ProECU Mazda MX-5

Tuning Guide

2005-onward Model Year

v1.23

Contents

ECU Map Descriptions

Fuel Control

Related Maps:

- Injector Scaling
  - Injector Opening Time Compensation[3D]
  - Injector Scale [1D]
  - Injector Scale Manifold Vacuum Compensation [2D]
  - Minimum Allowed Fuel Pulse Width [2D/1D]
- Fuel Map Closed Loop – Safe Mode [3D]
- Fuel Map Closed Loop High Det [3D]
- Fuel Map Closed Loop Low Det [3D]
- Fuel Map Open Loop – Safe Mode [3D]
- Fuel Map Open Loop High Det [3D]
- Fuel Map Open Loop Low Det [3D]
- Fuel Compensation [3D]

Shown in Live Data as:

- AFR (AFR)
- AFR (Lambda)
- AFR Actual
- Equivalence Ratio
- Equivalence Ratio Desired (AFR)
- Equivalence Ratio Desired (Lambda)
- Fuel Trim Short Term (%)
- Fuel Trim Long Term (%)
- Injector Pulse Width (ms)

Base Fuel Calculation

There are four 3D maps which control the base fuel calculation. “Fuel Map Closed Loop High / Low Det” and “Fuel Map Open Loop High / Low Det”. This sets the base AFR to which the car then adds the fuel adjustments.

During Closed Loop operation (controlled by Open Closed Loop Thresholds which will be explained in further detail) the ECU will attempt to maintain 14.7:1 AFR or Lambda 1. This only changes when the vehicle switches into Open Loop, at which time it will disregard the feedback control and attempt to meet the Open Loop fuel map target.

The 3D “Fuel Compensation” map is subtracted from the base map to provide a manual adjustment. This can be set to 0 under normal operation and the Open Loop Fuel Map used to control the required AFR.

Injector Scaling

The standard injector size is 280cc, and is calibrated at 380kPa. The “Injector Scale” map is used to set the size for the injector to ensure correct calculation of fuel.

The “Injector Open Time Compensation” sets the voltage and pressure compensation for the injectors and can be calculated using the data published by the manufacturer of injectors. This should not be changed unless the injectors are changed to a different size, type or manufacturer. Please refer to the tuning section for further information on how to calibrate the Injector Lag Time.

Vehicles running very large injectors will need to have the Minimum Allowed Fuel Pulse Width Value lowered to allow the injectors to open for a very small period of time, this is either a 2D map against ECT or a 1D value.

Ignition Control

Related Maps:

- Idle Control
  - Idle Ignition Timing #1
  - Idle Ignition Timing #2
- Temperature Compensation
  - Ignition Addition – Coolant #1
  - Ignition Addition – Coolant #2
  - Ignition Addition – Coolant #3
  - Ignition Compensation ECT IAT #1
  - Ignition Compensation ECT IAT #2
  - Ignition Compensation ECT IAT Multiplier
- Ignition Map HL Closed Loop High Det
- Ignition Map HL Closed Loop Low Det
- Ignition Map HL Open Loop High Det
- Ignition Map HL Open Loop Low Det
- Ignition Map Closed to Open Loop Fuel Threshold [1D]
- Ignition Max Advance
- Ignition Timing Maximum Allowed #1
- Ignition Timing Maximum Allowed #2

Shown in Live Data as:

- Ignition Timing (Deg)

Ignition Base Maps

There are four ignition base maps that set the ignition timing. These are chosen by Closed Loop High / Low Det, or Open Loop High / Low Det. The threshold for the Closed to Open Loop switch is set by the 1D value “Ignition Closed to Open Loop Fuel Threshold”. This sets the AFR at which the ECU changes map.

The threshold between High and Low Det maps are controlled by the 2D map “Low Det to High Det Threshold” and will be explained in the Knock Control section.

The ignition temperature compensations are applied to the value of the base ignition timing.

Ignition Temperature Compensation

There are two sets of temperature compensation for ignition timing. “Ignition Compensation ECT IAT #1 or #2” are multiplied by “Ignition Compensation ECT IAT Multiplier”, and then subtracted from the base ignition timing. The three 3D maps, “Ignition Addition – Coolant #1 - #3” are added to the ignition timing.

Idle Control

There are two idle control maps which set the ignition timing at idle based on desired RPM and engine load.

Knock Control

Related Maps:

- Knock Correction Increment Value
- Knock Correction Max RPM
- Knock Correction Min RPM
- Knock Correction Min ECT
- Knock Decrement Timer #1 – Knock Active
- Knock Decrement Timer #2 – Knock Inactive
- Maximum Allowed Knock Retard

Shown in Live Data as:

- Knock Correction

These maps control how knock retard is added and removed from the ignition timing on the detection of detonation. They can be found under the “Ignition Timing” category.

The “Knock Correction Max / Min RPM / Min ECT” control when the ECU turns the knock correction on and off. It is disabled by default below 1000 RPM and above 5500 RPM to avoid phantom knock as the engine vibrates.

There is a sensor scaling map “Knock Sensor Scaling” which can be used to adjust the overall sensitivity of the knock sensor. This is covered in more detail in the “Sensor Scaling” category.

Accelerator Pedal To Throttle

Related Maps:

- Limiters
    - Maximum Allowed Throttle Duty
    - Maximum Allowed Throttle Opening
- Accel Pedal to Throttle Duty – 1st Gear
- Accel Pedal to Throttle Duty – 2nd Gear
- Accel Pedal to Throttle Duty – 3rd Gear
- Accel Pedal to Throttle Duty – 4th 5th 6th Gear
- Accel Pedal to Throttle Duty – Neutral
- Accel Pedal to Throttle Duty – 1st Gear Trustful
- Accel Pedal to Throttle Duty – 2nd Gear Trustful
- Accel Pedal to Throttle Duty – 3rd Gear Trustful
- Accel Pedal to Throttle Duty – 4th 5th 6th Gear Trustful
- Accel Pedal to Throttle Duty – Neutral Trustful
- Throttle Duty To Angle Multiplier

Shown in Live Data as:

- Accelerator Pedal
- Accelerator Pedal Position #1
- Accelerator Pedal Position #2
- Accelerator Pedal Position Sensor #1
- Accelerator Pedal Position Sensor #2
- Throttle Angle
- Throttle Angle Desired
- Throttle Position #1
- Throttle Position #2
- Throttle Position Actual
- Throttle Position Desired
- Throttle Position Sensor #1
- Throttle Position Sensor #2

Accel Pedal to Throttle Duty Per-Gear Maps

These maps set the base throttle duty requested by the accelerator pedal and RPM, allowing detailed profiling of the throttle maps to suit the driving requirements.

The limiters will only need to be adjusted if your profile exceeds their set limits. The “Maximum Allowed Throttle Opening” map is usually set to the maximum angle of the throttle butterfly, and should not need to be adjusted.

There are five trustful maps which must be profiled to exactly the same as their corresponding per gear map otherwise you will get a checksum DTC error.

The throttle duty to angle multiplier converts the throttle duty value to an angle for use in the feedback and diagnostics systems this should not be changed unless you have changed the throttle body.

Engine Load

Related Maps:

- Engine Load Compensation
- Engine Load Compensation Trim
- Engine Load Limit #1
- Engine Load Limit #2

Shown in Live Data as:

- Engine Load
- Engine Load Absolute

The engine load compensation maps are used to calibrate the conversion from MAF to actual cylinder fill in g/rev. For most tuning these maps do not need to be changed as they have been carefully calibrated by Mazda. If significant modifications have been made or a forced induction kit has been fitted these may need to be altered to make sure the Engine Load is correct.

The Engine Load Limit maps control the maximum engine load for the ECU calculations. If the actual engine load exceeds these values then it will be capped. If a forced induction kit is fitted or significant modifications have been made such as camshafts then these values will have to be raised to accommodate the increased airflow

Cam Timing

Related Maps:

- VVT Inlet

Shown in Live Data as:

- VVT Intake

This map controls the angle of the intake cam (note that 1 degree at the camshaft is 2 degrees at the crankshaft). This number is in camshaft degrees before Top Dead Centre. Modifying the cam timing map can increase power and torque, but too much advance can significantly change cylinder pressures. This map should be tuned if any item is added to the engine that may change the VE.

Exhaust Gas Recirculation

Related Maps:

- EGR Target #1
- EGR Target #2
- EGR Target #3

Shown in Live Data as:

- EGR Target Duty

These maps change the desired Exhaust Gas Recirculation duty which affects the amount of clean air entering the engine. Altering the duty can significantly affect power and fuel efficiency by allowing more oxygen into the cylinders. It is also used for emissions regulations, and altering these maps can cause a vehicle to fail emissions testing.

Idle Control

Related Maps:

- Idle Speed #1 – Drive
- Idle Speed #2 – Neutral

Shown in Live Data as:

- Engine Speed Desired

These are two distinct modes for the idle speed; when the car is in gear, clutch up, with no accel pedal, controlled by “Idle Speed #1 – Drive”, and out of gear, no accelerator pedal, controlled by “Idle Speed #2 – Neutral”.

Intake Manifold Runner Control

Related Maps:

- IMRC RPM Threshold #1
- IMRC RPM Threshold #2
- IMRC Throttle Threshold

Shown in Live Data as:

- Engine Speed Desired

The Intake Manifold Runner Control adjusts the variable length runners in the inlet, altering the speed and quantity of air flowing into the cylinder, in turn adjusting the torque and power characteristics of the engine.

At idle and low loads the intake manifold runners are “on” or in the long position. If the throttle exceeds the threshold in the “IMRC Throttle Threshold” map, they switch to “off” or shorter runners.

If the RPM Exceeds “IMRC RPM Threshold #1” The runners will switch “on”, and when it exceeds “IMRC RPM Threshold #2” it will switch “off”. The RPM thresholds take precedence over the throttle threshold, so be mindful when setting the thresholds.

Limiters

Related Maps:

- Rev Limit #1
- Rev Limit #2 – ECT Based Rev Limit
- Rev Limit #2 – ECT Switch Threshold
- Rev Limit Hysteresis #1
- Rev Limit Hysteresis #2
- Rev Limit Throttle Cut #1
- Rev Limit Throttle Cut #2
- Rev Limit Throttle Cut In Gear Addition
- Speed Limit #1 – Minimum RPM
- Speed Limit #1 – Throttle Cut
- Speed Limit #2 – Fuel Cut
- Speed Limit #2 – Minimum RPM

Shown in Live Data as:

- Engine Speed
- Vehicle Speed

The rev limiters act by disabling the injectors when the RPM exceeds the threshold, and will re-enable when the RPM drops below the hysteresis margin. There are two different engine speed limiters, one acts by cutting the fuel and the other reduces the throttle angle, both need to be raised if you want to raise the engine speed.

Two different rev limits can be set based on engine coolant temperature, so a lower limit can be enabled when the vehicle is cold.

There are two separate speed limiters throttle cut and fuel cut. They each have separate minimum RPM and hysteresis values.

Open Closed Loop

Related Maps:

- Closed Loop – Open Loop Accel Threshold #1 – High Det
- Closed Loop – Open Loop Accel Threshold #2 – Low Det
- Closed Loop – Open Loop Engine load Threshold #1 – High Det
- Closed Loop – Open Loop Engine Load Threshold #2 – Low Det

These thresholds set the points at which the ECU changes from closed loop to open loop operation.

When any of these conditions are exceeded, the engine will switch; this switch is most obviously shown on the fuel map, as it will change from 14.7:1 to whatever is set in the “Fuel Map Open Loop High / Low Det” map.

Sensor Scaling

Related Maps:

- Engine Coolant Temperature Sensor Scaling
- Intake Air Temperature Sensor Scaling
- Knock Sensor Scaling
- MAF Scale #1
- MAF Scale #2
- MAP Sensor Scaling – Multiplier
- MAP Sensor Scaling – Offset
- Lambda Sensor Scaling

Shown in Live Data as:

- Barometric Pressure
- Barometric Pressure Sensor
- Engine Coolant Temperature
- Engine Coolant Temperature Sensor
- Intake Air Temperature
- Intake Air Temperature Sensor
- Mass Air Flow
- Mass Air Flow Sensor
- Manifold Absolute Pressure
- Manifold Absolute Pressure Sensor

The voltage scaling for several sensors can be changed to suit aftermarket components. E.g. larger capacity MAF sensor, or MAP sensor.

The “MAF Scale #1 & #2” should always be set the same, as the ECU is hardcoded to use a particular map, but it is impossible to state which map is used so.

