EC-204

<LAB- 1>

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a) BCD to seven segment decoder. Use the seven segment display in logisim for output. The pin details can be found in Help - Library Reference

D. Design

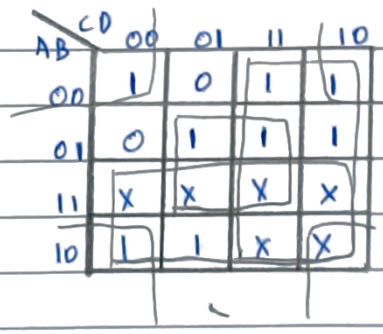
i) Truth table

A	B	C	D	a	b	c	d	e	f	g
0	0	0	0	1	1	1	1	1	1	0
0	0	0	1	0	1	1	0	0	0	0
0	0	1	0	1	1	0	1	1	0	1
0	0	1	1	1	1	1	1	0	0	1
0	1	0	0	0	1	1	0	0	1	1
0	1	0	1	1	0	1	1	0	1	1
0	1	1	0	1	0	1	1	1	1	1
0	1	1	1	1	1	1	0	0	0	0
1	0	0	0	1	1	1	1	1	1	1
1	0	0	1	1	1	1	1	0	1	1
1	0	1	0	x	x	x	x	x	x	x
1	0	1	1	x	x	x	x	x	x	x
1	1	0	0	x	x	x	x	x	x	x
1	1	0	1	x	x	x	x	x	x	x
1	1	1	0	x	x	x	x	x	x	y
1	1	1	1	x	x	x	x	x	x	x

Note: x represents dont care

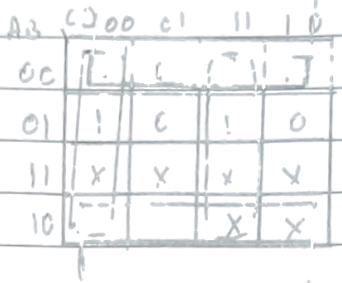
ii) K-Maps

for a



$a = A + BD + C + \bar{B}\,\bar{D}$

ii) # for b

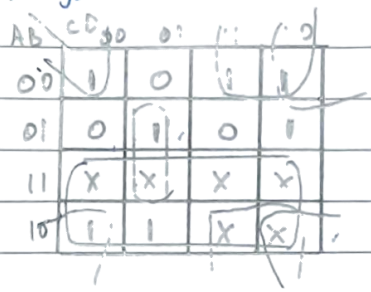


$b = \bar{B} + \bar{C}\bar{D} + CD$

iii) # for c

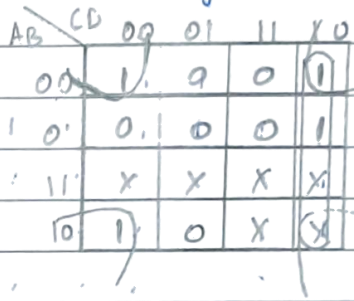
$C = \bar{C} + D + B$

iv) # for d



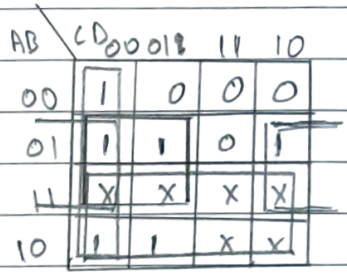
$d = \bar{B}\bar{D} + \bar{B}C + B\bar{C}D + C\bar{D} + A$

v) # for e



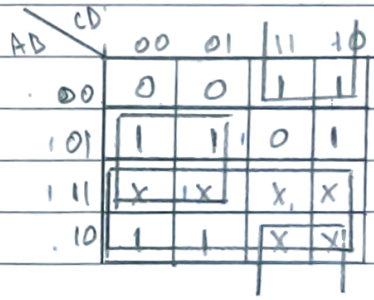
$e = \bar{B}\bar{D} + C\bar{D}$

vi) # for f



$f = A + B\bar{D} + \bar{C}\bar{D} + B\bar{C}$

vii) # for g



$g = \bar{B}C + B\bar{C} + A + B\bar{D}$

Explanation

7- Segment display decoder

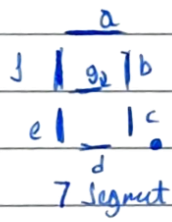
* BCD encoding decimal NO. [0, 9] are represented by its equivalent binary pattern (4 bit)

* A decimal NO. is changed to BCD equivalent signal by a decoder and is fed to the seven segment display.

* The decoder has 4 inputs (A B C D) and 7 outputs (a, b, c, d, e, f, g)

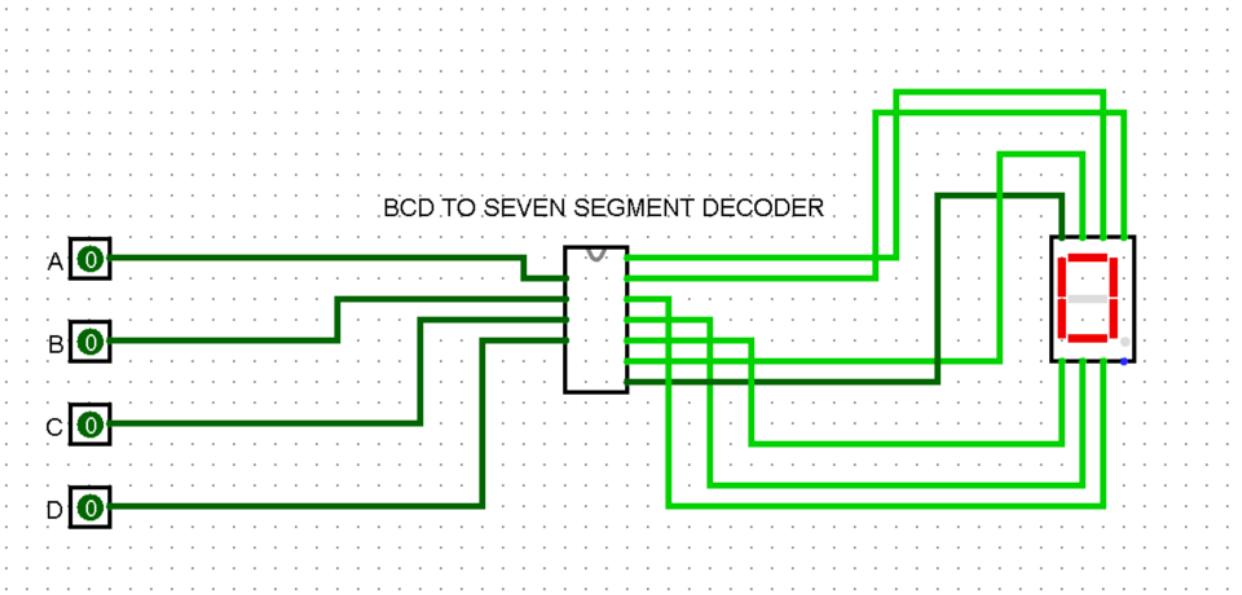
* BCD numbers range from [0, 9], the rest [10, 15] are invalid inputs.

For the combination where all A B C D are zero (see the truth table) a=1, b=1, c=1, d=1, e=1, f=1, g=0, so 7 segment LED shows 0.

