Digital System Design and Implementation

Lab. 1

(Due on 4/1 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. Behavior simulation results.
d. Synthesis timing report.

Total points :150 points.

In this Lab., we will learn how to light up LED and seven-segment display controlled by DIP switches.

Define the function of the DIP switch as below. The switches 1 to 3 are used to define the position for LED lighting. The switches 4 to 7 represent the pattern of lighting LEDs inside one the group. The increment/decrement indicates the pattern change for the next group.

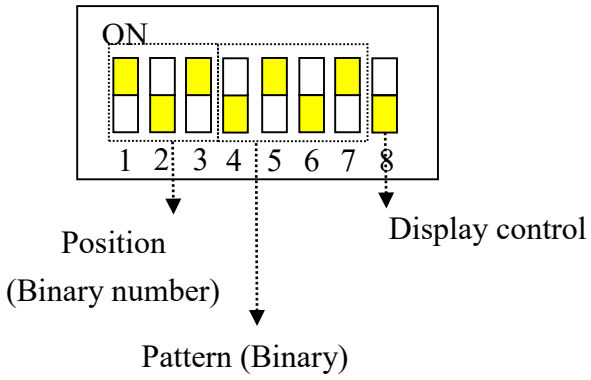

Fig. 1 Definitions of functions of the DIP switch

Display control is used to define the display on the seven-segment according to the position and pattern.

For even-numbered students, seven-segment display (**Left_Seg**, Right_Seg)= ($[\mathbf{Position} + a]_{16}$, **Pattern**), where a=your last digit of your student ID and $[\cdot]_{16}$ denotes the modulo-16 operation.

For odd-numbered students, seven-segment display (**Left_Seg,** Right_Seg) = (**Pattern**, $[\mathbf{Position} - a]_{\mathbf{16}}$).
The left segment and right segment are adjacent and located in the same seven-segment groups. If the display control is "OFF", the left segment displays. Otherwise, the right segment displays.

The LEDs are indexed from D1 to D16 and four LEDs are collected as one group. They will be lit up according to the setting of position and pattern. The position defines the style of group of lighting LEDs. For even-numbered and odd-numbered students, the settings of position and the active groups are defined as follows. Note that the group index of odd-numbered students starts from the left and the group index of even-numbered students starts from the right.

Table 1: Definition of Position

Position (1 = 'ON')	Active Groups
000	1, 2
001	1, 3
010	1, 4
011	2, 3
100	2, 4
101	3, 4
110	1, 2, 3
111	2, 3, 4

One example is illustrated in the following figure. Assume that the states of DIP switches 1, 2, 3 are "ON", "OFF", "ON", the **Pattern** is set to 9 (switches 4, 5, 6, 7 are set to "ON", "OFF", "OFF" and "ON" (4'b1001)). An odd-numbered student should light up the LED as the style given in Fig. 2.

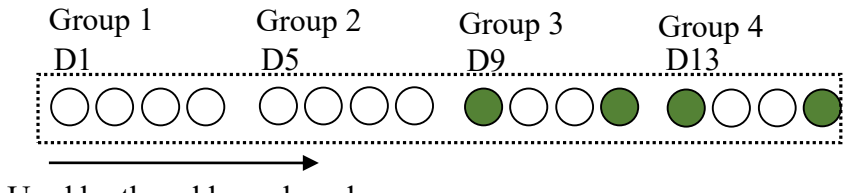

Fig. 2 Example 1 of LEDs

Another example is illustrated in Fig. 3. The states of DIP switches 1, 2, 3 are

“ON”, “ON”, “ON” with the **Pattern** of DIP switch 4, 5, 6, 7 defined as “OFF”, “ON”, “ON”, “ON”. An **even-numbered** student should light up his/her LED as shown in Fig. 3. Note that switches 1 and 2 for effective Group setting is

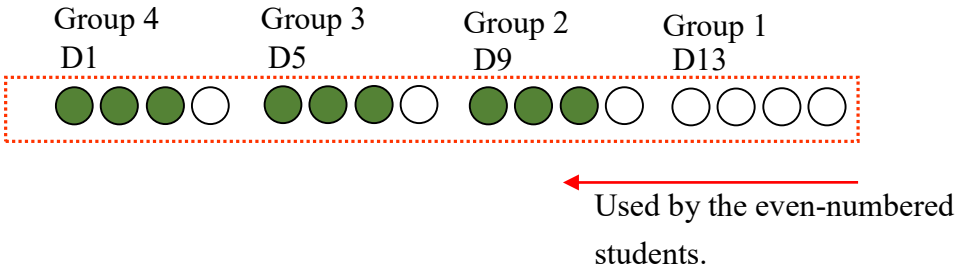

Fig. 3 Example 2 of LEDs

Note that for every student, all the switches must be configured arbitrarily according to the settings of the user.

Arbitrary two adjacent seven-segment displays are used in the same group to show the result of (Left_Seg, Right_Seg) with the settings of position and length. For example, given that

a. **Position** = “ON”, “ON”, “ON”
b. **Pattern** = “ON”, “ON”, “OFF”, “OFF”

For an even-numbered students with ID=9, the (Left_Seg, Right_Seg)=(0,12). If “Display Control” is “OFF”, “0” is shown. If “Display Control” is **“ON”**, “c”(hexadecimal) is given, as shown in Fig. 4.

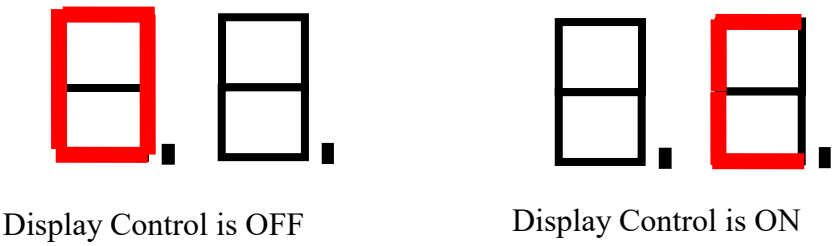

Fig. 4 Result given by seven-segment display

1. Write verilog codes for the required functions in the lab. (60%)
2. Write the test bench to apply the function key to the following 4 binary input patterns
   (a) “The last digit of your student ID” transformed to its binary representation,
   (b) “The second digit from the right of your student ID” transformed to its binary representation,

(if either digit in (a) or (b) is zero, then try to use 4'b1010 for (a) or 4'b1011 for (b).)

(c) "$1101_{(b)}$",

In (a)-(c), binary 1 means setting "ON" for the DIP switch, binary 0 means setting "OFF" for the DIP switch.

The waveform should be given as the following sequences, where "Dp ON" indicates **Display** is "ON", "Pos. 2" means that **Position** is set to 2 (3'b010).(15%)

Setting (a)		Setting (b)		Setting (c)	
Dp ON	Dp OFF	Dp ON	Dp OFF	Dp ON	Dp OFF
Pos. 2	Pos. 3	Pos. 4	Pos. 5	Pos. 6	Pos. 7

LED Pattern 1	LED Pattern 2	LED Pattern 3
Displayed Segment value	Displayed Segment value	Displayed Segment value

Fig. 5 The test sequences.

3. Show the behavior simulation results. Please show the "hexadecimal value" for seven segment display instead of the 0's and 1's of all segments (20%)
4. Show the synthesis timing report. (5%)
5. Demo in the lab time until 03/31 for Thursday students and 04/01 for Friday students. (50%)