



School of Sciences and Engineering

CMOS Circuit SPICE Generator Project

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Description:

A program that takes an input from the user as a boolean expression, and outputs the circuit corresponding to this expression. It checks the input and starts to call the main three functions we have, which are NOT, AND, and OR according to the precedence. Our Code output Y' , so we used the Not gate at the end to invert the output. After all, the output shows the connection between all MOSFETS in detail.

Main Data Structures & Algorithms:

Data Structures:

Class MOSFET:

It has the attributes that we need to show in the output which is the name, drain, gate, body, source, and type. We pass an object of this class to each function we have.

Vectors:

Vector of CMOS.

Vector of strings.

We mainly depended on string manipulation in this project to adjust the input and validate it.

Algorithms:

We mainly used Brute Force Algorithm and applied it in the following functions:

1. Notgate Function:

We pass to it the input by reference and two boolean flags. "Flag" is used to handle the case of the buffer when we have two Not gate after each other. For example, if the input is $Y = a\sim\sim$. The other flag is to check if the Not is last in the expression or not. If it is last it generates its output to Y otherwise it generates a wire. Finally, we used it at the end to invert the output because our functions generate Y' , so we use it to get Y .

2. Andgate Function:

It takes the input by reference and the two boolean flags. One to check if it is the first. In that case, it generates 4 Mosfets: 2 PMOS, and 2 NMOS. Otherwise, it generates only 2

MOSFETS: 1 PMOS, and 1 NMOS. The other boolean is to check if the last operator in the expression maps the output to be Y.

It generates the Pull-up MOSFETS to be parallel and the Pull Down to be series.

3. Orgate Function:

The or gate takes the same inputs as the AND gate and the same booleans, but the only difference is that it generates the Pull-up Mosfets to be in series and the Pull Down to be parallel.

4. Adjust Function:

It takes the input vector of CMOS and the vector of string includes the variables. Then, it loops over the vector of CMOS to finalize the expression as it was used to correct any mistakes in the expression and to connect any redundant points to make them the same, it looped over every point of the MOSFET to make sure it's correct.

5. Get_expression Function:

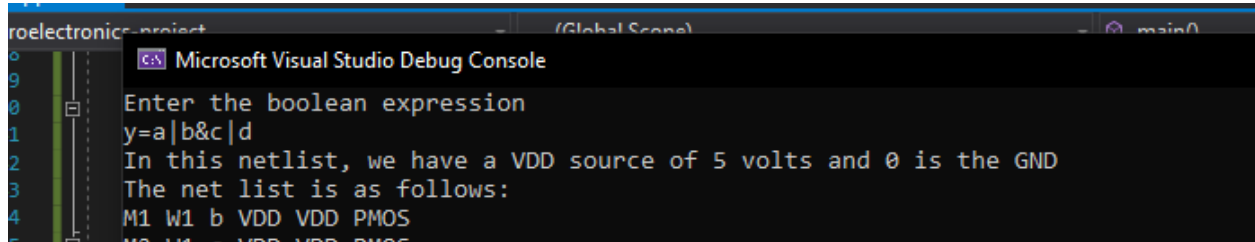
This function is used to get the boolean expression. Then, we save the indices of each operator we have in vector for each operator. For example, "notindices" save the indices of the operators. Then, we loop over each vector and after we call any gate function we replace what we finish by "@".

6. There were some more functions that we used inside these functions, like getting the missing characters and so on.

7. We used the function (indices of the operators) to where (&,| and ~) are found in our input

User Guide:

After running the code, the user will be asked to enter the Boolean expression. The user must enter the expression in the form of a letter = expression for example (y=a&b|c&d).The user Otherwise, the code will not run properly. An example of what the user should enter would be the following: After entering the expression, the output SPICE netlist will be displayed after pressing enter. The input can be (y=x (buffer), Y=x~ (inverter) , or any other circuit)

