ESC201T : Introduction to Electronics

Lecture 36: Combination circuit-3

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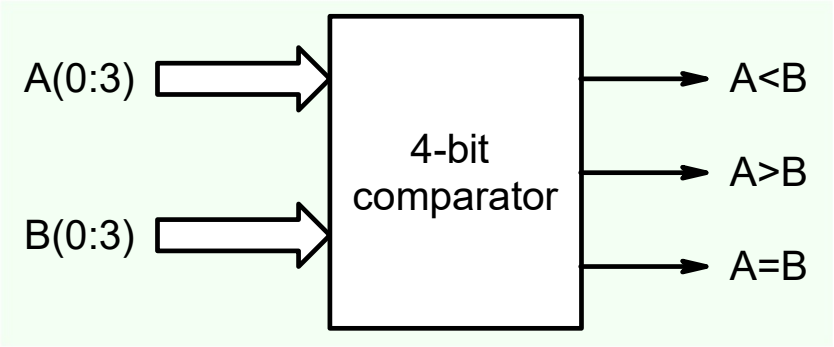
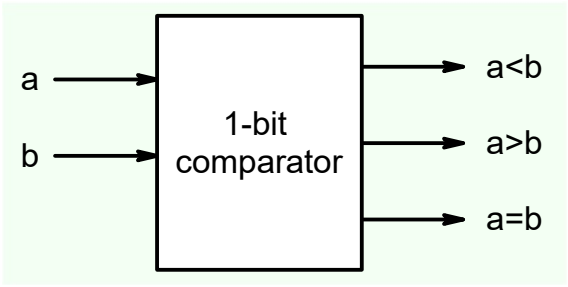
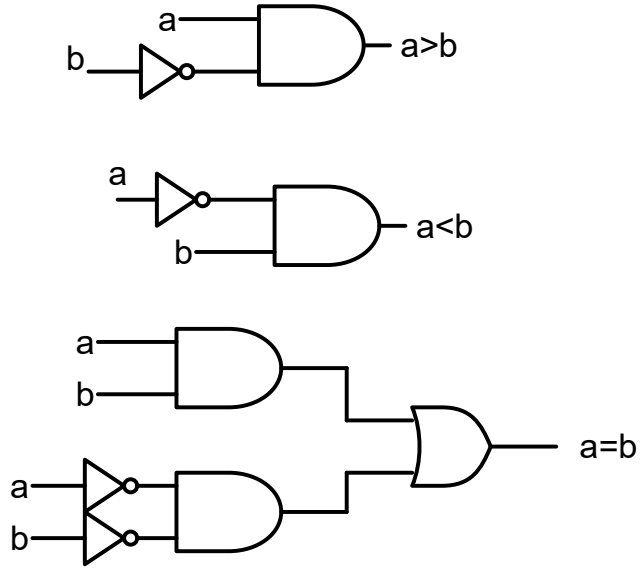
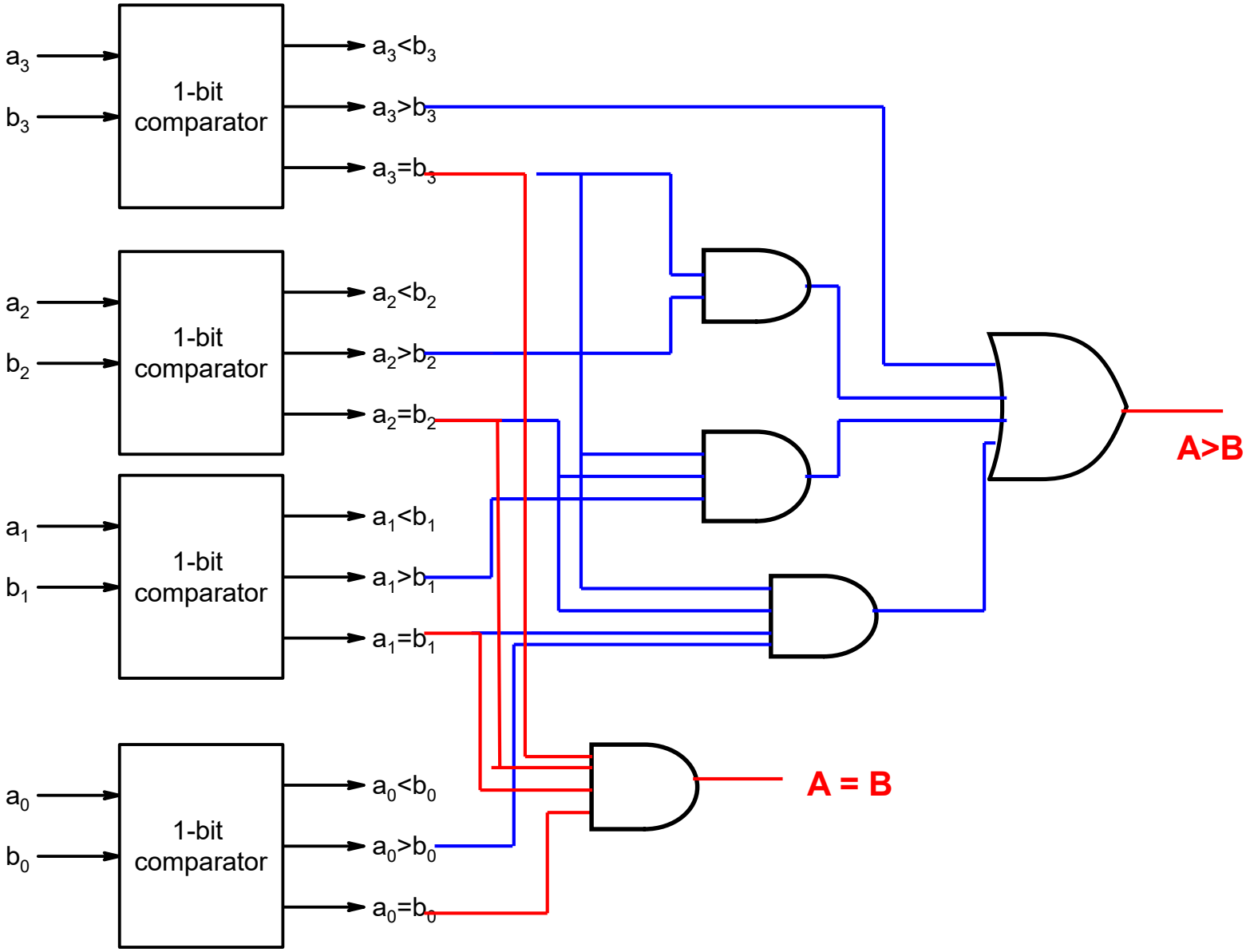
Comparator



