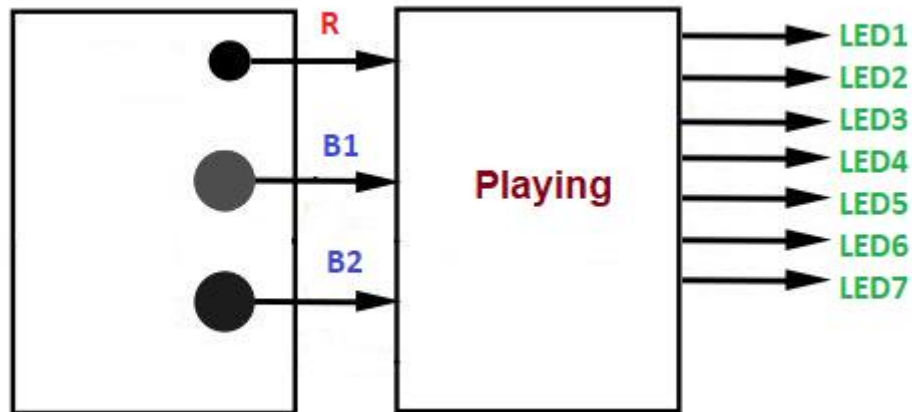


**GTU Department of Computer  
Engineering CSE 232 - Spring 2020  
Project 1 Report**

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## Problem Definition

The problem is to design an FSM controller using Logisim program. This will be a game implementation. A basic diagram to show the game;



**Inputs:** B1, B2, R (Buttons)

**Outputs:** LED1, LED2, LED3, LED4, LED5, LED6, LED7 (LEDs)

The game is players try to turn on the LED where their own side by pushing buttons.

As shown in figure according to current led status the winner will be determined.

If the leftmost led is 1 then the winner is **B1**, If the rightmost led is 1 then the winner is **B2**.

When you push the **reset** button, the game start from beginning where the LED is in the middle is 1.

### Some critical situation in the game;

The current state doesn't change when both players push the buttons at the same time or they do not push at all. In other words other than 1 input current status doesn't change.

Even if any player tries to hold down the button, current state changes just 1 time not more than 1 and until they leave the button the current doesn't change even other player push button.

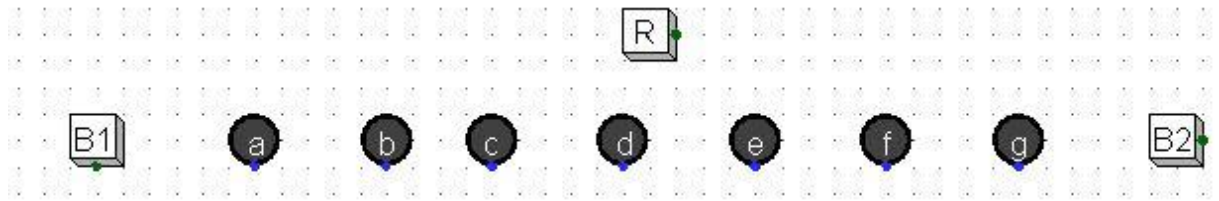
Lastly, If any player wins the game only reset input works.

For more information check the test result where end of the this report.

## Solution Step by Step

1) Decide states and draw the state diagram for your FSM controller.

A sample input and outputs positions in the game where abcdefg are LEDs;

