MATAKULIAH SISTEM DIGITAL
PERTEMUAN V
RANGKAIAN ARITMATIK

OLEH :
HIDAYAT

JURUSAN TEKNIK KOMPUTER
UNIKOM
2012

Penjumlahan bil. biner

- Mari kita hitung :

  0 + 0 = 0

  0 + 1 = 1

  1 + 0 = 1

  1 + 1 = 10; 0 sbg hasil dan 1 sbg carry

  1 + 1 + 1 = 11; 1 sbg hasil dan 1 sbg carry

Contoh

011 (3)	1001 (9)	11.011 (3.375)
+ 110 (6)	+ 1111 (15)	+ 10.110 (2.750)
1001 (9)	11000 (24)	110.001 (6.125)

Add the following pairs of binary numbers.

(a) 10110 + 00111 (b) 011.101 + 010.010 (c) 1001111 + 0000001

Bilangan tak bertanda

- Bilangan yang tidak memiliki tanda ‘+’ ataupun ‘-’
- Contoh :

  bilangan 8 bit : 0000000 - 11111111

  : 00 - FF_H

  : 0 – 255

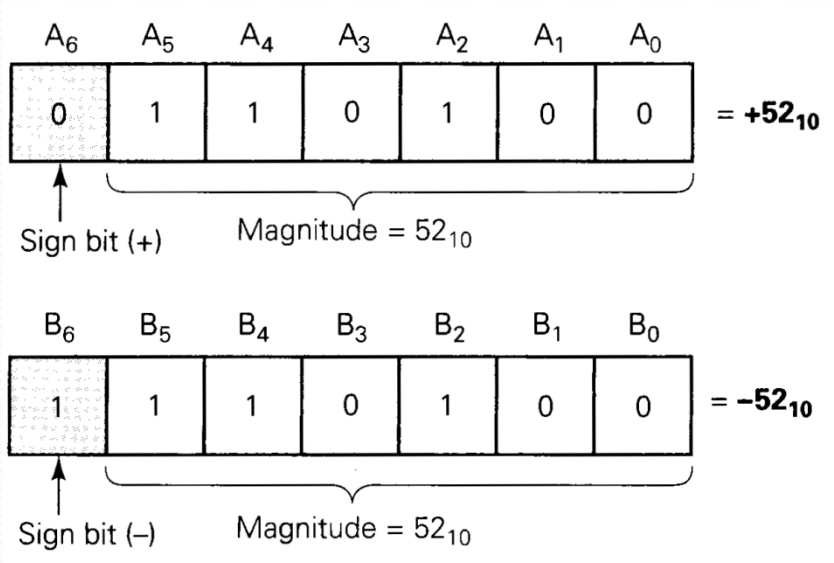
Penjumlah pada bil. tak bertanda dpt mengakibatkan *overflow* sehingga dibutuhkan *bit carry*.

Bilangan Bertanda

- Fungsi: untuk merepresentasikan nilai positif (+) dan negatif (-).
- Representasi bilangan bertanda:
  - Sign Magnitude System (bit paling "**besar**" sebagai tanda)
  - Complement 1
  - Complement 2

Sign Magnitude System

- Bilangan yang memiliki tanda ‘+’ ataupun ‘-’
- Bit MSB : tanda ‘+’ ataupun ‘-’
- ‘0’ : tanda positif, dan
- ‘1’ : tanda negatif.



Contoh :

+38 = **0** 0 1 0 0 1 1 0

-38 = **1** 0 1 0 0 1 1 0

+25 = **0** 0 0 0 0 0 0 1 1 0 0 1

-25 = **1** 0 0 0 0 0 0 1 1 0 0 1

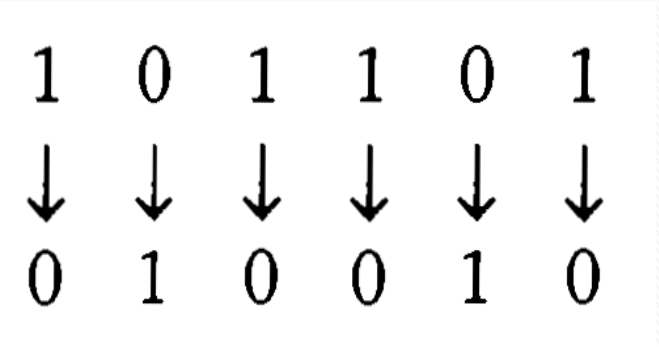
Bilangan bertanda

- Walaupun mudah dalam memberikan tanda positif dan negatif pada suatu bilangan namun sistem ini untuk diimplementasinya sangat komplek, sehingga sistem ini tidak diimplementasikan

Bilangan komplemen 1

- Komplemen 1 suatu bilangan biner diperoleh dengan cara membalikkan nilai bil. tersebut.

  Contoh : 101101 → 010010 (komplemen 1)

