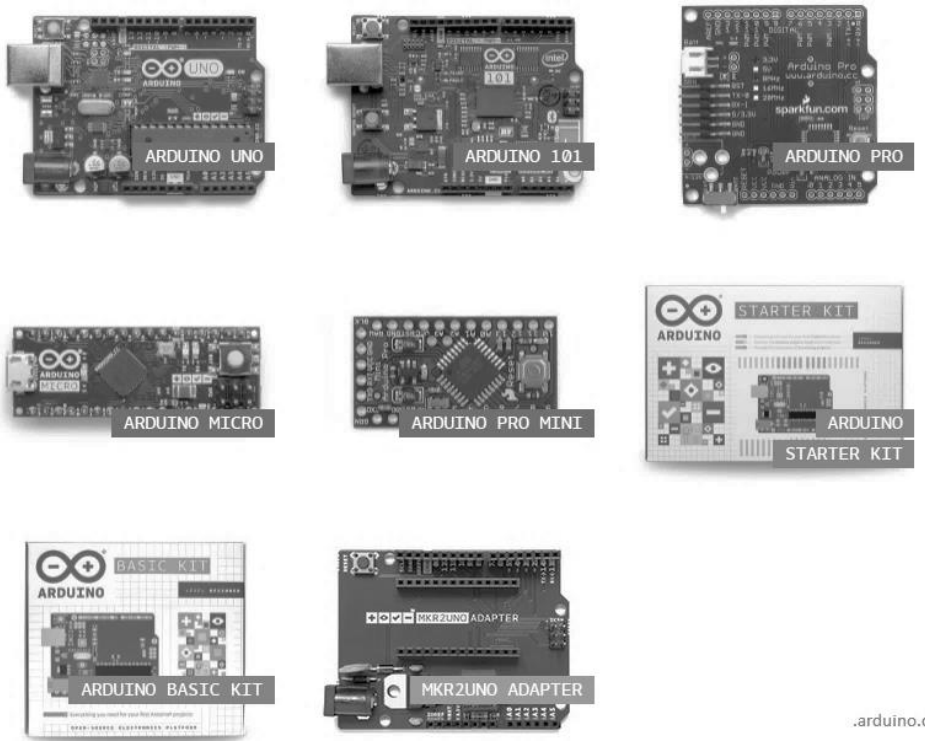
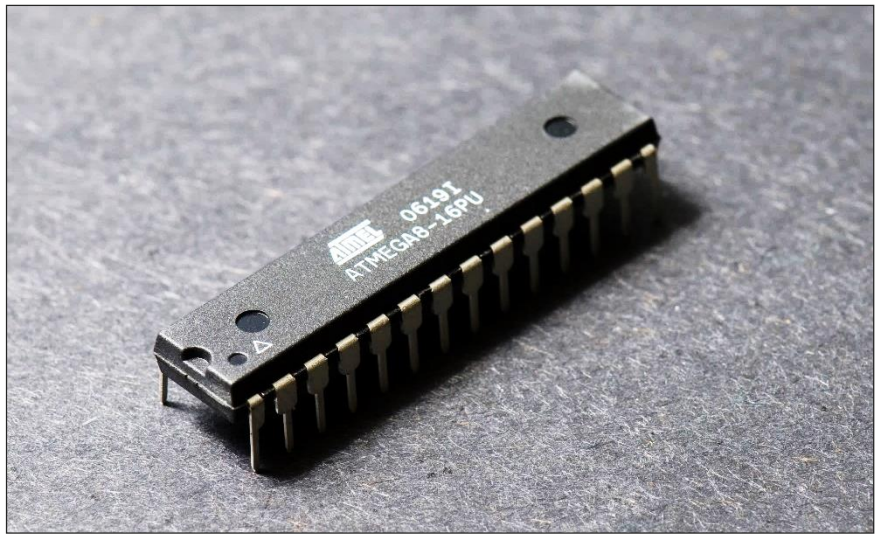
Arduino Hardware Overview

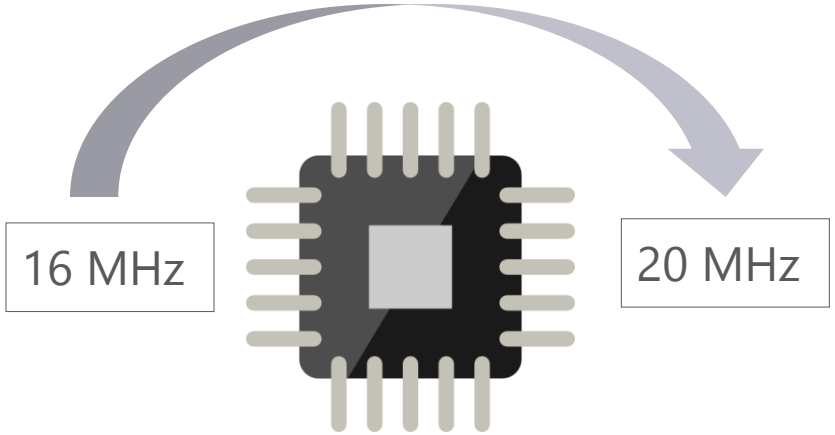
What is Arduino?



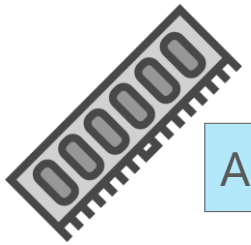
The **Arduino Family** has **revolutionized** programing microcontrollers

AVR Microcontroller





ATMEL **8 bit AVR** microcontroller



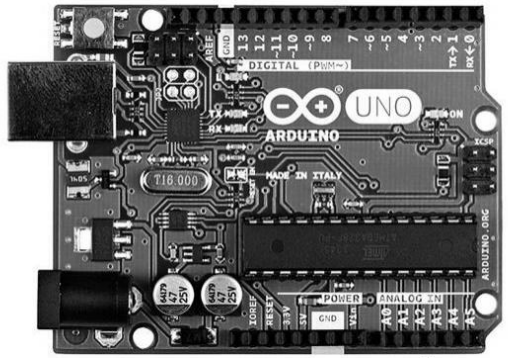
ARM and Intel cores

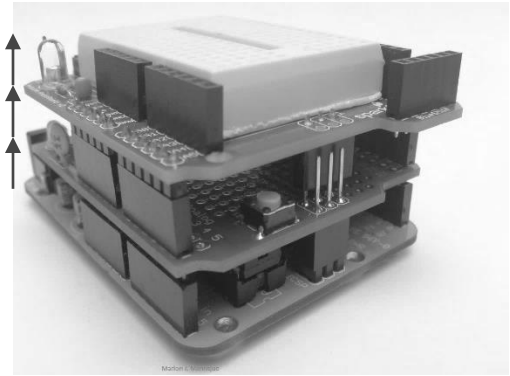
Power efficient
Wide setup of integrated peripherals

Boards and Shields

Boards

Modules



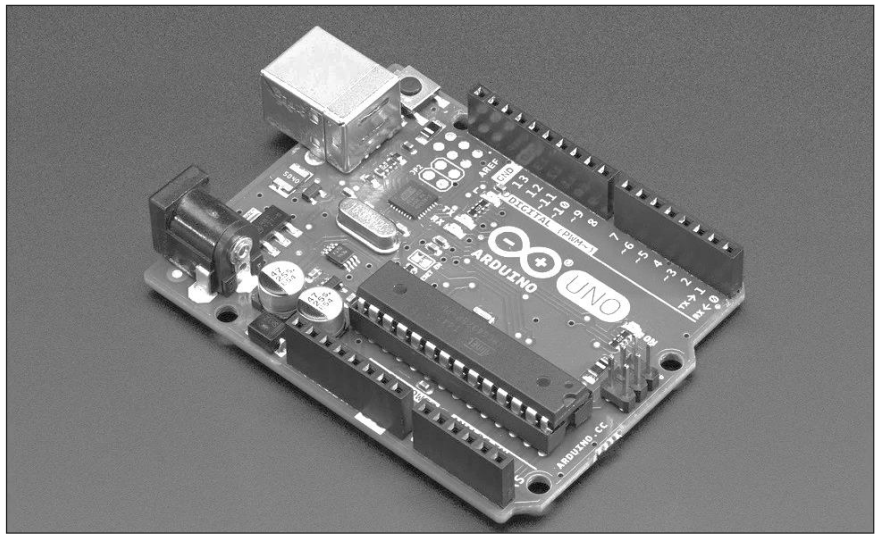


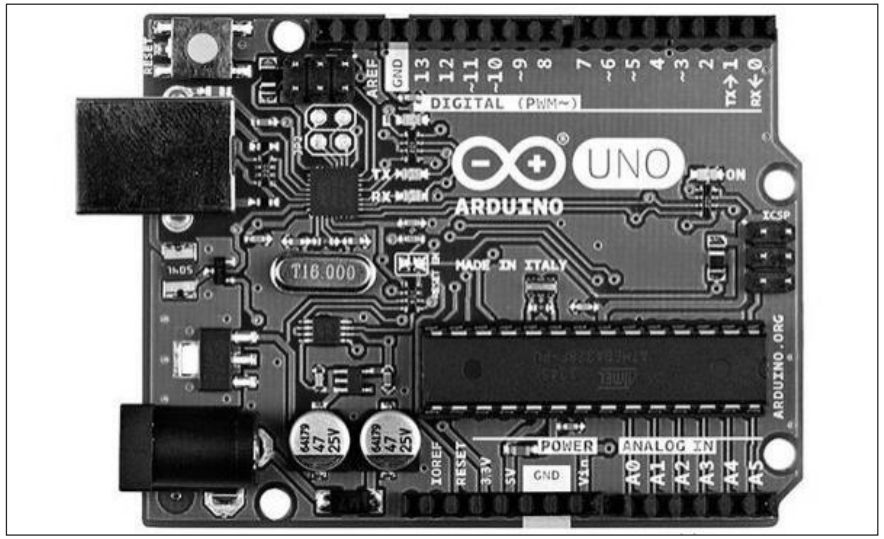
- Comes with a **Power Supply Socket**
- Powered through a regular power adaptor

Shields

- Features of boards can be extended by adding one or more shields
- Shields - **attachments** directly mounted on boards

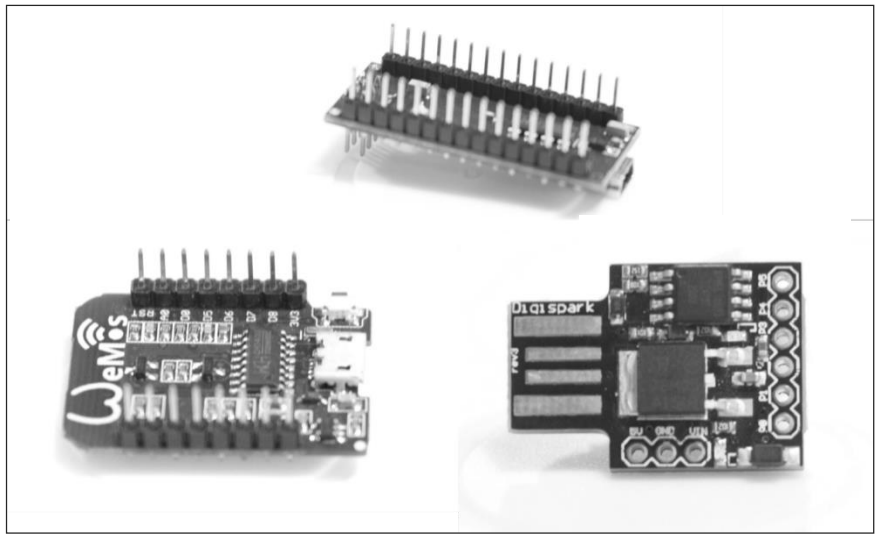
Arduino Boards - UNO

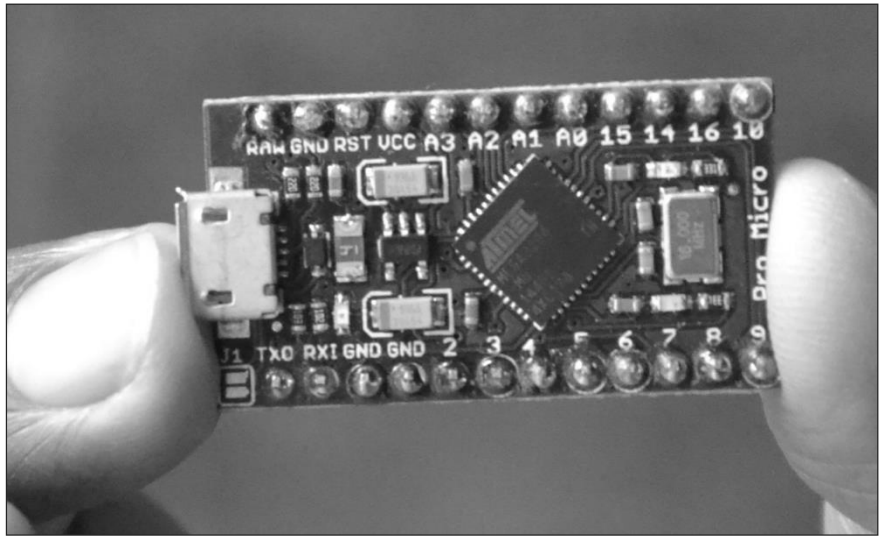




- Based on the ATmega328P (32 KB)
- **14 Digital** IO (6 PWM)
- **6 Analog** inputs
- Most commonly used Arduino board
- First in a series of USB Arduino boards
- Reference model for Arduino platform
- 'Uno' marked release 1.0 of Arduino IDE

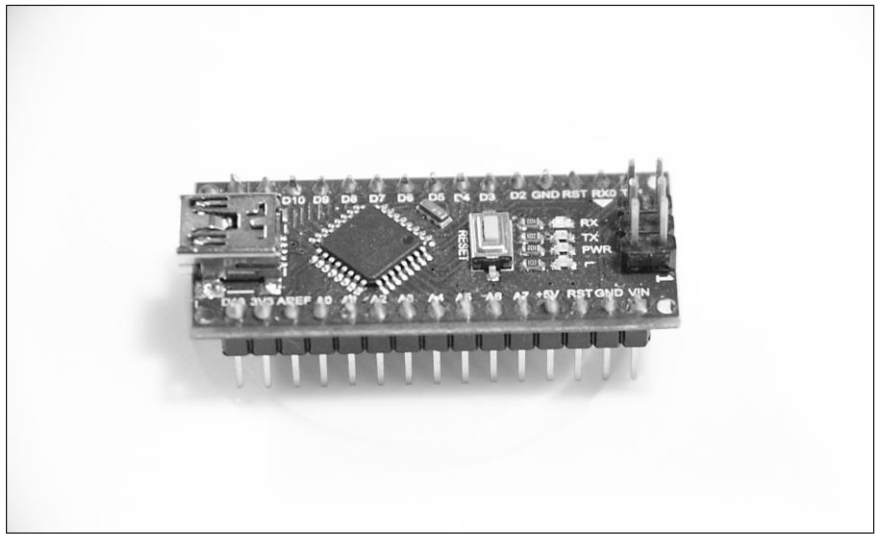
Modules





- Small in size
- Used for a specific function in a larger project
- Can be soldered directly on to a bigger PCB
- Can be mounted on a breadboard
- Cannot be used in conjunction with shields
- **Cost effective** and well suited for **rapid development**

Arduino Module - Nano



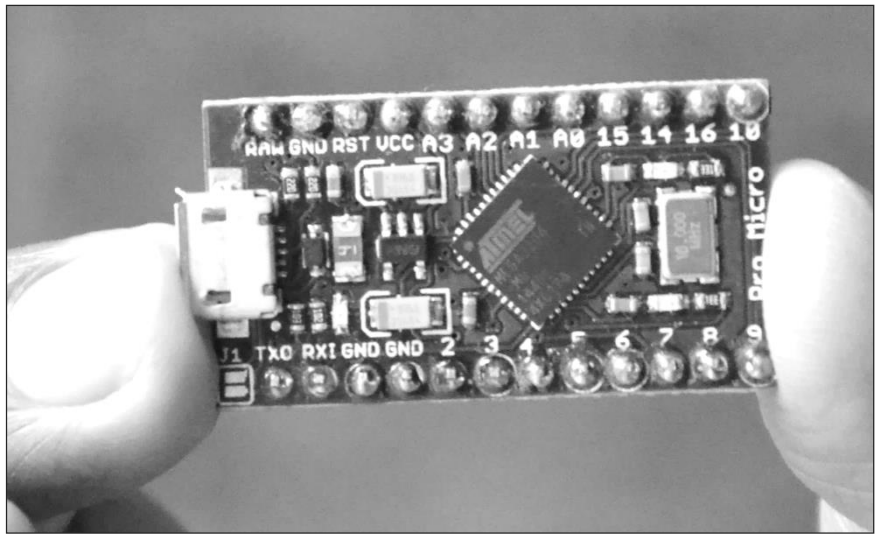
- Small
- Complete
- Breadboard friendly
- Inexpensive

- ATmega328P (32KB, v3.x)
  ATmega168P (16KB, v2.x)
- **18 Digital** IO (6 PWM)
- **8 Analog** inputs

Cannot be used in conjunction with Arduino shields

- Works with **Mini-B USB** cable
- Well suited for rapid development

Arduino Module - Micro

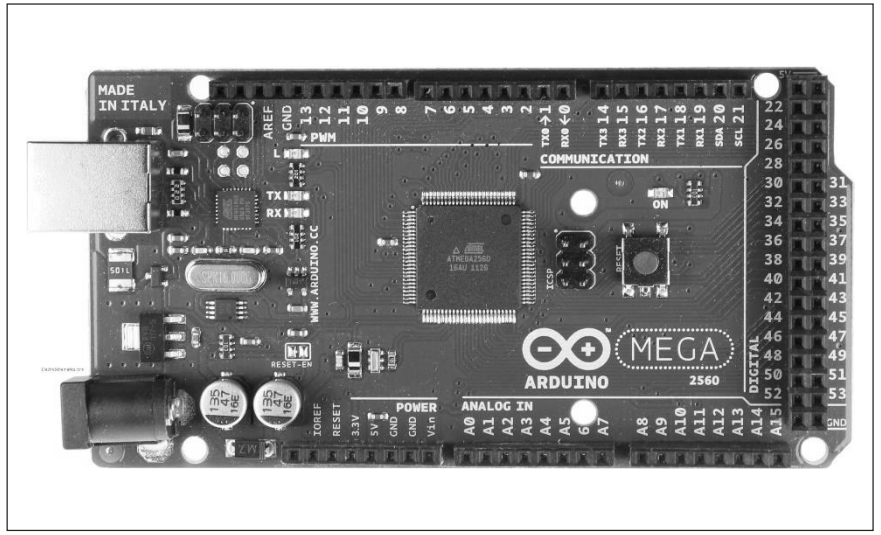


- ATmega32U4 (32KB, integrated USB)
- **20 Digital** IO
  - 7 PWM outputs
  - 12 Analog inputs

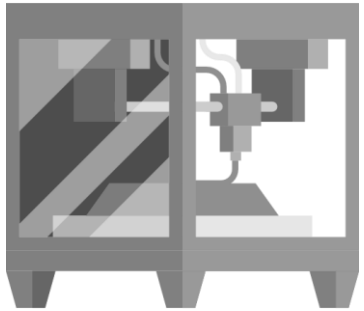
- Smallest Arduino module
- Breadboard-friendly
- **Built-in USB** communication (virtual serial, mouse & keyboard)

- Emulates keyboard & mouse from your sketch
- Works with micro USB cable

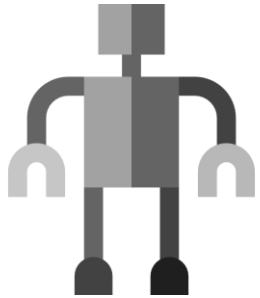
Arduino Module - Mega



- ATmega2560 (256 KB memory)
- **54 Digital** IO (15 PWM)
- **16 Analog** inputs
- **4 UARTs**
- **Bluetooth** module



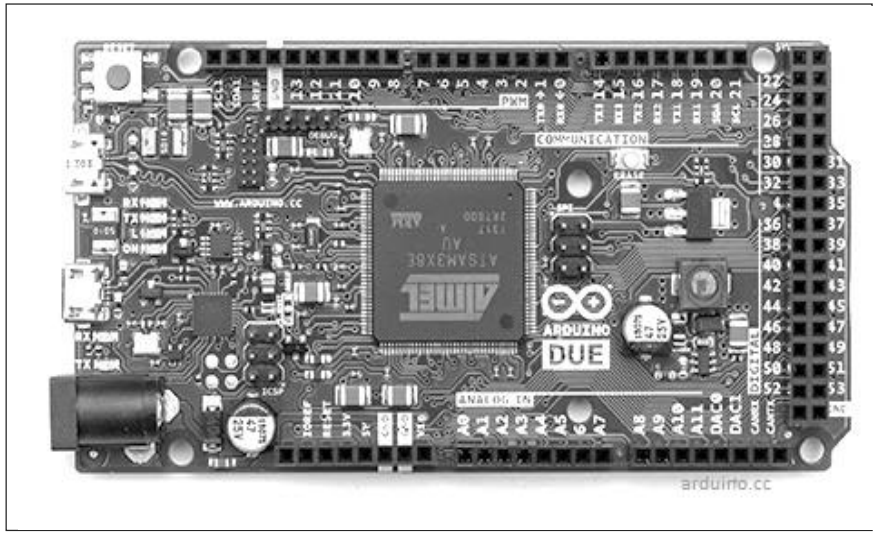
3D Printers



Robotics Project

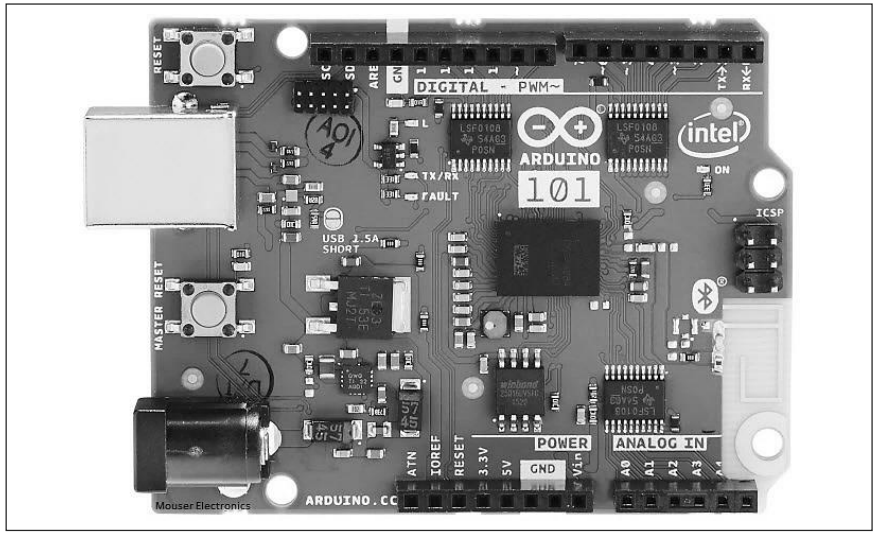
- Used in 3D printers, robotics
- Compatible with most shields designed for the Uno

Arduino Module - Due



- 32-bit **ARM Cortex** - M3 CPU
  - 84 MHz
  - 256-512 KB embedded flash
  - **MPU** - memory protection unit makes it possible to run high level operating systems such as LINUX
- **54 Digital IO** (12 PWM)
- **12 Analog**, 4 UARTs, 2 DACs
- Works at **3.3V**
- Applying voltage higher than 3.3 volts to any of the IO pins could **damage the board**
- Compatible with all Arduino shields that work at 3.3V

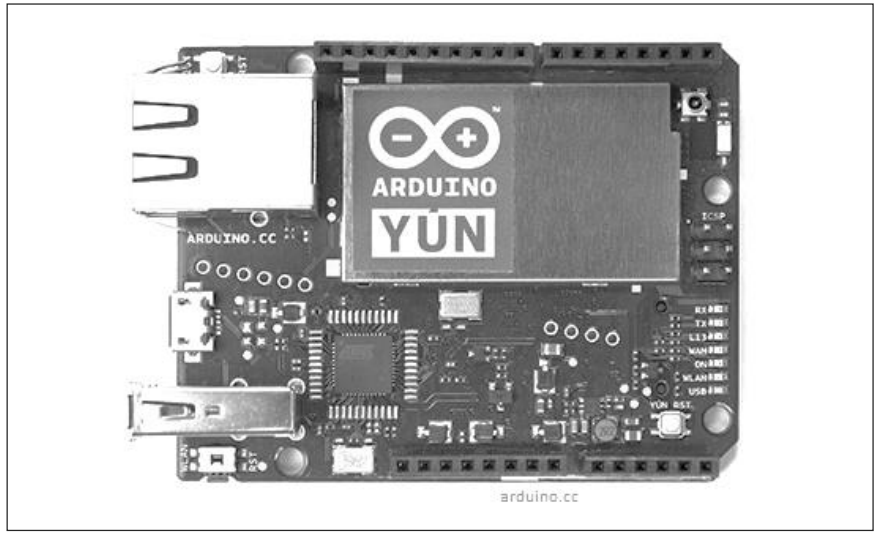
Arduino Module - 101



The intel tool chain compiles the Arduino sketch optimally across both cores to accomplish the most demanding tasks

- Based on **Intel Curie module**
  - x86 (Quark) + 32-bit ARC - clocked at 32 MHz
- Integrated **BLE**
- Integrated 6-axis **Accelerometer, Gyroscope**
- **Bluetooth** connectivity
- **20 Digital IO**
  - 4 PWM output
  - 6 Analog inputs
- Keeps the same form factor as UNO
- Works at **3.3 V**
  - Protected against **5 V overvoltage**
  - Outputs from pins maxes out the 3.3 V

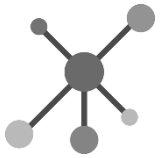
Arduino Module - Yún

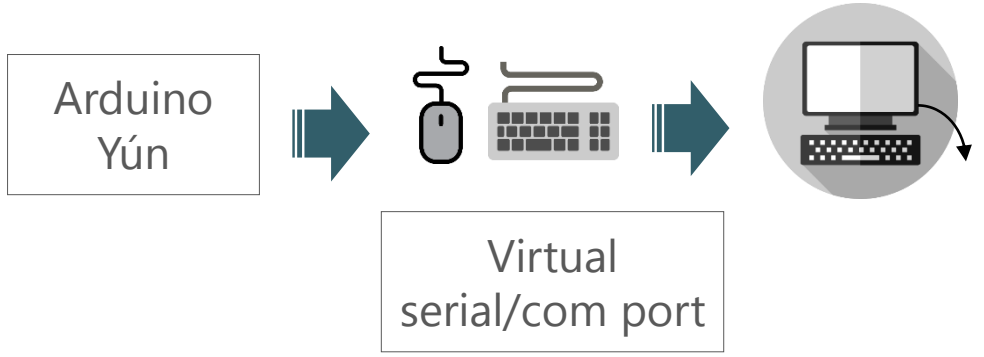


- Designed for connected devices and IOT projects
- ATmega32U4 + Atheros AR9331
- Atheros processor supports LINUX distribution based on open WRT - **OpenWrt- Yún**
- In addition to LINUX commands like **cURL**, shell scripts and python scripts can be written for robust interactions
- Built-in Ethernet & Wi-Fi support
- USB-A (host) port
- Micro-SD card slot

