Digital System Design and Implementation

Lab. 3

(Due on 05/13 PM 8:00)

Note: lease **upload** all your codes to eeClass with correct file names and hand in the **hardcopy** of this experiment including

a. Verilog codes

b. Test bench

c. Simulation results.

Total points :150 points including 50 points for demo.

In this Lab., we will learn to use sequential logic to sense the pressing of a push button and the debouncing technique. Also, we will learn how to sensing keyboard input.

Assume that we are designing a vending machine.

(a) Use the **RESET** button.

(b) Use the Keys "**c**" "**s**", "**f**", "**p**" from keyboard.

(c) Define push button "**S4**" as "**Put 50 dollars**" (Debouncing may be necessary for this button.)

(d) Define push button "**S3**" as "**Put 10 dollars**" (Debouncing may be necessary for this button.)

(e) Define push button "**S2**" as "**Put 1 dollar**" (Debouncing may be necessary for this button.)

(f) Define push button "**S1**" as "**Buy**"

Assume that we design a vending machine selling "**C**oca Cola", "**S**prite", "**F**anta", and "**P**epsi". For the even-numbered students, the left two digits of seven-segment group 0 show the price of the selected item and for the odd-numbered students, the right two digits of seven-segment group 1 show the price of the selected item. In the following we will use the example corresponding to even-numbered students to illustrate.

After reset, if keyboard "**c**" is pressed, the seven segments show

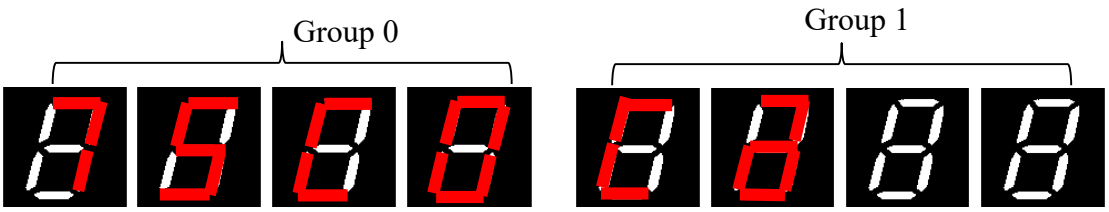


Fig. 1 Display after "c" is pressed for even-numbered students.

If keyboard "**s**" is pressed, the seven segments show

Fig. 2 Display after "s" is pressed for even-numbered students.

If keyboard "**f**" is pressed, the seven segments show

Fig. 3 Display after "f" is pressed for even-numbered students.

If keyboard "**p**" is pressed, the seven segments show

Fig. 4 Display after "p" is pressed for even-numbered students.

Please define **different** prices of the four drinks between 10 to 99 **as you wish.** The customer can press "**c**", "**s**", "**f**", "**p**" multiple times. The last one before the customer presses "**S4**", "**S3**", or "**S2**" is what the customer selects.

If "S4", "S3", or "S2" is pressed, the seven segments then show the money that the customer puts in the same position of the price. Note that you only need to consider money between 1 to 99. Given the selected item is "p", when the customer presses "S4", "S3, "S3, "S2", the accumulated money is shown as follows. If the accumulated money

exceeds 99, it will only display 99.

