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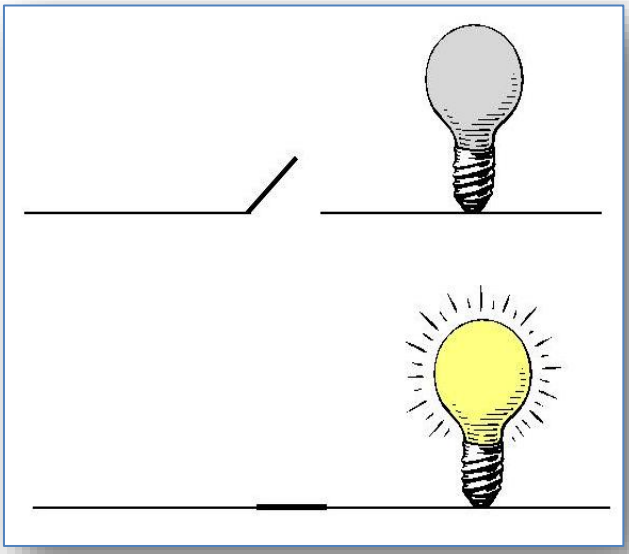
VCZ

CHAPTER 1

DIGITAL WORLD



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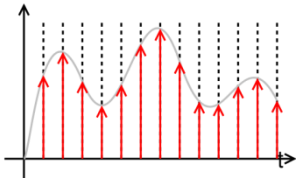
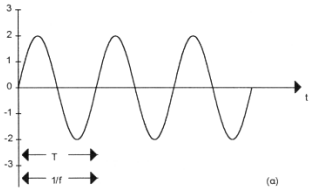
All daily electrical and electronic devices are divided into two basic categories, depending on how they manage current: **analog** devices and **digital** devices.

ANALOG SYSTEM

(the signal changes continually taking all the intermediate values)

- The signal **caries consecutive values** (infinite values)
- The signal intensity changes continually as time passes.
- Examples: voice (sound), telephone, radio, television (analog channels), mercury thermometres, analog watches (with indexes), driving speed (acceleration or **deceleration** etc.)

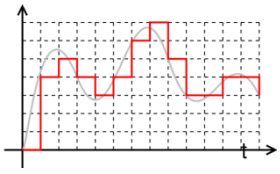


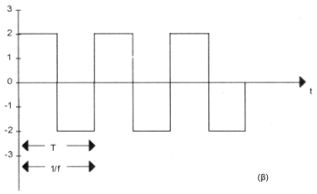


DIGITAL SYSTEM

(the signal changes **distinctively** taking specific values, usually two 0-1)

- The signal caries **discrete values** (distinct values).
- The signal intensity caries values from a specific set of values.
- Examples: computer (values 0 or 1), digital camera, television (digital channels), mobile phones, digital thermometers, digital watches (with digits) etc.

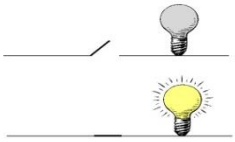




COMPUTERS PERFORM DIGITALLY

A computer is a digital machine that works electronically and recognizes two discrete electronic conditions:

- **Current flowing** through the cable (**bit 1**)
- **Current not flowing** through the cable (**bit 0**)



(with conductivity)

(without conductivity)

The first computers were not very successful in using the **decimal system** (digits 0 - 9) in order to carry out mathematical operations or represent computer data. It was a very complicated and expensive solution to build electronic circuits that would manage 10 different electronic states. Therefore, the 10 digits of the decimal system were replaced with 2 digits in **binary system** in order to represent better computer data.

BINARY SYSTEM

- In the binary system all numbers are represented with only 2 digits: **0** and **1**
- With the help of **B**inary Digi**ts** (**Bits**) hardware constructors describe the presence or absence of electric power inside computer cables more efficiently.
- A bit is the **minimum piece of information** which a computer can manipulate (access, save or transfer) and then it cannot be fragmented (cannot be broken into new pieces).
- All data inside a computer is represented in bits e.g. numbers, characters, images, sounds, videos

Number representation in numerical systems					
decimal	**binary**	**decimal**	**binary**	**decimal**	**binary**
0	0	**7**	111	**14**	1110
1	1	**8**	1000	**15**	1111
2	10	**9**	1001	**16**	10000
3	11	**10**	1010	**17**	10001
4	100	**11**	1011	**18**	10010
5	101	**12**	1100	**19**	10011
6	110	**13**	1101	**20**	11100

How many bits are needed to represent a number?

RULE: With **N** bits we can form 2^N different combinations of 0 and 1 so we can represent (encode) 2^N different numbers of the decimal system and change them into the binary system.

