NISTUNE

REALTIME ECU TUNING

Nissan ECU Tuning Basics

V1.6

INTRODUCTION

This document is intended as a practical guide for those who are encountering the Nissan ECU for the first time. It is not intended to be the "be all and end all" for Nissan ECU tuning. Nissan never intended for us to modify their product so there is no definitive document on this subject. But there are many people interested in Nisan ECU tuning, which has led to much investigation and so slowly the details have come to light.

This is an ongoing process and it is only with the help of owners and the Nissan community in general that more information will become available. If you have discovered something that is not covered here and wish to share it then please contact us and we'll incorporate it into the next revision of this document.

This is not a guide for using the NIStune system – please read other available documents on installing the hardware and using NIStune software – available at www.nistune.com

All examples relate to tuning turbocharged engines unless specified otherwise.

IMPORTANT INFORMATION

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1. A solid base to tune from

OK, before we start, maybe we should define the term “tuning” - because it has changed over the years. “Tuning” used to consist of changing the contact points for the ignition, setting ignition timing, changing sparkplugs and maybe making some basic adjustments to the carby. This was required because these parts would wear and go out of adjustment. “Tuning” brought everything back to the factory spec. These days tuning refers to alterations of ignition timing and fuel injection parameters to increase power output beyond factory spec. Often coinciding with hardware upgrades such as larger airflow meter (AFM), injectors and turbocharger size.

Before you start tuning it is vitally important that your vehicle is running properly. It is a common mistake to start tuning when there is actually a problem with the vehicle. This can be a very frustrating, time consuming and dangerous thing to do. Many owners will take their vehicle to a tuner and say that they “just want it tuned”. Thinking that by adjusting the ECU all faults will magically be cured. While what they really need is a diagnostic session – usually resulting in having spark plugs changed, AFM cleaned, and fuel pump/filter replaced - before any tuning actually takes place.

If you start to tune with a lazy fuel pump then you’ll be adding a lot more fuel than you should. And when the pump is finally replaced the mixtures will be excessively rich. Same deal with dirty AFM – in some cases the engine will run artificially rich, other times lean. Either way is bad!

Here’s a quick checklist (as a minimum):

1) **Check that no fault codes are present. Fault codes MUST be cleared before tuning. A common problem is tuning with a Knock Sensor code present. This can cause many problems – mostly resulting in the ECU running off the “Knock maps” and pulling extra timing. When you try to tune on the main maps you’ll find that you’re having no affect on the tune.**

2) Airflow Meter element cleaned/replaced. A dirty airflow meter will provide incorrect reading which can completely throw the tune. Use solvent, a fine modelling brush and a good light.

3) Fuel pump/filter – if these are not new or near new then it’s a good idea to either do a fuel pressure/flow check or at least do a baseline run and check that mixtures are where they should be (quite rich for most Nissan turbo engines) with a WB AFR meter.

4) IGN timing – check with timing light. You cannot just read the value out of NIStune – the value read from the diagnostic port must match the value read by the timing light on the crank pulley.

> When setting your timing it’s important that the ECU sees the same value as the engine (ie: what you read with the timing light). Adjust the CAS until the two figures line up. That's it.
>
> Whether it's 15 degrees or 17 or 12 isn't that important. Ideally you'll see 15 degrees on most Nissans (some are 20) when everything is set up correctly. But just to set your timing correctly you don't need to worry about it being 15 - *as long as the ECU matches actual timing.*
>
> What often happens is that the ECU will add/subtract timing in an attempt to maintain target idle speed. So if idle is turned up too high for some reason you'll often see less timing than you'd expect. If idle is too low it'll tip in a bit extra. If you can get your idle speed set correctly first - then you'll usually see a nice solid 15 degrees and it'll make checking/setting the timing easier.
>
> Nissan generally provide a loop in the coils wiring to trigger a timing light. But be careful if you use this – some timing lights will trigger on the wrong edge of the coil pulse and give an incorrect reading. This can see base timing up to 20 degrees out. Either clip onto cylinder number one sparkplug lead or remove the number one coil and use a spark plug lead to temporarily connect it to the spark plug. You can then get a reliable trigger from the spark plug lead.

5) TPS adjustment – make sure “TPS closed” light (in NIStune) comes on when the throttle is closed. Without this the ECU will not know that the engine should be idling and a stable idle will be

impossible to achieve. If in doubt set it to 0.5V. Many ECU's won't show "TPS Closed" immediately – they will learn where throttle closed is after a number of starts with closed throttle.

6) Sparkplugs – make sure they are at least in good condition. Preferably replaced. If somebody else has replaced them, make sure they are the correct heat range. If you are running higher boost than standard then it's a good idea to go one heat range colder (= higher number if using NGK plugs). Gapping to 0.8mm for turbo engines is a good starting point.

7) Fuel – make sure you have a tank of **fresh** fuel. If it's a "project car" that's been sitting around for months then it will have a tank of stale fuel. It's not the same.

More details on SR20 maintenance at www.plmsdevelopments.com – go to the SR20 Setup Tips section.

2. Background Knowledge

Please make sure you have read the NIStune documentation for your particular ECU. This is a guide on the practical side of tuning your Nissan – not a "How to use NIStune" document. Instructions are available at www.nistune.com. In particular make sure you read the software user's guide, and mapping guide. Please don't contact us saying "It doesn't work guys" when you haven't bothered to read the instructions.

This document assumes that the NIStune board is already fitted, NIStune software is installed and comms between ECU and laptop have been established. Once again instructions for board installation and communications diagnostics are on the NIStune website.

A basic knowledge of engine tuning is essential. Blindly adjusting parameters will result in engine damage. If you don't have this knowledge and are not prepared to research and learn then please pay somebody else to do the tuning. We can provide the tools for tuning of your Nissan engine, we can't provide the knowledge.

3. A quick overview for tuning Nissan ECU's

To use very broad terms, most tuning involves adjusting the Fuel/IGN maps to obtain correct mixtures/timing throughout all RPM and load points. If the engine is running upgraded injectors/AFM then things become a little more complex – starting with loading the correct VQ map for the AFM (Operations, Change Mass Airflow Sensor) and adjusting the Injection Multiplier (AKA "K Constant") to get mixtures roughly correct before fuel/IGN map tuning takes place.

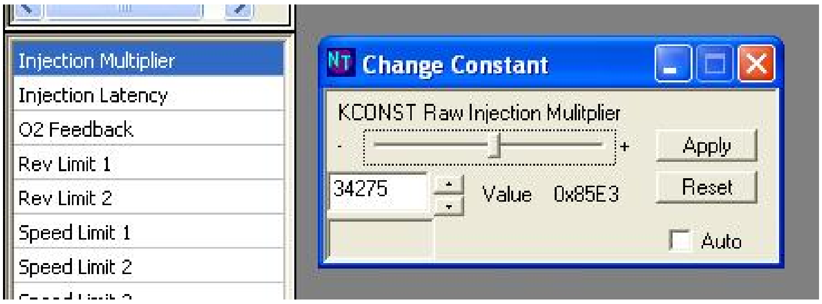
Here's a step-by-step guide to use as a starting point - assuming we're looking at a turbo engine which will have injectors and/or AFM upgraded as this represents the most complex scenario:

1) Ensure vehicle is running correctly as per Section 1. If possible do a "baseline run" and record AFR's across a full load pull. It's also good to do a log (in NIStune) of things like TPS voltage, AFM voltage, injector pulsewidth, IGN timing and RPM. This provides a handy reference.
2) If AFM/injectors are to be changed then fit the new AFM/injectors. If it's a used AFM then be sure to clean the sensing element. Ideally use a new AFM if it's being upgraded. *Please avoid cheap Chinese fake Z32 AFM's – they are not the same and often result in major tuning problems.*
3) Adjust K Constant/TIM until Fuel Trim figures are approximately neutral at cruise (2000 to 3000rpm at minimum load). You should be seeing around 14.7:1 AFR's. Don't touch K if you are using std AFM and injectors.
4) Check that IGN maps are "safe" (ie: take a few degrees out in high load areas).
5) Perform initial full load run on low boost and check full load AFR's.
6) Adjust values in fuel map to achieve desired AFR's across the RPM range (usually 11.5 – 12.3:1). This is only a rough tune – so don't get too carried away trying to get things perfect. We'll re-visit this step later.

7) Perform full boost run and check that Load scales are correct. Adjust so the last column is accessed at full boost. (Note: always monitor knock as boost levels increase).
8) Decrease boost in small increments and adjust fuel map to achieve correct mixtures at all load and RPM values.
9) Move to IGN maps. At max boost, slowly increase timing in the high load areas until torque stops rising (or knock is noted). Other methods of knock detection can be used (see “IGN Map Tuning).
10) Decrease boost in small increments and adjust IGN map to achieve optimum IGN timing at all load and RPM values.
11) When tuning is complete, perform another “logging” run, recording the same data as in Step 1. As a minimum record AFR’s and boost levels against RPM.
12) Road test to check for knock and any driveability issues.
13) Allow vehicle to cool and check cold start/idle performance.

4. Setting Injection Multiplier (K constant)

Please note that with the release of the NIStune Feature Pack (FP) in early 2015, adjustment of K Constant is a largely redundant concept. If you have a NIStune board with Feature Pack firmware programmed then use Total Injection Multiplier (TIM) instead. Please refer to the next section for details.



The Injection Multiplier (AKA "K Constant") is one of the primary values that the ECU uses to calculate injection times for most parts of the maps. So by adjusting this value we affect everything else.

If you've not changed airflow meter or injector size then K value need not be changed – only actual fuel map values should be altered. If you have changed AFM/injectors, then it is necessary to adjust K Constant. This is done automatically by NIStune if you use the "Resize Injectors" and/or "Change Mass Airflow Meter" utilities under the "Operations" menu.

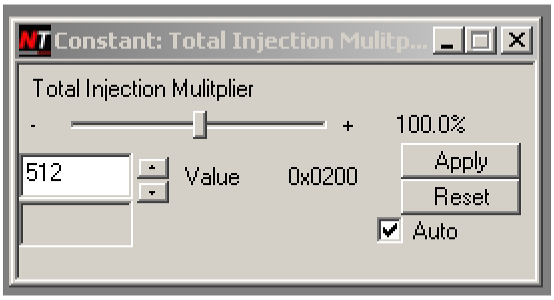
This calculation is based on a simple ratio of old vs new for both injectors and airflow meter. For example if the stock K value is 21,475 and injector size was changed from 370cc to 550cc then the new value will be 21,475 x (370/550) = 14,447. Bigger injectors require a smaller K value.

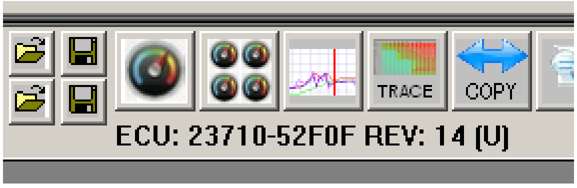
Same deal with airflow meters except we use maximum horsepower figures to do the calculation. For example it is taken that a standard SR20 airflow meter gives its maximum reading at around 290hp. If we fit a Z32 airflow meter, which has a max HP rating of approx 550hp then the calculation is 21,475 (standard K value) x (550/290) = 40,728.

