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DREAM XXI-P Diagnostic

User's Manual

Version 1.01

REG by OMVL

REG®Dream XXI-P Diagnostic User's Manual
Version 1.01.225

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Chapter 1: Introduction

Welcome to the user's manual for the REG Car Diagnostic software. This software lets you program, configure and fine-tune the REG automotive gas injection electronic control unit (ECU).

Picture 1.1: REG injection ECU.

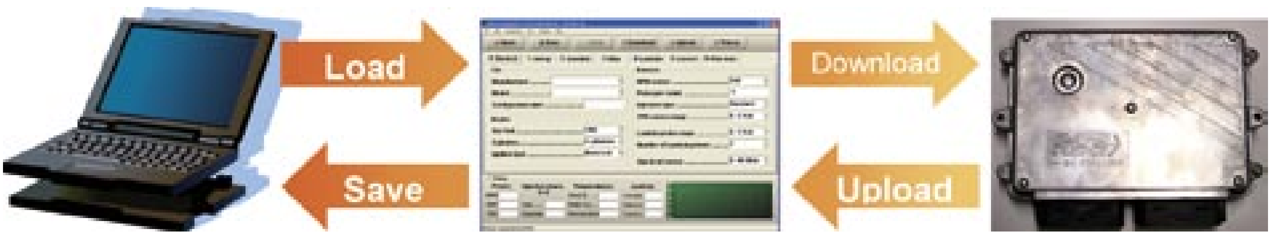
These are the key features of the REG injection system:

- Slave and Compensated mode on the same ECU
- Auto-tuning of gas map
- Adaptivity feature of gas and petrol maps
- Up to 8 cylinders supported by the same hardware
- 2 lambda probed system supported
- Petrol injectors emulation on board
- Gas injection in phase with petrol injection for each cylinder
- CNG and LPG compatible
- bi-fuel and mono-fuel systems supported
- USB connectivity

1.1 Main features

REG car diagnostic lets you edit the configuration of your ECU.
The main features of the program are the filing facility, that lets you save your configurations and load previously saved ones, and the communication facility, that lets you read the configuration parameters currently inside your ECU (Upload) and change them (Download). Moreover, the program constantly monitors the ECU status, giving means to diagnostic controls, and continuously acquires data from it to monitor engine's working point.
The Download and Upload procedures are available only when the ECU is connected to your PC and the program has established a communication with it, that is you are *on-line.*

Picture 1.2: main features diagram.



Upload is performed automatically when a communication is established with the ECU: this means that whenever you connect an ECU to your PC (while the program is running), the configuration currently stored in it is displayed automatically on screen.

Download is performed automatically each time you change a parameter on screen: this means that any modification becomes immediately effective.

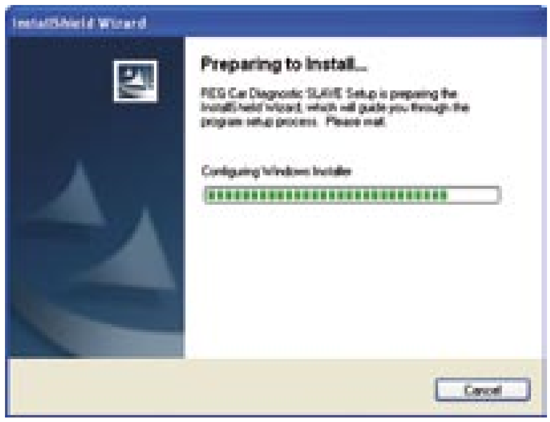
The Load and Save procedures are available at any time within the program, that is you can use them *on-line* as well as *off-line* (no ECU connected). The Load procedure simply loads a saved configuration from your hard disk: while *on-line*, the configuration is automatically downloaded to the ECU.
The Save procedure saves the current configuration to disk for future reference; while on-line, for example you can save to a file the current configuration uploaded from the ECU.

1.2 Installation

Please insert the installation CD-ROM in your PC: Windows operating system should detect the CD-ROM and start the installation procedure automatically. If the installation procedure does not show up in a minute, start it manually browsing the CD-ROM contents and double clicking on the installer icon.

The installation procedure creates a folder named REG Car Diagnostic in your Programs folder on your hard-drive and an entry on your Start/Applications menu. The program is compatible with Windows XP, Windows 2000 and Windows 98.

Picture 1.3: install procedure.

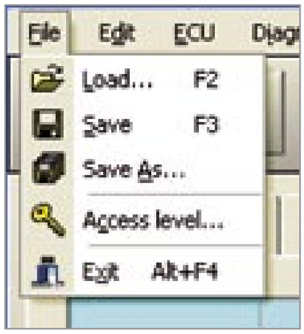


1.2.1 Higher access level

The software is sold in two trims: Lower access level and Higher access level. The lower trim has a simplified user interface, while the higher one has access to every parameter of the software. Please note that the parameters that are not available in the lower trim are set to default values so they do not need to be modified.
After the installation procedure you are logged in the lower access level: if you bought a higher access level password from your dealer, you can now activate the higher trim.
To enter the higher access level, please start the program: click on the Start button on the tool-bar of your desktop (usually on the bottom-left corner of your desktop), browse among the Programs and open the folder named REG Car Diagnostic, then click on the program's icon. Alternatively, locate the directory on your hard-drive where the program was installed *(usually C:\Program Files\REG Car Diagnostic)* and double click on the pro-

gram's icon. Once running, the program welcomes you with a splash window; there's no need to connect an ECU at this time.

Picture 1.4: File menu in the program's main window.



Please open the File menu of the menu-bar at the top-left of the main window and select the Access level menu-item: It pops-up a dialog where you can type the higher access level password. The password is made up of 16 characters, grouped 4 by 4: type the first four characters on the left-most box, then move to the right with your mouse or the **TAB** key on your keyboard. Once typed completely, press the **ENTER** key on your keyboard or click on the **Ok** button.

Picture 1.5: Higher access level dialog.

If the password is right, you are automatically logged-in at the higher access level: you can see it in the Access level box in the bottom of the dialog, that now should read **Access level: 2**.
If you mistyped the password, the dialog warns you that you entered a wrong password; please type it again.
Once you have done, close the dialog.

The higher level password is automatically stored and you don't need to repeat this operation anymore; from now on, at program start-up you are logged-in at higher access level.

1.3 Connections

Connect the ECU to the PC with the REG USB interface: plug the automotive Sigma connector to the socket on the ECU's harness and the RJ-45 connector on the other end of the cable to the RJ-45 socket in the interface.

1.3.1 REG USB interface

Locate a free USB connector on your PC and connect the interface to it with a standard USB cable with an USB-A connector on one end and an USB-B connector on the other: a standard USB printer cable will be fine.
When you connect The REG USB interface to your PC for the first time, the 'found new hardware' window should pop-up (only for

Windows XP and 2000): to complete the new hardware installation procedure you need the USB interface drivers, that are in the installation CD-ROM. Just insert the CD-ROM when requested.
The REG USB interface has got 2 leds (green and yellow) that monitor the communication between the PC and the ECU.

Picture 1.6: REG USB interface.

1.3.2 COM port settings

The program talks with the ECU thru a COM port of your PC: COM ports are communication devices identified by a number. Common port numbers are COM1, COM2 etc; whenever you plug a REG interface to your PC, it is accessed thru a COM port number. Its number depends on the USB port where the interface is plugged.

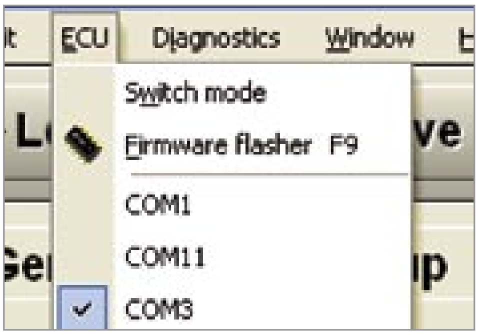
To be able to establish a communication with the ECU, the program needs to know the COM port number of the REG interface: once started, the program lists every COM port installed on your PC in the ECU menu of the main window. You should set the COM port number manually selecting one from the menu.

Beware that the program lists each and every COM port found on your PC: modems and other computer peripherals that use COM ports could interfere with it, slowing down the communication or crashing the system. Please disable internal and external modems on your PC if you're not sure about their COM port number.

Once the COM port settings are right, the program starts automatically to talk with the ECU: when this happens you should see a big green box over the Status Panel at the bottom of the main window, telling you the ECU operating mode (Slave or Compensated), along with the ECU's firmware id tag on the status-bar and some live measure on the Status panel.
This means that the program has successfully established a communication with the ECU and the COM port settings are right.

The COM port setting is automatically stored, so the next time you'll run the program it will be recalled.

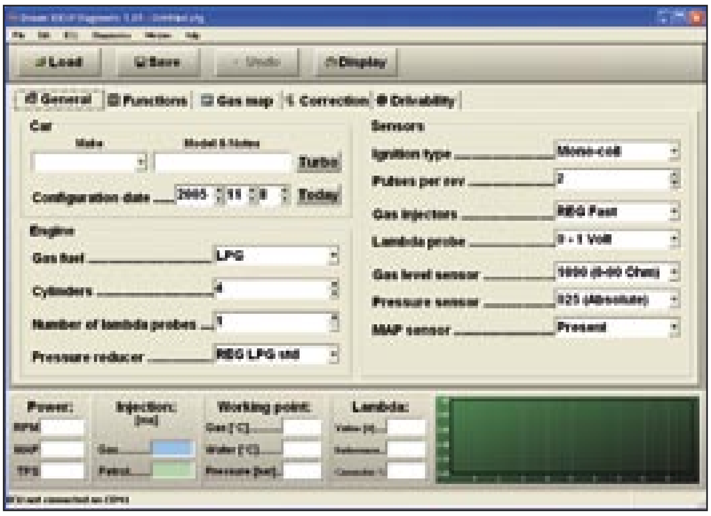
Picture 1.7: ECU menu.



Chapter 2: Main window

The main window appears at program **start** up. To start the program, click on the start button on your desktop (usually on the bottom-left corner of the screen), browse among the *Programs* and open the folder named *REG Car Diagnostic*, then click on the program's icon. Alternatively, locate the directory on your hard-drive where the program was installed (usually *C:\Program Files\REG Car Diagnostic*) and double click on the program's icon.
The program welcomes you with a splash window and then the main window shows up.

Picture 2.1: main window.



Once running, the program tries to locate the ECU thru your PC's COM ports: in order to communicate with the program, the ECU must be properly connected and powered and the COM port settings must be correct.

When a communication is established, the configuration stored inside the ECU is uploaded and displayed on screen; the ECU's firmware-id tag is shown on the status-bar at the bottom of the window. Whenever the program can't establish a communication, it displays 'ECU not connected' on the status-bar.

The main window is divided in 6 areas: starting from the top, its title-bar shows the program name and the currently opened configuration file. A star after the configuration name shows whether it has been modified or not.
Just below the window's title bar there is a menu-bar with File, Edit, ECU, Diagnostics, Window and Help menus. Below it there is the tool-bar with the **Open, Save, Undo, Display** and **Bank** selection button.

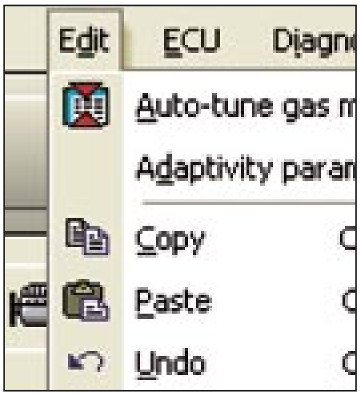
The central part of the window is folded in several tabs: General, Set-up, Petrol map (only visible while in Compensated mode), Gas map, Lambda, Corrections and Fine tune (the last three are accessible only within the higher access level). Each tab is divided in group-boxes showing the parameters of the ECU. To view a tab simply click on the tab label on the top of it, just below the tool-bar: the active tab is painted over the others, so you can see only one tab at a time.
Below the central tabs there is the Status panel, showing the working point of the engine and the lambda signal trace. On the bottom of the window there is the status-bar, showing messages like the ECU's firmware-id tag and current connection status.

2.1 The menu-bar

The menu-bar has 6 menus for the main operations of the program: File, Edit, ECU, Diagnostics, Window and Help.

2.1.1 File menu

The File menu contains the Open, Save, Save As, Access level and Exit items.
The Open menu-item simply pops-up a file-open dialog that lets you choose a configuration file *(.cfg)* to load into the program: it's equivalent to the **Open** button on the tool-bar. Beware that each time you open a configuration file, it's automatically downloaded it into the ECU: if the previous configuration is not saved, the program asks you to save it before opening the new configuration.



Picture 2.2: File menu

Each time a configuration is opened, the file name is shown in the title-bar of the main window aside the window's title.

The Save menu-item pops-up a file-save dialog that lets you create a file on your PC to store all the parameters of a configuration: use it if you want to keep the current configuration for future reference. If the current configuration has not been saved yet, the Save menu-item pops-up a file-save dialog where you can type-in a file name for it: on the other hand, if the configuration has already been saved, the Save menu-item simply saves the configuration over the same file.

The default name for a configuration is made up of the car's model and notes, the fuel type, the ECU mode and the configuration date; for example, if you have a configuration made on the 1st of July 2005 for a *Wolksvagen Golf GTI* running in Slave on LPG fuel, the default name when saving it to disk would be:

Golf GTI LPG Slave 2005-07-01.cfg

The *Save as* menu-item always pops-up a file-save dialog that lets you create a new file on your PC to store the current configuration, no matter if the configuration has already been saved or not; it's equivalent to the **Save** button on the tool-bar. Use the Save as command to copy the current configuration to a new file.

If the current configuration has been modified, a star appears aside its name on the title-bar of the main window reminding you that it should be saved. Whenever it's saved, the star disappears.

Please note that whenever the ECU is connected, each modification of the parameters is automatically downloaded to the ECU, so the current configuration is always stored in the ECU, no matter if you save it to disk or not: think of the save feature as a facility that lets you store in your hard-disk a copy of the configuration currently in the ECU.

Access level menu-item was discussed in the Introduction chapter, while the *Exit* menu-item simply closes the program: if the current configuration is unsaved, it asks you if you want to save it before closing the program.

2.1.2 Edit menu

The Edit menu has got the Auto-tune gas map, Adaptivity parameters, Copy, Paste, Undo, Reset to default cfg and Reset gas map items.

Picture 2.3: Edit menu

The Auto-tune menu-item is the same as the **Tune** button of the gas map in the *Set-up* tab of the main window, and it starts a procedure that tunes the gas map from the default values to figures suitable for your car and system: refer to the *Auto-tuning* chapter for details about that.

The Adaptivity parameters item pops-up a window where you can set-up the adaptivity feature for the gas and petrol maps: refer to the Adaptivity chapter for details about that. The menu-item has the same effect as clicking the right mouse-button over the **Adaptive** button of the gas map in the Set-up tab.

The **Undo** menu-item is exactly the same as the Undo button in the tool-bar of the main window. Please note that there is only one level of undo: only the last performed operation can be cancelled.
The *Reset* to defaults command clears all parameters and reset them to their default values. The only parameter that is not changed is the gas fuel selected in the General tab of the main window. So, depending on the gas fuel you've selected and the mode of the ECU (Slave or Compensated), you can reset the configuration to one of the 4 defaults: Slave CNG, Slave LPG, Compensated CNG, Compensated LPG. This command is useful if you have an unsatisfying configuration and you want to start from scratch again.
Reset gas map menu-item resets both banks of the Slave gas map to default: use this command whenever you have modified the gas maps and wish to start again from scratch.

There are 2 default maps, one for the CNG and the other for the LPG fuel: depending on the selected fuel in the General tab of the main window, this command will reset the current gas map to the CNG or LPG defaults.
This command is not available for the Compensated mode.

2.1.3 Copy & Paste

The *Copy and Paste* menu-items work with any map and table of the main window: simply select the cells you want to copy and activate the *Copy* menu item, or press *CTRL+C* on the keyboard. The selected cells are copied to the internal clipboard. Select then the cells you would like to replace with the clipboard, and activate the Paste menu item (or press *CTRL+V*).
Only the cells from the clipboard that fit into the current selection are pasted: for example, if you copied a block of 3x4 cells into the clipboard and want to paste them over a selection block of 2x5, you'll get that only the upper-left 2x4 cells in the clipboard are pasted onto the upper-left 2x4 cells of the destination selection. The other cells in the destination selection are not changed.

Copied cells can be pasted only into a destination that is compatible with the source of the clipboard's data: that is, you can copy figures from the gas map of one bank to the other, but you can not copy, for example, pressure figures from one table in the Corrections tab to temperature figures of another table!

