Sub :

Day

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Digital Logic And Circuit

Midterm Assignment

Course Faculty: Tawsif Ibne Alam

Section: G

Submission Date: 03-07-2021

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1. a) logic: output of an inverter is opposite of its input.

logic expression: $X = \bar{A}$; $X = A'$

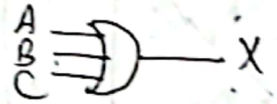
logic symbol:

truth table:

A	X
0	1
1	0

b) logic: The output of an OR gate is high whenever one or more input are high. Else, of input states, the output is low.

logic expression: $X = \bar{A} + \dot{B}$

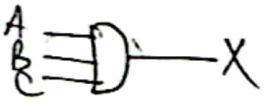
Logic symbol: 

truth table:

A	B	C	X
0	0	0	0
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	1

c) logic: The output of an AND gate is high when all inputs are high. Else, input is low.

logic expression: $X = A.B$

logic symbol: 

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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	0
1	1	0	0
1	1	1	1

d) logic: The output of an NAND gate is low when all inputs are high. Else, output is high

logic expression: $X = \overline{A \cdot B}$

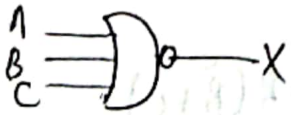
logic symbol: 

truth table:

A	B	C	X
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	0

e) logic: The output of an NOR gate is low when one or more inputs are high. Else, the output is high.

logic expression: $X = \overline{A+B}$

logic symbol: 

truth table:

A	B	C	X
0	0	0	1
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	0

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f) logic: The output for XOR gate is high when odd number of input are high. Else, output is low.

logic expression: $X = A \oplus B$

logic symbol:

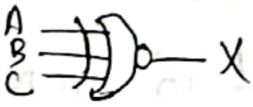
truth table:

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

g) logic: The output of XNOR gate is low when odd number of inputs are high. Else, output is high.

logic expression: $X = \overline{A \oplus B}$

logic symbol:



truth table:

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

2. a) $A\bar{B} + A(\overline{B+C}) + B(\overline{B+C})$

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

$= A\bar{B} + A\bar{B}\bar{C} + 0$

$= A\bar{B}$

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b) $\overline{AB+AC}+\bar{A}\bar{B}C$