If you change both injectors AND airflow meter you need to do both of the above calculations: 21,475 x (370/550) x (550/290) = 27,400. Experience has shown that changing to a larger AFM and injectors at the same time is a recipe for success because one increases K Constant and the other decreases it. **A K Constant that finishes close to the std value will always make tuning easier.**

This automatically calculated value for K is only a rough starting point. It needs to be verified/adjusted by running the engine and checking mixtures with a wideband AFR meter. You need to achieve appropriate mixtures in both the low load/cruise area and in the full load area by juggling K Constant, fuel map values and Injector Latency.

5. Setting Total Injection Multiplier (TIM)





Total Injection Multiplier is a new concept which has been added as part of the NIStune “Feature Pack”. It is custom code which does not exist in the standard ECU. A board with Feature Pack code can be identified by the “F” suffix in the part number displayed in NIStune when connected to the ECU (see above).

TIM allows adjustment of overall fuelling (just like K Constant) but it doesn’t affect TP. Remember back in the section on K Constant how we spoke of trying to select AFM and injectors to get K Constant back as close to standard as possible? Well TIM achieves just that. So we don’t touch our Load Scales. And just use TIM to bring things back into line when we change injectors.

What we’re trying to achieve is to keep our range of TP values in their original range. TP is extremely important in these ECU’s. It is used to reference almost everything that we care about. So if we throw K Constant out we affect TP. And that can have serious consequences.

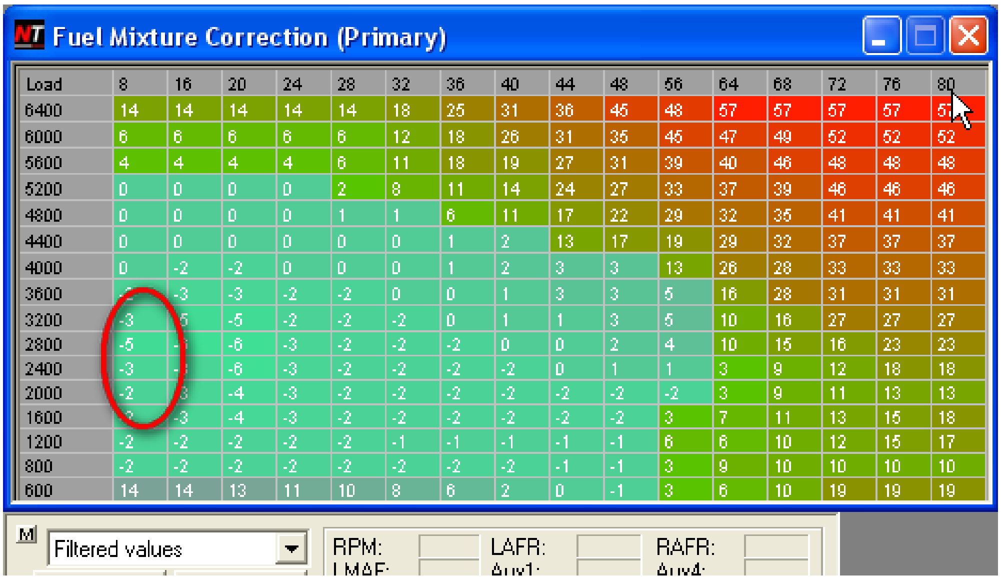
Adjusting TIM is similar to adjusting K Constant. But first check that Load Scale values are stock (or close to it). Now run the engine at low load and adjust TIM until your fuel trims are close to neutral. Then load up the engine and use your Fuel Map values to get high load mixtures correct. With small adjustments to TIM as necessary.

If the ECU is not operating within factory Load Scale values, then adjust K constant to achieve this. When you adjust K constant, this will affect your mixtures. So any adjustment will need to be offset with changes to TIM.

Using TIM you’ll find that you can use any AFM and/or injectors you want, and still get a good tune. Pesky little cold start/cranking bugs and other hard to pin down issues will largely be a thing of the past.

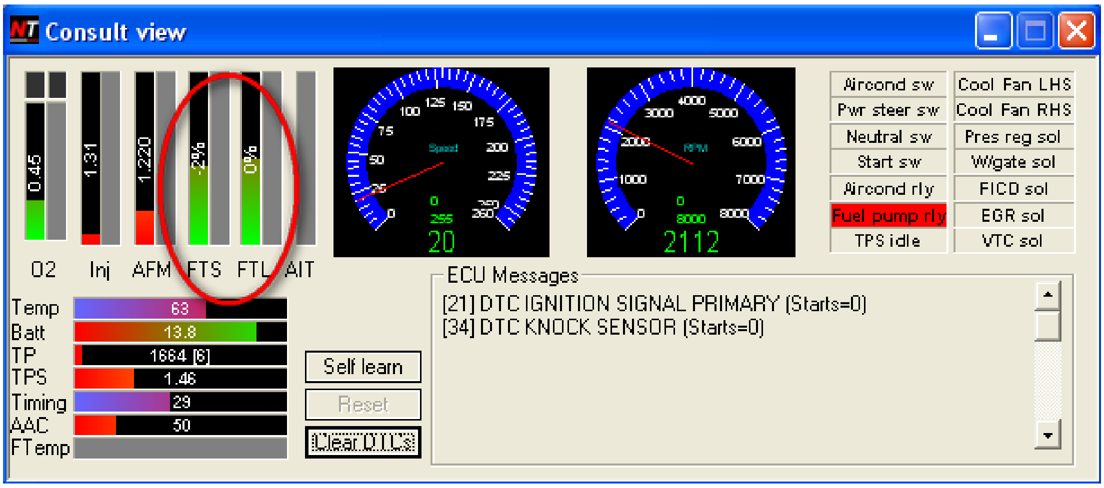
Low load mixtures

Run the vehicle at low load. On the dyno this can be achieved by letting the rollers turn unloaded with the vehicle in 4th gear at light throttle. This causes the ECU to access the “closed loop” area of the fuel map where it’s “chasing the O2 sensor” in an attempt to maintain 14.7:1 AFR.


Fuel Mixture Correction (Primary)

Load	8	16	20	24	28	32	36	40	44	48	56	64	68	72	76	80
6400	14	14	14	14	14	18	25	31	36	45	48	57	57	57	57	57
6000	6	6	6	6	6	12	18	26	31	35	45	47	49	52	52	52
5600	4	4	4	4	6	11	18	19	27	31	39	40	46	48	48	48
5200	0	0	0	0	2	8	11	14	24	27	33	37	39	46	46	46
4800	0	0	0	0	1	1	6	11	17	22	29	32	35	41	41	41
4400	0	0	0	0	0	0	1	2	13	17	19	29	32	37	37	37
4000	0	-2	-2	0	0	0	1	2	3	3	13	26	28	33	33	33
3600	[illegible]	-3	-3	-2	-2	0	0	1	3	3	5	16	28	31	31	31
3200	-3	[illegible]	-5	-2	-2	-2	0	1	1	3	5	10	16	27	27	27
2800	-5	[illegible]	-6	-3	-2	-2	-2	0	0	2	4	10	15	16	23	23
2400	-3	[illegible]	-6	-3	-2	-2	-2	-2	0	1	1	3	9	12	18	18
2000	-2	[illegible]	-4	-3	-2	-2	-2	-2	-2	-2	-2	3	9	11	13	13
1600	[illegible]	-3	-4	-3	-2	-2	-2	-2	-2	-2	3	7	11	13	15	18
1200	-2	-2	-2	-2	-2	-1	-1	-1	-1	-1	6	6	10	12	15	17
800	-2	-2	-2	-2	-2	-2	-2	-2	-1	-1	3	9	10	10	10	10
600	14	14	13	11	10	8	6	2	0	-1	3	6	10	19	19	19

Adjust K to roughly achieve neutral values for the Fuel Trims (both short and long term) when viewing in the Consult Gauges panel. Long term trim can be zeroed by selecting “Operations, Active Tests” and selecting “Clear Self Learn, Start, Stop”. Don’t spend too much time aiming for perfectly neutral fuel trims at this stage as further trimming will be required later. Approaching neutral is good enough.

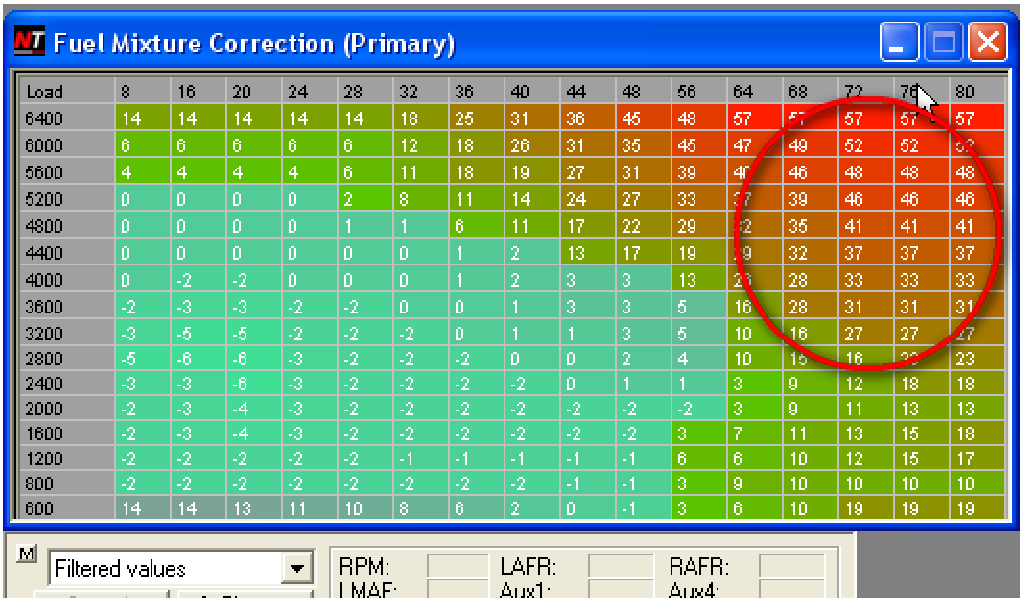


In reality you can often tell when you’ve got K close to the mark by the general behaviour of the engine around idle and light load. If it’s running well in these areas then you’re probably not far off the mark.

Fuel Trims or “Self learn” parameters are calculated by the ECU by watching the O2 sensor at low load. If the sensor is reporting mixtures that are too rich then the ECU will trim the mixtures slightly leaner to compensate – and vice versa. Short term fuel trim (STFT) happens quickly and is lost when IGN is turned off. Long term trim (LTFT) reacts more slowly and is kept after the IGN is turned off – this is used as the starting value for fuel trims next time the engine is started. It is only erased when the vehicle’s battery is disconnected.

High load mixtures

First ensure that your IGN maps are safe – monitor knock AT ALL TIMES when operating in the high load area. Apply enough load to access the high load areas of the fuel map. This is where the ECU ignores the O2 sensor and aims to achieve mixtures richer than 14.7:1. Right click on the Fuel Map and select "Highlight Flags" to show which areas are closed loop and which are not. You need to be outside of the blue shaded area before AFR's will go richer than 14.7:1. Closed loop cells can be toggled on/off by selecting the cell/cells and clicking the "O" (for O2 Sensing) key.



