MULTIPLEXERS
(PART - 03)

HALF ADDER USING 4:1 MUX

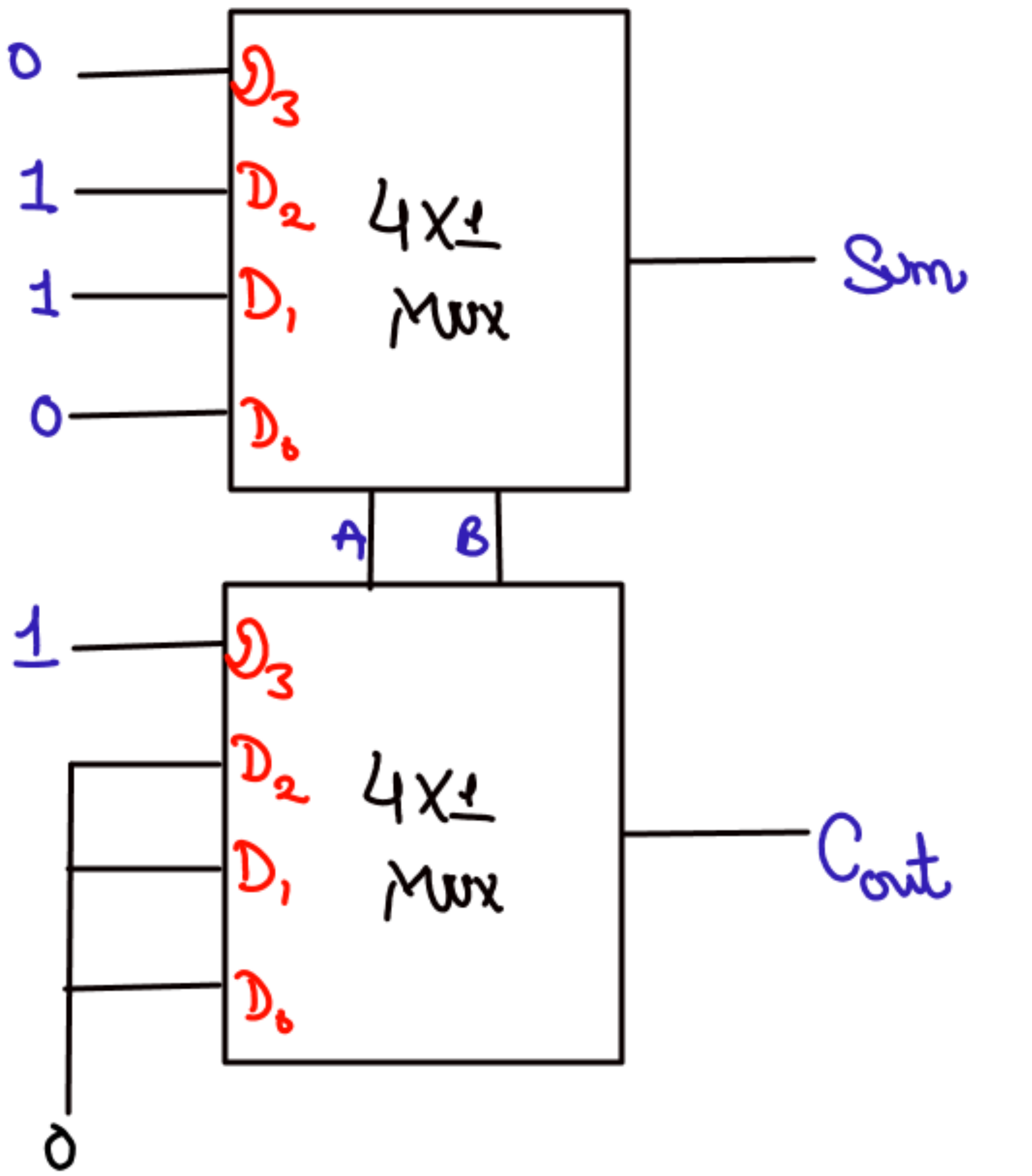
↓ 4 input lines

MSB LSB

A	B	Sum (S)	Carry (C)	
0	0	0	0	D_0
0	1	1	0	D_1
1	0	1	0	D_2
1	1	0	1	D_3

2 Mux

Sum Carry



HALF ADDER USING 2:1 MUX

A	B	Sum (S)	Carry (C)
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

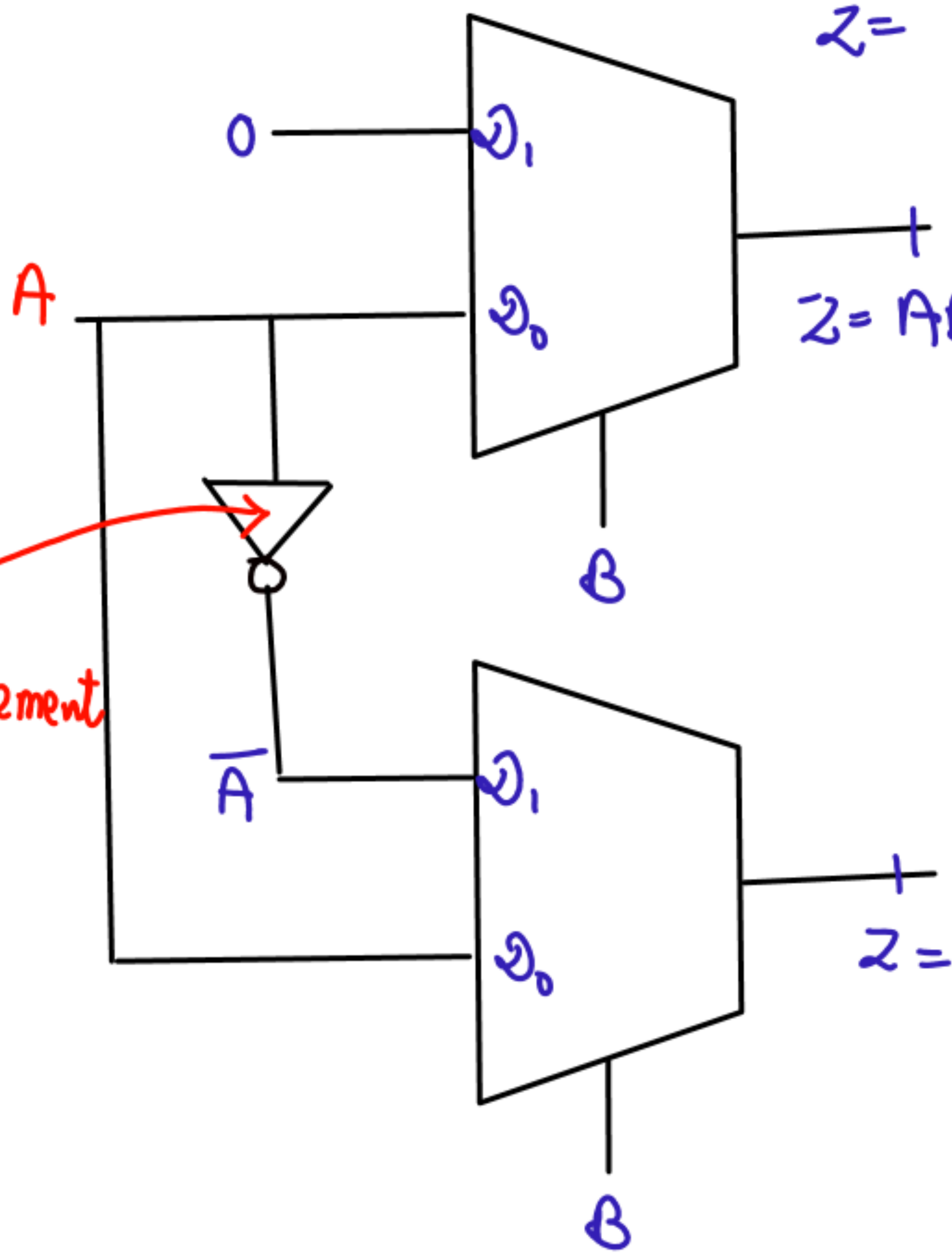
for half Adder:

$\boxed{\begin{array}{l} \text{Sum} = A \oplus B \\ \text{Carry} = AB \end{array}}$

XOR

AND

let A be the input line & B be the select line



We can Implement this Inverter using mux

$Z = \cancel{\bar{B}0} + BA$

$= AB$

$Z = AB$ (Carry)

