MERLINS
EcuFLASH
EVO 7-8-9 TUNING GUIDE

MITSUBISHI EVO 7-8-9 TUNING

REV: 1.7a

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Cover art from **Dannievo** from Rrykjavik Icelad and EvoM.

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. 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.

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**.

Acknowledgment of these contributors writings are included here, and are as follows:

INJECTOR TUNING, so many people contributed here, but significant entries were made by **nj1266, rarorlab, MalibuJack, mrfred, tephra, jcsbanks** and **JohnBradly**. All I did was make a stab of stitching it all together.

MIVEC TUNING, started out as part of **nj1266**'s write-up, but progressively evolved with my own findings and knowledge from South Australian tuner **Steve Knight**. In any case, at the heart of it are the contributions of **English_Racing** and **mrfred**.

KNOCK TUNING, is what I understand of the disassembly of the knock routines by **jcsbanks,** along with the valuable contributions the EvoM community.

I have lost track of exactly what and where, but scattered throughout the guide are snippets from **nj12666**'s write-up "How to Tune an Evo". This was the first thing I read on the forum when I first started seriously thinking about buying an EVO. After reading this discussion, my decision to get the EVO was set in stone. It was all possible, do-able and definitely fun. Thanks **nj1266**.

LOGGING BOOST, is almost pure **mrfred**. It is impossible to over-state this mans contribution to the EVO community.

So, to anyone reading this, anytime you see something posted by the guys in blue that I have mentioned, pay close attention, they are worth diamonds. Tuning the EVO is fun, but it will take time to get all bases covered. Good luck to us!

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 meaning 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 EVO 1,2,3. Later EVOs had both a cam and a crankshaft sensor.
DIY	Do It Yourself.
EBC	Electronic Boost Controller.
ECU	Engine Control Unit.
EDM	European Domestic Market
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.
IM	Inlet Manifold.
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.
MIAT	Manifold Inlet Air Temp and/or the MIAT sensor.
MTBT	Minimum Timing for Best Torque.
NA	Normally Aspirated, an engine without turbo or supercharger.
NBO2	Narrow Band Oxygen Sensor.
PITA	Pain In The Arse. Says it all really.
PCV	Positive Crankcase Ventilation. A one-way valve opens on vacuum.
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

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. 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.

5. **EvoScan v2.7:** This is a scanning/logging application, only the latest version works properly with the ACD+AYC ECU and requires the OpenPort2 cable. Earlier versions work fine with the older 1.3U cable which they still sell.
Available from: http://www.limitless.co.nz/

6. **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**.

There are some other items you can put to good use to enhance your tuning, these include:

7. **Mitsulogger:** This is a brilliant free logging application with many nice features from its author **MalibuJack**.
Available from: http://www.aktivematrix.com

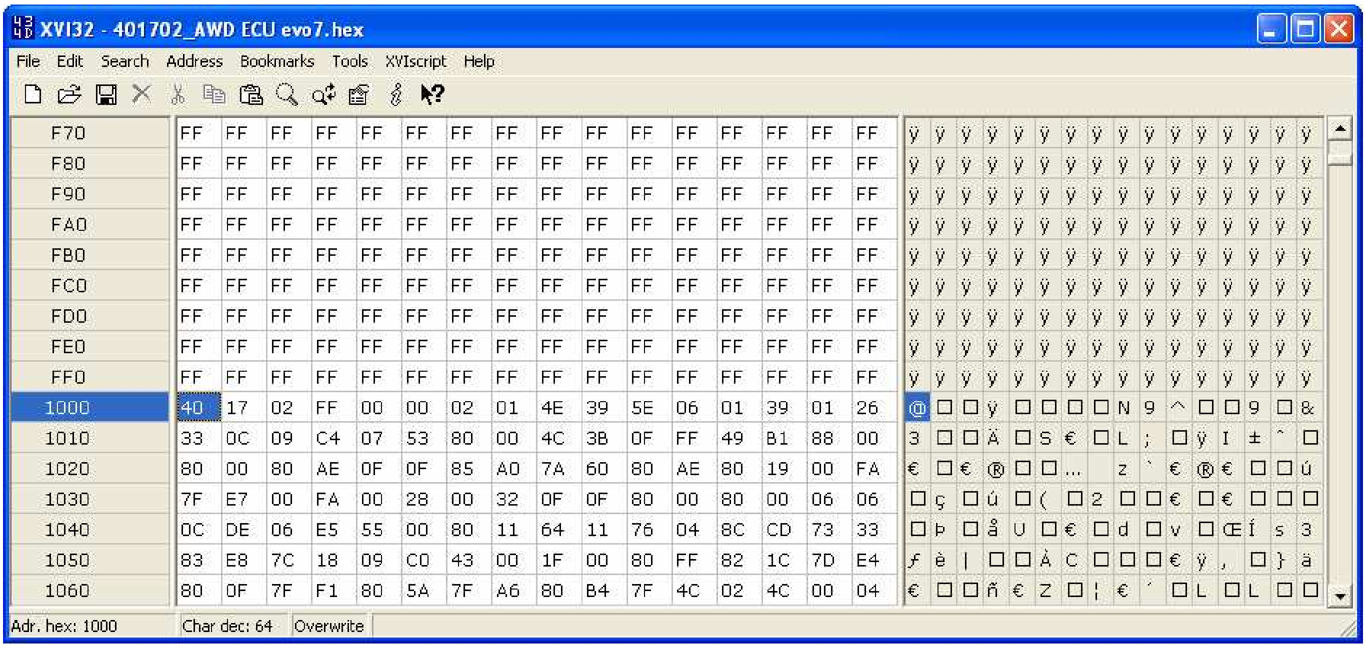
8. **1.3U OBDII Cable:** This cable can be used with older versions of EcuFLASH and EvoScan. Available from: http://www.limitless.co.nz/

9. **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

10. **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



```
F70   FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF   ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ
F80   FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF   ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ
F90   FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF   ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ
FA0   FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF   ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ
FB0   FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF   ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ
FC0   FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF   ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ
FD0   FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF   ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ
FE0   FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF   ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ
FF0   FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF   ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ ÿ
1000  40 17 02 FF 00 00 02 01 4E 39 5E 06 01 39 01 26   @ □ □ ÿ □ □ □ □ N 9 ^ □ □ 9 □ &
1010  33 0C 09 C4 07 53 80 00 4C 3B 0F FF 49 B1 88 00   3 □ □ Ä □ S € □ L ; □ ÿ I ± ˆ □
1020  80 00 80 AE 0F 0F 85 A0 7A 60 80 AE 80 19 00 FA   € □ € ® □ □ …   z ` € ® € □ □ ú
1030  7F E7 00 FA 00 28 00 32 0F 0F 80 00 80 00 06 06   □ ç □ ú □ ( □ 2 □ □ € □ € □ □ □
1040  0C DE 06 E5 55 00 80 11 64 11 76 04 8C CD 73 33   □ þ □ å U □ € □ d □ v □ Œ Í s 3
1050  83 E8 7C 18 09 C0 43 00 1F 00 80 FF 82 1C 7D E4   ƒ è | □ □ À C □ □ □ € ÿ , □ } ä
1060  80 0F 7F F1 80 5A 7F A6 80 B4 7F 4C 02 4C 00 04   € □ □ ñ € Z □ ¦ € ´ □ L □ L □ □
Adr. hex: 1000   Char dec: 64   Overwrite
```

11. **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.

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.

In particular, read the section on READING IMMOBILIZER CODE.

1.5-PROGRAM INSTALLATION AND 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 folder of your choosing as per normal.

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 Evo. These files will be located at:
C:\Program Files\Open ECU\EcuFlash\rommetadata\mitsubishi\evo

Right click on the selected file and select **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 been uncovered. 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 an 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 usually want upper case.

```
<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 it is called within.

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.

Note 1: toexpr="x/10" is a sample formula which converts the raw ROM data (decimal) value into suitable 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.

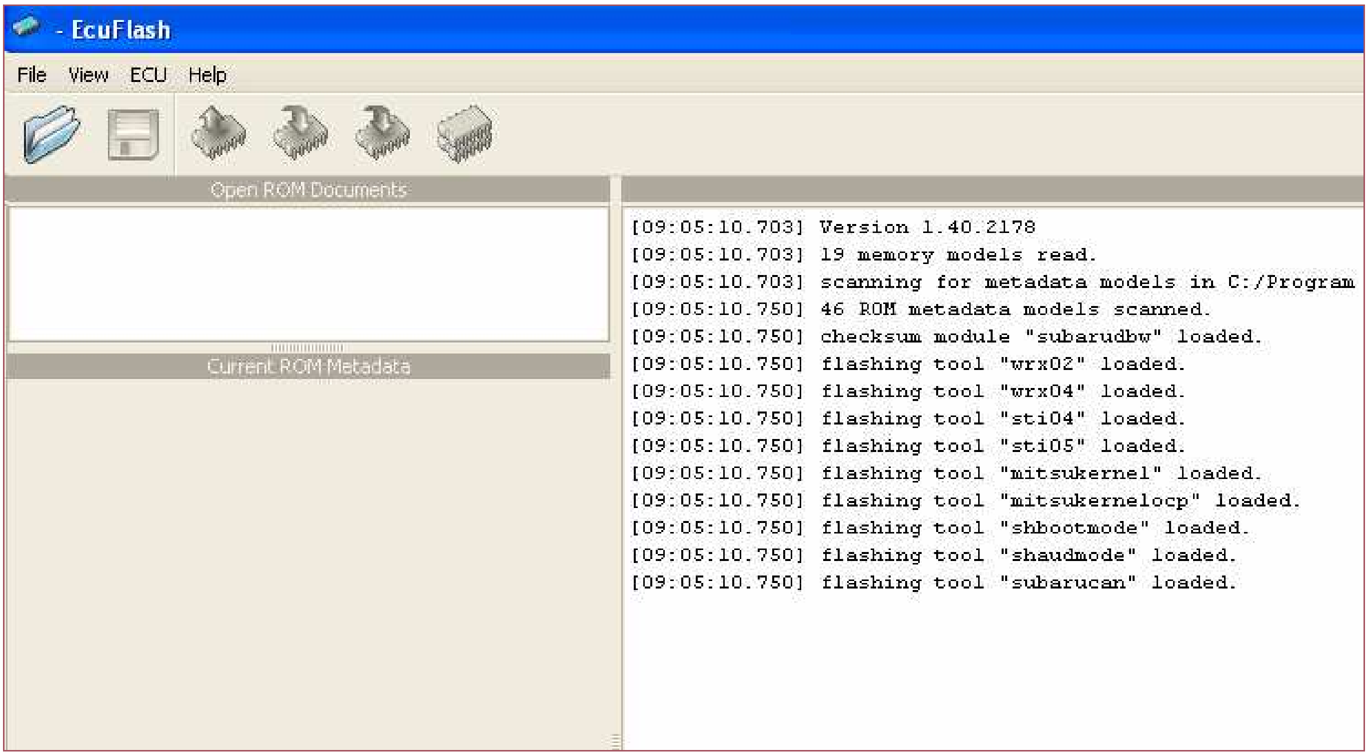
Note 3: format="%.1f" will give displayed values to 1 decimal place. %.0f will have no decimal places and will round off the displayed value.

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