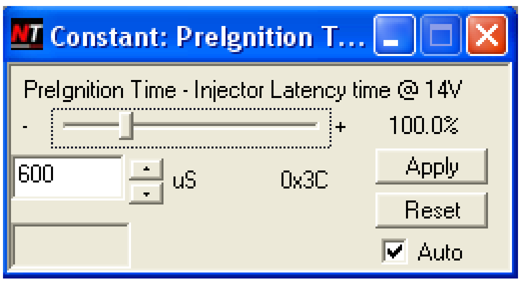
Load	8	16	20	24	28	32	36	40	44	48	56	64	68	72	76	80
6400	14	14	14	14	14	18	25	31	36	45	48	57	[illegible]	57	57	57
6000	6	6	6	6	6	12	18	26	31	35	45	47	49	52	52	[illegible]
5600	4	4	4	4	6	11	18	19	27	31	39	[illegible]	46	48	48	48
5200	0	0	0	0	2	8	11	14	24	27	33	[illegible]	39	46	46	46
4800	0	0	0	0	1	1	6	11	17	22	29	[illegible]	35	41	41	41
4400	0	0	0	0	0	0	1	2	13	17	19	[illegible]	32	37	37	37
4000	0	-2	-2	0	0	0	1	2	3	3	13	[illegible]	28	33	33	33
3600	-2	-3	-3	-2	-2	0	0	1	3	3	5	16	28	31	31	31
3200	-3	-5	-5	-2	-2	-2	0	1	1	3	5	10	16	27	27	27
2800	-5	-6	-6	-3	-2	-2	-2	0	0	2	4	10	15	16	[illegible]	23
2400	-3	-3	-6	-3	-2	-2	-2	-2	0	1	1	3	9	12	18	18
2000	-2	-3	-4	-3	-2	-2	-2	-2	-2	-2	-2	3	9	11	13	13
1600	-2	-3	-4	-3	-2	-2	-2	-2	-2	-2	3	7	11	13	15	18
1200	-2	-2	-2	-2	-2	-1	-1	-1	-1	-1	6	6	10	12	15	17
800	-2	-2	-2	-2	-2	-2	-2	-2	-1	-1	3	9	10	10	10	10
600	14	14	13	11	10	8	6	2	0	-1	3	6	10	19	19	19

Running outside of the closed loop area you should see mixtures go rich very quickly as this is the "on-boost" area. Adjust the values in the fuel map to achieve your desired full load AFR's. Usually somewhere between 11.5 and 12:1 for turbo engines, leaner for non-turbo.

Sometimes a little juggling of the K Constant and the values in the fuel map is required to achieve required mixtures. In general the fuel map values will be lower as injector size increases. Values down to 20 (using "Filtered Values" to view the figures) are not uncommon for injectors above 1000cc.

Now go back to low load/cruise and check your mixtures. If they're incorrect you can adjust them by changing the Injector Latency figure. This avoids re-adjusting K Constant and throwing out your full load mixtures. Injector Latency is a relatively small pulsewidth value (0 to 1 ms), so it affects low load mixtures quite markedly where injector pulsewidths will only be 1 to 2 ms. While having little affect on high load mixtures where injector pulsewidths are likely to be higher than 10ms.

Try to limit Injector Latency adjustments to 200 to 1200us (= 0.2 to 1.2ms). If you need to go outside of this range then there are probably other issues that need to be addressed.



Go back and check the high load mixtures – little or no adjustment should be required.

6. Fuel Map Tuning

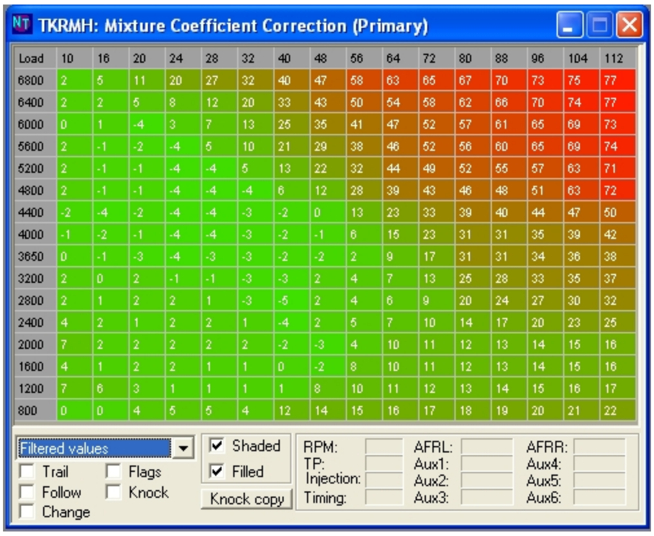
Coolant Temperature

Before doing any tuning you must be aware that the ECU may vary mixtures according to coolant temperature. For this reason you must try to keep coolant temperature stable to get consistent readings. On the dyno this means monitoring coolant temp, warming the engine properly before a run and letting it cool down between runs if necessary. Don't rely on the original Nissan temp gauge – it's close to useless. Use the readout from NIStune (open the "Consult Gauges" panel). This comes directly from the ECU. Default is to aim for 85 degrees C as this is where they tend to run on the road.

Track cars will run hotter so check mixtures at higher temps. Some cars will have lower temp thermostats fitted or no thermostat at all. Watch out for these as the engine can often cool enough between runs to go back into the cold start area (usually anything below 65 degrees will start to have some compensation added).

"Main" vs "Knock" maps

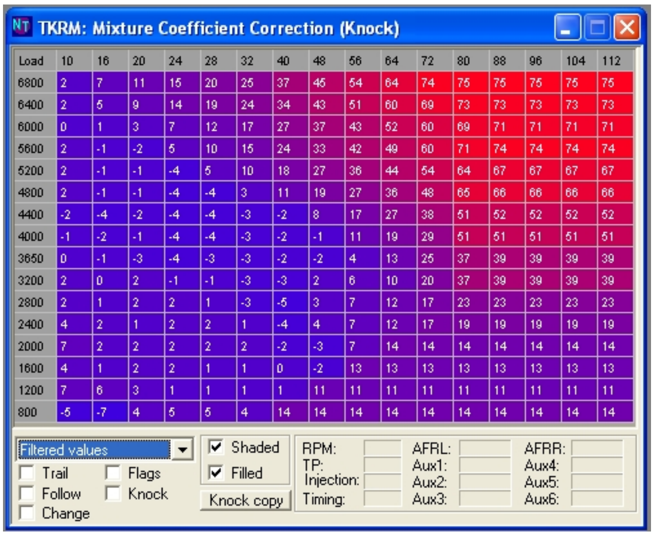
Most ECU's have two fuel maps. A "main" map and a "knock" map. Sometimes these are referred to as "premium" and "regular" maps - referring to running the engine on either premium or regular fuel. The idea is that the engine normally runs on the "main" map. If knock is sensed then it will jump to the "knock" map. In NIStune these are labelled "Fuel Map" and "Knock Fuel Map". The IGN maps use a similar system.



TKRMH: Mixture Coefficient Correction (Primary)

Load	10	16	20	24	28	32	40	48	56	64	72	80	88	96	104	112
6800	2	5	11	20	27	32	40	47	58	63	65	67	70	73	75	77
6400	2	2	5	8	12	20	33	43	50	54	58	62	66	70	74	77
6000	0	1	-4	3	7	13	25	35	41	47	52	57	61	65	69	73
5600	2	-1	-2	-4	5	10	21	29	38	46	52	56	60	65	69	74
5200	2	-1	-1	-4	-4	5	13	22	32	44	49	52	55	57	63	71
4800	2	-1	-1	-4	-4	-4	6	12	28	39	43	46	48	51	63	72
4400	-2	-4	-2	-4	-4	-3	-2	0	13	23	33	39	40	44	47	50
4000	-1	-2	-1	-4	-4	-3	-2	-1	6	15	23	31	31	35	39	42
3650	0	-1	-3	-4	-3	-3	-2	-2	2	9	17	31	31	34	36	38
3200	2	0	2	-1	-1	-3	-3	2	4	7	13	25	28	33	35	37
2800	2	1	2	2	1	-3	-5	2	4	6	9	20	24	27	30	32
2400	4	2	1	2	2	1	-4	2	5	7	10	14	17	20	23	25
2000	7	2	2	2	2	2	-2	-3	4	10	11	12	13	14	15	16
1600	4	1	2	2	1	1	0	-2	8	10	11	12	13	14	15	16
1200	7	6	3	1	1	1	1	8	10	11	12	13	14	15	16	17
800	0	0	4	5	5	4	12	14	15	16	17	18	19	20	21	22

Main fuel map



TKRM: Mixture Coefficient Correction (Knock)

Load	10	16	20	24	28	32	40	48	56	64	72	80	88	96	104	112
6800	2	7	11	15	20	25	37	45	54	64	74	75	75	75	75	75
6400	2	5	9	14	19	24	34	43	51	60	69	73	73	73	73	73
6000	0	1	3	7	12	17	27	37	43	52	60	69	71	71	71	71
5600	2	-1	-2	5	10	15	24	33	42	49	60	71	74	74	74	74
5200	2	-1	-1	-4	5	10	18	27	36	44	54	64	67	67	67	67
4800	2	-1	-1	-4	-4	3	11	19	27	36	48	65	66	66	66	66
4400	-2	-4	-2	-4	-4	-3	-2	8	17	27	38	51	52	52	52	52
4000	-1	-2	-1	-4	-4	-3	-2	-1	11	19	29	51	51	51	51	51
3650	0	-1	-3	-4	-3	-3	-2	-2	4	13	25	37	39	39	39	39
3200	2	0	2	-1	-1	-3	-3	2	6	10	20	37	39	39	39	39
2800	2	1	2	2	1	-3	-5	3	7	12	17	23	23	23	23	23
2400	4	2	1	2	2	1	-4	4	7	12	17	19	19	19	19	19
2000	7	2	2	2	2	2	-2	-3	7	14	14	14	14	14	14	14
1600	4	1	2	2	1	1	0	-2	13	13	13	13	13	13	13	13
1200	7	6	3	1	1	1	1	11	11	11	11	11	11	11	11	11
800	-5	-7	4	5	5	4	14	14	14	14	14	14	14	14	14	14

Knock fuel map

Most tuning is done on the "main" map and then the resultant map is copied over to the "knock" map using the "knock copy" button. The idea is that the "knock" map should be a bit richer than the "main" map so in the event of knock being detected the ECU will jump to the "knock" map and this will richen mixtures to help alleviate knock.

During tuning it's possible for the ECU to jump to the knock maps if it senses knock. This is generally a bad thing to have happen while tuning as you'll find that all your changes to the main maps are suddenly having no affect. A good trick here is to fill the entire high load area of the IGN Knock map with low values. 5 degrees usually works well. Then if the ECU jumps to the knock maps it's immediately apparent as power will dive significantly – without risking engine damage. The ECU will stay on the knock maps until power is cycled, so you'll need to stop the engine, wait 5 seconds, and re-start. Don't forget to burn your changes before you do this!

Another way to check if the ECU is accessing main or knock maps is by watching the IGN timing maps and the Gauges panel. Note the values being accessed in the maps (don't forget - the ECU averages across 4 cells) and check that they correspond with the IGN timing value reported in the Gauges panel.

Some vehicles with worn engines and/or running high boost will tend to sense knock due to mechanical noise. In these cases it will be necessary to disable knock sensing.