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

$\bar{B}D_0 + BD_1$,

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

$= A \oplus B$

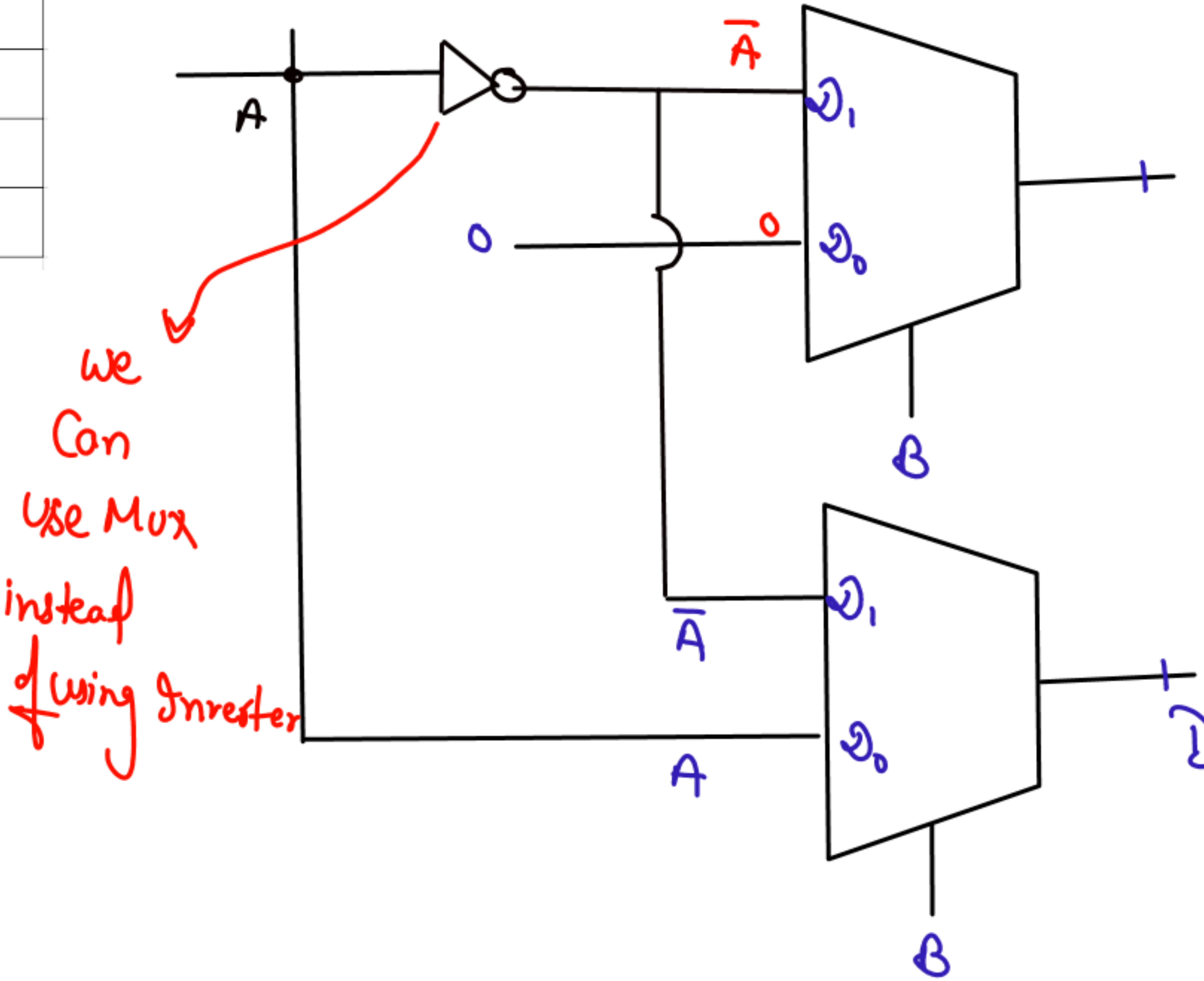
HALF SUBTRACTOR USING 2:1 MUX

A	B	Difference (D)	Borrow (B)
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

for half subtractor

Difference (D) = $A \oplus B$

Borrow = $\bar{A}B$



$\bar{B}D_0 + BD_1$

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

$\Rightarrow \bar{A}B$ (Borrow)