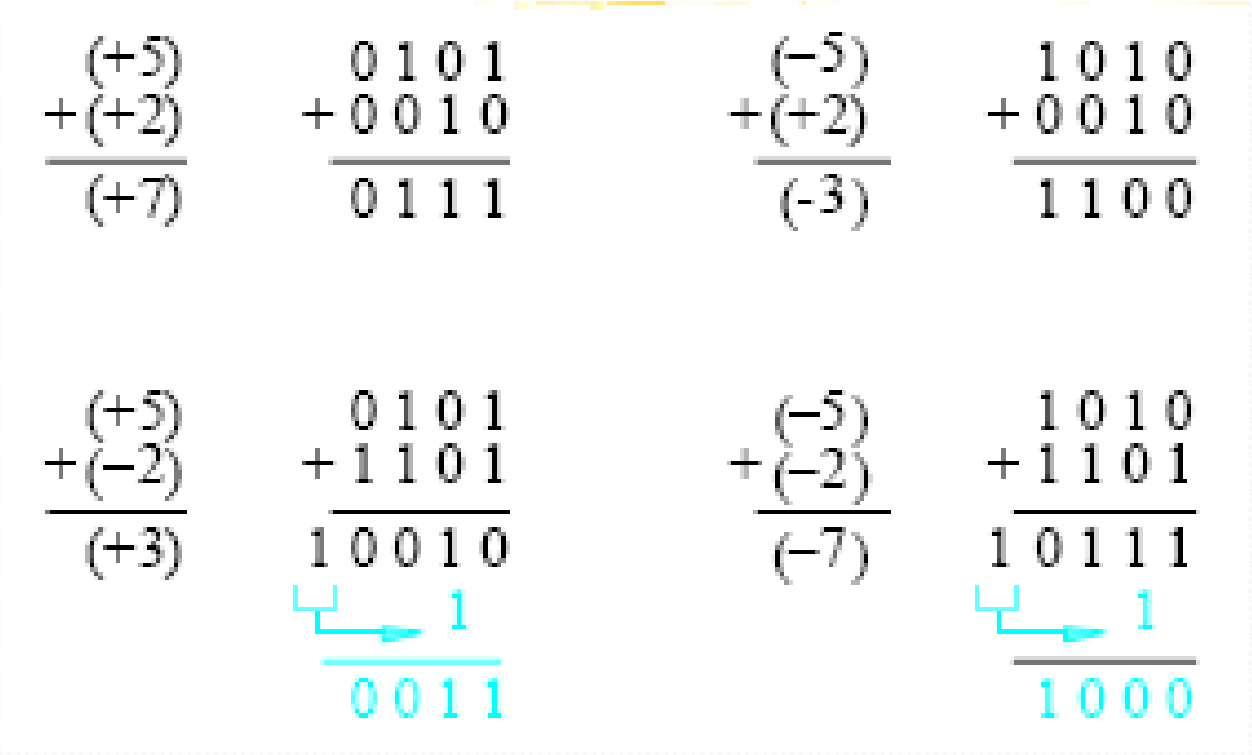


bilangan asli

hasil komplemen 1

Bilangan komplemen 1

Contoh :



Bilangan komplemen 2

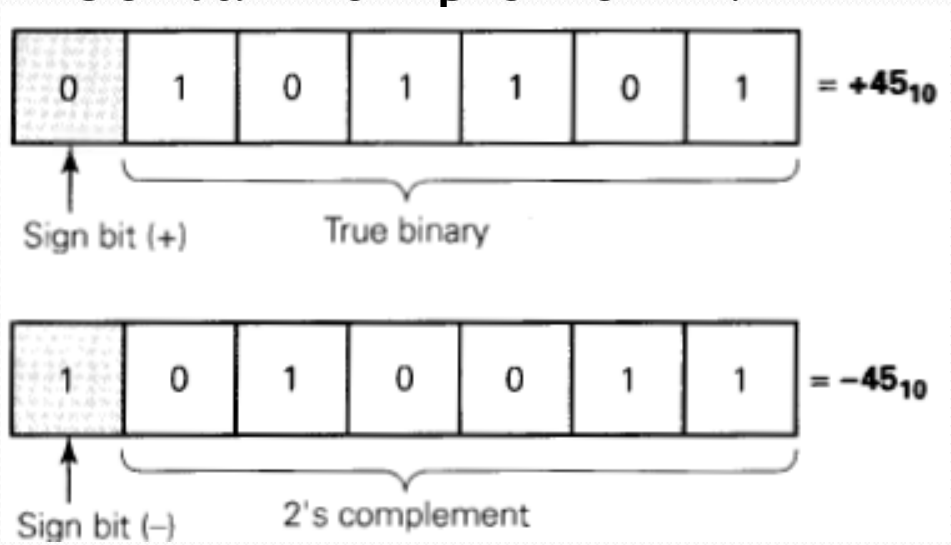
- Komplemen 2 suatu bilangan biner diperoleh dengan cara menambahkan ‘1’ pada LSB hasil komplemen 1 bilangan tersebut.

  Contoh : 101101 → 010010 + 1 = 010011 (kompl. 2)

	1 0 1 1 0 1	bilangan asli
	0 1 0 0 1 0	komplemen 1
+	1	
	0 1 0 0 1 1	komplemen 2

Bilangan komplemen 2

- Representasi bilangan bertanda pada komplemen 2
  - Jika nilai positif maka nilai bilangan direpresentasikan dalam bentuk aslinya.
  - Jika nilai negatif maka nilai direpresentasikan dalam bentuk komplemen 2 .



- Range nilai pada bilangan komplemen 2: -2^N to $+(2^N - 1)$

Decimal Value	Signed Binary Using 2's Complement
$+7 = 2^3 - 1$	0111
+6	0110
+5	0101
+4	0100
+3	0011
+2	0010
+1	0001
0	0000
−1	1111
−2	1110
−3	1101
−4	1100
−5	1011
−6	1010
−7	1001
$-8 = -2^3$	1000

Penjumlahan pada Bil. Kompl. 2

Contoh :

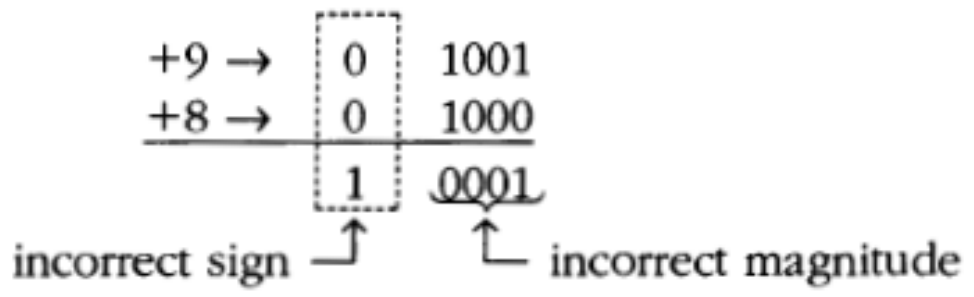
(+ 5)	0 1 0 1	(–5)	1 0 1 1
+ (+ 2)	+ 0 0 1 0	+ (+ 2)	+ 0 0 1 0
(+ 7)	0 1 1 1	(–3)	1 1 0 1

(+ 5)	0 1 0 1	(–5)	1 0 1 1
+ (–2)	+ 1 1 1 0	+ (–2)	+ 1 1 1 0
(+ 3)	1 0 0 1 1	(–7)	1 1 0 0 1
	ignore		ignore