Please note that the current version of the program uses an internal clipboard for the copy & paste operations: it doesn't use Windows clipboard, so you can't copy cells from the program to another application (for example, a spread-sheet) and vice-versa.

2.1.4 ECU Menu

This menu is used to switch the mode of the ECU and set the COM port settings to establish a communications between the PC and the ECU.

Picture 2.5: ECU menu.

The *Switch to Compensated* menu-item lets you toggle the ECU's mode between Slave and Compensated: while the ECU is working in Slave, this command turns it to Compensated, while when running in Compensated, the menu-item shows the *Switch to Slave* command and toggles back to Slave.

Each time you activate this command, a dialog will ask you to confirm the operation; Slave and Compensated have two independent configuration, that is you can switch between them and edit one configuration while preserving the other one.

The *Firmware* flasher is used to update the firmware in the ECU with a new one: refer to the Firmware flasher chapter for details about that.

The next menu-items in the ECU menu are used to set the COM port number (see the Introduction for details about COM port settings): any COM port found in your system is listed here.

When you select a COM port, the setting is stored, so it will be restored automatically the next time you run the program. The program is tied to COM1 the first time it's run.

2.1.5 Diagnostics menu

The Diagnostics menu contains the Display meters and Check nozzles items.

Picture 2.6: Diagnostics menu

The The *Display meters* menu-item simply pops-up the Meters window.
While this window is visible, the program continuously acquires data from the ECU and displays it in real time on the window.
Details about the Meters window are described in the last chapter.

The *Check nozzles* menu-item pops-up a dialog that gives some info about the quality of your gas map: read further details in the Auto-tuning chapter.

2.1.6 Window menu

The Window menu is useful to quickly switch the tabs of the main window. It contains the General, *Set-up*, Petrol map, Gas map, Lambda controller, Corrections and Fine tune items: they simply show the respective tab-sheet of the main window.
Petrol map is only visible while in Compensated mode.

Lambda controller and Fine tune are available only at the higher access level *(Power User).*

Picture 2.7: Window menu

2.1.7 Help menu

The Help menu has got only the Pin out and About menu-items. The About item gives some info about the program like version, serial code and access level.

Picture 2.8: ECU's pin out dialog.

The Pin out menu-item pops up a dialog reporting the ECU connector's pin out, with pin descriptions and a photo of the connector itself; when you select a pin on the lists, a marker will blink on the picture of the harness, showing the position of that pin.

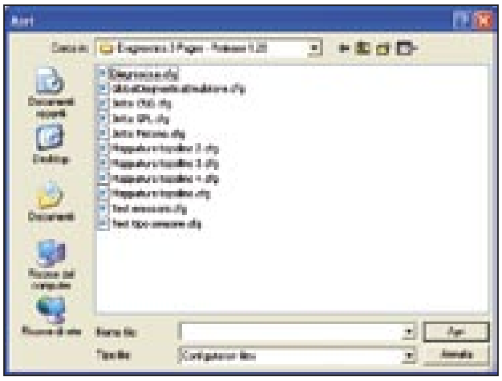
2.2 The tool-bar

The main commands of the program are associated with the buttons collected in the tool-bar on the top of the main window: **Load, Save, Undo, Display** and **Bank** selection.

Picture 2.9: tool-bar of the main window

2.2.1 Loading configuration files

The **Open** button in the tool-bar of the main window lets you load a saved configuration file from your PC and download it automatically into the ECU: once you click it, it pops-up a file-open dialog where you can search for a configuration file (.cfg files). If you don't have a configuration file that suits your car and system, you can auto-tune the default configuration (read the next chapters), or adjust it manually.



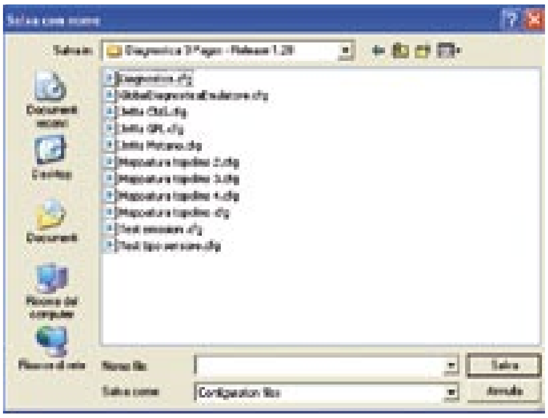
Picture 2.10: file-open dialog.

2.2.2
Saving a configuration file

Once you have uploaded or opened a configuration file, the program lets you fine-tune its parameters: be aware that any change made on screen is automatically downloaded to the ECU and so becomes immediately effective.

When you are satisfied with a configuration, you should save it to disk for future reference. To save a configuration file, you can click on the **Save** button on the tool-bar of the main window; the program pops-up a file-save dialog where you can type-in the name of the new file to save (or accept the default one), or choose to replace an existing one. The default name is made up of the car's model and notes, the fuel type (CNG or LPG), the ECU mode (Slave or Compensated) and the configuration date.

Picture 2.11: file-save dialog



2.2.3 Undo

Use the **Undo** button (or its equivalent menu-item: Edit/Undo) to cancel the last operation made: that is, if you modify a parameter and are not satisfied with the results, you can get back the last set of parameters as it was just before the last modification. Beware that the undo has only one level, so only the last operation can be cancelled.

2.2.4 Display meters

Traces of signals acquired from the engine can be useful to quickly check-out the ECU's functionalities: the program continuously acquires the most important measures from the ECU and shows them in real-time on the Status panel of the main window, but to thoroughly check all acquired signals you should open the Meters window.

The **Display** button in the tool-bar of the main window pops-up the Meters window, displaying the acquired data in a graphical format. See the last chapter to read more about the Meters window.

Picture 2.12: Meters window

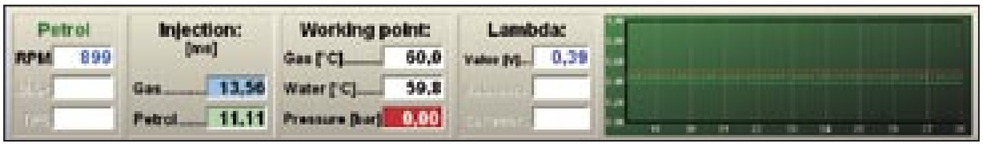
2.2.5 Bank selection

The last button shown on the right of the toolbar is the **Bank** button. If you are working on a 2 frontal lambda system (and set the general parameters accordingly), while the gas map is visible, you can toggle between the first and the second bank with this button. When the button is labeled Bank 1, the gas map shows the first bank figures, while if the button is labeled Bank 2 the map shows the second bank ones.

2.3 Status panel

This panel is at the bottom of the main window and shows the main data acquired from the ECU: it's quite useful to have a glance of the working point of the engine. The Status panel is attached to the bottom of the window, so it's always visible (no matter what tab you are browsing). It's divided in 4 boxes: Power, Injection, Working point and Lambda. The Status panel is updated automatically every 100ms (more or less).

Picture 2.13: Status panel of the main window



The Power box shows this measures:

- **Power:** the colored label at the upper-left corner shows which fuel is currently powering the engine. Whenever the power is switched, a white glowing label appears over the lambda chart at the right hand side of the Status panel. This control can show CNG or LPG in light-blue color, or Petrol in light-green color.
- **RPM** (Revs Per Minute): shows the current revs of the engine.
- **MAP** (Manifold Air Pressure): shows the currently measured MAP in mbar, if available in your system.
- **TPS** (Throttle Position Sensor): shows the currently measured TPS in Volts, if available in your system.

The Injection box shows the injection times of the petrol ECU and those computed by the gas ECU. If you are working with a single lambda probe it shows only cylinder's 1 timings, while if you are working on a 2 lambda probed system (2 banks), it shows both cylinder 1 and cylinder 5 timings.

- **Gas:** shows the gas injection time computed by the ECU, in milliseconds.
- **Petrol:** shows the petrol injection time measured from the petrol ECU, in milliseconds.

The Working point box shows some infos on the gas:

- **Gas:** shows the temperature (in Celsius degrees) of the gas at the injection rail.
- **Water**: shows the temperature of the water (in Celsius degrees) inside the pressure reducer.
- **Pressure:** shows the gas pressure (in bar). Note that if the gas pressure is too low, this control blinks in red. The low pressure threshold value is the left-most pressure reference value of the Gas pressure table in the Corrections tab.

The Lambda box shows some measures about the lambda:

- **Value:** shows the currently acquired voltage from the Lambda probe, in Volts. If you are working with a two lambda probed engine, two boxes are displayed showing the values of both.

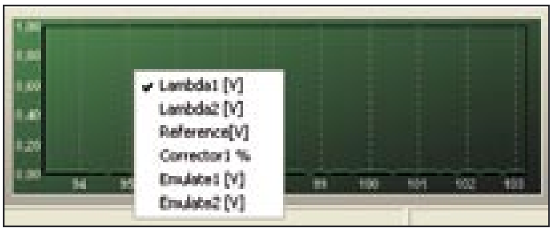
The value is painted in blue while the injection is lean (not enough fuel), while is painted in red when it's rich (too much fuel).

- **Reference:** shows the current Lambda reference value, as computed in the Lambda reference table (see next paragraphs), in Volts. This measure is active only if the Lambda controller or the Lambda emulation is active; see Lambda chapter for details about the controller and the emulation.
- **Corrector:** shows the percentage of correction applied by the Lambda controller (see next chapter). This measure is active only if the Lambda controller is active.

2.3.1 Traces chart

At the right hand side of the Status panel there is a chart showing the trace of the lambda signal: it plots the values acquired from the Lambda probes in real time.

Picture 2.14:
Lambda chart of the Status panel.



The chart can plot up to six traces: if you click the right-mouse button on the chart, a pop-up menu lets you choose which trace to plot. You can choose among:

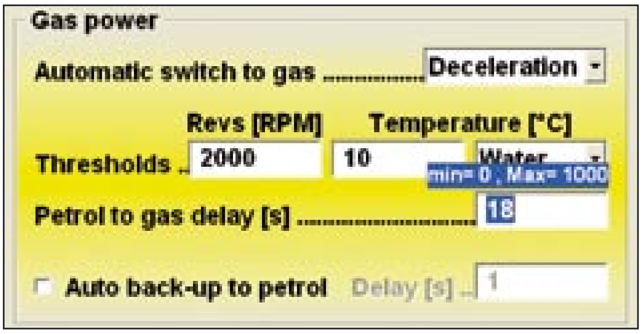
- **Lambda1**: shows the currently acquired voltage from the Lambda probe, in Volts. The trace is painted in solid green.
- **Lambda2**: shows the currently acquired voltage from the second Lambda probe, if any. The trace is painted in solid light blue.
- **Reference**: shows the current Lambda reference value, in Volts. The trace is painted in dotted yellow.
- **Corrector1 %**: shows the percentage of correction applied by the Lambda controller. 0% is plotted in the middle of the chart, so this trace can show positive or negative percentages (from –50% up to 50%). The trace is painted in solid red.
- **Emulated1**: shows the currently emulated Lambda 1 signal, in Volts. See the Lambda chapter for details about the emulated lambda. The trace is painted in solid white.
- **Emulated2**: shows the currently emulated Lambda 2 signal, in Volts. The trace is painted in solid gray.

At start-time only the Lambda 1 trace is plotted, but if you activate the lambda controller on the Lambda tab of the main window, the Reference and Corrector traces are automatically activated. Likewise, if you select two lambda probes in the Engine box of the General tab of the main window, the Lambda 2 trace appears automatically.

Chapter 3: Basic parameters

A configuration is made of a set of parameters that define the ECU behavior. They are organized in the tabs of the main window: General, Set-up, Petrol map (only for Compensated mode), Gas map, Lambda, Corrections and Fine tune (the last three are available only within the higher access level). Parameters are organized logically in the tabs and the most important are in the General and Set-up tabs, along with the Maps; they are accessible at any user access level. Parameters in the last three tabs (Lambda, Corrections and Fine tune) are used only for fine-tuning purposes.

The tabs themselves are divided in group-boxes, each showing a set of parameters focused on a particular aspect of the configuration. When you select a control in a group-box (just click over the it or press **TAB** to jump from a control to the next), the group-box glows in yellow reminding you where you are.



Picture 3.1: a glowing group-box. Notice the blue label above the focused control that shows its accepted values.

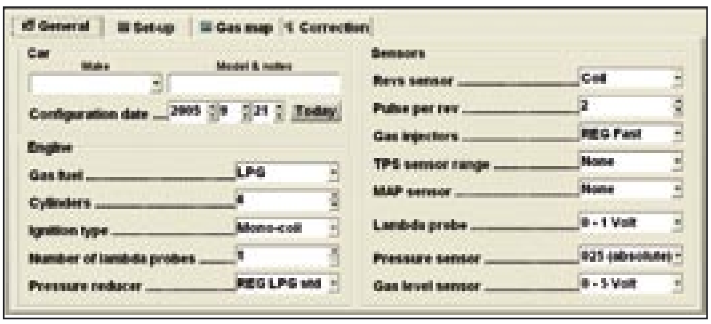
Parameters are displayed in numeric controls or drop-down lists: each time you press ENTER while editing them, their data is downloaded to the ECU. Data is downloaded automatically also when a control looses the focus, that is when you select on another one.

When you stop the mouse over any control, a small hint label pops-up under the mouse, telling you more about the parameter you are pointing. Moreover, if you select a numeric control, after one second a blue label will pop-up above the control showing the range of accepted values.

3.1 General

The first tab is the General and contains the

most basic parameters of a configuration. It's divided in 3 group-boxes: Car in the upper-left corner, Engine at the bottom-left corner and Sensors at the right corner.



Picture 3.2: General tab of the main window.

3.1.1 Car

This box is at the upper-left of the General tab and lets you type-in the make and model of the car and the configuration date: those parameters have no effect on the ECU behavior, so use them to keep track of those details for future reference.

The **Make** control is a drop-down list where you choose among some common car's manufacturers: if your can't find the manufacturer you are searching, you can type it in manually.

The **Model & notes** control is a simple text box where you can type the car's model and some notes about it.

The **Turbo** switch-button is an automatic facility that sets up the gas map for turbo engines: it should be switched on when the system is installed on a turbo car, and switched off for naturally aspirated cars.

The **Configuration date** is made up of three spin-boxes that let you set the configuration year, month and day respectively. At the right of those spin-boxes there is the **Today** button, which is a commodity that sets the configuration date to the current date for you. Please note that every time you change a parameter of a configuration, the date is automatically set to the current date.

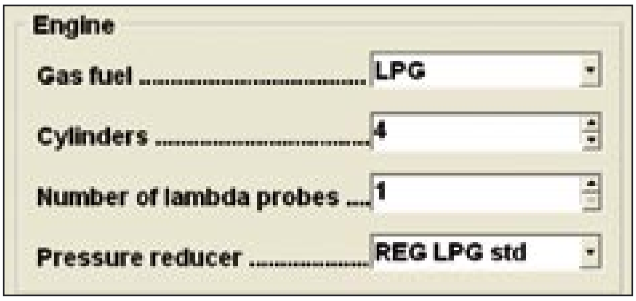
Picture 3.3: Car group of the General tab.

Please note that the car's **Model & notes** and the **Configuration date** make up the configuration's default name; any detail that could help identifying the current configuration should be typed in the **Model & notes** box, so it will appear in the configuration's file name.

3.1.2 Engine

This box is at the lower-left corner of the General tab and is used to set the basic information about the car's engine and the gas system.

Picture 3.4: Engine group of the General tab.



- **Gas fuel:** lets you choose between CNG (Combustion Natural Gas) or LPG (Liquid Petrol Gas) fuel.

- **Cylinders:** sets the number of cylinders of the engine. The ECU supports from 2 to 8 cylinders.

- **Number of lambda probes:** sets the number of frontal lambda probes installed in the car. You can set a single lambda-probed engine or a two lambda-probed one. Note that often two banked engines (6 and 8 cylinders) have two frontal lambda probes, but that's not a general rule. On the other hand, two probed engines are always divided in two banks of cylinders.
  The ECU manages the two lambda-probed systems a bit differently than single probed ones: for single lambda probed systems the figures used to compute gas injection times are the same for every cylinder (even if the engine has two banks), that is there is only one Gas map. On the other hand, two lambda-probed systems have two independent gas maps, one for each bank of cylinders: the ECU can use two different figures for gas injection for the two banks.

