MERLINS
RALLIART
and
EVOLUTION-X
TUNING GUIDE

tuning the MITSUBISHI 4B11T engine with
EcuFLASH - EvoSCAN - VIRTUAL DYNO

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Cover art: Ryan GATES (**BlackTrack**) and "Mumphry", Evolution X.
Go to http://Gates311.com

SECTION 1 – INTRODUCTION TO ECUFLASH TUNING

1.1-INTRODUCTION and ACKNOWLEDGMENTS

This tuning guide was concocted primarily for my own amusement and use, as there is an awful lot of knowledge and useful information available in the Evo community, but the details are not so easy to remember. There was clearly a need for a comprehensive document that described what **EcuFLASH** can do, and how to do it.

EcuFLASH was written by **Colby BOLES** (TACTRIX) and our collective thanks to Colby for the effort to get flashing the RALLIART and EvoX working so well. There must have been many setbacks and headaches along the way.

The definition files we use are largely the result of the un-paid hard work of enthusiasts like **tephra, mrfred, SiC** and **gunzo**, who have done most of the code dis-assembly, finding the maps and tables, and then describing them with correct scaling and axis.

Sitting alongside EcuFLASH is an equally important and useful program, called **EvoScan**. This program is used to log what is going on inside the ECU. Pretty-much all the useful engine parameters can be logged and this write-up includes many references to it. EvoScan was written by **Hamish** from limitless in New Zealand.

The third application that we will or should use is **Brad BARNHILL**s power calculation and graphing program, **Virtual Dyno**. I use this application with every tune and it has proved itself to be invaluable. So thanks Brad for providing this tool to the tuning community.

As I have indicated, this tuning guide is not just my input, it would not have been possible without the knowledge and generous contributions made by tuners and programmers in the Evo community, especially those who regularly contribute to the forums of **evolutionm.net**.

Tuned maps provided by GST Motorsports have been used throughout this guide and should provide the reader with some great examples and insight into 4B11T tuning.

1.2-TUNING ABBREVIATIONS AND ACRONYMS

Any discussion of engine tuning is inevitably going to be riddled with abbreviations, acronyms and trade names. Some have been in common usage in the automotive world since its inception, while others have been inspired since the regular use of turbos in the 1980's. Familiarity with these terms helps the owner/tuner understand what is going on inside and around the engine and will be required to follow the manual.

Table 1	**ABBREVIATIONS AND ACRONYMNS**
AFR	Air Fuel Ratio.
ATDC	After Top Dead Centre.
AUDM	Australian Domestic Market, also ADM.
BOV	Blow Off Valve - More correctly defined in the Evo world as an air re-circulation valve and required on engines fitted with a MAF to meet emissions.
BTDC	Before Top Dead Centre.
CAS	Crank Angle Sensor. Dual signal optical type on the inlet camshaft on Evo1-2-3. Later Evos have both a cam and a crankshaft sensor.
DIY	Do It Yourself.
DTC	Diagnostic Trouble Code
EBC	Electronic Boost Controller.
ECU	Electronic Control Unit.
ECT	Engine Coolant Temp
EDM	European Domestic Market
EFI	Electronic Fuel Injection
EvoM	www.evolutionm.net or http://forums.evolutionm.net
HFC	High Flow Cat -. Usually defined as 3" entry bore diameter or larger.
IAT	Intake Air Temperature – Either referring to the temp or the temp sensor.
IM	Inlet Manifold.
IMT	Inlet Manifold Temperature
JDM	Japanese Domestic Market.
MAF	Mass Air Flow - Usually referring to the MAF meter.
MBC	Manual Boost Control – May be either in-cabin or close to the turbo.
MBT	Maximum Brake Torque - The engine will have an optimal spark advance point that yields maximum torque. Exceed at your engines peril!
MIAT	Manifold Inlet Air Temp – Also refers to the MIAT sensor.
MTBT	Minimum Timing for Best Torque – see also MBT.
NA	Normally Aspirated - an engine without turbocharger or supercharger.
NBO2	Narrow Band Oxygen Sensor.
PCV	Positive Crankcase Ventilation - A one-way valve that opens on vacuum.
PPP	Peak Pressure Point – Approx. 11-18°ATDC that yield the maximum thrust to the crankshaft.
TBE	Turbo Back Exhaust - Usually defined as a 3 inch exhaust system and catalytic converter.
ROM	Read Only Memory - Misused in this context as the ECU memory can be re-written, as is the case when the memory is re-flashed.
TDC	Top Dead Centre
TPS	Throttle Position Sensor.
USDM	United States Domestic Market.
WBO2	Wide Band Oxygen Sensor.
WOT	Wide Open Throttle.

1.3-REQUIRED EQUIPMENT

If you have PASSION and TIME, then the next step is to get the best possible equipment that you can afford. So what will you need?

1. **EcuFLASH v1.42:** This application is for reading and flashing the EFI ECU and the ACD+AYC ECU. Available from:
http://www.openecu.org/index.php?title=EcuFlash

2. **OpenPort2 Cable:** This cable is USB to OBD-II and flash connectors. It has in-built driver software which self-loads when the cable is connected to the laptop PC. Available from: http://www.tactrix.com/
http://www.limitless.co.nz/

Figure 1: OpenPort2 CABLE SET

The two clear plastic connectors with loops are for the Subaru guys to initiate diagnostic mode, these are not used when tuning the RALLIART or the Evolution-X.

The black connector on the left of frame with a short lead and 3mm stereo plug is not required for flashing or logging CAN-BUS controllers as used in the RALLIART and Evolution-X. It is required for flashing the Evo7-8-9 though.

The SD memory card can/will be used for internal logging.

3. **Laptop:** You must have a laptop as EFI/AWD tuning is all about reading and manipulating data associated with the ECU and has to be capable of in-car operation for more than a few minutes. It thus follows that said laptop PC should have a good battery. Just about any post 2000 laptop running win-XP will do the job. The new mini net-book PCs with 7-9 inch screens for students are great for in-car tuning and logging. Expect some dramas with Vista, though win-7 seems to be ok.

4. **Power DC/AC Inverter:** Capable of powering your laptop from the 12 volt in-car cigarette lighter socket is a very useful addition. An alternative is an "In-Car-Adaptor" for laptops. This unit takes power from the usual cigarette lighter socket and converts the 12VDC to what ever the laptop requires, for example 19VDC is a common Toshiba voltage. The unit will have a voltage selector and multiple connector ends to suite various portable computers. They do away with the more bulky DC to AC inverters so you only have one power box at your feet instead of two!

5. **EvoScan v2.7:** This is a scanning/logging application, only the latest version works properly with the RALLIART and EvoX EFI ECU and requires the OpenPort2 cable.
Available from: http://www.evoscan.com

6. **Virtual Dyno:** This is a software power calculation application that works very well and is easy to use. The process is to log with EvoScan your 3rd gear or 4th gear power pulls, from about 2000rpm to redline at wide open throttle. The resulting log file is loaded into Virtual Dyno, select the appropriate vehicle, tyre size and enter the occupants weight and - instant power graph results. Too easy.

The application was written by **Brad Barnhill** and can be downloaded from his web site at

7. **Wideband Air Fuel Ratio Meter (WBO2):** Used to monitor the Air Fuel Ratio in real-time, most have either a serial or analog output that can be used for logging. Not to be confused with the factory fitted narrow-band O2 sensor (NBO2). The NBO2 is used in conjunction with **EvoScan** to monitor fuel trims and is a vital tool when installing and tuning larger injectors. I use the **INNOVATE** LM-1 as a general purpose WBO2 tuning tool and a **TechEdge** 2CO permanently wired into my Evo9.

Other very good units to consider are the **AEM** (very cute display) and the **Zeitronix**.

8. **Boost Gauge:** This item is pretty obvious but I will mention it anyway. Having a separate dedicated to tuning boost gauge is very useful if you are tuning other peoples cars. I have a nice big Auto-Meter mechanical vacuum / boost gauge on four meters of 3mm vacuum hose with a tee piece at the end to tap into the manifold. As it happens, not every boost gauge you come up against reads correctly so it is nice to have a gauge you can trust.

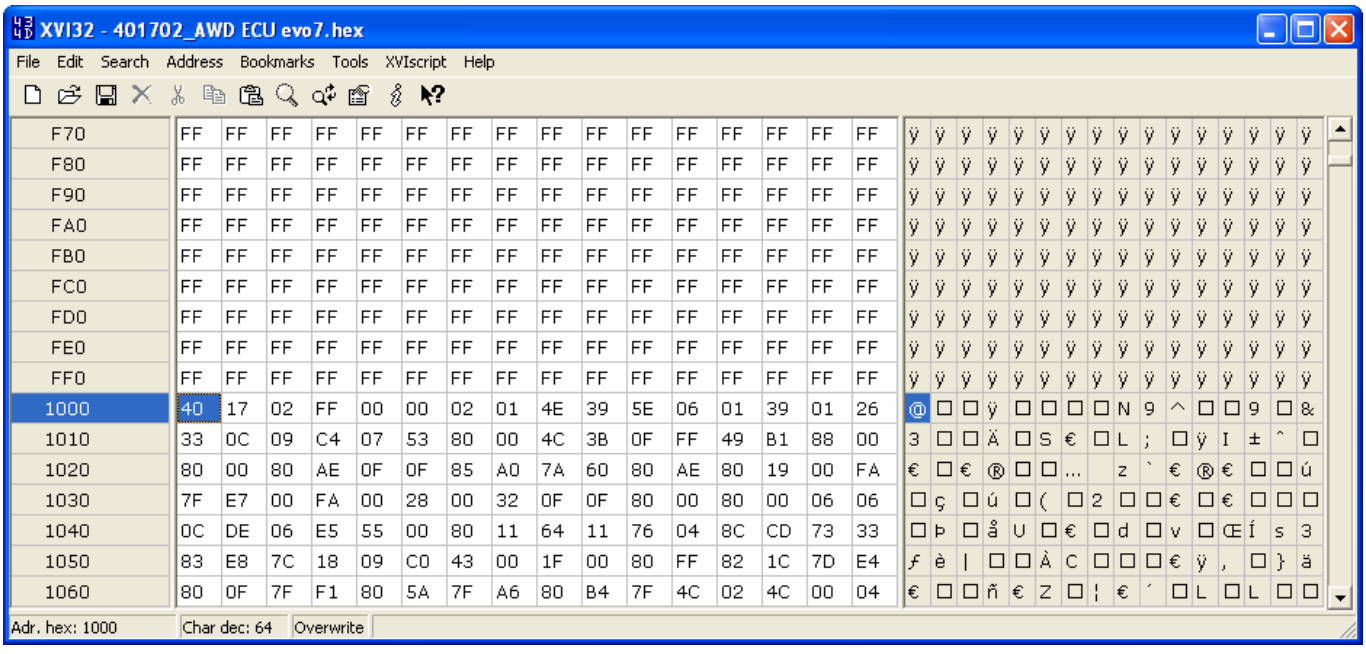
9. **OBD-II / USB Extension Cable:** This item is likely to prove invaluable, as the positioning of the OBD-II port under the dash fascia is such that bumping the cable while driving will surly happen. **TACTRIX** and **EVOSCAN** both have a suitable 1.8m cable with a right-angle head, so the cable does not hang down. It can be routed across the centre tunnel to the glove-box for easy connection to the OpenPort2 cable.

10. **xml Editor:** An application that is easy to use will make xml file editing easier. You can use **MS Notepad**, but a far better tool is **Notepad++Portable**, which is a free application available from: http://portableapps.com

11. **Hex Editor:** At some point you will need a hex code editor, though probably just for code examination and searches. I use **XVI32**, which is a free-ware hex editor application running under Windows 95 to XP. The current version is v2.51, available on the web at:
http://www.chmaas.handshake.de/delphi/freeware/xvi32

Here is a screen-shot of XVI32 being used to examine an ACD+AYC ECU ROM for the ID code to help create a valid xml file.

Figure 2: HEX Editor XVI32



12. **Det-Cans:** This is a microphone, amplifier and headset, used to listen for detonation and can also be used to help analyze bearing and valve-train noise.

One thing you wont need is an un-locker program, EVOX and RALLIART ECUs that have been flashed with EcuTek can be read and flashed directly with EcuFLASH.

1.4-EcuFLASH INTRODUCTION

EcuFLASH is a free software program to support the tuning of MITSUBISHI and SUBARU ECUs and can be configured for multiple engine types with a correctly configured definition file.

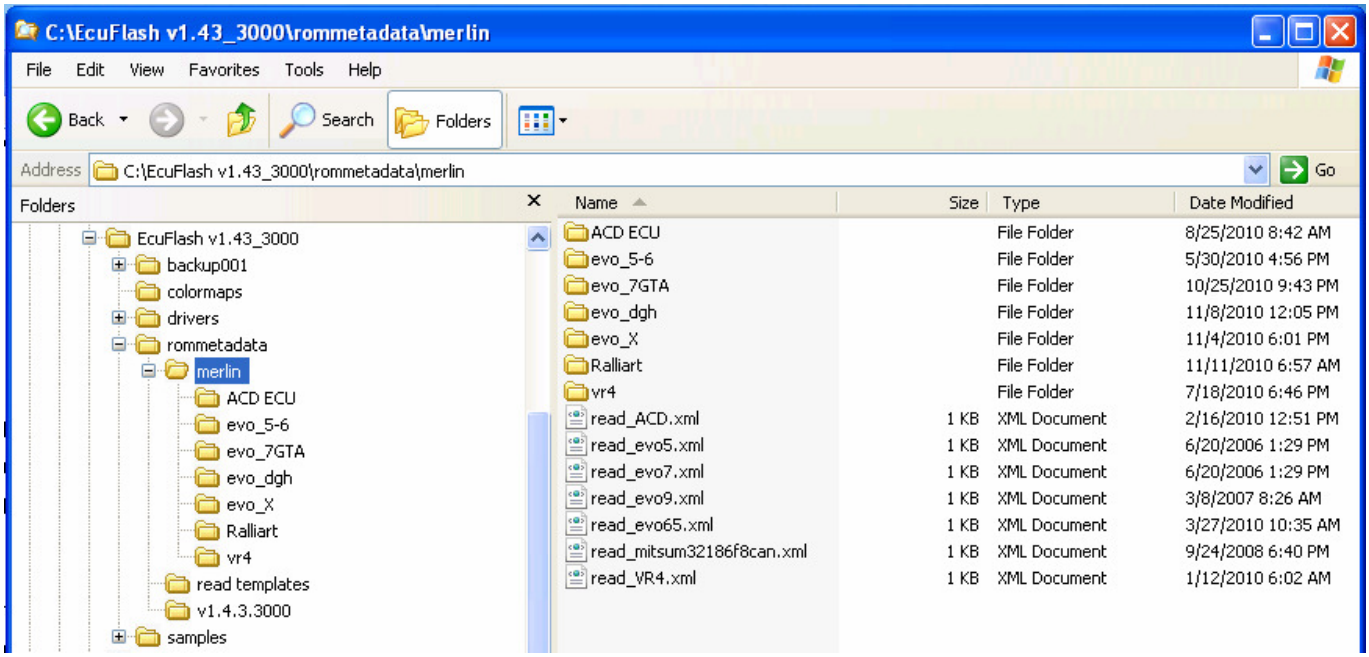
The program was written by **Colby Boles** and TACTRIX.

Regardless of whether you have a suitable OBD-II cable or not, you should read through the guide to familiarize yourself with the various capabilities of the EcuFLASH program. There is an amazing quantity of parameters that can be manipulated, but by no means should all items be altered. Indeed, part of the benefit of using the factory ECU is to retain most of the detailed factory settings.

1.5- EcuFLASH INSTALLATION & SETUP

Download the EcuFLASH program, save the application in a master EcuFLASH folder with the version number.

Launch the EcuFLASH installer application that you just downloaded. You can either let it install into **C:\Program Files\Open ECU\EcuFlash**, or you can set it to a location that is NOT under Program Files. It is in fact better to install EcuFlash and EvoScan to folders not under Program Files as Vista and Win7 both make duplicate copies of files held there and this becomes a problem when updating EcuFlash and EvoScan to newer versions. Consequently, I always install and setup as follows:



When first installed, the EcuFLASH will not look exactly like this. There will be a Subaru folder and a Mitsubishi folder, each having the standard release XML files for that particular release version. I delete the Subaru folders, rename the Mitsubishi folder to the current EcuFLASH version so I have a current copy. Then I copy across my current personal EcuFLASH folders with all my working definitions and client ROMs. You will be adding new items to your definition file as the months go by and new items to tune are found. These new items may never get included in the official releases, so they become quite valuable to you.

When finished installing, open the EcuFLASH folder, make a short-cut of the EcuFLASH exe file and set it into your desktop for easy access. Now have a quick look at the definition file for your vehicle. Right click on the selected file and select:

Open With > Notepad

Or

Open With > Notepad++Portable

1.6-XML DEFINITION FILES

While a lot has been revealed of what is in the ROM, by no means have all data items or tables been uncovered, or released. For example, at the time of writing this revision, the parameters for ignition cranking have not been available in the various Evo forums. There are many other functions yet to be described or defined.

In addition, parameters (1D), tables (2D) and maps (3D) may have been found and described for some ROMs that are in wide use in the EVO community, but not for the more obscure vehicles. Definition files for these cars/ROMs are either poor or non-existent. This means you as the tuner will have to do a lot of the hard slog to winkle the main data from the ROM binary file. With perseverance, it can be done by closely examining known files with a hex editor and then searching the unknown ROM.

Definition files can be created or altered with a plain text editor, such as Windows NOTEPAD. When working on definition files, the file name extension must be xml.

The definition file has to follow a specific format to be valid and thus read properly and requires the operator to know the absolute hex address in the raw binary (BIN) code of the parameter to be added or modified.

There are a strict set of format rules for definition files to work properly, so the best approach is to copy a section containing a similar function, paste it into the file, then edit it to the new parameters. Note that the datum 'level=x' refers to the user level, where Level1=Developer, Level2=Advanced, Level3=Intermediate. No level command allows access to all user levels. There is a good xml description, with rules, in Wikipedia.

Below is a stripped down section of definition file for a JDM Evo7, showing the essential elements for a valid definition file. For EcuFLASH to read your ROM the **xmlid**, the **internalidhex** and the four data bytes at address F52 have to match. Note that EcuFLASH likes hex data in lower case. Hex editors are usually case insensitive.

```
<rom>
        <romid>
                <xmlid>98640014</xmlid>
                <internalidaddress>f52</internalidaddress>
                <internalidhex>98640014</internalidhex>
                <make>Mitsubishi</make>
                <market>JDM</market>
                <model>Lancer</model>
                <submodel>Evo 7</submodel>
                <transmission>Manual</transmission>
                <year>2002</year>
                <flashmethod>mitsukernel</flashmethod>
                <memmodel>SH7052</memmodel>
        </romid>

<scaling name="Timing" units="degrees" toexpr="x" frexpr="x" format="%.0f" min="-61" max="61" inc="0.1" storagetype="int8" endian="big"/>

<scaling name="RPM" units="RPM" toexpr="x*1000/256" frexpr="x*256/1000" format="%.0f" min="0" max="11000" inc="50" storagetype="uint16" endian="big"/>

<scaling name="Load" units="g/S" toexpr="x*10/32" frexpr="x*32/10" format="%.0f" min="0" max="300" inc="1" storagetype="uint16" endian="big"/>

<table name="High Octane Ignition Map 1" category="IGNITION TIMING" address="3b85" type="3D" swapxy="true" scaling="Timing">
<table name="Load" address="503a" type="X Axis" elements="19" scaling="Load"/>
<table name="RPM" address="500a" type="Y Axis" elements="19" scaling="RPM"/>
</table>
</rom>
```

Following after all the romid stuff is the scaling data. These describe the size and format of the units being used. The scaling expression needs to be read by EcuFLASH before the function that references the scaling.

Then come all the parameters, tables and maps. All the essential elements to make a valid definition are shown, the name, category, the binary address, type, and scaling used. Then follows the scaling used on the two axis, in this case Load and RPM, with the relevant address and element size and the scaling.

The </rom> bit at the end is required to close the file correctly.

Note 1:
toexpr="x/10" is a sample formula which converts the raw ROM data from hex to a decimal value, then applies the formula for conversion to suitable scaling units for display on the EcuFLASH window.

Note 2:
frexpr="x*10" is the corresponding reciprocal formula to convert data entered in an EcuFLASH window back into the ROM which the ECU will understand.

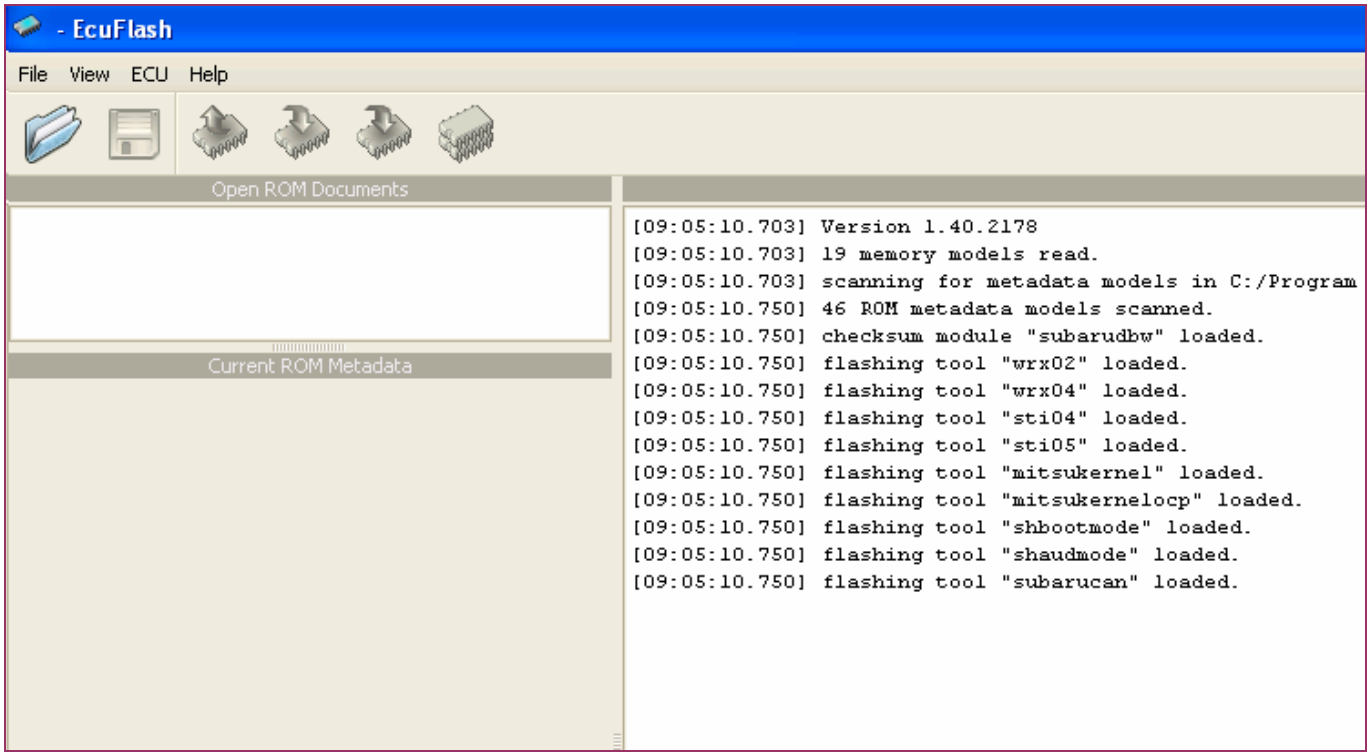
Note 3:
format="%.1f" will give displayed values to 1 decimal place. %.0f will have no decimal places and will round off the displayed value.

Note 4:
storagetype="uint8" means a one byte data variable (8 bits).
storagetype="uint16" means a two byte data variable (16 bits).

1.7-RUN ECUFLASH

Start the EcuFLASH program from the desktop icon you previously created. You will see The usual MS pull-down tabs, a Folder tab, a Save tab and four little integrated circuit icons, symbolizing the ECU, three with arrows and the fourth one doubled.

Figure 3: EcuFLASH – v1.40 OPENING VIEW



There are four preliminary steps to do before proceeding with connecting to the ECU for the first time.

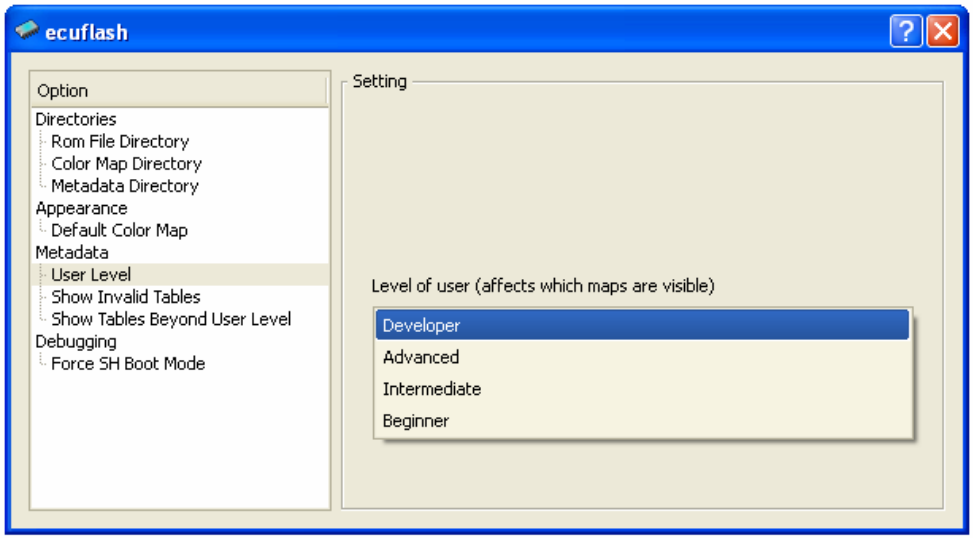
1.8-SETTING THE USER LEVEL & DIRECTORY

To set the User Level, select:
File \ Options to get the window shown below.

Then click on:
User Level \ Developer. This will allow you to gain access to all defined parameters.

If you don't want to be bothered with any of this "user level" palaver, then strip out the "level=1234" etc bit from the definition file. This is what I do, saves confusion.

Figure 4: EcuFLASH – USER LEVEL



To set the path to the ROM files for your ECU, click on:
Rom File Directory, then the file folder containing the desired ROM.

To set the path to the XML files for your ECU, click on:
Metadata Directory, then the file folder containing the required XML files.

It is a good idea to have the ROMs and matching xml files in the same directory. To help with file management and housekeeping, I have separate directories for: Evo5-6, VR4-LEGNUM, Evo7GTA, Evo7-8-9, EvoX, ACD+AYC and finally RALLIART.

Note: Do not nest or save old or backup xml or hex/bin files in the OpenEcu directory, as EcuFLASH tends to find them and use them instead of the file you think you have selected. A better idea is to save them under a completely different folder name.

Keep this window open for the moment to setup the default colour map.

1.9-SETTING THE DEFAULT COLOUR MAP

To set or change the COLOUR MAP style, select:
File \ Options

Then click on:
Default Color Map to get the window shown below.

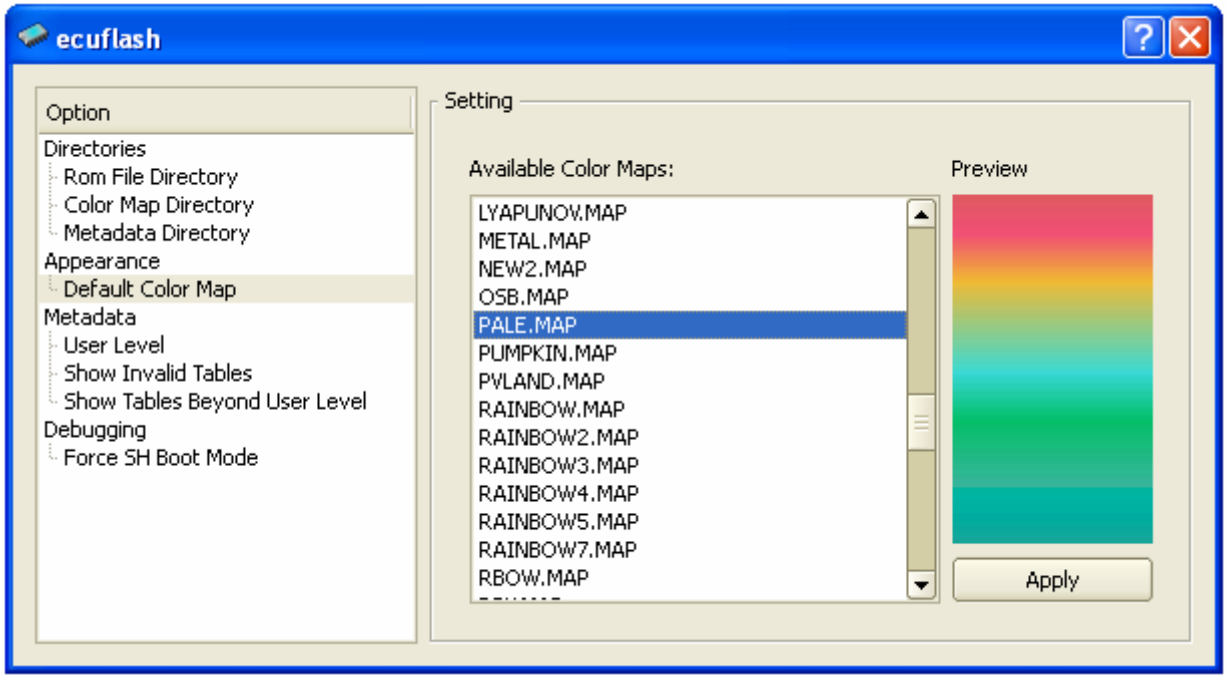
Scroll through the selections and select whatever suites, as some colour styles display better than others or allow easier data viewing. Some of the more readable styles with good graduation are:

BLUORNG, COLDFIRE, FIRESTRM, JFAN, PALE, RAINBOW, VULCANO, SUNSHINE.

FIRESTRM, for example is very good for fuel maps.

Click on:
Apply then close the window.

Figure 5: EcuFLASH – DEFAULT COLOUR MAP STYLE



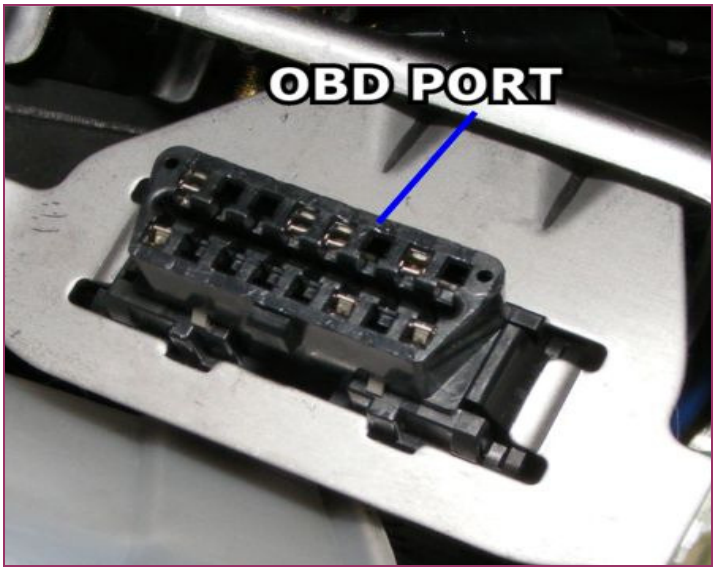
The colour maps can be tweaked to your own tastes. Open the .MAP file to be edited with NOTEPAD. The data is organized in columns, by the three primary colours: red, yellow, blue. The higher the number the percentage that colour.

1.10-CONNECTING to the ECU

First, a caution: It has been reported that cables fitted with a connection to pin 9 can, on very rare occasions, brick the ETACS unit. Pin 9 is a timing pulse signal required for flashing Subaru ECUs and is not required for flashing the Evo EFI controller. If your cable has this pin fitted, the safe move is to remove it with a pair of long-nose pliers.

Ok, you have your OBD-II cable, and have EcuFLASH up-and-running on your laptop. Take a quick look at the photo of the relevant connector. Proceed to the Evo and connect the OBD-II cable to the black OBD-II port. The connector is behind the dash facia, drivers side, adjacent to the centre tunnel. Just feel with your hand and plug the connector into the receptacle. Pix from **Biggles** on MLR.

Figure 6: OBD-II PORT



Plug the USB end of the cable into your laptop, it seems to be a good practice to always use the same port to prevent USB driver conflicts. At least this was a problem when mixing 1.3U cables and OpenPort2 cables.

The cable will talk to the laptop and proceed to install itself. Just follow the prompts and select **Proceed Anyway** when questioned about proceeding.

When the cable is installed and all is ready, the READ ECU icon will light-up with a blue arrow. **Important note, make sure the car battery is charged or the read/write operation may fail.** A failed write is bad news!

1.11-ECU OPERATIONS

There are four ECU operations that can be selected:

Read from ECU – Reads the ECU (all of the flash-ROM) into EcuFLASH.

Write to ECU – Writes the whole of a binary/hex file to the ECU flash-ROM, then checks the write was good.

Test Write to ECU – Uploads the flashing kernel to the ECUs read/write memory (RAM) and sends data blocks to the RAM, thus confirming communications to the ECU. Flash-ROM, where the ECU routines, data tables and maps reside is not written to or changed.

Compare to ECU – Compares the ECU flash-ROM to the ROM currently select in EcuFLASH.

Assuming you want to proceed and read the ECU, turn the ignition key to RUN (not START!). Click on the **Read from ECU** function and then select the type of vehicle type to read. On earlier versions of EcuFLASH, this read window could come up blank with no vehicle type to select. If this happens, close the application and copy the contents of the "read templates" folder into your ROM directory and then EcuFLASH will find the files it wants.

EcuFLASH will now proceed to download the ROM image from your ECU. When the read operation is completed, EcuFLASH will attempt to access the ROM, by reading the ROM identity code. If there is a matching XML definition file available in the selected mettadata directory, EcuFLASH will open the XML definition file and the ROMs contents can be examined with the menu bar.

Save the ROM now, use your own name or something you wont forget or lose. This is your base ROM file, from which all your on-going tuning will be derived. I would structure ROM labels in a uniform way so they will automatically stay organized in the ROM folder and it is easy to keep track of which is the latest version/mod. So my ROM files will typically look like the following:

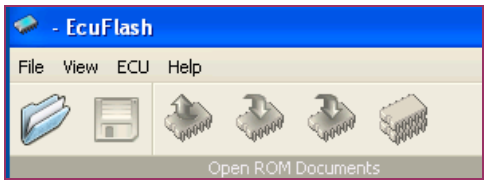
88590013_logic_01.hex

The first 8 digits are the ROM identifier, the second group is a name tag for whose ROM it came from, and the last two digits are the version/iteration/mod level. I use _00 as a base un-modified example for that ROM type, _01 for the first read and save for a clients ROM, thus ensuring his immobilizer code is not lost or obliterated. Subsequent tune versions get incremental numbers. Windows will thus keep all related files grouped and organized.

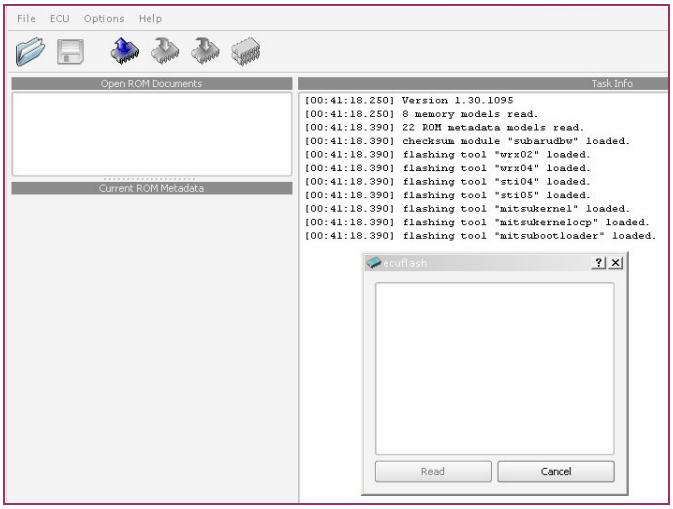
1.12-ECU READ FAILED or CANNOT CONNECT

There are several possible problems that may arise when first time connecting:

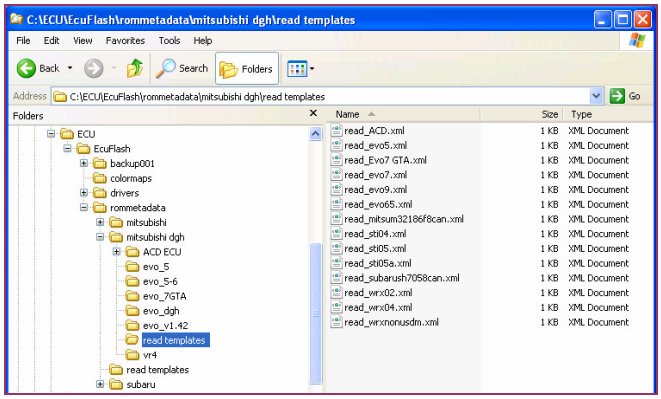
1. Grey Up-Load Icon - Nothing happens when you click on the Up-Load Icon, this is EcuFLASH indicating there is no OBD-II cable detected. Check the cable is connected properly. If it remains grey, the cable is faulty, or there is no 12 volt supply to pin 16 of the OBD-II connector.



2. Blank Vehicle Read Selection Window – EcuFLASH is looking for the vehicle "read template" in the wrong location or folder. The program can sometimes get its knickers in a knot over this, I don't know why.



Close EcuFLASH, open the directory tree with Explorer. Find the read templates folder. Copy the read templates folder into the ROM folder. If it still comes up blank, copy the template xml files directly into the ROM folder.

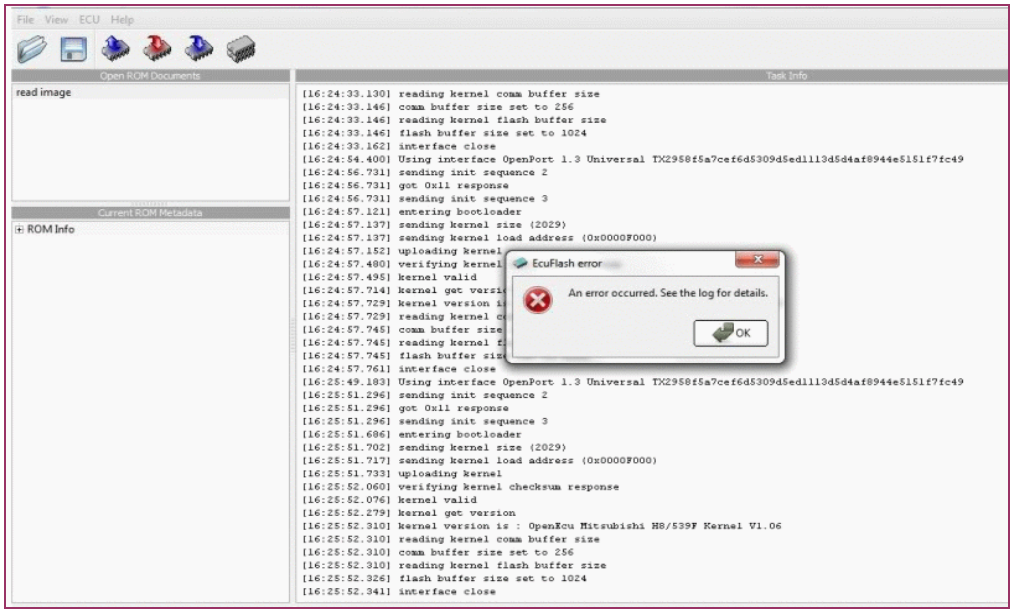


3. Ignition Key position set to ACC – Every one does this sooner or later. Set the ignition key to the ON position. The Check Engine Light is lit when the key is in the correct position.

4. Read Fails, Battery Voltage Low – This is more common with Evo9 than Evo7-8. If your battery voltage is a volt or two lower than the charged 13.8 volts it will not allow a read or write operation. If the car has been sitting for a week or more, start and run the engine for a few minutes before attempting a read/write.

If I am expecting to have the ECU switched on for an extended time (say over a half hour) with a number of read/write cycles, I would consider connecting a battery charger to the battery to make sure it is kept topped-up.

5. An error occurred. See log for details- There are a number of possibilities. In this case, trying to read an Evo6 (with a 7202 chip) with a 1.3U cable was the problem. The Evo5-6 ECU will require the OpenPort2 cable. Read the log message for some clues to the problem. Save a screen shot of the log for posting an enquiry on EvoM or MLR etc if you require further help.



1.13-UNKNOWN ECU ERROR

If there is no XML configuration file that is setup for your ECU/ROM, then EcuFlash will report it as "UNKNOWN" and will prompt you try and create a suitable file. I have never had much success with this and so I save the unknown ROM, and close EcuFlash. At this point I will read the unknown ROM with XVI32 hex editor application and find its ROM number.

Open XVI32, select **File\Open** brows to the new unknown ROM and select it. It is helpful to have XVI32 setup so that it displays data as a 16x16 grid. To achieve this, select **Tools\Options\Appearance**. Set the **Number of Rows** to 16 and **Number of Columns** to 16. The columns can be increased as required when using XVI32 as a search and examination tool on new ROMs.

When XVI32 has opened the ROM, select **Address\GoTo** 50020.
Note that the buttons **hexadecimal** and **absolute** should be selected.

The application will jump to address 50020 as the top line. The 8 digit ROM identifying number starts at address 50020A in hexadecimal and is four bytes long. Write these four two digit numbers down, they should be something like - 53 61 00 10.

Close XVI32 and open a RALLIART or EvoX XML file with a suitable editor such as Notepad, we will edit the file to get a starting XML for the new ROM.

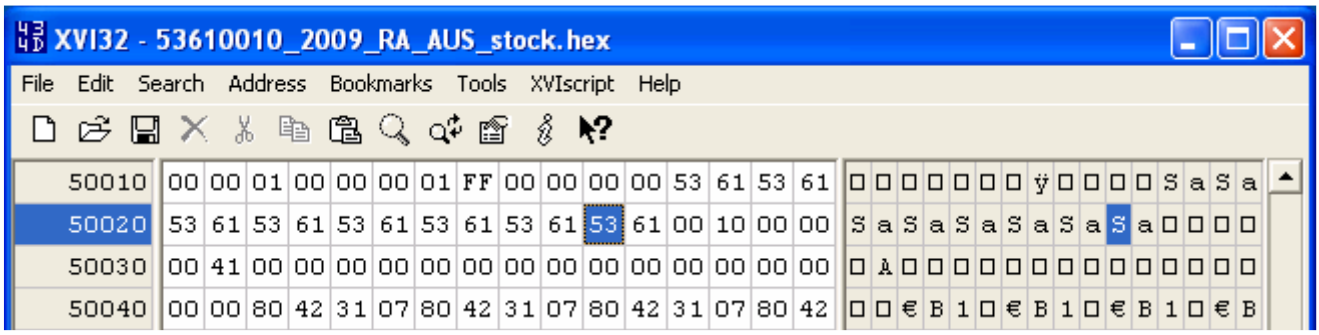
Edit the line <xmlid> to the number you found in the new ROM.

Edit the line <internalidhex> to the number you found in the new ROM.

Save the file with the new number as part of its file name, so you can easily identify it later for editing purposes.

Open EcuFlash, then select File\Open ROM and select the new ROM, EcuFlash should now be able to open the ROM. Likely many items will be wrongly defined but you now have a starter XML file to work with. The gents doing the code disassembly and patching are not attempting to modify or examine in-depth all the ECU codes Mitsubishi have produced, so it may be expedient to use another ROM code in your ECU if yours is not well supported by the tuning community.

Figure 7: XVI32 – ROM IDENTIFIER NUMBER



1.14-EDITING FUNCTIONS and 3D GRAPH VIEWING

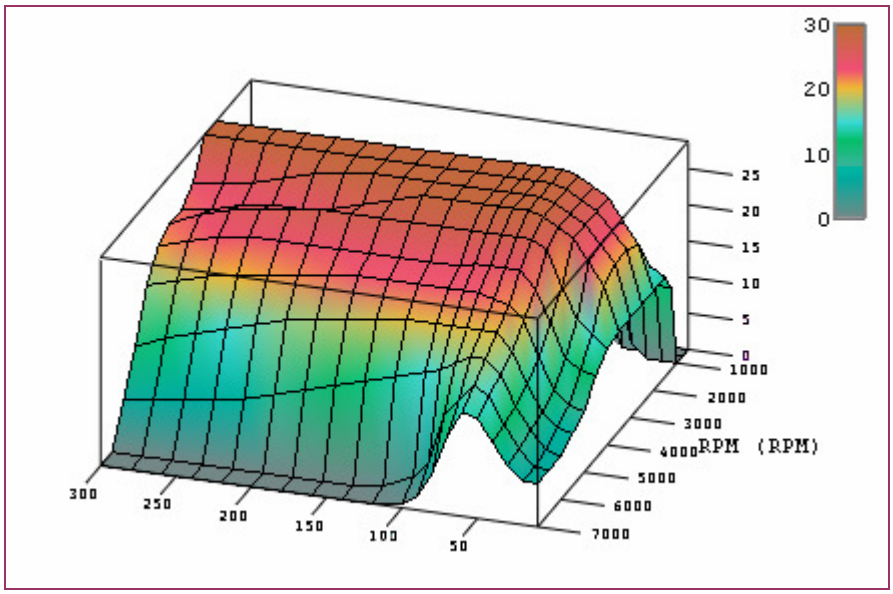
Select an item that you wish to view for editing.
Select Edit, the available editing functions are displayed and are as follows:

Decrement:	Use the **[** key to decrement map values.
Increment:	Use the **]** key to increment map values.
Move:	Use the ← ↑ → ↓ keys to move around the map.
Undo:	Ctrl+Z
Redo:	Ctrl+Y
Select All:	Ctrl+A
Copy:	Ctrl+C
Paste:	Ctrl+V
Revert:	Ctrl+R
Set Data:	=
Add to Data:	Alt++
Multiply Data:	*
Interpolate Vertically:	Alt+V
Interpolate Horizontally:	Alt+H
Interpolate 2-D:	Alt+B
Edit Map Definition:	Ctrl+M

Select a map that you wish to view in graphic mode for editing.
Select View\View Graph.
The graph can be toggled on/off with the Alt+G keys.

A sample MIVEC map is shown below in graphical view. It can be rotated etc by placing the mouse pointer near the graph, hold-down the left button and rotate as required.

Figure 8: EcuFLASH – GRAPHING EXAMPLE



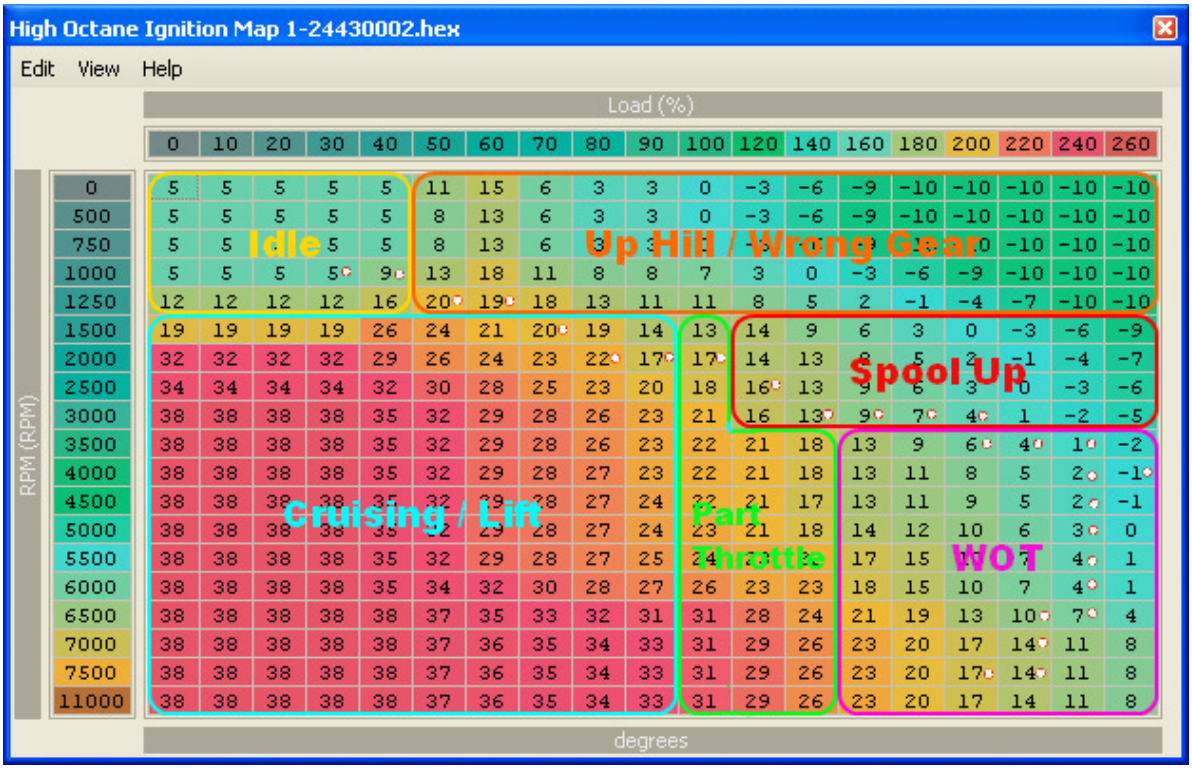
1.15-GETTING STARTED – PRELIMINARY TUNING ACTIVITIES

Next, if you have one, you should install the WBO2 properly on your Evo. Preferably, do not install the WBO2 sensor behind the Catalytic Converter, as this will give you erroneous (slightly leaner) AFR readings. The best position to place the sensor is in the down pipe 2 inches before the CAT flange in the three o'clock position where it won't knock against the transmission tunnel etc. Do not place the sensor in any position below horizontal, as condensation may form on the sensor and ultimately ruin it.

Next-up, you have to go out and log data from your Evo. This should include logs of warm-up running, idling, cruising, long straight up-hill runs in 3rd gear and 4th gear, WOT, from 2500 rpm all the way to 7500 rpm. Keep logging parameters to the essential data, AFR, timing, load, TPS, RPM, Knock, boost (if possible), coolant temp, IAT, injector pulse width, and injector duty cycle and fuel trims. You should study and understand what the data means.

The first points of critical interest to check are the fuel trims and knock. Fuel trims larger than ±5% should be rectified; the INJECTOR TUNING section has details on this. Knock will need to be identified and assessed as real or phantom/false. False knock can now be dialed-out, thanks to the efforts of **jcsbanks** and our Evo community dis-assemblers and tuners! The KNOCK TUNING section has all the details.

Now read-on through the guide and see just what can be tuned. Remember; make small incremental and smooth changes to the tables. The figure below, from **Ceddy** on EvoM shows the variously labeled areas commonly referred to in the guide.



