



BME



KJIT

Budapest University of Technology and Economics

Faculty of Transportation Engineering and Vehicle Engineering

Department of Control for Transportation and Vehicle Systems

Mechatronics, Microcomputers

Stipendium Hungaricum

2018/2019 Autumn Semester

Szilárd Aradi P.hD, István Ferenc Lövétei

BMEKOKAM604

General Informations

- Lectures: every Thursday from 12:15 to 13:45, in the room ST122,
 - Teaching Breaks: 20/09 and 01/11,
 - Lectureres:
 - István Ferenc Lovétei, in the 1st part of the semester, building ST, 1st floor, room 108,
 - e-mail: lovetei.istvan@mail.bme.hu,
 - Szilárd Aradi PhD, from 25 October, building ST, 1st floor, room 106,
 - e-mail: aradi.szilard@mail.bme.hu,
- Practices: every Wednesday from 16:15 to 17:45, in the room ST122,
 - Teaching Break: 14/11,
 - Lecturer:
 - Árpád Fehér, e-mail: feher.arpad@mail.bme.hu, building ST, 1st floor, room 105,

General Informations

- Tasks:
 - 2 midterm exam – theoretical questions, numerical examples and programming – dates????
 - no exam in the exam period – midterm grade, based on the midterm exams,
- <http://kjit.bme.hu/index.php/en/>
- Main topics:
 - Lectures: Computer Architectures, IC Technology, Digital Circuits, Computer Arithmetics, MCU Technology, Atmel AVR MCUs,
 - Practices: Numeral Systems, Number Representations in Computing, Atmel AVR MCU Programming in Language C.



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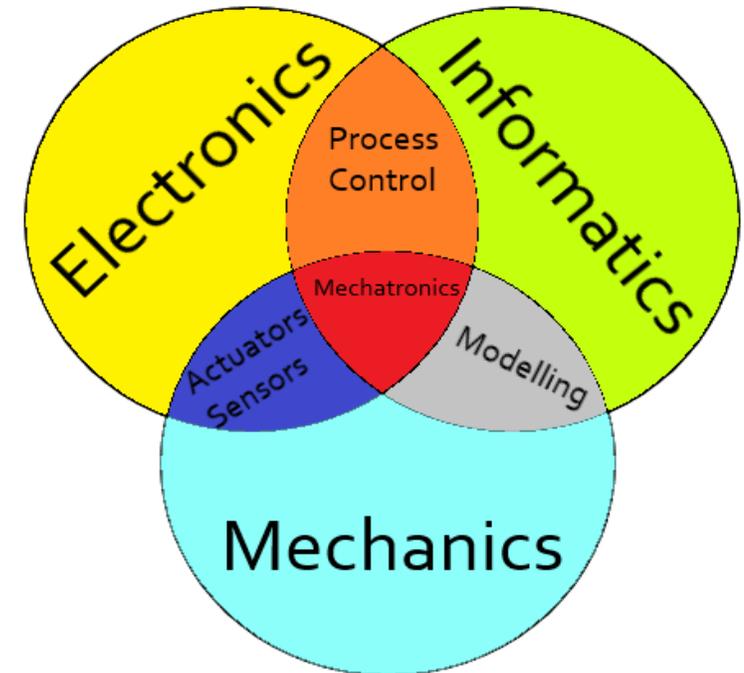
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INTRODUCTION

Lecture 1.

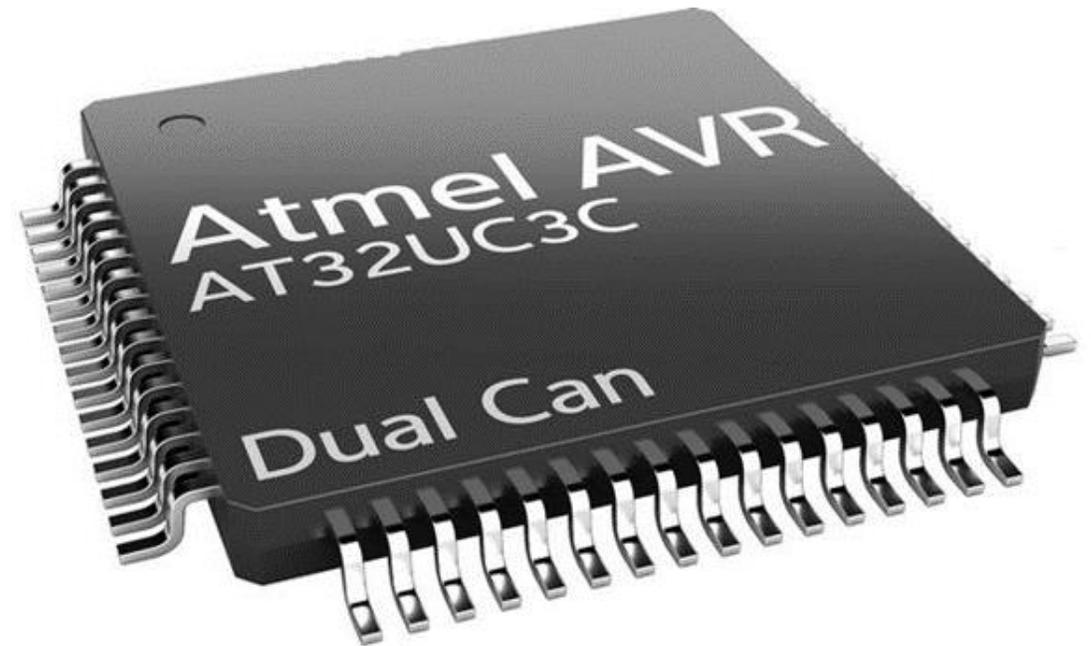
Mechatronics

- **Mechatronics (mechanics and electronics)** is a multidisciplinary field of engineering that includes a combination of mechanical engineering, electronics and informatics (computer engineering telecommunication engineering).
- Mechatronics is an engineering tool to design and product of computer-controlled systems and equipments:
 - CAD - Computer Aided Design,
 - CAM – Computer Aided Manufacturing.



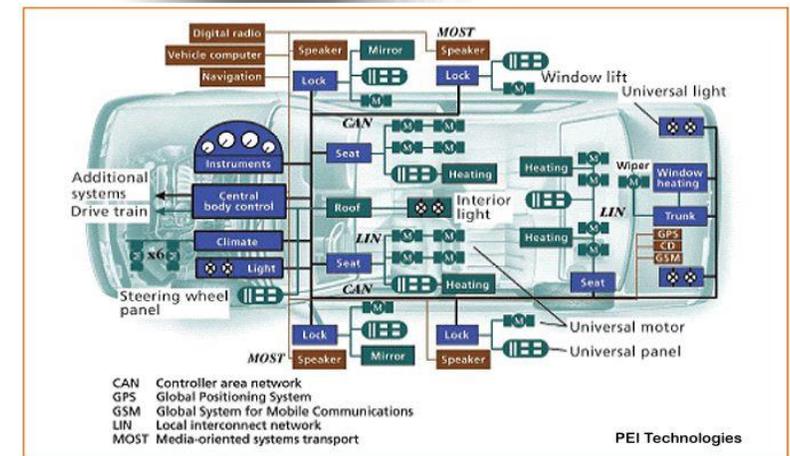
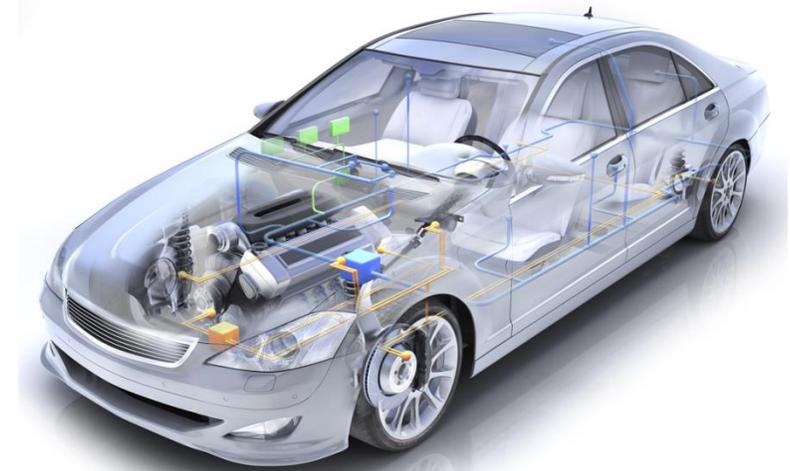
Microcontrollers

- **Microcontroller (MCU)** is a small computer on a single integrated circuit, they are evolved from **single-chip microcomputers**. The microcontrollers are typically used for dedicated applications such as automotive systems as embedded systems. Typical microcontrollers, therefore, include a CPU, timers, and A/D (analog to digital) and D/A (digital to analog) converters - all in a single chip.
- **Embedded System:** an embedded system is a computer system with a **dedicated function**:
 - traffic lights and measuring systems (road traffic);
 - railway interlocking systems, train controlling systems, controlling units of trains;
 - flight control units of aircrafts;
 - industrial process control;
 - **vehicle systems**;
 - etc...



