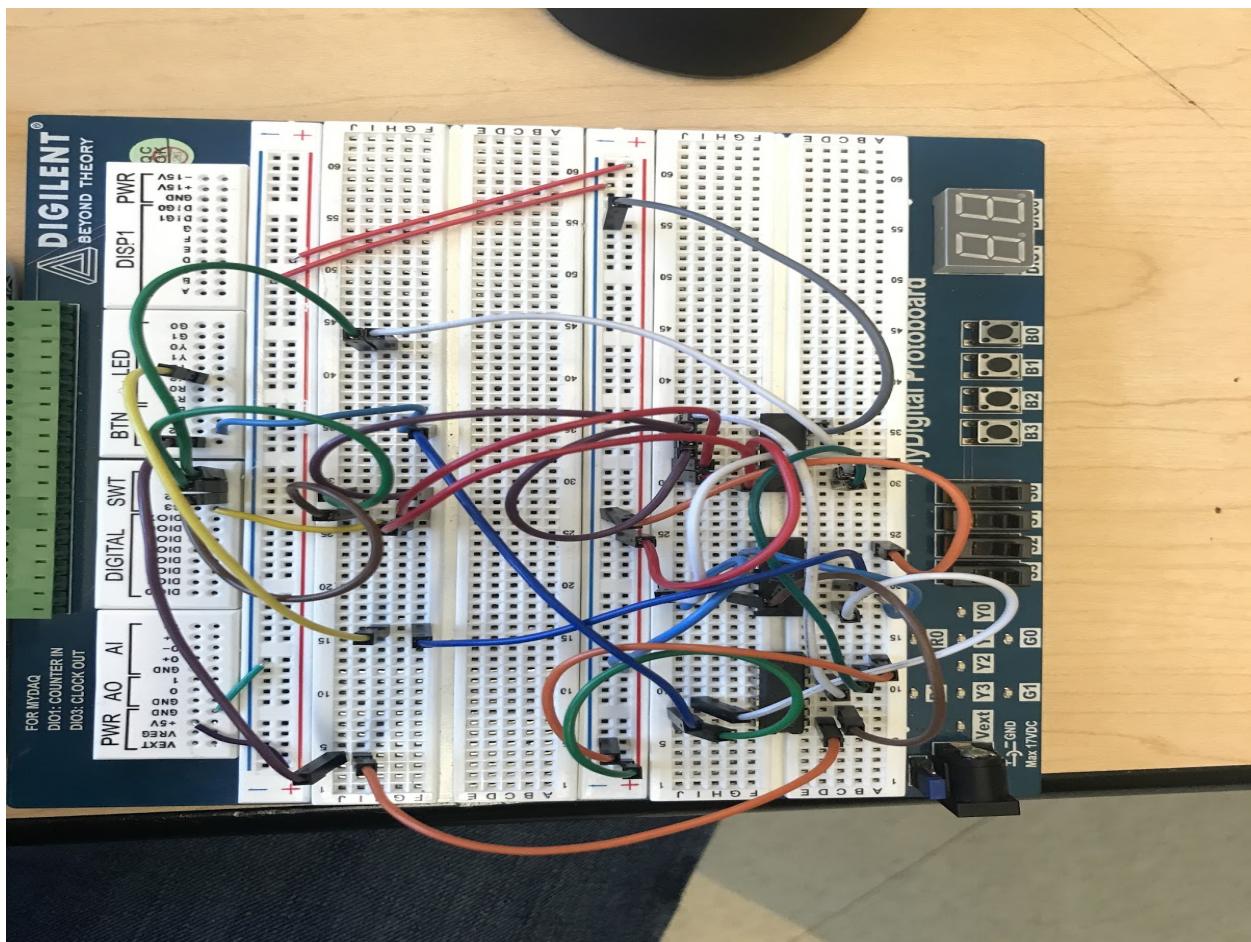


P2.1.6

AOI Circuit Design: Printer Lights



Gantt Chart  
DE 5th Period  
11/20/2019-12/10/2019  
Gorkem Guclu, Justin Thai

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## Design Brief

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<b>Client:</b>	Printer Co.
<b>Target Consumer:</b>	Anyone that uses a printer
<b>Designers:</b>	Gorkem Guclu, Justin Thai
<b>Problem Statement:</b>	Printer Co.'s Color Printer™'s manufacturing cost is \$40 above the budget.
<b>Design Statement:</b>	The logic used to warn the user to replace ink and paper in the printer uses more AOI logic gates than required to serve its purpose. Simplifying the expression and reducing the number of gates used will cut manufacturing costs.
<b>Constraints:</b>	<p>The resulting logic expression should utilize the least amount of gates possible to reduce manufacturing costs.</p> <p>The circuit should raise a warning for the user when there is no paper, no black ink, or, when printing in color, there is no cyan, yellow, or magenta ink.</p>
<b>Deliverables:</b>	<ul style="list-style-type: none"> <li>• Title Page - team members names, date, period, project name</li> <li>• Table of Contents - corresponding sections and page numbers</li> <li>• Design Brief - all design brief sections fit to one page</li> <li>• Design Specifications &amp; Truth Table - input/output definitions, truth table, paragraph explanation of output requirements</li> <li>• Output Logic Expression &amp; Simplification - algebraic expression and simplification showed neatly</li> <li>• Solution - Simulation &amp; Breadboard - images of simulation and breadboard are shown clearly, multiple views as necessary, labels and descriptions of the final design, spreadsheet with an estimated cost of implementing circuit with components used</li> </ul>

## Design Specifications & Truth Table

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### ➤ Design Specifications