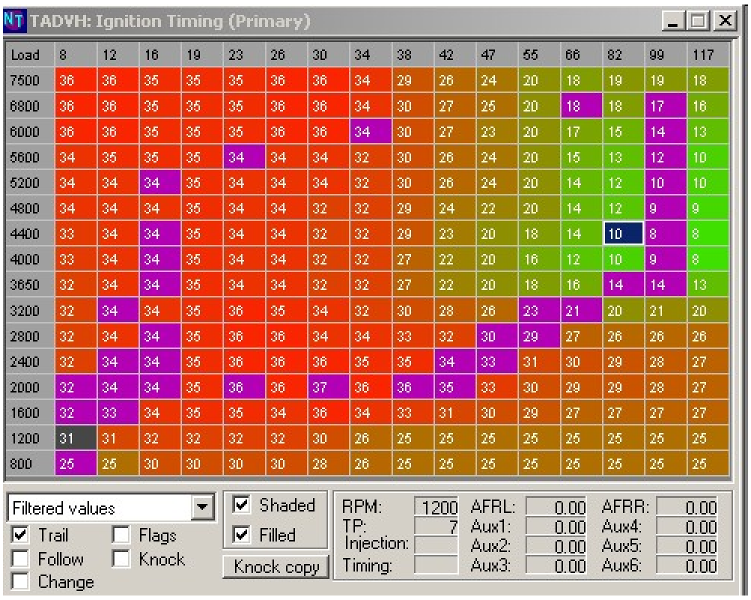
Checking the load scales

One of the first things you need to work out is which cells in the fuel map are being accessed under what conditions. Once the engine comes on boost, the cells towards the right side will be used. So the majority of full load tuning often takes place in the last 4 columns. Refer to section 8 on "RPM/Load Scale Adjustment". Nissan turbos (as delivered) tend to run very rich on full boost (particularly if boost has been increased over standard) so the first job is often to lower the fuel map values in the high load area.

Getting down to it

Always start at lower boost levels and work up to full boost. **Make sure you monitor knock as boost is increased**. Don't spend too much time getting perfect mixtures at this stage. Rather, get them close (err on the side of rich = safe) and then get boost turned up to the maximum level. The idea is to check that the correct portion of the map is being accessed at full boost – and then you can work back and check how things are looking at lower boost levels. You don't want to access the middle of the map at full boost - or slam into the last column as soon as any boost comes up. If it's accessing the last two columns then we're looking good. If not then the Load Scales will need to be adjusted (see relevant section). K constant also affects this.

If the load scales were adjusted then it pays to go back and re-check mixtures across the range of boost levels. Once full load is correct then you can check mixtures at part load. If K Constant is correct then very little work should be required in the part load areas.



Load	8	12	16	19	23	26	30	34	38	42	47	55	66	82	99	117
7500	36	36	35	35	35	36	36	34	29	26	24	20	18	19	19	18
6800	36	36	35	35	35	36	36	34	30	27	25	20	18	18	17	16
6000	36	36	35	35	35	36	36	34	30	27	23	20	17	15	14	13
5600	34	35	35	35	34	34	34	32	30	26	24	20	15	13	12	10
5200	34	34	34	35	34	34	34	32	30	26	24	20	14	12	10	10
4800	34	34	34	35	34	34	32	32	29	24	22	20	14	12	9	9
4400	33	34	34	35	34	34	32	32	29	23	20	18	14	10	8	8
4000	33	34	34	35	34	34	32	32	27	22	20	16	12	10	9	8
3650	32	34	34	35	34	34	32	32	27	22	20	18	16	14	14	13
3200	32	34	34	35	36	35	34	32	30	28	26	23	21	20	21	20
2800	32	34	34	35	36	36	34	34	33	32	30	29	27	26	26	26
2400	32	34	34	35	36	36	36	35	35	34	33	31	30	29	28	27
2000	32	34	34	35	36	36	37	36	36	35	33	30	29	29	28	27
1600	32	33	34	35	35	34	36	34	33	31	30	29	27	27	27	27
1200	31	31	32	32	32	32	30	26	25	25	25	25	25	25	25	25
800	25	25	30	30	30	30	28	26	25	25	25	25	25	25	25	25

This is an IGN map but the principle is the same

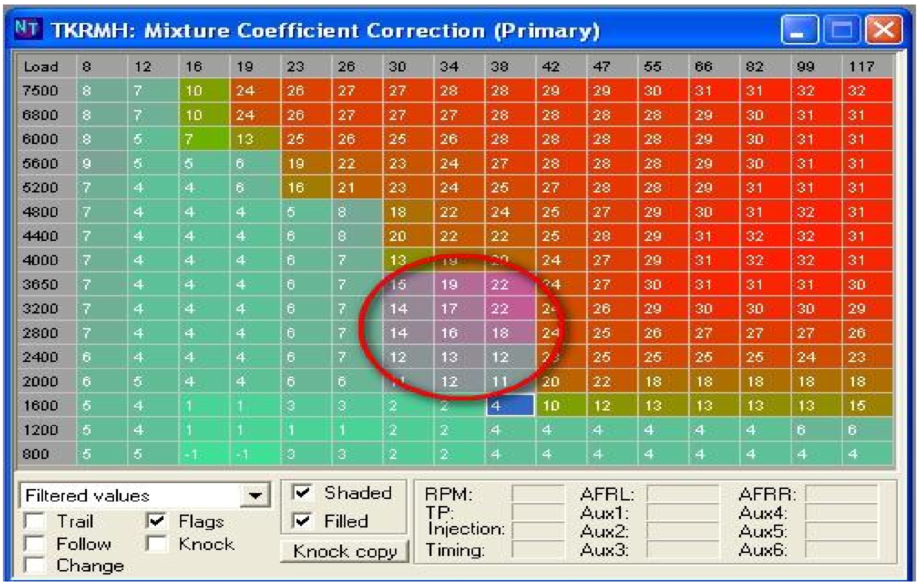
Be aware that there may be a small lag due to the time it takes for a WB AFR meter to react. So when checking graphs of "power runs" there may be a slight error between RPM and AFR readings. So if there's a peak in the mixtures showing up at 4000 rpm on the graph, then you may need to adjust the mixtures at slightly under 4000 rpm to correct the problem. This can cause much frustration if you don't know what's going on!

Boost transition

You should be seeing around stoichiometric in the light load areas, then getting richer as soon as boost starts to rise. Check the “boost transition” areas too. Usually around the centre of the map at 2500 – 3500 rpm. A lean spot here makes for very lazy boost response.

This area is often overlooked but is quite important when turbo size has changed as a different turbo can produce radically different airflows in this area.

Sometimes the area where the O2 sensor is operating needs to be adjusted as the engine will try to hold onto closed loop (= 14.7:1) when it has started to make boost. Stoichiometric mixtures while on boost will make the vehicle feel very sluggish as it won’t make power until mixtures approach 13:1 or richer.



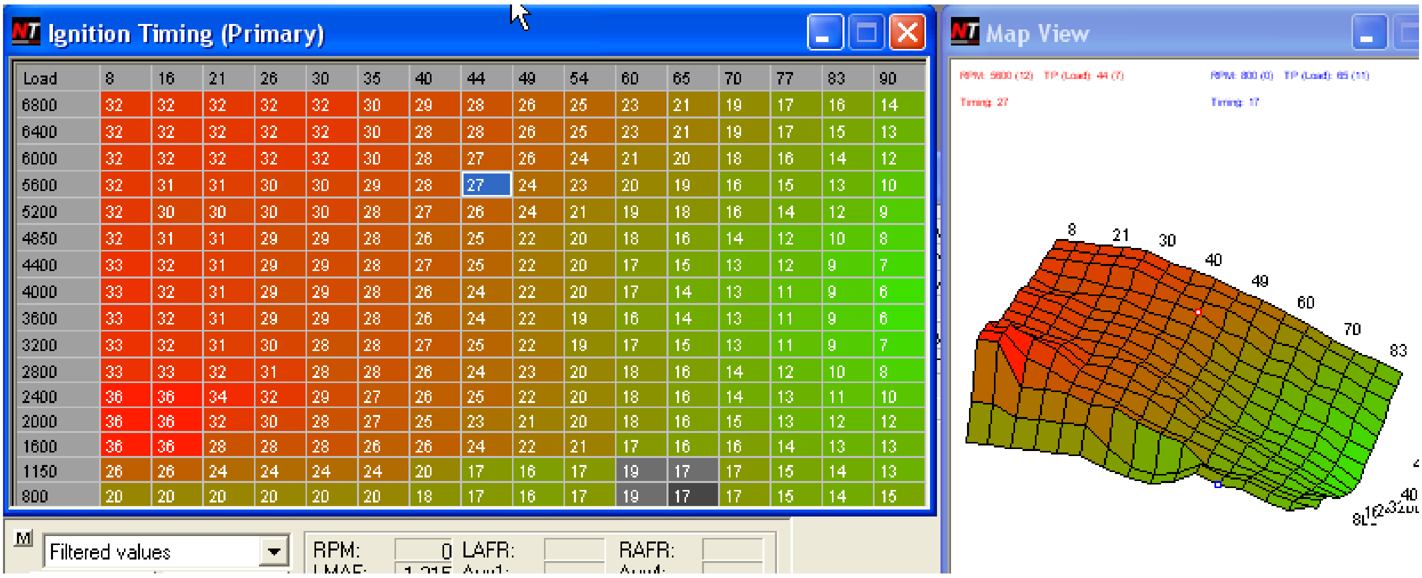
Load	8	12	16	19	23	26	30	34	38	42	47	55	66	82	99	117
7500	8	7	10	24	26	27	27	28	28	29	29	30	31	31	32	32
6800	8	7	10	24	26	27	27	27	28	28	28	28	29	30	31	31
6000	8	5	7	13	25	26	25	26	28	28	28	28	29	30	31	31
5600	9	5	5	6	19	22	23	24	27	28	28	28	29	30	31	31
5200	7	4	4	6	16	21	23	24	25	27	28	28	29	31	31	31
4800	7	4	4	4	5	8	18	22	24	25	27	29	30	31	32	31
4400	7	4	4	4	6	8	20	22	22	25	28	29	31	32	32	31
4000	7	4	4	4	6	7	13	19	[illegible]	24	27	29	31	32	32	31
3650	7	4	4	4	6	7	15	19	22	24	27	30	31	31	31	30
3200	7	4	4	4	6	7	14	17	22	[illegible]	26	29	30	30	30	29
2800	7	4	4	4	6	7	14	16	18	24	25	26	27	27	27	26
2400	6	4	4	4	6	7	12	13	12	[illegible]	25	25	25	25	24	23
2000	6	5	4	4	6	6	[illegible]	12	11	20	22	18	18	18	18	18
1600	5	4	1	1	3	3	2	2	4	10	12	13	13	13	13	15
1200	5	4	1	1	1	1	2	2	4	4	4	4	4	4	6	6
800	5	5	-1	-1	3	3	2	2	4	4	4	4	4	4	4	4

O2 flags active in boost transition area = wrong

7. IGN Map Tuning

A lot of the same ideas apply to both Fuel and IGN maps. For example load scales and “main vs knock” maps. So please ensure you’ve read these sections before continuing. Ensuring that the load scales are correct is particularly important for IGN maps. If the scale values are too high it’s more than likely that higher than required IGN numbers will be used = detonation.

Tuning IGN maps is often much more difficult than tuning Fuel maps. Mainly because you don’t have any easy-to-read feedback such as a wideband mixture meter. And IGN timing is very much load/boost dependant, so rather than being close to flat like a fuel map it will have a 3D slop to it, with IGN values changing significantly with both RPM and load.



