Digital System Design and Implementation

Lab. 2

(Due on 4/19 8:00PM)

Note: Please **upload** all your Verilog programs for TA verification and hand in the **hardcopy** of this experiment including the following items before the due day.

a. Verilog codes
b. Test bench
c. Simulation results.
d. Synthesis timing report.

Total points: 150 points including 100 points for reports and 50 points for demo.

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 DIP switch as below. Switch 1 is used for RESET. Switch 2 denotes the shining frequencies. Switch 3 sets the pair function. Switch 4 to 7 represent the LED starting position. Switch 8 indicates to inverse the ON/OFF pattern.

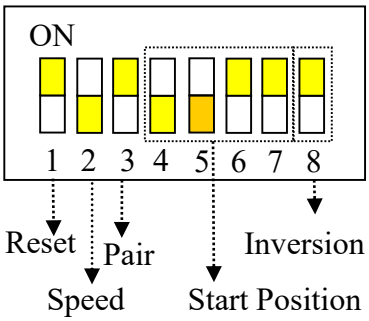


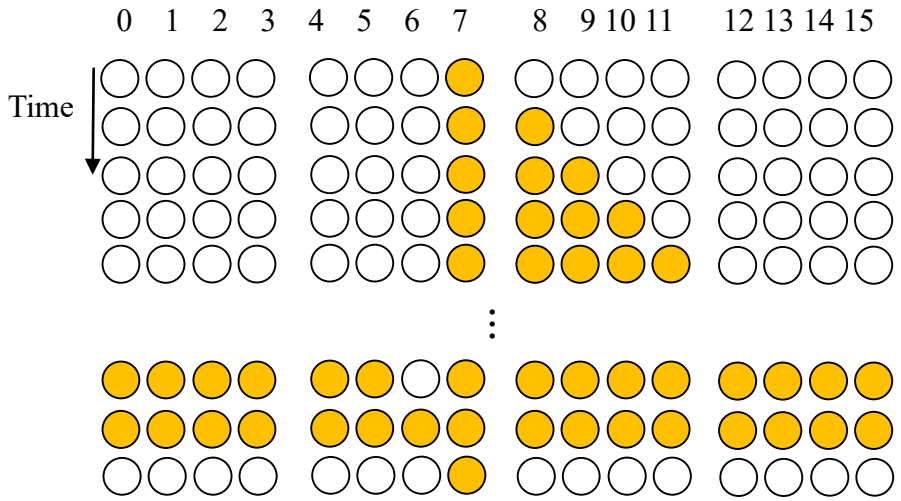
Fig. 1 Definitions of functions of the DIP switch

For even-numbered students, the moving direction is from the left to the right.

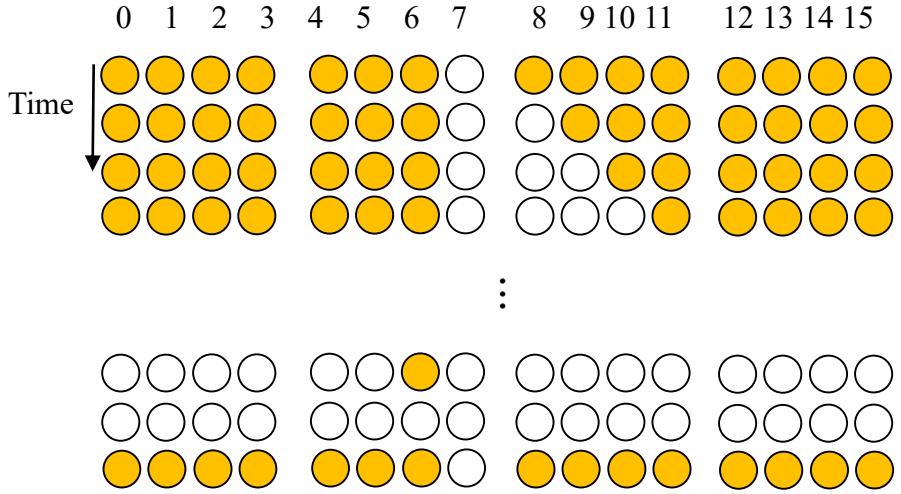
1. Speed “OFF” ～ 1Hz;
2. Speed “ON” ～ 2Hz;

