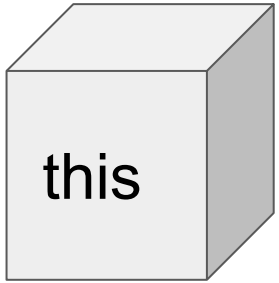
Digital Supersaw Synthesizer

Jacob Brown + Isabelle Liu
6.111 Fall 2018

Korg PS-3300 (1977-1981)

Yamaha DX7 (1983-1989)

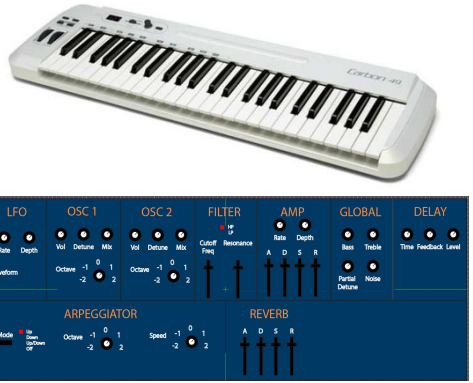
Roland JP-8000 (1996-2001)



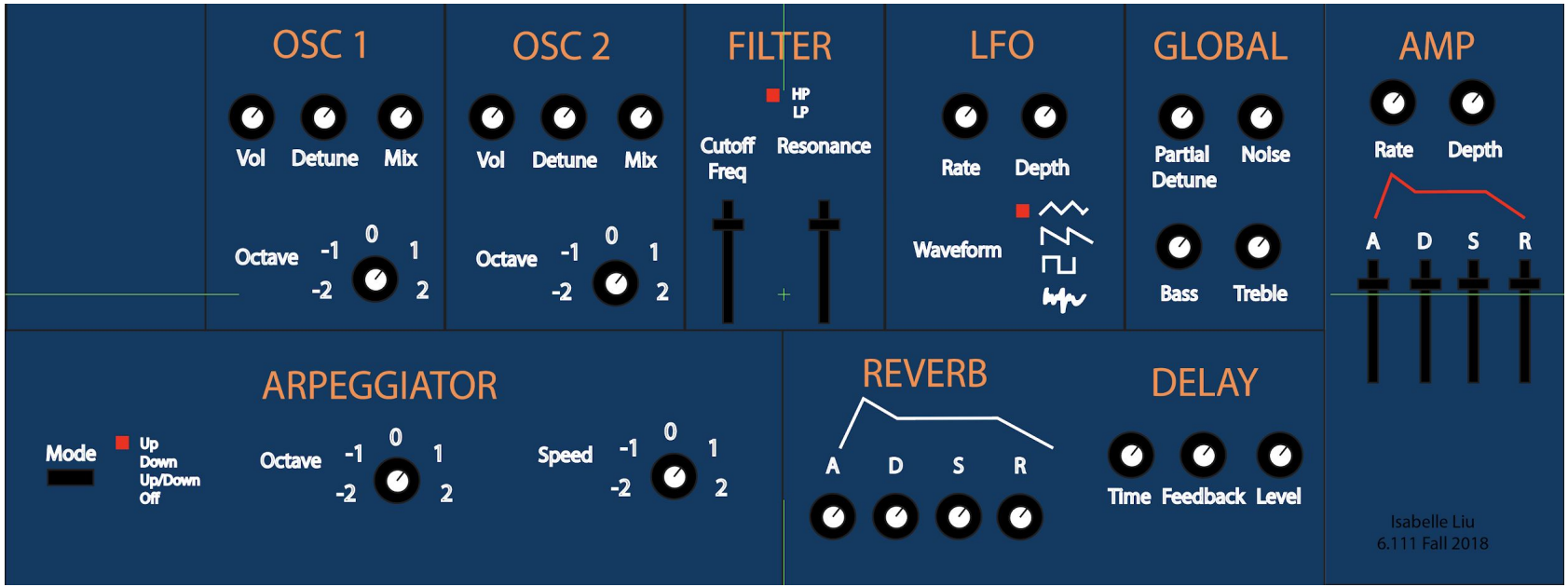
(2018)

