PAULA
USER MANUAL

Welcome

PAULA is a Max for Live instrument rack sampler that dynamically alters sample rate based on the MIDI note played. PAULA was initially built to emulate the resampling behaviour of ProTracker 2 running on a Commodore Amiga 1200. As of version 3.0, PAULA has been fully integrated with Ableton Live's Simpler device and includes major improvements, new features and bug fixes. PAULA will be actively maintained. From version 3.2 onwards, all future updates are forwards compatible.

Installation

IMPORTANT: Move the folder 'PAULA Sampler' anywhere into your Ableton user library folder!

Load the instrument rack 'PAULA.adg' from your user library via the Ableton browser.

Default Ableton user library location(s):

Mac OS: Macintosh HD/Users/[*username*]/Music/Ableton/User Library
**Windows:** \Users\[*username*]\Documents\Ableton\User Library

UPGRADE (v3.2 onwards): Replace the folder 'PAULA Sampler' in your user library to upgrade.

Update

IMPORTANT: PAULA 3.0 and above requires *Max 9* or later due to the new implementation of abl. objects! The most current version of Ableton (12.1.10) includes Max 8 natively and requires a manual update. *(Ableton are due to bundle Max 9 natively soon, therefore this update methodology will become redundant).*

1. Download Max 9 or above from: https://cycling74.com/downloads and install.

2. Open Ableton and navigate to 'Settings' then 'Files & Folder'.

3. Under 'Max Application', click the 'Browse' button. Navigate and chose the newly installed Max 9 application (Mac OS) or Max 9 application folder (Windows).

4. Restart Ableton Live.

5. Load PAULA from your **user library**.

Mac OS: /Applications/Max.app

Windows: C:\Program Files\Cycling '74\Max 9
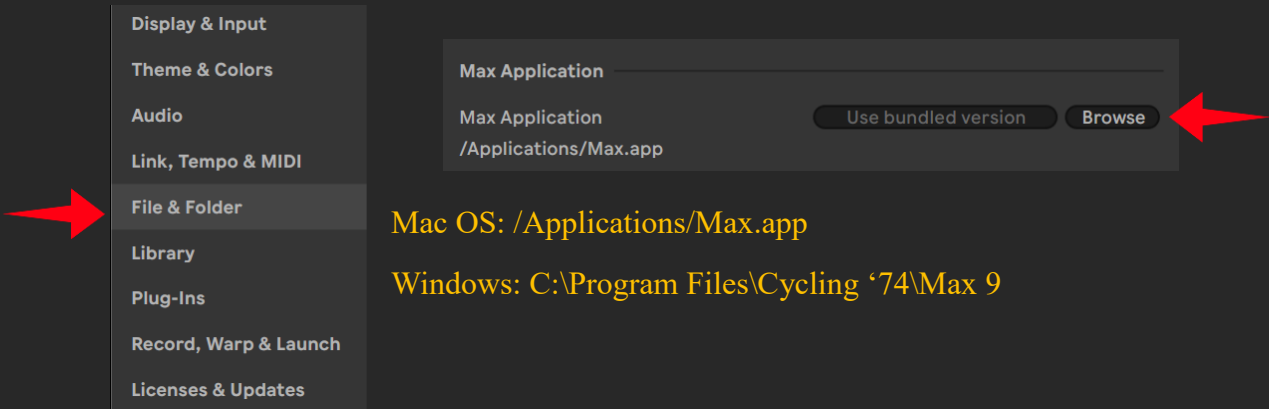
Usage

Introduction

PAULA 3.0 is an instrument rack (.adg). The device should be kept in an instrument rack in the order of: [(PAULA MIDI Send) → (Simpler) → (PAULA Audio Effect)] as shown below. You should be loading the instrument rack 'PAULA Sampler.adg' from your user library onto a new MIDI channel.

Info View / Hints

The 'Info view' now displays useful information in this manual inside of Ableton.
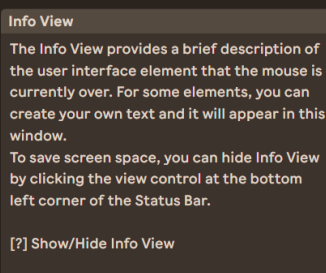
You'll find all of the information you need to use PAULA in the info view.

To see tips, hover your mouse cursor over the parameter in question and a nonobstructive popup will display.

Show/Hide Info View = [?]