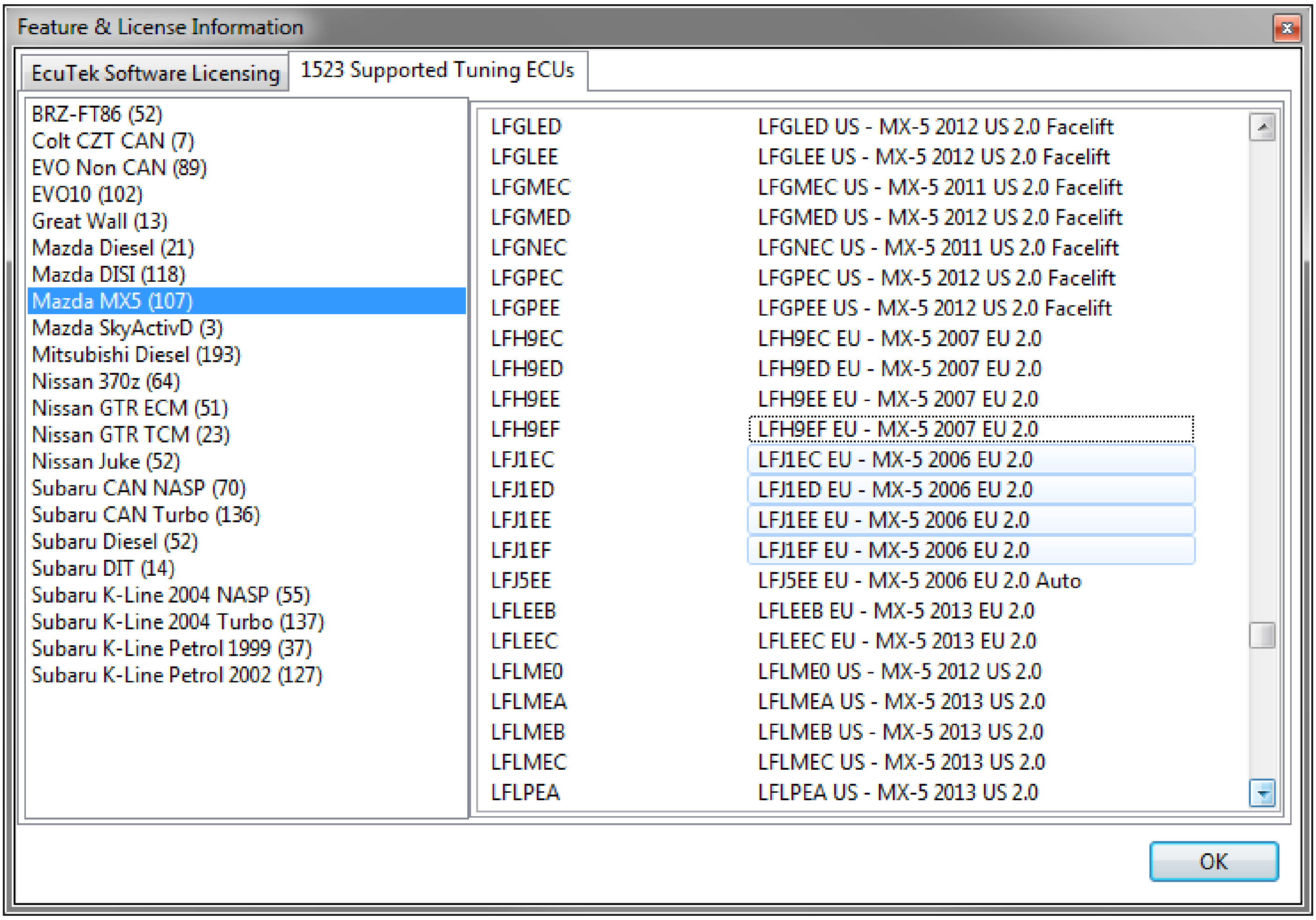
The knock sensor scaling can be used to dampen / enhance the knock sensor if phantom knock is detected. Care should be taken when adjusting this map as it may cause damage to your engine if knock occurs and no knock correction is performed. Conversely, an overly sensitive map will cause knock correction to be removed from the ignition unnecessarily.

Tuning Questions – Hints and Tips

Which ROM version to use?

All ROM versions are shown under HELP, FEATURE & LICENCE INFORMATION and SUPPORTED ECUs.
Only use the ROM that is specified for your region and always use the latest version available.
You can see below that the LFJ1E series has the following revisions:

LFJ1EC
LFJ1ED
LFJ1EE
LFJ1EF – This is the latest release that you should base your tuning on.



How do I know what my ECU ROM version is?

Open ProECU and choose Detect Vehicle, Program Engine ECU and Query ECU. The ECU ROM version will now be shown in the ECU Version window.

I can’t find a RRFF for my ECU ROM ID

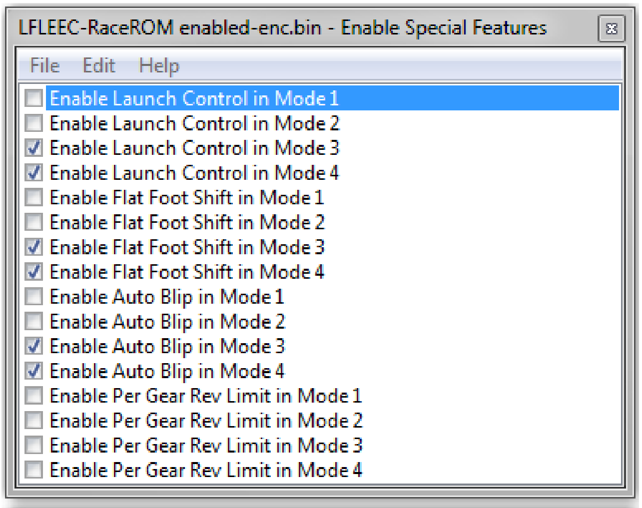
RaceROM Feature Files are only available for the latest ROM revision.
Denso are constantly developing, improving and bug fixing the ROMs so make the most of their hard work by using the latest revision.

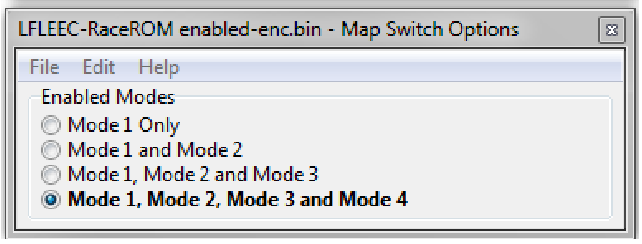
Can my current map switch mode be remembered?

Yes the current map switch mode is remembered even if the battery is disconnected then the ECU will still remember the Map Switch Mode.

Can I have Launch Control or Speed Density in certain modes?

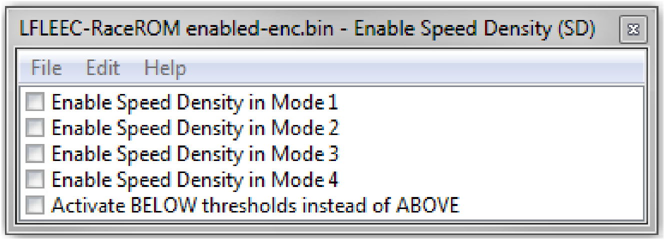
Yes, Launch Control, Flat Foot Shift and Autoblip are all configurable in any of the 4 modes, along with Speed Density.





Can I switch between MAF and Speed Density on the fly?

Yes, you can enable or disable SD in any of the 4 modes. You can also use the Hybrid SD function in any or all of the 4 map switch modes.



Can I use launch control whilst driving?

No, you must be below a set vehicle speed for Launch Control to be enabled, the default setting is 8kph.

Can the dealer over flash my tuned ECU?

No, the dealer reflash tool (or other tuning tools) cannot over flash the ProECU tuned ROM. If you flash back a 100% stock ROM then any other tools can flash over the ECU.

What happens if I have a problem during programming?

If the vehicle interface become disconnected or the laptop powers off during programming then the ECU will be part programmed. ProECU can recover the ECU from this state by manually selecting the ECU from the TOOLS menu.

Can I log a vehicle if I haven’t programmed it yet?

Yes you can log any MX5 even if it has not been programmed with ProECU but any custom parameters (EcuTek ORIGIN) will not be displayed until the ECU is programmed with a RRFF applied.

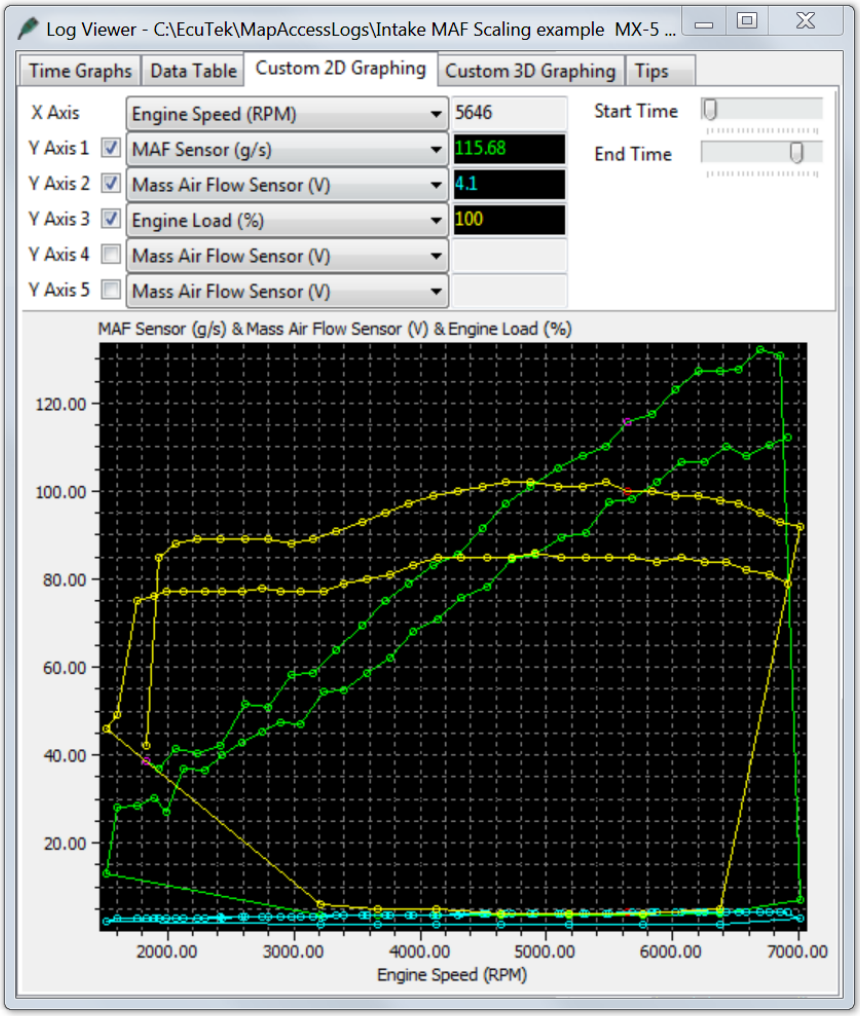
How to setup an Intake or Induction Kit

It's very important that the ECU knows the true amount of mass airflow (grams per second) that is entering the engine so it can accurately calculate the correct volume of fuel to inject and therefore achieve the correct AFR that's shown in the fuel map.

The factory fuel map has been calibrated to a stock factory intake and the values are what the vehicle runs when the mass airflow entering the engine is accurate.

When fitting most aftermarket intakes, induction kits or even replacement panel filters, the MAF sensor reading will be altered and the MAF sensor scaling will need adjusting.

Generally the Inside Diameter (ID) of an aftermarket MAF tube will be larger than the stock MAF tube. Most Intakes will change the way the air flows through the MAF tube and thus across the MAF sensor itself, this results in a lower MAF sensor voltage output that is given to the engine ECU for the same mass airflow. This lower mass airflow reading will lead to a lower engine load, more advanced Ignition timing and a leaner AFR. It's very important that the MAF scaling is adjusted (normally by increasing values) to counteract this problem.



The preferred setup would be making a 'before and after' log file showing the MAF volts, mass airflow, engine load, AFR etc for the stock intake and then new intake.

You can then cross reference the MAF Volts 'before and after' for each RPM and Manifold Pressure and increase the MAF Sensor scaling right hand column (grams) until the same mass airflow reading is achieved with the new intake compared to the old intake.

This can be seen on the left where two log files (Before Intake and After Intake) are added together, when the new Intake with larger Internal Diameter (ID) was fitted the MAF Sensor reading dropped from 115grams to 98 grams and the Engine Load dropped from 100% to 85%.

This reduced the Injector open time significantly making the AFR very lean and the Ignition Timing over advanced causing severe knocking.

Now this situation where we can fit the Intake and make a 'back to back' log like this doesn't always happen, quite often the vehicle already has an Intake fitted.
So in this case the existing Long Term Fuel Trims will be very important and can be used to make the MAF calibration.

How to Calculate your Power Output

Before starting a MAF calibration a simple formula for engine efficiency should be understood to ensure you are adjusting the map correctly.

By multiplying the peak Mass Airflow g/s value by 1.25 (or nearer 1.2 on some engines) you should get the BHP power output of the vehicle, it is also close to the wheel hp of the vehicle, this is a rough calculation but can save a lot of time especially if the vehicle has fundamental issues like air leaks, fuel pump issues or bad MAF sensors etc.