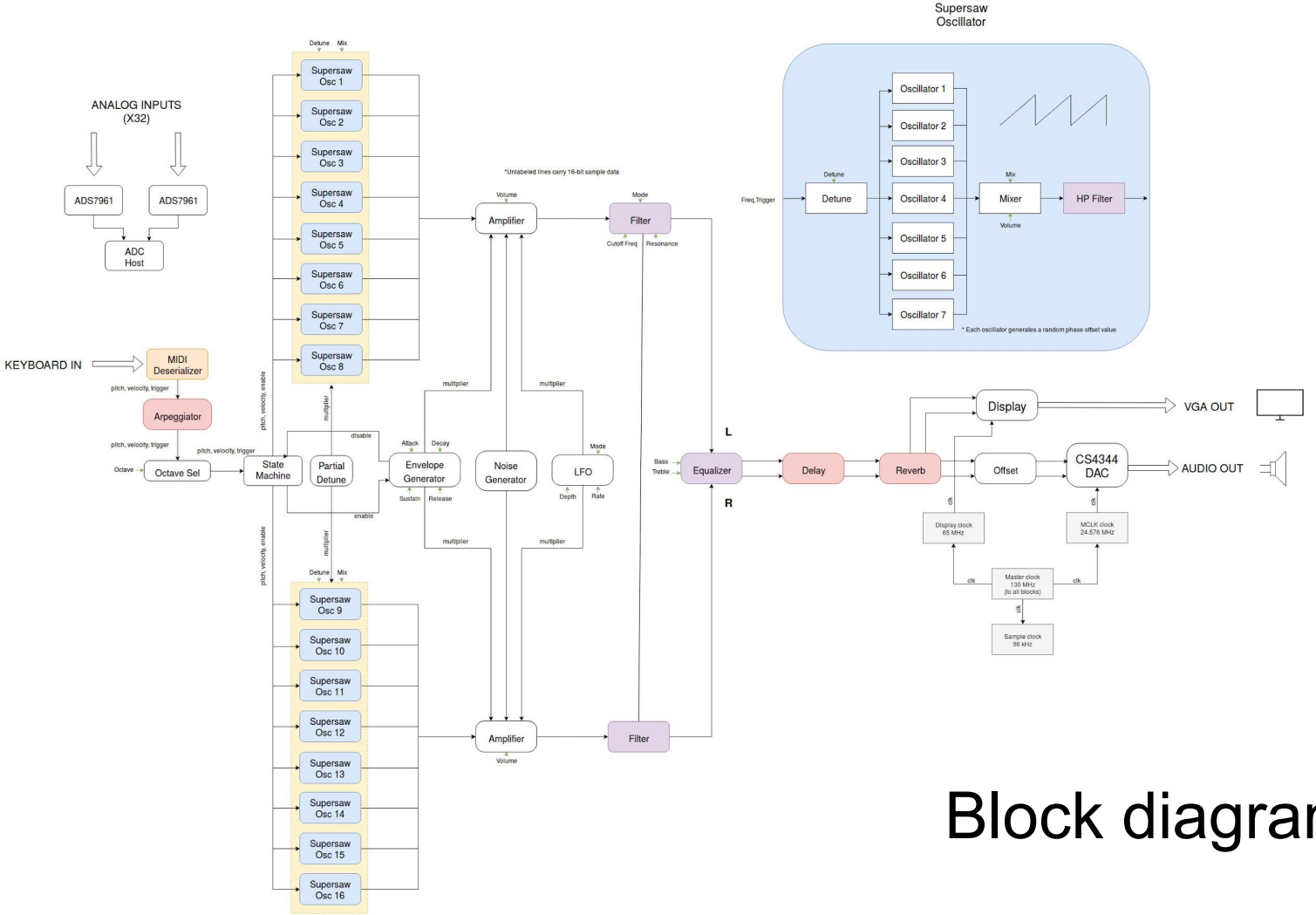
Overview

- Supersaw sound: popular in EDM (hardcore, trance)
- Serial data input from USB MIDI keyboard (laptop for handshaking)
- Up to 112 concurrent free-running sawtooth oscillators
- Analog instrument panel + Verilog DSP + Display

