UM1545
User manual

Using the Audio Processor Workbench (APWorkbench)

Introduction

The Audio Processor Workbench (APW) has been designed as a multi-device software control panel supporting all the products in the Sound Terminal® family from STMicroelectronics.

APW has been developed to fit the needs of both the beginner and the experienced user. The tool is quite flexible and its configuration can be simple or more advanced in order to access the multitude of features offered by the Sound Terminal® products.

Features of the APW include:

- I^2C register control: direct R/W access to all I^2C registers of the device.
- Equalizer editor: a powerful graphic tool to design filters (or a chain of them) and to download their coefficients directly into the device. APW makes the use of any other external tool unnecessary, thus simplifying device operation.
- Configuration presets: the capability of storing up to 8 device configurations that can be loaded just by pushing a button. Thanks to this feature the configuration process becomes a rare activity making device testing, measuring or listening faster than ever.
- Device common controls: embedded or external bridge power-up, device reset, power-up and initialization.
- Device-specific controls: the ST Sound Terminal® product family includes many devices. APW offers the control of all the various device-specific features (proprietary audio effects, I/O configuration and routing and so on).

For the complete list of the supported devices please refer to *Section 1.1: Supported devices*.

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1 Getting started

1.1 Supported devices

The products actually supported by the APW, all belonging to the ST Sound Terminal® family, include:

- STA308A
- STA309A
- STA321
- STA323W
- STA326
- STA333BW
- STA333W
- STA339BW
- STA339BWS
- STA350BW
- STA369BW
- STA369BWS
- STA381BW
- STA381BWS
- STA529
- STA559BW
- STA559BWS

Other customer-specific products are supported by the APW but require an activation code. For further information please contact your local ST sales office.

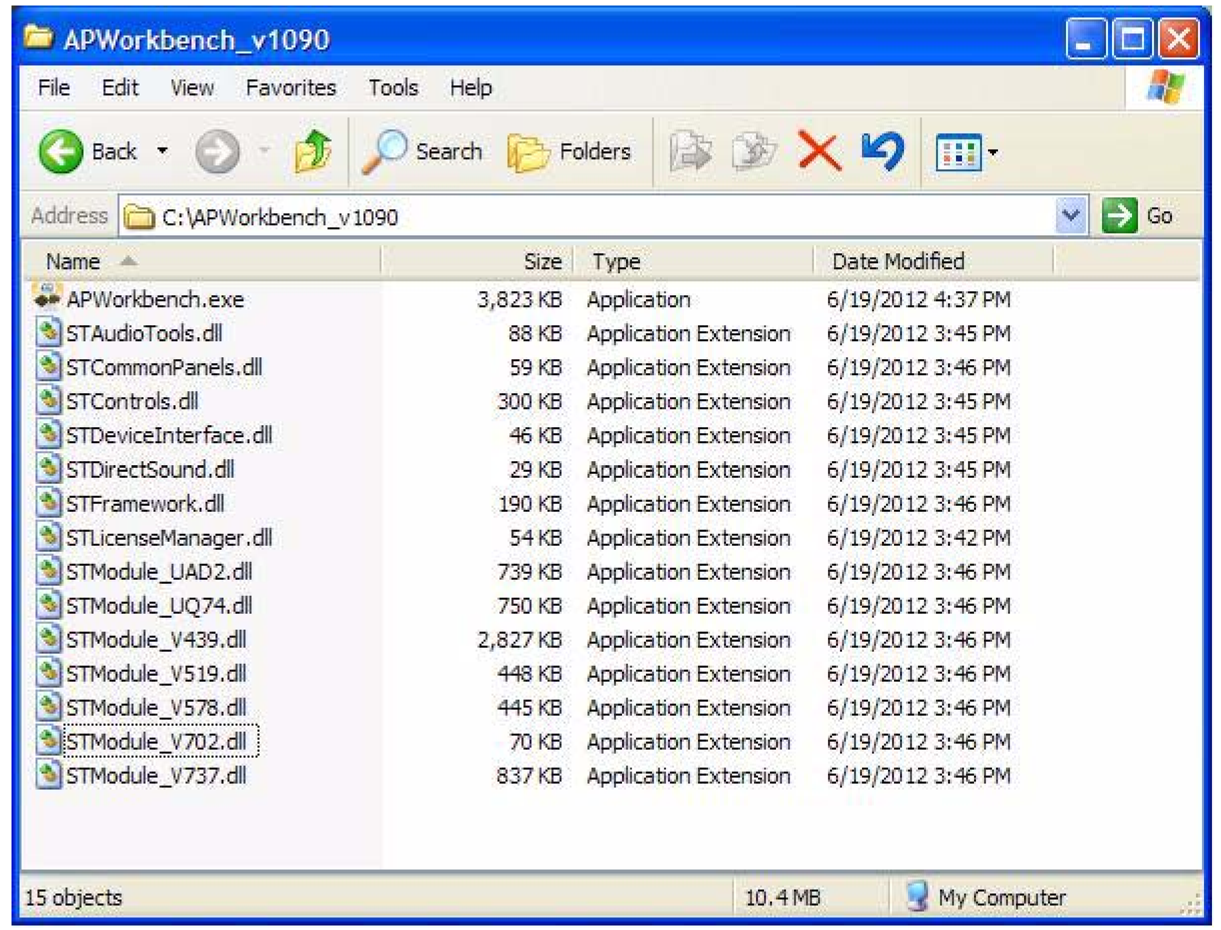
1.2 Supported interface

The APW needs an interface to interact with the various devices it supports. At the present time the supported interface is:

- APWLink™ interface (via FTDI© USB UART/FIFO I.C.), see AN4118, “APWLink™ USB interface board for Sound Terminal® demonstration boards” for further information.

1.3 Customer requirements

Figure 1. APW package folder



In order to quickly get started very few requirements have to be met. The user will need the following hardware:

- A supported interface (i.e. APWLink™). If this interface is not available, the tool will run in SIMULATION mode only and no communication with either the target device or the demonstration board will be possible.
- A demonstration board of one of the Sound Terminal® supported products.

The software requires:

- A complete APW package (a complete package consists of the files shown in *Figure 1*, please note that the structure might change according to the list of supported devices).
- MS Windows operating system (from Windows XP to Windows 7), no other OS is supported.
- The FTDI© driver (this driver is free and can be downloaded from http://www.ftdichip.com/Drivers/D2XX.htm). This driver will only be required to communicate with a target device or demonstration board through the APWLink™

interface. APW will run in SIMULATION mode only when the FTDI driver is not installed or the APWLink™ interface is not connected to the PC.

- Microsoft Visual C++ 2008 Feature Pack Redistributable package, if not already available on the target PC. These libraries can be downloaded for free from the Microsoft web site (see below *Section 1.3.1: Installation notes*).

1.3.1 Installation notes

- Microsoft Visual C++ 2008 Feature Pack Redistributable Package (x86)

To properly run APWorkbench on some machines the user may be required to install the updated Microsoft VC++ 2008 Feature Pack redistributable libraries, available at no cost from the Microsoft web page at:

http://www.microsoft.com/en-us/download/details.aspx?id=10015

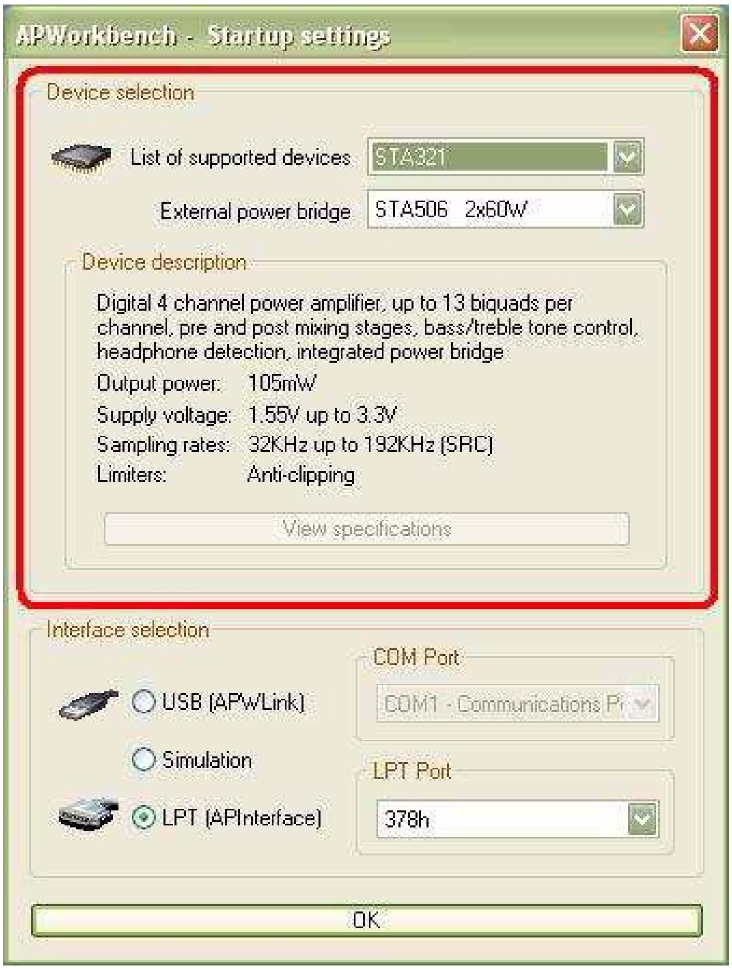
- FTDIChip USB communication driver (APWLink™ interface)

Concerning USB communication (APWLink™ interface), proper OS drivers must be installed, available for free from the FTDI website below. Note that different versions are available depending on the installed OS, either x86 (32-bit) or x64 (64-bit). All Windows versions, including Vista and Win 7 64-bit are supported.

http://www.ftdichip.com/Drivers/D2XX.htm

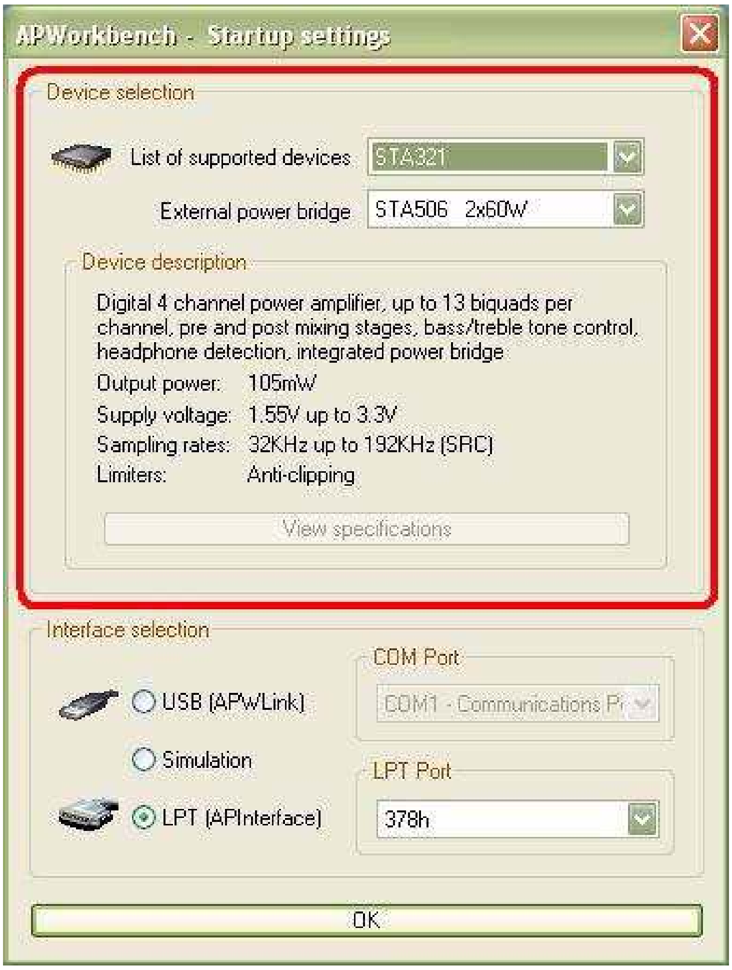
1.4 Quick start

Figure 2. Startup settings, device selection



To start the APW double click on the file APWorkbench.exe. Each time the APW is started, the *Startup settings* dialog pops up. The upper part of this dialog allows the product selection (*Figure 2*, highlighted in red). Use the drop-down menu to select between the supported devices. Please note that for each device a brief product description will be supplied in the frame underneath. For those products not provided with an embedded power bridge, the *Startup settings* dialog offers the possibility of specifying the external bridge in use. Selecting the correct power bridge allows the APW to automatically apply the settings to get the best audio performances. For those devices embedding a power bridge, this selection is not available. In the lower part of the *Device selection* frame the *View specifications* button allows quickly displaying the device datasheet (if provided together with the APW installation).

Figure 3. Startup settings, interface selection

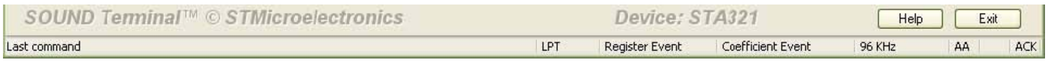


The lower part of the *Startup settings* dialog, instead, allows specifying the interface to be used (*Figure 3*, highlighted in red). Please note that when selecting the *AP Interface* (use this option for the LPT interface too) or the *USB* option, respectively the available parallel ports or the available COM ports will be enumerated in the drop-down menu on the right. Select the correct interface and communication port, then press OK. Among the physical interfaces the *Simulation* option is also available. Use this option if you do not want to be connected to an interface (APW evaluation and testing only).

Figure 4. APW main dialog, device controls

After pressing the *OK* button, the APW main dialog will be displayed, its presentation will depend on the device selected and may vary from product to product. On the right side of the APW main dialog, the *Device controls* frame (*Figure 4*, highlighted in red) is displayed. Use the *Device power up* button to start the device (when the IC is powered, the green LED will be switched on as well), then use the other controls (*Reset*, *Initialize*, …) as needed.

Figure 5. Status bar



At the bottom of the APW window a status bar provides some additional information regarding the last executed command concerning both the I^2C registers and the coefficients, the processing sampling frequency, the chosen interface (LPT, USB or SIM) and some of the selected preferences (AA = *Auto Apply*, AR = *Auto Retrieve*, ACK = *Warn for ACK Failures*).

Some of the APW features can be activated using easy shortcuts. The list is available in *Section Appendix F: Shortcuts quick reference*.

2 APW walkthrough

2.1 Introduction

This chapter will guide the user through many of the controls and features offered by the APWorkbench. Before proceeding with the following paragraphs an important concept has to be clarified. For each supported device, the APW has an internal registers bank and a coefficients bank (which will be referred to from now on as *local banks*), that reproduce the banks contained in the device (which will be referred to from now on as *device banks*). It is up to the user to decide how to handle the *local* and the *device banks* by setting the *Auto Apply* and the *Auto Retrieve* preferences. The consequences and the advantages of these choices will be thoroughly explained in *Section 2.2: Preferences*. Please note that the registers bank and the coefficients bank contain all the information needed to completely describe the device setup. Nevertheless, the APW also uses a third structure called *filter bank*. Starting from the filter's coefficients, this bank stores the filter's setup in terms of each filter's qualitative parameters (gain, cutoff frequency, filter type, etc…). From now on the ensemble of the registers bank, coefficients bank and the derived filters bank will be considered and referred to as the *device configuration*.

2.2 Preferences

The *Preferences* dialog allows customizing the behavior of the APW in order to fit the needs of every user. Select the *Tools* menu and left click on *Preferences* to show the dialog (*Figure 6*).

The dialog should appear as shown in *Figure 7*. It can be divided into three main areas. The left top side of the dialog groups all the controls concerning the tracing preferences (highlighted in red).