P = Paper	1 = Paper in printer	0 = No Paper
C <sub>O</sub> = Color	1 = Printing in color	0 = Printing in Black & White
B = Black ink	1 = There is still black ink	0 = No black ink remaining
C = Cyan	1 = There is still cyan ink	0 = No cyan ink remaining
Y = Yellow	1 = There is still yellow ink	0 = No yellow ink remaining
M = Magenta	1 = There is still magenta ink	0 = No magenta ink remaining
W = Warning	1 = Printer is not able to print; Outputs warning to user	0 = Printer can print with no errors

The circuit utilizes four switches, two buttons, a 74LS04 IC(Inverter Gate), a 74LS08 IC(AND Gate), and a 74LS32 IC(OR Gate). This circuit will send a warning if you do not have black ink, paper, or colored ink and if you are using color ink it will check if you have the cyan ink, the yellow ink, and the magenta ink that is included in the color ink package.

### ➤ Truth Table

P	C <sub>O</sub>	B	C	Y	M	Output	P	C <sub>O</sub>	B	C	Y	M	Output
0	0	0	0	0	0	1	1	0	0	0	0	0	1
0	0	0	0	0	1	1	1	0	0	0	0	1	1
0	0	0	0	1	0	1	1	0	0	0	1	0	1
0	0	0	0	1	1	1	1	0	0	0	1	1	1
0	0	0	1	0	0	1	1	0	0	1	0	0	1
0	0	0	1	0	1	1	1	0	0	1	0	1	1
0	0	0	1	1	0	1	1	0	0	1	1	0	1
0	0	0	1	1	1	1	1	0	0	1	1	1	1
0	0	1	0	0	0	1	1	0	1	0	0	0	0
0	0	1	0	0	1	1	1	0	1	0	0	1	0

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## Output Logic Expression and Simplification

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$$W = (P' + C_o + B' + C + Y + M) (P' + C_o + B' + C + Y + M') (P' + C_o + B' + C + Y' + M) (P' + C_o + C + Y' + M') \\ (P' + C_o + B' + C' + Y + M) (P' + C_o + B' + C' + Y + M') (P' + C_o + B' + C' + Y' + M) \\ (P' + C_o + B' + C' + Y' + M') (P' + C_o + B' + C' + Y' + M')$$

$$W = ((P' + C_o + B' + C + Y + M)' + (P' + C_o + B' + C + Y + M')' + (P' + C_o + B' + C + Y' + M)' + \\ (P' + C_o + C + Y' + M)' + (P' + C_o + B' + C' + Y + M)' + (P' + C_o + B' + C' + Y + M')' + \\ (P' + C_o + B' + C' + Y' + M)' + (P' + C_o + B' + C' + Y' + M')' + (P' + C_o + B' + C' + Y' + M'))'$$

