Embedded Systems

CSEE 4840

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1. Introduction

This project proposal outlines the development of a custom System Verilog-based Audio Visualizer, utilizing Fast Fourier Transforms (FFTs) implemented on Field-Programmable Gate Arrays (FPGAs) for high-frequency sampling. The core of this venture is to create a visual representation of the frequency spectrum of audio music signals.

The heart of our system is the FFT Module, meticulously designed to sample 64 instances and conduct FFTs on these samples, effectively translating the input analog signal into a discernible frequency spectrum. The visual output is displayed through a VGA Display, offering five distinct display modes. These modes are ingeniously manipulated by toggling LEDs in varying positions across each column, allowing for a range of customizable patterns easily modified or created by the user. Mode selection is facilitated by a push button, enabling users to cycle through display patterns with each press, ultimately reverting to the default setting. This push button is linked to a digital input, which is monitored at each cycle of display refresh, ensuring a dynamic and interactive user experience. This project not only aims to showcase technical prowess in FPGA programming and FFT analysis but also to enrich the audio experience with a visually stimulating spectrum display.

2. Hardware and Software Description

Hardware Components

- Altera DE1-SoC Board
- VGA Monitor
- Microphone

Software Components

- FFT Algorithm
- Visualization

3. Project Milestones

- Preliminary Research: Finalize project scope and objectives. Conduct a thorough literature review on FFTs, FPGA programming, and System Verilog. Acquire necessary hardware components (FPGA, ADC, VGA Display).
- Design Phase: Develop a detailed design document outlining the architecture of the Audio Visualizer, including the integration of the FFT Module, ADC, and VGA Display. Create a simulation model for the FFT algorithm to ensure accuracy in frequency spectrum analysis.

- Development of FFT Module: Implement the FFT algorithm in System Verilog to process analog signals. Test the FFT Module with simulated input signals to validate its functionality.
- Integration of ADC with FPGA: Configure the ADC to mix left and right audio channels and feed into the FPGA. Implement and test the signal acquisition process to ensure accurate capture of audio signals.
- VGA Display Interface Development: Design and implement the VGA display logic in System Verilog for visual output. Develop and test five distinct display modes for visualizing the frequency spectrum.
- Project Closure and Presentation: Prepare a final presentation summarizing the project development process, challenges encountered, solutions implemented, and demonstrations of the Audio Visualizer in action. Reflect on project outcomes, lessons learned, and potential future developments.