Development of Artificial Reverberation in C++

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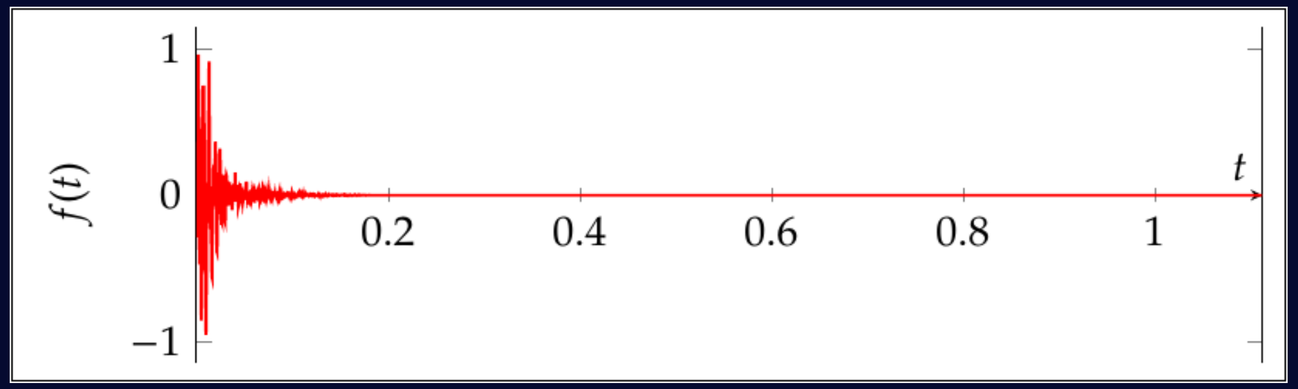
Overview

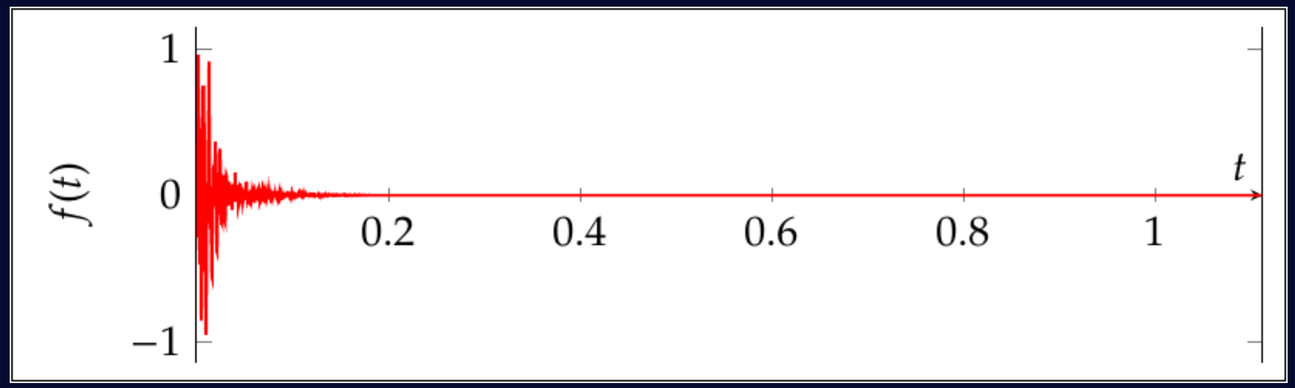
- Background Information
  - “What is reverb?”
- The Details
  - “How does digital audio work?”
- Measuring Reverb + The Code
  - “How does one create and evaluate reverb?”

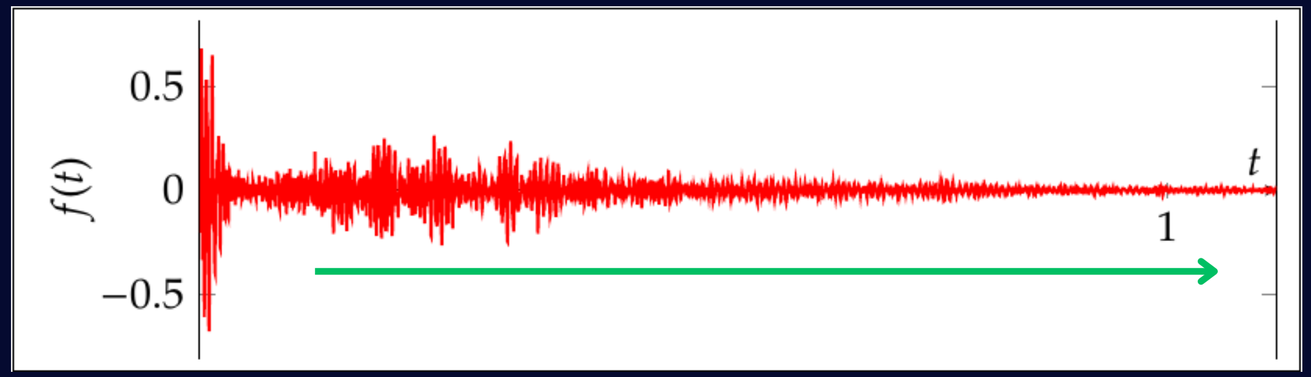
Background

Background

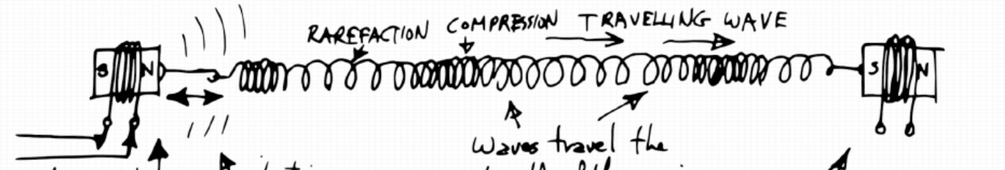


Background





Most Reverb units on synthesizers leave something to be desired but they are useful components none the less. Such units are usually spring type arrangements using the following basic principle:

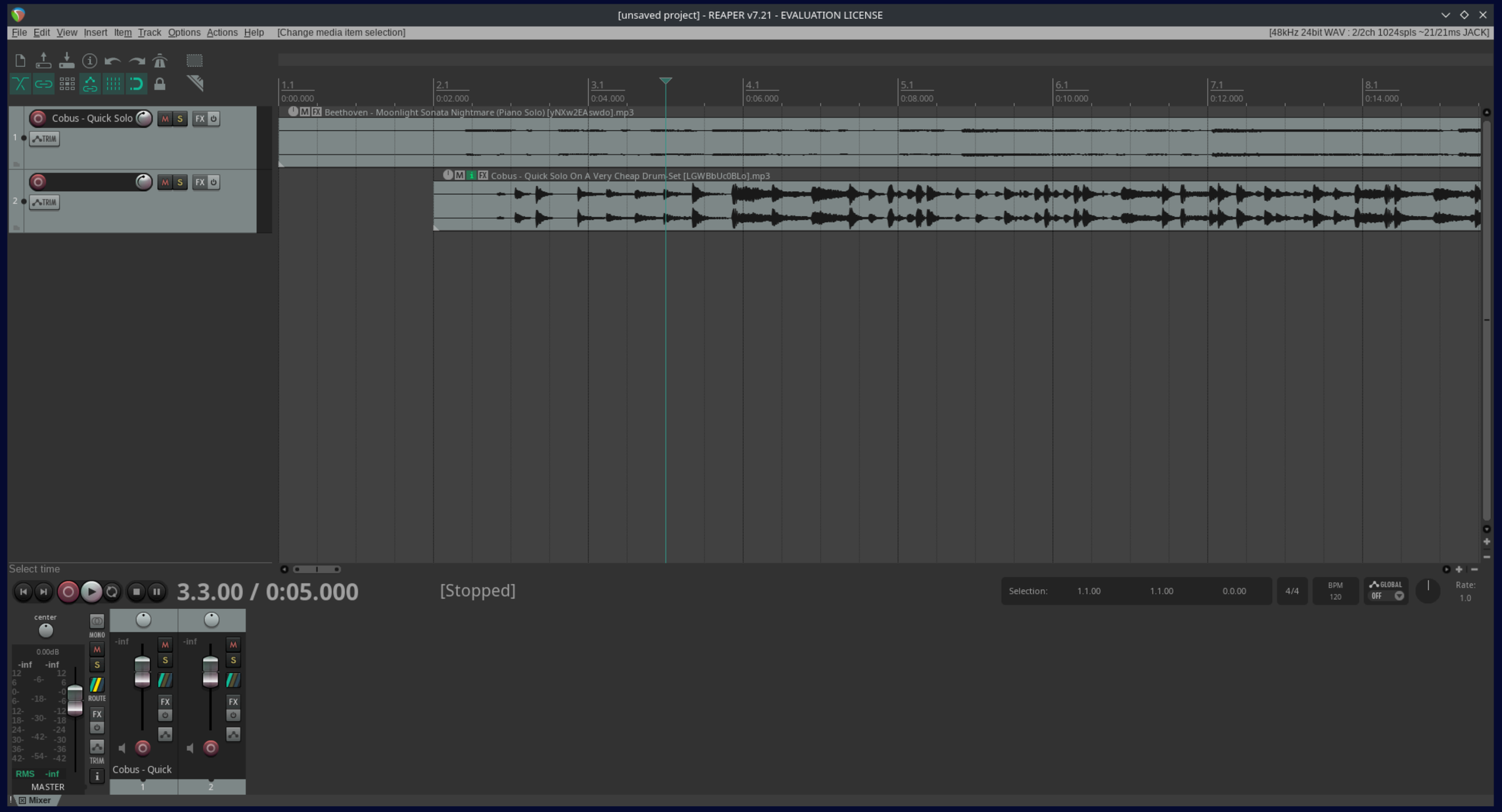


The sound is first reproduced here in a similar manner to a loudspeaker without a cone.

Vibrations cause the hook to vibrate the spring at audio frequencies.

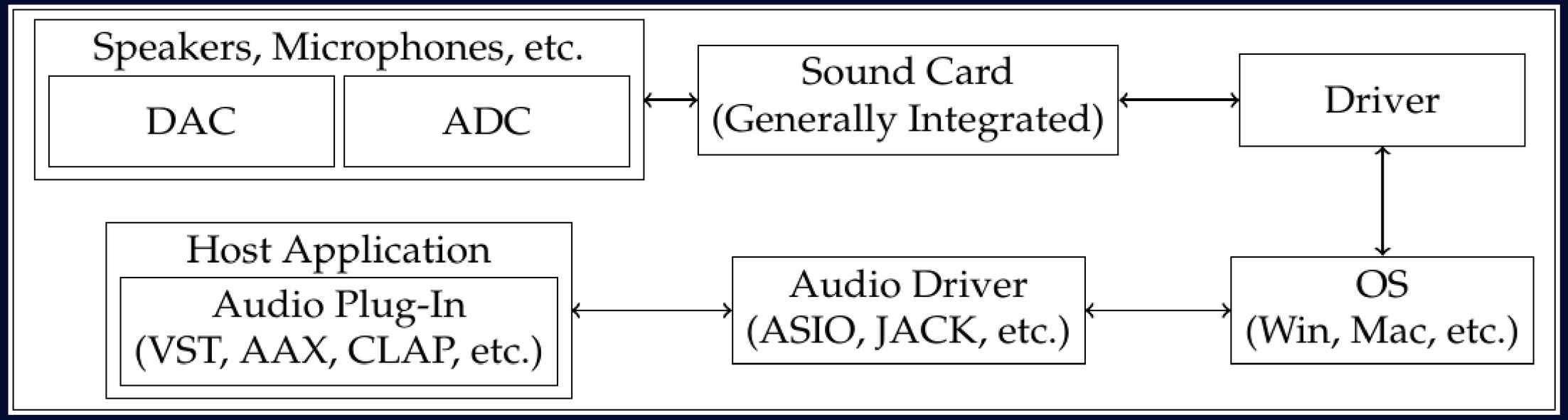
Waves travel the length of the spring much more slowly than in air.