PAULA MIDI Send

The Paula MIDI send device is a Max for Live MIDI effect that transfers incoming MIDI information on a per channel basis.

Clicking on the chip in the middle will flash green, resyncing the Live API parameter controls. Use it if any parameters in the simpler device unexpectedly become unmapped (Transpose, Detune, Warp Modes, Grain Size, Reverse, Voices, X2, /2 and Volume).

Simpler Device
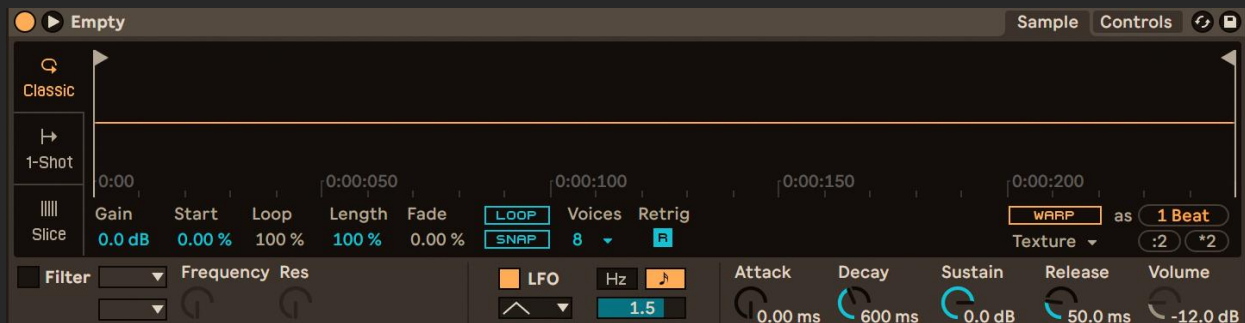
The Simpler device is the default Ableton live sampler. Check the online Ableton Live reference manual if you need help with this section.

IMPORTANT: PAULA dynamically updates the track name. If you'd like to rename the track, rename it from the simpler device title bar.

PAULA Audio Effect

IMPORTANT: Only MIDI keys C1 – B3 are enabled (see 'Tables' below).

Each MIDI note in the range of C-1 to B-3 is assigned a sample rate *(see 'Appendix')*. The lower keys are assigned lower sample rates, whereas the higher keys are assigned higher sample rates.

RESAMPLE 2NOTE

The 'RESAMPLE 2NOTE' section transposes the sample pitch. By default, C-3 play the sample at its original pitch. If you choose C-1, play the MIDI note C-1 to play it at its original pitch. This section theoretically combines both downsampling and upsampling and is based on ProTracker 2 resampling behaviour.
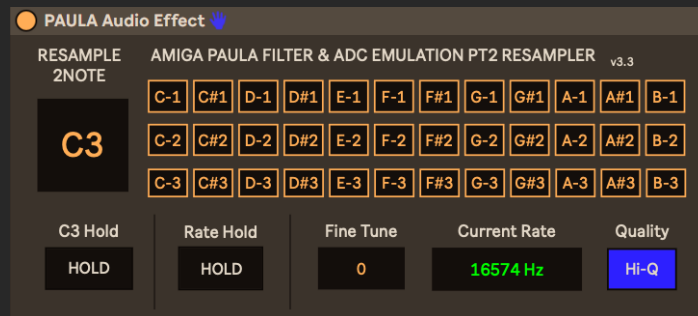
It was common to sample drums, cymbals, and other high frequency sounds at F3 or above to retain the high frequency information. For other sounds and instruments, it is best to experiment with different notes to resample to.

Choosing a note to resample to requires experimentation, for example, an 808 kick doesn't contain high frequency information, therefore it may be fine to resample at C2 or even C1 based on the Nyquist frequency. Note: The ProTracker 2.3D clone manual refers to E3 as "Lo-quality".

When 'C3 Hold' is enabled each MIDI note will play at its original pitch (C3) whilst only sample rate changes per key. Useful for quickly finding an optimal sounding 'RESAMPLE 2NOTE' sample rate at C3. It's recommended to disable 'C3 Hold' once a good resampling rate is found. Monophonic only.

'Rate Hold' locks the current sampling rate. It is recommended to enable 'Rate Hold Mode' while using slice mode.

