Check Out Our Soundcloud: The Wavetable Synth

Team A0

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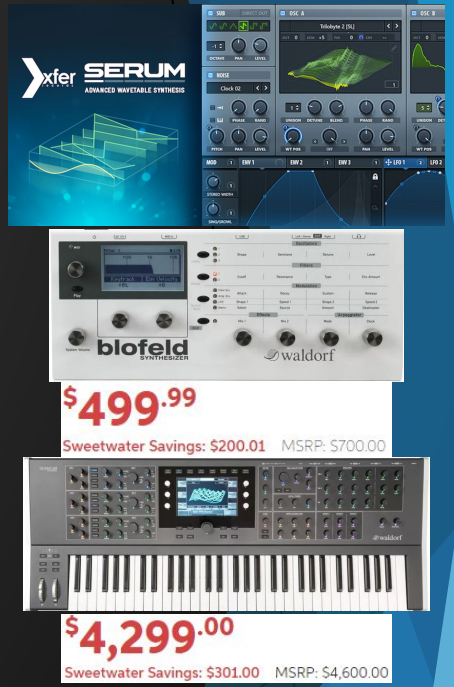
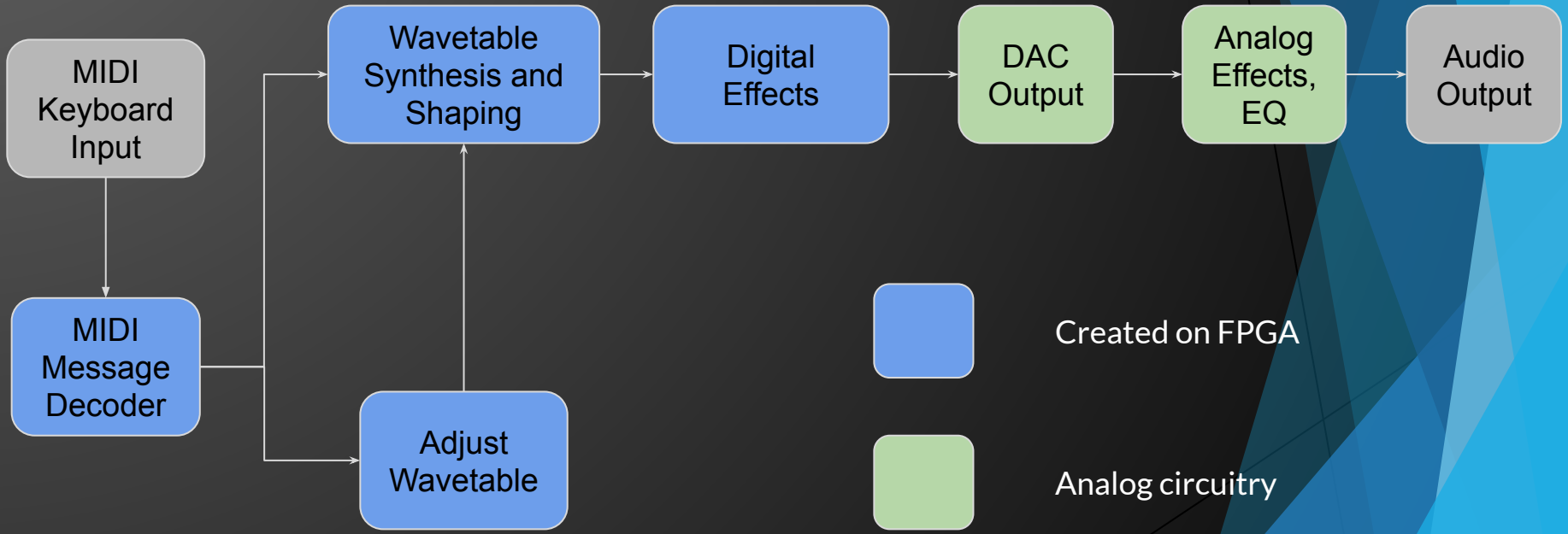
The Problem

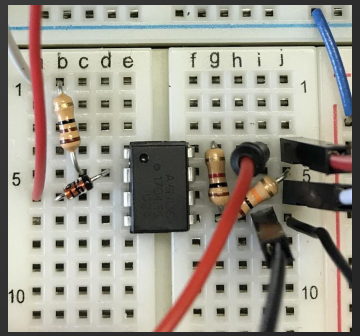
- Software Synthesizers
  - Interesting wave manipulation features
  - Trapped in computer audio environments
- Hardware Synthesizers
  - Cheap and missing core wave manipulation features
  - Expensive with full feature set
- Our Synthesizer
  - FPGA based
  - Wave Blending/Shaping
  - Features/effects of less expensive synths
  - Core features of more expensive synths

