

Gen III - Speed Density VE Table and MAF Tuning Instructions with a Wideband O2 Sensor

Create by 69lt1bird – Jeff Anderson

These instructions are written for the beginner and intermediate user of HP Tuners software. A wideband O2 sensor is required for the tuning described in these procedures.

If you have upgraded your fuel injectors, the injector data must be set correctly before you start. Read the Help files and Stickies on the HPtuners.com website. I cannot emphasize enough that you need to read the help section and the stickies so **you** can have an understanding of the various tables (I think over 400) that are in HP Tuners. You will not learn by everyone else doing the work for you, this is your responsibility.

Make sure you have the correct tire size and axle ratio loaded or your shifts points for automatic cars will not be correct.

Use these instructions are your own risk, proper understanding of the software and knowledge of the mods to the vehicle being tuned is critical. This information is from various sources on HP Tuners site, Wikipedia, LS1Tech and personal experience. Sources from the HP Tuners Forum are Cantelope Kid, EFICalibrator, RWTD, and several others and the original Cpig's HPT Tuning Guide. These fellow tuners are great assets to the tuning community. They are in no way affiliated with these instructions; I am solely responsible for its content.

Definitions:

STFT- Short Term Fuel Trim

The short term fuel trim is used by the control module in order to control the short term injector pulse width or the injector ON time. When the control module is in the Closed Loop mode, the control module monitors the heated oxygen sensor signals in order to determine if the fuel system is operating rich or lean. If the control module determines that no change in fuel delivery is needed in order to maintain correct short term fuel control for a particular engine operating condition, a short term fuel trim scan tool data value of 0 percent is indicated. If the control module determines that the fuel system is operating rich, short term fuel trim will compensate for the rich condition by decreasing the injector pulse width and a negative short term fuel trim value is indicated. If the control module determines that the fuel system is operating lean, short term fuel trim will compensate for the lean condition by increasing the injector pulse width and a short term fuel trim positive value is indicated.

When the control module is in the power enrichment (PE) mode, the short term fuel trim value will indicate 0 percent in order to prevent the fuel trim from compensating for the commanded rich condition of the PE mode.

LTFT- Long Term Fuel Trim

The long term fuel trim consist of groups of fuel control calibrations or cells. Each cell contains the short and long term fuel injector control values required to maintain the correct air and fuel mixture for a particular long term engine operating condition. The control module monitors the short term fuel trim values in order to determine if the short term fuel trim values are indicating a trend of rich or lean corrections to the fuel control. If the control module determines that the short term fuel trim is able to maintain control and is near 0 percent, the long term fuel trim within that particular cell will indicate a value of 0 percent. If the control module determines that the fuel

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system is operating rich, long term fuel trim will compensate for the rich condition by decreasing the injector pulse width, and a negative long term fuel trim is indicated. If the control module determines that the fuel system is operating lean, long term fuel trim will compensate for the lean condition by increasing the injector pulse width and a positive long term fuel trim value is indicated. If the control module determines that the long term fuel trim values indicate a trend toward a rich or a lean correction within that cell, the control module will switch to the appropriate cell, either rich or lean, and the short term value will return to 0 percent.

VE- Volumetric Efficiency

VE is map of predicted engine performance based on speed and MAP. VE is how much cylinder filling occurs based on engine displacement. This value can be over 100%.

MAP- Manifold Absolute Pressure

The manifold absolute pressure sensor provides instantaneous intake manifold pressure readings to the computer to calculate air density and determine the engine's air mass flow rate, which in turn is used to calculate the appropriate fuel flow.

MAF- Mass Air Flow Meter

GM uses a Hot Wire MAF design. This is achieved by heating a wire with an electric current that is suspended in the engine's air stream, not unlike a toaster wire. The wire's electrical resistance increases as the wire's temperature increases, which limits electrical current flowing through the circuit. When air flows past the wire the wire cools, decreasing its resistance, which in turn allows more current to flow through the circuit. As more current flows, the wire's temperature increases until the resistance reaches equilibrium again. The amount of current required to maintain the wire's temperature is directly proportional to the mass of air flowing past the wire. The integrated electronic circuit converts the measurement of current into a frequency signal (Hz) which is sent to the ECU.

If air density increases due to pressure increase or temperature drop, but the air volume remains constant, the denser air will remove more heat from the wire indicating a higher mass airflow.

SD- Speed Density

The speed density system is best described as a calculation procedure used by the computer that uses predetermined operating parameter values, volumetric efficiency tables, and the known volume of fuel delivery required per combustion event for a single cylinder. Management of fuel and spark functions is based mainly on a predetermined range of preprogrammed data and also on real-time feedback data from an array of sensors.

The "speed" signal is based on the calculated volume of a single cylinder. The "density" signal is a function of temperature and pressure measurements. To determine an engine's fuel delivery requirements, the speed density system infers airflow from several monitored sources, including engine speed (in RPM), intake manifold absolute pressure (MAP, to determine load), intake air temperature (IAT), throttle position, the heated oxygen sensors, engine coolant temperature and battery voltage.

AFR- Air Fuel Ratio

AFR is the mass ratio of air to fuel present during combustion. When all the fuel is combined with all the free oxygen, typically within a vehicle's combustion chamber, the mixture is chemically balanced and this AFR is called the stoichiometric (Stoich) mixture. Gasoline engines run at 14.7:1 air to fuel ratio. Ethanol based fuels require changing your Stoich calculations to a richer value.

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PE- Power Enrichment

Power enrichment tables are used when the VCM detects wide open throttle (WOT) operation and provides extra enrichment to achieve maximum power.

High Octane/Low Octane

Vehicle runs on the High Octane table unless engine knock is detect and then the Low Octane table is used. As a rule of thumb, the low octane table should be about 4* lower than the high octane table.

IFR – Injector Flow Rate

This value is the injector flow rate in g/sec. It is used to tell the VCM the size of the injectors and also how flow rate varies with manifold vacuum (ie. varying pressure characteristics). On a returnless system that have a non-vacuum controlled fuel pressure regulator, the IFR table will have an upward slope. On vehicles that have a vacuum regulate fuel pressure regulator, the IFR table will be flat with on fix pressure. There is a excel spreadsheet available that will help you build the IFR table if you know the values of your current injector, new injectors and at what pressure they are rated at, and the current fuel pressure. This is a critical setting for all of your tuning.