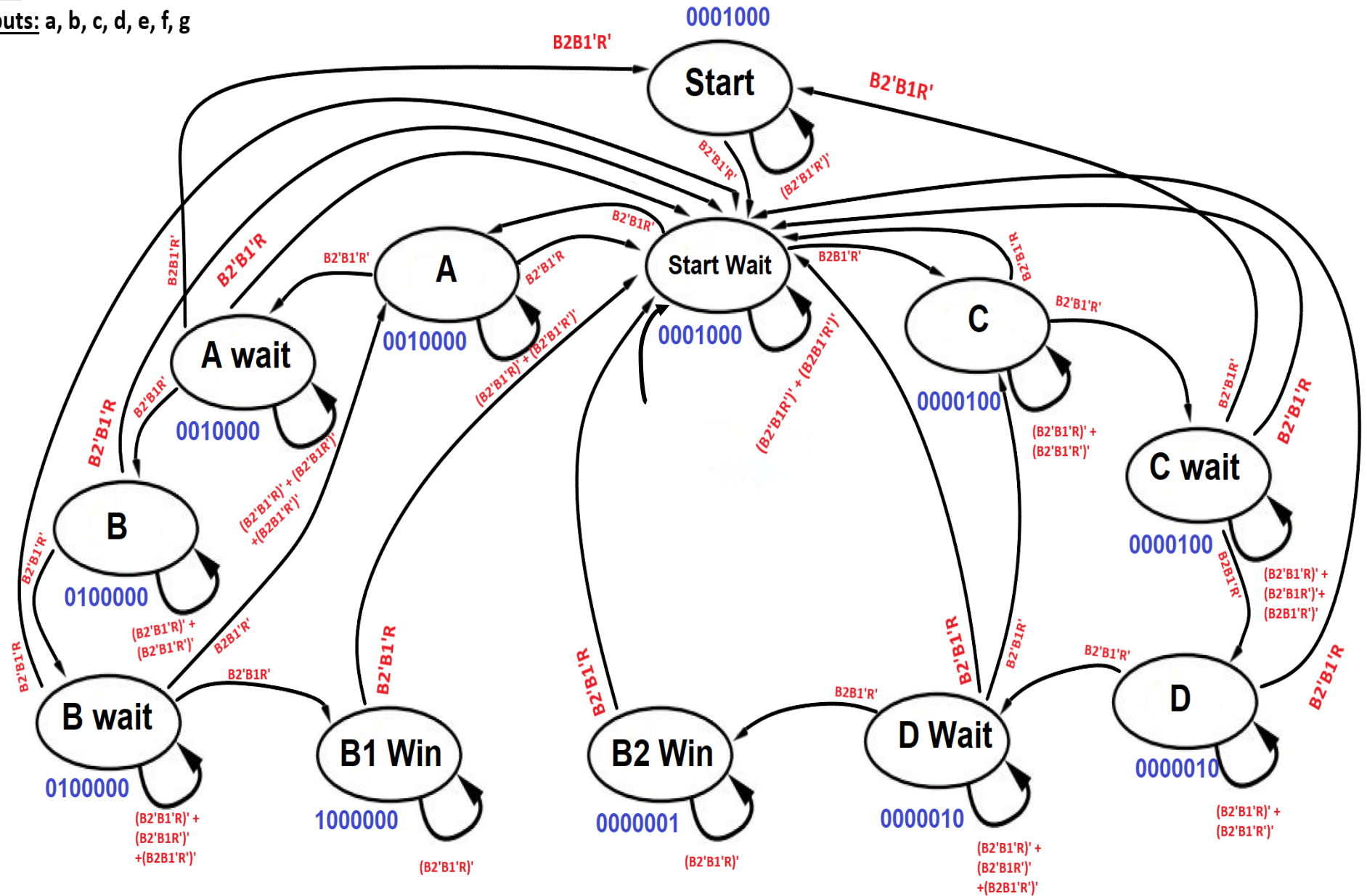


Information about the state diagram;

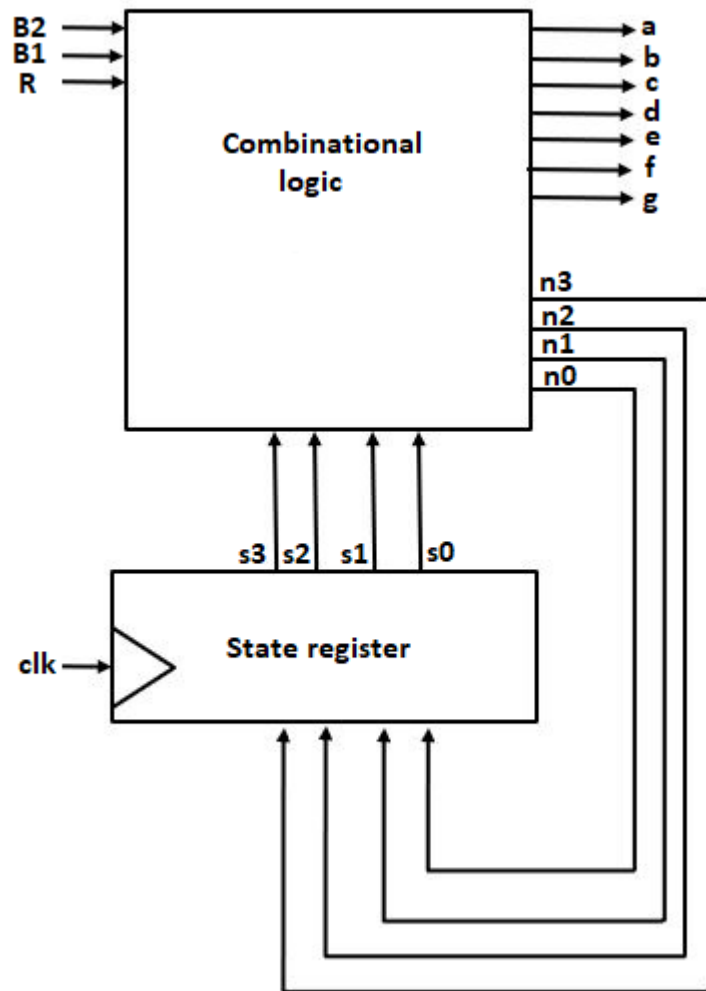
State Name	Description of the State
Start	This is the start state where the player is hold down the button while return this state from A wait state or C wait state. d is 1 in this state.
Start Wait	d is 1 where every inputs are 0.(No holding). Game starts from this state.
A	c is 1 where the player is hold down the button.
A Wait	c is 1 where every inputs are 0. (No holding)
B	b is 1 where the player is hold down the button.
B Wait	b is 1 where every inputs are 0. (No holding)
C	e is 1 where the player is hold down the button.
C Wait	e is 1 where every inputs are 0. (No holding)
D	f is 1 where the player is hold down the button.
D Wait	f is 1 where every inputs are 0. (No holding)
B1 Win	a is 1 where only reset input works.
B2 Win	g is 1 where only reset input works.