```
[09:05:10.703] Version 1.40.2178
[09:05:10.703] 19 memory models read.
[09:05:10.703] scanning for metadata models in C:/Program
[09:05:10.750] 46 ROM metadata models scanned.
[09:05:10.750] checksum module "subarudbw" loaded.
[09:05:10.750] flashing tool "wrx02" loaded.
[09:05:10.750] flashing tool "wrx04" loaded.
[09:05:10.750] flashing tool "sti04" loaded.
[09:05:10.750] flashing tool "sti05" loaded.
[09:05:10.750] flashing tool "mitsukernel" loaded.
[09:05:10.750] flashing tool "mitsukernelocp" loaded.
[09:05:10.750] flashing tool "shbootmode" loaded.
[09:05:10.750] flashing tool "shaudmode" loaded.
[09:05:10.750] flashing tool "subarucan" loaded.
```

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

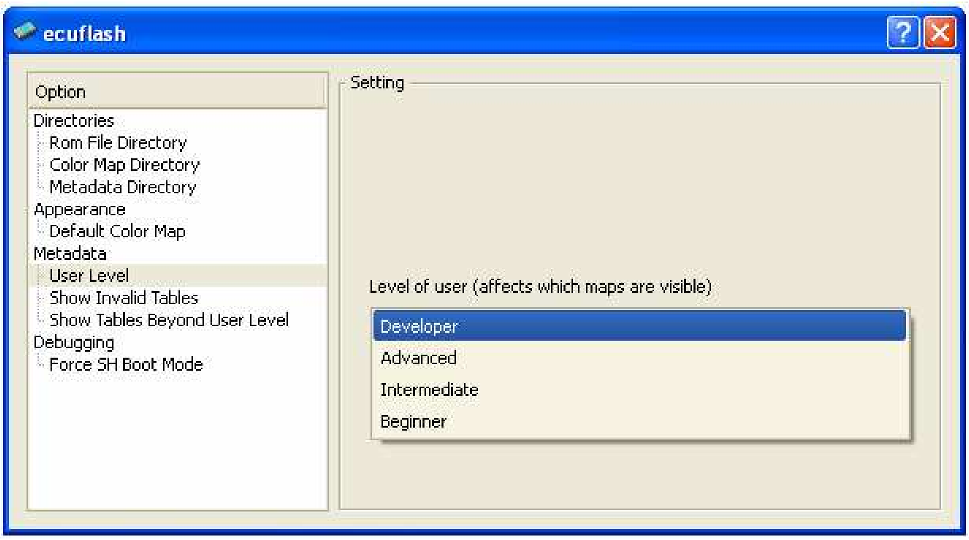
1.8-SETTING THE USER LEVEL & DIRECTORY

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.

Note: Do not nest or save old or backup xml or hex/bin files in the OpenEcu directory, As the EcuFLASH application 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.

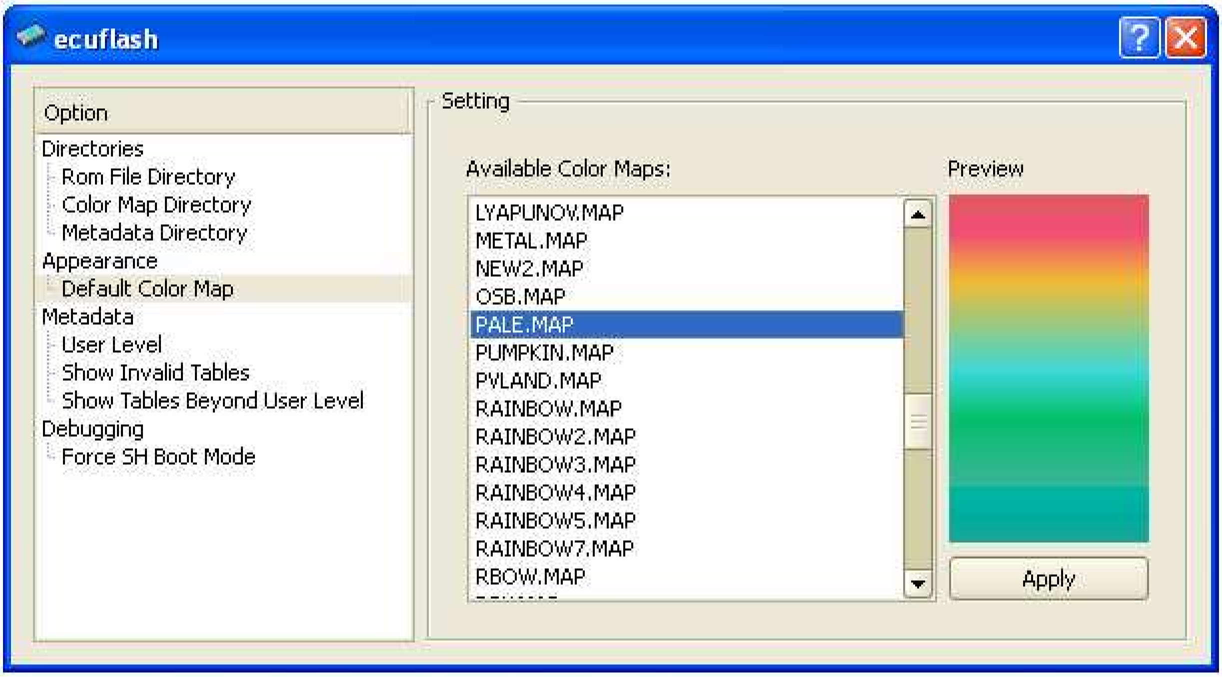
Scroll through the selections and select whatever suites, as some colour styles display better than others or allow easier data viewing. Some of the more readable styles with good graduation are:

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

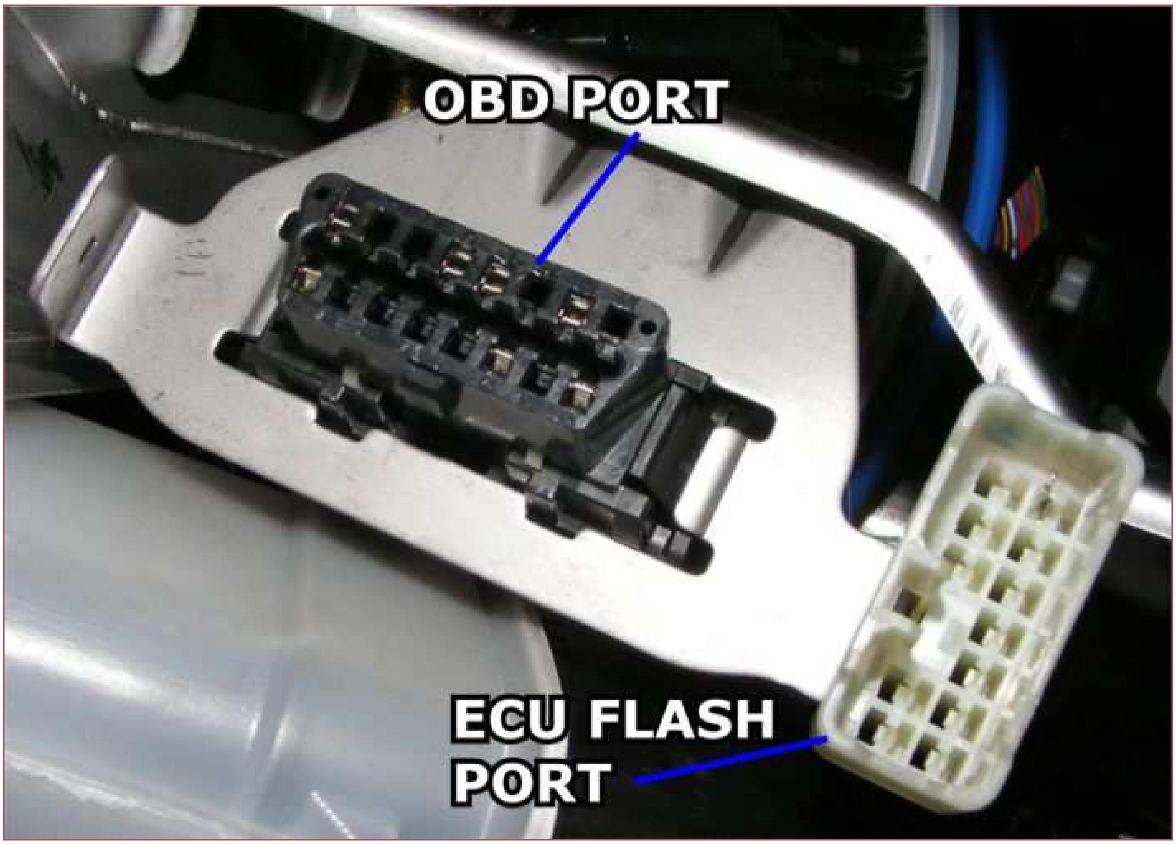


The colour maps can be tweaked to your own tastes. Open the .MAP file to be edited with NOTEPAD. The data is organized in columns, by the three primary colours: red, yellow, blue. The higher the number the percentage that colour.

1.10-CONNECTING to the ECU

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 connectors. Proceed to the Evo and connect the TACTRIX v1.3 cable black connector to the black OBD-II port and the white connector to the white re-flash port. The connectors are behind the dash facia, drivers side, adjacent to the centre tunnel. Just feel with your hand and plug the connectors into their receptacles. There is a latch on the white connector, requiring depression on removal. Pix from **Biggles** on MLR.

Figure 6: OBD-II PORT & ECU REFLASH 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.

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 would 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.

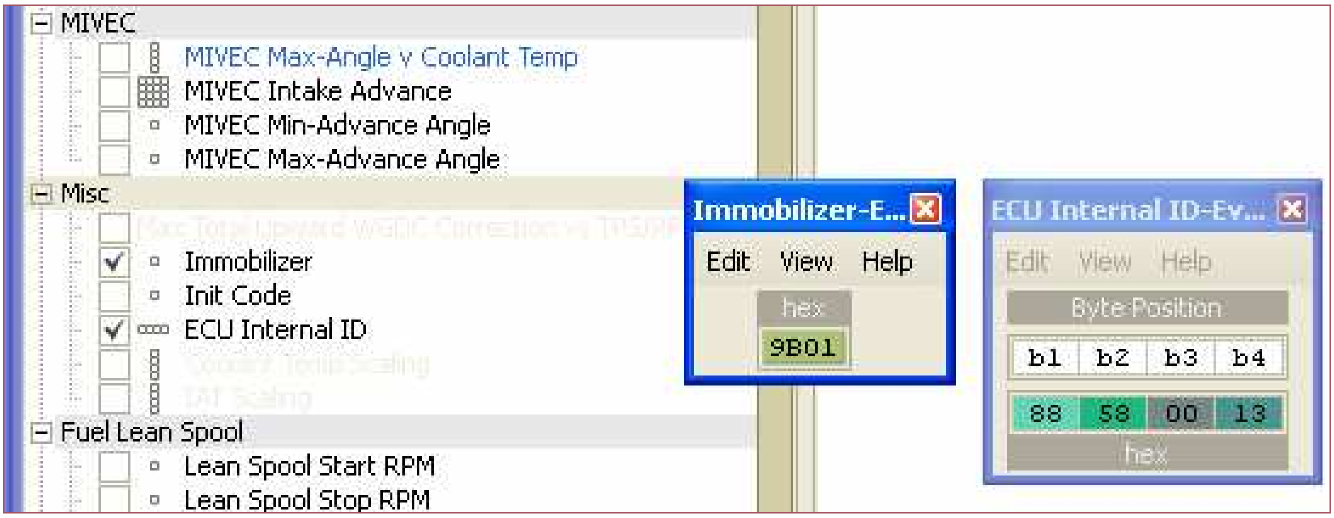
EcuFLASH will now proceed to download the ROM image from your ECU. When the read operation is completed, EcuFLASH will attempt to access the ROM, by reading the ROM identity code. If there is a matching XML definition file available in the selected \mettadata\mitsubishi\evo directory, EcuFLASH will open the XML definition file and the ROMs contents can be examined with the menu bar. Two data items need to be examined and written down before proceeding further.

1.12-READING THE IMMOBILIZER CODE

The EVO 7-8-9 ECU contains a code in ROM that is linked to the ignition key. This code should be read and stored away safely before any changes to the ROM are performed. A program from another ECU wont work in your ECU unless the Immobilizer code is set to match your vehicle and key. The Immobilizer code is only accessible when the User Level is set to Developer, Advanced or Intermediate level. Setting the User Level to Developer will allow access to all the variables defined in the .XML definition file associated with your ECU.

When ready, select **Immobilizer** from the Misc functions section. Record the four hex numerals, this is the code for your vehicle. This code is unique to your vehicle and is linked to your car-key remote. Lose this and you are screwed!

Figure 7: EcuFLASH – IMMOBILIZER and ECU CODEs



Immobilizer: 9B01

b1	b2	b3	b4
88	58	00	13

To get other maps to work in your EVO, this field will need to be edited with your code. Note that an immobilizer code of FFFF is a command to disable the immobilizer function.

Also shown is the ECU Internal ID field, which should not be altered. The screen-shot was taken with V1.38 of EcuFLASH. If un-familiar with your ROM identity, select **ROM Info**, and record the **Internal ID** number. This is the code or model number for the ROM for your type of EVO. For the EVO 5-9, this is an eight digit number. For example, the ID for my 2006 AUDM9 is 88580013. 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. Good advice on this topic can be found on the web from **rarorlab, mrfred, tephra, logic, phenm, fostytou, jcsbanks, cossie1** and **grayw**. Open the tables and maps in the ROM and have a look around, but do not change or modify them until you understand what they mean and what you need to change.

1.13-EDITING FUNCTIONS and 3D GRAPH VIEWING

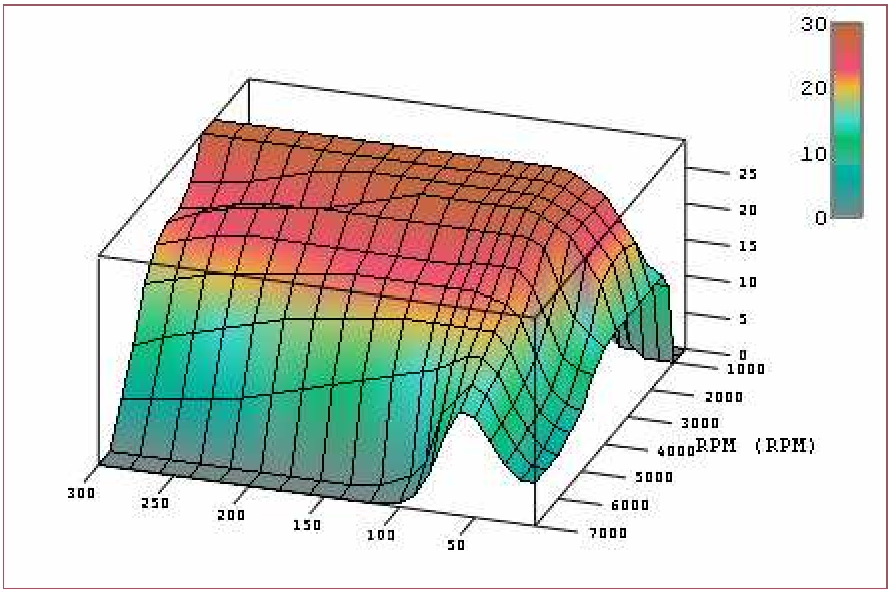
Select an item that you wish to view for editing.
Select Edit, the available editing functions are displayed and are as follows:

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



1.14-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 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 SECTION 2 and see just what can be tuned. Remember; make small incremental and smooth changes to the tables.

SECTION 2 – FUEL TUNING

2.01-INTRODUCTION TO EVO 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 Evo'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 air-flow meter utilizes the Karman-Vortex principal to measure the air-flow using ultra-sonic sound, which after processing outputs an alternating voltage (AC) proportional to the air-flow. The frequency of the MAF signal ranges from about 30Hz to 2600Hz, with very good resolution at low air-flow rates. This allows very precise AFR trimming at light engine loads.

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 Evo7, Evo8 and Evo9 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 Evo7, Evo8 or Evo9? The stock Evo HI-OCTANE fuel map clearly shows the Mitsubishi engineers intentions and what the 4G63T 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.

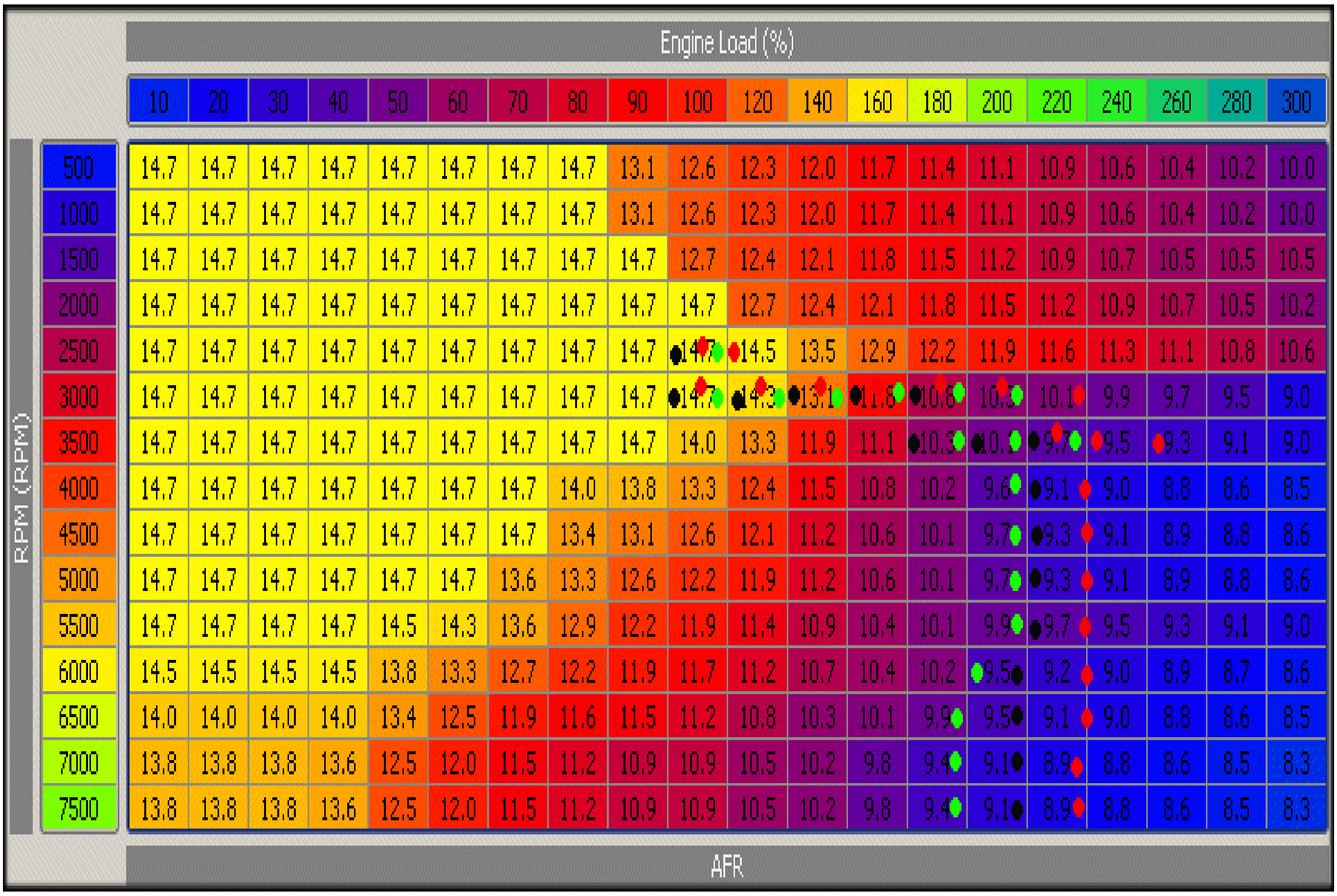
Below is a stock Evo9 fuel map with interposed coloured markings, showing which map cells are tracked under boost for three different equipment configurations:

1. Green dots for a stock Evo9.
2. Black dots for an Evo9 with TBE.
3. Red dots for an Evo9 with TBE and boost set to 22psi peak, tapering to 19psi at 7500rpm.redline.

You can also clearly see the lean spike extending out from the 14.7 closed loop section at 2500rpm on the Evo9 (2000rpm on the Evo7 and Evo8). This is where the turbo starts to spool-up and the leaner fueling promotes faster spool times and more power.

Note that a stock Evo hits lower load cells (180 to 200) than a TBE Evo (220 to 200) and a TBE Evo hits lower load cells than a TBE Evo with boost increase (260 to 230).

Figure 9: FUEL TUNING - WOT v LOAD & RPM, Evo9



	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300
500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.1	12.6	12.3	12.0	11.7	11.4	11.1	10.9	10.6	10.4	10.2	10.0
1000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.1	12.6	12.3	12.0	11.7	11.4	11.1	10.9	10.6	10.4	10.2	10.0
1500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	12.7	12.4	12.1	11.8	11.5	11.2	10.9	10.7	10.5	10.5	10.5
2000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	12.7	12.4	12.1	11.8	11.5	11.2	10.9	10.7	10.5	10.2
2500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.5	13.5	12.9	12.2	11.9	11.6	11.3	11.1	10.8	10.6
3000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.3	13.1	11.6	10.6	10.3	10.1	9.9	9.7	9.5	9.0
3500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.0	13.3	11.9	11.1	10.3	10.1	9.7	9.5	9.3	9.1	9.0
4000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.0	13.8	13.3	12.4	11.5	10.8	10.2	9.6	9.1	9.0	8.8	8.6	8.5
4500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.4	13.1	12.6	12.1	11.2	10.6	10.1	9.7	9.3	9.1	8.9	8.8	8.6
5000	14.7	14.7	14.7	14.7	14.7	14.7	13.6	13.3	12.6	12.2	11.9	11.2	10.6	10.1	9.7	9.3	9.1	8.9	8.8	8.6
5500	14.7	14.7	14.7	14.7	14.5	14.3	13.6	12.9	12.2	11.9	11.4	10.9	10.4	10.1	9.9	9.7	9.5	9.3	9.1	9.0
6000	14.5	14.5	14.5	14.5	13.8	13.3	12.7	12.2	11.9	11.7	11.2	10.7	10.4	10.2	9.5	9.2	9.0	8.9	8.7	8.6
6500	14.0	14.0	14.0	14.0	13.4	12.5	11.9	11.6	11.5	11.2	10.8	10.3	10.1	9.9	9.5	9.1	9.0	8.8	8.6	8.5
7000	13.8	13.8	13.8	13.6	12.5	12.0	11.5	11.2	10.9	10.9	10.5	10.2	9.8	9.4	9.1	8.9	8.8	8.6	8.5	8.3
7500	13.8	13.8	13.8	13.6	12.5	12.0	11.5	11.2	10.9	10.9	10.5	10.2	9.8	9.4	9.1	8.9	8.8	8.6	8.5	8.3

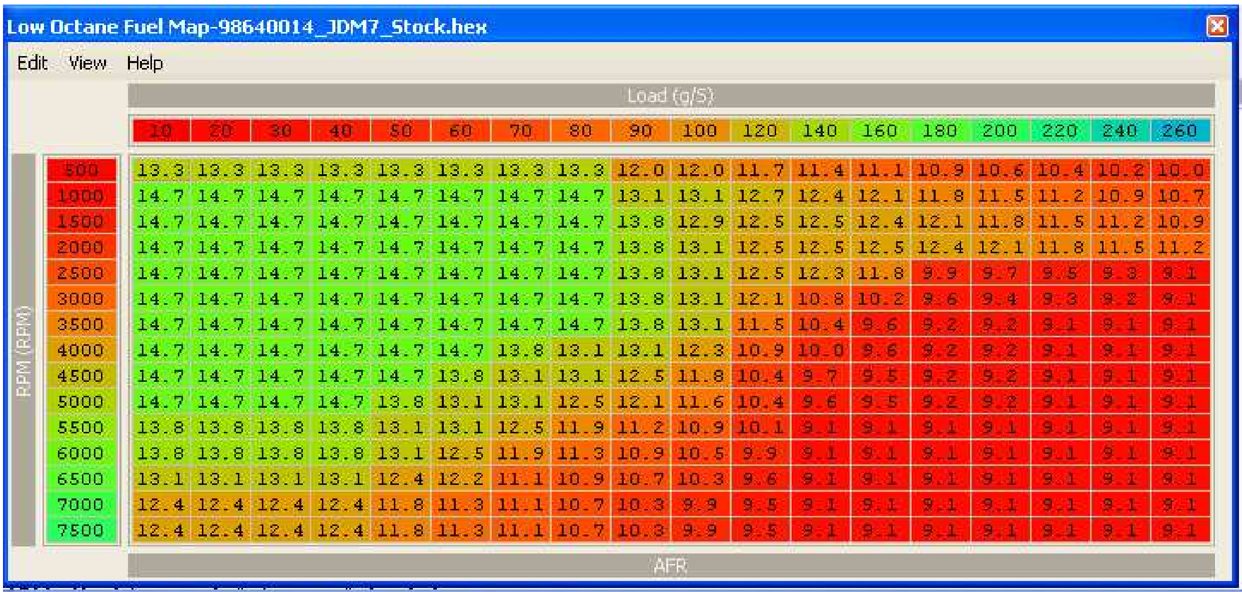
Setting your AFR depends to a large extent on the boost and timing that your car is running. I generally set the AFR at 12.5-12 during spool up, 11.7-11.5 during peak boost, and then slowly taper the AFR until it hits 11-10.8:1 by the 7500rpm redline point.

2.02-FUEL TUNING – STOCK LO-OCTANE FUEL MAP EVO7-8-9

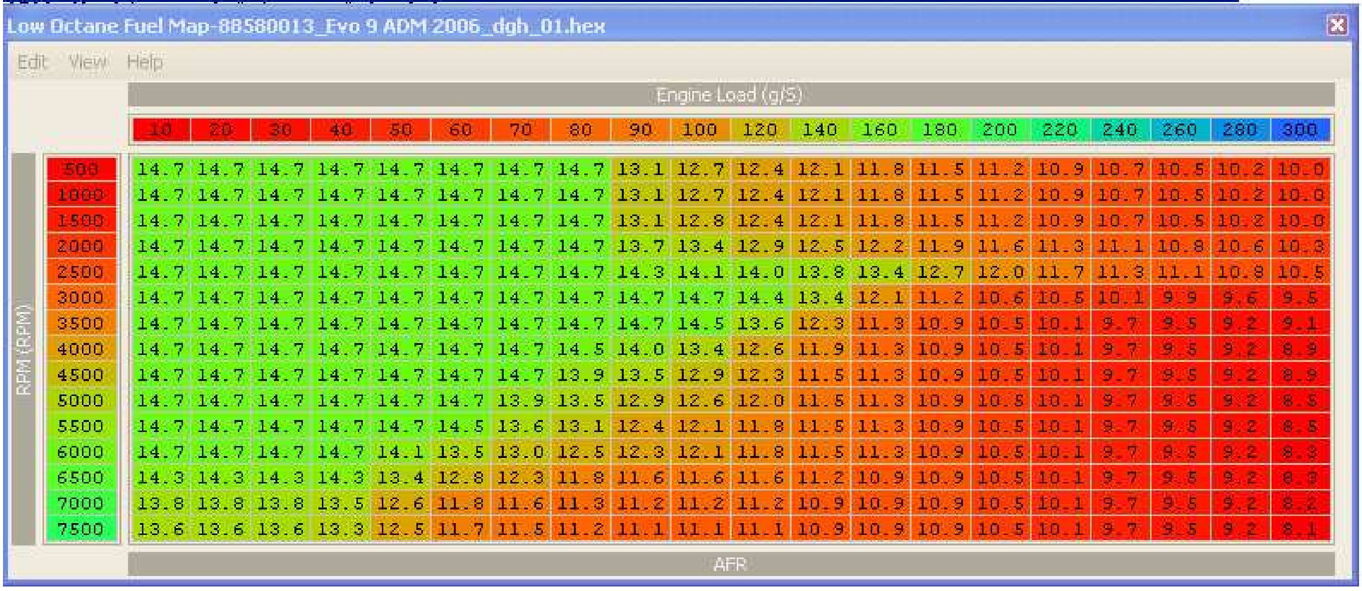
The LO-OCTANE fuel map should have similar values for idle and cruise, with progressively richer values as the engine comes on boost. The table scaling normally matches the HI OCTANE map, but does not have to be the same. The graphing function can be used with the fuel maps, this helps with spotting and smoothing any errant peaks and hollows.

The maps shown below are the stock LO-OCTANE fuel maps for Evo7 – 98640014, Evo8 – 93660005 (they are the same) and the Evo9 – 88580013. While there are strong similarities between them, the EVO9 has typically leaner values in the higher rpm area above 5500rpm.

Figure 10: FUEL TUNING - LO-OCTANE FUEL MAPS, EVO7-8 and EVO9



	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260
500	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	12.0	12.0	11.7	11.4	11.1	10.9	10.6	10.4	10.2	10.0
1000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.1	13.1	12.7	12.4	12.1	11.8	11.5	11.2	10.9	10.7
1500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.8	12.9	12.5	12.5	12.4	12.1	11.8	11.5	11.2	10.9
2000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.8	13.1	12.5	12.5	12.5	12.4	12.1	11.8	11.5	11.2
2500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.8	13.1	12.5	12.3	11.8	9.9	9.7	9.5	9.3	9.1
3000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.8	13.1	12.1	10.8	10.2	9.6	9.4	9.3	9.2	9.1
3500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.8	13.1	11.5	10.4	9.6	9.2	9.2	9.1	9.1	9.1
4000	14.7	14.7	14.7	14.7	14.7	14.7	13.8	13.1	13.1	12.3	10.9	10.0	9.6	9.2	9.2	9.1	9.1	9.1
4500	14.7	14.7	14.7	14.7	14.7	13.8	13.1	13.1	12.5	11.8	10.4	9.7	9.5	9.2	9.2	9.1	9.1	9.1
5000	14.7	14.7	14.7	14.7	13.8	13.1	13.1	12.5	12.1	11.6	10.4	9.6	9.5	9.2	9.2	9.1	9.1	9.1
5500	13.8	13.8	13.8	13.8	13.1	13.1	12.5	11.9	11.2	10.9	10.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1
6000	13.8	13.8	13.8	13.8	13.1	12.5	11.9	11.3	10.9	10.5	9.9	9.1	9.1	9.1	9.1	9.1	9.1	9.1
6500	13.1	13.1	13.1	13.1	12.4	12.2	11.1	10.9	10.7	10.3	9.6	9.1	9.1	9.1	9.1	9.1	9.1	9.1
7000	12.4	12.4	12.4	12.4	11.8	11.3	11.1	10.7	10.3	9.9	9.5	9.1	9.1	9.1	9.1	9.1	9.1	9.1
7500	12.4	12.4	12.4	12.4	11.8	11.3	11.1	10.7	10.3	9.9	9.5	9.1	9.1	9.1	9.1	9.1	9.1	9.1

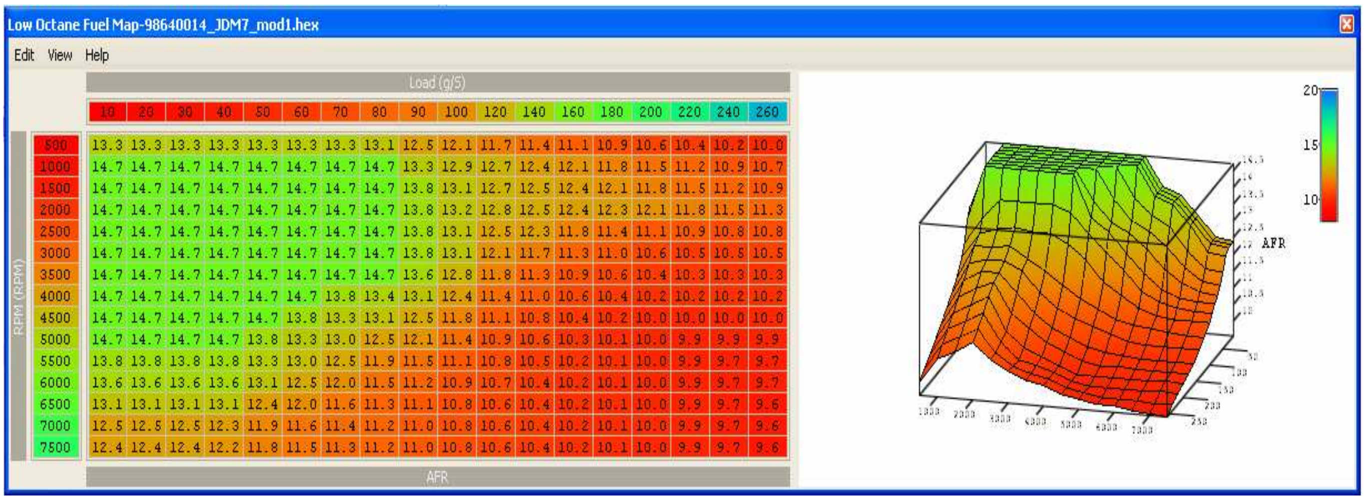


	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300
500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.1	12.7	12.4	12.1	11.8	11.5	11.2	10.9	10.7	10.5	10.2	10.0
1000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.1	12.7	12.4	12.1	11.8	11.5	11.2	10.9	10.7	10.5	10.2	10.0
1500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.1	12.8	12.4	12.1	11.8	11.5	11.2	10.9	10.7	10.5	10.2	10.0
2000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.7	13.4	12.9	12.5	12.2	11.9	11.6	11.3	11.1	10.8	10.6	10.3
2500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.3	14.1	14.0	13.8	13.4	12.7	12.0	11.7	11.3	11.1	10.8	10.5
3000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.4	13.4	12.1	11.2	10.6	10.5	10.1	9.9	9.6	9.5
3500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.5	13.6	12.3	11.3	10.9	10.5	10.1	9.7	9.5	9.2	9.1
4000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.5	14.0	13.4	12.6	11.9	11.3	10.9	10.5	10.1	9.7	9.5	9.2	8.9
4500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.9	13.5	12.9	12.3	11.5	11.3	10.9	10.5	10.1	9.7	9.5	9.2	8.9
5000	14.7	14.7	14.7	14.7	14.7	14.7	13.9	13.5	12.9	12.6	12.0	11.5	11.3	10.9	10.5	10.1	9.7	9.5	9.2	8.5
5500	14.7	14.7	14.7	14.7	14.7	14.5	13.6	13.1	12.4	12.1	11.8	11.5	11.3	10.9	10.5	10.1	9.7	9.5	9.2	8.5
6000	14.7	14.7	14.7	14.7	14.1	13.5	13.0	12.5	12.3	12.1	11.8	11.5	11.3	10.9	10.5	10.1	9.7	9.5	9.2	8.3
6500	14.3	14.3	14.3	14.3	13.4	12.8	12.3	11.8	11.6	11.6	11.6	11.2	10.9	10.9	10.5	10.1	9.7	9.5	9.2	8.3
7000	13.8	13.8	13.8	13.5	12.6	11.8	11.6	11.3	11.2	11.2	11.2	10.9	10.9	10.9	10.5	10.1	9.7	9.5	9.2	8.2
7500	13.6	13.6	13.6	13.3	12.5	11.7	11.5	11.2	11.1	11.1	11.1	10.9	10.9	10.9	10.5	10.1	9.7	9.5	9.2	8.1

2.03-FUEL TUNING – TUNED LO-OCTANE FUEL MAP EVO7-8

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.

Figure 11: FUEL TUNING – tuned LO-OCTANE FUEL MAP, JDM Evo7-8



Low Octane Fuel Map-98640014_JDM7_mod1.hex

	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260
500	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.1	12.5	12.1	11.7	11.4	11.1	10.9	10.6	10.4	10.2	10.0
1000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.3	12.9	12.7	12.4	12.1	11.8	11.5	11.2	10.9	10.7
1500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.8	13.1	12.7	12.5	12.4	12.1	11.8	11.5	11.2	10.9
2000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.8	13.2	12.8	12.5	12.4	12.3	12.1	11.8	11.5	11.3
2500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.8	13.1	12.5	12.3	11.8	11.4	11.1	10.9	10.8	10.8
3000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.8	13.1	12.1	11.7	11.3	11.0	10.6	10.5	10.5	10.5
3500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.6	12.8	11.8	11.3	10.9	10.6	10.4	10.3	10.3	10.3
4000	14.7	14.7	14.7	14.7	14.7	14.7	13.8	13.4	13.1	12.4	11.4	11.0	10.6	10.4	10.2	10.2	10.2	10.2
4500	14.7	14.7	14.7	14.7	14.7	13.8	13.3	13.1	12.5	11.8	11.1	10.8	10.4	10.2	10.0	10.0	10.0	10.0
5000	14.7	14.7	14.7	14.7	13.8	13.3	13.0	12.5	12.1	11.4	10.9	10.6	10.3	10.1	10.0	9.9	9.9	9.9
5500	13.8	13.8	13.8	13.8	13.3	13.0	12.5	11.9	11.5	11.1	10.8	10.5	10.2	10.1	10.0	9.9	9.7	9.7
6000	13.6	13.6	13.6	13.6	13.1	12.5	12.0	11.5	11.2	10.9	10.7	10.4	10.2	10.1	10.0	9.9	9.7	9.7
6500	13.1	13.1	13.1	13.1	12.4	12.0	11.6	11.3	11.1	10.8	10.6	10.4	10.2	10.1	10.0	9.9	9.7	9.6
7000	12.5	12.5	12.5	12.3	11.9	11.6	11.4	11.2	11.0	10.8	10.6	10.4	10.2	10.1	10.0	9.9	9.7	9.6
7500	12.4	12.4	12.4	12.2	11.8	11.5	11.3	11.2	11.0	10.8	10.6	10.4	10.2	10.1	10.0	9.9	9.7	9.6

2.04-FUEL TUNING – TUNED LO-OCTANE FUEL MAP EVO9

This is the tuned LO-OCTANE FUEL MAP I am currently using on the Evo9.

Figure 12: FUEL TUNING – tuned LO-OCTANE FUEL MAPS, JDM Evo9

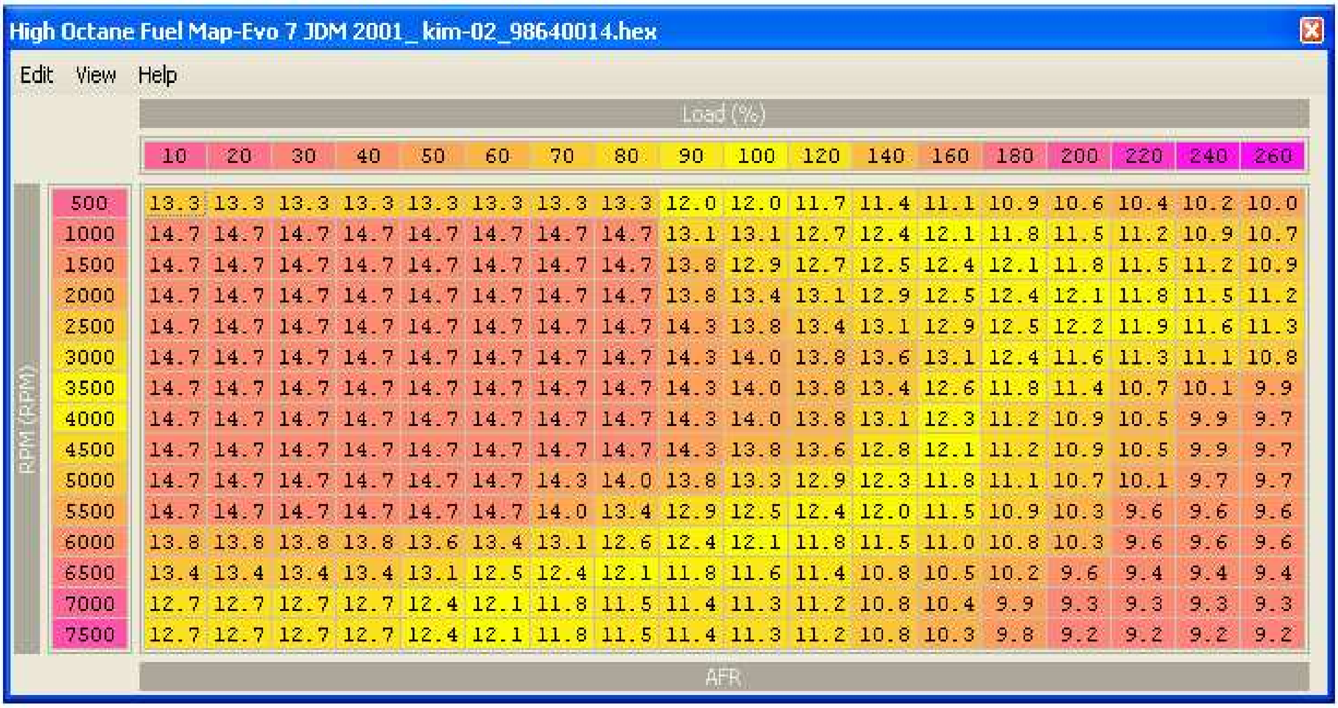
Low Octane Fuel Map-88580013_Evo 9 ADM 2006_dgh_29_knockCEL.hex

	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300
500	14.7	14.7	14.7	14.7	14.7	14.7	14.5	13.8	13.0	12.7	12.4	11.7	11.4	11.2	10.9	10.7	10.6	10.5	10.4	10.4
1000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.1	12.7	12.4	11.7	11.4	11.1	10.9	10.7	10.6	10.5	10.4	10.4
1500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.2	12.9	12.5	11.8	11.5	11.3	11.1	10.7	10.6	10.5	10.4	10.4
2000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.7	13.4	12.9	12.1	11.8	11.5	11.3	10.9	10.6	10.5	10.4	10.4
2500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.3	14.1	14.0	13.3	13.0	12.3	11.6	11.3	10.8	10.6	10.3	10.3
3000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.4	13.0	11.9	11.5	11.1	10.8	10.6	10.4	10.2	10.2
3500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.5	13.6	12.0	11.3	11.1	10.8	10.6	10.5	10.2	10.1	10.1
4000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.5	14.0	13.4	12.7	11.5	11.1	10.8	10.6	10.5	10.3	10.1	10.0	10.0
4500	14.7	14.7	14.7	14.7	14.7	14.7	14.5	13.9	13.5	12.9	12.3	11.3	10.9	10.6	10.5	10.3	10.2	10.0	9.9	9.9
5000	14.7	14.7	14.7	14.7	14.7	14.6	13.9	13.5	12.9	12.5	12.0	11.2	10.8	10.5	10.3	10.2	10.1	10.0	9.9	9.9
5500	14.7	14.7	14.7	14.7	14.6	14.3	13.5	13.1	12.5	12.1	11.7	11.1	10.7	10.4	10.3	10.1	10.0	10.0	9.7	9.7
6000	14.7	14.7	14.7	14.6	14.1	13.5	13.0	12.5	12.1	11.8	11.5	10.9	10.6	10.3	10.2	10.1	10.0	9.9	9.6	9.7
6500	14.3	14.3	14.3	14.1	13.4	12.8	12.3	11.9	11.7	11.5	11.2	10.8	10.5	10.2	10.1	10.0	9.9	9.7	9.6	9.6
7000	13.8	13.8	13.8	13.5	12.6	12.1	11.8	11.5	11.3	11.2	10.9	10.6	10.4	10.1	10.0	9.9	9.8	9.6	9.5	9.5
7500	13.6	13.6	13.6	13.3	12.4	11.8	11.5	11.3	11.1	10.9	10.7	10.5	10.3	10.1	10.0	9.9	9.8	9.6	9.5	9.5

2.05-FUEL TUNING – STOCK HI OCTANE FUEL MAP

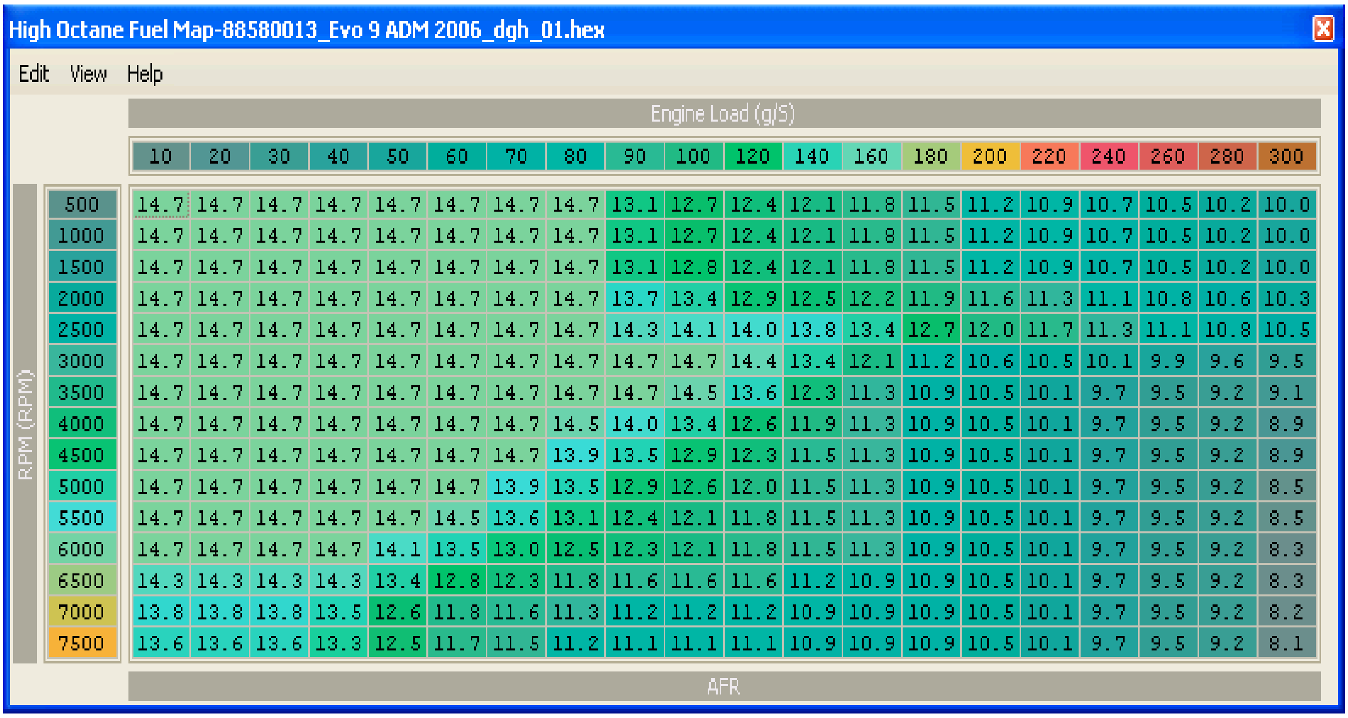
Two maps are shown here, a standard JDM Evo7 and a modified AUDM Evo9. Note the different size maps and scaling.

Figure 13: FUEL TUNING – HI-OCTANE FUEL MAP, JDM Evo7



	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260
500	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	12.0	12.0	11.7	11.4	11.1	10.9	10.6	10.4	10.2	10.0
1000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.1	13.1	12.7	12.4	12.1	11.8	11.5	11.2	10.9	10.7
1500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.8	12.9	12.7	12.5	12.4	12.1	11.8	11.5	11.2	10.9
2000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.8	13.4	13.1	12.9	12.5	12.4	12.1	11.8	11.5	11.2
2500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.3	13.8	13.4	13.1	12.9	12.5	12.2	11.9	11.6	11.3
3000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.3	14.0	13.8	13.6	13.1	12.4	11.6	11.3	11.1	10.8
3500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.3	14.0	13.8	13.4	12.6	11.8	11.4	10.7	10.1	9.9
4000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.3	14.0	13.8	13.1	12.3	11.2	10.9	10.5	9.9	9.7
4500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.3	13.8	13.6	12.8	12.1	11.2	10.9	10.5	9.9	9.7
5000	14.7	14.7	14.7	14.7	14.7	14.7	14.3	14.0	13.8	13.3	12.9	12.3	11.8	11.1	10.7	10.1	9.7	9.7
5500	14.7	14.7	14.7	14.7	14.7	14.7	14.0	13.4	12.9	12.5	12.4	12.0	11.5	10.9	10.3	9.6	9.6	9.6
6000	13.8	13.8	13.8	13.8	13.6	13.4	13.1	12.6	12.4	12.1	11.8	11.5	11.0	10.8	10.3	9.6	9.6	9.6
6500	13.4	13.4	13.4	13.4	13.1	12.5	12.4	12.1	11.8	11.6	11.4	10.8	10.5	10.2	9.6	9.4	9.4	9.4
7000	12.7	12.7	12.7	12.7	12.4	12.1	11.8	11.5	11.4	11.3	11.2	10.8	10.4	9.9	9.3	9.3	9.3	9.3
7500	12.7	12.7	12.7	12.7	12.4	12.1	11.8	11.5	11.4	11.3	11.2	10.8	10.3	9.8	9.2	9.2	9.2	9.2

Figure 14: FUEL TUNING – HI-OCTANE FUEL MAP, Evo9

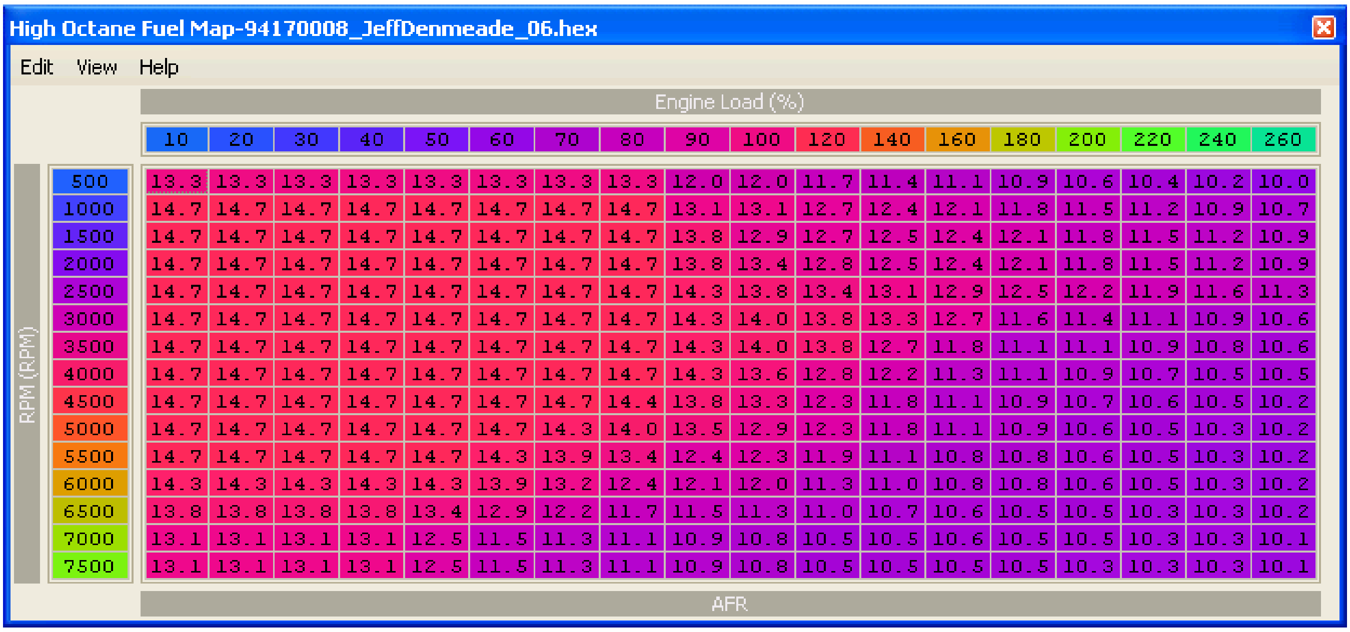


	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300
500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.1	12.7	12.4	12.1	11.8	11.5	11.2	10.9	10.7	10.5	10.2	10.0
1000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.1	12.7	12.4	12.1	11.8	11.5	11.2	10.9	10.7	10.5	10.2	10.0
1500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.1	12.8	12.4	12.1	11.8	11.5	11.2	10.9	10.7	10.5	10.2	10.0
2000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.7	13.4	12.9	12.5	12.2	11.9	11.6	11.3	11.1	10.8	10.6	10.3
2500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.3	14.1	14.0	13.8	13.4	12.7	12.0	11.7	11.3	11.1	10.8	10.5
3000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.4	13.4	12.1	11.2	10.6	10.5	10.1	9.9	9.6	9.5
3500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.5	13.6	12.3	11.3	10.9	10.5	10.1	9.7	9.5	9.2	9.1
4000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.5	14.0	13.4	12.6	11.9	11.3	10.9	10.5	10.1	9.7	9.5	9.2	8.9
4500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.9	13.5	12.9	12.3	11.5	11.3	10.9	10.5	10.1	9.7	9.5	9.2	8.9
5000	14.7	14.7	14.7	14.7	14.7	14.7	13.9	13.5	12.9	12.6	12.0	11.5	11.3	10.9	10.5	10.1	9.7	9.5	9.2	8.5
5500	14.7	14.7	14.7	14.7	14.7	14.5	13.6	13.1	12.4	12.1	11.8	11.5	11.3	10.9	10.5	10.1	9.7	9.5	9.2	8.5
6000	14.7	14.7	14.7	14.7	14.1	13.5	13.0	12.5	12.3	12.1	11.8	11.5	11.3	10.9	10.5	10.1	9.7	9.5	9.2	8.3
6500	14.3	14.3	14.3	14.3	13.4	12.8	12.3	11.8	11.6	11.6	11.6	11.2	10.9	10.9	10.5	10.1	9.7	9.5	9.2	8.3
7000	13.8	13.8	13.8	13.5	12.6	11.8	11.6	11.3	11.2	11.2	11.2	10.9	10.9	10.9	10.5	10.1	9.7	9.5	9.2	8.2
7500	13.6	13.6	13.6	13.3	12.5	11.7	11.5	11.2	11.1	11.1	11.1	10.9	10.9	10.9	10.5	10.1	9.7	9.5	9.2	8.1

2.06-FUEL TUNING – TUNED HI OCTANE FUEL MAP

These HI-OCTANE FUEL maps have been tuned to give 12:1 air fuel ratio mixtures, with the stock LEAN SPOOL AFR table settings 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.

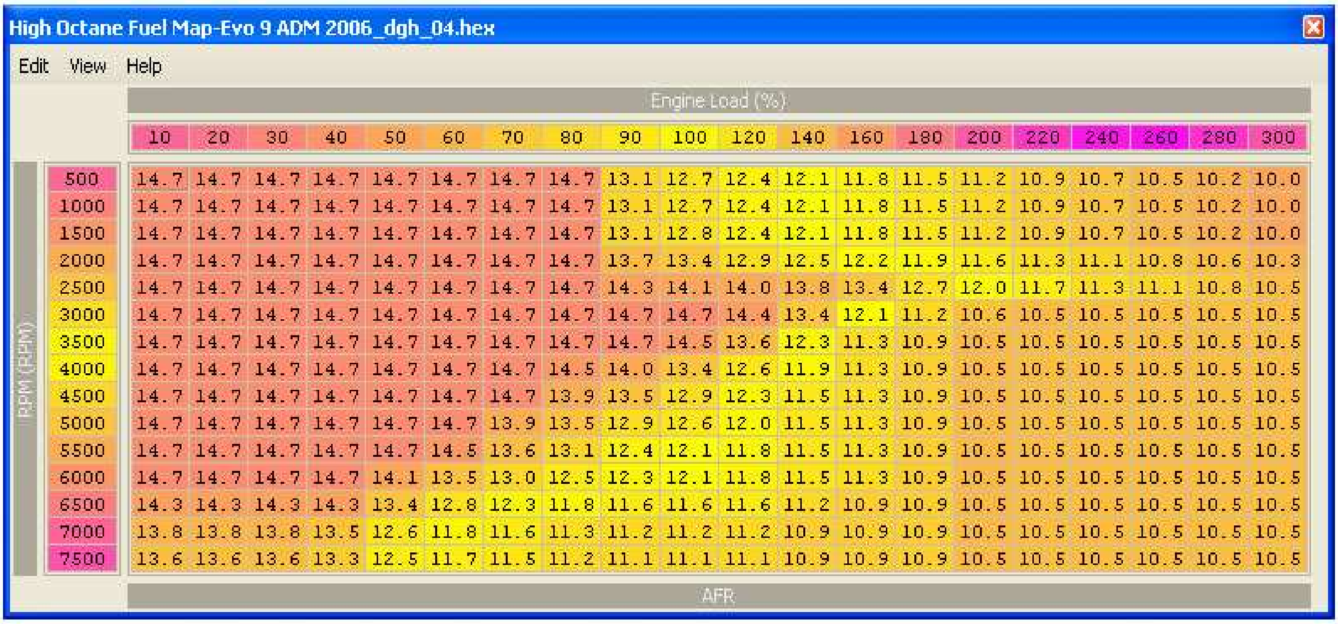
Figure 15: FUEL TUNING – tuned HI-OCTANE FUEL MAP, Evo7-8



High Octane Fuel Map-94170008_JeffDenmeade_06.hex

RPM (RPM)	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260
500	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	12.0	12.0	11.7	11.4	11.1	10.9	10.6	10.4	10.2	10.0
1000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.1	13.1	12.7	12.4	12.1	11.8	11.5	11.2	10.9	10.7
1500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.8	12.9	12.7	12.5	12.4	12.1	11.8	11.5	11.2	10.9
2000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.8	13.4	12.8	12.5	12.4	12.1	11.8	11.5	11.2	10.9
2500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.3	13.8	13.4	13.1	12.9	12.5	12.2	11.9	11.6	11.3
3000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.3	14.0	13.8	13.3	12.7	11.6	11.4	11.1	10.9	10.6
3500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.3	14.0	13.8	12.7	11.8	11.1	11.1	10.9	10.8	10.6
4000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.3	13.6	12.8	12.2	11.3	11.1	10.9	10.7	10.5	10.5
4500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.4	13.8	13.3	12.3	11.8	11.1	10.9	10.7	10.6	10.5	10.2
5000	14.7	14.7	14.7	14.7	14.7	14.7	14.3	14.0	13.5	12.9	12.3	11.8	11.1	10.9	10.6	10.5	10.3	10.2
5500	14.7	14.7	14.7	14.7	14.7	14.3	13.9	13.4	12.4	12.3	11.9	11.1	10.8	10.8	10.6	10.5	10.3	10.2
6000	14.3	14.3	14.3	14.3	14.3	13.9	13.2	12.4	12.1	12.0	11.3	11.0	10.8	10.8	10.6	10.5	10.3	10.2
6500	13.8	13.8	13.8	13.8	13.4	12.9	12.2	11.7	11.5	11.3	11.0	10.7	10.6	10.5	10.5	10.3	10.3	10.2
7000	13.1	13.1	13.1	13.1	12.5	11.5	11.3	11.1	10.9	10.8	10.5	10.5	10.6	10.5	10.5	10.3	10.3	10.1
7500	13.1	13.1	13.1	13.1	12.5	11.5	11.3	11.1	10.9	10.8	10.5	10.5	10.5	10.5	10.3	10.3	10.3	10.1

Figure 16: FUEL TUNING – tuned HI-OCTANE FUEL MAP, Evo9



High Octane Fuel Map-Evo 9 ADM 2006_dgh_04.hex

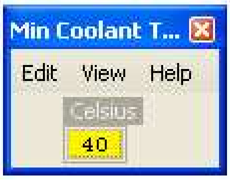
RPM (RPM)	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300
500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.1	12.7	12.4	12.1	11.8	11.5	11.2	10.9	10.7	10.5	10.2	10.0
1000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.1	12.7	12.4	12.1	11.8	11.5	11.2	10.9	10.7	10.5	10.2	10.0
1500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.1	12.8	12.4	12.1	11.8	11.5	11.2	10.9	10.7	10.5	10.2	10.0
2000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.7	13.4	12.9	12.5	12.2	11.9	11.6	11.3	11.1	10.8	10.6	10.3
2500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.3	14.1	14.0	13.8	13.4	12.7	12.0	11.7	11.3	11.1	10.8	10.5
3000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.4	13.4	12.1	11.2	10.6	10.5	10.5	10.5	10.5	10.5
3500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.5	13.6	12.3	11.3	10.9	10.5	10.5	10.5	10.5	10.5	10.5
4000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.5	14.0	13.4	12.6	11.9	11.3	10.9	10.5	10.5	10.5	10.5	10.5	10.5
4500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.9	13.5	12.9	12.3	11.5	11.3	10.9	10.5	10.5	10.5	10.5	10.5	10.5
5000	14.7	14.7	14.7	14.7	14.7	14.7	13.9	13.5	12.9	12.6	12.0	11.5	11.3	10.9	10.5	10.5	10.5	10.5	10.5	10.5
5500	14.7	14.7	14.7	14.7	14.7	14.5	13.6	13.1	12.4	12.1	11.8	11.5	11.3	10.9	10.5	10.5	10.5	10.5	10.5	10.5
6000	14.7	14.7	14.7	14.7	14.1	13.5	13.0	12.5	12.3	12.1	11.8	11.5	11.3	10.9	10.5	10.5	10.5	10.5	10.5	10.5
6500	14.3	14.3	14.3	14.3	13.4	12.8	12.3	11.8	11.6	11.6	11.6	11.2	10.9	10.9	10.5	10.5	10.5	10.5	10.5	10.5
7000	13.8	13.8	13.8	13.5	12.6	11.8	11.6	11.3	11.2	11.2	11.2	10.9	10.9	10.9	10.5	10.5	10.5	10.5	10.5	10.5
7500	13.6	13.6	13.6	13.3	12.5	11.7	11.5	11.2	11.1	11.1	11.1	10.9	10.9	10.9	10.5	10.5	10.5	10.5	10.5	10.5

2.07-FUEL TUNING – OPEN LOOP TEMP THRESHOLD

When the engine temperature is low (below a preset value), the ECU does not use the (front) oxygen sensor to control the stociometric 14.7:1 fueling as shown in the fuel maps. Instead, it just calculates from the air-flow and hopes for the best.

This OPEN LOOP TEMP THRESHOLD parameter sets the engine temperature at which the ECU starts CLOSED LOOP operation, by using the front O2 sensor to trim fueling to the desired 14.7:1 AFR as shown in the fuel maps. The value shown (40°C) has been altered from the 20°C factory ADM spec switch on point.

Figure 17: FUEL TUNING – tuned OPEN LOOP TEMP THRESHOLD, Evo9



Celsius
40

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).

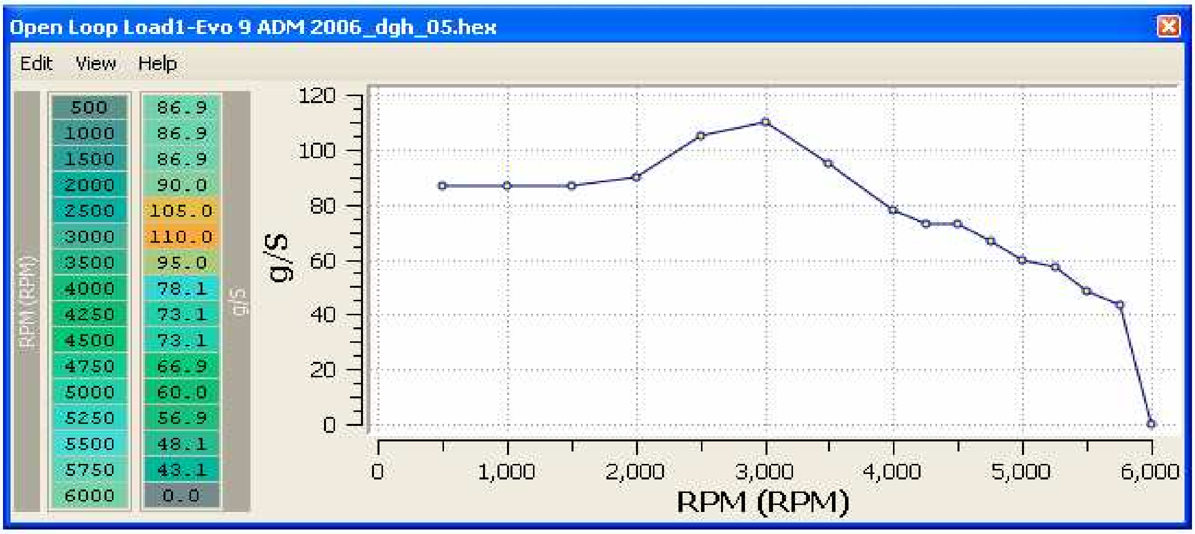
Note that when the ECU is in OPEN LOOP, the LONG TERM FUEL TRIM (LTFT) % that was applied in CLOSED LOOP is applied to the whole map. This is a great feature, but does mean you should try and get your trims close to zero by getting the scaling and injector latency set correctly. These should be very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

The Evo9 has a short term fuel trim range of ±25%, so it has plenty of adjustment range to work with.

2.08-FUEL TUNING - OPEN LOOP LOAD THRESHOLD v RPM

The values in the table set the LOAD threshold above which the ECU operates in OPEN LOOP. There are two of these tables, both tables had the same values and no tuning guru has posted how the two tables are differentiated. Set both tables to the same values.

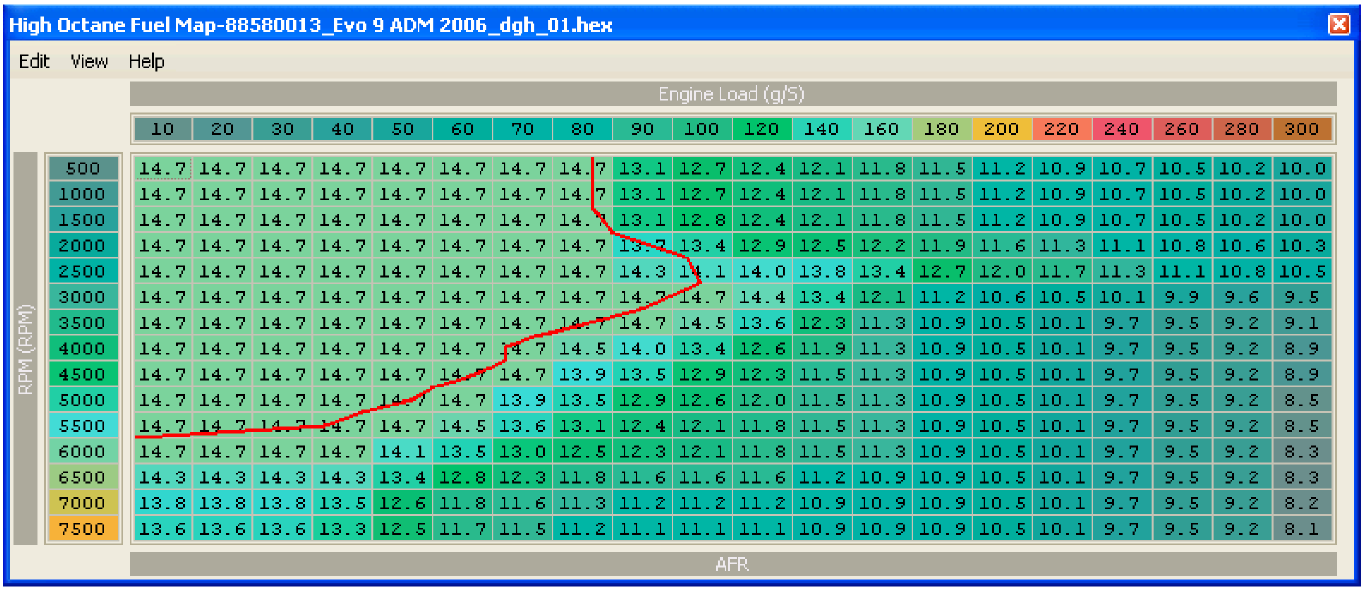
Figure 18: FUEL TUNING – OPEN LOOP LOAD THRESHOLD v RPM, ADM Evo9



RPM (RPM)	g/S
500	86.9
1000	86.9
1500	86.9
2000	90.0
2500	105.0
3000	110.0
3500	95.0
4000	78.1
4250	73.1
4500	73.1
4750	66.9
5000	60.0
5250	56.9
5500	48.1
5750	43.1
6000	0.0

This table can be tuned to force the ECU to run in OPEN LOOP in a specific rpm range, where the engine runs when cruising in top gear for example, to get better gas mileage. The load value has to be set lower than what is recorded when a cruise run is logged to ensure correct operation. You should also log TPS for this and make the appropriate changes to the OPEN LOOP TPS THRESHOLD v RPM table as well. The HI-OCTANE fuel map shown below has the OPEN LOOP LOAD THRESHOLD overlaid in red, clearly showing how the two parameters are interlinked.

Figure 19: FUEL TUNING – OPEN LOOP LOAD THRESHOLD v RPM, ADM Evo9



Engine Load (g/S)

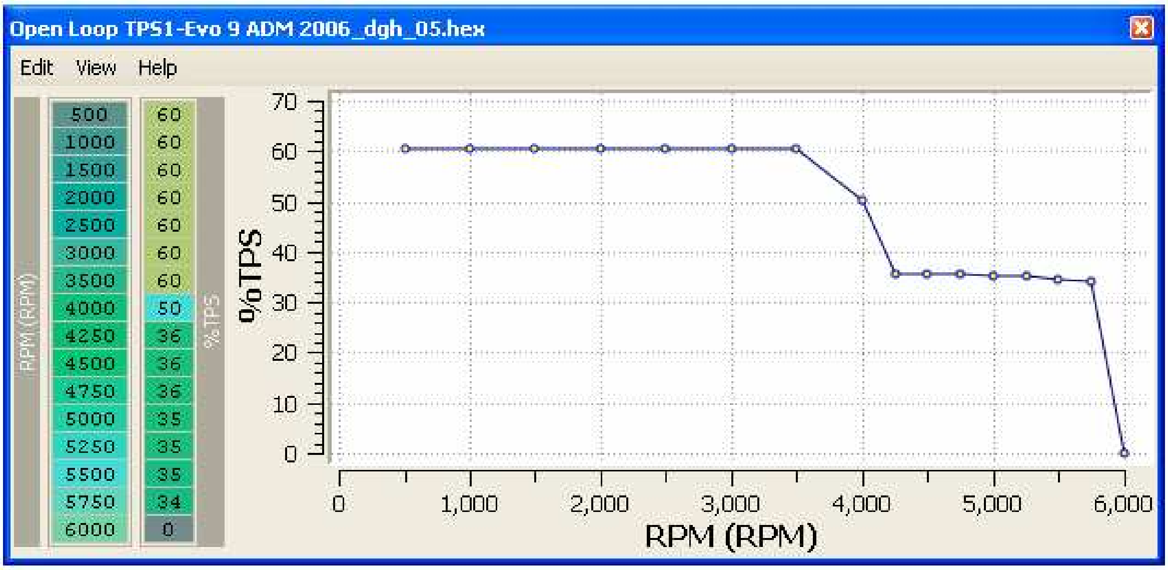
RPM (RPM)	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300
500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.1	12.7	12.4	12.1	11.8	11.5	11.2	10.9	10.7	10.5	10.2	10.0
1000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.1	12.7	12.4	12.1	11.8	11.5	11.2	10.9	10.7	10.5	10.2	10.0
1500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.1	12.8	12.4	12.1	11.8	11.5	11.2	10.9	10.7	10.5	10.2	10.0
2000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.7	13.4	12.9	12.5	12.2	11.9	11.6	11.3	11.1	10.8	10.6	10.3
2500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.3	14.1	14.0	13.8	13.4	12.7	12.0	11.7	11.3	11.1	10.8	10.5
3000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.4	13.4	12.1	11.2	10.6	10.5	10.1	9.9	9.6	9.5
3500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.5	13.6	12.3	11.3	10.9	10.5	10.1	9.7	9.5	9.2	9.1
4000	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.5	14.0	13.4	12.6	11.9	11.3	10.9	10.5	10.1	9.7	9.5	9.2	8.9
4500	14.7	14.7	14.7	14.7	14.7	14.7	14.7	13.9	13.5	12.9	12.3	11.5	11.3	10.9	10.5	10.1	9.7	9.5	9.2	8.9
5000	14.7	14.7	14.7	14.7	14.7	14.7	13.9	13.5	12.9	12.6	12.0	11.5	11.3	10.9	10.5	10.1	9.7	9.5	9.2	8.5
5500	14.7	14.7	14.7	14.7	14.7	14.5	13.6	13.1	12.4	12.1	11.8	11.5	11.3	10.9	10.5	10.1	9.7	9.5	9.2	8.5
6000	14.7	14.7	14.7	14.7	14.1	13.5	13.0	12.5	12.3	12.1	11.8	11.5	11.3	10.9	10.5	10.1	9.7	9.5	9.2	8.3
6500	14.3	14.3	14.3	14.3	13.4	12.8	12.3	11.8	11.6	11.6	11.6	11.2	10.9	10.9	10.5	10.1	9.7	9.5	9.2	8.3
7000	13.8	13.8	13.8	13.5	12.6	11.8	11.6	11.3	11.2	11.2	11.2	10.9	10.9	10.9	10.5	10.1	9.7	9.5	9.2	8.2
7500	13.6	13.6	13.6	13.3	12.5	11.7	11.5	11.2	11.1	11.1	11.1	10.9	10.9	10.9	10.5	10.1	9.7	9.5	9.2	8.1

AFR

2.09-FUEL TUNING - OPEN LOOP TPS THRESHOLD v RPM

The values in the table set the TPS % threshold above which the ECU operates in OPEN LOOP. Set both Evo9 tables to the same values. Set the 500-1000rpm cells to 0 for open loop fuel mapping at idle when using cams with a duration of larger than 264 duration, if idle stability is a problem.

Figure 20: FUEL TUNING – OPEN LOOP TPS% THRESHOLD v RPM, ADM Evo9



RPM (RPM)	%TPS
500	60
1000	60
1500	60
2000	60
2500	60
3000	60
3500	60
4000	50
4250	36
4500	36
4750	36
5000	35
5250	35
5500	35
5750	34
6000	0

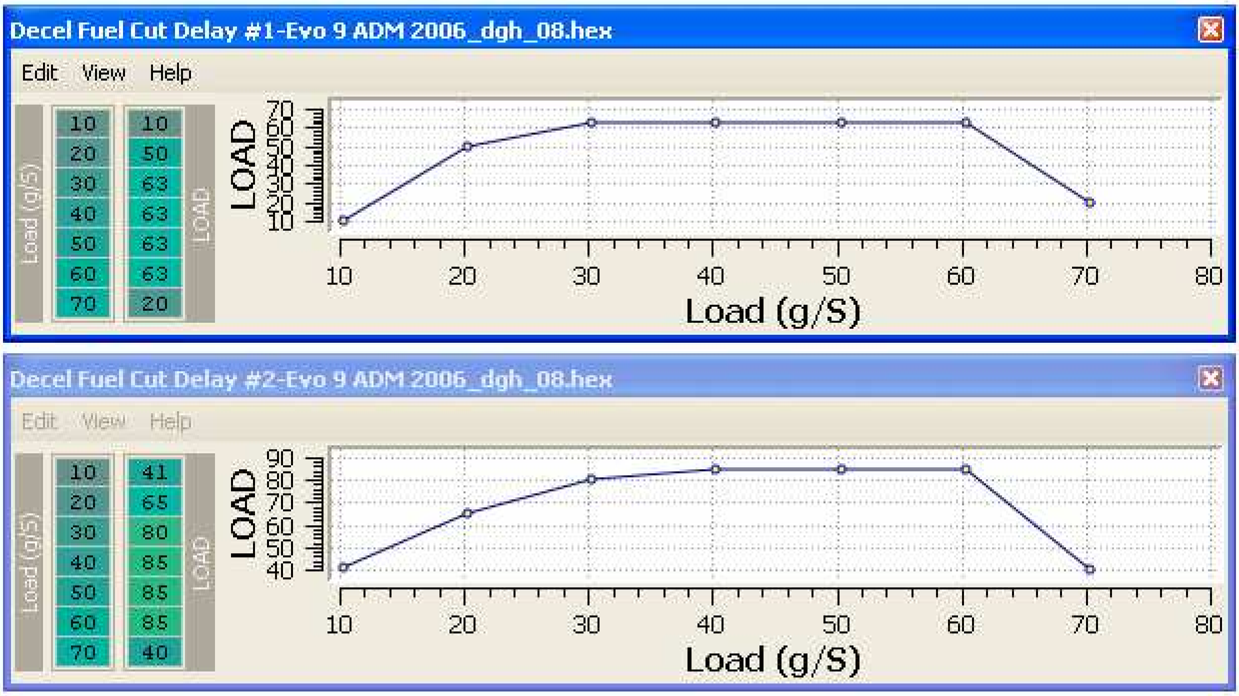
There are two of these tables, both tables had almost identical values and no tuning guru has posted how the two tables are differentiated. Set both tables to the same values.

2.10-FUEL TUNING - DECEL FUELCUT DELAY v LOAD

There are two tables controlling this function, the precise usage has not been defined as yet.

The DECEL FUELCUT DELAY tables are in effect timers controlling how long the injectors keep operating during decal condition before the injectors are shut-off. This parameter thus also has an effect on the “throttle hang” effect. The 60 and 70 load cells can be reduced to shorten the hang time. Leaving the lower cells as factory keeps the nice drivability in slow traffic and should be left as is.

Figure 21: FUEL TUNING – DECEL FUEL CUT DELAY v LOAD, merlin Evo9



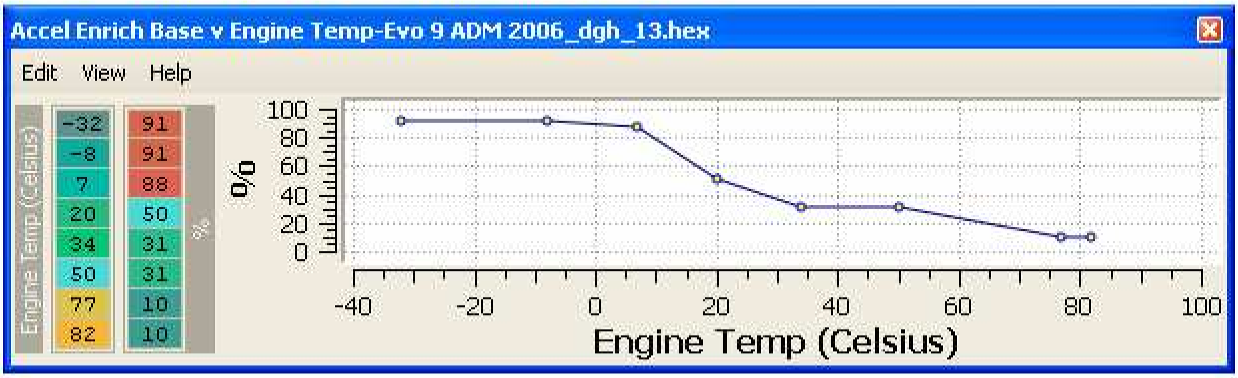
Load (g/S)	LOAD
10	10
20	50
30	63
40	63
50	63
60	63
70	20

Load (g/S)	LOAD
10	41
20	65
30	80
40	85
50	85
60	85
70	40

2.11-FUEL TUNING - ACCEL ENRICH BASE v ENGINE TEMP

This is the enrichment v engine temperature control table. All the other acceleration enrichment variables refer back to this table.

Figure 22: FUEL TUNING – ACCEL ENRICH BASE v ENGINE TEMP, Evo9

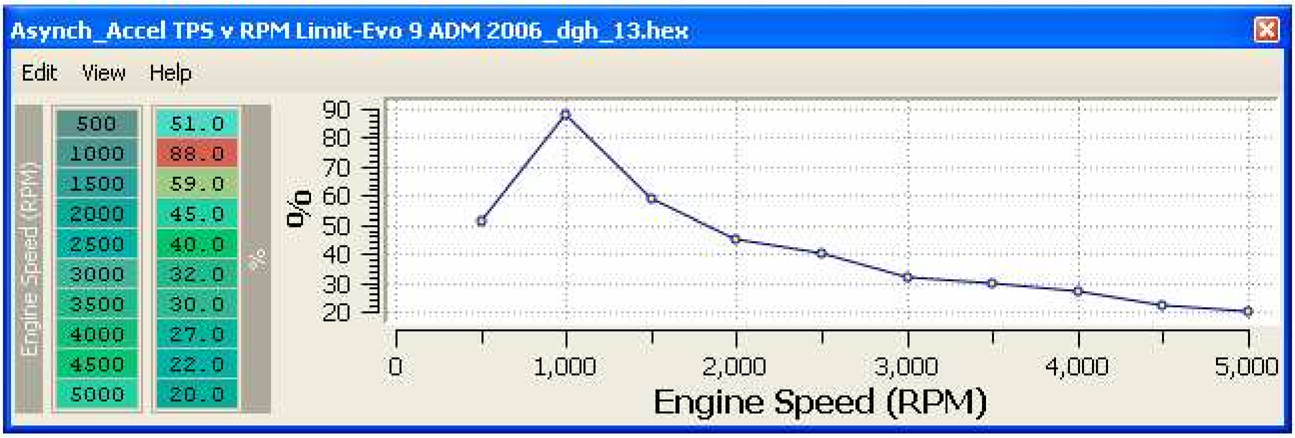


Engine Temp (Celsius)	%
-32	91
-8	91
7	88
20	50
34	31
50	31
77	10
82	10

2.12-FUEL TUNING - ASYNCH_ACCEL TPS v RPM LIMIT

This is an asynchronous acceleration enrichment based on TPS. As it is an asynchronous parameter, it is probably a one-shot enrichment as the accelerator peddle is rapidly prodded. It is used to overcome the momentary lean condition on rapid throttle opening.

Figure 23: FUEL TUNING – tuned ASYNCH ACCEL TPS v RPM LIMIT, Evo9

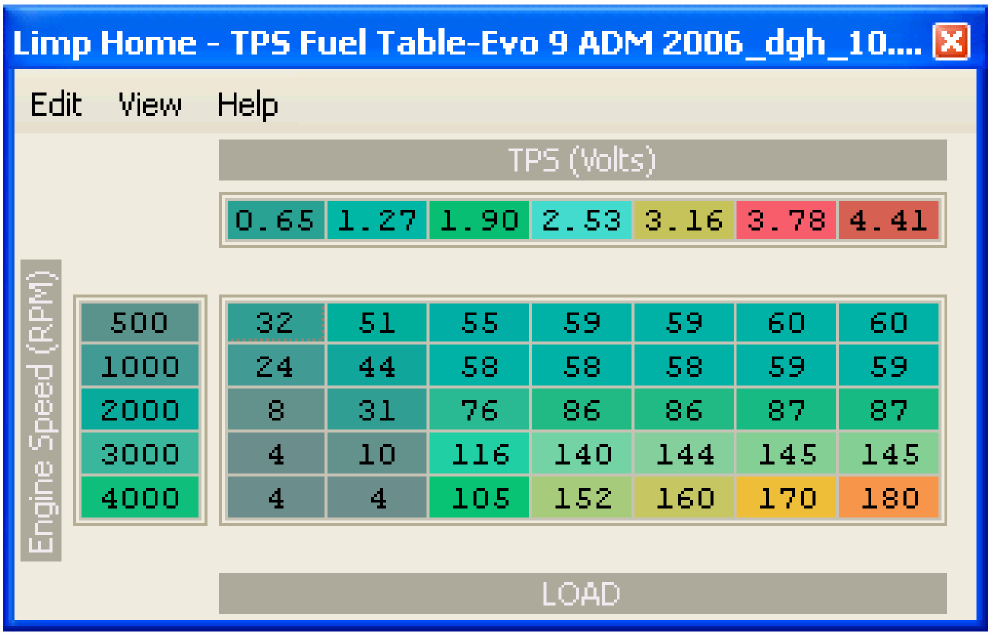


Engine Speed (RPM)	%
500	51.0
1000	88.0
1500	59.0
2000	45.0
2500	40.0
3000	32.0
3500	30.0
4000	27.0
4500	22.0
5000	20.0

2.13-FUEL TUNING - LIMP HOME LOAD MAP, TPS v RPM

If the MAF fails, the Evo has a limp home function, using just the throttle position sensor and the engine RPM to generate a simulated load value. This type of system is known as "alpha-N" fuel mapping.

Figure 24: FUEL TUNING – TPS v RPM LIMP HOME LOAD MAP, Evo9



	0.65	1.27	1.90	2.53	3.16	3.78	4.41
500	32	51	55	59	59	60	60
1000	24	44	58	58	58	59	59
2000	8	31	76	86	86	87	87
3000	4	10	116	140	144	145	145
4000	4	4	105	152	160	170	180

There are likely to be RPM and BOOST limits applied under this condition as well, but they have not been found/defined as yet.

2.14-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 real is a very good if subtle enhancement the stock ECU comes with. Its 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 3 – IGNITION TUNING

3.01-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 11.5-11:1 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.

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.

So how should I deal with knock?

As briefly mentioned earlier the Evo ECU spits out a parameter known as KNOCKSUM This parameter is one of the most important to log when tuning your Evo. EvoScan tells us that this parameter can vary from 0 to 36 with 36 as the maximum knock count that the Evo ECU can register.

When tuning your Evo it is advisable to tune timing, fuel, and boost without triggering an occasional KNOCKSUM more than one or two, three at the most. We know for a fact that 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:

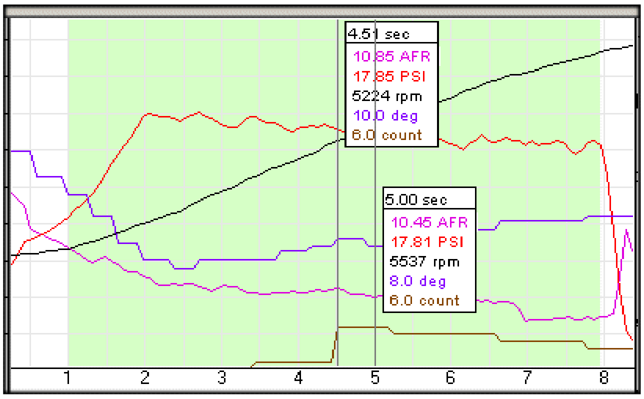
1. All cars knock on occasion. I have logged Evos that knocked the first log and then gave me three knock free WOT runs, including my own. Generally speaking, the first WOT log that you do tends to be knock prone. You have to do at least three back-to-back logs to make sure that knock is consistent. 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 25: IGNITION TUNING – WOT LOG, GRAPH #1, Evo9



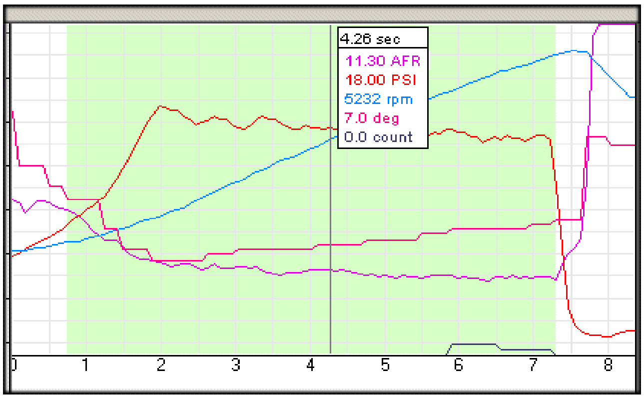
Notice that the timing @ 5224 rpm was 10° and after 6 counts of knock the timing was pulled to 8° by 5500 rpm. 6 counts of knock pulled 2° of timing, in line with our prediction that 3 counts of knock will pull 1° of timing.

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 26: 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 high octane ignition map(s) especially in the higher rpm.

The Evo7 and Evo8 have one high octane ignition map while the Evo9 has 4 high octane ignition maps. Map #1 is used when the engine temperature is below 149°F or °C. Map #2 is used as the normal ignition map engine warmed-up and no fault conditions. Map #3 is used in the event of a major sensor fault for example a MAF failure. Map #4 has more cruise timing and a block of retarded timing, its use is currently unknown

Most tuned maps that I have seen make the three high octane ignition maps the same. This gives you a consistent and repetitive timing curve at the expense of better ECU operation under different operating conditions. I think until the exact operating conditions of the maps are understood, it would make tuning a lot easier and predictable to set maps 1-2-3 to the same values.

Generally speaking Evos with a stock ROM tend to have a lot of timing advance. Timing advance refers to the degrees that the spark plug is fired prior to the piston reaching Top Dead Centre (TDC). The higher the timing number in the load cell that the car hits during WOT operation, the further ahead of TDC that the spark plug is fired. This is known as advanced timing. The lower the timing number in the load cell during WOT, the closer to TDC that the spark plug is fired.

In the timing map image below, I indicated the load cells that a tuned TBE EVO will hit during WOT operation in 3rd or 4th gear. If you look at load cells 220-260 @ 3500 rpm you will see 3, 3 and 2. These numbers tell us that the spark plug will fire between 3-2° BTDC. As the rpm increases so does the timing advance. Why? Well the engine has faster speeds and the spark plug must be fired earlier or else there would not be enough time to complete the burn of the air/fuel mixture. So in load cell 220/240 @ 7000 rpm the map indicates 10-9° BTDC. These cells are usually the cells that a tuned EVO 9 will hit during WOT operation in a 3rd or 4th gear log.

3.02-IGNITION TUNING – STOCK LO-OCTANE SPARK MAP

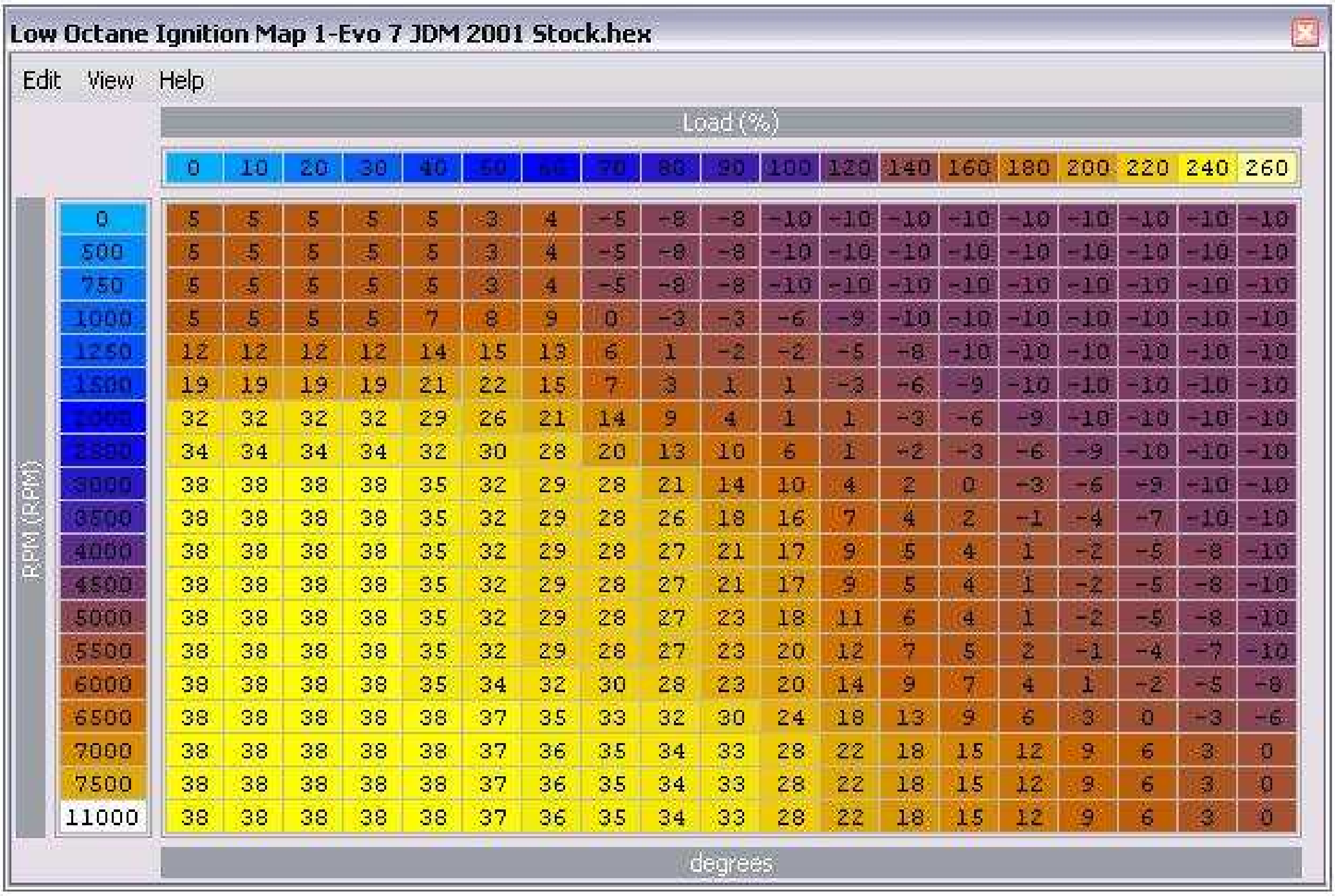
When the ECU initially detects detonation, it will retard timing by a preset number of degrees depending on the knock count and the conditions that the knock occurred. At the same time, the OCTANE NUMBER that the ECU has stored is reduced. If detonation continues to occur, then the ECU will interpolate 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 (safety boost).

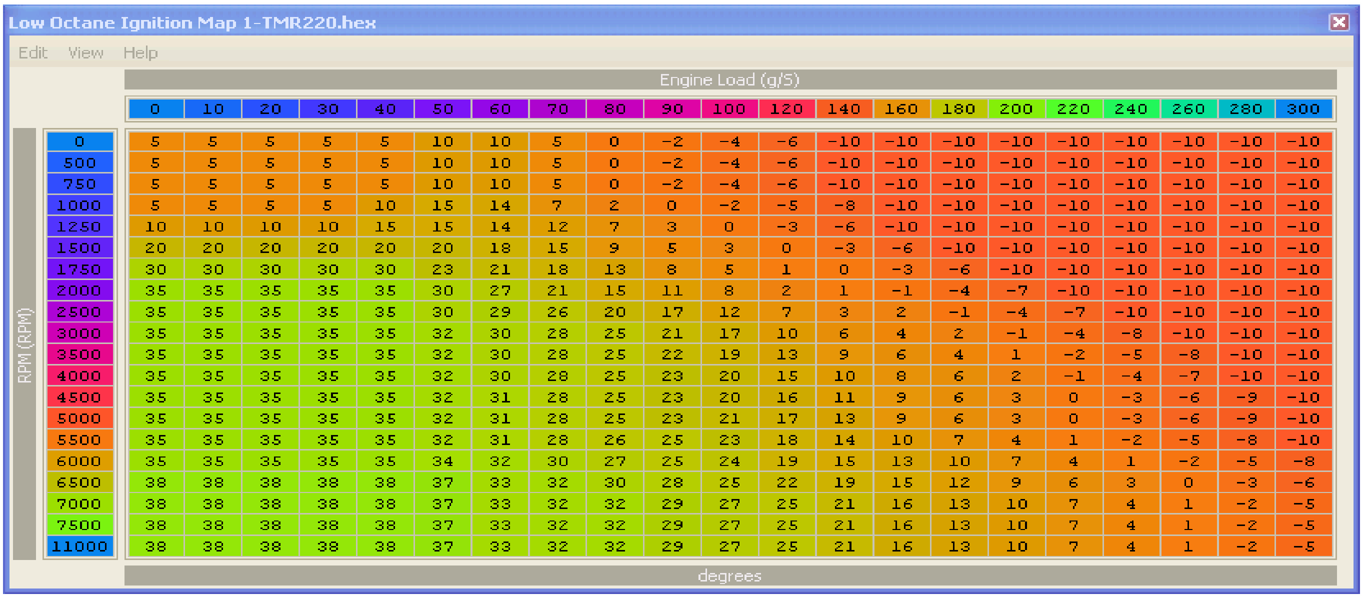
For further reading on this topic, refer to the section on KNOCK CONTROL.

Figure 27: IGNITION TUNING – LO-OCTANE SPARK MAP, JDM Evo7



	0	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260
0	5	5	5	5	5	3	4	-5	-8	-8	-10	-10	-10	-10	-10	-10	-10	-10	-10
500	5	5	5	5	5	3	4	-5	-8	-8	-10	-10	-10	-10	-10	-10	-10	-10	-10
750	5	5	5	5	5	3	4	-5	-8	-8	-10	-10	-10	-10	-10	-10	-10	-10	-10
1000	5	5	5	5	7	8	9	0	-3	-3	-6	-9	-10	-10	-10	-10	-10	-10	-10
1250	12	12	12	12	14	15	13	6	1	-2	-2	-5	-8	-10	-10	-10	-10	-10	-10
1500	19	19	19	19	21	22	15	7	3	1	1	-3	-6	-9	-10	-10	-10	-10	-10
2000	32	32	32	32	29	26	21	14	9	4	1	1	-3	-6	-9	-10	-10	-10	-10
2500	34	34	34	34	32	30	28	20	13	10	6	1	-2	-3	-6	-9	-10	-10	-10
3000	38	38	38	38	35	32	29	28	21	14	10	4	2	0	-3	-6	-9	-10	-10
3500	38	38	38	38	35	32	29	28	26	18	16	7	4	2	-1	-4	-7	-10	-10
4000	38	38	38	38	35	32	29	28	27	21	17	9	5	4	1	-2	-5	-8	-10
4500	38	38	38	38	35	32	29	28	27	21	17	9	5	4	1	-2	-5	-8	-10
5000	38	38	38	38	35	32	29	28	27	23	18	11	6	4	1	-2	-5	-8	-10
5500	38	38	38	38	35	32	29	28	27	23	20	12	7	5	2	-1	-4	-7	-10
6000	38	38	38	38	35	34	32	30	28	23	20	14	9	7	4	1	-2	-5	-8
6500	38	38	38	38	38	37	35	33	32	30	24	18	13	9	6	3	0	-3	-6
7000	38	38	38	38	38	37	36	35	34	33	28	22	18	15	12	9	6	3	0
7500	38	38	38	38	38	37	36	35	34	33	28	22	18	15	12	9	6	3	0
11000	38	38	38	38	38	37	36	35	34	33	28	22	18	15	12	9	6	3	0

Figure 28: IGNITION TUNING – LO-OCTANE SPARK MAPS – Evo9 TMR220

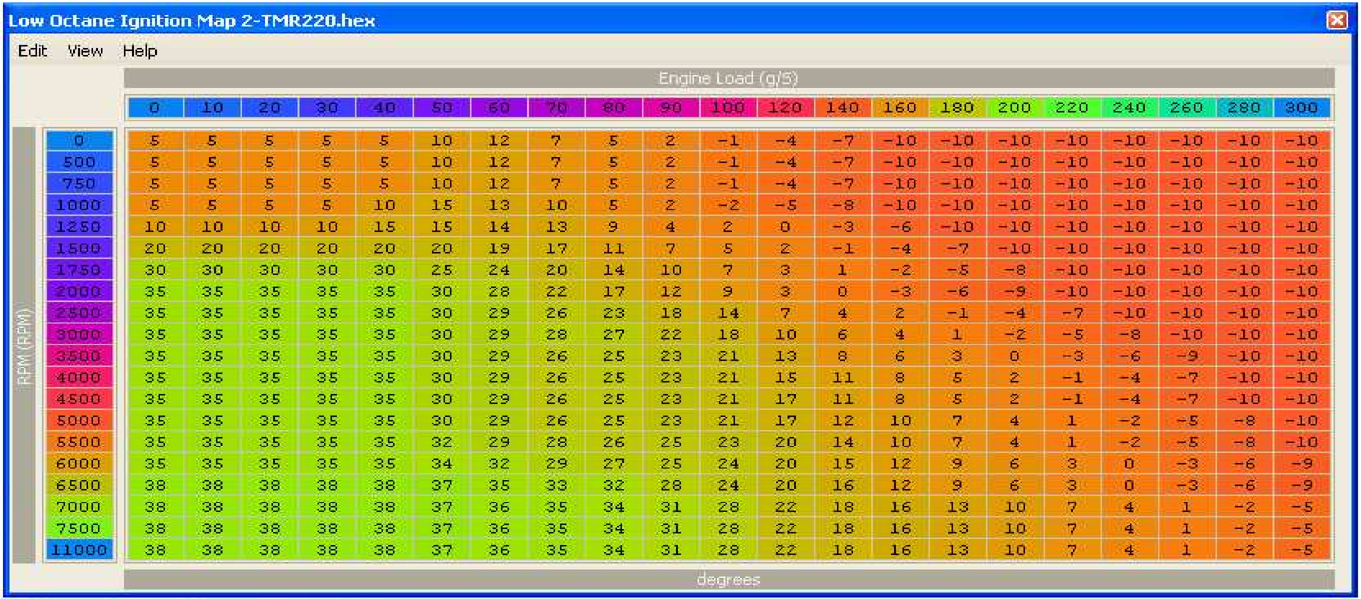


Low Octane Ignition Map 1-TMR220.hex

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
0	5	5	5	5	5	10	10	5	0	-2	-4	-6	-10	-10	-10	-10	-10	-10	-10	-10	-10
500	5	5	5	5	5	10	10	5	0	-2	-4	-6	-10	-10	-10	-10	-10	-10	-10	-10	-10
750	5	5	5	5	5	10	10	5	0	-2	-4	-6	-10	-10	-10	-10	-10	-10	-10	-10	-10
1000	5	5	5	5	10	15	14	7	2	0	-2	-5	-8	-10	-10	-10	-10	-10	-10	-10	-10
