Digital Logic Design Laboratory

Lab 4

Multiplexers

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Student number: 2

Class: 1

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I. Objectives

In this laboratory, students will study:

- Understand and design a multiplexer.
- Use a multiplexer and design/implement a circuit based on a function definition.
- Design combinational circuits using MUX.

II. Procedure

1. Design multiplexer using logic gates

a. Design 2-to-1 multiplexer using logic gates:

A 2-to-1 multiplexer has I_0 and I_1 are the two inputs, S is the selector input, and Y is the output. When S = 0 then Y = I_0 but when S = 1 then Y = I_1. The Figure 1 shows the illustration of MUX 2-1.

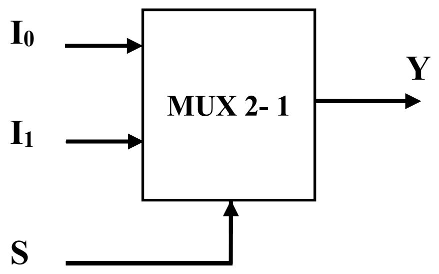


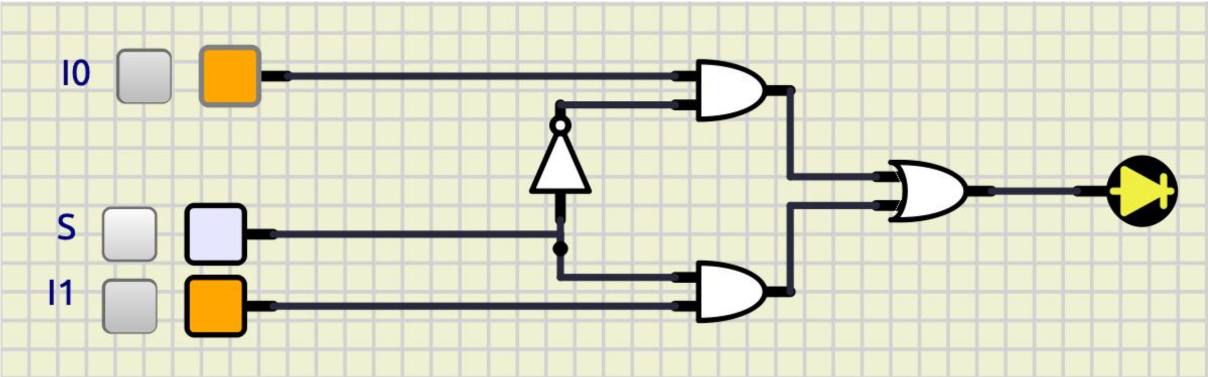
Figure 1. The illustration of MUX 2-1.

Built the truth table:

.			Output
S	**I_0**	**I_1**	**Y**
0	0	0	0
0	0	1	1
0	1	1	0
0	1	0	1
1	0	0	0
1	0	1	0
1	1	1	1
1	1	0	1

The expressions: Y = $\bar{S}$**I1 + SI0**

Implement the circuit via simulation software and paste the result in here



Make comment on the results: The outcomes demonstrate the idea of adjusting the control input S to switch between input lines (0 for I0 and 1 for I1).

b. Design 4-to-1 MUX using logic gates.

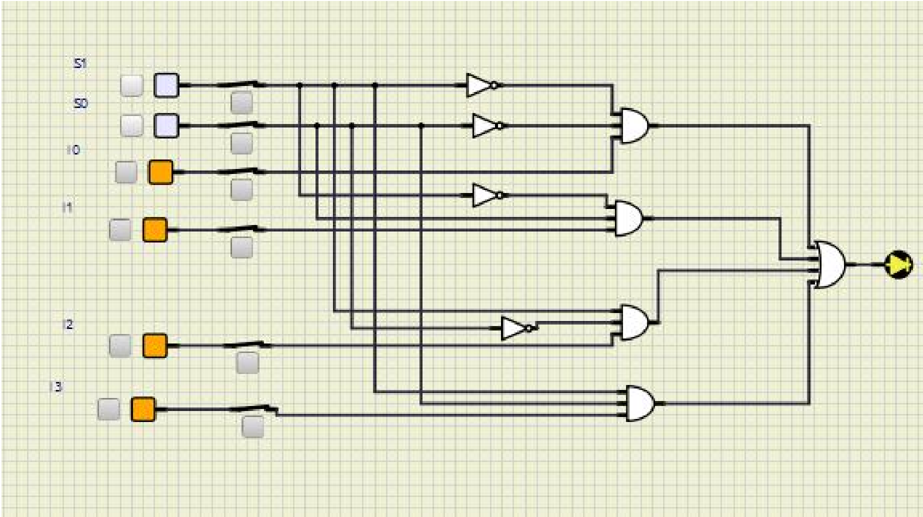
Build the circuit. The inputs S_0, S_1, I_0, I_1, I_2, I_3 are driven by 6 switches.

Input		**Output**
S_0	S_1	Y
0	**0**	I_0
0	**1**	I_1

1	**0**	I_2
1	**1**	I_3

The expressions: $Y = \overline{S0}\,\overline{S1}\,I0 + \overline{S0}\,S1\,I1 + S0\,\overline{S1}\,I2 + S0\,S1\,I3$

