

Digital System Design and Implementation

Lab. 5 (Due on 2021/06/03)

Note: Please **upload your codes and files (*.v, *.bit, *.xdc and report)** of this experiment including

Total points :100 points including 50 points for demo.

In this Lab., we will learn to use finite state machine to control the display on VGA screen.

Please control the movement of your eePac Man on the VGA screen like the game. Use the symbol that you define in Lab. 4. Define the push buttons

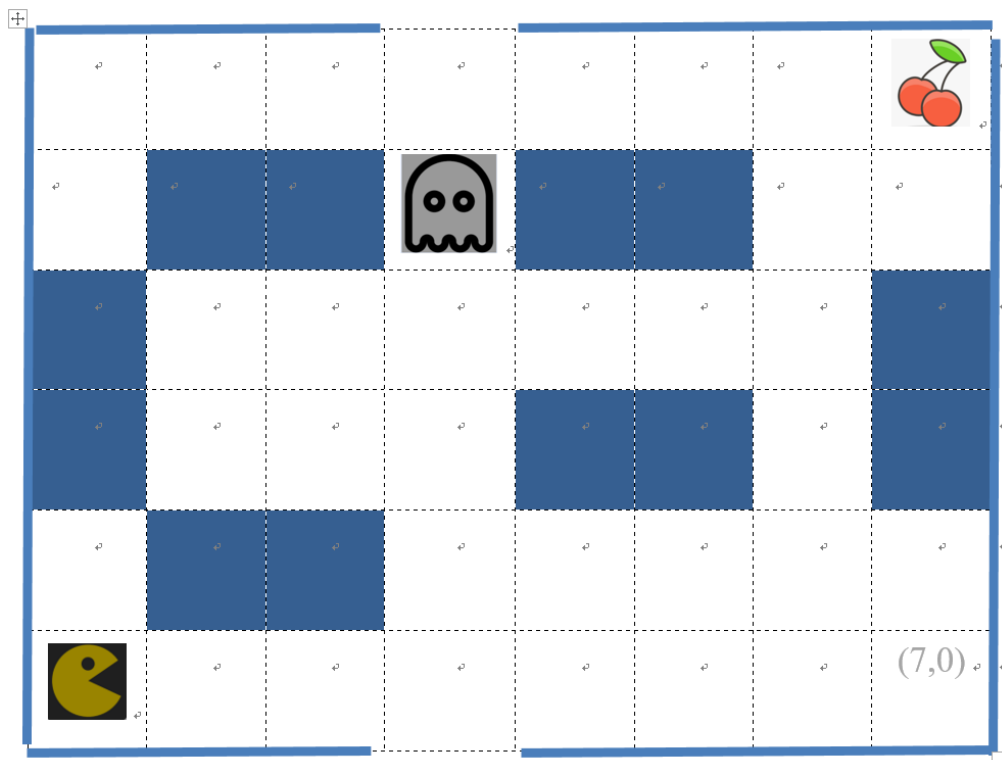
1. “S4” to make the eePac Man “**Move Up**”
2. “S1” to make the eePac Man “**Move Down**”
3. “S3” to make the eePac Man “**Move Left**”
4. “S0” to make the eePac Man “**Move Right**”

Initially, the eePac Man starts from (0,0) and the ghost goes upward from (a, b) , passes through the tunnel $(a, 5)$ and appear from the bottom $(a, 0)$, one step every one second as shown in Fig. 1.

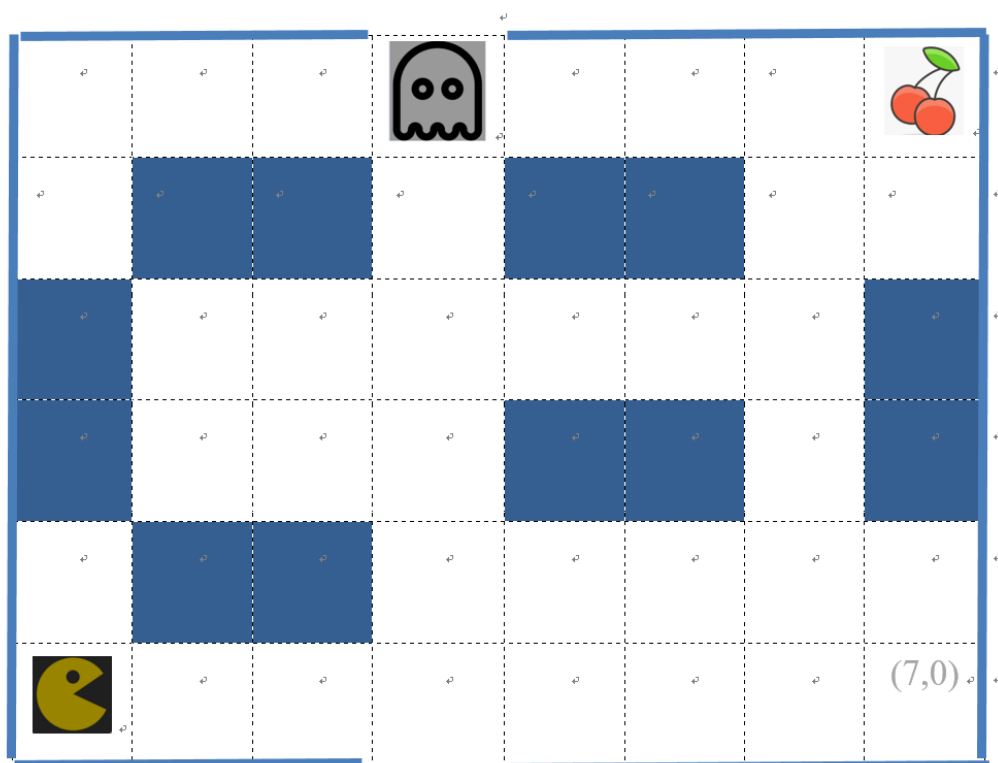
After “S0” is pressed, the screen will become the result in Fig. 2. Of course, the movement of the eePac Man is limited in the range of the 8×6 squares. That is, the push button “**Up**” will make the highest y position of the target symbol to be 5, and push button “**Down**” can only decrease the y position of the target symbol to be 0. The same rule is applied for the push button “**Left**” and “**Right**”, but the rightmost x position is 7. In addition, you need to press and release the button to control one movement. We will not test if the eePac Man can pass through the tunnel.

