BITS

BACK

1 2 3

1	2	3
10^2	10^1	10^0

1	2	3
10^2	10^1	10^0

$= 1 \times 10^2 + 2 \times 10^1 + 3 \times 10^0$

$= 1 \times 100 + 2 \times 10 + 3 \times 1$

$= 123$

4	1	2	3
?	10^2	10^1	10^0

4	1	2	3
10^3	10^2	10^1	10^0

$$= 4 \times 10^3 + 1 \times 10^2 + 2 \times 10^1 + 3 \times 10^0$$

4	1	2	3
10^3	10^2	10^1	10^0

$$= 4 \times 10^3 + 1 \times 10^2 + 2 \times 10^1 + 3 \times 10^0$$

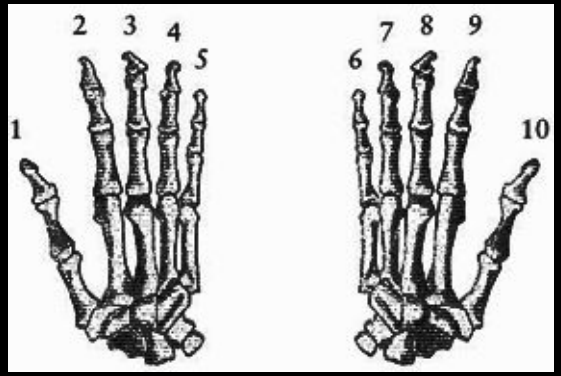
$$= 4 \times 1000 + 1 \times 100 + 2 \times 10 + 3 \times 1$$

4	1	2	3
10^3	10^2	10^1	10^0

$= 4 \times 10^3 + 1 \times 10^2 + 2 \times 10^1 + 3 \times 10^0$

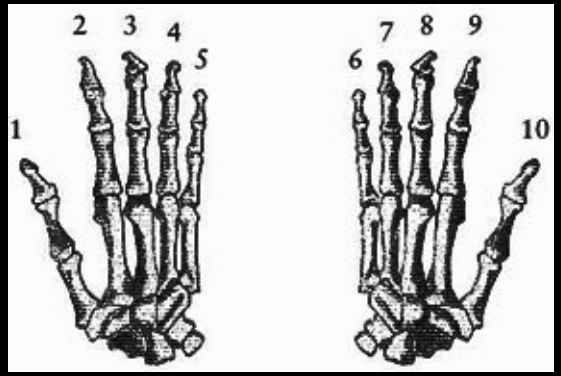
$= 4 \times 1000 + 1 \times 100 + 2 \times 10 + 3 \times 1$

$= 4123$

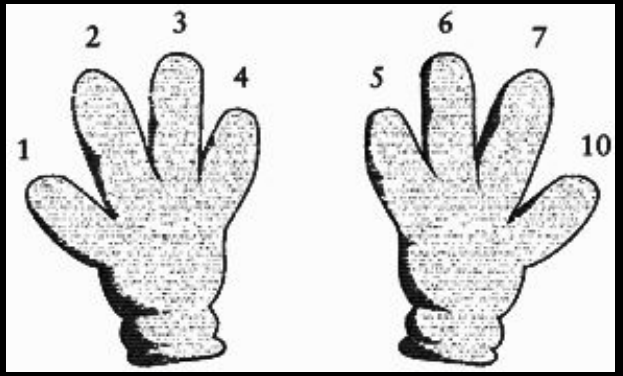


human hand

Image source: Petzold, Charles. Code: The Hidden Language of Computer Hardware and Software. 2nd ed., Microsoft Press, 2022.

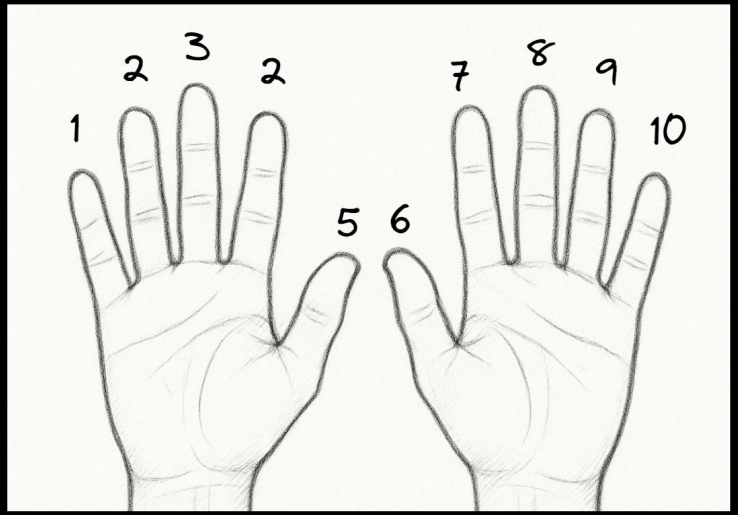


human hand

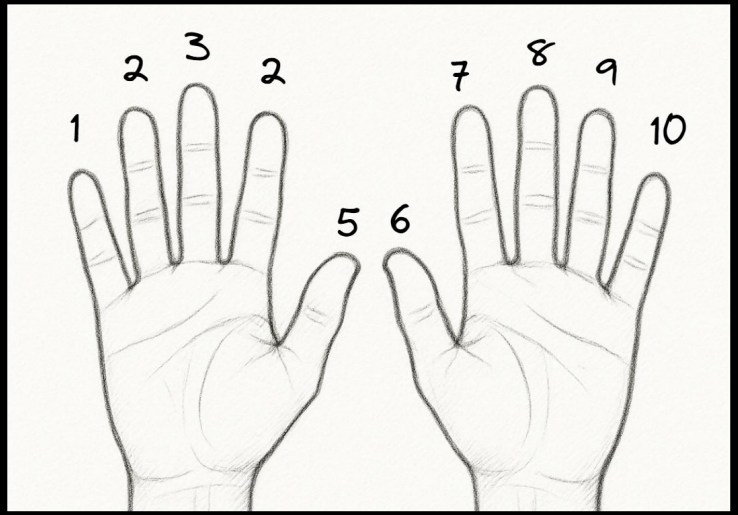


cartoon character’s hand

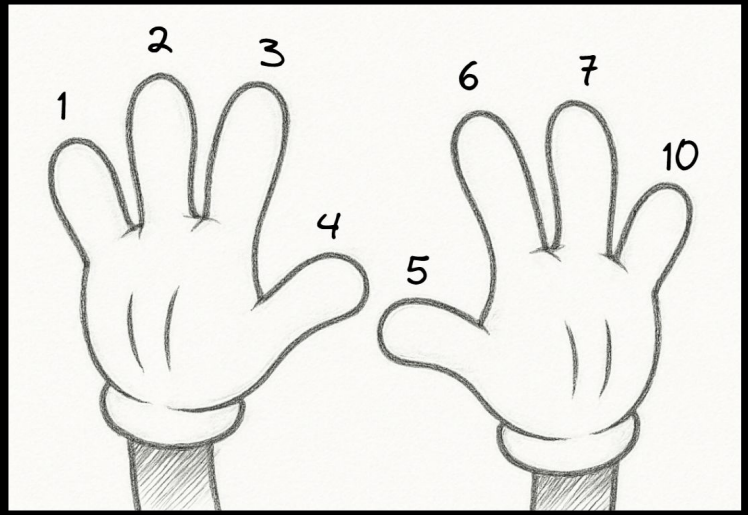
Image source: Petzold, Charles. Code: The Hidden Language of Computer Hardware and Software. 2nd ed., Microsoft Press, 2022.



human hand



human hand



cartoon character’s hand

Images created with ChatGPT following: Petzold, Charles. Code: The Hidden Language of Computer Hardware and Software. 2nd ed., Microsoft Press, 2022.

1 2 3 (octal)

1	2	3	(octal)
8^2	8^1	8^0	

1 2 3 (octal)

8^2 8^1 8^0

$= 1 \times 8^2 + 2 \times 8^1 + 3 \times 8^0$

1	2	3
8^2	8^1	8^0

(octal)

$$= 1 \times 8^2 + 2 \times 8^1 + 3 \times 8^0$$

$$= 1 \times 64 + 2 \times 8 + 3 \times 1$$

1	2	3
8^2	8^1	8^0

(octal)

$= 1 \times 8^2 + 2 \times 8^1 + 3 \times 8^0$

$= 1 \times 64 + 2 \times 8 + 3 \times 1$

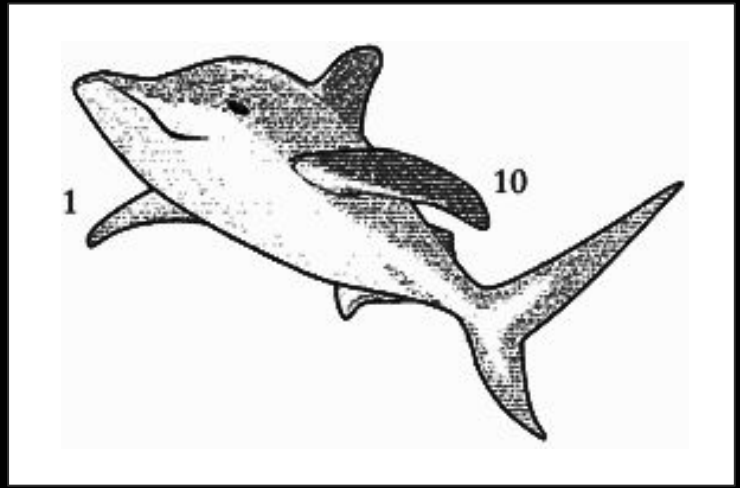
$= 83$ (decimal)

decimal
octal
8
?

decimal
octal
?
7

decimal
octal
16
?

decimal
octal
?
100



what now?