Implement the circuit via simulation software and paste the result in here

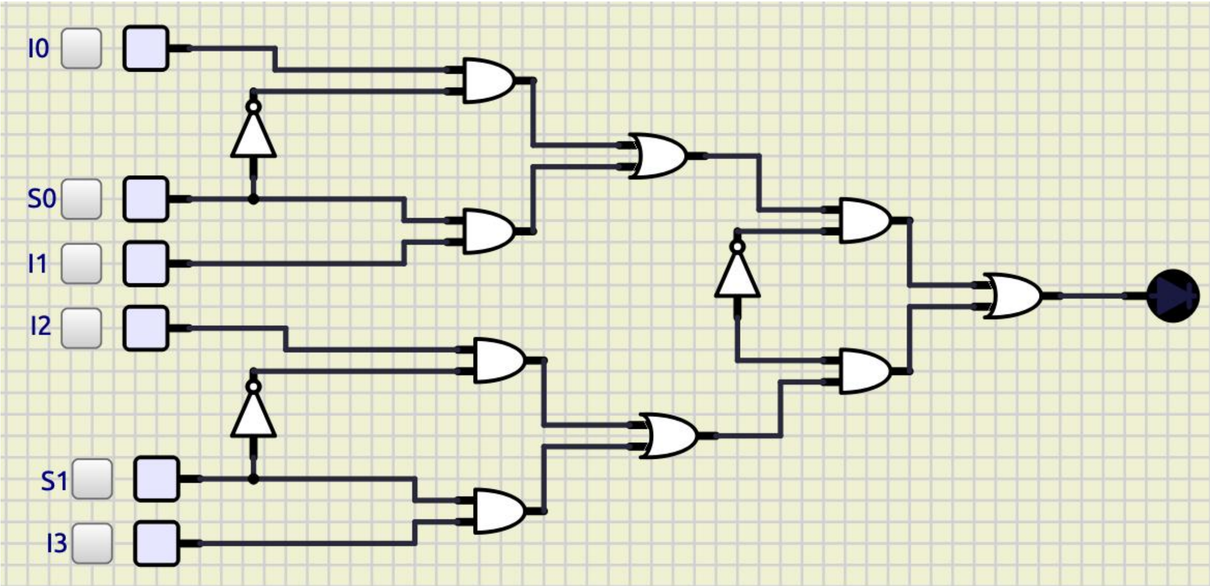


Make comment on the results

When we active all the switch of I0 I1 I2 I3, the led is light

c. Design 4-to-1 MUX using 3 MUX 2-1.

Implement the circuit via simulation software and paste the result in here



Input		Output
S_0	S_1	Y
0	**0**	I_0
0	**1**	I_1
1	**0**	I_2
1	**1**	I_3

$$Y = S0'S1'I0 + S0'S1'I1 + S0S1'I2 + S0S1I3$$

Make comment on the results

The results of designing a 4-to-1 MUX using three 2-to-1 MUXs are as expected. The truth table correctly represents the functionality of a 4-to-1 MUX, where the combination of the selection lines S1 and S0 determine which input (I0, I1, I2, I3) is passed to the output.

2. Investigate IC 8-to-1 Multiplexer (74HC151)

Construct the circuit as below:

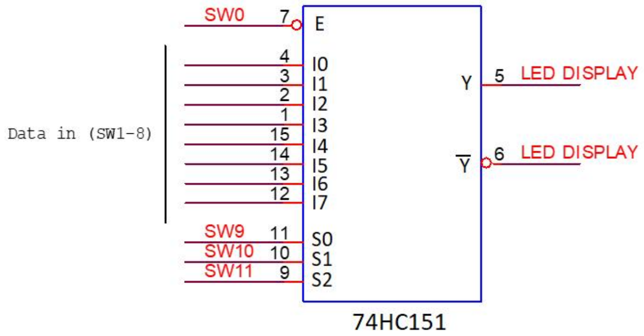
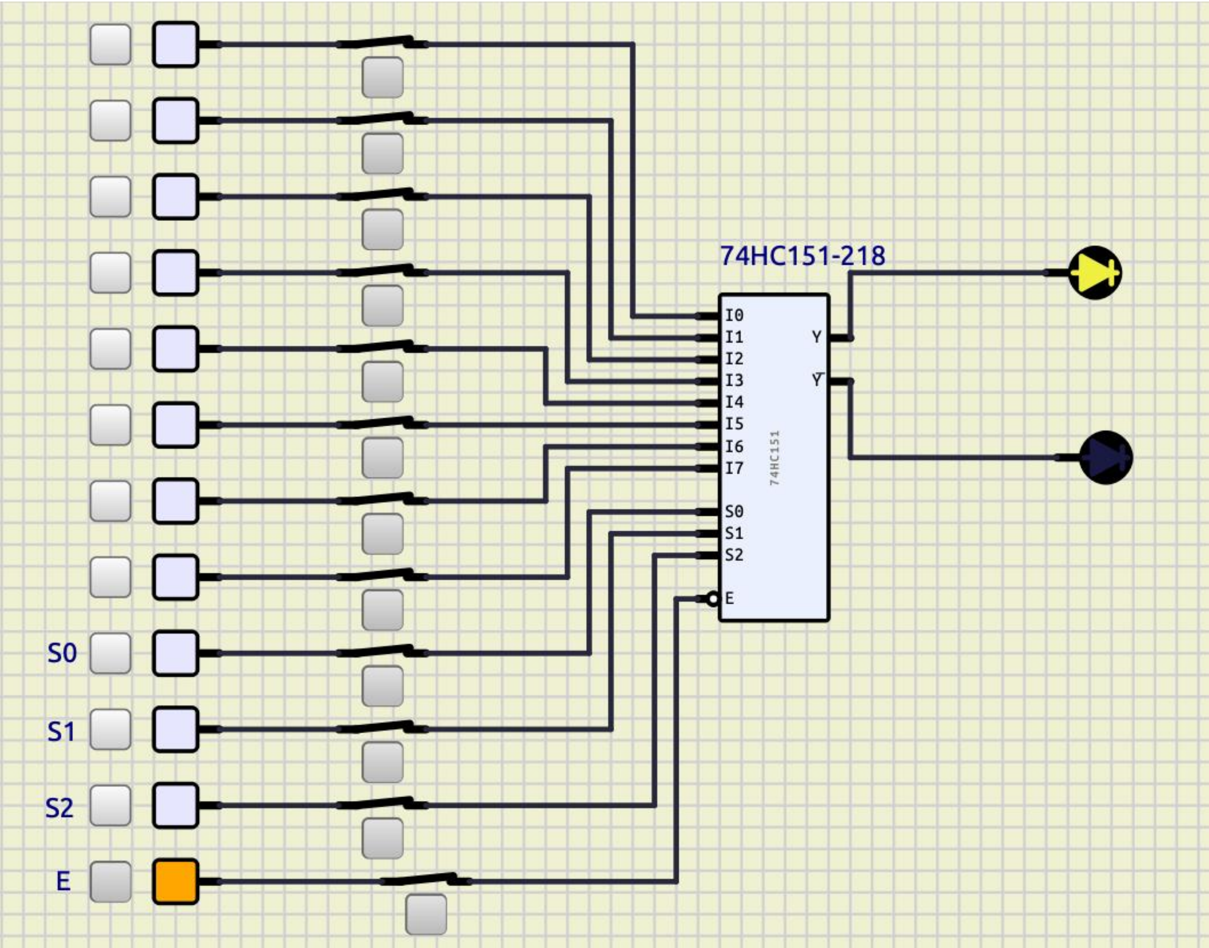


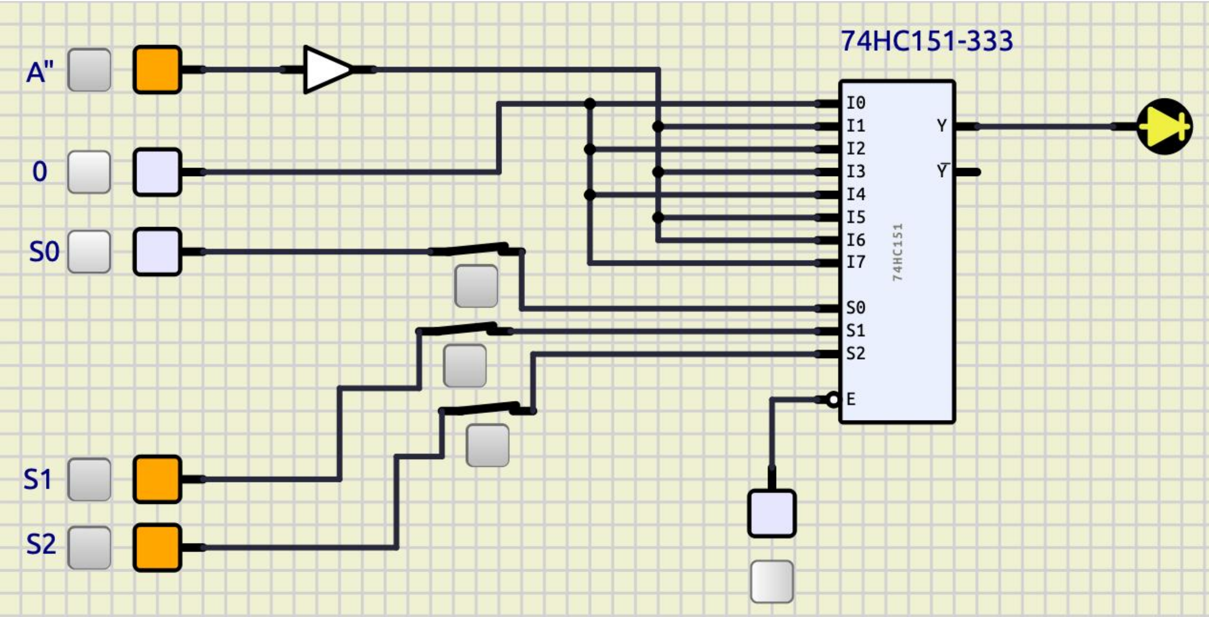
Figure 2. IC 8-to-1 Multiplexer (74HC151)

- 2 outputs are connected by using LEDs.
- The inputs are controlled by switches.
- Observe the results and fulfill the truth table

INPUT				OUTPUT	
S2	**S1**	**S0**	**E**	**Y**	**$\overline{Y}$**
X	X	X	1	1	0
0	0	0	0	0	1
0	0	1	0	0	1
0	1	0	0	0	1
0	1	1	0	0	1
1	0	0	0	0	1
1	0	1	0	0	1
1	1	0	0	0	1
1	1	1	0	0	1

Implement the circuit via simulation software and paste the result in here


74HC151-218
I0
I1
I2
I3
I4
I5
I6
I7
S0
S1
S2
E
Y
74HC151
S0
S1
S2
E


74HC151-333
A"
0
S0
S1
S2
I0
I1
I2
I3
I4
I5
I6
I7
S0
S1
S2
E
Y
74HC151

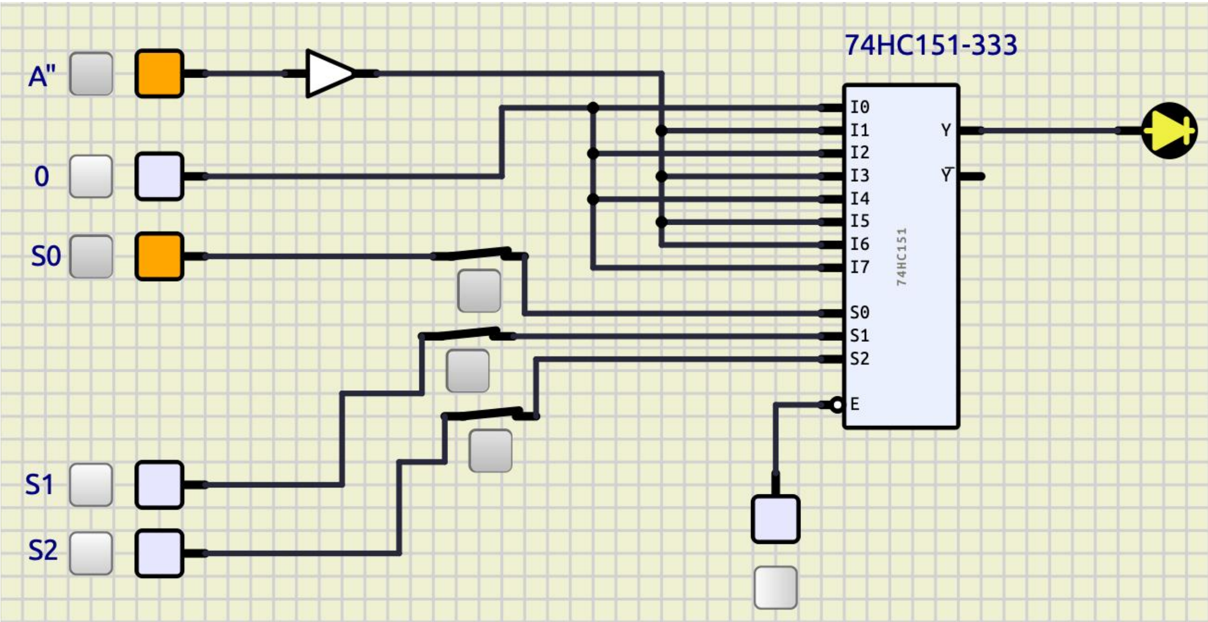
Briefly describe the operation of the **IC:** when the enable pin is pulled LOW (i.e., active), the IC 74HC151 selects its inputs using the binary combination of S2 – S1 – S0 inputs, with S2 being the MSB and S0 the LSB. For example, S2 – S1 – S0 equals to 1 – 0 – 1 selects input I5.

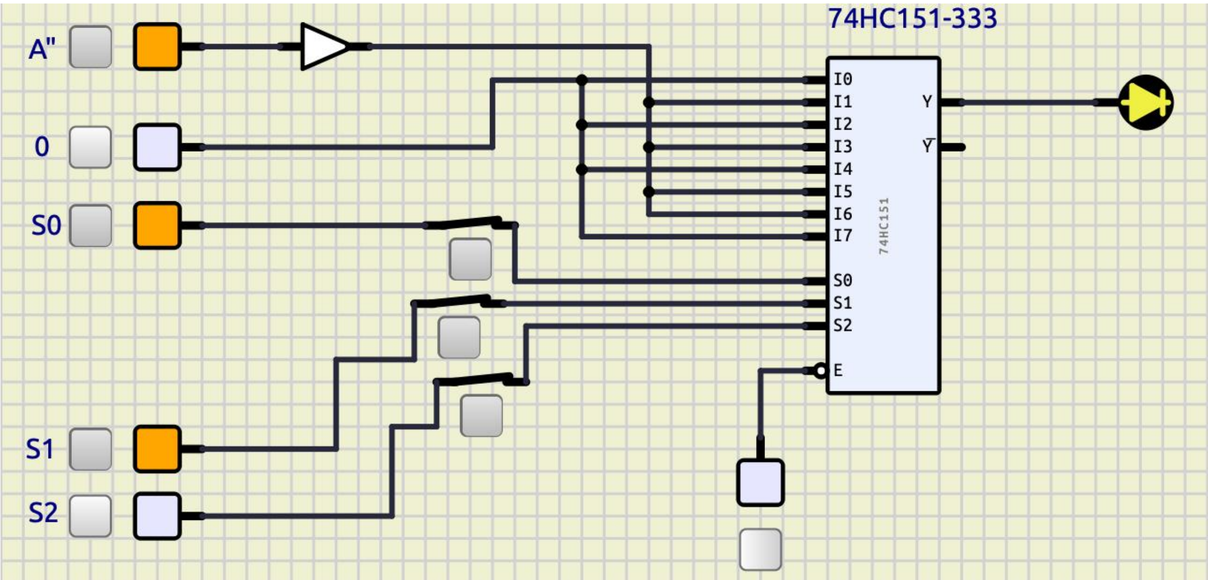
3. Implement the 3-variable logic function using 74HC151

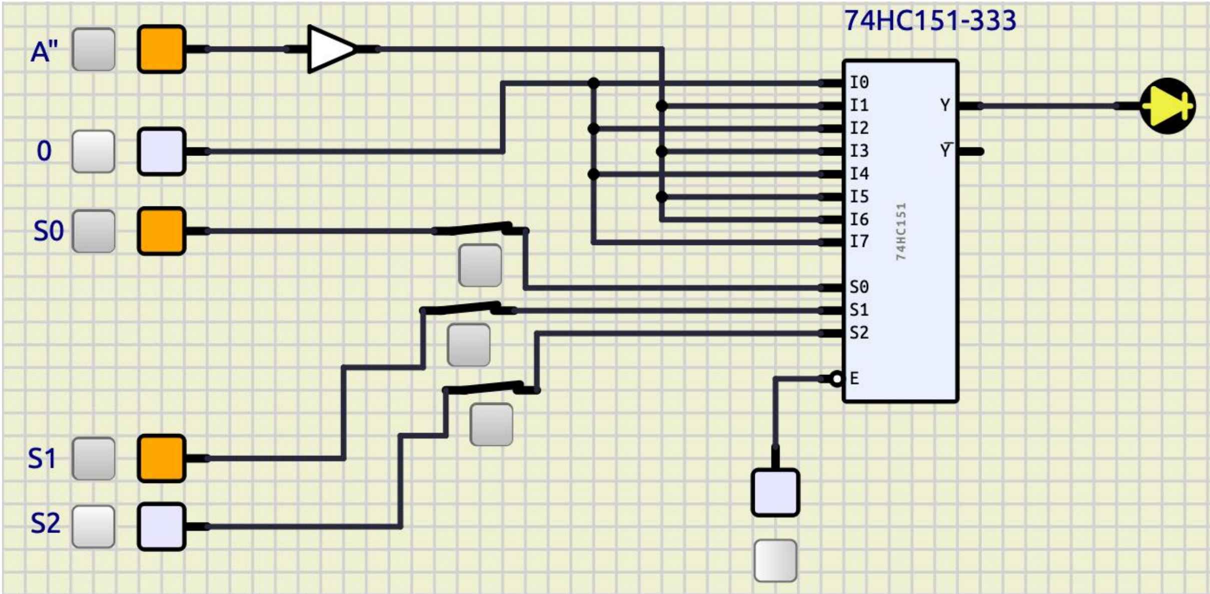
- Implement Boolean expression using IC 74HC151.
- The data inputs S0, S1, S2 are connected to switches.
- Implement the circuit and verify the truth table

