MegaSquirt

EFI Analytics

Data driven Tuning

MegaMeet 2014

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Overview

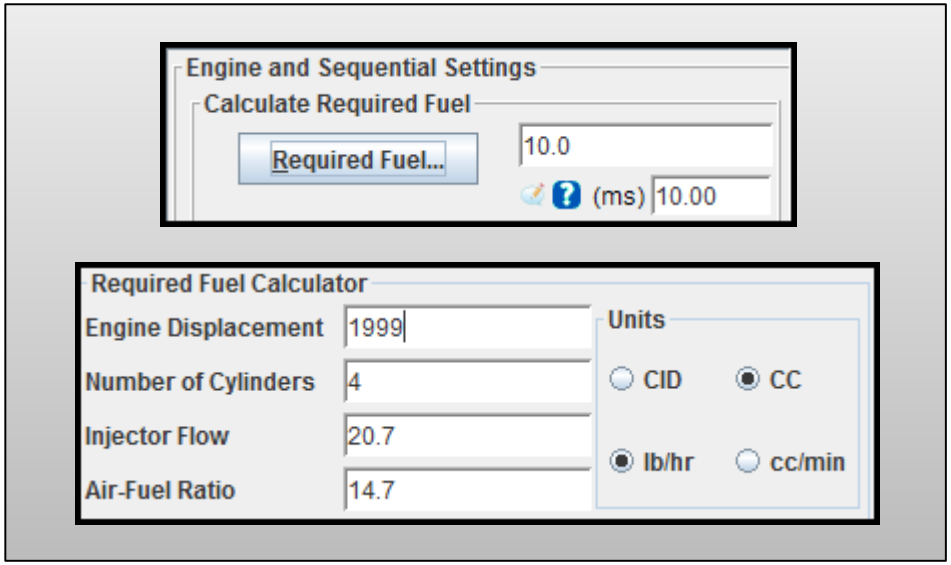
- Getting started – Basic tuning tips
- Review key configuration setting
- General Tuning rules
- Explanation of the different areas of the tune
- Common settings that can skew Ve Table Values
- What to look at before you begin tuning
- Check timing table values & tune Spark Table
- Tuning Ve Table
- Analyzing Data Logs
- Table Smoothing
- Cranking, ASE and Warmup Enrichment

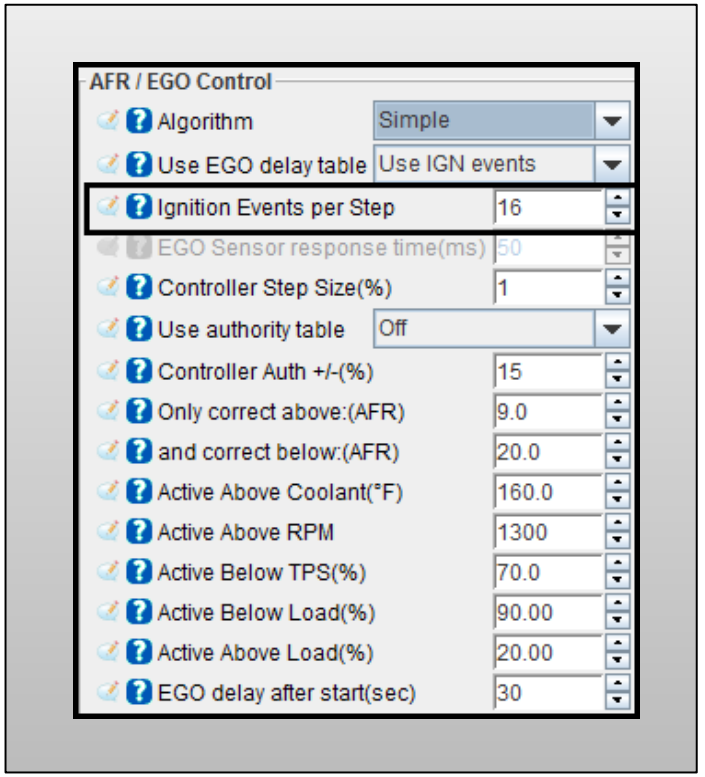
Getting started - Tuning Tips

- Tuning is a process you must be patient
- Always data log while making tune changes
- Use data logs to find what your engine wants
- 95% of the time the answers are in the data !
- Concentrate on one area of your tune at a time
- Only make one or two changes at a time (very easy to loose track)
- Save settings often in case you need to revert back
- Avoid lean AFR readings, especially under load
- Conservative timing advance (detonation kills engines & drains wallets)

Before you begin tuning

- Look over your settings
- Research what you do not know
- Verify Sensor calibrate
- O2 Correction

