The Leader in Performance Technology

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Printed: February 2005

Table of Contents

1 EMS Introduction

1.1 Help Formats

Help Formats

This guide is available in the following formats:

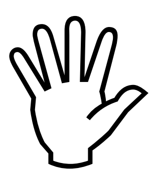
Windows Help
This can be accessed by selecting the Help menu in the AEMPro software.

Adobe PDF
This can be viewed as a electronic document or printed.

Microsoft Word
This can be viewed as a electronic document or printed.

HTML
This can be an interactive help file that can be run using your standard web browser.

1.2 Warning!

 !

This installation is not for the tuning novice nor the PC illiterate! Use this system with EXTREME caution! The AEM EMS System allows for total flexibility in engine tuning. Misuse of this product can destroy your engine! If you are not

well versed in engine dynamics and the tuning of management systems or are not PC literate, please do not attempt the installation. Refer the installation to a AEM trained tuning shop or call 800-423-0046 for technical assistance. You should also visit the AEM EMS Tech Forum at http://www.aempower.com NOTE: AEM holds no responsibility for any engine damage resulting from the misuse or misunderstanding of this product.

To ensure proper use of this system and to prevent risk of damage to your vehicle, you must read these instructions and understand them thoroughly before attempting to program this unit.

This product is legal in California for racing vehicles only and should never be used on public highways.

1.3 AEM EMS

AEM EMS

The AEM Programmable Engine Management System (AEM EMS) is a Windows™ based, user-programmable, Electronic Control Unit (ECU) that uses a powerful 16/32 Motorola microprocessor and has 512k of memory for data storage. On most applications, the AEM EMS is a "plug and play" (PnP) installation using the vehicle manufacturer's original equipment (OEM) connectors, wiring, and sensors, eliminating the need for expensive custom built wire harnessing and non-stock sensors.

The AEM Engine Management System includes a configurable, internal, data logger capable of recording over twenty minutes of information. Every AEM Engine Management System comes with all functions installed and activated, and there are no expensive options or upgrades to be performed.

If you do not have a comprehensive understanding of stand alone engine management systems, please read the AEM Basics manual (AEM Basics.pdf) found in the AEM | AEMPro | Instructions directory located on your computers hard drive before proceeding. It is a very good overview of engine management technology and addresses important areas that must be understood by the tuner if a successful installation is to be performed.

Next, you must read the **Glossary of Terms**. This is the key to understanding the system; it gives an explanation of each available parameter, it's configuration and what it controls. The answer to most questions can be found by referring to the **Glossary of Terms**.

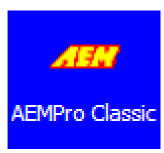
About the AEM EMS

The AEM EMS (Engine Management System) is a total Engine Management solution. The AEM EMS is a tool that allows the user to custom tune an engine by specific requirements. This is extremely useful and usually necessary when upgrading your engine for maximum performance, especially if installing a turbocharger, supercharger or building up a normally aspirated engine. The EMS is a stand alone system, which completely replaces the factory ECU and features unique plug and play technology, which means that each system is configured especially for your make and model of car. There is no need to modify your factory wiring harness and in most cases your car may be returned to stock in a matter of minutes. The AEMPro software is configured to work with the factory sensors and equipment, so that there is no need for expensive or hard to find sensors, making replacement and repairs as simple as with an unmodified car.

AEMPro Software

The AEMPro Software is a Windows® based program, that allows the user to customize the fuel/ignition settings as well as the input/output capabilities of the EMS. This allows the AEM EMS to function as a direct replacement for the OEM ECU as well as control optional equipment such as boost control solenoids, nitrous systems, etc. To open AEMPro, from the desktop, click on the AEMPro icon shown below.

To open AEMPro Classic, from the desktop, click on the AEMPro icon shown below.



AEMLog Software

The AEMLog Software is a Windows® based program, that allows the user to view data that was previously recorded using the AEM EMS on-board logger or the users computer (PC Logging). AEMLog is an invaluable tool for tuning the engine or diagnosing any problems that may occur during normal operation. To open AEMLog, from the desktop, click on the AEMPro icon shown below.

AEM EMS Features

Outputs:

- 10 Injector outputs
- 5 Ignition outputs
- 1 Fuel pump output

- 4 +12v User defined drivers (VTEC, EGR, etc) outputs
- 2 O2 Heater ground controls
- 2 Temperature controlled outputs (radiator fan etc.)
- 6 user defined (-) switched outputs (NOS, a/c, purge, etc..)
- 1 Check engine / shift light
- 1 Tachometer output
- 2 PWM outputs (may also be run as switched outputs) boost control, IAC motor, staged nitrous, etc)
- 2 Stepper motor drives (may also drive 4 wire antagonistic pair outputs)

Inputs:

- 2 Knock channels with control
- 2 O2 channels with control
- 4 Thermo couple inputs (RTD Type Only)
- 4 Speed sensor inputs
- 1 Spare temperature input
- Throttle position
- Manifold pressure / Mass air input
- Barometric pressure sensor
- 2 Spare 0-5v input (pressure sensor, or position sensor)
- Coolant sensor
- Air inlet temperature
- Battery voltage sensing
- Clutch or neutral input (may be used for 2-step rev control)
- Crank position (timed)
- Cam position (timed)
- Extra TDC or air flow (Vortex) input
- Speed sensor input (for gear selection, traction control, etc)
- Filtered sensor ground

Memory:

- 512 Kilobyte internal logging memory
- Flash ROM
- Fault logging

Communication:

- RS-232 pc com link
- High read/write duty

1.4 EMS Forum

EMS Forum

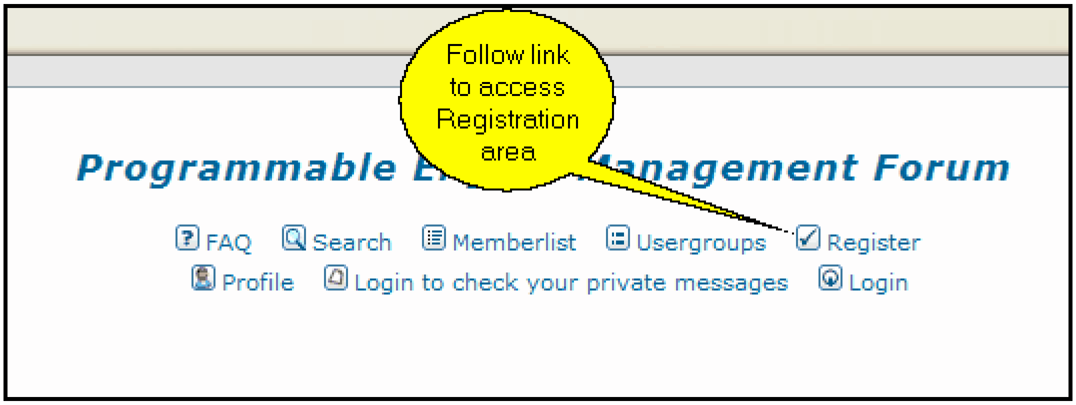
The AEM EMS forum is a website that is provided by AEM for customers to access information and updates 24 hour a day, 7 days a week. The forum is a valuable source of information and support from the AEM EMS engineers as well as other EMS users.

Accessing the Forum

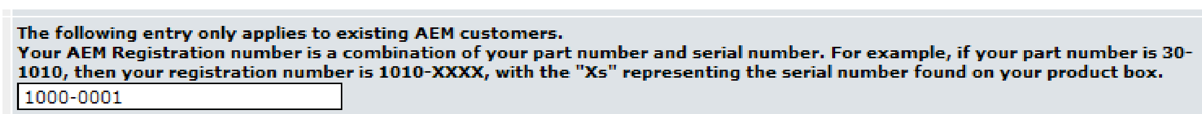
To access the AEM EMS Forum type www.aempower.com in your browser address bar.

How to Register

It is not necessary to register to access most of the information on the forum. Some information such as calibration files do require the user to register to access the files. To Register click on the **Register** link.



It is important to enter the EMS serial number in the correct format. The following illustration shows the correct format for entering the EMS serial number.



2 EMS Installation

2.1 Software Install from CD

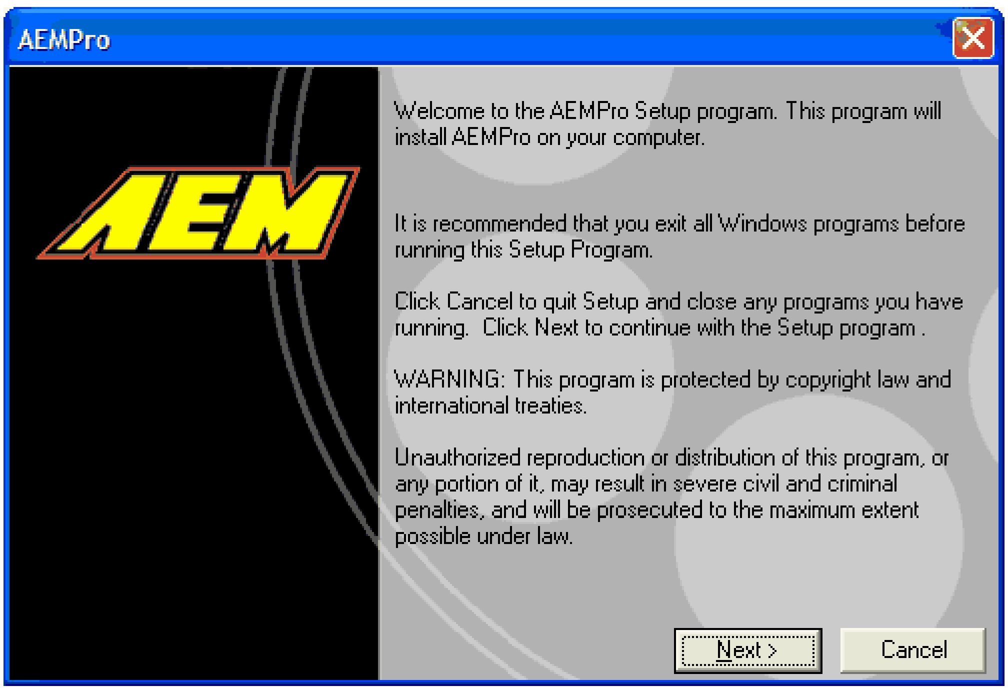
Software Install from CD

AEMPro CD contents:

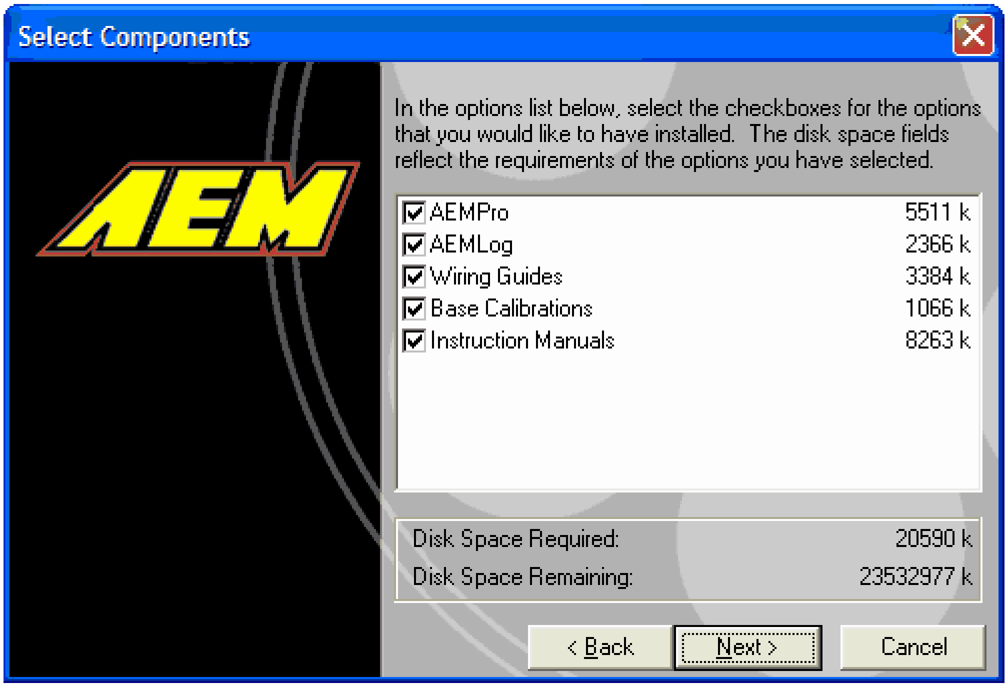
- AEMPro/AEMLog Installation Software (AEMReleaseXXXX.EXE, XXXX=Current version) Double click this file to start the installation process.
- Adobe Reader installation software (rp505enu.exe) Double click this file to start installation

All appropriate reference material will be available by accessing the Instructions folder located in the AEMPro Directory. (C:/Program files/AEM/AEMPro/Instructions)

- Insert the AEM CD into the CD-ROM drive of your computer
- The CD will auto-run to install the AEMPro and AEMLog software



- An installation dialog box will be displayed with options to install documentation and base calibrations.

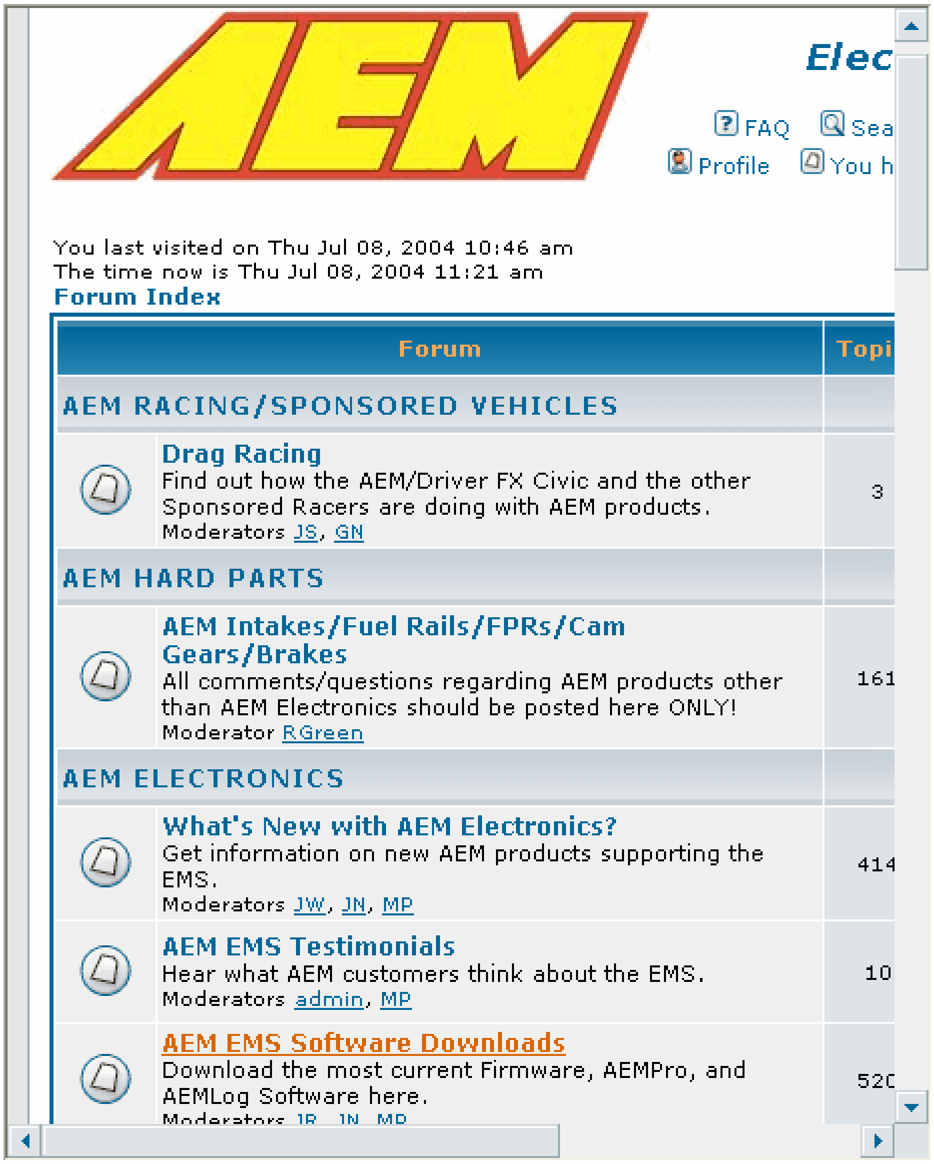


- If the auto run feature is disabled on the PC, use the following steps to begin installation
- Double click on the My Computer Icon | CD-ROM Drive | AEMReleaseXXXX.exe (where XXXX=latest version)
- Select Install AEMPro software
- Follow the instructions on the screen to complete installation
- It is recommended to leave the default target installation directory (c:/Program Files/AEM) unchanged, this will simplify future updates
- Restart the PC

2.2 Software Install from Website

Software Install from Website

The latest and most up-to-date software will be available on the AEM EMS forum website. To install the AEM software from the website follow these directions:



- Download all applicable files to a folder on your computer; do not change the name of the files when downloading.
- Double click on the first file in the series; it will be identified by the .exe extension.
- Follow the on-screen directions.
- It is recommended to leave the default target installation directory (c:/Program Files/AEM) unchanged, this will simplify future updates
- Restart the PC

2.3 AEM Interface Software

AEM Interface Software

The AEM EMS system uses 2 software programs, they are **AEMPro (or AEMPro**

Classic) and **AEMLog**. Unlike most engine management systems, the AEM software is supplied free of charge. It can be downloaded from the AEM EMS forum at www.aempower.com.

AEMPro (or AEMPro Classic)

This is the calibration/tuning editor software. This program allows the user to configure and tune an engine, in real time, which means all changes being made to the calibration file while connected to the ECU are effective immediately. There is no need to save the changes then upload them to the ECU.

AEMLog

This is a powerful data analysis program that allows the user to view and analyze logged data. This is a valuable tool in diagnosing and tuning an engine.

2.4 AEM Firmware

AEM Firmware

AEM firmware consists of two different files (.gin and .fin). The .gin file stays on the PC side while the .fin file stays on the EMS side and they communicate with one another. The two files will have to be matching versions for communication.

Definition (.gin)

Without the correct ECU configuration software, AEMPro will not be able to communicate with EMS. The installation program will automatically install the appropriate configuration software when initially configured. See http://www.aempower.com for any updates.

To install a new vehicle configuration software follow these steps:

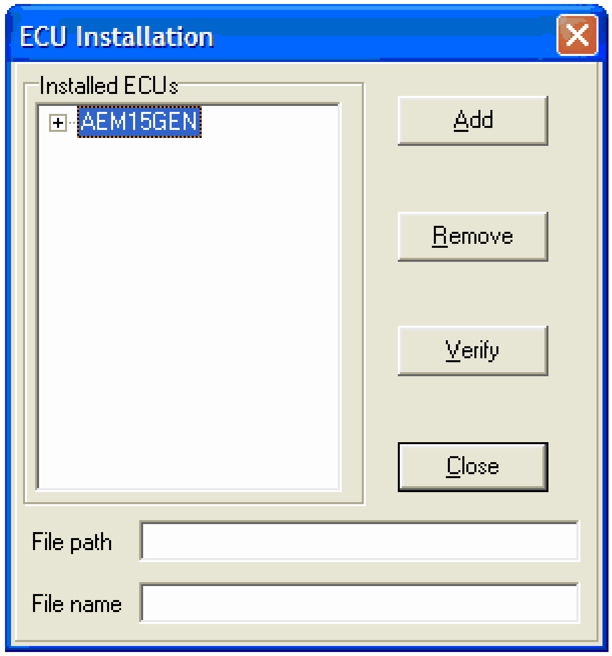
Select **ECU | Install ECU**

- Select **Add**
- Navigate to the configuration file that needs to be loaded (.*gin*) file.
    - The file that is to be loaded must agree with the firmware version you intend to run.
- Select the required configuration file from the **Open Window** and press the **Open** button.

The **Open Window** disappears. The name and version of the configuration file supported is displayed in the **New ECU Group Box**. If the selected file is not a valid configuration file a message box appears stating **Bad Initialisation File**.

- Press the **Yes** button in the **Confirm Box** to install the configuration file.

The ECU name and version is added to the list contained in the **Installed ECU Group Box**. Illustration shows The **ECU Installations** window. Any current installations of configuration files can be viewed by clicking on the (+).



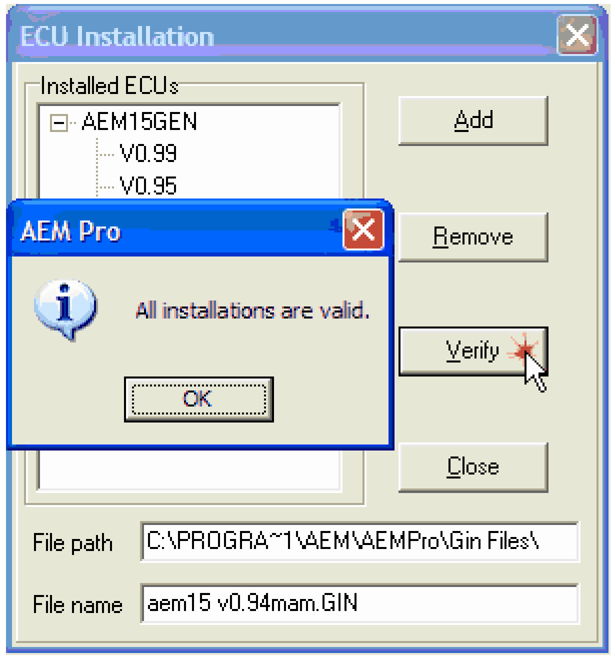
If there are problems communicating with the ECU, and you believe the correct configuration file is installed, the configuration file can be verified.

- Select **ECU | Install** from the menu.

The **ECU Installations** window appears. This shows all ECU types and versions currently installed, and allows installation and verification of configuration files.

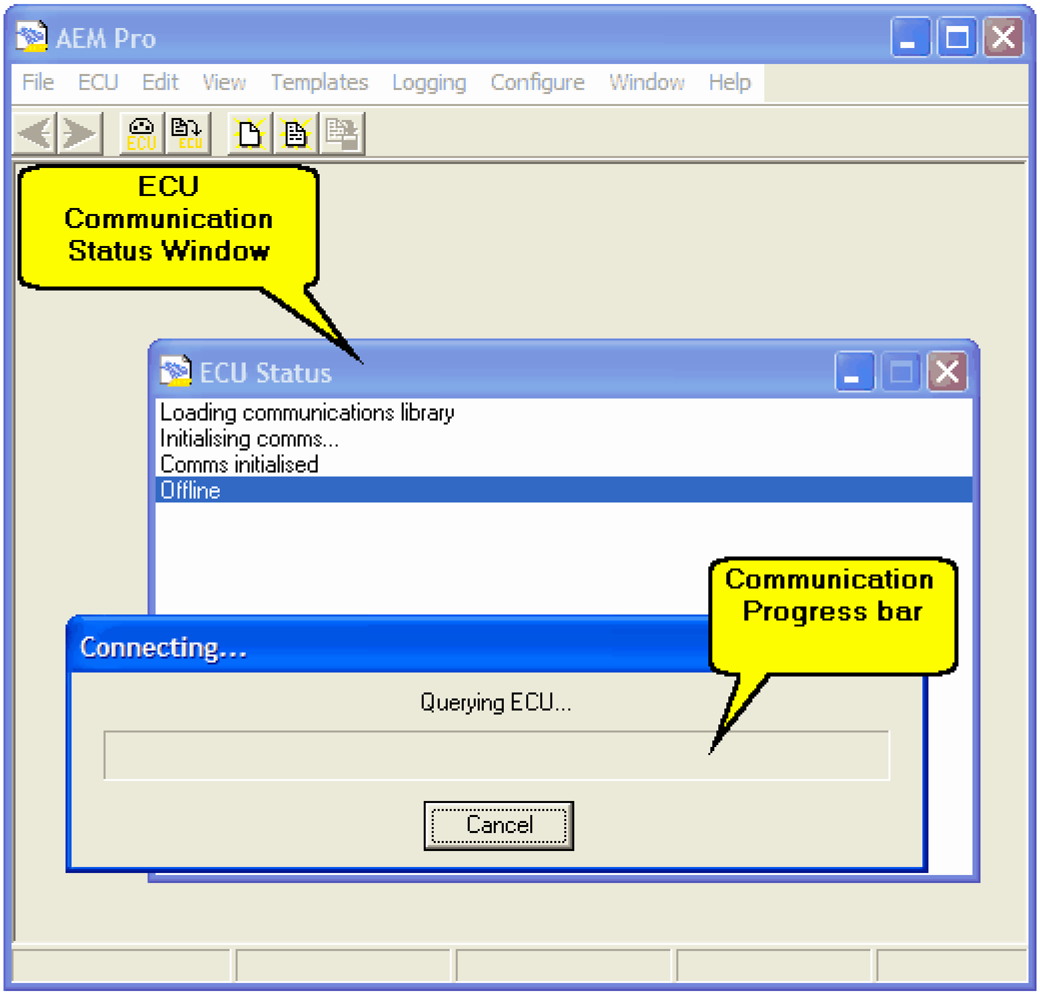
- Press the **Verify** button within the **Installed ECUs** group box.

If all installations are valid a message box appears stating **All installations are valid**. If any installation is not valid a message box appears stating, **The file XXXX does not exist. Remove reference?** where XXXX is the name of the missing configuration file. If you wish to remove this reference from the list of installed ECU's click on the **Yes** button otherwise click on the **No** button. Any further references, which do not exist, will also be displayed.



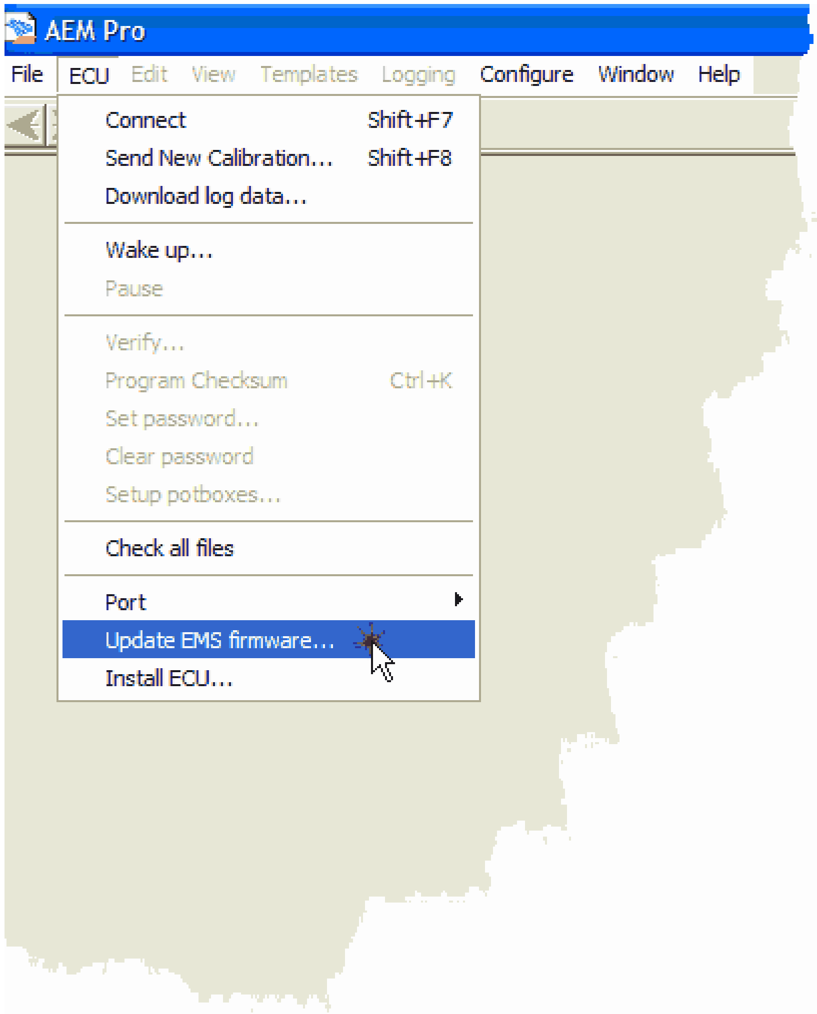
Firmware (.fin)

The FIN file is the operating system of the EMS. This file is what tells the EMS how to function. The current .FIN file installed in the EMS can be determined by viewing the **ECU Status** window that is displayed when connecting to the EMS.

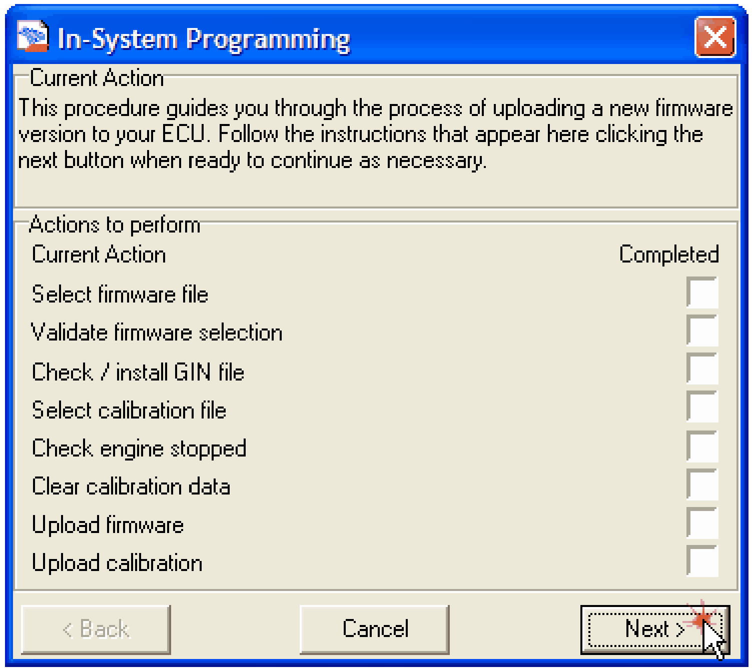


If the version you have is not the latest release, use the following steps to install the updated .FIN file:

1. Connect to EMS
2. Select the ECU drop down menu then Update EMS firmware.



3. Follow the instruction shown on the In System Programming window.



Note: It is important that the **In-System Programming** process not be interrupted. It is advisable to have the PC connected to AC power. Computer utilities such as screen saver, hibernate or sleep mode should be disabled.

2.5 Updating AEM Software

Updating AEM Software

To determine if the installed software is the most current version available, use the following steps:

- Open the AEMPro software by using the AEMPro icon on the Windows desktop, then click on the **Help** drop down menu then **About**, the software version will be displayed in the **About AEMPro** window, compare this number to the information on the EMS forum.

It is important to also note the version of the model specific calibration file (.cal) to be used. The file can be found by navigating to the AEMPro directory (C:/Program FIles/AEM/AEM Pro) and looking at the calibration file name. The 4 characters after the name designate the version (XXX.*V1.00.cal*). Compare installed version with the information posted on the EMS Forum.

Get Up-to-Date

After installing the AEMPro software it is important to go to the AEM forum website and register your EMS at www.aempower.com

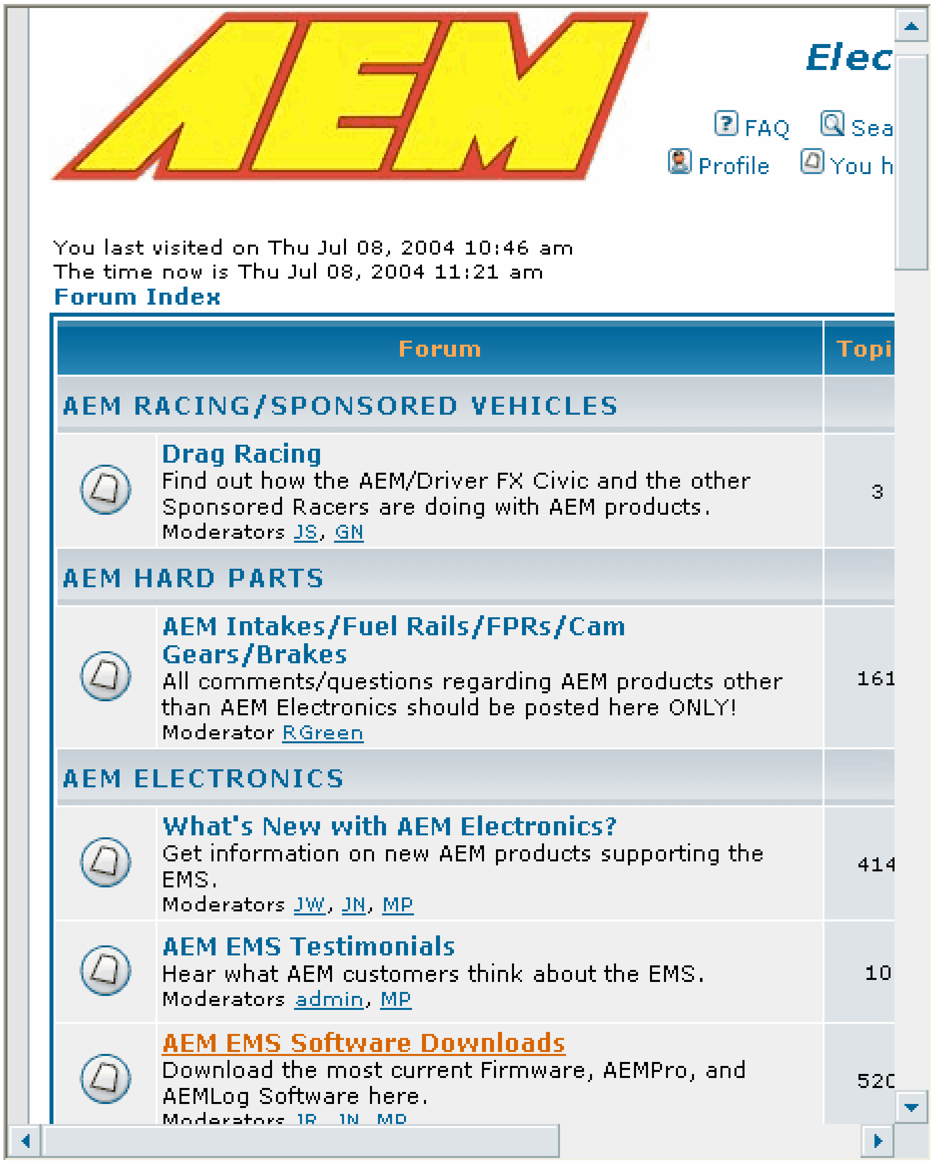
Doing so will allow you access to the most current information, calibrations, and updates. AEM is continually updating the software to add features as well as resolve issues discovered in the field.

ECU Strategy Updates

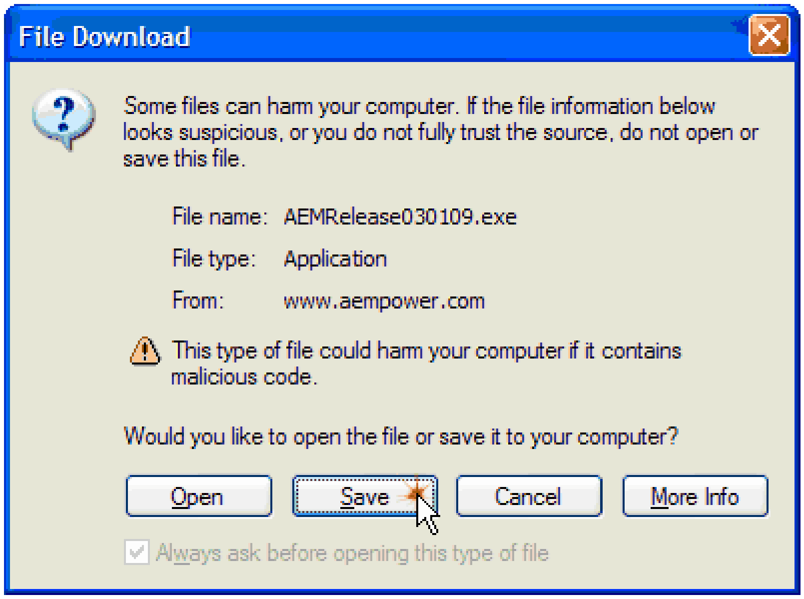
The EMS strategy is a combination of the firmware (.fin) and definition file (.gin). These files are usually developed and updated at the same time, although occasionally a firmware (.fin) will be released using a current definition file (.gin)

Updating the ECU Strategy

- Download the updated files by selecting the link from the AEM forum website



- Save the file to a folder on the PC hard drive that is easily found after the download is complete



- Note: Do not change the file name or extension when saving, it will cause problems when installing the files.
- Using Windows Explorer, navigate to the folder where the updated file was saved and double click on the downloaded file.
- Follow the on-screen instructions, same as original installation.
- There are 2 files associated with each strategy level.
- **.FIN* is the firmware and is uploaded into the EMS and should be stored in the AEM/AEMPro/FIN directory.
- **.GIN* is the definitions file, which allows AEMPro to recognize the specific file format and should be stored in the AEM/AEMPro/GIN directory.
- After the update is complete, the files then need to "install" into AEMPro.

Follow the direction in the file specific sections for more information on updating these files.

2.6 ECU Installation

ECU Installation

Note: Before installing this system, the vehicle must be in proper working condition.

Check the following before installation.

- Fuel pressure (must be set to factory specs)
- Spark plugs (recommend starting with new plugs)
- Ignition timing (must be set to factory specs)
- Fuel filter (recommend starting with new filter)
- Fuel injectors (must be in known good working condition)
- Spark plug wires
- Distributor cap and rotor (if applicable)

- See included fuel system recommendations before starting.

This system will not fix any mechanical issues that are causing running problems. Fix any pre-existing problems before installation.

1. Disconnect battery positive cable
2. Locate factory Engine Control Unit (ECU)
    a. Most ECU's are located in the passenger kick panel, or passenger floor.
    b. Others are located behind the center console
3. Unplug factory wiring harness plugs at ECU
4. Remove fasteners holding ECU in place, and remove ECU
5. Plug factory harness plugs into AEM unit
    a. Note, these will only plug in one way
6. Mounting the EMS
    a. Some of the AEM ECU's are not water resistant and must be placed in a location that protects it from moisture and water.
    b. It is recommended that the EMS be placed in an environment that does not expose it to temperatures above 70° Celsius (160F).
    c. In cases where the AEM EMS is to be used in place of the stock ECU, the location that the stock ECU occupied is best. On applications where the EMS is to be located in a different position than stock, the interior of the vehicle is best.
    d. It should be located in a place that allows the shortest length of wire to be used while maintaining an environmentally sound location for the EMS.
7. Once the ECU is mounted, run the COM cable to an easy access location away from moisture, and any sharp metal corners. Metal stamping can cut through wires very easily.
    a. Note: the glove box is an excellent choice for the COM cable location, as it will be used frequently.
8. If converting from mass/air to speed density, see attached sheet for installation instructions.
9. Re-connect battery cable.

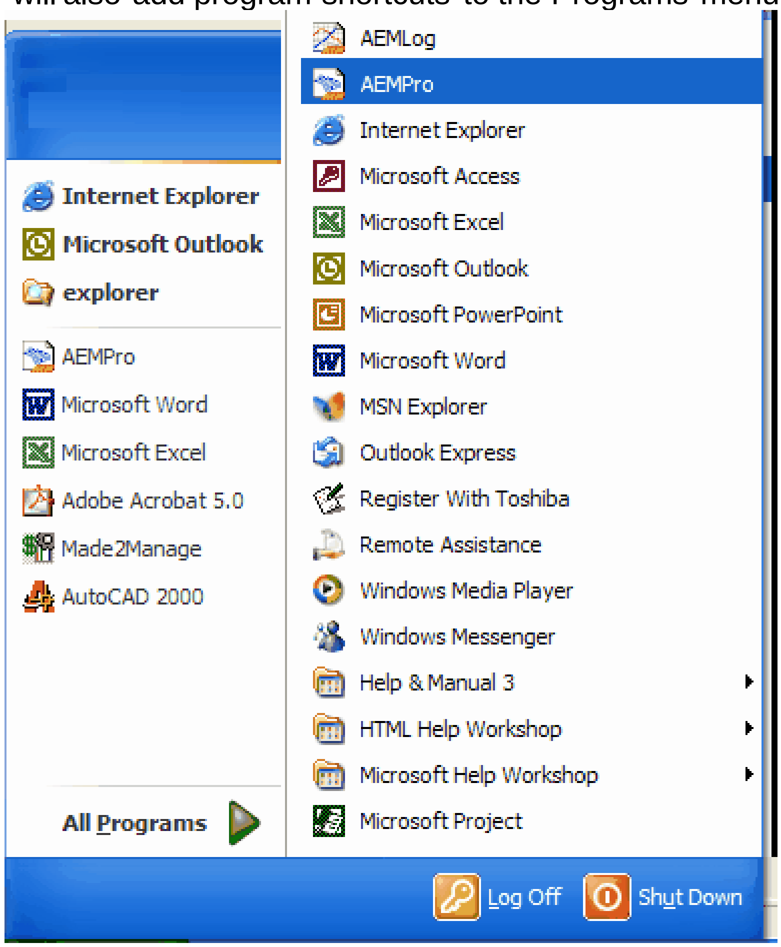
3 AEMPro Basics

3.1 Getting Started

Getting Started

After installation of AEMPro is completed there should be a shortcut icon placed on the computers main screen, also called the desktop. AEMPro can be started by double clicking on the icon below.

The installation will also add program shortcuts to the Programs menu.



File Extensions

The AEM EMS software uses several different file naming conventions.

.FIN: This file is the firmware or operating system for the ECU

.GIN: This is the definition or user interface file, this file allows AEMPro to read the data being sent from the ECU

.CAL: The Calibration file contains all the tune-up specifications such as fuel and ignition

.GTP: This file is created when saving a screen layout or template

.GDF: This is an obsolete file that was used in previous versions of AEMPro. It had the same function as the .CAL file

.DSH: User configurable dash setup files, this file is created when setting up a screen dash function

.MXP: This file is created when setting up custom menus in AEMPro

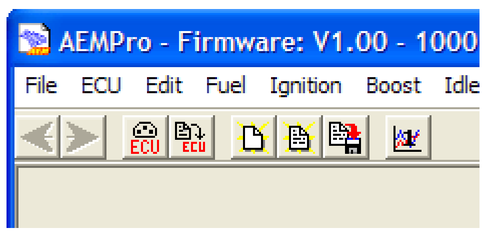
.PDF: These files are Adobe Reader files. All documentation will be in this format

.STF: These file are created when using the PC or Internal datalogger features

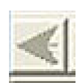
.ICO: These are the AEM file icons

Viewing AEMPro

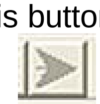
The AEMPro Toolbar contains icon buttons that are used as shortcuts to menu items.



Undo: After a change has been made to the calibration, this button will undo the change.



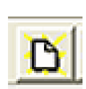
Redo: If an undo function was used this button will redo the change.



Connect: Use this button as a shortcut to connect to the EMS.

Upload: Opens the upload calibration window. Allows selection of the calibration file to upload to the EMS.

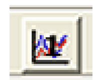
New: Opens a new blank calibration.



Open: Opens a saved calibration.

Save: Saves the current calibration.

Template: Applies a saved template to the screen.

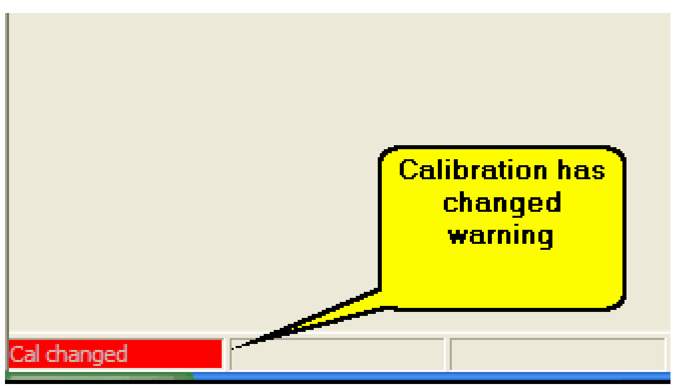


Keyboard Shortcuts

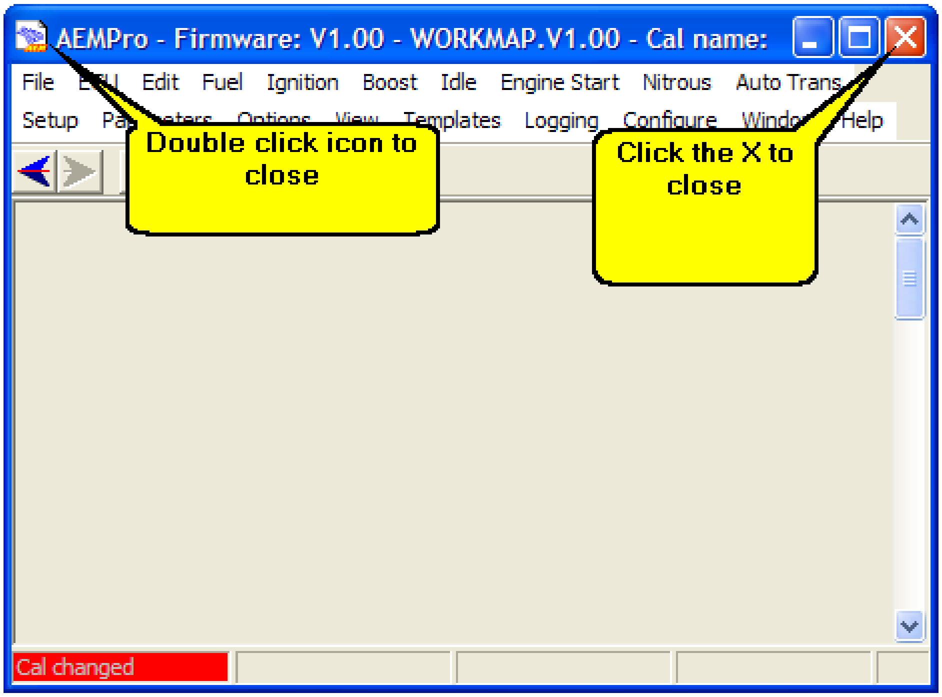
S: When viewing a table or graph this key will switch between views.
M: Brings up the sub-menu for the table or graph that is active. Same function as using the right mouse button.
CTRL+ F: Opens the **Fuel Map**.
CTRL+ I: Opens the **Ignition Map**.
F1: Opens the **Help** file.
F2: Edits the selected value (used in table views).
F3: Opens the **Calibration** window.
F4: Creates a **New Calibration**
Shift+F7: Connects to the ECU
Alt+Arrow keys: Copies the selected cell to each adjacent cell when moved using the arrow key.
F6: Start and stops PC datalogging

Closing AEMPro

It is advisable to save any changes made to the program while connected before closing the program. If changes have been made a warning will flash at the bottom of the screen.



There are several ways to close AEMPro, any of the following methods will work.



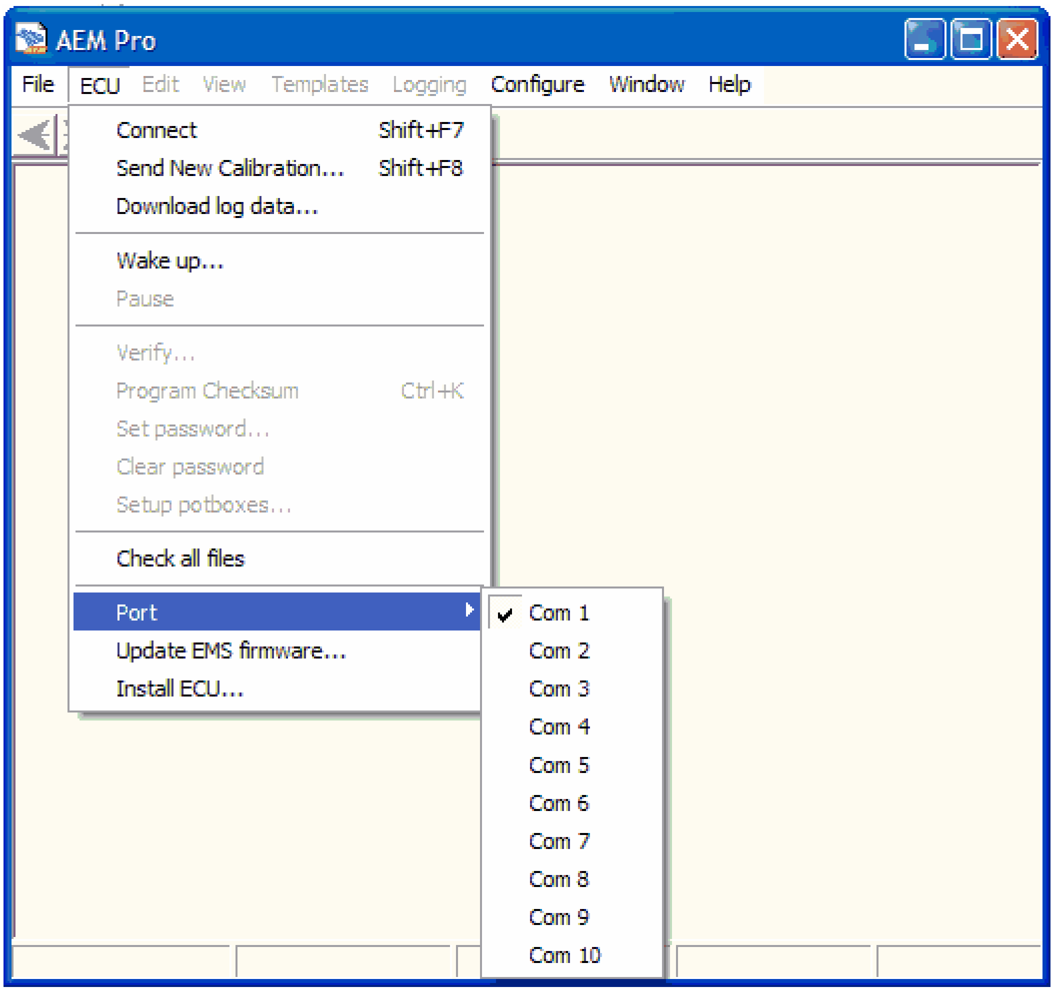
3.2 Connecting

Connecting

To connect to the EMS, the proper communication port must be selected. The default serial port for communication with an EMS is COM1.

- **It is important that the correct COM port to be used is set in the PC software, or no communication will occur**

To change the COM port the AEMPro will use, select **ECU | Port** from the menu in AEMPro, followed by the appropriate port. The available options are COM1 through COM10.

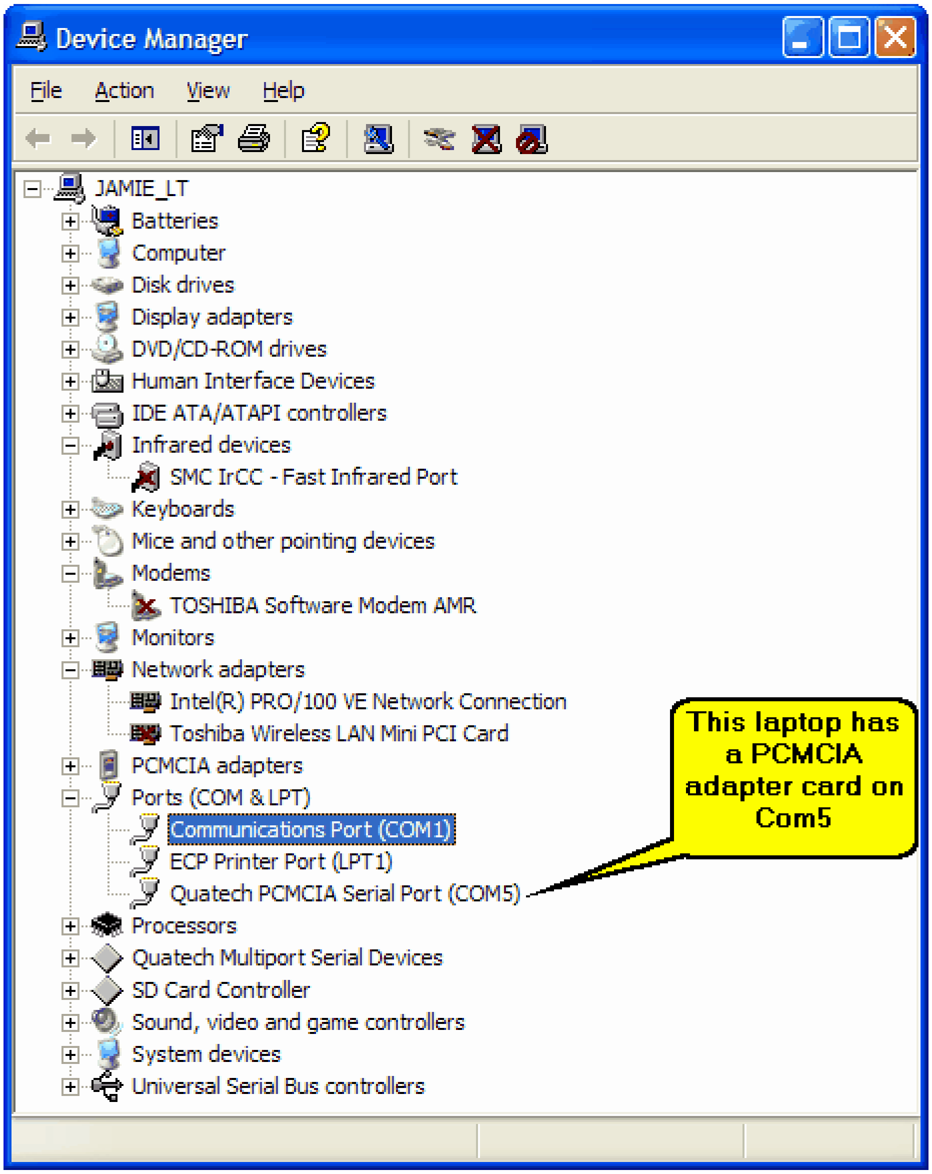


To determine which COM ports are available on your PC follow these instructions:

- Select *Start* | *Settings* | *Control Panel*
- Double click on *System*
- Enter the *Device Manager*
- Open the *Ports* entry by clicking on the plus sign next to it

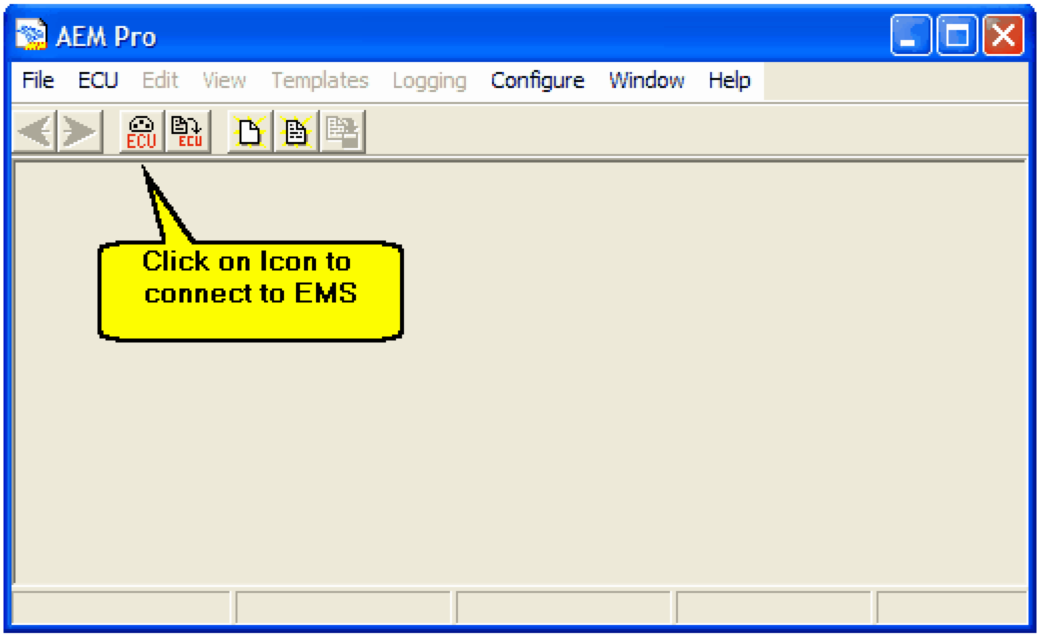
The different COM ports available on the PC will be displayed stating their type
It is very important that the PC port selection and the port selection in the AEMPro software agree

Note: If the COM port is not correctly set, any attempts to connect to the ECU will result in failure

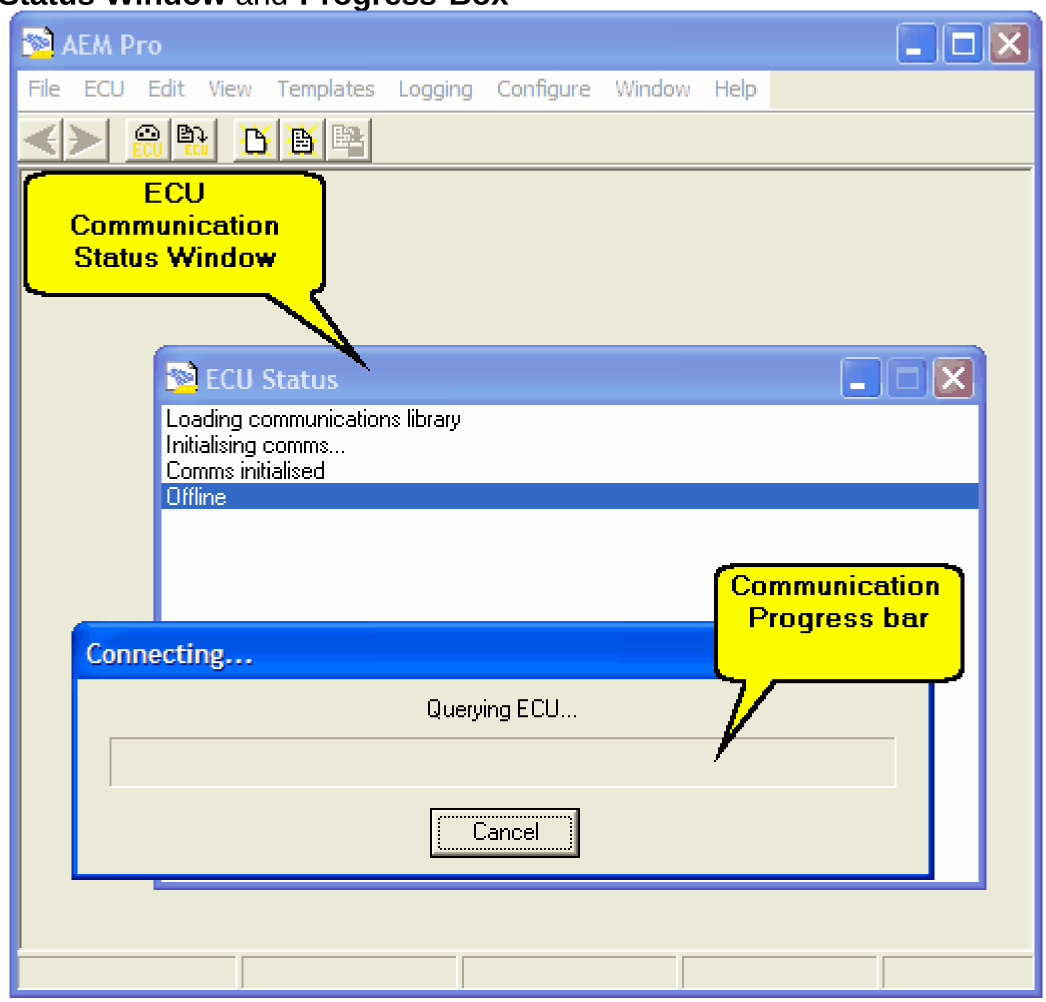


Connecting to the EMS

When AEMPro attempts to connect to the AEM EMS for any reason, the **ECU Status Window** and a **Progress Bar** will appear while AEMPro attempts to discover the EMS's configuration. It will then download the current calibration that is programmed into the ECU to the Laptop. If there is no calibration loaded into the EMS, one will need to be uploaded. To connect with the AEM EMS, click on the **ECU Connect Icon**, select the **ECU | Connect**, or **SHIFT + F7**



ECU Status Window and **Progress Box**



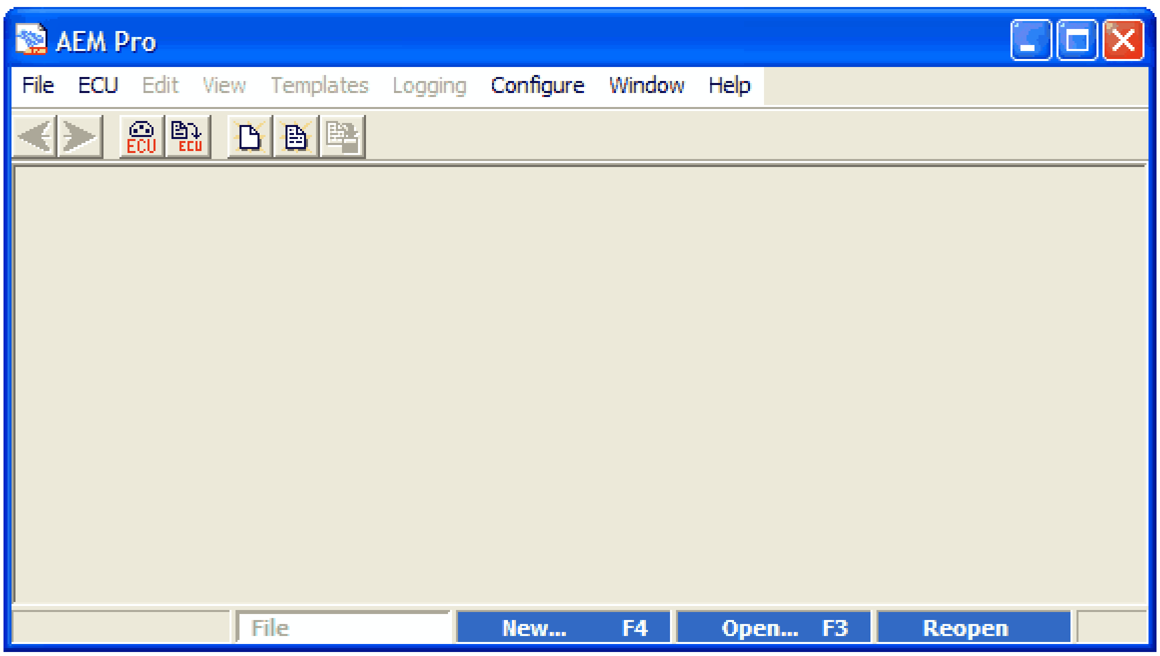
3.3 Calibrations

Calibrations

Calibration files is what the tuner modifies and will be specific to the engine setup. It is very important to select the correct base calibration file to fit the selected application. The base calibration files are named according to the part number of the EMS for the specific application.

Example: The EMS part number for the 93-98 Toyota Supra Turbo is 30-1100, all base calibration files for the Turbo Supra will start with the number 1100, then any specific configuration information may be included in the calibration name as well.

The illustration below shows the AEMPro Desktop as seen when opening AEMPro without a calibration loaded. To proceed from here a calibration should be opened or connection to the EMS should be made.



The Active EMS File

When working **Online**, a copy of the EMS calibration is held in a file called the **Workmap** file. AEMPro changes this file automatically as necessary. For example, if any part of the ECU calibration is changed the same change is effected in the **Workmap** file. Also when uploading or downloading a file, the **Workmap** file will be changed to the calibration held in the EMS. While working **Online** it is not possible to view or edit any other file. However, the **Workmap** file can be saved as a different calibration name. The most useful function this has is that you can always revert back to the EMS's last state of configuration **Offline**, by opening the **Workmap** file. This helps avoid losing data, even if you forget to save your changes.

Note: When making changes **Offline**, save the file under a new name. Do not use the **Workmap** file as a name to save the calibration. This file is over written when connecting to the EMS.

Downloading a Calibration

In AEM terms, downloading means reading data from the EMS to the PC. Connecting to an ECU will make AEMPro obtain a copy of the calibration held in the EMS. To connect to the EMS use any one of the following options.

- Select **ECU | Connect** from the menu.
- Click on **Connect** toolbar icon

- Press <Shift> + F7.

When connecting to the EMS, any open calibration is closed, and any live connection is terminated. AEMPro then queries the connected ECU to determine it's type. By default, AEMPro then downloads the calibration from the EMS. If the calibration is different than the **Active ECU File** another progress box appears as it downloads the calibration. The calibration is then saved as the **Active ECU File**. Finally the **ECU Status** window appears and the last displayed template is loaded.