Overflow

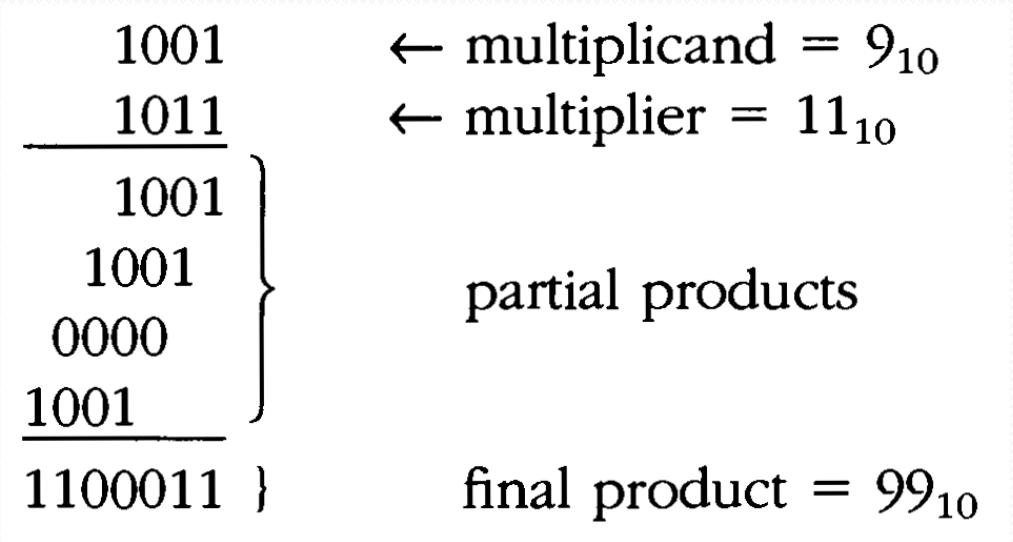
- Overflow terjadi ketika aritmatika pada komplemen 2 hasilnya salah. (hasil aritmatika melampaui tampungan bit nilai)

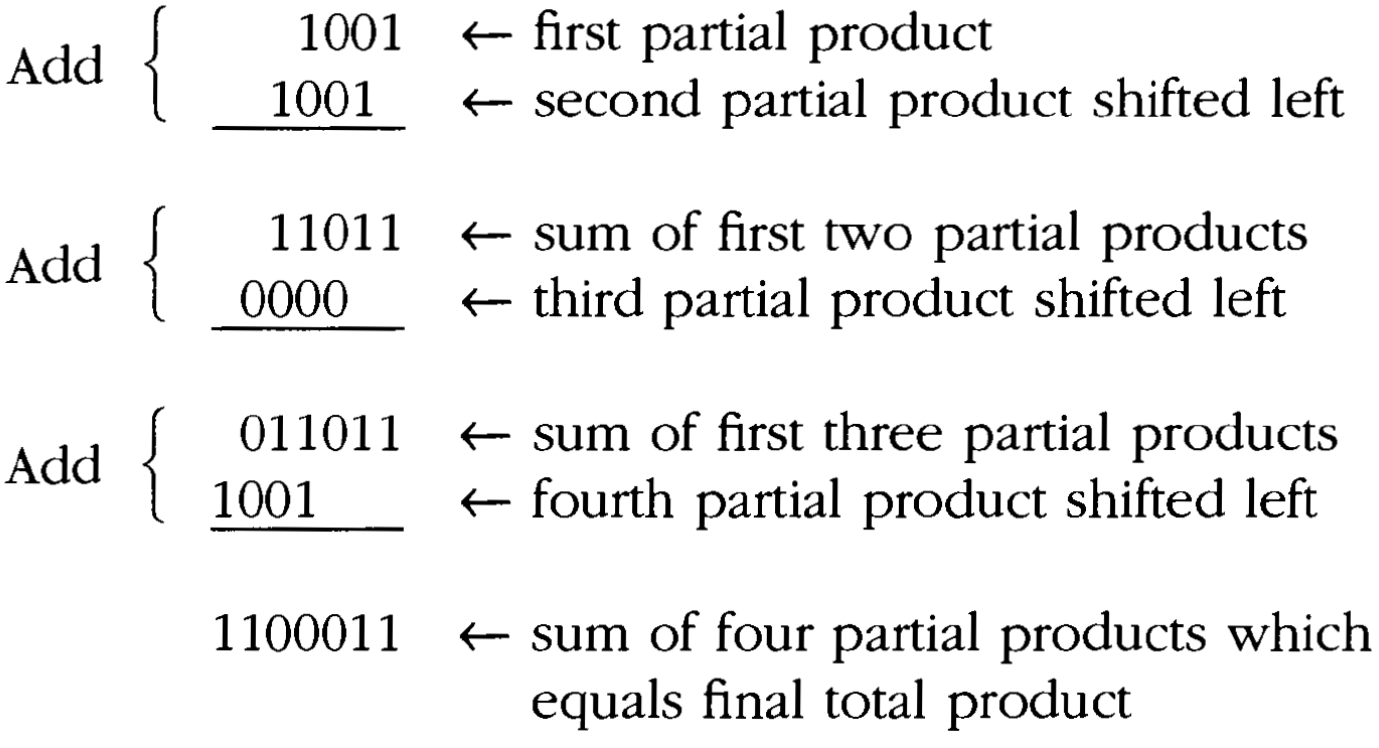
  Contoh:



Perkalian

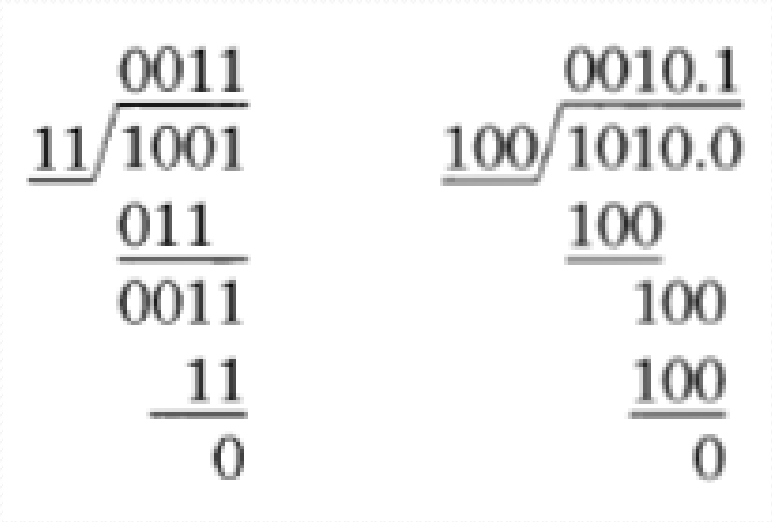
- a


1001
1011
1001
1001
0000
1001
1100011
← multiplicand = 9_{10}
← multiplier = 11_{10}
partial products
final product = 99_{10}


Add
1001
1001
← first partial product
← second partial product shifted left
Add
11011
0000
← sum of first two partial products
← third partial product shifted left
Add
011011
1001
← sum of first three partial products
← fourth partial product shifted left
1100011
← sum of four partial products which equals final total product

