$\boxed{-2^{n-1}}$ — $\boxed{+2^{n-1}-1}$

DATE ___/___/20___

Convential Method → 1's Complement method

$2^3 = 8$

000 +0
001 +1
010 +2
011 +3
$\boxed{100\ -0}$
101 −1
110 −2
$\boxed{111\ -3}$

1's Complement

000	+0	+0
001	+1	+1
010	+2	+2
011	+3	+3
100	−3	−4
101	−2	−3
110	−1	−2
$\boxed{111\ -0}$		−1

0 — 1
1 — 0
bitwise Operation

0 0 0
↓ ↓ ↓
1 1 1

001 → 110

−17

0 0010001 ① 10010001
② 11101110
③ 11101111

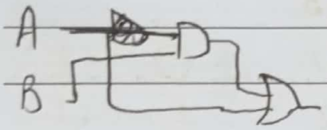
2's Complement

0 0 0
↓ ↓ ↓
1 1 1

Simplification

Using Boolean Algebra:
Rule / Properties / Law.

$A + AB$



$A + AB$
$A\cdot 1 + A\cdot B \quad \because A\cdot 1 = A$
$A(1+B) \quad \because DL$
$A(B+1) \quad \because CL$
$A(1) \quad \because A+1=1$
$\boxed{A}$

$\overline{AB}\,(\bar{A}+B)$
$\overline{AB}\cdot\bar{A} + \overline{AB}\cdot B \quad DL$
$(\bar{A}+\bar{B})\cdot\bar{A} + (\bar{A}+\bar{B})\cdot B \quad \because$ DeMorgan
$\bar{A}\bar{A} + \bar{A}\bar{B} + \bar{A}B + B\bar{B} \quad DL$
$\bar{A} + \bar{A}\bar{B} + \bar{A}B + 0 \quad \bar{A}\cdot\bar{A} = \bar{A}$ & $\bar{A}\cdot A = 0$
$\bar{A}(1+\bar{B}+B)$
$\bar{A}(1)$
$\boxed{\bar{A}}$

$A + \overline{AB}$
$A + (\bar{A}+\bar{B}) \quad \because A+\bar{A} = 1$
$1 + \bar{B}$
$\boxed{1}$

Q) $(A+B)(AD+A\bar{D}) + AB + B$
$AAD + AA\bar{D} + ABD + AB\bar{D} + AB + B$
$AA(D+\bar{D}) + AB(D+\bar{D}) + AB + B$
$AA + AB + AB + B$
$AA + AB + B$
$A + AB + B$
$A(1+B) + B$
$\boxed{A+B}$

Q) $A\bar{B}C + \bar{A}BC + \bar{A}\bar{B}C$
$C(A\bar{B} + \bar{A}B + \bar{A}\bar{B})$
$C[\bar{B}(A+\bar{A}) + \bar{A}B)]$
$C(\bar{B} + \bar{A}B)$
$C\bar{B} + \bar{A}BC$

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

$\overline{AB(\bar{C}D+\bar{E}F)}$
$\bar{A} + \bar{B} + \overline{(\bar{C}D+\bar{E}F)}$
$\bar{A} + \bar{B} + \overline{\bar{C}D}\cdot\overline{\bar{E}F}$
$\bar{A} + \bar{B} + (\bar{\bar{C}} + \bar{D} \cdot \bar{\bar{E}} + \bar{F})$
$\bar{A} + \bar{B} + [(C+\bar{D})\cdot(E+\bar{F})]$

Q) $\overline{\overline{AB}\cdot(CD+\bar{E}F)\cdot(\overline{AB}+\bar{C}D)}$

$\overline{\overline{AB}} + \overline{(CD\cdot\bar{E}F)} + \overline{(\overline{AB}+\bar{C}D)}$

$AB + \overline{\bar{C}D} + \overline{\overline{\bar{E}F}} + \overline{\overline{AB}}\cdot\overline{\overline{\bar{C}D}}$
$AB + \overline{CD} + \overline{\bar{E}F} + ABCD$
$AB + \bar{C} + \bar{D} + E + \bar{F} + ABCD$

GO GETTERS

IEEE
Floating Point
Number Standard.

32 bit (Single P)
64 bit (Double P)

Sign	Exponent	Magnitude (Mantisa)

① +ve FPN
② -ve FPN
③ +ve Power FPN
④ -ve Power FPN

+	-
$1.34\times10^{1} \leftarrow +13.4$	-13.4
$1.34\times10^{-3} \leftarrow +0.00134$	-0.00134
$1.34\times10^{0} \leftarrow +1.34$	-1.34

1-9

① Normalization $(\overset{1.}{a}.b\ldots\ast 10^{x})$

non-binary #
① Convert binary
② normalization

Q.) 19

10011.

$1.0011\times2^{+4}$

1	8	23
0	00000100	001000....
Sign	Exponent	Mantiss

Formula for unsigned No. $\boxed{2^{n}-1}$ n = no of bits in register
Range: $0 - 2^{n}-1$

Signed No $\boxed{2^{n-1}-1}$. Sign flag is high then the number is +ve.

+0 to +3 $\underbrace{1111}\underbrace{1111} = -1$
-0 to -3

OR & AND are commutative, associative and distributive
NAND is not associative
EX-OR is commutative, associative but not distributive.

GO GETTERS

Q) $(P'+Q+R)(P'+Q'+R)(Q'+R')$

$[P'P'+P'Q'+P'R+P'Q+QQ'+QR+P'R+RQ'+RR](Q'+R')$

$[P'+P'(Q'+Q)+P'R+0+R(Q+Q')+R+R](Q'+R')$

$P'+P'R+R+(Q'+R')$

$P'(1+R)+R+(Q'+R')$

$[P'+R](Q'+R')$

$P'Q'+P'R'+RQ'+RR'$

$\boxed{P'Q'+P'R'+RQ'}$

Q) $AB+AB'C+AB'C$

$AB+AB'C$

$A(B+B'C)$

$\boxed{A(B+C)}$

We need to solve this way.

$A(B+B'C+B'C)$

$A(B+C+B'C)$

$A(B+C+C)$

$\boxed{A(B+C)}$

Q) $a+a'b+a'b'c+a'b'c'd+a'b'c'd'e$

$a+a'(b+b'c+b'c'd+b'c'd'e)$ $\quad \therefore a+a'b=a+b$

$a+b+b'c+b'c'd+b'c'd'e$

$a+b+c+b'c'd+b'c'd'e$

$a+b+c+b'c'(d+d'e)$

$a+b+c+b'c'(d+e)$

Q) $X'Y+YZ'+YZ+XY'Z$

$X'Y+Y(Z'+Z)+XY'Z$

$Y+X'Y+XY'Z$

$Y(1+X')+XY'Z$

$Y+XY'Z$

Q) $W(W'+X'+Z')(W'+XZ)$

$0+WX'+WZ'(W'+XZ)$

$W(X'+Z')(W'+XZ)$

$(X'+Z')(WXZ)$

$WXX'Z+WXZZ'$

$0+0$

$\boxed{0}$

Q) $(P+\bar{Q}+\bar{R})(P+\bar{Q}+R)(P+Q+\bar{R})$

$[PP+P\bar{Q}+PR+\bar{Q}P+\bar{Q}\bar{Q}+\bar{Q}R+\bar{R}P+\bar{R}\bar{Q}+\bar{R}R](P+Q+\bar{R})$

$[P+P(1)+P(1)+\bar{Q}+\bar{Q}(1)+0](P+Q+\bar{R})$

$(P+\bar{Q})(P+Q+\bar{R})$

$PP+PQ+P\bar{R}+\bar{Q}P+\bar{Q}Q+\bar{Q}\bar{R}$

$P+P(1)+P\bar{R}+\bar{Q}\bar{R}$

$P(1+\bar{R})+\bar{Q}\bar{R}$

$\boxed{P+\bar{Q}\bar{R}}$

Twos Complement

DATE __/__/20__

Sign Magnitude

$\underbrace{0}_{}\underbrace{100}_{} = 4$

0 = +ve

1 = -ve

1's Complemet

01101

Reverse

10010

2's Complement

10010

\+ 1

10011

Binary Addition / Subtraction Using 1's Complement:

3 = + 0011

2 = - 0010

1st Complement

1101

3-2

0011

1101

(1)0000

1

0001

2 - 3 = -1

0010

\+ 1100 → 1's Complem

1110

1's Complement

\- 0001

-3 - 4

1100

1011

10111

0111

1000

$\boxed{-0111}$

GO GETTERS

DATE ___/___/ 20___

Addition/Subtraction Using 2's Complement:

3 - 2 = 1

$$\begin{array}{r} +0011 \\ -0010 \end{array} \xrightarrow{1's\ Comp} 1101$$

$$\xrightarrow{2's\ Comple} \begin{array}{r} 1101 \\ +1 \\ \hline 1110 \end{array}$$

$$\begin{array}{r} 0011 \\ 1110 \\ \hline \text{①}0001 \end{array}$$

over flow ↓ we ignore this bit

2 - 3 = -1

$$\begin{array}{r} 0010 \\ -0011 \end{array} \rightarrow \begin{array}{r} 1100 \\ +1 \\ \hline 1101 \end{array}$$

$$\begin{array}{r} 0010 \\ +1101 \\ \hline (-1)\ 1111 \end{array}$$

0000

$\boxed{0001}$ +1

-0001 (-1)

-3 - 2 = -5

$$\begin{array}{r} 1101 \\ 1110 \\ \hline 11011 \\ 0100 \\ 1 \\ \hline 0101 \end{array}$$

Binary Representation of Fraction values.

