

# *Digital System Design and Implementation*

## *Lab. 5 (Due on 2021/06/2)*

**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 animal on the VGA screen like the game. Use the symbol that you define in Lab. 4. Define the push buttons

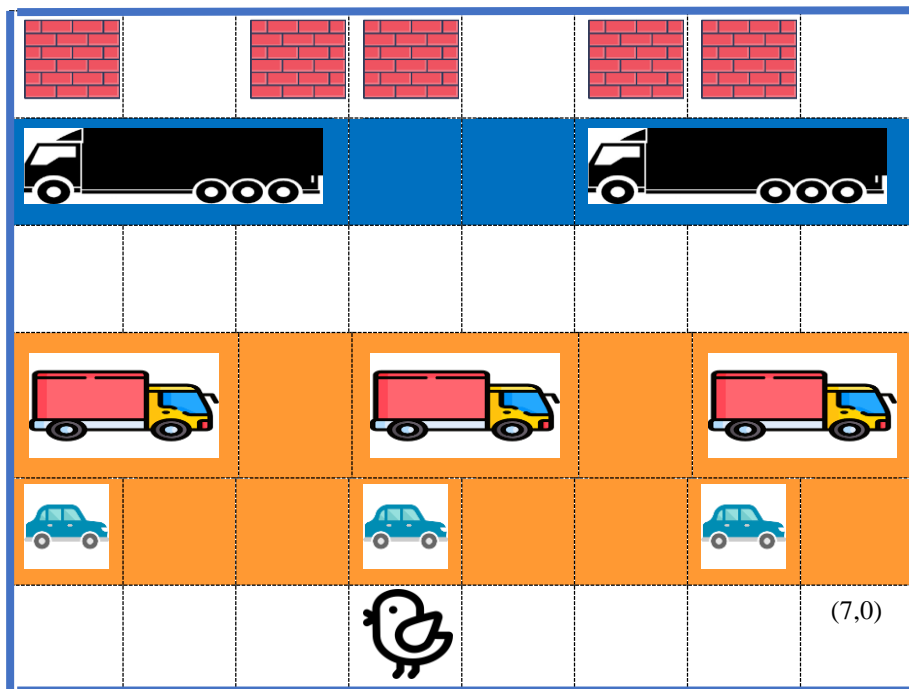
1. “S4” to make the eePac Man “**Move Up**”
2. “S3” to make the eePac Man “**Move Left**”
3. “S0” to make the eePac Man “**Move Right**”

Initially, the animal starts from the defined position and the cars in the orange lane move to the right one step every one second. The trucks in the orange lane and in the blue lane move one step every two seconds as shown in Fig. 1(a) and Fig. 1(b).

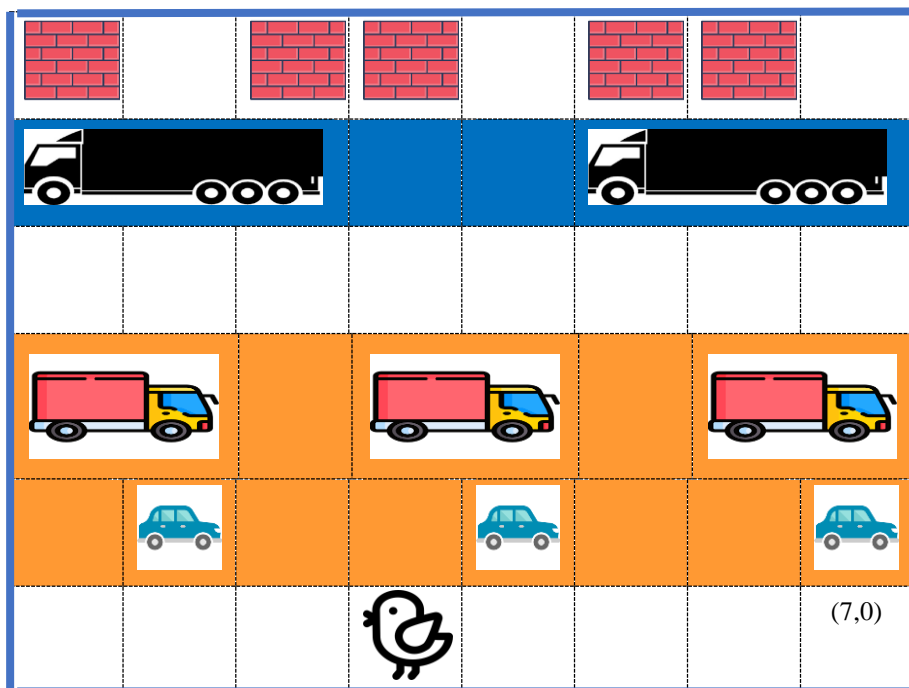
After “S4” is pressed, the screen will become the result in Fig. 2. Of course, the movement of the animal is limited in the range of the  $8 \times 6$  squares. That is, the push button “**Up**” will make the highest y position of the target symbol to be 5. The same rule is applied for the push button “**Left**” and “**Right**”, but the rightmost x position is 7. In addition, you need to press and release the button to control one movement.

