###### *CSE 260 – Introduction to Digital Logic and Computer Design Jon Turner*

Lab 4 Report

##### *Your name 4/1/2013*

***Part A***. (30 points) Paste your VHDL for the *fifteenPuzzle* component here. Highlight all your changes to the code by making them bold.

paste your code here

***Part B***. (10 points) Paste your VHDL for the *copyPattern* component here. Do not include the pattern memory initialization code. Highlight all your changes to the code by making them bold.

paste your code here

***Part C.*** (20 points). Simulate the *fifteenPuzzle* using the provided *testFifteenPuzzle* testbench. Configure your waveform window to include the following signals and organize them appropriately.

* all inputs and outputs to *fifteenPuzzle* (including the three auxiliary test signals), plus the state, the game board and the values of *emptySquare* and *randBits*. Use the unsigned radix for all multi-bit values except *randBits* (use hex for that).
* all inputs and outputs to *copyPattern*, plus the *dispAdr*, *patAdr* and *patOffset* signals. Use the unsigned radix for all multi-bit values.

Verify that there are no error messages on the simulation console coming from the assertions in the testbench.

Paste a screenshot showing the portion of the simulation from time 0 to 1600 ns below. Make sure that the game board contents is fully visible.

*paste your screenshot here*

What tile is at position 1 after the initial scrambling is done (remember that the first position is 0)? What tile is at position 9? What tile is at position 15?

Is the value of *emptySquare* consistent with the game board. Explain.

From this screenshot, you should be able to tell what direction the empty square moved in the first scrambling step. What direction was that and how do you know?

Paste a screenshot showing the portion of the simulation from time 4 ms to 7.5 ms below. Make sure that the first 12 squares of the board are visible at all times.

*paste your screenshot here*

In what direction did the empty square move at time 5 ms. How do you know?

Paste a screenshot showing the part of the simulation from time 3,031,100 ns to 3,031,500 below.

*paste your screenshot here*

The copyPattern block is starting a new copy operation here. What is the position on the game board that the pattern is being copied to. Calculate the display address for the first pixel in this pattern (show your work) and compare to the value of dispAdr that appears in the simulation.

What pattern is being displayed? Calculate the starting address of this pattern in the pattern memory (show your work) and compare to the value of *patAdr* that appears in the simulation.

***Part D***. (15 points) Paste your VHDL for the *top* and *outMod* components here. Highlight all your changes to the code by making them bold.

paste your screenshot here

***Part E***. (15 points) Complete the *testTop* testbench that you will find in your repository. Follow the instructions given there. Note, you may find it helpful to study the lab 3 testbenches and the *testFifteenPuzzle* testbench first.

paste your code here

***Part F***. (10 points) Simulate your circuit using your *testTop* testbench. Include all the signals from *fifteenPuzzle* that were included before and the character buffer from the *lcdDisplay* module.

Verify that there are no error reports on the simulation console from the assert statements in the testbench. Paste a testbench showing the 2 microsecond period before and after the very first move operation (where *moveNow* goes high). Make sure that the board state is fully visible both before and after the operation.

*paste your screenshot here*

What is the tile that is moved? In which direction does it move?

Find a place where the switches are changing and paste a screenshot below showing the switches, the LEDs, the auxiliary testing signals and the board configuration before and after the switches change (if the switches change in the first screenshot, you may use it to answer this question). How do the LEDs change? Explain the significance of these changes as the switches change?

Paste a screenshot below showing the final state of the board, including the complete contents of the *lcdDisplay*’s character buffer.

*your screenshot here*

Verify that the contents of the character buffer is consistent with the outputs from the *fifteenPuzzle* module.

***Part G***. (10 points) Proceed to this part only after you have completed the simulation in Part *F* and have convinced yourself that the complete circuit will work correctly when transferred to the prototype board. Prototype your circuit using one of the prototype boards available in Bryan 316. Once you have your circuit loaded onto the board and you have convinced yourself that it works correctly, fill in your name below on the printed copy and have one of the TAs check it and sign their name below, after assigning the appropriate number of demo points..

Student name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ has successfully demonstrated the *fifteenPuzzle* circuit on the prototype board.

TA name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

TA signature:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Demo points (out of 10):\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Comments (if the circuit does not work 100% correctly, make a note of all issues below):