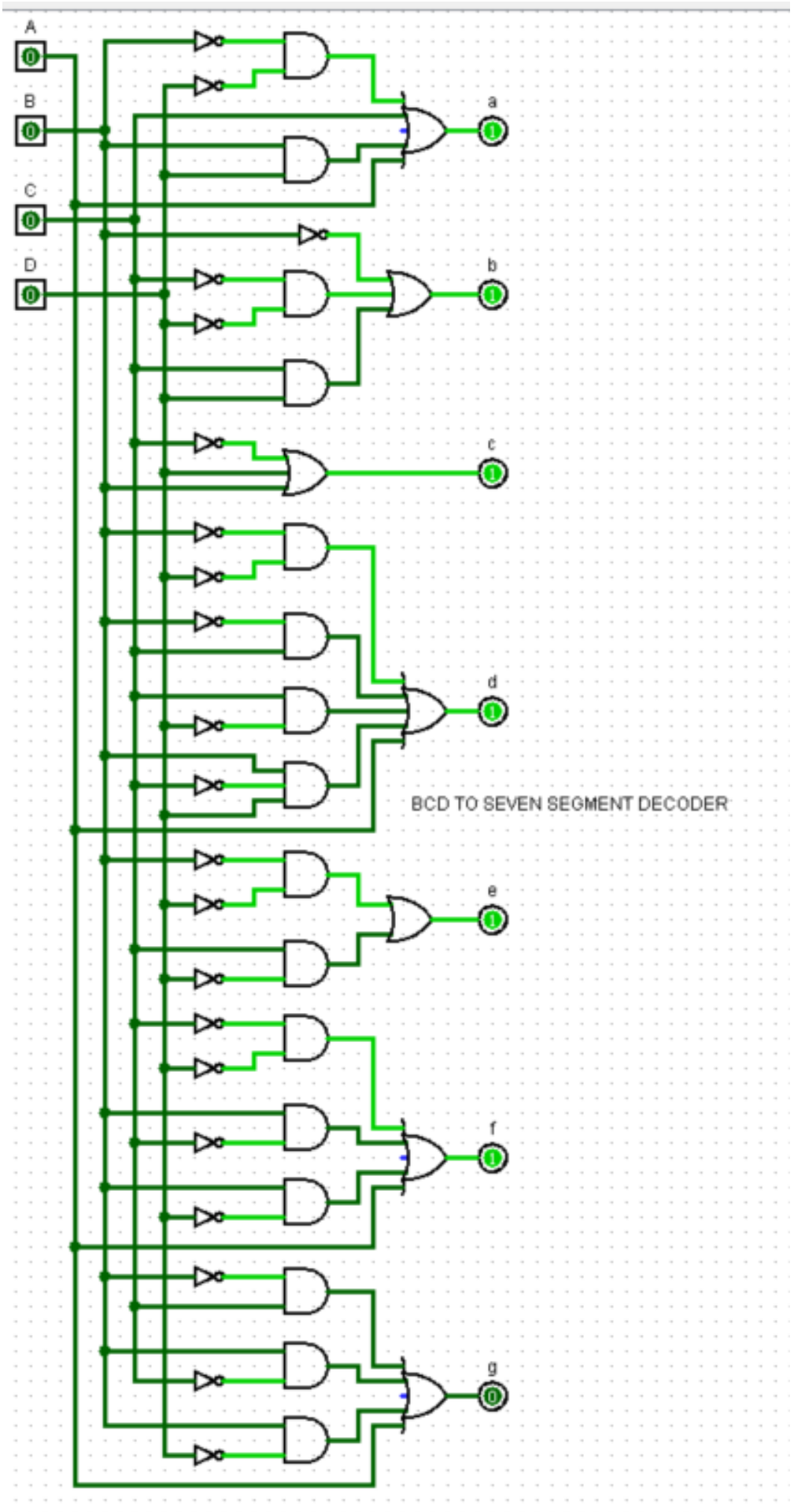


7 Segment LED

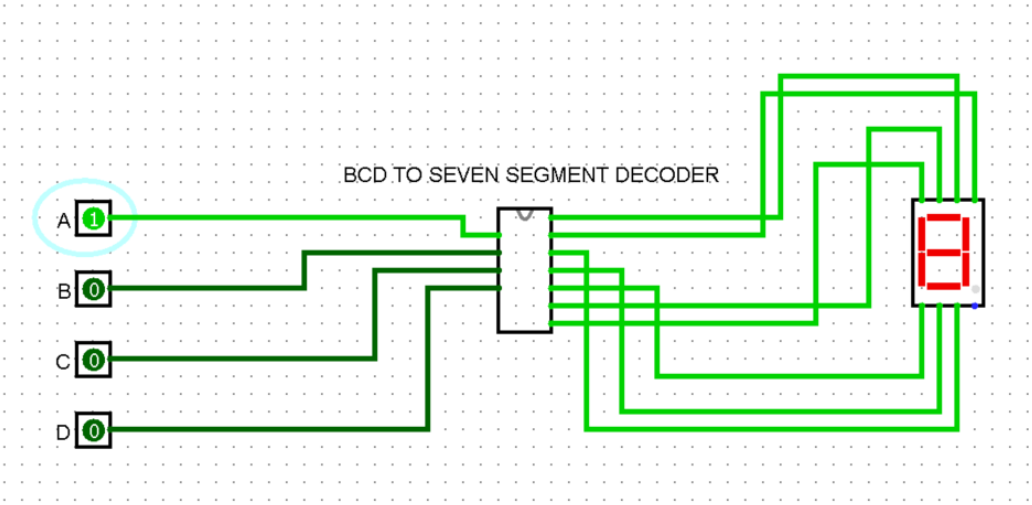
Circuit diagram from logisim



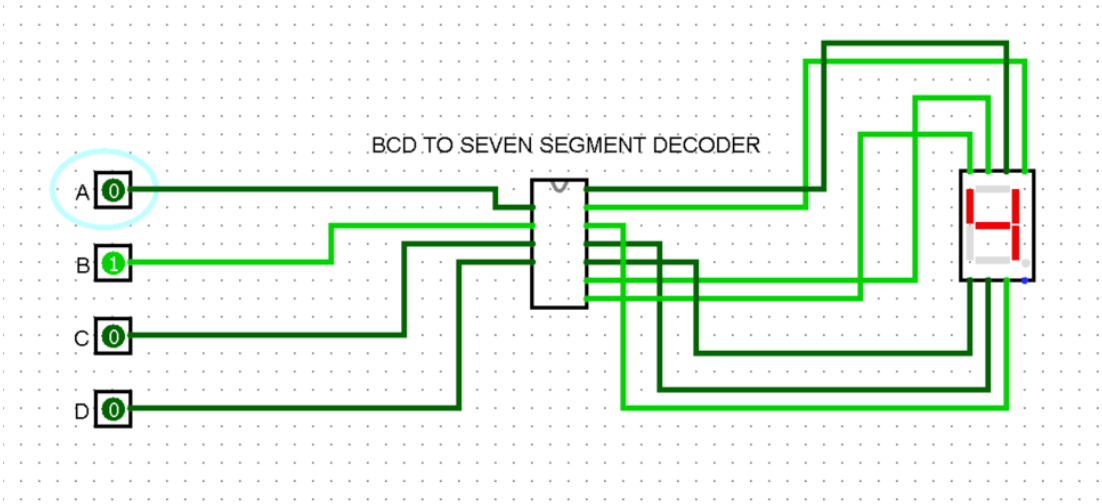
Circuit diagram from logisim



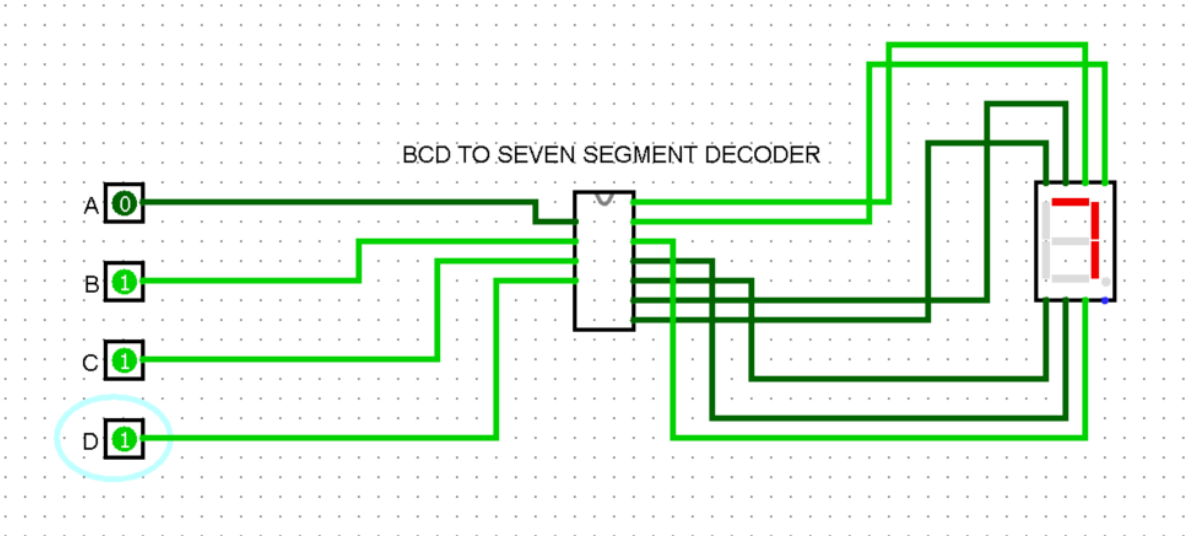
Results obtained – Test input and outputs



Input: A = 1, B = 0, C = 0, D = 0 and Output: 8

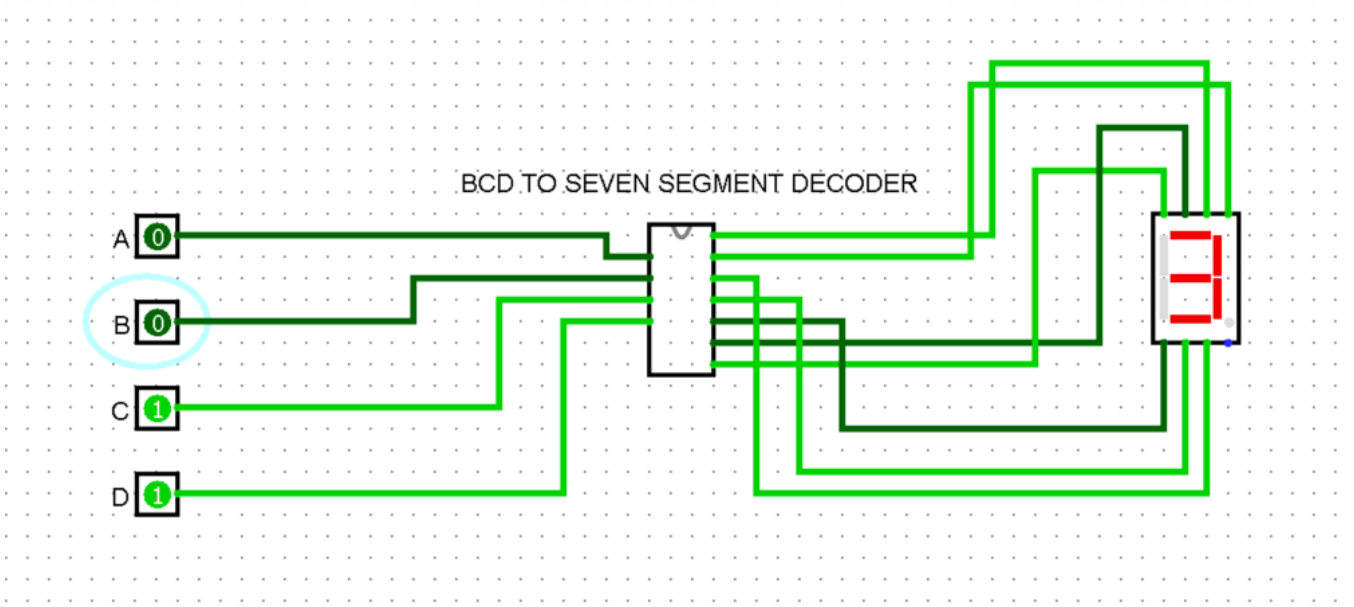


Input: A = 0, B = 1, C = 0, D = 0 and Output: 4



Input: A = 0, B = 1, C = 1, D = 1 and Output: 7

Results obtained – Test input and outputs



Input: A = 0, B = 0, C = 1, D = 1 and Output: 3

b) Connect the BCD to seven segment decoder to the output of the 4 bit adder implemented in last class. Test for inputs such that A+B <= 9

