NISTUNE

REALTIME ECU TUNING

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Nissan ECU Tuning Basics

INTRODUCTION

This document is intended as a 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 the subject, 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 worked out 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.

All examples relate to tuning turbocharged engines unless specified otherwise.

IMPORTANT INFORMATION

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1. A solid base to tune from

Before you start tuning it is very important to be confident 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 really what they need is to have the plugs changed, AFM cleaned, and fuel pump/filter replaced and base IGN timing checked. BEFORE any tuning 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) 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.
2) AFM element cleaned
3) Fuel pump/filter – if these are not new or near new then it's a good idea to either do a fuel pressure check or at least do a baseline run and check that mixtures are where they should be with a WB AFR meter.
4) IGN timing – check with timing light. You cannot just read the value out of NIStune/Datascan.
5) 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.

2. Background Knowledge

Please make sure you have read the NIStune documentation for your particular ECU. Documents are available at www.nistune.com for installation of real-time boards, software user's guide and quickstart guides for the various boards.

It is assumed that the RT board is fitted, NIStune software is installed and comms between ECU and laptop have been established.

A basic knowledge of engine tuning is essential. Blindly adjusting parameters will result in engine damage.

3. A tuning overview

To use very broad terms, most tuning involves adjusting the K constant (AKA Injection Multiplier) to roughly get mixtures correct and then adjusting the Fuel and IGN maps to obtain correct mixtures and timing throughout all RPM and load points. If the engine is running std injectors and AFM then the K Constant is rarely adjusted. Most tuning will be done in the Fuel/IGN maps themselves.

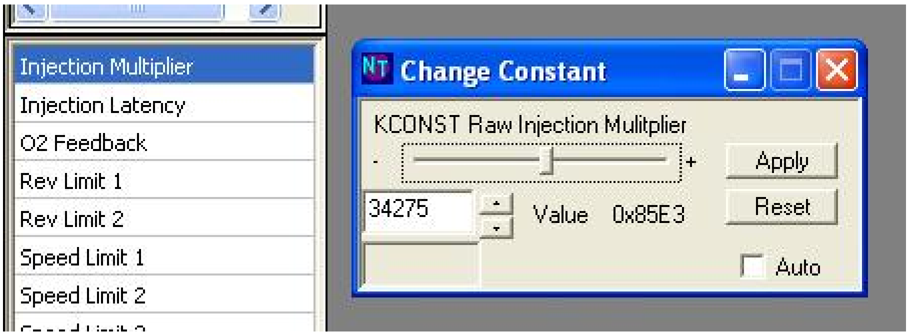
Here's a step-by-step guide to use as a starting point (assuming turbo engine):

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 nice to do a log of things like AFM voltage, injector duty cycle and IGN timing against RPM if you get the chance. This provides a handy reference.
2) If AFM/injectors are to be changed then fit the new AFM/injectors and adjust K Constant until low load AFR's are correct.
3) Check that IGN maps are "safe" (ie: take a few degrees out in high load areas)
4) Perform initial full load run on low boost and check AFR's.

5) Adjust values in fuel map to achieve desired AFR's across the RPM range (usually 11.5 – 12.0:1)
6) Increase boost in small increments and adjust fuel map to achieve correct mixtures at all boost levels. (note : monitor knock as boost levels increase).
7) Move to IGN maps. At max boost, slowly increase timing in the high load areas until torque stops rising then remove 2 to 3 degrees. Other methods of knock detection can be used (see "IGN Map Tuning).
8) When complete do one last "logging", recording the same data as in Step 1. As a minimum record AFR's and boost levels against RPM.
9) Repeat mixture and timing checks at lower load levels.

4. Some tips for dyno tuning

5. Setting Injection Multiplier



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

If you've not changed airflow meter or injector size then this value will usually not be changed – only actual map values will be altered. If you have then it is necessary to re-calculate the Injection Multiplier. This is done automatically by NIStune. Under the Operations menu you will find "Resize Injectors" and "Change Mass Airflow Meter".

