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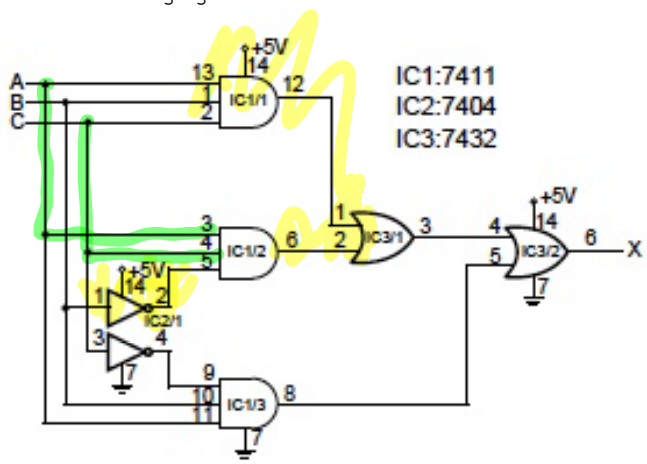
Laboratory 3

Boolean Algebra

1. Given a circuit as shown in the following figure:



1.1 Connect the circuit. Use logic switch to supply inputs as specified. The output signals should be connected to the logic monitor. Record the results in the following truth table.

A	B	C	X
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

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1.2 Find and simplify the Boolean expression for the given circuit

$$X = A\bar{B}C + AB\bar{C} + ABC$$
$$= AC(\bar{B}+B) + AB\bar{C}$$
$$= AC + AB\bar{C}$$
$$= A(B\bar{C}+C)$$
$$= A(B+C)$$

1.3 Connect the circuit according to the simplified Boolean expression found in 1.1. Redo the experiment as in 1.1.

A	B	C	X
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

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1.4 What can be concluded from the experiment?

The differ circuit provide the same result with less gate use.

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2. Assignments

2.1 Given the following truth table

A	B	C	X
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

a) Find a Boolean expression in sum of product (SOP) form. Connect the circuit according to the obtained SOP form and show the results are consistent with the given truth table.

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b) Find a Boolean expression in product of sum (POS) form. Connect the circuit according to the obtained POS form and show the results are consistent with the given truth table.

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2.2 Design a digital circuit that receives inputs as a BCD code of decimal digits (0-9). The circuit shall provide the following results and display in binary format. Use logic monitor D0 – D4 to display the results, where D0 is a least significant bit (LSB).

a) The circuit shall double the input value

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b) The circuit shall triple the input value

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2.3 Given the Boolean expression as X = A'B' + B'C' + CD + A'D' + B'D:

a) Construct a truth table for the given Boolean expression:

A	B	C	D	X
0	0	0	0	
0	0	0	1	
0	0	1	0	
0	0	1	1	
0	1	0	0	
0	1	0	1	
0	1	1	0	
0	1	1	1	
1	0	0	0	
1	0	0	1	
1	0	1	0	
1	0	1	1	
1	1	0	0	
1	1	0	1	
1	1	1	0	
1	1	1	1	

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b) Simplify the given Boolean expression and connect the corresponding circuit to show that the results are consistent with the truth table found in a)