Inputs: B2, B1, R

Outputs: a, b, c, d, e, f, g

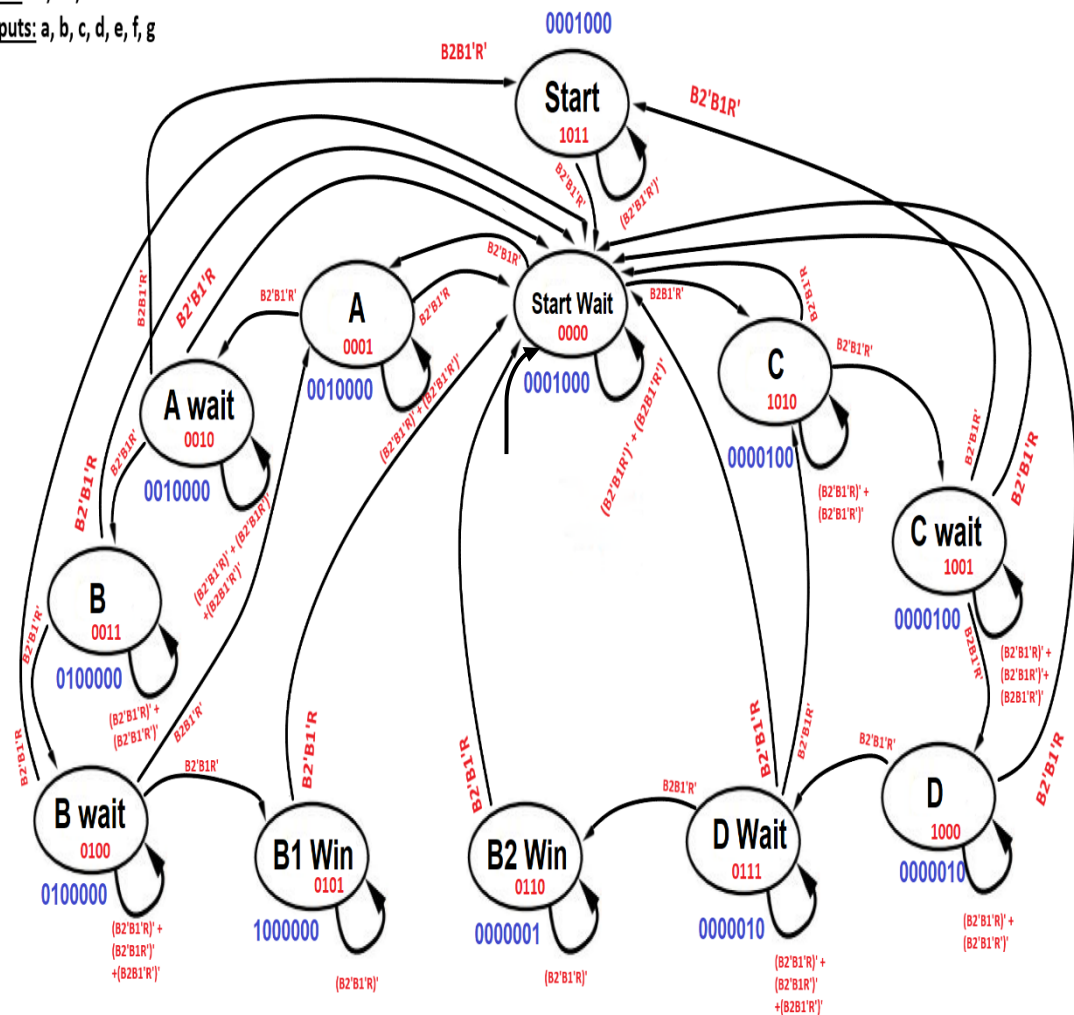


Step 1: Capture the FSM



Step 2A: Set up architecture

Inputs: B2, B1, R  
Outputs: a, b, c, d, e, f, g



Step 2B: Encode states

Encoding → Start Wait=0000, A=0001, A Wait=0010, B=0011, B Wait = 0100  
B1 Win = 0101, B2 Win = 0110, D Wait = 0111, D = 1000, C Wait = 1001,  
C=1010, Start = 1011

**2) Draw truth table.**

Inputs							Outputs											
S3	S2	S1	S0	B2	B1	R	a	b	c	d	e	f	g	n3	n2	n1	n0	
0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	
0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	
0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	
0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	
0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	1	0	
0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	
0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	
0	0	0	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	
0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	
0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	
0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	1	
0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	1	
0	0	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	1	
0	0	0	1	1	1	1	0	0	1	0	0	0	0	0	0	0	1	
0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	
0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	
0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1	
0	0	1	0	0	1	1	0	0	1	0	0	0	0	0	0	1	0	
0	0	1	0	1	0	0	0	0	1	0	0	0	0	1	0	1	1	
0	0	1	0	1	0	1	0	0	1	0	0	0	0	0	0	1	0	
0	0	1	0	1	1	0	0	0	1	0	0	0	0	0	0	1	0	
0	0	1	0	1	1	1	0	0	1	0	0	0	0	0	0	1	0	
0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	
0	0	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	
0	0	1	1	0	1	0	0	0	1	0	0	0	0	0	0	1	1	
0	0	1	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	
0	0	1	1	1	0	1	0	0	1	0	0	0	0	0	0	1	1	
0	0	1	1	1	1	0	0	0	1	0	0	0	0	0	0	1	1	
0	0	1	1	1	1	1	0	0	1	0	0	0	0	0	0	1	1	
0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	
0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	
0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	1	
0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	1	0	0	