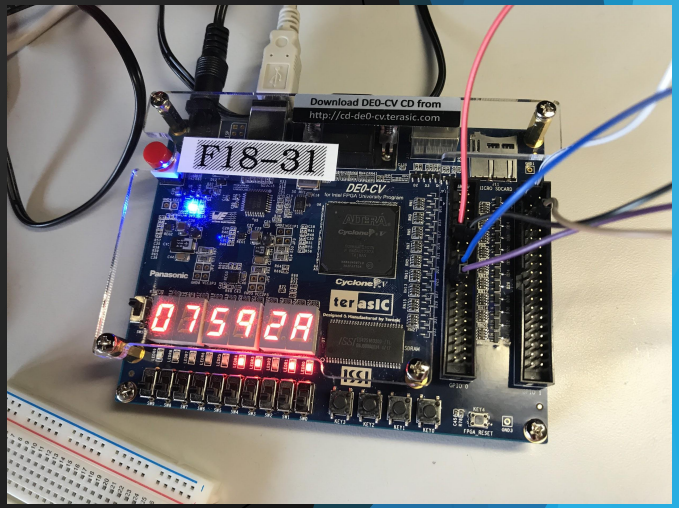


Solution Approach

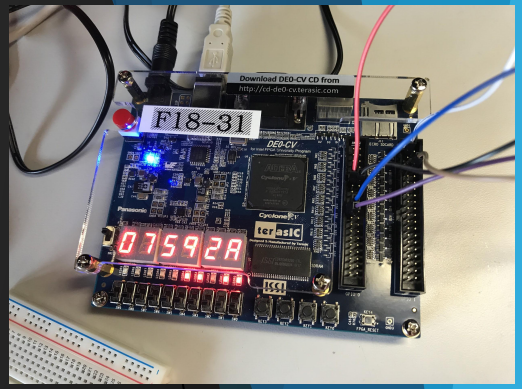


Complete Solution





Complete Solution



MIDI message receiver/decoder

Wavetable address calculator

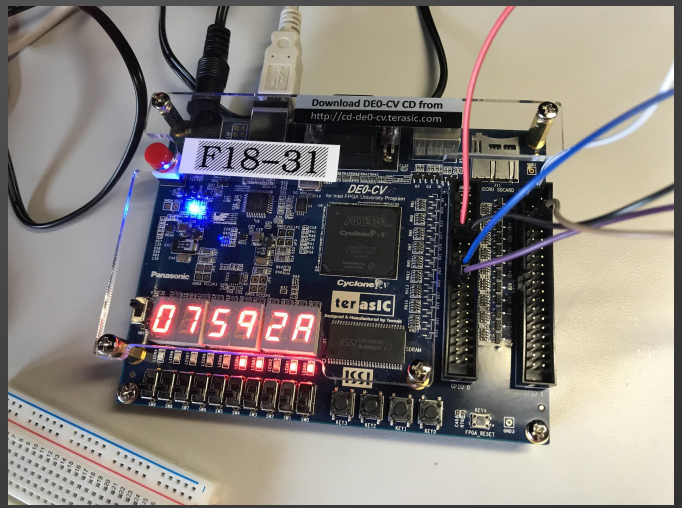
Wavetable access

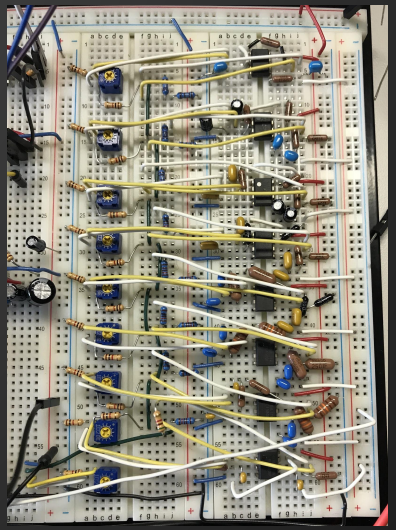
Envelope generator

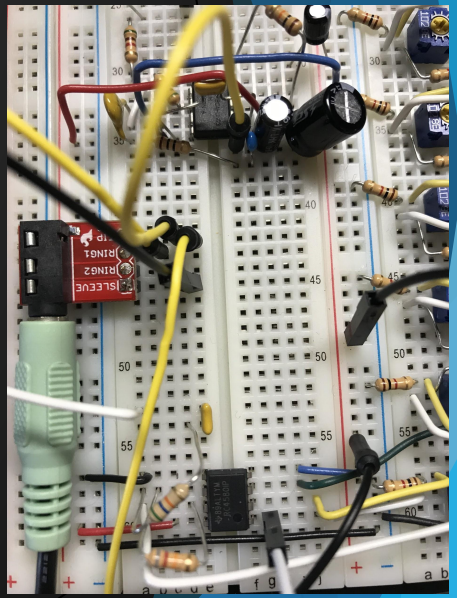
Mixer

Effects chain (distortion, delay, reverb)

