or kpa value.
    The aim of this is so that only the VE table is used to control fuelling, typically at full throttle/load conditions

Get the Engine Started and Idling

You start, naturally enough, by getting your engine started.

If you are running ignition control and fuel then you should read the ignition setup pages from your relavent system on the MSnS_Extra website

If you are running fuel only then be sure to set your base timing before starting your car (if it hasn't previously been set).

Typically, the first time someone tries to start their engine with MegaSquirt, it starts after about 5 minutes of alternating various cranking pulse widths numbers to get started (on the **Crank/Warmup** page), and REQ_FUEL to keep it from stalling (on the tuning page). It may take a bit of cranking, so you might need to keep a battery charger on hand.

Once you have it started and running, allow the engine to warm up and tune the idle VE values. Then you can reset the REQ_FUEL value back to its original number. It is very easy to change without having to re-enter the VE numbers. Start up MegaTune, go to **Tools->Scale VE Table,** and enter your original and new REQ_FUEL values. This adjusts the VE table.

Remember that when you start to drive the car be gentle on the throttle and keep an eye on your O2 readings.

Then go to **Settings->Constants** and change the REQ_FUEL from the value you used to start the engine to the value calculated in MegaTune. The injector pulse widths will be the same, but the VE numbers will more accurately reflect your actual volumetric efficiencies.

If you have been trying to start your engine for more than 10-15 minutes, you ought to investigate other sources of problems before continuing to try to start the engine.

Properly tuned, MegaSquirt will start your engine quickly and reliably. If you have trouble with starting, either hot or cold starts (or both):

- Be certain you have a valid VE table in your MegaSquirt. Check this with MegaTune ('Settings/VE Table'). If your table is all ones, you will have to create a new table. You can either:
    - Use a base setup from here, open the file and go to 'Settings/VE Table/File/Table Export'), then save it and re-open your config file and go to 'Settings/VE Table/File/Table Import')
    - Generate a new table based on your peak horsepower and torque figures ('Settings/VE Table/Tools/VE Specific/Generate VE Table').
- Use the "Tools/Calibrate TPS" function in MegaTune to ensure that you have an ADC count value well below the setting in "More Crank Settings" at closed throttle (ideally, your TPS at closed throttle will be 30 or less), and above 178 at wide open throttle (WOT). Many TPS are adjustable by loosening the screws and rotating it a bit. Also verify that the ADC count **increases** as you open the throttle, otherwise you have the TPS wired backwards. You should recheck the TPS range each time you change the idle position or reassemble the throttle linkage.
- Verify that the source you have chosen to supply +12 Volts to MegaSquirt with is receiving power **while cranking**. Some sources give 12 Volts in **RUN** but not **CRANK**. The engine will be very difficult to start if MegaSquirt is connected to such a source.
- Make sure the fuel pump is connected to a source that supplies 12 volts in **RUN** and **CRANK**
- . If you can, try to by-pass the fuel pump relay while testing in a 'no-start' situation. That is, give it 12 volts directly from the battery - be sure to get the correct wires connected.
- Make sure that you have enough voltage during cranking to open the injectors. For cold starts, you have a cold engine, and a cold

battery that make a lot of demands on the starting system. Make sure your battery/alternator, etc. are *"up to snuff"*.

- Make sure your PWM setting are not so low that your injectors no longer fully open for the commanded pulse widths in worst-case scenarios, which cold starts definitely are! Note, however, that V3 code disables PWM during cranking. This was done so that PWM values (% and threshold) could be lowered under running conditions. However, the PWM set-up needs to be sufficient for a poorly charged battery that has just had to start a cold engine, with the heater/defroster running full-blast, etc.
- Remember that the cranking pulse widths need to be with ~0.5 ms of the optimal value at both -40ºF and 170º F. Generally the -40ºF cranking pulse widths should be about 3 to 5 times the 170º number. If you overestimate the correct values, you WILL flood the engine.
- For tuning, the engine needs to be it a true "cold-start" state. That means not flooded - which can easily happen when you are playing with the numbers. If you suspect you may have flooded the engine, disconnect MegaSquirt and crank the engine for at least several seconds or more. Keep a battery charger handy!
- Check to make sure the injectors are actually firing, so that you are sure there is not a fault in the wiring causing you to run without a full deck of injectors. This is easy with throttle body injection, just look at them with the air cleaner off. With a port injection system, see if you can smell gas at the exhaust.
- Verify that your fuel lines to the fuel pressure regulator are the right way around. If your fuel is pumping, and your injectors are opening, but the spark plugs are dry, there's no fuel. So pull a spark plug to have a look. If they are dry, check your regulator connections.
- If the engine tries to start, but dies right away, you need to adjust the after start enrichment. Generally this should be between 20-30% for 100 to 250 cycles.
- If the engine starts but dies after a several seconds or minutes, then you need to adjust your warm-up enrichment.
- Check a datalog of your cranking to verify that your cranking speed is 300 rpm or less. If it is more then 300 rpm (not very common, but possible), you need to alter the setting in "More Cranking Settings"
- If the engine leans out when on overrun and the Injector PW drops to 0.0mS in the datalogs look at the overrun settings and turn them off whilst tuning.

You start tuning by just getting it to idle properly by adjusting the speed [with the throttle stop and/or FIdle solenoid], and mixture [with the VE table or REQ_FUEL]. There is little danger of harming anything, as there is not enough load on the engine to build the heat that would melt anything. The engine will idle on a very wide range of mixtures, so it is not too hard to get it started, you just play around with the REQ_FUEL until it fires. After you have the engine idling, note the pulse widths at idle. Then you can reset your REQ_FUEL to the calculated value as described above.

Once you can start the engine and have it idle, proceed by tuning your idle AFR. At idle, the exhaust gases may not be hot enough for a one wire O_2 sensor to read correctly, even though the engine is fully warmed up. In that case it will read lean all the time. This is especially true if you have:

- Headers (the thin metal and increased surface area conducts exhaust heat away much faster than a cast iron manifold),
- High compression (gives cooler exhaust gases), or
- Your O_2 sensor located far away from the head.

In any case, unless you are tuning for minimum emissions, the best strategy is to tune your idle for a minimum MAP reading at your chosen idle speed (by altering the VE values around the idle point). This will give you the smoothest idle, and best off idle response. You may have to reset the idle stop a few times as your adjust the mixture.

Just watch the MAP reading as you adjust the VE table. It should move up or down if you adjust the VE table enough.

If it is cold out, you may need to adjust the warm-up enrichments before you can get the engine warmed-up so that you can adjust the idle mixture, etc. The easiest way to do this is to use MegaTune's Warmup Wizard ("Runtime/Warmup Wizard"). There are more details here.

Later, when you have the engine started and idling well, you can fine tune the cranking pulse widths. General Motors uses stoichiometric mixtures for both idle and cranking pulse widths at full coolant temperature, and a 1.5:1 cranking AFR at -30°F or so. For example, to establish out some starting point pulse widths, lets assume a 4-cylinder engine, with the injector staging set to 2-squirts/alternating. The injector pulses look like this (**0** = injector pulse, **-** = no injector pulse):

o---o---o---... Bank 1
--o---o---o-... Bank 2

The picture when cranking is much easier, since it fires every injector on every igntion event:

oooooooo... Bank 1
oooooooo... Bank 2

So what we have is four times as many injection events when cranking compared to running. Now let's assume we have tuned:

- the idle so that the best idle PW = **2.2** ms,
- our "well-tuned" injector open/close time is **1.0** ms (this is important!), and

Then we get our "best idle" fuel delivery amount of:

2.2 - 1.0 = 1.2 milliseconds fuel deliver per injector pulse

Split this up into the 4 times as many injector events we see during cranking, add in the Open/Close time and get our hot cranking PW.

(1.2/4) + 1.0 = 1.3 ms

Now for cold we want 1.5:1, which is close to ten times as rich as 14.7:1, so just multiply that first part by 10 and we get our cold cranking PW.

(1.2/4)*10 + 1.0 = 4.0 ms

This calculation requires:

1. Good idle tuning to get that initial pulse width, and
2. Good tuning of the open/close time so that the actual fuel delivery number from the first equation is correct.

Setting the PWM Criteria

To tune the PWM [pulse width modulation] values for your engine, you need to know what kind of injectors you have: low impedance or high impedance.

- If you are running **high-impedance injectors** (greater than 10 Ohms), then set the:
  - **PWM Time Threshold** to **25.4 msec**, and the
  - **PWM Current Limit (%)** to **100%**.

  In essence you are disabling the PWM mode. This allows full voltage to the injectors throughout the pulse widths.
- For **low-impedance injectors** (less than 3 Ohms), you need to limit the current to avoid over heating the injectors. To do this, there is a period of time that you apply full battery voltage [peak] current, then switch over to a lower current-averaged [hold] current, i.e. peak and hold. Alternatively, you can add resistors in series with the injectors. See the Injectors and Fuel Supply section of this manual for more details.

  To run low-impedance injectors with the PWM current limit mode, you need to set two parameters - the "**PWM Current Limit (%)**" and the "**PWM Time Threshold (ms)**" - both are on the “Constants” page. The current limit % is the percent duty cycle when the current limit is invoked. The time threshold is the amount of time from when the injector is first opened until the current limit is activated.

1. Start with:
    - **PWM Time Threshold** = **1.0 millisecond**, and
    - **PWM Current Limit (%)** = **75%** (**30%** if you have the flyback board installed).
2. Once you get your engine idling, then first adjust the PWM duty cycle down in 1% increments until you notice a change in idle quality (be sure to hit the "send to ECU" button each time you change the value). This is the point where the current limit is too much and the injectors are not being held fully open.
3. Then move the value back up 3 - 5% (for example, if the idle falters at 45%, then put in a number of 48% to 50%).
4. Move on to adjusting the time threshold. Lower the time threshold by 0.1 milliseconds at a time until the idle quality deteriorates.
5. Then increase it 0.3 ms.
6. Now, repeat these steps (starting at #2). Adjust the duty cycle and time threshold alternately to get the optimum values for your set-up. You will converge on a set of numbers that work well for your set-up.

The injector opening time and PWM time threshold should be set to the same value. So adjust the PWM time threshold, and the opening time together. However, once you start to tune the 'fine tune' the idle, if you have to revisit the PWM parameters, change the PWM time threshold, not the opening time.

The reason for this is that changing the opening time also changes the AFR, especially at low rpms, so it forces you to also retune the VE table. So unless they get to be different by more than about 0.5 milliseconds, leave the opening time alone after tuning the idle and cruise VEs (unless your are willing to retune those areas).

On the car, setting the PWM parameters is very easy to do and only takes a few minutes. At idle the overall injector pulse widths are small compared to their close time, so this will allow you to adjust the values. In other words, adjust the PWM current limit before taking the car out on the street where injector pulse widths become high, increasing the possibility of overheating your injectors.

You may find that you can idle at a very low PWM%, but the engine will stumble or cough if given any throttle. This can be due to a too low PWM% especially if your injectors are large and the idle pulse width is approximately equal to the PWM Time Threshold. In that case you may be idling almost entirely on the PWM Time Threshold. So rev the engine occasionally as you are tuning the PWM parameters, to ensure that you haven't gone too low.

Also, for some setups, an initial PWM Current Limit of 75% may be too low, so they will need to increase this value - same for the time threshold. **Use PWM time threshold values greater than about 1.5 to 1.7 milliseconds only with great caution – it is possible to burn out your injectors!**

Note that if you are running the flyback board and need PWM% of 70% or more to run properly, **your flyback board isn't working properly**! Troubleshoot it carefully to find out why.

Setting the Cold Start and Warm-Up Enrichments

If it is cold out, you have to figure out the cold start enrichments/warm up enrichments right away to keep the engine running as it warms up. Otherwise you can leave this until you experience some cold weather. During cranking mode (defined when RPM is less than around 300 RPM, this can be set in "More Cranking Stuff", but 300RPM is around the normal setting), MegaSquirt shoots out cranking pulse widths depending on the settings in "Cranking Settings". the fuel map is completly ignored during cranking so don't alter it if it doesn't start, only alter the PW on the Cranking settings.

A typical setting for a Chevrolet small block V8 with a Tuned Port Injection set-up and 30 lb/hr injectors is 2 milliseconds at 170°F and 10 milliseconds at -40°F. The values for your combination are likely different, though generally should follow a similar pattern. During cranking, MegaSquirt injects one pulse for every ignition event, so for an 8-cylinder it shoots out 8 times for 720 degrees crankshaft, with all injectors squirting. So with the above values, at 170°F, the effective amount of fuel per cylinder is 8 * 2 = 16 milliseconds. For -40°F it is 10 * 8 = 80 milliseconds.

Once the engine fires up (defined by engine RPM greater than the setting in "More Cranking Settings" typically 300RPM), the engine starts to use the VE Table's fuel map and if the coolant is under 71C (170F) it goes into afterstart enrichment. The afterstart enrichment is generally set to increase the percentage of the fueling map it will run at for a pre-determined amount of time or ignition pulses so the engine has a chance to start and smoothen out. This can be set to a different value depending on the coolant temperature in "After Start Enrichment Settings" Start out at a user-defined percentage enrichment value (typically around 25%), and then it ramps down to 0% after so many ignition trigger events, which is user-defined (use about 200 for this number to start). This is an enrichment above the normal warm-up enrichment, which is temperature dependent. Please note that 0% means that it will run exactly what the VE table values are and 50% would mean 50% increase

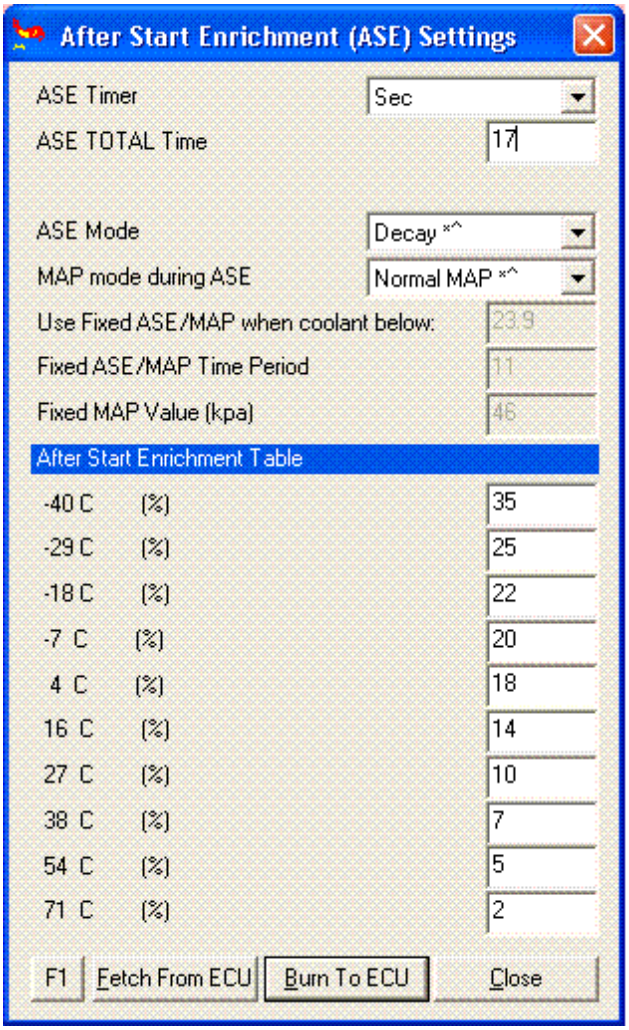
over the VE table.

It's been found that during winter the cranking and after start enrichments need tweeking in order to get the engine to start and run without restarting it several times from cold. The reason is felt that the after start and cranking enrichments don't necassarily follow temperature in a linear format.

After Start Enrich Counter is the length of time in Seconds or engine cycles that the after start enrich runs for. The percentage added is decayed down to zero as the time expires

Set ASE Mode to FIXED for a timed period of ASE that does not decay, after the timer the ASE will then decay as usual during the TOTAL ASE time period thats left. This has a temp setpoint as it should only be needed when the coolant temperatures are fairly low.

Setting MAP to a fixed value helps to maintain a constant PW during the initial start where the map drops quickly from around 100KPa to the tickover KPa. This is held during the FIXED time period. The FIXED period is a period of time at the start of the TOTAL ASE time. FIXED must be less than TOTAL.

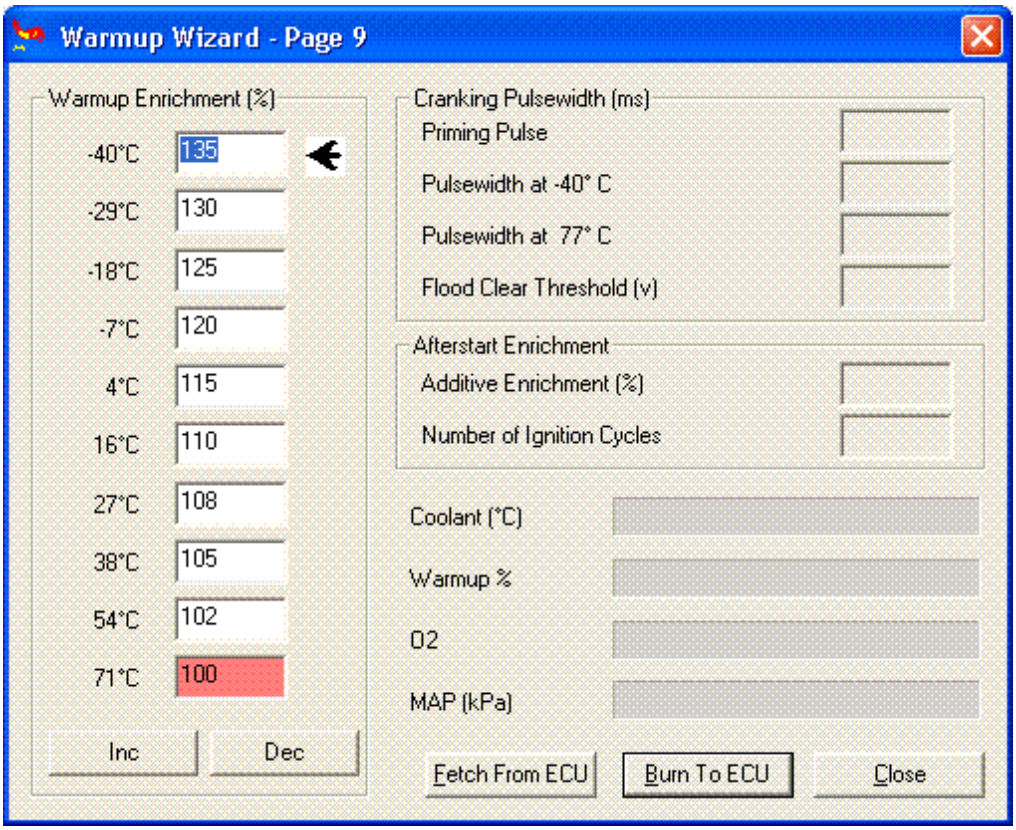


If the engine starts and runs for a few seconds, then stalls, this is usually a sign that the afterstart enrichment isn't quite right. Leave everything else the same, and adjust the afterstart % and number of cycles. 20% to 30% and 200 cycles are reasonable starting points for most engines, but yours may run better with more or less. There should be a point at which it works without stalling.

If the engine starts and runs for more than 20 seconds or so, then stalls, you need to adjust your warm-up enrichment bins. As you adjust your warm-up bins, you may need to re-adjust the afterstart, since these interact (i.e., a larger warm-up value may require a shorter or smaller afterstart enrichment).

To set the Warm-Up Enrichments, use the "**Warmup Wizard**" under "Crank/Warmup" on the main menu. This lets you adjust the cold start and the warm-up bins while indicating which bin(s) are currently active. Note that you have to start from a true cold start - the engine needs to sit for several hours, before trying to adjust the warm-up enrichments after running the engine.

With the above numbers tuned properly, nearly any engine can be tuned to fire immediately, every time, just like any OEM fuel injected car. It takes a while to converge on the best numbers, especially the after start enrichment, which needs to be just right, or the engine will run rough or stall immediately after starting.



You can do this as the engine warms by adjusting the warm-up bins, loading it to the ECU, and noting the effect on idle quality. It will take several starts {from a cold soak} to get this close. Then you can play around with revving the engine in neutral and adjusting the mix to stoichiometric. Up to here it easy enough to do without an O_2 sensor by adjusting for maximum vacuum (lowest MAP kPa) ant any given rpm.

Setting the VE Table

To set up the fuel curves for the engine with MegaSquirt, you have a number of parameters to work with. The most important of these are the Req_Fuel value and the VE table (12x12 volumetric efficiency table). You are aiming to achieve 12.5-13.1:1 air/fuel ratios under full throttle, and 15-17:1 under light loads for a naturally aspirated engine. Boosted engine may require a richer mixture under power.

The VE table represents the volumetric efficiency and air/fuel ratio at each rpm and kpa (0=total vacuum, 100=atmosphere, etc.).

Volumetric efficiency is the ratio of the amount of air actually fills the cylinder to the amount that would fill the cylinder in a static situation. The VE is used in the 'fuelling equation'.

There are a number of ways to specify VE. MegaSquirt specifies it relative to the manifold absolute pressure and includes the AFR in the VE table.