SECTION 2 – MODE23 LOGGING SETUP

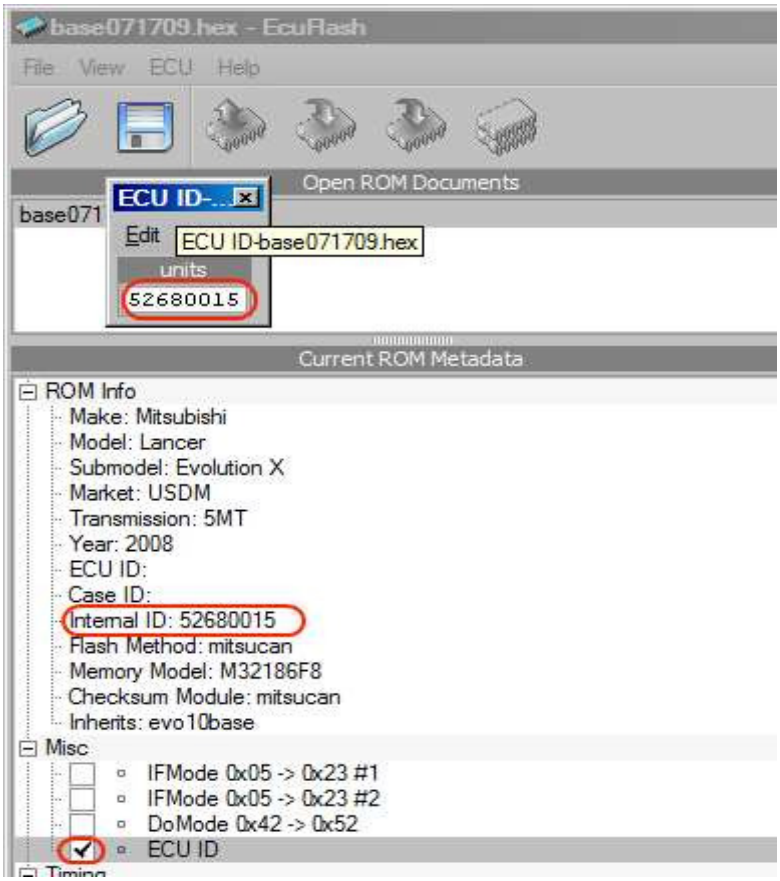
2.01-MODE23 SETUP – INTRODUCTION

OBD-Mode23 is a very cool function as it allows you to request any memory address and the ECU will fetch for logging the current stored value. The down-side is identifying the required addresses, this will take the dis-assemblers some time to accomplish.

The stock ROM image will require modifying to enable Mode23 before you will be able to perform any logging activities with EvoScan. There are three data items to be edited, and your XML file may also need additional settings before this can be done.

2.02-MODE23 SETUP – ROM IDENTIFICATION

It is essential that you ROM is correctly identified, as the addresses required are different for various models. Open EcuFlash, connect your cable to the car and read the ECU. Assuming there is a valid XML file available in the rommettadata folder, the ROM should open and you can identify the ROM as shown below.



2.03-MODE23 SETUP – XML DATA EDIT

Copy the section shown below for your ROM into the Misc section of your XML.

52690019
<table name="IFMode 0x05 -> 0x23 #1" category="Misc" type="1D" address="0x7f121" scaling="Hex8"/>
<table name="IFMode 0x05 -> 0x23 #2" category="Misc" type="1D" address="0x8aafd" scaling="Hex8"/>
<table name="DoMode 0x42 -> 0x52" category="Misc" type="1D" address="0x8ab02" scaling="Hex16"/>

53040007 -> 53040010
<table name="IFMode 0x05 -> 0x23 #1" category="Misc" type="1D" address="0x7f145" scaling="Hex8"/>
<table name="IFMode 0x05 -> 0x23 #2" category="Misc" type="1D" address="0x8aa59" scaling="Hex8"/>
<table name="DoMode 0x42 -> 0x52" category="Misc" type="1D" address="0x8aa5e" scaling="Hex16"/>

52680015 -> 52680020
<table name="IFMode 0x05 -> 0x23 #1" category="Misc" type="1D" address="0x7f121" scaling="Hex8"/>
<table name="IFMode 0x05 -> 0x23 #2" category="Misc" type="1D" address="0x8ab11" scaling="Hex8"/>
<table name="DoMode 0x42 -> 0x52" category="Misc" type="1D" address="0x8ab16" scaling="Hex16"/>

52360018
<table name="IFMode 0x05 -> 0x23 #1" category="Misc" type="1D" address="0x7f58d" scaling="Hex8"/>
<table name="IFMode 0x05 -> 0x23 #2" category="Misc" type="1D" address="0x8ada5" scaling="Hex8"/>
<table name="DoMode 0x42 -> 0x52" category="Misc" type="1D" address="0x8adaa" scaling="Hex16"/>

53600010
<table name="IFMode 0x05 -> 0x23 #1" category="Misc" type="1D" address="0x7efbd" scaling="Hex8"/>
<table name="IFMode 0x05 -> 0x23 #2" category="Misc" type="1D" address="0x8aa61" scaling="Hex8"/>
<table name="DoMode 0x42 -> 0x52" category="Misc" type="1D" address="0x8aa66" scaling="Hex16"/>

53050006 -> 53050009
<table name="IFMode 0x05 -> 0x23 #1" category="Misc" address="7f145" type="1D" scaling="Hex8"/>
<table name="IFMode 0x05 -> 0x23 #2" category="Misc" address="8a9f1" type="1D" scaling="Hex8"/>
<table name="DoMode 0x42 -> 0x52" category="Misc" address="8a9f6" type="1D" scaling="Hex16"/>

54060007
<table name="IFMode 0x05 -> 0x23 #1" category="Misc" address="7efc1" type="1D" scaling="Hex8"/>
<table name="IFMode 0x05 -> 0x23 #2" category="Misc" address="8aa7d" type="1D" scaling="Hex8"/>
<table name="DoMode 0x42 -> 0x52" category="Misc" address="8aa82" type="1D" scaling="Hex16"/>

54070007
<table name="IFMode 0x05 -> 0x23 #1" category="Misc" address="7efc1" type="1D" scaling="Hex8"/>
<table name="IFMode 0x05 -> 0x23 #2" category="Misc" address="8aa69" type="1D" scaling="Hex8"/>
<table name="DoMode 0x42 -> 0x52" category="Misc" address="8aa6e" type="1D" scaling="Hex16"/>

55570005
<table name="IFMode 0x05 -> 0x23 #1" category="Misc" address="7f10b" type="1D" scaling="Hex8"/>
<table name="IFMode 0x05 -> 0x23 #2" category="Misc" address="8ad5f" type="1D" scaling="Hex8"/>
<table name="DoMode 0x4D -> 0x5D" category="Misc" address="8ad66" type="1D" scaling="Hex16"/>

53610010 AUS RALLIART
<table name="IFMode 0x05 -> 0x23 #1" category="Misc" address="7efb1" type="1D" scaling="Hex8"/>
<table name="IFMode 0x05 -> 0x23 #2" category="Misc" address="8a919" type="1D" scaling="Hex8"/>
<table name="DoMode 0x42 -> 0x52" category="Misc" address="8a91e" type="1D" scaling="Hex16"/>

53610013 AUS RALLIART
<table name="IFMode 0x05 -> 0x23 #1" category="Misc" address="7f029" type="1D" scaling="Hex8"/>
<table name="IFMode 0x05 -> 0x23 #2" category="Misc" address="8ab39" type="1D" scaling="Hex8"/>
<table name="DoMode 0x42 -> 0x52" category="Misc" address="8ab3e" type="1D" scaling="Hex16"/>

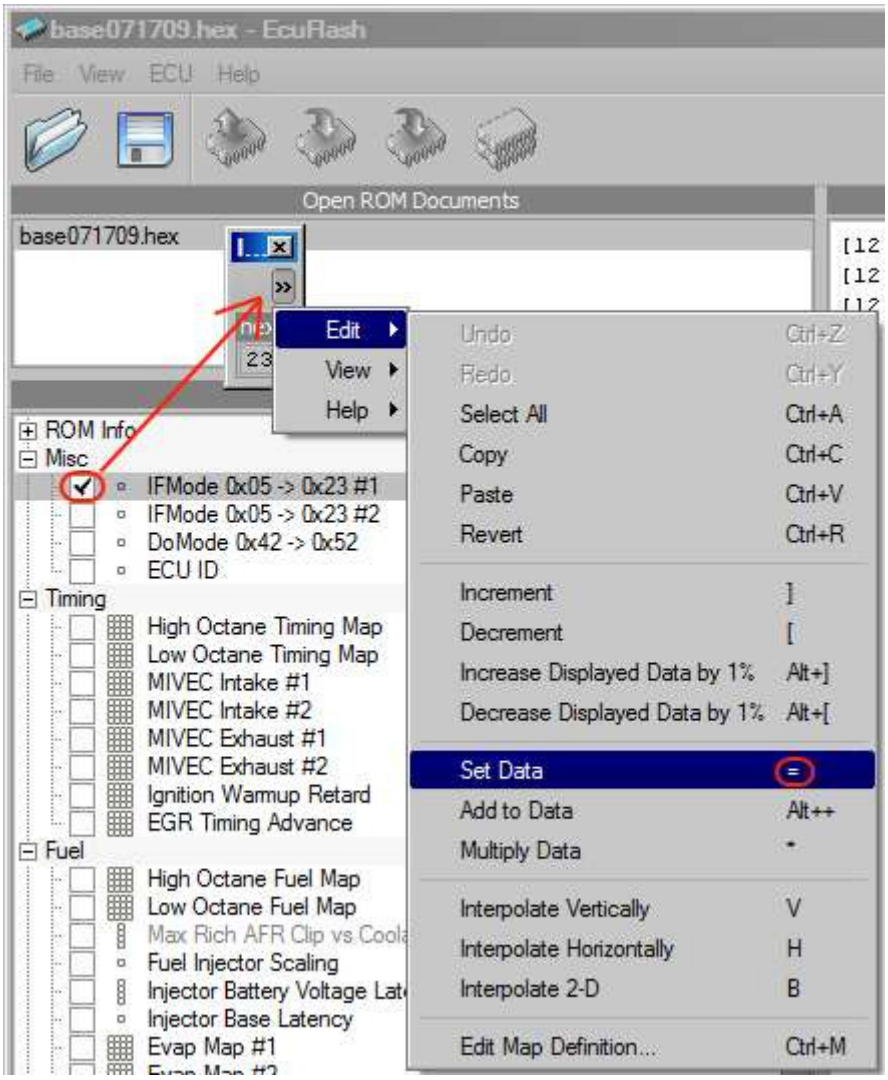
55580005 -> 55580006
<table name="IFMode 0x05 -> 0x23 #1" category="Misc" type="1D" address="0x7f10b" scaling="Hex8"/>
<table name="IFMode 0x05 -> 0x23 #2" category="Misc" type="1D" address="0x8ad4b" scaling="Hex8"/>
<table name="DoMode 0x4D -> 0x5D" category="Misc" type="1D" address="0x8ad52" scaling="Hex16"/>

55590006 -> 55590007 USA RALLIART
<table name="IFMode 0x05 -> 0x23 #1" category="Misc" address="7f107" type="1D" scaling="Hex8"/>
<table name="IFMode 0x05 -> 0x23 #2" category="Misc" address="8ad43" type="1D" scaling="Hex8"/>
<table name="DoMode 0x4D -> 0x5D" category="Misc" address="8ad4a" type="1D" scaling="Hex16"/>

2.04-MODE23 SETUP – ROM DATA EDIT

After saving the edited XML file, re-open EcuFlash and edit the data in your ROM.

All three items need to be changed, but open all three first. If the data does not match the description, stop and do not make any changes – your XML does not have the correct address for the data items.



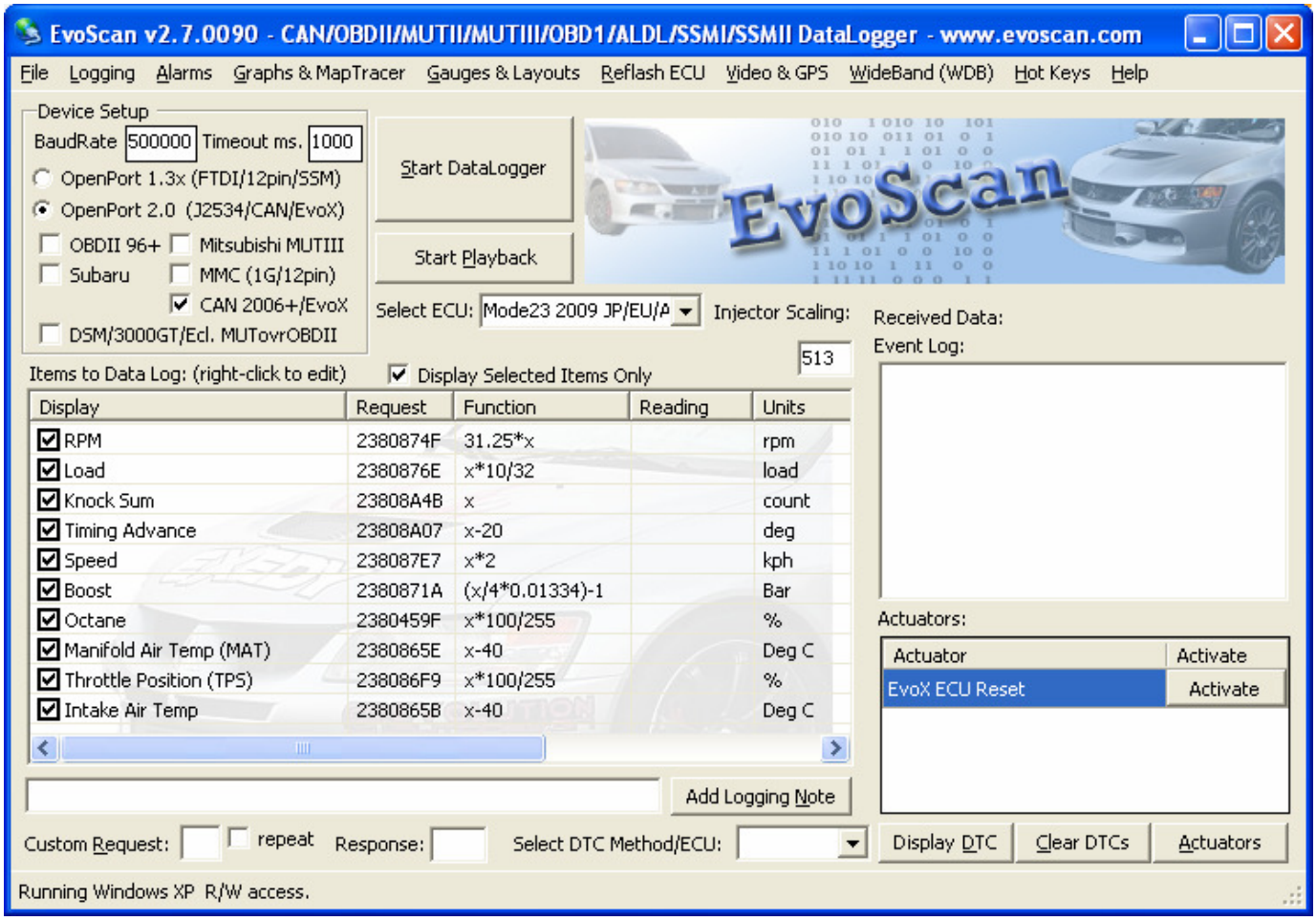
When the data items have been correctly edited, save the ROM to file, then flash the new edited ROM back into the ECU.

2.05-MODE23 SETUP – EVOSCAN SETTINGS

Open EvoScan, and setup as follows:

BaudeRate	500000
Timeout	1000
Cable	OpenPort 2.0
Interface	CAN 2006+/EvoX

There is a pull-down tab called Select ECU with a set of selections available. Select the value that best describes you vehicle.



Start a data log with the engine running and verify correct operation.

SECTION 3 – DIAGNOSTIC TROUBLE CODES

3.01-OBD-II DTC INTRODUCTION

The Diagnostic Trouble Code numbering follows a standardized structure. All Diagnostic Trouble Codes have a letter followed by a 4-digit number (e.g. P1234). The first letter indicates the type of code:

P = Power-train
C = Chassis
B = Body
U = Network Communication

The remaining 4-digit number specifies the problem within that system. The fault codes documented here have been abbreviated and restricted for simplicity to a four cylinder twin-cam with two oxygen sensors.

The RALLIART and EvoX coding has many sophisticated constraints embedded in the ROM that are not in earlier versions of the Evolution. What typically happens is when you make modifications to improve breathing and increase boost levels, one or more of the boundary or limit tables or timers will be exceeded, thus triggering some DTC.

This must have been a constant source of irritation through-out 2009 but the tuning community, spearheaded by **tephra** de-coding the various ROMs, have found ways to get around the problems.

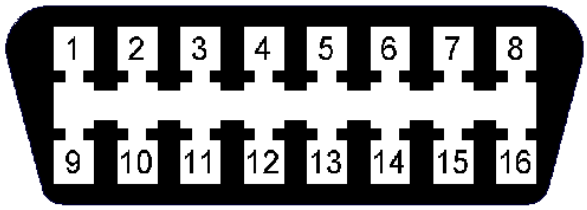
3.02-OBD-II DIAGNOSTIC CONNECTOR

The connector is behind the dash facia, drivers side, just out-board of the steering column on the EVOX and RALLIART. Just feel with your hand and plug the OpenPort2 cable into the 16 pin socket.

The OBD-II specification provides for a standardized hardware interface, SAE J1962 defines the pin-out of the connector as:

Table 2 OBDII CONNECTOR PIN FUNCTION

DESCRIPTION	PIN #		DESCRIPTION
	8	16	BATTERY VOLTAGE
ECU - K line	7	15	L line of ISO9141-2 & ISO14230-4
CAN high ISO15765-4 & SAE-J2234	6	14	CAN low ISO15765-4 & SAE-J2234
SIGNAL GROUND	5	13	
CHASSIS GROUND	4	12	
	3	11	
Bus positive line of SAE-J1850	2	10	Bus negative line of SAE-J1850
	1	9	ETACS



Note that it is now considered a good idea to remove pin 9 from the OpenPort2 cable to prevent damage to the ETACS ECU. Pin 9 is only used for flashing Subaru ECUs.

3.03-DTC ELIMINATION – REAR O2 SENSOR RELATED DTC

These are codes:

P0420 Catalyst System Efficiency Below Threshold
P0139 O2 Sensor Circuit Slow Response
P0140 O2 Sensor Circuit No Activity Detected

To eliminate these DTC, two steeps need to be done:

First, open ECU OPTION SET #2 and set bit 01 = 0.

Second, do the P0139 / P0140 disable, for your particular ROM, as shown below.

3.04-DTC ELIMINATION SETUP – XML DATA EDIT

The DTC Disable definition segments will look like the sample shown below.

Find the correct values for your ROM at evolutionm.net in "the DTC Disable thread".

Copy the section for your ROM into the Misc section of your XML. Or, you can do as I have done and make a new category called "DTC Disable".

Open each of the table entries and check that the data matches the label, before making any changes.

If it does not match, do not change the values, there is some error!

Check on evolutionm.net for an update or correction etc. Entering the wrong data here **will** brick your ECU.

```
53610010
<table name="DTC P1238 Disable 0x0384 -> 0xFFFF" category="DTC Disable" address="63210" type="1D"
scaling="Hex16"/>
<table name="DTC P1241 Disable 0x03E8 -> 0xFFFF" category="DTC Disable" address="63206" type="1D"
scaling="Hex16"/>
<table name="DTC P1235 Disable 0x0026 -> 0xFFFF" category="DTC Disable" address="549d4" type="1D"
scaling="Hex16"/>
<table name="DTC P1233 Disable 0x0028 -> 0xFFFF" category="DTC Disable" address="549d0" type="1D"
scaling="Hex16"/>
<table name="DTC P1234 Disable 0x0028 -> 0xFFFF" category="DTC Disable" address="549d2" type="1D"
scaling="Hex16"/>
```

SECTION 4 – FUEL TUNING

4.01-INTRODUCTION TO RALLIART & EVOX FUEL METERING

The basic function of the ECU is to calculate the correct amount of fuel and ignition advance required by the engine at any rpm and load, within it's normal design operating range. To make these calculations it needs an accurate measure of how much load the engine is under.

The RALLIART's primary load sensor is the Mass Air Flow Meter (MAF). It is the ECUs biggest asset, but it can be a limiting factor to the engines ultimate performance when attempting to tune beyond the factory parameters. The MITSUBISHI RALLIART and EVO X use a HOTWIRE type MAF, which has a varying DC output voltage, proportional to air-flow. The mass of the air is calculated by using the diameter of the intake tube the sensor is mounted on.

The MAF makes a measurement of the mass of air entering the engine. At this point the measurement is un-corrected and requires manipulation from the following tables:

1. MAF SIZE.
2. AIR TEMP.
3. BAROMETRIC PRESSURE.

At this point load is calculated and is applied to lookup the fuel and ignition maps. Note that not all the compensations have been factored-in yet. The ECU now determines the mass of fuel required for a specific Air Fuel Ratio by checking:

4. MAF SMOOTHING.
5. BARO + TEMP v RMP.
6. FUEL MAP.
7. INJECTOR SCALING.
8. INJECTOR LATENCY.

Now the conditional parameters can be included, such as:

9. ACCEL ENRICHMENT.
10. WARMUP ENRICHMENT.
11. CLOSED LOOP.
12. LEAN SPOOL.

Because of this, injectors and even the MAF itself can be up-graded to a larger size without requiring a major re-tune, as would be the case with a manifold absolute pressure (MAP) based load sensing, aka speed-density. The characteristics of the injectors are defined in ROM as the INJECTOR SCALING and INJECTOR LATENCY. Scaling defines the flow capacity of the injector in cc/min, while the latency parameter is the time in milli-seconds for the injector to turn on. This parameter may be variously referred to as 'dead-time' or 'void blast-off time'.

AFR refers to how many parts of air are mixed with how many parts of fuel. So an 11:1 AFR means that 11 parts of air are being mixed with 1 part of fuel to create the air/fuel mixture. When your EVO is at idle or when your EVO is at cruising speeds your AFR is around 14.5-14.7:1. This is known as stoichometric or stoich for short.

It has been found that the 14.7:1 mixture produces the least amount of emissions. And since city cars spend 90% of their time at idle, or in cruise, then that is the number that the manufacturers use to reduce the emissions on their car.

It is worth noting that the 14.7:1 AFR does not produce the best gas mileage. The best gas mileage is produced at approximately 15.2:1 AFR.

What AFR produces the best power for gasoline? Gasoline gives the best power when it burns at an AFR of 12.5:1. This is regardless of whether the car is normally aspirated, turbocharged, or supercharged.

The following summary shows the story – for **gasoline**:

AFR	COMMENT
06:1	Rich run limit.
09:1	Low power with black haze.
11.5:1	Rich best torque at WOT.
12.5:1	Safe best power at WOT.
13.2:1	Lean best torque at WOT.
14.7:1	Stociometric ideal burn AFR for gasoline.
15.5:1	Lean light load, cruise/part throttle.
16.2:1	Best economy, cruise/part throttle.
18:1	Lean run limit.

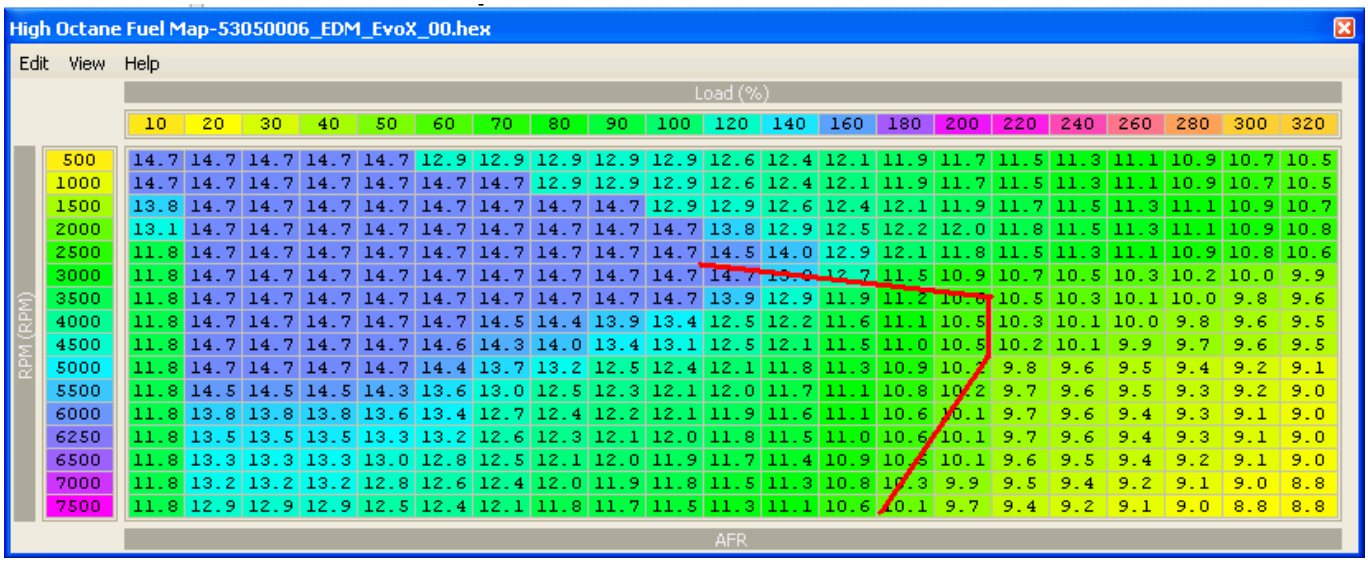
The RALLIART ECUs all have one HI-OCTANE fuel map and one LO-OCTANE fuel map, where the values in the 3D maps are shown as desired final AFRs.

So what does the AFR look like on a completely stock RALLIART? The stock HI-OCTANE fuel map clearly shows the Mitsubishi engineers intentions and what the 4B11 engine needs to run well. Large portions of the 3D map are set to an AFR of 14.7:1 and the closed loop control will happily track this fairly well. This yields good fuel economy and drivability.

But then comes the boost and the short answer is PIG RICH at high boost levels! It is tuned that way to maintain thermal management of the head, turbo and catalytic converter with sustained WOT operating conditions, and thus not incur warranty returns.

Here is the approx path a 100% stock EVO X takes through the Fuel map at WOT.

Figure 9: EcuFLASH – HI OCTANE FUEL MAP LOAD TRACE – EDM EVO X



So, low 10s for this EDM EVO X and mid 9 air fuel ratios for a 100% stock USDM EVO X. Such rich mixtures can cause ignition misfiring under wide open throttle as the engine is choking on it's own fuel. This will clear up once the car is leaned out and running mid 11 air fuel ratios.

With a good drop-in panel filter, like the K&N and HKS units, the AFR will lean out about 0.5 - 0.7 AFR or so. Dyno testing with a HKS drop-in filter will typically show a 20whp/15wtq improvement, just by the fuel being leaner.

An AEM intake with the whole upgraded intake tube and MAF housing will lean the car out over 1 full AFR point.

Setting your AFR depends to a large extent on the boost and timing that your car is running. I generally set the AFR at 12.5-12 during spool up, 11.7-11.5 during peak boost, and then slowly taper the AFR until it hits 11.3 by the 7000rpm.

4.02-FUEL TUNING – STOCK LO-OCTANE FUEL MAP

This is the LO-OCTANE FUEL MAP, which the ECU interpolates with the HI-OCTANE FUEL MAP, depending on knock activity.

When the ECU detects detonation, with a KNOCKSUM greater than six, the "octane number" that the ECU has stored is reduced. If detonation continues to occur, then the ECU will interpolate between the hi-low-octane maps, with a calculation using the octane number.

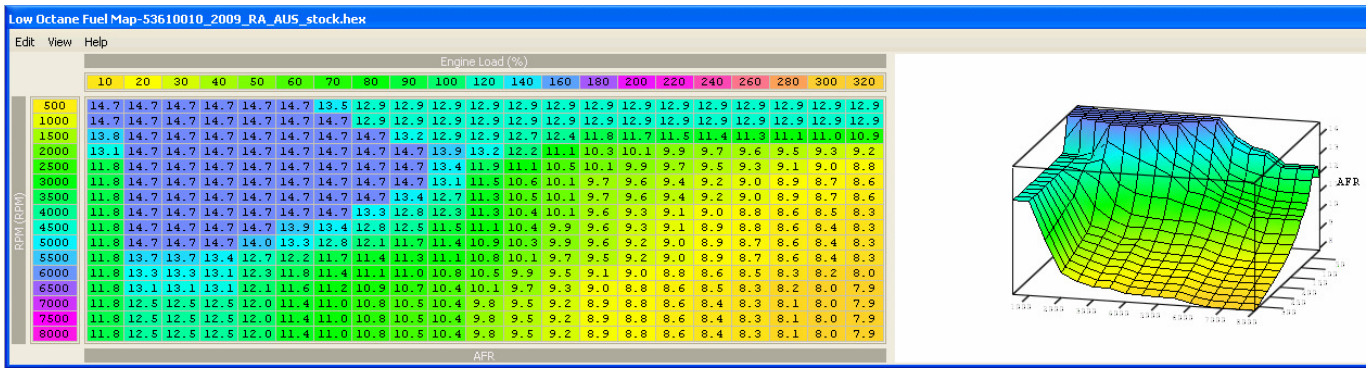
The ECU will then continue to operate proportionally between the high and low octane maps, until an absence of knock is noted in a boost condition (when operating above the OCTANE UPDATE THRESHOLD), at which point the octane number is progressively increased and operation rapidly reverts back to the HI OCTANE FUEL MAP.

The table scaling normally matches the HI OCTANE map, but does not have to be the same. The graphing function can be used with the fuel maps, this helps with spotting and smoothing any errant peaks and hollows.

The maps shown below are the stock LO-OCTANE fuel maps for 53610010 RALLIART and 53060006 EDM EvoX. They are quite similar and both are soggy rich. If you add warm-up enrichment the ignition system is going to have a hard time punching a spark through this lot. These could do with some tuning.

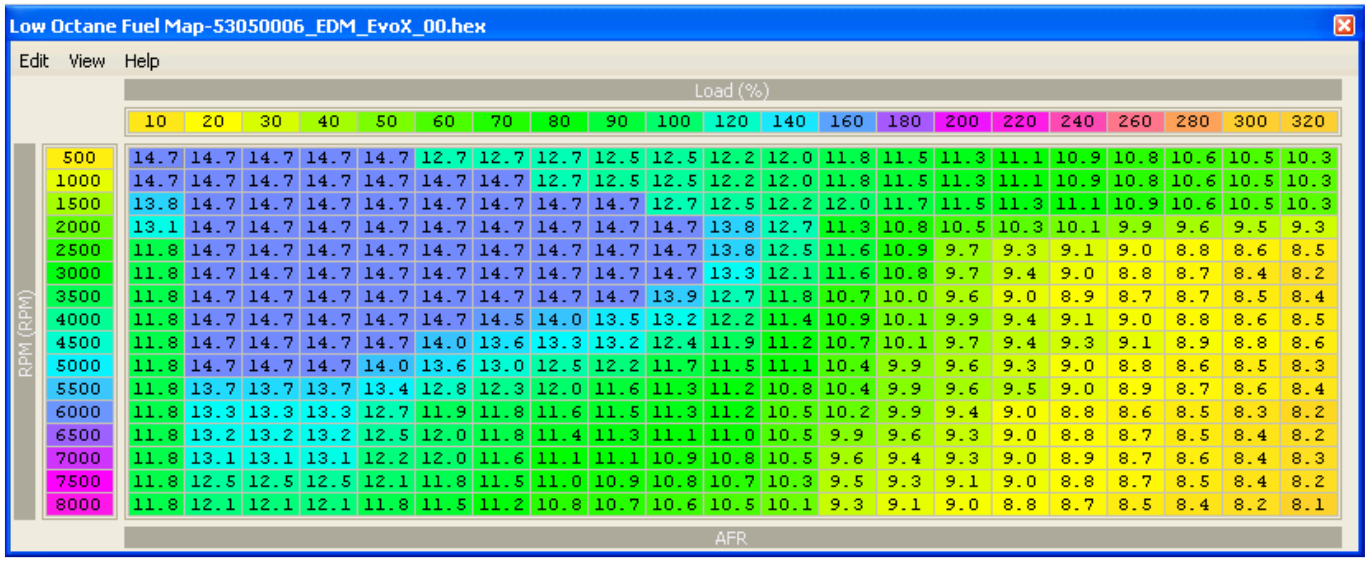
This is a standard ADM RALLIART with LEAN SPOOL activated.

Figure 10: FUEL TUNING - LO-OCTANE FUEL MAPS, RALLIART



This EVO X has LEANSPOOL de-activated.

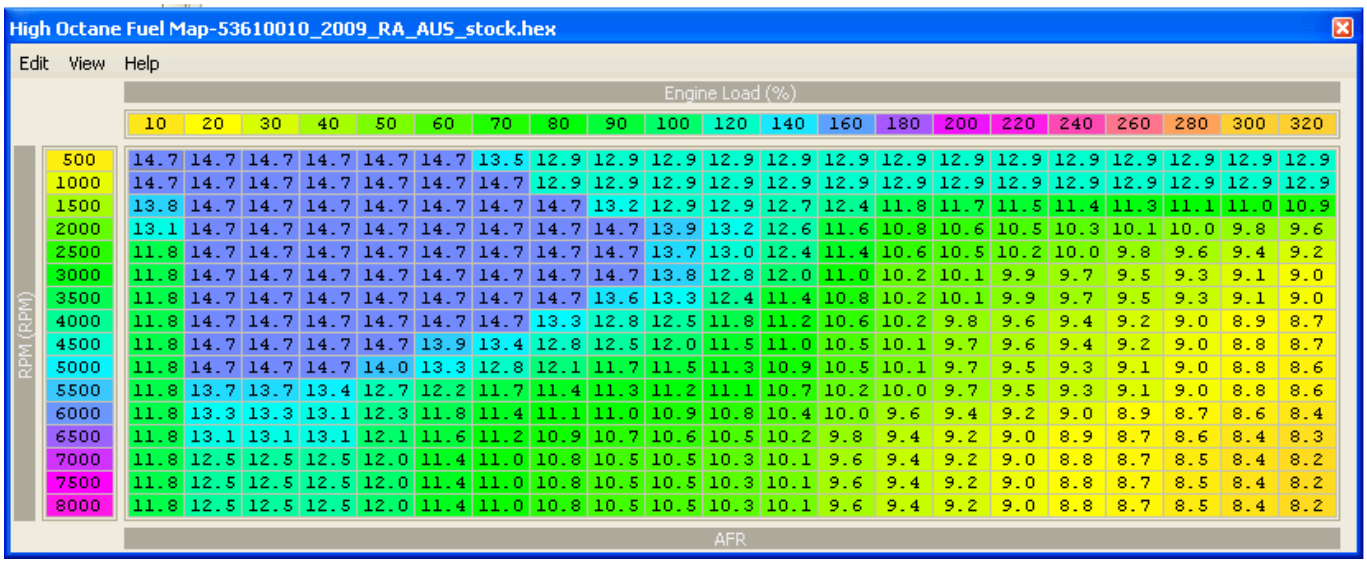
Figure 11: FUEL TUNING - LO-OCTANE FUEL MAPS, EV0 X



4.03-FUEL TUNING – STOCK HI OCTANE FUEL MAP

Two maps are shown here, a standard ADM RALLIART with LEAN SPOOL activated and a stock EDM EVO X with LEAN SPOOL de-activated.

Figure 12: FUEL TUNING – HI-OCTANE FUEL MAP, 2009 ADM RALLIART



RAINBOW2

Figure 13: FUEL TUNING – HI-OCTANE FUEL MAP, EDM EVO X

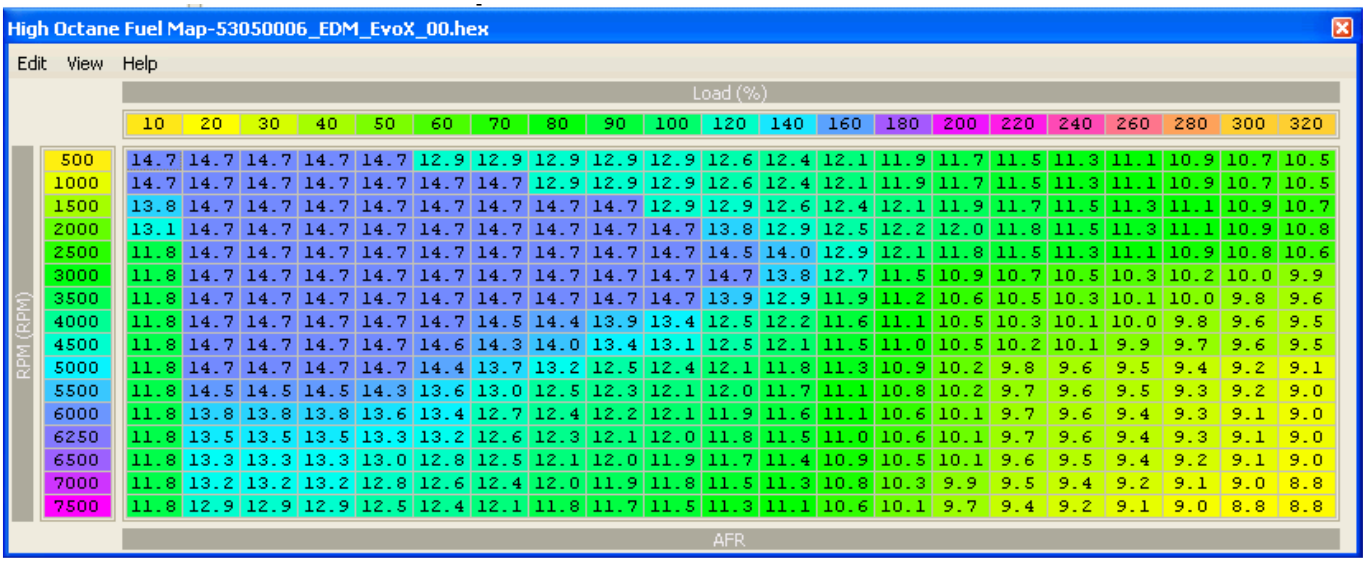
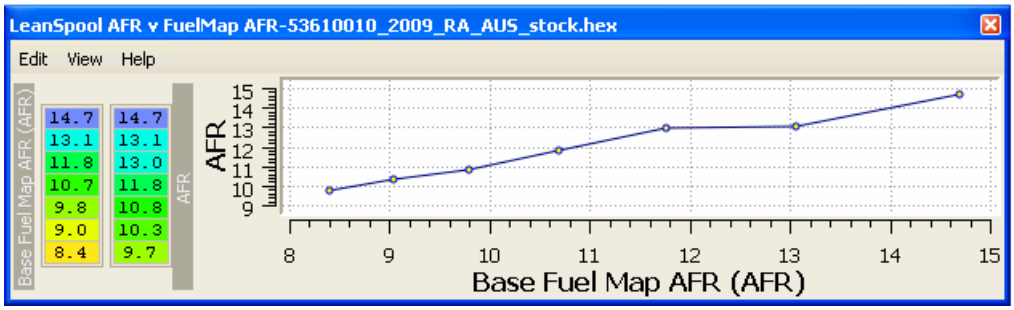


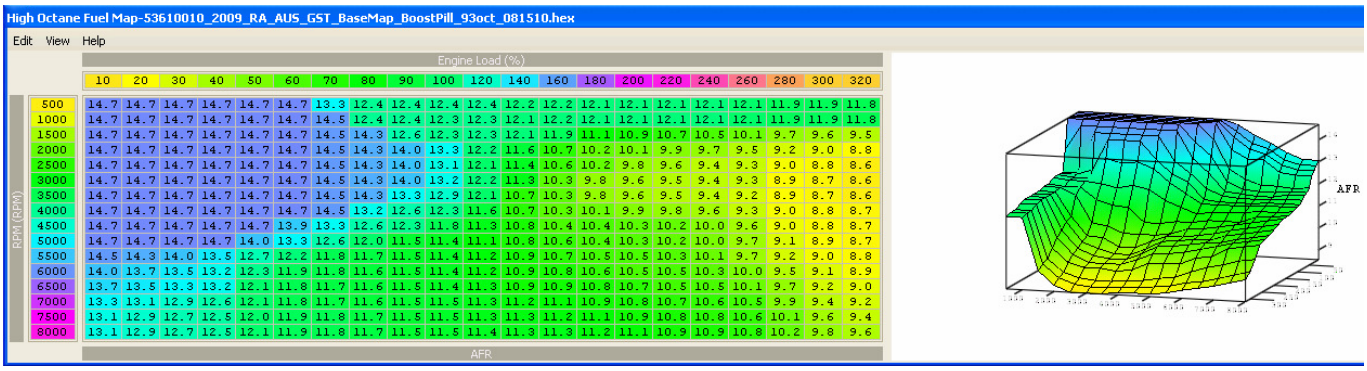
Figure 14: FUEL TUNING – stock LEAN SPOOL AFR TABLE, ADM RALLIART



4.04-FUEL TUNING – TUNED HI OCTANE FUEL MAP

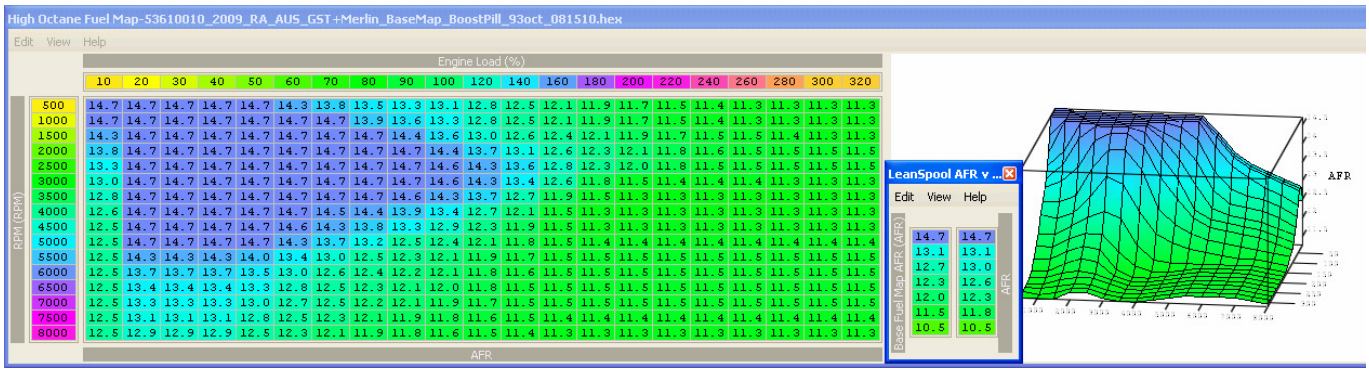
This GST tuned HI-OCTANE FUEL map has been tuned to give typically 11.8:1 air fuel ratio mixtures, with the stock LEAN SPOOL AFR table settings and LEAN SPOOL enabled.

Figure 15: FUEL TUNING – GST tuned HI-OCTANE FUEL MAP, RALLIART



This GST+Merlin tuned HI-OCTANE FUEL map has also been tuned to give typically 11.8:1 air fuel ratio mixtures, with a tuned LEAN SPOOL AFR table and LEAN SPOOL enabled. A lot of tuners will turn off LEAN SPOOL, I prefer to work with the system and make it work to my advantage. With this tune, the affect of LEANSPOOL is reduced to typically 0.3AFR leaner than the fuel map settings.

Figure 16: FUEL TUNING – Merlin tuned HI-OCTANE FUEL MAP, RALLIART



Before applying a fuel mapping setup like this, I will first verify just how close the overall fuel system is tracking the base fuel map. This can be done by turning off LEANSPOOL and setting the fuel map above load 100 to 11.5 and measuring the resultant AFRs with a wideband O2 meter. Once you know what AFR the system hits with 11.5 in the fuel map, adjust the fuel map to get your desired AFR.

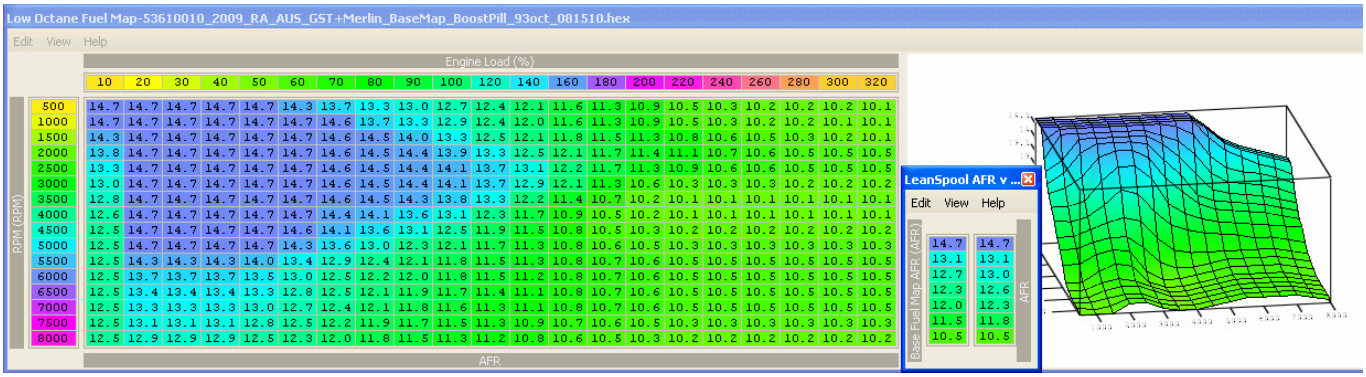
A good wideband O2 meter is such a useful and affordable tuning tool, they should be considered a must have item for everyone running a non-stock car.

4.05-FUEL TUNING – TUNED LO-OCTANE FUEL MAP

The tuned LO-OCTANE FUEL MAP shown below is an example of how this can be successfully modified so as to keep the essential characteristics while reducing fuel consumption. The stock coil-on-plug ignition system will struggle to fire the plugs at the extremely rich mixtures shown in the stock LO-OCTANE map.

This LO-OCTANE FUEL MAP is directly derived from the Merlin tuned HI-OCTANE FUEL MAP shown on the previous page. It is intended to be used with the included LEANSPOOL table as shown in the figure. To create a map like this, first copy your tuned HI-OCTANE map into the LO-OCTANE map. Then, highlight load columns 70 to 320 and decrement all those cells. Then highlight load columns 80 to 320 and decrement again. Repeat the process across the map to load 220, at which point the AFR will have been enriched one full AFR point. Note also that LEANSPOOL will now have almost no affect on the boost section of the map.

Figure 17: FUEL TUNING – Merlin tuned LO-OCTANE FUEL MAP, RALLIART

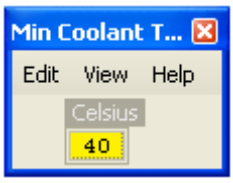


4.06-FUEL TUNING – LAMBDA CONTROL THRESHOLDS

When the engine temperature is low (below a preset value), the ECU does not use the (front) LAMBDA sensor to control the stociometric 14.7:1 fueling as shown in the fuel maps. Instead, it calculates the required AFR from the air-flow and then applies the warm-up enrichment.

This LAMBDA TEMP THRESHOLD parameter sets the engine temperature above which the ECU starts CLOSED LOOP operation, by using the front LAMBDA to trim fueling to the desired 14.7:1 AFR as shown in the fuel maps. The value shown below (40°C) has been altered from the 20°C factory ADM spec switch on point.

Figure 18: FUEL TUNING – tuned LAMBDA TEMP THRESHOLD



Engines with 264 degree or bigger cams may benefit from setting this value at 30-40 degrees centigrade so the engine can get more consistent fueling during warm-up. To do this however would require the injector SCALING and LATENCY values to be right, but you always need to do that anyway.

There are also four tables based on LOAD v RPM and TPS v RPM that control the transition from CLOSED LOOP to OPEN LOOP operation, once the engine temperature is above the switch threshold. When the value in the table is exceeded, the ECU ceases trying to operate in closed loop (adjusting fuel via O2).

Note that when the ECU is in OPEN LOOP, the LONG TERM FUEL TRIM (LTFT) % that was applied in CLOSED LOOP is applied to the whole map. This is a great feature, but does mean you should try and get your trims close to zero by getting the scaling and injector latency set correctly. These should be very close to zero trim if using 98-100 octane fuel and stock injectors.

The ECU has a short term fuel trim range of ±25%, so it has plenty of adjustment range to work with.

4.07-FUEL TUNING – AFR and KNOCKSUM

There is a little known adjustment to the air fuel ratio whereby the values in the HI-OCTANE FUEL MAP are progressively enriched when the KNOCKSUM exceeds a preset. If KNOCKSUM exceeds 6 the following is added to the raw number value of AFR from the fuel map:
(KNOCKSUM -6) * 160 / 256.

The result is limited to a maximum which is looked-up from a engine temp table, though all the values have been set to hex=0xD9, decimal=217, AFR=8.67.

The practical result of this is that if you have AFR=11.0 (decimal=171) in the fuel map and a KNOCKSUM=10 then you will end up with:
(10-6)*160/256 = 2
So the AFR fuel map value will be 171+2=173 or AFR=10.9.

Worst case example, if KNOCKSUM=36
(36-6)*160/256 = 18
So the AFR fuel map value will be 171+18=189 or an AFR=10.0.

Of course the OCTANE NUMBER would also be dropping which will push fueling towards the LO-OCTANE FUEL MAP, which will add additional enrichment. This is a very good if subtle enhancement the stock ECU comes with. It is nice to know it can throw in 10% extra fuel within six ignition events or three engine revolutions if it has to. In extremis this should also help to mitigate the rising exhaust gas temperature that retarding the ignition rapidly would inevitably produce.

On Evo7, AFR trip-point address = 17AE, 160 multiplier = 17B0.
On Evo8, AFR trip-point address = 17AE, 160 multiplier = 17B0.
On Evo9, AFR trip-point address = 13AE, 160 multiplier = 13B0.

Increasing the multiplier will increase the enrichment. This might be a very useful arrangement on a full race engine, giving an extra safety margin in the event of a typical plumbing failure.

SECTION 5 – IGNITION TUNING PART 1 - BASICS

5.01-IGNITION TUNING INTRODUCTION

An ideal combustion process behaves in the following manner:

1. The air fuel mixture is brought into the combustion chamber. Ideally this mixture should have around 12.5:1 AFR to extract maximum power from gasoline. Given that the Evo engine has evolved over about 17 years, crappy CA gas, and high boost, this ideal is pretty hard to achieve without running water/methanol injection. Most non race/track Evos run between 11.7 and 11:3 AFR.

2. The intake and exhaust valves close and the spark plug fires. On an Evo8 a spark plug fires at around 18-21° BTDC by 7000 rpm. On an Evo9 there is less timing advance with the spark plug firing around 14-16° BTDC by 7000 rpm. Why less timing advance on the Evo9 than the Evo8? In part, it is because the Evo9 is blessed with a better cooled and better flowing cylinder head than the Evo8. The Evo9 can run leaner AFRs. Leaner AFRs burn faster up to 12.5:1. Beyond that they burn slower. A faster burning mixture does not require as much timing advance as a slower burning one. I am not saying that the Evo9 has a leaner AFR from the factory. Far from it. What I am saying is that it has the potential to run leaner AFRs and consequently less timing advance.

3. After the spark is fired the burning of the mixture proceeds. It begins at the spark plug and progresses in an orderly fashion across the combustion chamber. It is as if you took a pebble and threw it in a pond and watched the ripples progress outward from where the pebble fell. The burn should be complete with no remaining air-fuel mixture by the end of the combustion process.

In reality, combustion sometimes does not progress in an orderly and smooth fashion. Sometimes the air-fuel mixture spontaneously combusts after the spark plug is fired but before the flame front reaches the mixture. This is known as detonation or knock. Why does that happen? Too much pressure and too much heat combined with a fuel of insufficient octane rating to resist self-combustion. Octane is a term to describe a property of a fuel, not an actual chemical component in the fuel. Think of octane as the ability of gasoline to resist self-combustion under pressure and heat. The higher the octane the less likely the gasoline will self-combust under high boost and heat that the Evo is known to generate.

When a car knocks, it causes a very sharp pressure spike that is outside the normal shape of the pressure curve during normal combustion. The pressure spike creates an abnormal force in the combustion chamber. The engine block will ring in reaction to the force generated from the pressure spike, just as if it had been hit with a hammer. That is where the knock sensor steps in.