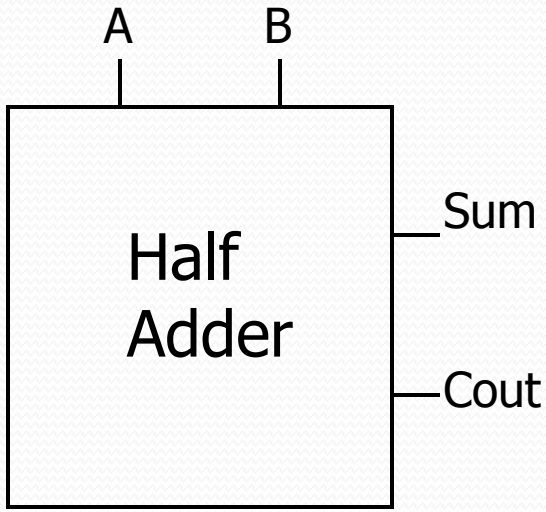
Pembagian

- a



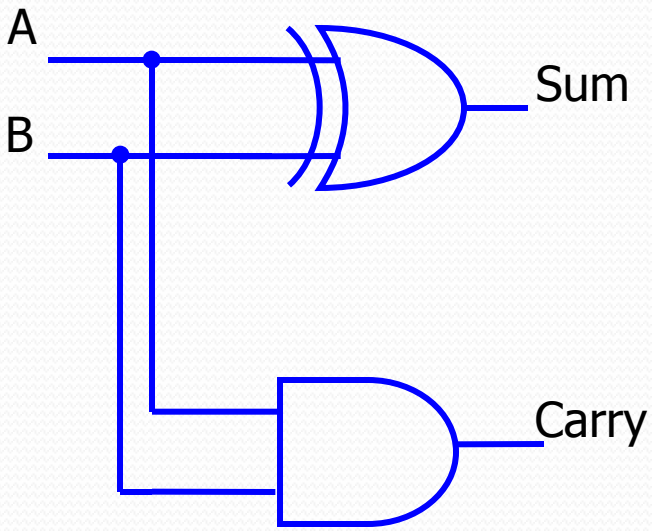
Rangkaian Aritmatik

Half Adder (1-bit)



A	B	S(um)	C(arry)
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Half Adder (1-bit)

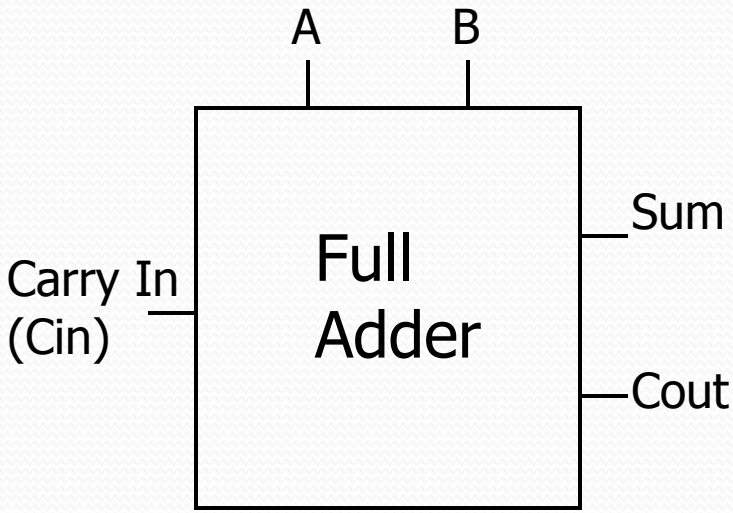


A	B	S(um)	C(arry)
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

$$S = \overline{A}B + A\overline{B} = A \oplus B$$

$$C = AB$$

Full Adder



Cin	A	B	S(um)	Cout
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

Full Adder

Cin	A	B	S(um)	Cout
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

Cin \ AB	00	01	11	10
0	0	1	0	1
1	1	0	1	0

$$S = Cin\,\overline{A}\,\overline{B} + \overline{Cin}\,\overline{A}B + CinAB + \overline{Cin}A\overline{B}$$

