Digital Electronics- 2CS303

UNIT-1
Complements (r's and (r-1)'s)

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1. Complement Theory
2. 1’s and, 2’s complement operation
3. (r-1)’s and r’s complement
4. 9’s and, 10’s complement operation
5. Binary Codes (BCD Arithematic)
6. Weighted Codes
7. Error Processing Codes
8. Alphanumeric codes.

Complements

- Complements are used in digital computers for simplifying the subtraction operation and for logical manipulation
- There are two types of complements for base-r system:

  Radix complement (also called r's complement) and

  Diminished radix complement (also known as (r-1)'s complement)
- For Binary numbers: 2's and 1's complements
- For Decimal numbers: 10's and 9's complements (Substitute the value of base-r)

Radix Complement (r's Complement)

- R's complement of an n-digit number N in base-r is $r^n - N$, $N \neq 0$ (and 0 for N = 0)

Example: N = 012398 (Decimal Number)

n = 6, r = 10 hence, 10^6 – 012398 = 987602

- **Shortcut Method for base-10:**
  - Leave all least significant zeros unchanged
  - Subtract the first non-zero least significant digit from 10
  - Subtract all higher significant digits from 9

Example: N = 012398 Answer???

- **Find 10's complement of 246700.**

Radix Complement (r's Complement) (Cont...)

- R's complement of an n-digit number N in base-r is $r^n - N$, $N \neq 0$ (and 0 for N = 0)

Example: N = 101100 (Binary Number)

n = 6, r = 2 hence, 2^6 – 101100 = 1000000 – 101100 = 010100

- **Shortcut Method for base-2:**

  - Leave all least significant zeros and first 1 unchanged

  - Replace 1's with 0's and 0's with 1's with 0's in all other higher significant digits

Example: N = 101100 Answer???

- **Find 2's complement of 1101100.**

Diminished Complement ((r-1)'s Complement)

- (r-1)'s complement of an n-digit number N in base-r is $(r^n - 1) - N$

Example: N = 546700 (Decimal Number)

n = 6, r = 10 hence, (10^6 – 1) – 546700 = 453299

- **Shortcut Method for base-10:**

  - Subtract all digits from 9

Example: N = 546700 Answer???

- **Find 9's complement of 012398.**

Diminished Complement ((r-1)'s Complement) (Cont..)

- (r-1)'s complement of an n-digit number N in base-r is $(r^n - 1) - N$

Example: N = 1011000 (Binary Number)

n = 7, r = 2 hence, (2^7 – 1) – 1011000 = 100111

- **Shortcut Method for base-2:**

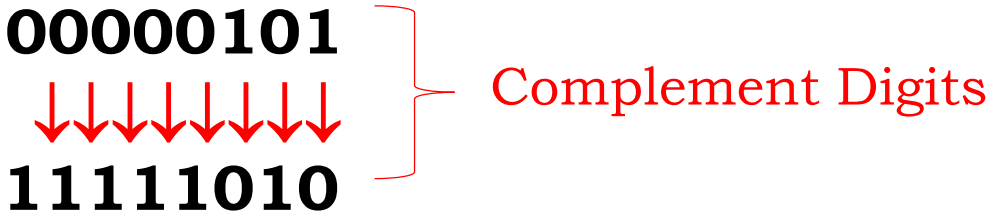
  - Change 1's to 0's and 0's to 1's

Example: N = 1011000 Answer???

- **Find 1's complement of 0101101.**

1. Complement Theory

Example 1 Get 1's complement of 00000101



1's Complement Arithmetic (ADD/SUB Method)

1. Read both the operands
2. Negative operand(s) (if any) is converted into 1's complement form
3. Add both the numbers
4. If carry is generated (i.e. =1) then the resultant number is positive.
5. Add ONE to the output of setp4, to get the final answer.
6. If carry is not generated then the answer is Negative and available in 1's complement form.
7. Convert output of step 6 into 1's complement to get final answer.