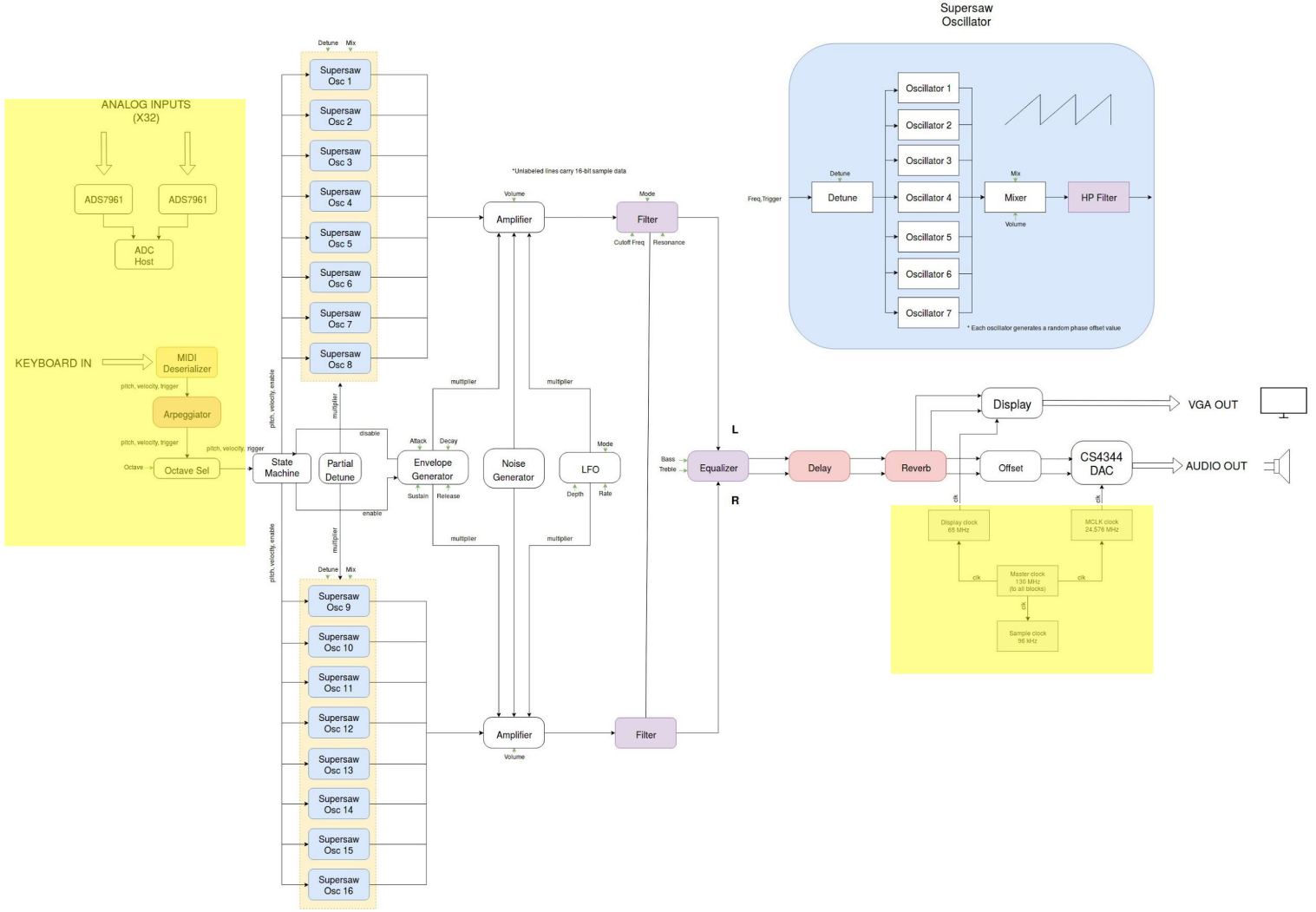


Analog control panel

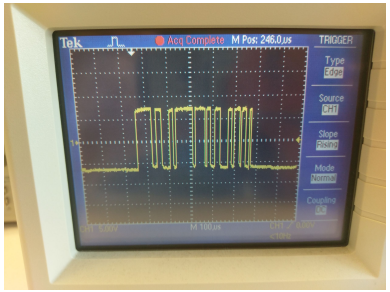


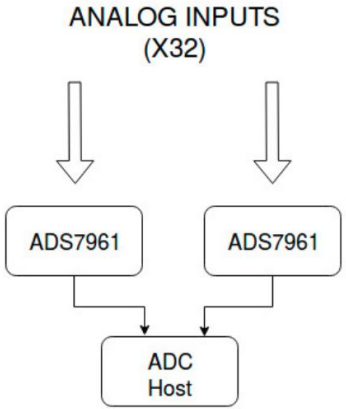


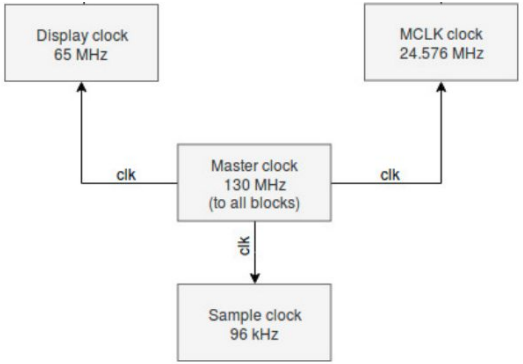
Block diagram

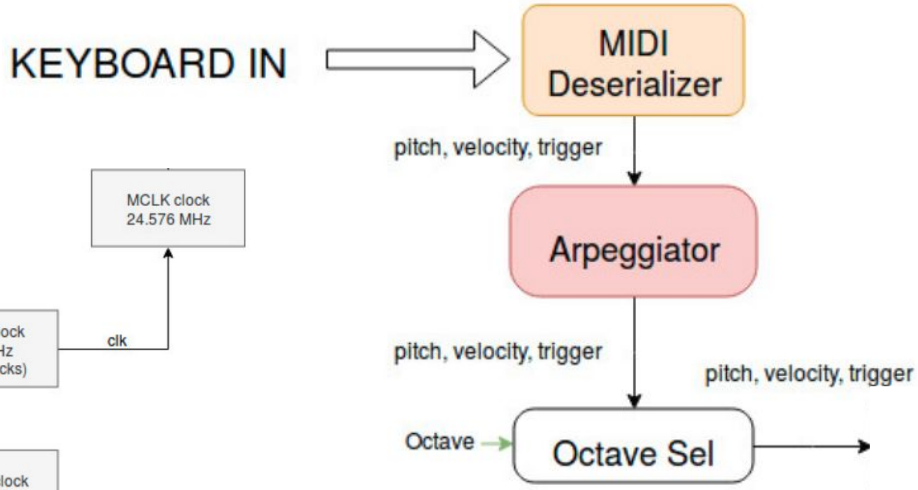

Supersaw Oscillator
ANALOG INPUTS (X32)
ADS7961
ADS7961
ADC Host
KEYBOARD IN
MIDI Deserializer
pitch, velocity, trigger
Arpeggiator
pitch, velocity, trigger
Octave
Octave Sel
pitch, velocity, trigger
Detune
Mix
Supersaw Osc 1
Supersaw Osc 2
Supersaw Osc 3
Supersaw Osc 4
Supersaw Osc 5
Supersaw Osc 6
Supersaw Osc 7
Supersaw Osc 8
*Unlabeled lines carry 16-bit sample data
Volume
Amplifier
Mode
Filter
Cutoff Freq
Resonance
Oscillator 1
Oscillator 2
Oscillator 3
Oscillator 4
Oscillator 5
Oscillator 6
Oscillator 7
Freq,Trigger
Detune
Mix
Mixer
Volume
HP Filter
* Each oscillator generates a random phase offset value
pitch, velocity, enable
multiplier
disable
State Machine
Partial Detune
Attack
Decay
Envelope Generator
Sustain
Release
Noise Generator
LFO
Depth
Rate
enable
Supersaw Osc 9
Supersaw Osc 10
Supersaw Osc 11
Supersaw Osc 12
Supersaw Osc 13
Supersaw Osc 14
Supersaw Osc 15
Supersaw Osc 16
Bass
Treble
Equalizer
L
R
Delay
Reverb
Display
Offset
CS4344 DAC
VGA OUT
AUDIO OUT
Display clock 65 MHz
MCLK clock 24.576 MHz
Master clock 130 MHz (to all blocks)
clk
Sample clock 96 kHz

