ROB - Basics lab

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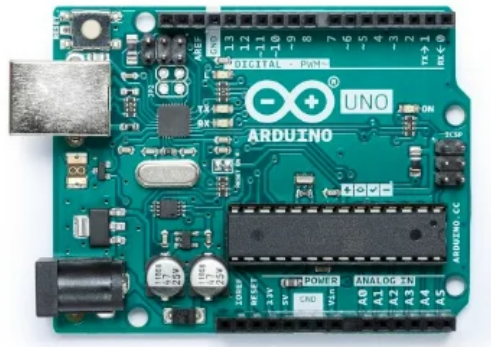
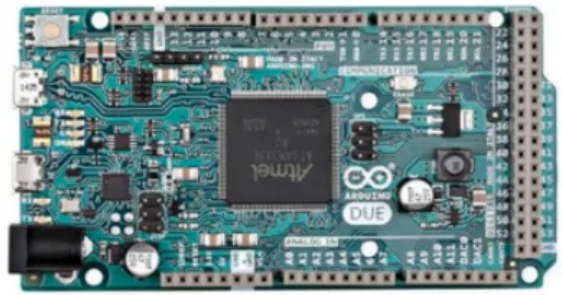
Today's lab will be focused on Basics of Arduino. You will learn

- Creating and uploading code for Arduino
- Prototyping electronic circuits using breadboard
- Reading and Writing digital signal
- Reading and Writing analog signal

What is Arduino

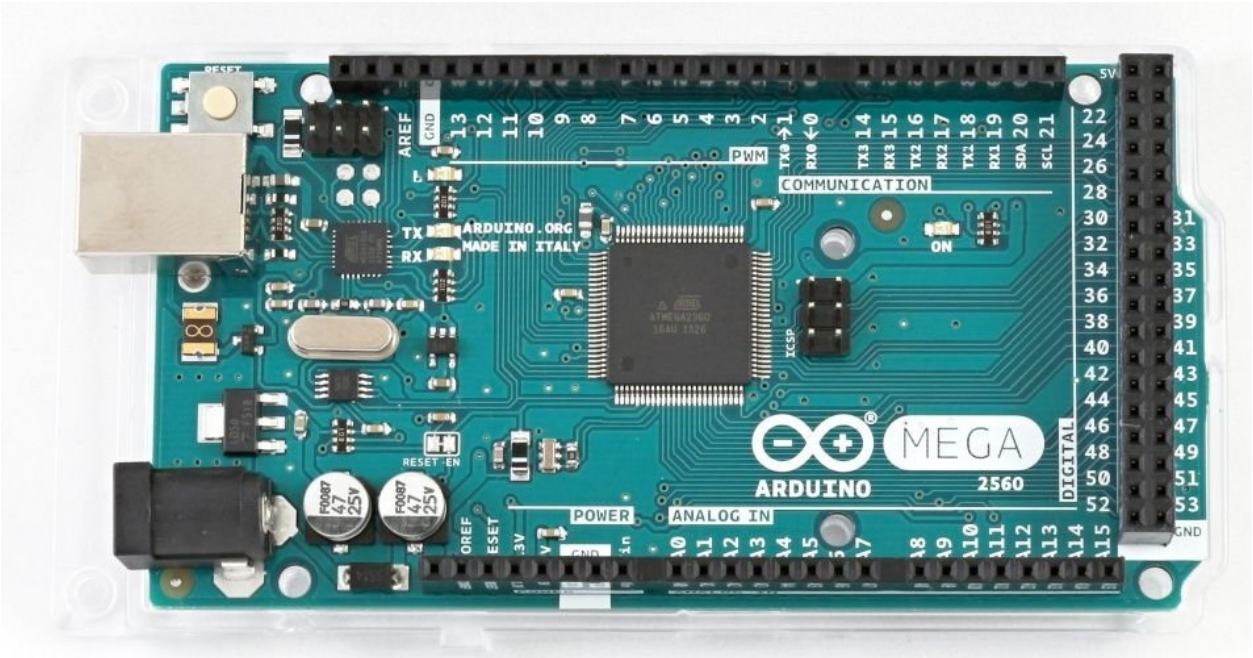
- Arduino is set of open source hardware and software projects used for fast prototyping of electronics circuits
- Lots of boards - Arduino Mega, Arudino Uno, Arduino Nano, Arduino Micro, Arduino Zero ...
- Supports a lot of kits, shields, sensors, tools, accessories.
- `https://www.arduino.cc`



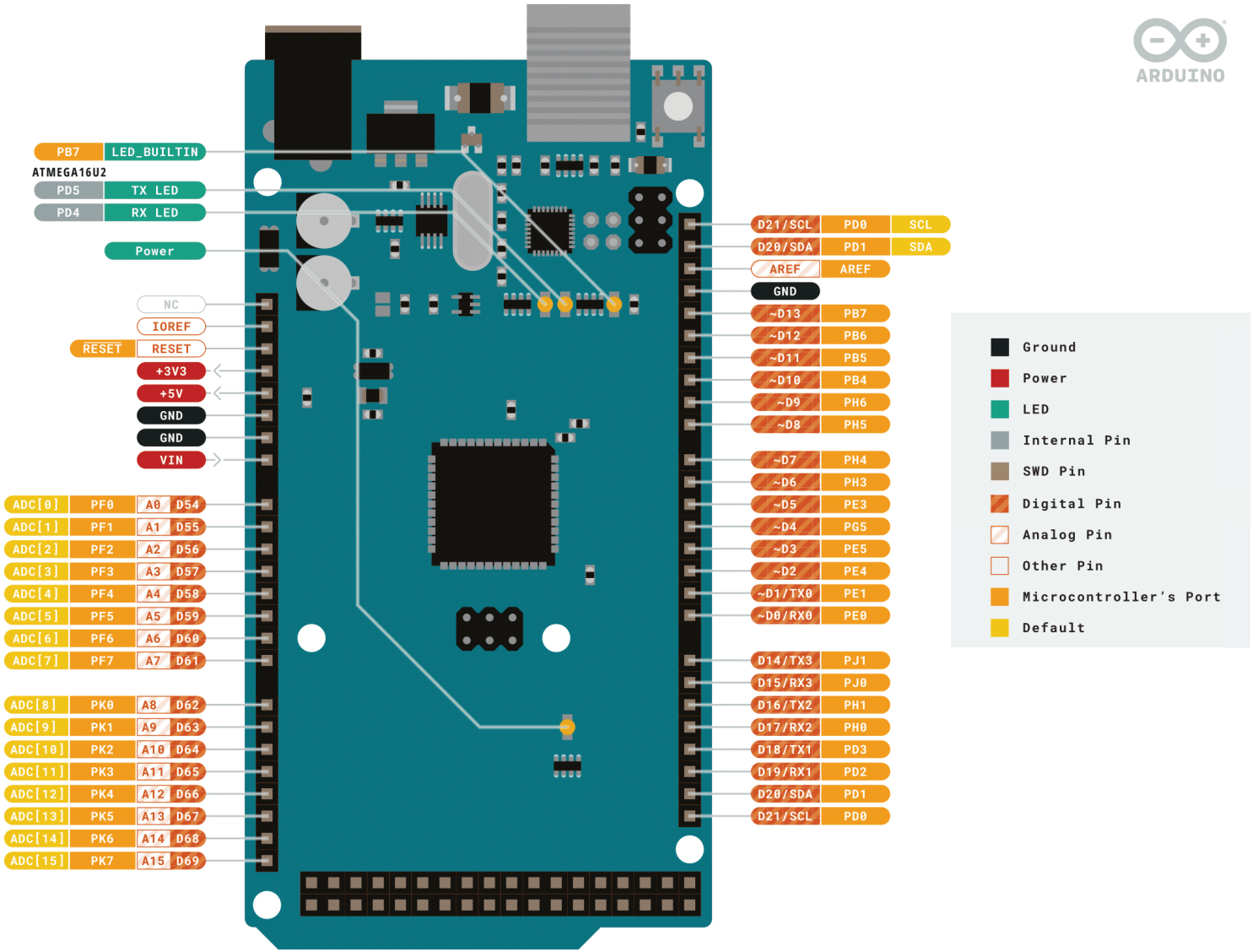


Arduino board used in this lab is Arduino Mega. It consists of:

- 16MHz ATmega2560 processor
- 54 Digital I/O Pins (of which 15 provide PWM output)
- 16 Analog Input Pins
- 256 KB Flash, 8 KB SRAM, 4 KB EEPROM
- Built in LED at pin 13



- https://store.arduino.cc/products/arduino-mega-2560-rev3



- For programming Arduino boards, you need to know c/c++
- https://www.arduino.cc/reference/en/

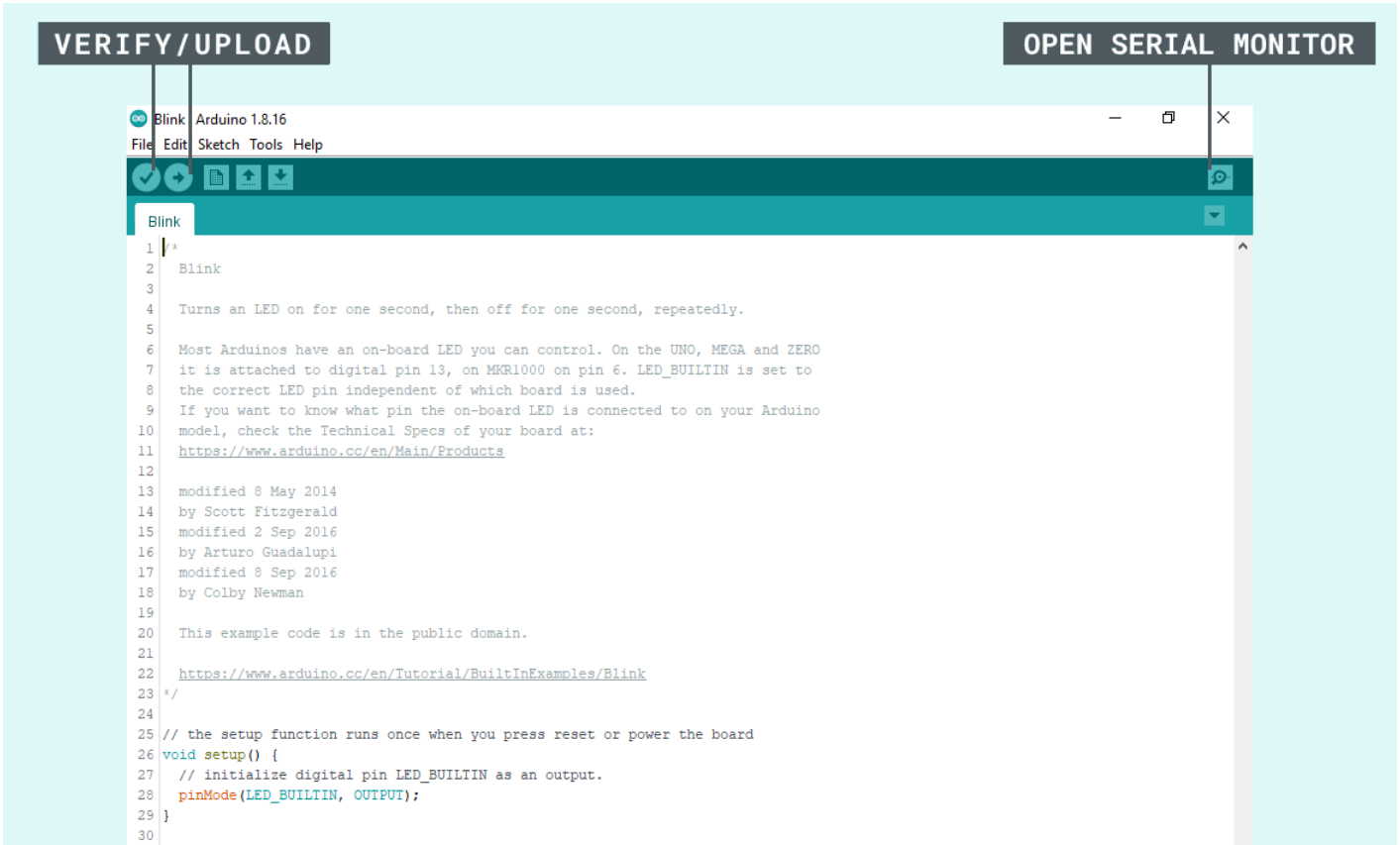
```
// If condition

int x = 0;
if(x == 10){
  do_something();
}else{
  do_something_else();
}
```

```
// For loop

for(int i=0; i < 10; i++){
  do_something();
}
```

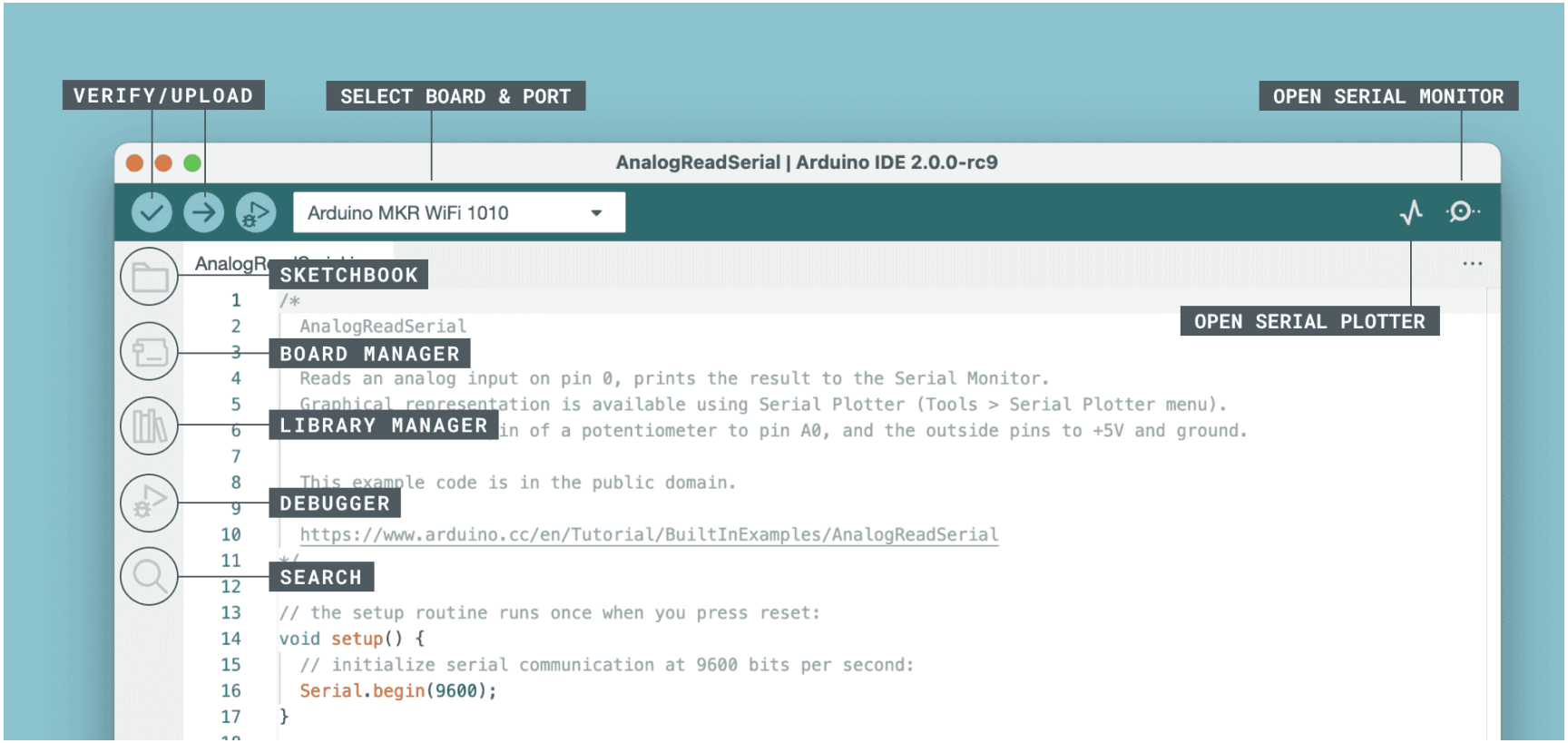
```
// While loop

int i = 0;
while(i < 10){
  do_something();
  i++;
}
```

