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Cairo University
Faculty of Engineering
Electronics and Communications Engineering Department –
4th Year

VLSI PROJECT

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1-Algorithm of modified Bough Wooley 2's complement multiplier

$$P = \sum_{i=0}^{N-2} \sum_{j=0}^{M-2} X_i y_j 2^{i+j} + x_{N-1} y_{M-1} 2^{M+N-2} - \left(\sum_{i=0}^{N-2} x_i y_{M-1} 2^{i+M-1} + \sum_{j=0}^{M-2} x_{N-1} y_j 2^{j+N-1} \right)$$

Here we have $N=5$ and $M=7$.

<div> <div> y_6 y_5 y_4 y_3 y_2 y_1 y_0 </div> <div> x_4 x_3 x_2 x_1 x_0 </div> </div>											
<div> <div> x_0y_5 x_0y_4 x_0y_3 x_0y_2 x_0y_1 x_0y_0 </div> <div> x_1y_5 x_1y_4 x_1y_3 x_1y_2 x_1y_1 x_1y_0 </div> <div> x_2y_5 x_2y_4 x_2y_3 x_2y_2 x_2y_1 x_2y_0 </div> <div> x_3y_5 x_3y_4 x_3y_3 x_3y_2 x_3y_1 x_3y_0 </div> </div>											
<div> <div> x_4y_6 </div> <div> 1 1 $(x_3y_6)'$ $(x_2y_6)'$ $(x_1y_6)'$ $(x_0y_6)'$ 1 1 1 1 1 1 </div> </div>											
<div> <div> 1 1 $(x_4y_5)'$ $(x_4y_4)'$ $(x_4y_3)'$ $(x_4y_2)'$ $(x_4y_1)'$ $(x_4y_0)'$ 1 1 1 1 </div> </div>											
<div> <div> $(x_0y_6)'$ x_0y_5 x_0y_4 x_0y_3 x_0y_2 x_0y_1 x_0y_0 </div> <div> $(x_1y_6)'$ x_1y_5 x_1y_4 x_1y_3 x_1y_2 x_1y_1 x_1y_0 </div> <div> $(x_2y_6)'$ x_2y_5 x_2y_4 x_2y_3 x_2y_2 x_2y_1 x_2y_0 </div> <div> $(x_3y_6)'$ x_3y_5 x_3y_4 x_3y_3 x_3y_2 x_3y_1 x_3y_0 </div> <div> x_4y_6 $(x_4y_5)'$ $(x_4y_4)'$ $(x_4y_3)'$ $(x_4y_2)'$ $(x_4y_1)'$ $(x_4y_0)'$ </div> </div>											
<div> <div> 1 </div> <div> 1 </div> </div>											
$P11$	$P10$	$P9$	$P8$	$P7$	$P6$	$P5$	$P4$	$P3$	$P2$	$P1$	$P0$

