Digital Electronics and Computer Organization

Digital Design

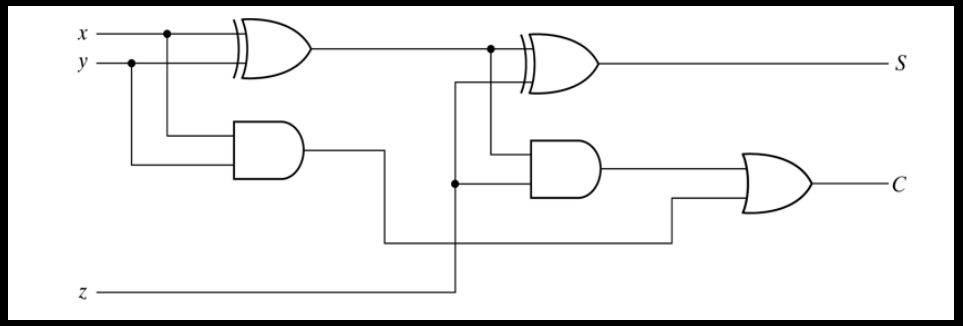
Lecture 12:
4 Bit Adders , Multipliers
and
Magnitude Comparators

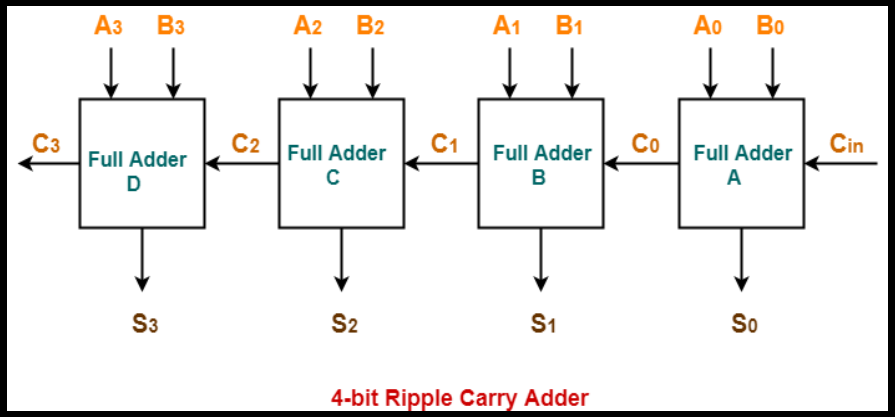
Birla Institute of Technology & Science, Pilani
Hyderabad Campus