Arduino IDE

- Arduino IDE is used for programming Arduino boards.
- Old looking but well functional
- Good for fast prototyping, but harder to use for bigger projects.

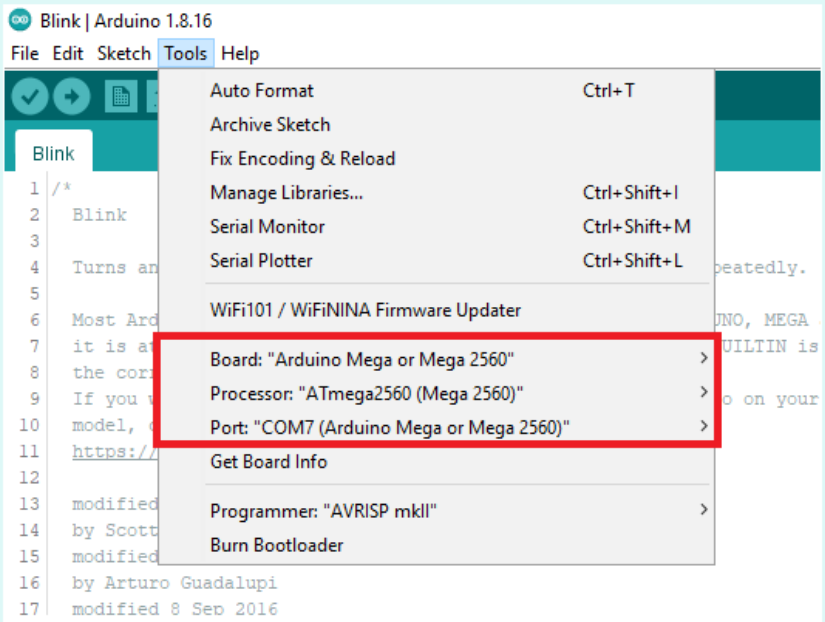


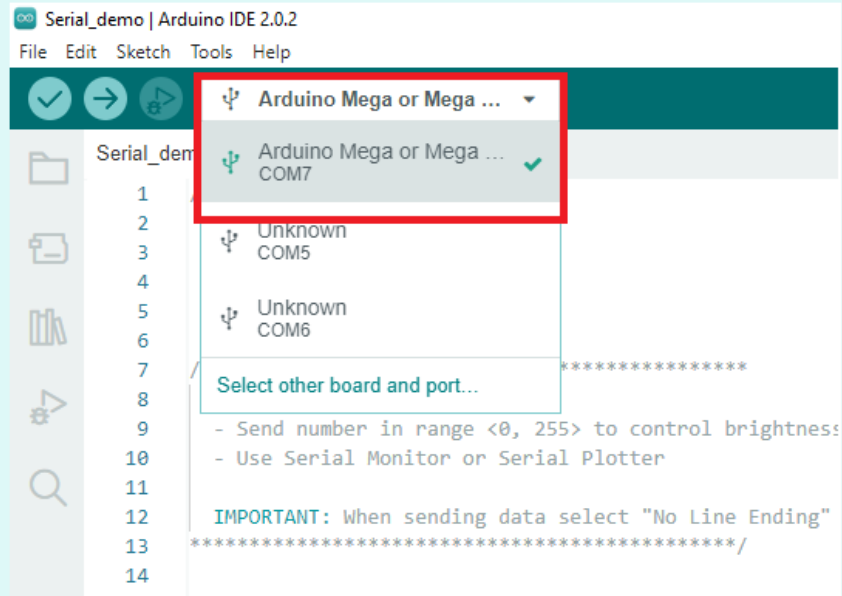
- Better looking than classic Arduino IDE
- Newer but still little bit buggy



Arduino IDE - before start

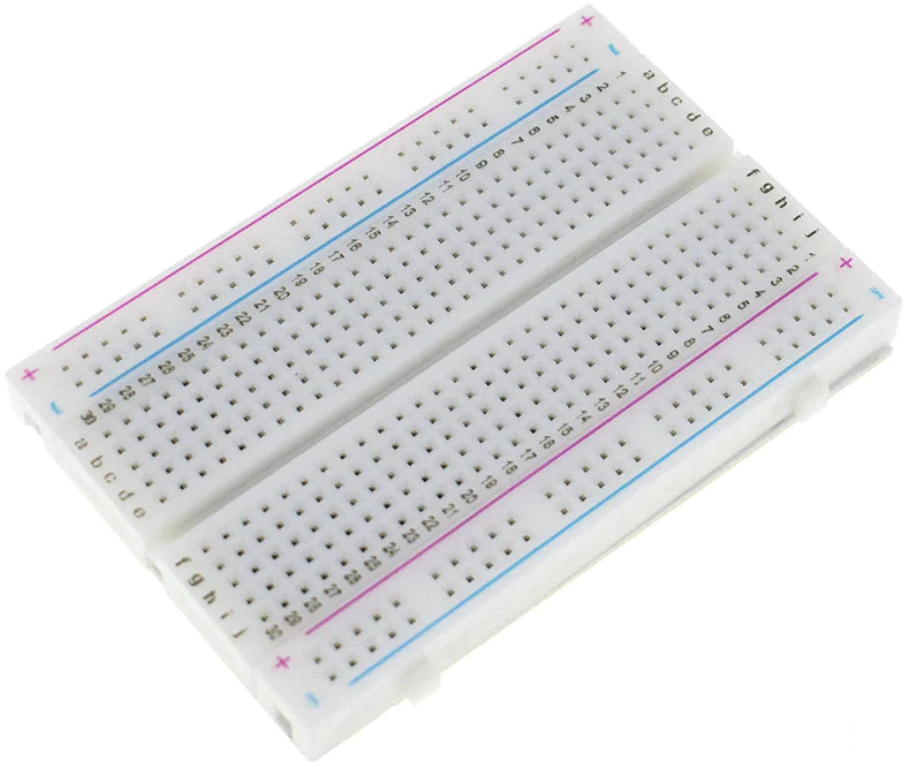
- Before uploading, check if there is correct Port and Board selected. Otherwise, you won't be able to upload code to Arduino.
- For this lab, you should have selected Arduino Mega