2-Block diagram of modified Bough Wooley 2's complement multiplier

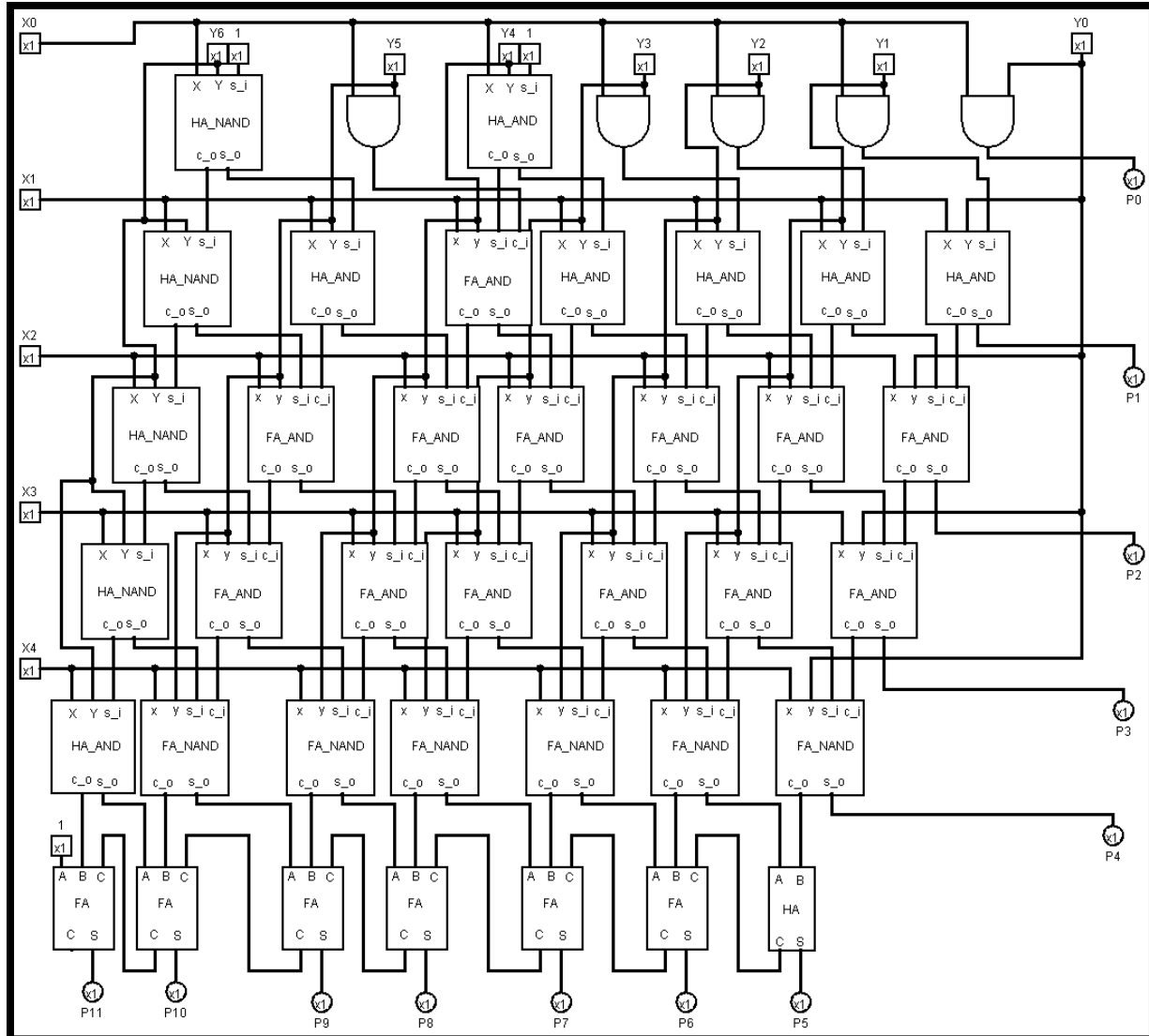


Figure1-Multiplier

As shown in Figure1, We used 7 different cells to optimize in area:

AND

Full Adder

Full Adder with AND

Full Adder with NAND

Half Adder

Half Adder with AND

Half Adder with NAND

3-Logic diagram of the cells used

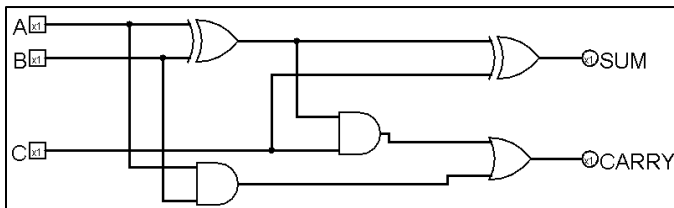


Figure2-Full Adder

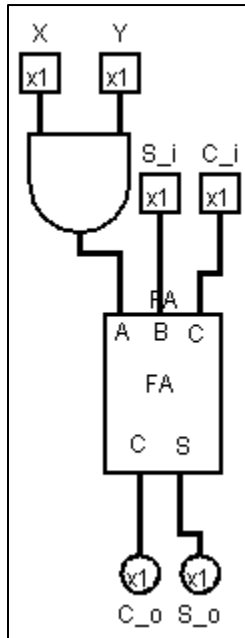


Figure3-FA AND

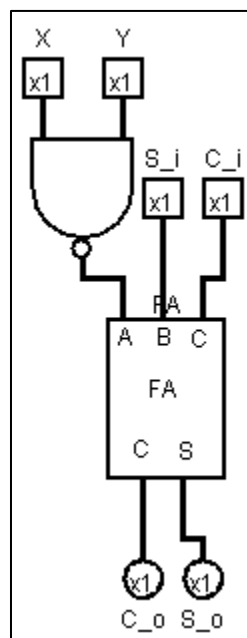


Figure4-FA NAND

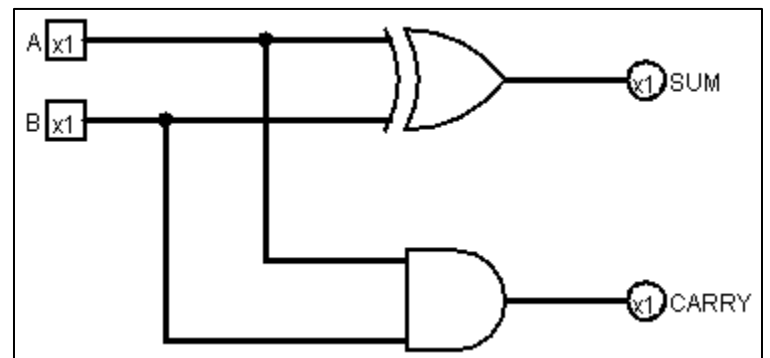


Figure5-Half Adder

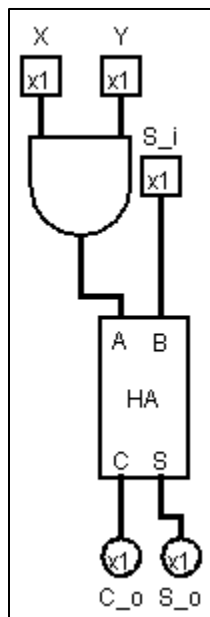


Figure6-HA AND

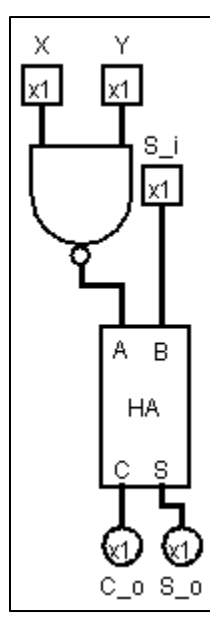


Figure7-HA NAND

4-Simulation of some corner Cases (using Logisim)