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

$= A \oplus B$

FULL ADDER USING 4:1 MUX

TRUTH TABLE

	A	B	Cin	SUM	CARRY
0	0	0	0	0	0
1	0	0	1	1	0
2	0	1	0	1	0
3	0	1	1	0	1
4	1	0	0	1	0
5	1	0	1	0	1
6	1	1	0	0	1
7	1	1	1	1	1

Let Input Variable = A
& BC_{in} be the Select line

$$Sum = \Sigma m(1, 2, 4, 7)$$

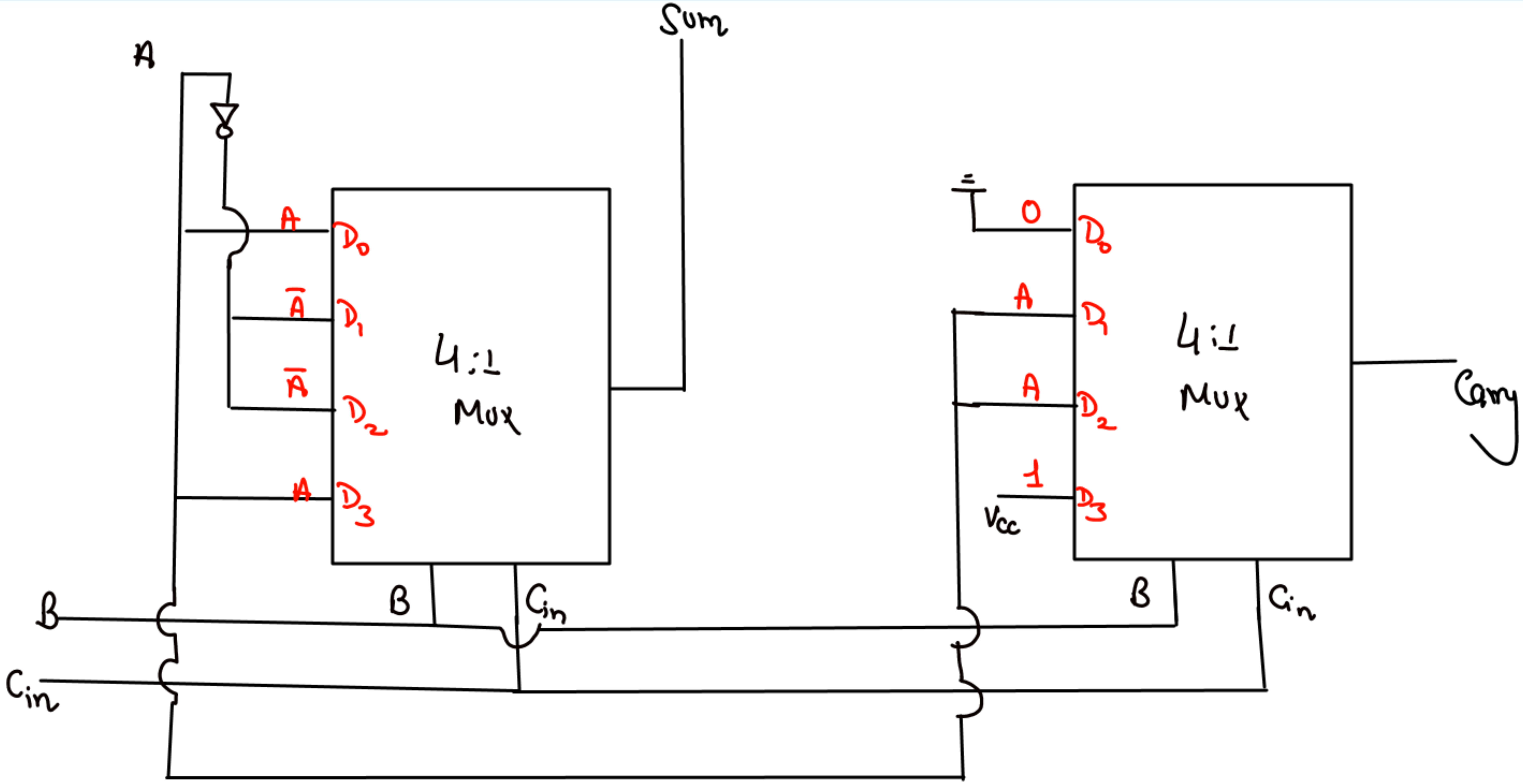
$$Carry = \Sigma m(3, 5, 6, 7)$$

for Sum

BC→	00	01	10	11
$\bar{A}$ 0	0 (000)	1 (001)	2 (010)	3 (011)
A 1	4 (100)	5 (101)	6 (110)	7 (111)
	A	$\bar{A}$	$\bar{A}$	A
	D_0	D_1	D_2	D_3

for Carry

BC→	00	01	10	11