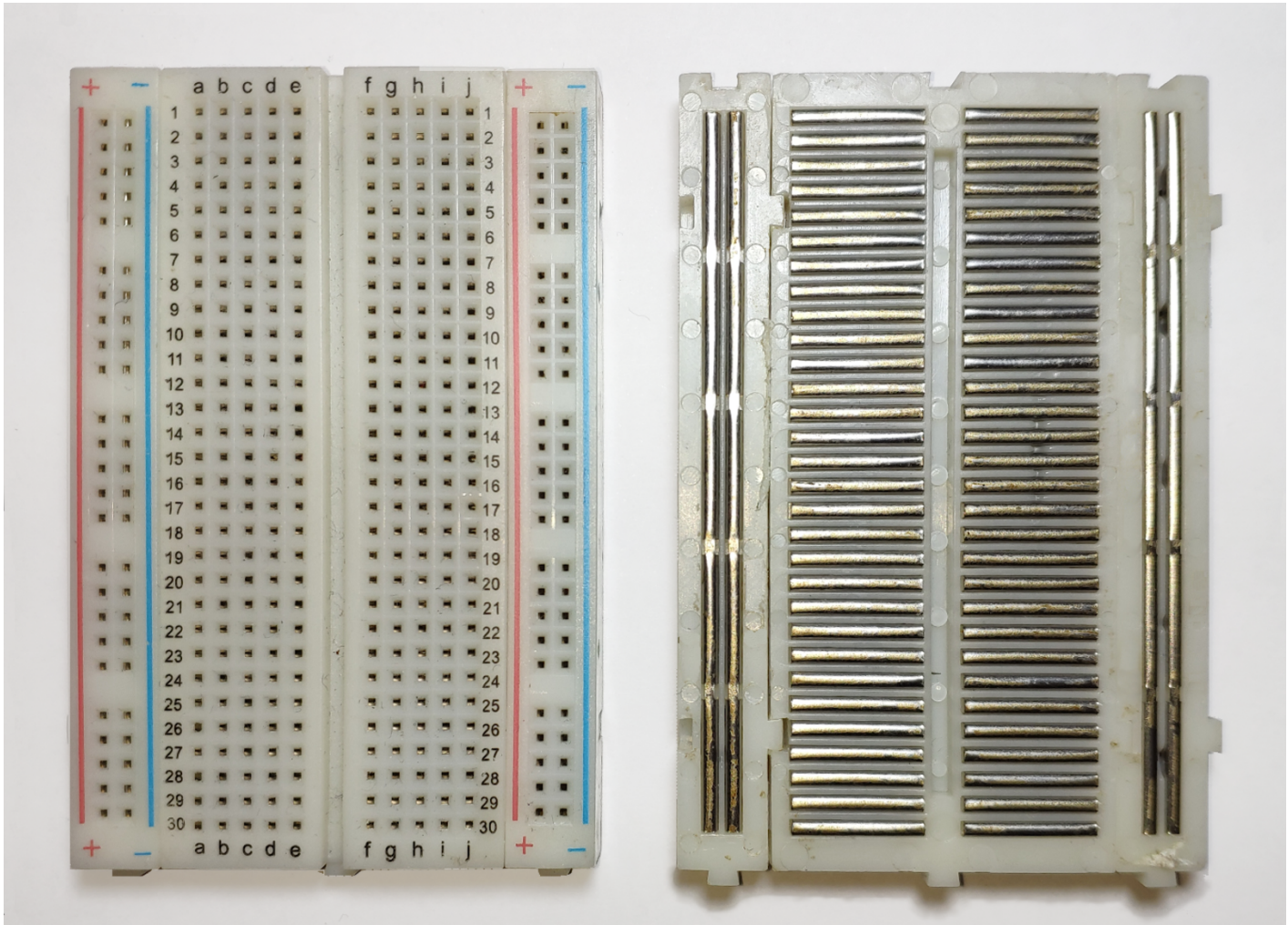
Breadboard

- Breadboard is used for prototyping electrical circuits
- Does not need soldering
- Every standard "trough hole" component can be fit into breadboard
- Does not support SMD



Breadboard - How it works

- Breadboard consists of 2 types of rails: Horizontal and Vertical
- Horizontal rails are used for any electrical parts
- Vertical rails are used for power supply and ground



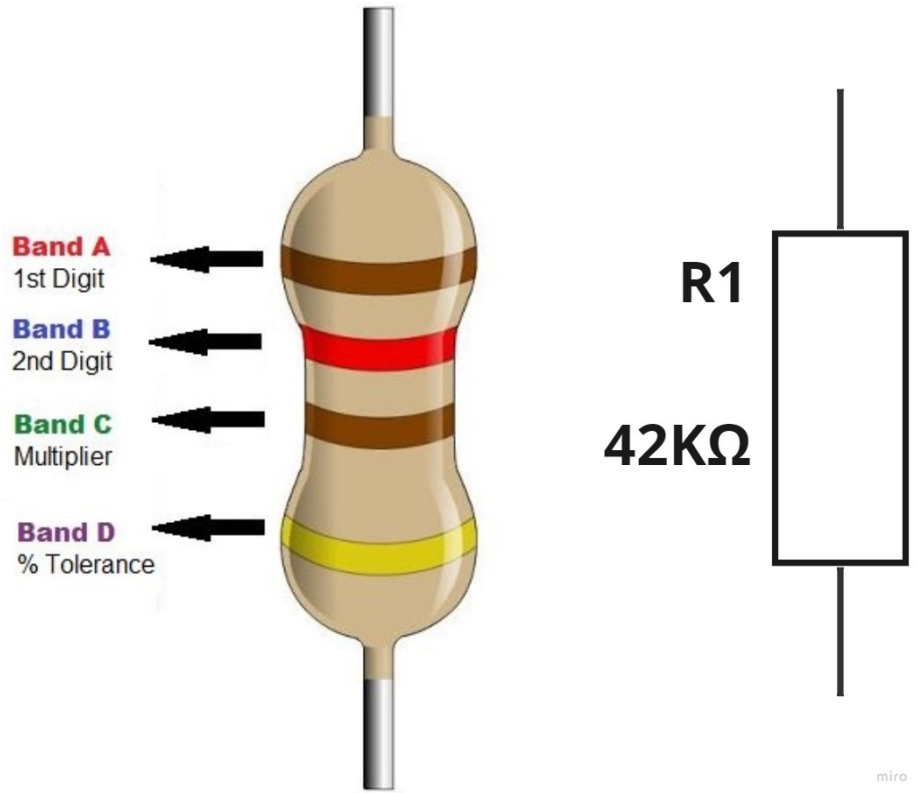
Parts used in this lab

Parts used in this lab:

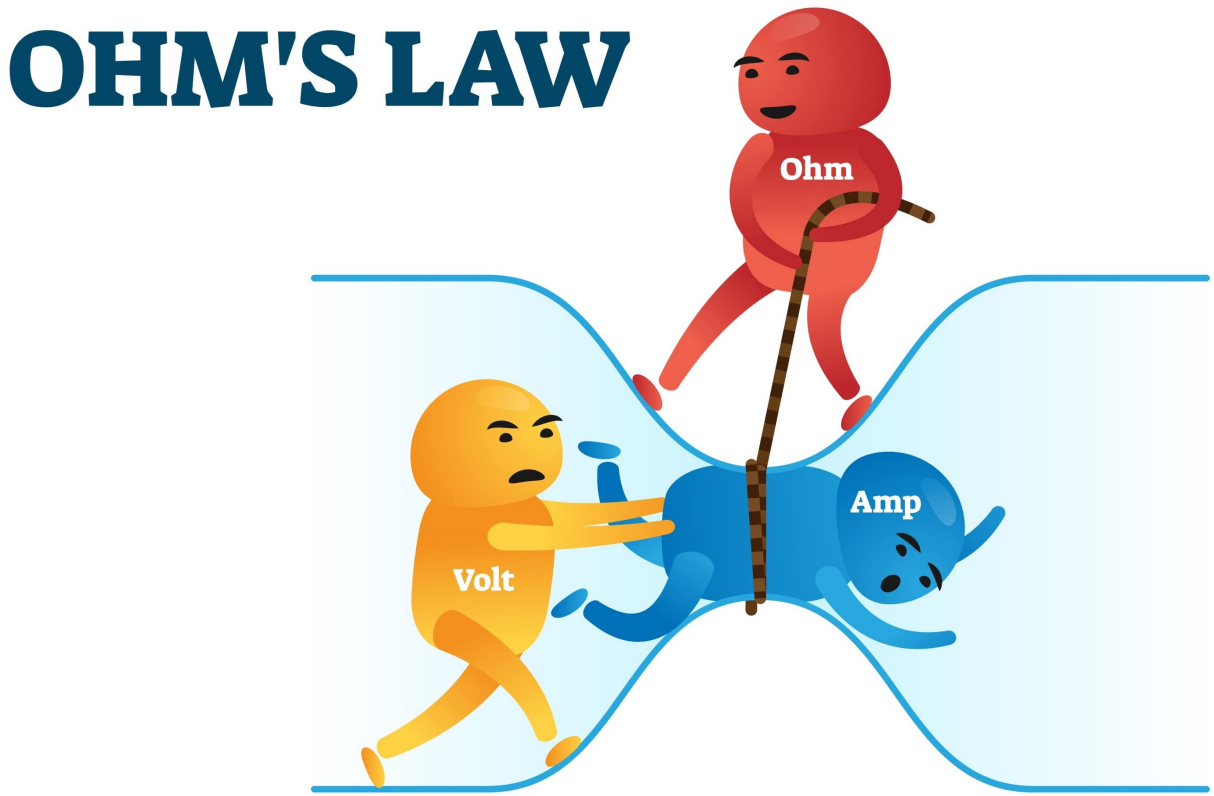
- Resistor
- Variable resistor (Potentiometer)
- LED - Light Emitting Diode
- Button

Resistor

- Passive electrical component
- Limits flow of a current
- Unit of ohm (Ω)

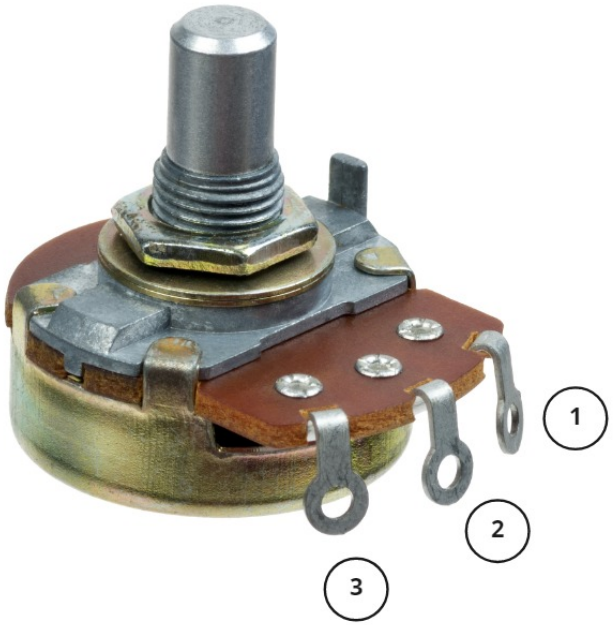


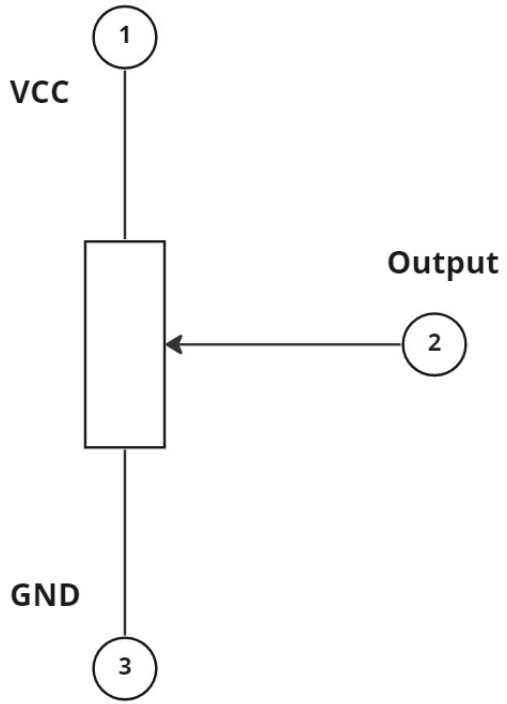
- Basic electrical law
- $U = R * I$
- Current flow through a conductor between two points is directly proportional to the voltage across the two points



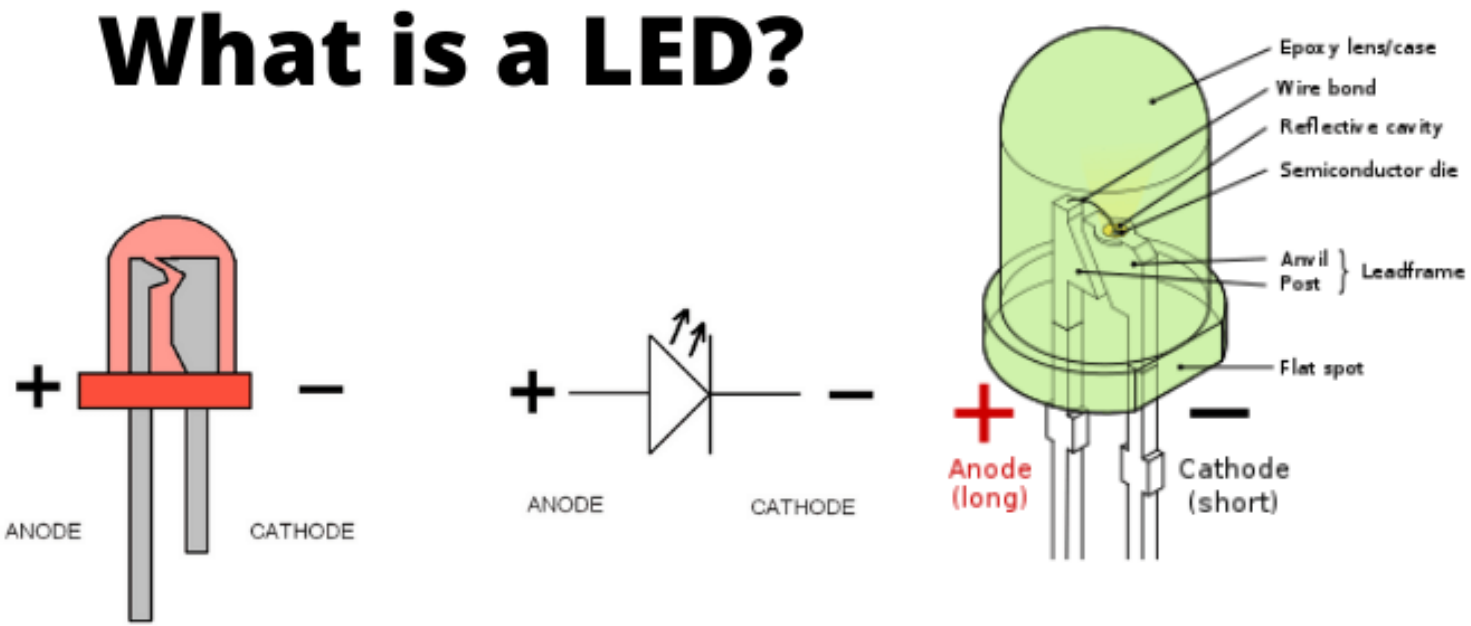
Variable resistor

- Passive electrical component
- Same as resistor but its resistance can be changed
- Usage - for example volume control



