3

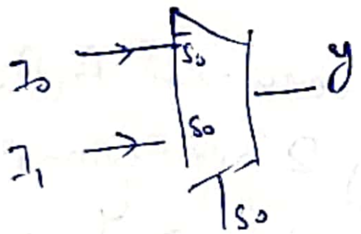
Multiplexer (Mux)

- ↳ Many to one converter,
- ↳ universal logic
- ↳ And - or logic.

Demultiplexer
↳ AND logic

Design a 2×1 MUX.

Step 1.



Step 2

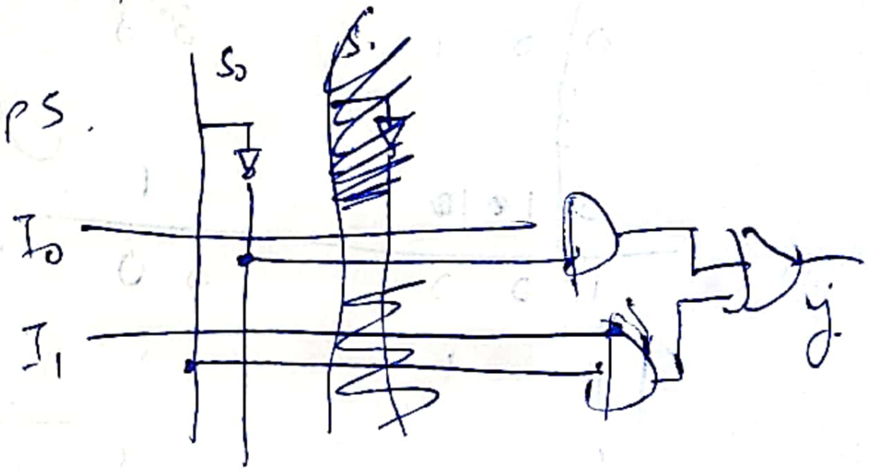
S_0	y
$\bar{S}_0 \to 0$	I_0
$S_0 \to 1$	I_1

Step. 3

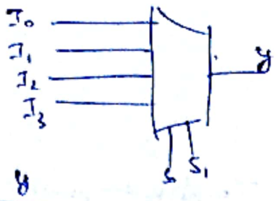
$$y = \bar{S}_0 I_0 + S_0 I_1$$

Step 4: Already minimized.

Step 5.

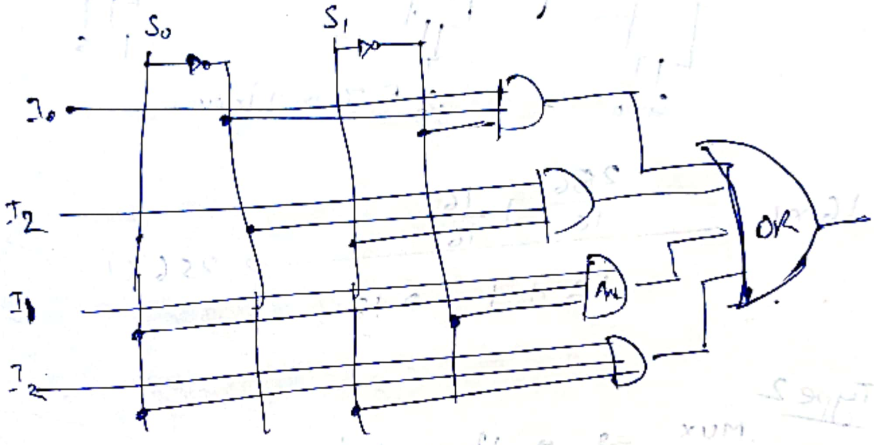


4x1 MUX



En	S_1	S_0	y
	0	0	I_0
	0	1	I_1
	1	0	I_2
	1	1	I_3

$y = \bar{S}_0\bar{S}_1 I_0 + S_0\bar{S}_1 I_1 + \bar{S}_0 S_1 I_2 + S_0 S_1 I_3$



Probable pattern of question.

Type 1

Design 4 x 1 MUX using 2x1 MUX.

$2\times1 \xrightarrow[2+1=3]{\frac{4}{2}+\frac{2}{2}} 4\times1$

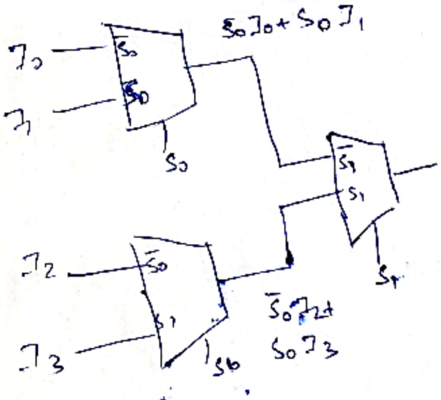
Total 3 2x1 MUX required.

4 x 1   2 x 1

$\frac{4}{2} + \rightarrow \frac{2}{2}$ -1 - - -

2 → 2   Untill and unless 1 or 0.

