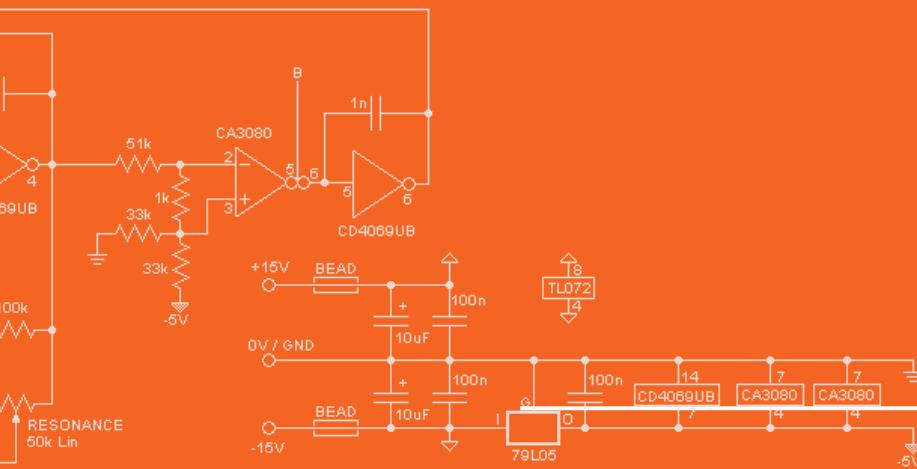
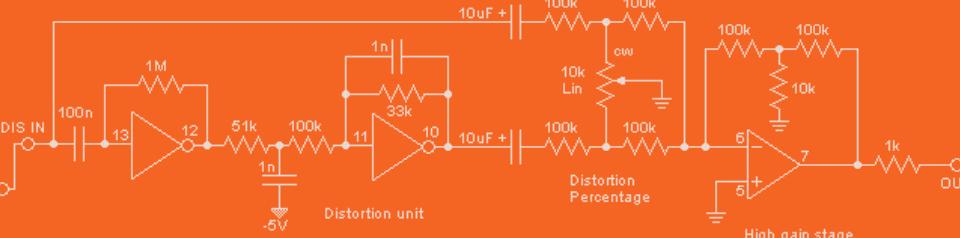


Hacking Synthesizers



Jozsef Ottucsak

Jozsef Ottucsak



Security Professional

Interested in music, DIY and creative coding

Wrote my first synthesizer in Pascal during high school

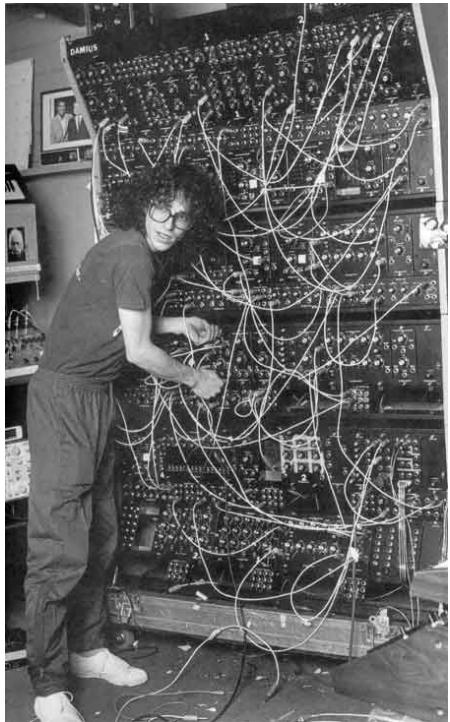
Making music since my age of 15

Got hooked after learning about hardware/IoT hacking

Key Topics

- Computers, consoles and synthesizer history
 - Interesting synthesizer hacks
 - DIY synthesizer scene
-

