Computer Architecture

A Generic CPU

Dr. Masood Mir

Week 5

2’s Complement Method

- In two's complement, negative numbers are represented by the bit pattern which is one greater (in an unsigned sense) than the ones' complement of the positive value.
- 2’s complement of a number = One’s complement + 1
- Two Methods: First Method

	Example 1	Example 2
1. Starting from the right, find the first "1"	00101001	00101100
2. Invert all of the bits to the left of that "1"	**11010111**	**11010**100

- Two Methods: Second Method

1. Invert all the bits through the number
2. Add one

Eight-bit two's complement

Binary value	Two's complement interpretation	Unsigned interpretation
00000000	0	0
00000001	1	1
⋮	⋮	⋮
01111110	126	126
01111111	127	127
10000000	−128	128
10000001	−127	129
10000010	−126	130
⋮	⋮	⋮
11111110	−2	254
11111111	−1	255

Addition / Subtraction by 2's Complement Method

- When negative numbers are expressed in binary addition using 2's complement the addition of binary numbers becomes easier. This operation is almost similar to that in 1's complement system and is explained with examples given below:
- A. Addition of a positive number and a negative number.
- Case I: When the positive number has a greater magnitude
- Solution: Take the 2's complement of smaller number and add. In this case the carry which will be generated is discarded and the final result is the result of addition.
- Examples: In a 5-bit register find the sum of the following by using 2's complement:

(i) 1011 and -0101

- Solution:

+ 1 0 1 1	⇒	0 1 0 1 1	
- 0 1 0 1	⇒	1 1 0 1 1	(2's complement)
(Carry 1 discarded)		0 0 1 1 0	

Hence the sum is + 0110.

Addition / Subtraction by 2's Complement Method

- (ii) 0111 and – 0011.

Solution: + 0 1 1 1 ⇒ 0 0 1 1 1

- 0 0 1 1 ⇒ 1 1 1 0 1

(Carry 1 discarded) 0 0 1 0 0 Hence the sum is + 0100.

- Case II: When the negative number is greater.
- When the negative numbers is greater no carry will be generated in the sign bit. The result of addition will be negative and the final result is in 2's complement form.
- In a 5-bit register find the sum of the following by using 2's complement:

(i) + 0 0 1 1 and - 0 1 0 1

Solution: + 0 0 1 1 ⇒ 0 0 0 1 1

- 0 1 0 1 ⇒ 1 1 0 1 1 (2's complement)

1 1 1 1 0 (it is -2)

- 2's complement of 1110 is (0001 + 0001) or 0010 (+2)

Addition / Subtraction by 2's Complement Method

(ii) + 0 1 0 0 and - 0 1 1 1

Solution:

+ 0 1 0 0	⇒	0 0 1 0 0	
- 0 1 1 1	⇒	1 1 0 0 1	(2's complement)
		1 1 1 0 1	

- B. When the numbers are negative.

Solution: When two negative numbers are added a carry will be generated from the sign bit which will be discarded. 2's complement of the magnitude bits of the operation will be the final sum.

- In a 5-bit register find the sum of the following by using 2's complement:

- (i) – 0011 and – 0101

- Solution:

Addition / Subtraction by 2's Complement Method

(ii) + 0 1 0 0 and - 0 1 1 1

Solution:

+ 0 1 0 0	⇒	0 0 1 0 0	
- 0 1 1 1	⇒	1 1 0 0 1	(2's complement)
		1 1 1 0 1	

- B. When the numbers are negative.

Solution: When two negative numbers are added a carry will be generated from the sign bit which will be discarded. 2's complement of the magnitude bits of the operation will be the final sum.

- In a 5-bit register find the sum of the following by using 2's complement:

- (i) – 0011 and – 0101

- Solution: