Real-Time Sound Analysis / Synthesis

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Overview

• Use FPGA buttons and switches for navigation
• The user sings/ hums/ plays an instrument
• A microphone picks up the sound
• The sound is saved onto memory for later playback
• Audio effects can be added to the sound samples
• Multiple audio samples can be recorded and played
Main Modules and External Components

- ZBT SRAM
- User inputs
- VGA
- Central FSM/Logic
- Audio Input/FFT/SFX
- Graphics
- Memory Handler
Block Diagram
Specific Number Figures

- Use ZBT Memory – two 512k x 36 bit memory bus
- 24 kHz sampling rate and 12 bit encoding scheme
- 288 kilobits per second data rate
- ~80 kAddresses of ZBT memory required for 10-second recording
- Use one bank of memory for each sound recording
- 2952K bits of BRAM available for images for graphics
Central FSM

- Standby
  - Stop
  - Record
  - Time out

- Record
  - Stop

- Playback
  - Stop
  - Time out
Central FSM

- Processes user inputs
- Coordinates the modules
- Choose which bank to record to and what effects to apply when playing back
- Each team member implements part of the FSM most pertinent to their individual module
Memory Handler

- Take in input from microphone
- Write audio samples to memory
- Retrieve sound samples from memory upon request
Memory Handler – Block Diagram
Audio Module - Block Diagram
Audio Module

- Process input from microphone and write to memory
- Take effects from FSM and apply them to recorded audio
- Output FFT data to Graphics module
- Output sound to speaker
- Most complex part of project
Audio Module - Proposed Effects

- Compression & Limiting
- Delay & Echo
- Expansion & Noise Gate
- Phasing
- Chorus (if time allows)
- Vocoders (stretch goal)
Graphics Module – Block Diagram
Graphics Module

- Take in graphics from memory
- Output FFT spectral data
- Display running statistics (predominant frequency, amplitude, sample characteristics)
- Take in preloaded data from block ROM
- Data saved as 6 bit pixel encoding
- 6 bit pixel encoding -> 24 bit color to VGA -> LUT
- Minimum 30+ different images for text/numbers/etc. (30 kBits)
## Task Timeline

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<thead>
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<th>Required Task</th>
<th>Week of Nov 9</th>
<th>Week of Nov 15</th>
<th>Week of Nov 23</th>
<th>Week of Nov 30</th>
<th>Week of Dec 7</th>
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<tbody>
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<td>Work on Individual Modules</td>
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<td>Work on FSM Logic</td>
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<td>Prove that Individual Modules Work</td>
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<td>Combine Modules / Interfacing</td>
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<td>Proof of Concept</td>
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<td>Debugging / Adding Extra Features</td>
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<td>Demonstration of Completed Project</td>
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Forseeable Challenges

• Getting FFT and statistics in real-time
• Simultaneous and offset playback of different recordings for sound effects and playback
• Effect complexity
  • Possible source of latency
  • Multiple effects at the same time?
• Playing multiple sound clips at the same time