1250	10	10	10	10	15	15	14	12	7	3	0	-3	-6	-10	-10	-10	-10	-10	-10	-10	-10
1500	20	20	20	20	20	20	18	15	9	5	3	0	-3	-6	-10	-10	-10	-10	-10	-10	-10
1750	30	30	30	30	30	23	21	18	13	8	5	1	0	-3	-6	-10	-10	-10	-10	-10	-10
2000	35	35	35	35	35	30	27	21	15	11	8	2	1	-1	-4	-7	-10	-10	-10	-10	-10
2500	35	35	35	35	35	30	29	26	20	17	12	7	3	2	-1	-4	-7	-10	-10	-10	-10
3000	35	35	35	35	35	32	30	28	25	21	17	10	6	4	2	-1	-4	-8	-10	-10	-10
3500	35	35	35	35	35	32	30	28	25	22	19	13	9	6	4	1	-2	-5	-8	-10	-10
4000	35	35	35	35	35	32	30	28	25	23	20	15	10	8	6	2	-1	-4	-7	-10	-10
4500	35	35	35	35	35	32	31	28	25	23	20	16	11	9	6	3	0	-3	-6	-9	-10
5000	35	35	35	35	35	32	31	28	25	23	21	17	13	9	6	3	0	-3	-6	-9	-10
5500	35	35	35	35	35	32	31	28	26	25	23	18	14	10	7	4	1	-2	-5	-8	-10
6000	35	35	35	35	35	34	32	30	27	25	24	19	15	13	10	7	4	1	-2	-5	-8
6500	38	38	38	38	38	37	33	32	30	28	25	22	19	15	12	9	6	3	0	-3	-6
7000	38	38	38	38	38	37	33	32	32	29	27	25	21	16	13	10	7	4	1	-2	-5
7500	38	38	38	38	38	37	33	32	32	29	27	25	21	16	13	10	7	4	1	-2	-5
11000	38	38	38	38	38	37	33	32	32	29	27	25	21	16	13	10	7	4	1	-2	-5

degrees

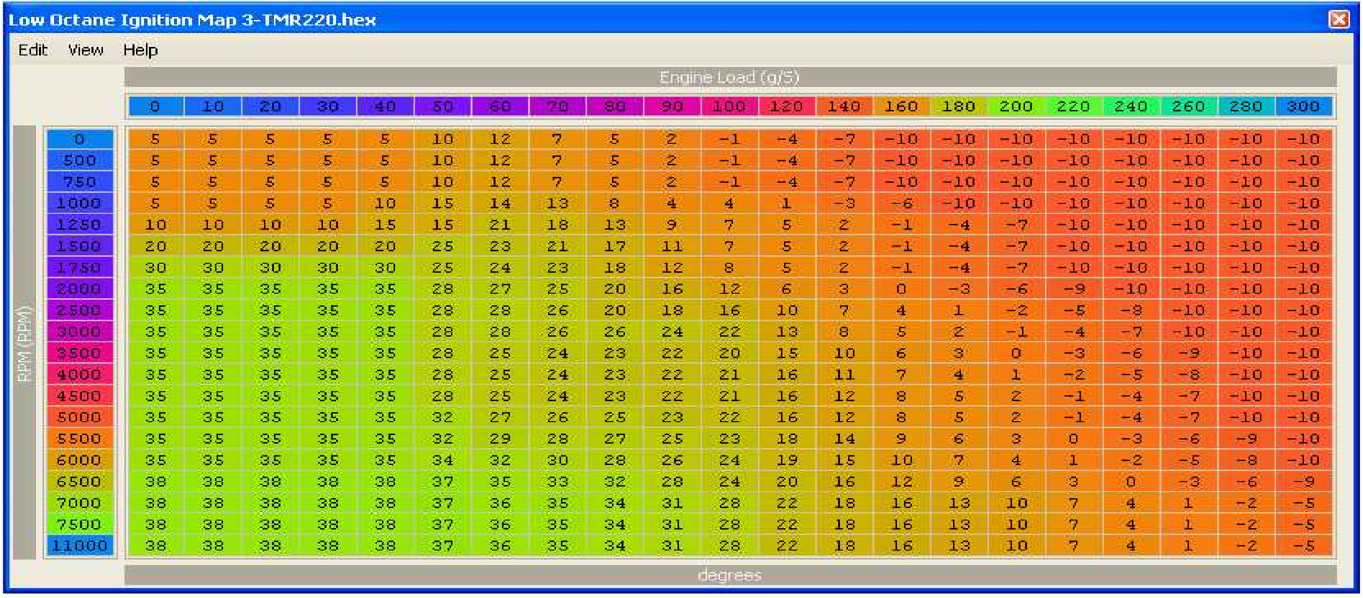


Low Octane Ignition Map 2-TMR220.hex

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
0	5	5	5	5	5	10	12	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10	-10	-10
500	5	5	5	5	5	10	12	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10	-10	-10
750	5	5	5	5	5	10	12	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10	-10	-10
1000	5	5	5	5	10	15	13	10	5	2	-2	-5	-8	-10	-10	-10	-10	-10	-10	-10	-10
1250	10	10	10	10	15	15	14	13	9	4	2	0	-3	-6	-10	-10	-10	-10	-10	-10	-10
1500	20	20	20	20	20	20	19	17	11	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10
1750	30	30	30	30	30	25	24	20	14	10	7	3	1	-2	-5	-8	-10	-10	-10	-10	-10
2000	35	35	35	35	35	30	28	22	17	12	9	3	0	-3	-6	-9	-10	-10	-10	-10	-10
2500	35	35	35	35	35	30	29	26	23	18	14	7	4	2	-1	-4	-7	-10	-10	-10	-10
3000	35	35	35	35	35	30	29	28	27	22	18	10	6	4	1	-2	-5	-8	-10	-10	-10
3500	35	35	35	35	35	30	29	26	25	23	21	13	8	6	3	0	-3	-6	-9	-10	-10
4000	35	35	35	35	35	30	29	26	25	23	21	15	11	8	5	2	-1	-4	-7	-10	-10
4500	35	35	35	35	35	30	29	26	25	23	21	17	11	8	5	2	-1	-4	-7	-10	-10
5000	35	35	35	35	35	30	29	26	25	23	21	17	12	10	7	4	1	-2	-5	-8	-10
5500	35	35	35	35	35	32	29	28	26	25	23	20	14	10	7	4	1	-2	-5	-8	-10
6000	35	35	35	35	35	34	32	29	27	25	24	20	15	12	9	6	3	0	-3	-6	-9
6500	38	38	38	38	38	37	35	33	32	28	24	20	16	12	9	6	3	0	-3	-6	-9
7000	38	38	38	38	38	37	36	35	34	31	28	22	18	16	13	10	7	4	1	-2	-5
7500	38	38	38	38	38	37	36	35	34	31	28	22	18	16	13	10	7	4	1	-2	-5
11000	38	38	38	38	38	37	36	35	34	31	28	22	18	16	13	10	7	4	1	-2	-5

degrees



Low Octane Ignition Map 3-TMR220.hex

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
0	5	5	5	5	5	10	12	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10	-10	-10
500	5	5	5	5	5	10	12	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10	-10	-10
750	5	5	5	5	5	10	12	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10	-10	-10
1000	5	5	5	5	10	15	14	13	8	4	4	1	-3	-6	-10	-10	-10	-10	-10	-10	-10
1250	10	10	10	10	15	15	21	18	13	9	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10
1500	20	20	20	20	20	25	23	21	17	11	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10
1750	30	30	30	30	30	25	24	23	18	12	8	5	2	-1	-4	-7	-10	-10	-10	-10	-10
2000	35	35	35	35	35	28	27	25	20	16	12	6	3	0	-3	-6	-9	-10	-10	-10	-10
2500	35	35	35	35	35	28	28	26	20	18	16	10	7	4	1	-2	-5	-8	-10	-10	-10
3000	35	35	35	35	35	28	28	26	26	24	22	13	8	5	2	-1	-4	-7	-10	-10	-10
3500	35	35	35	35	35	28	25	24	23	22	20	15	10	6	3	0	-3	-6	-9	-10	-10
4000	35	35	35	35	35	28	25	24	23	22	21	16	11	7	4	1	-2	-5	-8	-10	-10
4500	35	35	35	35	35	28	25	24	23	22	21	16	12	8	5	2	-1	-4	-7	-10	-10
5000	35	35	35	35	35	32	27	26	25	23	22	16	12	8	5	2	-1	-4	-7	-10	-10
5500	35	35	35	35	35	32	29	28	27	25	23	18	14	9	6	3	0	-3	-6	-9	-10
6000	35	35	35	35	35	34	32	30	28	26	24	19	15	10	7	4	1	-2	-5	-8	-10
6500	38	38	38	38	38	37	35	33	32	28	24	20	16	12	9	6	3	0	-3	-6	-9
7000	38	38	38	38	38	37	36	35	34	31	28	22	18	16	13	10	7	4	1	-2	-5
7500	38	38	38	38	38	37	36	35	34	31	28	22	18	16	13	10	7	4	1	-2	-5
11000	38	38	38	38	38	37	36	35	34	31	28	22	18	16	13	10	7	4	1	-2	-5

degrees

3.03-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.

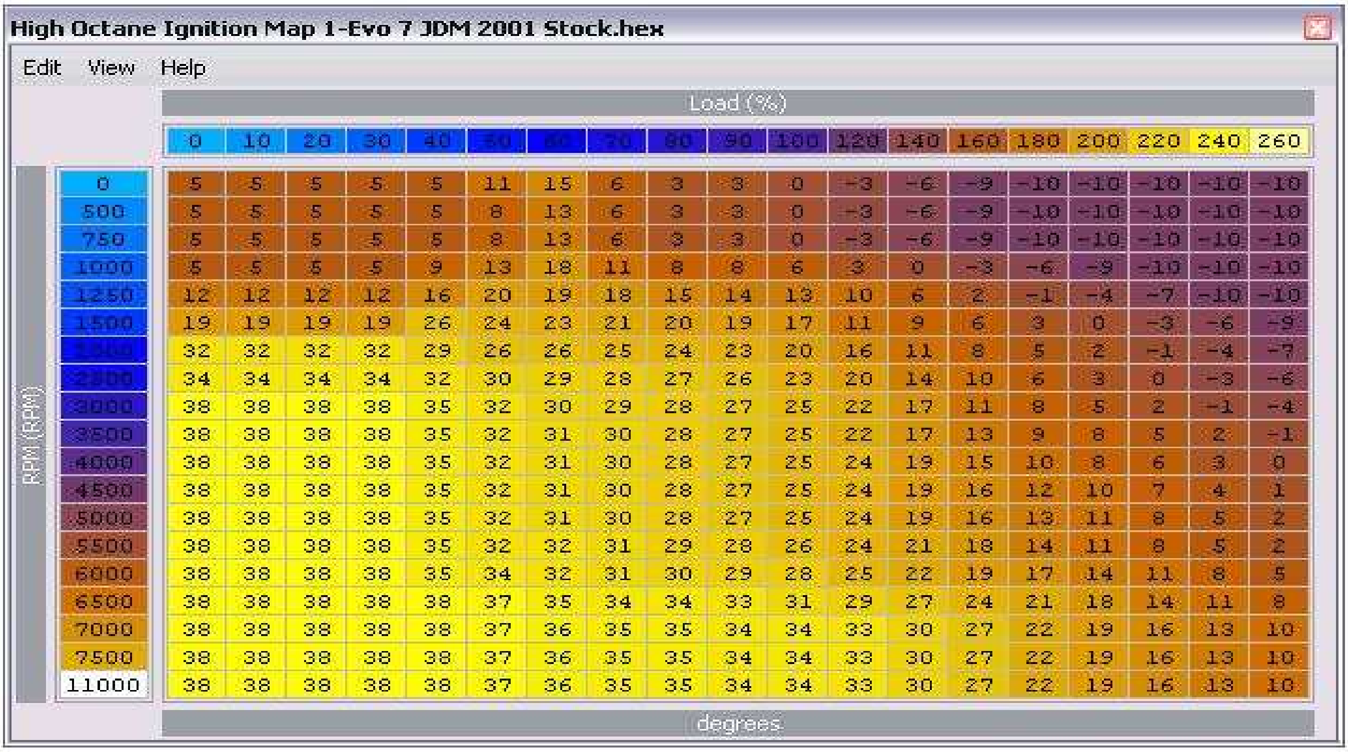
JDM maps typically have the most timing under boost and are probably intended to run on 100 octane fuel. When a JDM Evo7 is imported into Australia, and typically run on BP Ultimate 98 octane, owners report an improvement in performance when run on 100 octane fuel. This is indicative of the ECU re-gaining some timing advance. It is important to appreciate that the Evo 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/untuned JDM import Evo in Australia, using 98RON fuel, EvoScan should always be reporting some **low** (1-3) level of knock.

For Evos run on US fuel, pump gas between 91 and 93 octane, 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. US tuners report good results when using E85 and re-tuning the ECU and injectors to suite.

When using normal gasoline fuels, my thinking is to run the car on BP 98, run the **best** factory HI-OCTANE map and let the ECU do its thing via the knock sensor. And putting some 100 octane race fuel in the tank on track-days if available.

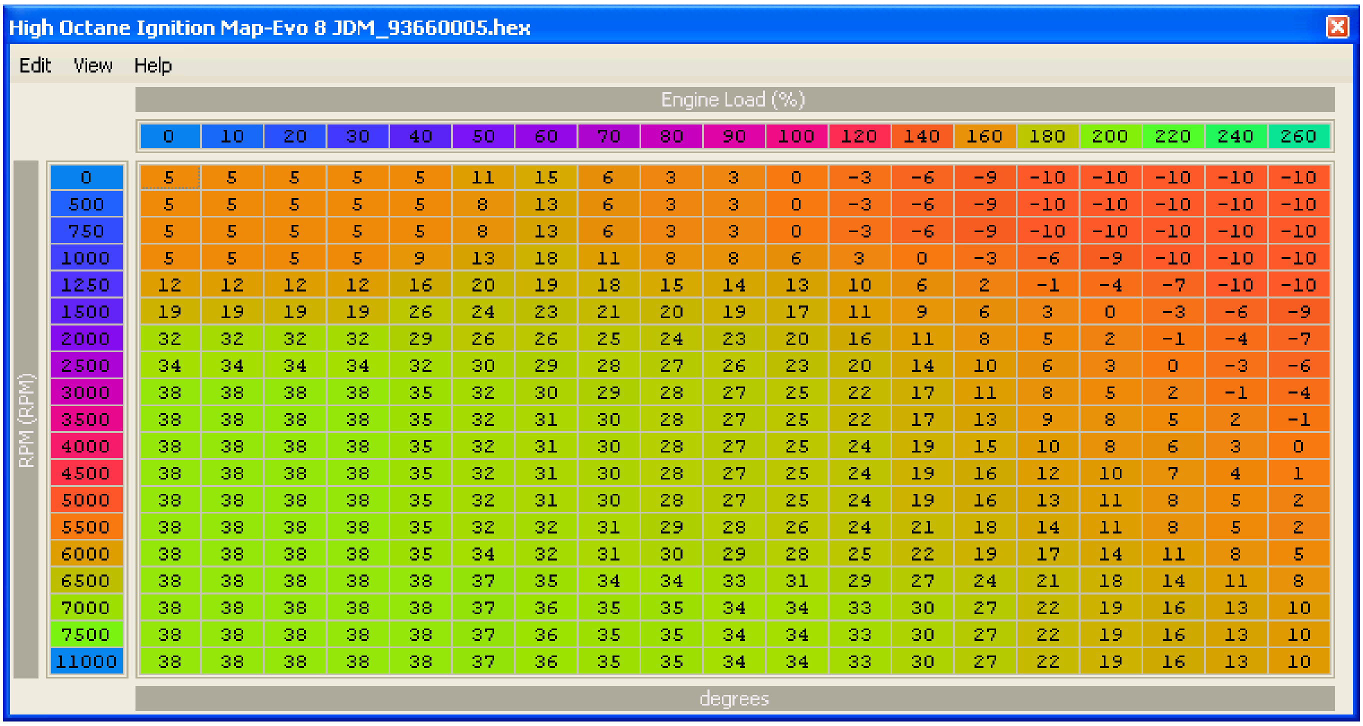
When you start using **E85** or similar **ethanol fuels** or when using meth-water injection, the spark map tuning gets a whole lot harder and you can no longer rely on the knock sensor to give you the definitive answer as how much timing is too much. E85 for example can accept spark advance that would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

Figure 29: IGNITION TUNING – HI-OCTANE SPARK MAP, JDM Evo7



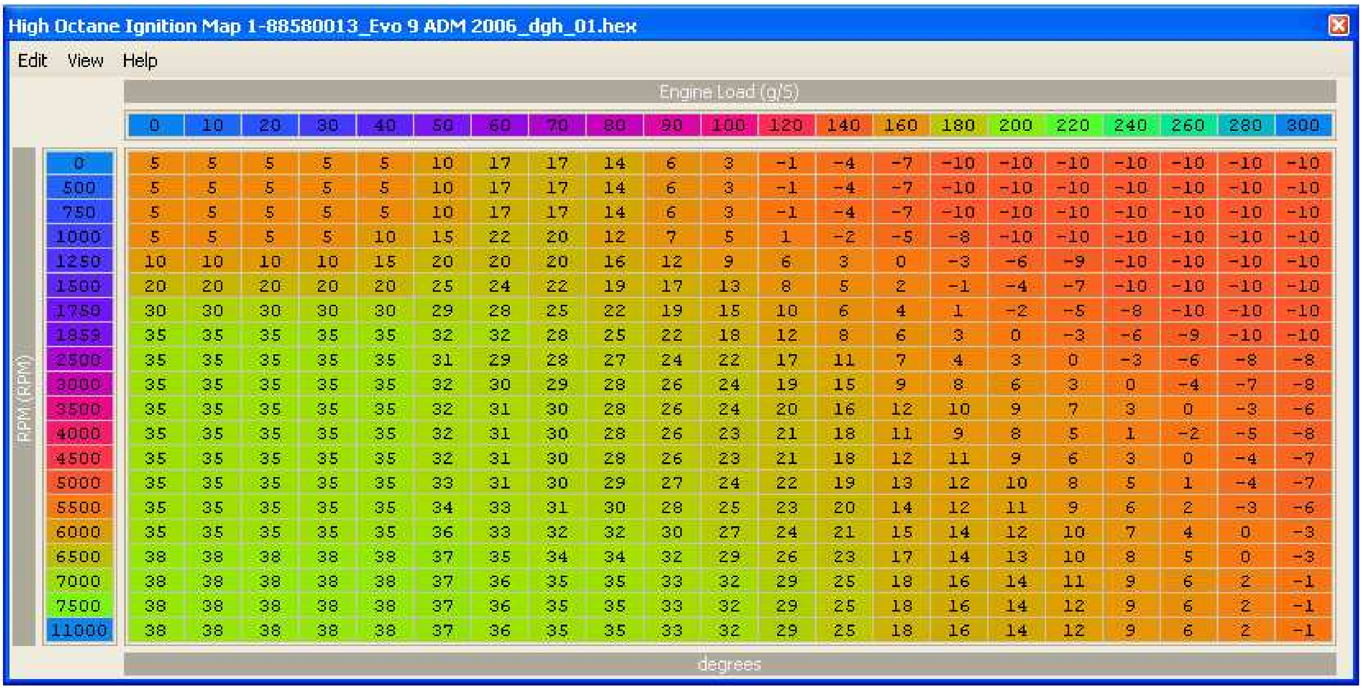
	0	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260
0	5	5	5	5	5	11	15	6	3	3	0	-3	-6	-9	-10	-10	-10	-10	-10
500	5	5	5	5	5	8	13	6	3	3	0	-3	-6	-9	-10	-10	-10	-10	-10
750	5	5	5	5	5	8	13	6	3	3	0	-3	-6	-9	-10	-10	-10	-10	-10
1000	5	5	5	5	9	13	18	11	8	8	6	3	0	-3	-6	-9	-10	-10	-10
1250	12	12	12	12	16	20	19	18	15	14	13	10	6	2	-1	-4	-7	-10	-10
1500	19	19	19	19	26	24	23	21	20	19	17	11	9	6	3	0	-3	-6	-9
2000	32	32	32	32	29	26	26	25	24	23	20	16	11	8	5	2	-1	-4	-7
2500	34	34	34	34	32	30	29	28	27	26	23	20	14	10	6	3	0	-3	-6
3000	38	38	38	38	35	32	30	29	28	27	25	22	17	11	8	5	2	-1	-4
3500	38	38	38	38	35	32	31	30	28	27	25	22	17	13	9	8	5	2	-1
4000	38	38	38	38	35	32	31	30	28	27	25	24	19	15	10	8	6	3	0
4500	38	38	38	38	35	32	31	30	28	27	25	24	19	16	12	10	7	4	1
5000	38	38	38	38	35	32	31	30	28	27	25	24	19	16	13	11	8	5	2
5500	38	38	38	38	35	32	32	31	29	28	26	24	21	18	14	11	8	5	2
6000	38	38	38	38	35	34	32	31	30	29	28	25	22	19	17	14	11	8	5
6500	38	38	38	38	38	37	35	34	34	33	31	29	27	24	21	18	14	11	8
7000	38	38	38	38	38	37	36	35	35	34	34	33	30	27	22	19	16	13	10
7500	38	38	38	38	38	37	36	35	35	34	34	33	30	27	22	19	16	13	10
11000	38	38	38	38	38	37	36	35	35	34	34	33	30	27	22	19	16	13	10

Figure 30: IGNITION TUNING – HI-OCTANE SPARK MAP, Evo8



	0	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260
0	5	5	5	5	5	11	15	6	3	3	0	-3	-6	-9	-10	-10	-10	-10	-10
500	5	5	5	5	5	8	13	6	3	3	0	-3	-6	-9	-10	-10	-10	-10	-10
750	5	5	5	5	5	8	13	6	3	3	0	-3	-6	-9	-10	-10	-10	-10	-10
1000	5	5	5	5	9	13	18	11	8	8	6	3	0	-3	-6	-9	-10	-10	-10
1250	12	12	12	12	16	20	19	18	15	14	13	10	6	2	-1	-4	-7	-10	-10
1500	19	19	19	19	26	24	23	21	20	19	17	11	9	6	3	0	-3	-6	-9
2000	32	32	32	32	29	26	26	25	24	23	20	16	11	8	5	2	-1	-4	-7
2500	34	34	34	34	32	30	29	28	27	26	23	20	14	10	6	3	0	-3	-6
3000	38	38	38	38	35	32	30	29	28	27	25	22	17	11	8	5	2	-1	-4
3500	38	38	38	38	35	32	31	30	28	27	25	22	17	13	9	8	5	2	-1
4000	38	38	38	38	35	32	31	30	28	27	25	24	19	15	10	8	6	3	0
4500	38	38	38	38	35	32	31	30	28	27	25	24	19	16	12	10	7	4	1
5000	38	38	38	38	35	32	31	30	28	27	25	24	19	16	13	11	8	5	2
5500	38	38	38	38	35	32	32	31	29	28	26	24	21	18	14	11	8	5	2
6000	38	38	38	38	35	34	32	31	30	29	28	25	22	19	17	14	11	8	5
6500	38	38	38	38	38	37	35	34	34	33	31	29	27	24	21	18	14	11	8
7000	38	38	38	38	38	37	36	35	35	34	34	33	30	27	22	19	16	13	10
7500	38	38	38	38	38	37	36	35	35	34	34	33	30	27	22	19	16	13	10
11000	38	38	38	38	38	37	36	35	35	34	34	33	30	27	22	19	16	13	10

Figure 31: IGNITION TUNING – Evo9 GSR HI-OCTANE SPARK MAP #1, WARMUP

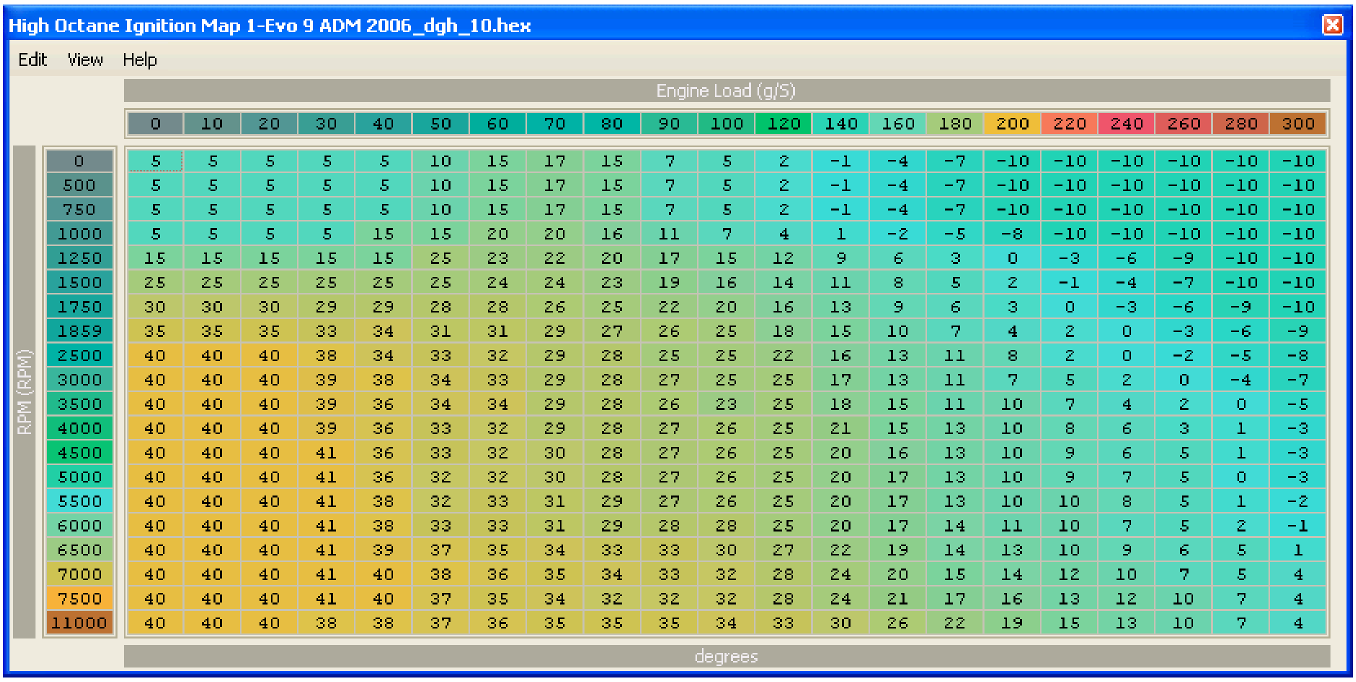


Engine Load (g/S)

RPM (RPM)	0	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300
0	5	5	5	5	5	10	17	17	14	6	3	-1	-4	-7	-10	-10	-10	-10	-10	-10	-10
500	5	5	5	5	5	10	17	17	14	6	3	-1	-4	-7	-10	-10	-10	-10	-10	-10	-10
750	5	5	5	5	5	10	17	17	14	6	3	-1	-4	-7	-10	-10	-10	-10	-10	-10	-10
1000	5	5	5	5	10	15	22	20	12	7	5	1	-2	-5	-8	-10	-10	-10	-10	-10	-10
1250	10	10	10	10	15	20	20	20	16	12	9	6	3	0	-3	-6	-9	-10	-10	-10	-10
1500	20	20	20	20	20	25	24	22	19	17	13	8	5	2	-1	-4	-7	-10	-10	-10	-10
1750	30	30	30	30	30	29	28	25	22	19	15	10	6	4	1	-2	-5	-8	-10	-10	-10
1859	35	35	35	35	35	32	32	28	25	22	18	12	8	6	3	0	-3	-6	-9	-10	-10
2500	35	35	35	35	35	31	29	28	27	24	22	17	11	7	4	3	0	-3	-6	-8	-8
3000	35	35	35	35	35	32	30	29	28	26	24	19	15	9	8	6	3	0	-4	-7	-8
3500	35	35	35	35	35	32	31	30	28	26	24	20	16	12	10	9	7	3	0	-3	-6
4000	35	35	35	35	35	32	31	30	28	26	23	21	18	11	9	8	5	1	-2	-5	-8
4500	35	35	35	35	35	32	31	30	28	26	23	21	18	12	11	9	6	3	0	-4	-7
5000	35	35	35	35	35	33	31	30	29	27	24	22	19	13	12	10	8	5	1	-4	-7
5500	35	35	35	35	35	34	33	31	30	28	25	23	20	14	12	11	9	6	2	-3	-6
6000	35	35	35	35	35	36	33	32	32	30	27	24	21	15	14	12	10	7	4	0	-3
6500	38	38	38	38	38	37	35	34	34	32	29	26	23	17	14	13	10	8	5	0	-3
7000	38	38	38	38	38	37	36	35	35	33	32	29	25	18	16	14	11	9	6	2	-1
7500	38	38	38	38	38	37	36	35	35	33	32	29	25	18	16	14	12	9	6	2	-1
11000	38	38	38	38	38	37	36	35	35	33	32	29	25	18	16	14	12	9	6	2	-1

degrees

Figure 32: IGNITION TUNING – Evo9 TMR220 HI-OCTANE SPARK MAP #1, WARMUP

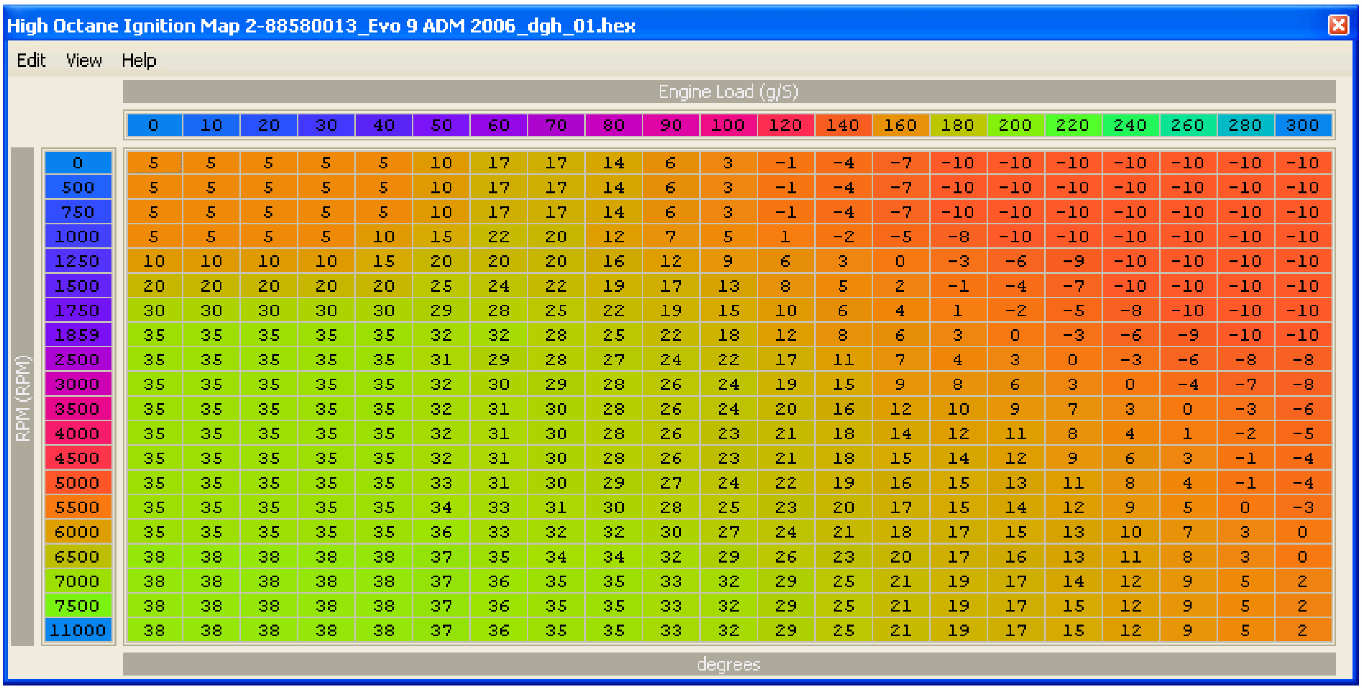


Engine Load (g/S)

RPM (RPM)	0	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300
0	5	5	5	5	5	10	15	17	15	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10
500	5	5	5	5	5	10	15	17	15	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10
750	5	5	5	5	5	10	15	17	15	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10
1000	5	5	5	5	15	15	20	20	16	11	7	4	1	-2	-5	-8	-10	-10	-10	-10	-10
1250	15	15	15	15	15	25	23	22	20	17	15	12	9	6	3	0	-3	-6	-9	-10	-10
1500	25	25	25	25	25	25	24	24	23	19	16	14	11	8	5	2	-1	-4	-7	-10	-10
1750	30	30	30	29	29	28	28	26	25	22	20	16	13	9	6	3	0	-3	-6	-9	-10
1859	35	35	35	33	34	31	31	29	27	26	25	18	15	10	7	4	2	0	-3	-6	-9
2500	40	40	40	38	34	33	32	29	28	25	25	22	16	13	11	8	2	0	-2	-5	-8
3000	40	40	40	39	38	34	33	29	28	27	25	25	17	13	11	7	5	2	0	-4	-7
3500	40	40	40	39	36	34	34	29	28	26	23	25	18	15	11	10	7	4	2	0	-5
4000	40	40	40	39	36	33	32	29	28	27	26	25	21	15	13	10	8	6	3	1	-3
4500	40	40	40	41	36	33	32	30	28	27	26	25	20	16	13	10	9	6	5	1	-3
5000	40	40	40	41	36	32	32	30	28	27	26	25	20	17	13	10	9	7	5	0	-3
5500	40	40	40	41	38	32	33	31	29	27	26	25	20	17	13	10	10	8	5	1	-2
6000	40	40	40	41	38	33	33	31	29	28	28	25	20	17	14	11	10	7	5	2	-1
6500	40	40	40	41	39	37	35	34	33	33	30	27	22	19	14	13	10	9	6	5	1
7000	40	40	40	41	40	38	36	35	34	33	32	28	24	20	15	14	12	10	7	5	4
7500	40	40	40	41	40	37	35	34	32	32	32	28	24	21	17	16	13	12	10	7	4
11000	40	40	40	38	38	37	36	35	35	35	34	33	30	26	22	19	15	13	10	7	4

degrees

Figure 33: IGNITION TUNING – Evo9 GSR HI-OCTANE SPARK MAP #2, MAIN

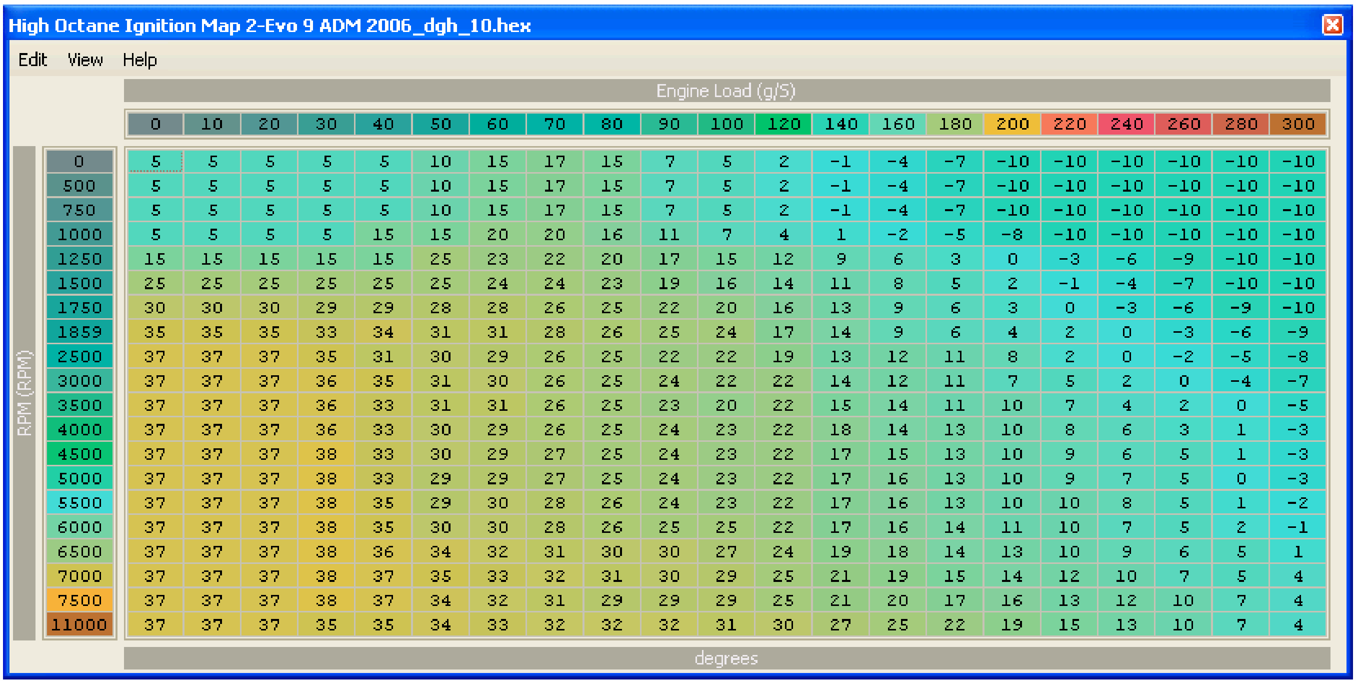


Engine Load (g/S)

RPM (RPM)	0	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300
0	5	5	5	5	5	10	17	17	14	6	3	-1	-4	-7	-10	-10	-10	-10	-10	-10	-10
500	5	5	5	5	5	10	17	17	14	6	3	-1	-4	-7	-10	-10	-10	-10	-10	-10	-10
750	5	5	5	5	5	10	17	17	14	6	3	-1	-4	-7	-10	-10	-10	-10	-10	-10	-10
1000	5	5	5	5	10	15	22	20	12	7	5	1	-2	-5	-8	-10	-10	-10	-10	-10	-10
1250	10	10	10	10	15	20	20	20	16	12	9	6	3	0	-3	-6	-9	-10	-10	-10	-10
1500	20	20	20	20	20	25	24	22	19	17	13	8	5	2	-1	-4	-7	-10	-10	-10	-10
1750	30	30	30	30	30	29	28	25	22	19	15	10	6	4	1	-2	-5	-8	-10	-10	-10
1859	35	35	35	35	35	32	32	28	25	22	18	12	8	6	3	0	-3	-6	-9	-10	-10
2500	35	35	35	35	35	31	29	28	27	24	22	17	11	7	4	3	0	-3	-6	-8	-8
3000	35	35	35	35	35	32	30	29	28	26	24	19	15	9	8	6	3	0	-4	-7	-8
3500	35	35	35	35	35	32	31	30	28	26	24	20	16	12	10	9	7	3	0	-3	-6
4000	35	35	35	35	35	32	31	30	28	26	23	21	18	14	12	11	8	4	1	-2	-5
4500	35	35	35	35	35	32	31	30	28	26	23	21	18	15	14	12	9	6	3	-1	-4
5000	35	35	35	35	35	33	31	30	29	27	24	22	19	16	15	13	11	8	4	-1	-4
5500	35	35	35	35	35	34	33	31	30	28	25	23	20	17	15	14	12	9	5	0	-3
6000	35	35	35	35	35	36	33	32	32	30	27	24	21	18	17	15	13	10	7	3	0
6500	38	38	38	38	38	37	35	34	34	32	29	26	23	20	17	16	13	11	8	3	0
7000	38	38	38	38	38	37	36	35	35	33	32	29	25	21	19	17	14	12	9	5	2
7500	38	38	38	38	38	37	36	35	35	33	32	29	25	21	19	17	15	12	9	5	2
11000	38	38	38	38	38	37	36	35	35	33	32	29	25	21	19	17	15	12	9	5	2

degrees

Figure 34: IGNITION TUNING – Evo9 TMR220 HI-OCTANE SPARK MAP #2, MAIN

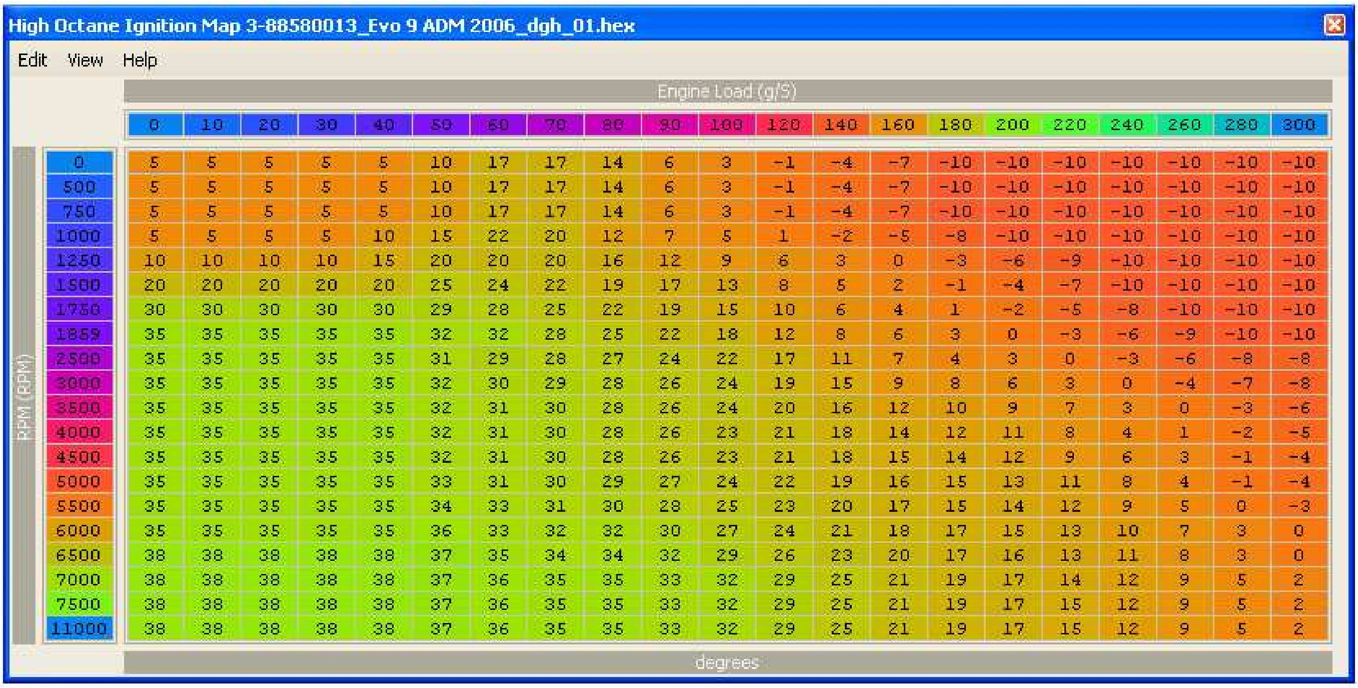


Engine Load (g/S)

RPM (RPM)	0	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300
0	5	5	5	5	5	10	15	17	15	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10
500	5	5	5	5	5	10	15	17	15	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10
750	5	5	5	5	5	10	15	17	15	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10
1000	5	5	5	5	15	15	20	20	16	11	7	4	1	-2	-5	-8	-10	-10	-10	-10	-10
1250	15	15	15	15	15	25	23	22	20	17	15	12	9	6	3	0	-3	-6	-9	-10	-10
1500	25	25	25	25	25	25	24	24	23	19	16	14	11	8	5	2	-1	-4	-7	-10	-10
1750	30	30	30	29	29	28	28	26	25	22	20	16	13	9	6	3	0	-3	-6	-9	-10
1859	35	35	35	33	34	31	31	28	26	25	24	17	14	9	6	4	2	0	-3	-6	-9
2500	37	37	37	35	31	30	29	26	25	22	22	19	13	12	11	8	2	0	-2	-5	-8
3000	37	37	37	36	35	31	30	26	25	24	22	22	14	12	11	7	5	2	0	-4	-7
3500	37	37	37	36	33	31	31	26	25	23	20	22	15	14	11	10	7	4	2	0	-5
4000	37	37	37	36	33	30	29	26	25	24	23	22	18	14	13	10	8	6	3	1	-3
4500	37	37	37	38	33	30	29	27	25	24	23	22	17	15	13	10	9	6	5	1	-3
5000	37	37	37	38	33	29	29	27	25	24	23	22	17	16	13	10	9	7	5	0	-3
5500	37	37	37	38	35	29	30	28	26	24	23	22	17	16	13	10	10	8	5	1	-2
6000	37	37	37	38	35	30	30	28	26	25	25	22	17	16	14	11	10	7	5	2	-1
6500	37	37	37	38	36	34	32	31	30	30	27	24	19	18	14	13	10	9	6	5	1
7000	37	37	37	38	37	35	33	32	31	30	29	25	21	19	15	14	12	10	7	5	4
7500	37	37	37	38	37	34	32	31	29	29	29	25	21	20	17	16	13	12	10	7	4
11000	37	37	37	35	35	34	33	32	32	32	31	30	27	25	22	19	15	13	10	7	4

degrees

Figure 35: IGNITION TUNING – Evo9 GSR HI-OCTANE SPARK MAP #3, FAULT



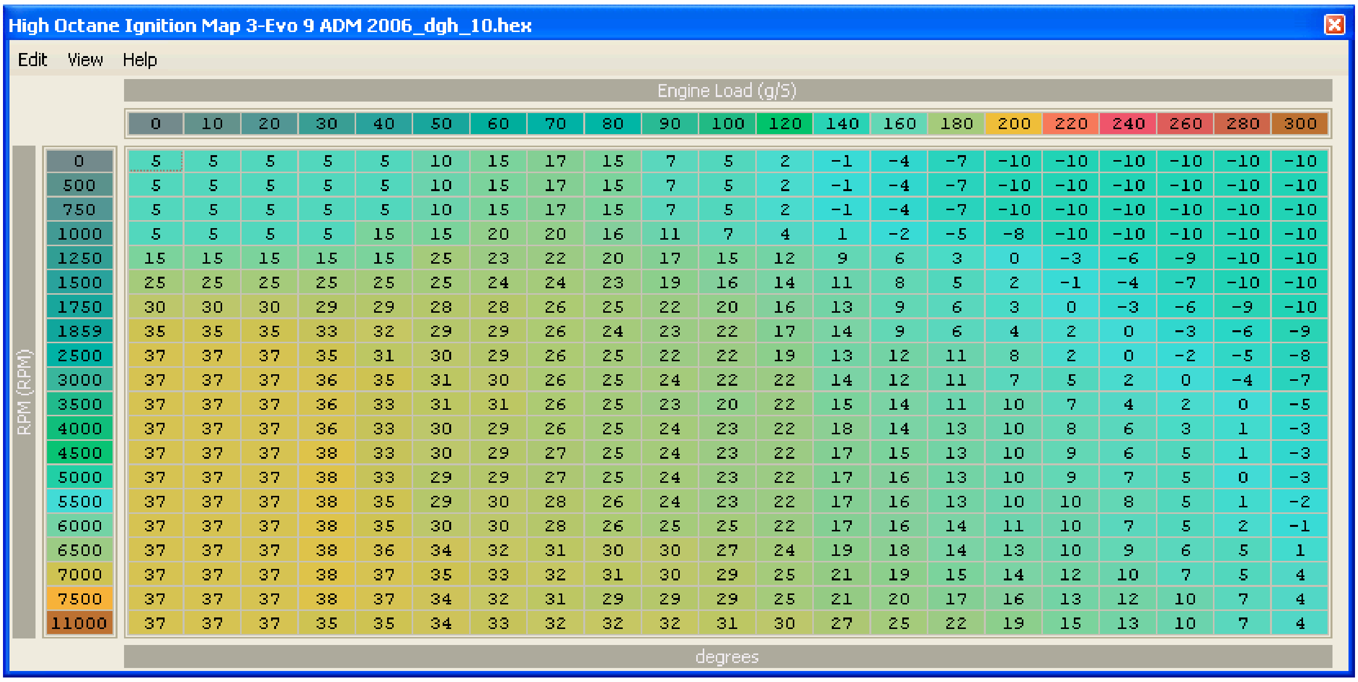
High Octane Ignition Map 3-88580013_Evo 9 ADM 2006_dgh_01.hex

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
0	5	5	5	5	5	10	17	17	14	6	3	-1	-4	-7	-10	-10	-10	-10	-10	-10	-10
500	5	5	5	5	5	10	17	17	14	6	3	-1	-4	-7	-10	-10	-10	-10	-10	-10	-10
750	5	5	5	5	5	10	17	17	14	6	3	-1	-4	-7	-10	-10	-10	-10	-10	-10	-10
1000	5	5	5	5	10	15	22	20	12	7	5	1	-2	-5	-8	-10	-10	-10	-10	-10	-10
1250	10	10	10	10	15	20	20	20	16	12	9	6	3	0	-3	-6	-9	-10	-10	-10	-10
1500	20	20	20	20	20	25	24	22	19	17	13	8	5	2	-1	-4	-7	-10	-10	-10	-10
1750	30	30	30	30	30	29	28	25	22	19	15	10	6	4	1	-2	-5	-8	-10	-10	-10
1859	35	35	35	35	35	32	32	28	25	22	18	12	8	6	3	0	-3	-6	-9	-10	-10
2500	35	35	35	35	35	31	29	28	27	24	22	17	11	7	4	3	0	-3	-6	-8	-8
3000	35	35	35	35	35	32	30	29	28	26	24	19	15	9	8	6	3	0	-4	-7	-8
3500	35	35	35	35	35	32	31	30	28	26	24	20	16	12	10	9	7	3	0	-3	-6
4000	35	35	35	35	35	32	31	30	28	26	23	21	18	14	12	11	8	4	1	-2	-5
4500	35	35	35	35	35	32	31	30	28	26	23	21	18	15	14	12	9	6	3	-1	-4
5000	35	35	35	35	35	33	31	30	29	27	24	22	19	16	15	13	11	8	4	-1	-4
5500	35	35	35	35	35	34	33	31	30	28	25	23	20	17	15	14	12	9	5	0	-3
6000	35	35	35	35	35	36	33	32	32	30	27	24	21	18	17	15	13	10	7	3	0
6500	38	38	38	38	38	37	35	34	34	32	29	26	23	20	17	16	13	11	8	3	0
7000	38	38	38	38	38	37	36	35	35	33	32	29	25	21	19	17	14	12	9	5	2
7500	38	38	38	38	38	37	36	35	35	33	32	29	25	21	19	17	15	12	9	5	2
11000	38	38	38	38	38	37	36	35	35	33	32	29	25	21	19	17	15	12	9	5	2

degrees

Figure 36: IGNITION TUNING – Evo9 TMR220 HI-OCTANE SPARK MAP #3, FAULT



High Octane Ignition Map 3-Evo 9 ADM 2006_dgh_10.hex

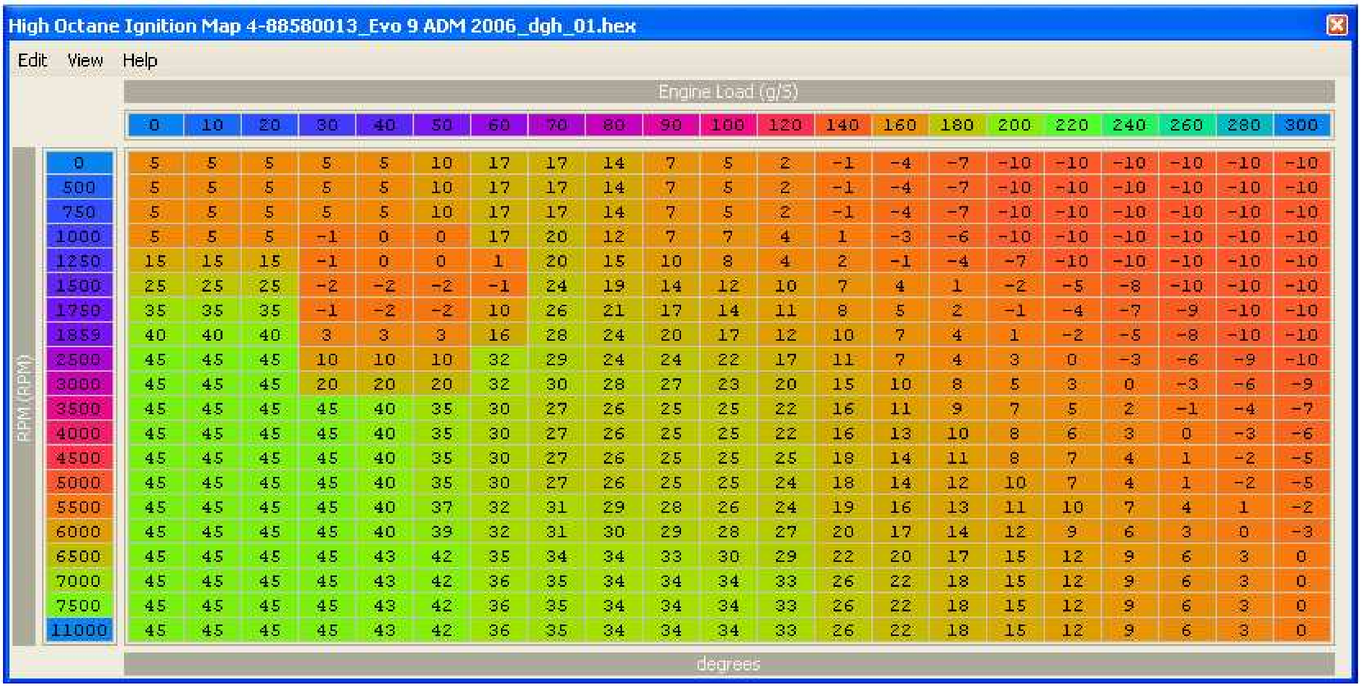
Engine Load (g/S)

RPM (RPM)	0	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300
0	5	5	5	5	5	10	15	17	15	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10
500	5	5	5	5	5	10	15	17	15	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10
750	5	5	5	5	5	10	15	17	15	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10
1000	5	5	5	5	15	15	20	20	16	11	7	4	1	-2	-5	-8	-10	-10	-10	-10	-10
1250	15	15	15	15	15	25	23	22	20	17	15	12	9	6	3	0	-3	-6	-9	-10	-10
1500	25	25	25	25	25	25	24	24	23	19	16	14	11	8	5	2	-1	-4	-7	-10	-10
1750	30	30	30	29	29	28	28	26	25	22	20	16	13	9	6	3	0	-3	-6	-9	-10
1859	35	35	35	33	32	29	29	26	24	23	22	17	14	9	6	4	2	0	-3	-6	-9
2500	37	37	37	35	31	30	29	26	25	22	22	19	13	12	11	8	2	0	-2	-5	-8
3000	37	37	37	36	35	31	30	26	25	24	22	22	14	12	11	7	5	2	0	-4	-7
3500	37	37	37	36	33	31	31	26	25	23	20	22	15	14	11	10	7	4	2	0	-5
4000	37	37	37	36	33	30	29	26	25	24	23	22	18	14	13	10	8	6	3	1	-3
4500	37	37	37	38	33	30	29	27	25	24	23	22	17	15	13	10	9	6	5	1	-3
5000	37	37	37	38	33	29	29	27	25	24	23	22	17	16	13	10	9	7	5	0	-3
5500	37	37	37	38	35	29	30	28	26	24	23	22	17	16	13	10	10	8	5	1	-2
6000	37	37	37	38	35	30	30	28	26	25	25	22	17	16	14	11	10	7	5	2	-1
6500	37	37	37	38	36	34	32	31	30	30	27	24	19	18	14	13	10	9	6	5	1
7000	37	37	37	38	37	35	33	32	31	30	29	25	21	19	15	14	12	10	7	5	4
7500	37	37	37	38	37	34	32	31	29	29	29	25	21	20	17	16	13	12	10	7	4
11000	37	37	37	35	35	34	33	32	32	32	31	30	27	25	22	19	15	13	10	7	4

degrees

Many people from the EvoM community have long complained of the apparent Evo9 timing inconsistencies and the usual answer is to set maps 1-2-3 to the same values. However this fourth map is also in the ROM, its use and application is un-documented at present but it could be a contributing factor.

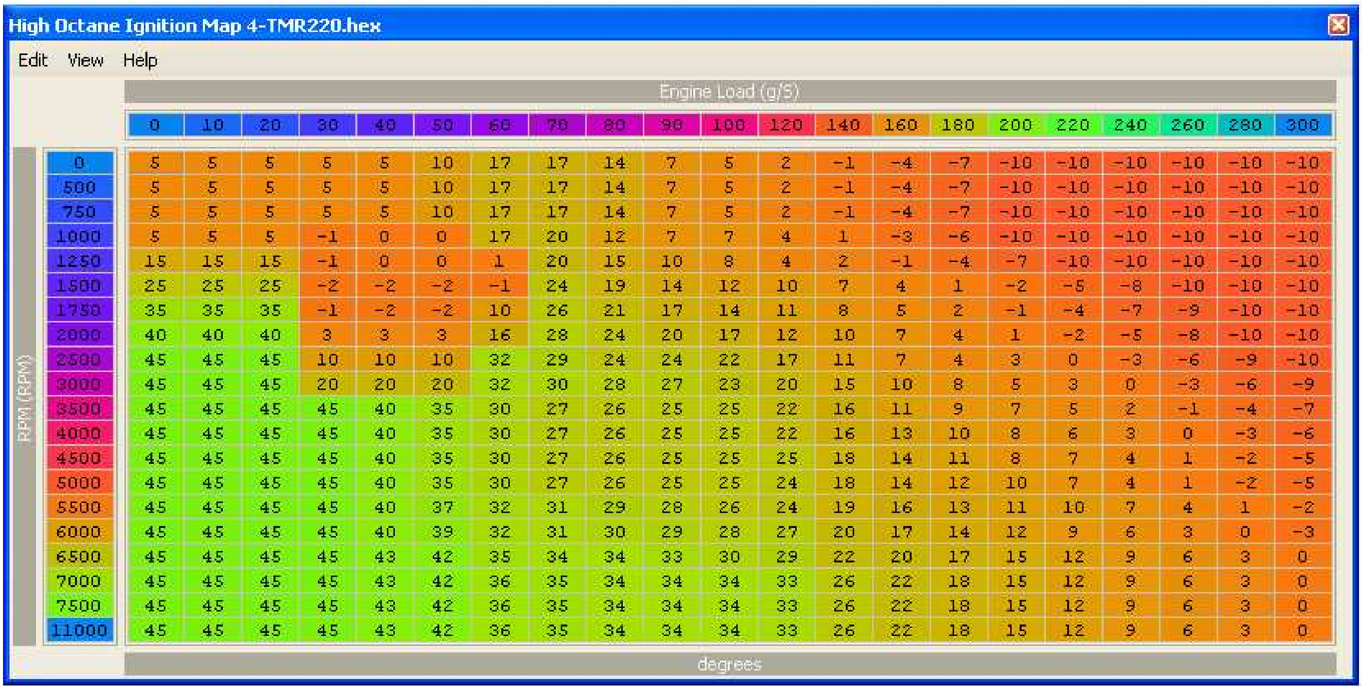
Figure 37: IGNITION TUNING – Evo9 GSR HI-OCTANE SPARK MAP #4, ?



High Octane Ignition Map 4-88580013_Evo 9 ADM 2006_dgh_01.hex

	0	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300
0	5	5	5	5	5	10	17	17	14	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10
500	5	5	5	5	5	10	17	17	14	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10
750	5	5	5	5	5	10	17	17	14	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10
1000	5	5	5	-1	0	0	17	20	12	7	7	4	1	-3	-6	-10	-10	-10	-10	-10	-10
1250	15	15	15	-1	0	0	1	20	15	10	8	4	2	-1	-4	-7	-10	-10	-10	-10	-10
1500	25	25	25	-2	-2	-2	-1	24	19	14	12	10	7	4	1	-2	-5	-8	-10	-10	-10
1750	35	35	35	-1	-2	-2	10	26	21	17	14	11	8	5	2	-1	-4	-7	-9	-10	-10
1859	40	40	40	3	3	3	16	28	24	20	17	12	10	7	4	1	-2	-5	-8	-10	-10
2500	45	45	45	10	10	10	32	29	24	24	22	17	11	7	4	3	0	-3	-6	-9	-10
3000	45	45	45	20	20	20	32	30	28	27	23	20	15	10	8	5	3	0	-3	-6	-9
3500	45	45	45	45	40	35	30	27	26	25	25	22	16	11	9	7	5	2	-1	-4	-7
4000	45	45	45	45	40	35	30	27	26	25	25	22	16	13	10	8	6	3	0	-3	-6
4500	45	45	45	45	40	35	30	27	26	25	25	25	18	14	11	8	7	4	1	-2	-5
5000	45	45	45	45	40	35	30	27	26	25	25	24	18	14	12	10	7	4	1	-2	-5
5500	45	45	45	45	40	37	32	31	29	28	26	24	19	16	13	11	10	7	4	1	-2
6000	45	45	45	45	40	39	32	31	30	29	28	27	20	17	14	12	9	6	3	0	-3
6500	45	45	45	45	43	42	35	34	34	33	30	29	22	20	17	15	12	9	6	3	0
7000	45	45	45	45	43	42	36	35	34	34	34	33	26	22	18	15	12	9	6	3	0
7500	45	45	45	45	43	42	36	35	34	34	34	33	26	22	18	15	12	9	6	3	0
11000	45	45	45	45	43	42	36	35	34	34	34	33	26	22	18	15	12	9	6	3	0

Figure 38: IGNITION TUNING – Evo9 TMR220 HI-OCTANE SPARK MAP #4, ?



High Octane Ignition Map 4-TMR220.hex

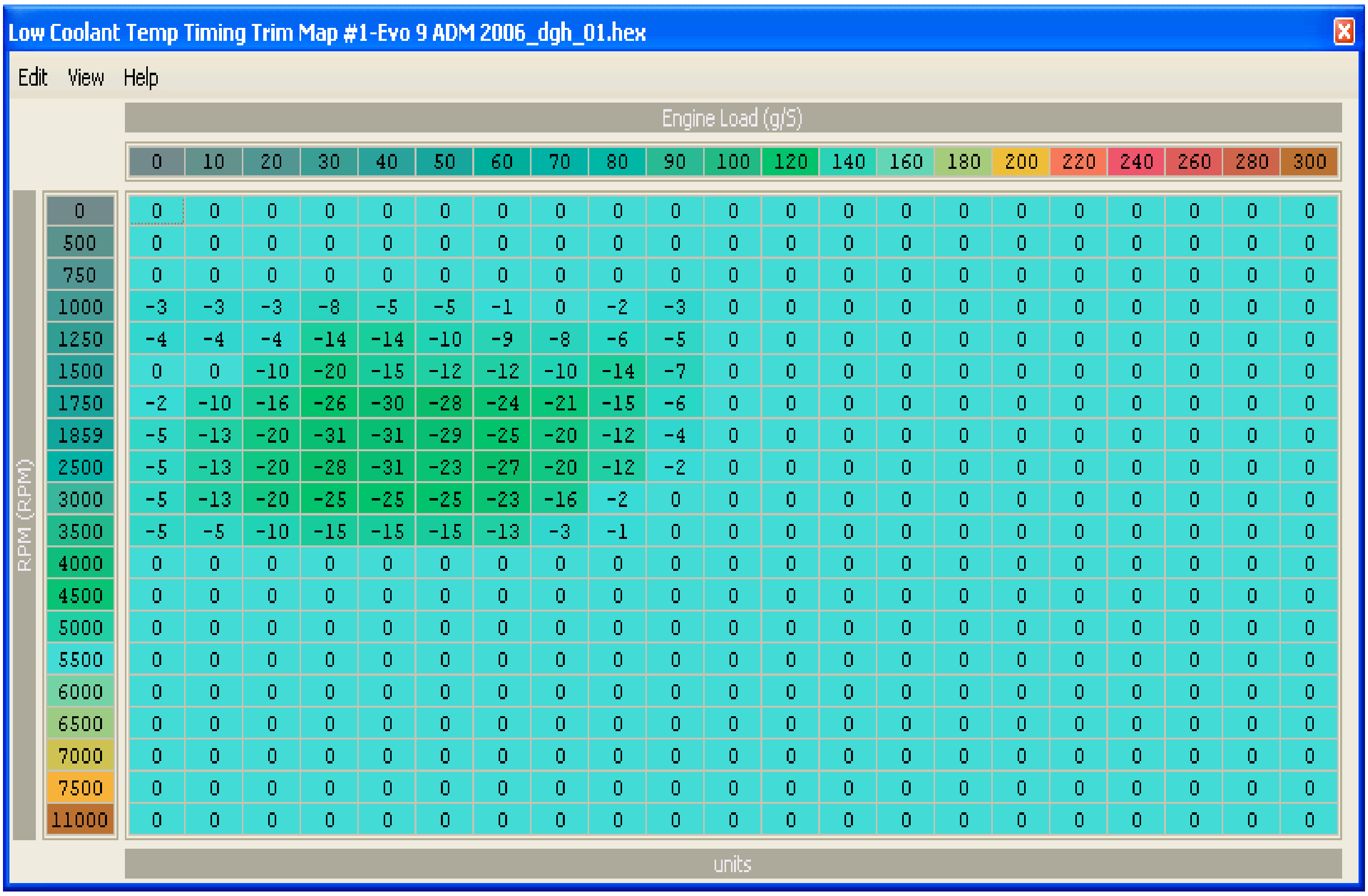
	0	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300
0	5	5	5	5	5	10	17	17	14	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10
500	5	5	5	5	5	10	17	17	14	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10
750	5	5	5	5	5	10	17	17	14	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10
1000	5	5	5	-1	0	0	17	20	12	7	7	4	1	-3	-6	-10	-10	-10	-10	-10	-10
1250	15	15	15	-1	0	0	1	20	15	10	8	4	2	-1	-4	-7	-10	-10	-10	-10	-10
1500	25	25	25	-2	-2	-2	-1	24	19	14	12	10	7	4	1	-2	-5	-8	-10	-10	-10
1750	35	35	35	-1	-2	-2	10	26	21	17	14	11	8	5	2	-1	-4	-7	-9	-10	-10
2000	40	40	40	3	3	3	16	28	24	20	17	12	10	7	4	1	-2	-5	-8	-10	-10
2500	45	45	45	10	10	10	32	29	24	24	22	17	11	7	4	3	0	-3	-6	-9	-10
3000	45	45	45	20	20	20	32	30	28	27	23	20	15	10	8	5	3	0	-3	-6	-9
3500	45	45	45	45	40	35	30	27	26	25	25	22	16	11	9	7	5	2	-1	-4	-7
4000	45	45	45	45	40	35	30	27	26	25	25	22	16	13	10	8	6	3	0	-3	-6
4500	45	45	45	45	40	35	30	27	26	25	25	25	18	14	11	8	7	4	1	-2	-5
5000	45	45	45	45	40	35	30	27	26	25	25	24	18	14	12	10	7	4	1	-2	-5
5500	45	45	45	45	40	37	32	31	29	28	26	24	19	16	13	11	10	7	4	1	-2
6000	45	45	45	45	40	39	32	31	30	29	28	27	20	17	14	12	9	6	3	0	-3
6500	45	45	45	45	43	42	35	34	34	33	30	29	22	20	17	15	12	9	6	3	0
7000	45	45	45	45	43	42	36	35	34	34	34	33	26	22	18	15	12	9	6	3	0
7500	45	45	45	45	43	42	36	35	34	34	34	33	26	22	18	15	12	9	6	3	0
11000	45	45	45	45	43	42	36	35	34	34	34	33	26	22	18	15	12	9	6	3	0

3.04-IGNITION TUNING – CAT 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 CAT WARMUP RETARD SPARK MAP is used where the cell values are subtracted from the main hi-octane map. This map is commonly referred to as the WARMUP RETARD MAP on some xml definitions.

There is one of these maps in the Evo7 and Evo8, but there are usually three with the Evo9 and they may have the same values. In any case, make your changes to all the cat warm-up maps. 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 39: IGNITION TUNING – CAT WARMUP SPARK RETARD MAP, Evo9



	0	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
500	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
1000	-3	-3	-3	-8	-5	-5	-1	0	-2	-3	0	0	0	0	0	0	0	0	0	0	0
1250	-4	-4	-4	-14	-14	-10	-9	-8	-6	-5	0	0	0	0	0	0	0	0	0	0	0
1500	0	0	-10	-20	-15	-12	-12	-10	-14	-7	0	0	0	0	0	0	0	0	0	0	0
1750	-2	-10	-16	-26	-30	-28	-24	-21	-15	-6	0	0	0	0	0	0	0	0	0	0	0
1859	-5	-13	-20	-31	-31	-29	-25	-20	-12	-4	0	0	0	0	0	0	0	0	0	0	0
2500	-5	-13	-20	-28	-31	-23	-27	-20	-12	-2	0	0	0	0	0	0	0	0	0	0	0
3000	-5	-13	-20	-25	-25	-25	-23	-16	-2	0	0	0	0	0	0	0	0	0	0	0	0
3500	-5	-5	-10	-15	-15	-15	-13	-3	-1	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
4500	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
5500	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
6500	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
7500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

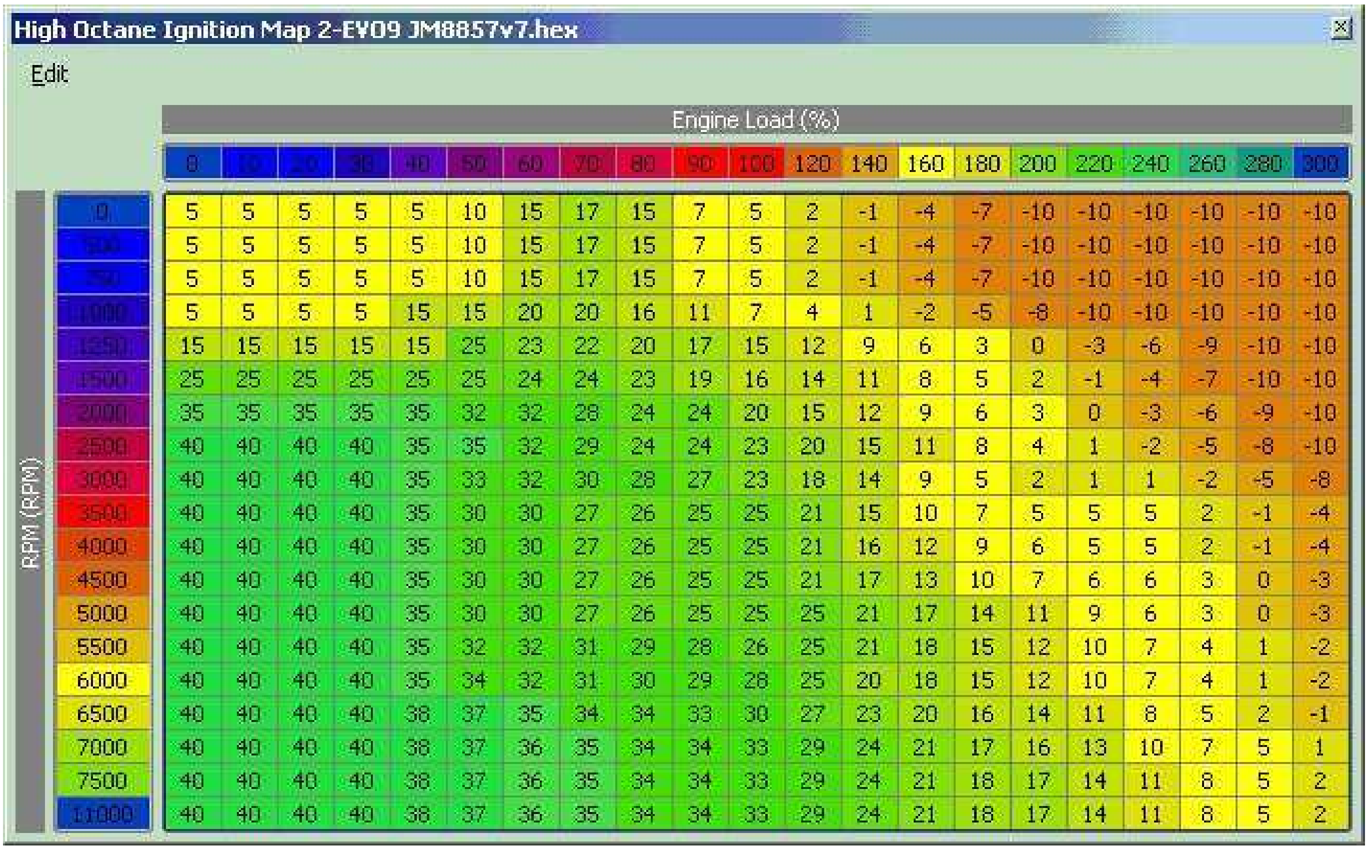
Note that if you have an Evo7-8 and re-scale the ignition load scale out to 300, then you are also changing the load scale on the CAT WARM-UP MAPS. This will really bugger things up if you forget to zero off the top three rows, as you will be retarding while on (low) boost.

3.05-IGNITION TUNING - ELIMINATING SHIFT KNOCK

The following HI-OCTANE SPARK MAP was posted by **jcsbanks** and is from his tuned FQ340 Evo9. It is included here to show some clever tuning. The engine is typically run on 98RON fuel.

This map is altered from the original JDM GSR by retarding 1 degree at 6000-6500, and flattening some timing at 120-220% from 3000-4500 RPM to get rid of lift off detonation. At 240 load or higher apart from at 6000-6500 RPM it runs stock timing.

Figure 40: IGNITION TUNING – tuned HI-OCTANE SPARK MAP – FQ340 EVO9



	0	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300
0	5	5	5	5	5	10	15	17	15	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10
500	5	5	5	5	5	10	15	17	15	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10
750	5	5	5	5	5	10	15	17	15	7	5	2	-1	-4	-7	-10	-10	-10	-10	-10	-10
1000	5	5	5	5	15	15	20	20	16	11	7	4	1	-2	-5	-8	-10	-10	-10	-10	-10
1250	15	15	15	15	15	25	23	22	20	17	15	12	9	6	3	0	-3	-6	-9	-10	-10
1500	25	25	25	25	25	25	24	24	23	19	16	14	11	8	5	2	-1	-4	-7	-10	-10
2000	35	35	35	35	35	32	32	28	24	24	20	15	12	9	6	3	0	-3	-6	-9	-10
2500	40	40	40	40	35	35	32	29	24	24	23	20	15	11	8	4	1	-2	-5	-8	-10
3000	40	40	40	40	35	33	32	30	28	27	23	18	14	9	5	2	1	1	-2	-5	-8
3500	40	40	40	40	35	30	30	27	26	25	25	21	15	10	7	5	5	5	2	-1	-4
4000	40	40	40	40	35	30	30	27	26	25	25	21	16	12	9	6	5	5	2	-1	-4
4500	40	40	40	40	35	30	30	27	26	25	25	21	17	13	10	7	6	6	3	0	-3
5000	40	40	40	40	35	30	30	27	26	25	25	25	21	17	14	11	9	6	3	0	-3
5500	40	40	40	40	35	32	32	31	29	28	26	25	21	18	15	12	10	7	4	1	-2
6000	40	40	40	40	35	34	32	31	30	29	28	25	20	18	15	12	10	7	4	1	-2
6500	40	40	40	40	38	37	35	34	34	33	30	27	23	20	16	14	11	8	5	2	-1
7000	40	40	40	40	38	37	36	35	34	34	33	29	24	21	17	16	13	10	7	5	1
7500	40	40	40	40	38	37	36	35	34	34	33	29	24	21	18	17	14	11	8	5	2
11000	40	40	40	40	38	37	36	35	34	34	33	29	24	21	18	17	14	11	8	5	2

Note that the rpm scaling shown with this Evo9 ROM has different values to the 88580013 ROM described earlier.

SECTION 4 – MIVEC TUNING

4.01-EVO IX MIVEC TUNING INTRODUCTION

The Evo9 has variable cam timing on the intake cam. It effectively works like an electrically adjustable cam-wheel and can vary the cam timing by 30 crank-shaft degrees, which is 15 degrees of camshaft movement. The values in the MIVEC table are degrees of crank rotation. Values can be entered from 0° to 28.8° in the table. You can input values beyond 29 in the table but the advance remains at 29°. At the time of writing, the Evo tuning community is not able log cam timing.

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.

4.02-EVO IX CAM TIMING

This is the general arrangement for the Evo9 from the 2006 Mitsubishi service manual.

Intake Valve Opens	0-30* BTDC	Inlet Valve Closes	80-50* ABDC
Exhaust Valve Opens	58* BBDC	Exhaust Valve Closes	18* ATDC

4.03-MIVEC TUNING– LIMIT ADJUSTMENTS

There are three MIVEC limiting parameters that can be modified. These are MIVEC Min-Angle Advance, MIVEC Max-Angle Advance and MIVEC Max-Angle v Coolant Temp.

Tuners have reported changing the MIVEC MIN-ADVANCE ANGLE to -20, then inputting negative values (eg -6) in the map at idle to get a smooth non-loopy idle with big cams. The factory cams will give a smooth non-loopy idle when set between -1.8 to 0.0.If you want a loopy idle on the factory cams, set the cam advance at idle from 14 to 19.

Figure 41: MIVEC TUNING, Min-Advance Angle & Max-Advance Angle

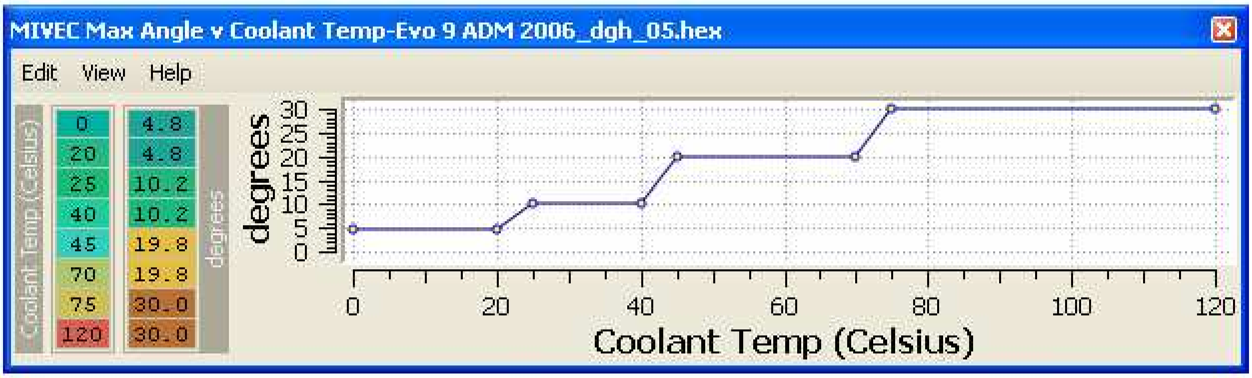
degrees 0.0

degrees 28.8

Due to the possible effect of having open valves hitting piston tops, I am not advocating changing the Min-Angle and Max-Angle values much past the factory set limits of zero and twenty eight point eight degrees

MIVEC Max-Angle v Coolant Temp can be modified to limit the maximum advance angle as the engine warms-up. The table shown below is modified to provide an increase in max-angle as the engine warms-up. The factory values are such that a limiting value is never imposed ie the temperature and angle values are set so no reduction in valve adjustment is implemented. However, the function is available for tuning if required. I use the values shown below in my own EVO9, as I have a long section of underground car-park to negotiate on a cold engine. As my MIVEC 3D map is quite aggressive, this eliminates any edgyness at low speed as the engine is warming-up.

Figure 42: MIVEC TUNING, tuned MIVEC Max-Angle v Coolant Temp



Coolant Temp (Celsius)	degrees
0	4.8
20	4.8
25	10.2
40	10.2
45	19.8
70	19.8
75	30.0
120	30.0

4.04-MIVEC TUNING - MAP DISCUSSION WITH EXAMPLES

MIVEC maps tend to follow a similar pattern: cam timing advance is set at zero 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 80 load, most tuners agree the advance should set to 29 degrees, or thereabouts, but there are only two rpm rows to transition from zero at 1000 rpm to 29 at 2000 rpm.

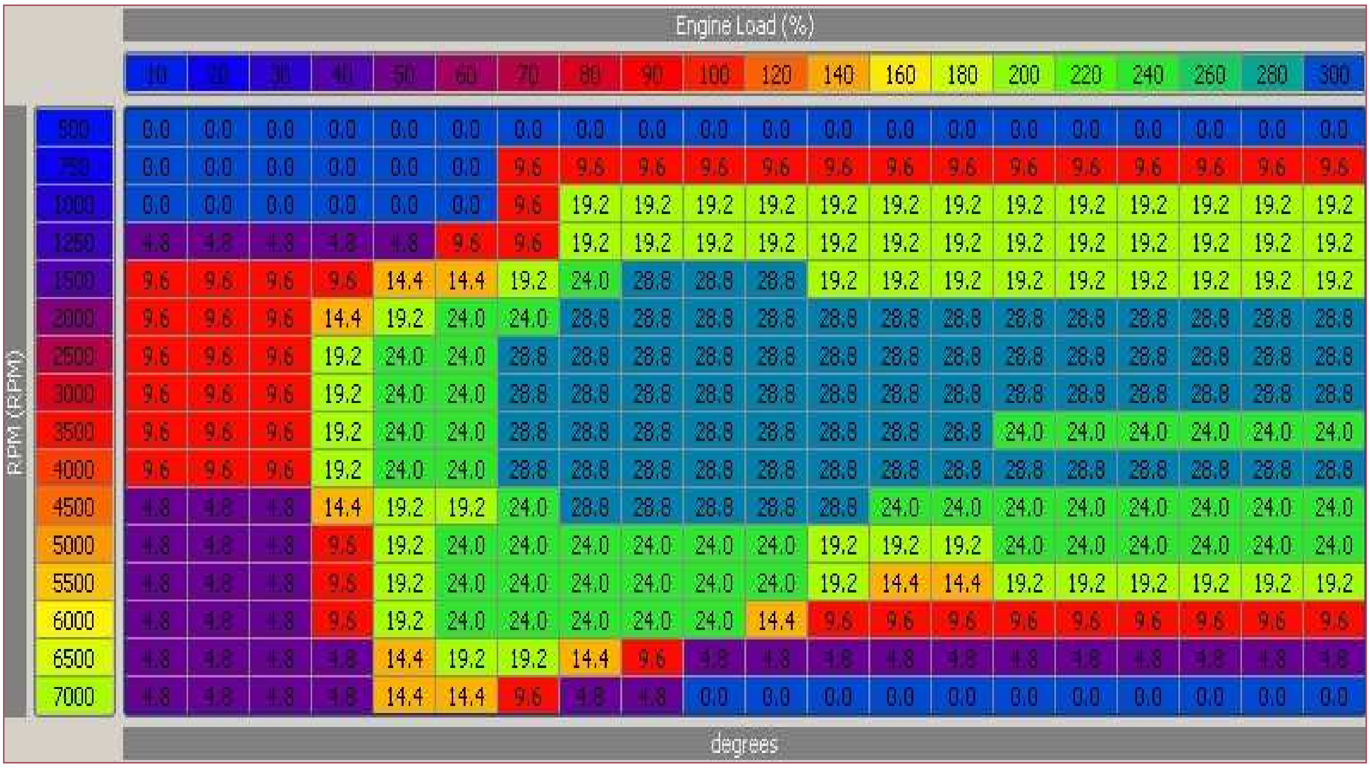
Due to higher exhaust gas back pressure, from 4500 rpm on stock and lightly modified setups, the advance should be progressively reduced, as per the JDM RS map or similar, so that at 6500 rpm and 100 load and above the advance is zero or very low. Numerous pro-tuners have reported no benefit to adding 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.

Most knowledgeable tuners start by using the EVO 9 JDM RS map. This map is the best or at least the most aggressive of the stock factory maps and is the basis for most MIVEC maps that are posted on **evelotutionm.net**.

Many of the posted maps, based on the JDM-RS map, have the advance in the “island” area changed from 24.0 to 28.8 or even 30. Two points about this are the maximum advance the system will give with the stock ECU MIVEC coding is 28.8 degrees and the island of 24 degrees from load 200 corresponds to the point of maximum torque. It is possible the factory set it like this as a safety measure against detonation, due to high exhaust gas back pressure.

When using high performance cams, the peak torque rpm point is likely to be different (at a higher rpm) so moving the island to the corresponding rpm may be beneficial.

Figure 43: MIVEC TUNING, JDM Evo9 RS MIVEC MAP



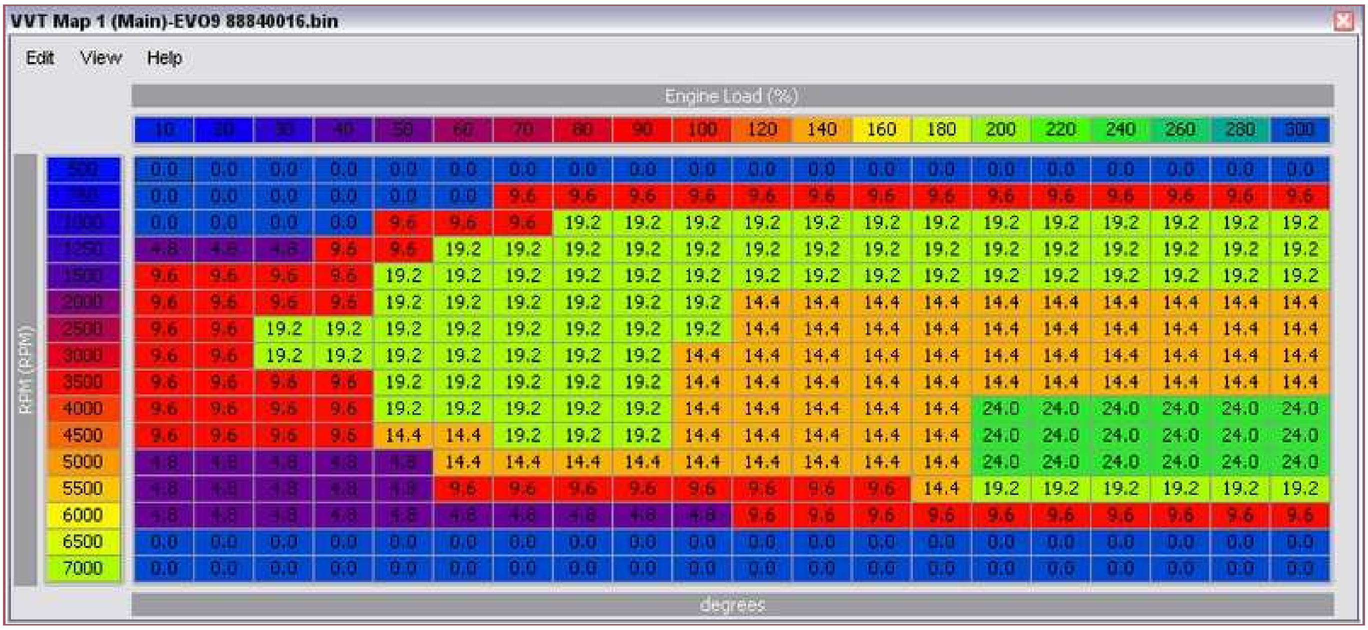
Engine Load (%)

RPM (RPM)	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300
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
750	0.0	0.0	0.0	0.0	0.0	0.0	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
1000	0.0	0.0	0.0	0.0	0.0	0.0	9.6	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
1250	4.8	4.8	4.8	4.8	4.8	9.6	9.6	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
1500	9.6	9.6	9.6	9.6	14.4	14.4	19.2	24.0	28.8	28.8	28.8	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
2000	9.6	9.6	9.6	14.4	19.2	24.0	24.0	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8
2500	9.6	9.6	9.6	19.2	24.0	24.0	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8
3000	9.6	9.6	9.6	19.2	24.0	24.0	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8
3500	9.6	9.6	9.6	19.2	24.0	24.0	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	24.0	24.0	24.0	24.0	24.0	24.0
4000	9.6	9.6	9.6	19.2	24.0	24.0	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8
4500	4.8	4.8	4.8	14.4	19.2	19.2	24.0	28.8	28.8	28.8	28.8	28.8	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
5000	4.8	4.8	4.8	9.6	19.2	24.0	24.0	24.0	24.0	24.0	24.0	19.2	19.2	19.2	24.0	24.0	24.0	24.0	24.0	24.0
5500	4.8	4.8	4.8	9.6	19.2	24.0	24.0	24.0	24.0	24.0	24.0	19.2	14.4	14.4	19.2	19.2	19.2	19.2	19.2	19.2
6000	4.8	4.8	4.8	9.6	19.2	24.0	24.0	24.0	24.0	24.0	14.4	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
6500	4.8	4.8	4.8	4.8	14.4	19.2	19.2	14.4	9.6	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
7000	4.8	4.8	4.8	4.8	14.4	14.4	9.6	4.8	4.8	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 JDM RS map above to the quite conservative USDM GSR map below. Both Evo9, but the RS map will give a much more responsive drive. This map is also used in European delivered Evo9s.

Figure 44: MIVEC TUNING, USDM Evo9 GSR MIVEC MAP - 88840016



Engine Load (%)

RPM (RPM)	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300
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
750	0.0	0.0	0.0	0.0	0.0	0.0	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
1000	0.0	0.0	0.0	0.0	9.6	9.6	9.6	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
1250	4.8	4.8	4.8	9.6	9.6	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
1500	9.6	9.6	9.6	9.6	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
2000	9.6	9.6	9.6	9.6	19.2	19.2	19.2	19.2	19.2	19.2	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4
2500	9.6	9.6	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4
3000	9.6	9.6	19.2	19.2	19.2	19.2	19.2	19.2	19.2	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4
3500	9.6	9.6	9.6	9.6	19.2	19.2	19.2	19.2	19.2	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4
4000	9.6	9.6	9.6	9.6	19.2	19.2	19.2	19.2	19.2	14.4	14.4	14.4	14.4	14.4	24.0	24.0	24.0	24.0	24.0	24.0
4500	9.6	9.6	9.6	9.6	14.4	14.4	19.2	19.2	19.2	14.4	14.4	14.4	14.4	14.4	24.0	24.0	24.0	24.0	24.0	24.0
5000	4.8	4.8	4.8	4.8	4.8	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	24.0	24.0	24.0	24.0	24.0	24.0
5500	4.8	4.8	4.8	4.8	4.8	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	14.4	19.2	19.2	19.2	19.2	19.2	19.2
6000	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
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
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

degrees

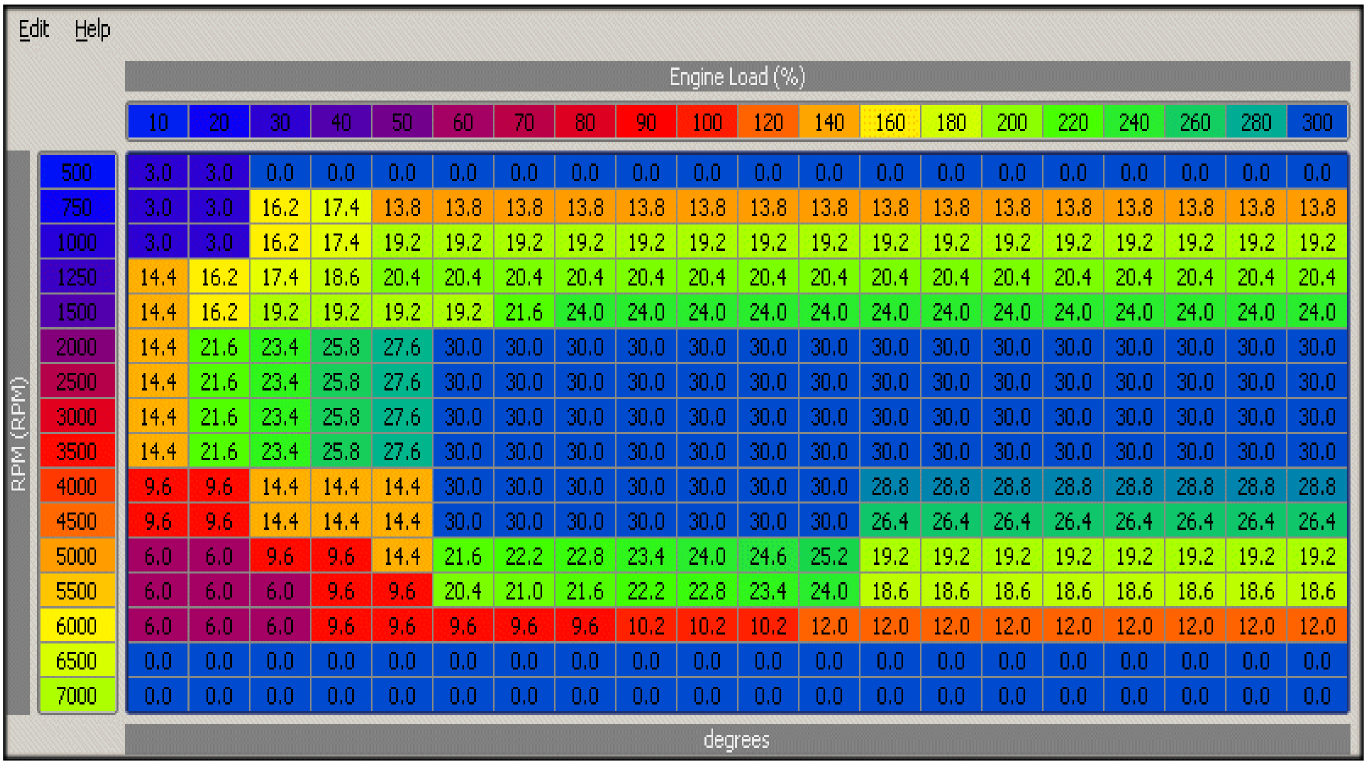
This next map was posted by **nj1266**, here are his comments on it.

"I tinkered with MIVEC and was able to come up with a map that I really liked. It is a fusion of two maps. The first map was posted in the MIVEC Tuning thread on EvoM and the second map was created by John Bradley who is the resident MIVEC guru on EvoM.

I took the top end (load cell 70 to 100) from one map and fused it with the bottom end from another map. I was very surprised by the increase in low end snappiness of my EVO. The car felt like an NA car. You can put it in high gear at low rpm and simply touch the accelerator and the car goes. I thought it was only in my mind, but when I tested it on other EVOs, the impressions of the drivers were the same.

Two caveats about this map: First, it will slightly increase your idle by about 100-200 rpm during normal driving. Second, after you hammer on the car for a while, your idle will go up to 1000 rpm. If you can tolerate this, then go ahead and use the map. If you cannot, then use the JDM 9 RS map."

Figure 45: MIVEC TUNING, nj1266 MODIFIED MIVEC MAP

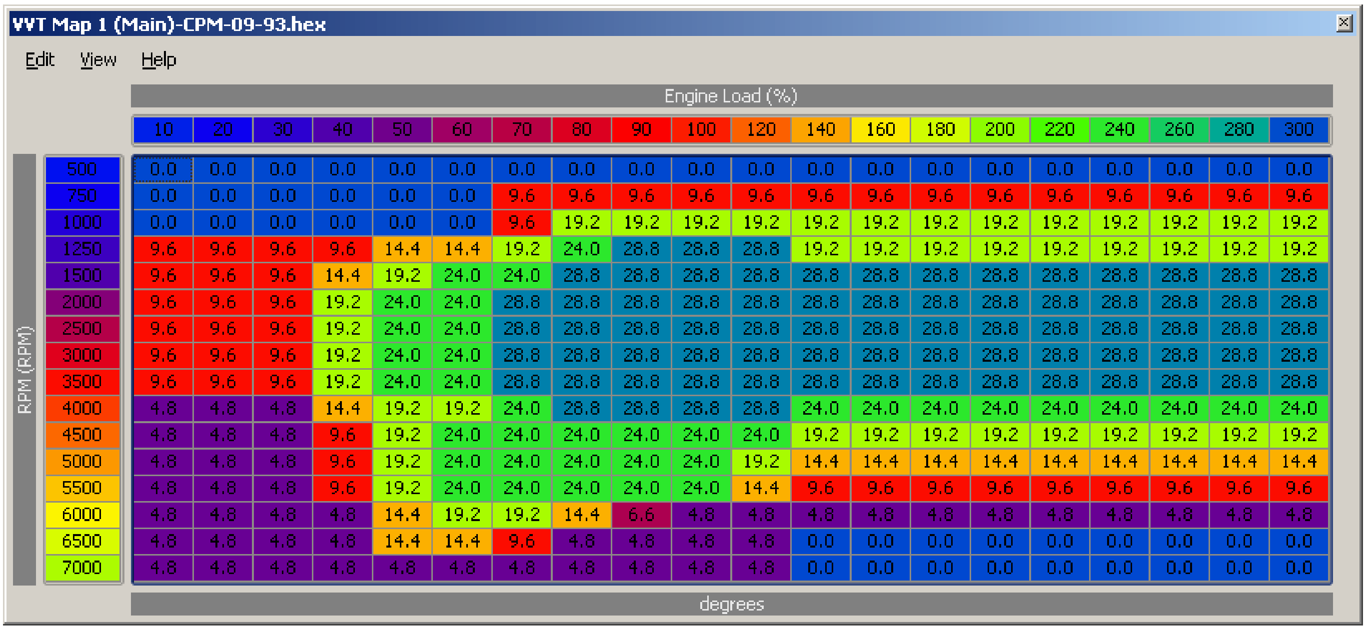


	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300
500	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
750	3.0	3.0	16.2	17.4	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8
1000	3.0	3.0	16.2	17.4	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
1250	14.4	16.2	17.4	18.6	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4
1500	14.4	16.2	19.2	19.2	19.2	19.2	21.6	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
2000	14.4	21.6	23.4	25.8	27.6	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
2500	14.4	21.6	23.4	25.8	27.6	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
3000	14.4	21.6	23.4	25.8	27.6	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
3500	14.4	21.6	23.4	25.8	27.6	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
4000	9.6	9.6	14.4	14.4	14.4	30.0	30.0	30.0	30.0	30.0	30.0	30.0	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8
4500	9.6	9.6	14.4	14.4	14.4	30.0	30.0	30.0	30.0	30.0	30.0	30.0	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4
5000	6.0	6.0	9.6	9.6	14.4	21.6	22.2	22.8	23.4	24.0	24.6	25.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
5500	6.0	6.0	6.0	9.6	9.6	20.4	21.0	21.6	22.2	22.8	23.4	24.0	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6
6000	6.0	6.0	6.0	9.6	9.6	9.6	9.6	9.6	10.2	10.2	10.2	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
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
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

This MIVEC map was posted by **Shameless Tuning** as his initial personal map, running boost as follows:

Rpm	Boost	Rpm	Boost
3000 – 4000	24psi	5500 - 6000	20psi
4000 – 5000	23psi	6000 - 6500	19psi
5000 – 5500	22psi	6500 – 7000	17psi

Figure 46: MIVEC TUNING, Shameless Tuning MODIFIED MIVEC MAP #1



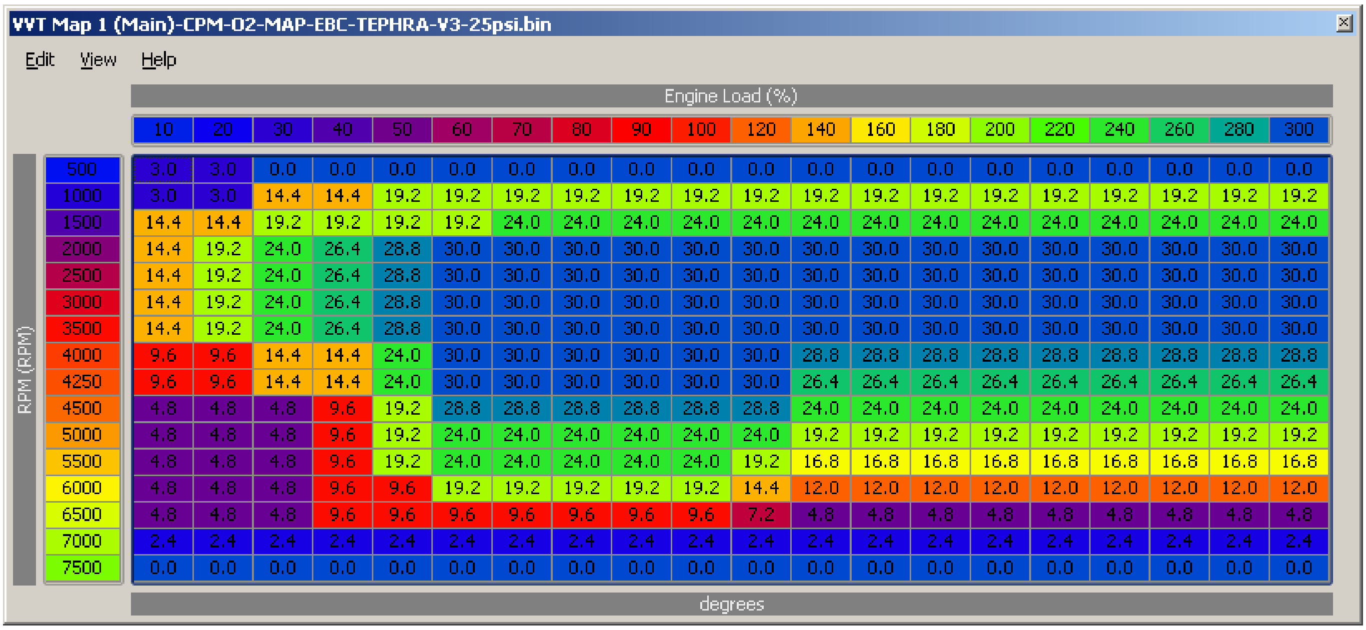
Engine Load (%)

RPM (RPM)	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300
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
750	0.0	0.0	0.0	0.0	0.0	0.0	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
1000	0.0	0.0	0.0	0.0	0.0	0.0	9.6	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
1250	9.6	9.6	9.6	9.6	14.4	14.4	19.2	24.0	28.8	28.8	28.8	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
1500	9.6	9.6	9.6	14.4	19.2	24.0	24.0	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8
2000	9.6	9.6	9.6	19.2	24.0	24.0	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8
2500	9.6	9.6	9.6	19.2	24.0	24.0	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8
3000	9.6	9.6	9.6	19.2	24.0	24.0	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8
3500	9.6	9.6	9.6	19.2	24.0	24.0	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8
4000	4.8	4.8	4.8	14.4	19.2	19.2	24.0	28.8	28.8	28.8	28.8	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
4500	4.8	4.8	4.8	9.6	19.2	24.0	24.0	24.0	24.0	24.0	24.0	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
5000	4.8	4.8	4.8	9.6	19.2	24.0	24.0	24.0	24.0	24.0	19.2	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4
5500	4.8	4.8	4.8	9.6	19.2	24.0	24.0	24.0	24.0	24.0	14.4	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
6000	4.8	4.8	4.8	4.8	14.4	19.2	19.2	14.4	6.6	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
6500	4.8	4.8	4.8	4.8	14.4	14.4	9.6	4.8	4.8	4.8	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7000	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

degrees

This map above was subsequently refined and re-scaled, deleting the 750rpm and 1250rpm row and adding rows at 4250rpm and 7500rpm. This is an aggressive map that works very well with the owner/tuners engine modifications. Same boost as above.

Figure 47: TUNING, Shameless Tuning MODIFIED MIVEC MAP #2



Engine Load (%)

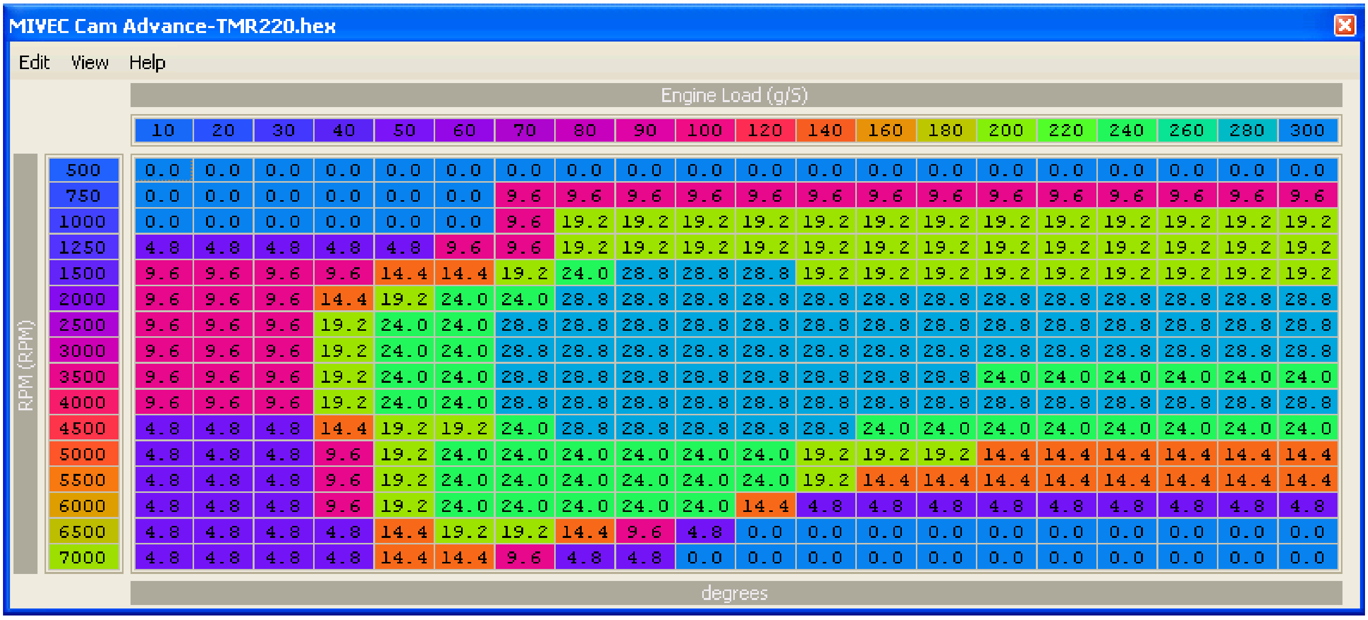
RPM (RPM)	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300
