Complement Notation

1's Complement There is a simple algorithm to convert a binary number into 1's complement. To get the 1's of a binary number, simply invert the given number.

for Ex 110010 → 001101
(1's complement)

it is use not gate for each input bit

2's Complement for getting 2's complement simply invert the given number and add 1 to the LSB of given result.

for Example
1100 10
1's Complement → 0011 01
Add 1 → 1
001110

→ use NOT gate along with full adder for each input bit.

Negative magnitude are represented in the same way as in the case of sign bit on 1's complement representation.

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Numericals of 1's complement and 2's complement

1. 1's Complement Subtraction:

Steps subtraction of small no to longe number

1. Determine 1's complement of the smaller no.
2. Add this to longe number
3. Remove the carry and add to Result. The carry is known as end around carry.

Example $(1111)_2 - (1010)_2$

Direct Subtraction

```
  1111
- 1010
------
  0101
------
```

1's complement method

```
  1111
+ 0101   ← 1's complement
------
 (1) 0100
     1   ← Add carry
------
  0101
------
```

EAC

2. Subtraction of longer no from a smaller one

1. Determine the 1's complement of the longer number.
2. Add this to smaller number
3. The answer in the 1's complement of the true result and opposite in sign There is no carry

Example ~~0000~~ $(1111)_2 - (1010)_2$

Solution

Direct Subtraction

```
 1111
-1010
------
 0101
------
```

2's Complement method

```
 1111
+0110
------
(1)0101
```

carry is diggarded

Answer is 0101

→ Subtraction of large number from smaller number

1. Determine the 2's complement of the longer number
2. Add the 2's complement to the smaller number
3. No carry is generated, Result in 2's complement form and is negative.
4. To get the answer in true form take the 2's complement and change the sign.

Example $(1000)_2 - (1010)_2$

Direct Subtraction

```
 1000
 1010
------
 0010
------
```

2's Complement method

```
 1000
 0110   ← 2's complement
------
(1)1110 ← no carry
------
```

So the answer is

$-0010 = -2$

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Different Case for 1's and 2's Complement method

1:- Addition in the 2's Complement method

Case 1 When both number are positive

Ex +29 +19

```
  0  001 1101   (augend)
  0  001 0011   (addend)
  0  011 0000   (sum = 48)
  ↑
signbit  + 48
```

for n bit = -2^{n-1} to $(2^{n-1}-1)$

5 bit = -2^{5-1} to $(2^{5-1}-1)$

-16 to 15

if the number is not in range then the result is in overflow range

Condition of Overflow

```
+9    01001
+7    00111
+16   10000
```

} no. represents in 5 bit number form

↳ The result is invalid

↳ it is not in the range

Case 2 When addition of positive of negative number

Positive number + negative number

+13
-6

+6 → 00110

2's Complement of 6 → 11010

+13 → 01101

-6 → 11010

Carry → (1) 00111

ignore the carry

= +7

Case 3

-15
+9

Negative number > positive number

+15 → 01111

10000 ← 1's comp of 15

+1

10001 ← 2's Comp of 15

-15 → 10001

+9 → 01001

(1) 11010

MSB shows that result is negative.

So it reverse the 6 into 2's complement form

Change the Result into 2's comp

11010 —2's→ 00110

+6

Case 4 Addition of two negative number

-8
-4

+8 → 01000

2's Complement → 11000

+4 → 00100

2's Complement → 11100

-8 → 11000

-4 → 11100

(1) 10100

Ignore ← 2's Complement

10100 → -12

01100 → +12

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Subtraction in the 2's Complement form:

Case 1 Both the number are positive

$5 - 3 = 5 + (-3)$

$+5 = 0\ 0\ 1\ 0\ 1$

$-3 = +\ 1\ 1\ 1\ 0\ 1$

$1\ 0\ 0\ 0\ 1\ 0 \rightarrow +2$

ignore the carry (1) ↓ the result is positive

Case 2 One positive and one negative number

$9 - (-6) \rightarrow 9 +$ 2's complement of (-6)

$+6 \rightarrow 0\ 0\ 1\ 1\ 0$

$+9 \rightarrow 0\ 1\ 0\ 0\ 1$

$-(-6) = +6 \rightarrow 0\ 0\ 1\ 1\ 0$

$0\ 1\ 1\ 1\ 1 \rightarrow +15$

Case 3 Both numbers are in 2's complement form

$P = 1\ 1\ 0\ 1\ 1$

$Q = 0\ 1\ 1\ 0\ 1$

$P - Q$

$P +$ (2's complement of Q)

0 11 01 → 2's complement of 6

↓

10011

+ 11011

(1) 01110 → the MSB of the result is 0 means the result is positive but the result required is in negative.

ignore the carry

11011 → the no is in negative form

-5 11011

+5 00101 2's complement

+13 01101

+13 + 5 = +18 the result is not in the range for 5 bit no representation

So the received output is not in the correct form.