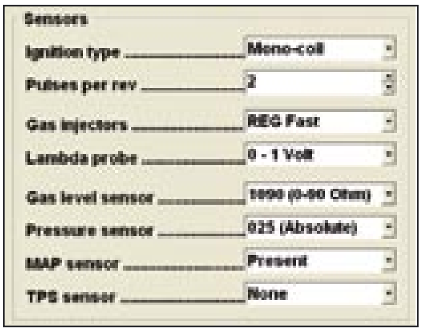
- **Pressure reducer:** this lets you select from a drop-down list what pressure reducer you have installed in your system. You can choose from:

  - **REG CNG std:** standard pressure reducer for CNG. Nominal pressure is 1.8 bar.
  - **REG LPG std:** standard pressure reducer for LPG. Nominal pressure is 900 mbar.
  - **REG LPG MP:** medium pressure reducer for LPG. Nominal pressure is 1.25 bar.
  - **REG LPG HP:** high pressure reducer for LPG. Nominal pressure is 1.8 bar.

  Please note that the different reducers work at different nominal pressures, so when you change the pressure reducer selection, the program asks you if you to update the pressure compensation table in the Corrections tab.

3.1.3 Sensors

This box is in the right half of the General tab and is used to set the type and range of sensors installed in the car.



Picture 3.5: Sensors box of the General tab.

- **Ignition type:** here you can select where the rev signal going to the gas ECU comes from:
  - **Mono-coil:** this means that you connected the RPM signal of the gas ECU to a coil pack of the ignition, and the petrol ECU sparks only once per rev.
  - **Bi-coil:** the RPM signal comes from the coil packs, but the petrol ECU sparks twice per rev.
  - **Crank / Cam shaft:** it means that you are taking the RPM signal from the crank shaft gear or the cam shaft gear.

- **Pulses per rev:** sets how many pulses the gas ECU receive per each rev of the engine; this is quite useful to trim the RPM reading on the Status panel when you take the RPM signal from the crank or cam shaft gear. Accepted values go from 1 to 255.
  If the Status panel reports a RPM speed that's different for the one you read on the car, try changing this parameter and the ignition type.

- **Gas injectors:** choose the type of the gas injectors installed in the system from REG Standard or REG Fast.

- **Lambda probe**: sets the type of Lambda probe installed in the engine. Choose from:
- None: select this if the lambda probe is not connected to the gas ECU.
  - **0 – 1 Volt:** the probe's voltage goes from 0 to 1 Volt.
  - **0 – 5 Volt:** the voltage goes from 0 to 5 Volts.
  - **5 – 0 Volt:** the voltage goes from 0 to 5 Volts, but the signal is inverted.
  - **0.8 – 1.6 Volt:** voltage goes from 0.8 to 1.6 Volts.
  - **UEGO:** voltage goes from 0 to 5 Volts, but the signal is inverted. The current version of the program supports only the Bosch UEGO lambda probe.

- **Gas level sensor:** sets the type of sensor used to monitor the gas level in the tank.
  - **AEB 1090 (411040):** standard resistive sensor for LPG systems; it ranges from 0 to 90 Ohm.
  - **AEB 820 (411027):** standard resistive sensor for LPG systems of some countries (for example Holland and England); it ranges from 0 to 100 Ohm.
  - **AEB 806 (411010):** standard led-driven sensor for CNG systems; it's reverse and ranges from 5 to 0 Volts.
  - **REG 1050 (411034)**: alternative resistive sensor for LPG systems; it's reverse and ranges from 5 to 0 Volts.
  - **Custom:** this enables the Custom gas levels table in the Set-up tab, where you can set the threshold voltages as you like.
  - **Reverse custom:** this is just like the previous Custom setting, but the voltages are reverse.

- **Pressure sensor:** sets the type of sensor installed in the system that measures the gas pressure at the rail. You can choose from 013 (differential) or 025 (absolute).

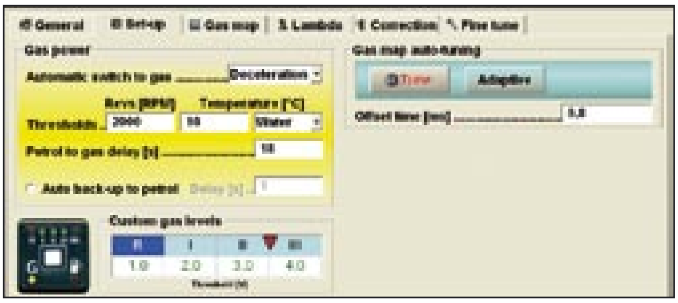
- **MAP sensor:** here you can specify if there is a MAP sensor in the system or not. If you set that to none, the MAP measure in the Power box of the Status panel, in the bottom left corner of the main window, is disabled.

- **TPS sensor range:** this parameter is available only at higher access level and lets you choose the TPS sensor type by its range:
  - **None:** the TPS signal is not connected to the gas ECU. This disables the TPS measure in the Power box of the Status panel, at the bottom-right of the main window.
  - **0–5 Volt:** TPS voltage goes from 0 to 5 V (full throttle).
  - **5–0 Volt:** TPS voltage goes from 5 to 0 V (full throttle).

3.2 Set-up

The second tab contains the remaining basic parameters of a configuration; it's divided in the Gas power, Custom gas levels, Auto-tuning and Injectors group-boxes (the Injectors group-box is available only at higher access level).

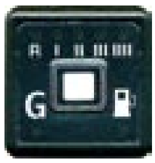
Picture 3.6: Set-up tab of the main window.



3.2.1 Automatic switch to gas

The switch that's installed inside the car lets you change the engine's power from petrol to gas and back: the switch-button on it let you manually choose which power to use. The leds on it show the status of the ECU: the petrol red led on its right is lit when the car is running on petrol, while the gas yellow led on the left is lit while the car runs on gas. The leds on the top of it are the gas level gauge and monitor the gas level in the tank; the gas level is shown only when running on gas.

Picture 3.7: the switch installed inside the car



Instead of manually switch to gas, the ECU has the facility to automatically switch to gas for you after the engine has warmed-up running in petrol power; the Gas yellow led on the switch blinks when the auto-switch is enabled and the ECU is waiting for the engine to warm up. You can activate the auto-switch to gas feature pushing the switch-button once: if the car was running on petrol, it starts blinking the Gas yellow led and the ECU waits for the engine to warm up. Once the warm-up conditions are met, the ECU switches to gas, so the Petrol red led is turned off and the Gas yellow led is lit.

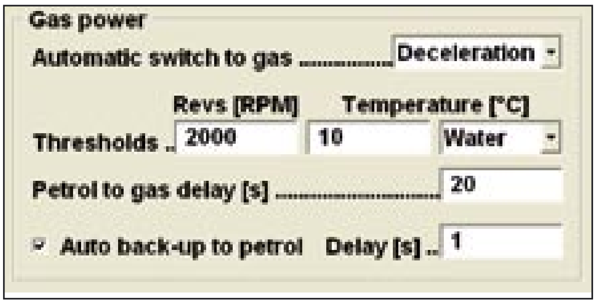
If you push the switch-button while the car is running on gas power, it turns back to petrol power (and the leds on the switch change accordingly). If you push the switch-button while the ECU is waiting to automatically switch to gas (Gas yellow led is blinking), the auto-switch procedure is aborted, and the car continues to run on petrol.

There are several override and emergency features on the switch: if the car is running on petrol and you want to switch to gas without waiting for the engine to warm-up, you can push the switch-button and keep it pushed for 2 seconds. This overrides the auto-switch to gas feature and forces the ECU to switch immediately to gas, no matter if the engine's warm-up conditions are met or not.

The auto-switch to gas feature can be disabled also setting the corresponding parameter in the configuration (see below): if the configuration is set to start on gas or to mono-fuel, the auto-switch to gas is disabled and the engine starts on gas automatically when you turn the key. There's no need to push the switch-button.

3.2.2 Gas power

This box is in the upper-left corner of the Set-up tab and controls the auto-switch to gas feature.



Picture 3.8: Gas power box of the Set-up tab.

- **Automatic switch to gas:** lets you choose if the auto-switch to gas feature should be enabled or disabled. The options are:
  - **Acceleration:** the auto-switch to gas feature is enabled and the ECU switches to gas when the revs of the engine are above a threshold (see below), thus when the car is accelerating;
  - **Deceleration:** the auto-switch to gas feature is enabled and the ECU switches to gas when the revs get under the threshold, thus when decelerating;
  - **Start on gas:** the auto-switch to gas feature is disabled and the engine starts-up on gas, thus petrol power is never used. The Auto back-up to petrol facility is available.
  - **Monofuel:** the auto-switch to gas feature is disabled and the engine starts-up on gas. The Auto back-up to petrol facility is disabled, thus petrol power can not be used. Note that the Monofuel cold-start table in the Fine tune tab is enabled only when Monofuel is selected.

- **Thresholds:** set here the warm-up conditions that should be met to activate the auto-switch to gas feature. These are:
  - **Revs:** sets the revs threshold (in RPM) at which the ECU switches to gas. Accepted values range from 500 to 4000 RPM, the default value is 2000. Please note that values are rounded in steps of 100 RPM.
  - **Temperature:** sets the minimum temperature (in Celsius degrees) above which the ECU can switch to gas. You can choose to monitor the water temperature of the gas temperature: select it in the drop-down list at the right of the numeric control. This condition inhibits the automatic switch when the engine is not warm enough. Accepted values go from 0 to 40 °C; the default value is 30 degrees.

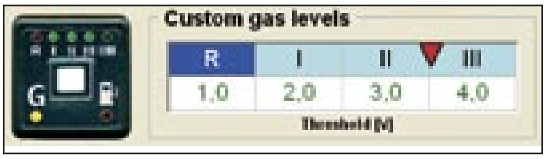
- **Petrol to gas delay:** this is the last warm-up conditions and sets the minimum time (in seconds) the ECU should wait before auto-switching to gas.
  Accepted values go from 0 to 1000 s; the default value is 40 seconds.

- **Auto back-up to petrol:** while running on gas, the ECU has the facility to switch back to petrol if the gas pressure is too low (that is, the gas tank is empty). Check the check-box to activate this feature. If you leave it unchecked, the feature is disabled and the ECU continues to power the engine with gas, whatever the gas level is; in that case the Delay control is disabled.
  - **Delay:** sets the delay the ECU should wait before switching back to petrol, when the gas is finished. Accepted values go from 1 to 3 s; the default value is 1 second.

3.2.3 Custom gas levels

This group-box is at the bottom-left corner of the Set-up tab; it's made up of a switch and a table. The switch at the far left is a software replica of the switch installed inside the car, that lets you switch from petrol to gas (and vice-versa) and monitor gas level gauge; the switch-button on it has the same features of the real one inside the car, so you can push it lightly to activate auto-switch to gas, or keep it pressed for 2 seconds to force the switch to gas.

Picture 3.9: Gas level box of Set-up tab.



The Custom gas levels table is enabled only if you selected **Custom** or **Reverse Custom** gas level sensor in the General tab: it lets you edit the voltage threshold that define the gas level gauge. You can set the thresholds for the reserve level (**R**), the one quarter full level (**I**), half-full (**II**) and three quarter full (**III**). Voltages range form 0 to 5 Volts.

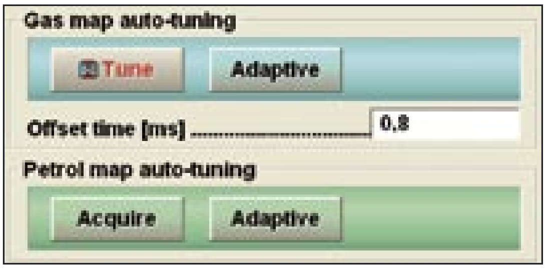
The red needle indicator above the table shows the current gas level gauge, and it moves accordingly to the changes you make to the threshold.

Refer to the next paragraph about maps to learn more about how to edit a table.

3.2.4 Auto-tuning

The Gas map and Petrol map auto-tuning group-boxes are at the upper-right corner of the Set-up tab: they contain 4 buttons that let you auto-tune the gas map and activate the adaptive features of the ECU.

Picture 3.10: Auto-tuning group-boxes of the Set-up tab.



The **Tune** button in the Gas map auto-tuning box activates the auto-tuning procedure on the Gas map. This is the same as the Auto-tune gas map item of the Edit menu.
The **Adaptive** button in the Gas map auto-tuning box activates the adaptive feature on the *Gas map*: this way the gas map is automatically tuned while the car runs on gas. If you right-click with the mouse over the Adaptive button of the Gas map, a window pops-up where you can set the auto-adaptivity parameters.
The Petrol map auto-tuning box is visible only while in *Compensated mode:* use the **Acquire** button to automatically acquire the petrol map while the car is running on petrol.
Use the **Adaptive** button to activate the adaptivity on the Petrol map: this tunes automatically the petrol map while running on gas.
Please read the *Auto-tuning* and **Adaptivity** chapters for more details.

3.2.5 Offset time

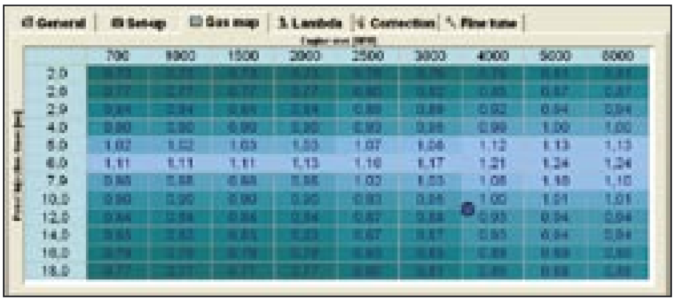
The **Offset time** in the Gas map auto-tuning box shows the fixed time (in ms) that's added to gas injection: you can use it to adjust the whole map with a single operation. You can enrich the map increasing the offset, and lean it decreasing that time: please be careful when changing the offset, because it deals directly with the gas injection times and a wrong value makes the engine run badly on gas. For example, if you have auto-tuned the map and then would like to get it richer, you can raise the offset value from the default 0.8 ms to, let's say, 1.0 ms: doing so you are increasing the gas injection times for the whole map by a 200 ms.

Beware that the offset influence is greater for lower injection times that for higher ones: in the example above, by adding 200ms to the offset time, you would enrich the map by a 5% in the idle zone (where injection times usually are around 4 ms), but only by a 1% for full-throttle (times usually around 20 ms).
Offset times should be close to 1.0 ms and not exceed 2.0 ms: if your system seems to need an higher value, it means that the gas map you are using is wrong. If this is the case, you should reset the offset time to its default (0.8 ms), reset the gas map to default and auto-tune it once more. Accepted values for the offset range from 0 to 10 ms; some systems do not need an offset time, so you can set the value to 0.0 for their configuration.

Chapter 4: Maps and tables

From the third tab on, the main window shows maps and tables: maps are made up of many rows and columns of cells, each showing a figure, with row and column headers too; tables are made only of a row header and a row of cells.

Picture 4.1: Gas map tab of the main window.



4.1 Gas map

The Gas map tab of the main window shows the main data that the ECU uses to compute the gas injection times. The computing algorithms are different in Slave and Compensated modes, so the Gas map shows different figures in the two modes:

- **Slave:** the gas map shows the ratios between the gas injection times and the petrol injection times, each column sampled at different revs of the engine and each row sampled at different petrol injection times. The table has 9 columns for each engine rev (in RPM) and 12 rows for each gasoline injection time (in ms). The ratios inside the map can span from 0.00 to 2.00; the column headers can range from 0 to 8160 RPM, while the row headers can go from 0.0 to 25.5 seconds.
  The ECU computes the gas injection times multiplying the petrol injection times acquired from the petrol ECU by those ratios, then adjusting the computed times with the Lambda controller and the compensations found on the Corrections tab.

- **Compensated:** the gas map shows the gas injection times (in ms), each column sampled at different revs of the engine and each row sampled at different MAP values (Manifold Air Pressure). The table has 9 columns for each engine rev (in RPM) and 12 rows for each MAP value (in mbar). Times inside the map can range from 0.00 to 25.50 ms; the column headers can range from 0 to 8160 RPM, while the row headers can go from 0 to 2550 mbar.
  The ECU uses the figures read on the gas map directly as gas injection times; those times are then adjusted with the Lambda controller and the compensations found on the Corrections tab.

Slave and Compensated gas maps are stored independently: you can modify one preserving the other. Even their column and row headers are independent and can be set to different values; more over, each bank in a two probed system has got its own Slave and Compensated gas map, so there is a total of 4 gas maps in the ECU.

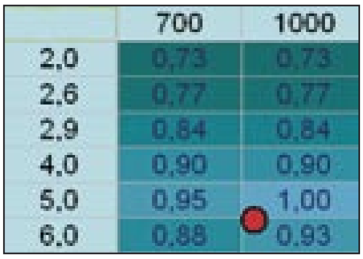
Cells of the gas map are painted in light blue: the higher the figure in them, the lighter the color. This gives a sort of 3D-rendering effect to the map.