500	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1000	3.0	3.0	14.4	14.4	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
1500	14.4	14.4	19.2	19.2	19.2	19.2	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
2000	14.4	19.2	24.0	26.4	28.8	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
2500	14.4	19.2	24.0	26.4	28.8	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
3000	14.4	19.2	24.0	26.4	28.8	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
3500	14.4	19.2	24.0	26.4	28.8	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
4000	9.6	9.6	14.4	14.4	24.0	30.0	30.0	30.0	30.0	30.0	30.0	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8
4250	9.6	9.6	14.4	14.4	24.0	30.0	30.0	30.0	30.0	30.0	30.0	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4
4500	4.8	4.8	4.8	9.6	19.2	28.8	28.8	28.8	28.8	28.8	28.8	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
5000	4.8	4.8	4.8	9.6	19.2	24.0	24.0	24.0	24.0	24.0	24.0	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
5500	4.8	4.8	4.8	9.6	19.2	24.0	24.0	24.0	24.0	24.0	19.2	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8
6000	4.8	4.8	4.8	9.6	9.6	19.2	19.2	19.2	19.2	19.2	14.4	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
6500	4.8	4.8	4.8	9.6	9.6	9.6	9.6	9.6	9.6	9.6	7.2	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
7000	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
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

degrees

This next example is from an Australian delivered TMR220 Evo9 (Team Mitsubishi Racing), where the MIVEC map has been evolved from the JDM RS RALLIART map.

This MIVEC map is probably the best map to start tuning from, if you are doing your own tuning. The EcuFLASH default colour scheme in this presentation is "RAINBOW3", which gives a good graduated display.

Figure 48: MIVEC TUNING, TMR220 Evo9 MIVEC MAP – TABLE VIEW



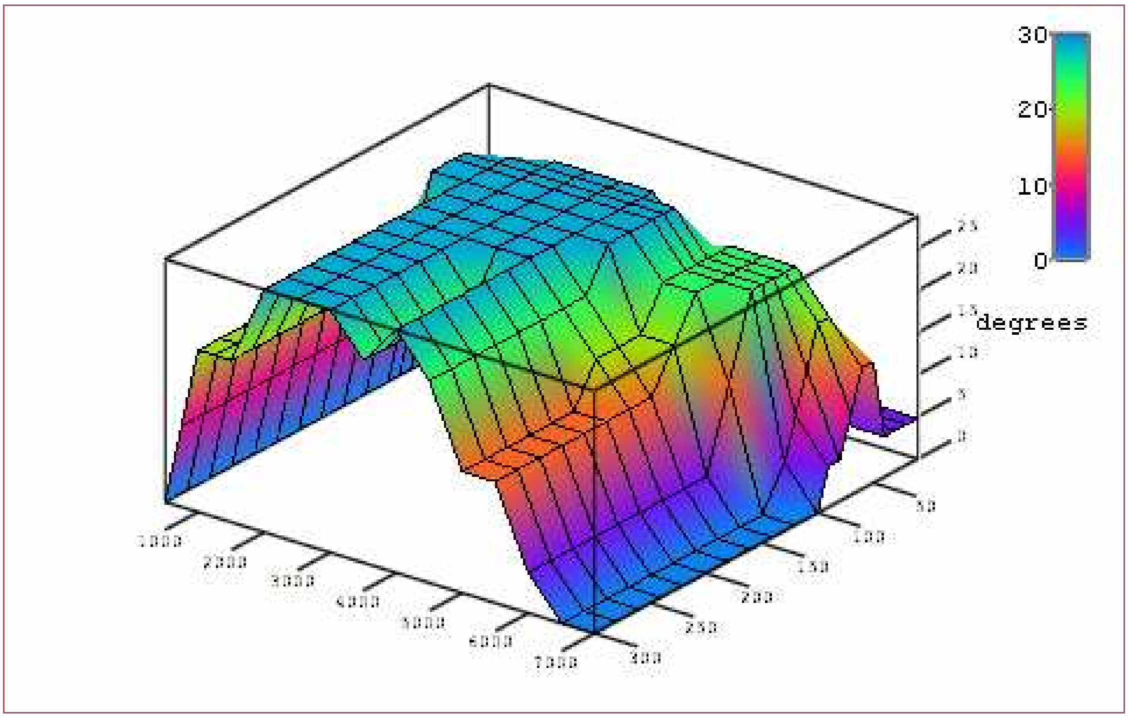
MIVEC Cam Advance-TMR220.hex

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
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
750	0.0	0.0	0.0	0.0	0.0	0.0	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
1000	0.0	0.0	0.0	0.0	0.0	0.0	9.6	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
1250	4.8	4.8	4.8	4.8	4.8	9.6	9.6	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
1500	9.6	9.6	9.6	9.6	14.4	14.4	19.2	24.0	28.8	28.8	28.8	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
2000	9.6	9.6	9.6	14.4	19.2	24.0	24.0	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8
2500	9.6	9.6	9.6	19.2	24.0	24.0	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8
3000	9.6	9.6	9.6	19.2	24.0	24.0	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8
3500	9.6	9.6	9.6	19.2	24.0	24.0	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	24.0	24.0	24.0	24.0	24.0	24.0
4000	9.6	9.6	9.6	19.2	24.0	24.0	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8
4500	4.8	4.8	4.8	14.4	19.2	19.2	24.0	28.8	28.8	28.8	28.8	28.8	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
5000	4.8	4.8	4.8	9.6	19.2	24.0	24.0	24.0	24.0	24.0	24.0	19.2	19.2	19.2	14.4	14.4	14.4	14.4	14.4	14.4
5500	4.8	4.8	4.8	9.6	19.2	24.0	24.0	24.0	24.0	24.0	24.0	19.2	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4
6000	4.8	4.8	4.8	9.6	19.2	24.0	24.0	24.0	24.0	24.0	14.4	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
6500	4.8	4.8	4.8	4.8	14.4	19.2	19.2	14.4	9.6	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7000	4.8	4.8	4.8	4.8	14.4	14.4	9.6	4.8	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

degrees

Figure 49: MIVEC TUNING, TMR220 Evo9 MIVEC MAP – 3D VIEW



This final example is from an Australian delivered Evo9, where the MIVEC map was modified from the RALLIART map by a pro-tuner and Evo racer **Steve Knight**, then further refined by **merlin**. I consider it a work-in-progress. The EcuFLASH default colour scheme in this presentation is "Pale", which gives a good graduated display.

Figure 50: MIVEC TUNING, merlin Evo9 MIVEC MAP – 3D VIEW

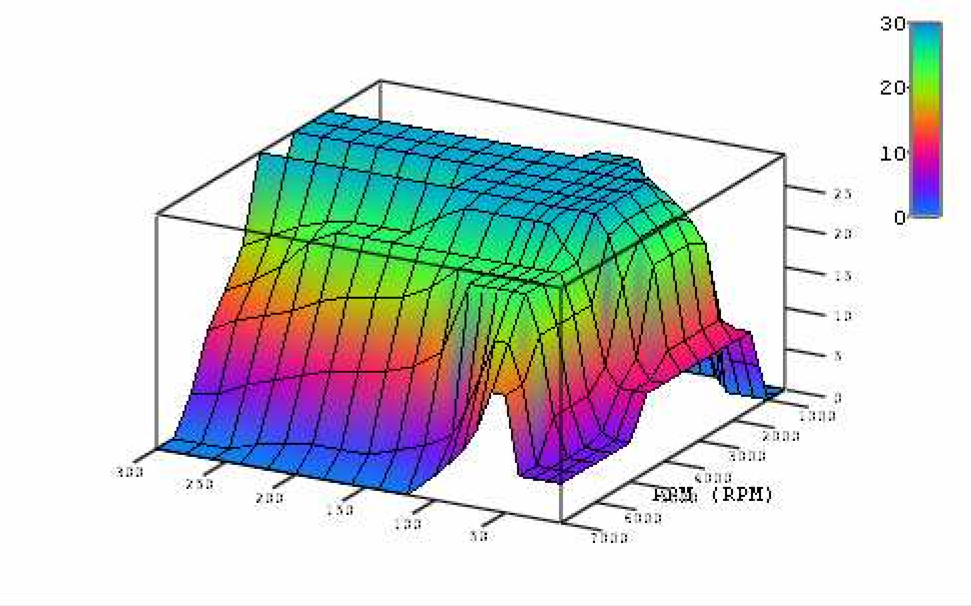
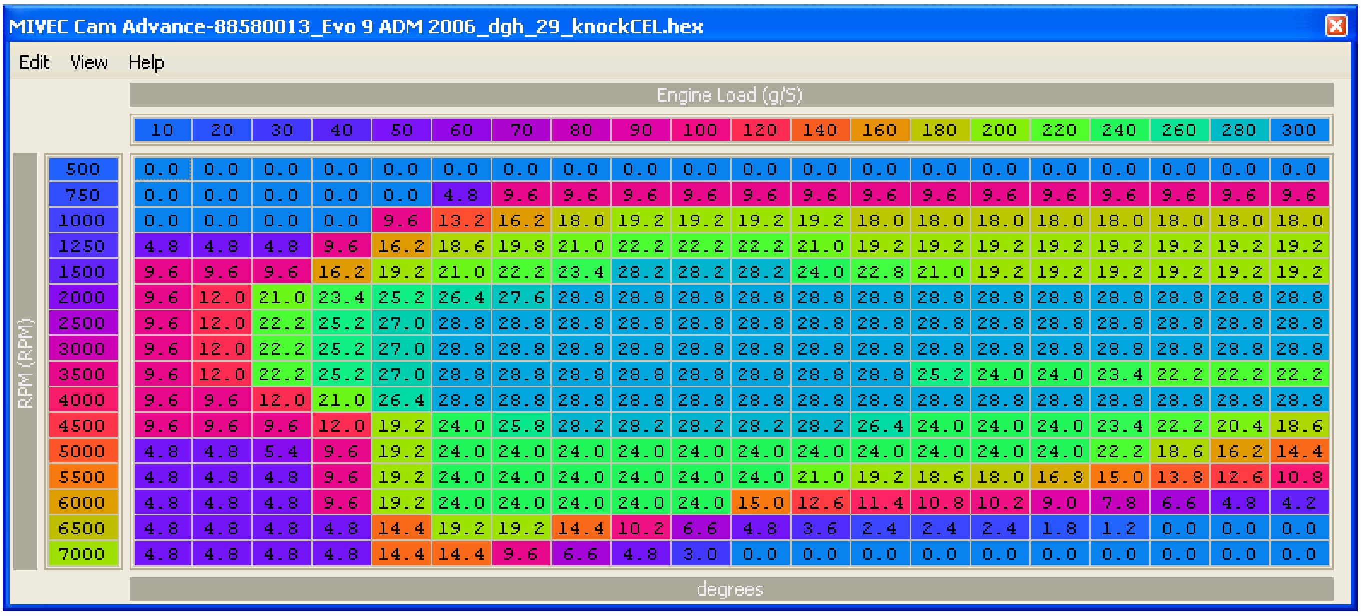


Figure 51: MIVEC TUNING, merlin Evo9 MIVEC MAP – TABLE VIEW


MIVEC Cam Advance-88580013_Evo 9 ADM 2006_dgh_29_knockCEL.hex

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
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
750	0.0	0.0	0.0	0.0	0.0	4.8	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
1000	0.0	0.0	0.0	0.0	9.6	13.2	16.2	18.0	19.2	19.2	19.2	19.2	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
1250	4.8	4.8	4.8	9.6	16.2	18.6	19.8	21.0	22.2	22.2	22.2	21.0	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2
1500	9.6	9.6	9.6	16.2	19.2	21.0	22.2	23.4	28.2	28.2	28.2	24.0	22.8	21.0	19.2	19.2	19.2	19.2	19.2	19.2
2000	9.6	12.0	21.0	23.4	25.2	26.4	27.6	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8
2500	9.6	12.0	22.2	25.2	27.0	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8
3000	9.6	12.0	22.2	25.2	27.0	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8
3500	9.6	12.0	22.2	25.2	27.0	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	25.2	24.0	24.0	23.4	22.2	22.2	22.2
4000	9.6	9.6	12.0	21.0	26.4	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8	28.8
4500	9.6	9.6	9.6	12.0	19.2	24.0	25.8	28.2	28.2	28.2	28.2	28.2	26.4	24.0	24.0	24.0	23.4	22.2	20.4	18.6
5000	4.8	4.8	5.4	9.6	19.2	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	22.2	18.6	16.2	14.4
5500	4.8	4.8	4.8	9.6	19.2	24.0	24.0	24.0	24.0	24.0	24.0	21.0	19.2	18.6	18.0	16.8	15.0	13.8	12.6	10.8
6000	4.8	4.8	4.8	9.6	19.2	24.0	24.0	24.0	24.0	24.0	15.0	12.6	11.4	10.8	10.2	9.0	7.8	6.6	4.8	4.2
6500	4.8	4.8	4.8	4.8	14.4	19.2	19.2	14.4	10.2	6.6	4.8	3.6	2.4	2.4	2.4	1.8	1.2	0.0	0.0	0.0
7000	4.8	4.8	4.8	4.8	14.4	14.4	9.6	6.6	4.8	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

degrees

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.

SECTION 5 – INJECTOR TUNING

5.01-INJECTOR SETUP INTRODUCTION

The stock injectors on the Evo5-9 are DENSO units rated at 560cc/min. Generally speaking, the stock injectors will give you adequate fuel flow with a TBE, a better hot-side intercooler pipe and 19-20 lbs of boost by redline. Once you get cams, then it is advisable to get bigger injectors. If you get a bigger turbo and raise the boost well into the 20's, then definitely get bigger injectors.

When you install bigger injectors, you will have to alter the SCALING and LATENCY parameters 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.

Above that and the ECU struggles or just cant cope as it 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.

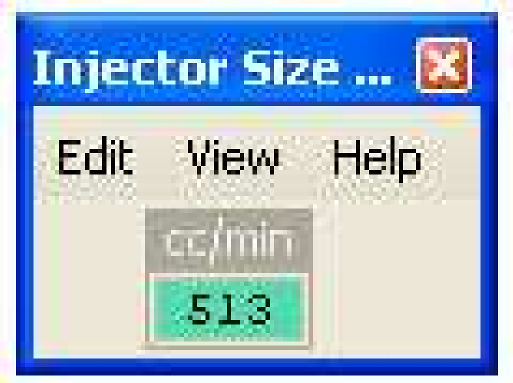
Note 3: LTFT range is ±12.5%. STFT range is ±25%. The trims are stored in ECU (RAM) memory and are reset every time you re-flash the Evo9 ECU.

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.

5.02-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 52: INJECTOR TUNING – INJECTOR SIZE SCALING, Evo9



cc/min

513

The following data should help with calculating a new injector size, based on expected horsepower:

cc/min = HP x 5

cc / min = lbs/hour x 10.2

HP = cc/min / 5

HP = lbs/hour x 2.04

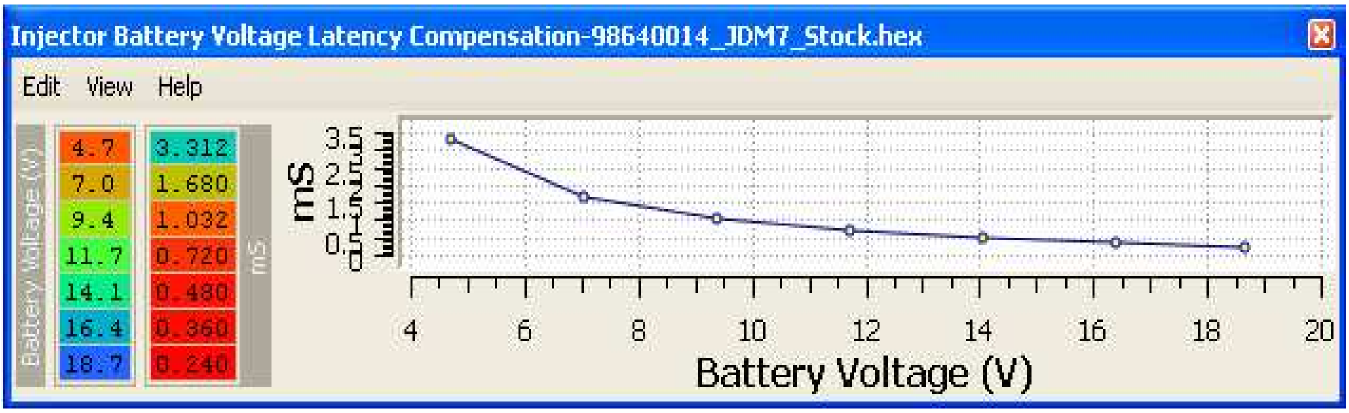
5.03-INJECTOR TUNING - LATENCY

Fuel injectors have to physically move the pintall 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 shorted 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.

The same injectors are fitted to the EVO7-8-9, yet EcuFLASH reports different latency values for the same injector. I believe this is because the EVO7 has the closing time added into the latency table as shown, whereas the EVO9 has it as a separate table, which has not been defined. It really does not matter, the coding looks after it.

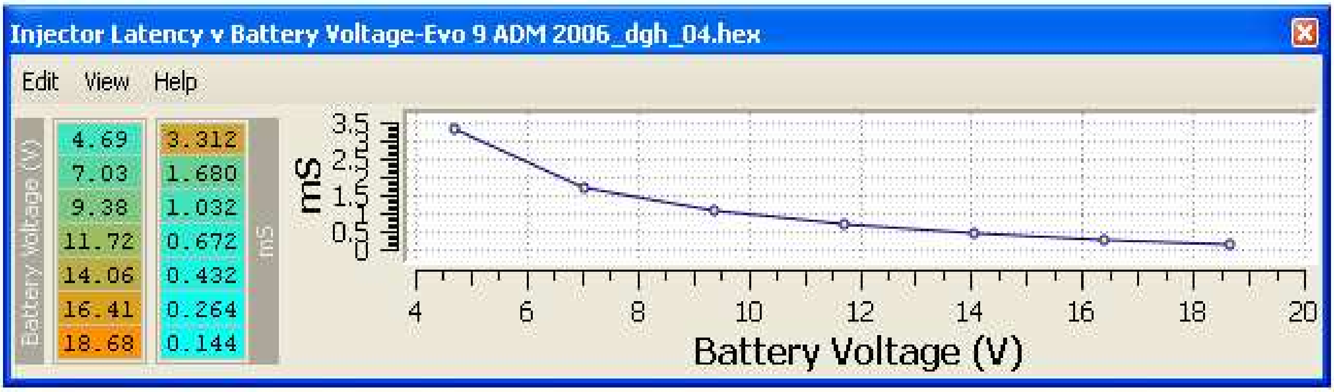
Additionally, Mitsubishi have put the same latency values in the 4.7V, 7.0V and 9.4V volt cell for both EVO7 and EVO9. This would imply that Mitsubishi do not expect the ECU to be operating at those voltages and in fact there is a parameter in the ECU setting an upper and lower supply voltage operating range.

Figure 53: INJECTOR TUNING - LATENCY v BATTERY VOLTS, Evo7



Battery Voltage (V)	mS
4.7	3.312
7.0	1.680
9.4	1.032
11.7	0.720
14.1	0.480
16.4	0.360
18.7	0.240

Figure 54: INJECTOR TUNING - LATENCY v BATTERY VOLTS, Evo9



Battery Voltage (V)	mS
4.69	3.312
7.03	1.680
9.38	1.032
11.72	0.672
14.06	0.432
16.41	0.264
18.68	0.144

5.04-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. These values were worked out for typically 93 octane fuel, using 98-100 octane or ethanol blends may require variations. The side note in the scaling column shows the fuel used.

Table 2 TYPICAL INJECTOR SCALING AND LATENCY PARAMETERS

				LATENCY in mSEC / BATTERY VOLTAGE						
TYPE	ORIGIN	SCALING	'Ω	4.7V	7.0V	9.4V	11.7V	14.0V	16.4V	18.6V
EVO 9	Mitsubishi	511	3	3.312	1.680	1.032	0.672	0.432	0.264	0.144
EVO 3	AndyF	511		4.056	1.944	1.272	0.912	0.696	0.576	0.480
PTE_680	Cossie1	650	2	3.312	2.184	1.416	0.960	0.696	0.480	0.360
PTE_680	?	?	2	3.312	2.186	1.413	0.957	0.687	0.486	0.349
PTE_680	?	622	2	3.888	2.136	1.440	1.056	0.812	0.624	0.480
PTE_680	Jorge_T	622	2	3.624	1.992	1.344	1.008	0.768	0.600	0.456
PTE_680	?	650	2	3.312	2.184	1.416	0.960	0.696	0.480	0.360
PTE_780	fostyou	680		3.642	1.992	1.344	0.984	0.744	0.576	0.456
PTE_780	merlin	696		3.600	1.968	1.320	0.960	0.720	0.552	0.432
PTE_780	joedr	713		3.504	2.184	1.224	0.960	0.792	0.552	0.432
PTE_780	cpoevo	696		3.504	1.872	1.224	0.960	0.774	0.552	0.432
PTE_880	nj1266	731		3.312	2.184	1.320	0.960	0.696	0.408	0.288
PTE_880	joedr	770		3.312	2.304	1.392	1.008	0.792	0.600	0.504
PTE_880	Ph3n1x	790		3.312	2.184	1.320	0.840	0.672	0.360	0.240
PTE_880	bigric09	770		3.648	2.088	1.224	0.912	0.744	0.552	0.456
PTE_1000	MalibuJack	665	2	3.312	1.680	1.392	1.104	0.960	0.696	0.504
PTE_1000	TeStUdO	725	2	3.312	2.186	1.281	0.771	0.458	0.283	0.172
PTE_1000	Brad74	886	2	3.720	2.088	1.440	1.080	0.840	0.672	0.522
RC_720	?	?	3	3.312	2.186	1.518	1.032	0.694	0.443	0.268
RC_750	Jamie_v1	696	3	3.312	2.184	1.560	1.056	0.720	0.480	0.360
RC_1000	Jamie_v1	943	3	3.312	2.184	1.560	1.056	0.720	0.480	0.360
RC_1000	rarorlab	835....100	3	3.600	2.184	1.560	0.936	0.672	0.432	0.336
RC_1000	nj1266	914	3	3.312	2.184	1.560	0.912	0.600	0.321	0.240
RC_1000	smartbomb	860	3	3.312	2.184	1.560	1.008	0.696	0.408	0.336
RC_1000	nj1266	835	3	3.312	2.184	1.560	0.936	0.624	0.384	0.288
RC_1000	GST	860	3	3.312	2.184	1.560	0.936	0.624	0.384	0.288
RC_1200	JB	1044....95	3	3.312	2.186	2.088	1.296	0.792	0.720	0.480
RC_1200	JB	680....E85	3	3.312	2.186	2.088	1.344	0.864	0.720	0.480
RC_1200	fostytou	622....E85	3	3.600	2.304	1.728	1.320	0.864	0.720	0.480
FIC_650	?	?	2.2	3.312	2.100	1.071	0.633	0.353	0.175	0.044
FIC_750	al\lupo	713	2.2	3.312	2.040	1.296	0.912	0.792	0.600	0.336
FIC_750	evoredy	696	2.2	3.312	1.680	1.200	0.792	0.720	0.456	0.360
FIC_750	bigric09	650	2.2	3.312	2.040	1.296	0.696	0.624	0.408	0.192
FIC_750	JB	650	2.2	3.312	1.680	1.032	0.864	0.648	0.552	0.360
FIC_850	JB	770	2.2	3.312	1.680	1.032	0.840	0.552	0.456	0.360
FIC_850	s2kracka	696	2.2	3.000	2.376	1.200	0.768	0.504	0.360	0.312
FIC_850	bigric09	770	2.2	3.480	1.920	1.368	1.008	0.768	0.600	0.456
FIC_950	Steve93	812	2.2	3.312	2.186	1.462	0.958	0.832	0.428	0.277
FIC_1000	JB	860	2.2	3.312	1.680	1.344	1.152	0.840	0.504	0.240
FIC_1000	Pd1	860	2.2	3.312	1.680	1.344	1.152	0.840	0.360	0.240
FIC_1000	IanevoMR9	636.....E85	2.2	3.312	1.704	1.416	1.200	0.840	0.576	0.264
FIC_1000	IanevoMR9	835.......95	2.2	3.312	1.704	1.416	1.200	0.840	0.576	0.264
FIC_1050	scheides	1008	2.2	4.440	3.192	1.752	1.032	0.840	0.576	0.432
FIC_1150	dan_I	1125	2.2	4.512	3.408	1.896	1.320	0.936	0.672	0.480
FIC_1250	alan678	1271... 95	2.2	4.008	3.096	2.208	1.512	1.056	0.816	0.648
FIC_1250	alan678	886.....E85	2.2	4.008	3.096	2.208	1.512	1.056	0.816	0.648
DENSO_720	rarorlab	636		6.120	3.120	1.992	1.320	0.888	0.672	0.408
DENSO_720	wesside	622		3.864	3.456	2.856	1.320	0.888	0.672	0.408
DENSO_720	merlin	636 98		3.768	2.136	1.488	1.128	0.888	0.720	0.600
DENSO_660	rarorlab	636		6.120	3.120	1.992	1.320	0.888	0.672	0.408
SARD_700	rarorlab	636		6.120	3.120	1.992	1.320	0.888	0.672	0.408
SARD_800			3			0.90	0.62	0.42		

5.05-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.

5.06-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.

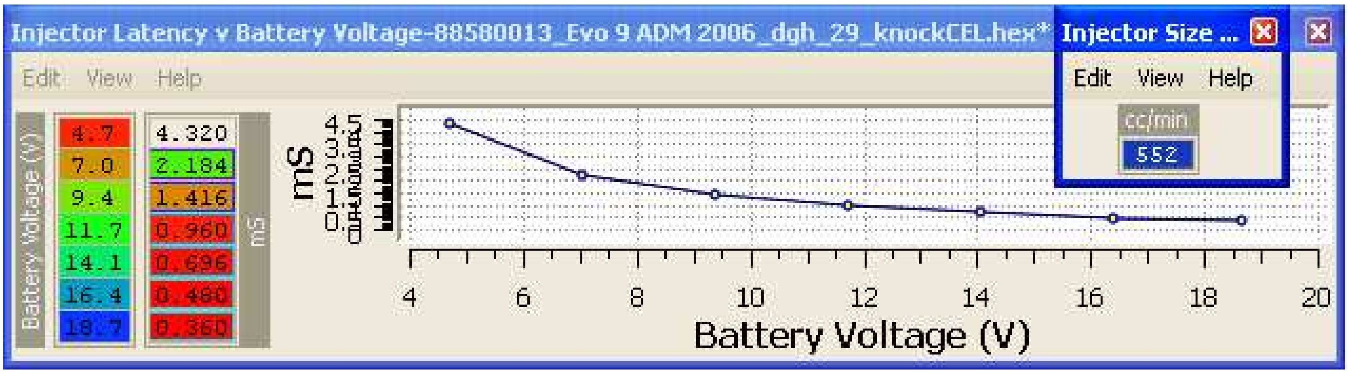
Look closely at the Latency table and the characteristic shape of the compensation curve produced when graphed. At no time should a value be entered that does not conform to this curve, though the curve will be shifted up or down as required and be a bit more or less curved for different injectors. The 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. The question is what numbers to start with. Unfortunately the table does not show what EVO they were tuned for, so some of the discrepancies may be due to ROM version coding between the EVO8 and EVO9.

Never the less, this is where the table of INJECTOR SCALING & LATENCY PARAMETERS is used. 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 could be entered.

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

Figure 55: INJECTOR TUNING – PTE680cc FIRST PASS SCALING & LATENCY



Injector Latency v Battery Voltage-88580013_Evo 9 ADM 2006_dgh_29_knockCEL.hex*

Battery Voltage (V)	mS
4.7	4.320
7.0	2.184
9.4	1.416
11.7	0.960
14.1	0.696
16.4	0.480
18.7	0.360

Injector Size ...

cc/min: 552

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** or **MalibuJack**'s **Mitsulogger**. Both will do a good job of logging fuel trims.

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.

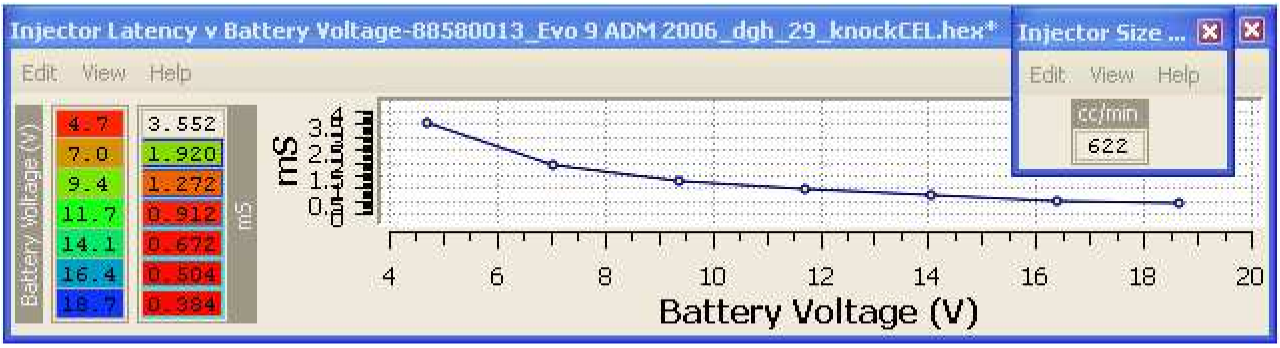
Now to check the latency for when battery voltage is less than 14 volts. Disconnect the alternator feed to the battery. Connect a multi-meter across the battery. Start and idle the engine. Switch on the lights, thus draining the battery voltage down to the next cell to be adjusted, 11.7V. When the battery 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 56: INJECTOR TUNING – PTE680cc FINAL INJECTOR SCALING & LATENCY



Battery Voltage (V)	mS
4.7	3.552
7.0	1.920
9.4	1.272
11.7	0.912
14.1	0.672
16.4	0.504
18.7	0.384

cc/min
622

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 or Mitsulogger 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.

5.07-INJECTOR TUNING – EXAMPLE CASES

As posted by **tseitz123**

“Well, I have read every damn post I could find and went out logging things the past two days. Made some adjustments and this is where I'm at:

PTE 880's scaled to 770

STFT(low)=.5%
IPW (low)=1.5mS IDLE
LTFT(low)=12.6%

STFT(mid)=.7%
IPW (mid)=2.3ms CRUISE
LTFT(mid)=.7%

Volts	Latency mS
4.7	= 3.696
7.0	= 2.568
9.4	= 1.704
11.7	= 1.224
14.1	= 0.960
16.4	= 0.552
18.7	= 0.432

Anyone have any thoughts/suggestions in order for me to pull my LTFT Low in line without f-ing up my cruise, etc.?
Tom”

And an excellent (edited) reply from **I2r99gst**

“Yes, you would add latency, which would bring both your LTFT Low and Mid down, but it would bring your LTFT Low down faster than the mid. Once they are close to being equal, then you would bring them both back to 0 with injector scaling.

However, this is somewhat important:

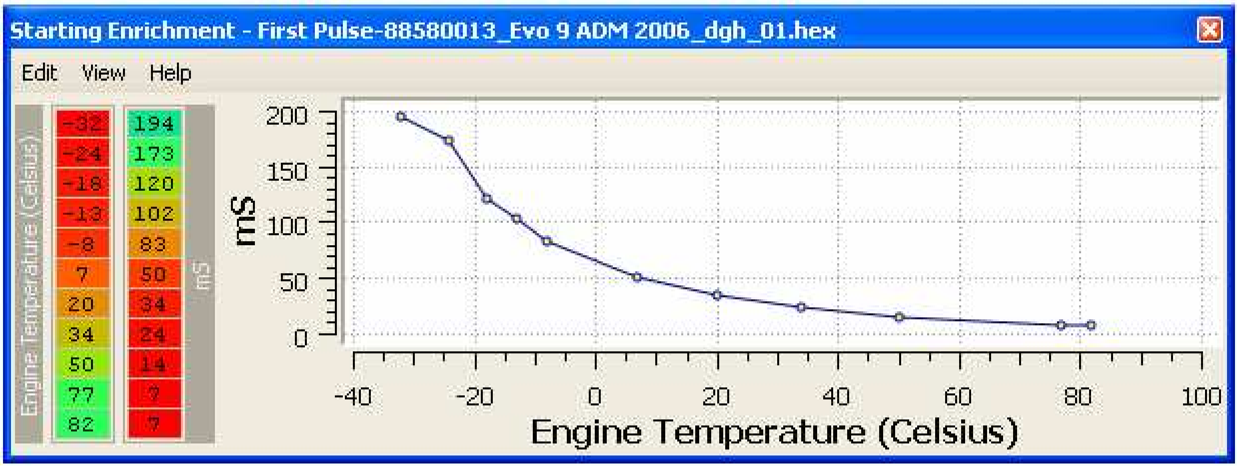
Make sure that you aren't running a breather filter on your valve cover where your breather hose should be connected to your turbo intake pipe. If you don't have the breather hose connected and are using a filter, you are letting un-metered air after the MAF into the inlet manifold (IM) from the PCV valve during high vacuum conditions, like idle and some cruising. This can cause positive idle trims like you are seeing.

If you don't want to follow these steps or you are running a breather filter, etc, you can still fix it with the MAF scaling. I consider this more of a band-aid fix, since MAF scaling should only be done if the MAF readings are truly off. But, to fix just your idle trims, you would alter the cell of the MAF table at the HZ that you are idling at. Please refer to the MAF scaling thread for detailed instructions.”

5.08-INJECTOR TUNING – START PRIMER IPW v TEMP

An engine will require a large START PRIMER IPW from the injectors when cold, it's function is to prime the engine by wetting the inlet manifold, thus providing extra fuel at starting due to poor fuel atomization. The table values are added to the latency values, thus directly adding the table to the final IPW. The table only applies when the engine speed is below 438 rpm and is for one pulse only. Following this first pulse are the CRANKING enrichment pulses.

Figure 57: INJECTOR TUNING – START PRIMER IPW ADDER v TEMP, Evo9



Engine Temperature (Celsius)	mS
-32	194
-24	173
-18	120
-13	102
-8	83
7	50
20	34
34	24
50	14
77	7
82	7

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

1. When using alcohol blended fuels.
2. When the injectors have been replaced with larger flow capacity types.

With case one, if you intend using E85 fuel, then the values from 20°C through to -32°C need to be progressively increased. Use the following as a starting point: 7,7,15,30,50,70,90,110,135,175,200.

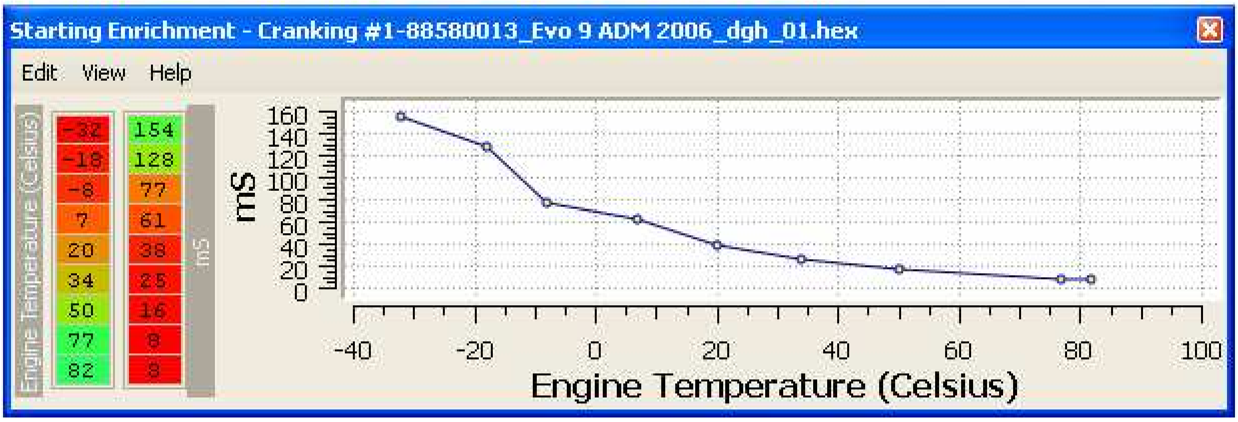
With case two, where the injector size has been increased, the STARTING IPW ADDER values will need to be reduced by the percentage difference between the old and new sizes. This is done to prevent flooding and/or plug fouling on start-up. So the IPW values will need to be altered based on the new injector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

New Cranking primer IPW = old IPW x [old injector scale / new injector scale]

5.09-INJECTOR TUNING – START CRANKING IPW v TEMP

An engine will require a large START CRANKING IPW from the injectors when cold, it's function is to prime the engine with a lot of extra fuel at starting due to poor fuel atomization. The table values are added to the latency values, thus directly adding the table to the final IPW. The table only applies when the engine is cranking ie below 438 rpm and this cranking enrichment decays on a timer.

Figure 58: INJECTOR TUNING – START CRANKING IPW ADDER v TEMP, Evo9



Starting Enrichment - Cranking #1-88580013_Evo 9 ADM 2006_dgh_01.hex

Engine Temperature (Celsius)	mS
-32	154
-18	128
-8	77
7	61
20	38
34	25
50	16
77	8
82	8

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

1. When using alcohol blended fuels.
2. When the injectors have been replaced with larger flow capacity types.

When using E85 alcohol blend fuel, multiply the table values by 1.3 and then round to the nearest whole integer, eg:

10, 10, 21, 32, 49, 79, 100, 166, 200

In practice, the requirement for extra fuel is exacerbated when the engine is stone cold, not so much when warmed-up, so the 34-82°C values may not need the full 30% increase in fuel for starting thus these data points could have lesser enrichment. Eg:

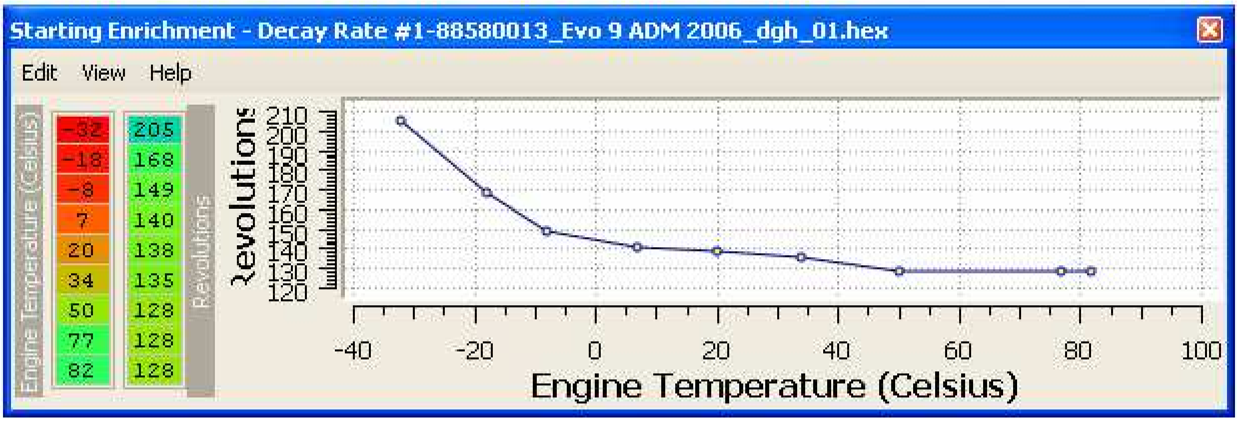
9, 9, 18, 29, 48, 78, 100, 166, 200

Follow the same adjustment method as described for the START PRIMER IPW ADDER. Note that when logging the IPW during starting, these two parameters are added to the calculated injector pulse width from the fuel map, plus the LATENCY time in mS. Also note that there are two of these tables in the EVO9, make any changes to both tables.

5.10-INJECTOR TUNING – POST START ENRICH DECAY v TEMP

This table controls the enrichment decay rate. The correct scaling has not been defined as yet, so this data presentation is based on decay rate by engine revolutions.

Figure 59: INJECTOR TUNING – POST START ENRICH DECAY v TEMP, Evo9



Engine Temperature (Celsius)	Revolutions
-32	205
-18	168
-8	149
7	140
20	138
34	135
50	128
77	128
82	128

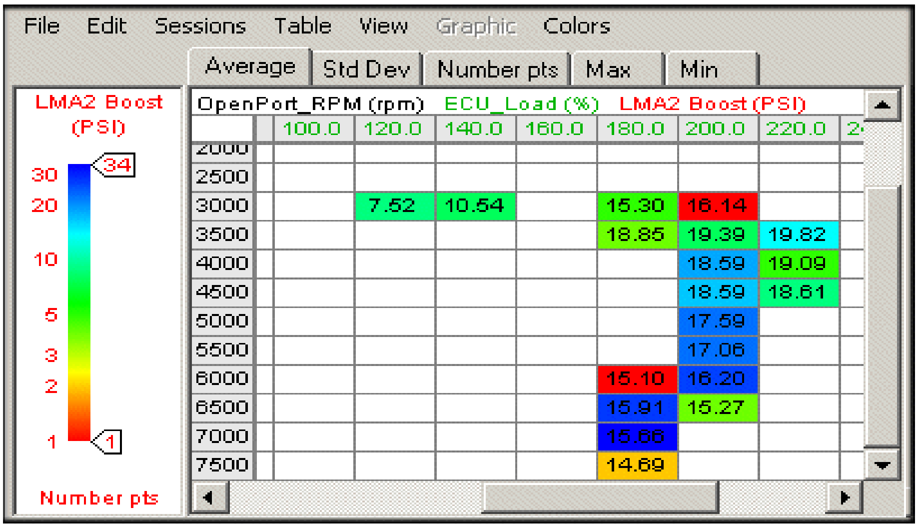
Note that there are two of these tables in the Evo9 ROMs, make any changes to both tables.

SECTION 6 – BOOST TUNING

6.01-BOOST TUNING INTRODUCTION

So what does the boost look like on a stock Evo9? A bone stock Evo9 should have the following boost profile:

Figure 60: BOOST TUNING – stock EVO9 BOOST PROFILE

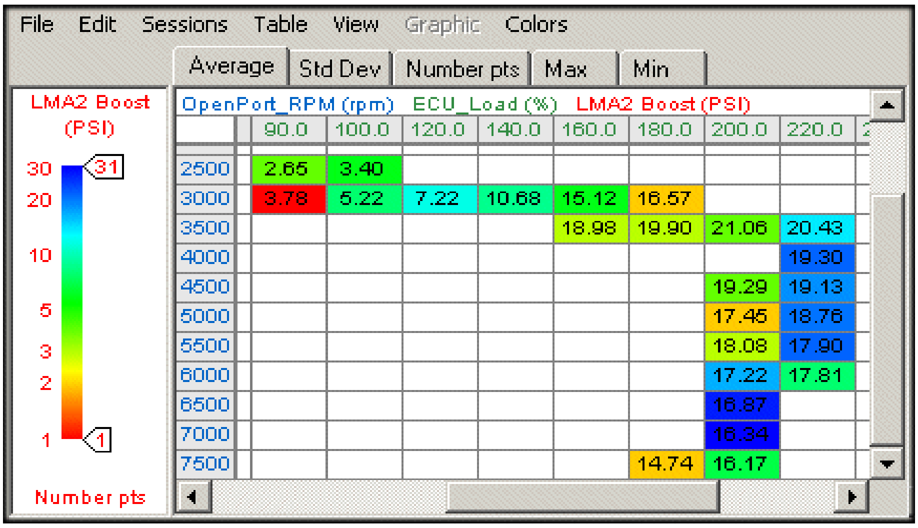


OpenPort_RPM (rpm) ECU_Load (%) LMA2 Boost (PSI)

	100.0	120.0	140.0	160.0	180.0	200.0	220.0
2000							
2500							
3000		7.52	10.54		15.30	16.14	
3500					18.85	19.39	19.82
4000						18.59	19.09
4500						18.59	18.61
5000						17.59	
5500						17.06	
6000					15.10	16.20	
6500					15.91	15.27	
7000					15.66		
7500					14.69		

First, the average boost number @ peak is close to the 20psi spec sheet boost for the Evo9. Environmental conditions and gear selection will make the boost vary. Also, the boost tapers off on the EVO9. By 6500 rpm the boost is below 16psi.

Figure 61: BOOST TUNING, TBE+HFC Evo9 BOOST PROFILE



OpenPort_RPM (rpm) ECU_Load (%) LMA2 Boost (PSI)

	90.0	100.0	120.0	140.0	160.0	180.0	200.0	220.0
2500	2.65	3.40						
3000	3.78	5.22	7.22	10.68	15.12	16.57		
3500					18.98	19.90	21.06	20.43
4000								19.30
4500							19.29	19.13
5000							17.45	18.76
5500							18.08	17.90
6000							17.22	17.81
6500							16.87	
7000							16.34	
7500						14.74	16.17	

The above boost chart is what the boost typically looks like on an Evo9 after installing a TBE and HFC. You will note that the boost climbed to an average of 20-21 psi at peak and stayed above 16 psi at redline. Also of note is how the load has climbed from 200 to 220.

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. There are several methods available to do this and all will require installing a MAP sensor and calibrating it properly based on atmospheric conditions in your area. The MAP sensor is usually teed into the short hose that connects the fuel pressure solenoid to the inlet manifold. The pressure/vacuum is converted by the sensor to an analog 0-5 volt signal and sent to a data logger. The data logger takes the signal and based on the sensor calibration data translates the voltage into psi.

I use two methods to log boost. The first uses the GM 3 Bar MAP sensor. This sensor is widely available and very easy to set up and use. I set it up using the calibration data that was provided by the manufacturer. The calibration data that I enter in my logger (Logworks logs the LM-1/LMA2) is as follows:

Table 3	**GM 3 BAR MAP SENSOR CALIBRATION**					
PSI	-14.7	-8.9	-4.4	0	20.1	29.4
VOLTAGE	0.000	0.631	1.134	1.600	3.884	4.914

The second method to log boost is to use a JDM MAP sensor specifically designed for the Evo. In Japan, the EvoX is equipped with a 3 bar MAP sensor that sits atop of the inlet manifold. The USDM Evo9 gets a worthless 1 bar MAP sensor. An enterprising genius on EvoM by the name of **mrfred** figured out how to use the JDM MAP sensor on the USDM EVO. The process involves swapping the sensors and modifying defined tables in the ECU to log the values from the JDM MAP sensor. The same principle that I outlined above applies to the JDM MAP sensor only now you can log the boost directly from the ECU provided you have properly modified your EvoScan xml file to log boost. The whole process will be described.

Some boost gauges, like the DEFI, have an internal logging feature with replay. This device can also be used for boost tuning.

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. If you look at the stock WASTEGATE DUTY CYCLE tables you can see there is little room for adjustment. Further, the stock BCS is flowing close to its maximum capacity. In short, you can only get another 1-2psi before the stock system is maxed-out. Don’t worry, there are ways around the problem, but they require some fiddling with the plumbing.

The first fix is to replace the stock pill with one having a smaller feed hole. A pill with 0.8mm 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.

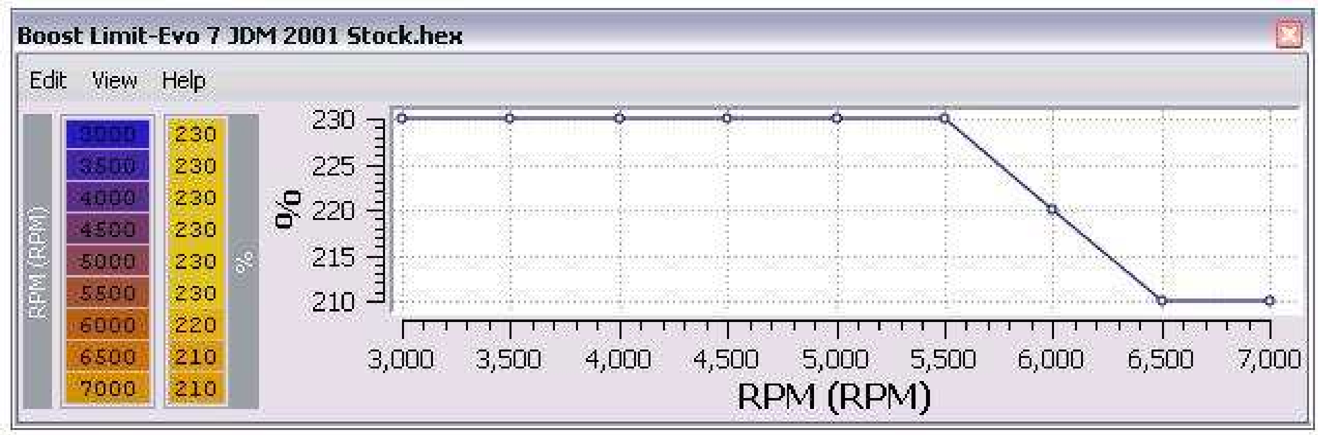
Both methods allows full use of the ECU boost control features including twin boost tables.

6.02-BOOST CONTROL - AIRFLOW / BOOST LIMIT v RPM

The factory ECU tune has a set of parameters, called AIRFLOW LIMIT, which is directly related to the calibrated output from the MAF. Once the ECU senses the AFM is at the AIRFLOW 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.

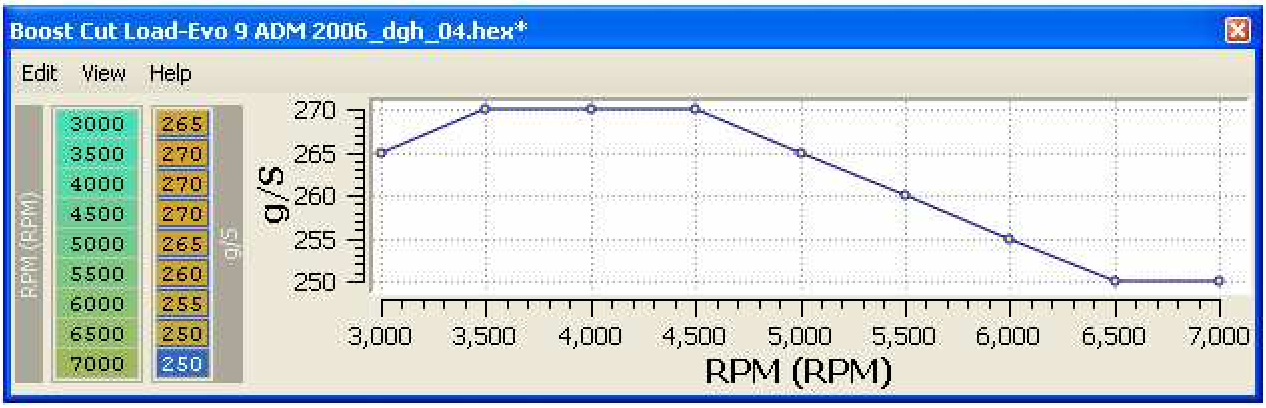
If the values of AIRFLOW LIMIT are set at maximum, to eliminate the boost cut function, there is no over boost protection, which is not good idea.

Figure 62: BOOST TUNING – stock AIRFLOW BOOST LIMIT v RPM, Evo7



RPM (RPM)	%
3000	230
3500	230
4000	230
4500	230
5000	230
5500	230
6000	220
6500	210
7000	210

Figure 63: BOOST TUNING – tuned AIRFLOW BOOST LIMIT v RPM, Evo9



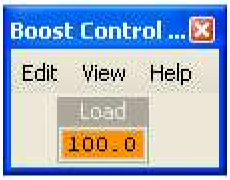
RPM (RPM)	g/S
3000	265
3500	270
4000	270
4500	270
5000	265
5500	260
6000	255
6500	250
7000	250

Note how this tables data roughly follows the expected boost curve, offset some 30g/S higher, thus allowing for some variations in temperature and operating conditions, gear etc.

6.03-BOOST CONTROL - BOOST v RPM

The ECU tune has a pair of tables, called DESIRED BOOST ENGINE LOAD, (#1 and #2, more on the two tables functionality to follow) which with the addition of the BOOST OFFSET parameter, is the target boost level. So, for an ADM EVO9, with 159 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 240.

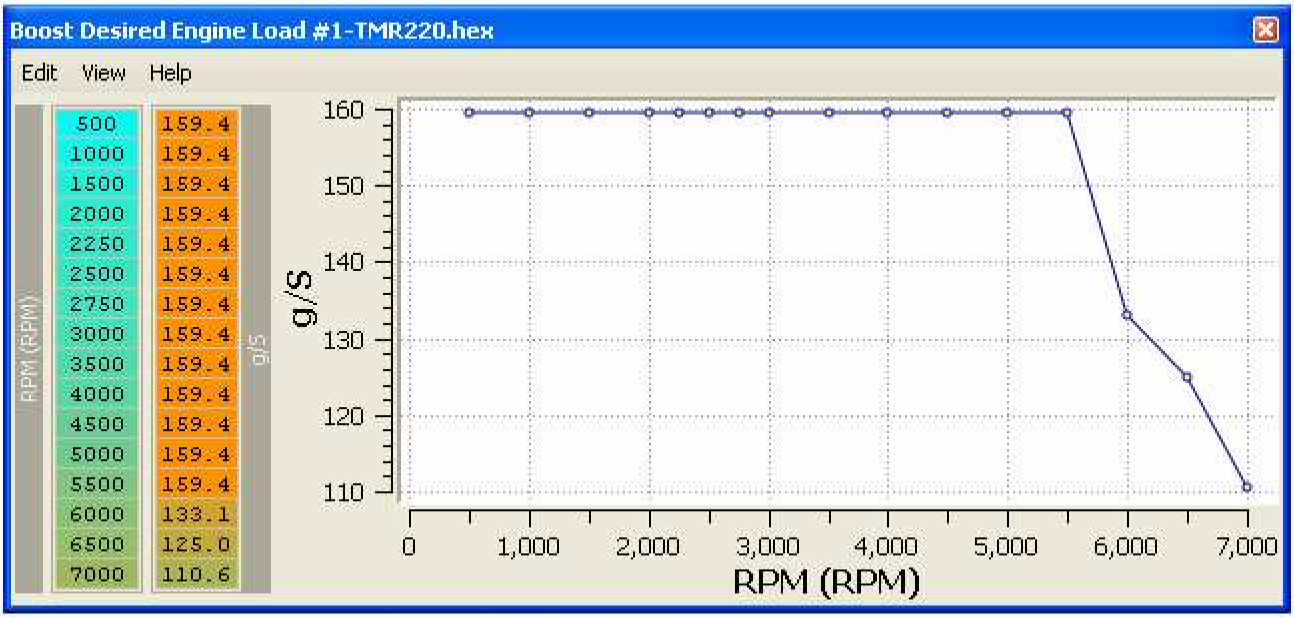
Figure 64: BOOST TUNING – BOOST CONTROL LOAD OFFSET, Evo9 TMR220



Load: 100.0

In the ADM TMR220, the DESIRED BOOST ENGINE LOAD table has values of 159 through the peak torque rpm band, with a BOOST OFFSET value of 100, giving a desired peak boost load level of 260, with a massive tail-off at 7000rpm.

Figure 65: BOOST TUNING – DESIRED BOOST ENGINE LOAD, Evo9 TMR220



RPM (RPM)	g/S
500	159.4
1000	159.4
1500	159.4
2000	159.4
2250	159.4
2500	159.4
2750	159.4
3000	159.4
3500	159.4
4000	159.4
4500	159.4
5000	159.4
5500	159.4
6000	133.1
6500	125.0
7000	110.6

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.

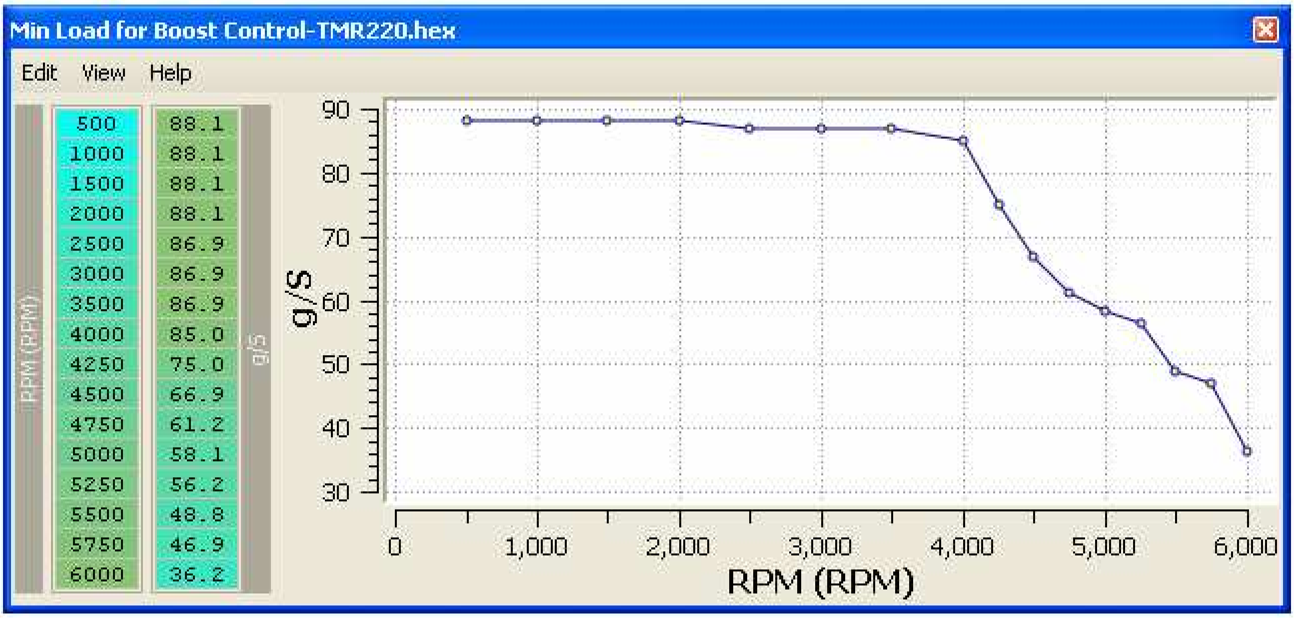
Table 4 ROUGH GUIDE TO LOAD v BOOST LEVEL - Evo9

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

6.04-BOOST CONTROL - MIN LOAD for BOOST CONTROL

The Min Load for Boost Control table sets the Load v rpm, above which boost control will start to operate. These parameters probably wont need to be modified.

Figure 66: BOOST TUNING – MIN LOAD FOR BOOST CONTROL, Evo9 TMR220

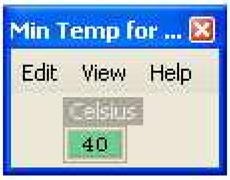


RPM (RPM)	g/S
500	88.1
1000	88.1
1500	88.1
2000	88.1
2500	86.9
3000	86.9
3500	86.9
4000	85.0
4250	75.0
4500	66.9
4750	61.2
5000	58.1
5250	56.2
5500	48.8
5750	46.9
6000	36.2

6.05-BOOST CONTROL - MIN TEMP for BOOST CONTROL

The Min Temp for Boost Control parameter sets the engine temperature for full boost control. The value of 40*C is a lot less than a lot of EVOs commonly use. This parameter may need to be modified, as in many cases, the temperature is set to 85*C. This causes boost cut when the engine is in warm-up mode.

Figure 67: BOOST TUNING – MIN TEMP FOR BOOST CONTROL, Evo9 TMR220



Celsius
40

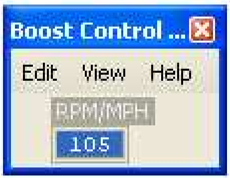
6.06-BOOST CONTROL - RPM/MPH CROSSOVER

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.

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 data set to FFFF, resulting in a crossover value of 2900 rpm/mph, which would never be exceeded so tables #2 were never used (except maybe on some RALLIART models). However the code is active and ready to be utilized.

Figure 68: BOOST TUNING – tuned BOOST CONTROL RPM/MPH CROSSOVER, Evo9



RPM/MPH
105

The table below shows the rpm/mph approximate values for several versions of Evo.

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 5 RPM per MPH Guide

GEAR	2006 Evo9 MR	2006 Evo9 GSR & RS	2005 Evo8 MR	2005 Evo8 GSR & RS	
	rpm/mph	rpm/mph	rpm/mph	rpm/mph	rpm/mph
1st	178	170	180	170	
2nd	119	119	120	119	
3rd	88	88	89	88	
4th	67	67	68	67	
5th	53	46	54	50	
6th	42		43		

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).

6.07-BOOST CONTROL - BOOST CUT DELAY

Boost Cut Delay Timer sets the time in milli-seconds after the boost Limit is exceeded before cut is instigated. 1000mS equals one second and works out ok for most applications.

The TMR220 I examined had this set to 3 seconds, but may not have been the factory value. 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. This parameter is factory set to 1000mS on all the Evo7 and Evo8 I have examined.

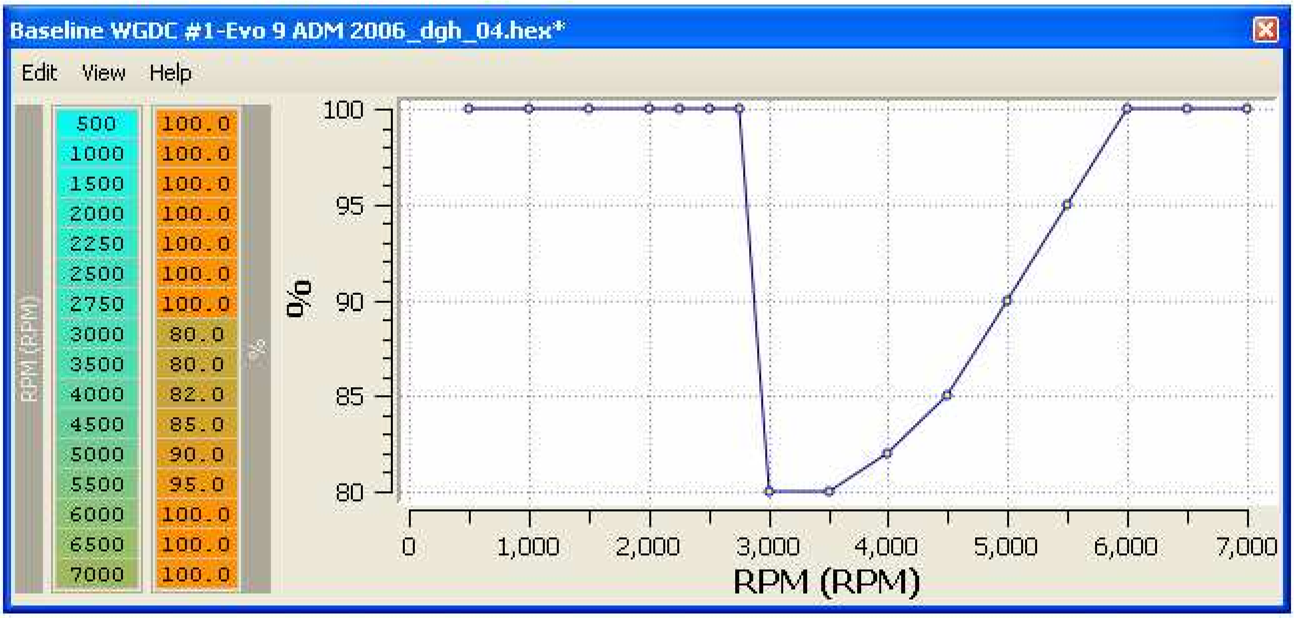
Figure 69: BOOST TUNING – BOOSTCUT DELAY - Evo7, Evo8, Evo9

ms: 1000

6.08-BOOST CONTROL - WGDC v RPM

The table is a base WGDC look-up table to 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 DESIRED BOOST ENGINE LOAD table + the BOOST OFFSET value.

Figure 70: BOOST TUNING – BOOST CONTROL WGDC % v RPM – ADM Evo9



RPM (RPM)	%
500	100.0
1000	100.0
1500	100.0
2000	100.0
2250	100.0
2500	100.0
2750	100.0
3000	80.0
3500	80.0
4000	82.0
4500	85.0
5000	90.0
5500	95.0
6000	100.0
6500	100.0
7000	100.0

On the Evo9 there are two sets of waste-gate solenoid control tables, some other EVOs have more. Which table is in use (1 or 2) is controlled by the RPM/MPH CROSSOVER set-point, previously discussed. Below the crossover set-point, the ECU uses table #1, and above the set-point, uses the table #2.

Note1: A WGDC of 100% will have the stock solenoid energized 100% of the time, with NO air getting to the waste-gate actuator. This is done for two reasons. It helps get the turbo spooled quicker and is a fail-safe for when the solenoid fails, the system reverts to the base waste-gate actuator operating pressure.

Note2: When using three port solenoids, they should be setup the same ie when there is no power to the solenoid, full air pressure is passed to the waste-gate actuator.

6.09-BOOST TUNING - 3-PORT BOOST CONTROL INTRODUCTION

A good 3-port BCS valve is much easier to tune than the stock single port unit. It is a faster responding unit and is very responsive to WGDC settings over a wider range of duty cycle percentage. Thus, it's 3-port design will be much more precise and responsive in boost management. This is something that can be felt in the performance of the car and boost response.

There are three main contenders to use in this application:

1. **GM (AC DELCO)**
2. **GrimmSpeed**
3. **Tactrix**

Several valves have been tested by **mrfred** and been found to be somewhat unsuitable for this application on the Evo ECU. These include the **Evo EGR** valve and the **MAC35A** valve.

I notice **mrfred** has recently completed testing on the **Evo EGR 3-port** solenoid as a boost control solenoid. The result was poor with very limited adjustment range and the valve is slow to bleed pressure from the wastegate actuator line, essentially resulting in spool-lag, so I think we can excuse this device from BCS duties.

Both the GM valve and the MAC35A valve have latencies approximately half the stock boost control valve. With a 1 ohm series resistor fitted, the stock valve latency = 10.3mS, the GM = 6.0mS and the MAC = 4.5mS. The ECU BCS operating frequency is 20Hz/50mS. So you can see why the 3-port valves will have better response and better tuning control than the stock valve.

Unfortunately, the **MAC35A** has a resistance of 11.6 ohms, which would result in a peak current of 1.2 ampers with a battery voltage of 14VDC. The stock valve has a resistance of 32 ohms, resulting in a peak current of 437mA at 14VDC battery voltage. The MAC valve at three times the stock current is probably more than the ECU was designed to operate at and may damage the ECU. If a padding series resistor of 22 ohms is used, the MAC valve does not operate and is barley operable at 8 volts. In addition, **mrfred**s testing of the MAC valves has shown that the control range is reduced to 80% -100% WGDC, as compared to the GM valves 20%-100% control range. People have tried to use the MAC35A, but it is not as good in this application as the GM valve. The Evo EGR valve has been used successfully though and has the same resistance as the original BCS.

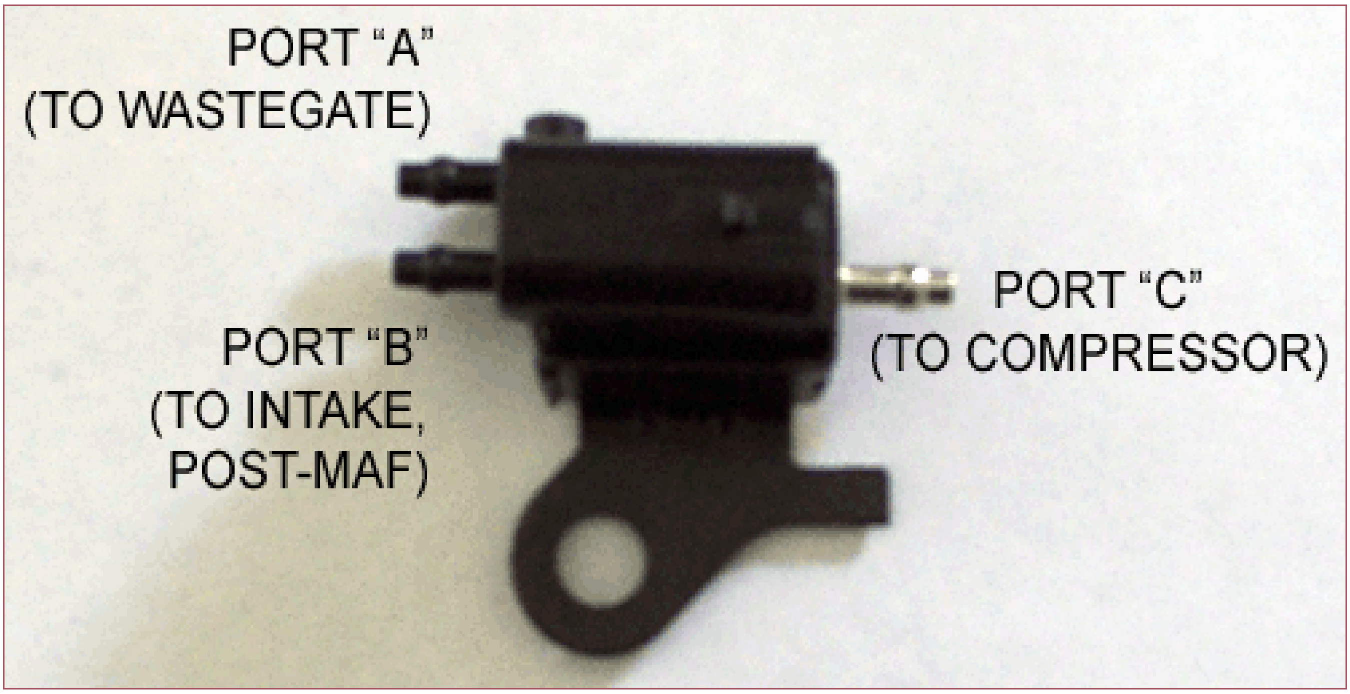
6.10-BOOST TUNING - GM 3-PORT BCS

The figure below shows the GM valve, details as follows:

Part Number:	ACDELCO 214-474	valve		
Part Number:	ACDELCO PT374	pigtail lead.		
Resistance:	26 ohms.			
Latency:	6mS.			
De-Energised:	Air-Flow from - Port A to Port C		0%	WGDC.
Energised:	Air-Flow from - Port A to Port B		100%	WGDC.

Spoolinup now has a plug-n-play adaptor harness for the GM valve.
Available from: http://www.szabaga.com/store/diy/html

Figure 71: BOOST TUNING – GM 3-PORT BCS



The stock solenoid is 32.5 ohms. In the past, a lot of users solder a 10 ohm 1 watt resistor in series when using the GM valve, which is 26 ohms. However, **mrfred**s testing shows that a 5 ohm resistor works better than 10 ohms. Additionally, no-one has reported damaging their ECU when running either a 5 ohm resistor or indeed no resistor.

6.11-BOOST TUNING – GRIMMSPEED EVO 3-PORT BCS

This is a plug-n-play Evo BCS that **GrimmSpeed** have had custom made by MAC. Its operating characteristics are similar to the GM valve and can be used with confidence. Available from: https://www.grimmspeed.com

Figure 72: BOOST TUNING – GrimmSpeed Evo 3-port BCS

6.12-BOOST TUNING – TACTRIX EVO 3-PORT BCS

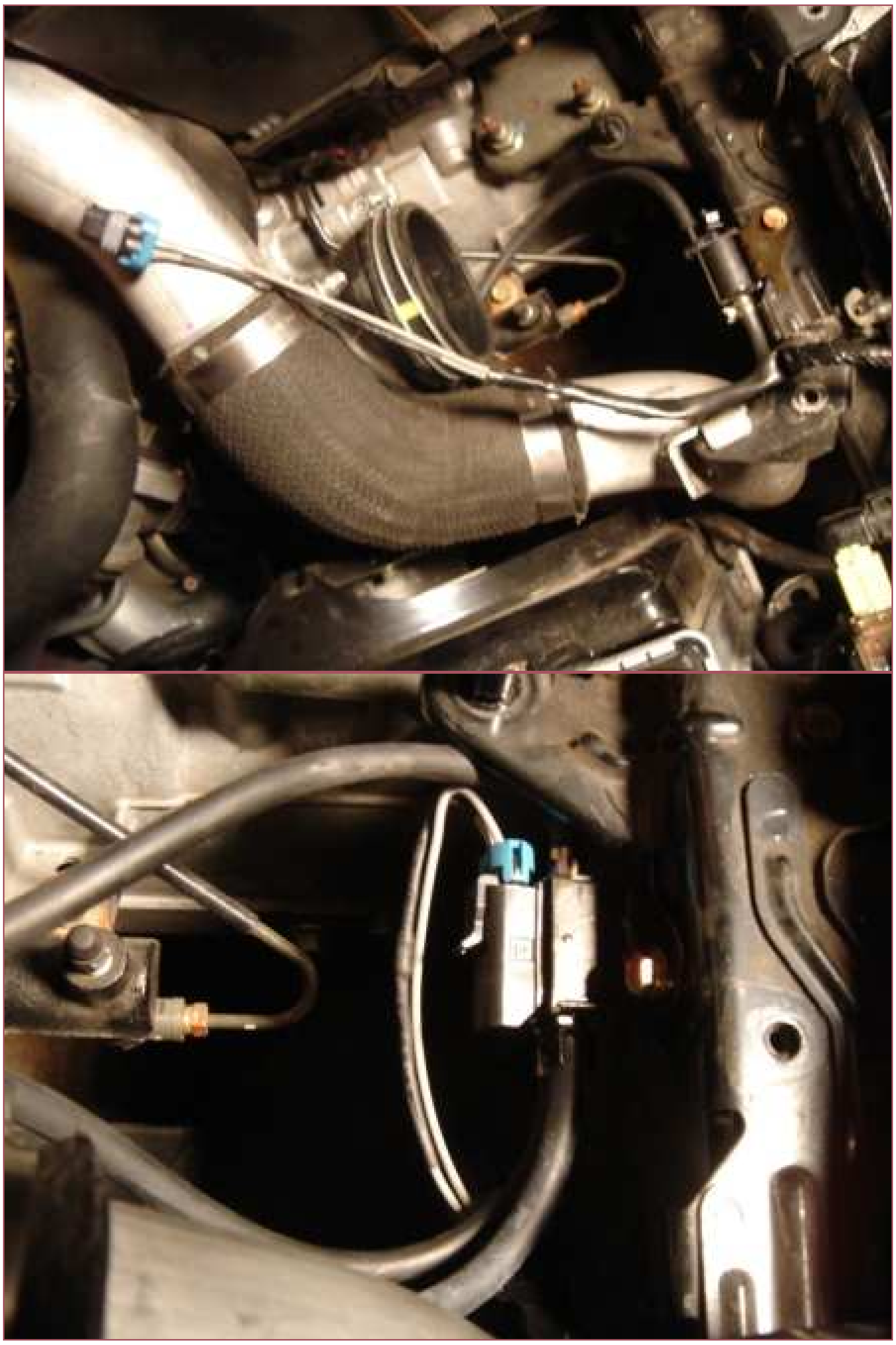
This is a plug-n-play Evo BCS from **TACTRIX**, originally derived from the ProDrive unit. Its operating characteristics are also similar to the GM valve and can be used with confidence. Available from: http://www.tactrix.com

Figure 73: BOOST TUNING – Tactrix Evo 3-port BCS

6.13- BOOST TUNING – 3-PORT BCS INSTALATION

Remove the standard air-box, all the bits to be swapped out are under here. Note the new solenoid mounted in the wrong position in this first figure, as it interferes with the stock air-box. It will be ok here with a pod filter though.
Pix and tech from **Evo Kid** on EvoM.

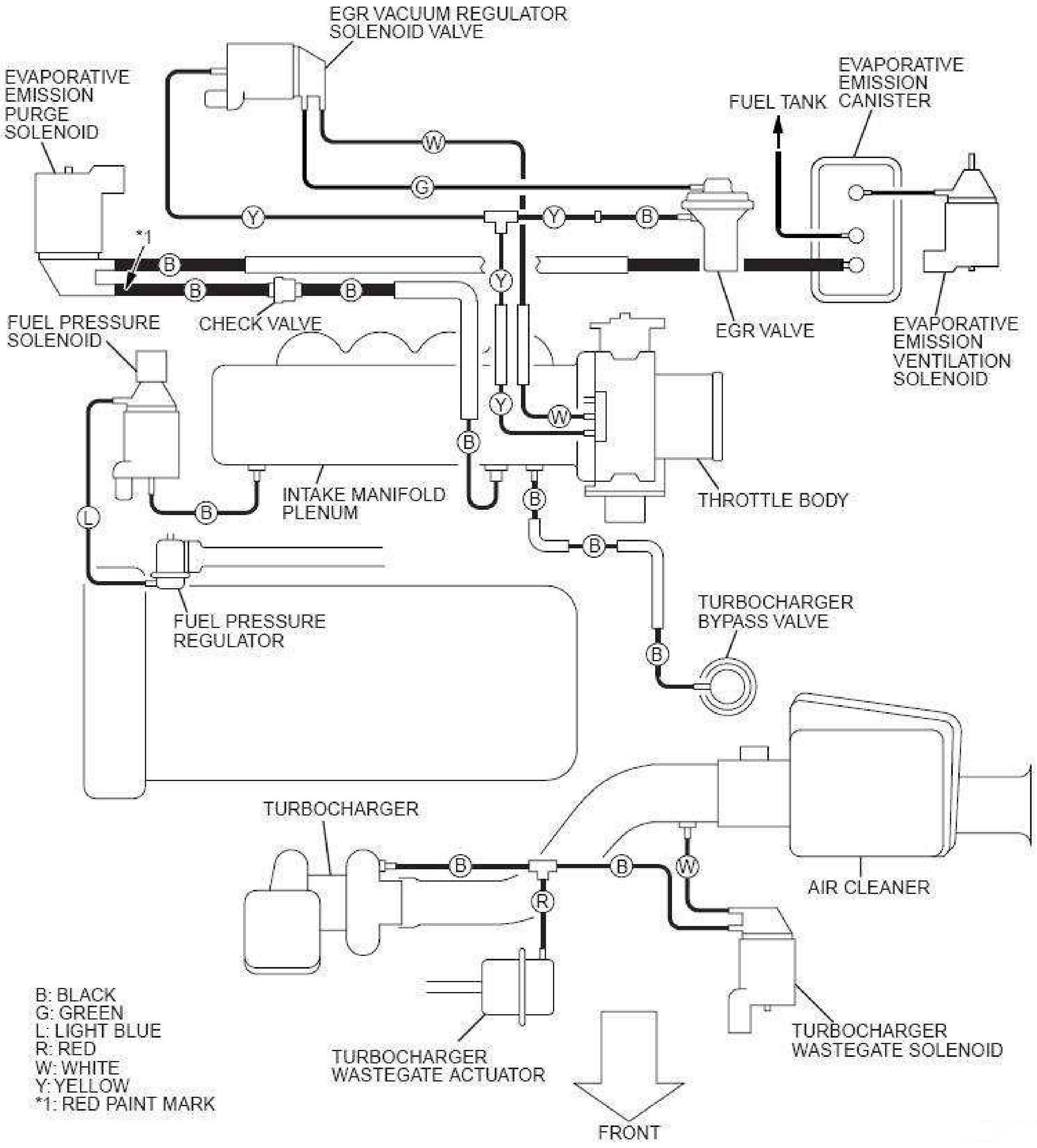
Figure 74: BOOST TUNING – GM 3-PORT BCS MOUNTING



This mounting position will work with the standard factory air-box. The series 5 ohm resistor can be seen covered with black heat-shrink here as well. Use zip-ties on the hose ends, we don't want them to blow off.

This diagram shows all the turbo related components and the stock hose plumbing arrangement.

Figure 75: BOOST TUNING – TURBO HOSE AND ACTUATOR DIAGRAM

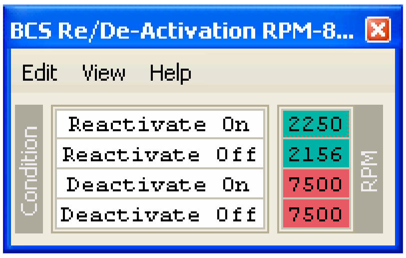


Now you have to run the new vacuum lines. The original T fitting has to be removed and the new BCS is fitted in its place so new longer hose has to be used. It is not necessary to use the brass restrictor when using the GM valve. The normally closed port (B) connects to the little port on the bottom of the stock air intake, near the MAF. If using an aftermarket intake with no return port, the line can just vent to atmosphere. However that may result in some crap getting into the valve, so it may be better to add a port and set it up properly. That would also meet "official" requirements.

Using the restrictor will slow the response of the wastegate actuator slightly, but it will also reduce the magnitude of the pressure oscillations from the BCS valve. An alternative is to fit a small bleed to atmosphere fitting in the line from the BCS valve to the WGA. This will definitely reduce the pressure oscillations, without changing response time, but the control range is reduced a little. This last option will likely yield the best compromise in practice. Most don't bother with the restrictors and it all works fine.

A point to note with the GM 3-port valve is if the WGDC is set to 100% up to the rpm where the turbo is making substantial boost (15psi for example), the turbo will spool faster than with the stock setup. This happens because the 3-port setup excludes positive pressure to the wastegate, thus preventing WG creep. The stock setup can at best only divert 50% of the pressurized air from the WG, which will allow some WG creep and thus a slower turbo spool. Using the GM 3-port BCS is a win all round! Note that this is dependant on the setting, "BCS RPM Activate On", which is normally set to 2250rpm. Below this rpm, the valve is de-energized, presumably to extend its life and also so you cannot hear it ticking at idle. This works ok as the turbo is only just starting to make boost at this rpm, though you could lower the value a bit. Wherever you set it too, set the "BCS RPM Activate Off" to 100rpm less.

Figure 76: BOOST TUNING – BCS ENERGIZED RPM SETPOINTS, EVO9



Condition	RPM
Reactivate On	2250
Reactivate Off	2156
Deactivate On	7500
Deactivate Off	7500

If EcuFLASH shows a table called MAX WASTEGATE DUTY CYCLE, please change your definition file for this parameter to read BASELINE WGDC. It is used as the starting WGDC value and is definitely not a maximum value, as the ECU will add or subtract to this from the TURBO BOOST ERROR CORRECTION table, in an effort to hit the BOOST DESIRED ENGINE LOAD.

An improvement to boost control has also been worked out by mrfred so the ECU will track the 2-byte load variable with air temperature and barometric pressure correction, rather than the stock load variable with no correction. This modification should give a bit more accurate response. Unfortunately, this mod has only been worked out for a few ROMs, see the table below.

First, add the following to your XML definition file. Substitute your ROMs correct address from the table below.