Microphone type pickup receives vibrations a fraction of a second later and this signal is added to the original

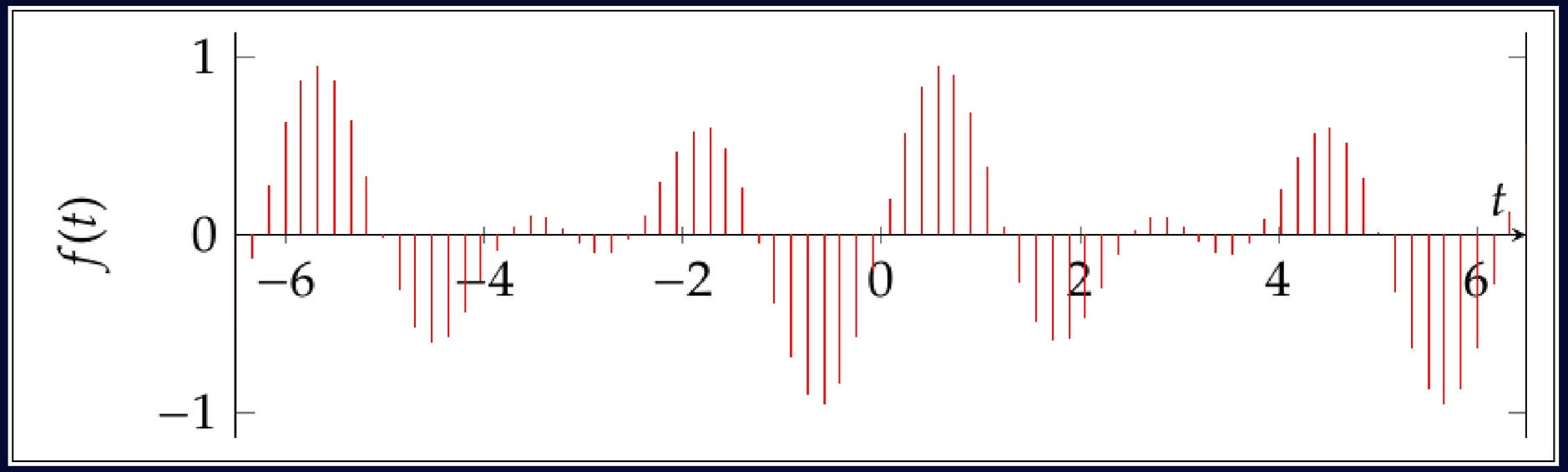

[unsaved project] - REAPER v7.21 - EVALUATION LICENSE
File Edit View Insert Item Track Options Actions Help
[Change media item selection]
[48kHz 24bit WAV : 2/2ch 1024spls ~21/21ms JACK]
Cobus - Quick Solo
Beethoven - Moonlight Sonata Nightmare (Piano Solo) [yNXw2EAswdo].mp3
Cobus - Quick Solo On A Very Cheap Drum Set [LGWBbUc0BLo].mp3
Select time
3.3.00 / 0:05.000
[Stopped]
Selection:
Cobus - Quick
MASTER
Mixer