For odd-numbered students, the moving direction is from the right to the left

1. Speed “OFF” ～ 2Hz;
2. Speed “ON” ～ 4Hz;



(a)



(b)

Fig. 2 The shining pattern of the LEDs (a) when the **Inversion** is "OFF" and (b) when the **Inversion** is "ON".

The speed defines the frequency for the LEDs to change its shining pattern. Given the **Starting Position** is set to "OFF", "ON", "ON", "ON" ("0111"), for the even-numbered students, if the **Inversion** is "OFF" and the **Pair** is "OFF", after reset, the "ON" LED will propagate to the right and the number of "ON" LEDs is increased by one at a time as shown in Fig. 2(a). If the **Inversion** is "ON", the shining pattern will be inverted, as shown in Fig. 2(b). Arbitrary two adjacent seven-segment displays are used. One digit of the seven-segment will indicate the starting position of the LED. The other digit will show the information of the latest and the leading "ON/OFF" LEDs

with the index using hexadecimal (0, 1, …, 9, a, …, f). For example, if the **Starting Position** is “0111” and the **Pair** is “OFF”, then the seven-segment display will show the sequence of “77”, “78”, “79”, “7a”, “7b”, ... as shown in Fig. 3.

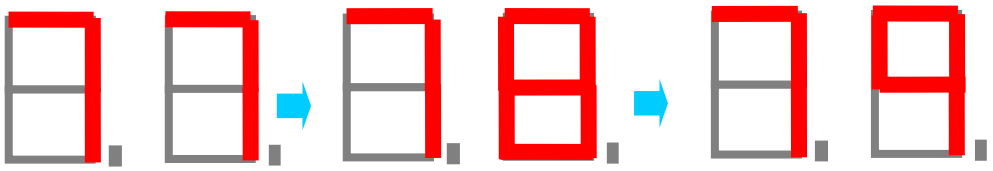


Fig. 3 The result shown by the seven-segment display

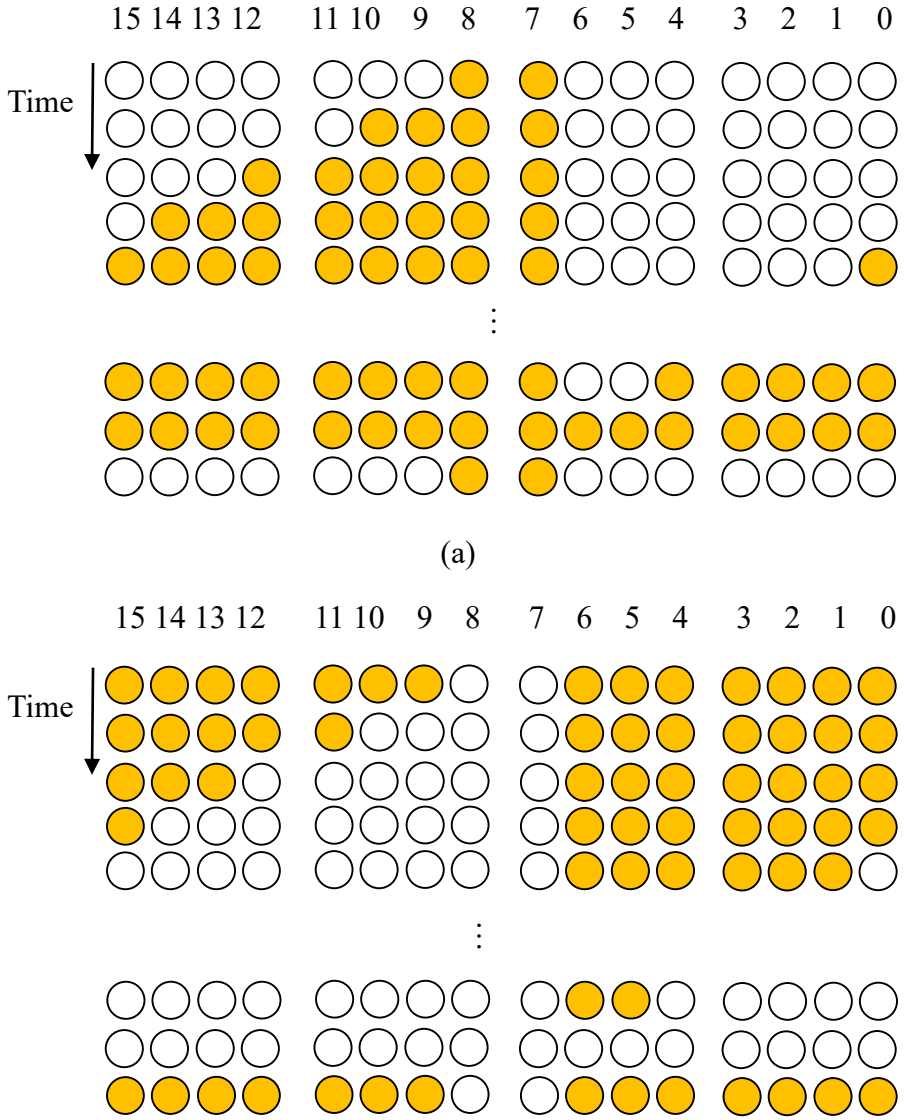


Fig. 4 The moving pattern 2 of the shining LED, (a) when the **Inversion** is “OFF” and (b) when the **Inversion** is “ON”.