Uploading a Calibration

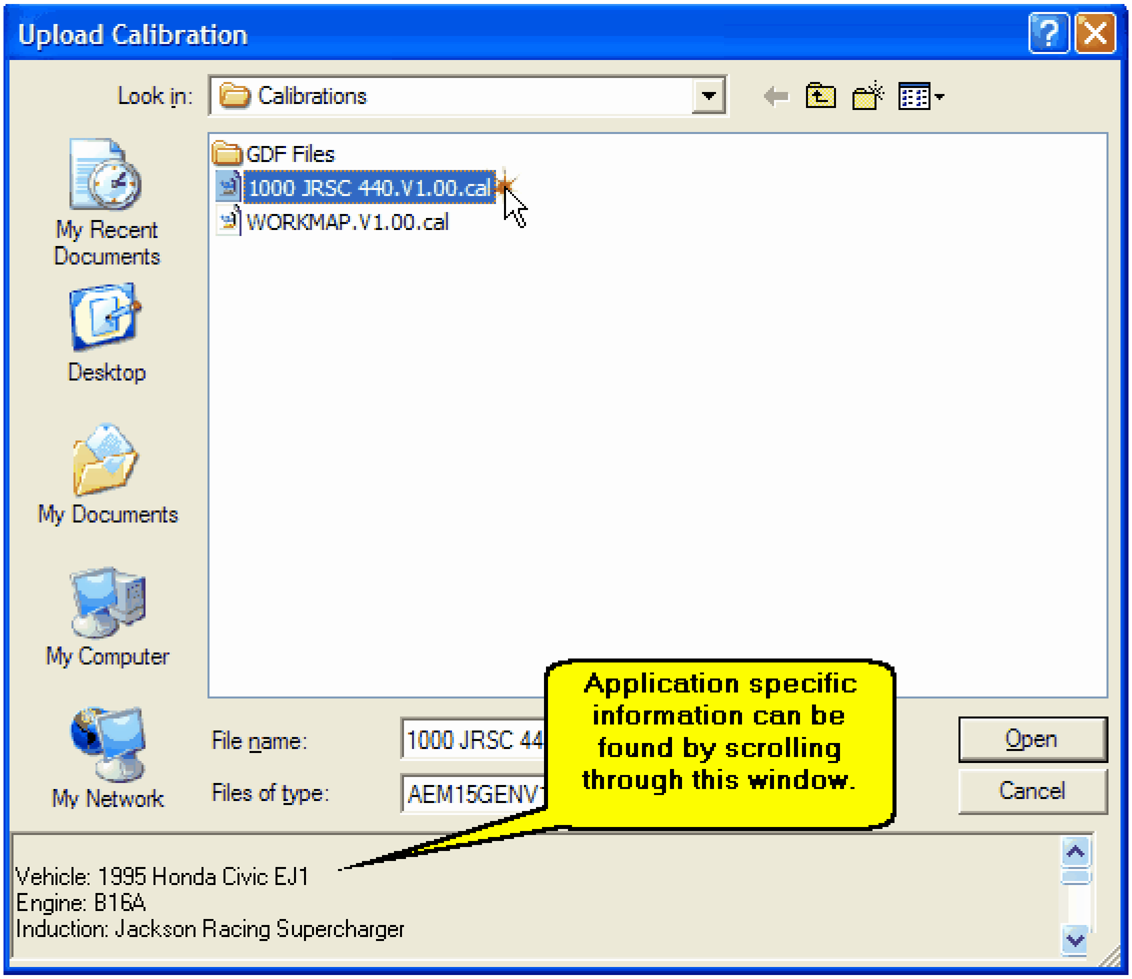
Uploading means writing data from the PC to the EMS. To upload a calibration, use any of the following options.

- Select **ECU | Send New Calibration** from the menu
- Click on **Send New Calibration** toolbar icon

- Press <Shift> + F8.

When connecting to the EMS, any open calibration is closed, and any live connection is terminated. AEMPro queries the connected ECU to determine its' type. Once the ECU type is determined the **Upload Calibration** window appears.

The **Upload Calibration** window shows the ECU type and a list of valid calibrations (if any exist). When viewing the base calibrations in the **Upload Calibration** window, specific application information can be found by scrolling down the **Notes** box located on the bottom portion of the **Upload Calibration** window.



To upload the selected calibration, press the **Open** button, or double click on the calibration name. The **Open Calibration** window disappears, and another **Progress Window** appears as it uploads the calibration. The calibration is then saved as the **Active ECU File**. Finally the **ECU Status** window appears and the last template displayed is loaded. To cancel the upload, press the **Cancel** button.

NOTE: If the engine is running, AEMPro will not upload the calibration.

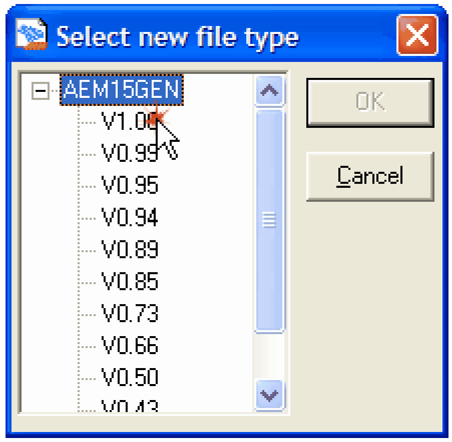
Creating a New Calibration File

To create a new calibration file use any of the following options.

- Select *File* | *New…* from the menu.
- Press the F4 button
- Click on the new calibration icon

If a file is currently open, it is closed or if **Online** the connection is terminated. The

New File window appears showing the ECU types available for which a new calibration can be made.



To create a new calibration of the selected ECU Type, press the **OK** button. A new calibration is created and the template for the last known state is loaded. To cancel the creation of a new calibration, press the **Cancel** button.

Opening a Calibration File

To open an existing calibration for viewing or editing *Offline* use any of the following options.

- Select **File | Open** from the menu.
- Press the F3 button.
- Click on the **Open** button.

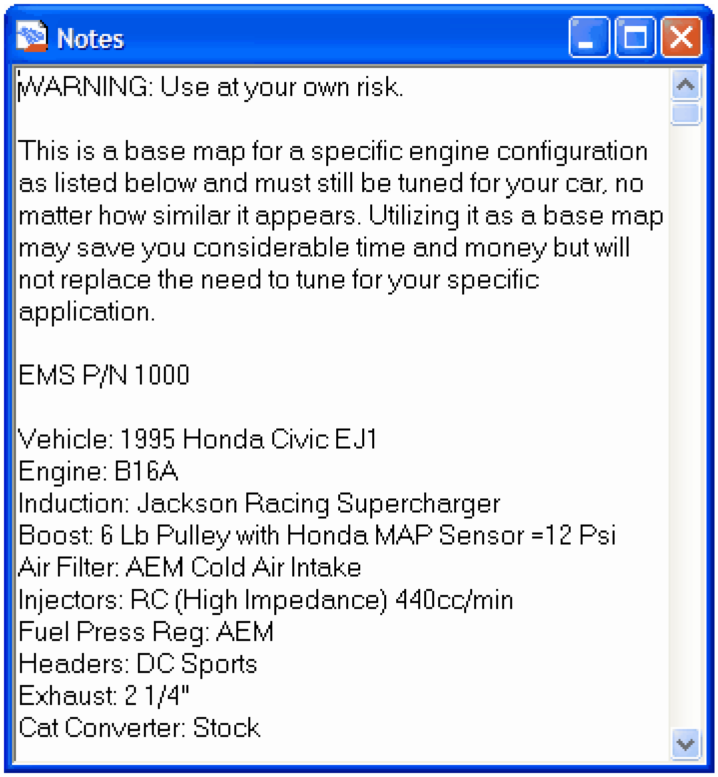
If a file is currently open, it is closed if **Online** the connection is terminated. The **Open Calibration** window appears showing files for the currently selected ECU type. The ECU type can be changed to any installed type by selecting it from the pull-down list box. To open the selected calibration, press the **Open** button. The calibration is opened and the template for the last known state is loaded. To cancel the opening of a calibration, press the **Cancel** button.

The Open Calibration window follows the same conventions as all Windows based Open File windows. To find a specific .cal file select the Look in: drop-down menu and navigate to the desired folder.

To find a specific version calibration file select the Files of type drop down menu. Here you will find all available versions that have been loaded into your computer. Select the desired version and the available calibrations files will be displayed in the Open Calibration window.

Select the available calibration file displayed in the window and then select Open. This will load the desired calibration into AEMPro.

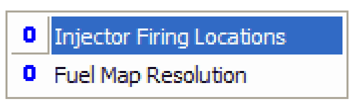
Each AEMPro calibration file has the ability to store notes about the specifics of each file, they can be viewed by selecting the menu Setup|Notes. This will display the window shown below, whose notes can be edited as needed, and when the changes have been made closing the window will save the notes to the calibration file. The Calibration will then need to be saved onto the PC.



3.4 Options

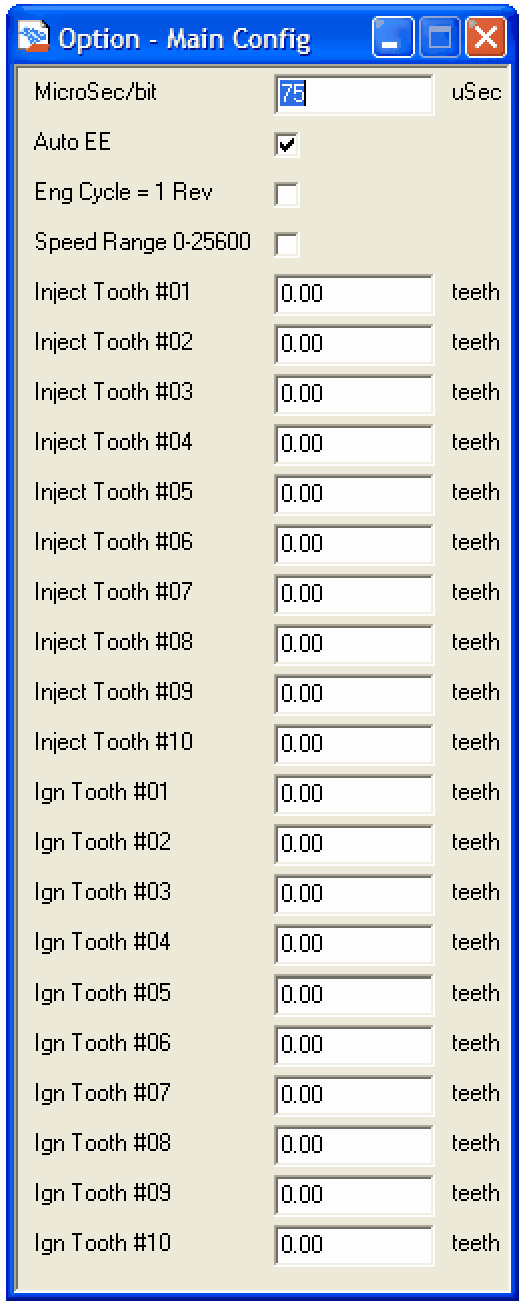
Options

Options are single values that are set by the user to change the operation of an ECU. These can be found by navigating through the menus and are noted by a highlighted **O**.



The option value is changed following this operation.

- Selecting **Options** from the menu.
- You then get the choice of displaying full list or selected list. A selected list will allow for organizing the options functions in a manner that better suits your needs. Multiple options windows can be opened.
- Selecting the option to be changed with the mouse will allow for that option site to be edited.
- Typing the required value and pressing the return key.
- Pressing the space bar can change options with an ON/OFF value.

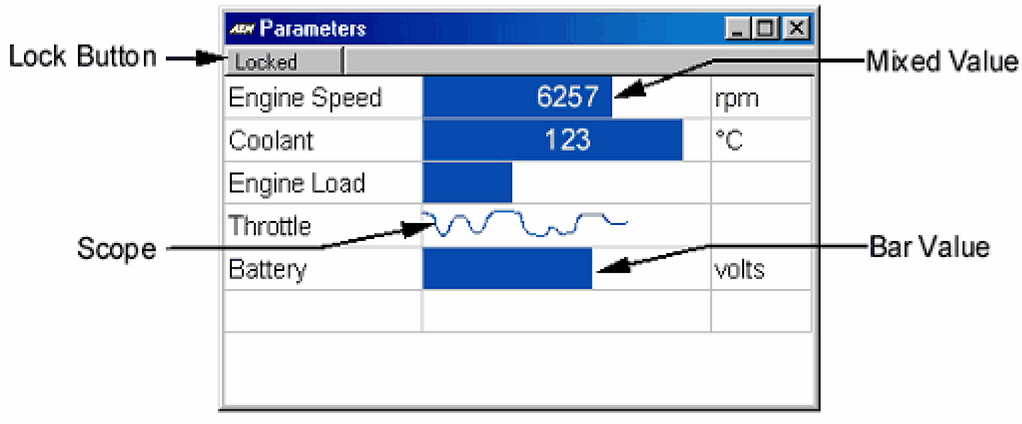


Warning: Use caution when changing the various Options, this will directly affect the operation of the EMS.

3.5 Parameters

Parameters

Parameters are for viewing and are, basically, the window to the engine. In other words, it tells you everything the engine is doing, and what all of the sensors are seeing. This window is one of the most valuable tools in helping to tune the engine. The **Parameters** window can be displayed in several ways. Parameters are values that the current status of a specific signal, such as engine speed, or engine load. The **Parameters** window can be viewed both **Online** and **Offline** (values are only displayed when **Online**). An empty **Parameters** window appears with a pull-down list box containing the list of viewable parameters. Multiple **Parameters** windows can be displayed at the same time.



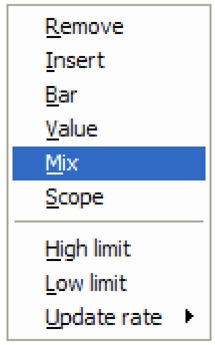
When a calibration is viewed **Offline** the **Parameters** windows can still be displayed although no data will be visible. This allows templates to be set up **Offline**.

The **Parameters** list window allows parameters to be added or modified by unlocking the lock button. By selecting an entry from the list the parameter is displayed. Navigating through the list of parameters is accomplished by pressing the tab button to move down the list or <Shift> + Tab to move up the list. When a parameter is selected, you can chang it by pressing the up or down arrow keys or re-selecting an entry from the drop-down list.

The lock button enables and disables editing of the parameter window layout. When the button reads **Locked**, the parameters cannot be edited. This is the default state of a parameter window when opened from a template. When the button reads **Unlocked**, the parameters can be edited. This is the default state of a parameter window when opened from the **View** menu. Clicking on it, with the mouse, toggles the button.

A parameter is inserted into the window by right clicking on the appropriate line and selecting **Insert** from the pop-up menu. A default parameter is inserted and the parameter name can then be changed as previously described. A parameter is deleted from the window by right clicking on the appropriate line and selecting **Remove** from the pop-up menu. The current value of a parameter is displayed in the mid section of the window in the defined type. There are four different display methods, which display. The default display method is **Mix**.

To select the display method for a parameter right click on the appropriate line, then select the desired view from the pop-up menu.



- **Remove** - Removes the selected parameter from the list.
- **Insert** - Inserts a new row to display a parameter.
- **Bar** - Displays the value relative to the lower and upper limits by filling in the space.
- **Value** - Displays the selected parameter as a numeric value.
- **Mix** - A combined display of both **Bar** and **Value**.
- **Scope** - Displays the selected parameter oscilloscope trace.
- **High Limit** - Sets a high limit value for the displayed parameter, value changes to red when exceeded.
- **Low Limit** - Sets a low limit value for the displayed parameter.
- **Update rate** - Sets the speed at which the parameter is updated on the computer screen. All rates are relative with rate 0 being the fastest rate and subsequent rates being half the speed of the previous rate. Note that parameters using the **Scope** type pan across the display at a rate relative to the update rate.

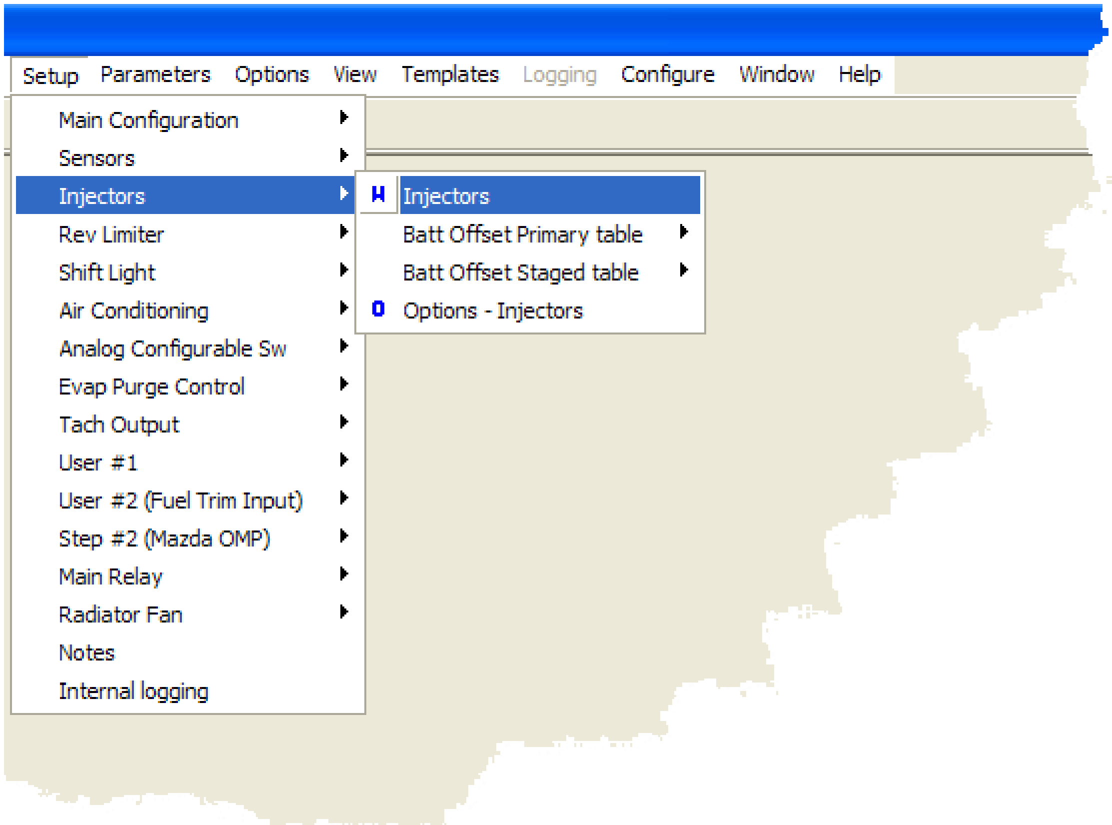
3.6 Wizards

Wizards

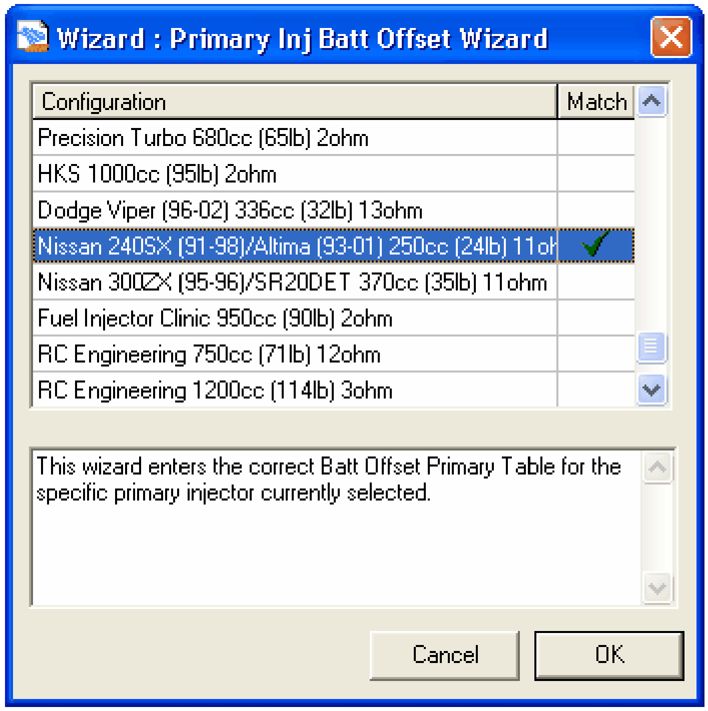
AEM has made the tuning process even easier with the addition of configuration wizards. The wizards have been introduced in the Version 3.17 AEMPro menu structure when using Version 1.0 firmware and later.

A wizard allows specific common functions to be changed at the click of a button. These configuration wizards include different: MAP Sensors, Injector Sizes, O2 Sensors, AIT Sensors, Coolant Sensors, O2 Feedback, Boost Control, Cam/Crank Pickups, EGT Sensors, Coil Dwell, Idle Motors, Transmission Types, etc. AEM has reconfigured all of these settings, which eliminates the thought process of how sensors or controls are typically setup for different applications.

A blue "W" in a menu identifies an available wizard, as shown below. If a wizard is found for a mechanical part or function, which requires tuning, AEM recommends applying it to the calibration file.



A window with two individual dialog boxes, as shown below, appears when a wizard is selected. The dialog box at the top of the window displays all available configurations that have been tested and calibrated by the engineers at AEM. The green check in the "Match" column represents the current data utilized in the calibration file. Each individual wizard may have multiple EMS functions associated with it depending on the wizard initiated. The bottom dialog box displays the EMS function that has been configured which may include options, tables, and/or maps.



3.7 Menus

Menus

The menus are pre-configured in groups, and named with a basic industry standard type name. These menus can be user configured in any group, and with any name defined by the user. To configure the menu, click on **Configure | Menu | Edit...** from the menu.

Select a current menu to modify from the **Menus** window. When adding a **Root menu**, select the **Insert Root menu** button, this will add a new menu entry into the **Menu View** window on the left. You can type over the default name, and enter the desired name by selecting the name menu and then pressing the F2 key or left click on menu a second time. Sub menus, options, parameters, and templates groups can be added using the same method as outlined above. After creating the menu items and groups, add the available tables, maps, options, parameters, etc. to the desired groups by selecting the menu or group then use the right and left arrows to add or remove items.

Note: Should you desire to change the layout of the default menus it is important to keep the tables and maps organized into logical groups. This way it is easy to find your way around the system without having to search for a particular table or parameter. AEM has organized the menus into logical groups to make things easier upon start up, however, if you find a different grouping makes more sense to you, the menus allow for endless configuration.

3.8 Templates

Templates

Templates contain information about window sizes and positions on the screen. The template function is one of the most useful tools to the tuner, allowing quick movements between maps and monitoring screens. AEM has made all of the templates functions to be user configurable, allowing each individual to select the screen layouts with which they are most comfortable. This helps save a lot of time in getting familiar with new software. This includes:

- Option Window
- Table Windows - both graphical and table views.
- Map Windows - both graphical and table views.
- Parameter Windows - including the parameters contained within them.
- Status Window
- Notes Window
- Overall Trim Control Window
- Dashboard Windows

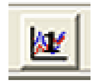
Templates can be opened from the template buttons and shortcut keys allowing different configurations of windows to be instantly brought up for different purposes such as calibrating a fuel map or monitoring the ECU. For example, a fuel template may display the layout and size of the fuel map and selected parameters, or a monitoring template may display other parameter lists and dashboards. Templates are specific to ECU types, however, other ECU templates can be run in other ECUs. Keep in mind, some functions may not transfer to other ECUs.

When a template is used in an offline calibration, only those windows that are accessible for offline calibration are displayed. When configured, the tool bar can contain numerous template buttons that allow faster access to commonly used templates.

When a calibration is opened the default template is automatically loaded. The default template describes the layout of windows when a calibration was last opened. The default template is automatically saved when a calibration is closed.

To make a template, set the screen up with the tables, option, parameters, etc. you would like in the template and organize them in an intuitive position. Go to: **Templates | Save...** and save to **C:\Program Files\AEM\AEMPro\Templates**.

To configure these buttons use the following operation. Select **Templates | Configure** from the menu. The **Configure Template Buttons** window appears. When configuring templates for the first time, there are no template buttons shown until the **Add** button is selected. Click on the **Add** button to enable templates. Select **Browse** and double click on the template to be configured. This puts the template on the selected button for the shortcut. By clicking on the template button, template icons can be assigned by the user.



When finished configuring the template buttons, click the **OK** button to finish. You will now see the template buttons displayed across the top below the menu, by clicking on any one of these, the configured screen will be displayed. Also the short cut <Shift> + F1 through F12 will provide the same function as clicking on the buttons with the mouse. After the template buttons are configured, selecting any one of the template buttons will open the template. If any changes are made to the screen, the template may be re-saved, or saved as a new template.

To delete an existing template use the following operation. Select **Templates | Configure…** from the menu. The **Configure** window appears. Select the template to be deleted (the red arrow points to selected template). Click on the **Delete** button to delete the selected template, and the template will be deleted. When no more templates are to be deleted press the **OK** button.

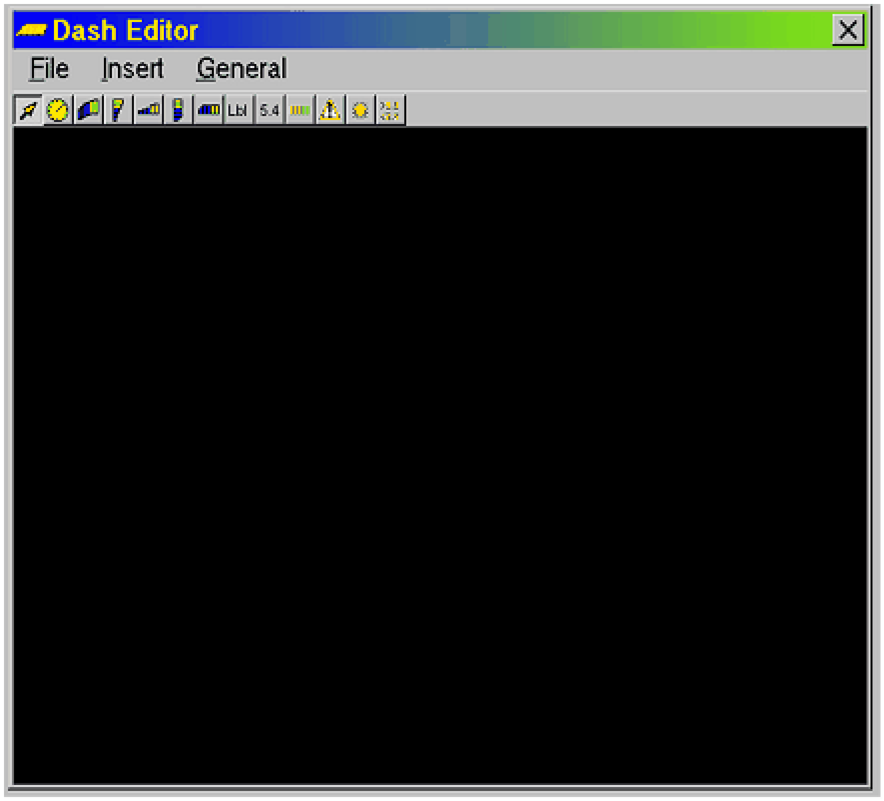
If you choose to load preconfigured templates from another ECU version it can be accomplished by following these steps.

Select **Template | Run** from the menu. The **Windows Open Dialog** window appears. Select the file types drop down arrow and select the desired ECU type to run. Note: If you wish to configure the selected template as a permanent template button, then you must select the file type from the **Template | Configure** menu instead of the run menu.

3.9 Dashboards

Dashboards

Dashboards are user-defined windows that allow various graphical representations of incoming data from a connected ECU. All of the parameters can be displayed as a variety of gauge types. These gauges can be grouped together in a single dashboard or kept singularly. Dashboards are only functional **Online** and are specific to ECU types. Once a dash is configured, it can be saved as a template for easy access for use during dyno sessions. A good idea is to save the dash as a window so it may be viewed on top of an existing window. To configure a dashboard use go to: **Templates | Dash | Configure** from the menu.



The **Dash Editor** window appears. This window allows creating, viewing, and modification of dashboards for the open ECU type. The **Dash Editor** window can be resized as required. When a dashboard is saved the size of the **Dash Editor** window is also saved and is used to determine the size of the dashboard when it is displayed. Resizing this window does not resize the gauges within it. When a dashboard is opened, the dash window is automatically resized according to the saved size. Resizing the dash window causes the gauges contained within it to be resized. With this in mind it is generally better to size the **Dash Editor** window such that it just contains all the gauges.

Adding and Delecting a Gauge

To add a gauge to a dashboard, use the following operation.

- Select the type of gauge required from the Insert menu or click on the appropriate button in the toolbar.
- Left click on the dashboard at the required location.

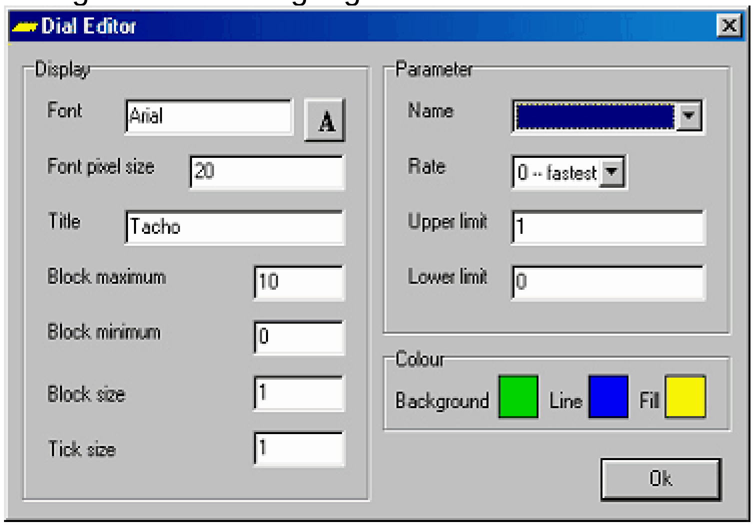
To delete a gauge, use the following operation.

- Highlight the required gauge by clicking on it with the left mouse button.
- Press the delete key.

Setting Gauge Attributes

To set a gauge's attributes, use the following operation.

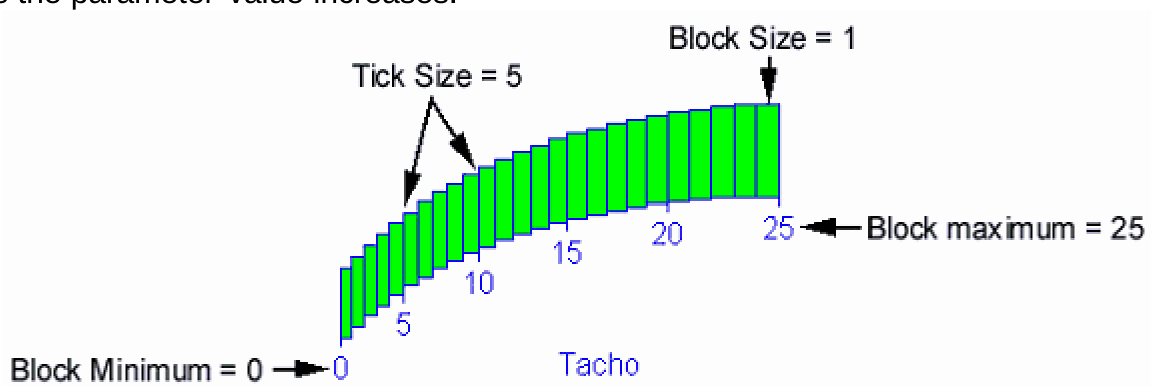
- Right mouse click on the appropriate gauge and the gauge editor window appears showing details of the gauge.



The **Dial Editor** window has 3 regions defining the display of the gauge, where it gets data from, and the color of the gauge. The effect of the display region is detailed in the section below. The **Parameter** area defines the parameter used to obtain data for the gauge and how quickly it is obtained. It also defines the upper and lower values, which are considered 'in-range'. When the data exceeds these values an error is generated to which specific gauge types react. For example, if the parameter is **Coolant Temp,** the upper limit may be set to 110. If it exceeds this value an error is generated which may be acted upon by a message gauge or warning gauge. The **Color** area defines the colors used to draw the gauge. The gauge is drawn in the background color using the line color for borders. When the dashboard is used the gauge appropriate areas of the gauge are filled using the fill Color.

Bar Tacho

The **Bar Tacho** is made of connected blocks forming an arc that are labeled at defined intervals. The title is displayed below it. The blocks are filled from left to right as the parameter value increases.

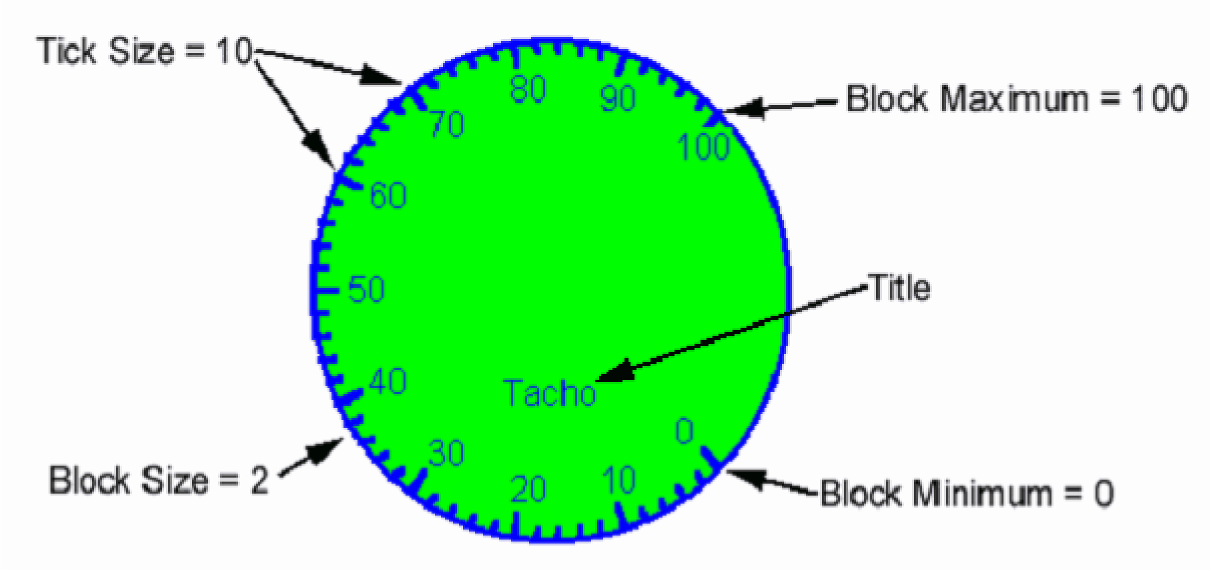


- **Tick** – The number of blocks between each numbered mark.
- **Block Minimum** – The minimum displayed value.

- **Block Maximum** – The maximum displayed value.
- **Block Size** – Number span of each block.

Circular Tacho

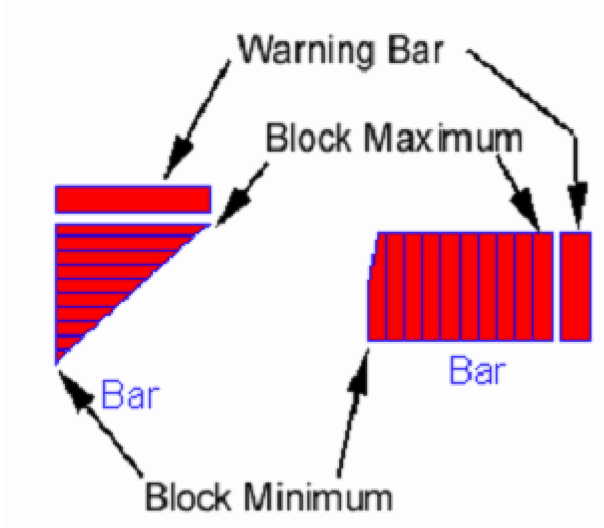
The **Circular Tacho** gauge has marks around the range of the meter, which are labeled at defined intervals. The title is displayed inside it. Note: this does not have to be a tachometer.



- **Tick** – The number of blocks between each numbered mark.
- **Block Minimum** – The minimum displayed value.
- **Block Maximum** – The maximum displayed value.
- **Block Size** – Number span of each block.

Triangular and Square Bar

There are 4 different bar gauges composed of vertical or horizontal and triangular or square characteristics. When the limit of a parameter is exceeded, the warning bar at the top or right highlights in the warning color.



Label

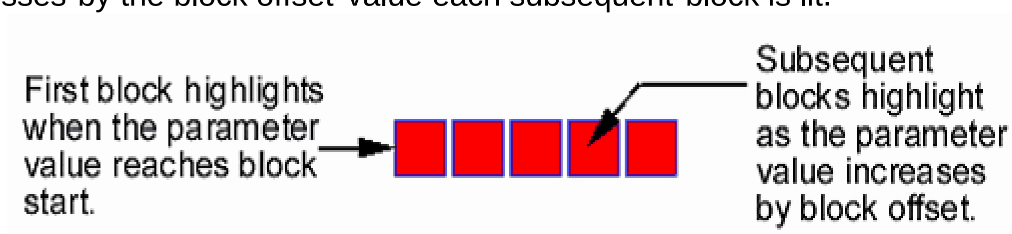
The **Label** gauge displays a fixed string of text. The font type and size and the title are the only required data.

Value

The **Value** gauge displays a parameter as a value. The font type and size and parameter details are the only required data.

Limit Mark

The **Limit Mark** gauge is generally used to signal an approaching limit. As the block start value is reached the first of a user defined number of blocks lights. As the value progresses by the block offset value each subsequent block is lit.



Messages

The **Messages** gauge displays warnings generated by other gauges. When a warning is generated the blocks on either end of the message highlight in the warning color.

Warning

The **Warning** gauge is a block that changes to the warning color when a warning is generated by another gauge.

Out of Range

The **Out of Range** gauge is only visible in the editor. The gauge monitors a parameter value and generates a warning when it exceeds either of the limits.

Background Color

To set the **Background Color** of a dashboard, use the following operation, select **General | Background Color…** from the dashboard menu. The **Color** window allows a color to be selected.

Warning Color

To set the **Warning Color** of a dashboard, use the following operation. Select **General | Warning Color…** from the dashboard menu. The **Color** window allows a color to be selected. All gauges that have an error condition use this color.

Saving, Deleting, and Opening Dashboards

To save an existing dashboard, select **File | Save As…** from the dashboard menu. The **Save Dash** window appears showing the list of available dashboards. Type a new name in and press the **Ok** button or double click on the dashboard to overwrite.

To open an existing dashboard, select **File | Open** from the dashboard menu. The **Open Dash** window appears showing the list of available dashboards. Select the name of the dashboard to open and click the **OK** button or double click on the dashboard to open.

To delete an existing dashboard, select **File | Delete…** from the dashboard menu. The **Delete Dash** window appears showing the list of available dashboards. Double click on a dashboard or type the name of the dashboard and press the **Delete** button.

3.10 Comparing Files

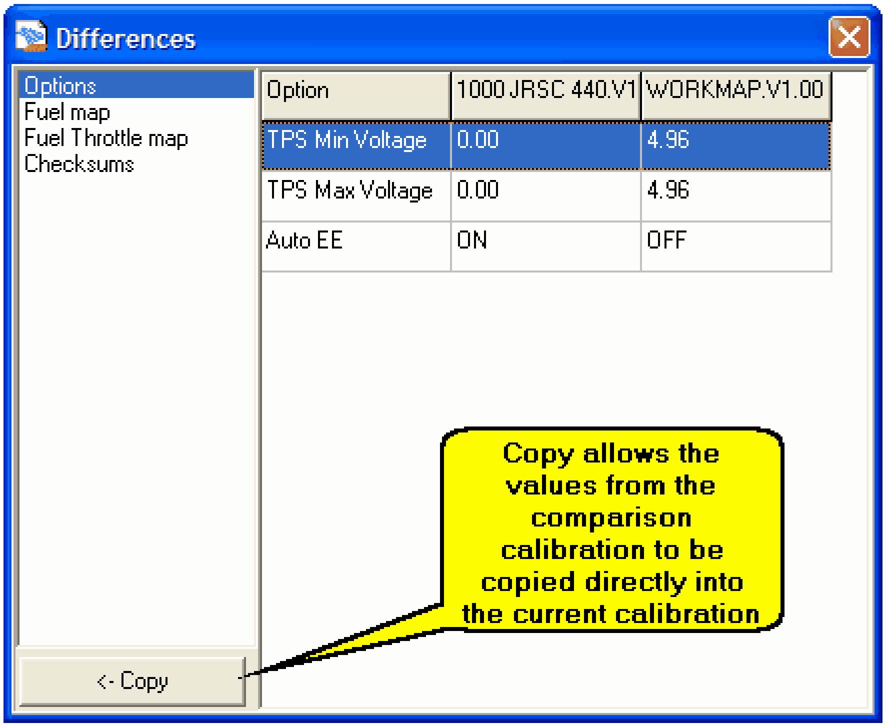
Comparing Files

Two calibrations can be compared to discover any differences between them. To compare files use the following operation.

- Open one of the calibration files to be compared.
- Select **File | Compare** from the menu.

The **Compare** window appears showing all calibrations to which the open calibration can be compared. To compare the two files press the **Open** button. If no differences are encountered this is stated in a message box. If there are differences the **Differences** window appears.

The **Differences** window shows the name of all areas of the calibration that have differences on the left. Highlighting the name of an area causes the details of the differences to be displayed in the grid on the right. This shows the exact location of each difference and the value of each calibration at that location.



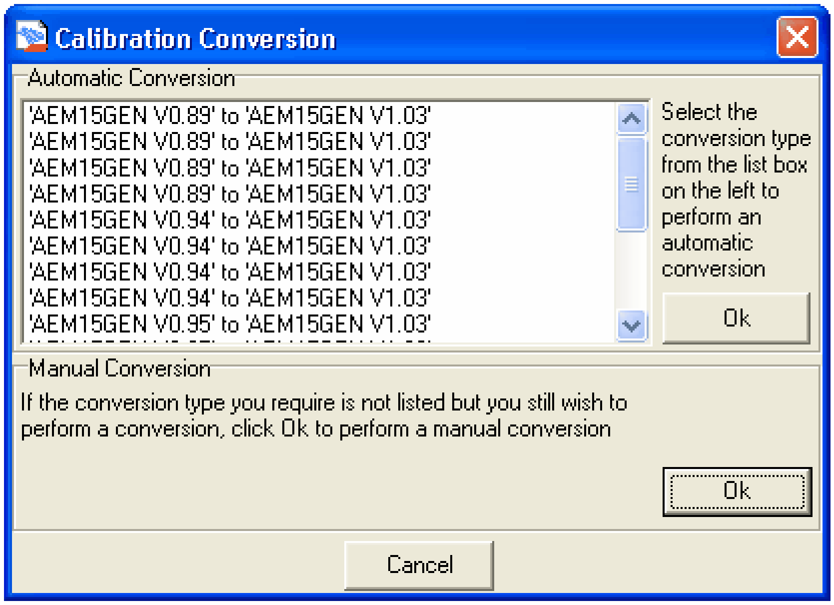
To cancel the comparison, press the **Cancel** button. To close the **Differences** window press the **Close** button (X).

3.11 Converting Files

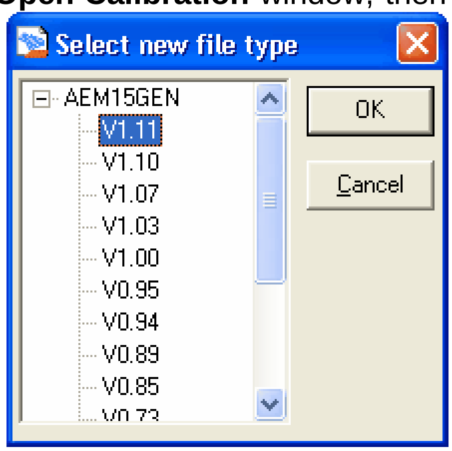
Converting Files

This feature will typically only be used if AEM has an updated firmware version available for your particular ECU. This allows the previous calibration map to be converted to the new firmware version.

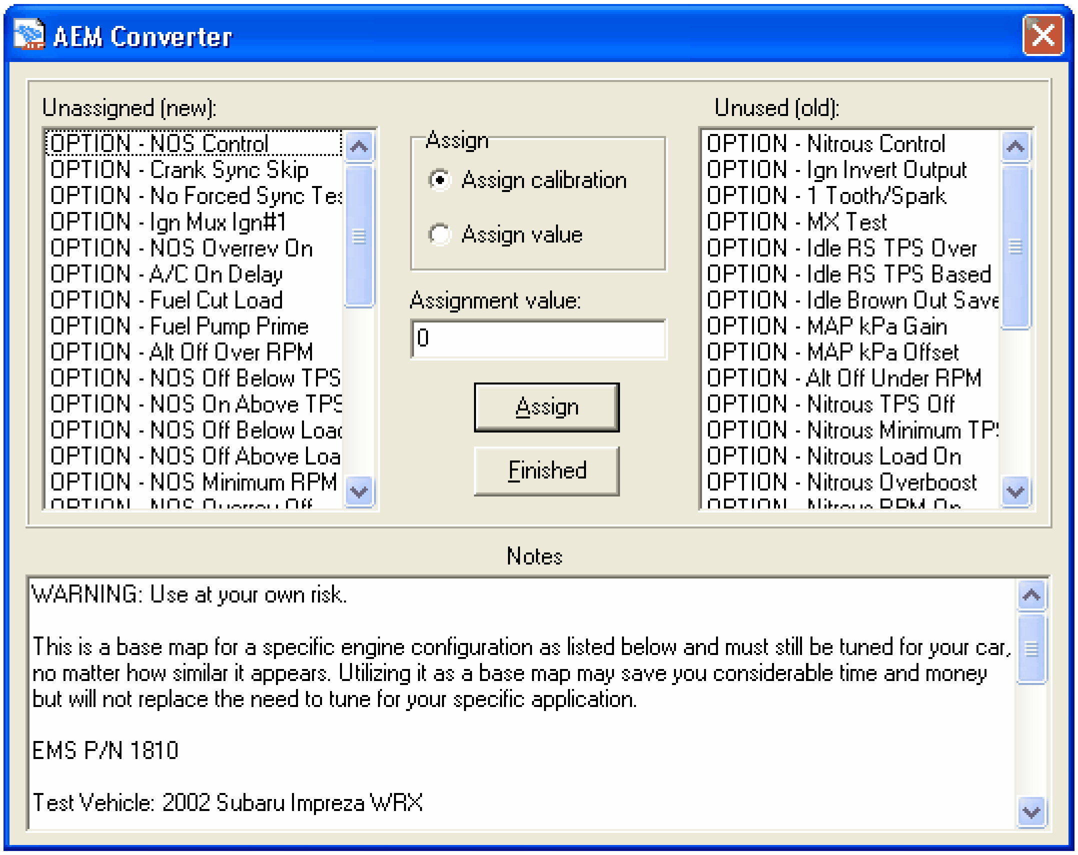
To convert a calibration file to another ECU type use the following operation. Select **File | Convert** from the menu.



Click **OK** for the **Manual Conversion** unless there is an available **Automatic Conversion** available for the conversion you are looking to do. Select the calibration you wish to convert in the **Open Calibration** window, then press the **Open** button.



The **Select new file type** window appears showing all installed ECU types to which the calibration can be converted. Highlight the ECU type to which the calibration is to be converted and click **OK**. AEMPro attempts to convert every option, table, and map contained in the open calibration's file to a respective option, table, or map in the converted calibration's file.



The **AEM Converter** window appears. The left list box shows the new options or tables that did not apply to the old calibration file, this is typical when upgrading to newer software that has added features. The right list box shows those items that are no longer used in the newer file (the **Unused List** box). The **AEM Converter** window allows those items in the unassigned list box to be assigned values from either an unused item in the unused list box or a user defined value. Note that when assigning an unused item to an unassigned item, only similar items can be assigned. For example, an option cannot be assigned a table's value but must be assigned an option's value.

To assign an unused item's value to an unassigned item's value, select the unassigned item and the unused item to which the value should be assigned. Click on the **Assign Calibration** box in the **Assign** group box and press the **Assign** button. The two selected items are removed from the lists.

To assign a value to an unassigned item's value, type the value to assign in the **Assignment value** box. The selected unassigned value is removed from the list. When the conversion process is complete press the **Finished** button. The save window appears showing the current name of the file and a list of all existing calibrations. A specific file name can be typed into the name box at the top left of the window. Highlighting a calibration name causes the notes of that calibration to be displayed in the text box on the right (if any exist) and the name of the file to be saved is changed to that of the selected file.

To save the calibration to that in the name box, press the **Save** button. If a file with that name already exists a prompt appears asking whether to overwrite the existing calibration. To overwrite the calibration press the **Yes** button, to choose another name press the **No** button. To cancel the save press the **Cancel** button.

4 Calibration Setup

4.1 Oxygen Sensor

Oxygen Sensor

For accurate air fuel ratio readings, AEM recommends using a wideband UEGO sensor.

User Definable Options for Oxygen Sensor

O2#1 Gain

Units: Gain Multiplier

Description: Sets the input gain for the #1 O2 Sensor. Scales the raw voltage to read the same as the measured voltage input.

O2#2 Gain

Units: Gain Multiplier

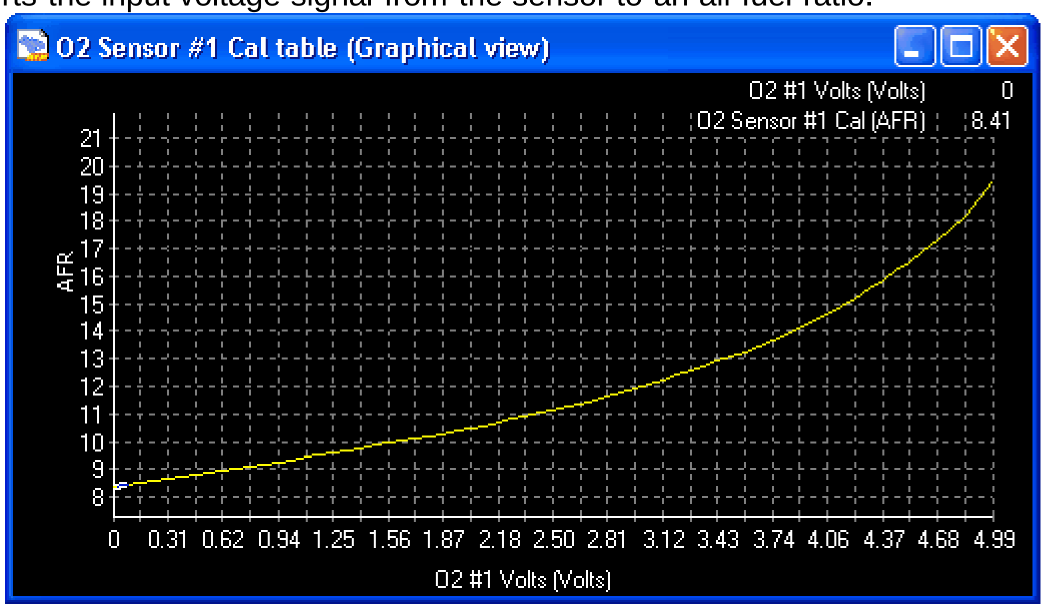
Description: Sets the input gain for the #2 O2 Sensor. Scales the raw voltage to read the same as the measured voltage input.

2-D Tables for Oxygen Sensor

O2 Sensor #1 Cal Table

Units: AFR vs. Volts

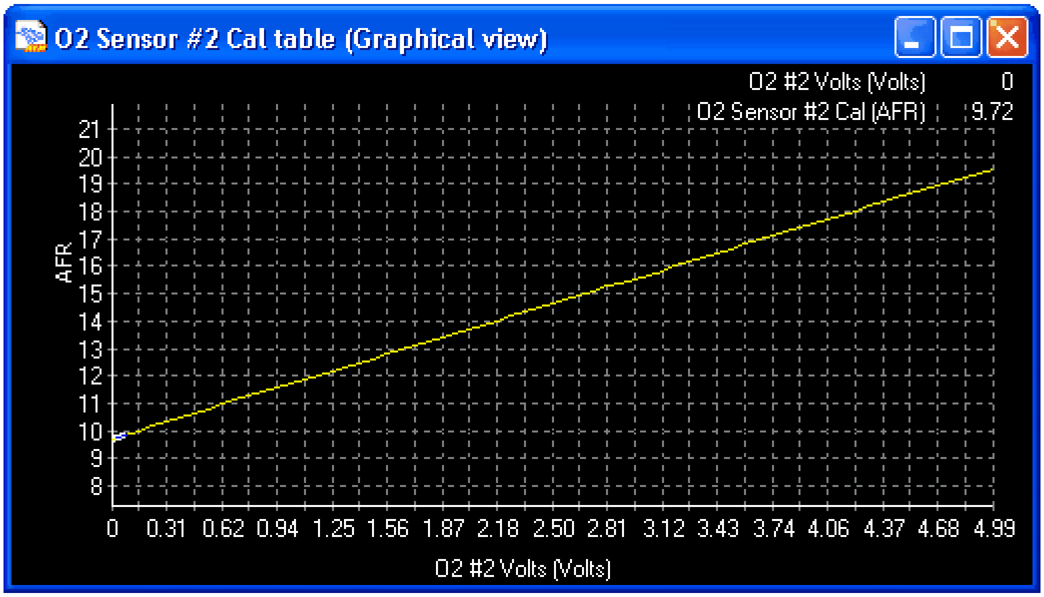
Description: Sensor calibration from the oxygen sensor manufacturer. This table converts the input voltage signal from the sensor to an air fuel ratio.



O2 Sensor #2 Cal Table

Units: AFR vs. Volts

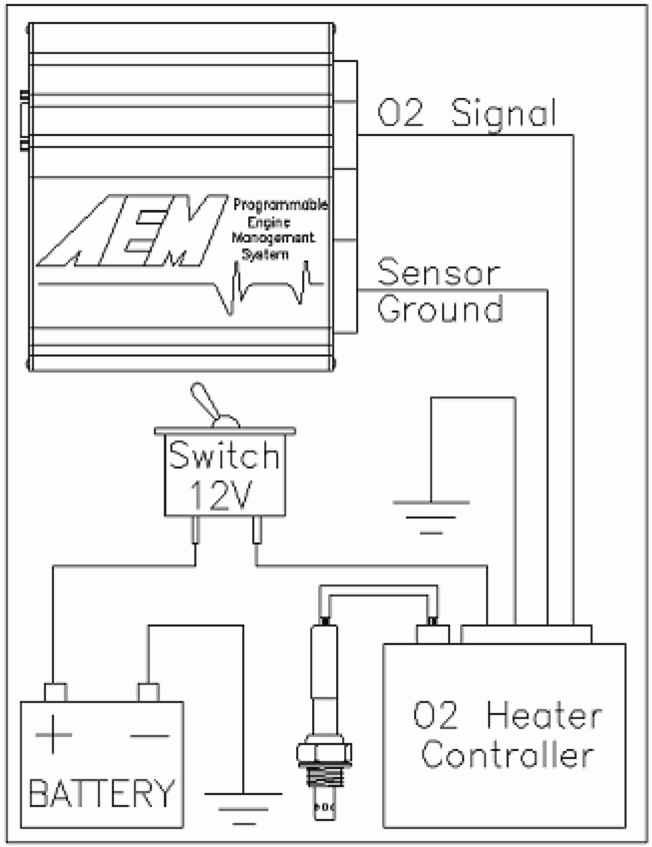
Description: Sensor calibration from the oxygen sensor manufacturer. This table converts the input voltage signal from the sensor to an air fuel ratio.



Parameters (can be viewed or logged)

<u>O2 #1 Volts</u>
Units: Voltage
Description: Raw voltage signal from the #1 O2 sensor.

<u>O2 #2 Volts</u>
Units: Voltage
Description: Raw voltage signal from the #2 O2 sensor.



4.2 Fuel Pump

Fuel Pump

To achieve proper fuel delivery, the correct fuel pump for your application is crucial. In most cases, where the engine has been modified only with "bolt on" performance items, there is rarely a need for a larger fuel pump. Vehicle manufacturers typically design a "safety factor" into the fuel pump to accommodate the deterioration of the fuel system over time. This safety factor is intended to compensate for a fuel filter that is nearing the end of its life, or for deposits in the injector orifice. Our research has revealed that generally there is about a 15-20% oversize in most factory fuel pumps.

If the engine is enhanced via forced induction or nitrous oxide, the stock fuel pump will, most likely, be inadequate. If the engine's power is increased, more than 15-20%. Fuel delivery must increase as a factor of the power gain. The way to determine the proper-size fuel pump is based on the desired brake specific fuel consumption (BSFC) of the engine. This term refers to how much fuel in pounds per hour (pph) the engine consumes per horsepower and is a measure of the efficiency of the engine. It is a useful term in determining the total fuel requirement of the engine.

On vehicles equipped with forced induction or nitrous oxide, a higher BSFC is required as an added measure of safety to prevent detonation or high combustion chamber temperatures. Naturally aspirated gasoline engines have a BSFC of 0.48 to 0.50. Forced induction gasoline engines have a BSFC of 0.65 to 0.68. Methanol (alcohol) powered engines require twice the amount of fuel, so the BSFC is doubled.

Calculating the total fuel requirement of an engine requires simple equations that are outlined in the following section. You must know how much power the engine is anticipated to make. The fuel requirement will be determined in pounds per hour of fuel flow. Since most pumps are rated in gallons/hour, the weight of the fuel/gallon being used must be determined. The vast majority of gasoline based fuels run at 7.25 lbs/gallon. With fuel pump sizing, always use a safety margin greater than 20%. The equations to determine the fuel requirement is as follows:

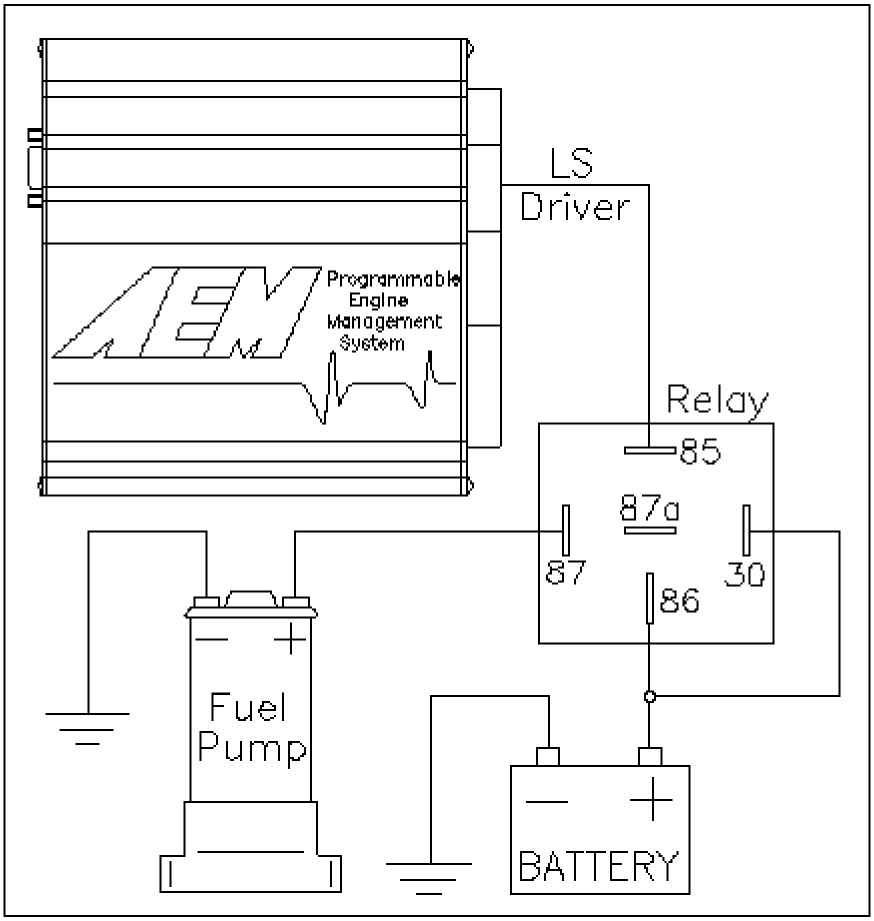
- (Power x BSFC) x (1 + Safety Margin) = Pounds/Hour
- Pounds/Hour / 7.25 = Gallons/Hour.

An example of this equation is:

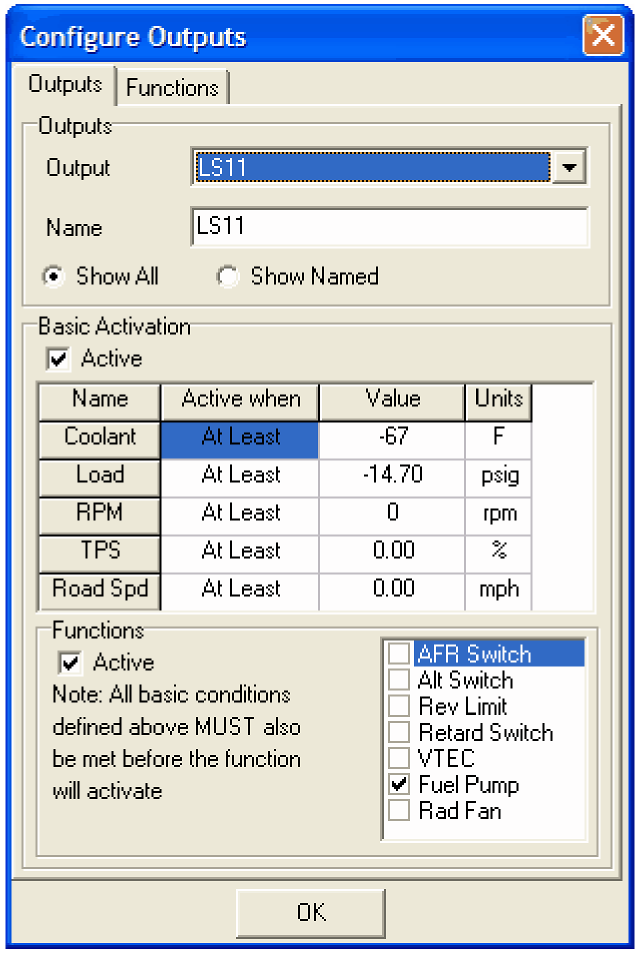
- 500 hp gasoline engine using moderate boost with a 30% safety margin
- (500 x 0.625) x 1.30 = 406.25 lbs/hr
- 406 lbs/7.25 = 56 gallons/hour
- If the pump that is being considered is rated in liters per hour, use the conversion factor of 3.785 liters/gallon. The pump described above would be rated at 56 gallons x 3.785 liters = 211.96 liters/hour.

The fuel pump should be located at a level that corresponds to the lowest part of the fuel tank. This does not mean that the pump should be in a vulnerable position such as hanging below the tank. The pump should also be positioned so that it is protected from road hazards, i.e.: speed bumps, curbs, road debris, etc. In the event of an accident, the vehicle structure around the fuel pump should not deform to a point where the pump and its electrical connections are compromised.

The wiring for the fuel pump must be rated for the amperage of the pump. As with all high current wiring, a fuse rated for the amperage of the pump should be used. The ground for the pump must be the same size as the power lead and be mounted to a location that is clean and clear of any undercoating or paint. We do not recommend running the fuel pump continuously (or from the ignition switch) as this is very dangerous.



Fuel pumps can be run off any available low side (LS) or high side (HS) driver. As shown in the diagram above, we encourage an LS, or pull to ground, driver to be used for fuel pumps because of the high current they draw. Below is an example of how fuel pumps are setup in the **Configure Outputs** window of the AEMPro software.



Notice the **Fuel Pump** option in the diagram above. When the **Fuel Pump** function is activated and the key is in the ON position, the circuit closes briefly to allow the fuel pump to prime. After a few seconds, the circuit deactivates and waits until an engine speed signal is met during cranking. The circuit will then be active until the RPM signal stops, at which time the circuit deactivates. Note: the option **Fuel Pump Prime** is a user definable time delay for the fuel pump to prime.

4.3 Tach/Speedo

Tach/Speedo

There are two different ways of controlling tachometers and speedometers with the AEM EMS. **Tacho** is the simplest and most common method. However, the **TP1 Frequency** method has finer control but may require a hardware modification depending on the EMS used.

Tacho

This method takes a specific low side driver and outputs an RPM signal to the tachometer with a programmable tooth selection. The value for **Tacho Output** is a decimal equivalent of the binary value. Refer to the tabel shown below:

Low Side Driver	Tacho Output
LS #3	128
LS #12	64
LS #11	32
LS #10	16
LS #9	8
LS #8	4
LS #7	2
LS #4	1

For the tachometer to be controlled by multiple EMS outputs, add the values together. Ex: **Low Side Driver #8** and **Low Side Driver #12**, set the option **Tacho Output** to 68 (LS8=4 + LS12=64).

The option **Tacho** can be calibrated to match the engine speed by using the crank sensor input signal. This is achieved by multipling the number of output pulses/rev required by the constant 2. Divide the pickup sensor teeth on the crankshaft by this number. See the formula below.

Tacho = Crank Teeth / (Required Output Pulses/Rev x 2)

Example: The requirement is 2 output pulses/rev with a 12 tooth pickup sensor mounted to the crankshaft.

2 (output pulses/rev) x 2 = 4
12 (crank teeth) / 4 = 3 (Tacho)

From the equations above, set **Tacho** to 3. This will allow the signal to turn ON after 3 teeth, turn OFF after 3 more teeth, ON after 3 more teeth, and OFF after 3 more teeth for a total of 2 complete (ON/OFF) pulses.

User Definable Options for Tacho

Tacho
Units: Teeth
Description: How many teeth before changing the state of the tacho output.

Tacho Output
Units: User Selectable Output
Description: Special case bit mask applied to the 8 bit XPORTG channel representing the following outputs:
LS#3 = 128
LS#12 = 64
LS#11 = 32
LS#10 = 16
LS#9 = 8

LS#8 = 4
LS#7 = 2
LS#4 = 1

TP1 Frequency

Because there are specific hardware modifications required, the **TP1 Frequency** method should only be used with applications that support it. This is currently only offered on the Dodge Viper plug n' play EMS to drive the speedometer. Applications that use this function, lose the input **Switch #2**. This input is converted to output specifically for this feature.

This method is very flexible and can drive other functions including a tachometer. The previous input, outputs a period which is scaled by the **Frequency M** option from a speed input selected from **Frequency Spd**. Example: If **Frequency Spd** is defined as **Vehicle Speed** and the parameter **T3PER** = 3000uS, the output signal from the **Switch #2** pin will have a period of 9000 uS.

User Definable Options for TP1 Frequency

TP1 Frequency Out
Units: On/Off
Description: When active, the **Switch #2** input switches to an output. Requires unique hardware to function properly. Currently used only on the Dodge Viper application to drive the factory speedometer.

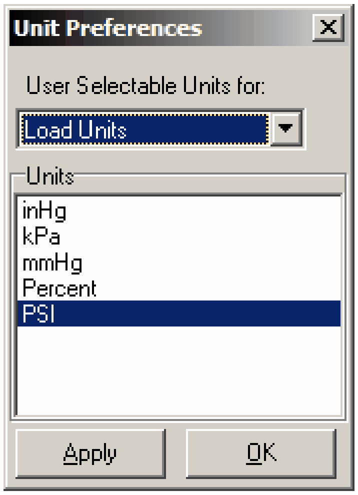
Frequency M
Units: Multiplier
Description: Multiplier for **TP1 Frequency Out** function. Requires unique hardware to function properly. Currently used only on Dodge Viper application to drive the factory speedometer.

Frequency M
Units: Multiplier
Description: Defines the speed input to be used for the **TP1 Frequency Out** option as input reference. Requires unique hardware to function properly. Currently used only on Dodge Viper application to drive the factory speedometer.

4.4 User Scalars

User Scalars

Starting with Firmware V1.00, the method for selecting engineering units has vastly improved. To select your preferred units, select the menu **Configure | Units...** The following window will appear.