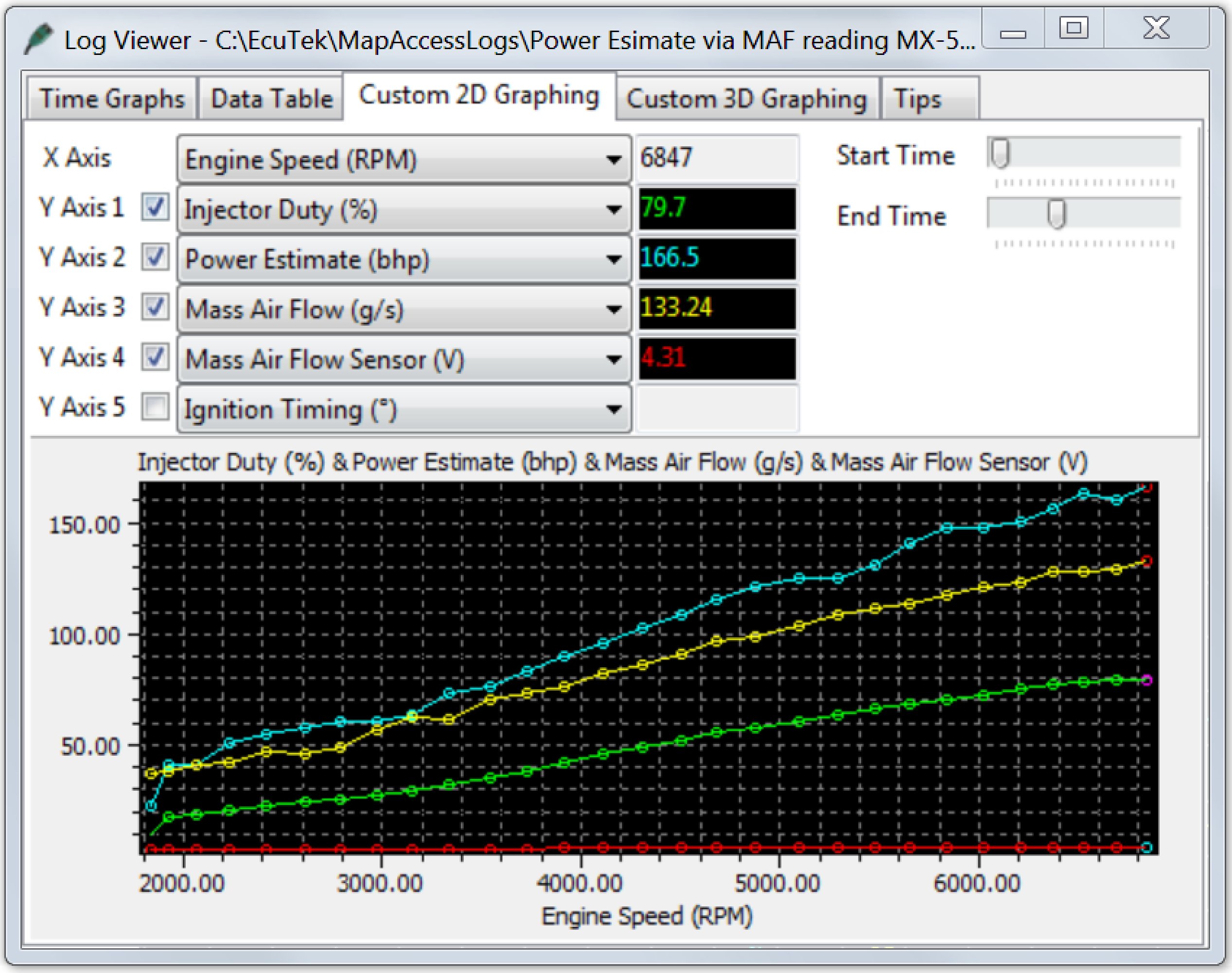
Examples:

- Stock Mazda MX5 pulls around 135 grams of Mass Airflow 135 * 1.25 = 168bhp
- Stock Mazda 3MPS pulls around 210 grams of Mass Airflow 210 * 1.25 = 262bhp
- Stock Mitsubishi EVO X pulls around 250 grams of Mass airflow 250 * 1.25 = 312bhp
- Stock Subaru BRZ pulls around 145 grams of Mass airflow 145 * 1.25 = 182bhp

Engines that have been produced more for torque and fuel consumption over ultimate peak power will have a reduced efficiency ratio factor more like 1.2

- Stock Nissan 370z pulls around 270 grams of Mass airflow 270 * 1.2 = 324bhp

Below you can see we added Power Estimate (BHP) and Injector Duty (%) into the log file



So if you supercharged your MX5 or BRZ/86 and it's pulling 380g/s at 0.5bar boost but only making 260 - 270bhp (as expected) then something is really wrong (like Injector Scaling, MAF housing design Fuel Pump delivery). If your MAF sensor reading is massively over or under reading then it can be caused by air turbulence in the MAF pipe, if it's too close to the compressor or re-circ valve or it located near a bend in the MAF intake, it can also be affected if it's too close to a bolt on air filter.

Adjusting the MAF scaling in closed loop

At Idle and light load (Closed Loop condition) you should log Fuel Trim Short Term (FTST) and Fuel Trim Long Term (FTLT), generally the MAF reading will be lower with a different intake so the FT will be adding +% to maintain closed loop 14.7AFR. Any continuous STFT will be transferred to LTFT for improved closed loop control. You should be watching both STFT and LTFT or the EcuTek Combined FT log parameter.

Typically the FT's will be adding +5% to +20% to maintain the closed loop target. So if we increase the whole MAF scaling by plus 5% this will make a coarse MAF scaling adjustment that will work quite well. Then continue to log and adjust the MAF scaling until the FT are within 10%, a good tuner will aim to have their Fuel Trims within plus or minus 5%.

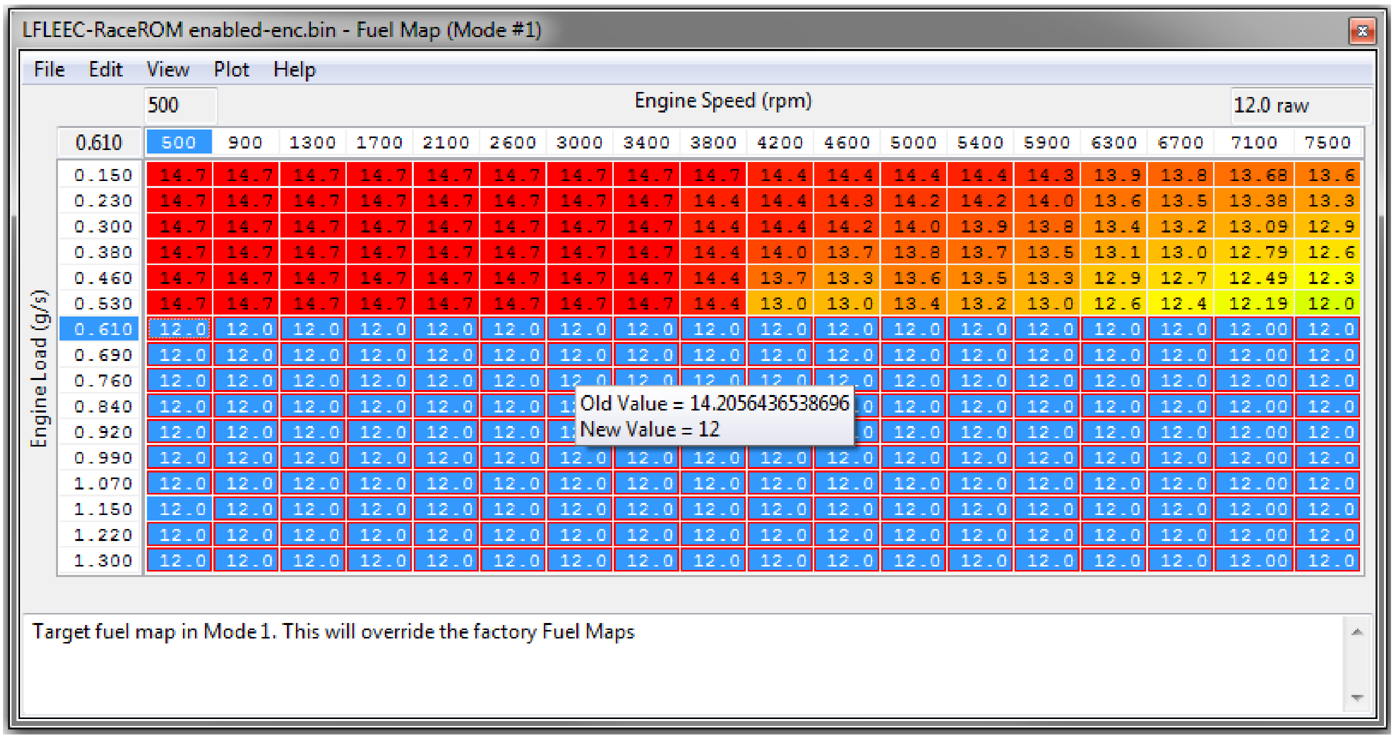
Adjusting the MAF scaling in open loop

Short Term Fuel Trims do not work in Open Loop so MAF scaling in Open Loop needs a slightly different approach.

To make a good MAF scaling (and this applies to forced induction conversions as well) we should fill the right hand side of the fuel map with a safe and friendly AFR, we will choose 12:1 AFR as shown below. Now make a power test and once the Engine Load exceeds 0.70 (g/rev) then the AFR should be 12:1.

- If the AFR is 14:1 then increase both 2D MAF scaling (g/sec) at that particular MAF voltage.
- If the AFR is 10:1 then reduce both 2D MAF scaling (g/sec) at that particular MAF voltage.

With a 12:1 AFR Target you should aim to get the AFR within 11.5:1 and 12.5:1 AFR across the board, good tuners will aim for 11.8 to 12.2 AFR but it depends on the time you have available.



0.610	500	900	1300	1700	2100	2600	3000	3400	3800	4200	4600	5000	5400	5900	6300	6700	7100	7500
0.150	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.4	14.4	14.4	14.4	14.3	13.9	13.8	13.68	13.6
0.230	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.4	14.4	14.3	14.2	14.2	14.0	13.6	13.5	13.38	13.3
0.300	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.4	14.4	14.2	14.0	13.9	13.8	13.4	13.2	13.09	12.9
0.380	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.4	14.0	13.7	13.8	13.7	13.5	13.1	13.0	12.79	12.6
0.460	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.4	13.7	13.3	13.6	13.5	13.3	12.9	12.7	12.49	12.3
0.530	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.4	13.0	13.0	13.4	13.2	13.0	12.6	12.4	12.19	12.0
0.610	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.00	12.0
0.690	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.00	12.0
0.760	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.00	12.0
0.840	12.0	12.0	12.0	12.0	12.0	12.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12.0	12.0	12.0	12.0	12.0	12.00	12.0
0.920	12.0	12.0	12.0	12.0	12.0	12.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12.0	12.0	12.0	12.0	12.0	12.00	12.0
0.990	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.00	12.0
1.070	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.00	12.0
1.150	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.00	12.0
1.220	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.00	12.0
1.300	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.00	12.0

The first time you make a MAF scaling in this way it may take a while but once you master the process then in future you will be tweaking the MAF curve on every flash.

Once the MAF scaling is good and smooth and you have 12:1 across the power curve, then you can profile the fuel map to your preferred AFRs.

In Open Loop (high load), the fuel trim feedback does not work anymore (no Short Term Fuel Trim) but Long Term Fuel Trim's that had been learned from Closed Loop could be applied in Open loop, this is why it's very important to get your Closed Loop Fuel Trims tight.

The longer the intake has been fitted the more accurate the FT Long Term will be, this will be a good indication on how far the MAF scale needs to be adjusted by.

Make sure that your Engine Load does not exceed the Y axis of the Fuel and Ignition maps, if it does then rescale the Engine Load axis so you do not reach the maximum engine load value in your log file.