2) 4-Bit adder

Let $a_3\ a_2\ a_1\ a_0$ represent a binary NO. where a_3 is MSB and a_0 is LSB

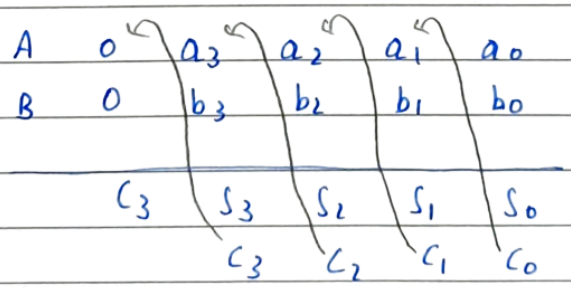
Similarly let us consider another binary NO $b_3\ b_2\ b_1\ b_0$

* Half adder adds 2 bits a and b and produces a sum (S) and a carry C.

* A full adder takes the 2 bits along with a carry C_0 and produces an output C_1 and a sum S.

* We implement the 4 bit full adder by using 1 half adder and 3 full adders, as shown in the upcoming fig.

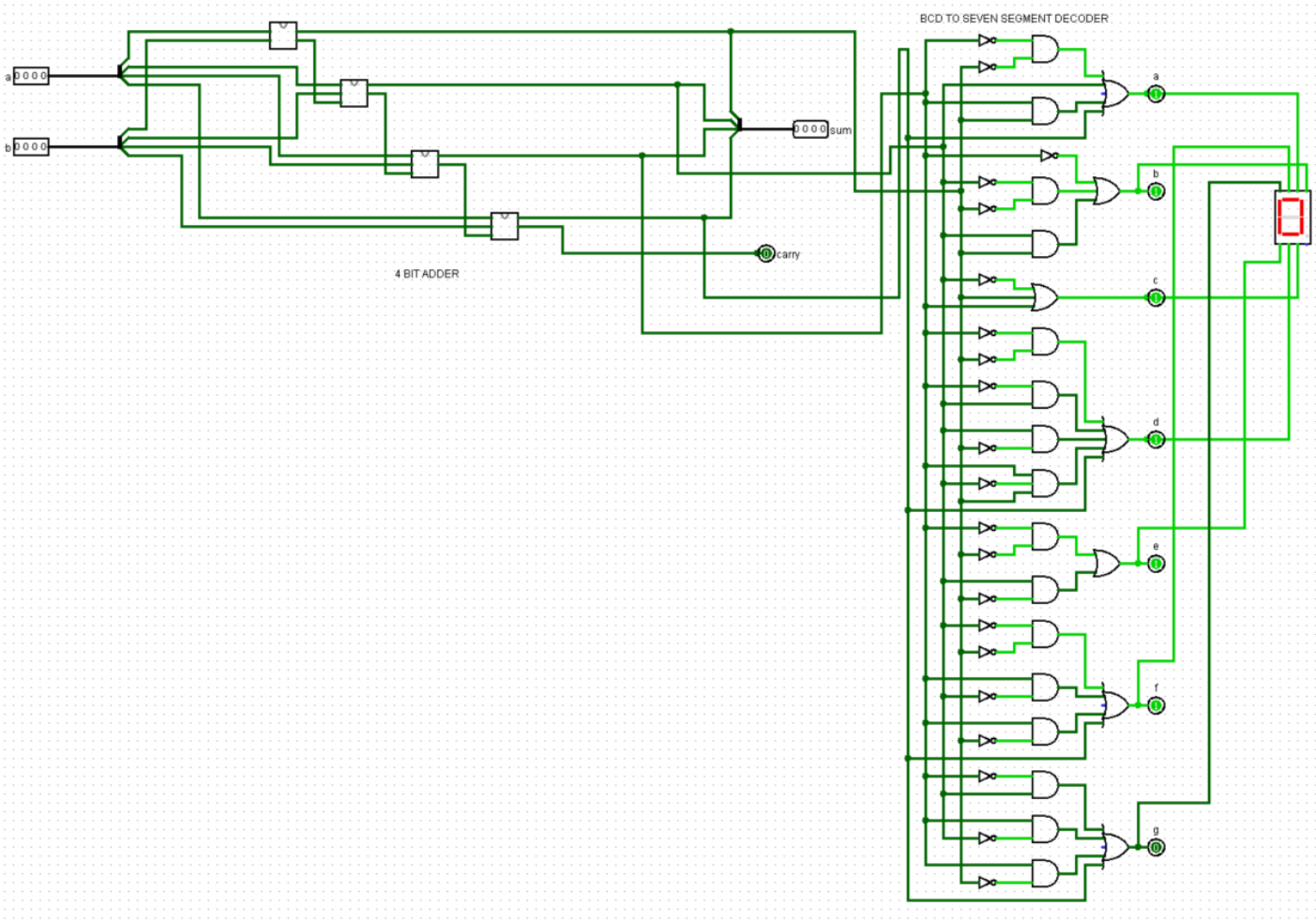
* The 4-bit full adder produces a five bit number sometimes, We connect the 4-bit full adder to our 7-Segment Display and keep the inputs such that $A+B \leq 9$ to produce the output on the screen.



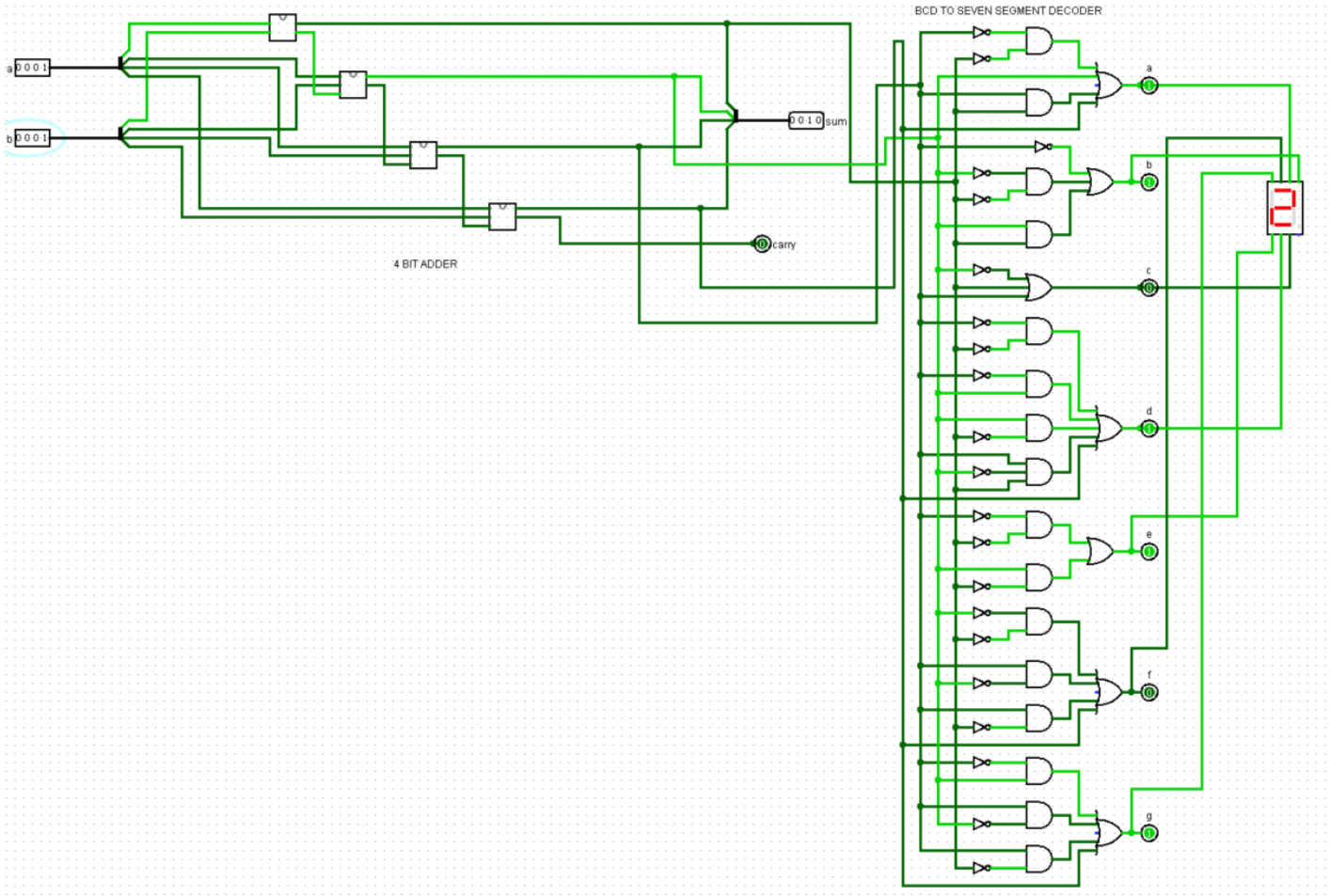
5 bit NO ⇒ $C_3\ S_3\ S_2\ S_1\ S_0$

* As explained in the previous question we use the BCD decoder to display the result in the display.