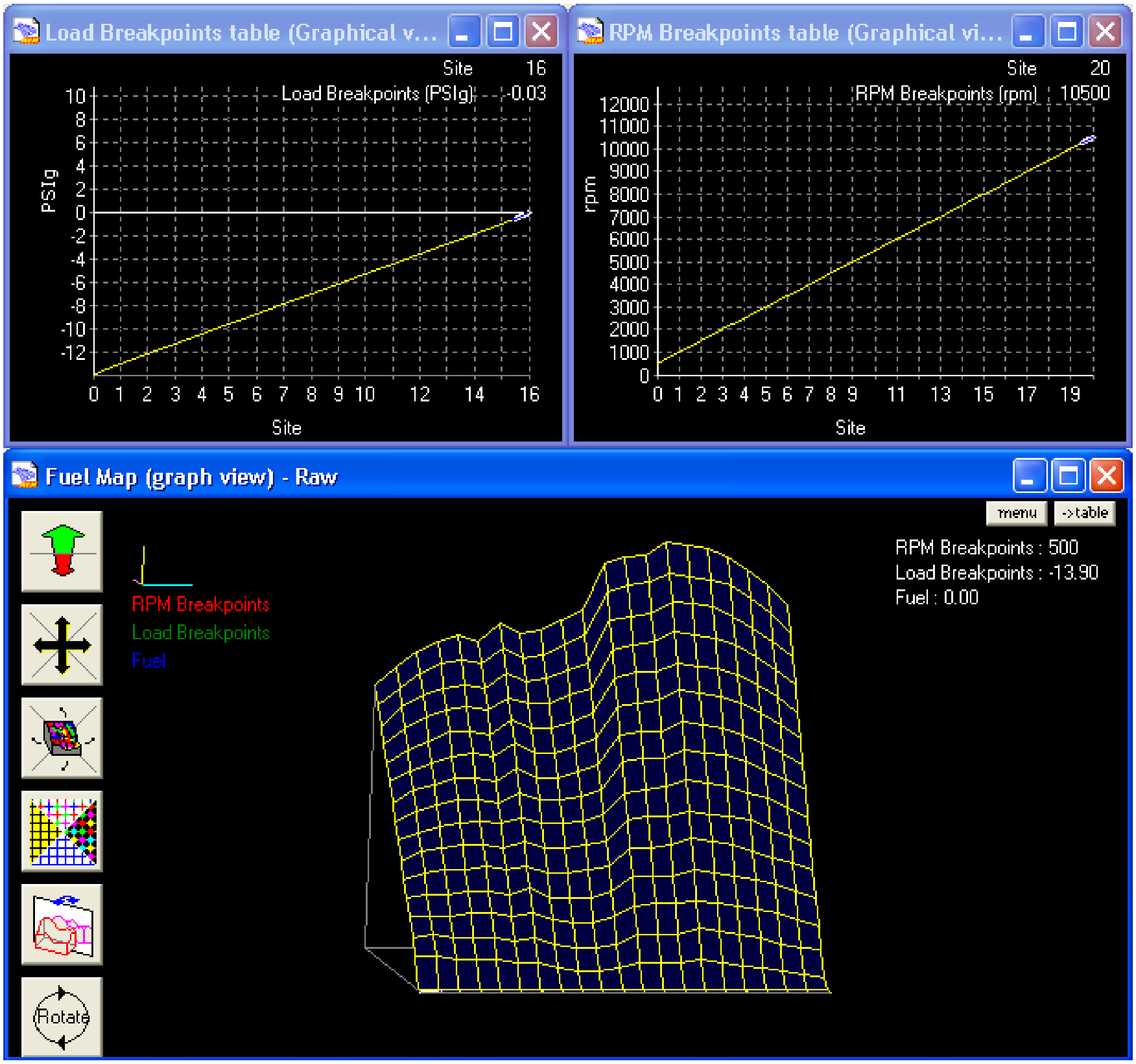
Scroll through the various options and select the one you wish to change. Select the specific engineering units you wish to display and select **OK**.

4.5 Breakpoints

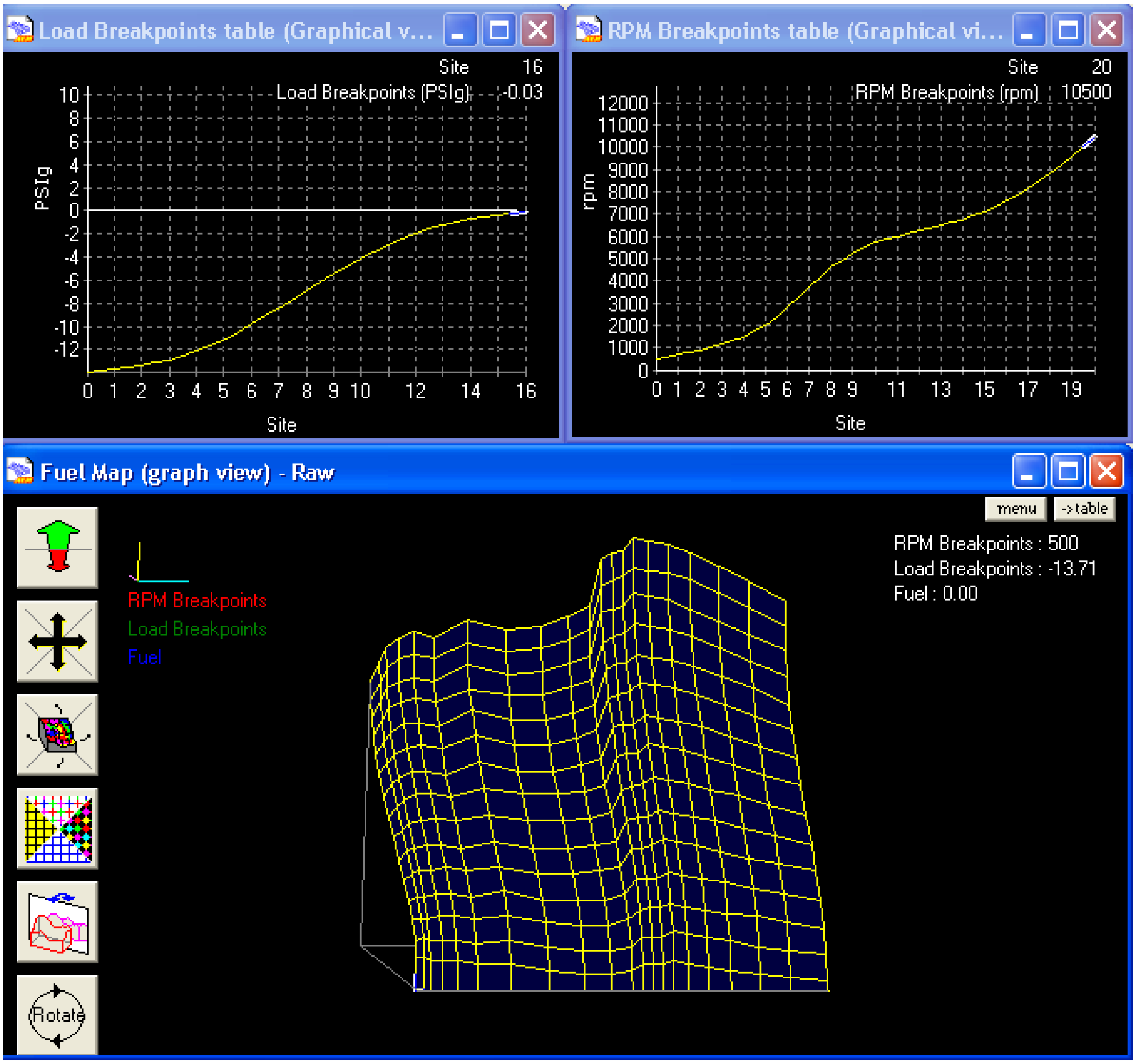
Breakpoints

If you want to customize the breakpoints to meet your specific motor requirements, it is important to note that this can drastically effect the base calibration. If you are going to change, now is the time to do so.

All breakpoints are user-definable in order to gain resolution in particular areas of the maps and/or tables. To access the the breakpoints, go to: **Setup | Breakpoints**



The example above shows a typical AEM base map. Notice both **RPM Breakpoints table** and **Load Breakpoints table** are linear. The **Fuel Map,** in the example, is very proportionate. This makes everything simple to use, especially for speed density vehicles where fuel maps are linear. However, when tuning a vehicle, for example, that has cams that exhibit poor drivability at low engine speed, closer set points will allow the troublesome "off cam" area of the map to be fine tuned. A Honda engine is used in this example, where the aggressive VTEC cam lobe comes in near 6,000RPM. We will also make this a street car, so idle is an important feature to get right.



Notice the increased resolution from the above tables (exaggerated for this example). There is more spots to tune for WOT, idle, and the cam changeover. Note the **Fuel Map** will have to be retuned after changing breakpoints.

4.6 Injector Change

Injector Change

There are two steps when changing the injector from the current calibration. All injectors ahve a different response with battery voltage. Go to the injector wizard to get the correct injector battery offset:

Setup | Injectors | Primaries | Primary Inj Batt Wizard

or for staged injection:

Setup | Injectors | Staged | Staged Inj Batt Wizard

Scroll down the list and find the injector that you are using. If your injector is not listed, it is quite possible that AEM is currently testing them and will be in the next software release. For the time being, find a similar injector made by the same manufacturer with the same resistance. If the injectors being used are common, contact AEM and we may test them for you.

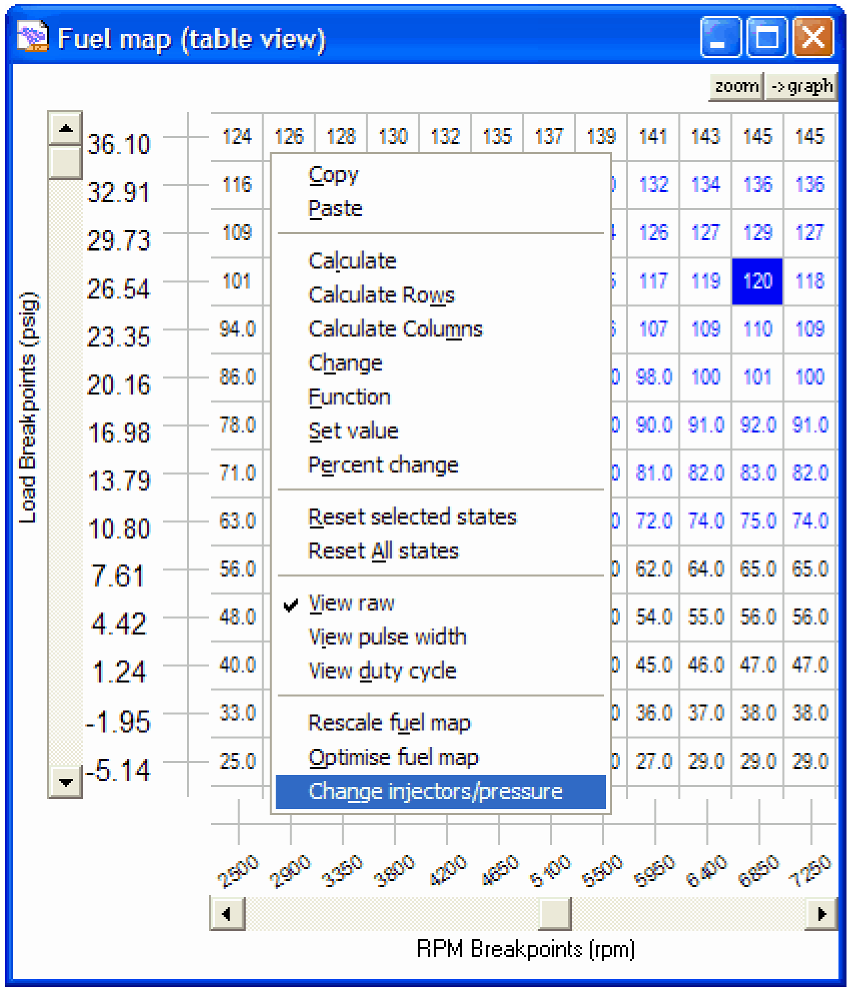
Next is to tell the **Fuel Map** that the injectors are a different size and possibly at a different base fuel pressure. The **Change Injectors/Pressure** function allows the tuner to scale an existing calibration file for the use of different size injectors or increased/decreased fuel pressure in one step.

When using this function it is very important to know the correct size/flow rate of the injectors the original calibration file was created on and the size/flow rate of the new injectors. This will allow an accurate adjustment of the fuel setting by the AEMPro software. This function will not only rescale the fuel map, but also will rescale all fuel functions associated with starting and idle as well.

To use this function:

- Select the **Fuel** drop down menu
- Open the **Fuel Template**
- Select the **Fuel Graph** by left clicking on it
- Change to the Table View by pressing the **S key** on the keyboard
- Right click anywhere on the table
- Select **Change injectors/pressure** from the menu
- Type in the required information then click **OK**

Note: It is a good idea to save the calibration file before making this change, then after making the changes save the file as a new name.

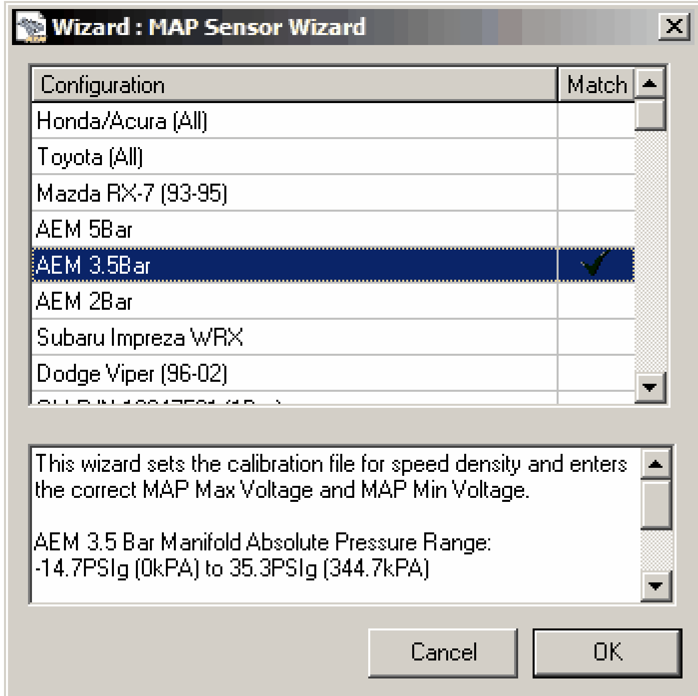


4.7 MAP Sensor

MAP Sensor

The AEM EMS is very flexible in allowing any 0-5V pressure sensor to be used as input for a manifold pressure based load. These sensors are typically all linear in response, making the setup rather straightforward. The parameters **Map Min Voltage** and **Map Max Voltage** are used to determine the sensors voltage load range.

Select the menu **Setup | Sensors | Manifold Pressure Sensor | Map Sensor Wizard**



Choose the appropiate sensor from the list and select **OK**

Map Min
Units: Voltage (0% load)
Description: This is the minimum voltage output that the load (MAP) sensor is capable of producing at it's lowest pressure value. Example: AEM 3.5 bar sensor = .5 volts at -14.7psig

Map Max
Units: Voltage (100% load)
Description: This is the maximum voltage output that the load (MAP) sensor is capable of producing at it's highest pressure value. Example: AEM 3.5 bar sensor = 4.5 volts at 36.75psig

Map Filter
Units: Crank Teeth
Description: The amount of crank teeth that pass to average and filter the MAP input signal

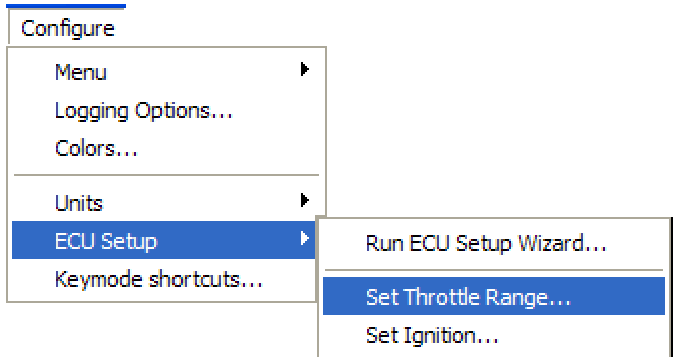
4.8 Throttle Setup

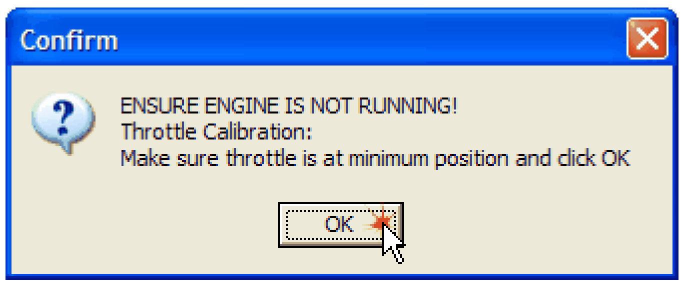
Throttle Setup

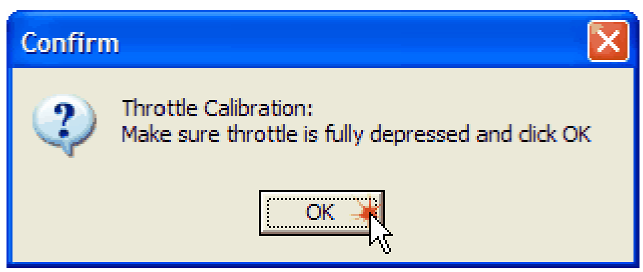
It is very important to set the throttle range before attempting any tuning on the car. There are may function of the EMS that must monitor correct throttle position to operate properly.

- From the AEMPro menu select **Configure | ECU Setup | Set Throttle Range**

- Follow the on screen instructions (shown below)
- It is advisable to save the calibration file as a new name once the throttle has been set





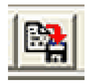


4.9 Save Calibration

Save Calibration

If a file is open, it can be saved as its' current file name or saved as a different file name. To save the calibration as the current file name, use any of the following options.

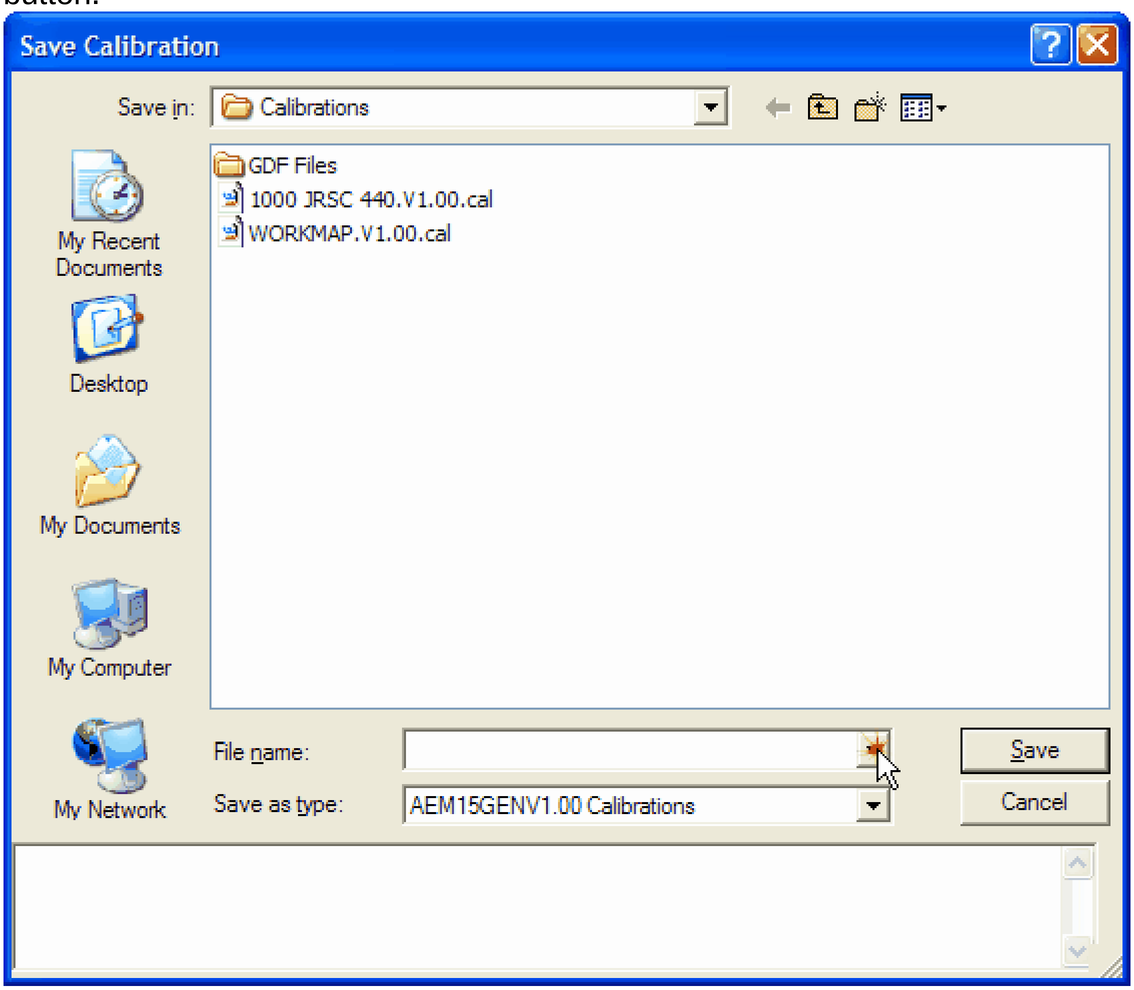
- Select **File | Save** from the menu.
- Press F2
- Click on the **Save** icon



The calibration is saved as the current File name. If **Online,** this will be the **Active ECU** file. To save the calibration to a different file name use the following operation.

- Select **File | Save As** from the menu.

A specific file name can be typed into the **File Name** box. To save the calibration to what is in the name box, press the **Save** button. If a file with that name already exists a prompt appears asking whether to overwrite the existing calibration. To overwrite the calibration press the **Yes** button, to choose another name press the **No** button and enter the name of the calibration. To cancel the save, press the **Cancel** button.



5 Starting the Engine

5.1 Pickup Confirmation

Pickup Confirmation

Before the engine will fire the coil(s) and injection fuel, the cam and crank sensor must be synchronized. If this is a plug n' play application, everything may be fine but confirmation is always recommended.

- Open **AEMPro** and **Connect**
- Go to **Options | Injector** and uncheck **Active** for all injectors being used.
- Because the injectors are disabled the engine will not start
- Open the **Home** template
- View the parameter **Stat Sync'd**, it should currently be OFF
- Crank the engine and verify that **Stat Sync'd** turns ON within a few seconds.

Crank Adv Sync

For motor safety, it is advisable to confirm the ignition timing before starting the motor the first time. However, this procedure should be done again when the motor is fired. Two people are required for this procedure.

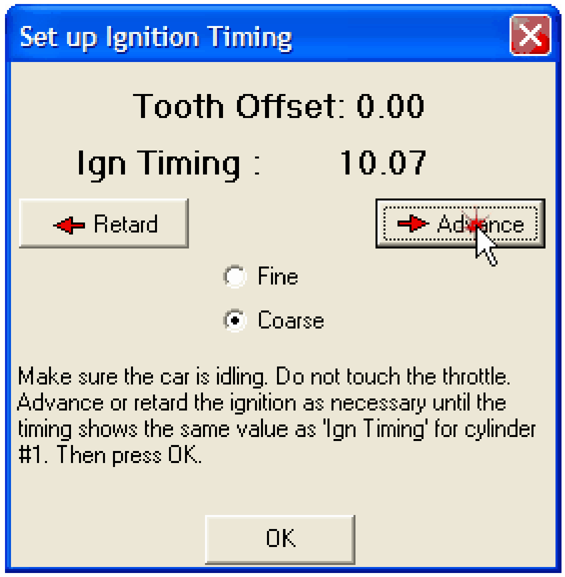
- Connect a timing light to coil #1. Note: some computer controlled timing lights will not give accurate values when running wasted spark ignitions.
- Go to **Options | Injector** and uncheck **Active** for all injectors being used (as stated above).
- Go to **Engine Start | Options - Engine Start**
- Set the option **Crank Adv** to a conservative value that is marked on the crank. This is specific to the application. Most motors have a TDC mark (0 degrees) on the crank.
- Go to **Configure | ECU Setup | Set Ignition**
- Crank the engine over.

Since the injectors are disabled, the engine will not start. However, do not crank the engine excessively as starter damage may occur. Also, a battery charger may be necessary if excessive cranking is required.

- The engine timing from timing light should agree with the **Ign Timing** parameter in the **Set up Ignition Timing** window.
- If the values do not match, use the **Advance** or **Retard** buttons to make the timing light match the displayed value **Ign Timing**.

Note: the **Advance** and **Retard** buttons will effect the actual engine timing, not the **Ign Timing** parameter.

- When the values match click **OK**



- It is advisable to save the calibration file as a new name once the ignition timing has been set.

Make sure to turn the injectors, that were disabled, back ON and put the **Crank Adv** option back to its previous ignition degrees.

5.2 All Systems Go

All Systems Go

There are several tables and options that affect the starting of the engine. The starting condition is defined as whenever the engine rpm is above the **Crank Min** option and below the **Crank Exit** option. Cranking is usually defined as being in the 50-400 RPM range. Before attempting to start the engine it is a good idea to open **AEMPro** and verify a few settings

Check the following:
- Latest version of Firmware is installed.
- Latest version of Software is installed.
- Correct calibration file is loaded into the EMS for the vehicle configuration.
- Throttle range has been set
- Crank advance has been verified

Open one of the predefined templates and check the following parameters:
- **Engine Load** = atmospheric pressure
- **Throttle** = 0-1%
- **Air Temp** (if available) = ambient temperature
- **Coolant Temp** = ambient temperature
- **Battery Volts** = 12-15 VDC
- **Stat Sync'd** = OFF

Crank the engine and check the following parameters:

- **Engine Speed** = 50-400 rpm
- **Engine Load** = vacuum reading
- **Stat Sync'd** = ON

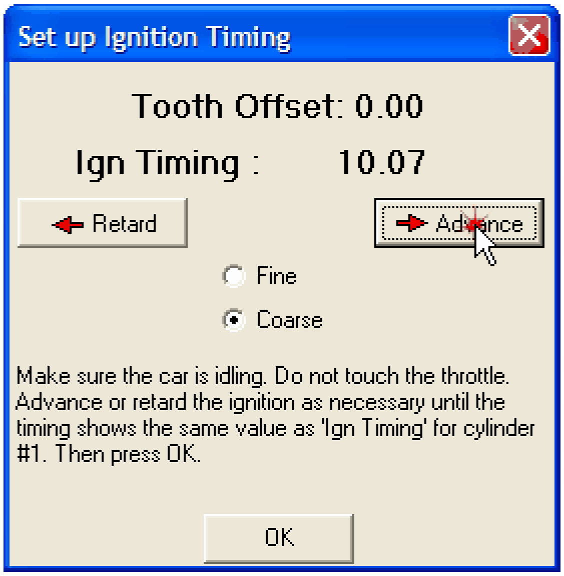
Syncing the Ignition Timing

This is a reconfirmation of the ignition timing at all conditions. Two people are required for this procedure.

- Connect a timing light to coil #1. Note: some computer controlled timing lights will not give accurate values when running wasted spark ignitions.
- Open **AEMPro** and **Connect**
- Go to the **Ignition | Ignition Map**
- Set the **Ignition Map** to a conservative value that is marked on the crank. This is specific to the application. Most motors have at least a TDC mark (0 degrees) on the crank.
- Go to the **Ignition | Advance Ign | Ignition Trims**
- Set all ignition trims to zero
- Go to **Configure | ECU Setup | Set Ignition**
- Start the engine.
- The engine timing from timing light should agree with the **Ign Timing** parameter in the **Set up Ignition Timing** window.
- If the values do not match, use the **Advance** or **Retard** buttons to make the timing light match the displayed value **Ign Timing**.

Note: the **Advance** and **Retard** buttons will effect the actual engine timing, not the **Ign Timing** parameter.

- When the values match click **OK**



The timing must now be synced at high engine speeds. This ignition timing drift is most common on magnetic-type pickup sensors.

- Rev the engine near the rev limiter and verify the ignition timing has not moved around.
- If the timing is not synced at high engine speed, adjust the **Pickup Delay Comp** option until the **Ign Timing** parameter and timing light match.
- Make sure to undo all ignition trims and put the normal **Ignition Map** back in the calibration when finished.
- It is advisable to save the calibration file as a new name once the ignition timing has been set.

6 Basic Tuning

6.1 Engine Start

Engine Start

There are several tables and options that affect starting the engine. The starting condition is defined as whenever the engine rpm is above **Crank Minimum RPM** and below **Crank Exit RPM**. Whenever the engine is cranking, the fuel and timing delivery is determined by the following options:

User Definable Options for Engine Start

Crank Minimum RPM
Units: Engine Speed
Description: This is the minumum rpm before any fuel and spark will be delivered. A typical value is 50RPM.

Crank Exit RPM
Units: Engine Speed
Description: This is the engine speed that determines when the fuel and timing will switch over from the cranking condition to the run condition. Note: when the engine exceeds the crank exit rpm, the fuel and ignition will be derived from the fuel and ignition tables plus any trims that are active. A typical value is 400RPM.

Crank Adv
Units: Degrees
Description: This is the amount of desired ignition advance while in the cranking mode. A typical value is 10 degrees advance.

Crank Inject All
Units: On/Off
Description: Injects fuel, according to the **Initial Crank Pulse table,** as soon as the EMS sees engine speed regardless of cam/crank sensor sychronization.

Fuel Pump Prime
Units: Seconds
Description: Time the fuel pump primes when the ignition switch powers the EMS. If this value is set to zero, the EMS has a hard-coded failsafe of a 2 second prime. Caution: While setting this value high (33sec max) may help engine starting, it can be dangerous. If the something catches on fire and the engine stalls, fuel will be delivered for this amount of time.

2-D Tables for Engine Start

Crank Injector Time table
Units: Fuel vs Throttle %
Description: Fuel (bit value x **MicroSec/bit**) injected upon cam/crank sensor synchronization when in the crank condition. If the engine cranks excessively and throttle input does not help, this typically means there is not enough fuel. Note: It is a good idea to take out fuel at high throttle conditions to clear extra fuel in the event

the engine becomes flooded.

Initial Crank Pulse table
Units: Microseconds of Fuel vs Coolant Temperature
Description: Injects this amount of fuel at the specified coolant temperature as soon as the EMS sees engine speed, regardless of cam/crank sensor sychronization.

Start Extra vs Temp table
Units: Fuel % vs Coolant Temperature
Description: This is fuel that is added when the engine exceeds the **Crank Exit RPM**, and is taken out over the **Start Extra Decay table**. Adding extra fuel upon start up helps the engine establish a stable idle before running off of the **Fuel Map** and fuel compensators. The **Fuel Map** will also affect this condition. It is important to get the engine to idle well, in a warmed up state, before fine tuning the **Start Extra vs Temp table**.

Start Extra Decay table
Units: Seconds vs Coolant Temperature
Description: This is a time table that determines how long the start extra fuel stays in.

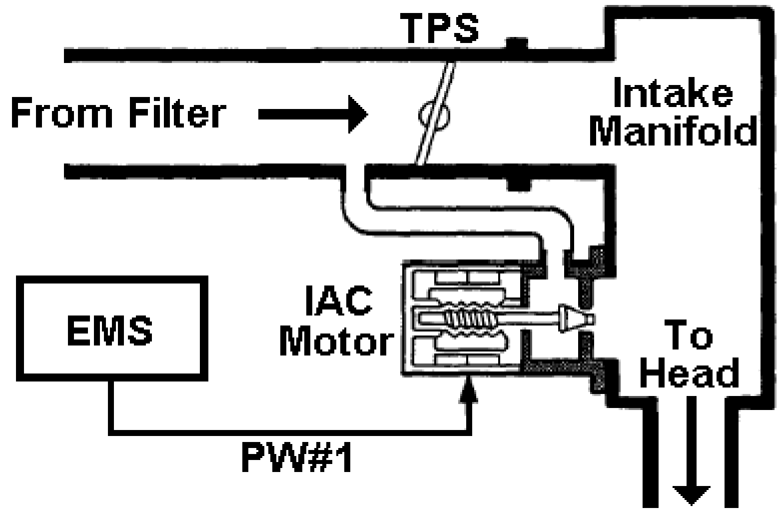
Warm Up Enrichment table
Units: Fuel % vs Coolant Temperature
Description: Fuel correction for coolant temperature that is used to safely warm-up the vehicle. There should be no correction when the engine is at normal operating temperature.

Ign vs Start Time table
Units: Degrees vs Seconds
Description: Sets an ignition timing correction to achieve quick engine starts

6.2 Idle Air Control

Idle Air Control

Idle air control (IAC) systems are used to stabilize idle speed during cold engine and after warm-up operations. The IAC system regulates the volume of air bypassed around a closed throttle butterfly valve. The EMS controls the IAC system by applying various input signals from the user-programmable software file. There are two major types of IAC systems. The stepper idle air control motor is, typically used by Toyota, Dodge, Mitsubishi, etc. The pulse width idle air control valve is commonly used by Honda, Subaru, Ford, Nissan, Volkswagen, etc. This instruction manual will address both types of IAC systems.



The stepper motor IAC valve consists of a step-motor with a seat, magnetic rotor, valve, four wires to each of the four coils and can vary bypass airflow by positioning its valve into one of many possible steps. Basically, the higher the IAC valve step number, the larger the airflow opening and the greater the volume of air bypassed around the closed throttle. However, if a voltage pulse is applied backwards, the motor will step in the other direction. The motor step will open or close, based on the number of pulses and the direction desired.

The advantage of a step type IAC motor is that once the motor is in the proper location, no signal or power is required to maintain this position. The only time action needs to be taken is when changing the location of the motor. The downside is there is an uncertainty to where the motor is at any given time. This can be overcome by routinely resetting the IAC motor to a known location. With tuning, this is achieved by stepping the motor all the way to its limit. However, this may damage the motor if not set correctly. This will reset the motor and is annotated in the options menu by "R/S".

Stepper motors do not have a position sensor. The location at engine start has to be assumed since there is no time for it to reset. Therefore, it must be parked in a known location when the engine is turned OFF. Parking of the stepper motor is crucial and is annotated in the options menu by "Park". After the engine is shut off, the EMS keeps power to the main relay and then resets and parks the stepper motor. This takes about 5-7 seconds and is usually unnoticed by the user.

The other major IAC system is a pulse width duty cycle valve. This system regulates air bypass volume by utilizing a duty cycle controlled solenoid. This electric solenoid controls an air valve which blocks passage of air from the intake pipe to the intake manifold. Since this solenoid is incapable of flowing high air volume, a separate mechanical air valve is typically used to perform cold fast idle. With this type system, the EMS varies bypass airflow by changing the duty ratio of the command signal to the IAC valve. By increasing the duty ratio, the EMS holds the air bypass valve open longer, causing an increase in idle speed.

The advantage of this type of IAC system is that it does not need to park and because it does not take steps, the valve is always at a known position. The disadvantage of this type of IAC system is that power is required to maintain idle unlike the stepper motor type. Pulse width idle air control systems also require specific frequencies to operate at. This frequency is defined in the EMS software but if not tuned right, they can be noisy.

User Definable Options for Idle

A/C On Delay

Units: Seconds

Description: The time between when the A/C request is switched ON and the A/C compressor is turned ON. Used to open the idle motor slightly before the increased load from the A/C compressor to counter-act idle surge.

Hi Idle RPM Offset

Units: RPM

Description: Additional RPM added to the idle target when in the "high idle" condition. Typically used for engine deceleration to help prevent engine stalling.

Hi Idle Car Speed

Units: Vehicle Speed

Description: When above this speed, the high idle condition will be maintained indefinitely. The vehicle speed sensor must be set up for this function to work. Typically used for engine deceleration to help prevent engine stalling.

Hi Idle Wait Time

Units: Seconds

Description: Counter limits how long the high idle offset conditions will be met once the idle conditions are met. Typically used for engine deceleration to help prevent engine stalling.

Idle Extra <12 Volt

Units: Idle %

Description: The amount of additional idle duty to add when the battery voltage is less than 12 volts. The number can be positive or negative depending on how the idle motor responds. Helps in charging the battery and keeping the vehicle from stalling.

Idle Brown Out Trig

Units: Voltage

Description: For stepper idle air control motors only. The position of the idle motor will be stored for a restart condition when the voltage drops below this value. A typical value is 9 volts. This is used when there is not enough voltage to continue idling so the position of the idle motor sets up for a restart condition.

Idle A/C Load Comp

Units: Idle %
Description: Amount of extra duty required to maintain the existing target RPM when the A/C compressor is enabled. The value can be positive or negative depending on how the idle air control motor responds. A typical value is (+/-) 5. Encourages a stable idle when the A/C is switched ON and is used in conjuction with the **A/C On Delay** option.

Idle FB Below rpm
Units: RPM
Description: Maximum RPM threshold for closed loop idle feedback. A typical value is 1700 RPM. Stalling can occur if this RPM value is too high. This stalling is typically caused from driving slow enough to never exit the closed loop idle condition. The idle air control motor will completely close in attempt to bring the idle to the target value and cannot react and open fast enough if the user lets off the throttle for an idle state. A steady "open loop" high idle can occur if this RPM value is too low. This is caused from the base idle speed (**Idle% vs Target table**) never dropping below the **Idle FB Below rpm** condition.

Idle FB Above rpm
Units: RPM
Description: Minimum RPM for closed loop idle feedback. The lowest idle speed possible that should mimic the **Crank Exit RPM**. A typical value is 400 RPM. Open loop idling can occur if this value is too large where the idle air control motor does not respond. If the Engine RPM goes below this value, idling will be solely dependant on the Ign Timing and Fuel Inj Base Pulse parameters.

Idle Park Target
Units: Idle %
Description: For stepper idle air control motors only. User defined position to park an idle stepper motor. Used to allow an easy restart.

Idle Park Key Off
Units: On/Off
Description: For stepper idle air control motors only. Stops the idle position and resets to the **Idle Park Target** position when the key is turned off. Enables a stepper motor to park and be controlled for specific idle functions.

Idle PW Frequency
Units: Hz
Description: For pulse width idle air control motors only. Sets a frequency that is specific to the idle pulse width motor being used. If the idle air control motor is noisy or has a lazy response, the frequency should be changed.

Idle Low Amp Step
Units: On/Off
Description: For stepper idle air control motors only. Reduces current and prevents overheating for poor quality stepper motors. Normally not used.

Idle RS At Key On
Units: On/Off
Description: For stepper idle air control motors only. Allows an idle stepper motor to reset to the **Idle Park Target** for start up. Roughly 10 seconds is required from the time the ignition is turned ON and the motor is cranked.

Idle RS Step Rate
Units: mS
Description: For stepper idle air control motors only. User defined amount of time a stepper motor will take to make a step while in the reset function. A typical value is 8 mS. Used to setup and match a specific stepper motor response time.

Idle RS At Key Off
Units: On/Off
Description: For stepper idle air control motors only. When the ignition key is turned OFF and the main relay function is active, this allows a stepper motor to reset to the **Idle Park Target** position. The function allows the end user to exit the vehicle while the stepper motor resets itself.

Idle Motor Rate
Units: mS
Description: Rate at which the output drives an idle air control motor. For stepper type idle air control motors, a typical value is between 4-30mS. For pulse width idle air control motors, the value should be the same as the drive frequency set in **Idle PW Frequency**. A typical value is 16mS. This is how fast the idle air control motor makes a change from the feedback supplied. If this rate is too fast, the under damped idle will constantly overshoot the target value and idle sporadically. If this rate is too slow, the over damped idle may stall from many transient responses.

Idle FB Maximum
Units: Idle %
Description: Maximum air bypass percentage allowed to maintain the target idle. A typical value is 15%. Before tuning the idle option, this value may need to be large in order to stabilize idle for normal tuning. After tuning idle, it is a good idea to narrow the feedback range to eliminate unwanted idle changes.

Idle FB Minimum
Units: Idle %
Description: Minimum air bypass percentage allowed to maintain the target idle. A typical value is -5%. Before tuning the idle option, this value may need to be a large negative number in order to stabilize idle for normal tuning. After tuning idle, it is a good idea to narrow the feedback range to eliminate unwanted idle changes.

Idle FB Dead Band-
Units: RPM
Description: Disables idle correction below the target idle speed. A typical value is -25. This function is very useful if exact idle speeds are not crucial, but reasonable

stable speeds are. If this value is too large, stalling may occur due to low idle speeds.

Idle FB Dead Band+
Units: RPM
Description: Disables idle correction above the target idle speed. A typical value is 50. This function is very useful if exact idle speeds are not crucial, but reasonable stable speeds are. If this value is too large, high idling may occur due to open loop feedback.

Idle FB Dir Invert
Units: On/Off
Description: Inverts the direction that the idle motor takes to achieve the target idle. Used in instances when the idle motor responds in the opposite direction to reach the target idle. If the **Idle Learned Value** parameter is moving away from 0% and the engine speed is moving away from the target idle RPM, this function needs to be switched to compensate for that application.

Idle FB Rate
Units: mS
Description: Idle air control feedback time base. Time allowed for an idle air control motor to respond and make decisions for idle feedback. This function determines how often the engine RPM is referenced for closed loop feedback in order to make adjustments and maintain the **Idle Target**. Decreasing this number speeds decision-making but may cause the idle control to "hunt". Increase this number to the largest value that can still accurately control the idle. If the idle motor responds slowly to RPM variations off the **Idle Target**, then decrease this number. If hunting or surging occurs, increase this number. A typical value is 200mS.

Idle Stepper Clock
Units: On/Off
Description: For stepper idle air control motors only. Allows the direction of a stepper motor to be reversed for raising and lowering the idle rpm. This function is used to switch the direction of a stepper motor to clockwise or counterclockwise depending on how the stepper motor responds.

Idle 1/2 Stepper
Units: On/Off
Description: For stepper idle air control motors only. Turn ON when outputting from this function. Turn OFF for user-defined control. If this function is not used to control an idle stepper motor, it should be turned OFF to run as a low or high side driver if applicable.

Idle 3/4 Stepper
Units: On/Off
Description: For stepper idle air control motors only. Turn ON when outputting from this function. Turn OFF for user-defined control. If this function is not used to control

an idle stepper motor, it should be turned OFF to run as a low or high side driver if applicable.

Idle 5/6 Stepper/DC
Units: On/Off
Description: When active, the Idle 5/6 output is used for the idle stepper motor function unless the "Motor DC" is active, then the "Motor" algorithm is applied. If this function is not used to control an idle stepper motor, it should be turned OFF to run as a low or high side driver if applicable or a DC motor.

Idle 7/8 Stepper/DC
Units: On/Off
Description: When active, the Idle 5/6 output is used for the idle stepper motor function unless the "Motor DC" is active, then the "Motor" algorithm is applied. If this function is not used to control an idle stepper motor, it should be turned OFF to run as a low or high side driver if applicable or a DC motor.

Idle On If TP Less
Units: Throttle %
Description: Throttle dependant idle feedback. Idle feedback is active when throttle percentage is below this number. This number should be the same or smaller than the **Idle Off If TP Less** option. A typical value is 3. In order for idle feedback to be active, make sure this value is larger than your **Throttle** parameter during an idle state.

Idle Off If TP Over
Units: Throttle %
Description: Exit of throttle dependent idle feedback. Idle feedback is disabled when the throttle percentage is above this number. This value also determines the re-instatement of idle feedback. This number should be the same or larger than the **Idle On If TP Less** option. A typical value is 3. This value is crucial in determining and allowing an idle state, but to prevent tip-in stalling, this value should be as close to the **Idle On If TP Less** option as possible.

Idle 1/2 Max Curren
Units: Amps
Description: Current setting for a specific motor which must always be set. Typical values are 1-2 Amps. When used for a stepper motor, 2 Amps is typical. When used for a solenoid, 1.5 Amps is typical.

Idle 3/4 Max Curren
Units: Amps
Description: Current setting for a specific motor which must always be set. Typical values are 1-2 Amps. When used for a stepper motor, 2 Amps is typical. When used for a solenoid, 1.5 Amps is typical.

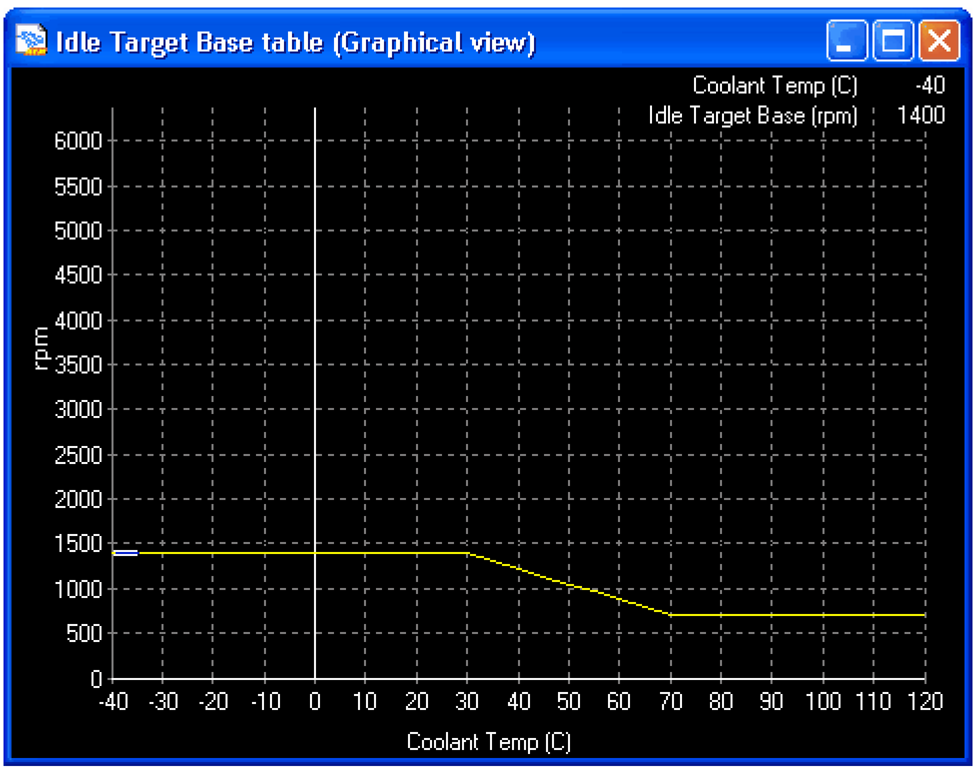
Idle 5/6 Max Curren

Units: Amps
Description: Current setting for a specific motor which must always be set. Typical values are 1-2 Amps. When used for a stepper motor, 2 Amps is typical. When used for a solenoid, 1.5 Amps is typical. When used for a DC motor, 1 Amp is typical.

Idle 7/8 Max Curren
Units: Amps
Description: Current setting for a specific motor which must always be set. Typical values are 1-2 Amps. When used for a stepper motor, 2 Amps is typical. When used for a solenoid, 1.5 Amps is typical. When used for a DC motor, 1 Amp is typical.

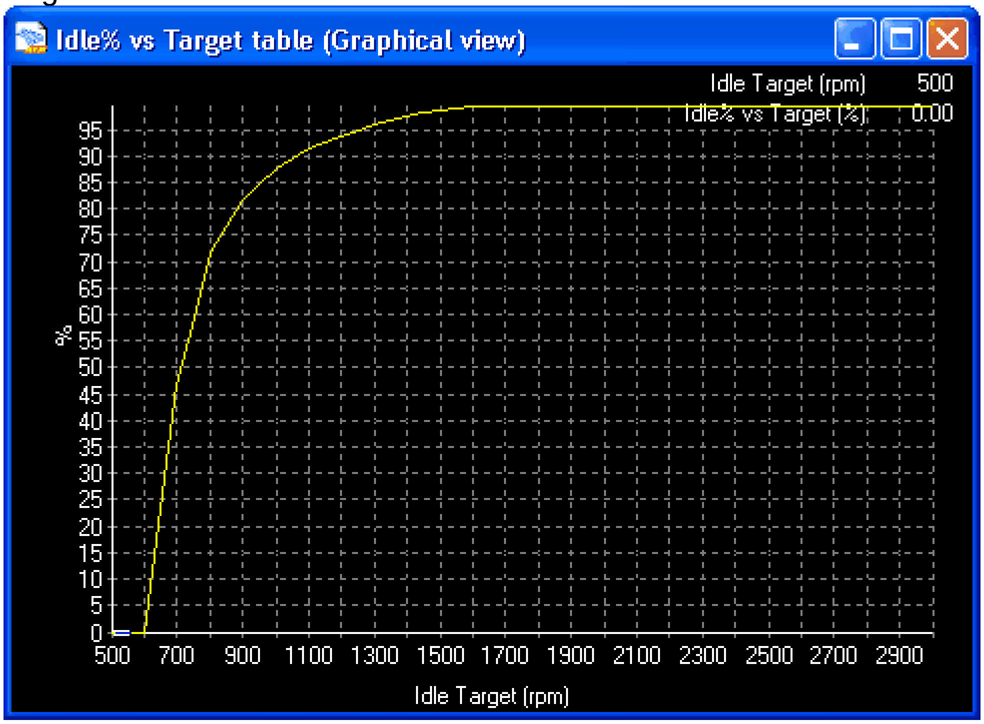
2-D Tables for Idle

Idle Target Base Table
Units: Target Idle RPM vs. Coolant Temp Temperature
Description: Coolant Temp dependant base table for target idle RPM. This table determines the target idle speed at specific engine coolant temperatures. The RPM values are, typically, greater at cooler temperatures to help stabilize idle and encourage the engine to warm up faster. During a very cold start up, 1500RPM is typical.

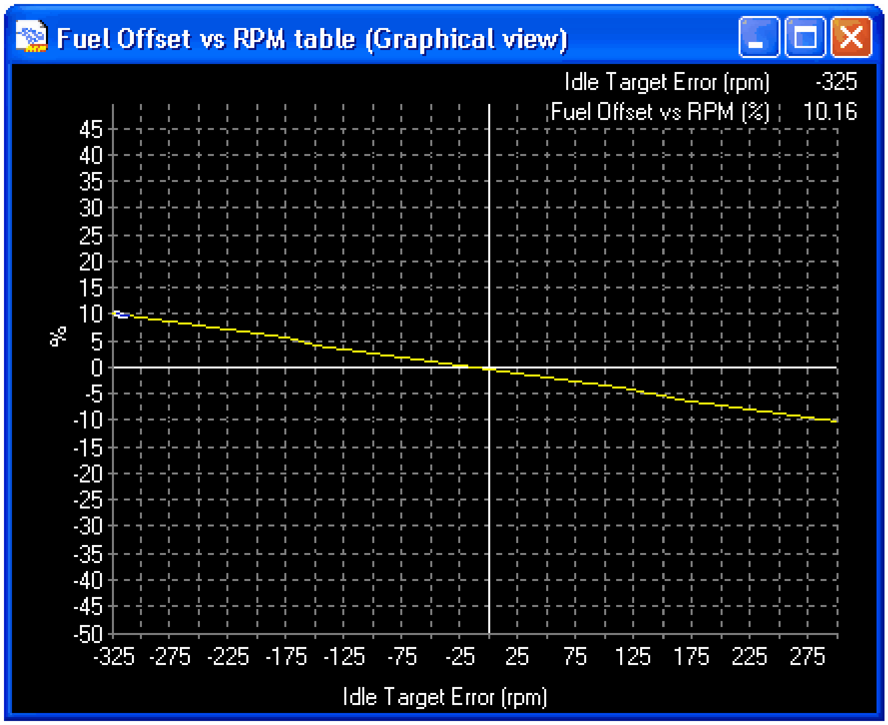


Idle% vs Target Table
Units: Idle Motor Range% vs Target Idle RPM
Description: Base bypass idle air percentage used to start the target idle descend. There is no typical values here because this varies greatly and depends on the idle control motor used. This table determines the air bypass necessary to obtain the

specific target idle.



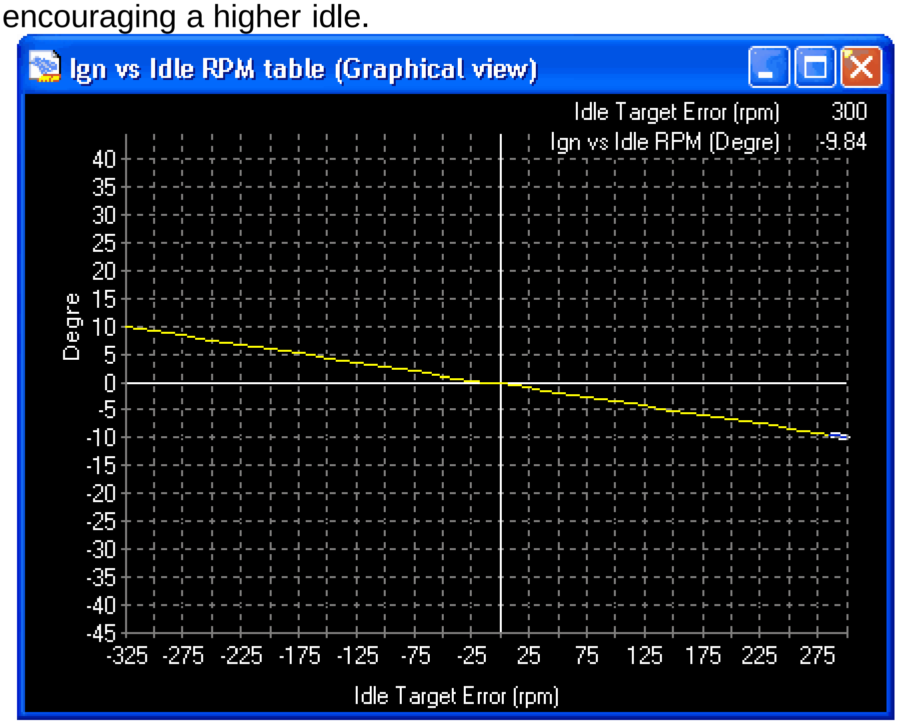
<u>Fuel Offset vs RPM table</u>
Units: Fuel % vs. Idle RPM
Description: Introduces the ability to tune a separate fuel table near the target idle to help maintain a specific air fuel ratio and a steady idle. Because there are many idle variables, this table should be set up at the end of a tuning session. If necessary, this table is used when large overlap conditions are present due to large cams or aggressive intake porting.



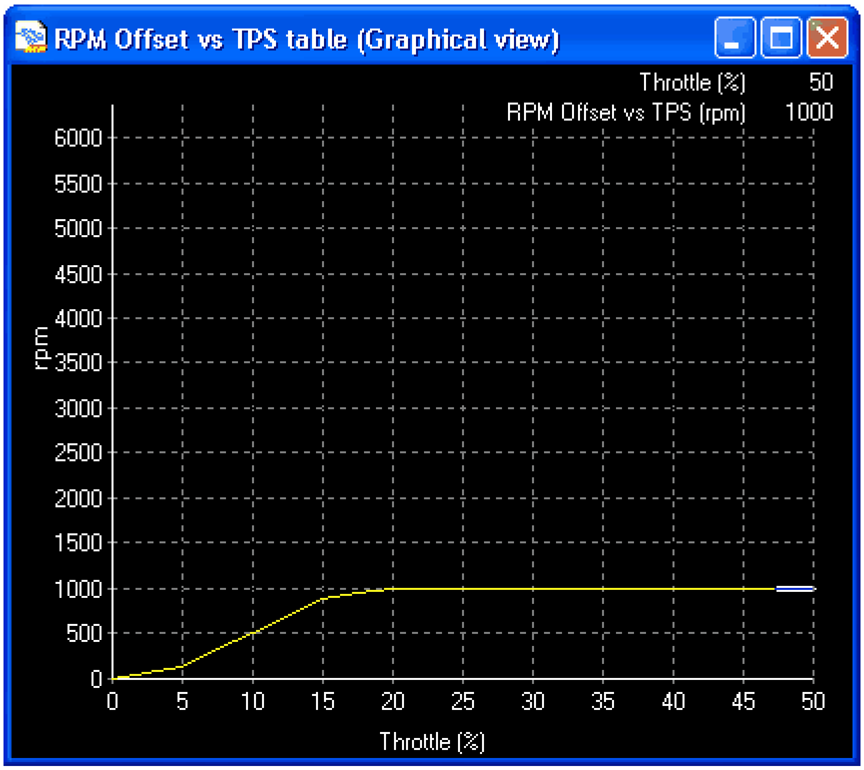
Ign vs Idle RPM table

Units: Ignition Degrees vs. Idle Target Error (RPM)

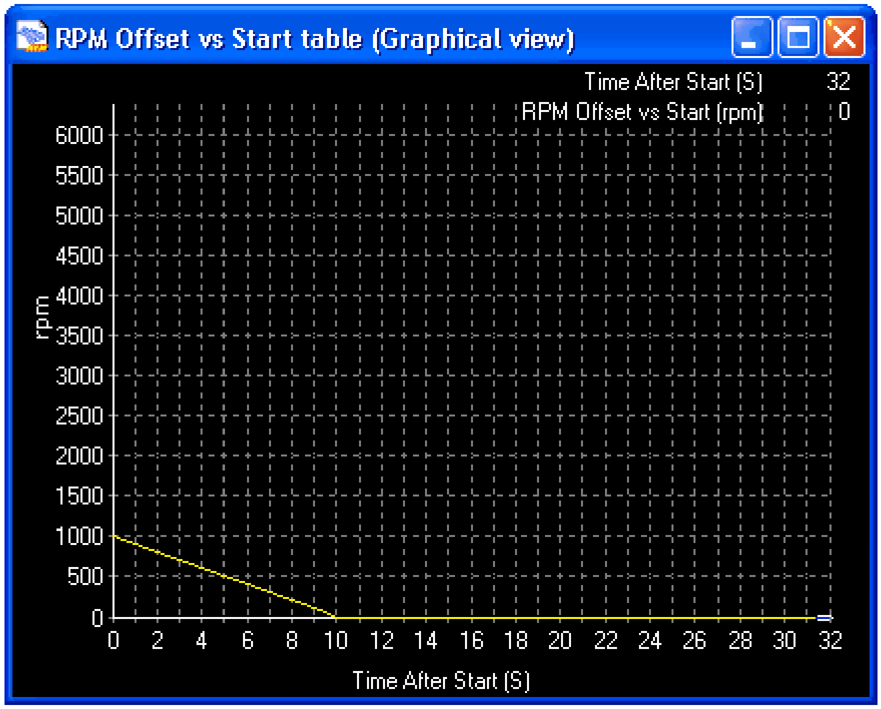
Description: Introduces the ability to tune ignition timing near the target idle to help maintain a steady idle. Because there are many idle variables, this table should be set up at the end of a tuning session. If necessary, this table is used to help prevent stalling by encouraging a higher idle.



RPM Offset vs TPS table
Units: RPM vs. Throttle %
Description: Increases the target idle speed based on throttle position to prevent stalling. Only used when the throttle percentage is below the **Idle Off If TP Over**. This table is useful while creeping in traffic where a very small throttle change could cause the idle air control motor to close and stall the motor. By increasing the RPM at low throttle percentages, it will increase the target idle and keep the idle air control motor open.



RPM Offset vs Start table
Units: RPM vs. Time After Engine Start
Description: Increases the Idle RPM Target RPM based on the time after the engine begins to crank. Used to increase RPM and encourage the engine to start and warm up quicker.



Parameters (can be viewed or logged)

Idle Target
Units: RPM
Description: This is the final idle target RPM that the IAC motor is attempting to achieve after all idle compensators.

Idle Target Error
Units: RPM
Description: RPM value above or below the Idle RPM Target value.

Idle Base
Units: %
Description: Percent of idle control motor position generated from the **Idle% vs Target table**.

Idle Position
Units: Idle %
Description: Final compensated idle air bypass percentage.

Idle Learned Value
Units: Idle %
Description: The idle percentage above or below the target idle. Zero percent would represent no correction to the IAC motor to achieve the target idle.

Idle RPM Trim Hi
Units: RPM

Description: The additional amount of RPM added anytime the system goes into idle control. The RPM is added for the length of time specified in the **Hi Idle Wait Time** option. This function is also used anytime the car is below the **Hi Idle Car Speed** Value.

Idle RPM Trim Start
Units: RPM
Description: Additional RPM added when the engine starts. Uses the **RPM Offset vs Start table** to determine decay time.

Idle Counter
Units: Idle %
Description: Idle percentage diagnostic.

Fuel Trim Idle
Units: Idle %
Description: Additional amount of fuel percentage added or subtracted that comes directly from the **Fuel Offset vs RPM table** duiring idle condition.

Idle Trim
Units: Idle %
Description: The amount of idle air bypass percentage from trim control.

Idle High Counter
Units: Seconds
Description: Time after the hi idle trim conditions are met to drop back into the normal idle conditions.

Idle R/S Count
Units: Raw
Description: The time for resetting the stepper idle air control motor.

Idle Rate Count
Units: Raw
Description: The amount of time it takes to make each step for a stepper motor.

Ign Trim Idle
Units: Ignition Degrees
Description: Additional amount of ignition timing added or subtracted that comes directly from the **Ign Offset vs RPM table** duiring idle condition.

Idle RPM Trim Start
Units: RPM
Description: The additional amount of RPM added during the time after starting the engine.

Idle Tuning Procedure

The first step before tuning the IAC system is to determine the direction of the motor. The language of the IAC motor is in percentage. This is not percent open or percent of airflow, it is rather the full-scale percentage of the motor where 100% may be fully closed or fully open. Do not assume that a larger idle percent gives a higher idle speed. Some factory units actually decrease Engine RPM as idle percentage increases. It is very easy to determine which way your specific IAC system works.

- Open AEMPro and connect to the EMS.
- Confirm that the throttle position is set properly (closed < 1%, WOT > 95%).
- Confirm the AFR or that the vehicle has sufficient fuel for idling and that the vehicle is at the normal operating temperature.
- Open the **Idle Template** and set **Idle FB Below rpm** to a conservative 3,000RPM and set **Idle FB Above rpm** to 400RPM. Set both **Idle On If TP Less** and **Idle Off If TP Over** to a conservative 5%.

These settings will activate the idle circuit whenever the engine RPM is below 3,000 RPM and the throttle is below 5%. These settings are not necessarily drivable but they will allow the vehicle to idle on its own so you can begin tuning.

- Start the engine.
- Get the vehicle to idle. This may require creative throttle movements to stabilize the idle until it catches itself.
- Confirm that an increase in the **Idle% vs Target Table** will increase RPM rises.
- If RPM decreases, select the **Idle Invert** option in the **Advanced Idle Template**.
- Shut off the engine.

Now that you know how the IAC motor responds, you can start setting up the idle tables and idle options.

- In the **Advanced Idle Template**, set the option **Idle FB Minimum** to -50% and **Idle FB Maximum** to 50%.
- Set the options **Idle FB Dead Band+** and **Idle FB Dead Band-** to 0.
- Open the **Idle Template** and set the entire **Idle Target Base table** to 3,000RPM.
- Start the engine.
- After a few seconds, confirm that the **Idle Target** parameter is 3,000RPM (if not zero-out all.
- Add or subtract idle percent from the **Idle% vs Target Table** until the **Idle Learned Value** parameter is 0% (you may notice that the idle motor will not rev the engine this high but that is common).
- Drop the **Idle Target Base table** to 2900RPM.
- Add or subtract idle percent from the **Idle% vs Target Table** until the **Idle Learned Value** parameter is 0%.

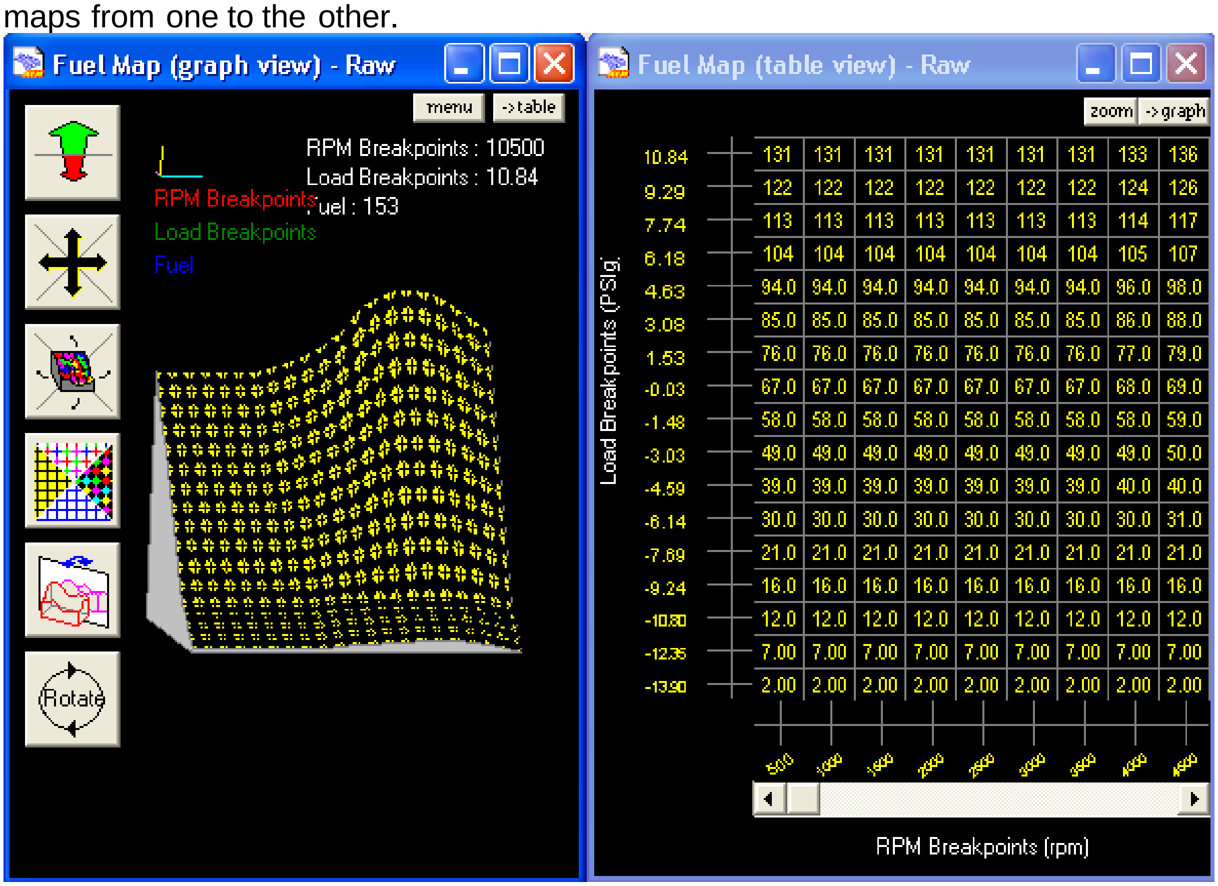
- Drop the **Idle Target Base table** to 2800RPM.
- Repeat this process for every 100RPMs until 500RPM is reached.
- Set the **Idle Target Base table** to your desire.

It is a good idea to set the **Idle FB Minimum** option to a small feedback percentage to keep the engine from stalling (5% is typical). The **Idle FB Maximum** can be set high to band aid tuning flaws (15% is typical). The **Idle FB Dead Band-** option is typically set at -25RPM while the **Idle FB Dead Band+** is typically set at +50RPM to keep the idle steady. A typical **Idle FB Below rpm** is 1700 which keeps the idle motor from trying to idle at slow vehicle speeds. Set both **Idle On If TP Less** and **Idle Off If TP Over** options 1% higher than the **Throttle** parameter when the engine is running and the throttle is at rest.

6.3 Fuel Map

Fuel Map

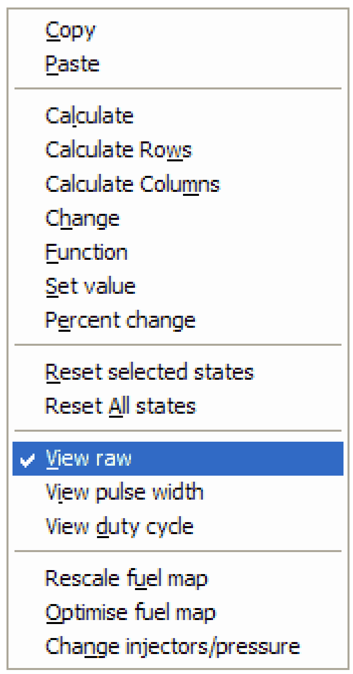
The **Fuel Map** can be viewed as a 3D graph, a table of values, or both simultaneously. The table can be displayed in duty cycle, pulse width, or raw numbers. The manipulation of data in the fuel map is very easy to accomplish. Simply highlight the area that needs to be adjusted, right click for a drop down menu of data adjustment choices and choose the appropriate one for the task. Because this is a Windows™ based system, you can even copy and paste values of different maps from one to the other.



Highlighting the points or area to change on the 3D graph changes the **Fuel Map**. With a right click of the mouse, the data in the highlighted area can be increased or decreased by dragging the mouse up or down. When changes to the map are made, the color changes in the affected area. The color also indicates the type of change that was made.

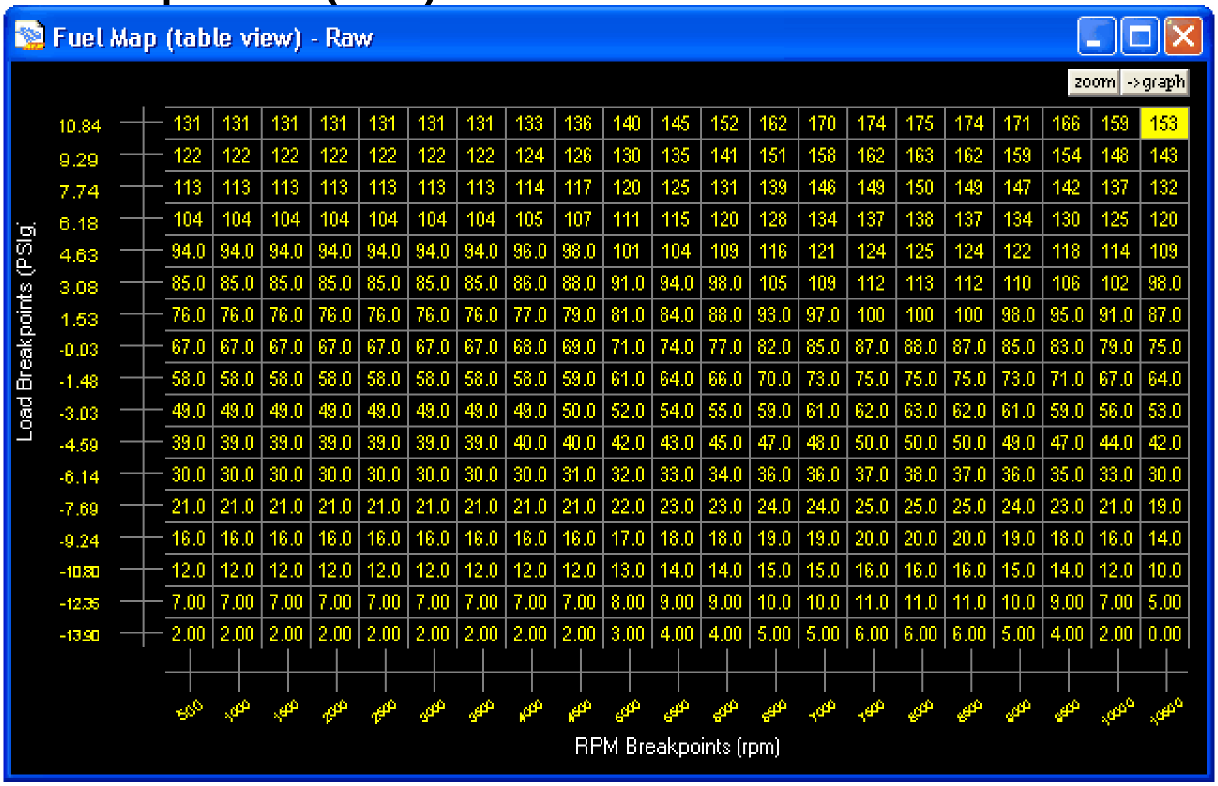
The data in the fuel table can be displayed in raw, pulse width, or duty cycle% format. To view the table in the various formats right click anywhere in the table and select the preferred view.

- **View raw** – This is the raw calculation number that is multiplied with other factors to give the final pulse width.
- **View pulse width** – This is the calculated pulse width that is delivered to the injectors from the base map. This pulse width excludes any modifiers for engine temp, air temp, etc..
- **View duty cycle** – This is the percentage of the injector that is being used at each point.



The three view options define the units in which the map is drawn. The current selection (by default **View Raw**) is ticked. **View Raw** shows the raw value from the map ranging between 0-255. **View Pulse Width** shows the actual pulsewidth before any other modifications, in milliseconds. This is calculated by multiplying the **Raw** value by the value of the option **MicroSec/bit**. Selecting **View Duty Cycle** brings up the duty cycle injection type window. This asks for the number of injections per cylinder per revolution from the choice of ½, 1, or 2. The **Fuel Map** then shows the percentage of time that the injectors are actually open. Note that a value exceeding around 90% can cause the injectors to work incorrectly due to opening and closing times.

Fuel Map Table (Raw)

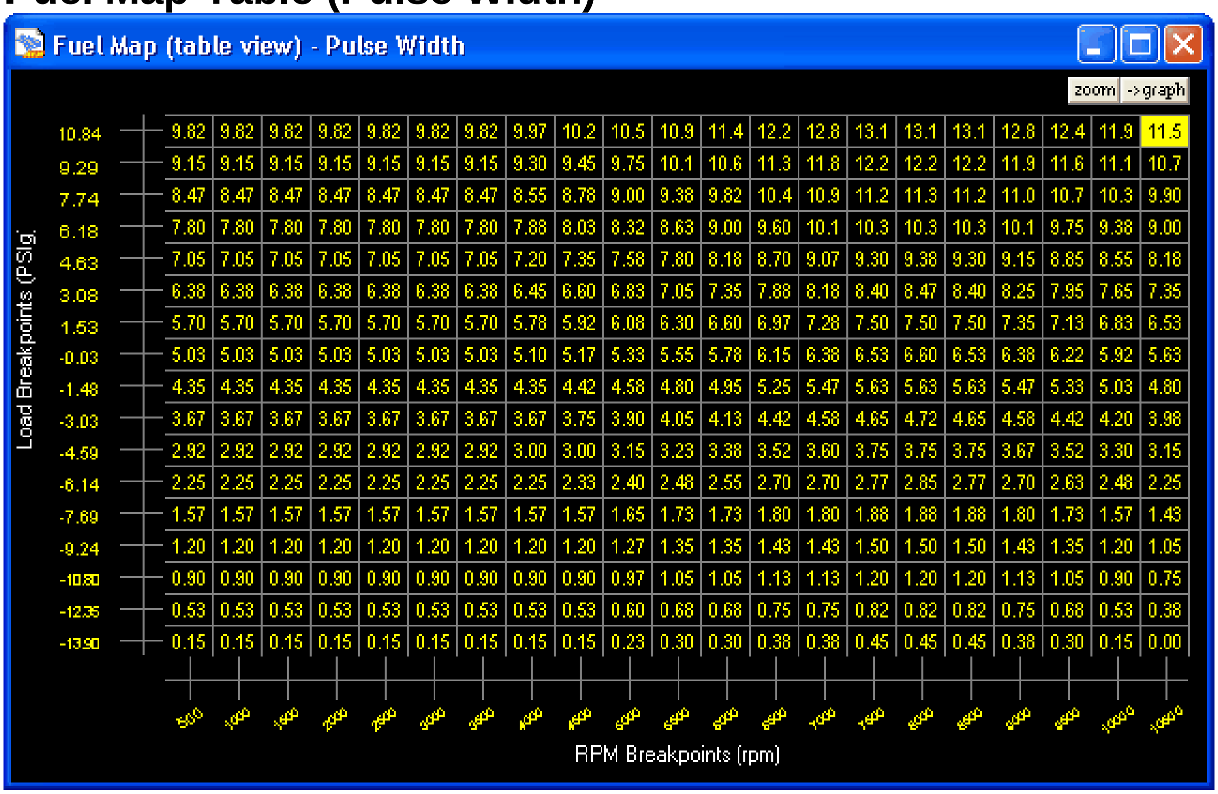


Fuel Map (table view) - Raw

Load Breakpoints (PSIg)																					
10.84	131	131	131	131	131	131	131	133	136	140	145	152	162	170	174	175	174	171	166	159	153
9.29	122	122	122	122	122	122	122	124	126	130	135	141	151	158	162	163	162	159	154	148	143
7.74	113	113	113	113	113	113	113	114	117	120	125	131	139	146	149	150	149	147	142	137	132
6.18	104	104	104	104	104	104	104	105	107	111	115	120	128	134	137	138	137	134	130	125	120
4.63	94.0	94.0	94.0	94.0	94.0	94.0	94.0	96.0	98.0	101	104	109	116	121	124	125	124	122	118	114	109
3.08	85.0	85.0	85.0	85.0	85.0	85.0	85.0	86.0	88.0	91.0	94.0	98.0	105	109	112	113	112	110	106	102	98.0
1.53	76.0	76.0	76.0	76.0	76.0	76.0	76.0	77.0	79.0	81.0	84.0	88.0	93.0	97.0	100	100	100	98.0	95.0	91.0	87.0
-0.03	67.0	67.0	67.0	67.0	67.0	67.0	67.0	68.0	69.0	71.0	74.0	77.0	82.0	85.0	87.0	88.0	87.0	85.0	83.0	79.0	75.0
-1.48	58.0	58.0	58.0	58.0	58.0	58.0	58.0	58.0	59.0	61.0	64.0	66.0	70.0	73.0	75.0	75.0	75.0	73.0	71.0	67.0	64.0
-3.03	49.0	49.0	49.0	49.0	49.0	49.0	49.0	49.0	50.0	52.0	54.0	55.0	59.0	61.0	62.0	63.0	62.0	61.0	59.0	56.0	53.0
-4.59	39.0	39.0	39.0	39.0	39.0	39.0	39.0	40.0	40.0	42.0	43.0	45.0	47.0	48.0	50.0	50.0	50.0	49.0	47.0	44.0	42.0
-6.14	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	31.0	32.0	33.0	34.0	36.0	36.0	37.0	38.0	37.0	36.0	35.0	33.0	30.0
-7.69	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	22.0	23.0	23.0	24.0	24.0	25.0	25.0	25.0	24.0	23.0	21.0	19.0
-9.24	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	17.0	18.0	18.0	19.0	19.0	20.0	20.0	20.0	19.0	18.0	16.0	14.0
-10.80	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	13.0	14.0	14.0	15.0	15.0	16.0	16.0	16.0	15.0	14.0	12.0	10.0
-12.35	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	8.00	9.00	9.00	10.0	10.0	11.0	11.0	11.0	10.0	9.00	7.00	5.00
-13.90	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	3.00	4.00	4.00	5.00	5.00	6.00	6.00	6.00	5.00	4.00	2.00	0.00

RPM Breakpoints (rpm)

Fuel Map Table (Pulse Width)

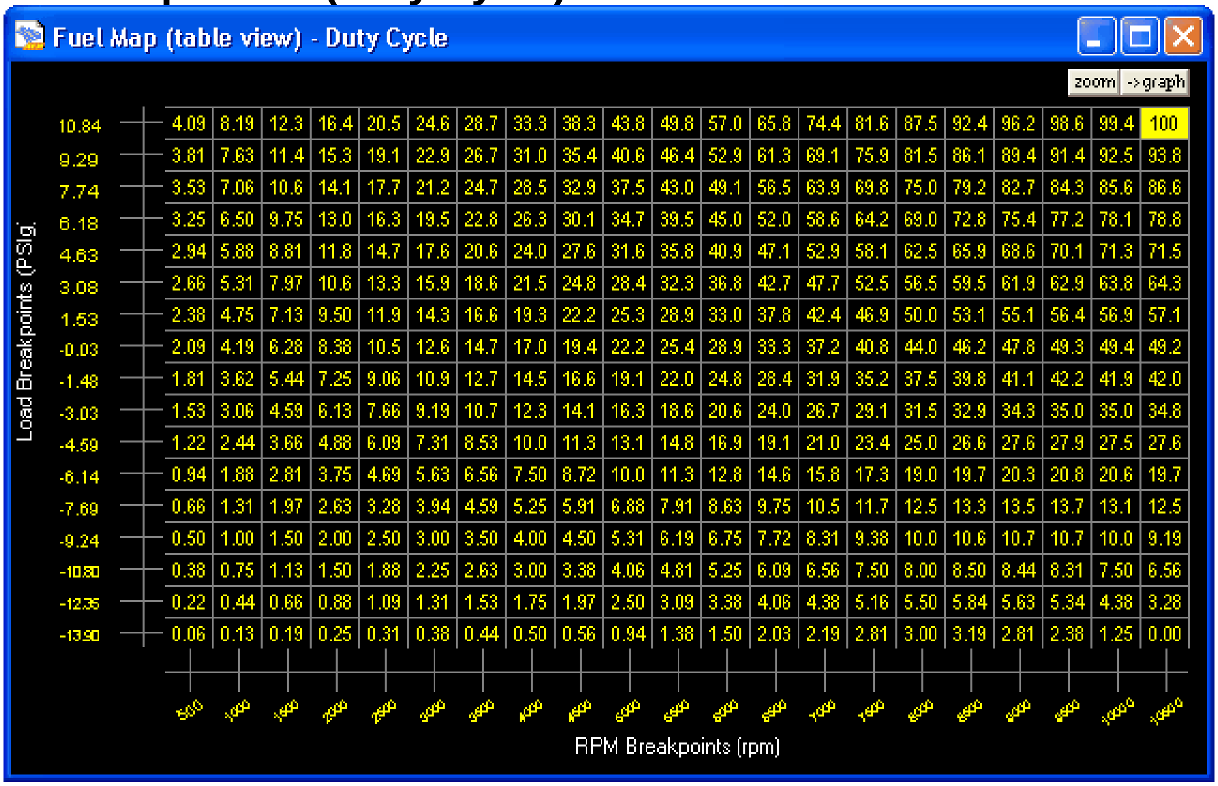


Fuel Map (table view) - Pulse Width

Load Breakpoints (PSIg)																					
10.84	9.82	9.82	9.82	9.82	9.82	9.82	9.82	9.97	10.2	10.5	10.9	11.4	12.2	12.8	13.1	13.1	13.1	12.8	12.4	11.9	11.5
9.29	9.15	9.15	9.15	9.15	9.15	9.15	9.15	9.30	9.45	9.75	10.1	10.6	11.3	11.8	12.2	12.2	12.2	11.9	11.6	11.1	10.7
7.74	8.47	8.47	8.47	8.47	8.47	8.47	8.47	8.55	8.78	9.00	9.38	9.82	10.4	10.9	11.2	11.3	11.2	11.0	10.7	10.3	9.90
6.18	7.80	7.80	7.80	7.80	7.80	7.80	7.80	7.88	8.03	8.32	8.63	9.00	9.60	10.1	10.3	10.3	10.3	10.1	9.75	9.38	9.00
4.63	7.05	7.05	7.05	7.05	7.05	7.05	7.05	7.20	7.35	7.58	7.80	8.18	8.70	9.07	9.30	9.38	9.30	9.15	8.85	8.55	8.18
3.08	6.38	6.38	6.38	6.38	6.38	6.38	6.38	6.45	6.60	6.83	7.05	7.35	7.88	8.18	8.40	8.47	8.40	8.25	7.95	7.65	7.35
1.53	5.70	5.70	5.70	5.70	5.70	5.70	5.70	5.78	5.92	6.08	6.30	6.60	6.97	7.28	7.50	7.50	7.50	7.35	7.13	6.83	6.53
-0.03	5.03	5.03	5.03	5.03	5.03	5.03	5.03	5.10	5.17	5.33	5.55	5.78	6.15	6.38	6.53	6.60	6.53	6.38	6.22	5.92	5.63
-1.48	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.42	4.58	4.80	4.95	5.25	5.47	5.63	5.63	5.63	5.47	5.33	5.03	4.80
-3.03	3.67	3.67	3.67	3.67	3.67	3.67	3.67	3.67	3.75	3.90	4.05	4.13	4.42	4.58	4.65	4.72	4.65	4.58	4.42	4.20	3.98
-4.59	2.92	2.92	2.92	2.92	2.92	2.92	2.92	3.00	3.00	3.15	3.23	3.38	3.52	3.60	3.75	3.75	3.75	3.67	3.52	3.30	3.15
-6.14	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.33	2.40	2.48	2.55	2.70	2.70	2.77	2.85	2.77	2.70	2.63	2.48	2.25
-7.69	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.57	1.65	1.73	1.73	1.80	1.80	1.88	1.88	1.88	1.80	1.73	1.57	1.43
-9.24	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.27	1.35	1.35	1.43	1.43	1.50	1.50	1.50	1.43	1.35	1.20	1.05
-10.80	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.97	1.05	1.05	1.13	1.13	1.20	1.20	1.20	1.13	1.05	0.90	0.75
-12.35	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.60	0.68	0.68	0.75	0.75	0.82	0.82	0.82	0.75	0.68	0.53	0.38
-13.90	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.23	0.30	0.30	0.38	0.38	0.45	0.45	0.45	0.38	0.30	0.15	0.00

RPM Breakpoints (rpm)

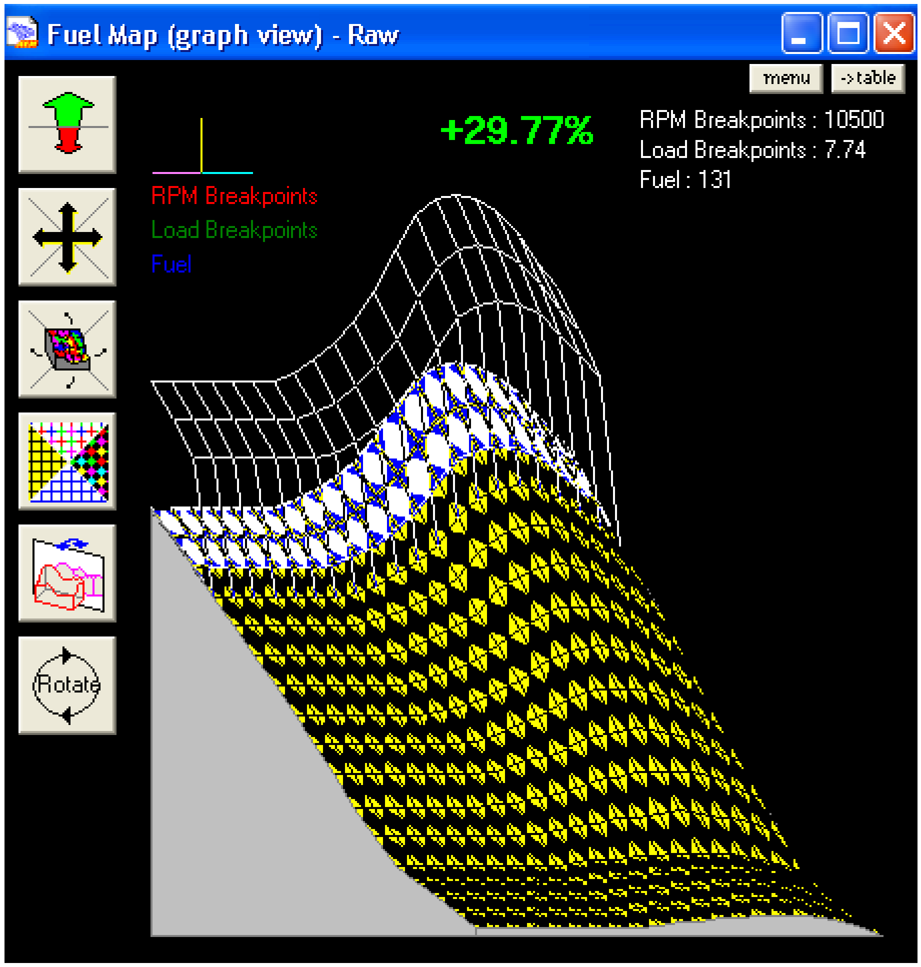
Fuel Map Table (Duty Cycle)



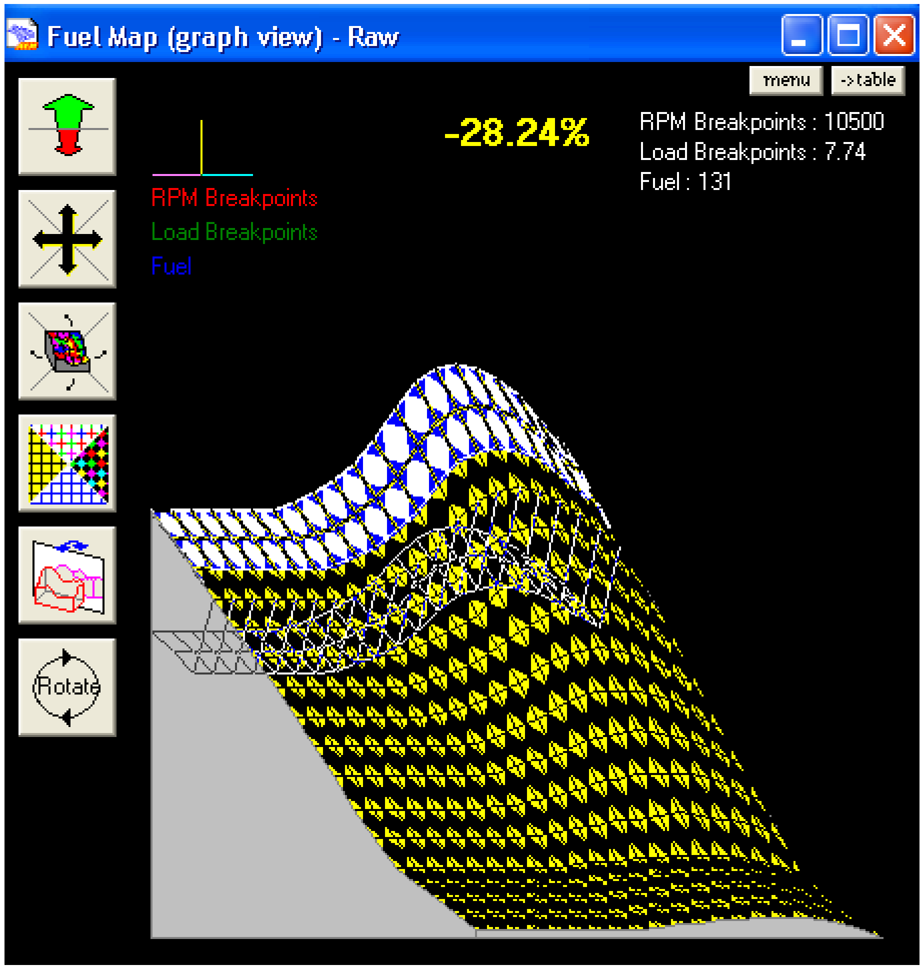
10.84	4.09	8.19	12.3	16.4	20.5	24.6	28.7	33.3	38.3	43.8	49.8	57.0	65.8	74.4	81.6	87.5	92.4	96.2	98.6	99.4	100
9.29	3.81	7.63	11.4	15.3	19.1	22.9	26.7	31.0	35.4	40.6	46.4	52.9	61.3	69.1	75.9	81.5	86.1	89.4	91.4	92.5	93.8
7.74	3.53	7.06	10.6	14.1	17.7	21.2	24.7	28.5	32.9	37.5	43.0	49.1	56.5	63.9	69.8	75.0	79.2	82.7	84.3	85.6	86.6
6.18	3.25	6.50	9.75	13.0	16.3	19.5	22.8	26.3	30.1	34.7	39.5	45.0	52.0	58.6	64.2	69.0	72.8	75.4	77.2	78.1	78.8
4.63	2.94	5.88	8.81	11.8	14.7	17.6	20.6	24.0	27.6	31.6	35.8	40.9	47.1	52.9	58.1	62.5	65.9	68.6	70.1	71.3	71.5
3.08	2.66	5.31	7.97	10.6	13.3	15.9	18.6	21.5	24.8	28.4	32.3	36.8	42.7	47.7	52.5	56.5	59.5	61.9	62.9	63.8	64.3
1.53	2.38	4.75	7.13	9.50	11.9	14.3	16.6	19.3	22.2	25.3	28.9	33.0	37.8	42.4	46.9	50.0	53.1	55.1	56.4	56.9	57.1
-0.03	2.09	4.19	6.28	8.38	10.5	12.6	14.7	17.0	19.4	22.2	25.4	28.9	33.3	37.2	40.8	44.0	46.2	47.8	49.3	49.4	49.2
-1.48	1.81	3.62	5.44	7.25	9.06	10.9	12.7	14.5	16.6	19.1	22.0	24.8	28.4	31.9	35.2	37.5	39.8	41.1	42.2	41.9	42.0
-3.03	1.53	3.06	4.59	6.13	7.66	9.19	10.7	12.3	14.1	16.3	18.6	20.6	24.0	26.7	29.1	31.5	32.9	34.3	35.0	35.0	34.8
-4.59	1.22	2.44	3.66	4.88	6.09	7.31	8.53	10.0	11.3	13.1	14.8	16.9	19.1	21.0	23.4	25.0	26.6	27.6	27.9	27.5	27.6
-6.14	0.94	1.88	2.81	3.75	4.69	5.63	6.56	7.50	8.72	10.0	11.3	12.8	14.6	15.8	17.3	19.0	19.7	20.3	20.8	20.6	19.7
-7.69	0.66	1.31	1.97	2.63	3.28	3.94	4.59	5.25	5.91	6.88	7.91	8.63	9.75	10.5	11.7	12.5	13.3	13.5	13.7	13.1	12.5
-9.24	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.31	6.19	6.75	7.72	8.31	9.38	10.0	10.6	10.7	10.7	10.0	9.19
-10.80	0.38	0.75	1.13	1.50	1.88	2.25	2.63	3.00	3.38	4.06	4.81	5.25	6.09	6.56	7.50	8.00	8.50	8.44	8.31	7.50	6.56
-12.35	0.22	0.44	0.66	0.88	1.09	1.31	1.53	1.75	1.97	2.50	3.09	3.38	4.06	4.38	5.16	5.50	5.84	5.63	5.34	4.38	3.28
-13.90	0.06	0.13	0.19	0.25	0.31	0.38	0.44	0.50	0.56	0.94	1.38	1.50	2.03	2.19	2.81	3.00	3.19	2.81	2.38	1.25	0.00

3D Graph Data Change - Fuel Increase/Decrease

When performing calibration operations, it is sometimes necessary to change a large area of the fuel map to obtain the desired AFR. This can be done by highlighting the area to be changed. A right click on the mouse locks the highlighted area, which can then be dragged up to enrich or down to lean out the mixture. Notice that the percentage change indicator is green in this view.



This is to indicate that this is the safer direction to go on the calibration rather than leaner. The indicator changes to yellow when the map values are leaned out.



Any selected sites can be edited by right clicking on the table or pressing the **Menu** button. The function desired is then selected from the pop-up menu by selecting it with a mouse click. The functions available are:

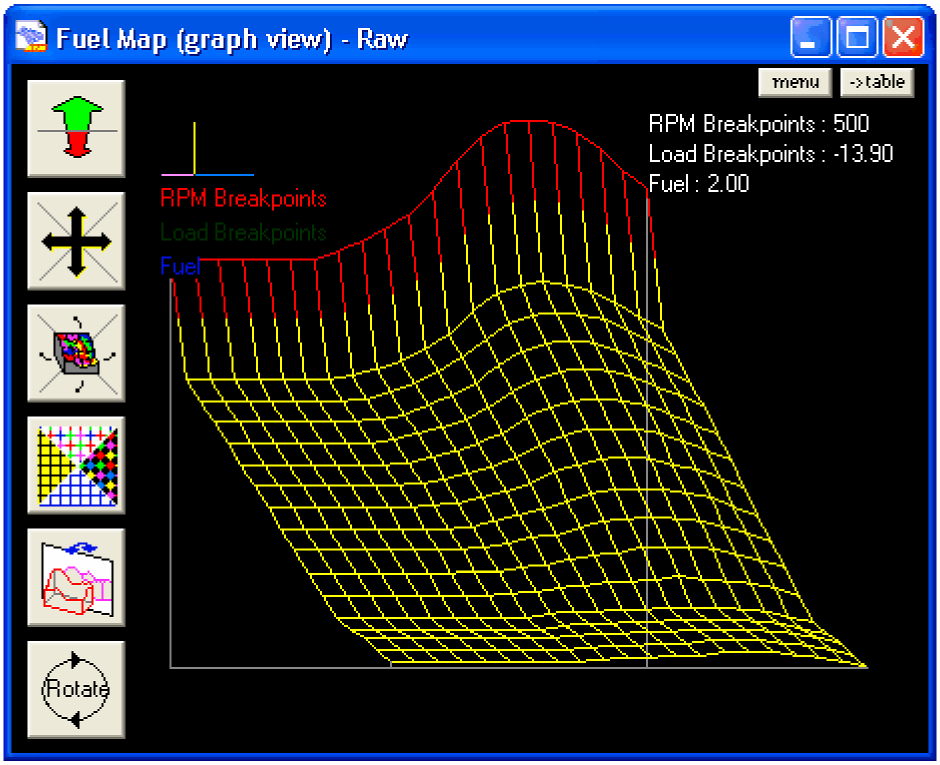
- **Copy** - The selected area is copied internally, so that a paste function can be used to "copy" the site(s).
- **Paste** - The last copy selection is pasted into the selected area. If the number of sites contained in the copy is different to the selected area, the copied sites are interpolated. For example, two sites containing 0 and 2 are copied. A group of three sites are selected and the paste command is selected. The sites are pasted with the values 0, 1 and 2.
- **Calculate** - the two values at either end of the selection highlighted are interpolated. For example, 3 sites are selected. The first and third site contain 0 and 2 respectively and the calculate command is selected. The first and third sites remain unchanged while the second site's value is set to 1.
- **Calculate Rows** - the two values at either end of the highlighted rows are interpolated.
- **Calculate Columns** - the two values at either end of the highlighted columns are interpolated.
- **Change** - An edit box prompts for a value. The selected sites' values are then

changed by the supplied value. For example the value was 10, a 5 is entered in the *change* function, 15 will be the new number, if –5 was entered then 5 would be the new number.

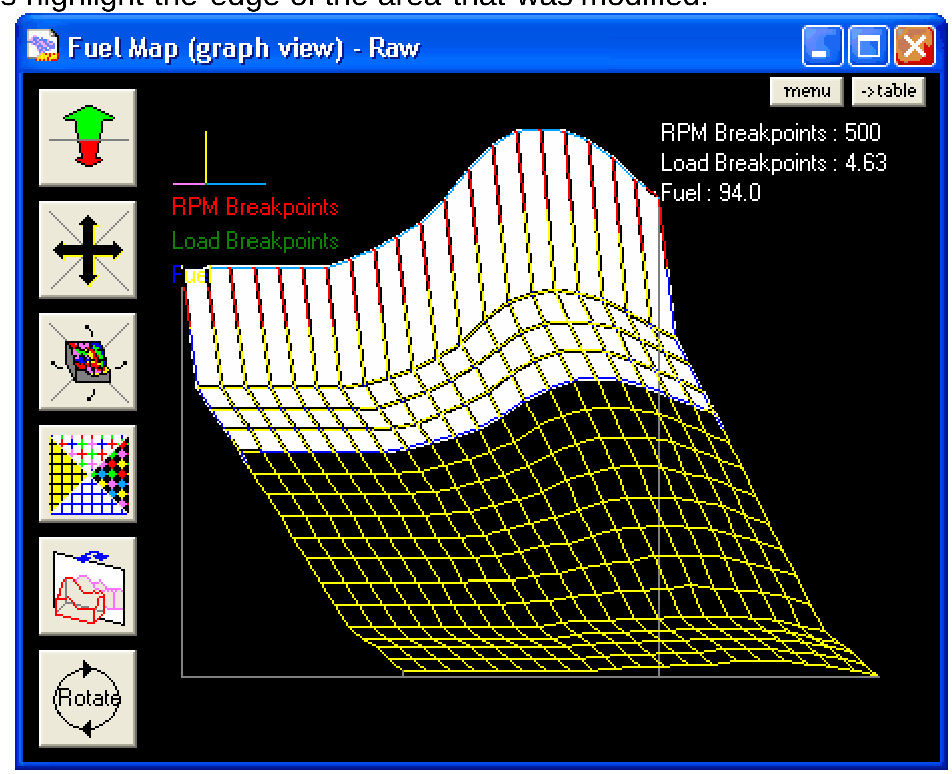
- **Function** - An edit box prompts for a function, this feature is equivalent of a calculator. The selected sites' values are then affected by the **function** to determine their new values. The **function** provided allows the use of the open and close brackets, multiply (*), divide (/), plus and minus and numbers. Any other character supplied in the equation is considered to be the value of the site that is being changed. For example, two sites are selected containing the values 0 and 2 and the function '(x * 2) + 3' is provided. The first and second sites are set to 3 and 7 respectively.
- **Set Value** - An edit box prompts for a value. The selected sites' values are all set to this value. For example if the entire map is highlighted, **Set Value** was selected, and a number of 10 was entered. The entire map would now have a new value of 10.
- **Percent change** - An edit box prompts for a value. The selected sites' values are changed by this percentage. So if you want to add 10%, then enter 110 if you enter 50, you get 50% of the value that was there. In other words you want to enter the percentage of the current site(s) you want.
- **Reset Selected States** - Sets the color change iteration to an unchanged state.
- **View Raw** - Displays table in raw values.
- **View Pulse width** - Displays table in pulse width (milliseconds).
- **View Duty cycle** - Displays table in duty cycle (%).
- **Rescale Fuel map** - Changes the value of microsec/bit to allow the highest resolution for the given map values. This can be used to obtain a greater resolution for fueling when the highest value was lower, and allows the pulse width to be widened if the resolution was too small.
- **Optimise Fuel map** - Changes the value of **Microsec/bit** to a non-linear value. This allows better resolution at the lower tables and a more coarse resolution at the higher map values. Some explanation of the option **LD0MPC** is needed to explain how this differs from the functionality of **Rescale Fuel Map**. **LD0MPC** is a fractional scaling factor applied to the 0 load line that progressively increases to 1 on the full load line. For example when **LD0MPC** is 128, the 0 load line values are halved (128 / 256) to obtain the actual fuel map value, the full load line values remain unchanged and those in between are proportionally scaled. Hence with this value, the resolution of the 0 load line fuelling is doubled. This is particularly useful when calibrating fueling for low load sites and stable idling.
- **Change Injectors/Pressure** - Changes all calibration file fuel settings when changing injector sizes or fuel pressure.

Smoothing the Map

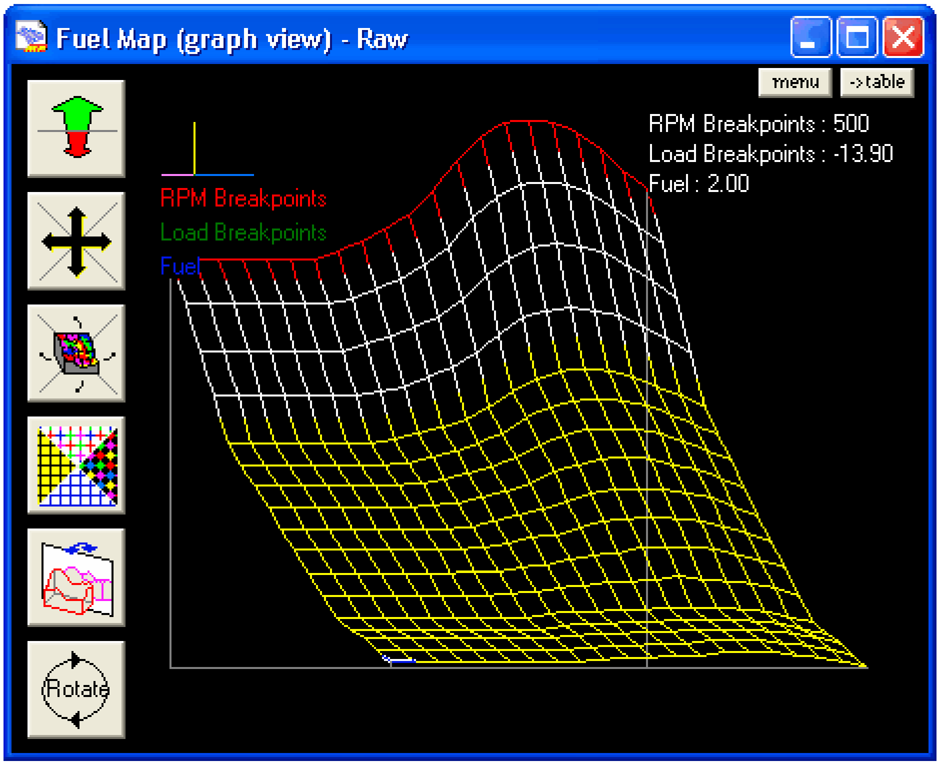
When a large area of the map has been changed, the edges of the affected area usually have to be smoothed out to prevent drivability problems.



To do this highlight the edge of the area that was modified.



Click the **Menu** button or select "**M**" on the keyboard. Choose **Calculate Columns**, because in this example, there was only a load (y-axis) dependant change. Notice the linear interpolation and also the color change which indicates the type of change performed. The colors are user definable so the tuner can create his or her own color scheme.

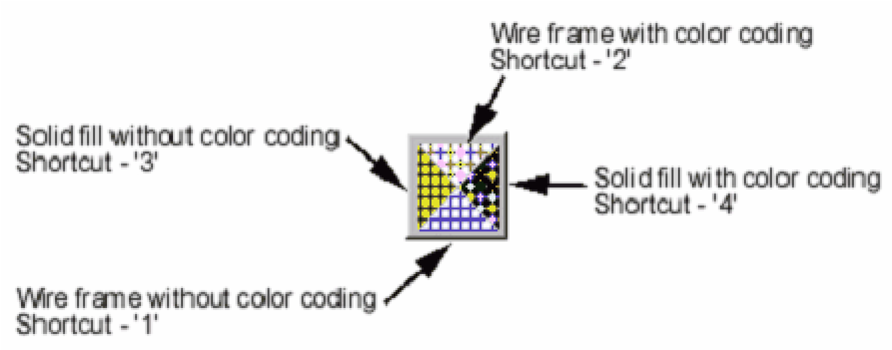


The following are shortcut keys for the **Fuel Map**.

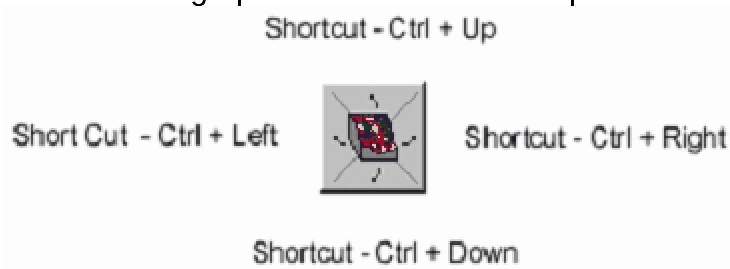
- Pressing the 'Z' key (zoom), will zoom in on the table or graph view.
- Pressing the 'S' key (swap), "swaps" between the table and graph views.
- If the **Follow ECU** box is checked, the site closest to the live location in the map is highlighted. To turn the **Follow ECU** ON or OFF, click on the **Follow ECU** box, or press the 'F' key. The **Follow ECU** box is only available for online calibrations.
- Pressing the space bar while on the table view of the fuel or ignition table freezes the cursor at the position where the space bar was pressed.
- The "+" and "-" keys allow for increase and decrease in the selected site.
- Holding the 'Ctrl' key and the "+" and "-" keys allow for 10 times increase on selected sites.
- Arrow keys allow for movement around the map.
- Pressing the 'S' key allows for swapping between the graph and table.

Graph Icons

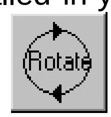
Four buttons are located on the left of the window allowing view changes to the graph.



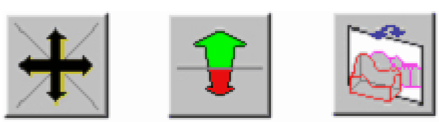
The graph is drawn in 4 different modes including wire-frame models and solid fill models both with and without color-coding. These modes are selected by clicking on the mode buttons above. The graph can be rotated in a quadrant rotation.



The graph can also be rotated in a dynamic rotation, which may be limited by the performance of the graphics card installed in your computer



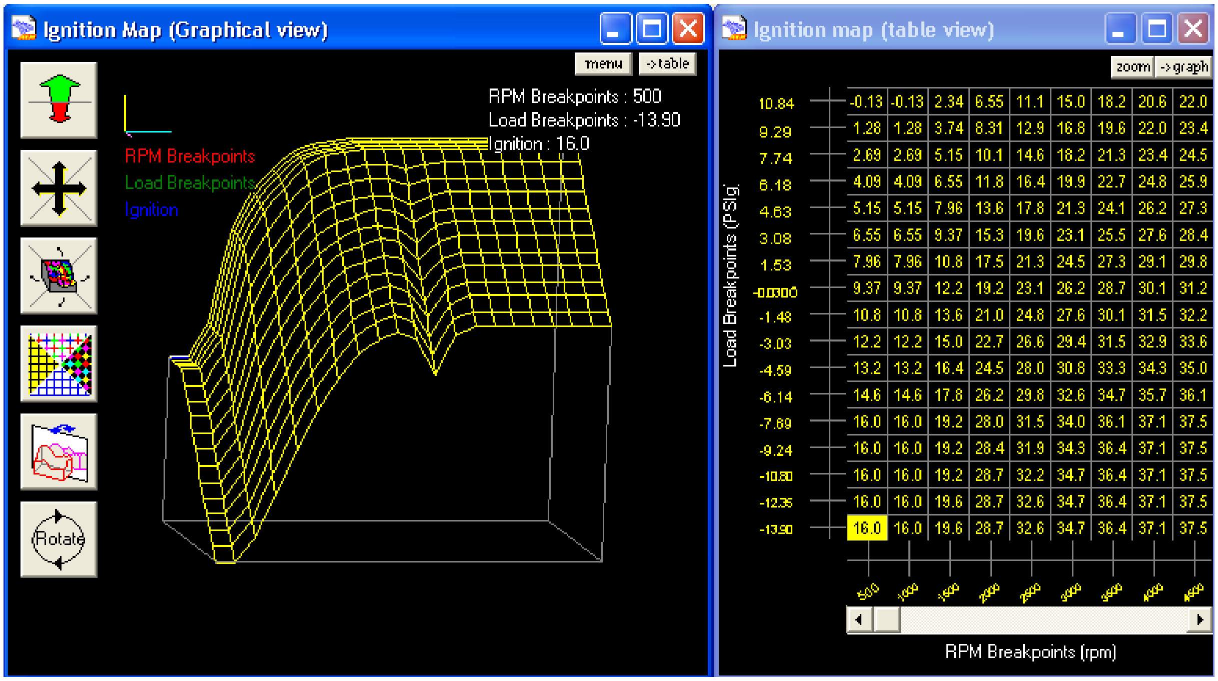
The graph can also be moved by clicking on the move button or using <Shift> + cursor key and zoomed in and out using the zoom button or 'Z' to zoom in and 'X' to zoom out. Finally the graph can be reflected with the reflect button or pressing the 'R' key.



6.4 Ignition Map

Ignition Map

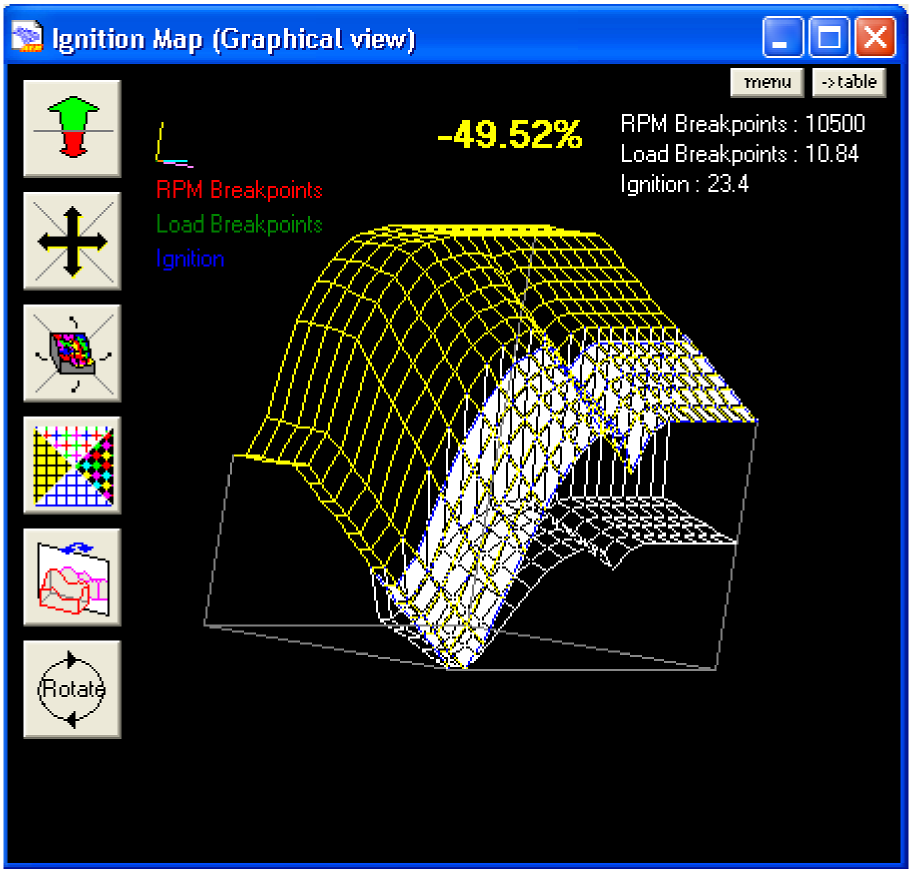
The **Ignition Map** can be viewed as a 3D graph, a table of values, or both simultaneously. The table is displayed in ignition timing advance (degrees). The manipulation of data in the **Ignition Map** is very easy to accomplish. Simply highlight the area that needs to be adjusted, right click for a drop down menu of data adjustment choices and choose the appropriate one for the task. Because this is a Windows™ based system, you can even copy and paste values of different maps from one to the other.



Highlighting the points or area to change on the 3D graph changes the **Ignition Map**. With a right click of the mouse, the data in the highlighted area can be increased or decreased by dragging the mouse up or down. When changes to the map are made, the color changes in the affected area. The color also indicates the type of change that was made.

3D Graph Data Change - Timing Increase/Decrease

When performing calibration operations, it is sometimes necessary to change a large area of the fuel map to obtain the desired ignition timing. This can be done by highlighting the area to be changed. A right click on the mouse locks the highlighted area, which can then be dragged up to add or lower the timing.



Any selected sites can be edited by right clicking on the table or pressing the **Menu** button. The function desired is then selected from the pop-up menu by selecting it with a mouse click. The functions available are:

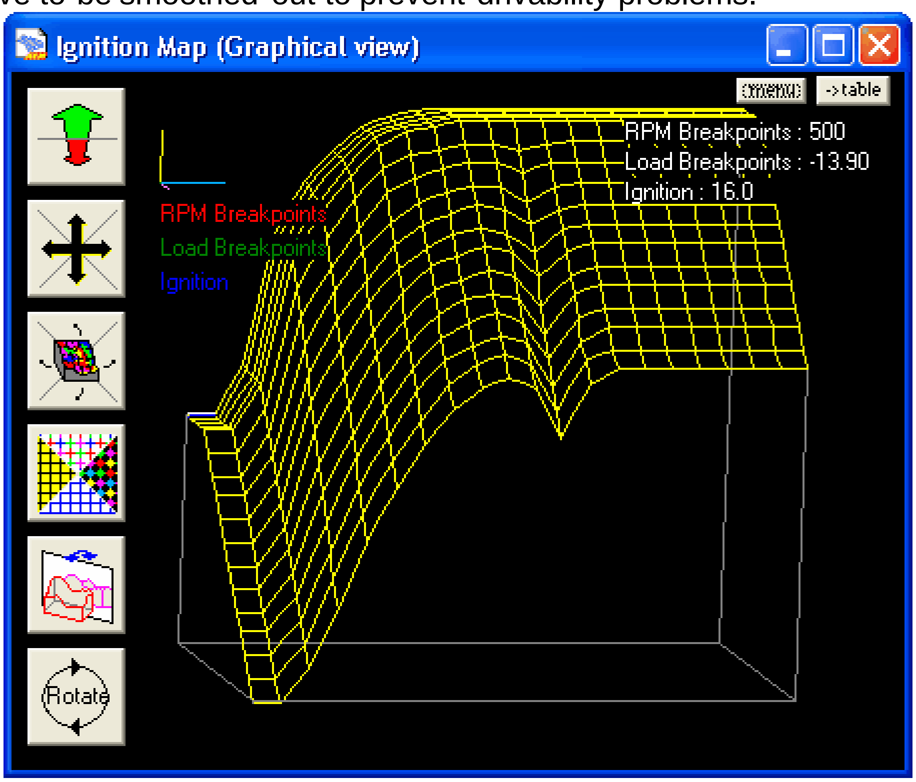
- **Copy** - The selected area is copied internally, so that a paste function can be used to "copy" the site(s).
- **Paste** - The last copy selection is pasted into the selected area. If the number of sites contained in the copy is different to the selected area, the copied sites are interpolated. For example, two sites containing 0 and 2 are copied. A group of three sites are selected and the paste command is selected. The sites are pasted with the values 0, 1 and 2.
- **Calculate** - the two values at either end of the selection highlighted are interpolated. For example, 3 sites are selected. The first and third site contain 0 and 2 respectively and the calculate command is selected. The first and third sites remain unchanged while the second site's value is set to 1.
- **Calculate Rows** - the two values at either end of the highlighted rows are interpolated.
- **Calculate Columns** - the two values at either end of the highlighted columns are interpolated.
- **Change** - An edit box prompts for a value. The selected sites' values are then changed by the supplied value. For example the value was 10, a 5 is entered in the *change* function, 15 will be the new number, if –5 was entered then 5

would be the new number.

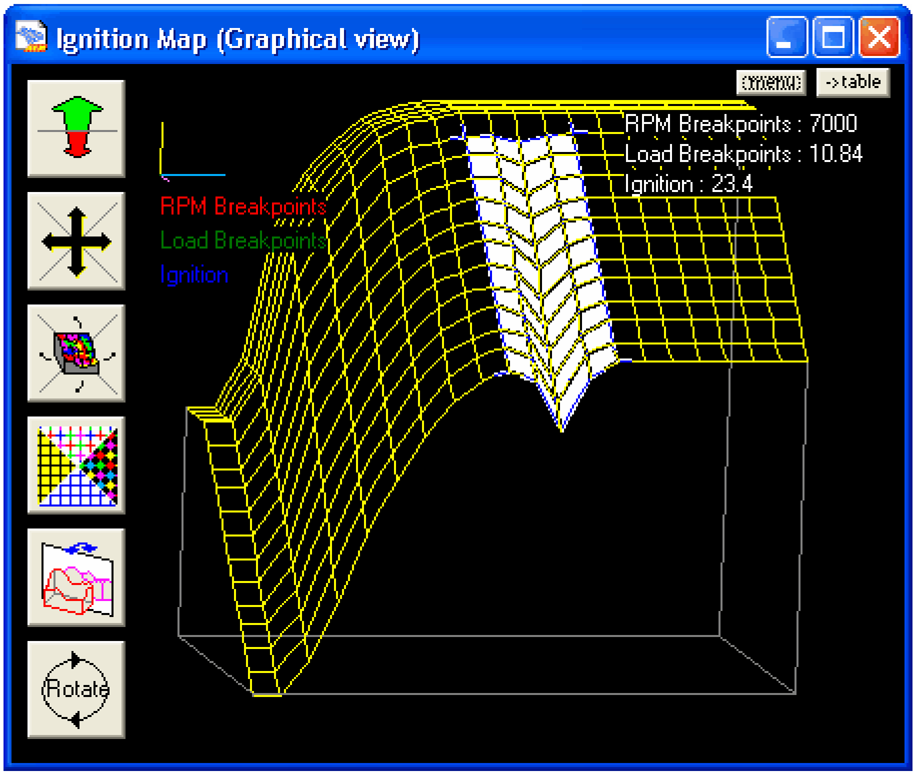
- **Function** - An edit box prompts for a function, this feature is equivalent of a calculator. The selected sites' values are then affected by the **function** to determine their new values. The **function** provided allows the use of the open and close brackets, multiply (*), divide (/), plus and minus and numbers. Any other character supplied in the equation is considered to be the value of the site that is being changed. For example, two sites are selected containing the values 0 and 2 and the function '(x * 2) + 3' is provided. The first and second sites are set to 3 and 7 respectively.
- **Set Value** - An edit box prompts for a value. The selected sites' values are all set to this value. For example if the entire map is highlighted, **Set Value** was selected, and a number of 10 was entered. The entire map would now have a new value of 10.
- **Percent change** - An edit box prompts for a value. The selected sites' values are changed by this percentage. So if you want to add 10%, then enter 110 if you enter 50, you get 50% of the value that was there. In other words you want to enter the percentage of the current site(s) you want.
- **Reset Selected States** - Sets the color change iteration to an unchanged state.

Smoothing the Map

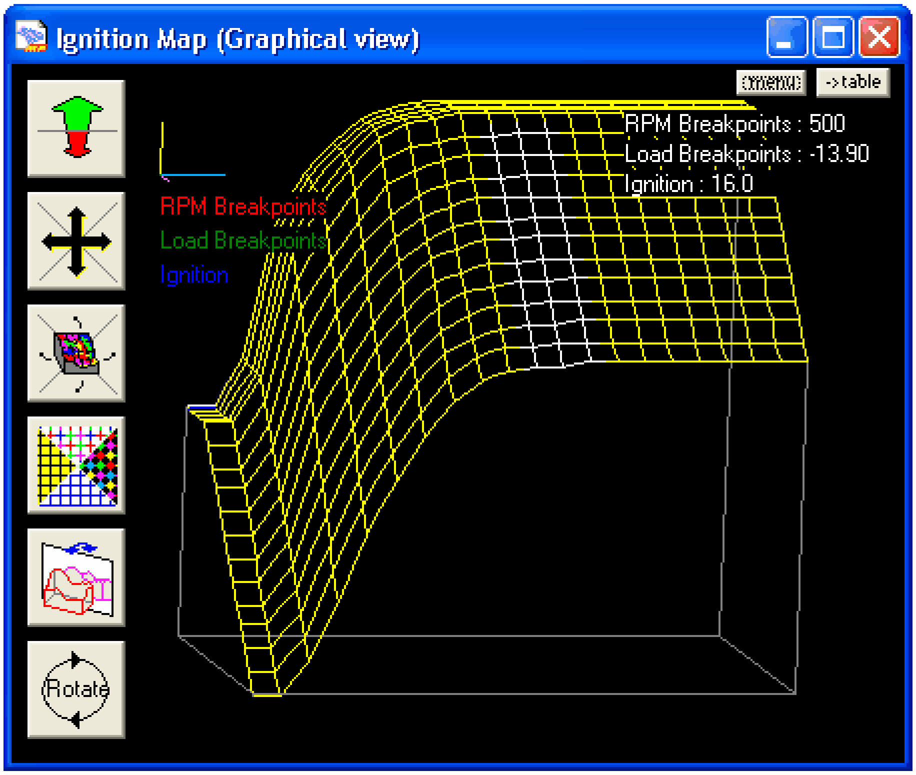
When a large area of the map has been changed, the edges of the affected area usually have to be smoothed out to prevent drivability problems.



To do this highlight the edge of the area that was modified.



Click the **Menu** button or select "**M**" on the keyboard. Choose **Calculate ROws**, because in this example, the **Engine Speed** (x-axis) neeeds to smoothed. Notice the linear interpolation and also the color change which indicates the type of change performed. The colors are user definable so the tuner can create his or her own color scheme.

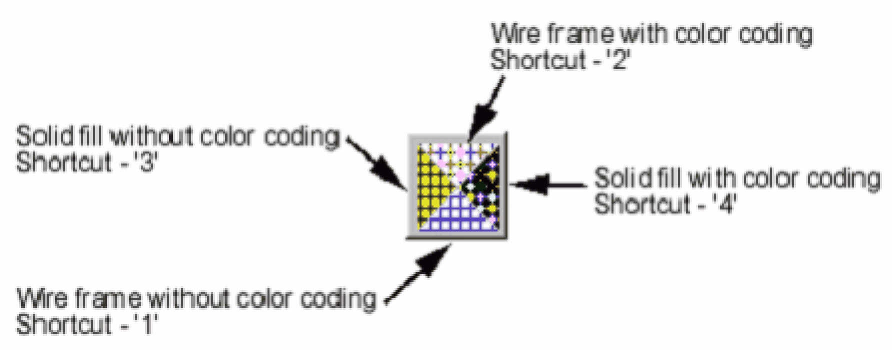


The following are shortcut keys for the **Ignition Map**.

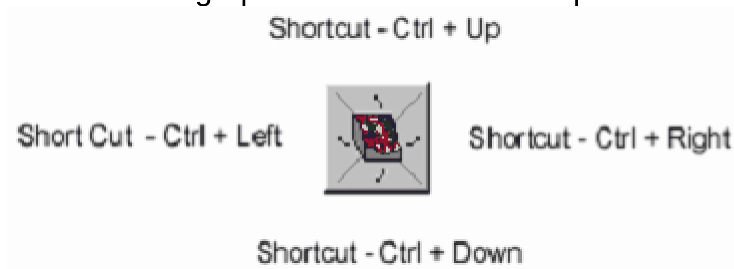
- Pressing the 'Z' key (zoom), will zoom in on the table or graph view.
- Pressing the 'S' key (swap), "swaps" between the table and graph views.
- If the **Follow ECU** box is checked, the site closest to the live location in the map is highlighted. To turn the **Follow ECU** ON or OFF, click on the **Follow ECU** box, or press the 'F' key. The **Follow ECU** box is only available for online calibrations.
- Pressing the space bar while on the table view of the fuel or ignition table freezes the cursor at the position where the space bar was pressed.
- The "+" and "-" keys allow for increase and decrease in the selected site.
- Holding the 'Ctrl' key and the "+" and "-" keys allow for 10 times increase on selected sites.
- Arrow keys allow for movement around the map.
- Pressing the 'S' key allows for swapping between the graph and table.

Graph Icons

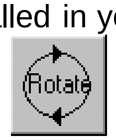
Four buttons are located on the left of the window allowing view changes to the graph.



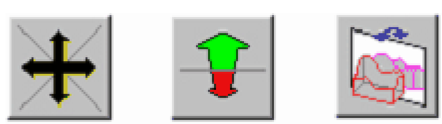
The graph is drawn in 4 different modes including wire-frame models and solid fill models both with and without color-coding. These modes are selected by clicking on the mode buttons above. The graph can be rotated in a quadrant rotation.



The graph can also be rotated in a dynamic rotation, which may be limited by the performance of the graphics card installed in your computer



The graph can also be moved by clicking on the move button or using <Shift> + cursor key and zoomed in and out using the zoom button or 'Z' to zoom in and 'X' to zoom out. Finally the graph can be reflected with the reflect button or pressing the 'R' key.



6.5 Vehicle Speed

Vehicle Speed

Setting up the vehicle speed sensor (VSS) is quite easy. Once setup, it can be logged and used for many functions including speed dependant boost control.

User Definable Options for Vehicle Speed

Speed Falling Edge

Units: On/Off

Description: Designates the falling edge of the **Speed Input** trigger signal to be a significant event, i.e. the ECU will see this as a valid VSS signal. Generally used for magnetic type sensors or logic level sensors.

Speed Rising Edge
Units: On/Off
Description: Designates the rising edge of the T3 trigger signal to be a significant event. i.e. the ECU will see this as a T3 trigger signal. Generally used for logic level sensors.

Speed H Sens Below
Units: Engine Speed
Description: Low channel sensitivity above this value. Logic level sensors (hall effect) set to 0.

Speed L Sens Above
Units: Engine Speed
Description: High channel sensitivity when below this value. Should be set below the on value (hysterisis). Logic level sensors (hall effect) set to 0

VSS Cal * 8
Units: On/Off
Description: This is the coarse adjust for the vehicle speed input. Setting this ON, increases the range of the **VSS Calibration** option.

VSS Calibration
Units: Multiplier
Description: This is the fine adjust for the vehicle speed input. Increasing this number makes the calculated vehicle speed increase. If 256 is not enough, set the option **VSS Cal * 8** to ON. This will allow more range.

VSS Filter
Units: On/Off
Description: Used to smooth the speed sensor, use as first defense.

VSS Minimum Display
Units: Vehicle Speed
Description: Minimum vehicle speed before a speed of 0 is assumed and displayed.

VSS Smooth
Units: On/Off
Description: Used to smooth the speed sensor. This is very aggressive. This should be used after **VSS Filter** but only if needed.

VSS Input
Units: User Definable Input
Description: Channel of the input for the Vehicle Speed Sensor.

Parameters (Can be viewed or logged)

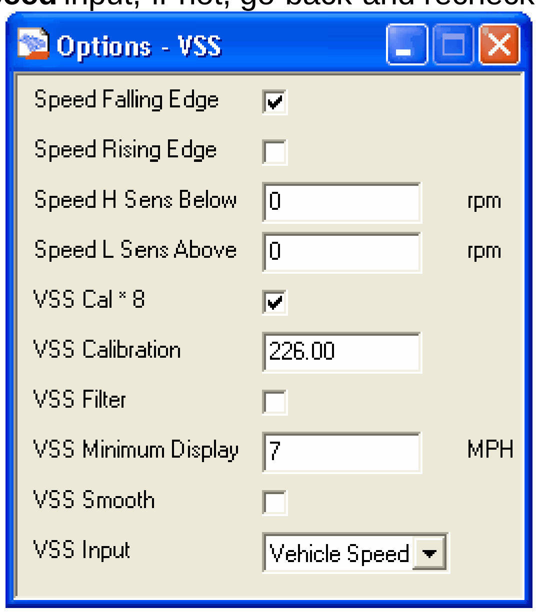
Vehicle Speed
Units: Vehicle Speed
Description: Displays the current scaled speed of the vehicle via the vehicle speed sensor.

Vehicle Speed Input
Units: On/Off
Description: Displays the current status of the vehicle speed sensor.

T3PER
Units: uS
Description: Displays the current period of the speed sensor input

Tuning the VSS

First, determine which channel the speed input is wired to. For plug n play applications, 99% of the time it will go to the **Vehicle Speed** input (also known as "Speedo" or "T3"). To confirm that it is hooked up this way, open AEMPro and connect to the ECU. With the wheel turning, you should see the **Vehicle Speed Input** parameter alternating between ON and OFF. If this is happening, the VSS is wired to the **Vehicle Speed** input, if not, go back and recheck the wiring.



The edge must now be defined. The falling edge is typically better with magnetic sensors, whereas hall effect sensors it does not matter. In the case where you are unsure of what type of sensor is being used, set **Speed Falling Edge** to ON. The EMS needs to be told that **Vehicle Speed** is the VSS. The option **VSS Input** is were you select the channel that the VSS signal can be found. Set **VSS Input** to **Vehicle Speed**.

Now, the sensor should be scaled so it reads the actual vehicle speed. Display the **Vehicle Speed** parameter and start adjusting **VSS Calibration** to scale the function.

If 256 is not enough, set **VSS Cal * 8** to ON. This will allow more adjustability.

6.6 Analog Inputs

Analog Inputs

The AEM EMS allows for configuring the analog input channels to several functions and tables throughout the software for a completely custom setup. The following chart displays the analog inputs available for selection. Note: A.D.C. stands for Analog Digital Converter.

