USER MANUAL
FREEDSP-AURORA

REVISION HISTORY

Revision	Description	Date
v1.0	Initial Version	01 Jul 2019

ABOUT FREEDSP-AURORA

The freeDSP-aurora is a cost-effective real-time audio signal processing solution for researchers and the do-it-yourself community and audio enthusiasts. It is a bare circuit board that can be incorporated into your own projects. It comes with no housing. Easy assembling and simple programmability are the main focus. It is based on Analog Devices' ADAU1452 DSP chip in bundle with the free graphical application auverdionControl.
Additionally the development environment SigmaStudio can be used. The programming model of SigmaStudio is function-block based – comparable to other graphical programming languages like PureData or Max/MSP. Many prebuilt blocks (e.g., filters, compressors, effects, or logic) can be placed in the signal path via drag and drop. If the included libraries do not have the functions needed, low-level blocks, such as multipliers and delays, can be wired together to create custom DSP plugins. For more information please refer to the Analog Devices website (https://www.analog.com/en/design-center/evaluation-hardware-and-software/software/ss_sigst_02.html#software-overview).

FreeDSP-aurora offers a wide range of DSP processing options and interface controls with easy programmability. It can be used in various audio applications, e.g.:

Room compensation / system equalization
Digital crossovers in active loudspeaker concepts
Multiband dynamics processing
Delay compensation / phase shift
Bass enhancement
Subwoofer integration
Advanced instrument audio effect units
Stereo image widening
…

A XMOS XE216-512-TQ128 MCU is used to expose an USB Audio Class 2 compliant interface to a host computer running macOS, Linux or Windows 10. The boards provides 8 balanced audio input and 8 balanced audio output channels. Additionally an ADAT input/output and a Wordclock input/output is provided by the XMOS MCU.

The ESP32 MCU controls the operation of the DSP. Furthermore, it provides WiFi and Bluetooth connectivity and handles peripherals like rotary encoder, display, temperature sensor, PWM controlled fan and IR sensor.

As part of the project the open source software auverdionControl is published that controls the operation of the freeDSP-aurora from macOS, Windows or iOS. Via the control software the user can access all parameters of the uploaded DSP plugin. Due to the open source licenses users can modify the control software for supporting their own DSP plugins.

IMPORTANT INFORMATION

The freeDSP-aurora board might generate signals that may damage your audio equipment. Please read and understand this manual before starting to work with your board. Adjust all hardware settings and configure your software before connecting any audio equipment to freeDSP-aurora. Always start with low volume on your amplifier and slowly increase the level to reduce the risk of damaging your audio system.

freeDSP-aurora is provided to you 'as is'. Auverdion makes no express or implied warranties whatsoever with respect to its functionality, operability, or use, including, without limitation, any implied warranties of merchantability, fitness for a particular purpose, or infringement. We expressly disclaim any liability whatsoever for any direct, indirect, consequential, incidental or special damages, including, without limitation, lost revenues, lost profits, losses resulting from business interruption or loss of data regardless of the form of action or legal theory under which the liability may be asserted, even if advised of the possibility or likelihood of such damages. Features and specifications might change without prior notice.

Please keep in mind that freeDSP-aurora is an open-source project. Because freeDSP-aurora is very flexible, many applications are possible. Questions and new ideas can be discussed online with other DIYers. Please use the *Digital Line Level* subforum @ diyAudio.com or the *Elektronik* subforum @ www.diy-hifi-forum.eu[1] to connect with other people working with freeDSP-aurora. Please create individual threads for your topics only if you cannot find your issue in the existing threads. Some questions can be answered by carefully reading this manual.

