TALLINNA
TEHNIKAÜLIKOOL

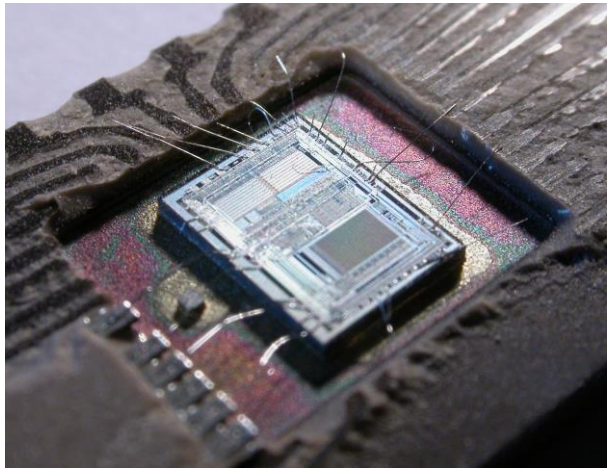
Microcontroller

Hardi Selg

What is a microcontroller?

- **Small control unit or an integrated circuit**
- Microcontroller consists of:
  - One or many processor cores (CPU)
  - Memory (RAM, EEPROM, Flash, …)
  - Programmable inputs/outputs

- Not all chips are microcontrollers
- There are also combinational circuit chips
  - For example **7400 series**



Intel 8742, Wikipedia

Why do we need microcontrollers?

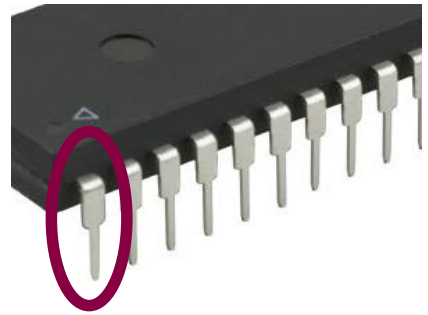
- Why can’t regular PC (personal computer) be used everywhere?
- Main reason: **power consumption**
- In addition:
  - Heat
  - Size
    - microcontrollers are compact
  - Relatively easy to use

Where are microcontrollers used?

- Nowadays, more or less everywhere
- For example: activity monitors, microwave ovens, smart fridges and regular ovens
- Definitely smart watches, mobile phones, tablets, laptops, personal computers, monitors, projectors
- In industry on different robots and control devices
- Last but not least also in cars, planes, ships, rockets (both in military and space applications)

- In conclusion microcontrollers are everywhere
  - 96% - 98% microcontrollers, the rest is personal computers

Input/Output



- PIN – metal filament on a chip
  - GPIO: can act as a input or a output (configured via **DIR register**)
  - Power/Ground
  - Microcontrollers **datasheet** contains detailed description of the pins

- PORT – array of **registers** on the microcontroller
  - Microcontroller may have multiple **PORTs**
  - PORT can be assigned as a output for a:
    - ADC, DAC, multiplier etc

ADC

- Analog-digital converter
- Converts incoming analog signal to a digital value
- Measurement precision depends on:
  - Reference voltage
  - Resolution of the ADC (width of the output)
- Example:
  - Voltage range of the ADC: 0 V - 5 V
  - Reference voltage 3.3 V
  - Width of the output is **8 bit**s
  - Accuracy of the ADC is **≈ 0.0129 V**

```
if (ADC_out > 10)
{
    printf("Voltage is greater than 0.129V\n");
}

if(ADC_out > 128)
{
    printf("Voltage is greater than 1.65V\n");
}
```

DAC

- Digital-analog converter
- Converts digital value to an analog signal (Voltage)
- Conversion accuracy depends on:
  - Reference voltage
  - Width of the DAC input
- Example:
  - Voltage range of the DAC: **0 V - 5 V**
  - Reference voltage: **3.3 V**
  - Input width: **8 bits**
  - Therefore the accuracy of the output is **≈ 0.0129 V**

Architecture

- Microcontrollers typically have **Harvard** architecture
- Program memory and data memory are located separately
- Generally are grouped based on the **bus** / **word** width
  - 8 bits, 16 bits, 32 bits or 64 bits
  - This specifies the max range of the operand
  - Also specifies max size for the memory
    - 2^8 is 256, this means 256 different memory addresses
    - Word length is 8 bits, in other words 1 byte. This means 8bit microcontrollers max single memory unit is 256 bytes
  - There are ways to address more memory using **PAGES**
- Basys MX3
  - Clock speed: 80MHz
  - 512KB Flash, 128KM SRAM

FPU (floating point unit)

- Typically 32 bit
  - Applies also to 8 bit microcontroller
- In addition to the ALU (Arithmetic – logic unit)
- Very large in size
- Operates fairly slowly
  - Operations may take multiple clock-cycles
- Difficult to use in a 8-bit controller
- Uses a lot of program memory

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