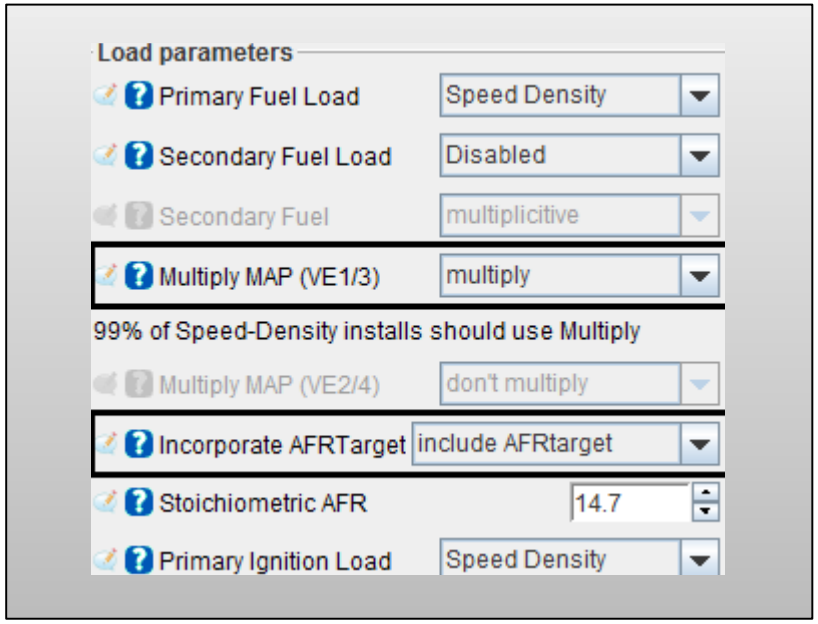


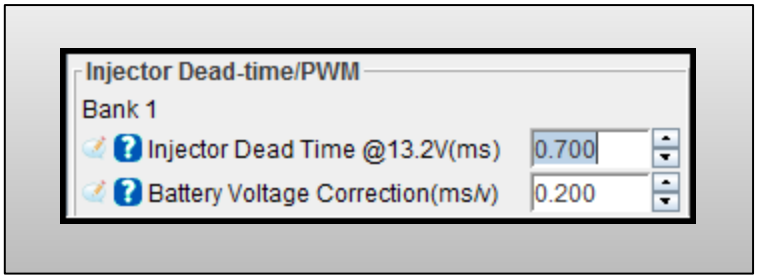


Before you begin tuning

Settings that can dramatically alter your VE Table

- Injector dead time
- Incorporate AFR target
- Multiply MAP





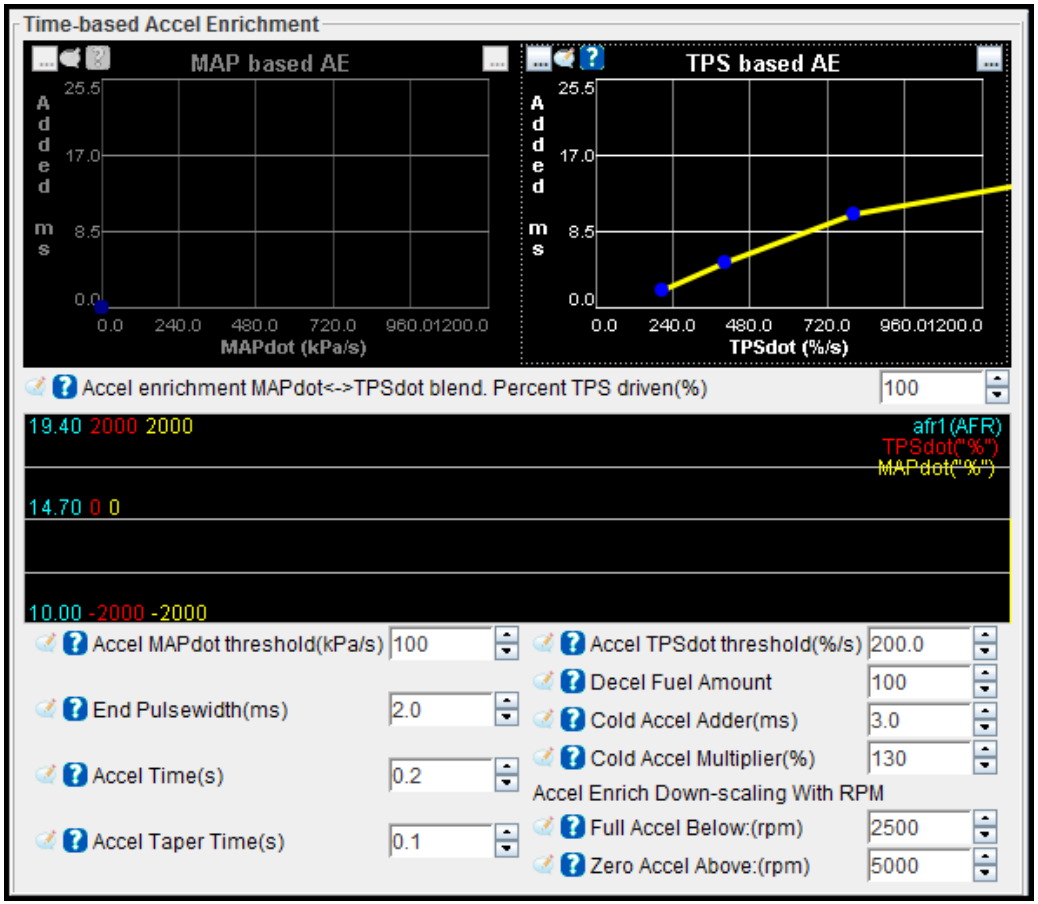
100	90	93	102	106	115	126	125	122	121	116	122	126
90	88	91	100	104	108	114	121	118	115	113	108	115
80	85	91	101	101	102	101	102	110	112	117	114	109
75	74	81	98	94	101	100	99	99	104	104	104	99
70	83	80	86	87	99	96	95	94	94	90	90	85
65	69	80	83	85	91	94	87	88	90	90	89	80
58	53	74	80	83	82	81	78	87	87	81	81	74
52	53	58	71	80	77	70	69	80	77	71	76	70
45	53	54	64	75	73	65	70	72	69	71	78	69
36	51	53	61	69	71	58	64	64	58	63	71	66
27	54	48	50	53	59	66	70	59	42	38	44	57
20	55	53	44	43	49	59	65	59	39	34	40	55
	700	1000	1400	1800	2200	2600	3200	4000	4600	5200	5800	6600

General Rules

Remedy	Fuel	Spark
Needs Reduced	Too Rich: • black smoke from exhaust, • sluggish throttle response, • reduced power, • black 'sooty' spark plug electrodes, • poor fuel consumption, • fuel in oil, • engine wear.	Too Advanced: • detonation, • 'kick back' while cranking, • Increased emissions.
Just Right	• good throttle response, • maximum power, • tan colored spark plug electrodes.	• maximum power, • no detonation, • good fuel economy.
Needs Increased	Too Lean: • 'coughs' (backfires) into intake, • reduced power, • white spark plug electrodes, • possible detonation, • burned pistons (high loads only)	Too retarded: • overheating, • reduced power, • exhaust glows red hot.

Acceleration

- Increase fueling to achieve AFR target
- Increased timing advance full timing around 3500
- Best Throttle response



- Accel enrichment options
- TPS
- MAP
- X-Tau
- EAE

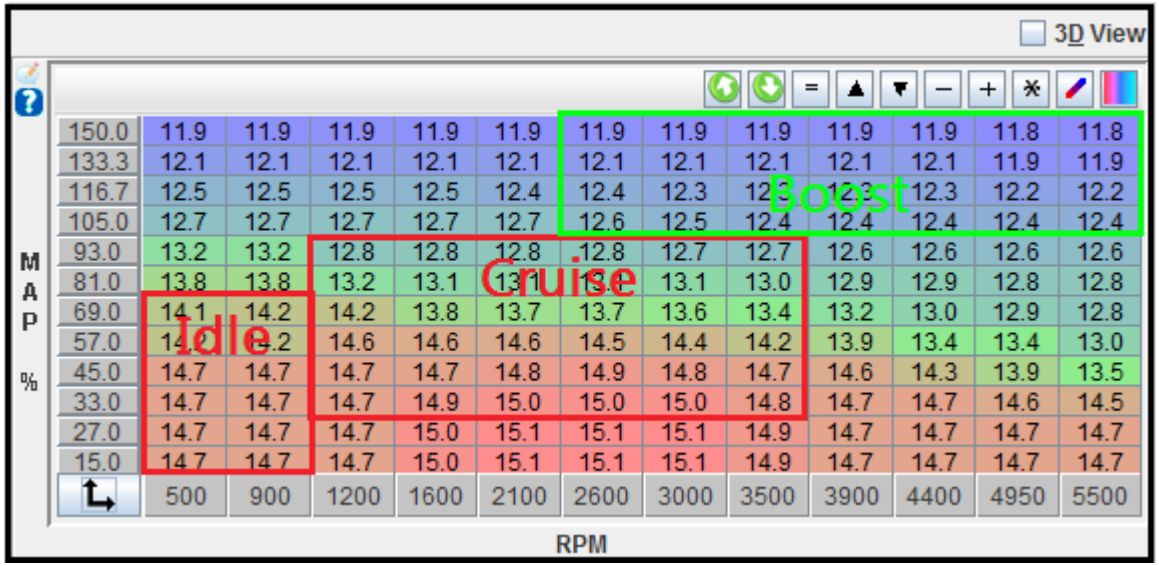
AFR Table

Idle – generally stoich or slightly rich

Cruise – Stoich to slightly lean

WOT / Boost – rich of stoich.

