"DERANGED GENIUS!" - WIRED MAGAZINE

PROGNOSTICATOR-6

A powerful synthesizer that won't break the bank

Team D2

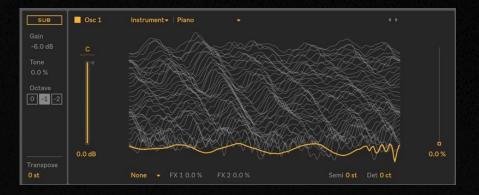
Sam Zeloof Tom Scherlis Graham MacFarquhar

Definition of Topics

- Synthesizer
 - Digital
 - Analog
- Wavetable
 - Modulation of wave shape
- Harmonic Distortion
 - Sound quality







Problem Statement

Analog Synthesizer

- Manipulation
 - Akin to an acoustic instrument
- Features
 - Expensive to implement
- Sound Quality
 - It sounds better! (maybe)

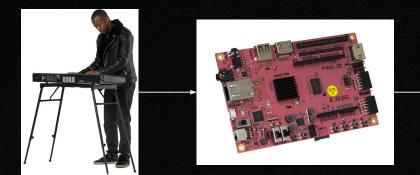
Digital Synthesizer

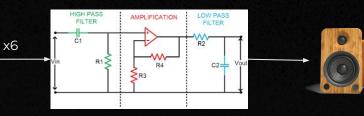
- Manipulation
 - Lives in a world of software
- Features
 - Simpler implementation
- Sound Quality
 - Imitation will never be the real thing

Solution

A Hybrid Synthesizer

- Implement more complex features in software
 - Wavetable synthesis, polyphony, voicing effects
- Signal output through analog components
 - Physical control over filter cutoffs





Aspects and Requirements

Polyphony (6 voices)

Wavetables (wave synthesis)

Oscillators (2 per voice)

Tunable Analog Filters (LPF Amp HPF)

Effects (pitch shifting, chords, arpeggiators)

Front Panel (rotary encoders, stretch: display)

Robust Enclosure (aluminium and/or wood)

Pitch Correctness	±3¢)
-------------------	------

Filter Cutoff (<5% off ideal)

THD (<10%)

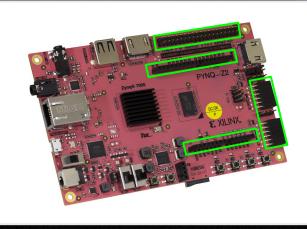
Competitive Pricing (<\$400)

User Enjoyment (>70% +ve feedback)

Portability (>= toaster, < microwave)

Potential Challenges

- Limited I/O on our FPGA
 - 6 voices
- Wavetables
 - Aliasing
- Real time Communication
- Filters
 - Programmable cutoff frequencies
- Enclosure
 - Experience with machining
- Display (stretch goal)
 - Software video drivers.
- Testing
 - Gathering data

