

"DERANGED GENIUS!" —WIRED MAGAZINE

# PROGNOSTICATOR-6



A powerful synthesizer that won't break the bank

## **Team D2**

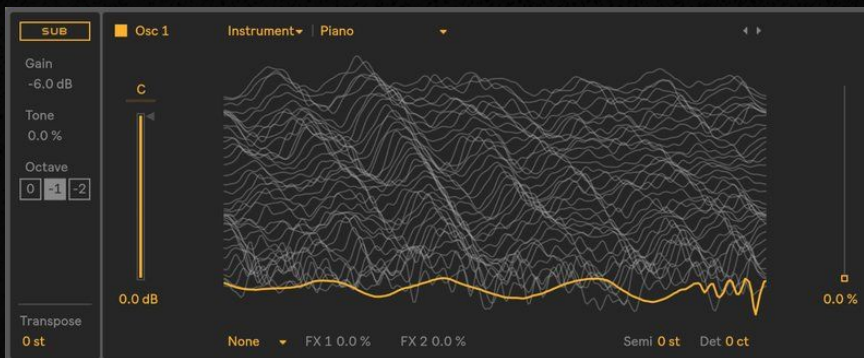
Sam Zeloof

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)

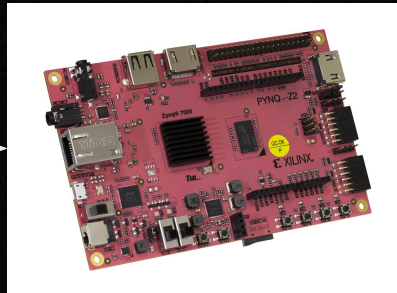
## Digital Synthesizer

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

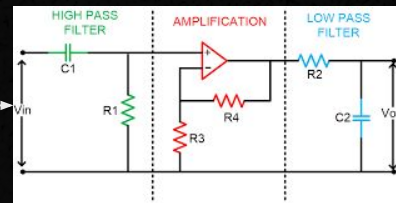
# Solution

## A Hybrid Synthesizer

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



x6



# 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 ( $\pm 3\text{¢}$ )

Filter Cutoff (<5% off ideal)

THD (<10%)

Competitive Pricing (<\$400)

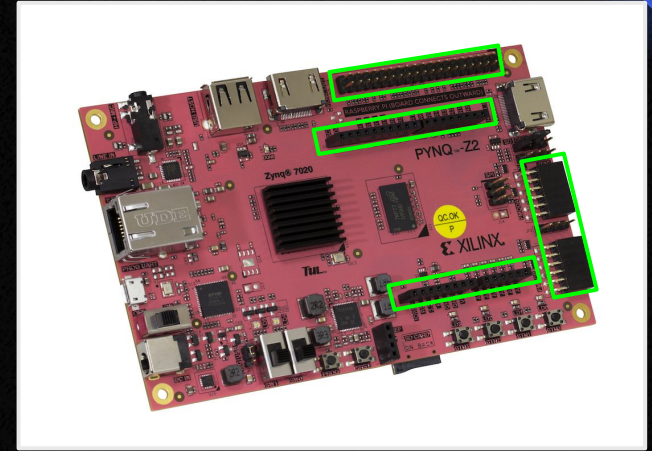
User Enjoyment (>70% +ve feedback)

Portability (>= toaster, < microwave)