Figure 6. Tools menu, preferences

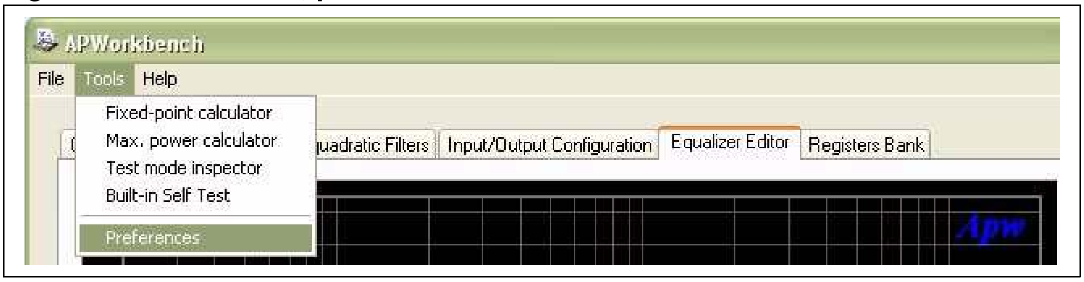
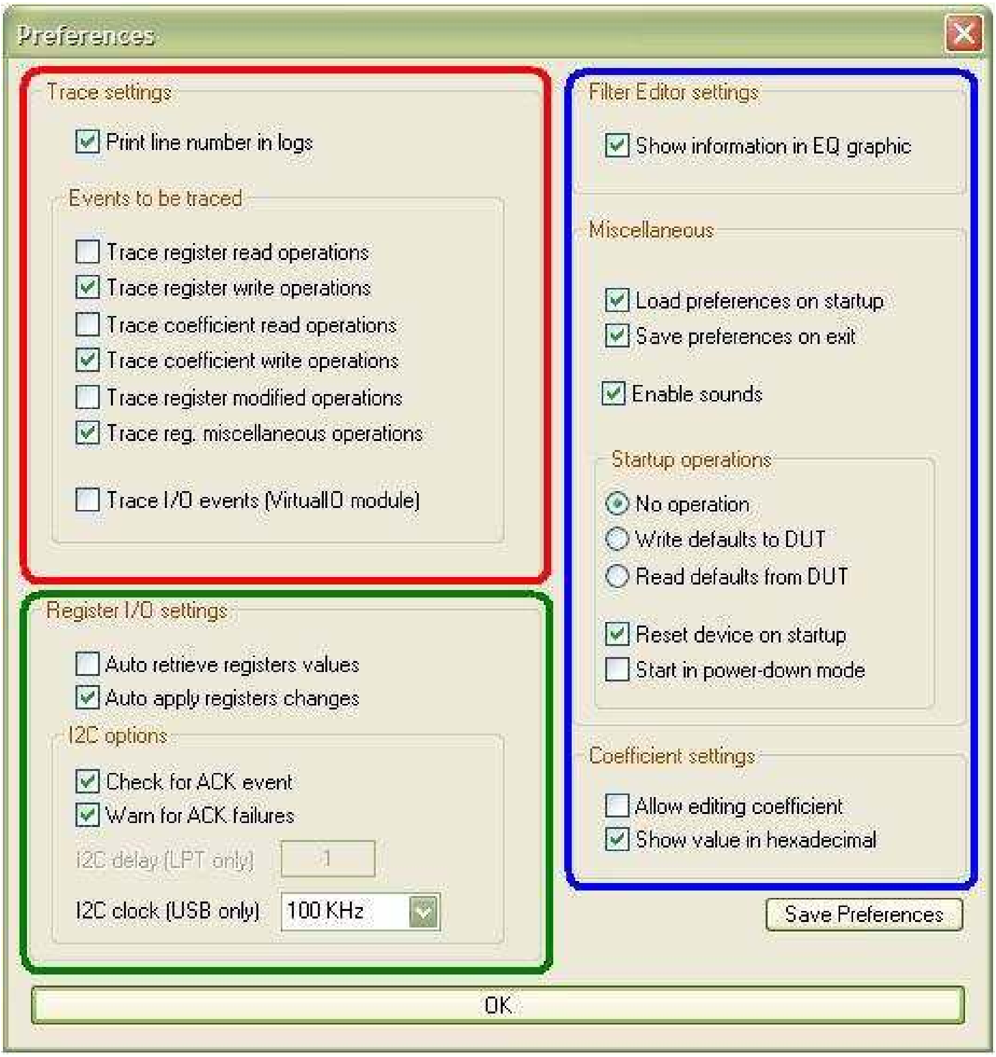


Figure 7. Preferences dialog



Using these options the user can decide which kind of events will be logged:

- Coefficient reading
- Coefficient writing
- Register reading
- Register writing
- Miscellaneous operations on registers
- Register modifications

As a last tracing option the user can also choose to trace all the operations occurring between the PC and the interface by selecting the *Trace I/O Events* flag. The log file can be provided with an automatic line numbering feature that can be enabled, if needed, through the *Print Line Number in Log* flag.

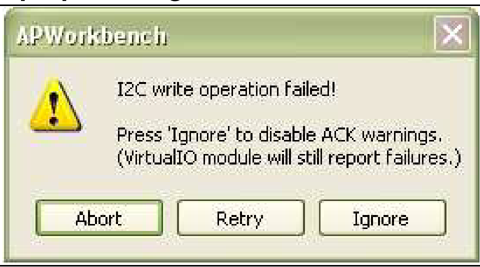
On the right side of the dialog (highlighted in blue) some miscellaneous preferences concerning the features of the APW are displayed. Hereafter a list of them by group and a brief explanation (if needed):

- *Coefficient Settings*:
  - *Allow Editing Coefficients*: this option enables the editing of the filter's coefficients.
  - *Show Value in Hexadecimal*: this option allows toggling between the hexadecimal and the decimal notation when displaying the coefficient's value. Please note that in case of decimal notation, the values are displayed with ten numbers after the comma. For this reason and for space constraints they might not be completely displayed.
- *Filter Editor Settings*:
  - *Show Information in EQ Graphic*: shows gain and frequency information when moving with the pointer over the graphic.
- *Miscellaneous*:
  - *Load Preferences on Startup*: the APW loads the preferences used the previous time.
  - *Save Preferences on Exit*: when quitting the APW, saves a copy of the current preferences setup.
- *Startup Operations*: this option modifies how the APW interacts with the device at startup. The APW can read the device configuration from the DUT (Device Under Test) or set it from its local banks (in this latter case the device defaults will be applied). A *No Operation* option is also available. If chosen, the APW will not perform any operation on the DUT at startup. Please note that by choosing this latter option the *device configuration* stored in the APW and the one stored in the device might not be the same.

On the bottom left side of the dialog are grouped all the preferences concerning the register I/O setup. Since these options will customize how the APW will behave when performing any I^2C operation, do not modify them unless strictly needed.

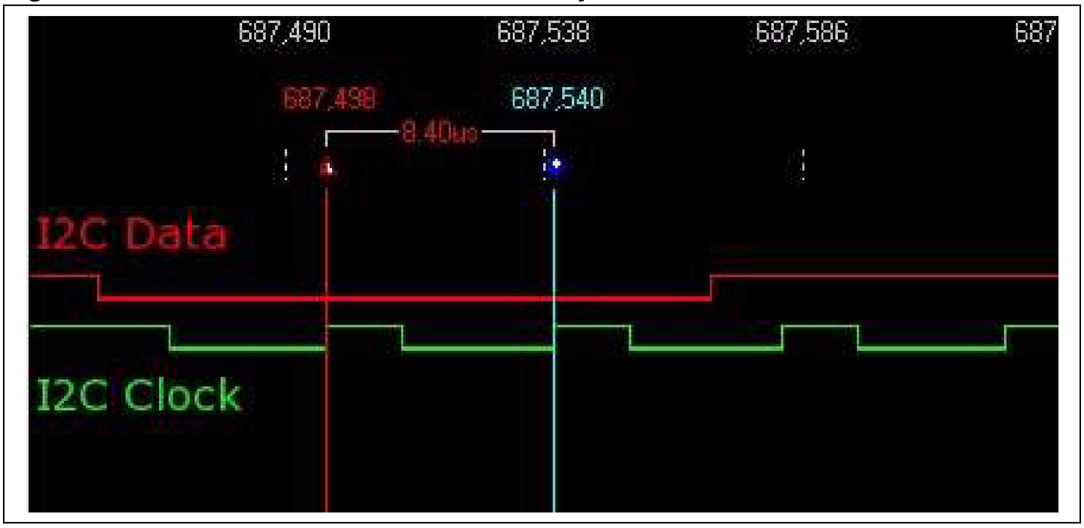
- *I^2C Options*
  - *Check for ACK Events*: if selected, the APW will check for I^2C operations acknowledge, otherwise it will be ignored.
  - *Warn for ACK Failures*: through this option the user can choose whether to be informed in case of I^2C failures or not. The *check for ACK events* option has to be checked first. Please note that when this option is set, a pop-up message (*Figure 8*) will warn the user at each I^2C failure, offering the user the possibility of aborting the operation, retrying it or ignoring any subsequent warning. If this last option is chosen, the APW will automatically disable the *warn for ACK Failures* option. To re-enable it, access the *Preferences* window as described above.

Figure 8. I^2C failure pop-up message



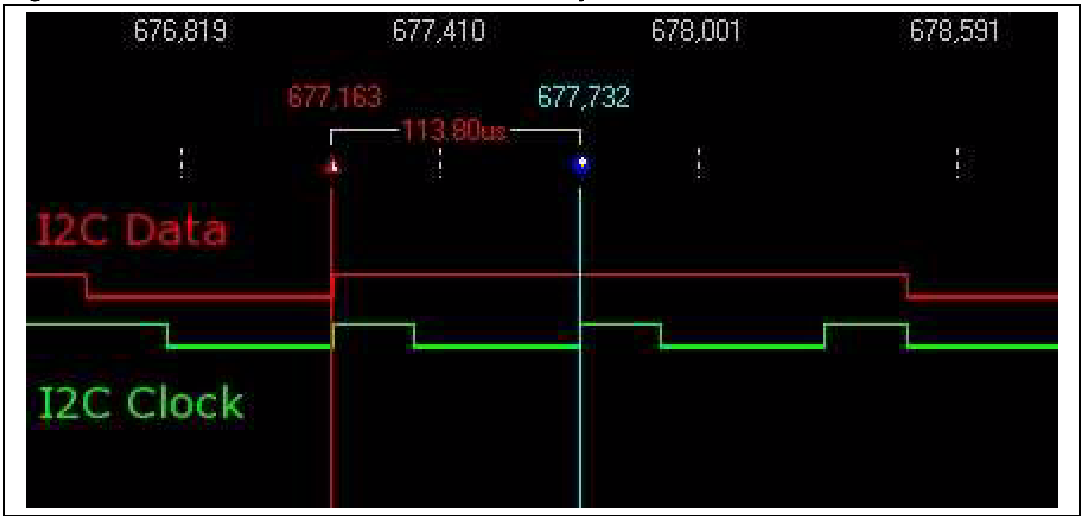
– *Delay (LPT Only)*: the I^2C clock speed generated through the LPT interface is strictly related to the performance of the PC the APW is running on and therefore it cannot be predicted with accuracy. For this reason, from the release 0.910, the *Delay* option has been added to make the I^2C operation slower or faster according to need. Its value is basically a counter that has to reach zero before toggling the I^2C clock line. The *Delay* range varies from 1 (which corresponds to the fastest configuration possible) to 10000 (which corresponds to the slowest one). Since its effect may vary from one machine to another, the following screenshots show three sample cases for *Delay* = 1 (*Figure 9*), 5000 (*Figure 10*) and 10,000 (*Figure 11*).

Figure 9. I^2C data and clock line when Delay = 1



Note: The clock period is 8.6 µs, hence F_{max} is 116 kHz

Figure 10. I^2C data and clock line when Delay = 5000



Note: The clock period is 113.8 µs, hence F_{max} is 8.8 kHz

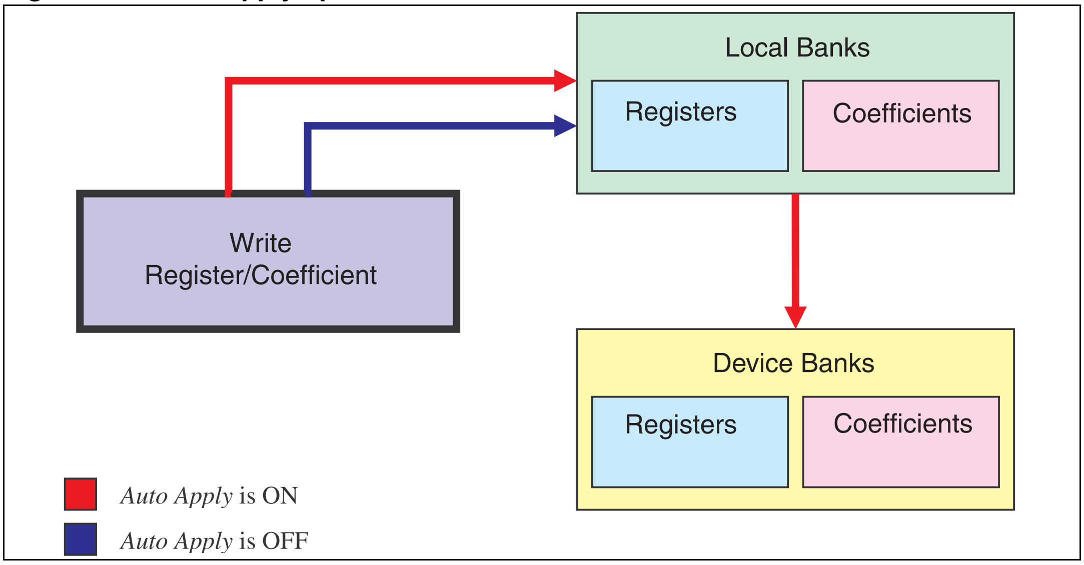
Figure 11. I^2C data and clock line when Delay = 10,000

Note: The clock period is 216 µs, hence F_{max} is 4.6 kHz

- *I^2C clock (USB only)*: when using the APWLink interface the user can set the I^2C bus clock using this control. The supported frequencies are 50 kHz, 100 kHz, 200 kHz and 400 kHz.

- *Register I/O settings*:
  - *Auto Apply Registers Values*: influences how the APW writes the I^2C register and the coefficient values. *Figure 12* shows the two possible configurations. If *Auto Apply* is set, the new register and coefficient values will be written in both the *local* and the *device banks* (red arrow). On the other hand, when this option is not set, the new information will be transmitted only to the *local banks* (blue arrow). In this latter case the content of the *local banks* can be copied into the *device banks* all at once using the *Apply* button in the upper right-hand corner of the APW window (see *Section 2.10: Miscellaneous controls*). By default, this option is set to guarantee the content alignment between the two banks.

Figure 12. Auto Apply option



– *Auto retrieve registers values*: influences how the APW retrieves the I^2C register and the coefficient values.

Figure 13. *Auto Retrieve* option

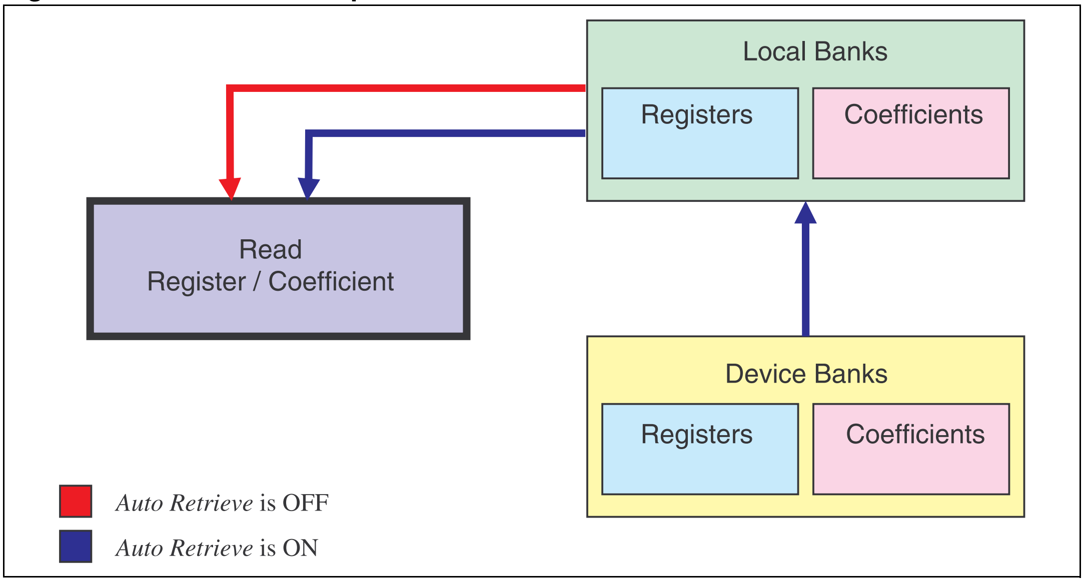
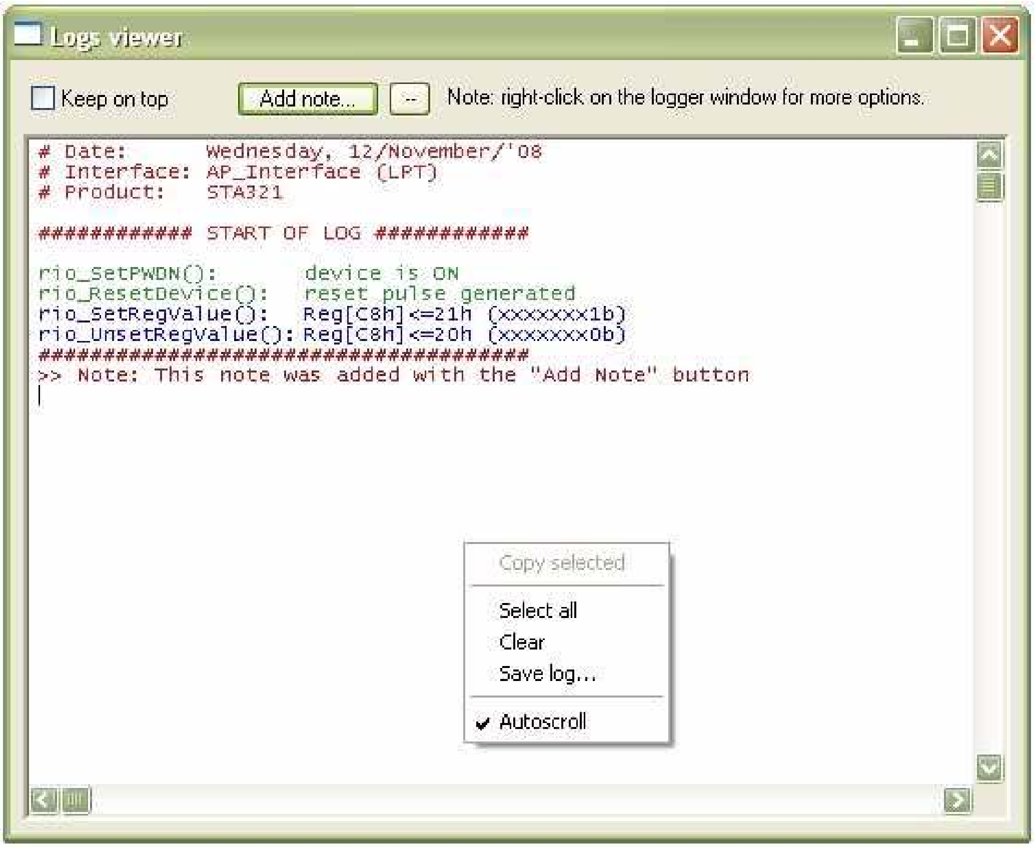


Figure 13 shows the two possible configurations. When the *Auto Retrieve* is on (blue arrow), the requested information is read from the device banks and then copied into the local banks and displayed to the user. On the other hand, when the *Auto Retrieve* is off, the requested information is read only from the Local Banks (red arrow). By default this option is not set since the content of the *local* and the device banks are meant to be aligned. It is suggested to keep this option disabled unless the *Auto Apply* option is also modified.

Use the *Save Preferences* button to save all the preferences set up.

