

# Binary Addition and Subtraction

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# Binary Arithmetic

- ▶ The binary number system is widely used in computer system.
- ▶ We need to know some essential concepts about binary arithmetic.

Input		$x + y$		$x - y$		$x \cdot y$
x	y	sum	carry	difference	borrow	product
0	0	0	0	0	0	0
0	1	1	0	1	1	0
1	0	1	0	1	0	0
1	1	0	1	0	0	1

# Binary Addition

Binary addition is done in the similar way to that of decimal addition. Corresponding bits are added, and if there is a carry that will be added to next left bit.

Examples: (Assume all numbers are positive)

1 1 1  $\Leftarrow$  Carry

0 1 0 1

0 1 1 1

1 1 0 0

1 1 1 1  $\Leftarrow$  Carry

1 0 1 1 0 1

1 0 0 1 1 1

1 0 1 0 1 0 0

# Binary Subtraction

- ▶ Binary subtraction is performed similar to decimal subtraction.
- ▶ We need to understand when the borrow will be generated.  
We have to use this borrow. we know that if we subtract 1 from 0 in that case borrow will be generated.

Example:

1 0 0  $\Leftarrow$  Borrow

1 0 0 1

0 1 0 1

0 1 0 0

1 1 0 0  $\Leftarrow$  Borrow

1 0 0 1 0

0 1 1 0 0

0 0 1 1 0

# Subtraction using 1's complement

Suppose we want to perform  $A - B$  using 1's complement. We have to follow the steps given below.

- ▶ Compute the 1's complement of (say  $\overline{B}$ ).
- ▶ Perform  $R = A + \overline{B}$ 
  - If a carry is obtained after addition. Add the carry with  $R$  (i.e.  $R = R + 1$ ). The result is a positive number.
  - Else  
The result is a negative and is in 1's complement form of  $R$

Examples:

Suppose we want to perform  $6 - 2$ . 1's complement of 2 is 1 1 0 1 (assume 4-bit representation).

$$6 = 0110$$

$$\underline{-2 = 1101}$$

$$10011$$

There is a carry and the carry will be added with 0 0 1 1 (i.e.  $0011 + 0001$ ). The result is 0 1 0 0 which is 4 in decimal.

# Subtraction using 1's complement

Example:

Suppose we want to perform  $3 - 5$ . The 1's complement of 5 is 1 0 1 0 (4-bit representation).

$$3 = 0011$$

$$\underline{-5 = 1010}$$

$$1101$$

Since there is no carry, the result is negative. [1 1 0 1] is the 1's complement of [0 0 1 0] that is, the result represents -2 in decimal.

# Subtraction using 2's complement

Suppose we want to compute  $A - B$  using 2's complement then, we have to follow the steps given below.

- ▶ Compute the 2's complement of B (say  $\overline{B}$ ).
- ▶ Compute  $R = A + \overline{B}$
- ▶ If a carry is generated after addition: Ignore the carry and the result is positive.
- ▶ Else The result is negative and it is in 2's complement form.

Examples: We want to compute  $(6 - 2)$  and  $(3 - 5)$   
2's complement of 2 is  $[1\ 1\ 1\ 0]$  and 2's complement of 5 is  $[1\ 0\ 1\ 1]$ .  
In case of  $(6 - 2)$  carry is generated and we have to ignore the carry. The result is positive. For the second case, there is no carry. Hence, the result is negative and it is in 2's complement form ( $[1\ 1\ 1\ 0]$  is the 2's complement of 2. so, the result is -2).

$6 =$	0	1	1	0
$-2 =$	1	1	1	0
<hr/>				
	1	0	1	0

$3 =$	0	0	1	1
$-5 =$	1	0	1	1
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	1	1	1	0