Circuit diagram from logisim

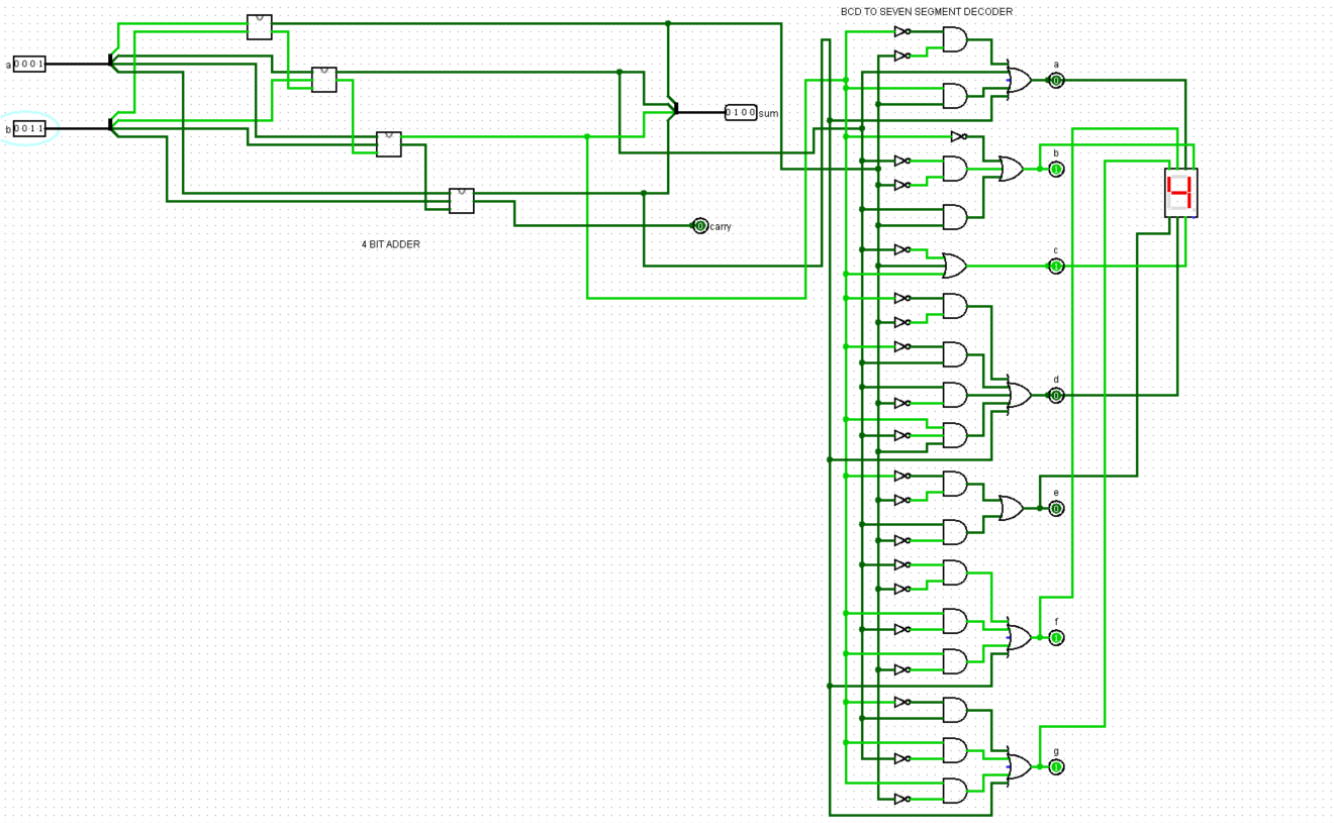


Results obtained – Test input and outputs



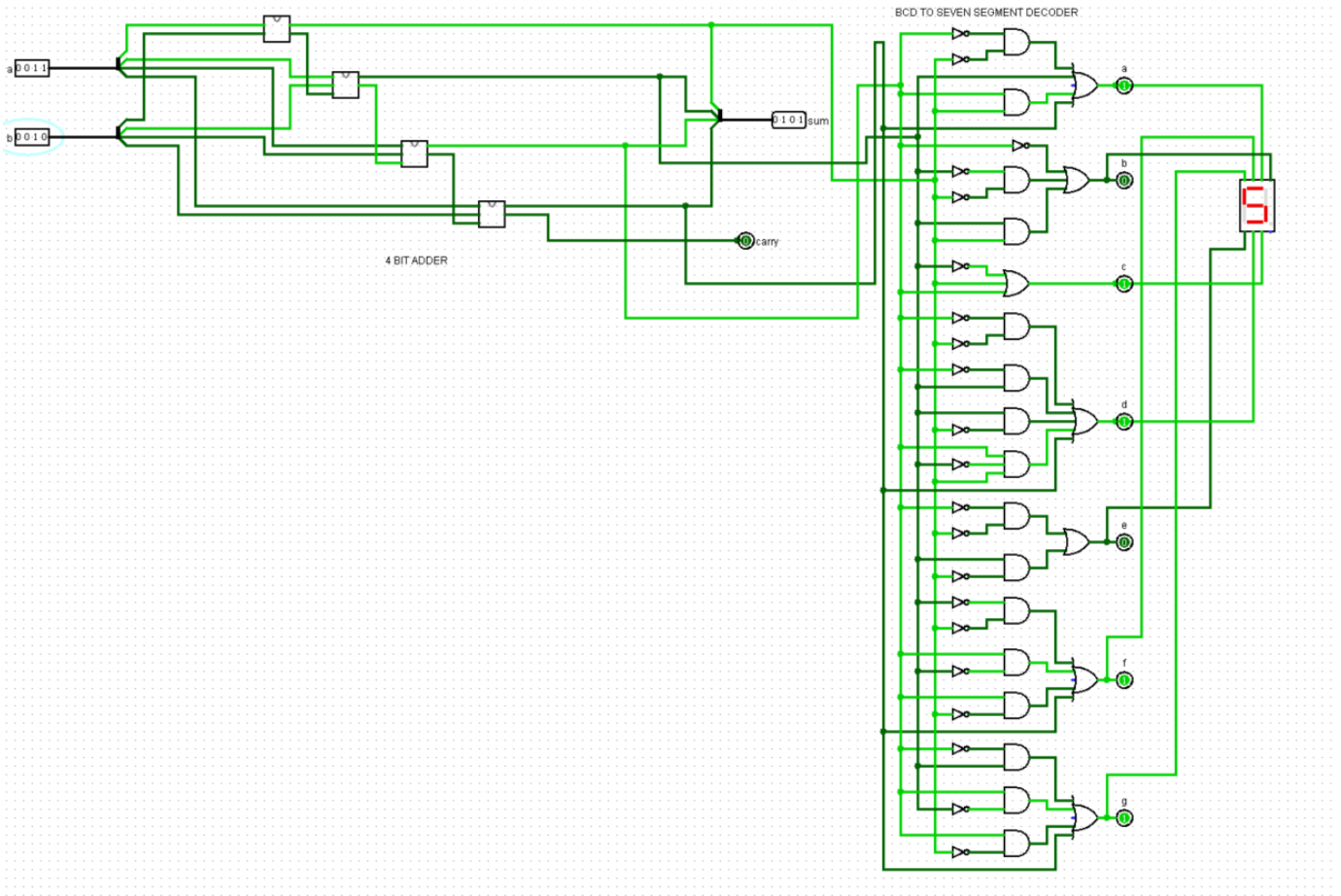
Input: A = 1, B = 1 and Output: 2

Results obtained – Test input and outputs



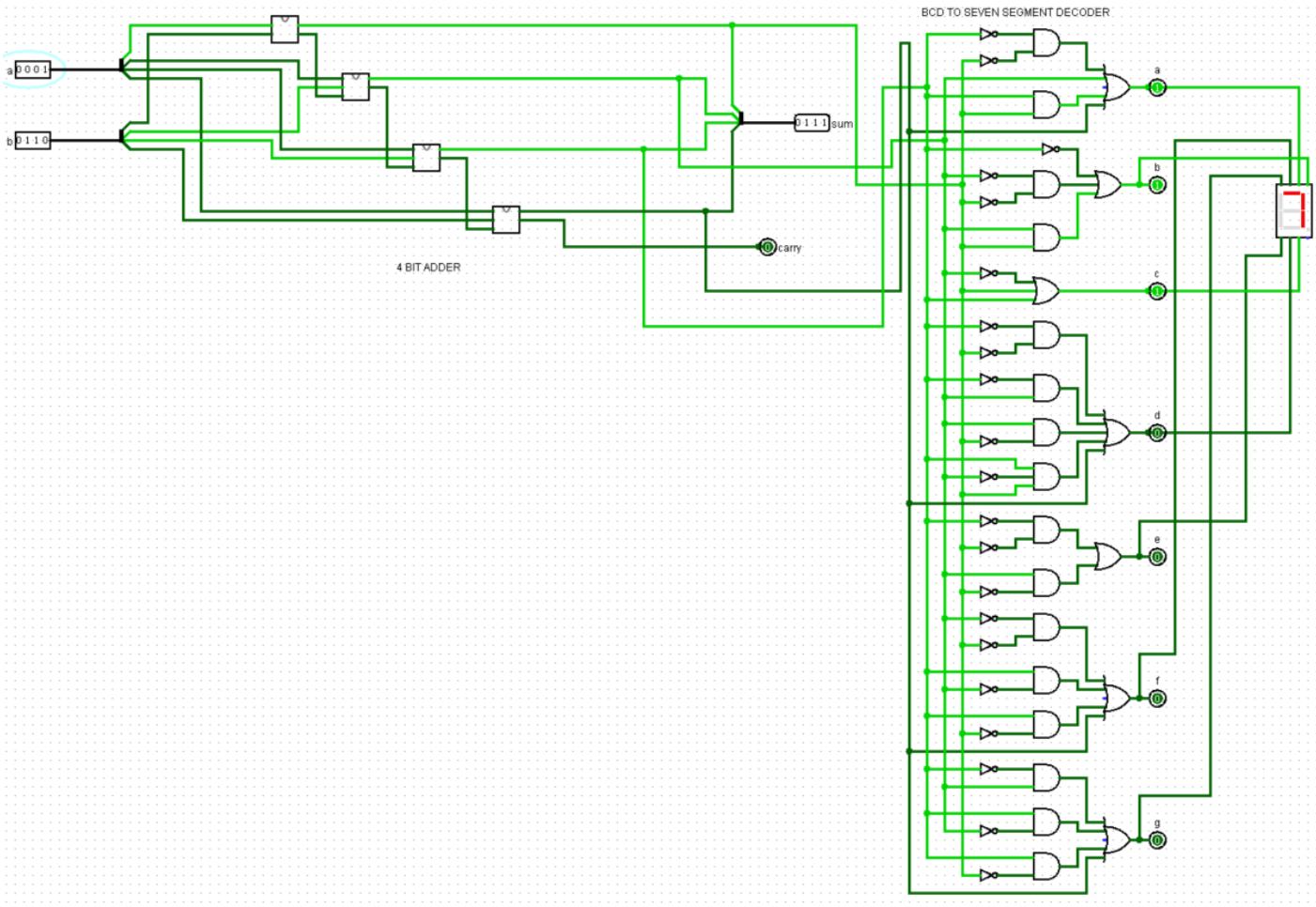
Input: A = 1, B = 3 and Output: 4

Results obtained – Test input and outputs



Input: A = 3, B = 2 and Output: 5

Results obtained – Test input and outputs



Input: A = 1, B = 6 and Output: 7

c) A four variable logic function that is equal to 1 if any three or all four of its variables are equal to 1 is called a majority function. Design a minimum cost POS circuit using NOR gates that implements this majority function