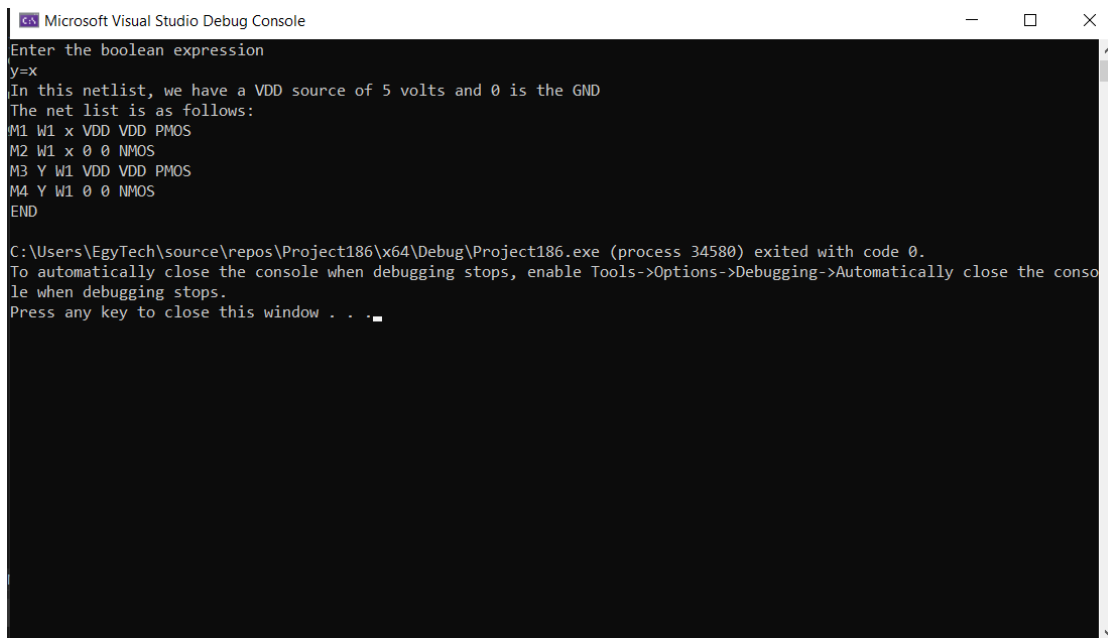


```
Microsoft Visual Studio Debug Console
8
9
0 Enter the boolean expression
1 y=a|b&c|d
2 In this netlist, we have a VDD source of 5 volts and 0 is the GND
3 The net list is as follows:
4 M1 W1 b VDD VDD PMOS
5 M2 W1 a VDD VDD PMOS
```

Test Cases:

1. The first test case is the buffer gate where the user enters $y=x$, in this case we put 2 not gates together

screenshot :-



```
Microsoft Visual Studio Debug Console
Enter the boolean expression
y=x
In this netlist, we have a VDD source of 5 volts and 0 is the GND
The net list is as follows:
M1 W1 x VDD VDD PMOS
M2 W1 x 0 0 NMOS
M3 Y W1 VDD VDD PMOS
M4 Y W1 0 0 NMOS
END

C:\Users\EgyTech\source\repos\Project186\x64\Debug\Project186.exe (process 34580) exited with code 0.
To automatically close the console when debugging stops, enable Tools->Options->Debugging->Automatically close the console when debugging stops.
Press any key to close this window . . .
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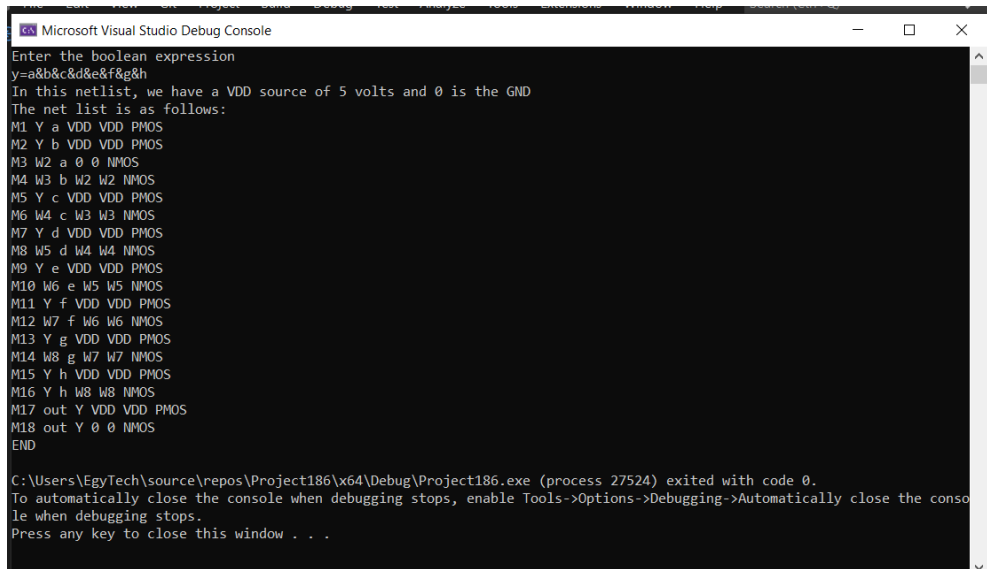
2. The second test case was the simple not gate($y=x\sim$)