The player must control the animal to cross the road safely. Hence, after each movement, the number of accumulated steps is given in the seven-segment display, as shown in Fig. 3. When the animal arrives the row of  $y = 5$  without brick walls, the player win 99 points which are shown in another two seven-segment. One example that the player moves animal 15 steps and the animal safely arrives the other side of the road is shown in Fig. 4. The episode ends.

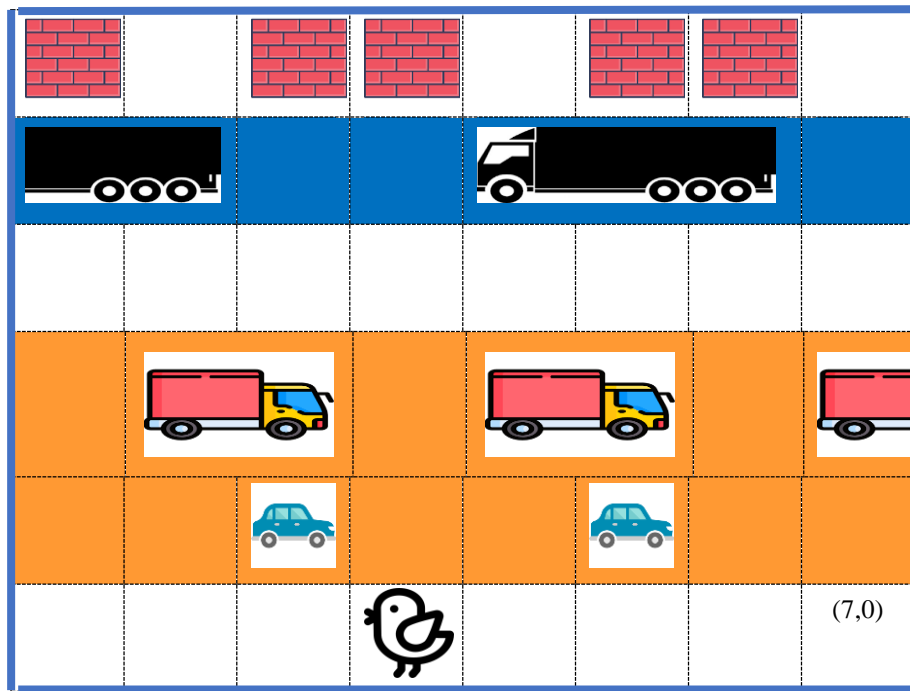
If the animal is hit by the car or truck (the animal and car/truck in the same position at the same clock cycle) or enters into brick wall, the episode ends and the LED blinks in the way described in Fig. 5. The screen stops updating and the animal overlaps the vehicle.



(a)



(b)



(c)