$=\overline{AB}\cdot\overline{AC}+\bar{A}\bar{B}C$

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

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

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

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

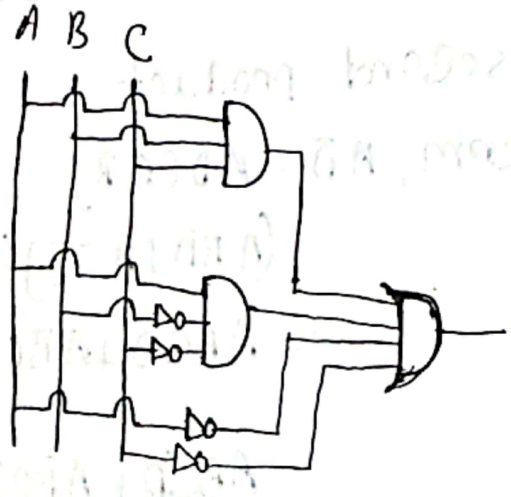
$=\bar{A}+\bar{A}\bar{B}$

$=\bar{A}$

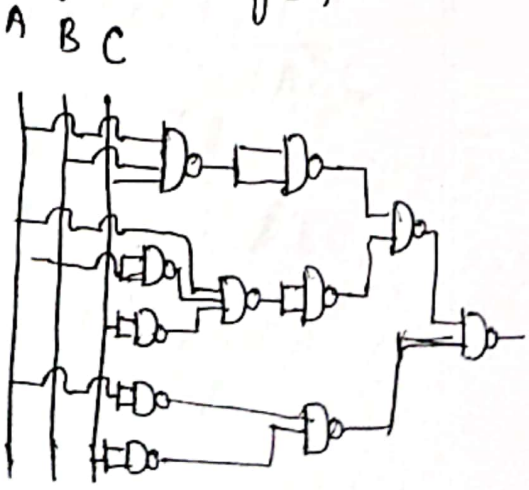
3. a) i) $ABC+A\bar{B}\bar{C}+A\bar{C}$

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

Using basic logic gate we get,



Now, by regarding this circuits with only NAND gate we get,



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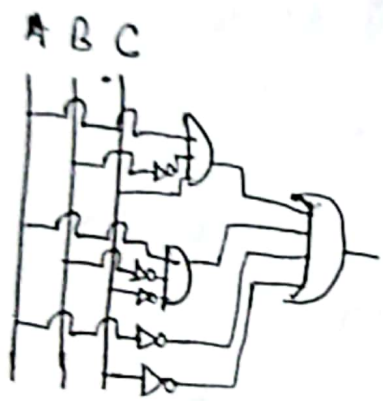
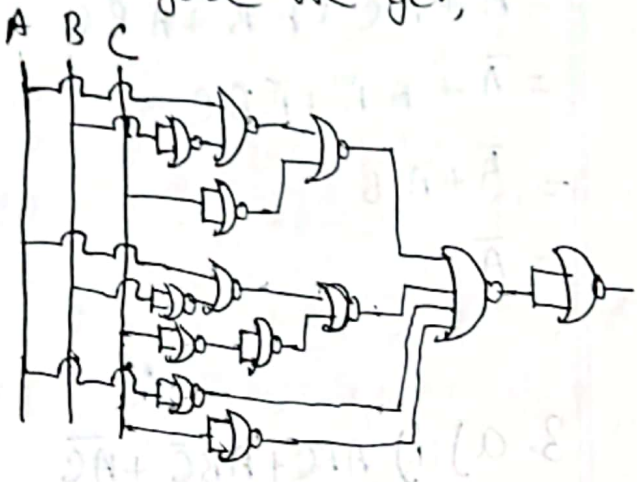
b) i) $ABC + AB\bar{C} + A\bar{C}$

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

Using basic logic gate, we get



Now, by regarding this circuit by using only NOR gate we get,



4. a) $\bar{A}BC + A\bar{D} + \bar{B}\bar{C}D$

Add input in the first product term, $\bar{A}BC = \bar{A}BC(D+\bar{D})$

$= \bar{A}BCD + \bar{A}BC\bar{D}$

Bringing inputs B and C in the second product term, $A\bar{D} = A\bar{D}(B+\bar{B})$

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

$= ABC\bar{D} + AB\bar{C}\bar{D} + A\bar{B}C\bar{D} + A\bar{B}\bar{C}\bar{D}$

$= ABC\bar{D} + AB\bar{C}\bar{D} + A\bar{B}C\bar{D} + A\bar{B}\bar{C}\bar{D}$

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Bringing input A in the last product term, $\bar{B}CD = \bar{B}CD(A+\bar{A})$

$= A\bar{B}CD + \bar{A}\bar{B}CD$

Now, Standard SOP expression $= \bar{A}BCD + \bar{A}BC\bar{D} + AB\bar{C}D + A\bar{B}C\bar{D}$

$+ A\bar{B}\bar{C}\bar{D} + A\bar{B}CD + \bar{A}\bar{B}CD$

Q.a) $A + B(AC + (B+\bar{C})D)$

Bringin input C, D in the first term $A+B = (A+B) + C\cdot\bar{C}$

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

Now for $(A+B+C)$

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

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

and for $(A+B+\bar{C})$

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

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

Bringing missing input in the second term. $AC + (B+\bar{C}) + D$

$= (AC + BD + \bar{C}D)$

Here, $AC = AC + B\cdot\bar{B} = ABC + A\bar{B}C$

for ABC

$= ABC + D\cdot\bar{D}$

$= ABCD + ABC\bar{D}$

for $A\bar{B}C$

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

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

Here, $BD = BD + A\cdot\bar{A} = ABD + \bar{A}BD$

for ABD

$= ABD + C\cdot\bar{C}$

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

for $\bar{A}BD$

$= \bar{A}BD + C\cdot\bar{C}$

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

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Here, $\bar{C}D = \bar{C}D + A \cdot \bar{A}$