Fuel Trim Cells LS1 V8

- 0 - 15 defined by the LTFT RPM and MAP boundaries
- 16 - Idle PN (AC on)
- 17 - Idle PN (AC off)
- 18 - Idle In Gear (AC on)
- 19 - Idle In Gear (AC off)
- 20 - Idle (EVAP closed)
- 21 – Coast down (EVAP closed)
- 22 - Non-Idle (EVAP Closed)

Open Loop

Open Loop fueling means that the oxygen sensors are not being used to control fueling and the VE table and Open Loop Fuel Air (OLFA) table are doing the primary fueling control.

Closed Loop

Closed loop fueling means that the oxygen sensors (O2) are being used to adjust fueling to keep the AFR at stoich. The O2 sensors must be at operating temperature, the engine coolant temperature (ECT) must meet the set parameter in the computer.

Diagnostic Trouble Code (DTC) Error Modes

Used for turning ON/OFF DTC's

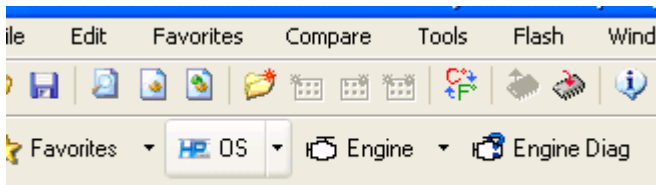
- 0 - MIL on First Error: Emissions related. Illuminates MIL the first time DTC sets.
- 1 - MIL on Second Error: Emissions related. Illuminates MIL, if fault is active for 2 consecutive drive cycles.
- 2 - No MIL Light: Non-emissions related. Does not illuminate MIL, but will illuminate SERVICE light.
- 3 - No Error Reported: Non-emissions related. Does not illuminate MIL or SERVICE light.

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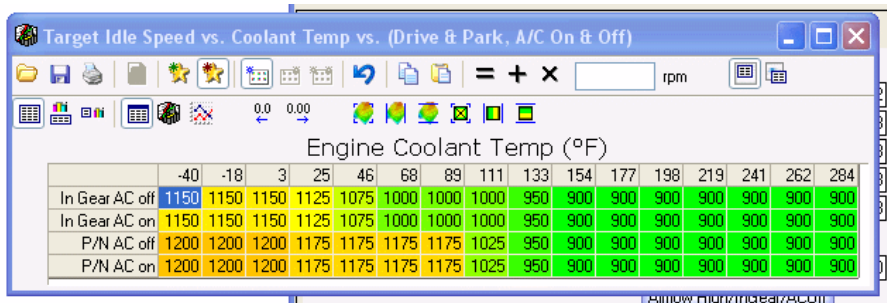
Connect your vehicle to HP Tuners.

1. Go to **Flash – Read Entire** and copy your stock tune and save it a different folder than you work in so the file does not get overwritten.
2. Do a Save As on the file and name SDtune.



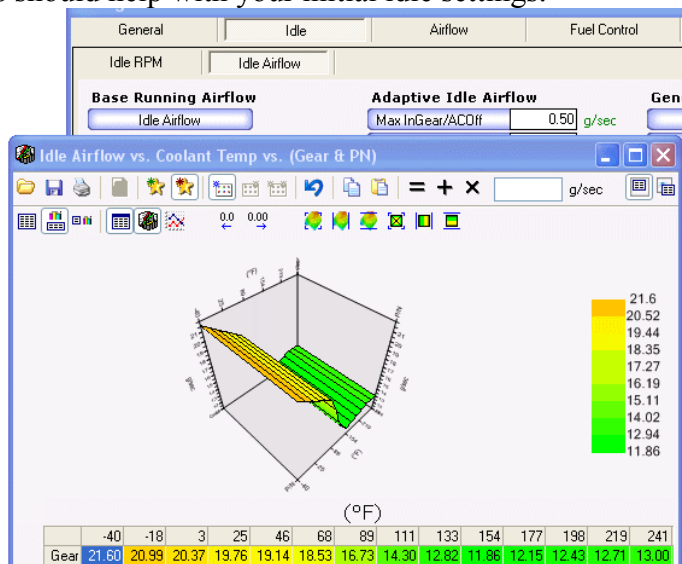
➤ Used to save a copy of your entire tune and operating system

3. **Engine – Idle – Idle RPM – Target Idle Speed** – Set the idle cells to at least 850-950 if you have a cammed engine.



➤ Table used to set your desired RPM's at idle

4. If you have a cam and other airflow mods, do the following. **Engine – Idle – Idle Airflow – Base Running Airflow – Idle Airflow** – Add 4 to each cell to get you started, this should help with your initial idle settings.

