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Zone	BCD
0000	0000
0001	1001
0010	
0011	

$2^8 = 256$.

27/2/23 - Zoned BCD

$B_7 \; B_6 \; \overset{0}{\underset{6}{B_5}} \; \overset{0}{\underset{5}{B_4}} \; \overset{24}{\boxed{B_3 \; B_2 \; B_1 \; B_0}}$

$2^6 = 64$

- 00 - Zone 0
  01 - Zone 1
  10 - Zone 2
  11 - Zone 3

- 10 + 26 + 26 + special
  small caps characters

- 2 bits were increased
  $2^8 = 256$

Space was also included as char

16 zone
16 characters in each zone } EBCDIC
Extended BCD information code

~~7~~ 6 ~~5~~ ~~4~~ ~~3~~ ~~2~~ 1

B_6 B_5 B_4 B_3 B_2 B_1 B_0

$2^7 = 128$

- ANSI provided Bell lab. recognization as ASCII
- ASCII was selected as standard alpha numeric codes for info. interchange.
- System adopted in 1963.
- Modified version of ASCII is Unicode. (or updated)

- Gray Codes. (Unit distance or Mirror image code)

	Binary	Gray
0	0000	0000
1	0001	0001
2	0010	0011
3	0011	0010
4	0100	0110
5	0101	0111
6	0110	0101
7	0111	0100
8	1000	1100
9	1001	1101
10	1010	

- Better for error detection.

0000 1010
Mirror 0001 1011
0011 1001
0010 1000

0110
0111
0101
0100

1100
1101
1111
1110

- Binary to gray

- $(7)_{10} \rightarrow$ 0 1 1 1
B_3 B_2 B_1 B_0

$G_3 = B_3$
$G_2 = B_3 \oplus B_2$
$G_1 = B_2 \oplus B_1$
$G_0 = B_1 \oplus B_0$

0 1 0 0
G_3 G_2 G_1 G_0

- 0 0 1 1
B_3 B_2 B_1 B_0

0 0 1 0
G_3 G_2 G_1 G_0

Note:
$A \oplus B$
0 0 = 0
1 1 = 0
0 1 = 1
1 0 = 1

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1 0 1 0
B_3 B_2 B_1 B_0

1 1 1 1
G_3 G_2 G_1 G_0

- Gray to Binary.

A	B	y
0	0	0
1	0	1
0	1	1
1	1	0

0 1 1 0
G_3 G_2 G_1 G_0

$B_3 = G_3$
$B_2 = B_3 \oplus G_2$
$B_1 = B_2 \oplus G_1$
$B_0 = B_1 \oplus G_0$

0 1 0 0
B_3 B_2 B_1 B_0

$(1010111)_2$
$\rightarrow (1111100)_g$

G_3 G_2 G_1 G_0

1 0 1 0 1 1 1
G_6 G_5 G_4 G_3 G_2 G_1 G_0
1 0 1 0 0 1 0 0

1 1 0 0 1 0 1
B_6 B_5 B_4 B_3 B_2 B_1 B_0

1 1 0 0 1 0 1
B_6 B_5 B_4 B_3 B_2 B_1 B_0

1 1 1 1 1 0
B_6 B_5 B_4 B_3 B_2 B_1

1 1 0 0 0 0 1

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- $(1011101)_g \longrightarrow (1101001)_2$ ✓

1	0	1	1	1	0	1
G_6	G_5	G_4	G_3	G_2	G_1	G_0

1	1	0	1	0	0	1
B_6	B_5	B_4	B_3	B_2	B_1	B_0

Ans: 1001010

• $(1110011)_2 \rightarrow (1011101)_g$

| XOR | XOR | XOR 0 XOR 0 XOR | XOR |

1 0 0 1 0 1 0

$$\begin{array}{ccccccc} 1 & 1 & 1 & 0 & 0 & 1 & 1 \\ B_6 & B_5 & B_4 & B_3 & B_2 & B_1 & B_0 \\ 1 & 0 & 1 & 1 & 1 & 0 & 1 \\ G_6 & G_5 & G_4 & G_3 & G_2 & G_1 & G_0 \end{array}$$

0 1 0 1 1

$0 \quad 0\oplus1 \quad 1\oplus1 \quad 1\oplus0 \quad 0\oplus1$

0 1 0 1 1

• $(1110011)_g \rightarrow (1011101)_2$ ✓

$$\begin{array}{ccccccc} 1 & 1 & 1 & 0 & 0 & 1 & 1 \\ G_6 & G_5 & G_4 & G_3 & G_2 & G_1 & G_0 \\ 1 & 0 & 1 & 1 & 1 & 0 & 1 \\ B_6 & B_5 & B_4 & B_3 & B_2 & B_1 & B_0 \end{array}$$