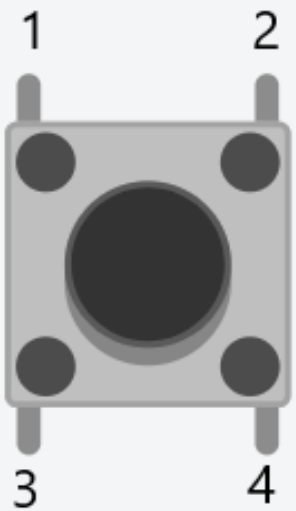


- Light Emitting Diode - diode that emits light when current flows through it
- Diode allows flow of current only in one direction
- 2 pins: positive Anode and negative Cathode
- Usage - light indication

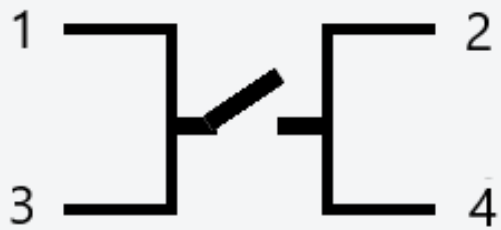


Push-button

- Simple electrical component
- Connects or disconnects electrical circuit
- Usage - ON/OFF button

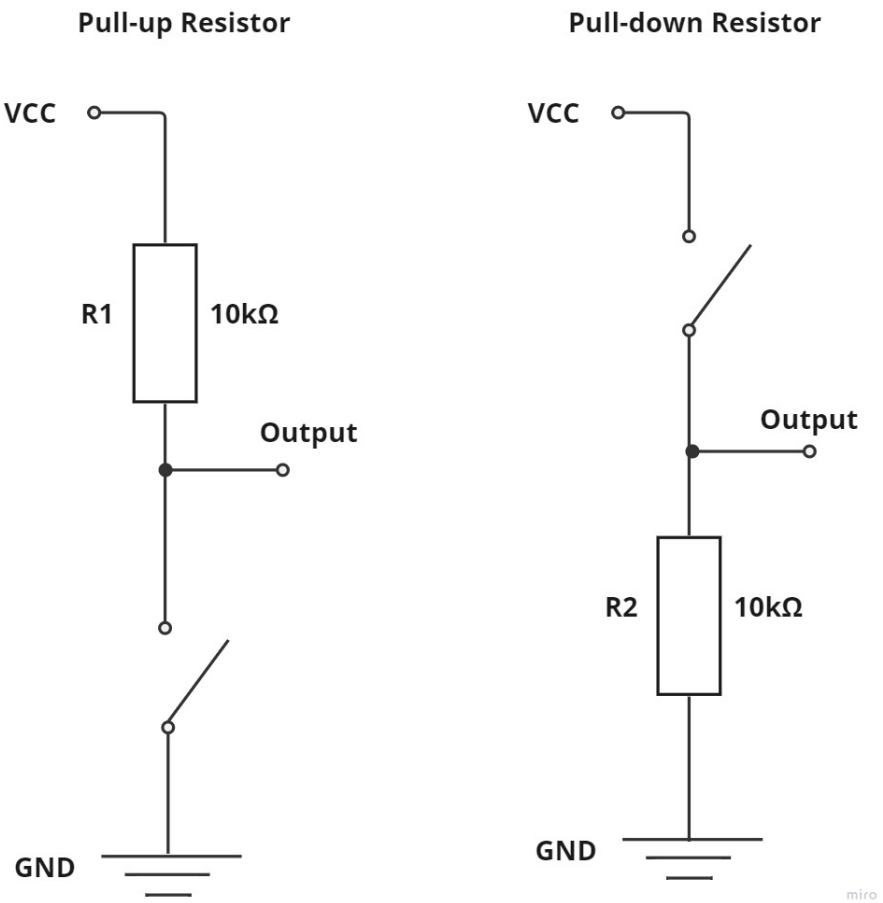


Pin 1 & 3 are connected
Pin 2 & 4 are connected



Pull-up / pull-down resistor

- Used to ensure a known state for a signal
- Pull-up ensures default Logic **1** signal and Pull-down ensured logic **0**



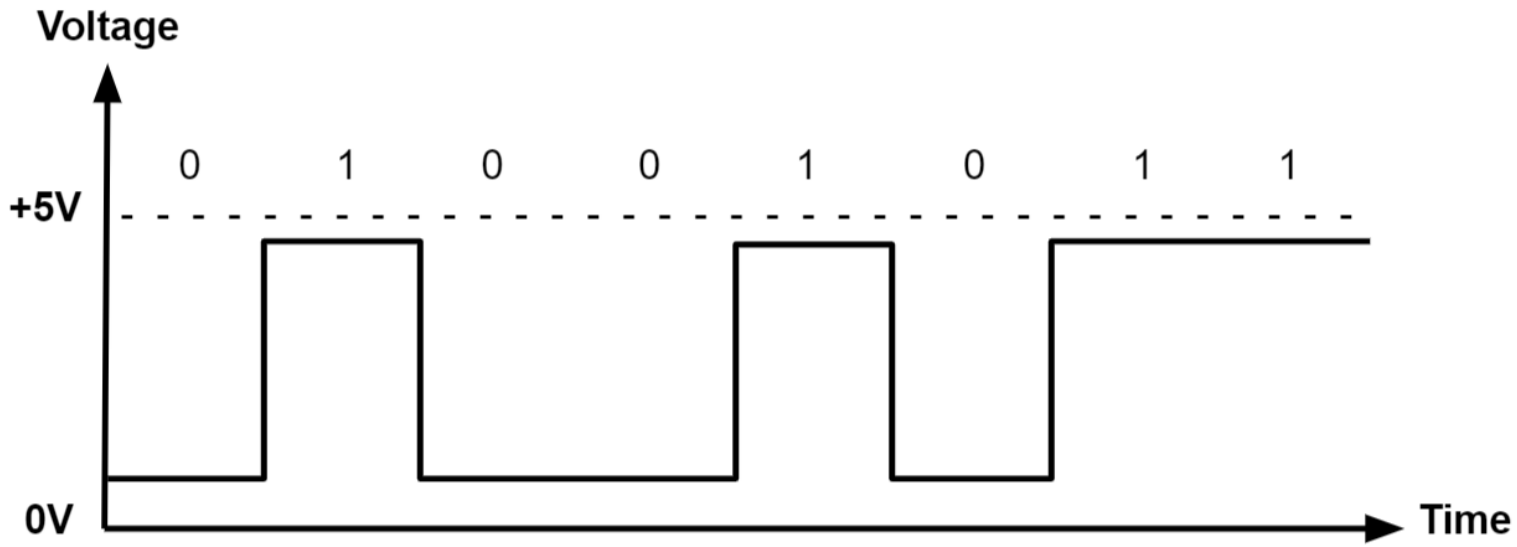
Types of signal

There are 3 types of signal that will be explored in this lab:

- Digital signal
- PWM
- Analog signal

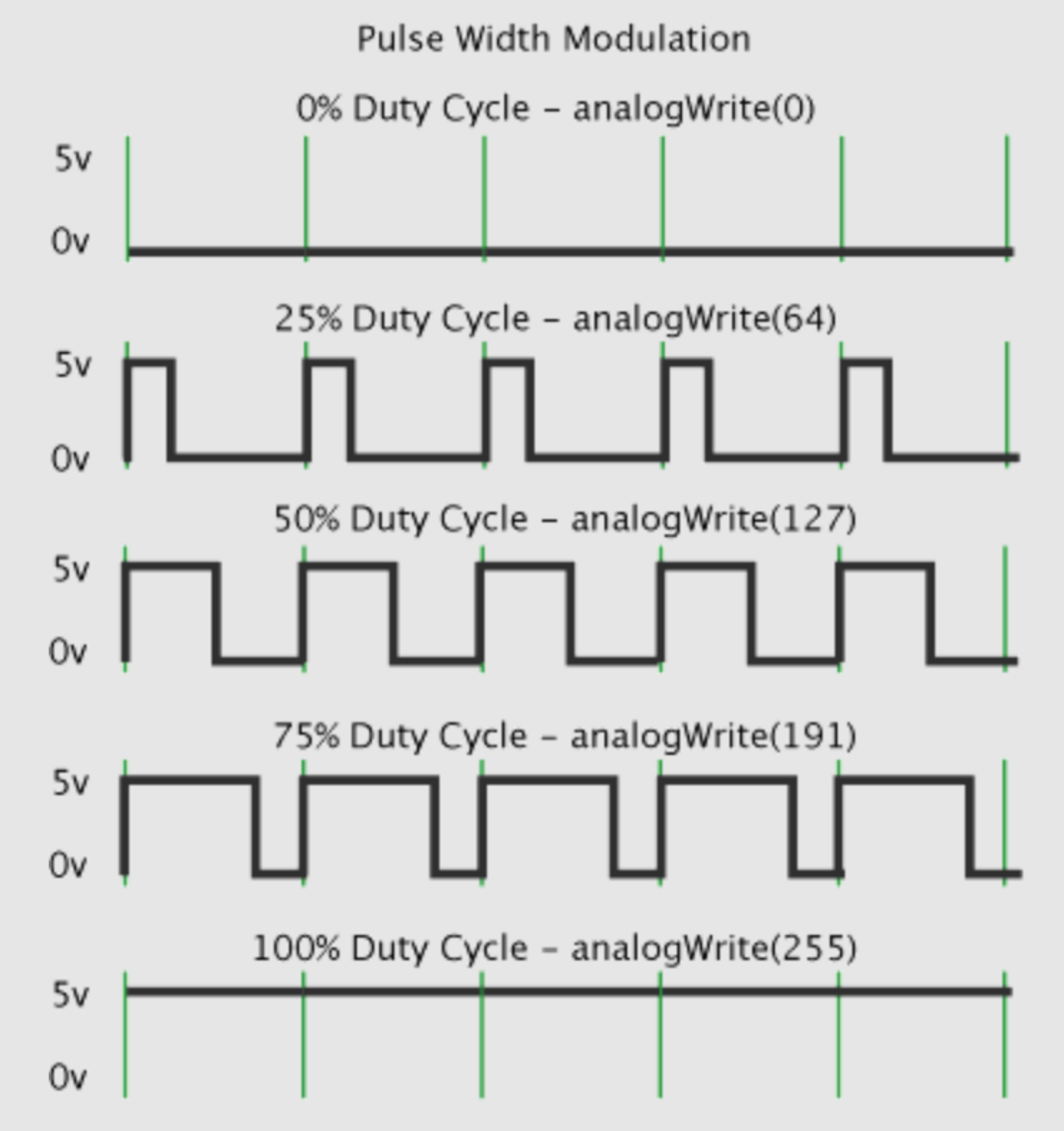
Digital signal consists of 2 possible states

- 1 - High - 5 Volts
- 0 - Low - 0 Volts



PWM or Pulse Width Modulation is

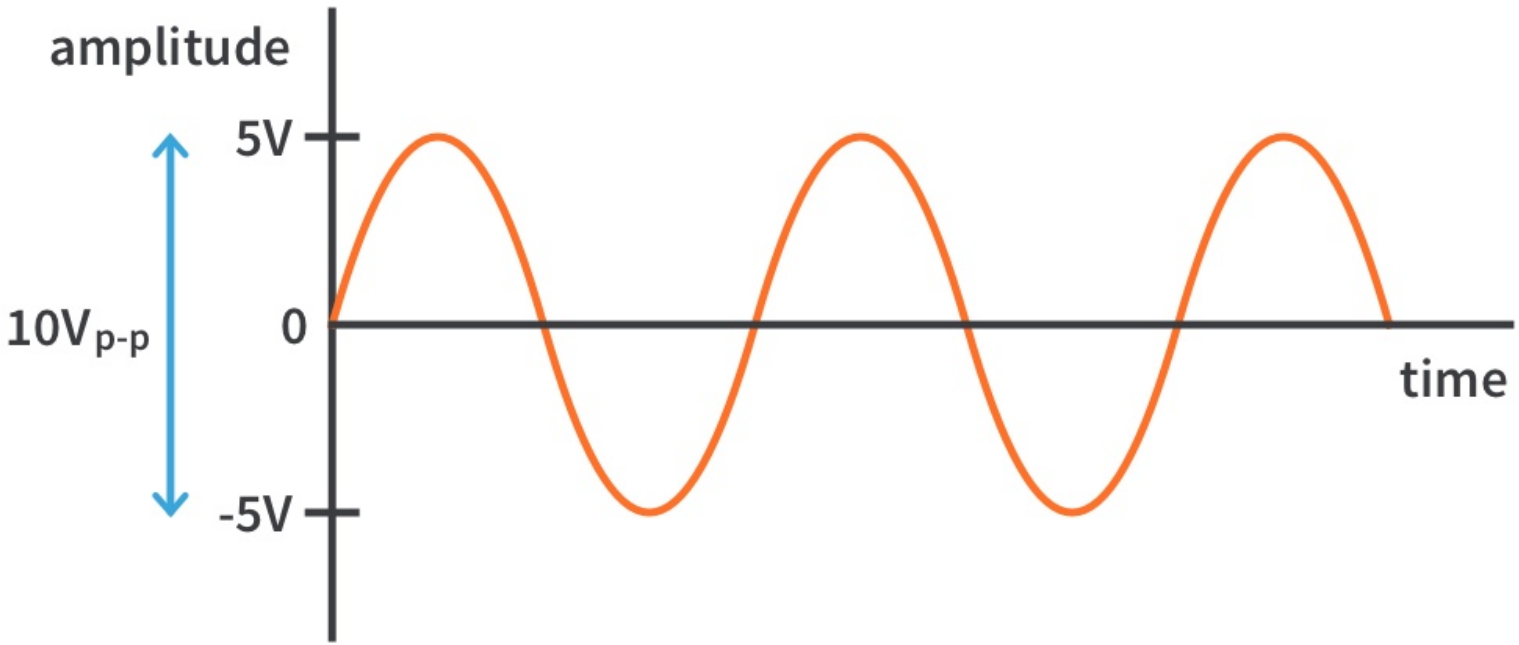
- method of reducing the average power delivered by an electrical signal
- Uses a repeating digital signal
- 2 attributes - frequency (or period) and duty cycle