Note: *if you press the SPACE bar while the gas map is visible, the ECU is forced to switch the fuel immediately - if the car is running on petrol, it's switched to gas, and vice-versa. This is useful when you are editing the map by hand and want to compare the engine's behavior between petrol and gas.*

4.1.1 The dot

A moving dot in painted over the map showing the engine's working point: when the dot is over a cell, it means that the engine's revs can be read on that cell's column header, while the current petrol time (or MAP value, in Compensated mode) can be read on that cell's row header.The dot is painted in blue when the injection is lean (not enough fuel); it's pained red when the injection is rich (too much fuel). Note that lean or rich injection is detected evaluating the lambda probe voltage.

Picture 4.2: dot on a map.



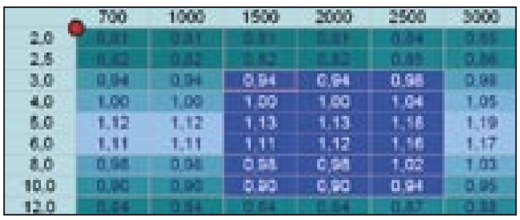
	700	1000
2,0	0,73	0,73
2,6	0,77	0,77
2,9	0,84	0,84
4,0	0,90	0,90
5,0	0,95	1,00
6,0	0,88	0,93

When the engine is running, the dot moves freely on the map; most of time it won't be over a single cell but between them. The injection time for that working point is computed interpolating the figures from the cells near the dot, so the actual injection time comes from the values of the 4 cells close to the working point

4.2 Editing cells

A cell of a map or table can be selected by clicking the left mouse button over it; if you want to select many cells, simply drag the mouse with the left button pressed over the cells you want to select. Selected cells are painted in blue.

Picture 4.3: selected cells in a map.



	700	1000	1500	2000	2500	3000
2.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3.0	0.94	0.94	0.94	0.94	0.98	0.98
4.0	1.00	1.00	1.00	1.00	1.04	1.05
5.0	1.12	1.12	1.13	1.13	1.18	1.19
6.0	1.11	1.11	1.11	1.12	1.16	1.17
8.0	0.98	0.98	0.98	0.98	1.02	1.03
10.0	0.90	0.90	0.90	0.90	0.94	0.95
12.0	0.84	0.84	0.84	0.84	0.87	0.88

You can copy and paste the selected cells as you like: read the Main window chapter to learn more about the copy & paste procedures. When you are working with a two lambda probed-system, if you copy and paste some cells of the gas map of one bank, the other bank is left unchanged: usually this is misleading, thus the program warns you that the other bank has not been changed.

Only selected cells can be edited: once you have selected the desired cells, click the right mouse button, press the *RETURN* key or type a number to pop-up the cell modify dialog. All selected cells are modified at once.

Picture 4.4: Modify dialog.

You can select the type of modification you need from:

- **Set:** the value entered is the exact value that will be put in any selected cell.
  Example: lets assume you have selected three cells with 4.00, 4.50 and 3.30 figures in them, respectively. If you type 5.32 in the value box and select Set, all the cells will change their values to 5.32.
  This feature can be activated also pressing *CTRL+S* on the keyboard.

- **Add:** the value entered is summed to any selected cell. You can enter positive or negative values.
  Example: lets assume you have selected three cells with 4.00, 4.50 and 3.30 figures in them, respectively. If you type 0.21 in the value box and select Add, the first cell's value will change to 4.21, the second to 4.71 and the third to 3.51. On the other hand, if you add –0.10 the cells would turn to 3.90, 4.40 and 3.20.
  This feature can be activated also pressing *CTRL+A* on the keyboard.

- **Add %:** the value entered is a multiplication factor (expressed as a percentage) that will be applied to any selected cell; positive percentages increase the underlying values, while negative ones decrease them.
  Example: lets take a cell with a 4.30 value in it. Adding a 10% would change its value to 4.73 (+10%), while adding –20% would turn it to 3.44 (that is 80% of the original value).
  This feature can be activated also pressing *CTRL+D* on the keyboard.

To confirm the modification, press the *RETURN* key on your keyboard or click on the **Ok** button with the mouse; to cancel it (and preserve the original values), simply press the ESC key or click on the **Cancel** button. Please note that when the Modify dialog pops up, the Value box shows the figure read on the top-leftmost cell of the selection.
While editing the gas map in a two lambda-probed system, the Modify dialog shows also the **Bank** selection switch: it lets you choose which bank to modify. When the dialog pops-up, the switch-button is unchecked and shows the current bank number: the ongoing modification will be applied only to the current bank. If you click it once, it becomes checked and shows **Bank 1+2:** the modification will be applied to both banks. If you click it another time, it switches the selected bank and shows the other bank number: now the modification is applied to the new bank. Clicking it once more, it goes back to the **Bank 1+2** option, and so on.

Once the modification is confirmed, the program checks if the new values are within the acceptable range for the map or table: if they are not, a warning dialog pops-up and lets you choose to clip them or to cancel the modification. If you chose to clip, the values are clipped to the closer range's boundary; if you chose to cancel, the Map is not modified.

Please remember that any modification is automatically downloaded into the ECU, so any modification to the maps and tables is stored immediately in the ECU; you can always change your mind and go back to the previous values with the **Undo** button of the tool bar (or its equivalent item in the Edit menu), but beware that there is only one level of undo.

Even the column and row headers of the maps (and most of the tables) can be copied, pasted and edited: select them and click the right mouse button, press the *RETURN* key or type a number to pop-up the Modify dialog. For example, in the gas map you can modify a column header to change the engine's rev reference of that column, or modify a row header to change the petrol time reference value (or MAP, in Compensated) for an entire row.

4.3 Petrol map

The ECU needs to know the petrol injection times while running in Compensated mode: those times are sampled at different engine's revs and at different MAP values in the Petrol map. The petrol injection times are shown in mill seconds and the map has got 9 columns for the engine's revs and 12 rows for the MAP values.

Picture 4.5: Petrol map tab of the main window.

The ECU uses the sampled times to compute a lambda emulated signal for the petrol ECU; read more about the emulated lambda in the Lambda chapter. Please note that the Petrol map tab is visible only while the Compensated mode is active: it's useless while in Slave, so it doesn't show up in that mode.

The ECU can create the petrol map automatically with the acquisition feature of the Auto-adaptivity facility: simply activate the **Acquire** switch-button of the Auto-tuning box in the Set-up tab of the main window.
While running on petrol, the ECU samples the petrol injection times and stores them in the petrol map. If you want to adjust the petrol map also while running on gas, you can activate the **Adaptive** switch-button for the Petrol map in the Set-up tab.

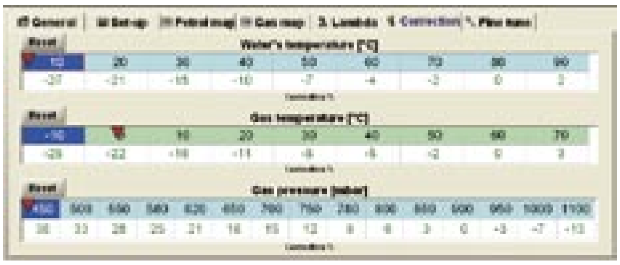
Cells of the petrol map are painted in light green: the higher the figure in them, the lighter the color. This gives a sort of 3D-rendering effect to the map.

Should you ever need to fine-tune the petrol map, you can edit it like any other map or table (see previous paragraph for details about editing); remember that accepted times inside the map span from 0.00 to 25.50 ms, while the column headers can range from 0 to 8160 RPM and the row headers can go from 0 to 2550 mbar. Please note that the column and row headers in the petrol map are independent from the ones in the gas map, so you can set them to completely different values.
A moving dot in painted on the map showing the engine's working point, just like in the gas map.

4.4 Corrections tables

The Corrections tab of the main window shows the three compensation tables.

Picture 4.6: Corrections tab of the main window.



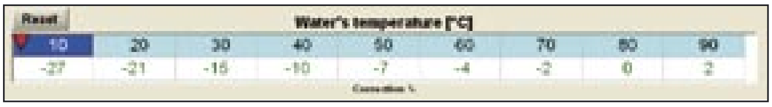
The gas injection times computed from the gas map are adjusted with the figures found in the compensation tables: the water's temperature table, the gas temperature and gas pressure table. Tables are made up of a row of column headers and a row of figures.

4.4.1

Water's Temperature table

This table is used to set the compensation factors for the temperature of the water inside the pressure reducer. The column headers show the reference temperature for each factor (in Celsius degrees), while the cells in the table show the corresponding compensation factor in percentage.

Picture 4.7:
Water's temperature table in Corrections tab.



You can set the factors simply selecting the cells and clicking the right-mouse button, or pressing the *RETURN* key, or typing a number: a Modify dialog will pop-up.
Refer to the Map paragraph for details about the Modify dialog. Accepted values go from –100% to 100%.

The column headers are modifiable, too: simply select them and click the right-mouse button to pop-up the Modify dialog. Modify a column header to change the water's reference temperature for that column. Accepted values go from -20 to 203 °C.
A red needle above the table shows the current water's temperature on it and thus also the currently selected correcting factor; it moves on the table according to the current measure of the water's temperature.

The **Reset** button above the table resets the correction table to its default values; when you click it a dialog will pop-up asking you to confirm.

4.4.2

Gas Temperature table

This table is used to set the compensation factors for the temperature of the gas inside the gas injection rail. The column headers show the reference temperature for each factor (in Celsius degrees), while the cells in the table show the corresponding compensation factor in percentage.

Picture 4.8:
Gas temperature table in Corrections tab.

You can set the factors simply selecting the cells and clicking the right-mouse button, or pressing the *RETURN* key, or typing a number: a Modify dialog will pop-up.

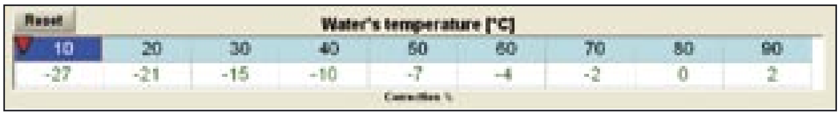
Accepted values go from –100% to 100%. The column headers are modifiable, too; edit one of them to change the water's reference temperature for that column.

Accepted values go from -20 to 203 °C. A red needle above the table shows the current gas temperature on the table.

The **Reset** button above the table resets the correction table to its default values; when you click it a dialog will pop-up asking you to confirm.

4.4.3 Gas Pressure table

This table is used to set the compensation factors for the pressure of the gas at the pressure reducer outlet manifold. The column headers show the reference pressure for each factor (in mbar), while the cells in the table show the corresponding compensation factor in percentage.



Reset

Water's temperature [°C]

10	20	30	40	50	60	70	80	90
-27	-21	-15	-10	-7	-4	-2	0	2

Correction %

Picture 4.8:
Gas temperature table in Corrections tab.

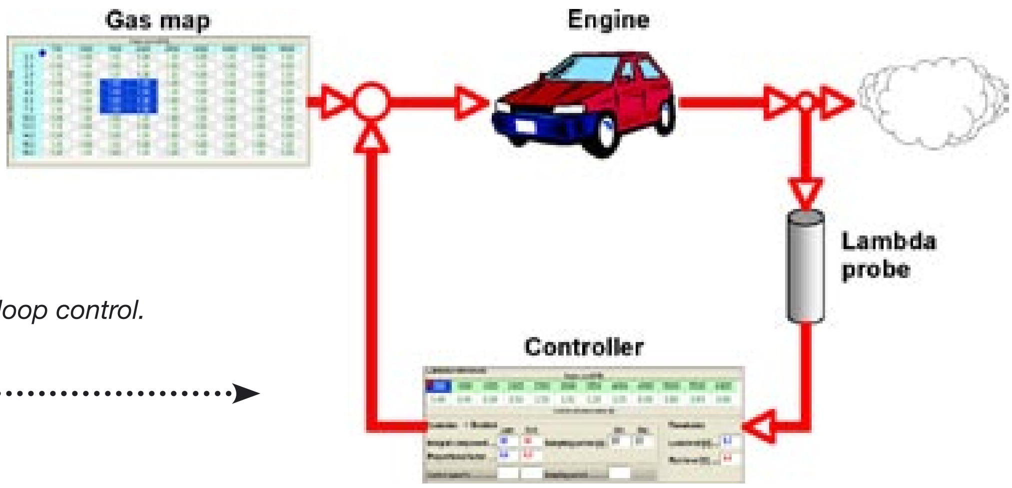
You can set the factors simply selecting the cells and clicking the right-mouse button, or pressing the *RETURN* key, or typing a number: a Modify dialog will pop-up.

Accepted values go from –100% to 100%. The column headers are modifiable, too; edit one of them to change the water's reference temperature for that column.
Accepted values go from 0 to 4080 mbar; please note that the values are rounded in steps of 50 mbar.

A red needle above the table shows the current gas.

The **Reset** button above the table resets the correction table to its default values; when you click it a dialog will pop-up asking you to confirm.

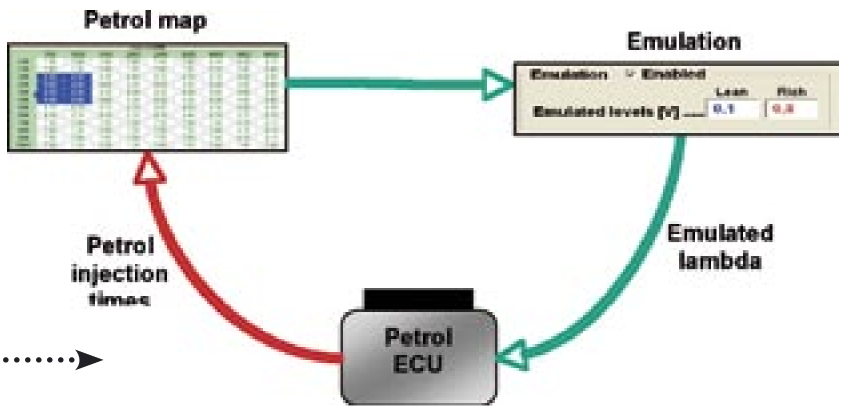
The ECU has got the facility to control the gas injection in closed-loop, just like what the petrol ECU do. To achieve that, the lambda probe wire should be connected to the gas ECU: the lambda signal is used to adjust the gas injection times with a negative feedback. Gas times are shortened when lambda is greater than a reference value, while they are stretched when it's lower than the reference.



Picture 5.1: lambda closed-loop control.

Another facility implemented in the ECU is the Lambda emulation: please note that you have to cut the lambda probe wire and connect it only to the gas ECU. The lambda signal will be fed to the petrol ECU thru the Emulated lambda wire of the gas ECU.

This facility generates a *virtual* lambda signal that's fed to the petrol ECU in order to fool it and should prevent Malfunction Indicator Lamps of the car's deck to light-on.
The algorithm used to compute the emulated lambda depends on the ECU's mode: in Compensated mode the signal is computed from the petrol map, in Slave from the lambda reference table.



Picture 5.2: Lambda emulation in Compensated mode.

Please remember that Lambda controller and Emulation must be active while in Compensated mode; on the other hand, Slave mode usually does not need them.
The parameters that control those feature of the ECU are available only at the higher access level.
They are a bit complicated and are set to default values: you hardly need to change them.

Chapter 5

5.1 Introduction

Lambda probes are installed in the exhaust manifold of the engine: sensing the oxygen in the exhaust gases, they generate a voltage that's (sort of) proportional to the air/fuel ratio in the fuel mixture that's going into the engine.

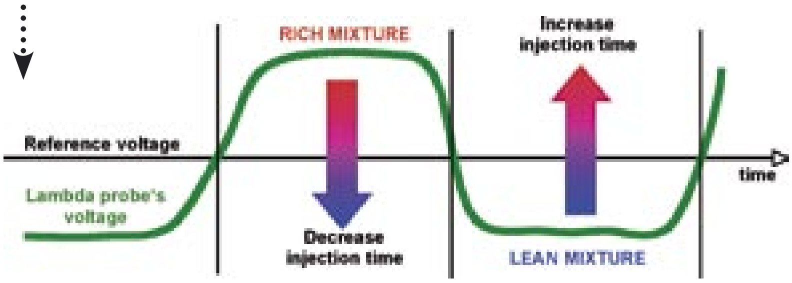
Usually, when lambda probes sense a stechiometric ratio in the fuel mixture, they generate an output voltage that's (more or less) at the middle of their voltage range; for example, a common 0 – 1 Volt probe generates a voltage that's more or less 0.45 V, when sensing a stechiometric ratio. On the other hand, they generate a voltage that's greater that the middle voltage, when sensing a rich mixture, while the voltage is lower than the middle voltage when sensing a lean mixture.

