Northeastern University
College of Engineering

SoundLab
Analog Synth

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Big Picture

SoundLab is an analog subtractive synthesizer, which was designed as an approachable learning playground for novice sound designers and aspiring electronic musicians.

Many newcomers to the field of subtractive sound synthesis face overwhelming terminology, complex interfaces, and prohibitive costs exceeding $500 for a beginner instrument. Perhaps even worse, becoming comfortable with synthesizers traditionally relies on trial and error purely by ear, which makes the process slow and confusing.

SoundLab offers an alternative. The combination of visual feedback, savable configurations, and hands-on interaction with genuine analog circuits provides a multisensory educational experience that effectively demystifies subtractive synthesis principles for beginners, potentially inspiring a new generation of electronic musicians and sound engineers.

Subtractive Synthesis



Oscillator
Generates the signal, user can control the wave shape and frequency

Filter
Shapes the sound, usually a low pass filter with adjustable cutoff frequency

Amplifier
Amplifies the signal to an audible, can be shaped by an ADSR envelope

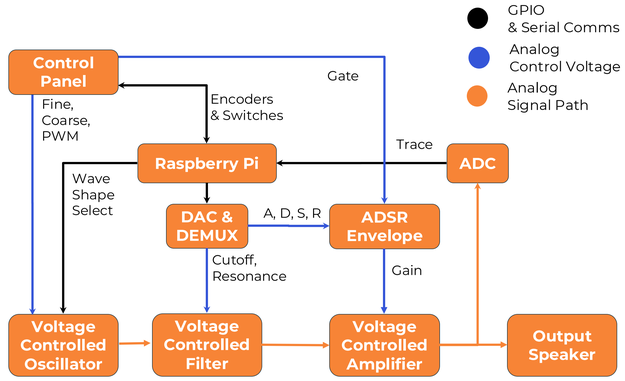
Key Features

Analog Sound
Authentic subtractive synthesis sound

Taste of Modular
Implements modules used in commercial synths to familiarize with workflow

ADC Trace
Traces the output signal in real time to build visual intuition

Presets
Has a collection of presets that allows for ease of use and sound design learning

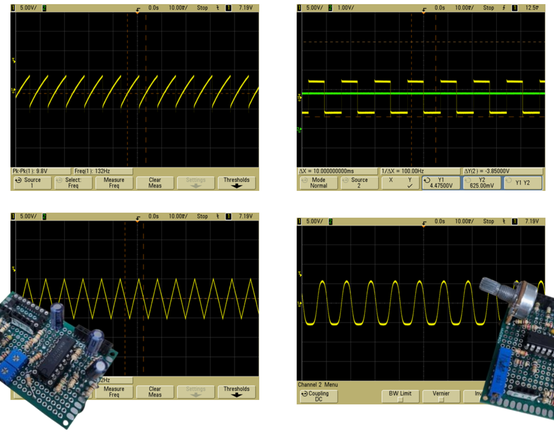


SoundLab is a fixed-architecture synth with a set of modules based on industry-grade chips. The analog signal path begins with a voltage-controlled oscillator (VCO) extended with a custom triangle-to-sine waveshaper. After passing through a multiplexer, a user-selected signal then feeds into a low pass voltage-controlled filter (VCF) with adjustable cutoff and resonance parameters. Finally, the signal passes through a voltage-controlled amplifier (VCA) managed by an ADSR envelope generator. The entire signal path is analog, preserving the characteristic "warm" analog sound.

VCO & Waveshaper

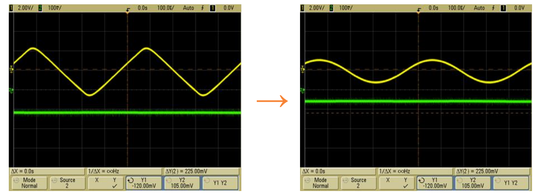
CEM3340 core
Outputs PWM-controlled square wave, triangle and sawtooth wave

