ECE532 Project

FPGA Implementation of the NES Audio Processing Unit

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Outline

- Project Goal
- Background
- System Design/Implementation
- **Demo:** NSF Player
- Design challenges

Project Goal(s)

Goal	Envisioned	Accomplished
Implement the NES Audio Processing Unit on the FPGA of Xilinx XUP Virtex™-II Pro Development System	✓	✓
To demonstrate standalone music playing ability by using MicroBlaze as the NES CPU.	✓	✓
To play NSF files	✗	✓
To interact with the other two NES hardware components, CPU and PPU from other teams	✓	?

NES Audio Processing Unit

- Nintendo Entertainment System (NES) CPU
  - Ricoh 2A03 (1.79 MHz) ≈ MOS Technology 6502 + APU
- Registers interface
  - 20 8-bit register, control + status registers
  - Memory mapped
- Five independent audio channels
  - 2 Rectangle
    - Variable duty cycle (12.5%, 25%, 50%, 75%),
    - 16-level volume control
    - Frequency range: 54 Hz to 28kHz
    - Frequency sweep
    - Volume decay

NES Audio Processing Unit

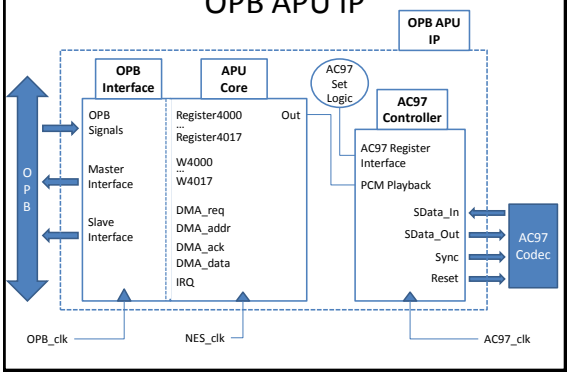
- Five independent audio channels (cont'd)
  - Triangle
    - Fixed volume
    - Frequency range: 27 Hz to 56kHz
  - Noise
    - 16-level volume control
    - Frequency range: 16 pre-programmed frequencies
    - Two modes (random sequences)
    - Volume decay
  - Delta Pulse-Width Modulation Channel (DMC)
    - DMA functionality
    - 16 pre-programmed sample rates
    - Capable of playing standard PCM sound

NES APU FPGA Implementation

- Implement APU as a standalone IP core
- Provide OPB interface
- Use AC97 codec for sound output
- Include logic to talk with AC97 codec

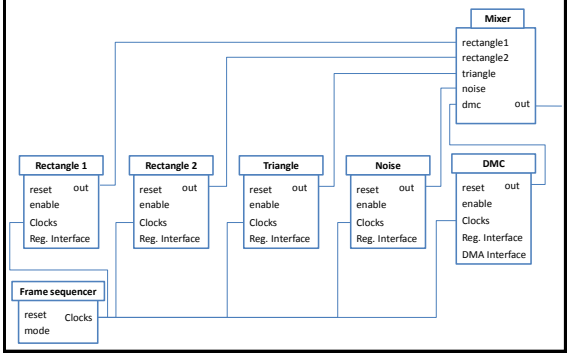
7 / 15

OPB APU IP



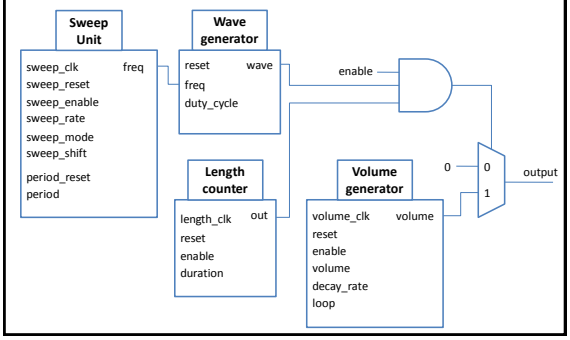
8 / 15

OPB APU IP: APU Core



9 / 15

OPB APU IP: Rectangle channel



10 / 15

OPB APU IP: Channels Showcase

Rectangle channels 1&2

Triangle channel

Noise channel

DMC channel

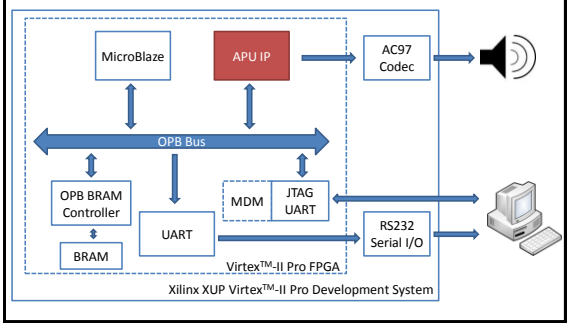
11 / 15

NSF Player

- Use developed APU IP to play NSF files
  - Use MicroBlaze to simulate NES CPU
- Hardware & Software
- Motivation:
  - Testing & debugging
  - Demo
  - There are a lot of NES sound enthusiasts out there
    - http://www.zophar.net/nsf/

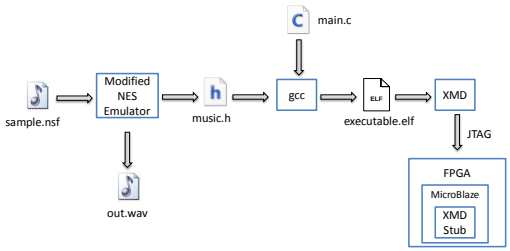
12 / 15

System Design: Hardware



13 / 15

System Design: Software



14 / 15

Demo: NSF Player

NSFs
Star Wars: The Empire Strikes Back
Aladdin
Final Fantasy 1
Bomberman 2
Dragonball
Donkey Kong
Adventures of Lolo 2
Mario Bros.
Zelda
Super Mario Bros. 1
Super Mario Bros. 2
Armed Dragon Fantasy Villgust

15 / 15

Design challenges

- Design process
  - Use “documentation” and NES emulator
  - Incremental
- Simulations
  - Frequency range from 25MHz to 27 Hz
  - What to expect?
- Download-Hear-And now what?
- Channel Mixing?
- There are still some bugs…
  - IRQ issues ignored

16 / 15

OPB APU IP: DMA Handling