- NA – 12:1 – 13:1
- Boost richen more as boost increases



MAP %	500	900	1200	1600	2100	2600	3000	3500	3900	4400	4950	5500
150.0	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.8	11.8
133.3	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	11.9	11.9
116.7	12.5	12.5	12.5	12.5	12.4	12.4	12.3	12.3	12.3	12.3	12.2	12.2
105.0	12.7	12.7	12.7	12.7	12.7	12.6	12.5	12.4	12.4	12.4	12.4	12.4
93.0	13.2	13.2	12.8	12.8	12.8	12.8	12.7	12.7	12.6	12.6	12.6	12.6
81.0	13.8	13.8	13.2	13.1	13.1	13.1	13.1	13.0	12.9	12.9	12.8	12.8
69.0	14.1	14.2	14.2	13.8	13.7	13.7	13.6	13.4	13.2	13.0	12.9	12.8
57.0	14.2	14.2	14.6	14.6	14.6	14.5	14.4	14.2	13.9	13.4	13.4	13.0
45.0	14.7	14.7	14.7	14.7	14.8	14.9	14.8	14.7	14.6	14.3	13.9	13.5
33.0	14.7	14.7	14.7	14.9	15.0	15.0	15.0	14.8	14.7	14.7	14.6	14.5
27.0	14.7	14.7	14.7	15.0	15.1	15.1	15.1	14.9	14.7	14.7	14.7	14.7
15.0	14.7	14.7	14.7	15.0	15.1	15.1	15.1	14.9	14.7	14.7	14.7	14.7

- Best values will vary some with engine
- Best targets will vary with Wideband accuracy
- AFR Table Generator will provide a good starting point
- Use dyno or ET's to find best WOT AFR
- Use fuel economy and best running for Cruise AFR
- Use best idle for Idle AFR

Idle, Cruise & WOT

- Typically Stoichiometric to 15.8:1 but can vary with application
- Roughly 5° to 15° BTDC

- Stoichiometric to 15.5 AFR
- High timing advance to full time

- Fairly rich (12.5:1 to 13.5:1) boosted applications will (11.5:1 to 12.1:1)

Generating Base line advance table

- Start with factory advance table if possible
- (NA) reduce whole advance table by 2°- 3°
- (Boosted) reduce by 2°- 3° / above 100kPa reduce an additional 1°- 2°

Generating advance Table based on engine parameters

- older engines (1960s to 1990) with two valves - max advance = 36
- Newer two-valve engines – max advance = 30°
- Three or four valve engines – max advance = 26°

Adjust for bore size

- Under 3.5” (89mm) – subtract 3°
- Between 3.5” & 4.0” (101.6mm) – no adjustment
- Over 4.001” (+101.6mm) – add 3°

Adjust for the fuel

- Regular – subtract 2°
- Mid-grade – subtract 1°
- Premium – no adjustment

Additional Modifiers

- Aftermarket combination good squish + optimized quench - subtract 2°
- Idle to 3000RPM @ 100kPa increase advance linearly to max advance
- Every 10kPa over 100kPa reduce advance - .5° to 1°
- Max advance at full boost roughly half of your total adv. at 100kPa

These are rules of thumb to help create a conservative spark advance table to get the engine runnable. The base line spark table you made from this information will need fine tuned to make optimal power.

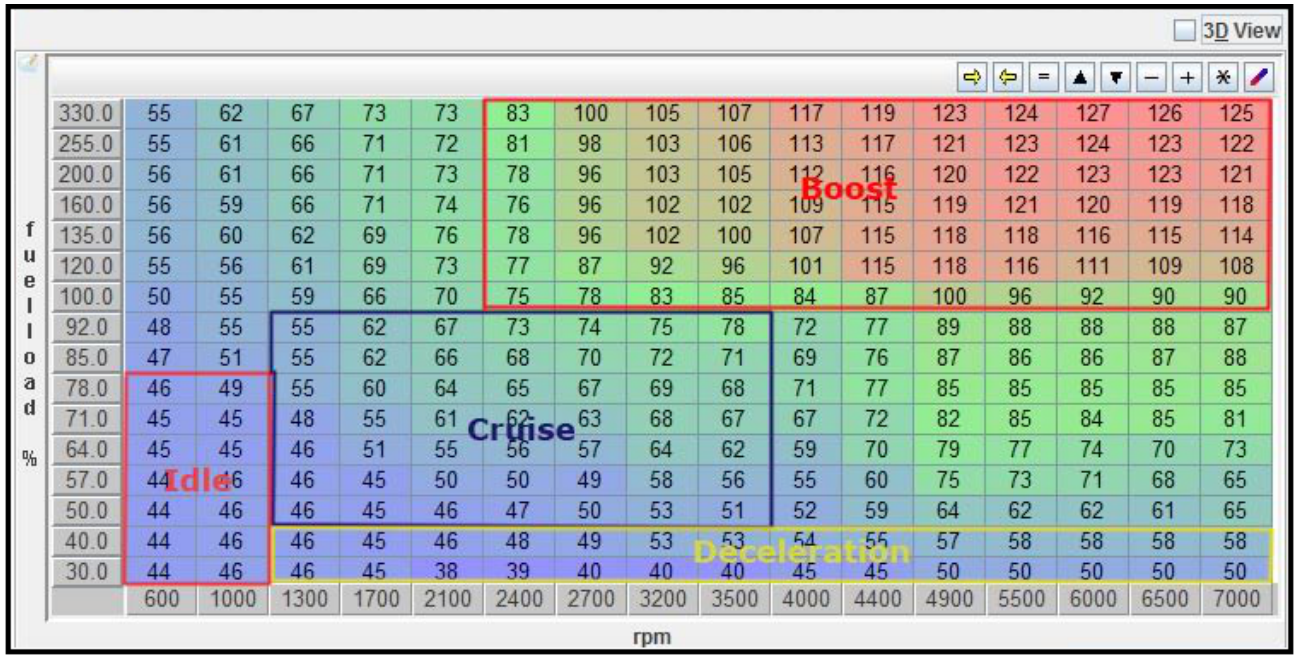
Ve Table Tuning

Ve Table Tuning

- MegaSquirt firmware uses 4 cell interpolation
- Good Ve Table Values guideline 30 – 130
- Values typically increase as you climb through the table
- If VE Values out of range adjust required fuel
- recommendedVE = currentVE * (egoCorrection/100) * (actualAFR / targetAFR)

Typical Values:

- Idle 30 – 60
- Cruise 50 – 80
- WOT 80 -130
- Boost 85 – 140
- Decel 30 - 50



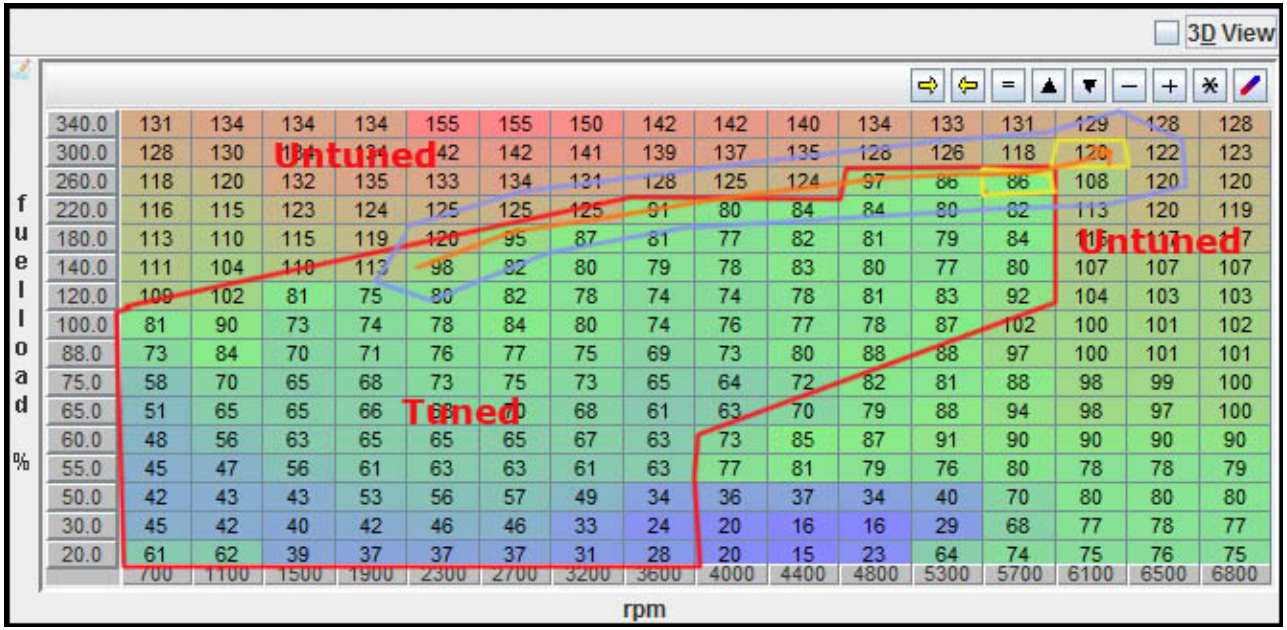
fuelload % \ rpm	600	1000	1300	1700	2100	2400	2700	3200	3500	4000	4400	4900	5500	6000	6500	7000
330.0	55	62	67	73	73	83	100	105	107	117	119	123	124	127	126	125
255.0	55	61	66	71	72	81	98	103	106	113	117	121	123	124	123	122
200.0	56	61	66	71	73	78	96	103	105	112	116	120	122	123	123	121
160.0	56	59	66	71	74	76	96	102	102	109	115	119	121	120	119	118
135.0	56	60	62	69	76	78	96	102	100	107	115	118	118	116	115	114
120.0	55	56	61	69	73	77	87	92	96	101	115	118	116	111	109	108
100.0	50	55	59	66	70	75	78	83	85	84	87	100	96	92	90	90
92.0	48	55	55	62	67	73	74	75	78	72	77	89	88	88	88	87
85.0	47	51	55	62	66	68	70	72	71	69	76	87	86	86	87	88
78.0	46	49	55	60	64	65	67	69	68	71	77	85	85	85	85	85
71.0	45	45	48	55	61	62	63	68	67	67	72	82	85	84	85	81
64.0	45	45	46	51	55	56	57	64	62	59	70	79	77	74	70	73
57.0	44	46	46	45	50	50	49	58	56	55	60	75	73	71	68	65
50.0	44	46	46	45	46	47	50	53	51	52	59	64	62	62	61	65
40.0	44	46	46	45	46	48	49	53	53	54	55	57	58	58	58	58
30.0	44	46	46	45	38	39	40	40	40	45	45	50	50	50	50	50

Ve Table Tuning

VE Analyze

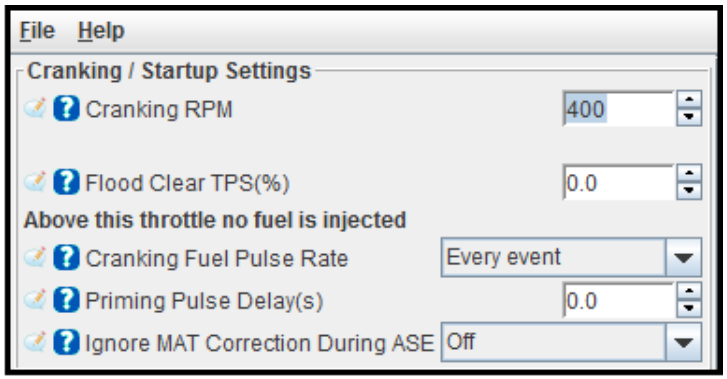
- Log based or Live in TS
- Must be able to identify when something isn't right
- Manually adjusting areas Ve Analyze live did not reach

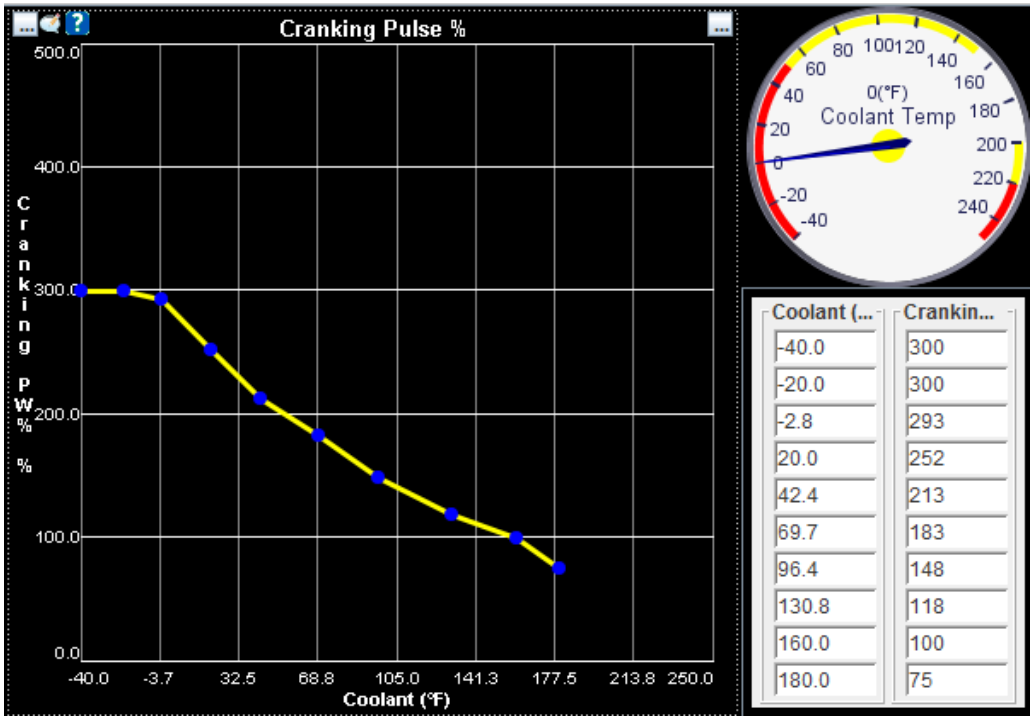
- Some sections of the table will not get enough or any data to be corrected.
- These areas of the table are not used while running the engine but you would likely want to manually correct



Cranking

- Increase fueling for cold conditions
- Low Ign advance (minimize kick back)
- Cranking Pulse Width
- Adjust for best start at temp





