1. $Z = ab + c(a+b)$, $\overline{F(a,b,c)} = F(\bar{a}, \bar{b}, \bar{c})$

↳ $\bar{Z} = \overline{ab + c(a+b)}$

$= \overline{ab} \cdot \overline{c(a+b)}$

$= (\bar{a} + \bar{b}) \cdot (\bar{c} + (\overline{a+b}))$

$= (\bar{a} + \bar{b}) \cdot (\bar{c} + \bar{a} \cdot \bar{b})$

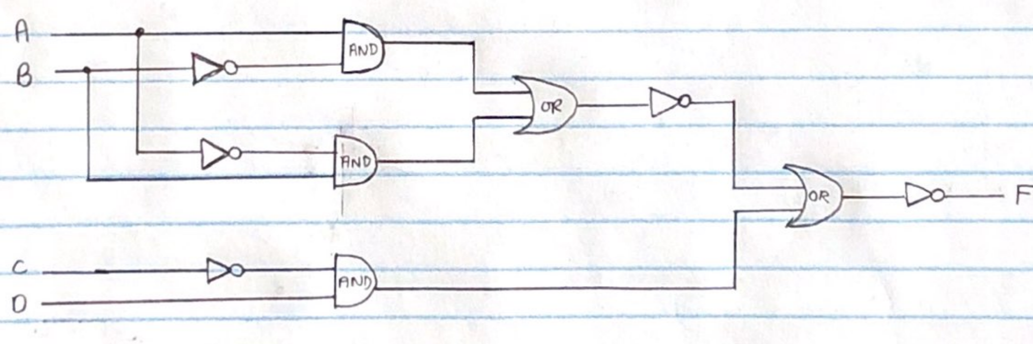
$= \bar{a}\bar{c} + \bar{a}\bar{b} + \bar{b}\bar{c} + \bar{a}\bar{b}$

$= \bar{a}\bar{b} + \bar{a}\bar{c} + \bar{b}\bar{c}$

$= \bar{a}\bar{b} + \bar{c}(\bar{a} + \bar{b})$

$\therefore \overline{z(a,b,c)} = z(\bar{a}, \bar{b}, \bar{c})$ meaning the function is self-dual

2. Convert NAND-NOR to AND-OR



3. a) $(11001.001)_2 = (?)_{10}$

$\hookrightarrow 1\times2^4 + 1\times2^3 + 0\times2^2 + 0\times2^1 + 1\times2^0 + 0\times2^{-1} + 0\times2^{-2} + 1\times2^{-3}$

$= 1\times16 + 1\times8 + 0\times4 + 0\times2 + 1\times1 + 0\times\frac{1}{2} + 0\times\frac{1}{4} + 1\times\frac{1}{8}$

$= 16 + 8 + 0 + 0 + 1 + 0 + 0 + \frac{1}{8}$

$= (25.125)_{10}$

b) $(1001110.11)_2 = (?)_8$

$\hookrightarrow 1\times2^6 + 0\times2^5 + 0\times2^4 + 1\times2^3 + 1\times2^2 + 1\times2^1 + 0\times2^0 + 1\times2^{-1} + 1\times2^{-2}$

$= 1\times64 + 0\times32 + 0\times16 + 1\times8 + 1\times4 + 1\times2 + 0\times1 + 1\times\frac{1}{2} + 1\times\frac{1}{4}$

$= 64 + 0 + 0 + 8 + 4 + 2 + 0.5 + 0.25$

$= (78.75)_{10}$

$\hookrightarrow \begin{array}{r|l} 8 & 78 \\ \hline 8 & 9 - 6 \\ \hline & 1 - 1 \end{array}$ $\qquad 0.11 \rightarrow \underbrace{0.110}_{6}$

$\therefore (116.60)_8$

c) $(1001110.11)_2 = (?)_{16}$

$\hookrightarrow 1\times2^6 + 0\times2^5 + 0\times2^4 + 1\times2^3 + 1\times2^2 + 1\times2^1 + 0\times2^0 + 1\times2^{-1} + 1\times2^{-2}$

$= 1\times64 + 0\times32 + 0\times16 + 1\times8 + 1\times4 + 1\times2 + 0\times1 + 1\times\frac{1}{2} + 1\times\frac{1}{4}$

