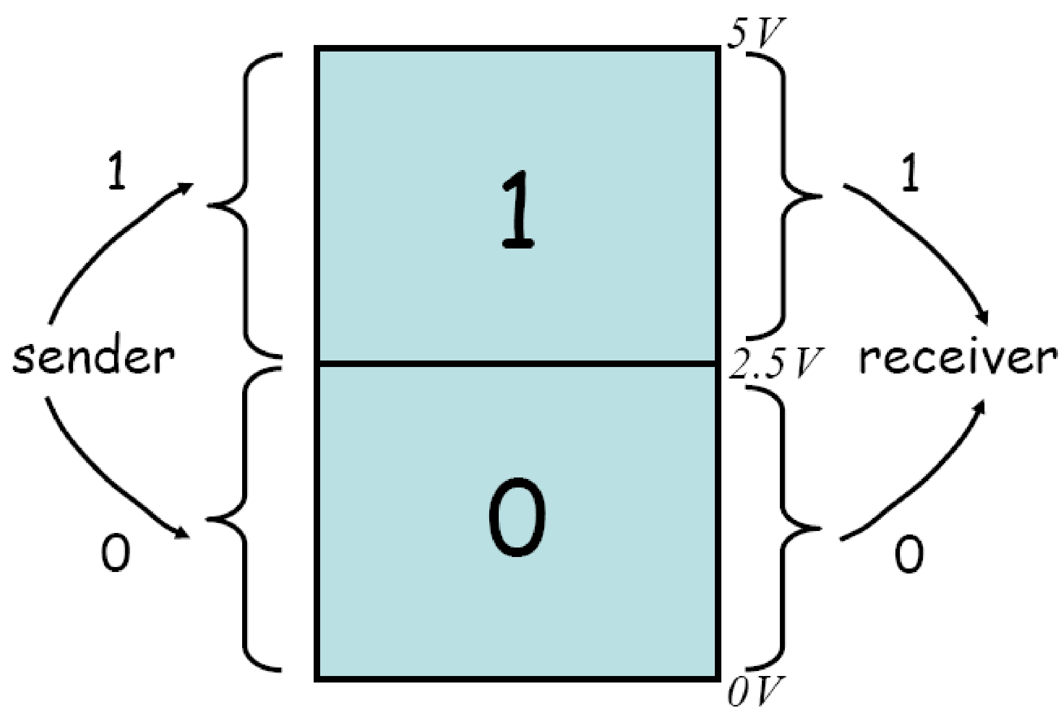
Digital System

- Better noise immunity
- Lots of "noise margin"
  - For "1": noise margin 5V to 2.5V = 2.5V
  - For "0": noise margin 0V to 2.5V = 2.5V