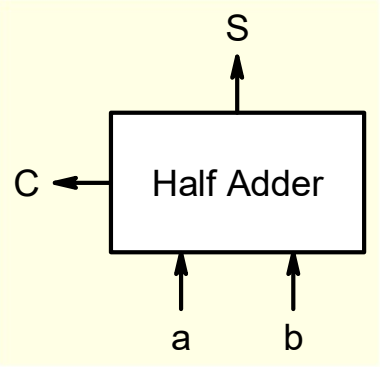
$A_3A_2A_1A_0$	$B_3B_2B_1B_0$	A<B	A>B	A=B
0000	0000	0	0	1
0000	0001	1	0	0
0001	0000	0	1	0
⋮	⋮	⋮	⋮	⋮



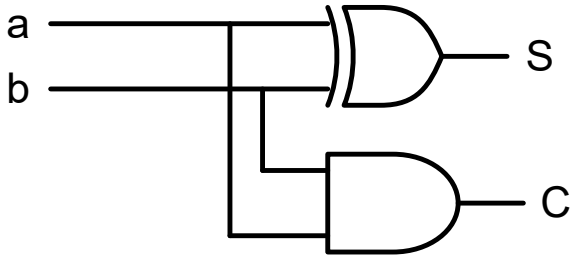



a3
b3
1-bit comparator
a3<b3
a3>b3
a3=b3
a2
b2
1-bit comparator
a2<b2
a2>b2
a2=b2
a1
b1
1-bit comparator
a1<b1
a1>b1
a1=b1
a0
b0
1-bit comparator
a0<b0
a0>b0
a0=b0
A>B
A = B