5.1.1 The closed-loop control

The lambda controller implemented in the ECU is a standard Proportional Integral closed-loop controller that uses the lambda probe voltage as a feedback signal. Generally speaking, the lambda probe signal is used to check if the fuel mixture is right; if it's not right, the ECU adjusts the mixture modifying the injection times (for example, the less the injection time, the less the gas in the mixture).

The controller automatically adjusts the injection times checking constantly the voltage generated by the lambda probe. When the lambda voltage is greater than a reference voltage (usually, the middle voltage of the lambda probe's range), the controller thinks that the fuel mixture is too rich, and so it leans out the mixture decreasing the gas injection times; on the other hand, when the lambda voltage is lower than the reference, the controller thinks that the mixture is too lean, and so it enriches the mixture increasing the gas injection times.

Picture 5.3: how the gas injection times are changed in a negative feedback control.



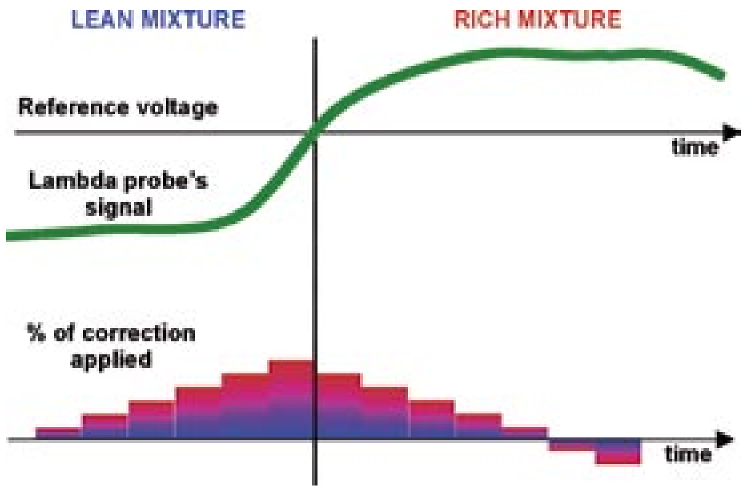
That kind of control has a closed loop because when the controller modifies the mixture, the lambda probe voltage changes accordingly: the controller in its turn senses the lambda voltage changing and modifies the mixture again, which causes the lambda voltage to change again, and so on.
Because the mixture is leaned out when the lambda senses a rich mixture, and enriched when it senses a lean mixture (it's a negative feedback control), a steady-state is always reached: this happens when the lambda probe reaches the reference voltage, that is the controller has reached the stechiometric mixture and so doesn't need to adjust the injection times any more.

5.1.2 Integral and proportional factors

The amount of correction the controller applies to the injection times depends on the controller's behavior: the controller implemented in the REG ECU is a Proportional and Integral (PI) standard controller (it can act as a proportional and an integral controller at the same time).

The **proportional controller** is quite simple: the amount of correction is proportional to the lambda voltage. It means that, for example with a 0 – 1 Volt probe, if the lambda voltage is much greater than the reference (let's say it's 0.9 Volt) the injection times would be reduced a lot, while if it's only slightly over the reference (it's 0.6 Volt) the times would be slightly reduced.

The **integral controller** on the other hand takes into account how the lambda probe's signal is evolving, not only it's current voltage. It samples the lambda voltage every certain period of time: the correction applied to the injection is increased at each period when the lambda signal is lean, and decreased at each period when it's rich. For example, if the lambda stays lean for a lot of time, the correction applied is increased constantly at each period.



Picture 5.4:
correction percentage of the integral control.

The integral controller computes a sort of integral of the lambda probe's signal over time; the petrol ECU has got an embedded controller that works exactly in the same way. The Compensated mode works using the integral controller of the gas ECU; you need to cut the lambda probe's wire that feeds the petrol ECU, if you want to use the Compensated mode. Doing so, you will open the petrol ECU's control loop thus inhibiting the petrol's controller; otherwise, the controller embedded in the two ECU (the gas and the petrol one) would conflict each other.

The Slave mode, on the contrary, uses the petrol's control loop, so there's no need to cut the lambda probe's wire (even if it doesn't hurt: Slave mode can work also with the wire cut), but the gas controller should be disabled (to avoid conflicts).

5.2 Lambda tab

The Lambda tab of the main window is available only at higher access level and collects all the parameters used to set the lambda controller and lambda emulation. It is divided in 4 boxes: Lambda references table at the top, Controller in the middle-left, Thresholds in the middle-right and Emulation at the bottom.

Picture 5.5: Lambda tab of the main window.

5.2.1 Lambda controller

The lambda controller group-box is divided in two halves: the upper collects the 6 editable parameters of the controller, while the lower shows the status of the controller and is not editable.

Picture 5.6: Lambda controller box in Lambda tab.

The main parameters for the controller are the correction factors that it should apply to the injection times. There are two sets of correction factors: one for the proportional controller (that fix its *strength*), the other for the integral one (that set its speed). The corrections applied by the two controllers are summed, thus they work together. More over, each controller have a pair of correction factors: one is for lean mixtures, the other for rich ones. If the lambda probe's voltage is lower than the reference voltage (meaning a lean mixture), the lean factors are used; if it's greater than the reference (rich mixture), the rich factors are used.

The last parameters of the controller are its sampling periods: the lambda signal is sampled at a certain rate, that is it's evaluated periodically over time. The sampling period is variable and changes with the engine's revs: at lower revs the sampling period is at its maximum, while at higher revs is at its minimum.
This is useful to have finer samples of the lambda signal at higher revs, when the lambda signal changes quickly, and with a coarser sampling rate at lower revs, when the lambda is quite slow. In between, the sampling period is interpolated between its min and max value.

The parameters in the group-box are:

- **Enabled:** this check-box is used to activate or by-pass the controller. Check it to enable the controller, or uncheck it to disable it.

- **Integral components:** these set the integral components used to correct lean or rich mixtures. Accepted values go from 0 to 255.

- **Proportional factors:** these set the proportional factors used to correct lean or rich mixtures. Accepted values go from 0.0 to 5.0.

- **Sampling periods:** these set the minimum and maximum sampling period (in ms). Min period is used at higher engine's revs, max period at lower ones. Accepted values go from 0 to 255 ms.

On the bottom of the group-box there is a status bar that shows the integral controller speed percentage and the current sampling period:

- **Control speed %:** these show the correction speed percentages for the integral controller, for lean and rich mixtures. They are updated automatically and are not editable.

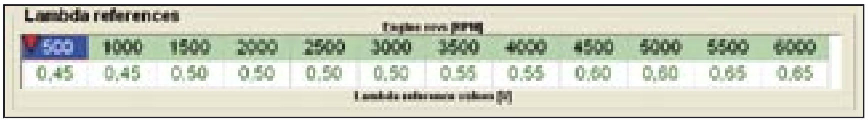
- **Sampling period:** this shows the current sampling period (in ms), computed interpolating the min and max periods at the current engine's revs. It's updated automatically and is not editable.

The Corrector trace plotted in red on the Lambda chart and the Corrector box on the Status panel show the current percentage of correction of the lambda controller (proportional and integral), that is the controller's strength.

5.2.2 Lambda references

The reference voltage used to check if the lambda probe is sensing a rich or a lean mixture is variable: it changes over the engine's revs. The lambda references' table is used to set the reference values for the lambda signal at different engine's revs. The cells of the table show the reference values in mill Volts: the Reference trace on the Lambda chart of the Status panel shows this reference value as it changes over time according to the engine's revs.

Picture 5.7: Lambda references table in Lambda tab



Lambda references

Engine revs [RPM]

500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000
0,45	0,45	0,50	0,50	0,50	0,50	0,55	0,55	0,60	0,60	0,65	0,65

Lambda reference values [V]

ou can set a value simply selecting a cell and clicking the right-mouse button, or pressing the *RETURN* key, or typing a number; refer to the Map chapter for details on how to edit cells.

Accepted values are bounded by the range of the Lambda probe set in Sensors box of the General tab: for example, if you set a lambda probe's range of 0 – 1 Volts, the accepted reference values go from 0 to 1V. On the other hand, with a probe's range of 0 – 5 Volts, the accepted references go from 0 to 5V.
A red needle above the table shows the current engine revs on the table and thus also the currently lambda reference voltage: if the needle falls between two cells, the reference value is interpolated between the two adjacent values. While the engine is running, the needle moves on the table according to the current engine revs.
Please note that the reference revs found on the column headers are not modifiable.

5.3 Emulation

The Emulation box is placed in the middle-right of the Lambda tab: it shows the two values used to compute the 'virtual' lambda signal for the gasoline ECU while using gas power.

Picture 5.8: Emulation box in Lambda tab.

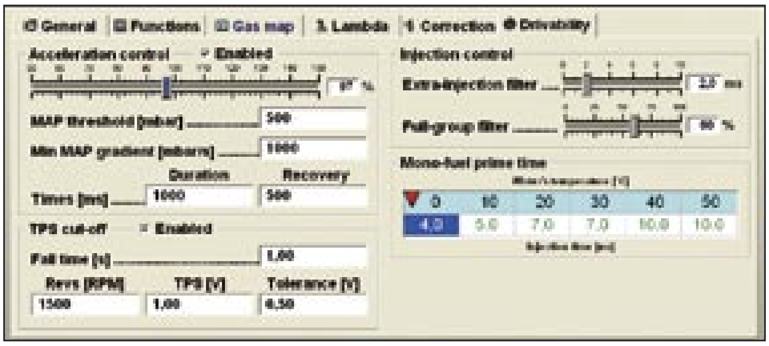
- **Rich level:** sets the value used to emulate a rich lambda signal (that is too much fuel). The value is expressed in Volts.

- **Lean level:** sets the value used to emulate a lean lambda signal (not enough fuel). The value is expressed in Volts.

Accepted values are bounded by the range of the Lambda probe set in Sensors box of the General tab.

Chapter 6: Drivability

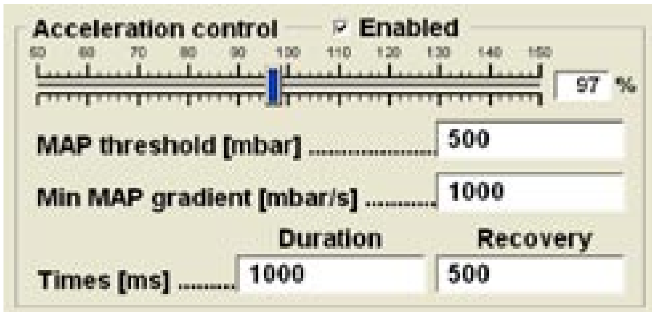
The last tab of the main window is used to fine-tune the engine performance when running on gas: These parameters are useful to enhance the drivability of the car. This tab is made up of five group-boxes: Acceleration control, TPS cut-off, Injection control and Mono-fuel prime time.



Picture 6.1:
Fine tune tab of the main window.

6.1 Acceleration control

This box is in the upper-left corner of the Fine tune tab: use it to enhance the drivability if you experience engine's vibrations when accelerating, for example if you push the throttle down abruptly while driving.



Picture 6.2:
Acceleration control group-box in Fine tune tab.

This feature is available only if your system acquires the MAP signal, that means that you connected a MAP sensor to the ECU; please note that if you are using the REG 025 absolute pressure sensor, the MAP signal is already present by default.

This group-box is enabled only if you set the **MAP sensor** to **Present** in the Set-up tab. The feature is activated when the MAP raises quickly above a threshold, signaling a great acceleration of the engine: when active, the feature enriches or leans out the mixture scaling the gas injection time by a fixed percentage for a while, then it restores the injection linearly to its original value.

You can set the percentage of injection that should be applied when the feature is activated with the fader on the top of the group-box: it ranges from 50% to 150 %.

Values lower than 100% lean out the injection, while higher values enrich it; beware that scaling too much can make the engine run badly during accelerations.

The other parameters are available only at higher access level and they are used to adjust the acceleration detection:

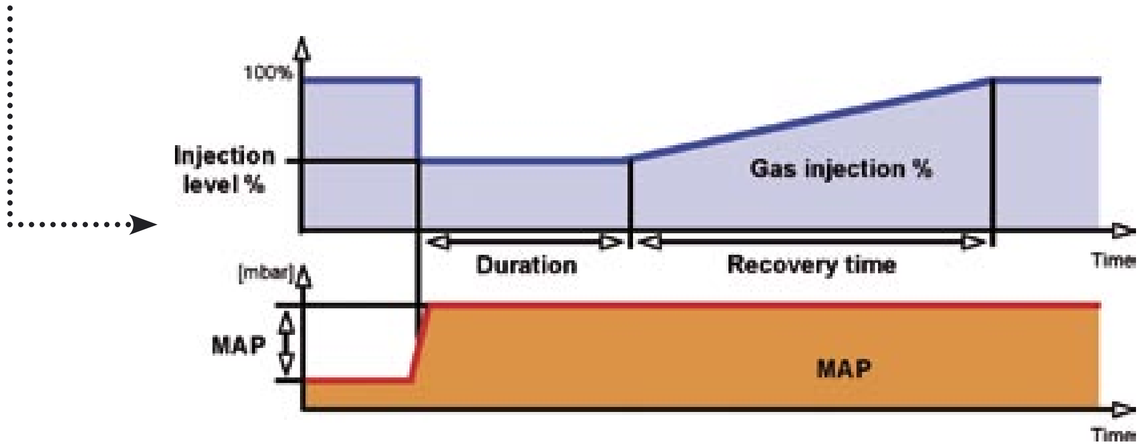
- **MAP threshold:** sets the minimum MAP value in mbar that activates this feature. If the MAP is lower than the threshold, the Smooth acceleration is not activated. Accepted values go from 0 to 1000 mbar.

- **Minimum MAP gradient:** sets the minimum MAP variation speed that activates the feature (in mbar/s). If the MAP varies more slowly than this value, the Smooth acceleration feature is not activated. Accepted values go from 0 to 2500 mbar/s.

- **Duration time:** sets the feature duration in mill seconds. In this period the gas injection is scaled by the injection level percentage. Accepted values go from 0 to 2000 ms.

- **Recovery time:** sets the time it takes to restore linearly the injection times to 100% of original value. Accepted values go from 0 to 2000 ms

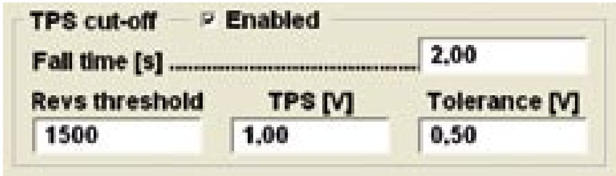
Picture 6.3:
example of transient with injection leaning.



The longer the duration and recovery times, the smoother the acceleration, but raising them too much can lead to a loss of engine's power.

6.2 TPS cut-off

This box is in the upper-right corner of the Fine tune tab: use it to enhance drive comfort if, for example, you experience engine's vibrations when quickly releasing the throttle (injection cut-off).



Picture 6.4:
TPS cut-off group-box in Fine tune tab.

During petrol injection cuts-off the petrol injection times goes to zero and the gas ECU cuts-off the gas injection immediately; in some cases the gas injection needs to be cut-off before the petrol, so you need a way to anticipate it using the TPS signal.

This group-box is enabled only if you set the **TPS sensor** range **to 0-5 Volt** or **5-0 Volt** in the Set-up tab. This feature delays the gas injection cut-off by a fixed period of time, reducing the injection times linearly from 100% of original value to 0. The speed of reduction depends on the fixed period of time. The petrol cut-off is detected when the TPS voltage falls beyond a threshold, but only if the engine speed is high enough.

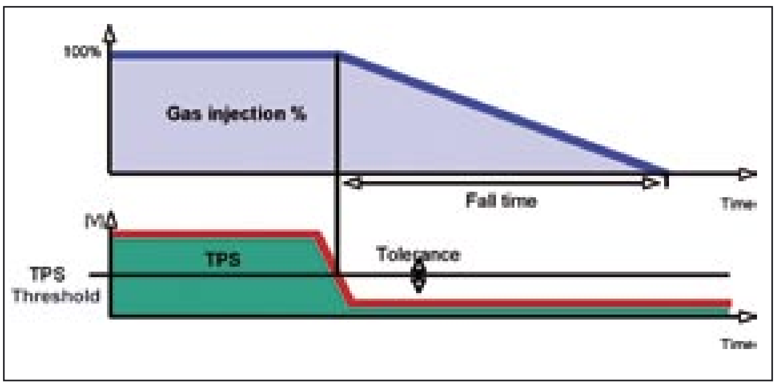
- **Fall time:** sets the time the ECU takes to decrease linearly the gas injection from 100% of original value to 0. Accepted values go from 0 to 2.5 s. The longer the time, the smoother the transition to injection cut-off.