1. 1's Complement Theory

Example 1 : Subtract 1010 from 1111 using 1's complement theory. (15-10 Small negative)

1 0 1 0 —1's complement→ **0 1 0 1**

$$
\begin{array}{rr}
 & 1\ 1\ 1\ 1 \\
+ & 0\ 1\ 0\ 1 \\
\hline
1] & 0\ 1\ 0\ 0 \\
+ & 0\ 0\ 0\ 1 \\
\hline
 & 0\ 1\ 0\ 1 = (5)
\end{array}
$$

Carry "1" means the answer is positive .

1. 1's Complement Theory

Example 2 : Subtract 1010 from 1000 using 1's complement theory. (Large negative 8-10)

1 0 1 0 —1's complement→ **0 1 0 1**

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

Carry "0" means the answer is negative and available in 1's complement form.

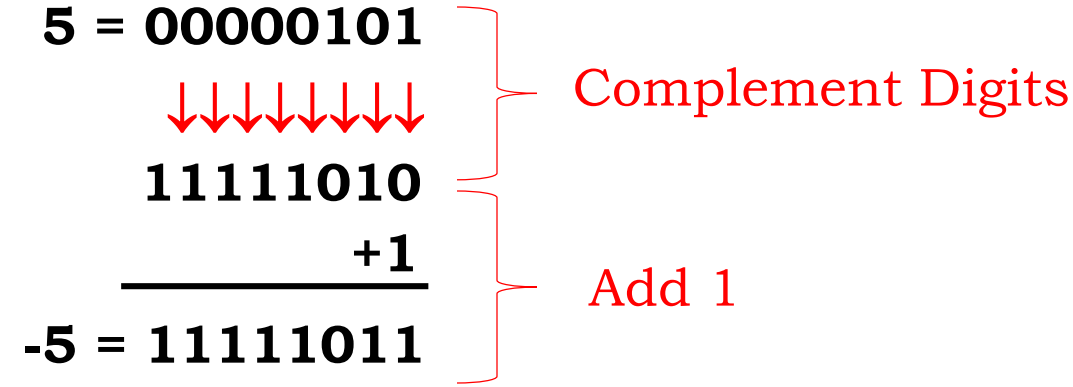
1 1 0 1 → - 0 0 1 0 = (-2)

2’s Complement Arithmetic

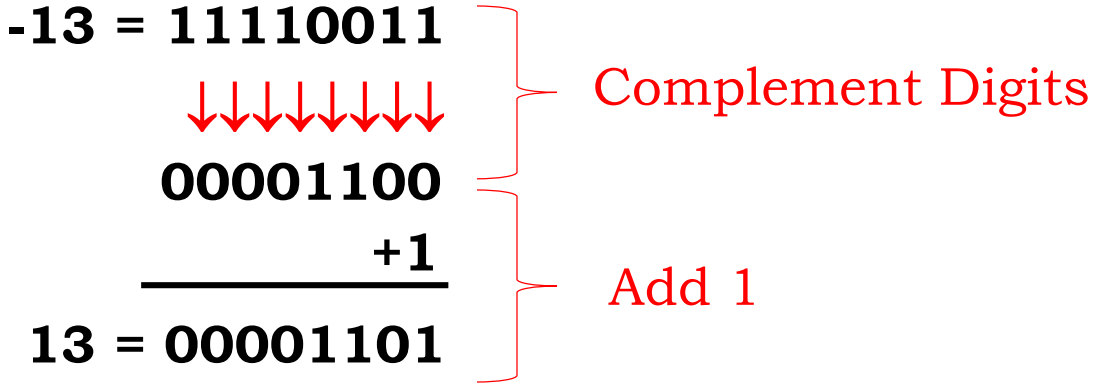
1. How to get 2’s complement form
2. Arithmetic operation using 2’s complement theory

2's Complement Arithmetic (How to get 2's complement form..?)