The knock sensor is usually connected to the side of the engine block, between cylinders two and three. It is a simple piezo microphone, converting engine noise and vibrations to an electrical signal which is then filtered, amplified and measured by the Evo ECU. The ECU then decides if any component of the signal, poking up above the general noise is detonation. If it is, the ECU retards the timing in order to save the engine from further detonation and possible damage. The knock sensing system is reactive and not pro-active. The timing pull happens after knock is detected and pulls timing to prevent further damage. It does not prevent knock an initial knock event, it tries to limit it after it has happened.

The signal that the ECU spits out is commonly known as KNOCKSUM. The logging tools that we use have the ability to log KNOCKSUM. Generally speaking the higher the knocksum the more timing will get pulled, the lower the knocksum the less timing will get pulled.

KNOCKSUM and OCTANE NUMBER are the parameters which combine to give the final ignition timing value, operating temperature corrections aside.

OCTANE NUMBER controls the interpolation between the HI-OCTANE and LO-OCTANE fuel and ignition maps and is a dynamic number stored in memory with a maximum value of 255. When logged with EvoScan, this number is re-scaled percentage, where 100% is the highest value and no interpolation with the LO-OCTANE map is being applied.

KNOCKSUM is generated by the ECU, from the input from the knock sensor and it has several tables and variables that can be manipulated to subtly alter the final KNOCK SUM result. This has particular relevance to the tuning fraternity, as some engines exhibit what has been described as “phantom” or “false” knock. This becomes even more important when engine internals, like forged pistons, are added to the equation. It has been reported that some aftermarket clutches can have an effect on false knock as well as general engine aging.

So what sort of damage does knock cause?

If left unchecked, knock can break the spark plugs insulator, damage the valves, break the compression rings and smash the ring lands around the pistons.

Knock can be very abrasive to the crown of the piston. Pistons on an engine that is suffering from excessive knock will look like as if it has been sandblasted and will show small pits in the top of the piston.

Finally, excessive knock will cause a premature failure of your rod bearings resulting in the very distinctive rod knock sound.

Having said the above about the dangers of knock do not be surprised to learn that almost all cars knock. As long as the knock is occasional and moderate cars can run for thousands of miles with little to no problems. While mild detonation is not an optimum situation for engine operation, it does not guarantee engine failure.

5.02-IGNITION TUNING – LO-OCTANE SPARK MAP

When the ECU initially detects detonation, it will retard timing by a preset number of degrees depending on the knock count and the conditions that the knock occurred. At the same time, the OCTANE NUMBER that the ECU has stored in its memory is reduced. If detonation continues to occur, then the ECU will interpolate between the HI and LO OCTANE maps, with a calculation using the octane number. Supposedly, the ECU never actually gets to operate fully on the LO-OCTANE map though.

The ECU will then continue to operate proportionally between the two maps, until an absence of knock is noted in a boost condition (when operating above the OCTANE UPDATE THRESHOLD), at which point the octane number is progressively increased and operation rapidly reverts back to the HI-OCTANE map, or close to it.

Should detonation still occur the ECU will reduce the maximum boost level to a safety boost level.

For further reading on this topic, refer to the section on KNOCK CONTROL.

Figure 19: IGNITION TUNING – LO-OCTANE SPARK MAP – RALLIART

Low Octane Spark Map-53610010_2009_RA_AUS_stock.hex

Edit View Help

Engine Load (g/S)

RPM (RPM)	0	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300	320
500	10	10	10	10	10	10	6	2	-2	-5	-8	-11	-14	-17	-18	-18	-18	-18	-18	-18	-18	-18
750	10	10	10	10	10	14	10	5	2	-1	-4	-7	-10	-13	-16	-18	-18	-18	-18	-18	-18	-18
1000	10	10	10	10	15	17	15	8	4	1	-2	-5	-8	-11	-14	-17	-18	-18	-18	-18	-18	-18
1250	17	17	17	17	17	18	17	12	8	4	1	-2	-5	-8	-11	-14	-17	-18	-18	-18	-18	-18
1500	24	24	24	24	24	24	20	17	12	8	4	1	-3	-6	-9	-12	-15	-18	-18	-18	-18	-18
1750	30	30	30	30	30	25	23	18	14	11	8	3	0	-3	-6	-9	-12	-15	-18	-18	-18	-18
2000	36	36	36	36	35	30	26	24	16	13	10	5	2	-1	-4	-7	-10	-13	-16	-18	-18	-18
2250	40	40	40	40	40	34	30	26	21	15	12	7	3	0	-3	-6	-9	-12	-15	-18	-18	-18
2500	40	40	40	40	40	36	33	29	24	17	13	8	4	1	-2	-5	-8	-11	-14	-17	-18	-18
2750	40	40	40	40	40	36	33	30	24	18	15	9	5	2	-1	-4	-7	-10	-13	-16	-18	-18
3000	40	40	40	40	40	37	34	31	26	21	16	11	6	3	0	-3	-6	-9	-11	-14	-17	-18
3250	40	40	40	40	40	38	37	34	28	23	19	13	8	5	2	-1	-4	-7	-10	-13	-16	-18
3500	40	40	40	40	40	38	37	35	33	28	22	15	10	7	4	1	-2	-6	-9	-12	-15	-18
3750	40	40	40	40	40	39	38	36	33	29	23	16	11	8	5	2	-1	-4	-7	-10	-13	-16
4000	40	40	40	40	40	39	38	36	34	33	27	20	13	9	6	3	0	-3	-6	-9	-12	-15
4500	40	40	40	40	40	40	38	36	34	33	29	24	17	13	9	6	3	0	-3	-6	-9	-12
5000	40	40	40	40	40	40	39	37	36	35	31	25	18	15	12	8	5	2	-1	-4	-7	-10
5500	40	40	40	40	40	40	39	37	36	35	33	27	20	16	14	10	7	4	1	-2	-5	-8
6000	40	40	40	40	40	40	39	38	38	36	33	27	20	17	15	13	10	7	4	1	-2	-5
6500	40	40	40	40	40	40	40	40	38	37	34	28	22	17	16	14	11	8	5	2	-1	-4
7000	40	40	40	40	40	40	40	40	40	38	35	29	23	19	17	14	11	8	5	2	-1	-4
7500	40	40	40	40	40	40	40	40	40	38	36	29	24	21	18	15	12	9	6	3	0	-3
8000	40	40	40	40	40	40	40	40	40	38	37	31	26	22	19	16	13	10	7	4	1	-2

degrees

The EvoX LO-OCTANE SPARK MAPs are typically very similar to this map, with a few slight variations between the model, market and year.

There is little reason to make changes to these maps, they are pretty good as-is and hopefully your car will never be fully utilizing them.

5.03-IGNITION TUNING – WARMUP RETARD SPARK MAP

When the engine is warming up, there is another timing function enabled to get the emissions systems catalytic converters operating efficiently as quickly as possible. This is to reduce NOX and to speed-up closed loop operation. To get the cats heated quickly, this WARMUP RETARD SPARK MAP is used where the cell values are subtracted from the spark map. This map is commonly referred to as the WARMUP RETARD MAP on some xml definitions.

The retarded ignition timing is frequently a cause of complaint from Evo drivers when their engine is cold, but is easily fixed by reducing the values or even zeroing them out, though this is not necessary. In any case though, zeroing the cells at 1000rpm and 1250rpm would result in better idle stability. Especially when using big cams.

Figure 20: IGNITION TUNING – WARMUP SPARK RETARD MAP, stock RALLIART

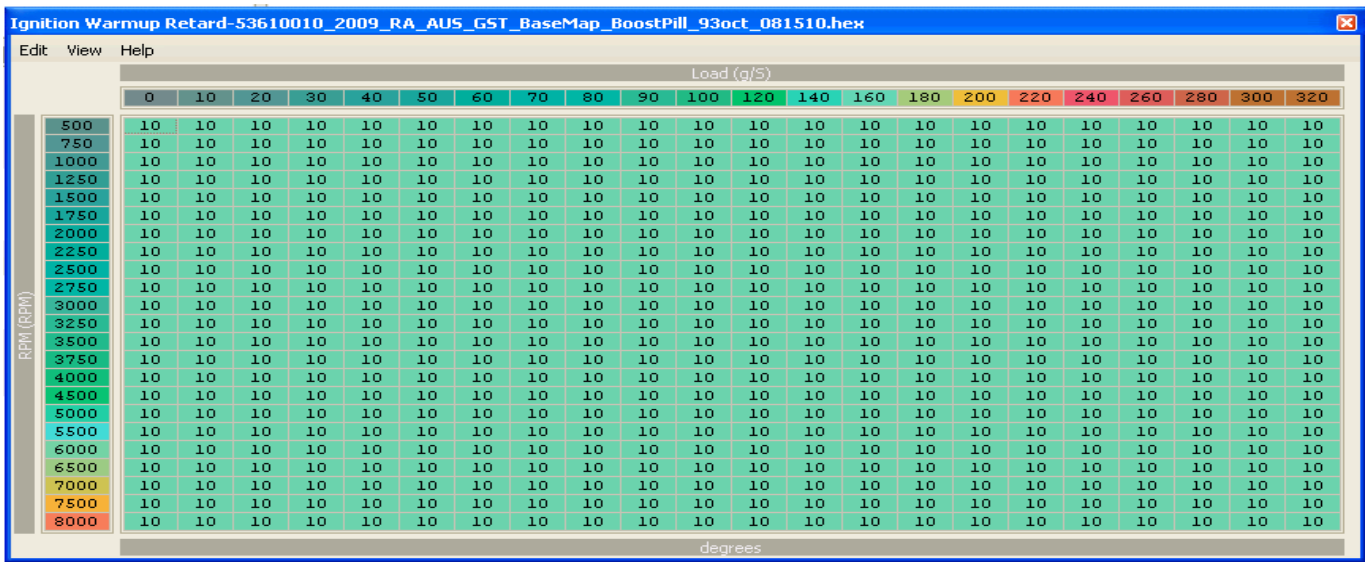
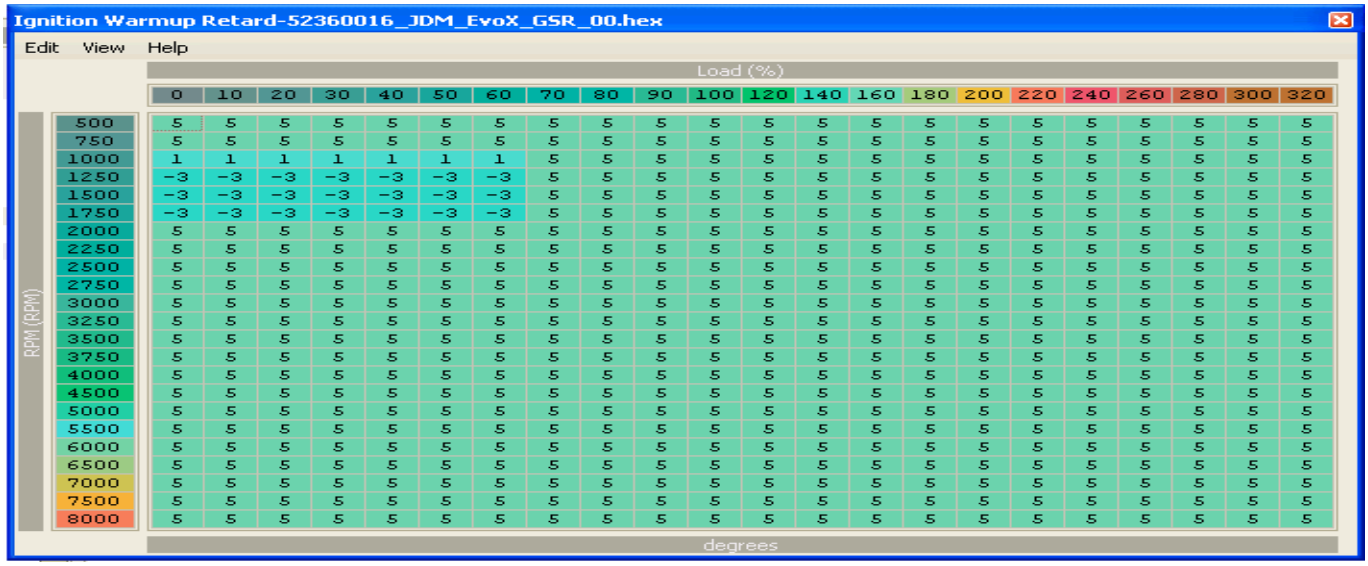


Figure 21: IGNITION TUNING – WARMUP SPARK RETARD MAP, stock EvoX



5.04-IGNITION TUNING – STOCK HI-OCTANE SPARK MAP

The HI OCTANE maps for the same model and year are frequently different from one country or region to another. The inference being that the maps are set for the local fuel and its octane rating.

JDM maps typically have the most timing under boost and are probably intended to run on 100RON fuel. It is important to appreciate that the ECU is constantly testing for an improvement in fuel if there is no knock detected when operating above the OCTANE UPDATE THRESHOLD, by increasing the octane number and trying to run fully on the HI-OCTANE map. Thus, for a stock un-tuned EvoX or RALLIART, using 98RON or 93MON fuel, EvoScan should always be reporting some **low** (1-3) level of knock.

Tuners typically spend the time to chase out the knock so they can get stable operating conditions and get on with chasing HP with increased boost and other modifications. Tuners report good results when using E85 and re-tuning the ECU and injectors to suite.

When you start using **E85** or similar **ethanol** fuels, or when using meth-water injection, the spark map tuning gets a whole lot harder and you can no longer rely on the knock sensor to give you the definitive answer as to how much timing is too much. E85 for example can accept spark advance that would show massive knock on regular fuel, with no evident knock, yet your rod bearings are being hammered to death.

An important additional feature to these ECUs, not previously used, are spark advance upper and lower limiting maps. Note that the upper limit map needs to have values higher than your HI-OCTANE SPARK MAP.

Figure 22: IGNITION TUNING – stock RALLIART SPARK ADVANCE UPPER BOUND MAP

Spark Advance Upper Boundry Map-53610010_2009_RA_AUS_stock.hex

Edit View Help

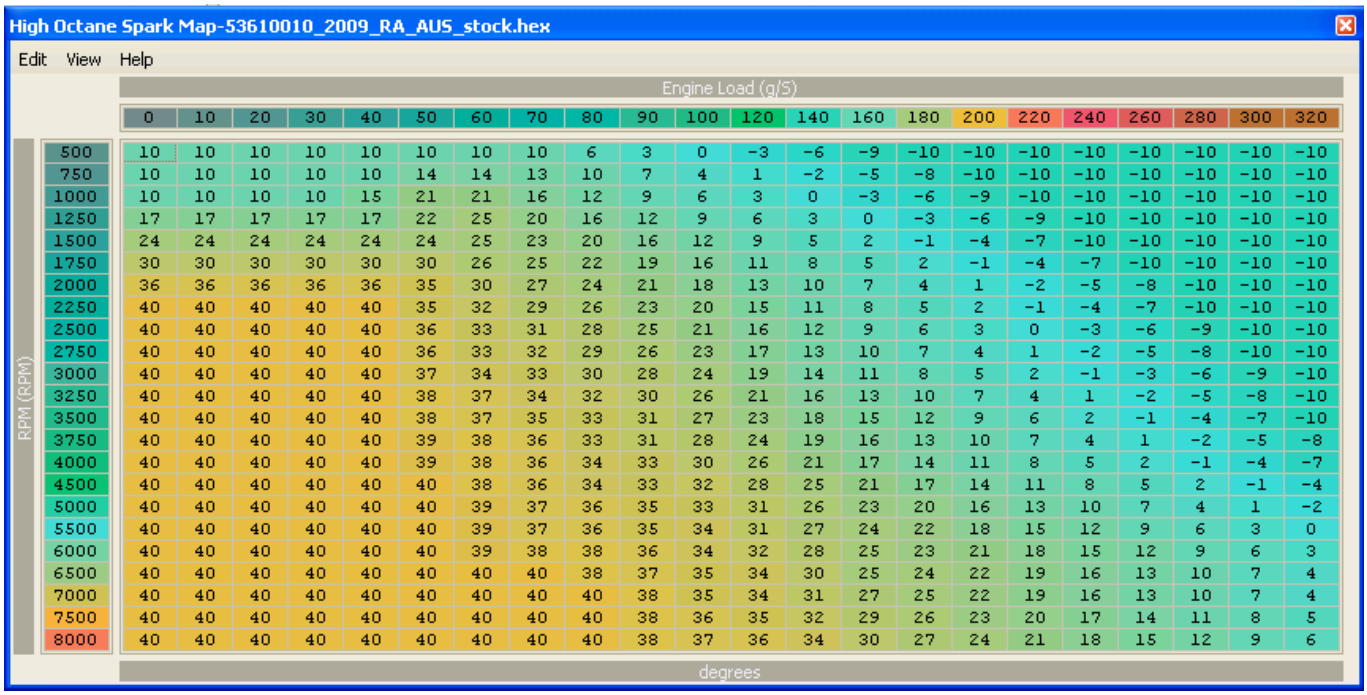
Engine Load (g/S)

RPM (RPM)	0	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300	320
500	30	30	30	30	30	26	26	22	18	15	10	-3	-6	-9	-10	-10	-10	-10	-10	-10	-10	-10
750	30	30	30	30	30	26	26	25	22	19	16	3	0	-5	-8	-10	-10	-10	-10	-10	-10	-10
1000	30	30	30	30	30	30	30	28	24	21	18	5	2	-3	-6	-9	-10	-10	-10	-10	-10	-10
1250	33	33	33	33	33	34	34	32	28	24	21	8	5	0	-3	-6	-9	-10	-10	-10	-10	-10
1500	36	36	36	36	36	36	37	37	32	28	22	14	9	2	-1	-4	-7	-10	-10	-10	-10	-10
1750	42	42	42	42	42	42	40	37	34	31	25	16	12	5	2	-1	-4	-7	-10	-10	-10	-10
2000	45	45	45	45	45	45	42	39	35	31	27	21	14	7	4	1	-2	-5	-8	-10	-10	-10
2250	45	45	45	45	45	45	42	40	37	34	29	21	15	10	7	2	-1	-4	-7	-10	-10	-10
2500	45	45	45	45	45	45	43	42	38	34	31	21	16	11	8	3	0	-3	-6	-9	-10	-10
2750	45	45	45	45	45	45	42	41	39	36	31	22	17	12	9	4	1	-2	-5	-8	-10	-10
3000	45	45	45	45	45	43	42	40	37	35	31	26	18	13	10	5	2	-1	-3	-6	-9	-10
3250	45	45	45	45	45	43	42	40	38	36	32	26	20	15	12	7	4	1	-2	-5	-8	-10
3500	45	45	45	45	45	43	42	40	38	36	32	28	22	17	14	9	6	2	-1	-4	-7	-10
3750	45	45	45	45	45	44	43	41	38	36	33	29	23	18	15	10	7	4	1	-2	-5	-8
4000	45	45	45	45	45	44	43	41	39	38	35	31	25	19	16	11	8	5	2	-1	-4	-7
4500	45	45	45	45	45	45	43	41	39	38	37	33	29	23	19	14	11	8	5	2	-1	-4
5000	45	45	45	45	45	45	44	42	41	40	38	36	30	25	22	16	13	10	7	4	1	-2
5500	45	45	45	45	45	45	44	42	41	40	39	36	31	26	24	18	15	12	9	6	3	0
6000	45	45	45	45	45	45	44	43	43	41	39	37	32	27	25	21	18	15	12	9	6	3
6500	45	45	45	45	45	45	45	45	43	42	40	39	34	27	26	22	19	16	13	10	7	4
7000	45	45	45	45	45	45	45	45	45	43	40	39	35	29	27	22	19	16	13	10	7	4
7500	45	45	45	45	45	45	45	45	45	43	41	40	36	31	28	23	20	17	14	11	8	5
8000	45	45	45	45	45	45	45	45	45	43	42	41	38	32	29	24	21	18	15	12	9	6

degrees

Two stock HI-OCTANE SPARK maps are shown here for easy comparison.

Figure 23: IGNITION TUNING – stock RALLIART HI-OCTANE SPARK MAP



High Octane Spark Map-53610010_2009_RA_AUS_stock.hex

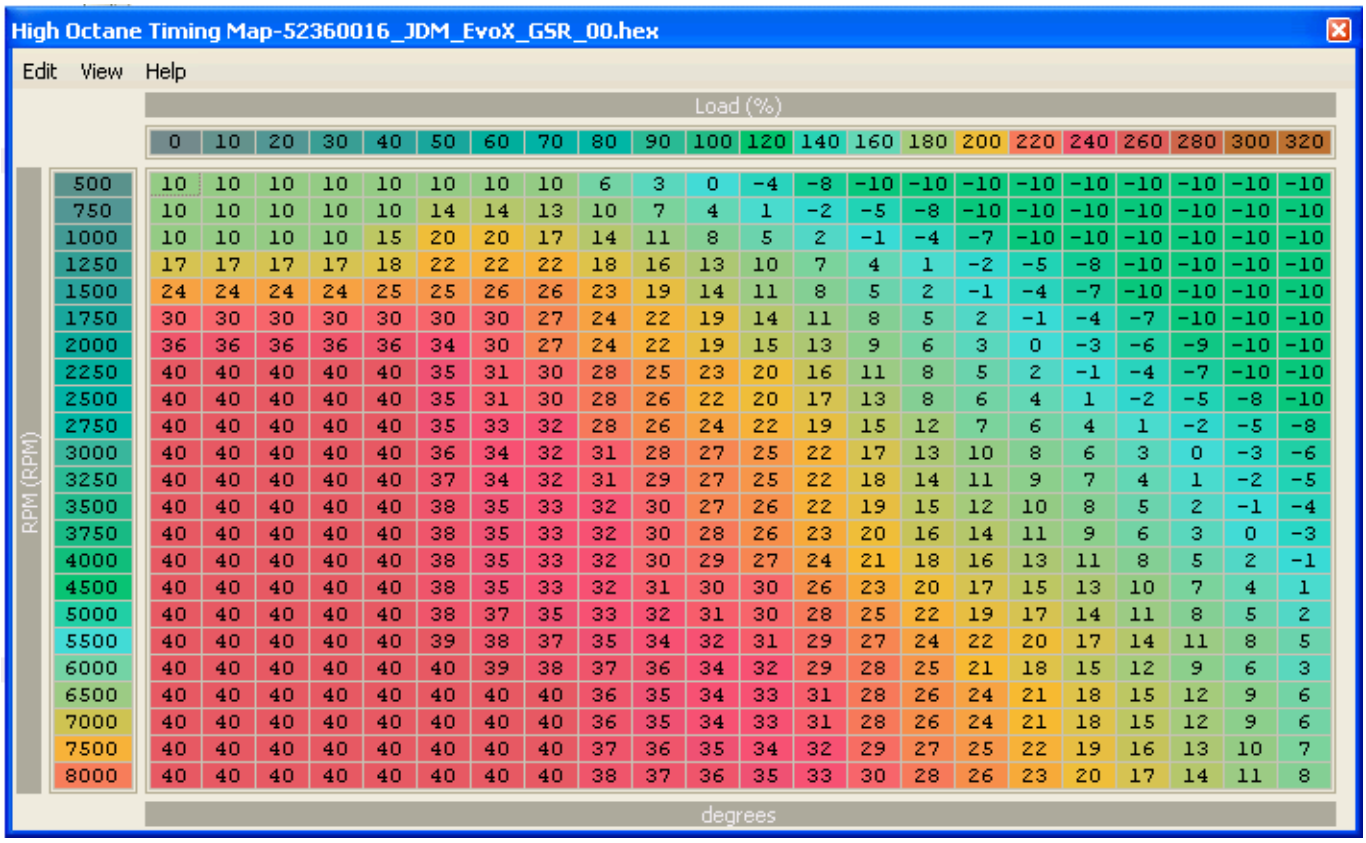
Edit View Help

Engine Load (g/S)

RPM (RPM)	0	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300	320
500	10	10	10	10	10	10	10	10	6	3	0	-3	-6	-9	-10	-10	-10	-10	-10	-10	-10	-10
750	10	10	10	10	10	14	14	13	10	7	4	1	-2	-5	-8	-10	-10	-10	-10	-10	-10	-10
1000	10	10	10	10	15	21	21	16	12	9	6	3	0	-3	-6	-9	-10	-10	-10	-10	-10	-10
1250	17	17	17	17	17	22	25	20	16	12	9	6	3	0	-3	-6	-9	-10	-10	-10	-10	-10
1500	24	24	24	24	24	24	25	23	20	16	12	9	5	2	-1	-4	-7	-10	-10	-10	-10	-10
1750	30	30	30	30	30	30	26	25	22	19	16	11	8	5	2	-1	-4	-7	-10	-10	-10	-10
2000	36	36	36	36	36	35	30	27	24	21	18	13	10	7	4	1	-2	-5	-8	-10	-10	-10
2250	40	40	40	40	40	35	32	29	26	23	20	15	11	8	5	2	-1	-4	-7	-10	-10	-10
2500	40	40	40	40	40	36	33	31	28	25	21	16	12	9	6	3	0	-3	-6	-9	-10	-10
2750	40	40	40	40	40	36	33	32	29	26	23	17	13	10	7	4	1	-2	-5	-8	-10	-10
3000	40	40	40	40	40	37	34	33	30	28	24	19	14	11	8	5	2	-1	-3	-6	-9	-10
3250	40	40	40	40	40	38	37	34	32	30	26	21	16	13	10	7	4	1	-2	-5	-8	-10
3500	40	40	40	40	40	38	37	35	33	31	27	23	18	15	12	9	6	2	-1	-4	-7	-10
3750	40	40	40	40	40	39	38	36	33	31	28	24	19	16	13	10	7	4	1	-2	-5	-8
4000	40	40	40	40	40	39	38	36	34	33	30	26	21	17	14	11	8	5	2	-1	-4	-7
4500	40	40	40	40	40	40	38	36	34	33	32	28	25	21	17	14	11	8	5	2	-1	-4
5000	40	40	40	40	40	40	39	37	36	35	33	31	26	23	20	16	13	10	7	4	1	-2
5500	40	40	40	40	40	40	39	37	36	35	34	31	27	24	22	18	15	12	9	6	3	0
6000	40	40	40	40	40	40	39	38	38	36	34	32	28	25	23	21	18	15	12	9	6	3
6500	40	40	40	40	40	40	40	40	38	37	35	34	30	25	24	22	19	16	13	10	7	4
7000	40	40	40	40	40	40	40	40	40	38	35	34	31	27	25	22	19	16	13	10	7	4
7500	40	40	40	40	40	40	40	40	40	38	36	35	32	29	26	23	20	17	14	11	8	5
8000	40	40	40	40	40	40	40	40	40	38	37	36	34	30	27	24	21	18	15	12	9	6

degrees

Figure 24: IGNITION TUNING – stock EvoX HI-OCTANE SPARK MAP



High Octane Timing Map-52360016_JDM_EvoX_GSR_00.hex

Edit View Help

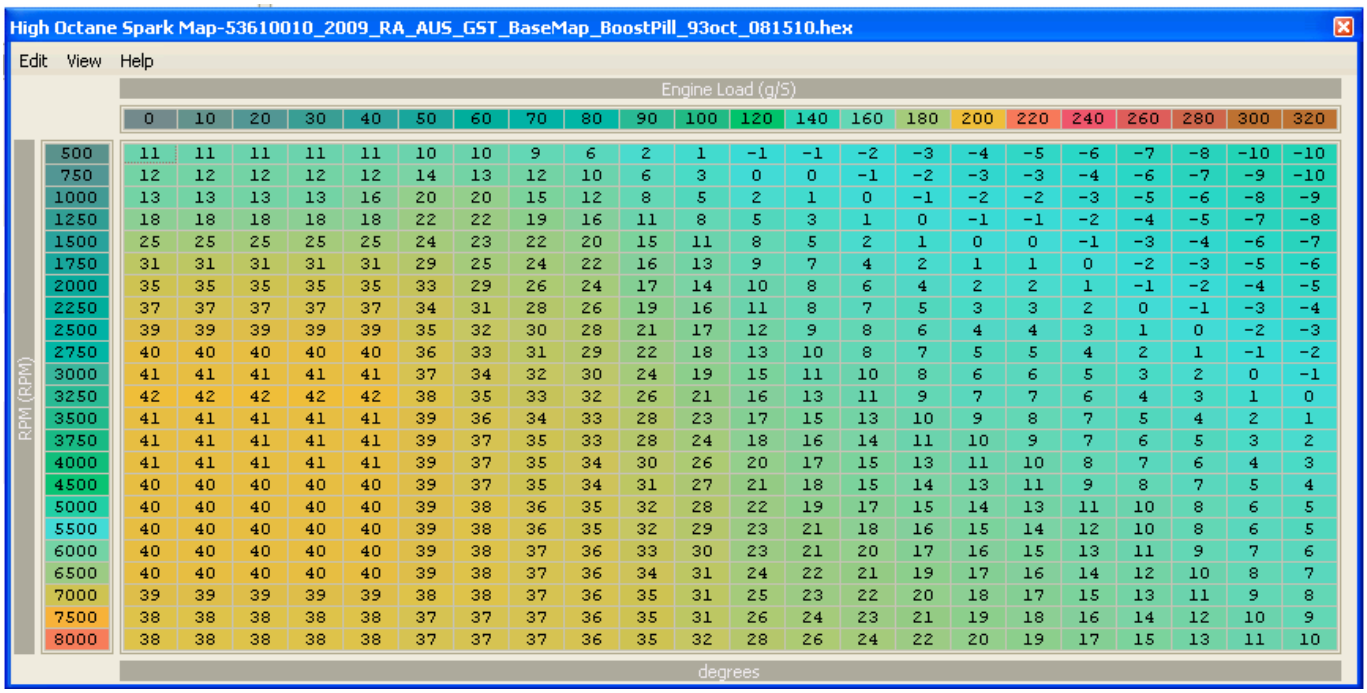
Load (%)

RPM (RPM)	0	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300	320
500	10	10	10	10	10	10	10	10	6	3	0	-4	-8	-10	-10	-10	-10	-10	-10	-10	-10	-10
750	10	10	10	10	10	14	14	13	10	7	4	1	-2	-5	-8	-10	-10	-10	-10	-10	-10	-10
1000	10	10	10	10	15	20	20	17	14	11	8	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10
1250	17	17	17	17	18	22	22	22	18	16	13	10	7	4	1	-2	-5	-8	-10	-10	-10	-10
1500	24	24	24	24	25	25	26	26	23	19	14	11	8	5	2	-1	-4	-7	-10	-10	-10	-10
1750	30	30	30	30	30	30	30	27	24	22	19	14	11	8	5	2	-1	-4	-7	-10	-10	-10
2000	36	36	36	36	36	34	30	27	24	22	19	15	13	9	6	3	0	-3	-6	-9	-10	-10
2250	40	40	40	40	40	35	31	30	28	25	23	20	16	11	8	5	2	-1	-4	-7	-10	-10
2500	40	40	40	40	40	35	31	30	28	26	22	20	17	13	8	6	4	1	-2	-5	-8	-10
2750	40	40	40	40	40	35	33	32	28	26	24	22	19	15	12	7	6	4	1	-2	-5	-8
3000	40	40	40	40	40	36	34	32	31	28	27	25	22	17	13	10	8	6	3	0	-3	-6
3250	40	40	40	40	40	37	34	32	31	29	27	25	22	18	14	11	9	7	4	1	-2	-5
3500	40	40	40	40	40	38	35	33	32	30	27	26	22	19	15	12	10	8	5	2	-1	-4
3750	40	40	40	40	40	38	35	33	32	30	28	26	23	20	16	14	11	9	6	3	0	-3
4000	40	40	40	40	40	38	35	33	32	30	29	27	24	21	18	16	13	11	8	5	2	-1
4500	40	40	40	40	40	38	35	33	32	31	30	30	26	23	20	17	15	13	10	7	4	1
5000	40	40	40	40	40	38	37	35	33	32	31	30	28	25	22	19	17	14	11	8	5	2
5500	40	40	40	40	40	39	38	37	35	34	32	31	29	27	24	22	20	17	14	11	8	5
6000	40	40	40	40	40	40	39	38	37	36	34	32	29	28	25	21	18	15	12	9	6	3
6500	40	40	40	40	40	40	40	40	36	35	34	33	31	28	26	24	21	18	15	12	9	6
7000	40	40	40	40	40	40	40	40	36	35	34	33	31	28	26	24	21	18	15	12	9	6
7500	40	40	40	40	40	40	40	40	37	36	35	34	32	29	27	25	22	19	16	13	10	7
8000	40	40	40	40	40	40	40	40	38	37	36	35	33	30	28	26	23	20	17	14	11	8

degrees

5.05-IGNITION TUNING – TUNED HI-OCTANE SPARK MAP

Figure 25: IGNITION TUNING – GST tuned RALLIART HI-OCTANE SPARK MAP



High Octane Spark Map-53610010_2009_RA_AUS_GST_BaseMap_BoostPill_93oct_081510.hex

Edit View Help

Engine Load (g/S)

RPM (RPM)	0	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300	320
500	11	11	11	11	11	10	10	9	6	2	1	-1	-1	-2	-3	-4	-5	-6	-7	-8	-10	-10
750	12	12	12	12	12	14	13	12	10	6	3	0	0	-1	-2	-3	-3	-4	-6	-7	-9	-10
1000	13	13	13	13	16	20	20	15	12	8	5	2	1	0	-1	-2	-2	-3	-5	-6	-8	-9
1250	18	18	18	18	18	22	22	19	16	11	8	5	3	1	0	-1	-1	-2	-4	-5	-7	-8
1500	25	25	25	25	25	24	23	22	20	15	11	8	5	2	1	0	0	-1	-3	-4	-6	-7
1750	31	31	31	31	31	29	25	24	22	16	13	9	7	4	2	1	1	0	-2	-3	-5	-6
2000	35	35	35	35	35	33	29	26	24	17	14	10	8	6	4	2	2	1	-1	-2	-4	-5
2250	37	37	37	37	37	34	31	28	26	19	16	11	8	7	5	3	3	2	0	-1	-3	-4
2500	39	39	39	39	39	35	32	30	28	21	17	12	9	8	6	4	4	3	1	0	-2	-3
2750	40	40	40	40	40	36	33	31	29	22	18	13	10	8	7	5	5	4	2	1	-1	-2
3000	41	41	41	41	41	37	34	32	30	24	19	15	11	10	8	6	6	5	3	2	0	-1
3250	42	42	42	42	42	38	35	33	32	26	21	16	13	11	9	7	7	6	4	3	1	0
3500	41	41	41	41	41	39	36	34	33	28	23	17	15	13	10	9	8	7	5	4	2	1
3750	41	41	41	41	41	39	37	35	33	28	24	18	16	14	11	10	9	7	6	5	3	2
4000	41	41	41	41	41	39	37	35	34	30	26	20	17	15	13	11	10	8	7	6	4	3
4500	40	40	40	40	40	39	37	35	34	31	27	21	18	15	14	13	11	9	8	7	5	4
5000	40	40	40	40	40	39	38	36	35	32	28	22	19	17	15	14	13	11	10	8	6	5
5500	40	40	40	40	40	39	38	36	35	32	29	23	21	18	16	15	14	12	10	8	6	5
6000	40	40	40	40	40	39	38	37	36	33	30	23	21	20	17	16	15	13	11	9	7	6
6500	40	40	40	40	40	39	38	37	36	34	31	24	22	21	19	17	16	14	12	10	8	7
7000	39	39	39	39	39	38	38	37	36	35	31	25	23	22	20	18	17	15	13	11	9	8
7500	38	38	38	38	38	37	37	37	36	35	31	26	24	23	21	19	18	16	14	12	10	9
8000	38	38	38	38	38	37	37	37	36	35	32	28	26	24	22	20	19	17	15	13	11	10

degrees

5.06-IGNITION TUNING – ASSESSING KNOCK

You need to get a number of wide open throttle logs, where the engine was run through the gears and some part throttle logs where the engine was run up through the gears. When you have these, if any knock is showing, you need to make an assessment as to why the engine is exhibiting knock.

Start by closely examining your log to see where the knock occurs and if the knock is random or repetitive and predictable. Check the relationship with gear-shift events, the engine will often show some degree of knock when shifting gears, especially as the boost level is raised. Frequently, when an engine starts knocking at a gear up-shift, it will carry-on knocking for a while. Confirm that other logs show the engine pulling cleanly through the affected area if there is no gear shift.

Vehicles with automatic transmissions can be particularly susceptible to shift knock, the SST equipped EvoX-MR and RALLIART are no exception.

If you have DET-CANS, use them to help confirm suspected real detonation. It should be pointed out however that as the ECU aggressively fights to reduce detonation, you may only fleetingly hear the event. This can be a real problem in identifying knock if there is a lot of other engine related noise. On the other hand, DET-CANS will allow you to easily identify noise from the hydraulic lifters or failed crankshaft or piston rod bearings. Not so easy to determine is piston slap noise from forged pistons, which usually run higher clearances. Experienced tuners can usually pick this though.

One of the best ways to identify real knock is using EvoScan to log KNOCKBASE and KNOCKFILTADC, see the graph shown. In that graph, you can see that KNOCKBASE in yellow is relatively consistent, but KNOCK FILTADV is a seemingly mess of noise, except where it solidly spikes over the KNOCKBASE line. This clear spike is real knock. If you see the KNOCK FILTADC (knock voltage) constantly hitting the KNOCKBASE line in a messy way, not clearly spiking through the line, then this is noise and can be tuned out by adjusting the KNOCK MULTIPLIER value.

There are four main presentations of knock that you may encounter:

1. Knock that appears to be random/non-repeatable and less than 3.

This type of knock you can usually ignore. It typically means your spark map is a good match for the fuel/boost/modifications that you are currently running.

2. Knock at part throttle, starting at less than 3500rpm.

This type of knock can be caused by many factors, many of which are effectively "False Knock", though each will require a specific remedy.

2.1 Low octane fuel, the knock is real, get the correct octane fuel and tune as per WOT knock tuning.

2.2 Noisy engine/driveline components:

Valve-lash adjusters - These can and should be replaced if they are the problem. Use electronic DET-CANS to diagnose the problem.

Plumbing rattles - Intercooler, exhaust or whatever. This is the knock sensor picking up loud engine noise and will require fixing the mechanical fault These can be somewhat harder to find sometimes. Use electronic DET-CANS to help diagnose the problem.

Forged pistons and piston slap - Some combinations cause a problem, others don't. This is a tough one, short of changing the pistons, it is better to fix with the ECU, see the **FALSE KNOCK** section. Note that you can hear piston slap with good electronic DET-CANS.

Balance shafts removed - Affects some cars, not others. Fix via the ECU, see the **FALSE KNOCK** section.

Clutch rattle - Some twin-plate clutches have been reported as causing a problem and can be difficult to diagnose. Use electronic DET-CANS to help diagnose the problem. Fix via the ECU, see the **FALSE KNOCK** section.

3. Knock at WOT not associated with a gear change.

This is generally real knock or detonation and will respond to reducing the ignition timing and/or using a fuel with a higher octane rating or AKI.

This type of knock we tune out by adjusting the HI-OCTANE SPARK MAP.
See **DEALING WITH WOT KNOCK**.

It is best to first check that the knock is directly related to the spark map by lowering the whole spark map above Load 100 by 6° and re logging. If the knock disappears, or is much reduced, the spark map will require tuning. If the knock remains much as it was, then the problem is not the spark map.

Light-tune engines having to run on low octane fuel will benefit from reducing the timing of the cells where knock occurs until it is eliminated. If you regularly have to use low octane fuel, look into using one of the **tephra** ROMs with alternate mapping. These can be setup to accommodate switching between good and poor fuel. They can also be used to switch between gasoline fuel and ethanol fuel.

4. Knock at WOT that is associated with a gear change.

This type of knock can be tricky to eliminate without sacrificing an otherwise good spark map.
See **ELIMINATING SHIFT KNOCK**.

SECTION 6 – IGNITION TUNING PART 2 - KNOCK TUNING

6.01-KNOCK TUNING - KNOCKSUM & OCTANE NUMBER

KNOCKSUM and OCTANE NUMBER are the parameters which combine to give the final ignition timing value, operating temperature corrections aside.

KNOCKSUM is generated by the ECU, from the input from the knock sensor and it has several tables and variables that can be manipulated to subtly alter the final KNOCKSUM result. This has particular relevance to the tuning fraternity, as some engines exhibit what has been described as "phantom" or "false" knock. This becomes even more important when engine internals, like forged pistons, are added to the equation. It has been reported that some aftermarket clutches can have an effect on false knock as well as general engine aging.

OCTANE NUMBER controls the interpolation between the HI-OCTANE and LO-OCTANE fuel and ignition maps and is a dynamic number stored in the ECU random access memory (RAM). The OCTANE NUMBER starts off at a value of hex 255, for 100%. HI-OCTANE map operation. The maximum value is not quite an arbitrary number, as its value would have an affect on the driving time it would take to transit from fully Hi to fully LO-OCTANE map operation for a given rate of knock.

The following equation describes the method for deriving the new ignition timing from the two timing maps:

$$(((255 - \text{octane\#}) \times \text{LO-MAP}) + (\text{octane\#} \times \text{HI-MAP})) \div 255$$

Using a LO-MAP value of 10° and a HI-MAP value of 20°, with an octane number of 128 will yield a ignition timing value of 15, a 50% shift. With the same map values, and an octane number of 250, ie 5 counts have been deducted, this yields an ignition timing value of 19.8°. Only a 2% shift, so the shift from the HI-MAP to the LO-MAP is gradual.

OCTANE NUMER is decremented y 100/255 = 0.39216. This can readily be observed from EvoScan log files.

If the KNOCKSUM is 6 or higher, then the OCTANE NUMBER in the ECU's RAM will be decreased by 1 on a timer.

If the KNOCKSUM is 3 - 5 then the OCTANE NUMBER is not changed.

If the KNOCKSUM falls to 0 - 2, then the OCTANE NUMBER will be increased by 1 on a timer. However, OCTANE NUMBER will not increment until the engine coolant temperature is above a preset value.

The timer mentioned above seems to be set at 500mSeconds on the Evo ECU.

In the short term, the timing will be reduced directly, based on the KNOCKSUM. Disassembly of the code has revealed that each knock count will reduce the timing by approximately 0.35 of a degree, thus a knock count of three will result in 1° of timing pulled from the ignition map. . The exact formula describing exactly how KNOCKSUM imparts a spark timing reduction is:

Knock Spark Retard = KNOCKSUM * 90 / 256

Thus a KNOCKSUM of 3 yields a spark retard of -1.05 degrees.

It has been reported that the octane number recovers to normal or near normal, quite quickly if the engine experiences knock-free operation above the KNOCK TRHESHOLD, which is a LOAD v RPM table. If it sees no knock, it will adjust the octane number back quickly. If the knock levels are only 1 or 2, it will adjust the octane number back slowly.

This is good news, as it allows for rapid recovery by adding some better fuel or octane enhancer product if a dud batch of fuel has been supplied.

The ECU holds the current OCTANE NUMBER in non-volatile random access memory when the ignition is switched off. If for example, a dyno session produced a number of knocks and you want to get the OCTANE NUMBER quickly back to 100%, the ECU will have to be disconnected if it an Evo7-8. For an Evo9, a re-flash will reset the OCTANE NUMBER.

Additionally, an OCTANE NUMBER of 154 or lower will affect the boost control setting, the net result being to reduce boost.

When the OCTANE NUMBER = 0, the ECU use 100% of the low octane spark and fuel maps.

However, your timing will be less than the LO-OCTANE map, as the ECU is still pulling timing if knock continues. In the short term, knock control is still pulling 1° of timing per 3 knock counts. So, if you have maxed your KNOCKSUM out to 36 counts of knock, you will be running 12° less timing than the ignition maps specify. Thus the LO-OCTANE map acts as a long-term timing adjustment.

If false knock has reduced your OCTANE NUMBER to zero, KNOCKSUM can continue to pull timing to the MAXIMUM RETARD value. This has been set on most ECUs to -10º. This parameter is starting to appear on some definition files.

So, to sum-up, you want to end-up with a tune that works with the knock sensor and gives 0-2 knock counts to prevent timing being pulled and running 100% on your HI-OCTANE ignition map.

6.02-KNOCK TUNING – KNOCKBASE

KNOCKBASE is the term used to describe the dynamic average noise threshold. When an incoming signal spike from the knock sensor/filter/amplifier system exceeds this level, it is regarded as knock.

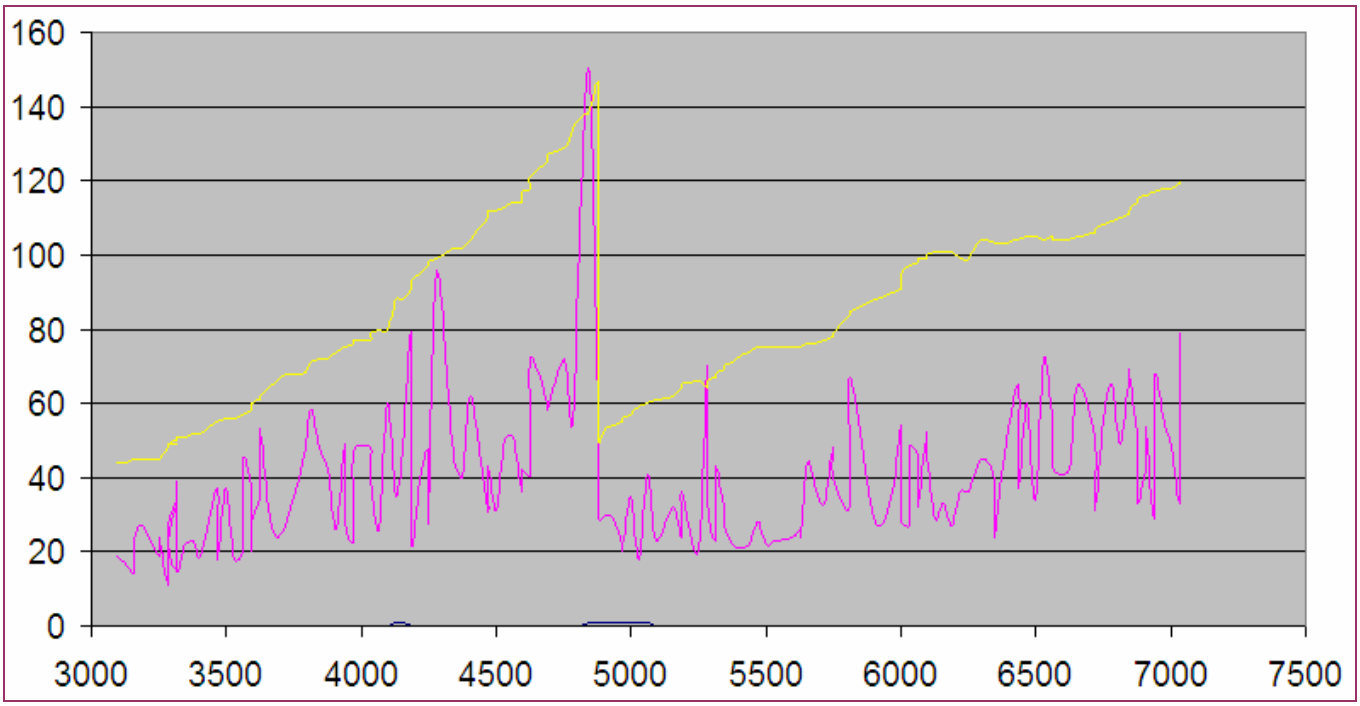
The KNOCKBASE level is derived from the knock sensor signal level, after filtering, and then being passed through a dual gain amplifier. The knock sensor amplifier system can switch from gain=x3 to gain=x1. This is used to give the system a high dynamic range and possibly to prevent input signal overload. The amplifier operates at high gain on low level signals. The resulting level as read by the internal analog to digital converter is then multiplied by the KNOCK MULTIPLIER value and the single/triple gain adders applied.

The multiplier is used to multiply the difference between the present filtered knock ADC and the long term average knock ADC, and the result is divided by the long term average knock ADC. This is a dynamic noise reference level in effect, which has the ability to learn the engines noise v rpm characteristics.

To update KNOCKBASE, the ECU takes the old value and multiplies it by 7, adds the latest knock free noise level, then divides by 8. So it takes 8 ignition events to fully update the KNOCKBASE.

The figure below shows a logged power pull from 3000rpm to 7000rpm. The yellow line is the ECU generated KNOCKBASE, that the multipliers adjust. The pink line is the knock sensor signal after the filter and switched-gain amplifier. The gain transition point can be seen at about 4800rpm. Where the pink knock sensor signal "pokes" through the yellow curve you get a knock count, which is added to the current KNOCKSUM value.

Figure 26: KNOCKBASE & KNOCK EVENT - jcsbanks



The main point of this graph is to show the sudden drop in KNOCKBASE and KNOCKFILTADC in the middle of the full throttle pull from 3000 to 7000 RPM.

The gain is suddenly divided by 3. The CPU changes an output port that switches the gain on the knock amplifier in the ECU before it reaches the CPU. This switch is triggered by KNOCKBASE reaching about 140.

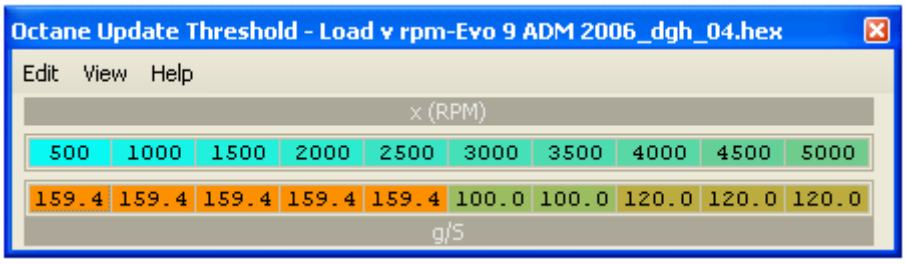
The level/gain change is so the amplifier and analog to digital converter have headroom to see big spikes and to help signal to noise ratio in a very volatile raw signal. It's switching is slick and comprehensively controlled by the ECU.

Recent versions of EvoScan can log KNOCKBASE at MUT6B and KNOCKFILTADC at MUT6A.

A typical knock sensors specifications:

VOLTAGE OUTPUT:	27mV ±10mV/g.
FREQUENCY RESPONSE:	1kHz to 18kHz, ±15% linearity.
LOAD RESISTANCE:	100kΩ.
OPERATING TEMPERATURE:	-40˚C to +150˚C.

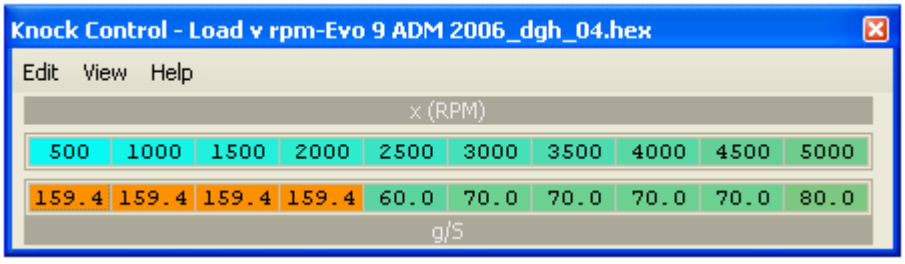
The engine has to operate above the OCTANE UPDATE THRESHOLD, with a KNOCKSUM less than 3, before the octane number will be incremented. These settings work well and there is little point in altering them. It is however useful to know where to run the engine in order to quickly recover the best possible OCTANE NUMBER.



This next table sets the load and rpm point where the knock control becomes fully active. Knock control is active at loads below the threshold, but the amount of spark retard is calculated differently – see below.

Note that the low rpm table cells all have a load value of 159.4. Because the load scaling is 5/8x, the maximum decimal value that can be put in the table is 255*5/8=159.4. This means that KNOCKSUM cannot be disabled at loads above 160. This is probably a good idea but it also means that Mitsubishi don't particularly care if the engine rattles below 2000rpm. In other words, you wont loose your OCTANE NUMBER just because of a crappy hill start that got the engine detonating a bit. If knock is detected at loads below the threshold, then the amount of spark retard is limited by the maximum Knocksum. In this instance,
Max Knocksum = 3*(HI-OCTANE SPARK – LO-OCTANE SPARK)
So the maximum knocksum that can be generated is no longer 36, but 3x the delta between the two spark maps at the point of knock.

