Cpr E 281 HW03 SOLUTION

ELECTRICAL AND COMPUTER ENGINEERING
IOWA STATE UNIVERSITY

Assigned Date: Third Week
Due Date: First class of 4th week

P1.

Starting with the canonical sum-of-products for f get

$$\begin{aligned} f &= \overline{x}_1\overline{x}_2x_3 + \overline{x}_1x_2\overline{x}_3 + \overline{x}_1x_2x_3 + x_1\overline{x}_2\overline{x}_3 + x_1\overline{x}_2x_3 + x_1x_2\overline{x}_3 + x_1x_2x_3 \\ &= x_1(\overline{x}_2\overline{x}_3 + \overline{x}_2x_3 + x_2\overline{x}_3 + x_2x_3) + x_2(\overline{x}_1\overline{x}_3 + \overline{x}_1x_3 + x_1\overline{x}_3 + x_1x_3) \\ &\quad + x_3(\overline{x}_1\overline{x}_2 + \overline{x}_1x_2 + x_1\overline{x}_2 + x_1x_2) \\ &= x_1(\overline{x}_2(\overline{x}_3 + x_3) + x_2(\overline{x}_3 + x_3)) + x_2(\overline{x}_1(\overline{x}_3 + x_3) + x_1(\overline{x}_3 + x_3)) \\ &\quad + x_3(\overline{x}_1(\overline{x}_2 + x_2) + x_1(\overline{x}_2 + x_2)) \\ &= x_1(\overline{x}_2 \cdot 1 + x_2 \cdot 1) + x_2(\overline{x}_1 \cdot 1 + x_1 \cdot 1) + x_3(\overline{x}_1 \cdot 1 + x_1 \cdot 1) \\ &= x_1(\overline{x}_2 + x_2) + x_2(\overline{x}_1 + x_1) + x_3(\overline{x}_1 + x_1) \\ &= x_1 \cdot 1 + x_2 \cdot 1 + x_3 \cdot 1 \\ &= x_1 + x_2 + x_3 \end{aligned}$$

P2.

Truth Tables a, b, c

X	Y	Z	a
0	0	0	0
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	1

A	B	C	b
0	0	0	1
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

a) Sum of Minterms: $\overline{X}YZ + X\overline{Y}Z + XY\overline{Z} + XYZ$

Product of Maxterms: $(X+Y+Z)(X+Y+\overline{Z})(X+\overline{Y}+Z)(\overline{X}+Y+Z)$

b) Sum of Minterms: $\overline{A}\overline{B}\overline{C} + \overline{A}\overline{B}C + \overline{A}BC + ABC$

Product of Maxterms: $(A+\overline{B}+C)(\overline{A}+B+C)(\overline{A}+B+\overline{C})(\overline{A}+\overline{B}+C)$

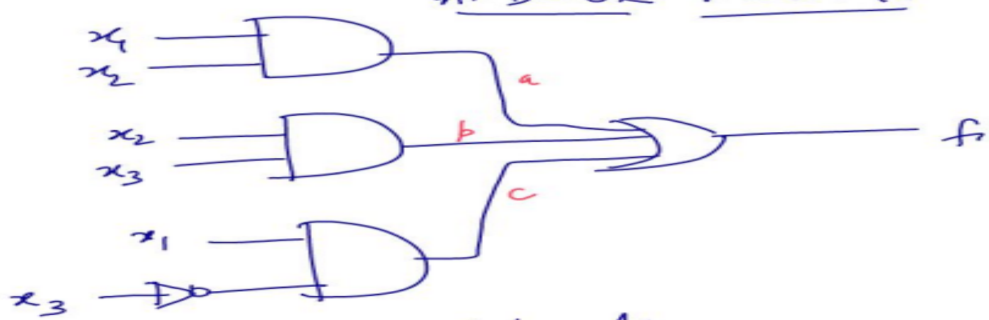
P3.