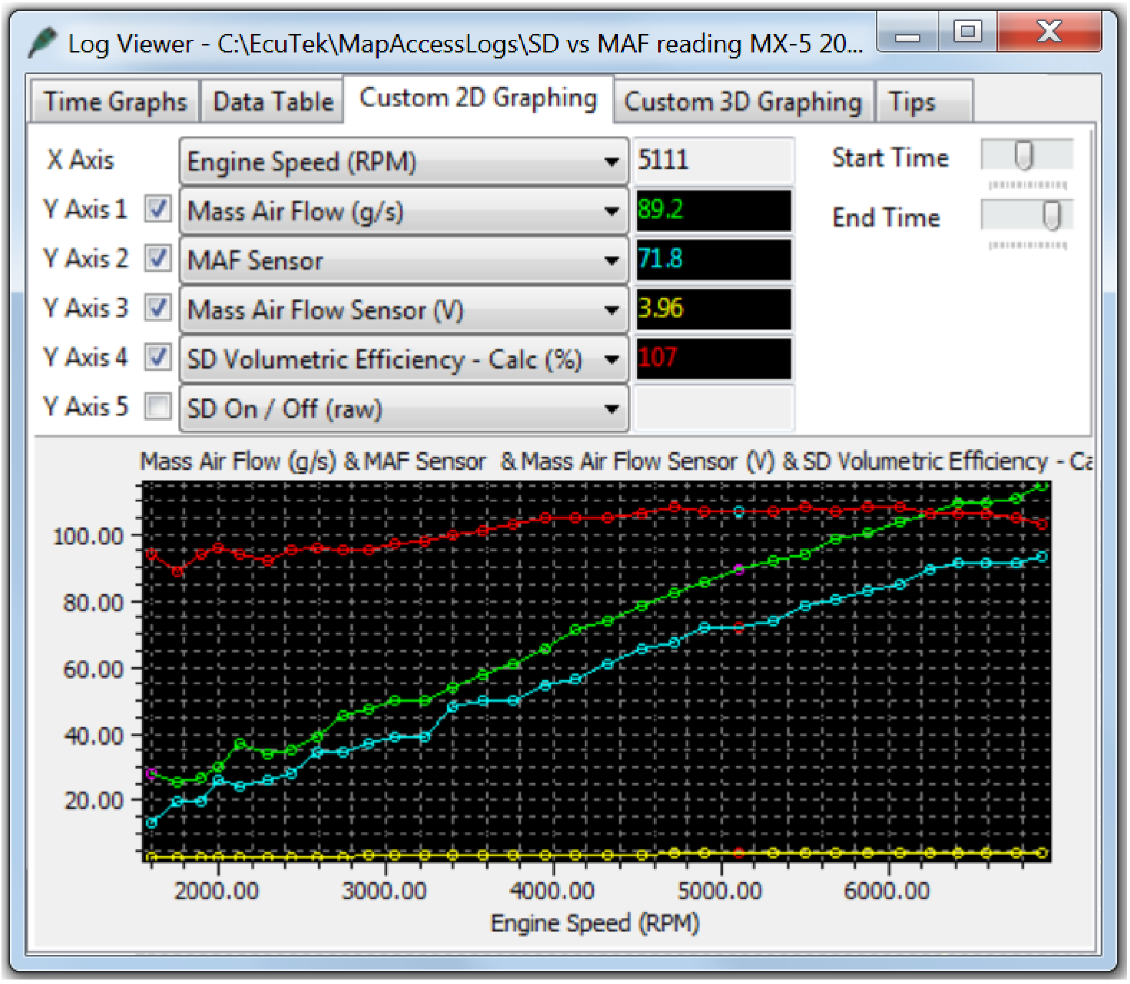
Adjusting the MAF scaling using SD

Another option for creating a new MAF curve (MAF scaling) can be to enable SD mode, with SD enabled the mass airflow (g/sec) will come from the SD VE map and not the MAF sensor itself. But the LIVE DATA custom logging parameter called 'MAF Sensor' can still LOG the output of the MAF sensor (even though the MAF sensor is NOT actually used for the load input at all).

Though this can be confusing to start with it is great for MAF scaling on relatively stock cars. Simply enable SD and the engine should run reasonably well then make a power run and be sure to include the logging parameter called MAF Sensor (g/s).

As seen below the ECU is running on SD, the Mass Airflow g/s is coming from the SD map not the MAF sensor and the engine is running well.

We can see and log the MAF Sensor output (the CYAN line) and it's under reading compared to the more accurate SD Mass Airflow calculation.



So by enabling SD we are able to LOG and SEE the affect the new Intake has had and we simply increase the 2D MAF scaling until the CYAN line meets the GREEN line, then turn OFF SD and we have a very close MAF scale!

How to calibrate Larger Injectors

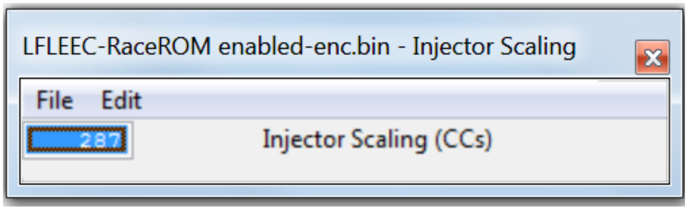
It's very important that the ECU knows the true size of the fuel Injectors that are fitted so it can accurately calculate the correct time period to open the injectors to deliver a required volume of fuel.

After fitting larger port injectors the following maps will need rescaling.

- Injector Scaling
- Injector Opening Time Compensation
- Injector Scaling Manifold Vacuum Compensation

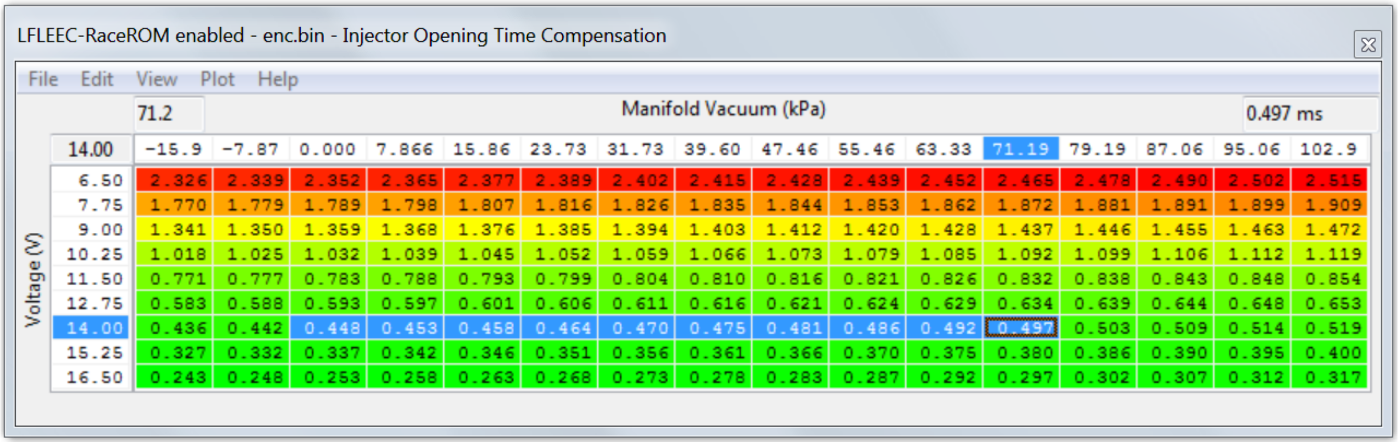
Injector Scaling

Generally the replacement larger Port Injectors will be supplied with an Injector calibration size and that should be entered here.



Injector Opening Time Compensation (Lag Time)

The different Injectors will have different characteristics to the stock injectors and will normally take longer to open. This time period is referred to as 'dead time, lag time or latency' and this time period is affected by the current battery voltage. Using the manufacturers technical data, enter the correct lag times for a given voltage in the maps called '**Injector Opening Time Compensation**'. If this data is not available then we suggest you just change the Injector size then leave the battery voltage comp map until you see how the engine is currently running.



LFLEEC-RaceROM enabled - enc.bin - Injector Opening Time Compensation

File Edit View Plot Help

71.2 Manifold Vacuum (kPa) 0.497 ms

Voltage (V) / 14.00	-15.9	-7.87	0.000	7.866	15.86	23.73	31.73	39.60	47.46	55.46	63.33	71.19	79.19	87.06	95.06	102.9
6.50	2.326	2.339	2.352	2.365	2.377	2.389	2.402	2.415	2.428	2.439	2.452	2.465	2.478	2.490	2.502	2.515
7.75	1.770	1.779	1.789	1.798	1.807	1.816	1.826	1.835	1.844	1.853	1.862	1.872	1.881	1.891	1.899	1.909
9.00	1.341	1.350	1.359	1.368	1.376	1.385	1.394	1.403	1.412	1.420	1.428	1.437	1.446	1.455	1.463	1.472
10.25	1.018	1.025	1.032	1.039	1.045	1.052	1.059	1.066	1.073	1.079	1.085	1.092	1.099	1.106	1.112	1.119
11.50	0.771	0.777	0.783	0.788	0.793	0.799	0.804	0.810	0.816	0.821	0.826	0.832	0.838	0.843	0.848	0.854
12.75	0.583	0.588	0.593	0.597	0.601	0.606	0.611	0.616	0.621	0.624	0.629	0.634	0.639	0.644	0.648	0.653
14.00	0.436	0.442	0.448	0.453	0.458	0.464	0.470	0.475	0.481	0.486	0.492	0.497	0.503	0.509	0.514	0.519
15.25	0.327	0.332	0.337	0.342	0.346	0.351	0.356	0.361	0.366	0.370	0.375	0.380	0.386	0.390	0.395	0.400
16.50	0.243	0.248	0.253	0.258	0.263	0.268	0.273	0.278	0.283	0.287	0.292	0.297	0.302	0.307	0.312	0.317

The X axis is for Battery Voltage and is common to most Injector Open Time Compensation calculations.

The Y axis is Manifold Vacuum and is more complex and difficult to visualise at first glance but if you consider the MX5 has a Naturally Aspirated engine and was not calibrated for positive pressure (Forced Induction) then this helps the understanding.

At sea level with the engine off, the X axis will be in the zero column. With the engine running at Idle it will be around 63 to 79 kPa column depending on your current inlet manifold depression.

For a turbo or supercharger vehicle then any positive boost pressure will move to the far left of the map and -15.9 kPa is actually 15.9 kPa of boost pressure, the X axis should be rescaled for high boost levels.
So,

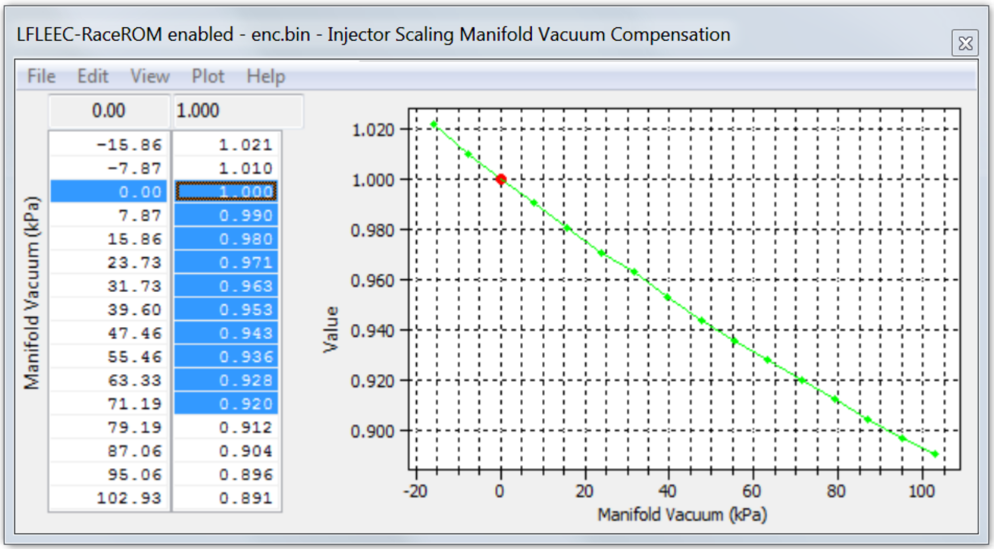
- -102 kPa would be 1 bar boost
- 0 kPa is 1 bar absolute
- 102kPa is just under 0 bar absolute

A custom logging parameter Manifold Relative Pressure has been added to the RaceROM Custom Live data list to aid in identifying which cell you're using.

Injector Scaling Manifold Vacuum Compensation

This 2D map has again an input axis as Manifold Vacuum and the following conversions should be noted to make the map easier to visualise and understand.

- -102 kPa would be 1 bar boost
- 0 kPa is 1 bar absolute - sea level
- 102kPa is just under 0 bar absolute and full vacuum



When fitting larger injectors the following sequence should be followed.

1) Set the Injector Scaling Size.
2) Set the 3D Battery Voltage Compensation (Lag Time) map as per the manufacturer's specification for the Injectors that you are fitting.
3) Set the 2D Injector Scaling Manifold Pressure Compensation map, this should be used for the majority of Injector calibration. This map has a major effect on Injector open time (ms) and should be used to dial in your FT in closed loop and hit your Fuel map AFR targets in open loop.

Setting the 2D Injector Scaling Manifold Vacuum Compensation map should be done in a similar way the MAF rescaling section.

Fill the higher load section of the fuel map with a fixed value like 12:1 AFR and then adjust the 2D Manifold Pressure Comp map to achieve the 12:1 AFR fuel map target when in Open Loop.

Now repeat the sequence for Closed Loop (14.7:1 AFR), so adjust the 2D map until the Fuel Trims are within +/- 10%.

Note: the Injector Opening Time Compensation values will have much **more** of an effect at Idle and light load when the Injector open times are much smaller (2-5ms at Idle and light load VS 10-18ms for full load) in addition the Injector Scaling Manifold Pressure Comp values will have the greatest affect overall.

You can see below all 3 maps have been adjusted to calibrate these 550cc Injectors correctly. When the vehicle is forced induction then we need to rescale the critical 2D Injector Scaling Manifold Pressure Compensation map.

If you have very large injectors fitted you may also need to adjust the Minimum Allowed Fuel Pulse Width 1D value to allow the injectors to open for a very small period of time.

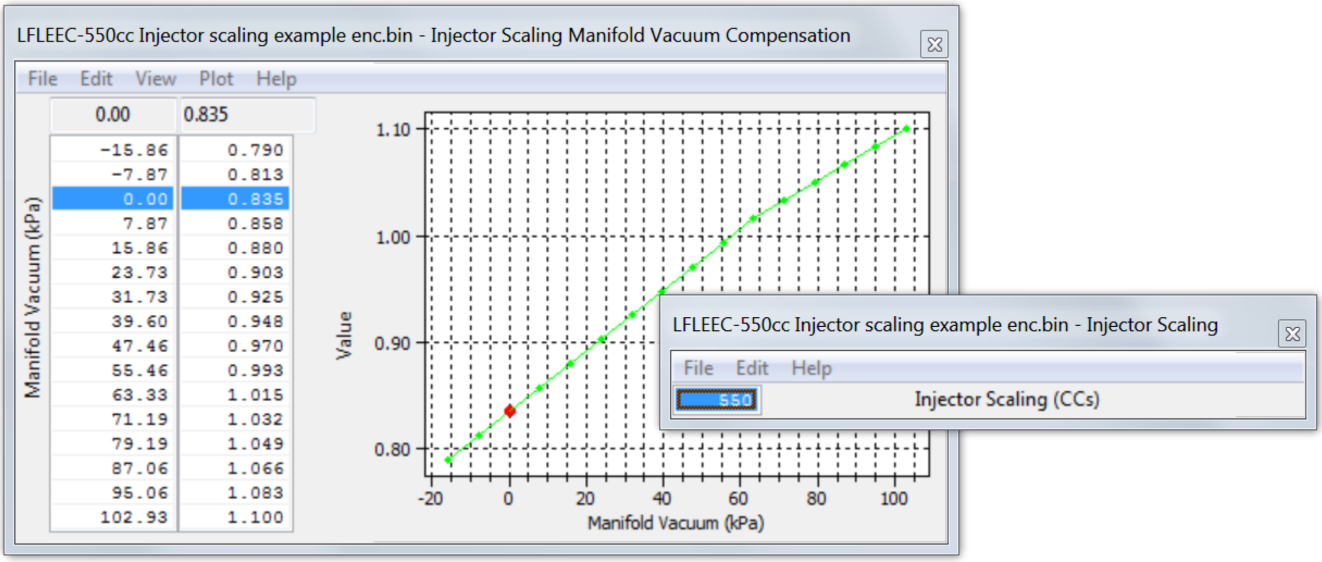
<u>DW550cc Injector setting for NA and FI setups</u>

LFLEEC-550cc Injector scaling example enc.bin - Injector Opening Time Compensation

File Edit View Plot Help

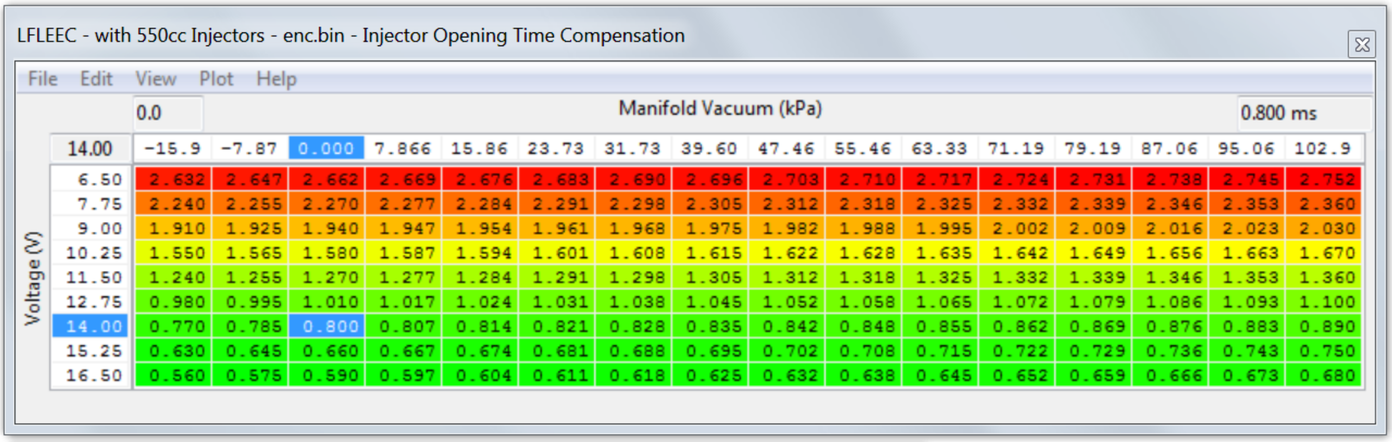
0.0 Manifold Vacuum (kPa) 0.800 ms

Voltage (V) \ Manifold Vacuum (kPa)	-15.9	-7.87	0.000	7.866	15.86	23.73	31.73	39.60	47.46	55.46	63.33	71.19	79.19	87.06	95.06	102.9
6.50	2.632	2.647	2.662	2.669	2.676	2.683	2.690	2.696	2.703	2.710	2.717	2.724	2.731	2.738	2.745	2.752
7.75	2.240	2.255	2.270	2.277	2.284	2.291	2.298	2.305	2.312	2.318	2.325	2.332	2.339	2.346	2.353	2.360
9.00	1.910	1.925	1.940	1.947	1.954	1.961	1.968	1.975	1.982	1.988	1.995	2.002	2.009	2.016	2.023	2.030
10.25	1.550	1.565	1.580	1.587	1.594	1.601	1.608	1.615	1.622	1.628	1.635	1.642	1.649	1.656	1.663	1.670
11.50	1.240	1.255	1.270	1.277	1.284	1.291	1.298	1.305	1.312	1.318	1.325	1.332	1.339	1.346	1.353	1.360
12.75	0.980	0.995	1.010	1.017	1.024	1.031	1.038	1.045	1.052	1.058	1.065	1.072	1.079	1.086	1.093	1.100
14.00	0.770	0.785	0.800	0.807	0.814	0.821	0.828	0.835	0.842	0.848	0.855	0.862	0.869	0.876	0.883	0.890
15.25	0.630	0.645	0.660	0.667	0.674	0.681	0.688	0.695	0.702	0.708	0.715	0.722	0.729	0.736	0.743	0.750
16.50	0.560	0.575	0.590	0.597	0.604	0.611	0.618	0.625	0.632	0.638	0.645	0.652	0.659	0.666	0.673	0.680



Manifold Vacuum (kPa)	0.835
-15.86	0.790
-7.87	0.813
0.00	0.835
7.87	0.858
15.86	0.880
23.73	0.903
31.73	0.925
39.60	0.948
47.46	0.970
55.46	0.993
63.33	1.015
71.19	1.032
79.19	1.049
87.06	1.066
95.06	1.083
102.93	1.100

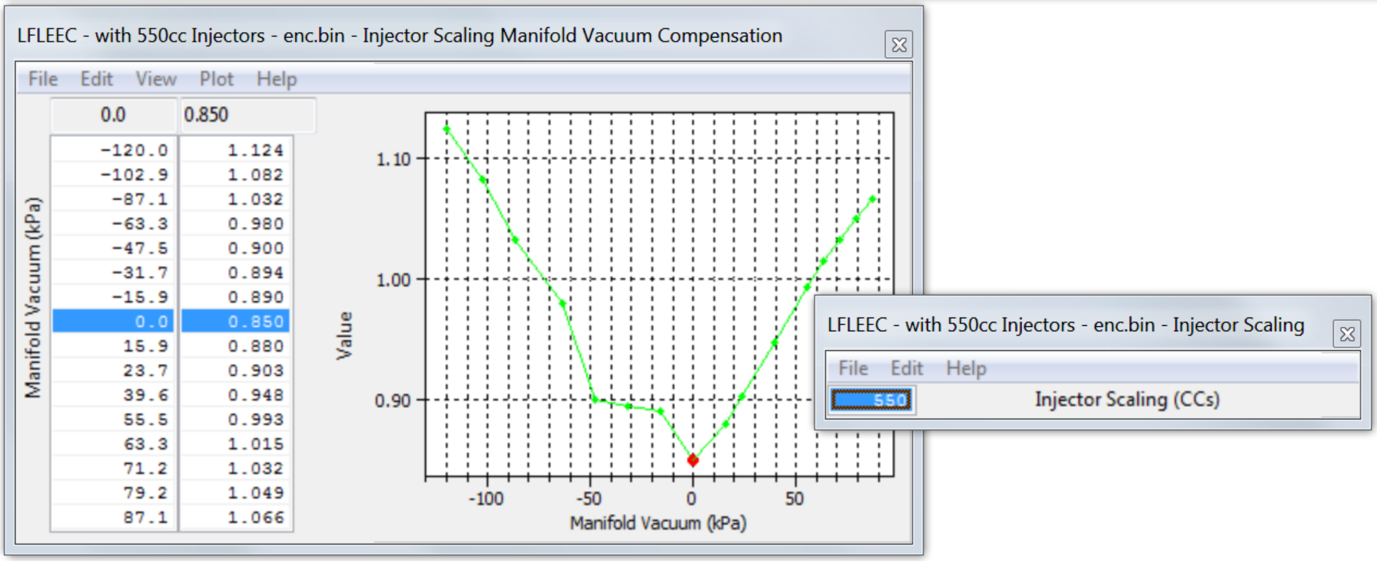
You can see below the 2D map has been rescaled on the Input axis for the positive boost pressure (FI setup). The map has now changed to a V shape with the lowest compensation values around 1bar absolute (0 psi boost). The exact reason for this shape is currently unknown but the combination of correct Injector scaling size, Injector Opening Time Compensation (Lag Time) set as per the manufacturer calibration and an accurately scaled Manifold Pressure compensation map produced an accurately scaled Injector scaling where FT were within +/-10% and the AFR achieved matches the fuel map.


LFLEEC - with 550cc Injectors - enc.bin - Injector Opening Time Compensation

File Edit View Plot Help

0.0 | Manifold Vacuum (kPa) | 0.800 ms

Voltage (V) \ 14.00	-15.9	-7.87	0.000	7.866	15.86	23.73	31.73	39.60	47.46	55.46	63.33	71.19	79.19	87.06	95.06	102.9
6.50	2.632	2.647	2.662	2.669	2.676	2.683	2.690	2.696	2.703	2.710	2.717	2.724	2.731	2.738	2.745	2.752
7.75	2.240	2.255	2.270	2.277	2.284	2.291	2.298	2.305	2.312	2.318	2.325	2.332	2.339	2.346	2.353	2.360
9.00	1.910	1.925	1.940	1.947	1.954	1.961	1.968	1.975	1.982	1.988	1.995	2.002	2.009	2.016	2.023	2.030
10.25	1.550	1.565	1.580	1.587	1.594	1.601	1.608	1.615	1.622	1.628	1.635	1.642	1.649	1.656	1.663	1.670
11.50	1.240	1.255	1.270	1.277	1.284	1.291	1.298	1.305	1.312	1.318	1.325	1.332	1.339	1.346	1.353	1.360
12.75	0.980	0.995	1.010	1.017	1.024	1.031	1.038	1.045	1.052	1.058	1.065	1.072	1.079	1.086	1.093	1.100
14.00	0.770	0.785	0.800	0.807	0.814	0.821	0.828	0.835	0.842	0.848	0.855	0.862	0.869	0.876	0.883	0.890
15.25	0.630	0.645	0.660	0.667	0.674	0.681	0.688	0.695	0.702	0.708	0.715	0.722	0.729	0.736	0.743	0.750
16.50	0.560	0.575	0.590	0.597	0.604	0.611	0.618	0.625	0.632	0.638	0.645	0.652	0.659	0.666	0.673	0.680

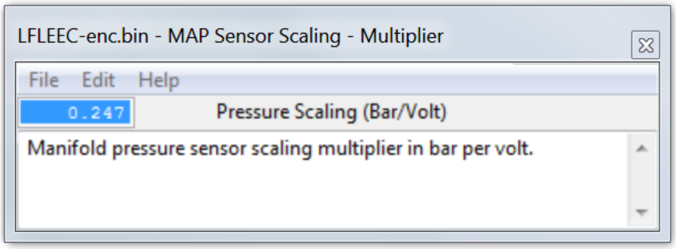


Manifold Vacuum (kPa)	0.850
-120.0	1.124
-102.9	1.082
-87.1	1.032
-63.3	0.980
-47.5	0.900
-31.7	0.894
-15.9	0.890
0.0	0.850
15.9	0.880
23.7	0.903
39.6	0.948
55.5	0.993
63.3	1.015
71.2	1.032
79.2	1.049
87.1	1.066

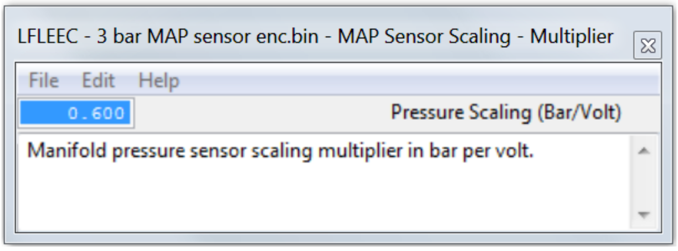
How to rescale the MAP sensor

The factory MAP sensor can read to around 1.37bar absolute, we recommend that the MAP sensor is replaced on all Forced Induction models. A popular plug and play replacement is the VAG Bosch 3bar sensor.

The stock MAP Sensor Offset value is set to zero, the Multiplier value is 0.247, so 0.247 bar per volt with a 5 volt MAP sensor.