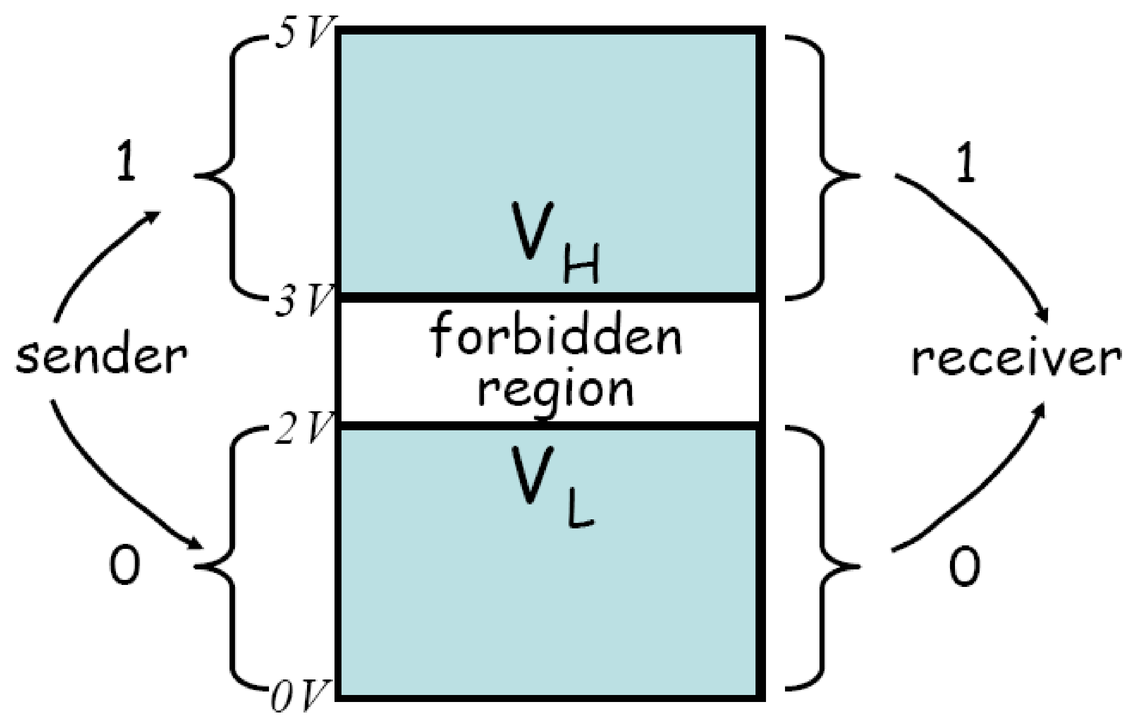
Voltage thresholds and logic values:



What about 2.5V?