$(93.75)_{10} = (?)_2$

$(1011101.11)_2$

64 32 16 8 4 2 1 ½ ¼

93 = 1011101

.75 = .11

64+16+8+4+1 = 93

$0.75 = \frac{1}{2} + \frac{1}{4}$

$(93.75)_{10}$

$(93.75)_{10} = (1011101.11)_2$

$0.75 \times 2 = 1$

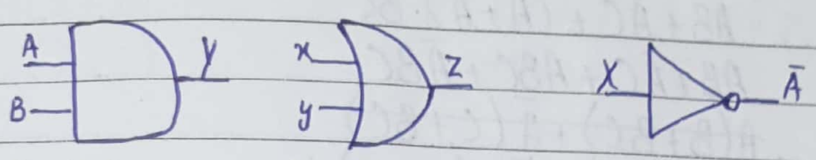
$0.50 \times 2 = 1$ ↓

DATE ___/___/20___

Logic Gates & Boolean Algebra:

Three basic gates AND $(\cdot)$ OR $(+)$ NOT $(\bar{\ }), ('), (\sim)$

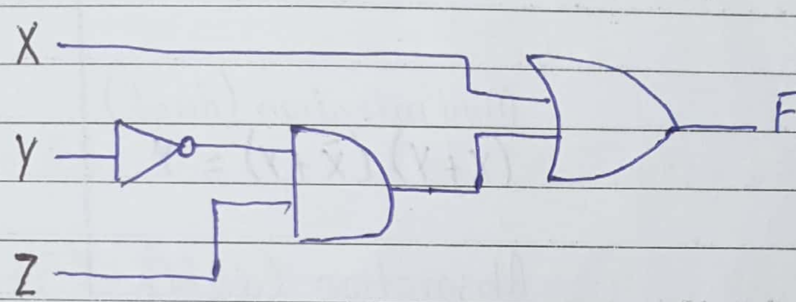
$Y = A \cdot B$ $Z = x + y$ $X = \bar{A}$



Switches in Series Switches in ~~[illegible]~~ Parallel Normally closed ~~[illegible]~~ switch

$F = X + \bar{Y}Z$

Order of evaluation
1) Parentheses
2) NOT
3) AND
4) OR



Laws of Boolean Algebra:

Double Negation
NOT $\bar{A} = A$

$A + 1 = 1$ $A \cdot 1 = A$ identity $\bar{\bar{X}} = X$ involution

$A + 0 = A$ $A \cdot 0 = 0$ Annulment

$A + A = A$ $A \cdot A = A$ Indempotent $AB + \bar{A}C + BC = AB + \bar{A}C$ (Consensus Theorem)

$A + \bar{A} = 1$ $A \cdot \bar{A} = 0$ Complement

$A + B = B + A$ $A \cdot B = B \cdot A$ Commutative

$\overline{A+B} = \bar{A} \cdot \bar{B}$ $\overline{A \cdot B} = \bar{A} + \bar{B}$ de Morgan's Theorem

$(A+B)+C = A+(B+C)$ $(AB).C = A.(B.C)$ Associative

$A(B+C) = AB + AC$ $A + BC = (A+B)(A+C)$ Distibutive.

$A \cdot A + A \cdot C + A \cdot B + B \cdot C$

$A + A \cdot C + A \cdot B + B \cdot C$

$A(1+C) + AB + BC$ $\therefore 1 + C = 1$

$A \cdot 1 + AB + BC$

$A(1+B) + BC$ $\therefore 1 + B = 1$

$A \cdot 1 + BC$

$\boxed{A + BC}$

DATE ___/___/ 20___

Consensus Theorum: $AB + \bar{A}C + BC = AB + \bar{A}C$

$$AB + \bar{A}C + 1 \cdot BC$$
$$AB + \bar{A}C + (A + \bar{A}) \cdot BC$$
$$AB + \bar{A}C + ABC + \bar{A}BC$$
$$\cancel{A(B + BC) + \bar{A}(C + BC)}$$
$$AB(1 + C) + \bar{A}C(1 + B)$$
$$AB \cdot 1 + \bar{A}C \cdot 1$$
$$\boxed{AB + \bar{A}C}$$

Useful Theorems:

Minimization:
$XY + \bar{X}Y = Y$

Minimization (dual)
$(X + Y)(\bar{X} + Y) = Y$

Absorption
$X + XY = X$

Absorption (dual)
$X \cdot (X + Y) = X$

Simplification
$X + \bar{X}Y = X + Y$

Simplification (dual)
$X \cdot (\bar{X} + Y) = X \cdot Y$

DeMorgan's
$\overline{X + Y} = \bar{X} \cdot \bar{Y}$

DeMorgan's (dual)
$\overline{X \cdot Y} = \bar{X} + \bar{Y}$

DATE ___/___/ 20___

Practice Questions:

(i) $(X+Y)(X+\bar{Y})(\bar{X}+Z)$

$(XX+X\bar{Y}+XY+Y\bar{Y})(\bar{X}+Z)$

$(X+X(\bar{Y}+Y)+0)(\bar{X}+Z)$

$(X+X\cdot 1)(\bar{X}+Z)$

$X(\bar{X}+Z)$

$X\bar{X}+XZ$

$0+XZ$

$\boxed{XZ}$

(ii) $XYZ+X\bar{Y}Z+XY\bar{Z}$

$XY(Z+\bar{Z})+X\bar{Y}Z$

$XY\cdot 1+X\bar{Y}Z$

$XY+X\bar{Y}Z$

$X(Y+\bar{Y}Z)$ Distributive Law

$X(Y+\bar{Y})(Y+Z)$

$X\cdot 1\cdot(Y+Z)$

$\boxed{X(Y+Z)}$

Example 6

a) $X=ABC+\bar{A}B+AB\bar{C}$

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

$=AB\cdot 1+\bar{A}B$

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

$=B\cdot 1$

$\boxed{X=B}$

b) $X=\bar{A}B\bar{C}+A\bar{B}\bar{C}+\bar{A}\bar{B}\bar{C}+\bar{A}\bar{B}\bar{C}$

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

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

$=\bar{A}\bar{C}\cdot 1+A\bar{B}\bar{C}$

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

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

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

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

c) $AB+\bar{A}C+BC=AB+\bar{A}C$

L·H·S

$AB+\bar{A}C+(A+\bar{A})BC$

$AB+\bar{A}C+ABC+\bar{A}BC$

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

$AB\cdot 1+\bar{A}C\cdot 1$

$\boxed{AB+\bar{A}C}$

Proved!

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

L·H·S $=(A\bar{A}+AC+\bar{A}B+BC)(B+C)$

$ABC+\bar{A}BB+BBC+ACC+\bar{A}BC+BCC$

$ABC+\bar{A}B+BC+AC+\bar{A}BC+BC$

$BC(A+\bar{A})+\bar{A}B+AC+BC$

$\bar{A}B+AC+BC$

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

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

$\boxed{(\bar{A}+C)(A+B)}$ Proved!

Binary Multiplication: 01010011 (multiplicand) 11000101 (multiplier)

Step1: The sign bit of the multiplicand is 0 and the sign bit for the multiplier is 1 - The sign bit for the product will be 1 (negative)

Step2: Take 2's Complement of multiplier to put it in true form.

11000101 → 00111011

Note: Only the magnitude bits are used in these steps.

```
          1010011        Multiplicand
        x 0111011        Multiplier
          1010011        1'st partial Product
        +1010011         2'nd Partial Product
         11111001        Sum of 1st & 2nd
        0000000          3rd Partial Product
        011111001        Sum
       1010011           4th Partial P
       1110010001        Sum
      1010011            5th Partial Product
     100011000001        Sum
     1010011             6th Partial Product
    1001100100001        Sum
    0000000              7th
    1001100100001
    0110011011110        1's Complement
                1
Sign Bit [1] 0110011011111   Answer.
```

Division:
Step1: Subtract the divisor from the dividend using 2's complement addition to get the first partial reminder and add 1 to the quotient - If this partial reminder is positive, go to Step 2 - If the partial remainder is zero or negative, the division is complete.
Step 2: Subtract the divisor from the partial remainder and add 1 to the quotient - If the result is positive, repeat for the next partial remainder - If the result is zero or negative, the division is complete.