Stock sensor multiplier: 0.247 * 5 = 1.23bar

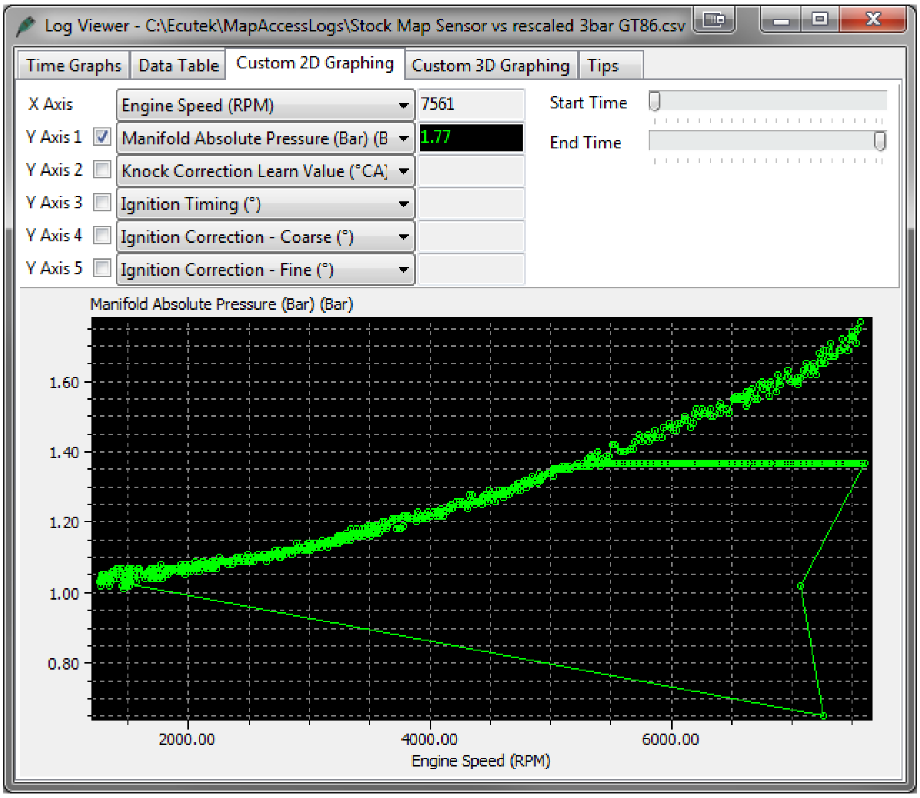


3Bar sensor multiplier: 0.6 * 5 = 3.0bar

NOTE: It’s very important that the MAP sensor scaling is accurate when using Speed Density.

Each sensor may be marginally different and you may find that a 3bar sensor is actually 3.15bar at 5volts so check with the manufacturer or compare it to the stock item by following this sequence:

1. With the stock MAP sensor make a log file and check the Manifold Absolute Pressure with ignition ON (engine not running), and then at stable idle.
2. Then fit new 3 or 4 bar MAP sensor and enter new scaling as above and repeat the test to ensure it's the same manifold pressure with the Ignition ON (engine not running) and at Idle.



The screenshot below shows two log files that have been added together in excel.

The first log is with standard MAP sensor that flat lines at 1.37bar. The second log is a 3bar sensor that has been correctly rescaled.

The two lines are identical till 5400rpm where the stock sensor flat lines and but the 3bar continues to read the true manifold pressure until 7600rpm.

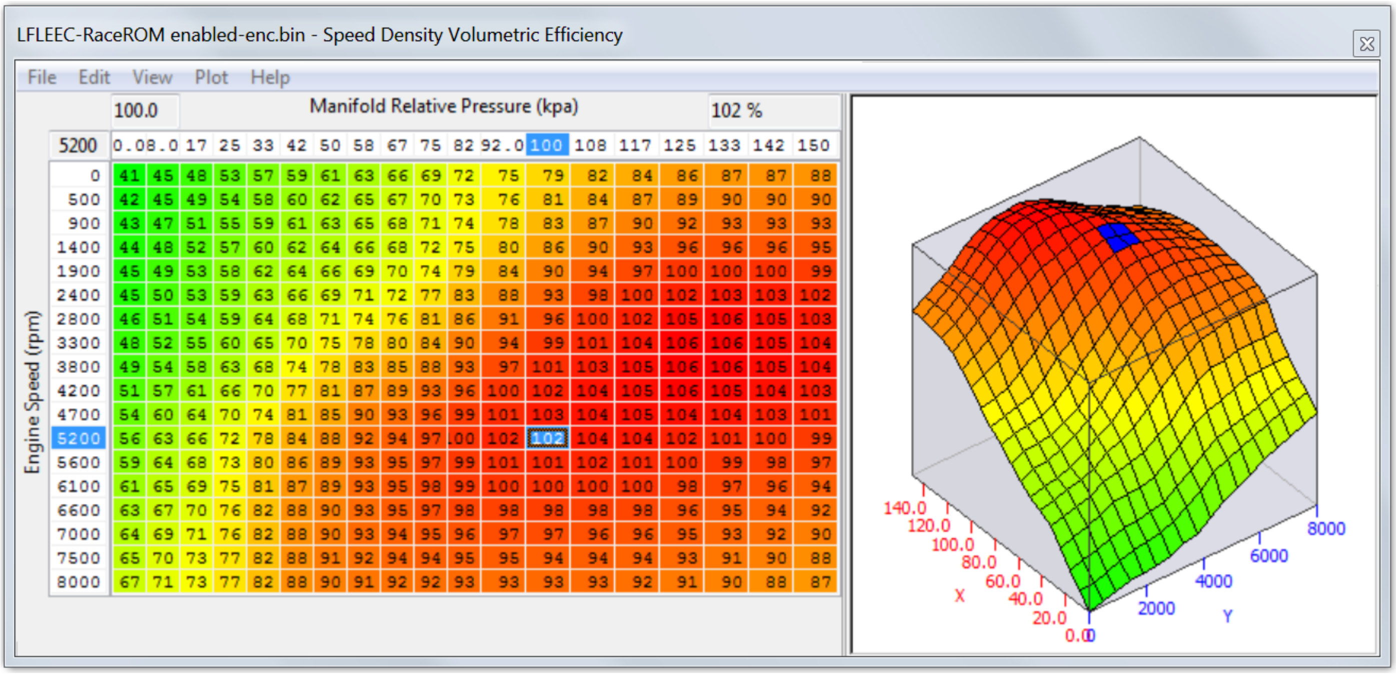
How to setup Speed Density (SD)

EcuTek RaceROM Feature Files (RRFF) offers a Speed Density tuning option. This is a MAP sensor based load input into the ECU (compared to the more forgiving factory MAF sensor based load input).

In certain situations Speed Density is more suitable over a MAF based input, these are usually:

- The air speed through Large MAF tubes is too slow to accurately measure for a stable Idle
- Turbo compressor wheel causes reverberations up the intake pipe and upset the MAF sensor reading
- Turbo installs use Vent-To-Atmosphere Blow-Off Valves (BOV's) instead of a preferred re-circulating design.
- Supercharger re-circulation valves cause reverberations up the intake pipe and upset the MAF sensor reading
- The stock MAF is flat lined at 5 volts and cannot read any higher than the 5 volt limit (where ideally a slightly larger MAF tube should be fitted like 69 to 76mm)

In these situations the Speed Density or Hybrid Speed Density can be used.



5200	0.0	8.0	17	25	33	42	50	58	67	75	82	92.0	100	108	117	125	133	142	150
0	41	45	48	53	57	59	61	63	66	69	72	75	79	82	84	86	87	87	88
500	42	45	49	54	58	60	62	65	67	70	73	76	81	84	87	89	90	90	90
900	43	47	51	55	59	61	63	65	68	71	74	78	83	87	90	92	93	93	93
1400	44	48	52	57	60	62	64	66	68	72	75	80	86	90	93	96	96	96	95
1900	45	49	53	58	62	64	66	69	70	74	79	84	90	94	97	100	100	100	99
2400	45	50	53	59	63	66	69	71	72	77	83	88	93	98	100	102	103	103	102
2800	46	51	54	59	64	68	71	74	76	81	86	91	96	100	102	105	106	105	103
3300	48	52	55	60	65	70	75	78	80	84	90	94	99	101	104	106	106	105	104
3800	49	54	58	63	68	74	78	83	85	88	93	97	101	103	105	106	106	105	104
4200	51	57	61	66	70	77	81	87	89	93	96	100	102	104	105	106	105	104	103
4700	54	60	64	70	74	81	85	90	93	96	99	101	103	104	105	104	104	103	101
5200	56	63	66	72	78	84	88	92	94	97	100	102	102	104	104	102	101	100	99
5600	59	64	68	73	80	86	89	93	95	97	99	101	101	102	101	100	99	98	97
6100	61	65	69	75	81	87	89	93	95	98	99	100	100	100	100	98	97	96	94
6600	63	67	70	76	82	88	90	93	95	97	98	98	98	98	98	96	95	94	92
7000	64	69	71	76	82	88	90	93	94	95	96	97	97	96	96	95	93	92	90
7500	65	70	73	77	82	88	91	92	94	94	95	95	94	94	94	93	91	90	88
8000	67	71	73	77	82	88	90	91	92	92	93	93	93	93	92	91	90	88	87

The SD VE map is against Engine Speed (RPM) and Manifold Pressure (Bar). The values in the map are volumetric efficiency (VE) %.

When the SD map is active, it simply replaces the current Mass Airflow (g/sec) reading that would normally come from the MAF sensor, therefore ALL load calculations are not affected by the MAF sensor at all.

When the SD map is correctly calibrated, there is little difference from running on MAF and the SD VE map works like this:

- INCREASING the SD values will increase Engine Load, therefore retarding the Ignition and increasing the Injection volume amount will make the AFR richer
- REDUCING the SD values will decrease Engine Load, therefore advancing the Ignition and reducing the Injection volume amount will make the AFR leaner

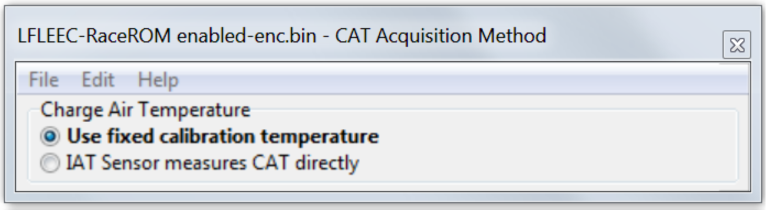
If SD is used, ensure that the MAP sensor can read to the pressure you are running!! (Any pressure over 1.37bar absolute will need a 3bar MAP sensor fitting etc)

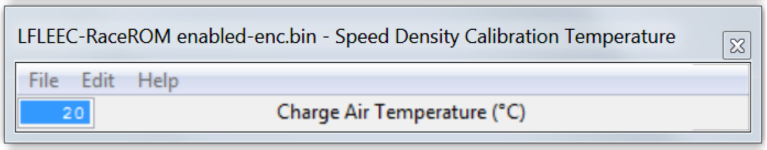
The V.E. based calculation is seriously affected by any fundamental change in VE and the base SD VE calibration has been made against a stock naturally aspirated engine (NA) with stock cam timing.

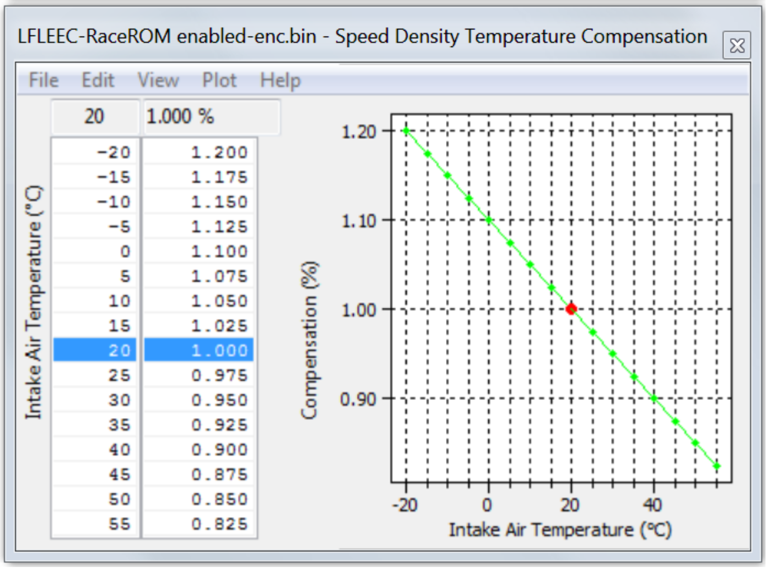
If you have changed the cams or added Forced Induction then you need to recalibrate the SD VE map.

Charge Air Temp (CAT) also plays a critical part in the VE calculation. As a Charge Air Temp sensor is NOT fitted by the factory, we have to assume a fixed temperature and then make a calibrated compensation based against Intake Air Temp.