```
Microsoft Visual Studio Debug Console
Enter the boolean expression
y=x~
In this netlist, we have a VDD source of 5 volts and 0 is the GND
The net list is as follows:
M1 Y x VDD VDD PMOS
M2 Y x 0 0 NMOS
END

C:\Users\EgyTech\source\repos\Project186\x64\Debug\Project186.exe (process 18012) exited with code 0.
To automatically close the console when debugging stops, enable Tools->Options->Debugging->Automatically close the console when debugging stops.
Press any key to close this window . . .
```

3. The third test case was (y=a&b&c&d&e&f&g&h)



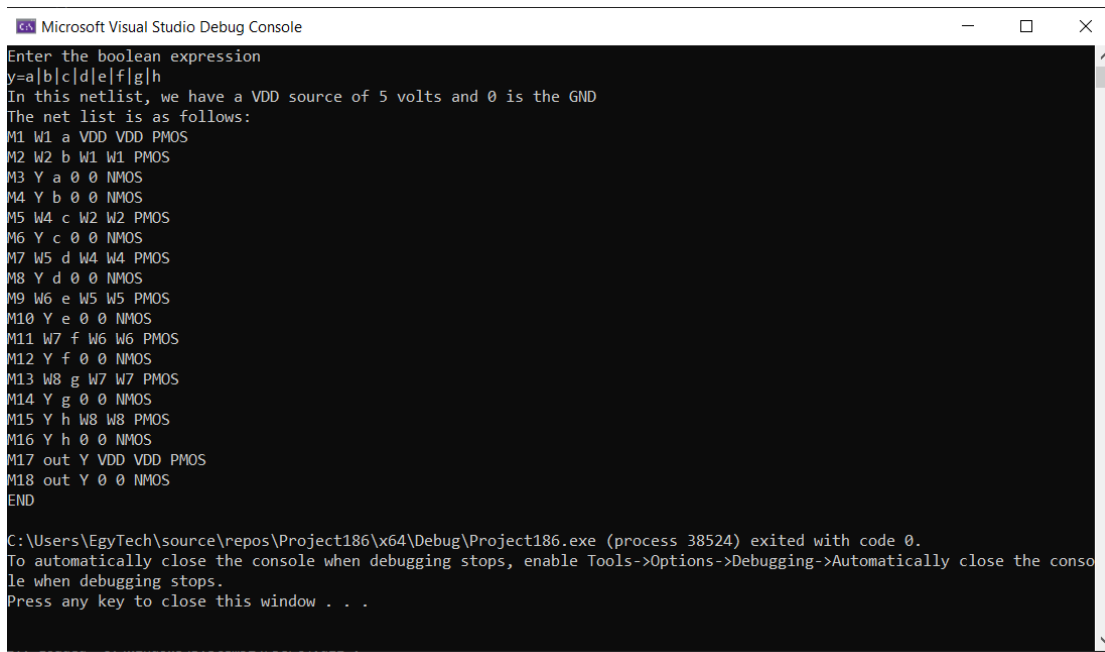
```
Microsoft Visual Studio Debug Console

Enter the boolean expression
y=a&b&c&d&e&f&g&h
In this netlist, we have a VDD source of 5 volts and 0 is the GND
The net list is as follows:
M1 Y a VDD VDD PMOS
M2 Y b VDD VDD PMOS
M3 W2 a 0 0 NMOS
M4 W3 b W2 W2 NMOS
M5 Y c VDD VDD PMOS
M6 W4 c W3 W3 NMOS
M7 Y d VDD VDD PMOS
M8 W5 d W4 W4 NMOS
M9 Y e VDD VDD PMOS
M10 W6 e W5 W5 NMOS
M11 Y f VDD VDD PMOS
M12 W7 f W6 W6 NMOS
M13 Y g VDD VDD PMOS
M14 W8 g W7 W7 NMOS
M15 Y h VDD VDD PMOS
M16 Y h W8 W8 NMOS
M17 out Y VDD VDD PMOS
M18 out Y 0 0 NMOS
END