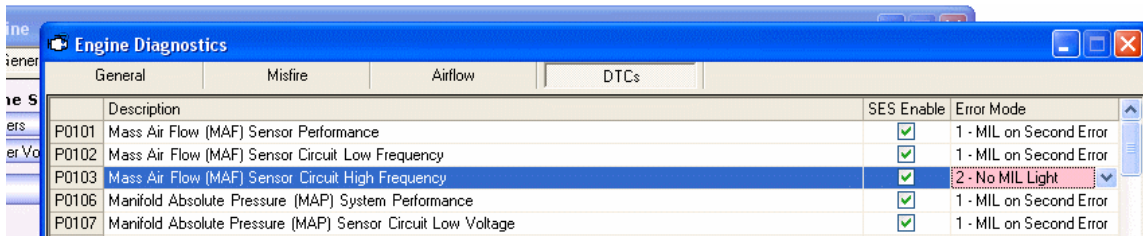


➤ Table used to correct Idle Airflow

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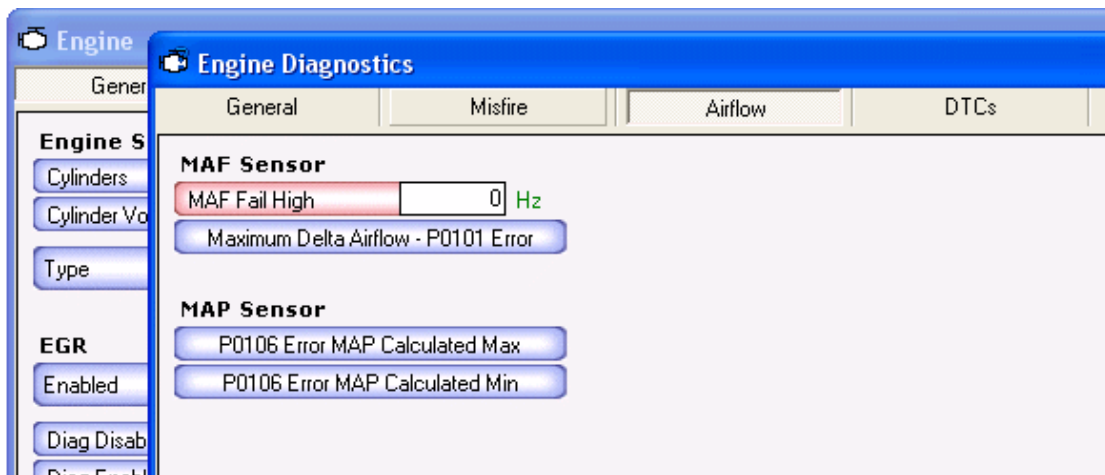
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5. **Engine Diagnostics – DTCs** – Set P0103 to 2-No MIL Light. Click your mouse on the words and a drop down arrow will appear, click arrow and the choices show up.



➤ Used to assure MAF is failed but does not cause Service Engine Soon light.

6. **Engine Diagnostics – Airflow – MAF Sensor – MAF Fail High** to 0 (zero).



➤ Table used to fail MAF so not MAF data is used to correct fueling issues.

7. Do this is it's the first time tuning on a fresh build - **Engine – Main VE – Primary VE** – select all – multiply table by 1.15 to cover for a potentially lean condition if you modded the engine.

EGR Airflow Cranking VE

Primary VE vs. RPM vs. MAP

1.15 %

0.0 0.00

Engine Speed (rpm)

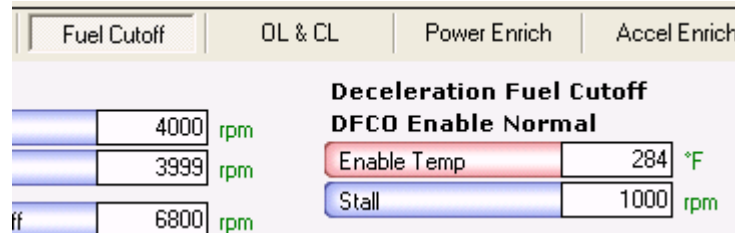
	400	800	1200	1600	2000	2400	2800	3200	3600	4000	4400	4800	5200
15	28.7	38.4	46.0	53.0	58.4	60.4	57.6	55.4	65.4	73.6	72.4	70.4	64.0
20	31.8	40.2	46.9	53.2	59.6	62.3	58.1	58.6	72.8	79.7	78.4	75.5	70.2
25	34.0	42.0	47.4	60.5	60.1	65.5	65.6	68.2	78.1	81.8	82.1	80.3	76.9
30	34.9	42.7	47.6	61.0	61.0	67.3	67.7	71.4	80.7	87.3	83.6	83.6	82.1

(kPa)

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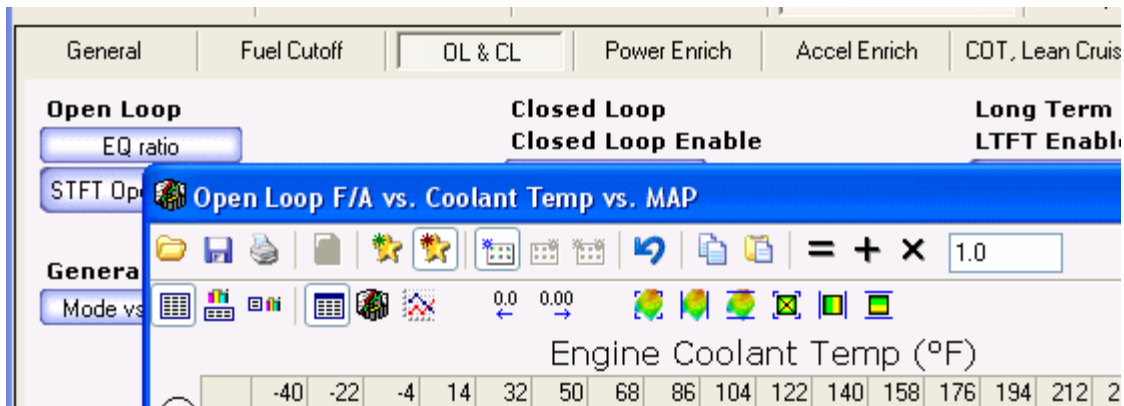
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- Fuel Control – Fuel Cutoff – Deceleration Fuel Cutoff – DFCO Enable Normal** – set Enable Temp to 284*.



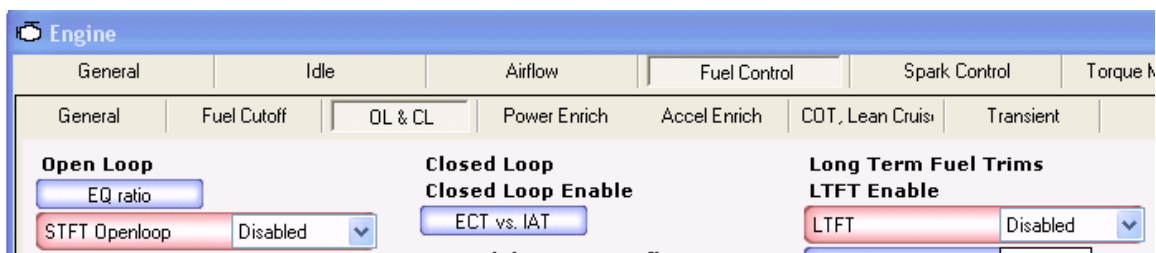
➤ Table used to disable DFCO so data is not skewed with false fueling issues

- OL & CL – EQ Ratio** – select columns 140 through 230 – put 1 in white box at top and click =. By making those cells 1, your PCM's stoich value will be the target for fueling. Vehicle needs to be at operating temperature before tuning VE table



➤ This table sets the Closed Loop fueling multiplier to so you are tuning to Stoich.