$(01101)_2 \rightarrow (01011)_g$

0 1 1 0 1

$\rightarrow (01011)_g$

Gray to Binary

$$\begin{array}{ccccc} 0 & 1 & 0 & 1 & 1 \\ G_4 & G_3 & G_2 & G_1 & G_0 \\ & 0\oplus1 & 1\oplus0 & 1\oplus1 & 0\oplus1 \\ 0 & 1 & 1 & 0 & 1 \end{array}$$

2/3/23 Unit-2 Binary Arithmatic

- Binary Addition

- 0+0=0
- 1+0=1
- 0+1=1
- 1+1=10

$(1)_2 \rightarrow (1)_{10}$

```
  1        1
+ 1      + 1
 10  <--   2
```

1+1+1=11 (result, carry)

$(3)_{10} \rightarrow (011)_2$

e.g.

```
 carry: 1   1   1   1   1
        16  8   4   2
        1   0   1   0   1        21
      + 1   1   0   1   1        27
      1 1   0   0   0   0        48
     32 16
     =48
```

```
        1   1   1   1
        1   1   1   1   1
      + 1   1   0   1   1
      1 1   1   0   1   0
```

```
   1             1 1 1   1 1 1 1
   1 1 0 1 1 0 1 1 . 1 1 0 1 1
 + 1 1 1 0 0 0 1 1 . 1 0 1 1 1
 1 1 0 1 1 1 1 1 1 . 1 0 0 1 0
```

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Binary Subtraction

Logic

	Diff	Borrow
	0 − 0 = 0	0
	1 − 0 = 1	0
	1 − 1 = 0	0
	10 − 1 = 1	1

(∵ is possible if there is a digit ava. for providing borrow).

$$\begin{array}{r} 99 \\ \cancel{1}\cancel{0}\cancel{0}\cancel{1}0 \\ -5 \\ \hline 995 \end{array}$$

- e.g. (1 1 1 — Borow, 2)

$$\begin{array}{r} \cancel{1}\,\cancel{0}\,\cancel{0}\,\cancel{0}\,1 \\ -\;1\;1\;1\;1 \\ \hline 0\;0\;1\;0 \end{array}$$

- e.g.

$$\begin{array}{r} 0\,1 \\ \cancel{1}\cancel{0}10\;\;0\,1\,1\,1 \\ -\;100\;\;1\;\;0\,1\,1\,1 \\ \hline 1\;1\;0\;0\;0\;0 \end{array}$$

- e.g.

$$\begin{array}{r} 1\,0\,1\,1 \\ \cancel{1}\;\cancel{1}\,\cancel{0}\;\cancel{1}0\;10\;1\;1 \\ -\;1\;1\;1\;\;1\;1\;1\;1 \\ \hline 1\;0\;\;0\;1\;0\;0 \end{array}$$

Ans
1001001

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

(A+B) − C

```
  1 1 0 1 1 0
+ 1 0 1 1 0 1
1101 1 0 1 1
```

```
  1 1 0 1 1 0
+ 1 0 1 1 0 1
1 1 1 1 0 1 1
```

```
  1 1 0 1 1 0 1 1
−       1 1 0 1 0
  1 1 0 0 0 0 0 1
```

```
  1 1 1 1 0 1 1
−     1 1 0 1 0
  1 1 0 0 0 0 1
```

```
  1 1 0 1 1 0
+ 1 0 1 1 0 1
1111 1 0 1 1
```

```
  1 1 0 1 1 0
  1 0 1 1 0 1
1 1 1 1 0 1 1
```

```
  1 1 1 1 1 0 1 1
          1 1 0 1 0
          0 0 0 0 1
```

```
  1 1 1 1 0 1 1
      1 1 0 1 0
  1 0 0 0 0 0 1
```

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```
  1 1 1
  1 1 0 1 1 0
+ 1 0 1 1 0 1
-------------
1 1 1 1 0 1 1
```

```
  1 1 1 1 0 1 1
-     1 1 0 1 0
---------------
      0 0 0 0 0
```

```
  1 1 1
  1 1 0 1 1 0
+ 1 0 1 1 0 1
-------------
1 1 1 1 0 1 1
-   1 1 0 1 0
-------------
1 1 0 0 0 0 1
```

```
  1 1 1
  1 1 0 1 1 1 0
+   1 0 1 1 0 1
---------------
1 1 0 0 0 0 1 1
```

```
      0 1 1
  1 1 0 0 0 0 1 1
-       1 1 0 0 0
-----------------
  1 0 0 1 0 0 1
```