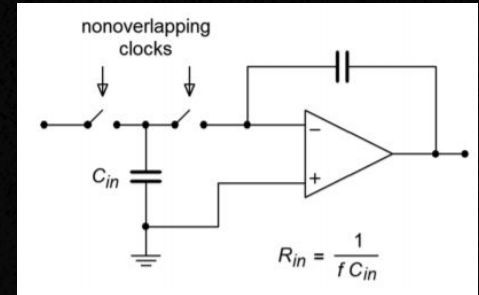
# Potential Challenges

- 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

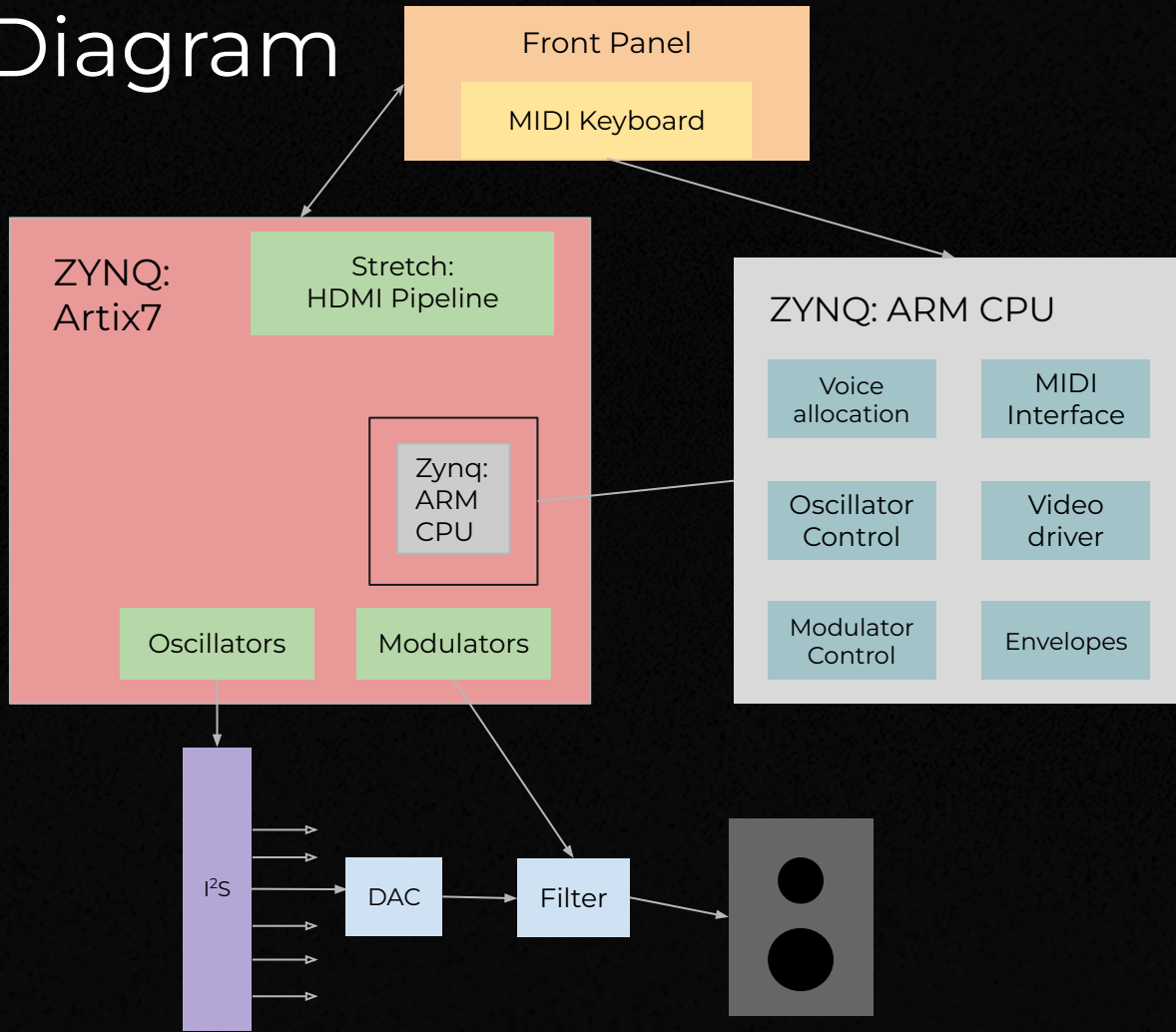


# Approach

- Physical
  - MIDI keyboard
  - Front panel
- FPGA (PYNQ Z2)
  - Wavetables
  - SoC handles many effects
  - Analog input
- I<sup>2</sup>S and DAC
  - Serial bus separates signals
  - DAC output to analog filter
- Analog Filters and Amplifier
  - Programmable cutoff frequencies
  - Switched-capacitor architecture