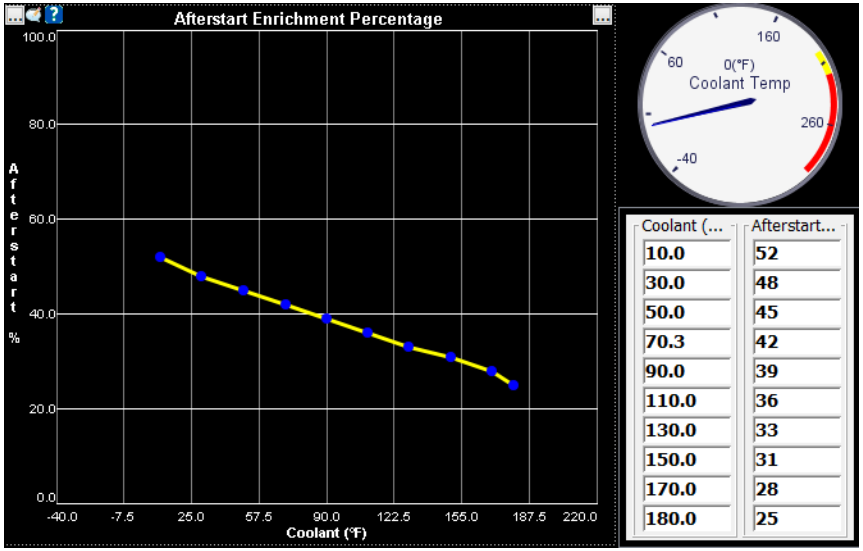
ASE – After Start Enrichment

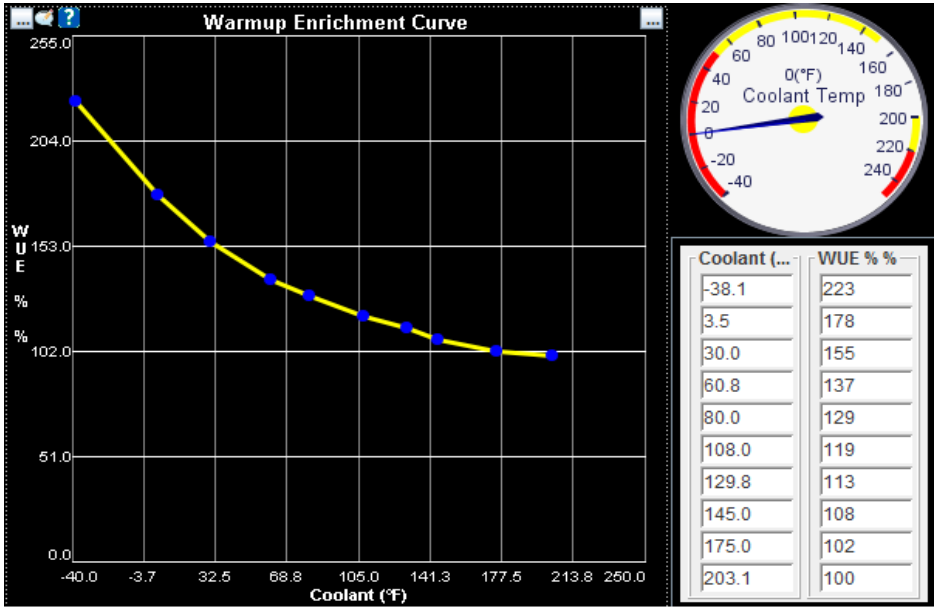
- Additional fuel for a short period after start
- Lean immediately after starting
- Data log of start up best to identify after start lean
- Hot engines need less

Warm - Up

WUE - Warm Up Enrichment

- Increased Fuel based on given conditions
- Increased timing advance
- Warm up enrichment





ASE – After Start Enrichment

- Additional fuel for a short period after start
- Lean immediately after starting
- Data log of start up best to identify after start lean
- Hot engines need less

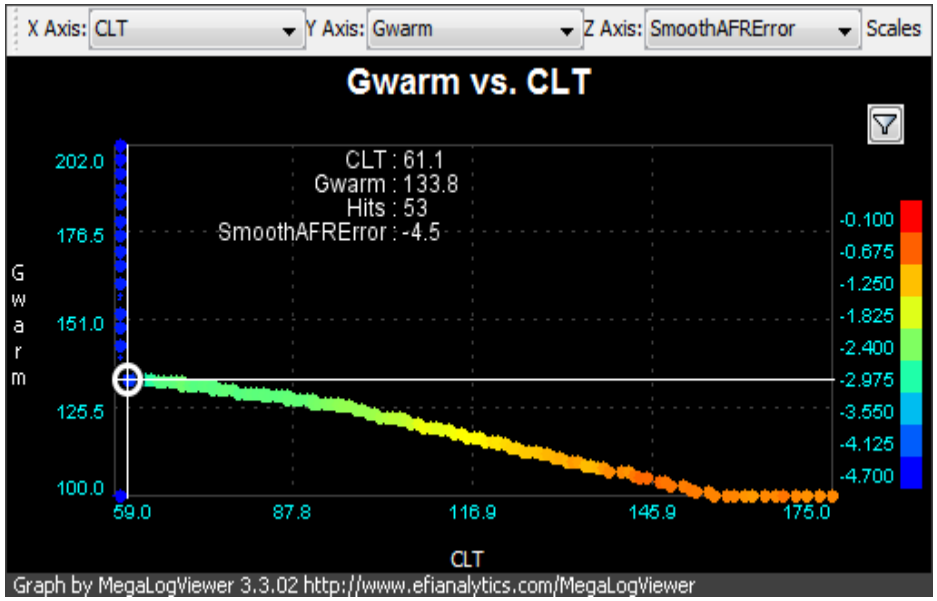
WUE with Scatter Plots

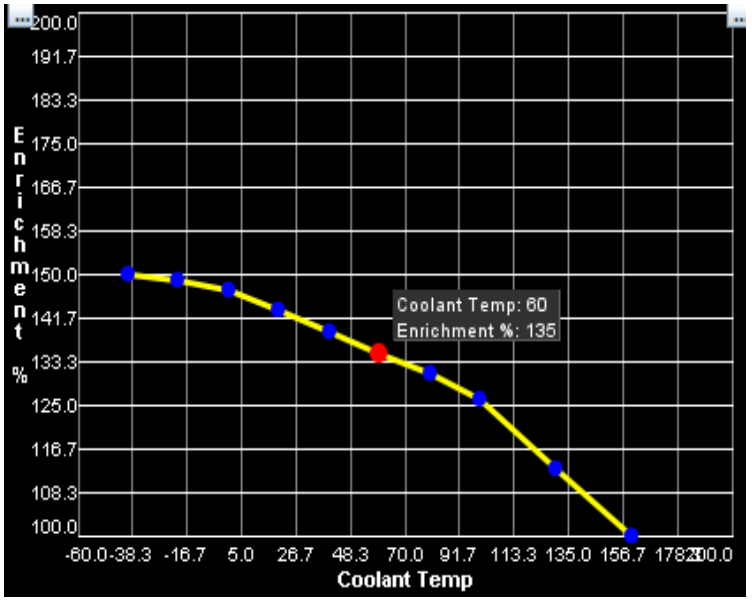
Correcting Warmup Enrichment with Scatter Plots
Full view for less iterations

CLT vs Gwarm with SmoothAFR for the Z Axis color

- Regenerate the Warmup Curve as it was set in TunerStudio
- Notice the Z Axis color that shows how far from target AFR it was at each temperature.