> This calculation is based on a ratio of old vs new for both injectors and airflow meter. For example if the stock K value is 34,275 and injector size was changed from 370cc to 550cc then the new value will be 21,475 x (370/550) = 14,447. Obviously if we have bigger injectors then we need 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 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.

This new value for K is only a starting point for tuning. Now the value needs to be verified/adjusted by running the engine and checking mixtures with a wideband AFR meter. This is most easily achieved by running the engine in a region of the fuel map where it would normally be running "closed loop" (AFR = 14.7:1). The problem here is that in this region the O2 sensor will be active, so the engine will "chase the O2 signal" no matter what values you set in the cells of the fuel map. To achieve meaningful results we need to make the ECU ignore the O2 sensor. This can be done in a number of ways:

1) Physically unplug the O2 sensor
2) Remove "closed loop flags" from the fuel map
3) Disable the O2 feedback flag

The first option is pretty self explanatory. The second option may be achieved by simply setting all values in the fuel map to zero. This gives a theoretical 14.7:1 AFR.

The third method is done by accessing the O2 feedback flags in NIStune. This is still being tested but once it's available for all ECU's it will simply be a matter of clicking a button. Until then we will have to continue with options 1 & 2….

On a dyno you can simply run the vehicle with no load on it in 4th gear and watch the AFR's. Click "Auto" under Injection Multiplier so changes take immediate effect and simply adjust the value until you obtain 14.7:1.

6. Fuel Map Tuning

Coolant Temperature

Before doing any tuning you must be aware that the ECU will 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. Don’t use the original Nissan temp gauge – it’s close to useless. Use the readout from NIStune. This comes directly from the ECU. I 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.

"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 detonation 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.

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. Some tuners leave both maps the same to ensure consistent running but 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.

Checking the load scales

The first thing you need to work out is which cells in the fuel map are being accessed under what conditions. Usually once the engine comes on boost, the cells towards the right side will be used. So the majority of full load tuning will take place in the last 3 columns. Nissan turbos tend to run very rich on full boost so the first job is to chop large amounts out of the map in the high load area. Usually resulting in a map that looks like a mountain with the top chopped off!

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. You don’t want it in the middle of the map at full boost - or slamming into the last column as soon as 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.

> If you are tuning on a chassis dyno then be aware that there is a lag due to the time it takes for a WB AFR meter to react. So when checking graphs of “power runs” there will 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’ll probably have 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 low 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.

Once mixtures are satisfactory over the whole map don’t forget to turn O2 sensing back on (if you disabled it via the maps). Sometimes the area that the O2 sensor is operating needs to be adjusted as the engine will try to hold onto closed loop when it has started to make boost. Stoichiometric mixtures while on partial boost will make the vehicle feel very sluggish!

7. IGN Map Tuning

A lot of the same stuff applies to both Fuel and IGN maps – load scales and “main vs knock” maps. So please read this before going on.

IGN maps can be a lot harder to get right than Fuel maps. Mainly because you don’t have any easy-to-read feedback. And IGN timing is very much boost dependant.

Like Fuel maps, a lot of the low load area can be left untouched. It’s those last few columns of the map where the work tends to be needed.

In most cases more timing means more power – until you reach the detonation 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. What value the timing is reduced to depends largely on the boost level. More boost = less timing. Backing it off to 10 degrees is not uncommon.

Once an engine passes peak torque the timing can slowly be increased again. Usually to around the 20 degree mark at redline.

Now all these ideas are well and good but the bottom line is that you need to be able to find the detonation threshold – and then stay away from it. Don’t be tempted to tune right to the edge of detonation and leave it there. You must allow a safety factor so that if the car is run on a very hot day it won’t suddenly start detonating.

> Detonation is the number one killer of turbo engines. Things that cause detonation:
>
> 1) Too much ignition advance for prevailing engine conditions.
> 2) High inlet air 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 dodgy fuel. Or running advanced ignition timing on a very hot day. I think you get the picture.

