

JDSPorsche SharkTuner for the Porsche 928 Type 4.XX
For LH2.2 MY85/86 US (early 32v) & MY85/86 (Euro 16v) & EZ-F
MY85/86 US & MY84/86 Euro. (Also covers MY87-95 LH2.3 and EZK)

IMPORTANT NOTICE !!

Any changes you make to engine components and its electronic management system may result in non optimum operation, and in extreme cases this could cause engine damage. In the following text we have described procedures which should prevent any such situation arising during analysis and remapping. However we stress that any use of the SharkTuner is at your risk entirely. The SharkTuner is intended for use by people with a good general knowledge of the principles of engine management systems. If in doubt on any issue, always take expert advice. If you believe we can improve the product, we welcome your constructive comments.

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INTRODUCTION AND OVERVIEW

This section of the SharkTuner User Manual should be read in conjunction with the main LH2.3 SharkTuner User Manual, Issue 10.

This is a modified version of the standard SharkTuner for LH/EZK 2.3 (MY 87-95). The modification includes an additional auxiliary input circuit board and new software.

When these updates are installed the same hardware and software will cover both LH/EZ-F (US and Euro MY85/86) fuel injection and ignition ECUs, and LH/EZK (S4/GT/GTS of MY87-95). In addition the auxiliary data board also allows display and data logging of 3 programmable data inputs with the LH2.3, 2 inputs with the LH2.2 and 1 input with EZ-F.

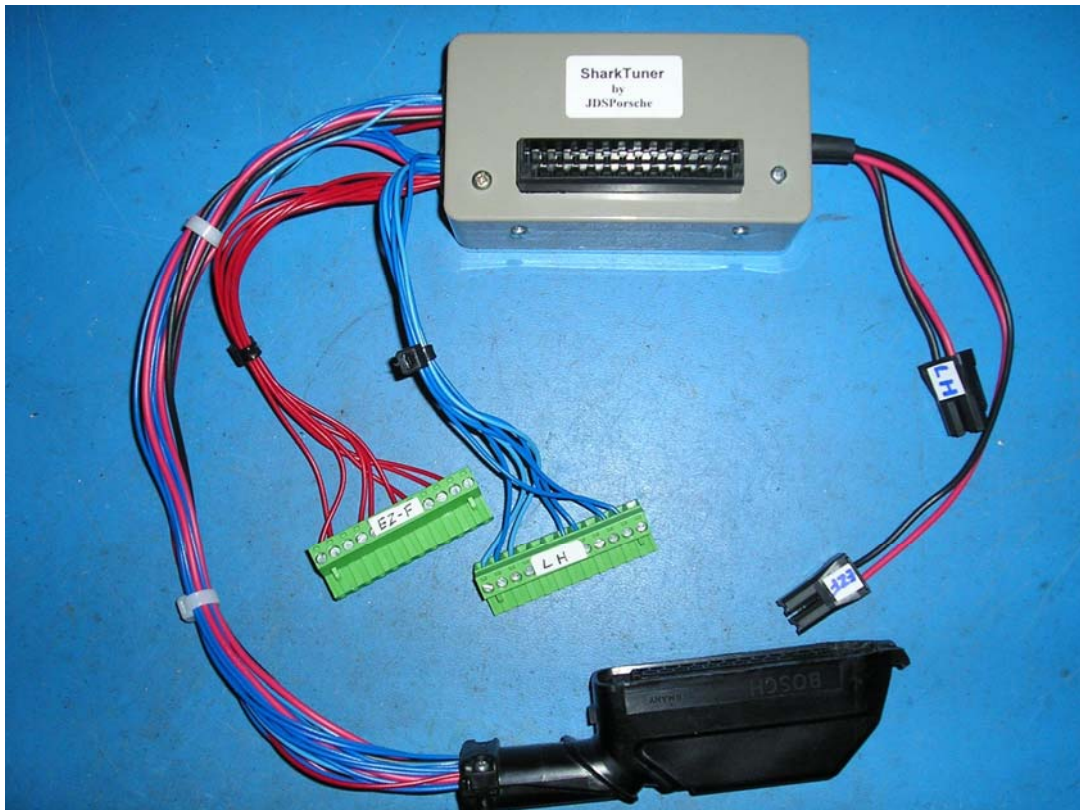
It will monitor, data log and remap the early 32 valve Porsche 928 (MY 1985/6) which use LH ECUs 928.618.123.03/04 & /05. and EZ-F ECU 928.618.124.05

It also is used with the Euro 16v LH for MY 85/86 which use 928.618.123.02. But **NOT** the LH fitted to MY 84 Euro 928.618.123.00.

This version of the SharkTuner will also remap all versions of the EZ-F ignition ECU fitted to Euro 16v 84-86 type 928.618.124.00 /03 & /CX

The LH2.2 and EZ-F ECUs do not support diagnostics, and so the signal lines and power lines from the diagnostic socket on the >MY87 cars are not available in the early cars. To use the LH2.2 SharkTuner it is necessary to make connection to the required signals in the main cableform of the car. Alternatively a “break out box “ can be constructed to allow “plugs and play” connection.

This plugs in between the cars cableform and the LH ECU, and splits out the required signals to the auxiliary board in the SharkTuner.



Many of the features of the LH2.3 SharkTuner are also available within the LH/EZ-F 2.2 version. These include real time operating point marker on the various fuel maps; real time data logging; full editing of fuel maps as you drive; and Autotuning of fuel/air mixture.

The SharkTuner allows the operator to make changes to the software of the LH or EZ-F ECU by modifying a special EPROM binary file provided with the SharkTuner. The standard EPROM is unplugged from the ECU, and the SharkTuner data lead plugged into the socket.

When any changes to the EPROM data have been finalised, these changes are saved, and this new data file is programmed into a new EPROM, using a low cost EPROM programmer. This modified EPROM is then fitted to the car's ECU, which then can be refitted to the car

WHAT YOU WILL NEED TO USE THE SHARKTUNER:

- 1) A wideband oxygen sensor and associated electronics for LH remapping.
- 2) A laptop computer running Windows 98SE/2000/XP, with a serial port (9 pin "D" connector) and also running Microsoft Excel spreadsheet. If a serial port is not available, an RS-232 to USB adapter can be used. Also, in many laptops the laptop itself does not have a serial port but the docking station for the laptop has one.
- 3) An EPROM reader/writer see <http://www.ustr.net/epromer5/index.shtml> or <http://www.futurlec.com/EPROMProg.shtml>. These devices require a parallel (printer) port. Programmers using a USB port are now becoming available http://www.mcumall.com/comersus/store/comersus_viewItem.asp?idProduct=3154
- 4) A supply of 2732A (200nS), 27C128 or 27C256 EPROMS 120nS in 28 pin DIL plastic package. You can use one time programmable or UV erasable devices. The 27C128 and 27C256 require the use of an adaptor board to fit them to the LH2.2. These adaptors are available from JDSPorsche.
- 5) A good general knowledge of the principles of engine management systems.
- 6) Be "computer literate"

PREPARATION FOR INSTALLATION

It is strongly recommended that you ensure that your 928 is in first class condition before any adjustments are made to the EPROM software.

Pre-tuning checks might include:

- 1) Compression and leak down test
- 2) MAF calibration check.
- 3) Dynamometer test, with monitoring of Air/fuel ratio.
- 4) Check inlet system for air leaks.

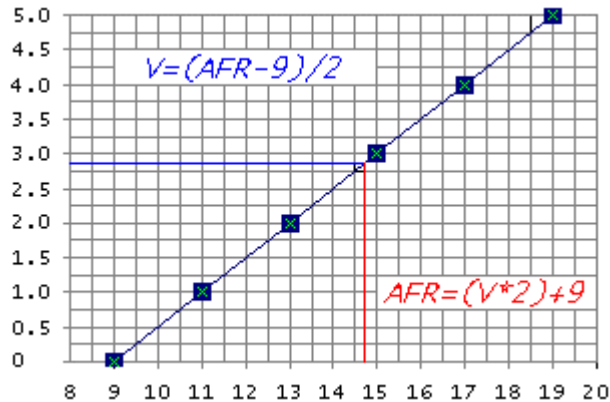
PREPARATION and INSTALLATION LH

- 1) Install a wideband O2 sensor if this has not been previously used. For a car already fitted with a standard O2 sensor and catalytic converter, the wideband sensor can screw in the same fitting to replace the existing standard narrow band sensor.
Refer to the LM1 or TechEdge handbook on the type of sensor required to suit your unit. The LM1 data will also describe the simulated narrow band output that is available from their units on Analog 1, which will require to be looped into the 3 pin O2 connector to replicate the standard narrow band sensor. **This is essential if your car normally has a narrow band O2 sensor and catalytic converters.**

Special leads for this are available to special order from JDSPorsche.

NOTE: Never run the engine without the wideband sensor being powered by the WBO2 electronics. Otherwise it will quickly become contaminated and unusable. See manufacturer's data sheets for the WBO2 units.

If you are using an LM1 or LC1 WBO2 unit, wire it to an ignition switched supply, fused as necessary. The use of the cigarette lighter socket for this is not recommended.



This is the graph of WBO2 law which is required to be fed into the WBO2 input of the SharkTuner. The horizontal axis is AF ratio; the vertical axis is the output voltage. This output is standard with the Tech Edge WBO2 units. 2A0, 2B0, 2C0 and 2E0 and is called WBLIN.

If you are using an LC-1 or LM1 WBO2 system, then program the “Analog out 2” port to the above law as this is the port wired into the SharkTuner via the 3mm jack lead provided.. See section 9.6 of the LM1 user manual.

The pre-programmed Analog 1 simulated narrow band sensor output must also be connected into your LH 3 pin O2 sensor plug if you are running closed loop. You will need to make a splitter lead for this, or JDSPorsche can supply this as an option.

Select “use air fuel ratio” and set “0.v at A/F ratio 9” also set “5.0v at A/F ratio 19” If you prefer to work in lambda then set “0v at lambda 0.61” also set “5.0v at lambda 1.29”

BEFORE fitting a new sensor to the exhaust, or with a brand new system, you MUST carry out a free air calibration of the WBO2 electronics. See the manufacturer’s data for instructions on this. It is recommended that you do this before proceeding further. When free air calibration is complete, fit the sensor to the exhaust system, and then make sure the sensor is ALWAYS powered whenever the engine is started.

Check that the three LEDs on the TechEdge unit are working as per the instructions on the TechEdge website.

For the LM1, check there are no error messages on the display. After free air WBO2 calibration is complete, proceed as follows.

The LH2.2 SharkTuner has a programmable WBO2 input law. This makes it possible to use with WBO2 systems that cannot be re-programmed to the same law as the TechEdge or Innovate unit. E.g. Zeitronix, PLX,

The WBO2 system used must NOT exceed 5v maximum on the WBO2 input on the SharkTuner.

- 2) Install the EPROM socket and ribbon cable to the LH ECU. **Disconnect the battery ground strap before starting this procedure!** The bolt (or wing nut) securing the strap to the car body is just under the front edge of the tool panel. After you have released the strap, put the end in a plastic bag or similar, to ensure it cannot touch any other metal part of the car.

You will need to extract both ECU's together on their cradle. Some people report it is easier to take out the passenger parcel shelf first. The units are located inside the passenger foot well at the side. Fold back the carpet, to expose the ECUs on their cradle. Remove the cover over the fuse and relay board.

Unplug the LH and EZK ECUs by releasing the small spring clip at the cable end of the connectors. Unbolt the cradle by unscrewing the four bolts (2 at the front edge of the plate, 2 at the rear). Remove the plate complete with ECUs.

- 3) Unbolt the LH ECU from the plate. The LH ECU is the larger of the two units and has a serial number in the series 928.618.123.XX. Carefully lever up the tabs securing the lid to the base plate of the LH ECU, and remove the lid, as indicated in the picture below. Try to unfold the tag along its length, rather than bend it at a single point. This will reduce the possibility of the tab fracturing. Remove the top cover.



- 4) Unscrew and remove the two screws and clip near the 25 way connector. Note that the screw on the right of this picture is a self tapping screw, the other a normal metric threaded screw...



- 5) On the base of the unit, unscrew and remove the two heatsink screws indicated in the picture.



- 6) At the back of the unit, unclip the three plastic clips shown below from the edge of the circuit board



- 7) Then by pushing gently on the 25 way connector at the front, and easing the circuit board up at the back, slide the circuit board out of the heatsink frame. Set the circuit board aside in a safe place.

Unscrew the screw indicated in the diagram below.



- 8) The cut off the end clip as shown below.....



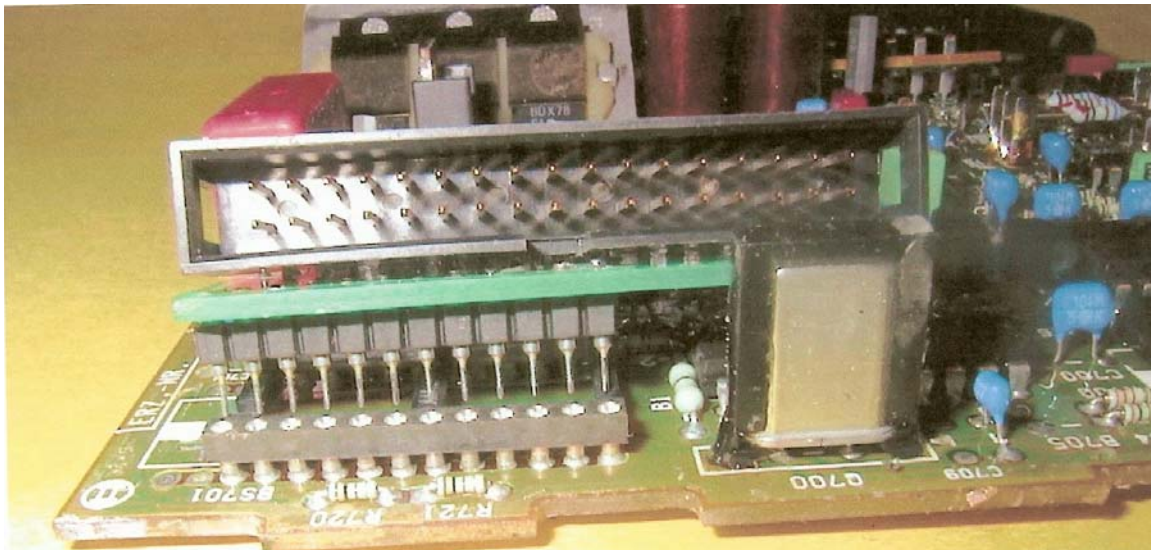
- 9) Carefully ease the EPROM out of its socket. Work from each end evenly. Make sure the screwdriver is inserted between the body of the socket and the EPROM, and not the socket and the circuit board...



- 10) Fit the ribbon cable adaptor to the EPROM socket as shown below. Make sure that the pins are located properly. (There should be no “spare pins” at either end!) Please note that the pins adaptor board are quite thin and can be damaged if care is not taken, especially when removing the adaptor board from the LH ECU. Do not pull the board unevenly from end to end or side to side, this will bend the pins which are then weakened. It is recommended that you unplug the ribbon cable before removing the adaptor board. Then use a large screwdriver to carefully ease the adaptor out of the EPROM socket, going from end to end to ensure as “straight” a pull as possible.



- 11) Some later versions of the LH2.2 board, produced towards the end of MY86 have a slightly different circuit board layout where the crystal is located slightly nearer the EPROM socket.



This prevents the ribbon cable adaptor from fitting into the EPROM socket. The solution is to remove the crystal, remove the plastic clip and extend the crystal leads so that the crystal can be moved through 80 degrees so that it lies over the top of the adjacent integrated circuit.

- 12) Refit the circuit board to the heatsink plate and clip it into place with the two remaining clips at the rear, then refit the two heatsink screws that were removed in step (5). This is essential for proper heat dissipation in the power semiconductors on the board. If the screws are omitted, damage could result to the devices.



- 13) The rear of the unit should then should be as per this picture



14) Insert the ribbon cableand the unit is ready for SharkTuning.



PREPARING THE CAR FOR SHARKTUNER CONNECTION

- 1) As mentioned previously, a diagnostic socket is not present on the 85/86 cars. Connections from the cars sensors and signals have to be manually connected to the Auxiliary circuit board of the SharkTuner.

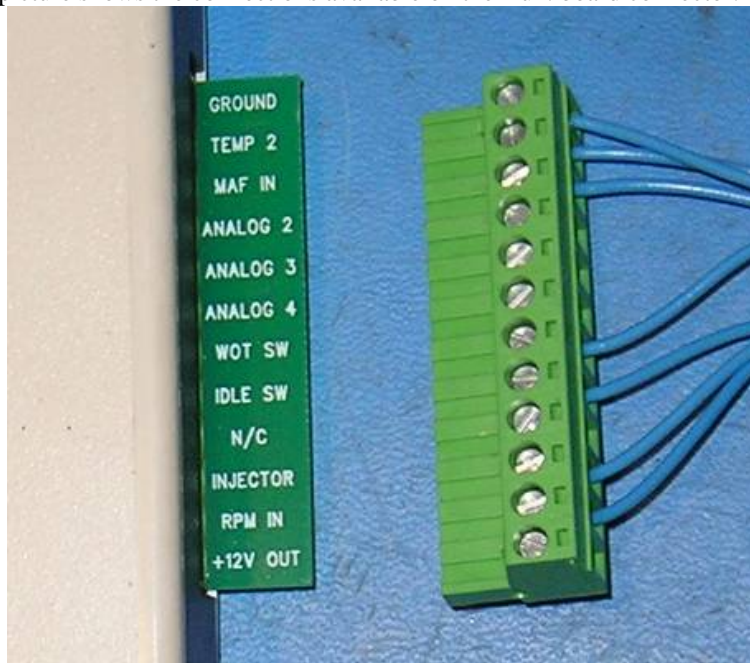
The picture below shows the SharkTuner with the new Auxiliary input board. Also shown is the mating connector which accepts the wires from the cars harness or Break out Box



- 2) This is a view of a typical break out box, made from a 25 way male (chassis mount) and female (cable mount) 25 way connector parts. These connectors were used on Volvo cars in the mid 1980s (e.g. Volvo 740 turbo) and are readily available from car breakers. This assemble makes it possible to “plug and play” to SharkTune a car. Also note the leads brought out into the SharkTuner auxiliary board connector.



3) This picture shows the connections available on the Aux. board connector.

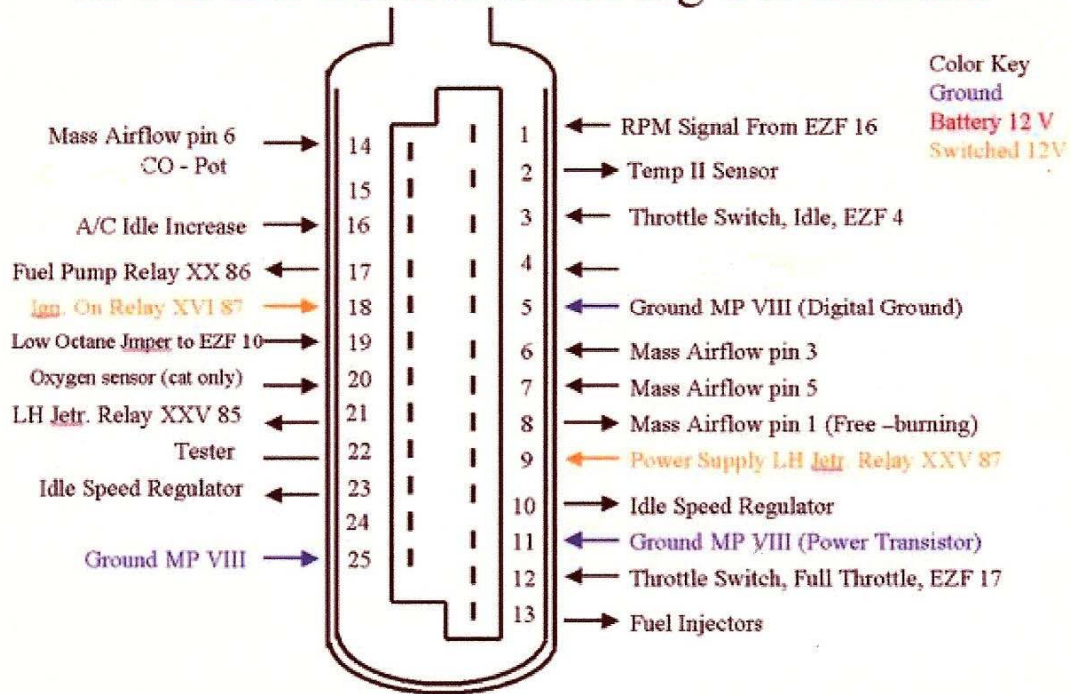


The necessary connections to the LH ECU, either directly into the cars LH cable form/plug, or from a break out box are (from the top)

GROUND	Pin 5 LH connector (also use for ground connections to external Aux inputs)
Temp 2 sensor	Pin 2 LH connector
MAF volts	Pin 7 LH connector
Analog 2	See later in text
Analog 3	See later in text
Analog 4	See later in text
WOT switch	Pin 12 LH connector
Idle switch	Pin 3 LH connector
N/C	(no connection)
Injector	Pin 13 LH connector
RPM pulses	Pin 1 LH connector
+12v put	Ignition switched +12v, thermal resetting fuse at 200mA maximum

If wiring into the LH cableform directly, the diagram below will assist in locating the LH connector pin numbers mentioned above.

25 Pin LH Control Unit Plug Connections



This view is looking into the open end of the disconnected cable connector

NOTE : The Auxiliary connector and power require different wiring for EZ-F usage. This is described later in this manual.

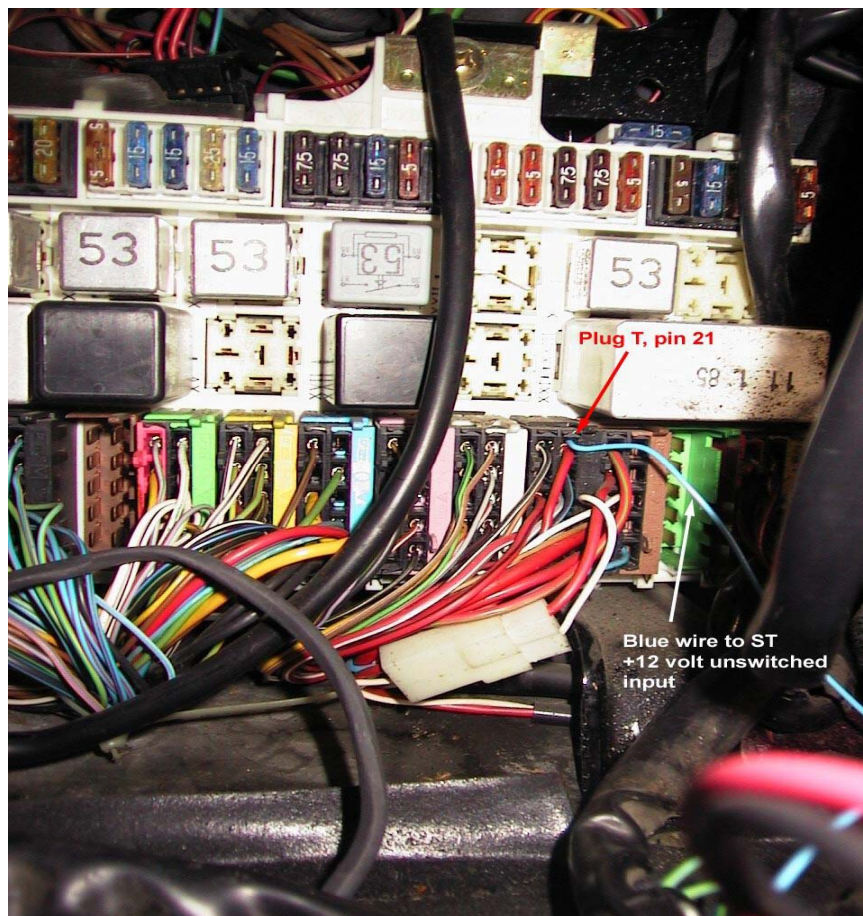
- The other necessary connections are the power supply feeds to the SharkTuner from the car. A additional type of power lead is supplied with this version of the SharkTuner .



The 3 connections required to this lead are :-

+12v unswitched **BLUE** :-

Wired from main +12v feed on fuse relay board. **It is recommended that an in line fuse is inserted in this line – rated at 5A.**



+12v ignition switched **RED** :-
This can be wired from Pin 18 of the LH connector

Ground (chassis) **BLACK** :-
This can be wired to pin 5 of the LH connector, or to the main fuse/relay panel.

NOTE – THE REQUIRED POWER CONNECTIONS FOR LH AND EZ-F ARE WIRED TO DIFFERENT PINS OF THEIR 25 WAY CONNECTORS !! DAMAGE MAY RESULT IN AN INCORRECT CONNECTION .

- 5) The power lead and Aux board connectors can now be plugged into the SharkTuner box –



- 6) Reconnect the ribbon cable from SharkTuner to LH adaptor connector, and then LH ECU 25 way connector.
- 7) Load the SharkTuner CD-ROM disc into the laptop, copy the installation software into a suitable directory on the laptop. Unzip the Installation software, and run the “Setup” file.

Please NOTE : if during installation you receive a message inviting you to update a file on your computer to a later version, do NOT accept this option.

However, if at any time the SharkTuner software instructs you to install the required version of SharkTuner firmware, accept this.

- 8) You can choose the directory you want to install the program into. Then make a shortcut of the “SharkTuner” (exe) file from your “Programs” menu onto the desktop for convenience. Then create a new folder for these initial tests ready to store your modified files.
- 9) Check that power LED (Yellow) on the SharkTuner is illuminated as soon as the Blue power wire is connected. Switch the ignition key to the first position, and check that the Green LED is also lit.
- 10) Switch off the ignition.

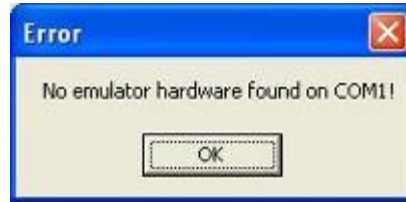
- 11) Run the SharkTuner .exe file. The flash screen below will be displayed for a few seconds...



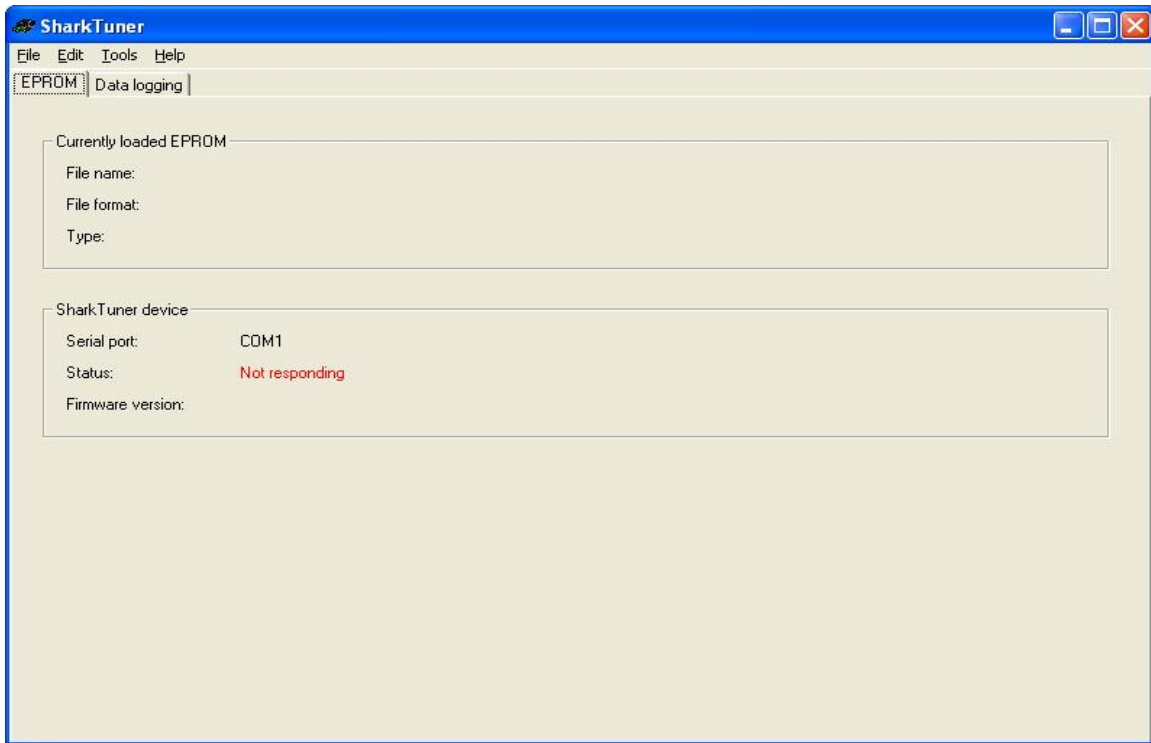
- 12) Then this screen should be shown...



12) If there is the error message -



And this screen,



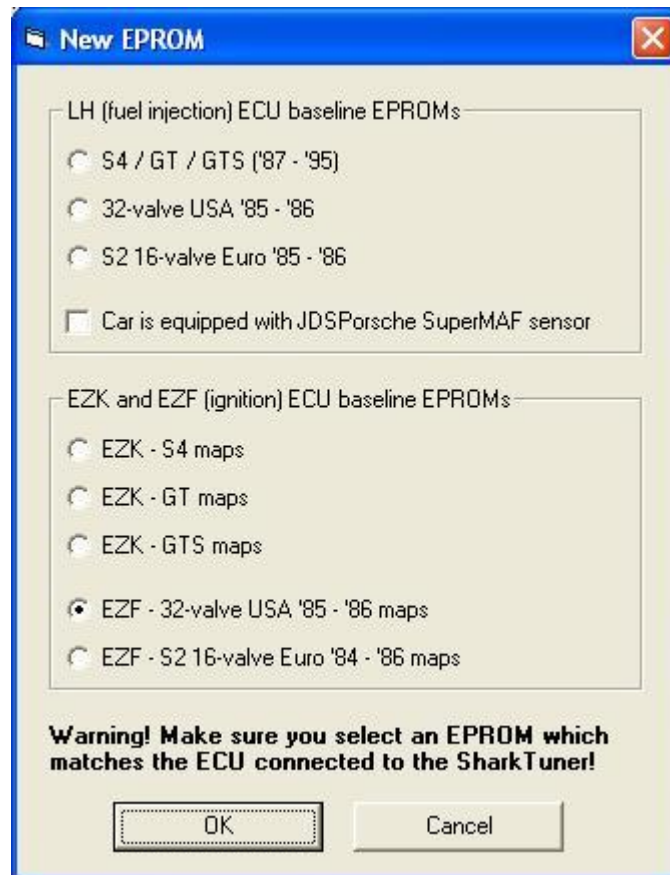
- followed by the message below, go to "Tools/options" and select another port that relates to the COM port you have connected to the SharkTuner, until you can establish data communications with the SharkTuner. Also confirm that the Yellow LED on the SharkTuner is lit. The lap top cannot communicate with the SharkTuner if the yellow LED is not lit.



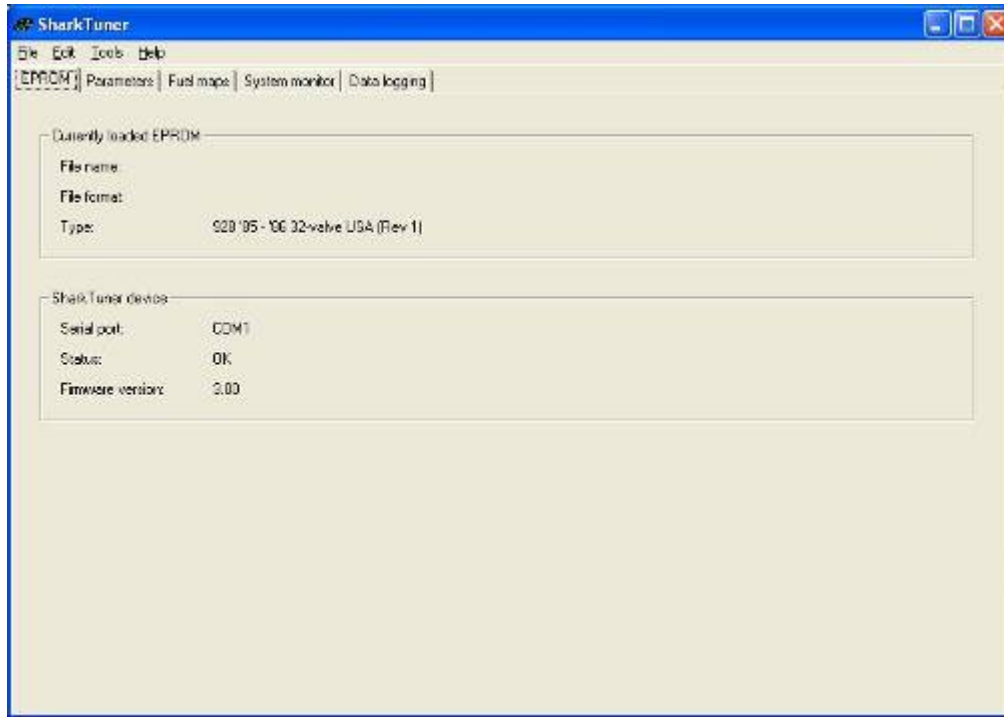
13) Once the correct port has been connected, you will then see that the "Status" will be "OK", and also that the "Firmware version" will also be shown, both near the bottom of the screen. Note that

it takes about 3 seconds for the COM port to be recognised, and the warning to change from red to the normal “OK”. The screen as shown in section 11) will then be displayed.

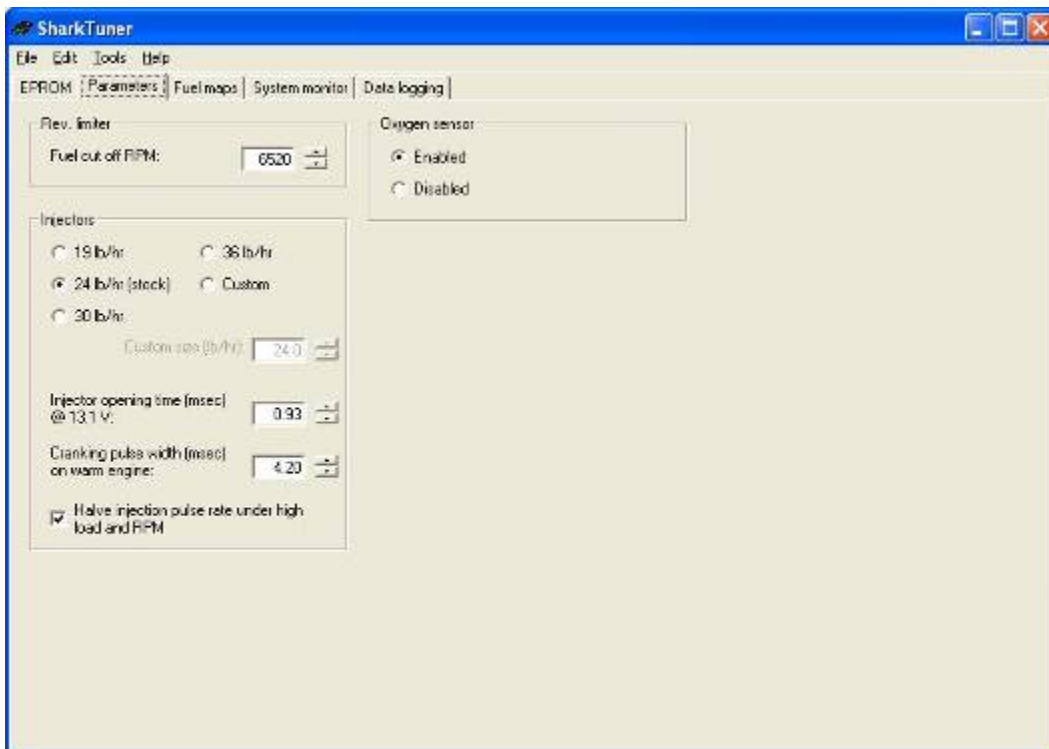
- 14) The firmware is the software which has been installed in the microcontroller of the SharkTuner at manufacture. If upgrades are issued in the future, they are installed into the SharkTuner using the “Tools” menu.
- 15) The next step is to load the special EPROM binary file (BIN file) which allows remapping and data monitoring. This is based on your 928’s standard software, but has some special features required for remapping. Go to File/New and select the appropriate file. A loading progress window will be shown, and the file should load in about 10 seconds



- 16) **In order that you retain an uncorrupted and unedited version of the two types of bin files for future reference, load File –new – for each of the LH2.2 and LH2.3 files type available on this screen.**
- 17) Select the 32v USA 85/86 binary file. The SuperMAF is not supported in the LH2.2 SharkTuner.
- 18) The following screen is then shown, with a selection of screen tabs, not available before the binary file download

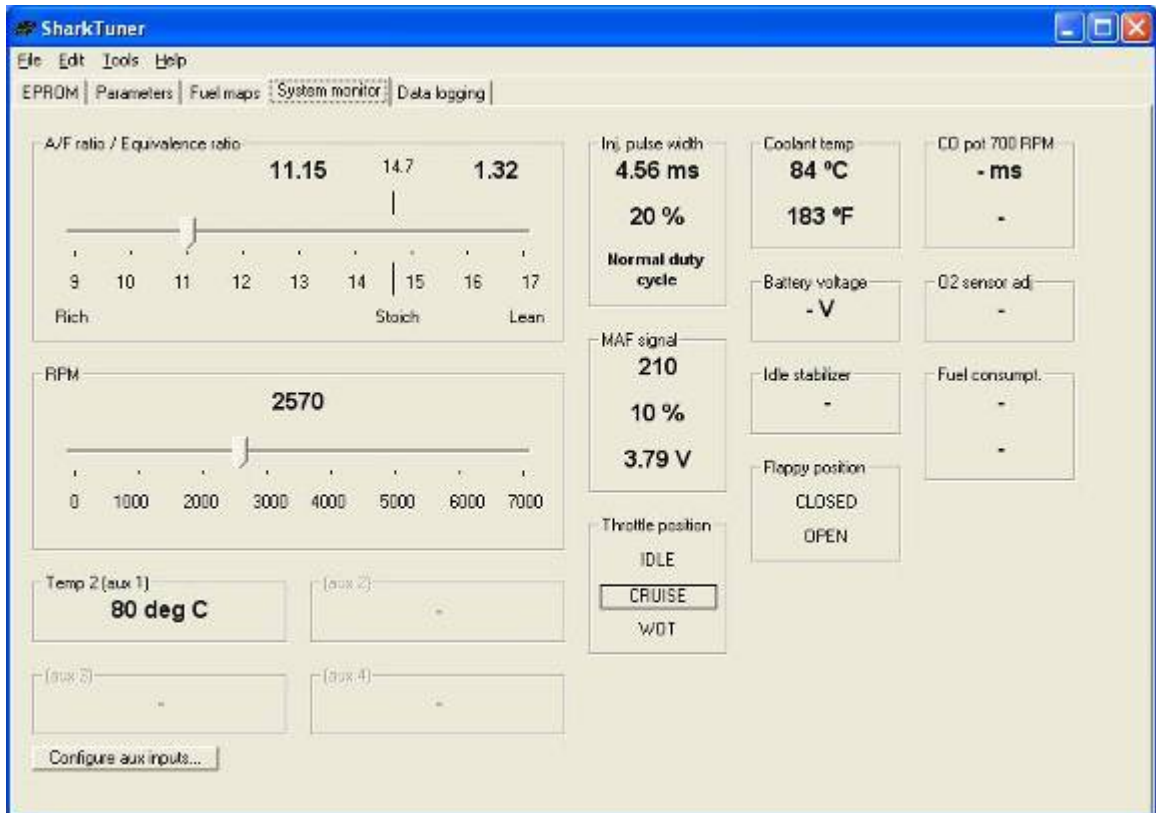


- 19) Select the “Parameters” tab, and check that the parameters selected agree with the configuration of your car, especially if it has already been modified from standard. e.g. larger size injectors. Note that injectors larger than 36# are not supported in LH2.2.



- 20) Switch on the ignition and check that the green LED on the SharkTuner is lit. The WBO2 should also now be powered. Check carefully that there are no error messages (LM1) or that the 3 coloured LEDs (Tech Edge) are showing a normal display. (Refer to manufacturers’ handbooks/websites). Wait until the WBO2 sensor has warmed up as shown by the indicator LEDs, and then start the car.

- 21) Start the car, select the “System monitor” screen, and check that the display responds to changes of rpm, throttle position etc. Also check that the A/F ratio display is indicating correctly. A/F ratio is also shown on the fuel map screens. The RED LED on the SharkTuner does not flash with LH2.2, as it does with MY >87 ECUs.



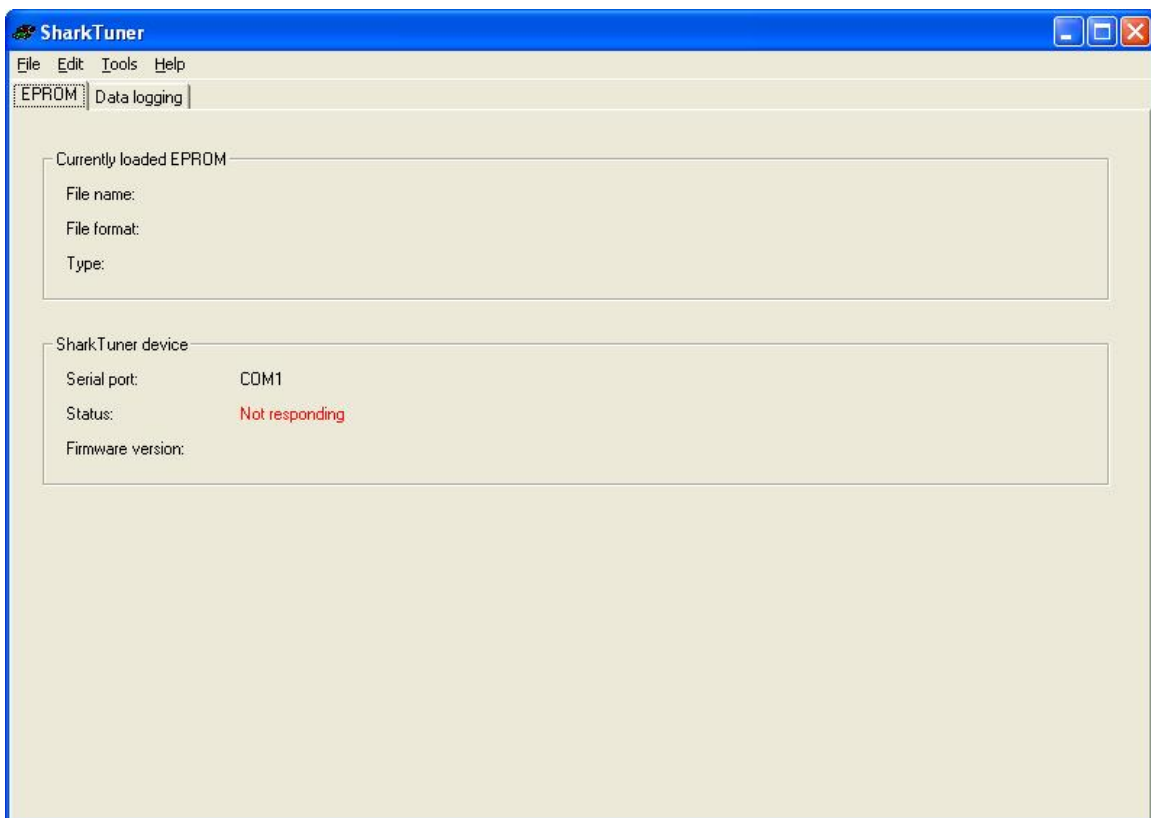
- 22) Installation is now complete. Switch off the engine BEFORE unplugging the SharkTuner power supply. Also note that once you have loaded a BIN file into the SharkTuner, you can close down the SharkTuner windows program on the laptop, and the car will run on the loaded BIN file - AS LONG AS THE SHARKTUNER REMAINS POWERED. Note that with ignition off, and SharkTuner powered for long periods, that the current consumption is approximately 70mA.
- 23) If you have made any changes to the Parameters screen you wish to retain, then do a “Save As” NOT a “Save”, before closing down the SharkTuner.
- 24) NOTE – you should ALWAYS load a BIN file into the SharkTuner before switching on the ignition. Other wise the ECU will repeatedly pulse the injectors. This might cause starting problems later.

DESCRIPTION OF SYSTEM SCREENS

Please read this section before proceeding to use the SharkTuner !

OPENING SCREEN - WHEN SHARKTUNER IS NOT CONNECTED TO THE LAPTOP

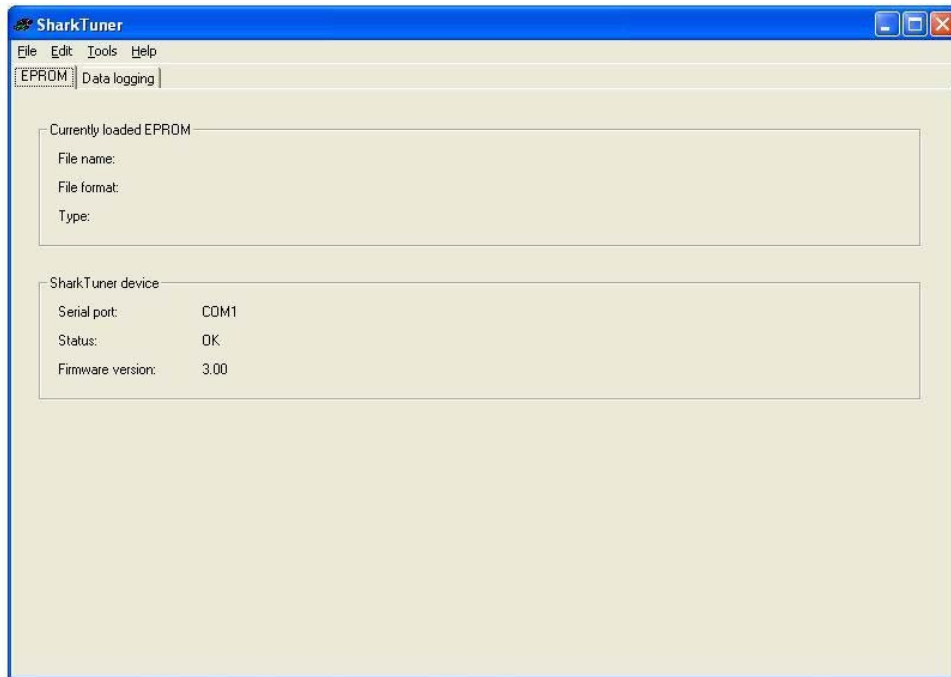
This screen can be used to view data log files, although the error message for no COM port communication is displayed. This is useful for viewing and graphing data logging files away from the car. See the Data logging section later for full details of how to use this feature



OPENING SCREEN BEFORE BIN FILE IS LOADED FROM LAPTOP

In the bottom section of the screen is shown the selected COM port. If communication has been established between the laptop and the SharkTuner device, then Status will be “OK” and the firmware version used will be indicated. If no communication is made, then “*Not responding*” is shown. See the Installation section above if there is a communication problem.

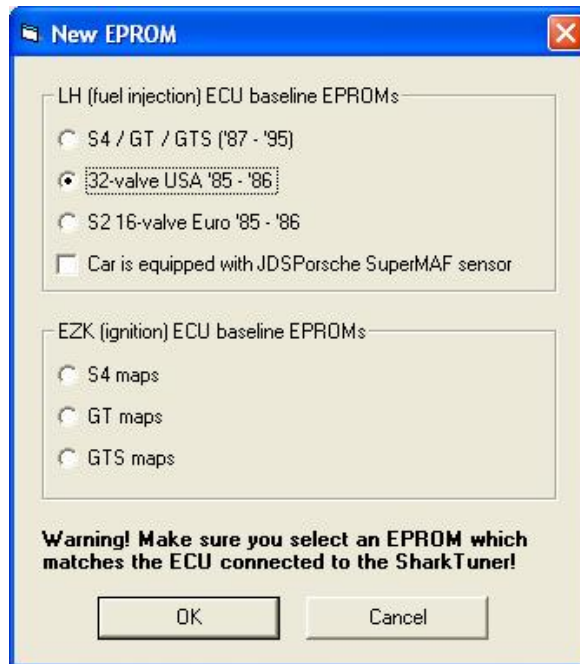
The upper part of the window shows “Currently loaded EPROM”. This will show the BIN file reference once a BIN file has been loaded.



Top Menu:

- 1) File - “New”

This function gives access to the basic supplied BIN files via this menu



FILE – “Open” –

Allows access to previously saved versions of the basic BIN files, which you may wish to re-open for further modification.

FILE - “Down Load from SharkTuner device” –

If the SharkTuner box remains powered, with a BIN file loaded, then the SharkTuner Windows program on the laptop can be closed down. The ECU will continue to run on the loaded file as long as the SharkTuner box is powered (doesn't care if ignition is switched on/off during this time). If you wish to start using the SharkTuner program again for file modification, or data logging, then after opening the program on the laptop, use this file option to reload the BIN file running in the SharkTuner box back into the laptop program.

FILE - “Save”

Saves the loaded file, without change of filename. Use this command sparingly if you are in the process of changing file parameters. Using this command will overwrite the previous version of data in the file. As described later in this document, we recommend that you use the “Save As” command for most situations.

FILE – “Save As”

Saves the loaded file with the option of changing its name to reflect any modifications you have made. If you intend to change a BIN file, then use “Save as” AS SOON AS YOU LOAD THE FILE, then the parent file will remain unaltered. Take note to select the correct EPROM type to suit your stock of blank EPROMS.

FILE – last 4 loaded BIN files

Lists the last 4 loaded BIN files. Clicking once on any of these will load that file into the SharkTuner laptop program and box.

FILE – “Exit”

Exits the SharkTuner program - also see b) above. If changes have been made to the loaded BIN file, you will get a warning window asking if you want to save those changes before exiting the program.