0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	
0	1	0	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	
0	1	0	0	1	1	0	0	1	0	0	0	0	0	0	1	0	0	
0	1	0	0	1	1	1	0	1	0	0	0	0	0	0	1	0	0	
0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	1	
0	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	
0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	1	0	1	
0	1	0	1	1	0	0	1	0	0	0	0	0	0	0	1	0	1	
0	1	0	1	1	1	0	1	0	0	0	0	0	0	0	1	0	1	
0	1	0	1	1	1	1	0	1	0	0	0	0	0	0	1	0	1	
0	1	0	1	1	1	1	1	1	0	0	0	0	0	0	1	0	1	

0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0
0	1	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
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0	1	1	0	0	1	1	0	0	0	0	0	1	0	1	1	1	0
0	1	1	0	1	0	0	0	0	0	0	0	1	0	1	1	1	0
0	1	1	0	1	0	1	0	0	0	0	0	1	0	1	1	1	0
0	1	1	0	1	1	0	0	0	0	0	0	1	0	1	1	1	0
0	1	1	0	1	1	1	0	0	0	0	0	1	0	1	1	1	0
0	1	1	1	0	0	0	0	0	0	0	1	0	0	1	1	1	1
0	1	1	1	0	0	1	0	0	0	0	1	0	1	0	1	0	0
0	1	1	1	0	1	1	0	0	0	0	1	0	0	1	1	1	1
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1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	1
1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
1	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0
1	0	0	0	0	1	1	0	0	0	0	1	0	1	0	0	0	0
1	0	0	0	1	0	1	0	0	0	0	1	0	1	0	0	0	0
1	0	0	0	1	1	0	1	0	0	0	1	0	1	0	0	0	0
1	0	0	0	1	1	1	0	0	0	0	1	0	1	0	0	0	0
1	0	0	0	1	1	1	1	0	0	0	1	0	1	0	0	0	0
1	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1
1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0
1	0	0	1	0	1	0	0	0	1	0	0	0	1	0	1	1	1
1	0	0	1	0	1	1	0	0	1	0	0	0	1	0	0	1	0
1	0	0	1	1	0	0	0	0	1	0	0	0	1	0	0	0	0
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1	0	0	1	1	1	0	1	0	0	0	1	0	0	1	0	0	1
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1	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1
1	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
1	0	1	0	0	1	0	0	0	1	0	0	0	1	0	1	1	0
1	0	1	0	0	1	1	0	0	1	0	0	0	1	0	1	0	0
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1	0	1	0	1	1	0	0	0	1	0	0	0	1	0	1	0	0
1	0	1	0	1	1	1	0	0	1	0	0	0	1	0	1	0	0
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1	0	1	1	1	1	0	0	0	1	0	0	0	1	0	1	1	1
1	0	1	1	1	1	1	0	0	1	0	0	0	1	0	1	1	1
1	0	1	1	1	1	1	1	0	0	0	0	0	1	0	1	1	1
1	0	1	1	1	1	1	1	1	0	0	0	0	1	0	1	1	1