Tuners have been able to eliminate false knock that occurred at load = 80 and rpm = 2700 by raising the threshold at that rpm point. The LOAD THRESHOLD v RPM table values can be raised to say 100, if the false knock was at 90 (for a given rpm). If the value is raised, it will eliminate that false knock condition, at the expense of having less knock protection below load 100 at that rpm.



This may be an acceptable solution in some instances. Certainly there are tuners who have done this and got a good result and cured their problem, but there is a better way forward to tune out False Knock.

6.02-KNOCK TUNING – DEALING WITH REAL KNOCK

So, by now you will have been using EvoScan to log your wide open throttle power pulls and have noticed some persistent knock in the KNOCKSUM column of the data-log that is not associated with a gear shift. These four parameters, RPM, Spark_LOAD and SPARK and KNOCKSUM are the most important to log when tuning your EvoX or RALLIART. KNOCKSUM can vary from 0 to 36, with 36 as the maximum knock count that the ECU can register.

When tuning your ECU it is advisable to tune timing, fuel, and boost without triggering an occasional KNOCKSUM more than one or two, three at the most. Each KNOCKSUM count will retard the spark advance 1/3 of a degree, thus a KNOCKSUM of 3 will pull 1° of timing.

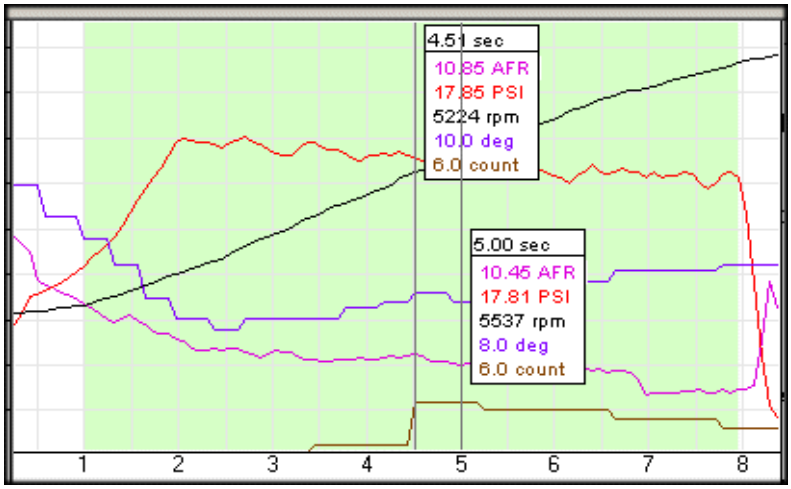
I tune for 1 to 2 occasional and sporadic counts of knock, three at most. Anything above that is unacceptable. Here is my take on knock:

1. All cars knock on occasion. I have logged Evos that knocked the first log and then gave me three knock free WOT runs, including my own. Generally speaking, the first WOT log that you do tends to be knock prone. You have to do at least three back-to-back logs to make sure that knock is consistent. I do not worry about an occasional log that has a single knock it. If the knock is transient and does not repeat, I usually ignore it.

2. Knock is a problem when it is consistent and repetitive, i.e., it happens every log and at the same point in the rpm range. That is the kind of knock to worry about and work hard to eliminate.

So, the Evo being tuned has more than 2 counts of knock and the knock is consistent and repetitive. What should I do to eliminate it? The common cause of knock on an Evo is too much timing advance. Let us take a look at my stock Evo9 with no tuning. My Evo9 consistently and repetitively registered 5-6 counts of knock from 5000rpm on. Below is a chart of a typical 3rd gear WOT run on my Evo9.

Figure 27: IGNITION TUNING – WOT LOG, GRAPH #1, Evo9



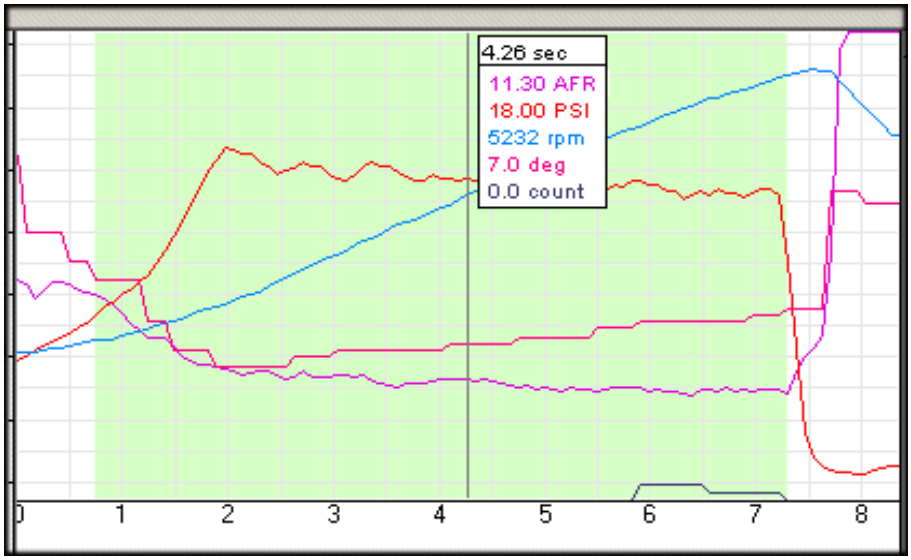
Notice that the timing @ 5224 rpm was 10° and after 6 counts of knock the timing was pulled to 8° by 5500 rpm. 6 counts of knock pulled 2° of timing, in line with our prediction that 3 counts of knock will pull 1° of timing.

So what is the ECU telling us to do to combat knock?

We know from MTBT (minimum timing best torque) theory that we should advance the timing until we either stop making power or we see the onset of knock. In this case we clearly see the onset of knock. So what we have to do is pull 2-3° of timing to combat the knock in that rpm range.

Here is the way the log looked after I pulled timing. The boost was almost unchanged and the AFR was slightly leaner in that rpm range. Pulling the timing from 10° to 7° @ 5200 rpm cured the knock in this instance.

Figure 28: IGNITION TUNING – WOT LOG, GRAPH #2, Evo9



So my first approach when tuning is to eliminate the knock. This means that you must retard the timing numbers (read fire the spark closer to TDC) in the HI-OCTANE SPARK MAP.

6.03-KNOCK TUNING - ELIMINATING SHIFT KNOCK

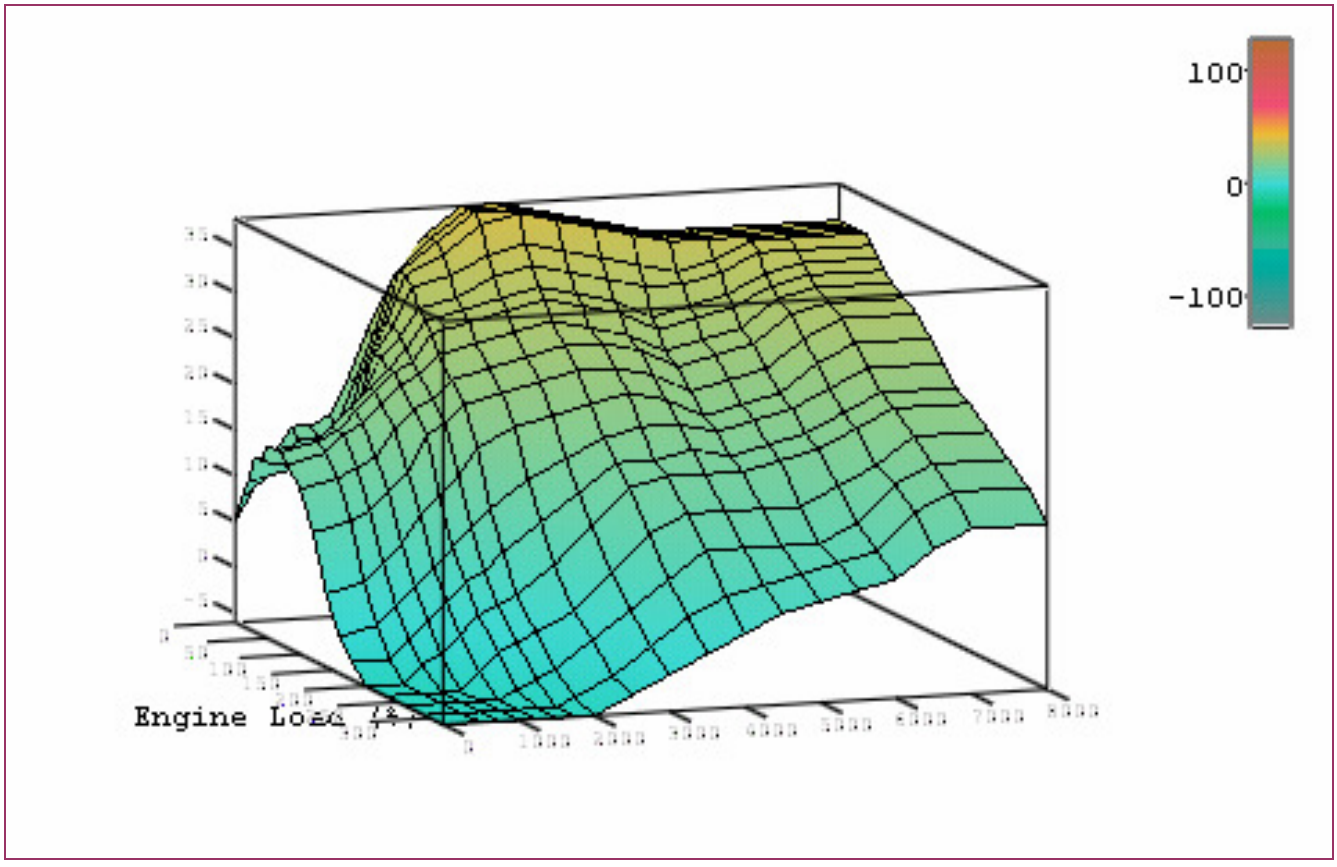
The following HI-OCTANE SPARK MAP graph is included here to show the technique to combat shift knock.

Shift knock is predominantly caused by residual boost pressure in the intake system when the throttle is closed from a WOT position and the MAF is (momentarily) not getting the right reading. So, for a brief period, there is too much spark advance being applied.

It is real knock too, and can be easily proved by reducing the spark advance in the affected areas will demonstrate.

So, the spark advance is reduced a few degrees in the area where the engine hits when changing to a higher gear.

Figure 29: IGNITION TUNING – Shift Knock tuned HI-OCTANE SPARK MAP



In addition, you need to correlate you HI-OCTANE SPARK MAP with your SPARK ADVANCE LOWER BOUND MAP, making sure that the SPARK ADVANCE LOWER BOUND MAP is set lower by 6-10°.

The RALLIART and EvoX have two spark limiting or "boundary" maps, the SPARK UPPER BOUNDARY MAP sets the maximum spark advance that could be used in the 3D HI-OCTANE and LO-OCTANE spark maps, while the SPARK LOWER BOUNDARY MAP applies a limitation on the minimum spark advance that could be applied. This does not actually prevent you from entering values outside the boundaries, they just wont be realized.

There are some pretty wild variations in these maps between GSR and SST equipped vehicles and variations form different year models too.

On the SST equipped vehicles (EvoX MR and RALLIART), the SPARK LOWER BOUNDARY MAP also sets the spark advance during gear shifts.

Reducing the amount of retard in the WOT part of the map will reduce the tendency to boost spike on SST shifts.

Reducing the -20* lower limit to about -5* or -7* in the cruise part of the map will soften the shift characteristics, making them seen less abrupt.

Here are the 53610010 RALLIART spark boundary maps, stock.

Figure 30: IGNITION TUNING – stock RALLIART SPARK ADVANCE LOWER BOUND MAP

Spark Advance Lower Boundry Map-53610010_2009_RA_AUS_stock.hex

Edit View Help

Engine Load (g/S)

RPM (RPM)	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300	320
500	-10	-10	-10	-10	-10	-10	-10	-10	-5	-8	-11	-14	-17	-18	-18	-18	-18	-18	-18	-18	-18
1000	-10	-10	-10	-10	-10	-10	-10	-10	-5	-5	-5	-8	-11	-14	-17	-18	-18	-18	-18	-18	-18
1500	-10	-10	-10	-10	-10	-10	-10	-10	-10	-8	-3	-3	-6	-9	-12	-15	-18	-18	-18	-18	-18
2000	0	0	-7	-10	-10	-10	-10	-10	-10	-10	-9	-9	0	-3	-6	-9	-12	-15	-18	-18	-18
2500	10	0	-5	-10	-10	-10	-10	-10	-8	-8	-7	-7	-7	-6	-6	-7	-10	-13	-16	-18	-18
3000	10	0	-5	-10	-10	-10	-8	-8	-8	-7	-5	-5	-5	-3	-3	-5	-8	-11	-14	-17	-18
3500	10	5	0	-7	-10	-8	-7	-7	-5	-1	-1	-1	-1	-1	-1	-3	-6	-9	-12	-15	-18
4000	16	10	0	-5	-8	-8	-7	-7	-5	-1	-1	0	0	2	2	0	-3	-6	-9	-12	-15
4500	15	10	0	-5	-8	-8	-7	-7	-5	-1	-1	2	2	4	4	3	-1	-4	-6	-9	-12
5000	15	10	0	-5	-8	-8	-7	-7	-5	-1	-1	3	4	6	8	5	1	-2	-4	-7	-10
5500	15	10	5	0	0	0	0	0	0	2	2	4	5	6	10	6	3	0	-3	-6	-9
6000	15	10	5	0	0	0	0	0	0	3	3	4	5	8	13	7	4	1	-2	-5	-8
6500	15	10	5	0	0	7	7	7	7	6	6	10	10	10	14	10	6	3	0	-3	-6
7000	15	10	5	0	2	9	12	13	13	13	14	15	15	17	14	11	8	5	2	-1	-4
7500	15	10	5	0	2	9	12	14	14	14	15	16	16	18	15	12	9	6	3	0	-3
8000	15	10	5	0	2	9	12	15	15	15	16	17	17	19	16	13	10	7	4	1	-2

degrees

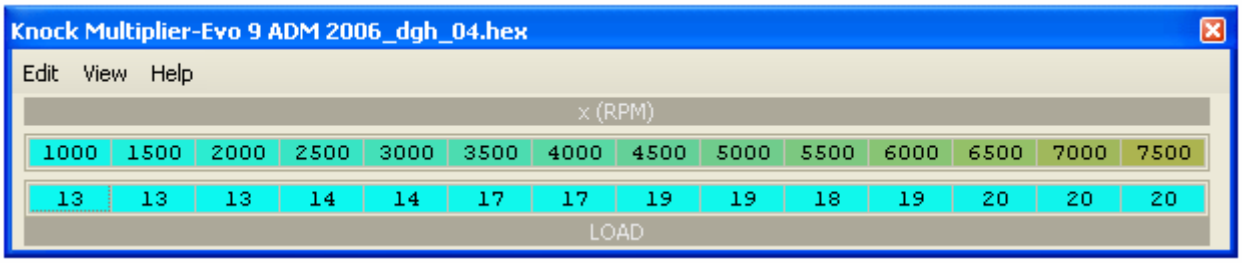
6.04-KNOCK TUNING – FALSE KNOCK

The knock events that you have logged have presumably now been assessed as FALSE KNOCK, but just to re-cap the basic principal:

Real detonation will respond to reducing the ignition timing and/or increasing the fuels octane rating.

False Knock will not respond to reducing the spark advance.

The KNOCK MULTIPLIER v RPM table provides a way to alter the KNOCKBASE profile, thus telling the ECU there is more engine noise at this load/rpm point, without loosing knock control. Adjust the value up at the rpm point where the false knock is occurring.



Here is the description **jcsbanks** provided to the Evo community on how this works in the EVO ECU.

"I would think of this as a KNOCKBASE predictor - ie the adaptive system is retrospective since it can only influence the KNOCKBASE upwards after the heavily filtered and slightly delayed (the digital filtering used adds a delay) noise level has increased. However, the right programming of the multiplier (and/or adder) by RPM will give a combination of adaptive and predictive.

The multipliers increase the KNOCKBASE, so if you increase the multiplier for a given RPM by x%, then you increase KNOCKBASE by x% also. To recap, KNOCKBASE is the level that the knock sensor noise has to exceed after each spark plug fires to cause that combustion event to register as knock and increase the KNOCKSUM. It will do this for every combustion event, so a small breach can quickly build to a big KNOCKSUM, so a small but persistent breach of KNOCKBASE will give big problems. If you think about how it is designed, it makes sense that if this was real knock and not going away quickly with KNOCKSUMs applied to the ignition timing that it would be appropriate to get aggressive with it quickly to prevent engine damage. By use of the OCTANE NUMBER, the ECU will always aim to have KNOCKSUMs of 5 or less in the long term."

Somewhat encouraging to note that at the time of writing, nobody has reported having to raise the multiplier by more than 20% to clear false knock!

SECTION 7 – MIVEC TUNING

7.01-4B11 MIVEC TUNING INTRODUCTION

The EvoX and RALLIART, equipped with the 4B11 engine, has variable cam timing on the intake and exhaust cams. It effectively works like an electrically adjustable cam-wheel and the values in the MIVEC tables are degrees of crank rotation. Thus 20° in the table will correspond to 10° of camshaft rotation.

Values for the inlet cam can be entered from 0° to 33.1° in the table. You can input values beyond 33 in the table but the advance remains at 33°.

Values for the exhaust cam can be entered from 0° to -13.8° in the table. You can input values beyond -14 in the table but the advance remains at -13.8°.

There are four MIVEC maps, two for inlet and two for exhaust. Each cam has a warm-up map (map #2) and a normal operating or hot map (map #1). The hot maps are in use when the engine temperature is above 77°C.

In the meantime, a lot of DIY tuners have experimented with cam timing and have posted their own maps and what they have found out on the web. Some of these and the factory maps for the various models will be discussed.

Previous tuning with the MIVEC equipped Evo9 has shown that aggressive MIVEC advance angles when the engine is cold will produce an edgy and irritating driving characteristic. To avoid this, set the cold map to less advance in the low rpm low load areas.

MIVEC maps tend to follow a similar pattern: cam timing advance is set very low for the idle area, set low in the lower rpm, but as the engine speed increases cam timing is advanced. Cam timing advance reaches its peak around 3500-4000 rpm and then cam timing is gradually brought back close to zero by 6500-7000 rpm.

There are good reasons for this general topography. Adding advance in the idle area will cause the engine to have a loopy idle and there is no real benefit for having advance here. Advance in the idle area will also increase emissions.

The engine will exhibit a much more sparkly light throttle response in the 1000rpm to 2500rpm range if advance is progressively added as rpm and load is increased. However, if the advance transitions across the table cells are too radical, the engine will exhibit some degree of jerky response, especially when cold or during warm-up. So the rate of advance needs to be tuned to suite the application and driving characteristics, especially if using hotter cams. There may be some knock for example, so logs should be checked.

By 2000 rpm and 100-120 load, most tuners agree the intake advance should set to 30 degrees, or thereabouts. Fortunately we have eight rpm bands in which to get a nice progressive tune, something lacking with the Evo9.

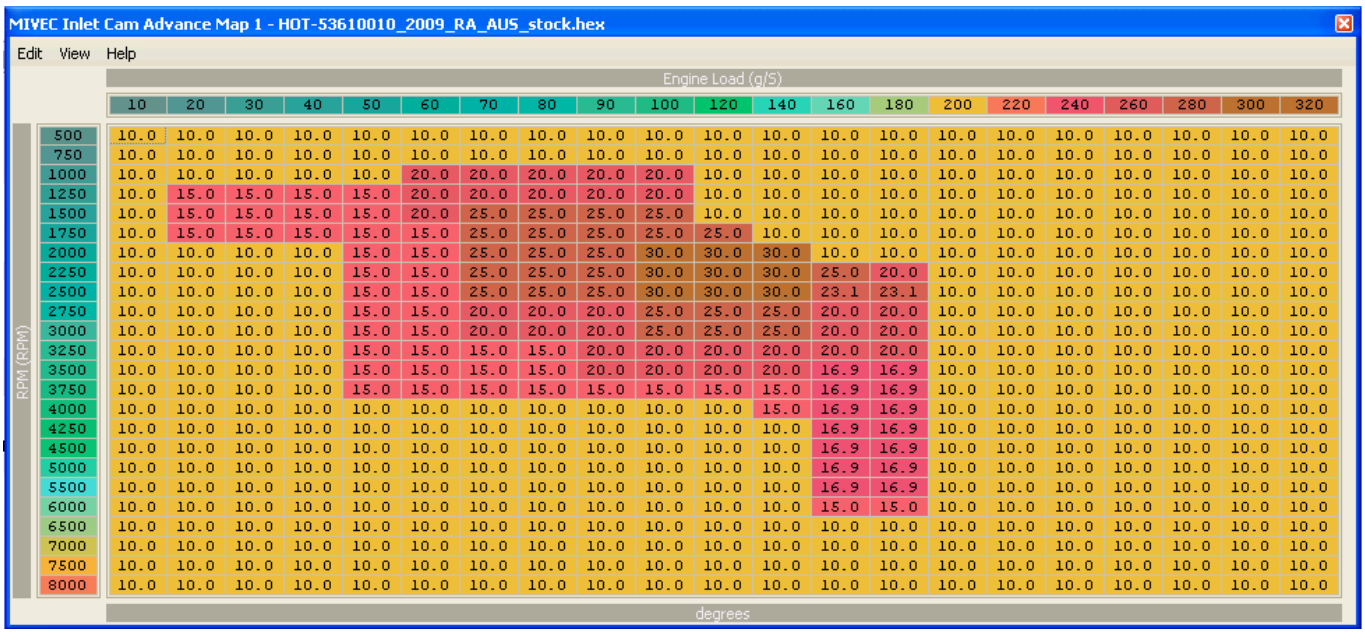
Due to higher exhaust gas back pressure, from 4500 rpm on, the intake cam advance should be progressively reduced, as per the GST tuned map, or similar, so that at 6500 rpm and 100 load and above the advance is minimal. Numerous pro-tuners have reported no benefit to adding cam advance in this area on engines with stock exhaust, and doing so will likely show reduced power. On engines with less restrictive exhausts, the exhaust manifold gas back pressure (EGBP) is reduced, so this top load and rpm area can benefit from some cam advance, though usually not as much as would be used on normally aspirated or supercharged engines.

Examine closely the tuned maps supplied by GST to the Evo community. Note how the amount of advance is reduced as the engine starts to make reasonable boost, and considerably reduced at the top-end. This is to get rid of the valve open overlap as the back-pressure in the exhaust will fight the inlet manifold boost pressure, thus reducing the amount of inlet charge in the cylinder and its effective octane rating. Measurements by tuners have shown in excess of 40psi in the exhaust manifold when under boost.

7.02-MIVEC TUNING – RALLIART INTAKE MAPS

Here is the stock 2009 AUS RALLIART intake map, both hot and cold have been set to the same values. This is ultra conservative MIVEC mapping.

Figure 31: MIVEC TUNING, 53610010 RALLIART, INTAKE MIVEC MAPS - Stock



MIVEC Inlet Cam Advance Map 1 - HOT-53610010_2009_RA_AUS_stock.hex

Edit View Help

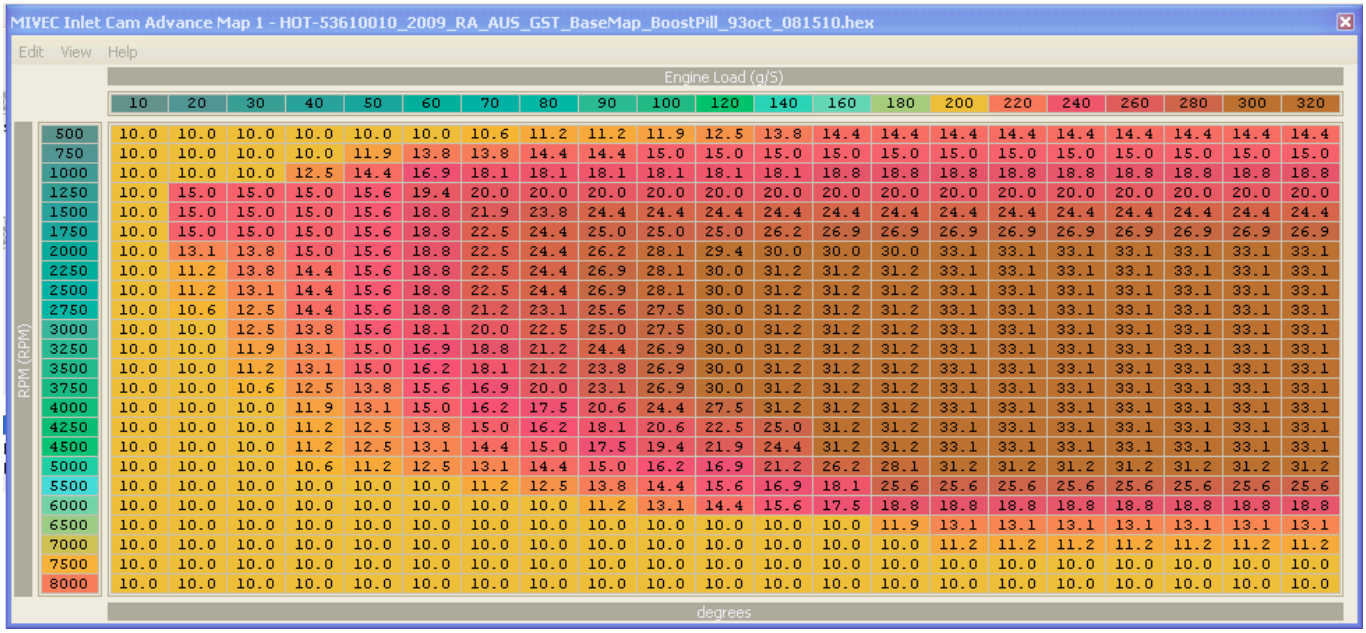
Engine Load (g/S)

RPM (RPM)	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300	320
500	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
750	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1000	10.0	10.0	10.0	10.0	10.0	20.0	20.0	20.0	20.0	20.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1250	10.0	15.0	15.0	15.0	15.0	20.0	20.0	20.0	20.0	20.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1500	10.0	15.0	15.0	15.0	15.0	20.0	25.0	25.0	25.0	25.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
1750	10.0	15.0	15.0	15.0	15.0	15.0	25.0	25.0	25.0	25.0	25.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
2000	10.0	10.0	10.0	10.0	15.0	15.0	25.0	25.0	25.0	30.0	30.0	30.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
2250	10.0	10.0	10.0	10.0	15.0	15.0	25.0	25.0	25.0	30.0	30.0	30.0	25.0	20.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
2500	10.0	10.0	10.0	10.0	15.0	15.0	25.0	25.0	25.0	30.0	30.0	30.0	23.1	23.1	10.0	10.0	10.0	10.0	10.0	10.0	10.0
2750	10.0	10.0	10.0	10.0	15.0	15.0	20.0	20.0	20.0	25.0	25.0	25.0	20.0	20.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
3000	10.0	10.0	10.0	10.0	15.0	15.0	20.0	20.0	20.0	25.0	25.0	25.0	20.0	20.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
3250	10.0	10.0	10.0	10.0	15.0	15.0	15.0	15.0	20.0	20.0	20.0	20.0	20.0	20.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
3500	10.0	10.0	10.0	10.0	15.0	15.0	15.0	15.0	20.0	20.0	20.0	20.0	16.9	16.9	10.0	10.0	10.0	10.0	10.0	10.0	10.0
3750	10.0	10.0	10.0	10.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	16.9	16.9	10.0	10.0	10.0	10.0	10.0	10.0	10.0
4000	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	15.0	16.9	16.9	10.0	10.0	10.0	10.0	10.0	10.0	10.0
4250	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	16.9	16.9	10.0	10.0	10.0	10.0	10.0	10.0	10.0
4500	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	16.9	16.9	10.0	10.0	10.0	10.0	10.0	10.0	10.0
5000	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	16.9	16.9	10.0	10.0	10.0	10.0	10.0	10.0	10.0
5500	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	16.9	16.9	10.0	10.0	10.0	10.0	10.0	10.0	10.0
6000	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	15.0	15.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
6500	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
7000	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
7500	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
8000	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

degrees

Compare the stock maps above with the GST tuned MIVEC INTAKE map shown below. GST have set both the hot and cold running maps to the same values. These changes point the way with MIVEC tuning and the result here is a much more responsive engine.

Figure 32: MIVEC TUNING, 53610010 RALLIART, INTAKE MIVEC MAPS – GST Tuned



MIVEC Inlet Cam Advance Map 1 - HOT-53610010_2009_RA_AUS_GST_BaseMap_BoostPill_93oct_081510.hex

Edit View Help

Engine Load (g/S)

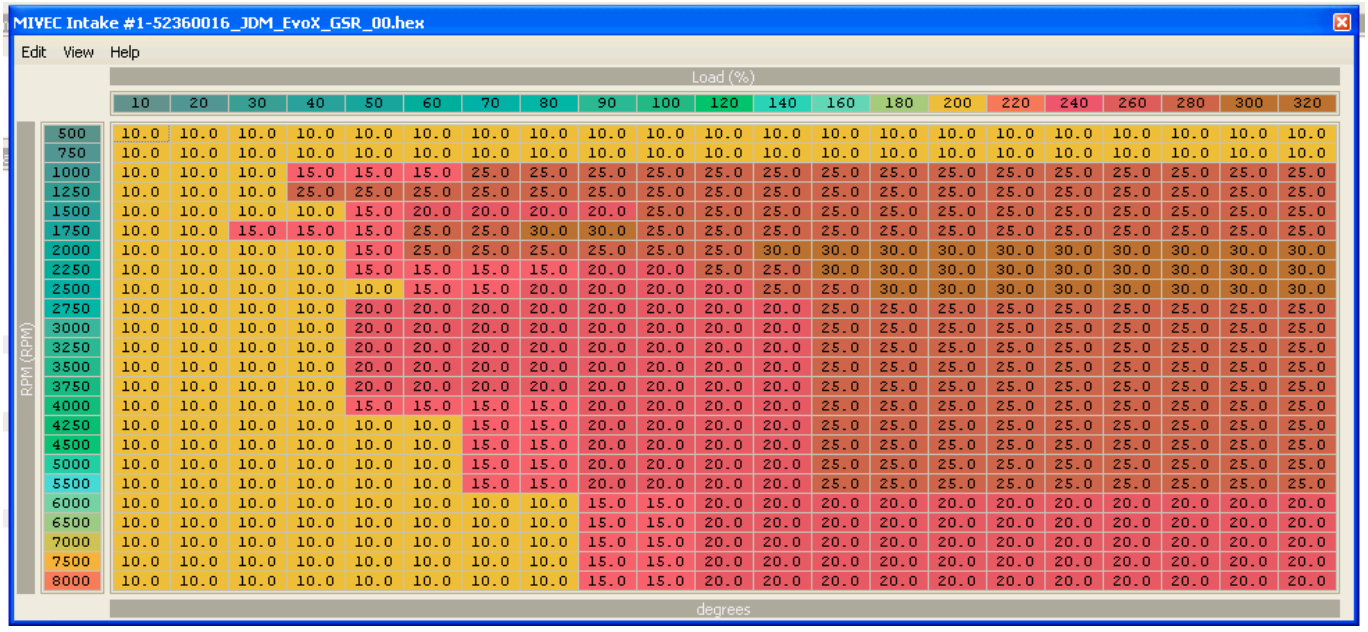
RPM (RPM)	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300	320
500	10.0	10.0	10.0	10.0	10.0	10.0	10.6	11.2	11.2	11.9	12.5	13.8	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4
750	10.0	10.0	10.0	10.0	11.9	13.8	13.8	14.4	14.4	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
1000	10.0	10.0	10.0	12.5	14.4	16.9	18.1	18.1	18.1	18.1	18.1	18.1	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8
1250	10.0	15.0	15.0	15.0	15.6	19.4	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
1500	10.0	15.0	15.0	15.0	15.6	18.8	21.9	23.8	24.4	24.4	24.4	24.4	24.4	24.4	24.4	24.4	24.4	24.4	24.4	24.4	24.4
1750	10.0	15.0	15.0	15.0	15.6	18.8	22.5	24.4	25.0	25.0	25.0	26.2	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9
2000	10.0	13.1	13.8	15.0	15.6	18.8	22.5	24.4	26.2	28.1	29.4	30.0	30.0	30.0	33.1	33.1	33.1	33.1	33.1	33.1	33.1
2250	10.0	11.2	13.8	14.4	15.6	18.8	22.5	24.4	26.9	28.1	30.0	31.2	31.2	31.2	33.1	33.1	33.1	33.1	33.1	33.1	33.1
2500	10.0	11.2	13.1	14.4	15.6	18.8	22.5	24.4	26.9	28.1	30.0	31.2	31.2	31.2	33.1	33.1	33.1	33.1	33.1	33.1	33.1
2750	10.0	10.6	12.5	14.4	15.6	18.8	21.2	23.1	25.6	27.5	30.0	31.2	31.2	31.2	33.1	33.1	33.1	33.1	33.1	33.1	33.1
3000	10.0	10.0	12.5	13.8	15.6	18.1	20.0	22.5	25.0	27.5	30.0	31.2	31.2	31.2	33.1	33.1	33.1	33.1	33.1	33.1	33.1
3250	10.0	10.0	11.9	13.1	15.0	16.9	18.8	21.2	24.4	26.9	30.0	31.2	31.2	31.2	33.1	33.1	33.1	33.1	33.1	33.1	33.1
3500	10.0	10.0	11.2	13.1	15.0	16.2	18.1	21.2	23.8	26.9	30.0	31.2	31.2	31.2	33.1	33.1	33.1	33.1	33.1	33.1	33.1
3750	10.0	10.0	10.6	12.5	13.8	15.6	16.9	20.0	23.1	26.9	30.0	31.2	31.2	31.2	33.1	33.1	33.1	33.1	33.1	33.1	33.1
4000	10.0	10.0	10.0	11.9	13.1	15.0	16.2	17.5	20.6	24.4	27.5	31.2	31.2	31.2	33.1	33.1	33.1	33.1	33.1	33.1	33.1
4250	10.0	10.0	10.0	11.2	12.5	13.8	15.0	16.2	18.1	20.6	22.5	25.0	31.2	31.2	33.1	33.1	33.1	33.1	33.1	33.1	33.1
4500	10.0	10.0	10.0	11.2	12.5	13.1	14.4	15.0	17.5	19.4	21.9	24.4	31.2	31.2	33.1	33.1	33.1	33.1	33.1	33.1	33.1
5000	10.0	10.0	10.0	10.6	11.2	12.5	13.1	14.4	15.0	16.2	16.9	21.2	26.2	28.1	31.2	31.2	31.2	31.2	31.2	31.2	31.2
5500	10.0	10.0	10.0	10.0	10.0	10.0	11.2	12.5	13.8	14.4	15.6	16.9	18.1	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6
6000	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	11.2	13.1	14.4	15.6	17.5	18.8	18.8	18.8	18.8	18.8	18.8	18.8	18.8
6500	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	11.9	13.1	13.1	13.1	13.1	13.1	13.1	13.1
7000	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	11.2	11.2	11.2	11.2	11.2	11.2	11.2
7500	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
8000	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

degrees

7.03-MIVEC TUNING – EvoX INTAKE MAPS

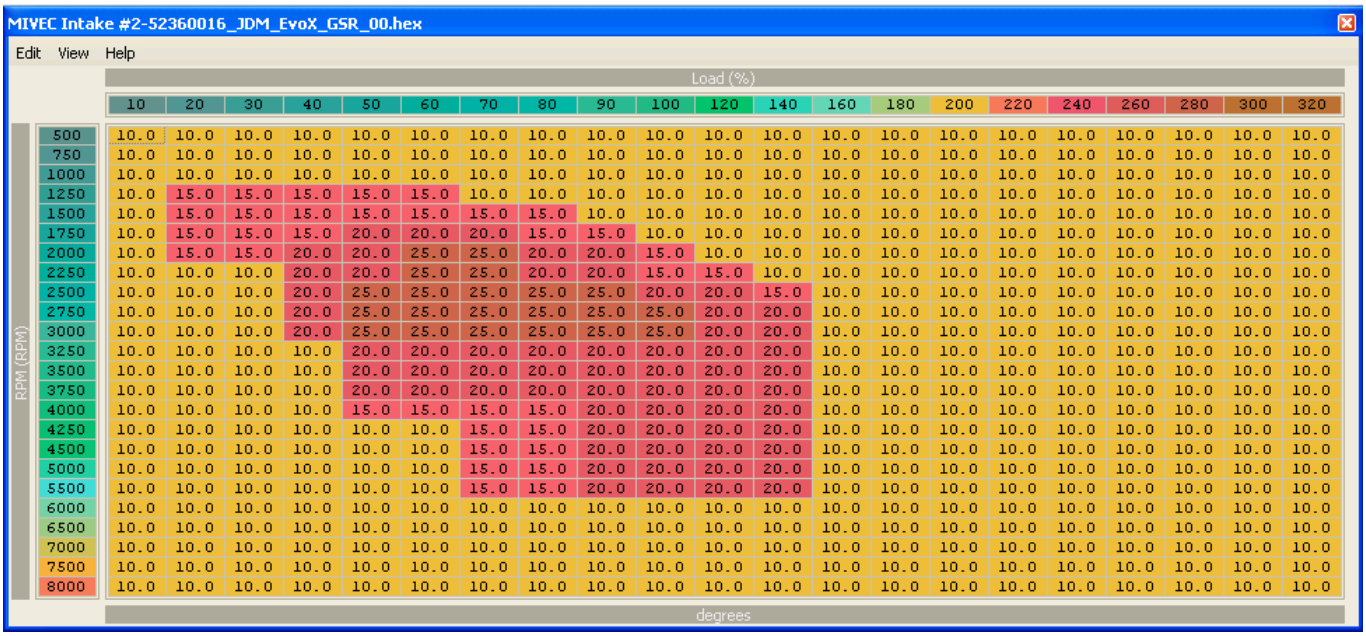
Here are the stock JDM EvoX intake MIVEC maps, the hot map is used at normal operating engine temperatures, while the cold map is used during warmup. This map is a lot more aggressive than the stock RALLIART map, but not as well tuned and progressive as the GST tuned map shown earlier. Also there is quite a lot of advance at high load / high rpm, where boost will be high. This can lead to the intake charge being blown out of the cylinder due to valve overlap, not a good tuning practice.

Figure 33: MIVEC TUNING, 52360016 EvoX, INTAKE/HOT MIVEC MAP – Stock



A fairly conservative stock cold operating Intake MIVEC map for the EvoX.

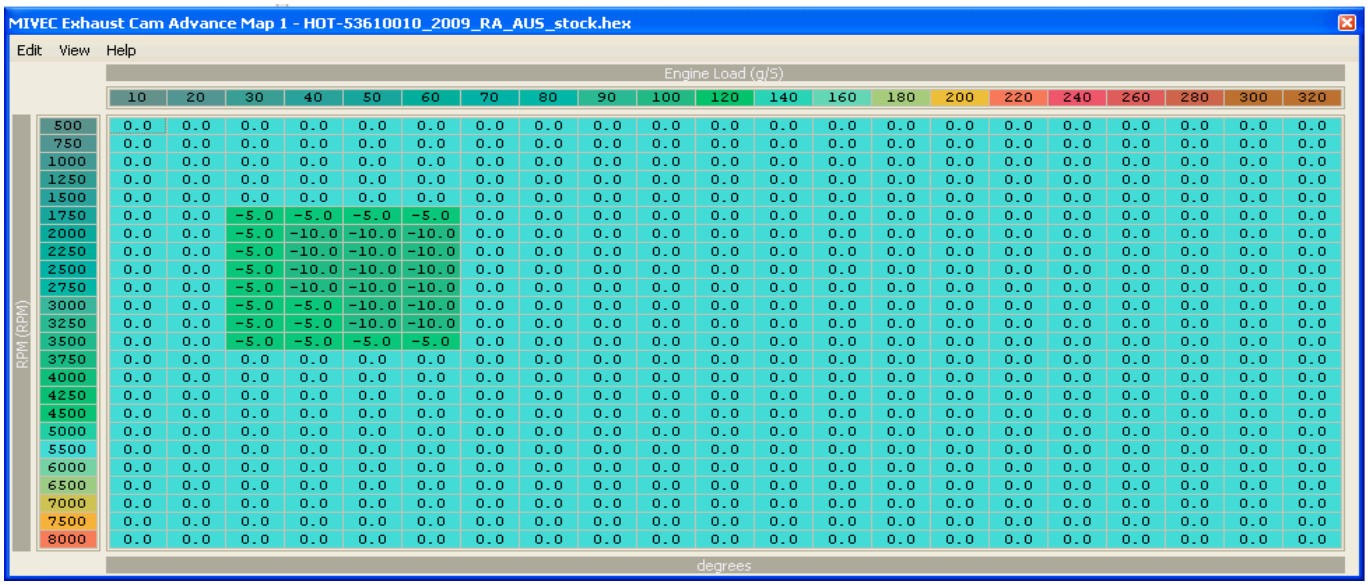
Figure 34: MIVEC TUNING, 52360016 EvoX, INTAKE/COLD MIVEC MAP – Stock



7.04-MIVEC TUNING – RALLIART EXHAUST MAPS

Here is the stock 2009 AUS RALLIART exhaust map, both hot and cold have been set to the same values. This is ultra conservative MIVEC mapping.

Figure 35: MIVEC TUNING, 53610010 RALLIART, EXHAUST MIVEC MAPS - Stock



MIVEC Exhaust Cam Advance Map 1 - HOT-53610010_2009_RA_AUS_stock.hex

Edit View Help

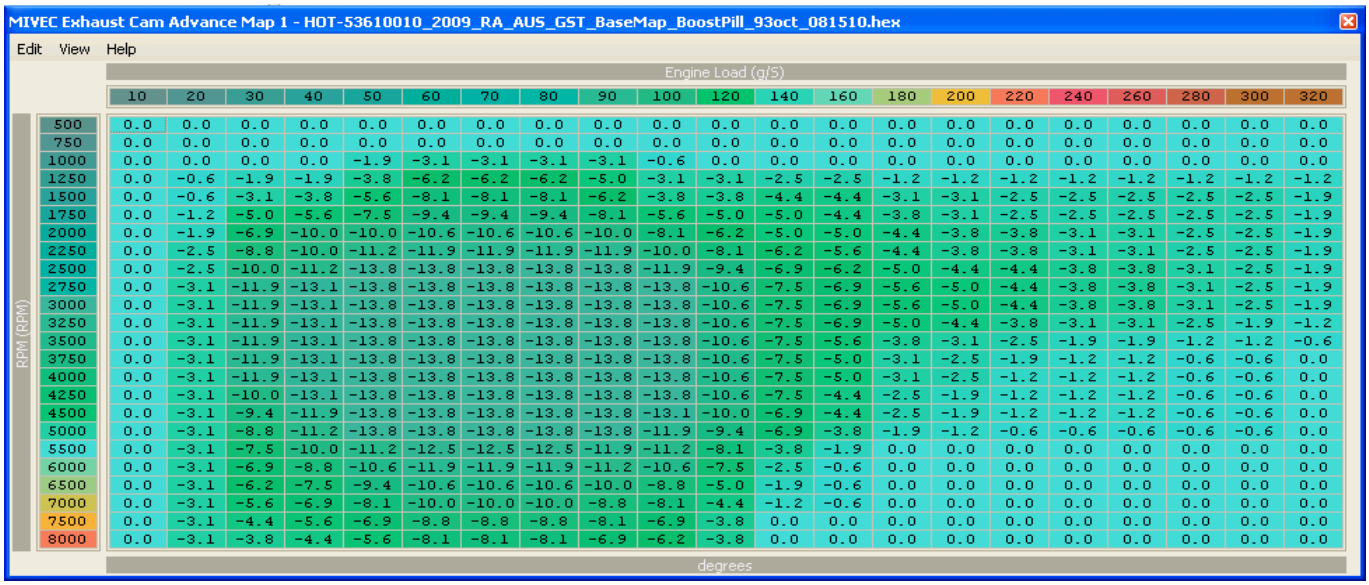
Engine Load (g/S)

RPM (RPM)	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300	320
500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
750	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1250	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1750	0.0	0.0	-5.0	-5.0	-5.0	-5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	-5.0	-10.0	-10.0	-10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2250	0.0	0.0	-5.0	-10.0	-10.0	-10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2500	0.0	0.0	-5.0	-10.0	-10.0	-10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2750	0.0	0.0	-5.0	-10.0	-10.0	-10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3000	0.0	0.0	-5.0	-5.0	-10.0	-10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3250	0.0	0.0	-5.0	-5.0	-10.0	-10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3500	0.0	0.0	-5.0	-5.0	-5.0	-5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3750	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4250	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

degrees

Compare the stock map above with the GST tuned MIVEC EXHAUST map shown below. GST have set both the hot and cold running maps to the same values. These changes point the way with MIVEC tuning and the result here is a much more responsive engine.

Figure 36: MIVEC TUNING, 53610010 RALLIART, EXHAUST MIVEC MAPS – GST Tuned



MIVEC Exhaust Cam Advance Map 1 - HOT-53610010_2009_RA_AUS_GST_BaseMap_BoostPill_93oct_081510.hex

Edit View Help

Engine Load (g/S)

RPM (RPM)	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300	320
500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
750	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000	0.0	0.0	0.0	0.0	-1.9	-3.1	-3.1	-3.1	-3.1	-0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1250	0.0	-0.6	-1.9	-1.9	-3.8	-6.2	-6.2	-6.2	-5.0	-3.1	-3.1	-2.5	-2.5	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2	-1.2
1500	0.0	-0.6	-3.1	-3.8	-5.6	-8.1	-8.1	-8.1	-6.2	-3.8	-3.8	-4.4	-4.4	-3.1	-3.1	-2.5	-2.5	-2.5	-2.5	-2.5	-1.9
1750	0.0	-1.2	-5.0	-5.6	-7.5	-9.4	-9.4	-9.4	-8.1	-5.6	-5.0	-5.0	-4.4	-3.8	-3.1	-2.5	-2.5	-2.5	-2.5	-2.5	-1.9
2000	0.0	-1.9	-6.9	-10.0	-10.0	-10.6	-10.6	-10.6	-10.0	-8.1	-6.2	-5.0	-5.0	-4.4	-3.8	-3.8	-3.1	-3.1	-2.5	-2.5	-1.9
2250	0.0	-2.5	-8.8	-10.0	-11.2	-11.9	-11.9	-11.9	-11.9	-10.0	-8.1	-6.2	-5.6	-4.4	-3.8	-3.8	-3.1	-3.1	-2.5	-2.5	-1.9
2500	0.0	-2.5	-10.0	-11.2	-13.8	-13.8	-13.8	-13.8	-13.8	-11.9	-9.4	-6.9	-6.2	-5.0	-4.4	-4.4	-3.8	-3.8	-3.1	-2.5	-1.9
2750	0.0	-3.1	-11.9	-13.1	-13.8	-13.8	-13.8	-13.8	-13.8	-13.8	-10.6	-7.5	-6.9	-5.6	-5.0	-4.4	-3.8	-3.8	-3.1	-2.5	-1.9
3000	0.0	-3.1	-11.9	-13.1	-13.8	-13.8	-13.8	-13.8	-13.8	-13.8	-10.6	-7.5	-6.9	-5.6	-5.0	-4.4	-3.8	-3.8	-3.1	-2.5	-1.9
3250	0.0	-3.1	-11.9	-13.1	-13.8	-13.8	-13.8	-13.8	-13.8	-13.8	-10.6	-7.5	-6.9	-5.0	-4.4	-3.8	-3.1	-3.1	-2.5	-1.9	-1.2
3500	0.0	-3.1	-11.9	-13.1	-13.8	-13.8	-13.8	-13.8	-13.8	-13.8	-10.6	-7.5	-5.6	-3.8	-3.1	-2.5	-1.9	-1.9	-1.2	-1.2	-0.6
3750	0.0	-3.1	-11.9	-13.1	-13.8	-13.8	-13.8	-13.8	-13.8	-13.8	-10.6	-7.5	-5.0	-3.1	-2.5	-1.9	-1.2	-1.2	-0.6	-0.6	0.0
4000	0.0	-3.1	-11.9	-13.1	-13.8	-13.8	-13.8	-13.8	-13.8	-13.8	-10.6	-7.5	-5.0	-3.1	-2.5	-1.2	-1.2	-1.2	-0.6	-0.6	0.0
4250	0.0	-3.1	-10.0	-13.1	-13.8	-13.8	-13.8	-13.8	-13.8	-13.8	-10.6	-7.5	-4.4	-2.5	-1.9	-1.2	-1.2	-1.2	-0.6	-0.6	0.0
4500	0.0	-3.1	-9.4	-11.9	-13.8	-13.8	-13.8	-13.8	-13.8	-13.1	-10.0	-6.9	-4.4	-2.5	-1.9	-1.2	-1.2	-1.2	-0.6	-0.6	0.0
5000	0.0	-3.1	-8.8	-11.2	-13.8	-13.8	-13.8	-13.8	-13.8	-11.9	-9.4	-6.9	-3.8	-1.9	-1.2	-0.6	-0.6	-0.6	-0.6	-0.6	0.0
5500	0.0	-3.1	-7.5	-10.0	-11.2	-12.5	-12.5	-12.5	-11.9	-11.2	-8.1	-3.8	-1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6000	0.0	-3.1	-6.9	-8.8	-10.6	-11.9	-11.9	-11.9	-11.2	-10.6	-7.5	-2.5	-0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6500	0.0	-3.1	-6.2	-7.5	-9.4	-10.6	-10.6	-10.6	-10.0	-8.8	-5.0	-1.9	-0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7000	0.0	-3.1	-5.6	-6.9	-8.1	-10.0	-10.0	-10.0	-8.8	-8.1	-4.4	-1.2	-0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7500	0.0	-3.1	-4.4	-5.6	-6.9	-8.8	-8.8	-8.8	-8.1	-6.9	-3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8000	0.0	-3.1	-3.8	-4.4	-5.6	-8.1	-8.1	-8.1	-6.9	-6.2	-3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

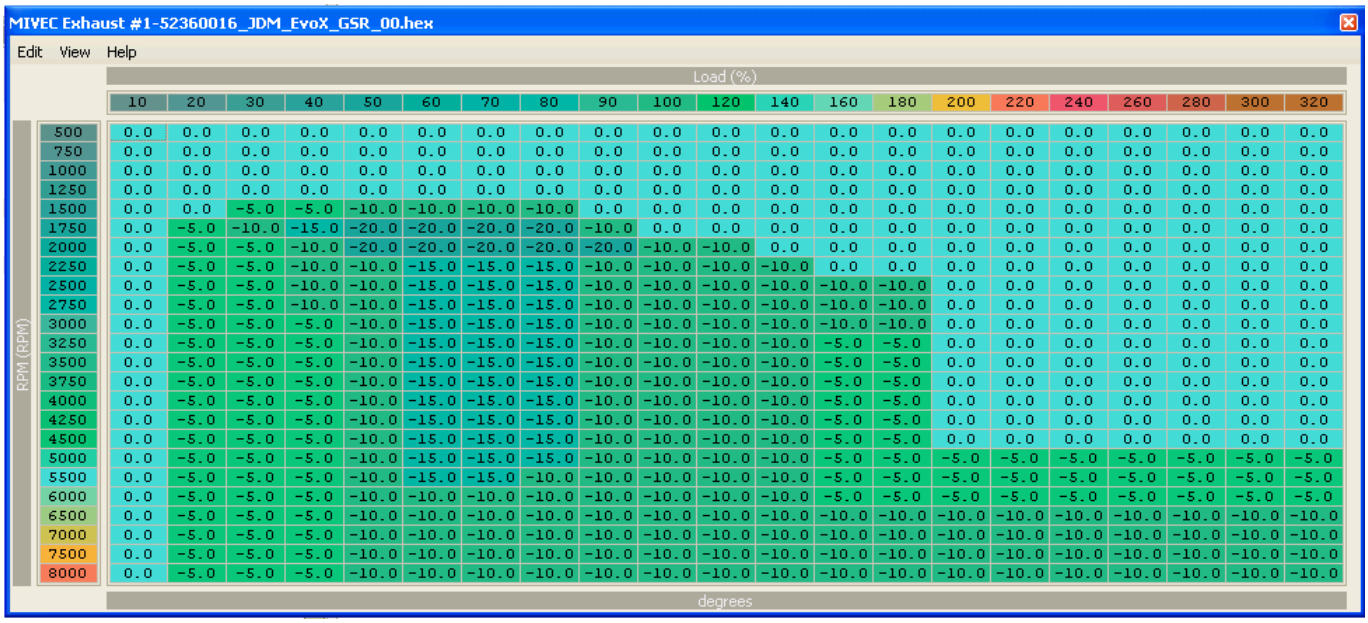
degrees

Note that there is no cam retard at idle – this would make the idle really lopey. Nor is there retard at high rpm and high load. These GST supplied maps are a very good place to start tuning from as your base-maps.

