

Digital Electronics- 2CS303

UNIT-1

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

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Agenda:

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

1.Complement Theory

Example 1 Get 1's complement of 5

$$\begin{array}{rcl} 5 = & 00000101 & \\ & \downarrow\downarrow\downarrow\downarrow\downarrow\downarrow\downarrow\downarrow & \\ & 11111010 & \end{array} \left. \vphantom{\begin{array}{r} 00000101 \\ 11111010 \end{array}} \right\} \text{Complement Digits}$$

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 step 4, 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 $\xrightarrow{\text{1's complement}}$ **0 1 0 1**

$$\begin{array}{r} \mathbf{1\ 1\ 1\ 1} \\ + \mathbf{0\ 1\ 0\ 1} \\ \hline \mathbf{1\ 1\ 0\ 0} \\ + \mathbf{0\ 0\ 0\ 1} \\ \hline \mathbf{0\ 1\ 0\ 1 = (5)} \end{array}$$

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 $\xrightarrow{\text{1's complement}}$ **0 1 0 1**

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

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

$$\mathbf{1\ 1\ 0\ 1} \longrightarrow \mathbf{0\ 0\ 1\ 0} = \mathbf{(2)}$$

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

$$\begin{array}{r} 5 = 00000101 \\ \downarrow\downarrow\downarrow\downarrow\downarrow\downarrow\downarrow\downarrow \\ 11111010 \\ \quad +1 \\ \hline -5 = 11111011 \end{array} \quad \begin{array}{l} \left. \begin{array}{l} \text{Complement Digits} \\ \text{Add 1} \end{array} \right\} \end{array}$$