Divide 01100100 by 00011001
Step1: Subtract the divisor from the divident using 2's complement addition. (remember the final carries are discarded)

```
  01100100   Dividend
+ 11100111   2's complement of divisor
  01001011   Positive 1st partial reminder.
```

Add 1 to quotient 00000000 + 00000001 = 00000001

Step2: Subtract the divisor from the 1st partial remainder using 2's Complement.

```
  01001011   1st Partial remainder
  11100111   2's complement of divisor.
  00110010   Positive 2nd partial remaindr
```

Add 1 to quotient 00000001 + 00000001 = 00000010

```
Step3   00110010   2nd Partial
        11100111   2's Comp divisor
        00011001   3rd Partia Rem
```

Add 1) 00000011

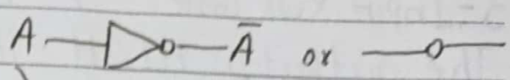
```
Step 4  00011001   3rd Partial
        11100111   2' Compl divisor
        00000000   Zero remainder
```

Add 1 to quotient 00000011 + 00000001 = $\boxed{00000100}$
Quotient.

DATE ___/___/ 20___

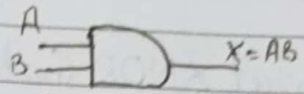
3 Design:
1) Truthteble
2) Logic Diagram
3) Expression

Logic Gates

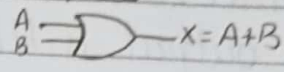


(~, !, ^, ⁻) NOT (Negate)

AND (all one) (·)



OR (any 1) (+ Similar)



$X = A \cdot B$

number of input = number of colum

for rows $2^{\text{number of input}}$

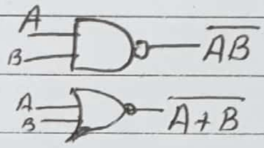
$\sim(AB) \neq \sim AB$

A	B
0	0
0	1
1	0
1	1

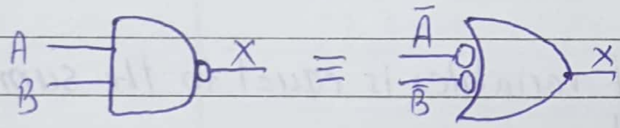
A	B	C
0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	1	0
1	1	1

NAND (Not of AND) $X = \overline{AB}$

NOR (Not of OR) $X = \overline{A+B}$

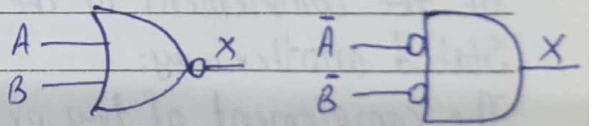


NAND = Negative-OR



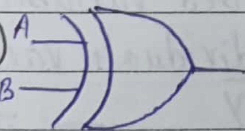
$\overline{AB} = \bar{A} + \bar{B}$

NOR = Negative-AND



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

Exclusive-OR (XOR)



Same = 0

Different = 1

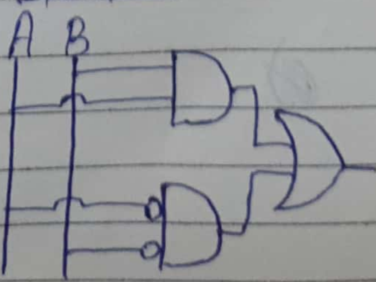
A	B	
0	0	0
0	1	1
1	0	1
1	1	0

Exclucive-NOR (XNOR)

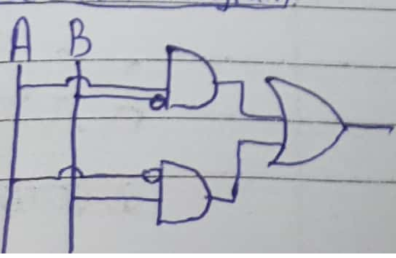
Same = 1 Different = 0

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

Equivilant



Equivilant Diagram:



3-Input XOR Gate: $Y = A \oplus B \oplus C$
The output is HIGH - if odd number of inputs are 1

3-Input XNOR Gate $Y = (A \oplus B \oplus C)'$
The output is HIGH - if even number of inputs are 1

~~De~~ Rule: 11

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

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

$(AA + AB) + \bar{A}B$ $\quad A = AA$

$A(A + AB) + \bar{A}B + A\bar{A}$ $\quad$ adding $A\bar{A} = 0$

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

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

$(A + B) \cdot 1$

$\boxed{A + B}$

Rule: 12

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

$AA + AC + AB + BC$

$A + AC + AB + BC$

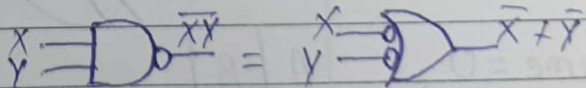
$A(1 + C) + AB + BC$

$A(1 + B) + BC$

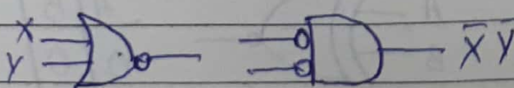
$\boxed{A + BC}$

De Morgan's First theorm
The complement of a product of variables is equal to the sum of the complement of the variables.
Stated another way:
The complement of two or more ANDed variable is equivalent to the OR of the complement of the individuals variables.

① $\overline{XY} = \bar{X} + \bar{Y}$



② $\overline{X + Y} = \bar{X} \cdot \bar{Y}$



$\overline{\overline{A + B\bar{C}} + D(\overline{E + \bar{F}})}$

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

$A + B\bar{C} \cdot [\bar{D} + (\overline{\overline{E + \bar{F}}})]$

Q) $\overline{(A + B + C)D}$

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

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

1110
0011
0010

$-8+4+2$

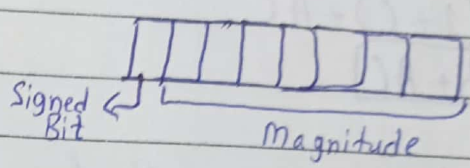
DATE ___/___/ 20___

The Largest decimal number $= 2^n - 1$

Example five bits $(n=5)$ $\qquad$ $(n=6)$

$2^5 - 1 = 31$ $\qquad$ $2^6 - 1 = 63$

Q) Decimal value of 1's Complement



a) 00010111 (16 8 4 2 1)

$16+4+2+1$

$\boxed{+23}$

(b) 11101000 (−128 64 32 16 8 4 2 1)

$-128+64+32+8$

-24

Add 1

$-24+1 = \boxed{-23}$

00011001 (+25)

10011001 (−25)

Q) 2's Complement

a) 01010110 (64 32 16 8 4 2 1)

$64+16+4+2$

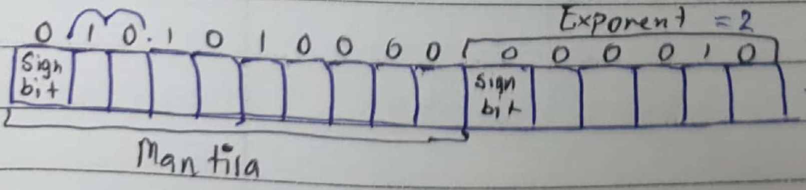
$\boxed{+86}$

(b) 10101010 (−128 64 32 16 8 4 2 1)

$-128+32+8+2$

$\boxed{-86}$

Normalization: FPN



$10.101 \quad 2^2$

$\boxed{2.625}$

0.1 0000000000 111110 Exponent = −2

0.001

$(0.125)_{10}$

DATE ___/___/ 20___

Q) $AB + A(B+C) + B(B+C)$

$AB + AB + AC + BB + BC$

$AB + B + AC + BC$

$B(1+A) + AC + BC$

$B(1+C) + AC$

$\boxed{B + AC}$

Q) $[A\bar{B}(C+BD) + \bar{A}\bar{B}]C$

$A\bar{B}CC + A\bar{B}BDC + \bar{A}\bar{B}C$

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

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

$\boxed{\bar{B}C}$

Standard Forms of Boolean Expressions:

2 Standard forms: (1) Sum of Product (SOP)

(2) Product of Sum (POS).

SOP: When two or more product terms are summed by Boolean addition, the resulting expression is a sum-of product (SOP)

Example: $AB + ABC$, $ABC + CDE + \bar{B}C\bar{D}$, $\bar{A}B + \bar{A}BC + A\bar{C}$.

Standard SOP Form: is one which all variables in the domain appear in each product term in the expression

Example: $A\bar{B}CD + \bar{A}BC\bar{D} + AB\bar{C}\bar{D}$

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

A	B	C	Output
0	0	0	0
✓0	0	1	1
0	1	0	0
0	1	1	0
✓1	0	0	1
1	0	1	0
1	1	0	0
✓1	1	1	1

CamScanner

SOP : 1

POS : 0

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DATE ___/___/20___

The karnaugh Map:

A karnaugh map provides systematic method for simplifying Boolean expressions and, if properly used, will produce the simplest SOP or POS expression possible, known as the minimum expression

3-Variable

AB \ C	0	1
00	0 $\bar{A}\bar{B}\bar{C}$	1 $\bar{A}\bar{B}C$
01	2 $\bar{A}B\bar{C}$	3 $\bar{A}BC$
11	6 $AB\bar{C}$	7 ABC
10	4 $A\bar{B}\bar{C}$	5 $A\bar{B}C$

010 is adjacent to 000, 010, 110

4-Variable

AB \ CD	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

Mapping SOP expression on k-map : $\bar{A} + A\bar{B} + AB\bar{C}$

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

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

1	1	1	1
1	1		1

The process that result in an expression containing the fewest possible terms with the fewest possible variables is called minimization.