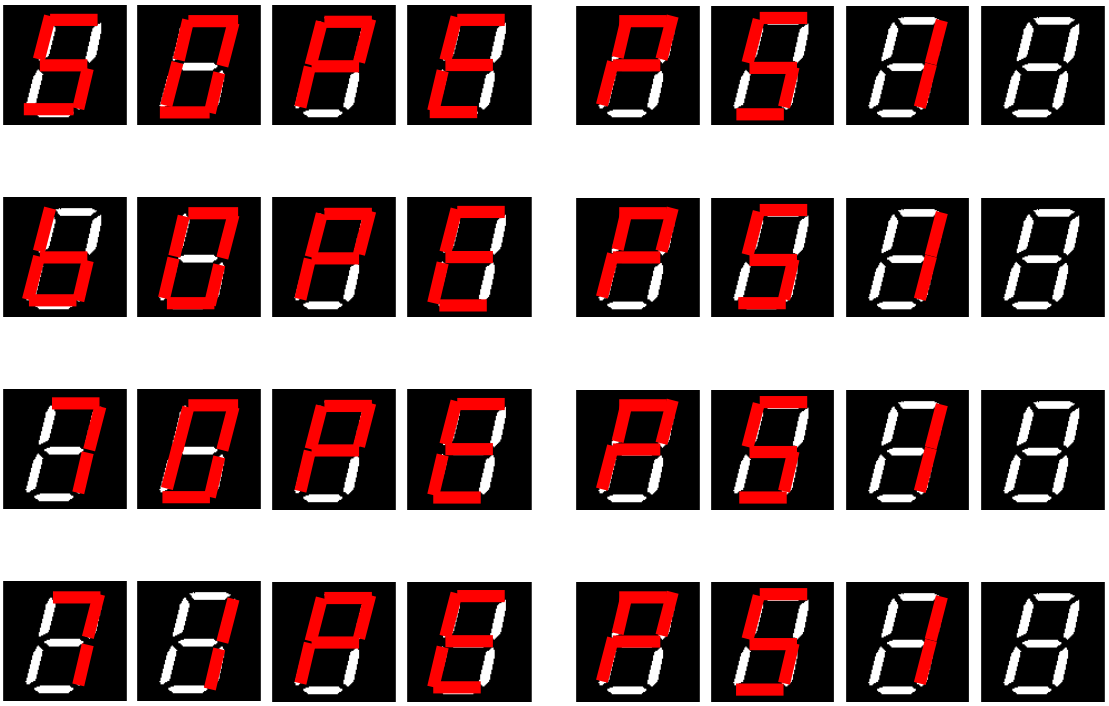
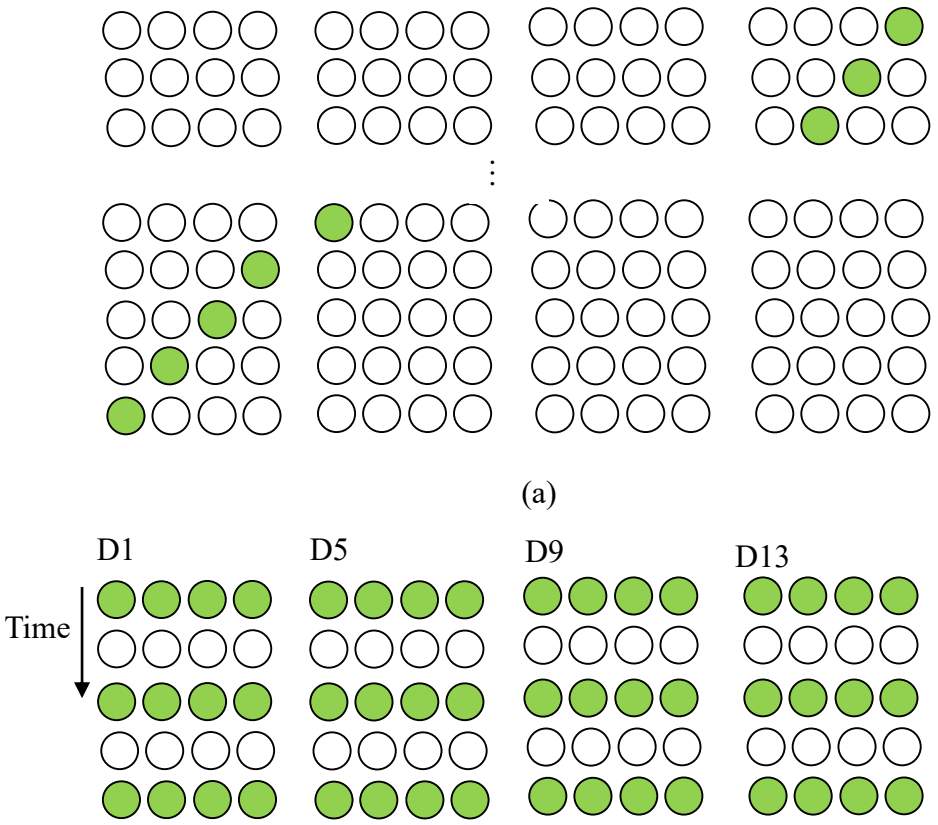