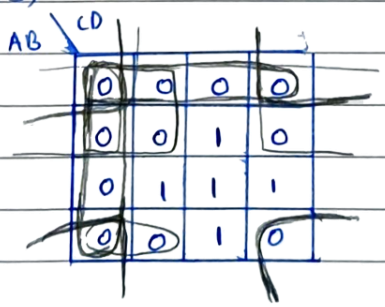
3) Design:-

i) Truth table

* Let A B C D be the inputs
* Y be the output for the majority function.

	A	B	C	D	Y
0	0	0	0	0	0
1	0	0	0	1	0
2	0	0	1	0	0
3	0	0	1	1	0
4	0	1	0	0	0
5	0	1	0	1	0
6	0	1	1	0	0
7	0	1	1	1	1
8	1	0	0	0	0
9	1	0	0	1	0
10	1	0	1	0	0
11	1	0	1	1	1
12	1	1	0	0	0
13	1	1	0	1	1
14	1	1	1	0	1
15	1	1	1	1	1

ii) K-Map (POS)



$Y = (A+B)(A+C)(A+D)(B+C)(B+D)(C+D)$

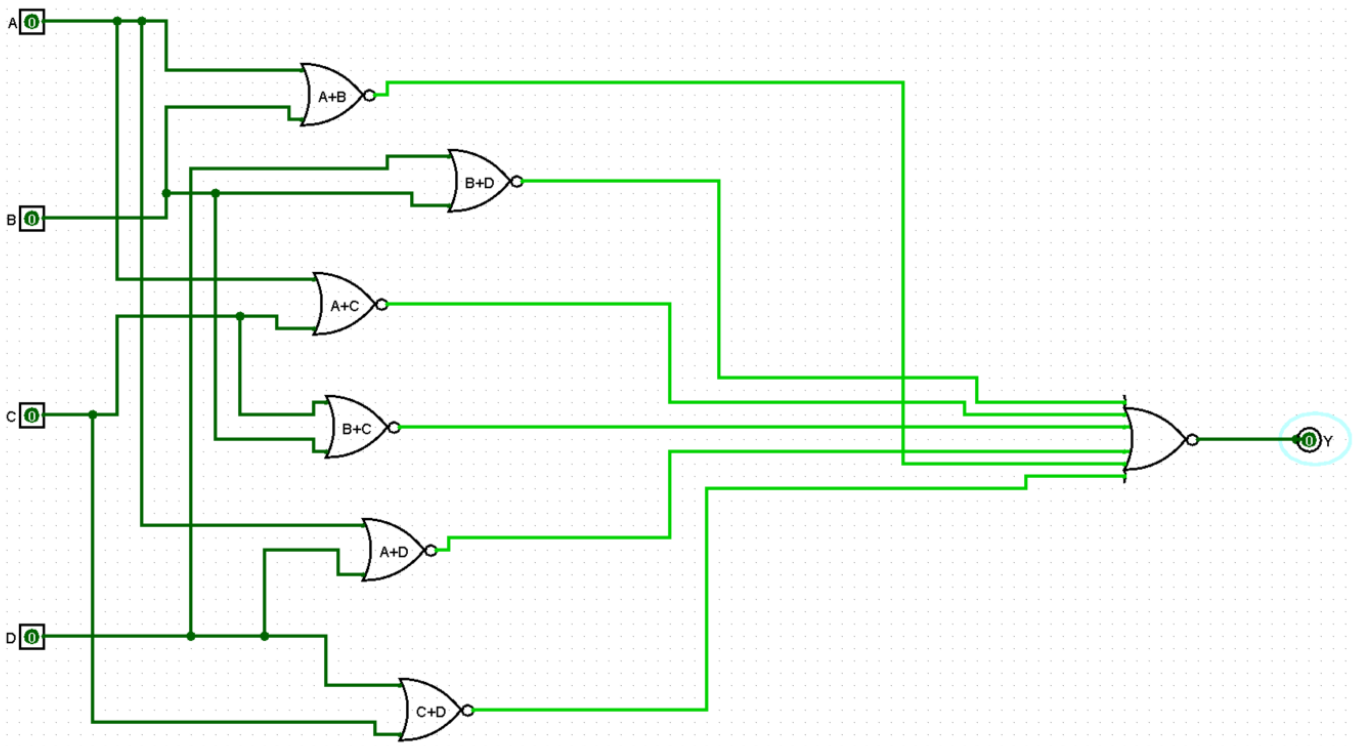
Explanation

* Y the output is equal to 1 if any three or all four of its variables are equal to 1, and is called the majority function.