The player can control the eePac Man to acquire the fruit. Hence, after each movement, the number of accumulated steps is given in the seven-segment display, as shown in Fig. 3. When the eePac Man get the fruit. The player win 50 points which are shown in another two seven-segment. One example that the player moves the eePac Man 12 steps and the eePac Man gets the fruit is shown in Fig. 4. The episode ends.

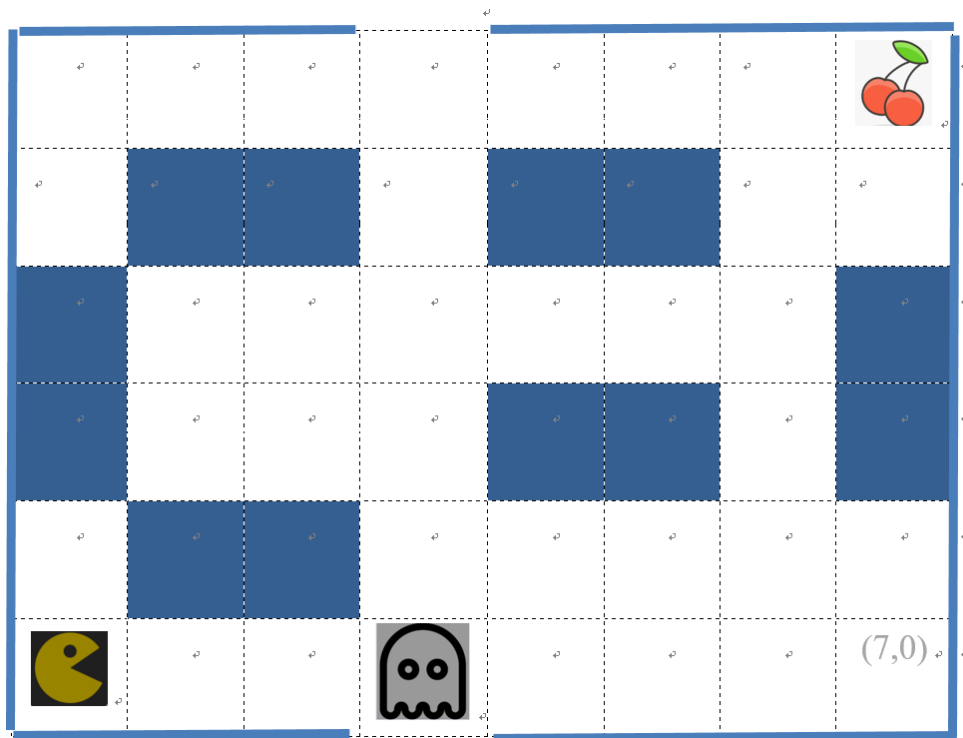
If the eePac Man is captured by the ghost, the episode ends and the LED blinks in the way described in Fig. 5.



(a)



(b)



(c)

Fig. 1: The VGA screen (a) at the beginning, (b) after 1 second, and (c) after 2 seconds.