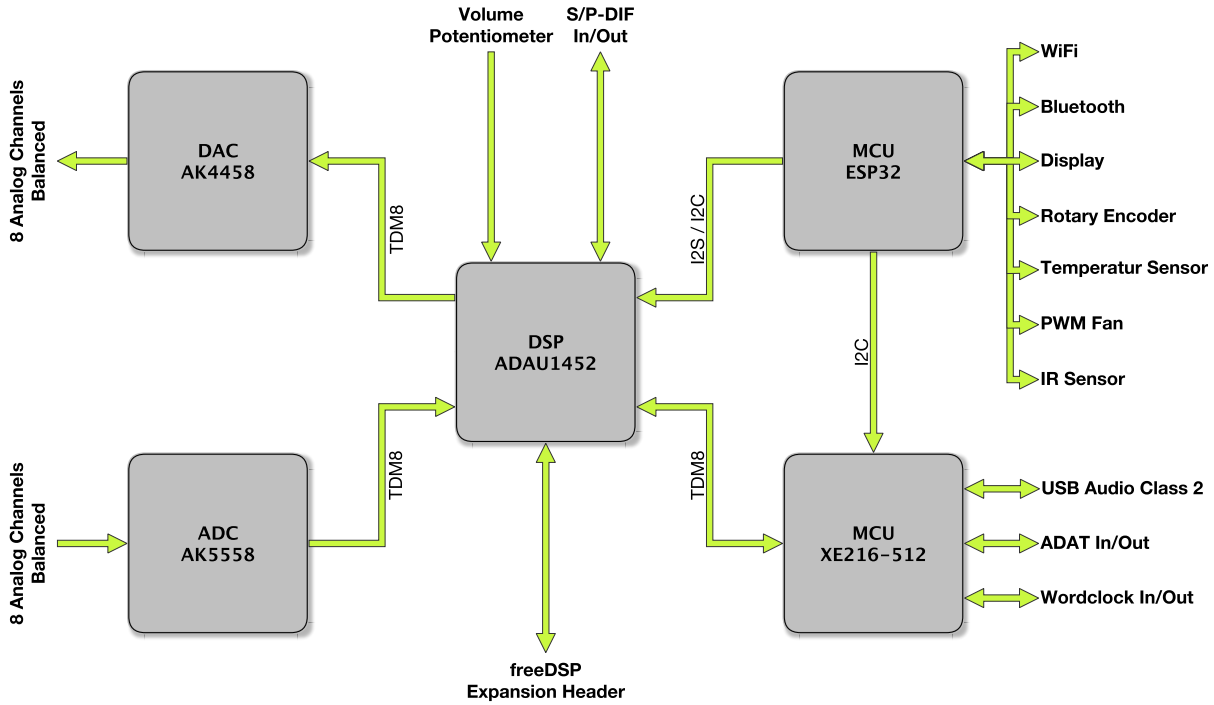
[1] Please see chapter Useful Web Links

FEATURES

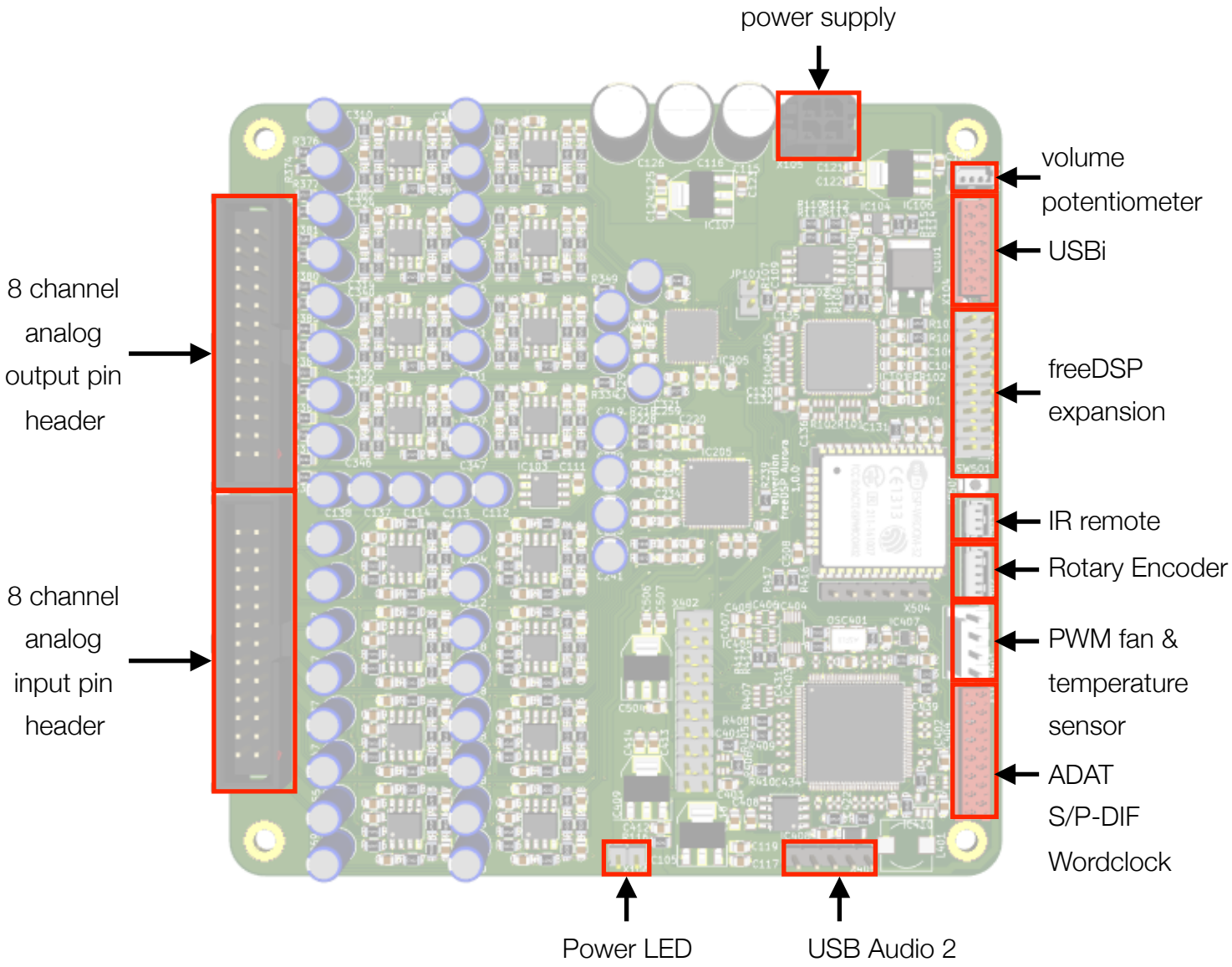
- Analog Devices ADAU1452, 294.912 MHz, 32-bit SigmaDSP
  - 6144 SIMD instructions per sample @ 48 kHz fs
  - 40kWords of data RAM
  - 800 ms digital audio delay pool @ 48 kHz fs
  - 8 stereo ASRCs with 139 dB DNR
- XMOS XE216-512-TQ128 for multichannel bidirectional audio streaming
- ESP32 for WiFi or Bluetooth control
- AKM AK4458 32bit-DAC
- AKM AK5558 32bit-ADC
- Supporting sample rates between 44.1 kHz and 192 kHz
- 8 analog balanced input channels, +6 dBu
- 8 analog balanced output channels, +6 dBu
- S/P-DIF input and output
- ADAT input and output
- Wordclock input and output
- Support for display, rotary encoder, volume potentiometer, temperature sensor, PWM controlled fan, IR sensor
- One freeDSP expansion header
- USB Audio Class 2 Bidirectional streaming with 8 channels in and 8 channels out, full-duplex. Works with ASIO driver under Windows 10 and driverless under macOS and Linux.
- Realtime control software for Windows, macOS, iOS; all available under an open source license.
- Connection to board by WiFi
- Board dimensions: 110 mm x 110 mm