Image source: Petzold, Charles. Code: The Hidden Language of Computer Hardware and Software. 2nd ed., Microsoft Press, 2022.

0, 1, …

0, 1, 10, …

0, 1, 10, 11, …

0, 1, 10, 11, 100, …

0, 1, 10, 11, 100, 101, …

0, 1, 10, 11, 100, 101, 110

1 1 0 (binary)

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

(binary)

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

(binary)

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

1	1	0	(binary)
2^2	2^1	2^0	

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

$$= 1 \times 4 + 1 \times 2 + 0 \times 1$$

1	1	0	(binary)
2^2	2^1	2^0	

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

$= 1 \times 4 + 1 \times 2 + 0 \times 1$

$= 6$ (decimal)

2 3 4 5 6

0, 1, 10, 11, 100, 101, 110

place value systems

$$N = d_n * R^{n-1} + \ldots + d_2 * R^1 + d_1 * R^0$$

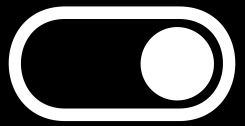
$d \in \{ 0, 1, \ldots R-1 \}$

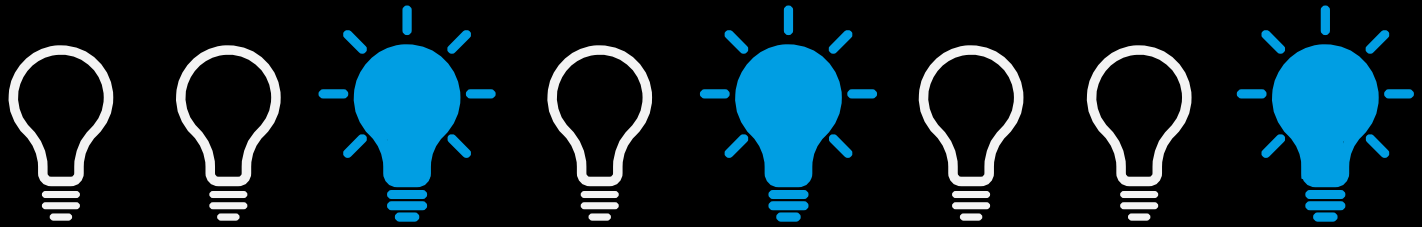
n = number of digits
R = base

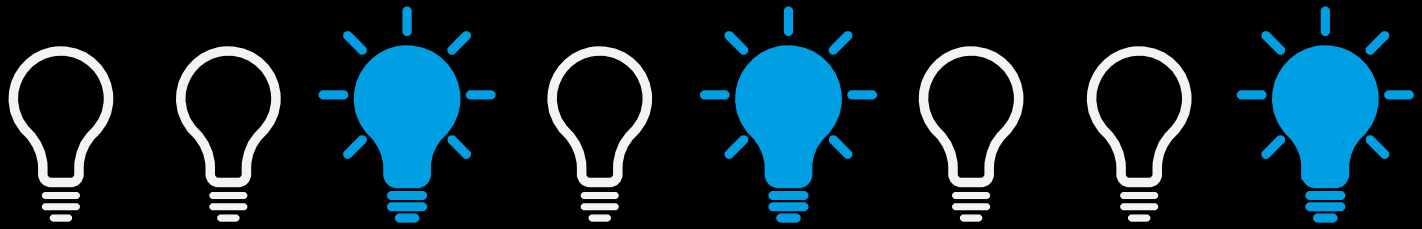
$$R \geq 2$$

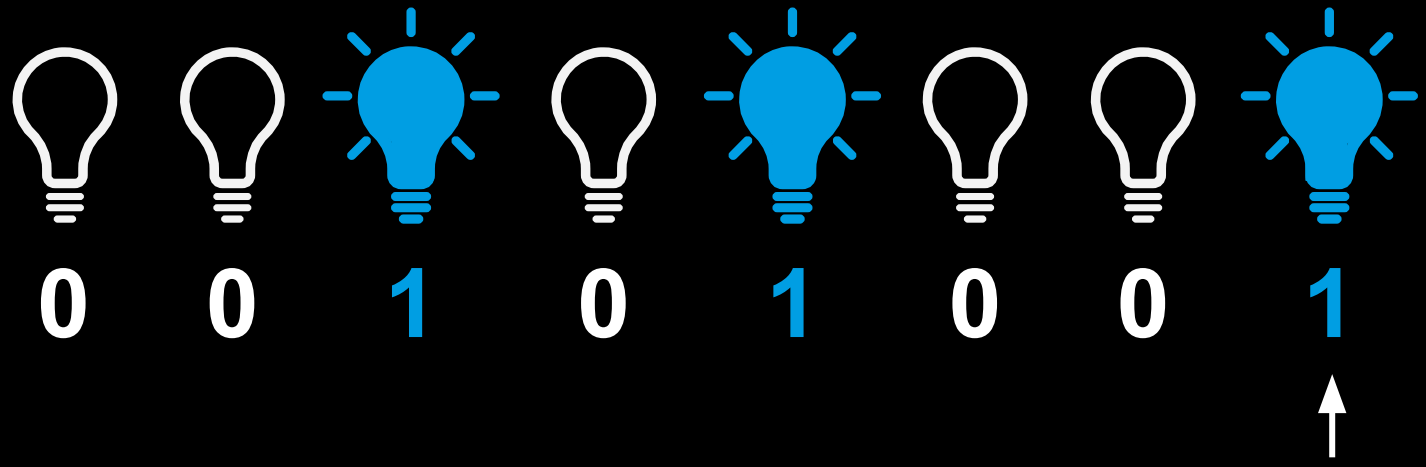
bits

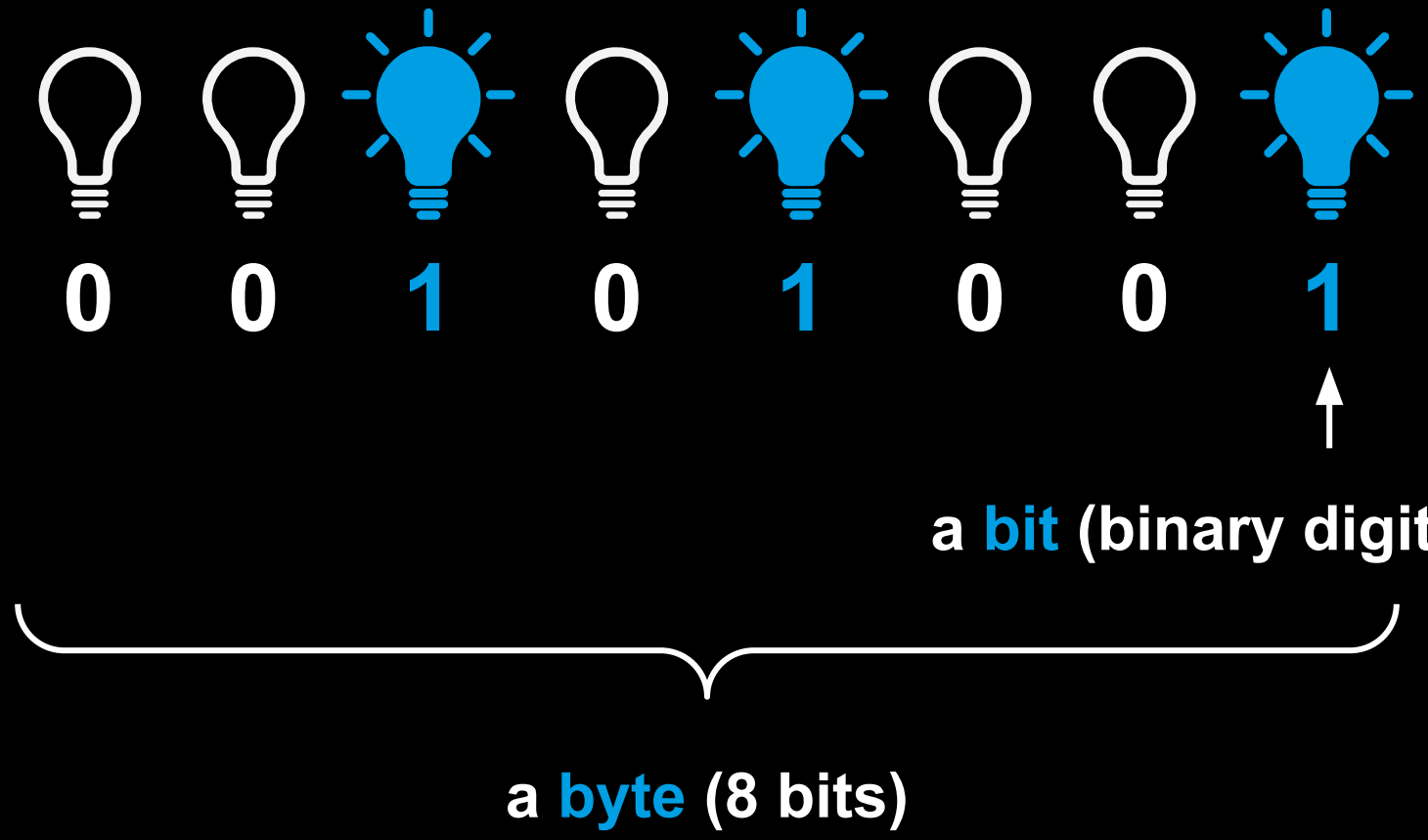
why do computers think binary?