No air temp sensor fitted in the charge pipe







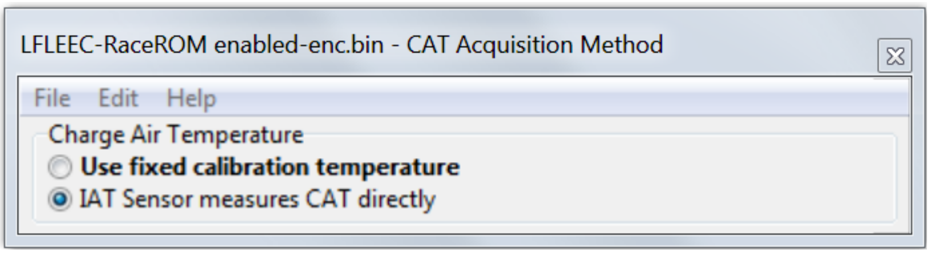
Intake Air Temperature (°C)	Compensation (%)
-20	1.200
-15	1.175
-10	1.150
-5	1.125
0	1.100
5	1.075
10	1.050
15	1.025
20	1.000
25	0.975
30	0.950
35	0.925
40	0.900
45	0.875
50	0.850
55	0.825

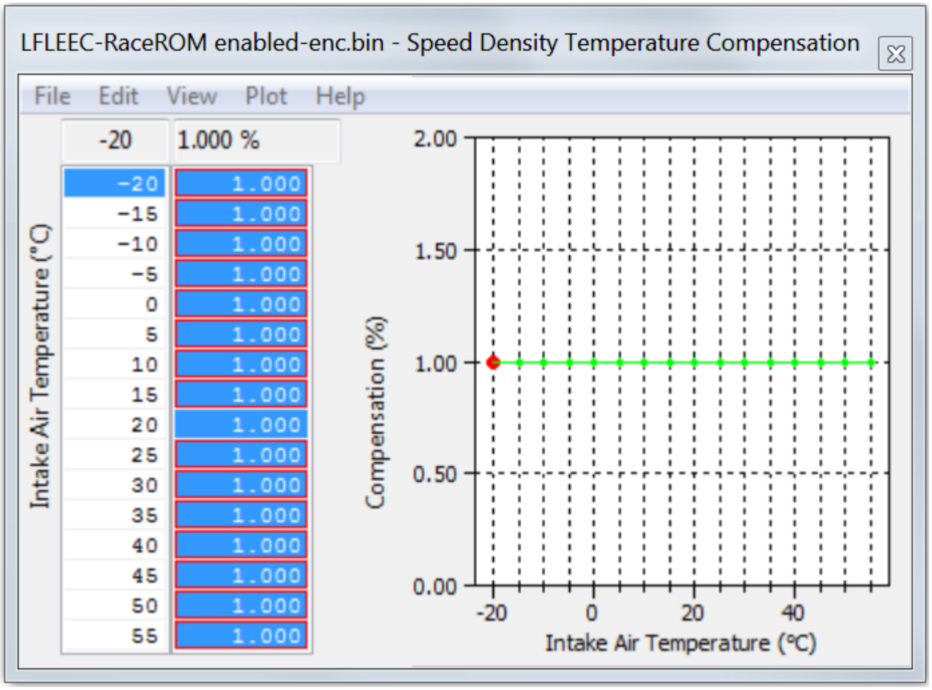
The Speed Density Temp Compensation map will adjust the SD VE calculation based on the current IAT, therefore attempting to calculate the true air density by calibration.

Intake Air temp sensor fitted in the charge pipe

If the Air Intake Temp sensor (AIT) has been placed in the charge pipe and the IAT is measuring true CAT (after the turbo/supercharger and intercooler) then we do NOT need to use the ‘Speed Density Temp Compensation’ map (as VE calculation is including true CAT). In this situation, we need to select the CAT Acquisition Method of ‘IAT sensor measures the CAT directly’ option.

We also need to set the values in the ‘Speed Density Temp Compensation’ to 100 as we are not ‘guessing’ the CAT anymore.



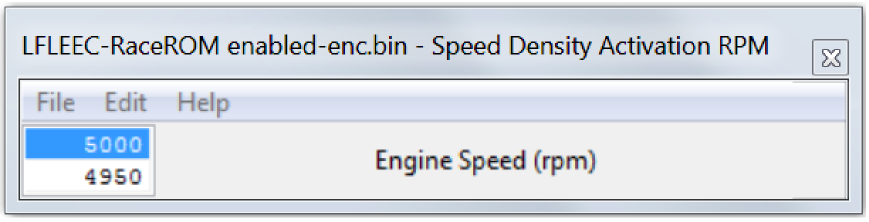


Hybrid SD mode options

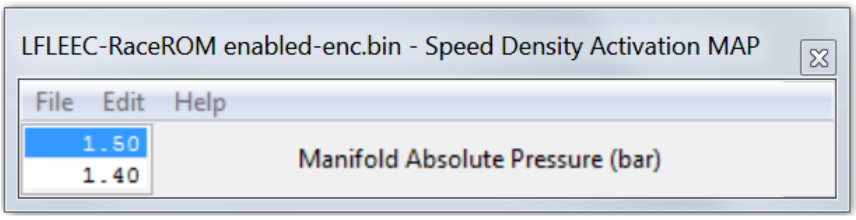
RaceROM implements a powerful Hybrid Speed Density mode which allows the Load Input to be switched between MAF and SD as required. This could be 'MAF then SD' or 'SD then MAF'. The condition to switch between the two inputs can be one or several of the following:

- Engine Speed (RPM)
- MAP (Bar)
- Mass Airflow (g/sec)

If you wish to have the engine running on MAF at Idle and low load and then continue on MAF until 5000rpm then switch to SD past 5000rpm, set the RPM threshold like this.



In addition you can specify that the boost pressure has to be over a certain pressure before the switch to SD as well (like over 5000rpm **and** over 1.5bar boost absolute or 7.5psi boost if you prefer), this is the Hybrid mode.



We need a smooth transition when swapping between 'MAF and SD' or 'between SD and MAF'. For this to happen the MAF and SD have to read very similar airflows at the switch point.

One major point to make is that ProECU can LOG the output of the MAF sensor (g/s) even if the MAF is not being used by the ECU (i.e. the ECU is running on SD not MAF).

So to calibrate for a hybrid transition we need to Enable SD earlier than the switch point, if the switch point is to be 5500rpm then enable SD over 4000rpm.
Even though the ECU is using SD past 4000rpm the MAF can still be logged, now we need to log the following three parameters.

Mass Airflow Absolute (MAF) (g/s) – The mass airflow reading from the MAF sensor

Mass Airflow Absolute (SD) (g/s) – The mass airflow calculation from the SD map

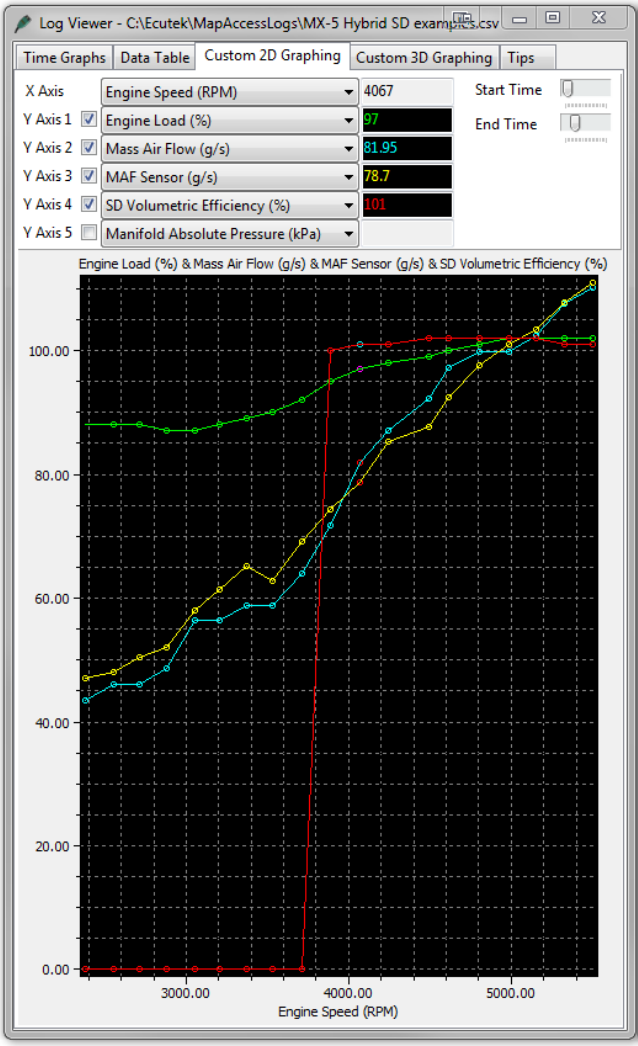
SD Volumetric Efficiency (%) – The output of the SD map and we can see when SD starts working

As seen below the ECU is currently running on SD, we know this because the SD VE (RED line) starts working after 3800rpm and shows SD VE as 101% in the left hand screen shot. If the ECU was using MAF the SD VE reading would be 0%.

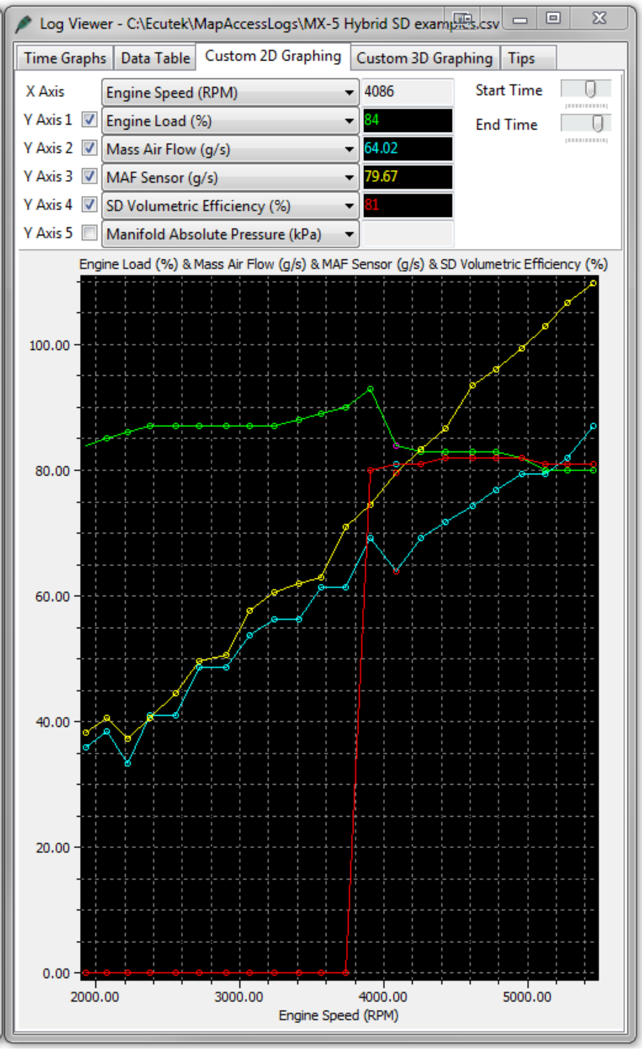
In the left hand log file (Good SD transition) the Mass Airflow readings for MAF and SD are very close between 3000 and 5000rpm so it would be a very smooth transition to swap from MAF to SD (or SD to MAF) at any RPM point shown below.

In the right hand log file (Bad SD transition) you can see the SD map is poorly calibrated and the SD VE values are too low, so when the SD map is enabled at 3800rpm the Mass Airflow drops which will cause a Lean AFR and Advanced Ignition Timing, the engine may hesitate as the transition occurs.