- Variables that occurs both uncomplemented & complemented within the group are eliminated. These are called contradictory variables.

Q) Determine the product terms for the k-map in the figure and write resulting minimum SOP expression.

AB \ C		
	1	
		1
	1	1

Product term: $\bar{A}\bar{B}\bar{C} + \bar{A}BC + AB\bar{C} + ABC$

For minimization:

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

$\cancel{\bar{A}}BC + \cancel{A}BC = BC$

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

Minimum SOP $= AB + BC + \bar{A}\bar{B}\bar{C}$.

$\bar C\bar D + \bar A\bar B\bar D + \bar A B\bar C$

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

$A+\bar B C$

$A\cdot(\bar B+C)$

DATE ___/___/ 20___

POS : 3-Variable

	C	$\bar C$
	$A+B+C$	$A+B+\bar C$
	$A+\bar B+C$	$A+\bar B+\bar C$
	$\bar A+\bar B+C$	$\bar A+\bar B+\bar C$
	$\bar A+B+C$	$\bar A+B+\bar C$

4-Variable

	$C+D$	$C+\bar D$	$\bar C+\bar D$	$\bar C+D$
$A+B$				
$A+\bar B$				
$\bar A+\bar B$				
$\bar A+B$				

Q) $(A+B+C)(A+B+\bar C)(A+\bar B+C)(A+\bar B+\bar C)(\bar A+\bar B+C)$

	0	0
	0	0
	0	

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

$(A+B)(A+\bar B)=A$

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

Conversion (POS to SOP) : For POS expression all the cells that donot contain 0's contain 1's for which the SOP expression is derived. Likewise for an SOP expression all the cells that donot contain 1's contain 0's from which the POS expression is derived.

POS to SPOS : $F(A,B,C)=(A+B)\cdot(A+C)\cdot(A+\bar C)$

$(A+B+C\bar C)\cdot(A+C+B\bar B)\cdot(B+\bar C+A\bar A)$

$(A+B+C)\cdot(A+B+\bar C)\cdot(A+B+C)\cdot(A+\bar B+C)\cdot(B+\bar C+A)\cdot(B+\bar C+\bar A)$

$(A+B+C)\cdot(A+B+\bar C)\cdot(A+\bar B+C)\cdot(\bar A+B+C)$.

DATE ___/___/ 20___

Don't Care Condition in K'Map:

Sometimes a situation arises in which some input variables combinations are not allowed. For example in BCD code.

Decimal	Binary	SOP Term	7-segment display
0	0000	$\bar{A}\bar{B}\bar{C}\bar{D}$	a, f, e, d, c, b
1	0001	$\bar{A}\bar{B}\bar{C}D$	b, c
2	0010	$\bar{A}\bar{B}C\bar{D}$	a, b, g, e, d
3	0011	$\bar{A}\bar{B}C\bar{D}$	a, b, g, c, d
4	0100	$\bar{A}B\bar{C}\bar{D}$	f, g, b, c
5	0101	$\bar{A}B\bar{C}D$	a, f, g, c, d
6	0110	$\bar{A}BC\bar{D}$	a, f, e, g, c, d
7	0111	$\bar{A}BCD$	a, b, c
8	1000	$A\bar{B}\bar{C}\bar{D}$	a, b, f, e, g, c, d
9	1001	$A\bar{B}\bar{C}D$	a, f, b, g, c
10	1010	X	
11	1011	X	
12	1100	X	
13	1101	X	
14	1110	X	
15	1111	X	

POS (Product of Sum)

$(+) \cdot (+) \cdot (+)$

0 – Var

1 – Var'

Σ : Sum.

0 → Var'

1 → Var

POS Maxterm	A	B	SOP minterm	
$A + B$	0	0	$\bar{A} \cdot \bar{B}$	m_0
$A + \bar{B}$	0	1	$\bar{A} \cdot B$	m_1
$\bar{A} + B$	1	0	$A \cdot \bar{B}$	m_2
$\bar{A} + \bar{B}$	1	1	$A \cdot B$	m_3

π (Product)

Product of Maxterm

M

A \ B	00 ($A+B$, $\bar{A}\bar{B}$)	01 ($\bar{A}B$ / $A+\bar{B}$)
	0	1
	2	3
	10 ($A\bar{B}$, $\bar{A}+B$)	11 (AB / $\bar{A}+\bar{B}$)

For k-map POS we consider 0

For SOP we consider 1

	A	B	C	F	
$A+B+C$	0	0	0	0	0
$A+B+\bar{C}$	0	0	1	1	1
$A+\bar{B}+C$	0	1	0	1	2
$A+\bar{B}+\bar{C}$	0	1	1	0	3
$\bar{A}+B+C$	1	0	0	1	4
$\bar{A}+B+\bar{C}$	1	0	1	0	5
$\bar{A}+\bar{B}+C$	1	1	0	0	6
$\bar{A}+\bar{B}+\bar{C}$	1	1	1	1	7

AND POS

	B	$\bar{B}$
A	0	0
$\bar{A}$	0	1

$\boxed{A \cdot B}$

SOP: $F(A,B) = m_3$

POS: $F(A,B) = \pi(M_0, M_1, M_2$

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

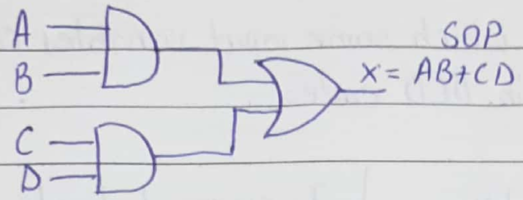
A \ BC	00	01	11	10
0	0	1	3	2
1	4	5	7	6

A \ BC	00	01	11	10
0	0	1	0	1
1	1	0	1	0

DATE ___/___/20___

Basic Combinational Logic Circuits:

1-AND - OR



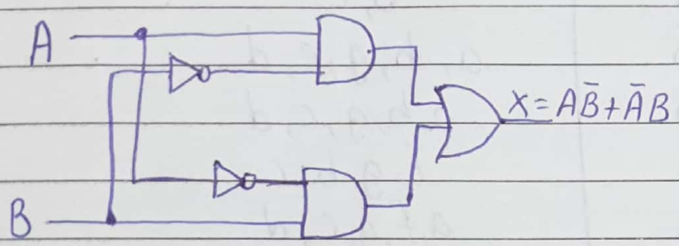
SOP $X = AB+CD$

2. AND-OR-Invert

$\overline{AB+CD}$

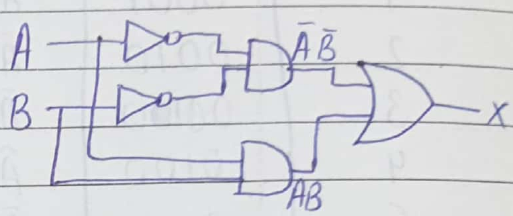
POS: $(\bar{A}+\bar{B})(\bar{C}+\bar{D})$

3. Exclusive-OR



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

4) Exclusive-NOR



$X = \overline{A\bar{B}+\bar{A}B} = (\overline{A\bar{B}})(\overline{\bar{A}B})$

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

Q) Reduce the combonimational logic circuit

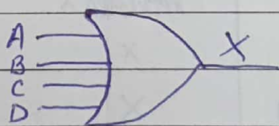
$X = (\overline{\bar{A}\bar{B}\bar{C}})C + \overline{\bar{A}\bar{B}\bar{C}} + D$

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

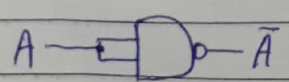
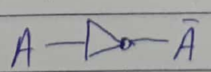
$= AC+BC+C+A+B+C+D$

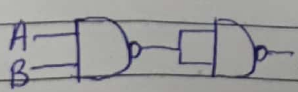
$= C(A+B+1)+A+B+D$

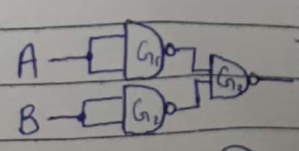
$X = A+B+C+D$

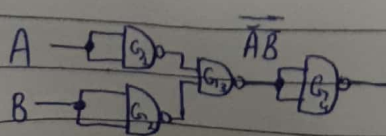


Universal Property of NAND Gate:

①  =  NOT

②  $\overline{\overline{AB}} = AB$ = AND Gate

③  $\overline{\bar{A}\bar{B}} = A+B$ = OR Gate

④  $\overline{A+B}$ = NOR Gate

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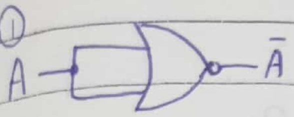
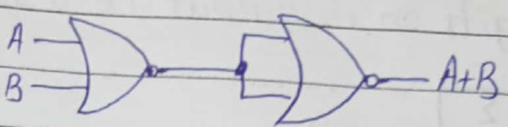
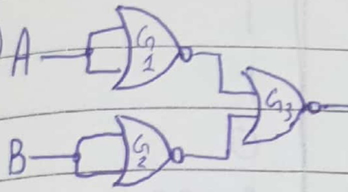
Universal Property of NOR Gate

① 

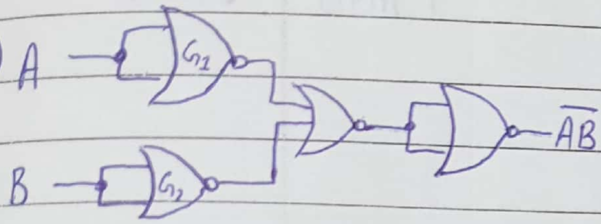
= NOT Gate

② 

= OR Gate

③ 

$\overline{\bar{A}+\bar{B}} = AB$ = AND Gate

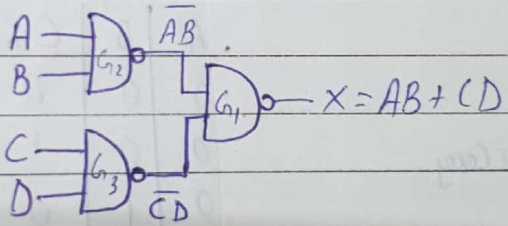
④ 

$\overline{AB}$ = NAND Gate

NAND Logic (De Morgan)

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

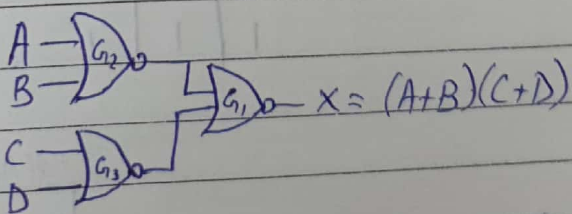
$$X = \overline{(\overline{AB})(\overline{CD})}$$
$$= \overline{(\bar{A}+\bar{B})(\bar{C}+\bar{D})}$$
$$= \overline{(\bar{A}+\bar{B})} + \overline{(\bar{C}+\bar{D})}$$
$$= \bar{\bar{A}} \cdot \bar{\bar{B}} + \bar{\bar{C}}\bar{\bar{D}}$$
$$= AB + CD$$



NOR Logic

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

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

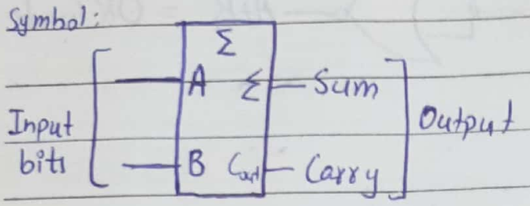


hongae carry 1 hoga

The Half Adder:

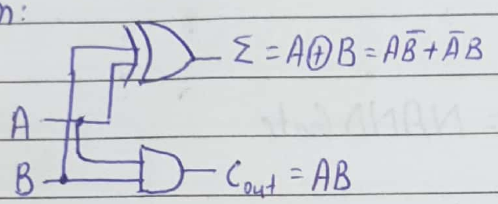
The half adder accepts two binary digits on its inputs and produce two binary digits on its output i.e a sum bit & a carry bit.

Logic Symbol:

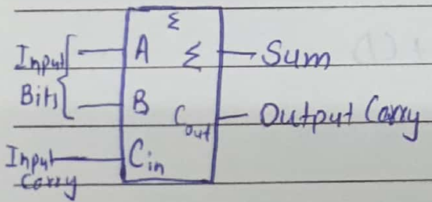


A	B	Cout	Σ
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0
		AND	XOR

Logic Diagram:

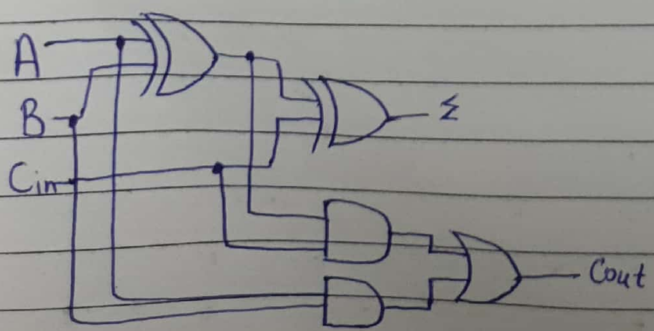


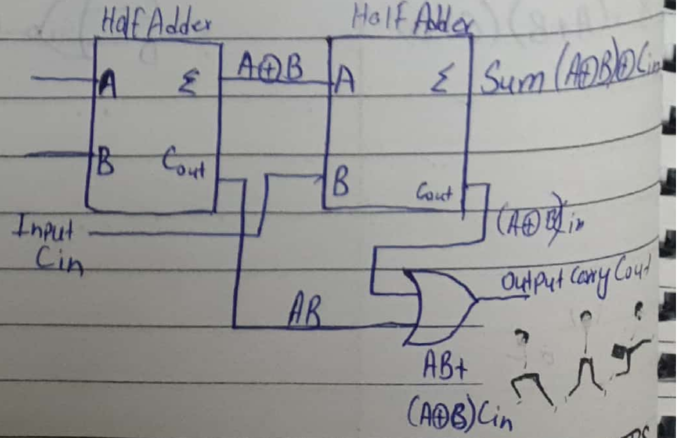
The Full Adder: accepts two inputs bits and an input carry and generates a sum output and a output carry.



A	B	Cin	Cout	Σ
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

Logic Diagram





GO GETTERS

Parallel Binary Adders:

Two or more full adder are connected to form a parallel binary adder

```
  1 1  └ Carry bit from right column
 + 0 1
 1 0 0
```

In this case carry bit from second column become a sum bit

```
   1 1
  0 1 1
  1 0 1
 1 0 0 0
```
$\Sigma_4\ \Sigma_3\ \Sigma_2\ \Sigma_1$

~~Notice tha~~

Note: Output carry bit become MSB in sum(Σ_3)

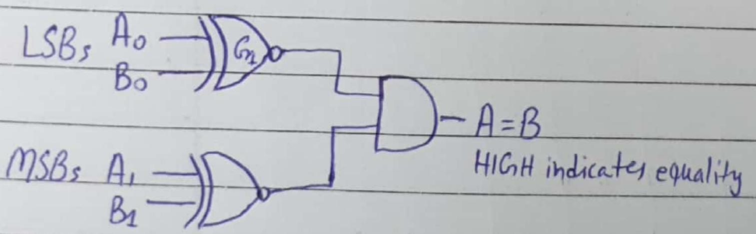
General format addition of two 2-bit numbers

$$\begin{array}{r} A_2\ A_1 \\ +\ B_2\ B_1 \\ \hline \Sigma_3\ \Sigma_2\ \Sigma_1 \end{array}$$

$$\begin{array}{r} A_4\ A_3\ A_2\ A_1 \\ B_4\ B_3\ B_2\ B_1 \\ \hline C_4\ \Sigma_4\ \Sigma_3\ \Sigma_2\ \Sigma_1 \end{array}$$

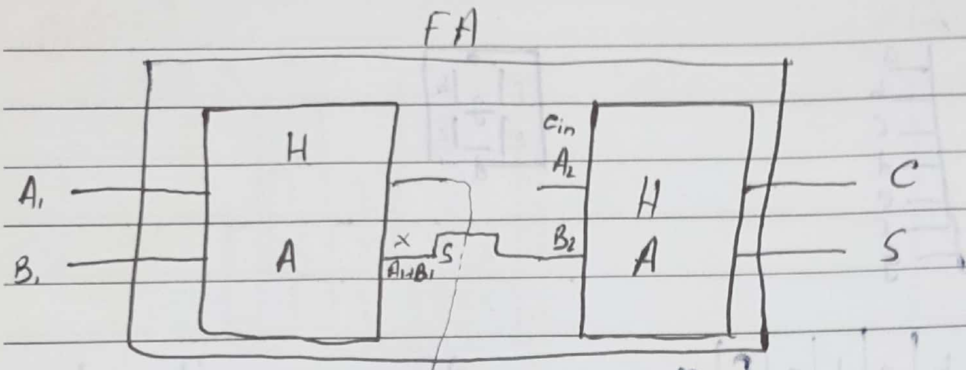
Comparators: The basic function of a comparators is to compare the magnitudes of two binary numbers to determine the relationship of those two numbers. In its simplist form, a comparator circuit determines wheter two numbers are equal

Equality: In order to compare binary numbers containing two bits each, an additional exclusive-NOR gate is necassary



Inequality: To determine an inequality of binary numbers A and B, you first examine the highest order bit in each number. The following conditions are possible:

1) If $A_3 = 1$ and $B_3 = 0$, number A is greater than number B
2) If $A_3 = 0$ and $B_3 = 1$, number A is less than number B
3) If $A_3 = B_3$ you must examine the next lower bit position for an inequality



$(A+B)+C$

$x+C$

HA

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

Carry Sum

1 $\boxed{010}$

A	B	Cin	Cout	S	
0	0	0	0	0	m_0
0	0	1	0	1	m_1
0	1	0	0	1	m_2
0	1	1	1	0	m_3
1	0	0	0	1	m_4
1	0	1	1	0	m_5
1	1	0	1	0	m_6
1	1	1	1	1	m_7

FA

$C_{in}=1$	$C_{in}=1$	0	Cin
1	1	1	A
1	0	1	B
S=1	S=0	S=0	
$C_{out}=1$	$C_{out}=1$	$C_{out}=1$	

Carry Sum

1 $\boxed{100}$

Riple Effect delay occur.