2.3 Operations logging

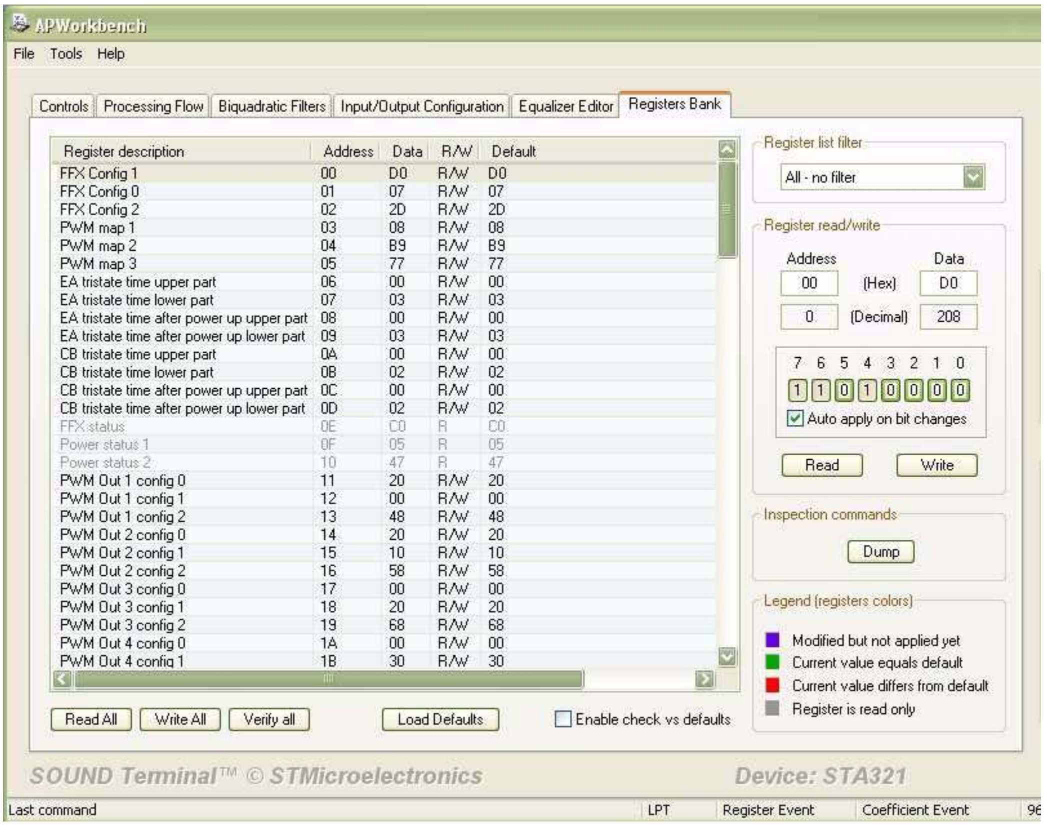
Figure 14. Real-time logger window



The APW offers the possibility of logging many of the events generated through its controls. These logs are automatically saved to a file named *debug.log* that can be found in the *APWorkbench/Log* folder. Real-time logging is also possible. By clicking on the *Logs Viewer* button (*Figure 39*) the logs viewer window will pop up and show different events in different colors as they are generated (*Figure 14*). Right-clicking on the log window will allow the user to copy, select, clear or save the log. Through the preferences customization, the user can choose in detail which events to log (see *Section 2.2: Preferences*). Using the controls placed on the top margin of the *Logs Viewer* window, the user can also choose between (from the left to the right most control): *keep on top* the logger, to add a note in the logs or to add an extra "#" break line. Please note that the operations regarding the I^2C register are logged both in hexadecimal and binary notation for easier interpretation.

2.4 Registers Bank

Figure 15. *Registers Bank* tab



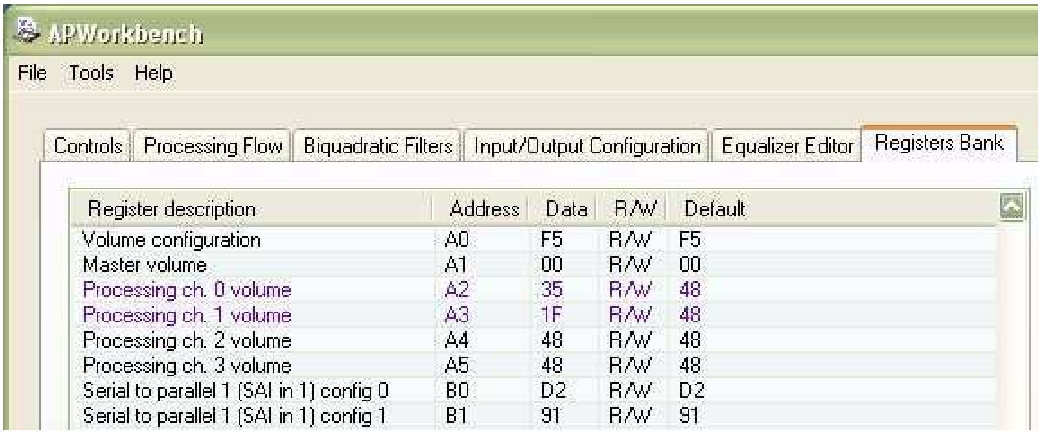
The *Registers Bank* tab offers the user direct access to the device I^2C registers (*Figure 15*).

The panel is mainly occupied by the list of the device registers. From the left column to the rightmost one, the list offers the following information:

- *Register description*: the register extended name
- *Address*: the register address (in hexadecimal notation)
- *Data*: the actual value of the register (in hexadecimal notation)
- *R/W*: register access type (if read/write or read only). Read-only or reserved registers are displayed in grey.
- *Default* (the register defaults are defined according to the device datasheet)

As additional information, the list of registers highlights in violet every register whose value in the *local bank* is not aligned with the value stored in the *device bank*, thus allowing to visualize all the modifications applied only the to *local bank*. *Figure 16* shows an example of this feature. A small reminder of the colors and their meanings is provided in the bottom right corner of the panel.

Figure 16. Registers modified in the local bank



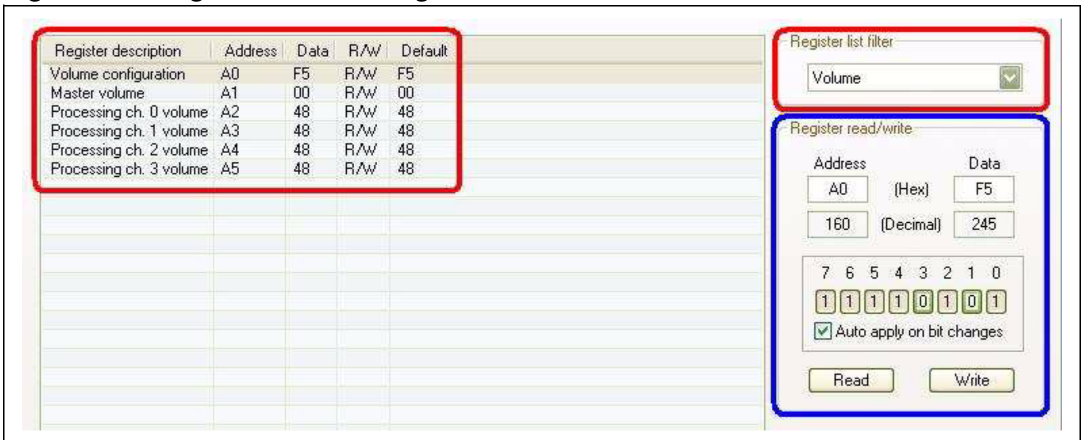
The registers list highlights in violet those registers modified in the local bank with respect to the device bank.

At the bottom of the tab four buttons (and a checkbox) implement the following functions:

- *Read All*: reads all the registers from the device bank (in this case the *Auto Retrieve* option is bypassed).
- *Write All*: writes the content of the local registers bank (the values shown in the *Data* column) into the device bank (in this case the *Auto Apply* option is bypassed).
- *Verify All*: compares the contents of the local banks with those of the device banks. If any difference is detected, the register is displayed in violet.
- *Load Defaults*: loads the registers default settings in the APW local register bank. To apply these default settings to the device bank, press *Write All*.
- *Enable Check vs Defaults*: enabling this option, the register values stored in the local bank are compared with the default values. If any difference is detected, the registers are displayed in red, otherwise they are displayed in green (*Figure 17*).

Figure 17. Example of the behavior of the “Enable check vs defaults” option

Figure 18. Register filter and register editor

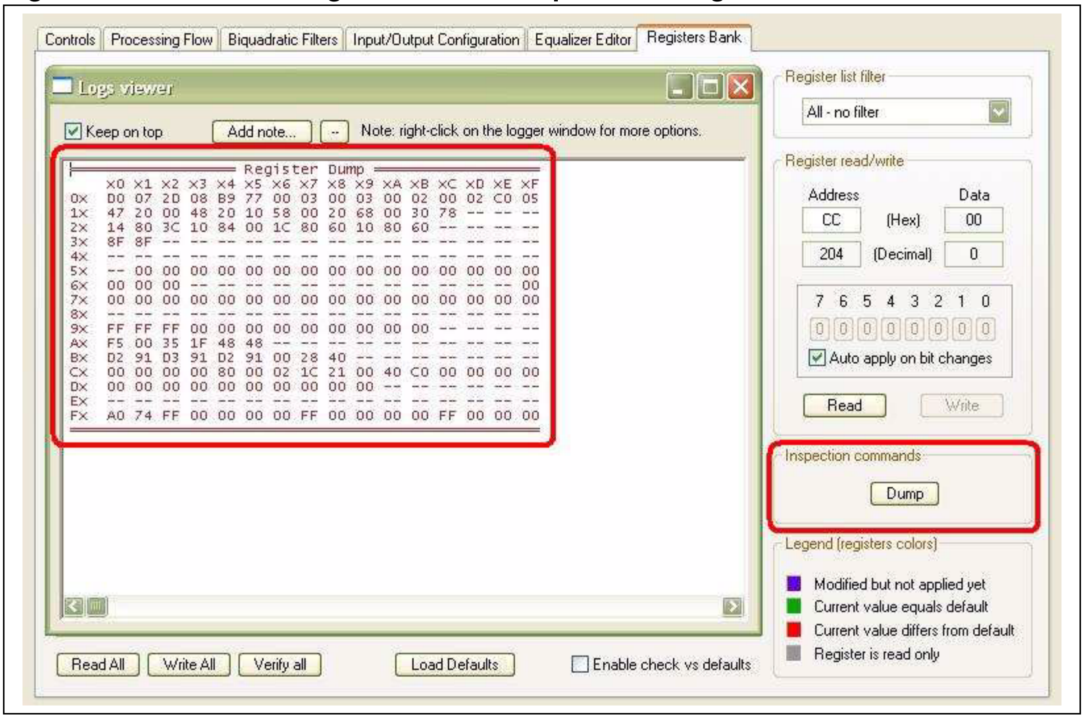


On the top right side of the tab is located the *Register Filter*. It allows displaying in the list of registers only those registers that have the same device features (*Figure 18*, highlighted in red). This option is very useful since it avoids moving along the whole list of registers (that can be very long) when looking for a specific register, thus making it easier and faster to access the device information.

The right side of the tab is also occupied by the controls that allow editing the registers (hexadecimal and binary notation are supported). After choosing the register, either from the list on the left or by typing its address (in hexadecimal notation) in the designated space, the user can modify its content by typing the new value for the whole register or by toggling only the desired bits by left clicking on the binary visualization (*Figure 18*, highlighted in blue). Press the *Write* button to apply the new register value, once it has been established. Please note that both the *Read* and *Write* buttons will follow the *Auto Apply* and *Auto Retrieve* preferences.

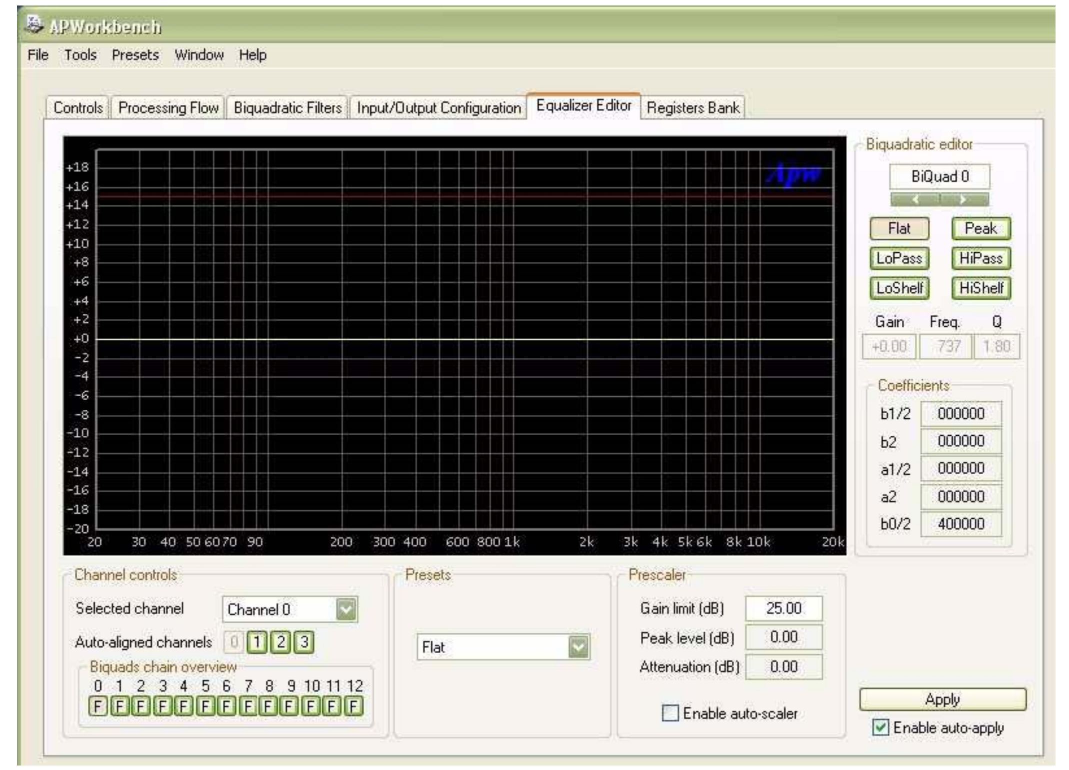
Finally, the *Dump* button allows dumping all the local bank registers in the log viewer windows as shown in (*Figure 19*, highlighted in red). Unavailable registers are displayed with the symbol "--".

Figure 19. Local bank register values dumped in the log viewer



2.5 Equalizer Editor

Figure 20. Equalizer Editor tab



The *Equalizer Editor* tab offers the possibility to design different types of filters and to compute and download into the device the relevant coefficients either by defining their graphs or their qualitative parameters. The supported filters are (see *Appendix A: Types of filters supported*):

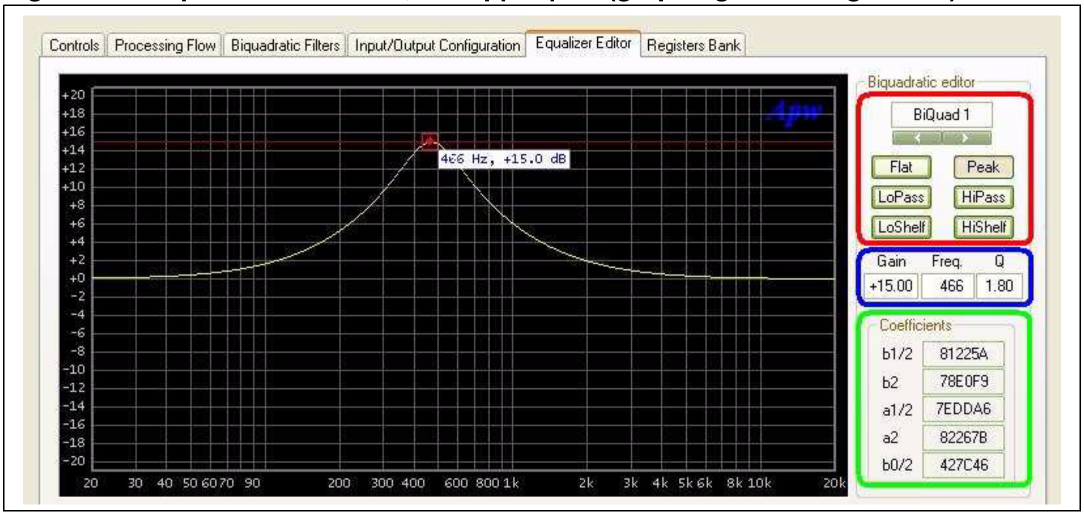
- Peak
- High-pass
- Low-pass
- High-shelf
- Low-shelf

The upper part of the tab is occupied by the graphical editor and by the design tools (*Figure 21*). To design a filter by defining its graph, follow the steps described below:

1. Select the kind of filter to be designed by pressing the button on the right side of the graph. It is also possible to select which biquadratic filter of the DUT to write in (*Figure 21*, highlighted in red).
2. After selecting the filter type, a default graph will be plotted. A red dot indicates the filter handler (*Figure 21*). Move the mouse over this point, left click with the mouse and keep pressed. While doing so, move the mouse pointer around the graph to modify the filter drawing as needed. Release the left button of the mouse when the filter fits the requirements. The filter handler may vary according to the filter type. In *Figure 21* a low-pass filter has been selected. For this kind of filter a red vertical line is used to clearly identify the frequency whose gain is -3 dB (i.e. the cutoff frequency).

Please note that when moving the mouse pointer to design a graph, the corresponding filter coefficients are continuously computed and applied to the device according to the preferences applied that will be discussed below. Also, the qualitative parameters of the filter (*Figure 21*, highlighted in blue) are coherently updated.

