

Relation between signed & unsigned Integer.

Let's say we have 3 bits to represent the counting.



C B A

0 0 0

{

0

0 0 1

A

1

0 1 0

B

2

1 0 0

C

4

0 1 1

AB

3

1 1 0

BC

6

1 0 1

AC

5

1 1 1

ABC

7

$$\Rightarrow 2^3 = 8$$

So, total allowed representations is

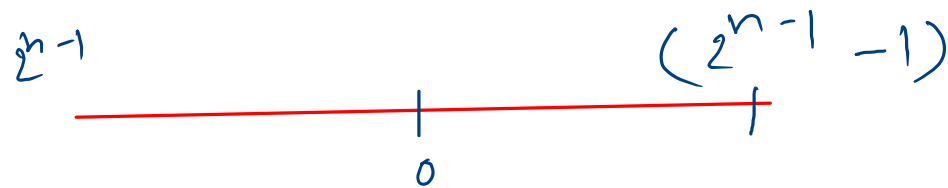
$$\underline{2^n}$$

where n is given
bits.

$$\text{Total unsigned numbers} = \underline{2^n}$$

$$\text{Total Signed numbers} = 2 \times 2^{n-1} = \left(\underset{\substack{\swarrow \\ \text{-ve} \\ \text{numbers}}}{2^{n-1}} + \underset{\substack{\searrow \\ \text{-ve} \\ \text{numbers}}}{2^{n-1}} \right)$$

Range of +ve & -ve numbers



Example: given bits = 3.

$$\text{total unsigned numbers} = 2^3 = 8$$

range = 0 to 7.

$$\text{Signed numbers} \Rightarrow 2 \times 2^2 = \left(\underset{\substack{\swarrow \\ \text{+ve}}}{2^2} + \underset{\substack{\searrow \\ \text{-ve}}}{2^2} \right)$$

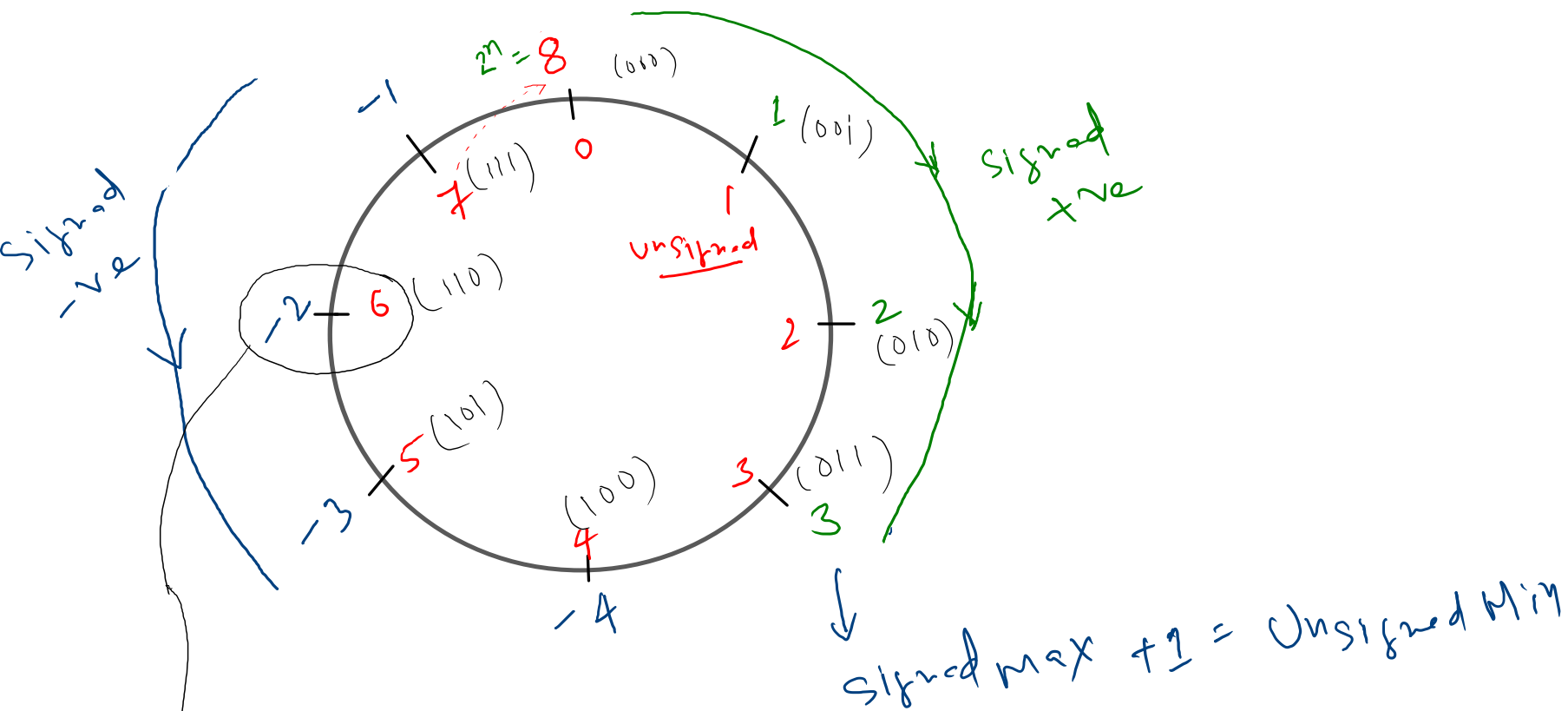
$$\text{+ve number range} = 0 \text{ to } 2^2 - 1$$