4.1 Zero X Zero

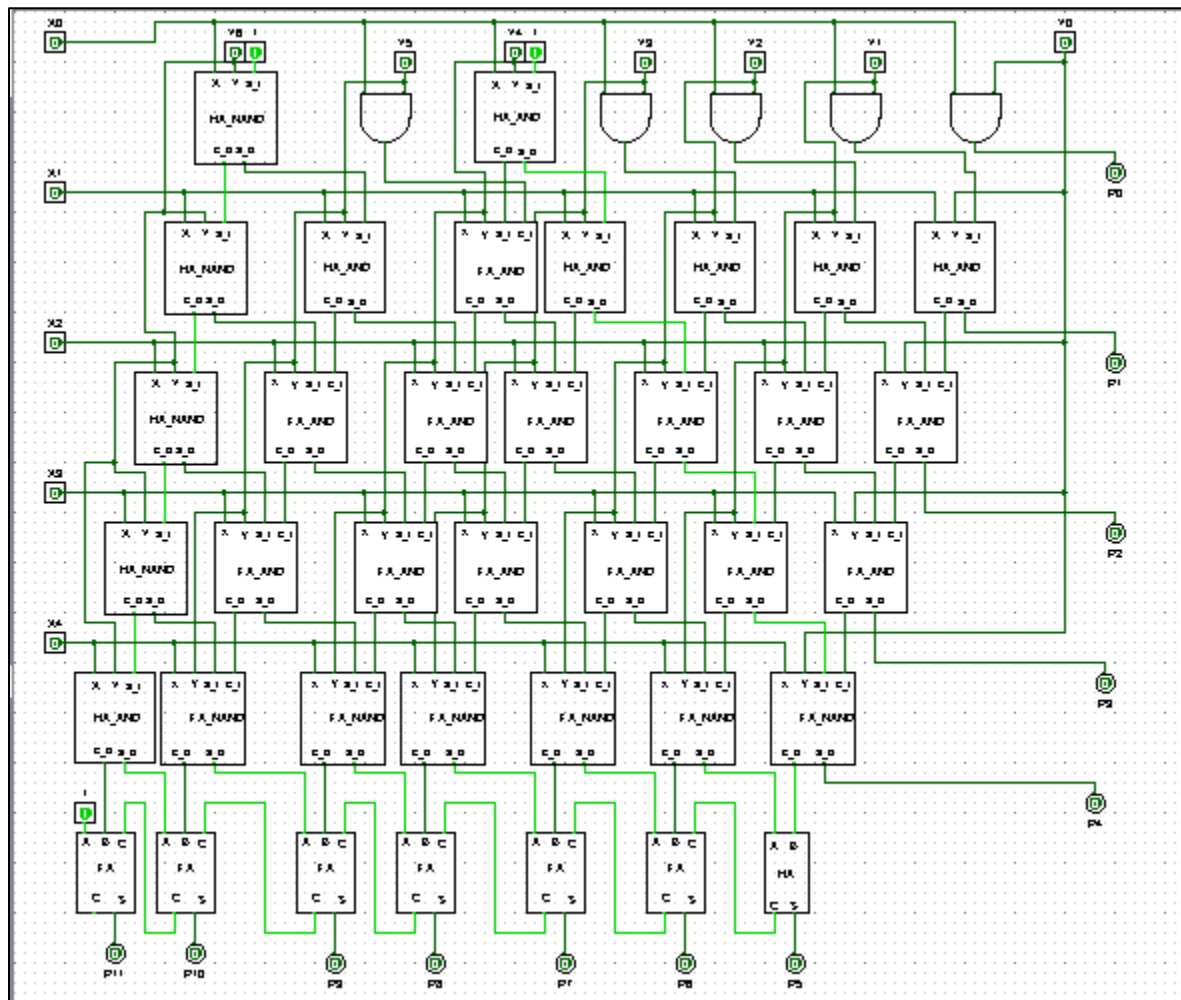


Figure8

As shown in Figure8, X=00000, Y=0000000 and the result P=000000000000

4.2 Max positive X Max positive

The Max positive $X=2^{N-1} - 1 = 15$ And The Max positive $Y=2^{M-1} - 1 = 63$.