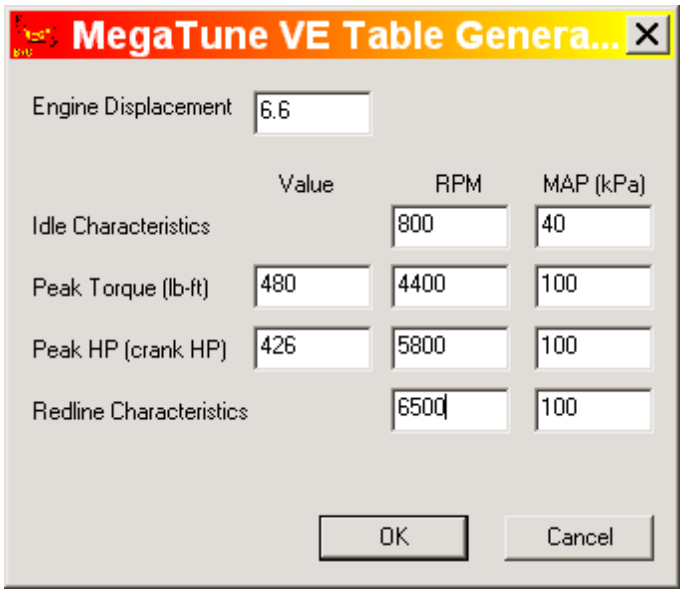
That is:

$$\mathbf{VE = (actual\ air\ mass)/(theoretical\ air\ mass)*AFR_{stoich}/AFR_{actual}}$$

So for MegaSquirt, entering a larger VE in the table makes that point richer, and a smaller number makes that point leaner.

To start you tuning efforts with MegaSquirt, you can calculate an initial VE table that has sufficient RPM and kPa bins, as well as an estimate of the VE based on your maximum torque and horsepower figures. The calculator is under the "Tools" section of MegaTune (version 2.25 and

higher). This calculated VE table will need to be tuned carefully to avoid damage to your engine, however.



Before starting to tune the VE Table it is recommended that you turn the Acceleration Enrichment (AE) off so you can see whats happening to the mixture as a direct result of the table rather than having fuel added from Acel Enrichment. To do this set the thresholds to 30V/S or 5000KPa/S see HERE for more details on AE. You may find that youll need to be light on the throttle as the AE is needed to fill 'holes' that occure when the throttle opens quickly. Remember to tune the AE when you have a tuned VE Table.

Another item to turn off during tuning is the Overrun settings as the PW may drop to 0.0mS causing lean spots. See HERE for more details

Tuning the VE table involves richening (by increasing the VE) or leaning (be decreasing VE) at each point in the VE table. Most of your driving will occur in a diagonal strip of the VE table, from low rpm, low kPa (i.e. idle) to high rpm, high kPa (i.e. WOT). You can adjust these values using the O_2 sensor, data logs and MSTweak, and/or the seat of your pants. Low rpm and low kPa (say less than half of the max rpm and max kPa) might be able to use stoichiometric or leaner. Richer mixtures would be used at high rpm and high kPa.

However, the low rpm/high kPa and high rpm/low kPa are not seen as often driving your vehicle. Basically, if the engine never runs in certain parts of the MAP, then the numbers there should not matter. However, since you may not be able to guess where you will run under every possible set of conditions, you put estimated VE numbers that make sense into the little used areas.

From this frequently used diagonal strip of the VE table, you will be able to see how much the VE rises from one rpm bin to the next, and use these differences to estimate the low rpm, very high kPa numbers and the high rpm, very low kPa numbers. Since you rarely (if ever) run in these parts of the table, the actual numbers will not make much difference, but they will be there "just in case". You are looking to create a smooth VE map wherever possible.

To set the VE table entries near idle, you should try to achieve the lowest MAP (in kPa) that you possibly can, at your chosen idle speed. This will give the highest idle vacuum and the most efficient idle. Don't try to get to a target idle mixture (stoichiometric, or some other number), instead adjust the VE table entries around your idle rpm and kPa to achieve the lowest MAP reading as seen in MegaTune. As you work to lower the MAP, the rpm will likely rise, and you'll have to reset the throttle stop to lower the rpm to your desired idle speed. When you have it set so that **either** raising or lowering the VE table entries increases the MAP, then you have the best idle mixture for your engine (it will require the smallest throttle opening).

At non idle areas of the VE table, you will generally run lean (low loads and speeds) or rich (high loads and speeds). High loads are associated with high kPa MAP values. Deciding exactly when (and how much) you should run rich is mostly a "seat of the pants" thing. When tuning, you will find the engine will surge (at low loads) and "coughs" at higher loads if it is run lean. Adjust the VE at the point where this happens so the this does not occur. Check the plugs for detonation (tiny black and white flecks) when tuning at high loads and rpms if you suspect detonation at all. A narrow band should read at least 0.8 volts under full throttle, at least for a starting point in tuning WOT. There are more

details later in this section.

For an example, look at the sample VE table later in this section. It is the default MegaSquirt table, from the 350cid Chevrolet V8 engine that Bruce Bowling has in his Jaguar. It will work adequately for starting your tuning efforts in many more applications than you might suspect.

Volumetric Efficiency (VE) entries in 12x12 MegaSquirt VE table actually are **VE * gamma**, where **gamma** is the (stoichiometric AFR)/(actual AFR), and **VE** is expressed as a percent (i.e. 65 represents 65% volumetric efficiency at 14.7:1 AFR).

Note: If you do not use the "correct" REQ_FUEL value, the VE numbers in the VE table will be skewed by the amount REQ_FUEL is "incorrect".

For MegaSquirt (and most MAP based EFI controllers), VE is based not on the percentage of cylinder filling relative to atmospheric pressure, instead it is based on the percentage of filling relative to the intake manifold pressure. So even with a highly "boosted" engine, VEs will not be much above 100%, except to richen the mixture.

You can tune your engine to a stoichiometric mixture with NB O_2 sensor, but not at high loads/rpms. You can then use a little math to "correct the mixtures". For example, if you get a stoichiometric mixture with 65% VE at a certain RPM and kPa, then to lean the mix to 16.0:1 you need:

65% * (14.7 / 16.0) = **60%**

To richen an 80% VE entry to 12.5:1 from stoichiometric:

80% * (14.7 / 12.5) = **94%**

Note that with MSTweak3000, you will get stoichiometric mixes if you set the crossover voltage to 0.45 - 0.50 volts with a narrow band O_2 sensor. This is where you should have the EGO switch point set on the enrichments page in MegaTune as well. You can then adjust the MSTweak suggested VE table as described above to get other mixtures. **Note the you will want to be sure of running rich mixture under high load/high RPM conditions.** This makes a narrow band sensor somewhat less useful. As a starting guide, make sure you have at least 0.8 - 0.9 volts from the sensor under "wide open throttle" (WOT).

MAP sensor values can be between 0 and 250 kPa for all V2.2 and V3 MegaSquirts. Naturally aspirated V1 MegaSquirts (from the very first group buy in 2001) can have MAP values between 0 and 115 kPa. Idle RPMs below 300 rpm will induce "cranking mode", so should be avoided.

You can set RPM and MAP sensor values for table wherever you want them, but they must be in the same order as in the table supplied with the software. Put them so they cover entire rpm/boost range of your engine. That is, you want to cover from your slowest idle speed to your red line, and from the kPa at idle or deceleration (whichever is lower) to full throttle (with boost, if applicable). Evenly spaced values work well, but you may choose different values to suit your combination.

Generally, VE table numbers above 100% are used only to richen mixtures. Even a turbocharged engine capable of 20 lbs/in of boost will generally not have extremely large VE numbers. The addition of fuel for boost comes through the MAP term in the fuel equation:

PW = REQ_FUEL * VE(kpa,rpm) * MAP * E + accel + Injector_open_time

Thus increasing the VE at higher boosts makes the mixture richer, but it would not have run leaner simply because of the higher boost.

In essence, the mass of the air is computed using the ideal gas law (**PV=NRT**), where the pressure **p** is a function of VE and MAP, the volume **v** = cylinder displacement, the air temperature **t** is a function of E,**r** is the gas constant. We are looking for **n**, the mass of inducted air) and then that result is combined with a characteristic number for a given injector.

If you get the injector opening time correct, and the REQ_FUEL accurately represents the flow rate of your injectors, then the VE entries will be close to the VE*gamma noted above. **However**, if your opening time is not right, or your REQ_FUEL is not, then the numbers will be skewed by the amount the values are in error. In general, except for when you are first trying to get your engine started, use the calculated value for REQ_FUEL and do not change it.

Here is a sample VE table (it is the default table in MegaSquirt, used for Bruce's 350 Chev V8 with Tuned Port Injection). Note that the

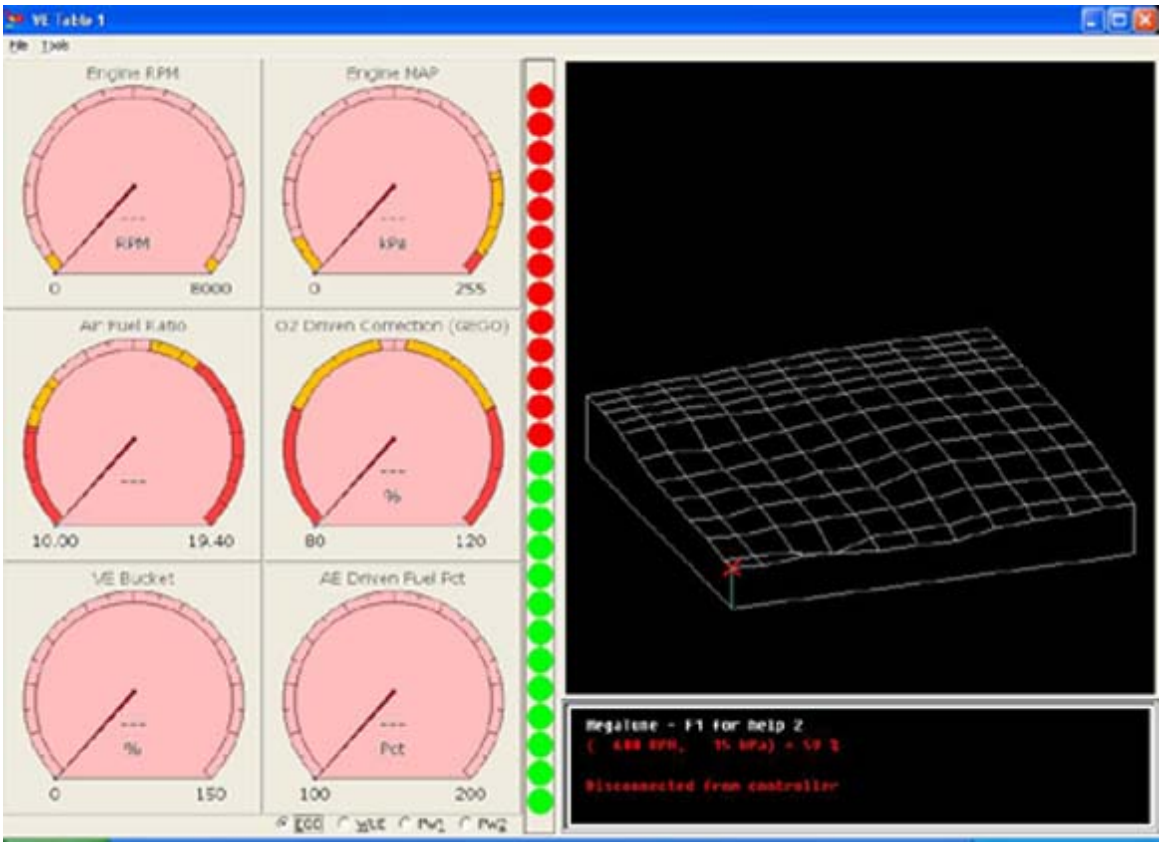
engine rpm range is from 500 rpm to 5200 rpm, and the MAP values range from 30 to 100 kPa (telling us that this is a naturally aspirated engine). Beyond these values, MegaSquirt will use the last value from the “edge” of the table. (It does not “shut down” by substituting zero values.) In theory, at stoichiometric mixtures, the values at 100kPa would reflect the torque curve of the engine at WOT, assuming a constant AFR level.

idle and cruise - lean	~stoichiometric - 14.7:1 AFR	WOT and acceleration - rich 12.5:1 -13.5:1 AFR	not normally seen

	100												
	95												
	90												
	80												
	75												
	65												
KPA	55												
or	45												
TPS	35												
	30												
	25												
	15												
		600	900	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000
						RPM							

Having an O_2 sensor makes the driving part of the setting up much easier, as you can datalog and use MegaTweak to get the VE table set up with a few easy drives up and down the street, a bit more tuning, and you are ready to go a bit harder. You do not go harder if there are any problems [typically a back fire means too lean, sluggish revving means too [rich]. Read the “Datalogging and MSTweak3000” section for more information.

Have someone ride with you and bring up the tuning page. See where the " Green dot" hangs around when you are under load - this is where you need to focus on tuning. Use the **up-arrow + shift** to richen the VE values - enrich (with increased VE number) the four corners around where the dot is - give each corner five up-arrow-shifts, and see if this helps. Turn off the O_2 closed-loop mode by setting the step size to zero. Watch the O_2 gauge on the tuning page and use this as feedback for rich and lean. The 02 gauge may move to fast from rich to lean to be able to tune. Another strategy that works is to turn on EGO correction, and then tune using the EGO correction gauge rather than the EGO voltage gauge. If correction is below 100%, then raise VE to raise correction and so on.



Basically, the strategy for tuning with an oxygen sensor is:

- If you're driving around tuning "real-time" with a laptop, then turn the EGO off (step size=0). This means you are directly affecting the fuel, so that the changes you make to the VE table are adjusting the fueling immediately. Otherwise the EGO can be pulling the injector pulse width back to some value, and not allowing your changes to have any effect (until your exceed the EGO authority range [EGO ± limit (%)]), at which point it will probably run like crap!
- However, if you are trying to create a datalog to feed to MSTweak3000, then turn the EGO feedback on (say step size =~3%, limit=~75%, ignition events=8), so that you generate lots of crossover points. Don't tune the VE table at all while you do this, just drive it and feed the resulting datalog to MSTweak. There is more on this below.

You can also use auto-tune to help tune your VE table.

Auto-tune is an algorithm built into recent releases of MegaTune that automatically tunes your VE table based on EGO feedback. It is similar to MSTweak3000, but operates in real-time, without a datalog, and on any variant of code and processor that uses MegaTune.

With a narrow band sensor, you can use auto-tune with any algorithm and any sensor to tune the low-power part of the table, it will get you to stoich (or AFR targets) quite nicely, which will give you a starting point from which to extrapolate the high-power part.

You don't need a dynomometer to get the high output regions of the VE table done, but you definitely should NOT use auto-tune with a narrow band sensor for that part of the table, you'll end up with broken or melted pistons. In order to use auto-tune for WOT tuning, you must be running a wide band lambda system (sensor and controller), with an appropriate EGO correction algorithm that allows you to set specific AFR targets (i.e., MSnS-Extra or MS-II). If one of these requirements is missing, then you must rely on seat-of-the-pants and experience.

The only evidence that you have auto-tune enabled is a check box at the bottom of the dialog. Note that auto-tune updates the VE table in RAM, and requires that you click "Burn" to save the changed VE table permanently.

Beware that if you go so rich that you start to see misfires, the lambda sensor will read the unburned mixture as dead lean (since unburned oxygen is present) and the closed loop algorithm will attempt to add fuel, which the auto-tune algorithm will detect and adjust the VE bin richer, thus making a bad situation worse. Use with caution, auto-tune will not perform magic!

To start with, set the EGO step size (in MegaTune) to 1%, and set the authority down to ~10%, so that auto-tune doesn't do unstable jumps. The default auto-tune gain is 50%, so if you could jump a VE entry by as much as 5% in a single operation with the above numbers.

The EGO control algorithms all turn off correction (i.e., set the correction factor to 100%) whenever AE, decel, warmup or any number of other enrichment types come active. The 100% EGO value in turn has the effect of turning off the auto-tune.

The EGO correction step doesn't come into play at all, that's only internal to the EGO algorithm itself and dictates how rapidly it moves when correcting. The auto-tune step is determined by the current EGO correction (which is limited by the EGO controller authority), and the proportional gain, so only those two values really play a role in computing how big the auto-tune step will be. So, things proceed like this:

1. The EGO algorithm uses whatever means necessary to come up with a number, this is limited to 100% +/- EGO authority with the familiar algorithms.
2. The auto-tune algorithm uses the EGO correction value from 1, multiplies its difference from 100% by the gain to get the adjustment proportion. Gain is 0.5, EGO correction is 110%, then the VE adjustment will be 5%.

There are a number of parameters that affect the operation of auto-tune. These are written into the custom.ini file found in c:/programfiles/megasquirt/Car1/mtCfg/

The settings for Autotune for MSnS_Extra code are found just under the MS1 Autotune settings. Find this section:

#else ; Actually only good for DualTable, MSnS-Extra and MegaSquirt-II.
table = veTable1Map

- allowAutoTune = on
- corrector = egoCorrection
- Vertex tolerance parameters
  - xRadius = 200 ; rpm
  - yRadius = 7 ; map
- Tuning block parameters
  - xLimits = 1500, 4000 ; rpm
  - yLimits = 60, 90 ; map
  - zLimits = 10, 200 ; VE
- Controller parameters
  - initialStartupInterval = 1.0 ; seconds
  - updateInterval = 1.0 ; seconds
  - proportionalGain = 0.5
  - lumpiness = 5 ; percent

The **radius** (or vertex tolerance parameters) is how near to a vertex the operating conditions must be before the VE will be adjusted. For example, with the above settings, auto-tune will adjust a vertex if the operating point is within 200 RPM and 7 kPa of that vertex. If you increase the radius parameters, which would allow tuning farther from a vertex, then you may be changing the wrong vertex (typically four are involved at any given time, but auto-tune only changes the nearest one). The radius parameters try to minimize this error by only tuning when the nearest vertex has overwhelming influence.

For the **limits** (or tuning block parameters), "X" is RPM. Y is normally MAP, TP or load. Z is the VE itself. The limit parameters box the tuning points, no changes will be made outside the box. The radius parameters dictate how close the operating point must be to the tuning point for auto-tune to operate, if the operating point falls outside this smaller box, then no action is taken. If you change the limits, then you don't change the accuracy or speed, just the region that is valid for tuning.

Initial startup interval is the time in seconds between when the operating point approaches a tuning point and when the first adjustment is made.

The **update interval** is the time between each subsequent adjustment.

Proportional gain is how much of the ego correction is used to adjust the VE value. If you set it to 1.0, and the ego correction indicates a 15% error, then the VE will be adjusted by 15%, while gain of 0.5 will adjust VE by 7.5%. I'd suggest keeping this at 0.5 or lower.

Lumpiness is a parameter to limit how far a vertex's VE can be adjusted. The example below will keep the vertex that is being tuned within 5% of the extremes of the four surrounding vertices, under the assumption that the table should be somewhat smooth and will be 'rough tuned'

to start. Note that the limits are transient, so if auto-tune changes vertex A by +5%, then moves to adjacent B, which also goes +5%, then the limit when we return to A will now be 5% above B.

```
[AutoTune]
   table = veTable1Map
      lumpiness = 5 ; percent
```

There are two diagnostic messages to tell you what is going on with the auto-tune algorithm when it is turned on, but isn't doing any tuning. They are:

- "***Auto-tune: Tuning point outside window***", which indicates that the operating point has gone outside the global x and y limits, so the no action will be taken. Likewise
- "***Auto-tune: Tuning point not near vertex***", which indicates that the operating point is inside the global window, but it is not near enough a vertex (as defined by the "radius" parameters), and so no action will be taken. These messages are intended to help you figure out why the algorithm is not changing a vertex on the table, and allow you to modify the xLimits, yLimits, xRadius and yRadius parameters accordingly.

Note that there are no menus to configure auto-tune in MegaTune (other than the EGO parameters). All the other data that MegaTune displays in dialogs for you to edit is stored somewhere inside your MegaSquirt; the tuning parameters for auto-tune are just MegaTune-specific data and really have nothing to do with MegaSquirt. This means that you need to edit the custom.ini file to make changes to the tuning algorithm's parameters. You may have to add to the custom.ini file:

```
;-------------------------------------------------------------------------------
; Add your customizations here, they will be read at the end of the
; standard megatune.ini processing and override any settings there.
;-------------------------------------------------------------------------------
[AutoTune]
table = veTable1Map ; Should be the map3d_id of a TableEditor entry.
allowAutoTune = on
corrector = egoCorrection

; Vertex tolerance parameters
xRadius = 200 ; RPM
yRadius = 7 ; MAP

; Tuning block parameters
xLimits = 1500, 4000 ; RPM
yLimits = 60, 90 ; MAP
zLimits = 10, 200 ; VE

; Controller parameters
initialStartupInterval = 1.0 ; seconds
updateInterval = 1.0 ; seconds
proportionalGain = 0.5
lumpiness = 5 ; percent
```

To make auto-tune work with earlier versions of MSnS-E (which require a INI file written before auto-tune was implemented) you'll need to use an old settings.ini and custom.ini, but cut the [AutoTune] section out of the new MT carMtCfg/custom.ini and paste it into your old one. Once you do this, you should scan your audit.log in the car1 directory to make sure that you are reading the old files an no new ones from the MT directories, as these might mess things up.