Load	8	16	21	26	30	35	40	44	49	54	60	65	70	77	83	90
6800	32	32	32	32	32	30	29	28	26	25	23	21	19	17	16	14
6400	32	32	32	32	32	30	28	28	26	25	23	21	19	17	15	13
6000	32	32	32	32	32	30	28	27	26	24	21	20	18	16	14	12
5600	32	31	31	30	30	29	28	27	24	23	20	19	16	15	13	10
5200	32	30	30	30	30	28	27	26	24	21	19	18	16	14	12	9
4850	32	31	31	29	29	28	26	25	22	20	18	16	14	12	10	8
4400	33	32	31	29	29	28	27	25	22	20	17	15	13	12	9	7
4000	33	32	31	29	29	28	26	24	22	20	17	14	13	11	9	6
3600	33	32	31	29	29	28	26	24	22	19	16	14	13	11	9	6
3200	33	32	31	30	28	28	27	25	22	19	17	15	13	11	9	7
2800	33	33	32	31	28	28	26	24	23	20	18	16	14	12	10	8
2400	36	36	34	32	29	27	26	25	22	20	18	16	14	13	11	10
2000	36	36	32	30	28	27	25	23	21	20	18	16	15	13	12	12
1600	36	36	28	28	28	26	26	24	22	21	17	16	16	14	13	13
1150	26	26	24	24	24	24	20	17	16	17	19	17	17	15	14	13
800	20	20	20	20	20	20	18	17	16	17	19	17	17	15	14	15

Like Fuel maps, a lot of the low load area can be left untouched. It’s usually the right half of the map where the work tends to be needed.

In most cases more timing means more power – until you reach the knock threshold. Turbo engines will run quite a bit of timing at low load – just like a non-turbo engine. Figures of 30 to 40 degrees are common. But as boost rises timing is pulled out very quickly. Many engines will tend to detonate easiest around peak torque. This is where volumetric efficiency (VE) of the engine is highest and maximum cylinder filling takes place. Final timing values depend largely on the boost. More boost = less timing. This is why you’ll often see a big “hole” in the IGN map around peak torque – particularly for SR20’s. RB’s tend to be more linear. Once an engine passes peak torque the VE starts to drop off and timing can often be increased with RPM. This of course varies depending on engine characteristics.

Now all these ideas are well and good but the bottom line is that you need to be able to find the knock threshold – and then tune to make sure the engine stays away from it. Don’t be tempted to tune right to the edge of knock and leave it there. You must allow a safety factor so that if conditions are not optimal it won’t push the engine into detonation. Hot weather, unusually high coolant temps and poor fuel will do it.

Knock is the number one killer of turbo engines. Factors that cause knock:

1) Too much ignition advance for prevailing engine conditions.
2) High inlet air/coolant temperatures – generally resulting from winding up the boost of an otherwise standard engine.
3) Too much boost.
4) Lean fuel mixtures.
5) Low octane fuel.

Problems generally happen when a combination of the above occur – like running increased boost with a tank of poor fuel. Or running advanced ignition timing on a very hot day.

There are many ways to find the knock threshold. Some better than others. At lower rpm you can often hear knock pretty easily. Above that things become more difficult because it's hard to tell the difference between knock and mechanical noise. Particularly on worn engines or engines running very high boost.

1) **The peak torque method.** Works well if you're using a dyno. Once AFR's are correct, start with mild timing and note torque level. Gradually add timing (2 degree steps works well) until torque stops increasing. So if you're getting 5nm for each 2 degrees, then you add another 2 degrees and only get 2nm then you're probably getting close.

2) **Audible knock.** This very much comes down to personal skills and practice. Some people are quite good at detecting knock using only their ears. This can be complimented by using some sort of listening device – anything from a piece of hose between engine and ear (don't laugh – it works!), to using a microphone in the engine bay, connected to an audio amplifier and a set of head phones (my personal favourite). One method that I've tried (that works very well) is to put you head in the engine bay (obviously only works on a dyno!) and run the engine up at full load. Clamp a set of good ear muffs tightly against your head to help remove engine noise. I've found that I can hear knock perfectly clearly by doing this. Not for the faint hearted though – if something lets go at full power you don't wanna have your head under the bonnet!

3) **Electronic detection**. There are various devices around. They all suffer from the same problem as the human ear – being able to discern knock from engine noise. The better ones have an adjustable threshold that can be varied across RPM. Because the threshold varies considerably across rpm you really need this. You can set a threshold at 5000 rpm and it'll work OK, but if the engine detonates at 3500rpm it won't be detected.

4) **Ionisation Current**. This system shows great promise. The current going to the sparkplugs is monitored - if knock occurs the current changes drastically. But this has to be designed into the IGN system. A few manufacturers are starting to do this now. Nice. But no use to us tuners at this point.

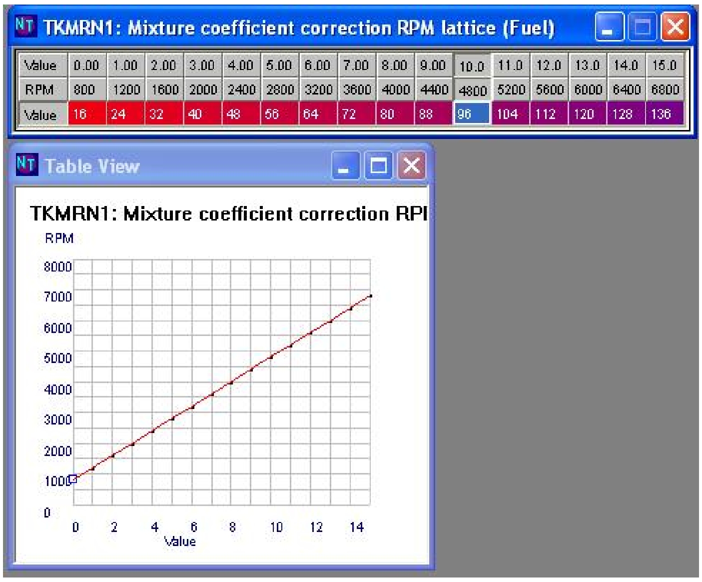
Whatever way you do it usually requires a good deal of practice before you can confidently find the knock limit. The other issue is that you don't want to be holding your engine anywhere near audible knock for any length of time. This is a place to tread lightly.

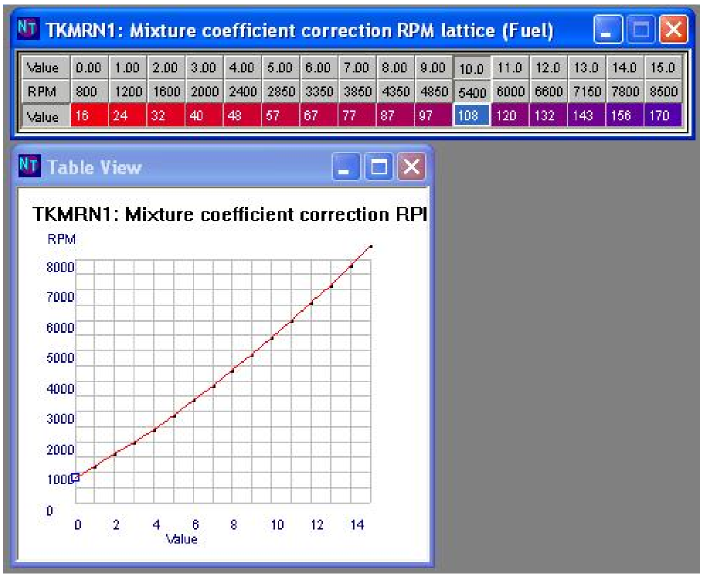
Once you find the knock threshold it's common practice to remove a couple degrees timing as a safety factor. If it's a track car you may need to take out more. To replicate worst case conditions a good technique is to perform 2 or 3 consecutive full load pulls without allowing a cool-down period. Watch coolant temps and monitor knock very carefully. Watch oil temps if possible as they can hit dangerous levels even though coolant temps appear to be OK.

Once all this is over, take the car for a road test and check once again for knock. They behave slightly differently on the road so sometimes you'll get knock where it wasn't apparent on the dyno. Often due to boost control issues – the dyno uses a fixed ramp rate. On the road "ramp rate" varies and you can get boost spikes that didn't show up on the dyno.

8. RPM/Load Scale Adjustments

RPM scales



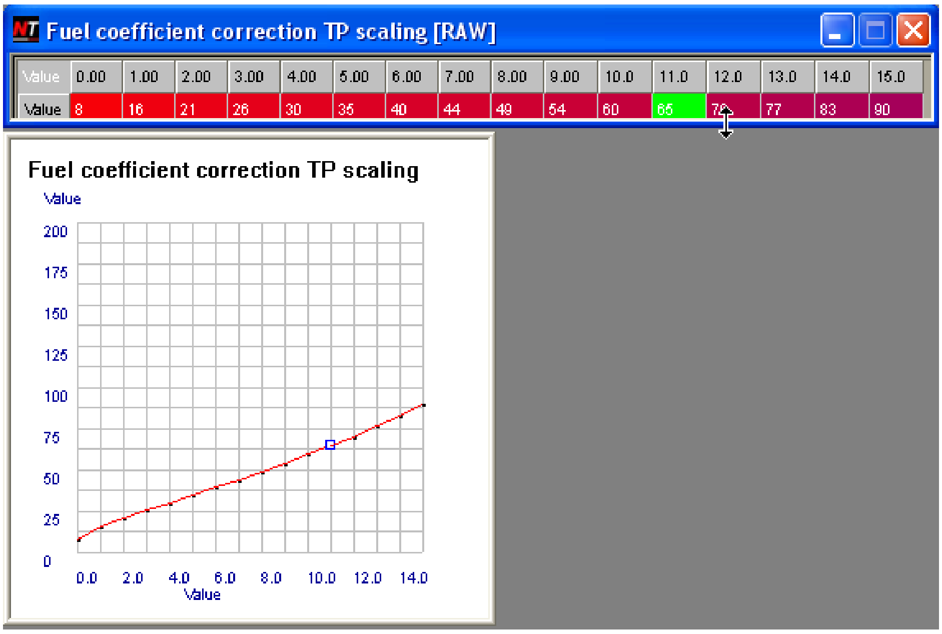


RPM Scale adjustment is simply a matter of selecting the "*Fuel RPM Scale*" and editing as required. The same procedure is used for editing the IGN RPM Scales. RPM Scales for both Fuel and IGN tables are usually best kept the same - right click over the table vales and select "Copy to Partner".

Edit by selecting a value in the table and use +/- keys to adjust. Use left/right arrow keys to move right/left. The scale is usually kept linear, or pretty close to it. Adjustments are in 50 rpm increments.

LOAD scales

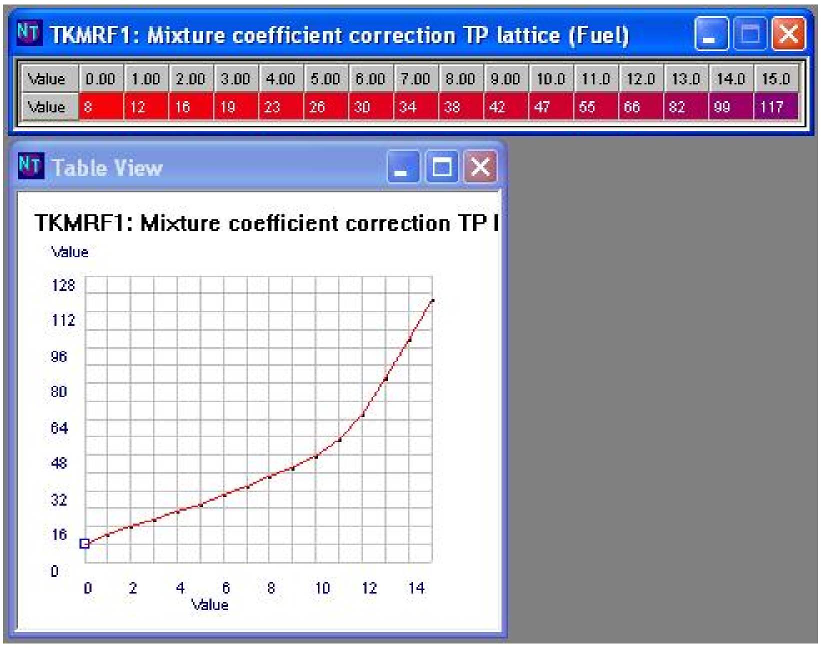
Load Scales are adjusted using the same method as RPM Scales but can take a little more work to get right. These scales are widely known as "TP scales" in the Nissan tuning world.