- OL & CL – Open Loop – STFT Openloop** – set to Disabled.
- OL & CL – Long Term Fuel Trims - LTFT Enable** – set to Disabled.

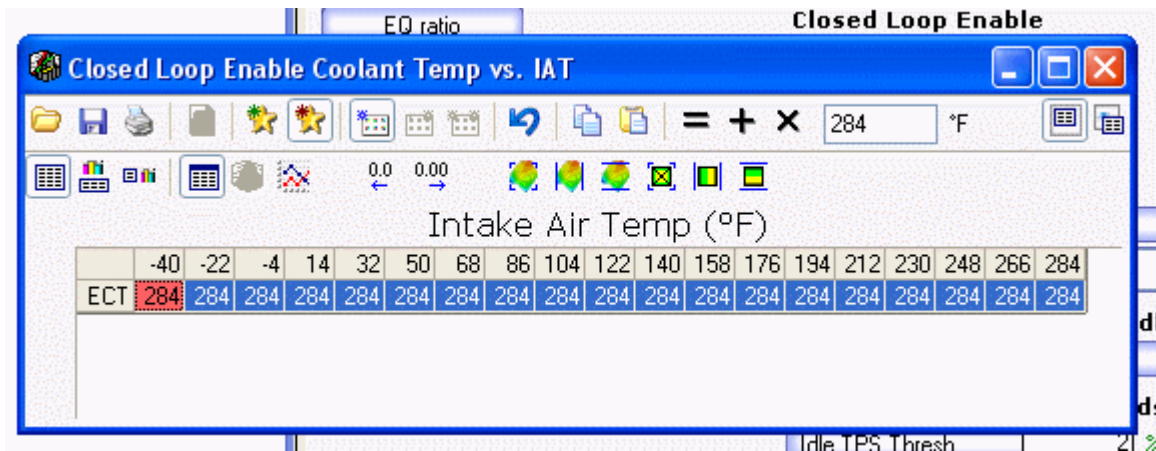


➤ Disables all fuel trims from working so no corrections are made while tuning.

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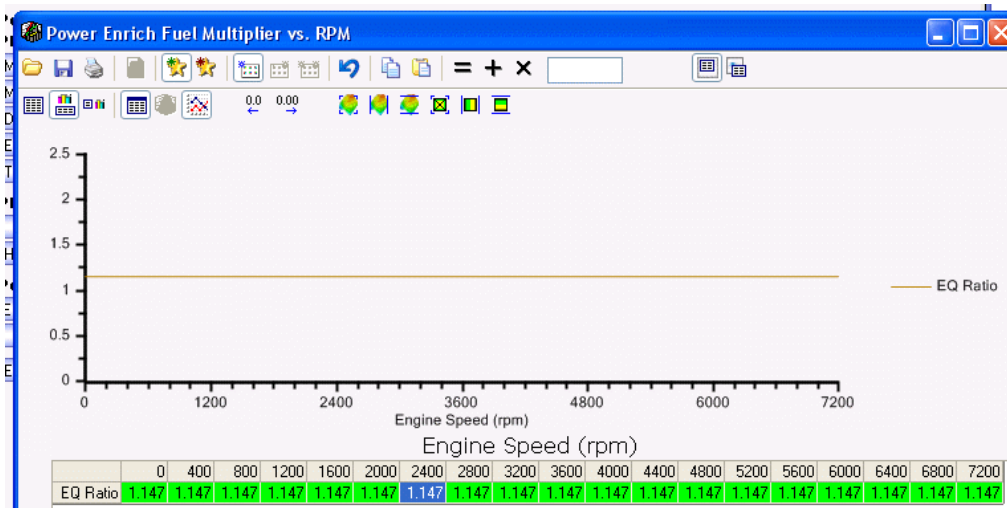
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12. **OL & CL – Closed Loop - Closed Loop Enabled** – select all – type 284 in box and click =.



- Tables used to force Open Loop mode.

13. **Fuel Control - Power Enrichment – Power Enrichment – EQ Ratio vs. RPM**
– set to your desired PE ratio for WOT. Example, if your Stoich is 14.63 and you set the PE to 1.13, you commanded AFR for WOT will be 12.95. Safe for NA, should be in the 11 -11.5 range for blower/turbo setups. Flat lining this is not a bad thing to do, you will see tunes that are all over the place, that is not correct.

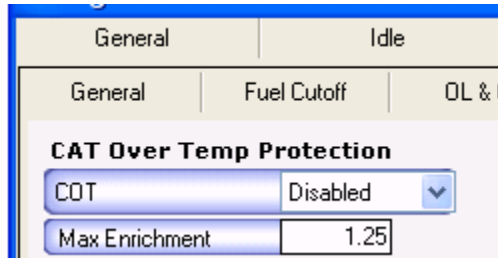


- This table is the Power Enrichment table that is used for WOT fueling.

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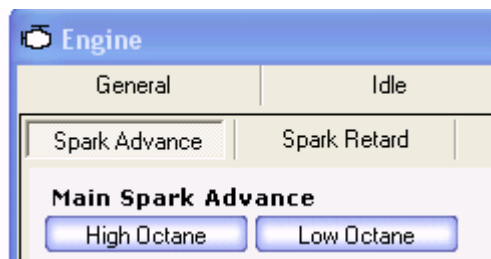
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14. **Fuel Control – COT, Lean Cruise – CAT Overtemp Protection – COT** – set to Disabled.



- This table is for catalytic converter protection, it is disabled so fuel is not added during tuning.

15. **Spark Control – Spark Advance** – Open High Octane Table, select all and copy. Open Low Octane table, select all, paste. This assures timing stays steady.



- These are the two spark tables, copying the high to low will eliminate the possible of timing being pulled do to spark knock issues.

16. **Flash – Write Calibration Only**, do not write Entire.