$\bar{A}$ 0	0 (000)	1 (001)	2 (010)	3 (011)
A 1	4 (100)	5 (101)	6 (110)	7 (111)
	0	A	A	1
	D_0	D_1	D_2	D_3


A
Sum
A
$\bar{A}$
$\bar{A}$
A
D_0
D_1
D_2
D_3
4:1
Mux
B
C_{in}
B
C_{in}
0
A
A
1
Vcc
D_0
D_1
D_2
D_3
4:1
Mux
B
C_{in}
Carry

FULL SUBTRACTOR USING 4:1 MUX

	TRUTH TABLE				
	A	B	Bin	Diff	Bout
0	0	0	0	0	0
1	0	0	1	1	1
2	0	1	0	1	1
3	0	1	1	0	1
4	1	0	0	1	0
5	1	0	1	0	0
6	1	1	0	0	0
7	1	1	1	1	1

Let Input Variable = A
& BC_{in} be the Select line

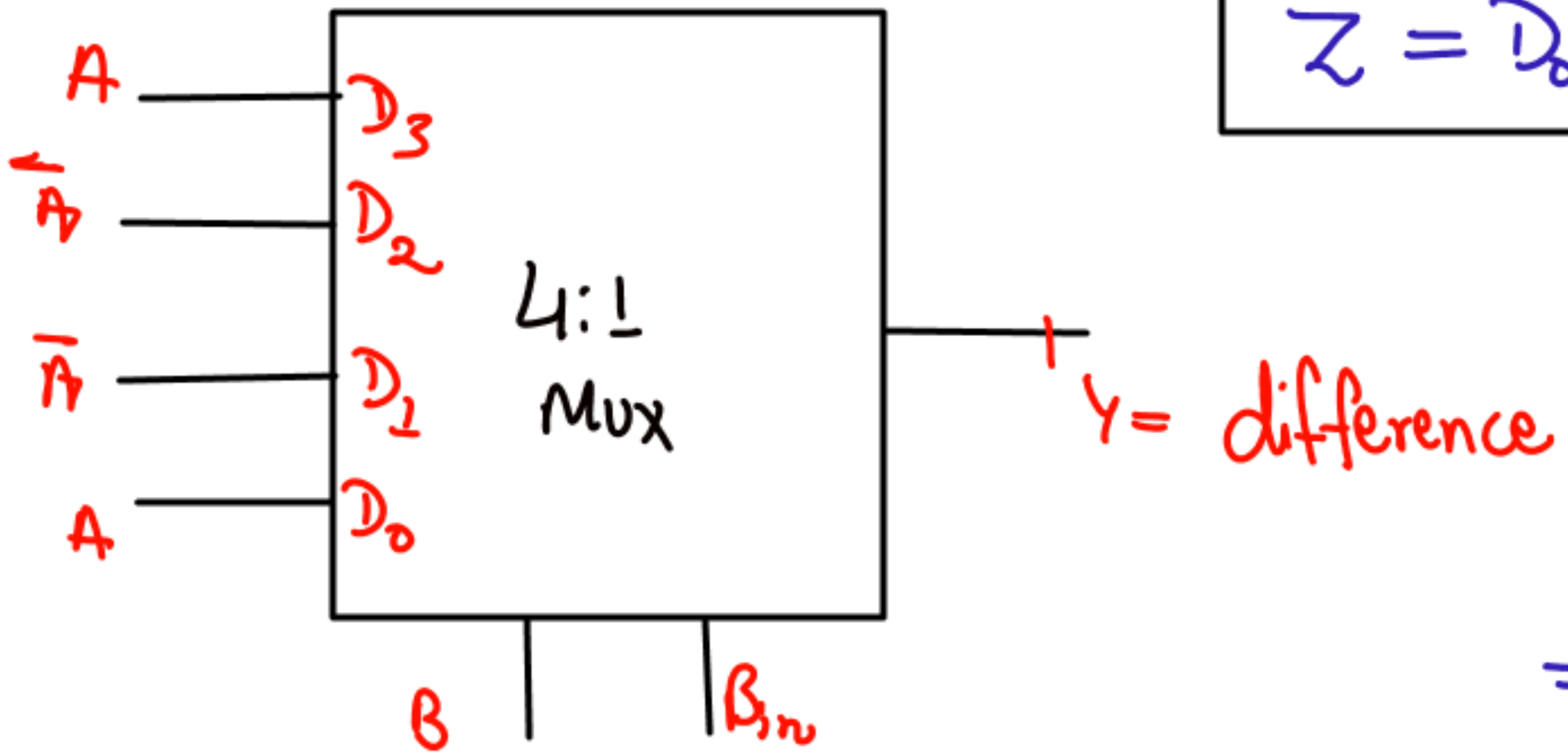
$$Sum = \Sigma m(1, 2, 4, 7)$$
$$Bout = \Sigma m(1, 2, 3, 7)$$