Pulse Width Modulation
0% Duty Cycle – analogWrite(0)
5v
0v
25% Duty Cycle – analogWrite(64)
5v
0v
50% Duty Cycle – analogWrite(127)
5v
0v
75% Duty Cycle – analogWrite(191)
5v
0v
100% Duty Cycle – analogWrite(255)
5v
0v

Analog signal

Analog signal is a continuous signal that can have any value from a given range

- Range in volts for Arduino: **<0V, 5V>**
- Arduino uses a 10 bit analog to digital converter to read the value
- Read value is in range **<0, 1023>**



Each Arduino code consists of 2 functions:

- void setup() - code in this function will run only once, used for setup
- void loop() - code in this function will run infinitely, place where you write main part of your code

```
1  void setup() {
2    // put your setup code here, to run once:
3
4  }
5
6  void loop() {
7    // put your main code here, to run repeatedly:
8
9  }
10
11
```

Setting up pins

- Before reading/writing signal from/to a pin there is need for that pin to be initialized
- pinMode(pin, INPUT/OUTPUT)
- Sets up given pin to be input or output
- Use this function before using any read or write functions
- Usually used in setup() function

Working with digital signal

- digitalWrite(pin, HIGH/LOW) - writes digital signal to given pin
- digitalRead(pin) - reads digital signal from given pin, returns its value 1 or 0

Working with analog signal

- analogWrite(pin, value) - writes analog value to given pin
- Value can be from range **<0, 255>** which corresponds to range in voltage **<0V, 5V>**
- Uses PWM

- analogRead(pin) - reads analog value from given pin
- Return value can be from range **<0, 1023>** which corresponds to range in voltage **<0V, 5V>**

Exercises

Exercises overview

Following exercises will focus on following:

- Creating electrical circuits on breadboard
- Outputting digital signal
- Reading digital signal
- Creating PWM (analog output)
- Reading analog signal
- Measurements with oscilloscope

Check if your Arduino is "Alive" and upload your first code.

- Open file Blinking_LED.ino
- Take a look at the code
- Specify correct port and board in Arduino IDE in tools-board and tools-port
- Upload the code by clicking at  or pressing **Ctrl+u**
- Built in LED on Arduino board should be blinking in 1 second intervals

Make your own circuit with LED on breadboard.

- Open file Blinking_LED_Breadboard.ino
- Take a look at scheme LED_scheme.png and create circuit as it shown at the image
- Upload the code by clicking at  or pressing **Ctrl+u**
- LED should be blinking in one second intervals

- Continue working with the same code and scheme.
- Modify the time intervals that are stored in constants TIMETIME_ON and TIMEIME_OFF as it is described in table below
- After each change upload code to Arduino
- What behavior of the LED do you observe?

	TIME_ON	TIME_OFF
1.	100	100
2.	30	30
3.	1	1
4.	1	10
5.	1	20

PWM - Custom method

Create PWM waves using knowledge from the last 2 exercises.

- Open file PWM_custom_method.ino
- Reuse circuit from previous exercise
- Upload the code
- Try and modify constant DUTY_CYCLE_PERCENTAGE and set it to values 1, 2, 5, 10, 100
- Observe behavior of the LED
- How would you do it, if you would have to blink win 2 LEDs with different duty cycles?

PWM - Proper method

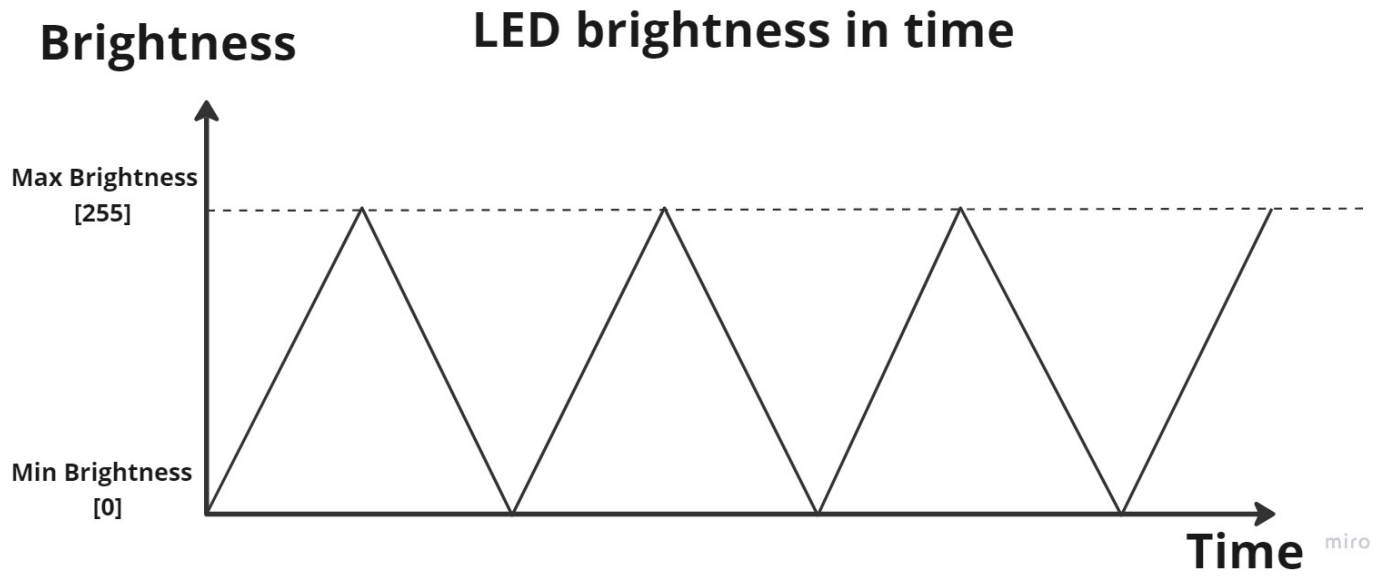
Use built-in Arduino function to create PWM wave.

- Open file PWM_proper_method.ino
- Reuse circuit from previous exercise
- Upload the code
- Try and modify integer brightness and set it to values 0, 1, 5, 10, 50, 100, 255
- Observe behavior of a LED

PWM - Fading LED

Write a code that will continually brighten and dim a LED

- Open file PWM_fading_LED.ino
- Reuse circuit from previous exercise
- Follow the instructions and implement brightening and dimming of the LED
- Upload the code
- Test your implementation by uploading your code and observing LED



Control LED using serial communication.

- Open file Serial_Demo.ino
- Reuse circuit from previous exercise
- Upload the code
- Open Serial Plotter (or Serial Monitor), select "No Line Ending" and send values in range <0,255> to control brightness of the LED

Sending signals is only half of the knowledge. The other half is to know how to read them.

- Open file Serial_Demo.ino
- Take a look at scheme Button_scheme.png and create the circuit as it shown in the image
- Upload the code
- Press the button and observe the behavior using Serial Plotter (or Serial Monitor)

Read analog signal from potentiometer.

- Open file Serial_Demo.ino
- Take a look at scheme Potentiometer_scheme.png and create the circuit as it shown in the image
- Upload the code
- Rotate the potentiometer and observe the behavior using Serial Plotter (or Serial Monitor)

Thank You For Your Attention !