Example 1



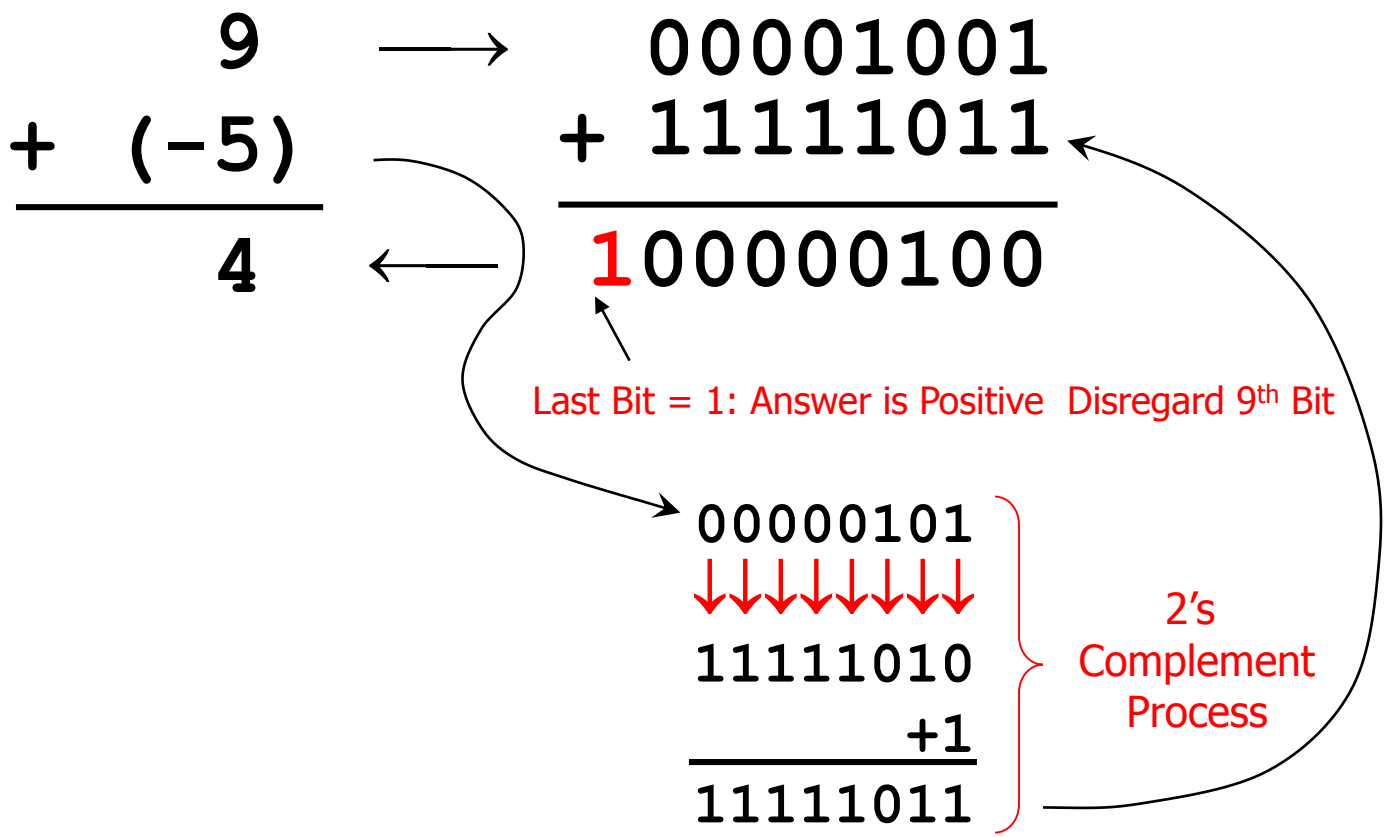
Example 2



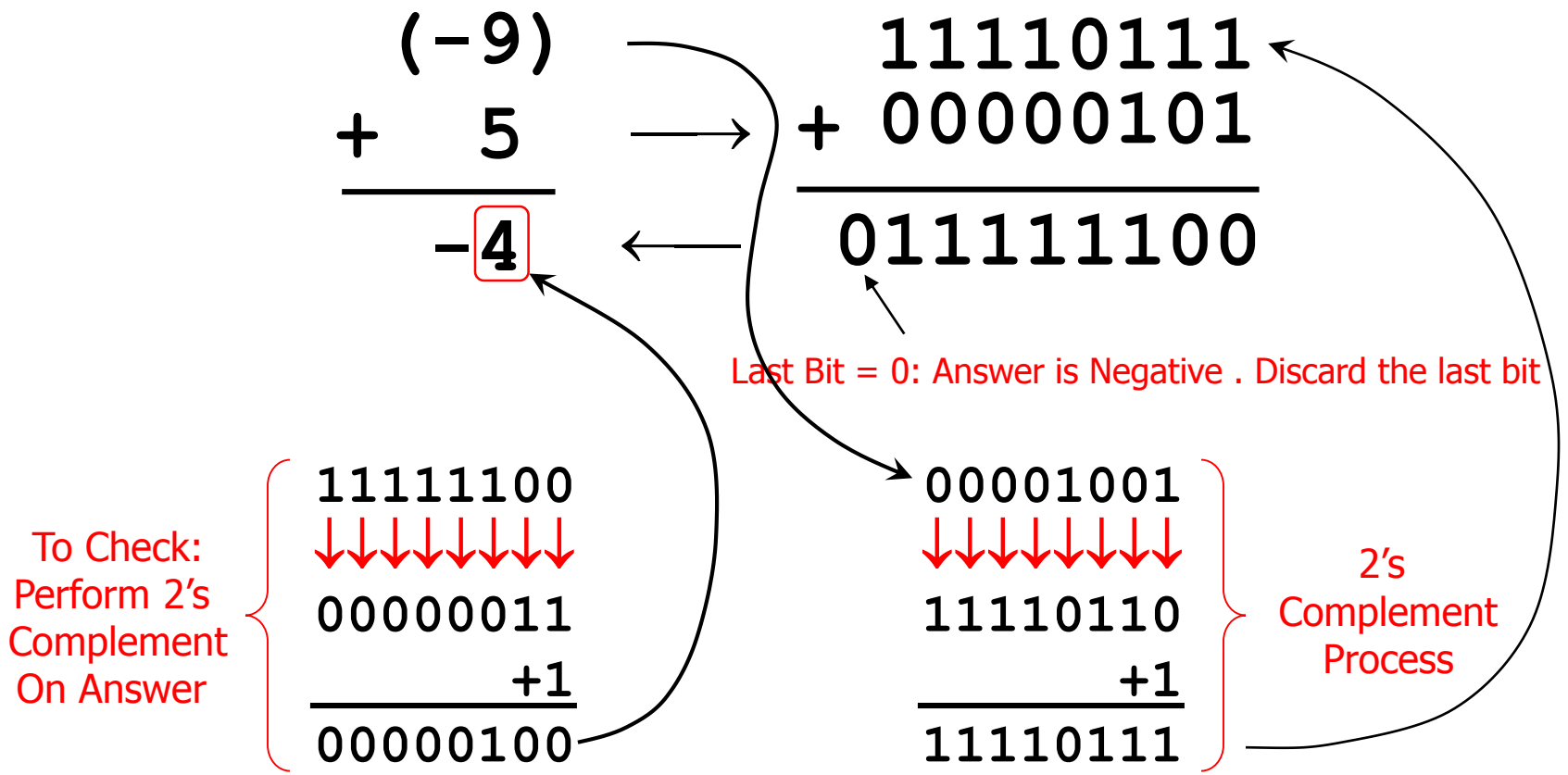
2's Complement Arithmetic (Method)

1. Read both the operands
2. Negative operand (if any) is converted into 2's complement form
3. Add both the numbers (2's complement of negative operand with the other one).
4. If carry is generated (i.e. =1) then the resultant number is positive and in original form
5. If carry is not generated(when we have negative operand) then the carry is assumed =0.
6. Carry zero means the resultant number is negative and in a 2's complement form.
7. Convert the 2's complement form into the original form.