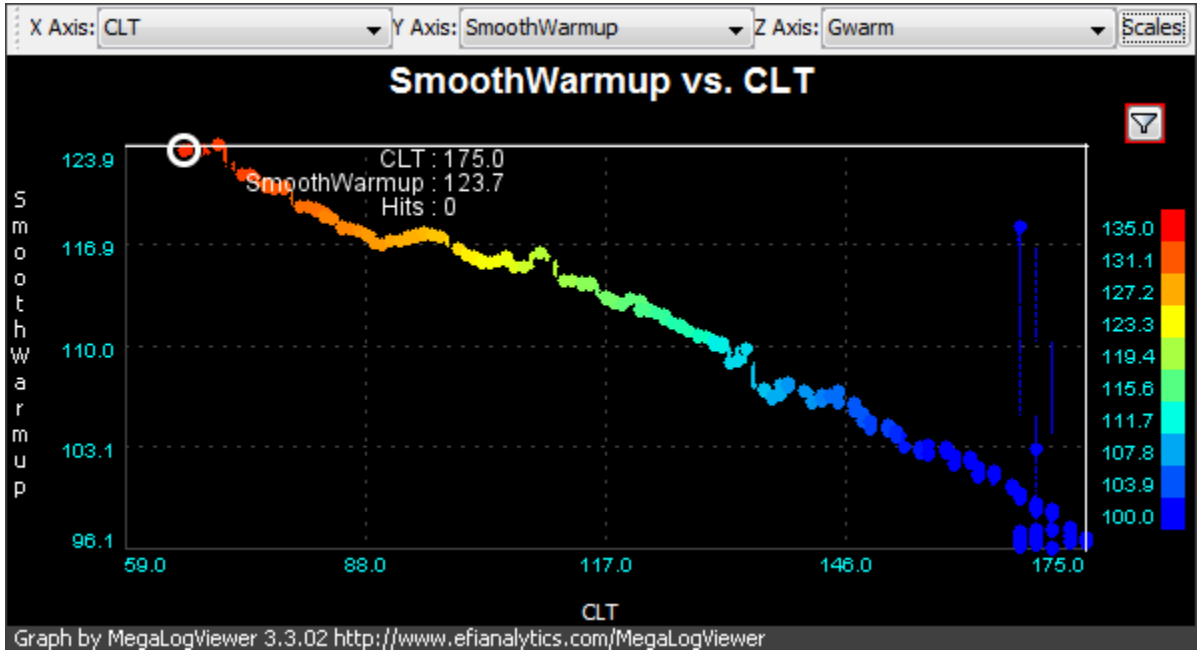
SmoothAFRError? What is that?
Custom Field explained on next slide





Solving WUE

Not only can you view what the warmup curve looked like, but you can generate the “Right” answer for it.



Note the Z Axis color illustrates the original Warm up enrichment value.

The X & Y Axis show the desirable value.

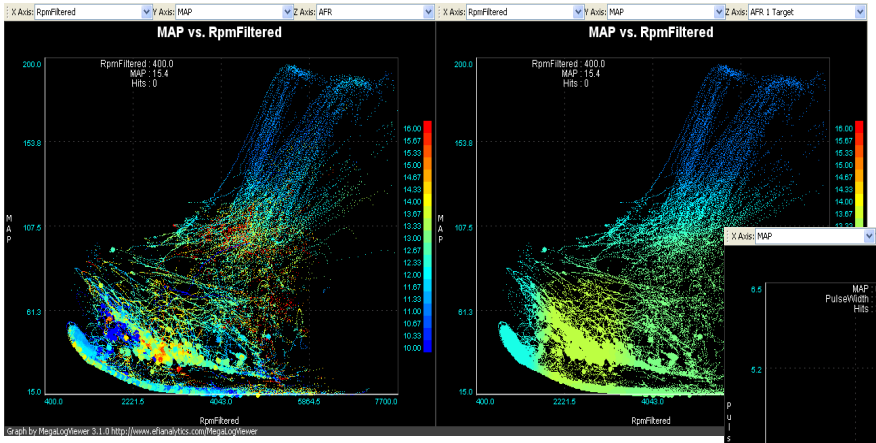
This car was running needlessly rich.

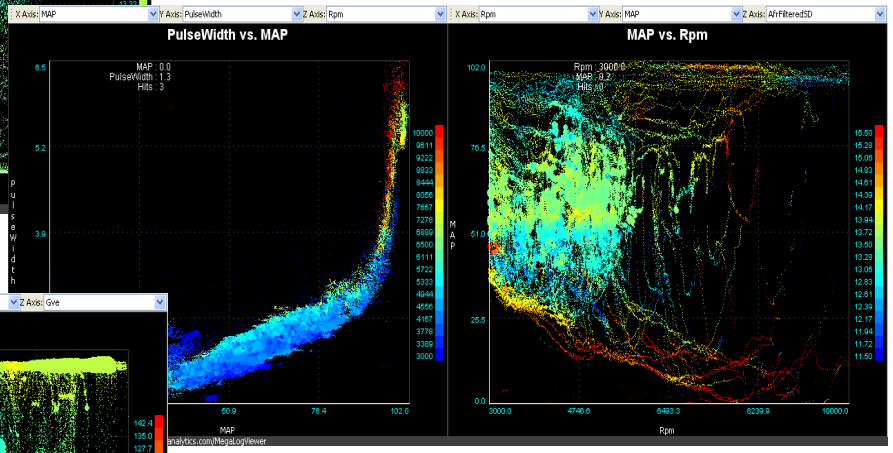
How?? Where did the new curve come from?
Desired Warm up for a single point would be:
Desired Warmup = [Gwarm] * ([Gego]/100) * ([AFR]/[targetAFR])
Add Smoothing:
Desired Warmup = [Gwarm] * (SmoothBasic([Gego], 20)/100) * (SmoothBasic([AFR], 20)/[targetAFR])

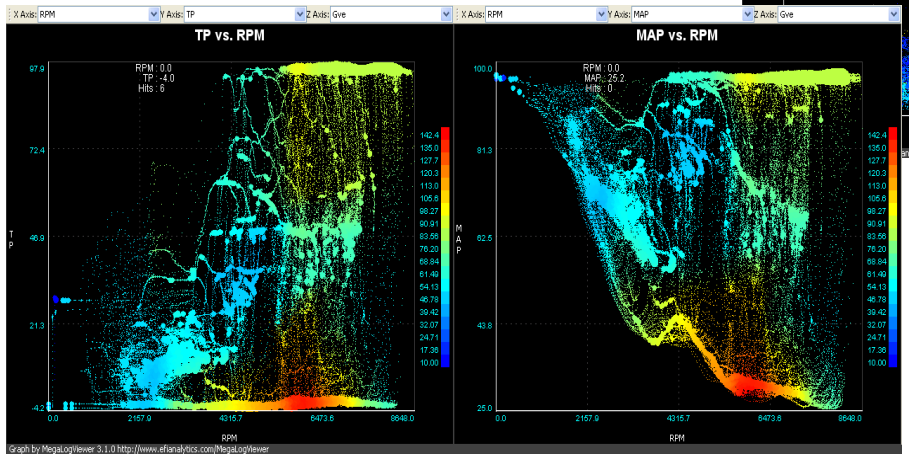
Analyzing the data to know what changes need made to your tune.

- Reducing condition changes
- Methods of looking at data
- Ways to spot issues

MegaLogViewer Scatter Plots







Abstract Art or valuable tuning tool?

Common Quote:
Sure it looks pretty, but what the hell do I do with it? What is it telling me?