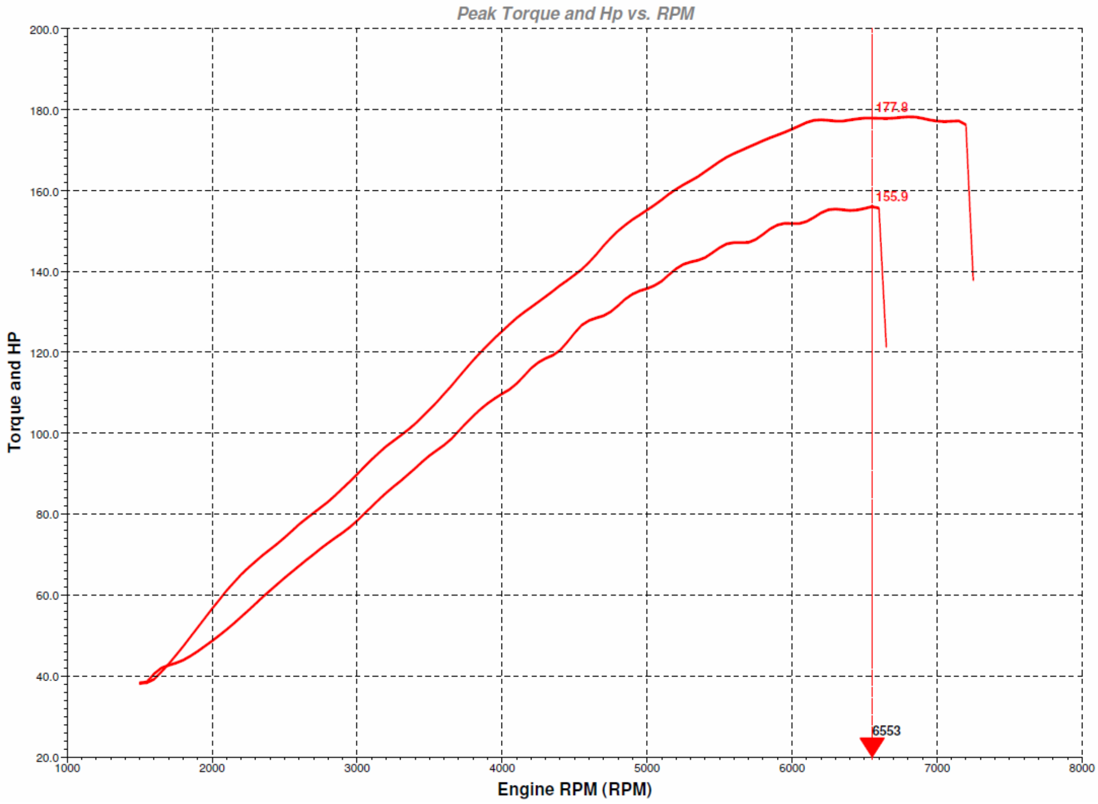
Good SD transition

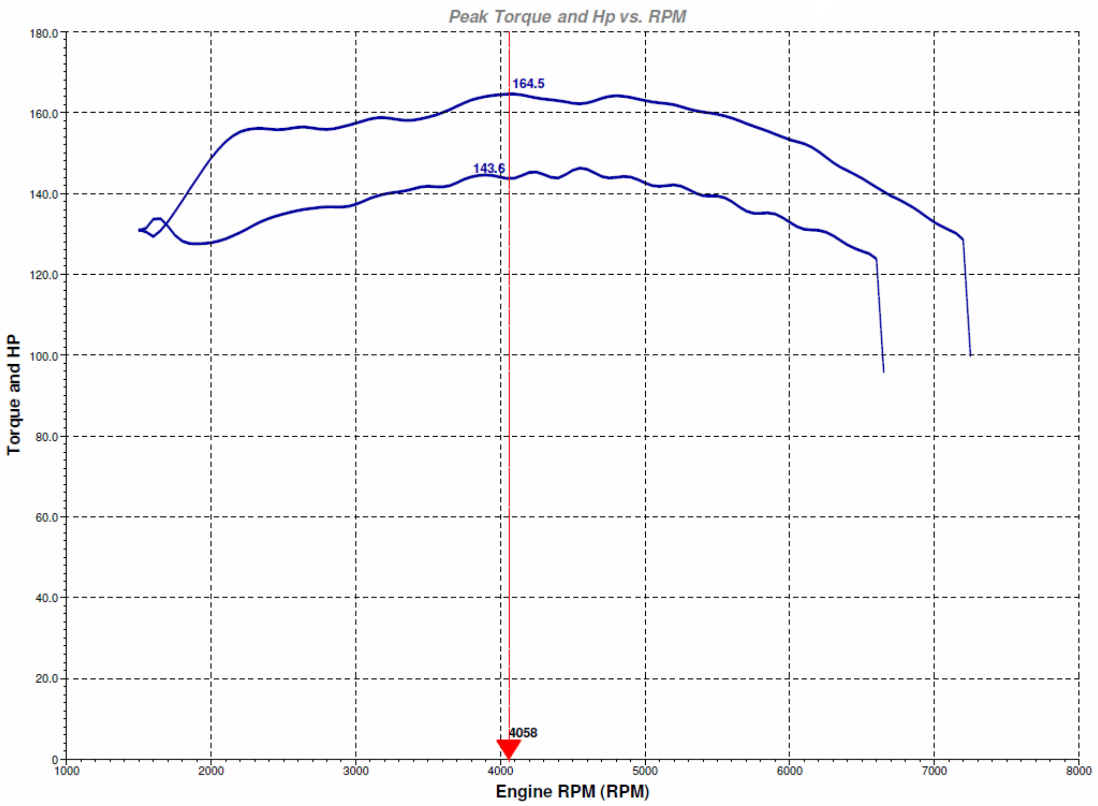


Bad SD transition



Typical Power Gains
Here are some example power gains that can be achieved:

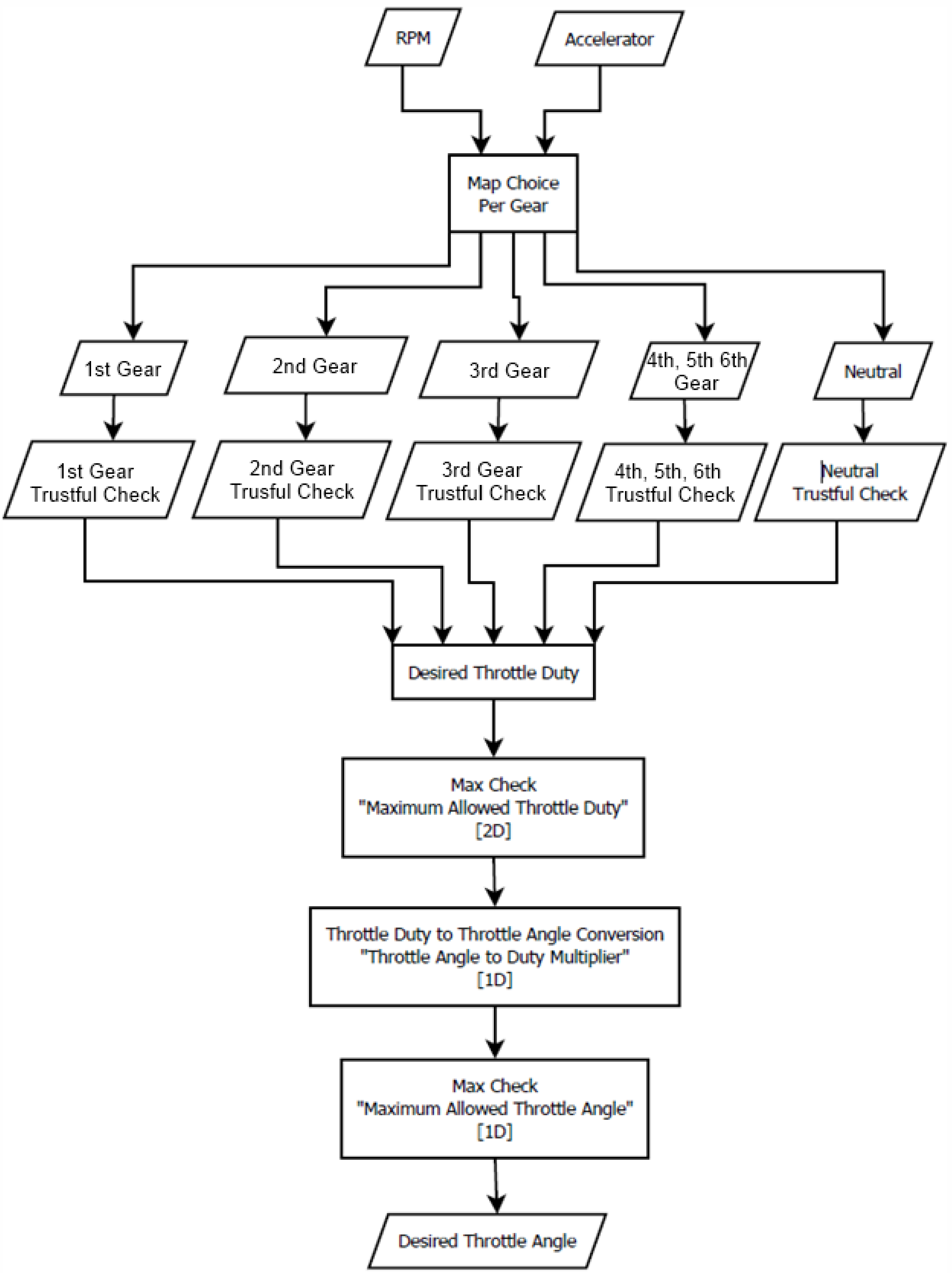




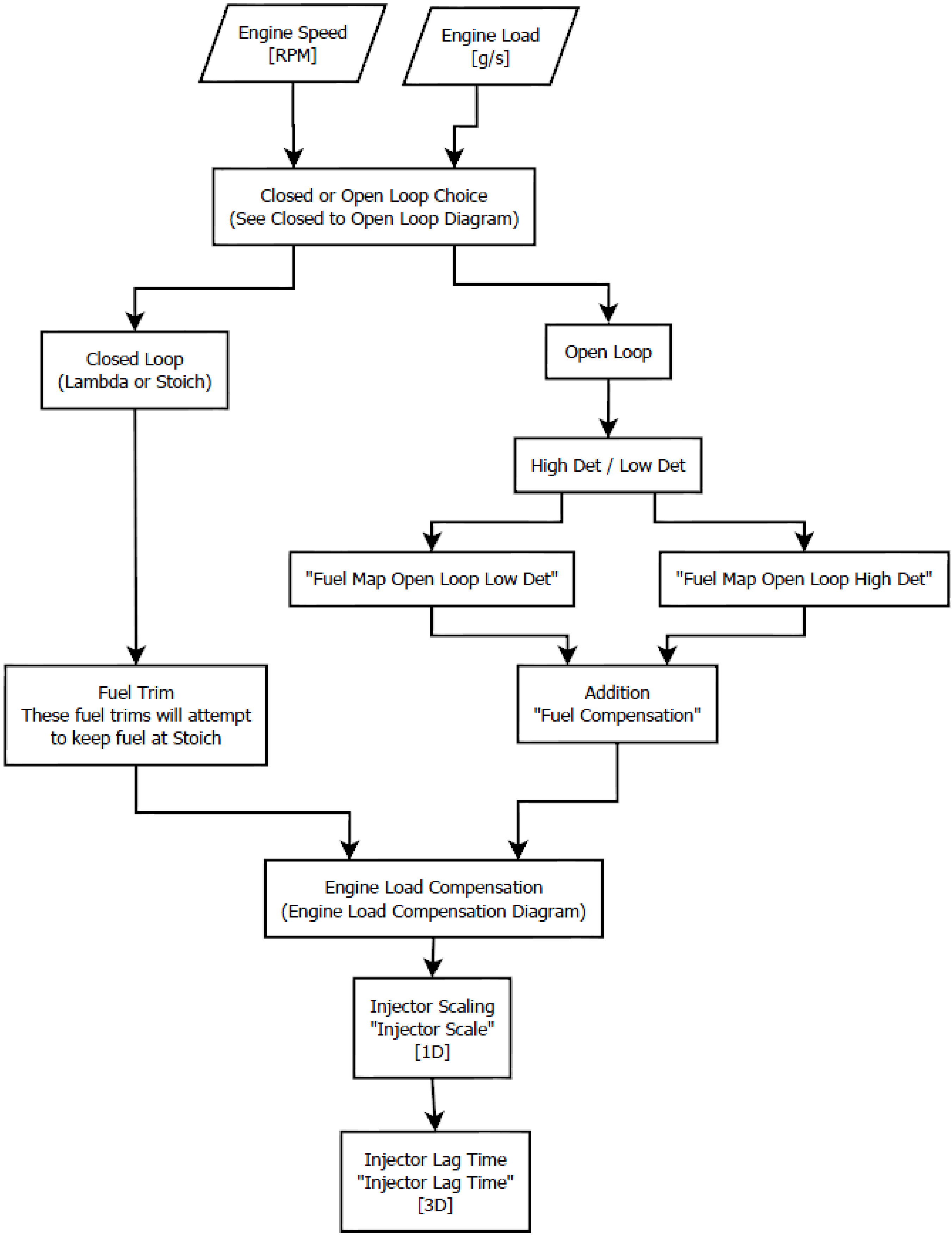
These graphs show the difference in power and torque between the standard car, and a full exhaust system with EcuTek ECU tuning.

Flow Diagrams

Accelerator Pedal to Throttle System



Fuel System


Engine Speed
[RPM]
Engine Load
[g/s]
Closed or Open Loop Choice
(See Closed to Open Loop Diagram)
Closed Loop
(Lambda or Stoich)
Open Loop
High Det / Low Det
"Fuel Map Open Loop Low Det"
"Fuel Map Open Loop High Det"
Fuel Trim
These fuel trims will attempt
to keep fuel at Stoich
Addition
"Fuel Compensation"
Engine Load Compensation
(Engine Load Compensation Diagram)
Injector Scaling
"Injector Scale"
[1D]
Injector Lag Time
"Injector Lag Time"
[3D]

Glossary

AFM
Air Flow Meter

AFR
Air Fuel Ratio

CAT
Charge Air Temp

ECT
Engine Coolant Temp

EGR
Exhaust Gas Recirculation

FI
Forced Induction

FTST
Fuel Trim Short Term

FTLT
Fuel Trim Long Term

FT
Fuel Trims

IAT
Intake Air Temp

IMRC
Intake Manifold Runner Control

MAF
Mass Air Flow (sensor)

MAP
Manifold Absolute Pressure (sensor)

NA
Naturally Aspirated

O2 Sensor
Lambda Sensor (oxygen sensor)

SD
Speed Density MAP based load input