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

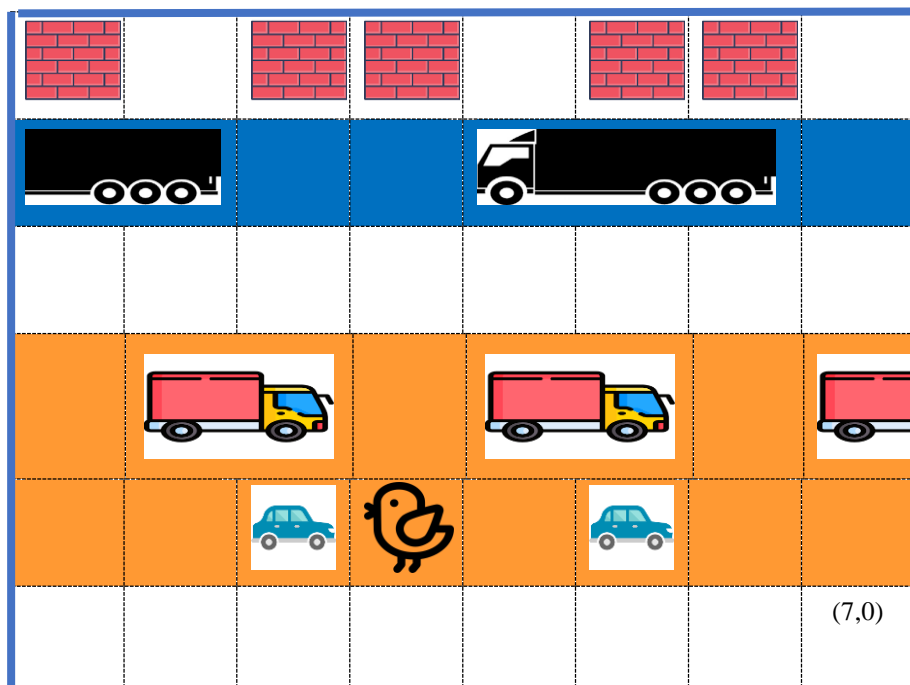


Fig. 2 The screen after “S4” is pressed.

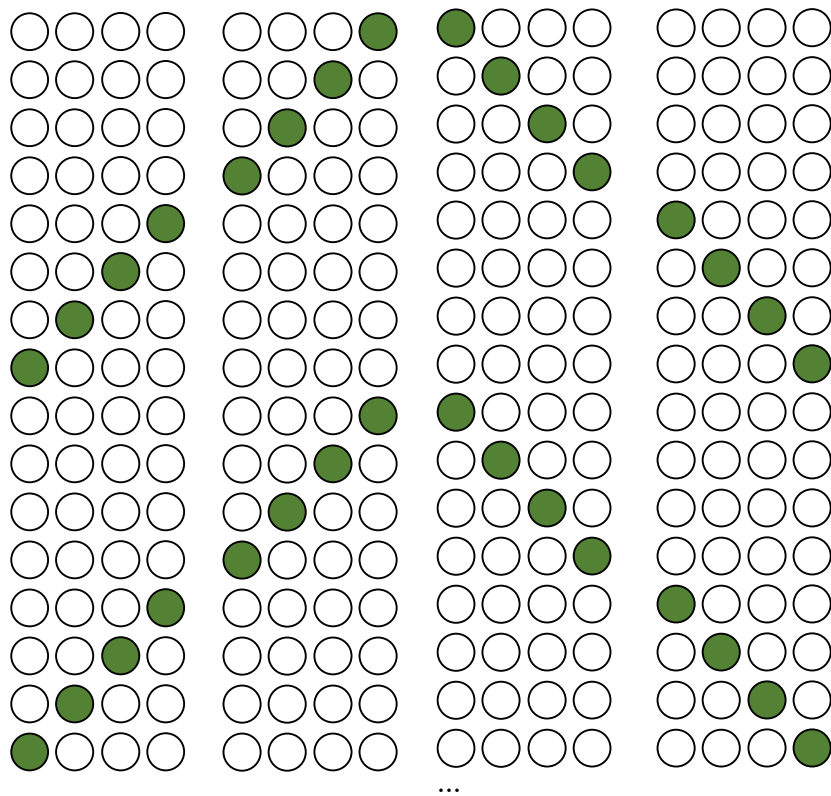
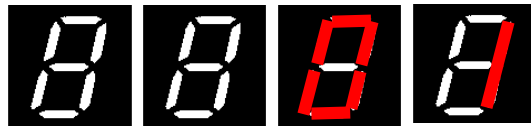


Fig. 6 LED blinks if the animal fails to cross the road safely.

Please simply check the correctness on the FPGA board.

1. Write verilog codes for the required functions in the lab.
  - a. Show that the animal can be moved according to the indication of push buttons.
  - b. Show that the cars and trucks move 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 99 points are correctly displayed if the animal arrives the other side safely.
  - f. Show that the LEDs blink if the episode ends due to the failure.
2. Demo in the lab time.