for difference

B Bin	00	01	10	11
$\bar{A}$ 0	0 000	1 001	2 010	3 011
A 1	4 100	5 101	6 110	7 111
	A	$\bar{A}$	$\bar{A}$	A
	D_0	D_1	D_2	D_3

for Bout

B Bin	00	01	10	11
$\bar{A}$ 0	0 000	1 001	2 010	3 011
A 1	4 100	5 101	6 110	7 111
	0	$\bar{A}$	$\bar{A}$	1
	D_0	D_1	D_2	D_3



$$\boxed{Z = D_0 \cdot \bar{B}\bar{B_i} + D_1\bar{B}B_i + D_2 B\bar{B_i} + D_3 B B_i}$$

$$\Rightarrow A\bar{B}\bar{B_i} + \bar{A}\bar{B}B_i + \bar{A}B\bar{B_i} + ABB_i$$

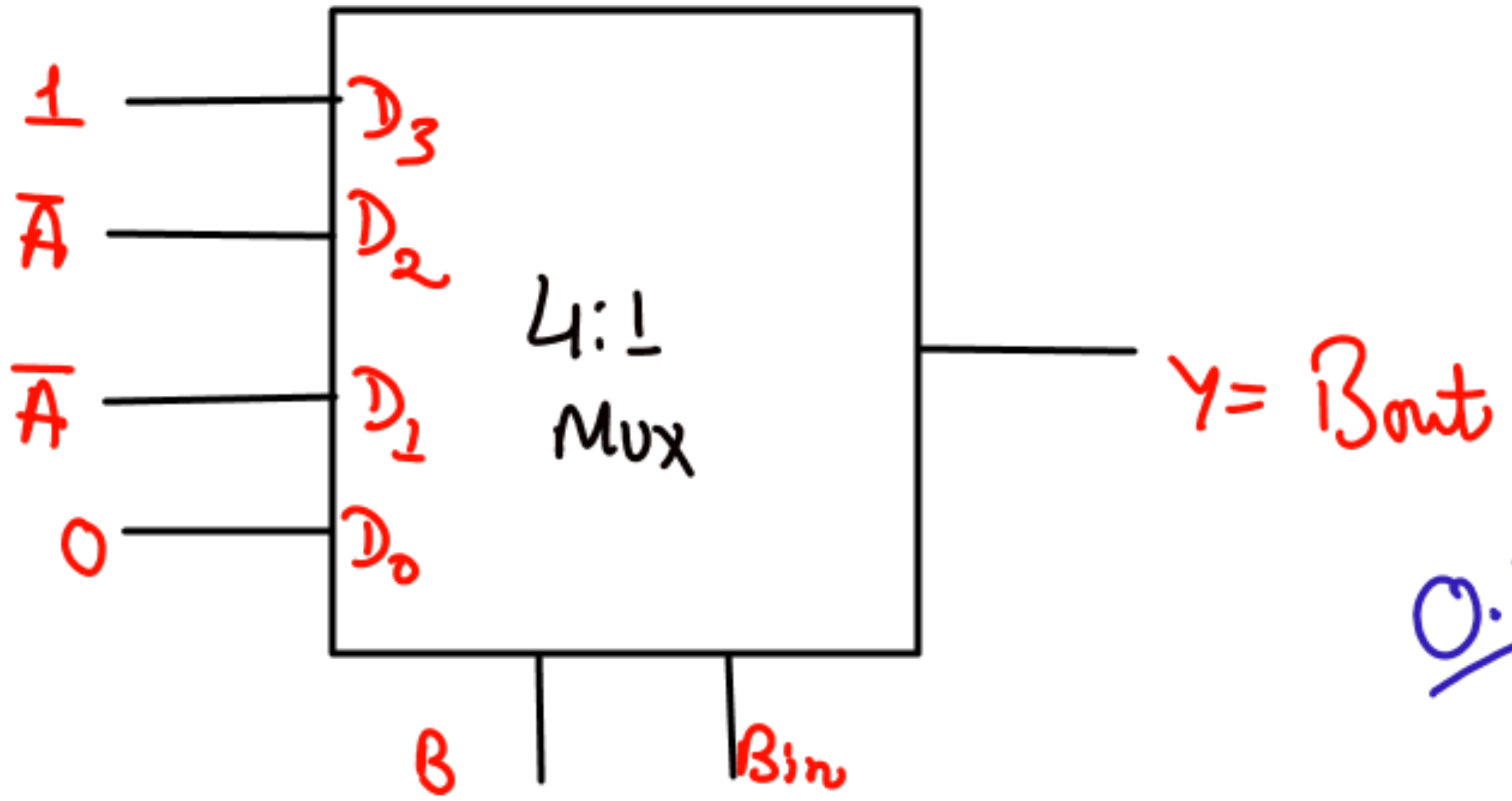
$$\Rightarrow \bar{B_i}(A\bar{B} + \bar{A}B) + B_i(\bar{A}\bar{B} + AB)$$