If you have a "strip-only" vehicle, an EGO feebdack is less useful. Some tuning hints are:

- Watch for increases in trap speed, this will be an indication of increasing power (under similar conditions),
- Cut the ignition at the end of the run, and coast down to a stop, then check the color/condition of the spark plugs. This can be a pretty good indication of the AFR (light tan is best with gasoline),
- Start rich and work towards lean very carefully (your O_2 sensor, if you have one, should always read rich during the run, at least 0.80 volts for a narrow band),

- If you experience detonation, or the engine backfires at all, you are probably too lean,
- If you can, have somone watch the exhaust during a run (from the sidelines) - there should not be big clouds of black smoke. If there is, you are probably too rich,
- Try to keep the VE table reasonably smooth.

Tuning with Alpha-N

MegaSquirt can be converted from speed-density to use RPM , temperature and TPS only. This is called "***Alpha-N***". Alpha-N uses the only throttle position and RPM to calculate the amount of fuel to inject as opposed to using the manifold absolute pressure and RPM to calculate the amount of fuel to inject. Before attempting to start the car in Alpha-n ensure you have set the "settings.ini" file up for Alpha-n, see here

With boosted engines, you MUST use the speed density algorithm with MegaSquirt, because the throttle position bears little relationship to the amount of air going into the engine. Alpha-N is for naturally aspirated engines ONLY.

Using the speed-density algorithm, MAP is the main variable and VE is a 'tweak'. On alpha-N the VE table is the **main** variable, as TPS is used as a lookup into this table. Actually it is a fuel map rather than a VE table.

Alpha-N is useful for long duration cams where the resolution of manifold air pressure (map) would be small. It is also useful to get smother idle on engines that have erratic map values.

For example: On a flat part of the torque curve, going from half to ¾ throttle might not require the value to change in the VE map on speed-density if the air/fuel ratio is the same for the 2 loads as the change in MAP will do this. On the alpha-N system the map bins will be different as this is the only way the MegaSquirt can find out about the higher fuel demand.

You must have v2.0 or higher of the embedded software installed. Start up the tuning software, go to the Constants dialog and change speed density to Alpha-N. Then you 're-map' your VE table.

In Alpha-N mode MS still makes 02 corrections (i.e runs 'closed loop'), if you have it enabled.

One thing you have to always remember with alpha-N that you don't actually know where the effective WOT is anymore (i.e., when you have enough throttle that opening it further doesn't affect the amount of air being ingested). At low RPM WOT could be only 20% throttle.

As an aside, there has been a change in the way the extra code's alpha-N works, it now multiplies in TPS as a factor.

In the MSnS_Extra embedded code the fuel equation (minus the enrichments and open/close time) looks like:

PW = Req_Fuel * tps * VE(tps,rpm)

as opposed to older MS1 V2.xxx code's, which looked like this:

PW = Req_Fuel * VE(tps,rpm)

Note the extra factor of TPS (in red) in the MSnS_Extra code.

*Since the idle fuel pulse width depends on VE table value for that engine speed and TPS position, which is then **mulitplied** by the TPS value (in the extra code), you **must** make sure that your closed throttle TPS value is not very low (otherwise you will be unable to generate sufficient idle pulse widths even with the VE table entries max'ed out at 255). To ensure sufficient idle adjustability, go to the Tools/Calibrate TPS in MegaTune, and verify that your closed throttle ADC count is **30** or more. Also note that on the stim, you may see lower pulse widths than expected (and be unable to adjust them in the VE table) if the TPS pot is set too low. This does not occur on V2 code, since the VE table alone is uses to determine fuel, and TPS is not a multiplier.*

*Also, since the TPS is now a multiplier once you reach the 'effective WOT' (where increasing the throttle opening no longer increases the manifold pressure), you will have to **decrease** the entries in the VE table as TPS continues to rise to maintain the same amount of fuel and*

air/fuel ratio.

Tuning with alpha-N its much the same as speed-density, except you no longer have an input for load. What this means is that you don't really know what full throttle is at the low and mid RPM ranges. For example, at 2000 RPM, 20% throttle might flow all the air the engine needs. So the usable area of the table will end up looking a bit like a triangle. The table itself will be actual fuel rather than a VE multiplier.

The tricky part with tuning alpha-N is working out where the effective WOT is. It is a very non-linear relationship and depends critically on the sizing of the throttle body.

Also, with alpha-N, the final fuel pulse is a simple product of the VE table entry and enrichments, so your VE table is far more critical than in speed-density mode.

If you are running alpha-N, disable closed loop operation until you have a good handle on where the effective WOT is. If you still have a MAP line connected you can (and should) log map to give you an idea of where full throttle is across the rev range.

If you are going to have varying loads,or are going to tow with your MegaSquirted vehicle, and you have good vacuum at idle and a good vacuum range, then go with speed-density because it reacts to changes in load a lot better than Alpha-N.

Alpha-N does have legitimate uses, and one would be an engine with a small intake vacuum range and a poor vacuum at idle. A strip/drag vehicle where there will be small changes in load and it'll see most of its use at WOT might benefit from alpha-N.

The original MegaTune TPS calibration tool was designed to allow alpha-N users the ability to move their TPS without having to re-tune their whole VE map. This is accomplished by storing the VE table in terms of TP%, and then using the tuning software to translate the TP% numbers into ADC counts.

In alpha-N, if you use barometric correction, it will look at the pressure at first power up and set the offset from that value. Otherwise if baro correction is off it does not use the map sensor at all.

Alpha-N still uses the temperature sensor to increase or decrease the fueling based on the ambient air temperature.

Even if you only plan to use alpha-N in your MegaSquirt, it is a good idea to build up the complete board. Use all the sensors. If you do not use liquid cooling and do not want cold start enrichment, hang the sensor in the air. Set the warm up bins to 100% across the board. Place the intake air temperature sensor in the intake or as close to the incoming air as possible. That way you have all the hardware and the board will operate properly. You can turn off almost any thing in MegaSquirt by placing the key values out of range.

<u>Idle Pulse Width</u>

You have to select your injectors based on the maximum horsepower your engine can produce to prevent the engine from running lean at wide open throttle. But why not just pick the biggest ones you can find?

The answer has to do with idle and cruise pulse widths. If you use very large injectors, your idle pulse widths get very short. This can drastically reduce the mixture ratio control that you have during idle and cruise situations, and lead to very poor driveability and seemingly strange tuning behavior.

To illustrate, suppose you have established that your engine produces the lowest MAP reading at an idle pulse widths of 1.2 milliseconds, and your opening time is 1.0 milliseconds (considered the 'standard opening time'). Recall that MegaSquirt can only change fuel by 0.1 milliseconds at a time.

And also recall that MegaSquirt assumes NO fuel is injected during opening (which is close to true, since the injectors remain closed until the coils charge, then they snap open at the end of the opening time). Now if the net effect of the enrichments change by 2%, the pulse widths don't change at all. Even if they change by 49%, nothing changes. But once they change by 50%, the pulse widths suddenly changes to 1.3 seconds.

So the next leaner possibility is 1.1 seconds, and the next richer is 1.3 seconds. However 1.3 milliseconds is not 1.3/1.2x100% = **8.3%** richer, instead it is (1.3-1.0)/(1.2-1.0) = **50%** richer! The mixture becomes very, very rich, and the engine runs poorly.

To confuse your tuning efforts further, it may be that you are already near a threshold, so that a small change in one parameter makes a very

big change in the air/fuel ratio in one direction, but no difference at all in the other direction!

But doesn't the EGO correct? Actually, it can't. Even if you set the step size to 1%, nothing happens until the 50% (i.e. 1.3 milliseconds) threshold is reached. That is, the step size only takes effect once the 0.1 threshold of PW is reached. And if the number of ignition events between steps is large, the engine may stumble and die before it recovers and leans out. So in fact you may be better to set the O_2 step high (50%), and the number of ignition events low (say 2) so that the average over just a few injections is correct. It is a band-aid approach, however, and likely to induce ignition related problems.

Obviously the converse is true if the engine goes lean. It has to go at least (1.1-1.0/(1.2-1.0)=50% lean before anything happens. If does go lean, it may back fire and die before it gets a chance to become richer.

You might think you can get around this by decreasing the injector opening time (to get a larger "adjustable time") and increasing the VE (or req_fuel), but that doesn't work because the 'ideal' injection time is still 1.2 seconds, and the permissible step is still 0.1msec, regardless of the way you add the components of the pulse width up.

And making matters worse is the fact that many high-performance engines will want even lower pulse widths at cruise than at idle, compounding the tuning problems and introducing more driveability issues. A system with a very short pulse widths like this will be difficult to tune. It will appear not to respond at all to enrichments over a certain range of a parameter (say IAT), then suddenly it will seem to change so drastically that you seem to require an entire new set tuning values.

Now even if your engines idles perfectly at a very low pulse widths, changing load, speed, and other variable (EGO, IAT, etc.) will demand slightly different air/fuel ratios. However, none of them are likely to need exactly the $\pm$50% you have to choose from!

This is why several aftermarket ECU manufacturers recommend an idle pulse widths of not lower than 1.7 milliseconds. If yours is lower than this, you need to address it before you will be able to tune your engine for all operating conditions. Ultimately the best solutions are appropriately sized injectors or staged injectors.

Datalogging and MSTweak3000

Datalogging allows you to create a running record of the MegaSquirt real-time variables. Once you have enabled datalogging (by clicking on the Datalog menu item on the File list), MegaTune polls the MegaSquirt controller when any of the front page, runtime display or tuning page are active, and writes this data to a file. The file has a comma-separated value format and defaults to having an extension of ".xls", so Microsoft Excel will open them automatically. The data logs can be used as input to the MSTweak3000 program to automatically correct your VE table. See the MSTweak3000 folder at the www.msefi.com site.

When datalogging is enabled, the second status box contains a bold "LOGGING" indicator. The rightmost indicator contains either grayed-out "CONNECTED", meaning that MegaTune is not communicating with MegaSquirt, dark "CONNECTED", indicating that MegaTune and MegaSquirt communications is working properly, or dark "RESET n", indicating that the MegaSquirt controller has been erroneously re-booted n times since MegaTune started talking to it.

Note: the **Logging** option under the *Communications* menu is a different function, and does not need to be selected to enable datalogging of the real time variables. See the MegaTune help menu for details on the Comm Logging function. If you can drive the car at all, start datalogging. Look through the log and MAP-RPM pairs that are near grid points in your VE map, when they O_2 sensor reading is significantly below 0.500 (say 0.014), jack up the VE at that point by 10%. When the O_2 sensor is significantly above 0.500 (say 0.825) then drop it down by 10%. A couple runs around the block should get things running pretty well.

Or you can use MSTweak3000, which will sort through your data logs and suggest what VE points need to be changed. Everybody (who is running and datalogging) should try MSTweak3000 - it is very powerful and easy to use. It allows you to read in your data logs, get rid of outlier points, and then generate a new VE map. You can pick new bin values - rpm especially (at the peaks and valleys of your filtered datalog) - then calculate a new VE map with the push of a button! No more gazing with crossed eyes at Excel spreadsheets to pick data for tweaking your VE table.

If you get errors when try to use MSTweak3000, you may need to change the regional settings on your computer (you need to use "." as the decimal marker, rather than ","). In your Windows **Start** menu (bottom left of the screen on the taskbar):

1. Go to **Settings / Control Panel / Regional Settings**(it's the icon with the globe), you probably have your local language selected,
2. Switch to **US English**, and the problem should be solved, (there's no need to change the keyboard layout).

This has been checked on numerous computers, and it solves errors in most cases.

MSTweak looks for points in the datalog where the EGO voltage crosses your chosen set point (~0.450 volts for a narrow band oxygen sensor at stoichiometric, 2.500 volts for a wide band sensor). If you are operating closed loop, then you will generate lots of these "crossover points" automatically. So:

- When using MSTweak is make sure you have EGO correction enabled in MegaSquirt. Set the EGO switch point in both MegaTune and MSTweak to the same value (0.450 volts or 2.500 volts, depending on your sensor type), and be sure to set the EGO Active Above RPM to a low value, say 1500 rpm. Also check that the other EGO values (ex. coolant temperature activation, EGO RPM limit, etc.) allow the EGO feedback to operate,
- Set the max ego correction % quite high (say > 50%), so that it has enough range to reach the sensor's switch point (there is more on this below).

When datalogging in cruise, watch the EGO voltage, and you should see it flip back and forth around the set point. If so, you are getting the crossover points logged that MSTweak needs.

Crossover points are where the EGO voltage cross the EGO switch point you have set on the enrichments page of MegaTune. So, for example, on a narrow band sensor and have set the switch point to 0.450 volts (for example), if you have gone from 0.400 volts to 0.600 volts, you get one cross-over point. If you then go back to 0.425 volts, you get another crossover point.

MSTweak uses these crossover points as an indication that the air/fuel ratio is very close to the 'desirable' ratio. So the more crossover points you have, the more certain MSTweak can be that it is setting the right mixture.

You use EGO feedback to generate crossover points, because what EGO feedback does is pull the voltage down if it is above the switch point (by lowering the fuel amount if it is narrow band), and pull the voltage up if it is below. In essence, EGO feedback is designed to generate crossover points.

The ignition events per step is a way of slowing and smoothing the EGO response, so that it doesn't react too fast, potentially getting into an oscillating loop. The step size is the same idea, larger steps react more quickly, however, larger steps also may not hit the exact ratio you need.

What MSTweak3000 does with these crossover point is use them to determine what VE entry value will give you an AFR of 14.7, based on the O_2 transition point recorded in the file. MSTweak3000 gives you a RegenVE, which is the VE value for 14.7:1. If you want another AFR, you can estimate it by taking the RegenVE value and multiply by the ratio of the stoichiometric over the desired AFR. For example, if MSTweak3000 gives you a value of 50% for the VE table, and you want 12.5:1 instead, then 50 * (14.7 / 12.5) = 59 - this is what you plug into the VE table. See the MegaTweak software and help file for more information. Note that the latest versions of MSTweak allow for the setting of wide-band O_2 sensor AFR targets for each MAP bin. See the MSTweak3000 manual for more details.

Do not get hung up on actual AFR numbers - for the example above to work, everything else must be dead on, including the injector offset, injector battery voltage correction, REQ_Fuel for your injector flow rate, and air temperature correction. It will get you close enough with the resolutions we are working with, but remember that the only AFR you can nail down with a NB O_2 sensor is 14.7:1, everything else is an estimate from this point. If you have a WB-O_2 sensor, then you can read the AFR directly from the sensor output voltage and use those results to tweak your VE table.

MSTweak3000 will not tune your MegaSquirt for you (yet) but it will suggest new VE table entries for you. It is a tool to help you visualize the VE map and choose better VE values and to better place the MAP and RPM bins for your engine. Keep in mind you need a good O_2 sensor to do this though (the WB-O_2 sensor will work great). To start, set the O_2 +/- limit to 100% for a really rough map, and if your map is more or less tuned in then 50-70% will work too (keep this high though for tuning).

The critical settings are O_2 step% and ignition events per step.

- When tuning anything in the lower RPM range (1000-3000 rpm) set the **EGO step (%) = 1** and **ignition events per step = 32** (2000 rpm with a V6 = 100 events per second = about 3% change in a second).
- Then when tuning the higher RPMs with a rough map; **EGO step (%) = 3** and **Ignition events per step = 64** (about 3.5 changes per second at 4500 rpm).
- When the map is tuned better set the **EGO step (%) = 1**and **ignition events per step = 72** which gives the closed loop control some more stability and allows for better fine tuning at the higher RPMs.

For fine tuning, keep the O_2 adjustments per second between 3 and 5. For roughing in VE maps, set the O_2adjustments between 5 and 10 per second (depending on how good the O_2 sensor is, if it is old, go lower).

Once the map is tuned in, set the:

- **EGO ± limit (%) = 5%** (it can go higher depending on how questionable the map is)
- **EGO step (%) = 1**, and
- ignition events to a value that would switch about 4x a second at your average cruising speed.

You can calculate your:

O_2 adjustments per second = ((rpm/120) * cylinders) / ignition events per step

Note that the datalog includes an 'EngineBit' field. This bit will tell you if the engine was accelerating, warming-up, etc., and can be used to sort unsuitable data lines (because O_2 correction is not active under acceleration, warm-up, etc.) from the file.

The enginebit has 6 binary bits. The rightmost bit represents running. It is 1 if running, zero if not running, so 000001 = 1 or 000000 = 0. The next rightmost value is for cranking, 000010 = 2 if cranking. Note that and engine is never both running and cranking, so you should never see 000011 = 3. The fields are:

Binary Bit	Decimal	Meaning
00000X	1	Running
0000X0	2	Cranking
000X00	4	Start-Up enrich
00X000	8	Warm-Up enrich
0X0000	16	TPS accel enrich
X00000	32	TPS decel enlean

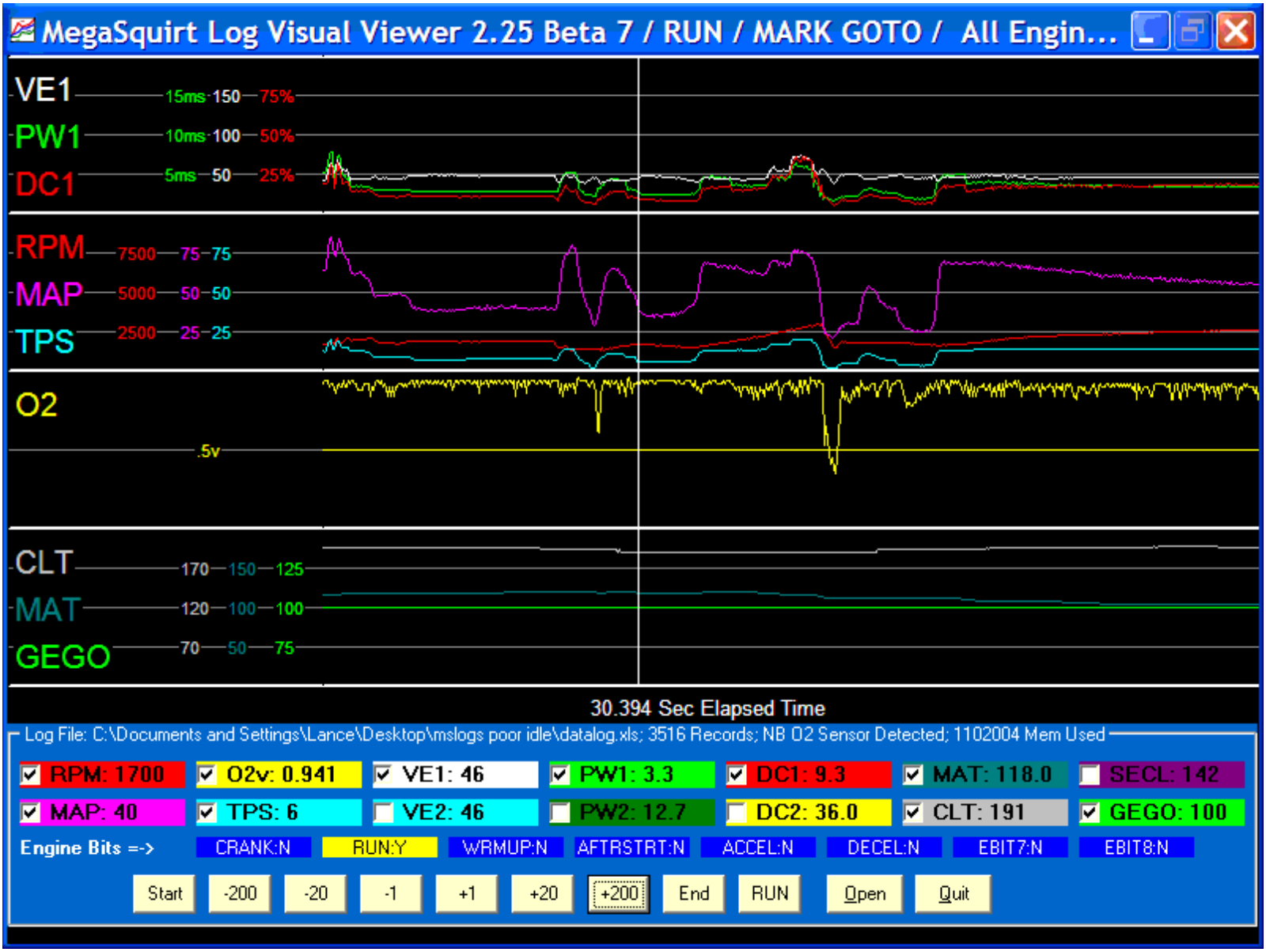
Note that the only suitable value for reading O_2sensor values is when the engine bit is equal to 1 (i.e. running and no enrichments). Here are examples of what some of the various values mean:

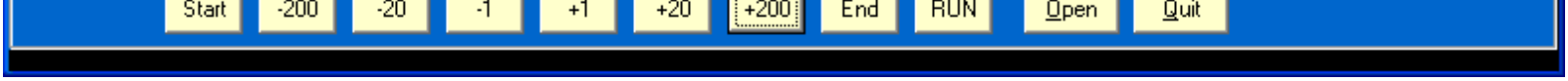
Engine Bit Examples		
Bit	Binary	Means:
1	000001	"running"
2	000010	"cranking"
5	000101	"running and start-up enrichment"
9	001001	"running and warm-up enrichment"
13	001101	"running and start-up enrichment and warm-up enrichment"
17	010001	"running and TPS acceleration enrichment"
25	011001	"running and warm-up and TPS acceleration enrichment"
33	100001	"running and TPS deceleration enrichment"

You can view your datalog files in graphical form using MS Logfile Visual Viewer, available from the files section of the msefi.com MegaSquirt support forums. Be sure to set your screen resolution to **1024x768** (for version 1.2, later versions may support other screen settings). MSLVV can be set for either narrow-band or wide-band oxygen sensor readings. Using the viewer, you can see the trends in your datalog, and spot trouble areas more easily than viewing the numbers in a spreadsheet.