A \ BC

0	1 1	3	2 1
4 1	5	7 1	6

encryption / Decryption.

input

$n = 2^m$

DATE ___/___/20___

Encoders

An encoder is a combinational logic circuit that essentially accepts an active high level on one of its inputs representing a digit, such as decimal or octal digit and converts it to a coded output such as BCD or binary

SOP: $\Sigma \rightarrow (1)$
POS: $\pi \rightarrow (0)$

(x) 0 … 9, 10 … 15] Don't Care

DATE ___/___/20___

BCD-Excess Code:

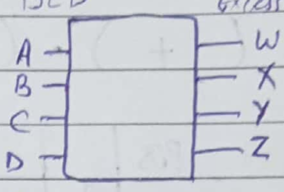
Equation for

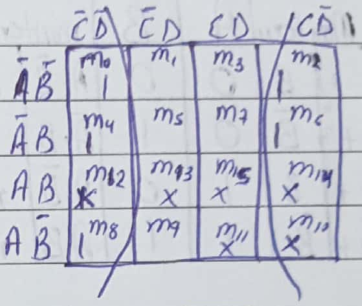
$W = \Sigma(m_5, m_6, m_7, m_8, m_9), X(m_{10}, m_{11}, m_{12}, m_{13}, m_{14}, m_{15})$

$X = \Sigma(m_1, m_2, m_3, m_4, m_9), X(\ldots\ldots)$

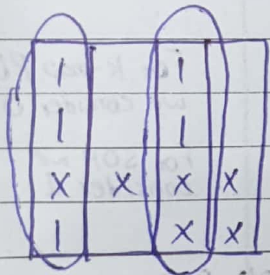
$Y = \Sigma(m_0, m_3, m_4, m_7, m_8), X(\ldots\ldots)$

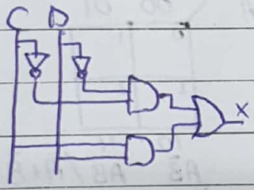
$Z = \Sigma(m_0, m_2, m_4, m_6, m_8), X(\ldots\ldots)$

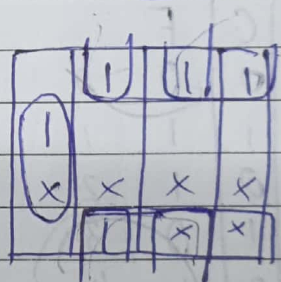




$\boxed{Z = \bar{D}}$







$Y = \bar{C}\bar{D} + CD$

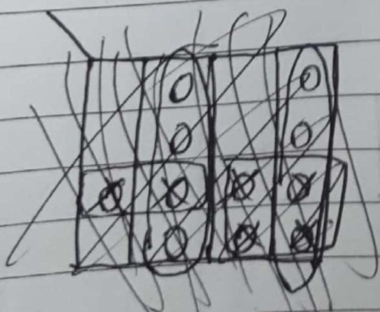
$\cancel{X = \bar{B}C + \bar{B}\bar{C}D + B\bar{C}\bar{D}}$

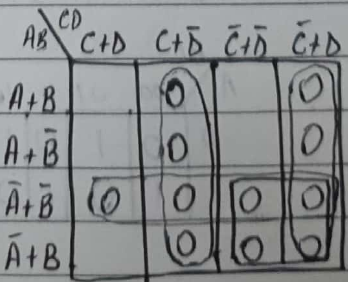
$X = \bar{B}C + \bar{B}D + B\bar{C}\bar{D}$

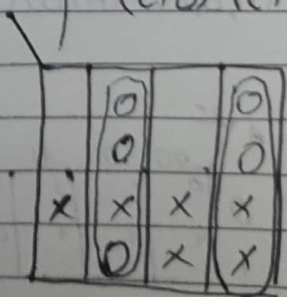
$Y = \Sigma(m_0, m_3, m_4, m_7, m_8)$

$Y = \pi(M_1, M_2, M_5, M_6, M_9, M_{10}, M_{11}, M_{12}, M_{13}, M_{14}, M_{15})$

$\rightarrow (C+\bar{D})\cdot(\bar{C}+D)$







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

GO GETTERS

•) Active High
•) Active Low
↳ ON = 0
OFF = 1

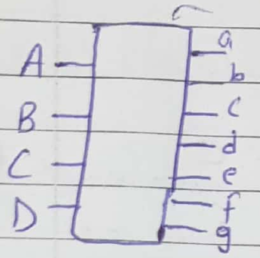
No matter
For SOP 1
For POS 0

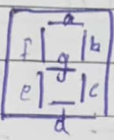
$n \times 2^n$

DATE ___/___/20___

→ Don't Care

BCD to 7 Segment Decoder:





Active High:

	A	B	C	D	a	b	c	d	e	f	g
0	0	0	0	0	1	1	1	1	1	1	0
1	0	0	0	1	0	1	1	0	0	0	0
2	0	0	1	0	1	1	0	1	1	0	1
3	0	0	1	1	1	1	1	1	0	0	1
4	0	1	0	0	0	1	1	0	0	1	1
5	0	1	0	1	1	0	1	1	0	1	1
6	0	1	1	0	1	0	1	1	1	1	1
7	0	1	1	1	1	1	1	0	0	0	0
8	1	0	0	0	1	1	1	1	1	1	1
9	1	0	0	1	1	1	1	1	0	1	1
	1	0	1	0	x	x	x	x	x	x	x
	1	0	1	1							
	1	1	0	0							
	1	1	0	1							
	1	1	1	0							
	1	1	1	1	x	x	x	x	x	x	x

•) For eqs we consider column so in this case we need to find 7 equation

a (SOP)

AB \ CD	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	1		1	1
$\bar{A}B$		1	1	1
AB	X	X	X	X
$A\bar{B}$	1	1	X	X

$\boxed{A + C + BD + \bar{B}\bar{D}}$

a (POS)

	C+D	$C+\bar{D}$	$\bar{C}+\bar{D}$	$\bar{C}+D$
A+B		0		
$A+\bar{B}$	0			
$\bar{A}+\bar{B}$	X	X	X	X
$\bar{A}+B$			X	X

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

b (SOP)

1	1	1	1
1		1	
X	X	X	X
1	1	X	X

$\boxed{A\bar{B} + CD + \bar{C}\bar{D} + \text{[illegible]}}$

POS
$(B' + C + D') \cdot (B' + C' + D)$

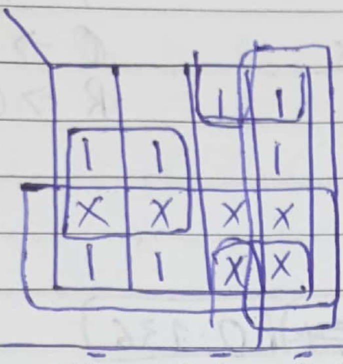
c (SOP)

1	1	1	
1	1	1	1
X	X	X	X
1	1	X	X

$\boxed{\bar{C} + D + B}$

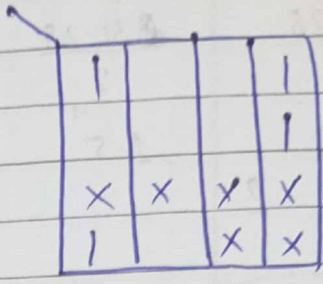
GO GETTERS

g(SOP)



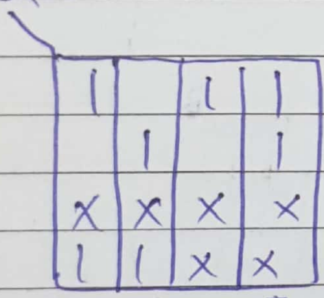
$A + C\bar{D} + B\bar{C} + \bar{B}C$

e(SOP)



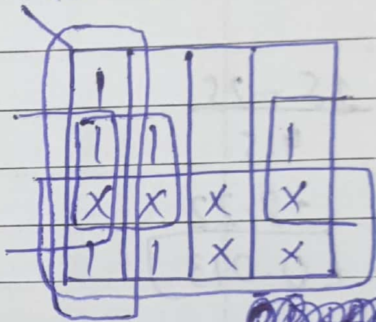
$\bar{B}\bar{D} + C\bar{D}$

d(SOP)



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

f(SOP)



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

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

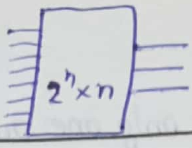
$\bar{0} + 00 + \bar{0}\bar{0}$

$1 + 0 + 1 \cdot 1$

$1 + 0 + 1$

1

I/P → Encoder (Machine Understand) → Decoder (Human Understand) → O/P



2 × 1
4 × 2
8 × 3

DATE ___ / ___ / 20___

Octal to Binary (Encoder)

E_0 = Enable Pin

if input is zero enable is 1.