Power of LINUX

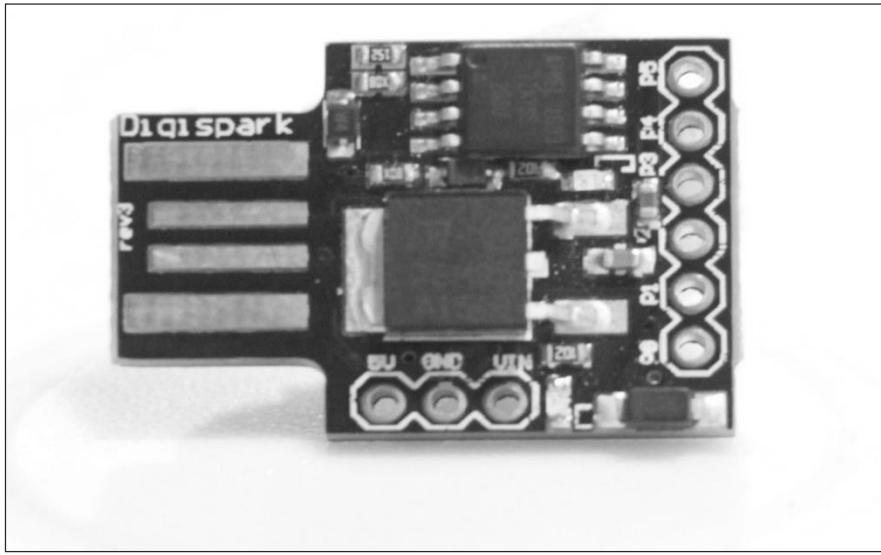
Ease of use of Arduino

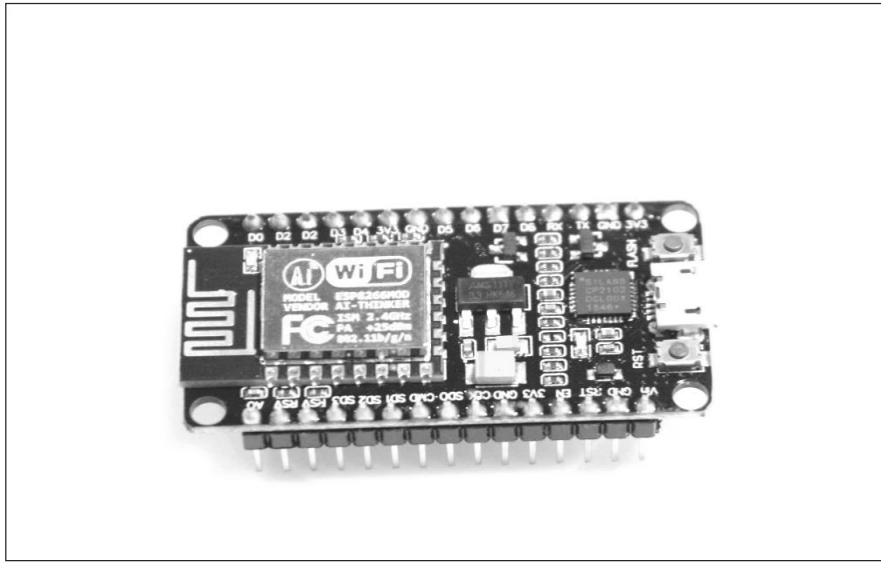




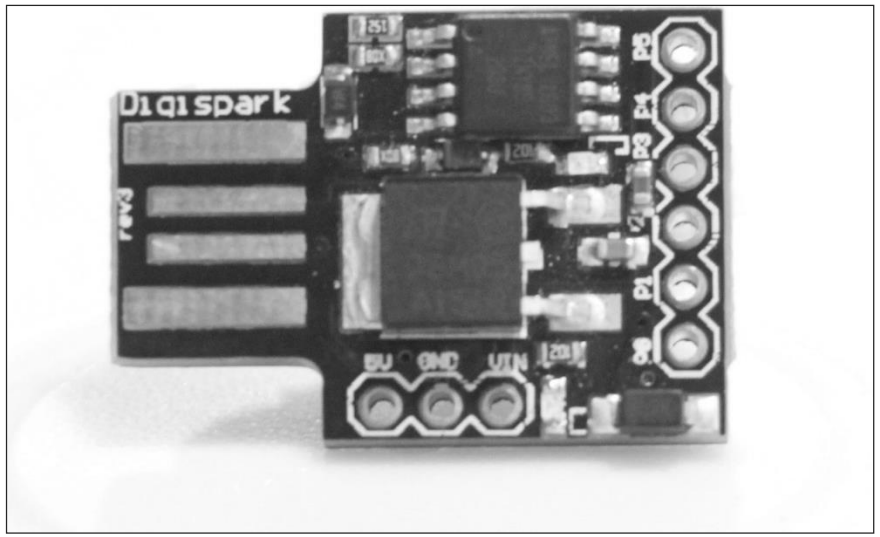
Non-official Arduino boards

- Non-official boards **compatible** with Arduino IDE
- Can be programmed with the **same ease** as Arduino boards





Digispark USB Development Board



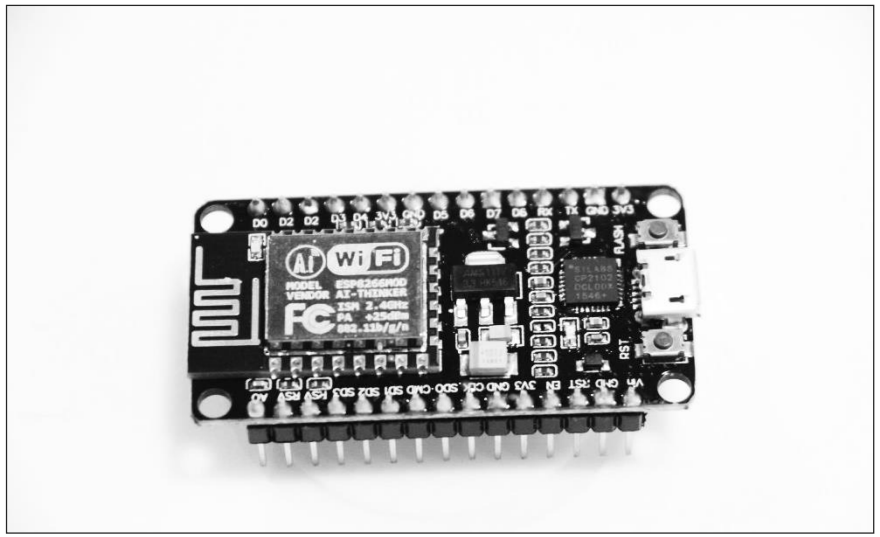
Made by **Digistump**

- ATtiny85 (8 Pins)
- **6 Digital** IO

- Simple board
  - A regulator
  - An on-board LED

- Directly connects to **USB-A connector**
- Uses **V-USB** - a software-only implementation of a low-speed USB device
- Emulates a keyboard or a mouse from the sketch
- Similar to other arduino boards but much cheaper, smaller and less powerful

NodeMCU Development Kit



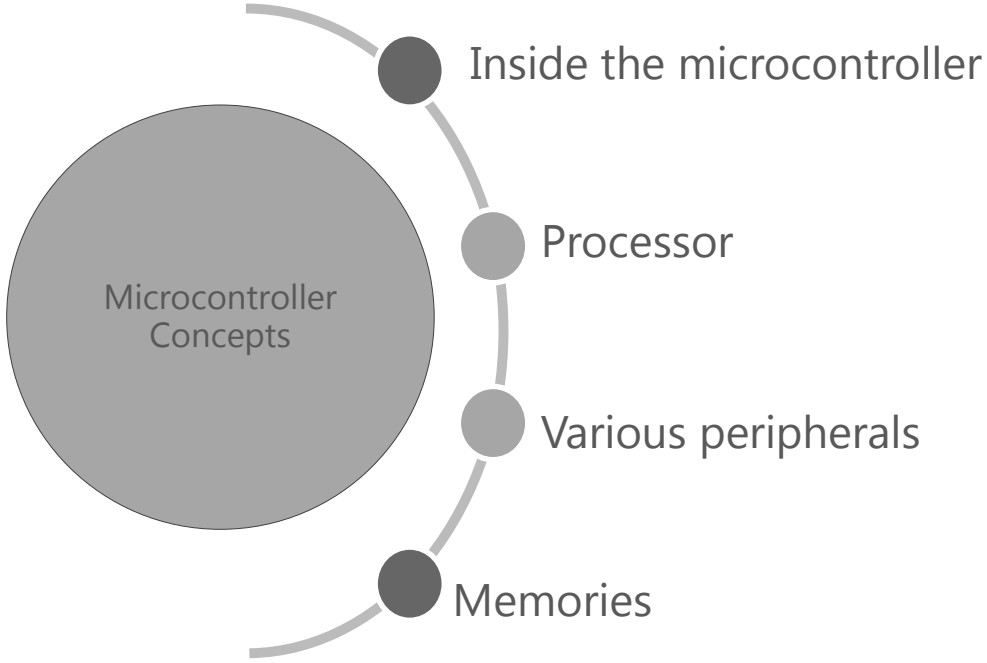
ESP8266 platform package comes with libraries to communicate over Wi-Fi (using TCP and UDP, set up HTTP, mDNS, SSDP, and DNS servers)

- **ESP8266 Wi-Fi MCU** (RISC architecture)
- Low cost
- Wi-Fi SoC
- 80 MHz RISC processor
- 96KB Data RAM
- 4MB Flash
- **11 Digital** IO (10 PWM)
- **1 Analog** input

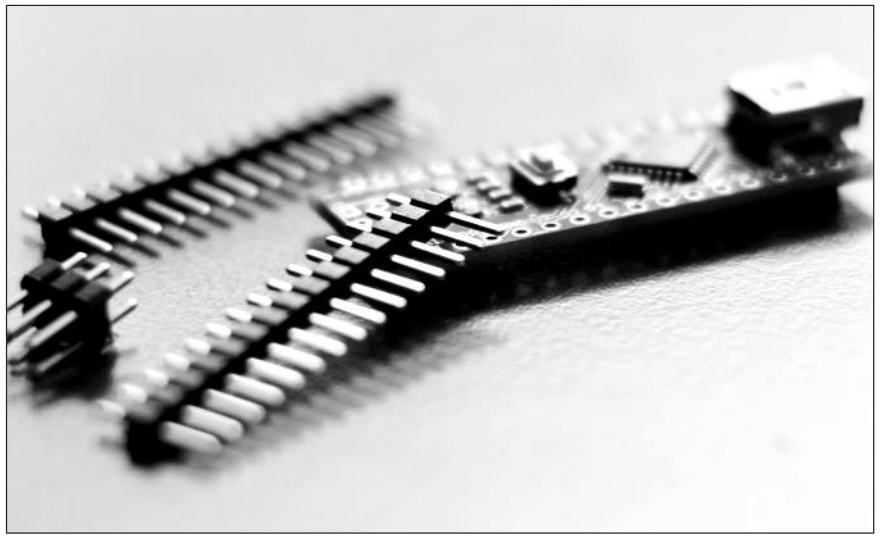
- **Wi-Fi module**
- Works at **3.3V**
- Compatible with Arduino IDE
- Uses a file system in flash memory, work with SD cards, servos, SPI and I2C peripherals