Ans



$\bar{S}_1(\bar{S}_0 I_0 + S_0 I_1) + S_1(\bar{S}_0 I_2 + S_0 I_3)$

$2\times1 \xrightarrow[4+2+1=7]{\frac{8}{2}+\frac{4}{2}+\frac{2}{2}} 8\times1$

S_0 S_1 S_2

$2\times1 \longrightarrow 2^n\times1$

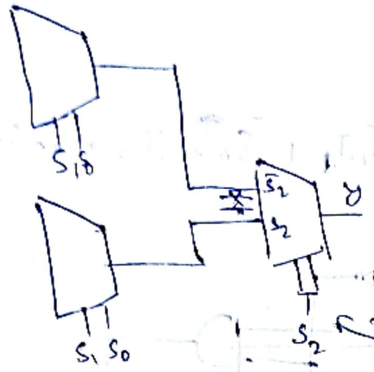
$2^n - 1$ MUX req.

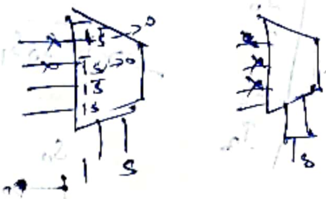
$4\times1 \xrightarrow[4+1=5]{\frac{16}{4}+\frac{4}{4}} 16\times1$

4×1 MUX $\xrightarrow{\frac{8}{4}+\frac{2}{4}} 8\times1$

$2+1$

To omit input





To omit inputs

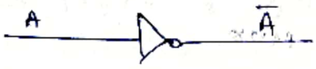
16×1 $\xrightarrow{\frac{256}{16}+\frac{16}{16}} 256\times1$

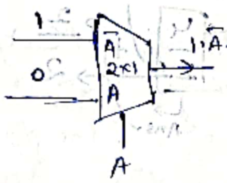
$16+1 \rightarrow 17$

Type 2

MUX as a Universal logic

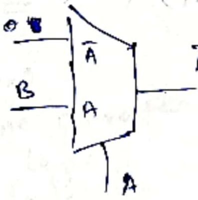
1. Not gate





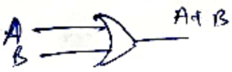
$1\cdot\bar{A}+0\cdot A = \bar{A}$

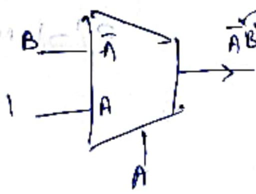
2. And gate



$\bar{A}\cdot0+A\cdot B = AB$

3. OR gate

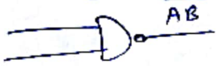


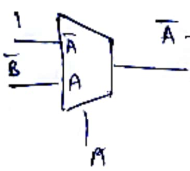


$\bar{A}B+1\cdot A \rightarrow (A+\bar{A})(A+B)$

$1\cdot(A+B)$

4. NAND gate



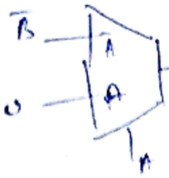


$\bar{A}+A\bar{B} \rightarrow (\bar{A}+A)(\bar{A}+\bar{B})$

$\overline{AB}$

NOR

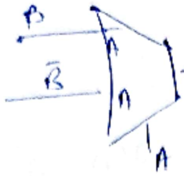
$\overline{A+B}$



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

X-OR

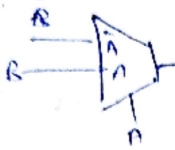
$\bar{A}B + A\bar{B}$



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

XNOR

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



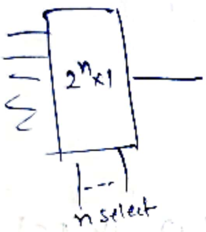
$\bar{A}\bar{B} + AB$

★ NOT, AND, OR → 1 2×1 Mux req.

NAND, NOR, XOR, XNOR → 2 2×1 Mux req.

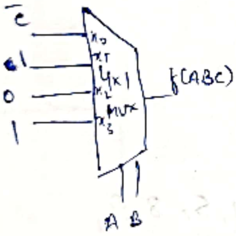
Becoz of making Bar '$\bar{B}$'

$M \left\{ 2^n \right.$



No. of select lines = $\log_2 M$

Type 3 Minimization.



$x_0 = \bar{A}\bar{B}$

$x_1 = \bar{A}B$

$x_2 = A\bar{B}$

$x_3 = AB$.

$f(A,B,C) = \bar{A}\bar{B}\bar{C} + \bar{A}B\cdot 1 + A\bar{B}\cdot 0 + AB\cdot 1$

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

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

$= \Sigma m(0,2,3,6,7)$

Both

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

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

$\bar{A}\bar{C} = x$.