```
  1 0 1 1 0 0 1 1
-       1 1 0 1 0
-----------------
            0 0 1
```

```
  1 1 0 1 1 0
+ 1 0 0 1 1 1 0 1
-----------------
1 0 1 1 0 0 1
```

```
  1 1 1
  1 1 0 1 1 0
+ 1 0 1 1 0 1
---------------
1 1 0 0 0 0 1 1
```

```
  1
  0
+ 1
---
  1
```

0+1 = 1 but 1 is carry so 1+1 = 10

```
      0 1
  1 1 0 0 1 0 0 1 1
-         1 1 0 1 0
-------------------
    1 0 0 1 0 0 1
```

Ans: 1001001

9/3/23

- For negative result fails

$$\begin{array}{r} \overset{0}{\cancel{1}}\ \overset{10}{\cancel{1}}\ 10 \\ 1\ \ 1\ \ 1 \\ \hline 1\ \ 1 \end{array}$$ – fails

– 1^{st} complement

- $1111 - XXXX =$ ____

- $11 - 10 = \boxed{0\ 1}$ 1^{st} comp

- $111 - 101 = 010$

- Short trick: Inverse the digits. Trick = 1^{st} comp.

- $101101 \rightarrow 010010$ left digits inverse

  1^{st} complement

– 2^s complement

2^s comp. = $1's$ comp. $+1$

$= 01 + 1 = 10$

$$\begin{array}{r} 010 \\ +\ 1 \\ \hline 11 \end{array}$$

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- 101101
  010011

- A= 1001001

1's complement = ~~0110110~~ ~~1001001~~

= 0110110

2's complement = 0110111

- 1100100100 to be retained

1's comp. = ~~0011011011~~ 11011011

2's comp. = 11011100

- B.S using 1's complement method

- 110 − 111

  ↓ 1's complement

  110 + 000

  = 110 if no carry is generated then ans. is −ve & is in 1's complement form

  = 001

  = −1

- 1001 − 1110

  ↓

  0001

  1001 + 0001 = 1010

  Carry generated known as end over carry

  010

  −5

- 111 − 110

  ↓

  001

  111 + 001 = 1000

  + 1

  1

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eg. 1110 − 1001
↓
1110 + 0110

$$\begin{array}{r} 1110 \\ 110 \\ \hline 10100 \\ +\ 1 \\ \hline 101 \\ \hline 5 \end{array}$$

- B.S. using 2's complement method.

· 110 − 111
↓ 2's comp.
110 + 001

111
001 2's comp.
−

· 1001 − 1110
↓
0010

1001 + 0010
1011
2's comp.
$0\boxed{101}$
−ve ans 5

A-B
=A+(-B)

- 111 − 110

$\downarrow$

010

111 + 010

1001

$$\begin{array}{r} ^{1}\\ 111 \\ 10 \\ \hline ~~1~~001 \end{array}$$

* Ignore that carry.

- 1110 − 1001

$\downarrow$

0111

$$\begin{array}{r} ^{1}\,^{1}\quad\quad \\ 1110 \\ +0111 \\ \hline ~~1~~0101 \end{array}$$

Q: Using 1's comp.

i) 1010111 − 1110011

$\downarrow$

0001100

$$\begin{array}{r} ^{1}\,^{1}\,^{1}\quad\quad\quad \\ 1010111 \\ +0001100 \\ \hline 1100011 \end{array}$$

0011100

(−)

ii) Using 2's comp.

1010111 − 1110011

↓

0001101

$$\begin{array}{r} 1010111 \\ +\ 0001101 \\ \hline 1100100 \end{array}$$

− 0011100

Q2. 11101 − 10011

i) Using 1's comp.

11101 − 10011

↓

01100

$$\begin{array}{r} 11101 \\ +\ 01100 \\ \hline 1\,01001 \\ +\ \quad 1 \\ \hline 1010 \end{array}$$

ii) Using 2's comp.

11101 − 10011

↓

01101

$$\begin{array}{r} 11101 \\ +\ 01101 \\ \hline 1\,01010 \end{array}$$

1010

14/3/23

- Binary Multiplication

-
```
   1 0 1     5
 × 1 1       3
 --------
   1 0 1
+1 0 1 0
 --------
 1 1 1 1 - 15
```

-
```
    8 4 2 1
    1 1 0 1     13
 ×  1 0 × 1     ×5
 ------------
    1 1 0 1
+ 1 1 0 1 0 0
 ------------
 1 0 0 0 0 0 1 - 65
64           1
```

