



# **JAX [ JUST AN EXTENSION ] SERIES**

**JAX : CONVOLUTOR PRO / PE [ AUDIO UNITS ]**

# **MANUAL**

Version 1.8

# JAX Convolver PRO / PE

## Advanced convolution reverberation effects

### Preface:

Remark: This is an Audio Unit, but you have to open the distribution app ones at least to install the included IR file library.

At first, the different JAX Convolver Audio Units differ in their ability to load user defined impulse response files. The free JAX Convolver PE cannot load external (user) impulse response files but can use a fairly complete set of commonly used inbuilt IR files (including very large files). All other functions are shared with its big brother, the JAX Convolver PRO. This manual is written for both versions.

Convolution effects are well known and commonly used in music production since many years. But creating a convolution reverb AUv3 Audio Unit remains a quite difficult task. Because there are several conceptual problems to solve, especially Apples limitations for real time (inter process communication) audio processes.

At first, AUv3 Audio Units are generally executed inside a sandboxed environment and have limited access to external resources. Secondly, multi threading and resource allocation (like reading and manipulating files at runtime) or even simple memory allocation during processing is strictly forbidden inside the core realtime audio process on Apples platforms due to their entire audio system architecture. But dynamic

memory allocation is a crucial factor with any convolution processor and a strict requirement.

So how to solve these fundamental problems?

Users usually want to change, load and convert their impulse response files, even possibly at runtime and not just use a limited set of prepared presets or a limited memory for this. A convolution reverberator that is limited to internal spaces does not make much sense. Also if it is limited in internal (static) memory usage.

So we have created the 'tricky' JAX Convolver Pro to provide the very first x-platform convolution AUv3 unit, that runs on iOS and macOS, that also can load and process very large IR files. JAX Convolver can load user selected IR (impulse response) files on the fly at runtime and performs single threaded convolution processing inside any audio unit enabled host.

The supplied impulse response files must (internally) fit certain requirements, so we have added the ability to import audio files directly with the JAX Convolver Pro. These files will then be converted on the fly and placed to the unique location, where the audio units actually can find it and these user defined files will be available and selectable when operating with a JAX Convolver Audio Unit instance at runtime from inside any host application.

Since version 1.5 we have added even ultra fast "on the fly" importing of IR Files. JAX Convolver will import any audio format (that is officially supported by the OS) while operation, convert and place to the shared folder for any future access. This includes various compressed streaming formats. Such imported and converted IRs will be loaded into the unit immediately after importing success.

It is now even possible to record your own IR files directly into the convolution engine of JAX Convolver PRO. ( This feature may not be available with the initial release. )

Please note, that it always will take the base name of the imported file and eventually overwrite an already existing file with that name. The file extensions are changed to “.aif” inside the imported user library. If you reopen the IR browser, the tree view will reflect any changes in that file structure.

JAX Convolver Pro and PE additionally provide a large factory set of fairly complete presets (inbuilt IR files) that can be used out of the box for complex sound manipulations or as a fallback, if loading user selected files fails for any reasons.

## **What is convolution ?**

Convolution is a highly complex signal processing approach, that needs some certain computation power. The recorded impulse response of a real world environment is used to render a reverberation effect onto any audio material, so that it sounds like the source was played in that original room or at that location. Some further adjustments and manipulations can be applied to refine these results.

Now this all may sound somewhat naive at first listen but the entire calculation is extremely complex math, so that the very first processors and computers were able to perform this in realtime rather around the end of the last millennium.

Basically, the impulse responses and the audio stream are completely analyzed with FFT algorithms and then the entire analysis data will be cross-modulated into the realtime audio stream by performing a repeated highly performance intensive re-synthesis and accumulation processing for each analysis block of the impulse response.

Therefore it is a crucial performance factor that you use JAX Convolver with larger processing buffer sizes (1024) samples. Shorter buffers may raise the CPU hit exorbitantly for several reasons.

## **A Note To Convolution Performance**

We have tested our audio units with Apples latest devices exclusively, as these are able to perform long convolutions with acceptable CPU usage. The length of an impulse response file absolutely does matter. This lies in nature of things, because the entire impulse response must be convoluted into the output : sample by sample!

We have compared our DSP code with Apples Accelerate Framework in some intense tests and found, that our own code fairly compares with the speed of this high performance DSP framework. However, we do not recommend to use our effect with any older device, as this may consume all of its computation power with a single processing instance, even when medium large IR files are used.

JAX Convolver is due to its internal processing structure not well optimized for fairly short IR files and also not for using mono IRs. There may be tools that are better suited for such purposes. Our audio unit is designed for creative usage with emphasis on realtime features and unlimited large IR stereo files.

## **FPU Vector Processing**

JAX Convolver uses highly optimized DSP up to low level Assembler (machine language) and especially intrinsic CPU functions (floating point vector operations, where 4 floating

point precision samples are processed at same time with one CPU instruction). On ARM processors this is commonly called NEON, on Intel architecture CPUs: SSE 1 to 4.

## **Designed To Perform Large IR Files**

Despite the missing multithreading features of AUv3, our unit is able to process VERY large files with reasonable performance inside a single audio thread, multiple instances, using multi-core features are generally supported, of course, but this depends on the used devices, the used IR files and the setup of your entire audio processing chain of the used host.

In our internal stress tests we were able to load and process up to 128 seconds long IR files without a problem. (To be somewhat more clear, these tests did only invoke the convolution kernel and not much other surrounding DSP or UI stuff, as additional filtering, mixing, automation and so on.) Latest performance optimizations enable to load and process 128 second files in realtime.

Such long files are b.t.w. quite ‘unreal’, because the physical laws usually do not allow such large spaces in nature. But music sometimes requires more.

## **Selective Convolution Range Technology**

With JAX Convolver we developed a special performance optimized technology, that we are calling “Selective Range Convolution”. This technology enables to drastically reduce the CPU usage with the side effect of having an additional filter on the reverb output for no extra costs.

Many users wanted an additional filter on the reverb part for adjusting sonic qualities. With our technology, we actually realized exactly that and additionally reduced the CPU impact of the entire processing this way. (Range Filter 2)

The optional reverb output range filter (S.R.C., a special LP / HP range filter) is directly implemented into the convolution kernel, so the smaller the filter range is, the LOWER the entire CPU usage will be. This is a quite unique approach to convolution - using the kernel itself to apply effective range filtering while reducing the CPU impact at same time.

By the way, convolution usually processes allot of inaudible frequency components, that require allot of CPU power that nobody actually would hear. One of our performance tweaks eliminates the ranges of inaudible frequencies and these are not processed at all.

And with JAX Convolver Pro we additionally have developed a special solution, that finally enables to load, record and manipulate IR files at runtime (while processing) without breaking the DSP flow and Apples strict rules for that.

## **The IR Files**

IR files are mostly files recorded with special equipment, but basically are just usual audio files (stereo) with a reverberated sound of an ultra short impulse. It is even possible to capture synthetic reverbs and other effects with this technique, for instance from famous ancient vintage equipment, as rare plate and spring reverbs. If other kind of files are used, some wired special effects can be achieved thru convolution or just some kind of creative audio garbage. But also rhythmic effects are possible when the correct IR sizes are used (correctly adopted to the current tempo of the composition).

By listening to the raw IR files one may distinguish how the final result will sound.

IR files, in principle, are impulsed, filtered kind of noise. Even with synthetically generated white, pink, brown noise, countless new variations of convolution effects become possible, effects that have no role model in nature. This has great potential for creative usage. Some ideas for this we included with the “Experimental” IR files inside the USER folder.

Quite often also very short responses of some real life equipment are used. So for instance the resonating bodies of several acoustic instruments are recorded, to achieve a more natural behaving sound of digitally sampled instruments. Also cabinets and other technical music equipment can be convoluted. But the latter are not well situated for usage with JAX Convolutor.

The impulse response files must be (finally) in Apples \*.aif format, stereo, 16 or 32 bit / 48000 Hz sampling rate, 16 bits (for the factory IRs) are mainly because of limited mobile device space. (Internally our convolution processor uses always 32 bit (parallel) floating point processing, especially because of vector CPU support).

If a user file is selected for import, the unit ensures that the IR file will be converted into the correct source format and placed permanently into a user folder of the shared memory, where the audio unit can access it at runtime from anywhere and anytime.

The size of imported stereo IR files is currently not limited in any way but we suggest to use files clearly under 128 seconds length for normal operation. The length of an IR file is absolutely NO quality criterion. It merely enlarges the decay

time and forces the convolution to take allot (exorbitantly) more cycles of computation.

The largest file in our provided preset library is 32 seconds long and can be stretched additionally to get a maximum of 128 seconds this way. Stretching IRs is often very useful for efficiently changing the frequency response of the resulting reverberation.

Please note, that using the Stretch parameter effectively will multiply the length of any loaded IR file in memory, because a loaded IR always must be precomputed.

Also all the factory and user files must be placed into a special “app group” folder, that is not directly accessible with the Files or Finder app, nor easily visible to the user (on both platforms). This special space will be generated and reserved by the operating system at installation time.

On macOS some of the same paradigms apply with AUv3 units. There is no free access to files of the operating system from within the app nor the plugins, it always requires special permissions and well defined sharing locations. The host app and the audio units are living inside a secured, “sandboxed” environment, so do their files for access. This is because the products are intended to be distributed via the Apple App Stores and this is a latest, strict and quite notorious requirement by the Apple distribution politics.

This means, the usage of the JAX Convolver AUv3 Audio Unit has small conceptual limitations:

(Please note, that these limits are of conceptual nature due to the AUv3 architecture of Apples realtime audio processing systems, not due to our disabilities.)

- ~~You (currently) cannot import new impulse response files at runtime with the Audio Unit, but you can import them with the main app for later usage.~~
- You cannot freely manage your own IR files inside the file system on iOS or macOS from within the Audio Unit.
- You cannot change the global storage location for the used IRs to your needs, because AUv3 is consequently sandboxed and has limited access to limited spaces.
- You must live with a (possibly) slightly higher processor usage because of missing internal AUv3 multithreading features. An Audio Unit instance can only use a single Thread and a single core. This is managed by iOS.

Nevertheless, the JAX Convolver may be a very welcome extension (especially on iOS/iPadOS) and users may enjoy these new possibilities with our extension.

## **The Parameters**

JAX Convolver has 2 strictly separated categories of parameters for the IR manipulation, editing and the realtime processing.

### **IR Manipulation**

An impulse response file must be loaded at initialization time into the engine and precomputed into a special internal processing format. The IR can be modified with several very powerful and unique methods in memory then, but before the reverberation process actually can start with these modifications, the file in memory must be virtually re-loaded and pre-calculated into the processing slot formats.

You can for instance change the sampling rate and the pitch of a recorded IR file independently. You also can re-define a start point and the end of the impulse response and you can even apply a specialized envelope and other functions.

All these changes are a kind of destructive by nature and will modify a copy of the loaded IR file in memory. The original IR files inside the library never will get modified, so the delivered and imported files on the disk remain absolutely untouched. However, these changes are not realtime-able, you must always apply any changes first.

If you apply the changes, some complex calculations will occur and while the unit still continues to process audio (or pass thru audio), a small gap may result in the continuity of the processes. This finally means, switching wildly loads of presets with convolution reverbs and expecting to automate this behaviour, will usually not work well. It also may last some time, until everything is ready and audible and the screen is updated with the latest data.

The screen update is consequently threaded and might generally appear somewhat delayed therefore. The preparing calculations are performed outside the core realtime audio process (threaded by the UI process) and will be applied by the core audio process, if everything is ready.

To simplify the editing of the IR files, JAX Convolver implements a special auditioning mode, where the pure impulse response is played continuously in loop by an internal sampler instance, unless the mode is switched off again. This process is completely decoupled from the real convolution process and will bypass the convolution.

Please note that loading new impulse response files will NOT reset the current IR parameters, which allows to try out different files without resetting the current editing. These

parameters are saved with a preset. However, the used or modified impulse memory cannot be saved directly with a preset.

We have developed an internal database for the IR files and only an index to the files on disk will be saved with the preset files. JAX Convolver Pro features its own preset file format but also supports generic AU presets, that are usually managed by the host application.

## None Realtime Parameters

- **IR Start:** The start of the recorded impulse response can be shifted in time. For instance a fixed pre delay (early reflections) can be easily cut away, smoothed or shortened this way, because it is often conflicting with the tempo in a mix. (Early reflections in reverbs are conceptually always of static nature.) This parameter is especially helpful, if the resulting reverb produces rhythmic problems or pumping or is far too prominent in attack and so on.