17. Open the HP Tuners scanner.

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18. Choose the PIDS you want to log. Do not log MAF data while VE tuning, keep it simple. Here is one I use.

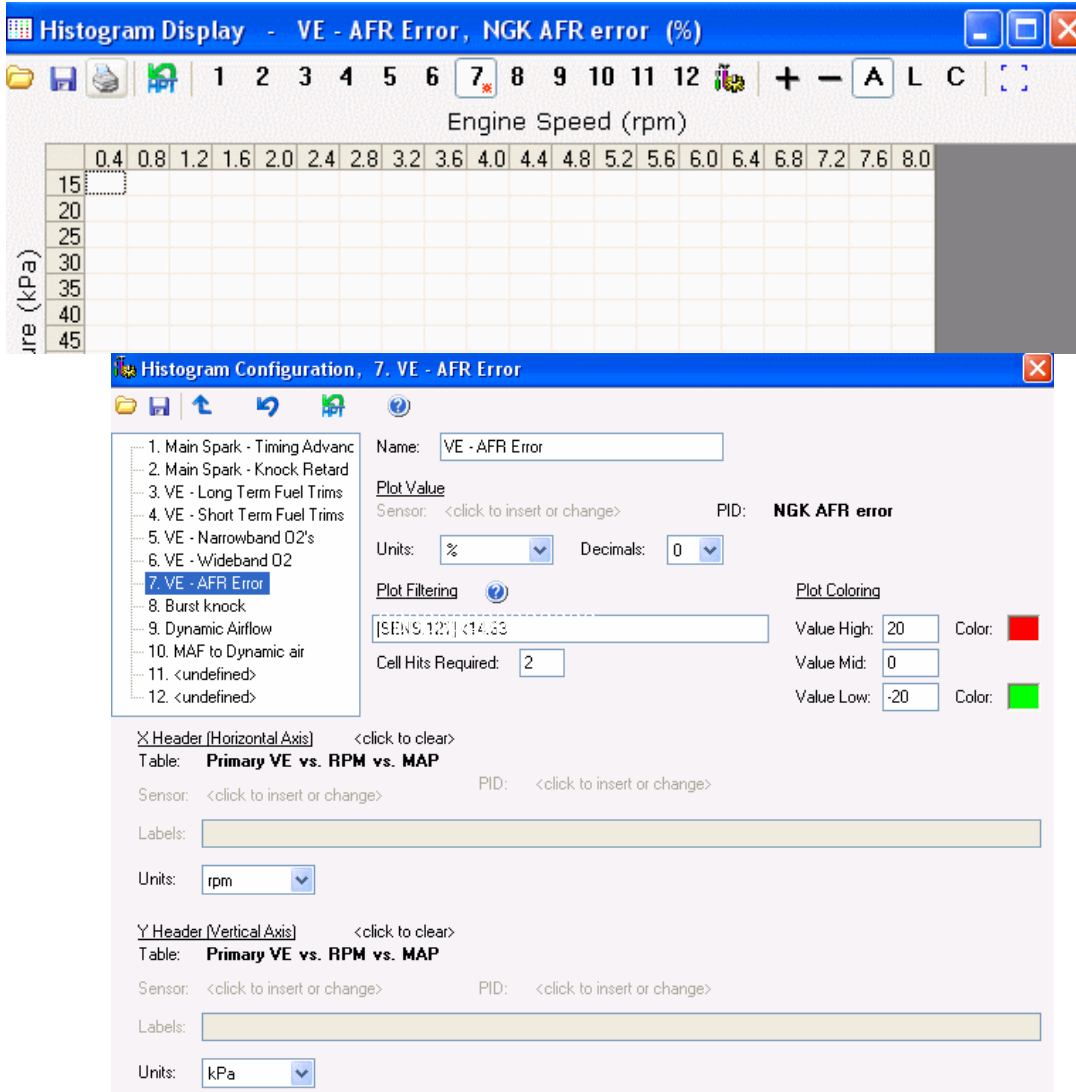
Engine RPM (SAE)			
Vehicle Speed (SAE)			
Throttle Position (SAE)			
Ignition Timing Advance (SAE)			
Knock Retard			
Burst Knock Retard			
Manifold Absolute Pressure (SAE)		Idle Advance	
		IAC Desired Position	
		IAC Position	
Engine Coolant Temp (SAE)			
Intake Air Temp (SAE)		NGK wideband	
		EGR Position	
		NGK AFR error	
Dynamic Airflow			
Dynamic Cylinder Air			
		Air Fuel Ratio Commanded Lo Re	

- PID table used to choose what monitored and used in the histograms. Must be in this table to be used in histograms.

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19. Create a VE AFR Error % histogram.

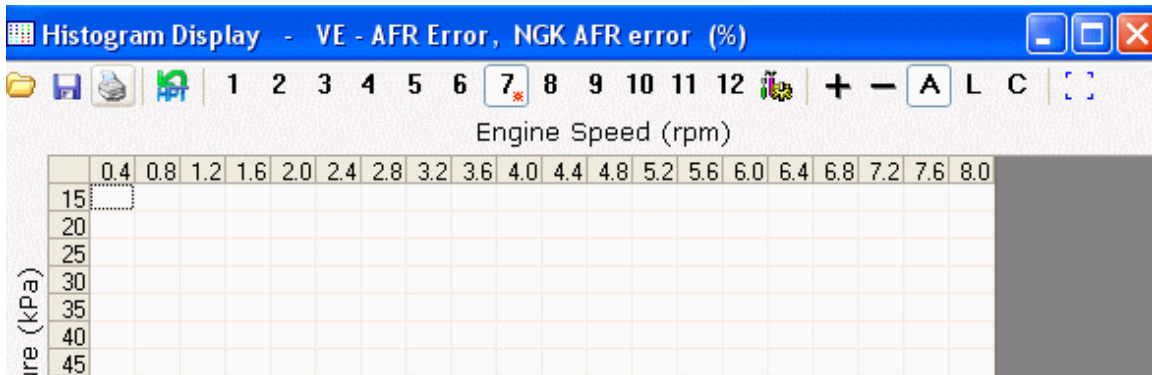


20. Start logging data, drive at very steady speed so the engine stays in “Steady State”, do not go WOT or do rapid throttle changes until the VE table has been tuned up to at least 4000 rpm’s.