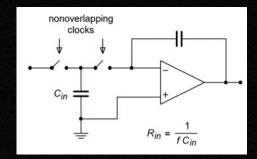


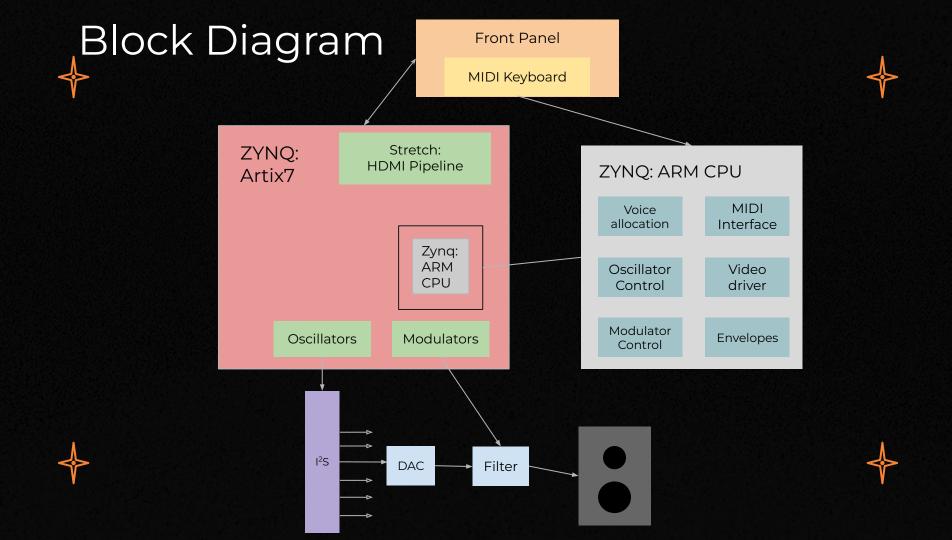




Approach

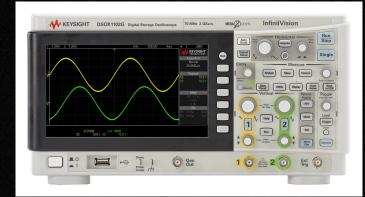
- Physical
 - MIDI keyboard
 - Front panel
- FPGA (PYNQ Z2)
 - Wavetables
 - SoC handles many effects
 - Analog input
- I²S and DAC
 - Serial bus separates signals
 - DAC output to analog filter
- Analog Filters and Amplifier
 - Programmable cutoff frequencies
 - Switched-capacitor architecture





Testing and Verification

- Sound Quality
 SNR
- Harmonic Distortion
 FFT
- Latency
 - Input to output delay
- Frequency response
 - Bode plots
- Pitch Correctness
 - Any old tuner



Task List

Tom Scherlis	Sam Zeloof	Graham MacFarquhar					
Software: Voice allocation	Analog Filter Design	FPGA: I ² S Drivers					
Software: Interface	PCB Design	FPGA: Wavetables					
Software: Envelopes	FPGA: Filter Drivers	Software: MIDI					
FPGA: Video	FPGA: I ² S Drivers	Software: LFOs					
FPGA: Wavetables	FPGA: Oscillators	Enclosure design					
Toolchain	Toolchain	Front panel design					

Gantt Chart

PROJECT TITLE	PROGNOSTIC	ATOR-6]		> All		> Tom		> Sam		> Graham	1				
TASK TITLE	OWNER	PCT OF TASK	1/30 - 2/5	2/6 - 2/12	2/13-2/18	2/19 - 2/26	2/27 - 3/5	3/6 - 3/12	3/13 - 3/19	3/20 - 3/26	3/27 - 4/2	4/3 - 4/9	4/10 - 4/16	4/17 - 4/23	4/23-4/30	5/1-5/7
Project Conception and Planning																
Abstract	T,S,G	100%														
Proposal Presentation	G	73%														
Bill of Materials	T,S,G	0%														
Analog Filter Design	S	0%														
Toolchain	T,S	0%														
Enclosure and Front Panel Design	T,S	0%														
Software																
Interface	т	0%														
Voice Allocation	Т	0%														
Envelopes	Т	0%														
LFOs	G	0%														
MIDI	G	0%														
FPGA																
Video	т	0%														
Wavetables	T,G	0%														
Filter Drivers	s	0%														
Oscillators	S	0%														
I2S Drivers	S,G	0%														
Hardware																
PCB	s	0%														
Filter Build	S	0%														
Enclosure	G	0%														
Front Panel	G	0%														
Testing	T,S,G															
User Enjoyment	G	0%														
THD	T,S,G	0%														
Filter Consistency	s	0%														
Pitch	G	0%														
Reports																
Design Review Presentation	s	0%														
Design Review Report	T,S,G	0%														
Final Review Presentation	т	0%														
Final Review Report	T,S,G	٥%														

Conclusion







nodern approach to old-school und synthesis 'Wilson

- Future of synthesizers
 - Modular and DIY
 - Accessible Analog
- Our hope
 - Create something beautiful
 - Open source
 - Well documented build and testing process