Take the 2's complement of the negative number and use regular binary 8-bit addition.



Take the 2's complement of the negative number and use regular 8-bit binary addition.



Verify the logic using following combinations:

1: (10) –(01)
2: (10) –(02)
3: (10) –(05)
4: (10) –(08)
5: (10) –(09)
6: (10) –(10)
7**: (210) –(08)**
8: (120) –(55)
9: (52) –(18)

2's Complement Arithmetic (Examples)

A+B	A	B	2's of B	Addition	Ans
A=10 B=-1	1 0 1 0	0 0 0 1	1 1 1 0 0 0 0 1 1 1 1 1	1 0 1 0 1 1 1 1 1 1 0 0 1 CY =1 So ans is +ve	+9
B=-2		0 0 1 0	1 1 0 1 0 0 0 1 1 1 1 0	1 0 1 0 1 1 1 0 1 1 0 0 0 CY =1 So ans is +ve	+8
B=-5		0 1 0 1	1 0 1 0 0 0 0 1 1 0 1 1	1 0 1 0 1 0 1 1 1 0 1 0 1 CY =1 So ans is +ve	+5
B=-8		1 0 0 0	0 1 1 1 0 0 0 1 1 0 0 0	1 0 1 0 1 0 0 0 1 0 0 1 0 CY =1 So ans is +ve	+2
B=-9		1 0 0 1	0 1 1 0 0 0 0 1 0 1 1 1	1 0 1 0 0 1 1 1 1 0 0 0 1 CY =1 So ans is +ve	+1
B=-10		1 0 1 0	0 1 0 1 0 0 0 1 0 1 1 0	1 0 1 0 0 1 1 0 1 0 0 0 0 CY =1 So ans is +ve	+0

Example: Perform 2's complement subtraction on 210-08

210= 1 1 0 1 0 0 1 0

8= 0 0 0 0 1 0 0 0 2's complement of 8 is = 1 1 1 1 1 0 0 0

Add both the numbers:

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

Carry = 1 means and is positive +202

2’s Complement Arithmetic (Examples on varying number of bits)

Example: Perform 2’s complement arithmetic for (30)-(50) using

1: 6-bit number system

2: 8-bit number system

Example: Perform 2's complement arithmetic for (30)-(50) using:

1: 6-bit number system

(30)= 0 1 1 1 1 0
(-50)= 1 1 0 0 1 0 2's complement 0 0 1 1 0 1
0 0 0 0 0 1

0 0 1 1 1 0

Add both the numbers

0 1 1 1 1 0
0 0 1 1 1 0

0 1 0 1 1 0 0

Carry =0 means number is negative and in 2's compl form

0 1 0 0 1 1
0 0 0 0 0 1

0 1 0 1 0 0 = -20

2: 8-bit number system

(30)= 0 0 0 1 1 1 1 0
(-50)= 0 0 1 1 0 0 1 0 2's complement 1 1 0 0 1 1 0 1
0 0 0 0 0 0 0 1

1 1 0 0 1 1 1 0

Add both the numbers

0 0 0 1 1 1 1 0
1 1 0 0 1 1 1 0

0 1 1 1 0 1 1 0 0

Carry =0 means number is negative and in 2's compl form

0 0 0 1 0 0 1 1
0 0 0 0 0 0 0 1

0 0 0 1 0 1 0 0 = -20

(r-1)’s and r’s complement

Example of decimal number system

So r becomes 10’s complement

And (r-1) becomes 9’s complement

How to get (r-1)'s complement of decimal number...?

How do we get (r-1)'s complement ...?

(r-1)'s i.e. 9's complement of decimal number can be obtained by $((10^n - 1)$-number) where n represents the number of digits in given number.

Example 1: Find 9's complement of $(1234)_{10}$

9's complement = $(10^4-1)-1234 = 9999-1234 = 8765$

How do we get (r)'s complement ...?

r's i.e. 10's complement can be obtained by $(10^n$ – number)
where n represents the number of digits in given number.

Example 2: Find 10's complement = $10^4-1234 = 8766$.