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- After logging a minimum of 20 hits in as many cells as possible, copy all data from the VE histogram. You will not be able to hit every cell so don't get too worried about that part.



- This is the VE histogram data that is logged while test driving. Populate as many cells as possible.
- Open the Editor, open the Primary VE table, select all cells by clicking the empty cell at the top left of the table, right click the same cell. Select Paste Special, Multiply by %. If your values in the scanner have moved below 10, select Multiply by % - Half so you do not over correct the table. If you have very high spikes or deep valleys, select the cells around the spike or valley and click Smooth, this will help minimize the issue.

	400	800	1200	1600	2000	2400	2800	3200	3600	4000	4400	4800	5200	5600	6000	6400	6800	7200	7600
15	39	40	43	47	50	54	58	64	66	51	44	43	43	38	31	29	26	24	23
20	43	46	48	51	54	56	58	60	53	51	50	52	50	48	44	41	38	36	36
25	48	50	52	54	55	53	54	53	54	63	60	58	56	55	53	51	48	48	48
30	51	53	55	55	49	51	53	54	59	68	69	66	66	65	61	58	58	58	58
35	53	55	56	49	50	51	56	59	62	72	73	67	72	71	66	64	64	66	66
40	54	56	56	50	52	54	60	62	67	78	84	71	74	76	74	72	72	72	72
45	56	56	50	49	54	56	63	65	72	83	85	80	80	82	80	78	76	76	76
50	58	56	49	50	55	59	64	68	75	85	90	85	83	84	84	82	80	79	79

- This is the Primary VE table in the editor that you copy and paste special the data from the scanner histogram into.
- If you have an operating system (OS) that has a secondary VE table, copy the even rows from the primary table over to the secondary table. During SD mode, the computer uses the secondary VE table for fueling data.

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24. Save the file and Flash Calibration Only and re-drive and log more data. Once you have adjusted the VE table up to 4000 rpm's you can try some higher MAP/RPM/WOT runs, perform the copy and paste steps from above until you log no higher than 2-3 in any cell. 0-1 will be the best you will get, shoot for that if you can. Hand smooth as needed to keep the table relatively smooth, don't get carried away with it being as smooth a production table, remember, your engine has been modified so it will have different needs now than before.
25. *Open your stock original file and do a Save As and rename Aftertune_date.*
26. *Copy the VE table(s) from your SD file to the newly saved stock file, this will save you from having to reset all of the various table settings you did to enter SD mode.*

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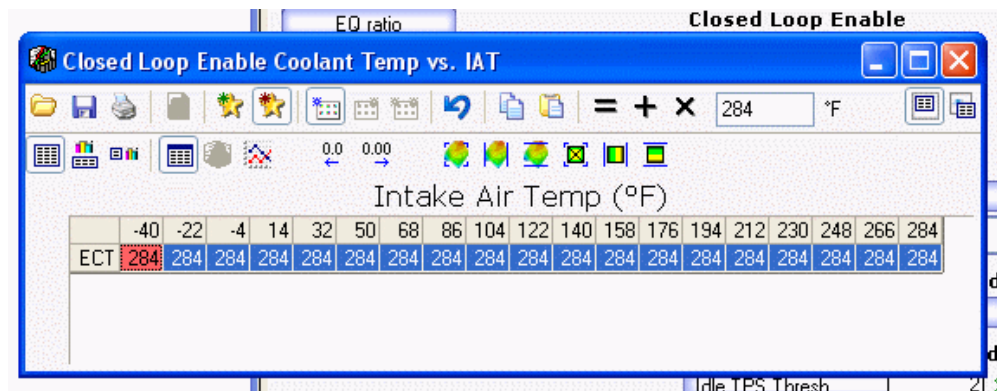
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MAF Only Tuning

Now that the VE table is all tuned, its time to turn everything back to normal. Follow the initial steps and reset all values to stock for the temps, OL, CL settings, DTC's MAF Fail etc.

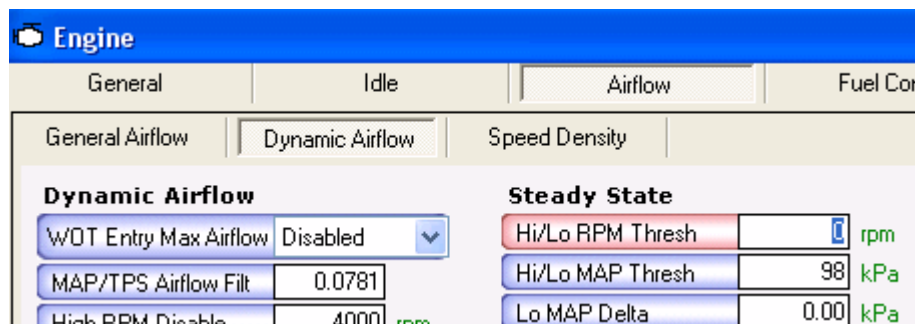
We will now move on to tuning the MAF if you are going to use one. Follow these steps to tune in MAF Only mode. By tuning the VE separate and then tuning the MAF separate you will end up with a tune that will transition very well during throttle transitions. These steps will force Open Loop MAF Only tuning.

- 1) Open the Aftertune_date you just created and rename OLMFAF.
- 2) **OL & CL – Closed Loop Closed Loop Enabled** – select all – type 284 in box and click =.



➤ Table used to force Open Loop mode.

- 3) **Engine – Airflow – Dynamic Air – Steady State – Hi/Lo RPM Thresh** – set to 0 (zero).



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- By setting the Hi/Lo RPM Thresh to 0 will for the computer to use the MAF Only and not reference the VE table so you can properly tune the MAF with no outside fueling references.

4) Create a PID table for MAF Only tuning.

