San Francisco State University

Electrical and Computer Engineering

ENGR 378 Digital Systems Design

Lab 6: VGA Controller and Pong Game

Objectives

• To learn how to draw color patterns on a computer monitor by asserting Red/Green/Blue signals via the VGA port.
• Write Verilog code to implement the game of pong.

Prelab

(Note that each member in the group should do this individually)
- Read the DE2 User Manual about "Using VGA" from page 51 to 53.

Instructions:

Task 1:

1) Open the VGA project files and compile the sample code provided with Lab 6. Connect the VGA cable to the computer monitor and the FPGA and download the design to the FPGA board. Note that the code written for this lab supports monitors with the pixel resolution of 1280x1024 and a 60 hertz frame refresh rate. The sample code contains a driver to assert the vertical synch and horizontal synch correctly while calculating the X and Y coordinates on the monitor. VGAInterface.v is the top module.

- For the code sample:
When SW 0 is set to the down position, the screen should display 3 different colors.

When SW 0 is set to the up position, the screen should display a white dot approximately one pixel by one pixel on a black background. In this mode you can move the dot up and down with buttons 2 and 3 and move it left and right with buttons 1 and 0. Also in this mode, the coordinates of the dot are displayed on the 8 LEDS in the following format:

Switch 1 Position	LED Displayed Information
Down Position	Displays the X Position of the Dot
UP Position	Displays the Y Position of the Dot

By placing the dot in the top left corner and bottom right corner of the screen, you can calculate the screen resolution by calculating the difference of the two X coordinates for the horizontal resolution, and the difference of the two Y coordinates for the vertical resolution.

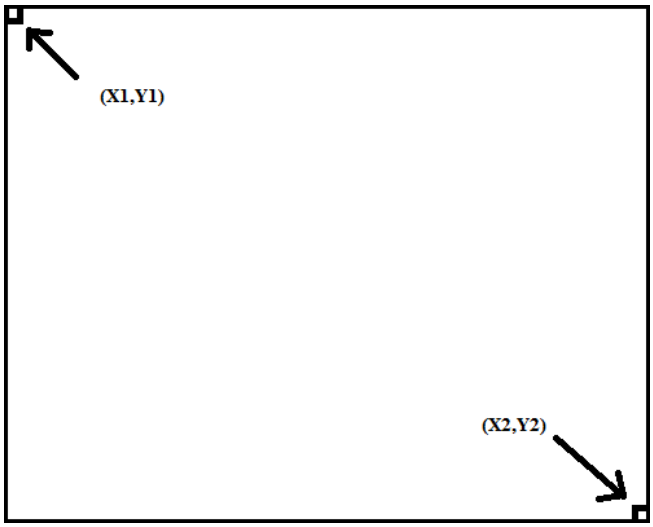

Fig 1: Resolution Measuring

Note: Make sure the sample code works before proceeding.

2) After getting the sample code to work, write/modify the code to display eight color combinations by drawing vertical stripes for each color as shown below. The eight colors that should be displayed are: red, blue, green, magenta, cyan, yellow, white, and black. Note that for this part, you should assign all ones or all zeros to the red/green/blue signals to generate a total of eight different color combinations.

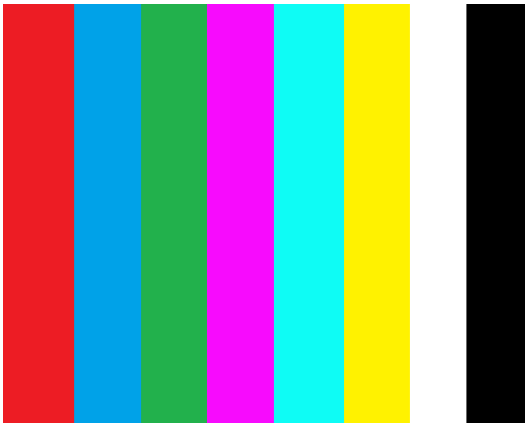

Fig 2: Eight color display

Note: Have the lab instructor signoff task 1 of the lab when all eight colors display as shown in the picture above.

Task 2:

Modify the sample code in order to implement a basic version of the game pong. The following features for the game of pong should be implemented in addition to following the rules of the game:

Features:

1) Green borders should be drawn to the screen to denote the left and right boundaries of the game.
2) Magenta borders should be drawn to screen to denote the top and bottom boundaries of the game.
3) Two blue rectangles should be drawn to represent the paddles for player one and player two.
4) A red circle (you may use a red square instead) should be draw to screen to implement the ball.
5) Two seven segment displays should be used to keep track of score for player one and two.
6) A switch should be used to reset the game in one position and run the game when in the other position. Resetting the game resets all the scores, sets the ball position to the center of the screen, and sets the position of the paddles halfway vertically on the screen.
7) Button 0 and button 1 should be setup to move the left paddle up and down respectively (player 1).
8) Button 2 and button 3 should be setup to move the right paddle up and down respectively (player 2).
9) The paddles should be allowed to move vertically but shouldn't overlap the top and bottom magneta borders by a significant amount. Paddles should be drawn at opposite ends of the screen from each other as shown below.
10) The ball should always be moving diagonally on the screen so it should always have an X and Y component for its movement.
11) The background color of the game board should be black.