C:\Users\EgyTech\source\repos\Project186\x64\Debug\Project186.exe (process 27524) exited with code 0.
To automatically close the console when debugging stops, enable Tools->Options->Debugging->Automatically close the console when debugging stops.
Press any key to close this window . . .
```

4. The fourth test case was (y=a|b|c|d|e|f|g|h)

Screenshot:-



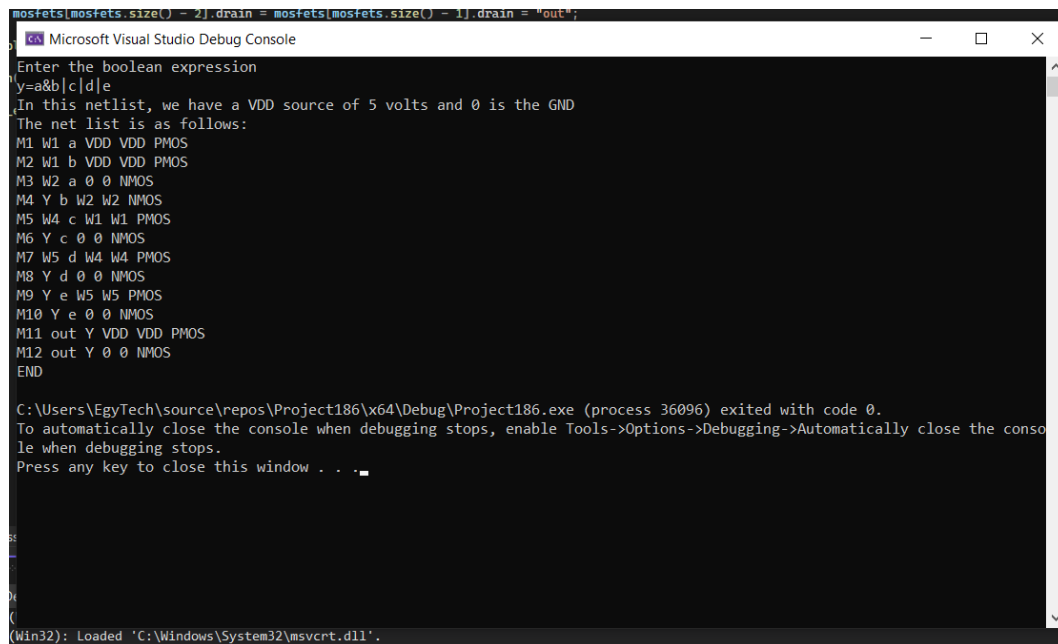
```
Microsoft Visual Studio Debug Console

Enter the boolean expression
y=a|b|c|d|e|f|g|h
In this netlist, we have a VDD source of 5 volts and 0 is the GND
The net list is as follows:
M1 W1 a VDD VDD PMOS
M2 W2 b W1 W1 PMOS
M3 Y a 0 0 NMOS
M4 Y b 0 0 NMOS
M5 W4 c W2 W2 PMOS
M6 Y c 0 0 NMOS
M7 W5 d W4 W4 PMOS
M8 Y d 0 0 NMOS
M9 W6 e W5 W5 PMOS
M10 Y e 0 0 NMOS
M11 W7 f W6 W6 PMOS
M12 Y f 0 0 NMOS
M13 W8 g W7 W7 PMOS
M14 Y g 0 0 NMOS
M15 Y h W8 W8 PMOS
M16 Y h 0 0 NMOS
M17 out Y VDD VDD PMOS
M18 out Y 0 0 NMOS
END

C:\Users\EgyTech\source\repos\Project186\x64\Debug\Project186.exe (process 38524) exited with code 0.
To automatically close the console when debugging stops, enable Tools->Options->Debugging->Automatically close the console when debugging stops.
Press any key to close this window . . .
```

5. $y = a \& b | c | d | e$

screenshot :-

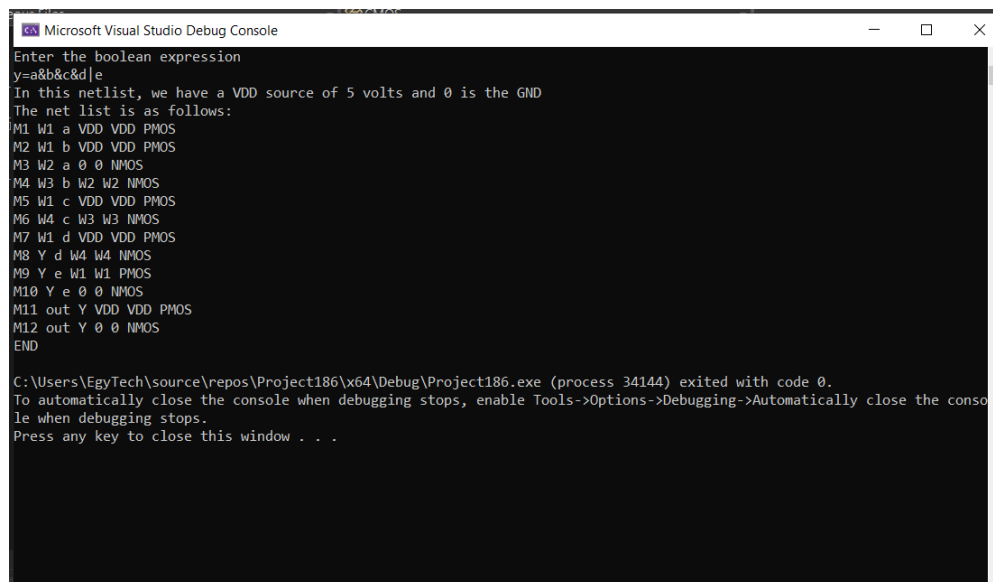