There are many ways to find the detonation threshold. Some better than others. At lower rpm you can often hear detonation pretty easily. Above that things become more difficult because it's hard to tell the difference between knock and mechanical noise:

1) **The peak torque method.** Works well if you’re using a dyno. Start with mild timing. Note torque level. Gradually add timing until torque stops increasing. Back timing off a tad as a safety factor.
2) **Audible knock.** This very much comes down to personal skills and practice. Some people are quite good at picking knock using only their ears. This can be complimented by using some sort of listening device – anything from a garden hose between engine and ear, to using an audio amplifier and a set of head phones (chassis ears). 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 detonation crystal clear by doing this. Not for the faint hearted though!
3) **Electronic detection**. There are various devices around. They all suffer from the same problem as the human ear – being able to pick knock from engine noise. The better ones have an adjustable threshold that can be varied across RPM. Because the threshold varies a lot across rpm you really need this. You can set a threshold at 5000 rpm and it’ll work OK, but you’ll find that if it detonates at 3500rpm you won’t pick it.
4) **Ionisation Current**. This is the goods. 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.

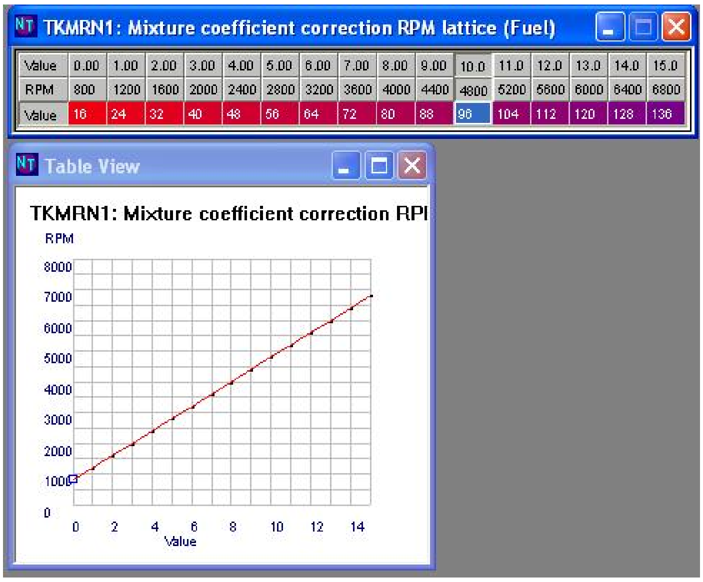
Whatever way you do it usually requires a good deal of practice before you can confidently find the knock limit. The other issue is that you don’t want to be holding your engine anywhere near detonation for any length of time. This is a place to tread lightly.

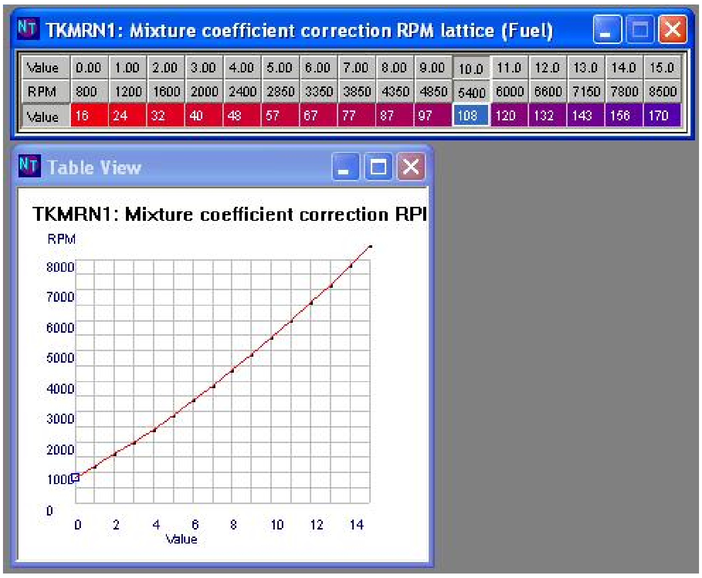
Once you find the detonation threshold you generally take a couple degrees timing out as a safety factor. If it's a track car you take out more. Also, load the engine up a bit to increase overall temps and monitor detonation.

