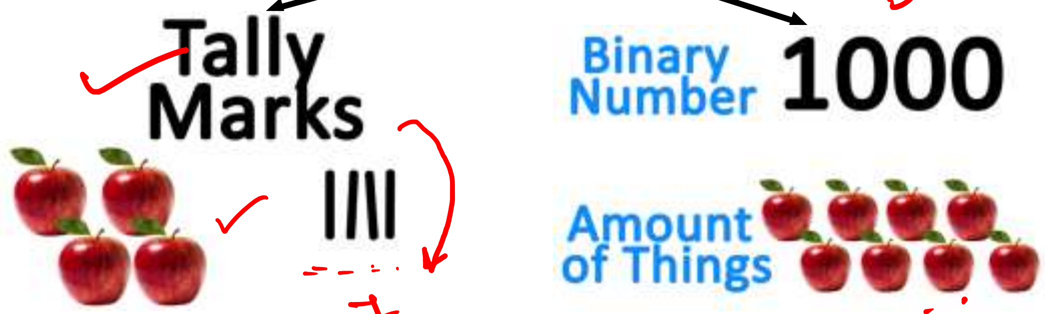
Why Binary [Digital] ?

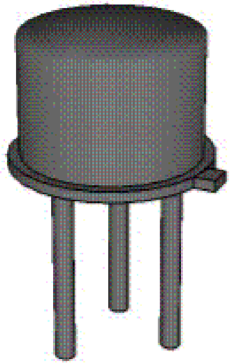
System of Counting



Binary

0 to 7

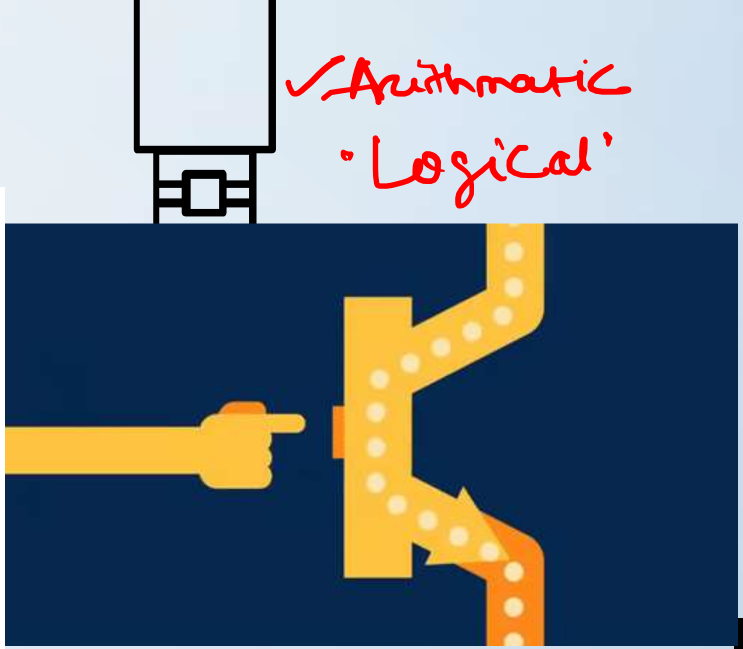
$3 = \log_2(8)$



✓ Computers are made of micro-transistors. [Millions of Transistors]

(MSB) LSB

ON: 1
OFF: 0



✓Arithmetic
·Logical'