'Fine Tune' follows ProTracker 2 fine tuning behaviour. Value range is between -8 to +7. Each step is equivalent to 12.5 cents. Changing this parameter also changes the resample rates each key is assigned, like ProTracker 2 (See Tables Below!).

'Current Rate' shows the current sample rate from the MIDI note played and is based on the ProTracker 2 Tables shown in the appendix.

'Quality' = Eco or Hi-Q. Using Eco mode and enabling 'POST FILTER' can get rid of harsh ringing in the high frequencies. Note: Hi-Q mode introduces 1.5 ms latency.

ADC / Sound Design / Time Stretching / EQ / Filters / FX

Experiment with all features of this section and adjust to taste. All of these parameters are fully automatable with the exception of the EQ section.
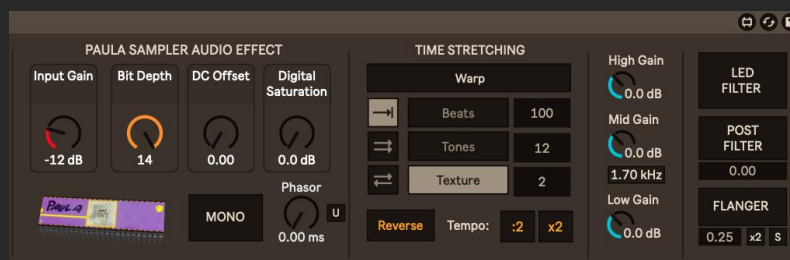
'Input Gain': Controls input gain. Remotely mapped to the 'Volume' control of Simpler. *Hint: Adjust to taste when in combination with the 'Bit Depth' control.*

'Bit Depth': Sets the bit depth.

'DC Offset': Shifts the waveform baseline away from zero.

'Digital Saturation': Simple digital saturation.

'MONO': Sets playback to mono, automatically enabled when using 'Phasor' effect.

'Phasor': Effect that slightly offsets the right channel by 0 - 50 ms.

'Warp': Enables warping in simpler. *Hint: If using timed percussion, ensure that the simpler device is in time with grid / project tempo. You can do this using the 'Warp Region' parameter on the simpler device [as 1 beat, 2 bars, etc].*

'Warp Mode': Select between Ableton's built in warping algorithms controlled within simpler. *Hint: Retrigger is required to update warp mode. When automation is drawn in, the undo history flooding won't persist – see 'Extra'.*

'Transient Envelope', 'Tone' and 'Texture Grain Size': Unique warp / time stretching parameters.

'Reverse: Reverses sample playback.

Tempo 'x2' & '/2': Halves and doubles sample playback length in respect to warping / time stretching.

EQ: Built in Ableton channel EQ.

LED FILTER: A1200 filter cutoff when enabled, applies a 2nd-order Butterworth low-pass filter at 3091 Hz.

POST FILTER: Antialiasing filter set at half the sample rate.

'Nyquist Limit Post-Filter Adjust': Tunes the position of the post-filter with respect to the resampling frequency. When zero, the filter is located at half the resampling rate.

FLANGER: Flanger effect with rate modulation, x2 feedback and stereo mode.'

U button: When enabled, the 'Phasor' and the 'MONO' effect are unlinked.

Saving Presets

It is recommended that whenever you finish designing a sound using PAULA 3.0, to save the preset as an instrument rack (*.adg*) file. To do this, simply drag and drop the device rack itself from the device title bar into your *user library*. Or click the floppy disk save icon on the instrument rack itself shown below and name it.

Click here to save a preset

This will embed/cache the sample loaded into the sample folder of your user library and prevent duplicate .amxd files from being created.

PAULA Audio Effect [STANDALONE]