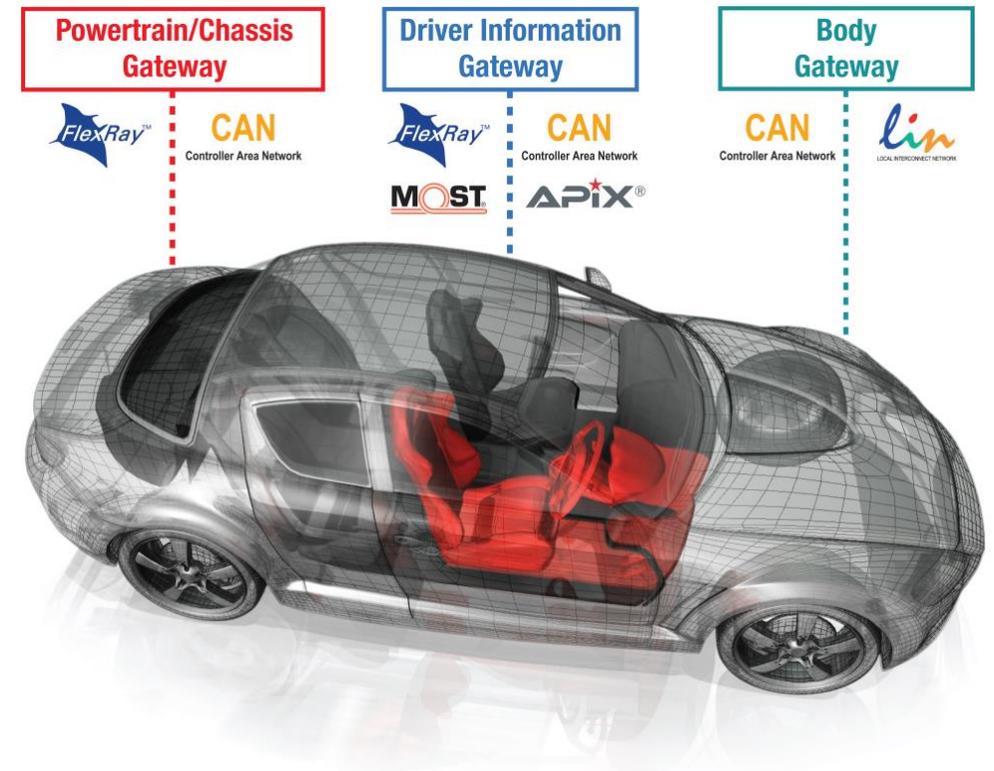
Introduction

- Nowadays, the ratio of electronic devices in a car is about 25%.
- In a top-category car, about 80 different **electronic control units (ECU)** can be found.
- In a modern aircraft, more than 700 **ECUs** are working in the same time.
- Generally, these devices form networks:
 - operating systems (power transmission, steering system, suspension system, instruments),
 - safety-related systems (active, passive),
 - comfort systems (air conditioning systems, consumer electronics, navigation systems).



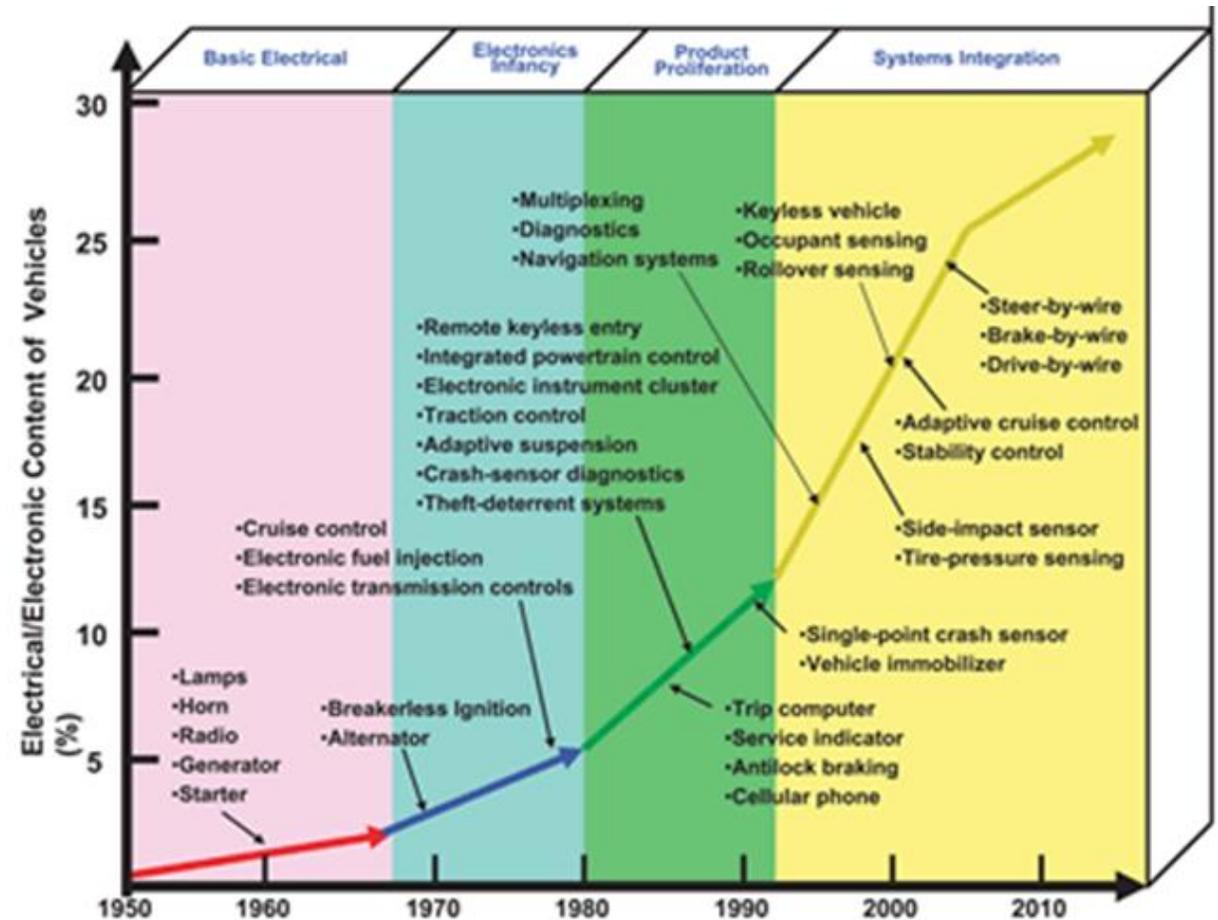
Introduction

- The ECUs send more, than thousands signals to each other.
- Depending on use, these devices apply different technologies:
 - Controller Area Network – CAN,
 - Local Interconnect Network – LIN,
 - Media Oriented System Transport – MOST,
 - FlexRay.



Introduction

- The first microprocessor controllers have appeared at the end of 1970.
- In 2000: ~15 processors in an average vehicle.
- In 2010: ~60 processors in an average vehicle.