Input Modules

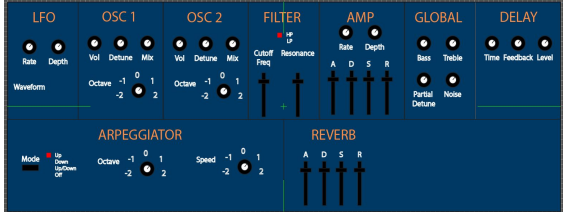


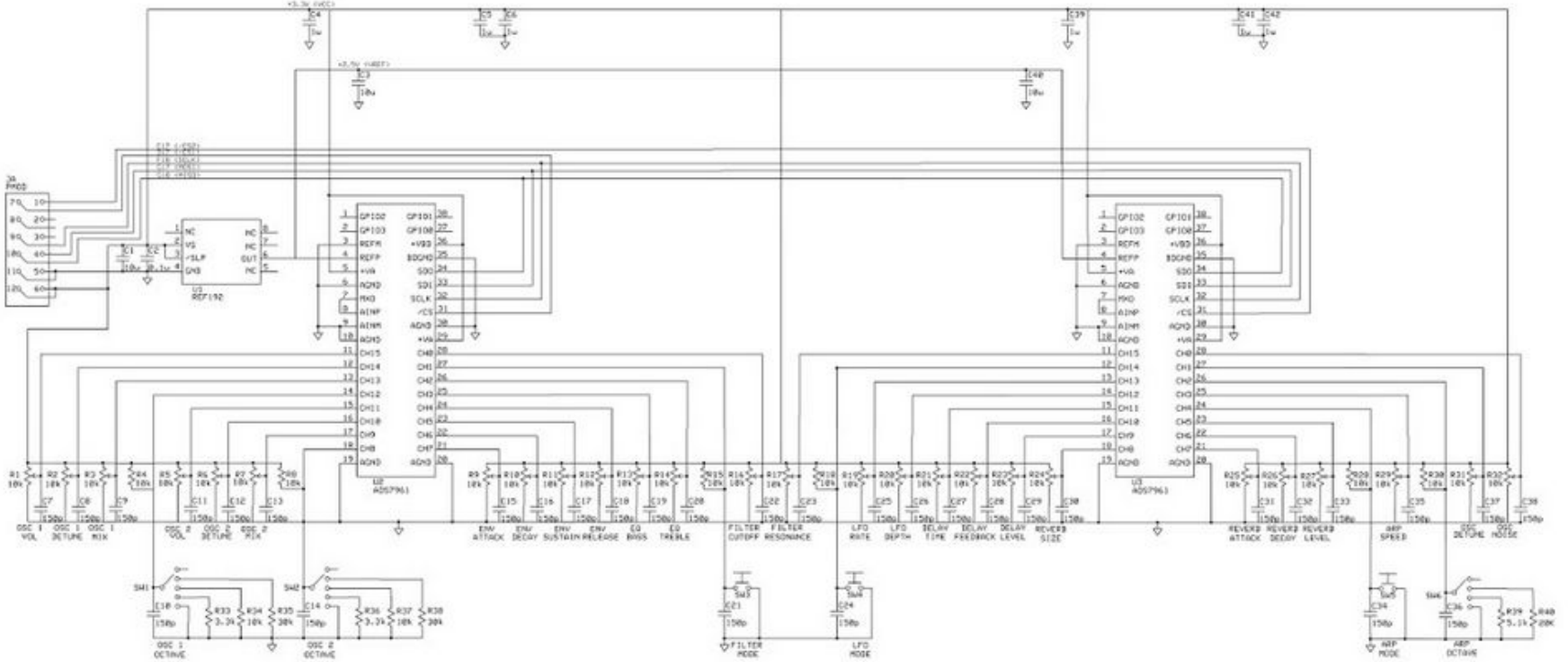


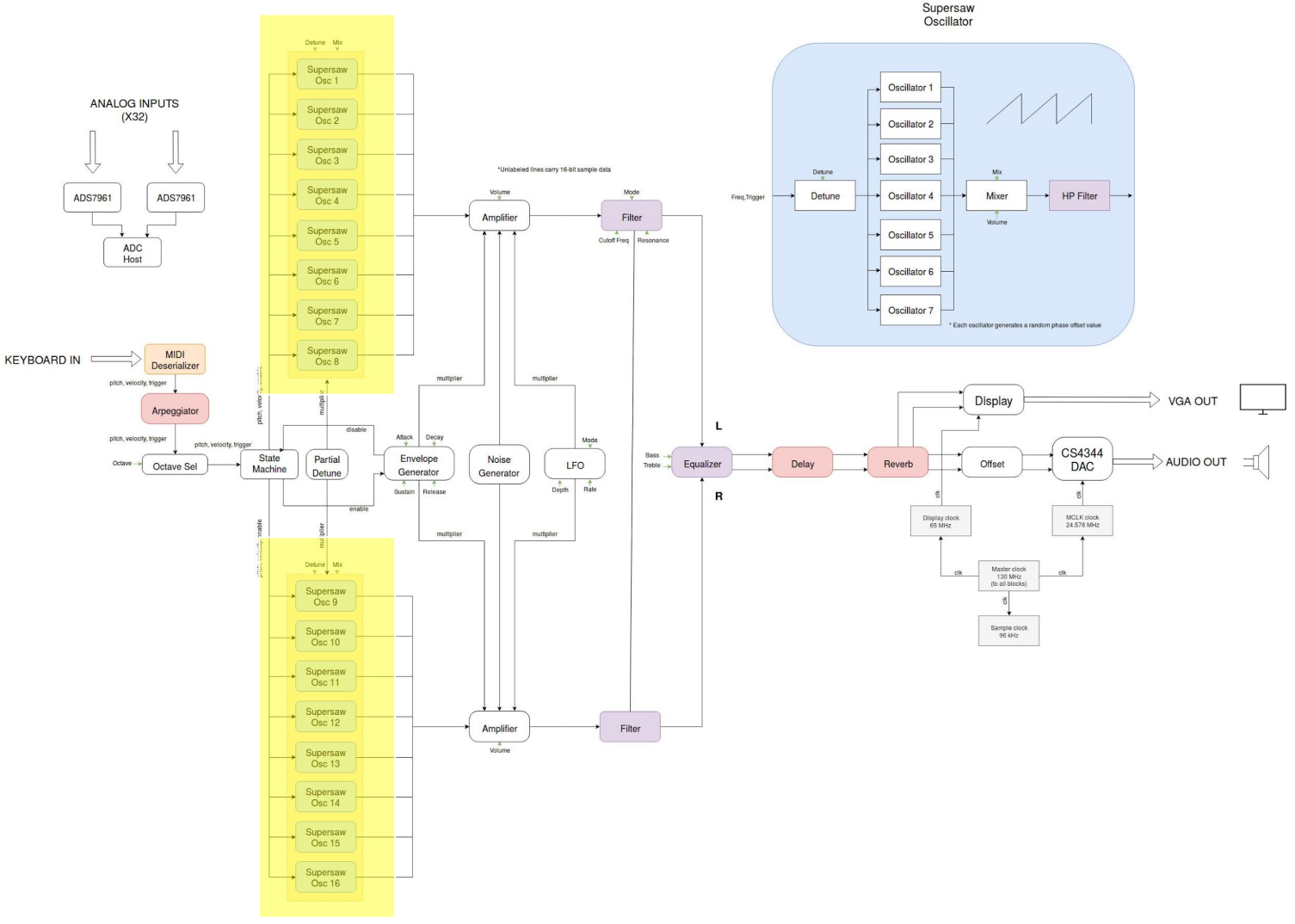




ADC (2x ADS7961)