$x\bar{B} + B \to (B+x)\cdot(\bar{B}+B)$

~~$xB+(B+\bar{B})$~~

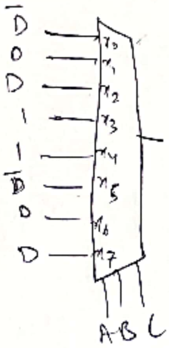
$B+x \to B + \bar{A}\bar{C}$

KMAP → $B + \bar{A}\bar{C}$

Shortcut

$\Sigma m(\bar{A}\bar{B}\bar{C}, \bar{A}B0, AB0)$

$\Sigma m(0,2,3,6,7)$



$x_0 = \bar{A}\bar{B}\bar{C} \to \bar{D}$

$1 = \bar{A}\bar{B}C \to 0X$

$2 = \bar{A}B\bar{C} \to D$

$3 = \bar{A}BC \to 1, 0$

$4 = A\bar{B}\bar{C} \to 1, 0$

$5 = A\bar{B}C \to \bar{D}$

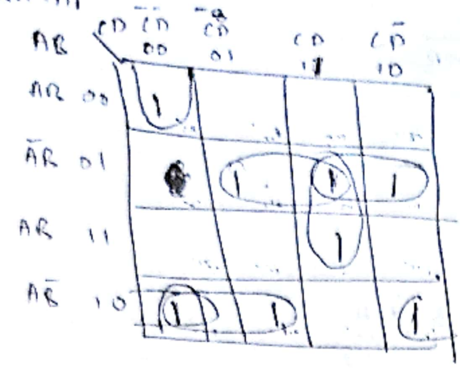
$6 = AB\bar{C} \to 0X$

$7 = ABC \to D$

$= \bar{A}\bar{B}\bar{C}\bar{D} + \bar{A}B\bar{C}D + \bar{A}BC\,\boxed{1} + A\bar{B}\bar{C}1 + A\bar{B}C\bar{D} + ABCD$

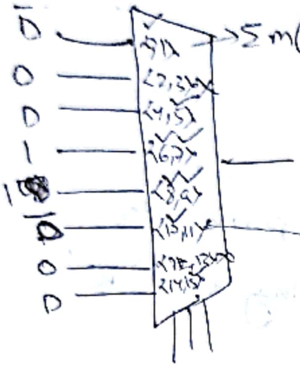
$= \Sigma m(0,5,6,7,8,9,10,15)$

K.MAP



$A\bar{C}\bar{D} + A\bar{B}\bar{C} + A\bar{B}\bar{D}$
$+ \bar{A}BD + \bar{A}BC + BCD$

Shortcut to find Σm ( ) . Only applicaple when $f(A,B,\underline{C})$ LSB is in input terminalls



$\to \Sigma m(0,5,6,7,8,9,10,15)$

3 select lines means $2^3 \to 16$ inputs can be handled

But only 8 input

$\therefore$ each terminal signify 2 input

if bar ($\bar{D}$), take smaller value from < , >

if direct input (D) larger value from ↑

if 1 → take both , if 0 take nothing

(1)

1 — x_0 <0, 1>

$\bar{S}$ — x_1 <2, 3>

S — x_2 <4, 5>

1 — x_3 <6, 7>

0 — x_4 <8, 9>

1 — x_5 <10, 11>

$\bar{S}$ — x_6 <12, 13>

1 — x_7 <14, 15>

P Q R

$\Sigma m(0,1,2,5,6,7,10,11,12,14,15)$

f(PQRS) → ~~This is~~

(2)

1 — x_7 14, 15

$\bar{S}$ — x_6 12 13

S — x_5 10 11

1 — x_4 8 9

0 — x_3 6 7

1 — x_2 4 5

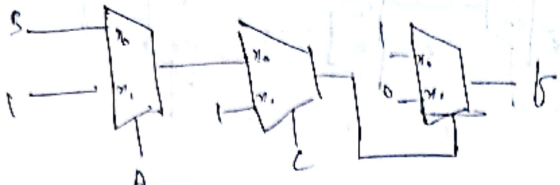
$\bar{S}$ — x_1 2 3

1 — x_0 0 1

$\Sigma m(0,1,2,4,5,8,9,11,12,14,15)$

Type 4. Cascading of MUX

1)



$\bar{A}B + A$

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

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

$1 \quad (A+B)$

$\bar{A}B\bar{C} + A\bar{C} + C \rightarrow f = \overline{\bar{A}B\bar{C} + A\bar{C} + \bar{C}}$

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

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

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

$x\bar{C} + C$

$(x+C)(C+\bar{C})$

$A+B+C$

$= \cancel{0 + AC +}$ $A\bar{C} + \bar{B}\bar{A}\bar{C} + \bar{B}\cancel{C\bar{C}} + \bar{A}\bar{C}$

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

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

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

$= \bar{A}\bar{C}$

$\bar{z}$

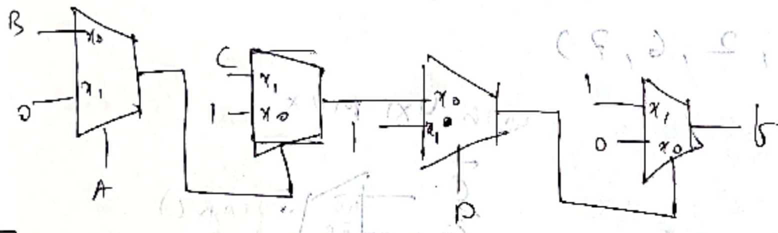
$\overline{A+B+C}$

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

$0+1=1$

$1+1=1$

2)



$\bar{A}B$

$\bar{A}BC + \bar{A}B \cdot 1$

$(\bar{A}BC + \bar{A}B)\bar{D} + D \rightarrow (\bar{A}BC\bar{D} + \bar{A}B\bar{D}) + D$