- Hmmm… create "no man's land" or forbidden region

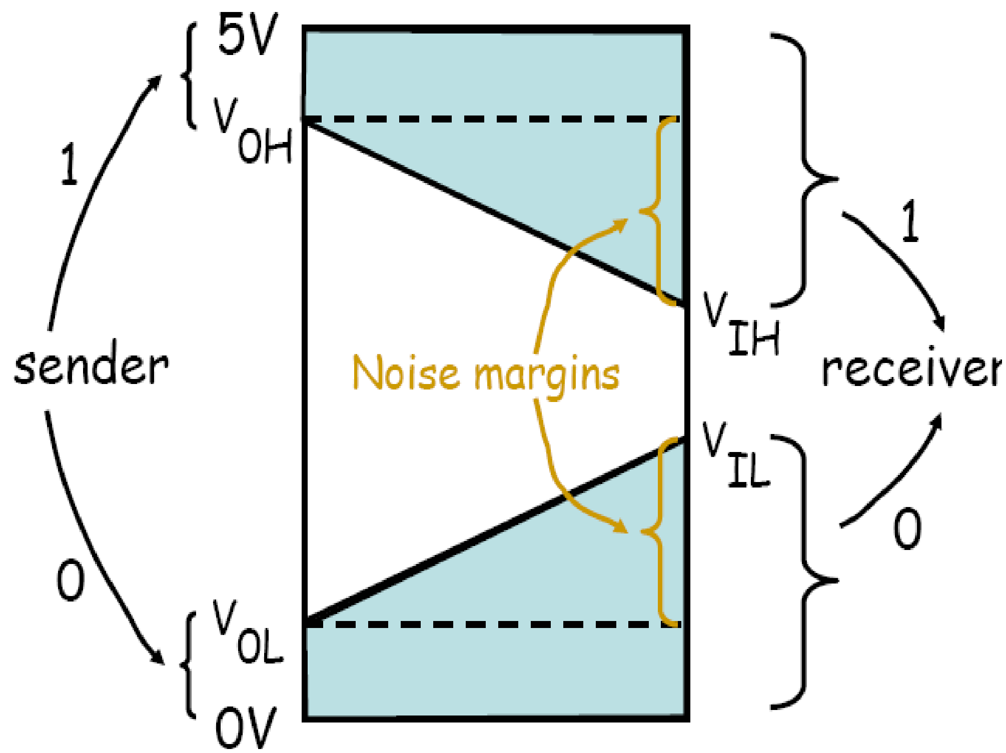
For example

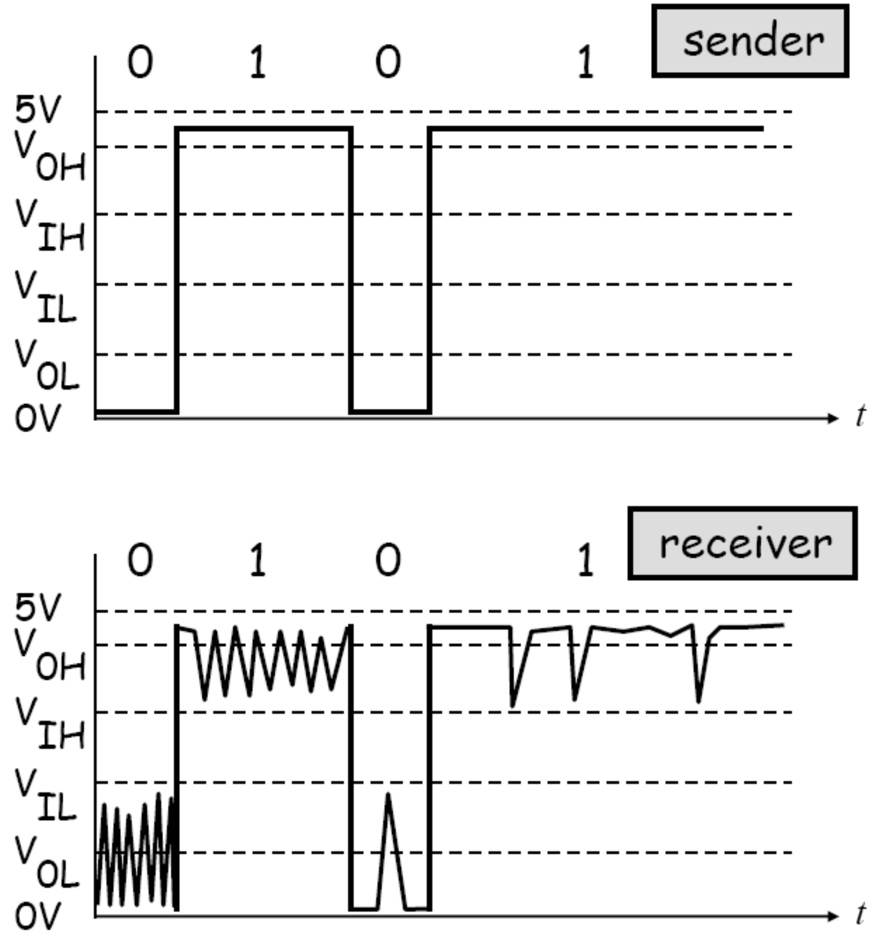


- But, but, but…

Where is the noise margin
What if the sender sent 1: V_H?

"1" noise margin: V_{IH}-V_{OH}
"0" noise margin: V_{IL} -V_{OL}





Digital systems follow static discipline: if inputs to the digital system meet valid input thresholds, then the system guarantees its outputs will meet valid output thresholds

Review of Decimal Counting

Most familiar!
"Place holders" are powers of 10

Power of 10:	3	2	1	0
Weight:	1000	100	10	1
	10^3	10^2	10^1	10^0

Ten symbols or characters needed:
0, 1, 2, 3, 4, 5, 6, 7, 8, and 9

Example

$$1998 = (1 \times 10^3) + (9 \times 10^2) + (9 \times 10) + 8$$

$$= 1000 + 900 + 90 + 8$$

Binary Counting

Base 10	Base 2	Base 10	Base 2
0	0	8	1000
1	1	9	1001
2	01	10	1010
3	11	11	1011
4	100	12	1100
5	101	13	1101
6	110	14	1110
7	111	15	1111