- **IR End:** The end of the impulse response file can be adjusted too, effectively shortening the complete response. The new end will be automatically smoothed by the envelope, which can be tweaked separately inside these bounds. Only the range between Start and Stop are loaded into the convolution engine. So shortening the reverb drastically changes the reverberation character (its decay). The envelope is always a fractional part between the start end end points.

- **IR Stretch:** It is possible to resample the selected IR file range up to 4 times longer or shorter (25 to 400%) of the original source file. The pitch will be re-adjusted automatically (resampling), if the Link option is switched on. If it is off, the Stretch will lower or raise the pitch, as the sampling rate gets

merely adjusted this way, not resampled. The step-less nature of the stretching and pitch parameters enable subtle to drastic changes in the sonic results of the reverberation.

- **IR Pitch:** The pitch can be tweaked independently, if the Link option is off. Sometimes a reverb is sounding just a bit too dark or too bright, so this is very helpful without affecting the natural decay / time of the reverb but merely its sonic character. This control is very efficient in changing the resulting sound spectrum.

- **IR Attack/Decay:** With the connected attack/decay relation, the impulse response can be adjusted to fine-tune the reverberation response (early reflections and decay). The attack can be drastically smoothed with this, taking away some possible aggressive or explosive ramble. The reverb distance can be decreased with this too. The envelope is done in a way, that smoothes out even rawly sampled IR files (which are spread out at loads everywhere). Such badly sampled reverbs mostly have a problematic decay, fading out too fast, resulting in clearly audible unnatural decay sound.

- **IR Envelope Curves:** The curves enable to adjust the linearity of the 2 connected envelope segments. By lowering the curve value, the volume will (logarithmically) increase/decrease faster, raising the curve value will make the continuous increasing/decreasing slower. But the nature of all impulse responses is generally an always naturally falling decay, except one wants a reverse reverb or ridiculous large ambient reverbs that have no role model in nature and/or are just physically impossible.

## Special Functions:

Note: Following features are not sure to be implemented finally, because most of them are actually realisable as realtime parameters.

There are a few special editing functions, which apply to the memory loaded impulse response, that may be useful for advanced (temporary) manipulation. Please note: These manipulations will become reset completely, if a new impulse response file is loaded. The changes are also NOT saved with a preset.

- IR Reverse: The impulse response can be inverted (playing backwards) to create various special effects. This can be repeated (alternated) several times without lost.

~~-IR Attenuator: The attenuation can be raised or lowered with this special function. By adjusting the line graph, either the volume will increase or decrease continuously in time. If the factor is 1.0 / 100% (middle position), the function has no effect. It can be useful to keep a fast falling decay longer alive, by continuously raising the volume (moving up) linearly in function of time. or smoothen by vice versa.~~

~~-IR Swap: This swaps the left and the right channels of the impulse response for rotating the the stereo information by 180 degrees, which can be useful when phase problems occur while mixing. This can be repeated (alternated) several times too.~~

~~-IR Invert: This inverts one of the (the left) channels. The stereo image is changed drastically with this. Possibly complete phase cancellation can occur. This happens, if there is no or less stereo information in the original recorded impulse, which usually is quite seldom or caused by a mono recording. This function can be repeated (alternated) several times.~~

- IR Audition: The audition mode enables to actually hear the pure impulse response to get an impression of what is happening while editing or manipulating the IR.

All IR and special functions must be applied explicitly to take effect with the reverberation effect.

## **Realtime Control**

JAX Convolver provides several sophisticated realtime parameter controls, which are not available with many other convolution reverbs. These parameters are saved with a preset but mainly intended for realtime usage and excessive automation, including MIDI control.

Usually convolution reverbs are quite static and aim to reproduce the original spaces of the IR files as good as even possible. Nothing less and nothing more. But we think, this is a creative barrier and have done it somewhat differently.

So you can for instance adjust several effective filters and the positions of the source and reverberation signal independently and you can change the resulting mixture and stereo image in realtime to get some excitement.

The selective range filters are very helpful for adjusting the frequency balance between input signal and reverberation effect. This technique is essential and extremely useful if you are adjusting the reverbs to perfectly fit into a mix.

With JAX Convolver you are finally not stuck to the static impulse response character of any recorded IR, which is often the industry standard, you can even create completely new spaces with it and control important aspects of the sound in realtime. Some really crazy effects are possible too, for instance using some none-standard IRs or with the reverb pitch modifier (currently experimental). We highly suggest to

get more creative with convolution reverbs and create something new! Just try to load some crazy noises and listen to what will happen.