a. $\boldsymbol{f(S_2, S_1, S_0) \;=\; \sum_{S_2S_1S_0}(1, 3, 5, 6)}$

Implement the circuit via simulation software and paste the result in here







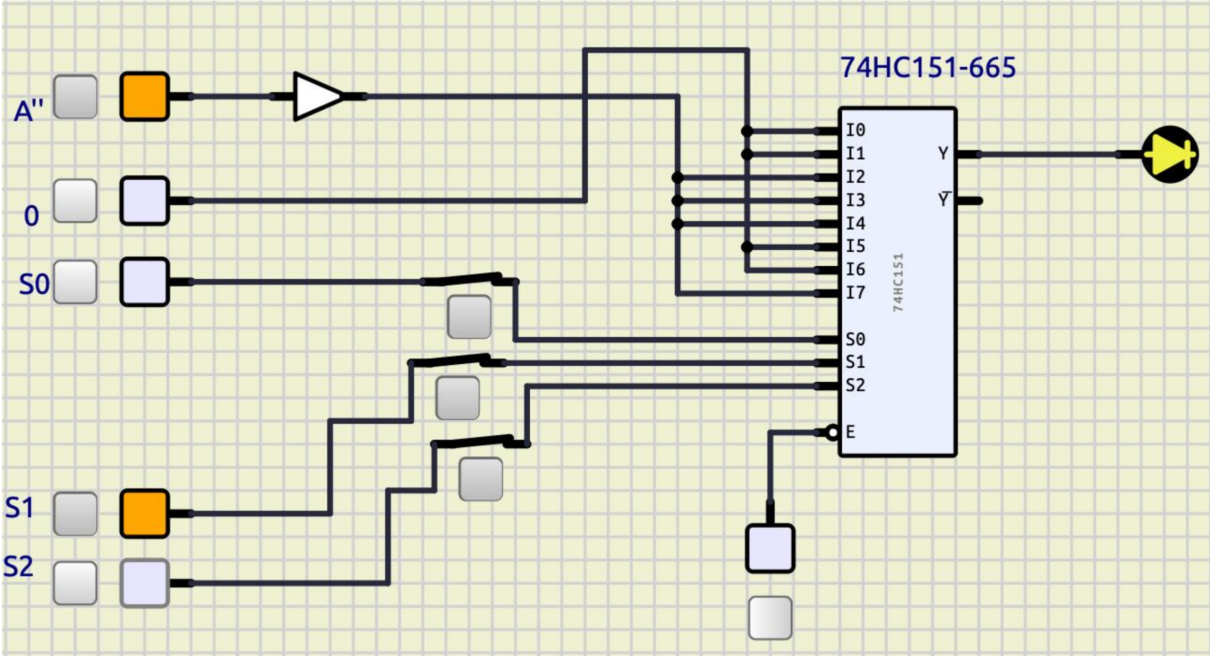
S2	S1	S0	Y	Selected	Out
0	0	0	0	I0	S0
0	0	1	1	I1	S0
0	1	0	0	I2	S0
0	1	1	1	I3	S0
1	0	0	0	I4	S0
1	0	1	1	I5	S0
1	1	0	0	I6	$\overline{S0}$
1	1	1	1	I7	$\overline{S0}$

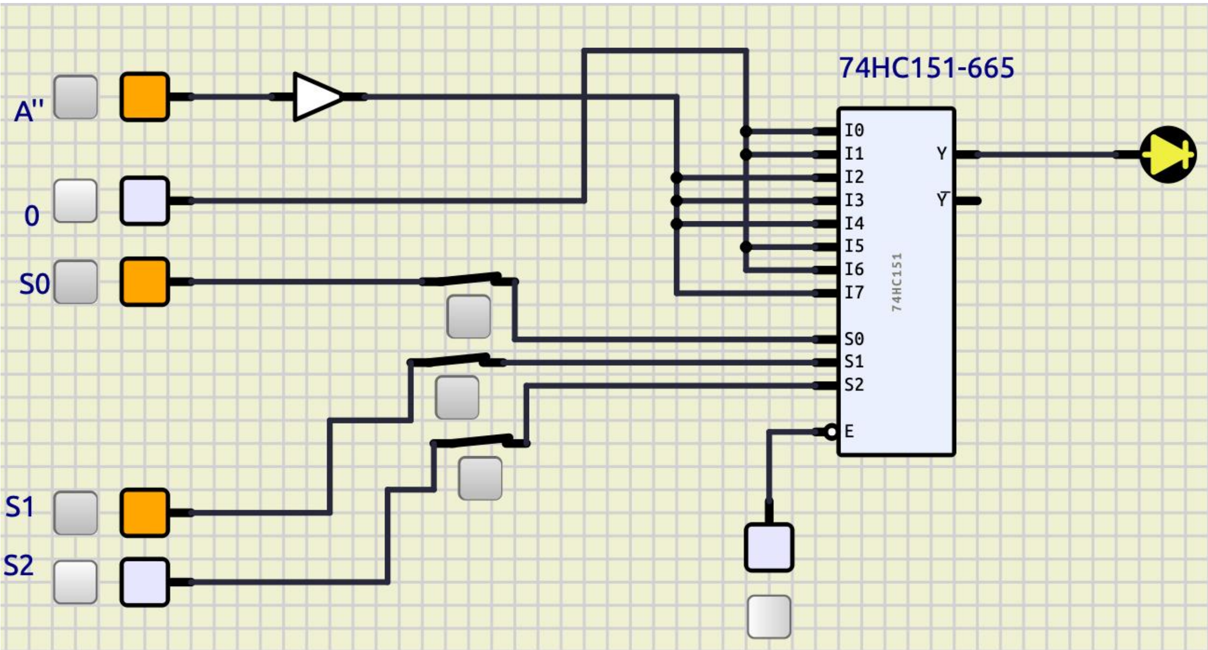
Make comment on the results: The S2,S1,S0 control the output of the IC equivalent to the input