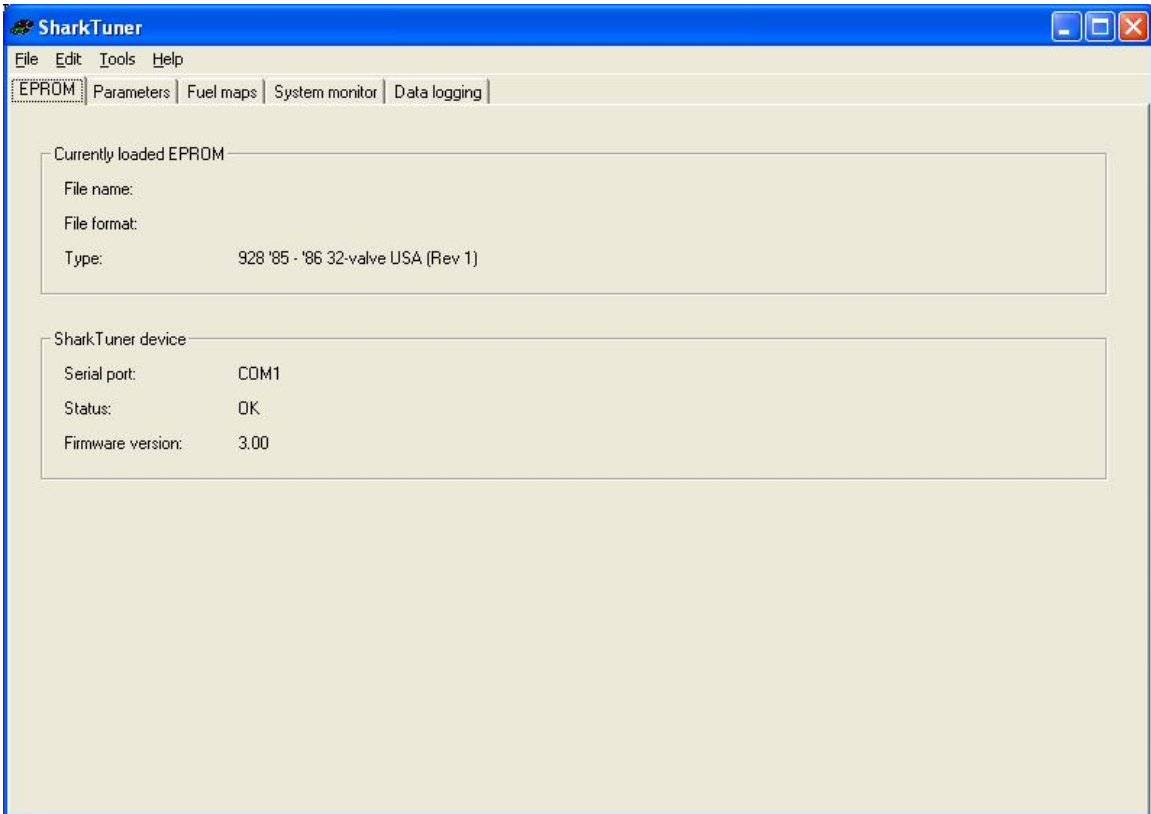
- 2) "EDIT" - This menu contains Copy and Paste functions which are available when working in the Fuel map or Data logging screens
- 3) TOOLS – "Options"
This gives the COM port selection, in order to establish communication between the laptop and the SharkTuner box.
- TOOLS – "auxiliary inputs"
This feature is described the "System monitor screen" section later in this document. It can also be accessed from that screen.
- TOOLS - "WBO2 law"
This feature is described the "System monitor screen" section later in this document. It can also be accessed from that screen via "configure aux inputs".
- TOOLS – "Firmware upgrade"
This enables a new version of the firmware to be loaded. The firmware is the software which has been installed in the microcontroller of the SharkTuner at manufacture. If upgrades are issued in the future, they are installed into the SharkTuner using this option.
- 4) HELP –
This gives the usual "about" information, and gives the version number of the SharkTuner EXE file that you are currently using.

EPROM SCREEN- Shows file name, format and type of the currently loaded EPROM BIN file, as described below.

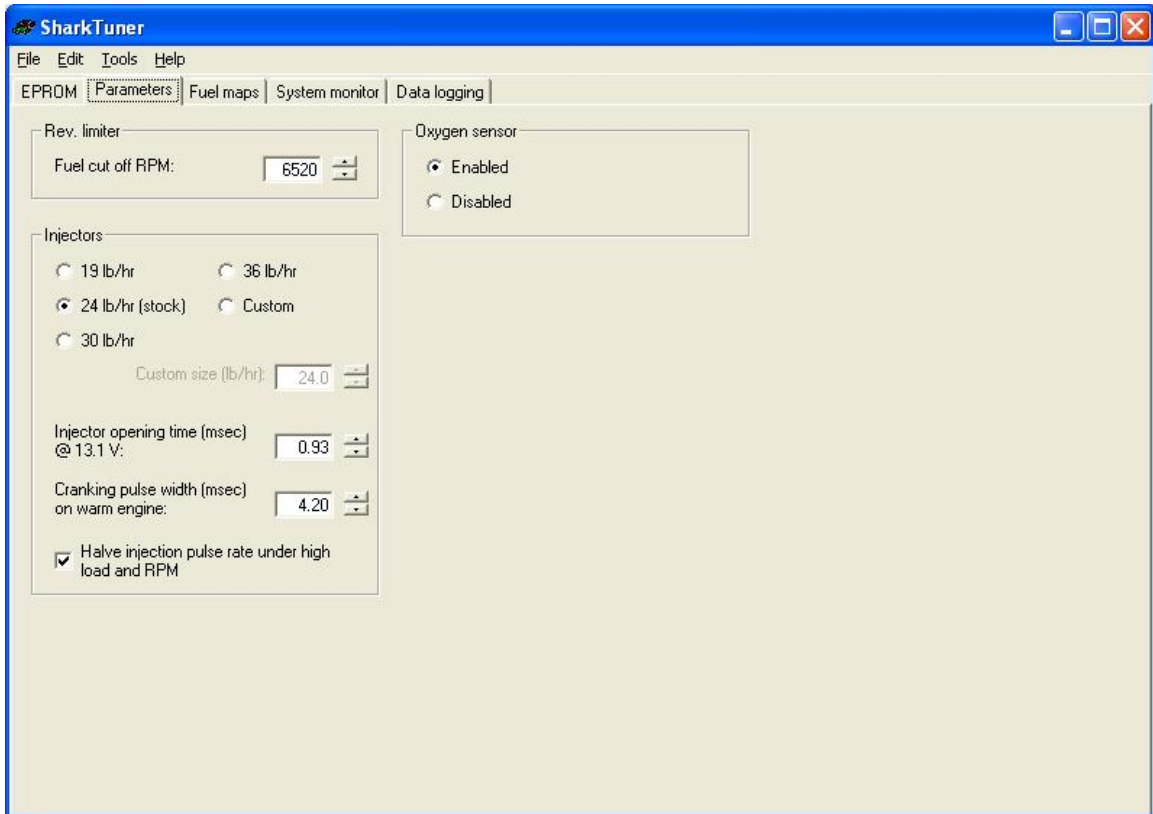
OPENING SCREEN AFTER BIN FILE IS LOADED

N.B. The following screen descriptions ONLY apply when 32v US 85/86 LH bin file is selected. The SuperMAF option is not available for LH2.2.

After a BIN file is loaded, the opening screen changes to the EPROM screen, and this opens additional secondary buttons which select the screens which are used to log, view and modify data and parameters. These screens are now described –



PARAMETERS SCREEN –



Top left are the fuel cut off variables – this is the “rev limiter”. The upper point is adjustable in preset steps, by using the up and down arrow to the right of each value. Adjusting the upper cut off point is a very useful device to limit rpm at a low point, to avoid damage during initial testing of a modified car.

Mid left is the setting for the fuel injector size used. This parameter is used in the calculation used for injector opening time. Standard injector values are available, or you can enter any custom size. It would be feasible to adjust the injector size parameter to compensate for a small change of fuel pressure, and avoid extensive remapping.

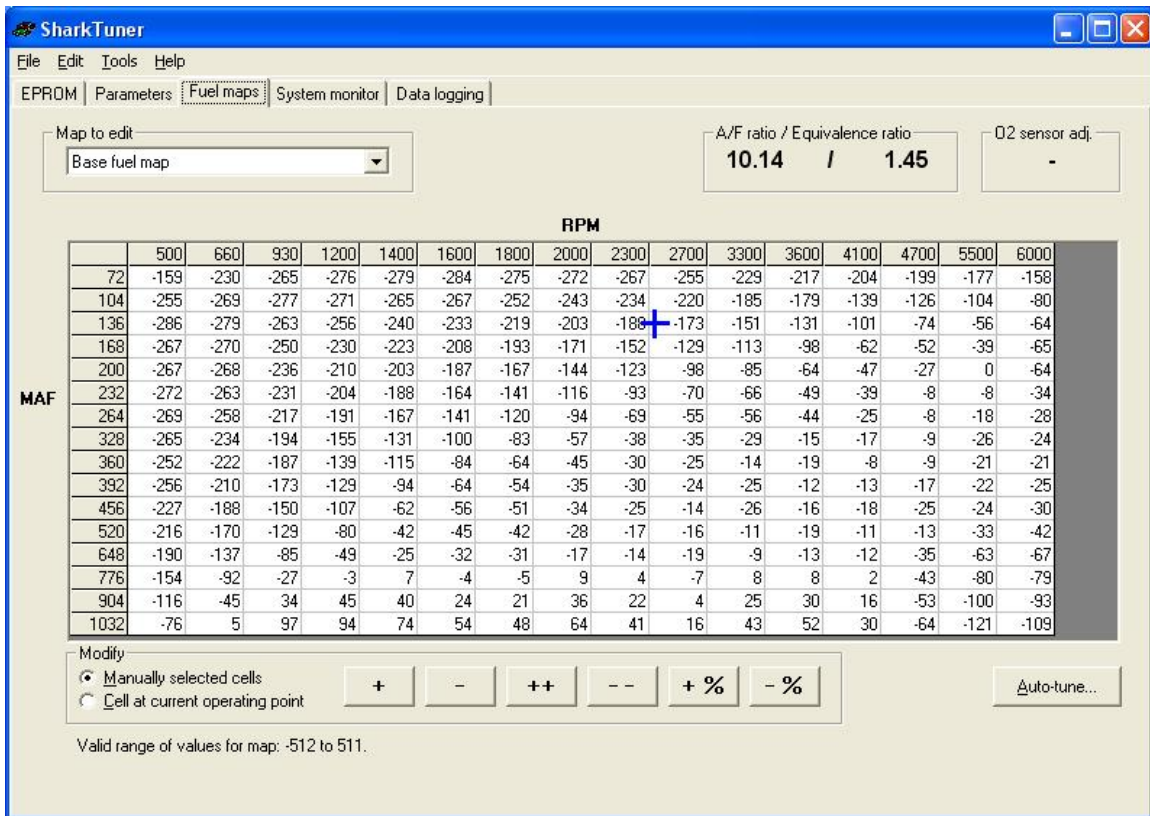
Note that the standard selection for injector size does NOT include 42# injectors. Although it is possible to select “Custom” and select sizes greater than 36# but this is not recommended for LH2.2.

Injector opening time is also a user adjustable variable. This is the time it takes for the injector to start spraying fuel once voltage is applied to it. Do not change this parameter unless you have good reason to do so.

It is also possible to adjust the cranking injector pulse width. This is automatically adjusted as injector size is varied, but some variation may be required with highly modified engines. Note that this parameter should be varied in conjunction with the “cranking fuel map” option in the Fuel map screen. More information is given in the “Editing the cranking fuel map” section later on page 29.

Edit fields for the “flappy”, coding plug, idle CO pot, idle speed, transient enrichment and O2 loop are not applicable to LH2.2 ECU.

Transient enrichment adjustments can be made with the “Acceleration enrichment” map. This is explained further in the “Editing acceleration enrichment fuel maps” section..



The “Map to Edit” tab has a drop down selection of 5 maps. However, the user usually will only want to modify the main maps. These are “Base fuel map” and “WOT map”. The Base fuel map controls the fuelling at idle, cruise and WOT. The WOT (wide open throttle) map is triggered at approximately 2/3 throttle travel by the WOT switch on the plenum. The fuel map being used (set by the coding plug, or the setting on the Parameters screen)) is indicated by the presence of a blue cross marking the operating point on the map being used.

Air/Fuel ratio is displayed in the top of all the fuel map screens. It is shown in both Air/Fuel ratio and Lambda formats.

When using Autotune the O2 loop is disabled automatically.

If manually remapping with LH2.2, disconnect the stock narrow band O2 sensor from the LH ECU. (or the simulated narrow band O2 output, if used). Alternatively you can defeat the O2 loop in the Parameters screen **But remember to re-enable the O2 loop before saving the bin file and blowing an EPROM from that file, otherwise the O2 loop will be permanently disabled when that EPROM is used.**

The O2 sensor loop indicator shown in the top right hand corner is not active with LH2.2.

EDITING THE BASE FUEL MAP.

When using Autotune the O2 loop is disabled automatically.

If manually remapping with LH2.2, disconnect the stock narrow band O2 sensor from the LH ECU. (or the simulated narrow band O2 output, if used). Alternatively you can defeat the O2 loop in the Parameters screen **But remember to re-enable the O2 loop before saving the bin file and blowing an EPROM from that file, otherwise the O2 loop will be permanently disabled when that EPROM is used.**

However, because these cars will normally run after tuning with the O2 loop enabled, it is ESSENTIAL that idle and cruise SharkTuning must aim for a 14.7:1 air/fuel ratio. WOT tuning (throttle position 3) can aim for whatever air/fuel ratio is desired.

The blue marker indicates the operating point of the engine on the selected map. It may fall on the boundary of 2 or more map points, due to the granularity of the increments. RPM is the horizontal axis, and MAF signal (or "load") is the vertical axis. To adjust the value of a cell falling on such a boundary, select both the indicated adjacent cells.

The vertical axis MAF signal is the signal applied to the uC in the LH ECU. The maximum value which can be mapped is 1032 which corresponds to a MAF voltage of 6.1v at 6000rpm. This equates to approximately 450bhp crank.

NOTE: At high rpm (above 5000rpm) there will be some jitter on the values shown on the SharkTuner. This is due to inherent limitation with both EZK and LH ECU. These changing values are not a cause for concern.

The values in the map are essentially correction factors. The LH ECU calculates a pulse width value which should theoretically deliver a 14.7:1 A/F ratio. However, due to various complex phenomena (such as differences in fuel atomization and vaporization under different conditions, air leakage past intake valve seals, etc) the theoretically calculated pulse width will not deliver a 14.7:1 A/F ratio. The fuel maps are used to compensate for this fact. A value of 0 means that the theoretically calculated pulse width will be used as is. Values above 0 mean the pulse width will be increased from the theoretically calculated value, and values lower than 0 mean the pulse width will be decreased

The values in the cells have a valid limit of upper and lower values of +512 and -512. This represents an available adjustment of fuelling of +/- 100%. A positive increase of value increases the fuelling.

At bottom left of the screen is an option which allows editing of selected cells, or editing of cells at the current operating point -

"Manually selected" cells for editing can be selected singly or in groups using the mouse. They can then be adjusted by the options at the bottom of the screen.

Alternatively, the **"Cell at current working point"**, can be selected for "on the fly" adjustments.

Using the "+" or "-" button will increment or decrement the value in the selected cells by 1, which represents a change of fuelling of approximately 0.2%

Alternatively, the selected cells can be incremented up or down in increments of 1 by using shortcut keys "q" and "a" respectively. Note that it is necessary to click with the mouse somewhere on the map to activate the shortcut keys. Also note that when manually selecting cells and using the shortcut keys, that no more than 4 cells should be selected.

Using the "++" or "==" buttons will change the value in the selected or operational cell by +10 or -10 for more rapid adjustments of cell values. The shortcut keys for these changes are "w" and "s" respectively

The +% and -% keys allow a percentage change to be made to the selected cells. The allowable change either side of the mid range value of 0 is +/- 100%. Note that the "%" in these cases is NOT a % change of

the value of the cell, but sets the cells to an absolute percentage change of fuelling. The shortcut keys to select these options are “e” and “d”.

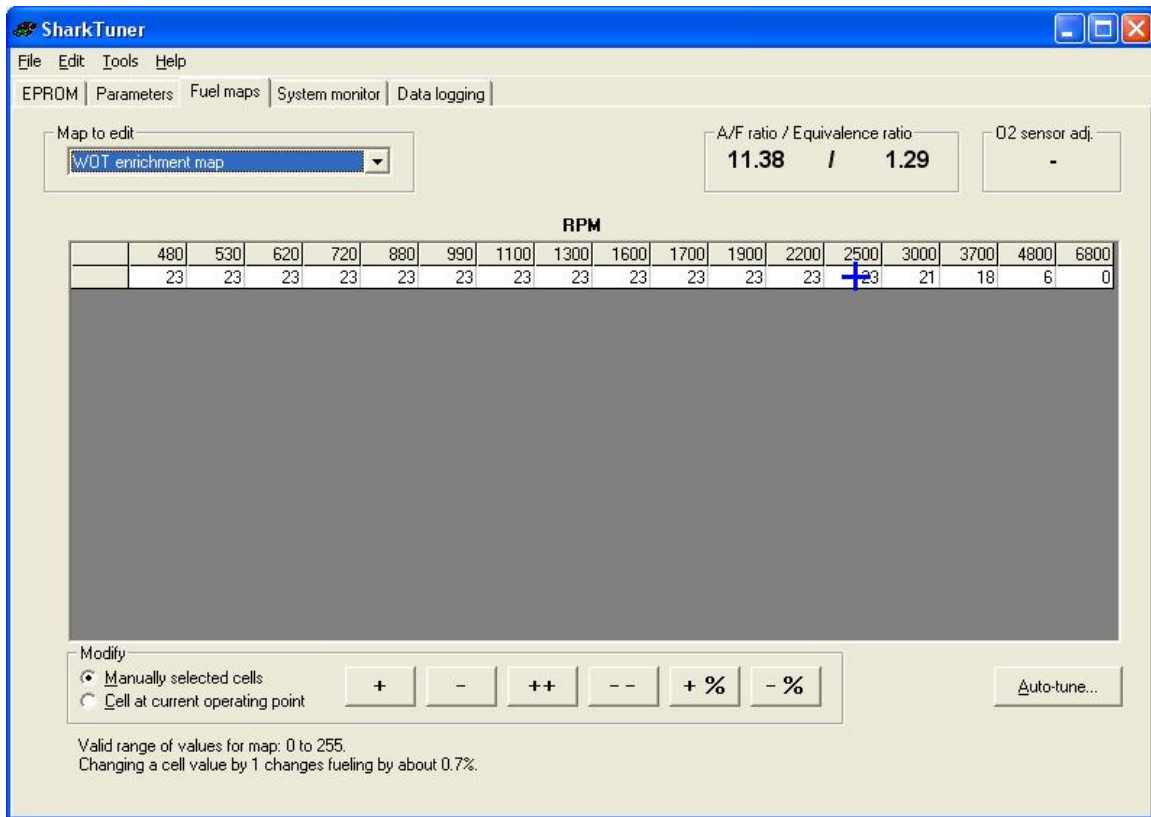
If you run out of adjustment range, then an increase in fuel pressure or injector size selection on the “parameters” screen may be required. See the later section on remapping

AUTOTUNE BUTTON

Using this button brings up a window giving the options for the Autotune function. These are largely self explanatory, and the use of the Autotune system is covered in detail in later section ”QUICK START REMAPPING USING AUTOTUNE”. Autotune is only available on the Base fuel maps.

Autotune and data logging cannot both run together.

EDITING THE WOT MAP



The WOT map is used when the wide open throttle switch is closed at approximately 2/3 throttle opening. The injector opening time is calculated using the base fuel map PLUS a value taken from the WOT map for extra mixture enrichment for maximum power. Therefore it is important that the base fuel map is correctly mapped before the WOT map is optimised.

Contrary to popular belief, the base fuel map is used for mapping values at WOT. For this reason, Autotune can remap the base map to a target A/F ratio at WOT. Autotune does NOT adjust the WOT map.

The WOT map is used to add additional fuelling if required, i.e. if a richer mixture is required as some points, or the required A/F ratio cannot be made rich enough within the adjustment range of the base map

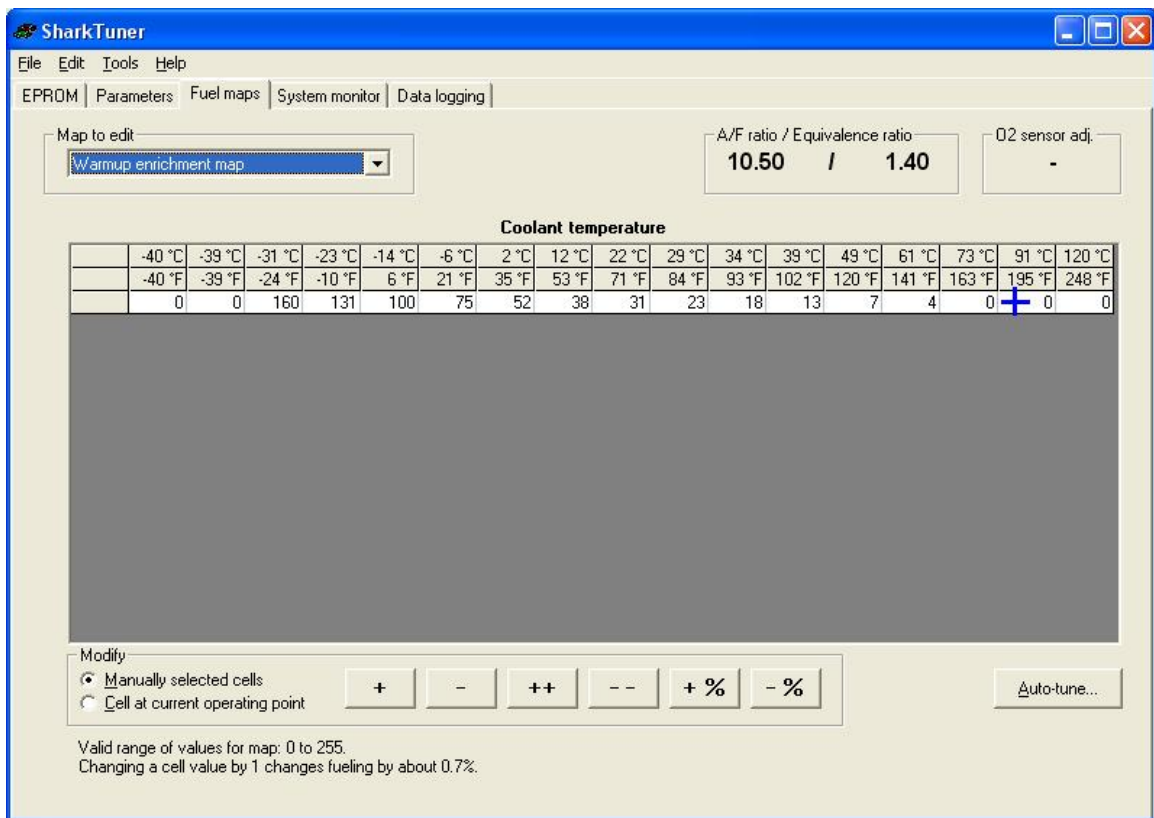
As can be observed from the WOT screen, the map is only using rpm as its look up value. The fuelling adjustment possible has a similar total range as the base fuel map, approximately 50% but in this case only *positive* values from 0 to 255 are applicable. Increasing the values in the map increases injector on time, and hence reduces the Air/fuel ratio (richens mixture). As this implies, you cannot have a weaker mixture at

WOT than at the upper load levels in the base fuel map. A value of 0 in the WOT map means that the fuelling is identical in WOT or non WOT conditions at that rpm/load setting.

EDITING THE WARMUP ENRICHMENT MAP

The third set of maps available are the warm up mappings which adjust fuelling according to water temperature. Note that the effective reference for this map is the fuelling at normal operating temperature. The fuelling at lower temperatures should only be adjusted if required after the normal operating temperature fuelling has been finalised. This is because only positive values (enrichment) can be entered into this map. Enrichment is progressively reduced as the engine warms up.

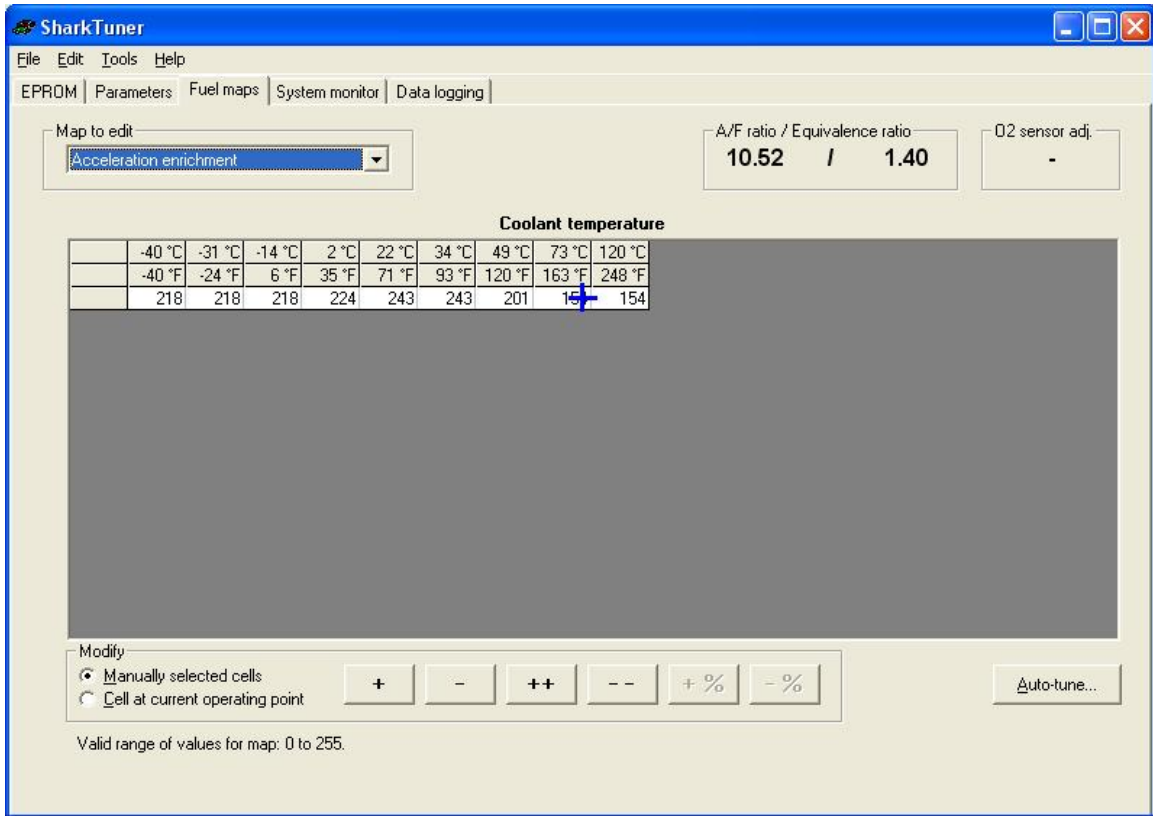
Autotune is not available on this map.



EDITING THE ACCELERATION ENRICHMENT FUEL MAP

The acceleration enrichment fuel map then allows adjustment of the transient enrichment versus water temperature, if required.

Autotune is not available on this map.



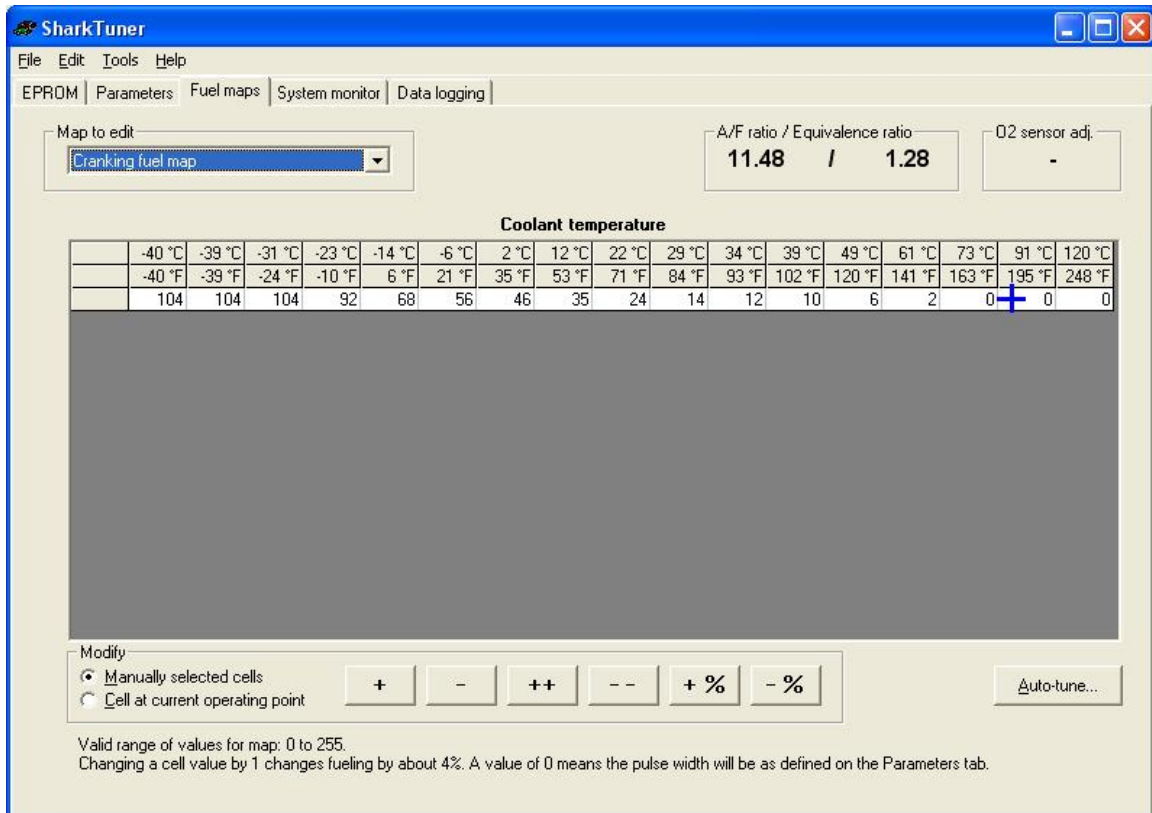
EDITING THE CRANKING FUEL MAP

The value of the cranking speed fuel injector pulse width is editable on the lower LHS of the Parameters screen. This should be optimised after final adjustment of the main fuel maps when the engine is at normal operating temperature. Note that a value of 0 in this map will give a cranking fuel pulse width as set on the parameters screen.

The cranking fuel map is then used to adjust the cranking fuel injector pulse width versus temperature. i.e. to provide extra enrichment required for starting a cold engine.

Note that for these reason only positive values are permissible in this map, from 0 to 255.

Autotune is not available on this map.



SharkTuner

File Edit Tools Help

EPRDM Parameters Fuel maps System monitor Data logging

Map to edit: Cranking fuel map

A/F ratio / Equivalence ratio: 11.48 / 1.28

O2 sensor adj.: -

Coolant temperature

	-40 °C	-39 °C	-31 °C	-23 °C	-14 °C	-6 °C	2 °C	12 °C	22 °C	29 °C	34 °C	39 °C	49 °C	61 °C	73 °C	91 °C	120 °C
	-40 °F	-39 °F	-24 °F	-10 °F	6 °F	21 °F	35 °F	53 °F	71 °F	84 °F	93 °F	102 °F	120 °F	141 °F	163 °F	195 °F	248 °F
	104	104	104	92	68	56	46	35	24	14	12	10	6	2	0	0	0

Modify:

Manually selected cells

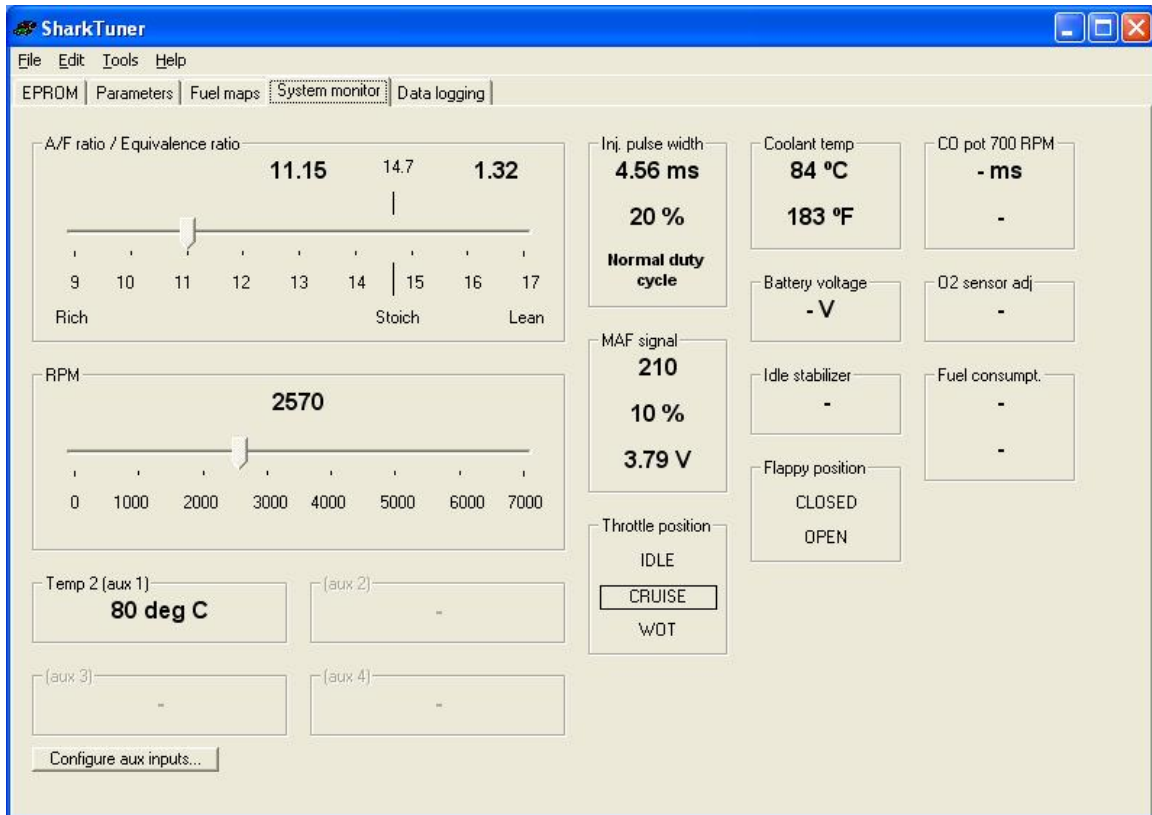
Cell at current operating point

+ - ++ -- +% -%

Auto-tune...

Valid range of values for map: 0 to 255.
Changing a cell value by 1 changes fueling by about 4%. A value of 0 means the pulse width will be as defined on the Parameters tab.

SYSTEM MONITOR SCREEN



This screen displays a series of parameters being used by the LH ECU, in real time. At top left, Air-Fuel ratio is displayed as A/F ratio or lambda. Below left is the rpm scale. At top right is injector on time which is the total pulse length including the turn on time. Also shown is the injector duty cycle %. Coolant temperature in degrees Celsius and equivalent Fahrenheit are shown. Note that the temperature values are not scientifically accurate and should be considered indicative.

Far right is shown “CO pot” – this is not active for LH2.2.

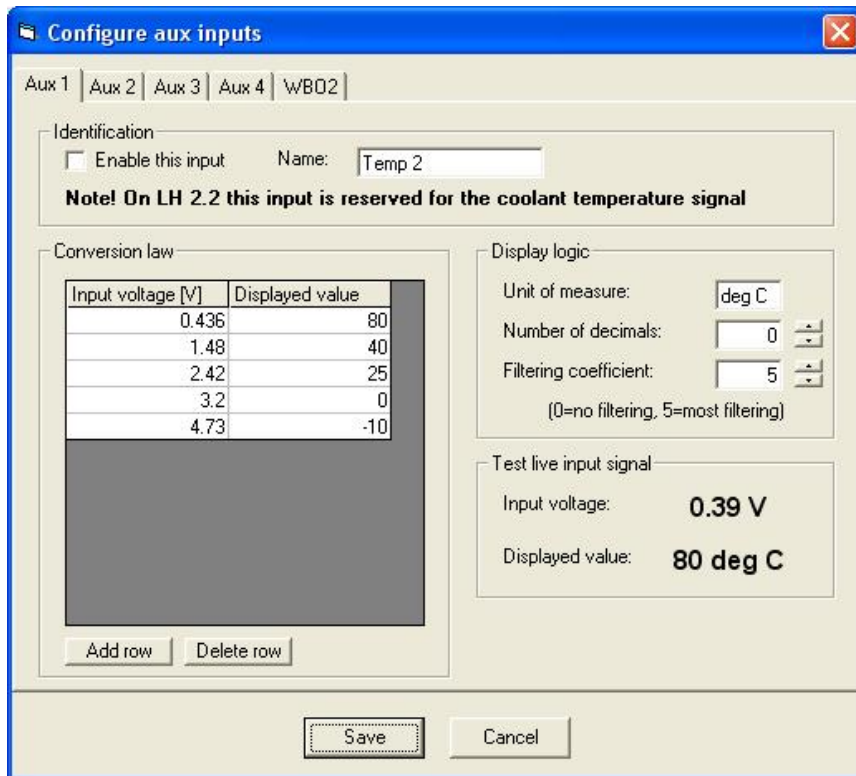
Centre screen are the MAF parameters. “MAF Signal” the top figure is MAF signal, and is the same quantity as on the MAF scale of the fuel maps. The % value is a measure of the percentage of the MAF signal range that is being used. Above this value, the hardware circuits in the LH ECU limit out any further increases of value.

The voltage value below is the value of MAF voltage registered within the LH ECU. This indicated voltage limits out to just above 5volts, due to hardware limitations, although the ECU can map MAF input voltages up to 6.1v. The % indication is the important one to use when mapping the car.

The “Throttle Position” tab is self explanatory.

“CO pot”, “O2 sensor adjust”, “battery voltage” and “Fuel consumption” are not active in LH 2.2

At bottom left, a set of auxiliary programmable inputs are available which are programmed by selecting the tab “configure aux inputs” –



On LH2.2 Aux Aux 1 is always allocated to temp 2. The conversion law shown in this screen shot has the values inserted to allow Temp 2 to be indicated.

The Aux 2,3 & 4 inputs are available for custom use. e.g. boost sensors, inlet air temperature sensors.

NOTE that input voltages MUST NOT exceed 5v dc. If sensors with higher voltages are required to be measured and displayed, then their maximum value must be attenuated to a maximum of 5v externally.

The displayed name and units can be programmed as required.

Data values in the table can be entered in steps as shown above. If the sensor law is known to be linear, then the lowest values and the highest values only can be entered. The intermediate values will be calculated and displayed assuming a linear law.

Filtering coefficient can be applied to smoothly noisy signals, but take account of the slower response times that will result from heavy filtering.

The Aux 1-4 values can also be data logged.

The last tab “WBO2” allows wideband O2 systems with slightly different laws to the TechEdge or Innovate to be used with the SharkTuner. Note that the maximum voltage that can be applied to this input is 5v. d.c.

DATA LOGGING SCREEN

The use of this screen is described in the “data logging” section of the chapter “Data acquisition, display and evaluation” later in this document

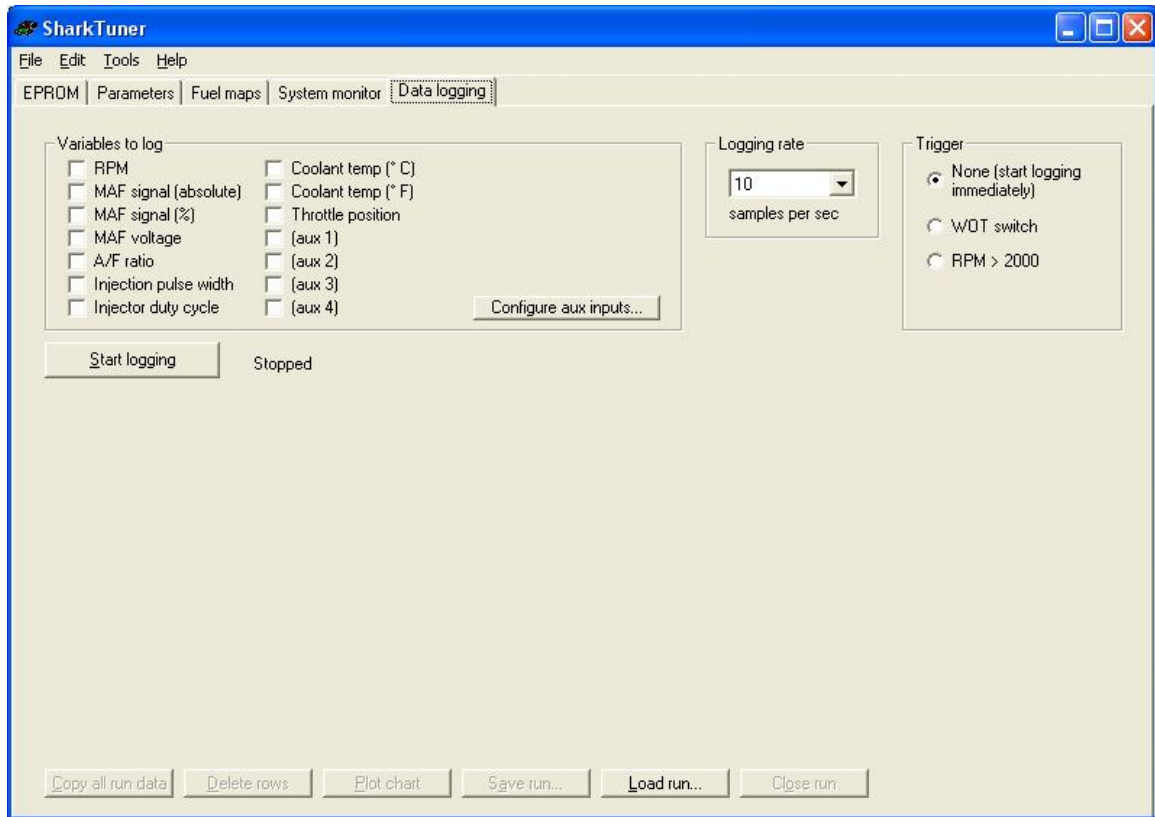
DATA ACQUISITION, DISPLAY AND EVALUATION.

General:

- 1) If you are starting a new development, use “File/New” to start, and then do a “Save as” with a new name.
- 2) If you are re-visiting a previously saved file , then use the “File/open” command.
- 3) Make a new directory for each tuning session. Copy the BIN file you wish to work on that day into the directory with a new version number as required, and then load this file onto the laptop after starting the SharkTuner program. The selected file may be one you have previously worked on – reopen this by using “Open”. For a new project, open the default BIN file from the “New” menu option.
- 4) NOTE. Always stop the car, and switch off the ignition before attempting to load a BIN file into the SharkTuner.
- 5) Always check the “Parameters” screen before starting the car. Confirm that injector size etc. agrees with your hardware. Check that the upper fuel cut-off (Rev limiter) is set correctly. For early testing of an engine, you may find it useful to limit the upper rpm limit so as to avoid accidental over stressing of the engine while optimising or data logging.
- 6) Also check that the correct fuel map has been selected for editing.
- 7) Start the car, and check that the values in the “System Monitor” screen are working, and responding as expected. In particular check that the Wideband A/F ratio figures appear to be indicated correctly (WB O2 sensor must be at normal working temperature)
- 8) After any tuning run when changes have been made to the loaded BIN file ALWAYS make a new copy of the file - “Save as” in the File menu. Note that in this menu you can select save as type 27C128 (16k) or 27C256 (32k) files types. Select the option that matches your available stock of EPROMs. Do NOT keep revising the same file without periodically doing “save as” otherwise you will loose the previous settings that you may want to go back to. If necessary include a text document in the folder with the file, noting the hardware setup for the tuning run, especially if you have been making several hardware changes.
- 9) Note that although changes to parameters and map cell values can be made in real time when the engine is running, it is not recommended you make any such changes whilst the car is moving.
- 10) Also note that once you have loaded a BIN file into the SharkTuner, you can close down the SharkTuner windows program on the laptop, and the car will run on the loaded BIN file AS LONG AS THE SHARKTUNER IS POWERED..
- 11) If you then wish to resume using the SharkTuner program to make changes, or start monitoring or data runs, proceed as follows – Start the program, select the Files menu, then click “Download from the SharkTuner device”

DATA LOGGING AND EVALUATION OF THE SYSTEM BEFORE RE-MAPPING:

- 1) The SharkTuner has an inbuilt data logger which will allow you to capture data while driving the car to determine which parts of the fuel maps require adjustment.



- 2) Check (tick) the required parameters that you wish to monitor from the “Variables to log” menu. Suggested variables for each phase of evaluation are noted below. **Always include rpm as one of the logged variables.** Then select the required trigger for the start of data logging. Data logging will then commence as soon as the “Start Logging” button is selected, and the trigger condition has been met. Data logging will automatically stop when the trigger condition ceases to be met, or the Stop Logging button is activated. Alternatively, you can use the WOT trigger or the >2000rpm trigger to initiate the data logging.

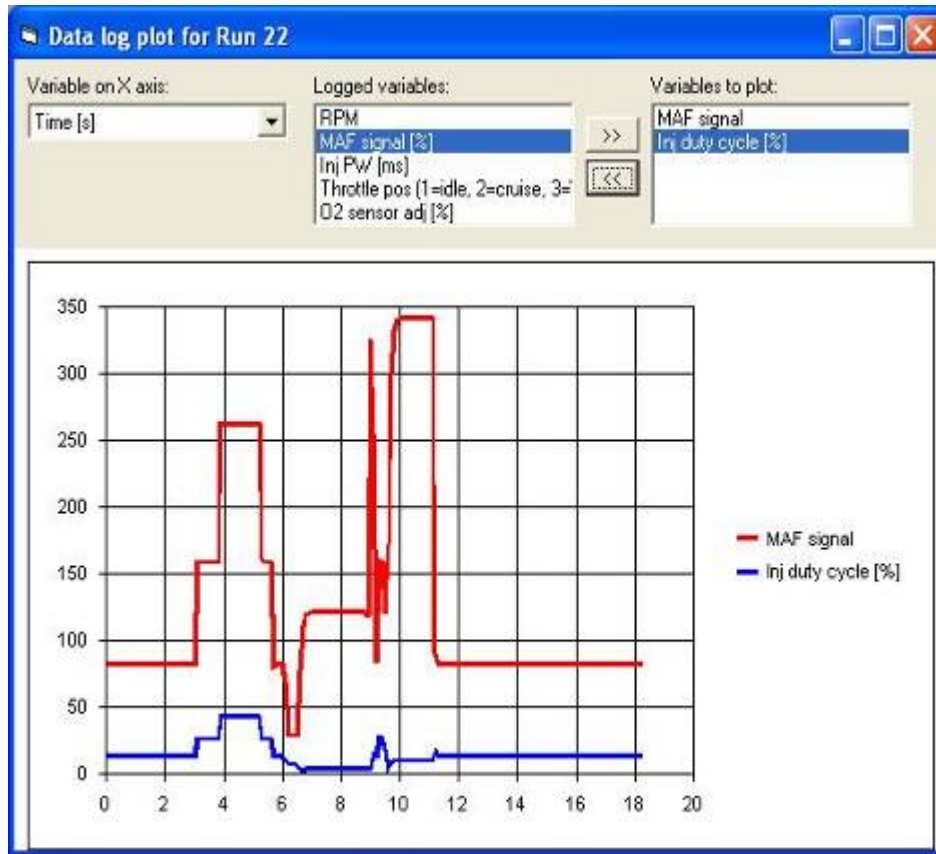
Also note that the new auxiliary programmable data inputs can also be selected for data logging

- 3) Note that the throttle switch position is logged as follows – 1 = closed, 2 = cruise and 3 = wide open throttle (“WOT”).
- 4) Once logging has started, the “Start logging” button changes to “Stop Logging” to enable the run to be terminated when required.
- 5) You may find it more convenient to use the tab key to scroll through the buttons until the “Start Logging” button is highlighted. It is then possible to start and stop logging using the space bar, or the return button of the keyboard
- 6) The logged data is immediately displayed in tabular form in the lower window, and you can scroll up and down the table using the up/down keys, or the slider on the RHS of the window. You will see that as the run is started, a new Run number tab is created. Up to 10 data runs may be stored, and used on screen at any time. You will get a warning if you have more than 10 runs displayed.

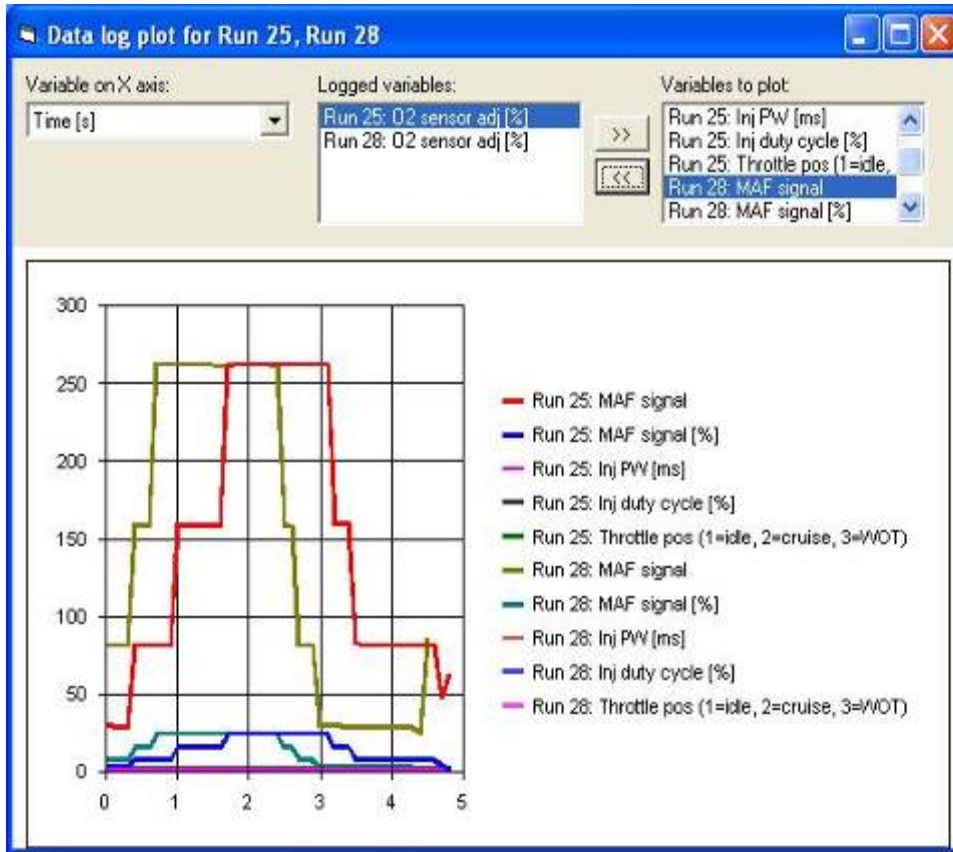
- 7) You can log up to a maximum of 5000 lines of data, this represents just over 8 minutes of data per run at the default 10samples per sec setting.
- 8) The six buttons along the bottom of the window are used to process the data further. Select the Run number tab you wish to process. The options then are (from left to right) –
 - a) “Copy all run data” - pastes the run data into the laptop clipboard where it is available for pasting into an Excel spreadsheet for manipulation, of presenting a graphical output.
 - b) “Delete rows” - to delete unwanted data rows from the data run. Select the row(s) for deletion in the time column, then use the Delete Rows button
 - c) “Plot Chart” - opens the chart facility within the SharkTuner” This powerful feature is described in more detail below.
 - d) “Save run” – to save the data as a text file in a directory and filename of your choice, and still retain it for on screen viewing.
 - e) “Load run” – allows you to open a previously saved text data run file. This is useful for comparison of results from a previous session
 - f) “Close Run” – to close the view of the run on the screen. You are given the option of saving the run to a file, if required.

