Tic Tac Toe Game

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Abstract-

The goal of this project was to use the knowledge gained from this class to build a playable Tic Tac Toe game. Using VHDL code, a Nexys board, and an external display this goal was achieved. By using multiple switches as well as a button as inputs the players of the game can display their color on one of the nine spaces of the Tic Tac Toe board. When a player has won, the Nexys Board will display a light signifying which player has won. To reset the game, a button must pressed.

I. Introduction

Tic tac toe is a widely known tabletop game, and while simple to play, it required many components studied in the course to design and build a functional game using only digital logic components. Tic tac toe is a game of wits between two players who must select one square at a time for their mark to be placed with the objective to score a line of three in a row either in the vertical, horizontal, or diagonal direction. Once the board is filled, if there are no consecutive lines then it is a draw. The project includes the use of an external display, Nexys board, knowledge of VHDL coding, and a firm understanding of logic gates. Players toggle switches to control the game and watch the

display for the results.The reset button on the board is pressed to play again.

II. Methodology

A.

The objective of the project is to create a circuit that abides by the rules of tic tac toe and perform efficiently. Two players are allowed to play at a time, traditionally one player plays as X and the other will play as O, however in our iteration of the game red and yellow LED's are used, so players choose whichever color they prefer. One player starts by selecting the position on the 3x3 play space then hands the turn to the next player. This goes on until one player gets three in a row, or the board fills with no winner resulting in a draw. The team started the approach to this problem by designing a number of logic flow charts, but ended up deciding the following flow chart would be the basis of the design. Refer to Figure 1.

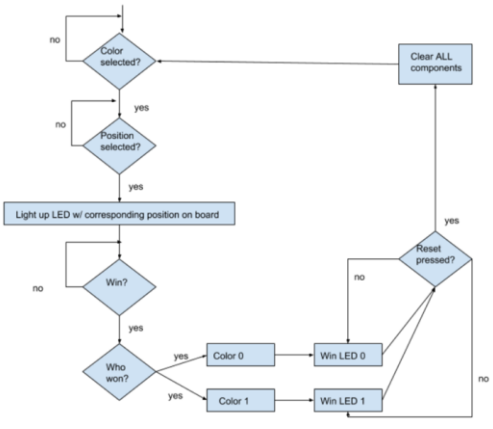

Figure 1.

Looking at the flow chart above, helps the team in designing the layout and programming in vivado.

1	2	3
4	5	6
7	8	9

Figure 2.
The above diagram shows the game board for tic-tac-toe.

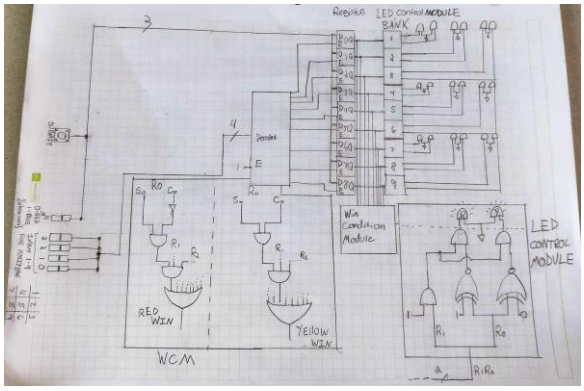

Figure 3.
The above diagram specifically details the way the team combined combinational components with sequential components to create the game.

As a quick overview of the circuit in **Figure 3.**, the major components included: a decoder, 9 2-bit registers, a win condition module (not, and, or gates), and 9 LED control module (xnor, and gates). A player would first select a color using the color switch, choose a position using the 4 position switches and then click the submit button. The position data is sent to the decoder and the decoder sends a logic high signal to the chosen register and a logic low signal to the others. On the clock ticks, the data gets loaded into the registers as the leftmost bit being the submit bit and the rightmost bit being the color bit. This information is sent to the win condition module as well as the LED control module. Within the win control module, the first objective is to check to see what color has been submitted. The color and submit bits go into an 'and' gate which produce an output signal to the next segment. Now that the state has been determined for that square, the system looks for other locations that also have similar colors. If a win condition is achieved then a signal gets output from a 3-input and gate to an 8-input or gate. This or gate is simply to tell that someone has one which would then light up a corresponding win LED. Within the LED control module, the same submit and color bits are given to 3 gates. The submit bit enters a 2-input and gate with a one, which will tell the system that someone submitted a choice. This choice gets sent to two different xnor gates. Depending on what color is sent, one of the 2-input or gates will turn off and the other will be on. The output from the and gate as well as the xnor gates is then sent to another and gate to check if two logic highs have been achieved and the corresponding positional LED will light up with the chosen color. This logic is not the most complex but did require some ingenuity and knowledge of combinational circuits.

B.

III. Experimental Setup

The setup used to display the results of our project was an external display of

the Tic Tac Toe board that utilized an array of LED lights. This game board was constructed out of wood which the Nexys board was also mounted to. The Nexys board was programmed using VHDL code written in Vivado which simulates the game. The outputs of the Nexys board are connected to a breadboard circuit through the use of jumper wires. The LEDs are mounted through holes drilled into the wooden Tic Tac Toe board. The expected outcome was to have a user select a player color via a switch on the Nexys board as well as a position on the board using switches that correspond to binary values. A shorthand equation is that board position (BP) equals the binary equivalent minus 1. For example, if a player wanted to place a move in position 9 (refer to **Figure 2**.) then the player would initially put the binary equivalent which would be 9 and the subtract 1 to get 8. The player would then manipulate the position switches such that the binary equivalent would equal 8. That position then would illuminate the LED of the chosen player at the desired position. In order to play a game of Tic Tac Toe, the players would continue this process until someone wins or the board is full.

IV. Results

The project was successful and the group was able to make a functional Tic Tac Toe game with an external display and programmed Nexus board. The original design for the project included using a VGA screen but after looking at past projects that included VGA screens the group wanted to do something a little more original so it was decided that an external display would be built instead. This display allows the game to be more portable than projects that utilized a VGA monitor.

V. Improvements

As touched on in the conclusion section, the biggest problem still with this project, is the ability to overwrite another players move. Whether it may be accidental or on purpose, this is a major flaw; however, the project group did attempt to remedy this. Referring to **Figure 3.**, each LED control module has two outputs, a Red and a Yellow signal, this signal would be the inputs to an xnor gate. The output of the xnor gate would then be one input to a 2-input and gate with the other input being the submit bit from the registers. This output would then be recombined with the color bit and resent to the LED control module. In theory this additional add-on would allow the system to check if an LED is already on in a certain position, and if it was then the data trying to be submitted would be ignored. This was decided to not be included in the final project for the reason of lack of time to fully troubleshoot and error check all the possibilities; however, the foundation has been set for potentially implementing this in the future should the lab team want to.

Conclusions

After designing and constructing even a simple game such as tic tac toe, a new found appreciation for the effort that goes into creating digitally controlled devices was obtained. There are numerous methods and approaches that can be taken to achieve the same goal, some simpler than others which was a valuable lesson. Sometimes the complicated solution is not the right way

to do things. Overall the team experienced quite the challenge while needing to design a functional circuit only from our past experiments and knowledge from lectures. After combining online resources from Professor Llamocca's website and group experience, the team was able to make a successful game of tic tac toe. However, improvements stand to be made on the design. One such flaw that was encountered is players were able to overwrite the other players past moves. Some sort of anti overwrite circuitry should be implemented; however, if a position was accidentally overwritten, the simple fix is to overwrite that same position with the correct color. A score board also would be a nice addition, as typically multiple rounds are to be played and keeping track would take that responsibility away from the player.

References

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