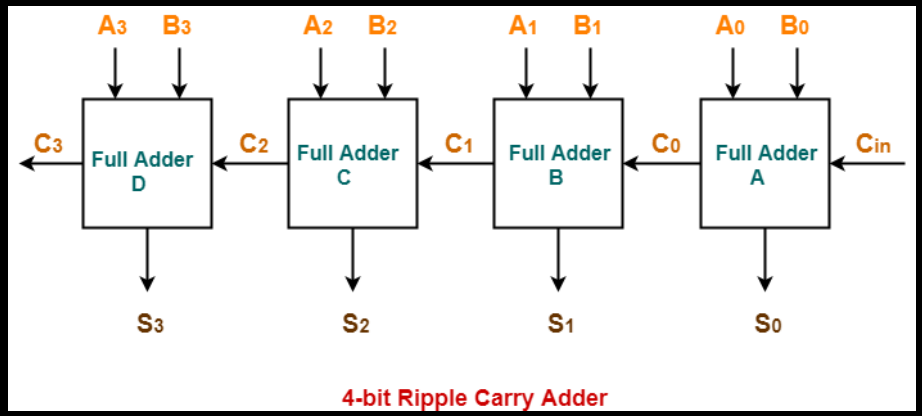
Innovate achieve lead

Ripple Carry Adder

8 Bit Full Adder



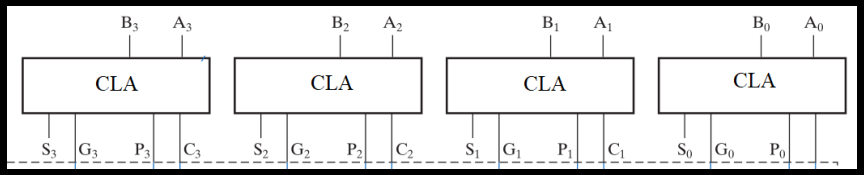


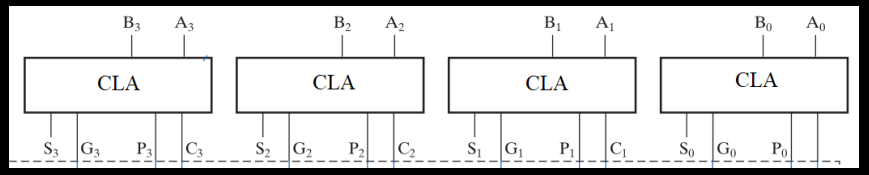