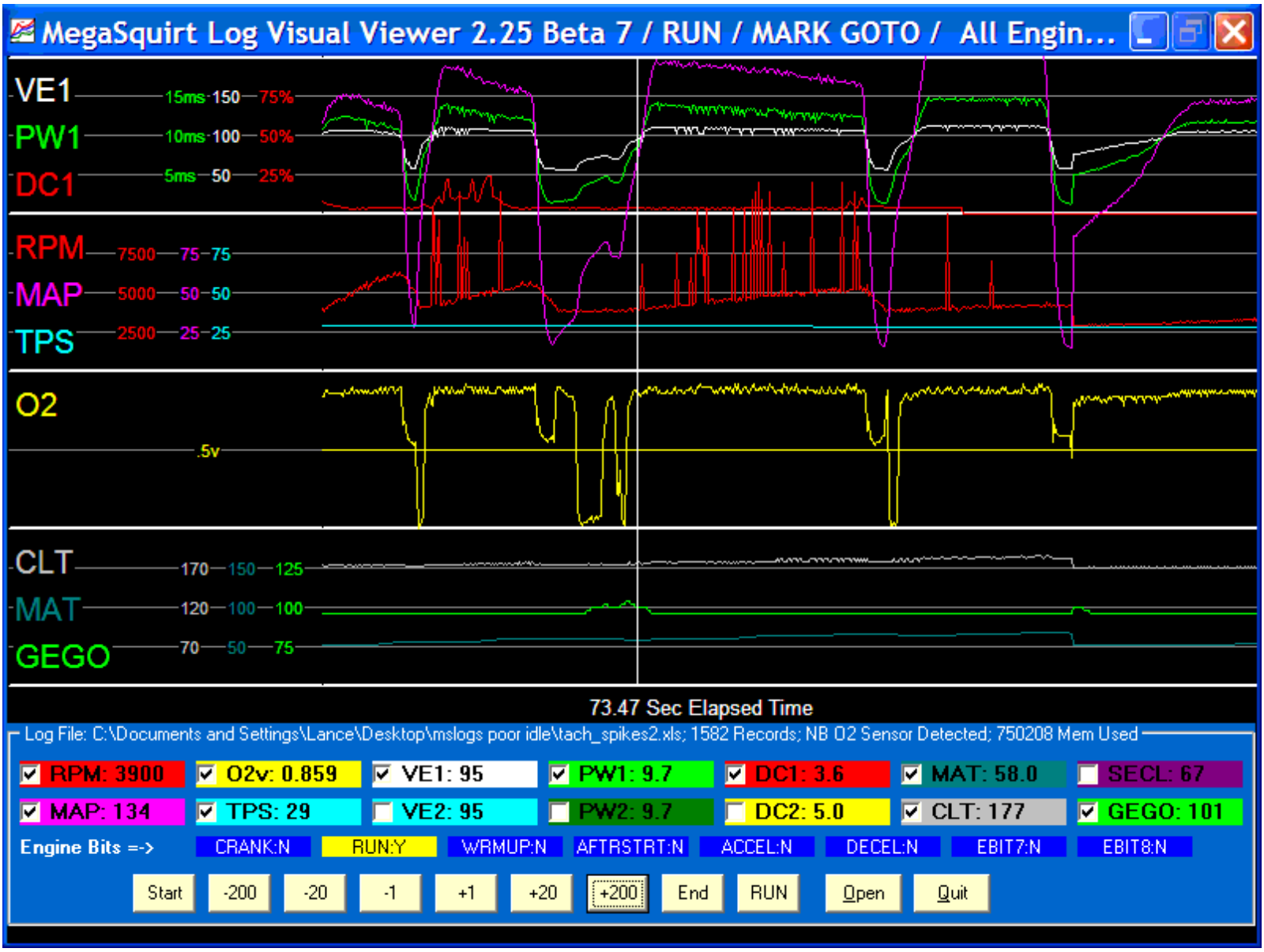
Using Datalogs for Tuning and Troubleshooting

Below are some screen shots of MSLVV showing datalogs with various diagnostic conditions.

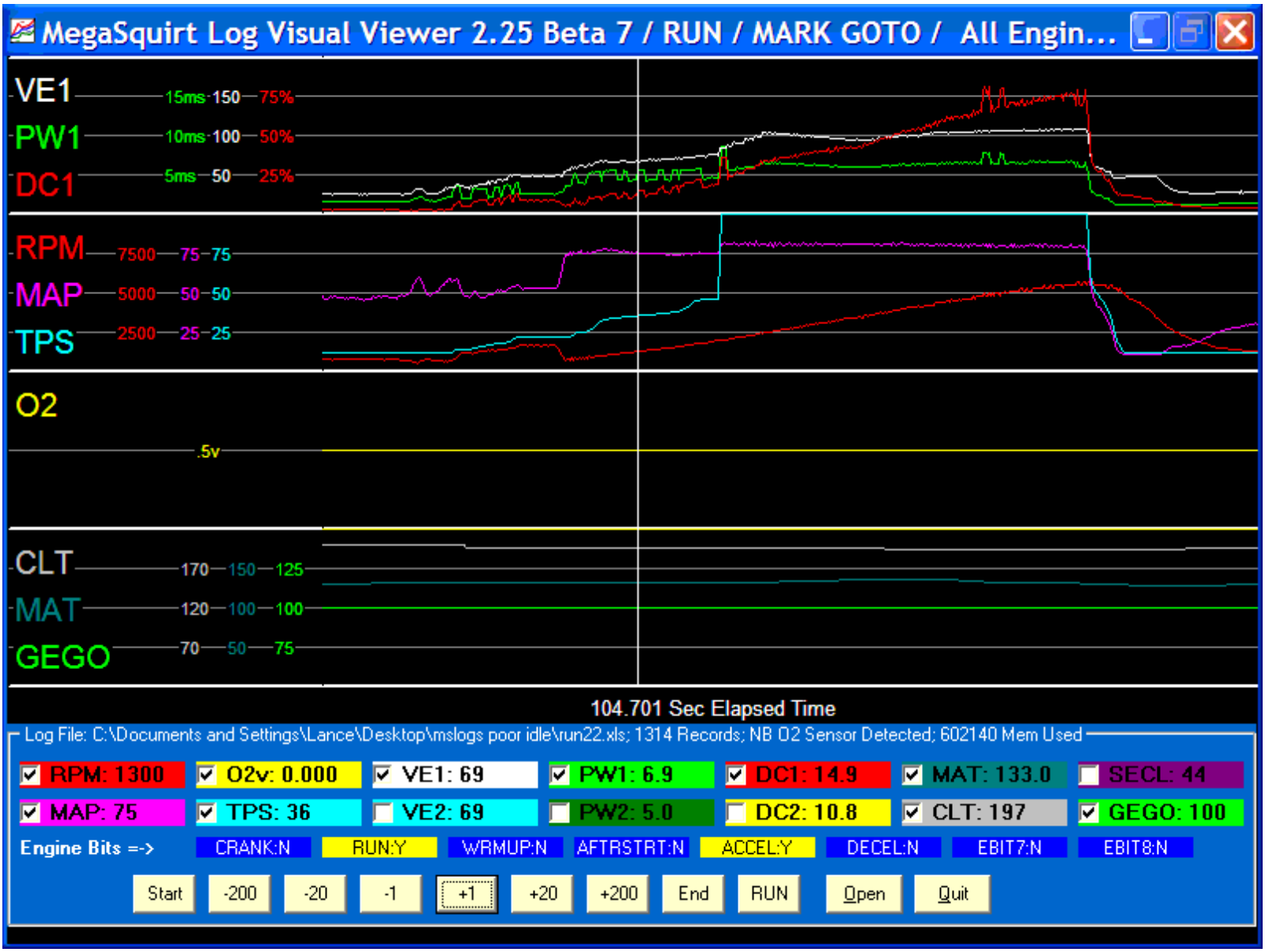




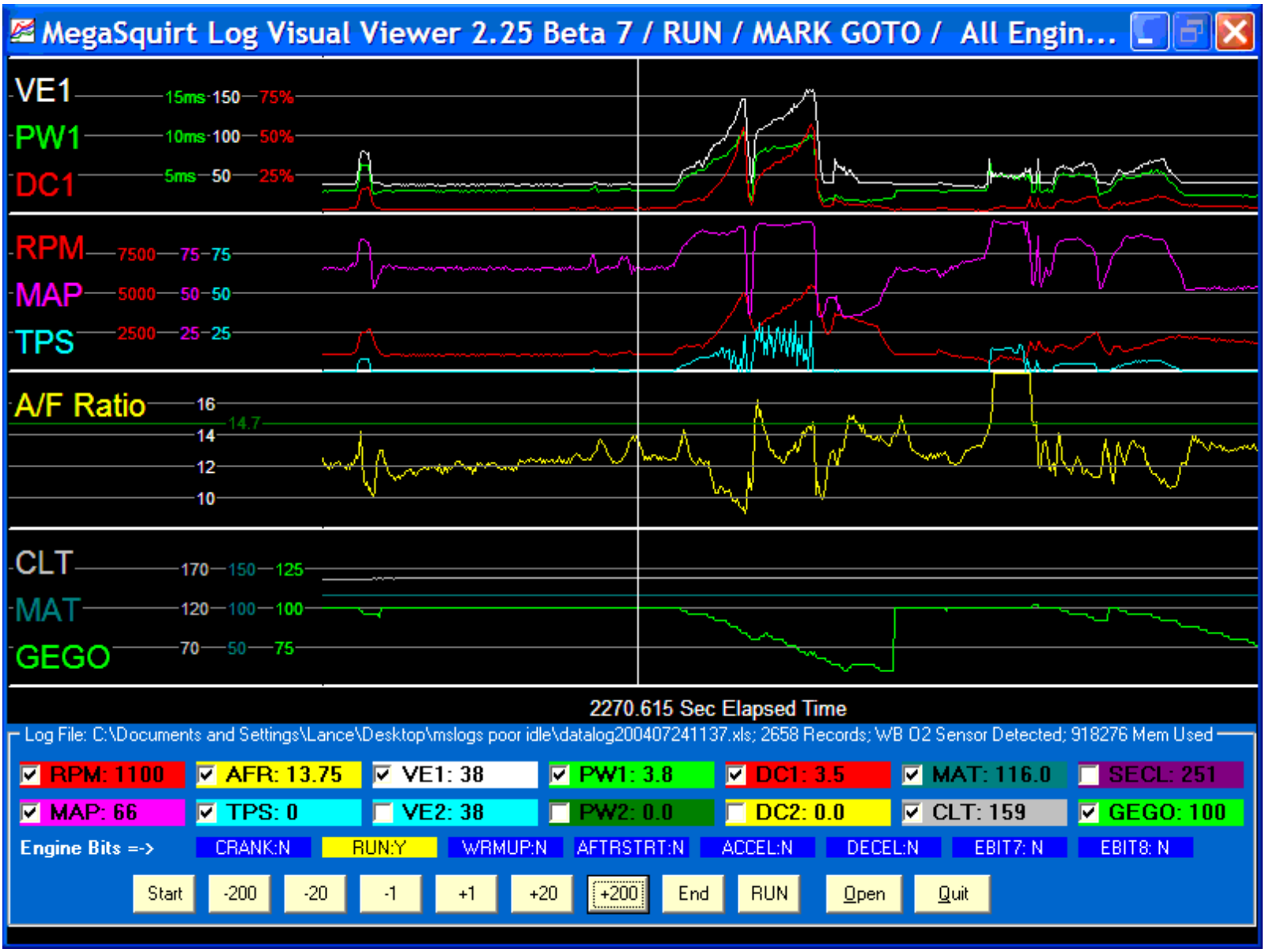
Above is an example of a good datalog. The sensors are all responding, and the MAP and RPM go up when the throttle is pressed, and not otherwise.



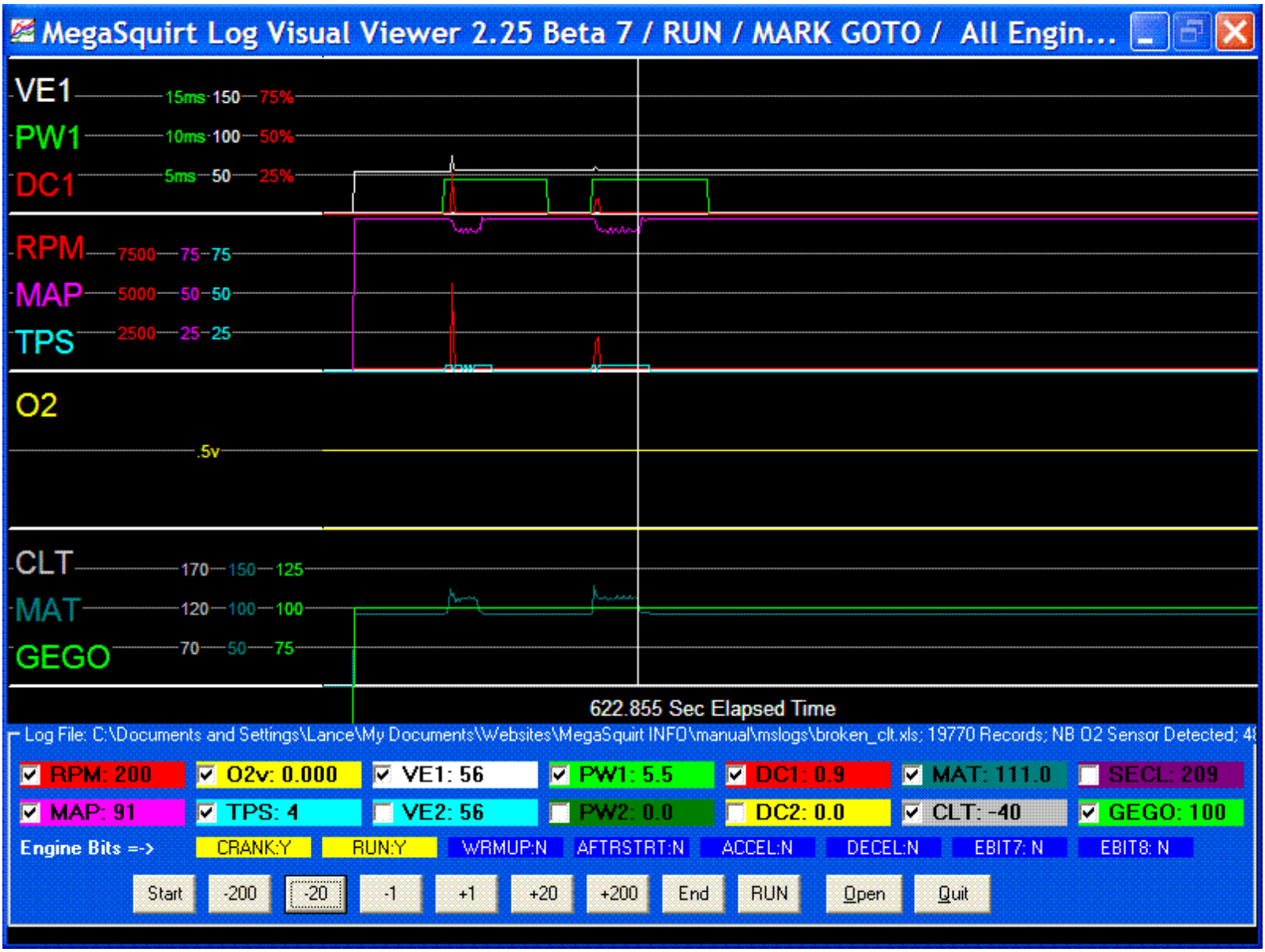
Above is a datalog showing the classic tach spikes. You can see that the RPM appears to rise very high, with the TPS seeming to be opened at all. The person tuning this engine has made the best of it by minimizing the accel enrichments (otherwise the pulse width and duty cycle would also rise very high), but the better solution is to fix the tach signal. There are hints on how to do this here.



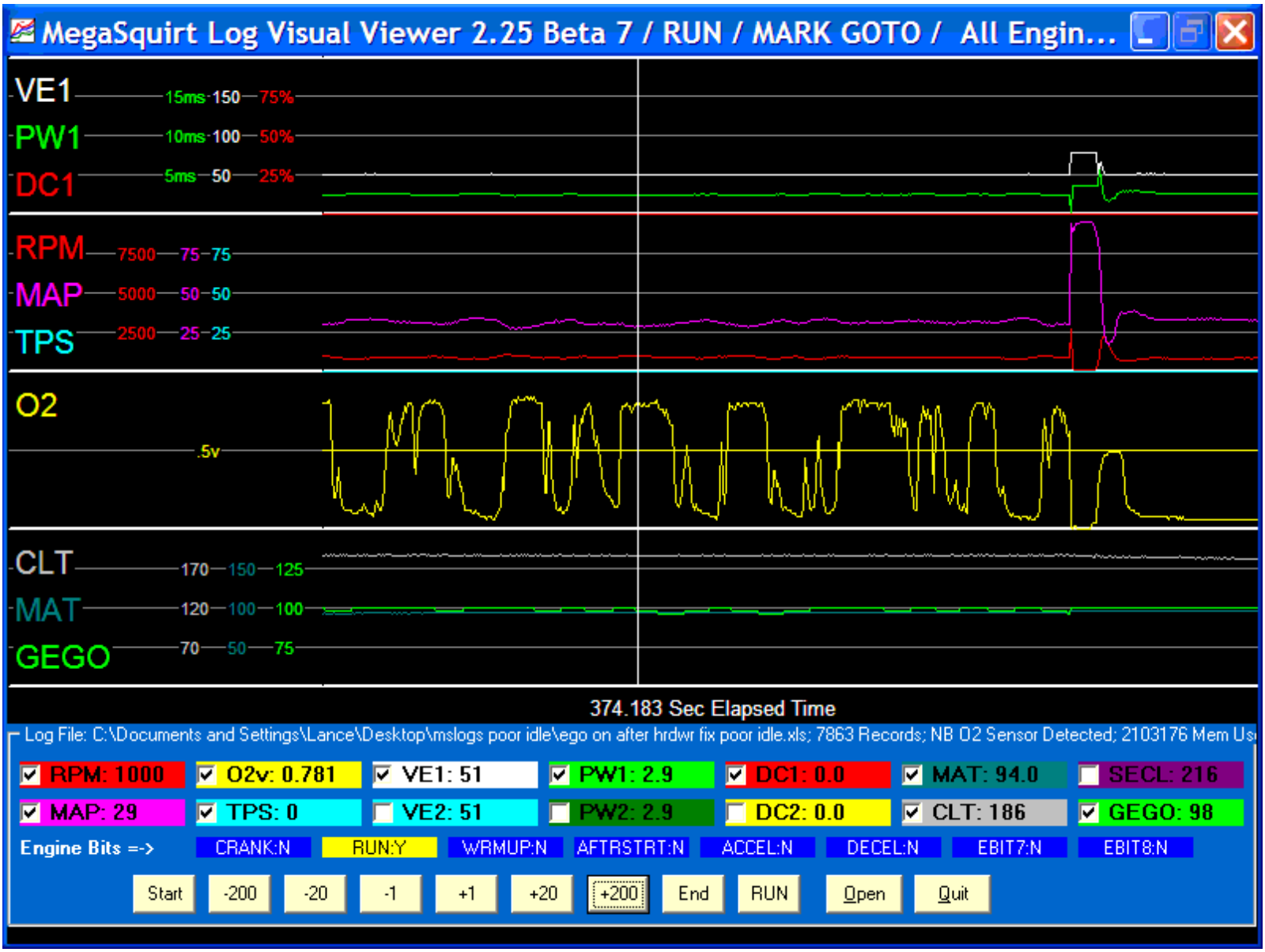
Above is an example of what happens when the TPSdot parameter is set too small (under ~1.0 is considered small). The usual amount of 'noise' in most TPS signals triggers the accel enrichment, and greatly increases the pulse width. The result is a very rich mixture and a poorly running engine that doesn't respond well to tuning. The solution is to increase the TPSdot parameter to 1.0 to 2.0.



Above is an example of a 'noisy' TPS signal. Unlike the above example, is this case the TPSdot threshold is set appropriately, but the TPS itself (or it's connecting wires) is generating a lot of noise. It may have a loose connection, it may have its wires running close to the spark plug wires or coil, or it may be damaged internally. In any case, it will trigger extra accel enrichment, and make tuning difficult.