- **Revs threshold:** sets the minimum engine's rev speed (in RPM) that activates the feature. If the speed is lower that this threshold, there's no cut-off delay. Accepted values go from 500 to 4000 RPM. Note that the values are rounded to 100 RPM.

- **TPS:** sets the TPS voltage threshold (in Volt) below which the feature is active. When the TPS voltage falls beyond this threshold, the feature is activated; if it stays higher that this, the feature is off. Accepted values go from 0 to 5V.

- **Tolerance:** sets the tolerated range of variation of the TPS voltage around its threshold, in Volt. If this voltage stays around its threshold value, setting a higher tolerance avoids the feature to be switched on and off continuously. Accepted values go from 0 to 5V.

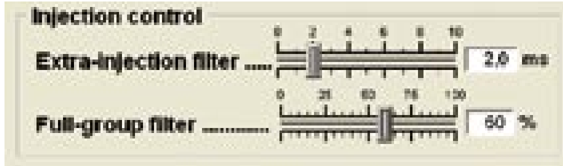
Picture 6.5: example of TPS-cut off.



6.3 Injection control

The Injection control box lets you trim two details of the gas injection that deal with extra-injection rejection and full-group injection filtering.

Picture 6.6:
Injection control group-box in Fine tune tab.



6.3.1 Extra-injection filter

Petrol ECUs can generate spurious injection times while the engine is running at higher rates. Those small injection times are used to shortly open the petrol injectors and spry a small amount of petrol to cool down the engine a bit. The extra-injections usually are shorter than 2 ms and are out of phase with the main injections used for combustion, so they can fool the gas ECU that would inject gas and make the mixture too rich.

Use the **Extra-injection filter** slider to set the sensitivity of the gas ECU to petrol injection times: if the petrol injection times are shorter than that threshold, the gas ECU completely ignores them and does not generate any gas injection.

If the car you're working on does not generate any extra-injection, leave the filter to zero; beware that raising the filter too much may cause bad gas injection, or no injection at all, because you would filter also primary petrol injections.

6.3.2 Full-group filter

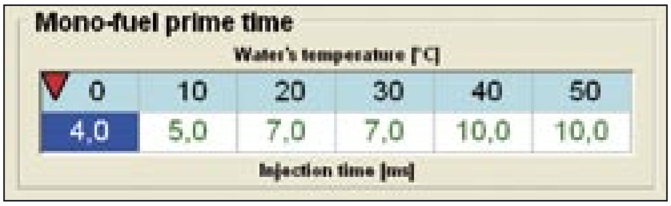
Petrol ECUs can inject fuel in the cylinders sequentially or it can handle the petrol injectors in what is called "full-group": for example, in a four cylinders car it could inject following the 1-4-2-3 sequence, or inject in all the cylinders at the same time twice per each engine revolution (full-group). Please notice that also other injection strategies could be applied.

The gas ECU always follows the petrol ECU strategy: if the petrol goes sequential, the gas does the same, if the petrol goes in full-group, also the gas goes in full-group.
Even if the petrol ECU changes its strategy over time (it happens usually in bigger engines at higher revs), the gas ECU changes its strategy immediately, too. In any situation where this automatic synchronization with petrol injection is not satisfying, you can filter out secondary petrol injections with the **Full-group filter**: once the primary petrol injection is detected, this feature holds off the injection detection.

The hold-off time is settable as a percentage of the engine revolution period minus the primary petrol injection time: if for example it's set to 50% and you're having a 10 ms petrol injection at 1000 RPM, the hold-off time would be 50% of 60 – 10 ms, that is 25 ms.
Setting it to 100% would filter any secondary injection that come before a new engine revolution, but in practice it would also partially cut the new primary injection because the engine period changes continuously while driving.
If you set it to 0 %, the filter is defeated.

6.4 Mono-fuel prime time

This group box is active only if you selected the **Start on gas** or **Mono-fuel** switch mode of the gas power, in Set-up tab. It contains a table of injection times that are applied when you turn on the key of the car: gas injection is therefore applied while cranking the engine with gas power.



Picture 6.7: Mono-fuel prime time group-box in Fine tune tab.

You can define up to six cold-start injection times for different temperatures: a red needle over the table shows the current water's temperature. Both temperatures and injection times can be edited, copied and pasted as usual.

Chapter 7: Auto-Tuning

The auto-tuning procedure is a facility that automatically creates a gas map suitable for your car and system, so you don't have to do it manually; it's available both in the Slave and Compensated mode. The Slave auto-tuning is based on the initial default gas map, that depends on the fuel you've selected in the General tab of the main window; the automatic procedure tunes the default map to fit the engine of the car where the system is installed.

In Compensated the auto-tune procedure is based on the Petrol map, that should be acquired while running on petrol: the automatic procedure creates the gas map starting from the petrol map.

7.1 Slave auto-tuning

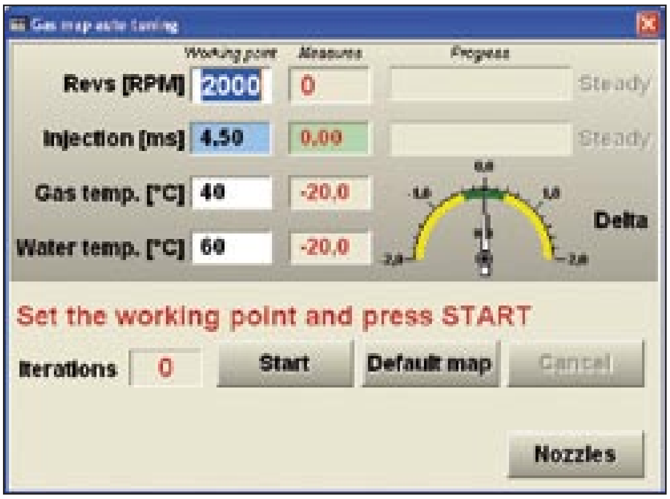
First of all you should reset the current gas map to default: select the Reset gas map item in the Edit menu of the main window. Depending on the fuel selected in the Engine box of the General tab, now you have the LPG or CNG default map on your configuration. Once selected, the command will ask you confirmation before resetting the map.

To start the auto-tuning procedure, click on the Auto-tune gas map item on the Edit menu of the main window, or click the **Tune** button in the Gas map auto-tuning box of the Set-up tab. The main window focuses on the gas map tab and the Slave map auto-tuning window pops-up on it.

Picture 7.1: Tune button in the Gas map auto-tuning box of the Set-up tab.

The window is divided in two parts: on the upper you can set the working point and check the acquired measures during the auto-tuning procedure. On the lower you can start or cancel the procedure, trim some settings and receive instructions on what to do during the process. You can reset the current gas map to the default one with the **Default map** button on this window.

Picture 7.2 Slave gas m ap auto-tuning window.

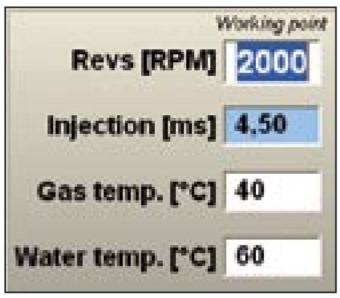


The auto-tuning procedure acquires the petrol injection time from the petrol ECU while running on petrol, then switches to gas power and compares the petrol injection time acquired while running on gas with the original ones. If the petrol ECU changes its injection time while running on gas, it means that the gas mixture is not correct and so the gas map should be corrected. The auto-tuning procedure changes the gas map automatically, and repeats this procedure till the petrol injection time is almost the same while running on petrol and on gas. This tunes the default map and make it suitable to your car.

7.1.1 Working point

The auto-tuning process should be performed with a warm engine and at a constant working point: this means that the gas and water temperatures should be high enough and the engine speed stable during the acquisition process. Before starting the procedure, set the working point to values suitable to the outside temperature and engine specs: during the auto-tuning process you must keep the working point stable, that is the engine's speed and temperature must meet the selected conditions. Most of all, while acquiring petrol injection times you are requested to rev up the engine to the selected RPM and keep the throttle position still till the end of the process; if for any reason the engine's speed changes while acquiring injection times, the acquisitions are paused and the process waits for the speed to return stable, then restarts the acquisitions automatically.

Picture 7.3: working point's parameters.



The parameters for the working point are:

- **Revs:** set the desired engine's speed at which the auto-tuning process should be performed. There is a 10% tolerance over that value, that is if, for example, you set it to 2000 RPM, the process will go on even if the engine revs down to 1800 or revs up to 2200 RPM. The default value is 2000 RPM; it's not advisable to run the auto-tuning at idle.

- **Injection time:** set the starting gas injection time in ms. This time will be applied to gas injectors when the auto-tuning process first switches to gas power: this feature lets you adjust the initial injection to a time that you know is suitable for the engine, gas nozzle size and pressure reducer type at the selected working point, so the engine won't shut down when the auto-tuning process switches to gas. Default value is 4.5 ms; the auto-tuning will take more time if the initial injection is too far from the right value, but at the end of the process the gas map will be the same, no matter what injection time you set.

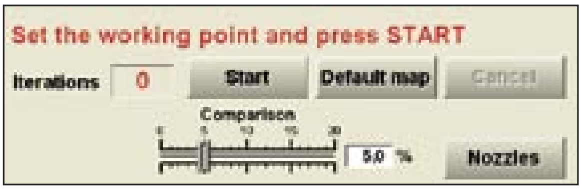
- **Gas temperature:** set the minimum temperature of the gas in the rail (in Celsius degrees) at which the auto-tuning can start. You won't be able to start the procedure until the gas temperature reaches that threshold. The default value is 40 °C.

- **Water's temperature**: set the minimum temperature of the coolant water in the pressure reducer (in Celsius degrees) at which the auto-tuning can start. You won't be able to start the procedure until the water's temperature reaches that threshold. The default value is 60 °C.

7.1.2 Slave auto-tuning process

The Slave auto-tuning process compares the injection times generated by the petrol ECU while running on petrol and while on gas: the goal of the auto-tuning is to trim the gas map until the petrol times are the same while running on petrol and gas. To achieve that, first the petrol time is acquired while running on petrol, then the gas power is switched on and the new petrol time is acquired. The original gas map is adjusted to cancel the variation of the petrol time; the process is repeated till the petrol time running on gas is close enough to the original one (acquired while running on petrol).

Picture 7.4: auto-tuning process settings.

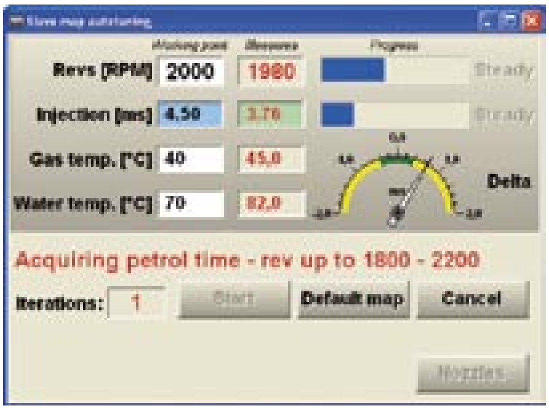


You can set the accuracy of the auto-tuning process with the **Comparison** slider on the bottom of the window: this parameter is available only at higher access level. By default it's set to 5%, meaning that the auto-tune procedure will end when the petrol time generated while on gas differs from the original petrol time no more than a 5%. Lower percentages give more accurate tuning, but takes more iterations and time to complete.

Once the parameters of the working point are set, you can start the auto-tuning process clicking on the **Start** button on the bottom half of the window: it waits for the gas and water temperature to reach their thresholds (as set in the working point), then it asks you to rev up the engine to the selected speed. You can do so while in neutral gear. When the engine revs up to the selected speed, it waits a couple of seconds for the petrol injection time to stabilize, and starts acquiring it.

You can stop the process at any time you want clicking on the **Cancel** button (it's activated when the auto-tuning process starts).

Picture 7.5:
Auto-tuning procedure in progress.



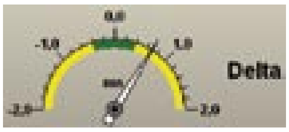
While the process is running, the acquired engine's speed and petrol injection times are displayed in the Measures boxes in the windows, along with the gas and water temperatures. Two blue progress bars on the right side of the engine's speed and petrol injection time measures show the acquiring status.

When the acquired speed and injection time get stable, the **Steady** labels on the right side of their progress bar light on; if for some reason the speed or time change too much (above 10% tolerance), the progress bar is cleared and the acquisition starts again.

Once the acquired petrol injection time while running on petrol is stable, the process switches to gas power, applying the selected initial gas injection time (set in the working point). The petrol ECU takes a while to adjust its injection when first switched to gas, then the auto-tuning process starts acquiring the petrol injection time while running on gas.

Note: it's important that you don't move the throttle position throughout the whole process.

Picture 7.6: Delta needle-meter.



The **Delta** needle-meter measures the difference (in ms) between the original petrol injection time and the one acquired currently: if the needle stays in the green sector, it means that the difference is within the selected accuracy, and so the current gas map is correct.
On the other hand, if it moves to the yellow portions it means the difference is higher than the selected accuracy, and so the current map should be changed and the process repeated. The number of iterations done is shown in the **Iterations** box. After two or three iterations the process should come to a satisfying gas map, and terminate the procedure: a message will pop-up over the Status panel of the main window informing you that the auto-tuning procedure was successful. Now you can close the window (or click on the Exit button): you have the right gas map now.
Two probed-systems are tuned automatically in the same way: the same procedure takes care of acquiring the petrol injection times of both banks (that is of cylinder 1 and 5) and modifies the two maps accordingly. So you'll end up with two different gas maps for the two banks.

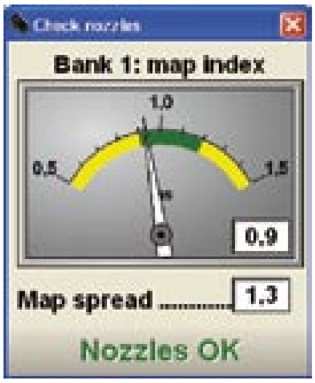
7.1.3 Nozzles check

Once you're done with the Slave auto-tuning, you can check the resulting gas map with the **Nozzles** button in the auto-tuning window. This pops-up a window with a needle-meter that shows you the average of the ratios in the map.

You get the best results if the gas injection times are equal or greater than the petrol ones, that is if the map average is above 1.0. If the needle is in the green portion of the meter, the map average is around 1.0, that is the nozzles you are using have the right size. Otherwise, if the needle is in the green segments, the map has too small (or too big) values because you are using a wrong size of nozzles. For example, if you are using too big nozzles, the auto-tuning procedure compensate for that lowering the map average below 1.0; the map average is a good indicator of the nozzles size.

This window informs you about the computed size of the nozzles with a green label on the bottom of the window for right sized nozzles, or a red flashing one for too big or too small nozzles.

Picture 7.7: Check nozzles window.



The **Map spread** is the ratio between the highest and the lowest ratio of the map: it shoes how much the ratios in the map are spread over the allowed value range.

You can check the Slave gas map any time you want with the Check nozzles item of the Diagnostics menu. For two probed system you have two gas map, so the window shows two needle-meters, one per each bank.

7.2 Compensated auto-tuning

The Compensated mode uses both the Petrol and the Gas map, so if you want to tune the system in Compensated mode, you have to tune both the maps (beware that for two-probed systems the gas maps are two, so you have a total of three maps).

7.2.1 Petrol map acquisition

The Petrol map can be acquired automatically while running on petrol: the ECU stores the injection times generated while running by the petrol ECU in the Petrol map. Of course you can edit the map also manually if you like. You can activate this feature clicking on the **Acquire** switch-button in the Petrol map auto-tuning box of the Set-up tab.

Picture 7.8: Acquire button in the Petrol map auto-tuning box of the Set-up tab.

If you browse the Petrol map tab of the main window while this feature is on, you can see the injection times getting stored in the cells under the moving dot. This feature implements also an auto-completion algorithm: not only the cells under the dot get filled, but also the ones surrounding them are changed while acquiring the petrol times.

Note: you should run on petrol while the Acquire feature is activated. If you switch to gas, the petrol map will not be updated till you get back to petrol. However, you can leave the Acquire feature on also while running on gas: the Petrol map won't be affected.

While the Acquire feature is on, the ECU continues to update the Petrol ECU while running on petrol; you can leave it on if you like. Each time you get back to petrol, the map will be updated if it needs to.
To completely fill the Petrol map you should reach every cells of the map, that is you should run the engine on every speed and load condition it allows: you can achieve the same results with the Acquire feature on and running the car on petrol on the most varied kind of road and speed you can find, for at least 20 minutes. The longer you stay on each cell of the map, the better the map will be, so it takes some time to have a good petrol map formed by the Acquire feature, but all you have to do is to drive it normally down the streets.