CHART PLOTTING

- 1) A data run can be displayed using the “Plot Chart” function on the “Data Logging” window. You can plot the results of a single data run, or plot several data runs on a common graph.



- 2) You have the choice of 2 variables for the X (horizontal) axis – either RPM or Time. These are available in the left hand top menu box “Variable on the X axis”. Time is always logged automatically for the X axis. If you require the alternative of RPM for the X axis, then this must be selected as one of the “variables to log”.
- 3) The middle top window gives the list of the logged variables that you selected. You can move any of these to the right hand window to have them displayed on the graph by highlighting them and then clicking the >> button. They can be deselected from the graph by using the << button, after highlighting them.
- 4) To display the results from more than one data run on the same graph, select the first run number tab, then hold down the CTRL key and select the other data run numbers required. Then click the "Plot chart" button.



- 5) The selected variables for comparison can then be selected or deselected from the graph as required.
- 6) Alternatively, results can be copied into Excel using “Copy all run data” and pasting directly into an Excel workbook.

EVALUATING DATA RUNS

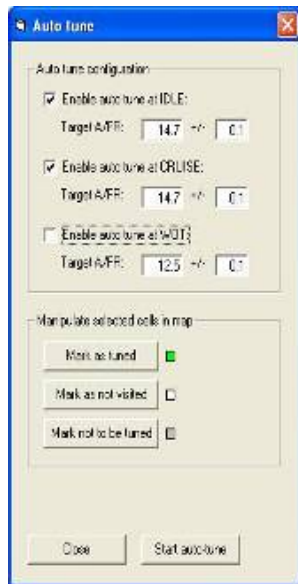
- 1) With the SharkTuner plugged into the car, the YELLOW LED should be lit (ignition off). Load the required BIN file from your COPIES on the laptop. These are modified versions of the standard files for these cars. The SharkTuner will ONLY operate using these special BIN files as a starting point. You cannot use a standard 928 BIN file.
- 2) A mildly modified car, but with somewhat larger injectors fitted may require very little optimisation of the main fuel map after the larger size injectors have been selected on the “Parameters” screen. In this case, minor adjustments to the WOT map may be the only adjustment required. This is especially true of cars running with the normal O2 loop enabled, as this will adapt the fuel to give 14.7:1 fuel ratio over much of the operating low load range of operation.
- 3) For O2 loop equipped cars, a good first step is to check that the O2 loop is well within its operating range. Select “O2 sensor adj.,” RPM, “Air/Fuel ratio” and “Throttle position” on the data logger menu. Select “none” on the data trigger menu. Then select “Start logging”. Make a “gentle” drive test, keeping throttle increases smooth and slow, and throttle opening below WOT i.e. < 2/3 open. This is to try and keep the O2 loop operating normally. Drive a few miles under various conditions. Start data logging only after normal engine temperature is reached.
- 4) Non O2 loop cars should be similarly tested, but you will not have a data output from the “O2 sensor adjust.” You will see much larger changes of A/F ratio than with an O2 loop car.

- 5) O2 loop cars - Stop the car, stop the data logging, and check that in the data log file the "O2 sensor adjust" parameter stays for the majority of the time within the range +/-10%. If you prefer a graphical output then select "Plot chart" and view the results. The maximum range of adaptation is +/-20%, so some margin is required. If it hits +/-20% then you will see that the A/F ratio will move away from stoich. If the A/F ratio suddenly decreases at various points, then you may find that the WOT switch was accidentally triggered, or that you hit the throttle too suddenly, which will also cause the O2 loop to be momentarily disabled. Also note that on the over-run (throttle closed, rpm above idle) the injectors are switched off.
- 6) If the data is not within the +/- 10% limits, then perform an "Autotune" on the idle and cruise maps by a test drive as described below. Otherwise if the number of cells requiring adjustment is small you can manually select and edit groups or individual cells with the on screen editor, which is self explanatory. After any changes are made to either the parameters of fuel maps you will automatically be prompted to save the changes you have made when exiting the program. ALWAYS use - "Save As" in the File menu then you will have a copy of the original before the run as well as the newer modified file in the directory for the session. Note that in this menu you can select save as type 27C128 (16k) or 27C256 (32k) files types. Select the option that matches your available stock of EPROMs
- 7) Non O2 loop cars – Stop the car, stop the data collection, and check the A/F ratio results. If you prefer a graphical output then select "Plot chart" and view the results. If the A/F is not within the reasonable limits, then perform an "Autotune" on the idle and cruise maps by a test drive as described below. Otherwise if only a small number of cells require adjustment you can manually select and edit groups or individual cells with the on screen editor, which is self explanatory. After any changes are made to either the parameters of fuel maps you will automatically be prompted to save the changes you have made when exiting the program. ALWAYS use - "Save As" in the File menu then you will have a copy of the original before the run as well as the newer modified file in the directory for the session. Note that in this menu you can select save as type 27C128 (16k) or 27C256 (32k) files types. Select the option that matches your available stock of EPROMs
- 8) Note that you cannot run data logging and Autotune at the same time.

QUICK START REMAPPING USING AUTOTUNE

- 1) It is possible to remap a modified 928 purely using Autotune, plus a little manual editing of map values as required. However it is essential that you understand the principles of what is going on, as described in this manual.
- 2) Autotune is a powerful feature allows "hands free" optimisation of the fuel maps. This can be used for non-cat cars, or for cars running with the normal O2 sensor and enabled O2 loop, selected by the 928 coding plug.
- 3) Due to various factors, Autotune may not always adjust all cells to a correct value. A second optimisation may often correct a cell value. Check your data runs to confirm that fuelling progressing smoothly as expected, without any sudden jumps in A/F ratio. Examination of the fuel map may also reveal a "rogue" cell. This can then be corrected by manual editing and extrapolation from adjacent cell values
- 4) You will have seen from earlier use of the SharkTuner that the operating point that is being used by the car under test is indicated by a moving BLUE cross, which moves into different cells of the map according to engine "load" i.e. MAF voltage, and engine rpm. When Auto tune is enabled, then as the pointer moves across the map, the cell values are adjusted to the target A/F ratio.
- 5) **When using Autotune the O2 loop is disabled automatically.**

- 6) If manually remapping with LH2.2, disconnect the stock narrow band O2 sensor from the LH ECU. (or the simulated narrow band O2 output, if used). Alternatively you can defeat the O2 loop in the Parameters screen **But remember to re-enable the O2 loop before saving the bin file and blowing an EPROM from that file, otherwise the O2 loop will be permanently disabled when that EPROM is used.**
- 7) With an O2 loop enabled cars like the LH2.2 equipped early US 32v, the target A/F ratio at idle and cruise have to be 14.7:1. This is not adjustable.
- 8) Idle and cruise A/F ratio **MUST** be optimised before any WOT runs and mapping are carried out.
- 9) Select the working Base Fuel Map. Select “Autotune” and the screen shown below will be displayed. Then select the required A/F ratio.
- 10) Check “Enable auto tune at IDLE” and also “Enable auto tune at CRUISE”. **Uncheck** “Enable auto tune at WOT”



- 9) Do a “gentle“ drive test, keeping throttle increases smooth and slow, and throttle opening below WOT i.e. < 2/3 open. Only select “Start Autotune” after the engine has reached normal water temperature. Drive several miles under various conditions including at idle.
- 10) As you drive, the cells on the map will be adjusted 10 times per second, and their colour will change accordingly. Corrected cells will change to GREEN, Cells which are still too rich are marked YELLOW, those which are too lean are marked RED. Cells not yet visited remain white. Many cells at the extreme top, bottom or sides of the table are never used, so do not expect all cells to be tuned.
- 11) If some cells are still in the YELLOW or RED range when tuning is complete, then first establish whether Autotune had completed, or whether it had run out of adjustment range on the cell. i.e. if a cell shows +1023 (max rich) and the cell is RED, then Autotune has run out of range. However, if the value in the cell is between +1023 and 0 Autotune has not completed adjustment on that cell. More driving is required.

Conversely, if a cell is YELLOW (too rich) and the cells is at 0, then the other limit of adjustment range has been reached.

If many cells are out of range, then it may be possible to correct the fuelling by selecting a different injector size on the “Parameters” screen. However, after such adjustment, all optimisation previously carried out will be invalid, and the remapping process will have to be repeated.

- 12) If YELLOW (too rich) then try increasing the chosen injector size by using the “Custom” option on the Parameters screen by a suitable %, based on the correction % required. Otherwise you could reduce the fuel pressure slightly if you have an adjustable FPR, but note that too low a fuel pressure may cause erratic spray patterns and poor throttle response. If you have to lower fuel pressure significantly, and “fool” the injector size parameter too much, then you have chosen injectors that are too large for the application. Note that fuel volume change versus pressure change follows an inverse square law. e.g. if you halve the fuel pressure, the flow will decrease by a factor of 0.7 times (reciprocal of square root of 2).
- 13) If RED cells are the majority, then mixture is too weak at these points. The first approach should be to reduce the injector size on the Parameters screen. A second approach could be to correct this by raising the fuel pressure. Doubling the fuel pressure will increase fuel flow rate by a factor of 1.4:1.

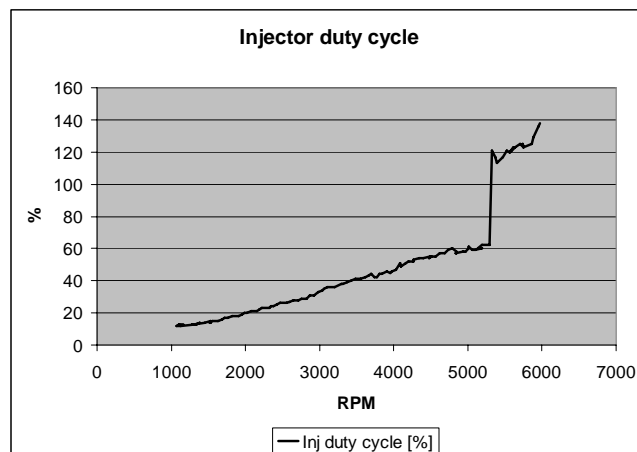
Bear in mind that a significant change required here suggests that the injectors are sized too small. Also note that you should keep a close eye on injector duty cycle when tuning the WOT map if there are these indicators that the injector size is too small size.

- 14) Please note that RED cells are a dangerous fault condition if they are ignored. At cruise they will result in weak running – not too serious. But if you attempt to run the car at WOT, then **SERIOUS DAMAGE COULD BE DONE TO THE ENGINE**. A weak mixture can cause detonation which can be very destructive. The early 32v (MY 85/86) engines do not have the knock sensor system of the later cars, so engine damage is a real possibility with a weak mixture.
- 15) When you return to the Autotune window when restarting Autotune, you will find that your previous settings have been retained.
- 16) When you have the majority of visited cells green, do a “save as” on the file.

AUTOTUNE WOT REMAPPING

- 1) The first requirement is that the idle and cruise portions of the base map have been checked and optimised as described above.
- 2) It is recommended with a new system that you set the fuel cut off to a low rpm limit for a first run e.g. 3500rpm. Set fuel restore to about 250rpm lower than the cut off rpm. Then increase the rpm limit in 500rpm steps, and optimise the fuelling each time.
- 3) Note that Autotune only operates on cells in the Base fuel map in use, and not cells on the WOT map. In general, this is valid, as these are cells which by definition are only used at high loads and rpm (i.e. are not used during normal “cruise” conditions). It is therefore unlikely that a cell is used at both WOT and non-WOT. If a cell shows up as not being able to be corrected at WOT, then adjust the WOT cell used at this load point to bring the fuelling within the range of Autotune on the base map.
- 4) Uncheck the “Enable auto tune at IDLE” and also uncheck “Enable auto tune at CRUISE”. **Check** “Enable auto tune at WOT”, and set the required A/F ratio. It is suggested that 13:1 is used for best power.
- 5) Then set the value of all the cells in the WOT map to *zero*.

- 6) If you are “tuning” on the public highway please enrol the help of a passenger to setup the Autotune, data runs, perform data analysis and adjust any values. Safety first!!
- 7) Note that although it is possible to edit map values manually while the car is running, this is not recommended on safety grounds.
- 8) Start the engine, check all is OK, start a gentle test drive (non-WOT) to warm the car up to normal temperature.
- 9) Make an Autotune run at WOT in a high gear up to the set rpm limit. This gives more time for the Autotune to work. Then review the map values. If any cells in the base map are near their maximum value of +1023 then manually select and increase the value in the corresponding rpm cell on the WOT map. Switch off the Autotune, and make a data logging run, logging rpm, injector duty cycle, A/F ratio and MAF signal absolute. Set the data logging trigger to “WOT switch”. Repeat the run with the modified values, then stop and review the data log file to confirm the desired A/F ratio is obtained within a reasonable margin – say +/- 0-5. Note that you cannot data log and Autotune at the same time.
- 10) Increase the rpm limit by 500rpm and repeat the process. Save the BIN file after each increment of rpm, with a suitable file name. Use as high a gear ratio as possible.
- 11) When you get to 4500rpm and above, make a careful note of “injector duty cycle” and “MAF signal %”. If the injector duty cycle is approaching 100% then more fuel pressure may be required, or the use of larger flow injectors. BUT note that any change of fuel pressure may require a readjustment of both the non WOT map as well as the values in the WOT map. Ideally, injector duty cycle should not exceed 85%
- 12) Note that you may observe a sudden jump in both injector duty cycle and also injector on-time values as you reach the higher load values in the map, as show in the example graph below. This step is due to the LH ECU software which switches the injector pulsing from once every engine rotation to once every engine firing cycle (i.e. once every 2 engine rotations.) This is to increase the fuelling time available at high rpm and load values. Under these conditions, the injector opening time becomes significant relative to the time for one engine rotation. Hence opening the injector only once per firing cycle rather than twice improves the available fuelling time by eliminating the injector opening time on the second rotation. In the example below, the maximum injector duty cycle is 70% at 6,000rpm.



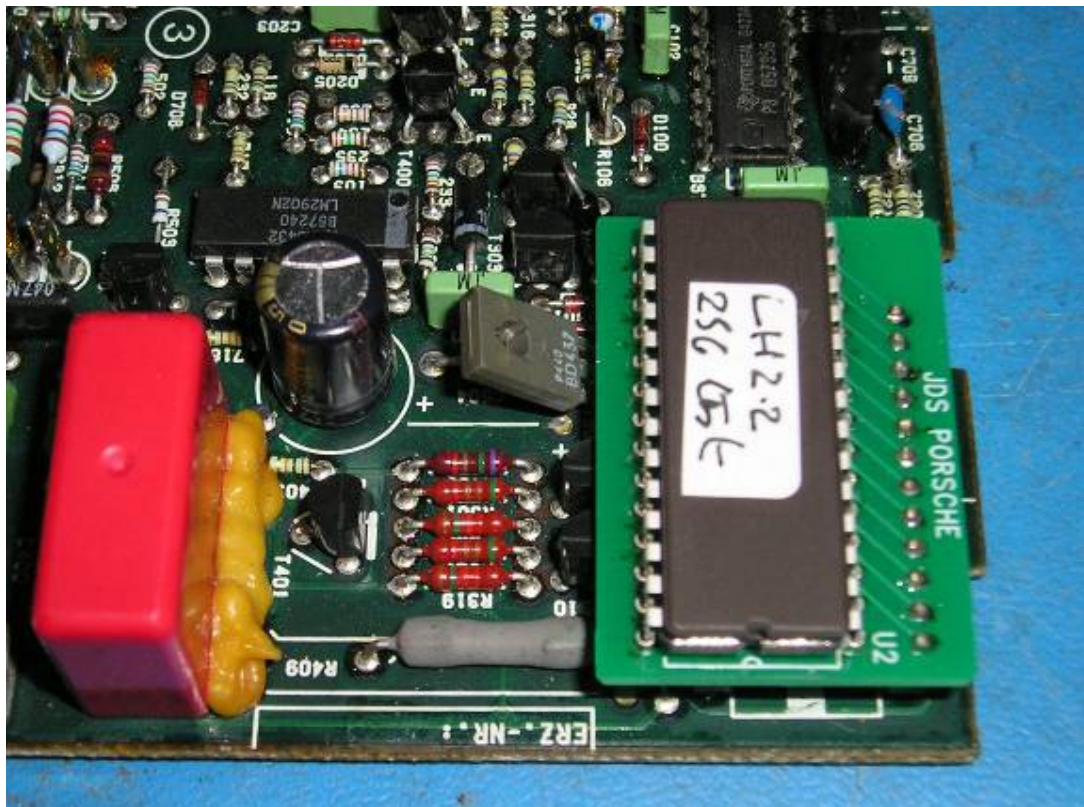
- 13) Note that the rpm point at which the transition occurs from 1:1 pulsing to 2:1 pulsing is adjustable in the Parameters screen
- 14) If the “MAF signal %” is near or at 100% then a recalibrated MAF unit may be required. However previous work has determined that up to about 450bhp crank, successful mapping to 12:1 A/F ratio has been achieved at WOT.

- 15) Note that above MAF signal 100%, you cannot map any higher values of fuelling accurately, and fuelling is then only based on an rpm basis only, with no load reference. This will result in no compensation for air density with variations of atmospheric changes, or changes in altitude.
- 16) Any final editing – for example if you require different A/F ratios at various rpm, rather than a standard value, can be carried out manually.
- 17) If all is well, save the data file “save as “Final XXX “ or whatever name you want. Make sure to save the file as the correct EPROM device type that matches your stock of devices.
- 18) Then reconnect the O2 sensor plug to the LH ECU.

MAKING A COPY EPROM

- 1) You will have to make a new EPROM to replace the SharkTuner connection to your LH ECU.
- 2) Connect your laptop to your EPROM reader/writer – usually via the printer parallel port.
- 3) Close down any other running programs, and start the EPROM program. Select the EPROM type that you wish to copy to.
- 4) When prompted, insert a blank EPROM into the reader/writer socket. Make sure pin alignment agrees with the instructions given with the programmer. Pin 1 is always at the “notched “ end of the EPROM. If the EPROM socket on the EPROM reader/writer has more than 28 sockets, be careful to align the EPROM pins according to the instructions provided with the reader/writer.
- 5) These EPROMS are pretty rugged, and quite difficult to damage, but bear in mind there are static sensitive. Take reasonable precautions.
- 6) Check that the reader/writer recognises that a blank EPROM has been fitted by monitoring the on screen messages.
- 7) Load the required (modified) BIN file that you have created, then “program”. Then check that the EPROM contents agree with the BIN file contents.
- 8) Remove the EPROM and place a label with filename and date over the UV window.
- 9) Disconnect the battery negative lead first, then unplug the LH ECU and remove it from the car.

Note that the LH2.2 requires an adaptor board in order to use EPROMs larger than the 2732A i.e. 28 pin 27C256, 27C512 etc. The adaptor allows these 28 pin EPROMs to plug into the 24 pin EPROM socket used in the LH2.2 ECUs.



Note carefully the fitted orientation of the adaptor board. And also the orientation of the EPROM notch relative to the “notch” marked as part of the legend on the adaptor board.

Fit the new EPROM into the adaptor board. Take care that all pins engage correctly before pushing the EPROM pins fully into the adaptor board.. Also take care not to bend the pins of the adaptor board. You may find it safer to fit the adaptor board to the LH socket first, and then fit the EPROM to adaptor board.

- 10) Reconnect and start the car and check that all is well. If you are using the TechEdge WBO2 system as supplied with the SharkTuner, you will need to continue to power the WBO2 electronics and the sensor and SharkTuner box. NEVER run the engine without the sensor being powered, or the sensor may be contaminated beyond recovery.
- 11) If you want to remove the WBO2 system, and you have remapped your car to run closed loop, you can remove the WBO2 sensor, and replace it with a standard narrow band sensor. This is then connected in the standard way via the 3 pin circular connector on the floor below the fuse/relay panel.
- 12) If your car was remapped to run open loop, then you can remove the WBO2 system and sensor, and block off the sensor port with a M18 x 1.5 blanking plug.
- 13) It is strongly recommended that you retain some type of A/F ratio monitoring device as a safety monitor if a fault develops with the engine management system.
- 14) Drive and enjoy!

EPROM TYPES

The LH/EZ-F 2.2 SharkTuner will save the bin file at the end of a tuning session in 2732A, 27C128, 27C256 and 27C512 formats for a LH2.2 bin file.

For LH2.3 ECUs the options available are 27C128, 27C256 and 27C512

If your EPROM programmer supports electrically erasable flash memory chips, then the type 27SF256 can be used for LH2.3 type ECUs.. These EEPROMs are slightly more expensive than their EPROM equivalents but have the advantage that they can be easily erased and reused. One make of programmer that supports EEPROMs can be found here

<http://www.progshop.com/shop/programmer/eprombrenner4/index.shtml>

EZ-F IGNITION ECU MONITORING, DATALOGGING AND REMAPPING

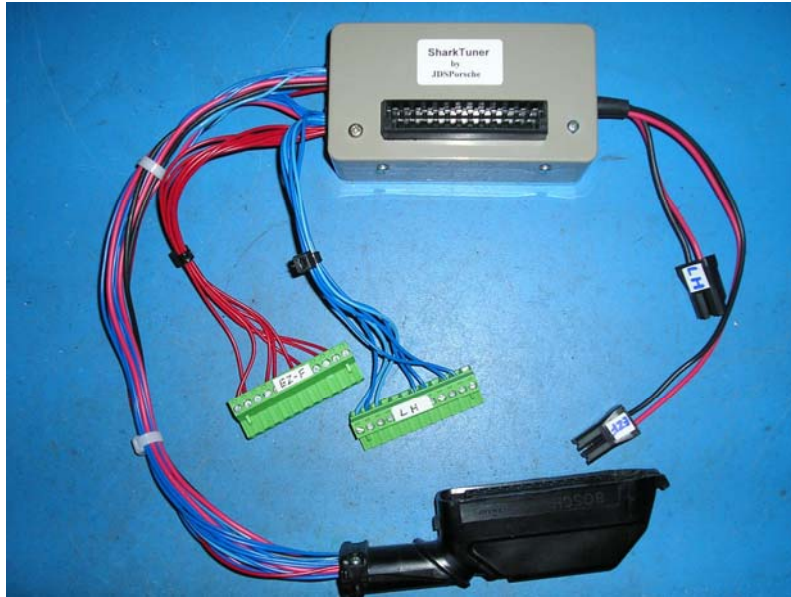
PREPARING THE CAR FOR SHARKTUNER CONNECTION

As mentioned previously, a diagnostic socket is not present on the 85/86 cars. Connections from the cars sensors and signals have to be manually connected to the Auxiliary circuit board of the SharkTuner.

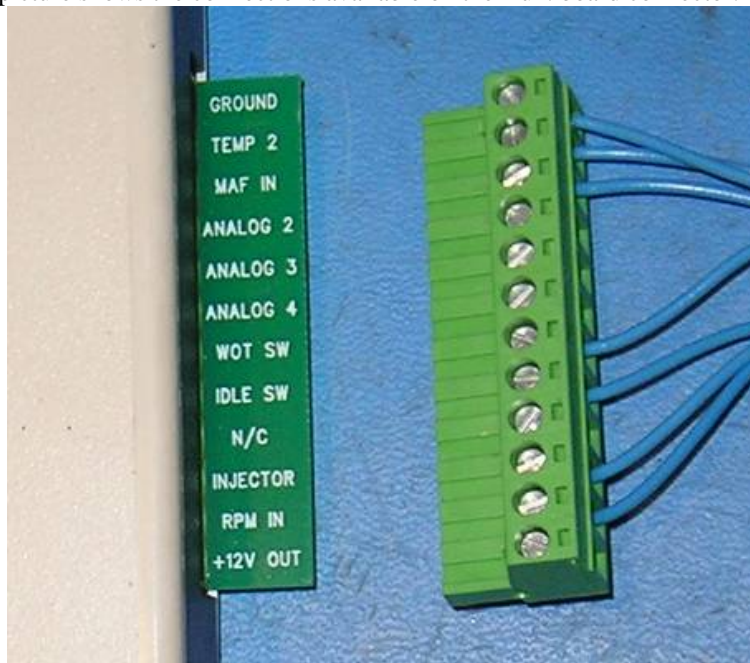
The picture below shows the SharkTuner with the new Auxiliary input board. Also shown is the mating connector which accepts the wires from the cars harness or Break out Box



- 25) This is a view of a typical break out box, made from a 25 way male (chassis mount) and female (cable mount) 25 way connector parts. These connectors were used on Volvo cars in the mid 1980s (e.g. Volvo 740/760 turbo) and are readily available from car breakers. This assembly makes it possible to “plug and play” to SharkTune a car. Also note the leads brought out into the SharkTuner auxiliary board connectors and power connections for ignition switched 12v and ground.