```
<table name="Variable for Boost Control" category="Turbo" address="41E12" type="1D" scaling="Hex16"/>
```

Open EcuFLASH and then VARIABLE FOR BOOST CONTROL. Change the data to the data shown in the table. The table is in hex format, so you will have to enter it as 0x6b22 or whatever your ROM requires etc. Boost control will now track the same 2-byte load variable we all log in EvoScan.

Table 6 2-BYTE AIR TEMP & BARO CORRECTED BOOST CONTROL

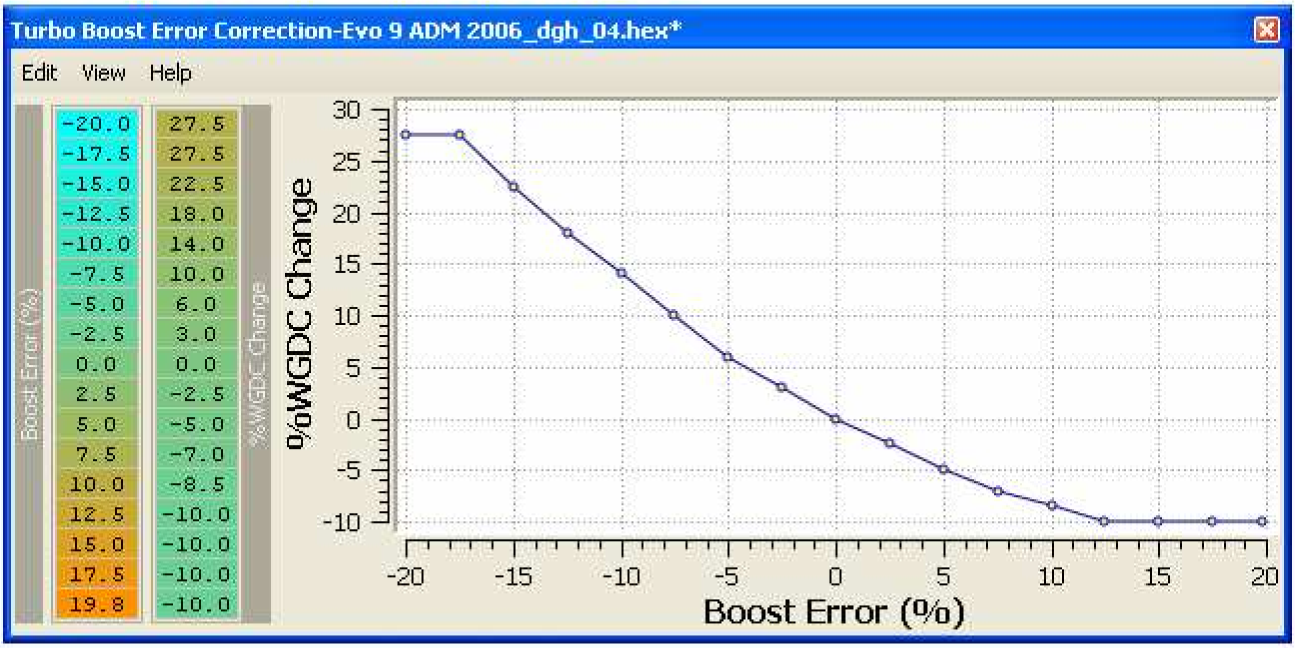
ROM	88580013 88580014	88590015	96940011	96420007 96420008	94170008 94170014 94170015	96530006	88840016	
ADDRESS	40882	41E12	204BA	1F96E	1EE8E	2025E	408B2	
DATA	6B22	6B42	899A	8984	895C	8984	6B22	

When taking the car out for the first test drive after installing the 3-port BCS, roll onto boost SLOWLY and constantly monitor boost. If it starts to boost more then a safe amount for your octane and tune, LET OFF THE GAS. It will take a couple pulls with adjustments to get boost where you want it.

6.14-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.

Figure 77: BOOST TUNING – BOOST ERROR CORRECTION, ADM EVO9



Boost Error (%)	%WGDC_Change
-20.0	27.5
-17.5	27.5
-15.0	22.5
-12.5	18.0
-10.0	14.0
-7.5	10.0
-5.0	6.0
-2.5	3.0
0.0	0.0
2.5	-2.5
5.0	-5.0
7.5	-7.0
10.0	-8.5
12.5	-10.0
15.0	-10.0
17.5	-10.0
19.8	-10.0

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 BASLINE WGDC v RPM table. At that point the ECU compares the actual load to the total DESIRED BOOST ENGINE LOAD table, which is its target load.

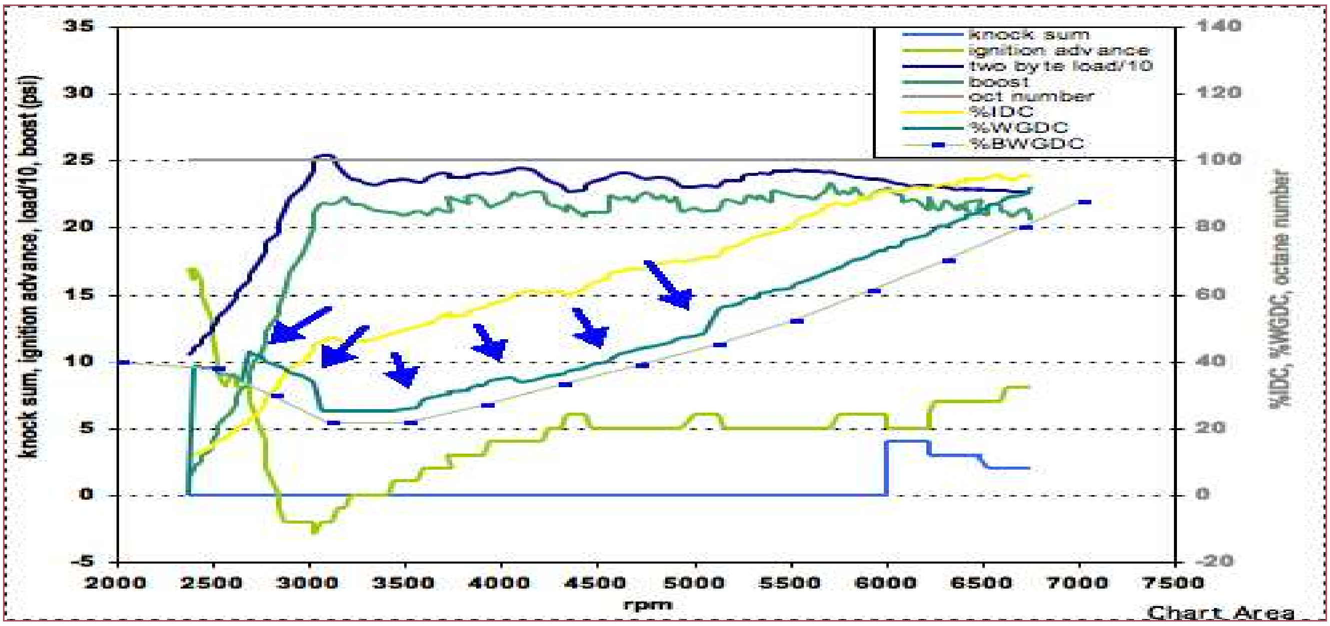
The rate at which the tracking check is made is set by the ERROR CORRECTION INTERVAL parameter, the stock value is at 1000mS.

If the actual load matches the target load (BDEL +BOOST OFFSET), then the ECU continues to follow the BASELINE 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.

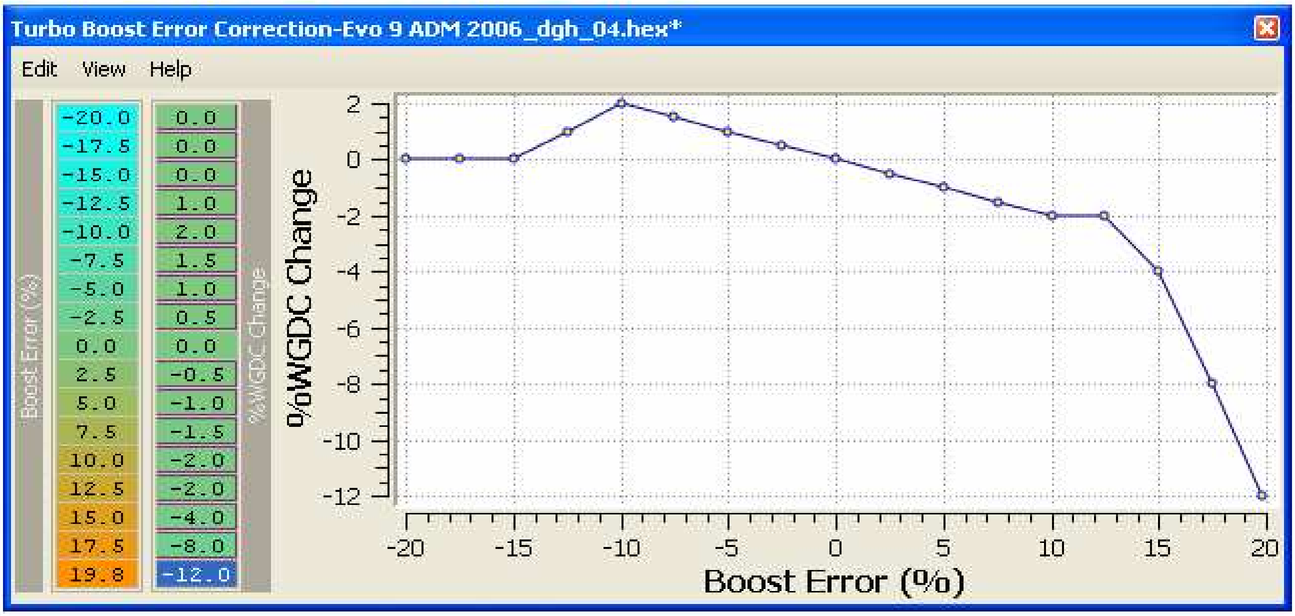
The graph shows the behaviour well. The blue arrows show when corrections are made, and it is apparent that the ECU is simply raising/lowering the BASELINE WGDC curve.

Figure 78: BOOST TUNING – BOOST ERROR CORRECTION - mrfred



This is **mrfred**s BOOST ERROR CORRECTION table when using a 3 port BCS. Note the much reduced value of upward correction to prevent boost spike.

Figure 79: BOOST TUNING – mrfred tuned BOOST ERROR CORRECTION, Evo9



Boost Error (%)	%WGDC Change
-20.0	0.0
-17.5	0.0
-15.0	0.0
-12.5	1.0
-10.0	2.0
-7.5	1.5
-5.0	1.0
-2.5	0.5
0.0	0.0
2.5	-0.5
5.0	-1.0
7.5	-1.5
10.0	-2.0
12.5	-2.0
15.0	-4.0
17.5	-8.0
19.8	-12.0

My own BOOST ERROR CORRECTION has a maximum correction of ±10 which is working well with a stock turbo and lots of breathing mods, so you can see that there is quite a wide range of variations that will work. However the key to good control and prevention of boost overshoot is to zero off the -20, and -17.5 cells because this is what the ECU is seeing as the turbo starts to spool. With error correction added to the WGDC while spooling, a much larger negative correction has to be done to get the load tracking the BOOST DESIRED ENGINE LOAD.

If the BOOST ERROR CORRECTION table is not used, the engine will over-boost in 4th, 5th and 6th gear when it did not in 1st 2nd or 3rd gear. It will also track the desired load value better with varying atmospheric and altitude conditions.

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 both the GM valve and the MAC valve.

If you zero out all the positive/upward correction, you will get less boost overshoot, but your BDEL + OFFSET will have to be on the money. In this case, if you're BOOST DESIRED ENGINE LOAD (BDEL) is spot-on, you would probably boost less in lower gears.

Some cars have a problem like this where they over-boost like that with the positive error correction #'s in, but it is very, very rare, at least from what I have seen. Usually it is from setting the WGDC% too high.

6.15-BOOST TUNING - ERROR CORRECTION INTERVAL

The WGDC correction algorithm runs on a timer between adjustments. 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 deviations of the load from the target load value BDEL + BCLO.

Recommended minimum value is 3-4 for faster boost error tracking. Note that when using a reduced correction interval you should also use **mrfred**s BOOST ERROR CORRECTION table or something similar, with reduced correction values to prevent over correction as the system will now be less laggy.

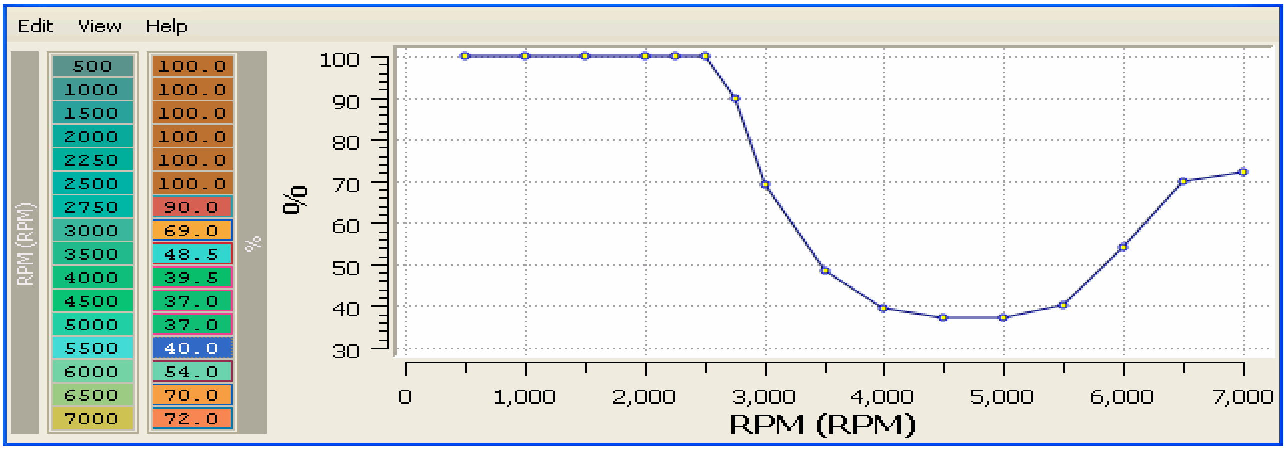
Figure 80: BOOST TUNING – ERROR CORRECTION INTERVAL,Evo9

LOAD
10

6.16- BOOST TUNING – 3-PORT EXAMPLE MAPS

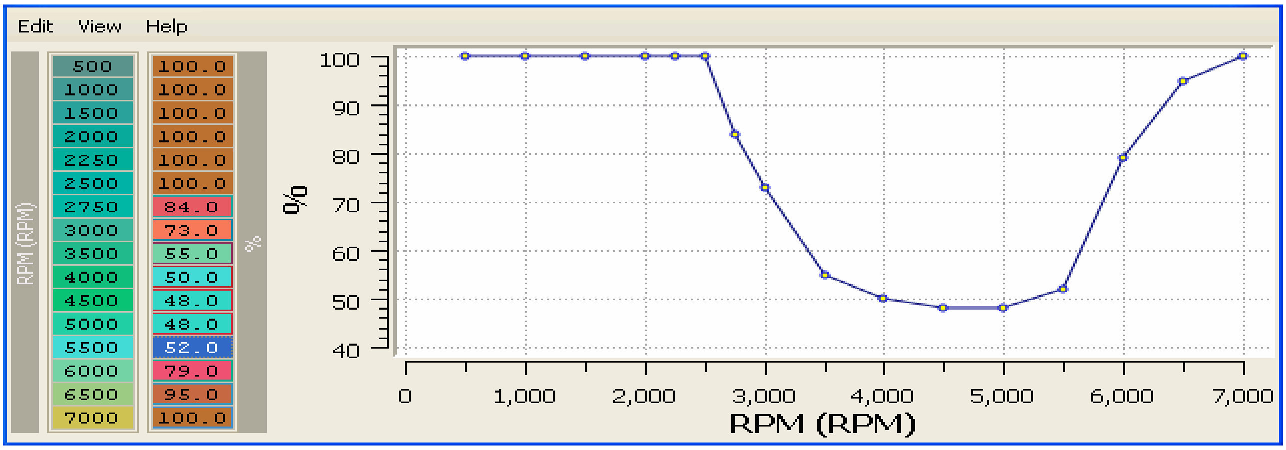
These examples are from **Razorlab** for a various Evo9, no pill used.

Figure 81: BOOST TUNING – Razorlab WGDC SETTINGS, 22psi flat, Evo9



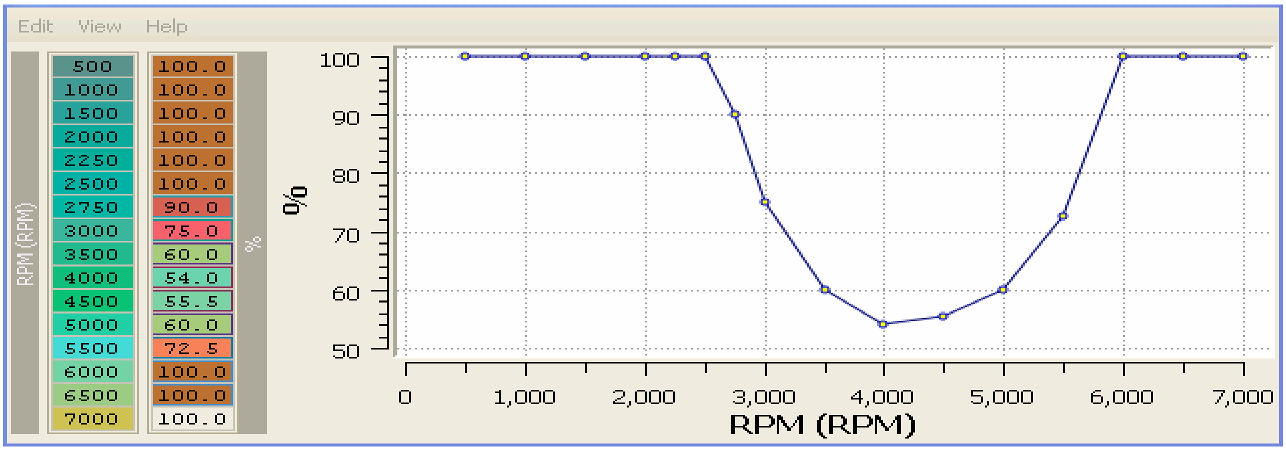
RPM (RPM)	%
500	100.0
1000	100.0
1500	100.0
2000	100.0
2250	100.0
2500	100.0
2750	90.0
3000	69.0
3500	48.5
4000	39.5
4500	37.0
5000	37.0
5500	40.0
6000	54.0
6500	70.0
7000	72.0

Figure 82: BOOST TUNING – Razorlab WGDC SETTINGS, 26psi peak to 24psi, Evo9



RPM (RPM)	%
500	100.0
1000	100.0
1500	100.0
2000	100.0
2250	100.0
2500	100.0
2750	84.0
3000	73.0
3500	55.0
4000	50.0
4500	48.0
5000	48.0
5500	52.0
6000	79.0
6500	95.0
7000	100.0

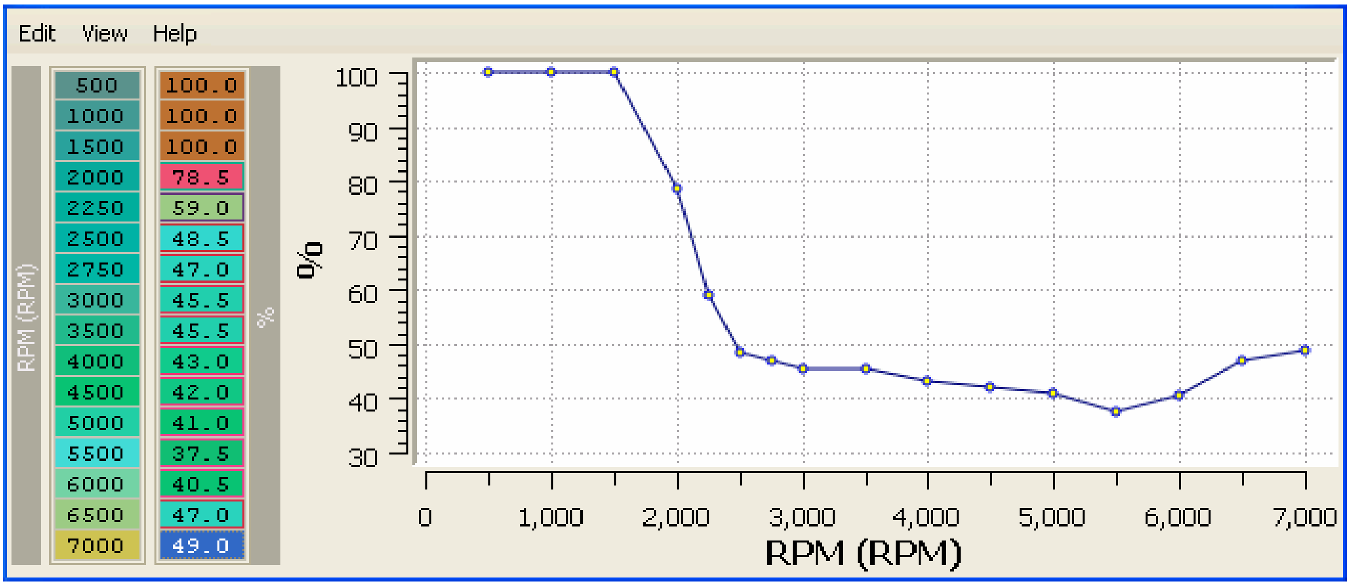
Figure 83: BOOST TUNING – Razorlab WGDC SETTINGS, 27psi peak to 24psi, Evo9



RPM (RPM)	%
500	100.0
1000	100.0
1500	100.0
2000	100.0
2250	100.0
2500	100.0
2750	90.0
3000	75.0
3500	60.0
4000	54.0
4500	55.5
5000	60.0
5500	72.5
6000	100.0
6500	100.0
7000	100.0

This example from **Razorlab** is his own EVO8 with a FP Green turbo, FP 18psi wastegate actuator and no pill used. The response was 22psi peak, holding 20psi. Quite a different duty cycle curve here!

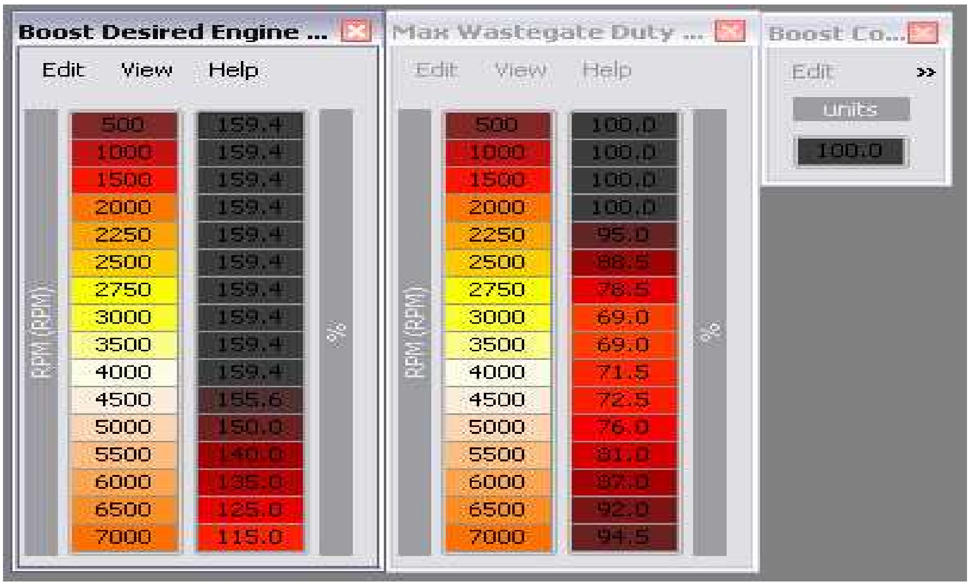
Figure 84: BOOST TUNING – Razorlab WGDC SETTINGS, FPGREEN+18psiWG, Evo8



500	100.0
1000	100.0
1500	100.0
2000	78.5
2250	59.0
2500	48.5
2750	47.0
3000	45.5
3500	45.5
4000	43.0
4500	42.0
5000	41.0
5500	37.5
6000	40.5
6500	47.0
7000	49.0

This example from **Razorlab** is for a stock Evo9, no pill used. The response was a flat 260 load.

Figure 85: BOOST TUNING – WGDC SETTINGS – razorlab for 260 LOAD– Evo9



500	159.4
1000	159.4
1500	159.4
2000	159.4
2250	159.4
2500	159.4
2750	159.4
3000	159.4
3500	159.4
4000	159.4
4500	155.6
5000	150.0
5500	140.0
6000	135.0
6500	125.0
7000	115.0

500	100.0
1000	100.0
1500	100.0
2000	100.0
2250	95.0
2500	88.5
2750	78.5
3000	69.0
3500	69.0
4000	71.5
4500	72.5
5000	76.0
5500	81.0
6000	87.0
6500	92.0
7000	94.5

100.0

SECTION 7 – LEAN SPOOL TUNING

7.01-LEAN SPOOL TUNING INTRODUCTION

LEAN SPOOL is tuning enhancement Mitsubishi employ to reduce the turbo spool time. A gasoline engine will produce a hotter exhaust gas and more power at an AFR of 12.5:1 than 10.5:1. It achieves this by running a leaner AFR during the rapid engine acceleration period than is set-out in the fuel map and in the process produce more torque. All of which results in a quicker on-road car.

The seemingly super rich areas of the factory tune fuel map are there to provide thermal management, not power. The hotter exhaust gas temperature from a lean AFR will produce hotter engine parts, head, valves, turbo cat etc. With prolonged use, component life will suffer and a head running at elevated temperatures is more susceptible to detonation and of course will eventually blow the head gasket. So the factory run the richer maps to save the engine when under high, extended loading.

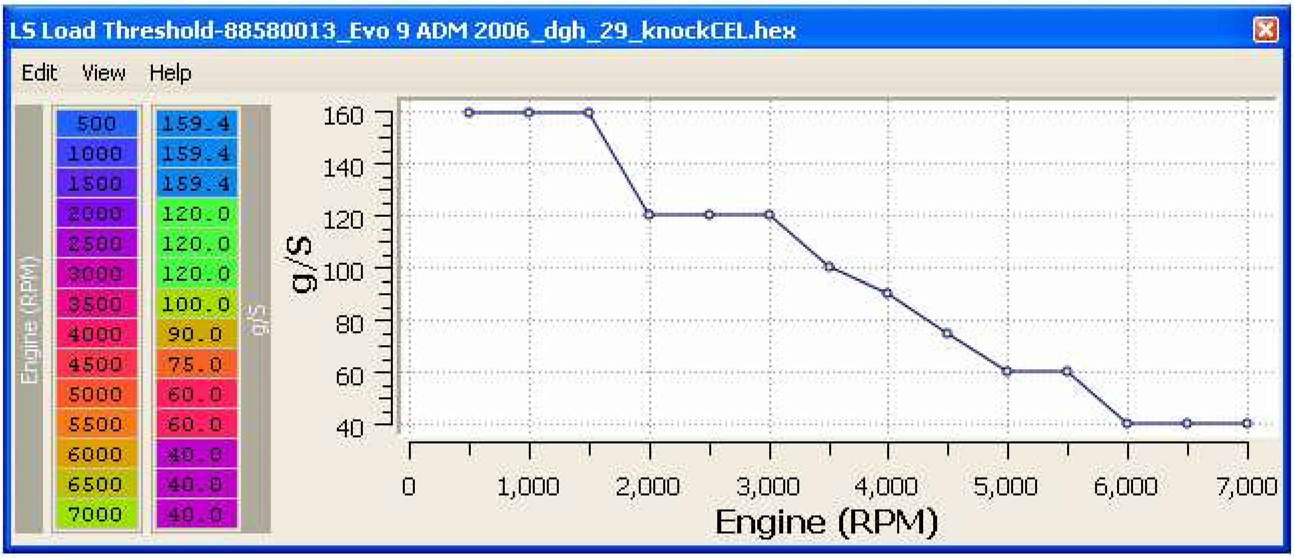
There are ten parameters in the ECU currently available for tuning and adjustments, though some are not well defined or have poor explanations. Luckily only two or three would probably need to be tweaked to get the desired result.

LEAN SPOOL can also be disabled via the Periphery bit settings.

7.02-FUEL LEAN SPOOL – LOAD THRESHOLD v RPM

Sets the LOAD v RPM threshold point, above which LEAN SPOOL operation will activate.

Figure 86: LEAN SPOOL - LOAD THRESHOLD v RPM, Evo9



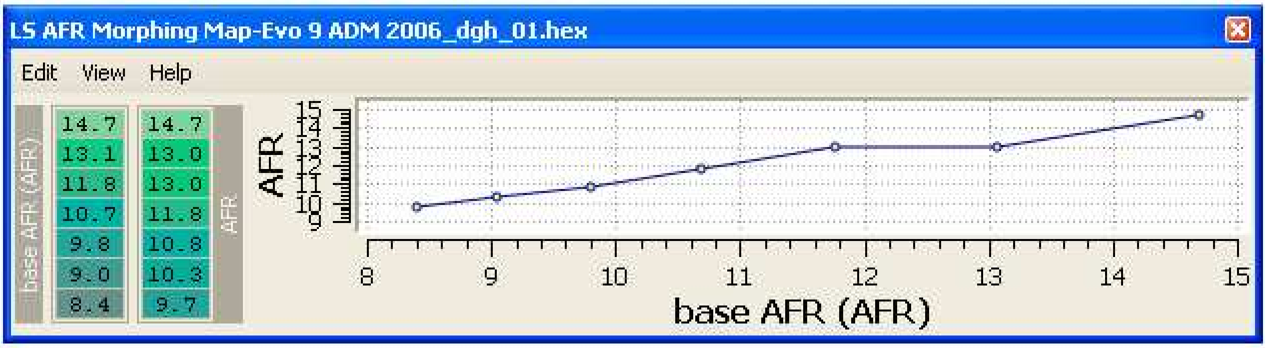
LS Load Threshold-88580013_Evo 9 ADM 2006_dgh_29_knockCEL.hex

Engine (RPM)	g/S
500	159.4
1000	159.4
1500	159.4
2000	120.0
2500	120.0
3000	120.0
3500	100.0
4000	90.0
4500	75.0
5000	60.0
5500	60.0
6000	40.0
6500	40.0
7000	40.0

7.03-FUEL LEAN SPOOL – AFR TABLE

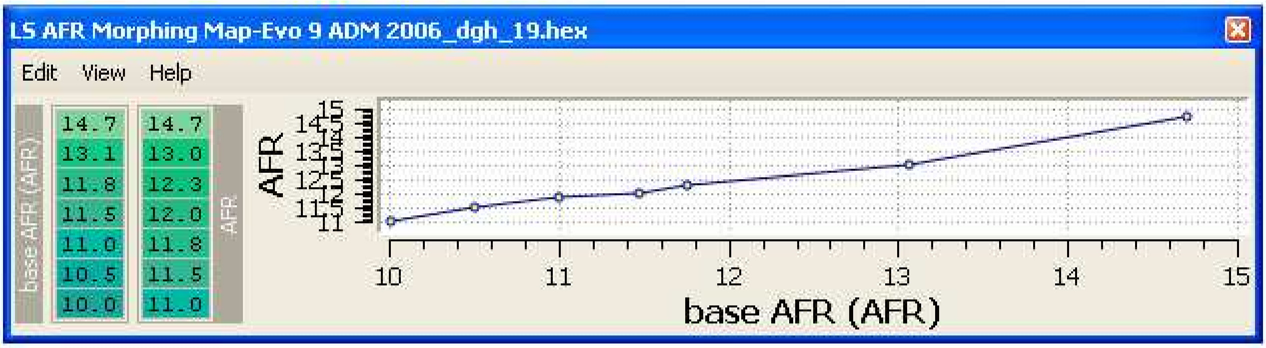
This first table is the stock Evo9 AFR table, showing how the AFR is shifted/morphed from what is in your HI OCTANE FUEL MAP (base AFR) to the expected actual AFR. The DECAY RICH SIDE timer controls the time of LS operation through the rev-band.

Figure 87: LEAN SPOOL - AFR TABLE, Evo9



base AFR (AFR)	AFR
14.7	14.7
13.1	13.0
11.8	13.0
10.7	11.8
9.8	10.8
9.0	10.3
8.4	9.7

Figure 88: LEAN SPOOL - AFR TABLE, HI-RESOLUTION, Evo9



base AFR (AFR)	AFR
14.7	14.7
13.1	13.0
11.8	12.3
11.5	12.0
11.0	11.8
10.5	11.5
10.0	11.0

One way to look at this table is ask yourself, “How much leaner AFR do I want the engine to run when accelerating?” If the answer is 0.5 AFR, then set the AFR to 0.5 leaner than the BASE AFR. I should also point out to not change the 14.7 and 13.1 settings. That would be playing with fire.

7.04-FUEL LEAN SPOOL – START RPM

Sets the starting rpm for LEAN SPOOL. There is not much point in adjusting this parameter as it is really a function defined by the choice of turbo.

Figure 89: LEAN SPOOL - START RPM, Evo9

RPM
2500

7.05-FUEL LEAN SPOOL – STOP RPM

Sets the rpm at which LEAN SPOOL ceases operation. This can be set to the same rpm as the start rpm, effectively disabling LEAN SPOOL.

Figure 90: LEAN SPOOL - STOP RPM, Evo9

RPM
7000

7.06-FUEL LEAN SPOOL – MIN TEMP

Sets the minimum temperature for LEAN SPOOL to be active. There is not much point in adjusting this parameter.

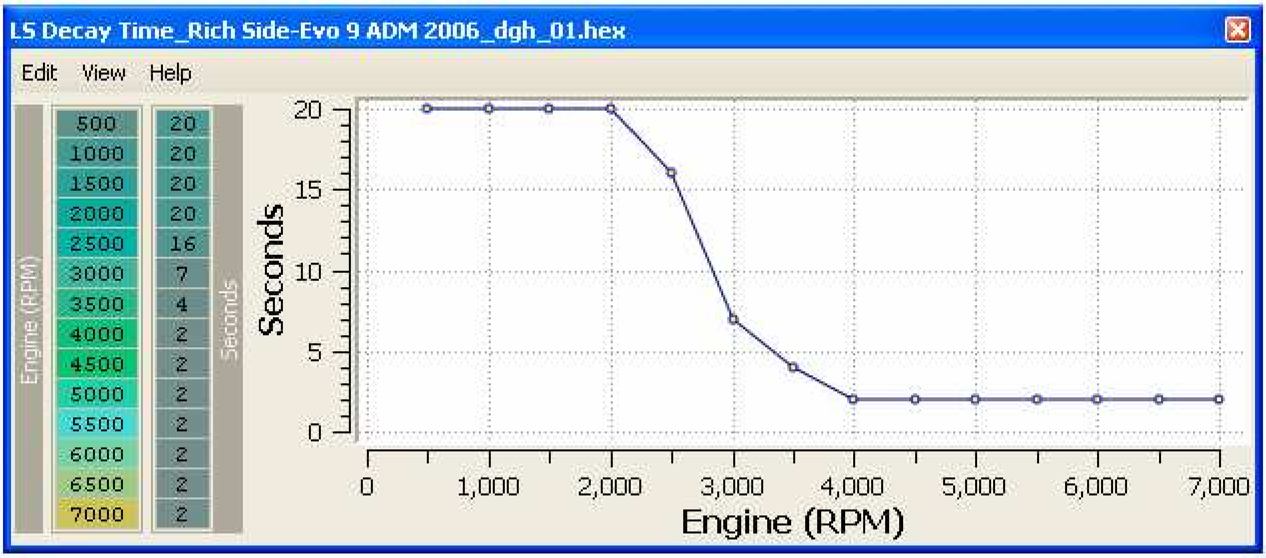
Figure 91: LEAN SPOOL - MIN TEMP, Evo9

Celsius
50

7.07-FUEL LEAN SPOOL – DECAY TIME RICH SIDE

Time units for how long it will take for the engine to decay from a lean condition (as controlled by the LS AFR table) to normal Hi-OCTANE fuel map operation. The units may not be seconds exactly. Reducing these values decreases the time spent in lean spool mode

Figure 92: LEAN SPOOL - TRANSITION TIME RICH SIDE v RPM, Evo9

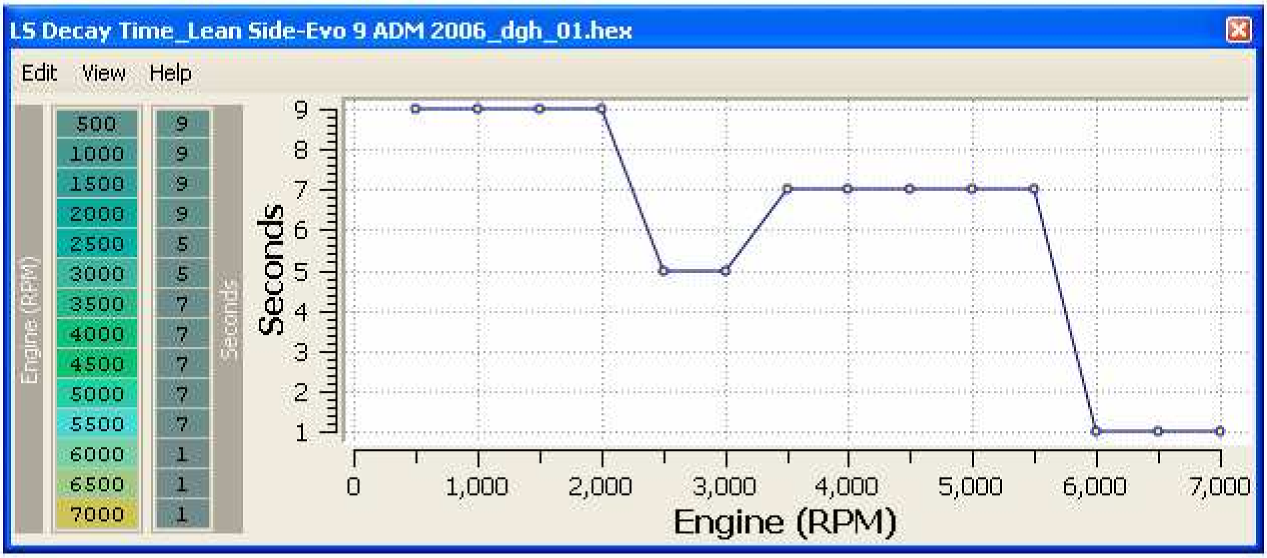


Engine (RPM)	Seconds
500	20
1000	20
1500	20
2000	20
2500	16
3000	7
3500	4
4000	2
4500	2
5000	2
5500	2
6000	2
6500	2
7000	2

7.08-FUEL LEAN SPOOL – DECAY TIME LEAN SIDE

Time units for how long it will take for the engine to decay from full HI-OCTANE fuel map operation back to a point where the AFR is dictated by the LS AFR table. The units may not be seconds exactly. Reducing these values decreases the time spent in normal AFR mode.

Figure 93: LEAN SPOOL - TRANSITION TIME LEAN SIDE v RPM, Evo9

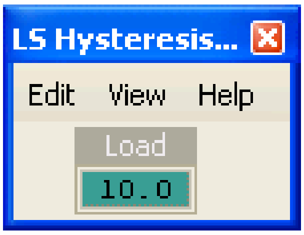


Engine (RPM)	Seconds
500	9
1000	9
1500	9
2000	9
2500	5
3000	5
3500	7
4000	7
4500	7
5000	7
5500	7
6000	1
6500	1
7000	1

7.09-FUEL LEAN SPOOL – LOAD HYSTERESIS

A load value parameter to prevent LEAN SPOOL operation rapidly toggling on and off. The factory value of 10 works fine and does not need adjusting.

Figure 94: LEAN SPOOL - LOAD HYSTERESIS, Evo9



Load
10.0

7.10-FUEL LEAN SPOOL – AFR ENABLE

Figure 95: LEAN SPOOL - ARF ENABLE, Evo9

AFR
13.0

7.11-FUEL LEAN SPOOL – AFR CLIP

Sets the maximum possible enleanment AFR value.

Figure 96: LEAN SPOOL - AFR CLIP, Evo9

AFR
14.7

SECTION 8 – KNOCK TUNING

8.1-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, OCTANE NUMBER is reported to have an affect on the boost control settings.

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.

8.2-KNOCK TUNING – OCTANE UPDATE THRESHOLD

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.

Figure 97: KNOCK TUNING – OCTANE UPDATE THRESHOLD, Evo9

500	1000	1500	2000	2500	3000	3500	4000	4500	5000
159.4	159.4	159.4	159.4	159.4	100.0	100.0	120.0	120.0	120.0

8.3-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.

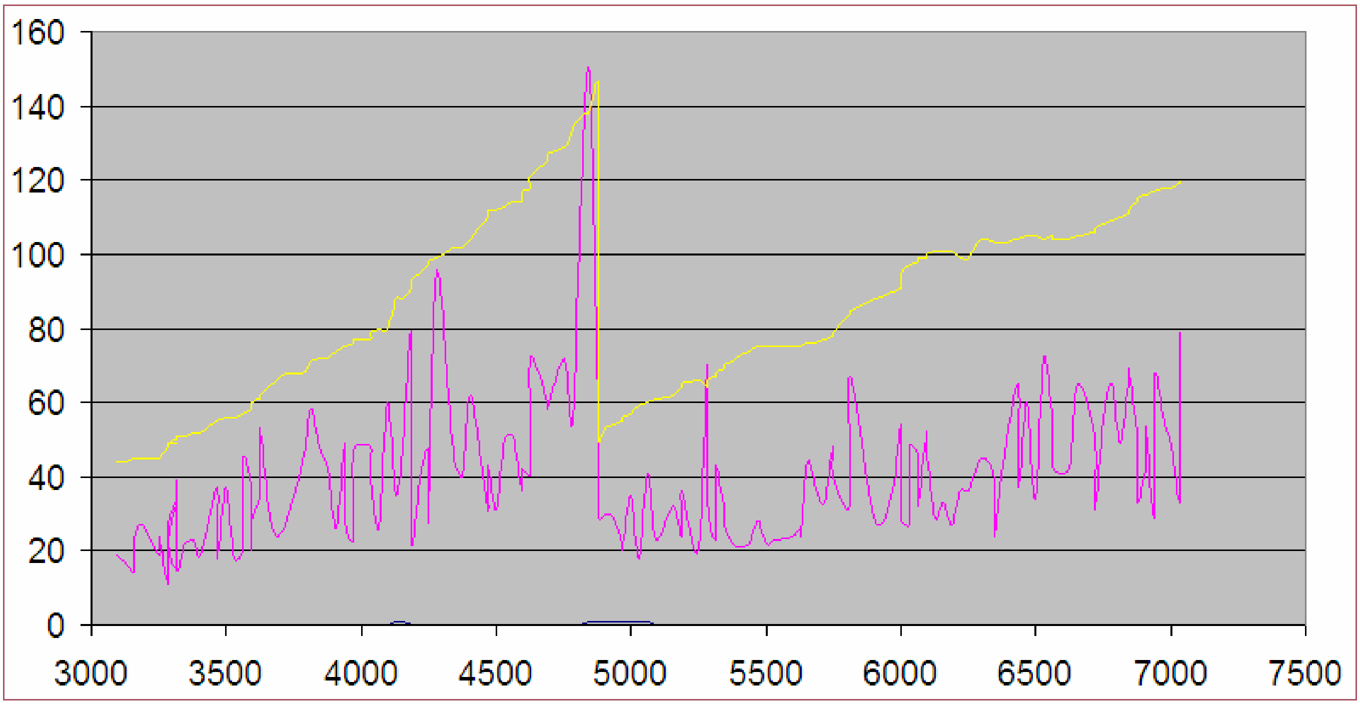
The KNOCKBASE level is derived from the knock sensor signal level, after filtering, and then being passed through a dual gain amplifier. The knock sensor amplifier system can switch from gain=x3 to gain=x1. This is used to give the system a high dynamic range and possibly to prevent input signal overload. 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 98: 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.

8.4-KNOCK TUNING – REAL or FALSE KNOCK?

The knock events that you have logged have to be assessed as to whether they are real knock or false knock. There are several ways this can be done. A very useful tool to assist with knock and ignition tuning is a set of “DET-CANS”.

Start by closely examining your log to see where the knock occurs and if the knock is random or repetitive and predictable. 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.

Real detonation will respond to reducing the ignition timing and/or increasing the fuels octane rating. Light-tune engines having to run on fuel with an octane rating less than 98RON will benefit from reducing the timing of the cells where knock occurs by 1-2 degrees.

False knock can have many mechanical causes that can be rectified without diving into the ECU. Some examples as follows:

1. Valve-lash adjusters. These can and should be replaced if they are the problem. Use electronic DET-CANS to diagnose the problem.
2. Plumbing rattles, intercooler, exhaust, whatever. Somewhat harder to find sometimes. Use electronic DET-CANS to diagnose the problem.
3. Forged pistons and piston slap. Some combinations cause a problem, others don’t. Tough one, short of changing the pistons, better to fix with the ECU. Note that you can hear piston slap with good electronic DET-CANS.
4. Balance shafts removed. Affects some cars, not others. Fix via the ECU.
5. Clutch rattle. Some twin-plate clutches have been reported as causing a problem. Difficult to diagnose.

One of the best ways to identify real knock is using EvoScan to log KNOCKBASE at MUT6B and KNOCKFILTADC at MUT6A, see the graph shown above. 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.

8.5-KNOCK TUNING – DET-CANS

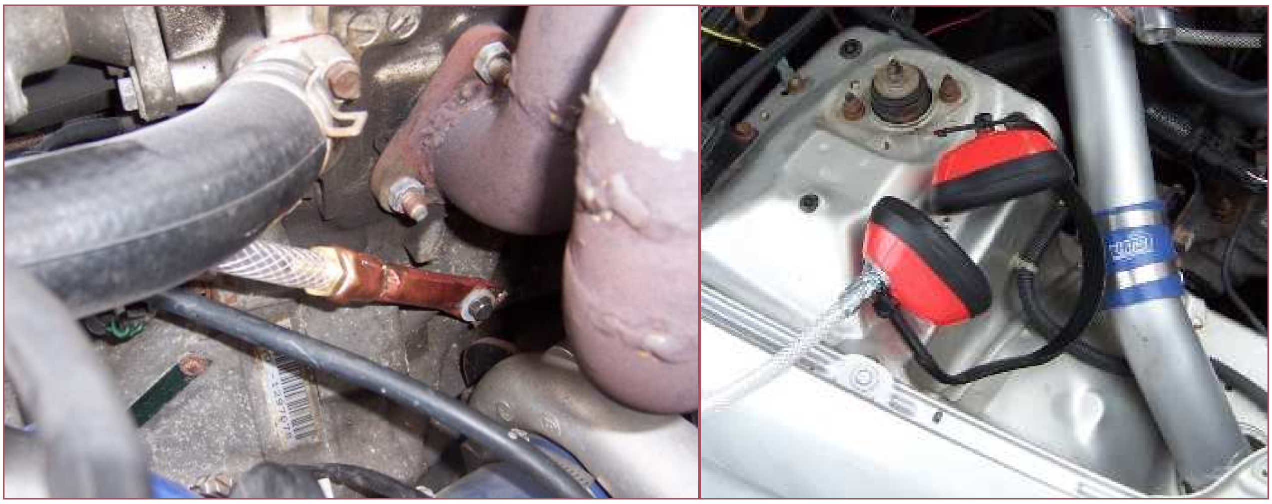
As mentioned before, DET-CANS can be of great assistance in resolving knock and/or KNOCKSUM.

These may be either a simple hose to a pair of ear-muffs or a full microphone /amplifier/headset affair. They can be purchased or built by the home tuner.

There is a caveat when using DET-CANS on the EVO ECU. The ECU works aggressively to save the engine from damaging detonation by immediately pulling timing. The net result of this is a detonation episode may only last for 5 to 10 counts before being knocked on the head, so-to-speak. So you may not even hear it with the DET-CANS. You should certainly hear any prolonged real detonation though.

Figure 99: KNOCK TUNING, ELECTRONIC DET-CANS

Figure 100: KNOCK TUNING, PASSIVE DET-CANS



8.6-KNOCK TUNING – ELIMINATING FALSE KNOCK

The knock events that you have logged have been assessed as false knock, so how do we get rid of the problem?

There are three ECU functions that can be altered:

1. The LOAD THRESHOLD v RPM table.
2. The MULTIPLIER table (EVO9) or MULTIPLIER LOW/MID/HIGH for EVO 7-8.
3. The ADDER tables.

8.7-KNOCK TUNING – ADJUSTING LOAD THRESHOLD v RPM

This table sets the load and rpm point where the knock control becomes fully active. On some ECUs it appears to be active below, but at most half as sensitive.

Note that the low rpm table cell 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.

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 no knock protection below load 100 at that rpm.

Figure 101: KNOCK TUNING, LOAD THRESHOLD v RPM, Evo9

500	1000	1500	2000	2500	3000	3500	4000	4500	5000
159.4	159.4	159.4	159.4	60.0	70.0	70.0	70.0	70.0	80.0

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.

8.8-KNOCK TUNING – ADJUSTING MULTIPLIER v RPM

The 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.

Figure 102: KNOCK TUNING, KNOCK MULTIPLIER v RPM, Evo9

1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500
13	13	13	14	14	17	17	19	19	18	19	20	20	20

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!

8.9-KNOCK TUNING – ADJUSTING KNOCK ADDERS

Although adjusting these parameters is largely untested at the time of writing, adjusting these should give a similar result to the multiplier adjustment.

Make sure any changes made to the single gain table are reflected in the triple gain table as tree times that number. They have to track.

I have not found an equivalent table or single parameter for this function in either the Evo7 or Evo8.

Figure 103: KNOCK TUNING – SINGLE & TRIPPLE GAIN KNOCK ADDERS, Evo9


Knock Adder - Single Gain-Evo 9 ADM 2006_dgh_04.hex

1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500
2	2	2	2	3	3	3	4	5	7	7	7	7	7


Knock Adder - Tripple Gain-Evo 9 ADM 2006_dgh_04.hex

1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500
7	7	7	7	9	9	9	12	15	21	21	21	21	21

8.10-KNOCK TUNING – KNOCK MULTIPLIERS EVO7 & EVO8

The KNOCK MULTIPLIER function is used to increase/decrease the noise threshold aka KNOCKBASE, across the RPM band that has to be breached to trigger a rise in KNOCKSUM. On the EVO7 and EVO8, this is replaced by three variables. These cover 0-3800RPM, 3800-4800RPM and 4800-8000RPM.

Table 7 TYPICAL Evo7 & Evo8 KNOCK MULTIPLIER PARAMETERS

BAND	RPM	STOCK	+10%	+15%	+20%
LOW	0-3800	13	14	15	16
MID	3800-4800	18	20	21	22
HIGH	4800-8000	20	22	23	24

SECTION 9 – ALS TUNING

9.1-ALS TUNING INTRODUCTION

Full ALS operation is generally only applied to full race and rally cars, as it can severely limit the operational life of a turbo. To get the full biscuit, all the engine secondary air system hardware needs to be installed and operational. This seems to have been limited to the JDM and UK delivered vehicles, presumably for homologation and cost reasons. It has not been provided on the US, Australian or some European countries.

Not all ROMs have working ALS code and tables in them as well. Here is a summary:
885900xx, the tables are resident but the ALS routines missing
888400xx, the tables are resident but the ALS routines missing.
96530006, the tables are resident but the ALS routines missing.
885800xx, the tables are resident and the ALS routines in and working.
90550001, the tables are resident and the ALS routines in and working.
98640014, the tables are resident and the ALS routines in and working.

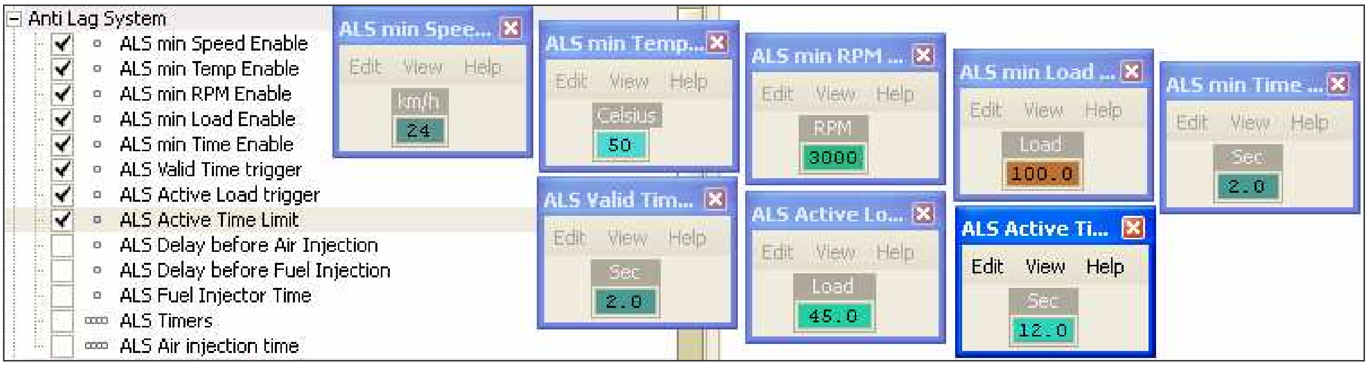
To get the air into the exhaust manifold, the two banjo-bolts that attach the SAS plumbing to the exhaust manifold need their two internal bleed holes opened up to typically 5-7mm. Otherwise, either insufficient or no air will be injected, depending on the banjo-bolts used as they usually only have 1-1.5mm holes.

As a final note on installations, ALS will not work satisfactorily where a vent to atmosphere BOV is installed. Use the (metal) Evo8 MR recirculation Valve.

9.2-ALS TUNING - TRIGGERS

These eight parameters set the conditions before ALS operation can commence. The values shown are from tuners in the UK (**Cossie1 BarryC GrayW jcsbanks**) who have been using ALS and have shared the results.

Figure 104: ALS TUNING, MINIMUM VALUE TRIGGERS



Anti Lag System
- ☑ ALS min Speed Enable
- ☑ ALS min Temp Enable
- ☑ ALS min RPM Enable
- ☑ ALS min Load Enable
- ☑ ALS min Time Enable
- ☑ ALS Valid Time trigger
- ☑ ALS Active Load trigger
- ☑ ALS Active Time Limit
- ☐ ALS Delay before Air Injection
- ☐ ALS Delay before Fuel Injection
- ☐ ALS Fuel Injector Time
- ☐ ALS Timers
- ☐ ALS Air injection time

ALS min Spee... km/h 24
ALS min Temp... Celsius 50
ALS min RPM ... RPM 3000
ALS min Load ... Load 100.0
ALS min Time ... Sec 2.0
ALS Valid Tim... Sec 2.0
ALS Active Lo... Load 45.0
ALS Active Ti... Sec 12.0

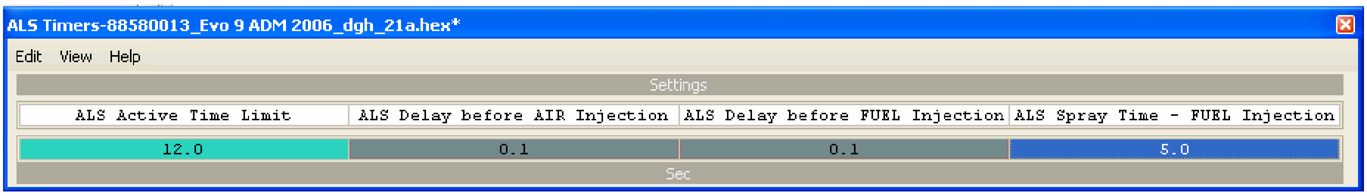
9.3-ALS TUNING - TIMERS

ALS ACTIVE TIME LIMIT is typically set to 12 seconds to prevent engine and turbo damage.

ALS DELAY BEFORE AIR/FUEL INJECTION are typically set to 0.1 seconds for a rapid trigger once conditions are met.

ALS FUEL SPRAY TIME is the time in seconds for the injectors to be activated.

Figure 105: ALS TUNING, DELAY TIMERS and FUEL INJECTION TIME

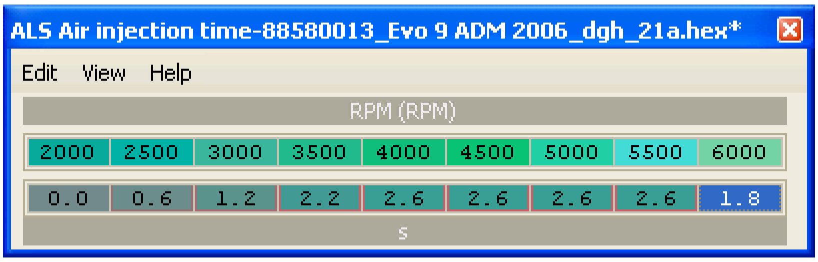


ALS Active Time Limit	ALS Delay before AIR Injection	ALS Delay before FUEL Injection	ALS Spray Time - FUEL Injection
12.0	0.1	0.1	5.0

9.4-ALS TUNING – AIR INJECTION TIME V RPM

The AIR INJECTION TIME values are always set at zero from the factory, so you have to set it up before the air injection valve will open and thus get the ALS operational. Values used are 1-3 seconds typically. In the example shown below, air will not be injected below 4000rpm.

Figure 106: ALS TUNING, AIR INJECTION TIME v RPM



2000	2500	3000	3500	4000	4500	5000	5500	6000
0.0	0.6	1.2	2.2	2.6	2.6	2.6	2.6	1.8

Cossie1 reports that 2.6 seconds gave good results in the 4000-5500 rpm segment.

AndyF reports set the min load to trigger to 80 and min time to trigger to 1S.

9.5-ALS TUNING – MAXIMUM IGNITION RETARD SETTING

This parameter is factory set at -5° on the EVO7 and -10° on the EVO9. This needs to be set at -15° to -20° for the best ALS effect.

The value is stored in ROM as a hex number, where -10° = CB = 203. Increment the hex value to get more retard. The retard value is raised by about 1/3 of a degree per increment. If the XML definition file for your ROM does weird things to the value when you try to alter the retard, try the adding the segment shown below to get this display shown. With this setup, the hex or the decimal value can be incremented/decremented and you will see the value change accordingly.

Figure 107: ALS TUNING, MAXIMUM IGNITION RETARD SETTING

MAX Retard Degrees - dec
-20.0

MAX Retard Degrees - hex
E9

Not all ROM definition files have the IGNITION MAX RETARD parameter defined, so you may have to add the following to your XML file. The scaling has now been accurately defined by **Ceddy**, so I have included a full scaling definition as shown below. To alter the value, use the **[** and **]** keys on the hex number. The expected decimal value will increment or decrement in response as you change the hex value.

Also note that the address entered in the XML for the hex entry is incremented by one, so it is only showing a hex byte, not a word. This is to limit the maximum entry to hex FF / decimal 255.

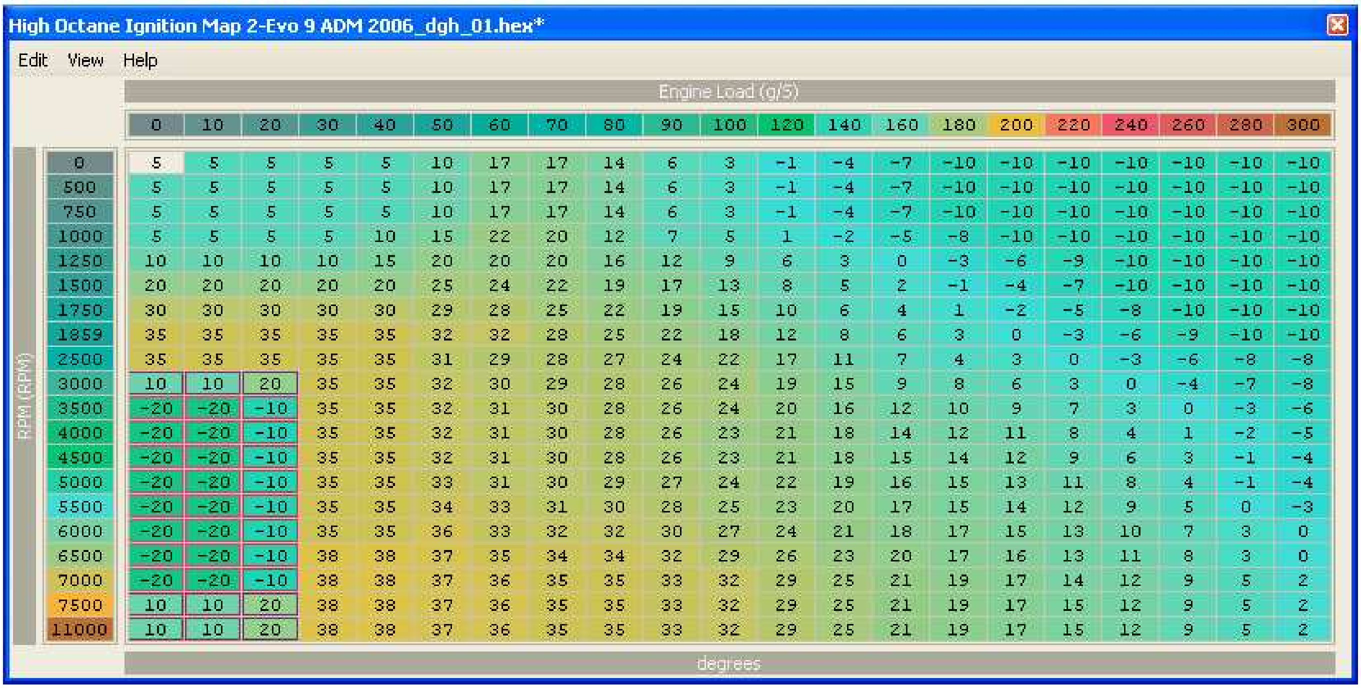
```
<scaling name="Retarduint16" units="MAX Retard Degrees - dec" toexpr="61-(x*90/256)" frexpr="256*(61-x)/90" format="%.2f" min="-200" max="255" inc="0.35" storagetype="uint16" endian="big"/>