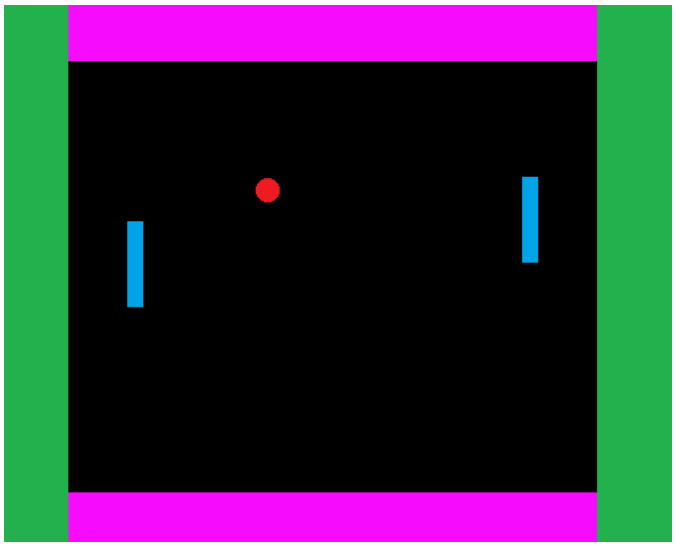

Fig 3: A Basic Pong Screen

Rules of the Game:

1) The ball always moves diagonally on the screen (how fast is up to you) and should bounce off any of the magenta or green borders.
2) The ball should bounce off either paddle when it hits a paddle.
3) A player scores a point when the ball hits the wall/green border on the opposite side of the screen.
4) You decide how many points are needed for a player to win a game so you **may** cap the points once it reaches a specific value. A winner is declared for the player whose score reaches the cap first.

Note: The dimensions of the game features (paddles, ball, walls, etc.) are up to you to decide and define as long as they are within reasonable parameters. Also how fast the ball/paddle moves or the game runs is up to you (within reason).

Suggested method of setting up pong (you don't have to follow this method but it's recommended):

1) First draw the magenta and green borders onto the screen with a black background.

Fig 4: Drawn borders

2) Next draw the two blue paddles onto the screen. At opposite ends of the screen as shown below.

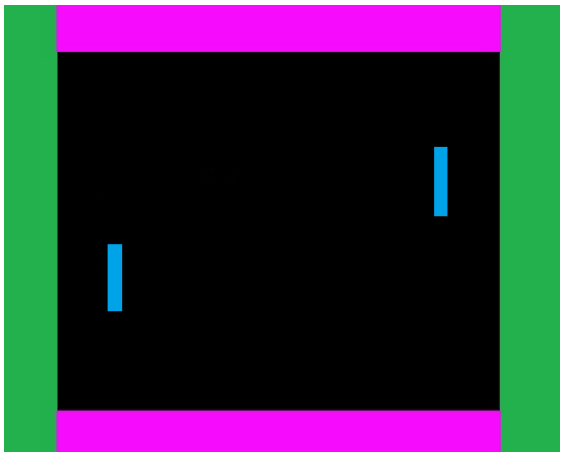

Fig 5: Drawn Paddles

3) Implement the buttons on the FPGA so that they move the paddles up and down. Button 0 and button 1 should be setup to move the left paddle up and down respectively (player 1). Button 2 and button 3 should be setup to move the right paddle up and down respectively (player 2). A paddle should stop moving if it hits a magenta border on top or bottom.

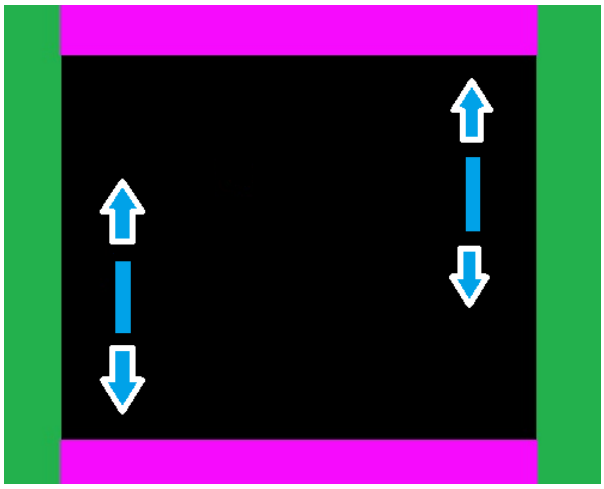

Fig 6: Moving paddles

4) Draw the ball to the screen and write the code so that it can bounce off the walls. The ball should always be moving diagonally on the screen. Note that you may draw the ball as a square if easier to code. Afterwards, write code so that the ball can bounce off the paddles.