ADCR1 (TPS Volts)
ADCR2 (MAP Volts)
ADCR3 (MAF Volts)
ADCR4 (Knock #1 Raw)
ADCR5 (Knock #2 Raw)
ADCR6 (Air Temp Volts)
ADCR7 (Coolant Temp Volts)
ADCR8 (Battery Volts)
ADCR9 (O2 #1 Volts)
ADCR10 (O2 #2 Volts)
ADCR11 (PR Press Voltage)
ADCR12 (Barometer Voltage)
ADCR13 (Gear Volts)
ADCR14 (Spare Temp Voltage)
ADCR15 (EGT #3 Voltage)
ADCR16 (EGT #4 Voltage)
ADCR17 (EGT #1 Voltage)
ADCR18 (EGT #2 Voltage)
Vehicle Speed
Engine Speed
Engine Load
MAP as Load
Throttle
MAF as Load
Injector Duty

There are several functions that can accept an analog channel as an input for configuration. For instance, there are 4 EGT analog inputs, however they can be used for any input that you may wish to monitor or correct with fuel compensation. An example would be a dash mounted fuel trim switch. You can setup a rotary switch to allow the driver to trim the fuel by up to (+/-)50%. You could also calibrate the **EGT Sensor Cal table** to be fuel pressure against voltage. This would allow a fuel compensation from an EGT input for a fuel pressure drop. Another idea is to calibrate the **EGT Sensor Cal table** to read nitrous bottle pressure and fuel can be compensated with an EGT input to take fuel away as nitrous bottle pressure drops.

These inputs can also be used with the **User #1** function to drive a duty controlled solenoid with a user specified output. The **Switch #7** function can also be used to convert an analog input to a switched input.

6.7 Acceleration Fuel

Acceleration Fuel

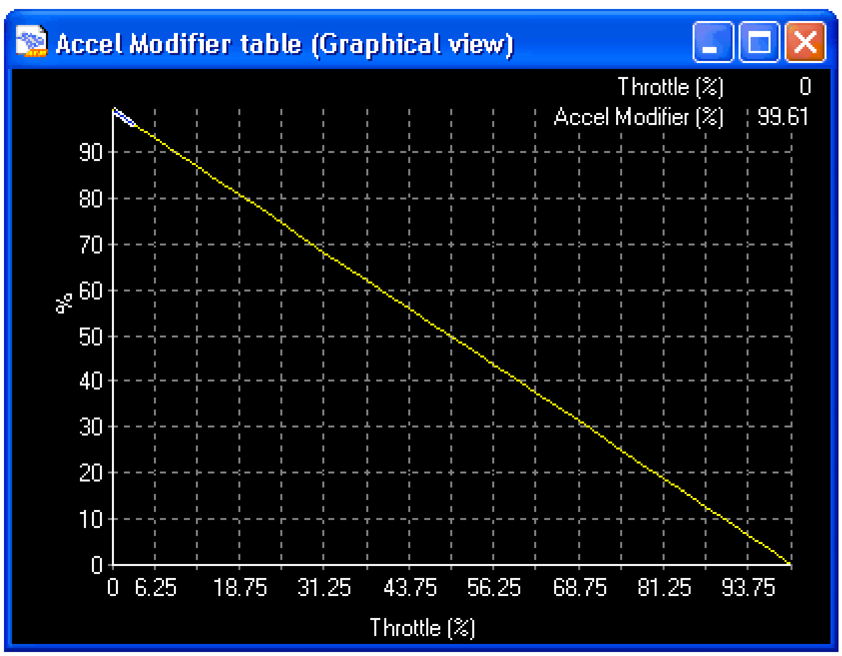
The AEM EMS has a traditional accelerator pump which consists of delta-throttle position (dTPS) and delta-load (dMAP) components. These both work on similar principles. The idea being that a rapid change of pressure in the intake system requires a change in fuel requirements, beyond that dictated by a simple air-fuel ratio calculation. The primary reason for this is the time lag for the fuel flow into the air stream at the injector and the fuel flow past the inlet valve. Chiefly, this is due to the liquid fuel that is on the intake track walls which travels much slower than the fuel vapor and small droplets of fuel being carried by the air stream. For this same reason, there is a "decel pump", which, acts opposite as the accel pump. By measuring the dTPS, you can judge how much extra fuel would be required. Alternately, if the dTPS does not give a good indication of the change in inlet pressure (huge throttle plates or a positive displacement supercharger), you may need to use dMAP directly.

2-D Tables for Accel Fuel

Accel Modifier Table

Units: Fuel Trim (Accel) Mult vs TPS

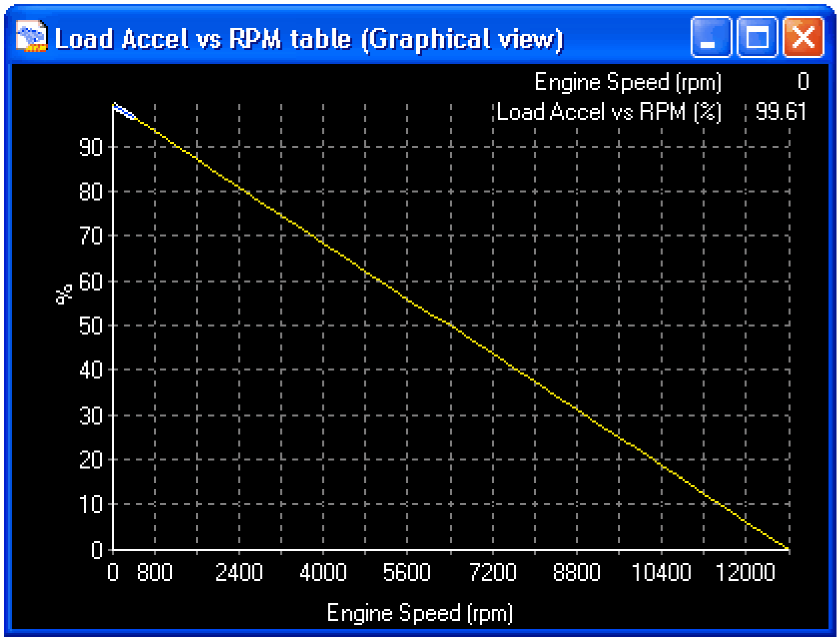
Description: Throttle dependant scalar for the dTP component of accel (and decel) fuel



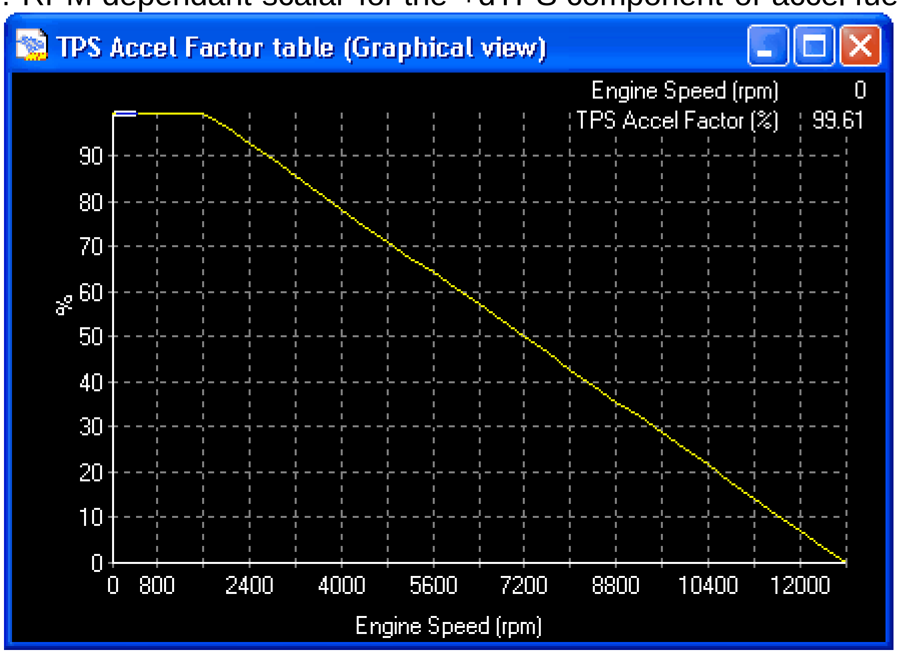
Load Accel vs RPM table

Units: Fuel Trim (Accel) Mult vs RPM

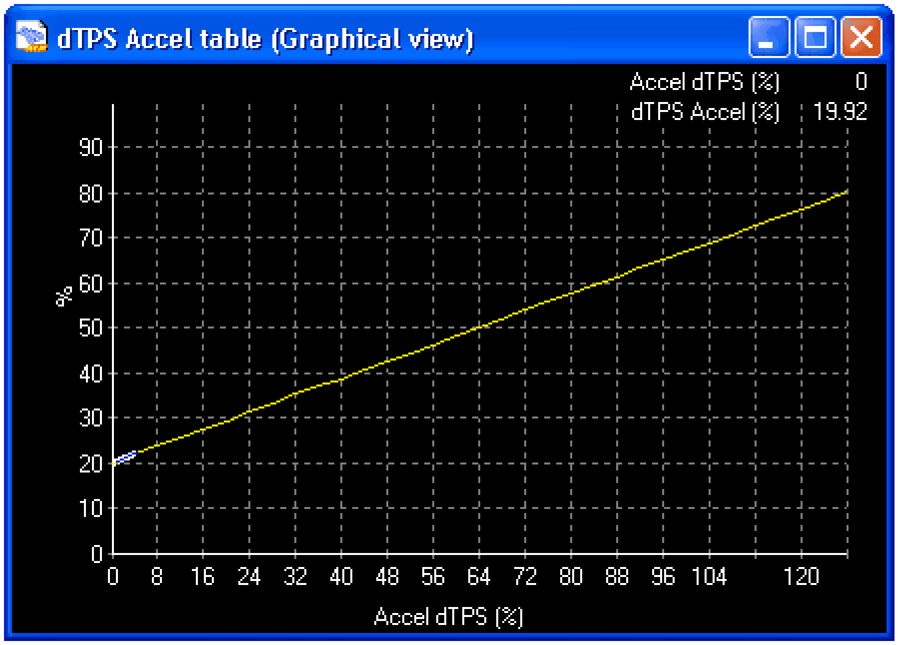
Description: RPM dependant scalar for the +load component of accel fuel.



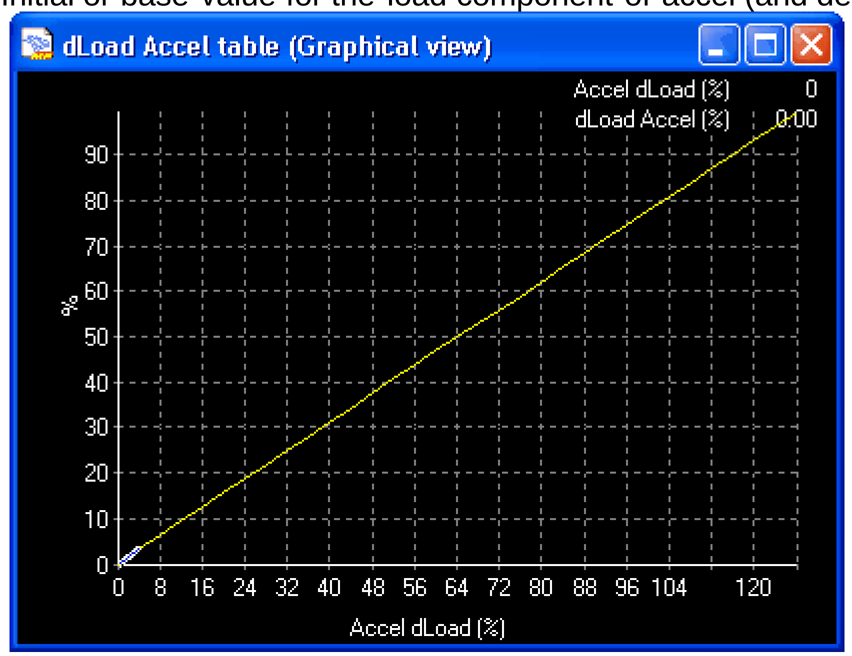
TPS Accel Factor table
Units: Fuel Trim (Accel) Mult vs RPM
Description: RPM dependant scalar for the +dTPS component of accel fuel.



dTPS Accel table
Units: Fuel Trim (Accel) vs dTP
Description: Initial or base value for the throttle component of accel (and decel) fuel.



dLoad Accel table
Units: Fuel Trim (Accel) vs dLoad
Description: Initial or base value for the load component of accel (and decel) fuel.



User Definable Options for Accel Fuel

Accel Pump Sustain
Units: %
Description: Determines the rate at which the **Fuel Trim (Accel)** goes away. Actual formula used is current **Fuel Trim (Accel)** * this number, each engine revolution. A larger number makes the **Fuel Trim (Accel)** stay longer. Typical value is 5%.

Accel Limit
Units: %
Description: Maximum **Fuel Trim (Accel)** allowed to be added. The software clamps the accel component to this value no matter how high the calculated value is.

Accel dLoad Trig
Units: %
Description: When the change in load (dLoad) exceeds this value, **Fuel Trim (Accel)** can be added. This acts as a minimum load change threshold for **Fuel Trim (Accel)**.

Accel dTPS Trigger
Units: %
Description: When the change in TPS (dTP) exceeds this value, **Fuel Trim (Accel)** can be added. This acts as a minimum TPS change threshold for **Fuel Trim (Accel)**.

Accel TP Sensitivity
Units: %
Description: Used for accel (and decel). Filters the TPS input and the effect can be viewed in **TPS Filtered**. It reduces the fault triggering for very sensitive throttle changes. A value of 0% completely kills the accel pump function. A value of 100% is essential no filter and creates a hyper/useless pump. A typical value is 75%-90%. Set this value while the engine is OFF and watching the **Accel dTPS** and **Accel dTPS Latched** parameters.

Parameters (can be viewed or logged)

Accel dTPS
Units: Throttle %
Description: The current positive (opening) delta throttle value.

Accel dTPS Latched
Units: Throttle %
Description: The latched positive delta throttle value for the current accel pump application. It saves the max Accel dTPS value so its easier to tune.

Fuel Trim (Accel)
Units: uS of Injection PW
Description: The total current size of the accel pump. Same as **Accel Fuel**.

Accel Mod
Units: Overall Multiplier of Accel Pump Size, %
Description: The current modifiers for the accel pump (temperature, throttle, RPM etc) 100% means you get the full pump size.

Accel Trigger Count
Units: Counts
Description: This is the number of times that the accel pump has been triggered. If

this increases by more than 10 at a time, change the **Accel TP Sensitivity** option.

Accel Fuel
Units: uS of Injection PW
Description: The total current size of the accel pump. Same as **Fuel Trim (Accel)**.

TPS Filtered
Units: %
Description: Derived from the **Accel TP Sensitivity** option.

Tuning Throttle Accel

The operating principle is pretty standard. When the throttle is moved, the dTP value is calculated. It gives a number proportional to the rate of change of the throttle. If this value is above the user-specified threshold **Accel dTPS Trigger** option, then the acceleration pump is enabled. But, since the TPS signal is usually noisy, the accel pump would be triggering all the time. So we need to filter it before the threshold test is performed. The filter specification can be set with the **Accel TP Sensitivity** option.

Once a dTP value is generated, the corresponding accel pump size is looked up from the **dTPS Accel table**. This table gives a % accel pump size, versus the dTP value. This % size is relative to the current injector pulsewidth (PW). So if the current PW is 1,400 uS (1.4mS) and the % value was 75%, the base accel pump size would be 75% * 1.4mS = 1.05mS.

Once a base accel pump size is generated, it is immediately multiplied by the **Accel Modifier table**. This is a TPS based table and serves to scale the output based on the throttle position when the accel pump was activated. This table usually starts at 100% and decreases to 0% at high throttle value. This yields an accel pump value that varies by throttle angle and is usually large for throttle movements near closed throttle and small for throttle movements near WOT.

Next, it is multiplied by the **TPS Accel Factor table**, which is the RPM based correction for the dTP component. This table usually starts at 100% and then decreases to a smaller value (sometimes 0%) at RPM values. This makes sense because the fuel delay is smaller at high port velocities; hence the accel pump can be smaller.

To recap what's happened, a filtered throttle position change has been detected and from this value, a base % accel pump was determined. Then it was corrected for TPS and RPM.

Now, it is checked against the user option **Accel Limit**. If it is larger than this value, then it is reset to this value. This percentage is multiplied by the current injector PW, giving a time in uS, and is applied as the starting value for the accelerator pump.

Once the pump is applied, the EMS decreases the pump size to zero, assuming there are no more accel pump actions in the meantime. This is controlled with the

Accel Pump Sustain option. On a fixed time basis, the EMS comes back, and multiplies the current value of the pump by the decay percentage, yielding the new, decayed pump. Thus, a larger value makes the pump decay slower.

Tuning Load Accel

The dLoad pump works on exactly the same principle as the dTP pump.

6.8 Deceleration Fuel

Deceleration Fuel

The AEM EMS has two completely different deceleration fuel functions that can be used in conjunction with one another for the ultimate in deceleration fuel. The two functions are deceleration fuel cut and deceleration fuel pump.

Deceleration fuel cut is the most common type of fuel solutions for deceleration because of its simplicity. The basic principle is that when above a specific RPM, but at very low throttle and load, it is safe to completely cut fuel. This helps fuel economy and reduces emissions.

User Definable Options for Decel Fuel Cut

Fuel Off Above RPM
Units: Engine Speed
Description: The engine RPM threshold for the decel fuel cut function.

Fuel Off Below Load
Units: Engine Load
Description: The load threshold for the decel fuel cut function.

Fuel Off Below TPS
Units: Throttle %
Description: The throttle position threshold for the decel fuel cut function.

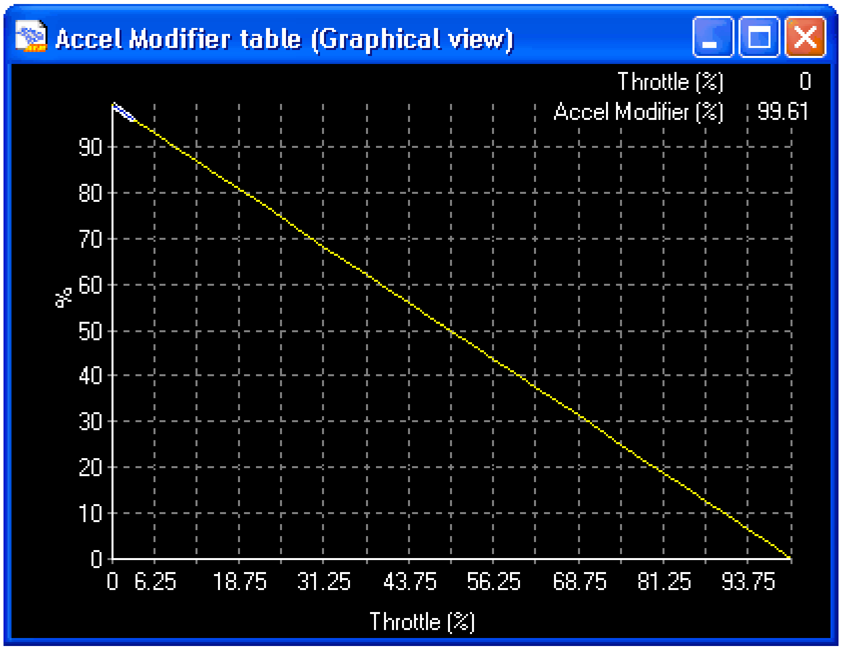
Fuel Off Coolant Mi
Units: Coolant Temperature
Description: The coolant temperature threshold for the decel fuel cut function.

The AEM EMS also has a decelerator pump which consists of delta-throttle position (dTPS) components. The idea being that a rapid change of pressure in the intake system requires a change in fuel requirements, beyond that dictated by a simple air-fuel ratio calculation. The primary reason for this is the time lag for the fuel flow into the air stream at the injector and the fuel flow past the inlet valve. Chiefly, this is due to the liquid fuel that is on the intake track walls which travels much slower than the fuel vapor and small droplets of fuel being carried by the air stream. For this same reason, there is a "accel pump", which, acts opposite as the decel pump. By measuring the dTPS, you can judge how much less fuel would be required.

2-D Tables for Decel Fuel Pump

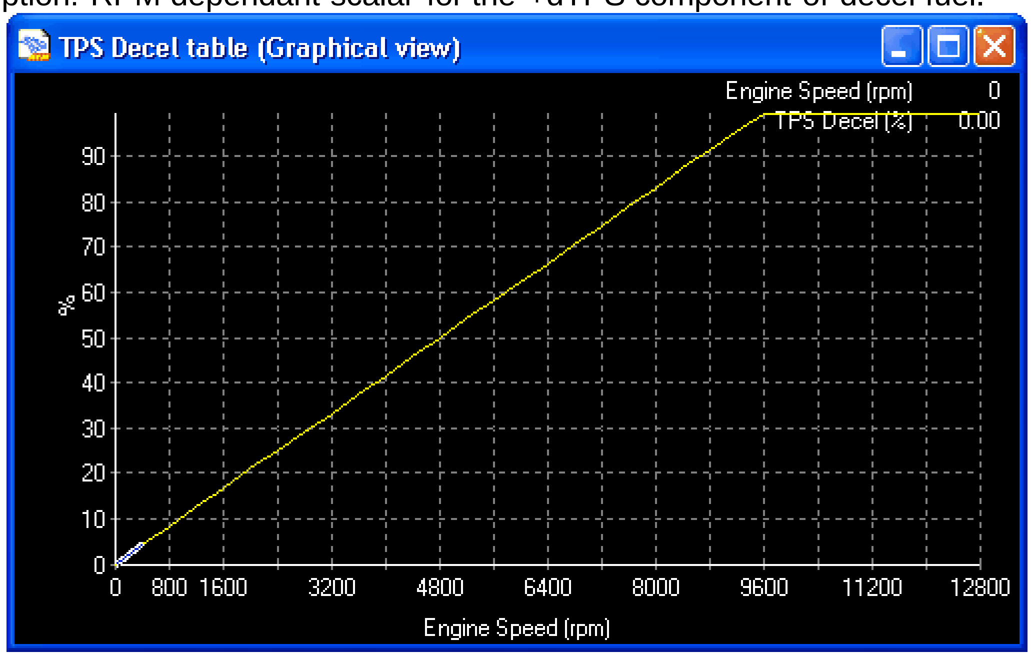
Accel Modifier Table

Units: Fuel Trim (Accel) Mult vs TPS
Description: Throttle dependant scalar for the dTP component of decel (and accel) fuel



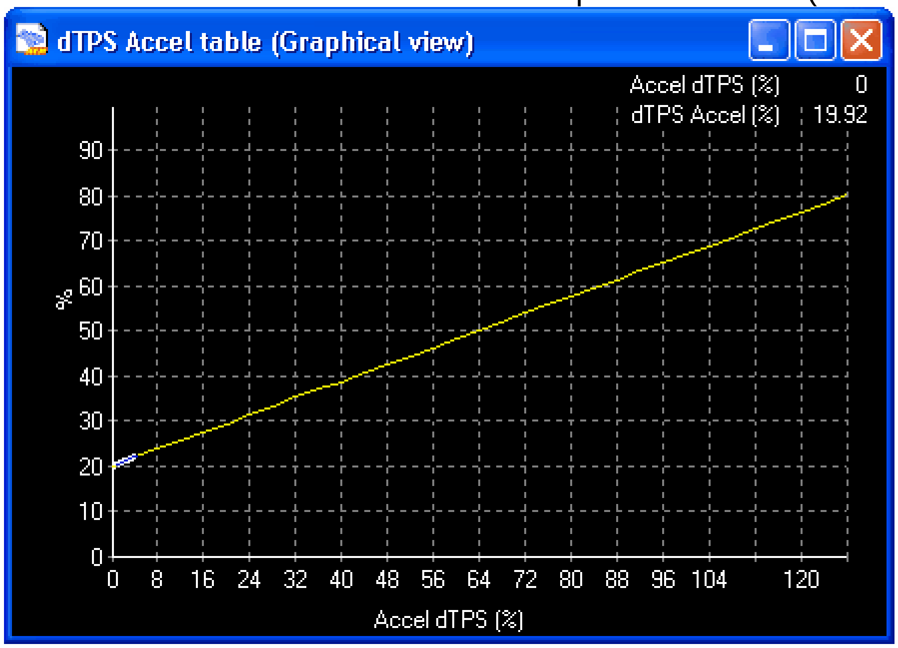
TPS Decel Factor table

Units: Fuel Trim (Accel) Mult vs RPM
Description: RPM dependant scalar for the +dTPS component of decel fuel.



dTPS Accel table

Units: Fuel Trim (Accel) vs dTP
Description: Initial or base value for the throttle component of decel (and accel) fuel.



User Definable Options for Decel Fuel Pump

Decel Decay
Units: %
Description: Determines the rate at which the **Fuel Trim (Accel)** goes away. Actual formula used is current **Fuel Trim (Accel)** * this number, each engine revolution. A larger number makes the **Fuel Trim (Accel)** stay longer. Typical value is 5%.

Accel Limit
Units: %
Description: Maximum **Fuel Trim (Accel)** allowed to be taken out. The software clamps the decel component to this value no matter how high the calculated value is.

Accel dTPS Trigger
Units: %
Description: When the change in TPS (dTP) exceeds this value, **Fuel Trim (Accel)** can be added. This acts as a minimum TPS change threshold for **Fuel Trim (Accel)**.

Accel TP Sensitivity
Units: %
Description: Used for decel (and accel). Filters the TPS input and the effect can be viewed in **TPS Filtered**. It reduces the fault triggering for very sensitive throttle changes. A value of 0% completely kills the accel/decel pump function. A value of 100% is essential no filter and creates a hyper/useless pump. A typical value is 75%-90%. Set this value while the engine is OFF and watching the **Decel dTPS** and **Decel dTPS Latched** parameters.

Parameters (can be viewed or logged)

Decel dTPS
Units: Throttle %
Description: The current positive (opening) delta throttle value.

Decel dTPS Latched
Units: Throttle %
Description: The latched positive delta throttle value for the current decel pump application. It saves the max Decel dTPS value so its easier to tune.

Fuel Trim (Accel)
Units: uS of Injection PW
Description: The total current size of the decel pump. Same as **Accel Fuel**.

Accel Trigger Count
Units: Counts
Description: This is the number of times that the accel pump has been triggered. If this increases by more than 10 at a time, change the **Accel TP Sensitivity** option.

Accel Fuel
Units: uS of Injection PW
Description: The total current size of the decel pump. Same as **Fuel Trim (Accel)**.

Accel Fuel -Max
Units: uS of Injection PW
Description: The total current size of the decel pump.

TPS Filtered
Units: %
Description: Derived from the **Accel TP Sensitivity** option.

Tuning Throttle Accel

The operating principle is pretty standard. When the throttle is moved, the dTP value is calculated. It gives a number proportional to the rate of change of the throttle. If this value is above the user-specified threshold **Accel dTPS Trigger** option, then the deceleration pump is enabled. But, since the TPS signal is usually noisy, the decel pump would be triggering all the time. So we need to filter it before the threshold test is performed. The filter specification can be set with the **Accel TP Sensitivity** option.

Once a dTP value is generated, the corresponding accel pump size is looked up from the **dTPS Accel table**. This table gives a % decel pump size, versus the dTP value. This % size is relative to the current injector pulsewidth (PW). So if the current PW is 1,400 uS (1.4mS) and the % value was 75%, the base accel pump size would be 75% * 1.4mS = 1.05mS.

Once a base accel pump size is generated, it is immediately multiplied by the **Accel**

Modifier table. This is a TPS based table and serves to scale the output based on the throttle position when the decel pump was activated. This table usually starts at 100% and decreases to 0% at high throttle value. This yields an decel pump value that varies by throttle angle and is usually large for throttle movements near closed throttle and small for throttle movements near WOT.

Next, it is multiplied by the **TPS Decel Factor table**, which is the RPM based correction for the dTP component. This table usually starts at 0% and then increases to a larger value (sometimes 100%) at RPM values. This makes sense because the fuel delay is smaller at high port velocities; hence the decel pump can be larger.

To recap what's happened, a filtered throttle position change has been detected and from this value, a base % decel pump was determined. Then it was corrected for TPS and RPM.

Now, it is checked against the user option **Accel Limit**. If it is larger than this value, then it is reset to this value. This percentage is multiplied by the current injector PW, giving a time in uS, and is applied as the starting value for the decelerator pump.

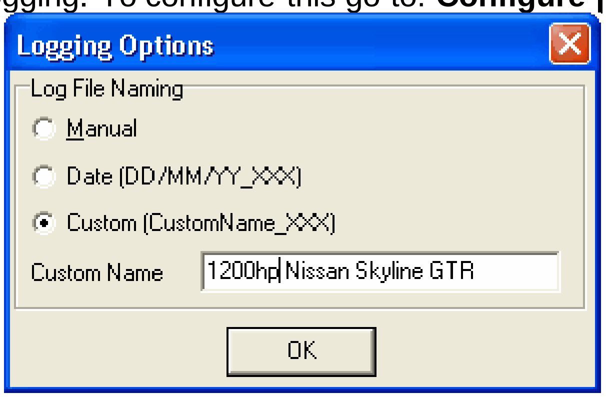
Once the pump is applied, the EMS increases the pump size to zero, assuming there are no more decel pump actions in the meantime. This is controlled with the **Decel Decay** option. On a fixed time basis, the EMS comes back, and multiplies the current value of the pump by the decay percentage, yielding the new, decayed pump. Thus, a larger value makes the pump decay slower.

6.9 Datalogging

Datalogging

The AEM EMS allows the user to collect data while the motor is running. This a very useful tool when tuning or trying to diagnose problems.

The AEM EMS has an auto naming function that helps save time in automatically naming the files for logging. To configure this go to: **Configure | Logging Options...**



The **Manual** method allows a different name to be saved on each logging event. The

Date method allows data logs to be saved by the date with each download incrementing by _001, _002, etc. The **Custom** method allows a specific name to be saved. Once it is entered, each download will be incremented by _001, _002, etc. Also, if the name is typed over, the new name automatically becomes the new default for the **Custom Name**.

It is important to note that the EMS hase 2 different options available to data log, i.e.: PC Logging and Internal Logging.

PC Logging

PC logging, or sometimes called external logging, allows the user to collect data directly onto the PC. This is very useful for tuning the car or diagnosing problems. With this option, the PC must be connected to the EMS.

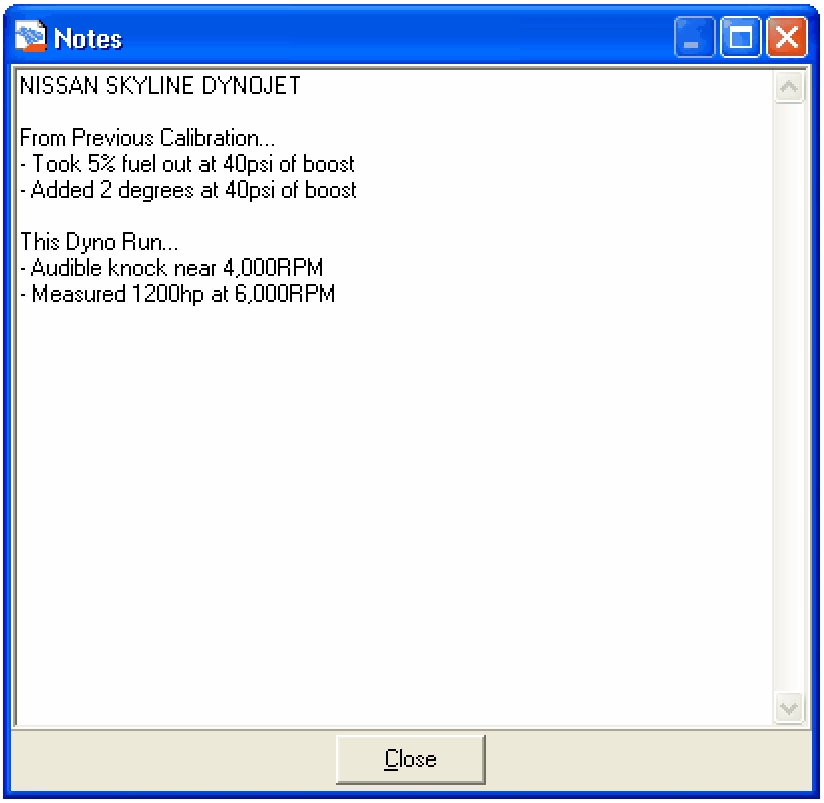
With AEMPro running, open any **Parameter** window. The parameter window tells the EMS what information will be logged to the PC. The main menu has several sets of parameters set up by AEM for typical datalogs. Note: if no parameter window is displayed, no information will be logged. If more than one parameter window is open, the active window will be logged.

Unlock the **Parameter** window. The **Locked** button, located in the upper left corner of the parameter window, prevents the user from accidentally changing a parameter. Note: to change or add any parameters, the lock button must be changed to read **Unlocked**. This is achieved by clicking on the bar with the mouse and adding the desired parameters to be logged.

Right click on each parameter and set the desired **Update rate**. The PC always logs the parameters as fast as possible. If there are numerous parameters being logged, then you can prioritize which ones are faster, and which ones are slower. For example, if 16 channels are being logged, then the PC will log each channel at the same fastest possible rate. If you wish to assign some channels slower, and some channels faster, then the pc will prioritize its speed ability accordingly. Note: the more parameters that are set to **(0) fastest**, the more memory the PC will need in order to keep up. Next, go to: **Logging | Start** (or just press the shortcut key F6). This will begin the data logging process.

Saving the PC Datalog

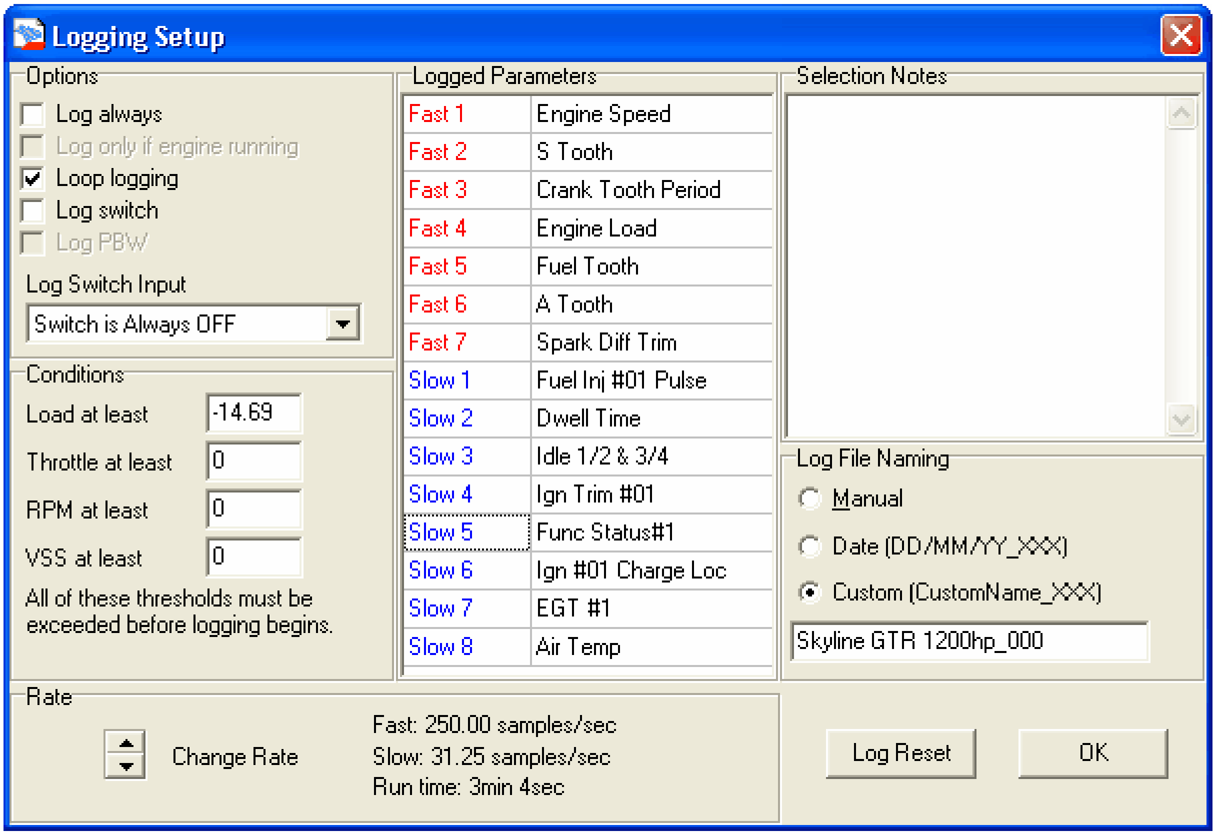
Once you have completed the amount of data you wish to record, go back to: **Logging | Stop and save...** (or press F6 again). This will bring up a dialog box that will prompt you to name the data file. Be sure to select a descriptive name so you will be able to find the data later. An optional **Notes** window will appear, you can type in any notes you wish to save with the data file.



Once the **Save** function is completed, go into the **AEMLog** software to view the data recorded. See the **AEMLog Users Manual** (located in **C:\Program Files\AEM**) to get full details on using AEMLog.

Internal Logging

The AEM EMS internal data logging memory is 512k and varies in time duration dependant upon the logging sample rate, and channels selected. To setup the internal data logging, first go to: **Setup | Internal logging**. There are 7 fast channels featuring recording rates of up to 250 times per second, and 8 slow channels. The log rate is displayed for the fast and slow channels separately, as well as the time duration that the log rate will allow.



User Definable Options for PC Logging

Log Always

Units: On/Off

Description: This allows the internal log memory to be written to any time there is switched power to the EMS. Typically this is not used.

Log only if Engine running

Units: On/Off

Description: This function is now controlled by the **Conditions** parameters.

Loop Logging

Units: On/Off

Description: This allows the datalog to continually write over itself in a loop, keeping the most current data in memory.

Log Switch

Units: On/Off

Description: This allows information to be written to the log memory only when a switch is active.

Conditions

This function allows the user to choose a set of conditions when the logger will start recording.

Log Load
Units: Engine Load
Description: The engine load must exceed this value to activate logging.

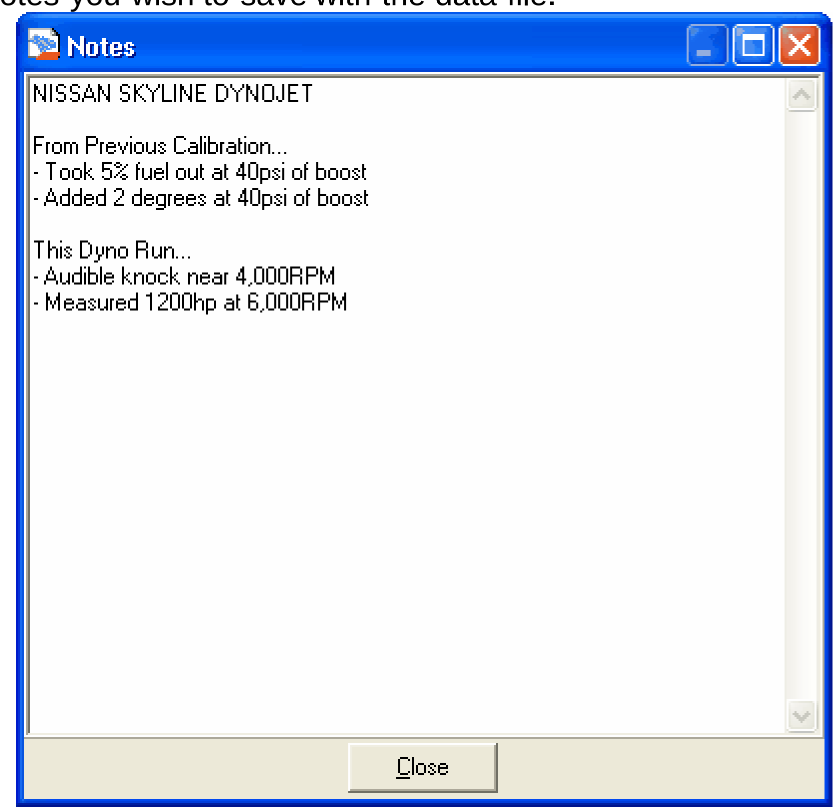
Log Throttle
Units: %
Description: The throttle position must exceed this value to activate logging.

Log Speed
Units: Engine Speed
Description: The engine speed must exceed this value to activate logging.

Log VSS
Units: Vehicle Speed
Description: The vehicle speed must exceed this value to activate logging.

Saving the Internal Datalog

Once you have completed the amount of data you wish to record, connect the PC to the EMS. Go to: **ECU | Download log data...** After the download process, a dialog box will prompt you to name the data file. Be sure to select a descriptive name so you will be able to find the data later. An optional **Notes** window will appear, you can type in any notes you wish to save with the data file.



Once the **Save** function is completed, go into the **AEMLog** software to view the data recorded. See the **AEMLog Users Manual** (located in **C:\Program Files\AEM**) to get full details on using AEMLog.

7 Advanced Tuning

7.1 Boost Control

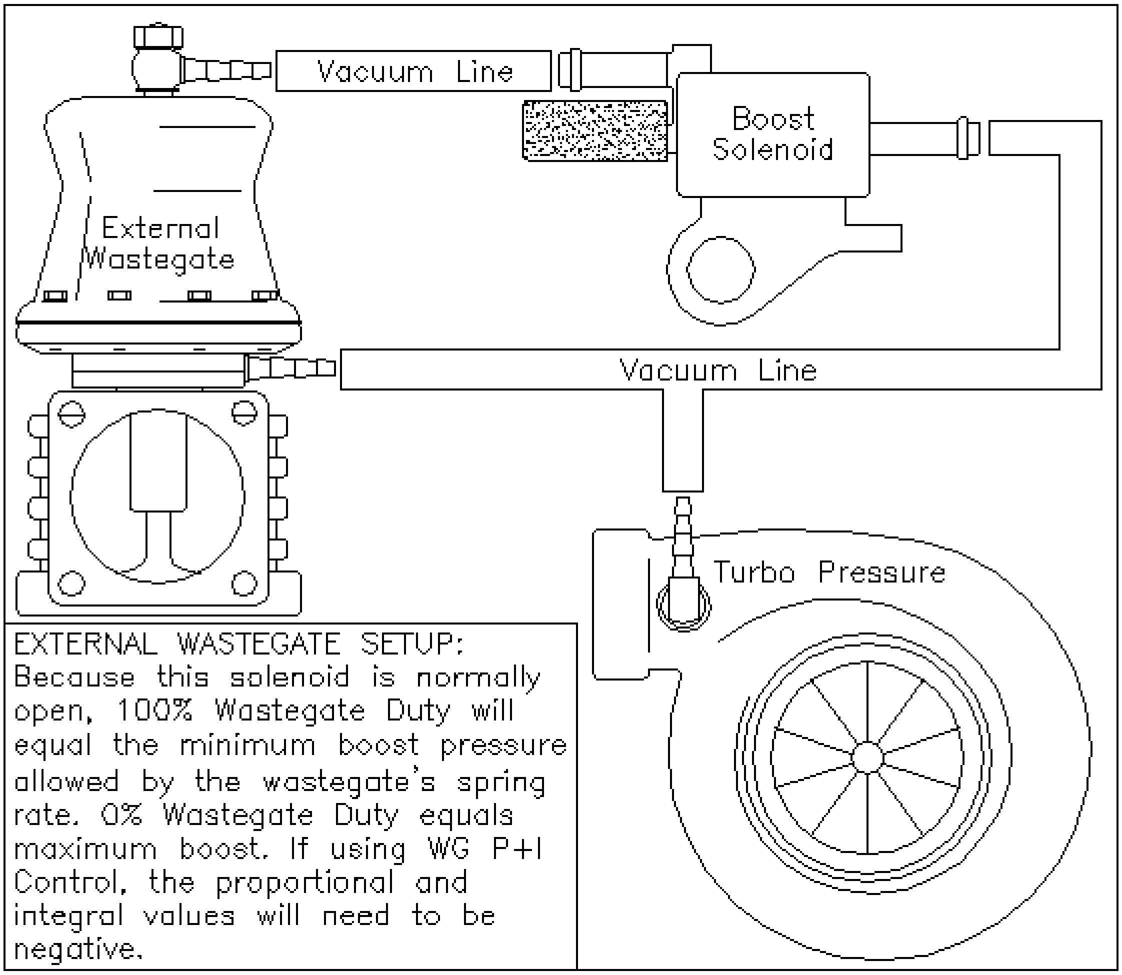
Boost Control

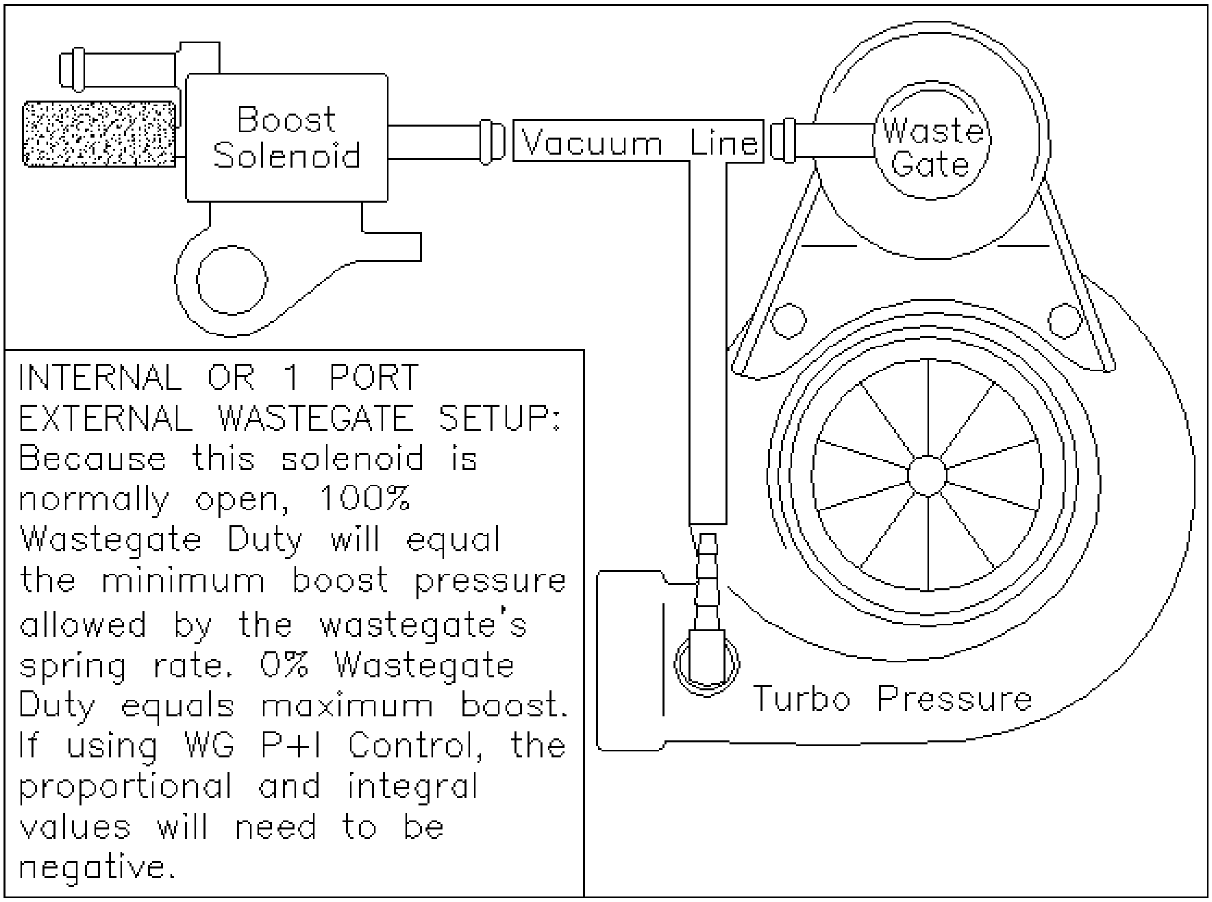
The AEM EMS has a very comprehensive and flexible boost control circuit. Using a pulse width actuated solenoid, boost can be controlled by vehicle speed, throttle position against rpm, and a switch input for low and high settings. At this time, AEM recommends the 3-way GM solenoid (PN 1997152).

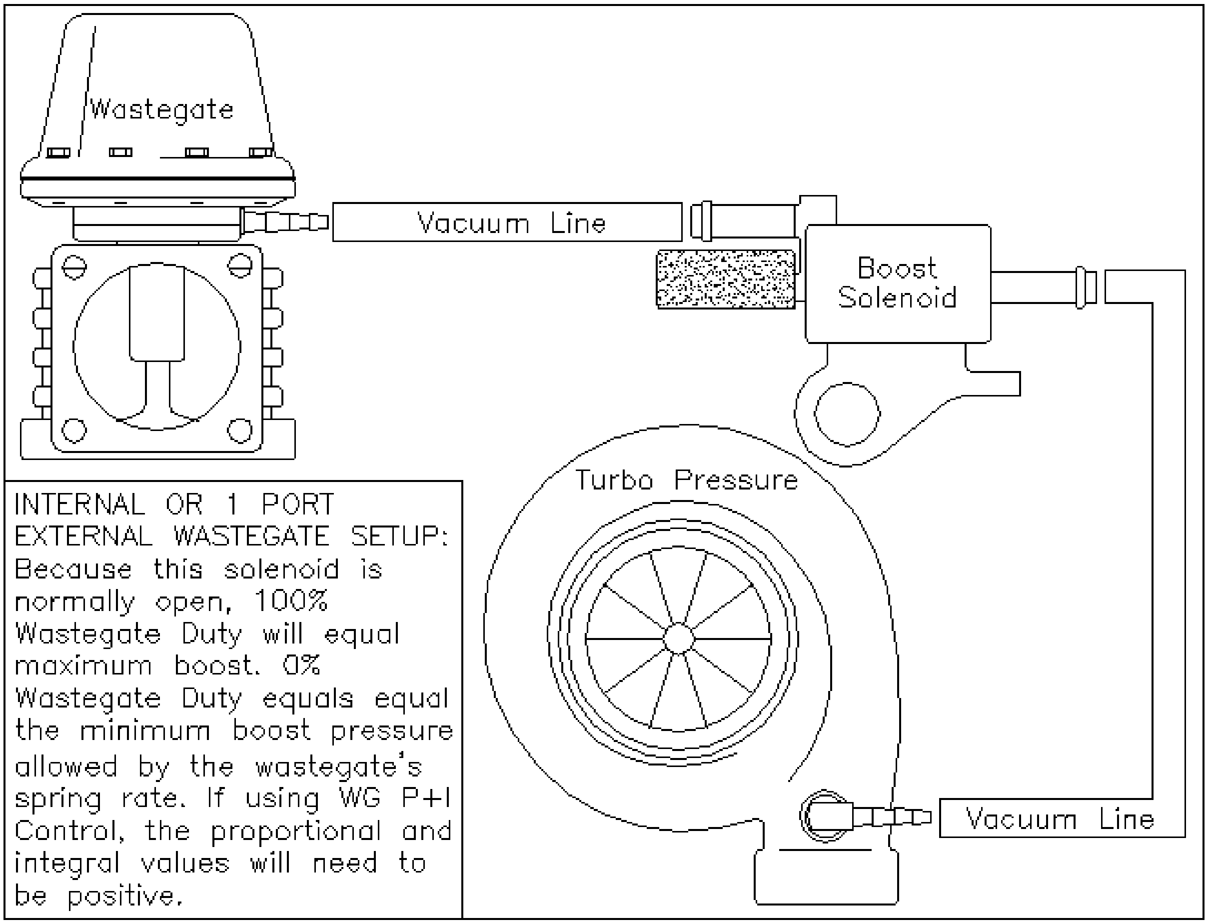
The first thing to do is determine what frequency at which the solenoid needs to be operated. This information is typically provided by the manufacturer of the part. If you are using a plug n' play with a factory boost control solenoid, this comes pre-configured by AEM.

The PW# 2 output pin needs to be determined when installing a boost solenoid. Refer to the Application Notes for the pinouts of the specific EMS used. This information can also be found on the AEM EMS forum (www.aempower.com). There are two wire connections for a boost solenoid and there is no polarity. One wire connects to 12 volt switched power and the other will connect to the PW #2 output on the EMS.

The specific wastegate type that will be used will also need to be determined when installing the boost solenoid. Illustrated below are typical ways of routing the boost (vacuum) lines with three different wastegate types.


Vacuum Line
Boost Solenoid
External Wastegate
Vacuum Line
Turbo Pressure
EXTERNAL WASTEGATE SETUP:
Because this solenoid is normally open, 100% Wastegate Duty will equal the minimum boost pressure allowed by the wastegate's spring rate. 0% Wastegate Duty equals maximum boost. If using WG P+I Control, the proportional and integral values will need to be negative.


Boost Solenoid
Vacuum Line
Waste Gate
Turbo Pressure
INTERNAL OR 1 PORT EXTERNAL WASTEGATE SETUP: Because this solenoid is normally open, 100% Wastegate Duty will equal the minimum boost pressure allowed by the wastegate's spring rate. 0% Wastegate Duty equals maximum boost. If using WG P+I Control, the proportional and integral values will need to be negative.



User Definable Options for Boost Control

Boost Duty Maximum

Units: % Duty Cycle

Description: Wastegate feedback maximum range. This sets the maximum allowable duty output to the boost control solenoid, preventing overdrive of the solenoid. Allows a narrow range of operation for precise boost control. Because certain solenoids will not function efficiently at specific duty cycles, manufacturers require limitations to be set.

Boost Duty Minimum

Units: % Duty Cycle

Description: Wastegate feedback minimum range. This sets the minimum allowable duty output to the boost control solenoid, preventing overdrive of the solenoid. Allows a narrow range of operation for precise boost control. Because certain solenoids will not function efficiently at specific duty cycles, manufacturers require limitations to be set.

Boost FB +Limit

Units: % Duty Cycle

Description: Sets the maximum feedback correction allowed in the positive duty direction when using P+I control only. Used to set correction limits and help stabilize boost. This function can help prevent overshooting.

Boost FB -Limit
Units: % Duty Cycle
Description: Sets the maximum feedback correction allowed in the negative duty direction when using P+I control only. Used to set correction limits and help stabilize boost. This function can help prevent overshooting.

Boost FB Int Gain
Units: Time Constant
Description: Integral control is implemented through the introduction of an integrator. Integral control is used to provide the required accuracy for the control system. This is used to fine tune the boost control at the target boost once the proportional has acted in getting close to the target. Note: start tuning the boost control feedback with this option at zero, until the proportional has the boost close to the target, then step this in slowly until the target boost is achieved. This value should be a negative value. When the **Boost FB On Error Control** is OFF, proportional and integral control is applicable.

Boost FB On Error
Units: On/Off
Description: Activates the **Boost Error Duty table**. Note: Both boost error control and proportional and integral control can be used at the same time for extremely fine control, this must be set up carefully or the two feedback circuits can fight each other. Enables closed loop boost control feedback to be controlled by the **Boost Error Duty table**.

Boost FB On P+I
Units: On/Off
Description: Switching this ON enables the proportional (P) and integral (I) feedback control logic for boost control. When this is OFF, the **Boost Error Duty Table** may be used to control boost. When **Boost FB On Error** is OFF and the **Boost Error Duty table** is not used, proportional and integral control is applicable.

Boost FB Pro Gain
Units: Gain Multiplier
Description: Proportional control is a pure gain adjustment acting on the error signal to provide the driving input. It is used to adjust the speed of the system and reach the target boost quickly. The advantage of a proportional-only control is its simplicity. If boost offsets can be tolerated, the use of a proportional controller may be optimal. However, it will not eliminate the steady-state error that occurs after a set-point change or a sustained load disturbance. Note: When tuning the boost control and overshoot occurs, lower this value. If undershooting the target boost, raise this value. This value should be a negative value. When the **Boost FB On Error Control** is OFF and the **Boost Error Duty table** is not used, proportional and integral control is applicable.

Boost FB VSS
Units: On/Off
Description: Activates the **Boost Target Speed Table**. Boost control becomes vehicle speed dependant and can be used as a traction control-type function. By default, the boost target is associated with the **Boost Target RPM-TH map**. This function is used to enable boost pressure to be vehicle speed based opposed to TPS and RPM dependant.

Boost from Load
Units: On/Off
Description: Determines if the boost control target is based on the load value or the MAP value. On MAF sensor equipped vehicles, engine load is produced from the mass airflow sensor opposed to a pressure sensor (MAP). Switch this function ON if controlling boost from a MAF sensor. Switch this function OFF if targeting boost control from a MAP sensor. If a MAF sensor is not used and/or not running boost, turn this function OFF.

Boost Switch Input
Units: Switch Input
Description: Optional alternative boost level controlled from a switch input. The new target should be set in the **Boost Switch Target** option. Used to enable both high and low boost settings via a flip of a switch.

Boost Switch Target
Units: Engine Load
Description: This new boost target activates when using the **Boost Switch Input** option. Used to enable both high and low boost settings via a flip of a switch.

Boost W/G Frequency
Units: Hz
Description: Specific frequency for the pulsewidth boost solenoid. If the boost solenoid is excessively noisy and/or slow to respond, the frequency should be changed. Note: Most boost solenoids make some noise.

Boost W/G Invert
Units: On/Off
Description: Inverts the PW #2 output signal. This option is based on tuner preference. Generally used when the wastgate type or solenoid is wired in such a way that low duty cycles equate to high boost and high duty cycles equate to low boost. When ON, this algorithm will be opposite.

Boost W/G Output
Units: On/Off
Description: Enables the wastegate (PW #2) output. Once ON, the wastegate solenoid operates according to the duty tables without feedback unless **Boost WG Feedback** is also ON.

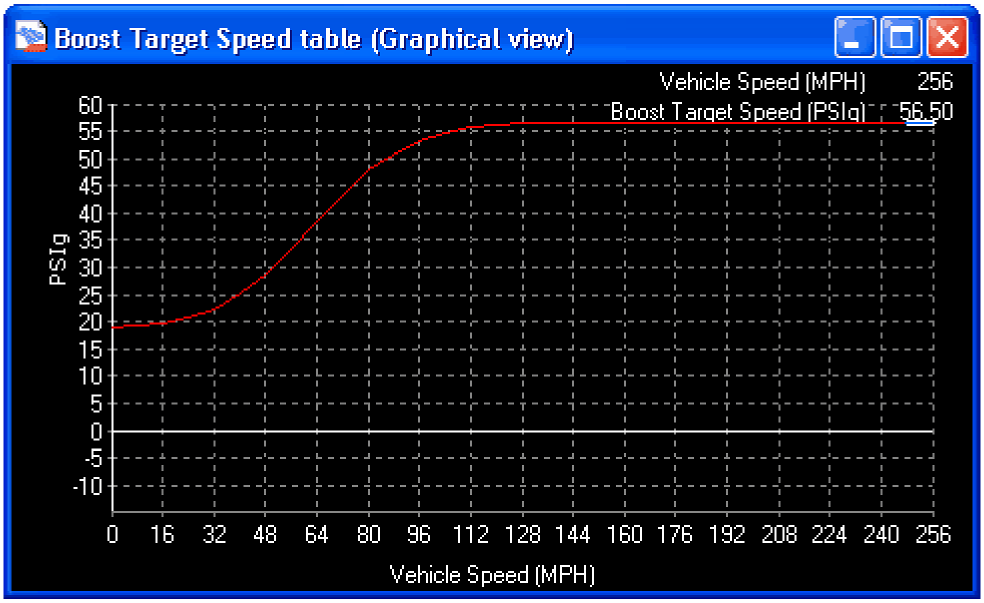
Boost WG Feedback
Units: On/Off
Description: Enables wastegate feedback. Once ON, the **Boost Error Duty Table** or **Boost FB On P+I** can be active to modify the duty cycle based on the target boost. Allows closed loop boost control feedback.

Boost/Idle PW TPS
Units: Throttle %
Description: The EMS has one frequency generator and two pulse width outputs (PW#1 and PW#2) that can operate at different frequencies. This option sets a throttle based switch point for the internal frequency generator. When below this throttle position, the EMS will be controlling idle at the frequency specified in the **Idle PW Frequency** option. When above this throttle position, the EMS will be controlling boost at the frequency specified in the **Boost W/G Frequency** option. If not using the boost control function, set this to 100%. If not using an IAC motor, set this to 0%. A typical value is 25% when using a pulse width idle motor and a boost solenoid.

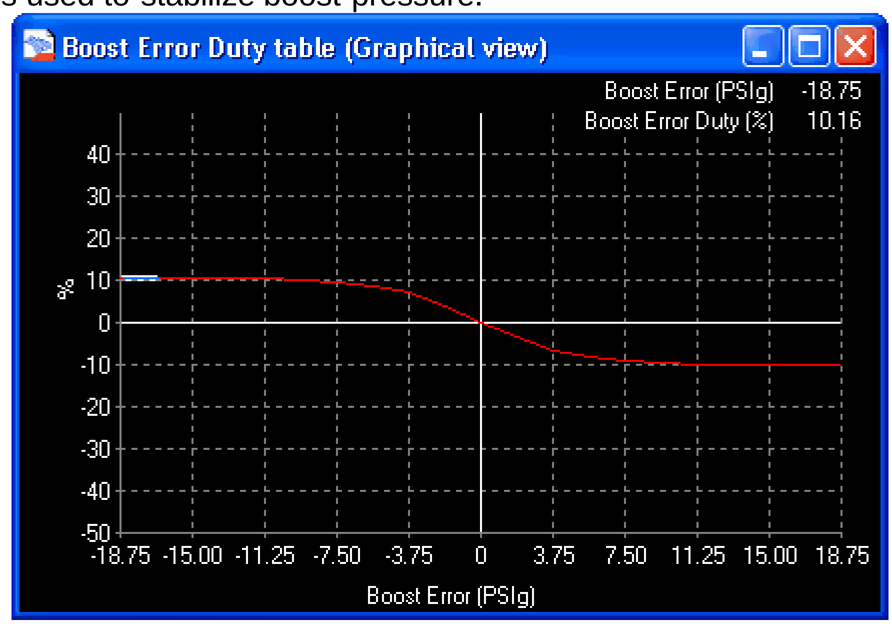
Fuel Cut Load
Units: Engine Load
Description: Boost fuel cut that when over the engine load specified, 100% fuel is cut. To keep the engine from overboosting.

2-D Tables for Boost Control

Boost Target Speed table
Units: Boost Target vs. Vehicle Speed
Description: Vehicle speed dependant boost control. Setting the boost values lower at lower vehicle speeds will help traction challenged vehicles achieve traction sooner. This table becomes active when both the **Boost FB VSS** and **Boost WG Feedback** options are ON. Note: When the Boost Switch input is being used, this table is over ridden by the **Boost Switch Target**. This table is used as a traction control device by adjusting the boost target from vehicle speed.

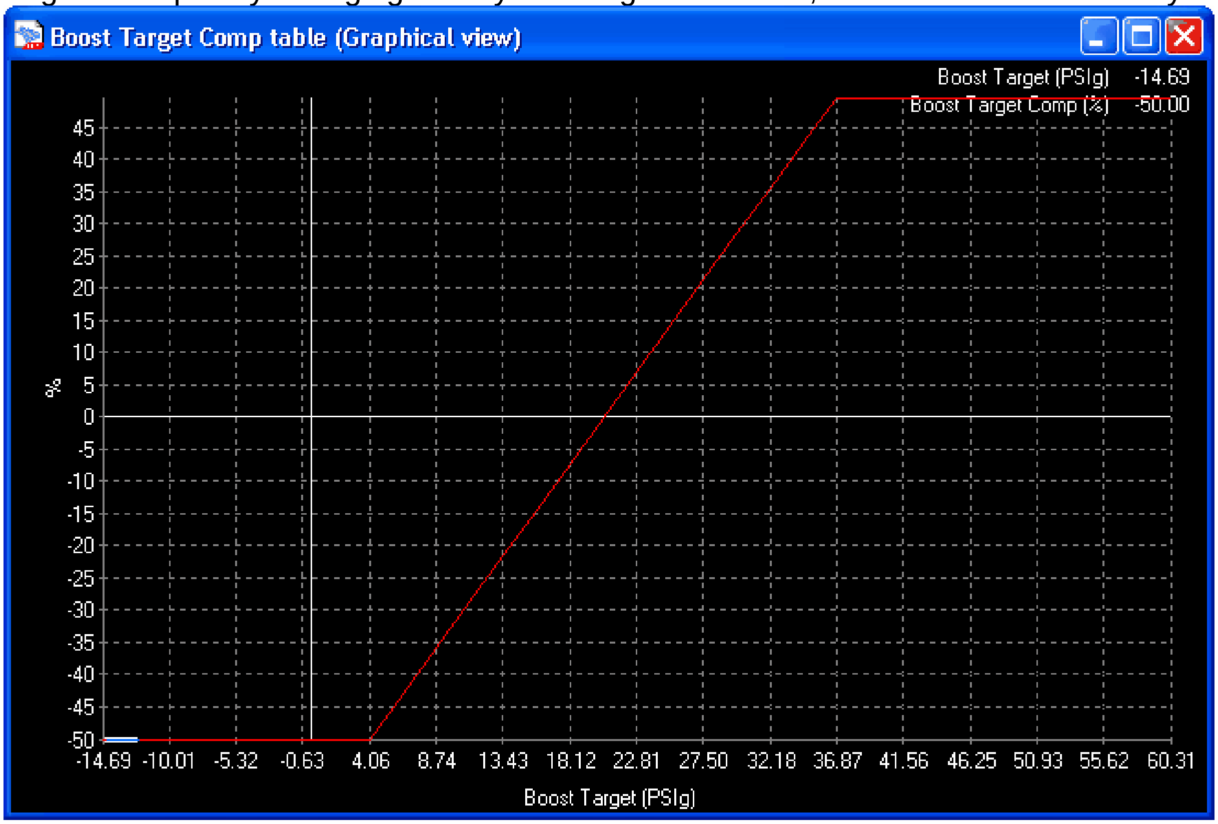


Boost Error Duty table
Units: Duty Cycle vs. Boost Error
Description: The vertical line in the center of the table, at zero boost error, represents the boost target that the solenoid is trying to achieve. The direction of this curve is dependant of how the wastegate is configured. See the above wastegate diagrams. This table is used to stabilize boost pressure.