Step 2C: Fill in truth table

**3) Derive Boolean expressions from the truth table.**

## Boolean expressions from truth table

➤ General Form

**a = !s3s2!s1s0**

$$\mathbf{b} = !s_3!s_2s_1s_0 + !s_3s_2!s_1!s_0$$

$$\mathbf{c} = !s3!s2!s1s0 + !s3!s2s1!s0$$

$$\mathbf{d} = !s3!s2!s1!s0 + s3!s2s1s0$$

$$\mathbf{e} = s_3!s_2s_1!s_0 + s_3!s_2!s_1s_0$$

$$f = s_3!s_2!s_1!s_0 + !s_3s_2s_1s_0$$

**g** = !s3s2s1!s0

$$\begin{aligned} \mathbf{n3} = & \text{!s3!s2!s1!s0B2!B1!R} + \text{!s3s2s1s0!B2B1!R} + \text{s3!s2!s1!s0!B2B1!R} + \text{s3!s2!s1!s0!B2B1R} + \text{s3!s2!s1!s0B2!B1!R} + \\ & \text{s3!s2!s1!s0B2!B1R} + \text{s3!s2!s1!s0B2B1!R} + \text{s3!s2!s1!s0B2B1R} + \text{s3!s2!s1s0!B2!B1!R} + \text{s3!s2!s1s0!B2B1R} + \\ & \text{s3!s2!s1s0B2!B1!R} + \text{s3!s2!s1s0B2!B1R} + \text{s3!s2!s1s0B2B1!R} + \text{s3!s2!s1s0B2B1R} + \text{s3!s2s1!s0!B2!B1!R} + \\ & \text{s3!s2s1!s0!B2B1!R} + \text{s3!s2s1!s0!B2B1R} + \text{s3!s2s1!s0B2!B1!R} + \text{s3!s2s1!s0B2!B1R} + \text{s3!s2s1!s0B2B1!R} + \\ & \text{s3!s2s1!s0B2B1R} + \text{s3!s2s1s0!B2B1!R} + \text{s3!s2s1s0!B2B1R} + \text{s3!s2s1s0B2!B1!R} + \text{s3!s2s1s0B2!B1R} + \\ & \text{s3!s2s1s0B2B1!R} + \text{s3!s2s1s0B2B1R} + \text{!s3!s2s1!s0B2!B1!R} + \text{s3!s2!s1s0!B2B1!R} \end{aligned}$$

$$\begin{aligned} \mathbf{n2} = & \text{\texttt{!s3!s2s1s0!B2!B1!R}} + \text{\texttt{!s3s2!s1!s0!B2!B1!R}} + \text{\texttt{!s3s2!s1!s0!B2B1!R}} + \text{\texttt{!s3s2!s1!s0!B2B1R}} + \text{\texttt{!s3s2!s1!s0B2!B1R}} + \\ & \text{\texttt{!s3s2!s1!s0B2B1!R}} + \text{\texttt{!s3s2!s1!s0B2B1R}} + \text{\texttt{!s3s2!s1s0!B2!B1!R}} + \text{\texttt{!s3s2!s1s0!B2B1!R}} + \text{\texttt{!s3s2!s1s0!B2B1R}} + \\ & \text{\texttt{!s3s2!s1s0B2!B1!R}} + \text{\texttt{!s3s2!s1s0B2!B1R}} + \text{\texttt{!s3s2!s1s0B2B1!R}} + \text{\texttt{!s3s2!s1s0B2B1R}} + \text{\texttt{!s3s2s1!s0!B2!B1!R}} + \\ & \text{\texttt{!s3s2s1!s0!B2B1!R}} + \text{\texttt{!s3s2s1!s0!B2B1R}} + \text{\texttt{!s3s2s1!s0B2!B1!R}} + \text{\texttt{!s3s2s1!s0B2!B1R}} + \text{\texttt{!s3s2s1!s0B2B1!R}} + \\ & \text{\texttt{!s3s2s1!s0B2B1R}} + \text{\texttt{!s3s2s1s0!B2!B1!R}} + \text{\texttt{!s3s2s1s0!B2B1R}} + \text{\texttt{!s3s2s1s0B2!B1!R}} + \text{\texttt{!s3s2s1s0B2!B1R}} + \\ & \text{\texttt{!s3s2s1s0B2B1!R}} + \text{\texttt{!s3s2s1s0B2B1R}} + \text{\texttt{s3!s2!s1!s0!B2!B1!R}} \end{aligned}$$

