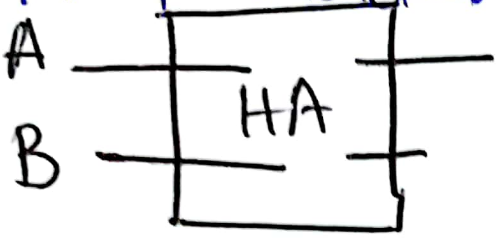
Telephone: + 92 (051) 3355700-30 Fax: +92 (051) 3355574

Half Adder



Sum

Carry

Adder

2 bits addition

A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

K-Map

A \ B	0	1
0	0	1
1	1	0

Sum Expression

$\bar{A}B$

$+ A\bar{B}$

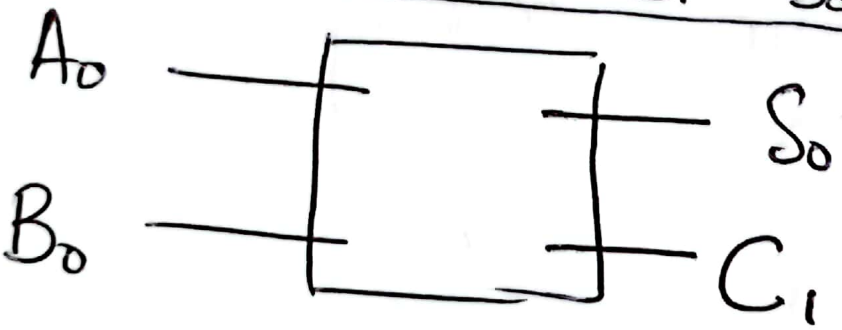
$= A \oplus B$

3 gate delay

Carry expression = AB

1 gate delay

	A_3	A_2	A_1	A_0
	C_3	C_2	C_1	C_0
A	1	0	1	1
	B_3	B_2	B_1	B_0
B	1	1	0	1
	S_3	S_2	S_1	S_0

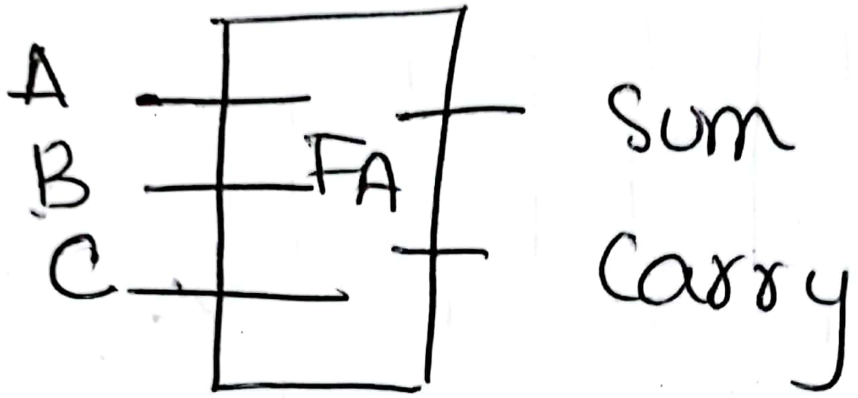


Use 2 Half Adders

$C_1 + A_1 = I_1$

$I_1 + B_1 = S_1$

Full Adder 3 bit add



A	B	C	Sum	Carry
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

Sum

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

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

$$= A \oplus B \oplus C$$ → 3 gate delay

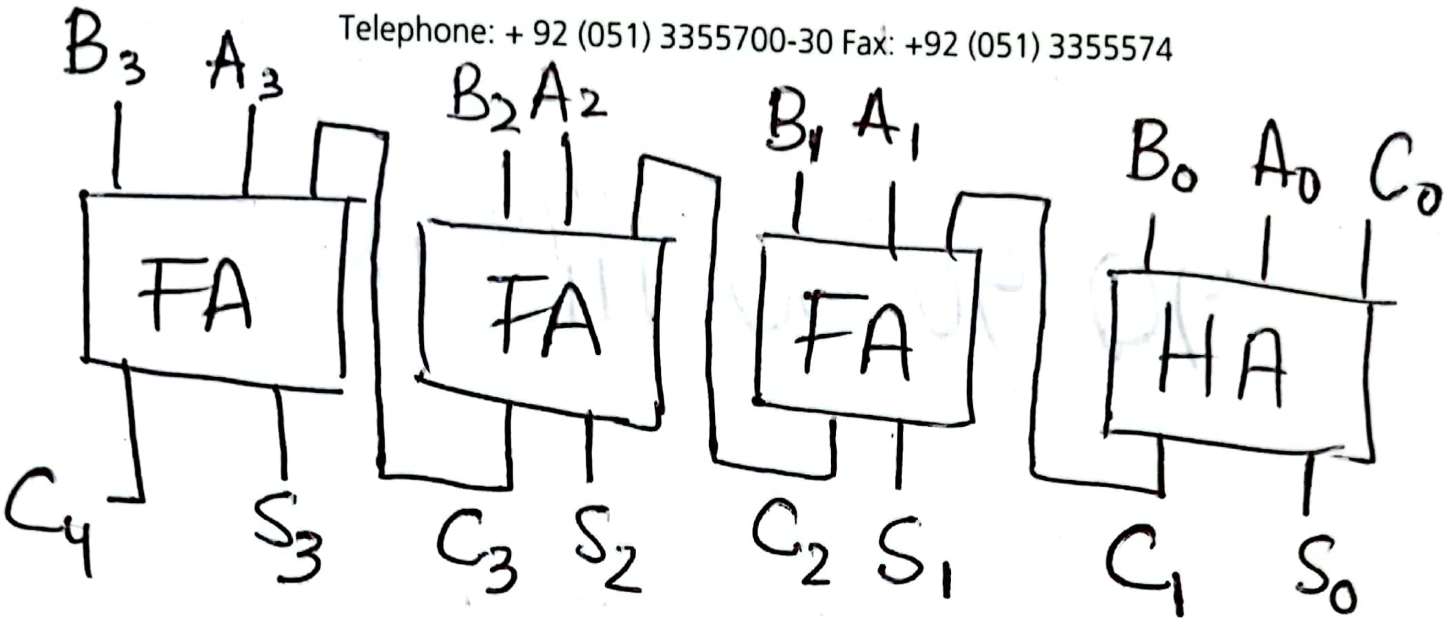
— sum of products

Carry

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

$$= BC + AC + AB$$ → 2 gate delay

— put this circuit in the block for carry



- Ripple adder

Delay!

- Issue: the carry causes delay!

64 bit

- The inputs A & B are available instantly
- however C_1 is not available until the addition is performed.

Look - Ahead Carry

- trade-off complexity for time efficiency

$P = A \oplus B$, $G = A \cdot B$

$C_1 = C_0 (A_0 \oplus B_0) + A_0 B_0$

$C_1 = C_0 P_0 + G_0$ — (1)

$C_2 = C_1 P_1 + G_1$ — (2)

$C_3 = C_2 P_2 + G_2$ — (3)

- Substitute equation (1) in (2) to get an expression for C_2 that is only a function of A, B and C_0 (input that is available immediately)
- Substitute (2) in (3) ....