Microcontroller basics

## Embedded systems for mortals

Topics

- Working with Arduino IDE
- Basic electronic components
- Your first program
- Digital input and output

Arduino IDE with Teensy MCU

- Download Arduino IDE from (version 1.8.7): https://arduino.cc/en/Main/Software

- Download Teensyduino from (version 1.44): https://pjrc.com/teensy/td_download.html

About Teensy

- Microcontroller used in these exercises is Teensy 2.0

- 16 MHz 8-bit Atmel Processor (ATMEGA32U4)
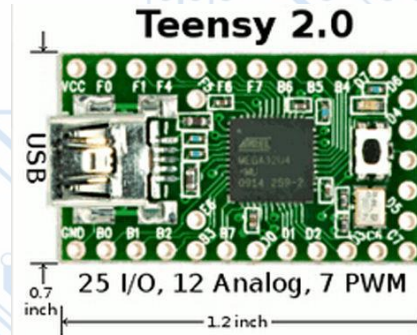
Basic Components

Passive components

Resistor
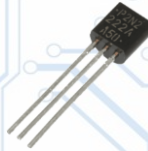
Capacitor

Push button

Inductor

Active components

LED
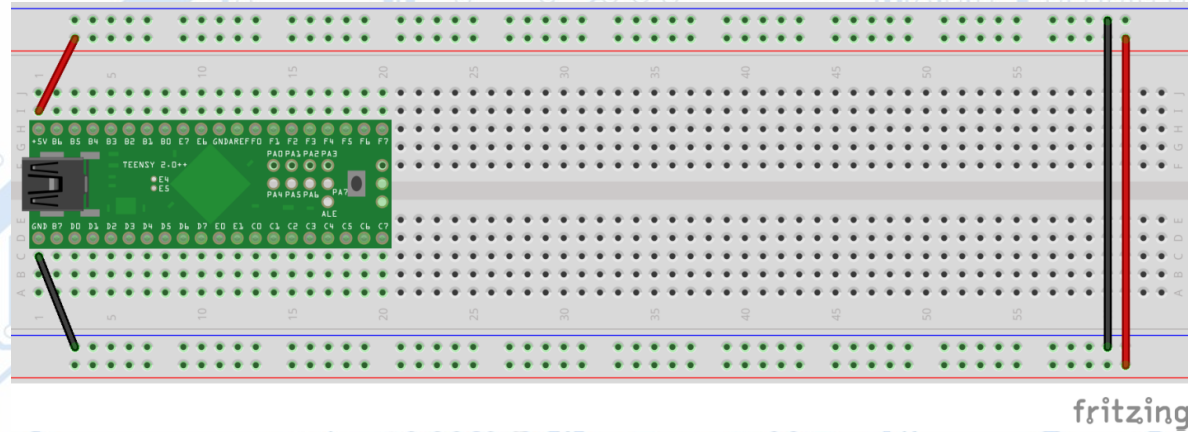
Transistor

Integrated circuit (IC)

Breadboard

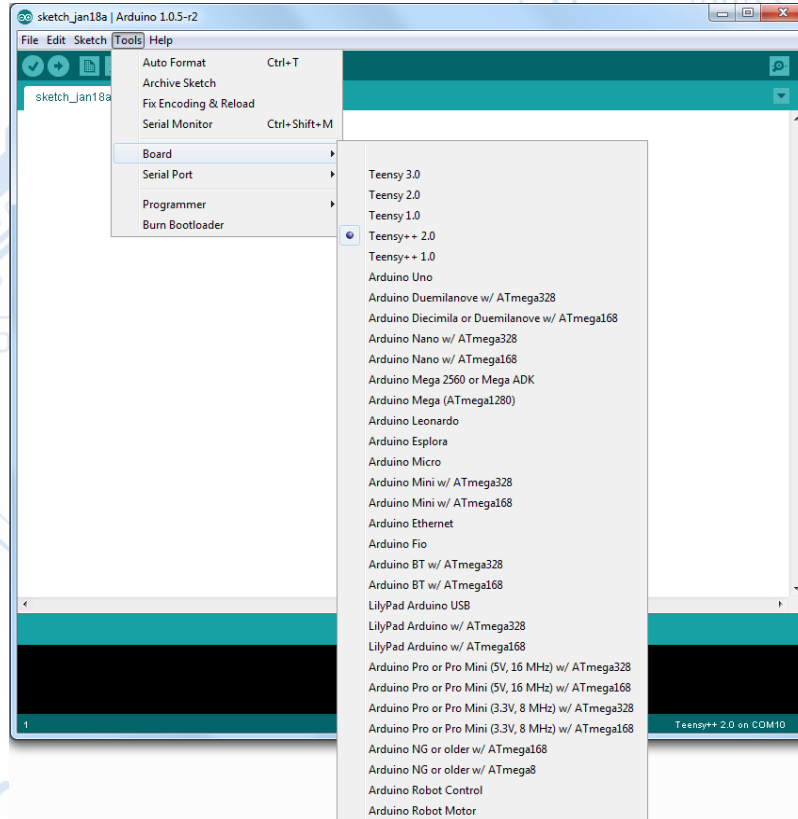Terminals with blue and red lines are called power busses and are connected together horizontally.

