Digital System Design and Implementation

Lab. 2

(Due on 4/15 8:00PM)

Note: Please **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.

d. Synthesis timing report.

Total points :150 points.

In this Lab., we will learn to use sequential logic to control the shining frequency and pattern of the LED and seven-segment display.

Define the function of the **large** switch as below. Switch 1 indicates the two shining frequencies, switch 2 defines the operation mode, and the switches 3 to 6 represent the Pattern. Switch 7 and 8 indicate the bouncing times of lighting LEDs. Assume that a pattern moves along the 16 LEDs. For even-numbered students, the pattern moves from the left to the right. For odd-numbered students, the pattern moves from the right to the left.

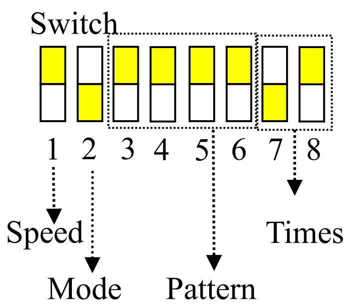


Fig. 1 Definitions of functions of the DIP switch

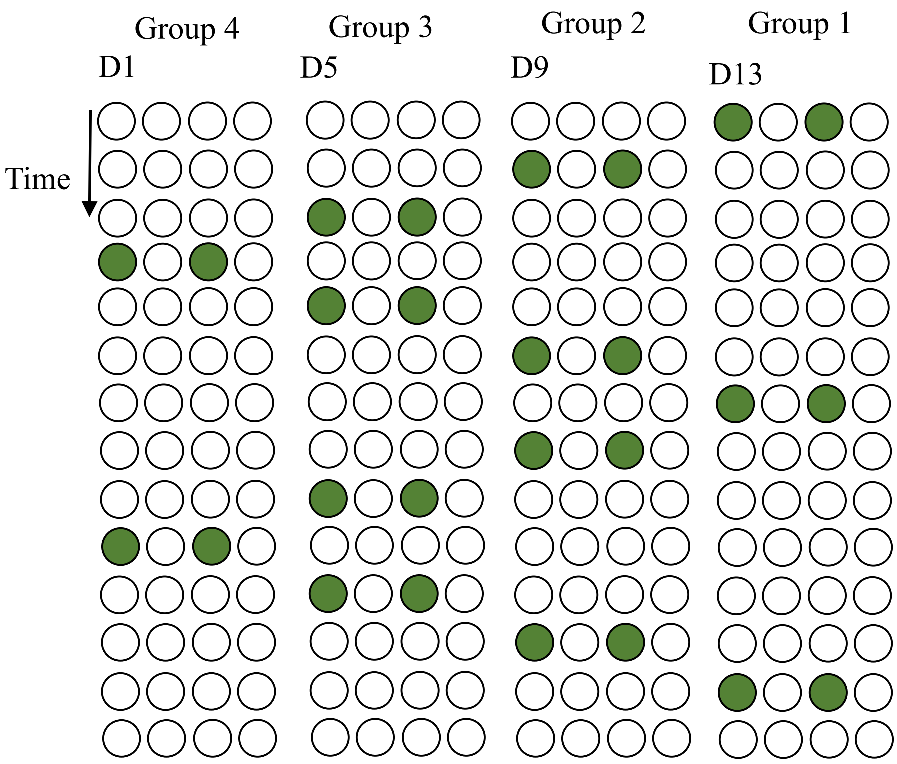
For even-numbered students,

1. Speed “ON” ～ 0.5Hz;
2. Speed “OFF”～ 1Hz;

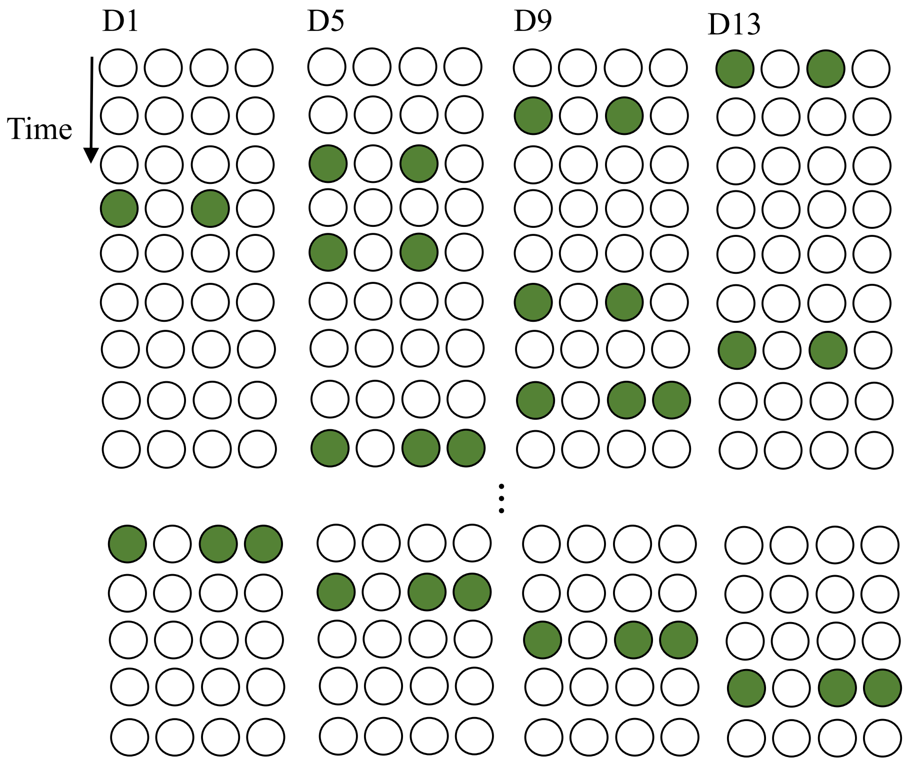
For odd-numbered students,

1. Speed "ON" ～ 0.5Hz;
2. Speed "OFF" ～ 2Hz;

The speed defines the frequency for the LEDs to change its shining pattern. For an odd-numbered student, assume that the "**Pattern"** is defined as "ON", "OFF", "ON", "OFF" ("a"). If "**Times"** is set to "ON" and "OFF" ("2"), after reset, the LED pattern will propagate to the left as shown in Fig. 2(a) and return back to the right for two times. If "**Mode"** is "ON", when the pattern re-propagates, the value of the pattern will be increased by 1 each time as shown in Fig. 2(b). Please use modulo-16 addition. It means if pattern is 16, it is equivalent to 0.



(a)



(b)

Fig. 2 The moving pattern of the shining LED for an odd-numbered student (a) when **Mode** is "OFF" and (b) when **Mode** is "ON".

For even-numbered students, the LED pattern will propagate to the right. If the "**Pattern"** is defined as "OFF", "ON", "ON", "ON", "**Times**" is "ON" and "ON" ("3"), and "**Mode**" is "ON", the moving LED pattern will be described as shown in Fig. 3.