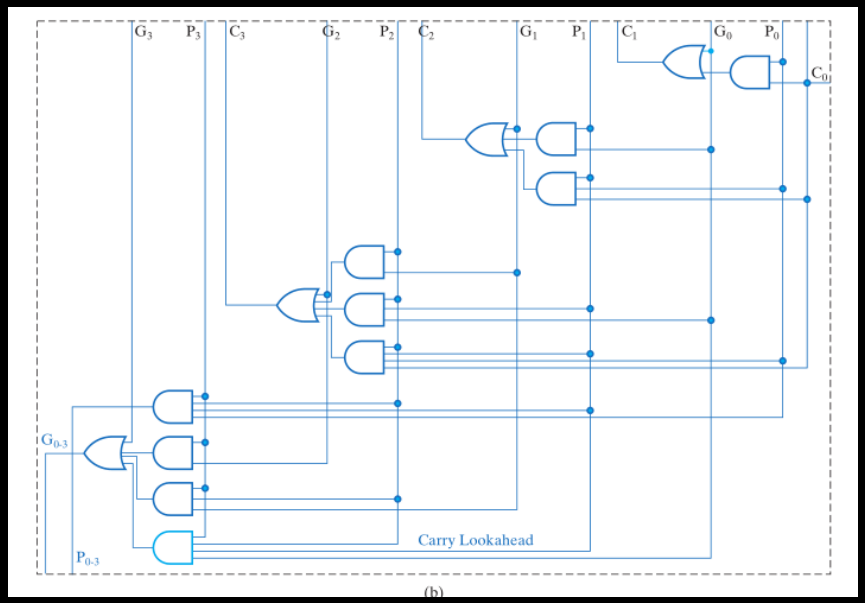
Delay = 8 X 3 Gate Delay

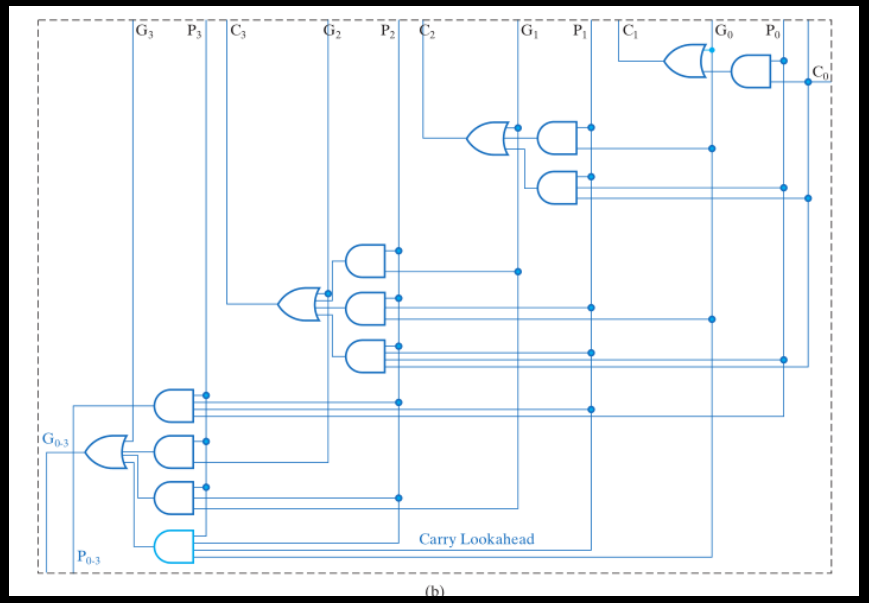
Carry Look-Ahead Adder

8 Bit Full Adder



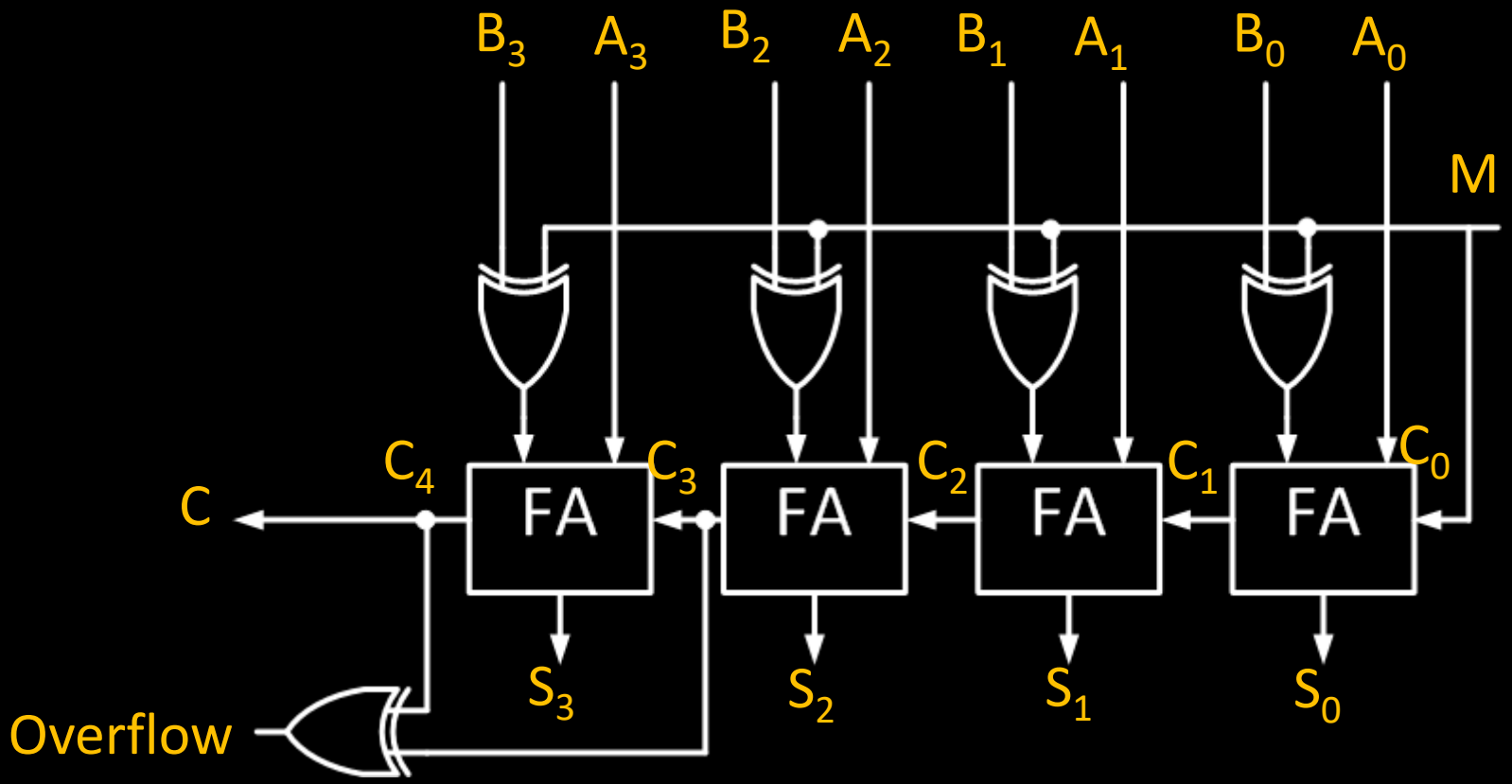