-
```
      1 0 0 0 0 0 1      A
 ×      1 0 1 1 1 1      B
 --------------------
        1 0 0 0 0 0 1
      1 0 0 0 0 0 1 0
    1 0 0 0 0 0 1 0 0
  1 0 0 0 0 0 1 0 0 0
1 0 0 0 0 0 1 0 0 0 0
1 0 0 0 0 0 1 0 0 0 0 0
 --------------------
1 1 1 1 1 1 0 1 1 1 1 1
```

B×A (for saving time)

```
          1 1 1 1 1 1
      × 1 0 0 0 0 0 1
 --------------------
          1 1 1 1 1 1
1 1 1 1 1 1 0 0 0 0 0 0
 --------------------
1 1 1 1 1 1 1 1 1 1 1 1
```

Binary Division

-
```
       100      4.
10 ) 1000       8
     10↓↓
     0000
```

-
```
11 ) 1001
     less than 11 so select 3 digits
```

```
        11
11 ) 1001
      11
       11
      -11
       00
```

-
```
       101
11 ) 1111
     11↓↓
     0011
       11
       00
```

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- e.g. $10 \overline{)1110}$ quotient 111

$$\begin{array}{r} 1110 \\ \underline{10} \\ 11 \\ \underline{10} \\ 10 \\ \underline{10} \\ 00 \end{array}$$

- e.g. $11 \overline{)101}$ quotient 1.100

$$\begin{array}{r} 101 \\ \underline{11} \\ 100 \\ \underline{11} \\ 200 \end{array}$$

$10 \overline{)101}$ quotient 10.1 (2.5)