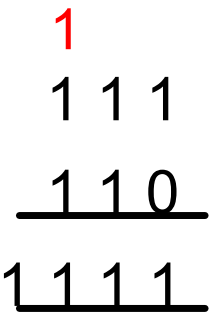
Adder/Subtractor

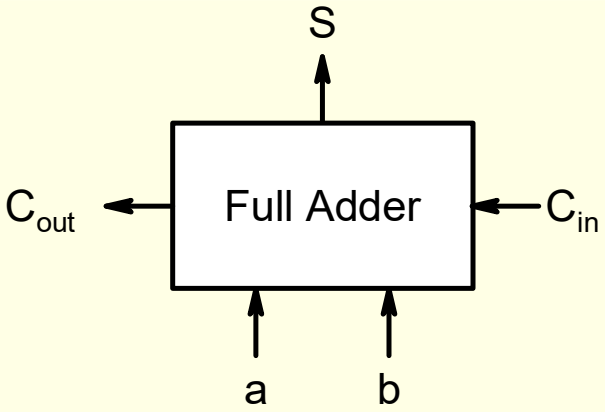


a	b	S	C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1



$$S = \overline{a}.b + a.\overline{b}; C = a.b$$





a	b	C_{in}	S	C_{out}
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

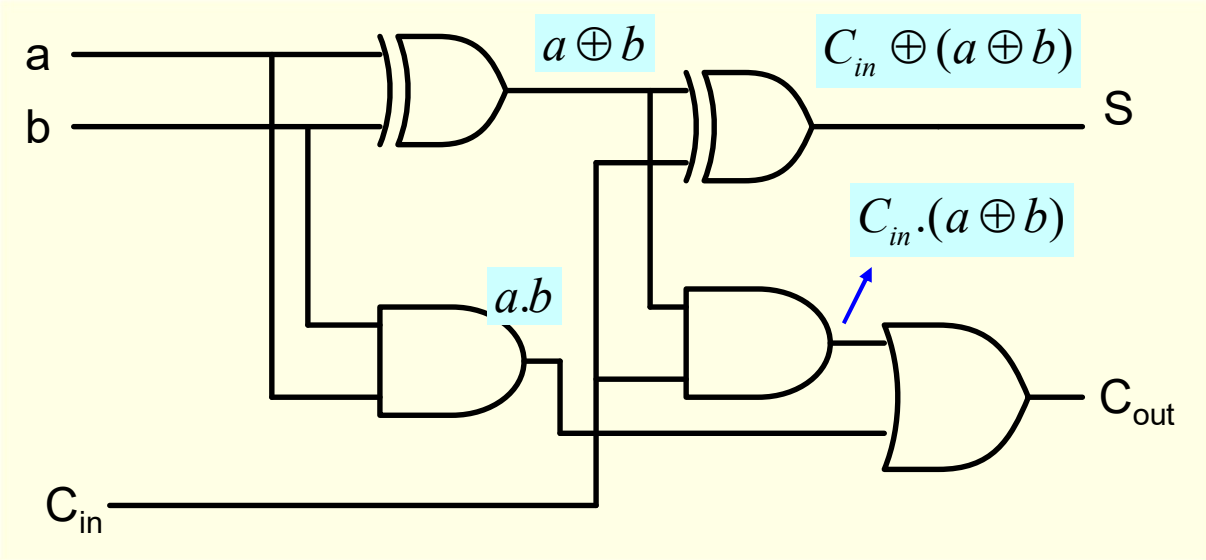
$$S = \overline{a}.\overline{b}.c_{in} + \overline{a}.b.\overline{c_{in}} + a.\overline{b}.\overline{c_{in}} + a.b.c_{in};\ C_{out} = a.b + a.c_{in} + b.c_{in}$$

$$S = \bar{a}.\bar{b}.c_{in} + \bar{a}.b.\overline{c_{in}} + a.\bar{b}.\overline{c_{in}} + a.b.c_{in}$$