Binary Counting

Power of 2:	7	6	5	4	3	2	1	0
Decimal Weight:	128	64	32	16	8	4	2	1
	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

Example: convert 1100010 to decimal

Binary Number:	0	1	1	0	0	0	1	0
Decimal Weight of Placeholders:	128	64	32	16	8	4	2	1
Contributions to Decimal Number:	0	64	32	0	0	0	2	0

A*nswer*: 64 + 32 + 2 = 98

"bit" is a contraction of "binary digit"

Conversion to binary

	22		$=a_n \times 2^n + a_{n-1} \times 2^{n-1} + \ldots\ldots + a_0$
		reminder	
2	11	0	$\Rightarrow a_0=0$
			$= a_n \times 2^{n-1} + a_{n-1} \times 2^{n-2} + .. + a_1$
2	5	1	$\Rightarrow a_1=1$
2	2	1	$\Rightarrow a_2=1$
2	1	0	$\Rightarrow a_3=0$
2	0	1	$\Rightarrow a_4=1$

22 = 10110

Addition of Binary number

1 + 0 =	1	-- No surprise.
1 + 1 =	10	-- Don't forget to carry!
1 + 1 + 1 =	11	

Concept Check: Binary Counting

In binary, which one of the following is not true?

A: 10 + 10 = 110

B: 11 + 11 = 110

C: 101 + 1 = 110

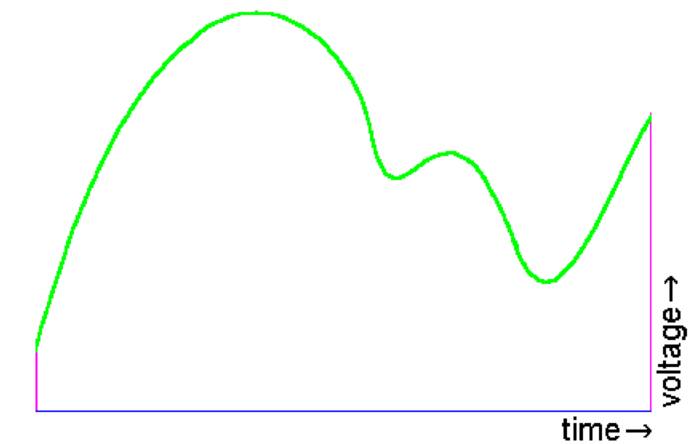
Hexadecimal Number

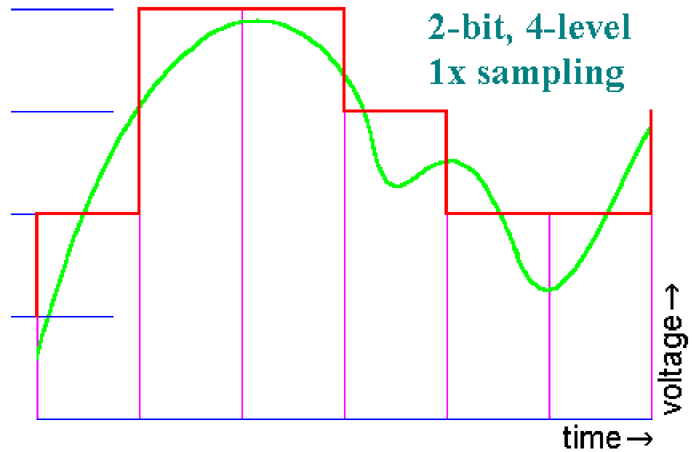
Decimal	Hex	Binary	Decimal	Hex	Binary
0	0	0000	8	8	1000
1	1	0001	9	9	1001
2	2	0010	10	A	1010
3	3	0011	11	B	1011
4	4	0100	12	C	1100
5	5	0101	13	D	1101
6	6	0110	14	E	1110
7	7	0111	15	F	1111