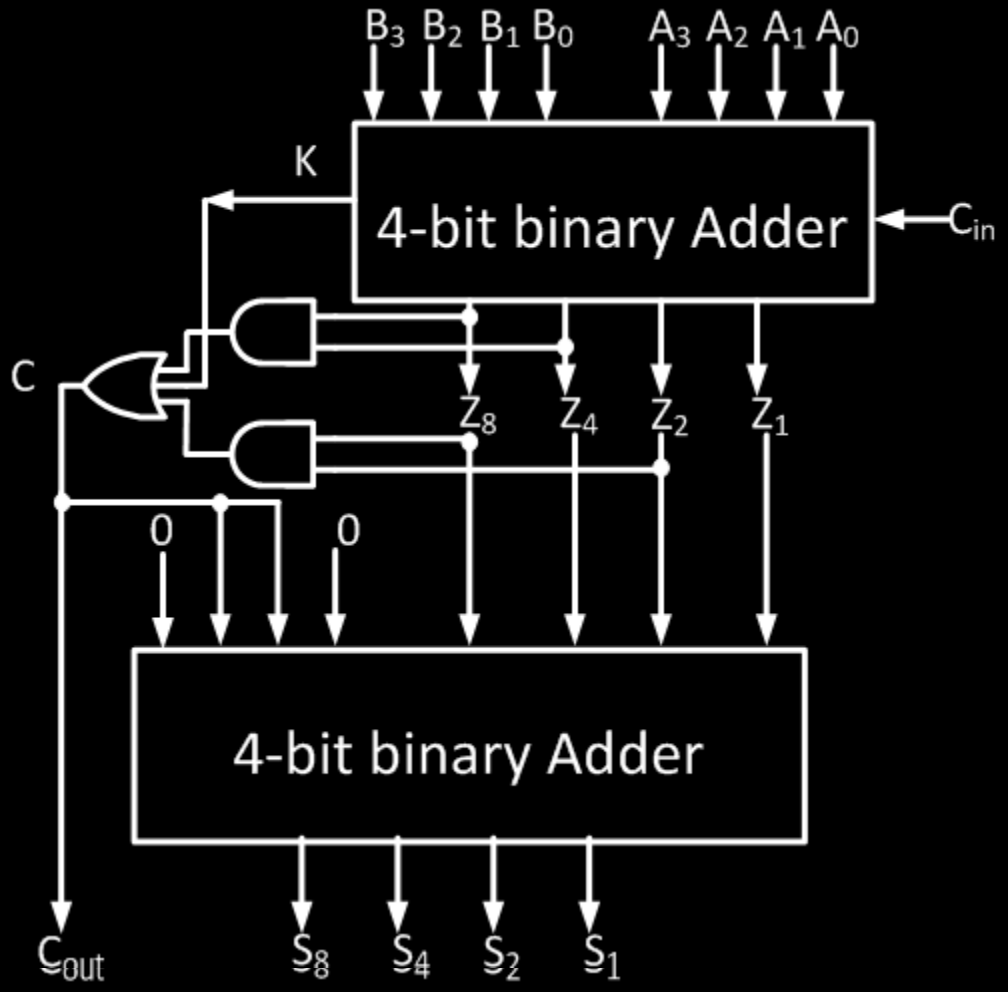
Delay = 2 X 3 Delay

4-bit Adder subtractor with overflow detection



BCD Adder

If C is 1 Add 6
If C is 0 Add 0



Binary Multiplier

	2	3
x	5	2

Binary Multiplier

		2	3
	x	5	2
		4	6
