EEL 4712C - Digital Design: Lab Report 5

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```vhdl
-- This is a test VHDL code block
library IEEE;
use IEEE.STD_LOGIC_1164.ALL;
use IEEE.STD_LOGIC_ARITH.ALL;

entity test is
    Port ( a : in  STD_LOGIC;
           b : in  STD_LOGIC;
           c : out  STD_LOGIC);
end test;
```

Listing 1: Test VHDL Code

Lab Report

Problem Statement

Lab 5 builds off of lab 4 by turning our simple VGA lab with a bouncing ball into the game "Pong". There are four main parts of the game outlined by the lab assignment:

1. **Start and Game Over**: The Start scren should display the word "PONG" in the middle of the screen. The Start screen should also display a "Press B1" message at the bottom of the screen. The game should start when the user presses button 1. The game should end when one player reaches 11 points. The game should display a "Game Over" message when the game ends.

2. **Ball Movement**: The ball should move in a straight line at a constant speed. It should bounce off the top and bottom of the scrren. It should also bounce off the paddles. When the ball hits the left or right side of the screen, the ball should be sent back the to middle of the screen.

3. **Paddle Movement**: The paddles should move up and down with the push buttons. The paddles should not be able to move off the screen.

4. **Scoreboard**: The game should keep track of the score. The game should end when one player reaches 11 points. The scoring of the game should be done using a bitmap of characters displayed on the screen.

Inputs

The inputs to control the game are the push buttons on the DE10-Lite board. Button 1 is used to start the game and button 2 is used to reset the game. The first two switches are used to control the ledt paddle and the third and fourth switches are used to control the right paddle. The ball moves at a constant speed and does not require any user input.

Outputs

The outputs are the VGA display output. This includes: VGA_HSYNC, VGA_VSYNC, VGA_R, VGA_G, and VGA_B. The VGA display will display the game screen, the paddles, the ball, the score, and the game over screen. The VGA display works best with a 640x480 resolution.

Function

The function of the system is broken into three main states of the game: the start screen, the game screen, and the game over screen. The start screen displays the word "PONG" in the middle of the screen and a "Press B1" message at the bottom of the screen. The game screen displays the paddles, the ball, and the score. The game over screen displays a "Game Over" message. The game starts when the user presses button 1 and ends when one player reaches 11 points.

Start Screen: The start screen displays the word "PONG" in the middle of the screen and a "Press B1" message at the bottom of the screen. The game starts when the user presses button 1. **Game Screen**: The game screen displays the paddles, the ball, and the score. The ball moves in a diagonal line at a constant speed. It bounces off the top and bottom of the screen and the paddles. When the ball hits the left or right side of the screen, the ball is sent back to the middle of the screen. The paddles move up and down with the push buttons. The game keeps track of the score and ends when one player reaches 11 points. **Game Over Screen**: The game over screen displays a "Game Over" message. The game ends when one player reaches 11 points.

Design

Components

The components used in the design are the VGA_sync module, a clock divider, and the a vga module. The design mimics the previous lab design with a change in the **vga.vhd** file to include the paddles and the ball. The vga module holds most of the logic for the game and incorporates the other two previously mentioned modules. The VGA_sync module is used to generate the horizontal and vertical sync signals for the VGA display. The clock divider is used to generate the 25MHz clock signal from the 50MHz clock signal. The clock divider is also used to create a slow clk that control the timing of the movement.

Signals

The signals that connect the components are the clk_50MHz signal, the clk_25MHz signal, the slow_clk signal, the VGA_HSYNC signal, the VGA_VSYNC signal, the VGA_R signal, the VGA_G signal, and the VGA_B signal. The clk_50MHz signal is the 50MHz clock signal from the DE10-Lite board. The clk_25MHz signal is the 25MHz clock signal generated by the clock divider. The slow_clk signal is the slow clock signal generated by the clock divider. The VGA_HSYNC signal is the horizontal sync signal generated by the VGA_sync module. The VGA_VSYNC signal is the vertical sync signal generated by the VGA_sync module. The VGA_R signal is the red signal generated by the vga module. The VGA_G signal is the green signal generated by the vga module. The VGA_B signal is the blue signal generated by the vga module.

Algorithms

The algorithms used in the design are the same as the previous lab with the addition of the paddles and the ball. The paddles move up and down with the push buttons. The ball moves in a diagonal line at a constant speed. It bounces off the top and bottom of the screen and the paddles. When the ball hits the left or right side of the screen, the ball is sent back to the middle of the screen. The game keeps track of the score and ends when one player reaches 11 points. In addition to the conditional logic used by the VGA, another component of the logic is the state machine responsible for controlling what to display on the screen.