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

for $A\bar{C}D$

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

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

for $\bar{A}\bar{C}D$

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

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

∴ Standard POS expression $= (A+B+C+D)(A+B+C+\bar{D})(A+B+\bar{C}+D)$

$(A+B+\bar{C}+\bar{D})(ABCD + ABC\bar{D} + AB\bar{C}D + AB\bar{C}\bar{D} + A\bar{B}CD + A\bar{B}C\bar{D} + A\bar{B}\bar{C}D + \bar{A}BCD + \bar{A}BC\bar{D} + \bar{A}B\bar{C}D + \bar{A}\bar{B}CD)$

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

$(ABCD + ABC\bar{D} + AB\bar{C}D + AB\bar{C}\bar{D} + A\bar{B}CD + A\bar{B}C\bar{D} + A\bar{B}\bar{C}D + \bar{A}BCD + \bar{A}BC\bar{D} + \bar{A}B\bar{C}D + \bar{A}\bar{B}CD)$

6. a) $\bar{A}B + AB\bar{C} + \bar{A}\bar{C} + ABC$

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

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

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

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

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

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Standard SOP form = $\bar{A}BC + A\bar{B}C + AB\bar{C} + ABC + A\bar{B}\bar{C} + \bar{A}\bar{B}C +$
$A\bar{B}\bar{C} + AB\bar{C} + \bar{A}B\bar{C} + \bar{A}\bar{B}\bar{C} + ABC$

Here, if we use High I/O system, we can develop a truth table. It is SOP form.

$\therefore Y = \bar{A}BC + A\bar{B}C + AB\bar{C} + \bar{A}B\bar{C} + \bar{A}\bar{B}\bar{C} + A\bar{B}\bar{C} + A\bar{B}C$

$1 = 0.1.1 + 1.0.1 + 1.1.0 + 0.0.1 + 0.0.0 + 1.0.0 + 1.0.1$

Truth table:

A	B	C	Y
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	0

SOP

→ POS $(\bar{A}\bar{B}\bar{C})$

7. a) $AC(\bar{B}+C) = A\bar{B}C + ACC = A\bar{B}C + AC$

Convent SOP. for $AC = AC(B+\bar{B}) = ABC + A\bar{B}C$

Here, $ABC + A\bar{B}C + A\bar{B}C = A\bar{B}C + ABC$

$= 1.0.1 + 1.1.1$

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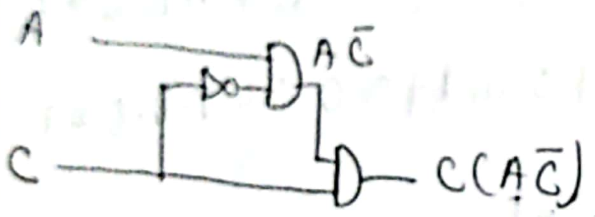
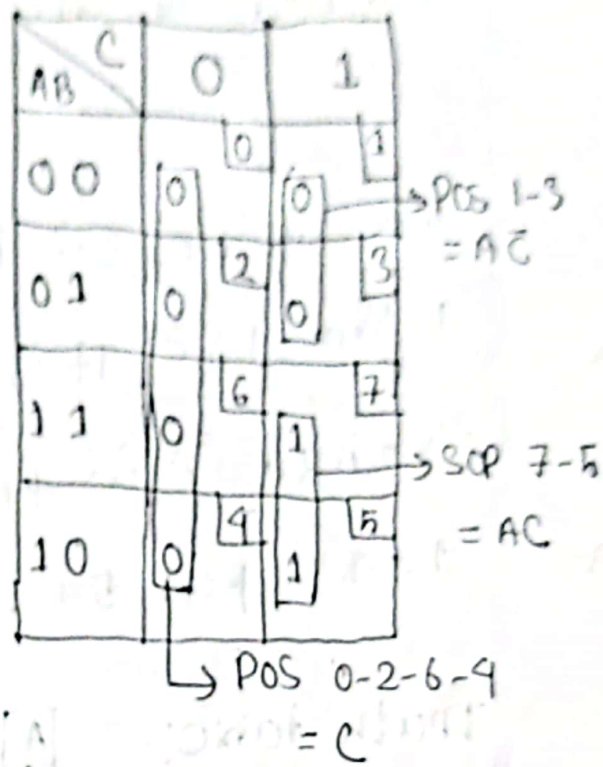
: SOP expression: AC

logic gate diagram:

POS expression: $C(A\bar{C})$

logic gate diagram:





b) $A+B\bar{C}+CD$

Convert SOP,

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

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

$= ABCD+ABC\bar{D}+AB\bar{C}D+AB\bar{C}\bar{D}+A\bar{B}CD+A\bar{B}C\bar{D}+AB\bar{C}D+A\bar{B}\bar{C}\bar{D}$

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

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

for $CD = CD(A+\bar{A}) = (ACD+\bar{A}CD)(B+\bar{B})$

$= ABCD+A\bar{B}CD+\bar{A}BCD+\bar{A}\bar{B}CD$

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∴ Standard SOP form = $ABCD + ABC\bar{D} + AB\bar{C}D + AB\bar{C}\bar{D} + A\bar{B}CD + A\bar{B}C\bar{D} + A\bar{B}\bar{C}D + A\bar{B}\bar{C}\bar{D} + \bar{A}BCD + \bar{A}BC\bar{D} + \bar{A}B\bar{C}D + \bar{A}B\bar{C}\bar{D} + \bar{A}\bar{B}CD + \bar{A}\bar{B}C\bar{D} + \bar{A}\bar{B}\bar{C}D + \bar{A}\bar{B}\bar{C}\bar{D}$

$Y = ABCD + ABC\bar{D} + AB\bar{C}D + AB\bar{C}\bar{D} + A\bar{B}CD + A\bar{B}C\bar{D} + A\bar{B}\bar{C}D + A\bar{B}\bar{C}\bar{D} + \bar{A}BCD + \bar{A}BC\bar{D} + \bar{A}B\bar{C}D + \bar{A}B\bar{C}\bar{D} + \bar{A}\bar{B}CD + \bar{A}\bar{B}C\bar{D} + \bar{A}\bar{B}\bar{C}D + \bar{A}\bar{B}\bar{C}\bar{D}$

$1 = 1\cdot1\cdot1\cdot1 + 1\cdot1\cdot1\cdot0 + 1\cdot1\cdot0\cdot1 + 1\cdot1\cdot0\cdot0 + 1\cdot0\cdot1\cdot1 + 1\cdot0\cdot1\cdot0 + 1\cdot0\cdot0\cdot1 + 1\cdot0\cdot0\cdot0 + 0\cdot1\cdot0\cdot1 + 0\cdot1\cdot0\cdot0 + 0\cdot1\cdot1\cdot1 + 0\cdot0\cdot1\cdot1$

SOP expression: $\bar{A}CD + A + \bar{A}B\bar{C}$

SOP 12-13-15-14-8-9-11-10 = A

POS 0-1 = A+B+C

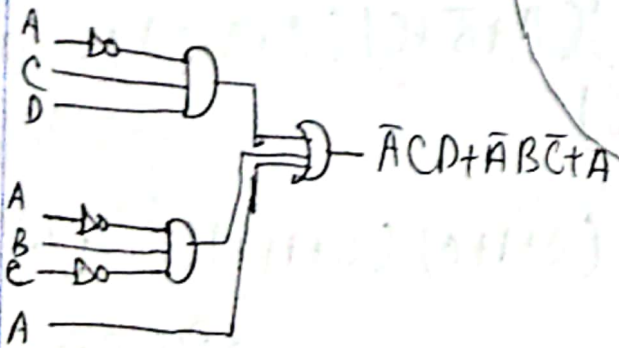
SOP 3-7 = $\bar{A}CD$

POS 2-6 = $A+\bar{C}+\bar{D}$

CD / AB	00	01	11	10
00	0	0	1	0
01	1	1	1	0
11	1	1	1	1
10	1	1	1	1

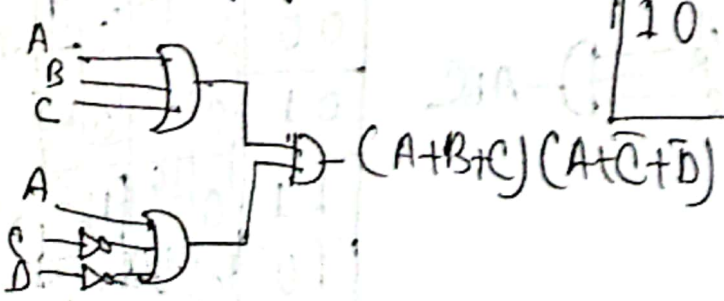
SOP 4-5 = $\bar{A}B\bar{C}$

Logic gate diagram:



POS expression: $(A+B+\bar{C})(A+C+\bar{D})$

Logic gate diagram:



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

Convert POS.

for $A = A + (B \cdot \bar{B}) + (A+B)(A+\bar{B})$

Now, $(A+B)+C+\bar{C}$ $\quad (A+\bar{B})+C\cdot\bar{C}$

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

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

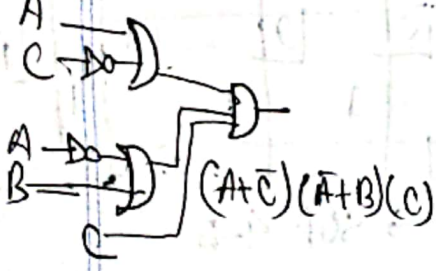
for $\bar{A}+C = (\bar{A}+C) + B\cdot\bar{B} = (\bar{A}+B+C)(\bar{A}+\bar{B}+C)$

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

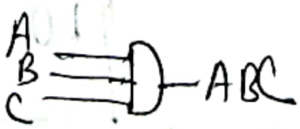
$= (A+B+C)(A+B+\bar{C})(A+\bar{B}+C)(A+\bar{B}+\bar{C})(\bar{A}+B+\bar{C})$
$(\bar{A}+B+C)(\bar{A}+\bar{B}+C)$

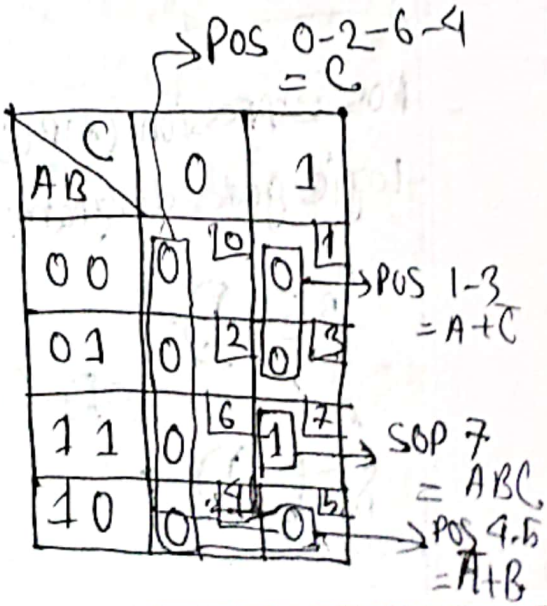
$0 = (0+0+0)(0+0+1)(0+1+0)(0+1+1)(1+0+1)(1+0+0)(1+1+0)$

POS expression:
$(A+\bar{C})(\bar{A}+B)(C)$



SOP expression:
ABC





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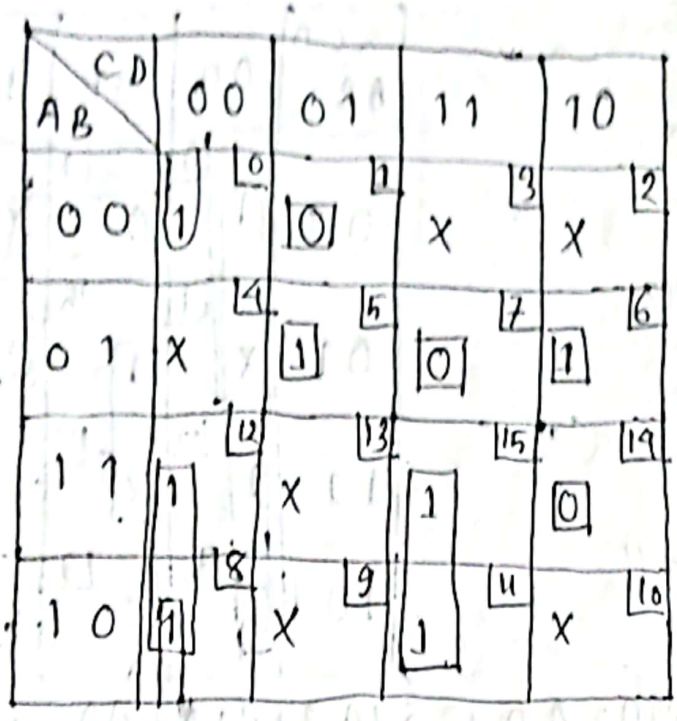
8qk map for the given truth table:



SOP 0-8 = $\bar{B}\bar{C}\bar{D}$ SOP 12-8 = $A\bar{C}\bar{D}$ SOP 15-11 = ACD SOP 6 = $\bar{A}B\bar{C}\bar{D}$ SOP 5 = $\bar{A}B\bar{C}D$

SOP expression:- $B\bar{C}\bar{D} + A\bar{C}\bar{D} + ACD + \bar{A}B\bar{C}\bar{D} + \bar{A}B\bar{C}D$

POS 1 = $A+B+C+\bar{D}$ POS 7 = $A+\bar{B}+\bar{C}+\bar{D}$ POS 14 = $\bar{A}+\bar{B}+\bar{C}+D$

POS expression:- $(A+B+C+\bar{D})(A+\bar{B}+\bar{C}+\bar{D})(\bar{A}+\bar{B}+\bar{C}+D)$

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b) using don't care values:-

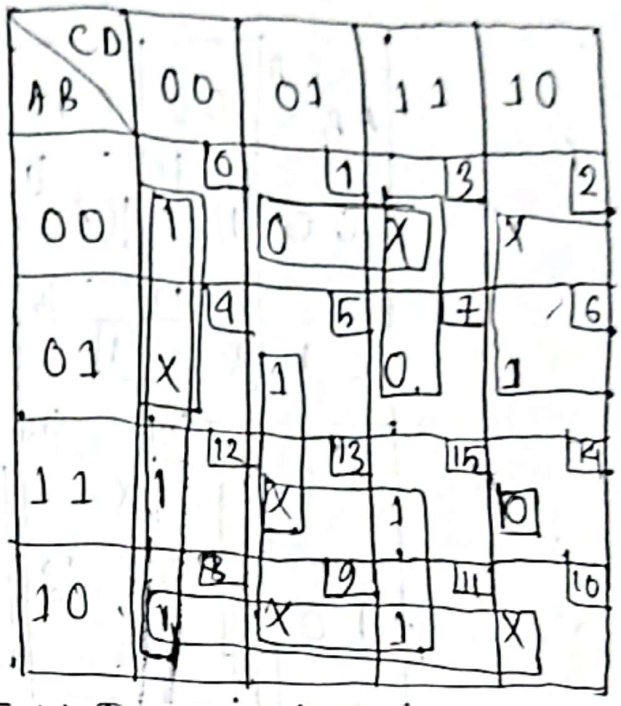
SOP 0-4-2-6
$= \bar{A}\bar{D}$

SOP 0-4-12-8
$= \bar{C}\bar{D}$

SOP 8-9-11-10
$= A\bar{B}$

SOP 5-13
$= B\bar{C}D$

SOP 13-15-9-11
$= AD$



∴ SOP expression $= \bar{A}\bar{D} + \bar{C}\bar{D} + A\bar{B} + B\bar{C}D + AD$

POS (1-3) POS 3-7 POS 14
$= A + B + \bar{D}$ $= A + \bar{C} + \bar{D}$ $= \bar{A} + \bar{B} + \bar{C} + D$

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

c) After solving, using don't care and not using don't care, I think using don't care value is more useful. Because, don't care values helps us increasing the size of the group. So, I can easily simplified the POS as well as SOP expression.

Here is my solution, while ~~don~~ not using don't care I got 5 SOP expression and 3 POS expression. Beside while using don't care I got the same but the grouping size was bigger than it.