Synth History



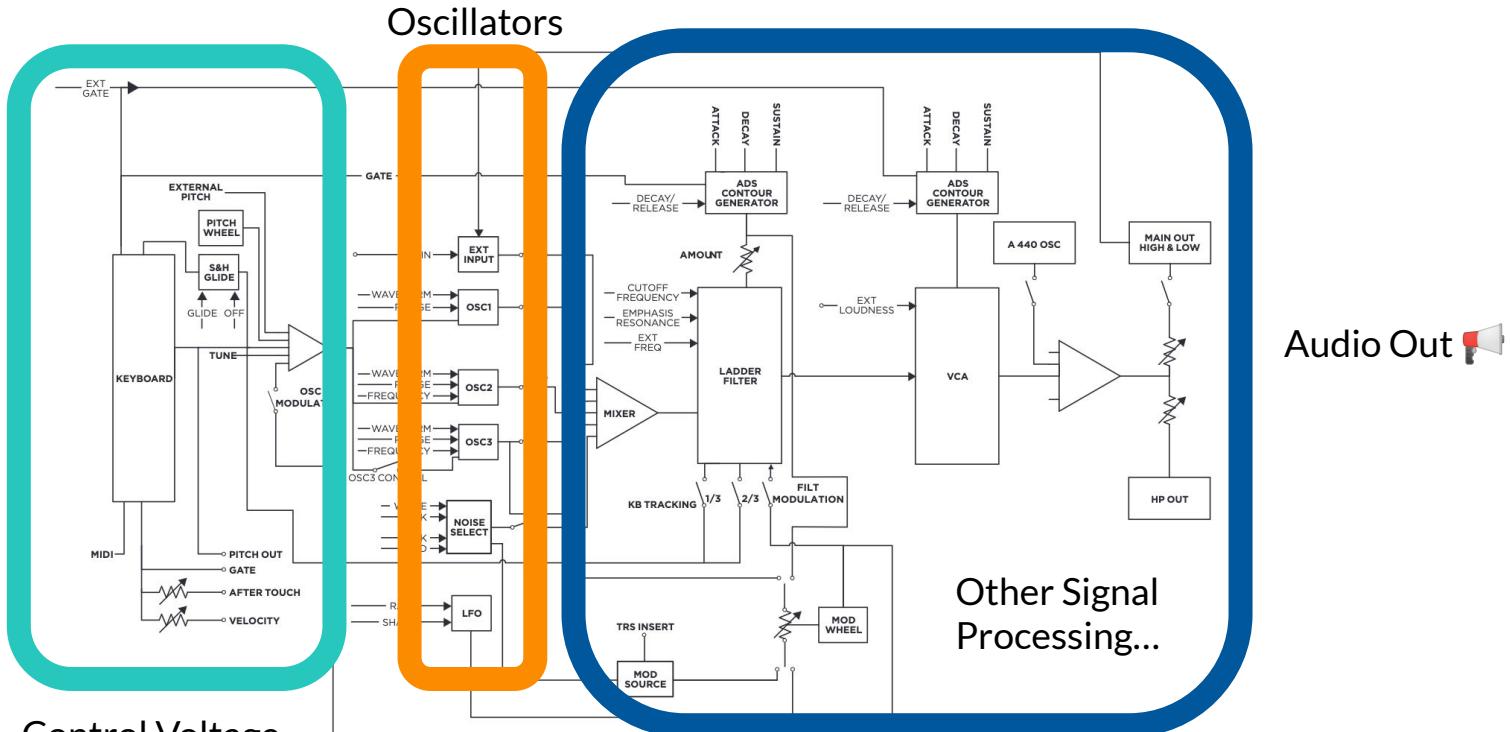
Synthesizer

"A synthesizer is an electronic musical instrument that generates sound using electronic circuits, digital signal processing, or a combination of both." - ChatGPT

In the context of this talk:

- Audio/video synthesizers and effects
- Sequencers
- Audio dev boards or computers

Analog Synthesizer Architecture



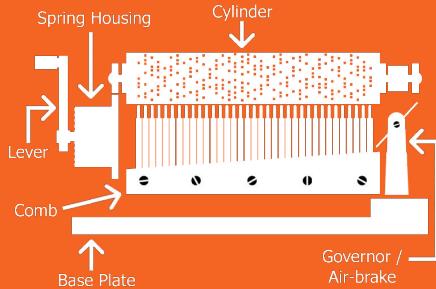
Control Voltage

Other Signal Processing...