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

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

$\rightarrow (\overline{\bar{A}BC\bar{D}})(\overline{\bar{A}B\bar{D}})\ \bar{D}$

$\bar{A}B$

$\bar{A}BC + \bar{A}B \cdot 1$

$\bar{A}B = x$

$xC + \bar{x}$

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

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

$\bar{x}+C$

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

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

$A+\bar{B}+C$

$Dx + \bar{D}$

$(D+x)(D+\bar{D})$

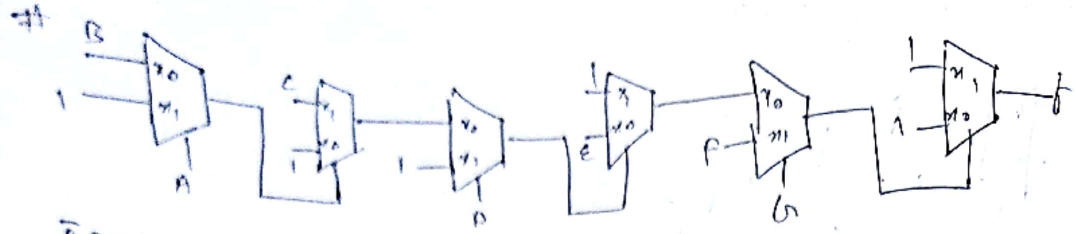
$= A+\bar{B}+C+D$

$1+0 \rightarrow 1$

$0+0 \rightarrow 0$

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

#



$\bar A B + A$

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

$(A+B) \to$

$x C + \bar x$

$(x+\bar x)(C+\bar x)$

$C + \overline{A+B}$

$C + \bar A \bar B$

$\bar D x + D$

$x + D$

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

$x + \bar x E$

$E + x$

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

$x\bar G + FG$

$(\bar x + x) \to 1$ Ans $\leftarrow E\bar G + C\bar G + \bar A \bar B \bar G + D\bar G + FG$

1.

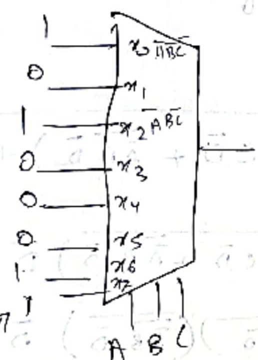
Type – 5

Implementation of function.

$f(A,B,C) = \bar A \bar B \bar C + \bar A B \bar C + A B \bar C + ABC$

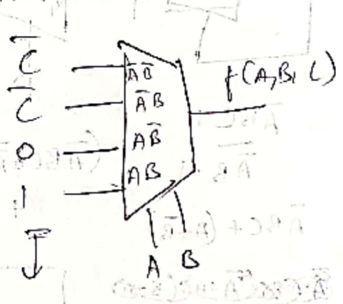
$= \Sigma m(0, 2, 6, 7)$

with 8x1 mux.



Input important

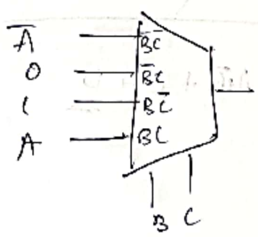
with 4x1 MUX



Not K MAP

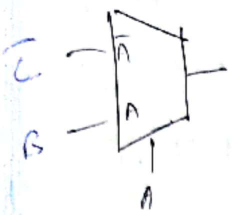
	$\bar A\bar B$	$\bar A B$	$A\bar B$	AB
$\bar C$	$\bar A\bar B\bar C$ 0	$\bar A B\bar C$ 2	$A\bar B\bar C$ 4	$AB\bar C$ 6
C	$\bar A\bar B C$ 1	$\bar A BC$ 3	$A\bar B C$ 5	ABC 7
	$\bar C$	$\bar C$	0	1

Let BC is select line



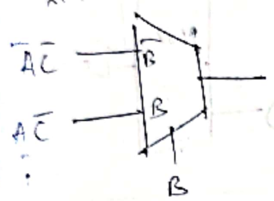
	$\bar B\bar C$	$\bar B C$	$B\bar C$	BC
$\bar A$	$\bar A\bar B\bar C$ 0	$\bar A\bar B C$ 1	$\bar A B\bar C$ 2	$\bar A BC$ 3
A	$A\bar B\bar C$ 4	$A\bar B C$ 5	$AB\bar C$ 6	ABC 7
	$\bar A$	0	1	A

with 2x1 MUX



	$\bar{A}$	A
$\bar{B}\bar{C}$	$\bar{A}\bar{B}\bar{C}$ 0	$A\bar{B}\bar{C}$ 4
$\bar{B}C$	$\bar{A}\bar{B}C$ 1	$A\bar{B}C$ 5
$B\bar{C}$	$\bar{A}B\bar{C}$ 2	$AB\bar{C}$ 6
BC	$\bar{A}BC$ 3	ABC 7
	$\bar{B}\bar{C}+B\bar{C}$ ↓ $\bar{C}$	$B\bar{C}+BC$ ↓ B

Let B as select line

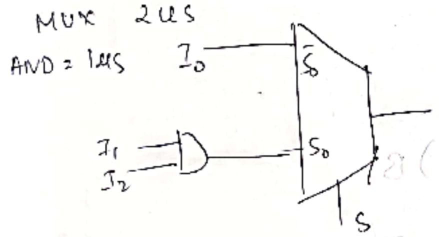


	$\bar{B}$	B
$\bar{A}\bar{C}$	$\bar{A}\bar{B}\bar{C}$ 0	$\bar{A}B\bar{C}$ 2
$\bar{A}C$	$\bar{A}\bar{B}C$ 1	$\bar{A}BC$ 3
$A\bar{C}$	$A\bar{B}\bar{C}$ 4	$AB\bar{C}$ 6
AC	$A\bar{B}C$ 5	ABC 7
	$\bar{A}\bar{C}$	$\cancel{\bar{A}\bar{C}}+A\bar{C}+AC$

$A\bar{C}$

Type-6 Delay .