$$\begin{array}{r} 101 \\ \underline{10\downarrow} \\ 0010 \\ \underline{10} \\ 00 \end{array}$$

$5/2 = 2.5$

$11 \overline{)110}$ quotient 10

$$\begin{array}{r} 110 \\ \underline{11\downarrow} \\ 000 \end{array}$$

- In exam just write R= & q=
- ~~e.g.~~

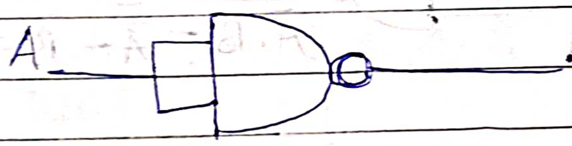
Logic Gates

- Basic
  - AND
  - OR
  - NOT
- Special
  - EXOR
  - EXNOR
- Universal
  - NAND
  - NOR

SSI small scale integration

- 5 nand gates then all diff. gates can be prepared

NAND as NOT



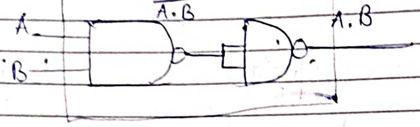
$\overline{A.B} = \overline{A.A}$

$= \overline{A}$

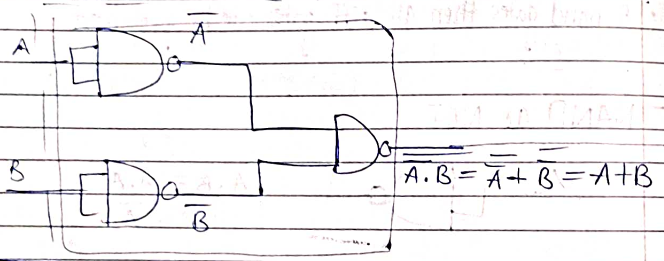
Formulas:

- $A+0=A$ • $A.A=A$
- $A+1=1$
- $A+\overline{A}=1$
- $A.0=0$
- $A.1=A$
- $A.\overline{A}=0$
- $A+A=A$

- NAND as AND

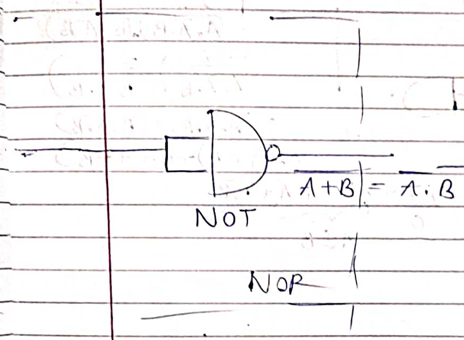


- NAND as OR



- $\overline{A.B} = \overline{A}+\overline{B}$
  $\overline{A+B} = \overline{A}.\overline{B}$ } De Morgan's Law

- Further Noting, & it becomes NOR gate.



At max 5 gates we can prepare all other gates

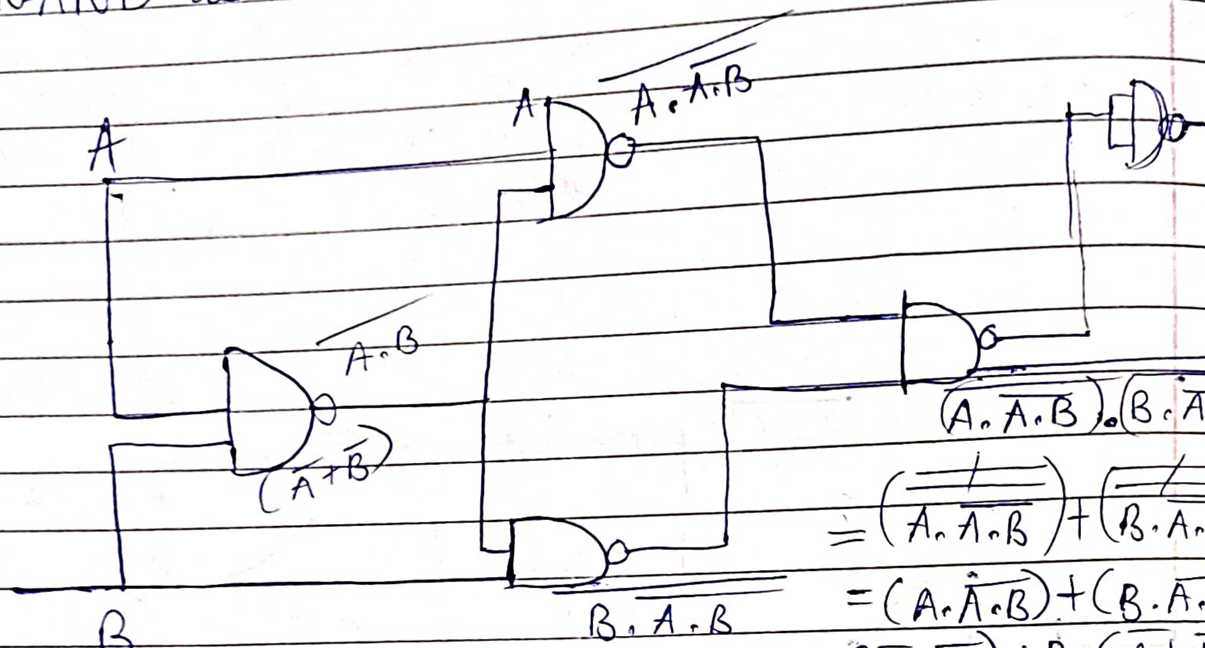
Exam

Why NAND & NOR gates are known as universal gates