The Details

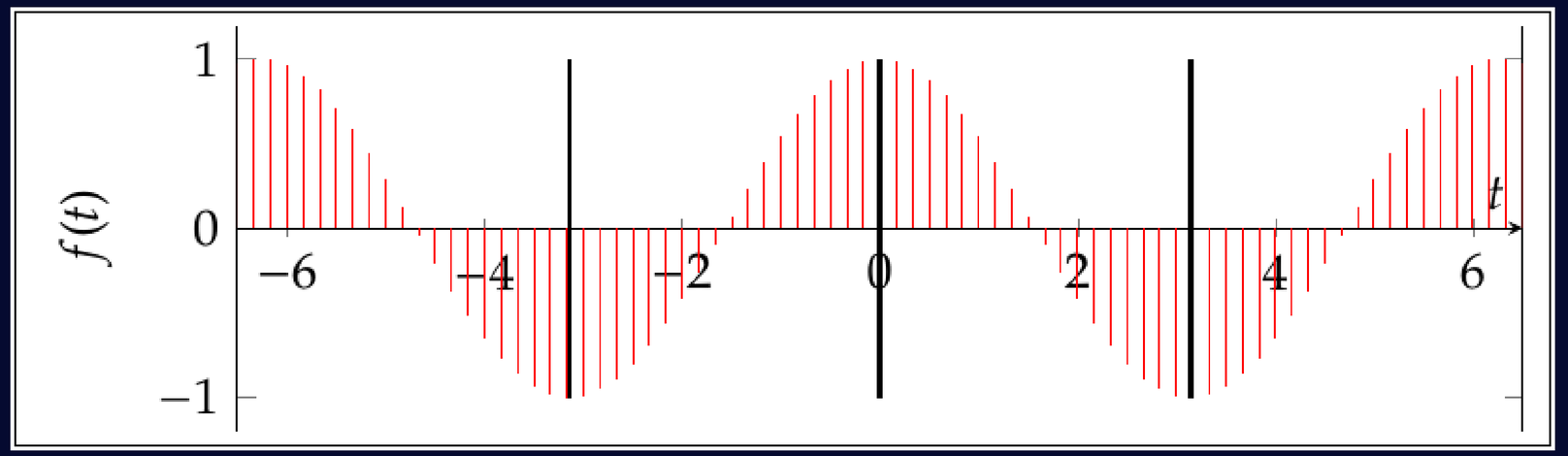
The Details

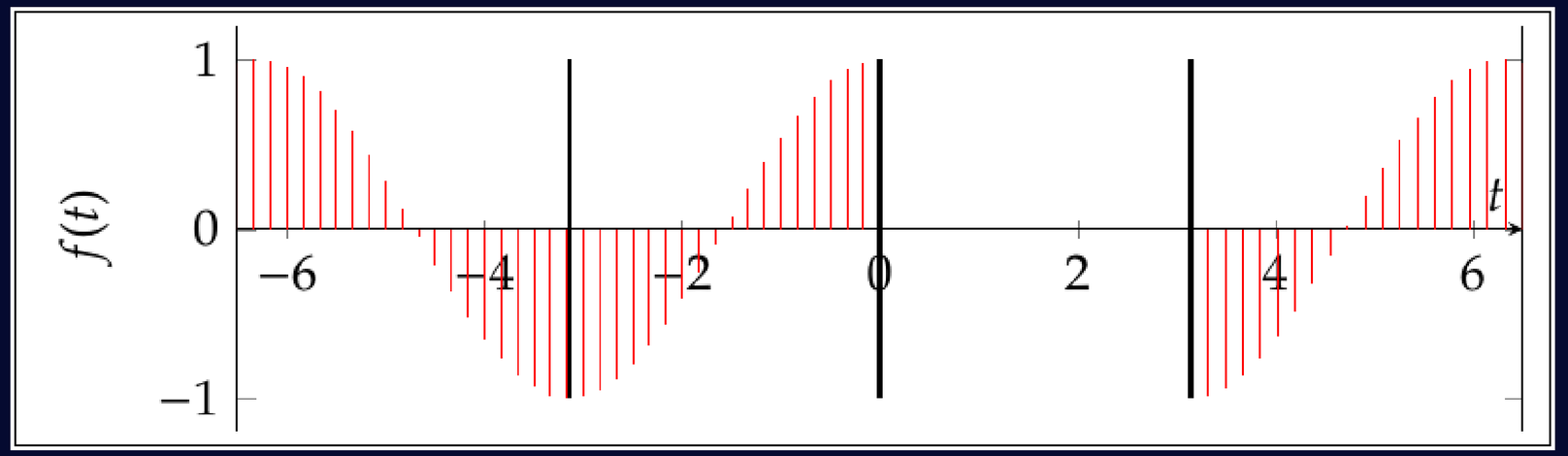

Speakers, Microphones, etc.
DAC
ADC
Sound Card
(Generally Integrated)
Driver
Host Application
Audio Plug-In
(VST, AAX, CLAP, etc.)
Audio Driver
(ASIO, JACK, etc.)
OS
(Win, Mac, etc.)

The Details



The Details





To Summarize...

- Think in terms of video games:
- MP3s are akin to “watching” someone play a game.
- DAWs generate audio on-the-fly - they “play the game itself”.

Measuring Reverb

- To test whatever algorithm is chosen, it is necessary to have a baseline to compare against.

- To do this, one can measure a real acoustic space.

Measuring Reverb

- Reverberation time is measured by how long it takes persisted sound to decrease by 60 dB.

- One can predict this value by measuring the room itself (Gault Recital Hall).

$$RT_{60} = 0.049\frac{V_R}{A_t}$$

$$A_t = S_1\alpha_1 + S_2\alpha_2 + S_3\alpha_3 + \ldots + S_n\alpha_n$$

Measuring Reverb

Materials	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	Average
Cushioned Seats	0.32	0.4	0.42	0.44	0.43	0.48	**0.415**
Wood Parquet	0.04	0.04	0.07	0.06	0.06	0.07	**0.057**
Rough Concrete	0.01	0.02	0.04	0.06	0.08	0.1	**0.052**
Plaster	0.01	0.02	0.02	0.03	0.04	0.05	**0.028**
Metal Panels	0.51	0.78	0.57	0.77	0.9	0.79	**0.72**

Table 5.1: Relevant Absorption Coefficients [33].

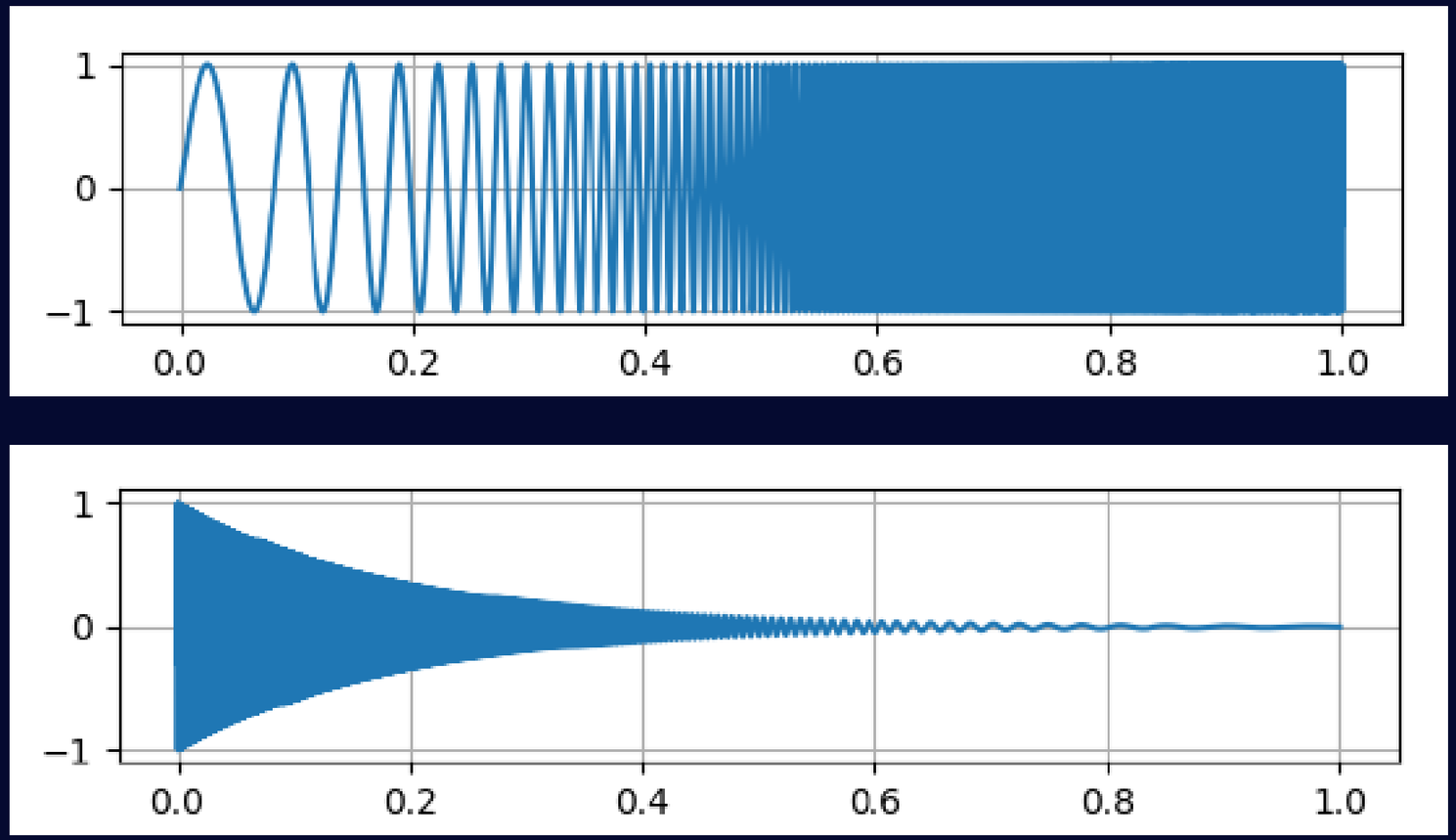
$$RT_{60} = 0.049\frac{104,609 ft^3}{4149.7}$$

