

Computer Architecture and Logic Design

Complements and Subtraction using complements

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Complements

- Complements are used to simplify subtraction operations. We do subtraction by adding.

$$A - B = A + (-B)$$

- There are two types:
 - The radix complement, called the r 's complement.
 - The diminished radix complement, called the $(r-1)$'s complement.

Diminished Radix Complement or $(r-1)$'s complement.

- Given a number N in base r having n digits
- The $(r - 1)$'s complement of N is defined as $(r^n - 1) - N$
- For Decimal Number System
- 9's Complement is $= (10^n - 1) - N$
- For example 9's complement of 53406 $= (10^5 - 1) - 53406$
 $= 99999 - 53406 = 46593$
- For Binary Number System
- 1's Complement is $= (2^n - 1) - N$
- For Example 1's complement of 10100110 is $= (2^8 - 1) - 10100110$
- $= 11111111 - 10100110 = 01011001$
- Note that 1's complement can be done by switching all 0's to 1's and 1's to 0's

Radix Complement

- 10's complement of 3229 is:
= 6771
- 2's complement of 101101 is:
= 010011

10's Complement Subtraction

- Using 10's complement, subtract $62513 - 2140$

$$\begin{array}{r} M = 62513 \\ 10's \text{ complement of } N = 97860 \\ \hline \text{Sum} \quad 160373 \\ \text{Discard end carry} \quad -100000 \\ \hline \text{Answer} \quad 60373 \end{array}$$

Note that the extra 9 in the 10's complement of N is to fill the space holder 0

10's Complement Subtraction

- Using 10's complement, subtract 2140 - 62513

M =	02140
10's complement of N =	37487
Sum	<hr/> 39627
There is no end carry.	
10's complement of 39627	60373
(Add - sign) Answer	<hr/> -60373

Your Turn

- 10's Complement of 356600
Answer= 643400
- Do the Subtraction using 10's Complement
 $5406 - 77362$
- Do the Subtraction using 10's Complement
 $-2708 - 1984$

2's Complement Subtraction

- Using 2's complement, subtract $1001001 - 1000110$

$$\begin{array}{r} M = 1001001 \\ 2's \text{ complement of } N = 0111010 \\ \hline \text{Sum} \quad 10000011 \\ \text{Discard end carry } 2^7 \quad -10000000 \\ \hline \text{Answer} \quad 0000011 \end{array}$$

1's Complement Subtraction

- Using 1's complement, subtract $1001001 - 1000110$

M =	1001001
1's complement of N =	<u>0111001</u>
Sum	10000010
Discard end carry 2^7	<u>-10000000</u>
	0000010
Add 1 to compensate	<u>+0000001</u>
Answer	0000011

1's Complement Subtraction

- Using 1's complement, subtract $1000110 - 1001001$

$$\begin{array}{rcl} M = & 1000110 & \\ 1's \text{ complement of } N = & 0110110 & \\ \hline \text{Sum} & 1111100 & \\ \text{There is no end carry.} & & \\ 1's \text{ complement of } 1111100 & 0000011 & \\ \hline \text{(Add - sign) Answer} & -0000011 & \end{array}$$

Practice Question

Given the two unsigned numbers $A=487.25_{10}$ and $B=542.3_6$, perform the subtraction $A-B$ using 1's complement method

Express your answer in decimal

So

lem

$$A = (487.25)_{10}$$

2	487	
2	243	1
2	121	1
2	60	1
2	30	0
2	15	0
2	7	1
2	3	1
	1	1

$$\begin{array}{r} 0.25 \\ \times 2 \\ \hline 0.50 \\ \times 2 \\ \hline 1.00 \end{array}$$

$$A = (487.25)_{10} = (111100111.01)_2$$

$$B = (542.3)_6 = 5 \times 6^2 + 4 \times 6 + 2 + 3 \times 6^{-1} = (206.5)_{10}$$

2	206	
2	103	0
2	51	1
2	25	1
2	12	1
2	6	0
2	3	0
	1	1

$$\begin{array}{r} 0.5 \\ \times 2 \\ \hline 1.0 \end{array}$$

$$B = (542.3)_6 = (206.5)_{10} = (11001110.1)_2$$

$$A = (111100111.01)_2$$

$$B = (011001110.10)_2$$

$$1's \text{ compl of } B = 100110001.01$$

$$A = \begin{array}{ccccccc} 1 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & . & 0 & 1 \end{array}$$

$$1's \text{ compl of } B = \begin{array}{ccccccc} 1 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 1 & . & 0 & 1 \end{array}$$

$$\begin{array}{r} 100110001.01 \\ + 100110001.01 \\ \hline 100011000.11 \end{array}$$

$$\text{Sum} = \begin{array}{cccccccc} 256 & 128 & 64 & 32 & 16 & 8 & 4 & 2 & 1 \\ 1 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & . & 1 & 1 \end{array}$$

$$= 256 + 16 + 8 + \frac{1}{2} + \frac{1}{4} = (280.75)_{10}$$

$$\text{Ans} = (280.75)_{10}$$

Example of 1's complement



Subtract $(1010)_2$ from $(1111)_2$

Direct Subtraction

$$\begin{array}{r} 1111 \\ - 1010 \\ \hline 0101 \end{array}$$

1's complement method

1's complement →

$$\begin{array}{r} 1111 \\ + 0101 \\ \hline \end{array}$$

Carry →

$$10100$$

Add Carry →

$$\begin{array}{r} 1 \\ \hline 0101 \end{array}$$

Example of 2's complement



Subtract $(1010)_2$ from $(1111)_2$

Direct Subtraction

$$\begin{array}{r} 1\ 1\ 1\ 1 \\ - 1\ 0\ 1\ 0 \\ \hline 0\ 1\ 0\ 1 \\ \hline \end{array}$$

2's complement method

2's complement →

Carry →

$$\begin{array}{r} 1\ 1\ 1\ 1 \\ + \\ 0\ 1\ 1\ 0 \\ \hline 1\ 0\ 1\ 0\ 1 \\ \hline \end{array}$$

The End