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

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

$$= Cin \oplus A \oplus B$$

Cin \ AB	00	01	11	10
0	0	0	1	0
1	0	1	1	1

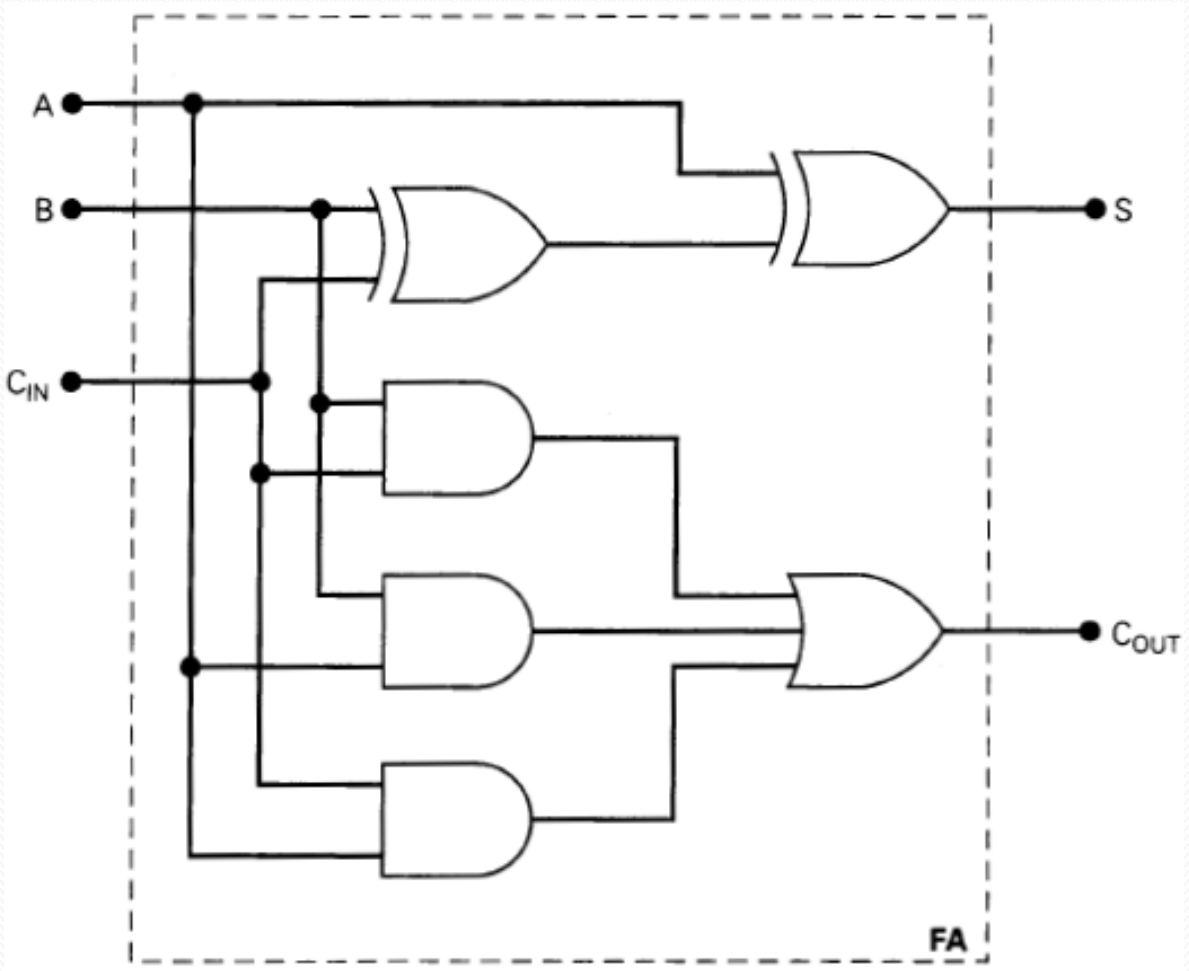
$$Cout = CinB + CinA + AB$$

ATAU

Cin \ AB	00	01	11	10
0	0	0	1	0
1	0	1	1	1

$$Cout = AB + Cin(\overline{A}B + A\overline{B}) = AB + Cin(A \oplus B)$$

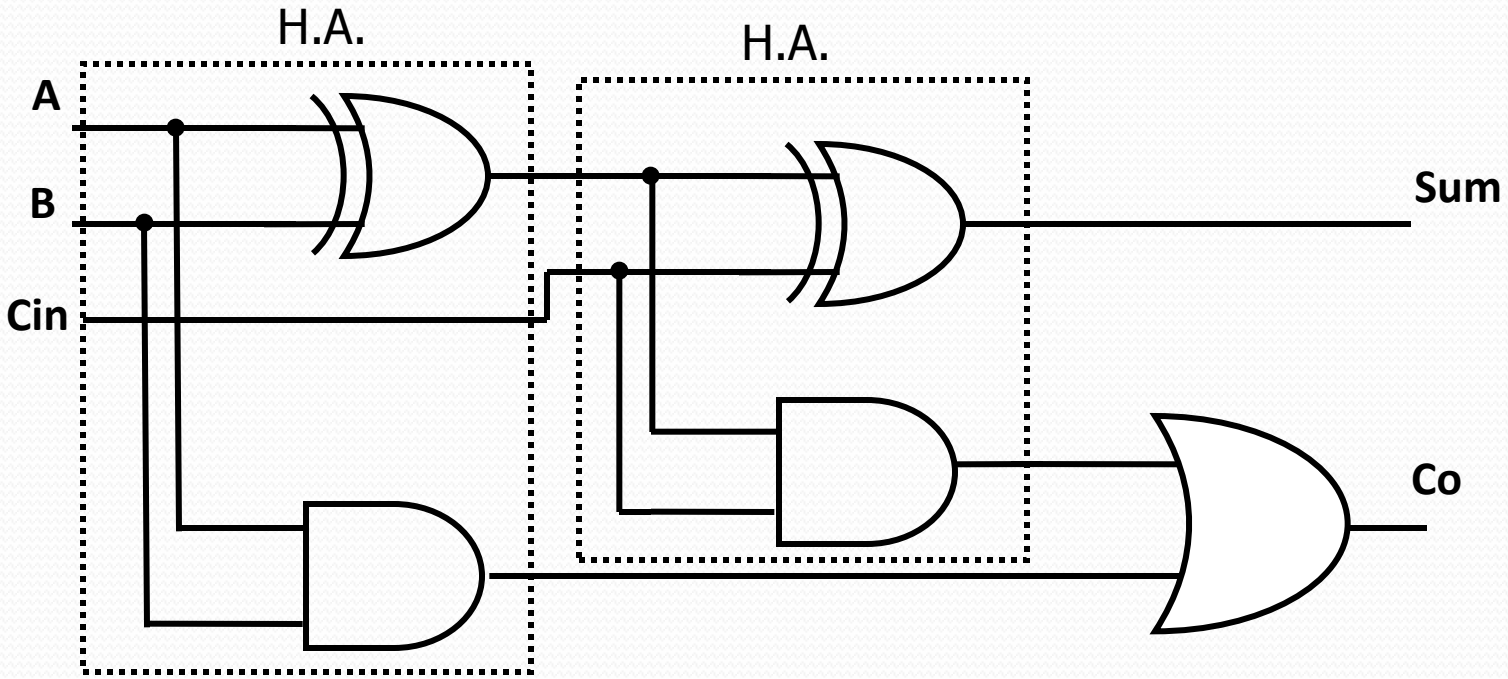
Full Adder



Full Adder

$$\text{Sum} = \text{Cin} \oplus \text{A} \oplus \text{B}$$

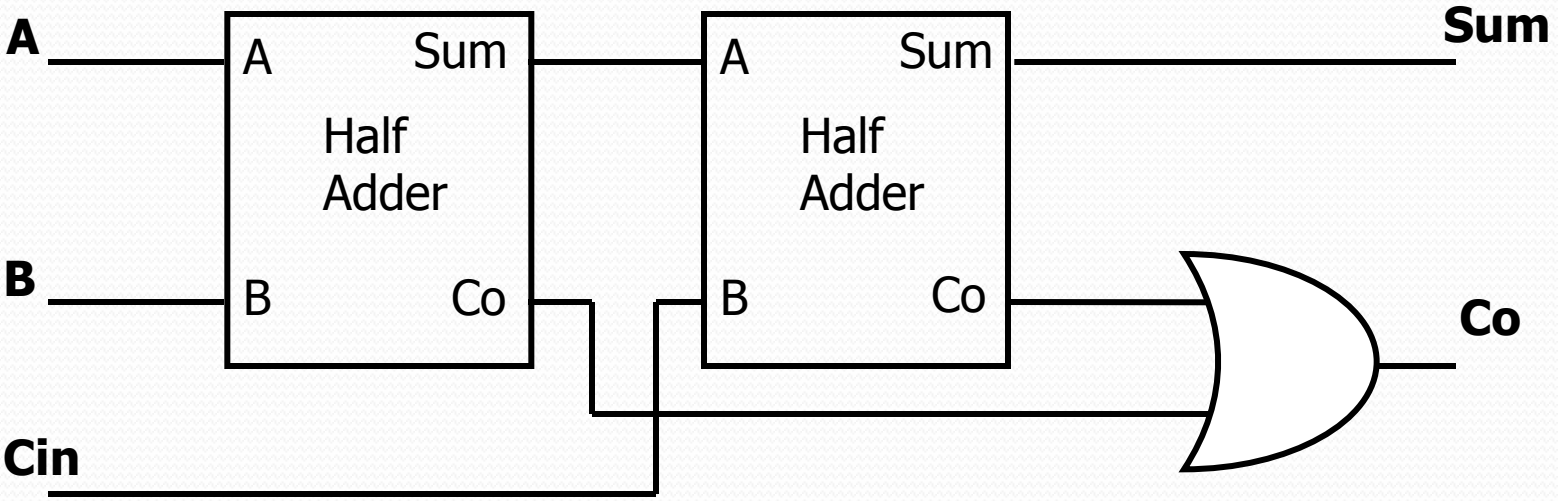
$$\text{Cout} = \text{AB} + \text{Cin}(\text{A} \oplus \text{B})$$