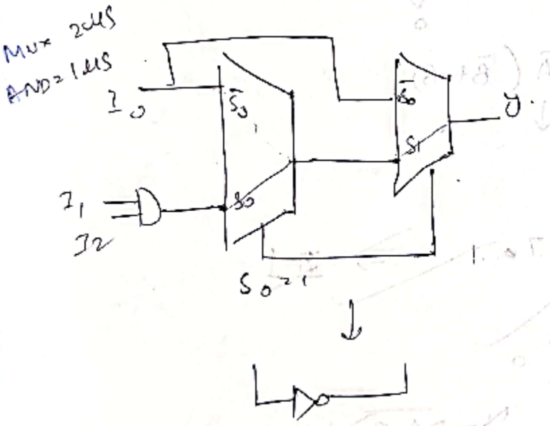
MUX 2μs
AND = 1μs



$S_0 = 0$ I_0 delay = 2μs (min)

$S_0 = 1$ $I_1 I_2$ delay = 3μs (max)

Mux 2μs
AND = 1μs



$S_0 = 0$ $I_0 = 2μs + \cancel{2μs}/ 2μs$

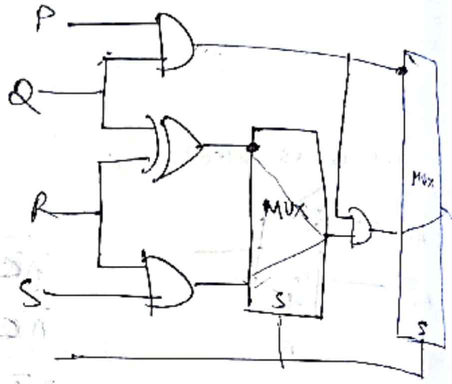
$S_1 = 1$ $I_1 I_2 =$ ~~3μs + 2μs = 5μs~~

~~2μs~~ 3μs.
~~+2μs~~ +2μs
~~4μs~~ 5μs

$S_0 = 0$ $I_0 = 2μs$ 2μs = 4μs

$S_0 = 1$ [1μs + 2μs] ✗ 2μs ✓ = 2μs only depend on I_0

Gate: The propagation delay of the XOR gate, AND gate Multiplexer (MUX) in the circuit shown in the figure are 4ns, 2ns, an 1ns. If all the inputs P, Q, R, S, T are applied simultaneously and held constant the max. propagation delay of the circuit is :-



S = 0

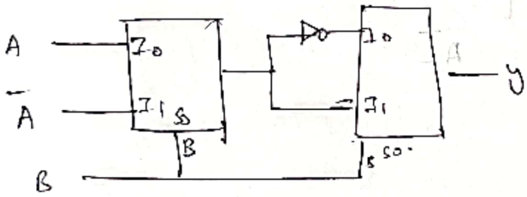
XOR = 4ns +1ns ——— ~~5ns~~	PQ AND = 2ns +1ns ——— 3ns ✓

S = 1

AND RS = 2ns +1ns +2ns ——— 5ns	MUX = 1ns = 5ns +1ns ——— 6ns

Ans 6ns.

#



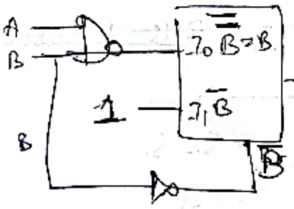
$\bar{B}A + \bar{A}B$, y = ~~$\bar{B}A + \bar{A}$~~

$A \oplus B$; $(A \oplus B)\bar{B} + \overline{(A \oplus B)}B$

$\bar{A}\bar{B}\bar{B} + A\cancel{B\bar{B}} + \bar{A}BB + A\cancel{\bar{B}B}$
0 0

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

#



~~B = 0 → I_0 1 → 1~~

~~B → 1~~ → I_0

$\bar{B}$ ~~$\bar{B}$~~ ↓

↳ $\bar{B}$

~~AB~~

~~$y = \overline{AB} + 1$~~
~~$= \overline{AB}$~~ $= \bar{A} + \bar{B}$

$\bar{B} \rightarrow \overline{AB}\,B$ ~~+~~

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

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

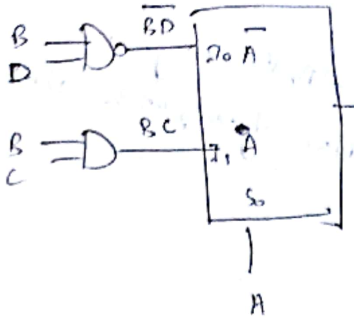
$\Rightarrow \bar{A}\bar{B} \rightarrow \overline{A+B}$

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

$(\overline{AB} + \bar{B})(B + \bar{B})$

↓

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



$f(ABCD) \Rightarrow \overline{A}\,\overline{BD} + ABC\,0$

$\overline{A}\,\overline{BD} + ABC$

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

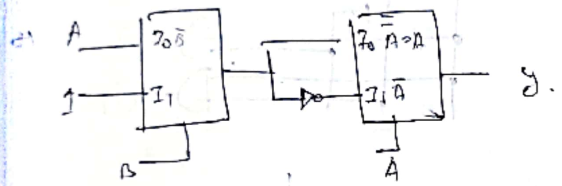
$\overline{A}\,\overline{B} + \overline{A}\,\overline{D}$

4 combo   4 combo   + 2

$\overline{A}\,\overline{B}$ 00 → 0 $\overline{A}$ 0 0 $\overline{D}$ → 0
01 → 1   01 → 2
10 → 2   10 → 4
11 → 3   11 → 6

8 4 2
A B C D → 14
1 → 15.