SYSTEM INFORMATION

BLOCK DIAGRAM



CONNECTORS


power supply
volume potentiometer
USBi
freeDSP expansion
IR remote
Rotary Encoder
PWM fan & temperature sensor
ADAT
S/P-DIF
Wordclock
8 channel analog output pin header
8 channel analog input pin header
Power LED
USB Audio 2

RECOMMENDED OPERATING CONDITIONS

Item	Min	Typ	Max	Unit	Notes
Supply Voltage	6.5	7	12	Vdc	
Input Level		6		dBu	Might be changed by AddOn
Output Level		6		dBu	Might be changed by AddOn

Note: Stresses beyond those listed in the table above may cause permanent damage to the device.

FreeDSP-aurora has to be placed in an enclosure with enough airflow. Please mount the PCB with spacers on a solid surface. None of the four mounting holes is connected to any voltage or signal on the board.

OPTIONAL INPUT AND OUTPUT ADDONS

FreeDSP-aurora was designed to support as many applications as possible. Therefore, all inputs and outputs are on pin headers or ribbon cable connectors. This way user can adapt the front-ends to their needs. Some add-on boards will be available for this project. These boards will cover the most common used input output configurations, e.g. active multi-way loudspeaker or an 8 channel loudspeaker management or buttons and displays for user interaction. Please check the github repository and/or the website for information about the add-on boards.

HOW TO GET FREEDSP-AURORA UP AND RUNNING

HARDWARE INSTALLATION

Before you can use freeDSP-aurora you may have to do some hardware connections. The connections vary with desired application. Not all connections are always needed.

Analog Audio Connections

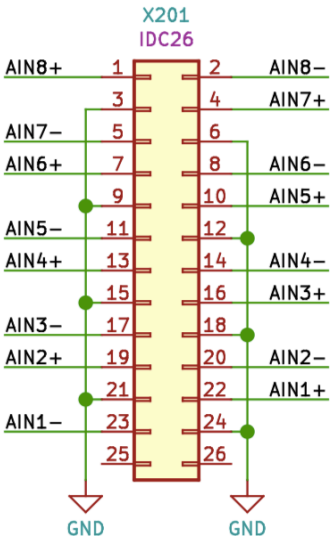
Analog audio input connections can be made on pin header X201. The audio inputs are designed for balanced operation at +6 dBu maximum input level. Unbalanced sources can be connected as well by grounding the negative input. In the latter case you may have to change the gain of the input stage to improve the signal to noise ratio. Alternatively you may want to use a conversion circuit if your audio sources use a different connection (e.g unbalanced) or have another level.

Analog audio output connections can be made on pin header X301. The audio outputs are designed for balanced operation at +6 dBu maximum output level. In case of unbalanced sinks leave the negative output unconnected. In the latter case you may have to change the gain of the output stage to improve the signal to noise ratio. Alternatively you may want to use a conversion circuit if your audio sinks use a different connection (e.g. unbalanced) or have another level.

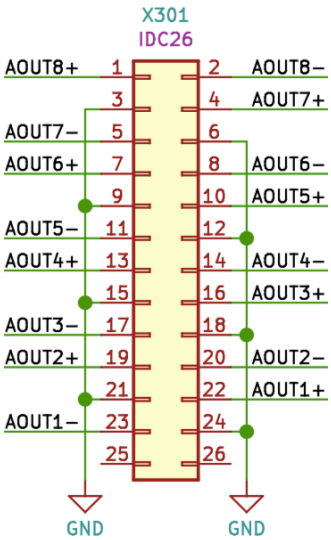
When making audio connections, make sure that your equipment is powered off to avoid any damage.

The gain of the analog audio input and output stage can only be changed by changing the resistors on the board to another value.