7.05-MIVEC TUNING – EVO X EXHAUST MAPS

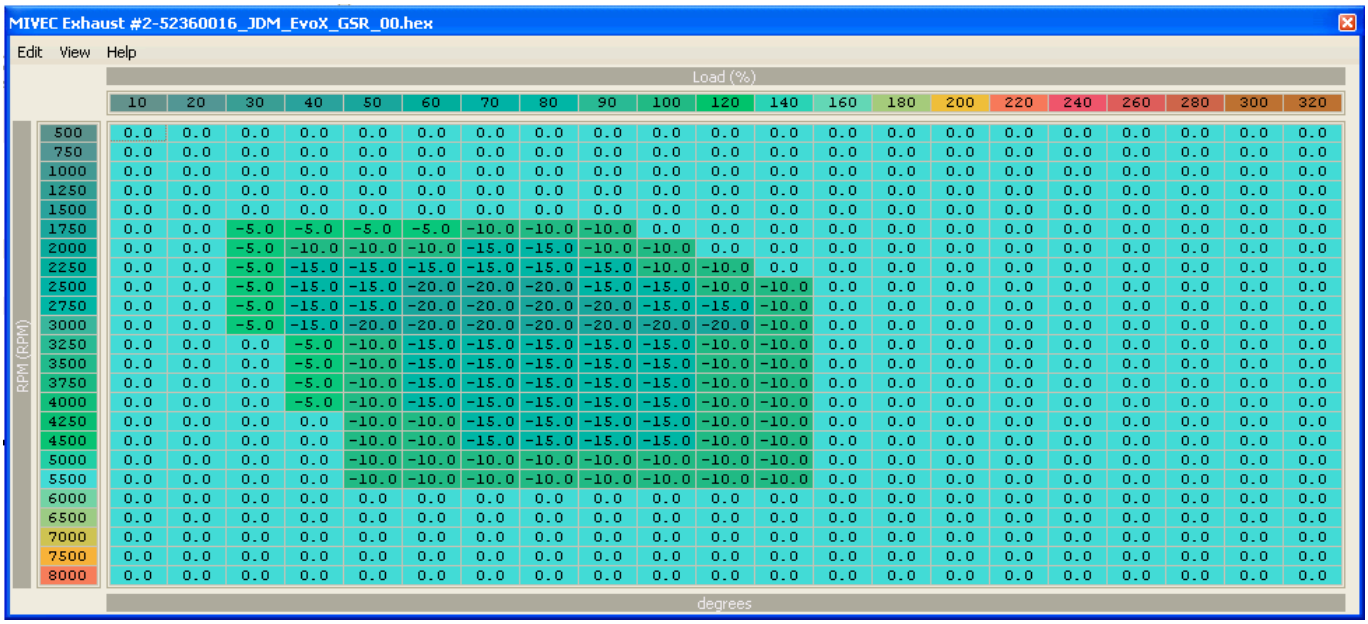
Here is the stock JDM EVO X EXHAUST/HOT MIVEC map. Considerably more aggressive than the stock RALLIART map, but the -10* area at high rpm high load may be a problem. That's a lot of overlap the turbo has to overcome and there must be some blow-through.

Figure 37: MIVEC TUNING, 52360016 EVO X, EXHAUST/HOT MIVEC MAP – Stock



Here is the stock JDM EVO X EXHAUST/COLD MIVEC map. Considerably more aggressive than the stock RALLIART map.

Figure 38: MIVEC TUNING, 52360016 EvoX, EXHAUST/COLD MIVEC MAP – Stock

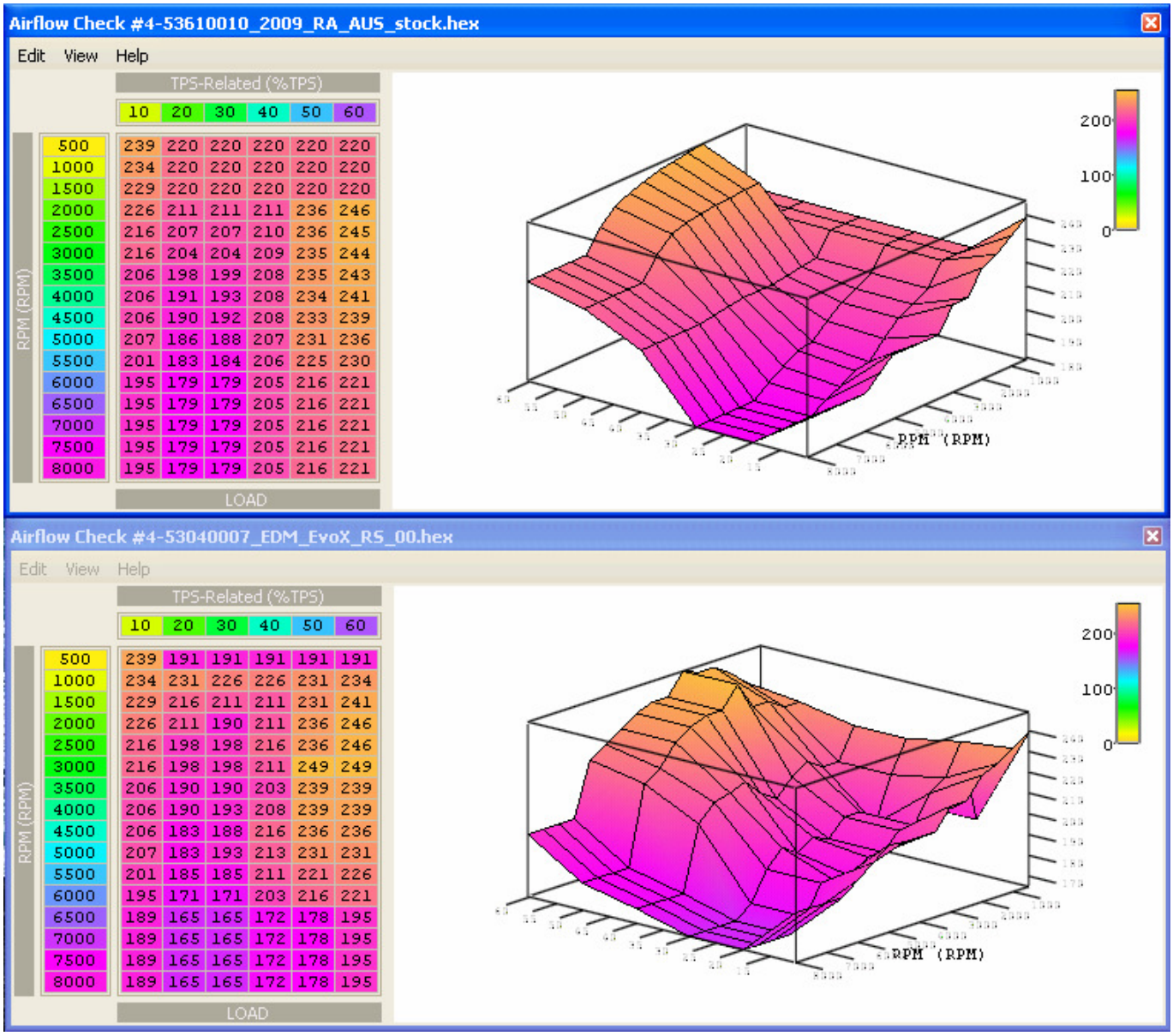


SECTION 8 – AIRFLOW AND TORQUE LIMITERS

8.01-AIRFLOW LIMITER MAPS

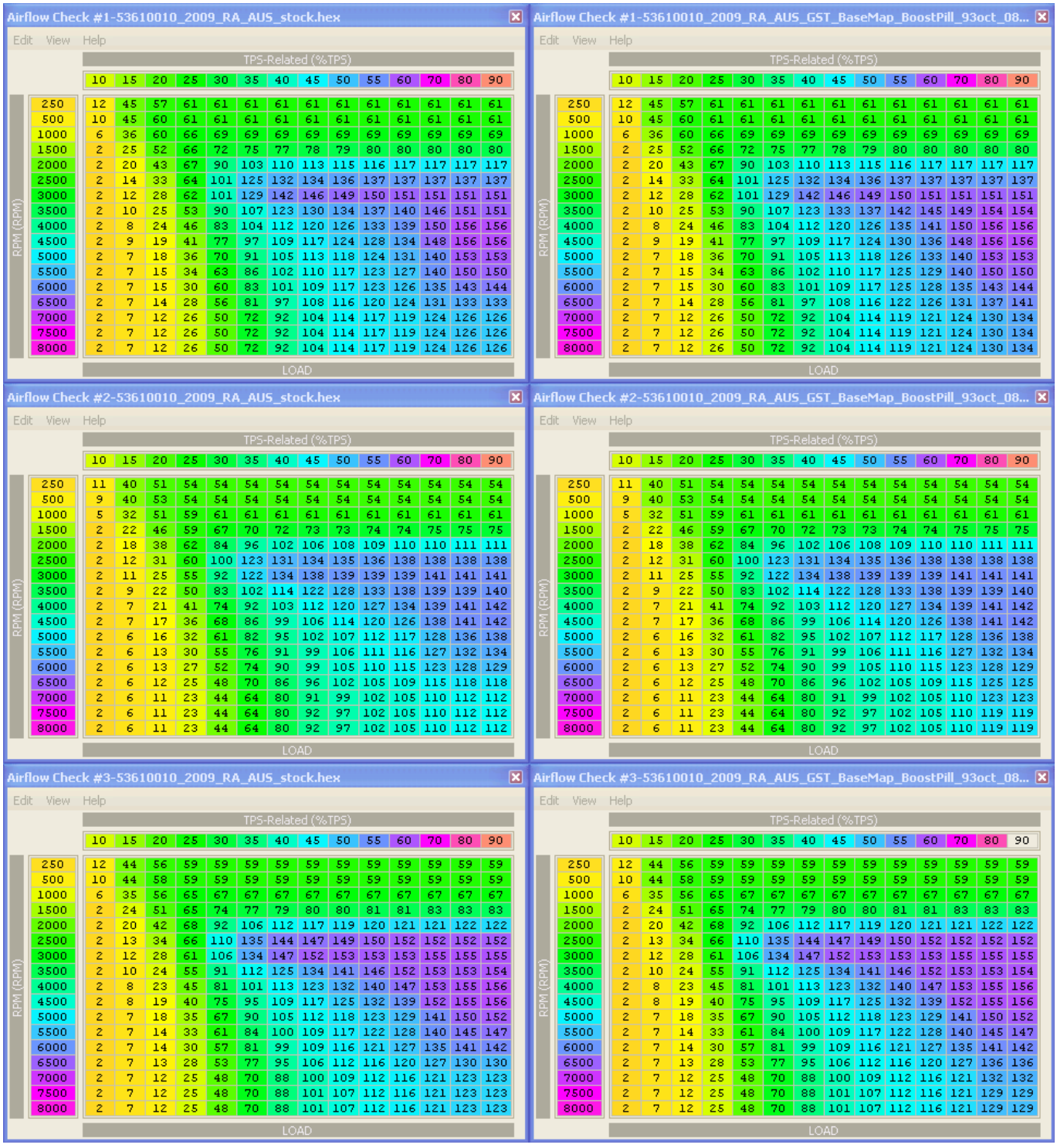
There are four air flow limit check maps and four torque limit check maps. Their operation is not yet fully understood, but if the boost level is raised past the values in the map then a CEL is triggered. These can now be circumvented by proper implementation of the DTC elimination settings, as shown in section 3.

Figure 39: AIRFLOW LIMIT MAP 4, stock RALLIART & stock EVO X RS



Here we have a comparison of stock to tuned AIRFLOW LIMITS maps 1-3. The changes are subtle indicative of what is required.

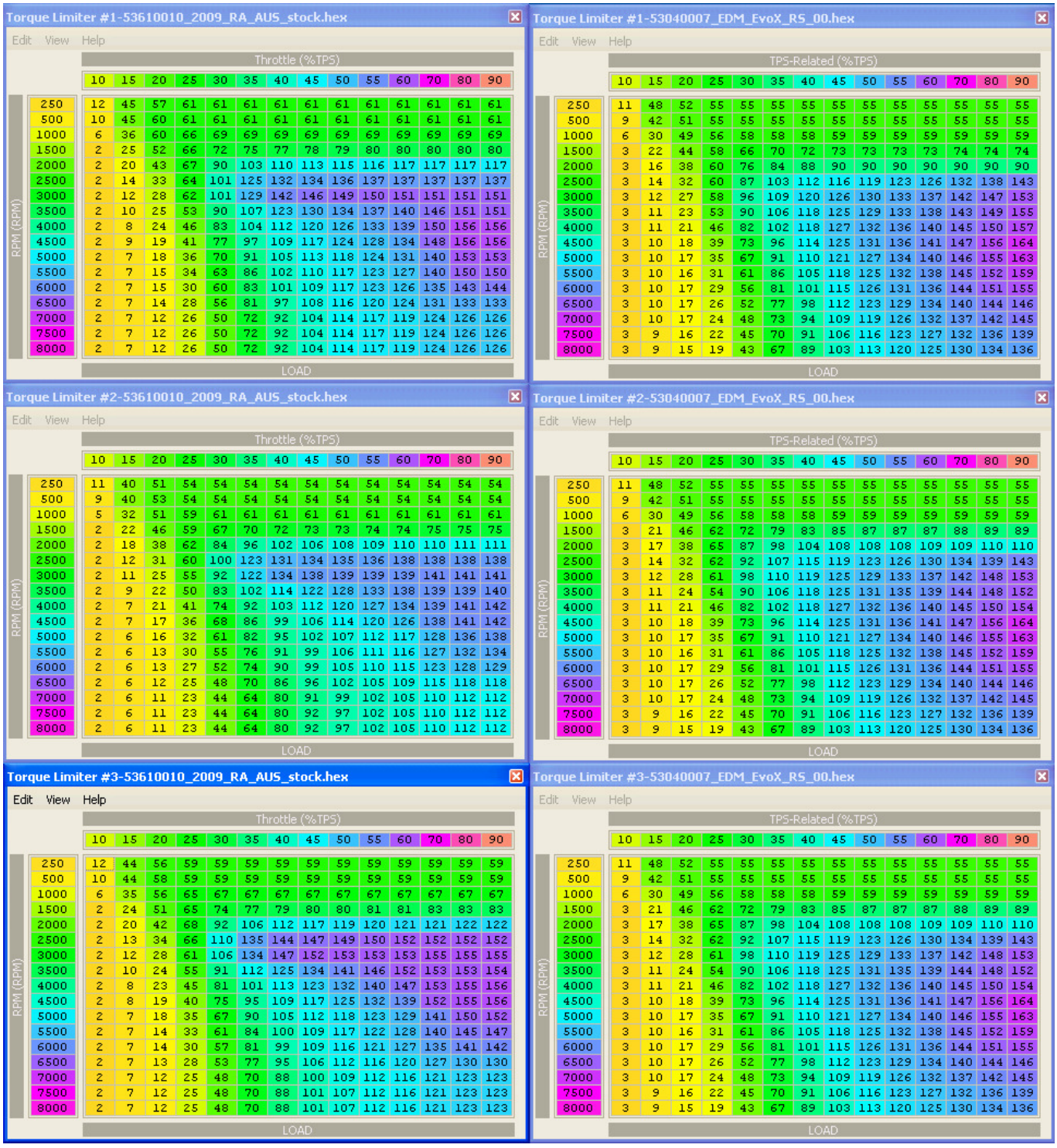
Figure 40: AIRFLOW LIMIT MAPS 1-3, RALLIART,stock & tuned by GST



8.02-TORQUE LIMITER MAPS

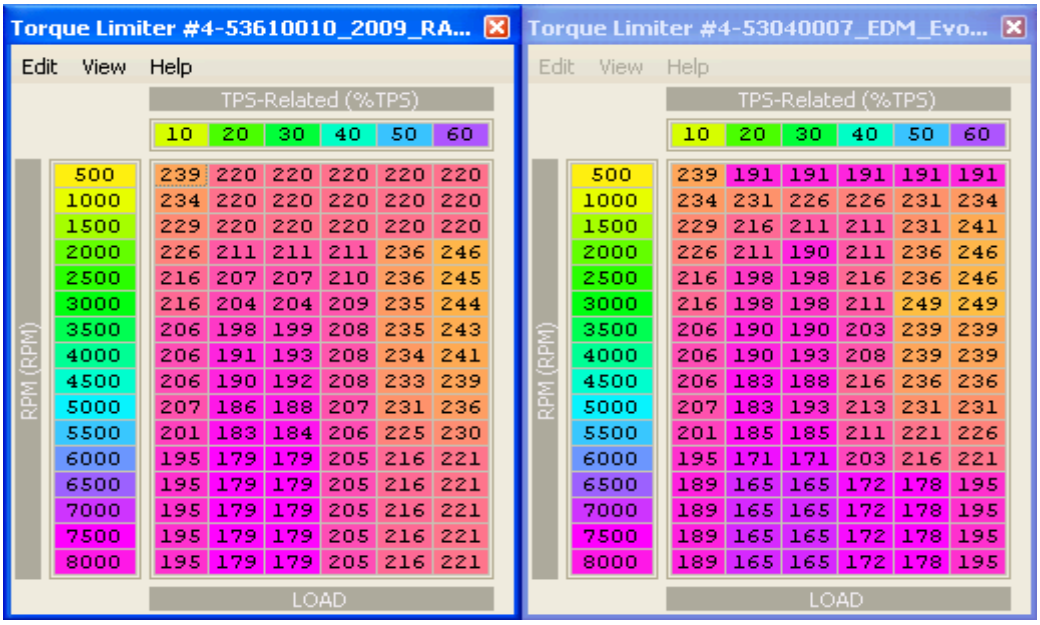
Here we have a comparison of stock TORQUE LIMITS maps 1-3, between a RALLIART and an EVO X RS. The changes are subtle indicative of what is required.

Figure 41: TORQUE LIMIT MAPS 1-3, RALLIART and EVO X RS



Here we have a comparison of stock TORQUE LIMITS map 4, between a RALLIART and an EVO X RS. The changes are subtle indicative of what is required.

Figure 42: TORQUE LIMIT MAP 4, RALLIART and EVO X RS



Torque Limiter #4-53610010_2009_RA...

Edit View Help

TPS-Related (%TPS)

RPM (RPM)	10	20	30	40	50	60
500	239	220	220	220	220	220
1000	234	220	220	220	220	220
1500	229	220	220	220	220	220
2000	226	211	211	211	236	246
2500	216	207	207	210	236	245
3000	216	204	204	209	235	244
3500	206	198	199	208	235	243
4000	206	191	193	208	234	241
4500	206	190	192	208	233	239
5000	207	186	188	207	231	236
5500	201	183	184	206	225	230
6000	195	179	179	205	216	221
6500	195	179	179	205	216	221
7000	195	179	179	205	216	221
7500	195	179	179	205	216	221
8000	195	179	179	205	216	221

LOAD

Torque Limiter #4-53040007_EDM_Evo...

Edit View Help

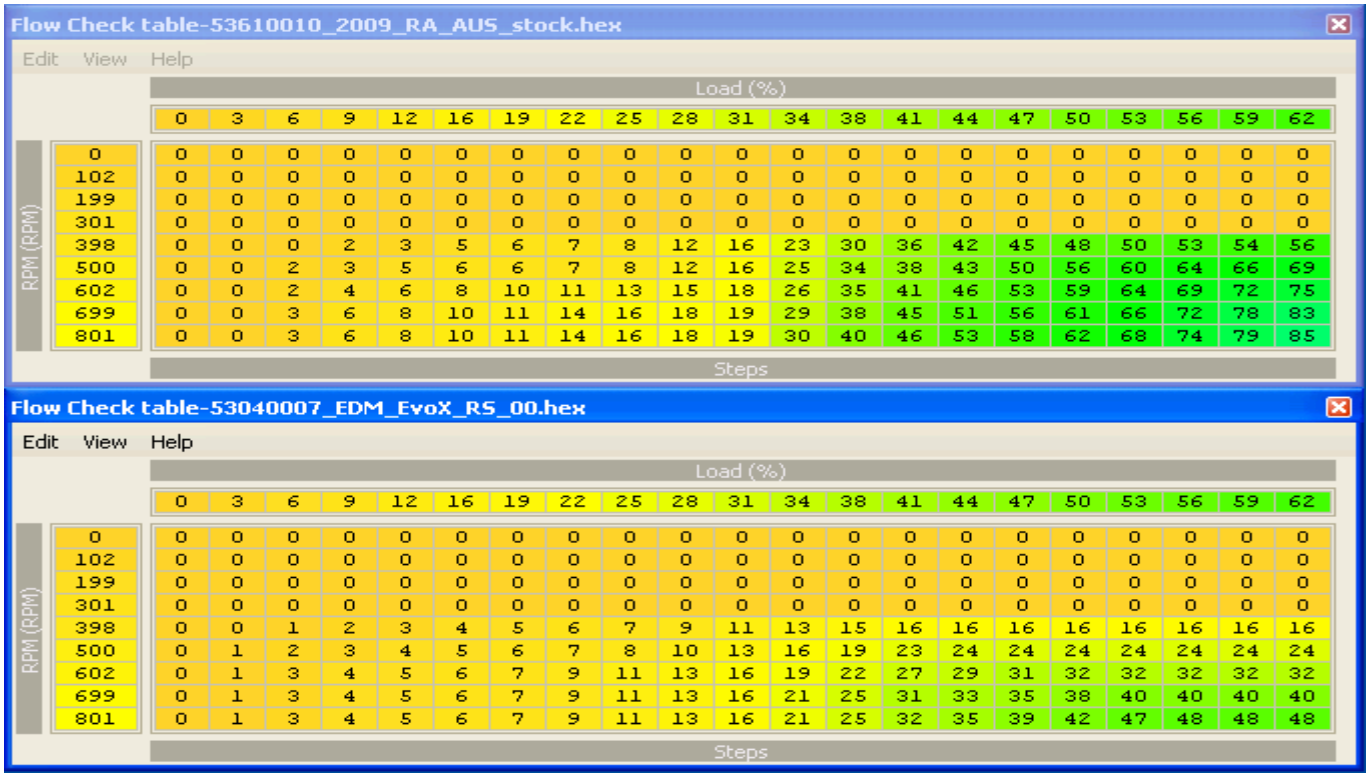
TPS-Related (%TPS)

RPM (RPM)	10	20	30	40	50	60
500	239	191	191	191	191	191
1000	234	231	226	226	231	234
1500	229	216	211	211	231	241
2000	226	211	190	211	236	246
2500	216	198	198	216	236	246
3000	216	198	198	211	249	249
3500	206	190	190	203	239	239
4000	206	190	193	208	239	239
4500	206	183	188	216	236	236
5000	207	183	193	213	231	231
5500	201	185	185	211	221	226
6000	195	171	171	203	216	221
6500	189	165	165	172	178	195
7000	189	165	165	172	178	195
7500	189	165	165	172	178	195
8000	189	165	165	172	178	195

LOAD

Here we have a comparison of stock TORQUE LIMITS maps 1-3, between a RALLIART and an EVO X RS.

Figure 43: FLOW CHECK MAPS, RALLIART and EVO X RS



Flow Check table-53610010_2009_RA_AUS_stock.hex

Edit View Help

Load (%)

RPM (RPM)	0	3	6	9	12	16	19	22	25	28	31	34	38	41	44	47	50	53	56	59	62
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
102	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
199	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
301	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
398	0	0	0	2	3	5	6	7	8	12	16	23	30	36	42	45	48	50	53	54	56
500	0	0	2	3	5	6	6	7	8	12	16	25	34	38	43	50	56	60	64	66	69
602	0	0	2	4	6	8	10	11	13	15	18	26	35	41	46	53	59	64	69	72	75
699	0	0	3	6	8	10	11	14	16	18	19	29	38	45	51	56	61	66	72	78	83
801	0	0	3	6	8	10	11	14	16	18	19	30	40	46	53	58	62	68	74	79	85

Steps

Flow Check table-53040007_EDM_EvoX_RS_00.hex

Edit View Help

Load (%)

RPM (RPM)	0	3	6	9	12	16	19	22	25	28	31	34	38	41	44	47	50	53	56	59	62
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
102	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
199	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
301	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
398	0	0	1	2	3	4	5	6	7	9	11	13	15	16	16	16	16	16	16	16	16
500	0	1	2	3	4	5	6	7	8	10	13	16	19	23	24	24	24	24	24	24	24
602	0	1	3	4	5	6	7	9	11	13	16	19	22	27	29	31	32	32	32	32	32
699	0	1	3	4	5	6	7	9	11	13	16	21	25	31	33	35	38	40	40	40	40
801	0	1	3	4	5	6	7	9	11	13	16	21	25	32	35	39	42	47	48	48	48

Steps

SECTION 9 – BOOST TUNING

9.01-BOOST TUNING INTRODUCTION

The boost control maps and tables for the RALLIART and the EXOX can be gear selected. In other words, the ECU will select which maps to use based on the gear currently in use. There is a single parameter which defines the rpm/mph and this parameter can be tweaked to flip the maps. However, Mitsubishi have elected to utilize this feature on the SST equipped vehicles only. So the maps and tables are generally set the same on manual gearbox vehicles.

You can utilize this feature though as the coding is fully active and working.

Another change from what we have had with earlier Evos (JDM excepted) is the use of two boost control solenoids on the EvoX – the RALLIART still only has one boost control solenoid. When you look at the tune using EcuFLASH, the waste-gate duty cycle tables labeled REACTIVE are the main tables (present in both EVOX and RALLIART) while the tables labeled PASSIVE are for the second BCS in the EVOX only. A RALLIART ROM XML may have these PASSIVE tables listed, they just don't do anything.

The PASSIVE BCS has not error correction code associated with it, so it just does what the table specifies.

The REACTIVE BCS has boost error correction coding that adjusts the wastegate duty cycle to try and get the engine load to match the target load.

To really get on top of boost tuning requires some method logging the boost with load and rpm so it is clear which map cells need to be modified. The data logger takes the signal and based on the sensor calibration data translates the voltage into psi. The EvoX is equipped with a 3 bar MAP sensor that sits atop of the inlet manifold, so now you can log the boost directly from the ECU provided you have properly modified your EvoScan xml file to log boost.

Now for the bad news. The stock boost control solenoid, in combination with the stock restriction pill will only allow a little further increase in boost and airflow.

The first fix is to replace the stock pill with one having a smaller feed hole. A pill with a 0.8mm hole will get the system back into reasonable adjustment range.

The second fix is to replace the stock 2-port BCS with a 3-port BCS. This method is by far the best setup and does not require any changes to the stock pill. Both methods allows full use of the ECU boost control features including twin boost tables.

9.02-BOOST CONTROL – PILLS, BOVS & PLUMBING

The stock boost control equipment as fitted to the EVO X and RALLIART definitely has some tuning restrictions, whether you hit them will depend on how much horsepower you are targeting.

The first item of priority will be the limitations imposed by the stock boost control solenoid (BCS) setup. The RALLIART has one BCS while the EVO X has two BCS, giving it a bit more capability. In both cases, the first modification is to change the BCS pill. This is a small brass restrictor fitted into the BCS hose before the Tee junction. Its job is to reduce the total air flow through the solenoids, giving them a better range of tuning adjustment.

See the pix below on the BCS hose and pill arrangement from GST MotorSports, check them out at: http://www.gstmotorsports.com

GST can supply a suitable new pill at reasonable cost.

Figure 44: BOOST TUNING – WASTEGATE ACTUATOR HOSE & PILL SETUP,EVO X

The second item to be addressed is the recirculation valve, more commonly known as the BOV.

Stock RALLIART plastic valves are just ok to about 23psi, by 25 psi they will typically open under boost pressure. A BOV that starts to leak will cause turbo overspeed and elevated inlet temperatures, essentially pushing the turbo past its best operating characteristics. The stock EVO X metal unit is somewhat better, but really only to about 26-27 psi, beyond which it is in trouble too.

So for boost pressures above 25 psi we really need to find a better valve. And there are some good units on the market. Probably the undisputed best BOV is the SYNAPSE SYNCHRONIC BOV, its poppet valve design is such that it basically cannot leak. It has a minor drawback in that it is quite a bit longer than other offerings. Other than that, its perfect. Installation pix from **Sean@DSG** on evoxforums.com.

Figure 45: BOOST TUNING – SYNAPSE BOV on EVO X, stock mounting position

And another top installation pix with AMS parts from **BigStevebowski** on evoxforums.com.

Figure 46: BOOST TUNING – SYNAPSE BOV on EVO X, on AMS intake pipe

Another very good BOV is the APS twin vent in plumb-back configuration. This is a conventional piston design, but made very well with good spring ratings for the EVO X.

Figure 47: BOOST TUNING – APS TWIN VENT BOV

9.02-BOOST CONTROL - AIRFLOW / BOOST LIMIT v RPM

The factory ECU tune has a set of parameters, called BOOST LIMIT, which is directly related to the calibrated output from the MAF. Once the ECU senses the air flow and thus the engine load, is at the BOOST LIMIT, as shown in the table below, it will cut fuel to protect the engine. This is referred to as the boost cut function, but is more accurately called Air Flow Cut. Once the MAF reads below the AIRFLOW LIMIT value, the ECU will inject fuel once again. If the values of AIRFLOW LIMIT are set at maximum, to eliminate the boost cut function, there is no over boost protection, which is not good idea.

Figure 48: BOOST TUNING – stock AIRFLOW BOOST LIMIT v RPM, RALLIART

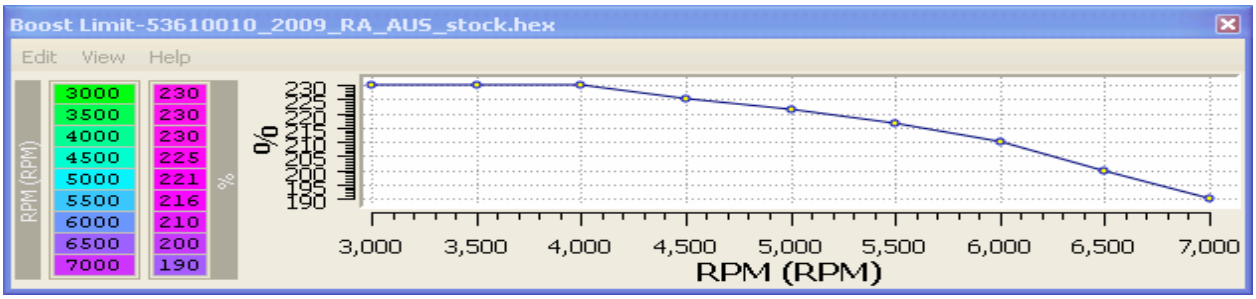
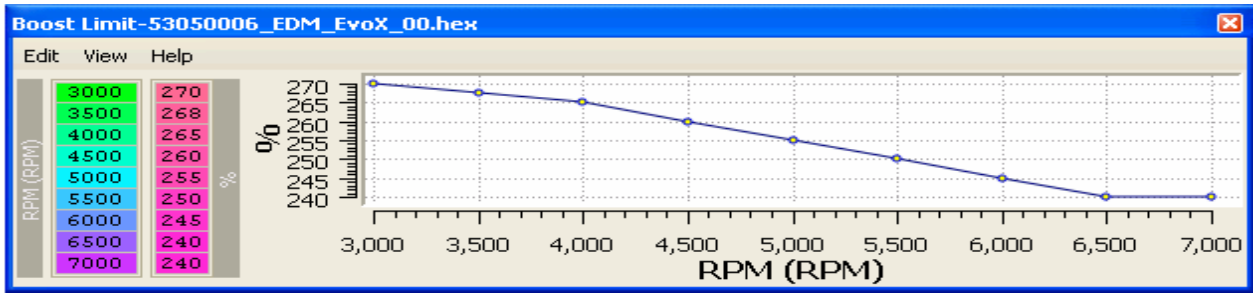


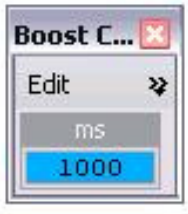
Figure 49: BOOST TUNING – stock AIRFLOW BOOST LIMIT v RPM, EVO X



Note how the values roughly follow the expected boost curve, offset some 30% higher, thus allowing for some variations in temperature and operating conditions, gear etc. When raising the boost level, this table will have to be raised or you will very quickly hit boost cut.

The BOOST CUT DELAY TIMER sets the time in milli-seconds after the BOOST LIMIT is exceeded before fuel cut is instigated. Setting the BOOSTCUT DELAY to three seconds will effectively allow for a mild over-boost spike without triggering boost cut. This can be quite a useful feature.

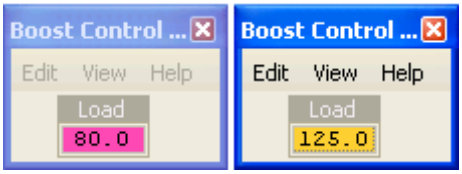
Figure 50: BOOST TUNING – BOOSTCUT DELAY TIMER



9.03-BOOST CONTROL - BOOST TARGET LOAD v RPM

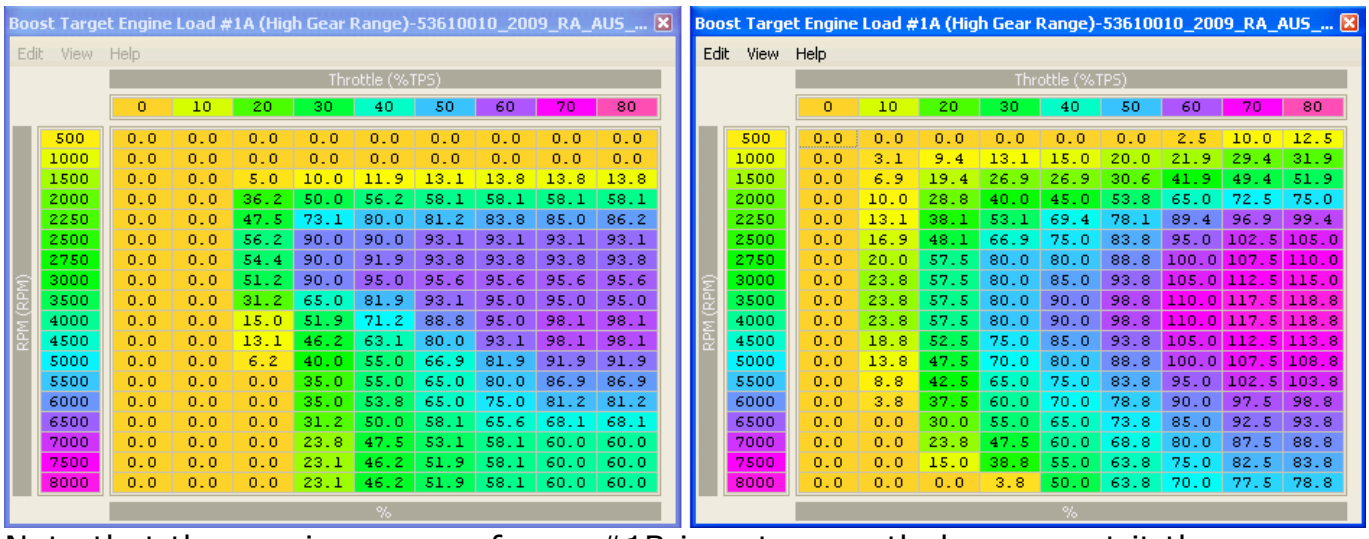
The ECU has three maps, called BOOST TARGET ENGINE LOAD, (#1A High Gear Range, #1B High Gear Range and #2 Low Gear Range) which with the addition of the BOOST CONTROL LOAD OFFSET parameter, sets the target boost level. So, for an ADM RALLIART, as shown in the tuning example below, with 98 in the DESIRED BOOST ENGINE LOAD table and an offset of 80 from the BOOST OFFSET data, gives a desired peak boost load level of 178. Or, roughly 15-17psi boost level.

Figure 51: BOOST TUNING – BOOST CONTROL LOAD OFFSET, stock & tuned



In the GST tuned ROM for the same car, the BOOST CONTROL OFFSET has been bumped to 125 and the BOOST TARGET ENGINE LOAD map has been raised to values of 118 through the peak torque rpm band. This should give a desired peak boost load level of 243, or roughly 21psi.

Figure 52: BOOST TUNING – TARGET LOAD, RALLIART, stock & tuned by GST



Note that the precise usage of map #1B is not currently known, set it the same as #1A. The switching between maps 1 and 2 is controlled by RPM/MPH CROSSOVER.

The table below will provide a rough guide (for a stock turbo) as to what the boost level is for a given load. The actual pressure will vary with gearing/temp/altitude and the rate of load change.

Table 3 ROUGH GUIDE TO LOAD v BOOST LEVEL

LOAD	120	140	160	180	200	220	240	260	280	300
BOOST RANGE	4.5 7.5	7.5 11.0	11 15	15 17	17 19	19 21	21 23	23 25	25	

9.04-BOOST CONTROL - RPM/MPH CROSSOVER

The BOOST CONTROL RPM/MPH CROSSOVER parameter is a very important item if you wish to modify the stock boost control for two boost levels, based on the gear selection.

When the rpm/mph is less than the crossover point, the ECU uses all the control tables labeled #1, ie BDEL#1 and WGDC#1. When the rpm/mph is more than the crossover point BDEL#2 and WGDC#2 are used.

Most examined ECUs have had the value set to 145rpm/mph, resulting in a crossover between 1st and 2nd gear. This parameter is fair game for tuning though, typically tuners will set it to crossover between 3rd and 4th gears.

Figure 53: BOOST TUNING – tuned BOOST CONTROL RPM/MPH CROSSOVER

The table below shows the rpm/mph approximate values for GSR and MR variants.

Thus, with a value of 105 rpm/mph, (as shown above) where the crossover is set halfway between 2nd and 3rd gear, the ECU will use the second set of tables for 1st and 2nd gear. Instant gear based boost control!

Table 4 RPM per MPH Guide

GEAR	2008 Evo X GSR			2008 Evo X MR		
	Gear Ratio	rpm/mph	Crossover	Gear Ratio	rpm/mph	Crossover
1st	2.857	175	1st-2nd = 145	3.655	194	1st-2nd = 145
2nd	1.950	119	2nd-3rd = 105	2.368	126	2nd-3rd = 110
3rd	1.444	88	3rd-4th = 75	1.754	93	3rd-4th = 80
4th	1.096	67	4th-5th = 57	1.322	70	4th-5th = 62
5th	0.761	47		1.008	54	5th-6th = 47
6th				0.775	41	

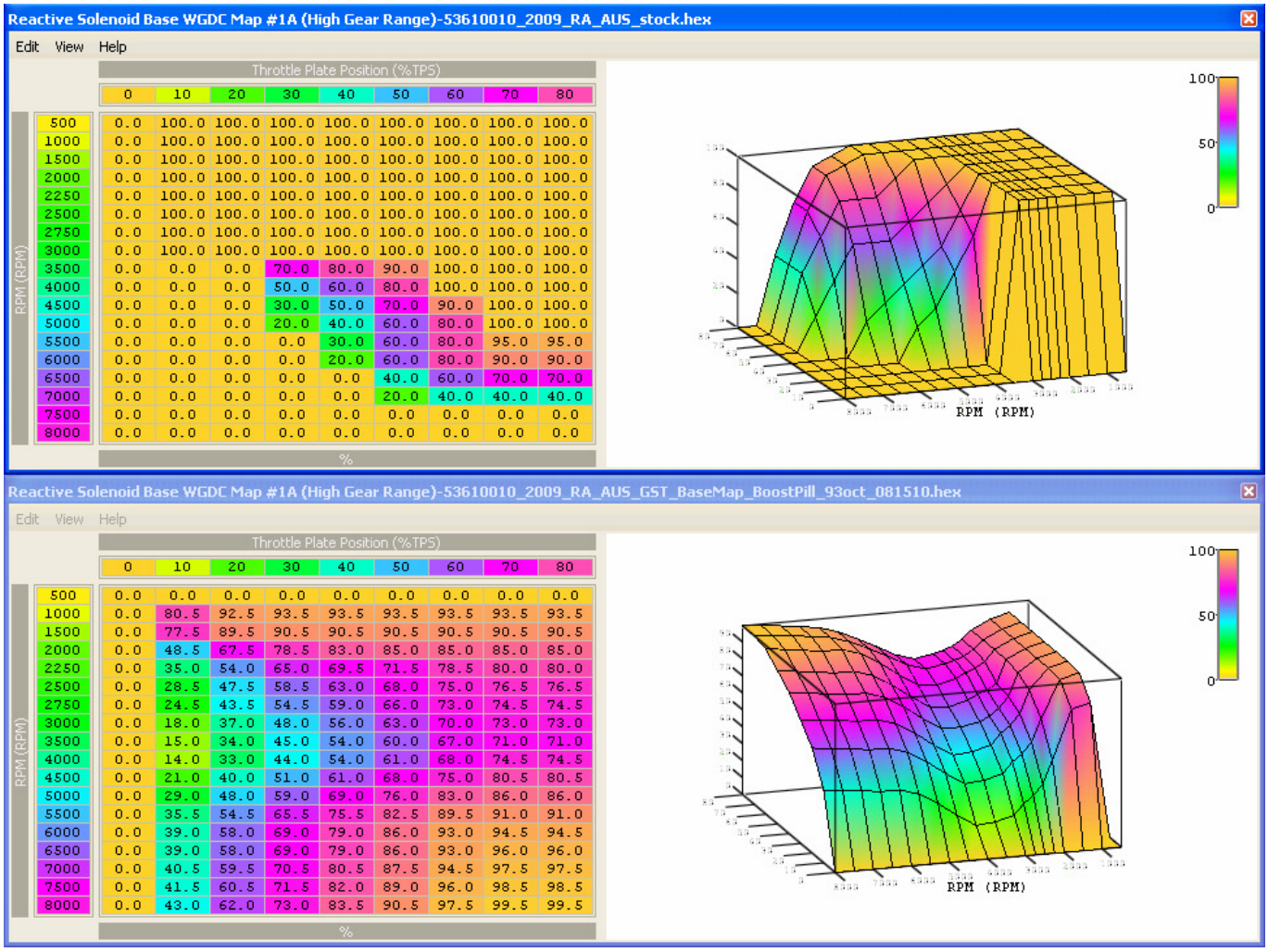
If you want to have all this as rpm/kph, then the factor in the scaling has to be changed from 22.6 (mph) to 37.7 (kph).

9.05-BOOST CONTROL – REACTIVE SOLENOID WGDC v RPM/TPS

There are three maps to control the REACTIVE SOLENOID WGDC, two high gear and one low gear as per the BOOST TARGET ENGINE LOAD maps. Un-like earlier Evos, the EvoX and RALLIART have 3D maps to set the base WGDC. They allow the ECU to quickly get the duty cycle close to the required value, then with the aid of the correction table, get the load to match the BOOST TARGET ENGINE LOAD map + the BOOST OFFSET value.

Shown below are the maps from a stock RALLIART and below it a GST tuned RALLIART using a boost pill to restrict the total air flow. See how with the stock setup the BCS has to be driven to 100% WGDC to get some measure of control and a decent boost level. With the new pill in place, a much higher level of control is possible at higher boost levels.

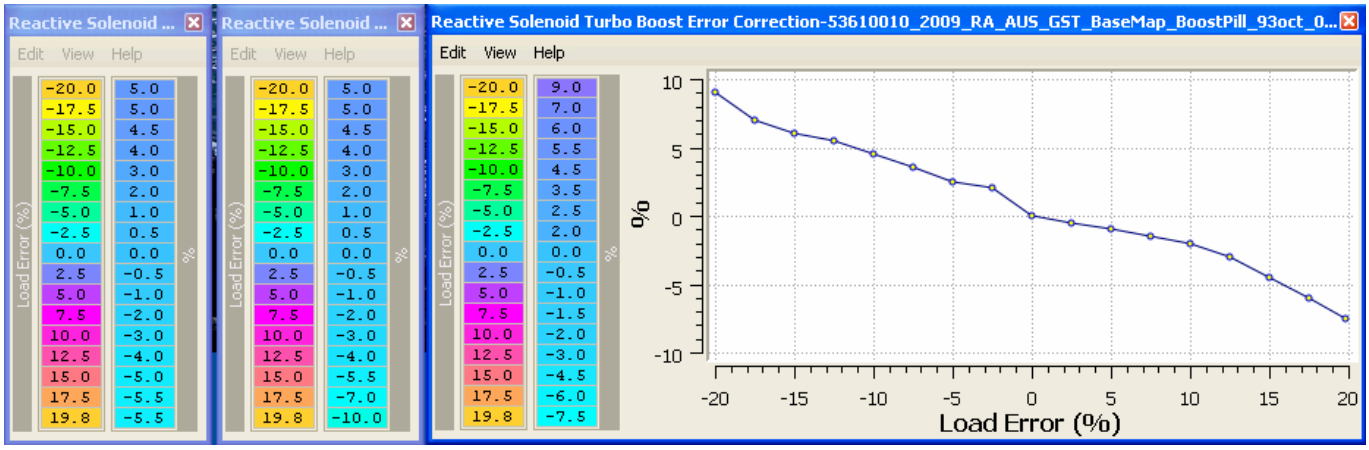
Figure 54: BOOST TUNING – REACTIVE SOLENOID WGDC % v RPM – RALLIART



9.06-BOOST TUNING - BOOST ERROR CORRECTION

The table is used to correct the boost control solenoid (BCS) pulse duty cycle to get the actual load to match the desired load. Shown below are three variants, from left to right: stock EvoX, stock RALLIART and GST tuned RALLIART. Note that the error correction only operates on the "Reactive Solenoid Base WGDC Maps". Both the RALLIART and the EvoX have the reactive tables, only the EvoX has the passive solenoid.

Figure 55: BOOST TUNING – BOOST ERROR CORRECTION



When the engine is idling or cruising, the BCS is at 0% WGDC. When the engine starts boosting and the load exceeds the MIN LOAD for BOOST CONTROL point, the ECU sets the BCS pulsing with a duty cycle from the BASE WGDC v RPM 3D map. At that point the ECU compares the actual load to the BOOST TARGET ENGINE LOAD map (plus the BOOST LOAD OFFSET) and makes an appropriate adjustment to the WGDC to the BCS.

The rate at which the tracking check is made is set by the ERROR CORRECTION INTERVAL timer. The stock value of 10 results in a correction interval of 1000mS between adjustments to the WGDC. This interval can be shortened to provide better boost control, a value of 3 gives a correction interval of 300mS and is a good setting to use with three corrections per second. By shortening the interval, the ECU will much more rapidly respond to load deviations from the target load value. Recommended minimum value is 3-4 for faster boost error tracking. Note that when using a reduced correction interval you should also reduce the BOOST ERROR CORRECTION table values to prevent over correction as the system will now have less lag and is effectively more sensitive.

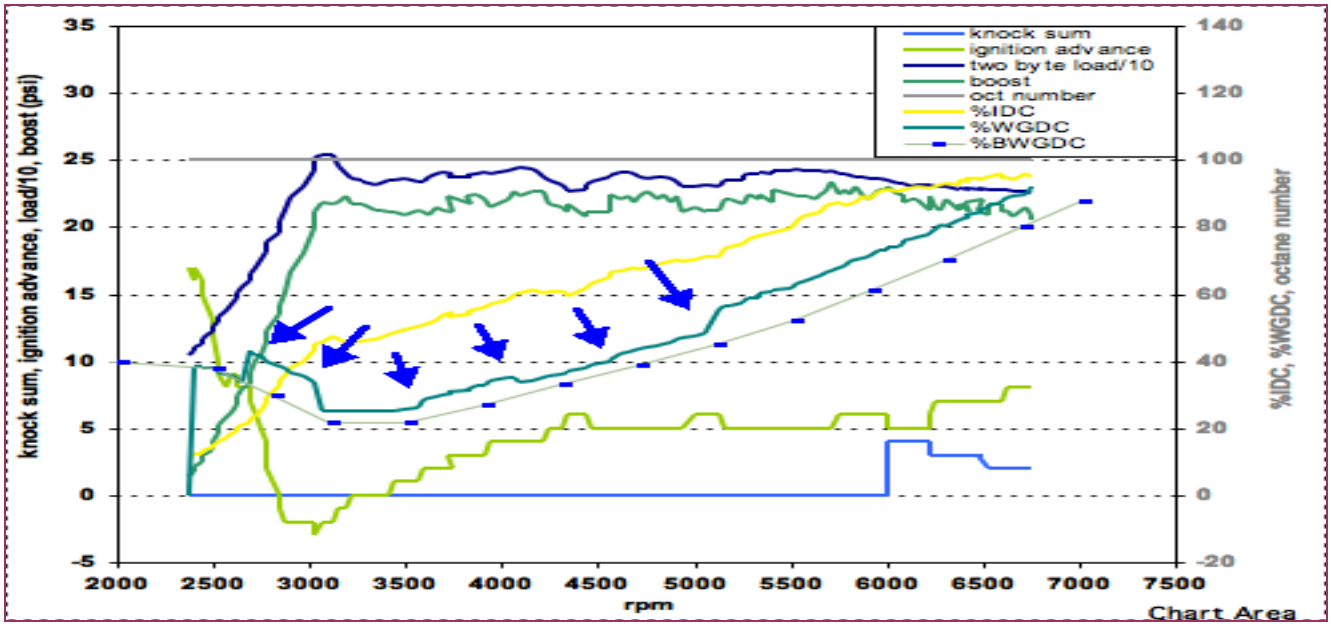
Figure 56: BOOST TUNING – ERROR CORRECTION INTERVAL

If the actual load matches the target load (BTEL + BOOST LOAD OFFSET), then the ECU continues to follow the BASE WGDC values as the engine accelerates. However, if the ECU sees a discrepancy between actual and target load, then it will apply a correction to the WGDC. The degree of correction is defined by the BOOST ERROR CORRECTION table, as a load unit increment or decrement to the BASELINE WGDC table. Thus the error correction serves to simply raise or lower the entire BASELINE WGDC curve. So, using the stock correction table shown above for example, if the load is 5 high, 5 is subtracted from the BASELINE WGDC table. Thus the correction will simply raise or lower the entire BASELINE WGDC table curve.

So after the correction is applied, the ECU follows the raised or lowered curve. It checks to see if actual load is tracking the DESIRED BOOST ENGINE LOAD again after the defined ERROR CORRECTION INTERVAL, and if necessary, raises or lowers the curve again. This is why the correction table isn't a function of RPM.

The graph shows the behaviour well. The blue arrows show when corrections are made, and it is apparent that the ECU is simply raising/lowering the BASELINE WGDC curve.