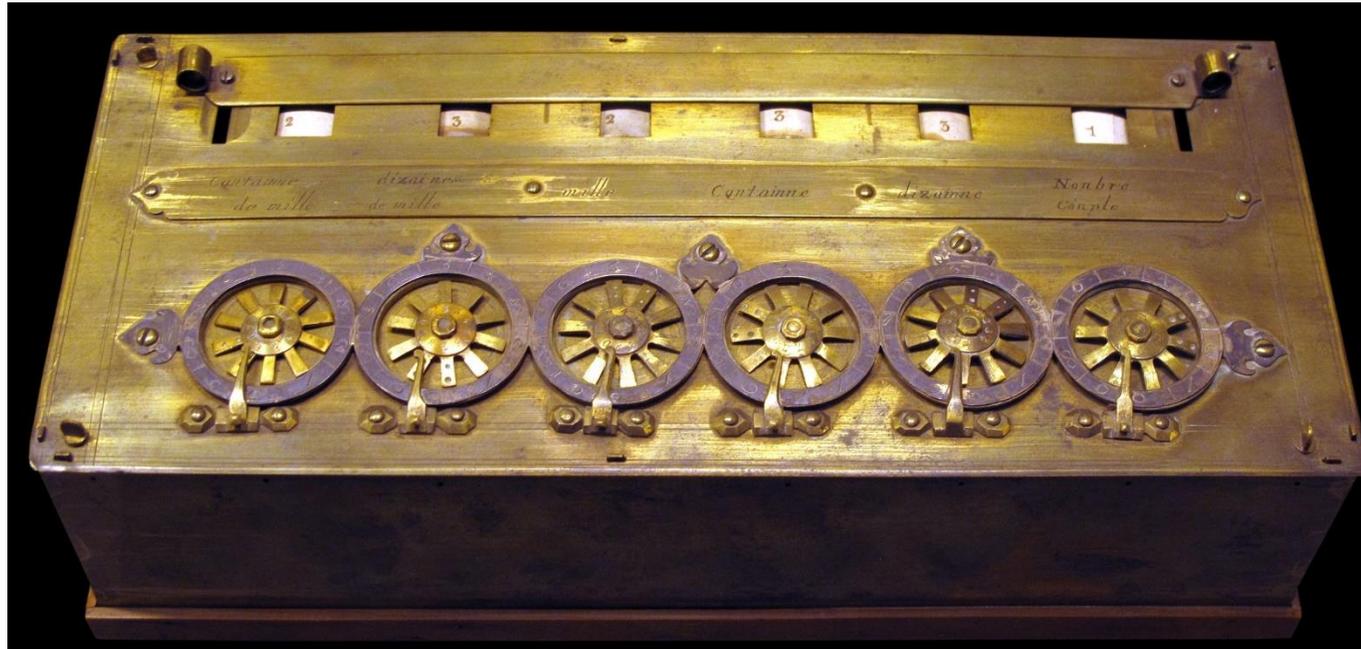
History of Computers

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- Pascal's mechanic calculator – arithmetic machine/Pascaline – 17th century:



- more information: https://en.wikipedia.org/wiki/Pascal%27s_calculator

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<https://www.youtube.com/watch?v=3h71HAJWnVU>

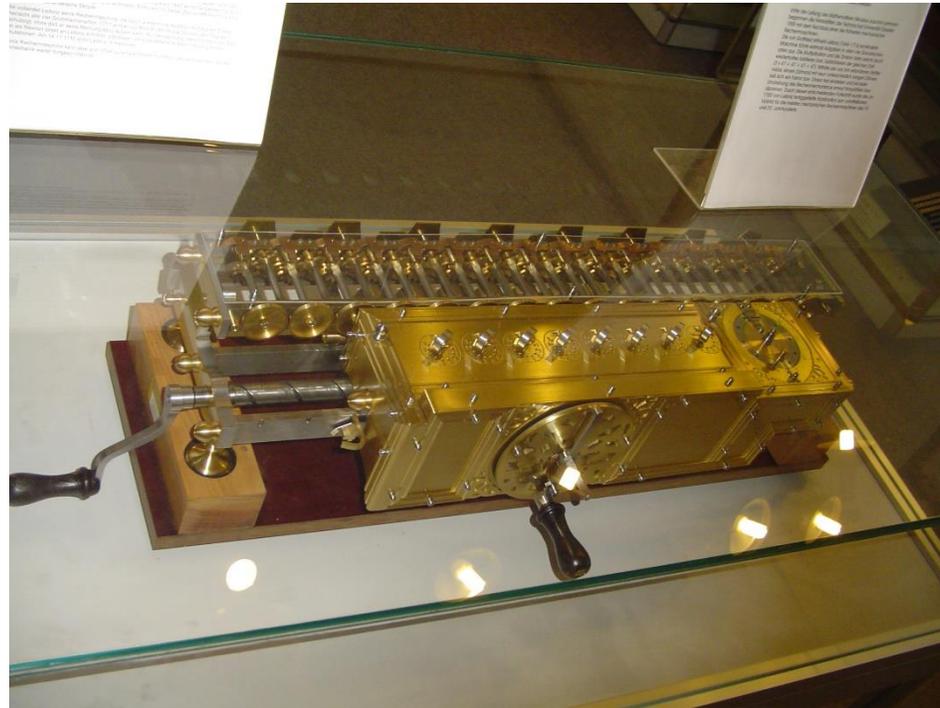
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- Leibnitz's Calculating Machine—Step Reckoner, 1673



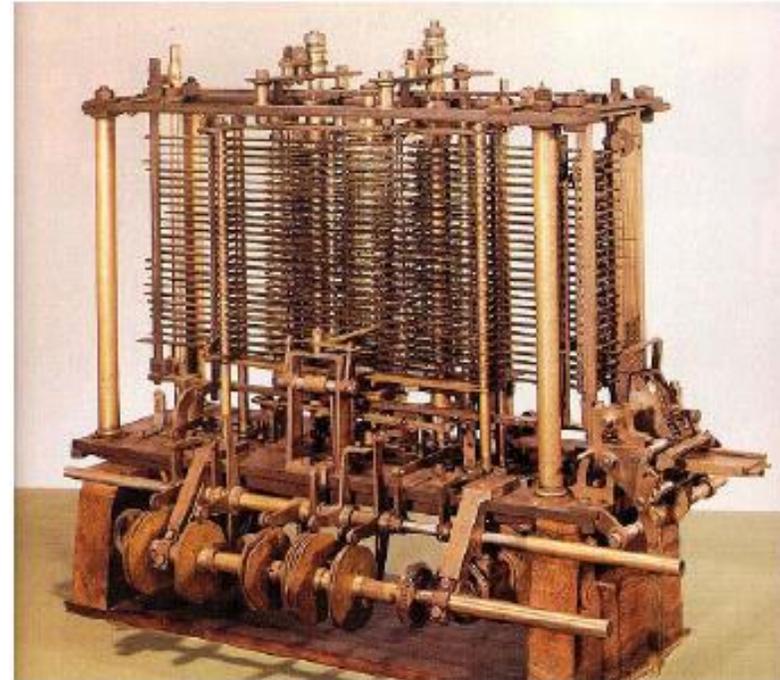
- more information: <http://www.gwleibniz.com/calculator/calculator.html>