Photo: Moog, Minimoog Model D Manual

Mechanical Synthesizers

Early "synthesizers" were physical using water, wind, etc



Phonautograph - 19th century - audio waveform is recorded

Telharmonium - 1896 - electro-mechanical synthesizer that weighs 7 tons uses gears, dynamos, broadcasted over telephone

The First Almost Synthesizers

1919+



Theremin - First "synthesizer", amplitude and frequency modulated by two antennas, created by Leon Theremin

Radio and test equipment is often repurposed for electronic sound creation by researchers and artists

Vacuum tubes made things huge

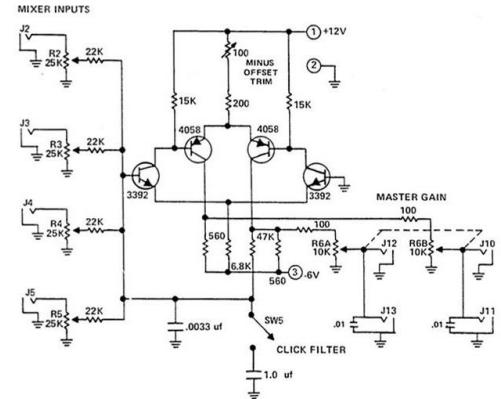
Analog Synthesizers 1960s

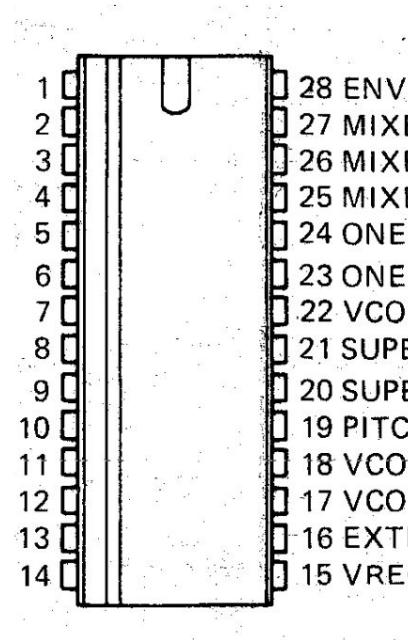
Using transistors for amplification -> circuits became smaller

Two classic "schools" of analog synthesis emerged in the USA

- West Coast - Don Buchla - experimental
- East Coast - Bob Moog - "traditional"

Everything was really expensive, hand-soldered and made to order





Programmable Sound Generators

1977

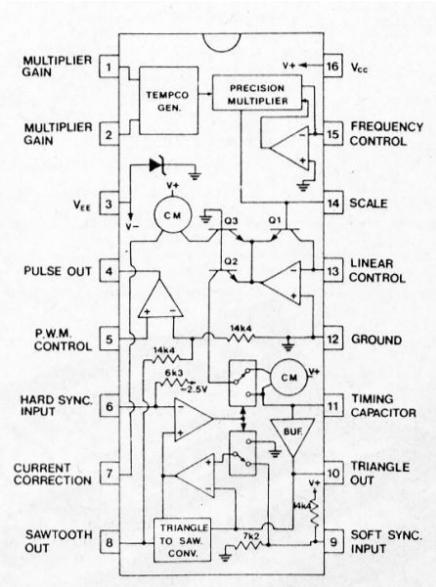
Arcade machines, game consoles, home computers

Cheap way to get acceptable quality sound

Not meant for "serious" music usage

Common config: three voices and a noise channel

Integrated Circuits for Music 1979



"Off-the-shelf" building blocks for common use cases

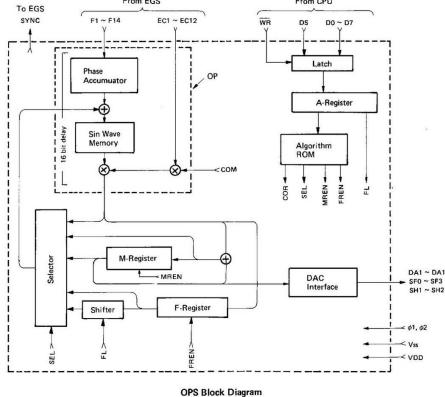
Smaller and cheaper components, "mass production" possible