- **Input Pan:** The input signal can be panned separately. This is ~~happening after the input passes into the reverberator to avoid unnatural reverb positioning.~~ (Reverbs are usually independent of the source position and not panned with the source.) But the reverb pan position can be adjusted separately nevertheless independently, for several special positioning and dynamic moving effects.

- **Input Frequency Range:** This control allows to limit the frequency range of the input signal. It is very helpful for eliminating low or high frequency content before it actually reaches the reverberator. So this effect is applied before the input signal goes thru the reverb but it is not applied to the source itself. So the dry signal always remains untouched this way.

This parameter works together with the Filter Mode Switch, which can be either Off, 6db LP/HP Range, 24db LP/HP Range or S.R.C. (Selective Range Convolution Filter Kernel). S.R.C. will have no effect on the input filter.

- **Dry/Wet Mix:** This is the most important control for adjusting the dry/wet relation of the resulting audio signal. A value of 0.0 (0%) means absolutely no reverberation (bypass). A value of 100% means only reverb (i.e. as being recorded from a very far distance of the reverberation source).

- **Reverb Pan:** The reverberation result can be adjusted and panned in realtime independently with this parameter. Dynamic changes (i.e. flying thru a space or moving the listeners head into different directions can be effectively emulated with this).

- **Reverb Frequency Range:** If the reverb is too prominent or weak in certain frequencies, this can adjust the range to better fit into a song. Convolution Reverbs are real spaces with full spectrum content, that most likely will not fit very well into a composition. So the filters allow to adjust effective range and presence with certain ease. This parameter is also important for so-called “shimmer” effects.

This parameter works together with the Filter Mode Switch, which can be either Off, 6db LP/HP Range, 24db LP/HP Range or S.R.C. (Selective Range Convolution Filter Kernel). Only S.R.C. is directly implemented into the convolution kernel.

- **Reverb Stereo Width:** The stereo width of the reverberation effect can be widened or narrowed from mono to wide stereo with this. This effect does not add any new stereo information to merely monophonic IR files. IR files always should have as wide stereo information as even possible. The stereo image of the input signal is also not affected by this control.

- **Reverb Enhancement:** Stereo enhancement and harmonic excitement can be applied with this (experimental, possibly not available with first release).

- **Reverb Pitch:** Special effects by modulating the reverberation effect (experimental, possibly not available with first release).

Other Parameters:

- **The Final Brickwall Limiter:** Like in all of our plugins, there is a final limiter built in, to prevent bogus signal levels and distortion due to very loud signals and to save your external equipment, it possibly has no extra parameters.

## The File Browsers

There are 2 different integrated file browsers in JAX Convolver. These browsers use the tree view paradigm on all operating systems.

With the IR File Browser you can select the impulse response file for loading into the current preset. All parameters of the IR will remain by doing that, even if the selected files have different sizes. Because start, stop and envelope parameters are relative fractional values, which makes this even possible.

IR files are organized in folders. If you tap on a folder item, it will expand and show its content. IR files are loaded by tapping on them. The browser will indicate the progress by temporarily fading the alpha value of its view.

IR files must be specially formatted with the Apple \*.aif audio file format, 44100 Hz, 16 or 32 bit stereo. Other formats must be imported and converted into this format with the main app. User files will be always placed into the "USER" folder.

The Preset Browser (JAX Convolver Pro) is quite similar to the IR browser. Presets are also organized in folders. The tree view structure inside the browsers reflects the file structure on the shared location on disk.

By loading a preset, all parameters and also the assigned IR file will be loaded. This is done by a lookup from the internal IR database, where all files are registered while importing with a unique index. If the assigned IR File cannot be found, a default IR will be assigned. You may always assign other IRs afterwards.

JAX Convolver uses its own file format, which are just classic macOS \*.plist files in text (UTF8 XML) format. These files are human readable files which can be edited manually. But the storage location for the audio units is generally inaccessible and only locate-able with special external tools (on iOS at least).

Upcoming product lines will possibly provide a solution for managing and editing shared resources of all of our Audio Units in the future.

User presets will be saved into the “USER” folder for presets.

## MIDI Implementation

[ Advanced MIDI implementation is scheduled for maintenance update 1 in January 2020 ]

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