Terminals in the middle are connected together vertically. The gap in the middle separates the two sides.

Breadboard

Example: How to connect Teensy++ 2.0

Setting up Arduino IDE

Writing your first program

Basic blinking LED

```
byte ledPin = 6; //Variable to store the pin number
                 //(the built in LED on Teensy++ 2.0 is connected to pin 6)
                 //(the built in LED on Teensy 2.0 is connected to pin 11)

void setup() {
  pinMode(ledPin, OUTPUT); //set ledPin as output
  digitalWrite(ledPin, LOW); //Set the default state of the pin to GND(0 Volts)
}

void loop(){
  digitalWrite(ledPin, HIGH); //LED ON
  delay(100); //Wait 100ms (=0,1s)
  digitalWrite(ledPin, LOW); //LED OFF
  delay(1000); //Wait 1000ms (=1s)
}
```
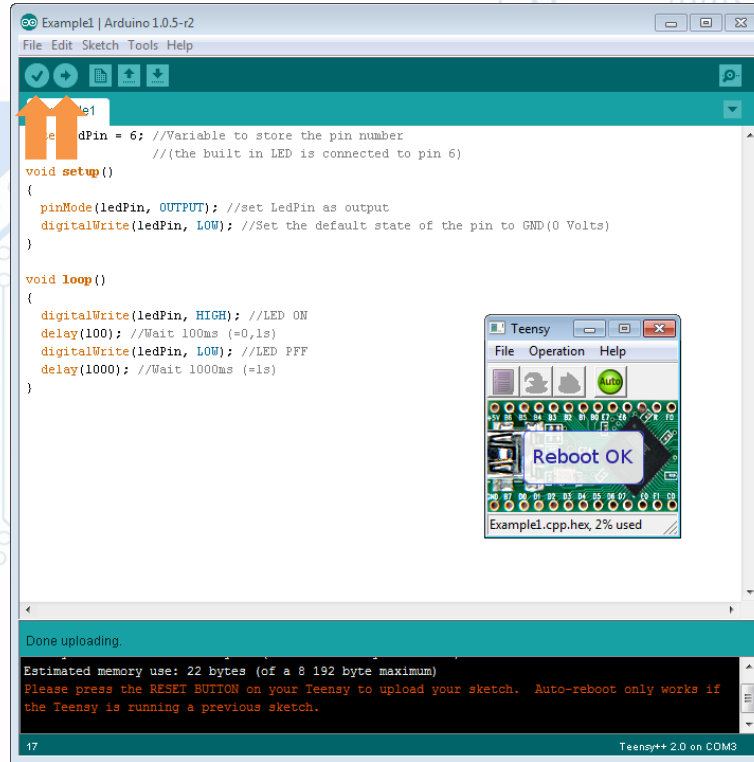
Uploading the program

1. Click Verify

2. Click Upload

3. Plug in and reset Teensy

Arduino C – Basic functions

`void setup()`
`{}`

Setup function is run <u>once</u>, when the microcontroller boots up or resets.

`void loop()`
`{}`

After setup function the processor moves to run code inside the loop function. Code inside loop function will be run over and over until the microcontroller is shut down.

`pinMode(var1, var2)`

pinMode functions sets the mode of given pin. Var1 is the number of the pin and var2 is the mode (INPUT, INPUT_PULLUP, OUTPUT)

`digitalWrite(var1, var2)`

digitalWrite changes the status of the pin. Var1 is the number of the pin and var2 is the status (LOW, HIGH).