Shown above is a fairly subtle problem. The CLT sensor is broken. Notice near the bottom of the page that it is stuck at -40°F. Because the CLT graph line is off the bottom of the page and is constant, it would be easy to overlook it. However, it will be adding a LOT of extra warm-up enrichment, and make it difficult to tune the warm-up parameters. If this had bee the IAT sensor, it would be even worse, since MegaSquirt uses that directly as part of the fuelling equation.

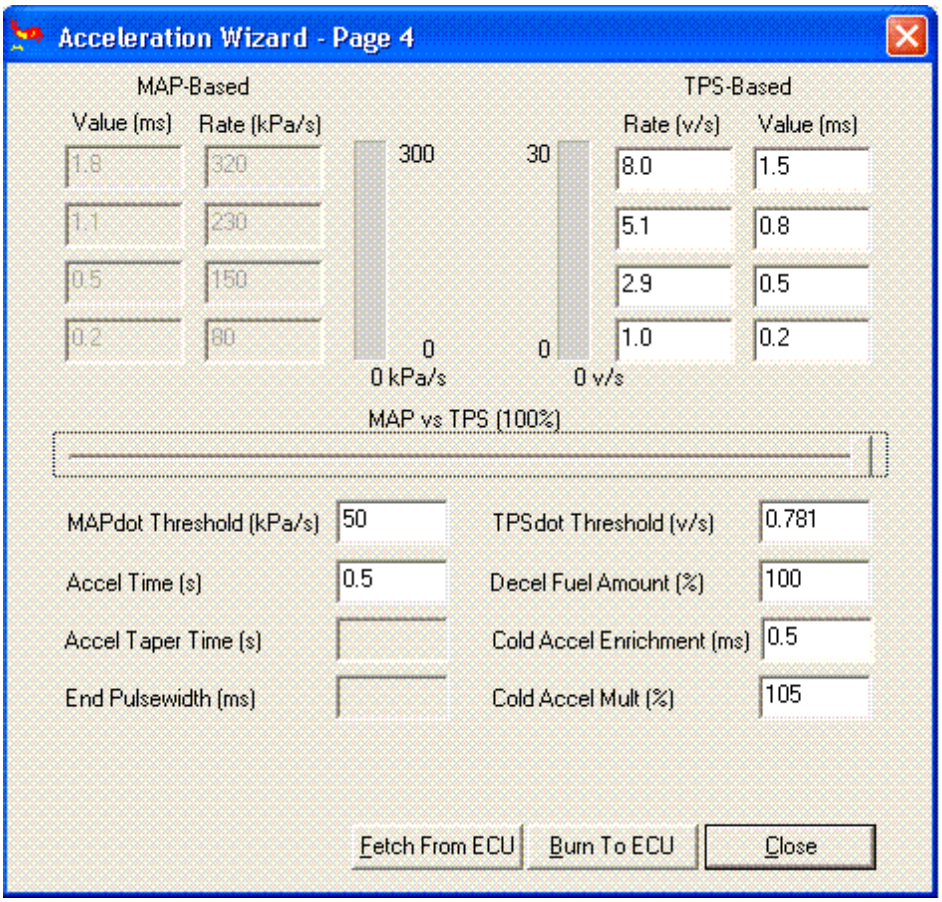


This screen shot above shows a very subtle example of a datalog, showing that the ego is causing an unstable idle. You can see that when the narrow band EGO is is rich (above 0.450 volts), the MAP is lower, and when the EGO is lean, the MAP is higher. In this case, richening the idle VEs, and turning off EGO correction at idle (by setting the EGO Active above rpm to a few hundred RPM higher than idle) will help this engine have a more stable idle.

Setting the Acceleration Enrichments

After you have the VE table dialed in, or if you have driveability problems initially, then start adjusting the acceleration enrichment.

The first thing to do is to ensure RPM Based Accel is not on, as this is for highly strung engines. Go into "RPM BASED ACCEL" and set it to Normal Based AE*^ . The next thing to set is your **TPSdot threshold (V/s)** or **MAPdot threshold (KPa/S),** try setting it to **TPSdot** first then if your not happy try **MAPdot**, this is in the Acceleration Wizard.



This setting determines the rate at which acceleration enrichment begins. If you set it too high, no accel enrichments will be applied, and the engine may respond poorly, backfiring or coughing under sudden throttle movements. If you set it too low, however, you may have inadvertent enrichment triggered by noise on the TPS signal. In general, use a setting between 0.5 and 2.00 (MegaTune may round these number slightly) - start with 1.00 unless you have a reason to do otherwise (it will be rounded to 0.977, which is fine). If using MAPdot then try 50-80KPa/S. Check you datalogs to see if the accel enrichment is being triggered when you don't want it to be (like at idle). This will show up as very large jumps in the pulse width for no apparent reason (though later versions of MSLVV will show the Accel indicator).

Other settings for Acceleration Enrichment can be found under "Accel Decel Mode"

The Accel Timer can be changed from Seconds to Engine Cycle counts. Note that a value of 0.3 could mean 0.3 seconds or 3 ignition pulses. The Cycles option is useful because the enrichment will reduce at higher rpms

Normal MS mode finds the increase in PW and holds that till the Accel Timer has timed out. By selecting Decay it will find the increase to add then it will linearly decrease the Enrichment, to the Decay Value by the time the Accel Timer has timed out.

If in MAP mode then you can turn off the accel/decel enrichment when the engine goes into boost.

You can also turn just the Decel off in either mode when in Boost to prevent a lean condition in boost

One of the reasons that there isn't a "magic formula" for accel tuning is that it really is a "feel" and "driving style" sort of thing. And it depends critically on your state of tune for the VE table, warm-up enrichments, manifolding, idle and cruise speed and AFR, TBI vs. port, injector flow rate, and a million other things.

In a nutshell, too much accel enrichment produces a sluggish throttle, too little accel enrichment produces backfires in the intake manifold.

The best way to get a rough accel tune is to "blip" the throttle with no load (at different rates, but you have to guess which bin was active), and adjust the accel bins for the best throttle response (and this will also depend on the decel amount).

The more rapidly you can get the engine to rev and recover, the better your accel/decel enrichments. If they are really tuned in, you should be able to rev the engine repeatedly, with the engine responding 'crisply' every time.

You may want to try a short **Accel Time** (like 0.2 ms) and jack up the accel enrichment bins.

A **Decel Fuel Amount (%)** setting of 100% means no cut. 1% means reduce the pulse width by 99%, to 1% of what it normally would be. The low MAP part of your VE table is probably a touch lean, so the NB sensor drops below stoichiometric. If the car does not buck too hard, you are close to correct settings. If it bucks and stumbles, then it is going too lean and you need to richen that part of the table.

Before tuning decel [or accel], try to make sure you have your VE table close to correct first. To get the VE table set up, set the delta-TPS setting very high (30v/s or something like that) so that **TPS enrich/enlean** never kicks in. Then, (in steady state) set up VE table. If the vehicle is undriveable without tuning the accel enrichments, by all means do it, but be sure to revisit the accel tuning as you tune your VE table.

To adjust the accel bins, start with them high, something like:

Bin	Default MegaSquirt (ms)	Start tuning at (ms)
2 volts/second (idle to WOT in 2.5 seconds)	0.5	1.0
4 v/s	2.0	4.0
8 v/s	4.0	8.0
15 v/s (idle>WOT in 3/10 sec.)	7.7	15.0

This will reduce the possibility of backfiring while trying to tune the VE table. If you experience backfires or bucking, increase the bin values even more, until the car no longer backfires when you step on the throttle.

Then reduce the lowest bin (2 v/s) value by 0.1 milliseconds at a time until the engine stumbles or coughs under gentle opening of the throttle. If the engine never stumbles, increase the rate at which you open the throttle and try again. If it stumbles even with the above values, double them and try again.

Then repeat with the next higher bin and slightly faster throttle movement. Continue with each higher bin and more aggressive throttle application until all the bins are satisfactory.

In addition to the accel enrichment bins, you also need to set the cold acceleration enrichments. These are the **Cold Accel Enrichment (ms)**, and the **Cold Accel Mult (%)**. Both of these affect the amount of enrichment when cold.

overall pulse width = Req_Fuel * MAP * VE + (AE *CM + CA) + ...

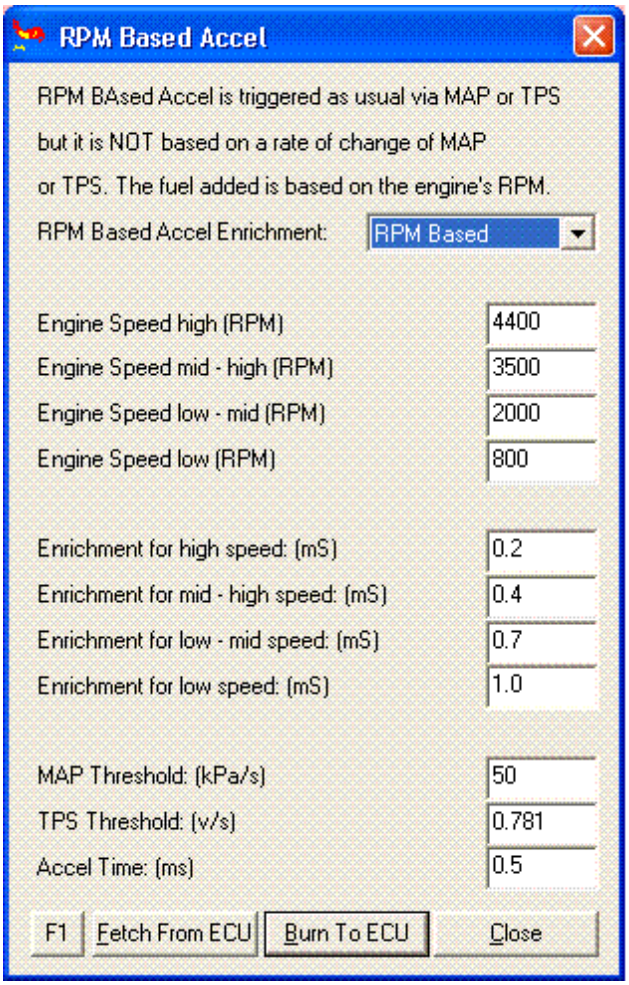
where:

AE = acceleration enrichment pulsewidth
CM = cold accel multiplier
CA = cold accel additive

Thus, the **cold accel mult (%)** a linear scalar for the acceleration enrichment that increases it by the specified percent, whereas the **cold accel enrichment (ms)** is an additive constant that does not depend on the accel bin settings at all. Both are linear functions of the coolant temperature (i.e. they have no effect at 160°F, 50% effect at 60°F, full effect at -40°F).

In general, you need to set both for best driveability when cold. Try settings of 3.0 milliseconds for the **Cold Accel Enrichment** (ms), and 130% for the **Cold Accel Mult** (%) to begin. Adjust them to get the best overall driveability when the engine is warming-up. When you get it right you should be able to start the car up and drive away with any stumbles at all.

RPM Based Acceleration Enrichment



THIS OPTION IS USED FOR A VERY SPECIALISED INSTALL!! 99.9% of installs will not need this option.
This is triggered via a rate of change of TPS or MAP as the usual Accel Stuff, BUT the enrichment is based on how fast the engine is running. The MAP and TPS based Accel erichment bins in the **Accel Wizard** will be ignored in this mode. This is often required with high strung small displacement MOTORS and race motors. The Trigger threshold values will still be current as this is still when the AE cuts in. The **threshold** values and **Accel time** are doubled up on this setting box and are the same as on the AE Wizard.

Check Certain Resistors

If you want your MegaSquirt to be reliable, do not skip this step. You need to tune two of the resistors to values appropriate for your ignition and injector set-up.

While then engine is running, check the temperature of R10 (kit supplied 390 ohm, 1/2 watt, orange-white-brown), which is used in the ignition input circuit from the coil. It should not be too hot to touch with your fingertip. If it is too hot, the value of this resistor may have to be changed depending on application - start with the supplied value (390 ohms), and if runs hot while running, then increase its value, in steps, up to 10K (like 470 ohms, 560 ohms, 680 ohms, 1K, ...). Some applications may require even higher resistance, check the MegaSquirt Forums group for advice. Use 1/2 watt resistors.

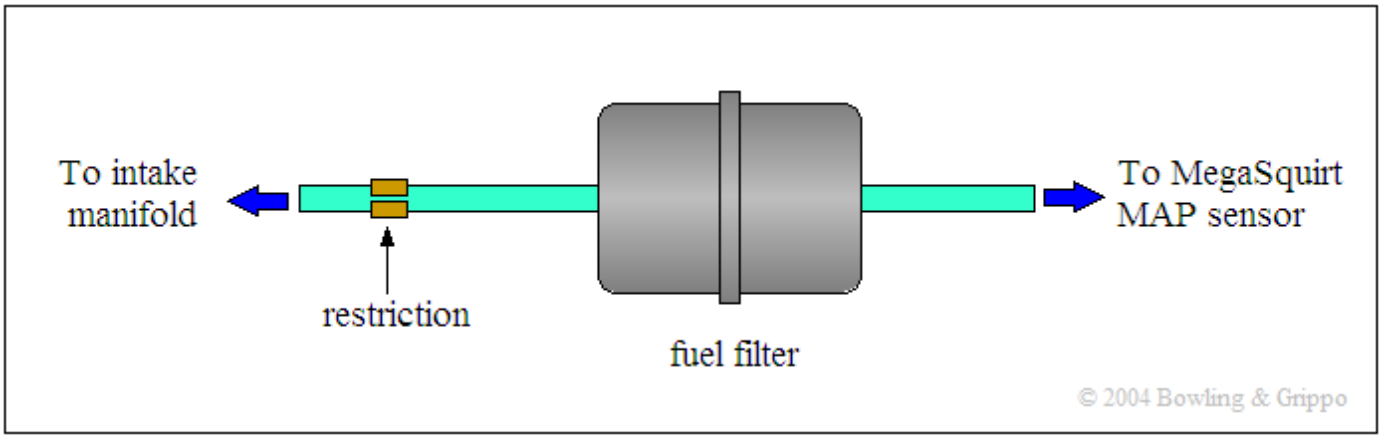
Also check the temperature of R32 (270 ohm, 1/2 watt). This resistor is used in the flyback circuit to control the closing of your injectors. It should not be too hot to touch with your fingertip. If it is too hot, the value of this resistor can be increased, or the Zener D21 can be replaced with a Zener diode that has a lower breakdown value than the 36 volt 1N4753 specified in the BOM. You might try 22 volts (1N4749).

Tuning Issues

If you have a very long duration cam in your motor, and it idles poorly, you might be able to get it to idle better through careful tuning with MegaSquirt. Often a rough idle may be caused by lean air/fuel ratios. This is really is more of a cam issue than a fueling issue. The exhaust valve is held open later into the intake stroke and the intake opens earlier near the end of the exhaust stroke. At low speeds and relatively high intake vacuum you get more exhaust contamination of the fresh air/fuel charge. As you get more contamination of the air/fuel charge you typically need a richer mixture to get it to ignite and burn properly.

This means you probably cannot run a stoichiometric [chemically correct] mixture of 14.7:1 with your long duration cam. You need to run richer. So you tune your idle by ear rather than with a narrow band EGO [oxygen] sensor. And make sure you are not allowing EGO correction at idle if you have a rowdy cam! It will be trying to “correct” your mixture back to a lousy idle. If your engine will not idle well at stoichiometric mixtures, set the EGO Active Above RPM to a few hundred RPM above your idle speed. This will ensure that MegaSquirt does not try to lean the mixture back to stoichiometric to compensate for your adjustments.

Another tip you can try if you have a large overlap cam is to pinch off the MAP hose slightly while the engine is idling, and see if the idle quality improves. If so, then try a restriction in the MAP vacuum line. This has the effect of damping the vacuum pulses that the MAP sensor sees. Start with a ~0.040" (1.0mm) restriction in the line. You may have to experiment with restrictor sizes to see what works best for your system.



A few more things to try:

1) Check your VE table entries near the idle point - if the RPM or MAP fluctuate, then you can get rolling idles, etc. You may have to move some of the bins around to bracket the idle RPM/MAP region, and keep flat VE values within this.

2) If you run low-impedance injectors, you need to tune your PWM current limit. Start with 75% PWM and 1.0 millisecond time threshold. Once you get idling, then first adjust the PWM duty cycle down until you notice a change in idle quality, then move the value back up 3 - 5%. Do the same with the time threshold. On the car it is very easy to do and only takes a few minutes. And, at idle, the overall injector pulse widths are small compared to their close time, so this will allow you to adjust the values. In other words, adjust the PWM current limit before taking the car out on the street where injector pulse widths become high.

Your engine will idle at a certain vacuum. It might help on a street use motor on the VE map to use a lower point for starting MAP than idle vacuum. For example you can have yours set at 20 even though you idle at 27 or so. This allows you to run less fuel on overrun deceleration and coast events (not just for a second like the TPS will do). This allows you a saving of 3-4 MPG on average driving and you might be able to run more advanced timing under this vacuum.

On the other hand, you may want to do the opposite. You can increase the VE values just to the left and above idle. You can make them really rich [say double the idle VE value, to keep the car from stalling. This seems to work really well, if the engine starts to stumble, the pulse width goes up and it recovers.

By working with the RPM and MAP bins, you should be able to work out a set of values that lets you run lean at cruise and decel [where the RPM is above idle, and MAP below idle], but rich when stalling [RPM below idle].

On the warm up enrichments page, the warm up enrichment only goes to 160º F. The 160º F bin value of the enrichment (which should ideally be 100%) is used at all temperatures above 160º F, so it is important to ensure that 100% is entered in there.

The system compensates automatically for any amount of idle solenoid bypass air because of the effect it has on the MAP value [i.e. the vacuum in the manifold is lowered by the bypass air, this is sensed by the Manifold Absolute Pressure sensor, and the processor decides to inject more fuel. The effect is exactly the same as if you had cracked open the throttle a bit. The fuel goes around the throttle plates, which are never truly closed. They are set at the opening required for the slowest throttle speed desired for the engine under optimal conditions, which

leave plenty of room for the fuel to get by. The fast idle air then adds to this baseline amount of air to raise the idle speed. In some circumstances, you may want to run without oxygen sensor feedback, called “open loop”. The best way of forcing MegaSquirt to run open loop is to change the O_2 sensor step to 0 [zero] on the enrichments page. It will still log the O_2 voltage, but not do anything about it.

The MegaSquirt Fuel Pump output is programmed with a priming pulse option to shut off the unit in case of an engine stall, etc. It can turn on the pump immediately when the power is applied and shuts it off 2 seconds later if the engine is not running. Go into "Cranking Settings" youll find

PRIME PUMP WHEN - Values for this item are either Prime Pulse > 0 or Always. If you select the first option, the pump will only be primed if the priming pulsewidth setting is greater than zero. If you select the latter option, Always, the pump will be primed regardless of your priming pulsewidth. You will most likely want to use Always as it will get your fuel pressure up before cranking, but you don't necessarily have to inject any fuel. The priming period is two seconds.

FIRE PRIMING PULSE - The **Fire Priming Pulse** option allows you to select when a priming pulse is fired. If you select **Power Up**, a priming pulse will be fired immediately upon turning on the ignition. If you select **Twice**, one priming pulse will be fired when you first key the ignition on and the second pulse will be fired after a second has passed. If you select After 2 Secs, there will be one priming pulse two seconds after turning on the ignition.
The first option was in the original stock code, however, it will not necessarily work for a cold-start because there there may not already be fuel pressure in the rail when you turn the ignition on. The other two options are just different methods of firing the priming pulse. If you select **Twice**, then there will most likely be no fuel injected on the first pulse, unless there is already fuel pressure in the fuel rail, and then there sould be fuel injected on the next pulse. If you select the After 2 Secs option, it will give the fuel pump time to build up pressure. With that option, however, remember that if you try and start the car before allowing two seconds to elapse, no priming pulse will ever be injected.

When you start cranking, the pump comes on, and times out two seconds after the last pulse on the tach signal.

If your MegaTune displays bizarre values for the barometer on the runtime display, 76 kPa, for example, you may be resetting while running. MegaTune has a check that detects most resets by watching the seconds value. If the seconds goes to zero from any value other than 255, then it signals a reset with an audible “beep” and sets a counter visible on the lower right corner of the screen, where it normally says "connected".

As well, you can check the datalog seconds count - make sure it counts up to 255, and then rolls over to zero and continues again and again. If you get shorter counts (like say 56 then a roll over) then the processor is resetting. Note that most of the time on the car you will not notice that the reset has occurred because it happens so fast. What happens when the engine has a running reset (when the engine is running and the processor resets), then it grabs the barometer near the beginning of the MegaSquirt processor boot procedure. If the engine is running, then it will grab engine vacuum and use this for barometer. See **HERE** for ways to get around this problem in the settings.

For normal operation the processor comes up so fast that it has grabbed the MAP value before the engine has a chance to start cranking, much less running.

You need Windows 95/98/ME/XP and a conventional serial port to communicate with MegaSquirt. USB will NOT work directly, however some people have reported that they have been successful using a USB-serial adapter. You do not need a fast computer to tune MegaSquirt, just about any computer that is capable of booting Windows 95 (or better) will be fast enough, but get the fastest machine you think is reasonably priced. if using a USB adaptor and you are finding communications is intermitant try setting the Buffer Received and Transmitted values lower, I have found setting them as low as they will go can help cure problems.

