Roshan Nair and Nicholas Paiva and Nicholas Saizan

- ALTERAudio™ allows musicians to add complex effects to their music live using MIDI enabled devices.
- Best current competition is guitar pedals/vocoders
  - Single axis control
  - Limited range of effects
- Targeted at musicians who like to experiment with their sound.
  - Live Performances
  - Studio Recordings
- Covered Areas
  - Circuits
  - Signals and Systems
  - Computer Hardware

The Competition

- Single Axis of Control ✗

- Few Effects ✗

- Not easily Layerable ✗

- Uses proprietary hardware ✗

- Intended to work with specific instruments ✗

ALTERAudio™

- Several Axes of Control ✓

- Limitless effects ✓

- Layerable effects ✓

- Works with existing MIDI devices ✓

- Intended to work with any instrument/audio ✓

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Simple Audio Effects:
1. Panning
2. Chorus
3. Frequency Filtering
4. Bit Crushing (8-bit audio emulation)
5. Amplitude Modulation

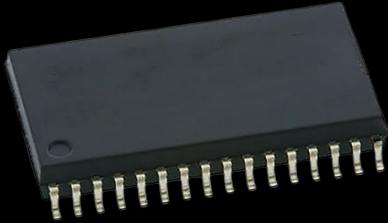**Complex Audio Effects:**
1. Echoing
2. Reverb
3. Pitch Adjustment
4. Autotune
5. Vocoder

Audio Quality:
- 16-bit audio
- 44.1kHz
- Dual Channel

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- Memory Management

- Fast Fourier Transforms in Hardware

- Pitch Shifting
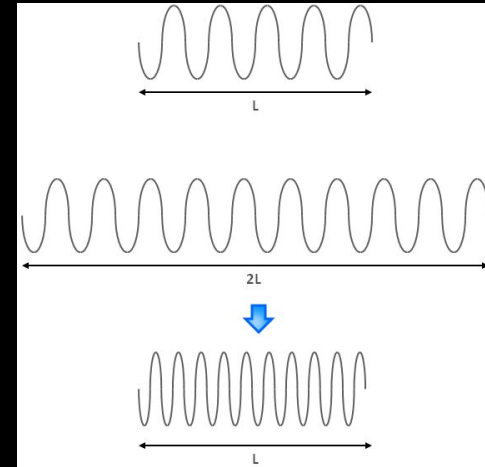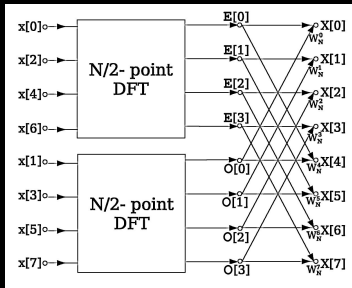
Any effects that require a range of values, also require a tradeoff between delay and quality, so we will have to find a balance between those.
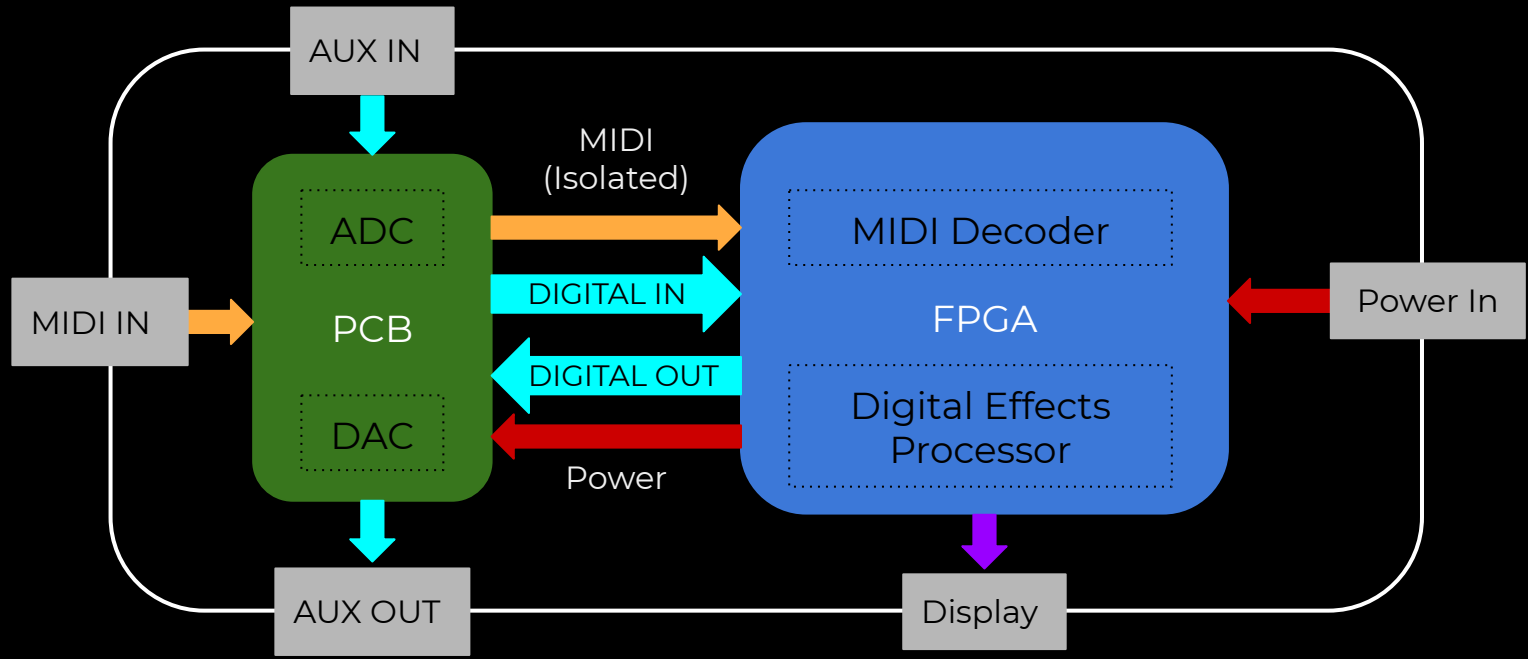
Libraries
- Altera SDRAM Controller
    - 64MB Size
    - Crossing clock domains (memory clocked faster than DSP)
    - Data buffered through use of Read/Write FIFOs
- I2C/SPI Driver for display
    - **optional**