<scaling name="RetardHex8" units="MAX Retard Degrees - hex" toexpr="x" frexpr="x" format="%02X" min="0" max="255" inc="1" storagetype="uint8" endian="big"/>

<table name="Ignition Retard Max Degrees - dec" category="Timing" address="133e" type="1D" scaling="Retarduint16"/>

<table name="Ignition Retard Max Degrees - hex" category="Timing" address="133f" type="1D" scaling="RetardHex8"/>
```

9.6-ALS TUNING – RETARDING the IGNITION MAP

The ignition map shown below has been modified for simple pops and bangs on throttle off when over 3000rpm.

The selection of 3000rpm was based on an Evo9 traveling at 110kph in 6th gear, so the system will not be pulling timing when cruising on the freeway. This is done to prevent excessive exhaust temperature rise and to keep the car driving nicely.

Figure 108: ALS TUNING, RETARDING THE IGNITION MAP



	0	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300
0	5	5	5	5	5	10	17	17	14	6	3	-1	-4	-7	-10	-10	-10	-10	-10	-10	-10
500	5	5	5	5	5	10	17	17	14	6	3	-1	-4	-7	-10	-10	-10	-10	-10	-10	-10
750	5	5	5	5	5	10	17	17	14	6	3	-1	-4	-7	-10	-10	-10	-10	-10	-10	-10
1000	5	5	5	5	10	15	22	20	12	7	5	1	-2	-5	-8	-10	-10	-10	-10	-10	-10
1250	10	10	10	10	15	20	20	20	16	12	9	6	3	0	-3	-6	-9	-10	-10	-10	-10
1500	20	20	20	20	20	25	24	22	19	17	13	8	5	2	-1	-4	-7	-10	-10	-10	-10
1750	30	30	30	30	30	29	28	25	22	19	15	10	6	4	1	-2	-5	-8	-10	-10	-10
1859	35	35	35	35	35	32	32	28	25	22	18	12	8	6	3	0	-3	-6	-9	-10	-10
2500	35	35	35	35	35	31	29	28	27	24	22	17	11	7	4	3	0	-3	-6	-8	-8
3000	10	10	20	35	35	32	30	29	28	26	24	19	15	9	8	6	3	0	-4	-7	-8
3500	-20	-20	-10	35	35	32	31	30	28	26	24	20	16	12	10	9	7	3	0	-3	-6
4000	-20	-20	-10	35	35	32	31	30	28	26	23	21	18	14	12	11	8	4	1	-2	-5
4500	-20	-20	-10	35	35	32	31	30	28	26	23	21	18	15	14	12	9	6	3	-1	-4
5000	-20	-20	-10	35	35	33	31	30	29	27	24	22	19	16	15	13	11	8	4	-1	-4
5500	-20	-20	-10	35	35	34	33	31	30	28	25	23	20	17	15	14	12	9	5	0	-3
6000	-20	-20	-10	35	35	36	33	32	32	30	27	24	21	18	17	15	13	10	7	3	0
6500	-20	-20	-10	38	38	37	35	34	34	32	29	26	23	20	17	16	13	11	8	3	0
7000	-20	-20	-10	38	38	37	36	35	35	33	32	29	25	21	19	17	14	12	9	5	2
7500	10	10	20	38	38	37	36	35	35	33	32	29	25	21	19	17	15	12	9	5	2
11000	10	10	20	38	38	37	36	35	35	33	32	29	25	21	19	17	15	12	9	5	2

Note that the MAX IGNITION RETARD parameter need to be altered to get timing retard more than -10° for the EVO 9 and more than -5° for the EVO 7.

9.7-ALS TUNING – JUST the POS and BANGS PLEASE!

If you don’t have the full ALS hardware, and/or just want some pop-bang and flame action on throttle off, the requirements are easy. Simply do the IGNITION MAP alteration and increase the MAX RETARD LIMIT value to -15°. Instant pops and bangs! You could also try adding fuel in the corresponding load/rpm fuel map cells, say set the values to 10.0 instead of the usual 14.7.

SECTION 10 – MISCELANEOUS ECU FUNCTIONS

10.01-LIMITS - SPEED

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. I have set the limit to something (moderately) sensible, based on the track I use. Re-set as required.

Figure 109: LIMITS – tuned SPEED LIMIT, Evo9

Condition	km/h
On	220
Off	216

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

10.02-LIMITS - REV LIMIT

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.

Figure 110: LIMITS – REV LIMITs, Evo9

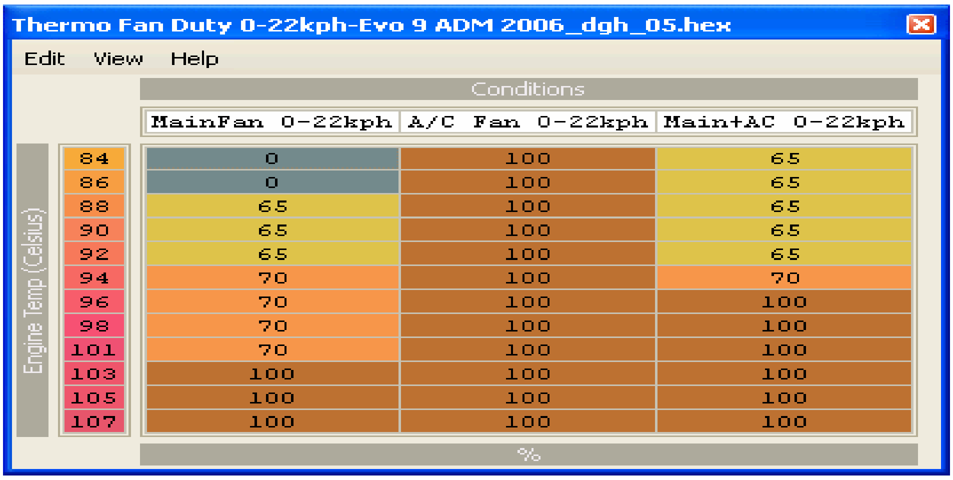
Rev Limit: RPM 7606

Stationary Rev Limit: RPM 7500

10.03-THERMO FAN - DUTY CYCLE, SPEED BELOW 20KPH

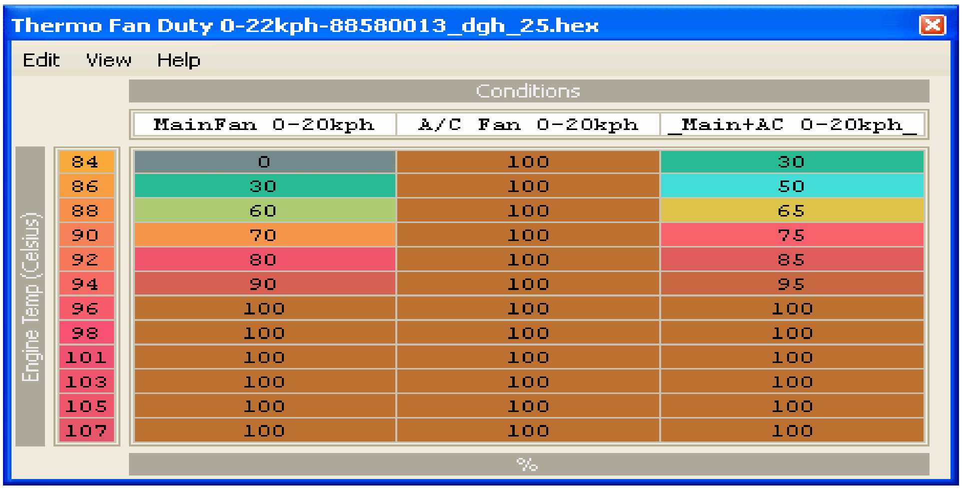
This table controls the two thermo-fans when the vehicle is stationary and up to 20kph. The table shows the duty cycle on time to the fans, thus controlling the fan speed. The Main Fan is behind the radiator, the A/C Fan (air conditioning) is in front of the radiator. The left column is for the Main Fan, the centre column is for the A/C Fan. The right column is for the Main Fan when the air conditioning is operating. It would be a reasonable change to add more Main Fan speed in the 86-101 °C area to assist cooling.

Figure 111: THERMO FAN - DUTY CYCLE below 20kph, stock Evo9



	MainFan 0-22kph	A/C Fan 0-22kph	Main+AC 0-22kph
84	0	100	65
86	0	100	65
88	65	100	65
90	65	100	65
92	65	100	65
94	70	100	70
96	70	100	100
98	70	100	100
101	70	100	100
103	100	100	100
105	100	100	100
107	100	100	100

Figure 112: THERMO FAN - DUTY CYCLE below 20kph, merlin Evo9



	MainFan 0-20kph	A/C Fan 0-20kph	_Main+AC 0-20kph_
84	0	100	30
86	30	100	50
88	60	100	65
90	70	100	75
92	80	100	85
94	90	100	95
96	100	100	100
98	100	100	100
101	100	100	100
103	100	100	100
105	100	100	100
107	100	100	100

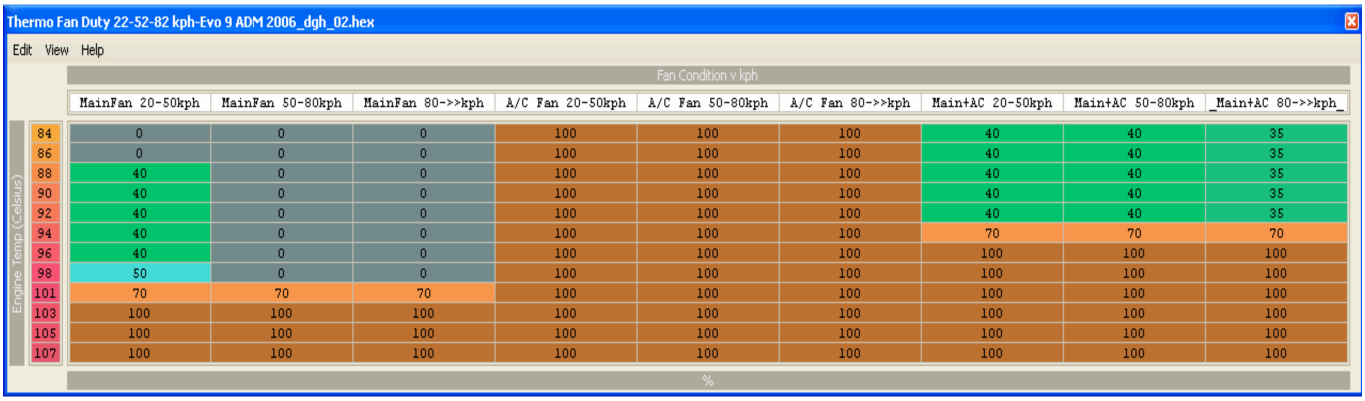
NOTE: On the Evo, the A/C FAN is powered by two relays to the fan motors two windings. So it is safe to assume the unit can only have two operating speeds, where 100% is the maximum speed available with both relays energized. No tuner has thus-far reported on what duty cycle % the fan speed drops to the low speed setting. Note that what-ever value is in the 84°C row is used through the warm-up cycle.

10.04-THERMO FAN - DUTY CYCLE, SPEED ABOVE 20KPH

This table controls the two thermo-fans when the vehicle speed is above 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.

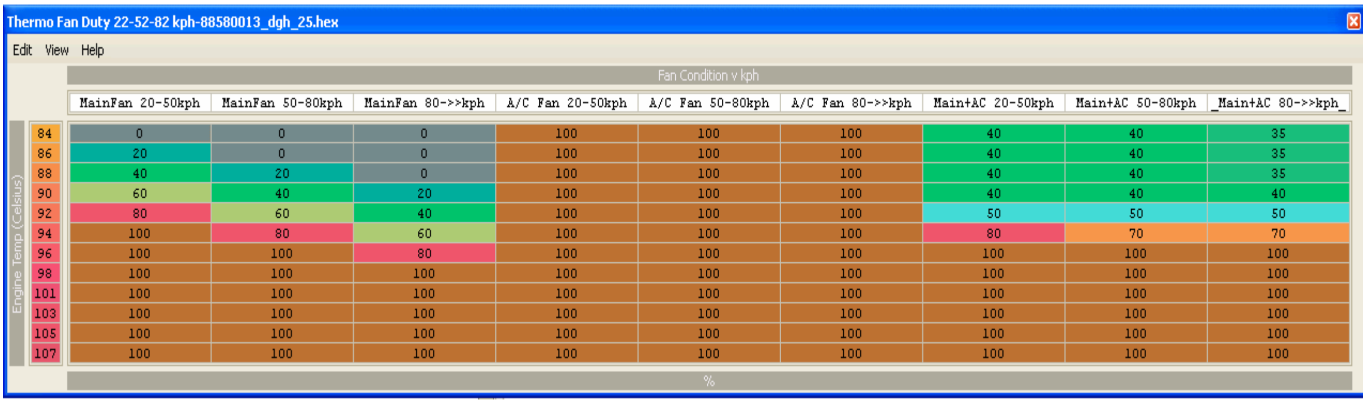
The three columns on the left column are for the Main Fan, at speeds above 20kph, above 50kph and above 80kph.
The three columns in the centre are for the A/C Fan, at speeds above 20kph, above 50kph and above 80kph.
The three columns on the right are for the Main Fan when the air conditioning is operating, at speeds above 20kph, above 50kph and above 80kph.

Figure 113: THERMO FAN - DUTY CYCLE above 20kph, stock Evo9



Engine Temp (Celsius)	MainFan 20-50kph	MainFan 50-80kph	MainFan 80->>kph	A/C Fan 20-50kph	A/C Fan 50-80kph	A/C Fan 80->>kph	Main+AC 20-50kph	Main+AC 50-80kph	_Main+AC 80->>kph_
84	0	0	0	100	100	100	40	40	35
86	0	0	0	100	100	100	40	40	35
88	40	0	0	100	100	100	40	40	35
90	40	0	0	100	100	100	40	40	35
92	40	0	0	100	100	100	40	40	35
94	40	0	0	100	100	100	70	70	70
96	40	0	0	100	100	100	100	100	100
98	50	0	0	100	100	100	100	100	100
101	70	70	70	100	100	100	100	100	100
103	100	100	100	100	100	100	100	100	100
105	100	100	100	100	100	100	100	100	100
107	100	100	100	100	100	100	100	100	100

Figure 114: THERMO FAN - DUTY CYCLE above 20kph, merlin Evo9



Engine Temp (Celsius)	MainFan 20-50kph	MainFan 50-80kph	MainFan 80->>kph	A/C Fan 20-50kph	A/C Fan 50-80kph	A/C Fan 80->>kph	Main+AC 20-50kph	Main+AC 50-80kph	_Main+AC 80->>kph_
84	0	0	0	100	100	100	40	40	35
86	20	0	0	100	100	100	40	40	35
88	40	20	0	100	100	100	40	40	35
90	60	40	20	100	100	100	40	40	40
92	80	60	40	100	100	100	50	50	50
94	100	80	60	100	100	100	80	70	70
96	100	100	80	100	100	100	100	100	100
98	100	100	100	100	100	100	100	100	100
101	100	100	100	100	100	100	100	100	100
103	100	100	100	100	100	100	100	100	100
105	100	100	100	100	100	100	100	100	100
107	100	100	100	100	100	100	100	100	100

As shown on this table, the A/C Fan is run at 100% duty cycle (max-speed) in all instances. The Main Fan is run faster when the air conditioning is operating, more-so at lower vehicle speeds.

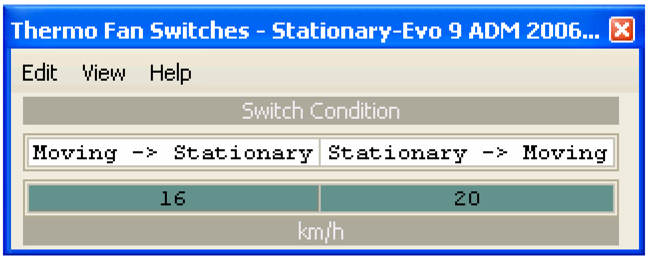
It would be a reasonable change to add more Main Fan speed in the 86-101 °C area to assist cooling.

10.05-THERMO FAN - SPEED SET-POINTS & HYSTERESIS

There are also tables controlling the actual speed set-points for the thermo fan tables. So the 20kph, 50kph and 80kph points can be altered if desired.

Both the tables have a 4kph hysterisis to ensure clean switchover between the table settings. So from stationary to 20kph, the below 20kph duty cycle table is used. As the vehicle speed exceeded 20kph, the <50kph duty cycle table is used. However, as the speed falls from say 40kph to stationary, the system switches to the less than 20kph table at 16kph, not 20kph. The code will only accept even numbers, so you could make the low value 18.

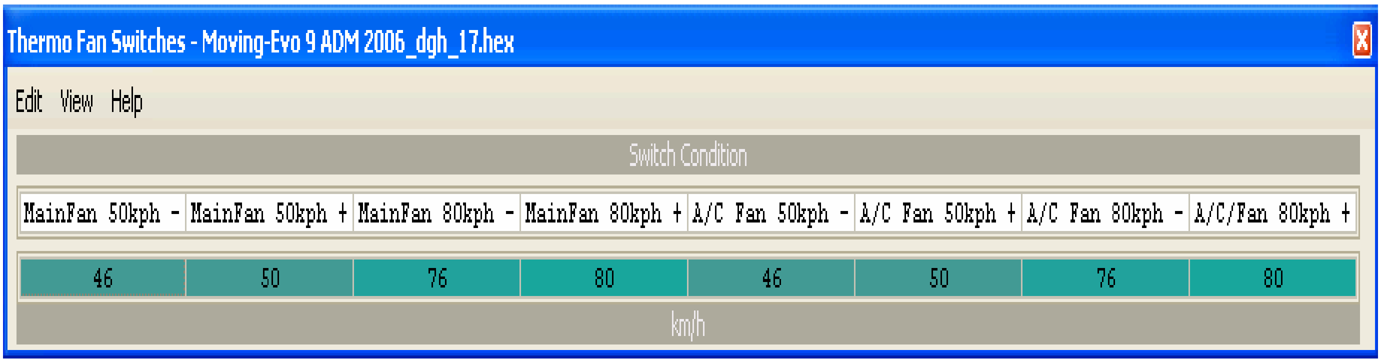
Figure 115: THERMO FAN - LO SETPOINT <20kph, Evo9



Moving -> Stationary	Stationary -> Moving
16	20

The same principal is applied to the over 20kph table. You would probably only need to alter these tables in a full race car application.

Figure 116: THERMO FAN - HI SETPOINT >20kph, Evo9

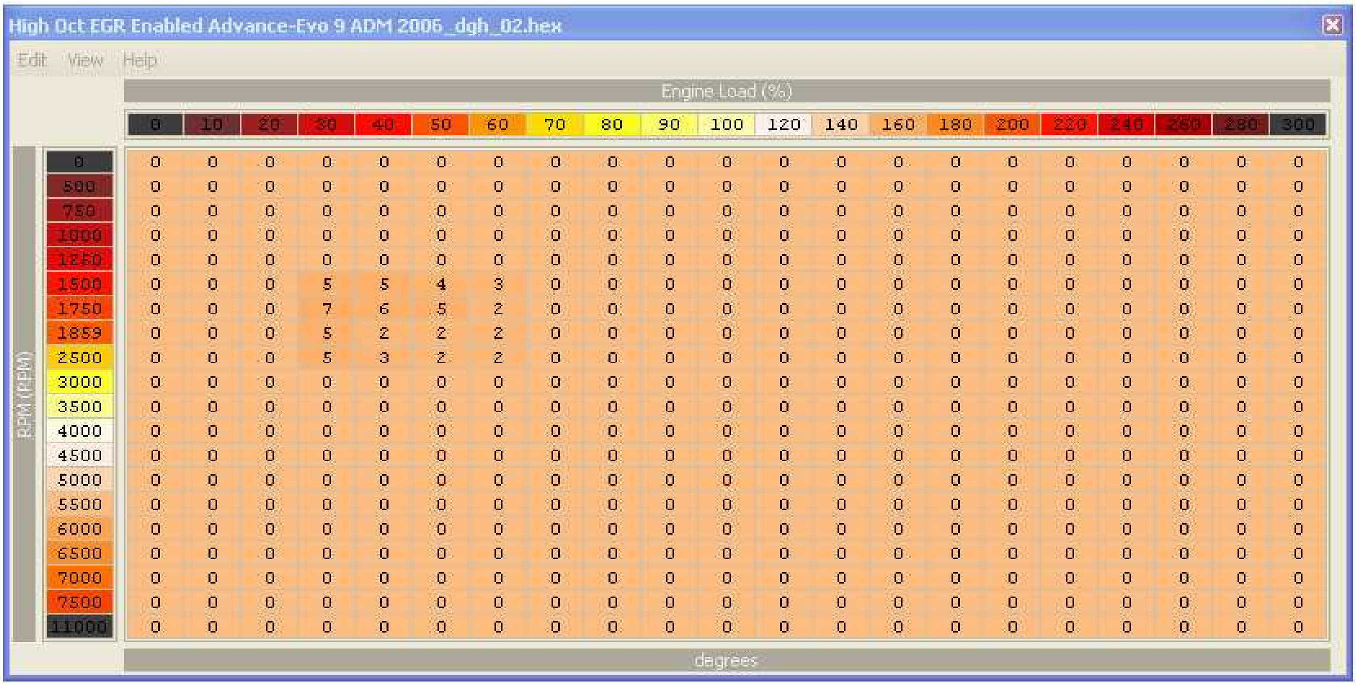


MainFan 50kph -	MainFan 50kph +	MainFan 80kph -	MainFan 80kph +	A/C Fan 50kph -	A/C Fan 50kph +	A/C Fan 80kph -	A/C/Fan 80kph +
46	50	76	80	46	50	76	80

10.06-EGR CONTROL - IGNITION ADVANCE DURING EGR

The EVO 9 has two additional ignition maps, with the same scaling as the main maps, which come into effect during Exhaust Gas Recirculation operation. The maps are labeled high octane and low octane, presumably with interpolation between them. The ECU adds the values to the main map when the EGR valve is open. This is setup to only occur when the engine is off-boost, so the map is set to zero at load 70% and above.

Figure 117: EGR – HI-OCTANE EGR ENABLED ADVANCE, Evo9



Engine Load (%)

RPM (RPM)	0	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
500	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
1000	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
1500	0	0	0	5	5	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1750	0	0	0	7	6	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1859	0	0	0	5	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2500	0	0	0	5	3	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3000	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	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
4500	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
5500	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
6500	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
7500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

degrees

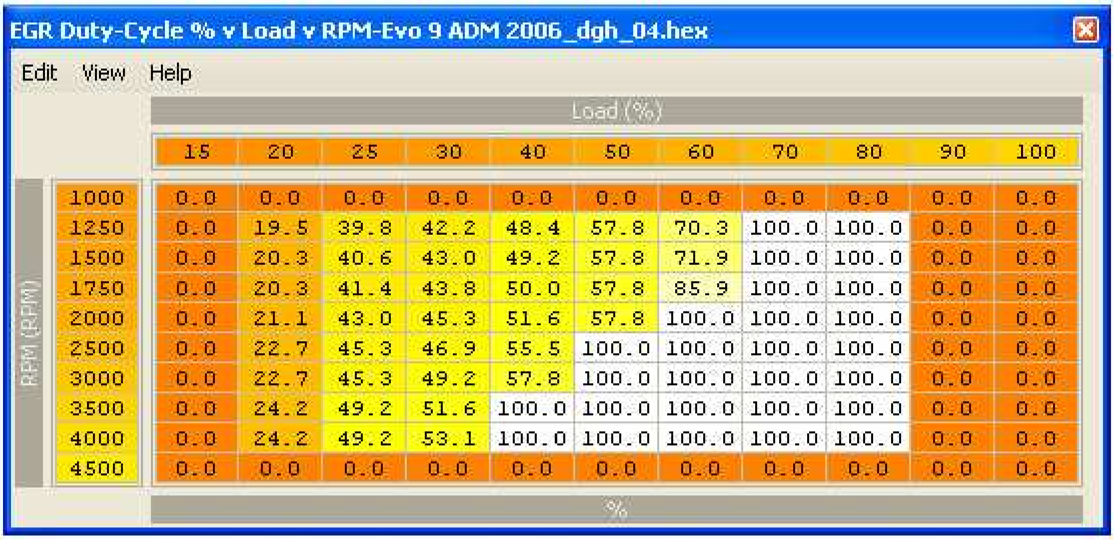
Note that this map shares the same load and RPM scaling as the normal ignition maps. It is because of this that this function has been the cause of knock, where tuners have re-scaled the load scale or the RPM scale on the main maps, not realizing that it was also moving the active portion of the map above into the (low) boost region.

10.07-EGR CONTROL - DUTY CYCLE v LOAD v RPM

The 3D map has the duty-cycle percent open parameters. Note that it is only operable to a load of 80%, at which point the engine is starting to produce boost.

These values are modified by DUTY FACTOR v TEMP table during warm-up.

Figure 118: EGR – EGR Duty-Cycle v LOAD v RPM, Evo9

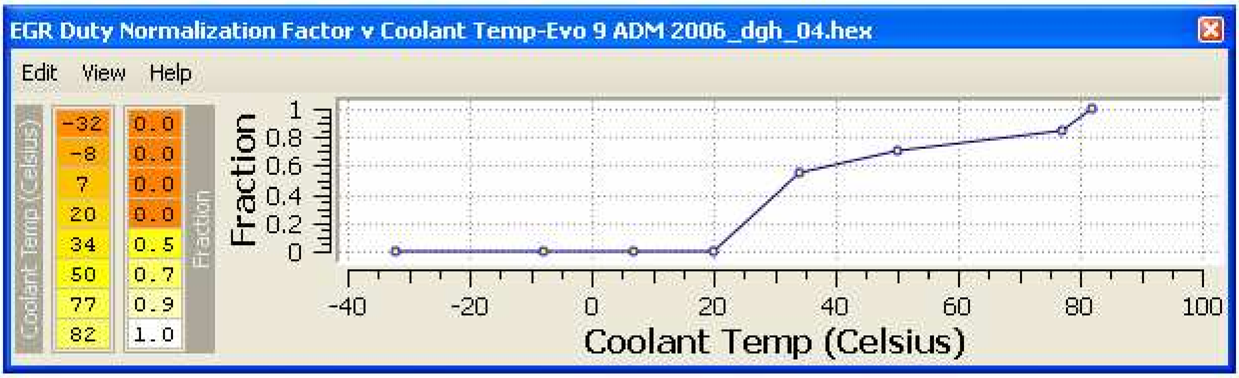


RPM (RPM)	Load (%)										
	15	20	25	30	40	50	60	70	80	90	100
1000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1250	0.0	19.5	39.8	42.2	48.4	57.8	70.3	100.0	100.0	0.0	0.0
1500	0.0	20.3	40.6	43.0	49.2	57.8	71.9	100.0	100.0	0.0	0.0
1750	0.0	20.3	41.4	43.8	50.0	57.8	85.9	100.0	100.0	0.0	0.0
2000	0.0	21.1	43.0	45.3	51.6	57.8	100.0	100.0	100.0	0.0	0.0
2500	0.0	22.7	45.3	46.9	55.5	100.0	100.0	100.0	100.0	0.0	0.0
3000	0.0	22.7	45.3	49.2	57.8	100.0	100.0	100.0	100.0	0.0	0.0
3500	0.0	24.2	49.2	51.6	100.0	100.0	100.0	100.0	100.0	0.0	0.0
4000	0.0	24.2	49.2	53.1	100.0	100.0	100.0	100.0	100.0	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

10.08-EGR CONTROL - DUTY FACTOR v TEMP

EXPLANATION: The table parameters are multiplied with the duty-cycle v load v RPM data to get the duty-cycle during warm-up.

Figure 119: EGR – DUTY FACTOR v TEMP, Evo9



Coolant Temp (Celsius)	Fraction
-32	0.0
-8	0.0
7	0.0
20	0.0
34	0.5
50	0.7
77	0.9
82	1.0

10.09-INTERCOOLER SPRAY CONTROL

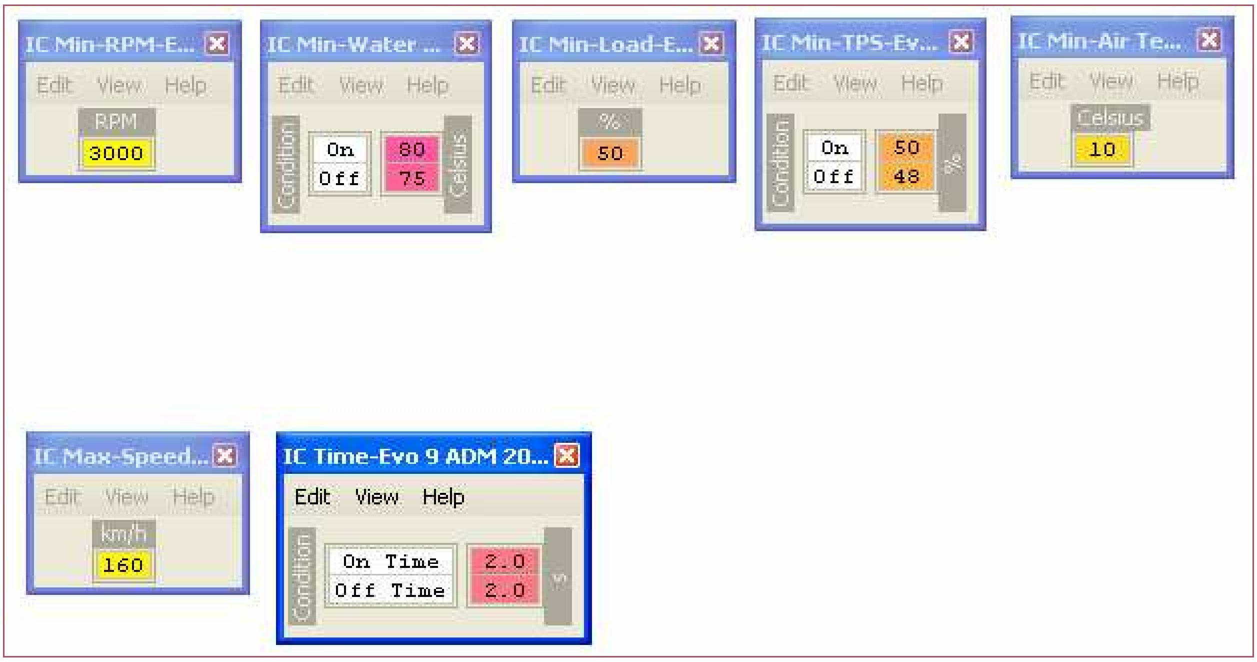
The seven parameters for controlling when the intercooler spray is activated are shown below.

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.

Figure 120: INTERCOOLER - SPRAY TABLES, Evo9



RPM 3000

On 80
Off 75
Celsius

% 50

On 50
Off 48
%

Celsius 10

km/h 160

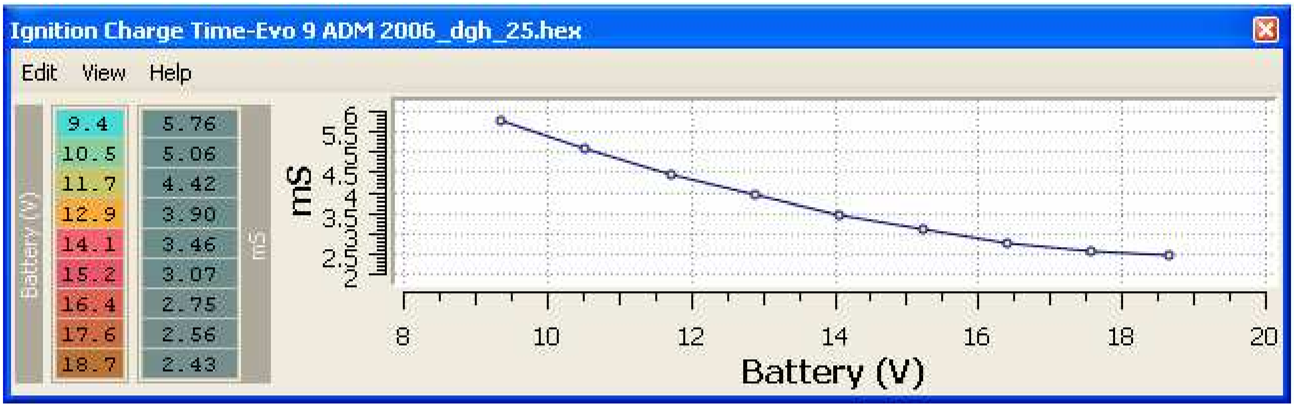
On Time 2.0
Off Time 2.0
s

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.

10.10-IGNITION_COIL CHARGE TIME v BATTERY VOLTAGE

The table defines the value of CHARGE TIME, or DWELL, which is the time the coil is energized for each ignition event. The table shows the coil charge times in mSec.

Figure 121: IGNITION COIL - CHARGE TIME v BATTERY VOLTS, Evo9

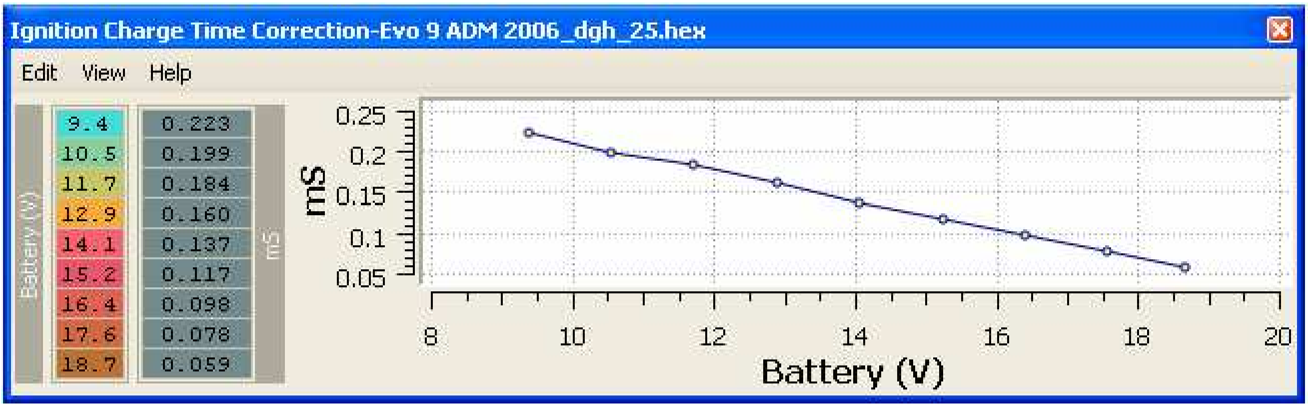


Battery (V)	mS
9.4	5.76
10.5	5.06
11.7	4.42
12.9	3.90
14.1	3.46
15.2	3.07
16.4	2.75
17.6	2.56
18.7	2.43

10.11-IGNITION_COIL CHARGE TIME CORRECTION v VOLTS

The table defines the value of CHARGE TIME OFFSET, which is believed to be added to the coil dwell time. The parameter controlling when the correction is applied is not known, though it may be temperature. The table shows the coil charge correction times in mSec, which may or may not be right!. It is not known if the correction is added or subtracted to the dwell time.

Figure 122: IGNITION COIL – COIL CHARGE TIME CORRECTION v VOLTS, Evo9

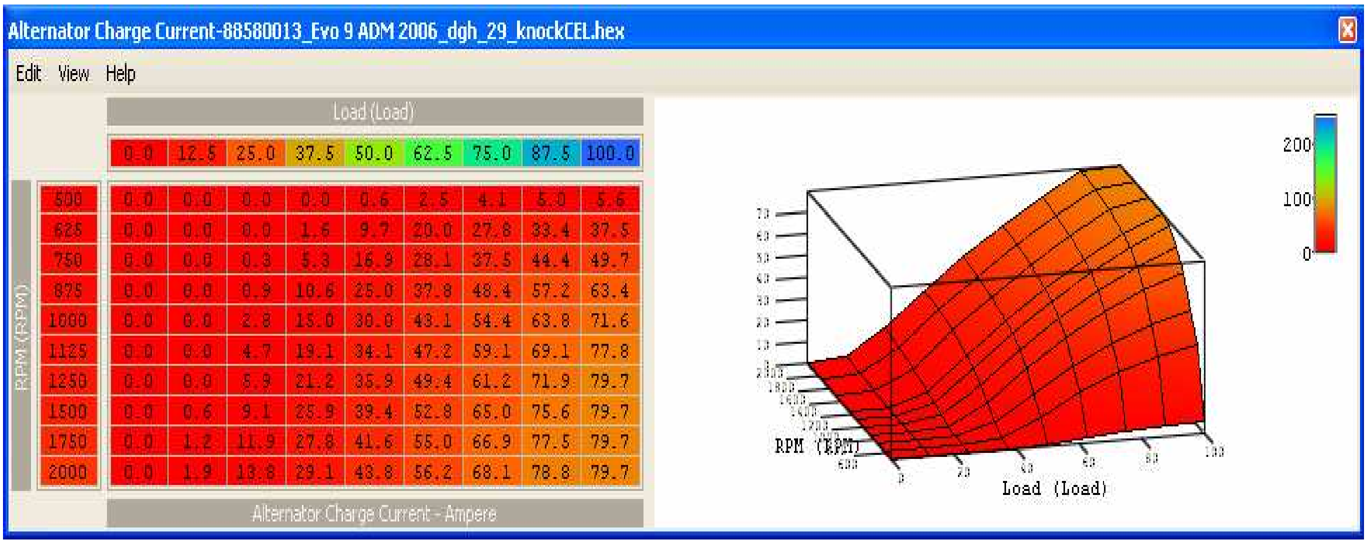


Battery (V)	mS
9.4	0.223
10.5	0.199
11.7	0.184
12.9	0.160
14.1	0.137
15.2	0.117
16.4	0.098
17.6	0.078
18.7	0.059

10.12-ALTERNATOR – CHARGE MAP

The ECU also controls the alternators field, the map below shows the maximum charge rate per load and rpm that can be generated. This same map has been found in the Evo7-8-9.

Figure 123: ALTERNATOR – CHARGE CURRENT v LOAD v RPM, Evo7-8-9



Alternator Charge Current-88580013_Evo 9 ADM 2006_dgh_29_knockCEL.hex

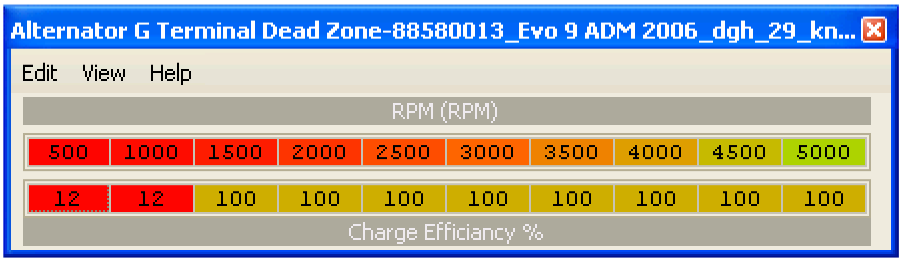
Load (Load)

RPM (RPM)	0.0	12.5	25.0	37.5	50.0	62.5	75.0	87.5	100.0
500	0.0	0.0	0.0	0.0	0.6	2.5	4.1	5.0	5.6
625	0.0	0.0	0.0	1.6	9.7	20.0	27.8	33.4	37.5
750	0.0	0.0	0.3	5.3	16.9	28.1	37.5	44.4	49.7
875	0.0	0.0	0.9	10.6	25.0	37.8	48.4	57.2	63.4
1000	0.0	0.0	2.8	15.0	30.0	43.1	54.4	63.8	71.6
1125	0.0	0.0	4.7	19.1	34.1	47.2	59.1	69.1	77.8
1250	0.0	0.0	5.9	21.2	35.9	49.4	61.2	71.9	79.7
1500	0.0	0.6	9.1	25.9	39.4	52.8	65.0	75.6	79.7
1750	0.0	1.2	11.9	27.8	41.6	55.0	66.9	77.5	79.7
2000	0.0	1.9	13.8	29.1	43.8	56.2	68.1	78.8	79.7

Alternator Charge Current - Ampere

10.13-ALTERNATOR – G TERMINAL DEAD ZONE

Figure 124: ALTERNATOR – G TERMINAL DEAD ZONE, Evo7-8-9



Alternator G Terminal Dead Zone-88580013_Evo 9 ADM 2006_dgh_29_kn...

RPM (RPM)

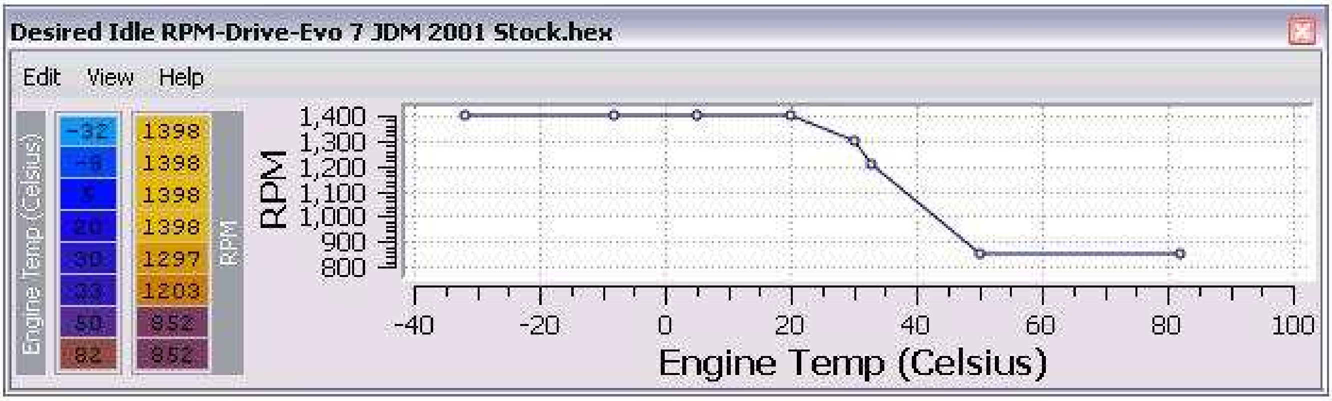
500	1000	1500	2000	2500	3000	3500	4000	4500	5000
12	12	100	100	100	100	100	100	100	100

Charge Efficiancy %

10.14-IDLE - RPM CONTROL v TEMP

Idle RPM-Drive, for setting the idle speed against temperature with the car in gear.

Figure 125: IDLE CONTROL – IDLE v TEMP IN GEAR, Evo7

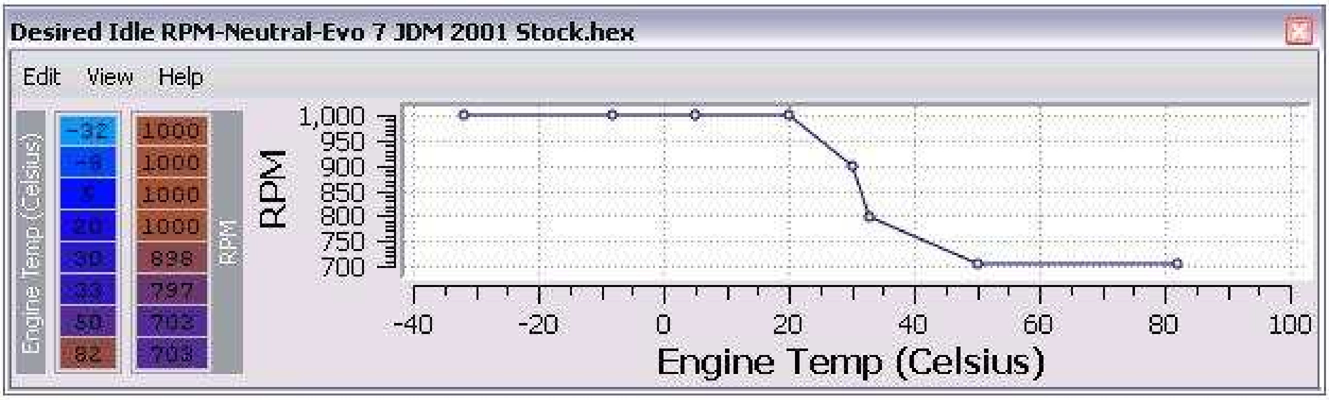


Desired Idle RPM-Drive-Evo 7 JDM 2001 Stock.hex

Engine Temp (Celsius)	RPM
-32	1398
-8	1398
5	1398
20	1398
30	1297
33	1203
50	852
82	852

Idle RPM-Neutral, for setting the idle speed against temperature when the car is in neutral. May be adjusted when using bigger cams.

Figure 126: IDLE CONTROL – IDLE v TEMP IN NEUTRAL, Evo7



Desired Idle RPM-Neutral-Evo 7 JDM 2001 Stock.hex

Engine Temp (Celsius)	RPM
-32	1000
-8	1000
5	1000
20	1000
30	898
33	797
50	703
82	703

This needs to be better defined.

Figure 127: IDLE CONTROL – IDLE SETPOINT LIMITS, Evo7

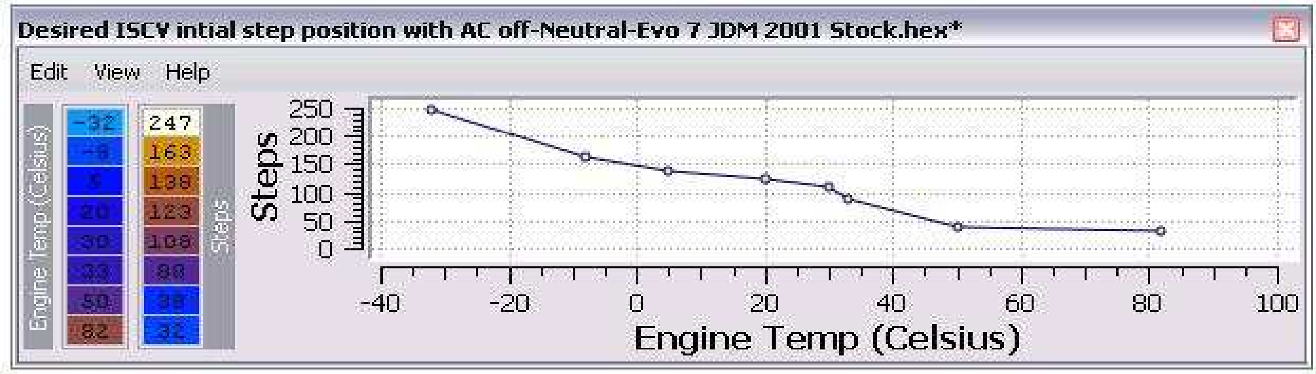
Desired Idle RPM ...

Condition	RPM
Neut	852
Drive	648
Neut	852
Drive	648

10.15-IDLE - STABILISATION CONTROL

These three tables provide the initial idle stepper motor target position to quickly get the engine idling at the target RPM. If the target RPM is changed significantly, then these should be tweaked to compensate. Otherwise, idle response will be slow.

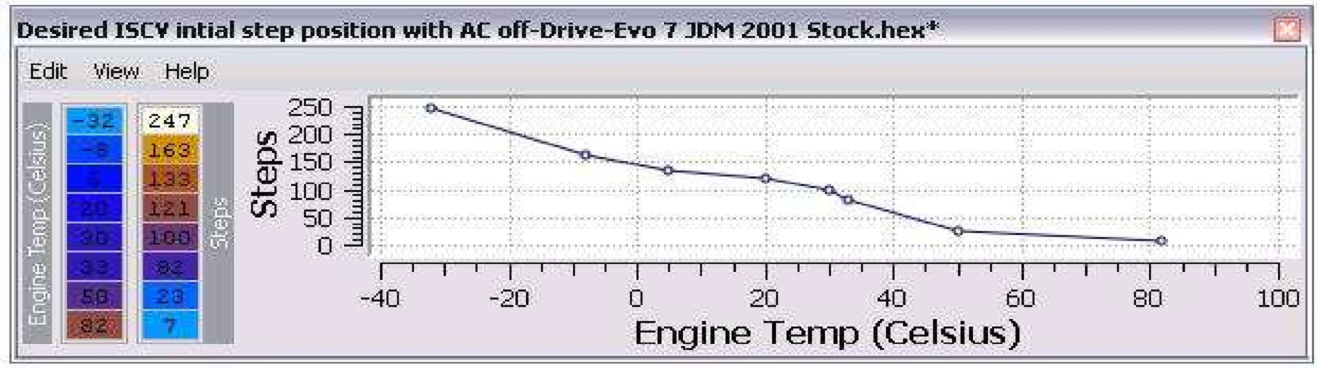
Figure 128: IDLE CONTROL – IDLE v TEMP STEPPERMOTOR TARGET NEUT. Evo7



Desired ISCV intial step position with AC off-Neutral-Evo 7 JDM 2001 Stock.hex*

Engine Temp (Celsius)	Steps
-32	247
-8	163
5	138
20	123
30	108
33	88
50	38
82	32

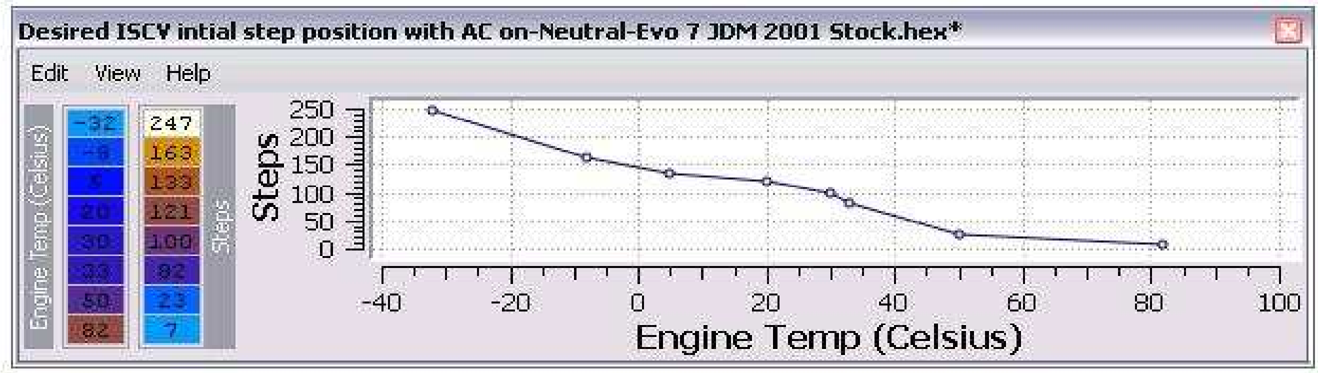
Figure 129: IDLE CONTROL – IDLE v TEMP STEPPERMOTOR TARGET AC OFF, Evo7



Desired ISCV intial step position with AC off-Drive-Evo 7 JDM 2001 Stock.hex*

Engine Temp (Celsius)	Steps
-32	247
-8	163
5	133
20	121
30	100
33	82
50	23
82	7

Figure 130: IDLE CONTROL – IDLE v TEMP STEPPERMOTOR TARGET AC ON, Evo7



Desired ISCV intial step position with AC on-Neutral-Evo 7 JDM 2001 Stock.hex*

Engine Temp (Celsius)	Steps
-32	247
-8	163
5	133
20	121
30	100
33	82
50	23
82	7

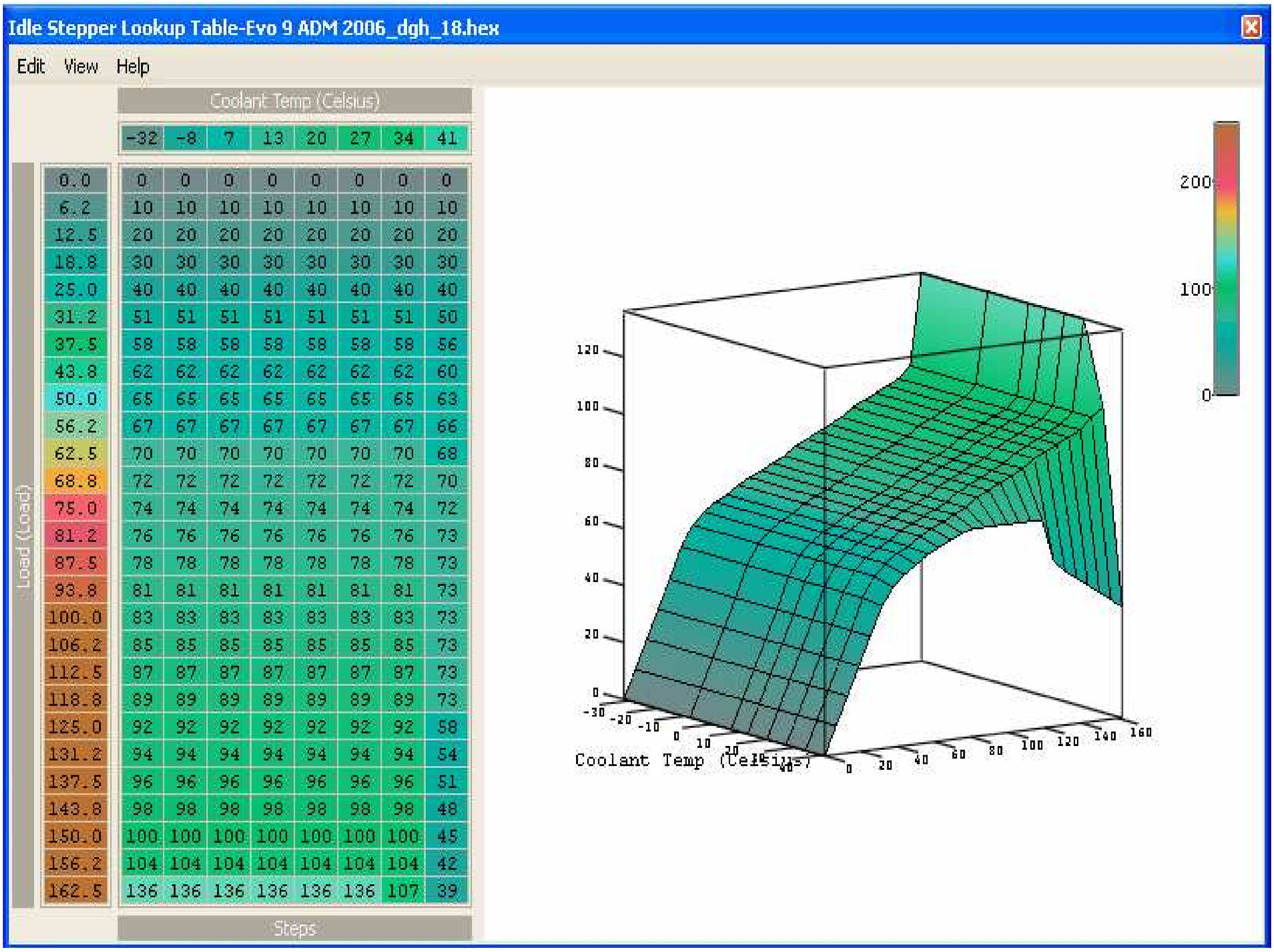
There are a further three idle control functions defined, however they are not likely to require any adjustment on a lightly modified engine. See the EcuFLASH menu.

10.16-IDLE – ISCV STEPPERMOTOR DEMAND v TEMP

This 3D map provides the initial idle stepper motor target position when the car is moving. The ISCV Demand is a parameter the ECU calculates from several factors including RPM, TPS, AIR-CON, AIR-TEMP, WATER-TEMP, POWER-STEERING and CRANKING. One of its uses is to control engine speed during throttle release, or deceleration. It has the effect of holding the throttle open slightly, resulting in the effect known as “throttle hang”.

This effect can be virtually eliminated by modifying the 41 degree temp column as shown in the accompanying figure. Reducing the whole column to some arbitrary low value causes detrimental driving characteristics. The modified table shown gives minimal throttle hang at high loads, while keeping the excellent low speed driving in traffic characteristics.

Figure 131: IDLE CONTROL – tuned IDLE STEPPERMOTOR DEMAND v TEMP, Evo9



Idle Stepper Lookup Table-Evo 9 ADM 2006_dgh_18.hex

	Coolant Temp (Celsius)							
Load (Load)	-32	-8	7	13	20	27	34	41
0.0	0	0	0	0	0	0	0	0
6.2	10	10	10	10	10	10	10	10
12.5	20	20	20	20	20	20	20	20
18.8	30	30	30	30	30	30	30	30
25.0	40	40	40	40	40	40	40	40
31.2	51	51	51	51	51	51	51	50
37.5	58	58	58	58	58	58	58	56
43.8	62	62	62	62	62	62	62	60
50.0	65	65	65	65	65	65	65	63
56.2	67	67	67	67	67	67	67	66
62.5	70	70	70	70	70	70	70	68
68.8	72	72	72	72	72	72	72	70
75.0	74	74	74	74	74	74	74	72
81.2	76	76	76	76	76	76	76	73
87.5	78	78	78	78	78	78	78	73
93.8	81	81	81	81	81	81	81	73
100.0	83	83	83	83	83	83	83	73
106.2	85	85	85	85	85	85	85	73
112.5	87	87	87	87	87	87	87	73
118.8	89	89	89	89	89	89	89	73
125.0	92	92	92	92	92	92	92	58
131.2	94	94	94	94	94	94	94	54
137.5	96	96	96	96	96	96	96	51
143.8	98	98	98	98	98	98	98	48
150.0	100	100	100	100	100	100	100	45
156.2	104	104	104	104	104	104	104	42
162.5	136	136	136	136	136	136	107	39

Steps

Note that when chasing throttle-hang, DECEL FUELCUT DELAY time should also be reduced, at load 70 and above, to get the best result. See the next topic.

10.17-IDLE - TIMING at IDLE & IDLE STABILITY

The Mitsubishi engineers have not setup this function as a table (as was expected), but have implemented an aggressive idle control strategy using ignition timing adjustment. This is a code based embedded algorithm and is not readily adjustable. The idle stepper motor is used to get the air flow in the right range for the desired idle speed, but the timing algorithm adjustment is used to dynamically keep the idle at the set/desired speed. So, if you were wondering why your idle ignition timing is bopping all over the place, this is the reason.

Two ROM variables have been found pertaining to idle stability v timing control. The first is a one byte sensitivity or gain variable (default=128), and the second is Idle Stability Timing Correction Limit, which defines the adjustment range (default=±8° for the EVO7 and 7GTA and ±3° for the EVO9).

The general equation for the timing adjustment is:

DeltaTiming = x/64 * (y / 500 * TargetIdle – 0.256 * CurrentEngineSpeed)

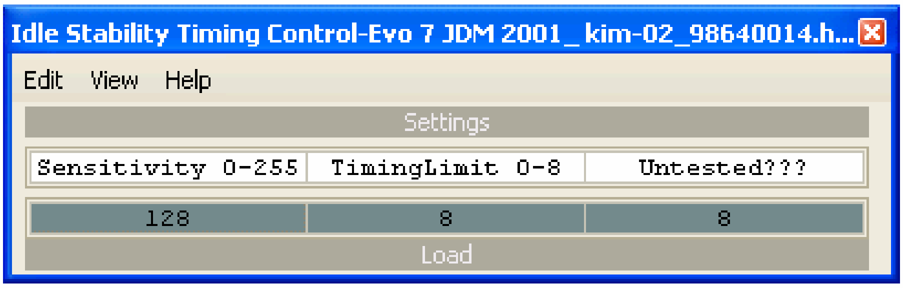
Where:
x = the 1D value at 174F, gain = x/100 deg./10rpm.
y = the 1D value at 1750, limit.

To illustrate this, if the TargetIdle=800 but the CurrentEnginSpeed=950, then the resulting DeltaTiming would be -7.2° from the ignition map. It is aggressive and very effective.

If the TIMING LIMIT valve is (temporarily) set to zero, the base timing can be verified with a timing light as the ECU would then run the 5 or whatever is set in the idle area of the map without all the fritzing around.

In practice though, most tuners will not have any reason to alter the factory preset values. Although I have resorted to reducing the TIMING LIMIT value on an EVO8, with 264 cams that had a poor idle. This did fix the problem as logging showed the ECU was making -7 degrees of timing reduction at idle with the stock value. Its nice to know how it works and it can be used to help a tune!

Figure 132: IDLE CONTROL – IDLE STABILITY TIMING CONTROL, Evo7



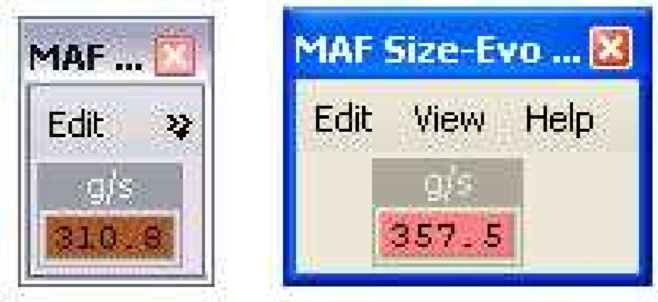
Idle Stability Timing Control-Evo 7 JDM 2001_kim-02_98640014.h...

Sensitivity 0-255	TimingLimit 0-8	Untested???
128	8	8

10.18-SENSOR CALIBRATION – MAF SIZE

These functions are available but most Evos will never need to have these parameters altered, unless a larger MAF is to be used. The Evo9 MAF has a higher read capacity than the Evo7.

Figure 133: SENSORS – MAS AIRFLOW METER SIZE LIMIT, Evo7 & Evo9

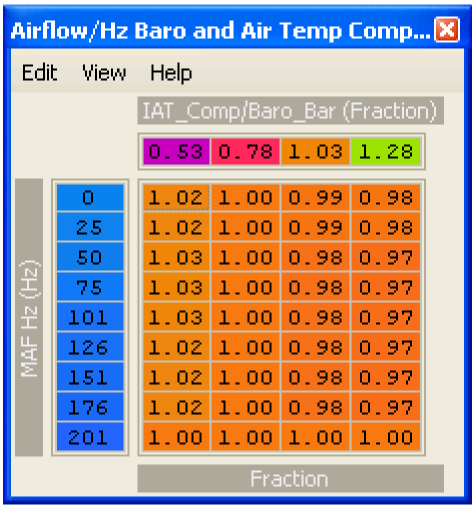


g/s 310.9

g/s 357.5

10.19-SENSOR CALIBRATION – MAF TEMP/BARO CORRECTION

Figure 134: SENSORS – MAF TEMP/BARO CORRECTION, Evo9



MAF Hz (Hz)	0.53	0.78	1.03	1.28
0	1.02	1.00	0.99	0.98
25	1.02	1.00	0.99	0.98
50	1.03	1.00	0.98	0.97
75	1.03	1.00	0.98	0.97
101	1.03	1.00	0.98	0.97
126	1.02	1.00	0.98	0.97
151	1.02	1.00	0.98	0.97
176	1.02	1.00	0.98	0.97
201	1.00	1.00	1.00	1.00

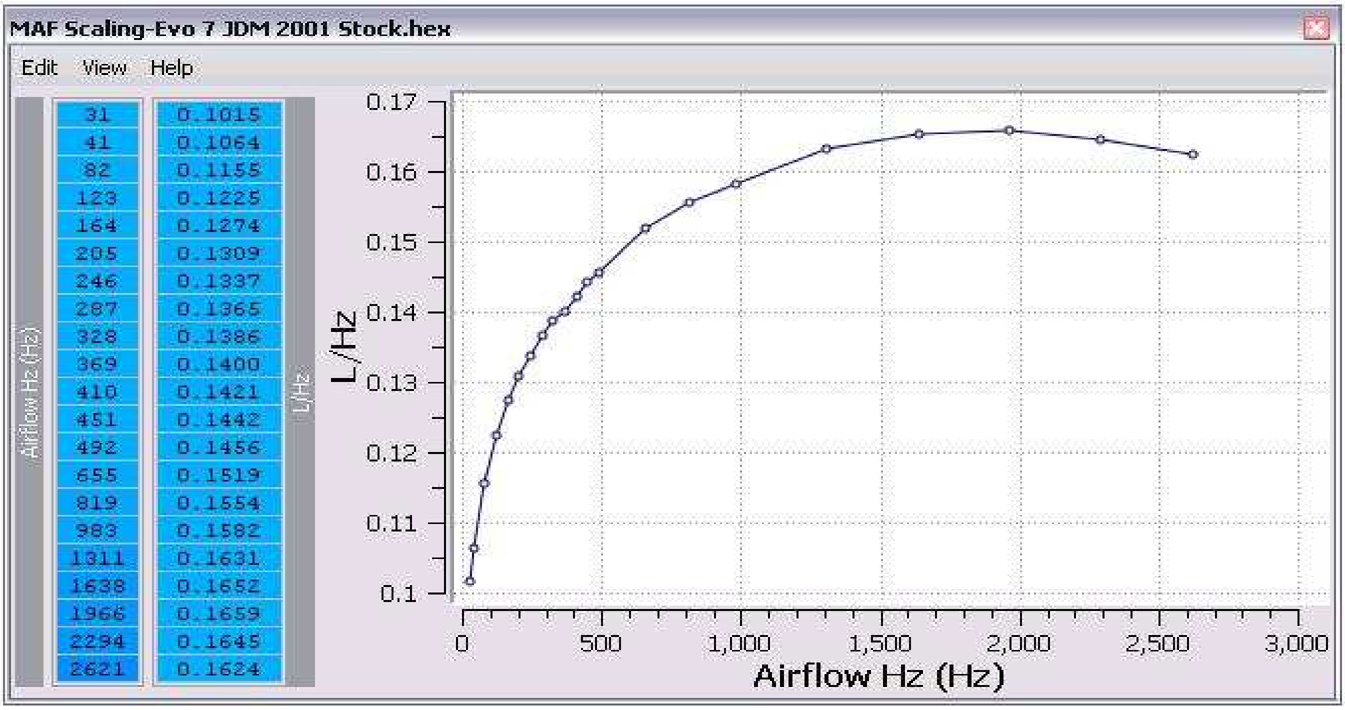
IAT_Comp/Baro_Bar (Fraction)

Fraction

10.20-SENSOR CALIBRATION – MAF SCALING

This shows the primary difference between the 7 and the 9 MAF meter scaling.

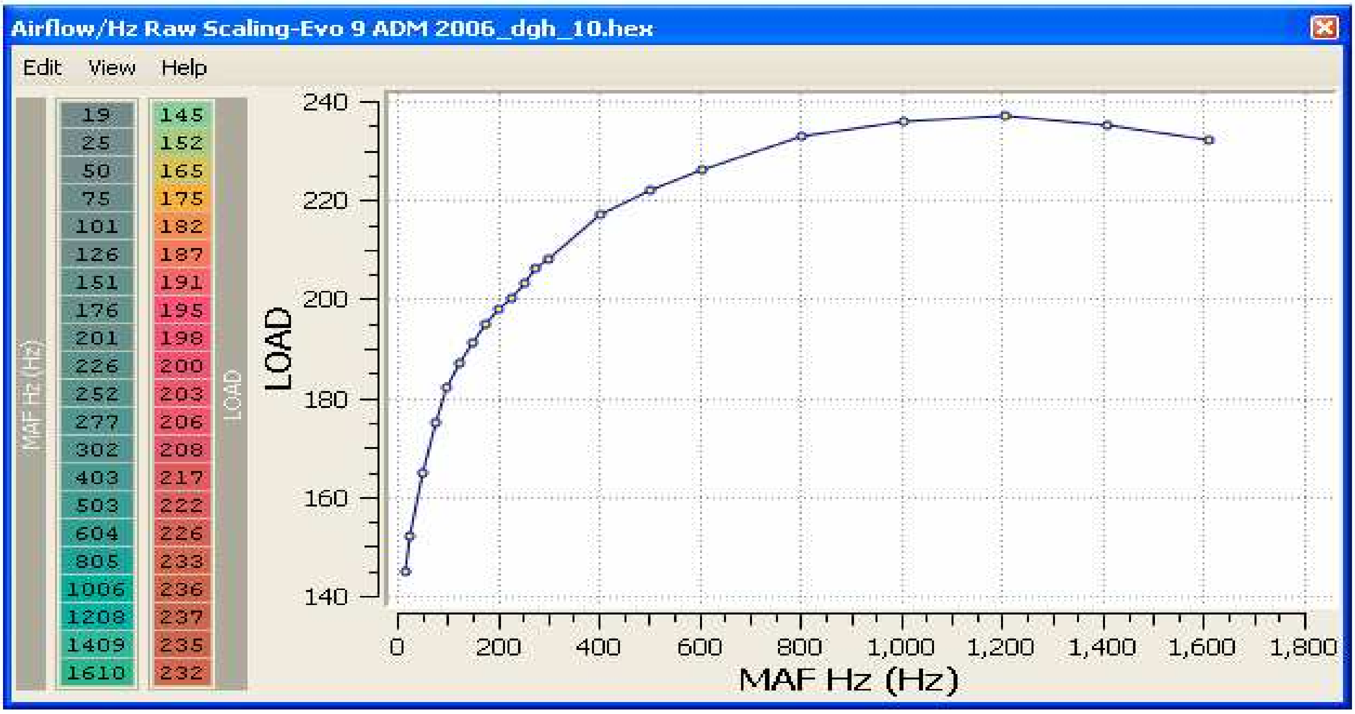
Figure 135: SENSORS – MASS AIRFLOW METER SCALING, Evo7



Airflow Hz (Hz)	L/Hz
31	0.1015
41	0.1064
82	0.1155
123	0.1225
164	0.1274
205	0.1309
246	0.1337
287	0.1365
328	0.1386
369	0.1400
410	0.1421
451	0.1442
492	0.1456
655	0.1519
819	0.1554
983	0.1582
1311	0.1631
1638	0.1652
1966	0.1659
2294	0.1645
2621	0.1624

Note how the scaling shown below has evolved due to better understanding and code disassembly.

Figure 136: SENSORS – MASS AIRFLOW METER SCALING, Evo9



MAF Hz (Hz)	LOAD
19	145
25	152
50	165
75	175
101	182
126	187
151	191
176	195
201	198
226	200
252	203
277	206
302	208
403	217
503	222
604	226
805	233
1006	236
1208	237
1409	235
1610	232

10.21-PERIPHERY BIT PARAMETERS

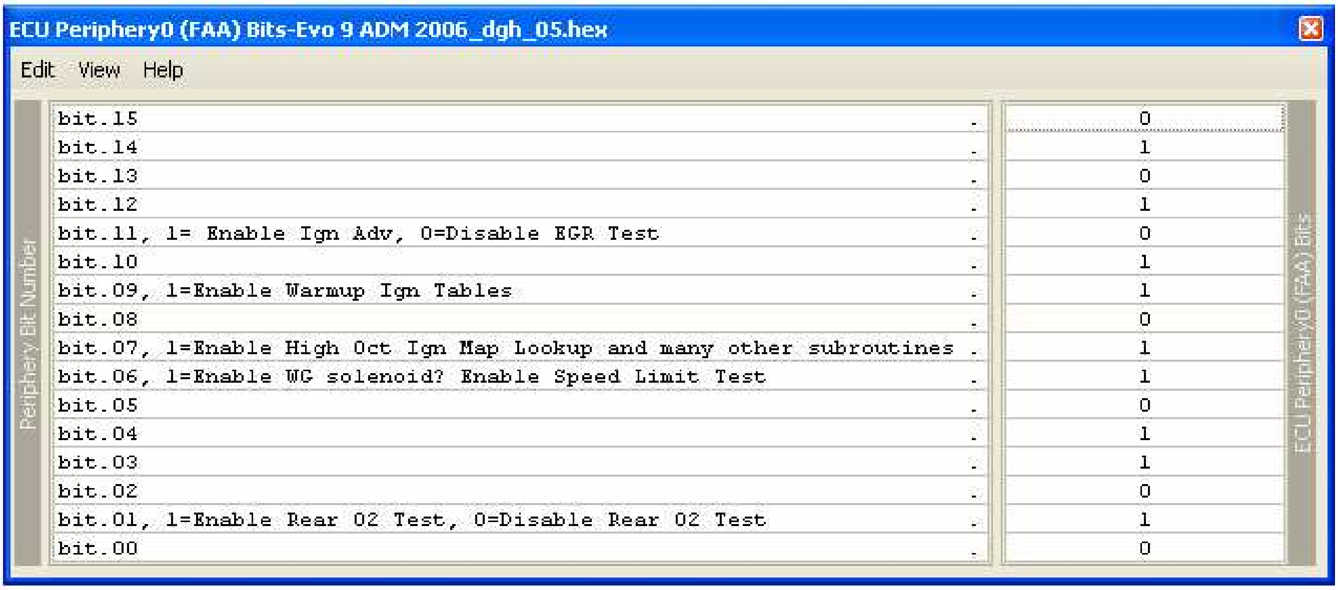
There are six sets of sixteen bit data parameters, called the Periphery bits, which are mainly single bit controls to enable or disable functions/attributes/tests/fault codes. The data can be presented in raw hex format, or as bits with some explanatory text if the function is known (and the xml file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

Periphery0 seems to be the most useful at the moment. I have edited my definition files to better present the current data lists. Periphery bits can also be edited/changed entering a new hex value into the table. The factory set hex value should be 56DA for an EVO 9.

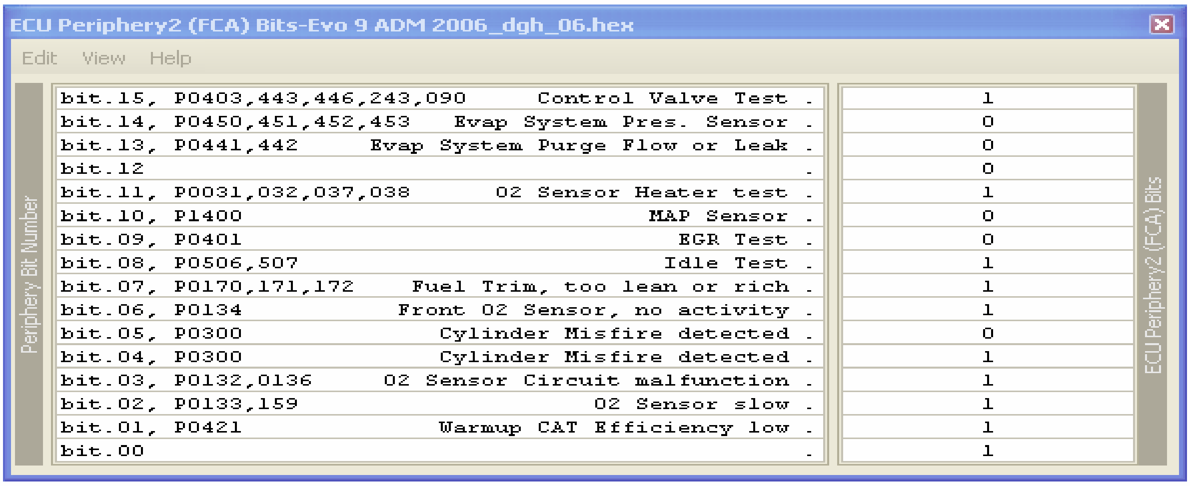
Figure 137: PERIPHERY BITS – PERIPHERY0, DATA BITS, Evo9



bit.15	0
bit.14	1
bit.13	0
bit.12	1
bit.11, 1= Enable Ign Adv, 0=Disable EGR Test	0
bit.10	1
bit.09, 1=Enable Warmup Ign Tables	1
bit.08	0
bit.07, 1=Enable High Oct Ign Map Lookup and many other subroutines	1
bit.06, 1=Enable WG solenoid? Enable Speed Limit Test	1
bit.05	0
bit.04	1
bit.03	1
bit.02	0
bit.01, 1=Enable Rear O2 Test, 0=Disable Rear O2 Test	1
bit.00	0

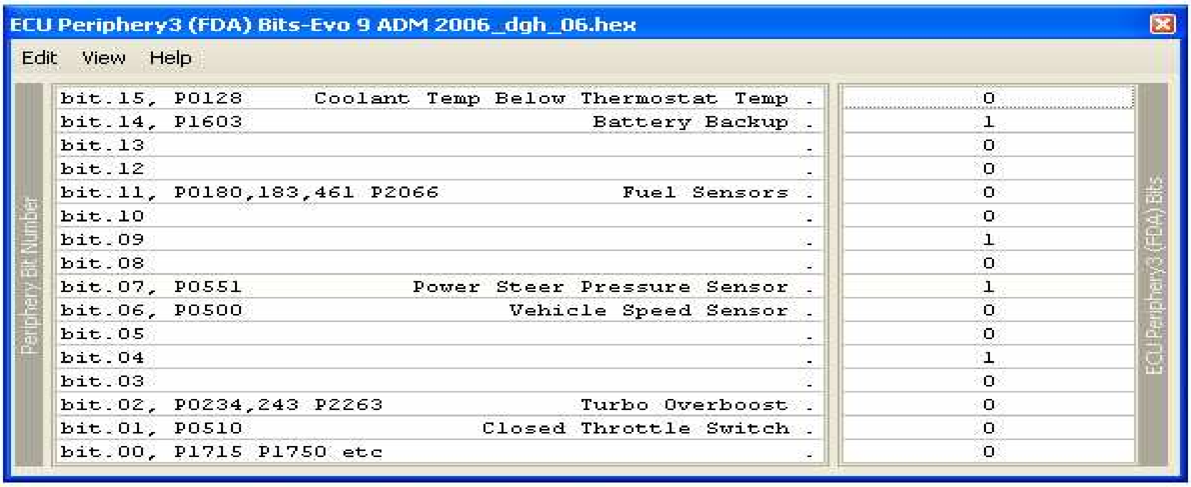
If you are using a high-flow front pipe, you may be getting some rear O2 sensor fault indications on the CEL indicator. While it is possible to circumvent this by adding a spacer to the rear O2 sensor, this may then cause the sensor to rub on the under-body. Setting Periphery0 bit 01 to zero and Periphery 2 bit 01 to zero will unfortunately NOT disable the rear O2 test completely and the ECU will still throw a CEL. To date, the only other fix is **mrfred** & **tephra**s rear O2 simulator.

Figure 138: PERIPHERY BITS – PERIPHERY2, DATA BITS, Evo9



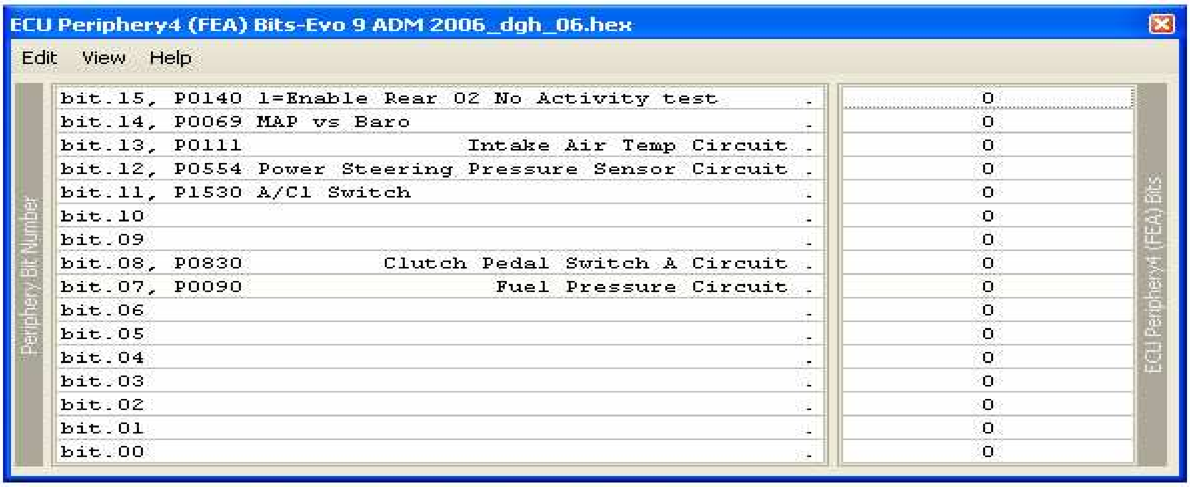
bit.15, P0403,443,446,243,090 Control Valve Test .	1
bit.14, P0450,451,452,453 Evap System Pres. Sensor .	0
bit.13, P0441,442 Evap System Purge Flow or Leak .	0
bit.12 .	0
bit.11, P0031,032,037,038 O2 Sensor Heater test .	1
bit.10, P1400 MAP Sensor .	0
bit.09, P0401 EGR Test .	0
bit.08, P0506,507 Idle Test .	1
bit.07, P0170,171,172 Fuel Trim, too lean or rich .	1
bit.06, P0134 Front O2 Sensor, no activity .	1
bit.05, P0300 Cylinder Misfire detected .	0
bit.04, P0300 Cylinder Misfire detected .	1
bit.03, P0132,0136 O2 Sensor Circuit malfunction .	1
bit.02, P0133,159 O2 Sensor slow .	1
bit.01, P0421 Warmup CAT Efficiency low .	1
bit.00 .	1

Figure 139: PERIPHERY BITS – PERIPHERY3, DATA BITS, Evo9



bit.15, P0128 Coolant Temp Below Thermostat Temp .	0
bit.14, P1603 Battery Backup .	1
bit.13 .	0
bit.12 .	0
bit.11, P0180,183,461 P2066 Fuel Sensors .	0
bit.10 .	0
bit.09 .	1
bit.08 .	0
bit.07, P0551 Power Steer Pressure Sensor .	1
bit.06, P0500 Vehicle Speed Sensor .	0
bit.05 .	0
bit.04 .	1
bit.03 .	0
bit.02, P0234,243 P2263 Turbo Overboost .	0
bit.01, P0510 Closed Throttle Switch .	0
bit.00, P1715 P1750 etc .	0

Figure 140: PERIPHERY BITS – PERIPHERY4, DATA BITS, Evo9



bit.15, P0140 1=Enable Rear O2 No Activity test .	0
bit.14, P0069 MAP vs Baro .	0
bit.13, P0111 Intake Air Temp Circuit .	0
bit.12, P0554 Power Steering Pressure Sensor Circuit .	0
bit.11, P1530 A/C1 Switch .	0
bit.10 .	0
bit.09 .	0
bit.08, P0830 Clutch Pedal Switch A Circuit .	0
bit.07, P0090 Fuel Pressure Circuit .	0
bit.06 .	0
bit.05 .	0
bit.04 .	0
bit.03 .	0
bit.02 .	0
bit.01 .	0
bit.00 .	0

SECTION 11 – EXPANDING MAXIMUM LOAD CAPABILITY

11.1-EXPANDING THE LOAD SCALE FOR HIGH BOOST

Some EVO owners are likely planning on running high boost levels in conjunction with bigger injectors and probably a higher flowing turbo. Will the stock ECU be able handle this situation? The answer is yes, to a point. The limiting factor is the mass airflow meter, the MAF, which has a maximum measurement capability of 309 grams of air per second. This means that somewhere around 28 to 32 PSI it can no longer translate the airflow. When this happens the AFR will start to lean-off, ultimately resulting in a broken engine if left unresolved. Recent developments have now identified the limiting code, such that the effective range is virtually doubled. The 4G63 will be producing a lot of power at this point. Competent tuners are regularly achieving 350-400HP have reported power levels of 600-700HP, on the Factory ECU with tuning.

What is required to get to this point is a re-scaling of the load scales on the fuel and particularly the ignition maps. There are many options open to the tuner on what values to use, this is my preferred setup.

Good fuel mapping will have the same AFR at 10PSI as the top end of the engines performance, when it is at full boost. This may be 15, 20 or 25 PSI, but the required AFR is still going to be about 11.5:1. This number is safe for engines that do not sit at maximum load and boost for long periods eg a street car that sees an occasional track day. It may not be appropriate for a dry-lakes racer though, which may have to run flat-out for eight miles. An endurance racer would have to do a lot of testing to find an AFR which kept the exhaust temperatures under control. But for the purposes of the exercise, I’ve settled on 11.5:1 AFR.

Open the high octane fuel map. Left click the mouse cursor on the 260% load scale cell. Press the = key. A dialog box will open. Type 300 and press enter. The end load column is now set to 300, but the values in the cells are unchanged.

Using the mouse cursor left button, highlight the entire two end columns. Press the = key. Enter the desired AFR eg 11.5 and press enter. The entire contents of the 240% and 300% columns should now be set to 11.5 AFR. This simplistic approach will work as the ECU will happily interpolate the correct value for load levels between 240 and 300 and its job is made a bit simpler as we want the same AFR across the map. Open the low octane fuel map. It now has the same load scaling as the high octane fuel map, but the cell values are unchanged. You could leave them as they are, or set the high end values to a new value eg 10.5:1 AFR. This is still very rich but not as pig rich as the factory values which are designed to keep the engine alive with long periods of WOT operation.

Now for the ignition map, which is a whole lot trickier

The high octane ignition map shown below is a close copy of the Evo7 RS ignition map. This is a good ignition map but does require the use of 100 RON fuel if knock, and subsequent ignition retardation is to be avoided. In any-case, you will have to log power runs and examine the results for knock and make adjustments to your map once the boost levels are raised.

Mitsubishi have deleted the 70% and 90% columns in their RS map and added 280% and 300%. This gives enough resolution at the top of the boost curve to get the ignition values right.

The process, stated simply is as follows:
Select the 70% load cell, set new value to 80%.
Highlight the original 80% column, then select Copy (Ctrl+C).
Highlight the new 80% column, then select Paste (Ctrl+V).
Select the 90% load cell, set new value to 100%.
Highlight the original 100% column, then select Copy (Ctrl+C).
Highlight the new 100% column, then select Paste (Ctrl+V).
Highlight the 120, 140, 160, 180, 200, 220, 240 and 260 columns, select Copy.
Highlight the eight columns to the right of the new 100% column, select Paste.
Select each of the load scale cells in turn and enter the new load values, 120, 140, 160, 180, 200, 220, 240, 260, 280, 300.

This leaves the new 280 and 300 columns with the same unchanged values. You have to manually go through these and any other cells requiring alteration and set the new values using the = key and entering the new value. A bit tedious but it does not take long.

As with the fuel maps, the low octane ignition map will now have had its scaling adjusted to match the high octane map. For a street car, you could leave the low octane ignition map as is. Save the file.

If you are wondering if this is a dodgy way to setup the maps, the Evo9 is setup this way from factory.

11.2-EXPANDING MAXIMUM LOAD & FUEL LIMITS

Embedded within the ECU code is a 380% maximum load limit. The data returned out the OBD-II port wont read past 380 ie you cannot get an accurate log. Nor can the ECU properly control the fuel or ignition when load 380% is exceeded. Normally, the boost cut function would have kicked in but in maximum attack applications this is set to maximum and the over-boost delay time is set to some arbitrary high number.

Thanks to the most excellent de-coding work of **jcsbanks**, this limitation can now be removed. You will have to add the following definition line to you ROMs XML file. Where you see the address shown in red, substitute the correct address for your ROM from the table.