Tuning for Economy

To get maximum fuel economy, you want the engine to run as slowly as you can (hence the proliferation of overdrive transmissions in the last 15 years), and to run an Air/Fuel ratio (AFR) of about *16.5:1* to *17:1*.

To tune for economy with a wide band oxygen sensor is relatively easy. Look up the sensor output at *~16.5:1* for your sensor (~2.65 volts for the DIY-WBO_2, for example). Put that value as your EGO trigger point in MegaTune, and if your EGO ± Limit (%) is sufficient (given the state of tune of your VE table), you should be getting good economy.

You can try mixtures leaner than *16.5:1*, however you may get a lean 'surge' that feels like someone is pushing the car forwards, then pulling it backwards. Generally, this is a sign that you are too lean.

With a narrow band, it's a bit tougher to set it for maximum economy. You can adjust the VE table, but the EGO correction tries to bring it

back to a stoichiometric AFR.

You could raise your EGO_RPM_limit to just above your cruise rpm, but depending on where that is, it might not be all that workable. A better method, if you have a narrow band oxygen sensor, is:

- first, get the VE table tuned with stoichiometric values around the 'cruise' rpm(s) and kPa(s).
- then recalculate the VE numbers around your cruise rpm and kPa to 16.5:1 **minus** 5%. For example, if you had a value of 56% (at stoich. AFR), you would replace it with:

$$\textit{new VE} = \{56\% \times (14.7 \div 16.5)\} - 5\% = 45\%$$

- then set the **EGO ± Limit (%)** to 5%.

Do this for all the values in the VE table you actually cruise at, but not the higher rpm, higher load areas of the VE table.

That keeps the EGO at 16.5:1 at cruise, but lets you set it anywhere else in the rest of the table.

Tuning for Emissions

To tune your engine for minimal emissions using MegaSquirt properly requires expensive test equipment. However, as a start, you can:

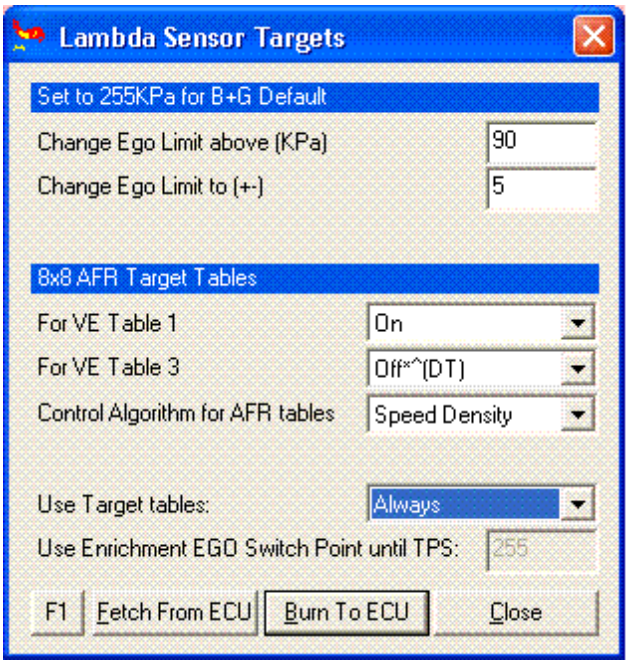
- Make sure your **ignition system is in good working condition** - a tune-up (distributor cap, rotor, wires, spark plugs, PCV, EGR, etc.) is a good idea before emissions testing,
- Make sure your engine is equipped with a **working catalytic converter(s**) if possible,
- Set your **EGO Switch Point** to **0.450 volts** for a narrow band sensor, stoichiometric for a wide band sensor (2.500 volts for the DIY-WBO_2 for example),
- **Retard** your ignition timing by ~5° to 10° (this creates a hotter exhaust that prolongs the burn and also helps the catalytic converters to operate at peak efficiency),
- **Increase your idle speed** slightly - if it idles well at 750 rpm, but stumbles a bit if set lower, set it to about 950-1000 rpm,
- If you have an adjustable electric fan, **increase the fan 'ON' temperature** to about 200°F to 215°F,
- If you have an oiled 'lifetime' air filter, replace it with a **plain paper filter** for testing (the oil in the filter can drive up emissions),
- Make sure your **vehicle is fully warmed-up** before testing,
- **Add some alcohol** (often available as gasoline anti-freeze) to your fuel tank - start by putting in twice the recommended amount for the anti-freeze. This helps by introducing additional oxygen into the combustion process, ensuring a complete burn.

Here is an example of how a few changes affected one engine:

	Baseline	Timing Retarded 10°	Timing Advanced 10°	Mixture richened	Mixture leaned
HC	1.00	**0.78**	1.14	1.39	0.88
CO	14.5	11.6	13.0	81.0	**9.8**
NO_x	2.91	1.89	5.18	**0.71**	3.03
O_2 Not usually tested	22.3	19.8	23.8	**17.4**	25.4
CO_2 Not usually tested	305	307	298	**246**	310

You can see that retarding the timing and leaning the mixture slightly gives the best possible compromise, increasing only the NO_x slightly among the regulated emissions. (*The above was without a catalytic converter. With a converter, emissions would have been best at stoichiometric mixtures and the timing retarded somewhat.*)

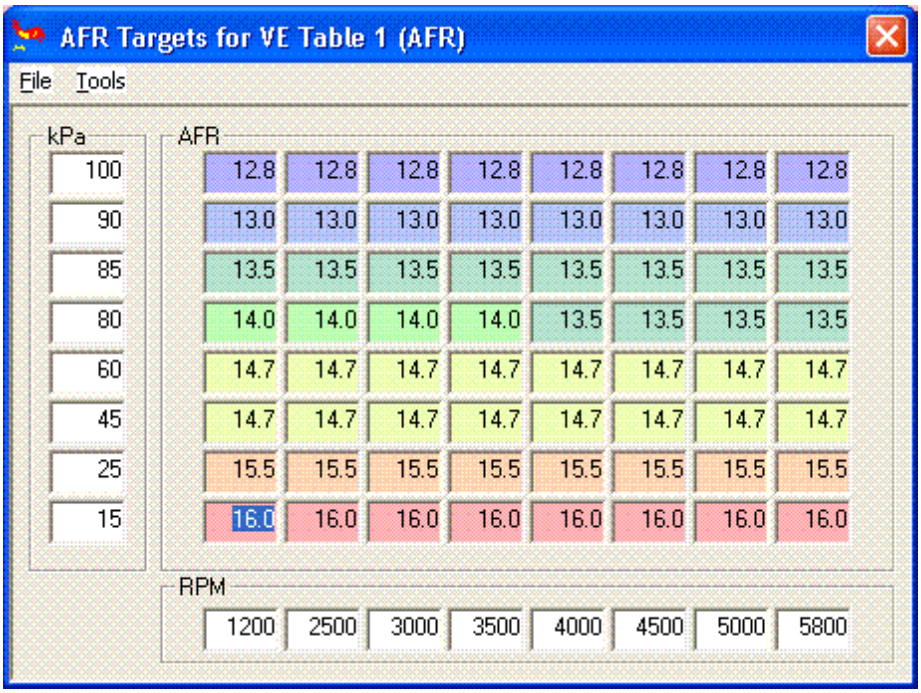
Lambda AFR Settings



You can now change the **Ego Limit** depending on the MAP KPa so the ECU can have a larger authority during cruising and a smaller authority when accelerating hard. If you don't want it to change simply put 255 in the KPa setpoint.

Widedband Lambda Target AFR Tables

If you are using a Wideband lambda sensor you can set the **AFR targets** that the ECU will correct for in a 8x8 table. See "**Lambda AFR Settings**" There are 2 AFR target tables, these do away with your EGO Switch point in Exhaust Gas Settings, but it is strongly recommended that this is only used when you have a Wideband Lambda sensor setup.
Table 1 contains the target AFR's for VE Table 1.
Table 2 contains the target AFR's for VE Table 3.
NOTE: These are just targets, they dont replace your VE table and should be thought of as a fine tune for the VE table.
If you dont want to use them simply select them off. The target will then be as set in the enrichments page. See the Lambda AFR Settings section for how to turn this option on **HERE**



AFR Targets for VE Table 1 (AFR)

File Tools

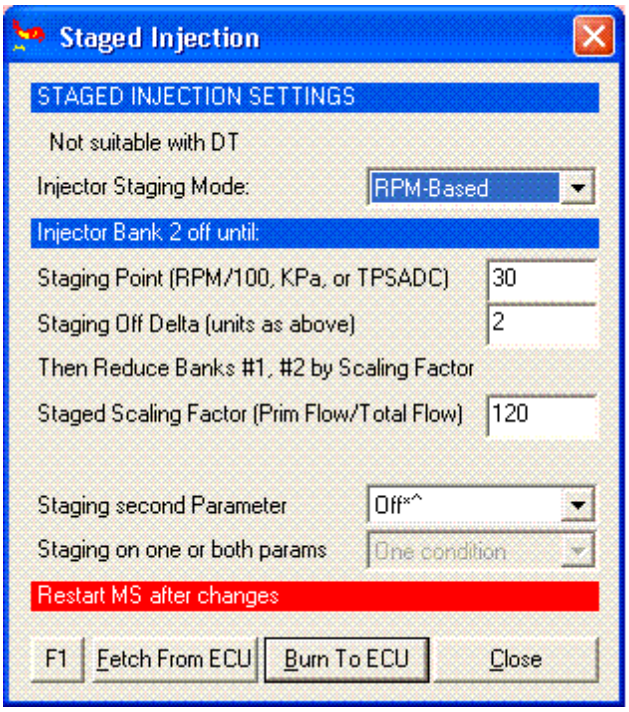
kPa	AFR							
100	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8
90	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
85	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
80	14.0	14.0	14.0	14.0	13.5	13.5	13.5	13.5
60	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7
45	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7
25	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5
15	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
RPM	1200	2500	3000	3500	4000	4500	5000	5800

Overrun Settings

This is used to cut fuel off during deceleration to aid engine braking and reduce fuel use. The **RPM setpoint** will need to be a bit higher than your tickover speed, I would suggest it was around 800rpm higher than the tickover RPM so as the fuel and engine has time to settle down again once fuel is switched back in.
The **KPa** should be set to slightly above the vacuum value pulled when decelerating, e.g. 20KPa.
A typical delay time of 1-2S is best to ensure it doesn't hunt.
To find your **TPS setting** value, go to **Tools, Calibrate TPS,** and with your foot completly OFF the throttle hit Get Current. Remember this value and hit CANCEL on the Calibrate TPS dialog. Add 2-3 to this value and enter it, so if you had a value of 20 enter 22 in the setting.

Staged Injection

Staged Injection System Not for use in Dual Table (DT) mode!
This runs Bank 1 injectors only untill the setpoint is satisfied, then Bank 1 and 2 will fire at a reduced amount depending on the scale factor. So by wiring a small set of injectors to Ch1 and a larger set to Ch2 you can have a good idle control with the first bank firing and then under load switch the second bank on to get enough fuel for the power the engine produces.
This is worked out by calculating Primary Injector Flow/Total Inj Flow. When the engine runs below the setpoint-delta the injectors change back to CH1 on normally and CH2 off. In this example the 2nd bank will turn on at 3000RPM and off at 2800RPM.



If you want to have 2 conditions to turn the second bank on and off you can select this and then use the "**More Staged Injection**" settings to select when that condition will apply.

There is also an "**injector staging delay**" in "**more staged settings**" where you can specify a number of ignition events to bring on the secondaries and scale down the primaries. It will gradually do the switch over on that many ignition events, if you specify 0, it just does it instantly. This helps people who have secondaries up the intake tract from primaries so the engine doesn't get a lean spot waiting for the fuel from the secondaries to get to the engine.

Coolant Related Air Density

This is for experienced users to alter their air density correction with coolant temperature rather than with air temperature. Some people have found that their engines lean out due to the air temp sensor becoming saturated by the engine's heat, this gives the ECU the impresion the incoming air is really hot when in fact it is simply the sensor thats been heated up by the mass of the engine.

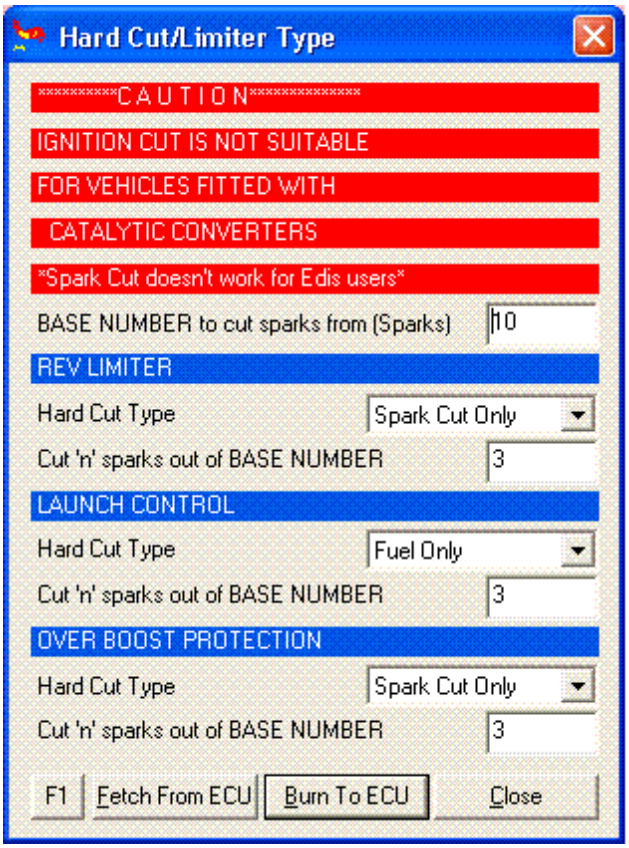
To help TUNE this we have added Coolant Correction percentage.
With this function enabled the correction percentage is interpolated from the table, depending on the coolant temperature. So Air Density would now be :
Air Density = (MAT Related Air Density) * Coolant related correction %
E.G. Air Density = 120 * 110 % = 132
This correction can then be reduced by the engines RPM. The Reduction Start value is where the coolant correction is started to be removed, and the correction End position is where there will no longer be any coolant correction. The coolant correction is interpolated between these 2 points. At engine speeds lower then the start point the correction will be as the Coolant Correction Table. Between the Start and End values the Coolant Correction is reduced at a linear rate. At the End value the Coolant Correction rate is removed totally.
The idea is that as rpm increases as does air flow, so the MAT sensor will be a more realistic measurement of density.
So if start is 3000rpm and end is 6000, and correction is 150%, then at 3000rpm correction will be 150%, at 4500rpm correction will be 125% and at 6000rpm correction will be 100% (i.e. no correction).
We have allowed the temperatures to be user defined, suggested temps would be :
Temp 1 = -40 F
Temp 2 = -20 F
Temp 3 = 0 F
Temp 4 = 20 F
Temp 5 = 50 F
Temp 6 = 80 F
Temp 7 = 120 F

To ensure this selection is OFF go into "**Coolant Related Air Density**" then select "**Settings**" and ensure the selection is "**NORMAL**

CORRECTION"

Rev Limiter

The rev limiter can cut fuel and or sparks depending on what system you are running, sparks cannot be cut in Edis mode or if you are using a catalitic converter.



The **Base Number** is the number of sparks that can be cut from (yy). This value will depend on the number of cylinders you have but generally 10 is the best value to use.
Then select how many **sparks to cut** in each mode(xx).
So you will get xx cuts in every yy sparks e.g. - - -*******,- - - *******, - - - ******* this allows all the cylinders to fire as the cut cylinders will roll round to the next cylinder next time around. The RPM that this cuts in at can be altered in the "**Rev Limits**" under **Hard Rev Limit**, the **soft rev limit** simply retards the ignition so reduce power produced, e.g. 8 DBTDC

Advanced Settings

Hybrid Alpha N system adds KPa to an Alpha_N setup. This means that the KPa value becomes part of the fueling calculations, the same as in Speed density, so when you go into boost the fueling will increase even when you have the same VE value. The addition of fuel for boost comes through the MAP term in the fuel equation:
PW = REQ_FUEL * VE * MAP * E + accel + Injector_open_time

Thus increasing the VE at higher boosts makes the mixture richer, but it would not have run leaner simply because of the higher boost. This is very important for turbo applications where Alpha_n is used.

We have added the facility for a Mass Air Flow Meter to run the fuel calculations rather than a MAP sensor. Connect the MAF 0-5V output up to pin X7 (JS5) via a filter circuit as described on the Extra website. In MegaTune ensure the Mass_Air_Flow Mode is set in the Settings.ini file. This is some what experimental, expect the VE table to look very linear with lots of rows of numbers the same value in the horizontal axis. Andy Whittle has had some sucess with this system and it is him I would try to contact if you are thinking of going over to this setup, Whittlebeast on the MSEFI forum. Air Density Correction is most likely built into the MAF you are using, so set to BUILT INTO MAF.

False trigger protection should always be set to Enabled, unless you are using the trigger logging feature. Whilst logging triggers it can be

handy to disable the protection so that all triggers (including noise) gets logged

300 and 400KPa Sensors / Map Sensor Settings

In some instalations the standard 250KPa (21psi of boost) sensor simply isn't enough. So it is possible to fit a 300 or even a 400KPa sensor in place of the original 250Kpa one. There are 2 types we recommend, the MPXH6300A (DATA SHEET) or the MPXH6400A (DATA SHEET) these are difficult to fit but DiyAutoTune does a small board with the 400KPa sensor fitted to it which fits where the 250Kpa sensor would have gone. Once the sensor has been fitted the settings in Megatune MUST be changed so your ECU knows what the signal from the sensor relates to. Open "settings.ini" file from c:/programfiles/megasquirt/Car1/mtCfg/ in a text editor. Find this section:

#group MAP_SENSOR "Map Sensor Type"
#unset MPX4115 "MPX4115 - 115 kPa, Usually only on v1.01 boards"
set MPX4250 "MPX4250 - 250 kPa, Default MAP sensor since v2.2 hardware"
;obsolete GM300KPa "GM 3.0 BAR - 300 kPa"
; Incorrect info from http://www.aquamist.co.uk/sl/plist/pics/mapm/mapm.html
; Correct info from http://www.not2fast.com/electronics/component_docs/MAP_12223861.pdf
; Use MPXH6300A instead of GM300KPa, they have identical specifications.
#**unset** MPXH6300A "MPXH6300 - 300 kPa" ; http://www.freescale.com/files/sensors/doc/data_sheet/MPXH6300A.pdf
#**unset** MPXH6400A "MPXH6400 - 400 kPa" ; http://www.freescale.com/files/sensors/doc/data_sheet/MPXH6400A.pdf
#endgroup

change this, depending on what sensor you have fitted, to:

#group MAP_SENSOR "Map Sensor Type"
#unset MPX4115 "MPX4115 - 115 kPa, Usually only on v1.01 boards"
#**unset** MPX4250 "MPX4250 - 250 kPa, Default MAP sensor since v2.2 hardware"
;obsolete GM300KPa "GM 3.0 BAR - 300 kPa"
; Incorrect info from http://www.aquamist.co.uk/sl/plist/pics/mapm/mapm.html
; Correct info from http://www.not2fast.com/electronics/component_docs/MAP_12223861.pdf
; Use MPXH6300A instead of GM300KPa, they have identical specifications.
#**unset** MPXH6300A "MPXH6300 - 300 kPa" ; http://www.freescale.com/files/sensors/doc/data_sheet/MPXH6300A.pdf
set MPXH6400A "MPXH6400 - 400 kPa" ; http://www.freescale.com/files/sensors/doc/data_sheet/MPXH6400A.pdf
#endgroup

Only have one SET and the rest must be UNSET. Save the file and next time Megatune is run it will allow values of greater than 250KPa to be set in the VE Table, etc.

In code versions older than 029 there were settings in "**Map Sensor Settings**" that need to be changed. If using the standard map sensor (250KPa) then simply set the '**Type of Map Sensor**' to B+G Sensor, if using a 3 or 400Kpa sensor then select the correct type and enter the barometric correction and KPa correction factors that are suggested (e.g. 78% and 50% repectively for a 400KPa sensor)

Idle Control valves

As long as the MS ECU has been upgraded internally (see the main MSnS Extra Website) with a high powered transitor in place of the standard idle transistor it can control most idle valves as long as they are NOT stepper motors (these have 4 wires/connectors) Most 2 or 3 wire valves (e.g. Bosch 0280 140 505)

Idle control can be used in **B&G on/off, Warm up, or Closed-Loop Modes.**

B&G on/off simply opens or closes a valve to provide additional air below a temperature threshold

Warm up mode linearly varies the duty cycle of a 2 or 3 wire solenoid actuated valve to provide additional air during cold startup, while gradually scaling down the duty cycle until the engine is warm.

Closed-loop mode attempts to keep the engine idling at a set rpm by using PWM with a 2 wire solenoid actuated valve, and actively varying the duty cycle to maintain rpm.