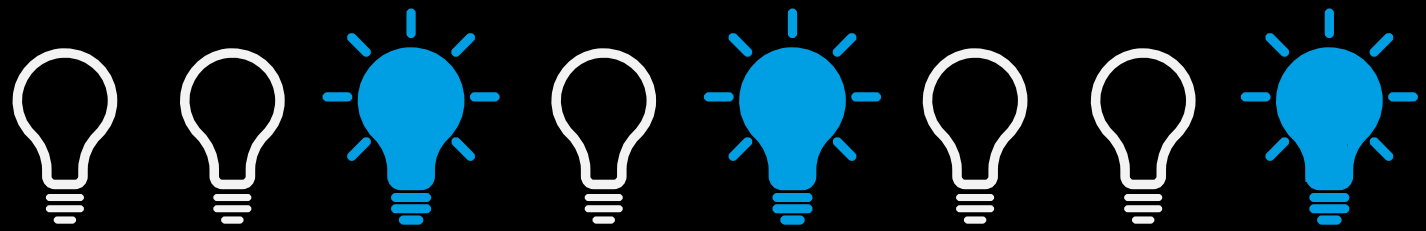





0 0 1 0 1 0 0 1

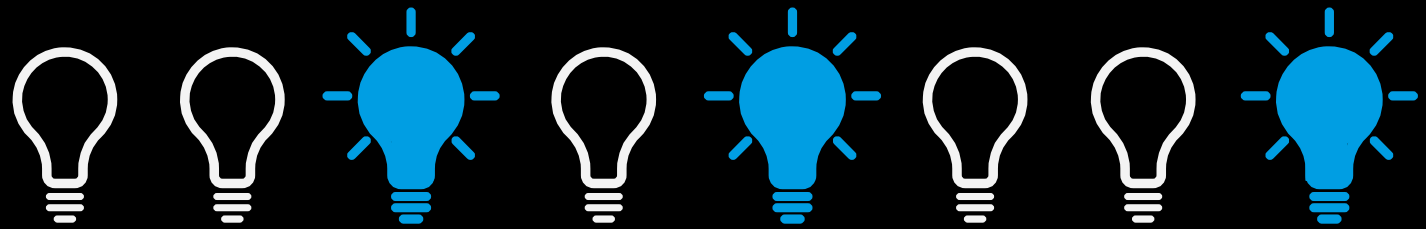

0 0 1 0 1 0 0 1
a bit (binary digit)


0 0 1 0 1 0 0 1
a bit (binary digit)
a byte (8 bits)



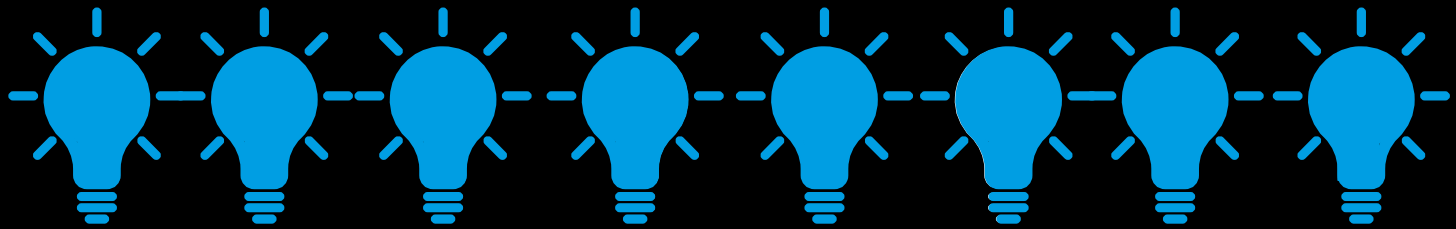
0 0 1 0 1 0 0 1

2^7 2^6 2^5 2^4 2^3 2^2 2^1 2^0



0	0	1	0	1	0	0	1

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1



what can we store in one byte?

what comes after the byte?

2^{10} bytes = 1.024 bytes = 1 Kibibyte (KiB)

2^{20} bytes = 1.048.576 bytes = 1 Mebibyte (MiB)

2^{30} bytes = 1.073.741.824 bytes = 1 Gibibyte (GiB)

10^3 bytes = 1.000 bytes = 1 Kilobyte (KB)

10^6 bytes = 1.000.000 bytes = 1 Megabyte (MB)

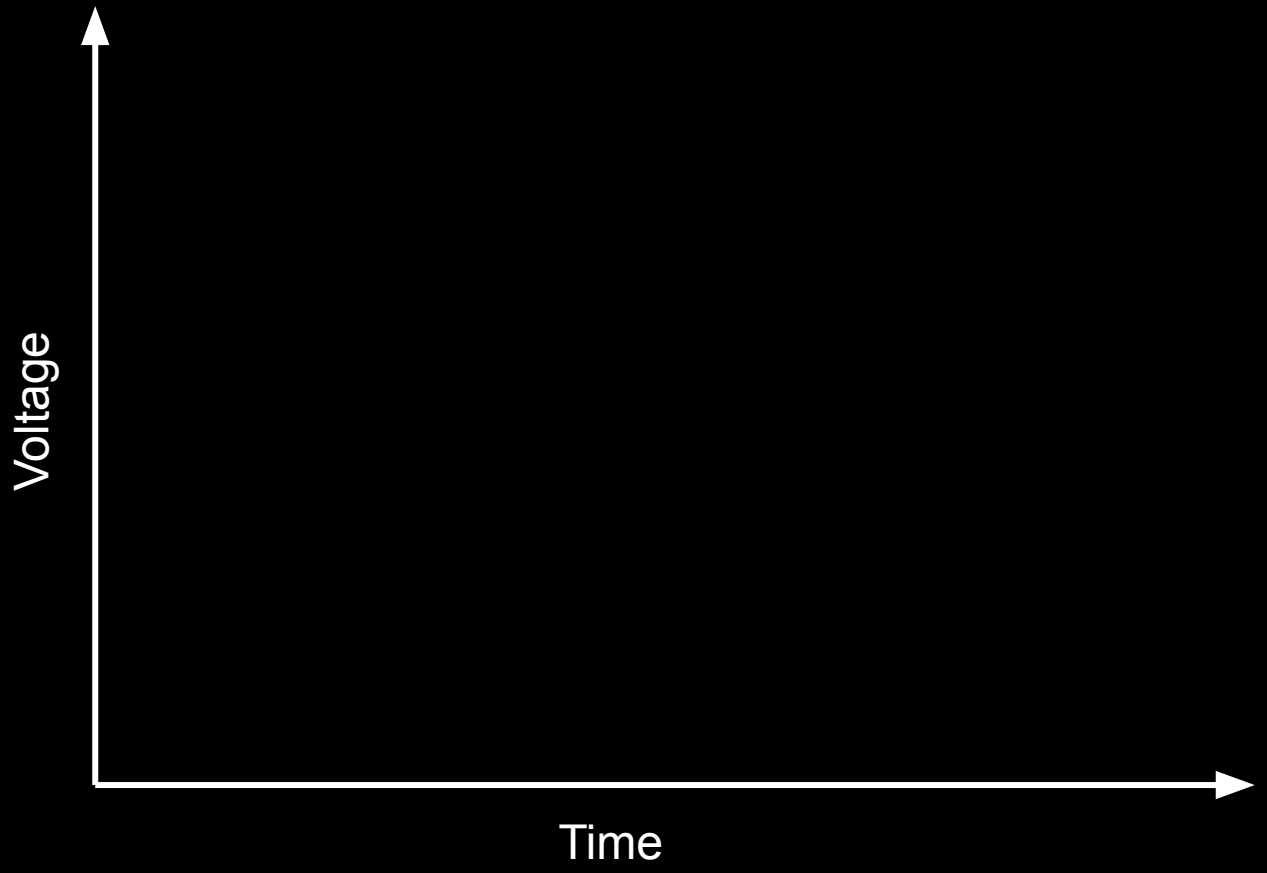
10^9 bytes = 1.000.000.000 bytes = 1 Gigabyte (GB)