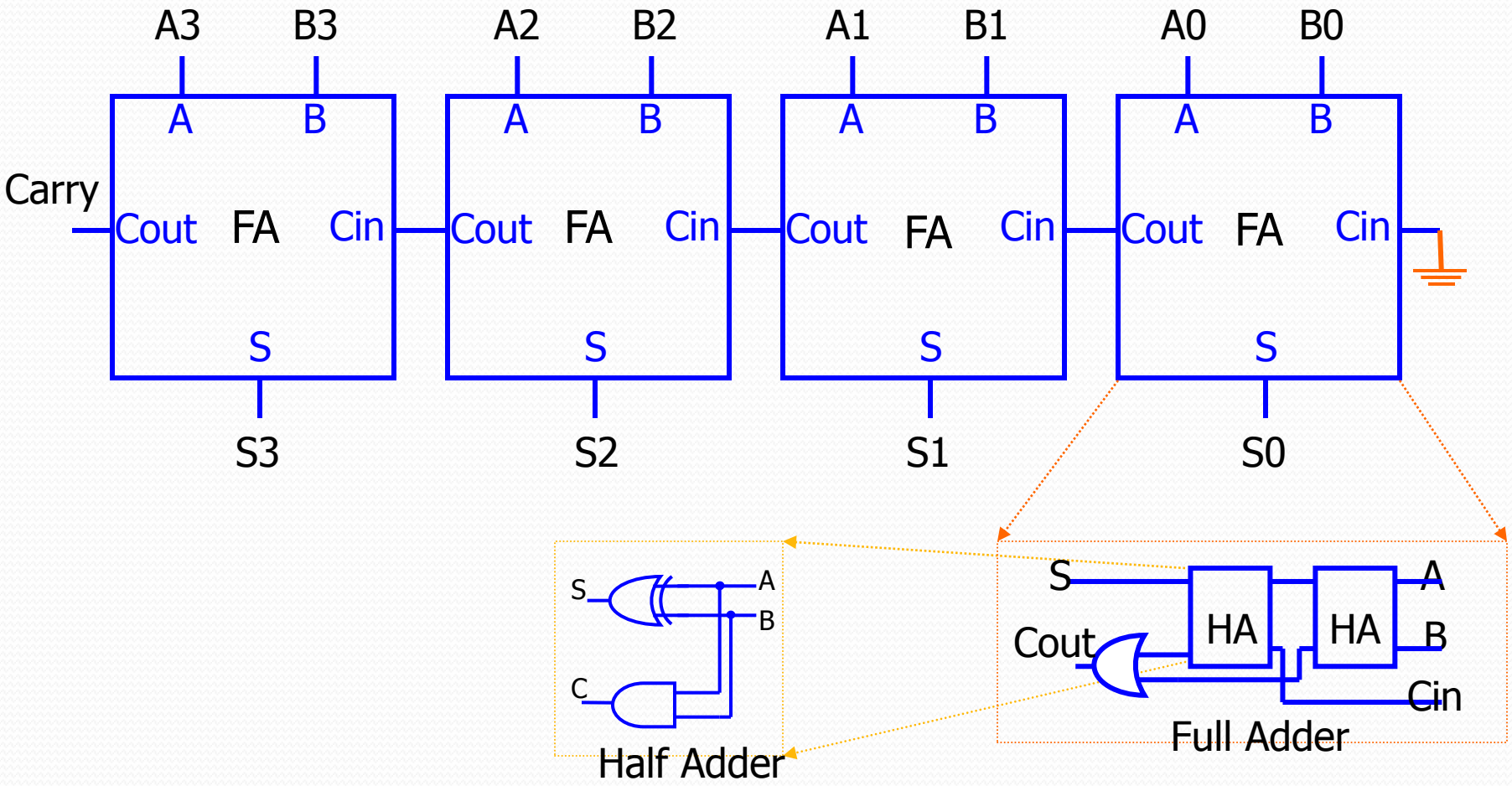
Full Adder

$$Sum = Cin \oplus A \oplus B$$

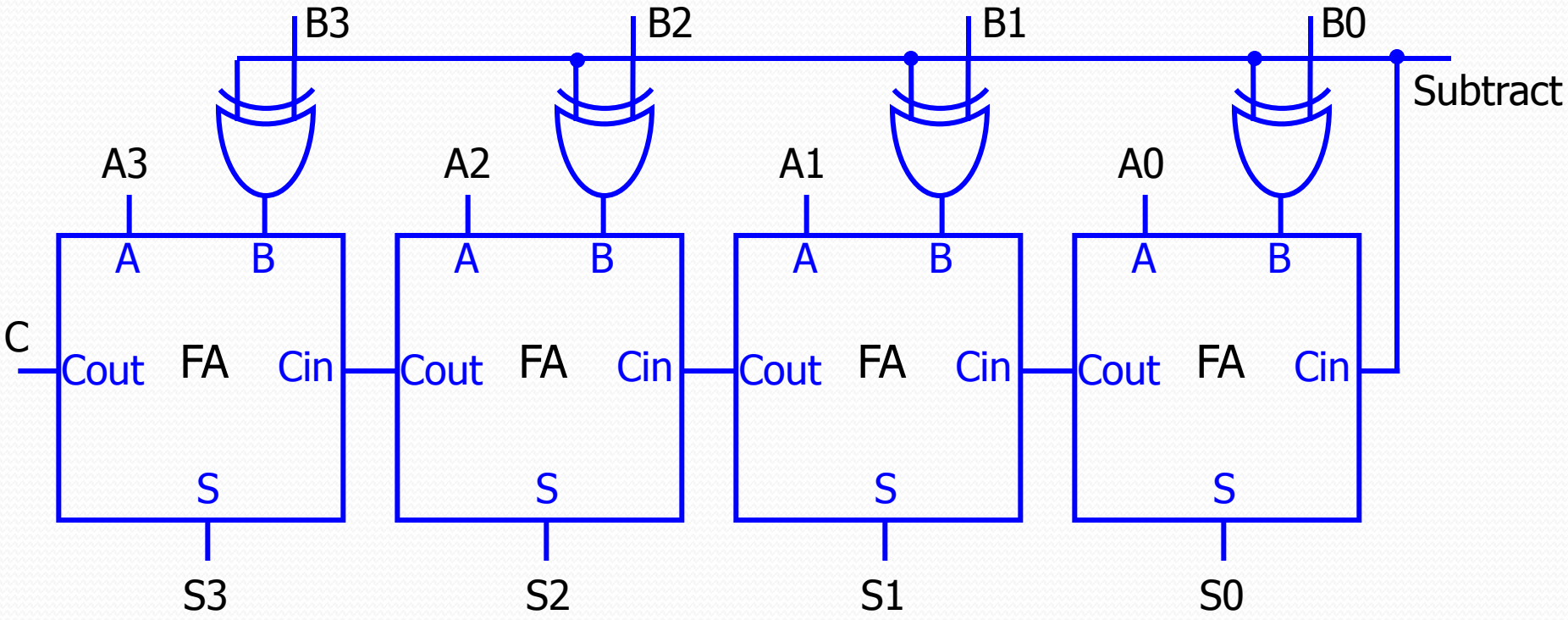
$$Cout = AB + Cin(A \oplus B)$$