$$\Rightarrow 0 \text{ to } 3$$

$$\text{-ve number range} = -2^2 \text{ to } -1$$

$$= -4 \text{ to } -1$$

Signed & Unsigned relations



Signed & Unsigned relations

$$\rightarrow 2^n + \text{Signed negative} = \text{Unsigned}$$

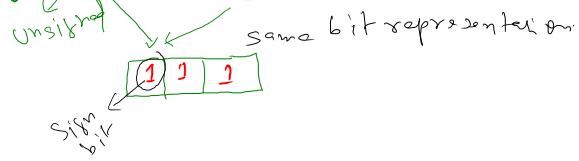
$$2^3 + (-1) = 7$$

same bit representations

1	1	1
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unsigned = $2^n + \text{signed negative}$

$$y = 7 = 2^3 - 1 \rightarrow \text{signed negative}$$



Signed value

→ Since it's the signed representation, so first we have to get its 2's complement

$$111 \xrightarrow{\text{1's complement}} 000 \xrightarrow{\text{add 1}} 001$$

$$0 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 = 1$$

→ Since sign bit is 1 so value is -1

Unsigned value

$$1 \times 2^2 + 1 \times 2^1 + 1 \times 2^0 = 7$$

Q. How to calculate bit representation of -ve number.

→ Get the 2's complement of its absolute value.

eg. -1, absolute value of -1 is 1, i.e. 001 and its 2's complement is 111

→ Unsigned & the signed have same bit representation.

∴ Let's see the value of 3 in '3' bit representation.

0	1	1
2^2	2^1	2^0

Signed value is 3

Since it is a signed number
so we need to first calculate
2's complement to see the relation

$$011 \xrightarrow{\text{1's complement}} 100 \xrightarrow{\text{add 1}} 101$$

$$101 \Rightarrow 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 = 5$$

$$\boxed{\text{Positive signed value} = 2^N - (\text{2's complement})}$$

$$\text{the signed } 3 = 2^3 - 5 \rightarrow \text{2's complement or unsigned}$$

Both unsigned value & +ve signed value are same.

$$0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0 = 3$$

$$\text{or } \frac{\text{2's complement}}{\text{Unsigned}} = 2^N - (\text{the signed})$$

$$\text{Unsigned} = 2^N + (\text{signed -ve})$$

$$2's \text{ complement} = 2^N - (\text{+ve signed})$$

eg 1 { $\rightarrow 7 = 2^3 + (-1)$

$$7 = 2^3 - (1)$$

eg 2

$$5 = 2^3 + (-3)$$

$$5 = 2^3 - (3)$$

$$[\text{unsigned} = 2^N + (-\text{ve signed})]$$

$$[2's \text{ complement} = 2^N - (\text{+ve signed})]$$

$$\begin{cases} \text{Unsigned} = 2^N + (-\text{ve Signed}) \\ \text{Unsigned} = 2^N - (+\text{ve Signed}) \end{cases}$$

2's complement.

So, Unsigned value is 2's complement.

$$\underline{5} = 2^3 + (-3)$$

bit representation of
2's complement of 3
and unsigned 5 are same

2's complement is 1's complement + 1

Since $(2^N - \text{Number})$ gives 2's complement

So, $(2^N - 1 - \text{Number})$ gives 1's complement.

What is the 2's complement of $x = 3$ in 3 bit system?

Q1

What is the bit representation of $x = -3$ in 3 bit system?

Solⁿ (1) : Find the 2's complement of absolute value of x i.e. 3.

Solⁿ 2 : Unsigned bit representation of $(2^n - x)$ i.e. $(2^3 - 3) = 5$

Q2 What is the 1's complement of $x = 3$ in 3 bit system?

$$\text{Solⁿ 1} = (2^n - 1 - x) \text{ i.e. } 2^3 - 1 - 3 = 4.$$

Solⁿ 2 = bit representation of 3 = 011 $\xrightarrow{\text{1's complement}}$ 100 $(1 \times 2^2 + 0 \times 2^1 + 0 \times 2^0 = 4)$