Diff Pair Sine
Differential pair (BJTs) triangle-to-sine waveshaper

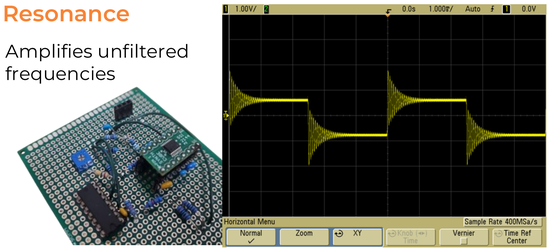


VCF & Resonance

Cutoff Frequency Control
High cutoff, harsher sound → Low cutoff, softer sound



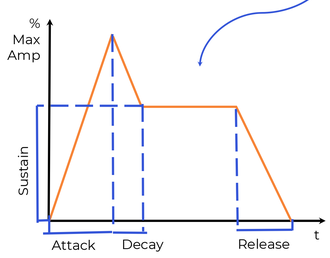
Resonance
Amplifies unfiltered frequencies

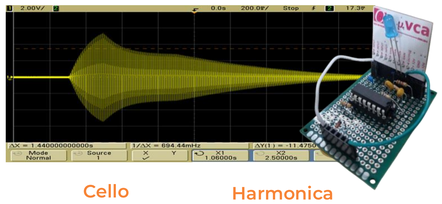


VCA & ADSR Envelope

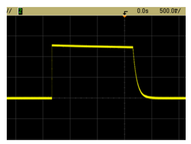
Key-Press Response
Allows to shape how the sound amplitude changes over time after a key is pressed

ADSR Envelope
Very common module in the industry, automates control of amplitude after a key press

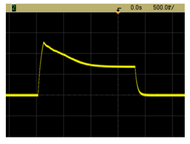




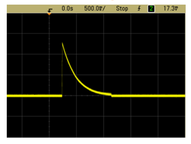
Cello



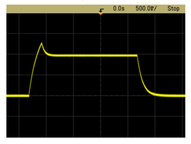
Harmonica



Banjo



Synth

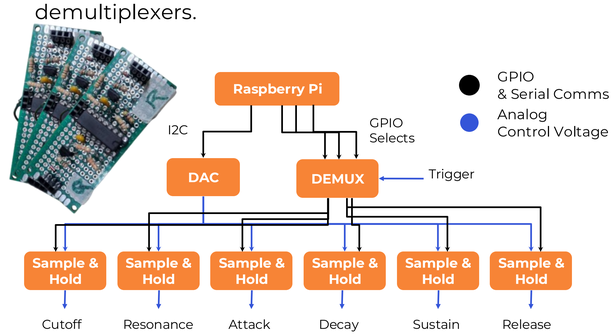


Budget

Category	Price
Raspberry Pi	$55
Display	$60
Resistors, Capacitors, Wires	$15
Casing (3D printing, paint, knobs)	$30
Panel Controls (encoders, switches)	$57
Core Chips	$59
Auxiliary Chips	$8
Power Circuit	$68
Speaker	$30
TOTAL	**$382**

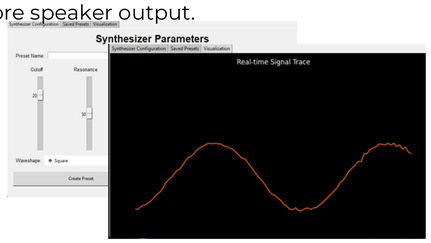
Presets

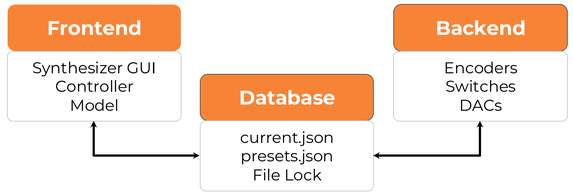
All sound-characteristic parameters are savable through a digital preset system, utilizing DAC signals and sample-hold circuits triggered via demultiplexers.



Software

The system features an interactive visual interface that displays the signal path configuration in real-time. The current configuration can be saved as a preset to be recalled and modified later. Another prominent feature is the built-in ADC oscilloscope, that visualizes the actual signal sampled right before speaker output.





Full Assembly

