logic gates

lecture 03

- Radix complement
  - ↳ r's complement
- Diminished Radix
  - ↳ r-1's complement
- Subtraction using complements
- unsigned / signed number
- minimum number of bits to represent unsigned and signed number
- what is the maximum and minimum number that can be represented by n-bit for signed and unsigned

Radix complement

r's complement $= r^{\hat{n}} - N$

Decimal

$r = 10$

10's complement

$= 10^{\hat{n}} - N$

Binary

$r = 2$

2's complement

$2^{\hat{n}} - N$

Hexadecimal

$r = 16$

16's complement

$16^{\hat{n}} - N$

Ex for a decimal number $X = 2953$ find the 10's complement

10's complement $= 10^{\hat{n}} - N$

n: no. of digits

N: value of a number

$n = 4$ $N = 2953$

10's complement = $10^4 - 2953$

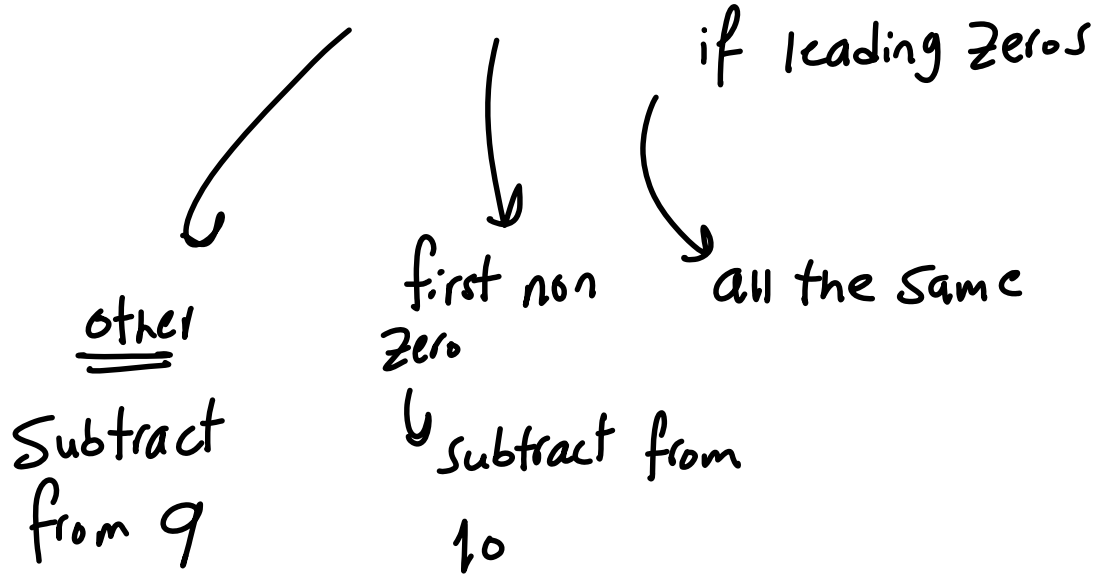
$$\begin{array}{r} 10000 \\ 2953 \\ \hline 7047 \end{array}$$