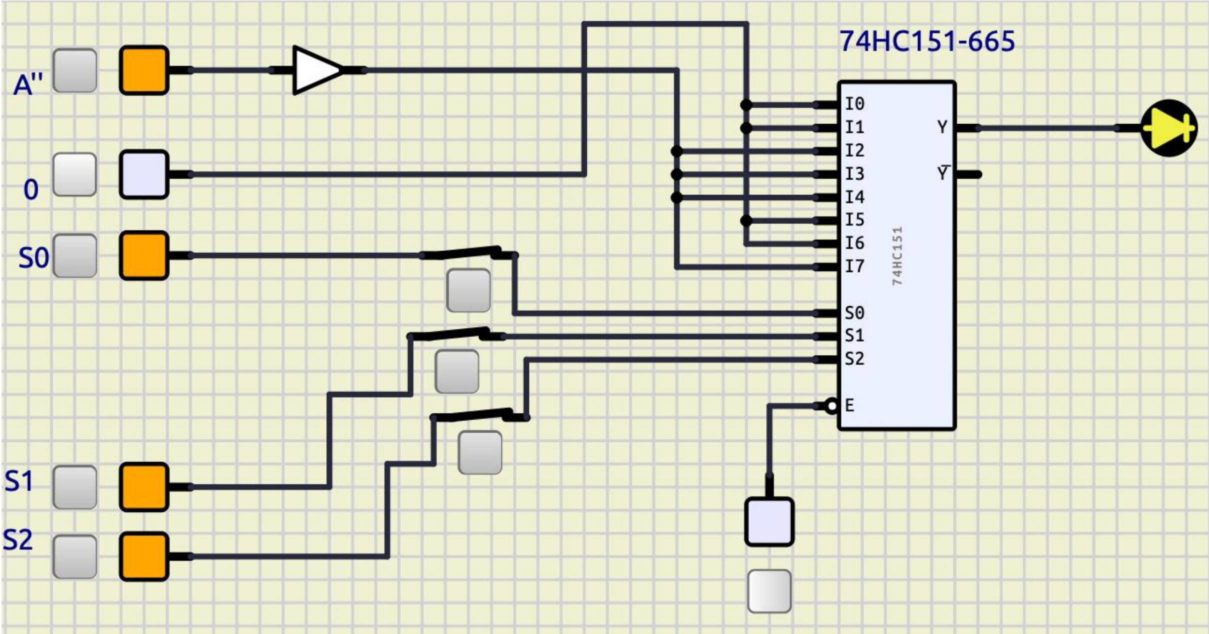
b. $\boldsymbol{f(S_2, S_1, S_0) = \sum_{S_2 S_1 S_0}(2, 3, 4, 7)}$

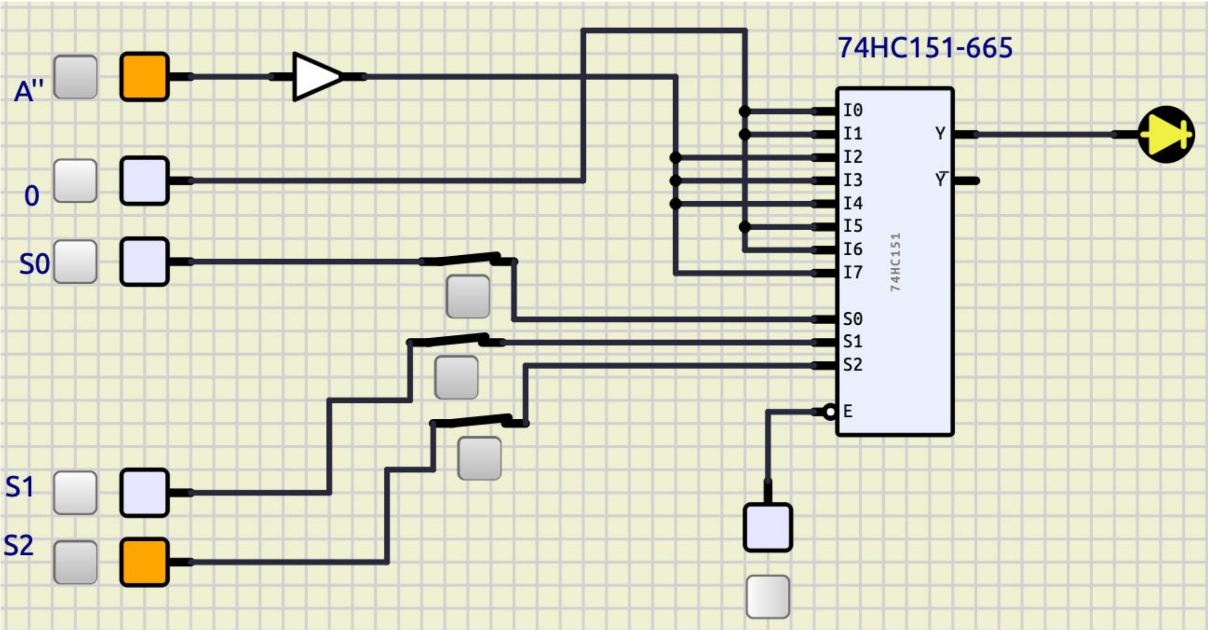
Implement the circuit via simulation software and paste the result in here