```
mosfets[mosfets.size() - 2].drain = mosfets[mosfets.size() - 1].drain = "out";
Microsoft Visual Studio Debug Console
Enter the boolean expression
y=a&b|c|d|e
In this netlist, we have a VDD source of 5 volts and 0 is the GND
The net list is as follows:
M1 W1 a VDD VDD PMOS
M2 W1 b VDD VDD PMOS
M3 W2 a 0 0 NMOS
M4 Y b W2 W2 NMOS
M5 W4 c W1 W1 PMOS
M6 Y c 0 0 NMOS
M7 W5 d W4 W4 PMOS
M8 Y d 0 0 NMOS
M9 Y e W5 W5 PMOS
M10 Y e 0 0 NMOS
M11 out Y VDD VDD PMOS
M12 out Y 0 0 NMOS
END

C:\Users\EgyTech\source\repos\Project186\x64\Debug\Project186.exe (process 36096) exited with code 0.
To automatically close the console when debugging stops, enable Tools->Options->Debugging->Automatically close the console when debugging stops.
Press any key to close this window . . .
```

6. $y = a \& b \& c \& d | e$

screenshot :-



```
Microsoft Visual Studio Debug Console
Enter the boolean expression
y=a&b&c&d|e
In this netlist, we have a VDD source of 5 volts and 0 is the GND
The net list is as follows:
M1 W1 a VDD VDD PMOS
M2 W1 b VDD VDD PMOS
M3 W2 a 0 0 NMOS
M4 W3 b W2 W2 NMOS
M5 W1 c VDD VDD PMOS
M6 W4 c W3 W3 NMOS
M7 W1 d VDD VDD PMOS
M8 Y d W4 W4 NMOS
M9 Y e W1 W1 PMOS
M10 Y e 0 0 NMOS
M11 out Y VDD VDD PMOS
M12 out Y 0 0 NMOS
END

C:\Users\EgyTech\source\repos\Project186\x64\Debug\Project186.exe (process 34144) exited with code 0.
To automatically close the console when debugging stops, enable Tools->Options->Debugging->Automatically close the console when debugging stops.
Press any key to close this window . . .
```

7. $y=a|b\&c\&d\&e$

```
Microsoft Visual Studio Debug Console
Enter the boolean expression
y=a|b&c&d&e
In this netlist, we have a VDD source of 5 volts and 0 is the GND
The net list is as follows:
M1 W1 b VDD VDD PMOS
M2 W1 c VDD VDD PMOS
M3 W2 b 0 0 NMOS
M4 W3 c W2 W2 NMOS
M5 W1 d VDD VDD PMOS
M6 W4 d W3 W3 NMOS
M7 W1 e VDD VDD PMOS
M8 Y e W4 W4 NMOS
M9 Y a W1 W1 PMOS
M10 Y a 0 0 NMOS
M11 out Y VDD VDD PMOS
M12 out Y 0 0 NMOS
END