$= 64 + 0 + 0 + 8 + 4 + 2 + 0.5 + 0.25$

$= (78.75)_{10}$

$\hookrightarrow \begin{array}{r|l} 16 & 78 \\ \hline 16 & 4 - E \\ \hline \end{array}$ $\qquad 0.11 \rightarrow \underbrace{0.1100}_{C}$

$\therefore (4E.C0)_{16}$

d) $AE72.B = (?)_2$

↳ $10 \times 16^3 + 14 \times 16^2 + 7 \times 16^1 + 2 \times 16^0 + 11 \times 16^{-1}$

$= 10 \times 4096 + 14 \times 256 + 7 \times 16 + 2 \times 1 + 11 \times 1/16$

$= 40960 + 3554 + 112 + 2 + 0.6875$

$= (44658.6875)_{10}$

↳ $A = 1010$ $0.6875 \times 2 = 1.375$

$E = 1110$ $0.375 \times 2 = 0.750$

$7 = 0111$ $0.750 \times 2 = 1.50$

$2 = 0010$

↳ $\therefore (1010111001110010.101)_2$

e) $(125.86)_{10} = (?)_2$ up to 3 fractional digits

2	125
2	62 - 1
2	31 - 0
2	15 - 1
2	7 - 1
2	3 - 1
	1 - 1

0.86×2	1.72
0.72×2	1.44
0.44×2	0.88

$\underbrace{\qquad\qquad}_{110}$

↳ $\therefore (1111101.110)_2$

f) $9F82.E = (?)_{10}$

↳ $9 \times 16^3 + 15 \times 16^2 + 8 \times 16^1 + 2 \times 16^0 + 14 \times 16^{-1}$

$= 9 \times 4096 + 15 \times 256 + 8 \times 16 + 2 \times 1 + 14 \times 0.0625$

$= 36864 + 3840 + 128 + 2 + 0.875$

$= (40534.875)_{10}$

4. A = 10101101
B = 01100110

a) A + B

$$\begin{array}{r} 10101101 \\ +\ 01100110 \\ \hline 100010011 \end{array}$$

overflow

b) A - B
↳ A + (-B)

B: 1's compliment → 10011001
+1
2's compliment → 10011010

$$\begin{array}{r} 10101101 \\ +\ 10011010 \\ \hline 101000111 \end{array}$$

overflow

c) B - A
↳ B + (-A)

A: 1's compliment → 01010010
+1
2's compliment → 01010011

$$\begin{array}{r} 01010011 \\ +\ 01100110 \\ \hline 10111001 \end{array}$$

no overflow

d) -A - B
↳ + (-A) + (-B)

A 2's compliment
B 2's compliment

$$\begin{array}{r} 01010011 \\ +\ 10011010 \\ \hline 11101101 \end{array}$$

no overflow

5. $z = a\bar{b}c + d\bar{c}b + adc + \bar{a}cd + a\bar{b}\bar{c}d + \bar{a}\bar{b}c\bar{d}$

↳ $x = 1$, $\bar{x} = 0$

= 101, 101, 111, 011, 1001, 0010

↳

		binary	decimal
$a\bar{b}c\underline{d}$	=	1010	10
$\underline{a}b\bar{c}d$	=	0101	5
$a\underline{b}cd$	=	1011	11
$\bar{a}\underline{b}cd$	=	0011	3
$a\bar{b}\bar{c}d$	=	1001	9
$\bar{a}\bar{b}c\bar{d}$	=	0010	2

AB \ CD	00	01	11	10
00	$_{0}$	$_{1}$	1_{3}	1_{2}
01	$_{4}$	1_{5}	$_{7}$	$_{6}$
11	$_{12}$	$_{13}$	$_{15}$	$_{16}$
10	$_{8}$	1_{9}	1_{11}	1_{10}

$= \bar{b}c + a\bar{b}d + \bar{a}b\bar{c}d$
 ① ② ③

↳ $\therefore z = \bar{a}b\bar{c}d + a\bar{b}d + \bar{b}c$

6. Simplify the K-Map

ab \ cd	$\bar{c}\bar{d}$	$\bar{c}d$	cd	$c\bar{d}$
$\bar{a}\bar{b}$	1	0	d	d
$a\bar{b}$	0	d	1	0
ab	0	1	d	0
$\bar{a}b$	d	d	0	1

↳ $\therefore z = ad + \bar{a}\bar{d}$