History of Computers

- Babbage's Difference Engine



Babbage's Analytical Engine



- more information: https://en.wikipedia.org/wiki/Analytical_Engine

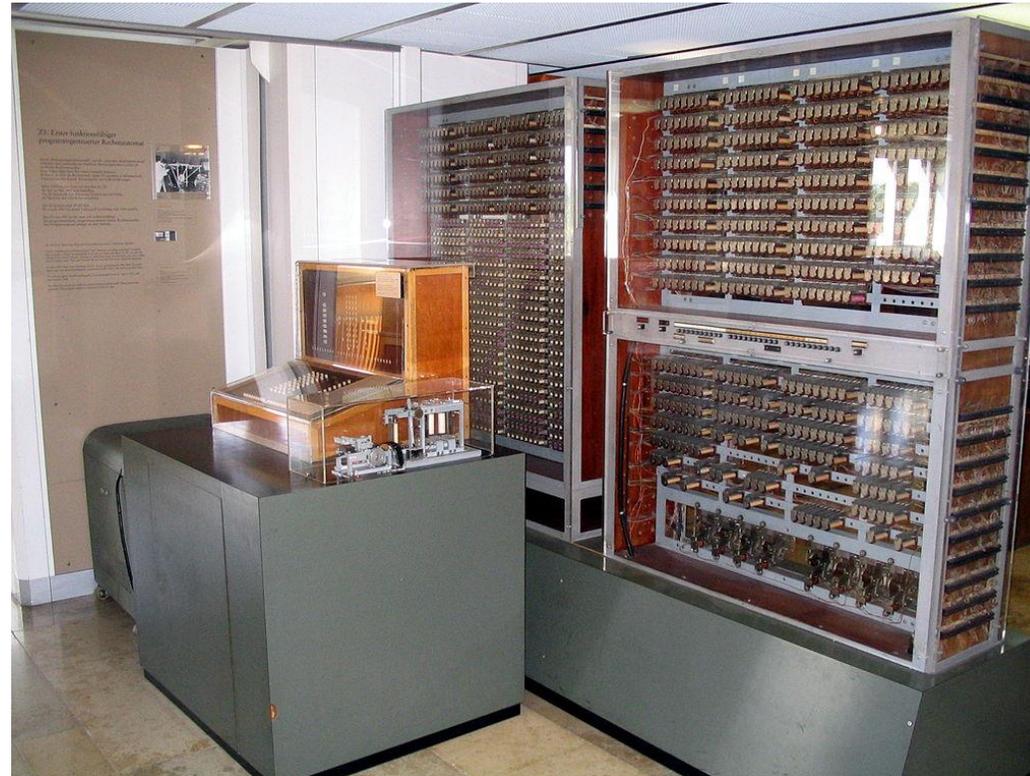
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- Konrad Zuse's Z3



- more information: <https://www.inverse.com/article/15542-konrad-zuse-s-z3-the-world-s-first-programmable-computer-was-unveiled-75-years-ago>

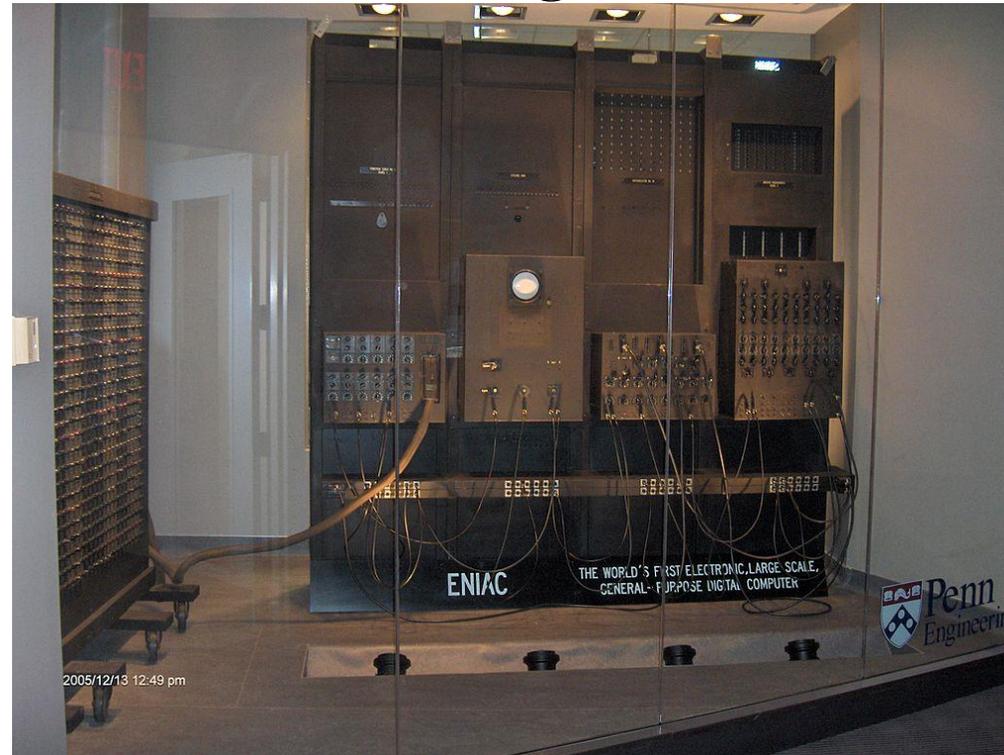
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- ENIAC – Electronic Numerical Integrator and Computer



- more information: <https://www.thoughtco.com/history-of-the-eniac-computer-1991601>

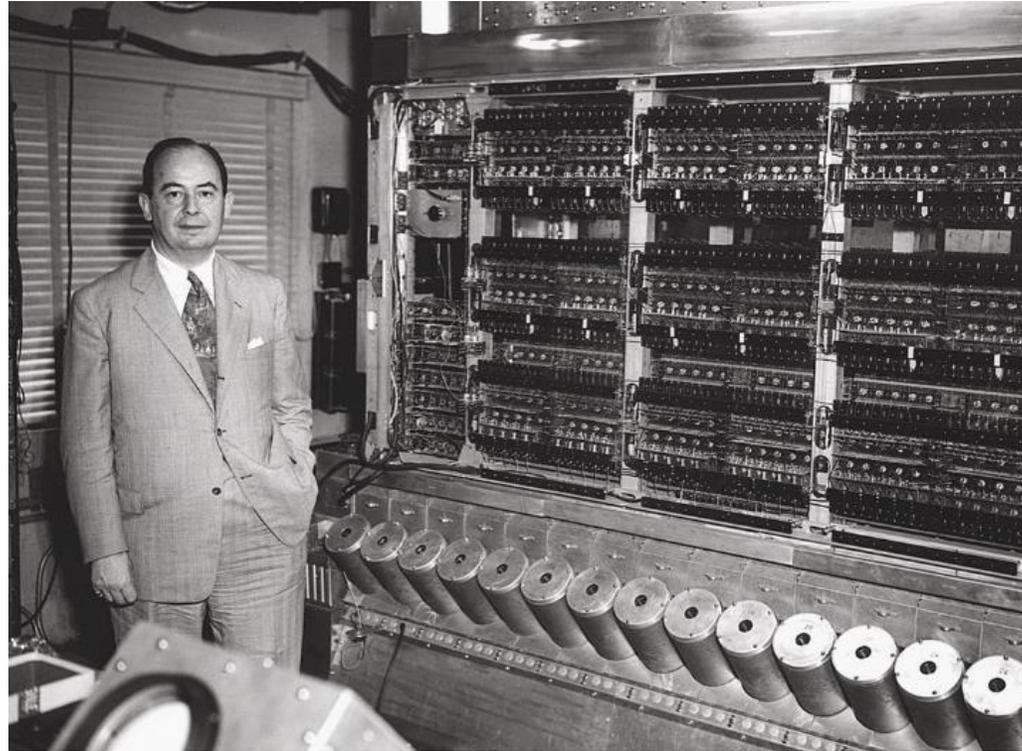
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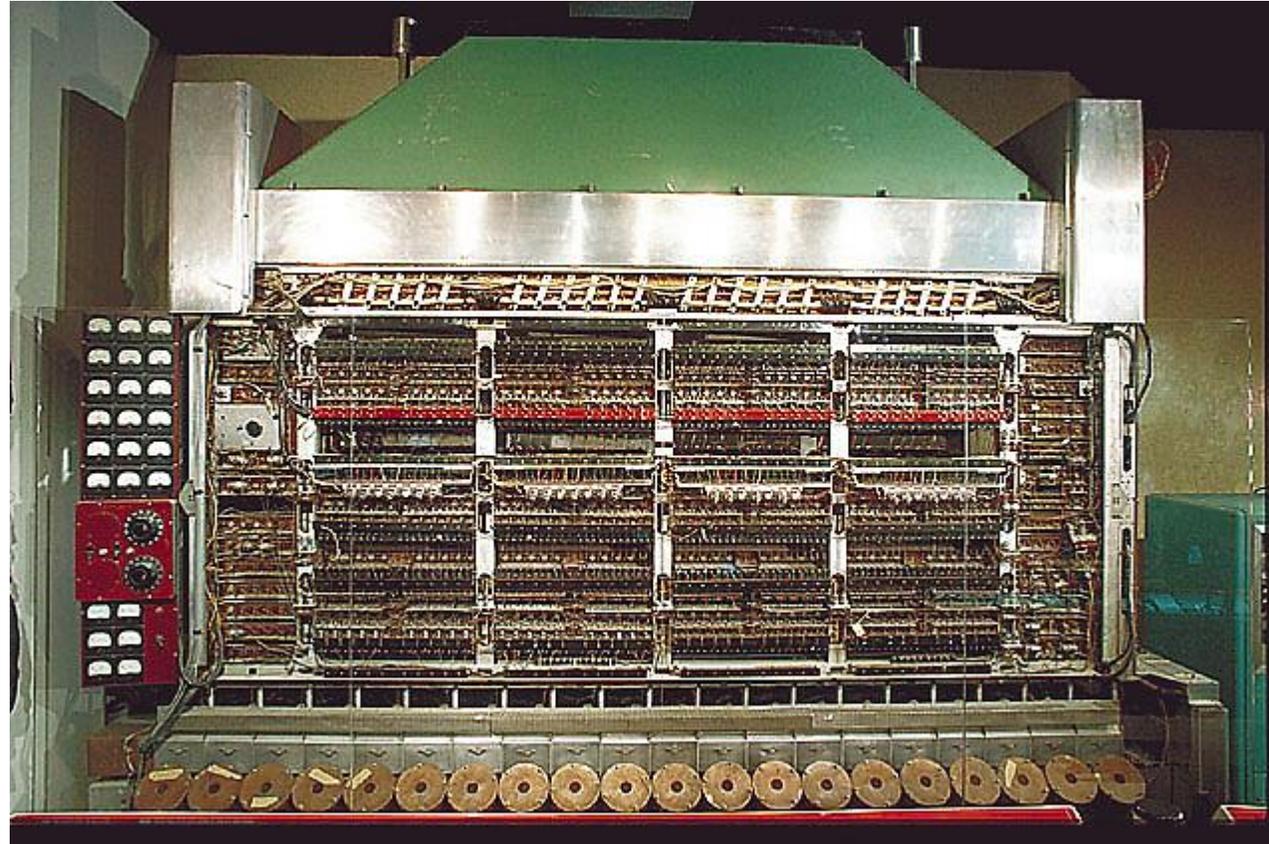
- EDVAC – Electronic Discrete Variable Automatic Computer