26) This picture shows the connections available on the Aux. board connector.



The necessary connections to the EZ-F ECU, either directly into the cars EZ-F cable form/plug, or from a break out box are (from the top)

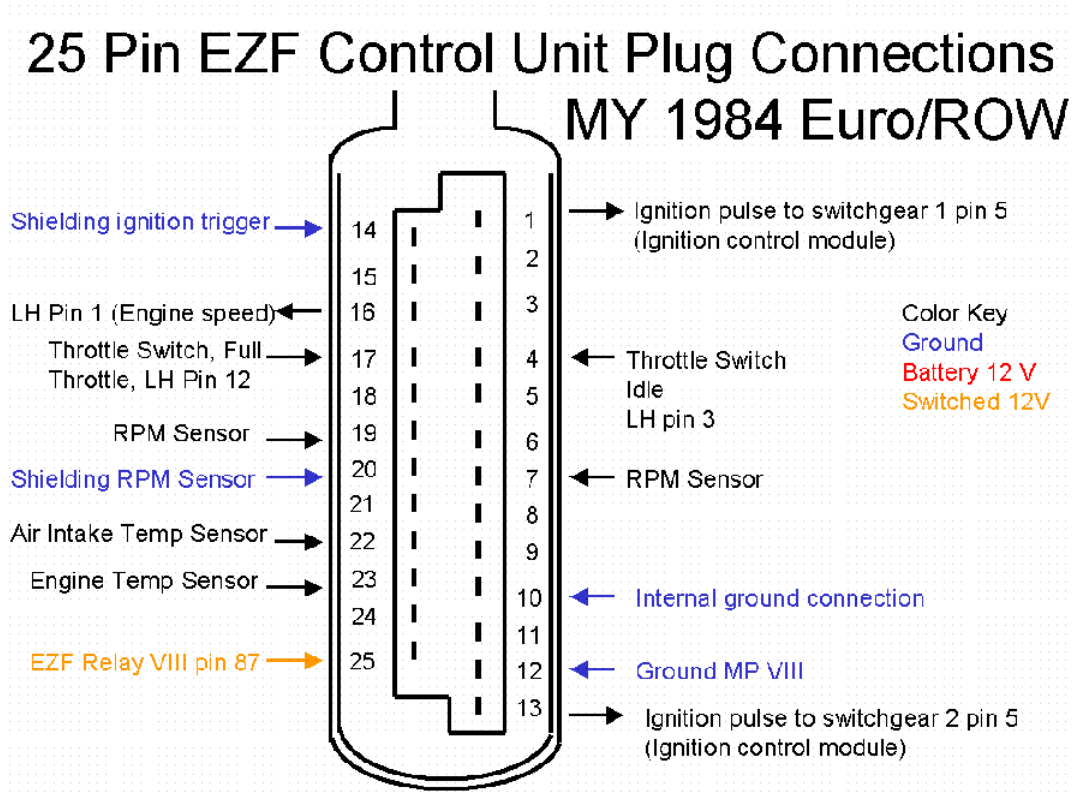
These connections are different to those required for the LH2.2 ECU

GROUND	Pin 12 EZ-F connector (also use for ground connections to external Aux inputs)
Temp 2 sensor	Pin 23 EZ-F connector
MAF volts	Not used
Analog 2	Pin 22 EZ-F connector (Air temp sensor #1)
Analog 3	Pin 15 EZ-F connector (Manifold vacuum sensor output, see later notes)
Analog 4	See later in text – available for Aux input
WOT switch	Pin 17 EZ-F connector
Idle switch	Pin 4 EZ-F connector
N/C	No connection
Injector	Pin 1 EZ-F connector (used for coil output stage signal input)

RPM pulses Pin 7EZ-F connector
 +12v put Ignition switched +12v, thermal resetting fuse 200mA maximum

If wiring into the EZ-F cableform directly, the diagram below will assist in locating the connector pin numbers mentioned above.

NOTE: If making a break out box, then the following extra pins require to be linked through -Pins 4, 15 and 22 in addition to those previously used from the LH ECU.



This view is looking into the open end of the disconnected cable connector

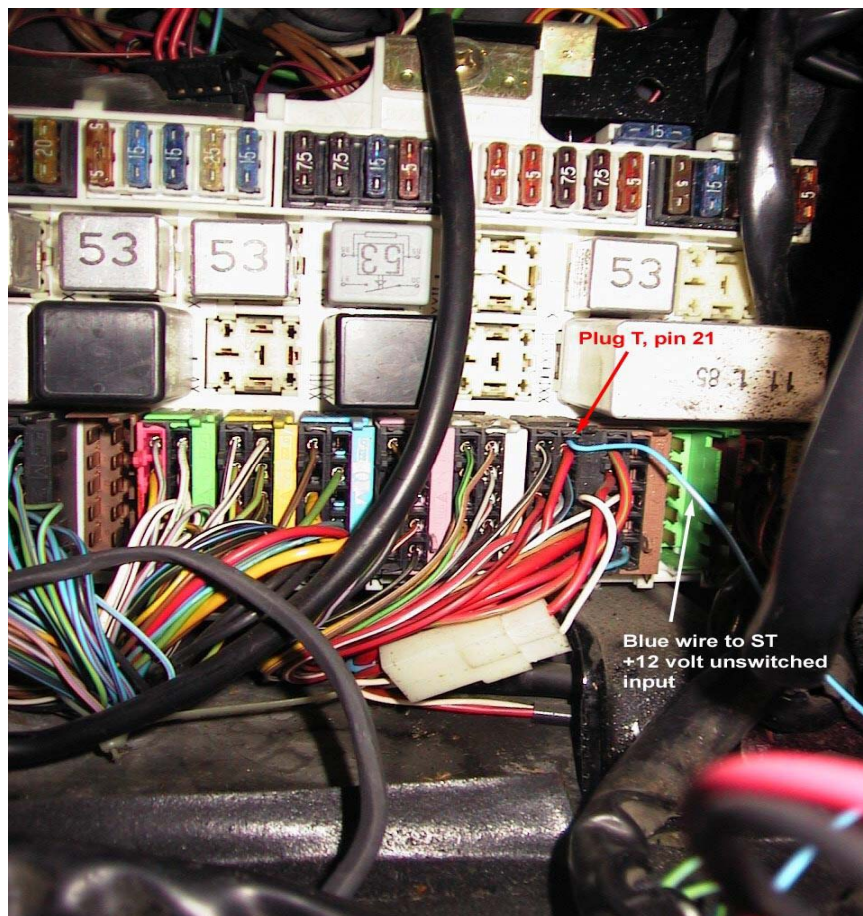
27) The other necessary connections are the power supply feeds to the SharkTuner from the car. A additional type of power lead is supplied with this version of the SharkTuner .



The 3 connections required to this lead are :-

+12v unswitched **BLUE** :-

Wired from main +12v feed on fuse relay board. **It is recommended that an in line fuse is inserted in this line – rated at 5A.**



+12v ignition switched **RED** :-
This can be wired from Pin 25 of the EZ-F connector

Ground (chassis) **BLACK** :-
This can be wired to pin 12 of the EZ-F connector, or to the main fuse/relay panel.

NOTE – THE REQUIRED POWER CONNECTIONS FOR LH AND EZ-F ARE WIRED TO DIFFERENT PINS OF THEIR 25 WAY CONNECTORS !! DAMAGE MAY RESULT IN AN INCORRECT CONNECTION .

28) The power lead and Aux board connectors can now be plugged into the SharkTuner box –

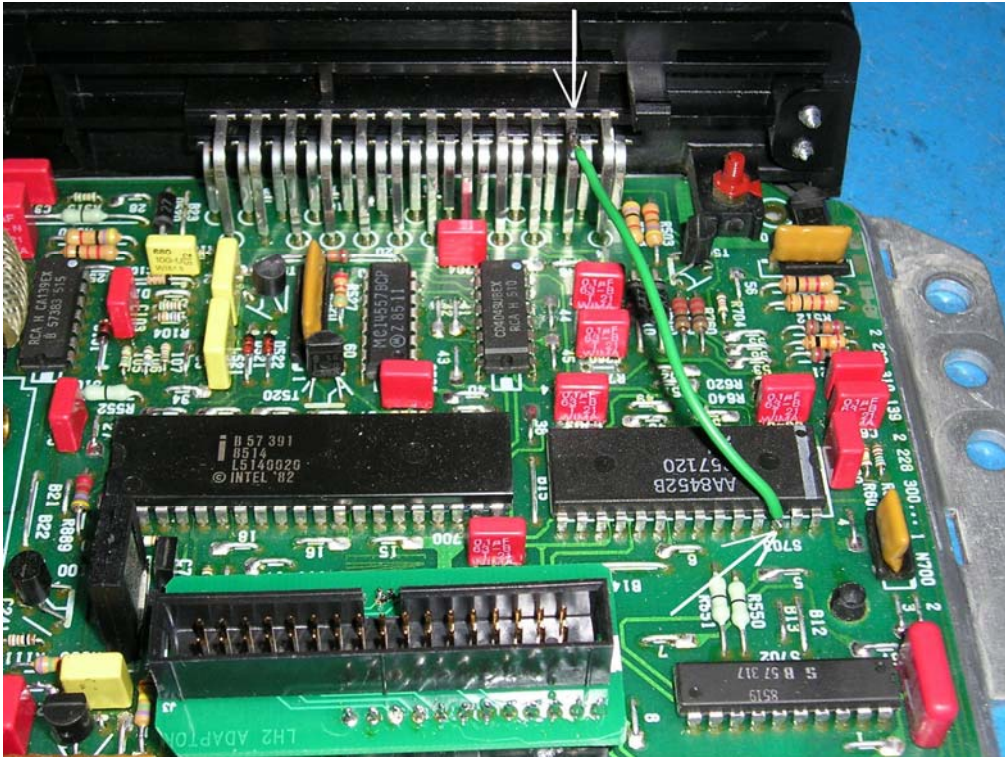


PREPARATION and INSTALLATION OF THE EZ-F ECU

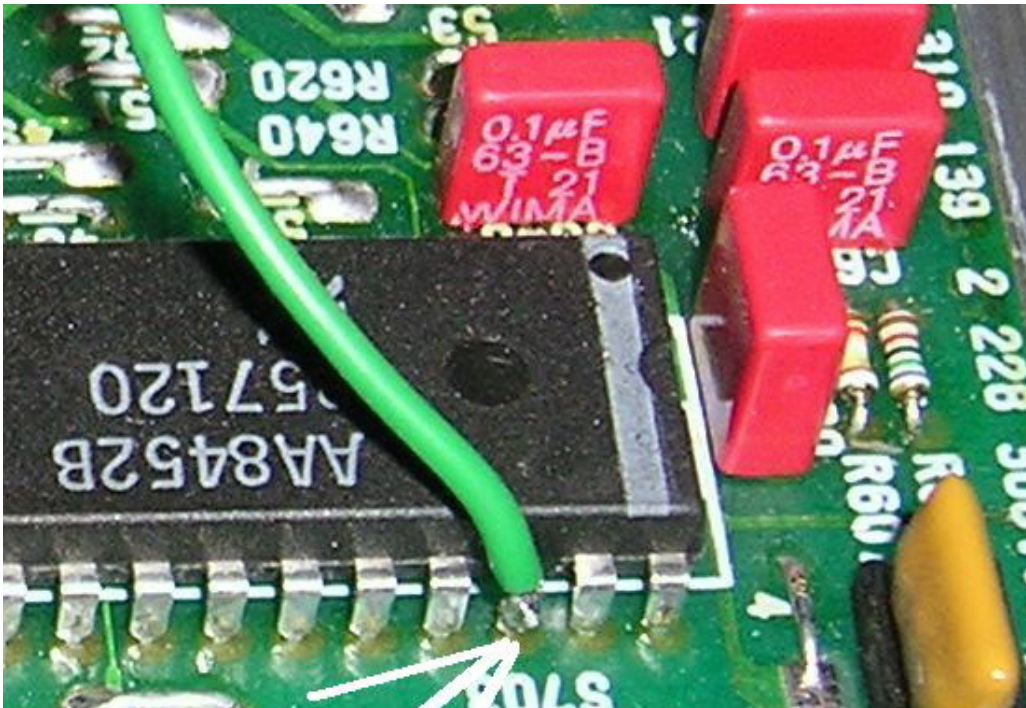
Remove the EZ-F ECU from the car after disconnecting the battery ground connection. Remove the lid after bending back the 8 retaining tags.

The “load” signal for the EZ-F is obtained from the manifold vacuum sensor fitted inside in the EZ-F (with the manifold vacuum pipe attached). This signal is required to obtain the operating point marker for the SharkTuner. However this signal is not normally brought out onto the 25way connector. It is necessary to make a connection from the vacuum sensor output to pin 15 of the 25 way connector with a wire link on any used for SharkTuning. Pin 15 is normally unused.

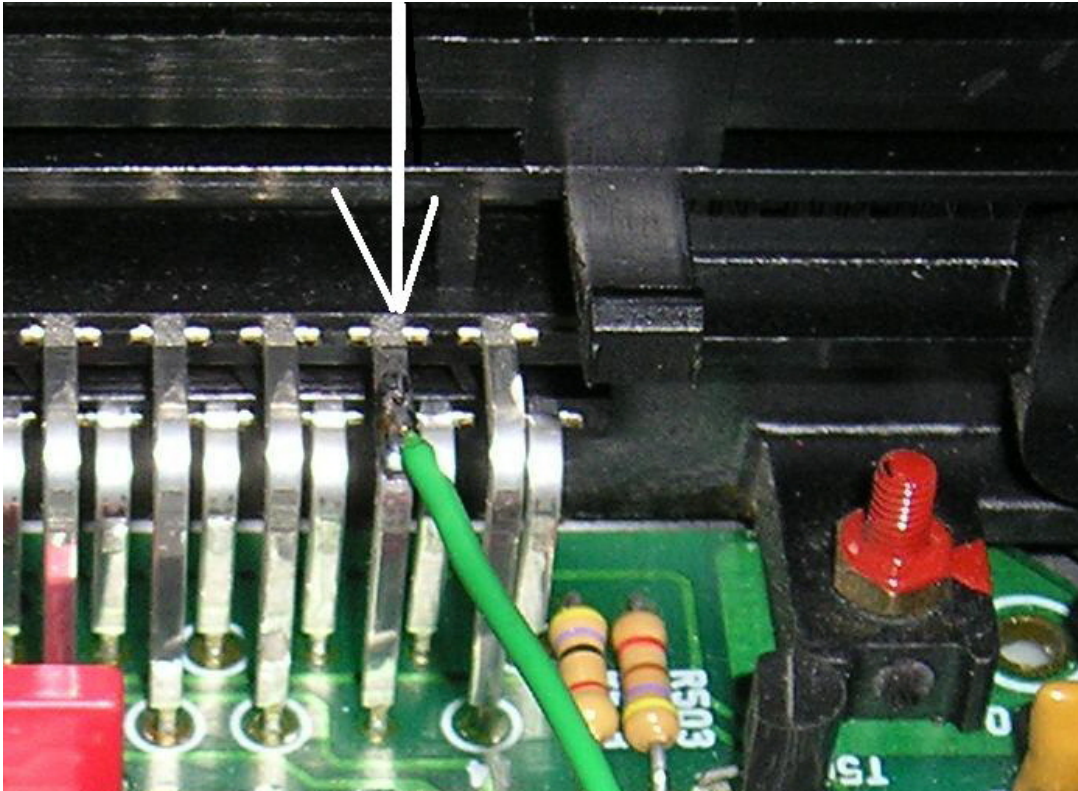
This picture is a general view of the required link:-



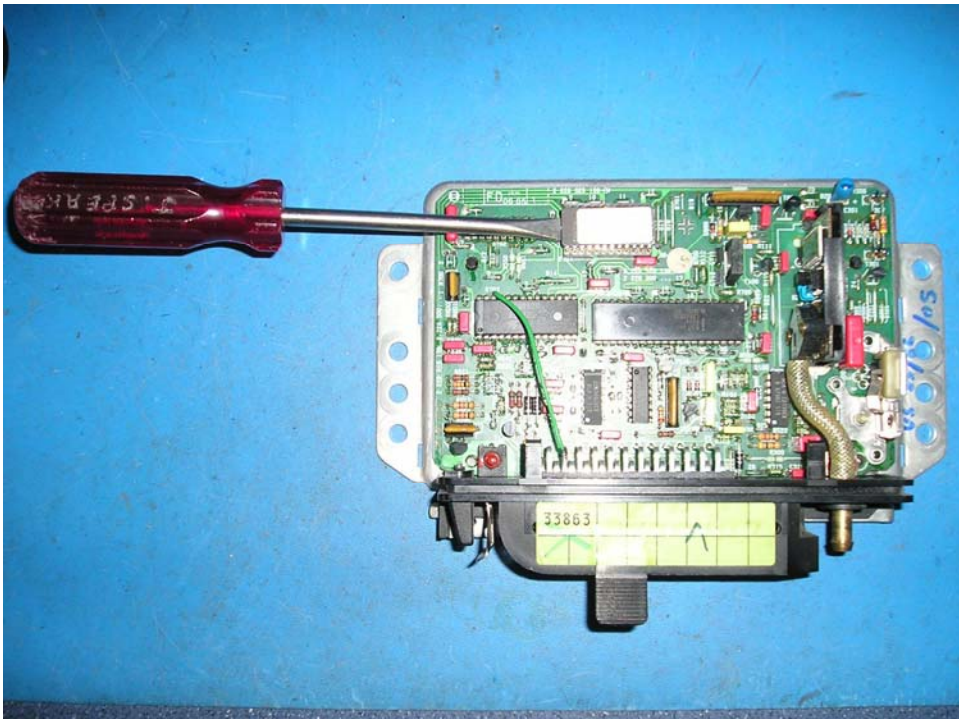
This is a closer picture of the connection to vacuum sensor output signal :-



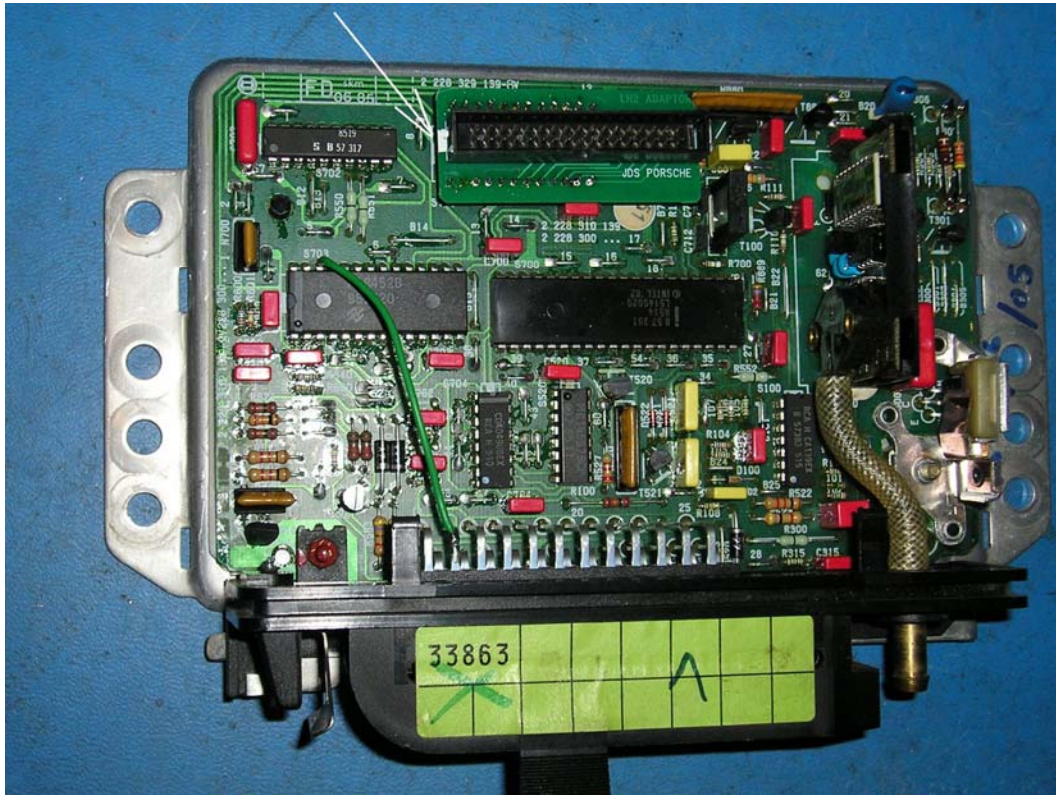
And this is a close up picture of the other end of the wire, connected to pin 15 of the 25 way connector. :-



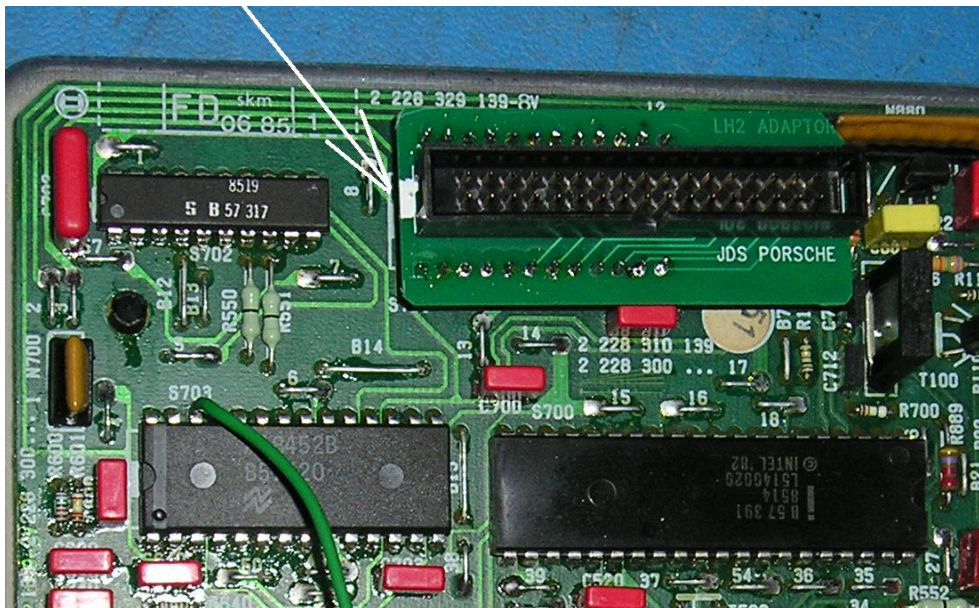
The EPROM should be carefully removed by carefully levering each end in turn with a flat bladed screwdriver.



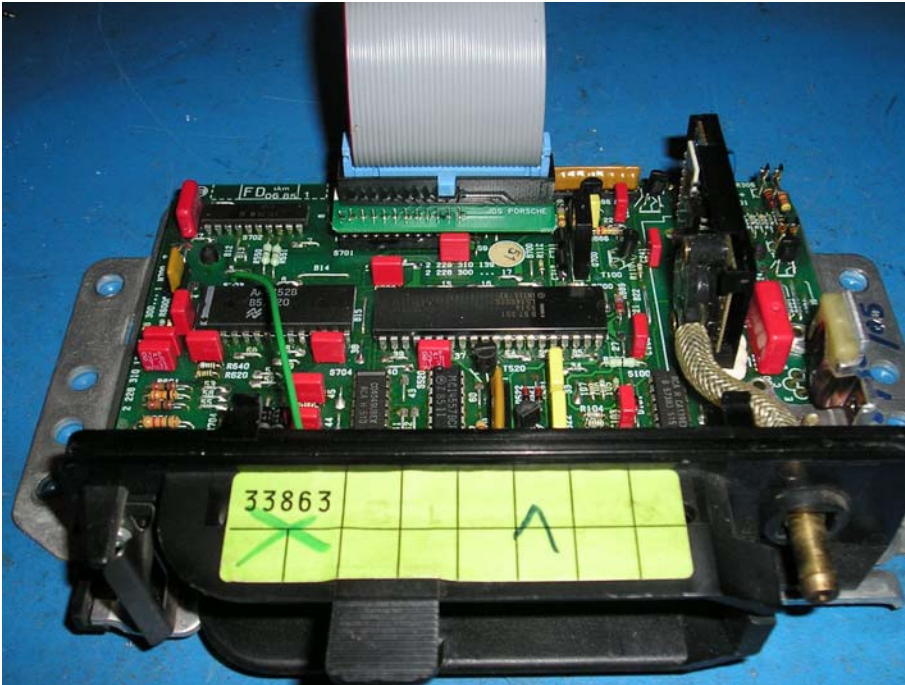
Then insert the EPROM adaptor. Not that his is a different version than the one used with LH2.2. The version for EZ-F has a vertical entry for the ribbon cable.



Note the white marker orientation...



Insert the ribbon cable.



The EZ-F ECU can now be plugged into the car's 25 way connector. Refit the vacuum pipe to the nozzle on the EZ-F ECU. Reconnect the battery ground lead.