IMPORTANT TO NOTICE:

- It's <u>required</u> to have both setup() and loop() functions in the code
- Depending whether the pin is set as an OUTPUT or INPUT the actual effect of digitalWrite() is different

Example 2 - Setup

Reading digital input (Using push button)
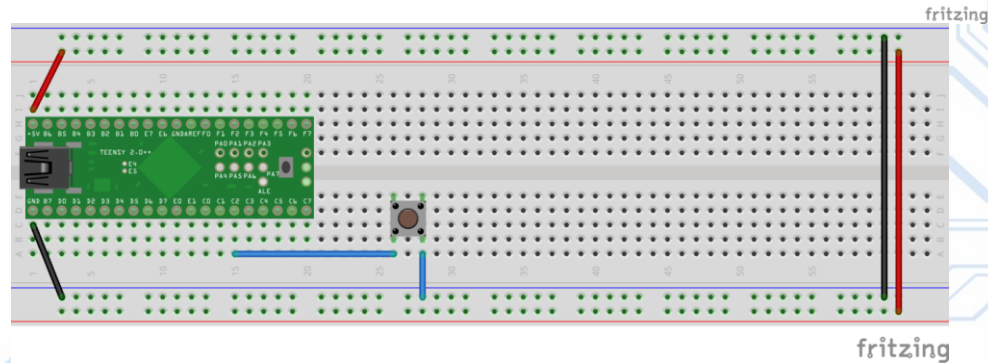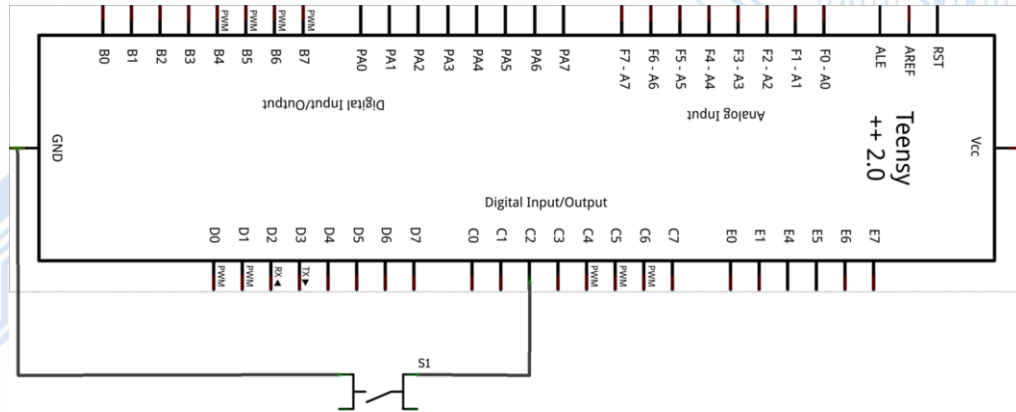
Example 2 - Code

Reading digital input (Using push button)

```
byte ledPin = 6; //(on Teensy 2.0 ledPin = 11)
byte buttonPin = 12;

void setup() {
  pinMode(ledPin, OUTPUT);
  digitalWrite(ledPin, LOW);
  pinMode(buttonPin, INPUT); //set buttonPin as input
  digitalWrite(buttonPin, HIGH); //Set the default state of the pin to HIGH(+5V)
}

void loop(){
  if(digitalRead(buttonPin) == LOW) {
    digitalWrite(ledPin, HIGH); //LED ON
  }
  else {
    digitalWrite(ledPin, LOW); //LED OFF
  }
}
```

P=U*I M U=R*I

- Microcontrollers typically operate on low voltages (0-5V) →You must be careful when connecting devices

- Know the electrical limits of the microcontroller: Teensy can handle max 5V/40mA per pin

- Always double check the wiring! If you see smoke it's already too late!

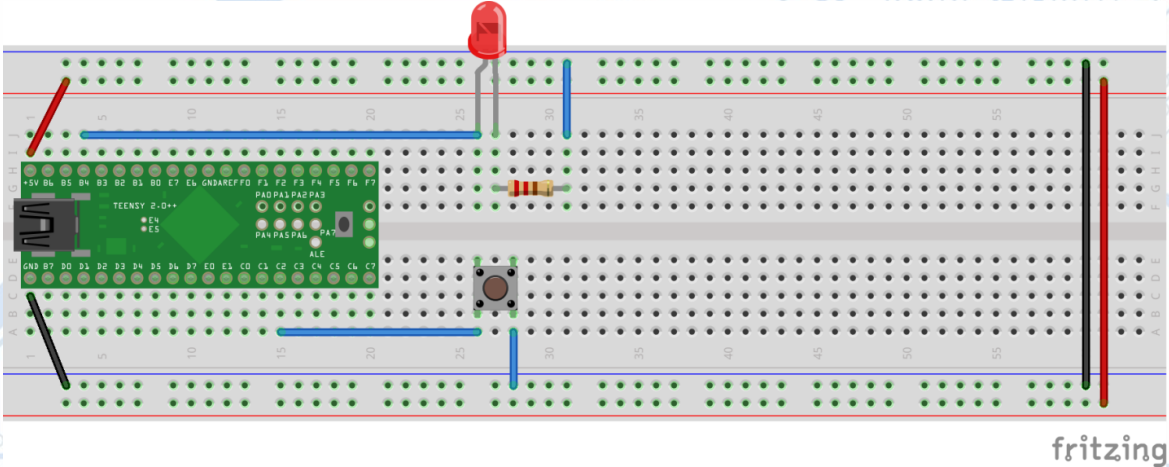$$\boxed{P=U*I} \quad \text{\textcolor{blue}{M}} \quad \boxed{U=R*I}$$