Number of bits	Possible combinations	Number of combinations
1	0, 1	$2^1 = 2$
2	00, 01, 10, 11	$2^2 = 4$
3	000, 001, 010, 011, 100, 101, 110, 111	$2^3 = 8$
4	0000, 0001, 0010, 0011, ... , 1110, 1111	$2^4 = 16$

CONVERSIONS IN NUMERICAL SYSTEMS

binary → decimal

- The binary number is analyzed as a summary of powers of 2.
- The number resulting from the summary is the decimal equivalent.

powers → ... 4 3 2 1 0

digits → $X_4\ X_3\ X_2\ X_1\ X_0$

$$X_0*2^0 + X_1*2^1 + X_2*2^2 + X_3*2^3 + X_4*2^4$$

0100110 = $0*2^0 + 1*2^1 + 1*2^2 + 0*2^3 + 0*2^4 + 1*2^5 + 0*2^6$ =
= 0 + 2 + 4 + 0 + 0 + 32 + 0 = **38**

decimal → binary

- The decimal number is divided consequently by 2.
- Each division by 2 gives a quotient and a remainder (1 or 0).
- This process is terminated when a division gives a zero quotient.
- Finally, placing the remainders in reverse order, we build the binary equivalent.

Number	2
X	X
X	X
X	X
X	X
X	X
X	X
0	X

105	2
52	1
26	0
13	0
6	1
3	0
1	1
0	1

105 = **1101001**

OPERATIONS IN BINARY SYSTEM

The basic arithmetic operations (additions and subtractions) are performed in the same way as with the decimal system.

ADDITION			
DIGIT	DIGIT	RESULT	CARRY
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

SUBTRACTION			
DIGIT	DIGIT	RESULT	CARRY
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

```
  0 1 0 0 1 1 0 1   ⇨  77
+ 0 0 0 1 1 1 0 0   ⇨  28
-------------------------
  0 1 1 0 1 0 0 1   ⇨  105
```

```
  0 1 1 0 0 0 1 1   ⇨  99
- 0 0 0 1 1 0 1 1   ⇨  27
-------------------------
  0 1 0 0 1 0 0 0   ⇨  72
```

REPRESENTATION OF SYMBOLS

- A computer not only encodes numbers into the binary form but also encodes characters and other symbols.
- The conversion of characters into bits is called **encoding.**
- For encoding characters two techniques are commonly used:

ASCII Code

(American Standard Code for Information Interchange)

- Each character is represented with 8 bits.
- Number of characters represented: $2^8 = 256$.
- It is used to represent Latin and Greek alphabets.

UNICODE Code

(Uniform – Universal - Unique)

- Each character is represented with 16 bits.
- Number of characters represented: $2^{16} = 65536$.
- It is used to represent more complicated alphabets such as Arabic, Chinese, Indian, Cyrillic etc.

e.g. encoding of word **BOOK** using ASCII code

B	O	O	K
01000010	01001111	01001111	01001011

Encoding of letter B

THE BYTE CONCEPT

- Each character in a computer is represented with 8 bits.
- Therefore, a new piece of information is created that is a better and more common measurement unit for representing data capacity in a computer. That measurement unit is called **Byte.**

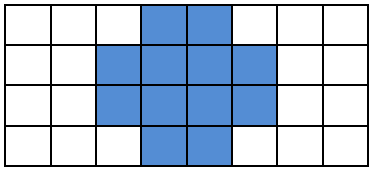
1 byte = 8 bits

- Most of the times, in order to measure the capacity of memory and other storage media or the size of files, folders and other applications of the computer, we use multiple measurement units of a byte:

UNIT	Explanation	BYTES	EQUALS TO
KB	Kilobyte	2^{10}	1024 bytes
MB	Megabyte	2^{20}	1024 KB
GB	Gigabyte	2^{30}	1024 MB
TB	Terabyte	2^{40}	1024 GB

REPRESENTATION OF IMAGES

- Every image in a computer is depicted as a **map of pixels** (grid of picture elements).
- Each pixel is a rectangular area on the screen which can be coloured (**bit 1**) or not (**bit 0**).
- The conversion of an image into a **map of bits** (**bitmap**) is called **digitalization.**



0	0	0	**1**	**1**	0	0	0
0	0	**1**	**1**	**1**	**1**	0	0
0	0	**1**	**1**	**1**	**1**	0	0
0	0	0	**1**	**1**	0	0	0

ANALOG OR DIGITAL TECHNOLOGY?

	IMAGE	SOUND
ANALOG	Higher fidelity of image Film pictures are gradually distorted	The vinyl disk is spoiled as time passes The quality of sound is poorer
DIGITAL	The quality and resolution is continually improved The photo quality is unchanged in time	CD sound is transmitted unchanged with no loss CD as a storage has greater capacity than a vinyl disk. Digital sound can be compressed in contrast to analog.