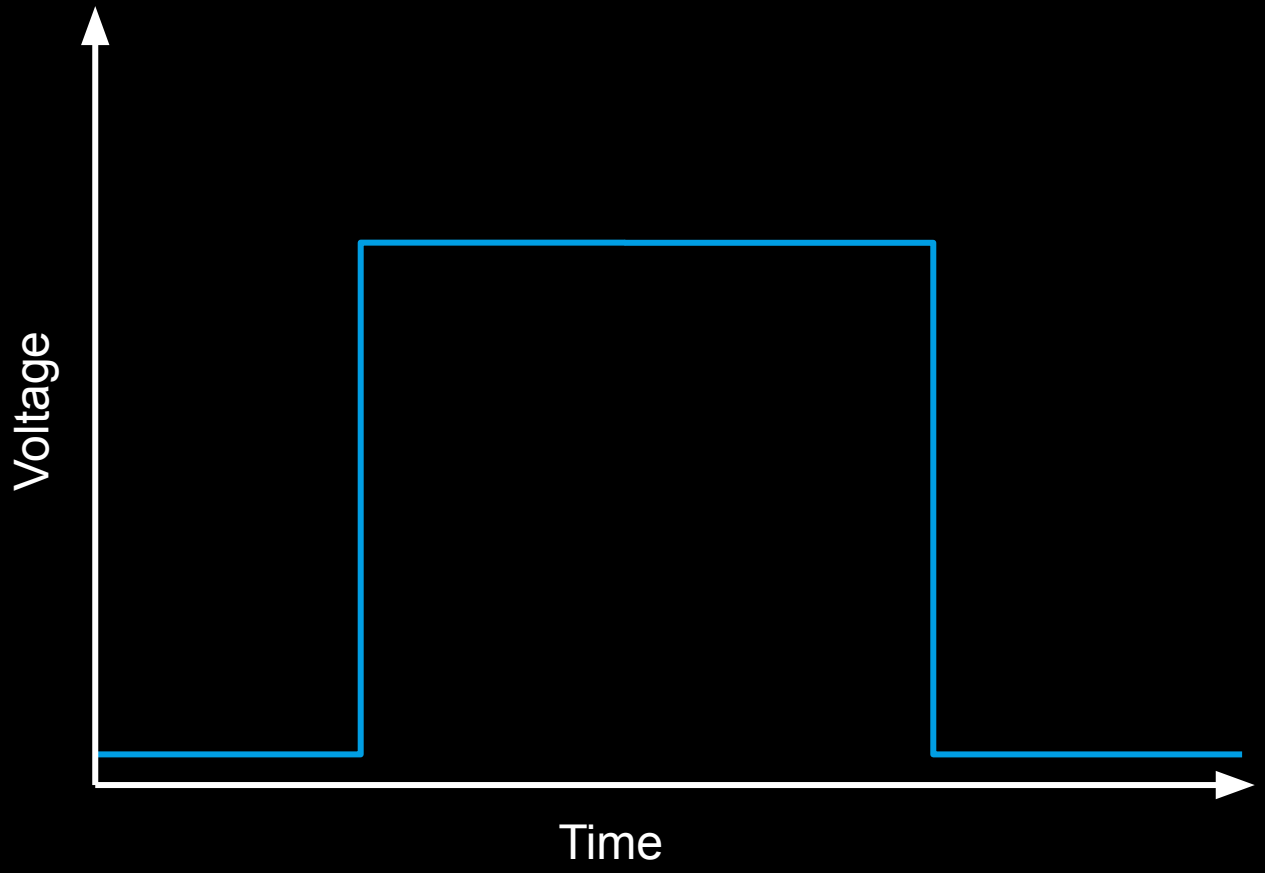
10^{12} bytes = ?

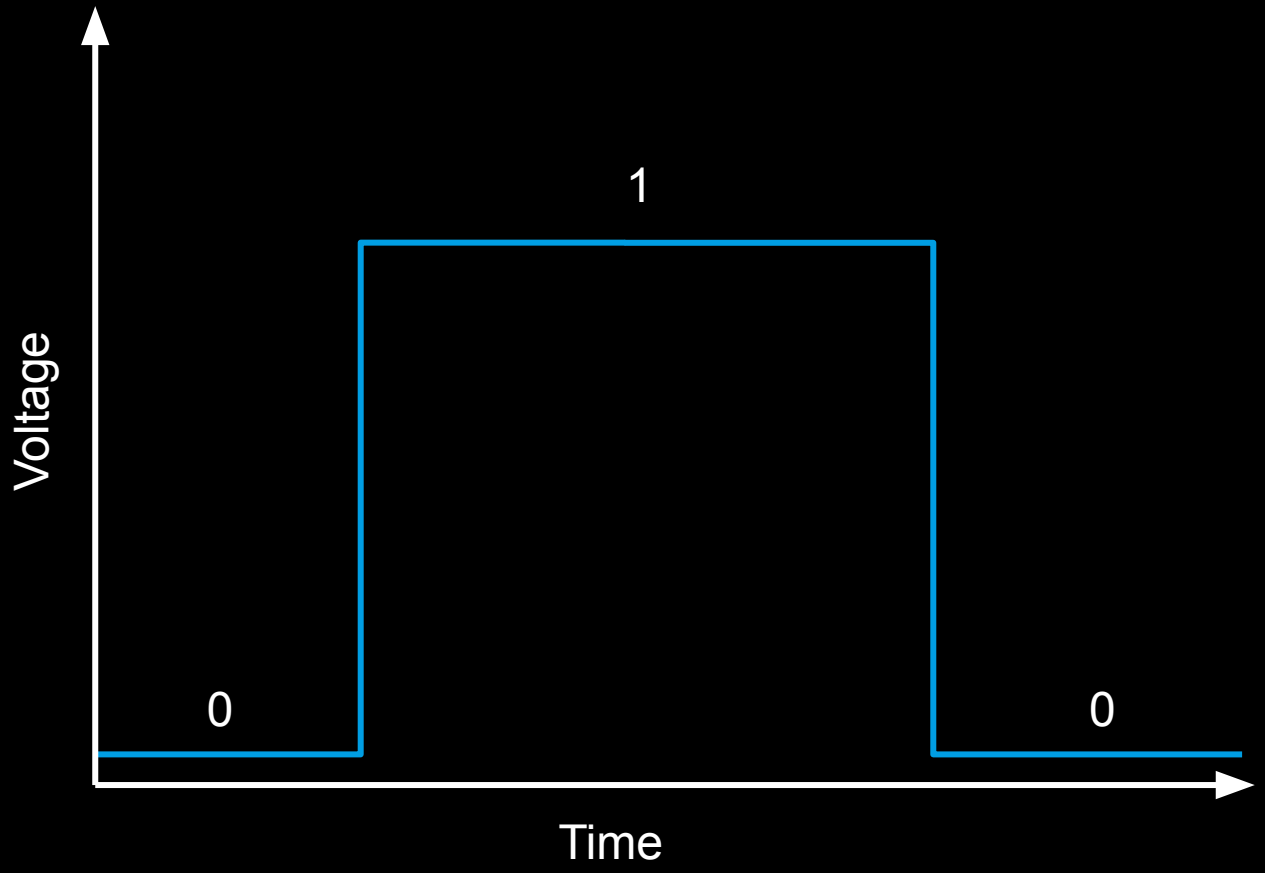
https://www.matheretter.de/wiki/zehnerpotenzen-namen

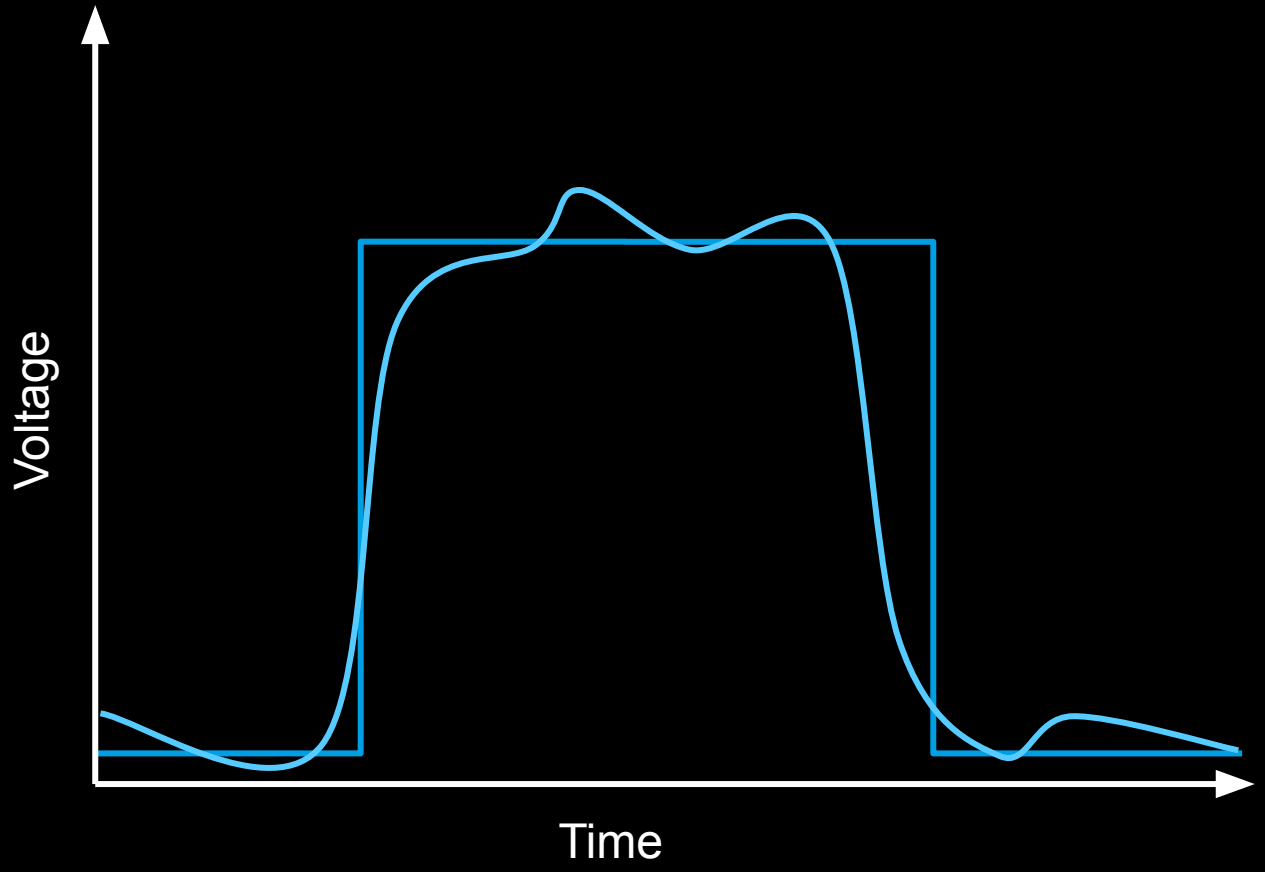
how many bits are on a DVD with 4.7 GB capacity?