$$W = (PC_o'BCY'M' + PC_o'BC'YM + PC_o'BC'YM' + PC_o'BC'YM + PC_o'BCY'M' + \\ PC_o'BCY'M + PC_o'BCYM' + PC_o'BCYM + PC_o'BCYM)'$$

$$W = (PC_o'B(C'Y(M'+M) + C'Y(M'+M) + CY(M'+M) + CY(M'+M)) + PC_oBCYM)'$$

$$W = (PC_o'B(C'(Y'+Y) + C(Y'+Y)) + PC_oBCYM)'$$

$$W = (PC_o'B(C' + C) + PC_oBCYM)'$$

$$W = (PB(C_o' + CYM))'$$

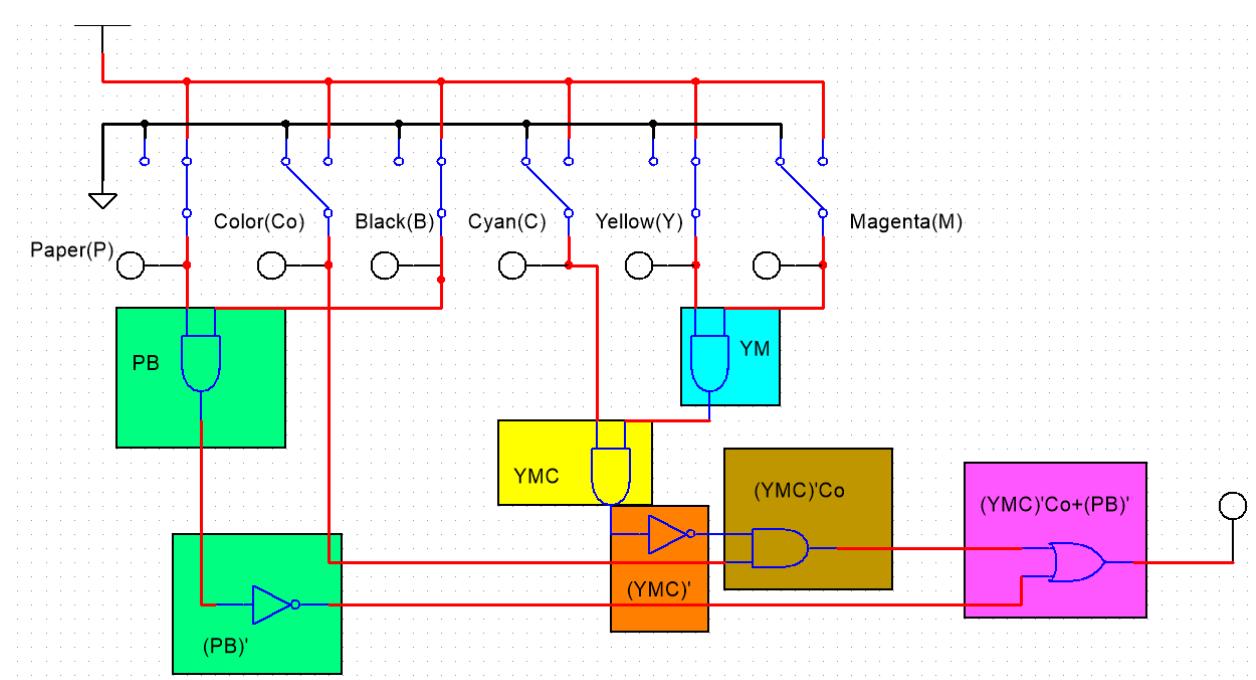
$$W = (PB)' + (C_o' + CYM)'$$

$$W = (PB)' + C_o(CYM)'$$

## Final Solution

One IC gate costs \$0.50 to manufacture. The original model for the Color Printer's warning system used 80 more gates than the model made using the simplified logic expression which has 7 gates. This will save the company \$40.00 in manufacturing one printer. This means that for every 1000 printers sold, Printer Co. will save \$40,000. Additionally, because the logic has to go through fewer gates, the speed at which the output is given increases. In general, creating the logic circuit based on a simplified logic expression is superior because the cost of manufacturing logic gates will be lower and the operating speed of the circuit will be faster. The circuit would demand less power and would therefore cost less to run.

## Final Simulation



## Final Breadboard Schematics