The .amxd 'PAULA Audio Effect [STANDALONE]' is a stripped down version of PAULA Sampler. It doesn't contain any of the simpler device integration and doesn't have a MIDI input and is designed to be used on an audio track. The 'RESAMPLE 2NOTE' functionality here only affect the sample rate, as well as fine tuning.
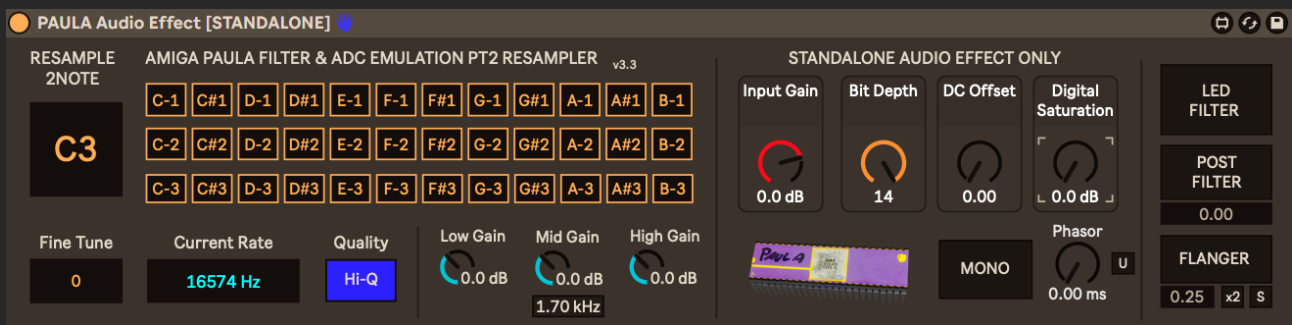
Extra

Shoutout and credit to 8bitbubsy for creating the open source pt2-clone, helping with my research. Also thank you Ableton for implementing .abl devices into Max helping me to migrate away from the dependency on TAL-DAC. Developed alongside creating the Many Worlds Sample CD. Signup to the mail list on my Bandcamp to get updates. I have many ideas for the future development of PAULA.

Note: PAULA 3.0 currently doesn't support multiple chains on the instrument rack due to how the Live API paths are queried. Please create a new channel rather than creating a new chain on the instrument rack. Also, if you intend to use any MIDI effects at the beginning of the channel, please insert them outside of the instrument rack!!

Note: PAULA 3.0 will flood the undo history when the 'Beat Envelope', 'Tone Grain Size' and 'Texture Grain Size' numbers are manually input via the live.numbox. However, when automation is drawn in, the undo history flooding won't persist. If any problems are encountered with the undo functionality, I recommend accessing the undo history (Live 12 only) by clicking cmd+option+z (mac) or ctrl+alt+z (windows). Another alternative is to freeze/flatten the track.

Any issues email me ash@wavefrontinsurgency.com.

Change Log

PAULA 3.3 Change Log:

- New Standalone Device: PAULA Audio Effect [STANDALONE]: Standalone device is free of all simpler integration and is designed for use on an audio track.
- Bug Fix: Input gain would unexpectedly un-map reopening a project. New method of controlling input gain implemented using macro control via the Live API.
- New parameter: U button: When enabled, the 'Phasor' and the 'MONO' effect are unlinked.

PAULA 3.2 Change Log:

- Renamed .amxd devices and instrument rack so that all future updates are forwards compatible!
- Added 'Nyquist Limit Post-Filter Adjust' parameter.
- Added: Automatic MIDI track naming.
- Bug Fix: Default value 'input gain' now correctly loads at -12 dB.
- Bug Fix: Default 'mid-range frequency' now loads at 1.7 kHz.
- Updated Ableton 'Info View' description of each parameter, including hints on hover.
- Updated manual.
- UI improvements.

PAULA 3.1 Change Log:

- Bug Fix: Missing transient warp icons now embedded correctly.
- Improvement: Simpler 'Volume' is now remotely controlled by the the 'Input Gain'. Also changed volume range -18 dB to +6 dB.
- Updated Manual (Small changes only).
- Improved UI colour scheme.
- 'PAULA MIDI Send.amxd' is now hidden in the rack by default.
- Changed EQ default mid-range frequence to 1.7 kHz.

PAULA 3.0 Change Log:

- Ableton's Simpler device has been fully integrated with PAULA, utilising the Ableton Live API – Controls include: Transposition, Fine Tune, Warping, Warp Mode, Warp Grain Size / Envelopes, X2, /2, Reverse and Voicing. As simpler is used, sample location is now managed by Ableton.
- Realtime time stretching: Ableton warp modes, grain size, x2 and /2 and reverse functionality. All support parameter automation.
- Fine tuning that follows ProTracker 2 behaviour and including slight sample rate variations.
- Quality mode: Eco and Hi-Q resampling algorithms available.
- LED filter moved to the end of the signal flow.
- Added optional antialiasing filter set at half the sample rate 'POST FILTER'.
- Added Ableton channel EQ abl. Object for ease of use.
- Added Flanger effect built in with rate modulation, x2 feedback and stereo mode.
- 'C3 Hold' enables monophonic playback, vice versa.
- Increased 'RESAMPLE 2NOTE' range to include A#3 and B-3 notes.