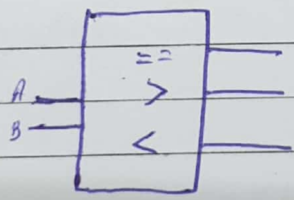
D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7	A_2	A_1	A_0	E
1	0	0	0	0	0	0	0	0	0	0	
0	1	0	0	0	0	0	0	0	0	1	
								0	1	0	
								0	1	1	
								1	0	0	
								1	0	1	
								1	1	0	
								1	1	1	

a == b

a != b → a > b, a < b

1 bit

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



2 bit

	A		B			A=B	A<B	A>B
a	A_0	A_1	B_0	B_1		==	<	>
0	0	0	0	0	0	1	0	0
0	0	0	0	1	1	0	1	0
0	0	0	1	0	2	0	1	0
0	0	0	1	1	3	0	1	0
1	0	1	0	0	0	0	0	1
1	0	1	0	1	1	1	0	0
1	0	1	1	0	2	0	1	0
1	0	1	1	1	3	0	1	0
2	1	0	0	0	0	0	0	1
2	1	0	0	1	1	0	0	1
2	1	0	1	0	2	1	0	0
2	1	0	1	1	3	0	1	0
3	1	1	0	0	0	0	0	1
3	1	1	0	1	1	0	0	1
3	1	1	1	0	2	0	0	1
3	1	1	1	1	3	1	0	0

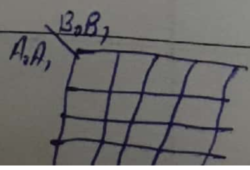
Equal = $\bar{A}\bar{B} + AB$

LT = $\bar{A}B$

GT = $A\bar{B}$

2 Bit

Equal = $\bar{A}_0\bar{A}_1\bar{B}_0\bar{B}_1 + \bar{A}_0A_1\bar{B}_0B_1 + A_0\bar{A}_1B_0\bar{B}_1 + A_0A_1B_0B_1$



Quiz

GO GETTERS

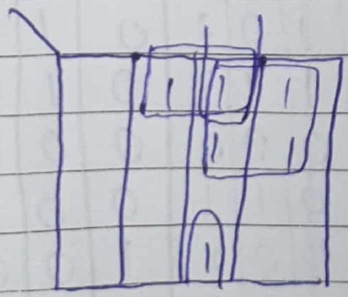
DATE ___/___/ 20___

Multiplexer: Many input but only one output

S_1	S_0	D_0 D_1 D_2 D_3	Output (Y)
0	0		$\bar{S}_1\bar{S}_0D_0$
0	1		$\bar{S}_1S_0D_1$
1	0		$S_1\bar{S}_0D_2$
1	1		$S_1S_0D_3$

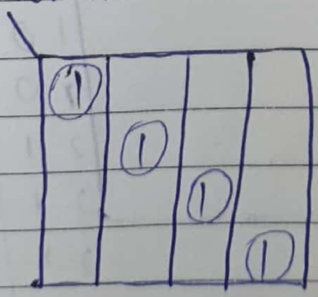
Comparator:

For $A<B$



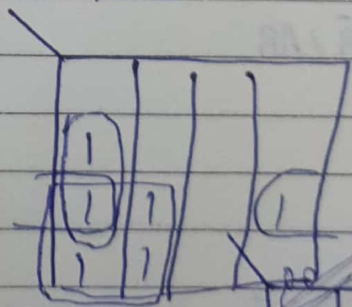
$\bar{A}_1\bar{A}_0B_0 + \bar{A}_1B_1 + \bar{A}_0B_1B_0$

For $A=B$



$(A_1 \odot B_1)(A_0 \odot B_0)$

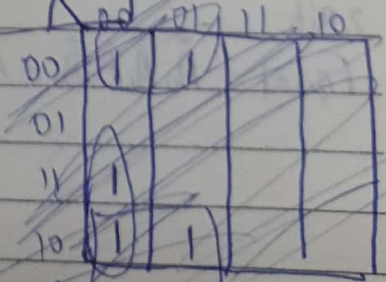
For $A>B$



$A_0\bar{B}_1\bar{B}_0 +$

$A_1A_0\bar{B}_0 +$

$A_1\bar{B}_1$



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

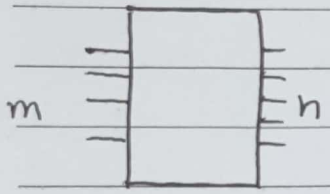
$2^{m} = n$

m → No. of input

n → No. of Output

DATE ___/___/20___

m : I/P   n : O/P



Encoder

Decoder (m×n Decoder)

I/P kam & O/P Ziada

Encoder

I/P Ziada & O/P kam

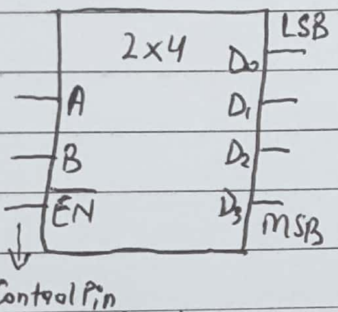
(output → 1)

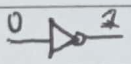
① Active High

② Active Low

(Output → 0)

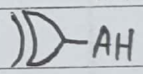
Decoder

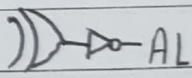


$\overline{EN}$: 

A	B	A = = B	
0	0	1	0
0	1	0	1
1	0	0	1
1	1	1	0
		AH	AL

XOR ← AH   AL → NOT Gate





$\overline{EN}$	A	B	D_0	D_1	D_2	D_3	
0	0	0	1	0	0	0	$A'B'$
0	0	1	0	1	0	0	$A'B$
0	1	0	0	0	1	0	AB'
0	1	1	0	0	0	1	AB
1	X	X					

minterms

data line $\rightarrow$ no. of select line

$2^m = n$ ↳ No. of input.

$m = \log_2 n$

$n = 4$

$m = \log_2 2^2 = 2$

DATE ___/___/20___

Multiplexers:

A MUX selects one data line from two or more input lines and routes data from the selected lines to output. The particular data line that is selected is determined by the select inputs.

Advantages:

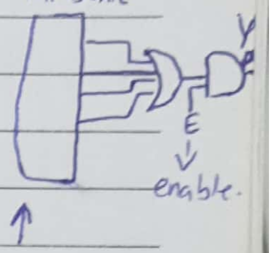
-) Reduce no. of wires -) Reduce circuit complexity & cost.

-) Implementing of various circuit using MUX.

TYPEs:

2:1 MUX, 4:1 MUX, 8:1 MUX, 16:1 MUX and 32:1 MUX.

1 2 3 4 5



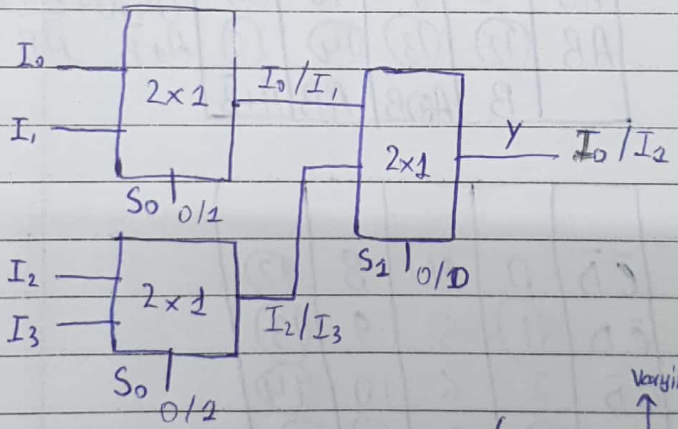
Implement 4x1 MUX using 2x1 MUX.