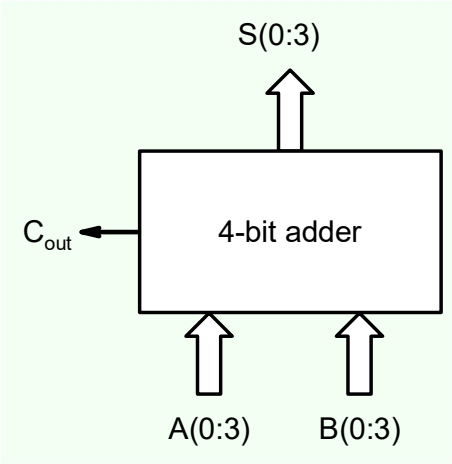
$$S = C_{in} \oplus (a \oplus b)$$

$$C_{out} = a.b + a.C_{in} + b.C_{in}$$

$$C_{out} = C_{in}(a.\bar{b} + \bar{a}.b) + a.b = C_{in}.(a \oplus b) + a.b$$



4-bit Adder



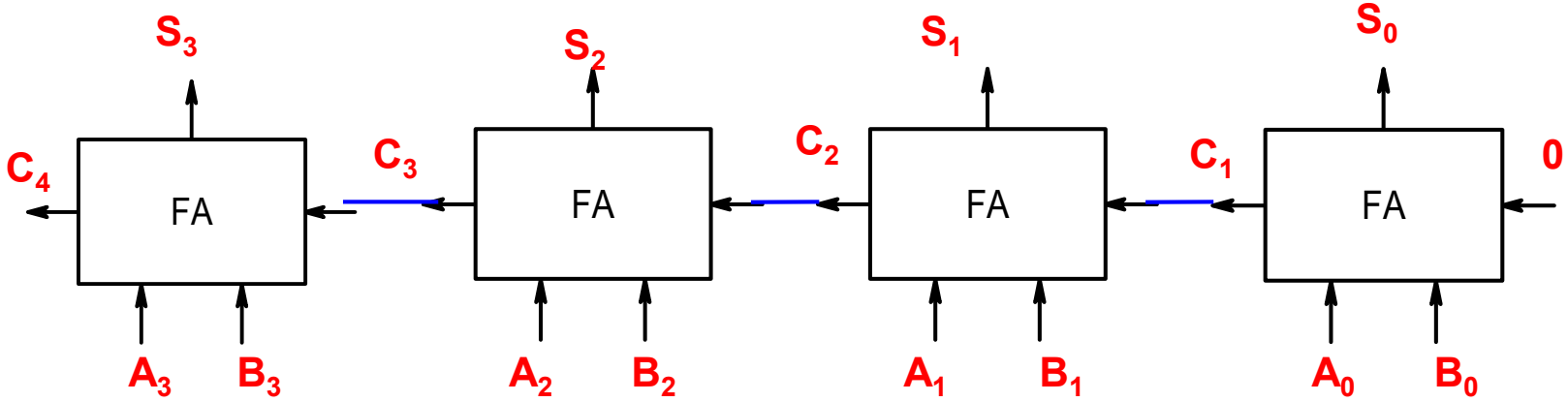
$A_3A_2A_1A_0$	$B_3B_2B_1B_0$	$S_3S_2S_1S_0$	C_{out}
0000	0000	0000	1
0000	0001	0001	0
0001	0000	0001	0
⋮	⋮	⋮	⋮