OR

universality of NAND & NOR gates

- NAND as EXOR



$\overline{(\overline{A\cdot\overline{A\cdot B}})\cdot(\overline{B\cdot\overline{A\cdot B}})}$

$= \left(\overline{\overline{A\cdot\overline{A\cdot B}}}\right) + \left(\overline{\overline{B\cdot\overline{A\cdot B}}}\right)$

$= (A\cdot\overline{A\cdot B}) + (B\cdot\overline{A\cdot B})$

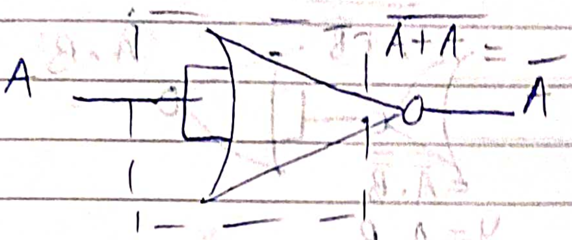
$= A\cdot(\overline{A}+\overline{B}) + B\cdot(\overline{A}+\overline{B})$

$= \underbrace{A\overline{A}}_{0} + \underbrace{A\overline{B} + B\overline{A}}_{A\oplus B} + \underbrace{B\overline{B}}_{0}$

21/3/23

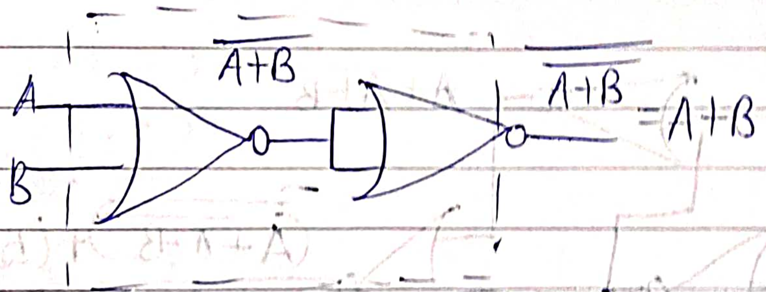
- Universality of NOR Gate.

- NOR as a NOT

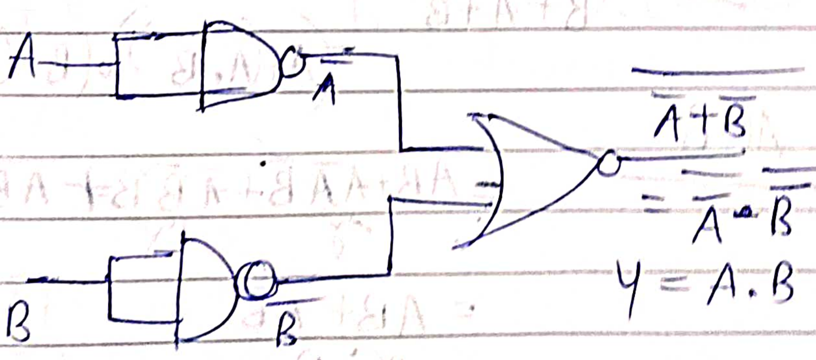


Short the inputs of NOR Gate

- NOR as OR



- NOR as AND

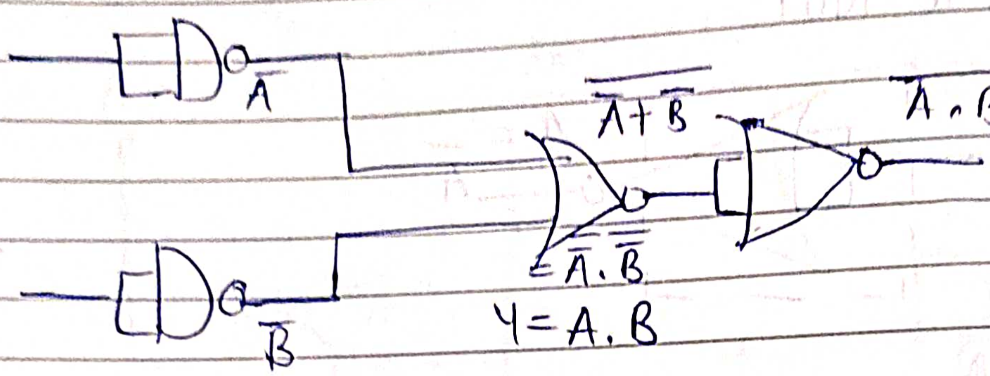


$Y = A \cdot B$

De Morgan's law

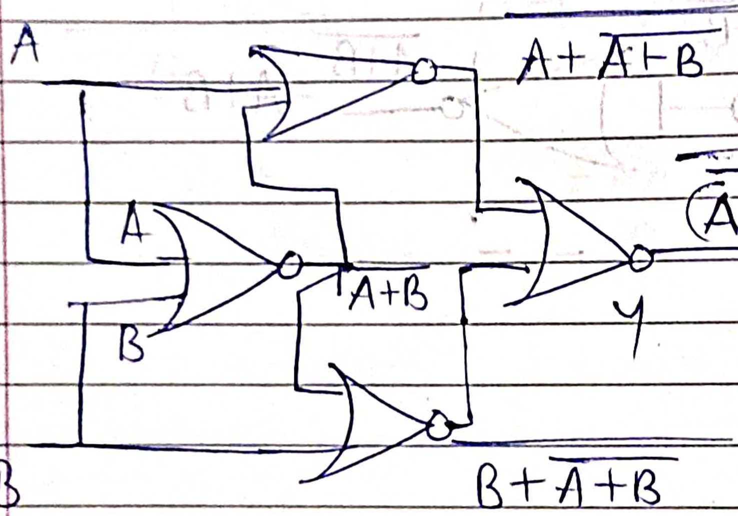
$$\overline{A+B} = \bar{A}\cdot\bar{B}$$
$$\overline{A\cdot B} = \bar{A}+\bar{B}$$

- NOR as NAND

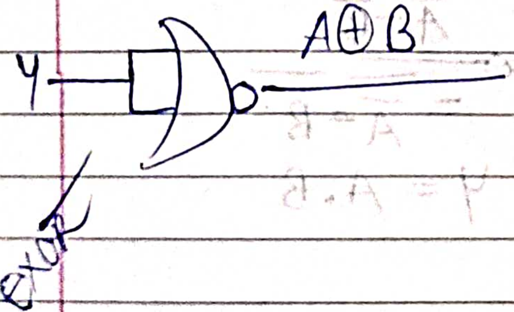


$Y = A\cdot B$

- NOR as EXNOR