Connector: IDC26, 2.54 mm Pitch, Bud Industries, BC-32677



Pinout Analog Input

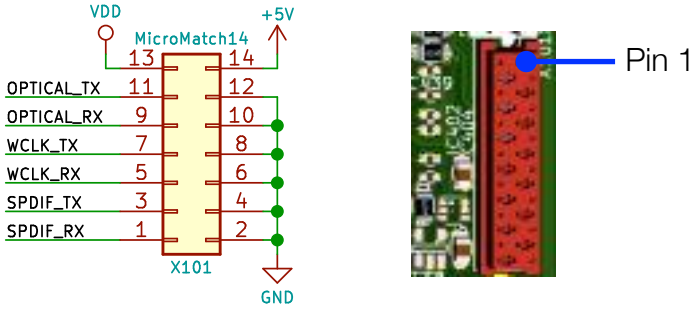


Pinout Analog Output

Digital Audio Connections

On connector X101 you can make your digital audio connections like S/P-DIF input and output and ADAT input and output. Wordclock input and output can be connected to X101, too.

Connector: MicroMatch-14, 2.54 mm pitch, TE Connectivity AMP Connectors, 1-215079-4

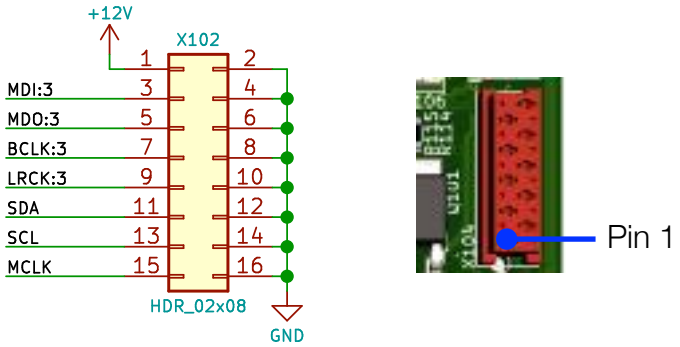


Pinout Digital Audio Connections

FreeDSP Expansion Header

X102 is the an expansion header for additional input and output boards. The pinout complies with the I2S expansion header specification of the freeDSP project. If you want to connect a I2C display please connect it to this header, too.

Connector: Header 2 x 8 pos, 2.54 mm pitch, Sullins Connector Solutions, PRPC008DAAN-RC



Pinout freeDSP Expansion Header

Fan and Temperature Sensor

On connector X501 you can connect a PWM controlled fan. Please use the Sense pin to connect a temperature sensor (e.g. NTC).

Connector: KK-100, 4 pos, 2.54 mm pitch, Molex, 0022232041

Pinout Fan and Temperature Sensor

Rotary Encoder

On connector X502 you can connect a rotary encoder with or without a push button.

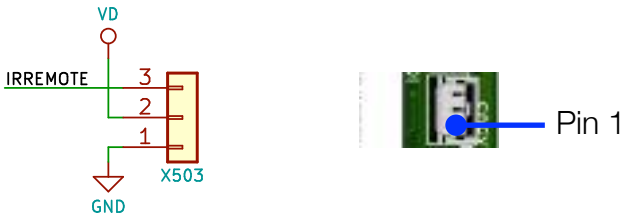
Connector: PicoBlade, 5 pos, 1.25 mm pitch, Molex, 530470510

Pinout Rotary Encoder

IR Sensor

On connector X503 you can connect an infra red receiving diode.

Connector: PicoBlade, 3 pos,1.25 mm pitch, Molex, 530470310

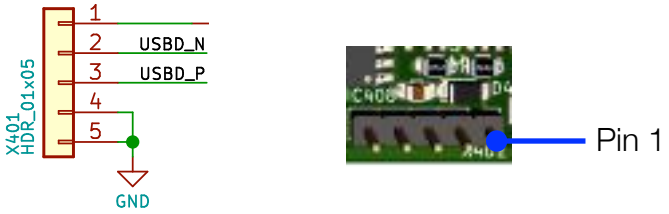


Pinout IR Sensor

USB Connection

Your host computer connects on the pin header X401. Please use a common off-the-shelf cable assemblies (typically used in computer hardware). Always confirm the pin-out with the manufacturer, or you could easily cause damage to your computer or freeDSP-aurora. Usually the GND-pins 4 and 5 can be identified by a black wire, but you can never be sure unless you checked the manufacturer's specifications of the connector.

Connector: Header, 5 pos, 2.54 mm pitch, Sullins Connector Solutions, PRPC005SAAN-RC

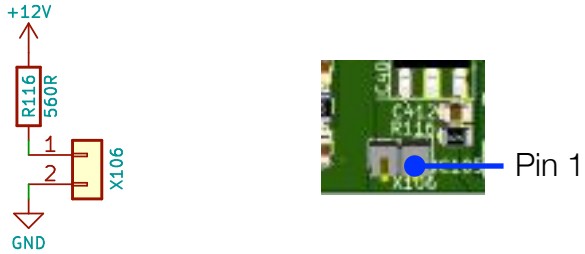


Pinout USB Connection

Power LED

On this connector you can connect a LED to show the power on/off status.

Connector: Header, 2 pos, 2.54 mm pitch, Wurth Electronics Inc., 61300211121



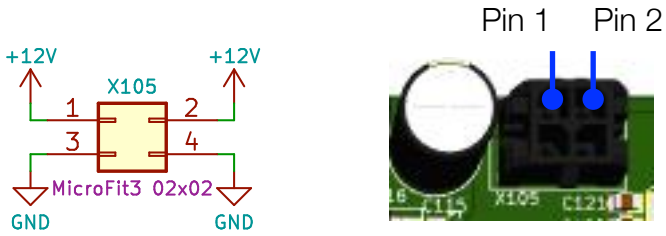
Pinout Power LED

Power Supply

freeDSP-aurora needs a power supply on X105. Together with the board you received a power cable. The white wires identify the positive voltage, the black wires are GND.