Simple Audio Effects:

1. Panning   ← Ensure that amplitude shifts full left & full right
   >16 bit digital range of amplitude adjustment per chnl - actuation through pressure sensitivity

2. Chorus (unison)   ← Qualitative analysis of audio samples.
   clipping rejection by scaling, with control of the size of chorus through velocity

3. Frequency Filtering   ← Compare recording to freq response graph.
   Not really that simple of an effect

4. Bit Crushing (8-bit audio emulation)   ← View digital data in and digital data out.
   Can inspect digitally using an automated test bench

5. Tremolo (Amplitude Modulation)   ← Compare output waveform to envelope wave
   full range of depth with rate determined by velocity (different keys for different carrier wave shapes)

Verification Methods:

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Complex Audio Effects:

1. Echoing   ← Retrieve original audio from instance of echo
   30ms - 1.5s (30ms is minimum for human to distinguish),
   echo with no decay to be digitally identical,
   decay: pressure on key, period: velocity of keypress

2. Reverb   ← Qualitative: comparison with audio sample
   0-30ms controlled similarly to echoing

3. Pitch Adjustment   ← Frequency response analysis to verify
   +- 2 semitones, which is a common value for pitch wheel range

4. Autotune   ← Ensure output is carried by discrete notes
                                                       60-band filtering
   telephone have range of 300-3400Hz... piano has 88 keys and range of 27-4100Hz,
   mapping of piano key to freq → 42 keys in audio range of telephone

5. Vocoder   ← Analysis of amplitudes at carrier frequencies
                                                       8-band 50-4kHz frequencies
   2-6 band is considered 'retro' anything above 16 band is considered 'high quality'

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Simulation:

- SystemVerilog Testbench Infrastructure
  - Generate sequences of 16 bit samples for input
  - Unit test DSP blocks
  - Pipeline tests
- Software models for complex math
  - Python script to create a ground truth
  - Assert RTL output against the model