Complete Solution

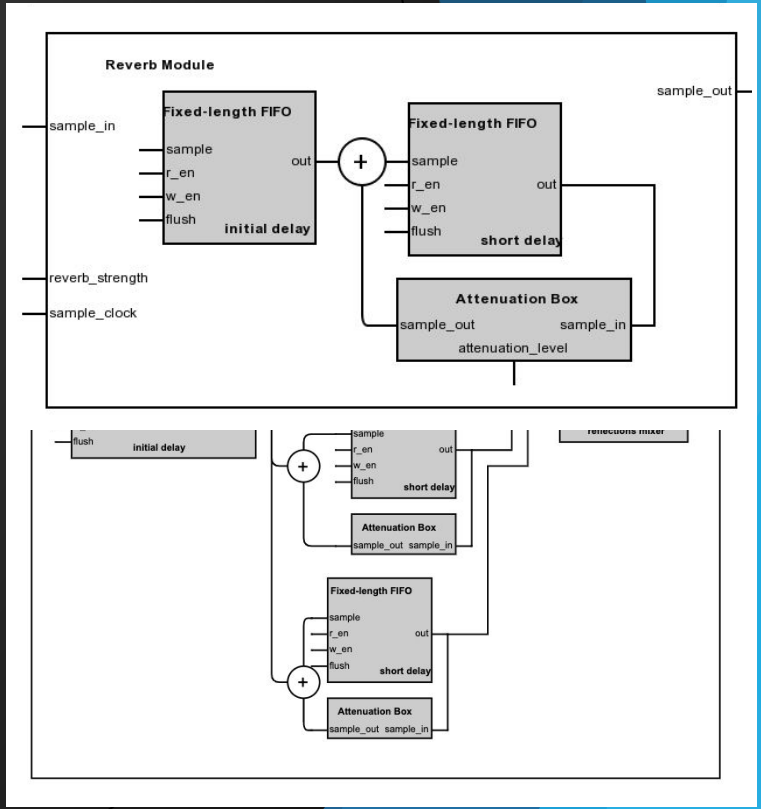






Additions from the Design Review

- Reverb overhaul
  - Redesign balancing accuracy and device resource usage
- Envelope generators (ADSR)
  - Shape the tone over time
- Drum synthesis on FPGA board buttons
  - Four drum kit (snare, bass, hats, toms)
  - Made with triangle waves and white noise



Metrics and Validation

Requirement	Testing Method	Passing Behavior
Effects	Testbenches	Correct outputs for all given test vectors
Note pitch	Off the shelf instrument tuner	<5 cents out of tune
Distortion	Frequency domain measurements of a single sine wave	<5% total power as harmonics
Frequency Response	Compare the output levels of all notes	<5% deviance output level
Filters	Generate Bode plots	<5% away from ideal -3dB cutoffs

Metrics and Validation

Requirement	Test Result	Pass?
Effects	Testbenches behaved as expected, output correct values according to model	Y
Note pitch	All notes in tune, smallest deviation at 0.1 cents, greatest deviation at 4.4 cents	Y
Distortion	Not including ground noise all other noise is down 40db from the peak of the note	N
Frequency Response	Note volumes are within 5% of each other until the last 8 piano notes (A0-E1)	N
Filters	Cutoffs were as expected, smallest deviation at 0.5%, greatest at 3.8%	Y

Additional metrics

- FPGA Area
  - ~10% of FPGA used, 5k Logic Elements
  - 1.3 Mb of block RAM used, mostly for delay and reverb effects
  - 100% embedded multiplier usage, plus some multipliers in LEs (integer)

- Power Consumption

18.25mA from 5V power supply for analog circuitry	91.25mW
18.34mA from 2.5V power supply for DAC output circuitry	45.85mW
3.21mA from 5V FPGA voltage rail	16.05mW
59.71mA from 5V wall outlet for FPGA	298.55mW
Total power	451.7mW

Project Management

- Necessary work
  - Clear up 60Hz harmonics noise
  - Final Polish
- Extra features in progress
  - Recording and looping of short snippets
  - Simple FM synthesis

		Week													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
		2/3-2/9	2/10-2/16	2/17-2/23	2/24-3/2	3/3-3/9	3/10-3/16	3/17-3/23	3/24-3/30	3/31-4/6	4/7-4/13	4/14-4/20	4/21-4/27	4/28-5/4	5/5-5/11
Task	First Status Report		A												
	MIDI Serial to 3 Byte MIDI Code Decoder	H	H												
	3 Byte MIDI to note and effects control signals	J			J										
	Analog Filter Design and Implementation	C		C											
	DAC Design and Implementation		C		C										
	Design Presentation/Document			A											
	Wavetable Incrementer		J		J										
	Wavetable Mixer					J	J								
	Amplifier						C	C							
	Bit manipulation distortion								H	H					
	Stereo Delay				H	H									
	Reverb					H	H								
	DAC Pre Prep module							C	C						
	Midterm Demo									A					
	Unison Mixer								J	J					
	Integration/Testing										A	A			
	Final Presentation Preparation													A	
	Final Report													A	A
	Slack			H/J		C		H/J		C			A		

Lessons Learned

- Digital to analog interface is messier than it seems
- Be careful with your grounds
- Don’t underestimate integration complexity
- Important for multiple people to understand each part