- Redesigned and improved MIDI flow.
- Improved UI including visual feedback.
- Updated manual.

PAULA 2.1 Change Log:

NOTE: IMPORTANT UPDATE - Fixes a bug that prevented some MIDI notes from playing!

- Bug fix: Enabled polyphonic voice stealing.
- Removed .alp installer for simplicity.
- Switched 'RESAMPLE2NOTE' parameter visibility to store only (disabled automation tracking).

PAULA 2.0 Change Log:

- No longer dependent on TAL-DAC and works entirely standalone using new Max abl. objects in Max 9.
- New features: C3 Hold, Sample Rate Hold, Trim, DC offset, Phasor Effect, High and Low Shelf EQ, Mono Button and the Current Sample Rate is now displayed.
- Bug fixes: Limited note range to C1-B3 in respect to the sample rate ranges pt2 tables (4144 – 31338 Hz). MIDI triggering now works as expected. No more random noises.
- .alp packing including lesson/example project.
- Created PDF manual.
- Added fade on load to remove audible pop/click.
- Check Max version displays pop-up/screen warning if below v9.0.0. - Improved UI.
- Implemented dynamic theming (light/dark mode)
- Switched to Bandcamp for distribution

Tables ProTracker note frequencies (PAL)

Fine Tune: +7

Note	Sample Rate (Hz)	Nyquist (Hz)
C-1	4357	2179
C#1	4618	2309
D-1	4892	2446
D#1	5186	2593
E-1	5491	2746
F-1	5815	2908
F#1	6169	3085
G-1	6532	3266
G#1	6914	3457
A-1	7328	3664
A#1	7761	3881
B-1	8229	4115
C-2	8715	4358
C#2	9237	4619
D-2	9771	4886
D#2	10371	5186
E-2	10981	5491
F-2	11629	5815
F#2	12316	6158
G-2	13040	6520
G#2	13855	6928
A-2	14657	7329
A#2	15557	7779
B-2	16421	8211
C-3	17387	8694
C#3	18473	9237
D-3	19596	9798
D#3	20742	10371
E-3	22030	11015
F-3	23335	11668
F#3	24631	12316
G-3	26080	13040
G#3	27710	13855
A-3	29313	14657
A#3	31113	15557
B-3	32842	16421

Fine Tune: +6

Note	Sample Rate (Hz)	Nyquist (Hz)
C-1	4325	2163
C#1	4583	2292
D-1	4859	2430
D#1	5148	2574
E-1	5448	2724
F-1	5777	2889
F#1	6115	3058
G-1	6484	3242
G#1	6874	3437
A-1	7283	3642
A#1	7711	3856
B-1	8173	4087
C-2	8651	4326
C#2	9165	4583
D-2	9718	4859
D#2	10281	5141
E-2	10914	5457
F-2	11553	5777
F#2	12231	6116
G-2	12945	6473
G#2	13748	6874
A-2	14536	7268
A#2	15421	7711
B-2	16345	8173
C-3	17302	8651
C#3	18378	9189
D-3	19382	9691
D#3	20621	10311
E-3	21760	10880
F-3	23032	11516
F#3	24461	12231
G-3	25890	12945
G#3	27495	13748
A-3	29073	14537
A#3	30843	15422
B-3	32540	16270

Fine Tune: +5

Note	Sample Rate (Hz)	Nyquist (Hz)
C-1	4294	2147
C#1	4553	2277
D-1	4819	2410
D#1	5111	2556
E-1	5415	2708
F-1	5730	2865
F#1	6073	3037
G-1	6437	3219
G#1	6821	3411
A-1	7224	3612
A#1	7661	3831
B-1	8116	4058
C-2	8588	4294
C#2	9095	4548
D-2	9638	4819
D#2	10222	5111
E-2	10814	5407
F-2	11479	5740
F#2	12147	6074
G-2	12851	6426
G#2	13642	6821
A-2	14477	7239
A#2	15288	7644
B-2	16196	8098
C-3	17218	8609
C#3	18189	9095
D-3	19277	9639
D#3	20384	10192
E-3	21627	10814
F-3	22883	11442
F#3	24294	12147
G-3	25702	12851
G#3	27284	13642
A-3	28837	14419
A#3	30577	15289
B-3	32540	16270