Polyphony (multiple voices) made possible

Bunch of legendary synths that use IC chips:

Roland SH-101, Sequential Prophet-5 and Pro One, Fairlight CMI, II/IIX MemoryMoog, Oberheim series, PPG Wave2

Digital Renaissance Mid 80s-90s



Digital technology became affordable

First hybrids, then fully digital synthesizers

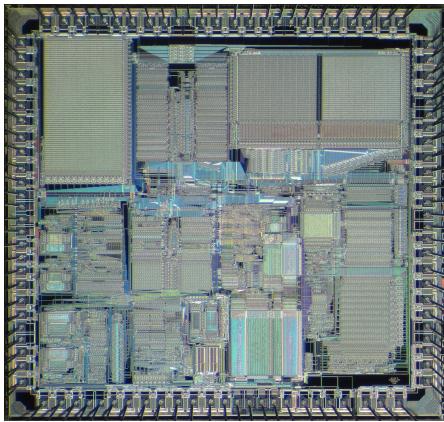
FM chips replace PSGs in consoles and computer sound cards

Japanese companies dominate the market (Korg, Roland, Yamaha)

Analog synths are sold off at rock bottom prices

Virtual Analog

Mid 90s-10s



DSP chips became affordable

Modelling is accurate, but lacks “character”

Polyphony/multitimbrality using multiple DSP chips

Emulation is now possible thanks to the community 😍

Audio Plugins Since mid 90s

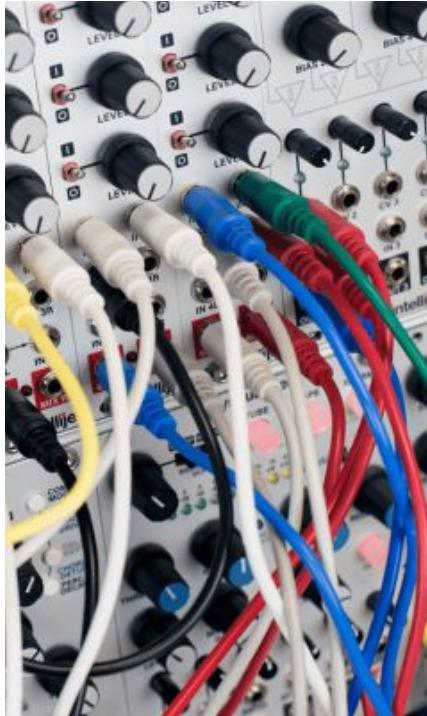


Computers became fast enough to process real-time audio

Low barrier of entry

Focus is mostly on analog emulation or flagship synths

Great FOSS synths: SurgeXT, Vital and many more



Eurorack From 1995

“Standard” for modular gear by Doepfer

Off-the-shelf, not proprietary building blocks

Became highly popular thanks to eyecandy YouTube videos

Mixture of analog, mechanical and digital modules

Big DIY community with lot of open-source modules

Analog Revival

Late 2000



Cheap, classic analog synths become popular (TB303, TRx0x)

SMD technology means lower costs and better stability

Good: affordable small analog synths

Bad: no innovation, just re-selling old circuits again and again



Farewell DSPs

👋

Mid 2010s

Manufacturers ditch DSP (\$\$\$ and lack of available talent)

Switch to ARM based MCUs (STM32, Raspberry Pi CM)

Better supply chain, lower barrier of entry

Cheaper synths, but less professional features

Running bare metal or Linux OS



Photo: Waldorf streichfett, Korg Electribe 2

<https://waldorfmusic.com/de/streichfett/>, <https://www.korg.com/us/products/dj/electribe/>

Interesting Synth Hacks

Why?



- Original hardware not supported by manufacturer
- Add new features
- Change existing behavior
- Block telemetry
- Have total control over your device
- FUN! 

Hardware Hacking



Modifications that add extra functionality to the device

MIDI in/output, different behaviour, etc.