$\therefore \sum m(0,1,2,3,4,6,14,15)$



→ $\overline{B}A + B$

$A + B$

$Ax + \overline{A}\,\overline{x}$

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

$\overline{A}\,\overline{B}$

A

$A + AB + \overline{A}\,\overline{B}$ $A + AB + \overline{A}\,\overline{B}$

$A[1+B] \rightarrow A$

$AB + A\overline{B} + AB + \overline{A}\,\overline{B}$

$AB + A\overline{B} + \overline{A}\,\overline{B}$

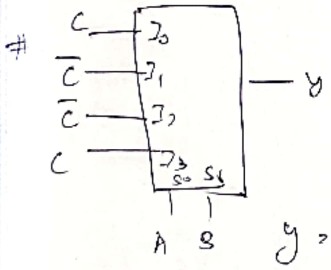
	$\overline{B}$	B
$\overline{A}$	1	
A	1	1

$\overline{B} + A \rightarrow$ $\overline{\overline{A}B}$

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

$\overline{\overline{A}B} \rightarrow \overline{\overline{A}} + \overline{B} \rightarrow A + \overline{B}$

#



odd 1   odd 1   odd 1   odd 1

$y = \overline{A}\,\overline{B}C + \overline{A}B\overline{C} + A\overline{B}\,\overline{C} + ABC$

$= (\overline{A}\,\overline{B} + AB)C + (\overline{A}B + A\overline{B})\overline{C}$

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

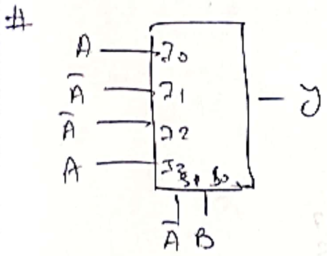
$\sum m(1,2,4,7)$

$= \sum(1,2,4,7)$

$A \oplus B \oplus C$

	$\overline{B}\,\overline{C}$	$\overline{B}C$	BC	$B\overline{C}$
$\overline{A}$	0	1 (1)	3	1 (2)
A	1 (4)	5	1 (7)	6

#



$\overline{A}\,\overline{B}A + \overline{A}B\overline{A} + A\overline{B}\,\overline{A} + ABA$

$\overline{B} + 0 + \overline{A}\,\overline{B} + 0$

$\overline{B}(1+\overline{A}) \rightarrow \overline{B}$

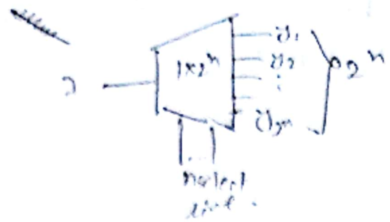
Scanned with OKEN Scanner

6 De-MUX

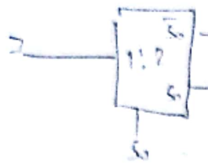
↳ Data Distributor.

AND logic

No. of AND req = No. of output in Demux



Design a 1×2 De-mux ?



→

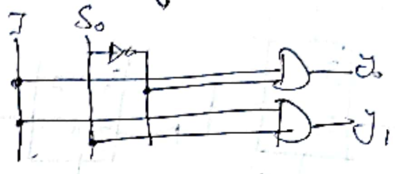
S_0	y_0	y_1
0	I	0
1	0	I

→ $y_0 = \bar{S_0} I$

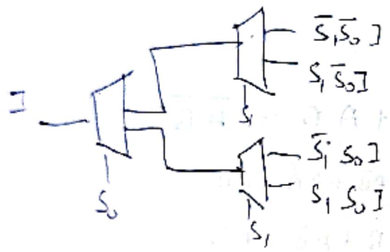
$y_1 = S_0 I$

Already minimized.

↓



1×2 Demux $\xrightarrow[2+1=3]{4/2 + 2/2}$ 1×4 Demux.



1:8 $\xrightarrow[1:2]{\text{Using}}$ $\frac{8}{2} + 4/2 + 2/2 = 7$

Encoder

↳ Any Coded $\xrightarrow{\text{Convert}}$ to Binary.

4×2 Encoder [Quard to Binary Encoder]

8×3

16×4.

Complement

(r−1)'s complement

(r)'s complement.

Base 2	1's	2's
Base 8	7's	8's
Base 10	9's	10's
Base 16	E's	F's

r−1's complement

Substract from max digit

Base 2 Complement of 0 = 1 − 0 = 1

" " 1 = 1 − 1 = 0

$$\begin{array}{r} 111 \\ -\ 101 \\ \hline 010 \end{array}$$

Base 8. 7's complement. 373 $\xrightarrow{7's\ cm}$

$$\begin{array}{r} 777 \\ -\ 373 \\ \hline 404 \end{array}$$

Base 10 → also a weighted code

$$\begin{array}{r} 9 \\ -1 \\ \hline 8 \end{array} \quad \begin{array}{r} 9 \\ -2 \\ \hline 7 \end{array}$$

8 ⟷ 7 → self complement

BCD → Binary Coded Decimal (Also a weighted code) But not self complemented

↳ Each decimal no. are represented by 4 bits

Ex: 2 → 0010   10 → 0001 0000   11 → 0001 0001

4 → 0100

9 → 1001

Excess-3 (Not a weighted code) But a self complemented.