Figure 21. *Equalizer Editor* tab, the upper part (graphing and design tools)



To design a filter by defining its qualitative parameters, follow the procedure below:

1. Select the kind of filter to be designed by pressing the appropriate button on the right side of the graph. It is also possible to select which biquadratic filter of the DUT to write in (*Figure 21*, highlighted in red).
2. Enter the desired parameters in their corresponding fields on the right side of the graph (*Figure 21*, highlighted in blue), then hit the "Enter" key to change the focus from the input field to another control of the panel.
3. The graph is immediately plotted, the filter coefficients are computed and they are applied to the device according to the apply option that will be discussed later on in this section.

It is important to point out that one filter design method does not exclude another. Indeed, it is possible either to modify the qualitative parameters of a filter designed starting from a desired graph or to adjust the filter graph generated from a set of qualitative parameters. Whichever is the design method applied, the hexadecimal values of the computed coefficients are displayed in the area highlighted in green in *Figure 21*. When changing the selected biquadratic filter, the table of coefficients is updated coherently.

Regardless of the filter design approach, the APW also embeds a set of controls to protect the user's hearing and the audio equipment from unpleasant effects when designing a filter:

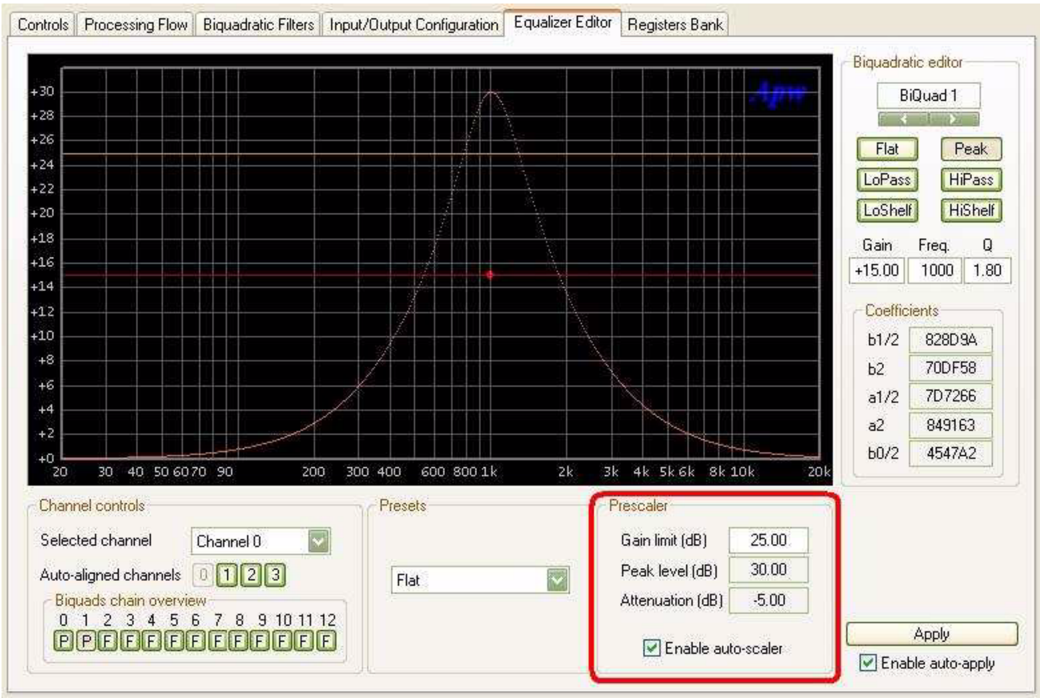
- Single filter gain limitation: the gain applicable with a single filter can be set between a range varying from +15 dB to -30 dB. This range is fixed and cannot be changed. The limits of this range are marked on the graph with a red line as shown in *Figure 21*. If a higher gain is desired, this limitation can be bypassed using a chain of two or more filters.
- *Auto-scaler*: APW offers also the possibility of limiting the overall maximum positive gain applicable with any chain of filters. This is done by enabling the *Enable auto-scaler* checkbox. This feature automatically computes the difference between the overall filter

gain and the maximum threshold. Then it applies the value as an attenuation, modifying the device prescaler. By acting in this way, the auto-scaler achieves two key goals:

– The overall filter's chain shape is unchanged
– The dynamic of the filtered audio signal remains within safe boundaries for both ears and speakers

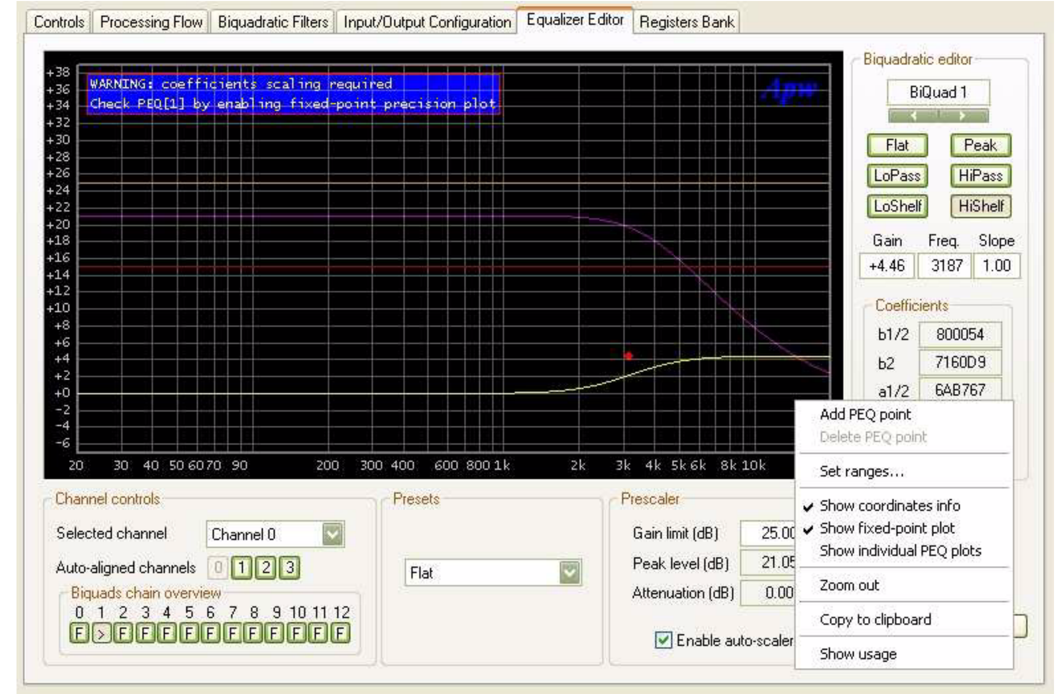
Figure 22 shows an example of how the *auto-scaler* works. Two peak filters with a +15 dB gain each are applied with a +25 dB threshold, thus with a +5 dB in excess. APW *auto-scaler* automatically computes the gain in excess and applies the attenuation using the prescaler. When the total frequency response exceeds the threshold, its plot becomes dark orange. The prescaler controls (highlighted in red) show the designed filter maximum gain and the attenuation required to satisfy the requirements. The threshold (marked by an orange line) is user-definable and can be changed either by editing the *Gain limit* box or by manually dragging the marker on the plot.

Figure 22. Auto-scaler



● Coefficient scaling: Sound Terminal® products adopt a 24-bit fixed point notation to handle the filter coefficients. APW is also able to check whether the computed coefficients fit the notation or not. In this latter case a warning message appears on the top left of the plot. Exceeding the mathematical notation limits generates a filter frequency response different from the desired one, to see the real frequency response, right click on the plot and select *Show fixed point plot*. A violet graph will appear showing the real applied filter. *Figure 23* shows an example of this behavior.

Figure 23. Scaling coefficients

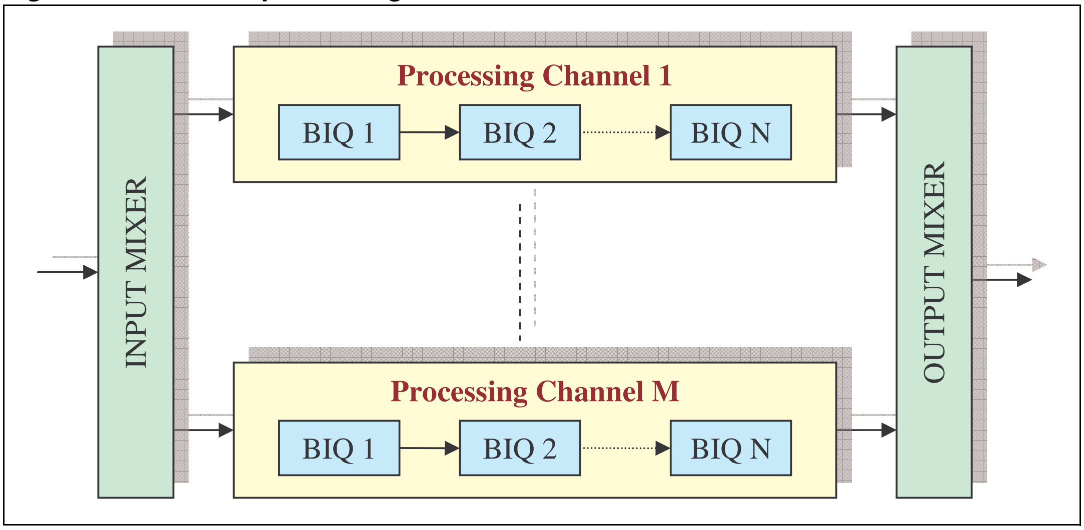


- Filter stability check : APW automatically checks the stability of the desired filter before applying it to the device. In the case of an unstable filter, the coefficients are not applied and a warning message appears on the top left of the plot.

Figure 24. Equalizer Editor tab (lower part concerning filter design customization)

The lower part of the *Equalizer Editor* tab groups several options to customize the design activity (*Figure 24*). On the left side the *Channel Controls* are displayed. Generally the Sound Terminal® products are characterized by more than one processing channel and each channel may include several biquadratic filters (*Figure 25*).

Figure 25. **Generic processing block**



Taking into account this kind of structure the Channel Controls allow the user to:

- Select the processing channel
- Select a specific filter among the ones available in the selected channel. Each button of the row at the bottom of the controls corresponds to a filter. Moreover each button, rather than indicating the biquad number, indicates the kind of filter in use according to the following abbreviations:
  - P: peak filter
  - F: flat, all-pass
  - L: low-pass
  - H: high-pass
  - < : low-shelf
  - > : high-shelf
  - R: reserved (a biquad is reserved when it is used for an alternate function such as a bass enhancement, de-emphasis filter, …)
- Auto-align two or more processing channels. Two or more channels are aligned when their biquadratic filters are configured in the same way. In other words, once a filter or a set of filters has been defined for a processing channel, the *Auto-Aligned Channels* option allows automatically applying the configuration to all the other linked channels, thus speeding up the setup process. The only exception concerns the reserved biquads. If a filter is reserved, its setting will not be applied to, or will not be changed from, another linked filter. Please be aware that this is a software option offered by the APW that is not related in any way to the physical implementation of the IC under test (thus it is available for every device). Depending on the Sound Terminal® product, similar options might be available also as hardware-implemented features that can be managed through a dedicated set of device-specific controls.

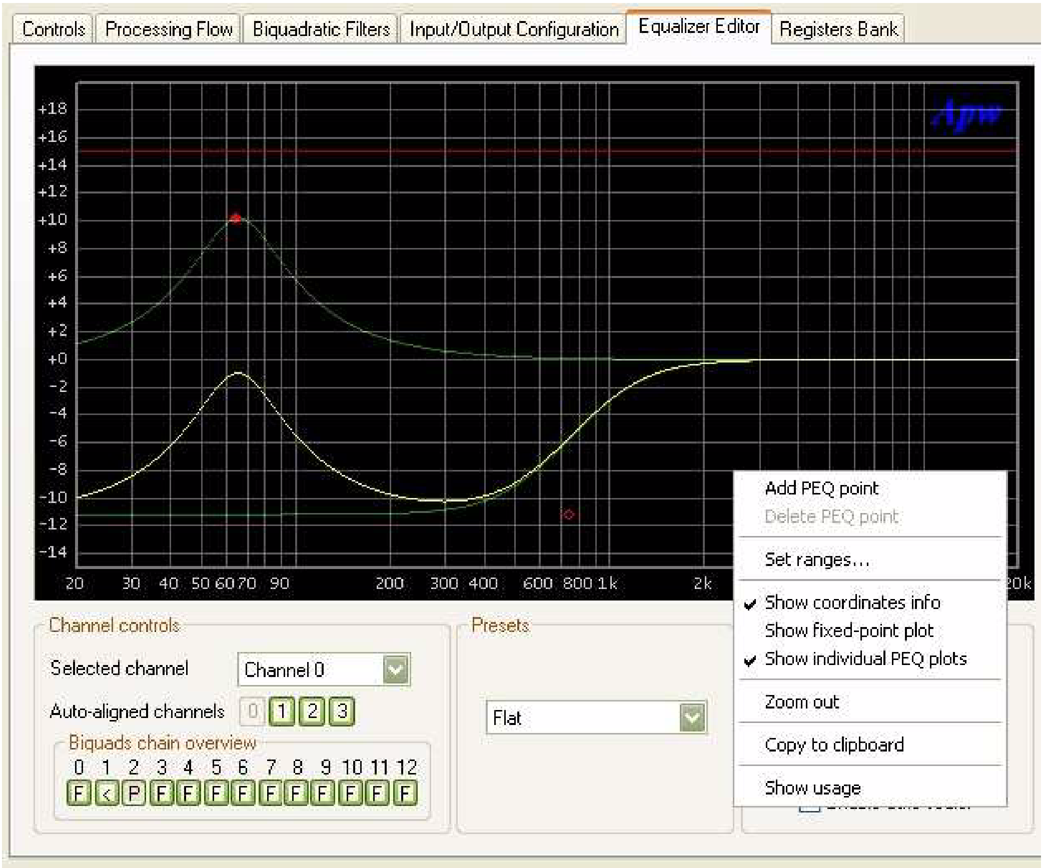
The controls described above will necessarily vary according to the device architecture and may slightly differ from those shown in *Figure 24*.

The center area of the lower part of this tab is occupied by the *Equalization Presets* (if available for the selected device) and the *Channel Controls* described above.

At the end the left lower side of the *Equalizer Editor* tab groups the filter apply option. The user, through the *Enable Auto-Apply* option, can choose whether to automatically apply a filter or not. In this latter case to transfer the filter (or filters) set up for the device, the *Apply* button has to be used. Please be aware that this button bypasses the *Auto Apply* option.

The figure below shows the global frequency response of the selected channel (yellow line) overlapped by the graphs of the two filters (green lines) contributing to it.

Figure 26. **Equalizer Editor *tab, miscellaneous options***



The last options available in this tab can be selected using the mouse controls on the graph area:

- By right clicking with the mouse on the graph area, a menu will pop-up (*Figure 26*):
  - *Add/Delete PEQ Point*: a shortcut to add/delete a peak filter in the point selected with the mouse.
  - *Set Ranges*: allows setting the ranges shown in the graph.
  - *Show Coordinates Info*: when this option is enabled, the coordinates of the point of the graph on which the mouse is located, will pop up.
  - *Show fixed-point plot*: by default (option) the APW plots the filter's frequency response using a floating point notation. Use this option to generate the plots using the 24-bit fixed point notation as used by the Sound Terminal® products.
  - *Show PEQ Curves*: the *Equalizer Editor* shows by default the whole frequency response of the selected processing channel. Since, as stated before, this curve

might be the sum of the contribution of two or more filters, this option forces the APW to plot also the graph of each single filter (*Figure 26*).
- *Zoom Out*: resets the zoom setup to the default.
- *Copy To Clipboard*: copies the graph to the clipboard.
- *Show Usage*: displays a short explanation about the usage of the *Equalizer Editor*.

- Moving the mouse wheel on a filter handler will increase or decrease its Q.
- Moving the wheel on any other point of the graph will vary the zoom.

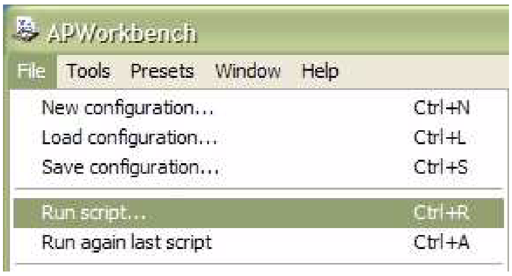
Please note that the Sound Terminal® products support different processing sampling frequencies and obviously this frequency is a key factor when plotting the filter graphs or computing the coefficients. The APW is able to take into account this parameter, thus plotting the correct frequency response. Depending on the selected device, this is performed either automatically or by setting manually the sampling frequency. In any case, the frequency in use is shown in the APW status bar.

2.6 Scripts

Another powerful tool offered by the APW is the capability of writing and running a script.

To run a script select from the APW *File* menu and left click on *Run Script* as shown in *Figure 27*.

Figure 27. Running a script



The *Run again last script* option allows using the last selected script, thus avoiding having to specify its location every time. For an example of a script, please refer to the file SampleScript.aps delivered together with the APWorkbench installation package or go to *Appendix C: Script file*. Hereafter is a brief description of the syntax and of the functionalities for each token available:

RESET

Resets the device reset pulse to last 50 msec. It also sets the I^2C registers and the coefficients to their default values (in the local banks).

SET_RST <I_state>

Sets the physical reset line to the logic state I_state. This command together with the *P* command allows having reset pulses longer than the default value applied with the RESET command.

P <pause>

Pauses the execution of the script for the time in milliseconds described by *pause*. This argument must be an integer value (decimal notation).

SECTION_BEGIN <n_iterations> /SECTION END

Defines a section of code that has to be cycled *n_iteration* times (decimal notation).

RW <address> <value>

Writes *values* into the I^2C register *address* (hexadecimal notation).

RR <address>

Reads the I^2C register *address* (hexadecimal notation).

RCMP <address> <value>

Reads the I^2C register *address* and compares it with *value* (hexadecimal notation).

CWA <address> <coeff 1> <coeff 2> <coeff 3> <coeff 4> <coeff 5>

Writes all five coefficients of a biquadratic filter at the location *address* (hexadecimal notation).

CWAF <address> <coeff 1> <coeff 2> <coeff 3> <coeff 4> <coeff 5>

The same as *CWA* (floating point notation).

CW1 <address> <coeff>

Writes a single coefficient (hexadecimal notation).

CW1F <address> <coeff>

The same as *CW1* (floating point notation).

CR1 <address>

Reads a single coefficient located at *address* (hexadecimal notation).

CRA <address>

Reads five consecutive coefficients starting from location *address* (hexadecimal notation).

CCMP1 <address> <coeff>

Reads the coefficient located at *address* and compares it with *coeff* (hexadecimal notation).

CCMPA <address> <coeff 1> <coeff 2> <coeff 3> <coeff 4> <coeff 5>

Reads five consecutive coefficients starting from location *address* and compares them with *coeff 1*, …, *coeff 5* (hexadecimal notation).

APWLINK_INIT_ADC

Initializes the APWLink onboard ADC (see AN4118, “APWLink™ USB interface board for Sound Terminal® demonstration boards” for further information).

APWLINK_ADC_RW <address><value>

Writes *value* into the I^2C register *address* of the APWLink onboard ADC (hexadecimal notation).

APWLINK_ADC_RR <address>

Reads the I^2C register *address* of the APWLink onboard ADC (hexadecimal notation).

CLEAR

Clears the log viewer contents.

DUMP_REGISTERS

Dumps all the device registers.

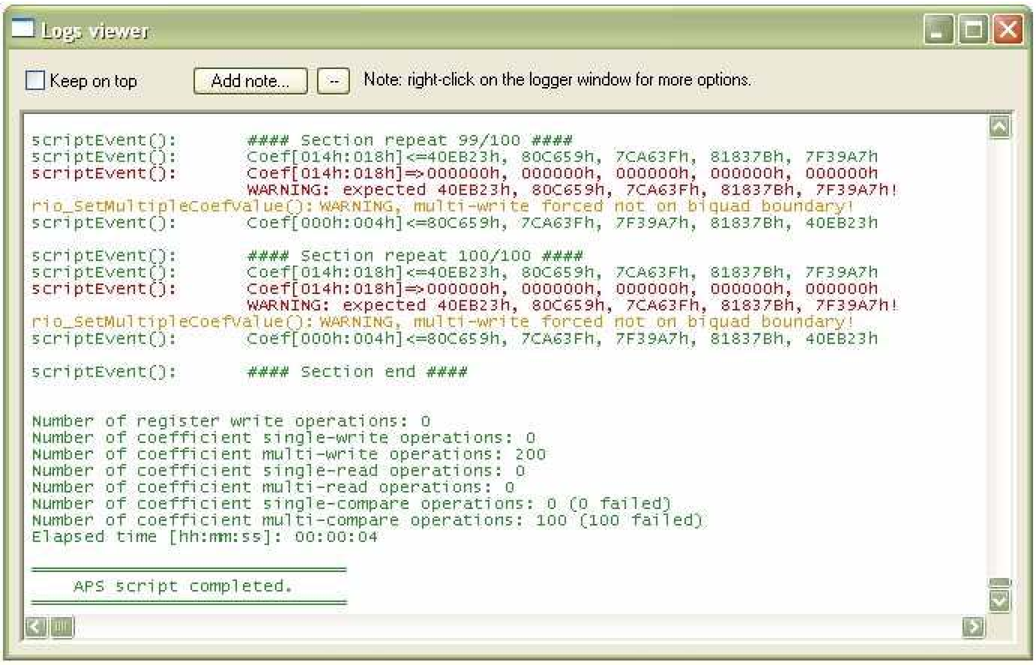
HELP

Displays a list of the available commands in the *Log Viewer*.

Comment

It is the comment token. Every word after this tag will be ignored by the command parser.

Figure 28. Events in logger upon completion of a script



After a script has been run, a summary of the completed operations is available in the *Log Viewer* window together with the log of the operations performed. Different colors are used to signal particular events (*Figure 28*):

- Green: the operation has ended successfully.
- Red: the operation failed.
- Orange: the operation has been performed with anomalous parameters (e.g. 5 coefficients have been written, starting from an address not corresponding to a biquadratic filter).

2.7 Command shell

The scripts tokens can also be cast as instantaneous commands through the *Command Shell*. To open it use the button on the right side of the APW window (*Figure 29*), or select it from the drop-down menu *Panels* (*Figure 30*). For a complete list of the available commands, please refer to *Section 2.6: Scripts* or type *help*, the list of available tokens will be displayed in the *Log Viewer*. The *Command Shell* will appear as depicted in *Figure 31*.

The *Command Shell* button is located on the right side of the APW window, just beneath the log viewer button. It can also be activated by left clicking on the *Panels* drop-down menu or pressing F3.

Figure 29. **Location of Command Shell button**

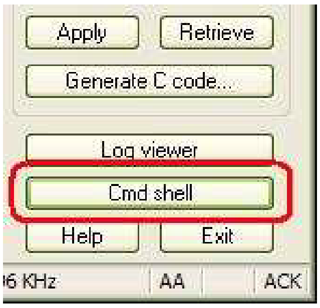


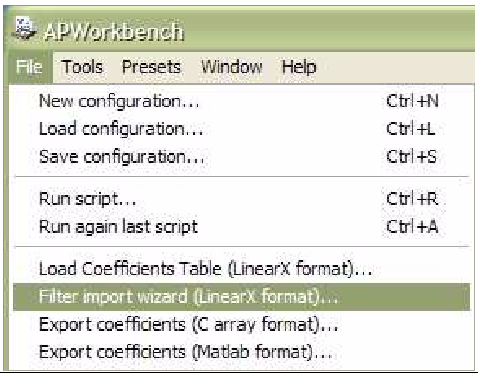
Figure 30. **Drop-down menu**

Figure 31. **Command Shell window**

2.8 Importing a filter

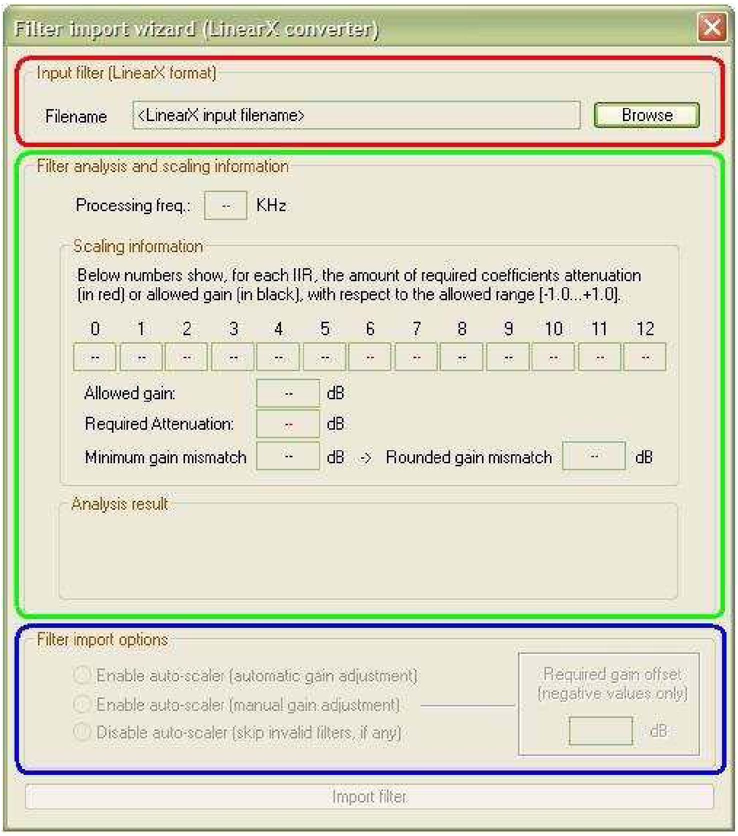
The APW also offers the possibility of importing the filters designed using the LinearX LEAP© suite (LinearX© Website). This feature is implemented by the *Filter import wizard* option that can be found in the *File* menu (*Figure 32*).

Figure 32. **File menu, Filter import wizard**



The import wizard appears as depicted in *Figure 33*. The window is divided into three main areas: on top (highlighted in red) the file selector, in the middle (highlighted in green) the *Filter analysis and scaling information* and at the bottom (highlighted in blue) the *Filter import options*. These latter options are available depending on the outcome of the filter analysis.

Figure 33. Filter import wizard

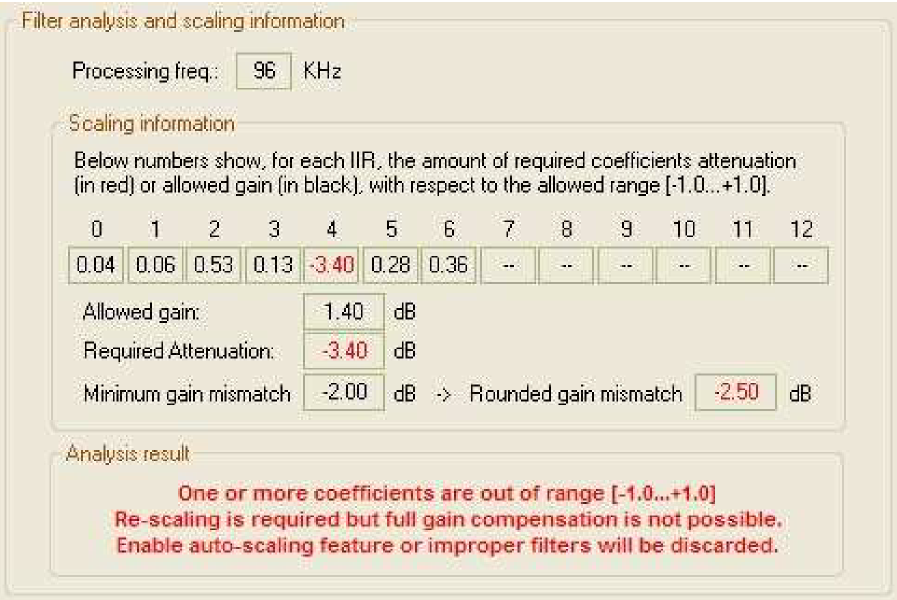


The LinearX LEAP© tool, as well as the APW, computes the coefficients using a floating point notation which allows a much broader range of values than the one allowed by the fixed point notation used by the Sound Terminal® devices ([-1, +1]). The *Filter import wizard* takes this difference into account and performs an analysis to verify whether the coefficients fit the fixed point notation or not. The outcome of this analysis is given in the *Filter analysis and scaling information* area (*Figure 34*). When a filter adopts one or more out-of-range coefficients, a scaling procedure is required. Rescaling a filter implies applying an attenuation in order to bring all its coefficients back into the allowable range. The wizard automatically computes the minimum attenuation to be applied. To preserve the global filter frequency response, an equal gain must be applied in order to compensate the attenuation. This goal is reached by applying a different gain Gi to each biquad such that (G0*G1*…*GN) = 1/A where A is the required attenuation. The wizard automatically computes also the maximum applicable gains (with respect to the notation limits) and checks whether the total amount of gain is equal to (or exceeds) the attenuation required or not. In this latter case (attenuation not adjustable) the minimum gain mismatch reachable between the desired filter frequency response and the rescaled one is displayed.

Figure 34 shows an example of a filter analysis, from the top to the bottom the following information is displayed:

- *Processing frequency*: the sampling frequency for which the coefficients have been computed. If it does not match the selected device processing frequency, an error message is displayed.
- *Scaling information*: the window shows in black the maximum gain applicable and in red the minimum attenuation required. This information is displayed for each filter and globally. In this latter case, if required, the minimum gain mismatch is also provided.
- *Analysis result*: a short description of the outcome of the analysis.

Figure 34. **Filter analysis and scaling information**

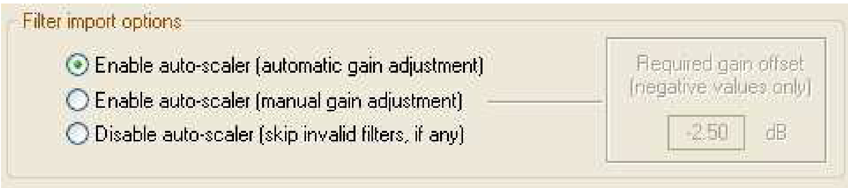


Depending on the outcome of the filter analysis, the user can choose between three possible solutions (*Figure 35*):

- *Enable auto-scaler (automatic gain adjustment)*: the import option automatically applies the best gains and attenuations to guarantee the preservation of the global frequency response. If this goal cannot be achieved, the import option will apply the best gains to minimize the gain mismatch between the desired overall frequency response and the actual response.

- *Enable auto-scaler (manual gain adjustment)*: the user is given the choice of the attenuation to apply. The resulting global frequency response envelope will be preserved, although attenuated by the selected gain. Under these circumstances the attenuation might be compensated using the volume controls.
- *Disable auto-scaler (skip invalid filters, if any)*: the scaling procedure is disabled and the filters that cannot be applied are skipped. The overall frequency response will differ from the desired response.

Figure 35. Filter import options



Once the scaling options are set, the filters are imported by pressing the *Import filter* button. Before downloading any information into the device, the APW also performs a stability check to prevent the user from applying unstable filters, thus causing dangerous and unpredictable behaviors. At the end of the procedure a message will give the user the number of applied coefficients. Invalid filter (whether instable or out of range) coefficients are skipped, each time this happens a warning message appears. For further information about the import process please refer to *Appendix D: Filter import wizard*.

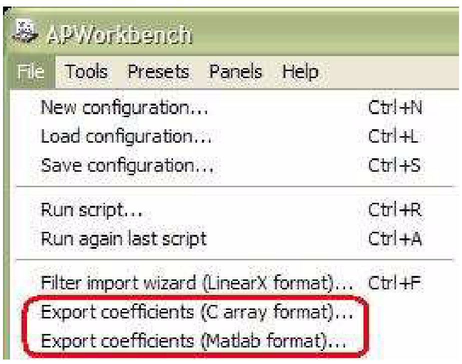
2.9 Exporting filter coefficients

Filter coefficients can be imported but they can also be exported. The APW offers two export formats:

- C/C++ arrays format (.c file)
- Matlab® arrays format (.m file)

The first format is very useful for MCU programming, while the second one might be used for in-depth filter analysis. Left click on the *File* menu to enable these features (*Figure 36*).

Figure 36. Exporting coefficients

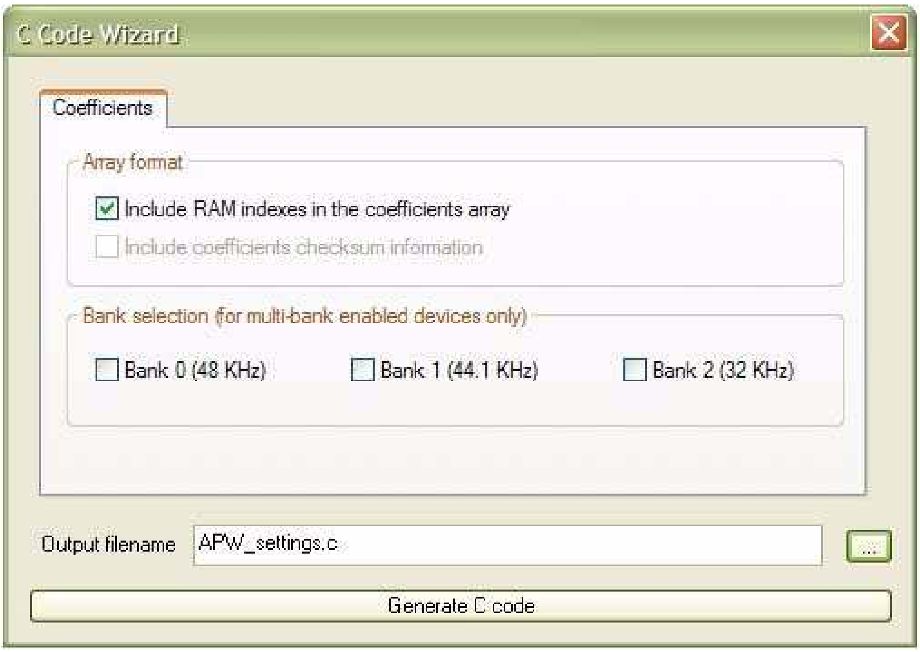


The C/C++ format export feature is also available through the Generate C Code button on the right side of the APW window. In both cases the wizard window will appear as depicted in *Figure 38*.

Figure 37. C/C++ format (using Generate C code button)

Through the wizard the user is given the possibility to customize the information to be exported.

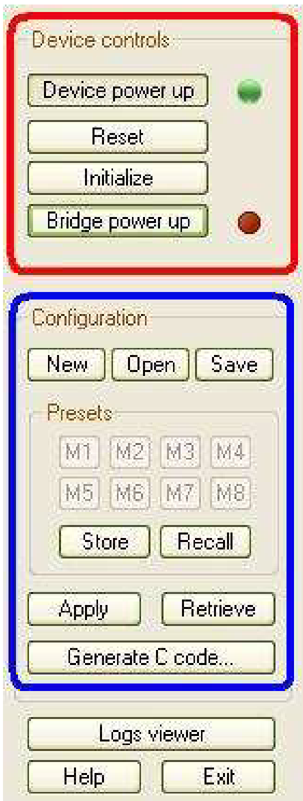
Figure 38. C code generation wizard



See *Section Appendix E: Exporting coefficients* for an example of the exported files.

2.10 Miscellaneous controls

Figure 39. **Miscellaneous controls**



On the right side of the window some miscellaneous controls can be found (*Figure 39*). The *Device Controls* frame (highlighted in red) groups the following functions:

- *Device power-up*: controls the device standby. This control physically handles the device standby pin.
- *Reset*: controls the reset of the device. This control physically handles the device reset pin (thus it forces the reset). It also writes the device default values into the local bank as described in the datasheet. It performs the same operations performed by the RESET token in the script (50 milliseconds reset pulse).
- *Initialize*: applies the minimum group of settings to bring the device to an operational status (these settings may vary from product to product).
- *Bridge power-up*: controls the power-up of the bridge.