4-bit Ripple Adder menggunakan Full Adder

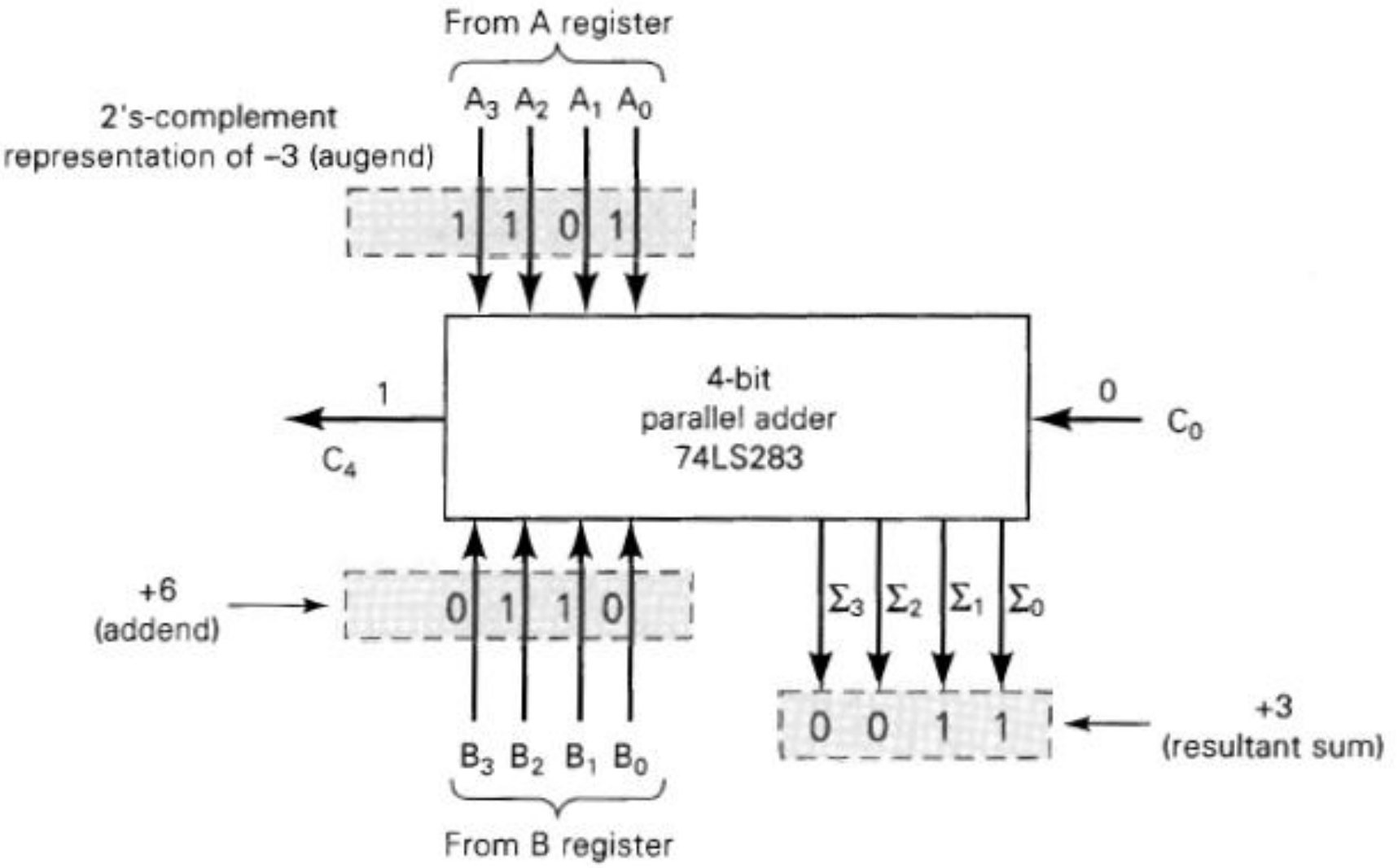


Disain Subtractor

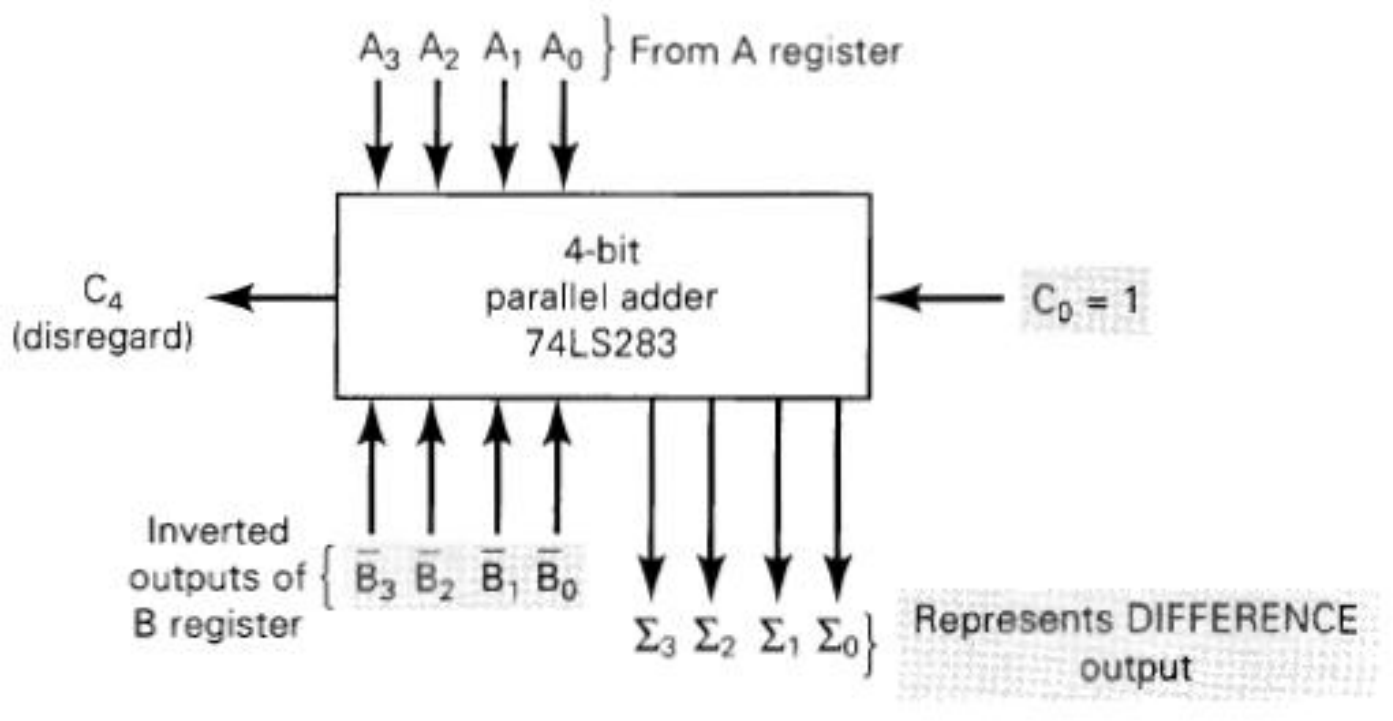


- $A - B = A + (-B)$
  - Lakukan komplemen 2 pada B