9's and 10's Complement

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9's Complement of a decimal number can by found by subtracting each digit the number from 9.

Decimal digit	9's Complement
0	9
1	8
2	7
3	6
4	5
5	4
6	3
7	2
8	1
9	

Example

Find 9's Complement of each of the following numbers

(a) 19 (b) 146

(a) 19 → subtract each digit in the number from 9 to get the 9's Complement

$$\begin{array}{r} 99 \\ -19 \\ \hline 80 \end{array}$$ 9's Complement of 19

(b)
$$\begin{array}{r} 999 \\ -146 \\ \hline 853 \end{array}$$ 9's Complement of 146

9's Complement Subtraction

Subtraction ~~is done~~ of a smaller number for the longer one system is done by the addition of the 9's Complement to the subtrahend Subtraction of longe number from a smaller no. one does not produce carry, the result is negative in the 9's Complement form.

Example

(a) 18 - 06

Regular Subtraction

```
  18
- 06
----
  12
----
```

9's Complement Subtraction

```
  18
  93   ← 9's Complement of 6
(1)11
 + 1   ← Add carry to Result
----
  12
----
```

(b)

```
  34
- 49
----
-15
```

```
  34
+ 50   ← 9's Complement
----
  84
   ↓
----
-15    9's Complement of 84
----
```

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10's Complement

10's Complement of a decimal number is equal to its 9's Complement + 1.

9 9 (b) 46

(a)
```
  9
 -9
---
  0   ← 9's Complement of 9
 +1
---
  1   ← 10's Complement of 9
```

(b)
```
  99
 -46
---
  53  ← 9's Complement of 46
 +1
---
  54  ← 10's Complement of 46
```

Example Subtract the following decimal numbers using the 10's Complement method.

Solution

(a) 9 - 4 (b) 69 - 32 (c) 347 - 265

The minued is added to the 10's Complement of the subtrahend and carry is dropped.

9. 9-4

Regular Subtraction

```
  9
 -4
  5
```

10's Complement

```
  9
 +6   ← 10's complement of 4
(1)5   Drop carry
```

(b) 69 − 32 = 37

Regular Subtraction

```
  69
 -32
  37
```

10's Complement

```
  69
 +68   ← 10's complement of 32
(1)37   Drop carry
```

(c) 347 − 265 = 82

Regular Subtraction

```
  347
 -265
   82
```

10's Complement

```
  347
 +735   ← 10's complement of 265
(1)082   DROP carry
```

R's Complement

Complement
- r's Complement [Radix Comp.]
- (r-1)'s Complement. [Diminished Radix Comp]

for finding the complement. r's Complement

Comp of $(7)_{10}$ = 10 - 7 = 3

$(9)_{10}$ = 10 - 9 = 1

N = 7
n = 1 → total no of digit
r = 10

Sothe generalized formuld.

$r^n - N$ r's Complement

1) N = 5690

determire 10's Complement.

r = 10
N = 5690
n = 4

$= 10^4 - 5690$
$= 10000 - 5690 = 4310$

Ex N = 1101 find 2's Comp by using formuld

r = 2
N = 1101
n = 4

$= 2^4 - 1101$
$= (16)_{10} - 1101$

$= 10000 - 1101$

$= 00011$

$(r-1)$'s Complement

	r's Comp.	$(r-1)$'s Comp
$r = 10$	10's Comp	9's Comp
$r = 2$	2's	1's
$r = 8$	8's	7's
$r = 16$	16's	15's

Calculate r's Complement using $(r-1)$'s Complement

$(r-1)$'s Comp = $r^n - N - 1$

$(r-1)$'s Comp = r's Comp $- 1$

$(r-1)$'s Comp $+ 1$ = r's Comp

In $(r-1)$'s Complement no borrow operation involved for reducing the circuit in lesser time.

Ex 1's Comp of 1101

by using formuld $2^4 - 1101 - 1$

$16 - 1 - 1101$

$= (15)_{10} - 1101$

$= 1111 - 1101$

$= 0010 \rightarrow$ 1's Comp

$+1$

$0011 \rightarrow$ 2's Complement

Ex2 7's Complement of octal no.

5674.

$= 8^4 - 5674 - 1$

$= (4096)_{10} - 5674 - 1$

$7777 - 5674 = 2103 \rightarrow$ 7's Complement

8's Comp of 5674 $= 2103 + 1$

$= 2104 \rightarrow$ 8's Complement