Fig. 5 Display after push buttons “S4”, “S3”, or “S2” is pressed for even-numbered students.

If the accumulated money exceeds the price of the item and the customer pressed “**S1**”, the name of the item disappears and the difference of the accumulated money and the price is shown in Fig. 6 to indicate what the machine pays back to the customer. The LEDs also blink in the way described in Fig. 7(a) to indicate the drop of the drink. For even-numbered students, the LEDs blink from the right to the left. For odd-numbered students, the LEDs blink from the left to the right.

Fig. 6 Display after push buttons “S1” is pressed

If the accumulated money is less than the price of the item and the customer presses “**S1**”, the seven segments remain and do not change. The LEDs blink in the way described in Fig. 7(b). (We will not test further after this condition and you can end your program.)

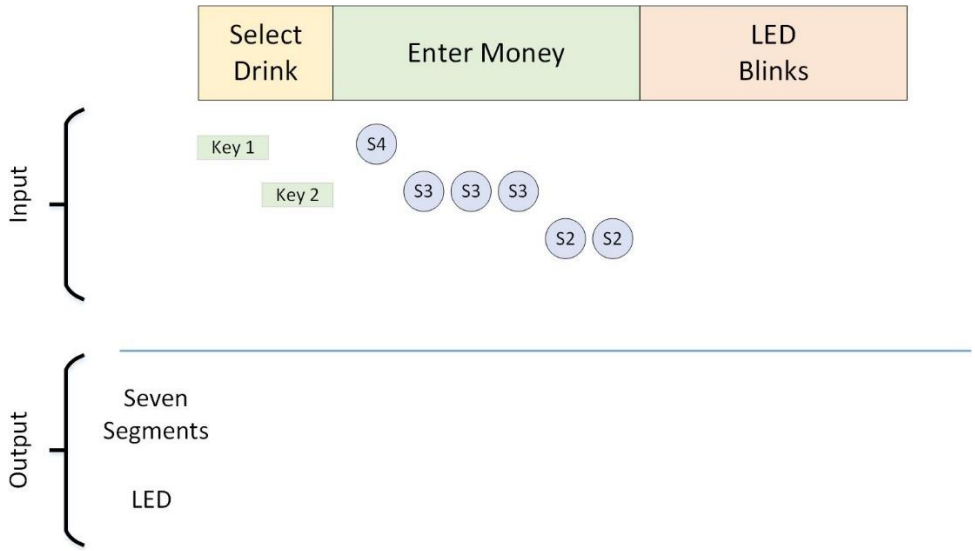


(a)

(a)

Fig. 7 LED blinks (a) if the customer can buy the drink and (b) if the customer can not buy the drink.

1. Write verilog codes for the required functions in the lab. (50%)
2. Write the test bench to check for correct select timing. Because of the long interval of two adjacent key-pressing operations compared to the clock frequency of 100 MHz, you can simply **a proper period** for your key-pressing operation in your test bench to observe the related output waveform and simulation time. (50%)
   (a) For even-numbered students, please test for buying “Fanta” and put “73 dollars”. For odd-number students, please test for buying “Sprite” and put “82 dollars”. The money that the machine pays back depends on your own price. Also you need to pressed at least two keys.
   (b) Show the RTL simulation results. You need to show the complete LED blinking pattern.



3. Demo in the lab time. Note the proper setting of the shining frequency and the debounce period.