S_1	S_0	Y
0	0	I_0
0	1	I_1
1	0	I_2
1	1	I_3

$n = 4$

$\frac{4}{2} = 2$ $\rightarrow$ 3 $\rightarrow$ 2x1 MUX

$\frac{2}{2} = 1$

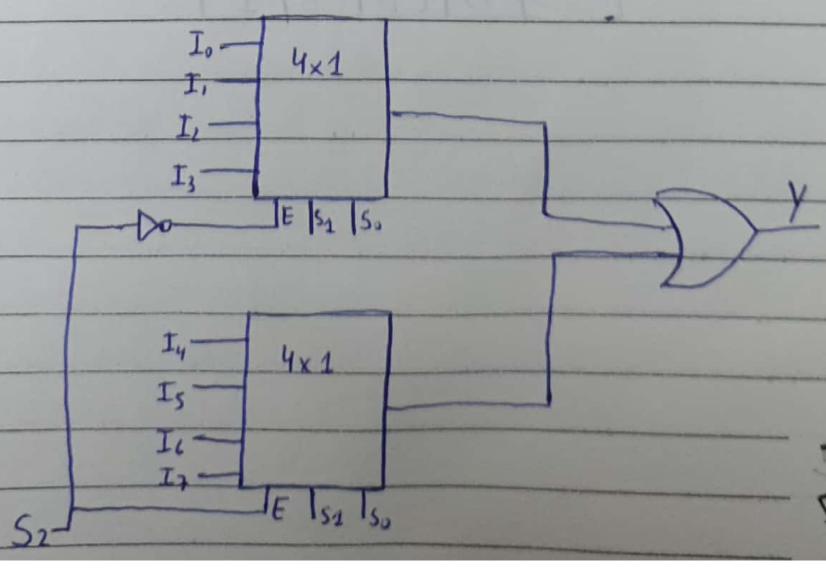


Implementing 8x1 MUX Using 4x1 MUX

Varying

(we use enable to implement 8x1 MUX)

S_2	S_1	S_0	Y
0	0	0	I_0
0	0	1	I_1
0	1	0	I_2
0	1	1	I_3
1	0	0	I_4
1	0	1	I_5
1	1	0	I_6
1	1	1	I_7



DATE ___/___/20___

8:1 MUX → $2^3 = 8$ 3 select lines

Q) $F(A,B,C,D) = \Sigma(1,3,4,11,12,13,14,15)$ using 8×1 MUX

No. of lines ≠ No of variables input

∴ Remaing 1 variable will be input variable & other 3 will be selection variable

	I_0	I_1	I_2	I_3	I_4	I_5	I_6	I_7
$\bar{D}$	0	2	4	6	8	10	12	14
D	1	3	5	7	9	11	13	15
	D	D	$\bar{D}$	0	0	D	1	1

A,B,C → select lines
D → will be mapped as input

Same on 4×1 MUX

	I_0	I_1	I_2	I_3
$\bar{A}\bar{B}$	0	1	2	3
$\bar{A}B$	4	5	6	7
$A\bar{B}$	8	9	10	11
AB	12	13	14	15
	B	$A\oplus B$	AB	$A+\bar{B}$

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

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

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

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

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

$\bar{C}\bar{D}$	0	4	8	12
$\bar{C}D$	1	5	9	13
$C\bar{D}$	2	6	10	14
CD	3	7	11	15
	D	$\bar{C}\bar{D}$	CD	1

1-Bit Full Adder using Multiplexer.

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

	I_0	I_1	I_2	I_3
$\bar{C}$	0	2	4	6
C	1	3	5	7
	C	$\bar{C}$	$\bar{C}$	C

	I_0	I_1	I_2	I_3
$\bar{C}$	0	2	4	6
C	1	3	5	7
	0	C	C	1

For Sum

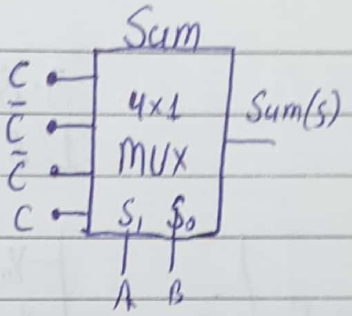
A \ BC	00	01	11	10
0		1		1
1	1		1	

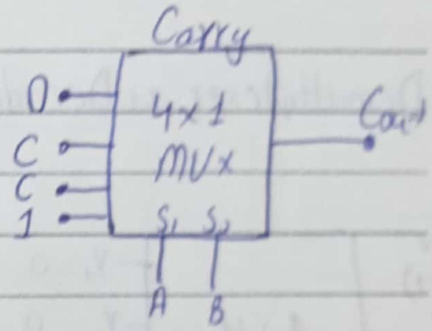
For Carry

A \ BC	00	01	11	10
0			1	
1		1	1	1

S_1 S_0

A	B	S
0	0	I_0
0	1	I_1
1	0	I_2
1	1	I_3





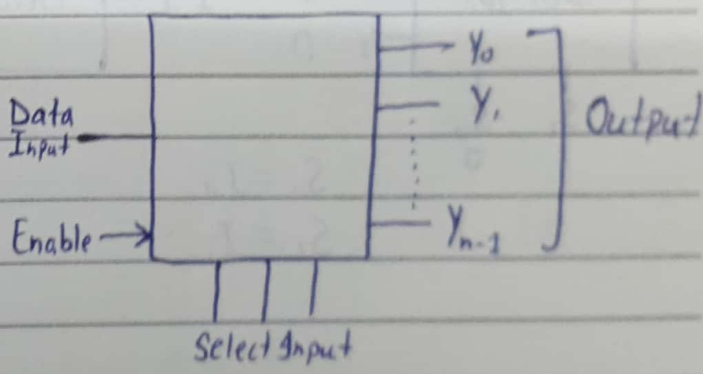
De-Multiplexer:

- One input & many output
- Reverse operation of multiplexer
- One to many ckt or data distributor.

n → O/P lines

m → select lines

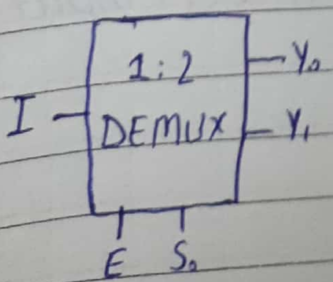
$n = 2^m$, $m = \log_2 n$



1:2 DEMUX

$m = \log_2 2$

$m = 1$



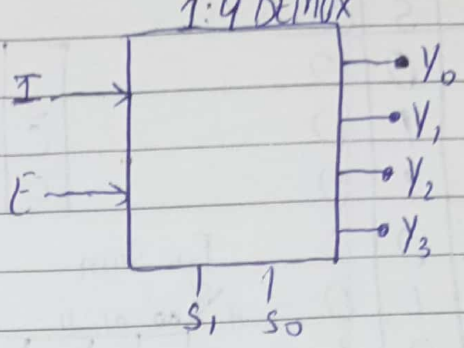
E	S_0	Y_0	Y_1
0	0	0	0
0	1	0	0
1	0	I	0
1	1	0	I

$Y_0 = E\bar{S_0} I$

$Y_1 = E S_0 I$

E	S_1	S_0	Y_0	Y_1	Y_2	Y_3
0	X	X	0	0	0	0
1	0	0	I	0	0	0
1	0	1	0	I	0	0
1	1	0	0	0	I	0
1	1	1	0	0	0	I

1:4 DEMUX



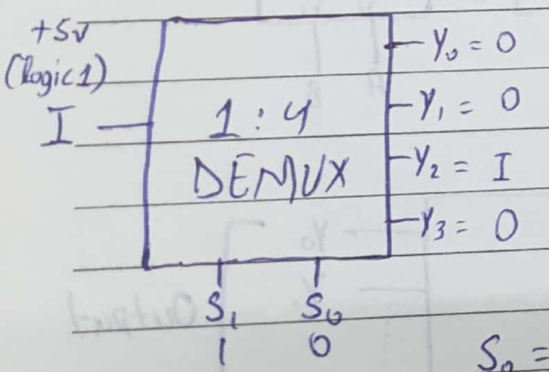
$n = 4$
$m = \log_2 n$
$m = \log_2 2^2$
$\boxed{m = 2}$

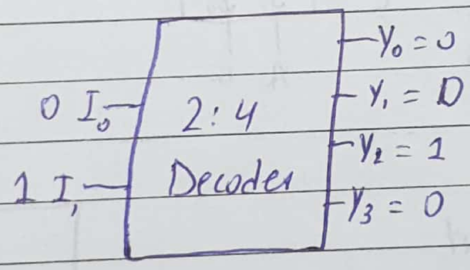
$Y_0 = E\bar{S}_1\bar{S}_0 I$ $\quad Y_2 = ES_1\bar{S}_0 I$ $\quad 4 \times (4$ input AND Gate$)$

$Y_1 = E\bar{S}_1 S_0 I$ $\quad Y_3 = ES_1 S_0 I$

Demultiplexer as Decoder:

3:8 Decoder
1:8 Demux





$S_0 = I_0$
$S_1 = I_1$

I_1	I_0	Y_0	Y_1	Y_2	Y_3
0	0	1	0	0	0
0	1	0	1	0	0
1	0	0	0	1	0
1	1	0	0	0	1

A DEMUX performs the opposite function from MUX - It switches data from one input line or two or more data lines depending on select input.