Once all this is over, take the car for a road test (assuming you were on a dyno to start with) and check once again for detonation. They behave slightly differently on the road so sometimes you’ll get detonation 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



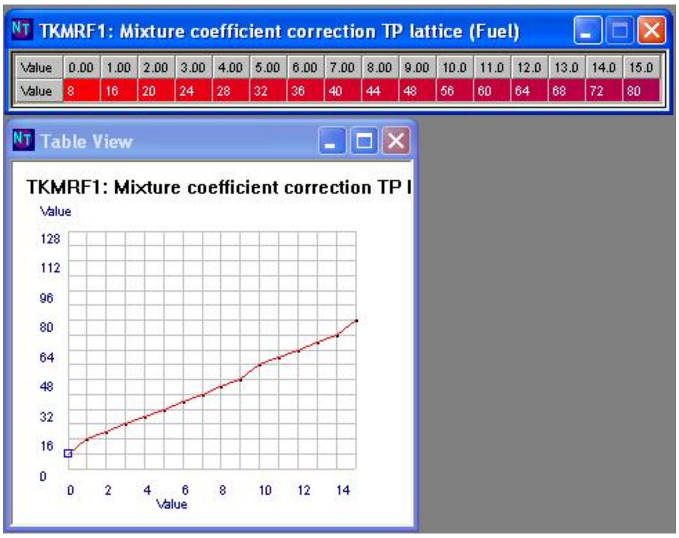


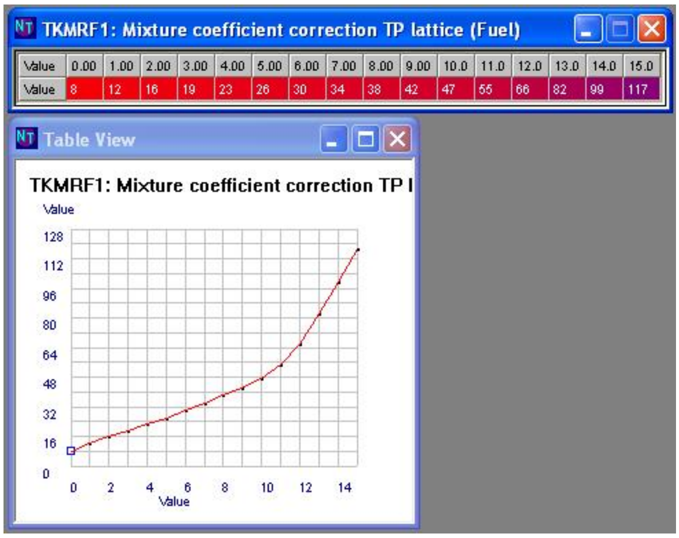
No surprises here. It's simply a matter of selecting the "*Fuel RPM Scale*" and editing as required.

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

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





The values in these tables are an arbitrary figure – they do not directly represent vacuum/boost. 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 has been changed. This may result in maximum load occurring off the scale or back towards the middle. Ideally maximum load will access the rightmost column of the fuel/IGN maps.

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.

Please note that if you need to adjust the Injection Multiplier (usually required when changing injectors and/or airflow meter) then this must be done before making adjustments to the load scales. The Injection Multiplier will affect how the load scales are accessed. Decreasing the Injection Multiplier will cause columns closer to the right (and vice versa) to be accessed in the fuel/IGN maps.

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.

10. Changing injector size

This is one of the simpler operations. From the “Operations” menu in NIStune choose “Resize Injectors”. Enter the old injector size, the new injector size, and hit “OK”. All this does is apply the old vs new ratio to the Injection Multiplier (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 existing vs new injector size.

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)

Injector Latency

Changing Airflow Meter

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11. Tuning example - basic

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12. Tuning example - advanced

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REVISION HISTORY

DATE	VERSION	DESCRIPTION	AUTHOR
23Nov07	1.0	Document Creation	PL