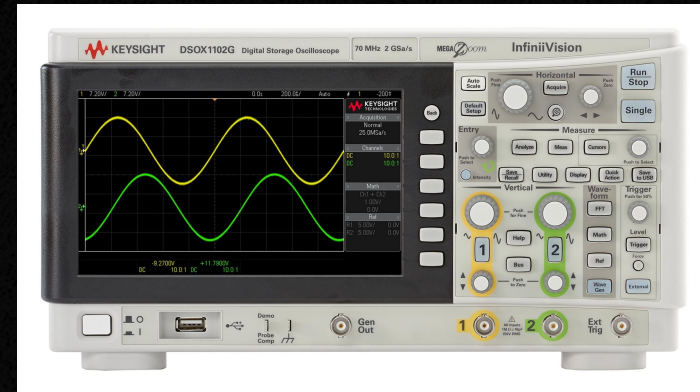
# Block Diagram





# Testing and Verification

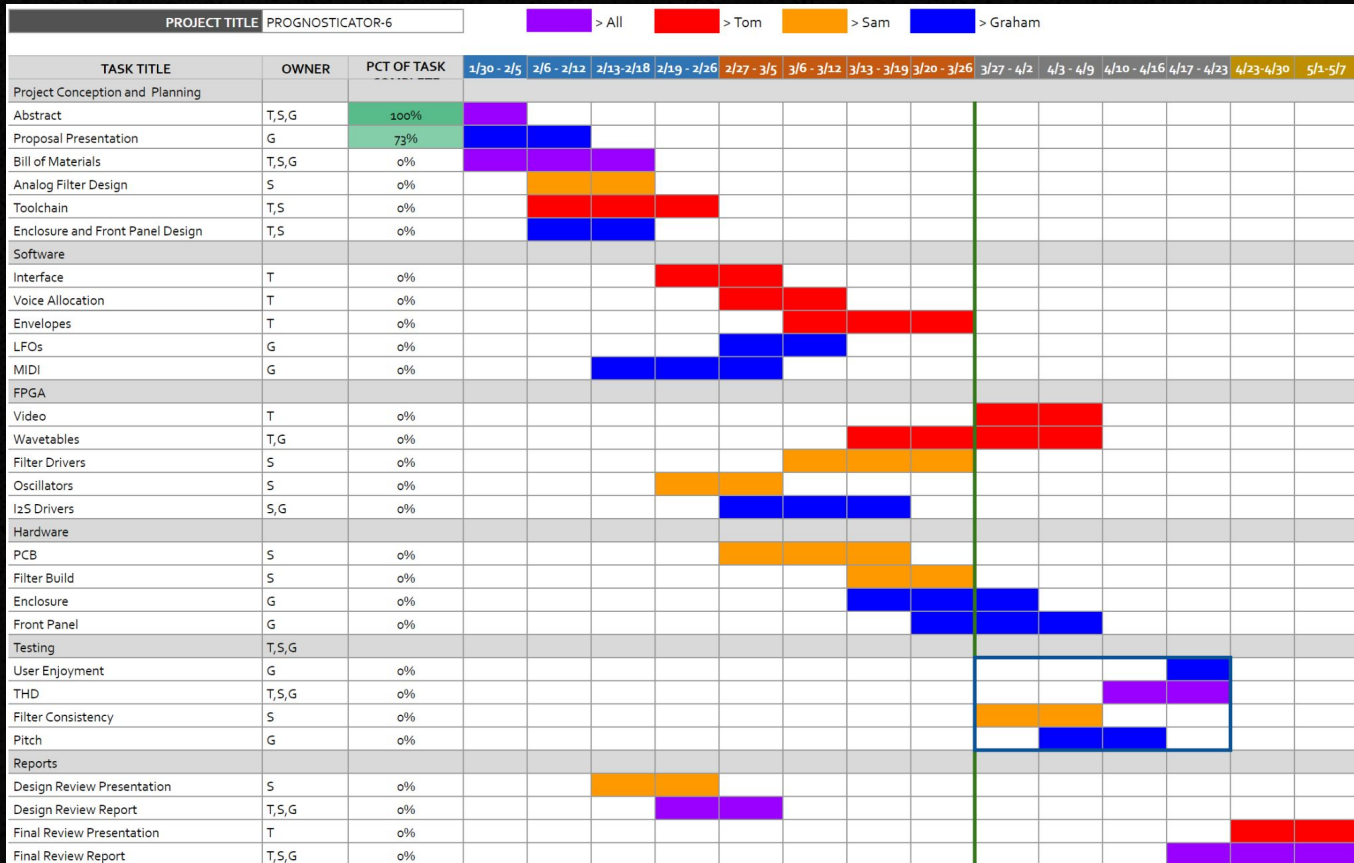
- Sound Quality
  - SNR
- Harmonic Distortion
  - FFT
- Latency
  - Input to output delay
- Frequency response
  - Bode plots
- Pitch Correctness
  - Any old tuner



# Task List

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

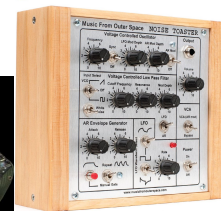
# Gantt Chart





# Conclusion

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



A modern approach to old-school analog synthesis  
by Wilson