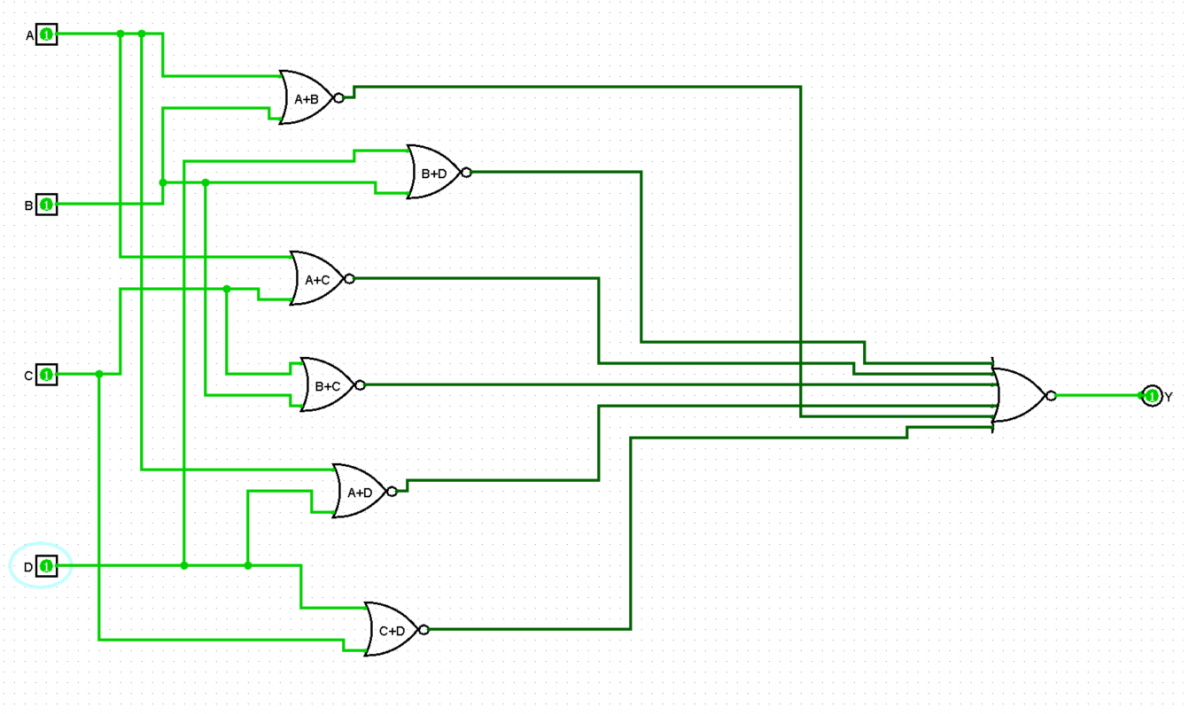
* The simplified expression of $Y = (A+B)(A+C)(A+D)(B+C)(B+D)(C+D)$

* In the following figure the above expression has been implemented using NOR gates.

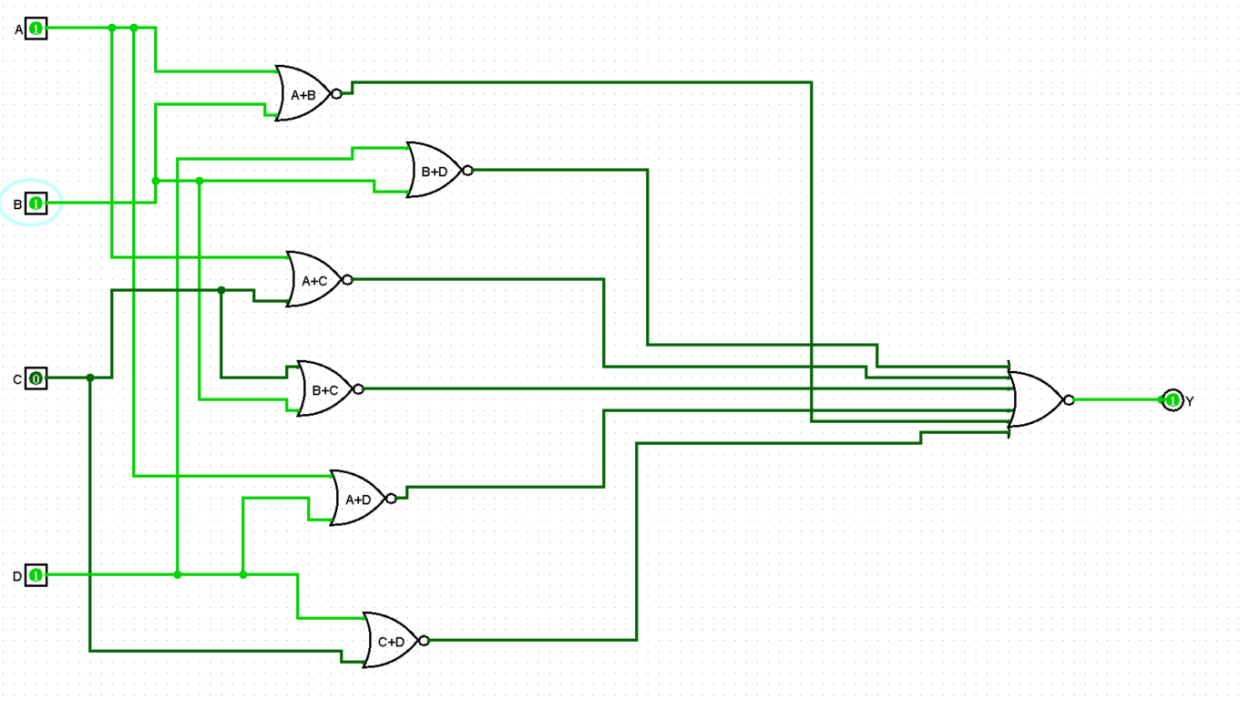
Circuit diagram from logisim



Results obtained – Test input and outputs

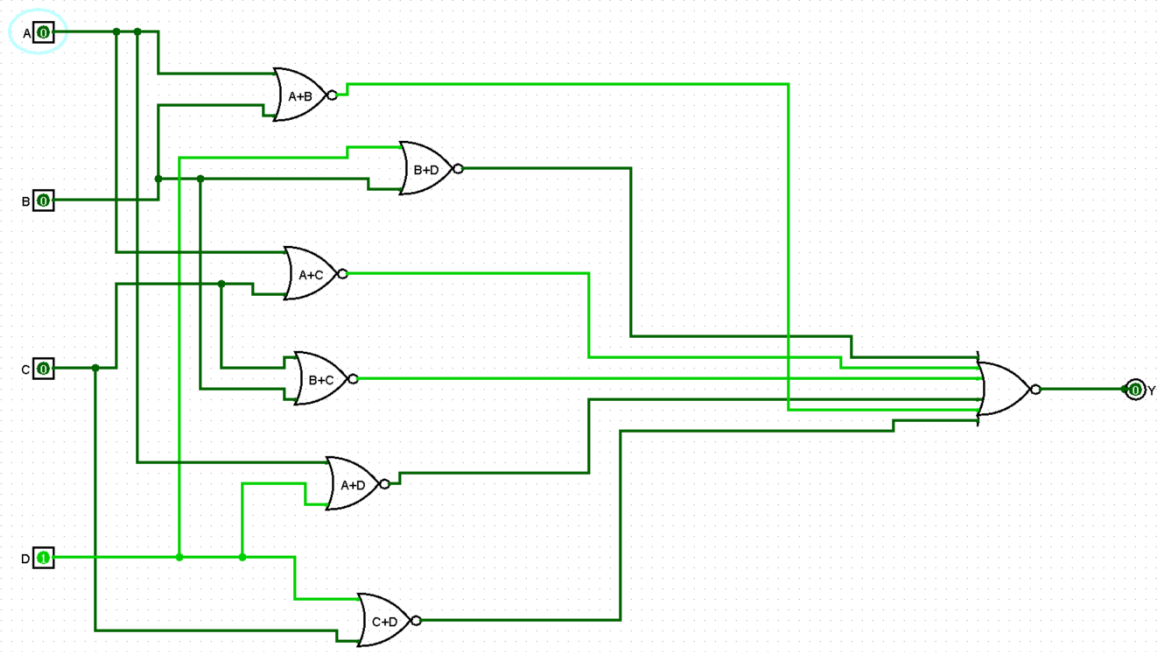


Input: A = 1, B = 1, C = 1, D = 1 and Output: Y = 1

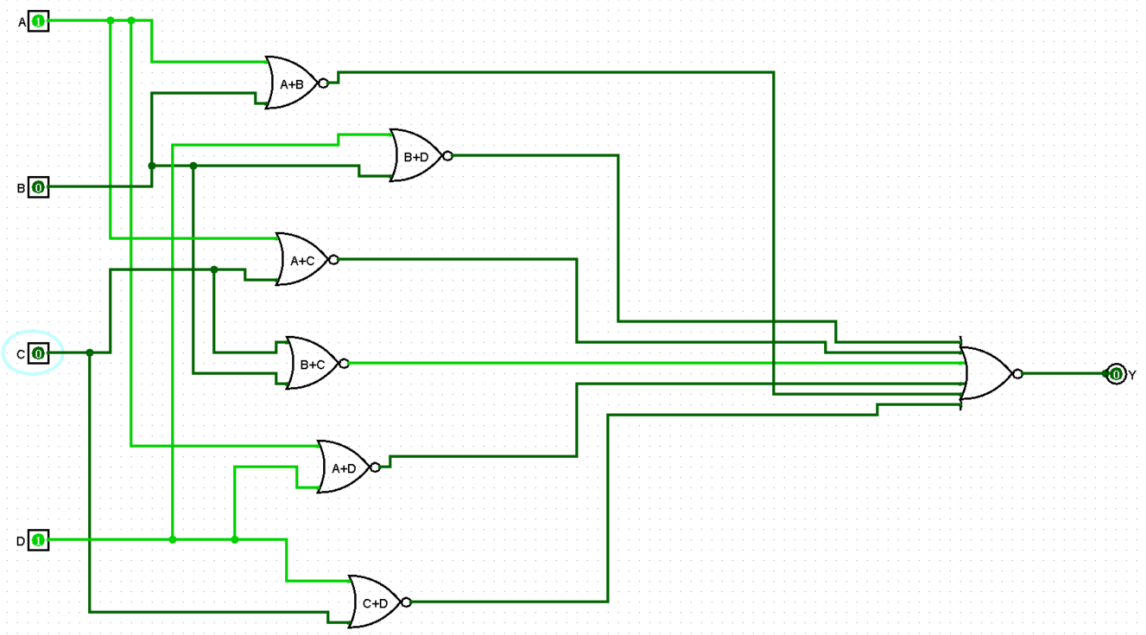


Input: A = 1, B = 1, C = 0, D = 1 and Output: Y = 1

Results obtained – Test input and outputs



Input: A = 0, B = 0, C = 0, D = 1 and Output: Y = 0



Input: A = 1, B = 0, C = 0, D = 1 and Output: Y = 0

d) A given system has four sensors that produce an output of 0 or 1. The system operates properly when exactly one of the sensors has its output equal to 1. An alarm must be raised when two or more sensors have the output of 1. Design the simplest circuit that can be used to raise the alarm. Use a red LED to indicate ALARM and a green LED to indicate the system operated properly.