Below these controls is located the *Configuration frame* (highlighted in blue). The APW, indeed offers the possibility of saving or loading a device configuration in order to avoid repeating long setup procedures. According to the definition given in the *Introduction*, the device configuration will comprise the registers bank, the coefficients bank and the filters bank. Each configuration is saved in a file with extension .apc. The functionalities of each button include:

- *New*: resets the APW controls and the device to allow the user to specify a new setup starting from the device default settings.
- *Open*: opens a configuration file and, if the *Auto Apply* option is set, it also applies the configuration to the device banks.
- *Save*: saves the device configuration in a configuration file (see *Appendix B: Audio processor configuration file*).
- *Apply*: applies the configuration loaded with the *Open* button (this control bypasses the *Auto Apply* preference). Once the configuration has been applied, a window will pop up to inform the user of the modifications.
- *Retrieve*: reads the device configuration and sets the APW control coherently (this control bypasses the *Auto Retrieve* preference).

Finally, the *Presets* frame offers the possibility of storing more than one configuration and switching between them on the fly, thus avoiding the *Load/Apply* procedure. Eight presets are available, the store and recall procedures are as follows:

- To Store:
1. Press the Store button
2. Select the memory in which the user wants to store the configuration
- To Load:
1. Press the Recall button
2. The APW will show the available presets
3. Select the memory from which the user wants to load the configuration

Please note that for each supported device the APW has a dedicated presets folder (*Figure 1*), thus ensuring that different presets for different devices will not be overwritten. The *device configuration* and *presets* options are also available through the *File* and *Presets* menu of the APW main window.

The lower part of the miscellaneous controls includes the *Logs Viewer*, the *Exit* and the *Help* buttons.

3 Device-specific controls

Apart from the controls described in *Section 2: APW walkthrough*, the APW offers, for each supported device, a dedicated set of tabs. Since these controls will vary significantly from product to product, a dedicated *Help* menu will be provided for each device.

4 F.A.Q.s

In this section we provide a few guidelines to answer the most common questions.

4.1 Questions & procedures

Q: "I need to interface with a device that has been already set from an external controller. How do I retrieve these settings with the APW?"

A: Follow this procedure:

1. Be sure that the interface is not connected to the device, start the APW and set the *no operation* option in the *Startup Preferences*. Save the preferences and close the program.
2. Connect the interface and start the APW.
3. Press the *Retrieve* button.
4. Press the *Save* button to save the configuration.

Q: "I want to apply all the settings at once and not step-by-step. How do I set the APW?"

A: Follow this procedure:

1. Uncheck the *Auto Apply* option in the preferences dialog.
2. Apply all the desired settings using the controls offered by the APW.
3. Select the *Registers Bank* tab and press the *Write All* button.

Q: "I'm not familiar with the device but I'd like to know what registers are changed when I configure it using the APW, is this possible?"

A: Follow this procedure:

1. Uncheck the *Auto Apply* option in the preferences dialog.
2. Apply all the desired settings using the controls offered by the APW.
3. Select the *Registers Bank* tab and move along the register list. Those R/W registers marked in violet are the ones you're interested in.

or this one:

1. Configure the device as needed.
2. Go to the Registers Bank tab and enable the *Enable Check vs Defaults* option.
3. Now the modified registers are displayed in red, move along the list and check.

Q: "This device has too many registers and moving along their list to find those I want to modify takes too much time, is it possible to show only those I'm interested in?"

A: Of course it is. Use the *Register List Filter* drop-down menu to filter the device registers depending on their function.

Q: "I'm setting up the device but I do not get the expected results. How do I check if the configuration of the device is coherent with the one depicted in the APW controls?"

A: Follow this procedure:

1. Go to the *Register Bank* tab and press the *Verify All* button.
2. When the previous operation is over, move along the registers list. The APW will display in violet the register whose value is different from the expected one.

Q: "I'm not comfortable with hexadecimal notation when editing the coefficient values in the control panel. Can I use the floating point one?"

A: Of course: uncheck *Show Values in Hexadecimal* in the preference window and you'll be able to enter the values in decimal notation. Please be aware that the floating point notation implies a long number of significant decimal digits that cannot be displayed all at once. As a result some digits might be hidden from view but can be easily displayed by highlighting the whole number with the mouse. Please remember that the coefficients range is from -1 to 1.

Q: "The reset pulse length applied by default using the RESET command in the script does not fit my needs. Can I set a different value?"

A: "There's no direct way to change the reset pulse length in a script. However, the reset procedure can be manually executed using the SET_RST command to move the reset line. Just use the following syntax:

```
SET_RST 0        # set RESET line at 0 (low_level)
P 200            # pause 200 ms
SET_RST 1        # set RESET line at 1 (high level)
```

The reset pulse will now last 200 milliseconds. This value can be changed as needed.

Q: "I want to add a note in the log to mark a section of interest for my work. How do I do that?"

A: Follow this procedure:

1. Press the *Add Note* button in the *Log Viewer* window.
2. Write the note and press enter. The note will be immediately displayed.

4.2 Problems

Q: "The device does not respond to the APW controls"

A: The possible causes are:

a. The device might be in standby.

b. The device may need to be initialized.

c. The *Auto Apply* option is unchecked.

Q: "I do not get any I^2C failure message, but I keep reading 00h or FFh. What's wrong?"

A: The possible causes are:

a. The interface board is not properly connected to the ST Sound Terminal® device board.

b. The interface board is not correctly powered.

Q: "I'm importing a LinearX LEAP© generated file but the import procedure always skips a filter. What's wrong?"

A: The possible causes are:

a. The *Disable auto-scaler* option is selected and one of the coefficients is out of range.

b. One filter might be unstable and to avoid dangerous effects it is not applied to the device.

Q: "I'm using an APWLink interface board but it is not listed in the APW startup dialog".

A: The possible causes are:

a. APWLink is a USB device: once such a device is connected, a short amount of time is required by the OS to recognize and initialize it. This time varies, depending on the computer. Close the APW and wait a few seconds, then start it again.

b. Another APW might be opened and using the APWLink. Close every APW session and try again.

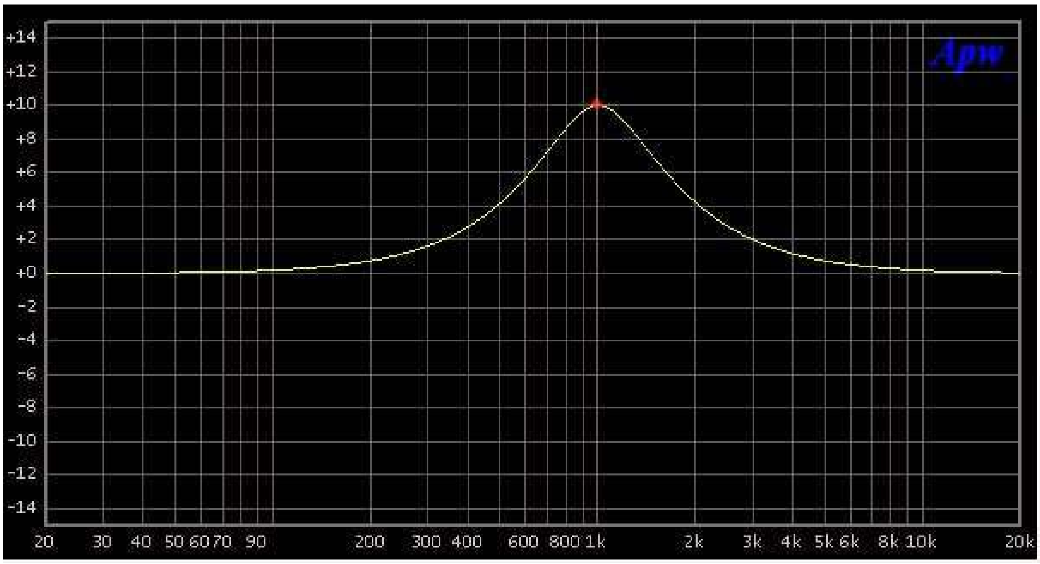
Q: "The DUT stopped reacting to I^2C commands in the middle of an APW session"

A: "A short-circuit either on the DUT board or on the APWLink board might have occurred. Under such circumstances the FTDI© chip on the APWLink board might hang. Close the APW, unplug the interface board and restart from the beginning".

Appendix A Types of filters supported

The following figures show an example of each filter supported by the *Equalizer Editor*.

Figure 40. Peak filter (gain +10 dB, freq 1 kHz, Q 1.41)



Note: The gain might also be negative.

Figure 41. Low-pass filter (gain 0 dB, freq 1 kHz, Q 0.71)

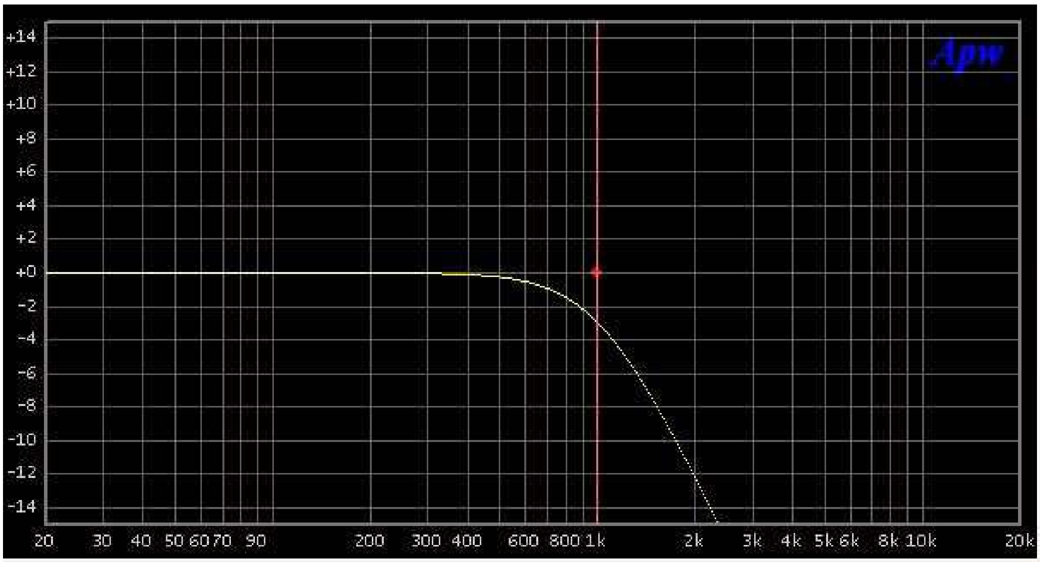


Figure 42. High-pass filter (gain 0 dB, freq 1 kHz, Q 0.71)

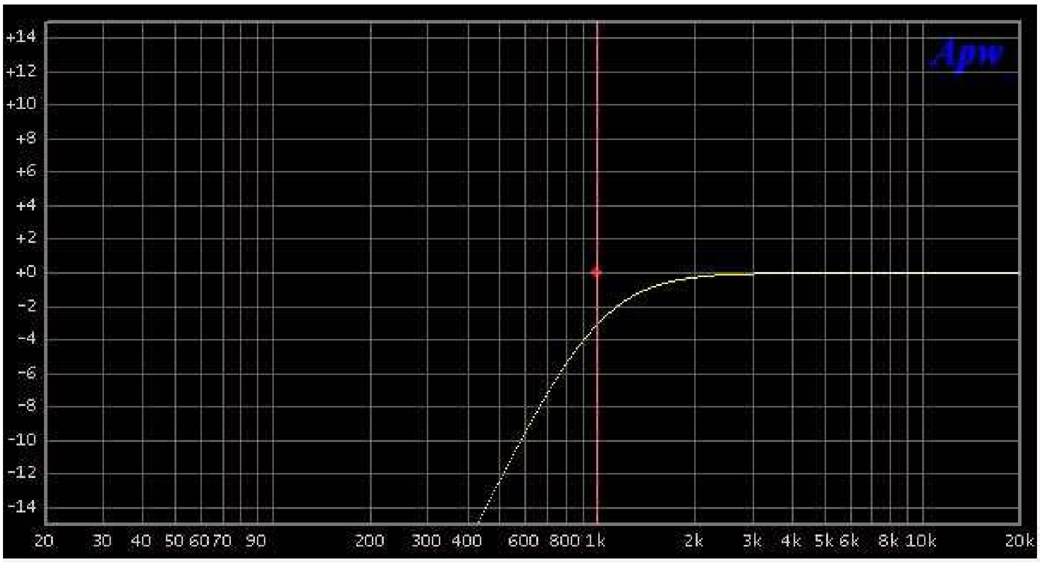
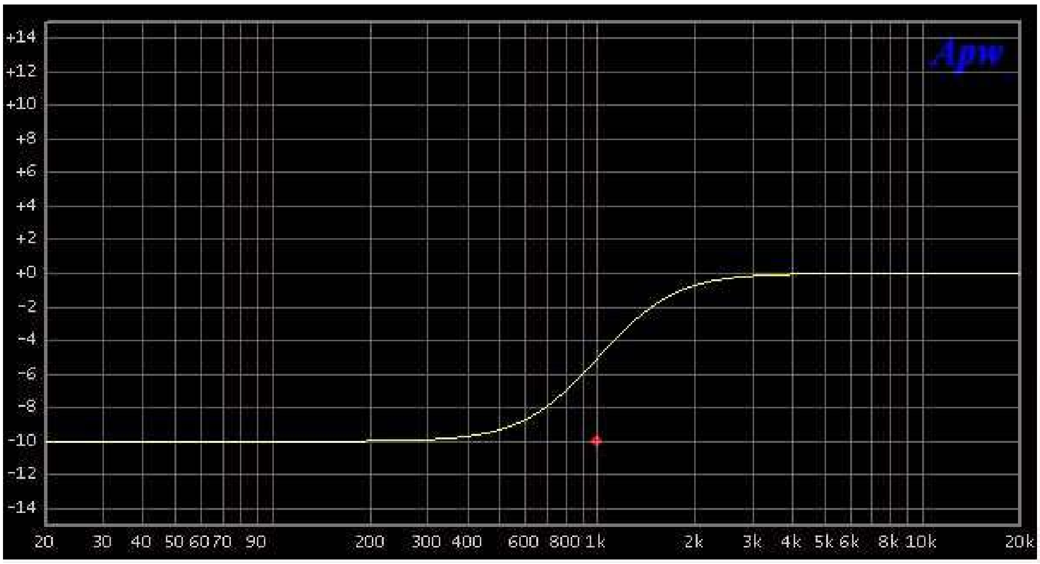
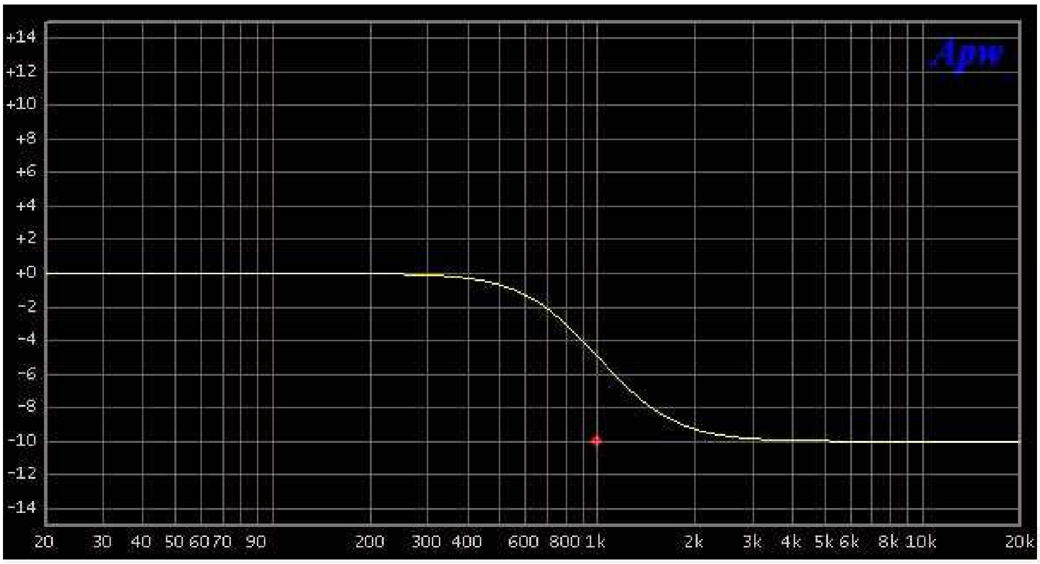


Figure 43. Low-shelf filter (gain -10 dB, freq 1 kHz, slope 1)



Note: As these filters are made to enhance or attenuate the low frequencies, the gain might be positive also. In any case, the gain of the high frequencies is always null.

Figure 44. High-shelf filter (gain -10 dB, freq 1 kHz, slope 1)



Note: As these filters are made to enhance or attenuate the high frequencies, the gain might be positive also. In any case, the gain of the low frequencies is always null.