$$\therefore RT_{60} = 1.23s$$

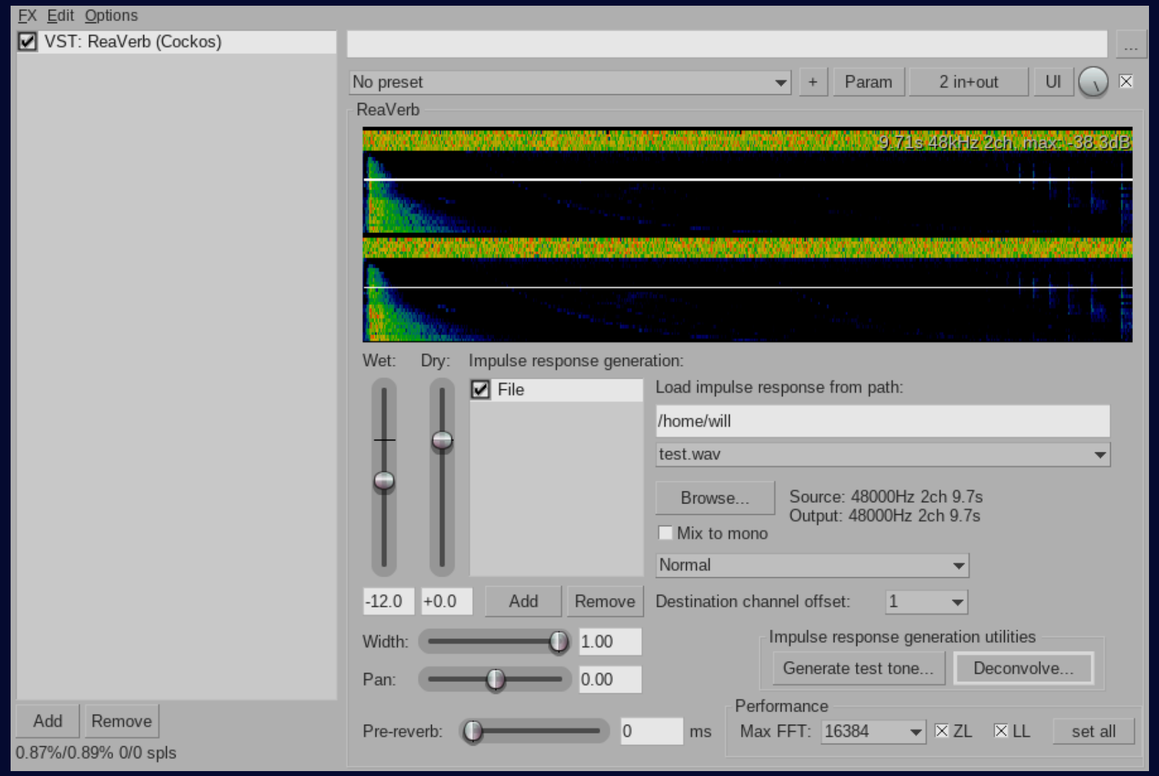
$$A_t = \underbrace{2360.3ft^2 \cdot 0.415}_{\text{Audience Floor}} + \underbrace{1473.75ft^2 \cdot 0.057}_{\text{Stage Floor}} + \underbrace{4953.3ft^2 \cdot 0.052}_{\text{Audience Walls}} + \underbrace{2431ft^2 \cdot 0.028}_{\text{Stage Walls}} + \underbrace{3834.1ft^2 \cdot 0.72}_{\text{Ceiling}}$$