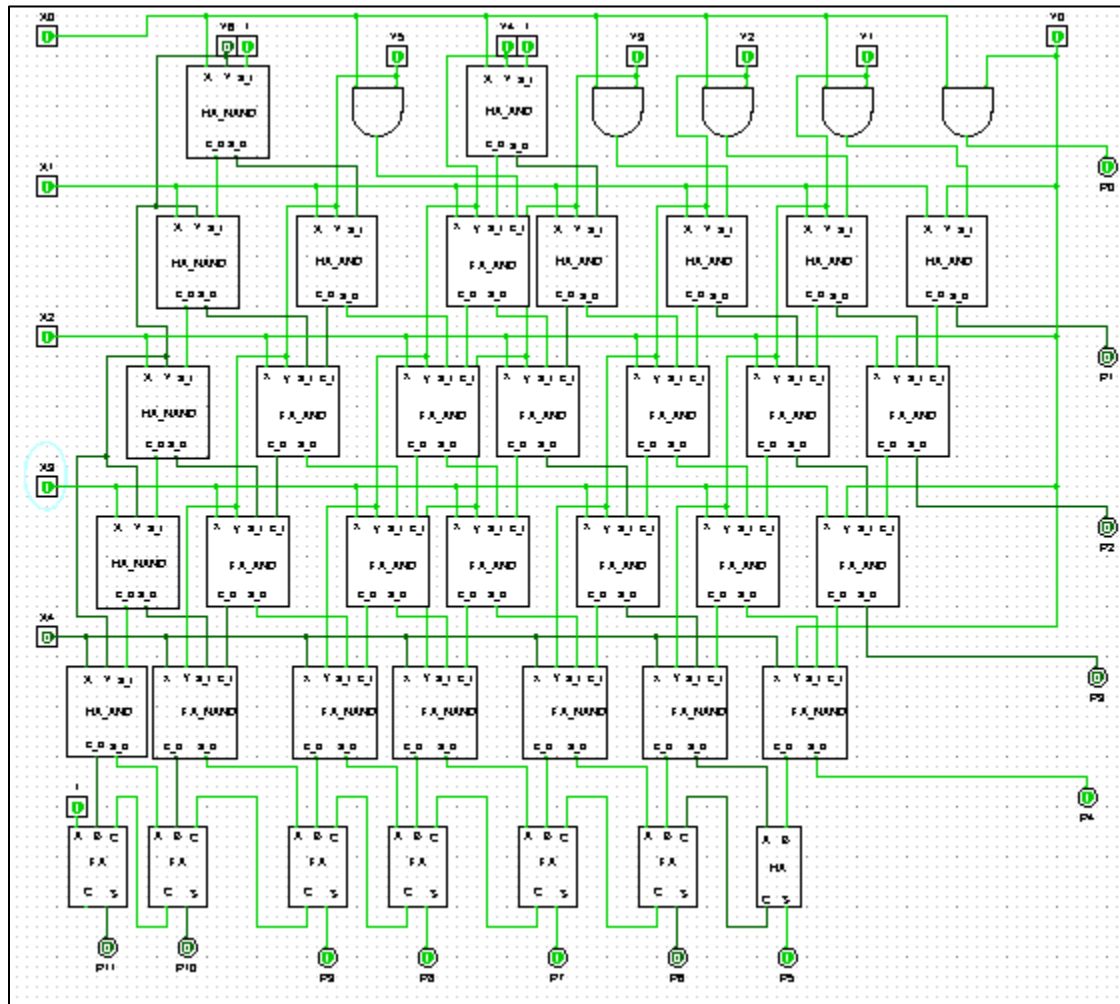


Figure9

As shown in Figure9, $X=01111$, $Y=0111111$ and the result $P=001110110001$

$XY=15*63=945=001110110001$

4.3 Max positive X Max negative

The Max positive $X=2^{N-1} - 1 = 15$ And The Max negative $Y=-2^{M-1} = -64$.