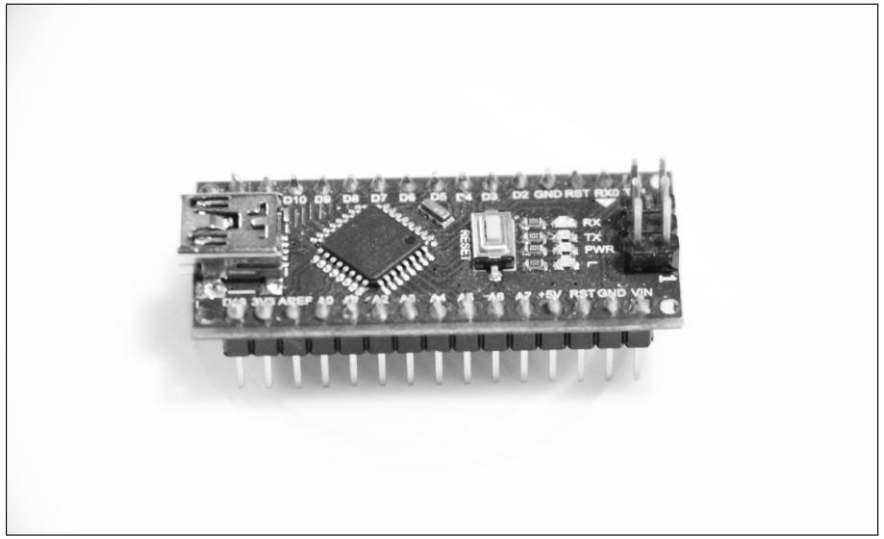
Microcontroller Concepts 1

Microcontroller Concepts

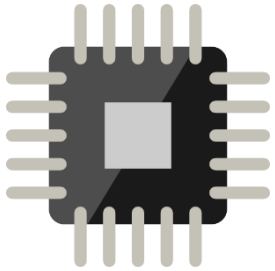


Inside Arduino Nano





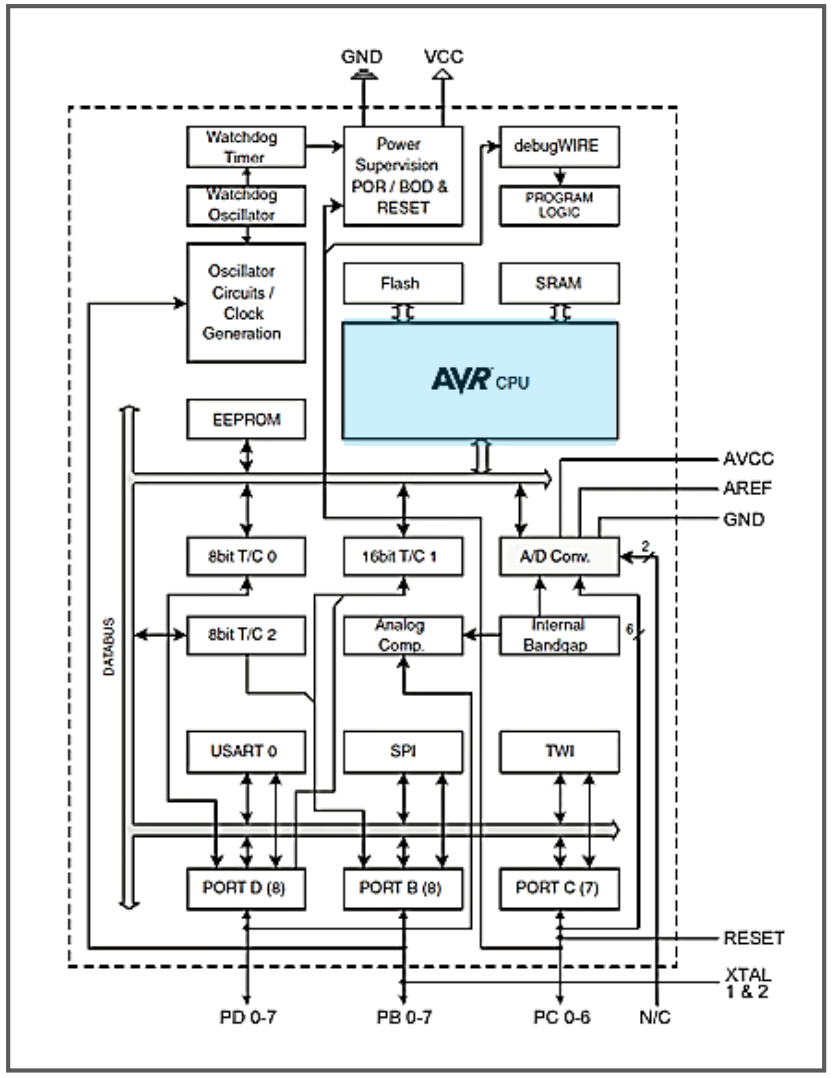
- Microcontroller inside the Arduino - **Atmega328T**
- Designed by Atmel