Supersaw Oscillator
ANALOG INPUTS (X32)
ADS7961
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ADC Host
KEYBOARD IN
MIDI Deserializer
pitch, velocity, trigger
Arpeggiator
Octave
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Attack
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Release
Noise Generator
LFO
Mode
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Supersaw Osc 1
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Resonance
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Detune
Oscillator 1
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Mix
Mixer
HP Filter
* Each oscillator generates a random phase offset value
L
R
Bass
Treble
Equalizer
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Display
VGA OUT
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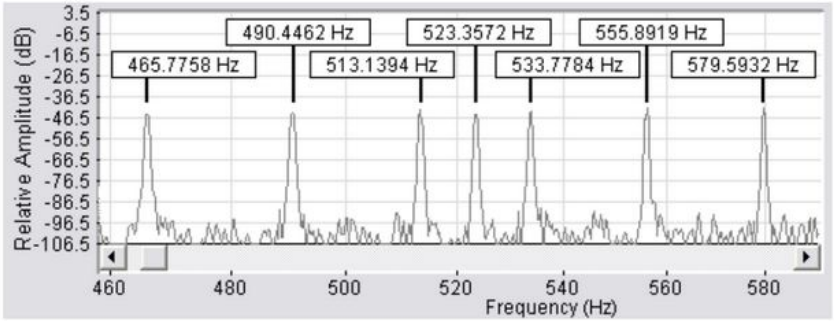
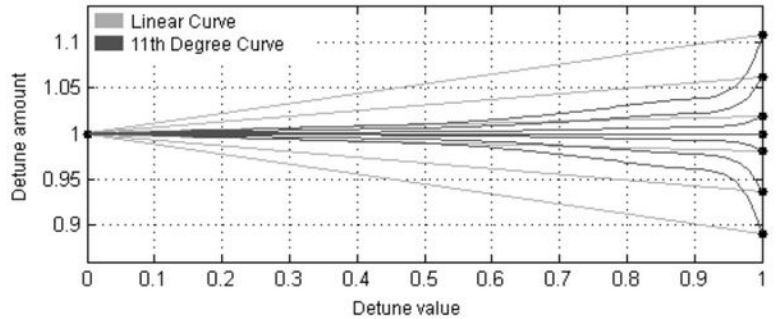
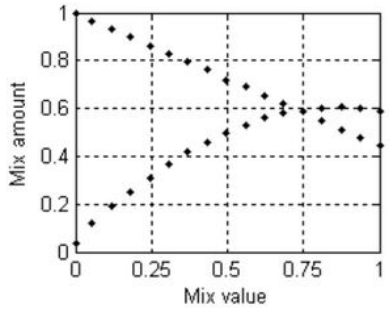
Display clock 65 MHz
MCLK clock 24.576 MHz
Master clock 130 MHz (to all blocks)
Sample clock 96 kHz

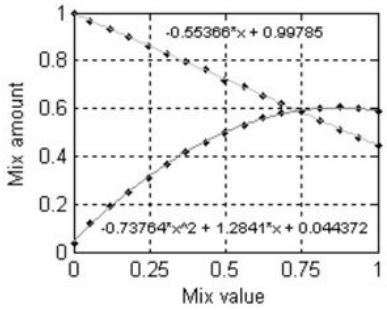
The Supersaw Algorithm

To represent a single note, seven sawtooth waves with random phase offset are superimposed and sent through a high-pass filter whose cutoff frequency tracks the fundamental frequency. The frequency of the center saw corresponds to the fundamental, while the other six saws are detuned according to a variable ratiometric spread. The spread control was found to follow an 11th order polynomial. Control of the mix ratio between center and side oscillators is also non-linear. [1]



