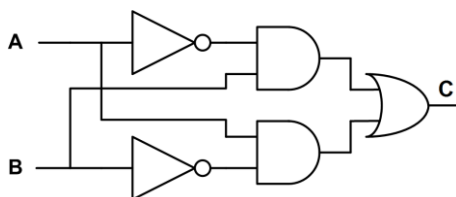


EE1001 - Assignment 3

1. Find the Boolean function of the following circuit. Use a truth table to find the input/output relationship, hence determine the function of this circuit



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

NOR gate

2. Prove that $(A+B)(A+C) = A + BC$, by means of (i) truth table, and (ii) Boolean algebra.

(i)

A	B	C	A+B	A+C	$(A+B)(A+C)$	BC	A+BC
0	0	0	0	0	0	0	0
0	0	1	0	1	0	0	0
0	1	0	1	0	0	0	0
0	1	1	1	1	1	1	1
1	0	0	1	1	1	0	1
1	0	1	1	1	1	0	1
1	1	0	1	1	1	0	1
1	1	1	1	1	1	1	1

(ii) $(A+B)(A+C) = (A+B)A + (A+B)C$

$$= A + AB + AC + BC$$

$$= A(1+B+C) + BC$$

$$= A + BC$$

3. For the following logic functions, find all the minterms and maxterms for each them and express them in canonical POS and SOP forms.

$$\begin{aligned}
 \text{(a)} \quad f(x,y,z) &= x'z + xy + xy'z' + y'z' \\
 &= x'z(y+y') + xy(z+z') + xy'z' + y'z'(x+x') \\
 &= x'y'z + x'y'z' + xyz + xyz' + xy'z' + xy'z' + x'y'z' \\
 &= \sum m(0,1,3,4,6,7) \\
 &= \prod M(2,5) \\
 &= (x+y'+z)(x'+y+z')
 \end{aligned}$$

$$\begin{aligned}
 \text{(b)} \quad F(A,B,C,D) &= B'(C+AD) + C'B' + AC'(AB+D') \\
 &= B'C + AB'D + B'C'(A+A') + ABC' + AC'D' \\
 &= B'C(A+A') + AB'D(C+C') + AB'C' + A'B'C' + ABC'(D+D') + AC'D'(B+B') \\
 &= AB'C + A'B'C + AB'CD + AB'C'D + AB'C'(D+D') + A'B'C'(D+D') + \\
 &\quad ABC'D + ABC'D' + ABC'D' + AB'C'D' \\
 &= AB'C(D+D') + A'B'C(D+D') + AB'CD + AB'C'D + AB'C'D + AB'C'D' + \\
 &\quad A'B'C'D + A'B'C'D' + ABC'D + ABC'D' + ABC'D' + AB'C'D' \\
 &= \textcolor{blue}{AB'CD} + AB'CD' + A'B'CD + A'B'CD' + \textcolor{blue}{AB'CD} + AB'C'D + \textcolor{red}{AB'C'D'} + \\
 &\quad A'B'C'D + A'B'C'D' + ABC'D + \textcolor{green}{ABC'D'} + \textcolor{green}{ABC'D'} + \textcolor{red}{AB'C'D'} \\
 &= \sum m(0,1,2,3,8,9,10,11,12,13) \\
 &= \prod M(4,5,6,7,14,15) \\
 &= (A+B'+C+D) \cdot (A+B'+C+D') \cdot (A+B'+C'+D) \cdot (A+B'+C'+D') \cdot \\
 &\quad (A'+B'+C+D) \cdot (A'+B'+C'+D')
 \end{aligned}$$

4. For the following logic functions, list all the minterms and maxterms for each of them.

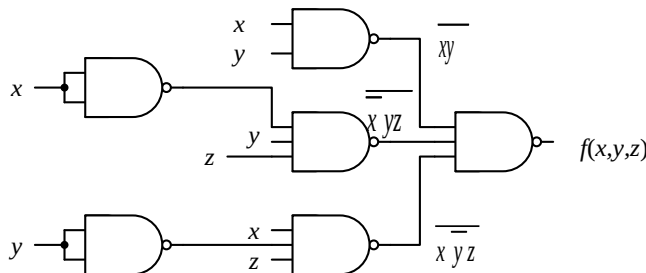
$$\begin{aligned}
 \text{(a)} \quad f(x,y,z) &= \sum m(0,2,5,7) \\
 &= x'y'z' + x'yz' + xy'z + xyz \\
 &= \prod M(1,3,4,6) \\
 &= (x+y+z')(x+y'+z)(x'+y+z)(x'+y'+z) \\
 \text{(b)} \quad f(x,y,z) &= \sum m(0,3,6) \\
 &= x'y'z' + x'yz + xyz' \\
 &= \prod M(1,2,4,5,7) \\
 &= (x+y+z')(x+y'+z)(x'+y+z)(x'+y+z')(x'+y'+z')
 \end{aligned}$$