- more information: <https://www.thocp.net/hardware/edvac.htm>

History of Computers

- IAS machine



- more information: <https://www.youtube.com/watch?v=UwgiOkIEWHA>

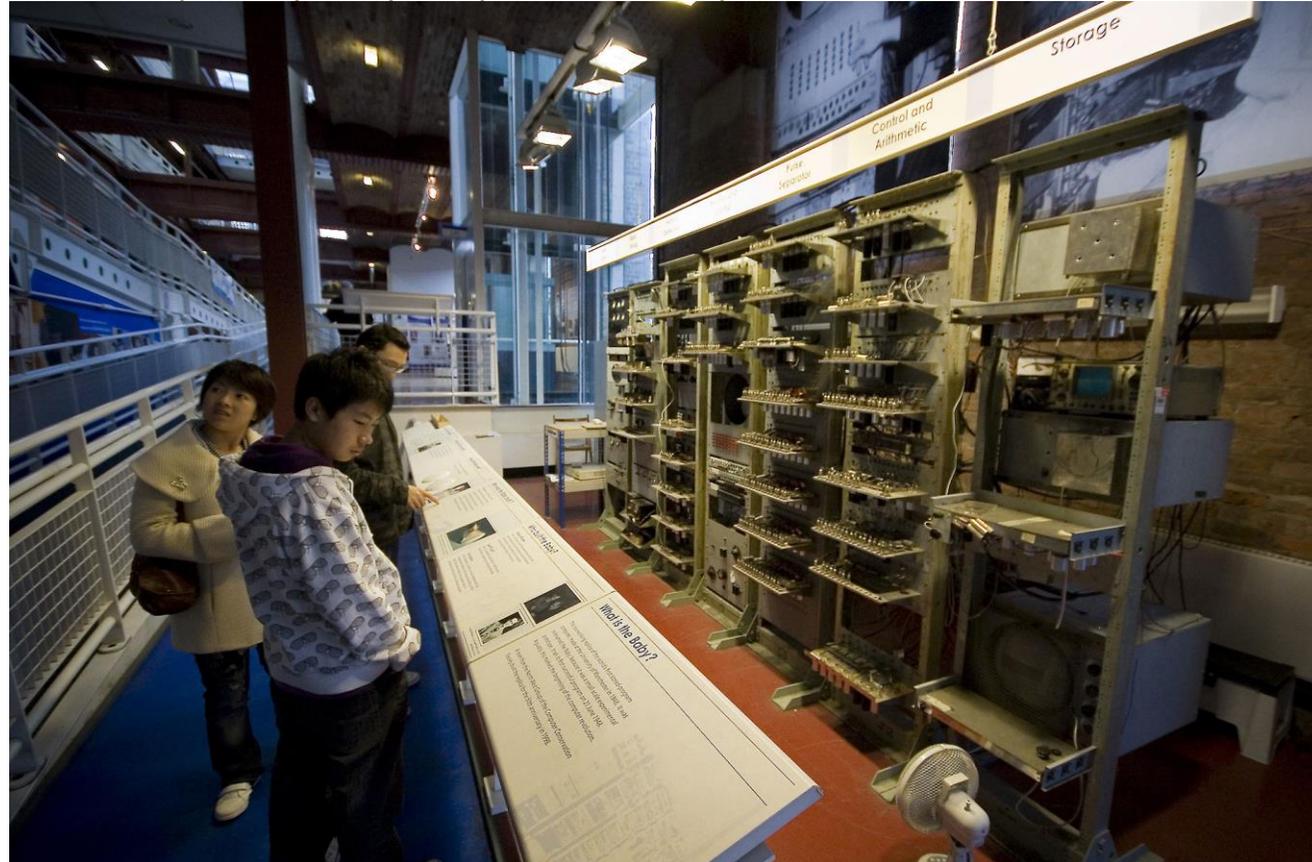
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- Manchester Baby



- more information: <http://www.computinghistory.org.uk/det/6013/The-Manchester-Baby-the-world-s-first-stored-program-computer-ran-its-first-program>

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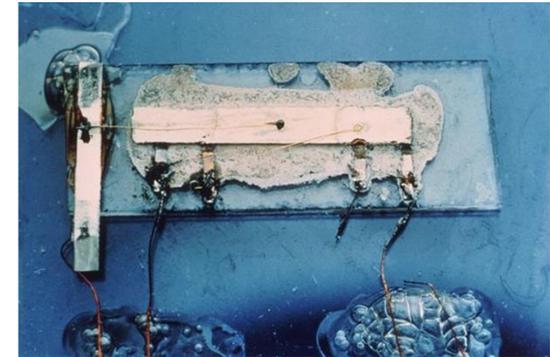
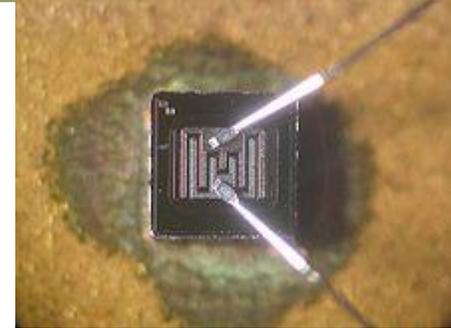
- IBM Model 701



- more information: https://www-03.ibm.com/ibm/history/exhibits/701/701_intro.html

History of Microcomputers

- Invention of bipolar transistors – 1947:
 - big push towards size and consumption reduction,
 - electron tubes can be made out.
- Invention of integrated circuit – 1958:
 - continuous development since 1960,
 - the first single-chip microprocessor has appeared,
 - every CPU function in a small flat of semiconductor material,
 - first – commercially available – microprocessor was the Intel 4004 in 1971.