$$\overline{\overline{(A+\overline{A+B})}+\overline{(B+\overline{A+B})}}$$
$$=\overline{\overline{(A+\overline{A+B})}}\cdot\overline{\overline{(B+\overline{A+B})}}$$
$$=(A+(\overline{A+B}))\cdot(B+(\overline{A+B}))$$
$$=(A+(\bar{A}\cdot\bar{B}))\cdot(B+(\bar{A}\cdot\bar{B}))$$
$$=AB+\underbrace{A\bar{A}}_{0}\bar{B}+\bar{A}\underbrace{\bar{B}B}_{0}+\bar{A}\bar{B}$$
$$=AB+\bar{A}\bar{B}$$
$$=A\odot B$$



Solving Expressions

$1 + 4 \quad 2 + 3 = 6$ AND, 3 OR

- $Y = A + AB + ABC + ABCD$
$= A(1 + (B + BC + BCD))$
$= A.$

- $Y = AB + BC$ (AND, OR, AND)
$= A.(B+C)$ OR AND

- $Y = A + (B.C)$
$= (A+B).(A+C)$
$= A + AC + AB + BC$
$= A + (A + \cancel{C} + B) + BC$
$= A + BC$

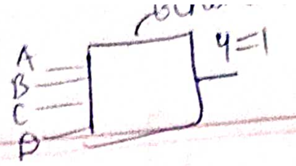
- $X \cdot (Y+Z)$
$= X \cdot Y + X \cdot Z$

$X + (Y.Z)$
$(X+Y).(X+Z)$

- $A + AB$
$= A$

- $A + \overline{A}B$
$= (A+\overline{A}).(A+B)$
$= 1.(A+B)$
$= A+B$

$A+1=1$
$A+0=A$
$A+\overline{A}=1$
$A+A=A$
$A.1=A$
$A.0=A$
$A.\overline{A}=0$
$A.A=A$



1. $Y = AB + BC + AC + \bar{C} + B\bar{C} + \bar{C}D + \bar{B}C + \bar{B}\bar{C}$

$\cancel{X = B(A+C) + \bar{C}(1+(B+D+\bar{B})) + \bar{B}(C+\bar{C}) + AC}$