P3.

$$f(x_1, x_2, x_3) = \sum m(3, 4, 6, 7)$$

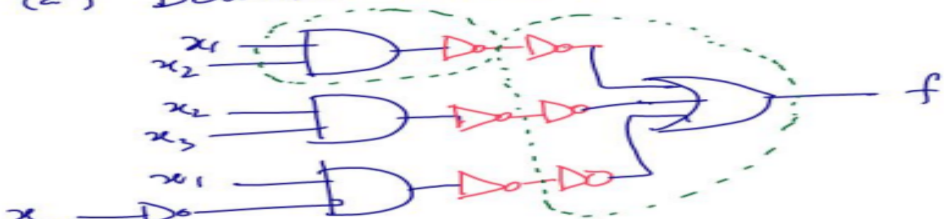
$$\begin{aligned}
f &= x_1'x_2x_3 + x_1x_2'x_3' + x_1x_2x_3' + x_1x_2x_3 \\
&= x_1'x_2x_3 + x_1x_2'x_3' + x_1x_2(x_3' + x_3) \\
&= x_1'x_2x_3 + x_1x_2'x_3' + x_1x_2 \\
&= x_1'x_2x_3 + x_1(x_2'x_3' + x_2) \\
&= x_1'x_2x_3 + x_1(x_2' + x_2)(x_3' + x_2) \\
&= \underline{x_1'x_2x_3} + x_1x_3' + \underline{x_1x_2} \\
&= x_1'x_2x_3 + x_1x_2 + x_1x_3' \\
&= x_2(x_1'x_3 + x_1) + x_1x_3' \\
&= x_2(x_1' + x_1)(x_3 + x_1) + x_1x_3' \\
&= x_1x_2 + x_2x_3 + x_1x_3'
\end{aligned}$$

AND - OR Network

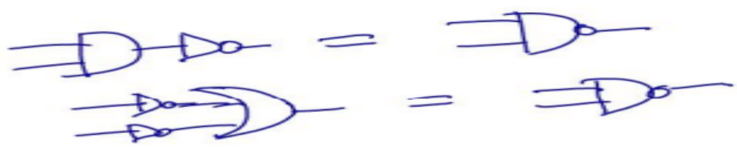


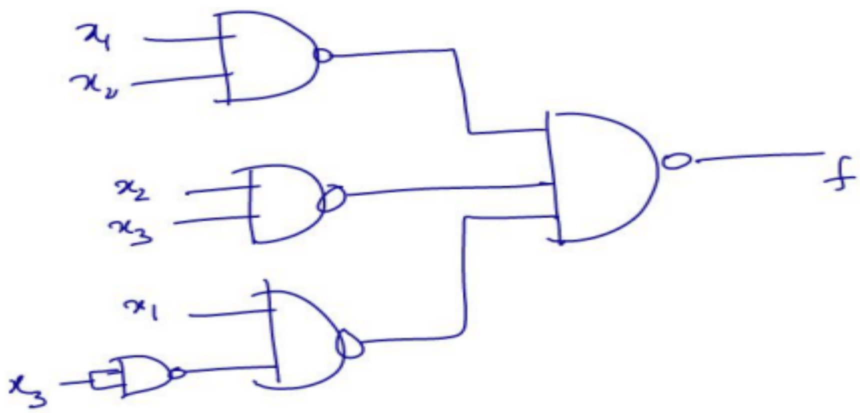
NAND only Network

(a) Double inversion on wires a, b, c



(b)





P4. a)

(a) Min terms

$M(X,Y,Z) = \sum m(3,5,6,7) = \bar{X}YZ + X\bar{Y}Z + XY\bar{Z} + XYZ$

$N(X,Y,Z) = \sum m(1,2,4,7) = \bar{X}\,\bar{Y}\,Z + \bar{X}Y\bar{Z} + X\,\bar{Y}\bar{Z} + XYZ$

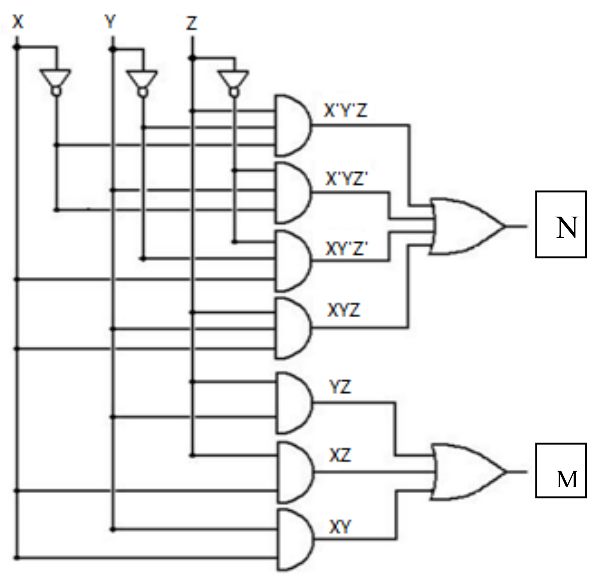
Max terms

$M(X,Y,Z) = \prod M(0,1,2,4) = (X+Y+Z)(X+Y+\bar{Z})(X+\bar{Y}+Z)(\bar{X}+Y+Z)$

$N(X,Y,Z) = \prod M(0,3,5,6) = (X+Y+Z)(X+\bar{Y}+\bar{Z})(\bar{X}+Y+\bar{Z})(\bar{X}+\bar{Y}+Z)$