$C_3\ C_2\ C_1$

$A_3\ A_2\ A_1A_0$

$B_3\ B_2\ B_1B_0$

$C_4\ S_3\ S_2\ S_1S_0$



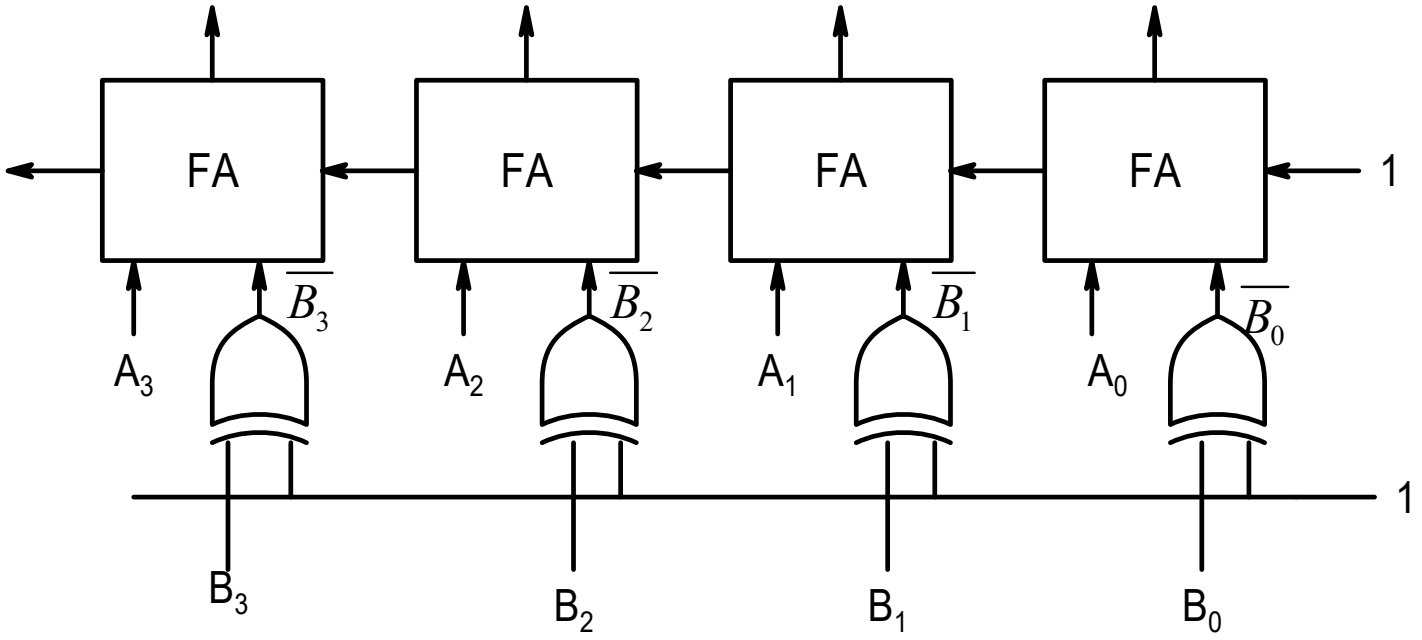
Ripple Carry Adder (20 gate circuit)