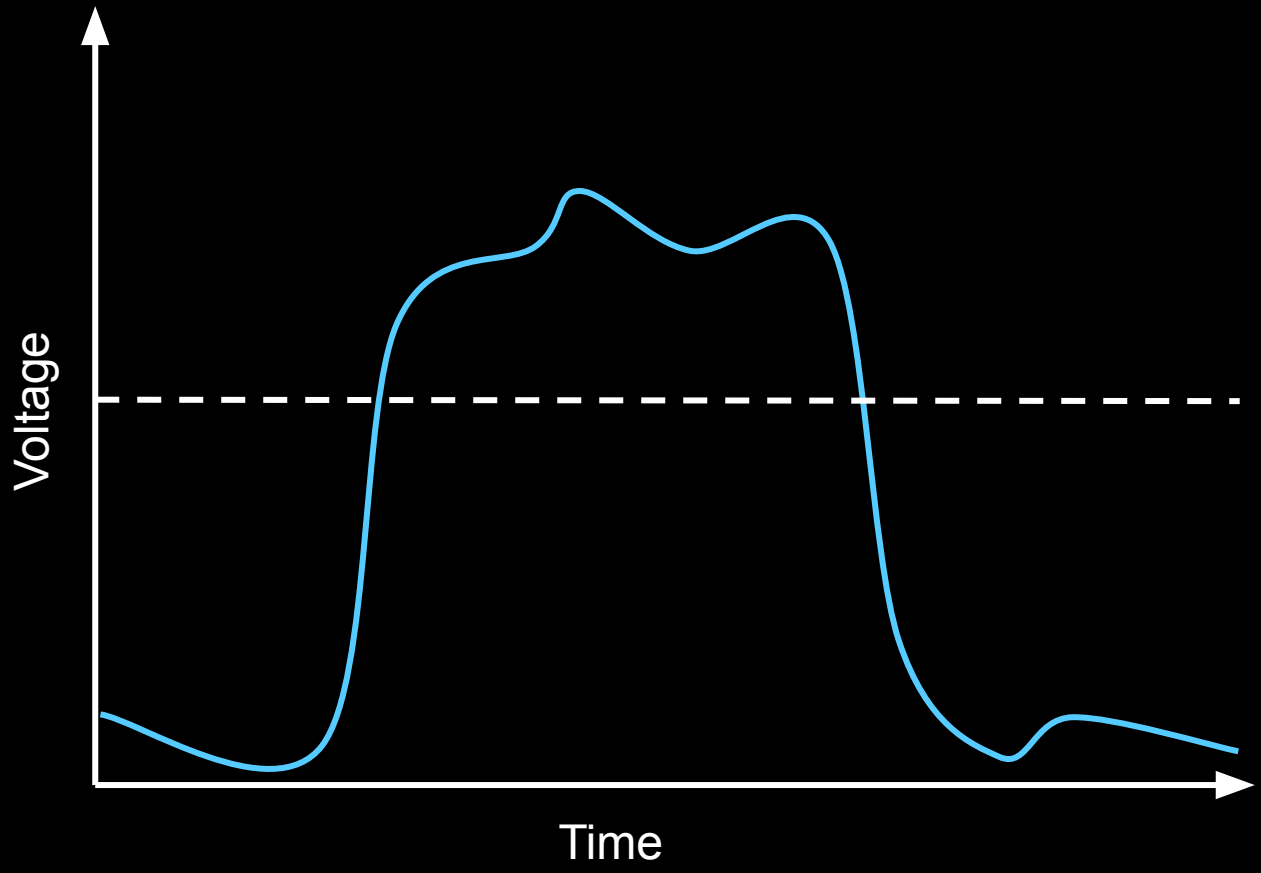
are we stuck with binary?