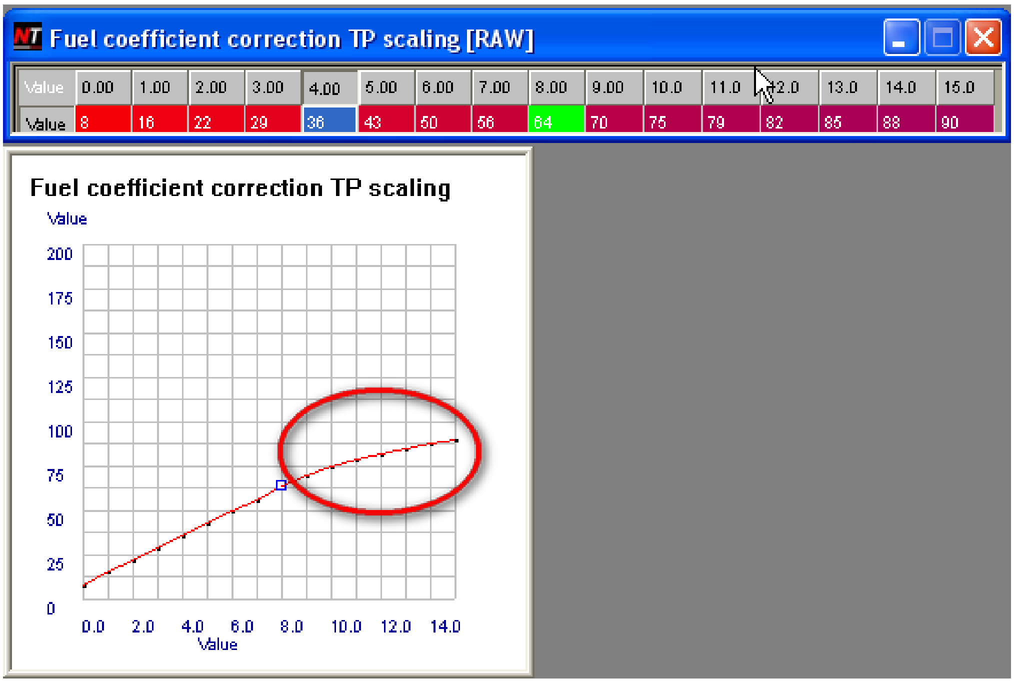
X axis is simply 0 to 16 - representing the 16 load columns. Y axis is load figures (TP) - these figures represent vacuum/boost but are not in any particular unit (psi, bar etc.). Minimum load is on the left end, max load on the right. The main reason for adjusting these scales is when boost is increased on turbocharged engines and/or the airflow meter/injectors have been changed. K Constant will usually be changed in these situations and K Constant affects the load scales.

This may result in maximum load occurring off the scale or back towards the middle. Ideally maximum load will access the two rightmost columns of the fuel/IGN maps. Watch the "TP" readout down the bottom of the fuel/IGN map (or in the Gauges panel) during a full power run and note the maximum value it reaches. Use this as the maximum value for your load scales and adjust all the other values working back from here.

The scales do not need to be linear. As in the example above, most of the scale can be left standard (leaving low load tuning untouched) but increased in the high load areas to prevent running off the end of the table.



Another technique is to trade off a little resolution in the low/mid area and increase resolution up top. This works very well on turbo engines to ensure that IGN values are optimised across different boost levels. If you find that changing boost results in little change to IGN timing figures then this technique is the answer.



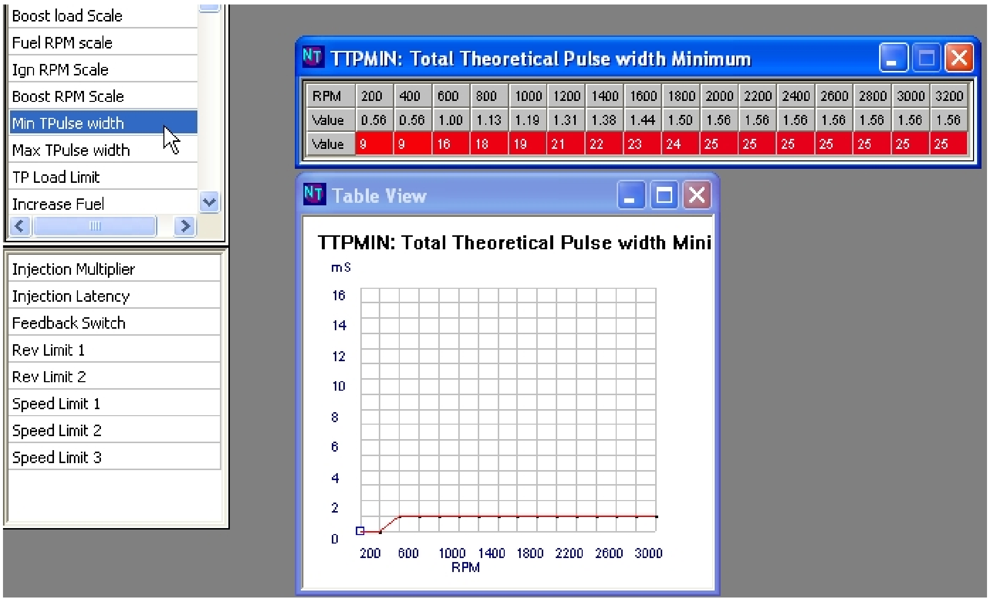
Note that changes to K constant will affect how the load scales are accessed because K constant is one of the factors involved in the ECU's "TP" (= load) calculation. Ideally you'll have the K constant worked out before setting the load scales – but it can often be an iterative process involving both adjustments. Increasing K constant will cause columns closer to the left to be accessed – and vice-versa.

9. Speed/RPM limits

The basics of these are pretty self explanatory. But different strategies are used by various ECU's. Some will only have one speed and one RPM limit. Others can have up to 3. Often one limit will be the cut out and the other will be where the engine cuts back in. If in doubt, set them all to the same value or add the same amount to each one. This can easily be verified.

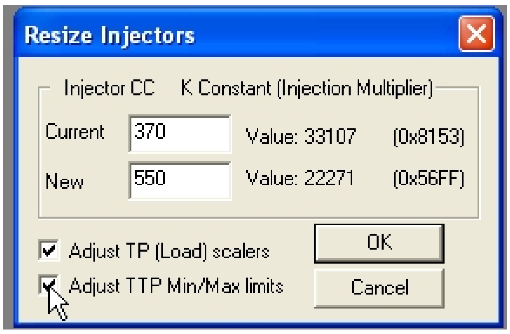
10. TTPmax & TTPmin

TTPmin = "Total Theoretical Pulsewidth Minimum". This value sets the absolute minimum injection pulsewidth. This is in case a calculation (eg: unusually low reading from AFM) results in an injection pulsewidth which would cause the engine to stall. Normally this value is only adjusted if different injectors are fitted. Multiply all values by the ratio of old injector size vs new injector size. This table can also be used for adjusting idle mixtures in some cases.



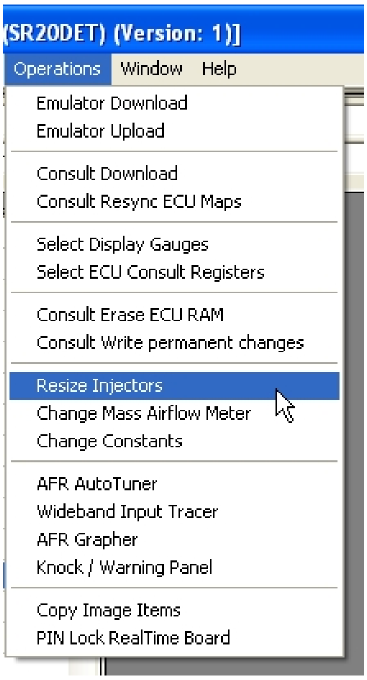
Similar deal for TTPmax. It limits the maximum pulsewidth that will be used under any conditions and values are modified in the same way. Watch out if TTPmax is set too low – it will limit the injector pulsewidth and you won't be able to richen the mixtures no matter what values you put in the fuel maps.

Example : If injectors were changed from 370cc to 550cc then multiply all values of TTPmin/max by 370/550 = 0.67. You can do it manually be editing the values in the table or NIStune will do this for you when you use the Resize Injectors function.



11. Changing injector size

This is one of the simpler tasks. From the "Operations" menu in NIStune choose "Resize Injectors". Enter the old injector size, the new injector size, and hit "OK". This simply applies the old vs new ratio to the K Constant (see section on Setting Injection Multiplier).

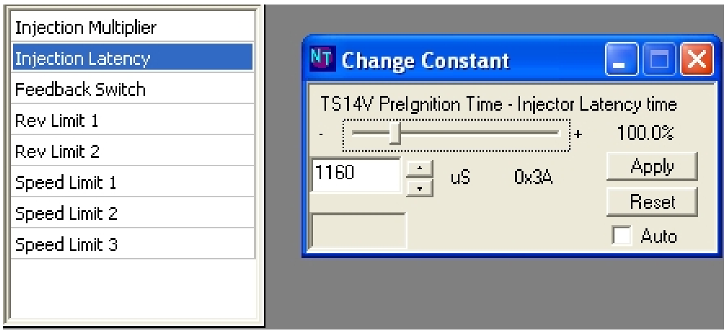


> The Nissan ECU does not record the injector size in any way, so NIStune has no way of knowing what size injectors are fitted other than grabbing the standard injector size from the address file. So if starting from other than stock injectors make sure you always enter the new AND old injector sizes.

You will see two check boxes in the Resize Injectors dialog box. You'll often find that when changing injectors, the Load Scales and TTPmax/min also need to be changed. NIStune gives you the option to perform this automatically if you choose. By ticking the boxes the old vs new injector ratio will also be applied to the Load Scales and TTPmax/min. (refer relevant sections).

12. Injector Latency

This represents the time it takes for the injector to open or close. If you're running standard injectors then leave this alone. Often even with larger injectors it doesn't need to be touched provided they are from the same manufacturer. Eg: SR20's all use JECS injectors. Many aftermarket injectors are also made by JECS – NISMO, HKS, Apexi, Tomei. All from the same place. If you go to very large injectors, or go to a different brand then you may need to adjust the latency figure.