S2	S1	S0	Y	Selected	Out
0	0	0	0	I0	S0
0	0	1	1	I1	$\overline{S0}$
0	1	0	0	I2	$\overline{S0}$
0	1	1	1	I3	S0
1	0	0	0	I4	$\overline{S0}$
1	0	1	1	I5	$\overline{S0}$
1	1	0	0	I6	S0
1	1	1	1	I7	S0


74HC151-665
A''
0
S0
S1
S2
I0
I1
I2
I3
I4
I5
I6
I7
S0
S1
S2
E
Y
74HC151


74HC151-665
A''
0
S0
S1
S2
I0
I1
I2
I3
I4
I5
I6
I7
S0
S1
S2
E
Y
74HC151





Make comment on the **results:** The IC's output is controlled by the S2,S1,S0, which are nearly equal to its input.

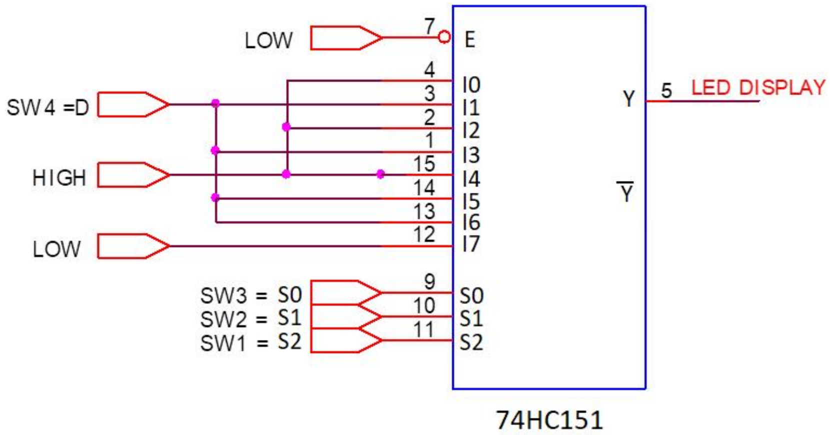
4. Implement the 4-variable logic function using 74HC151

a. Implement the connected diagram using 74HC151.

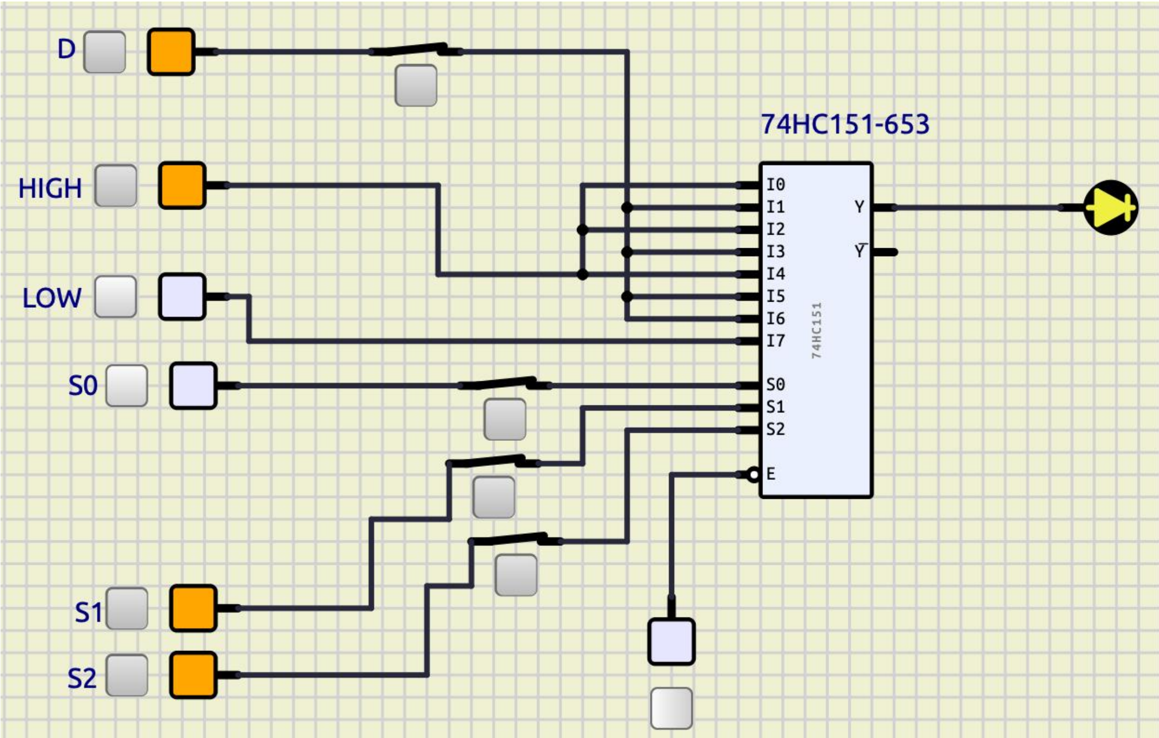
Construct the circuit as Figure 3:

Change the logic levels of the inputs C, B, A.