Putting things into different chassis

Leads to voiding warranty



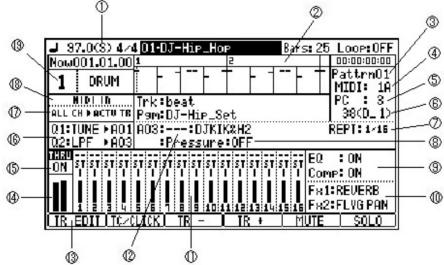
Custom firmware for devices

Paid replacement firmware for various hardware

Rewritten to expand capabilities

Zaquencer - replacement firmware for Behringer BCR2000

JJOS 1&2 - replacement firmware for MPC 1000



Korg Electribe (Sampler) 2



Same hardware, different enclosure

Only protection was a header check

Community maintained firmware combines features of both

<https://github.com/bangcorrupt/hacktribe>





Zoom FX Pedals

Effects locked to certain device types (\$\$\$)

All devices use the same OS and architecture

Python utility allows you to upload unsupported effects

<https://github.com/mungewell/zoom-zt2>

Pajen Volca Firmware



Replacement firmware for Volca Sample and Volca FM

Adds a LOT of additional features

Only for v1 devices, too many changes between v1 and v2

<https://ranzee.com/volca-sample-unofficial-firmware/>

<https://ranzee.com/volca-fm-firmware-1-09-unofficial/>

Hakai/MPC-LiveXplore



Rooted firmware versions for MPC X, Live and One

Allows SSH, VNC and possibly more

Unreleased hardware revisions identified in firmware

Running Akai MPC Force on your hardware

<https://github.com/TheKikGen/MPC-LiveXplore>

Ableton Push 3

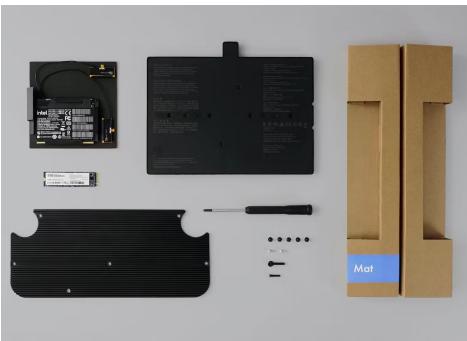


New modular design based on Intel NUC Compute Element

Sustainability and longer product lifecycle

Released on May 23 (two days ago!)

Runs Linux! 🐧



DIY Synths

DIY Synth Scene



Early synths were almost DIY in nature

DIY couldn't keep up in the 80s-90s (expensive or no chips)