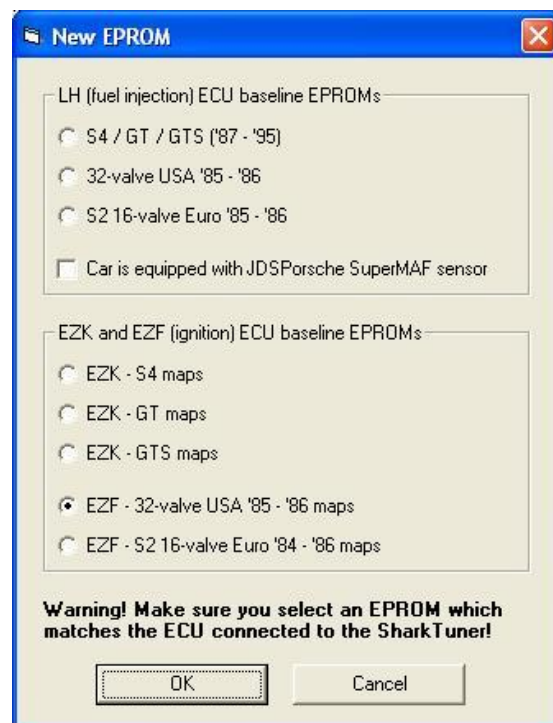
Preparation is now complete.

USING THE EZ-F SHARKTUNER

- 1) Plug the power lead, Auxiliary 12 way connector and data leads into the SharkTuner box.
- 2) Check that power LED (Yellow) on the SharkTuner is illuminated as soon as the Blue power wire is connected. Switch the ignition key to the first position, and check that the Green LED is also lit.
- 3) Switch off the ignition.
- 4) It is assumed that the SharkTuner programme has been installed on the laptop, and checked as working correctly, as per the LH section of this manual
- 5) Run the SharkTuner .exe file. The flash screen below will be displayed for a few seconds...

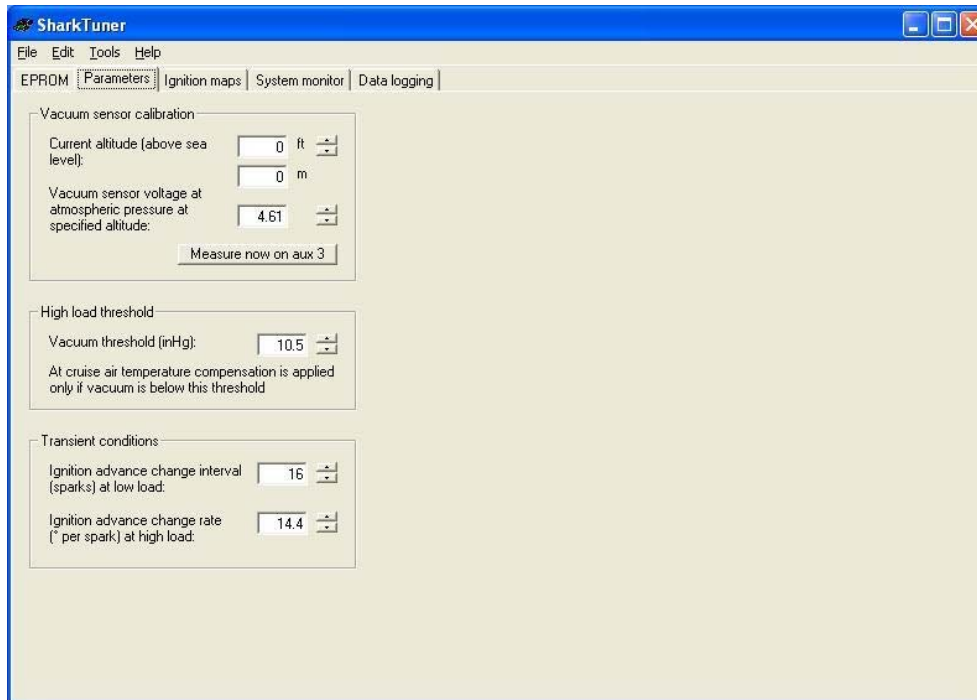


- 6) Then select the required bin file from the “File” and “New” menus :-



MEASUREMENT AND CALIBRATION OF THE VACUUM SENSOR

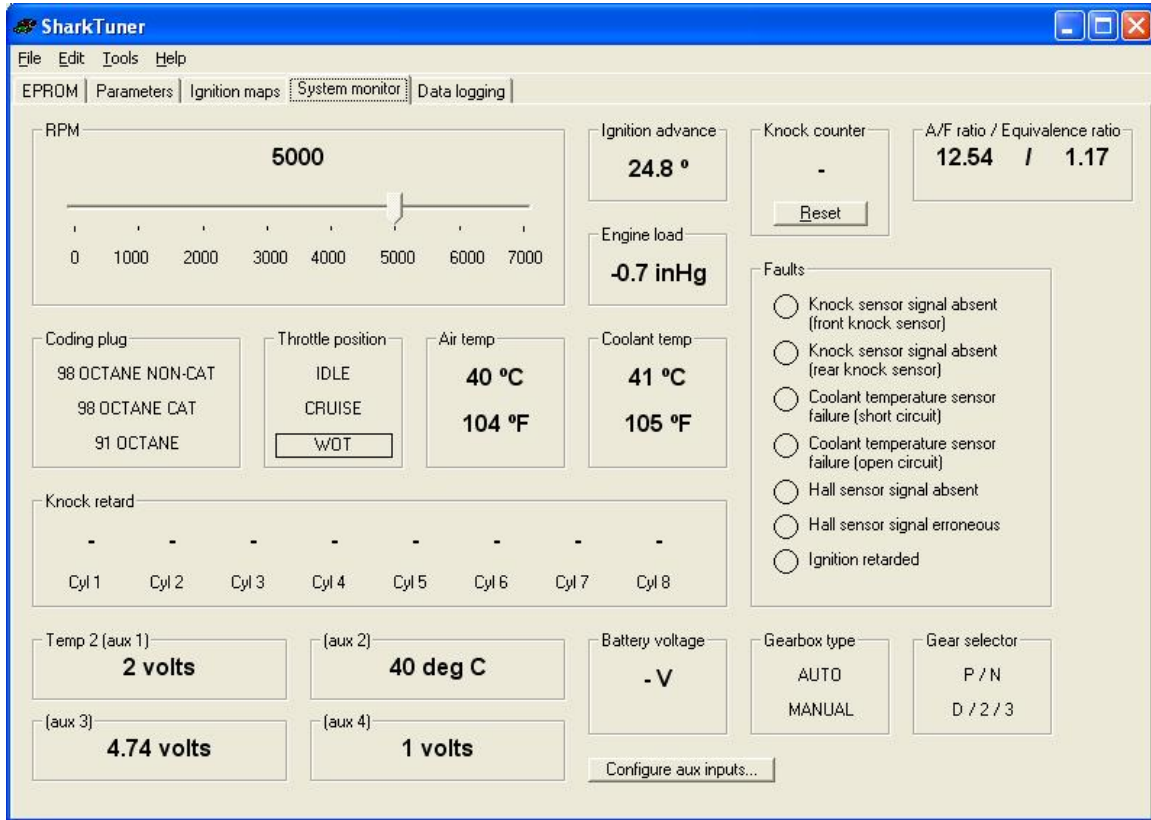
- 1) It is essential to measure the manifold vacuum sensor voltage with the SharkTuner, before starting work.
- 2) Switch to the “Parameters” screen.



- 3) **First** enter your present altitude in the top window using the radio buttons.
- 4) Then switch on the ignition but do not start the engine, and click the “measure now”. The value that has been read from the vacuum sensor via pin 15 will be entered automatically. The reading should typically be in the range 4.25 to 4.75v at sea level.. If the measurement is not in this range, disconnect the vacuum line to the EZ-F to confirm there is no residual vacuum, and try the measurement again. If the measurement is still substantially outside the range quoted then the vacuum sensor is faulty, and the unit repaired.
- 5) Note that the sensor in the EZ-F can only measure manifold vacuum. It cannot measure useful positive manifold pressures, as can be experienced with a forced induction engine.
- 6) Note that if any altitude greater than sea level is entered, the measured value will be offset to correctly compensate the value measured. So that at 1000ft altitude,. a sea level measurement of 4.71v will be offset and shown as 4.52v; at 2000ft it will be 4.34v and at 3000ft 4.17v. and so on. See Appendix 1) for a graphical display of the upper and lower limits of vacuum sensor output voltages at zero vacuum versus altitude above sea level.
- 7) The middle window allows variation of the vacuum value or “load” at which the air temp compensation map is brought into play. See later description of the ignition maps.
- 8) The lower window allows variation of the effective response time of the ignition timing changes as engine conditions change during driving.

THE SYSTEM MONITOR AND IGNITION MAP SCREENS

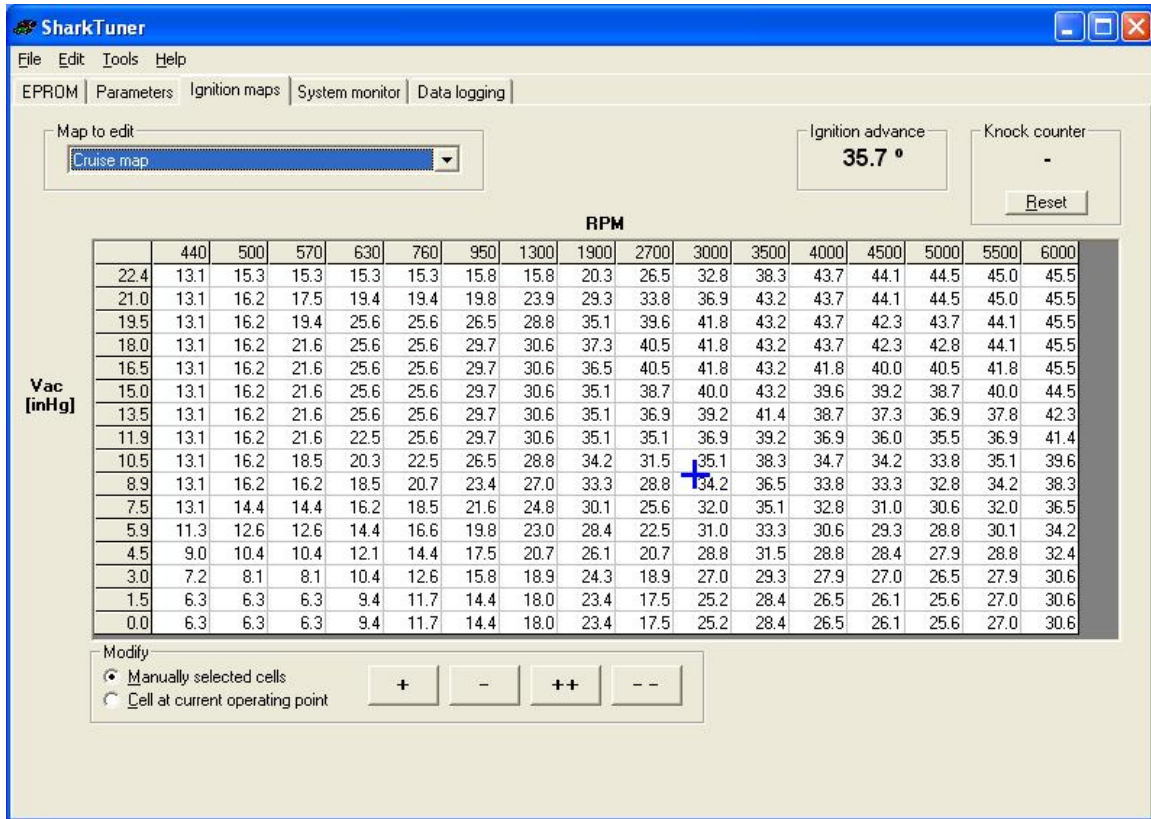
The engine can now be started. Switch to the System monitor screen...



- 1) As the EZ-F does not have any knock detection capability, the Knock retard, knock count and Faults windows do not register values. Similarly, Coding plug, battery voltage, gearbox type and gear selector do not display values.
- 2) Real time values (which all may be data logged) are rpm, load (measured as manifold vacuum relative to atmospheric pressure), throttle switch position, ignition advance, Coolant temperature (temp 2) and intake air temperature (Temp 1 in the base of the air filter base).
- 3) Air/fuel ratio is monitored if this input is connected to a suitable wideband system. See LH section of this manual for further details.
- 4) The “Configure Aux Inputs” button at the bottom of this screen allows use of the Auxiliary inputs. However, please note that as Analog 1, 2 and 3 are used for Temp 2, Temp 1 and vacuum sensor input respectively, so that only Analog 4 is available for other uses.
- 5) Confirm that all the above input signals are being registered logically.
- 6) Switch to the ignition map screen.

THE CRUISE MAP

The cruise ignition map is the first map shown...



Note that there are three separate maps, the cruise map, an idle map, and a WOT (wide open throttle – activated at typically 2/3 open throttle). The operating point marker will only appear on the map if the correct throttle position is in use.

The horizontal axis is rpm. The vertical axis is “load” or inlet vacuum relative to atmospheric pressure , measured in inches of mercury (inHg). High load values are at the bottom of the screen. A typical value at idle is about 22inHg. A value substantially less than 20 inHg suggests a vacuum leak or other engine problem.

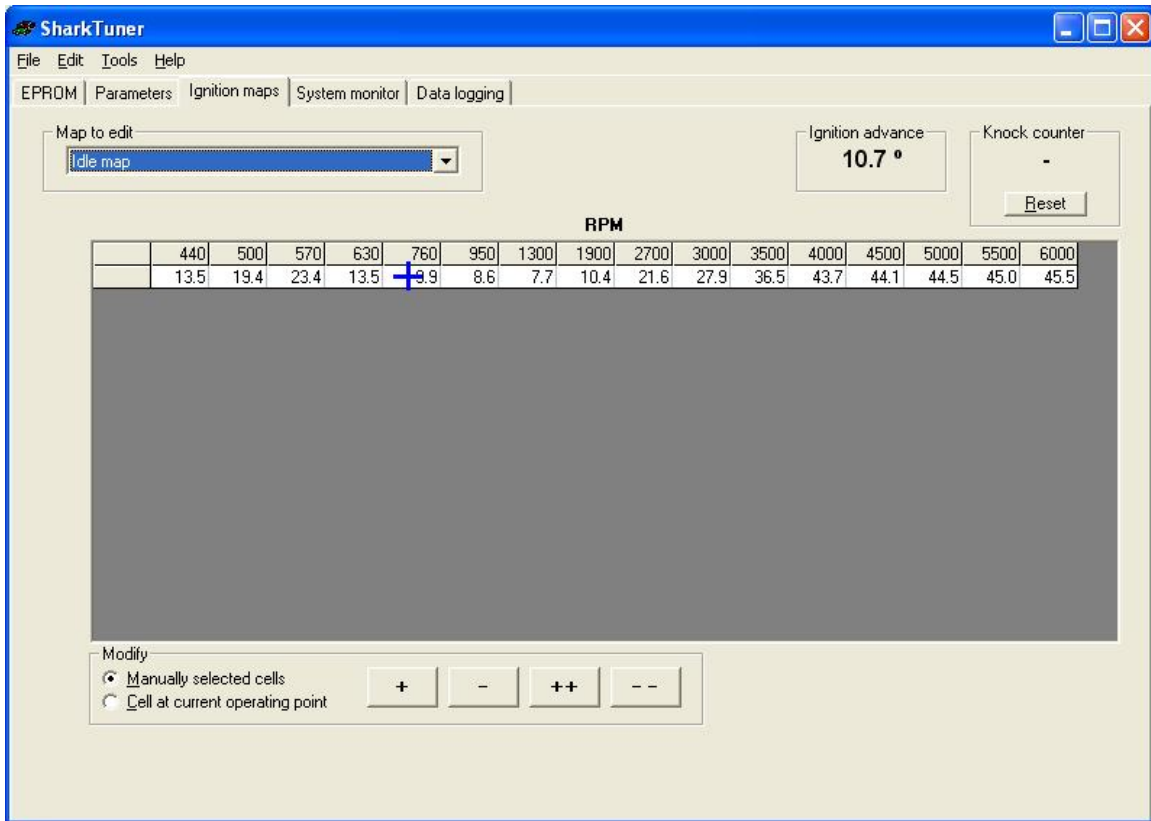
The “+” , “=” and “++” , “--”radio buttons change the ignition advance values by 1.8 degrees and 3.6 degrees respectively. The changes of value may be made on the cell at the operating point marker by selecting “Cell at current operating point” or a group of cells can be selected using the Left Hand mouse button in the normal manner.

The current ignition advance number is also indicated at top right of the window.

Note that the ignition advance applied to the engine is the sum of the cruise map value + warmup compensation map value + air temp map value.

Each of these three maps have a resolution of 0.45 degrees when editing. But the final advance value calculated by summing the three values mentioned above is rounded UPWARDS to the nearest multiple of 1.8 degrees.

THE IDLE MAP



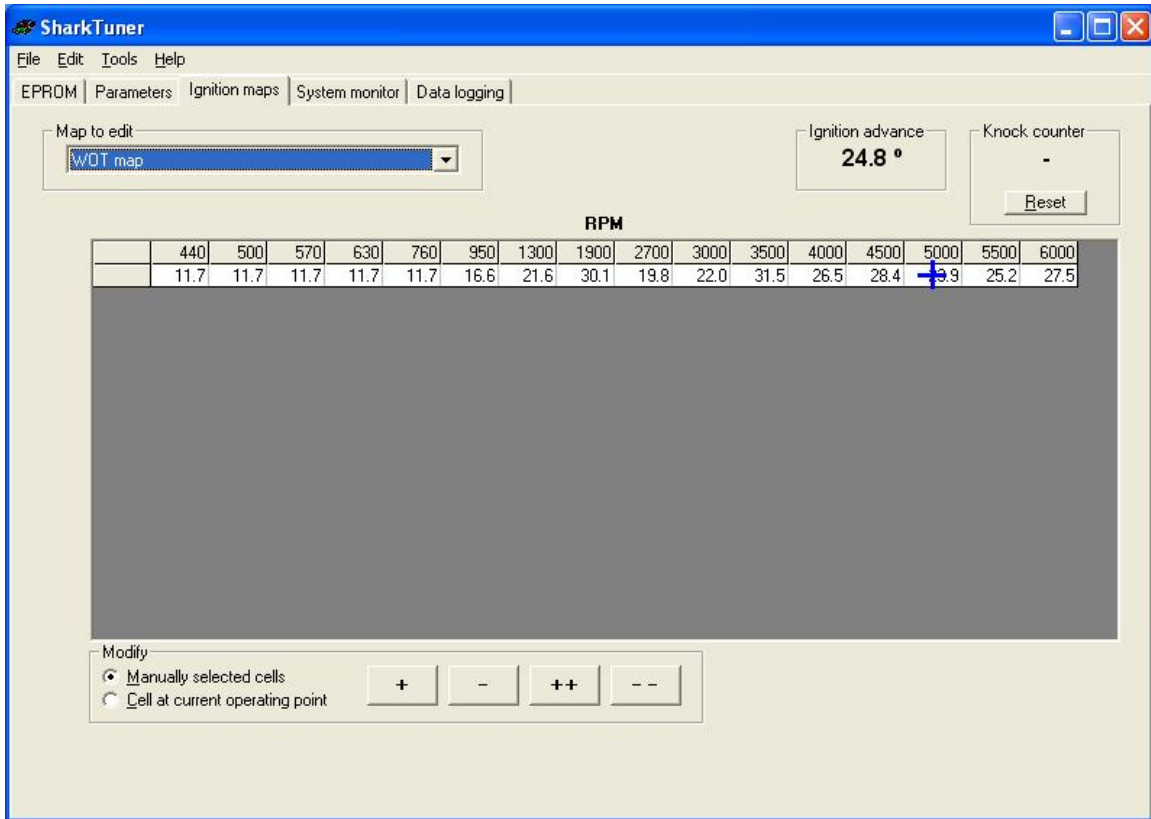
The idle ignition map is based on rpm only. Editing using the lower radio buttons is the same as for the cruise map.

The current ignition advance number is also indicated at top right of the window.

Note that the ignition advance applied to the engine is the sum of the idle map value + warmup compensation map value + air temp map value.

Each of these three maps have a resolution of 0.45 degrees when editing. But the final advance value calculated by summing the three values mentioned above is rounded UPWARDS to the nearest multiple of 1.8 degrees.

THE WOT MAP



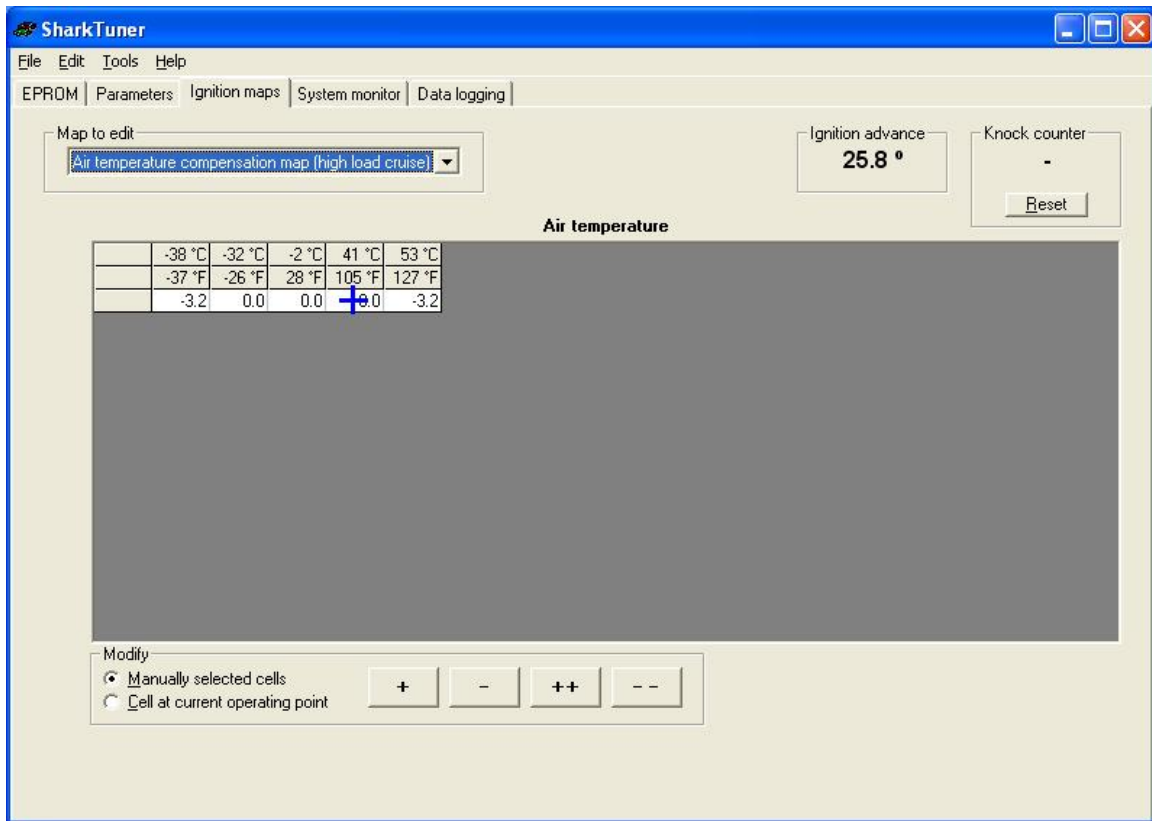
The WOT ignition map is based on rpm only. Editing using the lower radio buttons is the same as for the cruise map.

The current ignition advance number is also indicated at top right of the window.

Note that the ignition advance applied to the engine is the sum of the WOT map value + warmup compensation map value + air temp map value.

Each of these three maps have a resolution of 0.45 degrees when editing. But the final advance value calculated by summing the three values mentioned above is rounded UPWARDS to the nearest multiple of 1.8 degrees.

THE AIRTEMP COMPENSATION (HIGH LOAD CRUISE) MAP



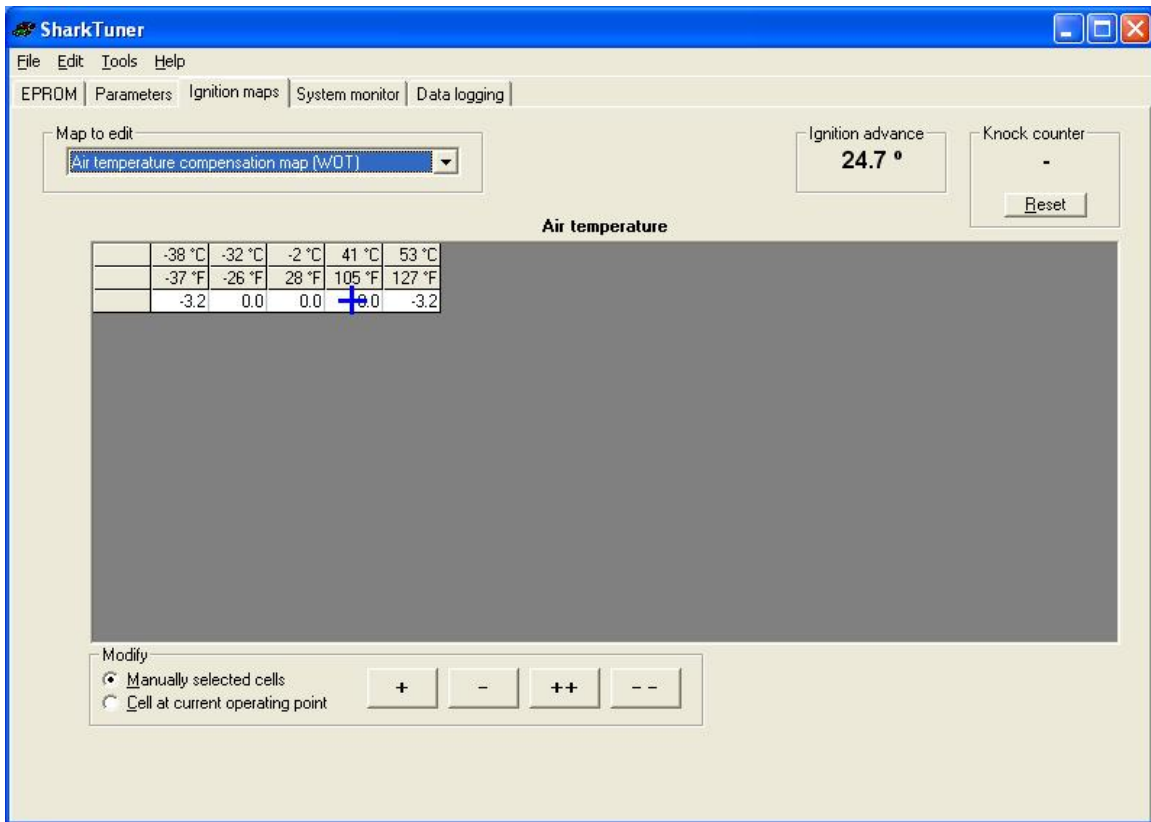
This map uses intake air temperature values, measured by the temperature sensor #1 which is fitted in the lower half of the engine air filter housing. The default setting is that this map is only activated when the load value (manifold vacuum) as the throttle is opened results in the inlet vacuum dropping to less than 10 inHg.