Atmega328T

- Microcontroller concepts are broadly applicable to other microcontrollers

Atmega328T – Block Diagram



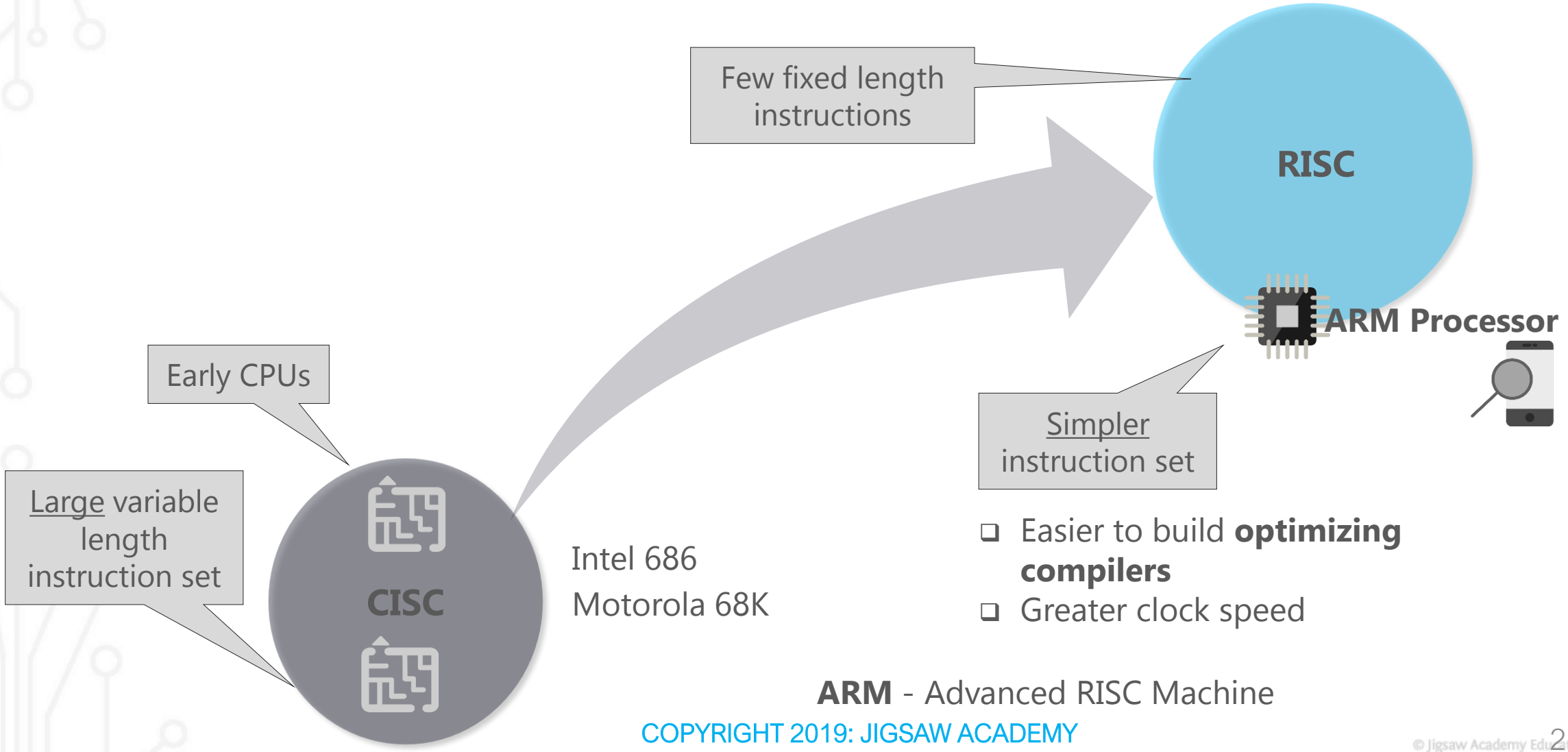
Block Diagram

Schematic representation of the components inside a microcontroller

CPU

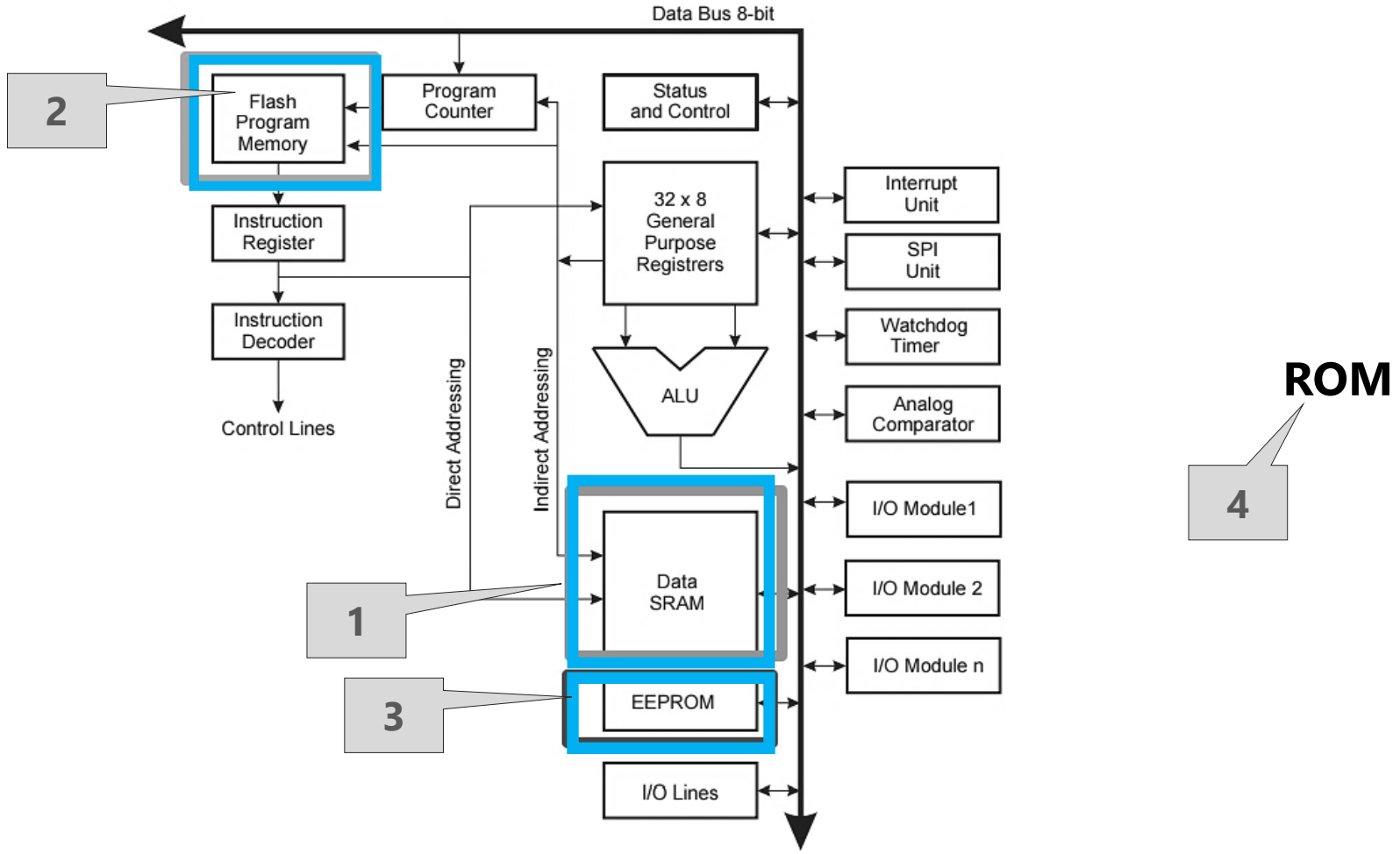
- Where the program runs
- Where the compiler translates code to a series of machine instructions
- Execution of those instructions
- Heart of the machine

CPU Architecture



ARM - Advanced RISC Machine

Memories



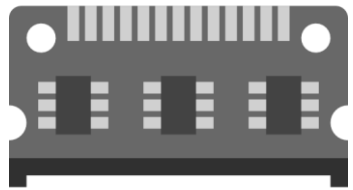
Memories

Memory	Volatile?	Read/Write?	Applications
SRAM	Yes	Yes	Used for data, constants, stack
Flash	No	Yes	Needs to be erased and written in blocks from host. Used for code (program memory)
EEPROM	No	Yes	Needs to be written using special instructions. Used for configuration (user settings
ROM	No	No	Fixed when chip is manufactured. Used for bootloader and commonly used code

Why Static?

SRAM- Static Random Access Memory

- Where all the data needed by the code is kept
- Can both read and write to it with no restriction
- **Volatile -** All contents are lost when power is switched off



Dynamic RAM - needs to be refreshed periodically, else all its contents will be lost

Static RAM - does not require a refresh cycle
Better, faster, but bulkier

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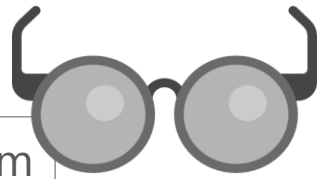
Flash

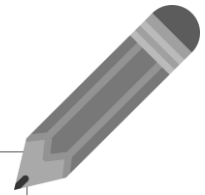
- Contents are not erased when power is turned off
- Can **write** to it but the **write** needs to happen in a special sequence
- An entire block of memory (typically 4 KB or 2 KB) has to be erased and then rewritten in one shot - relatively slow

Memories

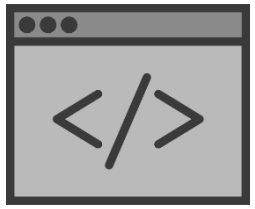
Flash Memory



Program

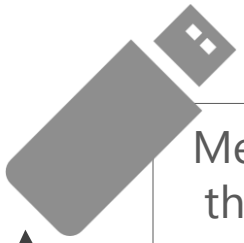


Programming Tool

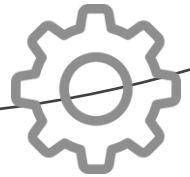


Compile code on Ardunio IDE

Upload sketch



Memory gets re-written with the code and constant data



AVR CPU

The only way to change flash content is through the host PC or using a dedicated external programmer

Memories

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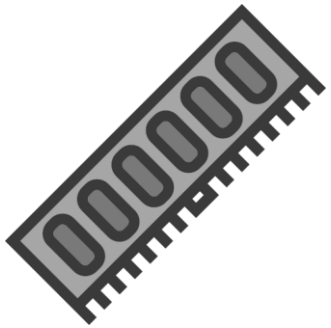
EPROM - Electrically Erasable Programmable Read Only Memory

- Can write individual bytes to it; can be done from the program
- Typically used for storing configuration value



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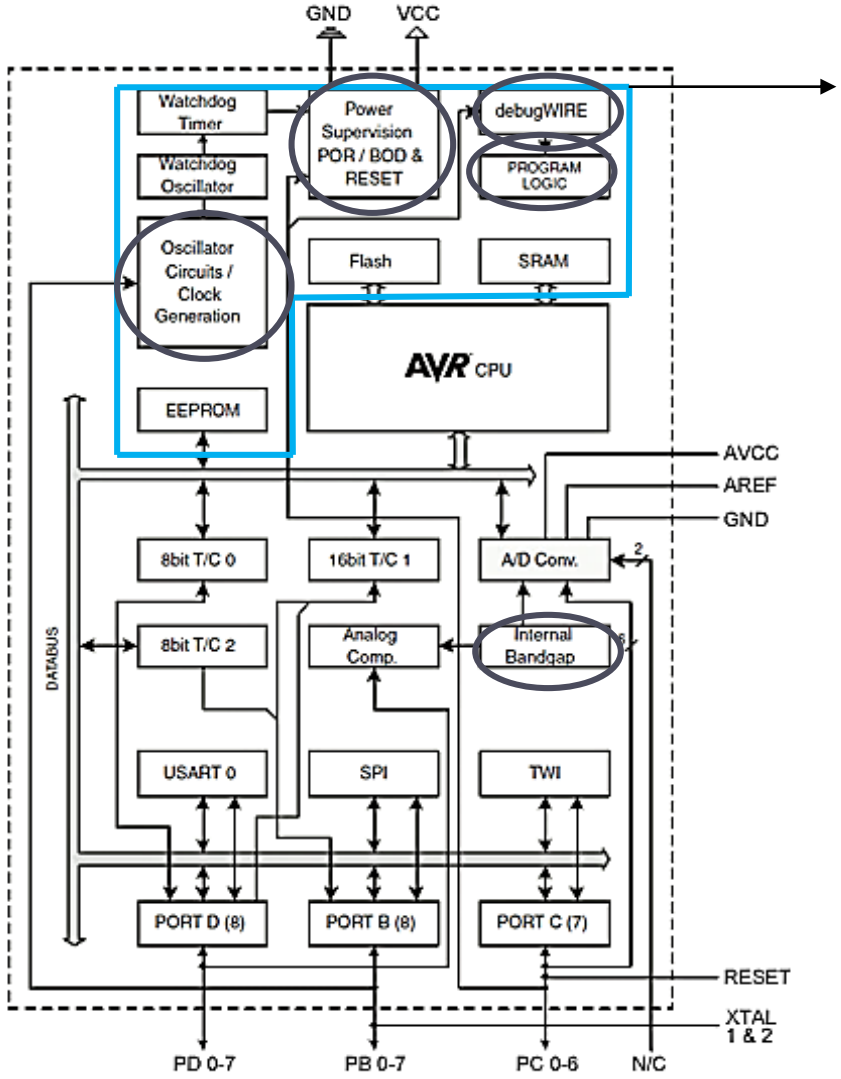
ROM - Read Only Memory

- Data that is built into the chip and can never be rewritten or changed in any way