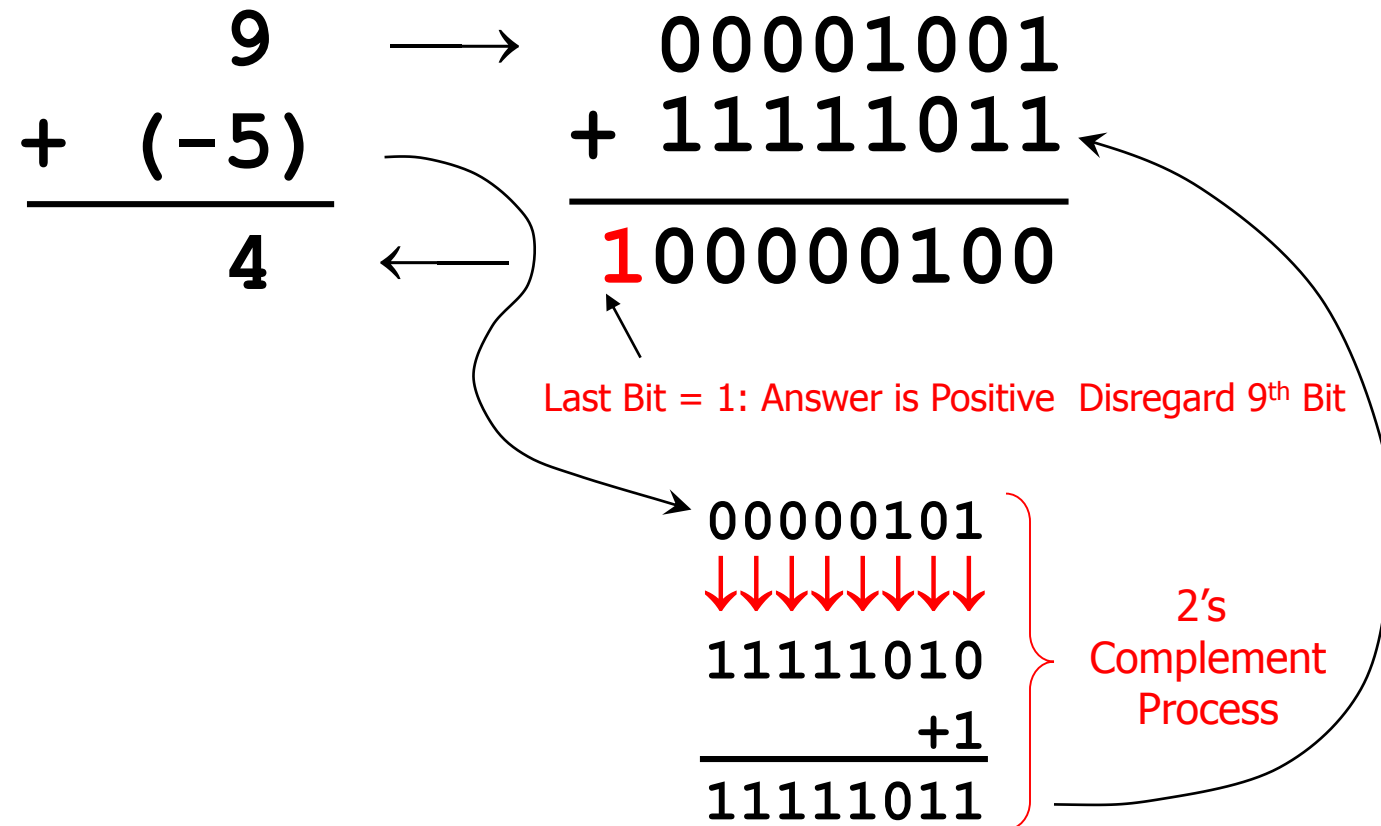
Example 2

$$\begin{array}{r} -13 = 11110011 \\ \downarrow\downarrow\downarrow\downarrow\downarrow\downarrow\downarrow\downarrow \\ 00001100 \\ \quad +1 \\ \hline 13 = 00001101 \end{array} \quad \begin{array}{l} \left. \begin{array}{l} \text{Complement Digits} \\ \text{Add 1} \end{array} \right\} \end{array}$$

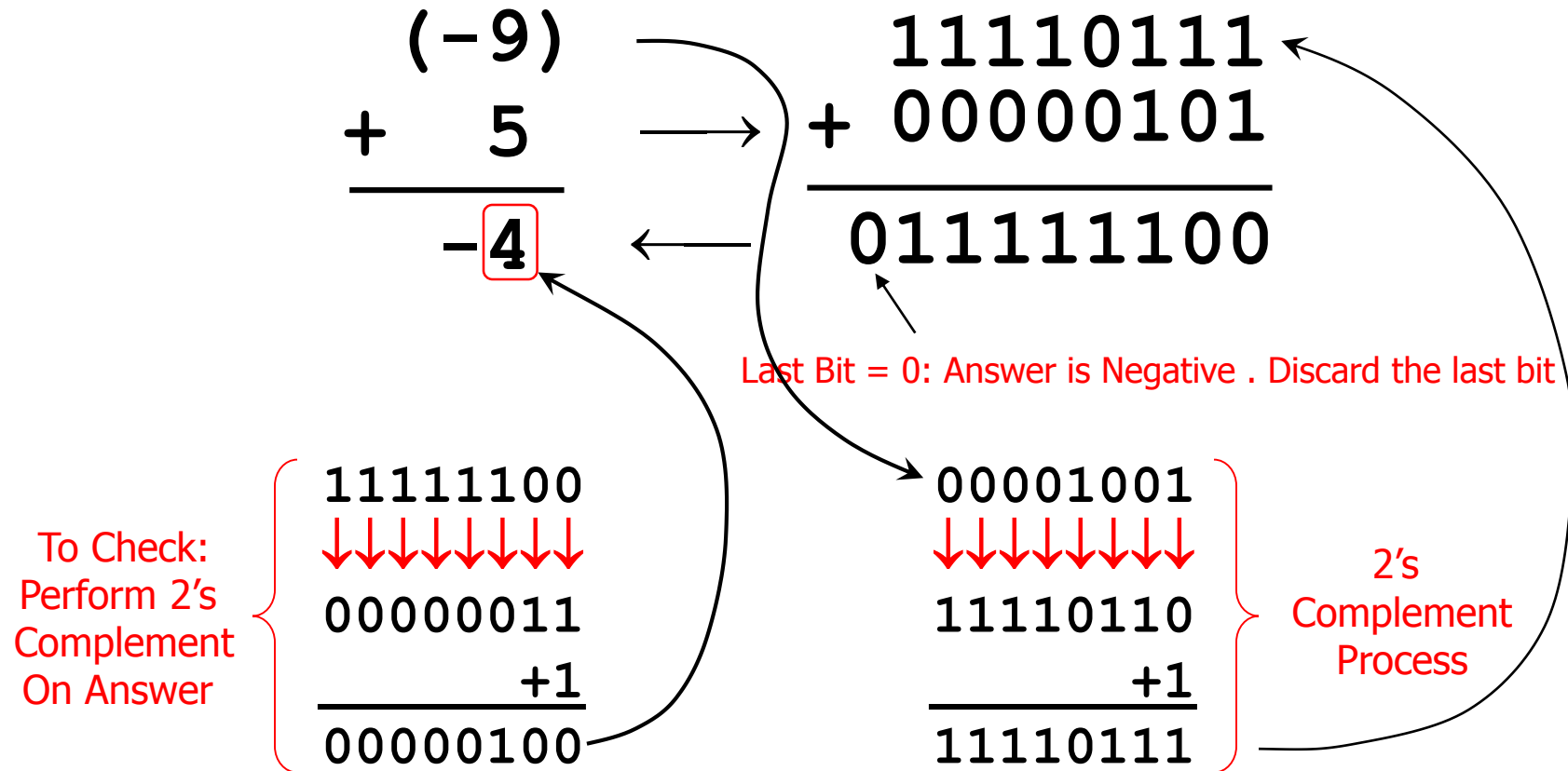
2's Complement Arithmetic (Method)