Note

for any number of n digits

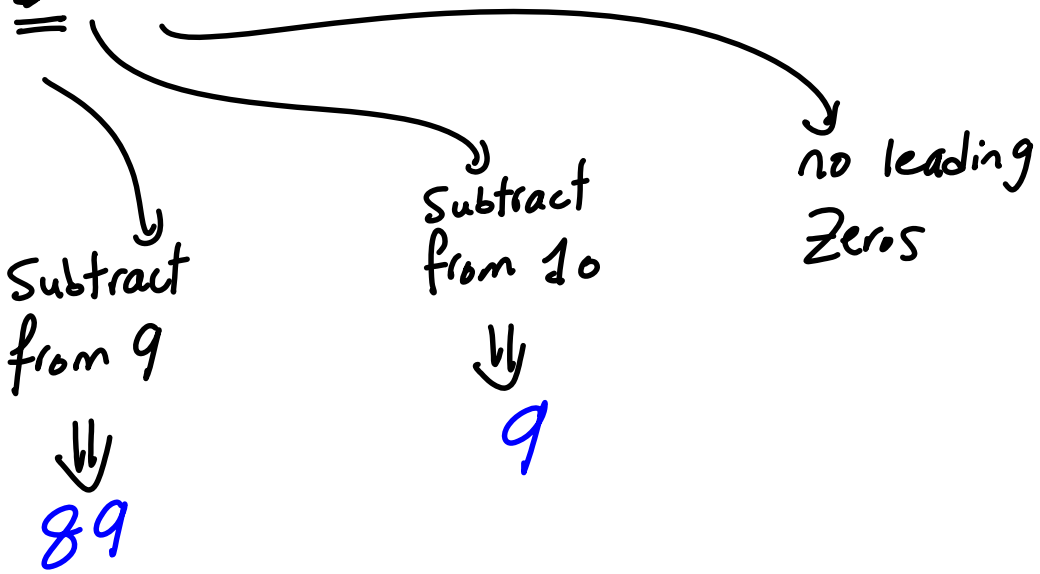
$10^n \Rightarrow 100\sim00$ ⇒ n zero

$-$ □□ — □ ⇒ number of n digit



Ex find 10's complement of

101



Ex find 10's complement of

3500 → 6500

125 → 875

1930 → 8070

Binary number

2's complement = $2^n - N$

n => no. of bits

N => value of number

Ex find the 2's complement of $(1011)_2$

$$2\text{'s complement} = 2^4 - 1011$$

$$\begin{array}{r} {\scriptstyle 1\ 1\ 1\ 2} \\ 10000 \\ -\ 1011 \\ \hline 0101 \end{array}$$

اول مجموعة اصفار تنزل تكاهد
اول رقم غير صفري تكاهد
باقي الارقام تقلب
1 ← 0
0 ← 1

Ex

10100	1011	10
⇓	⇓	⇓
01100	0101	10

Hexadecimal number

16's complement = $16^{\wedge} - N$

Ex

find the 16's complement of

2C0 → D40

69A → 966

Diminished radix ⇒ (r−1)'s complement

$= r^{\wedge} - 1 - N$

- Decimal: 9's complement $= 10^{\wedge} - 1 - N$
- Binary: 1's complement $= 2^{\wedge} - 1 - N$
- Hexadecimal: 15's complement $= 16^{\wedge} - 1 - N$