Warmup Settings:
Lower temp idle frequency is the higher duty cycle required to start and run a cold engine. (115 is a good starting point)
Upper temp idle frequency is the duty cycle the idle valve will be scaled down to as the engine warms up. (try zero here)

These two values are linearly interpolated from one to the other starting from the lower engine temp to the higher engine temp (fast idle temp, and slow idle temp.)
Idle valve frequency This is generally something most people will not need to mess with, however, different idle valves are designed to work best at specific operational frequencies. Note that the Frequency of actuation is 1000 / this value (255 is a good starting point)

Please Note: true DUTY CYCLE% = Lower or Upper dc * 100 / Idle Valve Frequency value example Freq value - 200 = 50 hz operation, a DC value of 80 = 80*100/200 = 40% true duty cycle

While most valves operate at 100 hertz, some older style 2-wire valves will work better at frequencies as low as 39 hertz. There is an inverse relationship between frequency of operation and control precision because of the algorithm Used to control the PWM output. Lower frequencies have more steps between dc values. 100hz operation has 100 steps and therefore has 1% control steps. 50hz operation has 200 steps and has 0.5% duty cycle steps and that is why the duty cycle values put into MT need to be double the true DC% value.
Some valves may emit a buzzing sound which can be eliminated by increasing the frequency above 100 hertz.

There is a formula for modifying the idle valve frequency. The formula is '10000/desired frequency = x where x is is the variable you input in megatune. For example '100' would be 100 hertz, and '50' would be 200 hertz
Closed Loop Settings:

This is fairly experimental code, but with careful manipulation of variables it should be possible to produce a stable idle.

Cranking (dc) is the duty cycle required at cranking. (try Zero here)
Minimum (dc) is the duty cycle slightly lower than a warm idle dc when regulated.
Closed (dc) is the duty cycle where the valve closes.
The values here follow the rule above and are related to the frequency selected and are not true DC except when the idlefreq values is 100.
Some valves are normally closed (use 0 here) others require a certain DC to clsoe and will regulate above this value. Bosch 2 wire valves are normally open, close at 25% and regulate at about 40%.
Fast Idle RPM is the idle target for the engine at, or below the fast idle temperature.
Slow Idle RPM is the idle target for the engine at, or above the slow idle temperature (fully warmed up).

The two RPM set points are linearly interpolated between the two temperatures to provide a smooth transition during warmup

TPS Threshold is the point above which the idle valve closes in ADC (as it is no longer needed).
Idle Activation (rpm) is 'how many rpm' above idle that the idle valve returns to operation after the throttle has been opened and closed again. This follows the idle speed as it is interpolated from Fast Idle RPM to Slow Idle RPM
Dashpot Settle is the wait time required after a dashpot event for the rpms to settle below the idle activation point. After a dashpot it is possible that rpms will overshoot the activation point and this is the time required to settle below activation point.
Dashpot Adder (dc) is the dashpot duty cycle added to the last controlled idle duty cycle which allows it to recover to a nice idle with minimal overshoot. These values should be low: 1-5 DC
Deadband range This is a range of rpm that you do not want it to bother changing duty cycle to regulate idle.
30 to 50 rpm seems to be good here try smaller values unitl it seems stable.

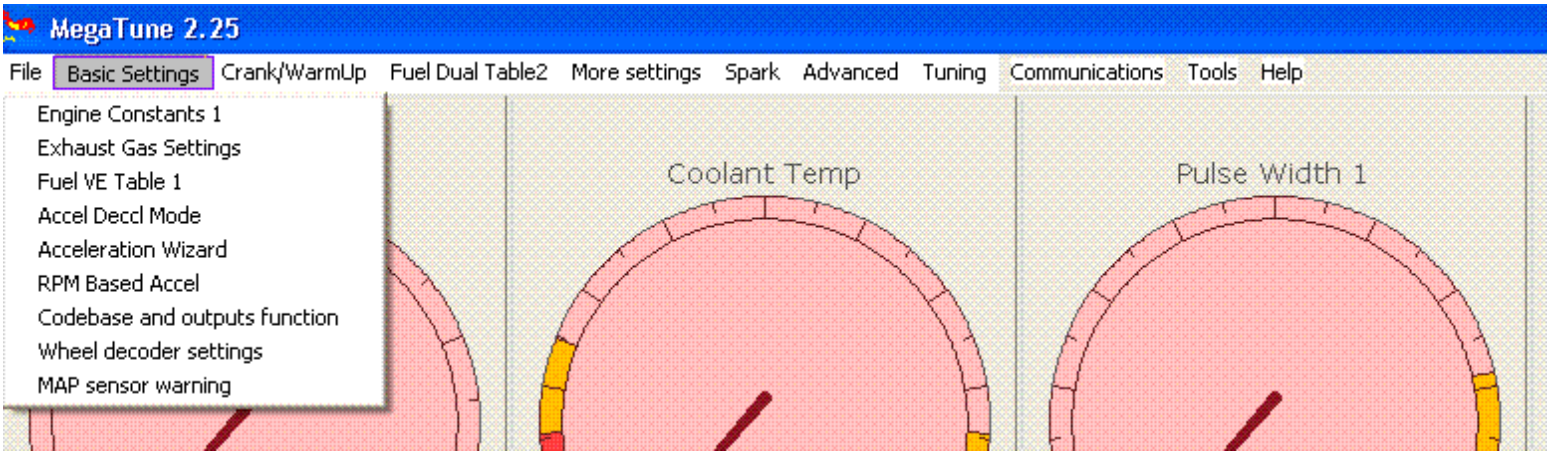
Adaptive idle control This controls the time between idle control events. The goal is to have a Slow Recovery which is tuned to the engine's time constant at idle. You do not want it to hunt nor have falling idle speed. The Fast Recovery is how fast you want it to recover to a decent idle when the idle speed is higher or lower than the target this can be tuned for startup and to see what is needed to recover if idle speed drops significantly below target for example when the A/C or electric fans kick on and the idle drops below target.
The rpm values determine the curve. The lower value should be close to the dead band value and the upper one should be a bit further away, maybe 100 or 200 rpm the next 2 values are time constants needed for startup and idle valve closure

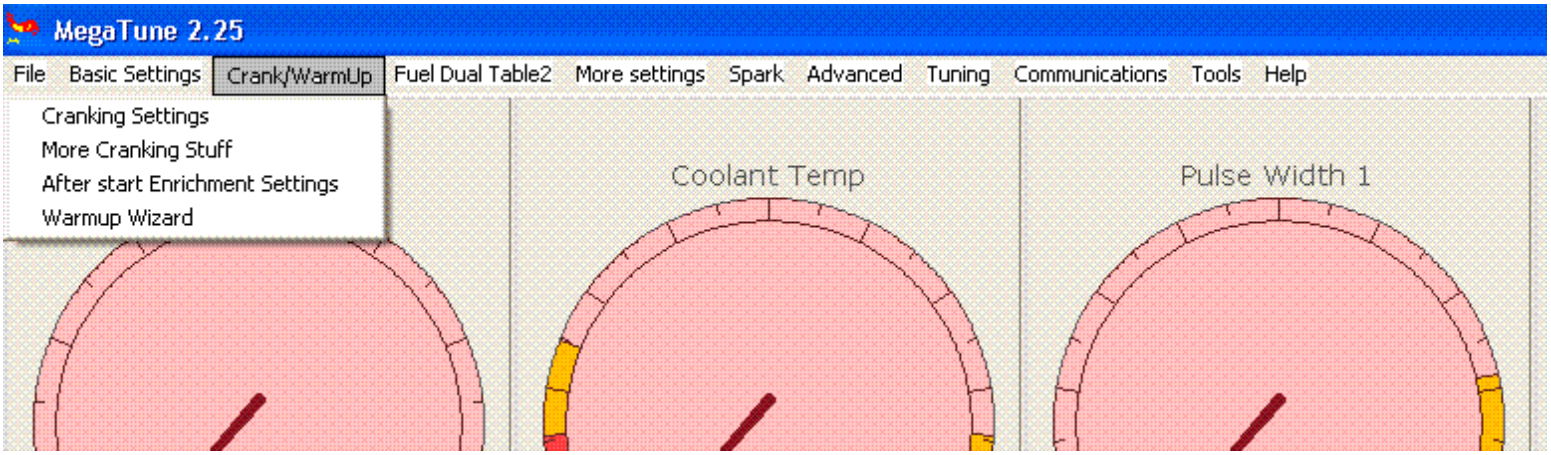
Closure speed controls the speed at which the idle valve closes. It is the time step delay between each as it steps to a closed dc value

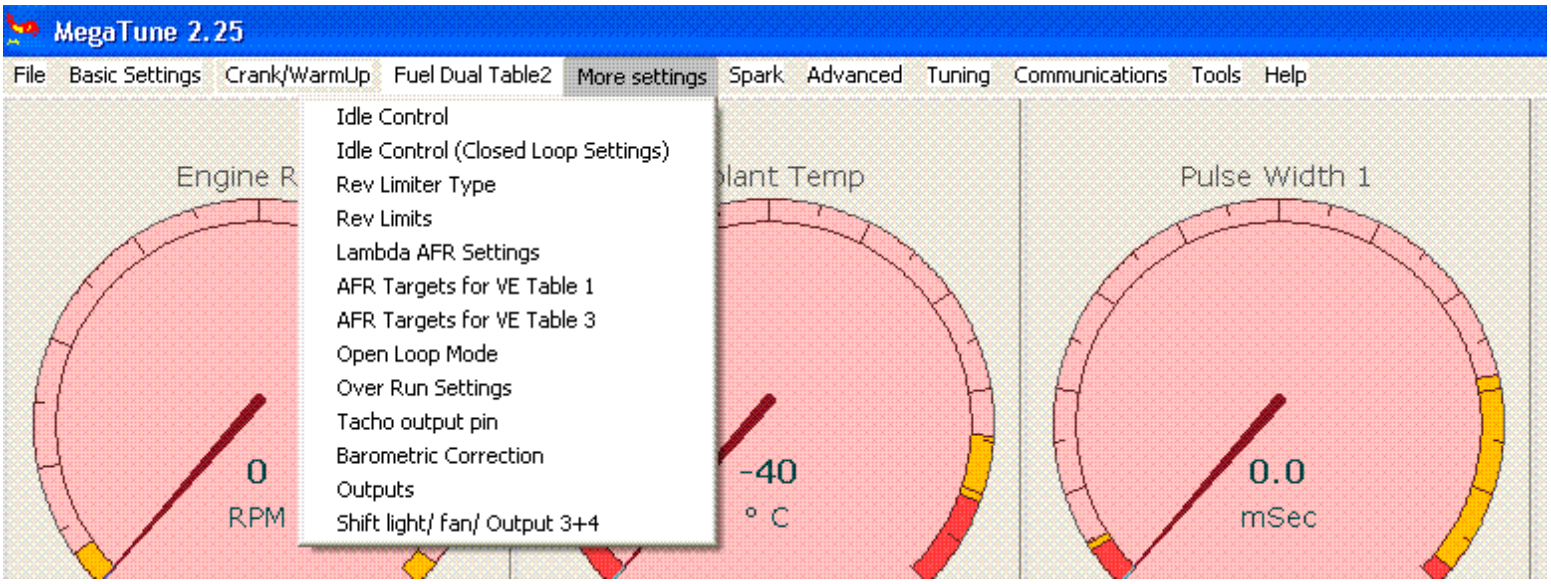
Startup delay is a wait time right after the engine is started that the system stabilizes before it attempts to find an idle speed

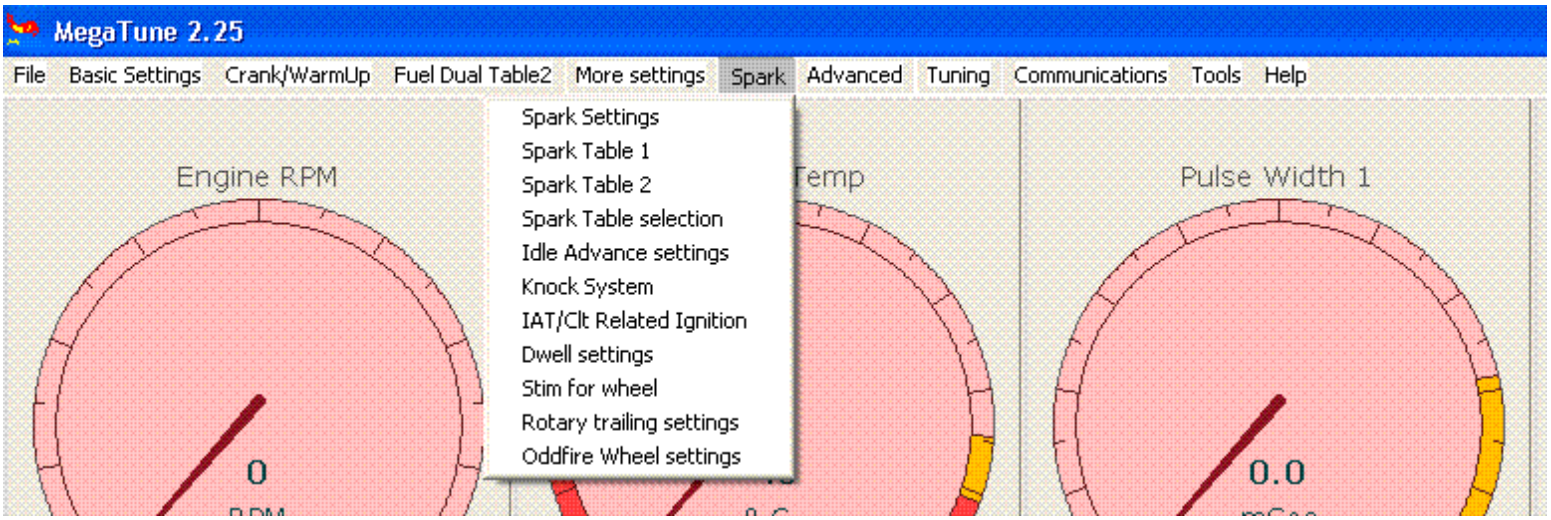
Layout of settings pages in Megatune

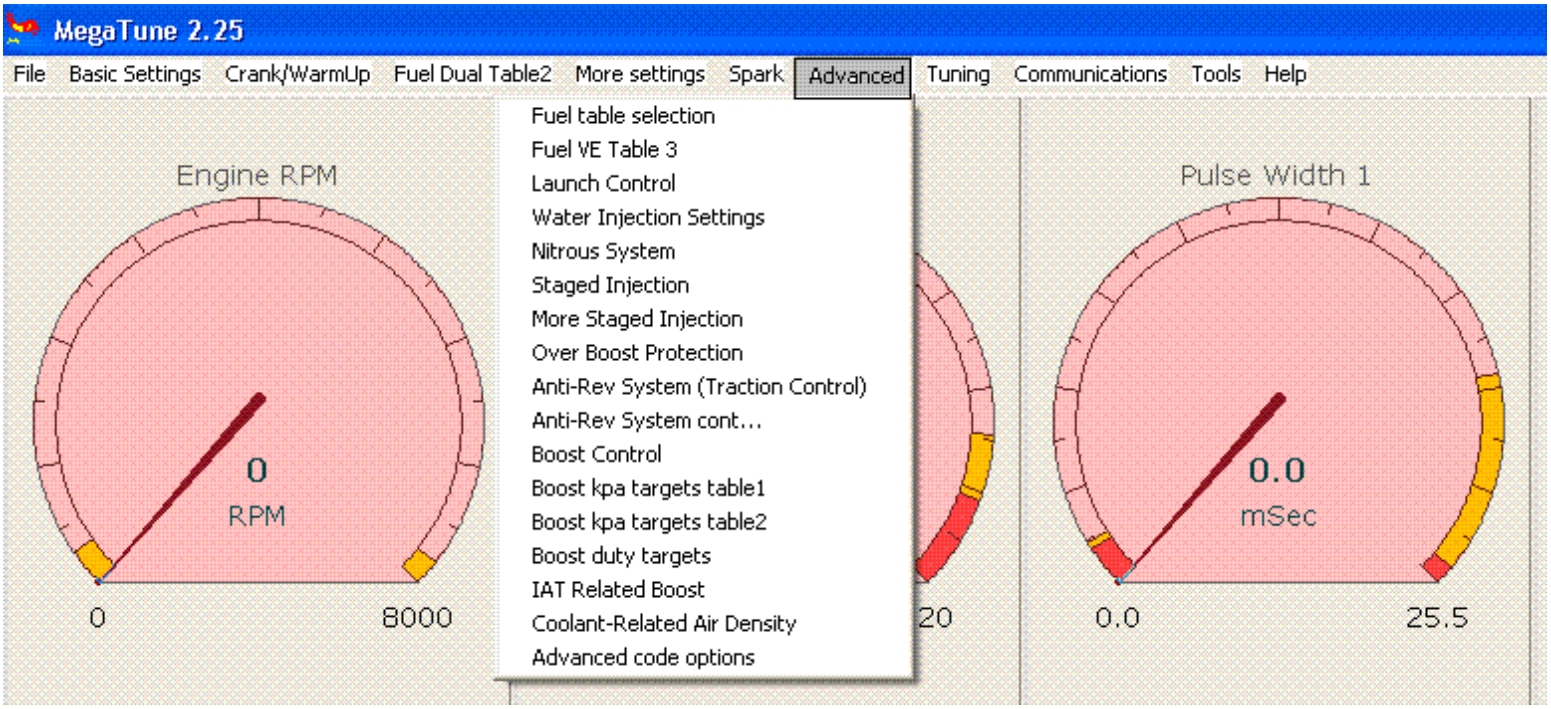
As of 029xx codes this is the general layout of where to find the relavent settings in Megatune.











Other Tuning Software and Platforms

MS-Palm is available from the files section of the MegaSquirt Forums. It has worked well for some. MS-Palm uses the HOTPaw basic, and does data logging. It is limited to about 60 datalog lines or about 15 seconds or so at 4 Hz. It writes the data out as Memopad entries, which are limited in size to 4k. The source code is there for anyone to modify. It would be easy to cut back on the variable list, to get a log time up over a minute if someone so desired. MS-Palm does allow editing of VE table, enrichment bins, etc. as well.

You might be able to use a Mac to tune MegaSquirt. Some people have successfully run MegaTune hooked up to the MegaSquirt board with the Stimulator, on a Mac using VirtualPC and Win98. They report using a Mini DIN 8 to DB9 cable, selecting the Mac serial port as COM1, and "shared" the Mac hard drive with Win98 as volume (F). Their set-up includes an Airport wireless network (802.11b), sharing the DSL connection, setting up VirtualPC to utilize various resources (e.g. Mac serial/printer port as COM1, Ethernet, faking the video and sound cards, etc). MegaTune runs great and there is no lag between turning a MegaStim pot and seeing the results on the screen.

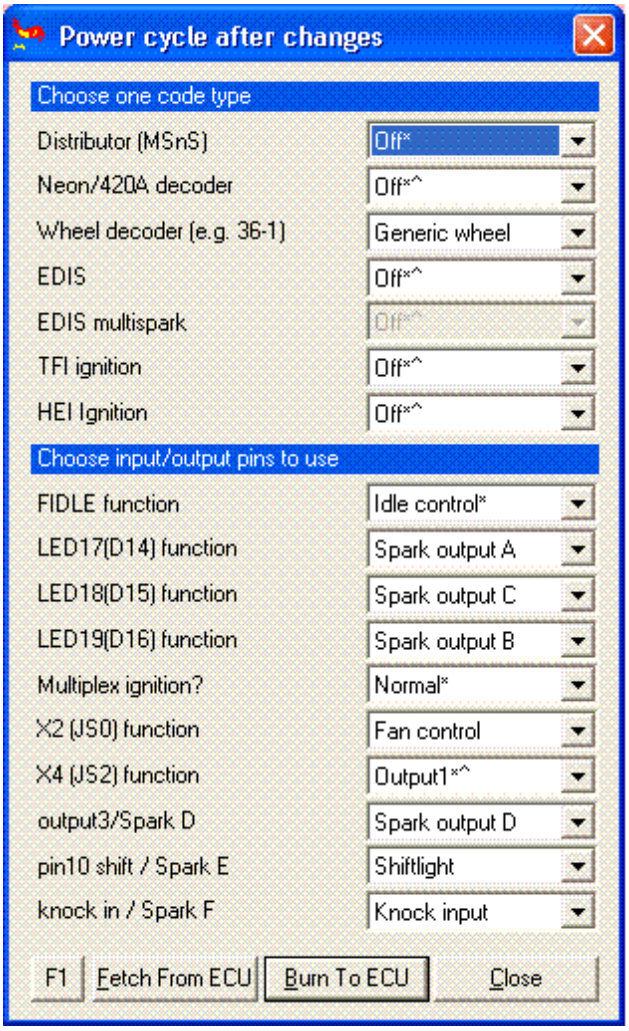
MegaView

Sorry but the MegaView display/digital dashboard does not work with the MSnS_Extra code's.