Attention: Apply power to the board only after all connections have been made and you have double-checked everything.

Connector: MicroFit, 2 x 2 pos, 3 mm pitch, Molex, 0430450428



Pinout Power Supply

SOFTWARE INSTALLATION

USB Driver Installation

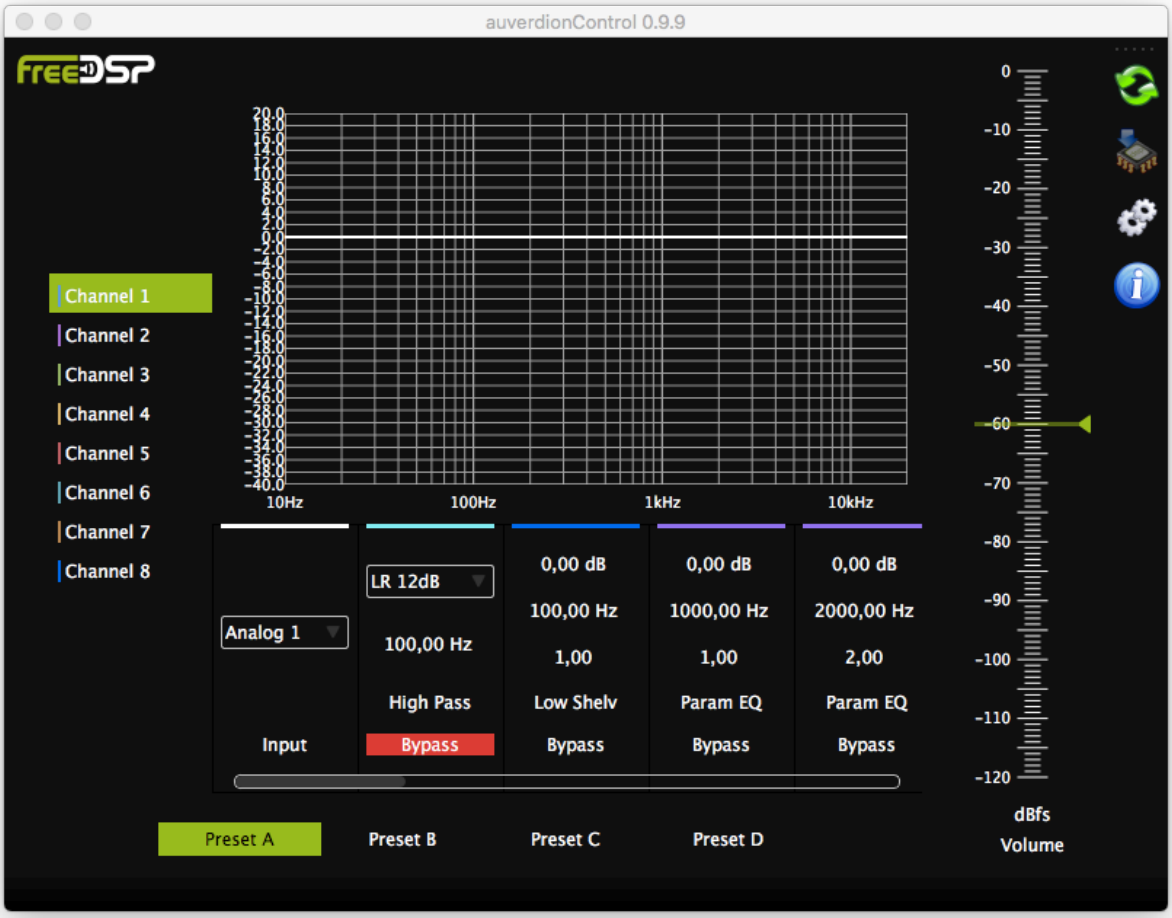
FreeDSP-aurora was designed to be class compliant with UAC2. Thus, on macOS and Linux you don't need to install any driver. Windows 10 comes with a UAC2 driver as well but you may have to install additional stuff like the free software asio4all and your audio software needs to support ASIO. Please note, that ASIO is only needed if you want to use the 8 input channels for recording audio. If you just want to use freeDSP-aurora to stream audio data to your audio equipment, ASIO is not needed and you can skip the asio4all installation.

Installation of auverdionControl

Please download the latest version of auverdionControl for your operating system from here
https://github.com/freeDSP/freeDSP-aurora/releases
and follow the instructions of the installer.