b) $M = YZ + XZ + XY$,

$N = \bar{X}\,\bar{Y}\,Z + \bar{X}Y\bar{Z} + X\,\bar{Y}\bar{Z} + XYZ$



P5.

x 1	x 2	y 1	y 2	X=x1x2	Y=y1y2	F
0	0	0	0	$(00)_2=(0)_{10}$	$(00)_2=(0)_{10}$	1
0	0	0	1	00=0	01=1	0
0	0	1	0	00=0	10=2	0
0	0	1	1	00=0	11=3	0
0	1	0	0	01=1	00=0	0
0	1	0	1	01=1	01=1	1
0	1	1	0	01=1	10=2	0
0	1	1	1	01=1	11=3	0
1	0	0	0	10=2	00=0	0
1	0	0	1	10=2	01=1	0
1	0	1	0	10=2	10=2	1
1	0	1	1	10=2	11=3	0
1	1	0	0	11=3	00=0	0
1	1	0	1	11=3	01=1	0
1	1	1	0	11=3	10=2	0
1	1	1	1	11=3	11=3	1

SOP=$x_1'x_2'y_1'y_2' + x_1'x_2y_1'y_2 + x_1x_2'y_1y_2' + x_1x_2y_1y_2$

POS= $(x_1+x_2+y_1+y_2')\,(x_1+x_2+y_1'+y_2)\,(x_1+x_2+y_1'+y_2')\,(x_1+x_2'+y_1+y_2)$
$(x_1+x_2'+y_1'+y_2)\,(x_1+x_2'+y_1'+y_2')\,(x_1'+x_2+y_1+y_2)\,(x_1'+x_2+y_1+y_2')$
$(x_1'+x_2+y_1'+y_2')\,(x_1'+x_2'+y_1+y_2)\,(x_1'+x_2'+y_1+y_2')\,(x_1'+x_2'+y_1'+y_2)$

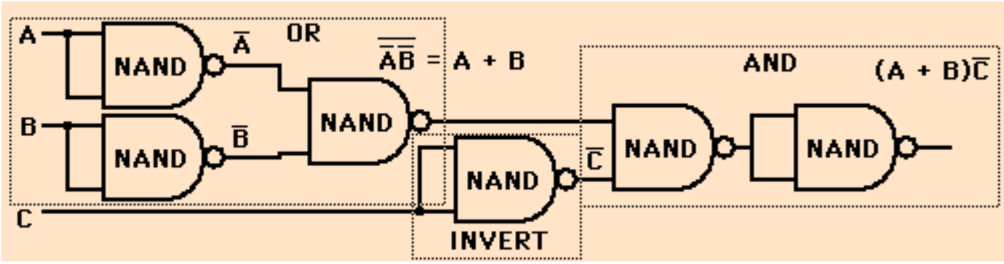
P6.

(a) The NAND function F = (A.B)’
If we set B=1, then F = (A.1)’=A’.
In other words, we can implement the NOT function by connecting one of the inputs of a 2-input NAND gate to 1 (Vdd).

(b) The NOR function F= (A+B)’
If we set B=0, then F = (A+0)’=A’.
In other words, we can implement the NOT function by connecting one of the inputs of a 2-input NOR gate to 0 (Gnd).

(c) The 2-1 MUX function F = S’.x0 + S.x1
If we set x0=1 and x1=0, then F = S’.1 + S.0 = S’.
In other words, we can implement the NOT function by connecting the x0 input of a 2-1 MUX to 1 (Vdd), the x1 input to 0 (Gnd), and the signal to be inverted to S.

P7.


A
B
C
NAND
NAND
NAND
NAND
NAND
NAND
$\overline{A}$
$\overline{B}$
OR
$\overline{\overline{A}\,\overline{B}} = A + B$
AND
$(A + B)\overline{C}$
$\overline{C}$
INVERT