Boost Target Comp table
Units: Duty Cycle vs. Boost Target
Description: This table is used to automatically compensate duty cycle for different boost targets. Inevitably, this allows the feedback control to do less work and will further enhance boost control. This table is highly recommended when the boost

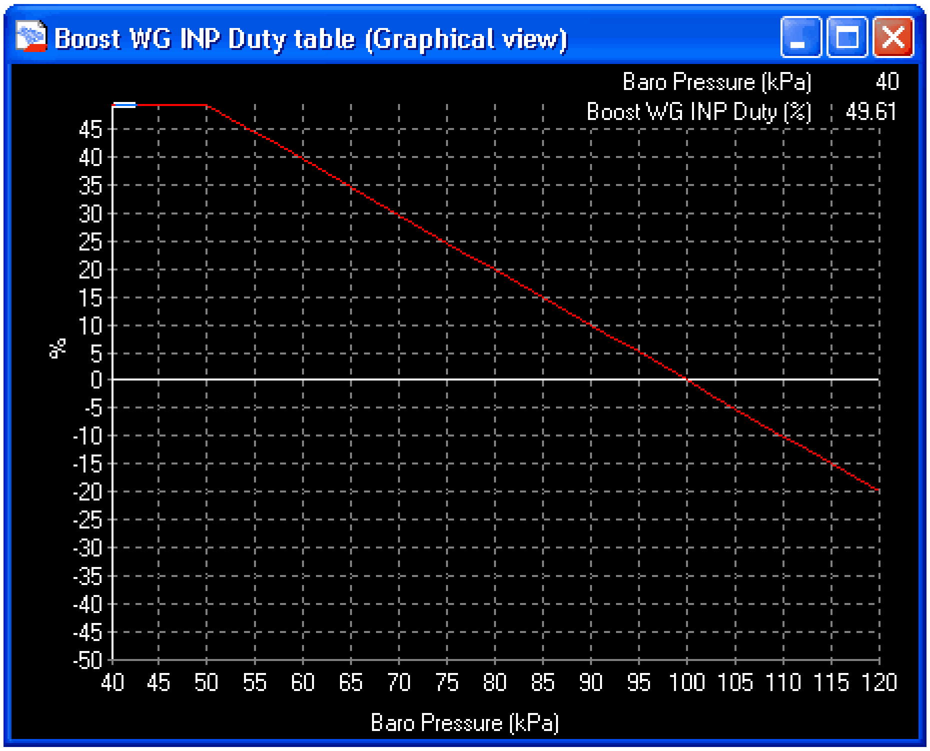
target is frequently changing. If only one target is desired, this will not be necessary.



Boost WG INP Duty table

Units: Duty Cycle vs. Barometric Pressure

Description: This table is used to compensate for target boost against barometric pressure. Typically only used when at high altitude conditions, and the turbocharger has to over spin to create the desired boost from lack of air density. Set this table when compressor surge is taking place at high altitude. This table is used to keep an appropriate duty cycle to maintain the boost target at different altitudes.

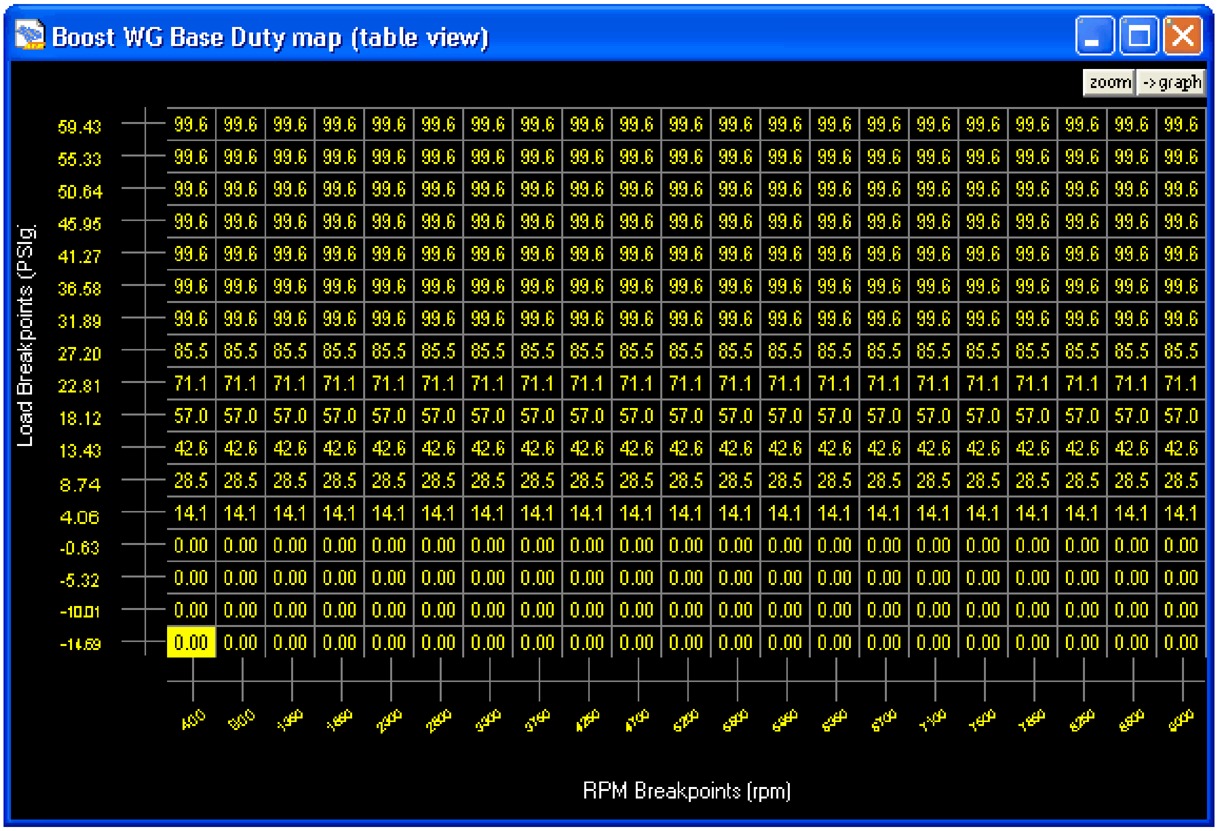


3-D Tables for Boost Control

Boost WG Base Duty map

Units: Load vs. RPM vs. Duty Cycle

Description: Base wastegate duty cycle at specific engine loads and engine speed. This map is used to set the base duty cycle to the boost control solenoid. Set this by turning all of the feedback controls OFF first. Adjust this map until the desired boost is as closely achieved as possible. The closer this map is from the target, the better the closed loop boost control feedback will work. This map determines the base duty cycle percentage used if or if not using closed loop boost control feedback. This is the first map to tune when using boost control.

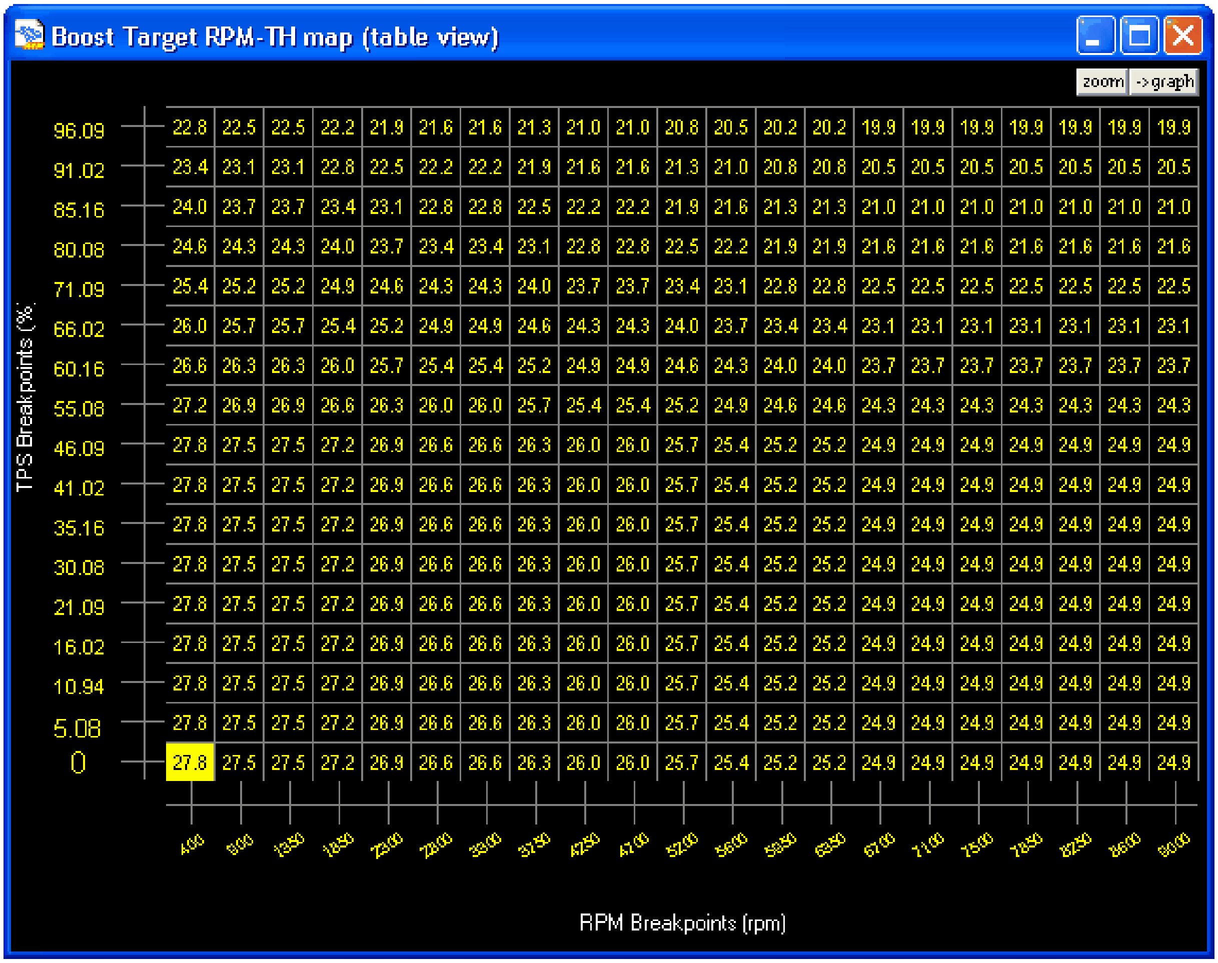


Load Breakpoints (PSIg)	400	800	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
59.43	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6
55.33	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6
50.64	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6
45.95	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6
41.27	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6
36.58	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6
31.89	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6	99.6
27.20	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5	85.5
22.81	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1	71.1
18.12	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0
13.43	42.6	42.6	42.6	42.6	42.6	42.6	42.6	42.6	42.6	42.6	42.6	42.6	42.6	42.6	42.6	42.6	42.6	42.6	42.6	42.6	42.6
8.74	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5
4.06	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1
-0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-5.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-10.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-14.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Boost Target RPM-TH Map

Units: TPS vs. RPM vs. Boost Target

Description: Throttle/RPM dependant boost target control. This is the map that determines the closed loop boost control against throttle position and engine speed. Note: When either the **Boost FB VSS** or **Boost Switch Input** is used, this map is not used. This map is used to alter the target boost pressure at specific throttle positions and engine speeds.



TPS Breakpoints (%) \ RPM Breakpoints (rpm)	400	900	1350	1850	2300	2800	3300	3750	4250	4700	5200	5600	5950	6350	6700	7100	7500	7850	8250	8600	9000
96.09	22.8	22.5	22.5	22.2	21.9	21.6	21.6	21.3	21.0	21.0	20.8	20.5	20.2	20.2	19.9	19.9	19.9	19.9	19.9	19.9	19.9
91.02	23.4	23.1	23.1	22.8	22.5	22.2	22.2	21.9	21.6	21.6	21.3	21.0	20.8	20.8	20.5	20.5	20.5	20.5	20.5	20.5	20.5
85.16	24.0	23.7	23.7	23.4	23.1	22.8	22.8	22.5	22.2	22.2	21.9	21.6	21.3	21.3	21.0	21.0	21.0	21.0	21.0	21.0	21.0
80.08	24.6	24.3	24.3	24.0	23.7	23.4	23.4	23.1	22.8	22.8	22.5	22.2	21.9	21.9	21.6	21.6	21.6	21.6	21.6	21.6	21.6
71.09	25.4	25.2	25.2	24.9	24.6	24.3	24.3	24.0	23.7	23.7	23.4	23.1	22.8	22.8	22.5	22.5	22.5	22.5	22.5	22.5	22.5
66.02	26.0	25.7	25.7	25.4	25.2	24.9	24.9	24.6	24.3	24.3	24.0	23.7	23.4	23.4	23.1	23.1	23.1	23.1	23.1	23.1	23.1
60.16	26.6	26.3	26.3	26.0	25.7	25.4	25.4	25.2	24.9	24.9	24.6	24.3	24.0	24.0	23.7	23.7	23.7	23.7	23.7	23.7	23.7
55.08	27.2	26.9	26.9	26.6	26.3	26.0	26.0	25.7	25.4	25.4	25.2	24.9	24.6	24.6	24.3	24.3	24.3	24.3	24.3	24.3	24.3
46.09	27.8	27.5	27.5	27.2	26.9	26.6	26.6	26.3	26.0	26.0	25.7	25.4	25.2	25.2	24.9	24.9	24.9	24.9	24.9	24.9	24.9
41.02	27.8	27.5	27.5	27.2	26.9	26.6	26.6	26.3	26.0	26.0	25.7	25.4	25.2	25.2	24.9	24.9	24.9	24.9	24.9	24.9	24.9
35.16	27.8	27.5	27.5	27.2	26.9	26.6	26.6	26.3	26.0	26.0	25.7	25.4	25.2	25.2	24.9	24.9	24.9	24.9	24.9	24.9	24.9
30.08	27.8	27.5	27.5	27.2	26.9	26.6	26.6	26.3	26.0	26.0	25.7	25.4	25.2	25.2	24.9	24.9	24.9	24.9	24.9	24.9	24.9
21.09	27.8	27.5	27.5	27.2	26.9	26.6	26.6	26.3	26.0	26.0	25.7	25.4	25.2	25.2	24.9	24.9	24.9	24.9	24.9	24.9	24.9
16.02	27.8	27.5	27.5	27.2	26.9	26.6	26.6	26.3	26.0	26.0	25.7	25.4	25.2	25.2	24.9	24.9	24.9	24.9	24.9	24.9	24.9
10.94	27.8	27.5	27.5	27.2	26.9	26.6	26.6	26.3	26.0	26.0	25.7	25.4	25.2	25.2	24.9	24.9	24.9	24.9	24.9	24.9	24.9
5.08	27.8	27.5	27.5	27.2	26.9	26.6	26.6	26.3	26.0	26.0	25.7	25.4	25.2	25.2	24.9	24.9	24.9	24.9	24.9	24.9	24.9
0	27.8	27.5	27.5	27.2	26.9	26.6	26.6	26.3	26.0	26.0	25.7	25.4	25.2	25.2	24.9	24.9	24.9	24.9	24.9	24.9	24.9

Parameters for Boost Control (can be viewed or logged)

Boost Error
Units: Engine Load
Description: Load needed to achieve the boost target value.

Boost Target
Units: Engine Load
Description: Engine load value that the boost solenoid is attempting to achieve.

Boost Target Comp
Units: Duty Cycle
Description: Duty cycle offset from the **Boost Target Comp Table**.

Boost Trim (INP)
Units: Duty Cycle
Description: Duty cycle offset from the **Boost WG INP Duty Table**.

Boost WG Map
Units: Duty Cycle %

Description: Duty cycle output directly from the **Boost WG Base Duty Map**.

Boost WG Mod
Units: Duty Cycle
Description: Wastegate duty cycle modification for trim control.

Boost WG Out
Units: Duty Cycle
Description: Final duty cycle output to the boost solenoid.

Boost WG Trim
Units: Duty Cycle
Description: Duty cycle modified from the **Boost WG Base Duty Map**.

Boost WG Trim (Err)
Units: Duty Cycle %
Description: Duty cycle difference between the **Boost WG Out** and **Boost WG Base Duty Map**.

Boost WG Trim (P+I)
Units: Duty Cycle %
Description: Duty cycle difference from the P+I control to the **Boost WG Base Duty Map**.

Tuning Boost Control

The first step before tuning the boost solenoid is to determine if duty takes away boost pressure or makes boost pressure. To determine this, find the particular wastegate setup being used from the diagrams above. The language of the boost solenoid is in percent duty cycle. This is not percent open or percent of airflow, it is rather the full-scale percentage of the solenoid where 100% is fully closed or fully open depending on the solenoid used.

- Open AEMPro and connect to the EMS
- Confirm that the throttle position is set properly (closed < 1%, WOT > 95%)
- Confirm the AFR so that the vehicle has sufficient fuel for boosting.
- Open the Boost Control Template and turn the **Boost W/G Output** option ON.
- Set the **Boost/Idle PW TPS** to 25%.
- Set the **Boost W/G Frequency, Boost Duty Maximum,** and **Boost Duty Minimum** options according to the manufacturer specifications.
- Set the **Fuel Cut Load** option to eliminate any possible overboosting.
- Turn ON **Boost From Load** if using a MAF sensor for the engine load input.
- Set the "boosted" section of the **Boost WG Base Duty Map** to 50%.
- Set your boost target in the **Boost Target Speed table** and/or the **Boost Target RPM-TH map** but turn OFF **Boost WG Feedback**.
- Log the parameters in the Boost Control Template (most importantly **Engine Load** and **Boost WG Out**).

Save this log and view it in the AEMLog software.
• From the log, the proper open loop wastegate duty can be determined.

It is a good idea to make a boost log sheet. This will speed up boost control tuning if feedback will be used by giving you an idea of the duty cycle that will achieve each boost level. The chart will be dependant on the mechanics of the turbo system, including: wastegate spring, turbocharger, exhaust backpressure, etc. See the example below:

Boost WG Out	Engine Load
0%	7psi
10%	9psi
20%	11psi
30%	13psi
40%	15psi
50%	17psi
60%	19psi
70%	21psi
80%	23psi
90%	25psi
100%	27psi

• After the appropriate duty cycle is found that is necessary for you boost target, the wastegate feedback (error control and/or P+I) can be enabled.

Proportional and Integral Control

One approach is to use a technique known as the Ziegler Nichols Tuning Method. The Ziegler Nichols closed loop method uses Proportional and Integral (or P+I) and should produce tuning parameters, which will obtain quarter wave decay.

1) Turn the options **Boost WG Feedback** and **Boost FB On P+I** to ON.
2) Turn the **Boost FB On Error** option OFF.
3) Set the **Boost FB +Limit** to 10% and **Boost FB -Limit** to -10%.
4) Set the integral time constant **Boost FB Int Gain** to zero.
5) Log the parameters **Engine Load** and **Boost WG Out**.
6) Increase the value of the **Boost FB Pro Gain** until the point of instability or a sustained oscillation is reached. Note: both **Boost FB Pro Gain** and the integral gain will be negative values.
7) From here, the ultimate proportional gain (Gu) is found.
8) From the log, measure the period of oscillation from peak to peak, in seconds, to obtain the critical time constant or ultimate period (Pu).

9) Once the values for Gu and Pu are obtained, the P+I parameters can be calculated from the following equation.

Boost FB Pro Gain = 0.45 (Gu)
Boost FB Int Gain = (Pu)/1.2

Note that these values are not optimal values and additional fine tuning may be required to obtain the best boost control performance.

Boost Error Control

Arguably, an easier tuning procedure is using the **Boost Error Duty table.** Since it does not use an integral time constant, the boost control may accrue a small steady-state error which is typically acceptable. The **Boost Error Duty table** does, however, use a "tuneable" proportional gain.

1) Turn the **Boost WG Feedback** and **Boost FB On Error** options ON.
2) Turn the **Boost FB On P+I** option OFF.
3) Set the **Boost Error Duty table** so the curve goes through the origin at (0,0). If high duty cycle equals high boost, the graph should slope downward from left to right. If high duty cycle equals low boost, the graph should slope upward from left to right.
4) Log the parameters **Engine Load** and **Boost WG Out** and tune the **Boost Error Duty table** until the desired control is reached.

7.2 Automapping

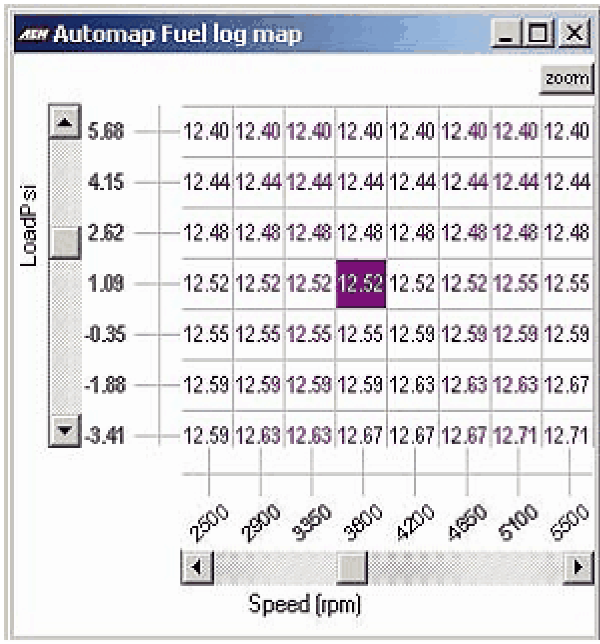
Automapping

Automapping is a tool that allows maps to be changed automatically. This is not to be confused with closed loop O2 feedback, which only makes fuel output corrections. Automapping makes changes to the actual map by extracting data from O2 #1, thus affecting air fuel ratios and simplifying the tuning process. This feature is active only above 5% throttle in order to keep the deceleration fuel function working and to maintain consistent idling. In the AEMPro software, the Automap function utilizes three adjustable windows:

Automap Fuel log map
Fuel target
Auto Mapping

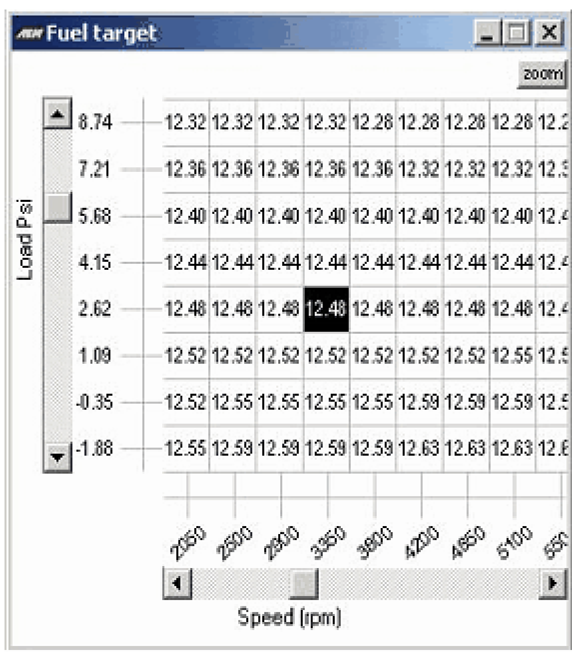
The **Automap Fuel log map** allows a parameter to be monitored and logged for different engine states, specifically for those, which correspond to sites of a map. Each site of the map has a value and a weighting. The weighting indicates the collected value for a specific cell. The value gives the average of this collected data.

The weight of any value is always between 0 and 1. This is dependant on how close it references a particular site. In other words, when engine load and engine speed approaches a particular site, the value of the air fuel ratio is logged into the corresponding site of the **Automap Fuel log map**. As more values of air fuel ratio are collected for that site, the values are averaged out. Eventually a map can be built showing how the air fuel ratio varies across the entire load and speed map (shown below).



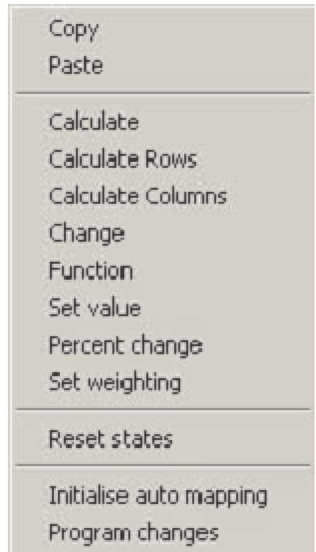
LoadPsi	2500	2900	3350	3800	4200	4650	5100	5500
5.68	12.40	12.40	12.40	12.40	12.40	12.40	12.40	12.40
4.15	12.44	12.44	12.44	12.44	12.44	12.44	12.44	12.44
2.62	12.48	12.48	12.48	12.48	12.48	12.48	12.48	12.48
1.09	12.52	12.52	12.52	12.52	12.52	12.52	12.55	12.55
-0.35	12.55	12.55	12.55	12.55	12.59	12.59	12.59	12.59
-1.88	12.59	12.59	12.59	12.59	12.63	12.63	12.63	12.67
-3.41	12.59	12.63	12.63	12.67	12.67	12.67	12.71	12.71

The **Fuel target** window enables target values to be entered via the end user. It is important to have an educated judgment and to check these values before starting the automapping function. It is also a good idea to monitor the shape that the **Fuel Map** is taking to ensure proper automapping correction. These air fuel ratio values correlate with the respective sites of the **Automap Fuel log map** as used when automapping.



Load Psi	2050	2500	2900	3350	3800	4200	4650	5100	55
8.74	12.32	12.32	12.32	12.32	12.28	12.28	12.28	12.28	12.2
7.21	12.36	12.36	12.36	12.36	12.36	12.32	12.32	12.32	12.3
5.68	12.40	12.40	12.40	12.40	12.40	12.40	12.40	12.40	12.4
4.15	12.44	12.44	12.44	12.44	12.44	12.44	12.44	12.44	12.4
2.62	12.48	12.48	12.48	12.48	12.48	12.48	12.48	12.48	12.4
1.09	12.52	12.52	12.52	12.52	12.52	12.52	12.52	12.55	12.5
-0.35	12.52	12.55	12.55	12.55	12.55	12.59	12.59	12.59	12.5
-1.88	12.55	12.59	12.59	12.59	12.59	12.63	12.63	12.63	12.6

Right clicking in the Automap Fuel log map will create an **Auto Mapping** dialog box (shown below).

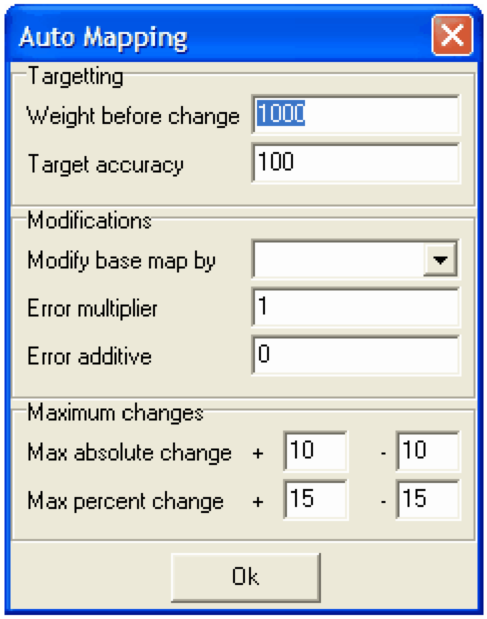


Start Automapping begins the process of automapping based upon the last values set in the **Fuel target** and **Auto Mapping** windows. The menu option will then change to **Stop Automapping** which, when clicked upon, stops the auto-mapping feature.

Reset states will reset the reference points for the limit constraints, thus allowing more movement in the map being modified if a cell has reached a limit.

When automapping is not employed, **Program changes** allows for the end user to extract the logged data and manually select appropriate cells for automatic correction.

Initialise auto mapping opens an option menu (shown below).



The **Weight before change** value determines the cumulative weight of values collected for a site before any modification is made to the base map.

The **Target accuracy** determines the minimum absolute difference between the average logged value and the target value for which a change should be made to the base map. In other words, from this value there will be no correction made within (+/-) of the targeted air fuel ratio value.

If both of these conditions are met, automapping will be enabled. However, the amount of change is constrained by **Maximum changes**. When these thresholds are met, there will be a limitation on the changes to the base map unless the **Reset states** button is used.

When modifications are made to the base map, the difference between the **Automap Fuel log map** and **Fuel target** is calculated and the **Error multiplier** and **Error additive** are applied to the result:

Change = (Target Map value - Log Map value) * Error multiplier + Error additive

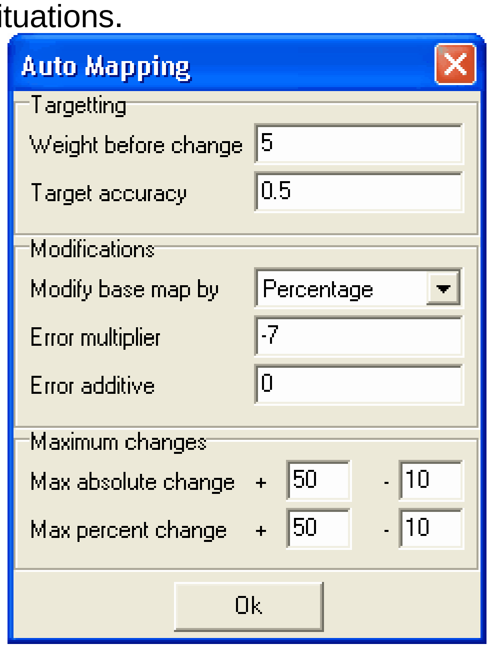
Since the default equation has the actual log value subtracted from the target value, the **Error multiplier** and **Error additive** will always be negative numbers in order to apply the correct direction for mapping control.

Assuming air fuel ratios will never leave the range of 9:1 to 17:1, the **Error multiplier** should never be less than (–11) or greater than (–6). However, the conservative approach is to keep this value close to 0 for more gradual changes. A large (negative) number is good for rich conditions and a small (negative) number is good for lean mixtures. After the map has been corrected for optimization and is drivable, a typical **Error multiplier** value is (–7).

This resultant value is then applied to the base map value as a **Max percentage change** or **Max absolute change** depending on the choice selected.

Tuning with Automapping

- Open AEMPro and connect to the EMS
- Confirm that the throttle position is set properly (closed < 1%, WOT > 95%)
- It is a good idea to start with a **Fuel Map** that you think may be close to the end result. Always round up, as too rich is better than too lean.
- Confirm that the option **O2 FB Control** is OFF.
- In the AEMPro software, go to: **Fuel | Automap Fuel log | Target**
- Set the **Fuel Target** window to the AFR targetted.
- Now go to: **Fuel | Automap Fuel log | Log**
- Right click anywhere in the **Automap Fuel log map** and click on **Initialise auto mapping**
- Set the **Auto Mapping** dialog box. These settings solely depend on the type of tuning being performed, i.e.: WOT, steady-state cruising, etc. Below is an example that can work for most situations.



- Click OK
- Open the **Fuel Map Graph** and go to the **Window** pull down menu and click **Tile**.
- There is now three windows to view, i.e.: **Fuel Map**, **Automap Fuel log map**, and **Fuel Target.**
- Right click again in the **Automap Fuel log map** and click **Start Automapping.**
- Start the automapping process keeping an eye on the **Fuel Map** for changes (remember automapping is disabled under 5% throttle).
- When finished, right click in the **Automap Fuel log map** and click **Stop Automapping.**

7.3 Knock Control

Knock Control

The AEM EMS has 2 inputs for knock sensors. These can be passive, where data is displayed and/or recorded or the feedback knock control can be enabled, letting the EMS take action to counter the knock. To do this, the EMS can either retard the timing, richen the fuel mixture, or both.

User Definable Options For Knock Control

Knock Control
Units: On/Off
Description: This enables the knock sensor control feedback function.

Knock %Rich/Volt
Units: Fuel % / Volt
Description: This is the amount of fuel added per volt over the **Knock Sensor Cal Table**.

Knock Decrease Fuel
Units: Fuel %
Description: This is the amount of fuel to be removed (every **Knock Restore Rate**) once knock has been removed.

Knock Fuel Add Max
Units: Fuel %
Description: This sets the maximum allowable fuel to be added under a knock condition.

Knock Ign Rtd Max
Units: Degrees
Description: This sets the maximum ignition retard allowed under a knock condition.

Knock Restore Rate
Units: Revolutions
Description: This is the number of engine revolutions at which to restore the normal running condition from a knock condition.

Knock Retard/Volt
Units: Degrees / Volt
Description: This is the amount of ignition timing to take out per volt over the **Knock Sensor Cal Table**.

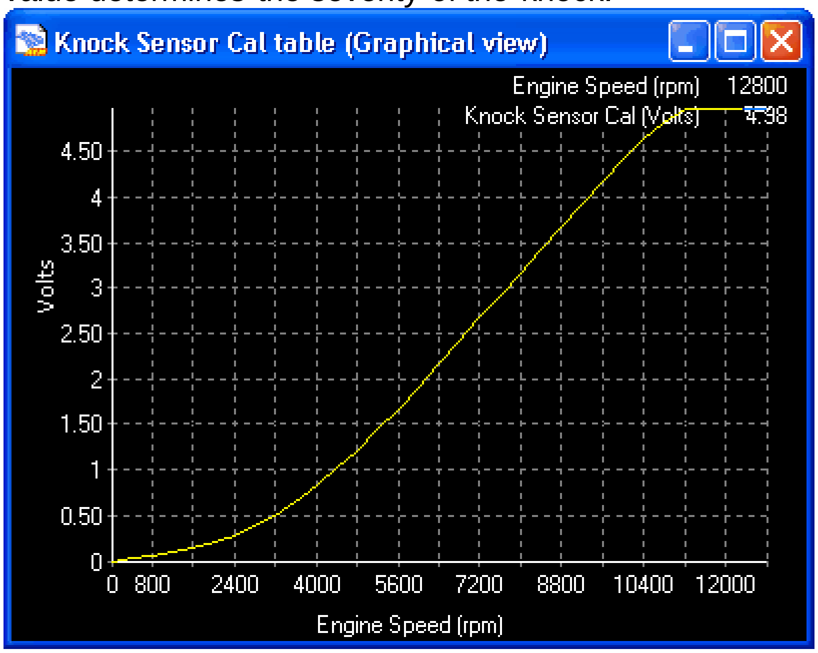
Knock Spark Advance
Units: Degrees
Description: This is the amount of ignition timing to add back in when knock has been removed.

2-D Tables for Knock Control

Knock Sensor Cal table

Units: Knock Volts vs. RPM

Description: Sets an RPM dependant threshold to filter out background noise. Setting up this table is key to the success of knock control. Whenever the knock sensor voltage output exceeds this table's value at the specified engine speed, it is considered to be "real knock". The difference between the actual knock signal and this threshold value determines the severity of the knock.



Parameters (can be viewed or logged)

Knock #1

Units: Volts

Description: Displays actual detonation from theory which is equal to **Knock #1 Raw** - **Knock Sensor Cal Table**.

Knock #1 Fuel

Units: Fuel %

Description: Displays the current fuel correction from the knock #1 sensor in an attempt to eliminate detonation.

Knock #1 Raw

Units: Volts

Description: Displays the current raw voltage input from the knock #1 sensor.

Knock #1 Retard

Units: Degrees

Description: Displays the current ignition retard from the knock #1 sensor in an attempt to eliminate detonation.

Knock #1 Tooth
Units: Teeth
Description: Displays the current crank tooth value for monitoring individual cylinder knock.

Knock #1 Volts
Units: Volts
Description: Displays the raw voltage input from the sensor at the ignition event for each coil that is assigned to **Knock #1**.

Knock #2
Units: Volts
Description: Displays actual detonation from theory which is equal to **Knock #2 Raw** - **Knock Sensor Cal Table**.

Knock #2 Fuel
Units: Fuel %
Description: Displays the current fuel correction from the knock #2 sensor in an attempt to eliminate detonation.

Knock #2 Raw
Units: Volts
Description: Displays the current raw voltage input from the knock #2 sensor.

Knock #2 Retard
Units: Degrees
Description: Displays the current ignition retard from the knock #2 sensor in an attempt to eliminate detonation.

Knock #2 Tooth
Units: Teeeth
Description: Displays the current crank tooth value for monitoring individual cylinder knock

Knock #2 Volts
Units: Volts
Description: Displays the raw voltage input from the sensor at the ignition event for each coil that is assigned to **Knock #2**.

Tuning with the Knock Sensor(s)

To setup the knock control:

- Identify which cylinders correspond to each knock sensor input.
- Identify the knock signal threshold where anymore voltage would be considered detonation.
- Define the rate of additional fuel to be added for knock.
- Set a maximum amount of fuel to be added for knock.

- Define the rate that the fuel will be removed after the knock is gone.
- Define the rate of spark retard to be added for knock.
- Set a maximum amount of ignition retard for knock.
- Define the rate of spark advance back to normal values after the knock is gone.
- Activate the knock control system.

This type of description is best described in an example:
- Engine: Inline 4-cylinder
- 1 knock sensor (wired to **Knock #1**)
- 1 coil (distributed)
- 4 primary injectors

To set the knock sensor up for the above motor example, follow the procedure below.
- Open the **Options | Coil** dialog box. This will allow the knock sensor(s) to be assigned to a specific coil(s).
- Activate **Knock #1** for **Coil #1** for this example. This allows all knock control actions, triggered by the **Knock #1** sensor, to be applied to **Coil #1**.
- Open the **Options | Injector** dialog box. This will allow the knock sensor(s) to be assigned to specific injectors.
- Activate **Knock #1** for all four injectors. This allows all knock control actions, triggered by the **Knock #1** sensor, to be applied to these four injectors.
- Additionally, disable all **Knock #2** channels.

It must be understood that knock sensors can pickup a lot of noise depending on the type of sensor and engine setup. The only way the EMS can determine when actual detonation occurs is by calibrating the knock sensor being used. In the AEMPro software, go to: **Setup | Sensors | Knock Sensor | Knock Sensor Cal Table**

The **Knock Sensor Cal Table** sets an RPM dependant threshold to filter out background noise. Setting up this table is key to the success of this function. Whenever the knock sensor voltage input exceeds this table's voltage value, it is considered to be detonation. The difference between the detonation signal and this threshold value determines the severity of the knock.

By logging the **Knock #1 Volts** parameter when the engine is under load and not knocking gives you a picture of the background noise on the knock sensor channel. This is mechanical noise in the engine that is near the same frequency as knock but is not real knock. By using this data, you can draw the **Knock Sensor Cal Table** with varying engine speeds. The table should be about 10-25% above the typical knock sensor value that you recorded and will start off very low and increase with RPM.

After setting up the knock sensors and the **Knock Sensor Cal Table**, the EMS knows what knock sensor applies to what cylinder and what knock signal constitutes real knock. So now we need to define what exactly the EMS should do when it sees knock.

Setting up the Fuel enrichment function should be the first response to knock as it does not reduce power as dramatically as retarding the ignition. To add fuel, you have to define how much extra fuel (expressed in %) to add for each volt the knock sensor input exceeds the **Knock Sensor Cal Table**. This is done with the **Knock % Rich/Volt** option. The amount to step the fuel back to normal (expressed in %) is the **Knock Decrease Fuel** option. The rate at which to increment the knock modifications back to normal is **Knock Restore Rate** and is expressed in engine revolutions. To keep the engine from becoming overly rich, there is a **Knock Fuel Add Max** option, which sets the maximum amount of fuel that the knock routine can add, no matter how severe the knock is.

So for our example, if we wanted to add 3% of fuel for each volt of knock, but not exceeding 10% of fuel in total and return the fuel back to normal 1% every 50 engine revolutions, we would set the following:

Knock Control = ON
Knock Restore Rate = 50 rev
Knock %Rich/Volt = 3%
Knock Decrease Fuel = 1%
Knock Fuel Add Max = 10%

Setting up the spark retard function retards the ignition timing in response to knock. To retard the timing, you have to define how much timing (expressed in degrees) to remove for each volt the knock sensor input exceeds the **Knock Sensor Cal Table**. This is done with the **Knock Retard/Volts** option. The amount to step the timing back to normal (expressed in degrees) is the **Knock Advance** option. The rate at which to increment the knock modifications back to normal is again, the **Knock Restore Rate**. To set the limit for timing retard there is the **Knock Ign Rtd Max** option that sets the maximum amount of spark retard that the knock routine implement, no matter how severe the knock is.

So for our example, if we wanted to also retard the timing 5 degrees for each volt of knock, but not exceeding 12 degrees of total retard and advance the timing back to base by 0.75 degrees every 50 engine revolutions, we would set the following:

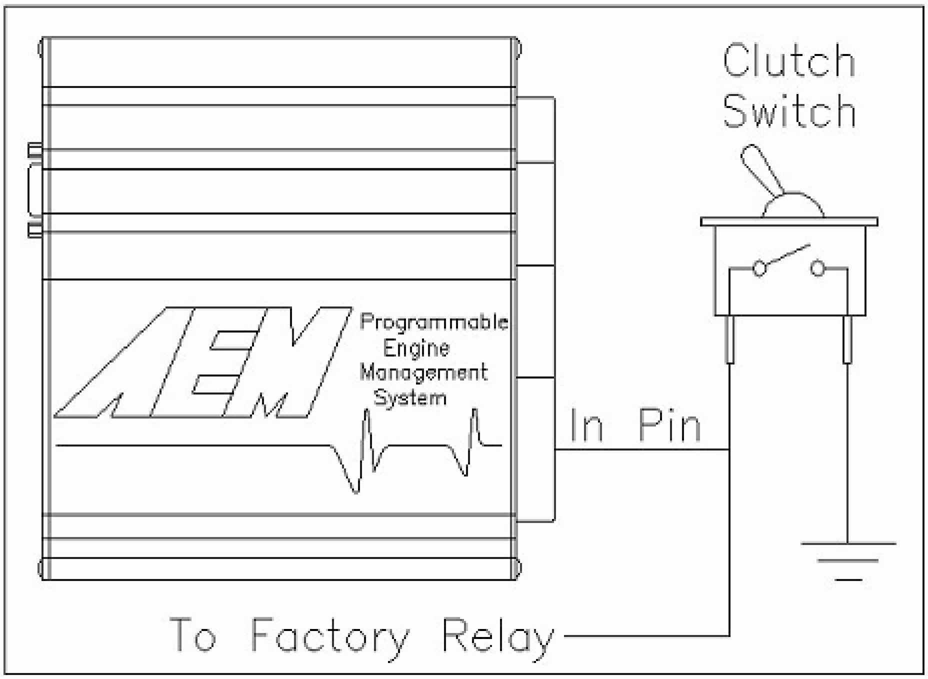
Knock Rtd/Volt = 5 degrees
Knock Advance = 0.75 degrees
Knock Ign Rtd Max = 12 degrees

7.4 2Step Rev Limiter

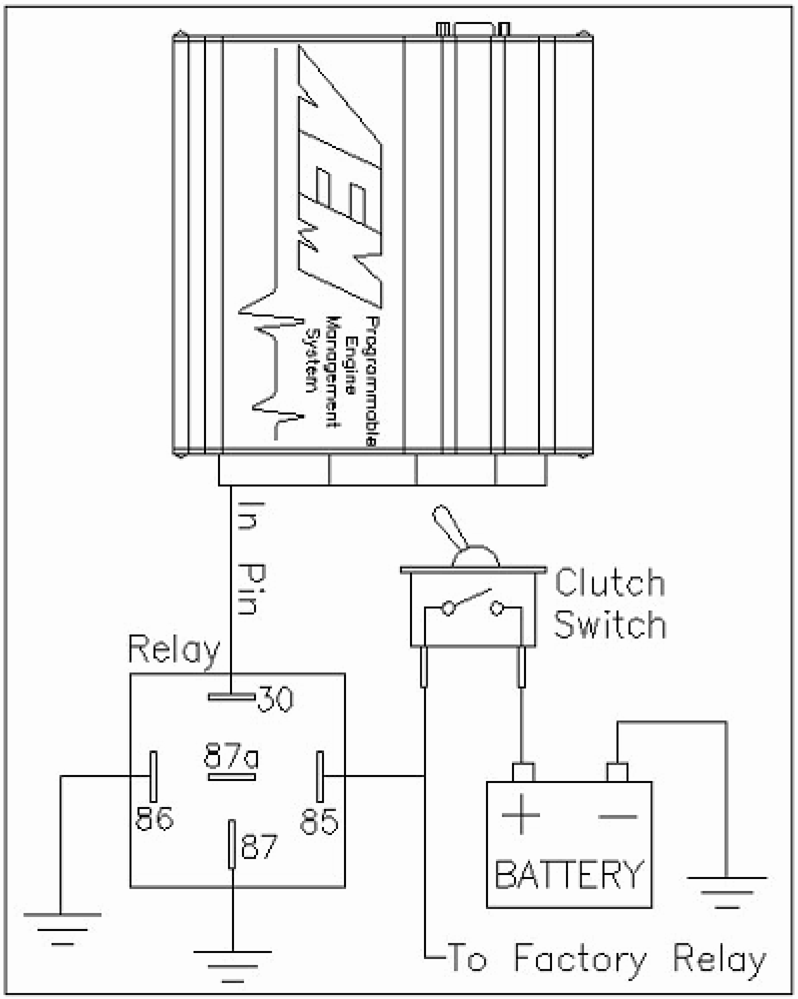
2Step Rev Limiter

Secondary rev limiters (2 step) are most commonly used in drag racing for consistent vehicle launches. However, secondary rev limiters can also be used for full throttle shifting, anti-lag, valet parking, etc.

There are many different ways to install and program a 2Step Rev Limiter with the AEM EMS. Although any switch can be used, utilizing the factory clutch switch is most common. Most vehicles use a pull to ground switch. This simple installation involves splicing a wire from the clutch switch location to an available switch on the EMS, as shown below. The switch information for your specific application can be found in the **Application Notes**.



Other vehicles, including the Toyota Supra Mark IV, use a 12-volt clutch switch. Since the EMS switches pull to ground, this situation will call for a relay to pull the switch to ground, as shown below.



Options for the 2Step Rev Limiter

2Step Fuel Cut

Units: RPM

Description: User defined RPM to enter the secondary fuel cut rev limiter. Naturally aspirated engines will use this for soft launches whereas turbocharged vehicles may not cut fuel to encourage anti-lag spool up.

2Step Ignition Cut

Units: RPM

Description: User defined RPM to enter the secondary ignition cut rev limiter.

2Step OK Below VSS

Units: Vehicle Speed

Description: Vehicle speed threshold to deactivate the 2step rev limiter. This is applied when full throttle shifting is not used. This feature helps allow automatic transmission vehicles to use the 2-step rev limiter.

2Step Input

Units: Switch Input
Description: Switch input used to activate the secondary rev limiter.

2Step Retard Rev
Units: RPM
Description: Target RPM point to begin ignition retard while 2Step conditions are met. The total amount of timing retard available is dependent on the ignition range. Typical range is -17 deg to +72 deg.

2Step Fuel Cut C
Units: Constant
Description: Offset used for rev limit fuel duty calculation while 2Step conditions are met. Cut Duty = Cut C + ((Desired RPM Control Range/50)) * Cut M. The higher the value for Cut C, the more initial cut duty is applied once the RPM target is reached. Once Desired Control Range is exceeded, 100% cut duty is applied. Automatically set by rev limiter setup wizard.

2Step Fuel Cut M
Units: Multiplier
Description: Multiplier used for rev limit fuel duty calculation while 2Step conditions are met. Cut Duty = Cut C + ((Desired RPM Control Range/50)) * Cut M. The higher the value for Cut M, the finer the control range. Once Desired Control Range is exceeded, 100% cut duty is applied. Automatically set by rev limiter setup wizard.

2Step Ign Cut C
Units: Constant
Description: Offset used for rev limit ignition duty calculation while 2Step conditions are met. Cut Duty = Cut C + ((Desired RPM Control Range/50)) * Cut M. The higher the value for Cut C, the more initial cut duty is applied once the RPM target is reached. Once Desired Control Range is exceeded, 100% cut duty is applied. Automatically set by rev limiter setup wizard.

2Step Ign Cut M
Units: Multiplier
Description: Multiplier used for rev limit ignition duty calculation while 2Step conditions are met. Cut Duty = Cut C + ((Desired RPM Control Range/50)) * Cut M. The higher the value for Cut M, the finer the control range. Once Desired Control Range is exceeded, 100% cut duty is applied. Automatically set by rev limiter setup wizard.

2Step Retard C
Units: Constant
Description: Offset used for ignition timing retard calculation while 2Step conditions are met. Cut Duty = Cut C + ((Desired RPM Control Range/50)) * Cut M. The higher the value for Cut C, the more ignition retard is applied once the RPM target is reached. Once Desired Control Range is exceeded, maximum ignition retard is applied. Maximum timing retard depends on ignition range. Typical range is -17

degrees to +72 degrees. Automatically set by rev limiter setup wizard.

2Step Retard M
Units: Multiplier
Description: Multiplier used for ignition timing retard calculation while 2Step conditions are met. Cut Duty = Cut C + ((Desired RPM Control Range/50)) * Cut M. The higher the value for Cut M, the finer the control range. Once Desired Control Range is exceeded, maximum ignition retard is applied. Maximum timing retard depends on ignition range. Typical range is -17 degrees to +72 degrees. Automatically set by rev limiter setup wizard.

2Step Rev Limiter Installation without a clutch switch

This installation does not require a clutch switch input, i.e.: no wiring! This strategy will work as long as the vehicle speed sensor (VSS) is still being used.

First, set the 2Step rev limiter up as normal referring to the instructions above. Next, go to:

- **Setup | Rev Limiters | 2Step Rev Limiter | Options - 2Step Rev Limit**
- Set the option **2Step Input** to **Switch is Always ON**.
- Set the option **2Step OK Below VSS** to the lowest speed your particular VSS will read. To figure this out, view the parameter **Vehicle Speed** and drive at low speeds to find the VSS gear resolution (**2Step OK Below VSS** should match the option **VSS Minimum Display**).

7.5 O2 Feedback

O2 Feedback

To control the engine's fuel delivery system, the EMS can be programmed to run open loop and/or closed loop O2 feedback. Closed loop uses feedback from the oxygen sensor to make temporary, but immediate, corrections to the injection to maintain a target AFR. The type of an O2 sensor will determine how O2 feedback can be controlled. Due to the nature of standard narrow band O2 sensors, 14.7:1 is the only air fuel ratio that can be accurately maintained in closed loop. However, wideband O2 sensors can be used in almost every feedback condition.

When the fuel system is open loop, the O2 sensor is ignored and the injector pulse width relies on the **Fuel Map** and fuel compensators to adjust injection duration. Open loop is necessary during engine starts, when the O2 sensor has cooled below its operating temperature. It may also be necessary when coolant temperatures are low. In this state, the fuel vaporization is poor and the engine will require a richer mixture to properly operate. When under heavy load, the engine typically requires an air fuel ratio that is out of a narrow band oxygen sensor's standard range and open loop will be necessary. When the accel fuel function is triggered during hard accelerations, open loop may be necessary to help stabilize the O2 feedback. When the decel function cuts fuel completely, O2 feedback will not be necessary.

User Definable Options for O2 Feedback

O2 FB Rich Limit
Units: Fuel %
Description: The maximum amount of fuel to add when O2 feedback is enabled.

O2 FB Coolant Min
Units: Coolant Temp Temperature
Description: O2 feedback will operate when the coolant temperature has exceeded this value. This value is typically set near operating temperature.

O2 FB Global Gain
Units: Gain Multiplier
Description: Overall O2 feedback gain. This value will always be one unless the proportional and integral gains are not sufficient in controlling the air fuel ratio.

O2 FB Lean Limit
Units: Fuel %
Description: The maximum amount of fuel to subtract when O2 feedback is enabled.

O2 FB Maximum Load
Units: Engine Load
Description: O2 feedback will operate when the engine load is below this value. When using a narrow band O2 sensor, O2 feedback is typically not used at high engine loads because of the sensor's inaccuracy outside the stoichiometric range and at high exhaust gas temperatures. However, O2 feedback can be used at high engine loads with a quality UEGO sensor.

O2 FB Rate
Units: mS
Description: O2 feedback base timer for both proportional and integral terms. This is how often the air fuel ratio is referenced to determine the necessary correction. A smaller number gives a faster response by effectively increasing the gain. This should be the same as the sampling rate of the O2 sensor being used. A typical value is 65.59 mS.

O2 FB Maximum RPM
Units: RPM
Description: O2 feedback will operate when the RPM is below this value but is not in cranking mode. Limits O2 feedback control above the user-defined rpm.

O2 FB Control
Units: On/Off
Description: Enables closed loop O2 feedback and the **O2 Target** parameter. After the **Fuel Map** has been tuned, O2 feedback can be enabled for automatic tuning

adjustments.

O2 FB Accel Inhibit
Units: microseconds
Description: O2 feedback threshold for accel fuel. O2 feedback will operate when the current **Fuel Trim (Accel)** amount is below this value. Because the acceleration fuel delivers an abundance of fuel in a very short amount of time, O2 feedback can ignore it to avoid possible air fuel ratio overshooting. However, using this function can still allow O2 feedback when there is a very small amount of acceleration fuel employed.

O2 FB Update Rate
Units: mS
Description: O2 feedback delay after the acceleration fuel has been disabled. This function allows the mixture to be restored without using O2 feedback in order to prevent air fuel ratio overshooting. A typical value is 196 mS.

O2 FB Decel Inhibit
Units: mS
Description: O2 feedback delay after the decel fuel function has been disabled.
Typical Use: This function allows the mixture to be restored without using O2 feedback in order to prevent air fuel ratio overshooting. A typical value is 196 mS.

O2 FB Accel Clear
Units: On/Off
Description: Sets O2 feedback to zero after both accel and decel fuel functions have been implemented. After utilizing accel/decel fuel, the next condition will typically be different from before. This function is used to allow the O2 feedback to clear its memory and start from zero again.

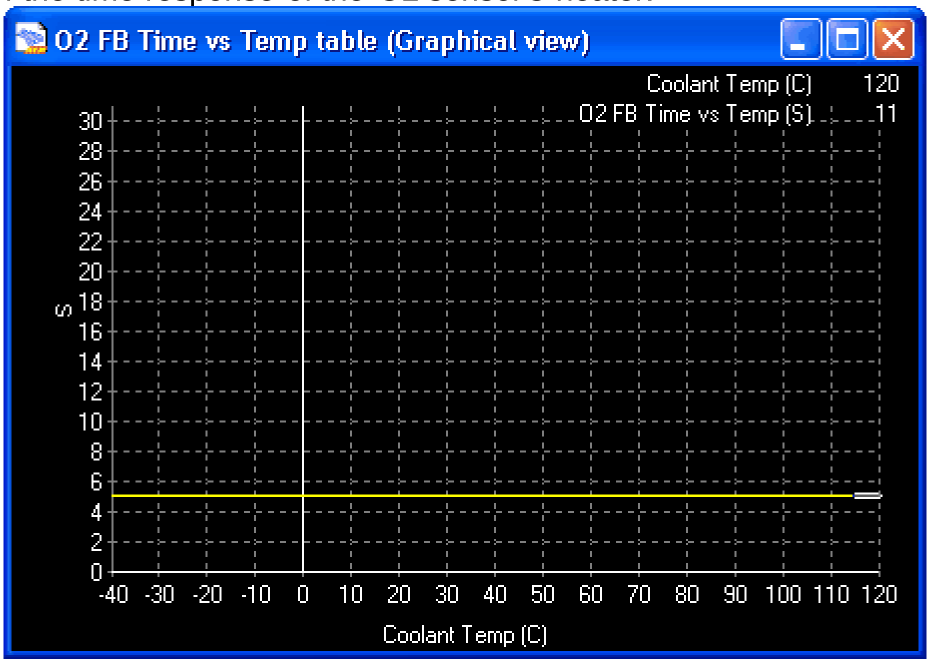
O2 FB DFCO Clear
Units: On/Off
Description: Sets O2 feedback to zero after decel cut fuel have been implemented. After utilizing decel cut fuel, the next condition will typically be different from before. This function is used to allow the O2 feedback to clear its memory and start from zero again.

O2 FB Over Clear
Units: On/Off
Description: Sets O2 feedback to zero when ouside the load, coolant, or engine speed thresholds. After these parameters are met, the next condition will typically be different from before. This function is used to allow the O2 feedback to clear its memory and start from zero again.

2-D Tables for O2 Feedback

O2 FB Time vs Temp Table
Units: Time After Start Time vs. Coolant Temperature

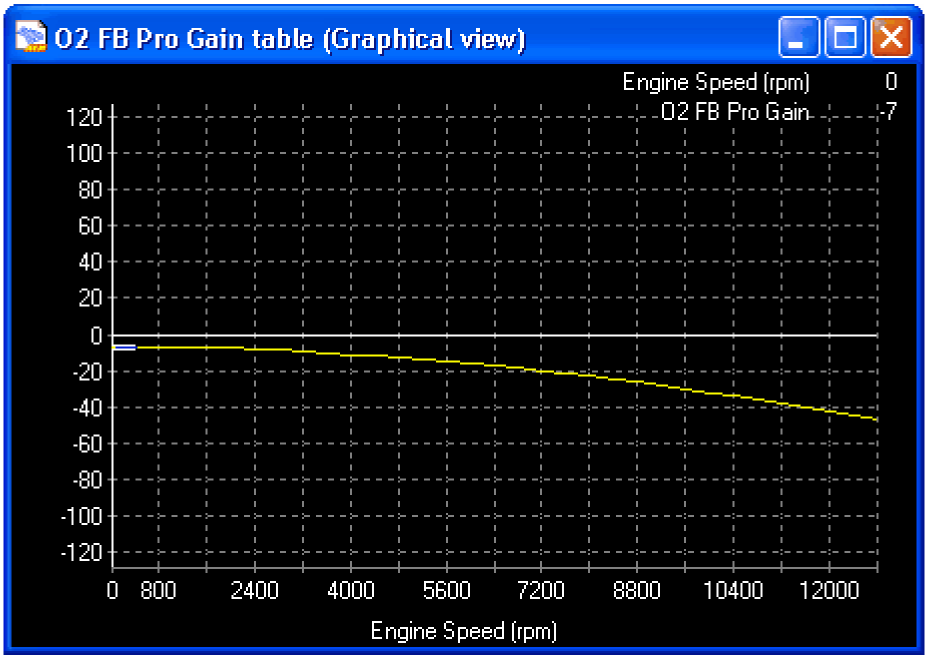
Description: This table disables the O2 feedback for a set amount of time to allow a rich engine start and allow time for the O2 heater to warm up. This should never be faster than the time response of the O2 sensor's heater.



O2 FB Pro Gain table

Units: Proportional Gain vs. RPM

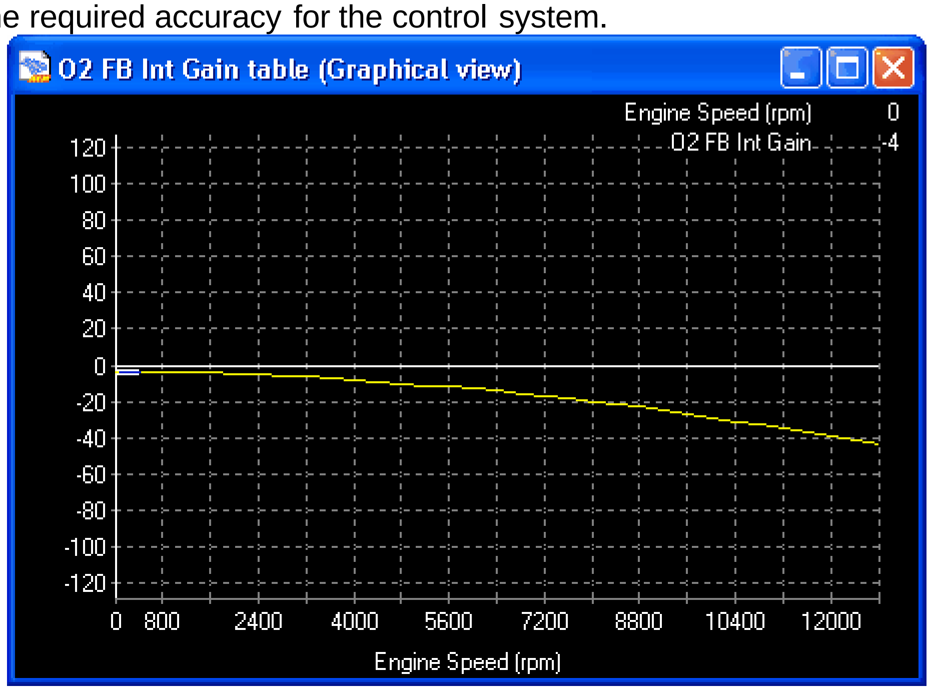
Description: Proportional control is a pure gain adjustment acting on the error signal to provide the driving input. The advantage of a proportional-only control is its simplicity. If AFR offsets can be tolerated, the use of a proportional controller may be optimal. However, it will not eliminate the steady-state error that occurs after a set-point change or a sustained AFR disturbance. Note: When tuning the O2 feedback and overshoot occurs, lower this number. If undershooting the O2 Target, raise this number. Used to adjust the speed of the system and reach the O2 Target quickly.



O2 FB Int Gain table

Units: Integral Gain vs. RPM

Description: Integral control is implemented through the introduction of an integrator. This is used to fine tune the O2 feedback at the O2 Target once the proportional has acted in getting close to the target. Note: start tuning the O2 feedback with this option at zero, until the proportional has the feedback close to the target, then step this in slowly until the feedback holds the O2 Target. Integral control is used to provide the required accuracy for the control system.

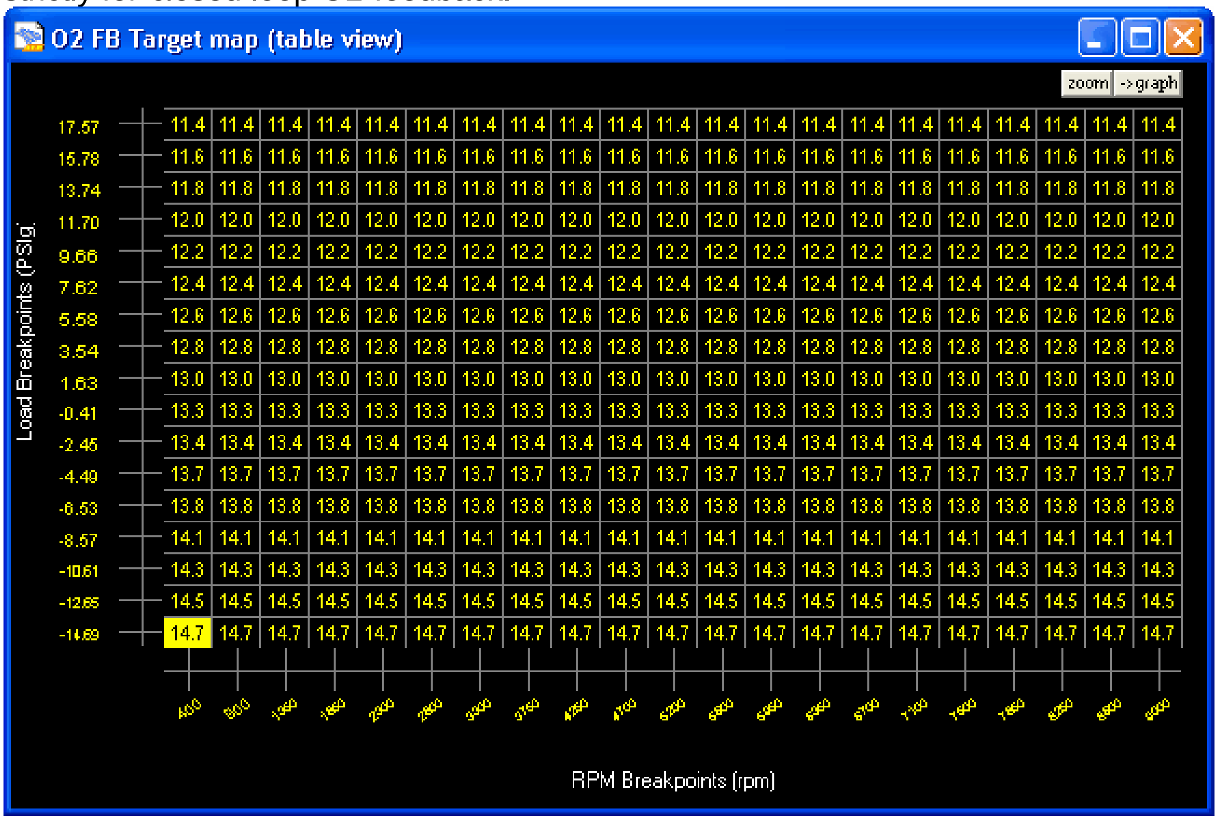


3-D Tables for O2 Feedback

O2 FB Target map

Units: Engine Load vs. RPM vs. AFR

Description: O2 feedback target for specific engine loads and RPM. This map is used strictly for closed loop O2 feedback.



Load \ RPM	400	800	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3750	[illegible]	4700	[illegible]	[illegible]	[illegible]	[illegible]	6700	7100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17.57	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4	11.4
15.78	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6
13.74	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8	11.8
11.70	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
9.66	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2	12.2
7.62	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4
5.58	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6	12.6
3.54	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8	12.8
1.63	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
-0.41	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3
-2.45	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4	13.4
-4.49	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7
-6.53	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8
-8.57	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1
-10.61	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3
-12.65	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5
-14.69	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7	14.7

Parameters (can be viewed or logged)

O2 FB Delay

Units: Seconds

Description: Time delay for O2 feedback operation after engine start.

O2 Target

Units: AFR

Description: Air fuel ratio that directly corresponds with the AFR Map.

O2 #1

Units: AFR

Description: Scaled air fuel ratio from Lambda #1.

O2 #1 Target Error

Units: AFR

Description: Difference between the actual air fuel ratio and the targeted air fuel ratio from Lambda #1.

O2 #1 FB Value
Units: Fuel %
Description: The current amount of fuel implemented in order to reach the air fuel ratio target.

O2 #2
Units: AFR
Description: Scaled air fuel ratio from Lambda #2.

O2 #2 Target Error
Units: AFR
Description: Difference between the actual air fuel ratio and the targeted air fuel ratio from Lambda #2.

O2 #2 FB Value
Units: Fuel %
Description: The current amount of fuel implemented in order to reach the air fuel ratio target.

O2 FB Cleared
Units: On/Off
Description: Displays if and when the O2 feedback has cleared its memory and resets back to zero when the closed loop conditions are met again.

O2 FB Frozen
Units: On/Off
Description: Displays if and when the O2 feedback has saved its previous fuel correction to reinstate when the closed loop conditions are met again.

O2 FB Pro Gain
Units: Multiplier
Description: Displays the current gain from the **O2 FB Pro Gain table**.

O2 FB Int Gain
Units: Multiplier
Description: Displays the current gain from the **O2 FB Int Gain table**.