Subtraction

A - B = A + 2's complement of B

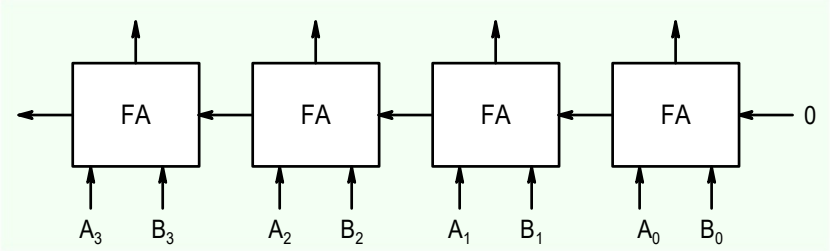
A - B = A + 1's complement of B+1

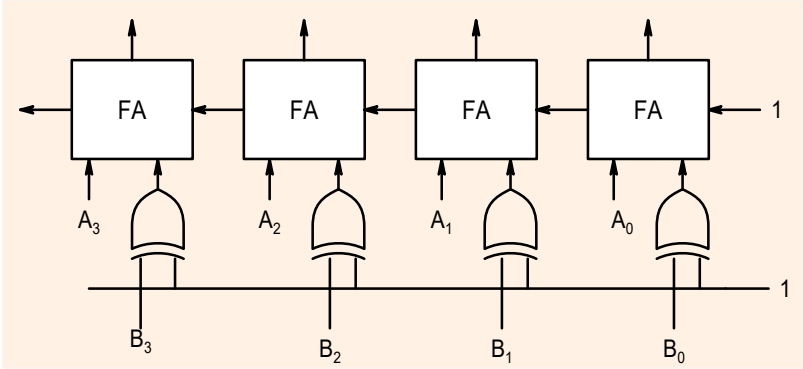
$$A - B = A + \overline{B} + 1$$

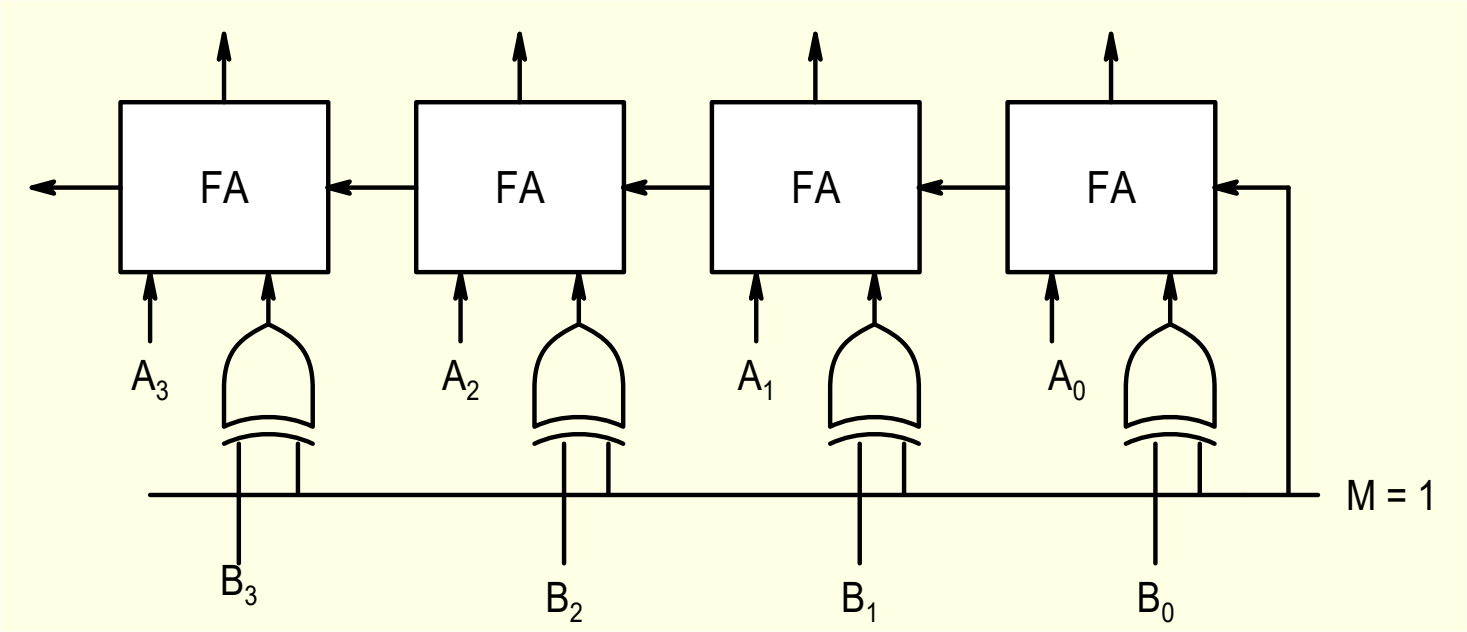


One needs add a circuit for predicting errors resulting from overflow