Bootloader Atmega's data sheet does not explain this

Functions in ROM are exposed to user codes - certain library functions can be placed in ROM

Microcontroller Peripherals

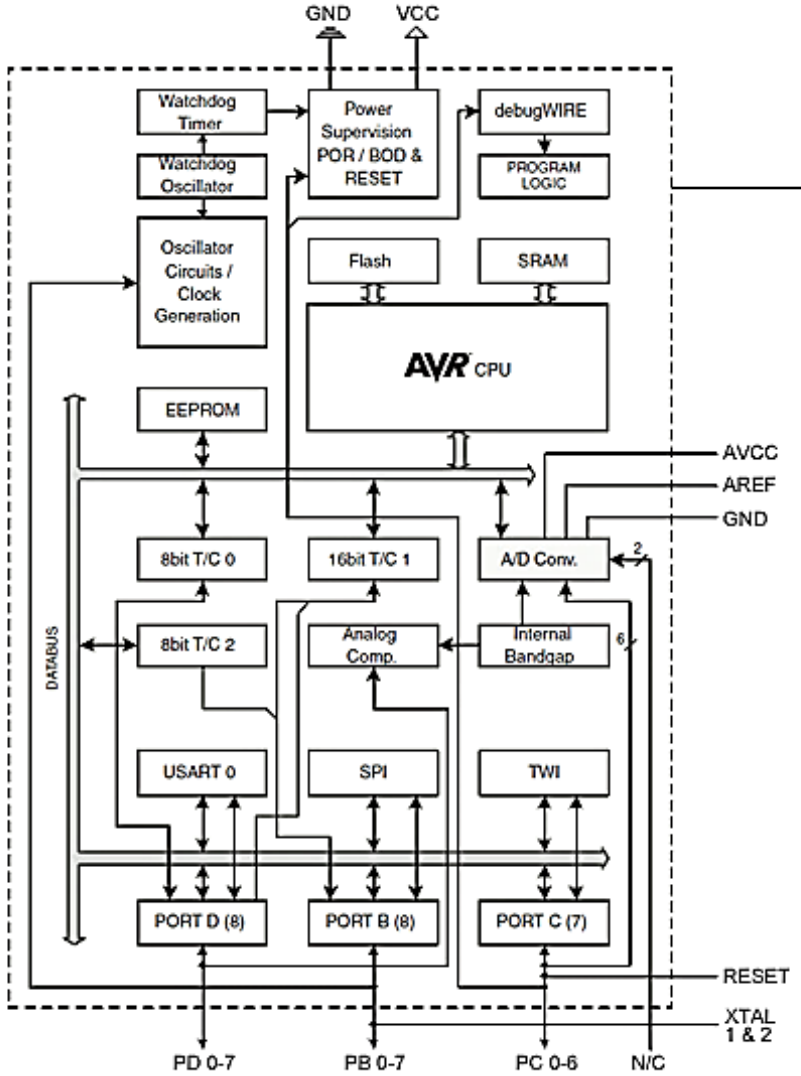


Peripherals

- Clock Generation
- Debug
- Program Logic
- Power Supervision
- Internal Bandgap

No reason to control the Peripherals

Microcontroller Peripherals



Input Output Peripherals - IO peripherals

- Each microcontroller comes with its own unique set of peripherals - based on what its application

Touch Screen

Display Controllers

- Specialized peripherals for connectivity and communication

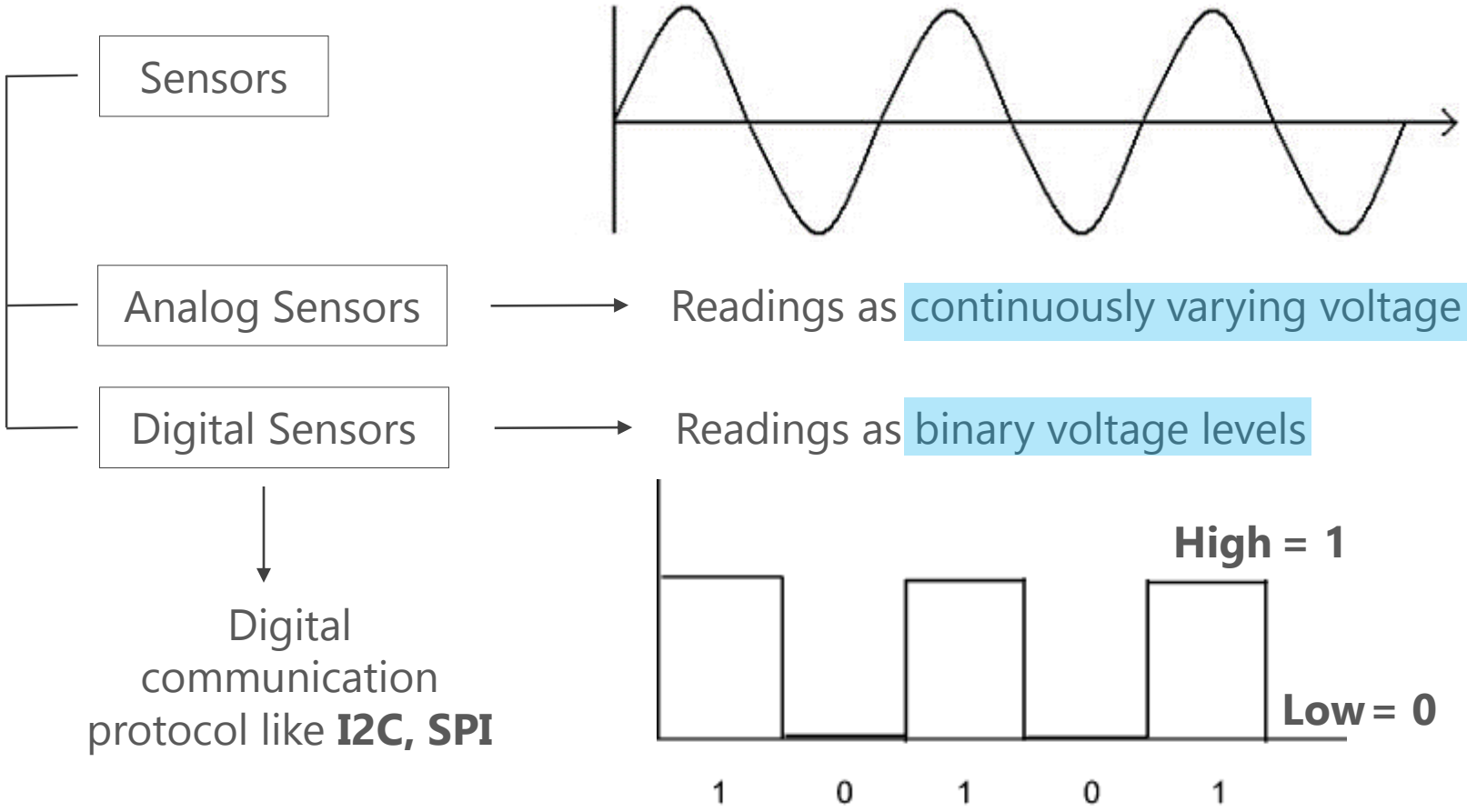
Ethernet

RS432

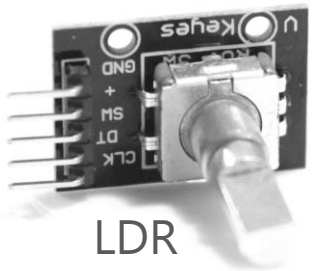
UART

USB

Types of Sensors



LDR or Light Dependent Resistor



LDR

Photo resistor made of a material whose **resistivity** is a function of the intensity of light incident on it

Automatic
- Street lights
- Pathway lights

Turns ON in dark and turns OFF in light

Sensor Modules

Advantages

Integrates necessary external components

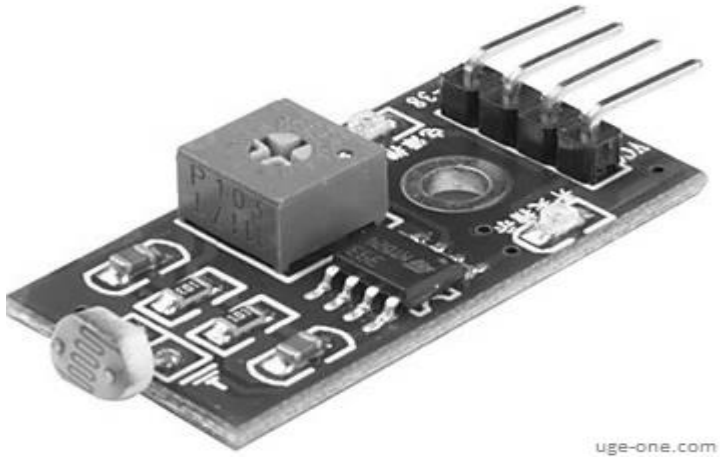
Saves the trouble of procuring components and assembling circuitry

Breadboard-friendly

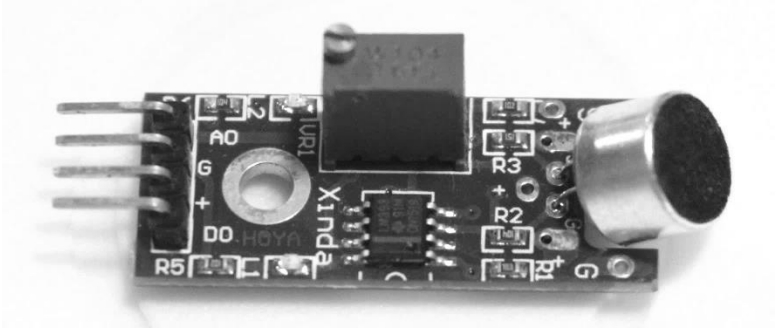
- Pins fit in standard breadboards easily
- Pins can be directly connected to a controller