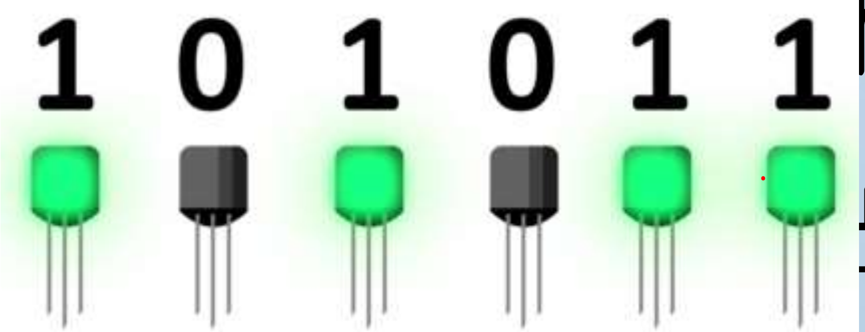
Transistor

0 to $2^6 - 1$

$? = \log_2(256)$

$= \log_2(2^8)$

$= 8$



Source: https://www.youtube.com/watch?v=Xpk67YzOn5w

Number System

- Binary
- Octal
- Decimal
- HexaDecimal

(10) Base = 10

$0 \le C \le 9$

Number Conversions

Sign number Representation

power of 2

$5\ 3\ 2\ 4 . 1$

10^3	10^2	10^1	10^0	10^{-1}
1000	100	10	1	

$1\ 0\ 1\ 0\ 1\ 0\ 1\ 1.$

"Base" "Exponent"

$C \cdot b^n$

"$0 \le C \le b-1$"

1 0 1 1 . 1

2^3	2^2	2^1	2^0	2^{-1}

$1\times2^3 + 0\times2^2 + 1\times2^1 + 1\times2^0 + 1\times2^{-1} = ?$ Decimal.

$b = 2$

$0 \leq C \leq 1$

$C = 0$ & 1

[12]

(1 5 4)

$(15)_{16}$

✓ (Octal, Binary, Hexadecimal) → (Decimal.) ✓

Octal = 0 to 7.

$0 \leq C \leq F$

Hex. = 0 to 15 = 0 to 9 & A B C D E F

$(15)_{16} = F$ ✗

$(F)_{16} = (15)$

$(15)_{16} = 1\times16^1 + 5\times16^0$

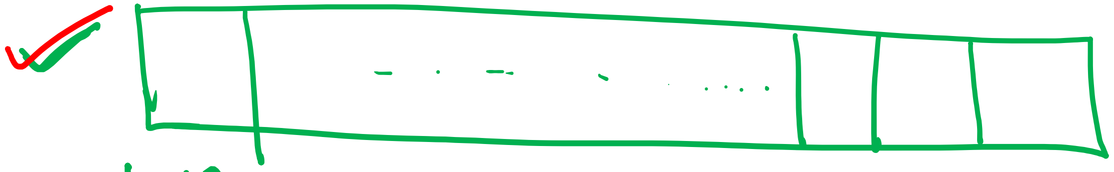
$= 16 + 5 = (21)_{10}$

$(5\,3\,2\,1.2)_8$

LSB = 1

MSB = 5

Fixed Bit Computer system "64-Bit"



D63 (MSB)

D0 LSB

$$5\times8^3 + 3\times8^2 + 2\times8^1 + 1\times8^0 + 2\times8^{-1}$$

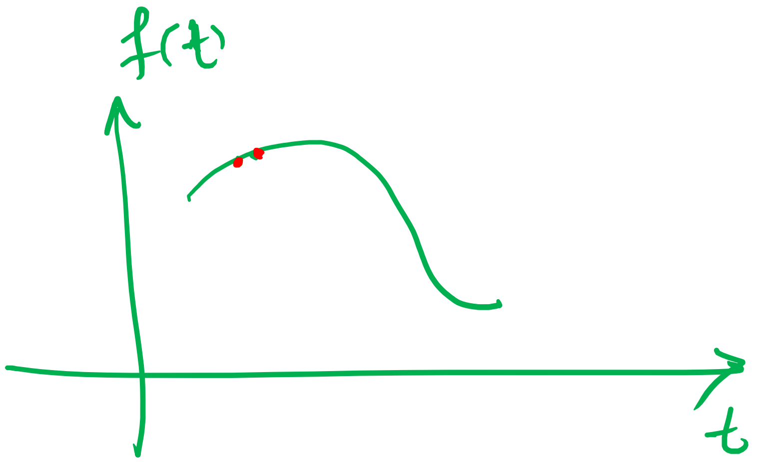
MSB

LSB

$$\frac{20}{6} = 3.3333\ldots\ldots$$

Pi = 3.141.........

