Kanto: FPGA Audio Player and Visualizer

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Project Overview

- Objective: Design and implement an audio player with frequency visualization.
- Hardware: Handles audio output and frequency visualization
- Software: Handles user interaction and system initialization
SD Controller

CMD8 → CMD0

Error → illegal?

illegal? → no → ACMD41

ACMD41 → ready?

ready? → yes → CMD58

CMD58 → Ready

Ready → no

start? → yes → CMD17

start? → no → illegal?
Audio Buffer

From SD Card

Audio RAM

WM8731 Interface

To Audio Codec
FFT Equations

\[ X_k = \sum_{n=0}^{N-1} x_n e^{-\frac{2\pi j}{N} nk} \] (1)

\[ X_k = \begin{cases} 
  E_k + e^{-\frac{2\pi j}{N} k} O_k & \text{if } k < N/2 \\
  E_{k-N/2} - e^{-\frac{2\pi j}{N} (k-N/2)} O_{k-N/2} & \text{if } k \geq N/2.
\end{cases} \] (2)
FFT Top-Level

- Time Domain RAM
- DFT
- MUX
- Frequency Domain RAM
- Controller
- DFT ROM
- Recomb
- MUX
- Recomb ROM-16
- Recomb ROM-32
- Recomb ROM-64
- Recomb ROM-128
DFT Unit

FSM controller

input

n +1

ROM

x

x

+1

k

Sum

output

+ + +
Complex Multiplier

\[
\begin{align*}
ax & \cdot ay \\
bx & \cdot by \\
ax & \cdot by \\
ay & \cdot bx \\
- \\
+ \\
az &= ax \cdot ay - bx \cdot by \\
bz &= ax \cdot by + ay \cdot bx
\end{align*}
\]
Software — Track Selection

```
Track 1 Address
Track 1 Title
```

```
track_table[0]
track_titles[0]
track_table[1]
track_titles[1]
```

```
Audio End
0
0
0
0
```

```
track_table[N]
```
The Hard Parts

- Interfacing to external hardware (SD card, audio codec, visualizer)
- Reducing Hardware Usage
- Timing Issues
Design Changes

- Removal of SRAM
- Adding Software Control
- Display Changes
Lessons Learned

- Connect components early
- Implement modularized design
- Testbench everything
- Clearly define milestones
- Communicate often and clearly with each other and the adviser