Engine RPM (SAE)		O2 Voltage B1S1
Throttle Position (SAE)		O2 Voltage B2S1
Vehicle Speed (SAE)		
		Short Term Fuel Trim Bank 1 (SAE)
Ignition Timing Advance (SAE)		Short Term Fuel Trim Bank 2 (SAE)
Knock Retard		Long Term Fuel Trim Bank 2 (SAE)
		Long Term Fuel Trim Bank 1 (SAE)
Manifold Absolute Pressure (SAE)		INJ. Pulse Width Avg. Bank 1
Mass Air Flow (SAE)		INJ. Pulse Width Avg. Bank 2
Mass Air Flow		
Dynamic Cylinder Air		
Dynamic Airflow		
		EGR Position
		NGK AFR error
Injector Duty Cycle		NGK wideband
Calculated Cylinder Air		Air Fuel Ratio Commanded Hi Res

- PID table used to choose what monitored and used in the histograms. Must be in this table to be used in histograms.

5) Setup a MAF AFR Error Histogram.

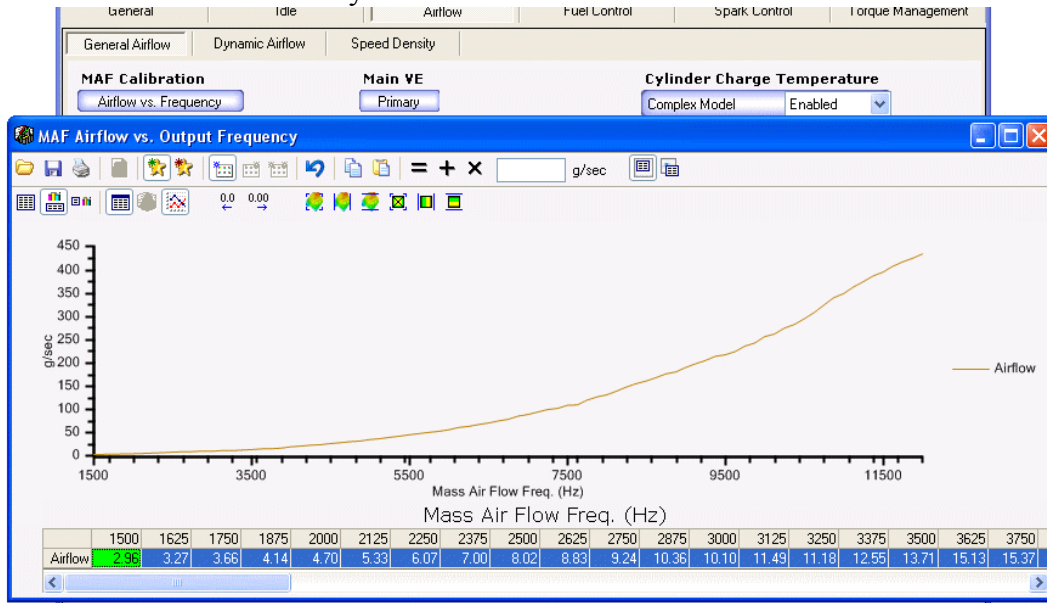
The screenshot shows the 'Histogram Configuration, 7. VE - AFR Error' window. The 'Name' field is 'VE - AFR Error'. Under 'Plot Value', the 'Sensor' is '<click to insert or change>' and the 'PID' is 'NGK AFR error'. The 'Units' are set to '%' and 'Decimals' to '0'. The 'Plot Filtering' field contains '[SENS.121] <14.63' and 'Cell Hits Required' is '2'. The 'Plot Coloring' section has 'Value High: 20' (red), 'Value Mid: 0', and 'Value Low: -20' (green). The 'X Header (Horizontal Axis)' section has 'Table: Primary VE vs. RPM vs. MAP', 'Sensor: <click to insert or change>', 'PID: <click to insert or change>', 'Labels: <input type="text" value="">', and 'Units: rpm'. The 'Y Header (Vertical Axis)' section has 'Table: Primary VE vs. RPM vs. MAP', 'Sensor: <click to insert or change>', 'PID: <click to insert or change>', 'Labels: <input type="text" value="">', and 'Units: kPa'.

- This one filters out DFCO data that will skew the histogram data.

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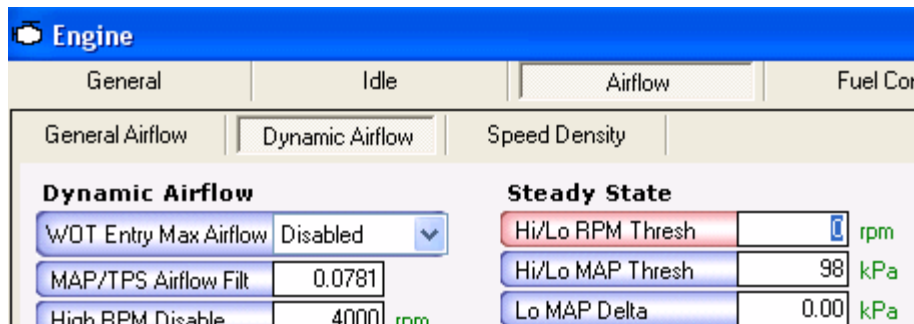
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- 6) Flash the tune to the PCM, **Calibration Only**.
- 7) Start the scanner and beginning logging data. Just like the VE table tuning, steady speed/throttle driving will give you the best results.
- 8) Copy the data from the histogram above and Paste Special – Multiply by % - just like the VE table. By half if less than 10 as before.



➤ MAF table in editor.

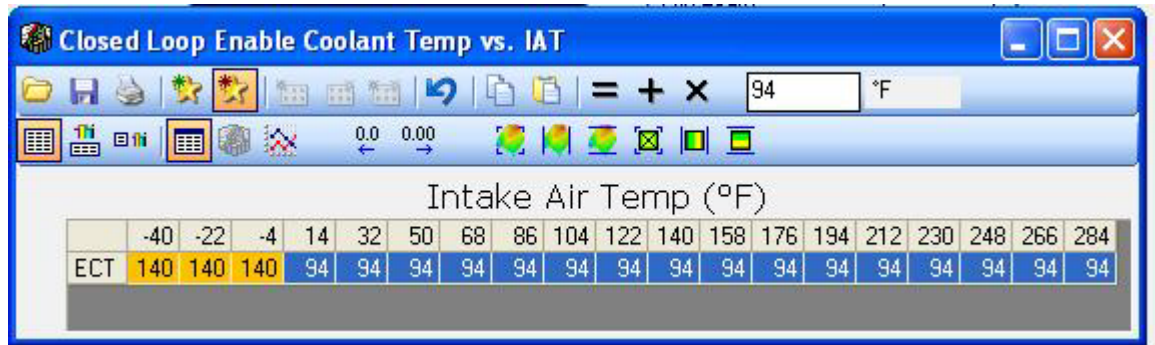
- 9) Re-flash the computer with a Calibration Only mode and re-drive again. Keep scanning and editing the tune file until you see 0-1 in the histogram cells. Remember to hand smooth here also, there should be no spikes or valleys. It does not have to be perfectly smooth like the factory, CAI, intakes, cams, heads, etc will create different demands and airflow requirements.
- 10) When completed with the MAF tuning, go to the **Engine – Airflow – Dynamic Air – Steady State – Hi/Lo RPM Thresh** – set to 2400 or whatever your file had in your stock cam.