4) Design

i) Truth table

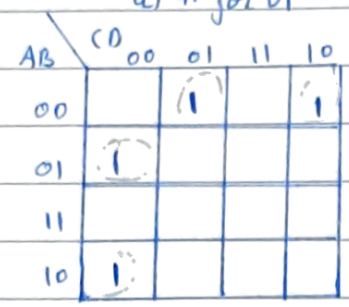
Let the inputs be A B C D

Let the boolean expression for GREEN LED be denoted by G and for red by R

A	B	C	D	R	G
0	0	0	0	0	0
0	0	0	1	0	1
0	0	1	0	0	1
0	0	1	1	1	0
0	1	0	0	0	1
0	1	0	1	1	0
0	1	1	0	1	0
0	1	1	1	1	0
1	0	0	0	0	1
1	0	0	1	1	0
1	0	1	0	1	0
1	0	1	1	1	0
1	1	0	0	1	0
1	1	0	1	1	0
1	1	1	0	1	0
1	1	1	1	1	0

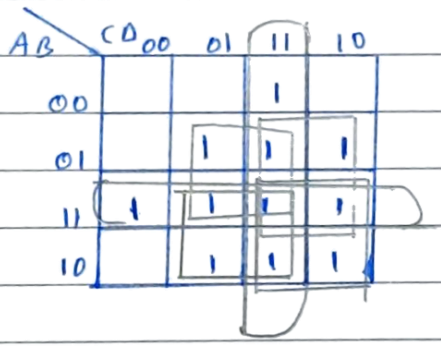
ii) K - MAP

a) # for G



$G = \bar{A}\bar{B}\bar{C}D + \bar{A}\bar{B}C\bar{D} + \bar{A}B\bar{C}\bar{D} + A\bar{B}\bar{C}\bar{D}$

b) # for R



$R = CD + BD + BC + AD + AC + AB$

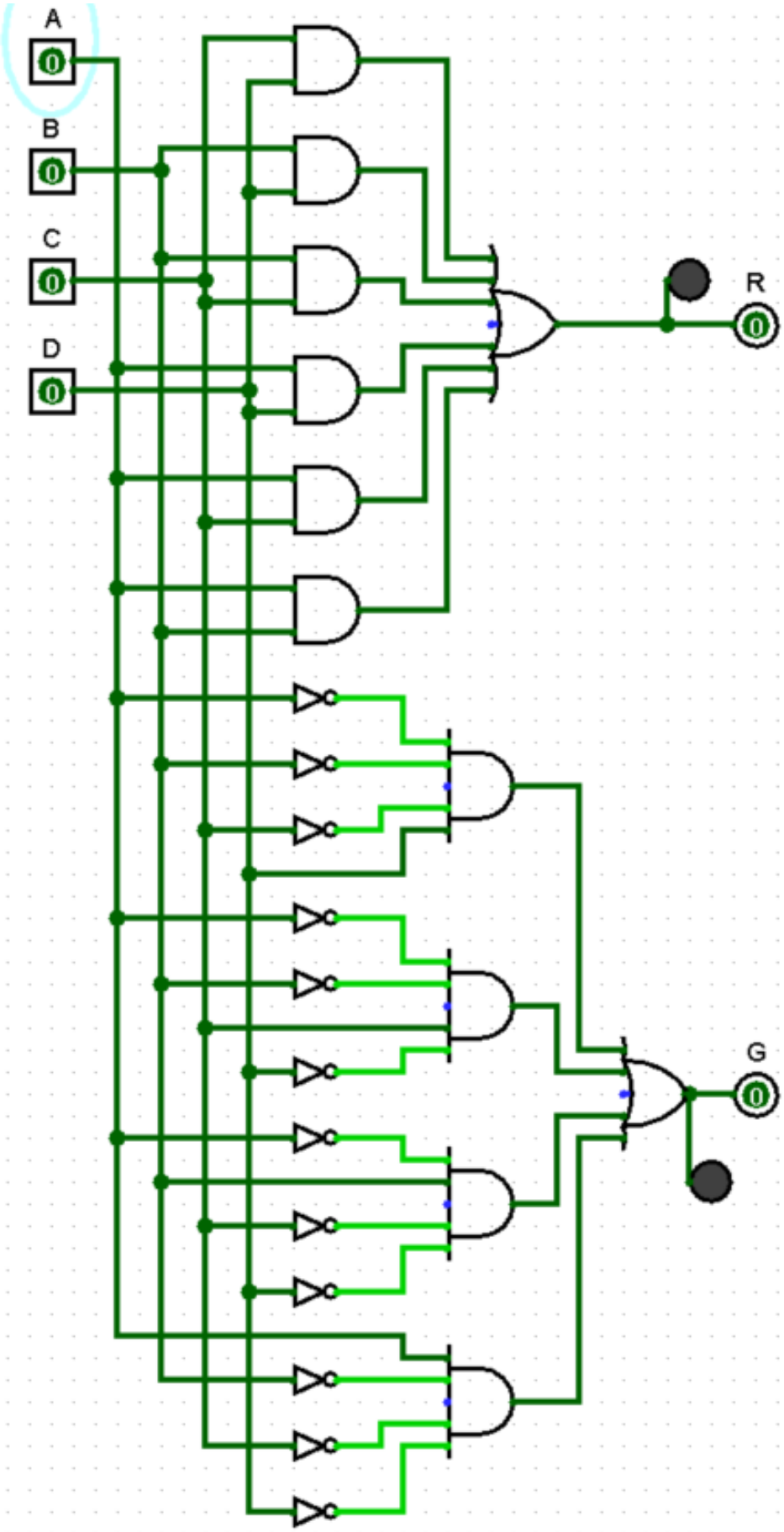
Explanation :-

* As given in the question the expression for Green LED to be ON is found when ~~atleast~~ one of the 4 inputs is high.
* If more than two inputs are high then the input for Red goes high thus raises an alarm.

Green indicates proper functioning of the system.

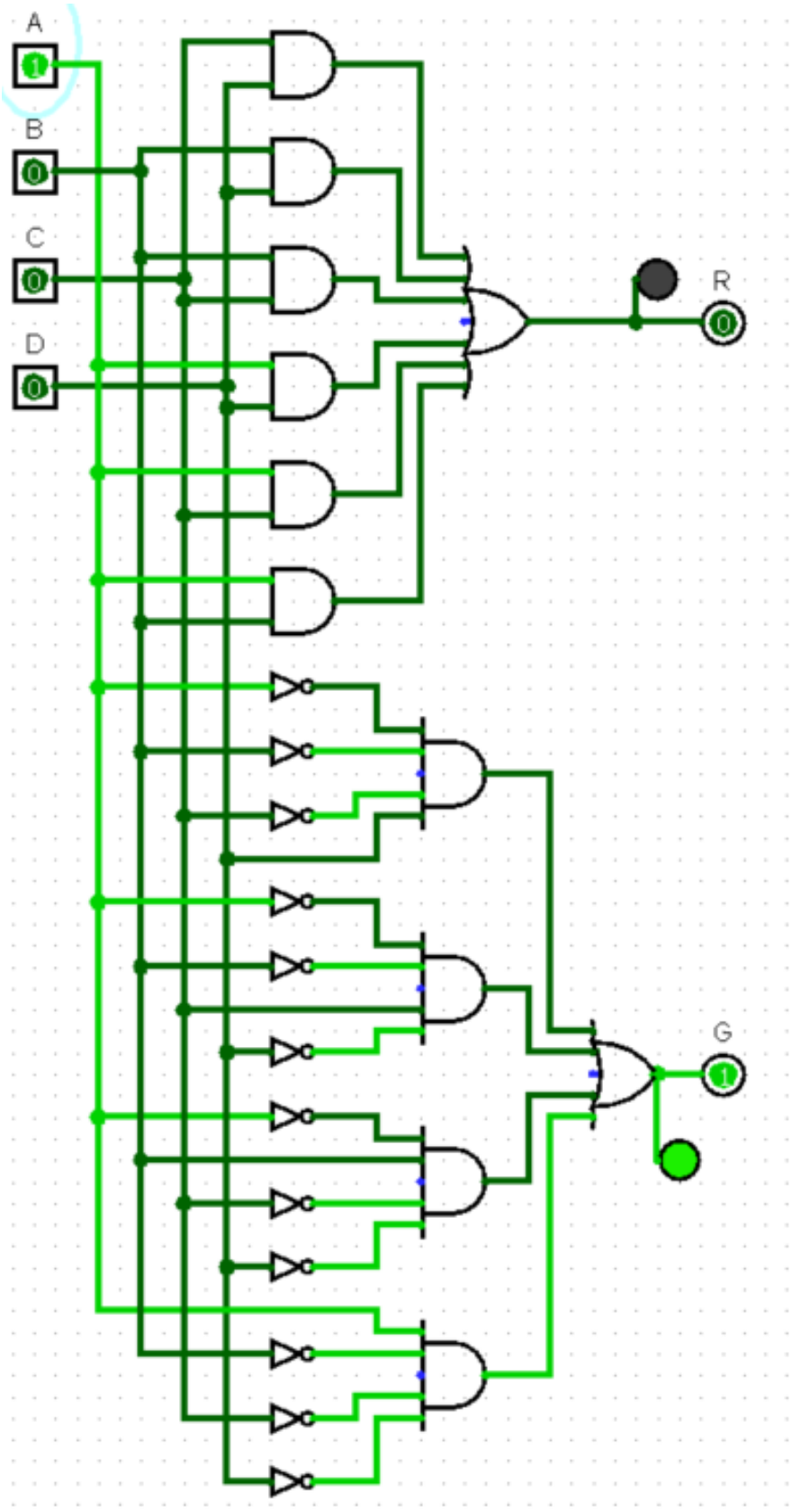
Red gives off an alarm.