We will move to subtraction using them. Remember always the number to be subtracted (negative number) is converted to 9's or 10's complement.

9's Complement Arithmetic

Example 1: Get 9's complement of following numbers $(19)_{10}$, $(146)_{10}$, $(4397)_{10}$

99	999	9999
-19	-146	-4397
80	853	5602

9's Complement Arithmetic

Example 1: Perform subtraction using 9's complement on the data set given below.

a: 18-06, b: 39-23 c: 34-49 d: 49-84

06 is negative number,
We will get 9's complement of 06

```
  9 9
- 0 6
-----
  9 3
```

We will ADD 93 and 18

```
  9 3
+ 1 8
-----
1 1 1
```

A carry is generated means answer is +ve
ADD the carry back to the sum "11".

```
  1 1
+   1
-----
  1 2
```

Try for (018) – (006)

9's Complement Arithmetic

Example 2: Perform 9's complement subtraction on the data set given below.

a: 18-06, b: 39-23 c: 34-49 d: 49-84

23 is negative number,
We will get 9's complement of 23

```
  9 9
- 2 3
-------
  7 6
```

We will ADD 76 and 39

```
  7 6
+ 3 9
-------
1 1 5
```

A carry is generated .
ADD the carry back to the sum "15".

```
  1  5
+    1
---------
  1    6
```

Try for 039-023

9's Complement Arithmetic

Example 3: Perform 9's complement subtraction on the data set given below.

a: 18-06, b: 39-23 c: 34-49 d: 49-84

49 is negative number,
We will get 9's complement of 49

```
  9 9
- 4 9
-----
  5 0
```

We will ADD 50 and 34

```
  5 0
+ 3 4
-----
0 8 4
```

A carry is **not** generated that means answer is Negative.
Get 9's complement of 84

```
  9 9
_ 8 4
-----
  1 5
```

Answer is -15

Try for 034-049

9's Complement Arithmetic

Example 4: Perform 9's complement subtraction on the data set given below.
a: 18-06, b: 39-23 c: 34-49 d: 49-84

84 is negative number,
We will get 9's complement of 84

```
  9 9
- 8 4
-------
  1 5
```

We will ADD 15 and 49

```
  4 9
+ 1 5
-------
  0 6  4
```

A carry is **not** generated that means answer is Negative.
Get 9's complement of 64

```
    9 9
  _ 6 4
--------
    3  5
```

Answer is -35

Try for 049-084

10's Complement Arithmetic

Example 1: Perform 10's complement subtraction on the data set given below.

a: 24-09, b: 69-32 c: 265-347

09 is negative number,
We will get 10's complement of 09

```
  9 9
- 0 9
-----

  9 0
+ 0 1
-----

  9 1
```

We will ADD 91 and 24

```
  2 4
+ 9 1
-----

1 1 5
```

A carry is generated that means answer is Positive.
Answer is +15

Try for 024-009

10's Complement Arithmetic

Example 2: Perform 10's complement subtraction on the data set given below.
a: 24-09, b: 69-32 c: 265-347

32 is negative number,
We will get 10's complement of 32

```
  9 9
- 3 2
-------

  6 7
+ 0 1
-------

  6 8
```

We will ADD 68 and 69

```
  6 8
+ 6 9
-------

1 3 7
```

A carry is generated that means answer is Positive.
Answer is +37

Try for 069-032

10's Complement Arithmetic

Example 3: Perform 10's complement subtraction on the data set given below.
a: 24-09, b: 69-32 c: 265-347

347 is negative number,
We will get 10's complement of 347

```
  9 9 9
- 3 4 7
-------
  6 5 2
+   0 1
-------
  6 5 3
```

We will ADD 653 and 265

```
  653
+ 265
-----
 0 918
```

A carry is not generated that means
answer is Negative and in 10's complement form.

Get 10's complement form of 918

```
 9 9 9
-9 1 8
------
 0 8 1
+0 0 1
------
 0 8 2
```

Ans = -82

Try for 0265-0347