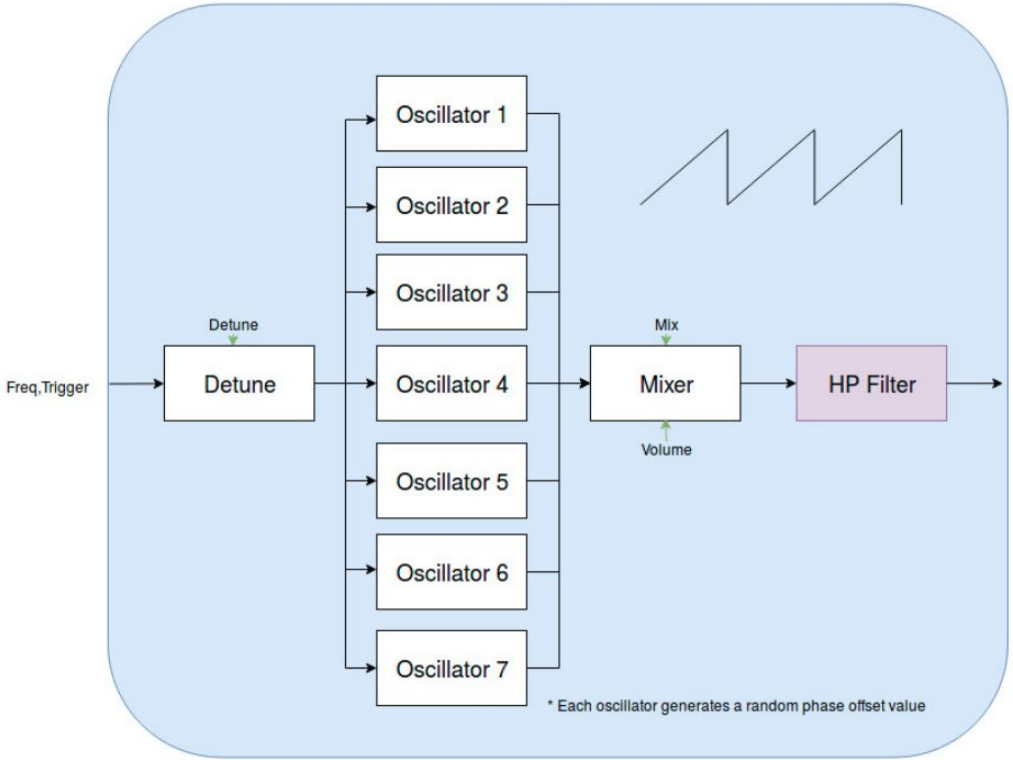


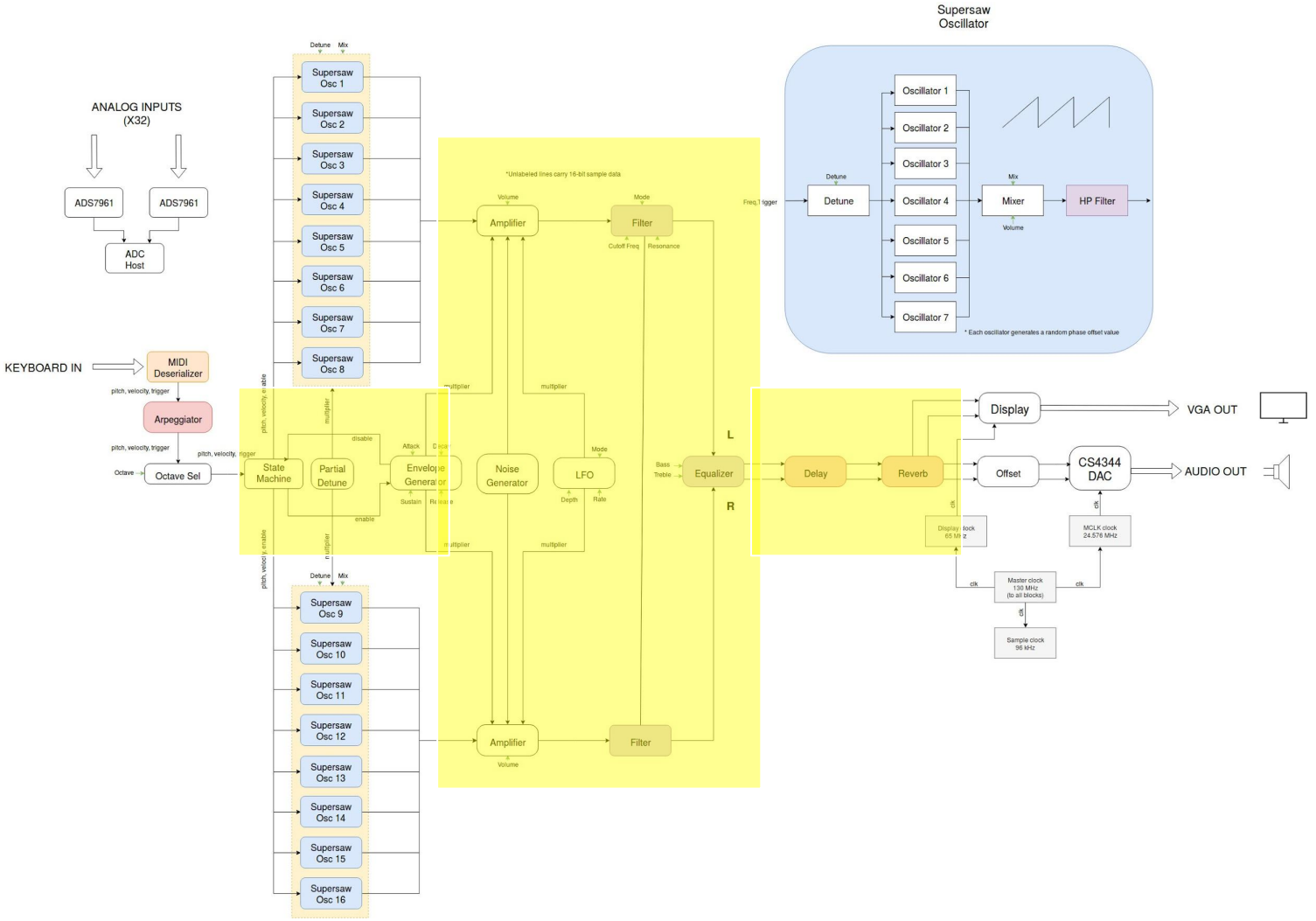




(1) https://www.nada.kth.se/utbildning/grukth/exjobb/rapportlistor/2010/rapporter10/szabo_adam_10131.pdf

Supersaw module

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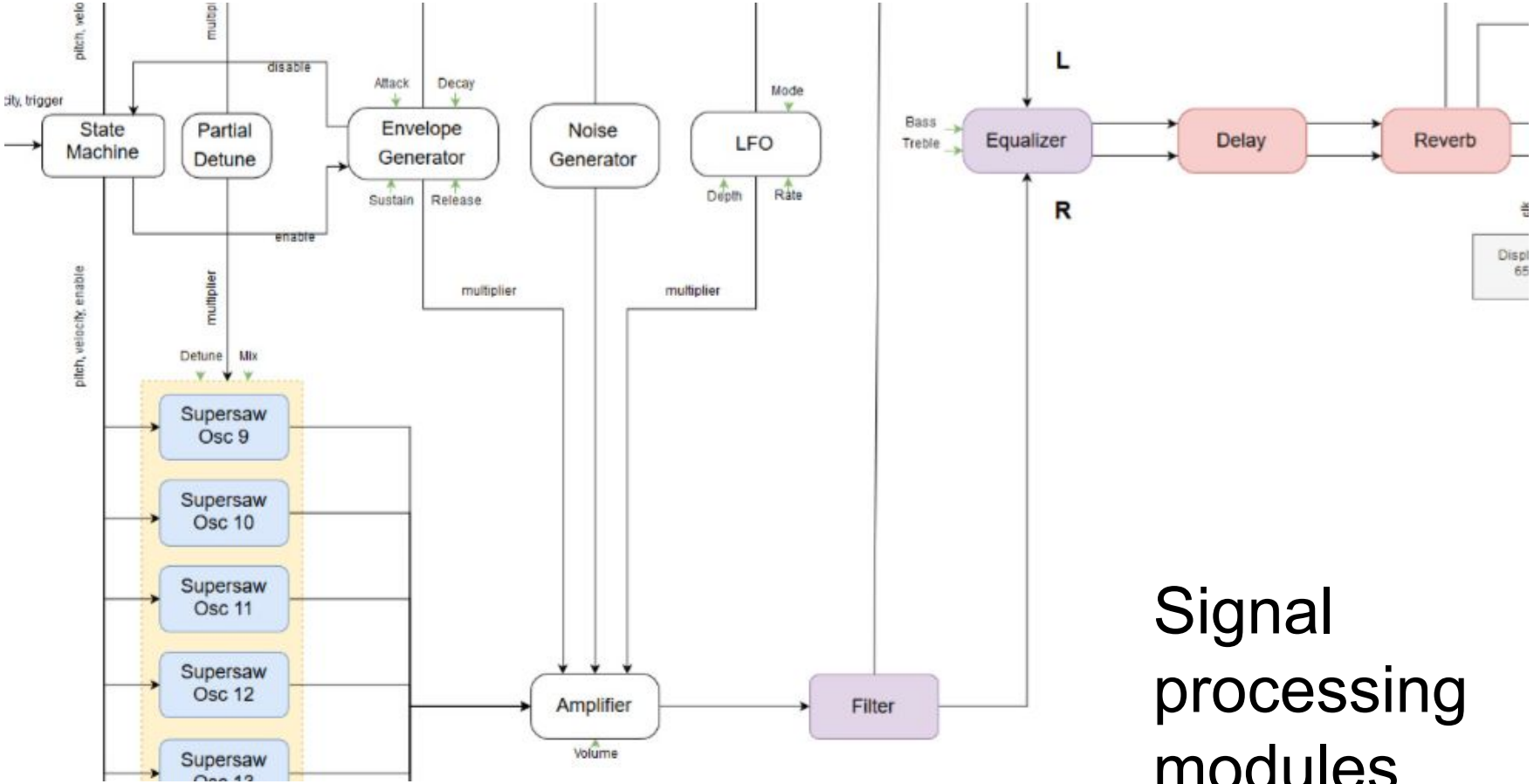
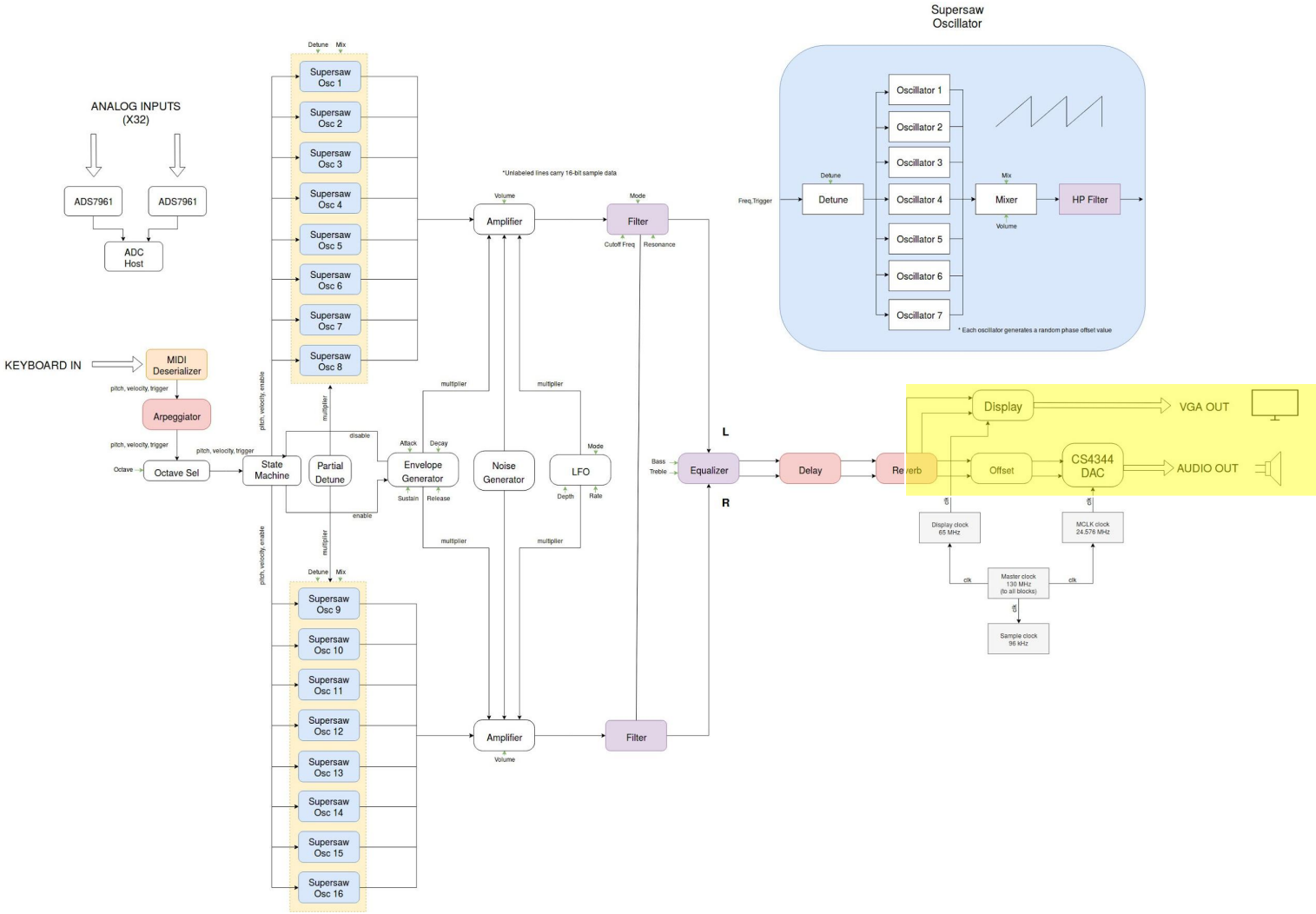