ASCII Table

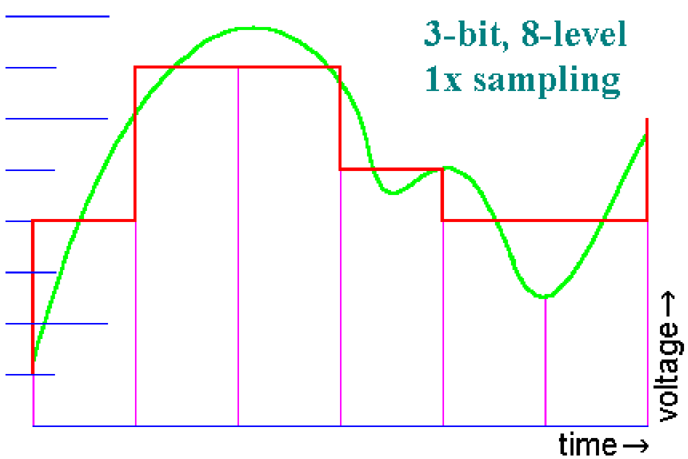
1 Byte = 8 bit
1 kB = 2^{10} B = 1024 B
1 MB=2^{10} kB= 2^{20} B = 1,048,576 B
1 GB=2^{30} B = 1,073,741,824 B