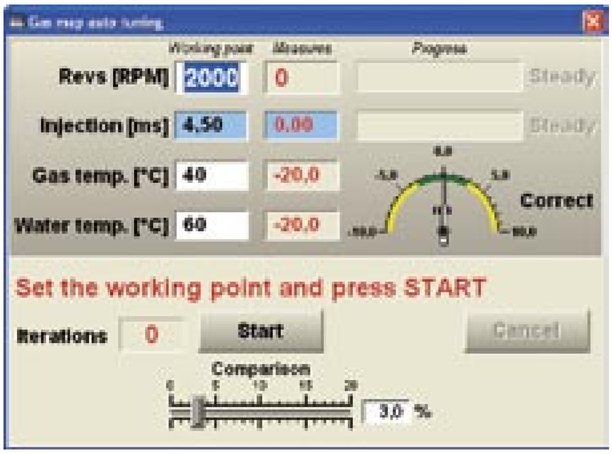
Of course you can edit the petrol map manually if you want, even when the Acquire feature is on.

The Petrol map is used for the lambda emulation for the petrol ECU, so it doesn't deal directly with gas injection, but for newer cars it's very important to have a good emulation, that is an accurate petrol map, otherwise the petrol ECU could light on the check engine lamp in the deck of the car while running on gas.

To avoid this you should acquire the Petrol map automatically and then activate its Adaptive feature: this way the petrol map will be updated also while running on gas. Read more about that on the next chapter.

7.2.2 Compensated auto-tuning process

Once you have a complete and satisfying Petrol map, you can create a Compensated gas map with the auto-tuning procedure. Simply click on the **Tune** button on the Gas map box of the Set-up tab and you'll get a window similar to the one used for the Slave auto-tuning. Alternatively you can use the Auto-tune gas map item from the Edit menu to get the same window. The main window focuses on the gas map tab and the Slave map auto-tuning window pops-up on it.



Picture 7.9:
Compensated gas map auto-tuning window

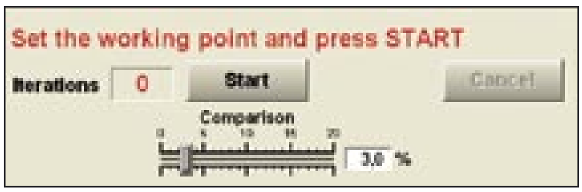
The window is divided in two parts, just like the Slave auto-tuning window: on the upper you can set the working point and check the acquired measures during the procedure while on the lower you can start or cancel the procedure, trim its accuracy and receive instructions on what to do during the process.
While in Compensated the Lambda controller must be enabled, because the control loop for the injection is closed by the gas ECU; the Lambda emulation must be on, too, to defeat the control loop on the petrol ECU (otherwise the two controllers would conflict). For this reason the gas ECU can read the lambda signal while in Compensated and tune the gas map according to percentage of correction of the Lambda controller.

The Compensated auto-tuning process takes the petrol map as a starting point to compute the gas map, then uses the lambda controller to fine-tune the map. In the first step it acquires the petrol injection time while running on petrol, just like in the Slave auto-tuning; then it switches to gas and waits for the lambda controller to stabilize.

When it has a stable reading of the lambda controller correction percentage, it applies that correction to the whole gas map.

Then the process is repeated, till the lambda controller does not need to correct the injection anymore, that is the correction percentage is close to zero.

Picture 7.10: auto-tuning process settings



You can set the accuracy of the auto-tuning process with the **Comparison** slider on the bottom of the window: this parameter is available only at higher access level. By default it's set to 3%, meaning that the auto-tune procedure will end when the lambda controller's correction percentage is smaller that 3% (positive or negative). Of course lower Comparison percentages give more accurate tuning, but takes more iterations and time to complete.

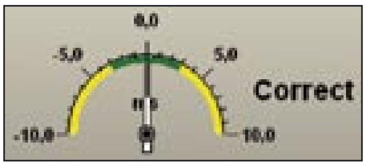
The Working point parameters work just like in the Slave auto-tuning procedure; once the working point is set, you can start the auto-tuning process clicking on the **Start** button on the bottom half of the window. Note that if the Petrol map is not completed, the Compensated auto-tuning procedure can't be performed: the program will warn you that the petrol map is not sufficiently complete and won't start the procedure. The procedure computes the gas map starting from the petrol map, so you need at least an 80% completion of Petrol map to perform the Compensated auto-tuning.

The procedure goes on exactly as it does in Slave: It waits for the gas and water to warm up to the selected temperatures, then starts acquiring petrol injection times while you rev up to the selected speed. After that, it switches to gas applying the selected injection and starts acquiring gas injection times.
You can stop the process at any time you want clicking on the **Cancel** button (it's activated when the auto-tuning process starts).
While the process is running, the acquired engine's speed and gas injection times are displayed in the *Measures* boxes in the windows (not petrol injection times, as they are in the Slave auto-tuning window), along with the gas and water temperatures.

Note:
it's important that you don't move the throttle position throughout the whole process.

The **Correct** needle-meter on the window shows the Lambda controller's correction percentage: the green sector in it shows the selected accuracy for the auto-tuning process, that is the Comparison percentage you set. When the Correct needle is in the green sector, it means that the gas map is correct and the tuning procedure can stop.
On the other hand, if the needle stays in the yellow sectors, it means that the map need to be trimmed a bit more, so the process is repeated; the number of iterations done is shown in the **Iterations** box.

Picture 7.11: Correct needle-meter.



After two or three iterations the process should come to a satisfying gas map, and terminate the procedure: a message will pop-up over the Status panel of the main window informing you that the auto-tuning procedure was successful. Now you can close the window (or click on the **Exit** button): you have the right gas map now.

Once the auto-tuning procedure is ended, you can manually tune the gas map or let the Adaptivity feature do the job for you. Read the next chapter for details about this feature.

Two probed-systems are tuned automatically in the same way: the procedure takes care of both lambda controllers (one per each bank) and modifies the two gas maps accordingly. So you'll end up with two different gas maps for the two banks.

Chapter 8: Adaptivity

The Auto-tune facility of the program lets you tune-up the default map and make it suitable for the engine of car where the system is installed; but that procedure only checks the gas map in the selected working point, because during the auto-tuning procedure you keep the engine at the same working point, while the program computes the right gas injection time for that point.
The other points of the map are adjusted consequently.

If you want to check the map point by point and adjust it to fit precisely the engine of the car, you should edit it manually scanning all the cells of the map one by one: this means you would have to scan all the loads and speeds allowed by the engine.

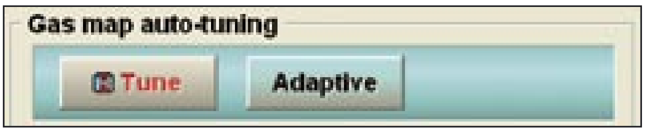
The Adaptivity feature of the ECU can this for you, while you're driving the car down the streets: it automatically takes into account the engine's speed and load and adjusts the map accordingly.

With this facility activated, the ECU auto-adapt its maps to the changing conditions of the engine and system it's working on.

8.1 Slave Adaptivity

The Slave mode is based on the gas map, so the ECU can auto-adapt simply adjusting it while running on gas. To activate this feature you should click on the Adaptive switch-button in the Gas map auto-tuning box of the Set-up tab, in the main window.

Picture 8.1:
Adaptive button in the Gas map auto-tuning box of the Set-up tab



If you browse the Salve gas map while the feature is active, you should notice that some ratios in the cells under the moving dot are changing; this means that the feature is adjusting the gas map. Please note that while the Auto-tuning feature modify the whole map, that is it changes it globally, the Slave Adaptivity adjusts only the cells under the moving dot, that is it fixes the map locally.

The Slave Adaptivity adjusts the gas map according to the lambda signal: if the lambda shows a rich mixture for a long time while the working point of engine doesn't change, the gas map is leaned: this means that the car is running in a steady state (so the dot on the map stays over the same cells) and the mixture is too rich (so the lambda signal is clipped to its high voltage).

If the system stays in this condition for too long time, it means that that cells of the gas map are too rich and need to be leaned out; the Adaptivity does that automatically.

On the other hand, if the lambda shows a lean mixture for too a long time, the map is enriched.

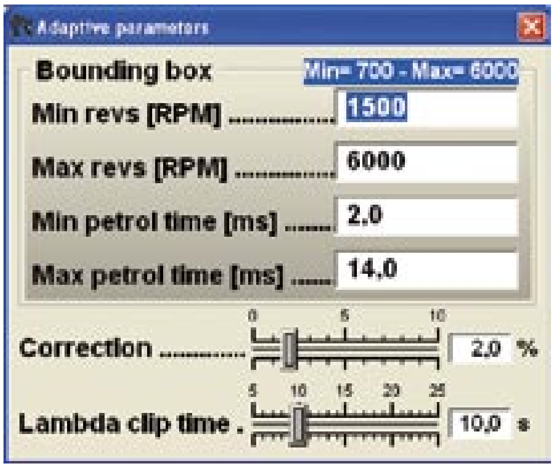
8.1.1 Parameters

You can define the behavior of the **adaptive** feature with the Adaptivity parameters item of the Edit menu, or clicking the right-mouse button on the Adaptive switch of the Gas map auto-tune box in the Set-up tab. This command pops-up a window where you can define the parameters.

The main parameter of the Adaptivity is its bounding box, that is the bounds that limit the action of the Adaptivity on the map: outside the bounding box the Adaptivity does not change the map, while inside it it's free to modify the map, if needed.
This is useful to preserve some areas of the map, like the idle (usually the first two columns) or the open-loop zone (the last two rows), where the Adaptivity is not needed.

The other parameter of the Slave Adaptivity is its strength, that is the percentage of modification applied to the map; the last is the time the lambda must stay rich or lean before the map is modified.

Picture 8.2:
Adaptivity parameters window for Slave mode



The parameters are:

- **Min revs:** the minimum engine's speed (in RPM) defines the minimum column of the map from which the Adaptivity should be enabled. Below this bound the feature is disabled and thus the map preserved.
  By default the feature is enabled beyond the third column of the Slave gas map, thus preserving the idle zone. The accepted values are bounded by the Slave gas map column headers range: if for example the map is defined from 700 to 6000 RPM, the accepted values go from 700 to 6000 RPM.
- **Max revs:** the maximum engine's speed (in RPM) defines the maximum column of the map till which the Adaptivity should be enabled. Beyond this bound the feature is disabled and thus the map preserved.
  By default the feature is enabled till the last column of the Slave gas map. The accepted values are bounded by the Slave gas map column headers range.
- **Min petrol time:** the minimum petrol injection time (in ms) defines the minimum row of the map from which the Adaptivity should be enabled. Below this bound the feature is disabled and thus the map preserved.

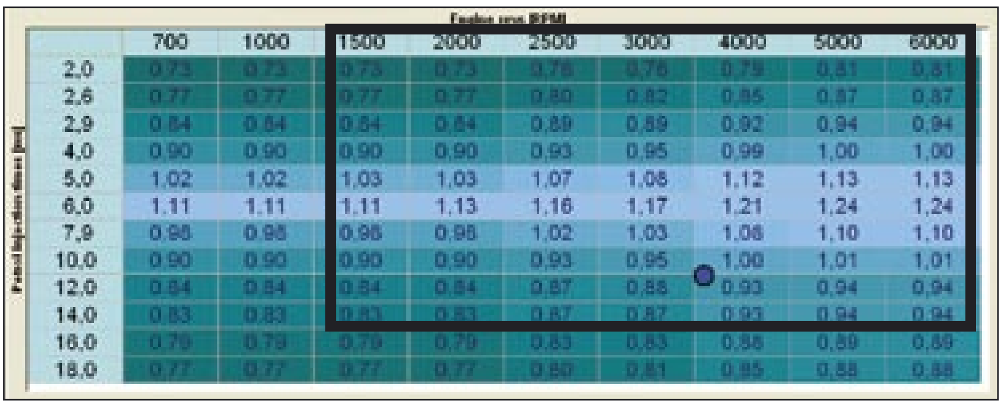
By default the feature is enabled from the first row of the Slave gas map.
The accepted values are bounded by the Slave gas map row headers range: if for example the map is defined from 2 to 18 ms, the accepted values go from 2 to 18 ms.

- **Max petrol time:** the maximum petrol injection time (in ms) defines the maximum row of the map till which the Adaptivity should be enabled. Beyond this bound the feature is disabled and thus the map preserved.
  By default the feature is disabled for the last two rows of the Slave gas map, thus preserving the open-loop zone.
  The accepted values are bounded by the Slave gas map row headers range.

- **Correction:** defines the strength of the Adaptivity, that is the percentage of modification that should be applied to the cells of the map when needed. The higher the value, the quicker the map will be trimmed, but the higher the risk of tuning it too roughly.
  By default the correction percentage for the Slave adaptivity is 2%.

- **Lambda clip time:** defines the time (in seconds) the lambda signal should remain clipped to its high or low voltage, before the Adaptivity is activated and so the map changed. The lambda voltage thresholds for detecting an high or low state are set respectively to the 30% and 60% of the lambda probe's range, that is, if you got a 0-1V lambda probe, an high state (rich mixture) is detected if the lambda voltage is higher than 0.6 V, and a low state (lean mixture) is detected when the voltage drops beyond 0.3V. By default the clip time is 10 seconds. Usually the lambda probes strobes from low to high voltage continuously if the mixture is correct (except UEGO probes, that have a linear voltage); thus if you set a too short clip time, that correctly oscillating voltage would be mistaken for a clipped one, modifying the map where it wouldn't be necessary. For that reason you should use long clip times, at least 5 seconds. On the other hand using long times would prevent that problem, but would enable the Adaptivity only for steady states, when the working point does not change for long periods.

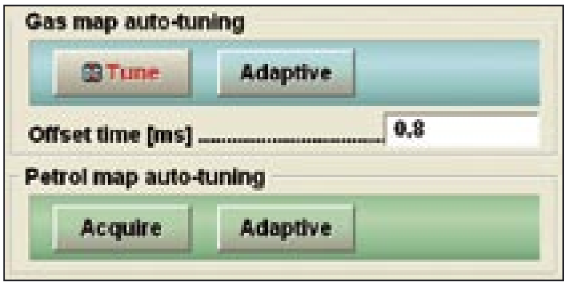
Picture 8.3:
default bounding box for the Slave Adaptivity.



8.2 Compensated Adaptivity

The Compensated mode is based on the Petrol map and the Gas map, so the Adaptivity adjusts both the maps while running on gas. To activate those features you should click on the Adaptive switch-buttons in the Petrol and in the Gas map auto-tuning box of the Set-up tab, in the main window.

Picture 8.4: Adaptive buttons in the Gas and Petrol map auto-tuning box of the Set-up tab.



If you browse the maps while the features are active, you should notice the Adaptivity adjusting the values.

The Slave Adaptivity adjusts the gas map according to the lambda signal: if the lambda shows a rich mixture for a long time while the working point of engine doesn't change, the gas map is leaned: this means that the car is running in a steady state (so the dot on the map stays over the same cells) and the mixture is too rich (so the lambda signal is clipped to its high voltage). If the system stays in this condition for too long time, it means that that cells of the gas map are too rich and need to be leaned out; the Adaptivity does that automatically.
On the other hand, if the lambda shows a lean mixture for too a long time, the map is enriched.

8.2.1 Petrol map Adaptivity

One of the key feature of the Compensated mode is the emulation of the lambda probe: as stated in the previous chapters, the Petrol map is used to compute that virtual lambda signal and apply to the petrol ECU.
The better the Petrol map, the better the emulation: the goal of the Petrol Adaptivity is to update the Petrol map to stay in touch with the petrol ECU over the changing conditions of the engine and the system.

While the Acquire feature learns the Petrol map while running on petrol, the Adaptivity for the Petrol map adjusts locally the cells while running on gas.

The Petrol Adaptivity adjusts the map according to the emulated lambda signal: if the signal stays high or low for a long period of time while the working point of engine doesn't change, it means that the petrol ECU is generating an injection time that's different from the one stored in the map, and so the Petrol map needs to be updated.
The map is changed by a fixed amount till the emulated lambda voltage oscillate: this way the petrol ECU is fooled that the mixture is correct.

The Petrol Adaptivity shares its parameters with the Compensated Gas map one.

Note: The Petrol Adaptivity's work is based on the emulated lambda, not the real one.

8.2.2 Gas map Adaptivity

The other key feature of the Compensated mode is the lambda controller embedded in the ECU: if the corrector is changing the injection time computed by the map, it means that some value in it is not correct and need to be modified.