O2 FB Status
Units: Binary Code
Description: Displays the current status of the O2 feedback function in binary code.

Accel O2 FB Hold
Units: mS
Description: The current hold time for the O2 feedback to be reinstated after the accel/decel function has been triggered.

Tuning O2 Feedback

The tuning procedure for O2 feedback can be quite tedious. One approach is to use a technique known as the Ziegler Nichols Tuning Method. The Ziegler Nichols closed loop method uses Proportional or P + I control and should produce tuning parameters which will obtain a quarter wave decay. The O2 feedback functions are located in the **Fuel** pull down menu in the AEMPro software.

1) Use the **O2 FB Pro Gain table** by itself and set the **O2 FB Int Gain table** to zero.
2) Log the parameters **O2 #1**(or #2) and **O2 #1 FB Value** (or #2).
3) Increase the proportional gain in the **O2 FB Pro Gain table** until the point of instability or a sustained oscillation is reached.
4) From here, the ultimate proportional gain (Gu) is found.
5) From the log, measure the period of oscillation from peak to peak, in seconds, to obtain the critical time constant or ultimate period (Pu).
6) Once the values for Gu and Pu are obtained, the P + I parameters can be calculated from the following equations.

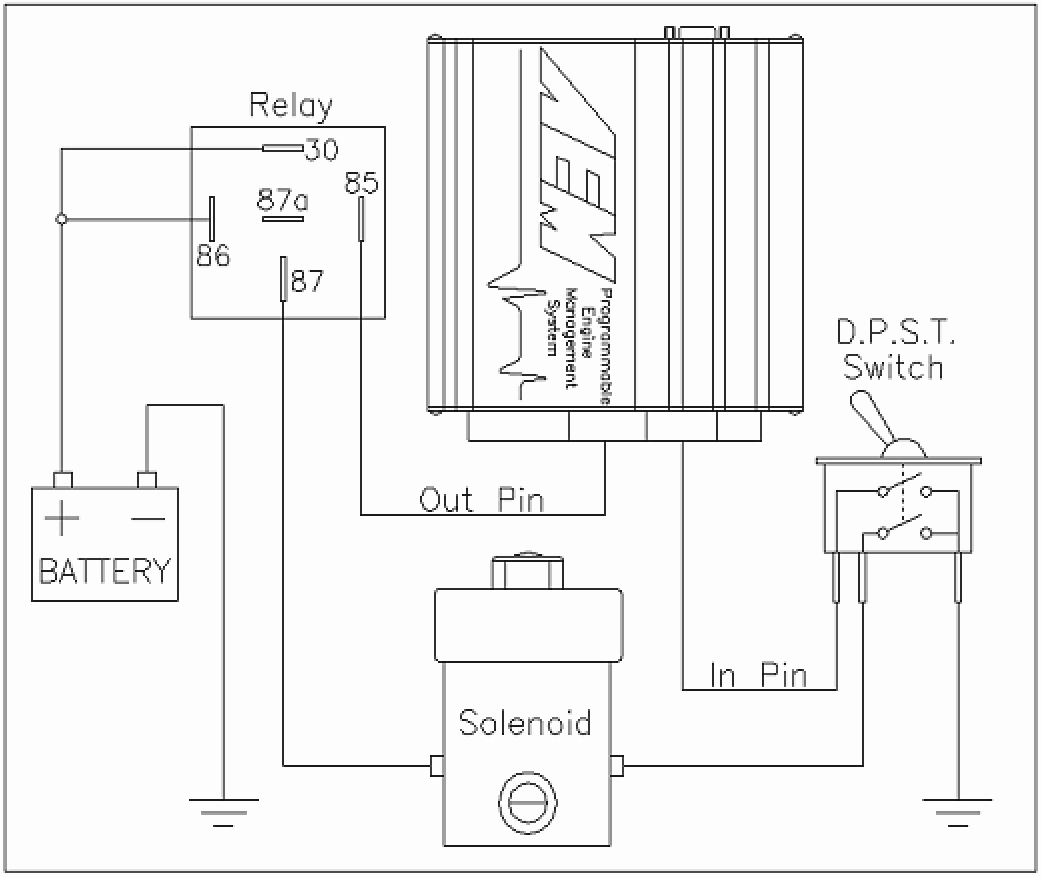
Proportional and Integral feedback
O2 FB Pro Gain table = 0.45 (Gu)
O2 FB Int Gain table = (Pu)/1.2

Note that these values are not optimal values and additional fine tuning may be required to obtain the best O2 feedback performance.

7.6 Nitrous Oxide

Nitrous Oxide

There are several ways to control nitrous oxide with the AEM EMS. The user has complete control over all of the nitrous functions, when it activates and deactivates the solenoids, and how much fuel and timing trims are added. Below is a diagram of how AEM recommends wiring a nitrous setup.



User Definable Options for Nitrous

NOS Control

Units: On/Off

Desciption: This option enables the nitrous control. Set this to ON to allow the nitrous control to become active.

NOS Switch In

Units: Switch Input

Desciption: This sets the input request for nitrous to become active under the set conditions.

NOS Output

Units: User Definable Output

Desciption: This sets the output which activates the relay for the nitrous control solenoid.

NOS Off Above Load

Units: Engine Load

Desciption: Above this engine load the EMS will deactivate the nitrous control. This can be used to spool a turbocharger, which will turn OFF the nitrous once the desired boost has been reached, or as a safety measure to prevent the nitrous from being active in an overboost situation. When the engine reaches this load point, the EMS will cut the active signal to the nitrous relay, and disable any trims that have been set. Set this to the maximum allowable pressure to be active.

NOS Reinstate Load
Units: Engine Load
Desciption: Hysteresis condition for nitrous load conditions. Must be set higher than **NOS Off Below Load** option and lower than the **NOS Off Above Load** condition.

NOS Off Below Load
Units: Engine Load
Desciption: The nitrous control will be OFF when below this engine load. Note: The nitrous will not necessarily be ON when above this engine load.

NOS Overrev Off
Units: RPM
Desciption: Nitrous will be activated only when the engine speed is below this value. This is an over-rev type function that should disable the nitrous under unsafe engine conditions or when on the rev limiter.

NOS Overrev On
Units: RPM
Desciption: Hysteresis condition for nitrous overrev condition. Must be set lower than **NOS Overrev Off** option.

NOS On Above TPS
Units: Thottle %
Desciption: Above this number, the nitrous will be active. Set this number just above the **NOS Off Below TPS** option.

NOS Off Below TPS
Units: Thottle %
Desciption: Below this number, the nitrous will be active. Set this number just below the **NOS On Above TPS** option.

NOS Maximum VSS
Units: Vehicle Speed
Desciption: Above this number, the nitrous will be deactivated. Set this number above the **NOS Minimum VSS** option.

NOS Minimum VSS
Units: Vehicle Speed
Desciption: Below this number, the nitrous will be deactivated. Set this number below the **NOS Maximum VSS** option.

3-D Maps for Nitrous

NOS Fuel map
Units: Engine Load vs Engine Speed vs Fuel %
Desciption: This map allows a percentage of additional fuel to be added or subtracted from the base map when the nitrous options become active. This map allows adjustment over engine speed and engine load.

NOS Ignition map
Units: Engine Load vs Engine Speed vs Degrees
Desciption: This map allows ignition timing to be advanced or retarded against the base ignition map when the nitrous control is active. This map is adjustable over engine speed and engine load.

Parameters (can be viewed or logged)

Nitrous
Units: On/Off
Description: Displays the current status of the nitrous function.

Nitrous Fuel
Units: Fuel %
Description: Displays the current amount of fuel added or subtracted from the **NOS Fuel map.**

Nitrous Spark
Units: Degrees
Description: Displays the current amount of ignition timing advanced or retarded from the **NOS Ignition map.**

Note: All of the nitrous options must be met for the EMS to activate the selected output and add the fuel and ignition trims. If any one of the options falls out of their ON conditions, the control will be disabled.

7.7 Cam/Crank Pickup

Cam/Crank Pickup

Unlike most engine management systems, the AEM EMS has a configurable pickup feature that supports many different timing patterns. Although this feature is found in the AEMPro software, all options, parameters, tables pertaining to this feature, will not be discussed. The use of the Cam/Crank Sensor Wizard is mandatory. Any problems with this wizard should be directed to AEM.

Setup | Sensors | Cam/Crank Sensor | Cam/Crank Sensor Wizard

7.8 Anti-Lag

Anti-Lag

Turbo lag is defined as the time delay before the turbocharger has produced boost pressure. Since turbochargers are designed and sized to operate at specific rpm ranges and air flow conditions, some turbo lag is inherent in the system. To fully understand turbo lag, you must first understand the operation principles behind what causes a turbo to make boost.

Boost is not made by rpm alone. There is a big difference in the airflow through an engine at 6,000 rpm in neutral, 6,000 rpm in first gear at part throttle, and 6,000 rpm in high gear at full throttle. Turbochargers are even more effected by these airflow differences and especially load differences than most other devices. This is why you may be able to see a small amount of boost with a positive displacement supercharger at WOT in neutral, but you will most likely not even see any boost at WOT in neutral with a turbocharger.

A given turbocharged vehicle may produce full boost in first gear by 3,500 rpm. This same vehicle may produce full boost in 4th gear by 2,300 rpm. The same vehicle, when pulling a heavy trailer, may produce full boost by 1,800 rpm even in 1st gear. These conditions are more specific to manual transmission vehicles as the boost has to build in each gear after the throttle is closed during the shift. Automatic transmission vehicles operate differently as they can be "loaded" by stalling up the converter and placing enough load to build boost before the vehicle even moves. Also, with an automatic transmission, the throttle is not shut during shifts which causes the boost to "pop up" because the turbo is supplying enough air flow to feed the boosted engine at high rpms and suddenly the rpms are drastically cut down by the shift as well as increased load has been placed on the system at the same time. This can cause an engine that is accelerating in 1st gear with low boost to instantly go to full boost upon shifting into 2nd gear.

Anti-lag is when a turbocharger is subjected to a very late burn causing the exhaust to expand in the turbine housing. This energy is concentrated at the turbocharger causing a very quick turbo spool up. The EMS supports two different types, including a rally style and drag race anti-lag.

User Definable Options for Drag Race Anti-Lag

Alt Ignition Fixed
Units: On/Off
Description: Enables the **Alt Spark Fixed** option in order to maintain a constant ignition timing value for anti-lag.

Alt Spark Fixed
Units: Degrees
Description: Sets a fixed ignition timing value while the alternate conditions are met. This is enabled by the **Alt Ignition Fixed** option.

Alt Spark Trim
Units: Degrees
Description: Amount of ignition spark to be trimmed (+/-) when the alternate trims are active.

Alt Fuel Trim
Units: %
Description: Percentage of fuel to be added when the alternate trims are active.

Alt Off Over RPM
Units: Engine Speed
Description: When above this rpm, the alternate trims and functions will deactivate.

Alt On Above RPM
Units: Engine Speed
Description: When above this rpm, but below the **Alt Off Over RPM** the alternate trims and functions will activate.

Alt Off Below TPS
Units: %
Description: When below this throttle position, the alternate trims and functions will deactivate.

Alt On Above TPS
Units: %
Description: When above this throttle position, the alternate trims and functions will activate.

Alt Overboost
Units: Engine Load
Description: When above this engine load, the alternate trims and functions will deactivate.

Alt On Above Load
Units: Engine Load
Description: When above this engine load, but below **Alt Overboost** the alternate trims and functions will activate.

Alt Function Output
Units: User Defined Output
Description: If the Alternate function is activated, this output channel will be activated also. Can be used to drive an LED, injector, etc.

Alt Function Input
Units: User Defined Input
Description: Input switch that triggers the alternate function.

Parameters (can be viewed or logged)

ALT
Units: On/Off
Description: Displays the current status of the alternate function.

Fuel Trim (Alt)
Units: uS
Description: Displays the fuel pulsewidth from the **Alt Fuel Trim** correction.

Tuning Drag Race Anti-lag

The basic idea is to fire the ignition after TDC to cause afterburn in the exhaust to spool the turbocharger to a desired boost level for launching the vehicle. There are a couple of things to consider to obtain the desired results.

- Engine Speed: The amount of engine speed is directly related to how much boost can be made under anti-lag conditions. A higher engine speed will equate to a higher boost level as well as a faster boost response. If you are unable to make the desired boost pressure for launching, no matter how much ignition retard is used, then more than likely you need to increase the **Alt On Above RPM**.
- Ignition Retard: The more the ignition is retarded, the more afterburn and heat will be put into the exhaust. Start at a conservative -10 degrees, and add more ignition retard until the desired time and boost is reached. Typical numbers are between -15 and -20 degrees of ignition. Either the **Alt Spark Fixed** or the **Alt Spark Trim** can be used for retarding the ignition.
- Engine Load: If the boost control is set at "x" pressure, then no more "x" pressure can be obtained when launching. The option **Alt Overboost**, however, will allow a lower launch boost than the operating boost setting, by turning OFF the alternate function when the engine load has surpassed the option.
- Additional Fuel: Added fuel will also aid in the anti-lag process by insuring the fuel mixture will be there throughout the engine cycle. A typical value for **Alt Fuel Trim** is 5-10%

User Definable Options for Rally Style Anti-Lag

Anti-Lag Control
Units: On/Off
Description: Enables the rally style anti-lag function.

Anti-Lag Input
Units: User Definable Switch
Description: Input switch to trigger the rally style anti-lag function.

2-D Tables for Rally Style Anti-Lag

Fuel Rev Limit table
Units: RPM vs Throttle
Description: TPS dependant fuel rev limiter at specific engine speeds for rally style anti-lag

Ign Rev Limit table
Units: RPM vs Throttle
Description: TPS dependant ignition rev limiter at specific engine speeds for rally style anti-lag

Retard Rev Limit table
Units: RPM vs Throttle
Description: TPS dependant ignition retard activation at specific engine speeds for rally style anti-lag

Parameters (can be viewed or logged)

Anti-Lag
Units: On/Off
Description: Displays the current status of the rally style anti-lag function.

Ign Retard Limit
Units: Degrees
Description: Displays the maximum allowable ignition retard from the rally style anti-lag function.

Tuning Drag Rally Style Anti-lag

7.9 EGT Control

EGT Control

With monitoring up to 4 EGT sensors, the AEM EMS can also control the exhaust gas temperature with the use of a temperature dependant fuel table. The EMS is configured to accept RTD (Resistant Temperature Device) EGT sensors. This type of sensor is faster responding than conventional K-type thermocouples and does not require a special wire type or length.

Ignition timing plays a significant part in exhaust gas temperature. High temperatures can be a result of retarded ignition timing as well as a lean condition in the fuel mixture. Always use an oxygen sensor in conjunction with EGT sensors to determine a proper engine tune.

User Definable Options for EGT Control

EGT Fuel Control
Units:On/Off
Description: This activates the EGT feedback which enables the **EGT Fuel Correction Table**

EGT Failsafe
Units: Temperature
Description: This is the default reading if the EGT sensor goes out of the **EGT Fail Minimum** or **EGT Fail Maximum** range.

EGT Fail Maximum
Units: Temperature

Description: This is the maximum allowable reading from the EGT Sensor before it goes to **EGT Default**.

EGT Fail Minimum
Units: Temperature
Description: This is the minimum allowable reading from the EGT Sensor before it goes to **EGT Default**.

EGT#1 Analog Input
Units: User Selectable Analog Input
Description: This assigns the input to read as **EGT #1**

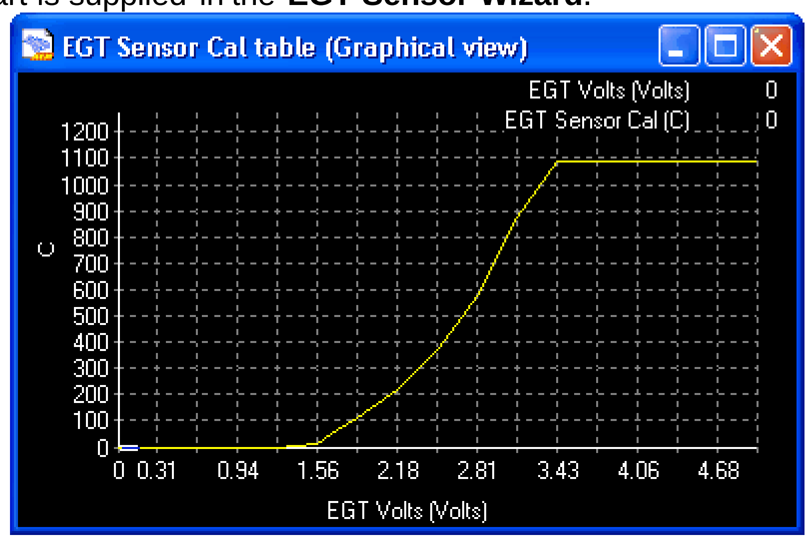
EGT#2 Analog Input
Units: User Selectable Analog Input
Description: This assigns the input to read as **EGT #2**

EGT#3 Analog Input
Units: User Selectable Analog Input
Description: This assigns the input to read as **EGT #3**

EGT#4 Analog Input
Units: User Selectable Analog Input
Description: This assigns the input to read as **EGT #4**

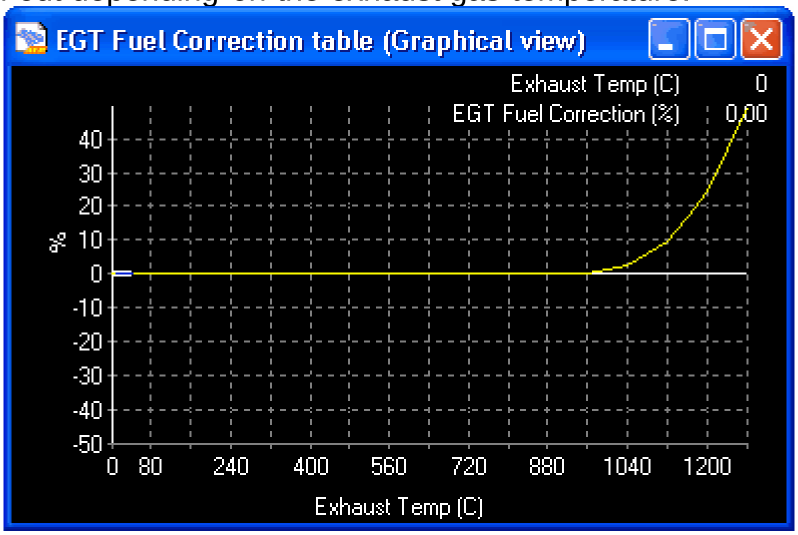
2-D Tables for EGT Control

EGT Sensor Cal table
Units: Temperature vs Voltage
Description: This table calibrates the input voltage from the sensor to the value that will be displayed at specific voltages. If using the EGT sensor from AEM, a calibration chart is supplied in the **EGT Sensor Wizard**.



EGT Fuel Correction table

Units: Fuel % vs Temperature
Description: This is the table for the feedback control of the EGT sensor for fuel to be added or taken out depending on the exhaust gas temperature.



Parameters (can be viewed or logged)

EGT #1
Units: Temperature
Description: Displays the current exhaust gas temperature for **EGT #1** in units specified by the end user

EGT #2
Units: Temperature
Description: Displays the current exhaust gas temperature for **EGT #2** in units specified by the end user

EGT #3
Units: Temperature
Description: Displays the current exhaust gas temperature for **EGT #3** in units specified by the end user

EGT #4
Units: Temperature
Description: Displays the current exhaust gas temperature for **EGT #4** in units specified by the end user

EGT #1 Voltage
Units: Volts
Description: Displays the current voltage directly from the **EGT #1** sensor.

EGT #2 Voltage
Units: Volts
Description: Displays the current voltage directly from the **EGT #2** sensor.

EGT #3 Voltage
Units: Volts
Description: Displays the current voltage directly from the **EGT #3** sensor.

EGT #4 Voltage
Units: Volts
Description: Displays the current voltage directly from the **EGT #4** sensor.

EGT #1 Fuel Corr.
Units: %
Description: Displays the current **EGT #1** fuel correction percentage from **EGT Fuel Correction table.**

EGT #2 Fuel Corr.
Units: %
Description: Displays the current **EGT #2** fuel correction percentage from **EGT Fuel Correction table.**

EGT #3 Fuel Corr.
Units: %
Description: Displays the current **EGT #3** fuel correction percentage from **EGT Fuel Correction table.**

EGT #4 Fuel Corr.
Units: %
Description: Displays the current **EGT #4** fuel correction percentage from **EGT Fuel Correction table.**

7.10 Variable Valve Control

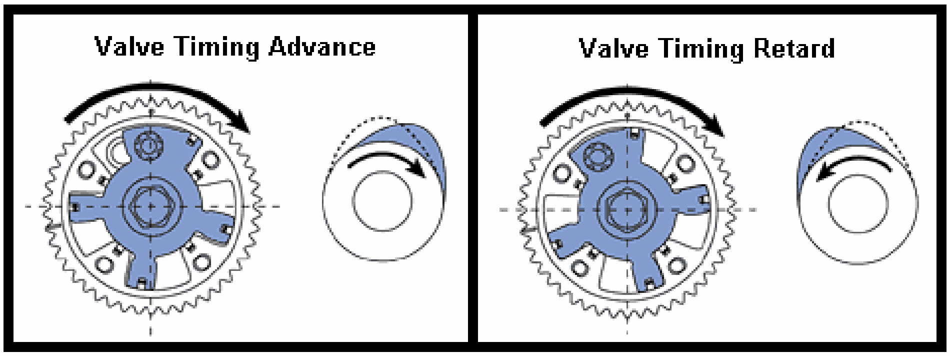
Variable Valve Control (VVC)

WARNING: Improper use of VVC in the AEMPro software will result in engine damage. AEM Plug N' Play base maps that use VVC are tuned for stock camshafts. Any different camshaft used will require a rework of the base calibration file.

Some engines use VVC with the addition of some form of alternating cam profile system like VTEC from Honda, VVL from Nissan, MIVEC from Mitsubishi, etc. It is important to note that even if stock camshafts are used with the base VVC mapping unchanged, engine failure can result if the alternating cam profile system is tuned improperly.

If the VVC system and camshaft mechanics are unknown, it is highly recommended to disable or set the VVC to a failsafe mode until the information is resourced and a plan of action is set forth.

The AEM EMS supports single and/or twin channel variable valve engines. This is performed in a closed loop system for maximum control. The cam signal is used to detect the cam position and a pulse-width modulated signal controls the position. In the AEMPro software, the variable valve control function is named VVC#1 and VVC#2. Note: Either VVC#1 or VVC#2 can be used for a single channel VVC engine.



Variable Valve Control

Variable Valve Control #1 Input

The input signal reference for VVC#1 is hard-coded as Cam. The cam positions are determined by capturing the relevant timing edge and scaling it into degrees:

$$\text{Cam\#1 Angle} =$$

$$\text{Cam\#1 ADV} = (\text{Cam\#1 Angle} - \text{Cam\#1 Start}) \times \text{Cam Range}$$

$$\text{Cam Range} = \qquad / \, 0.8$$

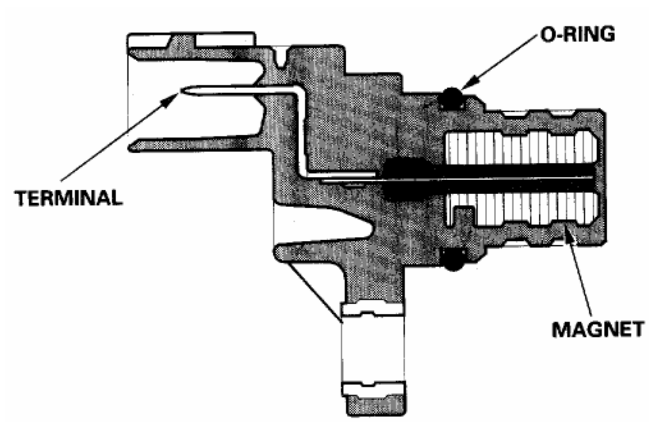
Variable Valve Control #2 Input

The input signal reference for VVC#2 is hard-coded as Speed. Note: the Speed input is typically used for Vehicle Speed. However, the VVS Input option is programmable and can be set to the Spare Speed Input. The cam positions are determined by capturing the relevant timing edge and scaling it into degrees:

$$\text{Cam\#2 Angle} =$$

$$\text{Cam\#2 ADV} = (\text{Cam\#2 Angle} - \text{Cam\#2 Start}) \times \text{Cam Range}$$

$$\text{Cam Range} = \quad / \ 0.8$$



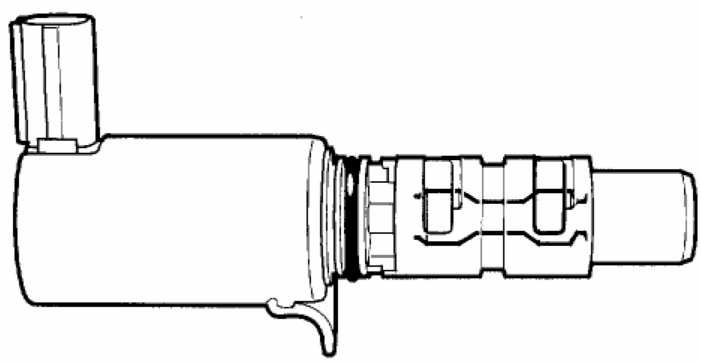
Variable Valve Control Position Sensor

Variable Valve Control Output

The pulse-width modulated output for VVC#1 is hard-coded as Injector #9. The pulse-width modulated output for VVC#2 is hard-coded as Injector #10.

To switch the injector outputs into a pulse-width modulated output for VVC, the Injector #9 and/or Injector #10 options must be OFF. The options PWM#9 and/or PWM#10 must be ON to enable the outputs for VVC. The option PWM#9/10 Period is a common time base used for both PWM#9 and PWM#10 to establish the appropriate frequency.

When the engine is below the Crank Exit RPM option, the duty cycle output is set at VVC#1(#2) Stopped. If above Crank Exit RPM, but the cam sensor has no signal, the duty cycle is set atVVC#1(#2) Default.


Variable Valve Control Solenoid

Variable Valve Controls

The open loop duty cycle is taken directly from the VVC#1(#2) Duty Table. This duty cycle is constrained by the options VVC Out min and VVC Out max.

The closed loop system modifies the open loop output using the VVC#1(#2) Error table and a proportional and integral feedback in an attempt to achieve the cam degree target that is entered in the Valve#1(#2) Map. The range of this duty cycle feedback is constrained by VVC FB min and VVC FB max.

$$\text{VVC\#1(\#2) Out} = \text{VVC\#1(\#2) Duty table} + \text{VVC\#1(\#2) Error table} + \text{VVC\#1(\#2) FB}$$

$$\text{VVC\#1(\#2) FB} = \text{VVC\#1(\#2) error} \times \text{VVC\#1(\#2) FB P} + \text{VVC\#1(\#2) I (old)} \times \text{VVC\#1(\#2) FB I}$$

User Definable Options for Variable Valve Control

Valve Control
Units: On/Off
Description: Enables VVC#1 and/or VVC#2

VVC#1 invert
Units: On/Off
Description: Inverts the VVC#1 duty cycle output signal. This can be used to switch the direction of the camshaft.

VVC#2 invert
Units: On/Off
Description: Inverts the VVC#2 duty cycle output signal. This can be used to switch the direction of the camshaft.

Cam Falling Edge
Units: On/Off

Description: Selects to trigger from the falling edge of the Cam input

Cam Rising Edge
Units: On/Off
Description: Selects to trigger from the rising edge of the Cam input

Cam High Sens Below
Units: Engine Speed
Description: Switches from low to high sensitivity when below this engine speed. This is used when the Cam input signal is not strong enough to trigger from.

Cam Low Sens Above
Units: Engine Speed
Description: Switches from high to low sensitivity when above this engine speed. This is used when the Cam input signal is not strong enough to trigger from.

Speed Falling Edge
Units: On/Off
Description: Selects to trigger from the falling edge of the Speed input

Speed Rising Edge
Units: On/Off
Description: Selects to trigger from the rising edge of the Speed input

Speed H Sens Below
Units: Engine Speed
Description: Switches from low to high sensitivity when below this engine speed. This is used when the Speed input signal is not strong enough to trigger from.

Speed L Sens Above
Units: Engine Speed
Description: Switches from high to low sensitivity when above this engine speed. This is used when the Speed input signal is not strong enough to trigger from.

PWM#9
Units: On/Off
Description: Switches the Injector #9 output to a pulse width modulated output for VVC#1

PWM#10
Units: On/Off
Description: Switches the Injector #10 output to a pulse width modulated output for VVC#2

PWM#9/10 period
Units: uS
Description: Sets the output frequency for both PWM#9 and PWM#10. This can be

found by looking up the manufacturer specification sheet or by taking an oscilloscope trace with the factory ECU installed.

Cam Range
Units: Degrees/tooth
Description: Allows the software to recognize the range of the camshaft by using the following formula: Cam Range = (360 Degrees / # of Fuel Teeth per rev) / 0.8

Cam#1 Start
Units: Teeth
Description: Tells the software the correct tooth of where the VVC#1 camshaft range begins

Cam#2 Start
Units: Teeth
Description: Tells the software the correct tooth of where the VVC#2 camshaft range begins

VVC#1 default
Units: Duty Cycle %
Description: Sets the VVC#1 camshaft to a safe position when the VVC#1 input signal has failed.

VVC#2 default
Units: Duty Cycle %
Description: Sets the VVC#2 camshaft to a safe position when the VVC#2 input signal has failed.

VVC#1 stopped
Units: Duty Cycle %
Description: Sets the VVC#1 camshaft to a safe position when below the Crank Exit RPM

VVC#2 stopped
Units: Duty Cycle %
Description: Sets the VVC#2 camshaft to a safe position when below the Crank Exit RPM

VVC Out max
Units: Duty Cycle %
Description: Sets the allowable solenoid range and constrains camshaft movement by limiting the PWM#9 and PWM#10 duty cycle output. This can also be used be whenever piston to valve contact is possible.

VVC Out min
Units: Duty Cycle %
Description: Limits camshaft movement by limiting the PWM#9 and PWM#10 duty

cycle output. This should be whenever piston to valve contact is possible.

VVC#1 FB I
Units: Time Constant
Description: Integral control is implemented through the introduction of an integrator. Integral control is used to provide the required accuracy for the control system. This is used to fine tune the VVC at the target cam degree once the proportional has acted in getting close to the target. Note: start tuning the VVC feedback with this option at zero, until the proportional has it close to the target, then step this in slowly until the target cam degree is achieved. This value should be a negative value.

VVC#2 FB I
Units: Time Constant
Description: Integral control is implemented through the introduction of an integrator. Integral control is used to provide the required accuracy for the control system. This is used to fine tune the VVC at the target cam degree once the proportional has acted in getting close to the target. Note: start tuning the VVC feedback with this option at zero, until the proportional has it close to the target, then step this in slowly until the target cam degree is achieved. This value should be a negative value.

VVC#1 FB P
Units: Gain Multiplier
Description: Proportional control is a pure gain adjustment acting on the error signal to provide the driving input. It is used to adjust the speed of the system and reach the target cam degree quickly. The advantage of a proportional-only control is its simplicity. If cam degree offsets can be tolerated, the use of a proportional controller may be optimal. However, it will not eliminate the steady-state error that occurs after a set-point change. Note: When tuning VVC and overshoot occurs, lower this value. If undershooting the target cam degree, raise this value. This value should be a negative value.

VVC#2 FB P
Units: Gain Multiplier
Description: Proportional control is a pure gain adjustment acting on the error signal to provide the driving input. It is used to adjust the speed of the system and reach the target cam degree quickly. The advantage of a proportional-only control is its simplicity. If cam degree offsets can be tolerated, the use of a proportional controller may be optimal. However, it will not eliminate the steady-state error that occurs after a set-point change. Note: When tuning VVC and overshoot occurs, lower this value. If undershooting the target cam degree, raise this value. This value should be a negative value.

VVC FB max
Units: Duty Cycle %
Description: Sets the maximum feedback correction allowed in the positive duty direction when using closed loop. Used to set correction limits and help stabilize cam angle. This function can help prevent overshooting.

VVC FB min
Units: Duty Cycle %
Description: Sets the maximum feedback correction allowed in the negative duty direction when using closed loop. Used to set correction limits and help stabilize cam angle. This function can help prevent overshooting.

2-D Tables for Variable Valve Control

VVC#1 Duty table
Units: Duty Cycle % vs. VVC#1 Target
Description: This table is used to automatically compensate duty cycle for different cam angle targets. Inevitably, this allows the feedback control to do less work and will further enhance valve control.

VVC#2 Duty table
Units: Duty Cycle % vs. VVC#2 Target
Description: This table is used to automatically compensate duty cycle for different cam angle targets. Inevitably, this allows the feedback control to do less work and will further enhance valve control.

VVC#1 Error Duty table
Units: Duty Cycle vs. VVC#1 Error
Description: The vertical line in the center of the table, at zero cam degree error, represents the cam angle target that the solenoid is trying to achieve. The direction of this curve is dependant of how the solenoid operates. This table is used to stabilize the cam angle.

VVC#2 Error Duty table
Units: Duty Cycle vs. VVC#2 Error
Description: The vertical line in the center of the table, at zero cam degree error, represents the cam angle target that the solenoid is trying to achieve. The direction of this curve is dependant of how the solenoid operates. This table is used to stabilize the cam angle.

3-D Maps for Variable Valve Control

VVC#1 map
Units: Load vs. RPM vs. Cam#1 Degree
Description: This map sets the target cam#1 angle in degrees for each engine load and engine speed breakpoint. It is important to know the engine's valve limitations before setting up this map.

VVC#2 map
Units: Load vs. RPM vs. Cam#2 Degree
Description: This map sets the target cam#2 angle in degrees for each engine load and engine speed breakpoint. It is important to know the engine's valve limitations before setting up this map.

Parameters for Variable Valve Control (can be viewed or logged)

Cam#1 ADV
Units: Cam Degrees
Description: Displays the current cam angle of cam#1

Cam#2 ADV
Units: Cam Degrees
Description: Displays the current cam angle of cam#2

Cam#1 Angle
Units: Teeth
Description: Displays the current tooth position from the Cam input

Cam#2 Angle
Units: Teeth
Description: Displays the current tooth position from the Speed input

VVC#1 Correct
Units: Duty Cycle %
Description: Displays the current amount of feedback correction for VVC#1 directly from the VVC#1 Error table.

VVC#2 Correct
Units: Duty Cycle %
Description: Displays the current amount of feedback correction for VVC#2 directly from the VVC#2 Error table.

VVC#1 Duty table
Units: Duty Cycle %
Description: Displays the current duty cycle directly from the VVC#1 Duty table

VVC#2 Duty table
Units: Duty Cycle %
Description: Displays the current duty cycle directly from the VVC#2 Duty table

VVC#1 error
Units: Cam Degrees
Description: Displays the current cam degree error from the VVC#1 Target

VVC#2 error
Units: Cam Degrees
Description: Displays the current cam degree error from the VVC#2 Target

VVC#1 FB
Units: Duty Cycle %

Description: Displays the current amount of feedback correction for VVC#1 from the P + I controller

VVC#2 FB
Units: Duty Cycle %
Description: Displays the current amount of feedback correction for VVC#2 from the P + I controller

VVC#1 Out
Units: Duty Cycle %
Description: Displays the actual PWM#9 duty cycle output to the VVC#1 solenoid

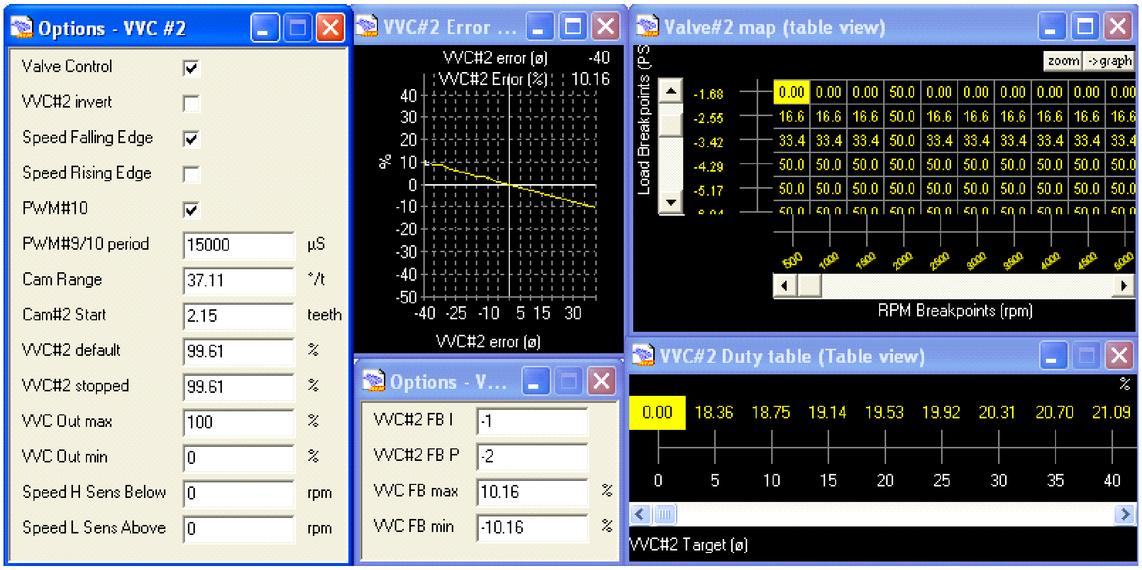
VVC#2 Out
Units: Duty Cycle %
Description: Displays the actual PWM#10 duty cycle output to the VVC#2 solenoid

VVC#1 Target
Units: Cam Degrees
Description: Displays the current cam degree target directly from the Valve#1 map

VVC#2 Target
Units: Cam Degrees
Description: Displays the current cam degree target directly from the Valve#2 map

Variable Valve Control Setup

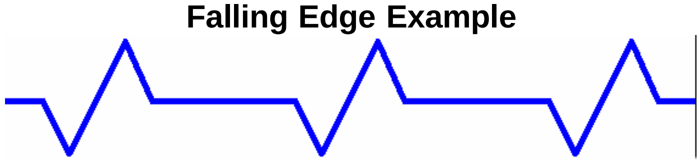
If using an AEM EMS Plug N' Play, the VVC is already setup in the base map(s). If not using an AEM EMS Plug N' Play, it is recommended to have an AEM EMS Factory Trained Tuner setup the VVC. It is important to note that it may be very easy to destroy your engine with improper use of VVC.



Variable Valve Control Setup Example

1. Go to: Setup | <<Advanced Setup>> | Variable Valve Control.
2. Select Valve #1 if using Cam as the input and Injector #9 as the output. Select Valve #2 if using Speed as the input and Injector #10 as the output.
3. To enable VVC, check the option Valve Control and check either PWM#9 (or PWM#10).
4. Set the option PWM#9/10 period to the appropriate solenoid frequency. This can be found by looking up the manufacturer specification sheet or by taking an oscilloscope trace with the factory ECU installed.
5. If a Hall Effect Sensor is being used for the VVC input, the Cam (or Speed) Falling Edge and/or Rising Edge can be selected.
6. If a Magnetic Sensor is being used for the VVC input, use an oscilloscope to trace the input signal.
7. Select the edge of the VVC input that passes rapidly through 0.

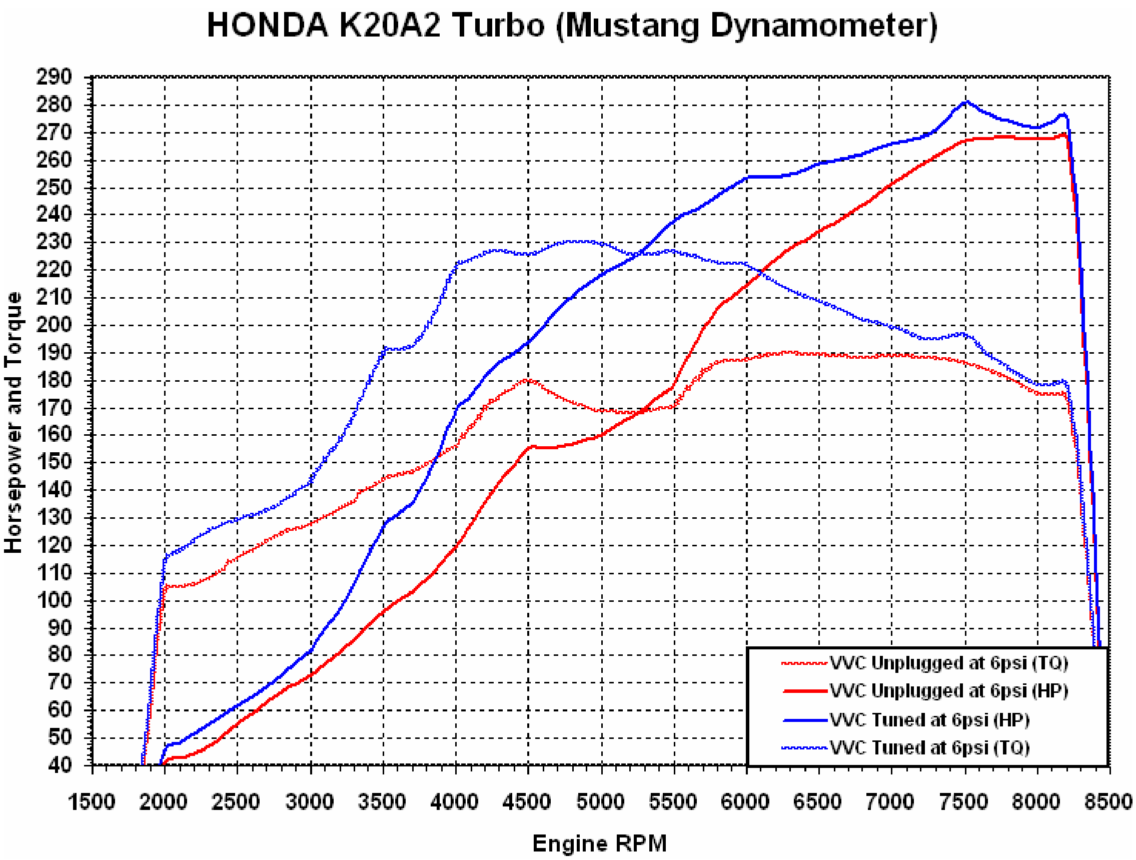
Falling Edge Example



Rising Edge Example

8. Calculate and enter in the option Cam Range = (360 Degrees / # of Fuel Teeth per rev) / 0.8
9. Set the entire VVC#1(#2) Error table to 0.
10. Set the options VVC Out min and VVC Out max to the maximum allowable range specified by the solenoid manufacturer. These options can also limit variable camshaft rotation to eliminate piston to valve contact if physically possible.

11. Set the option VVC#1(#2) default to a duty cycle that is safe when the sensor has failed.
12. Open the VVC#1(#2) Duty table (Table view)
13. At 0 degrees enter 0% duty cycle.
14. Enter 100% duty cycle at the maximum allowable degree that the cam gear will allow. Check with the engine manufacturer if this information is unknown. Highlight the table from this point by holding down the shift key and tapping on the left arrow until 0 is reached.
15. To interpolate the difference, click "M" for menu and "L" for calculate.
16. Open the Valve #1(#2) map
17. Set the appropriate degrees at low engine speed and low engine load for a stable idle. For testing VVC, set the map so the entire cam range will be used with just a quick low load rev up (this is for set up only).
18. Set the option VVC#1(#2) stopped to a duty cycle that is best for engine cranking.
19. Start the engine and log the parameter Cam#1(#2) Angle.
20. Rev the engine so the entire cam degree range is being logged. View the log.
21. Set the option Cam#1(#2) Start to the lowest Cam#1(#2) Angle found in the logged data. Note: the midpoint of the VVC range can now be determined and may be useful for a safe starting point.
22. Rev the engine again while watching the VVC#1(#2) Duty table and the VVC#1(#2) Error table making sure to test the entire cam range. Enter the appropriate values in the duty table so that the error table is maintained as close to 0 error as possible.
23. Enter a first pass estimate of required advance in the Valve#1(#2) map. Data log the relationship between VVC#`1(#2) Target, VVC#1(#2) Error, and Cam#1(#2) ADV.
24. From this data, fill in the VVC#1(#2) Error table with a restoring function. Set the option VVC FB max to 10% and VVC FB min to 10%. Check that the response has improved.
25. Now decrease from zero the VVC#1(#2) FB P and VVC#1(#2) FB I control loop settings.
26. Adjust the error table and proportional and integral control constants until acceptable control is achieved. Usually a bell error curve will result with a standard deviation of less than 2 degrees.
27. Tune the Valve#1(#2) map for best torque, fuel economy, and/or clean emissions.



Example of the torque potential from VVC tuning

7.11 Traction Control

Traction Control

Most OEM and available aftermarket traction control systems use the differential of a front and rear wheel speed sensor to determine traction conditions. While this is great way to control wheel slippage, it does not address all wheel drive (AWD) vehicles as all wheels spin at the same rate. AWD manufacturers do not use traction control on their vehicles as power distributing to four wheels is typically sufficient. However, AWD racing in snow, dirt, and gravel like WRC and Pike's Peak is a whole different story.

The AEM EMS traction control is the solution for all types of vehicles including 2WD and AWD. The EMS uses "acceleration" as the basis for traction control as all applications have an engine speed and vehicle speed input. And because most vehicles do not come standard with wheel speed sensors, this is the obvious choice for plug n' play traction control.

Under optimum traction conditions with no wheel slippage, the maximum rate of acceleration can be determined by:

1. Engine performance
2. Transmission gear ratios
3. Final drive ratio
4. Drive train losses
5. Tire size and tread pattern
6. Vehicle gross weight

If a loss of traction occurs during hard vehicle acceleration, the acceleration rate will exceed the rate possible under optimum conditions.

Theory of Operation

The EMS uses several different methods to calculate acceleration. The following are definitions for each calculation method:

A. Option **TC Timebase** OFF:

1. Option **TC Speed/Time** ON:

$$\text{Engine Accel Raw} = \frac{\Delta\ \text{RPM}}{\text{Engine Rev}}$$

2. Option **TC Speed/Time** OFF:

$$\text{Engine Accel Raw} = \frac{\Delta\ \text{Tooth Time}}{\text{Engine Rev}}$$

B. Option **TC Timebase** ON:

1. Option **TC Speed/Time** ON:

$$\text{Engine Accel Raw} = \frac{\Delta\ \text{RPM}}{4.1\ \text{ms}}$$

2. Option **TC Speed/Time** OFF:

$$\text{Engine Accel Raw} = \frac{\Delta\ \text{Tooth Time}}{4.1\ \text{ms}}$$

The parameter **Engine Accel raw** can be used to view or log the results from the calculation above. Once the Raw Engine Acceleration is calculated, a sensitivity factor is applied and the result is scaled versus the option **TC Max**. The calculation is as follows:

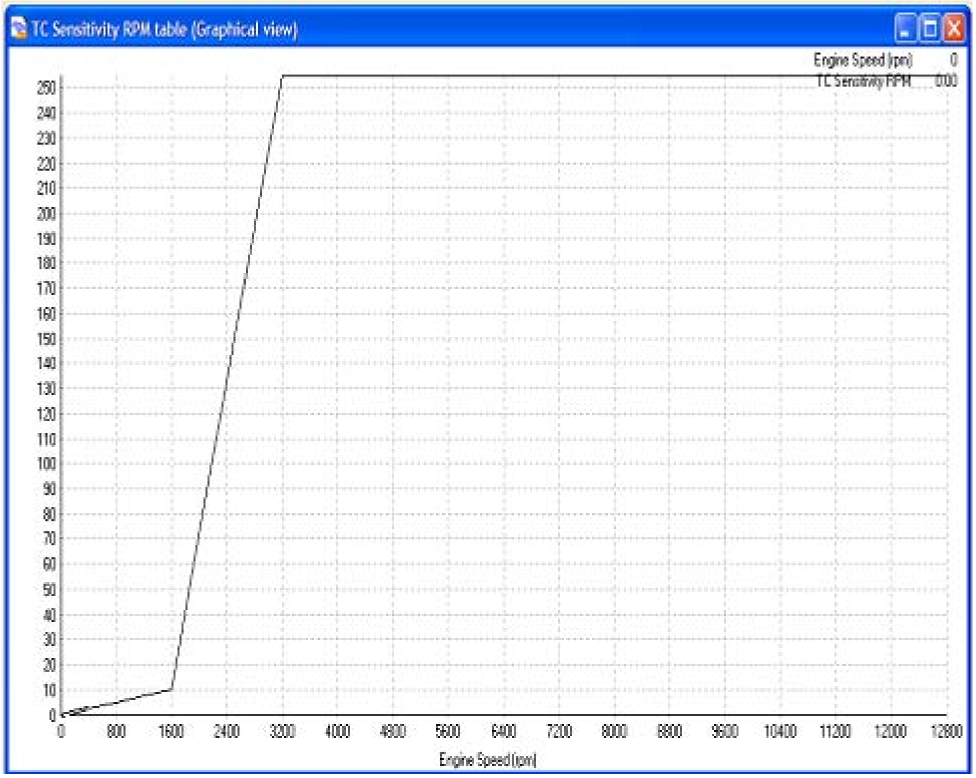
$$\text{Accel Rate} = \frac{(\text{Engine Accel Raw})*(\text{TC Sensitivity Table})}{\text{TC Max}}$$

Where **TC Max** is the maximum raw engine acceleration rate possible under optimum traction conditions.

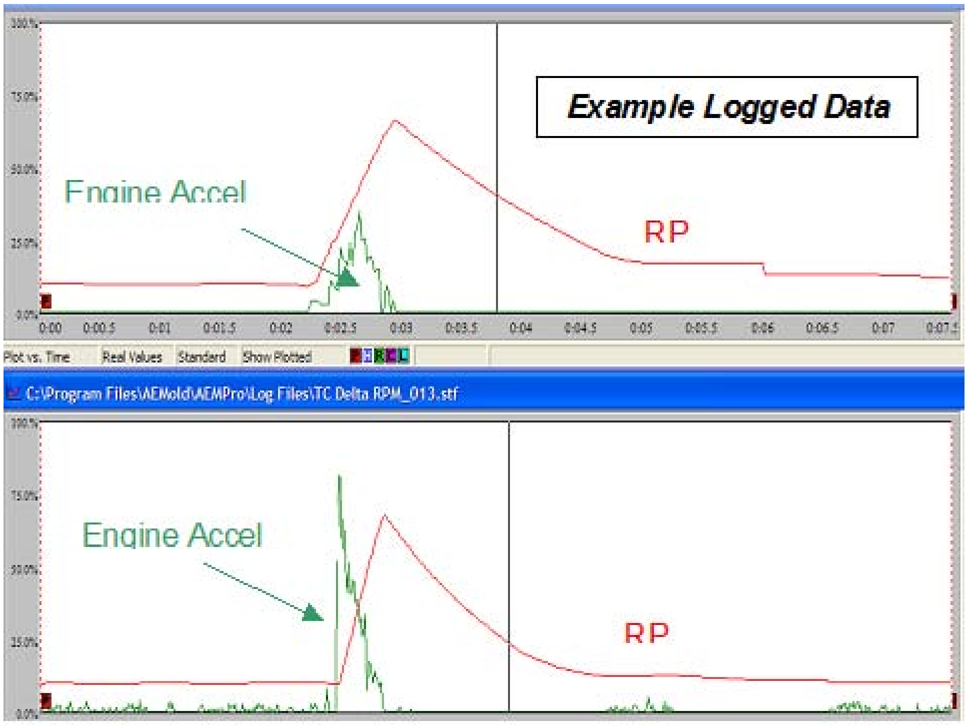
The **TC Sensitivity Table** can be based on either Engine RPM or Vehicle Speed and is used to adjust the acceleration sensitivity. A value of 255 represents maximum sensitivity. Note that the viewed or logged data for Engine Acceleration is *proportional to* actual Engine Acceleration in units such as Rev/Sec^2. The raw data can be manipulated in many ways to achieve the required results.

Sensitivity Tables

The following is an example of how the **TC RPM Sensitivity Table** affects *Engine Acceleration Rate*:



The log files below show the results. The top plot is a log of the parameters **Engine RPM** and **Engine Accel Rate** and was recorded using the **TC Sensitivity RPM Table** above. This log shows the effect of reduced sensitivity at low RPM. The bottom plot was recorded using a constant sensitivity. If the **TC vs Road Speed** option is checked, the sensitivity will be based on vehicle speed. If this option is not checked, the sensitivity is based on engine RPM.

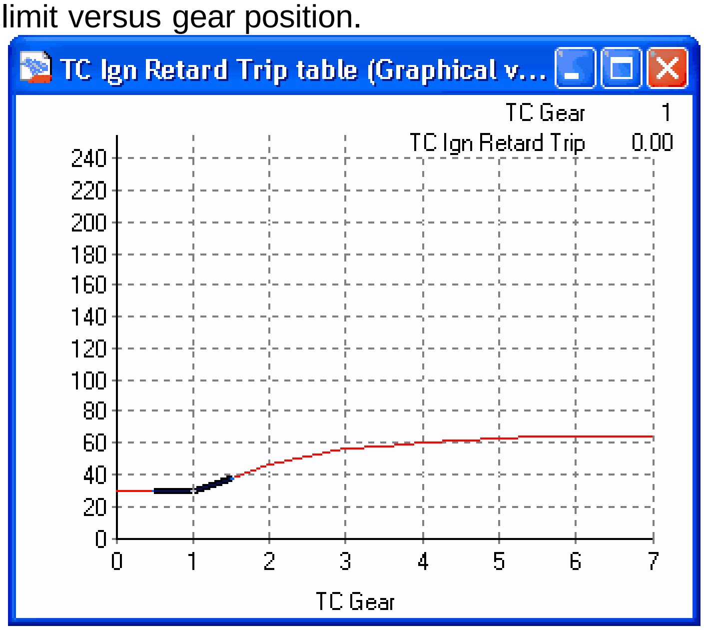


Trip Tables

With traction control enabled, the parameter **Engine Accel Rate** is compared to limits identified in the following tables:

1. **TC Ignition Retard Trip Table**
2. **TC Ignition Cut Trip Table**
3. **TC Fuel Cut Trip Table**

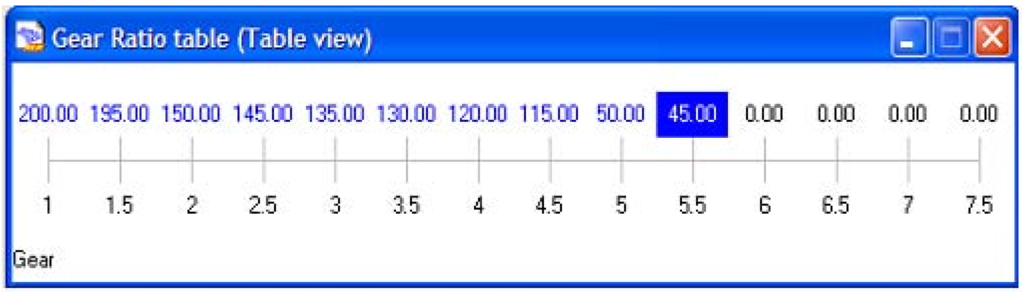
The above tables are gear position sensitive and allow the user to define an Engine Acceleration Rate limit versus gear position.



The above trip table for the ignition retard function shows a increasing limit with gear position. Using the above table, a value greater than 30 for the parameter **Engine Acceleration Rate** in first gear will enable the ignition retard function. A value greater than 60 in fourth gear will enable the ignition retard function.

The trip tables for the ignition cut and fuel cut functions are set up in a similar fashion. Normally, the first line of defense for a loss of traction condition is ignition retard. If the ignition retard function is unsuccessful, an ignition/fuel cut combination can be implemented.

To allow the EMS to correctly calculate gear position based on gear ratio, the **Gear Ratio table** must be defined as follows:



In the above example, first gear is defined as having a calculated gear ratio of between 200 and 195. Second gear is defined as having a calculated gear ratio of between 150 and 145. To define this table, drive in each gear position while logging the parameter **Gear Ratio**. If the logged values are very low, use the option **GearCal M** to increase the amplitude of the signal then fill in this table with low and high limits for each gear position. When this table is correctly defined, view or log the parameter **Gear Calculated** to determine gear position from the calculated parameter **Gear Ratio**.

User Definable Traction Control Options

Traction Control

Units: On/Off

Description: Enables traction control.

TC Speed/Time

Units: On/Off

Description: Allows engine speed to be used for the engine acceleration rate calculation. When OFF, traction control uses tooth time for engine acceleration rate calculation.

TC vs Road Speed

Units: On/Off

Description: Allows traction control to be vehicle speed dependant opposed to RPM dependant with enabling the **TC Sensitivity VSS Table**.

TC Max
Units: Accel Raw
Description: Sets the maximum raw engine acceleration rate possible under optimum traction conditions

TC Ign Retard
Units: Degrees
Description: Sets the amount of ignition retard used when the limit defined in the **Ignition Retard Trip Table** is exceeded.

TC Ign Cut
Units: %
Description: Sets the amount of ignition cut used when the limit defined in the **Ignition Cut Trip Table** is exceeded.

TC Fuel Cut
Units: %
Description: Sets the amount of fuel cut used when the limit defined in the **Fuel Cut Trip Table** is exceeded.

TC Ign Retard Resto
Units: Degrees
Description: Sets the amount of ignition advance returned to the ignition timing calculation per engine revolution. This option is used to remove the ignition retard. A small number will return the timing slowly. A large number will return the timing quickly.

TC Ign Restore
Units: %
Description: This option defines the amount of ignition cut % removed per engine revolution. A small number will remove the cut slowly. A large number will remove the cut quickly.

TC Fuel Restore
Units: %
Description: This option defines the amount of fuel cut % removed per engine revolution. A small number will remove the cut slowly. A large number will remove the cut quickly.

TC Gear From Sensor
Units: On/Off
Description: Use this option for automatic transmission applications where a variable resistance potentiometer is used to determine gear lever position.

TC Gear Ratio
Units: On/Off
Description: Select this option if gear position must be determined based on the ratio

of engine speed versus vehicle speed (manual transmission applications with no gear position sensor input).

TC Switch Input
Units: User Defined Switch Input
Description: Option used to define a switched input to enable traction control.

TC Adjust Input
Units: User Defined Analog Input
Description: Option used to setup a 0-5V input through a potentiometer. When this input is activated, the signal will adjust the acceleration sensitivity externally. This can be used to establish different settings for varying road conditions and tire selection.

TC Min VSS
Units: Vehicle Speed
Description: Traction control is disabled below the vehicle speed defined by this option.

TC Timebase
Units: On/Off
Description: When ON, the engine acceleration rate is calculated using a 4.1mS time constant opposed to engine revolutions.

GearCal Spd 1
Units: User selectable input
Description: Option normally reserved for engine RPM (Crank) and used along with vehicle speed to calculate gear ratio.

GearCal Spd 2
Units: User selectable input
Description: Option normally reserved for vehicle speed and used along with engine speed to calculate gear ratio.

GearCal M
Units: Multiplier
Description: Option to define a multiplier to scale the amplitude of the gear ratio calculation.

Traction Control Tuning Procedure

1. If the vehicle has a manual transmission with no gear position sensor, use the **TC Gear Ratio** option and define the **Gear Ratio Table** as described above. If the vehicle has an automatic transmission with a gear position sensor, select the option **TC Gear from Sensor**.

2. AEM recommends starting with the following options settings for calculating Raw Engine Acceleration:

TC Speed/Time = ON
TC Timebase = OFF

3. With the option **Traction Control** turned off, log the parameters **Engine Accel raw** and **Engine Speed** under hard vehicle acceleration through each gear with optimum traction conditions.

4. Review **Engine Accel raw** to determine a maximum acceleration rate. Define this value using the option **TC Max**.

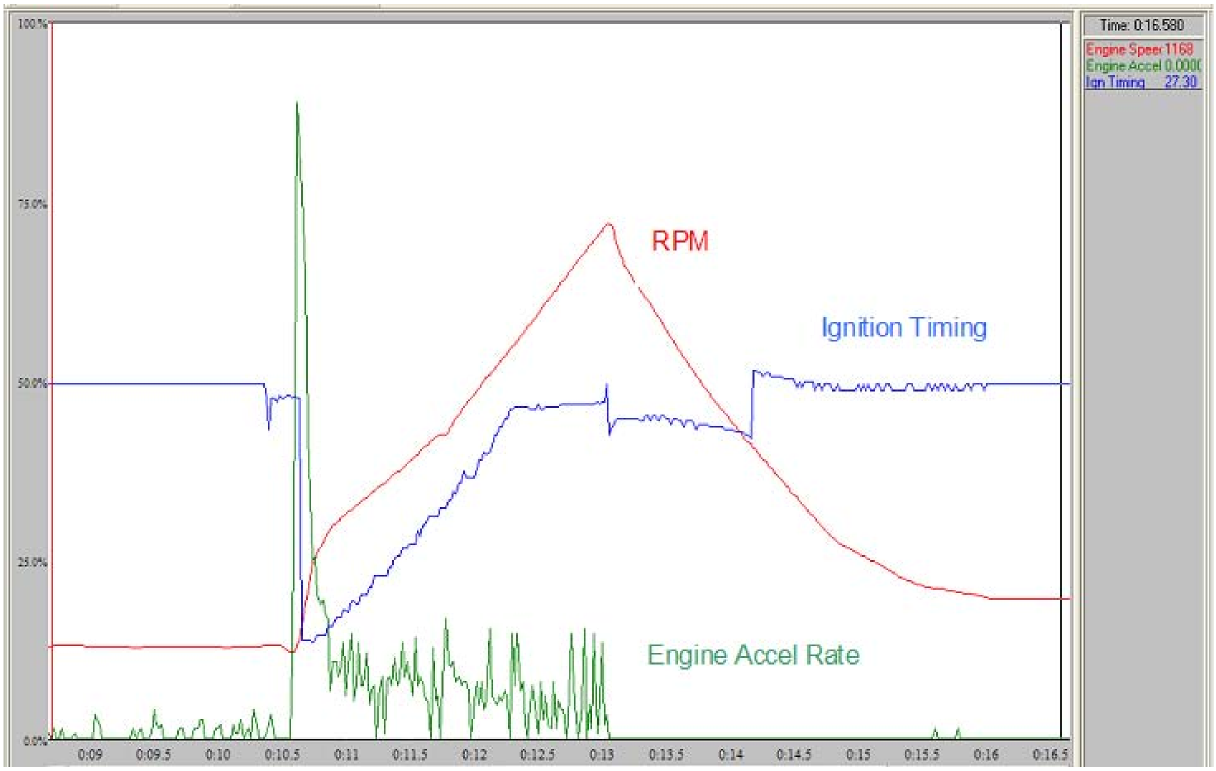
5. Use the sensitivity tables to adjust the acceleration sensitivity at varying engine or vehicle speeds. If vehicle speed is used, the option **TC vs Road Speed** must be enabled. The parameter **Engine Accel Rate** can be viewed or logged to see the results.

6. Once the sensitivity tables are defined and a good signal for **Engine Accel Rate** is established under optimum traction, define the trip tables. This should be just above the values for **Engine Accel Rate** under optimum traction conditions in each gear.

7. Start with the **TC Ign Retard** option by defining the amount of retard (20 deg is a good starting point). Define the **TC Ign Retard Resto** option (2 deg is a good starting point). These settings will retard the spark timing 20 degrees when the trip limits are exceeded and will restore the timing 2 degrees per engine revolution when the accel rate falls below the trip limits.

8. Enable traction control by selection the option **Traction Control** from the option list.

The settings and results can be tested under free-rev conditions by lowering the trip table limits until the traction control functions activate:



The above log shows **Engine Speed**, **Engine Accel Rate**, and **Ign Timing**. For this example, the low RPM sensitivity was set very high to illustrate the function. The ignition retard function can be clearly seen as well as the restore function. Notice the relatively smooth RPM increase.

7.12 Staged Injection

Staged Injection

The AEM EMS has 10 individually controlled injector drivers. By default, they are assumed to be driving primary fuel injectors. Alternately, they can be defined as secondary, or "staged" injectors. These can be activated on an as-needed basis or by a user defined ratio between the two based on engine speed and load. The staged injectors are fully sequential with user defined, independent phasing.

User Definable Options for Staged Injection

Fuel Difference Map

Units: On/Off

Description: When ON then the **Fuel Difference Map** is map is used to determine the % of fuel that will be routed through the secondary injectors.

Injector Min

Units: uS

Description: If the calculated injector pulse (not including the battery offset injection correction) is below this value, no injection is performed.