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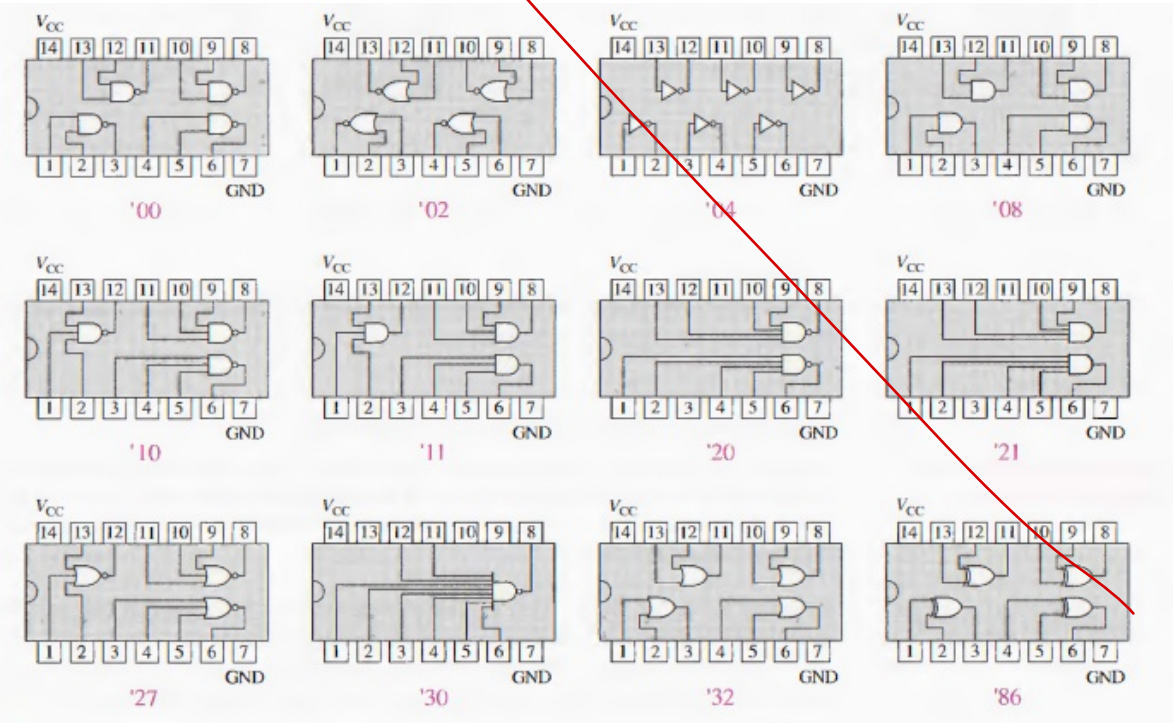
Logic Diagram of frequently used gates



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Document for Lab 03

2.1 The example of writing logical equation from the truth table in the configuration of SOP and POS.

Sum of Product (SOP)

A	B	C	Min term
0	0	0	$m_0 = \bar{A}\,\bar{B}\,\bar{C}$
0	0	1	$m_1 = \bar{A}\,\bar{B}\,C$
0	1	0	$m_2 = \bar{A}\,B\,\bar{C}$
0	1	1	$m_3 = \bar{A}\,B\,C$
1	0	0	$m_4 = A\,\bar{B}\,\bar{C}$
1	0	1	$m_5 = A\,\bar{B}\,C$
1	1	0	$m_6 = A\,B\,\bar{C}$
1	1	1	$m_7 = A\,B\,C$

I/P		O/P
A	B	Y
0	0	0
0	1	0
1	0	1
1	1	1

Product of Sum (POS)

A	B	C	Max term
0	0	0	$M_0 = A + B + C$
0	0	1	$M_1 = A + B + \bar{C}$
0	1	0	$M_2 = A + \bar{B} + C$
0	1	1	$M_3 = A + \bar{B} + \bar{C}$
1	0	0	$M_4 = \bar{A} + B + C$
1	0	1	$M_5 = \bar{A} + B + \bar{C}$
1	1	0	$M_6 = \bar{A} + \bar{B} + C$
1	1	1	$M_7 = \bar{A} + \bar{B} + \bar{C}$

$Y = AB + AB'$ ← SOP — POS → $Y = (A + B)\cdot(A + B')$

$= (AA + AB + AB + BB')$

$= AB + AB'$

So, How could we write the output equations for SOP and POS from the truth table assigned in the 2.2?

A	B	C	X
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

SOP: X = $\bar{A}\bar{B}C + A\bar{B}C + ABC = \bar{A}\bar{B}C + AC(\bar{B}+B) = \bar{A}\bar{B}C + AC = C(\bar{A}\bar{B}+A)$

$= C(\bar{B}+A)$

$= m_1 + m_5 + m_7$

$= \Sigma m(1, 5, 7)$

and POS: X = $(A+B+C)(A+\bar{B}+C)(A+\bar{B}+\bar{C})(\bar{A}+B+\bar{C})(\bar{A}+\bar{B}+C)$

$= M_0 + M_2 + M_3 + M_4 + M_6$

$= \Pi M(0, 2, 3, 4, 6)$

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2.2 a) The circuit shall double the input value