Fine Tune: +4

Note	Sample Rate (Hz)	Nyquist (Hz)
C-1	4263	2132
C#1	4518	2259
D-1	4787	2394
D#1	5074	2537
E-1	5374	2687
F-1	5693	2847
F#1	6032	3016
G-1	6391	3196
G#1	6769	3385
A-1	7165	3583
A#1	7595	3798
B-1	8043	4022
C-2	8526	4263
C#2	9048	4524
D-2	9586	4793
D#2	10134	5067
E-2	10748	5374
F-2	11368	5684
F#2	12064	6032
G-2	12759	6380
G#2	13538	6769
A-2	14360	7180
A#2	15223	7612
B-2	16122	8061
C-3	17052	8526
C#3	18096	9048
D-3	19172	9586
D#3	20268	10134
E-3	21496	10748
F-3	22737	11369
F#3	24129	12065
G-3	25517	12759
G#3	27076	13538
A-3	28604	14302
A#3	30315	15158
B-3	32245	16123

Tables ProTracker note frequencies (PAL)

Fine Tune: +3

Note	Sample Rate (Hz)	Nyquist (Hz)
C-1	4233	2117
C#1	4484	2242
D-1	4755	2378
D#1	5038	2519
E-1	5334	2667
F-1	5648	2824
F#1	5991	2996
G-1	6345	3173
G#1	6718	3359
A-1	7122	3561
A#1	7547	3774
B-1	7989	3995
C-2	8465	4233
C#2	8979	4490
D-2	9509	4755
D#2	10076	5038
E-2	10683	5342
F-2	11296	5648
F#2	11983	5992
G-2	12667	6334
G#2	13435	6718
A-2	14245	7123
A#2	15093	7547
B-2	15977	7989
C-3	16971	8486
C#3	17914	8957
D-3	18967	9484
D#3	20153	10077
E-3	21367	10684
F-3	22592	11296
F#3	23966	11983
G-3	25335	12668
G#3	26870	13435
A-3	28375	14188
A#3	30058	15029
B-3	31954	15977

Fine Tune: +2

Note	Sample Rate (Hz)	Nyquist (Hz)
C-1	4202	2101
C#1	4456	2228
D-1	4717	2359
D#1	5003	2502
E-1	5294	2647
F-1	5612	2806
F#1	5941	2971
G-1	6300	3150
G#1	6667	3334
A-1	7066	3533
A#1	7483	3742
B-1	7935	3968
C-2	8405	4203
C#2	8912	4456
D-2	9433	4717
D#2	9991	4996
E-2	10588	5294
F-2	11224	5612
F#2	11902	5951
G-2	12578	6289
G#2	13334	6667
A-2	14131	7066
A#2	14966	7483
B-2	15834	7917
C-3	16810	8405
C#3	17824	8912
D-3	18866	9433
D#3	20039	10020
E-3	21239	10620
F-3	22449	11225
F#3	23805	11903
G-3	25155	12578
G#3	26668	13334
A-3	28375	14188
A#3	30058	15029
B-3	31669	15835

Fine Tune: +1

Note	Sample Rate (Hz)	Nyquist (Hz)
C-1	4173	2087
C#1	4423	2212
D-1	4685	2343
D#1	4961	2481
E-1	5262	2631
F-1	5568	2784
F#1	5902	2951
G-1	6256	3128
G#1	6630	3315
A-1	7024	3512
A#1	7436	3718
B-1	7882	3941
C-2	8346	4173
C#2	8845	4423
D-2	9359	4680
D#2	9935	4968
E-2	10525	5263
F-2	11154	5577
F#2	11823	5912
G-2	12489	6245
G#2	13235	6618
A-2	14019	7010
A#2	14841	7421
B-2	15764	7882
C-3	16652	8326
C#3	17646	8823
D-3	18767	9384
D#3	19815	9908
E-3	20988	10494
F-3	22308	11154
F#3	23646	11823
G-3	24978	12489
G#3	26469	13235
A-3	28150	14075
A#3	29806	14903
B-3	31388	15694