Digitizing a signal

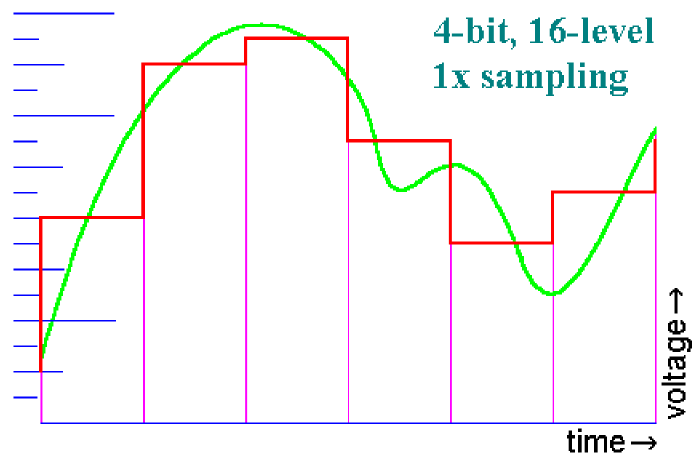




01 11 11 10 01 01

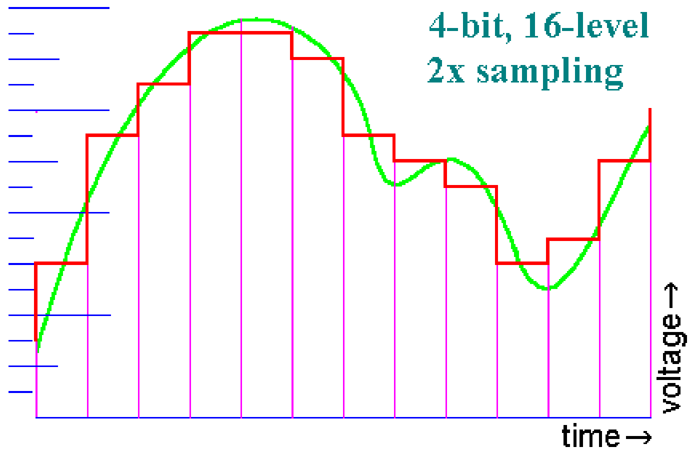


011 110 110 100 011 011

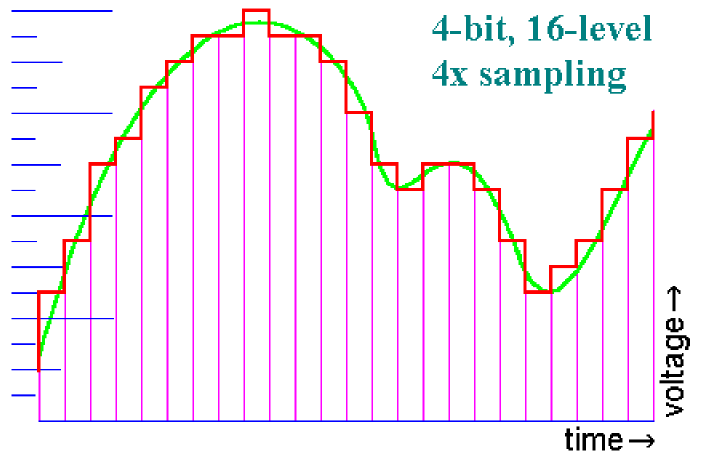


0111 1101 1110 1010 0110 1000

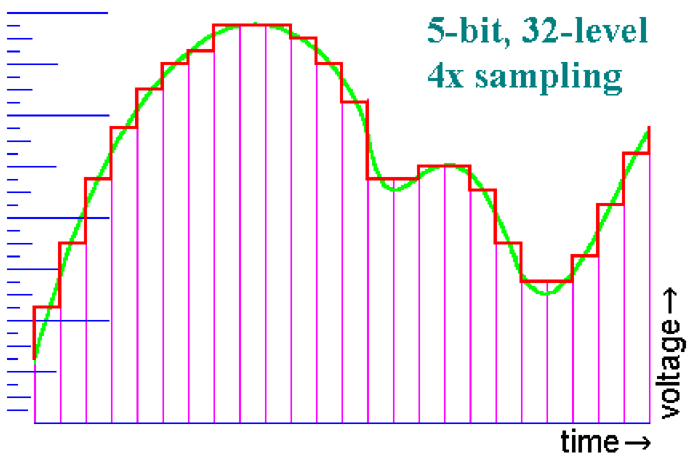
Digitizing a signal



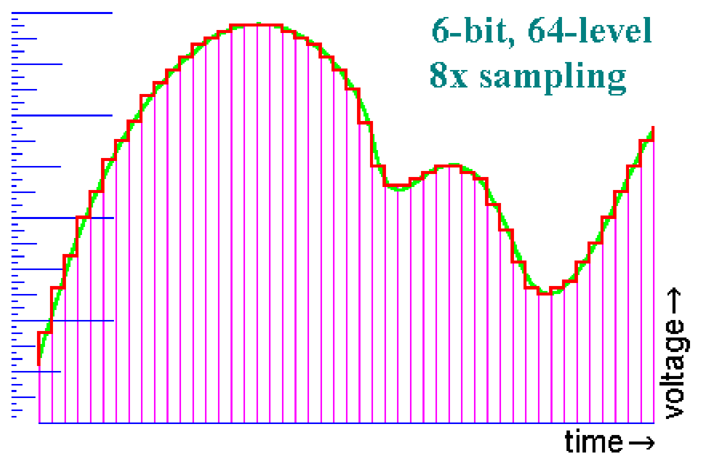
0101 1010 1100 1110 1110 1101 1010 1001 1000 0101 0110 1001



0100 0110 1001 1010 1100 1101 1110 1110 1111 1110 1110 1101 1011 1001 1000 1001 1001 1000 0100 0101 0110 1000 1010



01000 01101 10010 10110 11001 11011 11100 11110 11110 11110 11101 11011 11000 10010 10010 10011 10011 10001 01101 01010 01010 01100 10000 10100



001101 010100 011001 011111 101000 101011 101110 110010 110100 110110 111000 111010 111011 111100 111101 111101 111101 111101 111100 111011 111010 111000 110110 110011 101110 100111 100100 100100 100101 100110 100111 100111 100110 100101 100001 011101 011000 010100 010011 010100 010101 011000 011011 100000 100011 100111 101011

Digitizing a signal