Printed Circuit Board:
- Component Selection
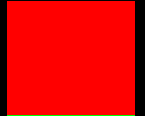- PCB Schematics
- PCB Layout

SystemVerilog:
- MIDI Decoder
- SDRAM
- Display
- Effects

System Construction:
- Wiring
- Box/Container

1. Panning
2. Chorus
3. Frequency Filtering
4. Bit Crushing
5. Amplitude Modulation
6. Echoing
7. Reverb
8. Pitch Adjustment
9. Autotune
10. Vocoder

Roshan

Nick P

Nick S

NUMBER	TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION	PCT OF TASK COMPLETE
1	**Project Conception and Initiation**					
1.1	BOM (Component Selection)	Nick	9/16/19	9/20/19	4	5%
1.2	Basic FPGA IO and SDRAM Tests	Roshan	9/16/19	9/19/19	3	0%
1.3	PCB Schematics	Nick	9/18/19	9/23/19	5	0%
1.4	PCB Layout	Nick	9/18/19	9/23/19	5	0%
1.5	MIDI Protocol Research	Nick S.	9/19/19	9/23/19	4	0%
1.6	Panning Effect Research	Roshan	9/19/19	9/23/19	4	0%
1.7	Chorus Effect Research	Nick S.	9/23/19	9/26/19	3	0%
1.8	Frequency Filtering Effect Research	Nick P.	9/23/19	9/26/19	3	0%
1.9	Bit Crushing Effect Resarch	Roshan	9/23/19	9/26/19	3	0%
2	**Project Integration**					
2.1	Audio Jack/ADC to PCB	Nick P.	9/27/19	10/3/19	6	0%
2.2	Speaker/DAC to PCB	Nick S.	9/27/19	10/3/19	6	0%
2.3	FPGA IO to PCB	Roshan	9/27/19	10/3/19	6	0%
2.4	MIDI to PCB	Nick S.	10/4/19	10/8/19	4	0%
2.5	FPGA Bypass Implementation	Roshan	10/4/19	10/7/19	3	0%
2.6	MIDI Decoder Implementation	Roshan	10/8/19	10/14/19	6	0%
2.7	Audio Stream Integration	All	10/8/19	10/17/19	9	0%
3	**Base Effect Implementation**					
3.1	Panning Effect Implementation	Roshan	10/14/19	10/18/19	4	0%
3.2	Chorus Effect Implementation	Nick S.	10/14/19	10/18/19	4	0%
3.3	Frequency Filtering Effect Implementation	Nick P.	10/14/19	10/18/19	4	0%
3.4	Bit Crushing Effect Implementation	Roshan	10/21/19	10/23/19	2	0%
4	**Core Effect Implementation**					
4.1	Amplitude Modulation Effect Research/Implementation	Nick S.	10/21/19	10/30/19	9	0%
4.2	Echoing Effect Research/Implementation	Roshan	10/21/19	10/30/19	9	0%
4.3	Display Implementation	Nick P.	10/21/19	10/30/19	9	0%
4.4	Reverb Effect Research/Implementation	Roshan	10/31/19	11/14/19	14	0%
4.5	Pitch Adjustment Effect Research/Implementation	Nick P.	10/31/19	11/14/19	14	0%
4.6	Autotune Adjustment Effect Research/Implementation	Nick P.	10/31/19	11/14/19	14	0%
4.7	Vocoder Adjustment Effect Research/Implementation	Nick S.	10/31/19	11/14/19	14	0%
5	**Extra**					
5.1	System Wiring/Construction	All	11/14/19	11/20/19	6	0%
5.2	Slack	All	11/21/19	11/29/19	8	0%

Phases:
- PHASE ONE — WEEK 1, WEEK 2, WEEK 3
- PHASE TWO — WEEK 4, WEEK 5, WEEK 6
- PHASE THREE — WEEK 7, WEEK 8, WEEK 9
- PHASE FOUR — WEEK 10, WEEK 11

Planning

Integration

Early Effects

Complex effects

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