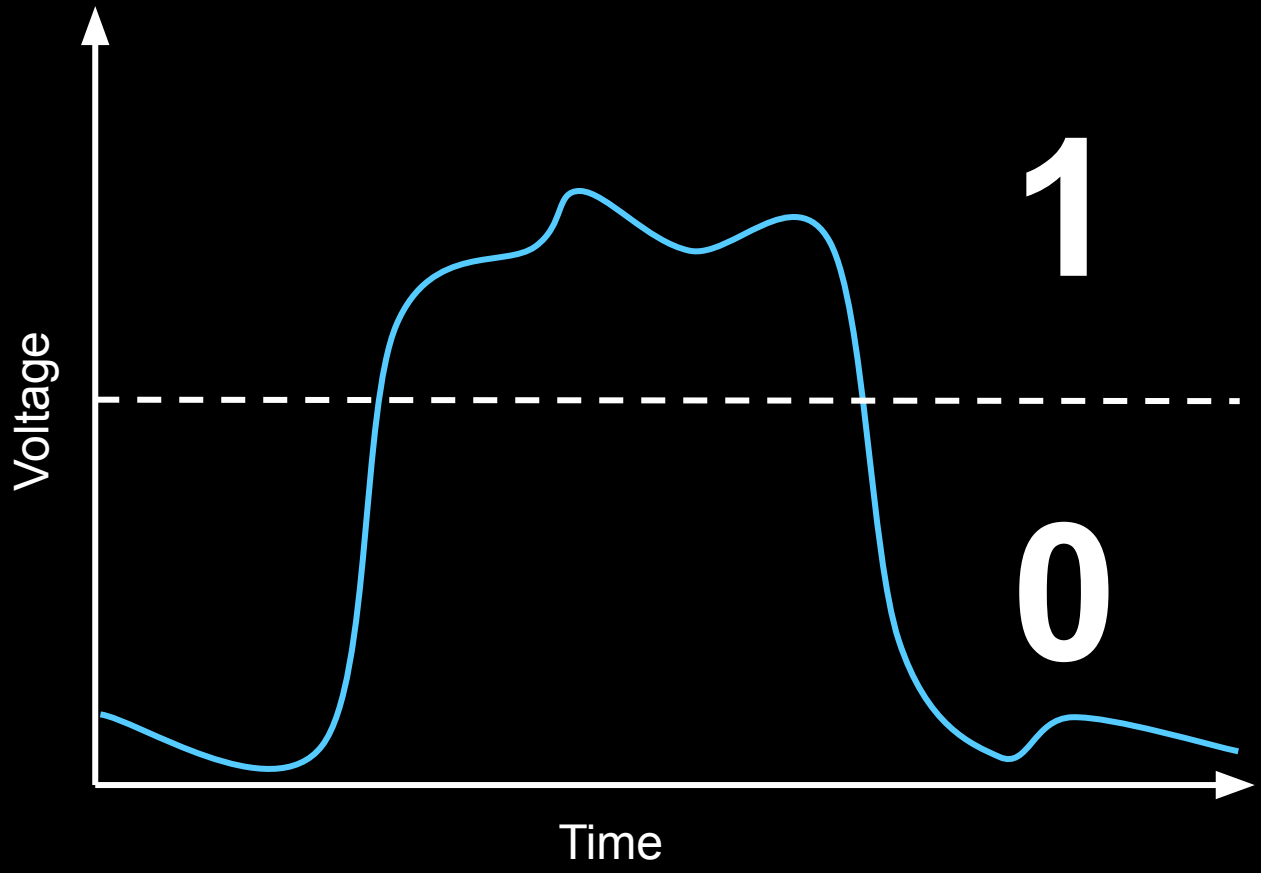

Voltage
Time

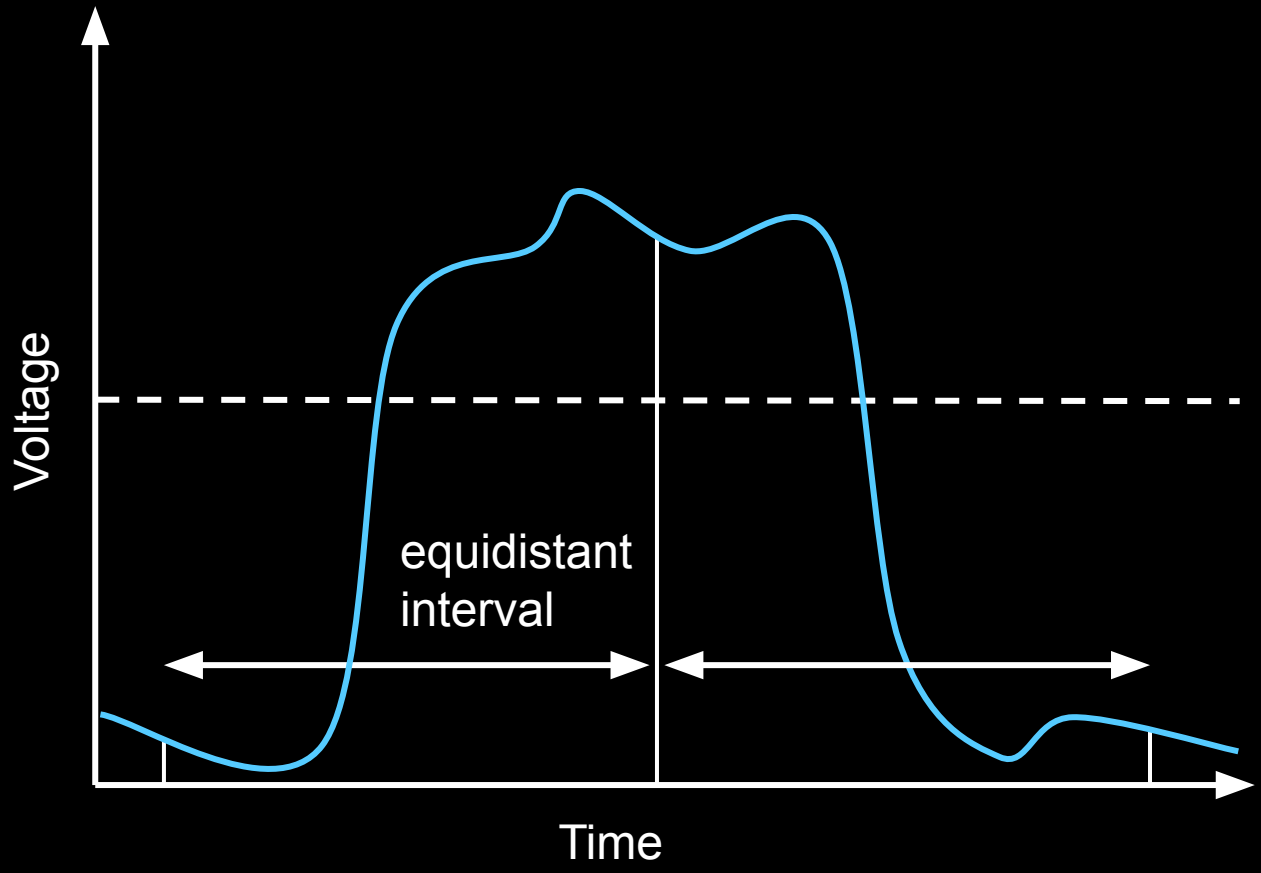

Voltage
Time

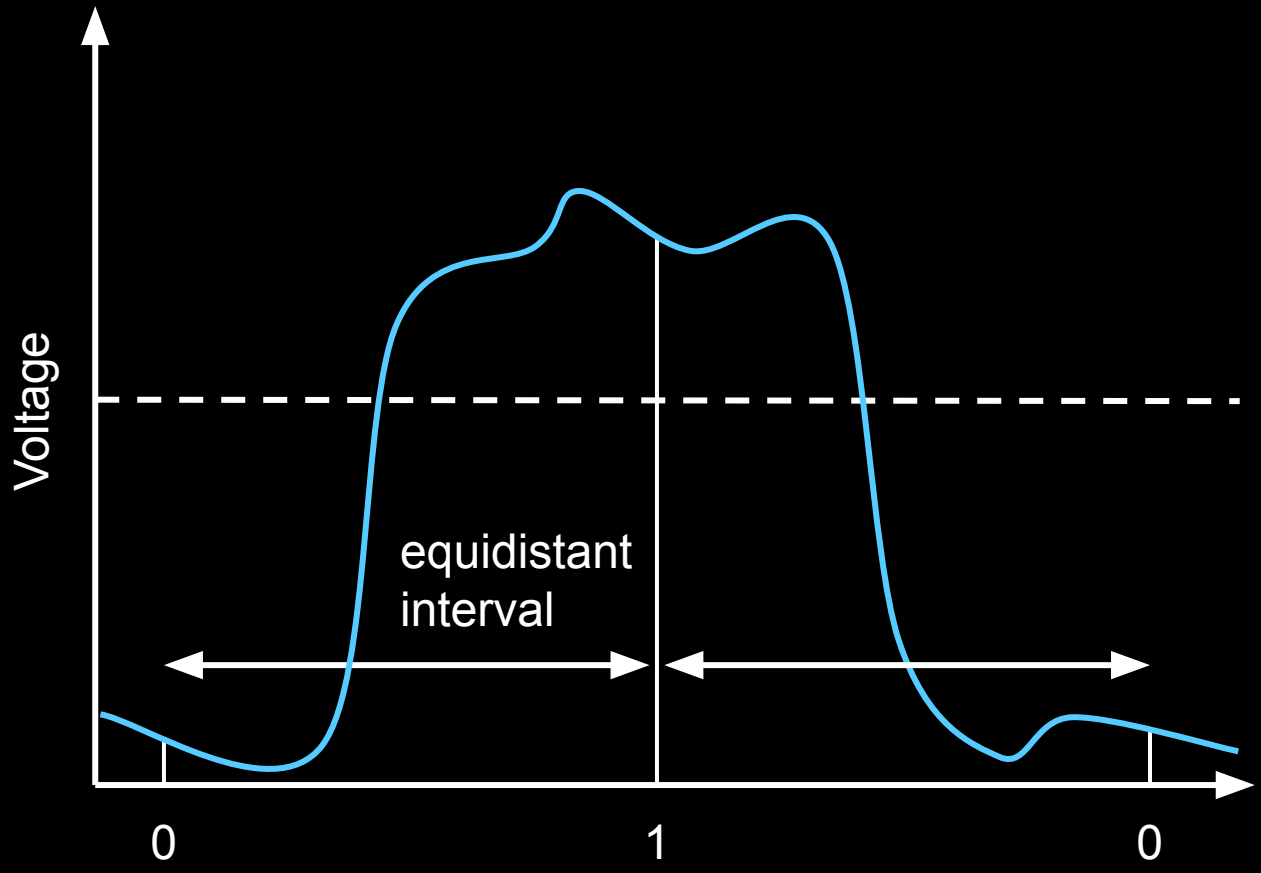

1
Voltage
0
0
Time

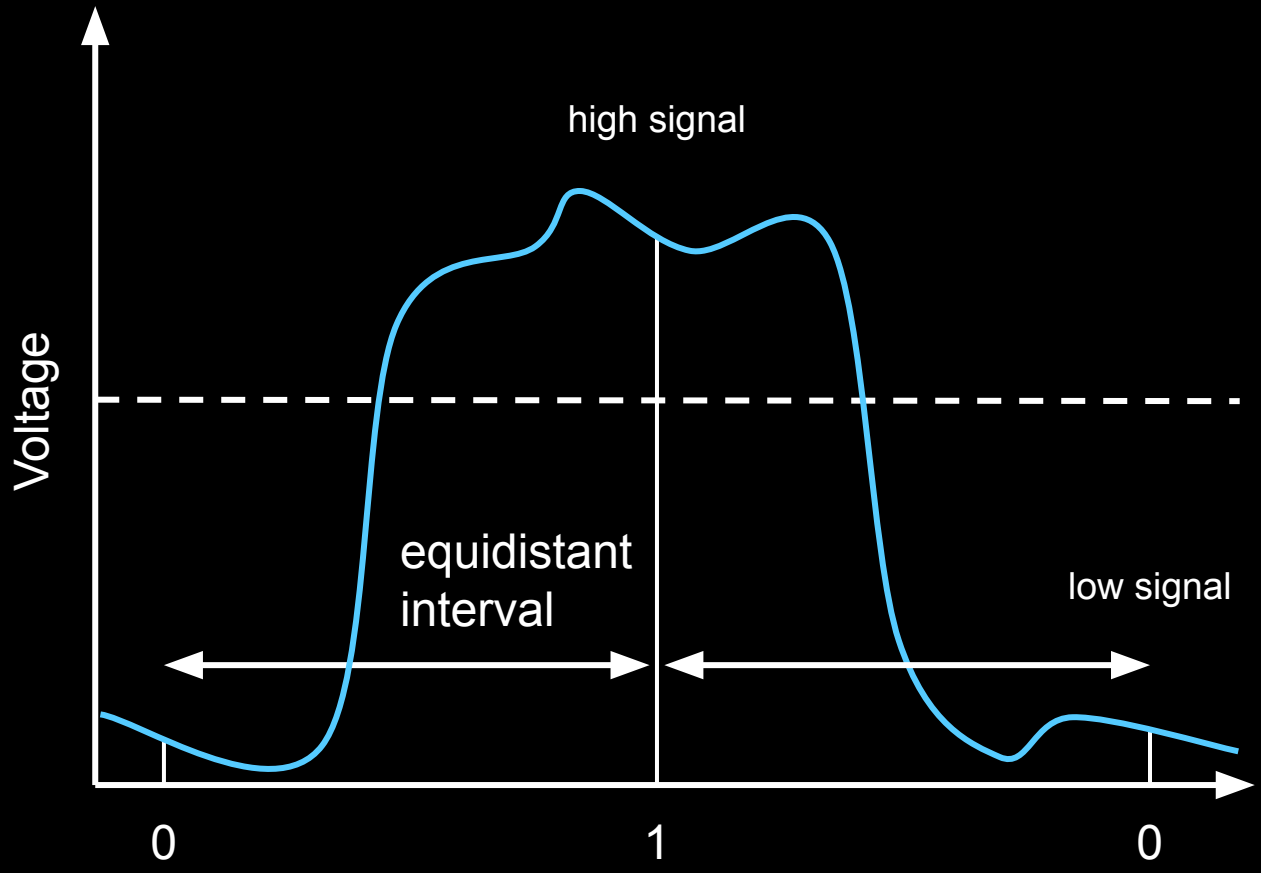

Voltage
Time


Voltage
Time


Voltage
Time
1
0

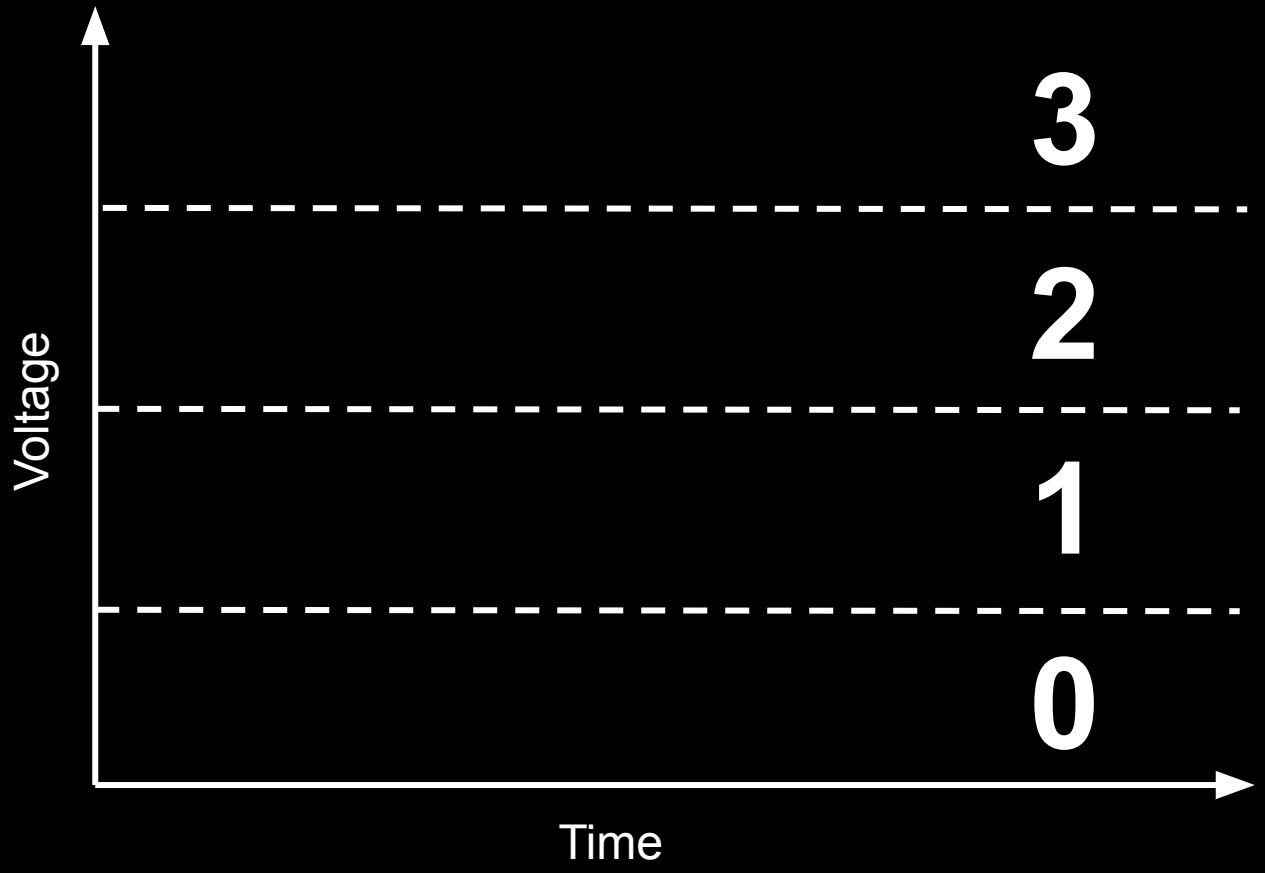

Voltage