Figure 57: BOOST TUNING – BOOST ERROR CORRECTION - mrfred



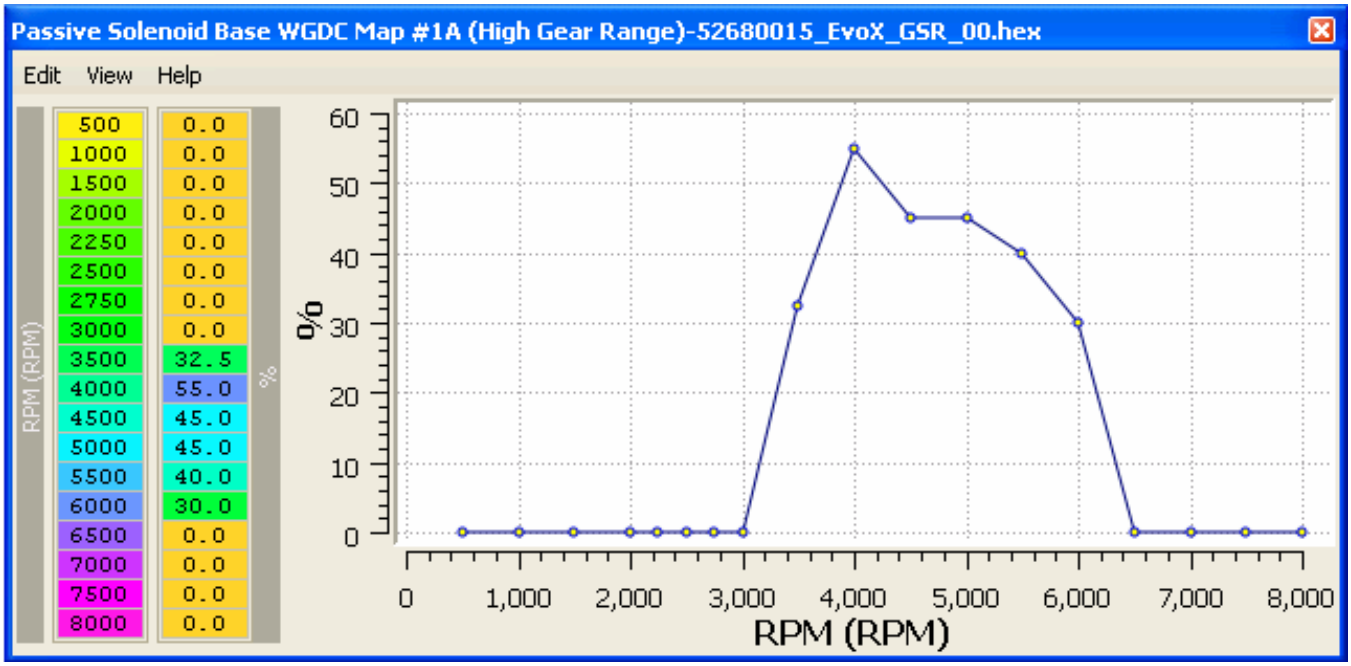
When using a 3-port BCS the BOOST ERROR CORRECTION values need to be less aggressive than the stock values as the 3-port setup flows more air and responds faster to ECU stimulus than the stock solenoid. This applies to all the 3-port BCS valves. In this case it is a good idea to reduce the positive/upward corrections, you will get less boost overshoot that way. Setting the positive corrections to all zero initially will help you get your base WGDC maps close to the right values.

9.07-BOOST CONTROL – PASSIVE SOLENOID WGDC v RPM

The second BCS on the EvoX, referred to as the PASSIVE SOLENOID, is used to effectively increase the capacity of the REACTIVE SOLENOID to flow (bypass) more air. This second BCS has a simple 2D table and typically has some degree of opening when the engine is making full torque, in the 3500 to 6000rpm band. Otherwise it is kept closed with 0% duty cycle stock. The net result is an ability to control much higher boost levels with an otherwise stock boost control system.

There is no error correction applied to this table, all corrections are done on the reactive tables.

Figure 58: BOOST TUNING – PASSIVE SOLENOID BASE WGDC % v RPM



There are three of these tables, with the usual labels:

#1A High Gear
#1B High Gear
#2 Low Gear

Typically, they are all set the same from the factory, but they are open to tuning.

SECTION 10 – INJECTOR TUNING

10.01-INJECTOR SETUP INTRODUCTION

The stock injectors on the EvoX and RALLIART are low impedance DENSO units rated at 532cc/min. Generally speaking, the stock injectors will give you adequate fuel flow with a TBE, a better hot-side intercooler pipe, stock turbo and 20-22 lbs of boost by redline.

If you plan to use a 20G or larger turbo and or raise the boost level to 25 psi or higher running gasoline, then it is advisable to get bigger injectors. In this case injectors in the 700 – 850 cc/min range will be required as suitable replacements.

If you plan to use E85, then think 1050 cc/min as a starting minimum injector size. The assumption here being that other power modifications will be employed, like a 20G or larger turbo and other breathing / plumbing modifications plus lots of boost.

When you install bigger injectors, you will have to alter these parameters:

SCALING
LATENCY
START – PRIMER IPW v TEMP
START - CRANKING IPW v TEMP

These tables must be altered in the ECU to suite the new injectors, otherwise the air fuel ratio settings will be way-out, your car will idle poorly and stall on occasion, run rich and generally behave poorly.

So how do you go about scaling your new injectors?

It has been said on the Evo forums that dialing-in new injectors is a pain in the arse and will require a lot of testing and logging. This may well prove to be the case if the injectors are not well documented and in common usage. However, the tuners have developed simple procedures to get just about anything "sensible" dialed-in fairly quickly. But you will have to log the trims using EvoScan etc. By "sensible" I mean something less than 1200cc/min flow rate on gasoline.

Above that and the ECU struggles or just cant cope as there is a minimum injector pulse width parameter that sets a floor value of IPW of 1.28ms. Also, the ECU does not have peak-and-hold injector drivers. The Evo uses a saturated driver with a ballast resistor in series with the injector. This setup will have higher latency times than a peak-and-hold injector driver system.As a side note, I have read of tuners adding an external interceptor injector driver box with peak-and-hold drivers. So, just about anything is possible.

The table "TYPICAL INJECTOR SCALING AND LATENCY VALUES" has settings for about twenty different common use Evo injectors, ranging in size from 680cc/min to 1200cc/min from well known reputable suppliers. If you want to save some setup time you could do worse than choose from the documented injectors. The scaling column has an additional note if the fuel is other than 95-98 RON octane gasoline. All the injectors listed are low impedance types, typically 2-4 ohms and will work with the Evo stock injector ballast resistor box.

Note 1: The origin of the tuning information is also supplied so you may be able to converse further with them for additional information and experiences. All entries have reported as yielding good tuned results on evolutionm.net.

Note 2: 02 feedback is STFT and what the car is doing, at that very moment, to keep everything happy. LTFT is what the car has learned over time, to keep the car as close to stoic as possible. So if LTFT is at +12 and 02 feedback/STFT is at +3, then the car is adding +15% at that very moment to try and maintain stoic.

Note 3: LTFT range is ±12.5%. STFT range is ±25%. The trims are stored in ECU (RAM) memory and are reset every time you re-flash the Evo9 ECU.

Note 4: When the injectors are up-rated, the CRANKING IPW and PRIMER IPW tables will usually require some adjustment, especially if using ethanol blend fuel.

Note 5: The fuel trims can be reset to zero by dropping backup power to the ECU. Lift the fuse cover in the engine bay, and remove the 7.5 amp fuse second from the left, for five second. Replace the fuse. All learned values in the ECU will be reset to factory defaults. This includes the learned idle control trims.

I have included in this section all the relevant START MODE tables and parameters, as they are directly affected by a change of injector type or fuel type like E85.

10.02-INJECTOR TUNING – INJECTOR SIZE SCALING

INJECTOR SIZE SCALING is used by the ECU to calculate the required IPW and will have a specific value for every type of injector that may be used.

Figure 59: INJECTOR TUNING – INJECTOR SIZE SCALING, RALLIART & EVO X

I usually setup two INJECTOR SCALING entries in my XML definition files, one that uses the usual scaling and a second to use where the injector size is larger than 800cc/min.

These are the two scaling definitions:

```
<scaling name="InjectorScaling1" units="cc/min" toexpr="29241/x" frexpr="29241/x" format="%.0f" min="0"
max="29241" inc="10" storagetype="uint16" endian="big"/>

<scaling name="InjectorScaling2" units="cc/min" toexpr="29241/x" frexpr="29241/x" format="%.0f" min="0"
max="29241" inc="30" storagetype="uint16" endian="big"/>
```

These are the two injector size definitions:

```
<table name="Injector Scaling LO" category="INJECTORS" address="1106" type="1D" scaling="InjectorScaling1"/>
<table name="Injector Scaling HI" category="INJECTORS" address="1106" type="1D" scaling="InjectorScaling2"/>
```

These are useful when tuning large injectors for either E85 or gasoline.

10.03-INJECTOR TUNING - LATENCY

Fuel injectors have to physically move the pintal from the seat before fuel can flow. This takes a finite period of time and which changes as the battery voltage varies. As the voltage is lowered, the time required to lift-off or open is increased. There is also a corresponding time delay when the injector is de-energised to the actual fuel shut-off. This closing period is much shorter than the opening time and the closing period gets shorter as the battery voltage is raised. The combination of these parameters is called INJECTOR LATENCY. Different make and model injectors will have different latency specifications.

In stock form the RALLIART and EvoX both use the same injectors, so the scaling size and latency have the same values.

Figure 60: INJECTOR TUNING - LATENCY v BATTERY VOLTS, RALLIART & EvoX

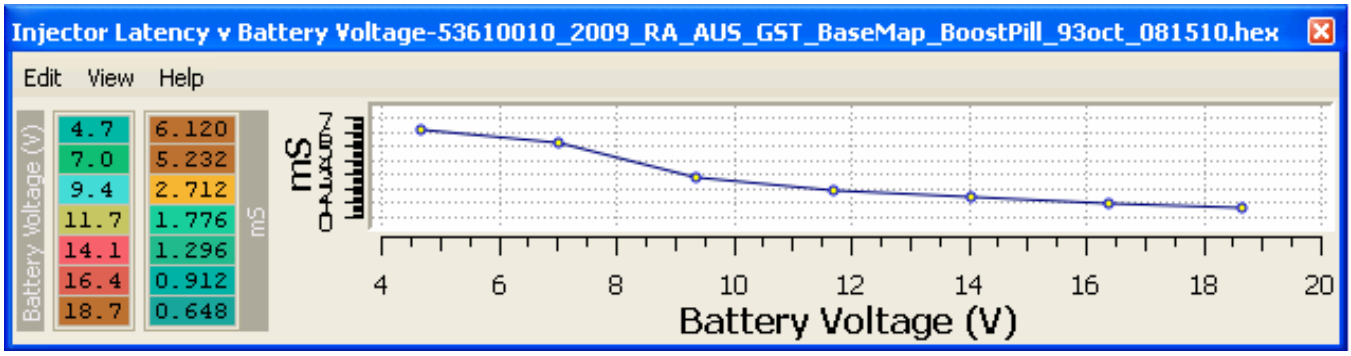
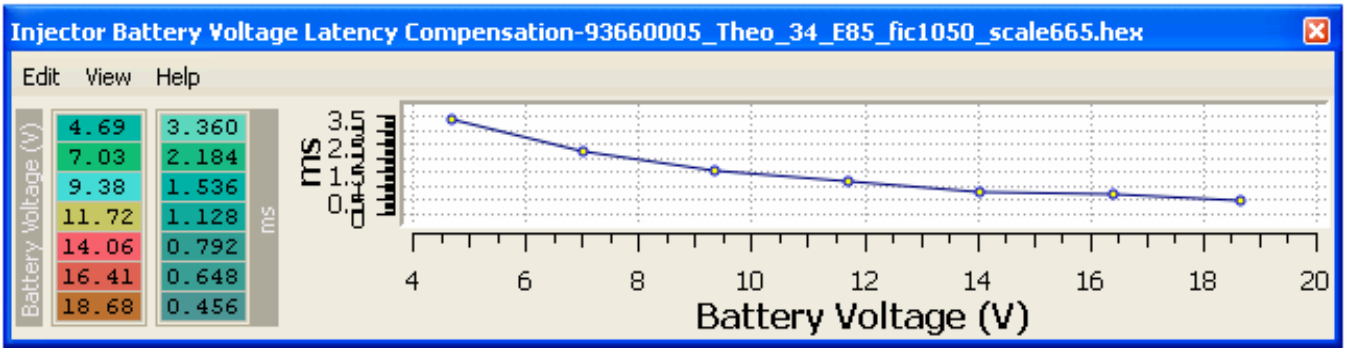


Figure 61: INJECTOR TUNING - LATENCY v BATTERY VOLTS, FIC-1050 & E85



10.04-INJECTOR TUNING - SCALING & LATENCY EXAMPLES

The table below shows SCALING and LATENCY values as submitted by various members of the Evo community, mainly from the USA. Note the fuel type specified and its affect on scaling and if for a JDM ROM.

Table 5 TYPICAL INJECTOR SCALING AND LATENCY PARAMETERS

				LATENCY in mSEC / BATTERY VOLTAGE						
TYPE	ORIGIN	SCALING	FUEL	4.7V	7.0V	9.4V	11.7V	14.0V	16.4V	18.6V
EVO 8-9	Mitsubishi	513	gas	3.312	1.680	1.032	0.672	0.432	0.264	0.144
PTE_680	Cossie1	650 JDM	gas	3.312	2.184	1.416	0.960	0.696	0.480	0.360
PTE_680	Jorge_T	622	gas	3.624	1.992	1.344	1.008	0.768	0.600	0.456
PTE_780	fostyou	680	gas	3.642	1.992	1.344	0.984	0.744	0.576	0.456
PTE_780	merlin	696	gas	3.600	1.968	1.320	0.960	0.720	0.552	0.432
PTE_780	joedr	713	gas	3.504	2.184	1.224	0.960	0.792	0.552	0.432
PTE_780	cpoevo	696	gas	3.504	1.872	1.224	0.960	0.774	0.552	0.432
PTE_880	nj1266	731	gas	3.312	2.184	1.320	0.960	0.696	0.408	0.288
PTE_880	joedr	770	gas	3.312	2.304	1.392	1.008	0.792	0.600	0.504
PTE_880	Ph3n1x	790	gas	3.312	2.184	1.320	0.840	0.672	0.360	0.240
PTE_880	bigric09	770	gas	3.648	2.088	1.224	0.912	0.744	0.552	0.456
PTE_1000	MalibuJack	665	gas	3.312	1.680	1.392	1.104	0.960	0.696	0.504
PTE_1000	Brad74	886	gas	3.720	2.088	1.440	1.080	0.840	0.672	0.522
RC_750	Jamie_v1	696	gas	3.312	2.184	1.560	1.056	0.720	0.480	0.360
RC_1000	Jamie_v1	943	gas	3.312	2.184	1.560	1.056	0.720	0.480	0.360
RC_1000	rarorlab	835	gas	3.600	2.184	1.560	0.936	0.672	0.432	0.336
RC_1000	nj1266	914	gas	3.312	2.184	1.560	0.912	0.600	0.321	0.240
RC_1000	smartbomb	860	gas	3.312	2.184	1.560	1.008	0.696	0.408	0.336
RC_1000	nj1266	835	gas	3.312	2.184	1.560	0.936	0.624	0.384	0.288
RC_1000	GST	860	gas	3.312	2.184	1.560	0.936	0.624	0.384	0.288
RC_1200	JB	1044	gas	3.312	2.186	2.088	1.296	0.792	0.720	0.480
RC_1200	JB	680	E85	3.312	2.186	2.088	1.344	0.864	0.720	0.480
RC_1200	fostytou	622	E85	3.600	2.304	1.728	1.320	0.864	0.720	0.480
FIC_750	al\lupo	713	gas	3.312	2.040	1.296	0.912	0.792	0.600	0.336
FIC_750	evoredy	696	gas	3.312	1.680	1.200	0.792	0.720	0.456	0.360
FIC_750	bigric09	650	gas	3.312	2.040	1.296	0.696	0.624	0.408	0.192
FIC_750	JB	650	gas	3.312	1.680	1.032	0.864	0.648	0.552	0.360
FIC_850	JB	770	gas	3.312	1.680	1.032	0.840	0.552	0.456	0.360
FIC_850	s2kracka	696	gas	3.000	2.376	1.200	0.768	0.504	0.360	0.312
FIC_850	bigric09	770	gas	3.480	1.920	1.368	1.008	0.768	0.600	0.456
FIC_950	Steve93	812	gas	3.312	2.186	1.462	0.958	0.832	0.428	0.277
FIC_1000	JB	860	gas	3.312	1.680	1.344	1.152	0.840	0.504	0.240
FIC_1000	Pd1	860	gas	3.312	1.680	1.344	1.152	0.840	0.360	0.240
FIC_1000	Ianevo	636	E85	3.312	1.704	1.416	1.200	0.840	0.576	0.264
FIC_1000	Ianevo	835	gas	3.312	1.704	1.416	1.200	0.840	0.576	0.264
FIC_1050	scheides	1008	gas	4.440	3.192	1.752	1.032	0.840	0.576	0.432
FIC_1050	mrfred	680	E85	4.512	3.408	1.920	1.320	0.936	0.672	0.480
FIC_1050	merlin	665 JDM	E85	3.360	2.184	1.536	1.128	0.792	0.648	0.456
FIC_1100 hi-z	mrfred	680	E85	5.59	3.504	2.088	1.44	1.08	0.86	0.774
FIC_1150	dan_I	1125	gas	4.512	3.408	1.896	1.320	0.936	0.672	0.480
FIC_1250	alan678	1271	gas	4.008	3.096	2.208	1.512	1.056	0.816	0.648
FIC_1250	alan678	886	E85	4.008	3.096	2.208	1.512	1.056	0.816	0.648
FIC_2150	Aaron / JB	1624	E85	3.000	1.488	0.936	0.672	0.528	0.408	0.360
DENSO_720	rarorlab	636	gas	6.120	3.120	1.992	1.320	0.888	0.672	0.408
DENSO_720	wesside	622	gas	3.864	3.456	2.856	1.320	0.888	0.672	0.408
DENSO_720	merlin	636	gas	3.768	2.136	1.488	1.128	0.888	0.720	0.600
DENSO_660	rarorlab	636	gas	6.120	3.120	1.992	1.320	0.888	0.672	0.408
SARD_700	rarorlab	636	gas	6.120	3.120	1.992	1.320	0.888	0.672	0.408
SARD_800			gas			0.90	0.62	0.42		

10.05-INJECTOR TUNING – NEW INJECTOR SETUP METHOD 1

This is a method for arriving at good scaling and latency setting in your ECU when installing new injectors, particularly when the injectors are known ie can be found in the injector table. You will need an air fuel ratio meter for this.

1a. For un-documented injectors: Divide the "rated" flow rate by 1.15 as a starting INJECTOR SIZE SCALING value. This should at least be reasonably close. Open the latency table in EcuFLASH for the stock injectors. Highlight/select all the latency values and increment the whole set until the 14 volt value equals 0.600mS. This of course will not be the correct final set of values, but the general shape of the compensation curve will be preserved.

Or…

1b. Find the injector data in the TYPICAL INJECTOR SCALING AND LATENCY PARAMETERS table and set the scaling and latency data into the ECU. This should be reasonably close.

2. After saving your current bin file, set all fuel map values 120 and above to 11.5.

3. Disable LEAN SPOOL by setting the start rpm to 7500rpm.

4. Start the car and allow the engine to reach operating temperature.

5. Run the car into some low level of boost ie above load 120. Keep the boost levels to less than 12 psi preferably. Compare the air fuel ratio reading to the set 11.5 value. Use some caution doing this, avoid running too lean. If the AFR reads lean, set the INJECTOR SIZE SCALING value smaller. If the AFR reads rich, set the INJECTOR SIZE SCALING larger. Repeat this until the AFR reads to about ±0.1 of the desired 11.5 AFR.

6. Re-load your desired or original fuel maps back into the ECU with your new INJECTOR SIZE SCALING value. Reset LEAN SPOOL start rpm to the correct value.

7. Log fuel trims at idle for 15-20 minutes. Add the long term fuel trim (LTFT) and the short term fuel trim (STFT). eg If LTFT =-12.5% and STFT LO = -3.5%, the total is -16%. So, shift the whole latency curve down 16% by the highlight and decrement method described above.

8. Log fuel trims at cruise for 20 minutes and then 5 minutes of idle.

9. If trims are roughly the same, but positive, then you need to lower your injector scaling value. If both trims are roughly the same, but negative, then you need to raise your injector scaling number. This adjustment should now be very small.

10. If idle trim is more positive than cruise trim, or +, then you need to increase the dead-time / latency value. If the idle trim is less positive than the cruise trim, or -, you need to decrease the dead-time / latency value.

11. Also note that the CRANKING IPW and POST START ENRICHMENT tables will usually require some adjustment, especially if using ethanol blend fuel.

10.06-INJECTOR TUNING – NEW INJECTOR SETUP METHOD 2

Open EcuFLASH and open your ROM. Under fuel locate the Injector Scaling table and the Injector Battery Voltage Latency table.

The scaling parameter refers to the injector size that the ECU is using when making its fuel supply calculations. The number in the table is usually smaller than the injector manufactures specified flow rate for a specified pressure. For example, the stock EVO9 injector size is specified at 560cc/min, but the number in the table is 513 on the EVO9, as reported by EcuFLASH. As a general rule of thumb for new injectors with unknown tuning parameters, enter a scale number in the table that is 15-20% less than the manufactures rated flow size.

For example, let us say that you are using 680cc/min rated injectors and you have entered in the injector scaling table the value 552. Note that this is only the starting point and not the end point of injector scaling. The final number will be determined through multiple logging sessions of your fuel trims and making some adjustments.

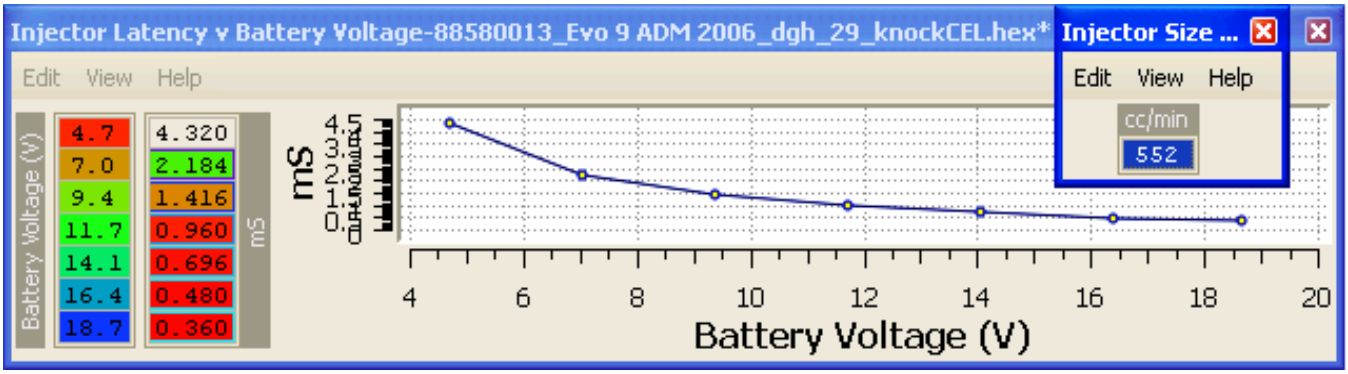
Look closely at the Latency table and the characteristic shape of the compensation curve produced when graphed. At no time should a value be entered that does not conform to this curve, though the curve will be shifted up or down as required and be a bit more or less curved for different injectors. The latency values in the right column are in milli-seconds. These refer to the amount of time that the injectors take to open completely and produce maximum flow. The numbers in the left column are in volts. As battery voltage decreases, the time between the injector receiving the signal to open and when it actually opens increases. Therefore, you must send the signal sooner to have the injector open at the appropriate time. Physically larger injectors usually require more time for them to open. You can see that none of the injectors documented in the INJECTOR SCALING & LATENCY PARAMETERS table have a latency value close to the stock value at 14 volts and this is the voltage that tuners will have to be most precise with. So you will have to increase the numbers in the millisecond column to compensate for larger injectors.

Select from the type of injector you are using, there are usually multiple choices for each type listed. It is a certainty that one will be better in your engine than the others, though you will likely still have to make some adjustments.

Note1: Injector latency can only increment/decrement by 0.024mS, so there are only a finite set of values that can be entered.

So, the initial injector scaling and latency on the PTE680cc/min injectors are as follows:

Figure 62: INJECTOR TUNING – PTE680cc FIRST PASS SCALING & LATENCY



You now need to make sure that the numbers that you have entered are working properly. To do that you MUST log your fuel trims for an extended period of time. The trims to log are:

STFT = Short Term Fuel Trim. STFT is what the ECU is doing right now to get as close to stoich (14.7:1) as possible, adding or subtracting fuel over the base fuel map to reach that target. If your STFTs are maxed out at ±25%, then you will probably get the P0171 fault code.

LTFT Low = Long Term Fuel Trim Low.

LTFT Mid = Long Term Fuel Trim Mid.

Both of these trims fluctuate between a maximum of ±12.5%. The LTFT Low is for idle and the LTFT Mid is for cruising. The aim is to keep both trims to ±5% or less. LTFT is a stored value that the ECU has learned to reach that target and has a range of ±12.5%. The LTFT value is updated by the ECU at four minute intervals, so you will need to have the car logging in cruise for typically 16-20 minutes to get a reliable update.

If the fuel trims are too positive, then the ECU will add fuel and this will royally make your AFR too rich. If your fuel trims are too negative, then the ECU will remove fuel and this will make your AFR too lean.

How do we log fuel trims? This is when you use **evo4mad**'s **EvoScan**.

We start with the LTFT Mid. You must drive the car at a steady speed for at least 16 minutes. Why? The fuel trims cycle approximately every 4 minutes. You will need to have them cycle multiple times until they settle on a number in your log. 16 minutes will allow your trims to cycle 4 times. That will give them ample time to settle.

Let us take my example above. We had the scaling at 552 for the PTE680cc injectors. We cruised at a steady speed of 60mph / 100kph for 16 to 20 minutes. We found that the trims went way negative and hit -10%. So we pulled over and incremented the injector scaling from 552 to 573 (+3.5%). Flash the new numbers into the ECU and then log again for another 16 minutes.

The trims are still going negative but not as much as before. This time our trims hit -8%. We now know that we are on the right track. But we are nowhere near the ±5% that we would like to hit. So we increment the injector scaling from 572 to 597 (+4.2%). The new scaling is flashed into the ECU and another 16 minute log recorded.

The numbers in the log are now much better, with the LTFT Mid logged at -3%. Increment the injector scaling again to 609 (+1.9%). Flash the new numbers into the ECU and then log again for another 16 minutes. The log reported a LTFT Mid of -1.86%. Increment the scaling again 622 (+2.1%). We have now dialed the LTFT Mid to as close to zero as possible. This is because the data conversion formula will only allow specific numbers to be entered. Pressing the [key decrements the value, while the] key increments the value. Thus for this example the only valid entries are 552, 562, 573, 585, 597, 609, 622 and 636. In this case, the value 622 gave the smallest trim error.

Also note that the total of the increments, when added was 3.5 + 4.2 + 1.9 +2.1= 12.7%. This is almost a perfect match for the initial trim error of -10%. Note also that the majority of tuners using these injectors finally settled on a scaling of 622!

The next step is to log the LTFT Low. This is done by logging the car for 16 minutes at idle. The LTFT Low was logged at a level of -1.66%. This can now be dialed-out by reducing the whole latency table by 1.7%, which will have a minimal effect on the LTFT MID and almost nil on WOT AFR numbers.

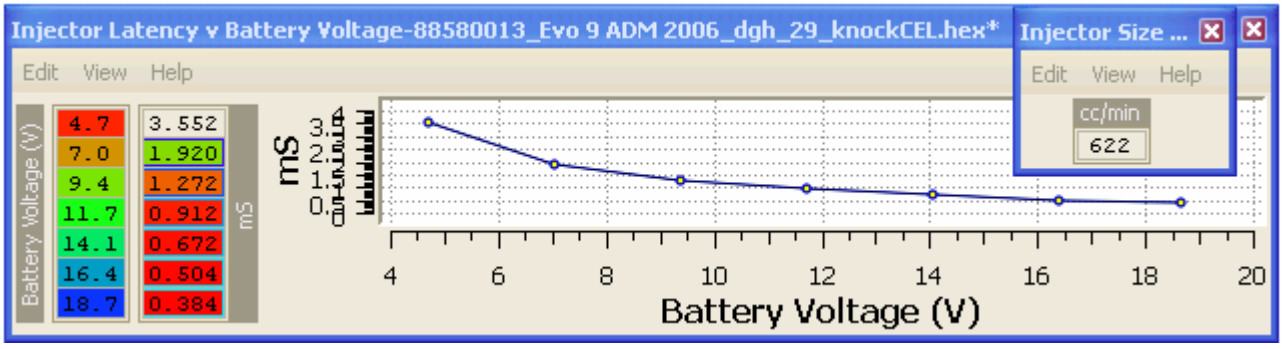
Now to check the latency for when battery voltage is less than 14 volts. Disconnect the alternator feed to the battery. Connect a multi-meter across the battery. Start and idle the engine. Switch on the lights, thus draining the battery voltage down to the next cell to be adjusted, 11.7V. When the battery voltage approaches 11.7V, observe the STFT value and write it down.

Continue draining the battery and repeat the procedure for 9.4V by further draining the battery with the headlamps. When the multi-meter reads 9.4V, observe the STFT and record the value.

Switch off the engine and then re-connect the alternator feed to the battery. The car will likely need to be jump started from another battery to get it started. When started, allow the battery to charge for at least ten minutes before proceeding.

When the battery is charged, switch off, re-launch EcuFLASH. Change the latency values for 11.7 volts and 9.4 volts by the value recorded for STFT for each voltage.

Figure 63: INJECTOR TUNING – PTE680cc FINAL INJECTOR SCALING & LATENCY



Examine the shape of the latency table values using the graph function. You will have to extrapolate the values for the 4.7V, 7.0V, 16V and 18V latency cells, but you are unlikely to need an accurate value. Most people end up using the stock injector values without any problem in the lower cells, as the ECU system will probably never be run at 7V.

The scaling and latency are now dialed-in for minimum trim error. You could now proceed to adjust your HI-OCTANE FUEL MAP to get the AFRs that you want to run with the new injector scaling. However, there is a further set of measurements and adjustments you can make such that your fuel map AFRs match what you actually get on your wide-band O2 meter. Read-on!

This next set of procedures will involve some adjustment to the values in your MAF scaling, so that the final WOT AFR is a close match to what is tabled in your fuel map.

1. Save you current bin file, with your working fuel maps.

2. Open the HI OCTANE FUEL MAP in EcuFLASH, highlight/select all the cells at 120 load and above set to =11.5.

3. Disable LEAN SPOOL by setting the start rpm to 7500rpm.

4. Start the car and allow the engine to reach operating temperature.

5. Run the car into some low level of boost ie above load 120. Keep the boost levels to less than 12 psi preferably. Have EvoScan logging Airflow Hz. Hint, turn off everything else except rpm and load. Compare and record the air fuel ratio reading to the set 11.5 value. If the error is less 0.2 then maybe you wouldn't bother with any further adjustments and just note the offset and allow for it. If more than 0.2 and you want to dial it out, proceed on.

6. Calculate the percentage error between the actual and mapped AFR. I will use 12.0 AFR as an example. This value is -4.17% (lean) from where it needs to be.

7. Open the AIRFLOW Hz / RAW SCALING table in EcuFlash. If the log indicates that at or about 300Hz the actual AFR was 12.0, that is the cell we will modify first. The corresponding value at 300Hz is 208.
Now increment this number by 4.17%
208 * 1.0417 = 216.6

8. Highlight all the cells above 300. Increment them all using the] key until the 300 cell value 216. Smooth the cells below 300 so the curve is even. Leave the cells in the idle area alone.

9. Re-load your desired or original fuel maps back into the ECU with your new INJECTOR SIZE SCALING value. Reset LEAN SPOOL start rpm to the correct value.

Useful tip: put Min Coolant Temp for Closed Loop extremely high to disable closed loop while measuring mixture on idle. An alternative method of disabling closed loop is to disconnect the front O2 sensor, though this will seen by the ECU as a fault condition.

In theory fuel economy during closed loop should be the same for any trim, seeing that the ECU is trying to keep a stoich 14.7:1. Different trims are just going to change the transitional AFRs from closed to open loop a small amount.

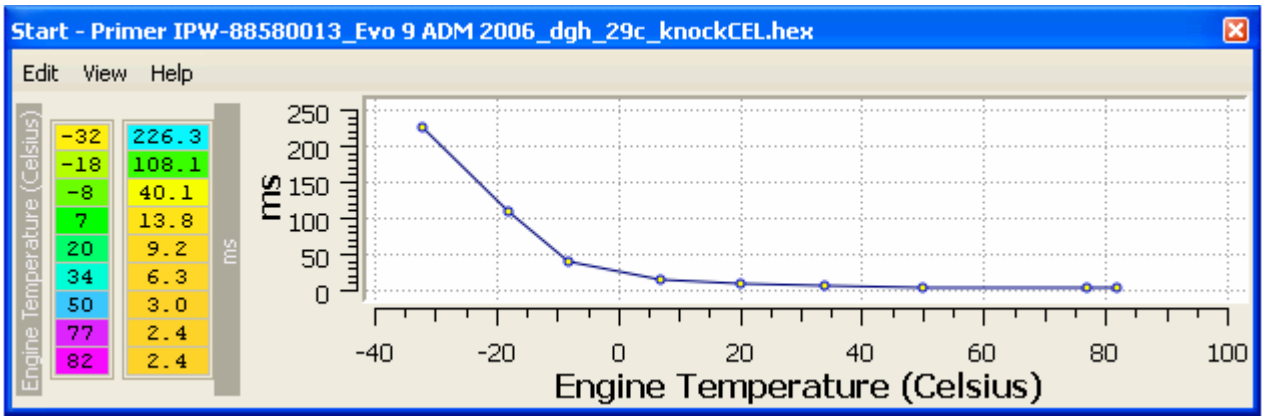
If you are having trouble with stumbling while the car is still cool, but the car has not gone into closed loop, then you have to make some minor adjustments to the fuel maps or the warm-up enrichment parameters.

10.08-INJECTOR TUNING – START PRIMER IPW v TEMP

A 4-cycle gasoline engine will require extra fuel when starting, particularly when cold. This is due to the poor atomization characteristics of cold fuel with a cold inlet manifold and head. The requirement for extra fuel diminishes as the engine temperature approaches full operating temperature. There are two tables providing for fuel enrichment when starting the engine.

The 9 element START PRIMER IPW v TEMP table function is to help prime the engine, by providing a single large initial fuel pulse to wet the inlet manifold. The table values are added to the latency values, thus directly adding the table to the IPW. The table only applies when the engine is cranking and only a single pulse is applied from this table. Following this first pulse are the CRANKING enrichment pulses.

Figure 64: INJECTOR TUNING – START PRIMER IPW v TEMP, Evo9



There are two cases where this parameter will need to be tuned for your specific application:

1. When the injectors have been replaced with larger flow capacity types.
2. When using alcohol fuel (E85) with bigger injectors.

With case one, where the injector size has been increased, the values will need to be reduced by the percentage difference between the old and new sizes. This is done to prevent flooding and/or plug fouling on start-up. So the IPW values will need to be altered based on the new injector scaling. Use the following formula to arrive at some initial values:

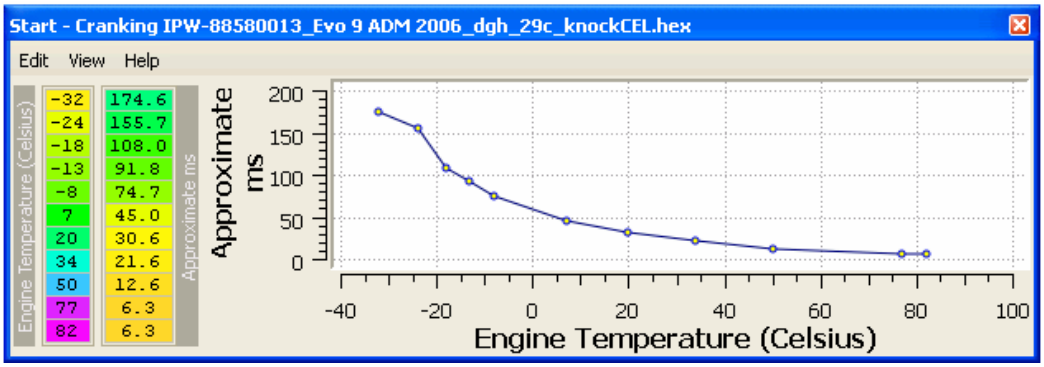
New START - PRIMER IPW = old IPW x [old injector scale / new injector scale]

When using E85 fuel, then the values from 34°C through to 82°C should to be progressively reduced down to about 1mS at 82*C.

10.09-INJECTOR TUNING – START CRANKING IPW v TEMP

Following on from the first primer shot of fuel is the cranking fuel enrichment. This series of injector pulses is calculated from the 11 element START CRANKING IPW v TEMP table. The value is not fixed though, there is a percentage v time table associated with it that controls the decay rate of the pulse width. This is to prevent the engine from flooding under prolonged cranking. Once again, the need for this parameter is due to poor cold fuel atomization. The table values are added to the latency values, thus directly adding the table to the final cranking IPW. The table only applies when the engine is in START MODE ie below 438 rpm.

Figure 65: INJECTOR TUNING – START CRANKING IPW v TEMP, Evo9



There are two cases where this parameter will need to be tuned for your specific application:

3. When the injectors have been replaced with larger flow capacity types.
4. When using alcohol E85 fuel with bigger injectors.

With case one, where the injector size has been increased, the values will need to be reduced by the percentage difference between the old and new sizes. This is done to prevent flooding and/or plug fouling on start-up. So the IPW values will need to be altered based on the new injector scaling. Use the following formula to arrive at some initial values:

New START - CRANKING IPW = old IPW x [old injector scale / new injector scale]

When using E85 alcohol blend fuel, multiply the new table values as follows:

-32*C to +7*C = x*1.30
+20*C = x*1.25
+34*C = x*1.20
+50*C = x*1.00
+77*C = x*0.9
+82*C = x*0.8

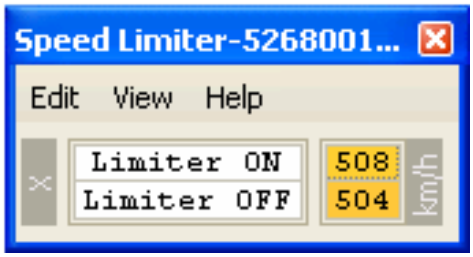
In practice with E85, the requirement for extra fuel is exacerbated when the engine is stone cold, not so much when warmed-up to operating temperatures. Note that the IPW during START MODE also has the LATENCY time in mS added to it.

SECTION 11 – MISCELANEOUS ECU FUNCTIONS

11.01-SPEED LIMIT

The Japanese domestic market cars are factory speed limited to 184kph, with a large speed difference to when normal operation is resumed. This is a dumb idea, as you could be unable to negotiate a corner while the engine is off without the drive traction while the vehicle is slowing down. Re-set as required.

Figure 66: LIMITS – SPEED LIMIT, EVO X



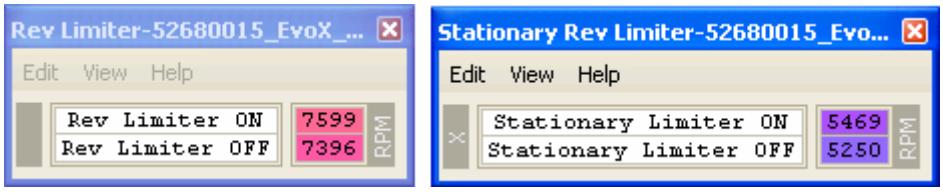
The ON value is the speed at which limiting is triggered.
The OFF value is the speed at which normal ECU operation is resumed.

11.02-REV LIMITS

The REV LIMIT is a hard fuel-cut. Leave it alone unless the motor is specially built with forged rods and pistons etc. Remember maximum torque is around 4000rpm with standard cams, so that's where you want up-shifts to land for max acceleration.

The SATIONARY REV LIMIT is a function available on EVO 8 and EVO 9, but not on the JDM GSR EVO 7. It may be available on some EVO 7 RS ROMs. It is only active when the clutch is depressed, so the ECU is looking at the clutch switch input to trigger the stationary limit.

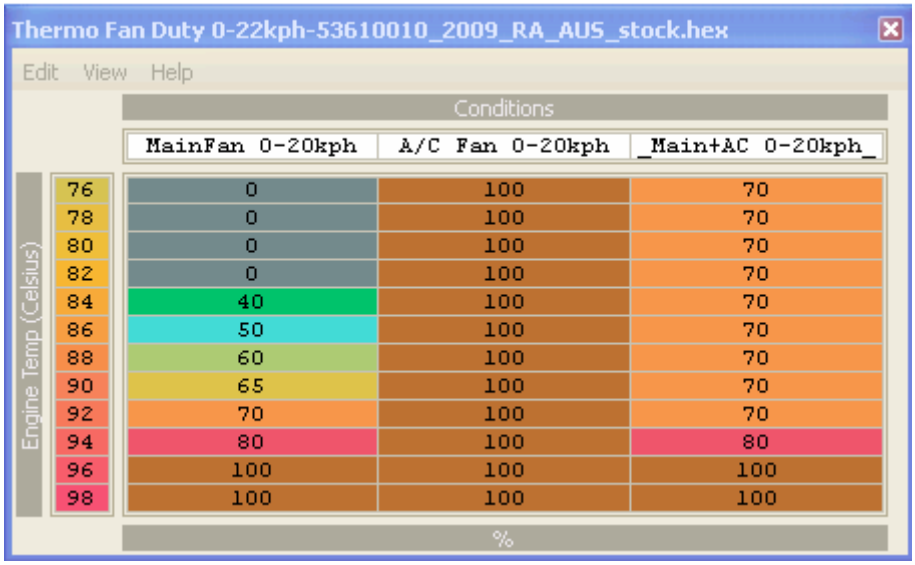
Figure 67: LIMITS – REV LIMITs, EVO X



11.03-THERMO FAN

This table controls the two thermo-fans when the vehicle is stationary and up to 20kph. The table shows the duty cycle on time to the fans, thus controlling the fan speed. The Main Fan is behind the radiator, the A/C Fan (air conditioning) is in front of the radiator. The left column is for the Main Fan, the centre column is for the A/C Fan. The right column is for the Main Fan when the air conditioning is operating. With earlier versions of the Lancer Evolution I have generally made some minor adjustment to the fan control settings. The EVO X settings however look similar to how I would tune an EVO 7-9, so I suggest leaving these alone unless you have a good reason to make a change.

Figure 68: THERMO FAN - DUTY CYCLE below 20kph, stock RALLIART



NOTE: On the EVO, the A/C FAN is powered by two relays, which drive the two windings of the A/C fan. So it is safe to assume the unit can only have two operating speeds, where 100% is the maximum speed available with both relays energized. No tuner has thus-far reported on what duty cycle % the fan speed drops to the low speed setting. Note that what-ever value is in the 76°C row is used through the warm-up cycle.

11.04-THROTTLE CONTROL - DRIVE BY WIRE 3D MAPS

There are five DRIVE BY WIRE THROTTLE maps. The x-AXIS seems to use a scale that runs out to 768, so I have set the scaling as a percentage of 768, and called it Throttle Peddle. This may in time prove to be incorrect though.

In all the EVO X and RALLIART ROMs I have examined, all cells passed the 60% mark have been set to 100%. To help with the presentation I have thus truncated the screen-shot to 62%.

Shown here are comparison screen-shots of the four throttle maps, using a stock 2009 RALLIART with SST and an EDM EVO X RS manual. The maps show a softer throttle plate opening action on the RALLIART than the EVO X.

Speculation on the usage of these maps is either gear based switching or transmission temperature. I favour gear based myself, but time will tell.