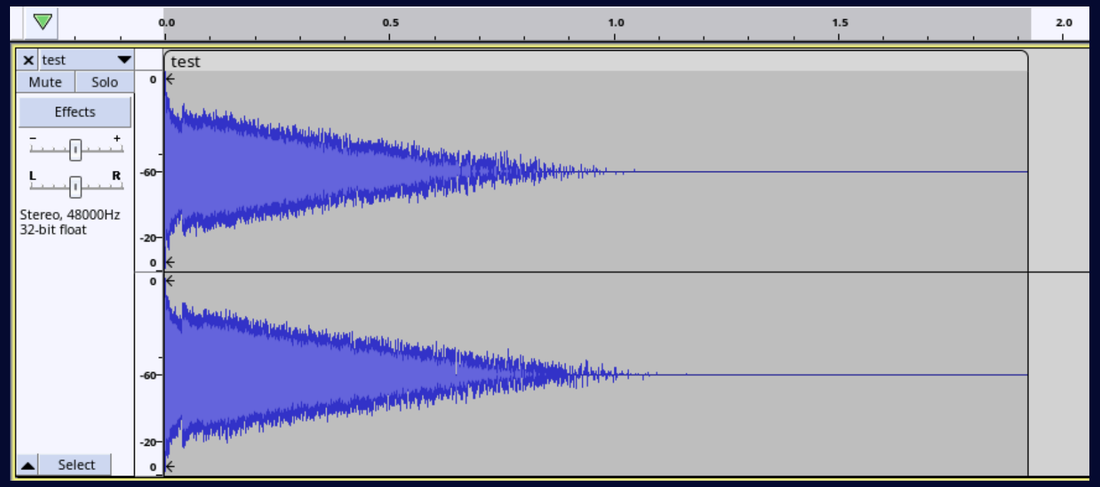
$$A_t = 4149.7 \text{ sabins}$$

Measuring Reverb



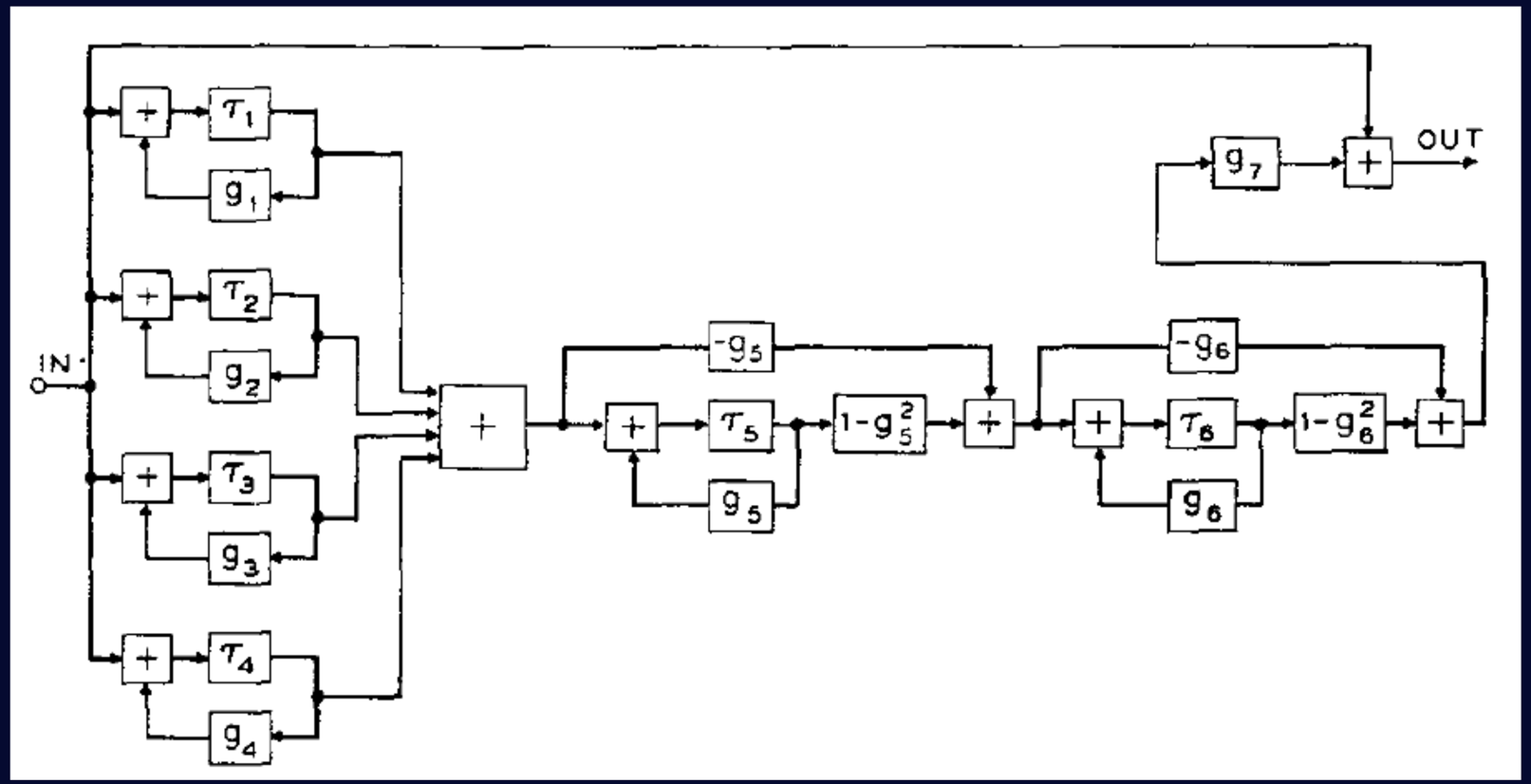
Measuring Reverb



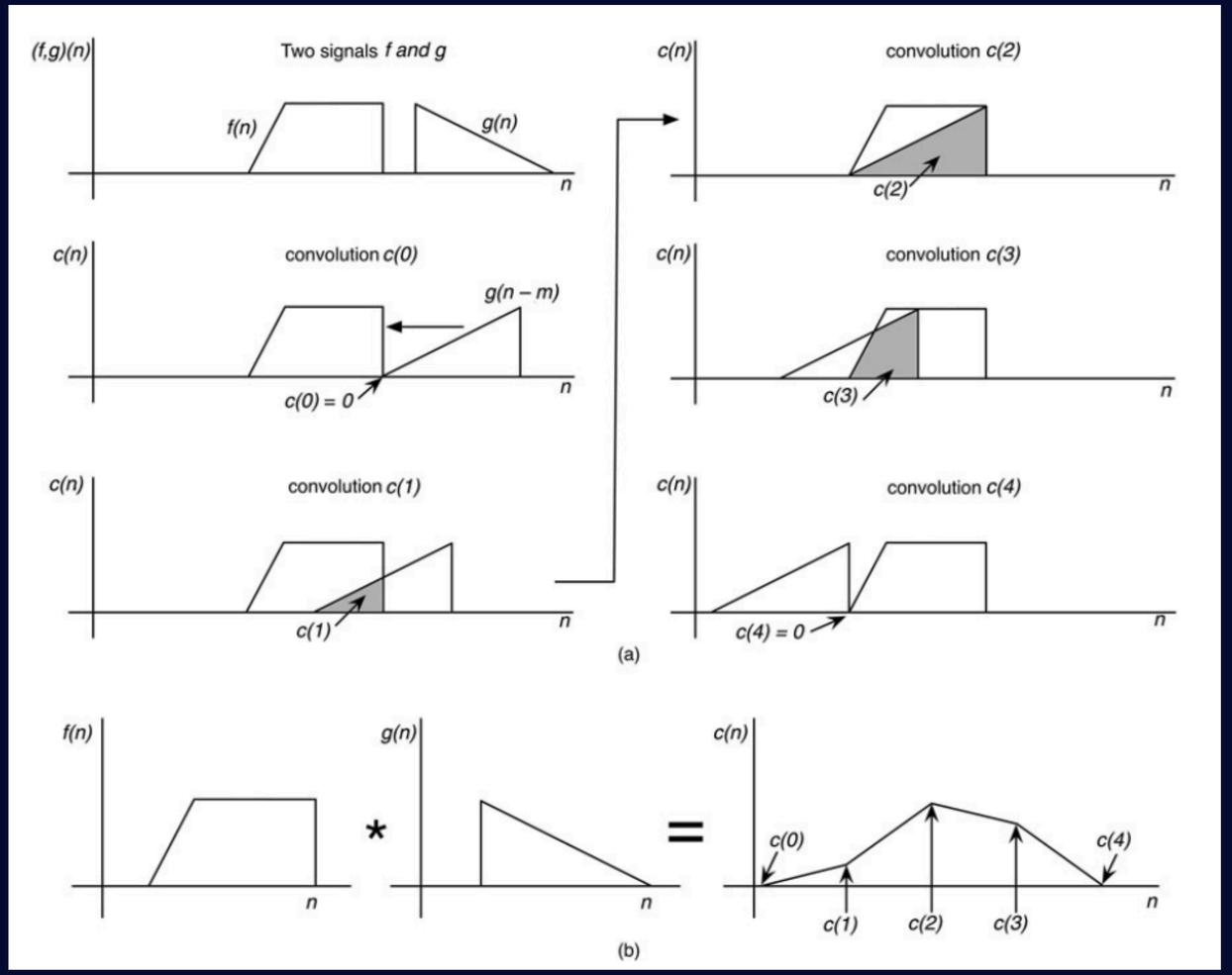