3141



Decimal → Binary

$(154.2)_{10} \to (?)_2$

$2^7 - 1 = 127$

Decimal → Binary, Octal, Hex.

$$
\begin{array}{r|l}
2 & 154 \\
2 & 77 \to 0 \ \text{LSB} \\
2 & 38 \to 1 \\
2 & 19 \to 0 \\
2 & 9 \to 1 \\
2 & 4 \to 1 \\
2 & 2 \to 0 \\
2 & 1 \to 0 \\
 & 0 \to 1 \ \text{MSB}
\end{array}
$$

$$
\begin{aligned}
&.2 \times 2 = 0.4 \quad \text{MSB} \\
&.4 \times 2 = 0.8 \\
&.8 \times 2 = 1.6 \\
&.6 \times 2 = 1.2 \quad \text{LSB}
\end{aligned}
$$

$(10011010.0011)_2$

'12-Bit'

1	0	1	1	0	1	0	1

0	0	1	0	1	1	1	1

$(754.2)_{10} \longrightarrow$ ~~Decimal~~ $(\ ?\ )_8$

$8 \,\underline{|\ 754}$

0.2
$\times 8$

$(854.2)_{10} \longrightarrow (\ ?\ )_{16}$

$16 \,\underline{|\ 854}$

0.2
$\times 16$

Decimal $\longrightarrow$ Octal ✓
Binary ✓
Hex ✓

Binary to Octal

$(\overline{001}\,\overline{101}\,\overline{011}.\overline{011}\,\overline{100})_2 \longrightarrow (\ ?\ )_8$

$(\ )_{256}$ $(\ )_{32}$

✓(5) Bits

↓ Decimal

$0\times2^2 + 1\times2^1 + 1\times2^0 + 1\times2^3 + 0\times2^4 + 1\times2^5 + 1\times2^6 + 0\times2^{-1} + 1\times2^{-2} + 1\times2^{-3} + 0\times2^{-4}$

$= ?\ (\ )_{10}$

↓

Division & multiplication
Before fraction | After fraction

$(153.30)_8$

0 to 31

2^5

$8\ (7)_8$

$0, 1, 2, \ldots 7$

$\log_2(32) = ?$

$\log_2(256) = \log_2(2^8) = 8$

number of Bits = $\log_2(N)$

N = maximum number that can be represented in the number system +1

C – 1100

D – 1101

E = 1110

F – 1111

0 → 000

1 → 001

2 → 010

3 → 011

4 → 100

5 → 101

6 → 110

7 → 111

8 → 1000

9 – 1001

A ~~10~~ – 1010

~~11~~ B – 1011

Binary to Hex.

$$(0\,0\,1\,0\;\;1\,1\,0\,1\;\;1\,0\,1\,1 \cdot 1\,1\,0\,1\;\;0\,0\,0\,0)_2 = (\quad ? \quad)_{16}$$

$$(2\,D\,B \cdot D\,0)_{16}$$

Octal to Hex.