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- 11) **OL & CL – Closed Loop Closed Loop Enabled** – reset -40 to -4 to 140 and the rest to 94.



- 12) Everything is now back on so its time to re-drive and log some more data. Build a new PID table and setup the histograms you want to log. Here is one config file that I use. It tracks MAF, IAC, various timing and knock data points.

Engine RPM (SAE)	O2 Voltage B1S1
Vehicle Speed (SAE)	O2 Voltage B2S1
Throttle Position (SAE)	
Ignition Timing Advance (SAE)	IAC Desired Position
Knock Retard	IAC Position
Burst Knock Retard	
Knock Learn Factor	
Base Advance	Mass Air Flow
Engine Coolant Temp (SAE)	Mass Air Flow (SAE)
Intake Air Temp (SAE)	Manifold Absolute Pressure (SAE)
	Dynamic Airflow
NGK wideband	
NGK AFR error	
Air Fuel Ratio Commanded Hi Res	Short Term Fuel Trim Bank 1 (SAE)
EGR Position	Short Term Fuel Trim Bank 2 (SAE)
	Long Term Fuel Trim Bank 1 (SAE)
	Long Term Fuel Trim Bank 2 (SAE)

- 13) You should see hardly any cells above 2-3 (hopefully 0-1) in the VE and MAF histograms if the first two steps above went well and you tuned the VE and MAF correctly. You can leave the 2-3 or you can set up the VE – STFT histogram and the MAF – STFT histogram and do some very minor fine tuning in the cells as needed. Do individual cells if they are high and hand smooth when done. Just like before, copy the data from the histogram and Paste Special, Multiply by % - Half. Do not use the Multiply by %, it will go too far.
- 14) Open the Aftertune_date file and copy the MAF table data from CLMAF into Aftertune_date and save file.

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IAC Relearn Procedure

If you are having idle issues you may need to reset your Idle Air Control (IAC) and TPS, do this before you start drilling holes in your throttle body (TB) blade. I have used this procedure on some huge cammed cars and it worked.

- 1) Monitor your IAC, Idle Speed, throttle position voltage and your throttle position %.
- 2) With the key in the ON position, adjust your TB set screw until your throttle position is 2%.
- 3) Turn your key to the OFF position.
- 4) Unplug your Throttle Position Sensor (TPS) and IAC.
- 5) Turn your key to the ON position for a few seconds, and then OFF again.
- 6) Plug in the TPS and IAC and then turn your key to the ON position and restart logging. Your throttle position will now be reset to 0 degrees and about .45-.55 volts.
- 7) Start your engine, your IAC should be 40-60 for a cammed engine.

If you are not at your desired IAC position, redo the above procedures in smaller increments.

DELETING REAR O2 SENSORS:

In Editor, go to ENGINE DIAGNOSTICS>DTCs

Under the far right column under Error Mode set these to “3-No Error Reported”

Driver Side

- 137 - HO2S Circuit Low Voltage Bank 1 Sensor 2
- 138 - HO2S Circuit High Voltage Bank 1 Sensor 2
- 140 - HO2S Circuit Insufficient Activity Bank 1 Sensor 2
- 141 - HO2S Heater Performance Bank 1 Sensor 2
- 420 - Catalyst System Low Efficiency

Passenger Side

- 157 - HO2S Circuit Low Voltage Bank 2 Sensor 2
- 158 - HO2S Circuit High Voltage Bank 2 Sensor 2
- 160 - HO2S Circuit Insufficient Activity Bank 2 Sensor 2
- 161 - HO2S Heater Performance Bank 2 Sensor 2
- 430 - Catalyst System Low Efficiency Bank 2

Gen III - Speed Density VE Table and MAF Tuning Instructions with a Wideband O2 Sensor

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Spark and Timing Control

If you want to eliminate all of the torque management spark reduction, including transmission, zero out this table. This will cause more stress on your transmission so use with caution unless you have a known good transmission. Look for other tables that have a maximum torque value, usually 640 and put the max value in all of the cells. This varies by vehicle and operating system.

The screenshot shows two windows from a tuning software interface. The top window is titled "Engine" and has tabs for General, Idle, Airflow, Fuel Control, Spark Control, and Torque. The "Torque" tab is active, showing sub-tabs for General, Engine Torque, Abuse, Supercharger, and Turbocharger. The "Engine Torque" sub-tab is selected, displaying several control options: "Maximum Torque" (RPM vs. Gear, vs. RPM), "Max Torque" (Max Torque: 640 ft.lb, Tip In Torque, Trans Input Max: 610 ft.lb), "ETC Limits" (ETC TPS Max, ETC Injector Disable, Power-Hop Inj Disable), "Spark Retard" (vs. Torque Reduction), and "Traction Control System" (TCS Method: Retard vs. RPM, Aggressive Retard vs. RPM).

The bottom window is titled "Retard vs. % Torque Reduction" and displays a table with the following data:

	0.0	3.1	6.2	9.3	12.5	15.6	18.7	21.8	25.0	28.1	31.2	34.3	37.5	40.6	43.7	46.8	50.0	53.1	56.2	59.3	62.5	65.6	68.7	71.8	75.0
Retard	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15	15	15	15	15	15	15	15	15

- This table is used to adjust torque management and will affect the feel of the car and the crispness of the shifts.