Input	A	B	C	D	Output	A	B	C	D
0	0	0	0	0	0	0	0	0	0
1	0	0	0	1	2	0	0	1	0
2	0	0	1	0	4	0	1	0	0
3	0	0	1	1	6	0	1	1	0
4	0	1	0	0	8	1	0	0	0
5	0	1	0	1	10	1	0	1	0
6	0	1	1	0	12	1	1	0	0
7	0	1	1	1	14	1	1	1	0
8	1	0	0	0	16=d				
9	1	0	0	1	18=d				
A	1	0	1	0	20=d				
B	1	0	1	1	22=d				
C	1	1	0	0	24=d				
D	1	1	0	1	26=d				
E	1	1	1	0	28=d				
F	1	1	1	1	30=d				

d

The circuit is:

Output A = $\bar{A}B\bar{C}\bar{D} + \bar{A}B\bar{C}D + \bar{A}BC\bar{D} + \bar{A}BCD$

$= \bar{A}B\bar{C}(\bar{D}+D) + \bar{A}BC(\bar{D}+D)$

$= \bar{A}B\bar{C} + \bar{A}BC$

$= \bar{A}B(\bar{C}+C) = \bar{A}B$

Output B = $\bar{A}\bar{B}C\bar{D} + \bar{A}\bar{B}CD + \bar{A}BC\bar{D} + \bar{A}BCD$

$= \bar{A}\bar{B}C(\bar{D}+D) + \bar{A}BC(\bar{D}+D)$

$= \bar{A}\bar{B}C + \bar{A}BC$

$= \bar{A}C(\bar{B}+B) = \bar{A}C$

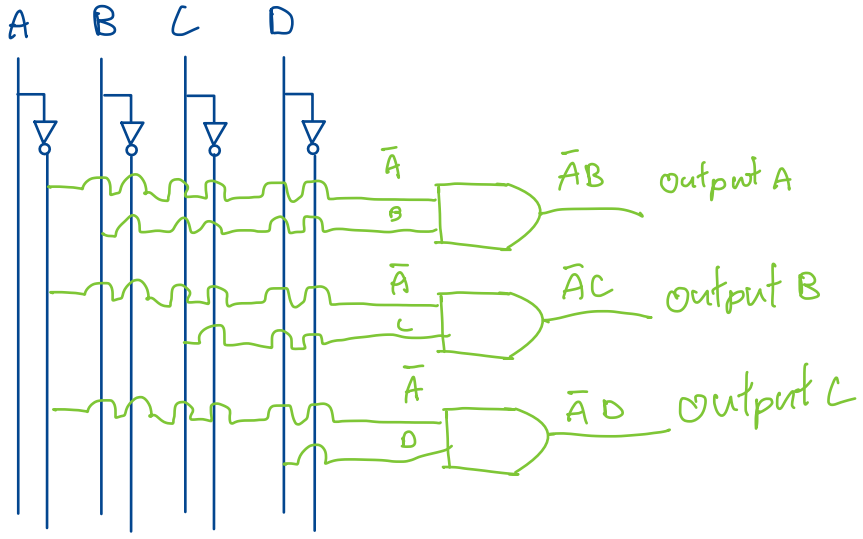
Output C = $\bar{A}\bar{B}\bar{C}D + \bar{A}\bar{B}CD + \bar{A}B\bar{C}D + \bar{A}BCD$

$= \bar{A}\bar{B}(\bar{C}D+CD) + \bar{A}B(\bar{C}D+CD)$

$= \bar{A}\bar{B}D + \bar{A}BD$

$= \bar{A}D$

Output D = 0



output D
no input

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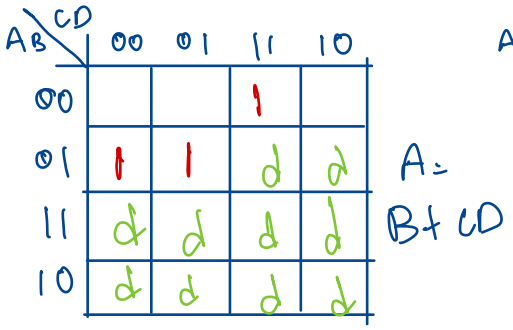
b) The circuit shall triple the input value