**n1** = !s3!s2!s1!s0B2!B1!R + !s3!s2!s1s0!B2!B1!R + !s3!s2s1!s0!B2!B1!R + !s3!s2s1!s0!B2B1!R + !s3!s2s1!s0B2!B1R + !s3!s2s1!s0B2B1R + !s3!s2s1s0!B2!B1!R + !s3!s2s1s0!B2B1R + !s3!s2s1s0B2!B1!R + !s3!s2s1s0B2B1R + !s3s2s1!s0!B2!B1!R + !s3s2s1!s0!B2B1!R + !s3s2s1!s0!B2B1R + !s3s2s1!s0B2!B1!R + !s3s2s1!s0B2B1R + !s3s2s1s0!B2!B1!R + !s3s2s1s0!B2B1!R + !s3s2s1s0B2!B1!R + !s3s2s1s0B2B1!R + !s3s2s1s0B2!B1!R + !s3s2s1s0B2B1R + !s3s2s1s0B2!B1!R + !s3s2s1s0B2B1R + !s3s2s1s0B2B1R + s3!s2!s1!s0!B2!B1!R + s3!s2s1!s0!B2B1!R + s3!s2s1!s0!B2B1R + s3!s2s1!s0B2!B1!R + s3!s2s1!s0B2B1R + s3!s2s1s0!B2B1!R + s3!s2s1s0!B2B1R + s3!s2s1s0B2!B1!R + s3!s2s1s0B2!B1R + s3!s2s1s0B2B1!R + s3!s2s1s0B2B1R + !s3!s2s1!s0B2!B1!R + s3!s2!s1s0!B2B1!R

$$\begin{aligned} n0 = & !s3!s2!s1!s0!B2B1!R + !s3!s2!s1s0!B2B1!R + !s3!s2!s1s0!B2B1R + !s3!s2!s1s0B2!B1!R + !s3!s2!s1s0B2!B1R + \\ & !s3!s2!s1s0B2B1!R + !s3!s2!s1s0B2B1R + !s3!s2s1!s0!B2B1!R + !s3!s2s1s0!B2B1!R + !s3!s2s1s0!B2B1R + \\ & !s3!s2s1s0B2!B1!R + !s3!s2s1s0B2!B1R + !s3!s2s1s0B2B1!R + !s3!s2s1s0B2B1R + !s3s2!s1!s0!B2B1!R + \\ & !s3s2!s1!s0B2!B1!R + !s3s2!s1s0!B2!B1!R + !s3s2!s1s0!B2B1!R + !s3s2!s1s0!B2B1R + !s3s2!s1s0B2!B1!R + \\ & !s3s2!s1s0B2!B1R + !s3s2!s1s0B2B1!R + !s3s2!s1s0B2B1R + !s3s2s1s0!B2!B1!R + !s3s2s1s0!B2B1R + !s3s2s1s0B2!B1R \\ & + !s3s2s1s0B2B1!R + !s3s2s1s0B2B1R + s3!s2!s1!s0!B2!B1!R + s3!s2!s1s0!B2!B1!R + s3!s2!s1s0!B2B1R + \\ & s3!s2!s1s0B2!B1R + s3!s2!s1s0B2B1!R + s3!s2!s1s0B2B1R + s3!s2s1!s0!B2!B1!R + s3!s2s1s0!B2B1!R + \end{aligned}$$



$s3!s2s1s0!B2B1R + s3!s2s1s0B2!B1!R + s3!s2s1s0B2!B1R + s3!s2s1s0B2B1!R + s3!s2s1s0B2B1R + !s3!s2s1!s0B2!B1!R$   
 $+ s3!s2!s1s0!B2B1!R$