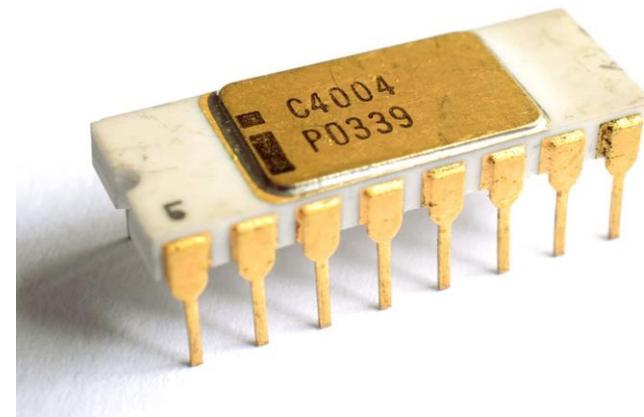
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- Intel 4004 – with 2300 transistors and 10000 nm feature size:
 - CPU clock rate: 740 kHz,
 - instruction cycle: 8 clock cycle, 10,8 μ s,
 - run time of 1 instruction: 1 or 2 instruction cycle, 46300 – 92600 instructions/1 sec,
 - ALU: 4-bit BCD arithmetics,
 - instruction set: 46 instructions,



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- IBM System 370



- more information: <http://www.computinghistory.org.uk/det/2224/IBM-370-138/>

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- IBM PC - 1981



- more information: <http://oldcomputers.net/ibm5150.html>

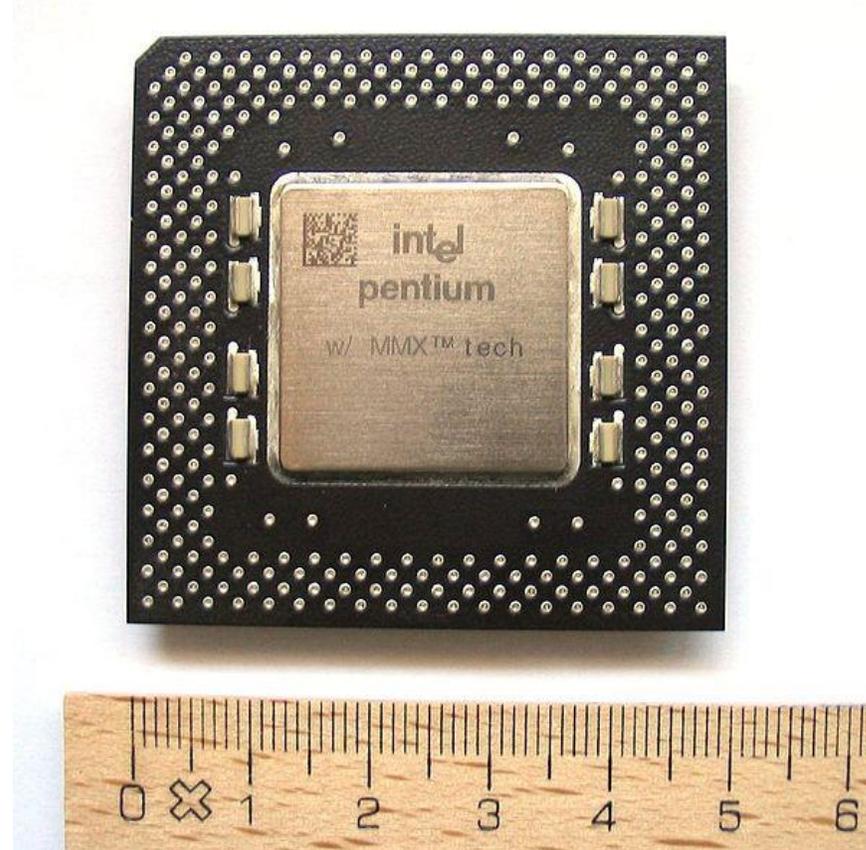
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- Intel Pentium – 1993



- more information: <https://dayintechhistory.com/dith/march-22-1993-pentium-processor-shipped/>

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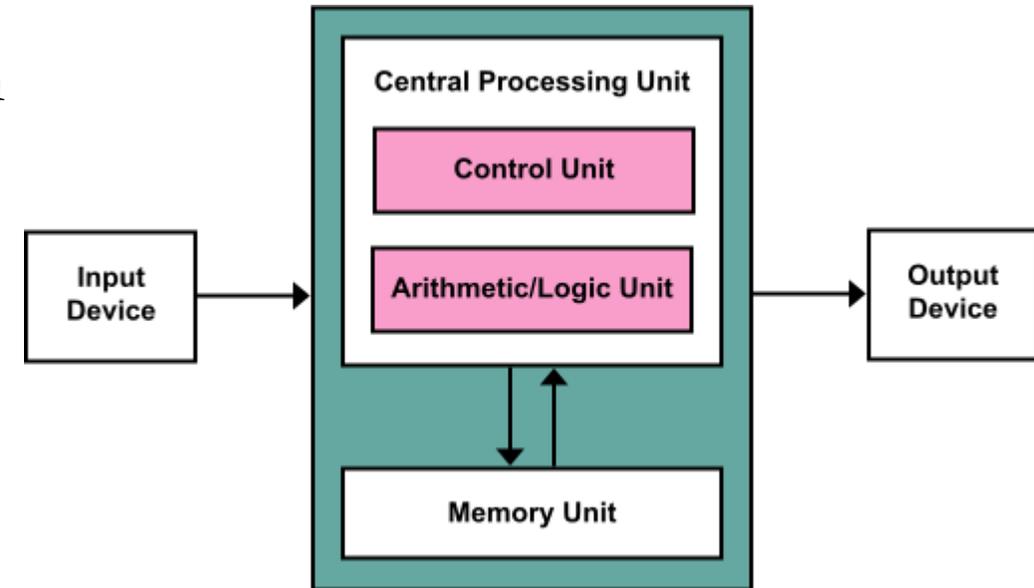
- Intel Core i9 – 2017



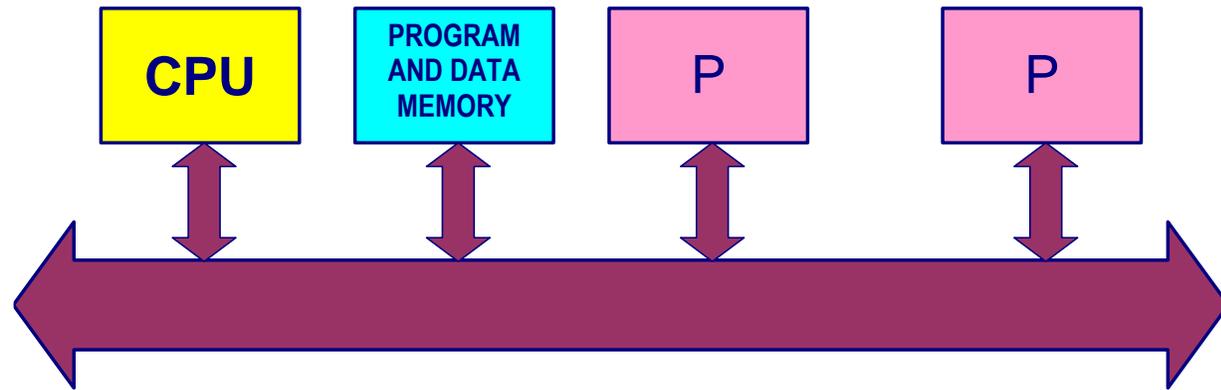
- more information: <https://www.intel.com/content/www/us/en/products/processors/core/x-series/i9-7900x.html>

Architectures of Computers

- Von Neumann Architecture (1945):
 - using the binary numeral system,
 - common used memory to store both instructions (code) and data,
 - universal usability.
 - <https://www.youtube.com/watch?v=5BpgAHBZgec>
- Harvard Architecture (1944):
 - separated code (instructions) and data memory,
 - generally used by microcontrollers (MCUs).