Ignition Section

Ignition selection -- Wheel Decoder Settings -- Spark Settings -- Spark Map Tuning Basics -- Idle Advance Settings -- Knock Settings -- IAT/CLT_Related Ignition -- Dwell Settings -- Stim for Wheel -- Rotary Trailing Edge and Odd Fire Wheel Settings

Ignition Selection



The first section here (top 7 boxes) are where the code decides what it is going to do with the trigger input/s. This is very important to get setup correctly. Please see the **Codebase and Outputs** section earlier in the manual for setting the outputs including the Spark outputs. After setting this section you will need to set the "**Spark Settings**" and the **"Dwell Settings"**

Distributor (MSnS)
This is designed for distributor based ignition systems. It requires a "locked" dizzy or a crank trigger that triggers at the same rate as a distributor would (twice per crank rev on a 4cy. Three times per crank rev on a 6cy, etc). Engines with even numbers of cylinders benefit from using a crank trigger as it gives a more stable spark. Odd number (e.g. 3,5) must trigger from the dizzy.
Odd fire engines are not currently supported (ie. some Olds V6s or 90 deg V twins) if the plug leads on you dizzy are evenly spaced as most are you will be ok.
The trigger is usually a hall sensor or a VR sensor either in the distributor or on the crank.
The coil is fired using either the ECU's on-board high-current ignition driver **(SparkA)** or with an external ignition module, this would be fired by the MS ECU.

Many installations triggering from the dizzy will require modifications to get correct rotor arm to trigger phasing. See **HERE** for more info on this setup.

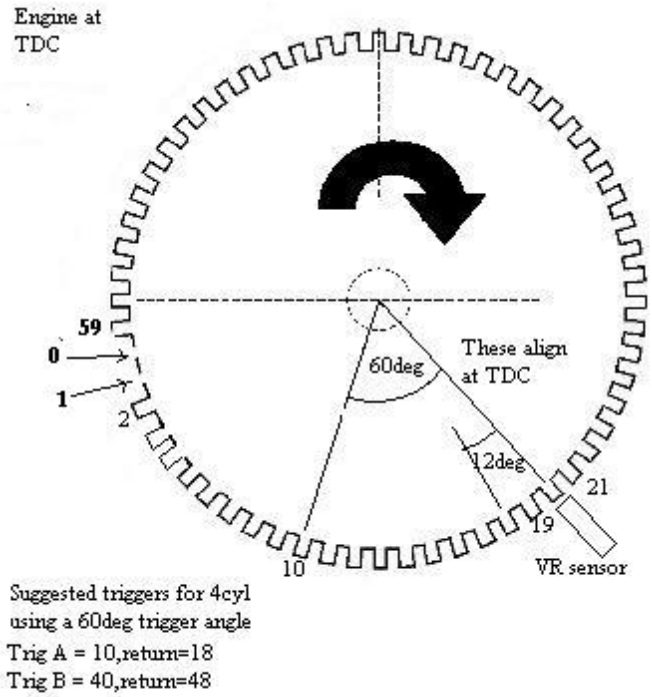
Neon/420A mode
This mode is to decode the pattern machined into the crank on a pre-2003 Dodge Neon engine, this also theoretically supports the following vehicles when equipped with a 2.0 or 2.4 4cylinder Chrysler engine.
"NS" body models:
1996-2000 Chrysler Town and Country
1996-2000 Dodge Caravan/Grand Caravan
1996-2000 Plymouth Voyager/Grand Voyager
"JA" body models:
1995-02 Chrysler Cirrus
1995-02 Dodge Stratus
1996-2000 Plymouth Breeze
"JX" body models:
1996-02 Chrysler Sebring Convertible
"PL" body models:
1995-02 Dodge Neon
1995-2001 Plymouth Neon
"PT" body models:
01-02 Chrysler PT Cruiser
"FJ" body models:
1995-02 Chrysler Sebring Coupe
1995-2000 Dodge Avenger
And (of course) the Talon and Eclipse as produced by DSM/eagle/mitsu.

Trigger Angle needs to be set to **69** for this type of setup.

See **HERE** for more details of this setup.

Wheel Decoder
When this code option is selected in Ignition Selection of "**Codebase and Output Functions**" the ECU will decode a missing tooth crank wheel (e.g. 12-1, 36-1, 60-2) and gives single or multiple wasted spark outputs. These wheels are found as standard on Fords (36-1 *this has space for 36 equally spaced apart teeth with one missing so it has 35 teeth and a single tooth gap*) and many vehicles that use a Bosch ECU (60-2)
Simple crank triggers such as 4-1 or 6-1 can also be used but the easiestway to get a wasted spark ignition setup from a distributor single coil setup is to fit a Ford 36-1 wheel onto the crank and use this code setting and directly drive a set of Ford coil packs. With this option you need to set up the **"Wheel Decoder Settings"**, this means you need to know where the first missing tooth passes the sensor with respects to the timing, or what tooth the sensor is detecting when the timing is at TDC. There is an Excel file that calculates the wheel decoder settings for you if you can find the relavent info **HERE**

Please note the teeth are counted when the ECU detects the first gap, (this gap is tooth Zero) the first tooth on a -1 setup (or second gap on a 60-2 wheel) is tooth 1, etc. The last tooth would therefore be 35 on a 36-1 or 59 on a 60-2. ***The MS ECU can NOT trigger on a missing tooth, so you must ensure that all of the*** **used** **Trigger Position Teeth** ***as set in "*****Wheel Decoder Settings*****" are NOT set to ZERO, if they are then you may have to alter the*** **Trigger Angle** ***a little to select another tooth. However all of the*** **UNUSED** **Trigger Position Teeth** ***MUST be set to ZERO!***



EDIS mode
Controls Ford EDIS ignition module for wasted spark distributorless ignition, this can be installed on most even fire 4,6,8 cylinder 4 stroke automotive engines.
This setup requires a 36-1 trigger disc mounted on the crank, many Fords from 1990 onwards already have the trigger disc or teeth cut into the flywheel. Suitable discs are available new and used.
EDIS has a quoted upper limit of 9000rpm, but in practice some have seen 9300 or 10500rpm. EDIS8 appears to limit just above 6000rpm.
The EDIS install offers another DIY ignition solution on engines that are distributorless from the factory, unlike the Wheel Decoder version it uses the Edis module to fire the coil packs rather than directly from the ECU. See **HERE** for more info on this setup.

Ford TFI mode
This provides native support for the Ford TFI distributors used on millions of vehicles during the eighties. (Currently only Push Start modules tested.) The aim is to make some additions to the megasquirt board, connect the loom and go. No changing rotor phasing or second modules.
This mode could likely be used on a retro fitted TFI module in a non original installations. The module provides takes an input from a hall sensor and has a coil driver in one compact unit with a "next cylinder" scheme of operation that gives a "limp home" base timing if the computer is disconnected. Ensure the **Trigger Angle** is set to **10 deg** and the **Spark Output Inverted = YES** for this setup, for more info see **HERE**

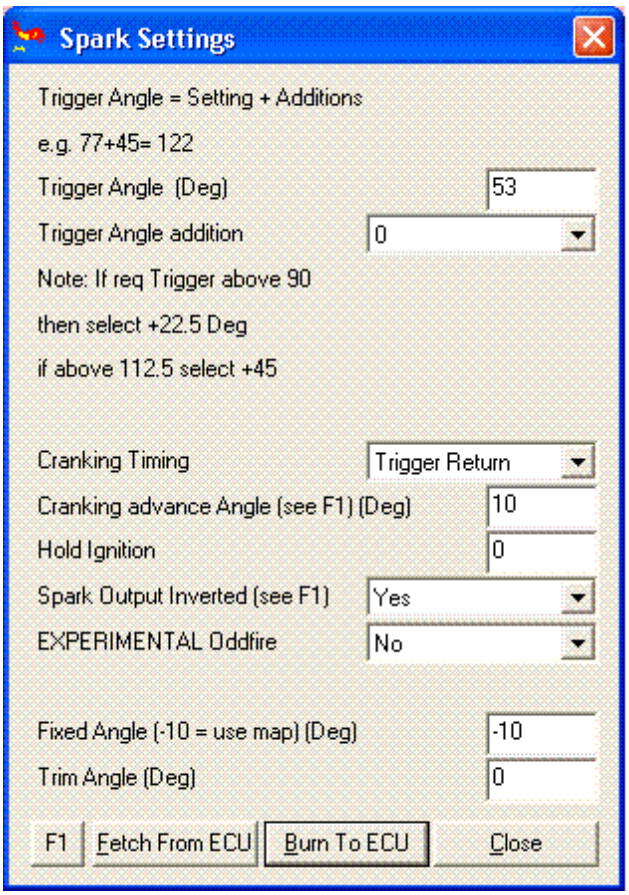
GM 7pin HEI mode
This to provides native support for the GM 7pin HEI distributors used on millions of vehicles from the early eighties onwards. The aim is to make a few small modifications on the megasquirt board, connect the loom and go. No changing rotor phasing or second modules.
This mode could likely be used on a retro fitted 7pin module in a non original installation. The module provides VR sensor signal conditioning and a coil driver in one compact unit with a "next cylinder" scheme of operation that gives a "limp home" base timing if the computer is disconnected. See **HERE** for more details on this setup.

The Nippondenso dual wheel / 2nd trigger
Many Mazda and Toyota engines utilise Nippondenso ignition which uses a dual wheel crank angle sensor (CAS) which has one 24 tooth wheel and a 2 or single tooth second wheel.
This option can also be used inventively to give 4 cyl COP or could be used with the dual pickup crank trigger from SDS for 4cyl wasted spark. See **HERE** for more info on this type of setup

GM DIS
This is used on GM vehicles like the Camaro from the mid nineties that use GM's own DIS system. The page describes the 4cyl, V6 and Northstar V8 variants **HERE**

Buick C3I
Some Buicks use a system similar in concept to the GM DIS but requiring a slightly different setup, see **HERE** for more info on this setup.

Spark Settings



Trigger Angle This is the angle BTDC when the selected trigger tooth, vane, etc, passes the sensor. This is used for the ECU to calculate when to fire the coil(s). When the engine is first started this is the angle that needs to be altered to get the spark fired at the correct time, this is done by setting the "**Fixed Angle**" *(this ignores the spark map and holds the sparked angle to the value you enter)* to around 10deg and, using a timing light, ensure the ECU is firing the coil at the **Fixed Angle**. If the timing is not being fired at the **fixed angle** then alter the "**Trigger Angle**" untill the timing is at the **fixed angle**. Once the **trigger angle** has been changed so the **fixed angle** is being fired by the ECU then change the **Fixed Angle** back to **-10** so the ECU will follow the spark map.
Typically you should aim for 60-70deg as this is outside the usual range that the spark is needed. (this can be altered by using a different tooth for triggering on the wheel decoder or by altering the sensor position on MSnS setups)
If using an OEM distributor setup like HEI7 or TFI then 5-15deg is typical, see the relavent section earlier.
Do NOT use a value between 15 and 40 deg as this is in the usual range that your engine will need to fire the coil and your engine will not run correctly.

Trigger Addition Angle - As angles of over 90 are not allowed in the **Trigger Angle**, if you need an angle between 90-112.5 then select the '**+22.5**' and enter the angle needed -22.5
If you need an angle between 112.5-125 then select '**+45**' then enter the angle needed -45
The actual **Triggered Angle** the code will use is :
Trigger Angle + **Trigger Additional Angle** (**22.5** or **45** if selected)
e.g. 78 + 45 = 123
88 + 22.5 = 110.5
65 + 0 = 65

Crank Timing is the way the ECU decides when to fire during cranking. **Time Based** works out when to fire by taking in the trigger pulses and working out the **Cranking Advance Angle**, this is OK as long as your starter turns the engine at a fairly constant speed. **Trigger Return** uses the raising edge of the trigger input in most modes or the **Trigger Return Tooth** when using **Wheel Decoder** mode. When using **dwell control** and **trigger return** cranking you MUST still specify the cranking advance which needs to match the trigger return angle. The dwell calculations need this for accurate cranking dwell .

Spark Output Inverted Choosing spark output inverted **YES** or **NO** is *VERY IMPORTANT*. This is determined by the way you drive your coil(s) When the VB921 (directly driven spark coils) is used per the diagrams you will choose **Inverted = YES.** *Get it right or you will risk damaging components as well as getting wildly inaccurate timing.*

Trim Angle is simply a method to advance by xx deg or retard up to 9 deg from the entire spark map, so if you are running in an area where the 12x12 map is at 20deg entering 5 in here will add 5 to the spark angle, making a 25deg spark angle. (to retard from main map enter -1 to -9), use **-10** to follow the map and have no trim.

Spark Map Tuning

Tuning the **spark map** may not seem the easiest thing in the world to do and it can be difficult to know where to start. Here is a base map that we enter into the code for you to start from.

Ignition Advance Main Table

File Tools

kPa \ RPM	500	700	1300	2000	3000	4000	5000	6000	6100	6200	6300	6400
140	10	10	8	10	14	19	19	19	19	19	19	19
130	10	10	9	11	15	20	22	22	22	22	22	22
120	10	10	10	13	16	21	23	23	23	23	23	23
110	10	10	11	14	17	22	24	24	24	24	24	24
100	10	10	13	15	19	23	26	26	26	26	26	26
90	10	10	13	15	19	23	26	26	26	26	26	26
80	10	10	13	15	19	23	26	26	26	26	26	26
70	10	10	13	15	19	23	26	26	26	26	26	26
60	10	10	13	15	19	27	28	28	28	28	28	28
50	10	10	13	15	20	28	30	30	30	30	30	30
40	9	9	10	15	21	30	32	32	32	32	32	32
30	9	9	10	15	22	32	36	36	36	36	36	36

Tuning Basics - The idea is that the idle and low speed area's are retarded to around 8-20deg, usually idle will be around 8-12deg, but this depends on your engine's design. If you set the first row in the RPM range as a little under your usual idle (e.g.600 if your engine idles at 800ish) and add some advance here, so if the engine stumbles into this area the slight increase in advance will help it to speed up a little so it doesn't stall. The cruising area of the map should have a reasonably high advance, (low to high 30's) as the mixture will be reasonably lean and therefore will give a slower burn. The overrun area can have an even greater advance, this will allow you to run lean in that section. If you want some engine breaking in a section of the overrun, don't advance the overrun area too far. As you can see in this race tuned 5.5L V8 (RV8) spark map the timing is around 15deg at 1500-2000rpm on overrun.

Ignition Advance Main Table

File Tools

kPa	500	700	1000	1500	2000	2500	3000	3500	4000	4500	5000	6000
100	18	18	18	12	18	18	21	23	24	26	26	28
90	18	18	18	12	18	20	23	24	24	26	26	28
80	18	18	18	12	18	22	25	24	24	24	24	28
70	17	12	12	20	23	26	25	35	24	24	24	28
65	17	12	12	22	26	32	34	27	26	24	24	28
60	17	12	12	25	34	32	35	28	26	26	26	28
55	17	12	12	26	30	34	34	34	28	26	26	28
45	17	12	12	28	35	34	34	34	30	28	26	28
35	17	12	12	20	20	30	30	30	30	28	28	28
30	17	12	12	20	20	25	30	30	30	28	28	28
25	20	20	22	15	15	30	30	30	30	30	30	30
20	22	22	22	15	15	25	25	25	25	30	30	30

As the Kpa increases (load increase) the spark map should retard as the mixture will be richer and the chances of detonation will also increase with the load. When going into boost the advance will need to be lower than when out of boost and as the boost level increases the advance will need to decrease with it, as detonation is more likely. It has been said that 1deg of advance should be removed for every 2PSI of boost; this is simply a rough guide and lots of things can depend on how much to remove. Detonation Cans are a great option for tuning in boost, use a piece of copper pipe flattened at one end with a flexible tube connected to it. Bolt the flattened end to the cylinder head. Get an old set of air defenders and drill a hole into the side of them, push the other end or the tube into the hole and you should be able to hear any detonation as it occurs.

There is a thread on the MSEFI forum discussing timing tuning further that can be found **HERE**.

Idle Advance Settings

This feature holds the timing to a fixed value when the engine is idling to help it run smoothly and it allows you to have a more flexible spark map around the idle area. To find your **TPS setting** value, go to **Tools, Calibrate TPS**, and with your foot completely OFF the throttle hit **'Get Current'**. Remember this value and hit **CANCEL** on the **Calibrate TPS** dialog. Add 2-3 to this value and enter it, so if you had a value of 20 enter 22 in the setting. A delay time of 1-3 Sec has been found to be suitable.

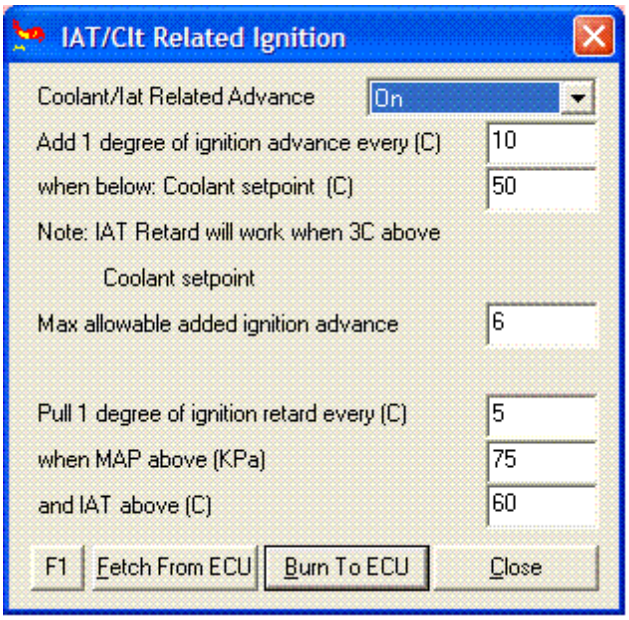
Knock settings

Please see the MSnS-Extra Website **HERE** for more details on this function

IAT/CLT Related Ignition

It is recommended that this setting should only be used once your spark map is tuned.

When an engine is cold, advancing the timing a little above the base map, can help the engine run smoother and idle faster, this can also aid warm-up times a little. In the example below the engine will run an additional 1 deg of advance for every 5C the coolant is below 50C.



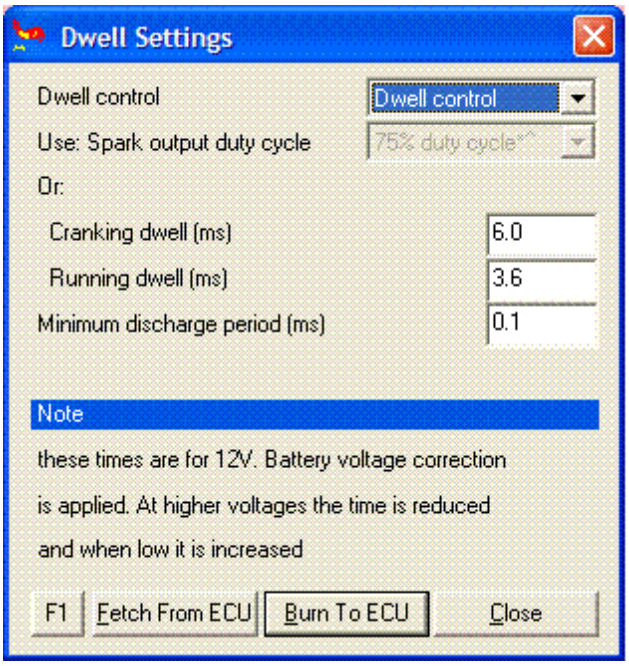
So at a coolant temp of 20C the timing will be increased by:
50C-20C = 30C difference
30C / 5C = 6 degs additional advance.
The Maximum allowable added advance can be limited to stop too much advance being added in extreme temperatures. A value of around 4-6 is suitable.

The inlet air temperature has a massive effect on how much advance you can safely run, if the temperature increases above the norm, due to sitting in traffic, long/hard runs in boost, etc, the amount of advance can be retarded proportionately with the temp increase to help prevent detonation. This works in much the same way as the coolant related ignition but it RETARDS the ignition from the base map. In the example the ignition will be retarded by 1 deg every 5C the air temperature rises above 60C, so at 80C the spark map will be retarded by 4 deg.

As there is no need to retard the ignition when cruising (detonation is highly unlikely) there is a **Kpa set point**, so the retard only comes in when the engine is being driven harder, this should be set so it is higher than your Kpa at cruise and idle.

Dwell Settings

If you use Direct Coil Control (your coil's are driven from the MS ECU directly) or a non-smart dwell ignition module it is VITAL that you enable dwell control with the correct spark invert/non-invert setting, see **Spark Settings**. The dwell numbers given are get-you-going numbers but will need adjusting.
If your ignition driver/coil are getting warm or hot then the dwell is too high
Min discharge is the time the coil is allowed to spark before charging starts again.



Some Bosch ignition modules are smart-dwell and need **Fixed Dwell** with a setting of **75%** , MSD ignition needs a setting of **50%** and **Spark Inverted = YES** instead of true dwell. For other setup requirements other than direct driven coils see the Extra Website Ignition setup pages.

Stim for Wheel

This setting is purely for use on a Stimulator and should **NEVER** be used when the ECU is attached to the engine, it must be set to **OFF.** The number of steps/outputs needs to be set to the value of spark outputs your setup is using but only if using it on a Stimulator!

Rotary Trailing Edge and Odd Fire Wheel Settings

These are described on the Extra web site.

If you have a question, comment, or suggestion for this FAQ, e-mail Phil or James or post it on the forum.
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Many thanks to Lance for giving us permission to edit and adapt his MS Manual for MSnS-Extra use.