The Adaptivity for the Compensated Gas map changes the cells of the map around the current working point each time the lambda controller is performing an adjustment: you can read the percentage of the controller adjustment in the Status panel of the main window, at the left of the lambda chart. While the controller is at 0% (that is it's not adjusting the injection time), the map is left unchanged, otherwise the map is changed by a fixed amount till the controller gets back to 0%.

This feature adjusts the map locally, cell by cell, so if it's left running for enough time it leads to a perfect Gas map.

8.2.3 Parameters

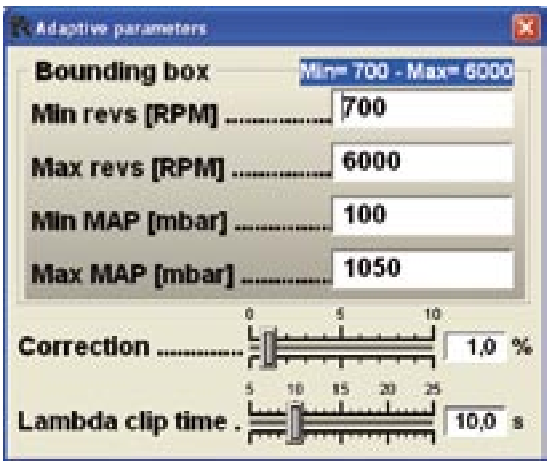
The Compensated *Adaptivity* for both the Petrol map and the Gas map can be defined with the *Adaptivity* parameters item of the Edit menu, or clicking the right-mouse button on the **Adaptive** switch of the Gas map auto-tune box in the Set-up tab.

This command pops-up a window where you can define the parameters.

Just like the Slave Adaptivity, the Compensated one is bounded by a box: outside the bounding box the Adaptivity does not change the maps, while inside it it's allowed to modify them if needed. This preserves the idle zone of the maps. The other parameter of the Compensated Adaptivity is its strength, that is the percentage of modification applied to the map.

The Petrol Adaptivity needs also an emulated lambda clip time, that is the time the emulated lambda must stay rich or lean before the map is modified.

Picture 8.5:
Adaptivity parameters window for Compensated mode.



The parameters are:

- **Min revs:** the minimum engine's speed (in RPM) defines the minimum column of the map from which the Adaptivity should be enabled. Below this bound the feature is disabled and thus the map preserved.
  By default the Compensated Adaptivity is enabled over the whole map.
  The accepted values are bounded by the Compensated Gas map column headers range: if for example the map is defined from 700 to 6000 RPM, the accepted values go from 700 to 6000 RPM.

- **Max revs:** the maximum engine's speed (in RPM) defines the maximum column of the map till which the Adaptivity should be enabled. Beyond this bound the feature is disabled and thus the map preserved.
  The accepted values are bounded by the Compensated gas map column headers range.

- **Min MAP:** the minimum MAP (in mbar) defines the minimum row of the map from which the Adaptivity should be enabled. Below this bound the feature is disabled and thus the map preserved.
  The accepted values are bounded by the Compensated gas map row headers range: if for example the map is defined from 100 to 1000 mbar, the accepted values go from 100 to 1000 mbar.

- **Max MAP:** the maximum MAP (in mbar) defines the maximum row of the map till which the Adaptivity should be enabled. Beyond this bound the feature is disabled and thus the map preserved.
  The accepted values are bounded by the Compensated gas map row headers range.

- **Correction:** defines the strength of the Adaptivity, that is the percentage of modification that should be applied to the cells of the map when needed. The higher the value, the quicker the map will be trimmed, but the higher the risk of drivability issues due to the injection changing quickly while the Adaptivity does its job.
  By default the correction percentage for the Compensated Adaptivity is 1%.

- **Lambda clip time:** defines the time (in seconds) the emulated lambda signal should remain clipped to its high or low voltage, before the Adaptivity is activated and so the Petrol map changed.
  By default the clip time is 10 seconds. Don't set a too short time, otherwise the Adaptivity would change also good values of the map, where the emulated lambda oscillates correctly.

Note:
this parameter is used only by the Petrol Adaptivity; the Gas map is not affected by that.

Chapter 9: Firmware flasher

The firmware on the ECU is the piece of software that's executed during any operation of the ECU: this program handles all the tasks and features of the ECU.
Like any other software, the firmware is continuously under development to add new features and patch bugs. When a new release of firmware is available, you can upgrade your ECU flashing its memory with the procedure provided here.

9.1

Flashing a new firmware

The Firmware flasher item of the ECU menu pops-up a window that guides you thru the flashing procedure: flashing the memory is a completely automated task, so you don't need to do anything.

Picture 9.1: Firmware upgrade window

9.1.1 Initial steps

The procedure is broke down in a sequence of steps performed automatically: you need only to check the COM settings and connections. When you are sure that those settings are correct, you can start the firmware flasher. Each step is clearly reported on the top of the window in red; instructions to the user are printed in the same place. While in the initial steps, you can stop the procedure at any time just clicking the close button of the window.

Once started, it tries to communicate with the ECU and asks it its current firmware version: the current firmware id-tag is reported on the window and shows the revision number. This id-tag is the same you can read on the status-bar of the main window when the ECU is connected to the PC and communicates with the program.

Then it performs an upload of the current configuration inside the ECU: the configuration is preserved, so even if you upgrade the firmware on the ECU, it keeps its previous configuration.

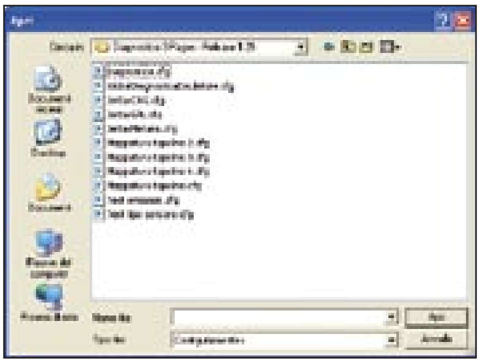
After that, the ECU is reset: this starts a small piece of software inside the ECU that came from the factory, the boot-loader. The boot-loader is a special software that communicate with the firmware flasher procedure on the PC and writes the ECU's memory. It starts each time the ECU is powered or reset and can't be overwritten, so even in case of the worst damage to the ECU memory's content, you are always able to start with the boot-loader and flash a new firmware.

If the ECU does not respond to the reset or any other previous step, the flashing procedure asks you to manually switch the ECU off, then on: this forces the boot-loader to start. This could happen if the ECU memory's content are seriously damaged.

9.1.2 File selection

When the initial steps of the procedure are completed, the program asks you to choose a file from your hard-disk that will be written on the ECU's memory. The procedure checks the file's content and warns you if the file is not valid; in that case the ECU won't be upgraded. Please use only firmware files provided by your dealer. You can select the firmware file with a standard file-open dialog; the file name should report the new firmware's id-tag and release date.

Picture 9.2:
select the firmware file in this dialog.

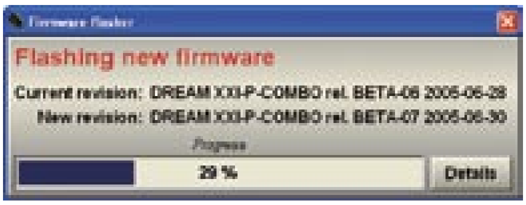


Once you've selected a valid file, the id-tag of the new firmware is printed on the window and the program asks you confirmation to start the flashing of the ECU's memory. While doing this, the procedure can't be stopped and its window can't be closed; if the ECU is accidentally powered off during firmware flashing, the firmware would not be written completely in its memory, so the ECU won't work. In that case, simply start the flashing procedure again: this time it will ask you turn the ECU off then on manually.

9.1.3 Writing the ECU's memory

The flashing procedure starts erasing the ECU's memory, then it is re-written with the new firmware; a progress bar shows you the percentage of completion of the process. It should take a couple of minutes to completely write a new firmware on the ECU.

Picture 9.3: firmware flashing in progress



Once finished, the previous configuration is downloaded into the ECU and the flashing window is closed: now your ECU is successfully upgraded and ready to be used.

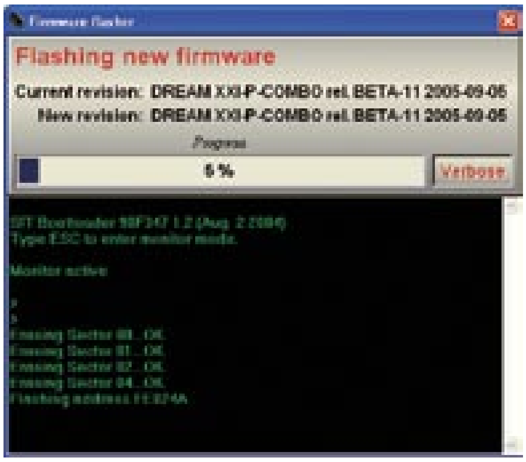
A *'download successful'* label will pop-up over the Status panel of the main window, signaling that the upgrade procedure is over and has been successful.

If for some reason the previous configuration of the ECU could not be uploaded during the initial steps, the procedure can't download it at the end of the flashing, so it asks you if you want to reset the ECU to the LPG Slave defaults.

9.2 Details

There is a Details switch-button on the right-bottom side of the firmware window: it shows or hide a child-window attached under the firmware flasher one, that shows more detailed information about the ongoing process.

Picture 9.4:
firmware flasher with the Verbose mode on



This shows a terminal-like window where you can read all the communication between the firmware flasher on the PC and the boot-loader on the ECU. Those information are useful only for trouble-shooting issues, so you don't need to bother about those details in normal operations.

Chapter 10: Meters window

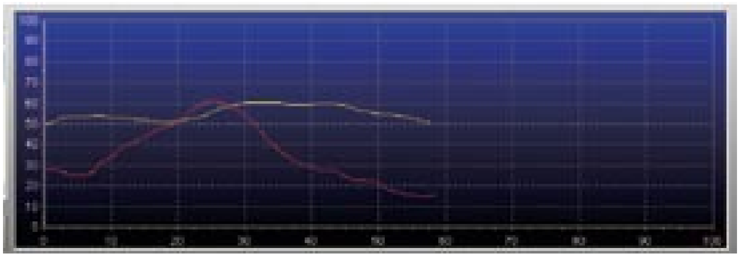
The Meters window is shown when you click the Display button in the tool-bar of the main window or select the Display meters menu-item of the Diagnostics menu. It's useful to have a quick graphical look of all the signals acquired by the ECU.

Picture 10.1: Meters window.

While the ECU is connected and powered-up, all the graphical meters show the currently acquired data from the ECU as they change in real-time, thus allowing to monitor how the ECU is working. The Meters window is divided in three parts: the Chart, the Engine and the Injectors boxes.

10.1 Chart

The Chart can show a window of 100 seconds of the measured signal: each signal acquired by the ECU can be traced on the Chart. The Chart automatically scrolls to the left while the acquisitions go on; if the acquisitions are idle, you can scroll it manually dragging the right-mouse button over it. Please note that only scrolling to the left or the right is allowed.



Picture 10.2: Chart of the Meters window

You can even zoom-in a rectangle while the acquisitions are idle: simply draw a rectangle from left to right, top to bottom over the Chart while clicking the left-mouse button. To zoom-out and reset the Chart simply draw a right-to-left or bottom-to-top rectangle with the left-mouse button.

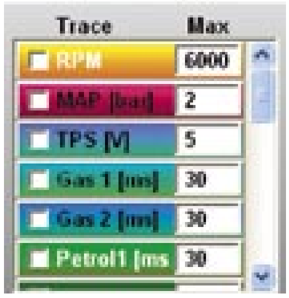
You can have a full screen look at the Chart if you double-click the left-mouse button: the Chart will enlarge and hide completely the Engine box, leaving only the Injectors visible. To reset the Chart to its original size simply double-click on it once more.

Picture 10.3: full screen view of the Chart

10.1.1 Traces of the Chart

You can choose what you want to trace with the legend at the left of the graph itself: the legend lists all available traces in a scrollable box. Each trace is labeled with its name and measuring unit; to see a trace on the Graph, simply check-mark the box on the trace's left and un-check it to hide it. The color of the trace legend tells you what's the color of the trace plotted in the Chart for that signal.

Picture 10.4: Legend of the Chart



The signals are all different in nature, thus their acquired measures have different ranges: if you want to trace them on the same graph you have to scale their measures. For that reason the traces are drawn in the Chart as percentages of their maximum value: the Y-axis of the Chart shows percentages from 0 to 100%. You can define the maximum value of each trace entering a value in the Max box at the right of the trace label, in the legend.

The 22 available traces are:

- **RPM:** this is the engine's speed in RPM.
- **MAP:** the MAP signal, in bar.
- **TPS:** the TPS voltage in Volt.
- Gas 1: the gas injection time for the first cylinder, in ms.
- **Gas 2:** the gas injection time for the fifth cylinder, in ms. For two-banked systems this represent the second bank gas injection time.
- **Petrol 1:** the petrol injection time for the first cylinder, in ms.
- **Petrol 2:** the petrol injection time for the fifth cylinder, in ms. For two-banked systems this represent the second bank petrol injection time.
- **Lambda 1:** the lambda probe's voltage, in Volt.
- **Lambda 2:** the second lambda probe's voltage in Volt, if any.
- **Reference:** the lambda reference in Volt, as reported in the reference tables of the Lambda tab in the main window.
- **Correct 1 %:** the percentage of correction of the lambda corrector.
- **Correct 2 %:** the percentage of correction for the second bank of the lambda corrector, for two-banked systems.
- **Emulated 1:** the emulated lambda voltage in Volt.
- **Emulated 2:** the emulated lambda voltage in Volt, for the second bank, if any.
- **Gas °C:** the temperature of the gas in the injection rail.
- **Water °C:** the temperature of the water inside the pressure reducer.
- **Gas press:** the pressure of the gas on the pressure reducer's outlet.
- **Gas level:** the voltage of the gas level sensor, in Volt.
- **Battery:** the voltage of the battery of the car.
- **Vcc:** the measured 5V power line of the ECU, that feeds the sensors.
- **Coil 1:** the current applied to the gas injector of the first cylinder, in Ampere.
- **Coil 2:** the current applied to the gas injector of the fifth cylinder, in Ampere, that is the current for the second bank, if any.

10.2 Engine

This box is in the center of the Meters window and shows the current engine's working point.

Picture 10.5: Status box of Traces window

The needle-meter at the far left of this box shows the engine's speed (in thousands of RPM): its scale is painted in red above 6000 RPM, because usually gas maps are bounded to that speed. Below the meter there is a small white box showing the numerical value of the engine's speed.

The next needle-meter to the right shows the Lambda voltage in mill Volts; the white box below it shows the lambda voltage numerically. On the bottom of it there is a small led-meter that shows the car's battery voltage.

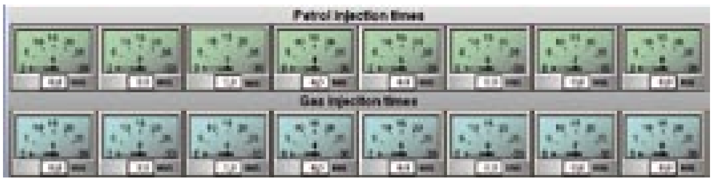
The next needle-meter to the right shows the gas pressure (in bar): the green portion of its scale is where normally the needle should be, that is the normal pressure expected from the selected pressure reducer. The red portion signals the higher pressure that can be reached while the yellow one shows the lowest pressure, reached when the gas tank is nearly empty. Below the needle meter, the white box shows the numerical value of the pressure.

The next item on the right is a led-meter for the percentage of gas level in the tank. It turns red if the gas level is too low (reserve).

The two right-most meters show the temperature (in Celsius degrees) of the gas at the injection rail and of the water in the pressure reducer. The white box above them show the numerical value of the temperatures.

10.3 Injectors

At the bottom of the Meters window there is the Injectors box: it shows the petrol and gas injection times for all the supported cylinders.



Picture 10.6
Injectors box of the Meters window

The most common configurations are:

- **Single-banked systems**
  - 4 cylinders: the first four gas meters (1,2,3,4) should show an injection times, while the others should be 0.
  - 5 cylinders: injectors 1, 2, 3 and 5, 6 should be powered, the other shouldn't.
  - 6 cylinders: for six cylinders-car with a single lambda probe the injectors should be 1, 2, 3, 4, 5, 6.
- **Two-banked systems**
  - 6 cylinders: the first bank should be mapped to injectors 1, 2 and 3, while the second to 5, 6 and 7, thus leaving injectors 4 and 8 un-powered.
  - 8 cylinders: the first bank should be mapped to injectors 1, 2, 3 and 4, while the second to 5, 6, 7 and 8. No injector can be un-powered.

Notes:

Notes:

OMVL spa

Components

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