↳ It means the value is added with 3.

Like $0 + 3 = 3 = 0011$

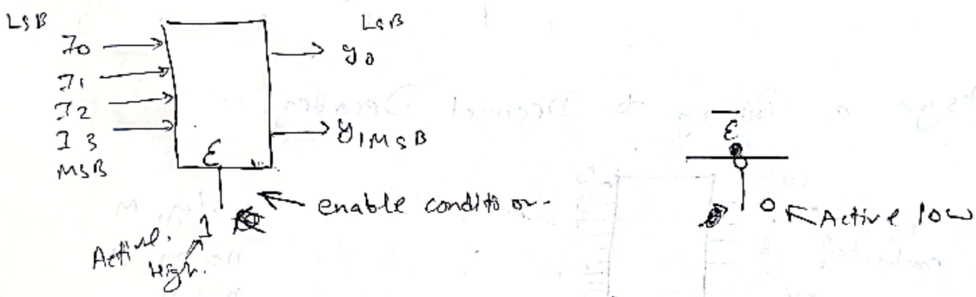
$7 + 3 = 10 = 1010$

4221 code.   4 2 2 1 → weighted and self complemented

	4	2	2	1
0 →	0	0	0	0
1	0	0	0	1
2 →	0	0	1	0
2 →	0	1	0	0
3 →	0	1	0	1

Encoder

4×2 encoder.

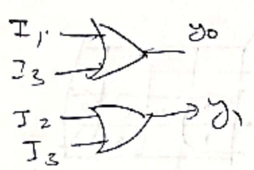


Truth table.   when $E = 1$

I_3 (MSB)	I_2	I_1	I_0 (LSB)	y_1	y_0
0	0	0	1	0	0
0	0	1	0	0	1
0	1	0	0	1	0
1	0	0	0	1	1

$y_0 = I_1 + I_3$ $y_1 = I_2 + I_3$

No minimization possible



Priority Encoder.

MSB I_3	I_2	I_1	LSB I_0	MSB y_1	LSB y_0
X	X	X	1	0	0
X	X	1	0	0	1
X	X	1	0	0	1

2nd LSB Priority Encoder.

MSB priority encoder

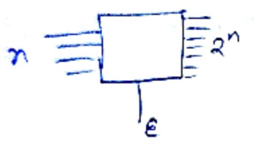
0 0 1 X   0 1

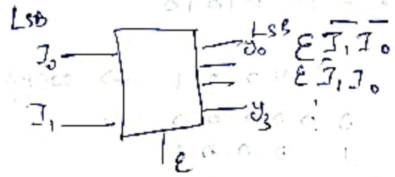
Decoder

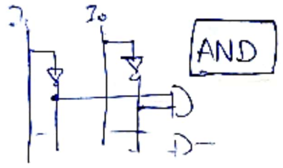
Circuit which converts Binary into any other code.

~~No. of AND gate req. = No. of outputs~~

1. 2×4 Decoder
   3×8
   4×16 . . .

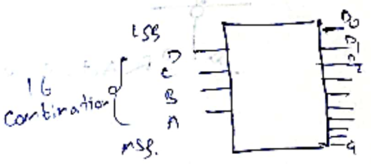






I_1	I_0	y_3	y_2	y_1	y_0
0	0	0	0	0	1
0	1	0	0	1	0
1	0	0	1	0	0
1	1		0	0	0

Design a Binary to Decimal Decoder!



$n = \log_2 M$

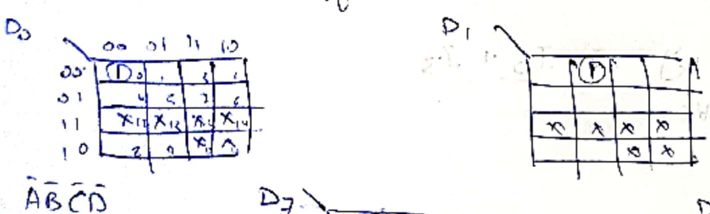
$n = \log_2 10$

$n = 4.$

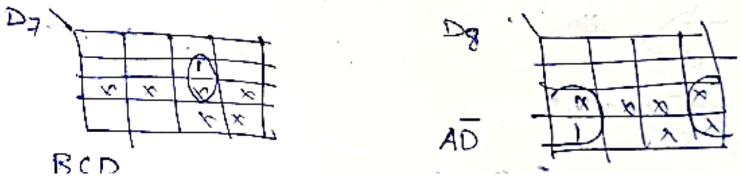
$2^n \geq M$

0 0 0 0
:
1 0 0 1   1 0 0 0 0 - - - - 0
1 0 1 1   x x x x x x - x x
:
1 1 1 1   x x x - - x.