MegaLogViewer Scatter Plots

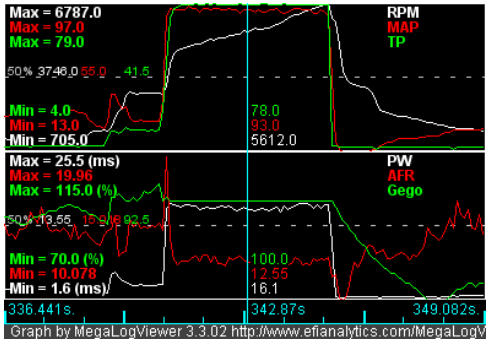
Overview: Scatter Plot graph are commonly used for statistical and data analysis to identity correlations

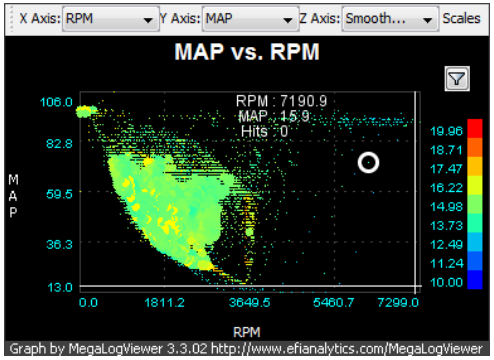
MegaLogViewer Scatter Plots were designed for Tuning

- Handles high data volumes
- 3 Axis view
- Custom Calculated Fields to combine and manipulate
- **Data Filtering!!!**

Common Belief – For tuning high data rates are very important.
FALSE – for most tuning slow data rates will work fine as long as each record is well correlated and you have sufficient time to collect data. More data is better with Scatter Plots, not necessarily faster data.

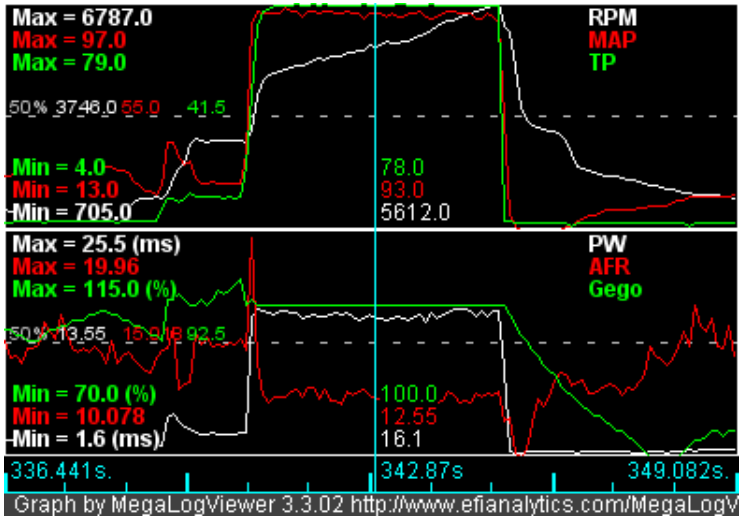
Normal log viewing work great for viewing specific details, but you can only see so much data at once. Using scatter plots you can view thousands of records or hours of data in 1 view to quickly get a big picture view.

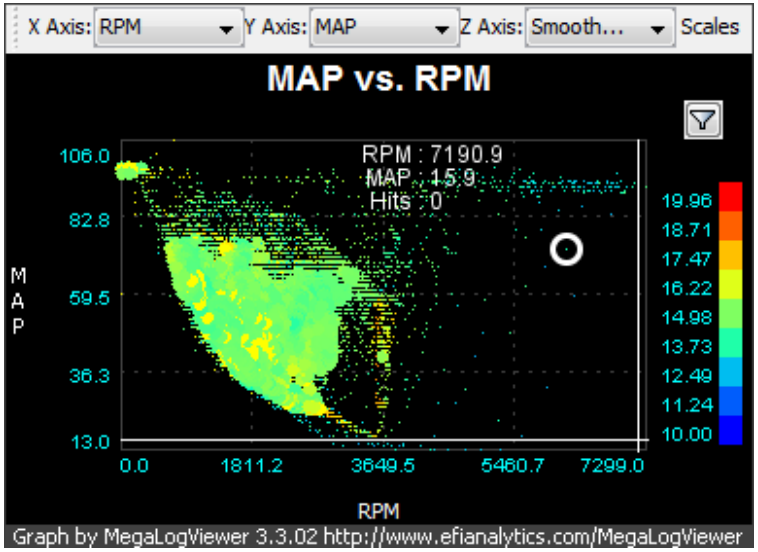




MegaLogViewer Scatter Plots

When a scatter plot over a traditional graph?





- View many fields at once

- Step through record by record to see specifically what was happening at any point in time.

- Can see that at this specific point in time the RPM=5612, MAP=93 kPa, AFR is 12.55:1 and Ego Cor is 100

- Difficult to realize the impact of conditions not happening at other points in time are having on the viewed fields

- 3 Fields at a time

- Full picture view as if it is your Speed density VE Table. X Axis:RPM, Y Axis: MAP, Z Axis:AFR

- Notice the Yellow spots, they quickly reveal areas of the VE Table where it is running over 16:1. This is a trend over a large amount of data, not a specific point.

- Can peel back the layers with filters to see what conditions may be effecting the view. AE, Warmup.

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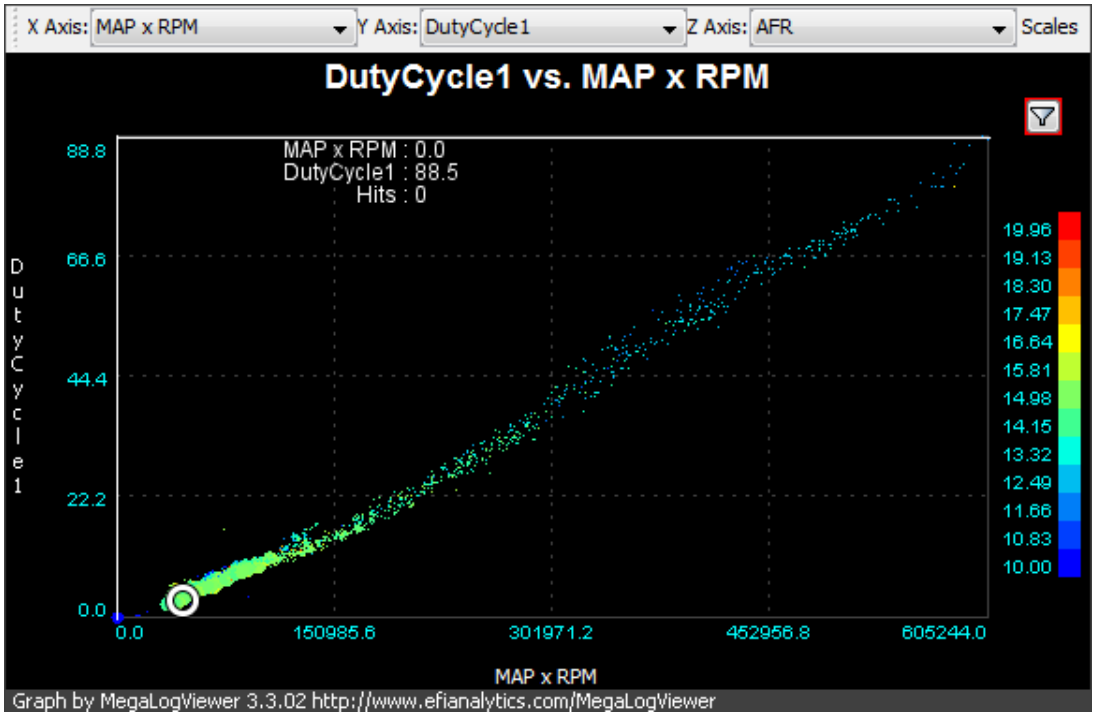
Quick View of Tune

Calculated Field MAPxRPM vs DutyCycle – gives tight correlation on a well tuned engine.