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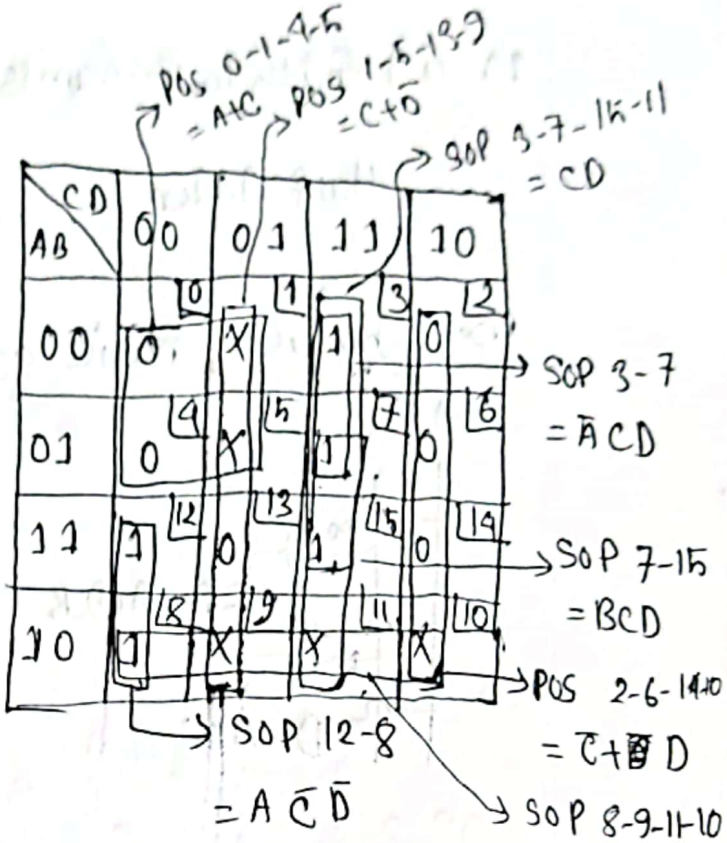
9. 1) $F(A,B,C,D) = \Sigma(3,7,8,12,15)$

$d(A,B,C,D) = (1,5,9,10,11)$



∴ SOP expression

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

2) SOP expression:

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

POS expression $= (A+C)(\bar{C}+D)(C+\bar{D})$

3) After solving using don't care and not using don't care, ~~values~~ 1 thing using don't care value is more useful. Because don't care value helps us increasing the size of the group so I can easily simplified the POS aswell as SOP expression

Here in my solution, while not using don't care I got 3 SOP expression. Beside, while using don't care, I got the same but the grouping size was bigger than not using don't care grouping

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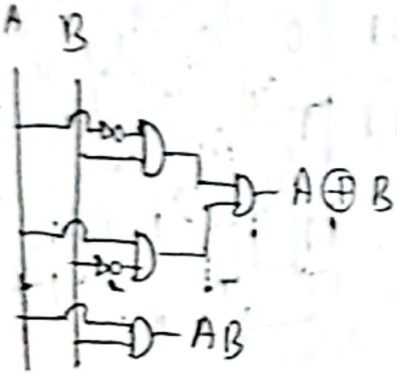
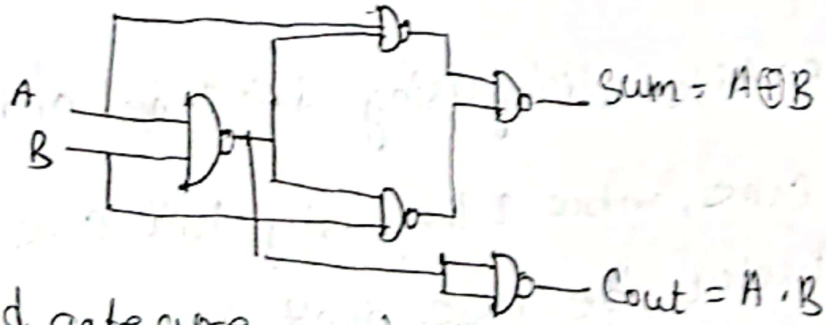
10. a) truth table: sum (S) and Carry (Cout) of a Half Adder.

A	B	S	Cout
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Now, by using basic gate:



Now, by using NAND gate:



Total 5 Nand gate are required to implement half adder.

(b) truth table: Difference (D) and Borrow (B) of a half ~~adder~~ Subtractor.