Decimal

9's complement = $10^n - 1 - N$

$100\cdots0$

$-\quad 1$

$999\cdots9 \Rightarrow n$ digit

$-\quad \square\square\square \quad \square \Rightarrow n$ digit

Subtract each digit from 9

Ex find 9's complement of 224

9's complement $= (10^3 - 1) - 224$

$= 999 - 224$

$= 775$

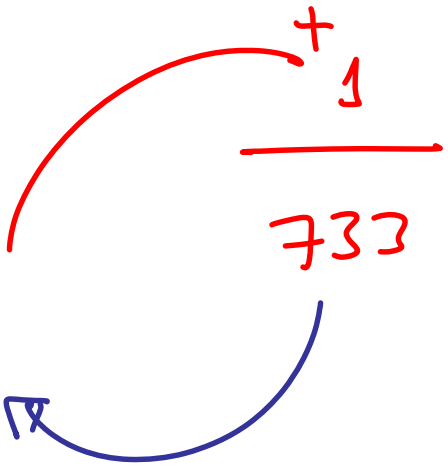
Ex find 9's complement of

4500	603	740
⇓	⇓	⇓
5499	396	259

Ex find 9's and 10's complement of 267

9's complement = 732

10's complement = 733



∴ 9's complement + 1 = 10's complement

Binary Number

1's Complement $= (\hat{2} - 1) - N$

n bit of 1 value

1111 --- 111 $\overset{0}{\underset{1}{\longleftarrow}}$

□□□ −

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flip each bit

Ex

1101 ⇓ 0010

1000 ⇓ 0111

1010 ⇓ 0101

Hexadecimal

15's complement ⟹ Subtract each digit from 15

Ex find 15's complement of

AOC9 ⇓ 5F36

478 ⇓ B87

95A0 ⇓ 6A5F

Ex

$$\begin{array}{r} 742 \\ 551- \\ \hline 191 \end{array} \Rightarrow \begin{array}{r} 742 \\ 449+ \\ \hline \boxed{1}\,191 \\ \times \end{array}$$

WOW

$$\begin{array}{r} 742- \\ 551 \\ \hline \end{array} \Rightarrow \begin{array}{r} 742 \\ 448+ \\ \hline \boxed{1}\,190 \\ \quad\;\; + \\ \hline 191 \end{array}$$

Ex

$$\begin{array}{r} 37 \\ 45- \\ \hline -8 \end{array} \Rightarrow \begin{array}{r} 37 \\ 55+ \\ \hline \square\,92 \\ \quad\;\; 10's \\ \hline -08 \end{array}$$

Ex Subtract using two's complement

$$\begin{array}{r} 110 \\ 010- \\ \hline \end{array} \Rightarrow \begin{array}{r} 110 \\ 110 \quad + \\ \hline \boxed{1}\,100 \\ \times \end{array}$$

How to represent signed number

the best method is two's complement

$111 \Rightarrow 7$ unsigned

$0111 \Rightarrow +7$ signed

2's

$1001 \Rightarrow -7$ signed

Ex Represent -24 in two's complement form

$24 \Rightarrow 11000 \Rightarrow 24$ unsigned

$011000 \Rightarrow +24$ signed

take 2's complement

$101000 \Rightarrow -24$ signed

Ex if this number 1011 represent signed number, what is this number

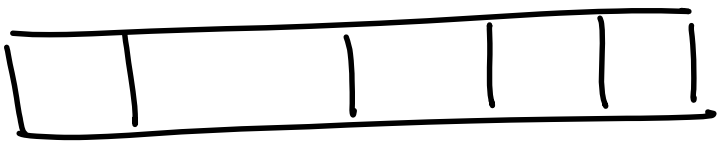
1011 $\Rightarrow$ negative

take 2's complement

$0101 \Rightarrow 5$

so $1011 \Rightarrow -5$

Note



Sign bit

0 tve

1 negative

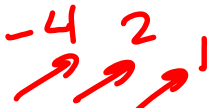
Ex ⇒ Represent −15 in binary format

−16	8	4	2	1
1	0	0	0	1

Ex Represent −8 in binary format

−8	4	2	1
1	0	0	0

Ex what is the signed number represented by 110 , 1110, 11110



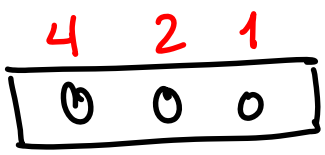
⇒ −2

⇒ −2

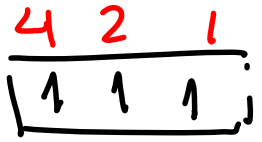
⇒ −2

Ex What is the maximum & minimum decimal number that can represent by 3-bit?

unsigned



$\Rightarrow 0$



$\Rightarrow 7$

signed

1 0 0 $\Rightarrow -4$

0 1 1 $\Rightarrow 3$

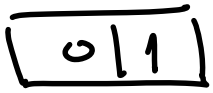
unsigned

$0 \leq n\text{-bit} \leq 2^n - 1$

signed

2-bit

$\Rightarrow -2$



$\Rightarrow 1$

$-2 \leq 2\text{-bit} \leq 1$

$-4 \leq 3\text{-bit} \leq 3$

$-2^{n-1} \leq n\text{-bit} \leq 2^{n-1} - 1$