Signal processing modules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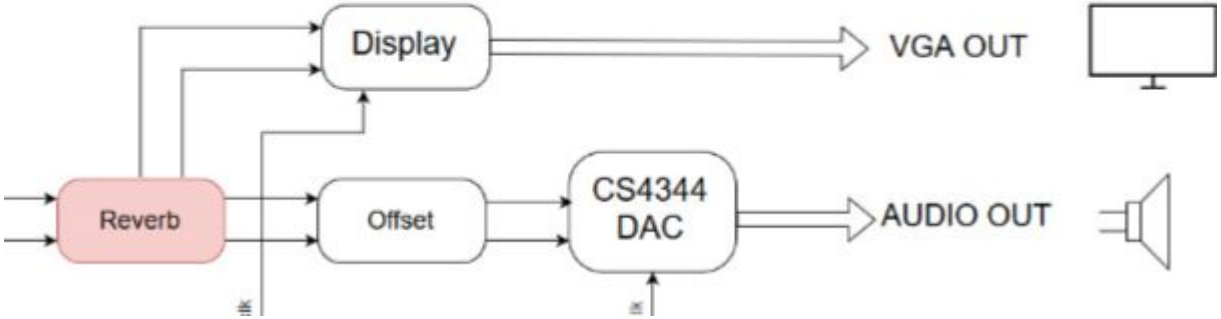
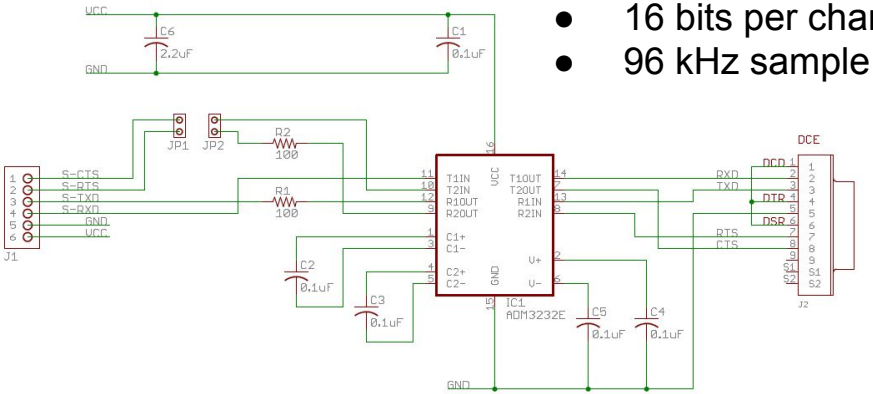
Output modules