$$\begin{aligned}
 \text{(c)} \quad f(a,b,c) &= \Pi M(1,5,7) \\
 &= (a+b+c')(a'+b+c')(a'+b'+c') \\
 &= \sum m(0,2,3,4,6) \\
 &= a'b'c' + a'bc' + a'bc + ab'c' + abc'
 \end{aligned}$$

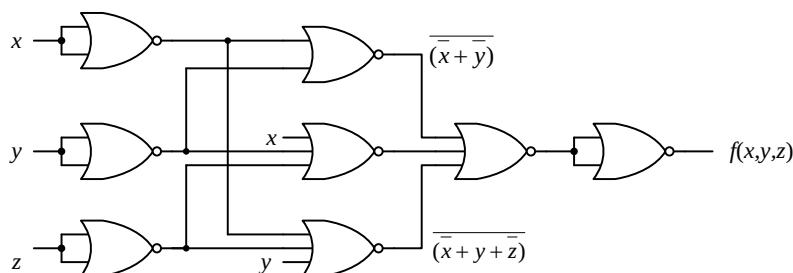
$$\begin{aligned}
 \text{(d)} \quad f(a,b,c,d) &= \Pi M(0,3,4,7,9,10,11) \\
 &= (a+b+c+d) \cdot (a+b+c'+d') \cdot (a+b'+c+d) \cdot (a+b'+c'+d') \cdot (a'+b+c+d') \cdot \\
 &\quad (a'+b+c'+d) \cdot (a'+b+c'+d') \\
 &= \sum m(1,2,5,6,8,12,13,14,15) \\
 &= a'b'c'd + a'b'cd' + a'bc'd + a'bcd' + ab'c'd' + abc'd' + abc'd + abcd' + abcd
 \end{aligned}$$

5. Using DeMorgan's theorem, convert the following Boolean expressions to equivalent expressions that can be implemented with (i) NAND gates only, and (ii) NOR gates only. Draw the circuits.

$$\begin{aligned}
 \text{(a)} \quad f(x,y,z) &= \overline{xy + \bar{x}yz + x\bar{y}z} \\
 &= \overline{xy + \bar{x}yz + x\bar{y}z} \quad \text{(NAND Gate)} \\
 &= \overline{xy} \cdot \overline{\bar{x}yz} \cdot \overline{x\bar{y}z} \\
 &= \overline{xy} \cdot x\bar{y}z \cdot x\bar{y}z
 \end{aligned}$$



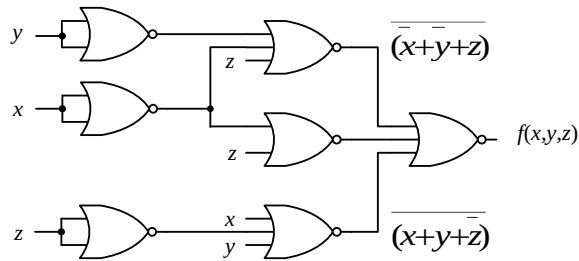
$$\begin{aligned}
 &= \overline{xy + \bar{x}yz + x\bar{y}z} \\
 &= \overline{(x+y) + (x+\bar{y}+\bar{z}) + (\bar{x}+y+\bar{z})} \quad \text{(NOR Gate)}
 \end{aligned}$$



(b)
$$f(x, y, z) = \overline{\overline{(x + y + \bar{z})}(\bar{x} + z)(\bar{x} + \bar{y} + z)}$$

$$= \overline{\overline{(x + y + \bar{z})}(\bar{x} + z)(\bar{x} + \bar{y} + z)} \quad (\text{NOR Gate})$$

$$= \overline{(x + y + \bar{z}) + (\bar{x} + z) + (\bar{x} + \bar{y} + z)}$$



$$= \overline{\overline{(x + y + \bar{z})}(\bar{x} + z)(\bar{x} + \bar{y} + z)}$$

$$= \overline{\overline{(x + y + \bar{z})} \cdot \overline{(\bar{x} + z)} \cdot \overline{(\bar{x} + \bar{y} + z)}} \quad (\text{NAND Gate})$$

$$= \overline{\overline{(xyz)}(\overline{xz})(\overline{xyz})}$$