WORKING WITH AUVERDIONCONTROL

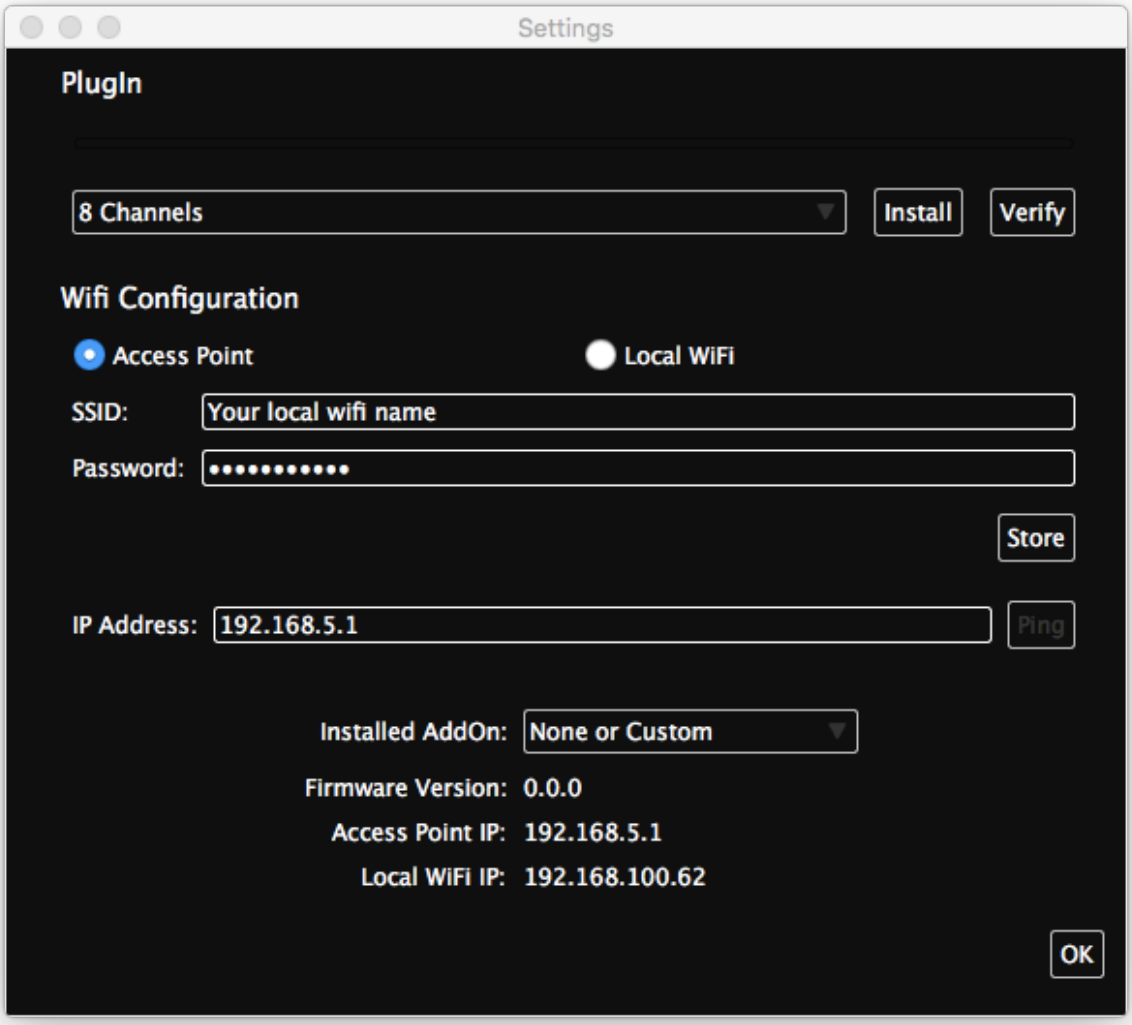
As part of the project the open source software auverdionControl is published that controls the operation of the freeDSP-aurora. With auverdionControl you can configure and control the operation of your freeDSP-aurora and upload new DSP plugins to it. AuverdionControl communicates via WiFi with freeDSP-aurora.



WIFI CONFIGURATION

When you power up freeDSP-aurora for the first time or after updating the ESP32 firmware you can connect with your board only by an ad-hoc wifi connection. Therefore, the access point *AP-freeDSP-aurora* is provided by the board. Please refer to the documentation of your operating system for how to establish an ad-hoc WiFi connection for your computer[2].

Once you have connected to the board launch auverdionControl and click on  to open the settings dialog:



[2] See chapter Useful Web Links

By selecting the *Access Point* option you let auverdionControl communicate with your freeDSP-aurora using the access point provided by freeDSP-aurora. By selecting the *Local WiFi* option you let auverdionControl communicate with your freeDSP-aurora via your local WiFi network. You can switch the communication path at any time.
When you have just unboxed your freeDSP-aurora or your local WiFi has changed, you need to type in the SSID and the password first. Therefore, please make sure that the option *Local WiFi* is selected. Now you can type in the SSID and the password of your local WiFi. Once you click on *Store* your settings are submitted to freeDSP-aurora and freeDSP-aurora tries to connect to your WiFi. If this is successful the IP address it got from your WiFi router is displayed in the line *IP Address Local*.
If you now select the option *Local WiFi* auverdionControl will communicate with freeDSP-aurora by using the new address[3].
You can overrule the IP address by writing another address into the text field *IP Address*. This is helpful if you have multiple freeDSP-auroras in the same network and you want to talk to another one.
At any time you can switch between Access Point mode and Local WiFi mode but you may have to reestablish the adhoc connection in the settings of your operating system first.
Even if a freeDSP-aurora cannot connect to a local WiFi network later (e.g. because the SSID or the password has changed) it still provides the access point for an adhoc connection.