Fine Tune: 0

Note	Sample Rate (Hz)	Nyquist (Hz)
C-1	4144	2072
C#1	4390	2195
D-1	4655	2328
D#1	4926	2463
E-1	5231	2616
F-1	5542	2771
F#1	5872	2936
G-1	6223	3112
G#1	6593	3297
A-1	6982	3491
A#1	7389	3695
B-1	7830	3915
C-2	8287	4144
C#2	8779	4390
D-2	9309	4655
D#2	9852	4926
E-2	10463	5232
F-2	11084	5542
F#2	11745	5873
G-2	12445	6223
G#2	13185	6593
A-2	13964	6982
A#2	14779	7390
B-2	15694	7847
C-3	16574	8287
C#3	17559	8780
D-3	18668	9334
D#3	19705	9853
E-3	20864	10432
F-3	22168	11084
F#3	23489	11745
G-3	24803	12402
G#3	26273	13137
A-3	27928	13964
A#3	29557	14779
B-3	31388	15694

Tables ProTracker note frequencies (PAL)

Fine Tune: -1

Note	Sample Rate (Hz)	Nyquist (Hz)
C-1	4115	2058
C#1	4357	2179
D-1	4618	2309
D#1	4892	2446
E-1	5186	2593
F-1	5491	2746
F#1	5815	2908
G-1	6169	3085
G#1	6532	3266
A-1	6914	3457
A#1	7328	3664
B-1	7761	3881
C-2	8229	4115
C#2	8715	4358
D-2	9237	4619
D#2	9771	4886
E-2	10371	5186
F-2	10981	5491
F#2	11629	5815
G-2	12316	6158
G#2	13040	6520
A-2	13855	6928
A#2	14657	7329
B-2	15557	7779
C-3	16421	8211
C#3	17472	8736
D-3	18473	9237
D#3	19596	9798
E-3	20742	10371
F-3	22030	11015
F#3	23335	11668
G-3	24631	12316
G#3	26080	13040
A-3	27710	13855
A#3	29313	14657
B-3	31113	15557

Fine Tune: -2

Note	Sample Rate (Hz)	Nyquist (Hz)
C-1	4086	2043
C#1	4325	2163
D-1	4583	2292
D#1	4859	2430
E-1	5148	2574
F-1	5448	2724
F#1	5777	2889
G-1	6115	3058
G#1	6484	3242
A-1	6874	3437
A#1	7283	3642
B-1	7711	3856
C-2	8173	4087
C#2	8651	4326
D-2	9165	4583
D#2	9718	4859
E-2	10281	5141
F-2	10914	5457
F#2	11553	5777
G-2	12231	6116
G#2	12945	6473
A-2	13748	6874
A#2	14536	7268
B-2	15421	7711
C-3	16345	8173
C#3	17302	8651
D-3	18378	9189
D#3	19382	9691
E-3	20621	10311
F-3	21760	10880
F#3	23032	11516
G-3	24461	12231
G#3	25890	12945
A-3	27495	13748
A#3	29073	14537
B-3	30843	15422

Fine Tune: -3

Note	Sample Rate (Hz)	Nyquist (Hz)
C-1	4054	2027
C#1	4294	2147
D-1	4553	2277
D#1	4819	2410
E-1	5111	2556
F-1	5415	2708
F#1	5730	2865
G-1	6073	3037
G#1	6437	3219
A-1	6821	3411
A#1	7224	3612
B-1	7661	3831
C-2	8116	4058
C#2	8588	4294
D-2	9095	4548
D#2	9638	4819
E-2	10222	5111
F-2	10814	5407
F#2	11479	5740
G-2	12147	6074
G#2	12851	6426
A-2	13642	6821
A#2	14477	7239
B-2	15288	7644
C-3	16196	8098
C#3	17218	8609
D-3	18189	9095
D#3	19277	9639
E-3	20384	10192
F-3	21627	10814
F#3	22883	11442
G-3	24294	12147
G#3	25702	12851
A-3	27284	13642
A#3	28837	14419
B-3	30577	15289

Fine Tune: -4

Note	Sample Rate (Hz)	Nyquist (Hz)
C-1	4026	2013
C#1	4263	2132
D-1	4518	2259
D#1	4787	2394
E-1	5074	2537
F-1	5374	2687
F#1	5693	2847
G-1	6032	3016
G#1	6391	3196
A-1	6769	3385
A#1	7180	3590
B-1	7595	3798
C-2	8043	4022
C#2	8526	4263
D-2	9048	4524
D#2	9586	4793
E-2	10134	5067
F-2	10748	5374
F#2	11368	5684
G-2	12064	6032
G#2	12759	6380
A-2	13538	6769
A#2	14360	7180
B-2	15223	7612
C-3	16122	8061
C#3	17052	8526
D-3	18096	9048
D#3	19172	9586
E-3	20268	10134
F-3	21496	10748
F#3	22737	11369
G-3	24129	12065
G#3	25517	12759
A-3	27076	13538
A#3	28837	14419
B-3	30315	15158