let $A\bar{B} + \bar{A}B = x = A \oplus B$

$A \odot B = \overline{A \oplus B}$

$$\Rightarrow \bar{B_i}x + B_i\bar{x}$$

$$\Rightarrow B_i \oplus x \rightarrow \boxed{B_i \oplus A \oplus B}$$



$$\boxed{Z = D_0 \cdot \bar{B}\bar{B_i} + D_1\bar{B}B_i + D_2 B\bar{B_i} + D_3 B B_i}$$

$$\cancel{0 \cdot \bar{B}\bar{B_i}} + \bar{A}\bar{B}B_i + \bar{A}B\bar{B_i} + 1BB_i$$

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

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

$$\boxed{\bar{A}(B \oplus B_i) + B \cdot B_i}$$

IMPLEMENTATION OF HIGH ORDER MUX TO LOWER ORDER MUX

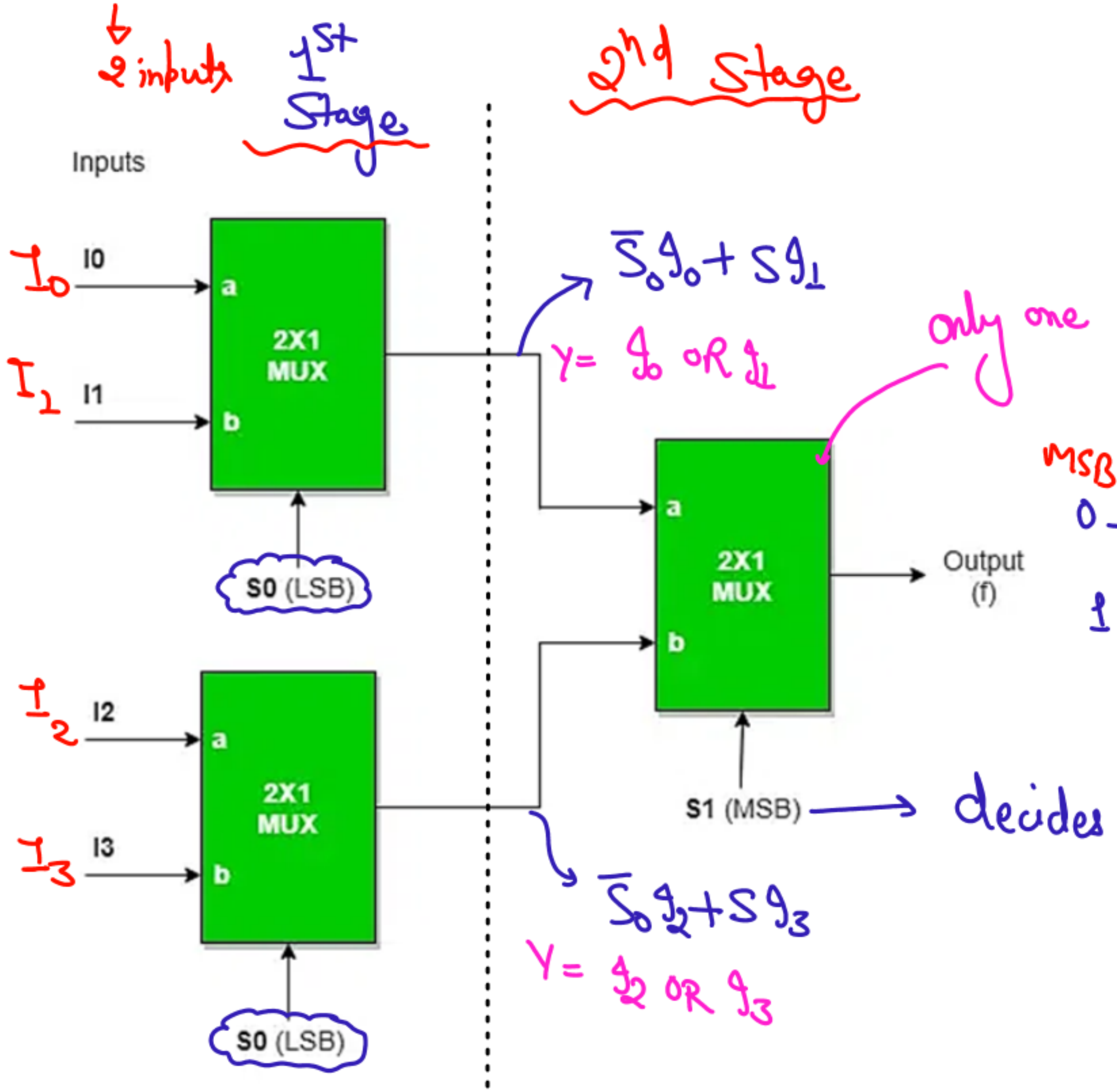
4 : 1 MUX using 2 : 1 MUX

4 inputs

2 inputs

MSB ही खास क्यों है?