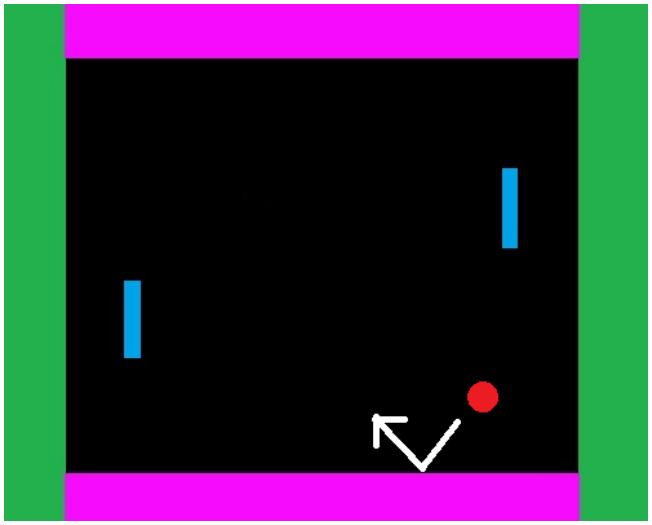

Fig 7: Pong ball

Note: You can consider the ball like a finite state machine shown below where the direction of the ball is denoted by the arrows for each state:

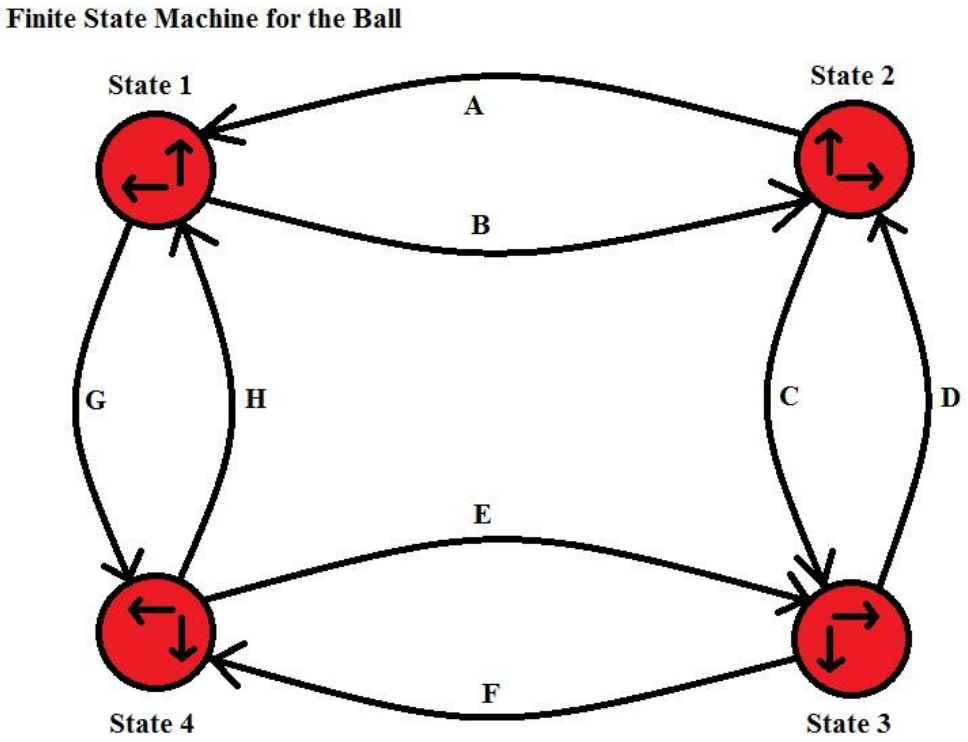

Fig 8: FSM for Pong Ball

State changes for the pong ball FSM are as follows:

A) The ball bounces off the right wall or the right paddle.
B) The ball bounces off the left wall or the left paddle.
C) The ball bounces off the top wall.
D) The ball bounces off the bottom wall.
E) The ball bounces off the left wall or the left paddle.
F) The ball bounces off the right wall or the right paddle.
G) The ball bounces off the top wall.
H) The ball bounces off the bottom wall.

5) Finally write the code to implement a game reset (game resets from a switch), and implement the scoring on two of the seven segment display (one seven segment display for each player's score). Make sure that the pong game implements all features and follows all game rules as noted above.

Note: Once the game has been fully implemented, have the lab instructor signoff for task two.