Injector Duty Max
Units: %
Description: This determines the maximum pulsewidth duty to the primary injectors when staged injection is being used. Once primary injector duty exceeds this, the EMS automatically puts all additional fuel to the secondary injectors. Typical value is 90%

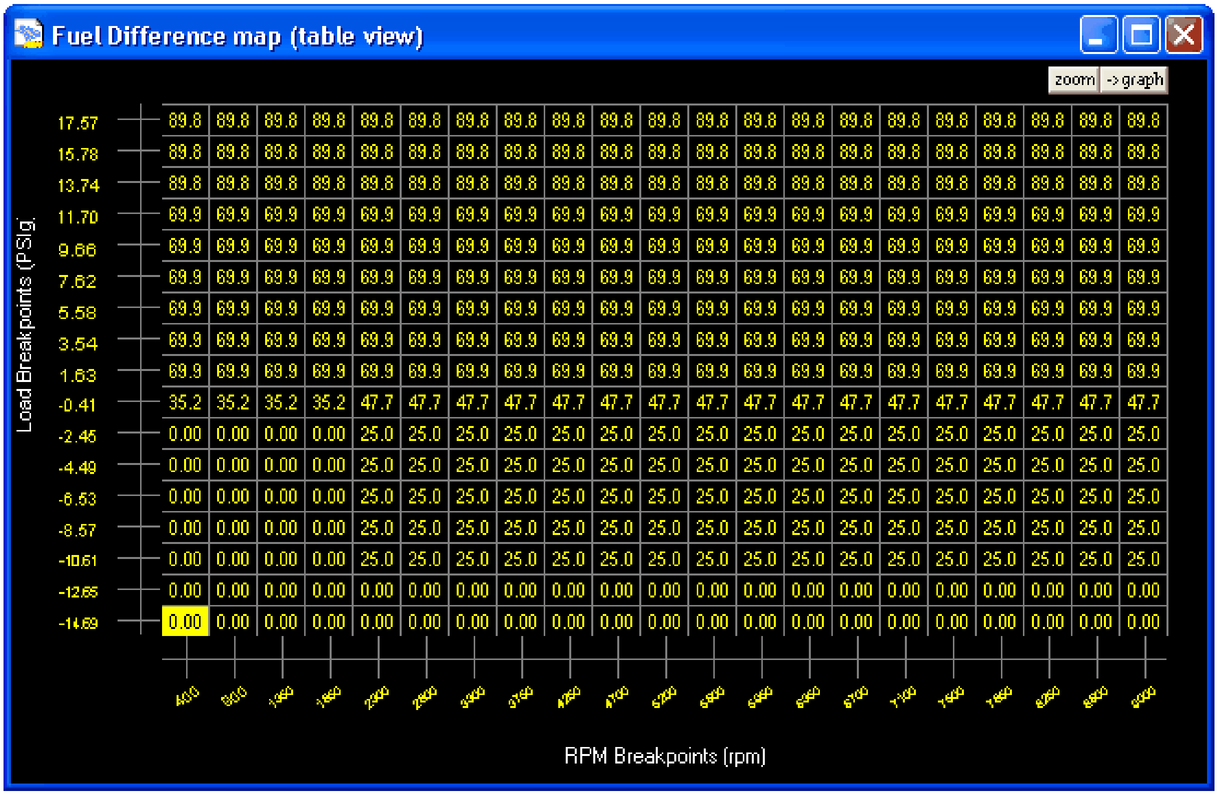
Staged Flow Ratio
Units: %
Description: Multiplier for staged injection. This tells the EMS the flow rate difference between the secondary injectors versus the primary injectors. If you have the same number & same size of secondary injectors as your primaries, this value is 100%. If you have secondary injectors that flow 3 times the primaries, the value is 33%. If you have 4 times secondaries, but only 2 (on a 4 cyl), the value should be 50%. Remember to account for the total primary flow rate (flow x number of injectors) and the total secondary flow rate (flow x number of injectors). This value must always be 100% or less, i.e. the secondaries must flow as much or more than the primaries.

Staged Flow 2 exp
Units: Multiplier
Description: Multiplier used on the **Staged Flow Ratio** option to allow low flow secondary injectors. This is only used when the maximum flow rate of the primary injectors is greater than the maximum flow rate of the secondary injectors. Note: A value of "0" does nothing.

Diff Switch Input
Units: Switch Input
Description: This assigns an input channel to activate the **Fuel Difference map**.

3-D Maps for Staged Injection

Fuel Difference map
Units: Fuel vs RPM vs Load
Description: Allows a programmable fuel percentage when using the **Diff Switch Input** option.



17.57	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8
15.78	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8
13.74	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8
11.70	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9
9.66	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9
7.62	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9
5.58	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9
3.54	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9
1.63	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9	69.9
-0.41	35.2	35.2	35.2	35.2	47.7	47.7	47.7	47.7	47.7	47.7	47.7	47.7	47.7	47.7	47.7	47.7	47.7	47.7	47.7	47.7	47.7
-2.45	0.00	0.00	0.00	0.00	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
-4.49	0.00	0.00	0.00	0.00	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
-6.53	0.00	0.00	0.00	0.00	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
-8.57	0.00	0.00	0.00	0.00	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
-10.61	0.00	0.00	0.00	0.00	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
-12.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-14.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Parameters (can be viewed or logged)

Fuel Diff

Units: %

Description: Displays the current % of fuel (from the **Fuel Difference map**) that is being directed to the staged injectors.

Fuel Diff Trim

Units: %

Description: Displays a programmable staged fuel trim parameter which can not be saved and is only for live tuning

Fuel Difference

Units: On/Off

Description: Displays if the **Fuel Difference map** is currently being used for staged injection.

Fuel Inj Duty Pri

Units: %

Description: Displays the current injector duty cycle of the primary injectors.

Fuel Inj Duty Sec

Units: %

Description: Displays the current injector duty cycle of the staged injectors.

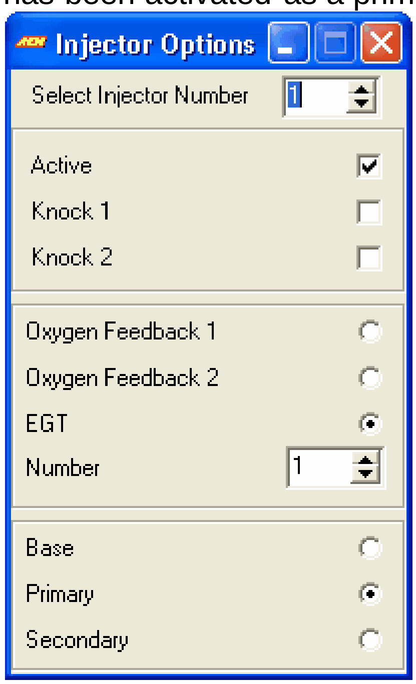
Fuel Inj Pulse Max
Units: uS
Description: Displays the maximum available injector time for the current engine speed.

Fuel Inj Pulse Pri
Units: uS
Description: Displays the current pulsewidth of the primary injectors minus the **Battery Offset Primary Table.**

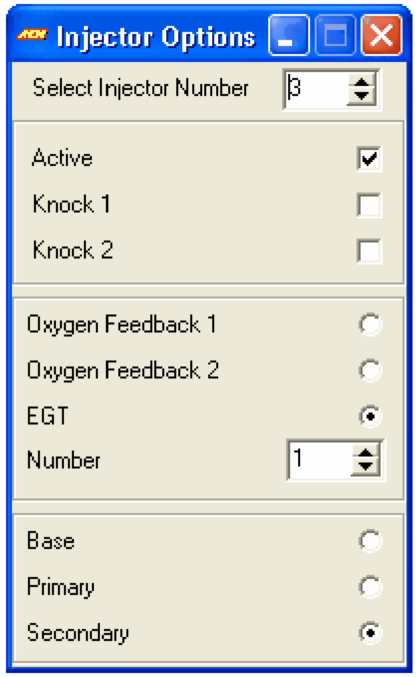
Fuel Inj Pulse Sec
Units: uS
Description: Displays the current pulsewidth of the staged injectors minus the **Battery Offset Staged Table**.

Tuning Staged Injection

First, confirm that all of your primary injectors are defined properly. They must be "active" as well as defined as **Primary.** To do this, go to **Options | Injectors**. In the example below, **Injector #1** has been activated as a primary injector.



Next, confirm that all of your staged injectors are defined properly. They must be "active" as well as defined as **Secondary**. In this example, **Injector #3** has been activated as a secondary injector.



You need to define where, in the engine cycle, you want the staged injectors to begin their injection pulse. This is set in the same manner as primary injectors and is done with the option called: **Inject Tooth #X** (where X = injector number being assigned). This value is in crankshaft pickup teeth (a.k.a. fuel teeth) after TDC #1 compression. This value is proportional to degrees of crankshaft rotation. It is actually quite helpful to understand that the EMS actually counts the number of crankshaft teeth passing until it gets to this number and then starts injection.

For a 12 tooth crank trigger wheel on a 4 stroke engine, there are 24 teeth per cycle (numbered 0 to 23.999). If the **Inject Tooth #6** was set to 6.5 teeth, that would tell the EMS to let 6.5 teeth pass (720/24 x 6.5 = 195 crankshaft degrees into the cycle) and then activate **Injector #6**. It is important to note that this is not the final injection location, it is just a reference point. All primary and staged injectors are under control of the **Inj Advance Map,** which is a load vs. engine speed table that is used to set the actual injection phase.

The flow rate difference between the primary and staged injectors is necessary to accurately distribute the required fuel between the two different delivery systems. It represents the percent of primary injection time needed to flow an equivalent amount of fuel from the secondary injectors and is entered in the **Staged Flow Ratio** option.

Staged Flow Ratio = ((number of primary injectors x primary flow rate) / (number of secondary injectors x secondary flow rate) x 100) - 100

Remember, this is not simply the flow ratio between the 2 different injectors, it factors in the number of injectors as well. This number can range from -100 to +100.

The last thing required to define the injectors is to tell the EMS how fast the injector responds to the fuel pulse signal. Under the **Setup | Injectors** menu is the **Battery Offset Staged table**. This is how long the secondary injectors take to start flowing fuel after they have been turned ON and is a function of battery voltage. There are actually 2 different tables, one for primary and the other for the staged injectors. Since the primary and staged injectors are usually different types, these tables should be different. If your injector response data is not represented in the wizards library, you can either select an injector from the same family or manually enter the data in the **Battery Offset Staged table**.

The staged injectors are now completely defined in software. The only thing remaining is to specify when and how much fuel should be directed to the new staged injection system. There are 2 different methods for transferring fuel from the main injectors to the staged injectors.

The most basic is based on the duty cycle of the primary injectors where you set the maximum injector duty you want to run through the primaries and the minimum ON time for the secondary injectors. This sets the injectors to run only on the primary injectors until the base injector duty cycle exceeds the **Injector Duty Max** option. Once that has occurred, the fuel in excess of **Injector Duty Max** is routed to the staged injectors. The time set in the **Injector Min** option keeps the system from quickly switching back and forth between the two if the duty were to stay right at the **Injector Duty Max** threshold. The staged injectors will stay ON until the base injector duty cycle decreases below **Injector Duty Max**.

The second method for mapping fuel to the staged injectors uses the **Fuel Difference map** and the **Injector Duty Max** threshold in unison. The **Fuel Difference map** allows you to specify what percentage of fuel should be delivered via the staged injectors. The number entered into this map is the percentage of total fuel that will be delivered to the staged injectors. This can be set based on load and enginen speed and gives the best control. To set this up you need to put the appropriate values into the **Fuel Difference map** and turn the **Fuel Difference Map** option to ON.

Additionally, there is a switch input available, called **Diff Switch Input** where the staged injection can be disabled from the cockpit. If this is used, it needs to be assigned to a switch input. If only the software operating criteria is used, set the **Diff Switch Input** to **Switch is Always On**. This says the switch is always ON so only the software criteria is used. It is important to remember that the **Injector Duty Max** limit will still be used so set that value to a reasonable number.

You can view and/or log the actual base injection times with the **Fuel Inj Pulse Pri** and **Fuel Inj Pulse Sec** parameters. You can view and/or log the actual injector duty cycles with the **Fuel Inj Duty Pri** and **Fuel Inj Duty Sec** parameters. To view the current battery Injector offsets, use the **Fuel Trim Bat-Pri** and **Fuel Trim Bat-Sec** parameters. To determine how the **Fuel Difference Map** is being used monitor the **Fuel Difference, Fuel Diff Trim** and **Fuel Diff** parameters.

7.13 Analog Input Switch

Analog Input Switch

The AEM EMS can turn a 0-5V input into a switched input. This allows you to configure any analog channel with a switching point to activate. The is commonly used with shift retard with a 0-5V strain gauge. However, the analog input switch can be used for many other purposes. The analog input (**Switch #7)** works by setting a high and low voltage range with a throttle and engine speed threshold. When the input exceeds the range of the selected voltage and the other conditions are met, the switch will turn ON/OFF. If a shift cut/retard is to be used with **Switch #7**, see the **Shift Cut/Retard** section.

User Definable Options for Switch #7

Switch #7 Analog In

Units: Analog Input

Description: User selectable analog input which is used to make a switched input. Typically used with shift retard function.

Switch #7 On Above

Units: Volts

Description: Voltage threshold above which the **Switch #7** will be active. Should be set higher than **Switch #7 On Below**.

Switch #7 On Below

Units: Volts

Description: Voltage threshold below which the **Switch #7** will be active. Should be set lower than **Switch #7 On Above**.

Switch #7 Min RPM

Units: Engine Speed

Description: Speed threshold that you must be above for the **Switch #7** function to be met.

Switch #7 Min TPS

Units: Throttle %

Description: Throttle threshold that you must be above for the **Switch #7** function to be met.

Parameters (can be viewed or logged)

Switch #7

Units: On/Off

Description: Displays the current status of the analog input **Switch #7** function.

7.14 Auto Transmission

Auto Transmission

The AEM EMS is capable of extensive automatic transmission control as long as the solenoids to be driven are compatible with the drivers in the AEM EMS. Note: It is important to determine the compatibility of the transmission solenoids with the AEM EMS, otherwise the EMS could be damaged. The automatic transmission control can be more complex than tuning an engine.

User Definable Options for A/T

A/T CClutch Period
Units: mS
Description: Frequency for converter clutch solenoid

A/T CClutch Valve
Units: User Selectable Output
Description: Channel assigned to be converter clutch output control

A/T CPress Period
Units: mS
Description: Frequency for converter clutch pressure solenoid

A/T CPress Valve
Units: User Selectable Output
Description: Channel assigned to be converter clutch line pressure solenoid

A/T LPress 1 Period
Units: mS
Description: Line pressure 1 frequency

A/T LPress 1 Valve
Units: User Selectable Output
Description: Channel assigned to be line pressure 1 valve

A/T LPress 2 Period
Units: mS
Description: Line pressure 2 frequency

A/T LPress 2 Valve
Units: User Selectable Output
Description: Channel assigned to be line pressure 2 valve

A/T LPress 3 Period
Units: mS
Description: Line pressure 3 frequency

A/T LPress 3 Valve
Units: User Selectable Output
Description: Channel assigned to be line pressure 3 valve

A/T Shift 1 Period
Units: mS
Description: Shift solenoid 1 frequency

A/T Shift 1 Valve
Units: User Selectable Output
Description: Channel assigned to be shift solenoid 1

A/T Shift 2 Period
Units: mS
Description: Shift solenoid 2 frequency

A/T Shift 2 Valve
Units: User Selectable Output
Description: Channel assigned to be shift solenoid 2

A/T Shift 3 Period
Units: mS
Description: Shift solenoid 3 frequency

A/T Shift 3 Valve
Units: User Selectable Output
Description: Channel assigned to be shift solenoid 3

A/T Gear 4 Input
Units: User Selectable Switch
Description: Input to use as overdrive gear 4 switch

A/T Auto/Man Toggle
Units: On/Off
Description: Input to be used for selecting auto mode or manual mode.

A/T Gear Control
Units: On/Off
Description: This activates the automatic shift scheme.

A/T Gear Drive A
Units: Multiplier
Description: Used for testing purposes only

A/T Gear Drive M
Units: Multiplier
Description: Used for testing purposes only

A/T Gear Hysterisis
Units: On/Off
Description: This adds an upshift/downshift delay for smoother driving conditions

A/T Manual Input
Units: User Selectable Switch
Description: This selects what input will be used for manual gear selection.

A/T Manual Output
Units: User Selectable Output
Description: This is an optional output to trigger a light to warn that manual gear selection is engaged

A/T Gear Chg Mask
Units: Multiplier
Description: Used for testing purposes only.

A/T WOT Gear Delay
Units: mS
Description: Programmable delay for wide open throttle shifting.

A/T WOT Gear Max
Units: Multiplier
Description: Enter the maximum allowable forward gear for the specific automatic transmission used.

A/T WOT Off Below
Units: Throttle %
Description: When under this throttle position all gear changes will be made from the **A/T Gear Desired map**.

A/T WOT On Above
Units: Throttle %
Description: When above this throttle position all upshift gear changes will be made from the **A/T WOT Shift Point table**.

Gear Hy Defeat
Units: Throttle %
Description: Sets the throttle position threshold for the A/T Gear Hysterisis option to be inactive.

Switch Rtd Advance
Units: Degrees
Desciption: Advances the timing by this amount every 4.1 ms until the nominal timing is restored after the **Switch Rtd** function is turned OFF. The timing amount is returned to normal in steps, not all at once. A larger number here returns the timing to the normal faster. Typical value is 1 degree.

Switch Rtd Input
Units: Switch Input
Desciption: Switch input from which the **Shift Rtd** function triggers from.

Switch Rtd Max Rtd
Units: Degrees
Desciption: Total amount if ignition retard desired while the **Shift Rtd** function is ON.

Switch Rtd ReArm
Units: mS
Desciption: Time to wait after **Shift Rtd** is fully restored before allowing another **Shift Rtd** function to be recognized. Acts as a switch debounce. Typical value is 500 mS.

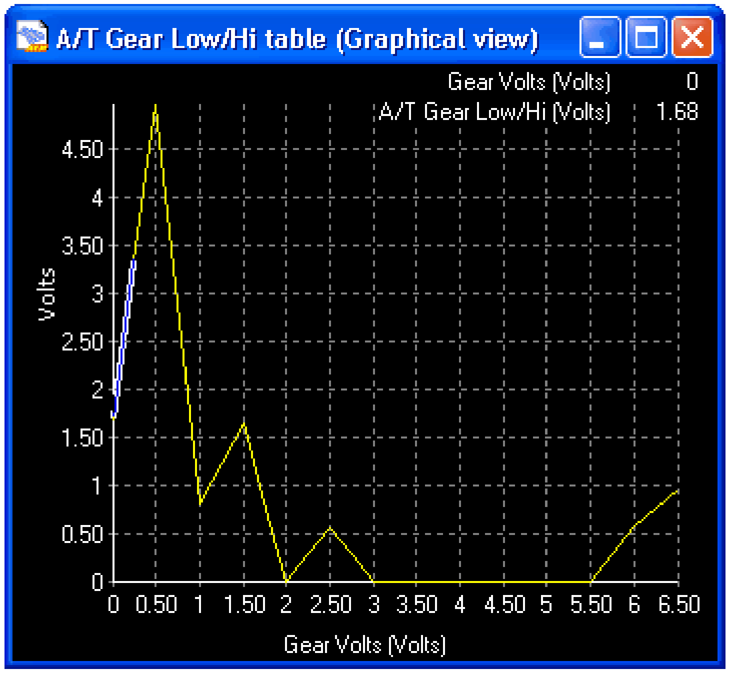
Switch Rtd Step
Units: Degrees
Desciption: Retards the timing by this amount every 4.1 ms until the total retard amount specified in **Switch Rtd Max Rtd** is achieved. The timing amount is retarded in steps, not all at once. A larger number here retards the timing faster. Typical value is 1 degree.

Switch Rtd Ign Cut
Units: On/Off
Desciption: Activates an ignition cut during the **Shift Rtd**. The ignition cut works with the ignition retard and only cuts the ignition after the full retard is achieved. After the **Shift Rtd** function is deactivated by the switch, the timing is then advanced back to normal according to **Switch Rtd Advance** and is rearmed after the time in **Switch Rtd ReArm** has elapsed.

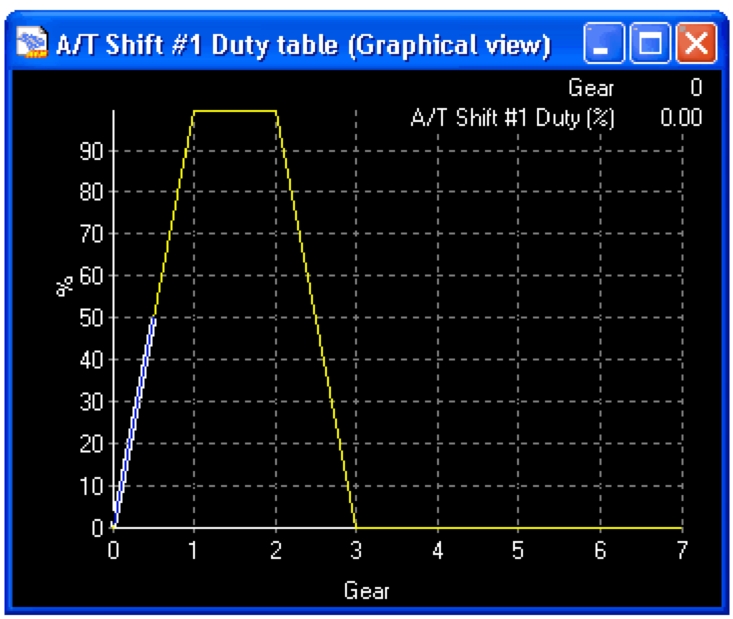
Switch Rtd Time Out
Units: mS
Desciption: Max switch ON time before it is assumed to be a failed switch input and kills the function.

2-D Tables for A/T

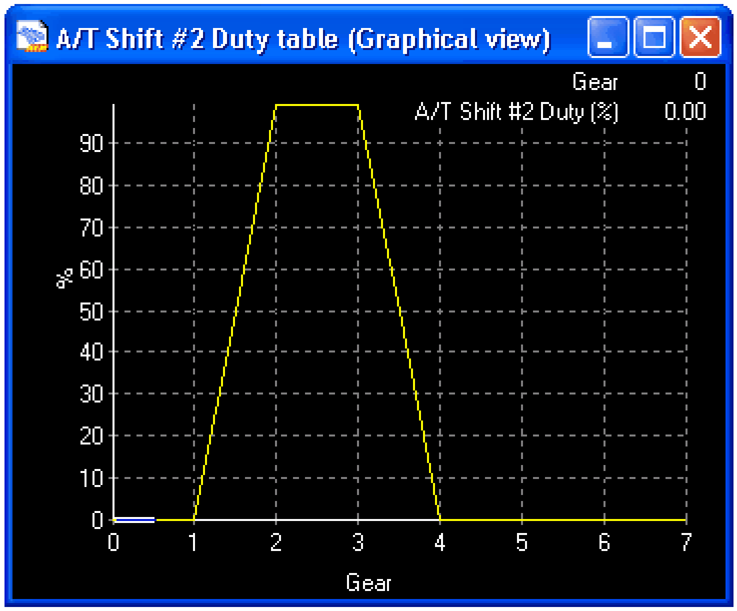
A/T Gear Low/Hi Table
Units: Volts vs Gear Volts
Description: 100% makes the solenoid active in that gear position 0% makes it inactive



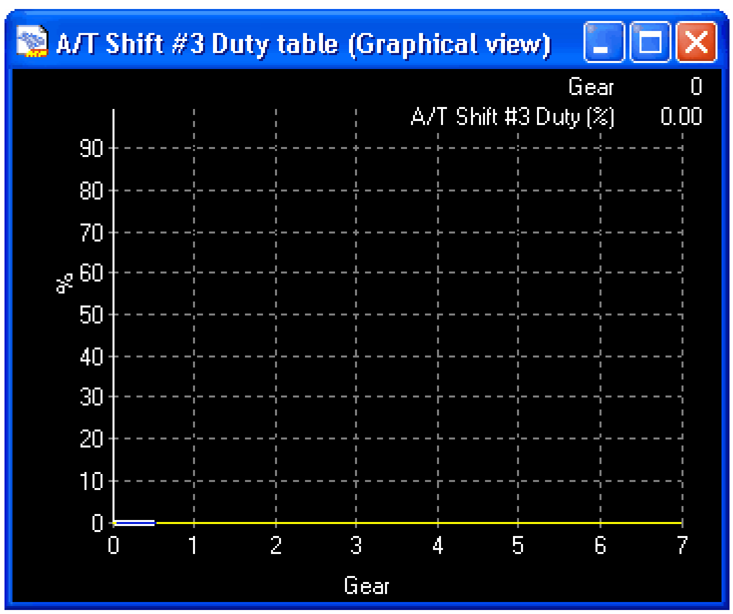
A/T Shift #1 Duty Table
Units: Duty % vs Gear
Description: 100% makes the solenoid active in that gear position 0% makes it inactive.



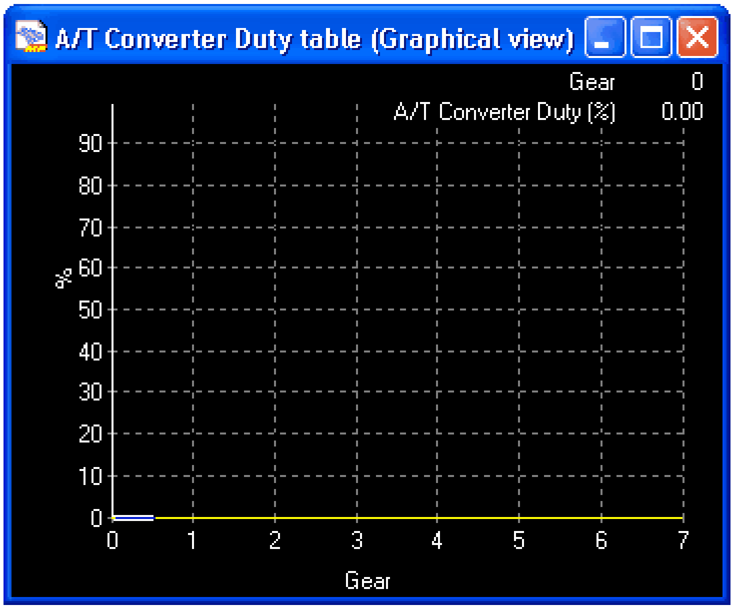
A/T Shift #2 Duty Table
Units: Duty % vs Gear
Description: 100% makes the solenoid active in that gear position 0% makes it inactive.



A/T Shift #3 Duty Table
Units: Duty % vs Gear
Description: 100% makes the solenoid active in that gear position 0% makes it inactive.



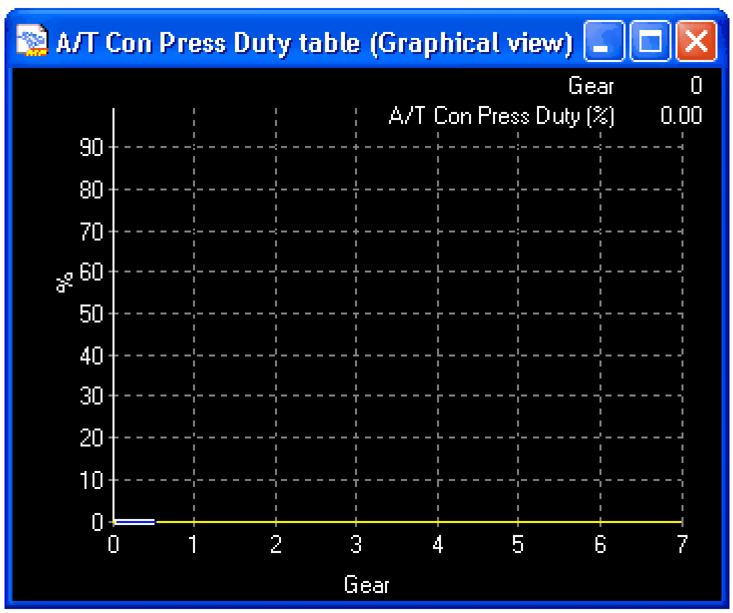
A/T Converter Duty Table
Units: Duty % vs Gear
Description: 100% makes the solenoid active in that gear position 0% makes it inactive.



A/T Con Press Duty Table

Units: Duty % vs Gear

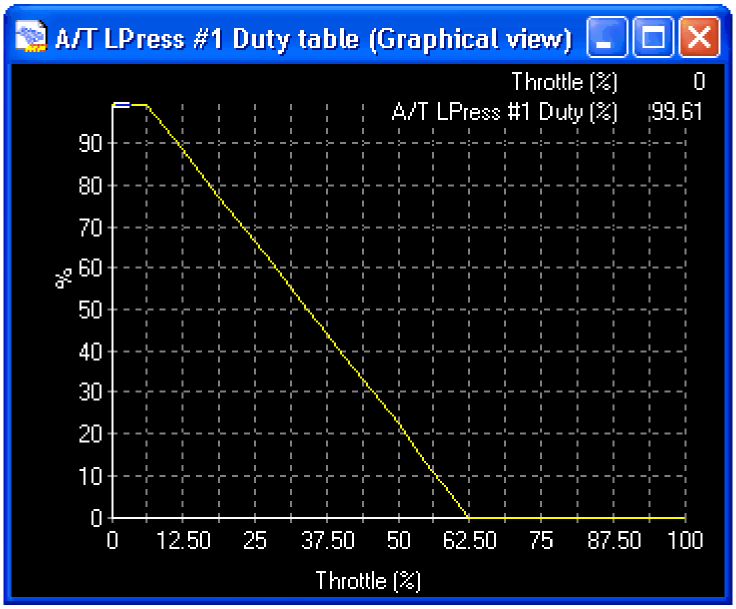
Description: 100% makes the solenoid active in that gear position 0% makes it inactive.



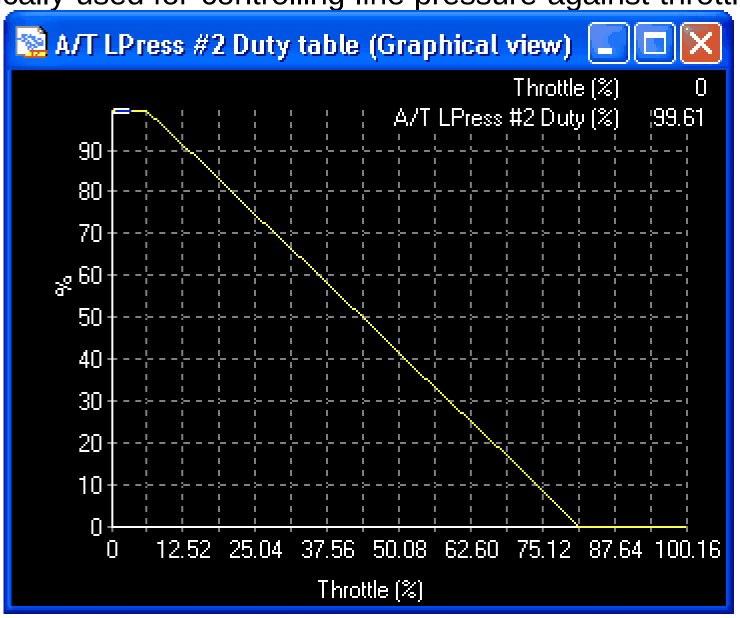
A/T LPress #1 Duty Table

Units: Duty % vs TPS

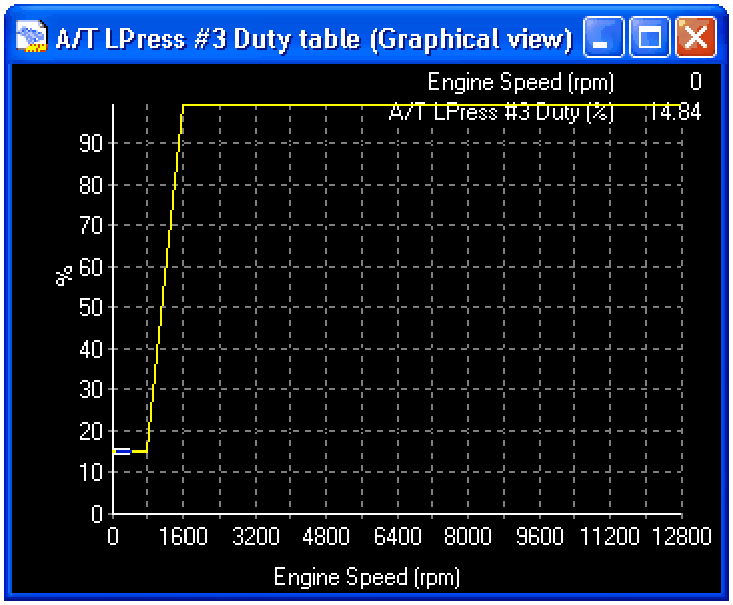
Description: Typically used for controlling line pressure against throttle position.



A/T LPress #2 Duty Table
Units: Duty % vs TPS
Description: Typically used for controlling line pressure against throttle position.



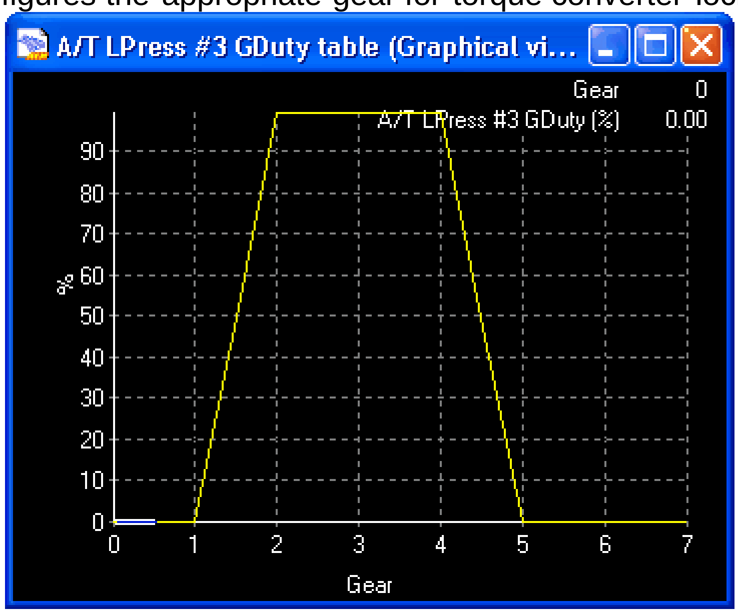
A/T LPress #3 Duty Table
Units: Duty % vs RPM
Description: Configures the line pressure #3 duty output for specific RPMs.



A/T LPress #3 GDuty Table

Units: Duty % Gear

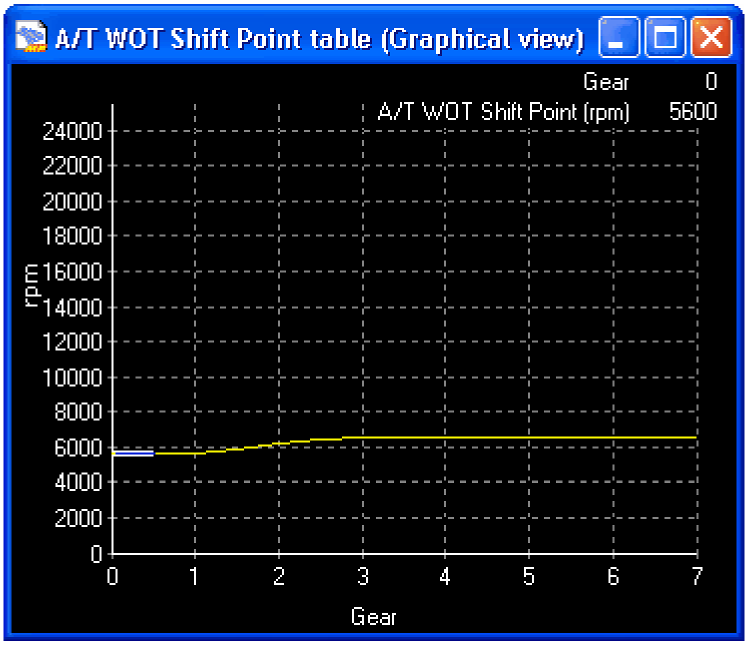
Description: Configures the appropriate gear for torque converter lock-up.



A/T WOT Shift Point Table

Units: RPM vs Gear

Description: This table defines the maximum allowable RPM to make the shift and is independently adjustable in each gear.

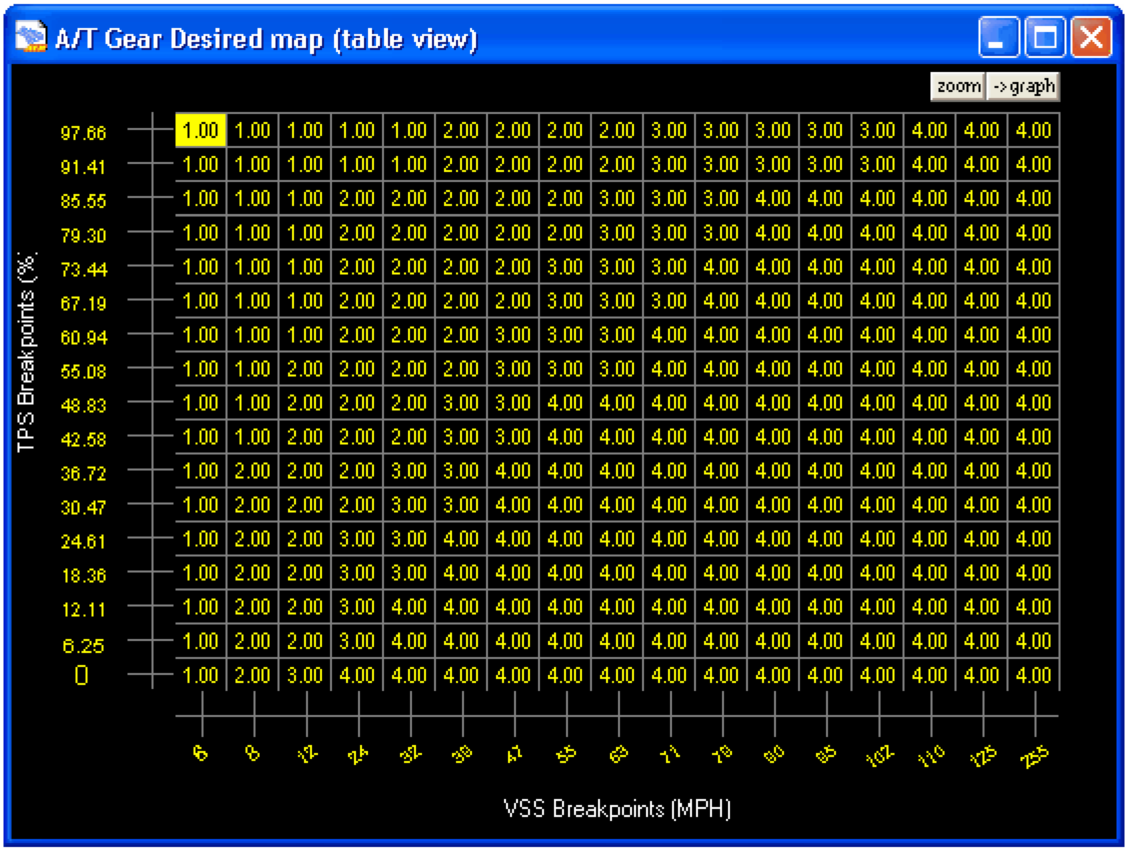


3-D Maps for A/T

A/T Gear Desired Map

Units: Gear vs VSS x TPS

Description: This map is throttle against vehicle speed, and determines the shift schedule for the automatic transmission shift scheme. Enter the desired gear in each load and vehicle speed point, the EMS uses this as the lookup table to determine what gear the transmission should be in.

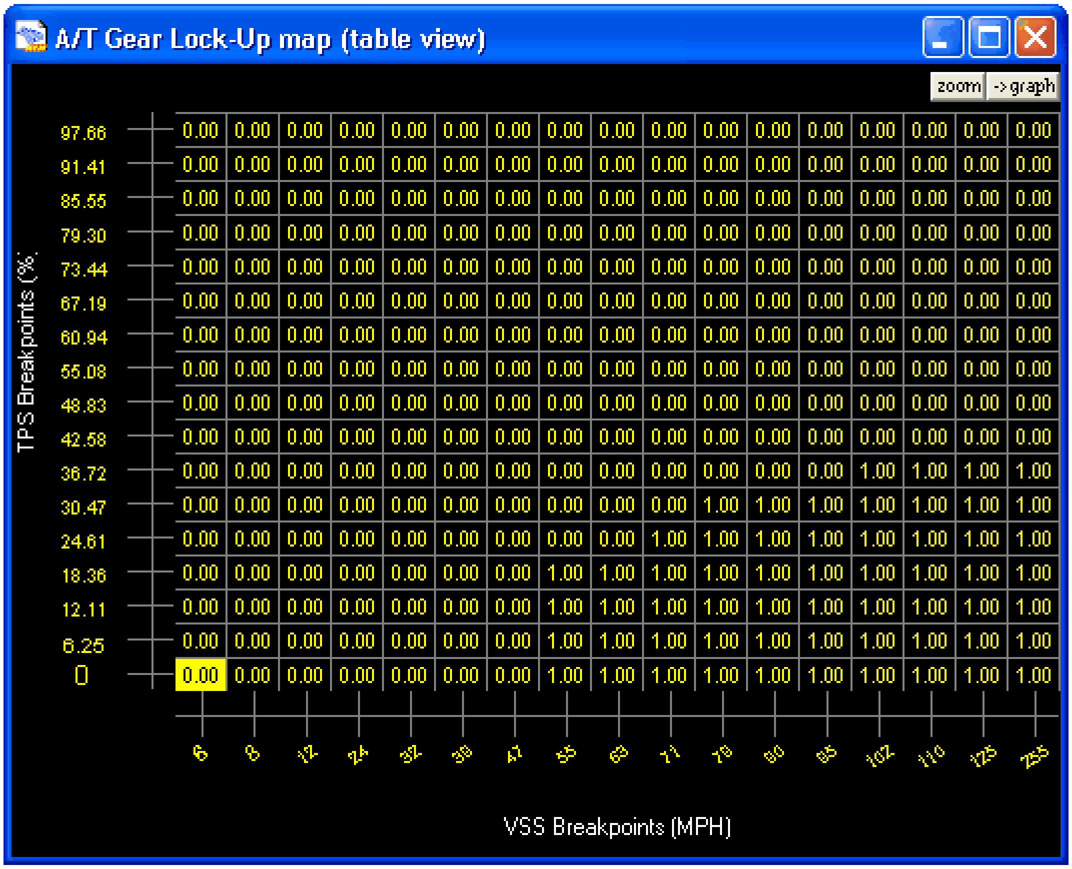


TPS \ VSS	6	8	12	24	32	38	47	55	63	71	78	80	85	102	110	125	255
97.66	1.00	1.00	1.00	1.00	1.00	2.00	2.00	2.00	2.00	3.00	3.00	3.00	3.00	3.00	4.00	4.00	4.00
91.41	1.00	1.00	1.00	1.00	1.00	2.00	2.00	2.00	2.00	3.00	3.00	3.00	3.00	3.00	4.00	4.00	4.00
85.55	1.00	1.00	1.00	2.00	2.00	2.00	2.00	2.00	3.00	3.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00
79.30	1.00	1.00	1.00	2.00	2.00	2.00	2.00	2.00	3.00	3.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00
73.44	1.00	1.00	1.00	2.00	2.00	2.00	2.00	3.00	3.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
67.19	1.00	1.00	1.00	2.00	2.00	2.00	2.00	3.00	3.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
60.94	1.00	1.00	1.00	2.00	2.00	2.00	3.00	3.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
55.08	1.00	1.00	2.00	2.00	2.00	2.00	3.00	3.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
48.83	1.00	1.00	2.00	2.00	2.00	3.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
42.58	1.00	1.00	2.00	2.00	2.00	3.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
36.72	1.00	2.00	2.00	2.00	3.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
30.47	1.00	2.00	2.00	2.00	3.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
24.61	1.00	2.00	2.00	3.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
18.36	1.00	2.00	2.00	3.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
12.11	1.00	2.00	2.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
6.25	1.00	2.00	2.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
0	1.00	2.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00

A/T Gear Lock-Up Map

Units: Gear vs VSS x TPS

Description: Determines if the automatic transmission torque converter should lock up (1) or remain unlocked (0) based on the current throttle position and load values.



TPS \ VSS	6	8	12	24	32	38	47	55	63	71	78	80	85	102	110	125	255
97.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
91.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
85.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
79.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
73.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
67.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
60.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
55.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
42.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00
30.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
24.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
18.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Parameters (Can be viewed or logged)

A/T Con Press Duty

Units: mS

Description: Displays the current time of the converter pressure duty cyle.

A/T Converter Duty

Units: mS

Description: Displays the current time of the converter duty cycle.

A/T Gear Change Rqd

Units: On/Off

Description: Displays the gear change requirement status

A/T Gear Lock

Units: %

Description: Displays the current output duty for converter lock up control

A/T Gear Manual

Units: On/Off

Description: Displays the current status of the manual gear mode function

A/T Gear Map

Units: Gear
Description: Displays the current gear selected from the **A/T Gear Desired Map**

A/T Gear Next
Units: Gear
Description: Displays the next available gear

A/T Gear Over Drive
Units: On/Off
Description: Displays the current status of the over drive switch

A/T Gear Raw
Units: Volts
Description: Displays the current raw voltage from the gear position sensor

A/T Gear Ready
Units: On/Off
Description: Displays when the A/T gear is ready.

A/T Gear Selector
Units: Gear
Description: Displays the current position of the gear lever from the sensor

A/T Gear Status
Units: Binary Code
Description: Displays the current status of the A/T gear in binary code.

A/T LPress #1 Duty
Units: mS
Description: Displays the current pulse width output from the **A/T LPress #1 Duty Table** and the **A/T LPress 1 Period** option

A/T LPress #2 Duty
Units: mS
Description: Displays the current pulse width output from the **A/T LPress #2 Duty Table** and the **A/T LPress 2 Period** option

A/T LPress #3 Duty
Units: mS
Description: Displays the current pulse width output from the **A/T LPress #3 Duty Table** and the **A/T LPress 3 Period** option

A/T Shift #1 Duty
Units: mS
Description: Displays the current pulse width output from the **A/T Shift #1 Duty Table** and the **A/T Shift 1 Period** option

A/T Shift #2 Duty
Units: mS
Description: Displays the current pulse width output from the A/T Shift #2 Duty Table and the A/T Shift 2 Period option

A/T Shift #3 Duty
Units: mS
Description: Displays the current pulse width output from the **A/T Shift #3 Duty Table** and the **A/T Shift 3 Period** option

A/T WOT Delay
Units: mS
Description: Displays the current delay time of the WOT function

Gear
Units: Gear
Description: Displays the gear the transmission should currently be using

Gear From Sensor
Units: Gear
Description: Displays the current gear from the gear sensor

Gear Volts
Units: Volts
Description: Displays the current voltage from the gear position sensor

Gear WOT Wait
Units: On/Off
Description: Displays the current status of the WOT function.

Switch Rtd
Units: On/Off
Description: Displays the current status of the **Switch Rtd** function.

Switch Rtd Amount
Units: Degrees
Description: Displays the current amount of ignition retard from the **Switch Rtd** function.

Switch Rtd Inhibit
Units: mS
Description: Displays the current time after the **Switch Rtd** function has ended. The **Switch Rtd** is only accessible after this is zero.

Switch Rtd Time
Units: mS
Description: Displays the current time of how long the **Switch Rtd** function has been

enabled.

Converter Lock-up for 30-1100 and 30-1101

The converter lockup control with the AEM EMS for the Toyota Supras may be accomplished by hooking up a relay to be triggered from a pull to ground signal from the AEM to trigger the relay for higher current capacity to the converter lock-up solenoid. Pin 14B on the Toyota Supra plug (refer to pinout instructions for exact location of this pin) needs to be connected to one side of the relay coil, while the other side is connected to switched 12V+. When activated, the realy will complete a ground circuit from the chassis ground to the converter lockup solenoid.

7.15 Shift Cut/Retard

Shift Cut/Retard

With the AEM EMS, a switch input can activate an ignition retard and ignition cut. This setup is typically used for a sequentially shifted transmission to aid in the gear change process, overboost protection, etc. See the **Analog Input Switch** section to set a 0-5V input, like a strain gauge, as a switch input to activate the **Shift Rtd** function.

User Definable Options for Shift Retard

Switch Rtd Advance
Units: Degrees
Desciption: Advances the timing by this amount every 4.1 ms until the nominal timing is restored after the **Switch Rtd** function is turned OFF. The timing amount is returned to normal in steps, not all at once. A larger number here returns the timing to the normal faster. Typical value is 1 degree.

Switch Rtd Input
Units: Switch Input
Desciption: Switch input from which the **Shift Rtd** function triggers from.

Switch Rtd Max Rtd
Units: Degrees
Desciption: Total amount if ignition retard desired while the **Shift Rtd** function is ON.

Switch Rtd ReArm
Units: mS
Desciption: Time to wait after **Shift Rtd** is fully restored before allowing another **Shift Rtd** function to be recognized. Acts as a switch debounce. Typical value is 500 mS.

Switch Rtd Step
Units: Degrees
Desciption: Retards the timing by this amount every 4.1 ms until the total retard amount specified in **Switch Rtd Max Rtd** is achieved. The timing amount is retarded in steps, not all at once. A larger number here retards the timing faster. Typical value

is 1 degree.

Switch Rtd Ign Cut
Units: On/Off
Desciption: Activates an ignition cut during the **Shift Rtd**. The ignition cut works with the ignition retard and only cuts the ignition after the full retard is achieved. After the **Shift Rtd** function is deactivated by the switch, the timing is then advanced back to normal according to **Switch Rtd Advance** and is rearmed after the time in **Switch Rtd ReArm** has elapsed.

Switch Rtd Time Out
Units: mS
Desciption: Max switch ON time before it is assumed to be a failed switch input and kills the function.

Parameters (Can be viewed or logged)

Switch Rtd
Units: On/Off
Description: Displays the current status of the **Switch Rtd** function.

Switch Rtd Amount
Units: Degrees
Description: Displays the current amount of ignition retard from the **Switch Rtd** function.

Switch Rtd Inhibit
Units: mS
Description: Displays the current time after the **Switch Rtd** function has ended. The **Switch Rtd** is only accessible after this is zero.

Switch Rtd Time
Units: mS
Description: Displays the current time of how long the **Switch Rtd** function has been enabled.

7.16 DC/Stepper Motor

DC/Stepper Motor

The motor control is a unique closed loop feedback system. In the AEMPro software, the motor control is found in the **Advanced Setup** pull down menu.

The motor control can be used for many different purposes. For a DC motor example, this function is used on the Subaru Impreza WRX as a plug n' play feature. There are 4 Tumble Generator Valves (TGV) found on the intake manifold of the WRX. These valves are paired up and driven by 2 DC motors (one per side). 100% output closes the valves while 0% output open the valves. The parameters **PR Press**

Voltage and **Spare Temp Voltage** display the current position of the valves. When these parameters are near 0Volts, the valves are open. When the parameters are near 5Volts, the valves are closed.

The motor control can also be used for stepper motors. As an example, this function is used on the Mazda RX-7 for their oil metering pump as a plug n' play feature. The AEM EMS receives the signal from the MAF input and controls the oil metering pump stepper motor as a function of **Injector Duty%**.

User Definable Options for Motor Control

Motor #1 Analog Inp
Units: Analog Input
Description: Configurable input that uses the "Motor #1 Target Table" to drive the motor to a desired position. Note: This input may be derived from a parameter such as injector duty.

Motor #1 Clock
Units: On/Off
Description: Reverses the direction of Motor #1. This option is used for stepper motors only.

Motor #1 Dead Band
Units: Position%
Description: A small "Motor #1 Dead Band" allows a quick motor response, but too small may cause valve oscillation. A large "Motor #1 Dead Band" allows the motor to become very stable, but too much may slow down the valve response and may not achieve the position desired.

Motor #1 Default
Units: Position%
Description: When "Motor Failsafe" is active and the "Motor #1 Analog In" is between 0-2.5% and 97.5-100% of its full-scale, the EMS assumes the sensor has failed and defaults the motor position sensor value to the position specified.

Motor #1 FB Input
Units: Analog Input
Description: Selectable analog input from the Motor #1 position sensor that reports the valve's current location to the EMS.

Motor #1 Power Save
Units: On/Off
Description: When active, the DC Motor #1 current is reduced if the motor position is within the "Motor #1 Dead Band" range. This option is used for dc motors only.

Motor #2 Analog Inp
Units: Analog Input

Description: Configurable input that uses the "Motor #2 Target Table" to drive the motor to a desired position.

Motor #2 Clock
Units: On/Off
Description: Reverses the direction of Motor #2. This option is used for stepper motors only.

Motor #2 Dead Band
Units: Position%
Description: A small "Motor #2 Dead Band" allows a quick motor response, but too small may cause valve oscillation. A large "Motor #2 Dead Band" allows the motor to become very stable, but too much may slow down the valve response and may not achieve the position desired.

Motor #2 Default
Units: Position%
Description: When "Motor Failsafe" is active and the "Motor #2 Analog In" is between 0-2.5% and 97.5-100% of its full-scale, the EMS assumes the sensor has failed and defaults the motor position sensor value to the position specified.

Motor #2 FB Input
Units: Analog Input
Description: Selectable analog input from the Motor #2 position sensor that reports the valve's current location to the EMS.

Motor #2 Power Save
Units: On/Off
Description: When active, the DC Motor #2 current is reduced if the motor position is within the "Motor #2 Dead Band" range. This option is used for dc motors only.

Motor #2 Swap Motor
Units: On/Off
Description: When active, the stepper motor driven by idle pairs 5/6 and 7/8 will be swapped with idle pairs 1/2 and 3/4 and vice versa.

Motor DC
Units: On/Off
Description: Changes the "Motor" algorithm to drive a DC Motor rather than a Stepper Motor for outputs: Idle 5/6 and Idle 7/8 only. This option is used for dc motors only. Note: Idle 5/6 Stepper and/or Idle 7/8 Stepper must also be "On".

Motor DC Pair
Units: On/Off
Description: When active, both Motor #1 and Motor #2 will feedback on the "Motor #1 Position" sensor and the "Motor #1 Target Table". When "Off", both dc motors will be independent of one another using their respective tables and options. This option is

used for dc motors only.

Motor Fail Detect
Units: On/Off
Description: Sets the EMS output to the "Motor #(1or2) Default" position when the "Motor #(1or2) Position" parameter is between 0-2.5% and 97.5-100% of its full-scale.

Motor Update Rate
Units: mS
Description: Time period for checking the location of the motor's position sensor(s). A small time value updates faster than a large time value.

Idle 1/2 Max Curren
Units: Amps
Description: Sets a maximum allowable current flow for the Idle 1/2 output.

Idle 1/2 Stepper
Units: On/Off
Description: When active, the Idle 1/2 output is used for the idle stepper motor function only.

Idle 3/4 Max Curren
Units: Amps
Description: Sets a maximum allowable current flow for the Idle 3/4 output.

Idle 3/4 Stepper
Units: On/Off
Description: When active, the Idle 3/4 output is used for the idle stepper motor function only.

Idle 5/6 Max Curren
Units: Amps
Description: Sets a maximum allowable current flow for the Idle 5/6 output.

Idle 5/6 Stepper/DC
Units: On/Off
Description: When active, the Idle 5/6 output is used for the idle stepper motor function unless the "Motor DC" is active, then the "Motor" algorithm is applied.

Idle 7/8 Max Curren
Units: Amps
Description: Sets a maximum allowable current flow for the Idle 7/8 output.

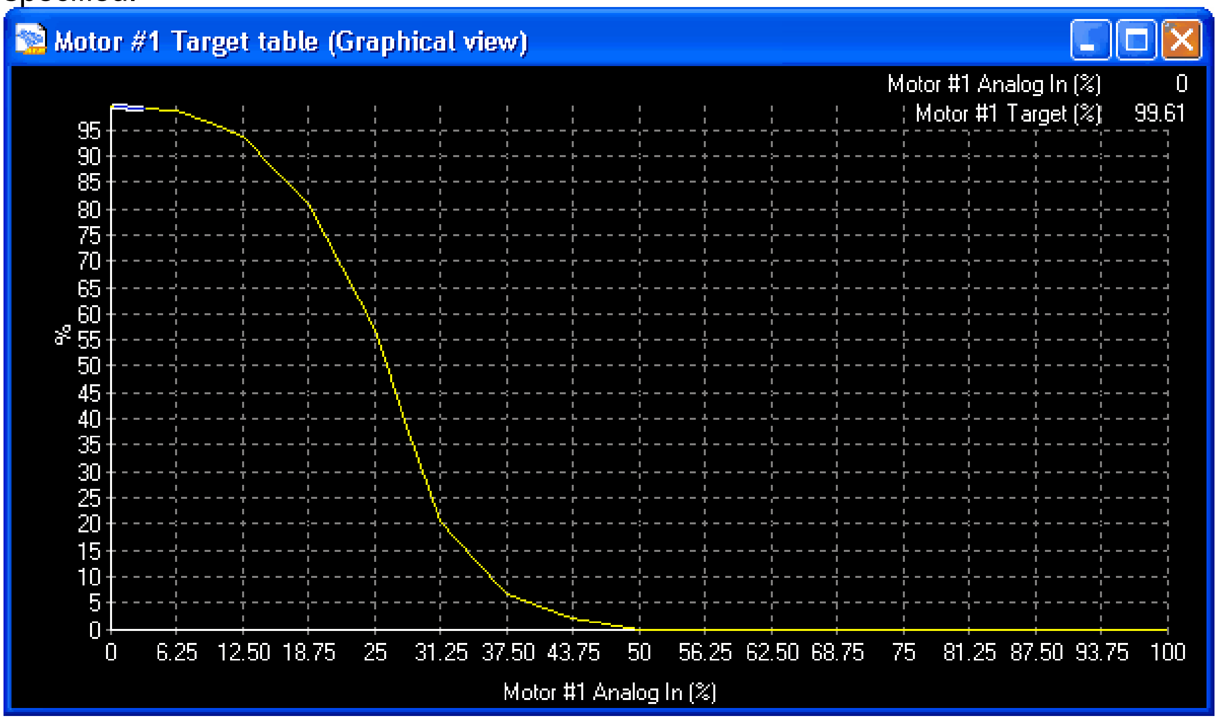
Idle 7/8 Stepper/DC
Units: On/Off
Description: When active, the Idle 7/8 output is used for the idle stepper motor

function. However, if "Motor DC" is active as well, the idle functions are disabled and the "Motor" algorithm is applied.

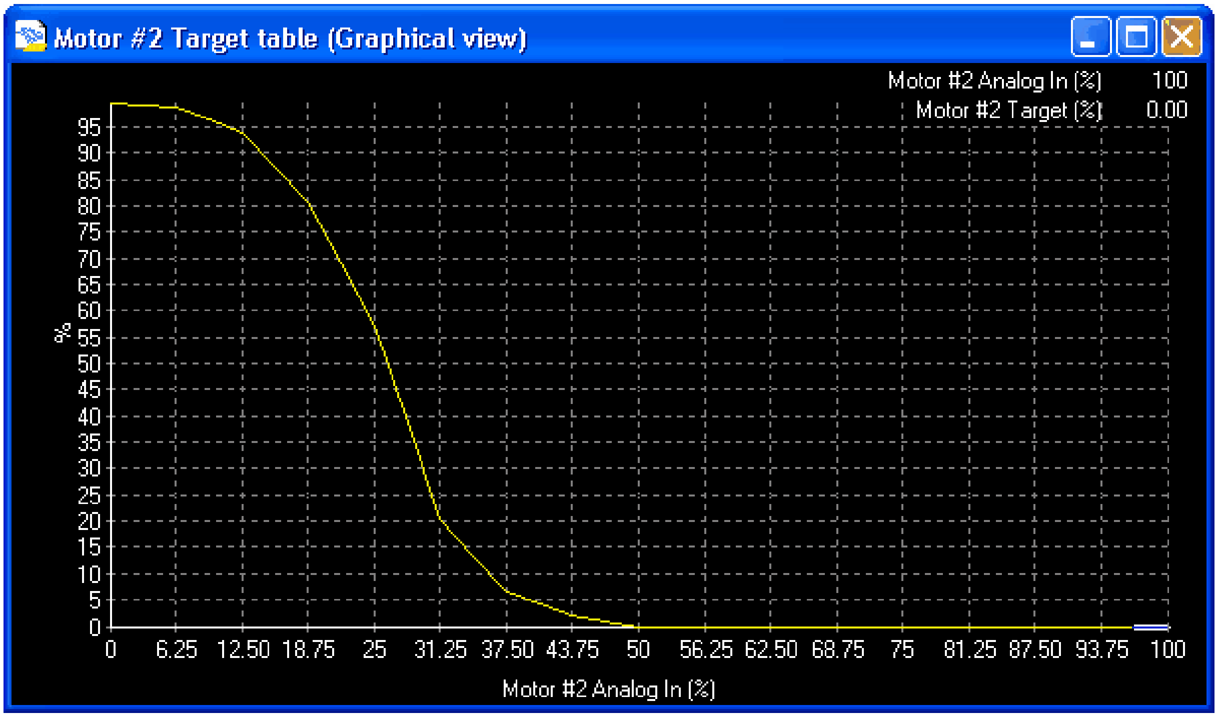
Idle Stepper Clock
Units: On/Off
Description: When active, the stepper motor inverts the direction of rotation (clockwise or counterclockwise). This option is for stepper motors only.

2-D Tables fro Motor Control

Motor #1 Target
Units: Position vs. Motor #1 Analog In
Description: Desired motor position versus the current "Motor #1 Analog In" specified.



Motor #2 Target
Units: Position vs. Motor #2 Analog In
Description: Desired motor position versus the current "Motor #2 Analog In" specified.



Parameters (can be viewed or logged)

Idle 1/2 & 3/4

Units: Binary Code

Description: Displays the current status of the stepper motor driven by outputs Idle 1/2 and Idle 3/4.

Idle 5/6 & 7/8

Units: Binary Code

Description: Displays the current status of the stepper motor driven by outputs Idle 5/6 and Idle 7/8.

Motor Step Counter

Units: %

Description: Displays the current step count rate. This parameter is used for stepper motors only.

Motor #1 Position

Units: Position %

Description: Displays the current position of Motor #1. Note: the "Motor #1 Dead Band" may keep the "Motor #1 Position" parameter from reaching the "Motor #1 Target" parameter.

Motor #1 Analog In

Units: %

Description: Displays the current status of the "Motor #1 Analog In" from the "Motor #1 Target Table".

Motor #1 Target
Units: Position %
Description: Displays the current target position of Motor #1 from the "Motor #1 Target Table".

Motor #2 Position
Units: Position %
Description: Displays the current position of Motor #2. Note: the "Motor #2 Dead Band" may keep the "Motor #2 Position" parameter from reaching the "Motor #2 Target" parameter.

Motor #2 Analog In
Units: %
Description: Displays the current status of the "Motor #2 Analog In" from the "Motor #2 Target Table".

Motor #2 Target
Units: Position %
Description: Displays the current target position of Motor #2 from the "Motor #2 Target Table".

8 Glossary

8.1 Glossary

Glossary

A/F: Air Fuel Ratio. This is the number of air molecules to the number of fuel molecules. This is an expression that is determined by the mass of air to fuel.

AIT: Air Inlet Temperature sensor. This is used to measure intake air temperature. The result of this measurement is used by the ECU to correct the fuel and ignition curves for variances in inlet air density.

Bar: Metric measurement of pressure. 1 bar = .987 atmosphere. Generally referred to as an absolute number.

Barometric Pressure Sensor: This is similar to the manifold pressure sensor (MAP), however this only measures atmospheric pressure. This sensor helps the ECU compensate fuel for altitude changes.

Batch Fire: This is when a group of injectors are fired simultaneously, regardless of cylinder position. With a batch fire system, the ability to control individual cylinder fueling is lost. Batch fire systems are adequate in most applications.

BSFC: Brake Specific Fuel Consumption. This is the amount of fuel required (in lbs/hour) by the engine to make 1 horsepower/hour.

Cam Sensor: This sensor tells the ECU when top dead center of the number 1 cylinder is at the firing position (top of compression stroke). This allows correct sequencing for DIS systems and sequential injection.

Crank Angle Sensor: This is the sensor that tells the ECU the crank angle. It is used for timing input.

Delay Angle: This is the number that is determined by the difference between actual timing displayed with a timing light, and the timing advance displayed on the screen of the PC. Used to synchronize the computer with actual ignition timing.

Direct Fire Ignition: Distributorless ignition with an individual coil for each plug.

DIS: Distributorless Ignition System.

Dry Nitrous System: Injects only nitrous through a nozzle, the fuel is added independently of the nitrous system. Usually the additional fuel is injected through the injectors by increasing the opening time (pulse width) of the injector.

ECU: Engine Control Unit. This is the computer that controls the engines functions.

EFI: Electronic Fuel Injection.

EGT: Exhaust Gas Temperature. Used to measure the temperature of the exhaust.

High Impedance Injectors: This is an injector with a resistance of 7 ohms or higher. The common high impedance injector has 16 ohms, and is known as saturated type injectors.

HS: High Side circuit. This is a circuit that outputs 12 volts to a device. The HS drivers in the AEM EMS are capable of outputting 12V at 4.5 amps. A typical device that would be driven by a HS driver is VTEC or nitrous oxide solenoids.

IAC: Idle Air Control. Most late model fuel injected cars are equipped with a solenoid or stepper motor to control idle conditions and help prevent stalling under varying engine loads at idle. These loads are encountered when air conditioning is turned ON or when the transmission is put in drive.

Knock: This is also known as detonation. This happens when the combustion charge ignites too early in the compression cycle and causes a rattling or pinging sound. By the time knocking is audible engine damage is imminent. Conservative ignition timing, fuel mixtures, and adequate octane fuel should be used to prevent this situation.

KPA: Kilopascal. Metric measurement of pressure, 101.325 Kpa is equal to 1 atmosphere. 1 atmosphere is equal to 14.7 pounds per square inch. 100 KPA is 1 bar.

Low Impedance Injectors: This is an injector with a resistance of less than 7 ohms of resistance, also known as peak/hold injectors.

LS: Low Side circuit. This is also known as a "pull to ground" circuit. LS circuits have power supplied through the device and the driver grounds the circuit to complete the electrical path. An example of this would be a shift light that would be activated by a LS circuit. The maximum current that can be run on the AEM EMS LS drivers is 1.5 amps.

MAP Sensor: Manifold Absolute Pressure sensor. These sensors are typically 1 bar (for non-turbo engines) to 3 bar (turbo engines).

MAF Sensor: Mass Air Flow sensor. This is used to calculate airflow into the engine.

O2 Sensor: Exhaust gas oxygen sensor.

Port Injection: This is when the injector fires directly into each intake port for each cylinder.

Static: This is when the fuel injectors have achieved an always-open status, which happens when the injector's open signal is long enough, and the speed of the engine is such that the injector has received another open signal before it closes.

TBI: Throttle Body Injection. These systems have injectors firing into a throttle body, similar to a carburetor, instead of firing directly into the intake port on the cylinder head.

Template: This is a user defined screen layout. The layout can consist of tuning tools such as fuel or ignition maps, monitored engine functions, or any ECU options. Through the use of template buttons, the tuner can easily switch between displayed tuning functions.

TPS: Throttle Position Sensor. This sensor is used to detect throttle input angle.

UEGO Sensor: Universal Exhaust Gas Oxygen Sensor. This is a high-speed wide band oxygen sensor. As of the printing of this manual, it is the most accurate oxygen sensor available. They, typically, read accurately from 9:1 to 30:1 air fuel ratios.

Wasted Spark: Distributorless ignition with one coil shared between 2 cylinders. This system fires two spark plugs each ignition event, one plug on its compression cycle, one on exhaust cycle.

Wet Nitrous System: Nitrous system that also adds fuel with the nitrous injected through a nozzle.