MSB → 0, 1



MSB

LSB

Truth Table

S1	S0	f
0	0	I0
0	1	I1
1	0	I2
1	1	I3

4 o/p

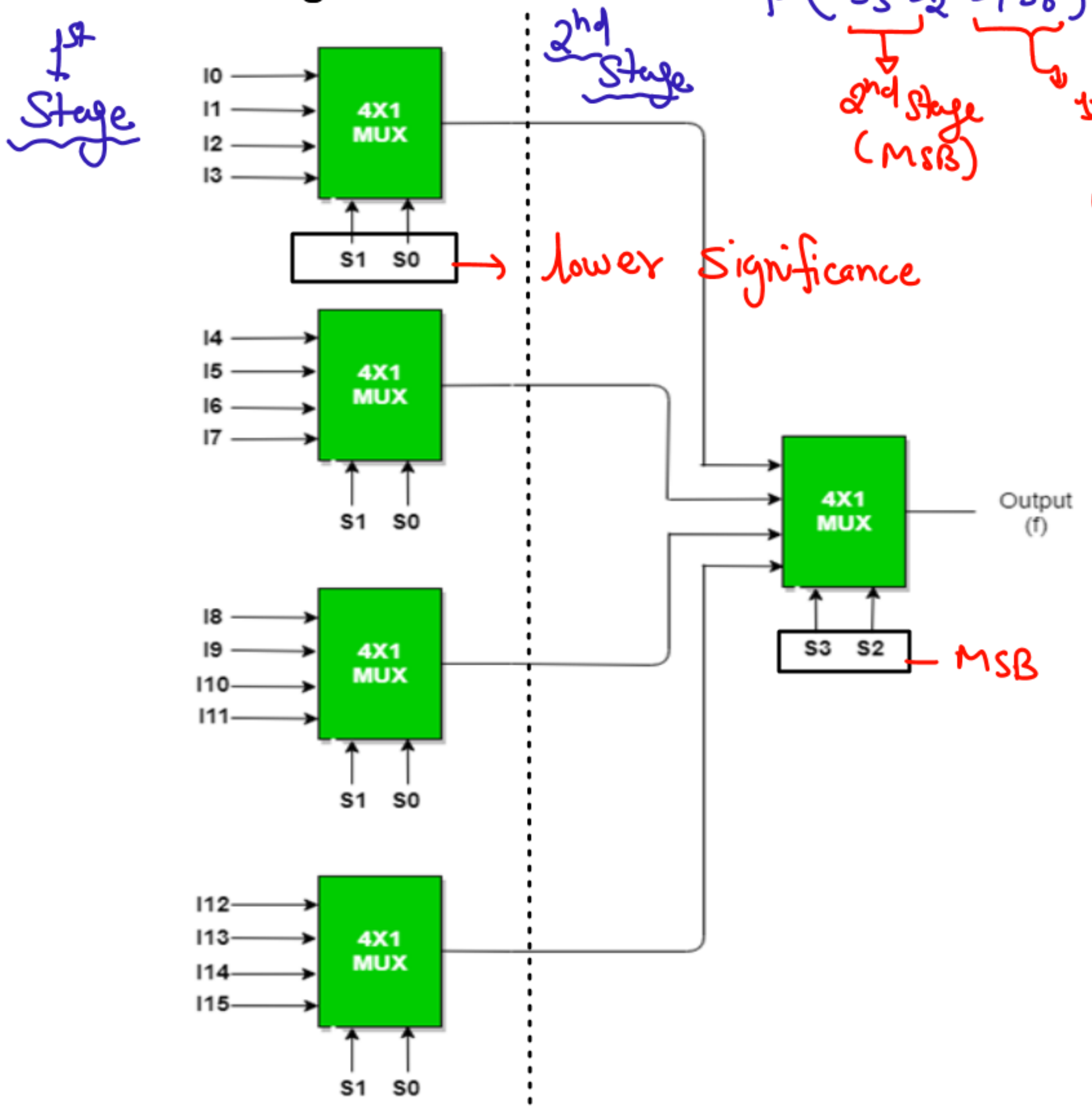
IMPLEMENTATION OF HIGH ORDER MUX TO LOWER ORDER MUX

16 : 1 MUX using 4 : 1 MUX

$f(S_3 S_2 S_1 S_0) = \sum m(\ldots)$

$S_3 S_2$ → 2nd Stage (MSB)

$S_1 S_0$ → 1st Stage (LSB)



General formula to implement B:1 mux from A:1 Mux

for implementing B:1 mux using A:1 Mux we have to follow the following sequence

Stage 1 $\longrightarrow$ Stage 'n'