Input	A	B	C	D	Output	A	B	C	D
0	0	0	0	0	0	0	0	0	0
1	0	0	0	1	3	0	0	1	1
2	0	0	1	0	6	0	1	1	0
3	0	0	1	1	9	0	0	0	1
4	0	1	0	0	12	1	1	0	0
5	0	1	0	1	15	1	1	1	1
6	0	1	1	0	18=d				
7	0	1	1	1	21=d				
8	1	0	0	0	24=d				
9	1	0	0	1	27=d				
A	1	0	1	0	30=d				
B	1	0	1	1	33=d				
C	1	1	0	0	36=d				
D	1	1	0	1	39=d				
E	1	1	1	0	42=d				
F	1	1	1	1	45=d				

d

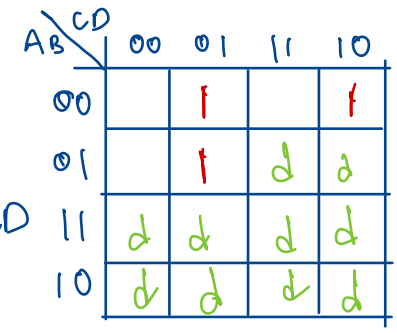
The circuit is:

A



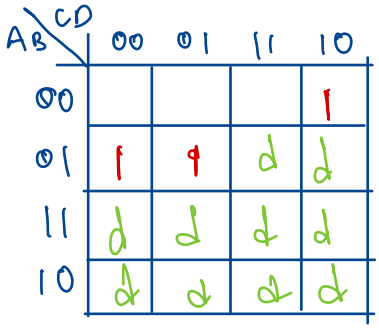
A = B + CD

C



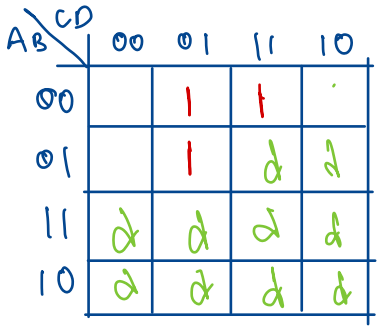
C = $\bar{C}D + C\bar{D}$

B

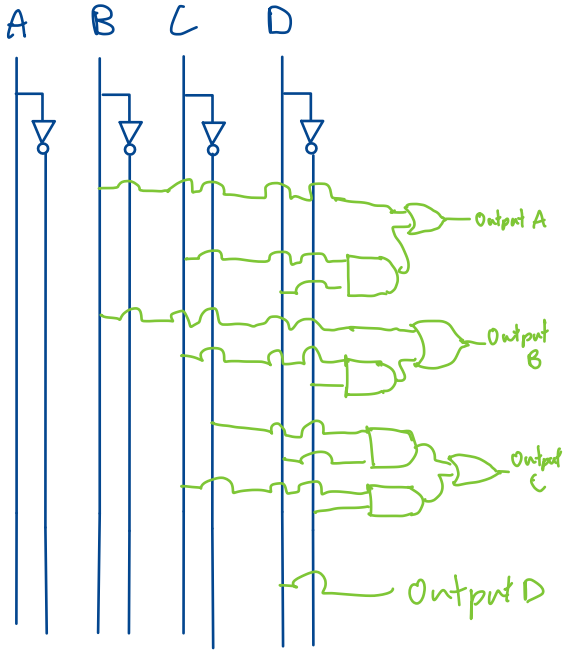


B = B + $C\bar{D}$

D



D = D



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2.3 Given the Boolean expression as X = A'B' + B'C' + CD + A'D' + B'D:

a) Construct a truth table for the given Boolean expression:

A	B	C	D	X
0	0	0	0	1
0	0	0	1	1
0	0	1	0	1
0	0	1	1	1
0	1	0	0	1
0	1	0	1	1
0	1	1	0	1
0	1	1	1	1
1	0	0	0	1
1	0	0	1	1
1	0	1	0	0
1	0	1	1	1
1	1	0	0	0
1	1	0	1	0
1	1	1	0	0
1	1	1	1	1

d

Hint: The term A'B' would be concerned only A = 0 and B = 0, but don't care the logic of the other variables.

b) Simplify the given Boolean expression and draw the corresponding circuit to show that the results are consistent with the truth table found in a)