The Code

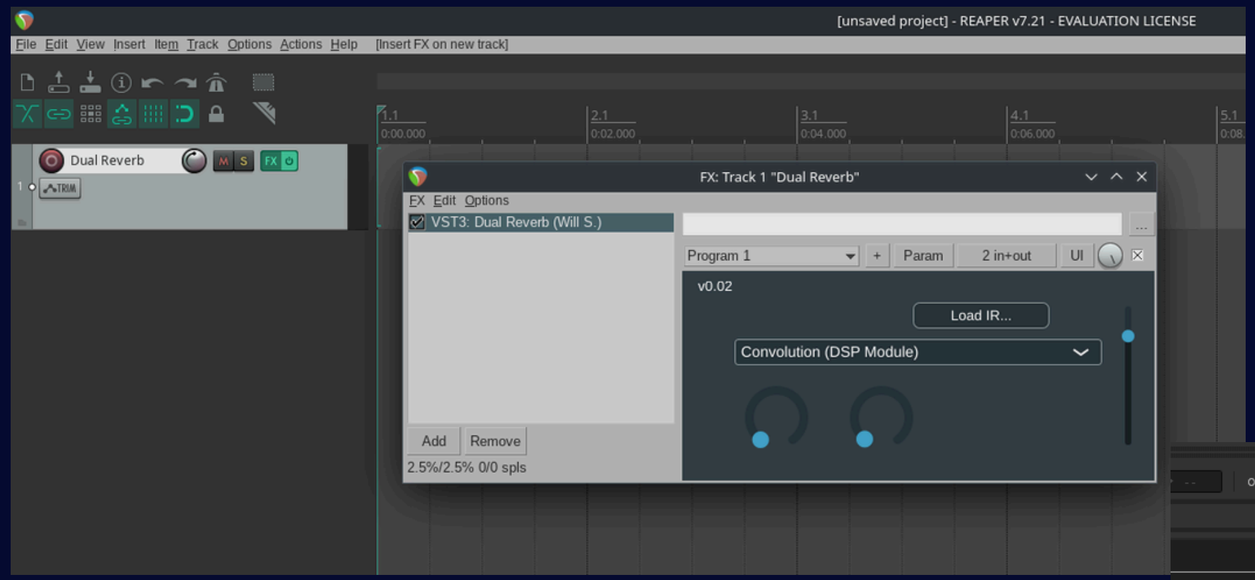
The Code

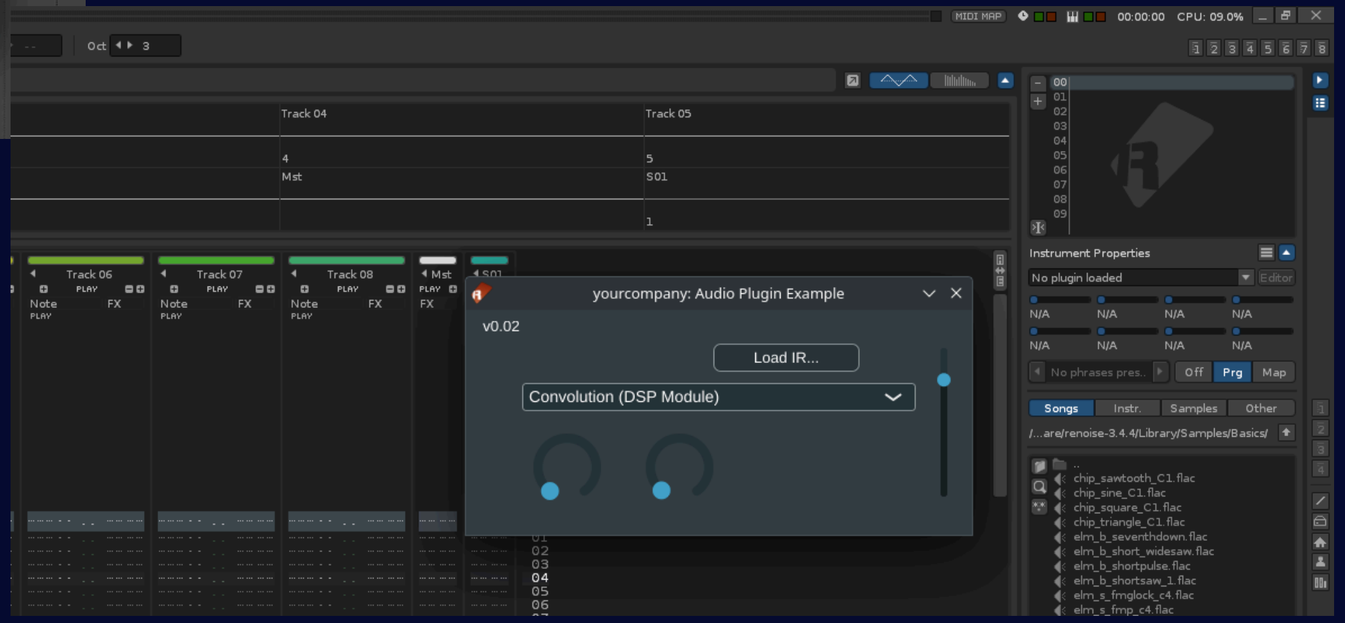

IN
+
τ_1
g_1
τ_2
g_2
τ_3
g_3
τ_4
g_4
$-g_5$
τ_5
g_5
$1-g_5^2$
$-g_6$
τ_6
g_6
$1-g_6^2$
g_7
OUT