1	1	5	
1	1	9	6

	1	0
x	1	1

Binary Multiplier

		2	3
	x	5	2
		4	6
1	1	5	
1	1	9	6

		1	0
	x	1	1
		1	0
	1	0	
	1	1	0

2 x 3 = 6

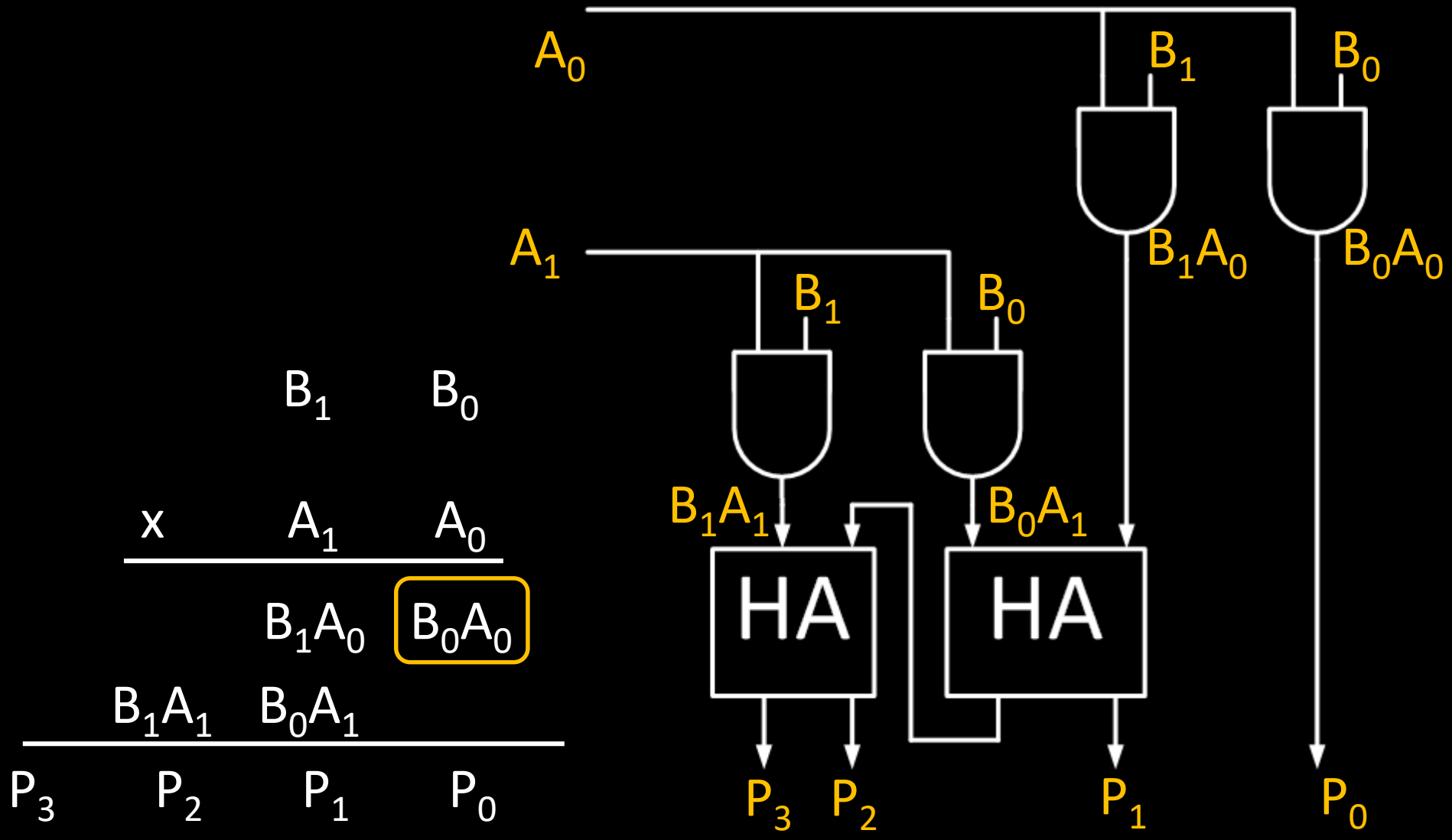
Binary Multiplier (2-bit x 2-bit)