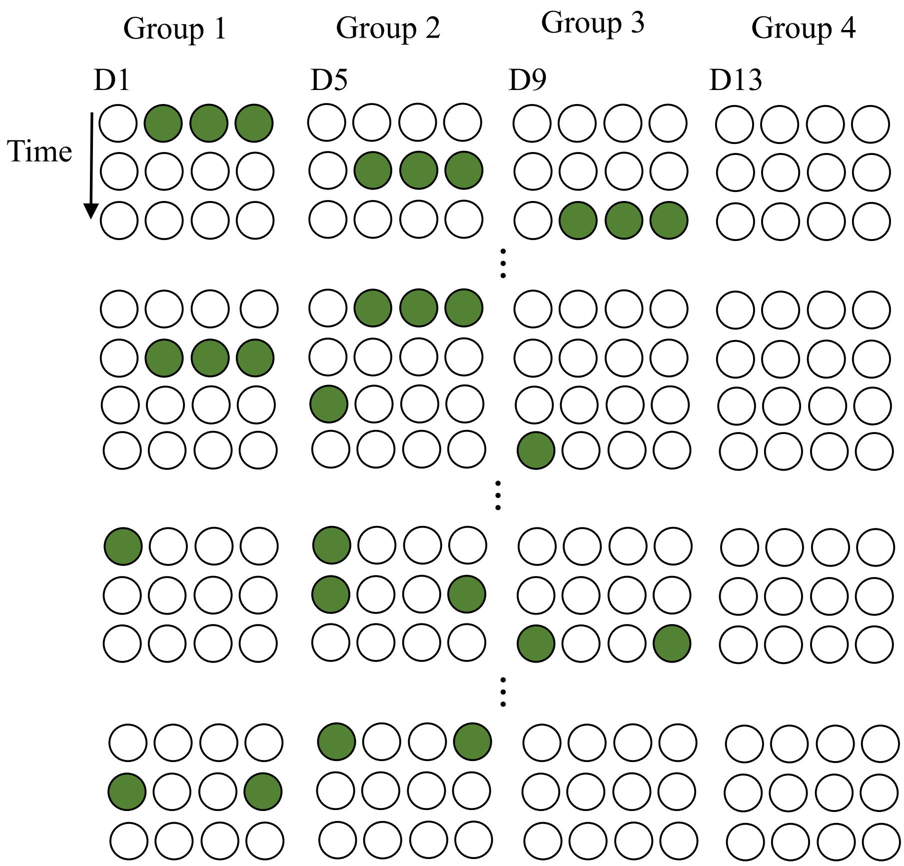


Fig. 3 Example 2 for an even-numbered student with “**Mode**”=”ON”

Two adjacent seven-segment displays **in one group** are used to show the information of the shining LEDs. The left digit of the seven-segment indicates the current pattern. The right digit indicates the current LED group. For example, if the LED moving pattern is defined as in Fig. 3, then the seven-segment display will show the sequence of “71”, “72”, “73”, “74”, “73”, “72”, “71”, “82”, “83”... as shown in Fig. 4. Note that the group indices for even-numbered and odd-numbered students are different for the 16 LEDs.

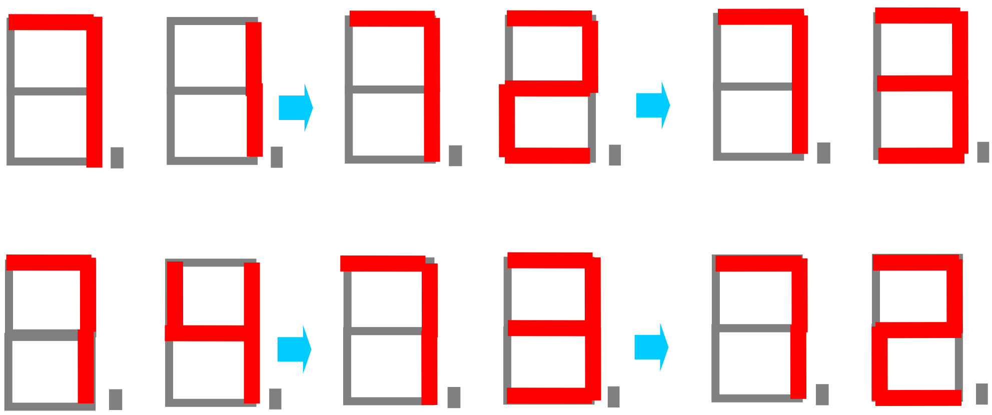


Fig. 4 The result shown by the seven-segment display for Fig. 3.

1. Write verilog codes for the required functions in the lab. (50%)
2. Write the test bench and use the last digit of your student ID (***x***) to set the pattern. Show the simulation results for **complete cycles until the LED pattern travels with the pre-defined times**. Because of the slow shining frequency of the LED compared to the clock frequency of 100 MHz, you can simply use a **one/two/three-bit** counter for the LED shining frequency in your test bench to observe the related output waveform. (Namely, do not use the original frequency divider of more than 20 bits.) (20%)
   (a) "**Mode"**="OFF" and **"Times"**=2
   (b) "**Mode"**="ON" and **"Times"**=3
3. Show the behavior simulation results. If your **Pattern** is "4'b0000", then please use "4'b1011"(25%).
4. Show the synthesis timing report. (5%)
5. Demo in the lab time. Check for the proper setting of the shining frequency. Note that TA will set arbitrary starting position. (50%)