For the odd-numbered students, if the **Starting Position** is “0111”, the **Inversion** is

“OFF”, and the **Pair** is “ON”, the “ON” LED will propagate from the right to the left and two LEDs will be lit on at a time as shown in Fig. 4(a). If the **Inversion** is “ON”, the pattern is given in Fig. 4 (b). The seven-segment display will show the sequence of “77”, “79”, “7b”, “7d”, “7f”, ... as shown in Fig. 5

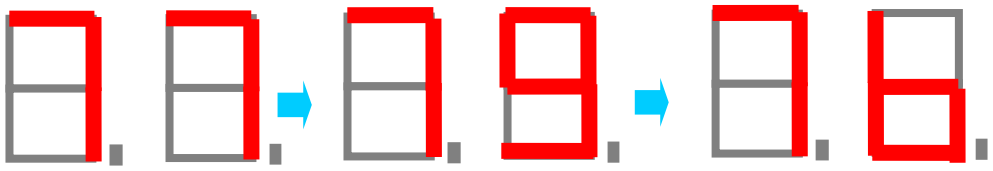


Fig. 5 The result shown by the seven-segment display when the **Pair** is set to 2.

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 as the setting of the **Starting Position (for example, if your last digit is 8, please set 4’b1000 in the test bench**.) Because of the slow shining frequency of the LED compared to the clock frequency of 40 MHz, you can simply use 40 MHz for the LED shining frequency in your test bench to observe the related output waveform. You can set **Inversion** to always “ON” or “OFF” in the whole test pattern. Please given as follows and observe outputs of LED pattern (16bits) and two digits of seven-segment display. Note that you need to show a complete period for 16 LEDs all “ON”(15%)

Starting Position	
Pair OFF	Pair ON

LED Pattern	LED Pattern
Two Digits for 7-Segment	Two Digits for 7-Segment

3. Show the behavior simulation results. (25%)
4. Show the synthesis timing report. (10%)
5. Demo in the lab time. Note the proper setting of the shining frequency. (50%)