Observe and make comment on the results.



Implement the circuit via simulation software and paste the result in here



D	S2	S1	S0	Y
0	0	0	0	0
0	0	0	1	1
0	0	1	0	0
x	0	1	1	1
0	1	0	0	0
0	1	0	1	0
0	1	1	0	1
0	1	1	1	0
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	0
1	1	0	0	0
1	1	0	1	1
1	1	1	0	0

1	1	1	1	0

Write down the expression of $\boldsymbol{f(D, S_2, S_1, S_0)}$ **:**

$$f(D, S2, S1, S0) = D.S2.S1.\overline{S0} + D.\overline{S2}.S1.S0 + D.S2.\overline{S1}.S0 + D.S2.S1.\overline{S0} + \overline{S2}.\overline{S1}.\overline{S0} + \overline{S2}.S1.\overline{S0} + S2.\overline{S1}.\overline{S0}$$

Make comments on the results:

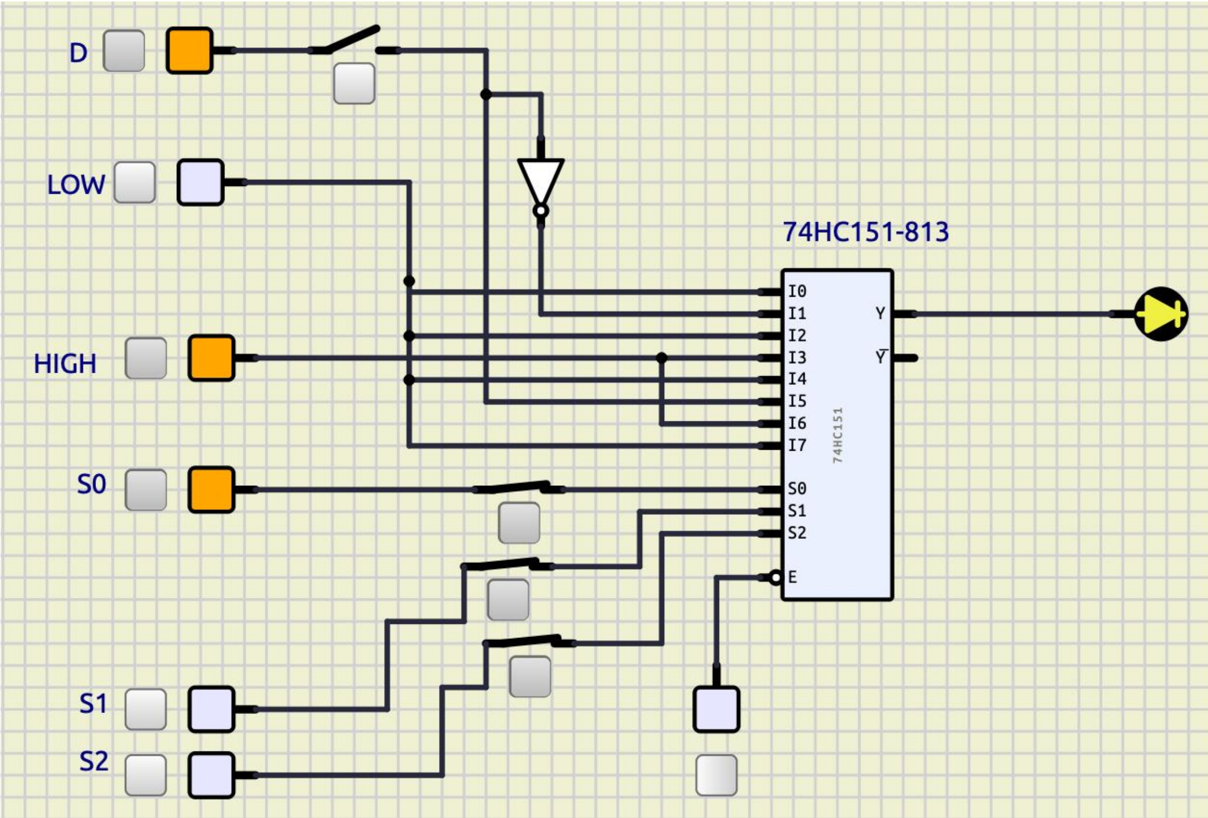
b. Implement logic expression using 74HC151

Given the expression:

$$\boldsymbol{f(D, S_2, S_1, S_0) = D\, S_2\, \overline{S_1}\, S_0 + S_2\, S_1\, \overline{S_0} + \overline{S_2}\, S_1\, S_0 + \overline{D}\overline{S_2}\, \overline{S_1} S_0}$$

Draw the block diagram

Implement the circuit via simulation software and paste the result in here



S2	S1	S0	D	f
0	0	0	X	0
0	0	1	0	1
0	0	1	1	1
0	1	X	X	0
1	0	0	X	0
1	0	1	X	0
1	1	0	X	0
1	1	1	0	0
1	1	1	1	1

Make comments on the results

The given Boolean function f(D,S2,S1,S0) seems to be a specific combination of the input variables that result in a '1' output.

The function returns '1' only when:

a. D is 0, S2 and S0 are 0, and S1 is 1. This could be interpreted as a specific condition where the absence (or '0') of D, S2, and S0 and the presence (or '1') of S1 triggers a '1' output.

b. D and S1 are 0, and S2 and S0 are 1. This is another specific condition that triggers a '1' output.

c. D is 0, S1 and S2 are 1, and S0 is 0. This is a third specific condition that triggers a '1' output.

d. D and S2 are 1, S1 is 0, and S0 is 1. This is the last condition that triggers a '1' output.