For 0-9. 10 different K-MAP

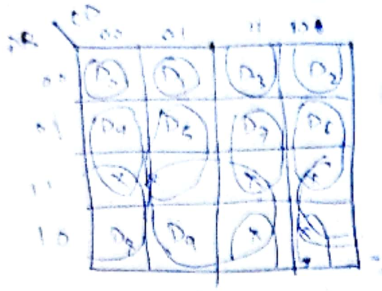


$\bar{A}\bar{B}\bar{C}\bar{D}$ $\bar{A}\bar{B}\bar{C}D$



BCD $A\bar{D}$

Shortcut in K-map



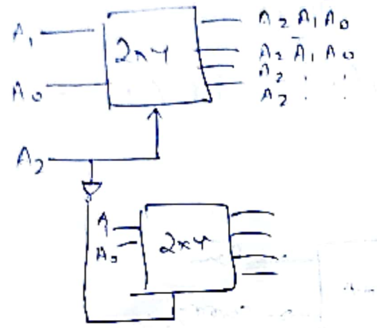
Taken D_0 represent 0. $\bar{A}\bar{B}\bar{C}\bar{D}$

D_5 $\bar{A}B\bar{C}D$

$D_9 = A\bar{D}$

Then Design.

Design 3x8 Decoder by using 2x4 Decoder.



$8/4 = 2$. Ans.

3x8 using 2x4

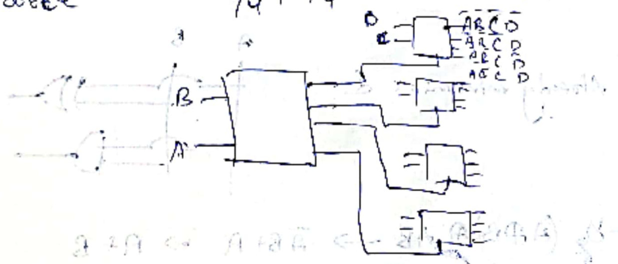
This should not be double.

$$2\times4 \xrightarrow{8/4 = 2} 3\times8$$

$$2\times4 \longrightarrow 4\times16$$

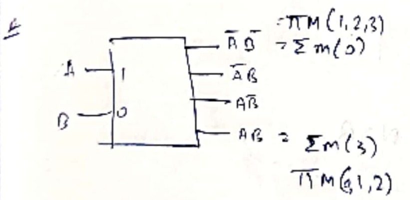
Double

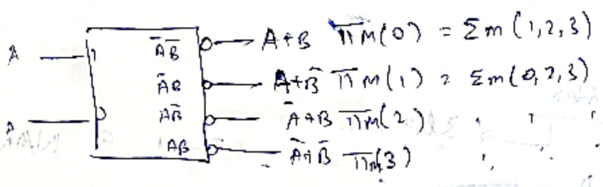
$16/4 + 4/4 = 4+1 = 5.$



$$3\times8 \longrightarrow 6\times64$$

$$\frac{64}{8} + \frac{8}{8} = 8+1 = 9$$





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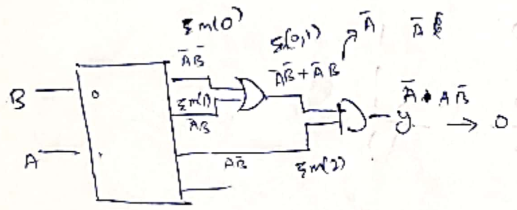

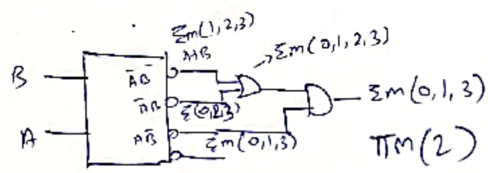

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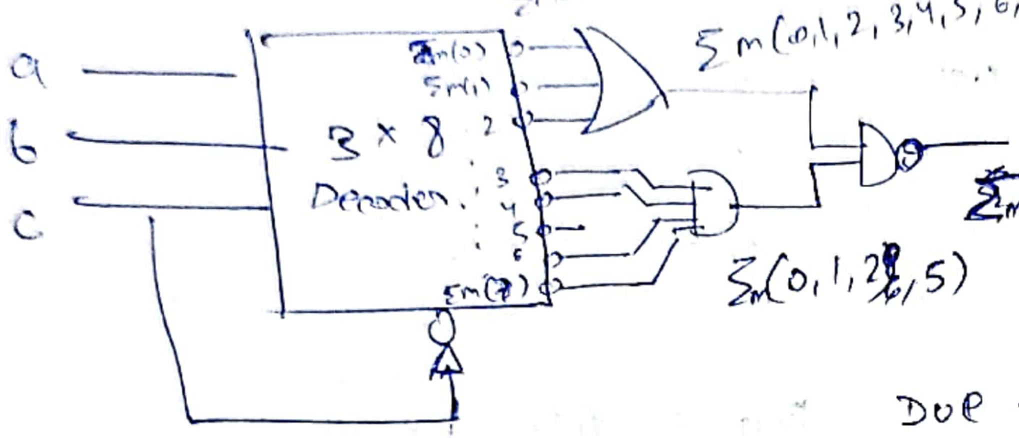

$\Sigma m(3,4,6,7) = \Pi M(0,1,2,5)$

Due to enable,

$y = \bar{C}\, \Sigma m(3,4,6,7)$

$= \bar{C}\,[\underbrace{\bar{A}BC}_{0} + A\bar{B}\bar{C} + AB\bar{C} + ABC]$

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

$= \Sigma m(4,6) = \Pi M(0,1,2,3,5,7)$