➤ Simplified form

**a** =  $!s3s2!s1s0$

**b** =  $!s3!s2s1s0 + !s3s2!s1!s0$

**c** =  $!s3!s2!s1s0 + !s3!s2s1!s0$

**d** =  $!s3!s2!s1!s0 + s3!s2s1s0$

**e** =  $s3!s2s1!s0 + s3!s2!s1s0$

**f** =  $s3!s2!s1!s0 + !s3s2s1s0$

**g** =  $!s3s2s1!s0$

**n3** =  $(s3!s2s1!s0!R) + (s3!s2!s1s0!R) + (s3!s2B2) + (s3!s2B1) + (!s3s2s1s0!B2B1!R) + (!s2!s0B2!B1!R)$

**n2** =  $(s3!s2!s1!s0!B2!B1!R) + (!s3s2s1!B1!R) + (!s3s2!s1s0!R) + (!s3s2!s0!B2!R) + (!s3s2B2B1) + (!s3s2B2R) +$   
 $(!s3s2B1R) + (!s3s1s0!B2!B1!R)$

**n1** =  $(s3!s2!s1!s0!B2!B1!R) + (s3!s2s0!B2B1!R) + (!s3s2s1!R) + (!s3!s2!s1s0!B2!B1!R) + (!s3!s2!s0B2!B1!R) +$   
 $(!s3s1!s0!R) + (!s3s1B2) + (!s3s1B1) + (!s2s1B2) + (!s2s1B1)$

**n0** =  $(s3!s2!s1!B2!B1!R) + (s3!s2!s0!B2!B1!R) + (!s3s2!s1B2!B1!R) + (!s3s2s0!B2!B1!R) + (!s3!s2s1B2!B1!R) +$   
 $(!s3!s2!B2B1!R) + (!s3!s1s0B2) + (!s3!s1!B2B1!R) + (!s3s0B2B1) + (!s3s0B2R) + (!s3s0B1R) + (!s2s1s0B2) + (!s2s0B2R) +$   
 $(!s2s0B1)$

**4)** Draw the circuit on Logisim.

➤ Check **full.circ** file to see whole circuit.

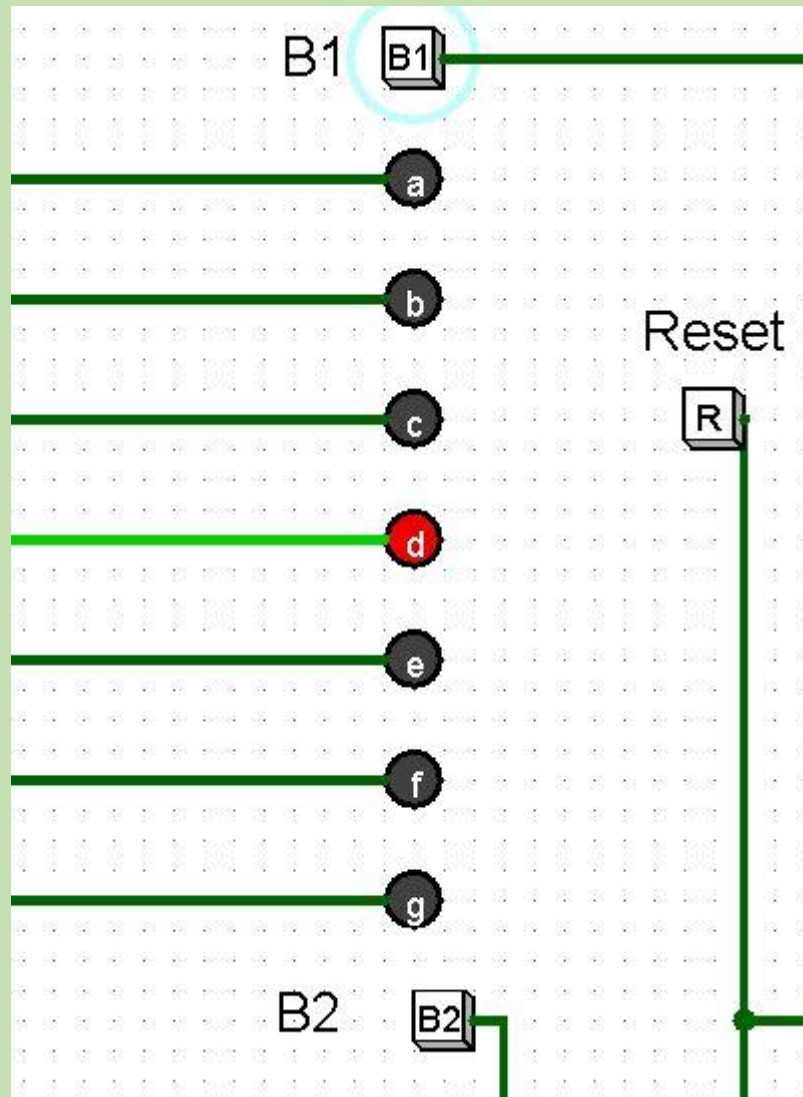
**5)** Simulate and see whether it works.