```
<table name="Set to 9 to remove LOAD limit" address="26694" type="1D" level="1" scaling="Hex16"/>

<table name="Set to 9 to remove FUEL limit" address="26592" type="1D" level="1" scaling="Hex16"/>
```

Change the values from "0x2ba1" to "0x9".

Table 8 EVO LOAD & FUEL LIMIT ADDRESS

ROM	MODEL	LOAD LIMIT	FUEL LIMIT
88840017		2901a	
94170008	VIII - 2004 USDM	26592	265ae
94170015	VIII - 2004 USDM	26694	265ae
90550001	VII – 2001 EDM RA	22014	
96530006	VIII	27824	27926
96940011	VIII	28140	282c6
96260009	VIII	25d40	

SECTION 12 – TUNING WITH CAMS PRIMER

12.1-CAM TUNING - INTRODUCTION

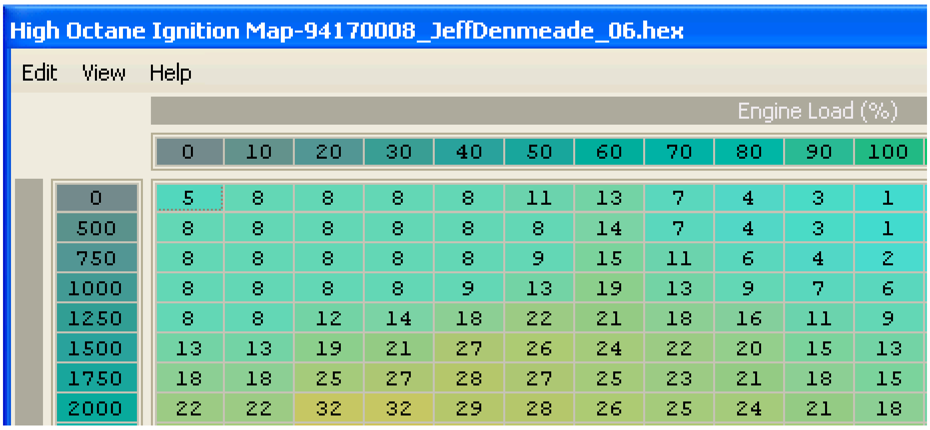
This section is not currently intended to be all encompassing, but rather a primer to show tuners new to the topic some guidance on what to expect and what parameters are likely to require some adjustment.

I will be using a USDM spec Evo8, with 272* cams and ROM code ID 94170008 as the tuning example. Also note this is when using 98 octane (RON) fuel.

12.2-CAM TUNING - SPARK MAP for STARTING & IDLE

High duration cams will inevitably have an effect on starting and idle quality. Most tuners have simply upped the idle section of the HI-OCTANE SPARK map to 8-10° and this will certainly give an improvement as the extra torque available will smooth the idle somewhat. This has been applied to the spark map shown below, but the cranking cell at LOAD=0 and RPM=0 has been left at the factory 5° point for improved cranking and quicker startup.

Figure 141: CAM TUNING, SPARK MAP for STARTING & IDLE, Evo8



High Octane Ignition Map-94170008_JeffDenmeade_06.hex

	Engine Load (%)										
	0	10	20	30	40	50	60	70	80	90	100
0	5	8	8	8	8	11	13	7	4	3	1
500	8	8	8	8	8	8	14	7	4	3	1
750	8	8	8	8	8	9	15	11	6	4	2
1000	8	8	8	8	9	13	19	13	9	7	6
1250	8	8	12	14	18	22	21	18	16	11	9
1500	13	13	19	21	27	26	24	22	20	15	13
1750	18	18	25	27	28	27	25	23	21	18	15
2000	22	22	32	32	29	28	26	25	24	21	18

12.3-CAM TUNING - IDLE STABILITY TIMING CONTROL

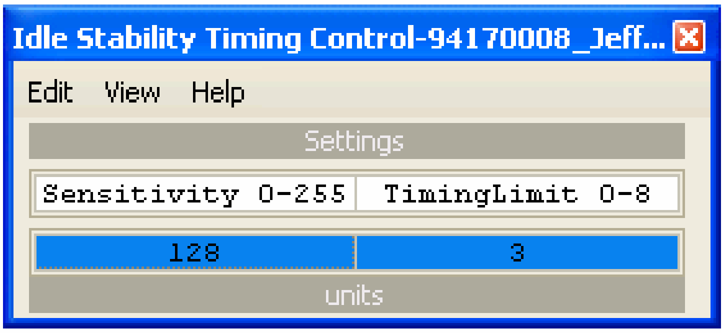
There are three main components controlling idle in the Evo, these being the target idle speed table (which we probably wont need to change), the ISCV step tables which we will need to change and the IDLE STABILITY TIMING CONTROL, which we are about to change.

The ISCV is used to set the approximate required air supply (it will be dynamically adjusted by the ECU) but Mitsubishi have implemented an aggressive idle control strategy using ignition timing adjustment. The idle stepper motor is used to get the air flow in the right range for the desired idle speed, but the timing algorithm adjustment is used to dynamically keep the idle at the set/desired speed.

Two ROM variables have been found pertaining to idle stability v timing control. The first is a one byte sensitivity or gain variable (default=128), and the second is Idle Stability Timing Correction Limit, which defines the adjustment range (default=±8° for the EVO7, the Evo7-GTA and Evo8, and ±3° for the EVO9).

It turns out that ±8° is too much adjustment range when using aggressive cams, we simply need to adjust the TIMING LIMIT value down until an acceptable idle is found. For the 272 degree cams used here the right value was ±3°.

Figure 142: CAM TUNING, IDLE STABILITY TIMING CONTROL, Evo8



Sensitivity 0-255	TimingLimit 0-8
128	3

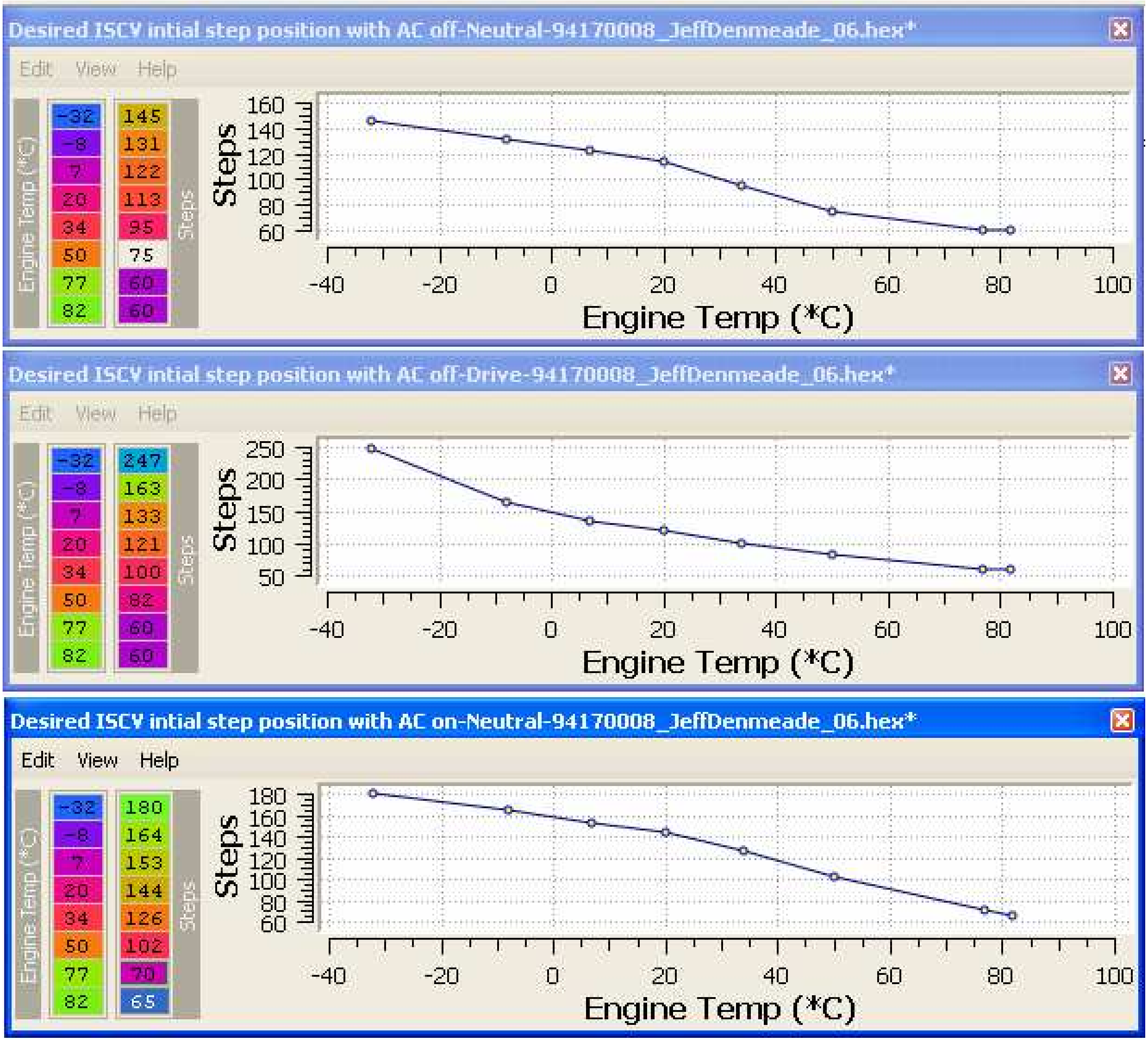
12.4-CAM TUNING - IDLE CONTROL ISCV SETTINGS

The next set of adjustments to be made here are to the various ISCV tables. These are the initial step settings the ECU uses to get idle air close to the expected requirement. The stock settings are fine for stock cams, but not for high duration cams with more overlap.

In general terms, the step settings need to be raised, ie allow more air into the cylinders. This is not only important for idle but also when cranking the engine at startup.

Depending on the cams, the changes required can be quite substantial, the method to find out what the settings need to be is found by logging the ISCV parameter and engine water temperature with EvoScan, preferably for a complete warm-up cycle. Note that the stock 82°C values were 7, 7,and 32

Figure 143: CAM TUNING, IDLE CONTROL ISCV SETTINGS, Evo8



Desired ISCV intial step position with AC off-Neutral-94170008_JeffDenmeade_06.hex*

Engine Temp (*C)	Steps
-32	145
-8	131
7	122
20	113
34	95
50	75
77	60
82	60

Desired ISCV intial step position with AC off-Drive-94170008_JeffDenmeade_06.hex*

Engine Temp (*C)	Steps
-32	247
-8	163
7	133
20	121
34	100
50	82
77	60
82	60

Desired ISCV intial step position with AC on-Neutral-94170008_JeffDenmeade_06.hex*

Engine Temp (*C)	Steps
-32	180
-8	164
7	153
20	144
34	126
50	102
77	70
82	65

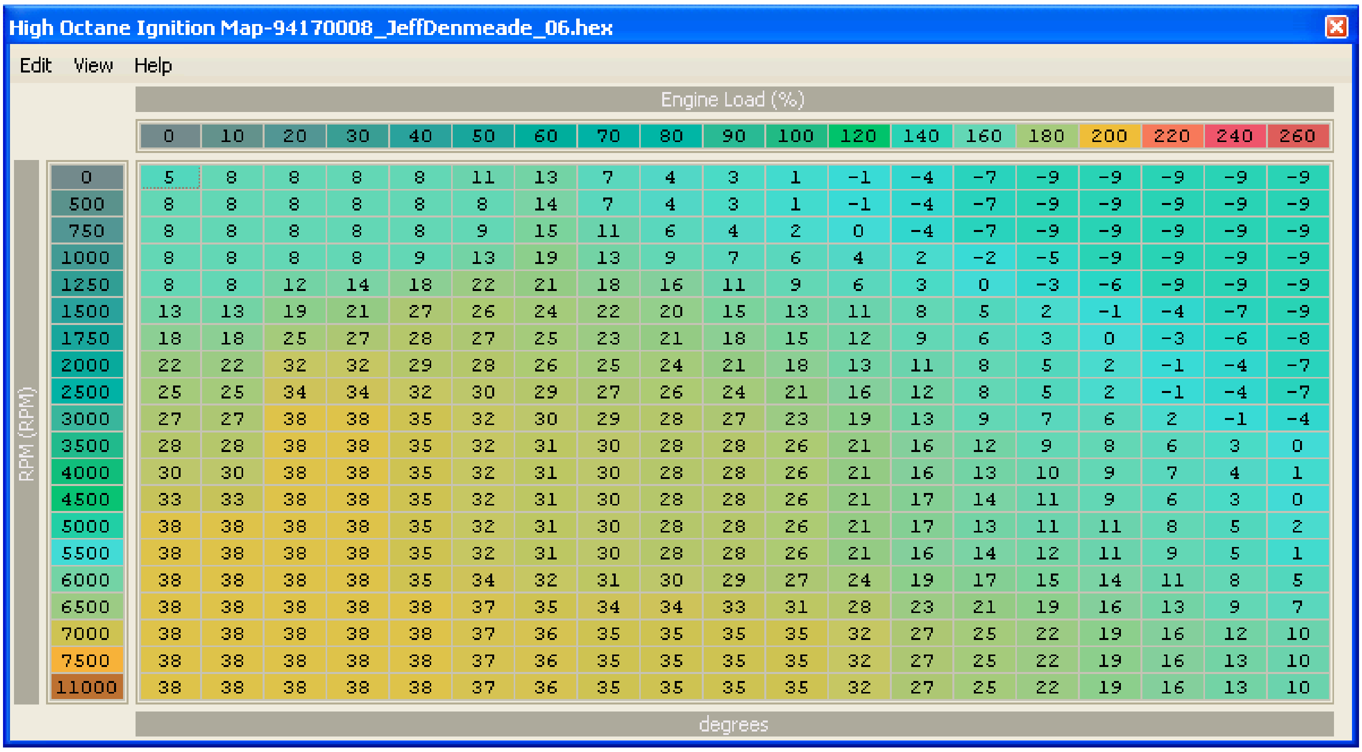
12.5-CAM TUNING - HI-OCTANE SPARK MAP

This particular Evo8 had been well tuned and raced, and prior to the new cams logging with EvoScan showed only the odd 1-2 counts of knock, nothing solid or particularly repeatable and consistent.

Logging with the new cams showed knock counts of 5-6 in the 5500 to 6500 rpm band at 220 load. These cells were trimmed down by two degrees and several power pulls revealed the knock count was reduced to 0-1 in the previously affected area. So while cams can make a major change to the engines volumetric efficiency the spark map in this instance did not require major changes.

Here is the complete HI-OCTANE map as it currently stands for the 272 degree cams.

Figure 144: CAM TUNING, HI-OCTANE SPARK MAP, Evo8



Engine Load (%)

RPM (RPM)	0	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260
0	5	8	8	8	8	11	13	7	4	3	1	-1	-4	-7	-9	-9	-9	-9	-9
500	8	8	8	8	8	8	14	7	4	3	1	-1	-4	-7	-9	-9	-9	-9	-9
750	8	8	8	8	8	9	15	11	6	4	2	0	-4	-7	-9	-9	-9	-9	-9
1000	8	8	8	8	9	13	19	13	9	7	6	4	2	-2	-5	-9	-9	-9	-9
1250	8	8	12	14	18	22	21	18	16	11	9	6	3	0	-3	-6	-9	-9	-9
1500	13	13	19	21	27	26	24	22	20	15	13	11	8	5	2	-1	-4	-7	-9
1750	18	18	25	27	28	27	25	23	21	18	15	12	9	6	3	0	-3	-6	-8
2000	22	22	32	32	29	28	26	25	24	21	18	13	11	8	5	2	-1	-4	-7
2500	25	25	34	34	32	30	29	27	26	24	21	16	12	8	5	2	-1	-4	-7
3000	27	27	38	38	35	32	30	29	28	27	23	19	13	9	7	6	2	-1	-4
3500	28	28	38	38	35	32	31	30	28	28	26	21	16	12	9	8	6	3	0
4000	30	30	38	38	35	32	31	30	28	28	26	21	16	13	10	9	7	4	1
4500	33	33	38	38	35	32	31	30	28	28	26	21	17	14	11	9	6	3	0
5000	38	38	38	38	35	32	31	30	28	28	26	21	17	13	11	11	8	5	2
5500	38	38	38	38	35	32	31	30	28	28	26	21	16	14	12	11	9	5	1
6000	38	38	38	38	35	34	32	31	30	29	27	24	19	17	15	14	11	8	5
6500	38	38	38	38	38	37	35	34	34	33	31	28	23	21	19	16	13	9	7
7000	38	38	38	38	38	37	36	35	35	35	35	32	27	25	22	19	16	12	10
7500	38	38	38	38	38	37	36	35	35	35	35	32	27	25	22	19	16	13	10
11000	38	38	38	38	38	37	36	35	35	35	35	32	27	25	22	19	16	13	10

degrees

As a final point on the spark maps, it would be a good idea to copy the 0-60 load section of your HI-OCTANE map into your LO-OCTANE map for a degree of timing consistency between the two. Then blend the junction area into your original LO-OCTANE map.

APPENDIX 2: LOGGING BOOST or AFR with EvoScan

A2.1-INTRODUCTION

The intention here is to use a spare analog input on the factory ECU to log either BOOST or AFR via the OBD-II port and the EvoScan logging program. Boost logging would be accomplished with a 3-BAR MAP sensor, either the Mitsubishi unit from the EvoX or the GM sensor. Air Fuel Ratio logging would be accomplished with a wideband O2 sensor and support interface.

In either case the plan is to connect the nominal 0-5V analog output from the sensor into the ECU at a spare analog input. Read-on.

A2.2-BOOST LOGGING INTRODUCTION

The following is **mrfred**'s discussion (mostly un-abridged) on how to get the USDM EVO8 and USDM EVO9 boost logging via the ECU.

USDM EVOs have a 1 bar MAP sensor that can only measure up to 2.2 psi of boost. However, the JDM Evo9 uses a 3 bar MAP sensor that can measure up to 32 psi of boost. The JDM EVO9 sensor is identical in appearance to the USDM sensor, so it can be easily swapped for the USDM sensor. In order for the sensor to work properly with the USDM cars, a few mods must be made to some of the tables in the ROM for your car. Total time for the sensor swap should be 10 minutes or less. Mods to the ROM using EcuFLASH could take up to an hour. I would like to thank **bez_bashni** and **jcsbanks** for helping me get started on this project.

A2.3-ROMs CURRENTLY COVERED

At the time of writing, this is USDM only mod.

Evo8s: 94170008, 94170014, 94170015, 96420007, 96420008, 96940011

Evo9s: 88590013, 88590014, 88590015

To see which ROM you have, open it in EcuFLASH, and expand on the "ROM Info" section. You'll see your ROM version there. If your ROM is not one of these, email it to me, and I will find the tables.

A2.4-MAP SENSOR SWAP

Here is a picture of the MAP sensor location (right on top of the intake manifold):
Pix from **mrfred** on EvoM.

Figure 145: USDM EVO9 ENGINE & 3 BAR MAP SENSOR

To remove the electrical plug, it is necessary to pry up the metal clip. Slide a thin blade screw driver under it, and it will easily pry up. It is spring loaded, so it will go flying if you don't keep your hand on it when removing it.

After you swap in the JDM sensor, you'll need to perform some ROM mods. If the ROM mods are not done at the same time, the car will either not run or throw a CEL.

The next sections describe what mods need to be done to each of the different USDM Evo ROMs. The final section describes how to setup EvoScan or Mitsulogger to log boost.

A2.5: 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/cm² = 14.223 psi
1kg/cm² = 99.06 kPa

A2.6-ROM Mods for USDM EVO9 ROMs 88590013, 88590014, 88590015

First is to add some definitions to your ECUFlash ROM XML definition file found in:

C:\Program Files\OpenECU\EcuFlash\rommetadata\mitsubishi\evo

Open the 885900XX.xml file with the text editor of your choice. Scroll down to the bottom of the file. Add the following lines just before the </rom> tag:

```
<table name="MAP Scaling" category="MAPSensor" address="670c" type="2D" scaling="uint8">
<table name="MAP Output" address="800e" type="Y Axis" elements="9" scaling="Volts16"/>
</table>

<table name="MAP Fault Trig: Mid VE Max #1" category="MAPSensor" address="29d6" type="1D" scaling="Volts16"/>

<table name="MAP Fault Trig: Mid VE Min #1" category="MAPSensor" address="29b6" type="1D" scaling="Volts16"/>

<table name="MAP Fault Trig High VE #1" category="MAPSensor" address="29bc" type="1D" scaling="Volts16"/>

<table name="MAP vs Baro" category="MAPSensor" address="283c" type="1D" scaling="uint16"/>

<table name="EGR MAP Offset #1" category="MAPSensor" address="4936" type="2D" scaling="uint8">
<table name="RPM" address="74de" type="Y Axis" elements="9" scaling="RPM"/>
</table>

<table name="EGR MAP offset #2" category="MAPSensor" address="4946" type="2D" scaling="uint8">
<table name="RPM" address="74de" type="Y Axis" elements="9" scaling="RPM"/>
</table>

<table name="EGR Pressure Diff" category="MAPSensor" address="1B7C" type="1D" scaling="Volts16"/>

<table name="MAP Comparison" category="MAPSensor" address="2838" type="1D" scaling="Volts16"/>

<table name="ECU Periphery2" category="ECUPeriphery" address="fca" type="1D" scaling="Hex16"/>
<table name="ECU Periphery4" category="ECUPeriphery" address="fea" type="1D" scaling="Hex16"/>
```

After modifying and saving the ROM xml file, launch EcuFLASH, open your ROM, and find the new entries. Note that they have their own category. Here is what needs to be changed in EcuFLASH:

MAP SCALING

0.84	11
1.37	20
1.89	31
2.42	40
2.95	48
3.48	57
4.00	67
4.53	80
4.98	255

Change it to the JDM values:

0.51	20
0.90	40

1.29	57
1.68	78
2.07	97
2.46	117
2.85	138
3.24	158
3.63	255

Change the "MAP Fault Trig: Mid VE Max #1" value from 4.80 to 4.90.
Change the "MAP Fault Trig: Mid VE Min #1" value from 0.20 to 0.10.
Change the "MAP Fault Trig High VE #1" value from 1.80 to 0.51.
Change the USDM "MAP vs Baro" parameter from 162 to the JDM value of 93.

The "EGR MAP Offset #1" table will read:

750	95
1000	70
1250	60
1500	51
1750	45
2000	42
2500	49
3000	50
3500	48

The "EGR MAP Offset #2" table will read:

750	97
1000	86
1250	84
1500	67
1750	52
2000	56
2500	65
3000	63
3500	60

Change *both* tables to the following values:

750	84
1000	84
1250	73
1500	65
1750	60
2000	55
2500	48
3000	43
3500	23

Change the "EGR Pressure Diff" from 0.12 to 0.04.
Change the "MAP Comparison" value from 4.00 to 1.46.

Change ECU Periphery4 parameter from F980 to B980. (Enter hex in ECUFlash by typing 0xB980.)

If you wish to disable the EGR test, change the ECU Periphery2 parameter from EFDF to EDDF. (Type 0xEDDF.)

Save the ROM file, and flash your ECU with it. That's it for the Evo 9 ROM mods. Now skip down to the end of this post to see instructions for setting up EvoScan/Mitsulogger to log boost in psig.

A2.7-Logging Boost in EvoScan/Mitsulogger

MAP sensors do not know the local atmospheric pressure. To log boost in psig (what all boost gauges show and what people always use to discuss boost values), the conversion formula for the logging program needs to have an offset for your local atmospheric pressure. The general formula for the JDM MAP sensor is:

psig = **(x*0.17886 + 0.161) - 14.5**

Where 14.5 is the local atmospheric pressure in psi. The local atmospheric pressure is strongly affected by altitude. For example the pressure at sea level is 14.7 psi, but at 5000 ft, the pressure is 12.2 psi. That's a pretty big difference when you want to log boost. Use this table of altitude v pressure to determine the offset pressure for your formula:

Table 9 ALTITUDE v ATMOSPHERIC PRESSURE

feet	0000	0500	1000	1500	2000	2500	3000	3500	4000	4500	5000	6000	7000
psi	14.7	14.4	14.2	13.9	13.7	13.4	13.2	12.9	12.7	12.5	12.2	11.8	11.3

For example, if you are living at 750 ft, then you'd want to use 14.3 psi as your offset, and the formula would be:

(x*0.17886 + 0.161) - 14.3

In the following instructions, please use your formula in place of the words FORMULA HERE.

For EvoScan, the MAP logging definition in the Data.xml file should be set to:

<DataListItem DataLog="Y" Color="" Display="JDM MAP" LogReference="JDMMAP" RequestID="38" Eval="**FORMULA HERE**" Unit="psig" MetricEval="" MetricUnit="" ResponseBytes="1" GaugeMin="-15" GaugeMax="30" ChartMin="-15" ChartMax="30" ScalingFactor="1" Notes=""/>

To log boost in psi in Mitsulogger (pre v2), the MAP logging definition should be changed to:

<Request LogReference="JDMMAP" RequestID="38" Eval="**FORMULA HERE**" Unit="psig" Logged="y" Response="2"/>

To log the boost pressure in kpa, use the following formula:

kpa = **((5.0*x/255) + 0.01765) / 0.01591**

A2.8-INCREASING LOGGING BAUD-RATE

The standard baud rate is quite good if EvoScan is setup for efficient logging.

1. In the EvoScan "Logging" pull-down menu, select "Logger SuperSpeed". This alone makes a huge difference.

2. In the EvoScan main window, deselect all the crap that you're not interested in logging. For a typical logging run for tuning afr/spark/boost, the key items to log are TPS, RPM, IPW, AFR, 2-byte load, boost, timing adv, knock sum, air temp, and coolant temp. If you're trying to control boost with the ECU, then you'll also want to log WGDC.

3. In the EvoScan "Logging" pull-down menu, deselect "Log Data to Screen". This is good for about a 15% increase in logging speed (and I never try to watch the computer screen while doing a WOT run).

With this recipe, the logging interval is right about 0.06-0.07 sec (on my 3 year old laptop) which is excellent for data logging under almost any circumstance.

A2.9-WIRING the 3-BAR MAP SENSOR to EDM & AUDM EVO9

For an EDM and AUDM Evo9, connect as follows:

Pin 92 = MAP signal, yellow wire if fitted.
Pin 42 = +5V power, grey wire.
Pin 49 = Analog sensor ground, black wire.

That is from the manual, but just double check it yourself. The nice thing about logging MUT38 (MAP sensor) is you don't need to change anything in the ECU to get it to work. So just wire it up and then log MUT38 and it should just work.

A2.10-SENSOR PART NUMBER

Mitsubishi part number for the EvoX map sensor is 1865A052.

A2.11-Logging AIR FUEL RATIO in EvoScan

The general formula for logging the AFR from an INNOVATE LC-1, via its analog output #2:

AFR = **x*0.05859 + 7.35**

APPENDIX 3: ECU PIN DESCRIPTIONS AND WIRING

A3.1: EVO7 ECU PIN FUNCTION & WIRE COLOUR

Table 10 Evo7 JDM ECU PIN FUNCTION & WIRE COLOUR

1	INJECTOR 1	O	🟧	🟧	71	START	B-R	⬛	🟥
2	INJECTOR 3	G	🟩	🟩	72	AIR TEMP SENSOR	R-L	🟥	🟦
3	FUEL PRESS SOL	W-B	⬜	⬛	73				
4	IDLE SERVO PIN 1	Y-L	🟨	🟦	74				
5	IDLE SERVO PIN 4	R-G	🟥	🟩	75	LAMBDA - REAR	Gr	▨	▨
6	EGR SOLENOID	G-O	🟩	🟧	76	LAMBDA - FRONT	W	⬜	⬜
7					77				
8	A/C COMP RELAY	P	🟪	🟪	78	KNOCK SENSOR	W	⬜	⬜
9	PURGE SOLENOID	Y-G	🟨	🟩	79	DIAGNOSTICS/FLASH	G-W	🟩	⬜
10	IGNITION COIL 1	B-Y	⬛	🟨	80	BACKUP 12V SUPPLY	R-B	🟥	⬛
11	WASTEGATE SOLENOID	LG	🟩	🟩	81	+5V to SENSORS	Gr	▨	▨
12	12V SWITCHED PWR	R-Y	🟥	🟨	82	IGNITION SW SUPPLY	B-R	⬛	🟥
13	GROUND	B	⬛	⬛	83	WATER TEMP SENSOR	Y-W	🟨	⬜
14	INJECTOR 2	W-R	⬜	🟥	84	THROTTLE POS SENSOR	G	🟩	🟩
15	INJECTOR 4	R	🟥	🟥	85	BARROMETRIC SENSOR	Y-L	🟨	🟦
16					86	ROAD SPEED SENSOR	B-Y	⬛	🟨
17	IDLE SERVO PIN 3	Y	🟨	🟨	87	ACD/AYC SENSOR I/P	R-Y	🟥	🟨
18	IDLE SERVO PIN 6	LG	🟩	🟩	88	CAM SENSOR	L-R	🟦	🟥
19	MASS AIR FLOW RESET	L-B	🟦	⬛	89	CRANK SENSOR	Br-G	🟫	🟩
20					90	AIR FLOW SENSOR	W-R	⬜	🟥
21	RAD FAN SPEED	L	🟦	🟦	91	INTERCOOLER MANUAL	L-R	🟦	🟥
22	FUEL PUMP RELAY 2	V	🟪	🟪	92	SENSOR GROUND	B	⬛	⬛
23	IGNITION COIL 2	B-G	⬛	🟩					
24	AIRCON CONTROL UNIT	G-Y	🟩	🟨					
25	12V SWITCHED PWR	R-Y	🟥	🟨					
26	GROUND	B	⬛	⬛					
31									
32	AICON FAN RELAY HI	G-R	🟩	🟥					
33	ALTERNATOR pin G	L-B	🟦	⬛					
34	AIRCON FAN RELAY LO	L	🟦	🟦					
35	INTERCOOLER SPRAY	R-Y	🟥	🟨	51	IMMOBILIZER	R-W	🟥	⬜
36	ECU CHECK ENG LAMP	W-L	⬜	🟦	52				
37	PWR STEERING SW	R-W	🟥	⬜	53	SAS SOLENOID	Br	🟫	🟫
38	ECU RELAY	R	🟥	🟥	54	LAMBDA HEATER	Y	🟨	🟨
39	FUEL PUMP RLY HI	R-B	🟥	⬛	55	INTERCOOLER RELAY	R-W	🟥	⬜
40					56	DIAGNOSTICS pin 1	LG	🟩	🟩
41	ALTERNATOR pin FR	W	⬜	⬜	57				
42					58	TACHO	G-W	🟩	⬜
43					59				
44	INTERCOOLER AUTO	L-W	🟦	⬜	60	LAMBDA HEATER FRONT	L-R	🟦	🟥
45	AIRCON PRESSURE SW	P	🟪	🟪	61				
46					62	DIAGNOSTICS pin 7	O	🟧	🟧

A3.2: EVO6 ECU PIN FUNCTION & WIRE COLOUR

Table 11 Evo6 JDM ECU PIN FUNCTION & WIRE COLOUR

1	INJECTOR 1	Y-L	🟨	🟦	71	START	B-Y	⬛	🟨
2	INJECTOR 3	L-G	🟦	🟩	72	AIR TEMP SENSOR	R-L	🟥	🟦
3	FUEL PRESS SOL	W-B	⬜	⬛	73				
4	IDLE SERVO pin 1	Y-L	🟨	🟦	74				
5	IDLE SERVO pin 4	W	⬜	⬜	75	LAMBDA - REAR			
6	SEC AIR SOLENOID	Br	🟫	🟫	76	LAMBDA SENSOR	W	⬜	⬜
7					77				
8	FUEL PUMP RELAY	B-L	⬛	🟦	78	KNOCK SENSOR	W	⬜	⬜
9	PURGE SOLENOID				79	DIAGNOSTICS/FLASH	G-W	🟩	⬜
10	IGNITION COIL 1	B-Y	⬛	🟨	80	BACKUP 12V SUPPLY	R-B	🟥	⬛
11	WASTEGATE SOLENOID	Br-W	🟫	⬜	81	+5V to SENSORS	G-L	🟩	🟦
12	12V SWITCHED PWR	R-Y	🟥	🟨	82	IGNITION SW SUPPLY	B-W	⬛	⬜
13	GROUND	B	⬛	⬛	83	WATER TEMP SENSOR	Y-G	🟨	🟩
14	INJECTOR 2	Y-B	🟨	⬛	84	THROTTLE POS SENSOR	G-W	🟩	⬜
15	INJECTOR 4	LG-W	🟩	⬜	85	BARROMETRIC SENSOR	Y-W	🟨	⬜
16					86	ROAD SPEED SENSOR	Y	🟨	🟨
17	IDLE SERVO pin 3	Y	🟨	🟨	87	IDLE SWITCH I/P	Y-R	🟨	🟥
18	IDLE SERVO pin 6	G	🟩	🟩	88	CAM SENSOR	L-R	🟦	🟥
19	MASS AIR FLOW RESET	L	🟦	🟦	89	CRANK SENSOR	Br-G	🟫	🟩
20	RAD FAN HI	L-W	🟦	⬜	90	AIR FLOW SENSOR	W-R	⬜	🟥
21	RAD FAN LO	L	🟦	🟦	91	GROUND	B	⬛	⬛
22	AIRCON COMP RELAY	G-W	🟩	⬜	92	SENSOR GROUND	B	⬛	⬛
23	IGNITION COIL 2	B-G	⬛	🟩		DIFFERENCES TO THE Evo7 ECU HIGHLIGHTED IN TAN			
24									
25	12V SWITCHED PWR	R-Y	🟥	🟨					
26	GROUND	B	⬛	⬛					
31									
32	AICON FAN RELAY LO	L-Y	🟦	🟨					
33	ALTERNATOR G								
34	AIRCON FAN RELAY HI	L	🟦	🟦					
35	INTERCOOLER SPRAY				51	IMMOBILIZER			
36	ECU CHECK ENG LAMP	LG-B	🟩	⬛	52				
37	PWR STEERING SW	Y-B	🟨	⬛	53	SAS SOLENOID			
38	ECU RELAY	R	🟥	🟥	54	LAMBDA HEATER			
39	FUEL PUMP RLY HI	L	🟦	🟦	55	INTERCOOLER RELAY			
40					56	DIAGNOSTICS pin 1	LG	🟩	🟩
41	ALTERNATOR FR	W	⬜	⬜	57				
42					58	TACHO	W	⬜	⬜
43					59				
44	INTERCOOLER AUTO				60	LAMBDA HEATER	R	🟥	🟥
45	AIRCON PRESSURE SW	G-B	🟩	⬛	61				
46					62	DIAGNOSTICS pin 7	O	🟧	🟧

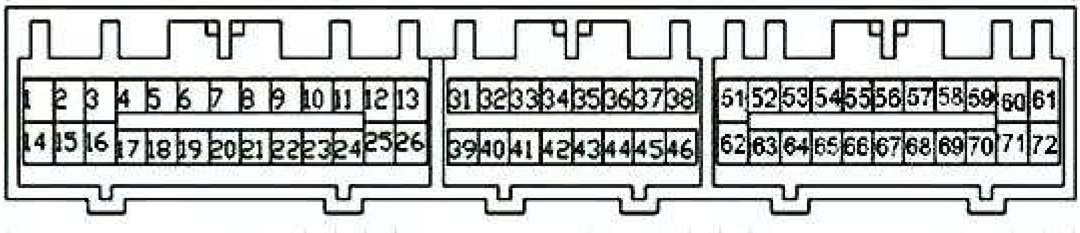
A3.3: EVO9 ECU PIN FUNCTION & WIRE COLOUR

Table 12 Evo9 ECU PIN FUNCTION & WIRE COLOUR

1	INJECTOR 1	O	🟧	🟧	52	ALTERNATOR - FR	W	⬜	⬜
2	INJECTOR 4	R	🟥	🟥	53	CAM SENSOR - INLET	L-R	🟦	🟥
3	LAMBDA HEATER FRONT	L-R	🟦	🟥	54	PWR STEERING SW	R-W	🟥	⬜
4					55	FUEL PUMP RLY 3-HI PWR	R-B	🟥	⬛
5	SAS SOLENOID	Br	🟫	🟫	56	INTERCOOLER SPRAY RELAY	R-W	🟥	⬜
6	BOOST CONTROL VALVE 2	LG-B	🟩	⬛	57	ECU RELAY	R	🟥	🟥
7					58	CHASSIS GROUND - PWR	B	⬛	⬛
8	ALTERNATOR-G	L-W	🟦	⬜	59	12V PWR from ECU relay	R-Y	🟥	🟨
9	INJECTOR 2	W-R	⬜	🟥	60	BACKUP 12V SUPPLY	R-B	🟥	⬛
10					61	MAF - AIR FLOW signal	W-R	⬜	🟥
11	IGNITION COIL 1	B-Y	⬛	🟨	62	MAF - AIR TEMP signal	R-L	🟥	🟦
12	IGNITION COIL 2	B-G	⬛	🟩	63	?			
13					64	MUT83			
14	IDLE SERVO PIN 1	Y-L	🟨	🟦	65	AIRCON FAN RELAY LO	G-Y	🟩	🟨
15	IDLE SERVO PIN 4	R-G	🟥	🟩	66	INTERCOOLER SW - AUTO	L-W	🟦	⬜
16	PURGE CONTROL VALVE	Y-G	🟨	🟩	67	INTERCOOLER SW - MANUAL	L-R	🟦	🟥
17					68	STARTER SOLENOID signal	B-R	⬛	🟥
18	RAD FAN SPEED output sig.	L	🟦	🟦	71	LAMBDA - FRONT	W	⬜	⬜
19	MAF – RESET signal	L-B	🟦	⬛	72	LAMBDA - REAR	W-L	⬜	🟦
20	A/C COMP RELAY	P	🟪	🟪	73				
21	FUEL PUMP RELAY 2	V	🟪	🟪	74				
22	CHECK ENGINE LAMP	W-L	⬜	🟦	75				
23					76				
24	INJECTOR 3	G	🟩	🟩	77				
25					78	TPS signal	G	🟩	🟩
26					79	ACD/AYC SENSOR I/P	R-Y	🟥	🟨
27					80	ROAD SPEED SENSOR	B-Y	⬛	🟨
28	IDLE SERVO PIN 3	Y	🟨	🟨	81				
29	IDLE SERVO PIN 6	LG	🟩	🟩	82				
30	A/C FAN RELAY - HI SPEED	G-R	🟩	🟥	83	AIRCON PRESSURE SW	P	🟪	🟪
31	A/C FAN RELAY - LO SPEED	L	🟦	🟦	84				
32	OIL CONTROL VALVE	P-B	🟪	⬛	85	OBD-II signal K-LINE	O	🟧	🟧
33					86				
34	MAF+CAS SENSOR GROUND	B	⬛	⬛	87				
35					88				
					89				
41	BOOST CONTROL VALVE 1	W-B	⬜	⬛	90	INTERCOOLER SPRAY LAMP	R-Y	🟥	🟨
42	+5V to MAP+MAF+TPS	Gr	▨	▨	91	KNOCK SENSOR	W	⬜	⬜
43	CRANK SENSOR	Br-G	🟫	🟩	92	MAP SENSOR MUT38	Y	🟨	🟨
44	WATER TEMP SENSOR	Y-W	🟨	⬜	93	MUT39			
45	TACHO METER	G-W	🟩	⬜	94				
46	CHASSIS GROUND - PWR	B	⬛	⬛	95				
47	12V PWR from ECU relay	R-Y	🟥	🟨	96	AIR TEMP SENSOR MUT87	G-R	🟩	🟥
48	FUEL PRESS SOLENOID	W-B	⬜	⬛	97				
49	ANALOG SENSOR GROUND	B	⬛	⬛	98	IMMOBILISER signal	R-W	🟥	⬜
50	CAM SENSOR - EXHAUST	L-R	🟦	🟥	99	12V SWITCHED PWR	B-R	⬛	🟥
51	ATMOSPHERIC PRESSURE	Y-L	🟨	🟦	100	DIAGNOSTICS signal pin 26	G-W	🟩	⬜

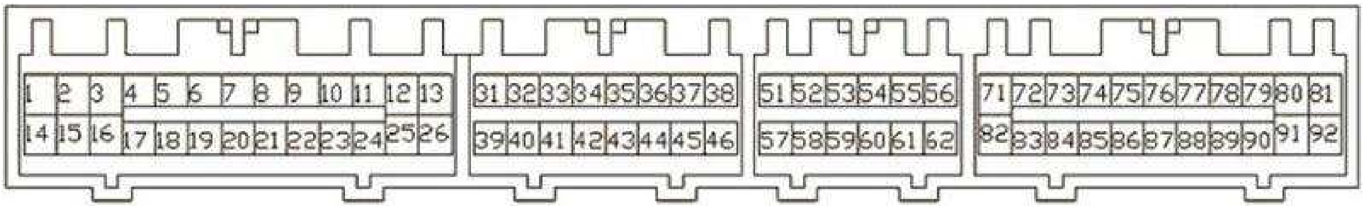
A3.4: EVO1 to EVO3 & RVR ECU PIN CONFIGURATION

Figure 146: ECU WIRE SIDE VIEW, Evo1 to Evo3 & RVR



A3.5: EVO4 to EVO8 ECU PIN CONFIGURATIONS

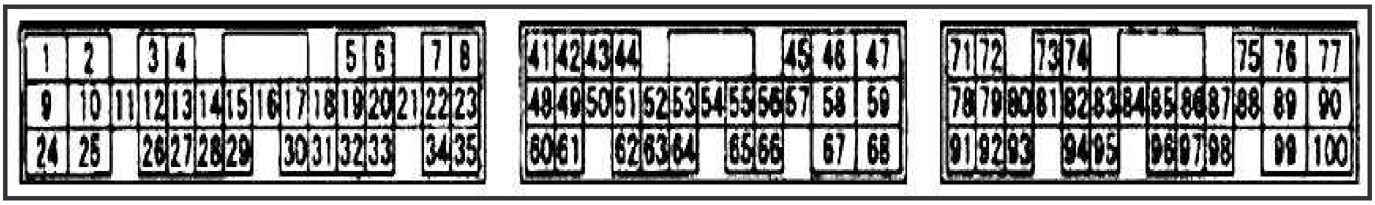
Figure 147: ECU WIRE SIDE VIEW, Evo4 to Evo8



NOTE: Some later model Evo8 have the same 3 x 3 connector arrangement as the Evo9.

A3.6: EVO 9 ECU PIN CONFIGURATION

Figure 148: ECU WIRE SIDE VIEW, Evo9



NOTE 01: ANALOLG SENSOR GROUND on pin 49 is the ground return for the TPS, ENG-TEMP, AIR-TEMP, MAP and O2 sensors. The MAF return is on pin 34, with the CAS signal ground returns.

NOTE 02: Some known variations to EVO 9 pin-out designations:

Table 13 Evo 9 ECU PIN VARIATIONS

ECU PIN #	JDM MODEL	USDM MODEL	AUDM MODEL
5	Secondary Air solenoid	Unused	NOTE 03
6	Wastegate #2 solenoid	EGR solenoid	
26	unused	Rear O2 sensor heater	
35	unused	Evap. Vent solenoid	
56	ICS relay	Unused	
66	ICS Auto switch	Unused	
67	ICS Manual switch	Unused	
72	?	?	Rear O2 sensor
73	unused	Rear O2 sensor	
88	?	Clutch Peddle switch	
90	ICS dash-cluster light	Unused	
92	MAP sensor, 3 bar	MAP sensor, 1 bar	NOTE 04
93	Unused	Fuel Tank pressure	
95	Unused	Fuel Level main	
96	MAT sensor	Fuel Tank temp.	
97	Unused	Fuel Level sub.	

NOTE 03: The ALS code and tables required to drive the SAS solenoid is implemented in the AUDM Evo9, but the piping, SAS valve and reservoir are not fitted.

NOTE 04: The MAP sensor is not fitted to the AUDM Evo9, but the pin is an ADC input and can be logged.

APPENDIX 5: MISCELLANEOUS EVO ROM FILE 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 14 MISC EVO ROM FILE IDENTIFIER

YEAR	MARKETS	VERSION	ROM	NOTES - COMMENTS
2001	JDM	EVO 7	93390000	
2001	JDM	EVO 7 RA	92460000	
2001	JDM	EVO 7	99860002	
2001	EDM	EVO 7 RA	90550001	T5,L300
2001	JDM	EVO 7	98640014	
2002	JDM	EVO 7 GTA	80700010	
2003	EDM	EVO 7 RA	98650012	
2004	JDM	EVO 8	93660005	
2004	USDM	EVO 8	94170008	
2004	USDM	EVO 8	94170014	
2004	USDM	EVO 8	94170015	T5
2004	JDM	EVO 8	96260009	T5
2004	USDM	EVO 8	96420007	
2004	USDM	EVO 8	96420008	
2004	USDM	EVO 8	96420011	
2004		EVO 8 RA	97250001	
2004	EDM	EVO 8	99270000	
2005	EDM	EVO 8	96940011	
2005	EDM	EVO 8	96530006	T5
2005	EDM+USDM	EVO 9	88840013	
2005	AUDM+SA	EVO 9	88580013	
2005	JDM	EVO 9	88570008	T5
2006	JDM	EVO 9	89280002	
2006	USDM	EVO 9	88590013	
2006	USDM	EVO 9	88590014	
2006	USDM	EVO 9	88590015	T5,T6
2006	USDM+MEX+EDM	EVO 9 MR	88840016	
2006	AUDM	EVO 9	88580014	T5
2006	EDM	EVO 9	88840017	T6
2006	JDM	EVO 9	89960000	
			98650014	
			98640016	
			96420011	T5

NOTES LEDGEND
L300 = 300% load scaling standard. Otherwise 260% load scaling.
B2 = 2 boost control valves. Otherwise only 1 boost control valve.
T5 = **tephra** V5.1 variant available, T6 = **tephra** V6.0 variant available.
M1 = 1 bar map sensor, M3 = 3 bar map sensor, otherwise no map sensor.

APPENDIX 6: 2-BYTE LOGGING & MUT TABLE SETUP

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

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.

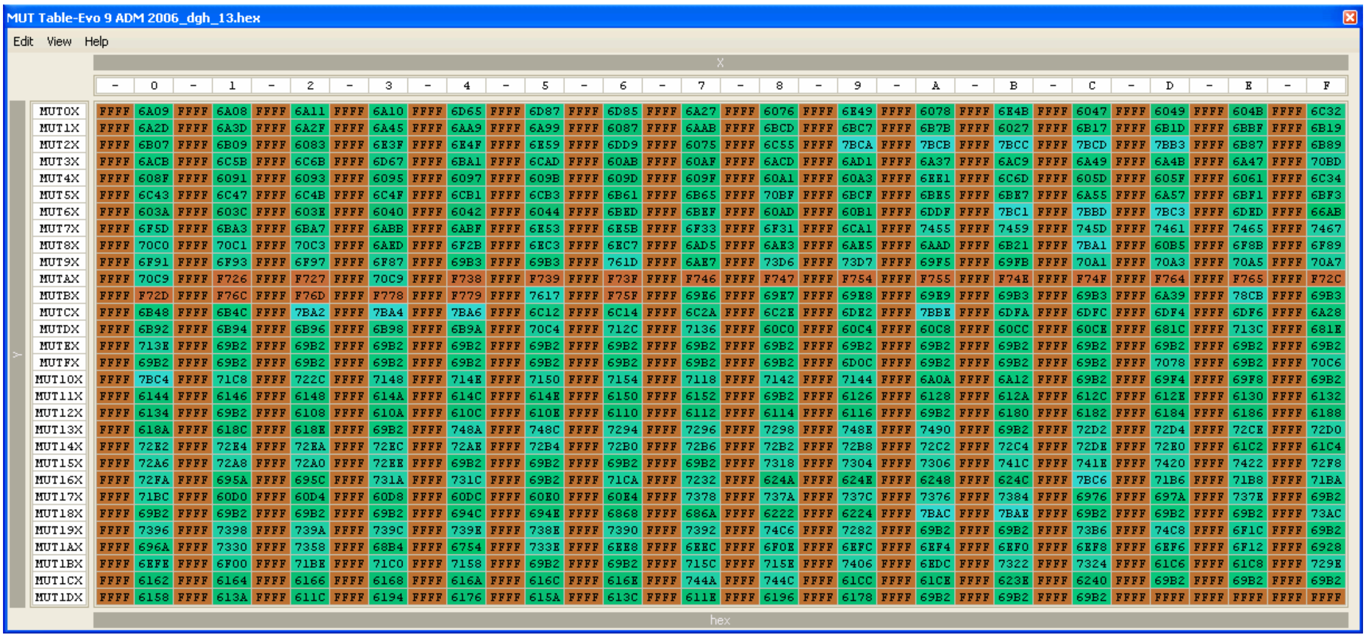
EvoScan is already setup to log the following 2-byte data:

LOAD at MUT 00 and MUT 01.

RPM at MUT 02 and MUT 03.

AIRFLOW at MUT 04 and MUT 05.

Figure 149: MUT TABLE, EVO9



	-	0	-	1	-	2	-	3	-	4	-	5	-	6	-	7	-	8	-	9	-	A	-	B	-	C	-	D	-	E	-	F
MUT0X	FFFF	6A09	FFFF	6A08	FFFF	6A11	FFFF	6A10	FFFF	6D65	FFFF	6D87	FFFF	6D85	FFFF	6A27	FFFF	6076	FFFF	6E49	FFFF	6078	FFFF	6E4B	FFFF	6047	FFFF	6049	FFFF	604B	FFFF	6C32
MUT1X	FFFF	6A2D	FFFF	6A3D	FFFF	6A2F	FFFF	6A45	FFFF	6AA9	FFFF	6A99	FFFF	6087	FFFF	6AAB	FFFF	6BCD	FFFF	6BC7	FFFF	6B7B	FFFF	6027	FFFF	6B17	FFFF	6B1D	FFFF	6BBF	FFFF	6B19
MUT2X	FFFF	6B07	FFFF	6B09	FFFF	6083	FFFF	6E3F	FFFF	6E4F	FFFF	6E59	FFFF	6DD9	FFFF	6075	FFFF	6C55	FFFF	7BCA	FFFF	7BCB	FFFF	7BCC	FFFF	7BCD	FFFF	7BB3	FFFF	6B87	FFFF	6B89
MUT3X	FFFF	6ACB	FFFF	6C5B	FFFF	6C6B	FFFF	6D67	FFFF	6BA1	FFFF	6CAD	FFFF	60AB	FFFF	60AF	FFFF	6ACD	FFFF	6AD1	FFFF	6A37	FFFF	6AC9	FFFF	6A49	FFFF	6A4B	FFFF	6A47	FFFF	70BD
MUT4X	FFFF	608F	FFFF	6091	FFFF	6093	FFFF	6095	FFFF	6097	FFFF	609B	FFFF	609D	FFFF	609F	FFFF	60A1	FFFF	60A3	FFFF	6EE1	FFFF	6C6D	FFFF	605D	FFFF	605F	FFFF	6061	FFFF	6C34
MUT5X	FFFF	6C43	FFFF	6C47	FFFF	6C4B	FFFF	6C4F	FFFF	6CB1	FFFF	6CB3	FFFF	6B61	FFFF	6B65	FFFF	70BF	FFFF	6BCF	FFFF	6BE5	FFFF	6BE7	FFFF	6A55	FFFF	6A57	FFFF	6BF1	FFFF	6BF3
MUT6X	FFFF	603A	FFFF	603C	FFFF	603E	FFFF	6040	FFFF	6042	FFFF	6044	FFFF	6BED	FFFF	6BEF	FFFF	60AD	FFFF	60B1	FFFF	6DDF	FFFF	7BC1	FFFF	7BBD	FFFF	7BC3	FFFF	6DED	FFFF	66AB
MUT7X	FFFF	6F5D	FFFF	6BA3	FFFF	6BA7	FFFF	6ABB	FFFF	6ABF	FFFF	6E53	FFFF	6E5B	FFFF	6F33	FFFF	6F31	FFFF	6CA1	FFFF	7455	FFFF	7459	FFFF	745D	FFFF	7461	FFFF	7465	FFFF	7467
MUT8X	FFFF	70C0	FFFF	70C1	FFFF	70C3	FFFF	6AED	FFFF	6F2B	FFFF	6EC3	FFFF	6EC7	FFFF	6AD5	FFFF	6AE3	FFFF	6AE5	FFFF	6AAD	FFFF	6B21	FFFF	7BA1	FFFF	60B5	FFFF	6F8B	FFFF	6F89
MUT9X	FFFF	6F91	FFFF	6F93	FFFF	6F97	FFFF	6F87	FFFF	69B3	FFFF	69B3	FFFF	761D	FFFF	6AE7	FFFF	73D6	FFFF	73D7	FFFF	69F5	FFFF	69FB	FFFF	70A1	FFFF	70A3	FFFF	70A5	FFFF	70A7
MUTAX	FFFF	70C9	FFFF	F726	FFFF	F727	FFFF	70C9	FFFF	F738	FFFF	F739	FFFF	F73F	FFFF	F746	FFFF	F747	FFFF	F754	FFFF	F755	FFFF	F74E	FFFF	F74F	FFFF	F764	FFFF	F765	FFFF	F72C
MUTBX	FFFF	F72D	FFFF	F76C	FFFF	F76D	FFFF	F778	FFFF	F779	FFFF	7617	FFFF	F75F	FFFF	69E6	FFFF	69E7	FFFF	69E8	FFFF	69E9	FFFF	69B3	FFFF	69B3	FFFF	6A39	FFFF	78CB	FFFF	69B3
MUTCX	FFFF	6B48	FFFF	6B4C	FFFF	7BA2	FFFF	7BA4	FFFF	7BA6	FFFF	6C12	FFFF	6C14	FFFF	6C2A	FFFF	6C2E	FFFF	6DE2	FFFF	7BBE	FFFF	6DFA	FFFF	6DFC	FFFF	6DF4	FFFF	6DF6	FFFF	6A28
MUTDX	FFFF	6B92	FFFF	6B94	FFFF	6B96	FFFF	6B98	FFFF	6B9A	FFFF	70C4	FFFF	712C	FFFF	7136	FFFF	60C0	FFFF	60C4	FFFF	60C8	FFFF	60CC	FFFF	60CE	FFFF	681C	FFFF	713C	FFFF	681E
MUTEX	FFFF	713E	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	69B2
MUTFX	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	6D0C	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	7078	FFFF	69B2	FFFF	70C6
MUT10X	FFFF	7BC4	FFFF	71C8	FFFF	722C	FFFF	7148	FFFF	714E	FFFF	7150	FFFF	7154	FFFF	7118	FFFF	7142	FFFF	7144	FFFF	6A0A	FFFF	6A12	FFFF	69B2	FFFF	69F4	FFFF	69F8	FFFF	69B2
MUT11X	FFFF	6144	FFFF	6146	FFFF	6148	FFFF	614A	FFFF	614C	FFFF	614E	FFFF	6150	FFFF	6152	FFFF	69B2	FFFF	6126	FFFF	6128	FFFF	612A	FFFF	612C	FFFF	612E	FFFF	6130	FFFF	6132
MUT12X	FFFF	6134	FFFF	69B2	FFFF	6108	FFFF	610A	FFFF	610C	FFFF	610E	FFFF	6110	FFFF	6112	FFFF	6114	FFFF	6116	FFFF	69B2	FFFF	6180	FFFF	6182	FFFF	6184	FFFF	6186	FFFF	6188
MUT13X	FFFF	618A	FFFF	618C	FFFF	618E	FFFF	69B2	FFFF	748A	FFFF	748C	FFFF	7294	FFFF	7296	FFFF	7298	FFFF	748E	FFFF	7490	FFFF	69B2	FFFF	72D2	FFFF	72D4	FFFF	72CE	FFFF	72D0
MUT14X	FFFF	72E2	FFFF	72E4	FFFF	72EA	FFFF	72EC	FFFF	72AE	FFFF	72B4	FFFF	72B0	FFFF	72B6	FFFF	72B2	FFFF	72B8	FFFF	72C2	FFFF	72C4	FFFF	72DE	FFFF	72E0	FFFF	61C2	FFFF	61C4
MUT15X	FFFF	72A6	FFFF	72A8	FFFF	72A0	FFFF	72EE	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	7318	FFFF	7304	FFFF	7306	FFFF	741C	FFFF	741E	FFFF	7420	FFFF	7422	FFFF	72F8
MUT16X	FFFF	72FA	FFFF	695A	FFFF	695C	FFFF	731A	FFFF	731C	FFFF	69B2	FFFF	71CA	FFFF	7232	FFFF	624A	FFFF	624E	FFFF	6248	FFFF	624C	FFFF	7BC6	FFFF	71B6	FFFF	71B8	FFFF	71BA
MUT17X	FFFF	71BC	FFFF	60D0	FFFF	60D4	FFFF	60D8	FFFF	60DC	FFFF	60E0	FFFF	60E4	FFFF	7378	FFFF	737A	FFFF	737C	FFFF	7376	FFFF	7384	FFFF	6976	FFFF	697A	FFFF	737E	FFFF	69B2
MUT18X	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	694C	FFFF	694E	FFFF	6868	FFFF	686A	FFFF	6222	FFFF	6224	FFFF	7BAC	FFFF	7BAE	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	73AC
MUT19X	FFFF	7396	FFFF	7398	FFFF	739A	FFFF	739C	FFFF	739E	FFFF	738E	FFFF	7390	FFFF	7392	FFFF	74C6	FFFF	7282	FFFF	69B2	FFFF	69B2	FFFF	73B6	FFFF	74C8	FFFF	6F1C	FFFF	69B2
MUT1AX	FFFF	696A	FFFF	7330	FFFF	7358	FFFF	68B4	FFFF	6754	FFFF	733E	FFFF	6EE8	FFFF	6EEC	FFFF	6F0E	FFFF	6EFC	FFFF	6EF4	FFFF	6EF0	FFFF	6EF8	FFFF	6EF6	FFFF	6F12	FFFF	6928
MUT1BX	FFFF	6EFE	FFFF	6F00	FFFF	71BE	FFFF	71C0	FFFF	7158	FFFF	69B2	FFFF	69B2	FFFF	715C	FFFF	715E	FFFF	7406	FFFF	6EDC	FFFF	7322	FFFF	7324	FFFF	61C6	FFFF	61C8	FFFF	729E
MUT1CX	FFFF	6162	FFFF	6164	FFFF	6166	FFFF	6168	FFFF	616A	FFFF	616C	FFFF	616E	FFFF	744A	FFFF	744C	FFFF	61CC	FFFF	61CE	FFFF	623E	FFFF	6240	FFFF	69B2	FFFF	69B2	FFFF	69B2
MUT1DX	FFFF	6158	FFFF	613A	FFFF	611C	FFFF	6194	FFFF	6176	FFFF	615A	FFFF	613C	FFFF	611E	FFFF	6196	FFFF	6178	FFFF	69B2	FFFF	69B2	FFFF	69B2	FFFF	FFFF	FFFF	FFFF	FFFF	FFFF

Table 15 2-BYTE LOAD & RPM MUT ADDRESS – EVO ROMS

88570008 2byte load MUT 00 = 6B12 MUT 01 = 6B13 2byte RPM MUT 02 = 6AFE MUT 03 = 6AFF 2byte AirFlow* MUT 04 = 6B6A MUT 05 = 6B6B MUT 3D TABLE ADDRESS = 35920	88580013 AU IX GSR 88580014 AU IX GSR 2byte load MUT 00 = 6B22 MUT 01 = 6B23 2byte RPM MUT 02 = 6AFE MUT 03 = 6AFF 2byte AirFlow MUT 04 = 6B7E MUT 05 = 6B7F MUT 3D TABLE ADDRESS = 373C4	88580015 2byte load MUT 00 = 6B22 MUT 01 = 6B23 2byte RPM MUT 02 = 6AFE MUT 03 = 6AFF 2byte AirFlow MUT 04 = 6B7E MUT 05 = 6B7F MUT 3D TABLE ADDRESS = 374DC	88590013 US IX 88590014 US IX 88590015 US IX 2byte load MUT 00 = 6B42 MUT 01 = 6B43 2byte RPM MUT 02 = 6B1E MUT 03 = 6B1F 2byte AirFlow MUT 04 = 6B9E MUT 05 = 6B9F MUT 3D TABLE ADDRESS = 3EE84	
	88840013 2byte load MUT 00 = MUT 01 = 2byte RPM MUT 02 = MUT 03 = 2byte AirFlow MUT 04 = MUT 05 = MUT 3D TABLE ADDRESS =	88840016 2byte load MUT 00 = 6B22 MUT 01 = 6B23 2byte RPM MUT 02 = 6AFE MUT 03 = 6AFF 2byte AirFlow MUT 04 = 6B7E MUT 05 =6B7F MUT 3D TABLE ADDRESS = 377F8	88840017 2byte load MUT 00 = 6B22 MUT 01 = 6B23 2byte RPM MUT 02 = 6AFE MUT 03 = 6AFF 2byte AirFlow MUT 04 = 6B7E MUT 05 =6B7F MUT 3D TABLE ADDRESS = 37944	**90550001 EU VII** 2byte load MUT 00 = 885C MUT 01 = 885D 2byte RPM MUT 02 = 883A MUT 03 = 883B 2byte AirFlow MUT 04 = MUT 05 = MUT 3D TABLE ADDRESS = 2e9e0
92460000 2byte load MUT 00 = MUT 01 = 2byte RPM MUT 02 = MUT 03 = 2byte AirFlow MUT 04 = MUT 05 = MUT 3D TABLE ADDRESS =	93660005 2byte load MUT 00 = 8960 MUT 01 = 8961 2byte RPM MUT 02 = 893E MUT 03 = 893F 2byte AirFlow MUT 04 = MUT 05 = MUT 3D TABLE ADDRESS = 33400	94170008 2003 US 8 2byte load MUT 00 = 895C MUT 01 = 895D 2byte RPM MUT 02 = 893A MUT 03 = 893B 2byte AirFlow MUT 04 = 89BA MUT 05 = 89BB MUT 3D TABLE ADDRESS = 38060	94170014 2004 US 8 94170015 2004 US 8 2byte load MUT 00 = 895C MUT 01 = 895D 2byte RPM MUT 02 = 893A MUT 03 = 893B 2byte AirFlow MUT 04 = 89BA MUT 05 = 89BB MUT 3D TABLE ADDRESS = 38158	
	96420007 2004 US 8 96420008 2004 US 8 2byte load MUT 00 = 8984 MUT 01 = 8985 2byte RPM MUT 02 = 8962 MUT 03 = 8963 2byte AirFlow MUT 04 = 89E2 MUT 05 = 89E3 MUT 3D TABLE ADDRESS = 39FA0	96420011 2byte load MUT 00 = MUT 01 = 2byte RPM MUT 02 = MUT 03 = 2byte AirFlow MUT 04 = MUT 05 = MUT 3D TABLE ADDRESS =	96530006 2004 EU 8 2byte load MUT 00 = 898A MUT 01 = 898B 2byte RPM MUT 02 = 8962 MUT 03 = 8963 2byte AirFlow MUT 04 = 89E2 MUT 05 = 89E3 MUT 3D TABLE ADDRESS = 36200	96940011 2005 US 8 2byte load MUT 00 = 899A MUT 01 = 899B 2byte RPM MUT 02 = 8976 MUT 03 = 8977 2byte AirFlow MUT 04 = 89F6 MUT 05 = 89F7 MUT 3D TABLE ADDRESS = 3F314
98640014 J-VII GSR 2byte load MUT 00 = 885C MUT 01 = 885D 2byte RPM * MUT 02 = 883A MUT 03 = 883B 2byte AirFlow MUT 04 = MUT 05 = MUT 3D TABLE ADDRESS = 2E9E0	98640016 2byte load MUT 00 = MUT 01 = 2byte RPM MUT 02 = MUT 03 = 2byte AirFlow MUT 04 = MUT 05 = MUT 3D TABLE ADDRESS = 2EA9C	98650014 2byte load MUT 00 = MUT 01 = 2byte RPM MUT 02 = MUT 03 = 2byte AirFlow MUT 04 = MUT 05 = MUT 3D TABLE ADDRESS =	99270000 2byte load MUT 00 = MUT 01 = 2byte RPM MUT 02 = MUT 03 = 2byte AirFlow MUT 04 = MUT 05 = MUT 3D TABLE ADDRESS =	99860002 2byte load MUT 00 = MUT 01 = 2byte RPM MUT 02 = MUT 03 = 2byte AirFlow MUT 04 = MUT 05 = MUT 3D TABLE ADDRESS = 302D8

APPENDIX 7: INTAKE HARDPIPES & IDLE CONTROL ISSUES

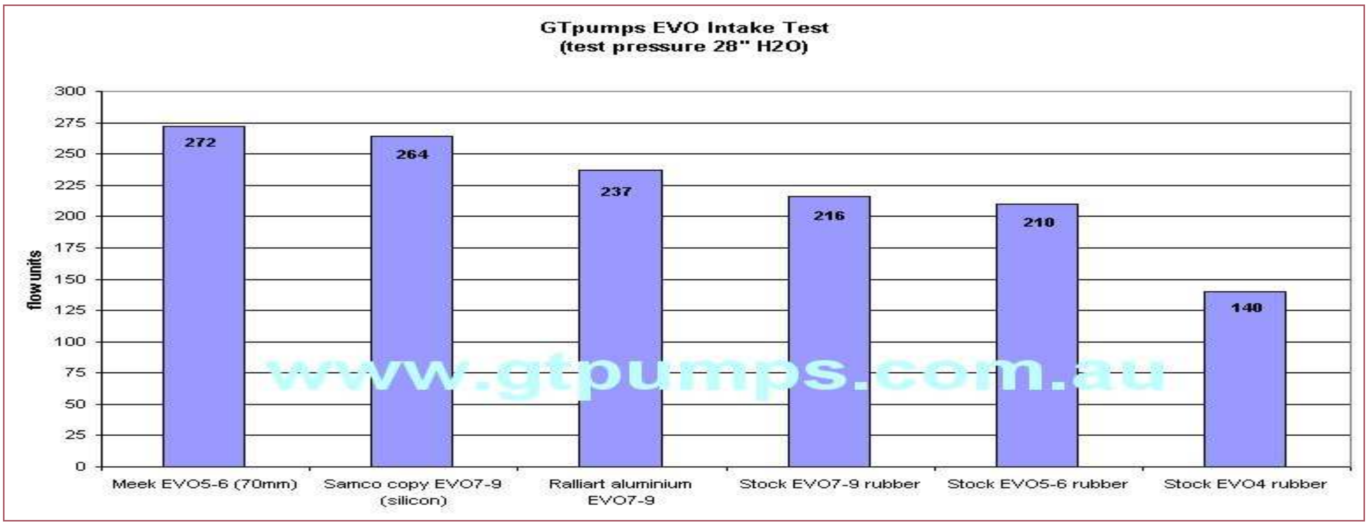
Many people report having idle control issues after installing a “hard” suction pipe between the MAF and the turbo inlet. The problems are exacerbated with the addition of big cams. These problems are usually rough and unsteady idle, cutting out at idle or cutting out when coming to a stop. Another problem is an inability to correctly scale new/larger injectors. In an attempt to get some stability, tuners have raised the idle target speed, but this can cause other problems.

One related issue is when the MAF (at idle) gives a airflow signal of 52Hz or higher. When this happens, the LONG TERM FUEL TRIM LOW will not operate. What you should do, before installing the new hard-pipe, is to use EvoScan to check what your idle airflow Hz signal is doing. Stock units will typically run between 25-35 Hz when warmed-up. Check it again after installing the new hard-pipe. If it is erratic, or over 52Hz, you can expect to have some problems.

Not all up-graded or hot-rodded intake pipes cause problems. I have a PLAZMAMAN silicon unit on my Evo9, which gives the same idle airflow Hz figures as the stock convoluted rubber item. This silicon unit and the stock rubber unit, probably work satisfactorily due to a lack of self-resonance (low Q) in the pipe. Aluminium intake pipes, by their very nature, will have a higher Q at self resonance. Some problem hard-pipes have been cured by the addition of a silicon coupling from the MAF to the pipe.

Not surprisingly, not all intake pipes flow the same rate for a given pressure drop.
A number of units were flow-bench tested at GT PUMPS (Sydney Australia) with some interesting results. The graph below shows the results.

Figure 150: GT-PUMPS EVO INTAKE PIPE TEST RESULTS



Keep in mind that altering the MAF scaling is more a fix for fuel trim issues, though it may be of some benefit when using a hard-pipe.

APPENDIX 8: OBDII CONNECTOR & CLEARINGFAULT CODES

A8.1-OBD-II CODE 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:

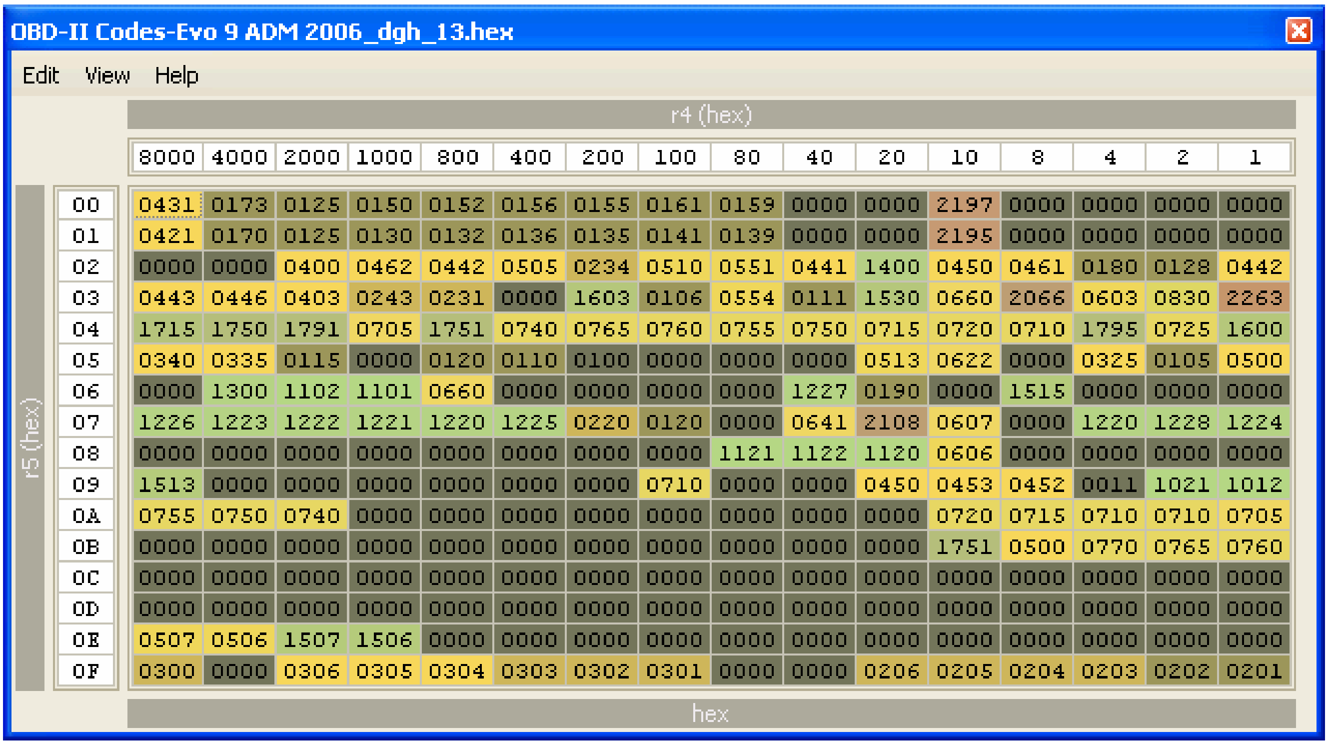
P = Power-train
C = Chassis
B = Body
U = Network Communication

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.

A8.2-MITSUBISHI ECU SELF-DIAGNOSTICS & FAULT CODES

Self-diagnosis of faults can be performed by indications from the CHECK ENGINE LAMP in the dash combination meter, or by displaying data on a laptop PC screen using suitable software with adapter cable. PC software is available on the web and includes the following: EvoScan, MITSULOGGER. Shown below are the fault codes the ECU can flag.

Figure 151: OBD-II CODES, Evo9

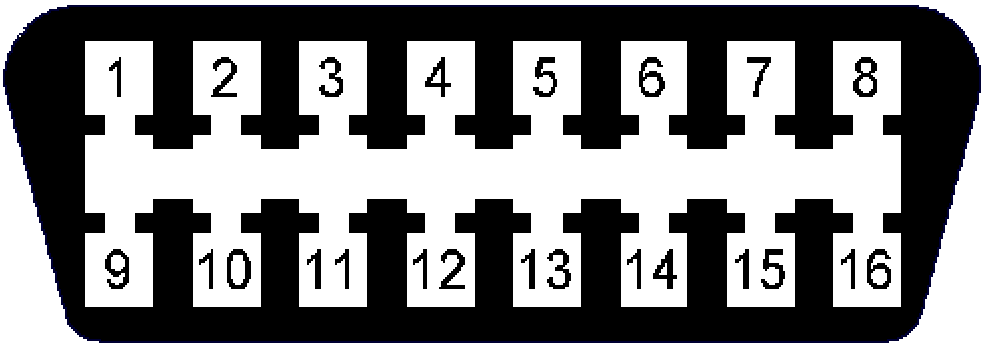


	8000	4000	2000	1000	800	400	200	100	80	40	20	10	8	4	2	1
00	0431	0173	0125	0150	0152	0156	0155	0161	0159	0000	0000	2197	0000	0000	0000	0000
01	0421	0170	0125	0130	0132	0136	0135	0141	0139	0000	0000	2195	0000	0000	0000	0000
02	0000	0000	0400	0462	0442	0505	0234	0510	0551	0441	1400	0450	0461	0180	0128	0442
03	0443	0446	0403	0243	0231	0000	1603	0106	0554	0111	1530	0660	2066	0603	0830	2263
04	1715	1750	1791	0705	1751	0740	0765	0760	0755	0750	0715	0720	0710	1795	0725	1600
05	0340	0335	0115	0000	0120	0110	0100	0000	0000	0000	0513	0622	0000	0325	0105	0500
06	0000	1300	1102	1101	0660	0000	0000	0000	0000	1227	0190	0000	1515	0000	0000	0000
07	1226	1223	1222	1221	1220	1225	0220	0120	0000	0641	2108	0607	0000	1220	1228	1224
08	0000	0000	0000	0000	0000	0000	0000	0000	1121	1122	1120	0606	0000	0000	0000	0000
09	1513	0000	0000	0000	0000	0000	0000	0710	0000	0000	0450	0453	0452	0011	1021	1012
0A	0755	0750	0740	0000	0000	0000	0000	0000	0000	0000	0000	0720	0715	0710	0710	0705
0B	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	1751	0500	0770	0765	0760
0C	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
0D	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
0E	0507	0506	1507	1506	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	0000
0F	0300	0000	0306	0305	0304	0303	0302	0301	0000	0000	0206	0205	0204	0203	0202	0201

A8.3-OBD-II DIAGNOSTIC CONNECTOR

The connectors are behind the dash facia, drivers side, adjacent to the centre tunnel. On an EVO9, just feel with your hand and plug the connectors into their receptacles. There is a latch on the white connector, requiring depression on removal.

Figure 152: OBD-II CONNECTOR – PIN SIDE VIEW



The OBD-II specification provides for a standardized hardware interface—the female 16-pin (2x8) J1962 connector. The OBD-II connector is nearly always located on the driver's side of the passenger compartment near the center console. SAE J1962 defines the pin-out of the connector as:

Table 16 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
ECU	1	9	ETACS

A8.4-CLEARING A FAULT CODE with EvoScan

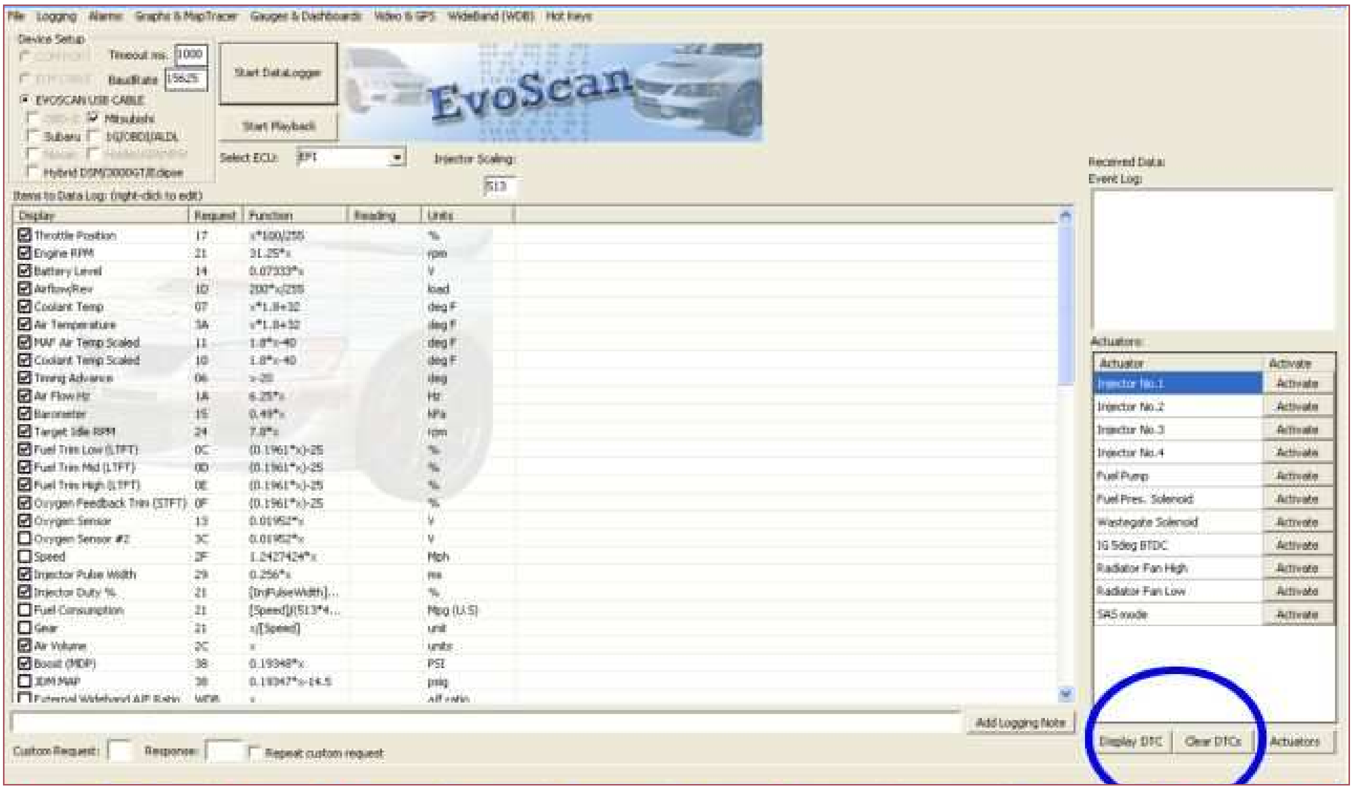
Follow the following procedure to clear a CEL fault code.

Open EvoScan, connect the TACTRIX cable to the OBD-II connector only and switch on the ignition.

Click Display DTC and then Clear DTC. See the bottom right-hand of the display.

Turn of the ignition and disconnect the cable from the OBD-II port, the faults are cleared. Or at least the current flags are cleared. If there is still a fault with the system, it will get flagged the next time the engine is run.

Figure 153: EvoScan - CLEARING FAULT CODES



Timeout ms: 1000

BaudRate 15625

● EVOSCAN USB CABLE

☑ Mitsubishi

☐ Subaru ☐ 16/OBD1/ALDL

☐ Hybrid DSM/3000GT/Eclipse

Select ECU: EP1

Injector Scaling: 513

Items to Data Log: (right-click to edit)

Display	Request	Function	Reading	Units
☑ Throttle Position	17	x*100/255		%
☑ Engine RPM	21	31.25*x		rpm
☑ Battery Level	14	0.07333*x		V
☑ AirflowRev	1D	200*x/255		load
☑ Coolant Temp	07	x*1.8+32		deg F
☑ Air Temperature	3A	x*1.8+32		deg F
☑ MAF Air Temp Scaled	11	1.8*x-40		deg F
☑ Coolant Temp Scaled	10	1.8*x-40		deg F
☑ Timing Advance	06	x-20		deg
☑ Air Flow Hz	1A	6.25*x		Hz
☑ Barometer	15	0.49*x		kPa
☑ Target Idle RPM	24	7.8*x		rpm
☑ Fuel Trim Low (LTFT)	0C	(0.1961*x)-25		%
☑ Fuel Trim Mid (LTFT)	0D	(0.1961*x)-25		%
☑ Fuel Trim High (LTFT)	0E	(0.1961*x)-25		%
☑ Oxygen Feedback Trim (STFT)	0F	(0.1961*x)-25		%
☑ Oxygen Sensor	13	0.01952*x		V
☐ Oxygen Sensor #2	3C	0.01952*x		V
☐ Speed	2F	1.2427424*x		Mph
☑ Injector Pulse Width	29	0.256*x		ms
☑ Injector Duty %	21	[InjPulseWidth]...		%
☐ Fuel Consumption	21	[Speed]/(513*4...		Mpg (U.S)
☐ Gear	21	x/[Speed]		unit
☑ Air Volume	2C	x		units
☑ Boost (MDP)	38	0.19348*x		PSI
☐ JDM MAP	38	0.19347*x-14.5		psig
☐ External Wideband AF Ratio	WDB	x		AF ratio

Custom Request: Response: ☐ Repeat custom request

Actuator	Activate
Injector No.1	Activate
Injector No.2	Activate
Injector No.3	Activate
Injector No.4	Activate
Fuel Pump	Activate
Fuel Pres. Solenoid	Activate
Wastegate Solenoid	Activate
IG 5deg BTDC	Activate
Radiator Fan High	Activate
Radiator Fan Low	Activate
SAS mode	Activate

A8.5-CLEARING A FAULT CODE without EvoScan

A CEL can also be cleared on the Evo9 by re-flashing the ECU. You still need the OBD-II cable but don't have to have EvoSCAN.

With the Evo7-8, re-flashing may not work. In this case, the battery will have to be disconnected from the ECU for approximately 10 seconds. Clunky, but it works.

APPENDIX 9: OBD-II POWERTRAIN FAULT CODES

A9.1-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)

A9.2-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

A9.3-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

A9.4-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

A9.5-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)

A9.6-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

A9.7-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)

A9.8-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