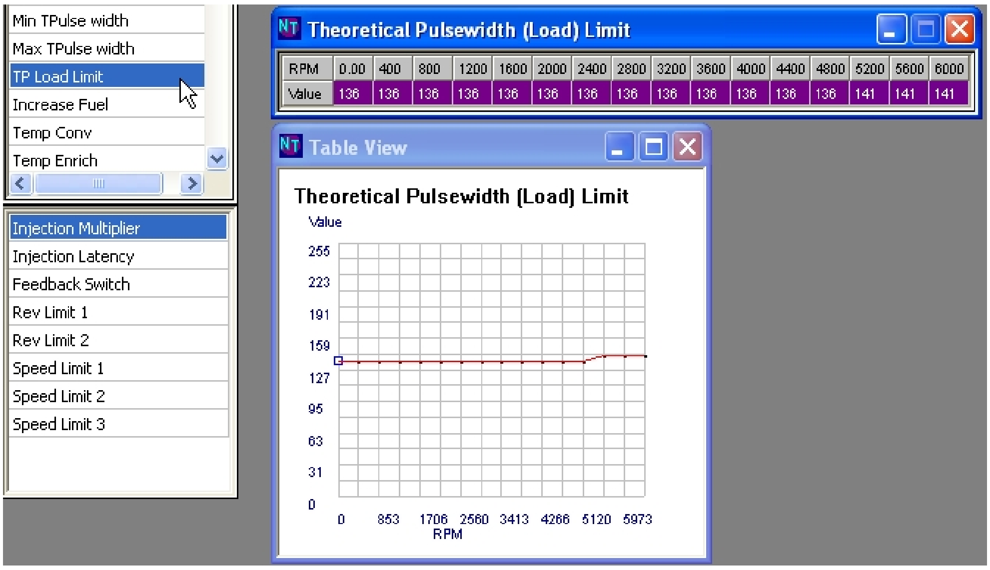
You may be able to obtain latency figures for your injectors, in which case you can enter the value directly. Beware though that injector latency varies with voltage and fuel pressure. Different manufacturers quote latency at different voltages and pressures.

Because latency figures represent a relatively small time, the effect will be most marked at small pulsewidths. So mixtures at high load won't see much change, but idle and low load will. Sometimes if idle and low load mixtures are incorrect even though K constant is right and high load mixtures are fine then adjusting injector latency can be a good method of tuning this area.

Ticking the "Auto" box will cause changes to be updated instantly. Otherwise "Apply" will need to be pressed each time you want updates to occur in the ECU. It's usually best to tick "auto" and then use the +/- keys to quickly adjust the latency figure. Changes to mixtures will then happen instantly.

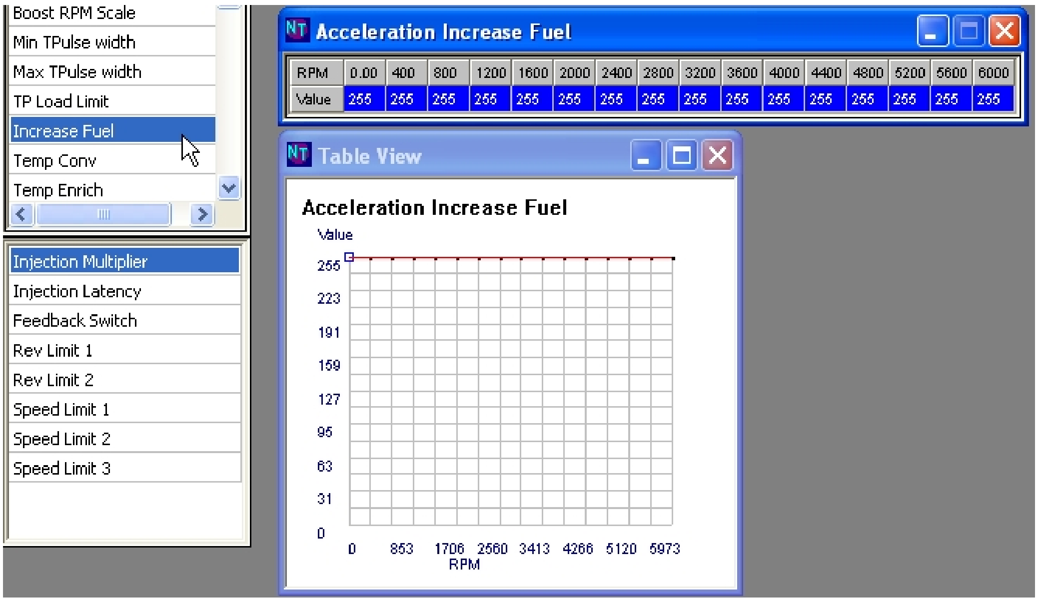
13. TP Load Limit

Commonly referred to as “Boost Cut” or “Fuel Cut”. Many tuners set all values to 255, effectively eliminating boost cut. But a better strategy (assuming boost has been increased) is to adjust the values so that a boost cut still exists but at a higher level. Values refer to TP, so work out what your maximum TP is and then adjust the numbers in this table to slightly over this figure. This gives protection if boost control is lost (which can easily happen if for example the hose to the WG actuator becomes damaged or dislodged).



14. Acceleration Enrichment

This is an easy one for those brought up on a diet of Holley and Weber carbs. It represents the old accelerator pump facility. It controls how much fuel is injected on fast throttle movement. Usually not touched, but quite a good place to cut back when chasing fuel economy figures. Don’t get too carried away though, or you’ll create a big flat spot.



15. Changing Airflow Meter

The main concept to understand here is that there is a table in the ECU ("VQ map") which converts airflow to a number that the ECU can work with. Different airflow meters have different responses so when you change your AFM you need to change the VQ Map - "Operations, Change Mass Airflow Sensor".

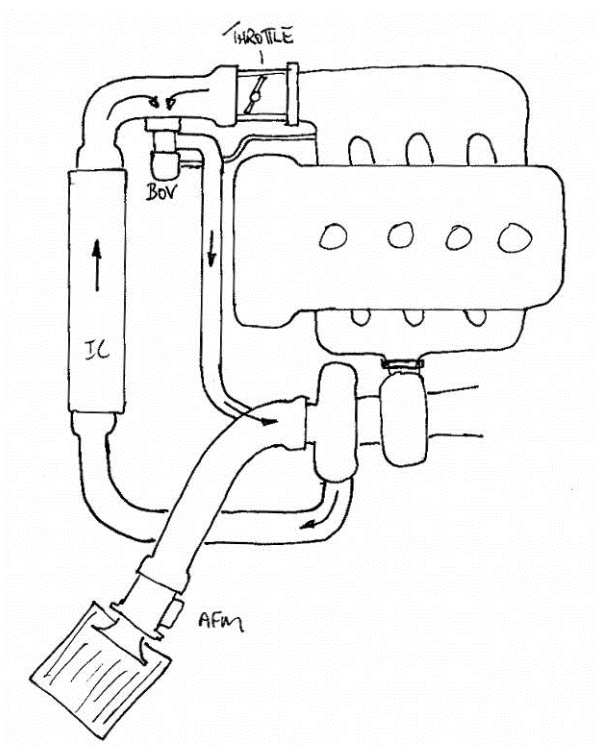
In the real world there's a little more to it than that. But because different AFM's are capable of flowing vastly different amounts of air, the K constant/TIM also need adjustment. NIStune does a basic calculation based on the maximum horsepower capability of the new AFM vs old AFM. This ratio is applied to the K constant (and optionally the Load Scales). This should get these figures in the ballpark. It's then time for some work on the dyno to fine tune the K constant/TIM (refer section 4 "Setting Injection Multiplier").

In general you should see around 1V at idle (sometimes down to 0.5V for big AFM's), 1 to 2V at low load and then voltage will quickly increase when load is applied. Maximum is 5.12V. They're extremely non-linear, so you'll find they're very sensitive at the lower end but at full noise the voltage changes very little.

> Tip: some AFM's can be very touchy with respect to physical position. Z32 AFM's can suffer badly if mounted too close to compressor inlets or if plumbing doesn't promote smooth airflow in and out. Keep plumbing smooth, no sudden changes in diameter and with **AFM as far as possible from turbo to avoid reversion affects. Always tune with air filter fitted**. Try to use an air filter with a bell-mouth into the AFM. Problems manifest themselves as extreme richness and general bad manners at idle and low load. This is important and has the potential to cause huge tuning headaches.

16. Blow-off Valves

"Recirculation valves" or "Blow-off valves" (BOV's) should always be used. Without a BOV fitted the AFM will see major reversion when the throttle is closed. Air gets stopped by the suddenly closed throttle and then surges backwards through the compressor and out the AFM. Bad for turbo and bad for tuning! The AFM measures airflow the same in either direction so this surge of air creates a burst of fuel at the injectors, resulting in a big rich cough each time the throttle is closed. On cars with auto trans this can easily stall the engine completely.



Similarly for BOV's that vent to atmosphere. You don't get the reversion back to the AFM but the sudden rush of air to atmosphere is still being measured by the AFM so you get the big rich patch on closed throttle.

The return air from the BOV should be angled away from the AFM if possible – reducing the risk of airflow backwards into the AFM.

17. Tuning example

Vehicle : S13 SR20DET
Modifications : Larger turbo, 3” exhaust, FMIC, 550cc injectors, Z32 AFM

Preliminary Work

1) Firstly the vehicle was given a basic check before any modifications took place. Most checks were done via diagnostic port:
   - O2 Sensor working (always a good sign – it should oscillate back and forth at low load)
   - Idle speed correct (another good sign)
   - Fuel trims close to midrange if possible (big swings away from midrange usually mean trouble)
   - Oil and coolant levels checked
   - Inlet plumbing checked and clamps tightened
   - Tyre pressures checked
   - IGN timing checked with timing light at exactly 15 degrees.
   - TPS reading 0.5V and TPS Closed indicator on when throttle closed
   - No fault codes

2) Fuel pump was recently replaced so no problems expected there.
3) NIStune board fitted to ECU.
4) Suitable maps were created in NIStune by changing AFM to Z32 and re-sizing injectors from 370 to 550cc.
5) IGN map values were decreased slightly in high load areas in preparation for more boost.
6) New maps were then sync’d into the ECU.
7) New injectors and AFM fitted to vehicle.
8) Vehicle started and K constant was adjusted so that vehicle drove smoothly off boost.

Dyno Day – Rough tune

1) Once car was setup on dyno it was brought up to operating temperature and mixtures were checked at low load to check if K constant adjustment was necessary. The low load/rpm corner of the fuel map was temporarily set to all “0” and O2 sensing turned off. A small tweak to K constant was required to obtain 14.7:1. Engine was run in the 3000 rpm area at minimal load.