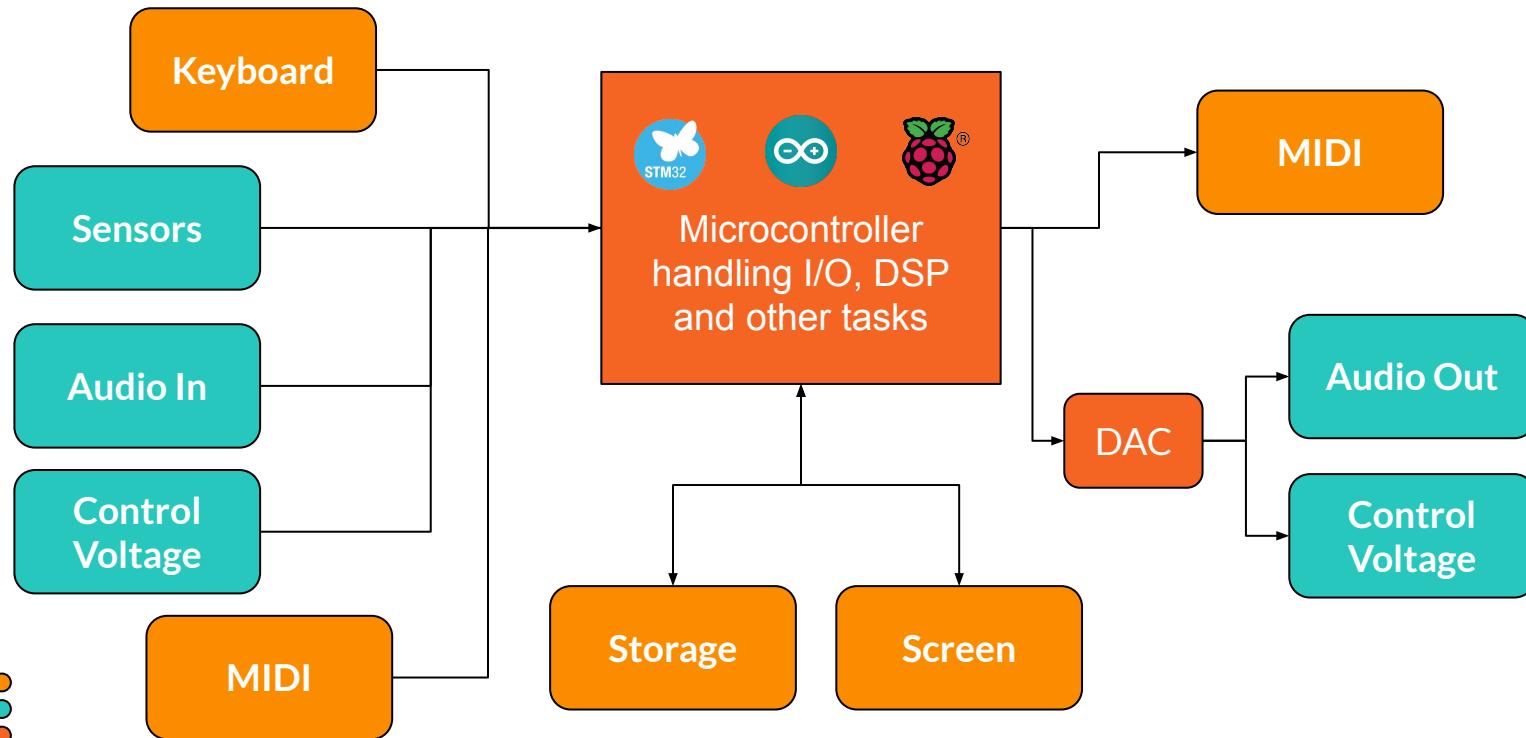
Arduino and web 2.0 revived the DIY electronics scene 

Used PSG and FM chips stripped from old consoles

Microcontrollers became “good enough” for synthesis

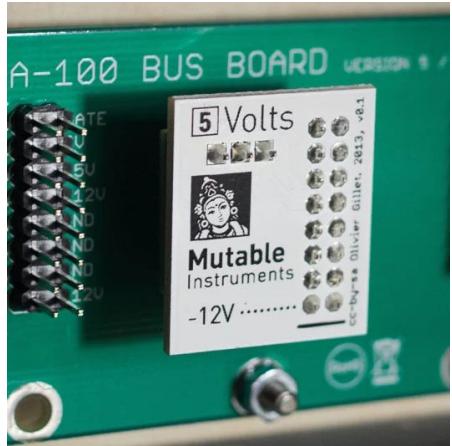
Cheap prototyping thanks to chinese PCB fabs

Digital Synth Architecture



Digital ~
Analog ~
Hardware

Mutable Instruments



The original open-hardware synth company by Émilie Gillet

All designs were eventually open-sourced

She shared a lot of knowledge about circuit and DSP design

Her code is used by large manufacturers like Behringer

Company shut down in 2022

Monome Norns



US based artist collective creating unique synths

Lot of open-source and open-hardware projects

Community driven

Norns Shield - runs on Raspberry Pi, OSH

Use SuperCollider to code your own synths

Critter & Guitari Organelle & EYESY



US based boutique synth manufacturer

Most synths use Raspberry Pi CM

Organelle and EYESY runs Linux, Python or whatever

Users modify and publish software changes, hacks

Can create your own synths/FX using PureData

Sources for learning, PCBs or projects

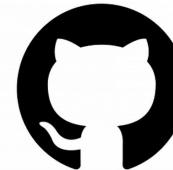
electro-music.com



OG forums, LOT of knowledge, old topics could be outdated



Projects, community, DSP



Projects, PCBs, etc.



Local workshops (affordable)

*: Lines or <https://||||||.co>



Notable YouTube Channels

HAGIWO (affordable modular)

Moritz Klein

Synth DIY Guy

LOOK MOM NO COMPUTER

That's it, thank you!