A	B	D	B
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

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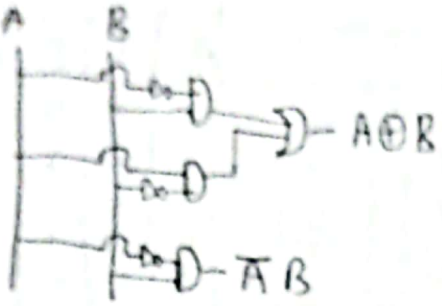
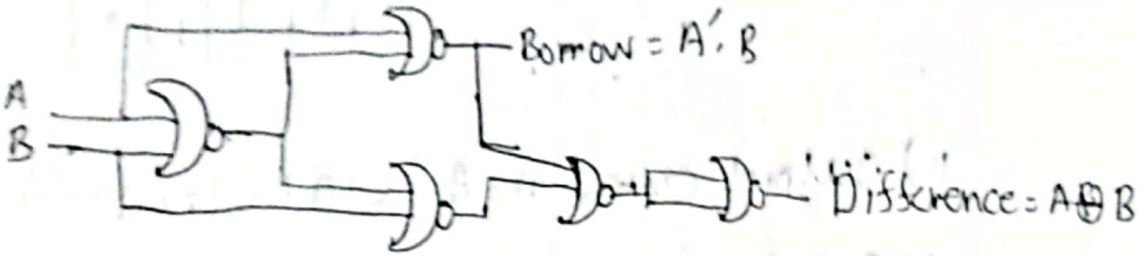
Now, by using basic gate:

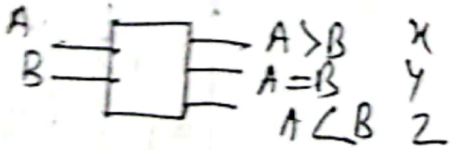


Now, by using NOR gate:



total 5 Nor gate are required to implement half subtractor.

12. For 1-bit magnitude comparator, there will be 2 input, 3 output.

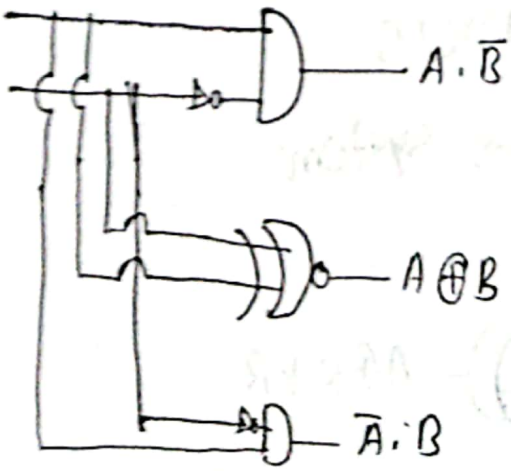


A	B	A>B	A=B	A<B
0	0	0	1	0
0	1	0	0	1
1	0	1	0	0
1	1	0	1	0

$X = A \cdot \bar{B}$

$Y = AB + \bar{A}\,\bar{B}$

$Z = \bar{A} \cdot B$



SOP expression $= A \cdot \bar{B} + (A \oplus B) + \bar{A} \cdot B$

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13. i) truth table of the system:

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

ii) Output expression = $\bar{A}\bar{B}C + \bar{A}B\bar{C} + AB\bar{C} + ABC + \bar{A}BC + AB\bar{C}$

SOP 2-3-6-7 = B

SOP 6-4 = $A\bar{C}$

SOP 1-3 = $\bar{A}C$

AB \ C	0	1
00	0	1
01	1	1
11	1	1
10	1	0

Minimized output expression

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

$= A \oplus C + B$

iii) output expression = $A \oplus C + B$

logic diagram for the system:

Sub: Name: Nafiour Leo
Id: 20-42196-3

14. truth table of the system:

A	B	C	D	Z
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	1
0	1	0	0	0
0	1	0	1	0
0	1	1	0	1
0	1	1	1	1
1	0	0	0	0
1	0	0	1	0
1	0	1	0	1
1	0	1	1	1
1	1	0	0	0
1	1	0	1	0
1	1	1	0	1
1	1	1	1	1

ii) $Z = \bar{A}\bar{B}CD + \bar{A}BC\bar{D} + A\bar{B}CD + A\bar{B}C\bar{D} + A\bar{B}CD + ABC\bar{D} + ABCD$

SOP 7-6-15-14 $= BC$

SOP 15-14-11-10 $= AC$

SOP 3-7-15-11 $= CD$

AB \ CD	00	01	11	10
00	0	0	1	0
01	0	0	1	1
11	0	0	1	1
10	0	0	1	1

∴ minimized output expression $= BC + AC + CD$

iii) Output expression $= BC + AC + CD$

logic diagram for the system