INSTALLING A DSP PLUGIN

A new freeDSP-aurora comes with the 8 Channels DSP plugin installed. If you want to install another DSP plugin open the settings dialog and select the desired DSP plugin from the drop-down list. Now click on *Install* and the selected DSP plugin will be uploaded to your freeDSP-aurora.
If you just want to verify that the installed DSP plugin on the board is equal with the selected one click on *Verify*.
Please reboot your freeDSP-aurora by a power off-on cycle after a successful installation of a new plugin.

[3] On some systems you have to disconnect your adhoc connection first and reconnect to the same WiFi network as freeDSP-aurora is connected to.

INSTALLING AN ADDON

When you connect an AddOn you have to inform freeDSP-aurora about the AddOn to make use of all features that might be added by the AddOn. Some AddOns may change audio input and/or output configurations and you probably want to see these changes in auverdionControl when selecting an audio channel.
Therefore, open the settings dialog and select you desired AddOn from the drop-down list *Installed AddOn*. Your choice will be stored on the freeDSP-aurora board.

SYNCHRONIZING WITH FREEDSP-AURORA

Before you can make settings to your freeDSP-aurora auverdionControl needs to connect and synchronize with your DSP. Therefore, click on  and auverdionControl will connect to freeDSP-aurora and request all parameters for each preset stored on your freeDSP-aurora board.

STORING PARAMETER SETTINGS

Every parameter change you do is sent to your freeDSP-aurora board. You can immediately hear your changes. Yet your changes are not stored non-volatile on your freeDSP-aurora board. Once you cycle power off and on your settings will be lost.
If you are satisfied with your settings and you want to store them on your freeDSP-aurora board you have to click on  . This will upload all settings for each preset to your freeDSP-aurora board. After rebooting the freeDSP-aurora by a power off-on cycle the new settings are loaded into the DSP.
Please note:  becomes only enabled after you have connected and synchronized with your freeDSP-aurora board.

MASTER VOLUME

With the volume slider on the right side you can set the master volume on all output channels. This is the global master volume for all presets.

Please note: The master volume setting is only stored non-volatile on your freeDSP-aurora board when you click on  .

USING PRESETS

If you click on a preset on the bottom your freeDSP-aurora will load the preset and auverdionControl will switch to this preset. You can now make changes to the selected preset. All changes to a preset are volatile and will be lost when you select another preset. If you want to store the changes you made to a preset you click on  before you switch to another preset.
Please note: If you want your freeDSP-aurora to boot with a certain preset you have to click on  while the desired preset is selected.

SWITCHING CHANNELS

Most of the DSP plugins support multiple channels. These can be switched on the left side. Settings you have made to another channel before remain valid.
By right-clicking on the frequency response plot you can select which channels are displayed in the frequency response plot for the currently selected channel. This helps you to see how the settings of several channels sum up to a resulting frequency response when you are e.g. building an active loudspeaker.

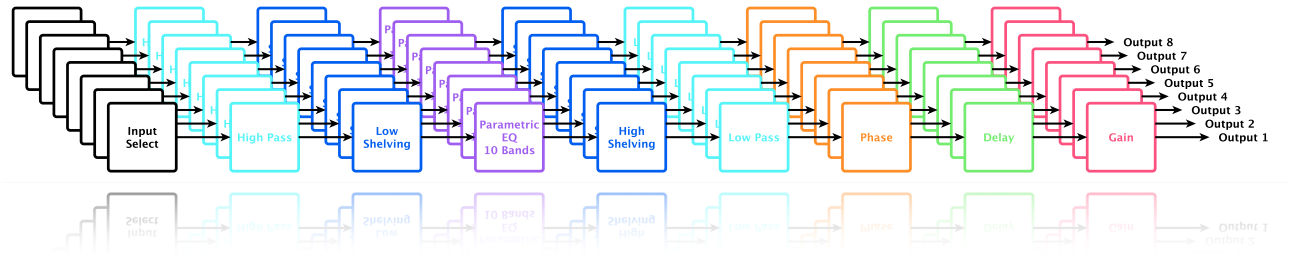
ABOUT DIALOG

To view the license and the current version of auverdionControl click on  . This opens the About dialog with some useful information about your app.

DSP PLUGINS

8CHANNELS

The 8channels DSP plugin is the default DSP plugin for any new freeDSP-aurora. It provides eight channel strips with identical configuration.