Additional value added functions

- E.g.: Threshold output in LDR
- Without sacrificing any flexibility
- Good to have features, for use with low power microcontrollers

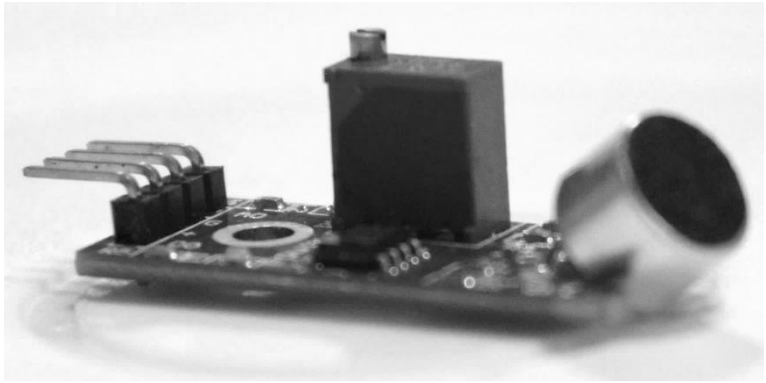


Microphone Module

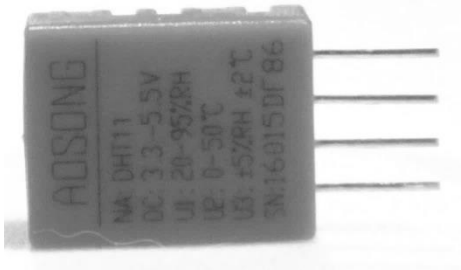


High or Low output depending upon the intensity of the sound

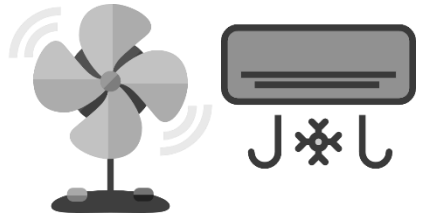
Module incorporates all external circuitry needed for the microphone to measure sound



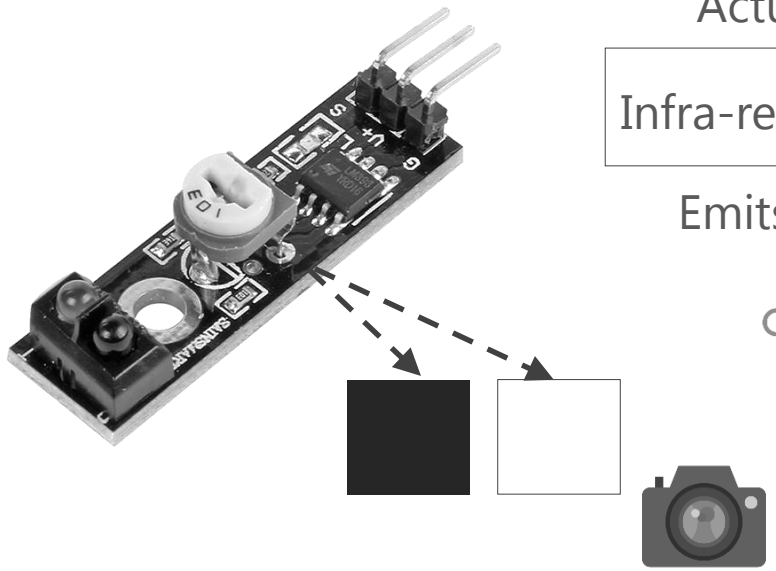
DHT11 Sensor



- Used to measure temperature and relative humidity in its surrounding area
- Uses a proprietary, 1-wire protocol for communication
- Libraries for taking readings from this sensor are readily available for Arduino and other controllers
- Typically used in household applications



Tracking Sensor



Actuator

Infra-red (IR) LED

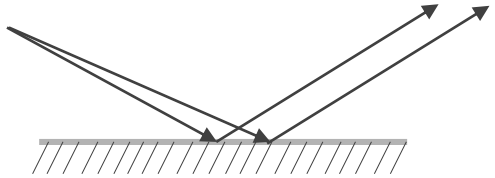
Emits IR light

Sensor

IR Photo Diode

Matching Wavelength

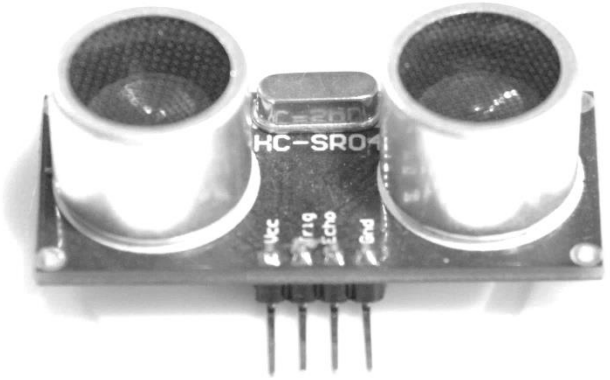
Measures amount of light reflected from nearby surface



High Accuracy

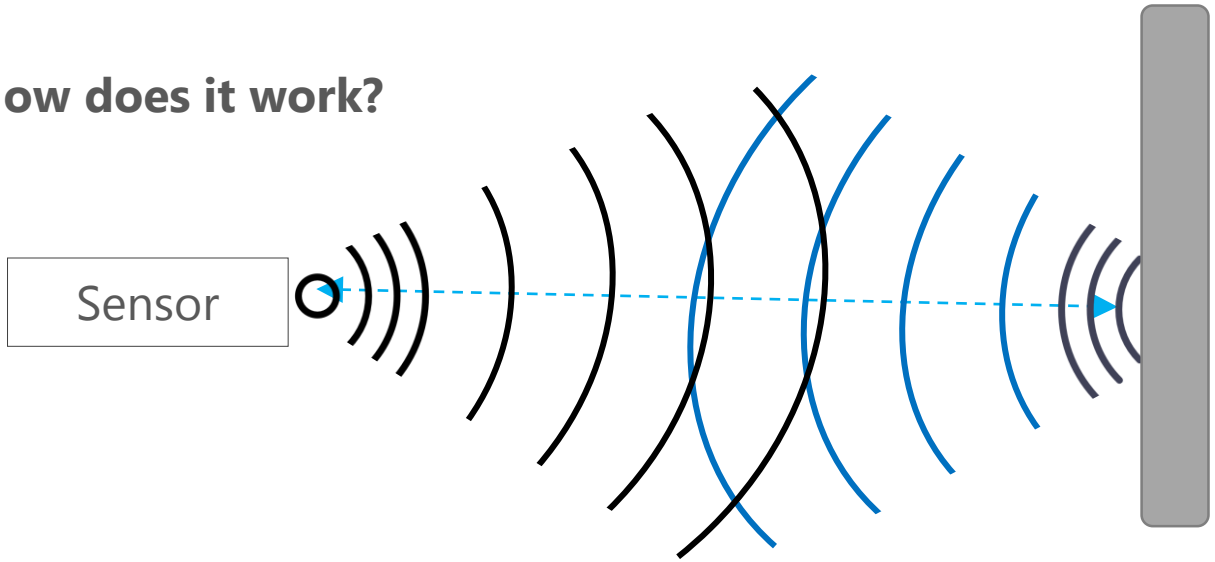
This mechanism can be used to detect an object within 1mm to 3cm from the sensor

Ultrasonic Distance Sensor



- Used to find distance of an object within 3cm to 70cm range
- Longer range than IR sensor but does not require a black line on floor

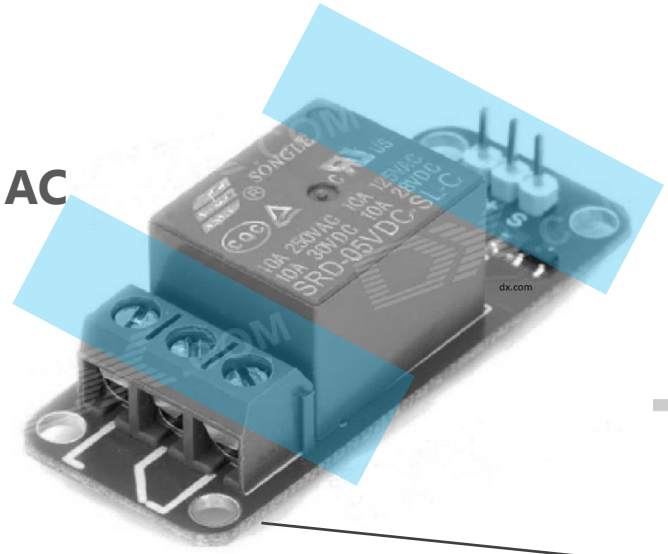
How does it work?



- Time measured is converted to distance
- Used for **obstacle detection**, **gesture detection** or a simple **contact-less counter**

Relay Module

240 V AC



Interfaces with the controller - operates at **5 V or 12 V**

- Controls high-voltage electrical appliances from a low-voltage controller
- Widely used in Home & Industrial Automation

Summary

Sensor Modules	Type	Applications
LDR	Analog	Automatic room/path lights, Burglar alarm
Microphone Module	Digital	Presence detection, 'Clap' controlled devices
DHT11	Digital	Home automation, Personal weather station
Magnetic Sensors	Digital	Door Alarms
Tracking Sensor	Digital	Contact-less switch, Line follower robot
Ultrasonic Distance Sensor	Digital	Gesture Detection, Industrial Automation
Motion Detection	Digital	Smart Lights, Surveillance Systems