Appendix B Audio processor configuration file

The following example of a device configuration file has extension .apc. Moving along the text, the registers bank, the coefficients bank and the filters bank, that together comprise the device configuration as described in the introduction of *Section 2.1: IntroductionSection 2: APW walkthrough*, can be easily identified.

```
####################################################
# Date:      Wednesday, 12/November/'08
# Interface: Simulation (NONE)
# Product:   STA339BWS
####################################################

################### FFX registers ###################

Reg[00h] = 63h ## Configuration Register A
Reg[01h] = 80h ## Configuration Register B
Reg[02h] = 97h ## Configuration Register C
Reg[03h] = 40h ## Configuration Register D
Reg[04h] = C2h ## Configuration Register E
Reg[05h] = 5Ch ## Configuration Register F
Reg[06h] = 10h ## Master Mute
Reg[07h] = FFh ## Master Volume
Reg[08h] = 60h ## Channel 1 Volume
Reg[09h] = 60h ## Channel 2 Volume
Reg[0Ah] = 60h ## Channel 3 Volume
Reg[0Bh] = 80h ## Audio Preset Register 1
Reg[0Ch] = 00h ## Audio Preset Register 2
Reg[0Dh] = 00h ## Reserved
Reg[0Eh] = 00h ## Channel 1 Config
Reg[0Fh] = 40h ## Channel 2 Config
Reg[10h] = 80h ## Channel 3 Config
Reg[11h] = 77h ## Bass and Treble Tone Control
Reg[12h] = 6Ah ## Limiter 1 Attack/Release Rate
Reg[13h] = 69h ## Limiter 1 Attack/Release Threshold
Reg[14h] = 6Ah ## Limiter 2 Attack/Release Rate
Reg[15h] = 69h ## Limiter 2 Attack/Release Threshold
Reg[16h] = 00h ## Coefficient Address Bits 5..0
Reg[17h] = 00h ## Coefficient b1 Data Bits 23..16
Reg[18h] = 00h ## Coefficient b1 Data Bits 15..8
Reg[19h] = 00h ## Coefficient b1 Data Bits 7..0
Reg[1Ah] = 00h ## Coefficient b2 Data Bits 23..16
Reg[1Bh] = 00h ## Coefficient b2 Data Bits 15..8
Reg[1Ch] = 00h ## Coefficient b2 Data Bits 7..0
Reg[1Dh] = 00h ## Coefficient a1 Data Bits 23..16
Reg[1Eh] = 00h ## Coefficient a1 Data Bits 15..8
Reg[1Fh] = 00h ## Coefficient a1 Data Bits 7..0
Reg[20h] = 00h ## Coefficient a2 Data Bits 23..16
Reg[21h] = 00h ## Coefficient a2 Data Bits 15..8
Reg[22h] = 00h ## Coefficient a2 Data Bits 7..0
Reg[23h] = 00h ## Coefficient b0 Data Bits 23..16
Reg[24h] = 00h ## Coefficient b0 Data Bits 15..8
Reg[25h] = 00h ## Coefficient b0 Data Bits 7..0
```

```
Reg[26h] = 00h ## Coefficient Write Control
Reg[27h] = 1Ah ## Max Power Correction Config Msb
Reg[28h] = C0h ## Max Power Correction Config Lsb
Reg[29h] = F3h ## Variable Distortion Compensation Msb
Reg[2Ah] = 33h ## Variable Distortion Compensation Lsb
Reg[2Bh] = 00h ## Fault Detect Recovery Bits Msb
Reg[2Ch] = 0Ch ## Fault Detect Recovery Bits Lsb
Reg[2Dh] = 7Fh ## Device Status
Reg[2Eh] = 00h ## Bist Activate
Reg[2Fh] = 00h ## Bist End
Reg[30h] = 00h ## Bist Bad
Reg[31h] = 00h ## EQ Coeff and DRC Configuration
Reg[32h] = 30h ## Limiter 1 Ext.Attack Threshold
Reg[33h] = 30h ## Limiter 1 Ext.Release Threshold
Reg[34h] = 30h ## Limiter 2 Ext.Attack Threshold
Reg[35h] = 30h ## Limiter 2 Ext.Release Threshold
Reg[36h] = 00h ## Extended Configuraton Register
Reg[37h] = 00h ## EQ Soft Volume Config (fade-in)
Reg[38h] = 00h ## EQ Soft Volume Config (fade-out)
Reg[39h] = 01h ## DRC RMS Filter Coefficient C0 Bits 25..16
Reg[3Ah] = EEh ## DRC RMS Filter Coefficient C0 Bits 15..8
Reg[3Bh] = FFh ## DRC RMS Filter Coefficient C0 Bits 7..0
Reg[3Ch] = 7Eh ## DRC RMS Filter Coefficient C1 Bits 25..16
Reg[3Dh] = C0h ## DRC RMS Filter Coefficient C1 Bits 15..8
Reg[3Eh] = 26h ## DRC RMS Filter Coefficient C1 Bits 7..0
Reg[3Fh] = 00h ## Reserved

################# FFX coefficients ##################

Coef[000h] = 000000h ## Coefficient 0x00 - C1H10 (b1/2)
Coef[001h] = 000000h ## Coefficient 0x01 - C1H11 (b2)
Coef[002h] = 000000h ## Coefficient 0x02 - C1H12 (a1/2)
Coef[003h] = 000000h ## Coefficient 0x03 - C1H13 (a2)
Coef[004h] = 400000h ## Coefficient 0x04 - C1H14 (b0/2)
Coef[005h] = 000000h ## Coefficient 0x05 - C1H20 (b1/2)
Coef[006h] = 000000h ## Coefficient 0x06 - C1H21 (b2)
Coef[007h] = 000000h ## Coefficient 0x07 - C1H22 (a1/2)
Coef[008h] = 000000h ## Coefficient 0x08 - C1H23 (a2)
Coef[009h] = 400000h ## Coefficient 0x09 - C1H24 (b0/2)
Coef[00Ah] = 000000h ## Coefficient 0x0A - C1H30 (b1/2)
Coef[00Bh] = 000000h ## Coefficient 0x0B - C1H31 (b2)
Coef[00Ch] = 000000h ## Coefficient 0x0C - C1H32 (a1/2)
Coef[00Dh] = 000000h ## Coefficient 0x0D - C1H33 (a2)
Coef[00Eh] = 400000h ## Coefficient 0x0E - C1H34 (b0/2)
Coef[00Fh] = 000000h ## Coefficient 0x0F - C1H40 (b1/2)
Coef[010h] = 000000h ## Coefficient 0x10 - C1H41 (b2)
Coef[011h] = 000000h ## Coefficient 0x11 - C1H42 (a1/2)
Coef[012h] = 000000h ## Coefficient 0x12 - C1H43 (a2)
Coef[013h] = 400000h ## Coefficient 0x13 - C1H44 (b0/2)
Coef[014h] = 000000h ## Coefficient 0x14 - C2H10 (b1/2)
Coef[015h] = 000000h ## Coefficient 0x15 - C2H11 (b2)
Coef[016h] = 000000h ## Coefficient 0x16 - C2H12 (a1/2)
Coef[017h] = 000000h ## Coefficient 0x17 - C2H13 (a2)
Coef[018h] = 400000h ## Coefficient 0x18 - C2H14 (b0/2)
Coef[019h] = 000000h ## Coefficient 0x19 - C2H20 (b1/2)
```

```
Coef[01Ah] = 000000h ## Coefficient 0x1A - C2H21 (b2)
Coef[01Bh] = 000000h ## Coefficient 0x1B - C2H22 (a1/2)
Coef[01Ch] = 000000h ## Coefficient 0x1C - C2H23 (a2)
Coef[01Dh] = 400000h ## Coefficient 0x1D - C2H24 (b0/2)
Coef[01Eh] = 000000h ## Coefficient 0x1E - C2H30 (b1/2)
Coef[01Fh] = 000000h ## Coefficient 0x1F - C2H31 (b2)
Coef[020h] = 000000h ## Coefficient 0x20 - C2H32 (a1/2)
Coef[021h] = 000000h ## Coefficient 0x21 - C2H33 (a2)
Coef[022h] = 400000h ## Coefficient 0x22 - C2H34 (b0/2)
Coef[023h] = 000000h ## Coefficient 0x23 - C2H40 (b1/2)
Coef[024h] = 000000h ## Coefficient 0x24 - C2H41 (b2)
Coef[025h] = 000000h ## Coefficient 0x25 - C2H42 (a1/2)
Coef[026h] = 000000h ## Coefficient 0x26 - C2H43 (a2)
Coef[027h] = 400000h ## Coefficient 0x27 - C2H44 (b0/2)
Coef[028h] = 000000h ## Coefficient 0x28 - C12H0 (b1/2)
Coef[029h] = 000000h ## Coefficient 0x29 - C12H1 (b2)
Coef[02Ah] = 000000h ## Coefficient 0x2A - C12H2 (a1/2)
Coef[02Bh] = 000000h ## Coefficient 0x2B - C12H3 (a2)
Coef[02Ch] = 400000h ## Coefficient 0x2C - C12H4 (b0/2)
Coef[02Dh] = 000000h ## Coefficient 0x2D - C3H0  (b1/2)
Coef[02Eh] = 000000h ## Coefficient 0x2E - C3H1  (b2)
Coef[02Fh] = 000000h ## Coefficient 0x2F - C3H2  (a1/2)
Coef[030h] = 000000h ## Coefficient 0x30 - C3H3  (a2)
Coef[031h] = 400000h ## Coefficient 0x31 - C3H4  (b0/2)
Coef[032h] = 7FFFFFh ## Coefficient 0x32 - Channel 1 Pre-scale
Coef[033h] = 7FFFFFh ## Coefficient 0x33 - Channel 2 Pre-scale
Coef[034h] = 7FFFFFh ## Coefficient 0x34 - Channel 1 Post-scale
Coef[035h] = 7FFFFFh ## Coefficient 0x35 - Channel 2 Post-scale
Coef[036h] = 7FFFFFh ## Coefficient 0x36 - Channel 3 Post-scale
Coef[037h] = 5A9DF7h ## Coefficient 0x37 - Twarn/Oc Limit
Coef[038h] = 7FFFFFh ## Coefficient 0x38 - Channel 1 Mix 1
Coef[039h] = 000000h ## Coefficient 0x39 - Channel 1 Mix 2
Coef[03Ah] = 000000h ## Coefficient 0x3A - Channel 2 Mix 1
Coef[03Bh] = 7FFFFFh ## Coefficient 0x3B - Channel 2 Mix 2
Coef[03Ch] = 400000h ## Coefficient 0x3C - Channel 3 Mix 1
Coef[03Dh] = 400000h ## Coefficient 0x3D - Channel 3 Mix 2
Coef[03Eh] = 000000h ## Reserved
Coef[03Fh] = 000000h ## Reserved

################### FFX filters ###################

Filt[Ch:0][00] = type:F gain:+0.000000 freq:01000 q:1.414000 ## BiQuad 0
Filt[Ch:0][01] = type:F gain:+0.000000 freq:01000 q:1.414000 ## BiQuad 1
Filt[Ch:0][02] = type:F gain:+0.000000 freq:01000 q:1.414000 ## BiQuad 2
Filt[Ch:0][03] = type:F gain:+0.000000 freq:01000 q:1.414000 ## BiQuad 3
Filt[Ch:0][04] = type:F gain:+0.000000 freq:01000 q:1.414000 ## BiQuad 4
Filt[Ch:0][05] = type:F gain:+0.000000 freq:01000 q:1.414000 ## BiQuad 5
Filt[Ch:0][06] = type:F gain:+0.000000 freq:01000 q:1.414000 ## BiQuad 6
Filt[Ch:0][07] = type:F gain:+0.000000 freq:01000 q:1.414000 ## BiQuad 7
Filt[Ch:1][00] = type:F gain:+0.000000 freq:01000 q:1.414000 ## BiQuad 0
Filt[Ch:1][01] = type:F gain:+0.000000 freq:01000 q:1.414000 ## BiQuad 1
Filt[Ch:1][02] = type:F gain:+0.000000 freq:01000 q:1.414000 ## BiQuad 2
Filt[Ch:1][03] = type:F gain:+0.000000 freq:01000 q:1.414000 ## BiQuad 3
Filt[Ch:1][04] = type:F gain:+0.000000 freq:01000 q:1.414000 ## BiQuad 4
Filt[Ch:1][05] = type:F gain:+0.000000 freq:01000 q:1.414000 ## BiQuad 5
Filt[Ch:1][06] = type:F gain:+0.000000 freq:01000 q:1.414000 ## BiQuad 6
Filt[Ch:1][07] = type:F gain:+0.000000 freq:01000 q:1.414000 ## BiQuad 7
```

Appendix C Script file

The following example of a script file has extension .aps.

```
####################################################
# Test script used to show available commands
# and their usage.
####################################################

# This is a comment line

# Note: all values are in hex but the SECTION
#       repeat counter.

####################################################
# List of available commands
####################################################

#    "RW"                  Register Write
#    "CW1"                 Coefficient write single (hex value)
#    "CW1F"                Coefficient write single (float value)
#    "CWA"                 Coefficient write all (5 coeffs. - hex values)
#    "CWAF"                Coefficient write all (5 coeffs. - float values)
#    "CR1"                 Coefficient read single
#    "CRA"                 Coefficient read all (5)
#    "CCMP1"               Coefficient compare single
#    "CCMPA"               Coefficient compare all (5)
#    "P"                   Pause
#    "SECTION_BEGIN"       Section begin marker (then repeat)
#    "SECTION_END"         Section end marker
#    "RESET"               Device reset (high->low->high cycle)
#    "SET_RST"             Set RESET line

# NOTE: The CWA/CWAF commands make use of the multi-write coeffs.
#       capability only if the coeff. start index is aligned with
#       a bi-quadratic starting address. Single-write operation is
#       used otherwise. In any case coeffienct order on the command line
#       is the same as per the relevant device RAM mapping.
#       For instance:
#        >> in case of STA321: CWA <index> <B0/2> <B1/2> <B2> <-A2> <-A1/2>
#        >> in case of STA33x: CWA <index> <B1/2> <B2> <-A1/2> <-A2> <B0/2>
```

```
RESET                                # reset the device
P 125                                # pause 125 ms

SET_RST 0                            # set RESET line at 0 (low_level)
P 200                                # pause 200 ms
SET_RST 1                            # set RESET line at 1 (high_level)
P 200                                # pause 200 ms

RW    01 23                          # write value 23h in reg. 01h
CW1   002 123456                     # write value 123456h in coeff. 02h
CR1   002                            # read coeff. 02h
CW1F  003 0.500                      # coefficient single write with float value
CW1F  004 -1.00                      # coefficient single write with float value
CW1F  005 1.00                       # coefficient single write with float value
CWAF  000 1.0 -1.0 0.033 -0.5 0.5    # coefficient multi-write with float values

SECTION_BEGIN 100

RR  0A
RW 0A CC
RCMP 0A CC

CWA   005 ABCDEF 123456 6789AB 315683 987654
CWA   00A ABCDEF 123456 6789AB 315683 987654

CCMPA  005 ABCDEF 123456 6789AB 315683 987654
CCMPA  00A ABCDEF 123456 6789AB 315683 987654

CWA   005 347267 ABEFCD 937583 AFEBCD 268439
CWA   00A 347267 ABEFCD 937583 AFEBCD 268439

CCMPA 000 347267 ABEFCD 937583 AFEBCD 268439
CCMPA 005 347267 ABEFCD 937583 AFEBCD 268439

SECTION_END

CWA   005 347267 ABEFCD 937583 AFEBCD 268439
CWA   00A 347267 ABEFCD 937583 AFEBCD 268439

#RESET
```

Appendix D Filter import wizard

A complete description of the LinearX LEAP© suite file import procedure is as follows:

1. Press the *File* menu and select the *Filter import wizard*
2. Press the *Browse* button and select the file to import
3. Check the outcome of the filter analysis, three cases are possible:
   a) All coefficients are in range (*Figure 45*). In this case the auto-scaler feature is not required and the filters can be imported without hesitation. However, the user is given the option to apply a user-definable attenuation.
   b) One or more coefficients exceeds the allowable range, the scaling is possible and the required attenuation can be compensated (*Figure 46*). In this case the auto-scaler feature is recommended. Choose between the automatic gain (to preserve the overall frequency response), or the manual gain (to preserve its envelope, but not the gain). The auto-scaler can be disabled as well. Under these circumstances the invalid filters are skipped and the overall frequency response is unpredictable.
   c) One or more coefficients exceeds the allowable range, the scaling is possible but the attenuation required cannot be compensated (*Figure 47*). In this case the auto-scaler feature is recommended. Choose between the automatic gain (to minimize the gain mismatch between the desired overall frequency response and the actual response and to preserve the response envelope), or the manual gain (to preserve the envelope, but not minimize the gain mismatch). The auto-scaler can be disabled as well. Under these circumstances the invalid filters are skipped and the overall frequency response is unpredictable.

In the case of processing frequency mismatch (*Figure 48*), use the LinearX LEAP© suite to recompute the coefficients at a sampling frequency supported by the device in use, then repeat the analysis with the new coefficients.