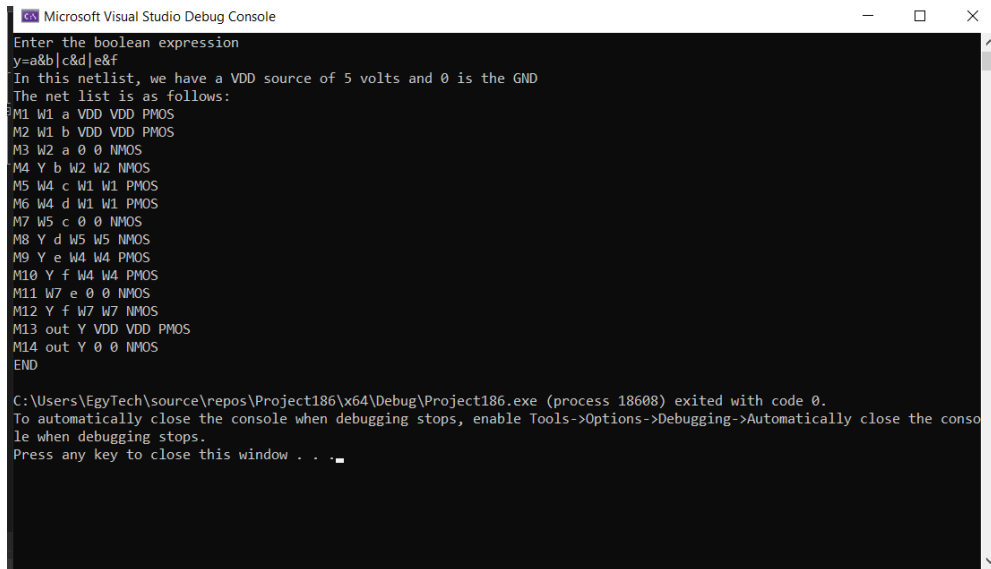
C:\Users\EgyTech\source\repos\Project186\x64\Debug\Project186.exe (process 13116) exited with code 0.
To automatically close the console when debugging stops, enable Tools->Options->Debugging->Automatically close the console when debugging stops.
Press any key to close this window . . .
```

8. $y=a|b\&c|d|e|f$

```
Microsoft Visual Studio Debug Console
Enter the boolean expression
y=a|b&c|d|e|f
In this netlist, we have a VDD source of 5 volts and 0 is the GND
The net list is as follows:
M1 W1 b VDD VDD PMOS
M2 W1 c VDD VDD PMOS
M3 W2 b 0 0 NMOS
M4 Y c W2 W2 NMOS
M5 W4 a W1 W1 PMOS
M6 Y a 0 0 NMOS
M7 W5 d W4 W4 PMOS
M8 Y d 0 0 NMOS
M9 W6 e W5 W5 PMOS
M10 Y e 0 0 NMOS
M11 Y f W6 W6 PMOS
M12 Y f 0 0 NMOS
M13 out Y VDD VDD PMOS
M14 out Y 0 0 NMOS
END

C:\Users\EgyTech\source\repos\Project186\x64\Debug\Project186.exe (process 29084) exited with code 0.
To automatically close the console when debugging stops, enable Tools->Options->Debugging->Automatically close the console when debugging stops.
Press any key to close this window . . .
```


9. $y = a \& b | c \& d | e \& f$



```
Microsoft Visual Studio Debug Console
Enter the boolean expression
y=a&b|c&d|e&f
In this netlist, we have a VDD source of 5 volts and 0 is the GND
The net list is as follows:
M1 W1 a VDD VDD PMOS
M2 W1 b VDD VDD PMOS
M3 W2 a 0 0 NMOS
M4 Y b W2 W2 NMOS
M5 W4 c W1 W1 PMOS
M6 W4 d W1 W1 PMOS
M7 W5 c 0 0 NMOS
M8 Y d W5 W5 NMOS
M9 Y e W4 W4 PMOS
M10 Y f W4 W4 PMOS
M11 W7 e 0 0 NMOS
M12 Y f W7 W7 NMOS
M13 out Y VDD VDD PMOS
M14 out Y 0 0 NMOS
END

C:\Users\EgyTech\source\repos\Project186\x64\Debug\Project186.exe (process 18608) exited with code 0.
To automatically close the console when debugging stops, enable Tools->Options->Debugging->Automatically close the console when debugging stops.
Press any key to close this window . . .
```

Contributions:

In this project, we all worked together equally as it was done through on-campus meetings where we used to brainstorm together, write the codes together and solve the bugs that we used to see in the code. Since we are all dorm residents, we met in the library and worked together on the project from A to Z and no one worked on something alone as we liked to share ideas together as if someone worked on a part alone, it was a bit difficult to adjust his ideas to the rest of the code.

Presentation link:-

<https://drive.google.com/file/d/1WrV3fAmrGaFUtIyp5uXfe69ahdqg41hY/view?usp=sharing>