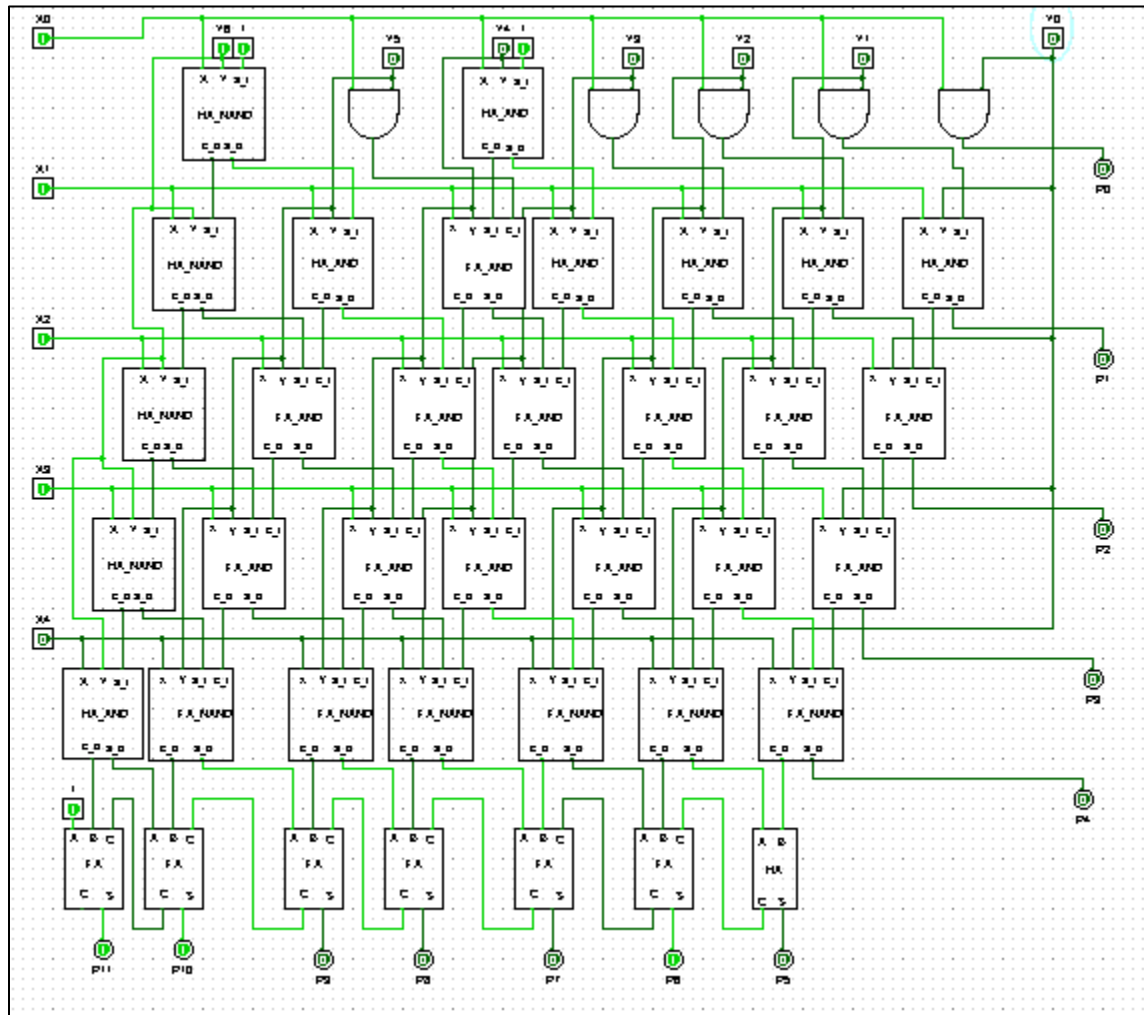


Figure10

As shown in Figure9, $X=01111$, $Y=1000000$ and the result $P=110001000000$

$XY=15 \times -64 = -960 = 110001000000$

4.4 Max negative X Max positive

The Max negative $X = -2^{N-1} = -16$ And The Max positive $Y = 2^{M-1} - 1 = 63$.