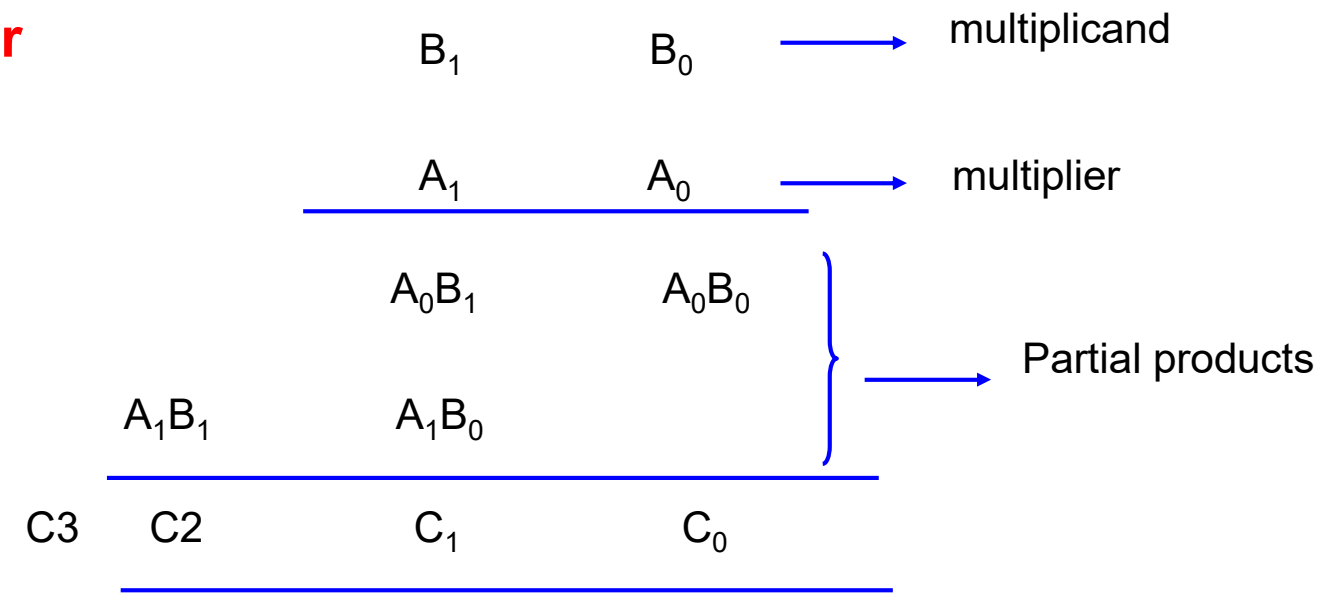
Adder/Subtractor

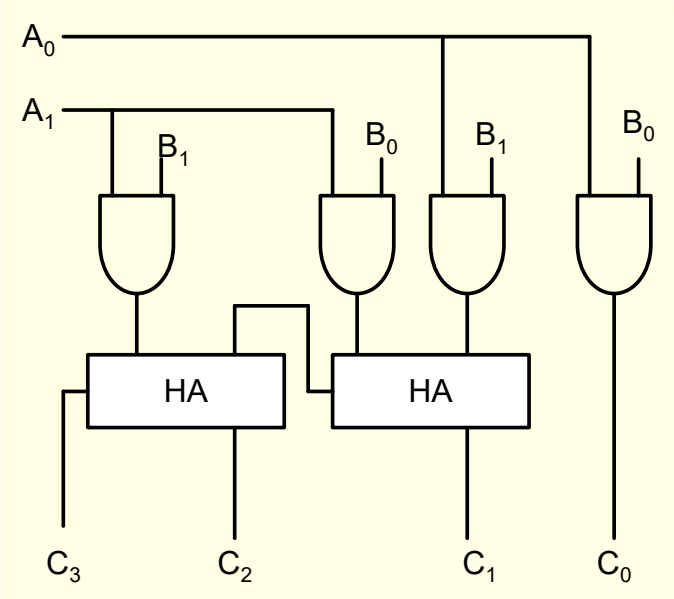






Multiplier


B_1 B_0
multiplicand
A_1 A_0
multiplier
A_0B_1 A_0B_0
A_1B_1 A_1B_0
Partial products
C3 C2 C_1 C_0


A_0
A_1
B_1
B_0
B_1
B_0
HA
HA
C_3
C_2
C_1
C_0