equidistant
interval
Time

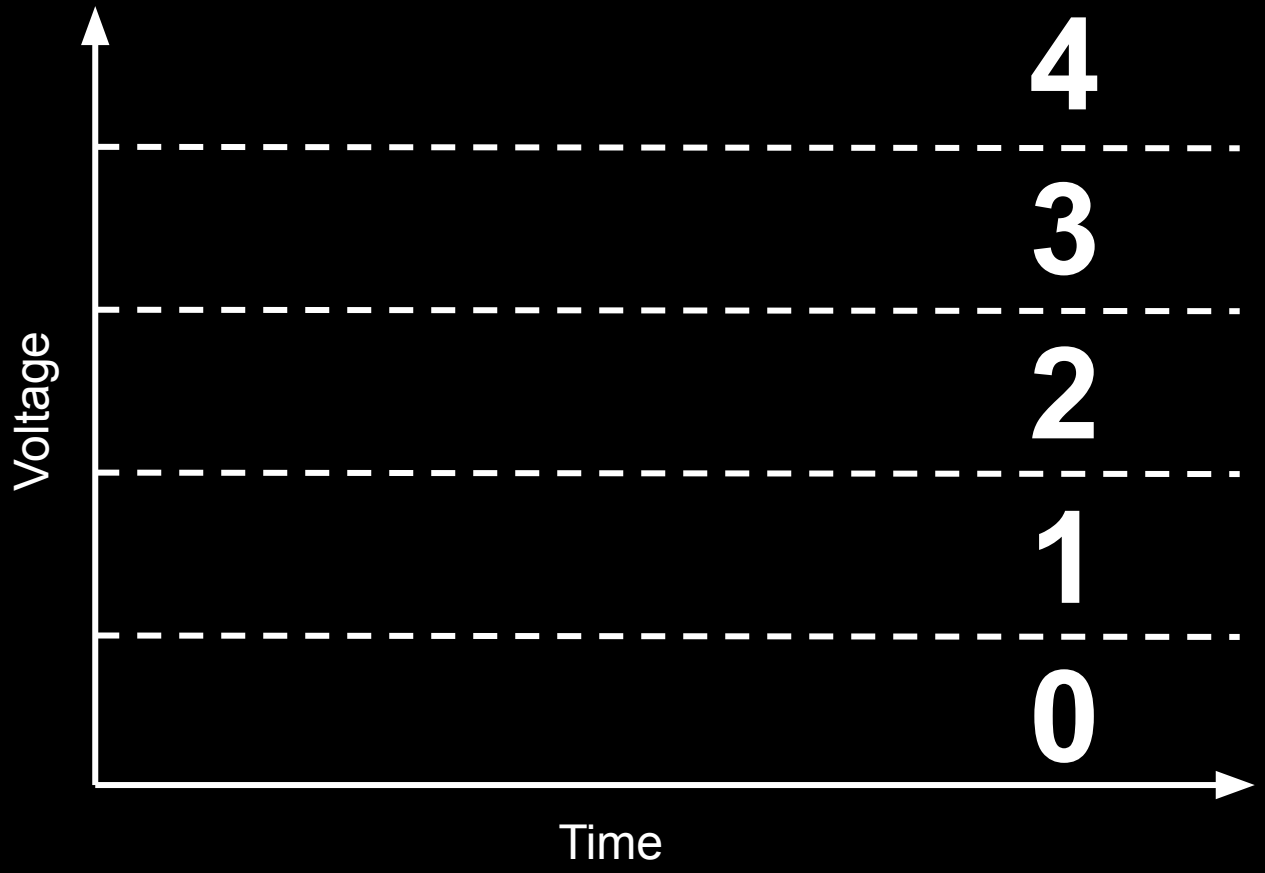

Voltage
equidistant
interval
0
1
0

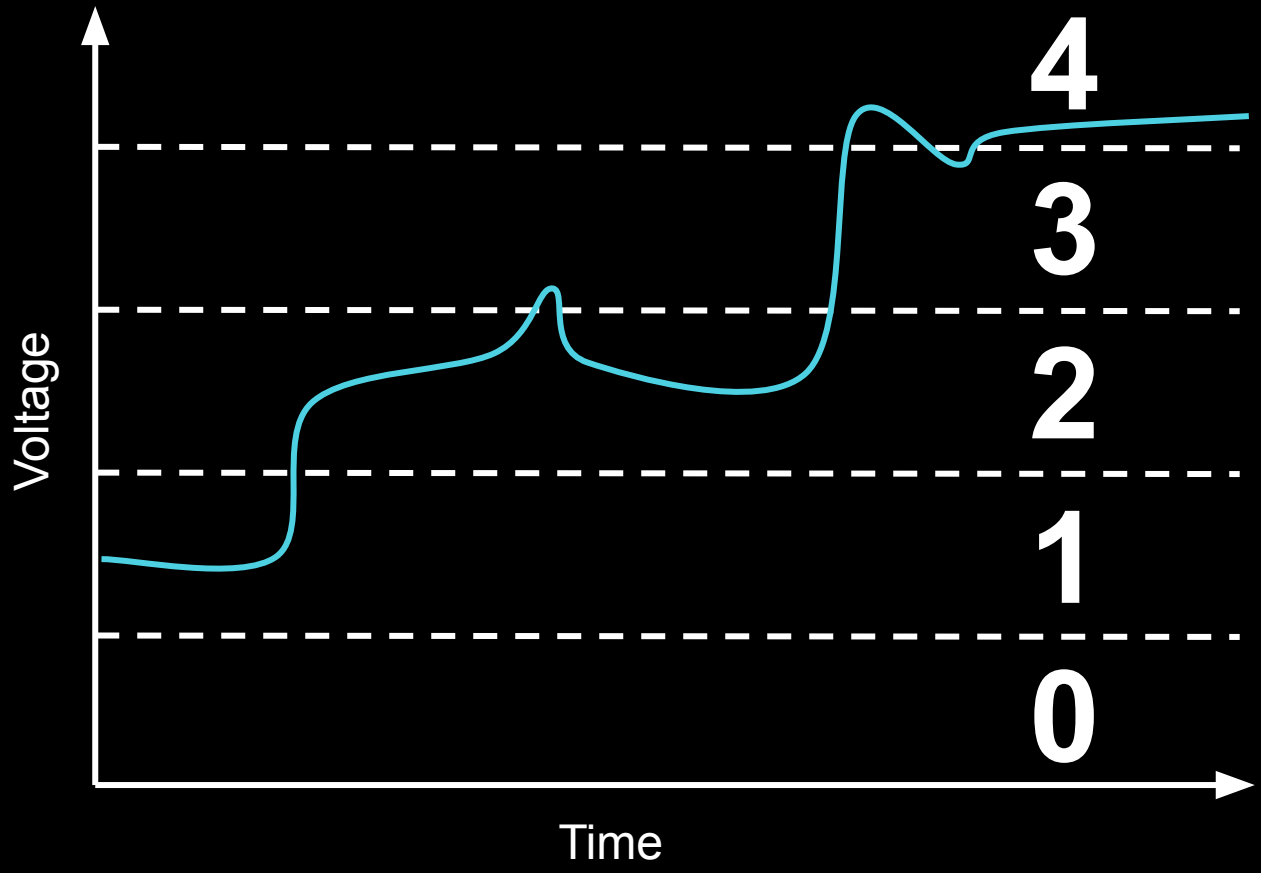

high signal
Voltage
equidistant
interval
low signal
0
1
0

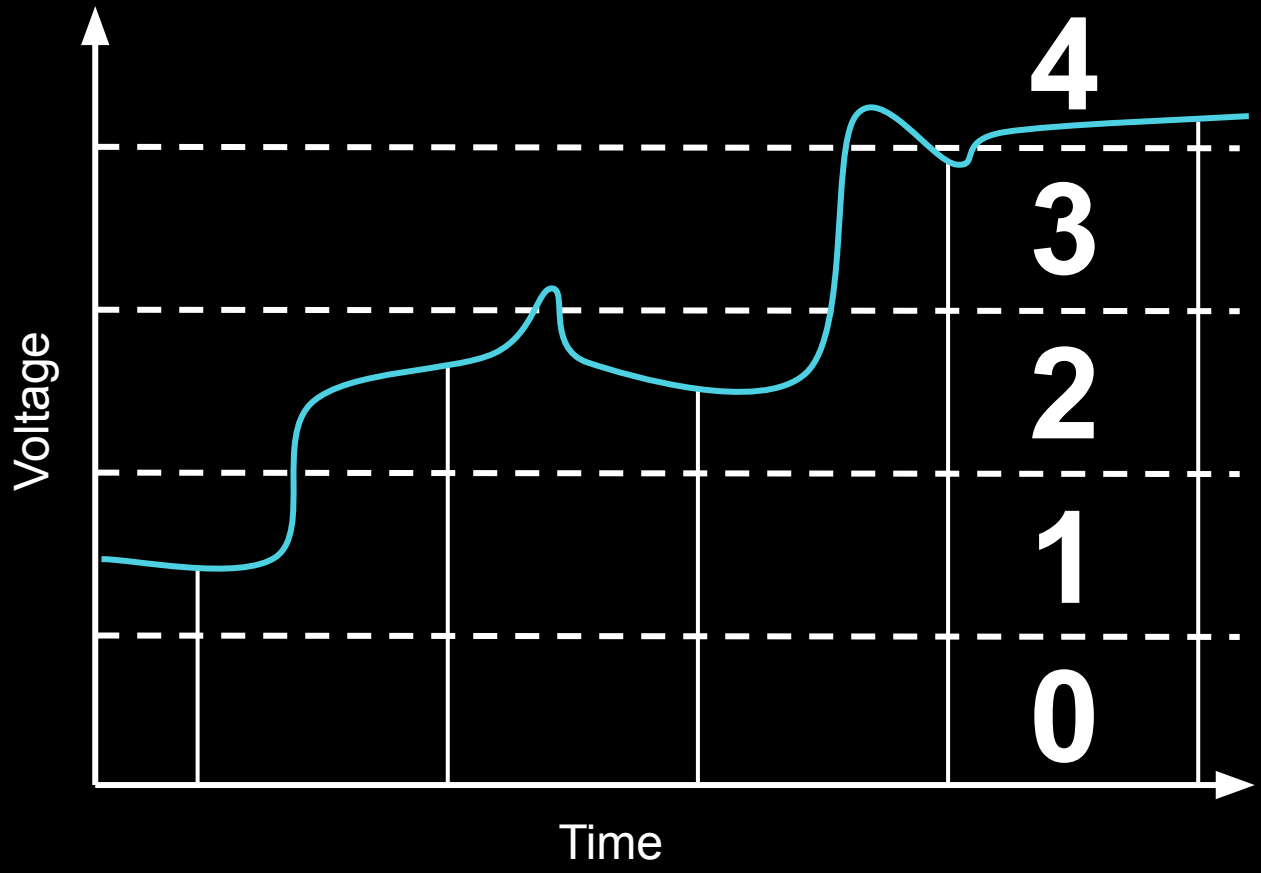
what about $R > 2$?

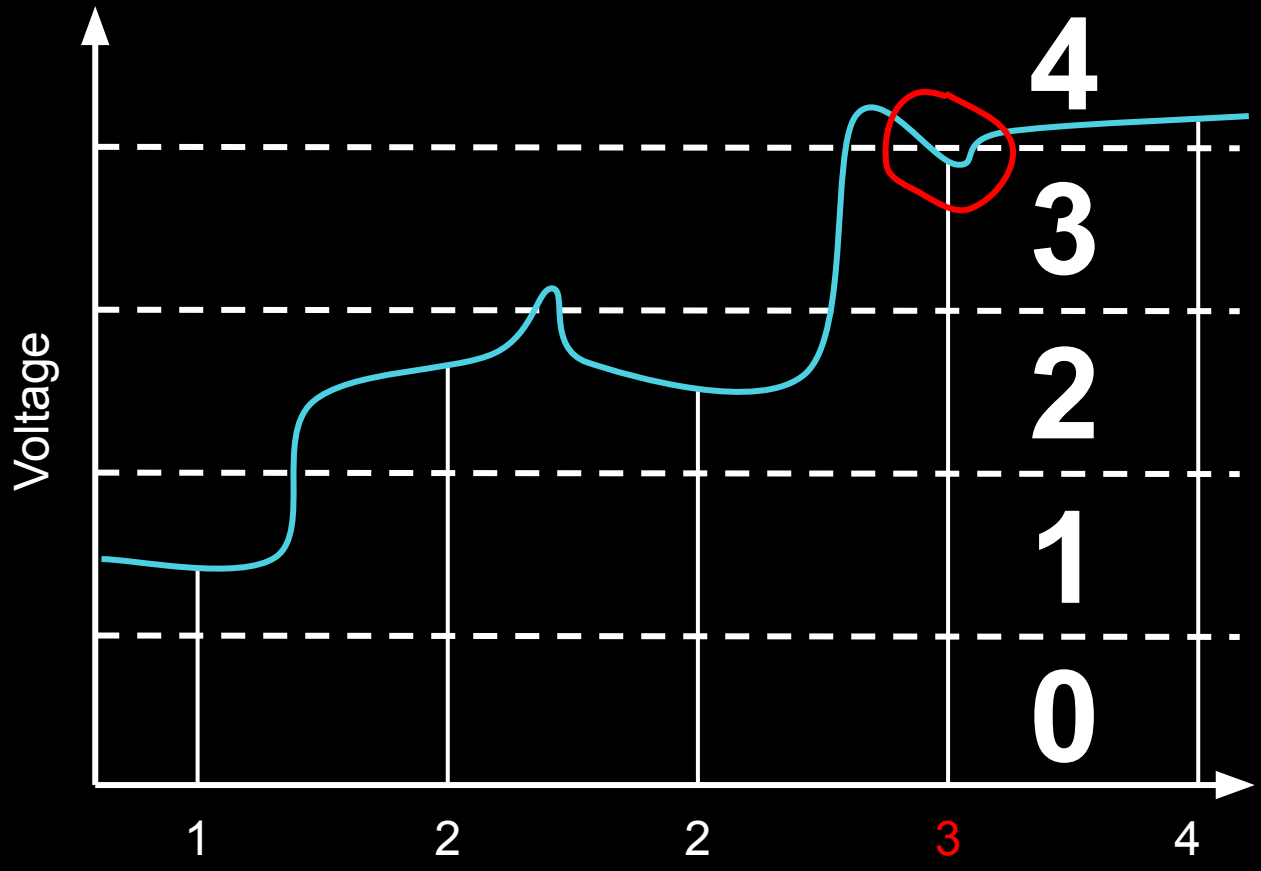
2
1
0
Voltage
Time


3
2
1
0
Voltage
Time


4
3
2
1
0
Voltage
Time


4
3
2
1
0
Voltage
Time


4
3
2
1
0
Voltage
Time


Voltage
4
3
2
1
0
1
2
2
3
4

a higher base means less hardware

a higher base means less hardware

but more complex devices

a higher base means less hardware

but more complex devices

and more errors