- To prevent overloading a pin ar a component with excessive current you need to use a resistor

- Example: Using an LED - Calculating the required resistor size

  - Operation voltage for LED: 5V

  - Recommended current 23mA

$$U = R * I \rightarrow R = \frac{U}{I} = \frac{5V}{0{,}023A} \approx 220\Omega$$

Example 3 - Schematic
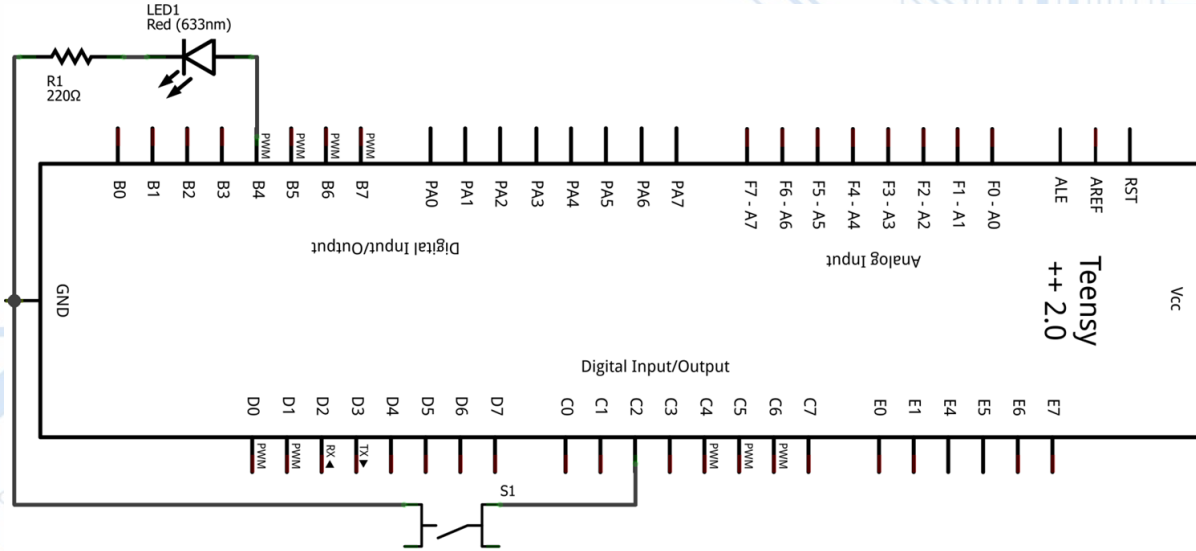
Example 3 – Breadboard Setup

Example 3 - Code

Controlling external LED with push button

```
byte ledPin = 24; //new ledPin value
byte buttonPin = 12;

void setup() {
  pinMode(ledPin, OUTPUT);
  digitalWrite(ledPin, LOW);
  pinMode(buttonPin, INPUT);
  digitalWrite(buttonPin, HIGH);
}

void loop(){
  if(digitalRead(buttonPin) == LOW){
    digitalWrite(ledPin, HIGH); //LED ON
  }
  else {
    digitalWrite(ledPin, LOW); //LED OFF
  }
}
```

You have just entered the Matrix

Where to find help?

Google
Try to see if someone else has had the same problem
Copy code –> Profit

Stack Overflow
A great place of coders who help each other out
https://stackoverflow.com/

Arduino Reference
All Arduino IDE functions and a ton of example code
https://www.arduino.cc/reference/en/

Online books and manuals
There are a punch of different electrical books and manuals online
https://www.instructables.com/
https://www.hackster.io/
https://hackaday.com/