  - Jadikan penjumlahan A dan komplemen 2 dari B

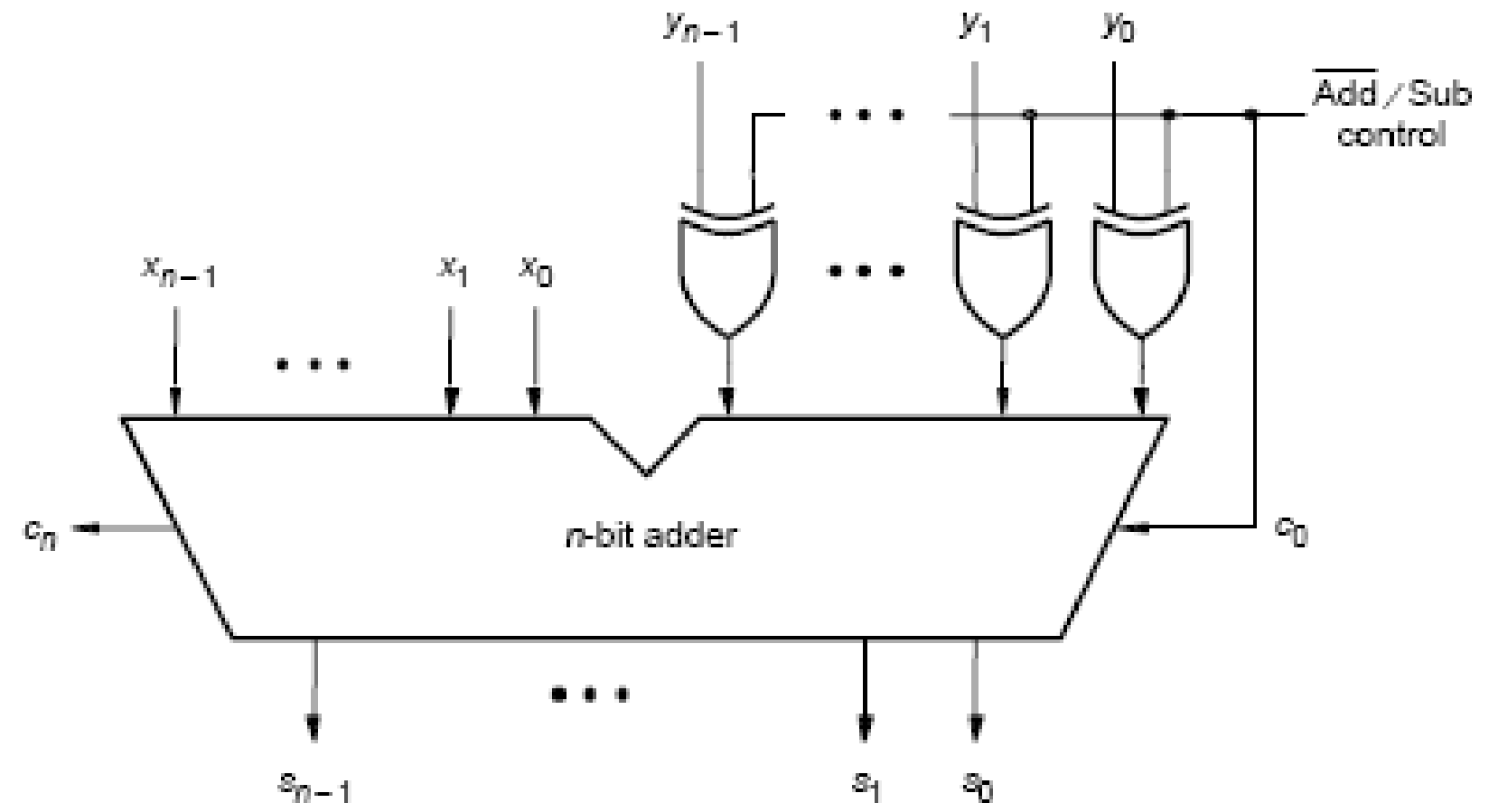
Paralel adder - Adder



Paralel adder - Subtractor



UNIT ADDER/SUBSTRACTOR



SELESAI