$\cancel{= B(A+C) + \bar{C}(1+(1+D)) + \bar{B}(1) + AC}$

$= AB + C(B + A + \bar{B}) + \bar{C}(1 + B + D + \bar{B})$

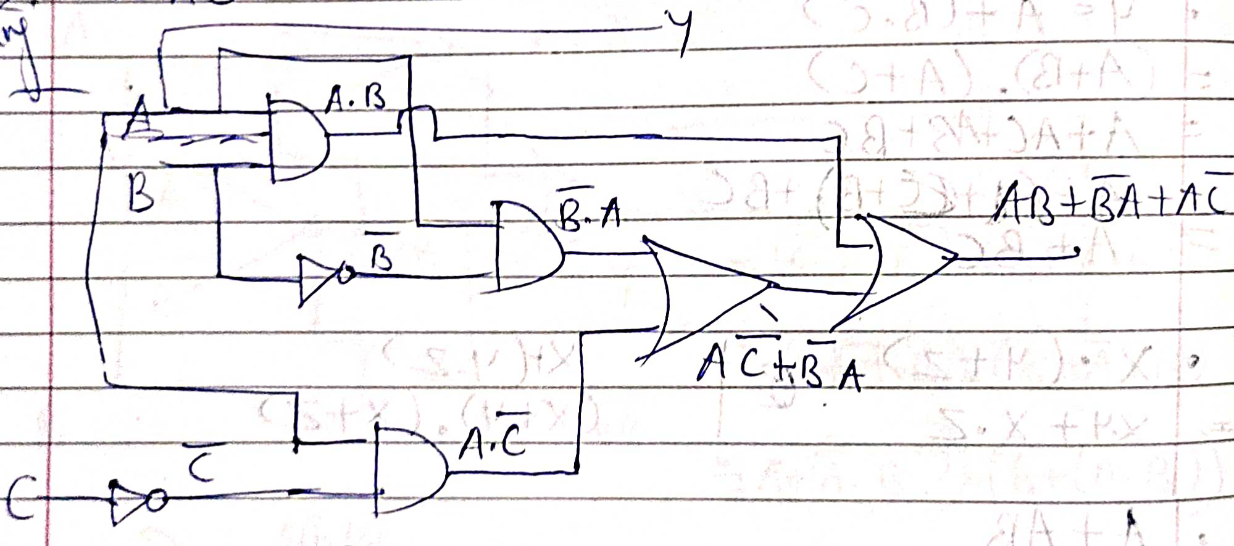
$= AB + C + \bar{C}$

$= AB + 1 = 1$

1 — Y
A
B
C
D

2. $Y = AB + \bar{B}A + A\bar{C}$

Designing ckt



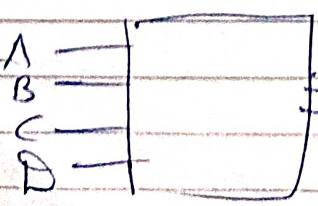
$= A.(B + \bar{B} + \bar{C})$

$= A(1 + \bar{C})$

$= A$

$A \longrightarrow Y$

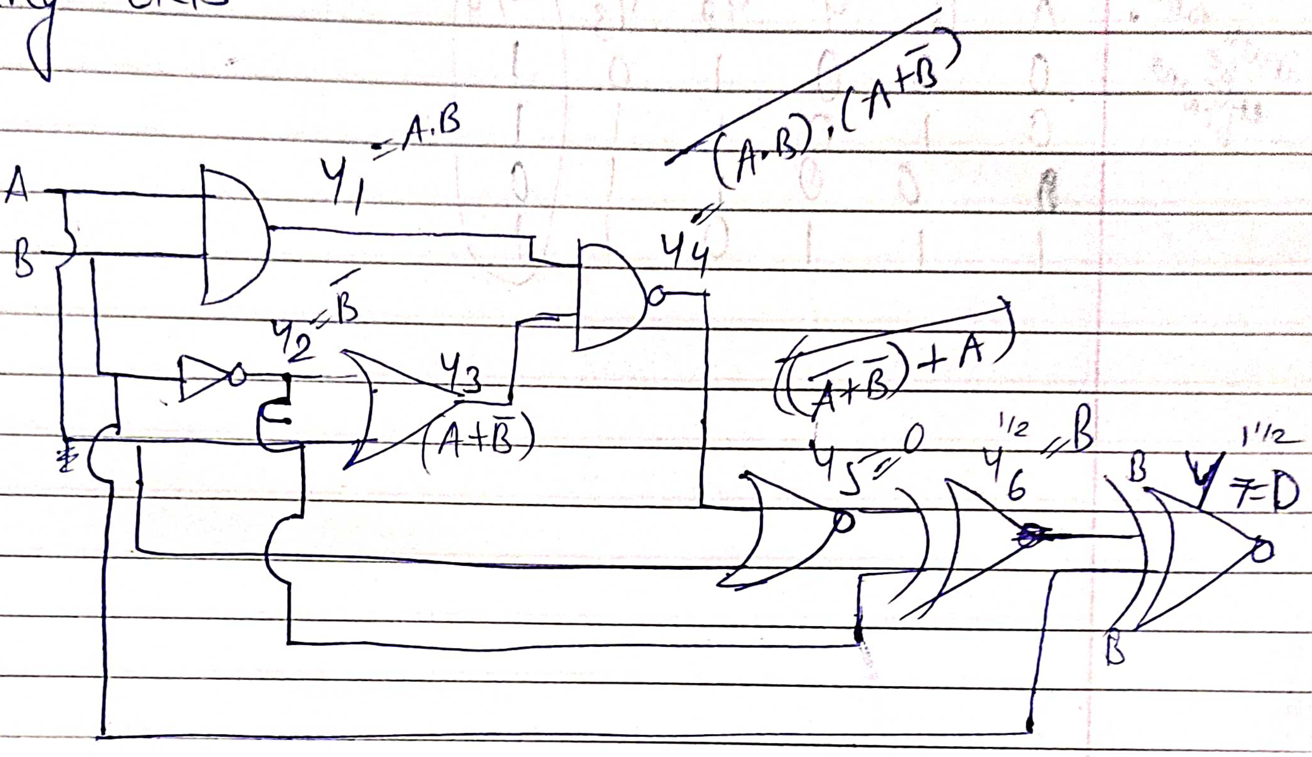
but if we have



Y=AB+CD

we have to draw the ckt

Solving Ckts



$Y_1 = A.B$
$Y_2 = \cancel{A} + \overline{B}$
$Y_3 = \overline{B} + A$
$Y_4 = A.B$

$Y_4 = \overline{(A.B)\cdot(A+\overline{B})}$
$= \overline{AB + AB\overline{B}}$
$= \overline{AB}$
$= \overline{A} + \overline{B}$

$Y_5 = \overline{(\overline{A+\overline{B}}) + A} = \overline{\overline{A+\overline{B}}\,.\,A}$
$= \overline{(\overline{A}.\overline{\overline{B}}).\overline{A}}$
$= A.B.\overline{A}$
$= 0$

$Y_6 = \cancel{B}\; Y_5\overline{B} + \overline{Y_5}.B$
$= 0.\overline{B} + 1.\overline{B}$
$= \overline{B}$

$Y_7 = B.B + \overline{B}\,\overline{B}$
$= B + \overline{B}$ B EXNOR $\overline{B}$
$= 1$ $= 0$