Figure 45. Filter import wizard, all coefficients in range

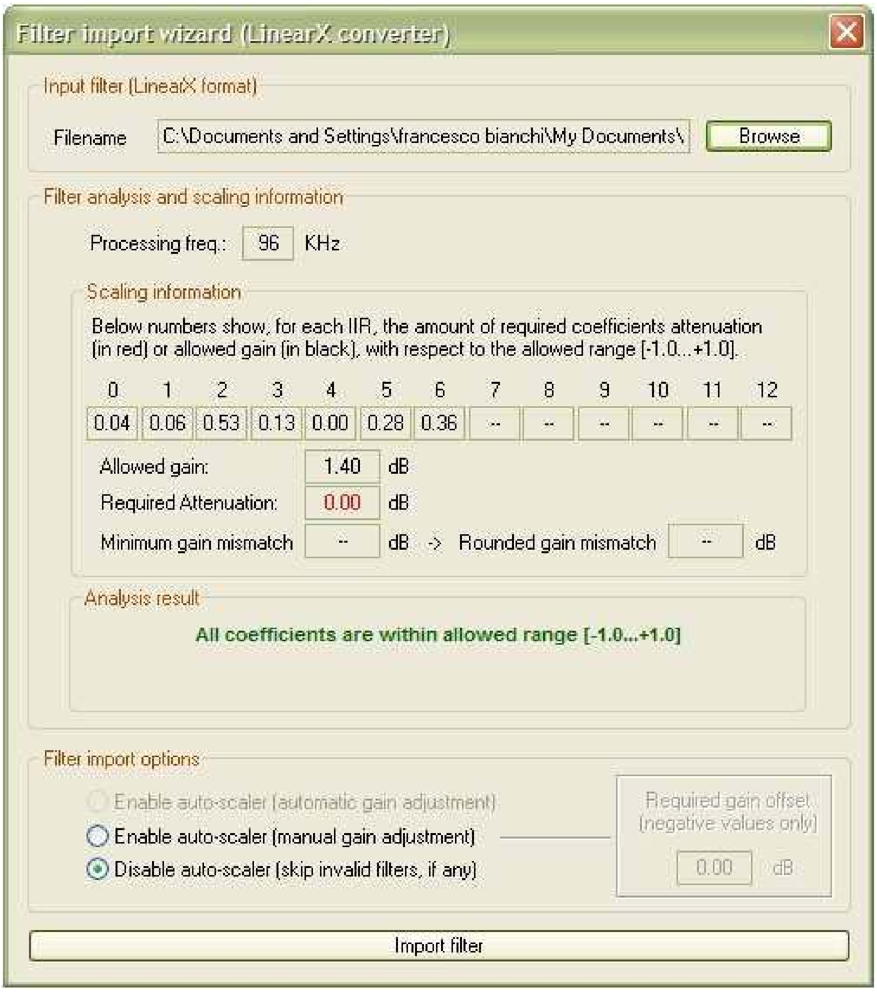
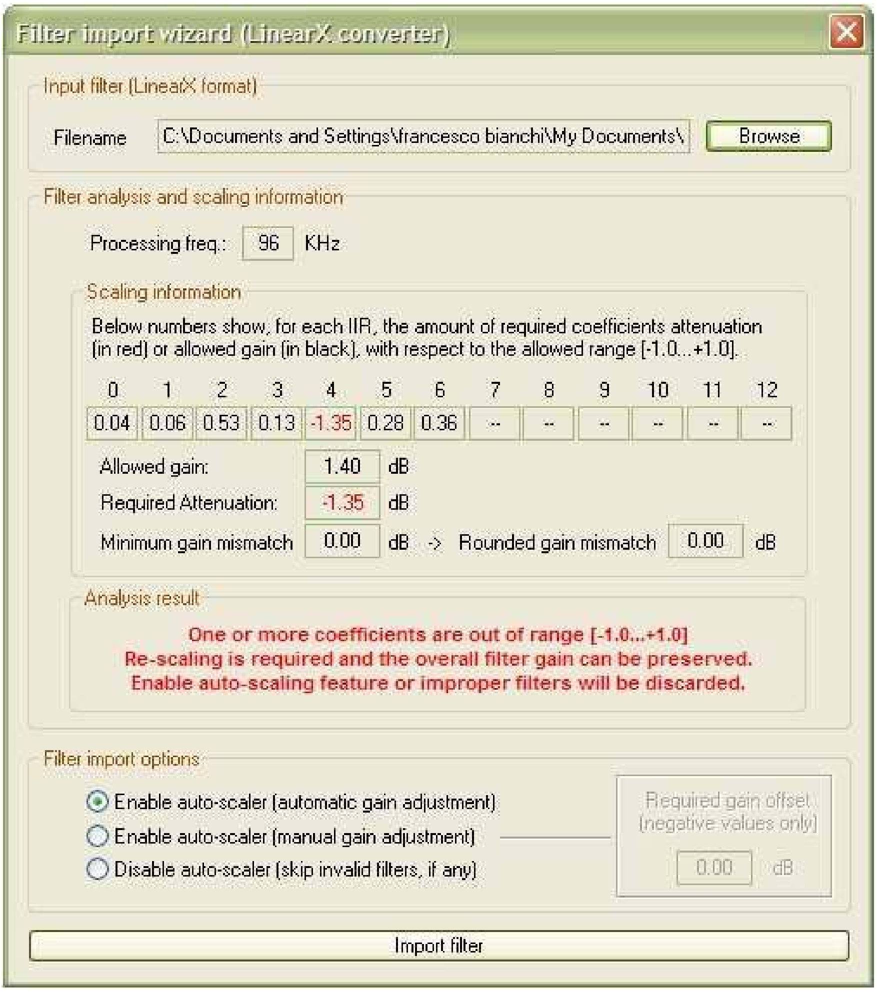


Figure 46. Filter import wizard, adjustable attenuation (one coefficient out of range)



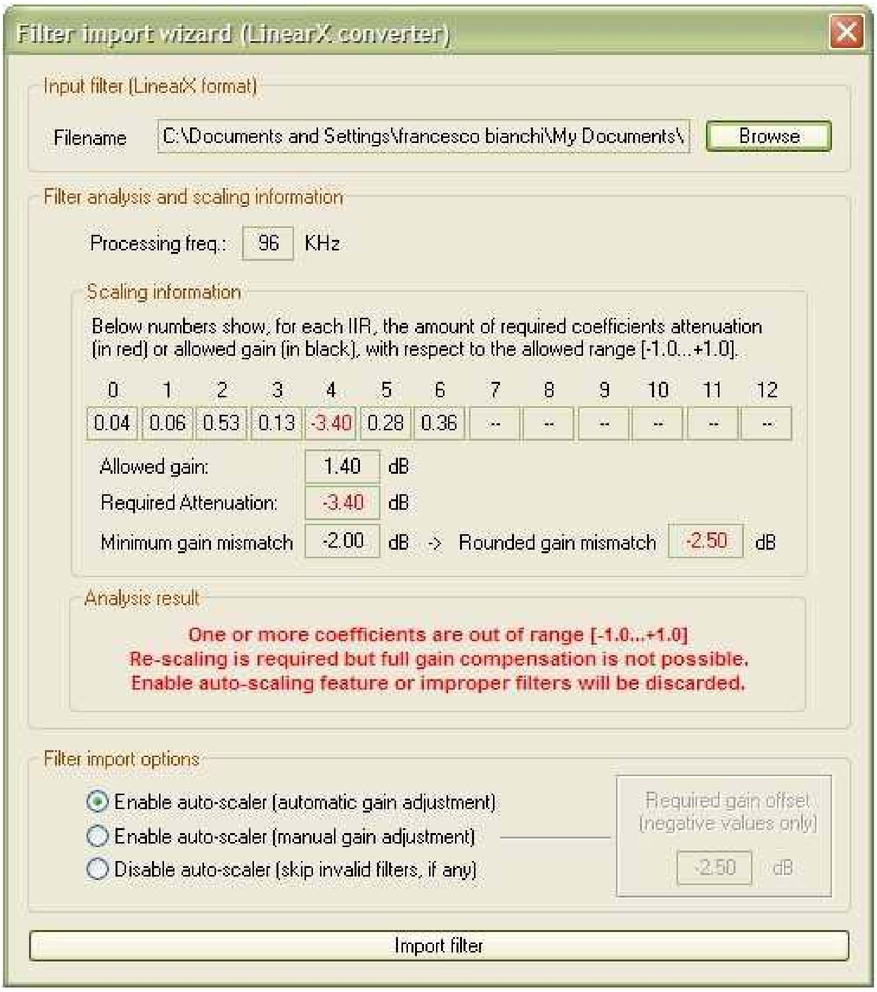
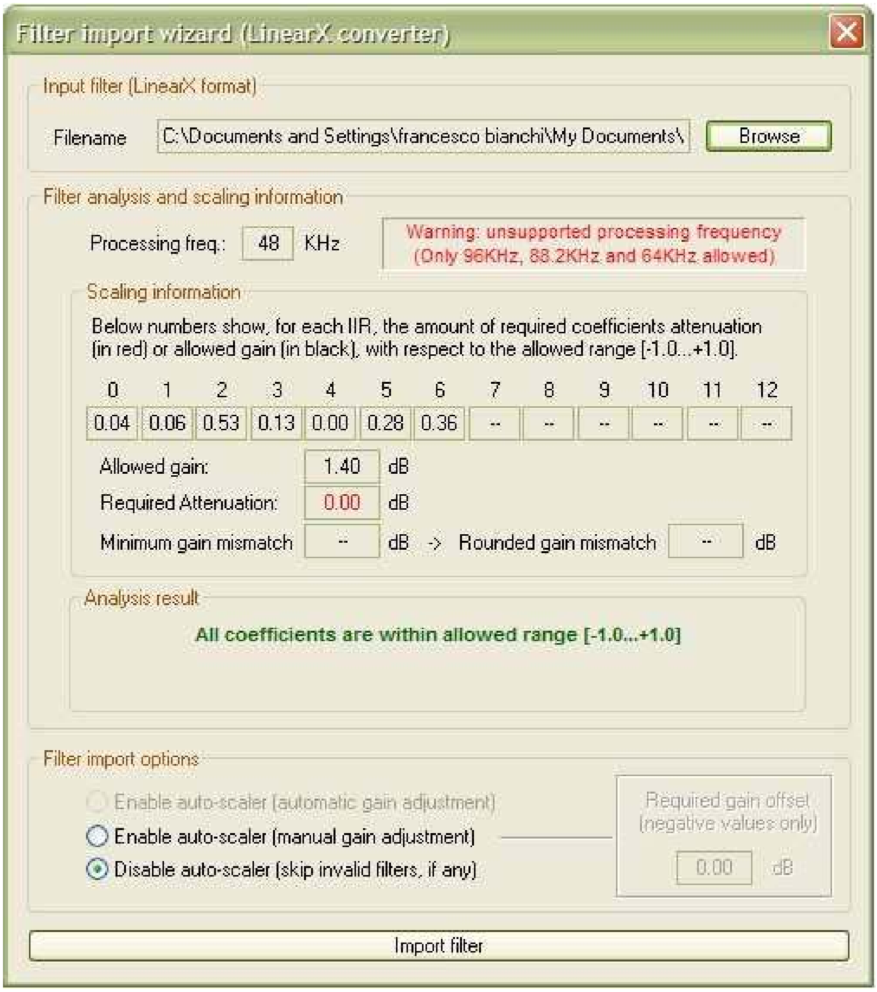


Figure 47. Filter import wizard, gain not adjustable (one coefficient out of range)

Figure 48. Filter import wizard, wrong processing frequency



Appendix E Exporting coefficients

The following two examples of the available formats are respectively the C/C++ arrays and the Matlab® arrays. In the C/C++ syntax example, the stability information shows the magnitude of the filter poles and is provided to avoid exporting unstable filters with unpredictable behaviors.

```
Speaker_EQ_Table_48000[] = {

{0x00,0x809120},{0x01,0x7EE0FE},{0x02,0x7F6EE0},{0x03,0x8118C8},{0x04,0x4045D5},
// 48KFs, Biquad1, Address: 0x00~0x04 (stability: 0.995706)

{0x05,0x80D639},{0x06,0x7F2974},{0x07,0x7F28A8},{0x08,0x80F10F},{0x09,0x3F95F0},
// 48KFs, Biquad2, Address: 0x05~0x09 (stability: 0.996315)

{0x0A,0x8786A9},{0x0B,0x77CE73},{0x0C,0x787957},{0x0D,0x8A9AF7},{0x0E,0x412486},
// 48KFs, Biquad3, Address: 0x0A~0x0E (stability: 0.957677)

{0x0F,0x81EFC8},{0x10,0x7BD84F},{0x11,0x7E1038},{0x12,0x83ADC1},{0x13,0x403CEF},
// 48KFs, Biquad4, Address: 0x0F~0x13 (stability: 0.985525)

{0x14,0x8005C8},{0x15,0x6EF977},{0x16,0x4FEB18},{0x17,0xBA3B90},{0x18,0x58B9B3},
// 48KFs, Biquad5, Address: 0x14~0x18 (stability: 0.738280)

{0x19,0x841969},{0x1A,0x785560},{0x1B,0x7BE697},{0x1C,0x8825A7},{0x1D,0x403D7B},
// 48KFs, Biquad6, Address: 0x19~0x1D (stability: 0.992950)

{0x1E,0x8533B0},{0x1F,0x75AB4A},{0x20,0x7ACC50},{0x21,0x881BD5},{0x22,0x3F8A7B}
// 48KFs, Biquad7, Address: 0x1E~0x22 (stability: 0.967807)

};
```

```
% -------------------------------------------------
% Coefficient array for 96 KHz processing frequency
% Creation date:        Wednesday, 04/March/'09
% Selected product:     STA339BWS
% Note: only channel 0 is exported
% -------------------------------------------------

% Biquad 00
FILT00_B = [1.004262 -1.991142 0.991241];
FILT00_A = [1.000000 -1.991142 0.991431];
FILT00_B0 = 1.004262;        % Hex: 4045D5h       Address: 04h
FILT00_B1 = -1.991142;       % Hex: 809120h       Address: 00h
FILT00_B2 = 0.991241;        % Hex: 7EE0FEh       Address: 01h
FILT00_A0 = 1.000000;        % Hex: 7FFFFFh       Address: ----
FILT00_A1 = -1.991142;       % Hex: 7F6EE0h       Address: 02h
FILT00_A2 = 0.991431;        % Hex: 8118C8h       Address: 03h

% Biquad 01
FILT01_B = [0.993526 -1.986925 0.993453];
FILT01_A = [1.000000 -1.986856 0.992643];
FILT01_B0 = 0.993526;        % Hex: 3F95F0h       Address: 09h
FILT01_B1 = -1.986925;       % Hex: 80D639h       Address: 05h
FILT01_B2 = 0.993453;        % Hex: 7F2974h       Address: 06h
FILT01_A0 = 1.000000;        % Hex: 7FFFFFh       Address: ----
FILT01_A1 = -1.986856;       % Hex: 7F28A8h       Address: 07h
FILT01_A2 = 0.992643;        % Hex: 80F10Fh       Address: 08h

% Biquad 02
FILT02_B = [1.017854 -1.882406 0.935988];
FILT02_A = [1.000000 -1.882406 0.917146];
FILT02_B0 = 1.017854;        % Hex: 412486h       Address: 0Eh
FILT02_B1 = -1.882406;       % Hex: 8786A9h       Address: 0Ah
FILT02_B2 = 0.935988;        % Hex: 77CE73h       Address: 0Bh
FILT02_A0 = 1.000000;        % Hex: 7FFFFFh       Address: ----
FILT02_A1 = -1.882406;       % Hex: 787957h       Address: 0Ch
FILT02_A2 = 0.917146;        % Hex: 8A9AF7h       Address: 0Dh

% Biquad 03
FILT03_B = [1.003719 -1.969740 0.967539];
FILT03_A = [1.000000 -1.969740 0.971260];
FILT03_B0 = 1.003719;        % Hex: 403CEFh       Address: 13h
FILT03_B1 = -1.969740;       % Hex: 81EFC8h       Address: 0Fh
FILT03_B2 = 0.967539;        % Hex: 7BD84Fh       Address: 10h
FILT03_A0 = 1.000000;        % Hex: 7FFFFFh       Address: ----
FILT03_A1 = -1.969740;       % Hex: 7E1038h       Address: 11h
FILT03_A2 = 0.971260;        % Hex: 83ADC1h       Address: 12h
```

```
% Biquad 04
FILT04_B = [1.386334 -1.999647 0.866988];
FILT04_A = [1.000000 -1.248724 0.545057];
FILT04_B0 = 1.386334;       % Hex: 58B9B3h     Address: 18h
FILT04_B1 = -1.999647;      % Hex: 8005C8h     Address: 14h
FILT04_B2 = 0.866988;       % Hex: 6EF977h     Address: 15h
FILT04_A0 = 1.000000;       % Hex: 7FFFFFh     Address: ----
FILT04_A1 = -1.248724;      % Hex: 4FEB18h     Address: 16h
FILT04_A2 = 0.545057;       % Hex: BA3B90h     Address: 17h

% Biquad 05
FILT05_B = [1.003752 -1.935949 0.940105];
FILT05_A = [1.000000 -1.935949 0.936351];
FILT05_B0 = 1.003752;       % Hex: 403D7Bh     Address: 1Dh
FILT05_B1 = -1.935949       % Hex: 841969h     Address: 19h
FILT05_B2 = 0.940105;       % Hex: 785560h     Address: 1Ah
FILT05_A0 = 1.000000;       % Hex: 7FFFFFh     Address: ----
FILT05_A1 = -1.935949;      % Hex: 7BE697h     Address: 1Bh
FILT05_A2 = 0.936351        % Hex: 8825A7h     Address: 1Ch

% Biquad 06
FILT06_B = [0.992827 -1.918720 0.919290];
FILT06_A = [1.000000 -1.918720 0.936651];
FILT06_B0 = 0.992827;       % Hex: 3F8A7Bh     Address: 22h
FILT06_B1 = -1.918720;      % Hex: 8533B0h     Address: 1Eh
FILT06_B2 = 0.919290;       % Hex: 75AB4Ah     Address: 1Fh
FILT06_A0 = 1.000000;       % Hex: 7FFFFFh     Address: ----
FILT06_A1 = -1.918720       % Hex: 7ACC50h     Address: 20h
FILT06_A2 = 0.936651;       % Hex: 881BD5h     Address: 21h

% Biquad 07
FILT07_B = [1.000000 0.000000 0.000000];
FILT07_A = [1.000000 0.000000 0.000000];
FILT07_B0 = 1.000000;       % Hex: 400000h     Address: 2Ch
FILT07_B1 = 0.000000;       % Hex: 000000h     Address: 28h
FILT07_B2 = 0.000000;       % Hex: 000000h     Address: 29h
FILT07_A0 = 1.000000;       % Hex: 7FFFFFh     Address: ----
FILT07_A1 = 0.000000;       % Hex: 000000h     Address: 2Ah
FILT07_A2 = 0.000000;       % Hex: 000000h     Address: 2Bh
```

Appendix F Shortcuts quick reference

The following table lists the key shortcuts implemented in the APW.

Table 1. Shortcut table

Key combination	Feature
Ctrl+N	New configuration file
Ctrl+L	Load configuration file
Ctrl+S	Save configuration file
Ctrl+R	Run script
Ctrl+A	Run again last script
Ctrl+F	Filter import wizard
Shift+1...8	Save memory preset
Ctrl+1...8	Load memory preset
F2	Log viewer
F3	Command shell
F4	APWLink settings
Ctrl+T	Transparent mode enable/disable
Ctrl+Q	Increase transparency
Ctrl+W	Decrease transparency

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5 Revision history

Table 2. Document revision history

Date	Revision	Changes
22-Jun-2012	1	Initial release.