$$
\begin{array}{cccc}
 & & B_1 & B_0 \\
 & x & A_1 & A_0 \\
\hline
 & & B_1A_0 & B_0A_0 \\
 & B_1A_1 & B_0A_1 & \\
\hline
P_3 & P_2 & P_1 & P_0
\end{array}
$$

Gate for 1-bit Multiplication (B_0A_0) ?

A_0	B_0	F
0	0	0
0	1	0
1	0	0
1	1	1

Binary Multiplier



$$
\begin{array}{cccc}
 & & B_1 & B_0 \\
\times & & A_1 & A_0 \\
\hline
 & & B_1A_0 & B_0A_0 \\
 & B_1A_1 & B_0A_1 & \\
\hline
P_3 & P_2 & P_1 & P_0
\end{array}
$$

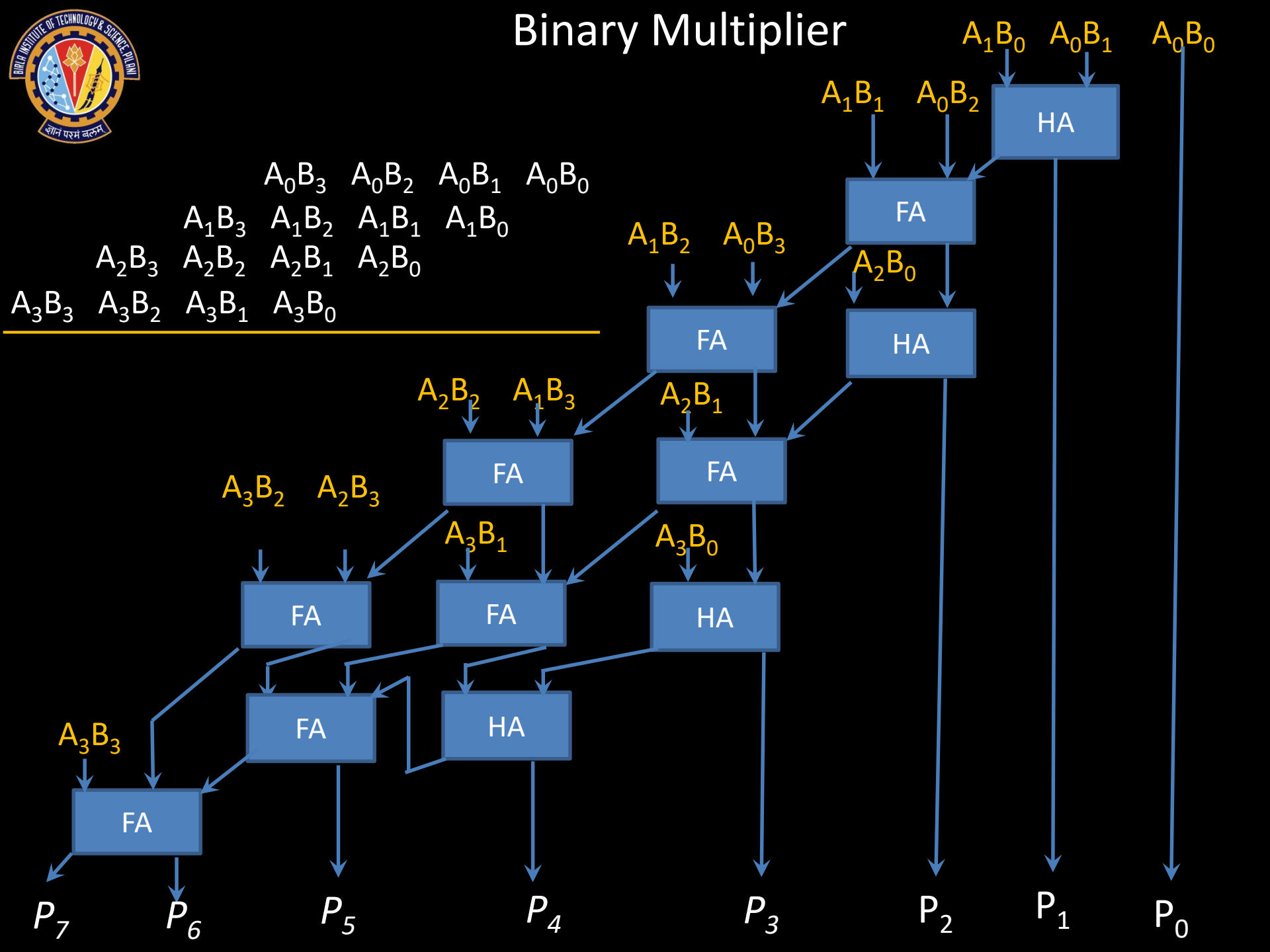
Binary Multiplier

(Multiplicand) $B_3\ B_2\ B_1\ B_0$

(Multiplier) $A3\ A_2\ A_1\ A_0$

		A_0B_3	A_0B_2	A_0B_1	A_0B_0
	A_1B_3	A_1B_2	A_1B_1	A_1B_0	
A_2B_3	A_2B_2	A_2B_1	A_2B_0		
A_3B_3	A_3B_2	A_3B_1	A_3B_0		

Binary Multiplier



Magnitude Comparator

A Magnitude comparator is a combinational circuit that compares two numbers A and B .

The output of the magnitude comparator are three signals that indicate if (A>B), (A<B), (A=B)

Even a 3-bit comparator results in 6 inputs – Too complex to solve using K-maps

Look for Regularity in design

Magnitude Comparator

How do you compare two numbers?

2	3	4
5	6	4

Compare most significant digit

If most significant digit of first number is greater than the most significant digit of second number then

First Number > Second number

Magnitude Comparator

If most significant digits are equal ??

2	3	4
2	6	4

Compare the next significant digit

If next significant digit of first number is greater than the next significant digit of second number then