The Code

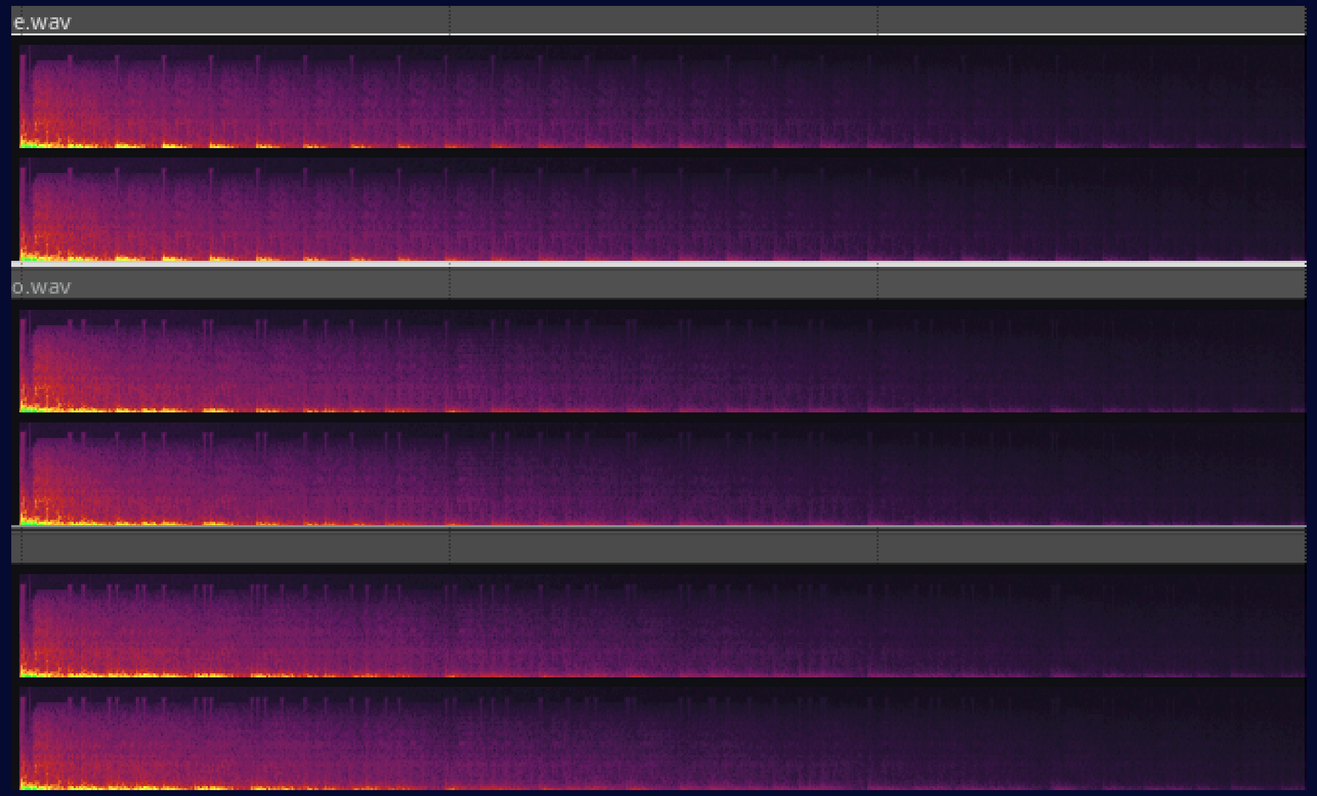

(f,g)(n)
Two signals f and g
f(n)
g(n)
n
c(n)
convolution c(2)
c(2)
convolution c(0)
g(n – m)
c(0) = 0
convolution c(3)
c(3)
convolution c(1)
c(1)
convolution c(4)
c(4) = 0
(a)
f(n)
g(n)
*
=
c(0)
c(1)
c(2)
c(3)
c(4)
(b)

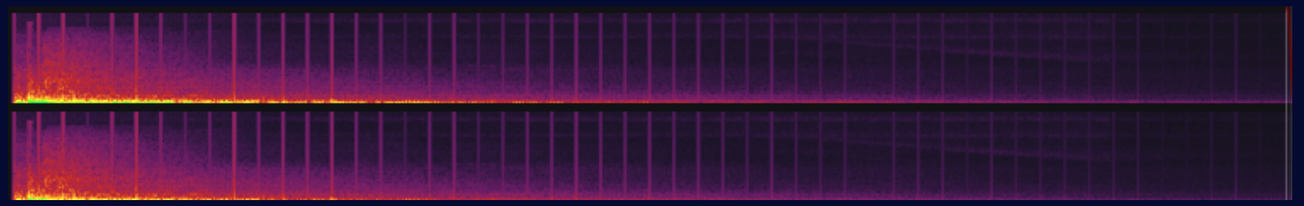
The Code


[unsaved project] - REAPER v7.21 - EVALUATION LICENSE
File Edit View Insert Item Track Options Actions Help [Insert FX on new track]
Dual Reverb
FX: Track 1 "Dual Reverb"
FX Edit Options
VST3: Dual Reverb (Will S.)
Program 1
Param
2 in+out
UI
v0.02
Load IR...
Convolution (DSP Module)
Add
Remove
2.5%/2.5% 0/0 spls


Track 04
Track 05
Track 06
Track 07
Track 08
yourcompany: Audio Plugin Example
v0.02
Load IR...
Convolution (DSP Module)
Instrument Properties
No plugin loaded
chip_sawtooth_C1.flac
chip_sine_C1.flac
chip_square_C1.flac
chip_triangle_C1.flac
elm_b_seventhdown.flac
elm_b_short_widesaw.flac
elm_b_shortpulse.flac
elm_b_shortsaw_1.flac
elm_s_fmglock_c4.flac
elm_s_fmp_c4.flac

The Code





Future Work

- Exploring Different Algorithms (FDN).
- Creating more efficient code that relies less on JUCE.
- Use these sample principles to create different effects.

Thank You!