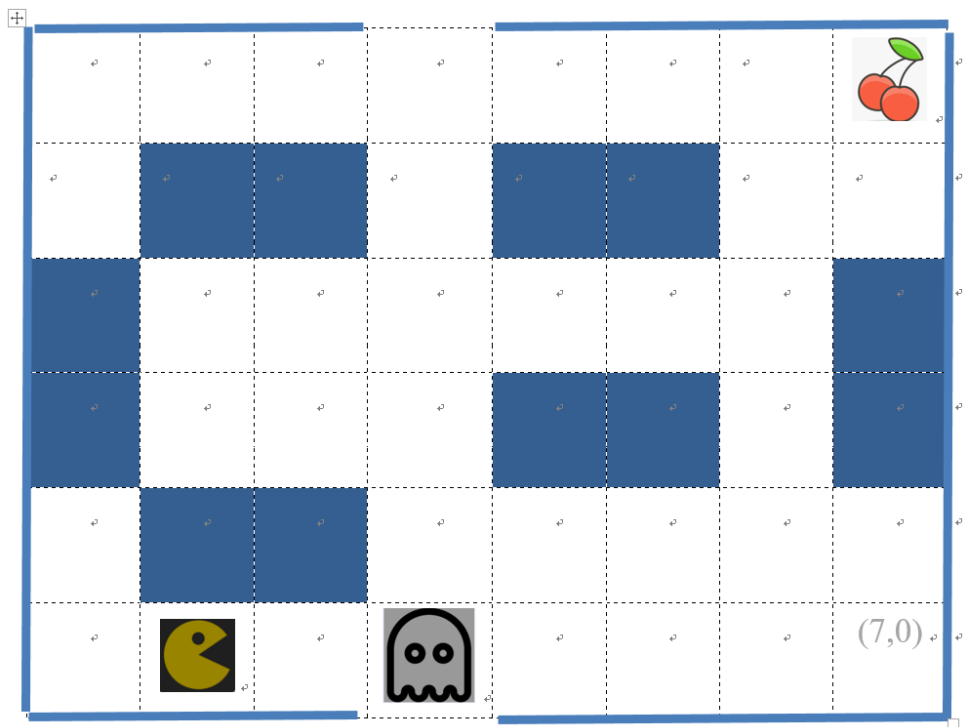


Fig. 2 The screen after “S0” is pressed.



Fig. 3 Accumulated steps.



Fig. 4 Seven segment display after 12 steps. Two left digits show the points that the player gets. Two right digits show the accumulated steps.

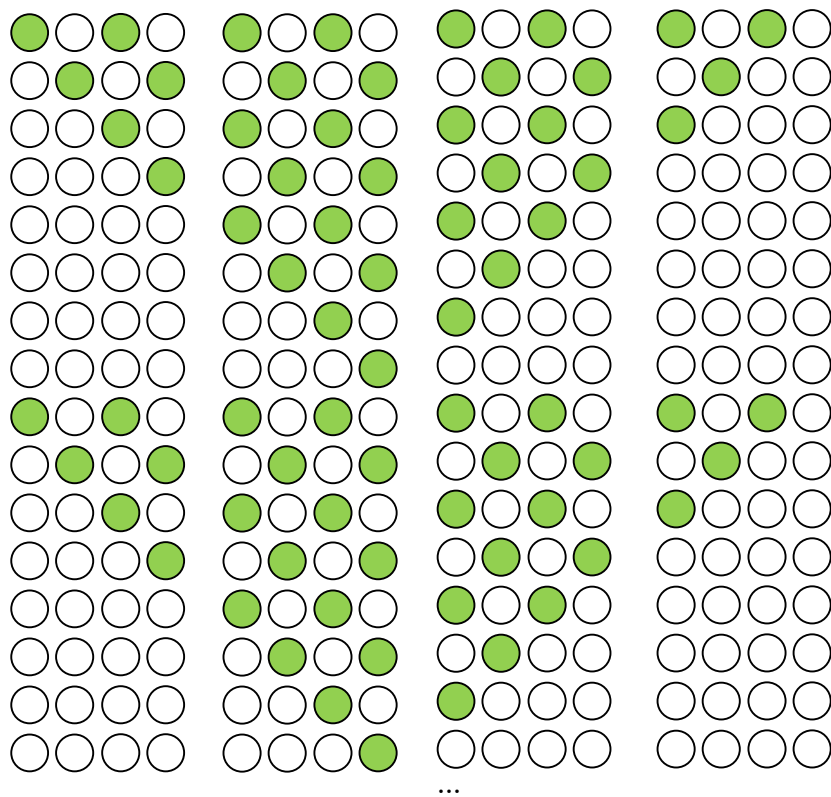


Fig. 6 LED blinks if the eePac Man is captured by the ghost.

Please simply check the correctness on the FPGA board.

1. Write verilog codes for the required functions in the lab.
 - a. Show that the eePac Man can be moved according to the indication of push buttons.
 - b. Show that the ghost moves correctly.
 - c. Show that the number of accumulated steps is displayed correctly by the seven

segment.

- d. Show that the push button will become useless if the movement will exceed the boundary of the panel.
 - e. Show that 50 points are correctly displayed if the eePac man gets the fruit.
 - f. Show that the LEDs blink if the episode ends due to the eePac man captured by the ghost.
2. Demo in the lab time.