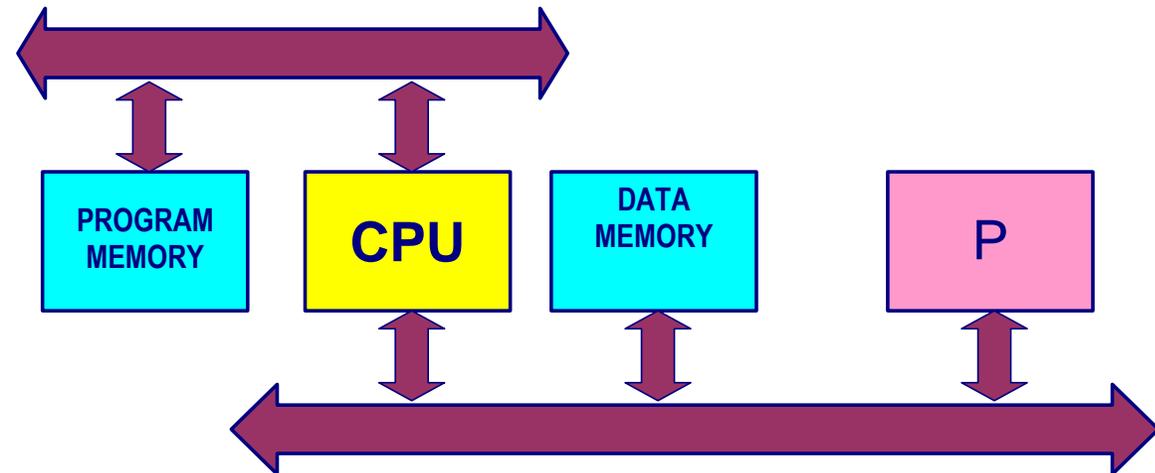


Architectures of Computers



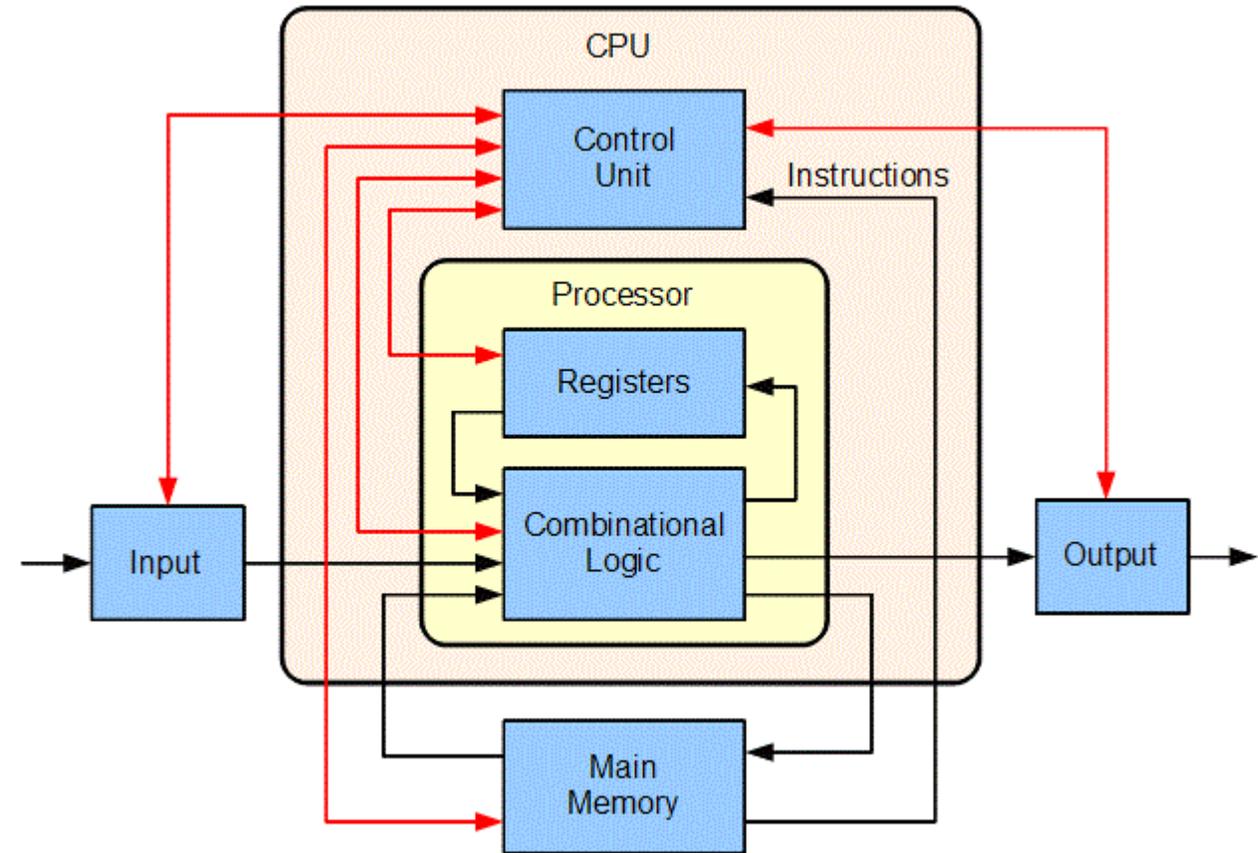
- Von Neumann Architecture (1945)

- Harvard Architecture (1944)



