Nexys4IO Peripheral and PWM Analyzer Integration

ECE 544 Project 1

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# 1. Introduction

This project integrates the Nexys4IO peripheral with a PWM Analyzer on a MicroBlaze soft-core processor implemented on an FPGA. The system provides real-time control and monitoring of RGB LED duty cycles, switch inputs, and button interactions while displaying relevant information on the 7-segment display. The Fixed Interval Timer (FIT) interrupt-driven mechanism ensures continuous system updates.

# 2. Objectives

Implement real-time control of RGB LED brightness using push buttons.

Read and process PWM signals via an external Digilent PWM Analyzer.

Display switch and button states on LEDs and 7-segment display.

Develop a modular and scalable software architecture in C for MicroBlaze.

Ensure efficient communication via AXI registers and GPIO interfaces.

# 3. System Architecture

## 3.1 Hardware Components

FPGA Board: Digilent Nexys A7-100T

Processor: MicroBlaze soft-core processor

Peripherals:

Nexys4IO module (7-segment display, RGB LEDs, buttons, and switches)

AXI Timer (to generate PWM clocks for RGB LEDs)

Digilent PWM Analyzer (for external duty cycle measurements)

## 3.2 Software Components

Embedded C Firmware: Controls LED brightness, handles button presses, and manages FIT interrupts.

PWM Analyzer Library: Provides functions to read on-time, period, and duty cycle values from AXI registers.

GPIO Interface: Enables register read/write operations for real-time updates.

# 4. Implementation

## 4.1 Peripheral Initialization

AXI Timer initialized to generate PWM signals.

Nexys4IO initialized for switch/button monitoring and LED control.

GPIO configured for PWM Analyzer communication.

FIT interrupt handler set up for periodic system updates.

## 4.2 Main Loop Behavior

Continuously monitors push-button states.

Adjusts duty cycles accordingly and updates RGB LEDs.

Reads PWM duty cycle values from the Analyzer.

Displays computed duty cycles on the 7-segment display.

## 4.3 Interrupt Handling

FIT Handler triggers every 0.5 seconds.

Reads button states and updates duty cycle variables.

Retrieves PWM Analyzer data and updates the RGB2 LED accordingly.

Updates the 7-segment display to reflect PWM duty cycle percentages.

# 5. Testing and Results

## 5.1 Functional Tests

Verified LED brightness adjustment using push-buttons.

Confirmed real-time PWM readings from the Analyzer.

Ensured 7-segment display correctly reflects duty cycle values.

## 5.2 Debugging and Challenges

Issue: Initial AXI register reads always returned 0.

Solution: Confirmed address mapping in Vivado, initialized GPIO properly.

Issue: 7-segment display did not correctly show duty cycle values.

Solution: Scaled PWM values from 0-255 to 0-99% range.

# 6. Future Improvements

Implement additional PWM control for external devices.

Add support for different LED color profiles via software presets.

Extend 7-segment display capabilities to show dynamic messages.

# 7. Conclusion

This project successfully integrates the Nexys4IO peripheral with a PWM Analyzer on an FPGA-based MicroBlaze system. The software architecture ensures real-time updates of LED brightness and PWM duty cycle monitoring. Future work can further optimize performance and introduce advanced control features.

References:

Digilent Nexys A7 Reference Manual

Xilinx MicroBlaze User Guide

Digilent PWM Analyzer Documentation  
RK IP Documentation