This vacuum threshold setting can be changed on the “Parameters” screen, as shown in the picture on page 58.

The map is used to retard the ignition at high loads when the throttle switch is at cruise and when the air temperature has risen to a high value. This temperature can be reached when the car is stationary for a few minutes, even when the ambient air temp outside the car is temperate i.e. 20deg C (68 deg F)

Only zero or negative values may be entered.

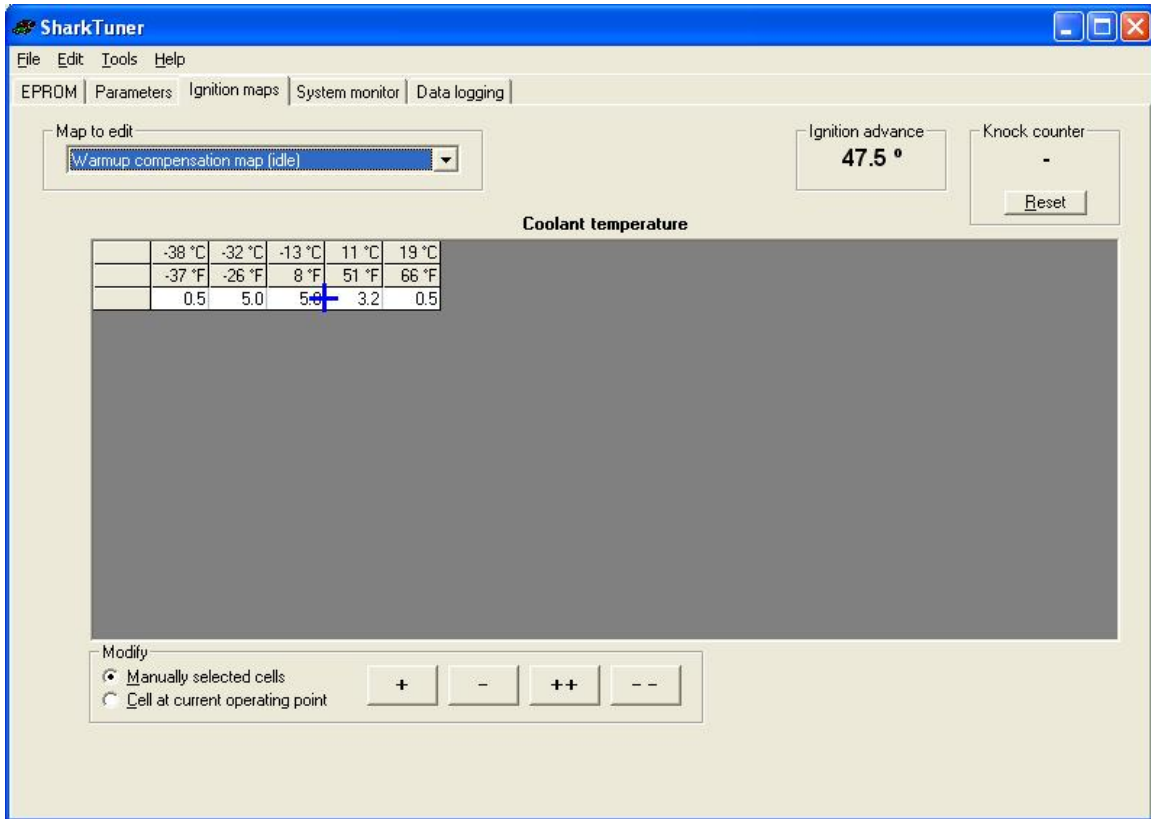
THE AIRTEMP COMPENSATION (WOT) MAP



This map also uses intake air temperature values, measured by the temperature sensor #1 which is fitted in the lower half of the engine air filter housing. This map is only used when at WOT, and the marker only appears at WOT. The map is used to retard the ignition at WOT when air temperature rises to a high value. This can be reached when the car is stationary for a few minutes, even when the ambient air temp outside the car is temperate i.e. 20deg C (68 deg F)

Editing using the lower radio buttons is the same as for the cruise map. Only zero or negative values may be entered.

THE WARMUP COMPENSATION MAP (IDLE)

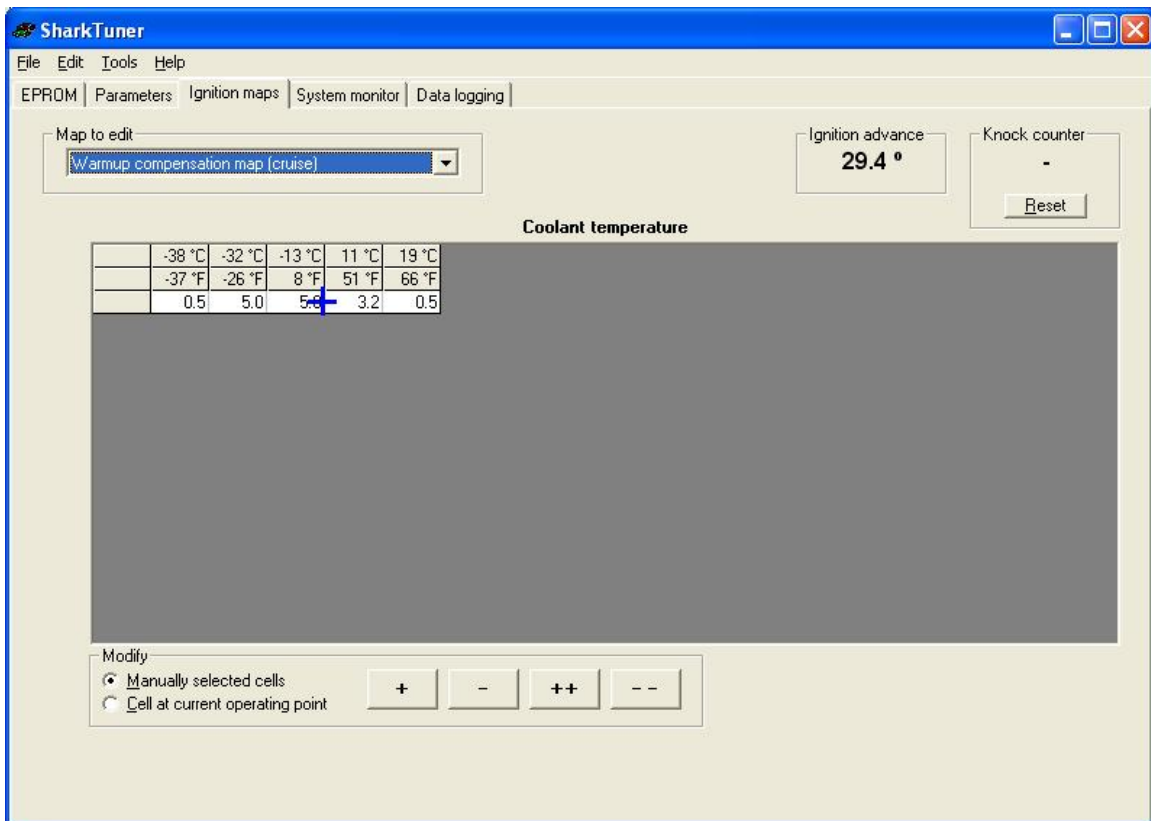


This map uses engine water temperature (Temp sensor #2). The idle compensation map is only effective at very low water temperatures.

Note that only positive values may be entered on this map i.e. ignition advance

Editing using the lower radio buttons is the same as for the other maps.

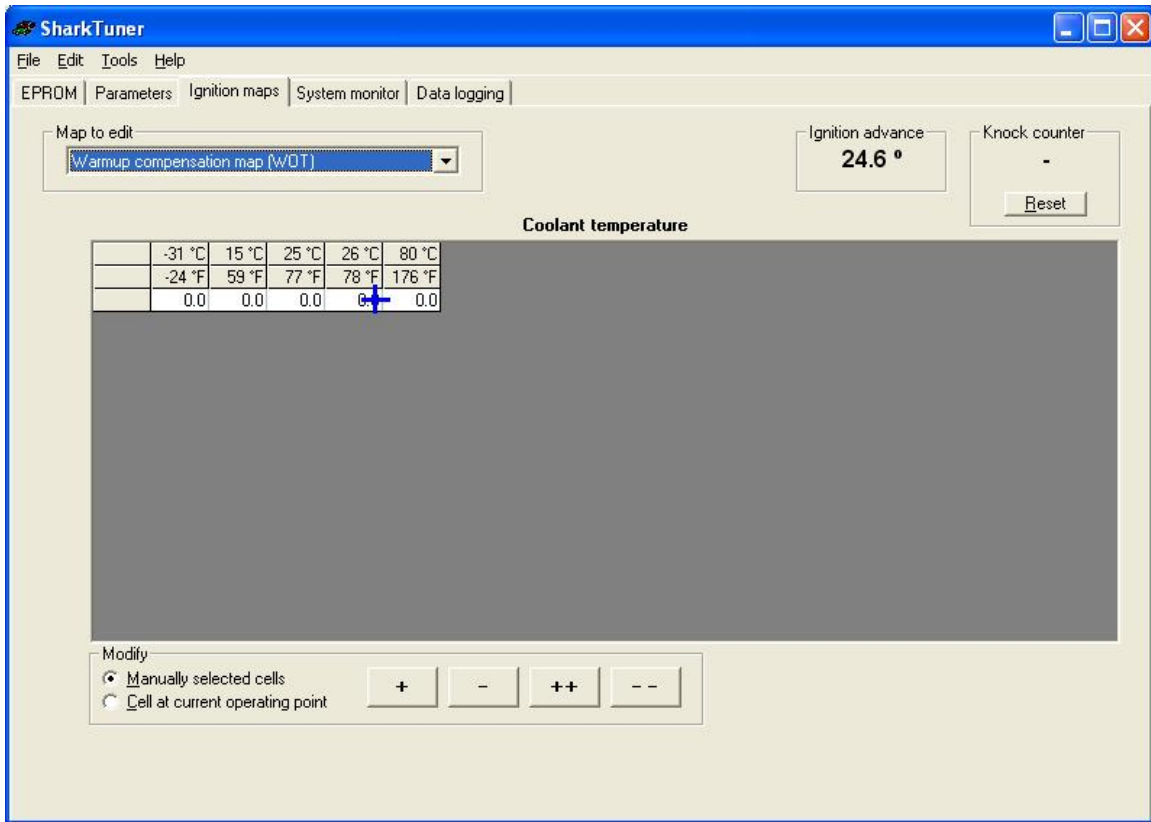
THE WARMUP COMPENSATION MAP (CRUISE)



This map uses engine water temperature (Temp sensor #2). This compensation map is only effective at very low water temperatures.

Editing using the lower radio buttons is the same as for the other maps

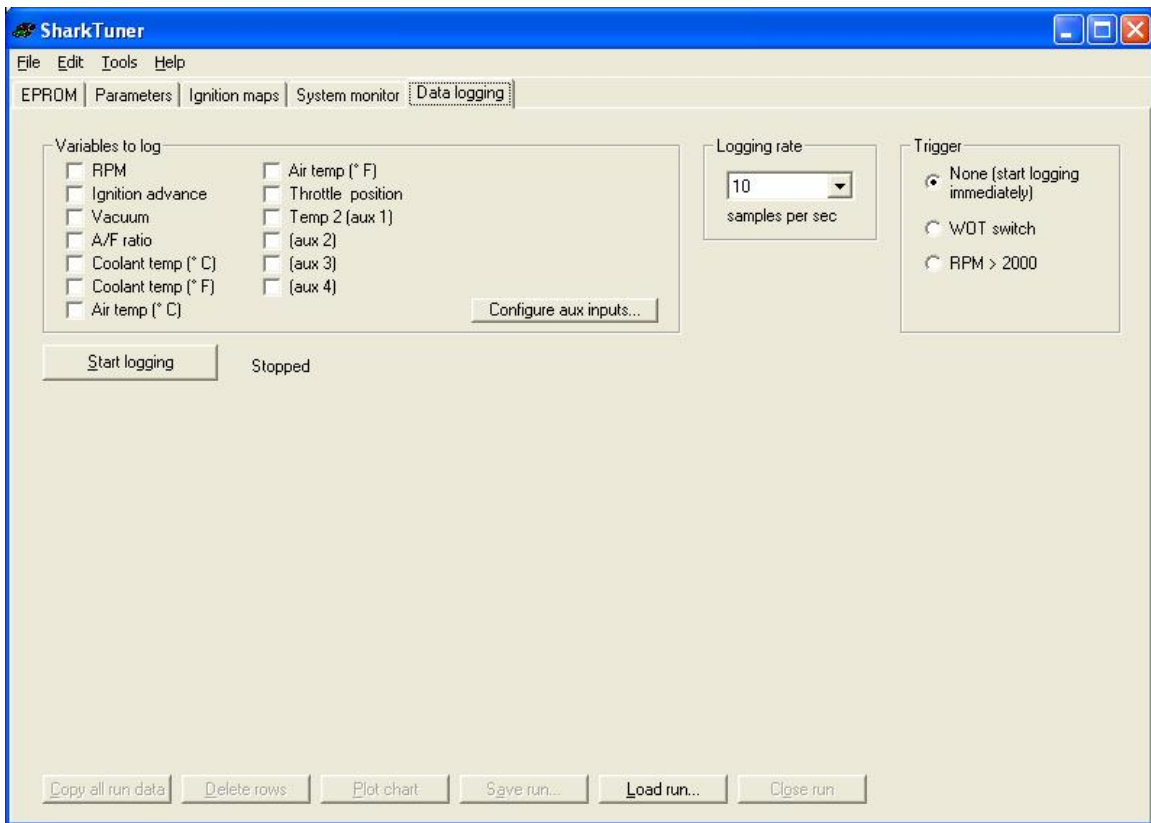
THE WARMUP COMPENSATION MAP (WOT)



This map uses engine water temperature (Temp sensor #2). This compensation map is used over a wider range of water temperatures than the warm up idle and cruise maps.

Editing using the lower radio buttons is the same as for the other maps

DATALOGGING



Apart from the EZ-F specific set of parameters that can be data logged, the operation of the EZ-F data logger is identical in operation to that previously described.

Results can be viewed in tabular form, or graphically with the built in graphical tool. If preferred, the data can be copied and pasted from the data tables into Excel spreadsheets and post processed there.

Data logs can be viewed with the SharkTuner powered but not connected to the car.

REMAPPING THE EZ-F

The EZ-F does not have a knock monitoring system. This makes remapping more difficult than with the EZK system fitted to the later 32v cars.

There is the potential for serious engine damage if ignition maps are adjusted “blind” to see “if this improves power”. Destructive detonation can occur which is not audible to the operator, especially at high rpm and high boost.

Maximum power occurs at ignition advance settings that are less advanced than those which cause detonation. This gives some margin for error, but that margin can be reduced by factors such as high air temperatures, poor fuel quality etc. Any adjustments should be made with caution.

ADJUSTING THE WOT MAP WITH A ROLLING ROAD DYNOMETER

The safest way to set ignition advance is using a rolling road Dynometer but you should proceed with caution, especially with a supercharged or turbocharged engine... Do a “save as” on the stock map, and rename as “test 1” or similar.

Make an initial reference run with stock timing.

With a mildly tuned normally aspirated engine, select a section of the WOT map, say 1900-3000rpm and advance the ignition by 1.8 degrees with the “+” button.

Repeat the dyno run, and compare the torque in the edited rpm range with that measured on the reference run. If the power/torque have improved then advance the ignition by a further 1.8 degrees. If power has not improved, then retard back to the previous setting.

Work on other sections of the rpm range in small steps, always checking your results. As a safety check, if you have reduced the ignition advance, and obtained a faster time to accelerate through the speed range, then reduce the advance by a further 1.8degrees, and observe if a better or worse result is obtained. If a worse (longer time) is obtained, then the previous +1.8 degree advance can be reset. If power is not degraded at the lower value of advance, then use that setting for safety.

For a forced induction engine one rule of thumb often used as a starting point is to retard all the WOT map points where boost is present by 1 degree per pound of boost. A larger safety margin may be safer in the first instance.

Then proceed as previously described, working on small parts of the WOT mapping at a time, and slowly increasing ignition advance in small steps until no increase in torque is recorded. The usual precautions of maintaining similar conditions between runs apply (e.g. intake air temperature, etc) so that results can be properly compared.

ADJUSTING THE WOT MAP WITHOUT A ROLLING ROAD DYNOMETER

If a Dynometer is not available, then some work can be carried out using the data logging facility available within the SharkTuner. However, performance testing on the open road is not recommended. If you choose this approach, then always have a passenger to operate the laptop, make notes of changes as so on.

Another issue is being able to obtain identical conditions between runs to be able to properly compare results. Slight differences in incline, wind speed and so on can mask the true effects of any changes. This is why the relatively controlled environment of the rolling road Dynometer will always give more accurate results.

As the SharkTuner data logs cannot measure torque directly then the data logged results require some post processing to give some useful comparisons between runs.

For a manual gearbox car, selecting a suitable gear ratio and making a data run with the data logging set to start at ">2000rpm" is suitable.

For an Automatic gearbox selecting "2" and then editing the results to just leave the 2nd gear run from 2000rpm upwards can be satisfactory. For higher power cars a run in "3" may be required to stop wheel spin from corrupting the results.

One comparison method is to copy and paste the time and rpm columns for the first run into an Excel spreadsheet. Then copy the rpm results from subsequent runs into the same sheet. If the data log was triggered by the ">2000 rpm" option, then all plots should start at the same rpm. Any slight differences can be adjusted by manipulation. See Appendix 2 for more information on this topic.

Changes can be made to the WOT map in small steps. The acceleration run results can then be compared graphically. Using this method makes it easier to compare results in different in various sections of the rpm range, and the timing adjusted accordingly.

Always keep a note of the figures obtained, rename the data log files clearly and save them for future reference. Always do a "save as" on all subsequent modifications of the bin file.

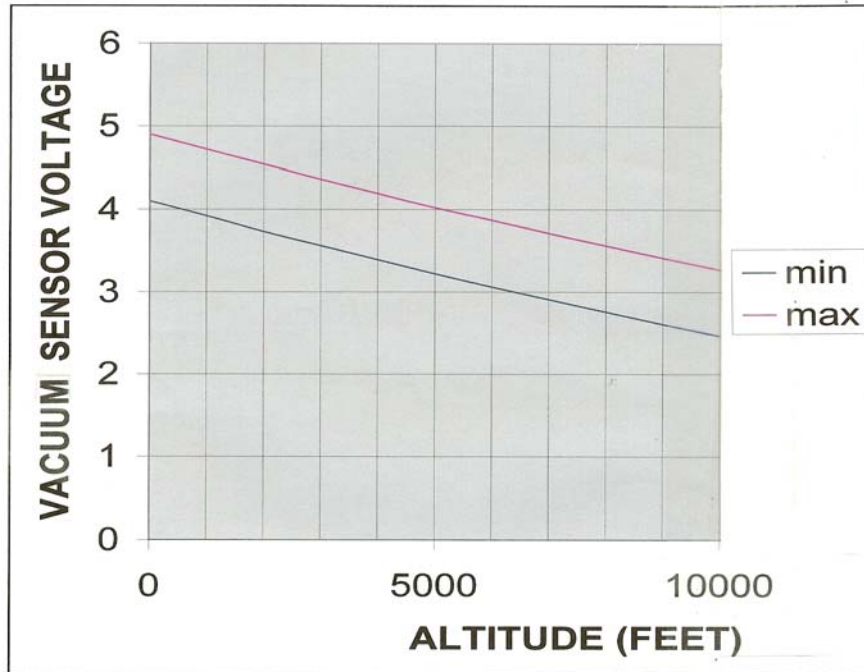
Work on the various sections of the rpm range in small steps, always checking your results. As a safety check, if you have reduced the ignition advance, and obtained a lower time to accelerate through the speed range, then reduce the advance by a further 1.8degrees, and observe if a better or worse result is obtained. If a worse (longer time) is obtained, then the previous +1.8degree advance can be reset.

An after market knock detect system can be installed to assist with tuning. Two locations in the middle of the "V" of the 928 engine are available. These locations gives a good response from all cylinders.

However, all aftermarket knock systems require a sensitivity calibration. This usually depends on the audible confirmation that when knock is occurring the unit registers the knocks. This obviously has risks as we know that the onset of detonation can be inaudible.

To obtain the maximum possible safety, choose a system that is triggered on each ignition firing. This gives greater resolution between engine noise and detonation noises.

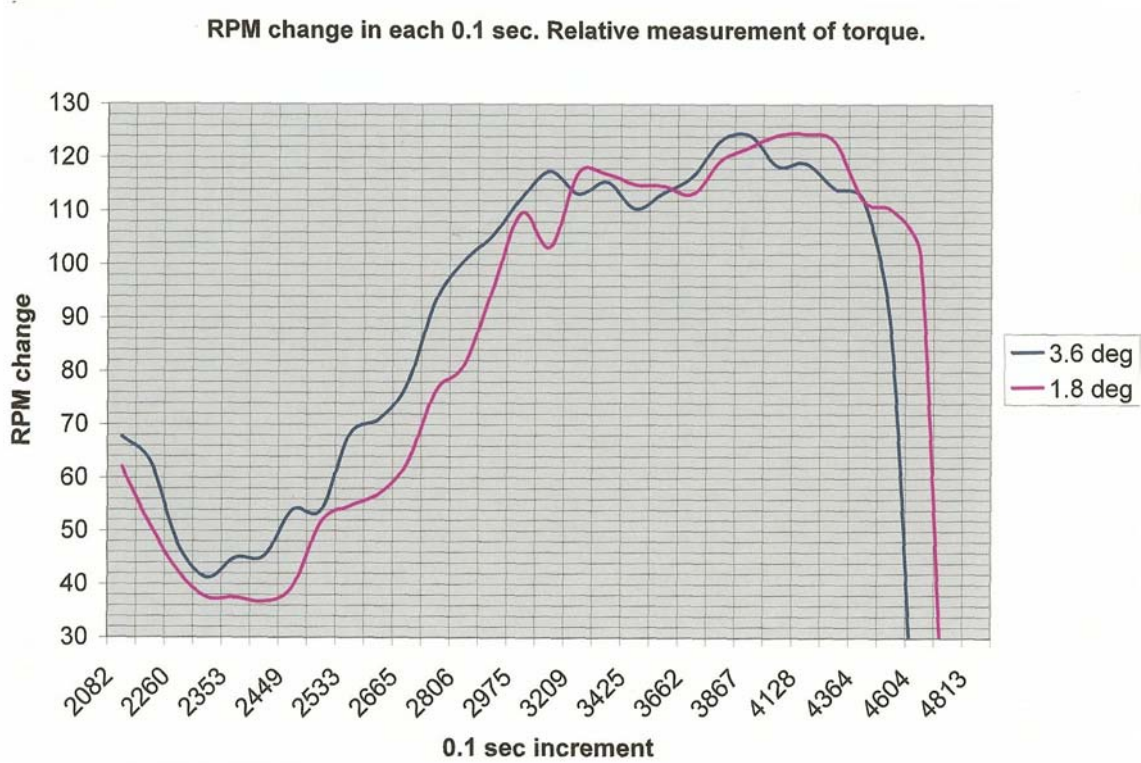
Appendix 1) VACUUM SENSOR VOLTAGE RANGE VERSUS ALTITUDE



The area between the minimum and maximum lines represents an acceptable vacuum sensor voltage range.

Outside this range the ECU should be checked by a reputable repairer.

Appendix 2) **PROCESSED RPM (ACCELERATION) RATE VS TIMES**



This graph uses a common starting rpm point for both sets of rpm vs. time data. The rpm change per 0.1second increment is plotted vertically. The rpm measurement at each 0.1sec. interval is plotted horizontally.

A larger rpm increase vs. time represents the larger acceleration and is a representation of torque.

The acceleration figures were averaged over 4 x 0.1sec.periods in order to smooth out fluctuations on the resulting plots.

In this example graph it can be observed that 3.6 degrees gives an advantage from 2082 to 3209rpm. There is little to choose between the two graphs until about 4000rpm where 1.8 degrees gives the superior result.

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