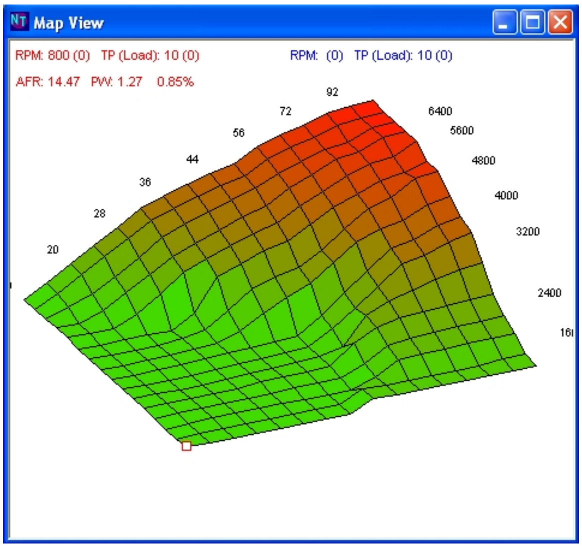
   ** This step not needed if injectors/AFM not changed**

5600	4	3	3	4	17	20	23	24	27	28	28	28
5200	2	2	2	4	14	19	23	24	25	27	28	28
4800	0	0	0	0	0	0	20	22	24	25	27	29
4400	0	0	0	0	0	0	17	20	22	25	28	29
4000	0	0	0	0	0	0	15	19	23	24	27	29
3650	0	0	0	0	0	0	15	19	22	24	27	30
3200	0	0	0	0	0	0	14	19	22	24	26	29
2800	0	0	0	0	0	0	14	18	20	24	25	26
2400	0	0	0	0	0	0	12	15	19	23	25	25
2000	0	0	0	0	0	0	11	12	13	20	22	18
1600	0	0	0	0	0	0	3	3	5	10	12	13
1200	0	0	0	0	0	0	2	2	4	4	4	4
800	0	0	0	0	0	0	2	2	4	4	4	4

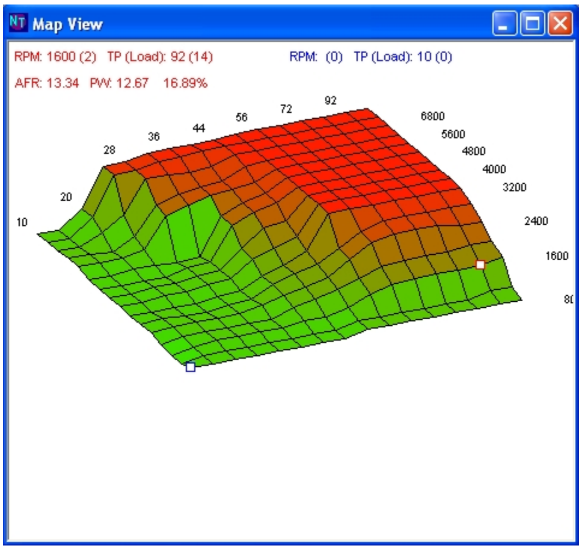
Filtered values | Shaded | RPM: | AFRL:

2) Cells which were “zeroed” were set back to stock values and the O2 sensing was re-enabled. The first full load run was performed with boost set to minimum (8psi). If everything is well then this will usually result in rich mixtures if running factory maps – which is safe but not great for making power. It’s not unusual to see AFR’s as low as 10:1 for Nissan turbo engines, particularly if boost has been increased above std.

3) Fuel map was adjusted until mixtures were roughly correct (aiming for around 11.7:1). Please note that in the example below large injectors were being used so values in fuel maps were quite small.



Standard fuel map



Roughly tuned fuel map

4) Once AFR's were safe, boost was increased to 12psi. Knock was monitored using both aural and electronic (Knocklite) methods.

5) Boost was then increased to the maximum of 15psi and a run was performed while knock was carefully monitored.

6) Load scales were adjusted to ensure that correct columns were being accessed. You want to just be accessing the last load column at maximum boost.

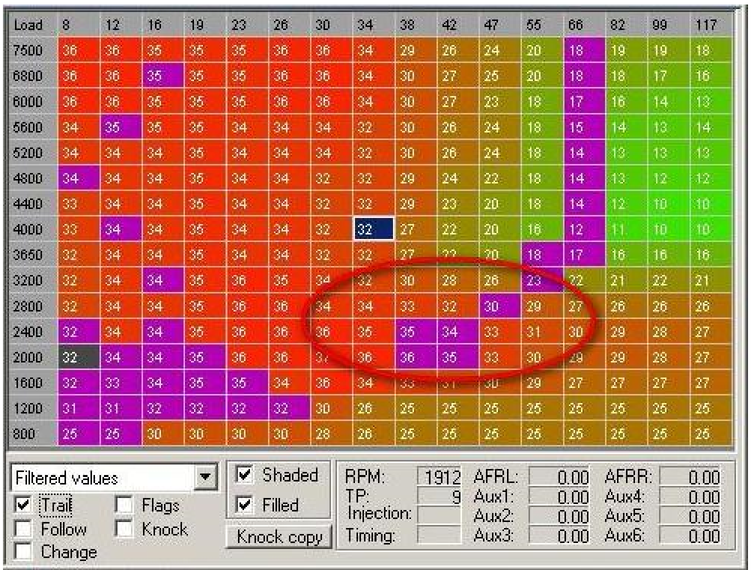
7) Mixtures were then adjusted for approx 11.7:1. This is now what I'd call a rough tune.

Fine Tuning

1) IGN timing was increased in 2 degree increments with boost at 15psi. With each run torque increase was measured and knock was carefully monitored. Timing was increased until torque stopped improving – which is generally close to the knock threshold. Once this point was found the timing was backed off to allow a "safety factor".

2) Boost was then lowered in steps. IGN timing and mixtures were checked at each boost level. Slightly leaner mixtures were run at lower boost levels.

3) Mixtures and IGN timing in boost transitional areas were then adjusted to ensure optimum boost response.

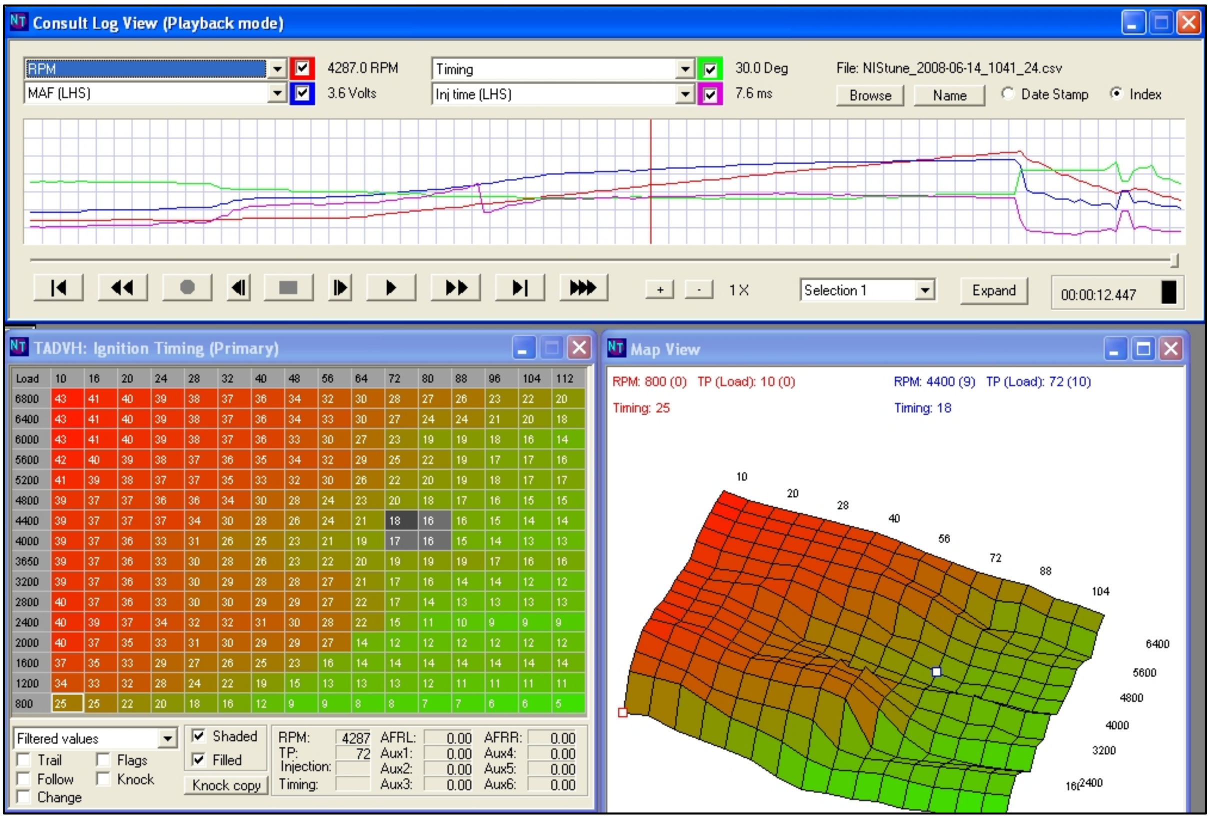


Load	8	12	16	19	23	26	30	34	38	42	47	55	66	82	99	117
7500	36	36	35	35	35	36	36	34	29	26	24	20	18	19	19	18
6800	36	36	35	35	35	36	36	34	30	27	25	20	18	18	17	16
6000	36	36	35	35	35	36	36	34	30	27	23	18	17	16	14	13
5600	34	35	35	35	34	34	34	32	30	26	24	18	15	14	13	14
5200	34	34	34	35	34	34	34	32	30	26	24	18	14	13	13	13
4800	34	34	34	35	34	34	32	32	29	24	22	18	14	13	12	12
4400	33	34	34	35	34	34	32	32	29	23	20	18	14	12	10	10
4000	33	34	34	35	34	34	32	32	27	22	20	16	12	11	10	10
3650	32	34	34	35	34	34	32	32	27	[illegible]	20	18	17	16	16	16
3200	32	34	34	35	36	35	34	32	30	28	26	23	22	21	22	21
2800	32	34	34	35	36	36	34	34	33	32	30	29	27	26	26	26
2400	32	34	34	35	36	36	36	35	35	34	33	31	30	29	28	27
2000	32	34	34	35	36	36	[illegible]	36	36	35	33	30	29	29	28	27
1600	32	33	34	35	35	34	36	34	33	[illegible]	30	29	27	27	27	27
1200	31	31	32	32	32	32	30	26	25	25	25	25	25	25	25	25
800	25	25	30	30	30	30	28	26	25	25	25	25	25	25	25	25

Boost transition area

4) Three consecutive dyno pulls were then performed to increase coolant temps above normal and knock was carefully monitored, removing timing in any areas where knock was apparent.

5) A final “logging run” was performed where all parameters were logged. This can be a really useful reference. Particularly because NIStune can perform log replay that includes map trace. So you can effectively replay the whole run later and check exactly which map cells were referenced. Use “Stream Mode” instead of “Tuner Mode” to increase resolution when logging.



Log playback with map trace

6) A road test was then done to make sure there was no sign of knock under real-world conditions. A small amount of timing was removed to counter knock due to a boost spike at 3500. This can sometimes happen as ramp rate on the dyno will be different to what happens on the road.

7) Vehicle was left overnight and cold start parameters checked next morning.

8) Revision History

DATE	VERSION	DESCRIPTION	AUTHOR
Nov2007	Draft	Document Creation	PL
Jun2008	Draft+	Added tuning examples and images	PL
Feb2010	1.1	Improved wording, fixed minor errors, added BOV info, added general detail	PL
Mar2010	1.2	Added detail to tuning example	PL
Aug2010	1.3	Added detail for setting base IGN Timing	PL
May2014	1.4	Changed detail for initial K setting	PL
Oct2015	1.5	Added detail for tuning TIM	PL
Jul2016	1.6	Small changes to detail for tuning TIM	PL

List of Acronyms

AFM	Airflow Meter (= MAF Sensor)
AFR	Air Fuel Ratio
BOV	Blow Off Valve (= Recirculation Valve)
ECU	Electronic Control Unit
FMIC	Front Mount Intercooler
IGN	Ignition
K Constant	Injection Multiplier
TIM	Total Injection Multiplier
TP	Theoretical Pulsewidth (engine load signal)
TPS	Throttle Position Sensor
TTPmin	Total Theoretical Pulsewidth minimum
TTPmax	Total Theoretical Pulsewidth maximum
VQ Map	Voltage-Quantity map
WB AFR	Wideband AFR (ie: Wideband AFR meter)