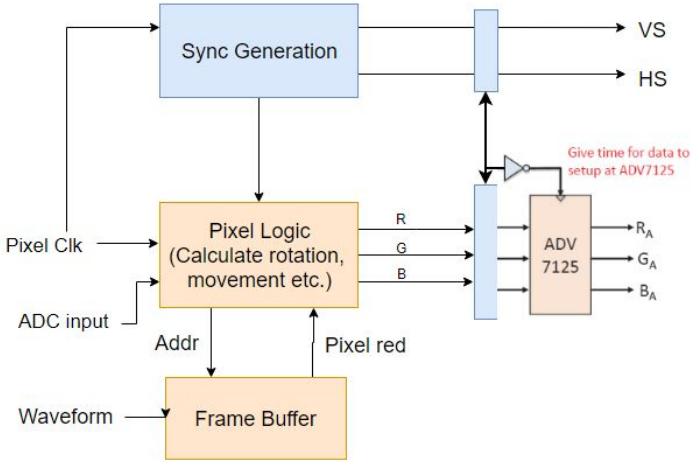
Audio Output (DAC)

- 2 channels
- 16 bits per channel
- 96 kHz sample rate



VGA Output (Display)

- Top half : waveforms
- Bottom half : controls



Commitment

The commitment goal includes everything needed to hear the basic Supersaw waveform in stereo and monitor it with the display. The following modules apply to this level: **ADS7961 ADC**, **ADC Host**, **Deserializer**, **State Machine**, **Oscillator**, **Supersaw** (to be further subdivided), **Amplifier**, **Offset**, **CS4344 DAC**, and **Display**.

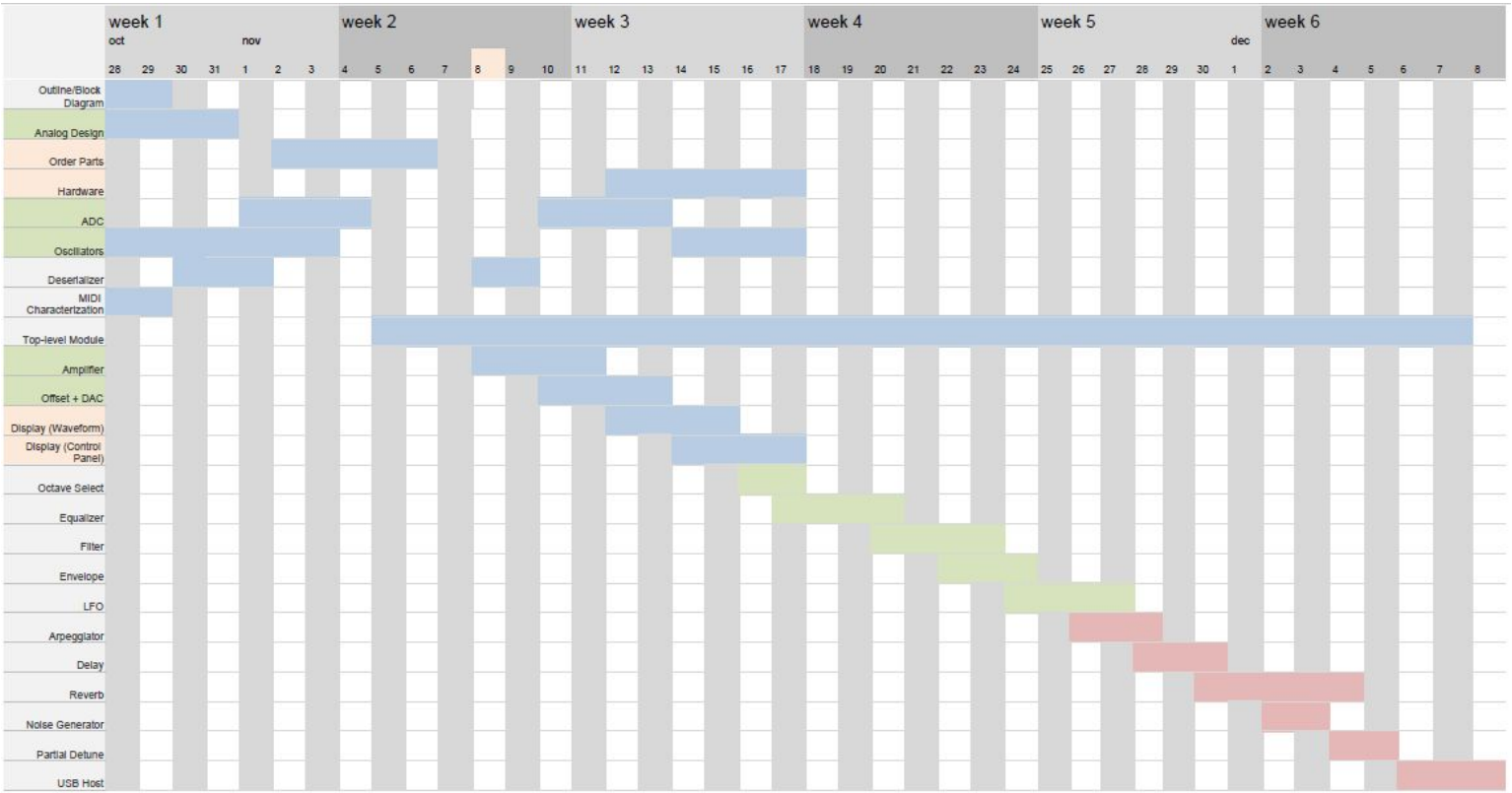
Goal

The primary goal includes the commitment modules plus the **Octave Select**, **Equalizer**, **Filter**, **Envelope**, and **LFO** modules. This represents what we believe to be the most useful addons to the core of the project.

Stretch

The stretch goal includes all of the above plus the **Arpeggiator, Delay, Reverb, Noise Generator**, **Partial Detune,** and **USB Host** modules. These are features that have the potential to create the richest, most pleasing musical palette but which have an uncertain requirement on time investment.

Timeline


week 1
week 2
week 3
week 4
week 5
week 6
oct
nov
dec
28 29 30 31 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 1 2 3 4 5 6 7 8
Outline/Block Diagram
Analog Design
Order Parts
Hardware
ADC
Oscillators
Deserializer
MIDI Characterization
Top-level Module
Amplifier
Offset + DAC
Display (Waveform)
Display (Control Panel)
Octave Select
Equalizer
Filter
Envelope
LFO
Arpeggiator
Delay
Reverb
Noise Generator
Partial Detune
USB Host

Questions?