LSB $\longrightarrow$ MSB

$B/A = K_1$ (K_1 are the number of MuX at first stage)

[Set less significant Bits as select line]

$K_1/A = K_2$ (No of mux at 2^{nd} stage)

$K_2/A = K_3$ (3^{rd} Stage)

$\vdots$

$\frac{K_{n-1}}{A} = K_n = 1$ (till we get 1)

Total Mux Required $= K_1 + K_2 + K_3 + \ldots + K_n \Rightarrow \sum_{K=1}^{n} K_i$

$$\boxed{\text{If } \frac{K_{n-1}}{A} = K_n \neq 0}$$

Eg $\boxed{\text{design } 16:1 \text{ mux using } 8:1 \text{ mux}}$

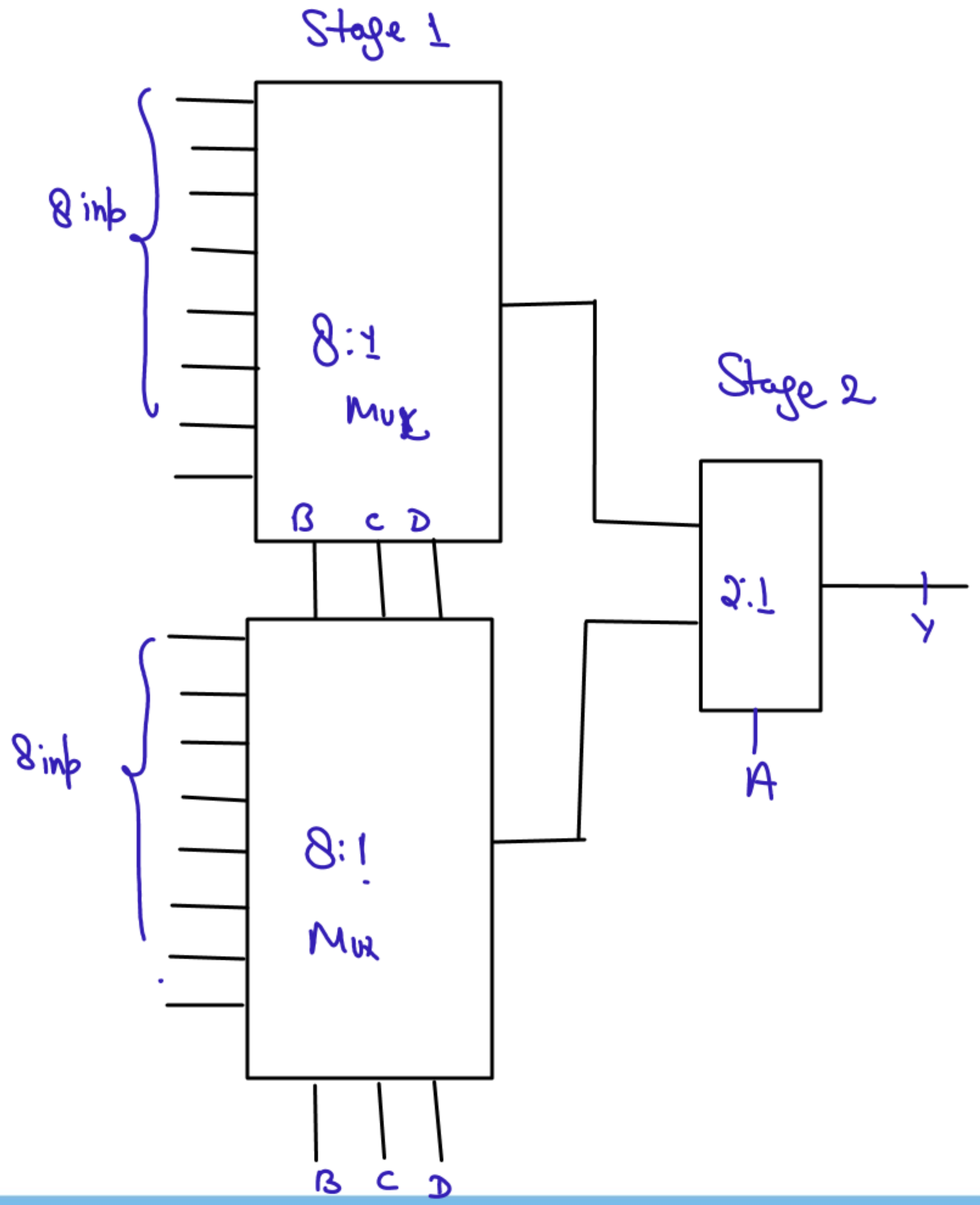
B : 1 A : 1

$B/A \Rightarrow \frac{16}{8} = 2$ (first Stage = 2 mux)

$2/8 = ?$ take 2:1 mux at 2^{nd} Stage

let

Select lines Be $(\underbrace{A}_{MSB}, \underbrace{B, C, D}_{LSB})$



IMPLEMENTATION OF HIGH ORDER MUX TO LOWER ORDER MUX

How many 4:1 mux are required to implement a 64:1 mux?

A:1

B:1

$64/4 = 16$ (Stage 1)

$16/4 = 4$ (Stage 2)

$4/4 = 1$ (Stage 3)

total Mux required

$= 16 + 4 + 1$

$= 21$ mux