Circuit diagram from logisim



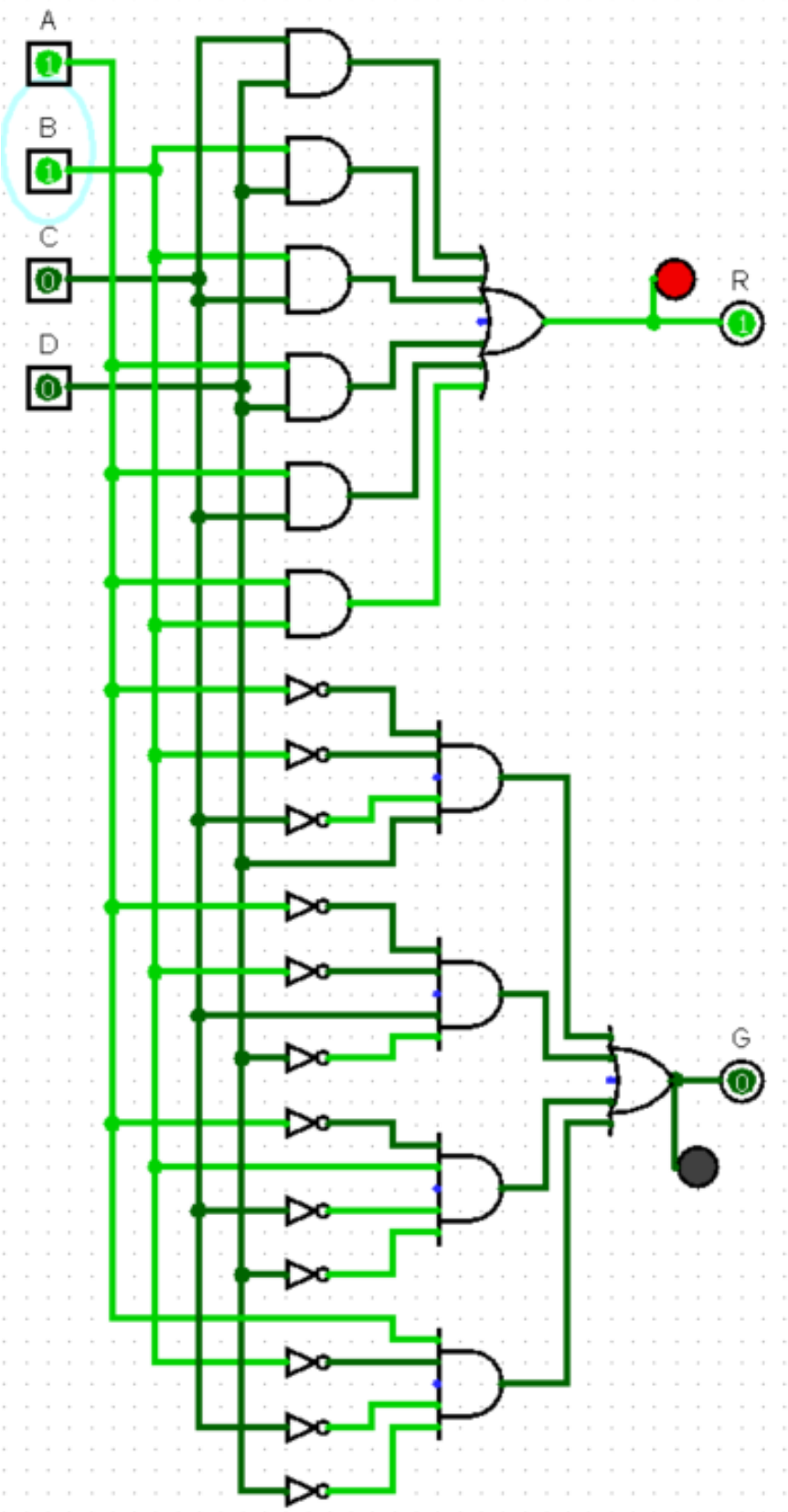
Results obtained – Test input and outputs

Input: A = 1, B = 0, C = 0, D = 0 and Output: R = 0, G = 1



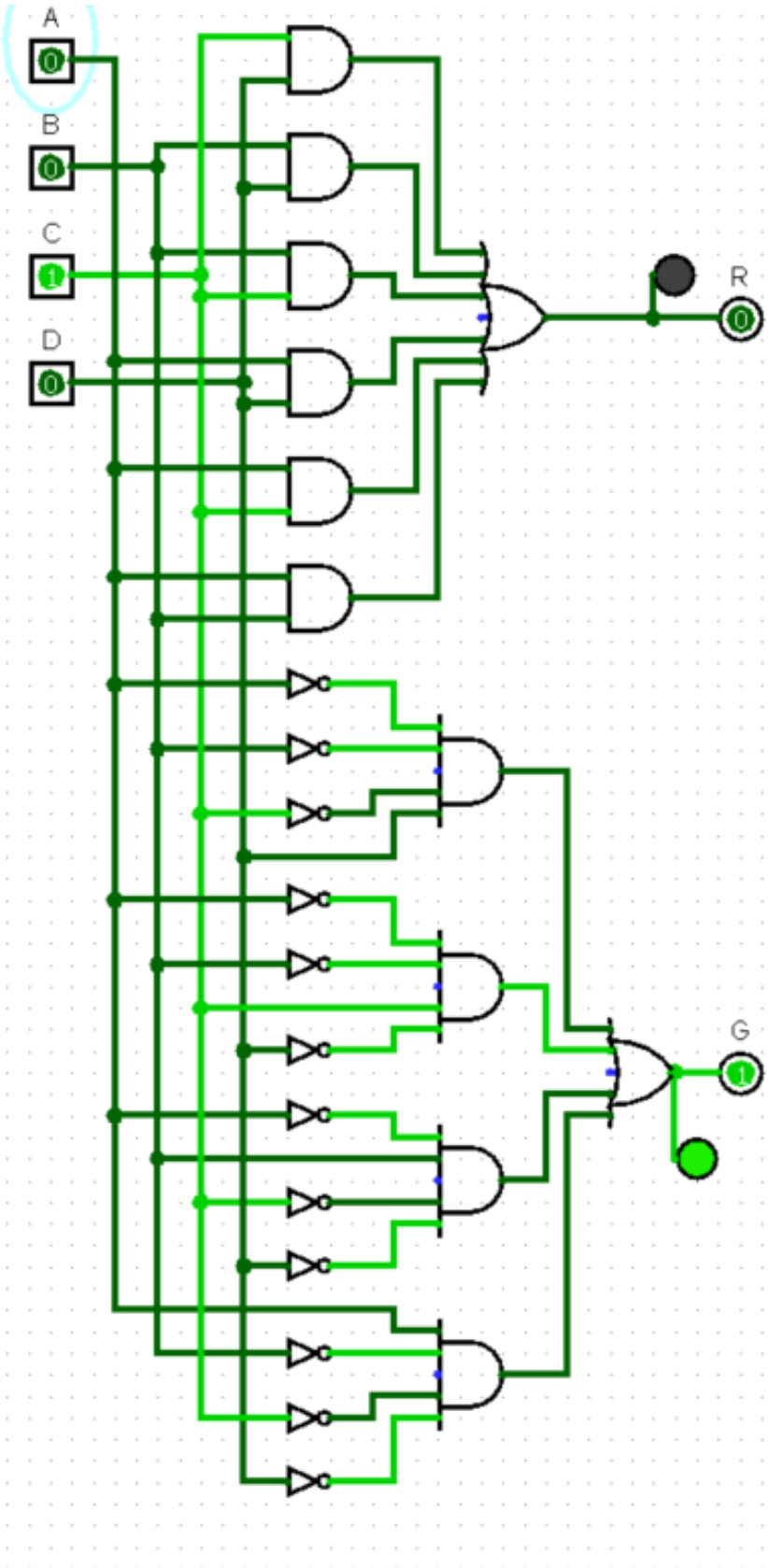
Results obtained – Test input and outputs

Input: A = 1, B = 1, C = 0, D = 0 and Output: R = 1, G = 0



Results obtained – Test input and outputs

Input: A = 0, B = 0, C = 1, D = 0 and Output: R = 0, G = 1



Results obtained – Test input and outputs

Input: A = 1, B = 1, C = 1, D = 0 and Output: R = 1, G = 0