

# Two Complement

## Negative Numbers in Binary

### 1. Negative bit sign

Problems with negative bit sign approach

a) Two values for 0

1 0 0 1 - 1

1 0 0 0 - 0

b) Addition

$$\begin{array}{r}
 \begin{array}{c} 5 \\ + (-5) \end{array} \\
 \hline
 \end{array}
 \quad
 \begin{array}{r}
 \begin{array}{c} 0101 \\ + 1101 \\ \hline (1)0010 \end{array} = 2
 \end{array}$$

1 1 1 1 - 7

1 1 0 1 - 6

1 1 0 0 - 4

1 0 1 1 - 3

1 0 1 0 - 2

1 0 0 1 - 1

1 0 0 0 - 0

0 0 0 0 0

0 0 0 1 1

0 0 1 0 2

0 0 1 1 3

0 1 0 0 4

0 1 0 1 5

0 1 1 0 6

0 1 1 1 7

## 2. Ones complement

Flipping the bits for negative numbers

1 0 0 0 -7

1 0 0 1 -6

1 0 1 0 -5

1 0 1 1 -4

1 1 0 0 -3

1 1 0 1 -2

1 1 1 0 -1

1 1 1 1 -0

0 0 0 0 0

0 0 0 1 1

0 0 1 0 2

0 0 1 1 3

0 1 0 0 4

0 1 0 1 5

0 1 1 0 6

0 1 1 1 7

### Problems with One Complement

a) Two zeroes

1 1 1 1 -0

0 0 0 0 0

b) Addition (Two low by one)

0 1 0 1 5

1 0 1 0 + (-5)

1 1 1 1 -0

0 0 1 1 + (-3)

1 1 0 0

1 1 1 1 -0

0 1 0 1 + (-3)

1 1 0 0

(1) 0 0 0 1

0 1 1 0 + (-2)

1 1 0 1

(1) 0 0 1 1

+ 1

+ 1

3 +

## 3. Two Complement

Negative numbers are created by negation of positive number and addition of 1:  $-(0101) = 1010 + 1 = 1011$

and we can look at them like that: last bit is negative and we add every

other (positive) bit to it:  $1001 = -8 + 1 = -7$



$$-8+0$$

$$1 \ 0 \ 0 \ 0 \quad -8$$

$$1 \ 0 \ 0 \ 1 \quad -7$$

$$1 \ 0 \ 1 \ 0 \quad -6$$

$$1 \ 0 \ 1 \ 1 \quad -5$$

$$1 \ 1 \ 0 \ 0 \quad -4$$

$$1 \ 1 \ 0 \ 1 \quad -3$$

$$1 \ 1 \ 1 \ 0 \quad -2$$

$$1 \ 1 \ 1 \ 1 \quad -1$$

$$0 \ 0 \ 0 \ 0 \quad 0$$

$$0 \ 0 \ 0 \ 1 \quad 1$$

$$0 \ 0 \ 1 \ 0 \quad 2$$

$$0 \ 0 \ 1 \ 1 \quad 3$$

$$0 \ 1 \ 0 \ 0 \quad 4$$

$$0 \ 1 \ 0 \ 1 \quad 5$$

$$0 \ 1 \ 1 \ 1 \quad 6$$

$$\begin{array}{r} 5 \quad 1 \ 1 \ 1 \\ +(-5) \quad 0 \ 1 \ 0 \ 1 \\ \hline 1 \ 0 \ 1 \ 1 \end{array}$$

$$\textcircled{1} \ 0 \ 0 \ 0 \ 0$$

6 6