➤ Check following test results.

## Description

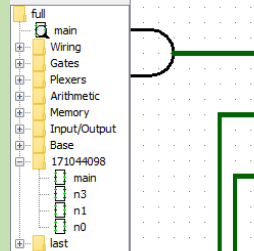
## Test Result

Start position  
(All inputs are 0)

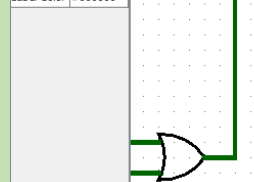


Hold down  
B2 button

Logisim: main of full  
File Edit Project Simulate Window Help

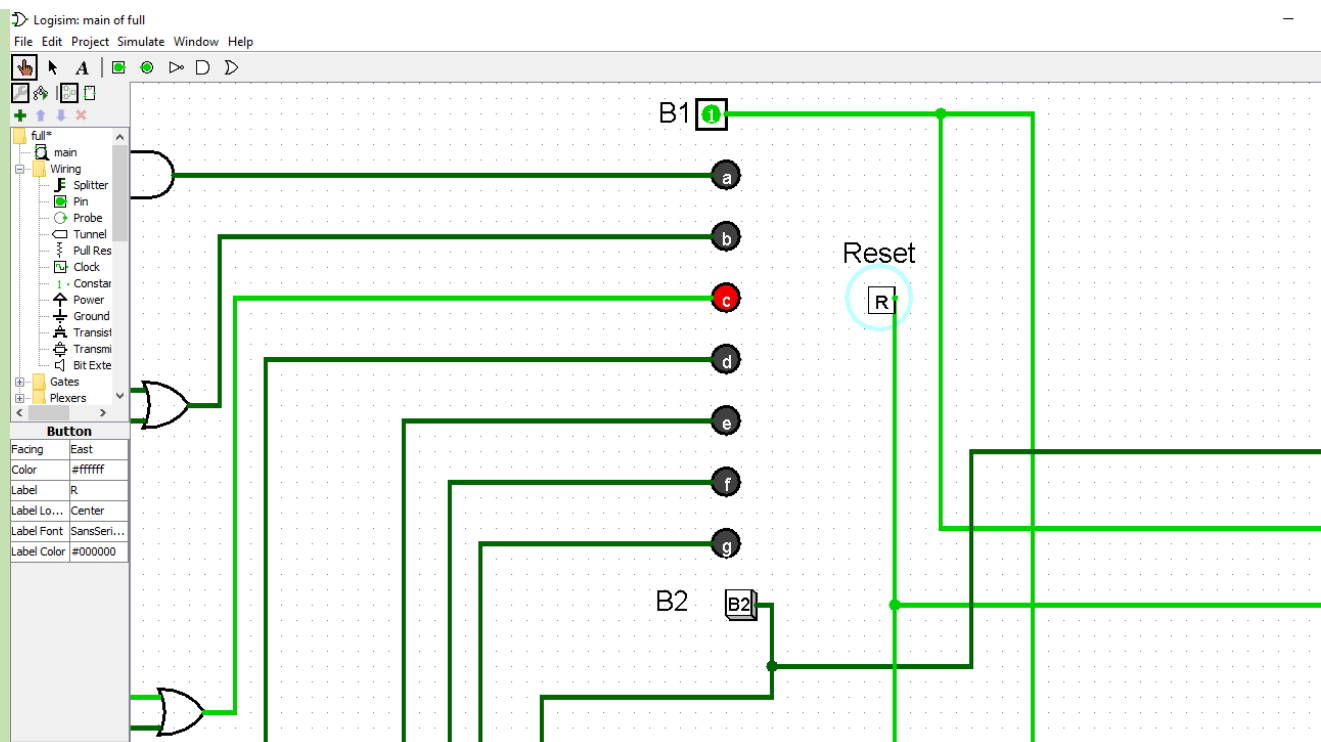


Button	
Facing	East
Color	#ffffff
Label	B2
Label Lo...	Center
Label Font	SansSer...
Label Color	#000000





Pushing 2 button at the same time (To test this B1 is always 1) (Current State doesn't change)



Winning status (Only reset button works)