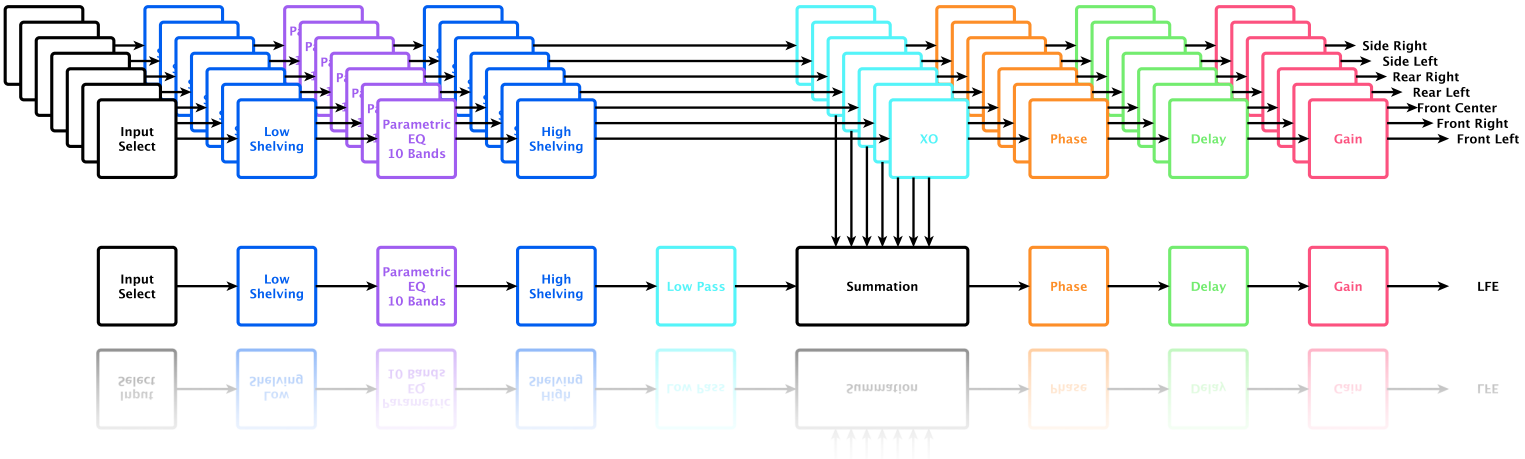
Block diagram of 8channels plugin

Each channel holds:

- input channel select
- low shelving and high shelving filter
- lowpass and highpass filter up to 48 dB/oct roll off steepness
- 10 parametric EQs
- Allpass filter
- Polarity Inversion
- Delay up to 100 ms per channel
- Gain

HOMECINEMA71

The Homecinema71 DSP plugin is a speaker management for your home cinema. It consists of 7 satellite channels and 1 subwoofer channel.
Each satellite channel contains a crossover formed by a highpass and a lowpass filter. The output of the highpass filter is forwarded to the following signal processing blocks of the channel while the output of the lowpass filter is mixed into the subwoofer channel.



Block diagram of Homecinema71 plugin

Each satellite channel holds:

- input channel select
- low shelving and high shelving filter
- 10 parametric EQs
- crossover with lowpass and highpass filter up to 48 dB/oct roll off steepness
- Allpass filter
- Polarity Inversion
- Delay up to 100 ms per channel
- Gain

The subwoofer channel holds:

- input channel select
- low shelving and high shelving filter
- 10 parametric EQs

- lowpass filter up to 48 dB/oct roll off steepness
- insert point for satellite lowpass output sum
- Allpass filter
- Polarity Inversion
- Delay up to 100 ms per channel
- Gain

DISCLAIMER

All products, product specifications and data are subject to change without notice to improve reliability, function or design or otherwise.
Auverdion, its affiliates, agents, and employees, and all persons acting on its or their behalf, disclaim any and all liability for any errors, inaccuracies or incompleteness contained in any datasheet, manual, application note or any other document relating to any product.
This subassembly is designed for use in music reproduction equipment only. No representations are made as to fitness for other uses. Except where noted otherwise any specifications given pertain to this subassembly only. Responsibility for verifying the performance, safety, reliability and compliance with legal standards of end products using this subassembly falls to the manufacturer of said end product.

Auverdion makes no express or implied warranties whatsoever with respect to its functionality, operability, or use, including, without limitation, any implied warranties of merchantability, fitness for a particular purpose, or infringement. We expressly disclaim any liability whatsoever for any direct, indirect, consequential, incidental or special damages, including, without limitation, lost revenues, lost profits, losses resulting from business interruption or loss of data regardless of the form of action or legal theory under which the liability may be asserted, even if advised of the possibility or likelihood of such damages.

Life support policy: Use of auverdion products in life support equipment or equipment whose failure can reasonably be expected to result in injury or death is not permitted.

WARRANTY

Auverdion warrants freeDSP-aurora to be free from all provable material and production defects for the duration of 12 months starting from sales. All damage, which is caused by wrong or inappropriate operation, incorrect connection, improper or undocumented use, modification or alteration of the board in any way is excluded from the warranty.

USEFUL WEB LINKS

Please visit https://github.com/freeDSP/freeDSP-AURORA for updates, bugfixes and new DSP plugins.

The development story of freeDSP-aurora:
https://www.diy-hifi-forum.eu/forum/showthread.php?15019-Verst%E4rkermodul-mit-DSP-600W-1-4Kan%E4le-low-budget-high-quality

FreeDSP-aurora at diyaudio.com:
https://www.diyaudio.com/forums/digital-line-level/334055-freedsp-aurora-dsp-8-os-usb-audio-dif-adat-bluetooth-wifi-contro.html

The freeDSP project:
http://www.freedsp.cc

How to connect to a wireless access point on iOS:
https://support.apple.com/en-us/HT202639

How to connect to a wireless access point on macOS:
https://support.apple.com/en-us/HT201735

How to connect to a wireless access point on windows 7/10:
https://ittutorials.net/microsoft/windows-7/how-to-connect-to-a-wireless-access-point-in-windows-7/

Enjoy your freeDSP-aurora!