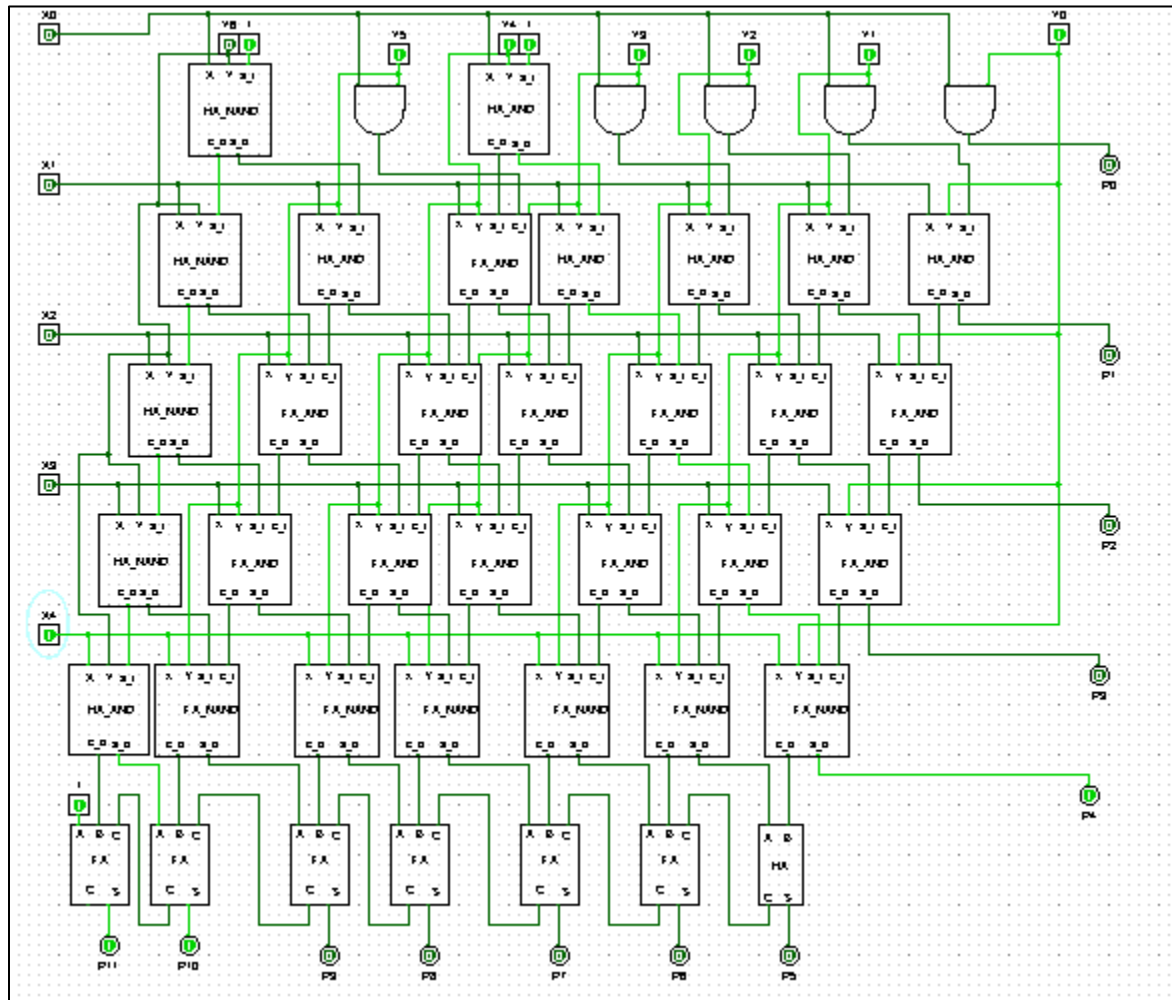


Figure11

As shown in Figure9, $X=10000$, $Y=0111111$ and the result $P=110000010000$

$XY = -16 * 63 = -1008 = 110000010000$

4.5 Max negative X Max negative

The Max negative $X = -2^{N-1} = -16$ And The Max negative $Y = -2^{M-1} = -64$.