First Number > Second number

Magnitude Comparator

1	0	1
1	1	0

Magnitude Comparator

1	0	1
1	1	0

Magnitude Comparator

1-Bit Comparator

A_0

B_0

Let G_0 indicate greater, L_0 indicate Lesser and E_0 indicate equal

A_0	B_0	G_0	L_0	E_0
0	0	0	0	1
0	1	0	1	0
1	0	1	0	0
1	1	0	0	1

$G_0 = A_0B_0'$

$L_0 = A_0'B_0$

$E_0 = (A_0 \oplus B_0)' = (A_0 \odot B_0) = (G_0 + L_0)'$

Magnitude Comparator

1-Bit Comparator

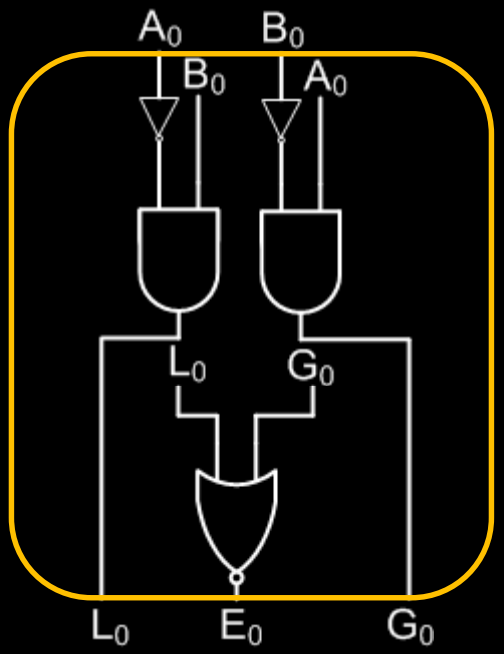
A_0

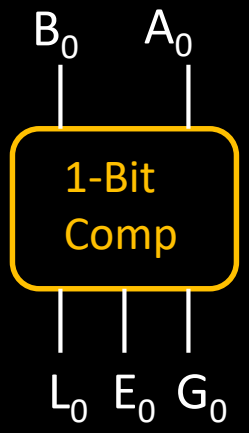
B_0

$G_0 = A_0B_0'$

$L_0 = A_0'B_0$

$E_0 = (G_0 + L_0)' = (A_0 \oplus B_0)'$



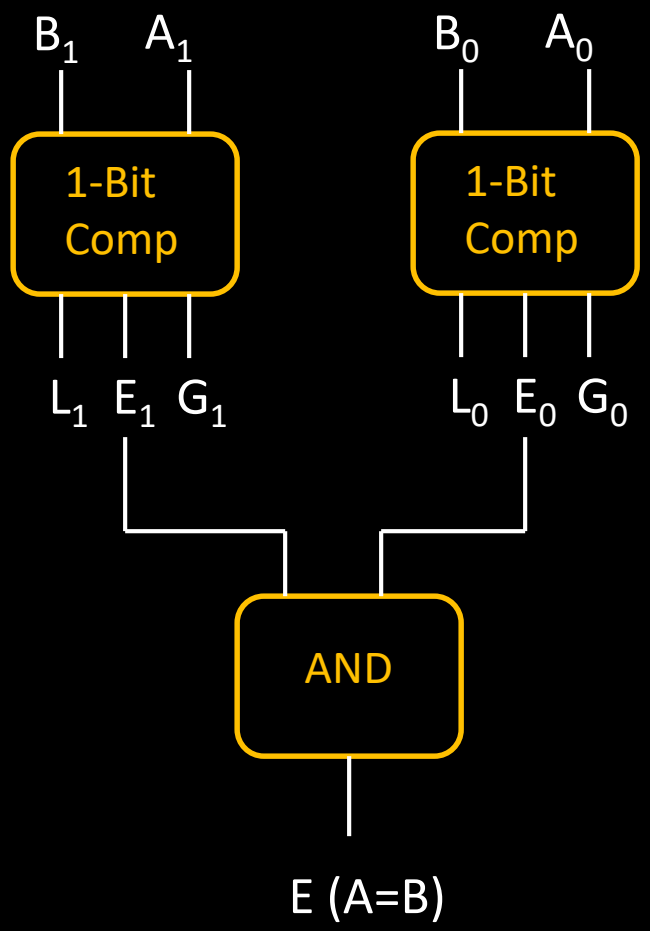


Magnitude Comparator

2-Bit Comparator

A $A_1 A_0$

B $B_1 B_0$



A = B When $A_0 = B_0$ and $A_1 = B_1$

$E = E_0 . E_1$

Magnitude Comparator

2-Bit Comparator

A $A_1 A_0$

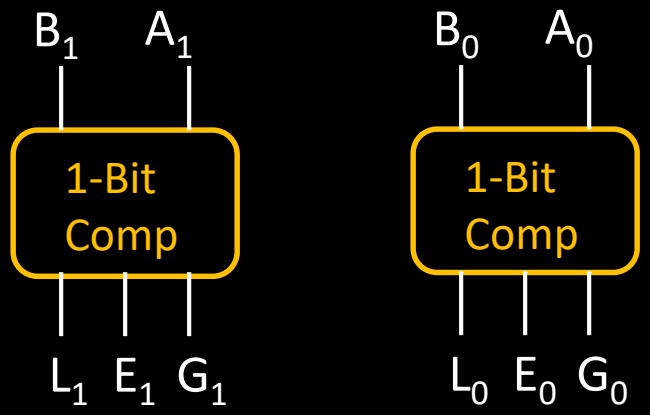
B $B_1 B_0$

Magnitude Comparator

2-Bit Comparator

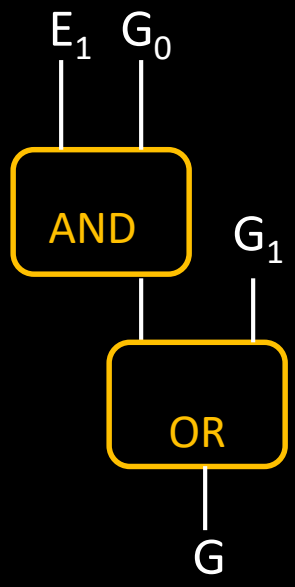