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	$\begin{array}{r} 1\ 1\ 1\ 0 \\ 0\ 0\ 0\ 1 \\ \hline 1\ 1\ 1\ 1 \end{array}$	$\begin{array}{r} 1\ 0\ 1\ 0 \\ 1\ 1\ 1\ 1 \\ \hline 1\ 1\ 0\ 0\ 1 \end{array}$ CY =1 So ans is +ve	+9
B=-2		0 0 1 0	$\begin{array}{r} 1\ 1\ 0\ 1 \\ 0\ 0\ 0\ 1 \\ \hline 1\ 1\ 1\ 0 \end{array}$	$\begin{array}{r} 1\ 0\ 1\ 0 \\ 1\ 1\ 1\ 0 \\ \hline 1\ 1\ 0\ 0\ 0 \end{array}$ CY =1 So ans is +ve	+8
B=-5		0 1 0 1	$\begin{array}{r} 1\ 0\ 1\ 0 \\ 0\ 0\ 0\ 1 \\ \hline 1\ 0\ 1\ 1 \end{array}$	$\begin{array}{r} 1\ 0\ 1\ 0 \\ 1\ 0\ 1\ 1 \\ \hline 1\ 0\ 1\ 0\ 1 \end{array}$ CY =1 So ans is +ve	+5
B=-8		1 0 0 0	$\begin{array}{r} 0\ 1\ 1\ 1 \\ 0\ 0\ 0\ 1 \\ \hline 1\ 0\ 0\ 0 \end{array}$	$\begin{array}{r} 1\ 0\ 1\ 0 \\ 1\ 0\ 0\ 0 \\ \hline 1\ 0\ 0\ 1\ 0 \end{array}$ CY =1 So ans is +ve	+2
B=-9		1 0 0 1	$\begin{array}{r} 0\ 1\ 1\ 0 \\ 0\ 0\ 0\ 1 \\ \hline 0\ 1\ 1\ 1 \end{array}$	$\begin{array}{r} 1\ 0\ 1\ 0 \\ 0\ 1\ 1\ 1 \\ \hline 1\ 0\ 0\ 0\ 1 \end{array}$ CY =1 So ans is +ve	+1
B=-10		1 0 1 0	$\begin{array}{r} 0\ 1\ 0\ 1 \\ 0\ 0\ 0\ 1 \\ \hline 0\ 1\ 1\ 0 \end{array}$	$\begin{array}{r} 1\ 0\ 1\ 0 \\ 0\ 1\ 1\ 0 \\ \hline 1\ 0\ 0\ 0\ 0 \end{array}$ 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:

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      1 1 0 1 0 0 1 0
    + 1 1 1 1 1 0 0 0
    1 1 1 0 0 1 0 1 0
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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

$$\begin{array}{rcl} (30) & = & 011110 \\ (-50) & = & 110010 \end{array} \quad \begin{array}{r} \text{2's complement} \\ 001101 \\ 000001 \\ \hline 001110 \end{array}$$

Add both the numbers

$$\begin{array}{r} 011110 \\ 001110 \\ \hline 0101100 \end{array}$$

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

$$\begin{array}{r} 010011 \\ 000001 \\ \hline 010100 = -20 \end{array}$$

2: 8-bit number system

$$\begin{array}{rcl} (30) & = & 00011110 \\ (-50) & = & 00110010 \end{array} \quad \begin{array}{r} \text{2's complement} \\ 11001101 \\ 00000001 \\ \hline 11001110 \end{array}$$

Add both the numbers

$$\begin{array}{r} 00011110 \\ 11001110 \\ \hline 011101100 \end{array}$$

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

$$\begin{array}{r} 00010011 \\ 00000001 \\ \hline 00010100 = -20 \end{array}$$

$(r-1)$'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 $((10^n - 1) - \text{number})$ where n represents the number of digits in given number.

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

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

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

r's i.e. 10's complement can be obtained by $(10^n - \text{number})$ 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
<hr/>		
80	853	5602

$$((10^n - 1) - \text{number})$$

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

$$\begin{array}{r} 99 \\ - 06 \\ \hline 93 \end{array}$$

We will ADD 93 and 18

$$\begin{array}{r} 93 \\ + 18 \\ \hline 111 \end{array}$$

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

$$\begin{array}{r} 11 \\ + 1 \\ \hline 12 \end{array}$$

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

$$\begin{array}{r} 99 \\ - 23 \\ \hline 76 \end{array}$$

We will ADD 76 and 39

$$\begin{array}{r} 76 \\ + 39 \\ \hline 115 \end{array}$$

A carry is generated .

ADD the carry back to the sum "15".

$$\begin{array}{r} 15 \\ + 1 \\ \hline 16 \end{array}$$

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

$$\begin{array}{r} 99 \\ - 49 \\ \hline 50 \end{array}$$

We will ADD 50 and 34

$$\begin{array}{r} 50 \\ + 34 \\ \hline 084 \end{array}$$

A carry is **not** generated that means
answer is Negative.

Get 9's complement of 84

$$\begin{array}{r} 99 \\ - 84 \\ \hline 15 \end{array}$$

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

$$\begin{array}{r} 99 \\ - 84 \\ \hline 15 \end{array}$$

We will ADD 15 and 49

$$\begin{array}{r} 49 \\ + 15 \\ \hline 064 \end{array}$$

A carry is **not** generated that means
answer is Negative.

Get 9's complement of 64

$$\begin{array}{r} 99 \\ - 64 \\ \hline 35 \end{array}$$

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

$(10^n - \text{number})$

09 is negative number,

We will get 10's complement of 09

$$\begin{array}{r} 99 \\ - 09 \\ \hline 90 \\ + 01 \\ \hline 91 \end{array}$$

We will ADD 91 and 24

$$\begin{array}{r} 24 \\ + 91 \\ \hline 115 \end{array}$$

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

$$\begin{array}{r} 99 \\ - 32 \\ \hline 67 \\ + 01 \\ \hline 68 \end{array}$$

We will ADD 68 and 69

$$\begin{array}{r} 68 \\ + 69 \\ \hline \mathbf{1}37 \end{array}$$

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

$$\begin{array}{r} 999 \\ - 347 \\ \hline 652 \\ + 01 \\ \hline 653 \end{array}$$

We will ADD 653 and 265

$$\begin{array}{r} 653 \\ + 265 \\ \hline 0918 \end{array}$$

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

Get 10's complement form of 918

$$\begin{array}{r} 999 \\ - 918 \\ \hline 081 \\ + 001 \\ \hline 082 \end{array}$$

Ans = -82

Try for 0265-0347