$$(\cancel{875}\,4.3)_8 = (\quad ? \quad)_{16}$$

$$(754.3)_8 = (\quad ? \quad)_{16}$$

$$(0\,0\,0\,1\;\;1\,1\,1\,0\;\;1\,1\,0\,0 \cdot 0\,1\,1\,0)_2$$

$$(1\,E\,C \cdot 6)_{16}$$

Hex to octal

$$(AEC.D)_{16} = (\,?\,)_8$$

8-Bit

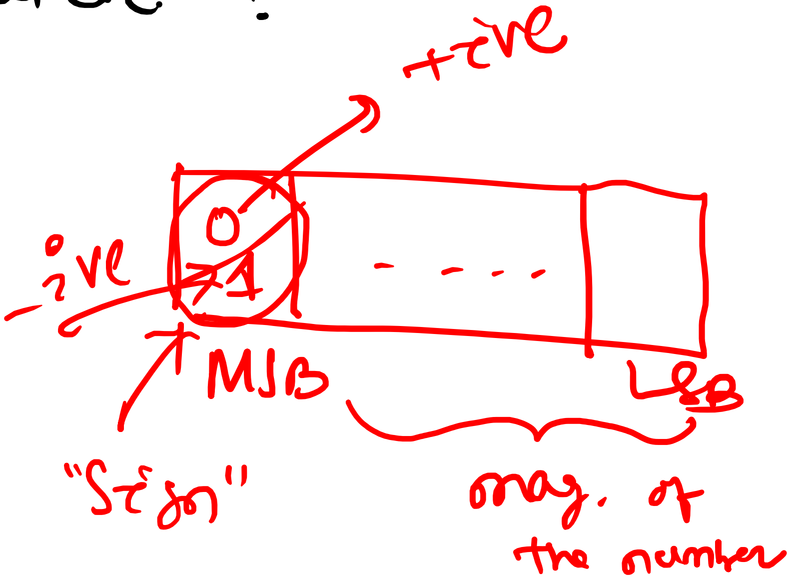
0 to 255

$\pm$ (0 to 127)

Sign Number Representation :-

X(−16) in a 4-Bit computer ?

- Sign magnitude repn
- 1's complement form
- 2's complement form



Sign mag. form

$[2^4 = 16]$

1/0							

MSB (Sign) — magnitude

$+0$ (4-Bit)

0	0	0	0

+ive, 0

$-0 \longrightarrow$

1	0	0	0

-ive, 0

"$+0 = -0 = 0$"

n = number of Bits in your computer

n = 4-Bit

Range: $-(2^{n-1}-1)$ to $+(2^{n-1}-1)$

$-(2^{4-1}-1)$ to $+(2^{4-1}-1)$

-7 to $+7$

Range: $-7, -6, -5, -3 \ldots 0, 1, 2 \ldots 7$
$= 15$ ✓

1's complement form

| MSB | | | . . . . | LSB |

Sign Bit

magnitude (1's complement)

(−3) in 4-Bit

0 0 1 1

↓ 1's complement

1 1 0 0

+0
−0 in 1's 4-Bit

| 1 | 1 | 0 | 0 | ← sign representation using 1's comp.

MSB ~~0~~ 1
−ive number

1's complement to find mag.

0 0 1 1 = 3

0 0 0 0 ← +0

| 1 | 1 | 1 | 1 |

~~to~~ −0

(−3)

+0

0	0	0	0

−0

1	1	1	1

+1 ← 4-Bit

0	0	0	1

+ive $\underbrace{\quad\quad\quad}_{\text{mag.}}$

−1 ← 1's comp. 4-Bit

0001

1110

1	1	1	0

MSB −ive

0001 ← +1

n-Bit

Range:

$-(2^{n-1}-1)$ to $+(2^{n-1}-1)$

4-Bit

-7 to $+7$ total = 15 numbers

$= 2^4 = 16$ numbers

2's complement

MSB		- - - - -	LSB

0 ← +ive

1 ← -ive

mag. (2's complement)

+0 ← 4-Bit

0	0	0	0

−0 ← 4-Bit

1 1 1 1 ← 1's comp.

+1

Discard 1 0 0 0 0 ← 2's comp.

0	0	0	0

+0

1 1 0 1

↓ 1's

0 0 1 0

↓ 2's

0 0 1 1

'3'

4-Bit

+3 2's complement

0	0	1	1

−3 2's complement

1 1 0 0 ← 1's comp.

+1

1 1 0 1 ← 2's complement

1	1	0	1

-ive

2's complement form Sign Representation

→ Unique 0 represen^n

→ Range: (-2^{n-1}) to $(+2^{n-1}-1)$

"8-Bit" Computer : Range: $(-128$ to $+127)$

Total numbers = 256

also we know 8 Bit

$2^8 = 256$