A $A_1 A_0$

B $B_1 B_0$



A > B When $A_1 > B_1$ OR
When $A_1 = B_1$ and $A_0 > B_0$

$G = G_1 + E_1 . G_0$

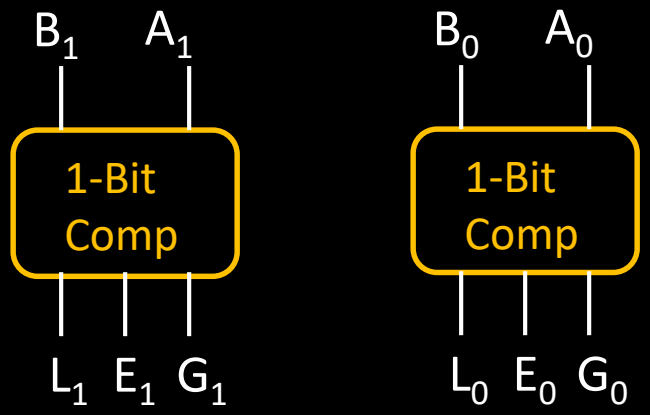


Magnitude Comparator

2-Bit Comparator

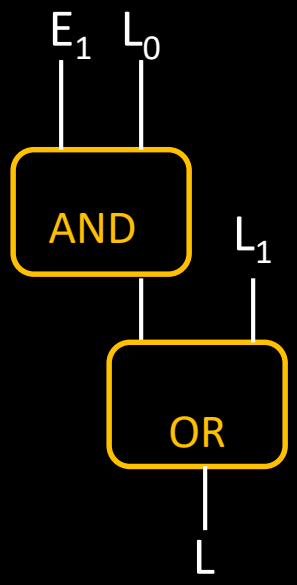
A $A_1 A_0$

B $B_1 B_0$



A < B When $A_1 < B_1$ OR
When $A_1 = B_1$ and $A_0 < B_0$

$L = L_1 + E_1 \cdot L_0$



Magnitude Comparator

1-Bit Comparator

$G = G_0$ $L = L_0$ $E = E_0$

2-Bit Comparator

$G = G_1 + E_1 . G_0$ $L = L_1 + E_1 . L_0$ $E = E_1 . E_0$

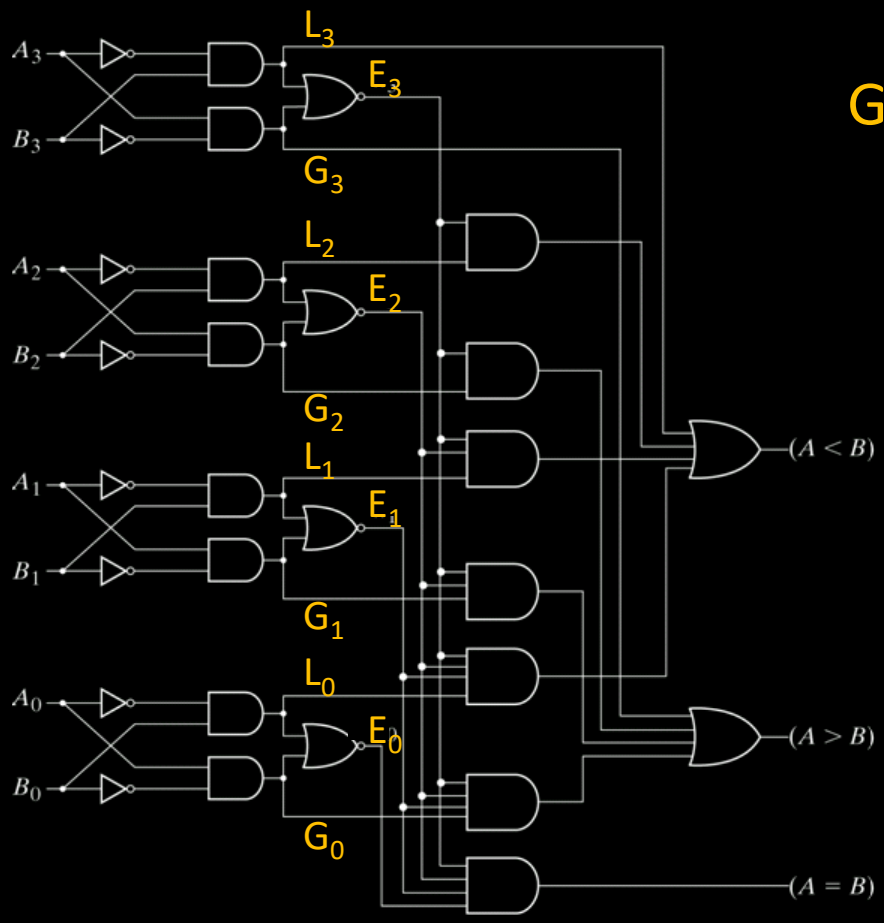
3-Bit Comparator

$G = G_2 + E_2 . G_1 + E_2 . E_1 . G_0$

$L = L_2 + E_2 . L_1 + E_2 . E_1 . L_0$

$E = E_2 . E_1 . E_0$

Magnitude Comparator



4-Bit Comparator

$$G = G_3 + E_3.G_2 + E_3.E_2.\ G_1 + E_3.E_2.\ E_1.\ G_0$$

$$L = L_3 + E_3.L_2 + E_3.E_2.\ L_1 + E_3.E_2.\ E_1.\ L_0$$

$$E = E_2\ .E_1.\ E_0$$

Can you draw the circuit ??

Next Module

Decoders

Encoders

Multiplexers

Thank You