Figure 69: EcuFLASH - THROTTLE MAPS #1 – RALLIART & EVOX

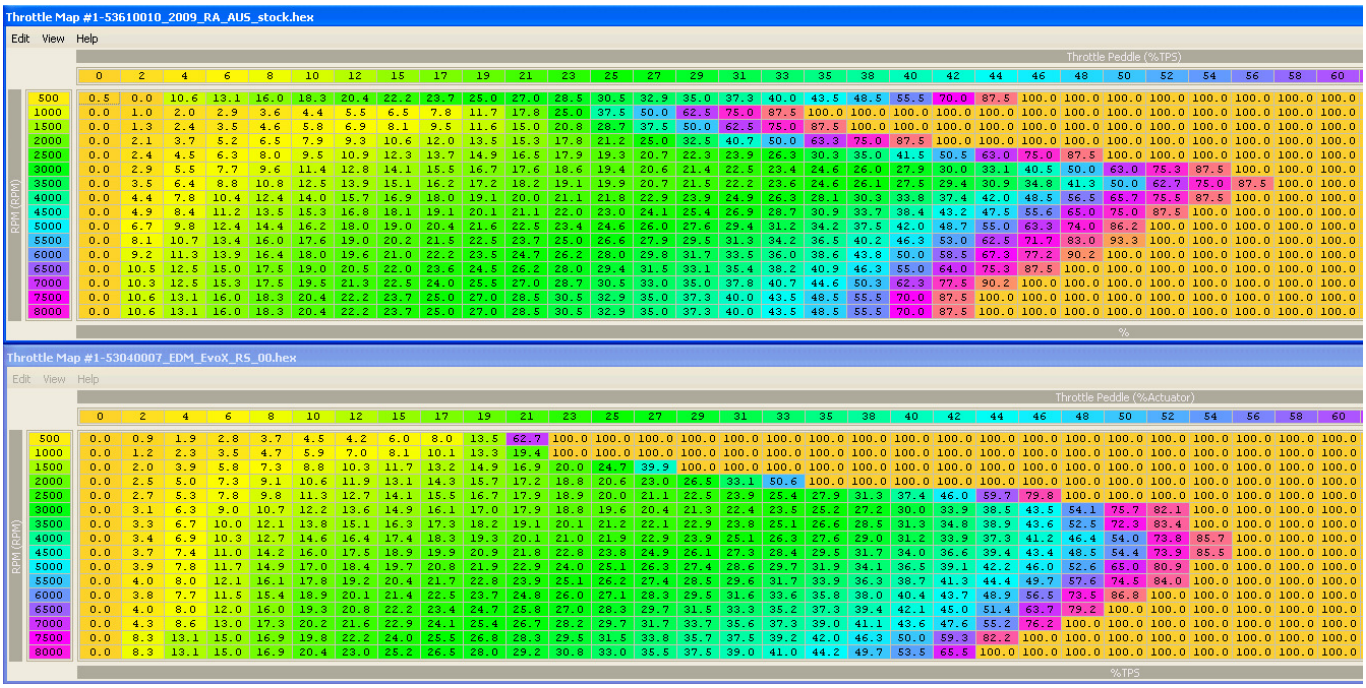


Figure 70: EcuFLASH - THROTTLE MAPS #2 – RALLIART & EVOX

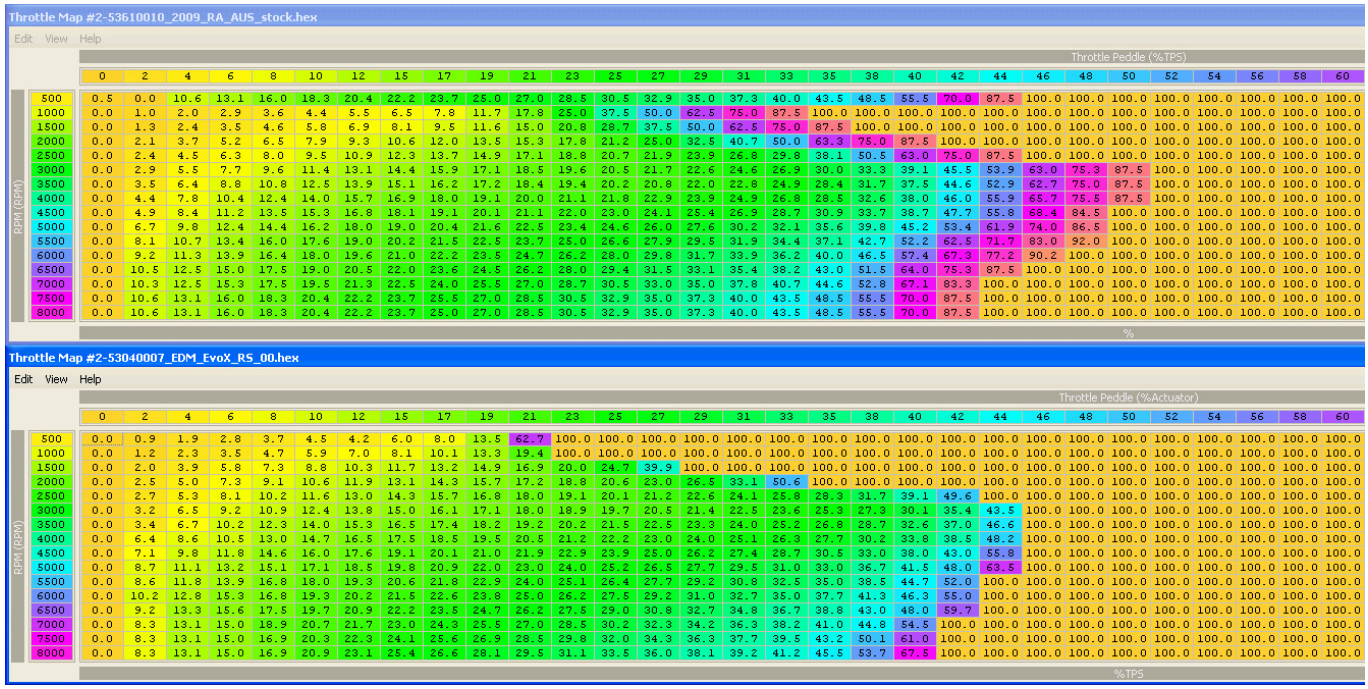


Figure 71: EcuFLASH - THROTTLE MAPS #3 – RALLIART & EVOX

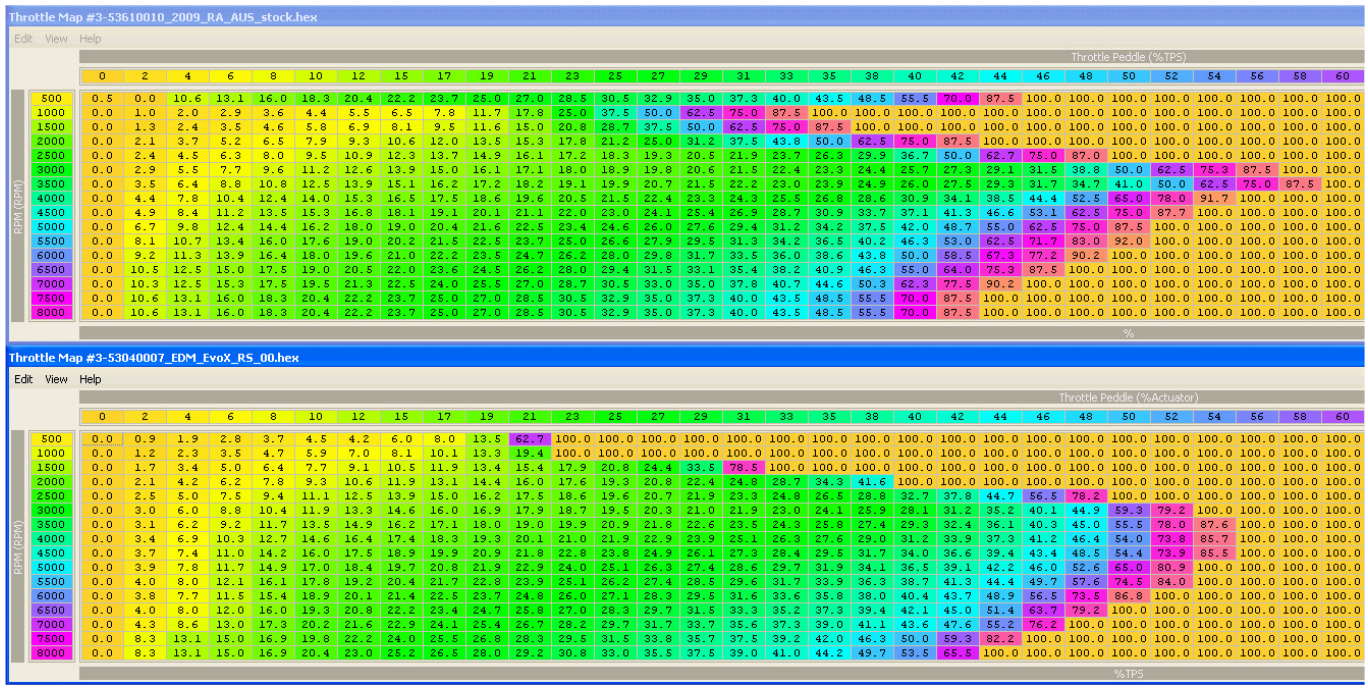


Figure 72: EcuFLASH - THROTTLE MAPS #4 – RALLIART & EVOX

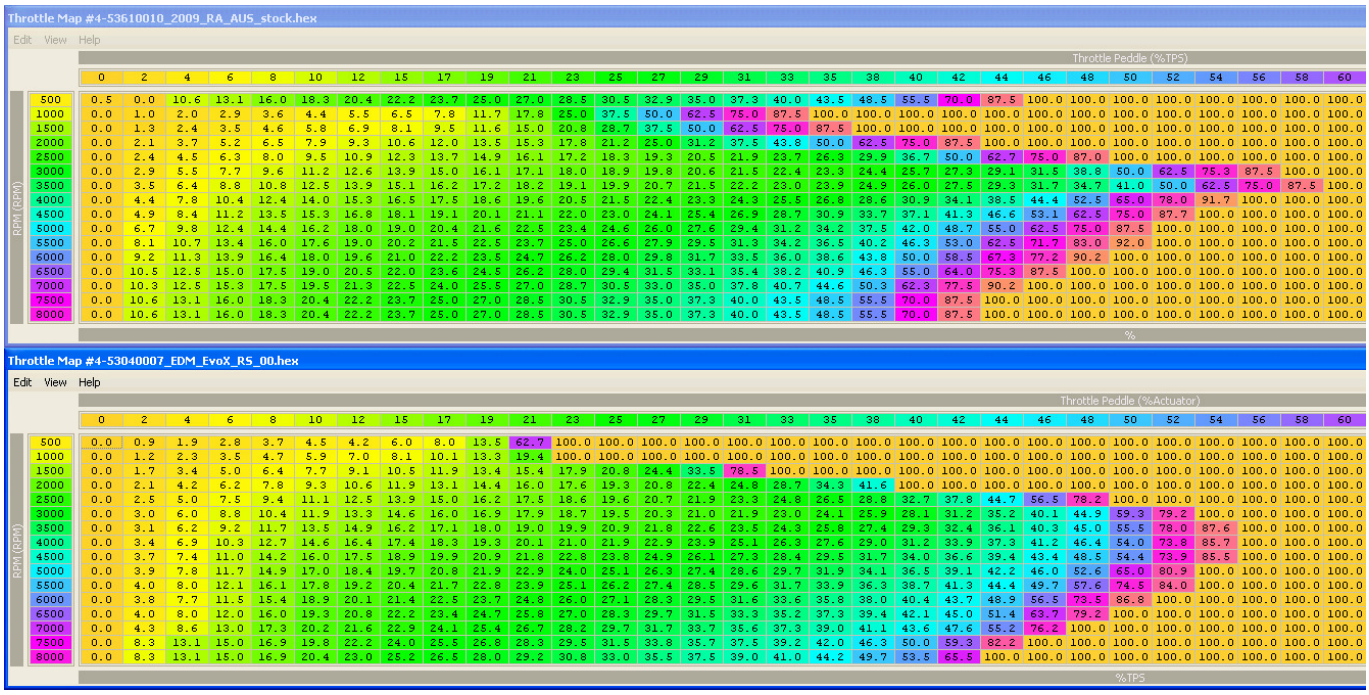
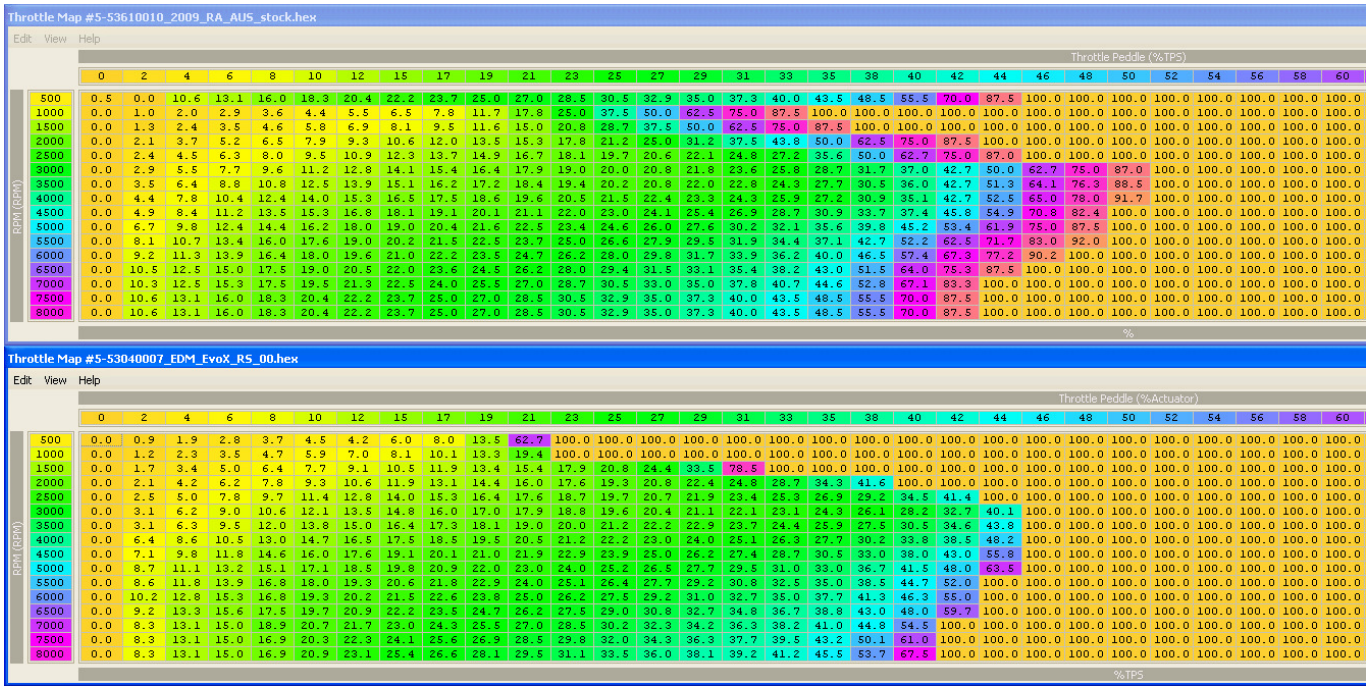


Figure 73: EcuFLASH - THROTTLE MAPS #5 – RALLIART & EVOX



11.05-INTERCOOLER SPRAY CONTROL

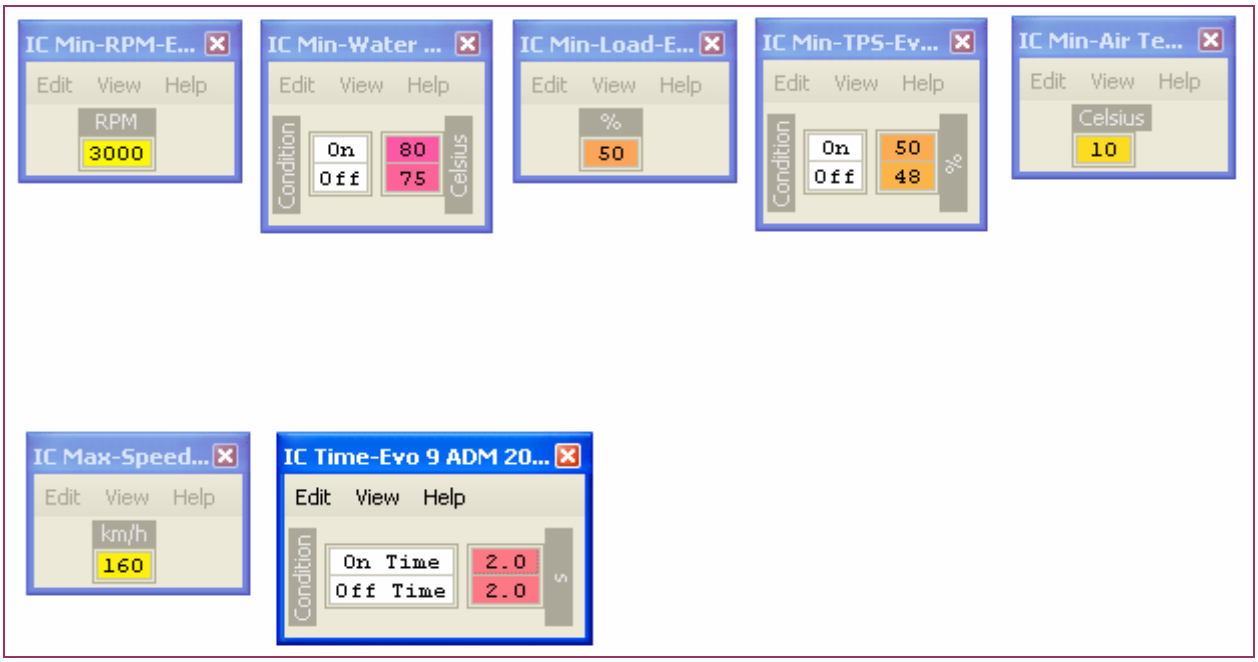
The seven parameters for controlling when the intercooler spray is activated are shown below.

To get the spray activated, **all** the "Min" variables have to be exceeded ie these act as an "and" function. These are as follows:
IC Min-RPM, the minimum RPM that IC spray can start to operate.
IC Min-Water, the minimum engine water temperature above which the IC spray can start to operate. There are two parameters, On Temp and Off Temp in degrees Celsius. These provide some switch on to switch off hysteresis.
IC Min-Load, the engine load has to be above this value for IC spray operation.
IC Min-TPS, the minimum throttle % above which the IC spray can start to operate. There are two parameters, On % and Off %. These provide some switch on to switch off hysteresis.
IC Min-Air, the minimum ambient air temperature above which the IC spray can start to operate, in degrees Celsius.

The spray will cease when the set speed in kph is exceeded - lots of air cooling going on here. The timer data are simple on and off periods, like a slow duty-cycle, defined in seconds.

Shown below are the intercooler parameters for the EVO 9, hopefully the parameters for the EVO X and RALLIART are similar and found soon.

Figure 74: INTERCOOLER - SPRAY TABLES, Evo9



In the screen-shot above, the definitions have been edited such that the function label can be read more easily. All the "and" parameters are on the top row.
The "On Time" and "Off Time" have been altered from factory.

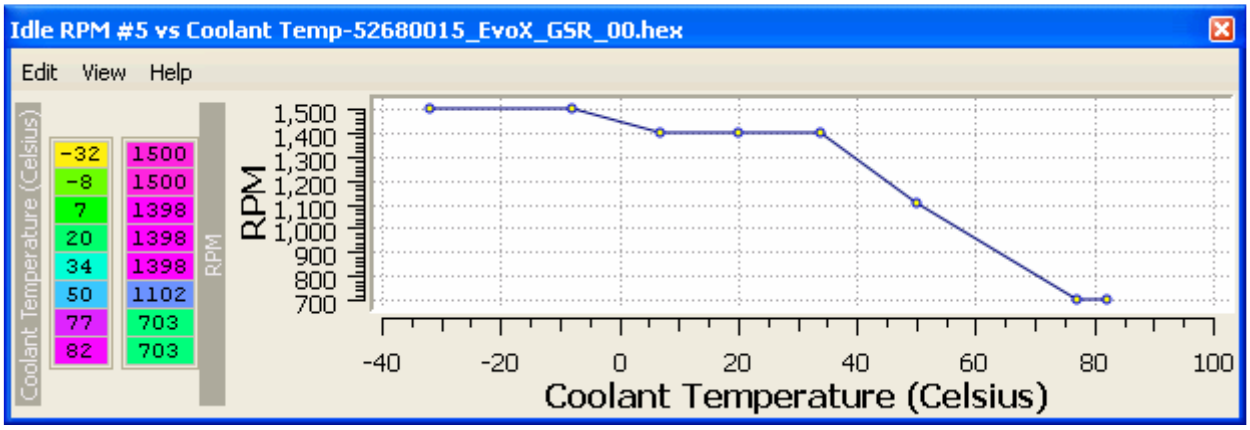
11.06-IDLE CONTROL

This section of the ECU has been inaccurately described in the past and even in the current release of EcuFLASH (v1.42 at time of writing) the definitions are inaccurate. **Mrfred** and **gunzo** have done the dis-assembly of the idle control sub-routines in the ECU for ROM 88590015 (USDM9) and found it to be extremely convoluted and complicated. So we no longer have nice simple ISCV tables and idle rpm v temp tables. Depending on the ROM version there are approximately twenty four defined parameters, including sixteen ISCV Demand tables.

I will limit this topic to the parameters that are most likely to be adjusted from the stock settings.

This is the idle speed target that the ECU will try to achieve, however there are five of these tables and no clear description on when they are used. The values at 77*C and 82*C may require some adjustment when using high lift and high duration cams.

Figure 75: IDLE CONTROL – TARGET MINIMUM IDLE v TEMP, EVO X



SECTION 12 – ECU OPTIONS

12.01-ECU OPTIONS BIT PARAMETERS

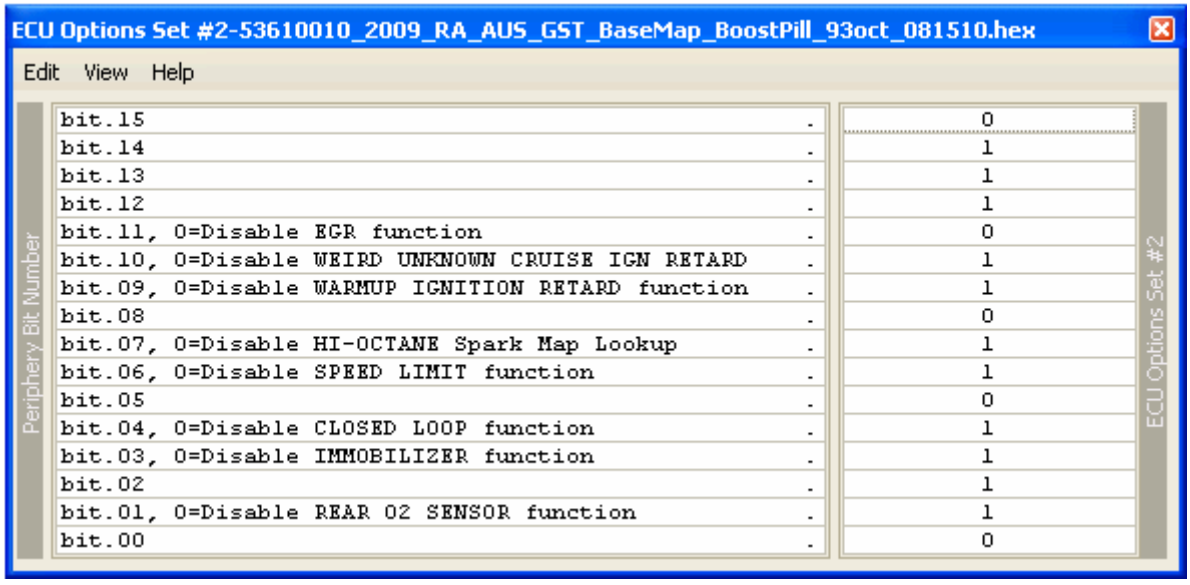
There are six sets of sixteen bit data parameters, called the ECU OPTION SETS, which used to be named Periphery bits. These are mainly single bit controls to enable or disable functions/attributes/tests/fault codes. The data can be presented in raw hex format, or as bits with some explanatory text if the function is known (and the xml file up-dated).

Not all the bits have been defined, **mrfred, jcsbanks, Mattjin, acamus** and others are continuing to work on identifying parameters as and when they can.

The usual arrangement is a 0 will disable the function, a 1 will enable it. Some bits control several functions at the one time. Some are used in conjunction with another bit as an "or" function for the parameter.

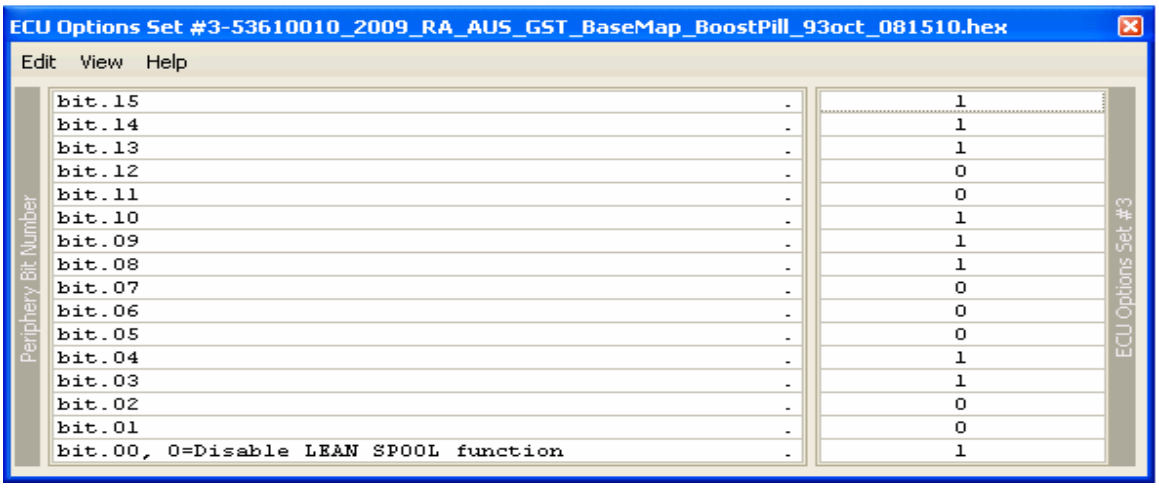
ECU OPTIONS SET #2 seems to be the most useful at the moment. I have edited my definition files to better present the current data lists. OPTIONS bits can also be edited/changed entering a new hex value into the table.

Figure 76: ECU OPTION SET #2



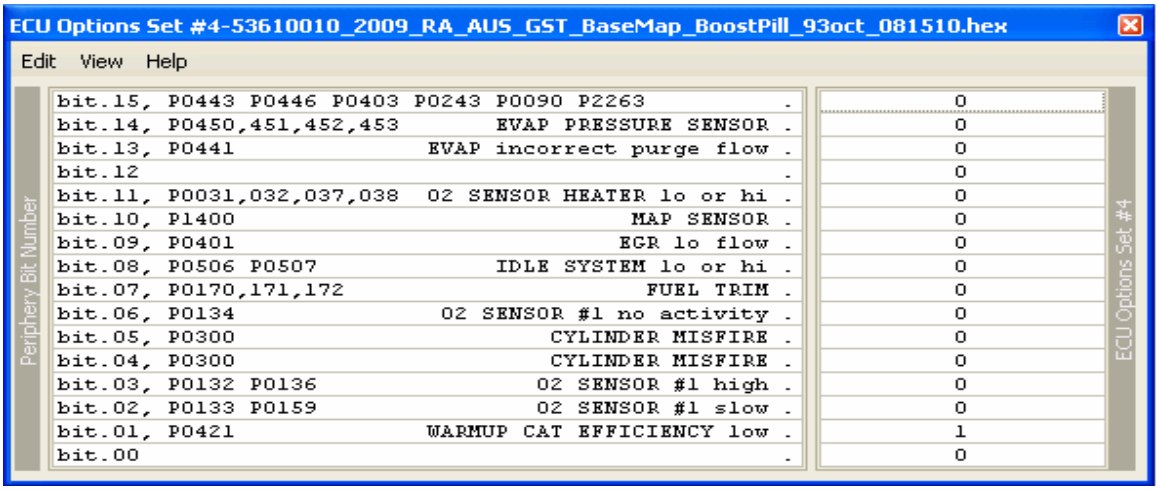
If you are using a high-flow front pipe, you may be getting some rear O2 sensor fault indications on the CEL indicator. Attempting to disable this function via the ECU OPTION SET #2 bit-01 will usually not give a satisfactory result. You need to also do the DTC Disable items. There is also a simple mechanical fix, fit a 90 degree elbow to the rear lambda sensor. This moves the sensor tip out of the direct gas path and effectively simulates a front CAT.

Figure 77: ECU OPTIONS SET #3



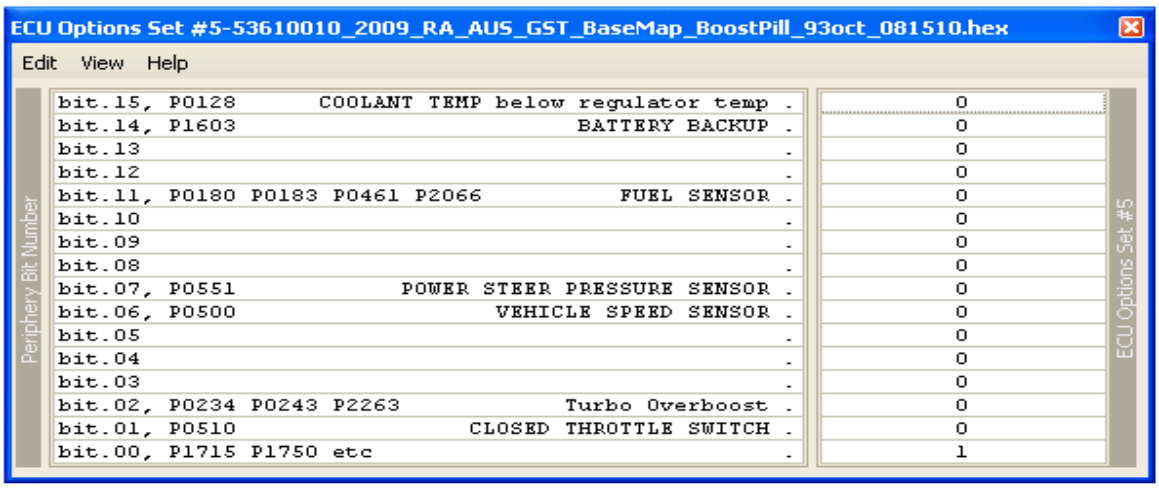
bit.15 .	1
bit.14 .	1
bit.13 .	1
bit.12 .	0
bit.11 .	0
bit.10 .	1
bit.09 .	1
bit.08 .	1
bit.07 .	0
bit.06 .	0
bit.05 .	0
bit.04 .	1
bit.03 .	1
bit.02 .	0
bit.01 .	0
bit.00, 0=Disable LEAN SPOOL function .	1

Figure 78: ECU OPTIONS SET #4



bit.15, P0443 P0446 P0403 P0243 P0090 P2263 .	0
bit.14, P0450,451,452,453 EVAP PRESSURE SENSOR .	0
bit.13, P0441 EVAP incorrect purge flow .	0
bit.12 .	0
bit.11, P0031,032,037,038 O2 SENSOR HEATER lo or hi .	0
bit.10, P1400 MAP SENSOR .	0
bit.09, P0401 EGR lo flow .	0
bit.08, P0506 P0507 IDLE SYSTEM lo or hi .	0
bit.07, P0170,171,172 FUEL TRIM .	0
bit.06, P0134 O2 SENSOR #1 no activity .	0
bit.05, P0300 CYLINDER MISFIRE .	0
bit.04, P0300 CYLINDER MISFIRE .	0
bit.03, P0132 P0136 O2 SENSOR #1 high .	0
bit.02, P0133 P0159 O2 SENSOR #1 slow .	0
bit.01, P0421 WARMUP CAT EFFICIENCY low .	1
bit.00 .	0

Figure 79: ECU OPTIONS SET #5



bit.15, P0128 COOLANT TEMP below regulator temp .	0
bit.14, P1603 BATTERY BACKUP .	0
bit.13 .	0
bit.12 .	0
bit.11, P0180 P0183 P0461 P2066 FUEL SENSOR .	0
bit.10 .	0
bit.09 .	0
bit.08 .	0
bit.07, P0551 POWER STEER PRESSURE SENSOR .	0
bit.06, P0500 VEHICLE SPEED SENSOR .	0
bit.05 .	0
bit.04 .	0
bit.03 .	0
bit.02, P0234 P0243 P2263 Turbo Overboost .	0
bit.01, P0510 CLOSED THROTTLE SWITCH .	0
bit.00, P1715 P1750 etc .	1

SECTION 13 – VIRTUAL DYNO

13.01-VIRTUAL DYNO - INTRODUCTION

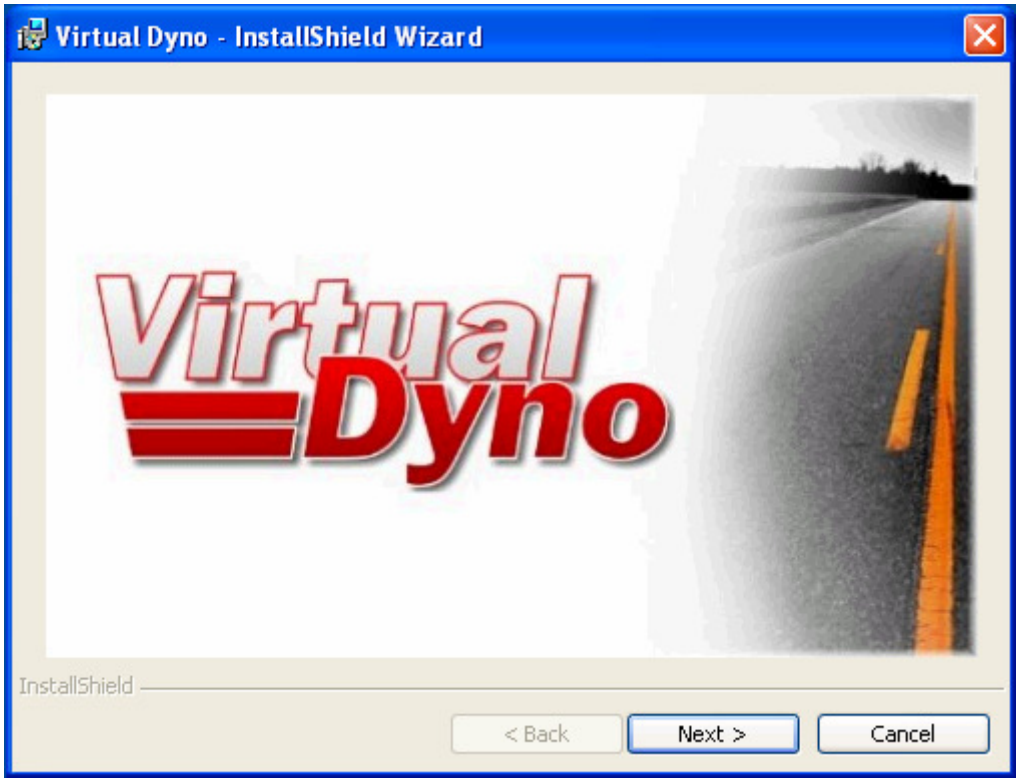
VIRTUAL DYNO is Brad BARNHILL's standalone HORSEPOWER/TORQUE GRAPHING application. It is a really useful tuning tool and is easy to use. In fact it just keeps on getting better with each release. At the time of writing, the current version is 1.0.7 (October 26 2010).

13.02-VIRTUAL DYNO - SETUP

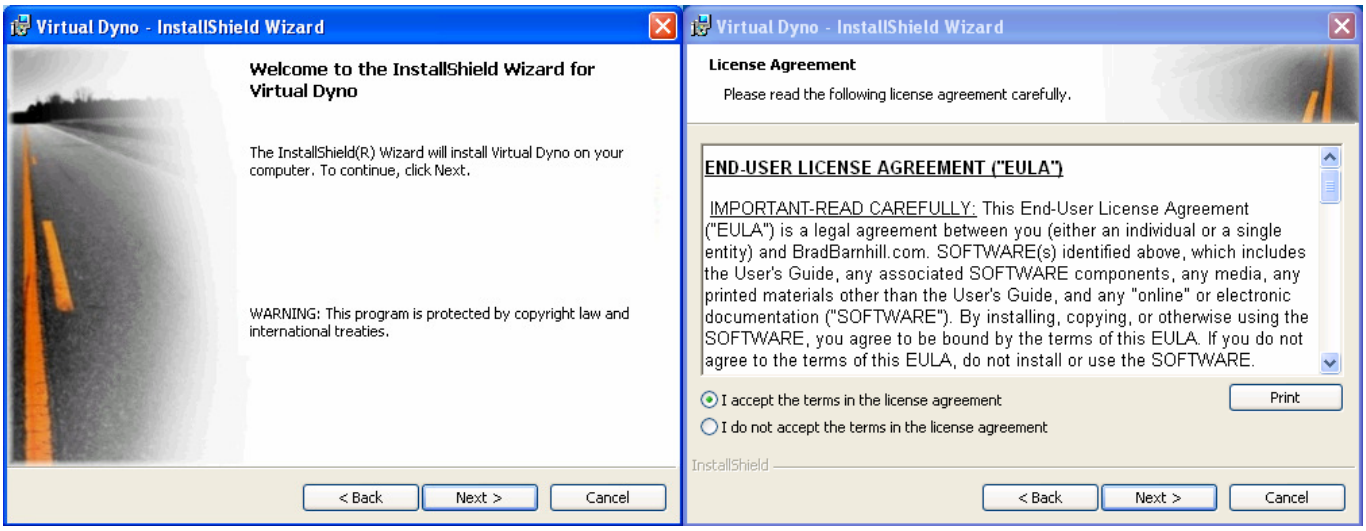
Download the current version of the application from Brads website at:

http://www.bradbarnhill.com.projects/VirtualDyno/

Save the download to a Virtual Dyno Masters folder, you will probably end up with several versions. When the master copy is saved, run the .exe file. The InstallShield Wizard screen should appear.



Follow the on-screen instructions, click the "**I accept the terms in the license agreement**" button and then click the **Next >** tab.

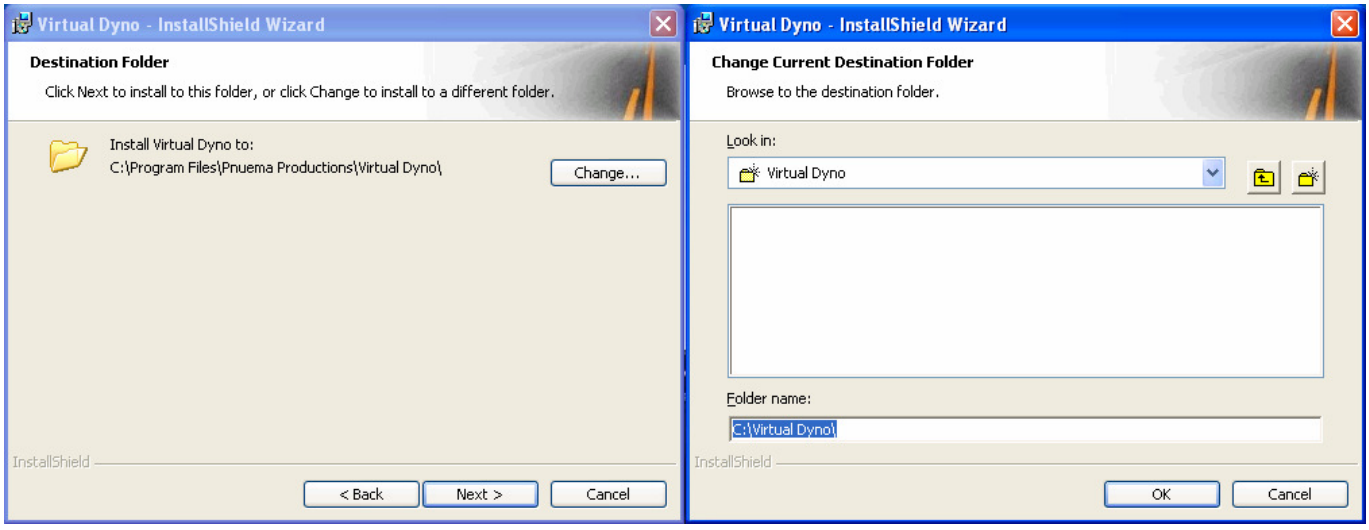


The next bit is the destination folder. The default folder is:

C:\Program Files\Pnuema Productions\Virtual Dyno\

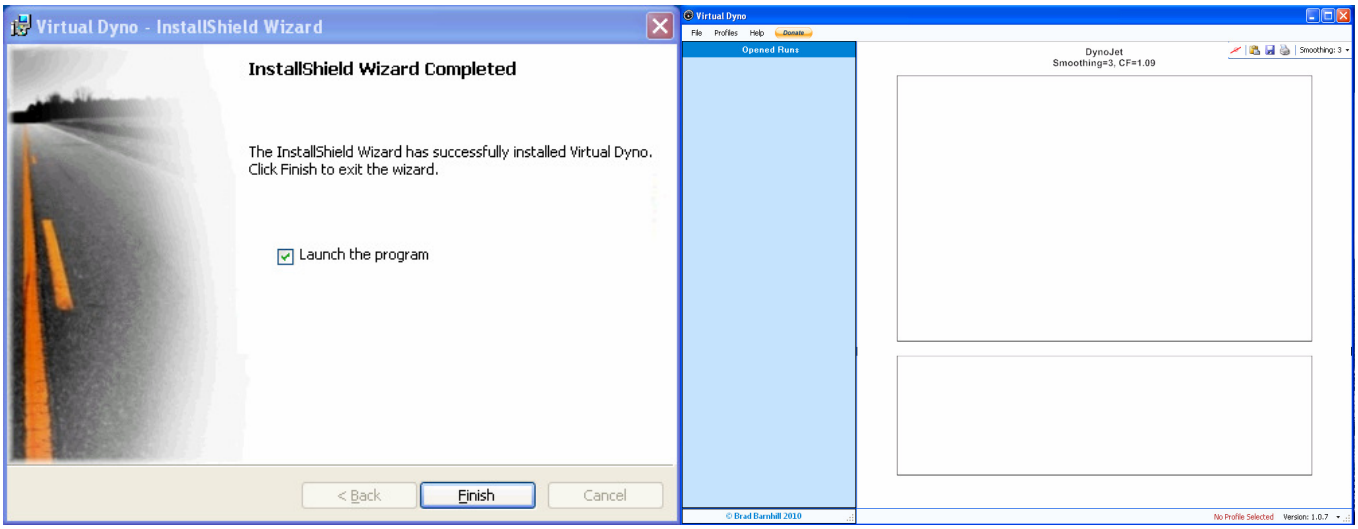
I suggest you click the Change tab, and change the destination folder to:

C:\Virtual Dyno



This will get around Vista and Win7 annoying penchant of saving duplicate file copies. This can really mess you around when you start modifying and updating files. When you are done entering a folder, click **OK** and then **Next >**.

The Preparing to Install screen will appear, click Next and finally you will be rewarded with the InstallShield Wizard Completed screen. Click Finish and you are done.

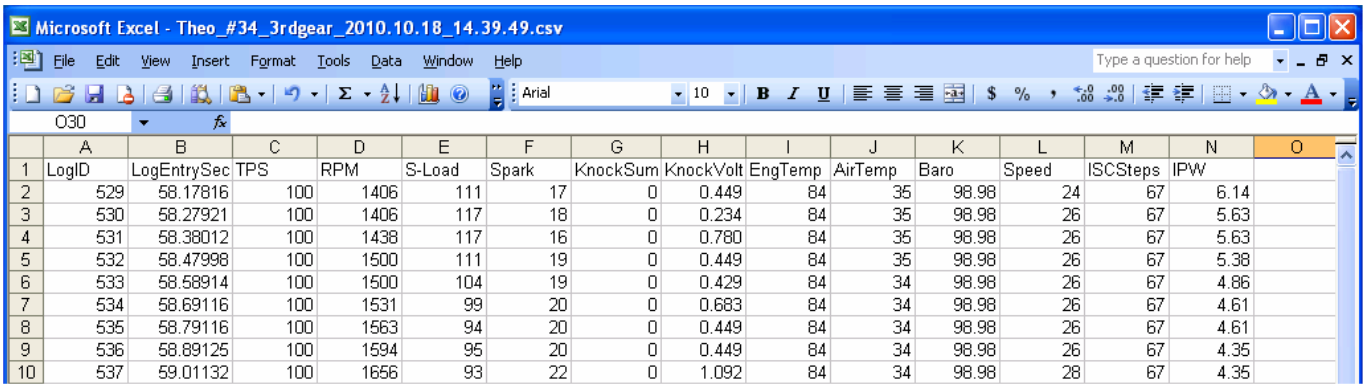


A Virtual Dyno icon will be loaded onto your desktop and Virtual Dyno application will start but with no csv file loaded.

13.03-VIRTUAL DYNO – LOG FILES

VIRTUAL DYNO requires .csv files to operate, these are usually derived from the normal logging process using the EvoScan logging application. What we are looking for is wide open throttle power pulls, on flat road, in either 3rd or 4th gear. Where practical, I will try and start going WOT from about 1500rpm, and hold WOT right out to redline. Power pulls like this are also very good for assessing knock and your spark maps. This is simple enough, but there are things you can do to improve the final graphed results.

Understand that the application calculates the wheel power by the rate of change in vehicle speed, ie its acceleration. Curiously, this is one time where you do not want the log sample rate to be to short or close together, this will create errors and a very lumpy graph. It is easy to get good results though, you just need to pad the log with an appropriate number of log items. What we want is rpm samples about every 100mS to 250ms, this will give a very good result. Here is a sample for discussion.


Microsoft Excel - Theo_#34_3rdgear_2010.10.18_14.39.49.csv

File Edit View Insert Format Tools Data Window Help

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	LogID	LogEntrySec	TPS	RPM	S-Load	Spark	KnockSum	KnockVolt	EngTemp	AirTemp	Baro	Speed	ISCSteps	IPW	
2	529	58.17816	100	1406	111	17	0	0.449	84	35	98.98	24	67	6.14	
3	530	58.27921	100	1406	117	18	0	0.234	84	35	98.98	26	67	5.63	
4	531	58.38012	100	1438	117	16	0	0.780	84	35	98.98	26	67	5.63	
5	532	58.47998	100	1500	111	19	0	0.449	84	35	98.98	26	67	5.38	
6	533	58.58914	100	1500	104	19	0	0.429	84	34	98.98	26	67	4.86	
7	534	58.69116	100	1531	99	20	0	0.683	84	34	98.98	26	67	4.61	
8	535	58.79116	100	1563	94	20	0	0.449	84	34	98.98	26	67	4.61	
9	536	58.89125	100	1594	95	20	0	0.449	84	34	98.98	26	67	4.35	
10	537	59.01132	100	1656	93	22	0	1.092	84	34	98.98	28	67	4.35	

This sample log shows the parameters I will log, and the order I place them in the log for good readability. Note that the sample rate is about every 100mS which will yield a smoother graph without having to use a high smoothing factor.

This sample log has also been manipulated to improve readability:

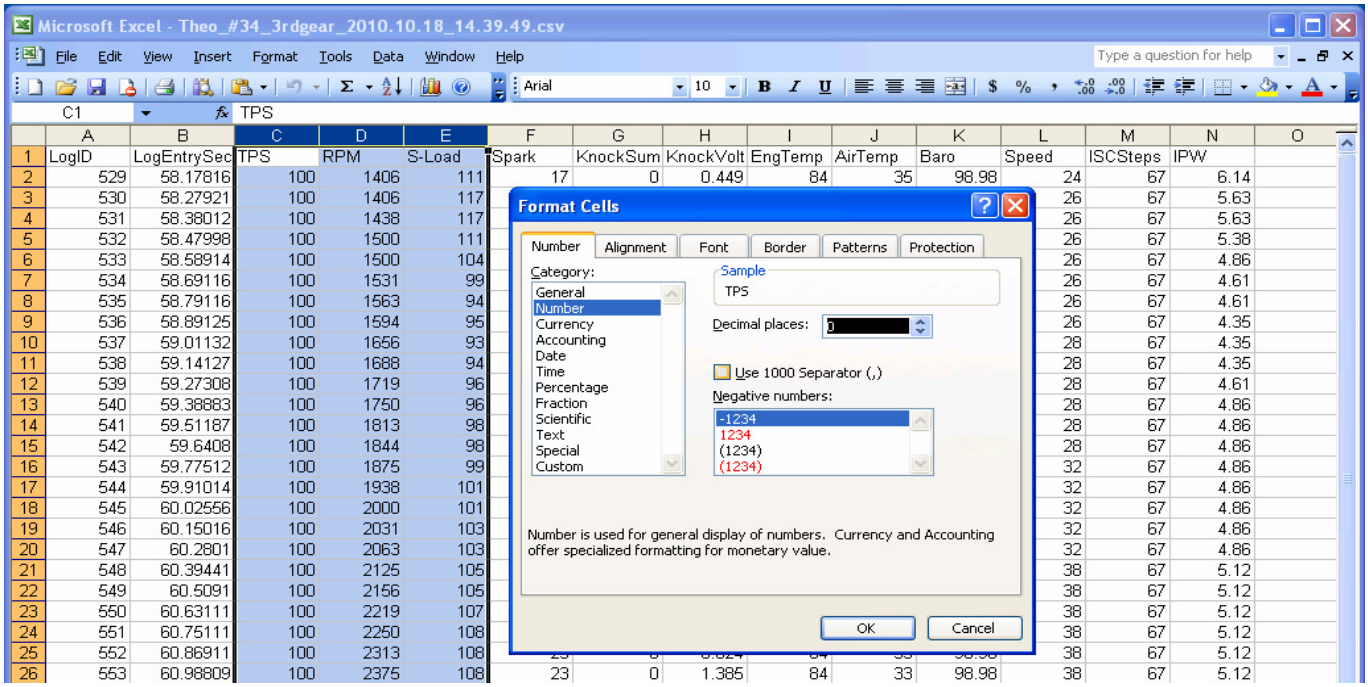
Removal of unwanted columns.
Removal of unwanted decimal places in the data.
Top and tail the log to remove all unwanted stuff like idling and run-down etc at the start and end of the log.

First off, I delete from the raw csv file all the columns I do not want in the log, such as LogEntryDate, LogEntryTime, LogNotes and then all the columns to the right of the last wanted column.

To do this, left click on column alpha lable, eg B, C, E, then right click and delete.

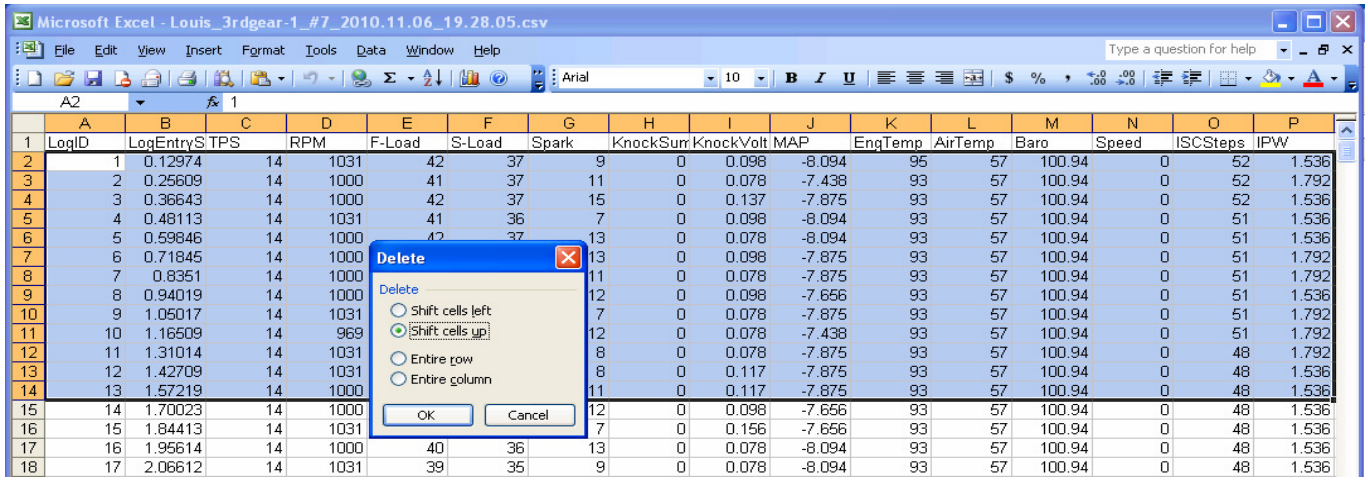
To delete all the columns to the right of the last wanted column, left click and hold, then drag across all the unwanted columns, then delete.

My next step is to fix the decimal places in the data columns, who needs 5 decimal places for TPS or four for Load etc. To do this, left click on the columns you want to fix, eg we want to set zero decimal places in the TPS, RPM and Load columns. With the desired columns highlighted, select **Format/Cells**.



Select **Number** and then set the **Decimal places** to zero. You can see that in this log I have also set the IPW to two decimal places but you can set as desired for your purposes. Don't manipulate the LogEntrySeconds column though, as that would corrupt the power calculation.

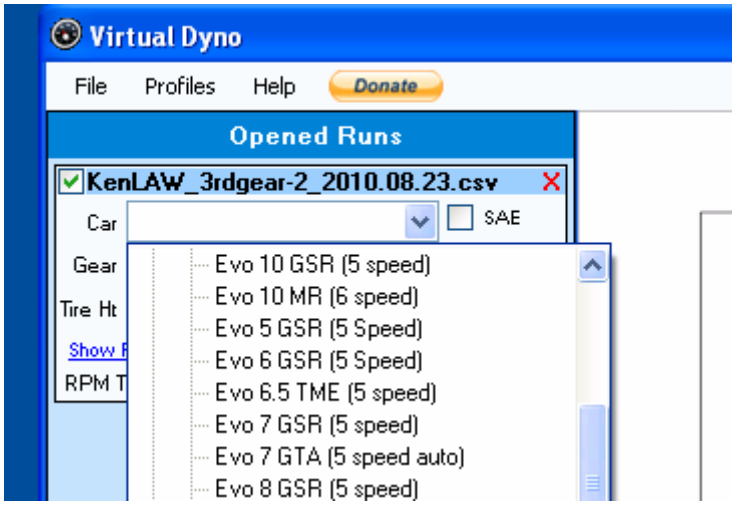
The final tidy-up step is to top and tail the log, stripping from the log everything that is not the power pull. This is not really necessary now as Brad has improved the application such that it will find the power pull automatically. I still do it though so it is easier for me to review client data later or when sending the file via email. Left click and drag the mouse to highlight the area to be removed. Hold the pointer over the highlighted section and right click, then delete. A little window will open, with Shift cells up selected. Click OK and the highlighted section is removed.



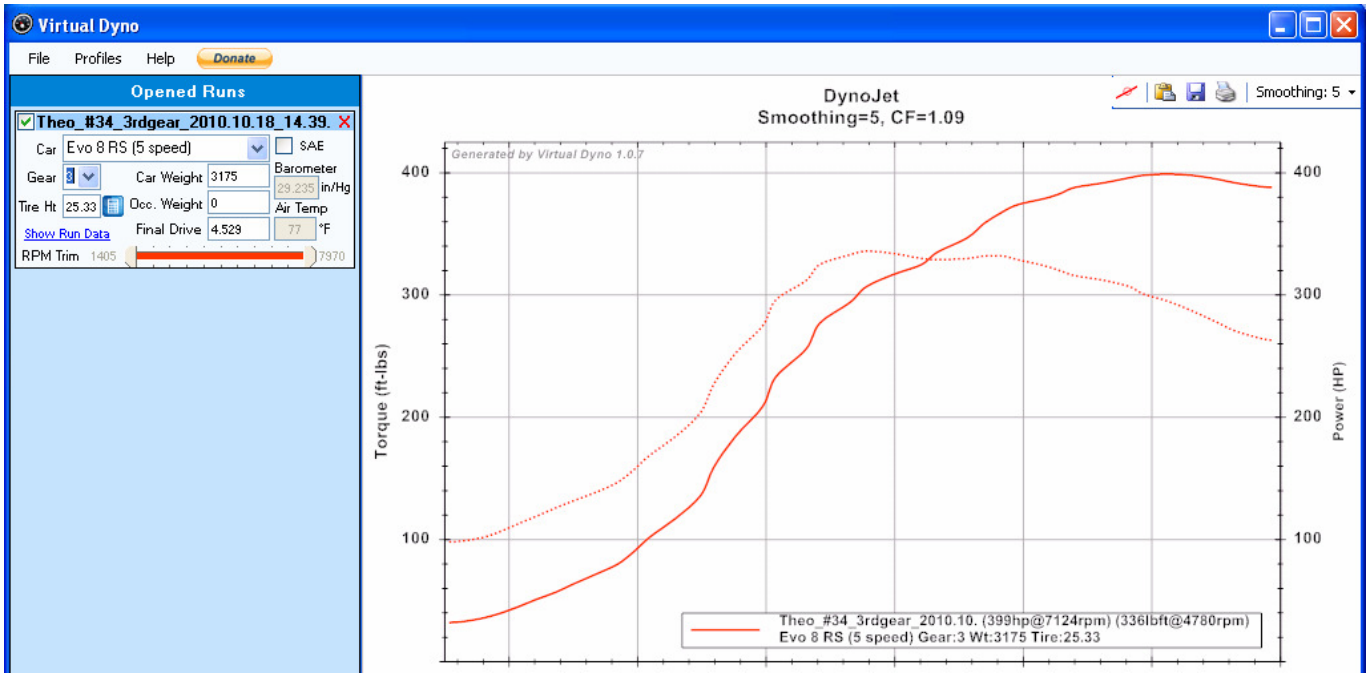
13.04-VIRTUAL DYNO – LOADING & GRAPHING FILES

Make a copy of the desired log files (from EvoScan\SavedDataLogs) into the Logs folder under Virtual Dyno. It is a good idea to unambiguously label them with the tune number for future reference.

Start Virtual Dyno, select **File\Load Runs**. The logs folder will open, select the desired log file to be graphed. A window with **Opened Runs** will now appear. Select the type of car from the **Car** pull-down menu.



Now select the gear used from the **Gear** pull-down menu. At this point if the selected log file is valid power and torque traces will be shown in the graph area.