So what?

- MAPxRPM is just that: [MAP] * [RPM]
- Compare to DutyCycle or MAF on the Y Axis

This is really fast way to spot a rough tune or better, where the problems are, one quick view.

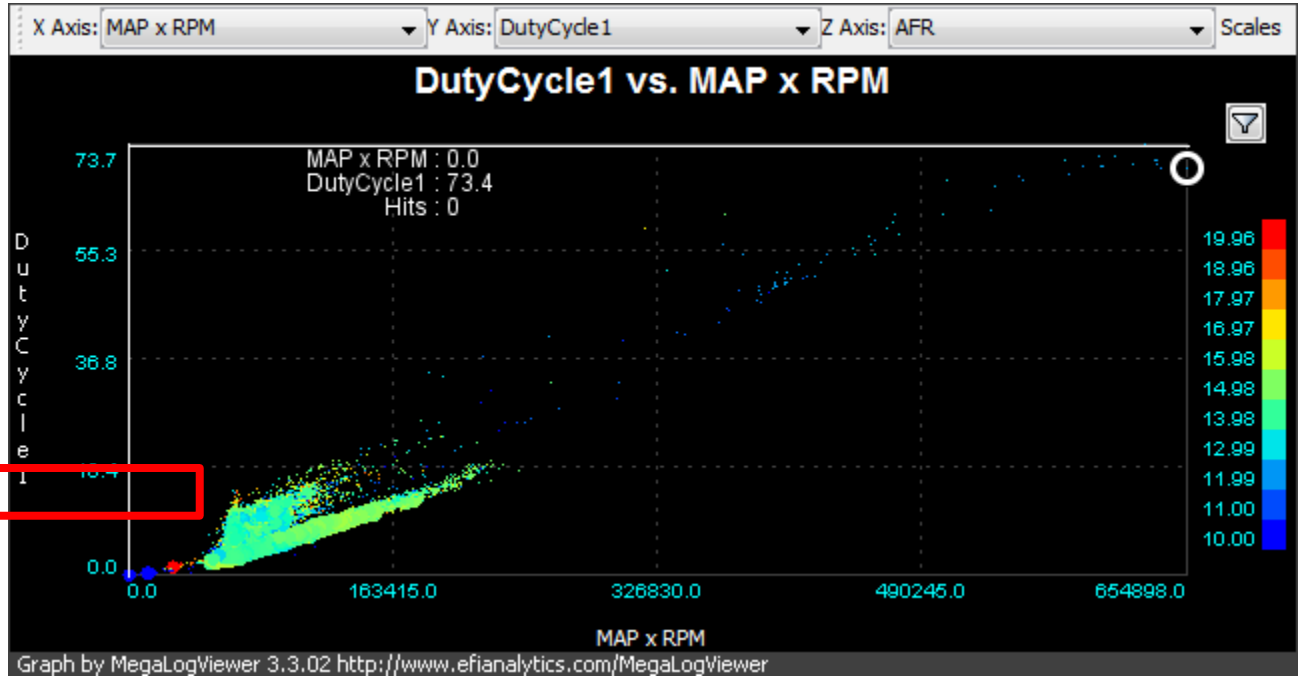
Quick View of Tune

Not showing a clear correlation.

Why?

What looks wrong?

What is causing this hump?



Let's look at this log in MegaLogViewer.

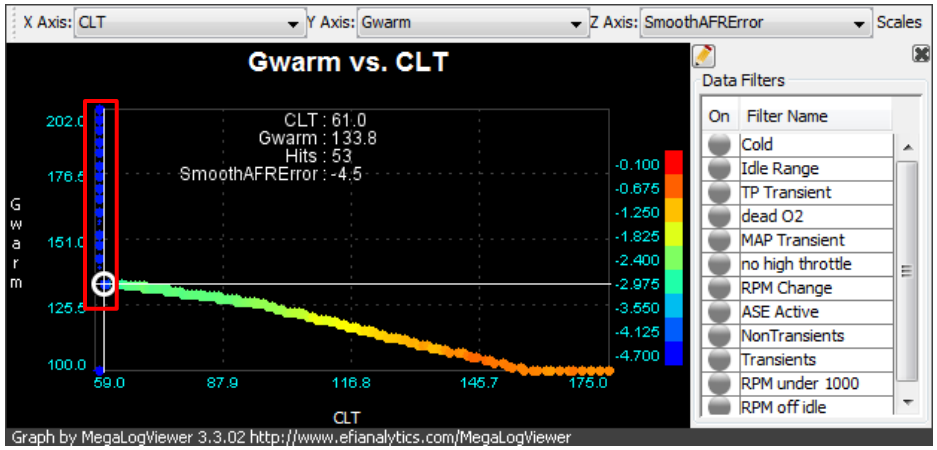
- Bring up the Scatter Graph MAPxRPM vs DutyCycle1
  - The Dead O2 Filter removes some records in the hump, but an insignificant number.
- Click on the hump
  - Switch to normal log viewing
  - Observe what is happening on many of those records.

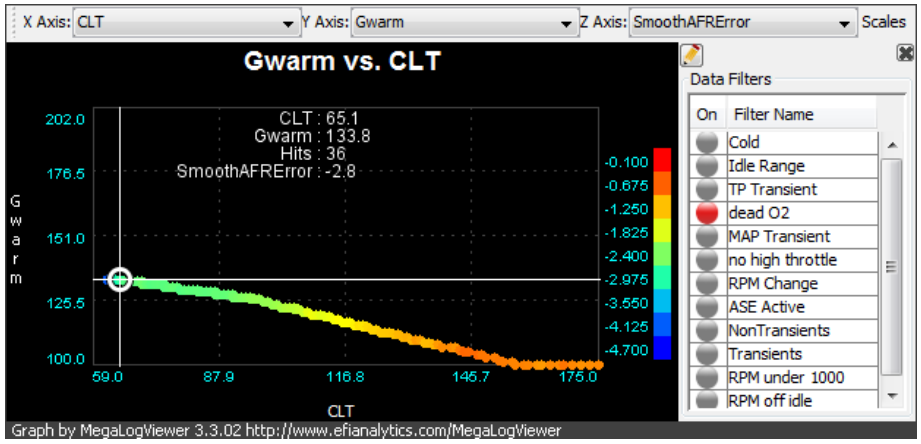
The scatter plot showed there was a problem and where to looks. The normal log shows specifics.

Scatter Plot Filters

Filtering:

Back to our CLT vs Gwarm with SmoothAFR for the Z Axis color





Filters can quickly remove anomalous data, or help to find the cause of that data.

Notice the blue dots up the left axis of top picture. Activate the dead O2 Filter to remove in picture 2.

Now you know you would want to filter that data from any formulas that it would skew the results.

Dead O2 Filter expression with Innovate 10:1-20:1:
[Field.AFR] < 10.3

Numerous built in Filters where you can see the expressions used:

TP Transient: (abs([Field.TP] - [TP-4]) > 3)
ASE Active: [Engine] | 4 == [Engine]

MAP Transients:
(abs([Field.MAP] - [MAP-4]) > ([Field.MAP] * 0.15))

These transient filters are built in and available for use after install.

Questions?

Hiring

Interested in working with the MegaSquirt team?
EFI Analytics is hiring

- Tech Support
- Java Developer

Please catch up with me here today if interested or email me