Tables ProTracker note frequencies (PAL)

Fine Tune: -5

Note	Sample Rate (Hz)	Nyquist (Hz)
C-1	3999	2000
C#1	4233	2117
D-1	4484	2242
D#1	4755	2378
E-1	5038	2519
F-1	5334	2667
F#1	5648	2824
G-1	5991	2996
G#1	6345	3173
A-1	6718	3359
A#1	7122	3561
B-1	7547	3774
C-2	7989	3995
C#2	8465	4233
D-2	8979	4490
D#2	9509	4755
E-2	10076	5038
F-2	10683	5342
F#2	11296	5648
G-2	11983	5992
G#2	12667	6334
A-2	13435	6718
A#2	14245	7123
B-2	15093	7547
C-3	15977	7989
C#3	16971	8486
D-3	17914	8957
D#3	18967	9484
E-3	20153	10077
F-3	21367	10684
F#3	22592	11296
G-3	23966	11983
G#3	25335	12668
A-3	26870	13435
A#3	28375	14188
B-3	30058	15029

Fine Tune: -6

Note	Sample Rate (Hz)	Nyquist (Hz)
C-1	3967	1984
C#1	4202	2101
D-1	4456	2228
D#1	4717	2359
E-1	5003	2502
F-1	5294	2647
F#1	5612	2806
G-1	5941	2971
G#1	6300	3150
A-1	6667	3334
A#1	7066	3533
B-1	7483	3742
C-2	7935	3968
C#2	8405	4203
D-2	8912	4456
D#2	9433	4717
E-2	9991	4996
F-2	10588	5294
F#2	11224	5612
G-2	11902	5951
G#2	12578	6289
A-2	13334	6667
A#2	14131	7066
B-2	14966	7483
C-3	15905	7953
C#3	16810	8405
D-3	17824	8912
D#3	18866	9433
E-3	20039	10020
F-3	21239	10620
F#3	22449	11225
G-3	23805	11903
G#3	25155	12578
A-3	26668	13334
A#3	28375	14188
B-3	30058	15029

Fine Tune: -7

Note	Sample Rate (Hz)	Nyquist (Hz)
C-1	3941	1971
C#1	4173	2087
D-1	4423	2212
D#1	4685	2343
E-1	4961	2481
F-1	5255	2628
F#1	5577	2789
G-1	5902	2951
G#1	6256	3128
A-1	6630	3315
A#1	7024	3512
B-1	7436	3718
C-2	7882	3941
C#2	8346	4173
D-2	8845	4423
D#2	9359	4680
E-2	9935	4968
F-2	10525	5263
F#2	11154	5577
G-2	11823	5912
G#2	12489	6245
A-2	13235	6618
A#2	14019	7010
B-2	14903	7452
C-3	15764	7882
C#3	16731	8366
D-3	17734	8867
D#3	18767	9384
E-3	19815	9908
F-3	20988	10494
F#3	22308	11154
G-3	23646	11823
G#3	24978	12489
A-3	26469	13235
A#3	28150	14075
B-3	29806	14903

Fine Tune: -8

Note	Sample Rate (Hz)	Nyquist (Hz)
C-1	3911	1956
C#1	4144	2072
D-1	4390	2195
D#1	4655	2328
E-1	4926	2463
F-1	5231	2616
F#1	5542	2771
G-1	5872	2936
G#1	6223	3112
A-1	6593	3297
A#1	6982	3491
B-1	7389	3695
C-2	7830	3915
C#2	8287	4144
D-2	8779	4390
D#2	9309	4655
E-2	9852	4926
F-2	10463	5232
F#2	11084	5542
G-2	11745	5873
G#2	12445	6223
A-2	13185	6593
A#2	13964	6982
B-2	14779	7390
C-3	15694	7847
C#3	16574	8287
D-3	17559	8780
D#3	18668	9334
E-3	19705	9853
F-3	20864	10432
F#3	22168	11084
G-3	23489	11745
G#3	24803	12402
A-3	26273	13137
A#3	27928	13964
B-3	29557	14779