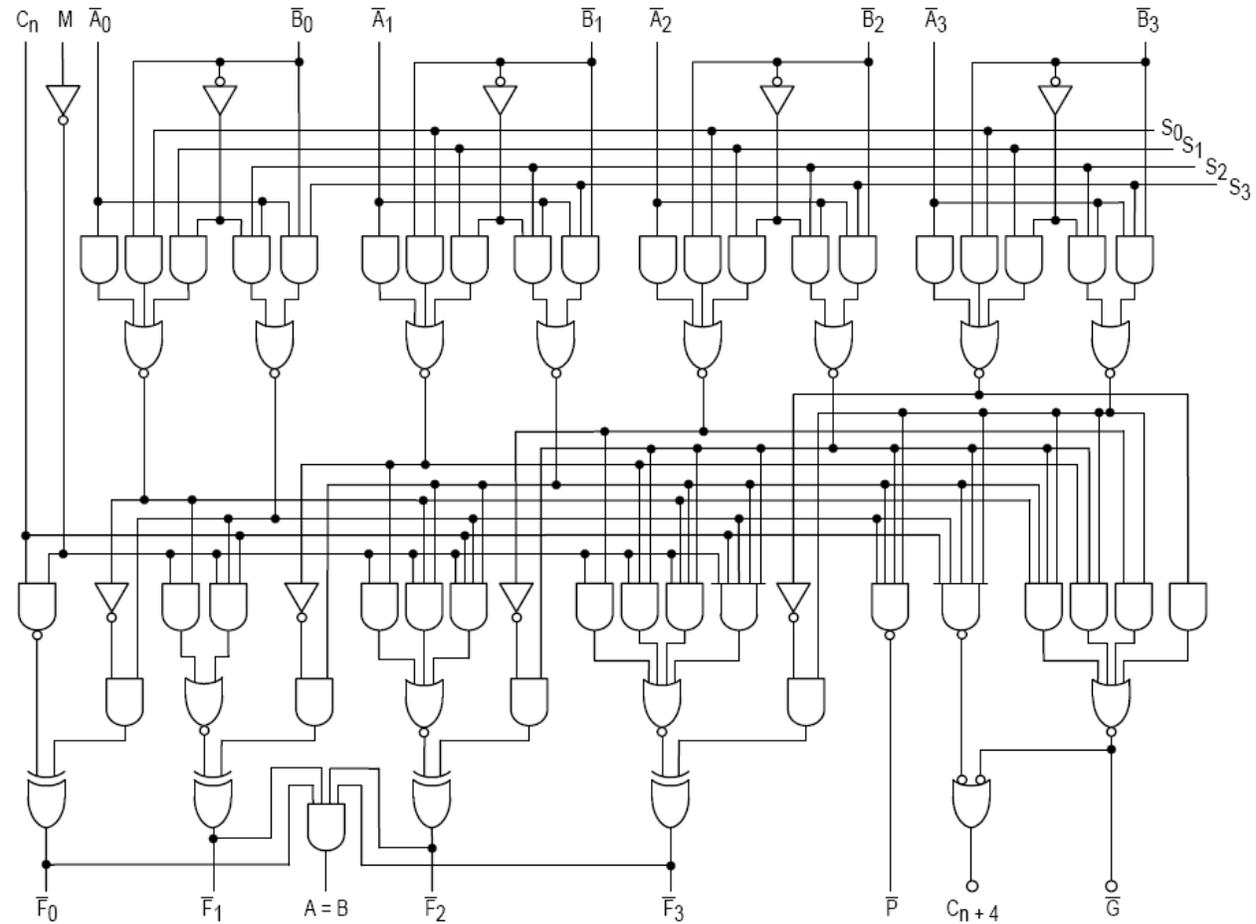
CPU

- CU- Control Unit:
 - The control unit does not execute program instructions; rather, it directs other parts of the system to do so.
- ALU – Arithmetic Logic, Unit (Combinational Logic):
 - Performs integer arithmetic and bitwise logic operations.
- Registers (internal):
 - Processor register is a quickly accessible location available to the CPU. Registers usually consist of a small amount of fast storage, although some registers have specific hardware functions, and may be read-only or write-only.



ALU

- 74181 IC, 4-bit ALU



CPU vs. MCU

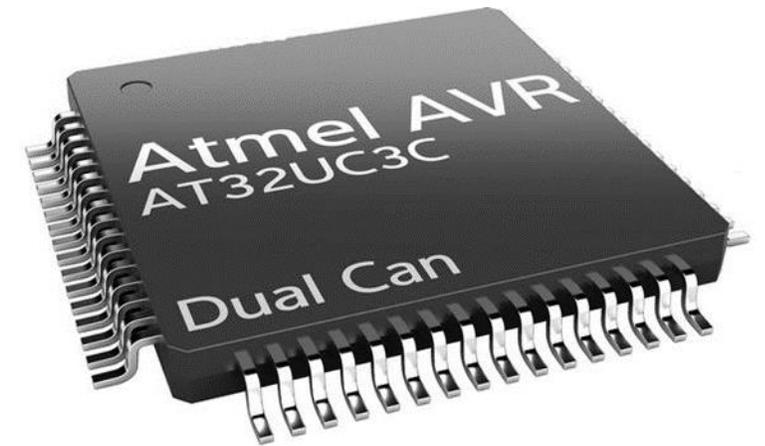
- **Central Processing Unit:**
 - large, generally used instruction set and other special instruction sets*,
 - complex memory management,
 - it requires a complex additional circuit, itself is inoperable,
 - capable to doing complicated calculating performing it in a high-speed,
 - capable to running complex operating systems.



*:by performing the basic arithmetic, logical, control and input/output (I/O) operations specified by the instructions.

CPU vs. MCU

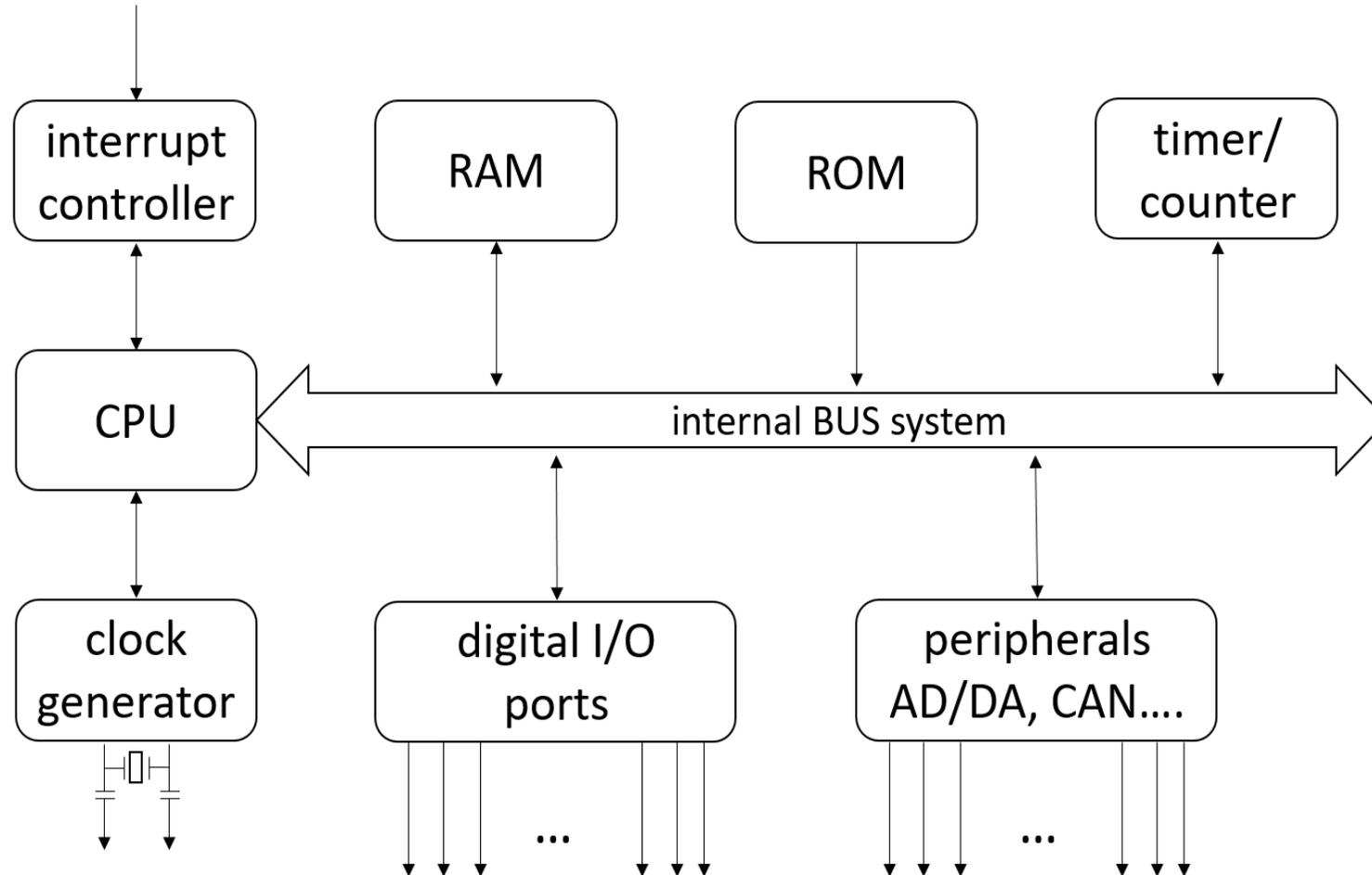
- **Micro Controller Unit:**
 - CPU and:
 - RAM, ROM,
 - digital I/O ports,
 - timers/counters,
 - clock generator,
 - lower computing capacity,
 - suitable for industrial control tasks,
 - not capable to running complex operating systems,
 - hardware based on MCU is called „**Embedded System**”.



MCU

- General properties of MCUs:
 - register width (word): 8, 16, 32 bits:
 - expected distribution in 2017:
 - 8 bits – 28 %, 16 bits – 34 %, 32 bits – 38%,
 - 16 and 32 bits are used generally in the automotive industry,
 - frequency: 2 – 100 MHz,
 - size of the memory:
 - RAM: 128 bytes – 64 Kbytes,
 - ROM: 2 Kbytes – 256 Kbytes;
 - power supply:
 - voltage level: 5 V, 3,3V;
 - energy consumption: 10x mA.

MCU





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End of Lecture 1.

Thank you for your attention!