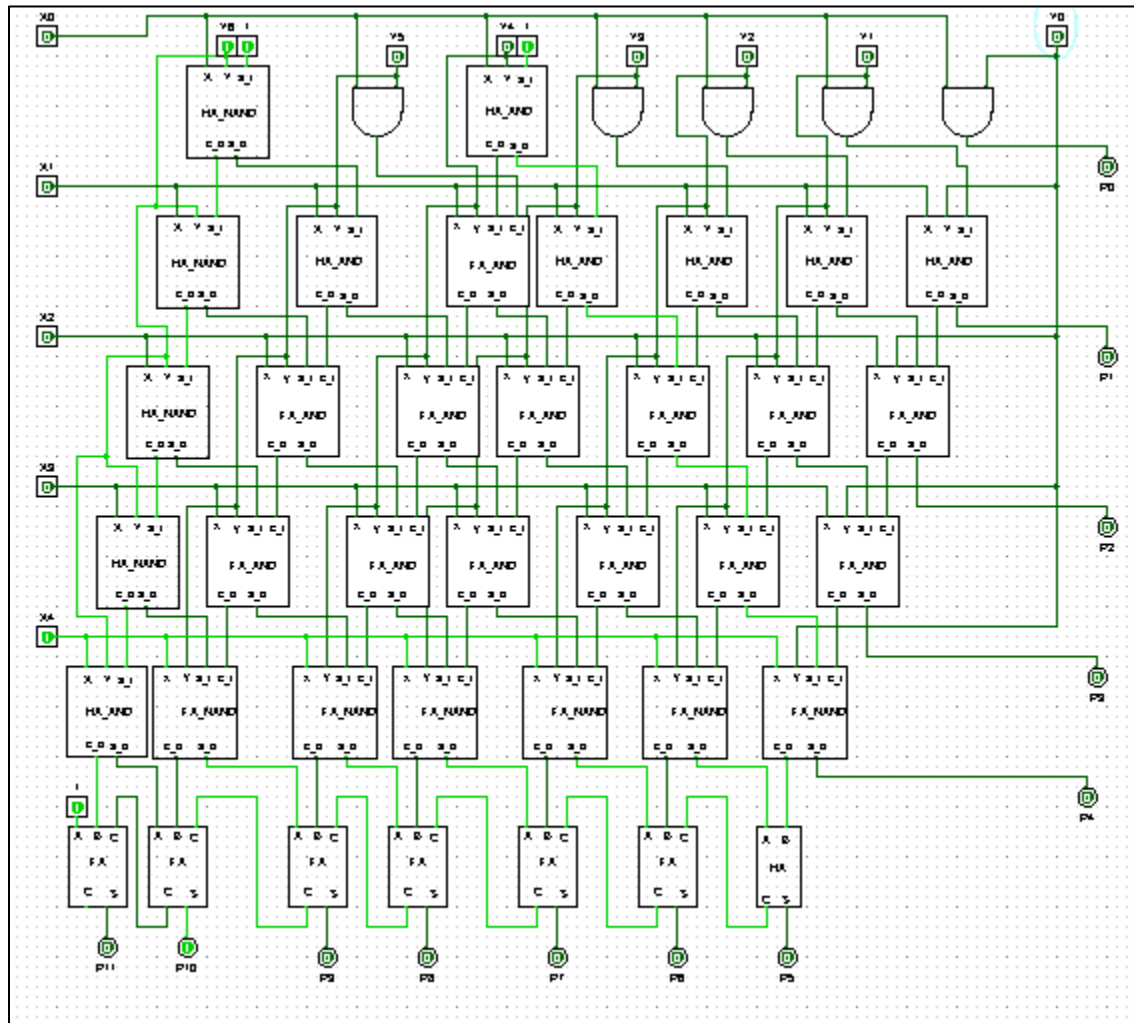


Figure12

As shown in Figure9, $X=10000$, $Y=1000000$ and the result $P=010000000000$

$XY = -16 * -64 = 1024 = 010000000000$