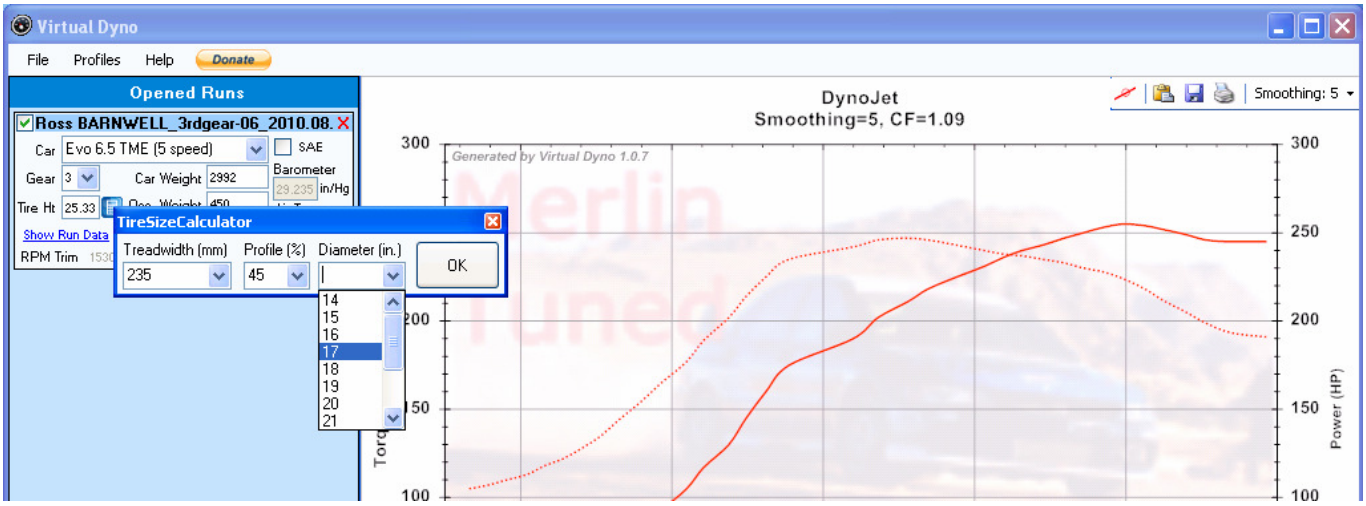
Want to add more power runs to the graph? Just click **File\Load Runs** and add more logs to the graph.

13.05-VIRTUAL DYNO – CORRECTIONS & OPTIONS

Now the **Tire Ht**. and **Occ.Weight** corrections need to be included – you did remember to note the tire size and quiz the car owner on his weight and any heavy items in the car, like subs and amps etc etc.

Add the correct weight (in lbs) and watch the power jump up. If you need to convert from kilos to pounds, multiply the kilograms by 2.2 for a weight in pounds.

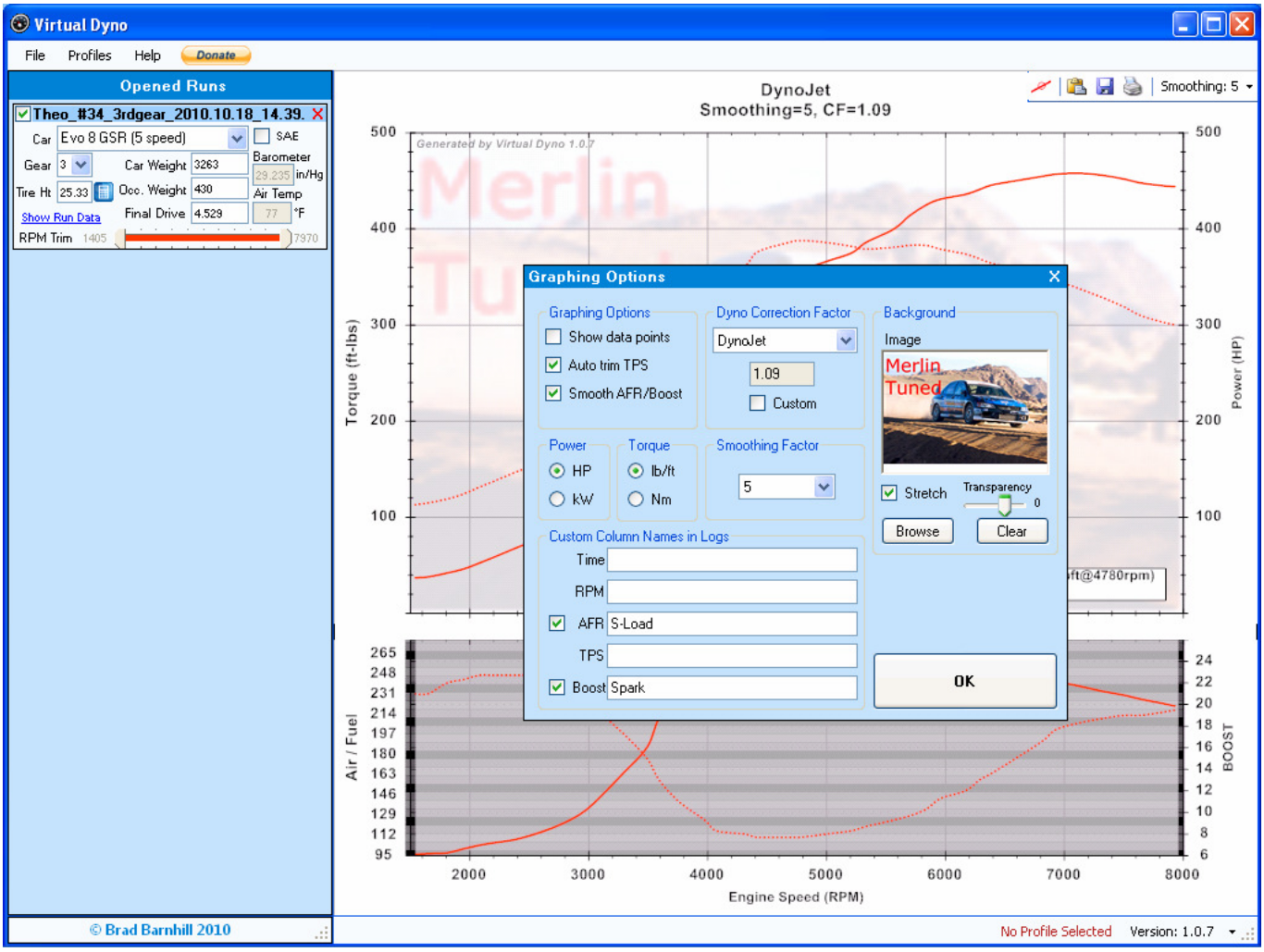
The tire height calculator works fine if the car has non-standard wheel height. Click the blue tab and the **TireSizeCalculator** will appear. Use the pull-down table to enter the correct dimensions



Another nice feature is the ability to add environmental corrections with the **SAE** tab. With SAE ticked, the barometric pressure and ambient air temperature corrections can be entered. Imperial only though here.

The cars gear ratios, final drive ratio, co-efficient of drag (CD) and vehicle weight are all stored in the cars.xml file that comes with the Virtual Dyno package. These can be edited if any errors are found and new vehicles can be added by tuners if they need to. Gear and differential ratios and weights can be found on the web for most cars, you might have to take a guess on the CD but the result will still be quite good.

Now select File\Options for the options that allow you to customize the graph.



Graphing Options:

Show Data Points, allows you to see on the graph the log data points.
Auto Trim TPS, graphs all continuous data above a preset TPS percentage.
Smooth AFR/Boost, smoothes the second graph with a fixed factor.

Dyno Correction Factor:

DynoJet, correction is preset to 1.09.
Mustang, correction is preset to 0.95.
Custom, correction can be customized for other dynomometers.

Background:

You can customize the graph with a tuner shop logo or some other image. The Browse tab look for an image in the Logs folder but you can browse to any folder in the computer. JPG files of 200-300kbytes work ok here. If the image needs to be better fitted to the graph size, tick the Stretch tab. The Transparency slider control allows the image to be faded so that the traces are distinct.

Power & Torque:

Allows you to select whatever units you want the graph to use. While the kW / Nm selection works correctly, the actual graph will have a large difference in plot size with the SI units. A graph with imperial units fills the whole plot area.

Smoothing Factor:

Sets the degree of artificial smoothing of the data to even out the lumps in the trace. The lumps and bumps are caused by small errors in the time sampling and corresponding RPM data. Longer times between data points yields naturally smoother graphs, without having to use a high smoothing factor. Don't use 2-byte RPM in the logs, it gives rise to more errors due to mismatch of the data. RMP should be either the first or second item in your log, so that it is closely aligned with the LogEntrySeconds time stamp.

Custom Column Names in Logs:

Time, allows you to enter an alternate log column name for time stamp.
RPM, allows you to enter an alternate log column name for revolutions.
AFR, allows you to enter an alternate log column name for air fuel ratio.
TPS, allows you to enter an alternate log column name for throttle.
Boost, allows you to enter an alternate log column name for boost.

The ability to manipulate the column names facilitates importing log files from sources other than EvoScan. For example, Autronic log or Hondata logs can be accommodated and graphed.

In addition, you can graph some alternate data in the AFR and Boost graph. An example of this would be to graph Load in the AFR tab and spark advance in the Boost tab. The application automatically adjusts the scaling to suite but unfortunately the graph label remains unchanged. Still, a very useful feature.

APPENDIX 1: ECU PIN DESCRIPTIONS AND WIRING

Figure 80: ECU WIRE SIDE VIEW - EvoX & RALLIART

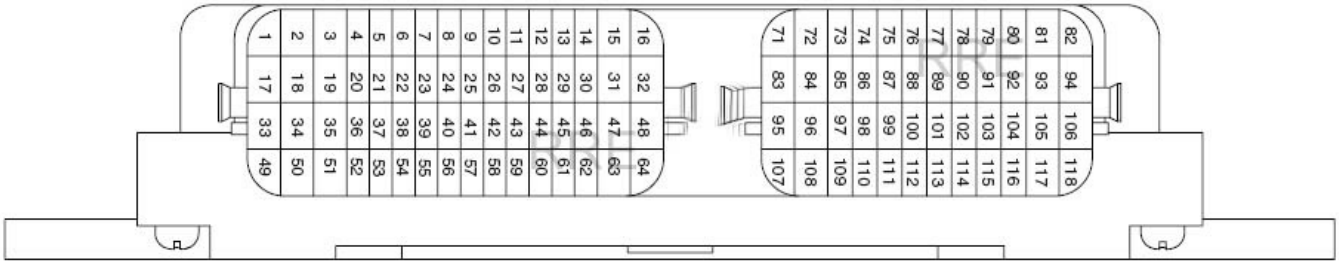


Table 6 EvoX & RALLIART ECU PIN FUNCTION			
1	Intake Cam Oil Control valve	71	Throttle Actuator Control Motor ground
2	No.1 Injector	72	Throttle Actuator Control Motor power supply
3	No.2 Injector	73	MFI relay (power supply)
4	No.1 Ignition Coil	74	Accelerator Pedal position sensor [main] (signal)
5	No.2 Ignition Coil	75	Accelerator Pedal Position sensor [main] (+DC)
6	Starter active signal	76	Accelerator Pedal Position sensor [main] (ground)
7	Exhaust Camshaft Position sensor	77	Accelerator Pedal Position sensor [sub] (signal)
8	Crankshaft Position sensor	78	Accelerator Pedal Position sensor [sub] (+DC)
9	Sensor power supply +5VDC	79	Accelerator Pedal Position sensor [sub] (ground)
10	Throttle Position sensor (main)	80	ECM K Line
11	Throttle Position sensor (sub)	81	ECM ground
12	Throttle Position Sensor - +5VDC	82	ECM +12VDC Power supply
13	Throttle Position sensor ground	83	Throttle Actuator Control Motor (ground)
14	Intake Camshaft Position sensor	84	Throttle Actuator Control Motor relay
15	Throttle Actuator Control motor (+)	85	Clutch Pedal Position switch
16	Throttle Actuator Control motor (-)	86	
17	Exhaust Cam Oil Control valve	87	Mass Airflow sensor (signal)
18	No.3 Injector	88	Mass Airflow sensor (ground)
19	No.4 Injector	89	Intake air temperature sensor 1
20	No.3 Ignition coil (ignition power transistor)	90	CAN Interface (high)
21	No.4 Ignition coil (ignition power transistor)	91	CAN Interface (low)
22*		92	Ignition switch-IG
23	Exhaust Camshaft position sensor (ground)	93	ECM ground
24	Crankshaft Position sensor (ground)	94	
25	Knock sensor (+)	95	Cruise Control Set
26	Engine Coolant Temperature sensor (signal)	96	Fuel Pump relay 2
27	Engine Coolant Temperature sensor (ground)	97	Intake Air Temperature sensor 2 (ground)
30	Intake Camshaft Position sensor ground	98	Intake Air Temperature sensor 2 (signal)
34	Lambda sensor heater [front]	99	
35	Lambda sensor heater [rear]	100	
36	Engine Oil Pressure switch	101	
37	Evaporative Emission Purge solenoid	102	Air Conditioner Compressor relay
38	Lambda sensor [front]	103	Flash EP-ROM power supply
39	Lambda sensor [front] offset voltage	104	Backup power supply
40	Lambda sensor [rear]	105	Ignition switch-ST
41	Lambda sensor [rear] offset voltage	106	Starter relay
42	Knock sensor (-)	107	Cruise Control (+DC supply)
44	Manifold Absolute Pressure sensor (+DC supply)	108	Cruise Control Brake (signal)
45	Manifold Absolute Pressure sensor (signal)	109	
46	Manifold Absolute Pressure sensor (ground)	110	
51	Fuel Pump relay 1	111	
52	Turbocharger Wastegate solenoid 1	112	Fuel Tank Differential Pressure sensor (signal)
53	Turbocharger Wastegate solenoid 2	113	Fuel Tank Differential Pressure sensor (ground)
58	Power Steering Pressure switch	114	Fuel Tank Differential Pressure sensor (+DC supply)
60	Alternator - G terminal	115	Fuel Tank Temperature sensor (signal)
61	Alternator - FR terminal	116	
62	Alternator - L terminal	117	Evaporative Emission Ventilation solenoid
63	* These pin function not known, see below	118	
64	22, 28-29, 31-33, 43, 47-50,54-57, 59, 63-64		

APPENDIX 2: USEFUL INFORMATION

A2.1: PRESSURE CONVERSIONS

1 bar = 100 kPa
1 bar = 1000 mbar
1 bar = 750 mm of Hg
1 bar = 29.53 inch of Hg
1 bar = 14.503 psi

1”Hg = 0.4912 psi
1”Hg = 3.3864 kPa
1”Hg = 33.864 mbar

1psi = 2.036 “Hg
1psi = 6.8947 kPa

1kg/cm□ = 14.223 psi
1kg/cm□ = 99.06 kPa

A2.2: SERVICE REMINDER RESET

The RALLIART and EVO X Multi Information Meter, located between the speedo and tacho, will show a multitude of information and fault indications etc and it also shows when the next service is due. This not will explain how to reset the counter after servicing the car.

1. Set the IGNITION switch to the OFF position.

2. Press the INFO button and ODOMETER button until NEXT SERVICE is shown.

3. Press and hold the INFO button for two seconds, the SERVICE INDICATOR wrench symbol will flash.

4. While the SERVICE INDICATIOR is flashing, press and hold the INFO button for two seconds.

5. The SERVICE INDICATOR should now show the message CLEAR for three seconds to confirm the SERVIVE INTERVAL has been correctly reset.

APPENDIX 3: EVOX & RALLIART ROM IDENTIFIER

Not all ROMs will have good definition files, as the work involved for the ECU gurus is massive to find the addresses for all the parameters. If the definition file for your ROM is much less than 10k bytes, it wont have a lot of detail, so you would be better to transfer to a better supported ROM.

Table 7 MISC EVOX & RALLIART ROM IDENTIFIER

YEAR	ROM NUMBER	MARKET	TRANS	NOTES - COMMENTS
2008				
2008				
2008	51520020	USDM	6MT	EVOX
2008				
2008	52360016	JDM	6MT	EVOX
2008	52550003	EDM	6MT	EVOX
2008	52680015	USDM	5MT	EVOX GSR
2008	52680016	USDM	5MT	EVOX GSR
2008	52680017	USDM	5MT	EVOX GSR
2008	52680018	USDM	5MT	EVOX GSR
2008	52680020	USDM	5MT	EVOX GSR
2008	53040007	EDM	5MT	EVOX RS
2008	53040008	EDM	5MT	EVOX GSR
2008	53050006	EDM	SST	EVOX MR
2008	53050009	EDM	SST	EVOX MR
2009				
2009				
2009	53600009	USDM	SST	RALLIART
2009	53600010	USDM	SST	RALLIART
2009				
2009				
2010				
2010	53610010	AUDM	SST	RALLIART
2010	53610013	AUDM	SST	RALLIART
2010	55590006	USDM	SST	RALLIART
2010				
2010				
2010				
2010				
2011				
2011				

NOTES LEDGEND

APPENDIX 4: LOGGING & EVOSCAN ADDRESS SETUP

For ROM: 52680015 – 52680020, 52690019

RPM:0x80874f:1:x,31.25,*:1
PSIG:0x80871a:2:x,4,/,0.19347,*,14.5,-:1
TimingAdv:0x808a07:1:x,20,-:1
KnockSum:0x808a4b:1:x:1
Load:0x80876e:2:x,10,*,32,/:1
IPW:0x80a944:2:x,1000,/:1
TPS:0x8086f9:1:x,100,*,255,/:2
Speed:0x8087e7:1:x,2,*:5
ActiveWGDC:0x808b53:1:x,2,/:1
PassiveWGDC:0x80a53f:1:x,2,/:1
FuelTrim_Idle:0x804573:1:x,0.1953125,*,25,-:20
FuelTrim_Cruise:0x804575:1:x,0.1953125,*,25,-:20

For ROM: 53040007 – 53040010, 52360016 - 52360018

RPM:0x808747:1:x,31.25,*:1
PSIG:0x808712:2:x,4,/,0.19347,*,14.5,-:1
TimingAdv:0x8089ff:1:x,20,-:1
KnockSum:0x808a43:1:x:1
Load:0x808766:2:x,10,*,32,/:1
IPW:0x80a934:2:x,1000,/:1
TPS:0x8086f1:1:x,100,*,255,/:2
Speed:0x8087df:1:x,2,*:5
ActiveWGDC:0x808b4b:1:x,2,/:1
PassiveWGDC:0x80a52f:1:x,2,/:1
FuelTrim_Idle:0x804573:1:x,0.1953125,*,25,-:20
FuelTrim_Cruise:0x804575:1:x,0.1953125,*,25,-:20

Spark maps, for MAF air temps less than 77°F / 25°C, use BARO+IAT compensated Load.

Spark maps, for MAF air temps more than 77°F / 25°C, BARO compensated Load.

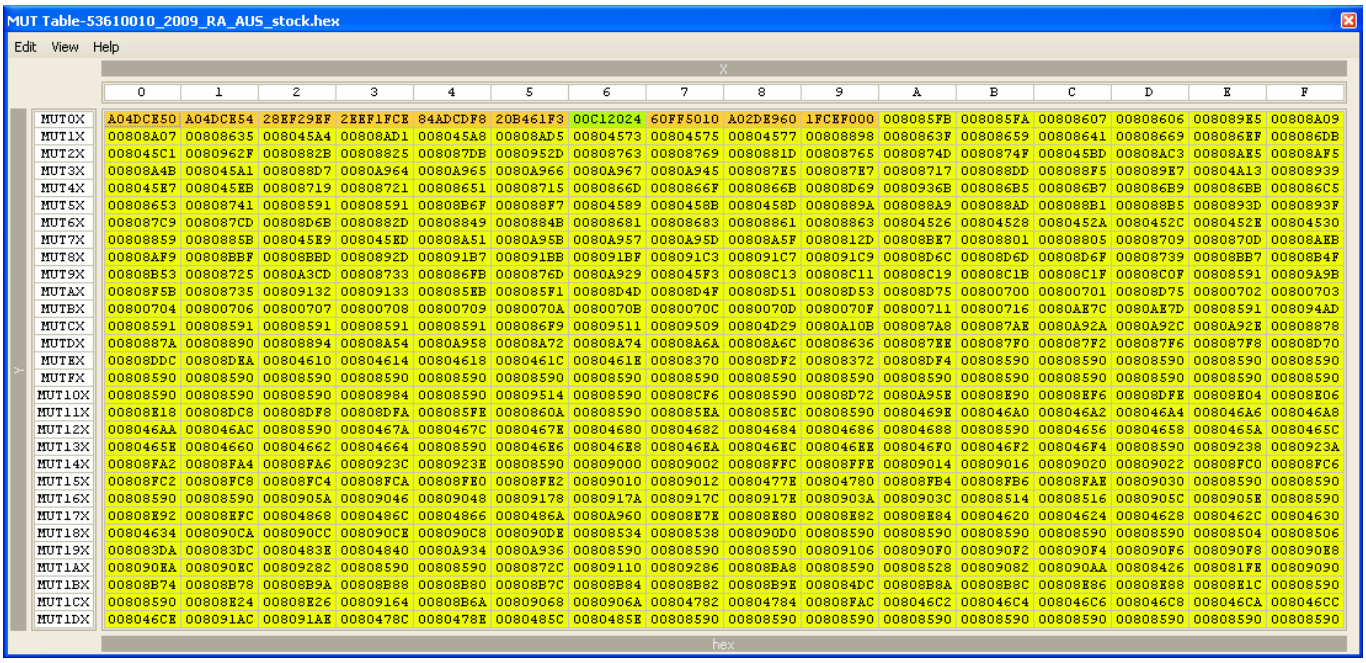
Fuel maps, normally use BARO+IAT compensated Load.

Fuel maps use un-compensated Load when load is less than 20 while in Closed Loop.

Enter the HEX addresses from the table for your ROM into the MUT TABLE to enable 2-byte logging of LOAD.

They are entered on the top line of the table, starting at the left. Ignore the FFFF bits. Data is to be entered in the usual way for HEX, eg 0x6b12. EvoScan is already setup to log the following 2-byte data:

Figure 81: MUT TABLE, 53610010 RALLIART



APPENDIX 5: BRICKED ECU RECOVERY

A5.1-INTRODUCTION

A potential problem has been identified with flashing the RALLIART and EVOX ECU whereby the flash fails. This procedure explains the recovery method.

Note that this is different to an issue that sometimes occurs with the MR, where the CEL is lit after flashing. This can be cleared with EvoScan reading and clearing the DTC code.

A5.2-BRICKED ECU RECOVERY PROCEDURE

The EFI ECU will need to be removed from the vehicle and connected to the OpenPort 2 cable and a 12VDC power supply as shown in the wiring connections section.

Start EcuFlash and open a copy of your STOCK ROM.

Select from the EcuFlash Options menu:

Alternate Flash Method

This will take a long time – patience. When the flash has finished, de-select Alternate Flash Method from the Options menu.

Flash your STOCK ROM again – this should configure the ECU properly.
Re-connect the ECU back into the vehicle and start the engine to verify all is well.

You can now proceed to re-flash your tuned ROM into the ECU.

This cable is available from: http://cct-elec.en.made-in-china.com...ctor-Core.html

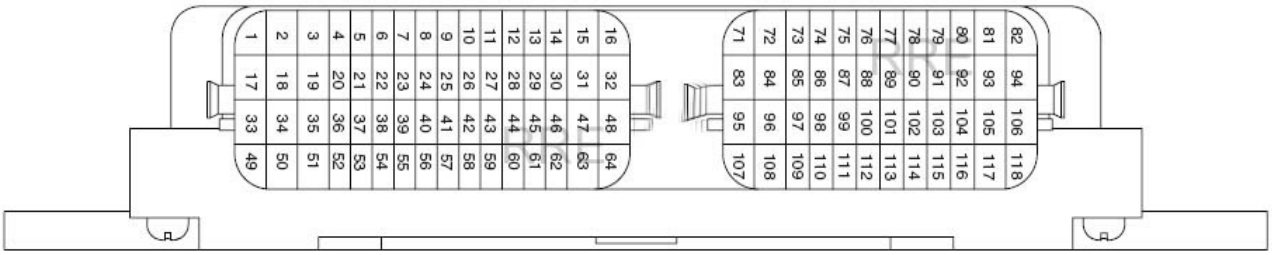
A5.3-BRICKED ECU RECOVERY WIRING PROCEDURE

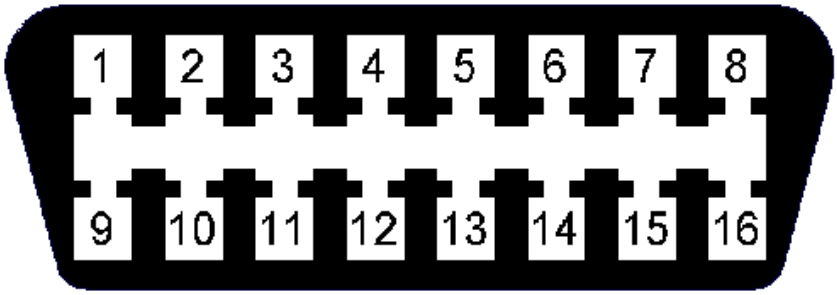
ECU POWER CONNECTIONS

ECU pin 71	to	0VDC
ECU pin 82	to	+12VDC
ECU pin 92	to	+12VDC
ECU pin 104	to	+12VDC

OBD POWER CONNECTIONS

OBD pin 4	to	0VDC
OBD pin 5	to	0VDC
OBD pin 16	to	+12VDC





ECU TO OBD CONNECTIONS

ECU pin 80	to	OBD pin 7	ECU K LINE
ECU pin 90	to	OBD pin 6	CAN BUS – HI LINE
ECU pin 91	to	OBD pin 14	CAN BUS – LOW LINE
ECU pin 103	to	OBD pin 12	FLASH EEPROM POWER

APPENDIX 6: OBD-II POWERTRAIN FAULT CODES

A6.1-P00XX Fuel, Air Metering & Aux Emissions Controls

P0010	"A" Camshaft Position Actuator Circuit	(Bank 1)
P0011	"A" Camshaft Position - Timing Over-Advanced	(Bank 1)
P0012	"A" Camshaft Position - Timing Over-Retarded	(Bank 1)
P0013	"B" Camshaft Position - Actuator Circuit	(Bank 1)
P0014	"B" Camshaft Position - Timing Over-Advanced	(Bank 1)
P0015	"B" Camshaft Position -Timing Over-Retarded	(Bank 1)
P0030	HO_2S Heater Control Circuit	(Bank 1 Sensor 1)
P0031	HO_2S Heater Control Circuit Low	(Bank 1 Sensor 1)
P0032	HO_2S Heater Control Circuit High	(Bank 1 Sensor 1)
P0033	Turbo Charger Bypass Valve Control Circuit	
P0034	Turbo Charger Bypass Valve Control Circuit Low	
P0035	Turbo Charger Bypass Valve Control Circuit High	
P0036	HO_2S Heater Control Circuit	(Bank 1 Sensor 2)
P0037	HO_2S Heater Control Circuit Low	(Bank 1 Sensor 2)
P0038	HO_2S Heater Control Circuit High	(Bank 1 Sensor 2)
P0042	HO_2S Heater Control Circuit	(Bank 1 Sensor 3)
P0043	HO_2S Heater Control Circuit Low	(Bank 1 Sensor 3)
P0044	HO_2S Heater Control Circuit High	(Bank 1 Sensor 3)
P0065	Air Assisted Injector Control Range/Performance	
P0066	Air Assisted Injector Control Circuit or Circuit Low	
P0067	Air Assisted Injector Control Circuit High	
P0070	Ambient Air Temperature Sensor Circuit	
P0071	Ambient Air Temperature Sensor Range/Performance	
P0072	Ambient Air Temperature Sensor Circuit Low Input	
P0073	Ambient Air Temperature Sensor Circuit High Input	
P0074	Ambient Air Temperature Sensor Circuit Intermittent	
P0075	Intake Valve Control Solenoid Circuit	(Bank 1)
P0076	Intake Valve Control Solenoid Circuit Low	(Bank 1)
P0077	Intake Valve Control Solenoid Circuit High	(Bank 1)
P0078	Exhaust Valve Control Solenoid Circuit	(Bank 1)
P0079	Exhaust Valve Control Solenoid Circuit Low	(Bank 1)
P0080	Exhaust Valve Control Solenoid Circuit High	(Bank 1)

A6.2-P01XX Fuel and Air Metering

P0100	Mass or Volume Air Flow Circuit	
P0101	Mass or Volume Air Flow Circuit Range/Performance Problem	
P0102	Mass or Volume Air Flow Circuit Low Input	
P0103	Mass or Volume Air Flow Circuit High Input	
P0104	Mass or Volume Air Flow Circuit Intermittent	
P0105	Manifold Absolute Pressure/Barometric Pressure Circuit	
P0106	Manifold Absolute Pressure/Baro. Pressure Circuit Range/Perf. Problem	
P0107	Manifold Absolute Pressure/Barometric Pressure Circuit Low Input	
P0108	Manifold Absolute Pressure/Barometric Pressure Circuit High Input	
P0109	Manifold Absolute Pressure/Barometric Pressure Circuit Intermittent	
P0110	Intake Air Temperature Circuit	
P0111	Intake Air Temperature Circuit Range/Performance Problem	
P0112	Intake Air Temperature Circuit Low Input	
P0113	Intake Air Temperature Circuit High Input	
P0114	Intake Air Temperature Circuit Intermittent	
P0115	Engine Coolant Temperature Circuit	
P0116	Engine Coolant Temperature Circuit Range/Performance Problem	
P0117	Engine Coolant Temperature Circuit Low Input	
P0118	Engine Coolant Temperature Circuit High Input	
P0119	Engine Coolant Temperature Circuit Intermittent	
P0120	Throttle/Pedal Position Sensor/Switch A Circuit	
P0121	Throttle/Pedal Position Sensor/Switch A Circuit Range/Perf. Problem	
P0122	Throttle/Pedal Position Sensor/Switch A Circuit Low Input	
P0123	Throttle/Pedal Position Sensor/Switch A Circuit High Input	
P0124	Throttle/Pedal Position Sensor/Switch A Circuit Intermittent	
P0125	Insufficient Coolant Temperature for Closed Loop Fuel Control	
P0126	Insufficient Coolant Temperature for Stable Operation	
P0127	Intake Air Temperature Too High	
P0128	Coolant Temperature < Thermostat Reg. Temp.)	
P0130	O2 Sensor Circuit	(Bank 1 Sensor 1)
P0131	O2 Sensor Circuit Low Voltage	(Bank 1 Sensor 1)
P0132	O2 Sensor Circuit High Voltage	(Bank 1 Sensor 1)
P0133	O2 Sensor Circuit Slow Response	(Bank 1 Sensor 1)
P0134	O2 Sensor Circuit No Activity Detected	(Bank 1 Sensor 1)
P0135	O2 Sensor Heater Circuit	(Bank 1 Sensor 1)
P0136	O2 Sensor Circuit Malfunction	(Bank 1 Sensor 2)
P0137	O2 Sensor Circuit Low Voltage	(Bank 1 Sensor 2)
P0138	O2 Sensor Circuit High Voltage	(Bank 1 Sensor 2)
P0139	O2 Sensor Circuit Slow Response	(Bank 1 Sensor 2)
P0140	O2 Sensor Circuit No Activity Detected	(Bank 1 Sensor 2)
P0141	O2 Sensor Heater Circuit	(Bank 1 Sensor 2)

P0148 Fuel Delivery Error
P0149 Fuel Timing Error
P0168 Fuel Temperature Too High
P0169 Fuel Incorrect Composition

P0170 Fuel Trim (Bank 1)
P0171 System too Lean (Bank 1)
P0172 System too Rich (Bank 1)
P0176 Fuel Composition Sensor Circuit
P0177 Fuel Composition Sensor Circuit Range/Performance
P0178 Fuel Composition Sensor Circuit Low Input
P0179 Fuel Composition Sensor Circuit High Input

P0180 Fuel Temperature Sensor A Circuit
P0181 Fuel Temperature Sensor A Circuit Range/Performance
P0182 Fuel Temperature Sensor A Circuit Low Input
P0183 Fuel Temperature Sensor A Circuit High Input
P0184 Fuel Temperature Sensor A Circuit Intermittent
P0185 Fuel Temperature Sensor B Circuit
P0186 Fuel Temperature Sensor B Circuit Range/Performance
P0187 Fuel Temperature Sensor B Circuit Low Input
P0188 Fuel Temperature Sensor B Circuit High Input
P0189 Fuel Temperature Sensor B Circuit Intermittent

P0190 Fuel Rail Pressure Sensor Circuit
P0191 Fuel Rail Pressure Sensor Circuit Range/Performance
P0192 Fuel Rail Pressure Sensor Circuit Low In put
P0193 Fuel Rail Pressure Sensor Circuit High Input
P0194 Fuel Rail Pressure Sensor Circuit Intermittent

P0195 Engine Oil Temperature Sensor
P0196 Engine Oil Temperature Sensor Range/Performance
P0197 Engine Oil Temperature Sensor Low
P0198 Engine Oil Temperature Sensor High
P0199 Engine Oil Temperature Sensor Intermittent

A6.3-P02XX Fuel and Air Metering

P0200 Injector Circuit
P0201 Injector Circuit - Cylinder 1
P0202 Injector Circuit - Cylinder 2
P0203 Injector Circuit - Cylinder 3
P0204 Injector Circuit - Cylinder 4

P0215 Engine Shutoff Solenoid
P0216 Injector/Injection Timing Control Circuit
P0217 Engine Coolant Over Temperature Condition

P0218 Transmission Fluid Over Temperature Condition
P0219 Engine Over Speed Condition

P0220 Throttle/Pedal Position Sensor/Switch B Circuit
P0221 Throttle/Pedal Position Sensor/Switch B Circuit Range/Performance
P0222 Throttle/Pedal Position Sensor/Switch B Circuit Low Input
P0223 Throttle/Pedal Position Sensor/Switch B Circuit High Input
P0224 Throttle/Pedal Position Sensor/Switch B Circuit Intermittent
P0225 Throttle/Pedal Position Sensor/Switch C Circuit
P0226 Throttle/Pedal Position Sensor/Switch C Circuit Range/Performance
P0227 Throttle/Pedal Position Sensor/Switch C Circuit Low Input
P0228 Throttle/Pedal Position Sensor/Switch C Circuit High Input
P0229 Throttle/Pedal Position Sensor/Switch C Circuit Intermittent

P0230 Fuel Pump Primary Circuit
P0231 Fuel Pump Secondary Circuit Low
P0232 Fuel Pump Secondary Circuit High
P0233 Fuel Pump Secondary Circuit Intermittent

P0234 Turbo/Super Charger Over-boost Condition
P0235 Turbo/Super Charger Boost Sensor A Circuit
P0236 Turbo/Super Charger Boost Sensor A Circuit Range/Performance
P0237 Turbo/Super Charger Boost Sensor A Circuit Low
P0238 Turbo/Super Charger Boost Sensor A Circuit High
P0239 Turbo/Super Charger Boost Sensor B Circuit

P0243 Turbo/Super Charger Wastegate Solenoid A
P0244 Turbo/Super Charger Wastegate Solenoid A Range/Performance
P0245 Turbo/Super Charger Wastegate Solenoid A Low
P0246 Turbo/Super Charger Wastegate Solenoid A High

P0251 Injection Pump Fuel Metering Control A (Cam/rotor/Injector)
P0252 Injection Pump Fuel Metering Control A Range/Performance (C/R/I)
P0253 Injection Pump Fuel Metering Control A Low (Cam/Rotor/Injector)
P0254 Injection Pump Fuel Metering Control A High (Cam/Rotor/Injector)
P0255 Injection Pump Fuel Metering Control A Intermit. (Cam/Rotor/Injector)

P0261 Cylinder 1 Injector Circuit Low
P0262 Cylinder 1 Injector Circuit High
P0263 Cylinder 1 Contribution/Balance
P0264 Cylinder 2 Injector Circuit Low
P0265 Cylinder 2 Injector Circuit High
P0266 Cylinder 2 Contribution/Balance
P0267 Cylinder 3 Injector Circuit Low
P0268 Cylinder 3 Injector Circuit High
P0269 Cylinder 4 Contribution/Balance
P0270 Cylinder 4 Injector Circuit Low
P0271 Cylinder 4 Injector Circuit High
P0272 Cylinder 4 Contribution/Balance
P0298 Engine Oil Over Temperature

A6.4-P03XX Ignition and Trigger Systems and Knock Sensor

P0300	Random/Multiple Cylinder Misfire Detected	
P0301	Cylinder 1 Misfire Detected	
P0302	Cylinder 2 Misfire Detected	
P0303	Cylinder 3 Misfire Detected	
P0304	Cylinder 4 Misfire Detected	
P0313	Misfire Detected with Low Fuel	
P0314	Single Cylinder Misfire (Cylinder not Specified)	
P0320	Ignition/Distributor Engine Speed Input Circuit	
P0321	Ignition/Distributor Engine Speed Input Circuit Range/Performance	
P0322	Ignition/Distributor Engine Speed Input Circuit No Signal	
P0323	Ignition/Distributor Engine Speed Input Circuit Intermittent	
P0324	Knock Control System Error	
P0325	Knock Sensor 1 Circuit	(Bank 1 or Single Sensor)
P0326	Knock Sensor 1 Circuit Range/Perf.	(Bank 1 or Single Sensor)
P0327	Knock Sensor 1 Circuit Low Input	(Bank 1 or Single Sensor)
P0328	Knock Sensor 1 Circuit High Input	(Bank 1 or Single Sensor)
P0329	Knock Sensor 1 Circuit Input Intermit.	(Bank 1 or Single Sensor)
P0335	Crankshaft Position Sensor A Circuit	
P0336	Crankshaft Position Sensor A Circuit Range/Performance	
P0337	Crankshaft Position Sensor A Circuit Low Input	
P0338	Crankshaft Position Sensor A Circuit High Input	
P0339	Crankshaft Position Sensor A Circuit Intermittent	
P0340	Camshaft Position Sensor A Circuit	(Bank 1 or Single Sensor)
P0341	Camshaft Position Sensor A Range	(Bank 1 or Single Sensor)
P0342	Camshaft Position Sensor A Low Input	(Bank 1 or Single Sensor)
P0343	Camshaft Position Sensor A High Input	(Bank 1 or Single Sensor)
P0344	Camshaft Position Sensor A Intermit.	(Bank 1 or Single Sensor)
P0350	Ignition Coil Primary/Secondary Circuit	
P0351	Ignition Coil A Primary/Secondary Circuit	
P0352	Ignition Coil B Primary/Secondary Circuit	
P0353	Ignition Coil C Primary/Secondary Circuit	
P0354	Ignition Coil D Primary/Secondary Circuit	
P0365	Camshaft Position Sensor B Circuit	(Bank 1)
P0366	Camshaft Position Sensor B Circuit Range/Perf.	(Bank 1)
P0367	Camshaft Position Sensor B Circuit Low Input	(Bank 1)
P0368	Camshaft Position Sensor B Circuit High Input	(Bank 1)
P0369	Camshaft Position Sensor B Circuit Intermittent	(Bank 1)
P0370	Timing Reference High Resolution Signal A	
P0371	Timing Reference High Resolution Signal A Too Many Pulses	
P0372	Timing Reference High Resolution Signal A Too Few Pulses	

P0373 Timing Reference High Resolution Signal A Intermittent/Erratic Pulses
P0374 Timing Reference High Resolution Signal A No Pulse
P0375 Timing Reference High Resolution Signal B
P0376 Timing Reference High Resolution Signal B Too Many Pulses
P0377 Timing Reference High Resolution Signal B Too Few Pulses
P0378 Timing Reference High Resolution Signal B Intermittent/Erratic Pulses
P0379 Timing Reference High Resolution Signal B No Pulses

A6.5-P04XX Auxiliary Emission Controls

P0400 Exhaust Gas Recirculation Flow
P0401 Exhaust Gas Recirculation Flow Insufficient Detected
P0402 Exhaust Gas Recirculation Flow Excessive Detected
P0403 Exhaust Gas Recirculation Control Circuit
P0404 Exhaust Gas Recirculation Control Circuit Range/Performance
P0405 Exhaust Gas Recirculation Sensor A Circuit Low
P0406 Exhaust Gas Recirculation Sensor A Circuit High
P0407 Exhaust Gas Recirculation Sensor B Circuit Low
P0408 Exhaust Gas Recirculation Sensor B Circuit High
P0409 Exhaust Gas Recirculation Sensor A Circuit

P0410 Secondary Air Injection System
P0411 Secondary Air Injection System Incorrect Flow Detected
P0412 Secondary Air Injection System Switching Valve A Circuit
P0413 Secondary Air Injection System Switching Valve A Circuit Open
P0414 Secondary Air Injection System Switching Valve A Circuit Shorted
P0415 Secondary Air Injection System Switching Valve B Circuit
P0416 Secondary Air Injection System Switching Valve B Circuit Open
P0417 Secondary Air Injection System Switching Valve B Circuit Shorted
P0416 Secondary Air Injection System Relay A Circuit
P0419 Secondary Air injection System Relay B Circuit

P0420 Catalyst System Efficiency Below Threshold (Bank 1)
P0421 Warm Up Catalyst Efficiency Below Threshold (Bank 1)
P0422 Main Catalyst Efficiency Below Threshold (Bank 1)
P0423 Heated Catalyst Efficiency Below Threshold (Bank 1)
P0424 Heated Catalyst Temperature Below Threshold (Bank 1)
P0425 Catalyst Temperature Sensor (Bank 1)
P0426 Catalyst Temperature Sensor Range/Perf. (Bank 1)
P0427 Catalyst Temperature Sensor Low Input (Bank 1)
P0428 Catalyst Temperature Sensor High Input (Bank 1)
P0429 Catalyst Heater Control Circuit (Bank 1)

P0440 Evaporative Emission Control System
P0441 Evaporative Emission Control System Incorrect Purge Flow
P0442 Evaporative Emission Control System Leak Detected (small leak)
P0443 Evaporative Emission Control System Purge Control Valve Circuit

P0444 Evaporative Emission Control System Purge Control Valve Circuit Open
P0445 Evaporative Emission Control System Purge Control Valve Shorted
P0446 Evaporative Emission Control System Vent Control Circuit
P0447 Evaporative Emission Control System Vent Control Circuit Open
P0448 Evaporative Emission Control System Vent Control Circuit Shorted
P0449 Evaporative Emission Control System Vent Valve/Solenoid Circuit
P0450 Evaporative Emission Control System Pressure Sensor
P0451 Evaporative Emission Control System Pressure Sensor Range/Perf.
P0452 Evaporative Emission Control System Pressure Sensor Low Input
P0453 Evaporative Emission Control System Pressure Sensor High input
P0454 Evaporative Emission Control System Pressure Sensor Intermittent
P0455 Evaporative Emission Control System Leak Detected (gross leak)
P0456 Evaporative Emission Control System Leak Detected (very small leak)
P0457 Evaporative Emission Control System Leak Detected (fuel cap loose/off)

P0460 Fuel Level Sensor Circuit
P0461 Fuel Level Sensor Circuit Range/Performance
P0462 Fuel Level Sensor Circuit Low Input
P0463 Fuel Level Sensor Circuit High Input
P0464 Fuel Level Sensor Circuit Intermittent

P0465 EVAP Purge Flow Sensor Circuit
P0466 EVAP Purge Flow Sensor Circuit Range/Performance
P0467 EVAP Purge Flow Sensor Circuit Low Input
P0468 EVAP Purge Flow Sensor Circuit High Input
P0469 EVAP Purge Flow Sensor Circuit Intermittent

P0470 Exhaust Pressure Sensor
P0471 Exhaust Pressure Sensor Range/Performance
P0472 Exhaust Pressure Sensor Low
P0473 Exhaust Pressure Sensor High
P0474 Exhaust Pressure Sensor Intermittent
P0475 Exhaust Pressure Control Valve
P0476 Exhaust Pressure Control Valve Range/Performance
P0477 Exhaust Pressure Control Valve Low
P0478 Exhaust Pressure Control Valve High
P0479 Exhaust Pressure Control Valve Intermittent

P0480 Cooling Fan 1 Control Circuit
P0481 Cooling Fan 2 Control Circuit
P0482 Cooling Fan 3 Control Circuit
P0483 Cooling Fan Rationality Check
P0484 Cooling Fan Circuit Over Current
P0485 Cooling Fan Power/Ground Circuit
P0486 Exhaust Gas Recirculation Sensor B Circuit
P0487 Exhaust Gas Recirculation Throttle Position Control Circuit
P0488 Exhaust Gas Recirculation Throttle Position Control Range/Performance
P0491 Secondary Air Injection System (Bank 1)
P0492 Secondary Air Injection System (Bank 2)

A6.6-P05XX Speed, Idle & Auxiliary Inputs

P0500 Vehicle Speed Sensor
P0501 Vehicle Speed Sensor Range/Performance
P0502 Vehicle Speed Sensor Circuit Low Input
P0503 Vehicle Speed Sensor Intermittent/Erratic/High

P0505 Idle Control System
P0506 Idle Control System RPM Lower Than Expected
P0507 Idle Control System RPM Higher Than Expected
P0508 Idle Control System Circuit Low
P0509 Idle Control System Circuit High

P0510 Closed Throttle Position Switch
P0512 Starter Request Circuit
P0513 Incorrect Immobilizer Key

P0515 Battery Temperature Sensor Circuit
P0516 Battery Temperature Sensor Circuit Low
P0517 Battery Temperature Sensor Circuit High

P0520 Engine Oil Pressure Sensor/Switch Circuit
P0521 Engine Oil Pressure Sensor/Switch Range/Performance
P0522 Engine Oil Pressure Sensor/Switch Low Voltage
P0523 Engine Oil Pressure Sensor/Switch High Voltage
P0524 Engine Oil Pressure Too Low

P0530 A/C Refrigerant Pressure Sensor Circuit
P0531 A/C Refrigerant Pressure Sensor Circuit Range/Performance
P0532 A/C Refrigerant Pressure Sensor Circuit Low Input
P0533 A/C Refrigerant Pressure Sensor Circuit High Input
P0534 Air Conditioner Refrigerant Charge Loss

P0540 Intake Air Heater Circuit
P0541 Intake Air Heater Circuit Low
P0542 Intake Air Heater Circuit High

P0544 Exhaust Gas Temperature Sensor Circuit (Bank 1)
P0545 Exhaust Gas Temperature Sensor Circuit Low (Bank 1)
P0546 Exhaust Gas Temperature Sensor Circuit High (Bank 1)

P0550 Power Steering Pressure Sensor Circuit
P0551 Power Steering Pressure Sensor Circuit Range/Performance
P0552 Power Steering Pressure Sensor Circuit Low Input
P0553 Power Steering Pressure Sensor Circuit High Input
P0554 Power Steering Pressure Sensor Circuit Intermittent

P0560 System Voltage
P0561 System Voltage Unstable
P0562 System Voltage Low
P0563 System Voltage High

P0564 Cruise Control Multi-Function Input Signal
P0565 Cruise Control On Signal
P0566 Cruise Control Off Signal
P0567 Cruise Control Resume Signal
P0568 Cruise Control Set Signal
P0569 Cruise Control Coast Signal
P0570 Cruise Control Accel Signal
P0571 Cruise Control/Brake Switch A Circuit
P0572 Cruise Control/Brake Switch A Circuit Low
P0573 Cruise Control/Brake Switch A Circuit High
P0574 Cruise Control System - Vehicle Speed Too High
P0575 Cruise Control Input Circuit
P0576 Cruise Control Input Circuit Low
P0577 Cruise Control input Circuit High
P0578 Reserved for Cruise Control Codes
P0579 Reserved for Cruise Control Codes
P0579 Reserved for Cruise Control Codes
P0580 Reserved for Cruise Control Codes

A6.7-P06XX ECU and Auxiliary Inputs

P0600 Serial Communication Link
P0601 Internal Control Module Memory Check Sum Error
P0602 Control Module Programming Error
P0603 Internal Control Module Keep Alive Memory (KAM) Error
P0604 Internal Control Module Random Access Memory (RAM) Error
P0605 Internal Control Module Read Only Memory (ROM) Error
P0606 ECM/PCM Processor
P0607 Control Module Performance
P0608 Control Module VSS Output A
P0609 Control Module VSS Output B
P0610 Control Module Vehicle Options Error
P0615 Starter Relay Circuit
P0616 Starter Relay Circuit Low
P0617 Starter Relay Circuit High
P0618 Alternative Fuel Control Module KAM Error
P0619 Alternative Fuel Control Module RAM/ROM Error
P0620 Generator Control Circuit
P0621 Generator Lamp “L” Terminal Control Circuit
P0622 Generator Field “F” Terminal Control Circuit
P0623 Generator Lamp Control Circuit

P0624	Fuel Cap Lamp Control Circuit	
P0630	VIN Not Programmed or Mismatch - ECM/PCM	
P0631	VIN Not Programmed or Mismatch - TCM	
P0635	Power Steering Control Circuit	
P0836	Power Steering Control Circuit Low	
P0637	Power Steering Control Circuit High	
P0638	Throttle Actuator Control Range/Performance	(Bank 1)
P0639	Throttle Actuator Control Range/Performance	(Bank 2)
P0640	Intake Air Heater Control Circuit	
P0645	A/C Clutch Relay Control Circuit	
P0646	A/C Clutch Relay Control Circuit Low	
P0647	A/C Clutch Relay Control Circuit High	
P0648	Immobilizer Lamp Control Circuit	
P0649	Speed Control Lamp Control Circuit	
P0650	Malfunction Indicator Lamp (ML) Control Circuit	
P0654	Engine RPM Output Circuit	
P0655	Engine Hot Lamp Output Control Circuit	
P0656	Fuel Level Output Circuit	
P0660	Intake Manifold Tuning Valve Control Circuit	(Bank 1)
P0661	Intake Manifold Tuning Valve Control Circuit Low	(Bank 1)
P0662	Intake Manifold Tuning Valve Control Circuit High	(Bank 1)

A6.8-P08XX Manual Transmission

P0801	Reverse Inhibit Control Circuit
P0803	1-4 Upshift (Skip Shift) Solenoid Control Circuit
P0804	1-4 Upshift (Skip Shift) Lamp Control Circuit
P0805	Clutch Position Sensor Circuit
P0806	Clutch Position Sensor Circuit Range/Performance
P0807	Clutch Position Sensor Circuit Low
P0808	Clutch Position Sensor Circuit High
P0809	Clutch Position Sensor Circuit Intermittent
P0810	Clutch Position Control Error
P0811	Excessive Clutch Slippage
P0812	Reverse Input Circuit
P0813	Reverse Output Circuit
P0814	Transmission Range Display Circuit
P0815	Upshift Switch Circuit
P0816	Downshift Switch Circuit
P0817	Starter Disable Circuit
P0818	Driveline Disconnect Switch Input Circuit
P0820	Gear Lever X-Y Position Sensor Circuit
P0821	Gear Lever X Position Circuit
P0822	Gear Lever Y Position Circuit

P0823 Gear Lever X Position Circuit Intermittent
P0824 Gear Lever Y Position Circuit Intermittent
P0825 Gear Lever Push-Pull Switch (Shift Anticipate)

P0830 Clutch Pedal Switch A Circuit
P0831 Clutch Pedal Switch A Circuit Low
P0832 Clutch Pedal Switch A Circuit High
P0833 Clutch Pedal Switch B Circuit
P0834 Clutch Pedal Switch B Circuit Low
P0835 Clutch Pedal Switch B Circuit High

P0836 Four Wheel Drive (4WD) Switch Circuit
P0837 Four Wheel Drive (4WD) Switch Circuit Range/Performance
P0838 Four Wheel Drive (4WD) Switch Circuit Low
P0839 Four Wheel Drive (4WD) Switch Circuit High

P0840 Transmission Fluid Pressure Sensor/Switch A Circuit
P0841 Transmission Fluid Pressure Sensor/Switch A Circuit Range/Performance
P0842 Transmission Fluid Pressure Sensor/Switch A Circuit Low
P0843 Transmission Fluid Pressure Sensor/Switch A Circuit High
P0844 Transmission Fluid Pressure Sensor/Switch A Circuit Intermittent
P0845 Transmission Fluid Pressure Sensor/Switch B Circuit
P0846 Transmission Fluid Pressure Sensor/Switch B Circuit Range/Performance
P0847 Transmission Fluid Pressure Sensor/Switch B Circuit Low
P0848 Transmission Fluid Pressure Sensor/Switch B Circuit High
P0849 Transmission Fluid Pressure Sensor/Switch B Circuit Intermittent