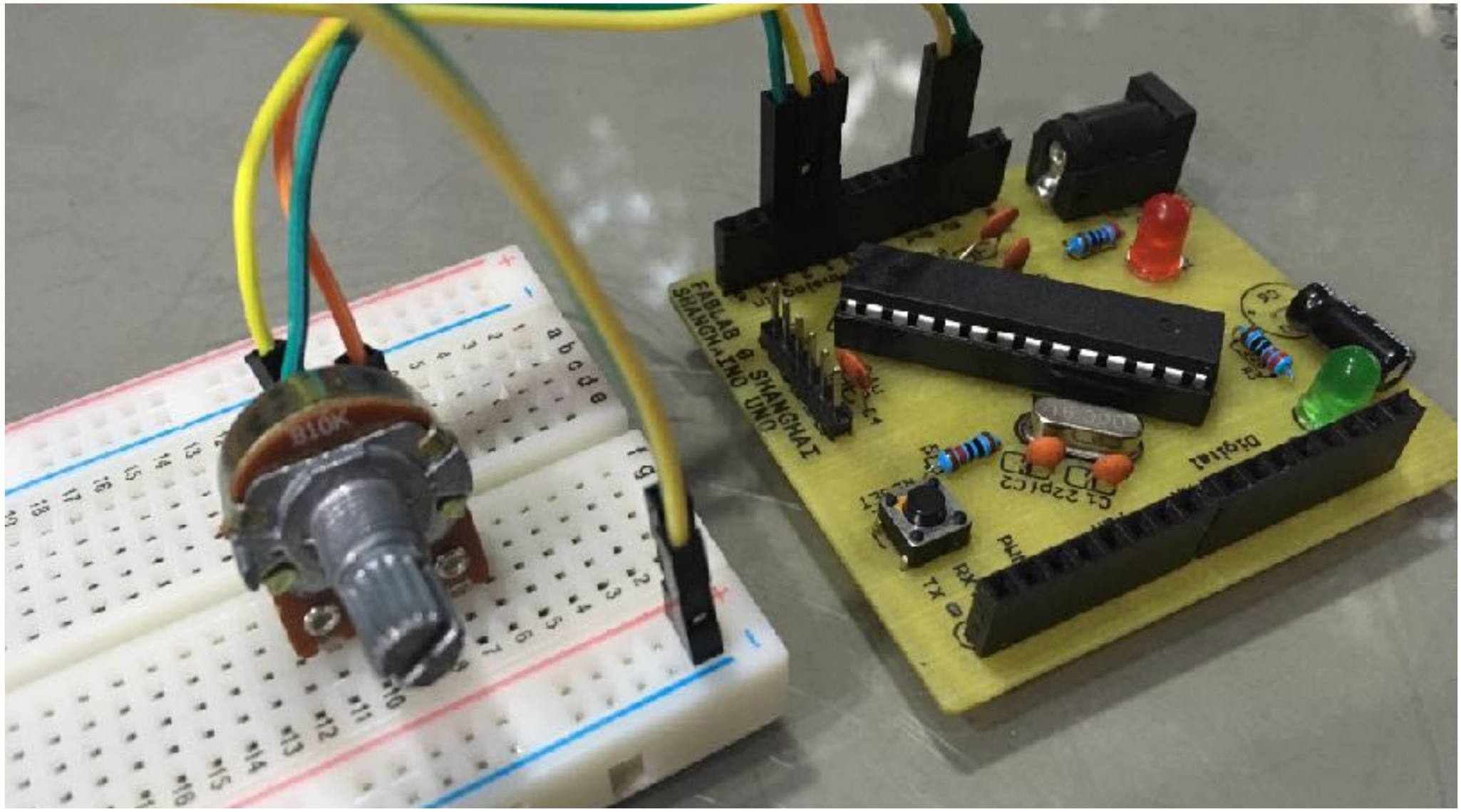
FABO ACADEMY X

ELECTRONIC DESIGN



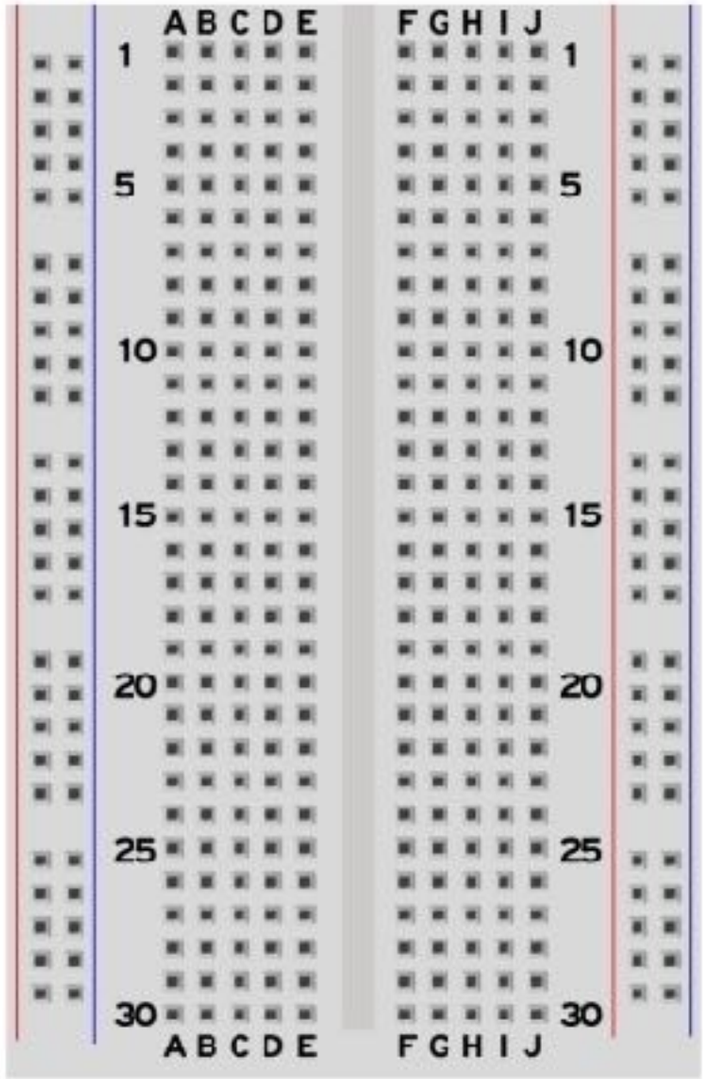
MAKE A DEVICE WITH INPUT & OUTPUT

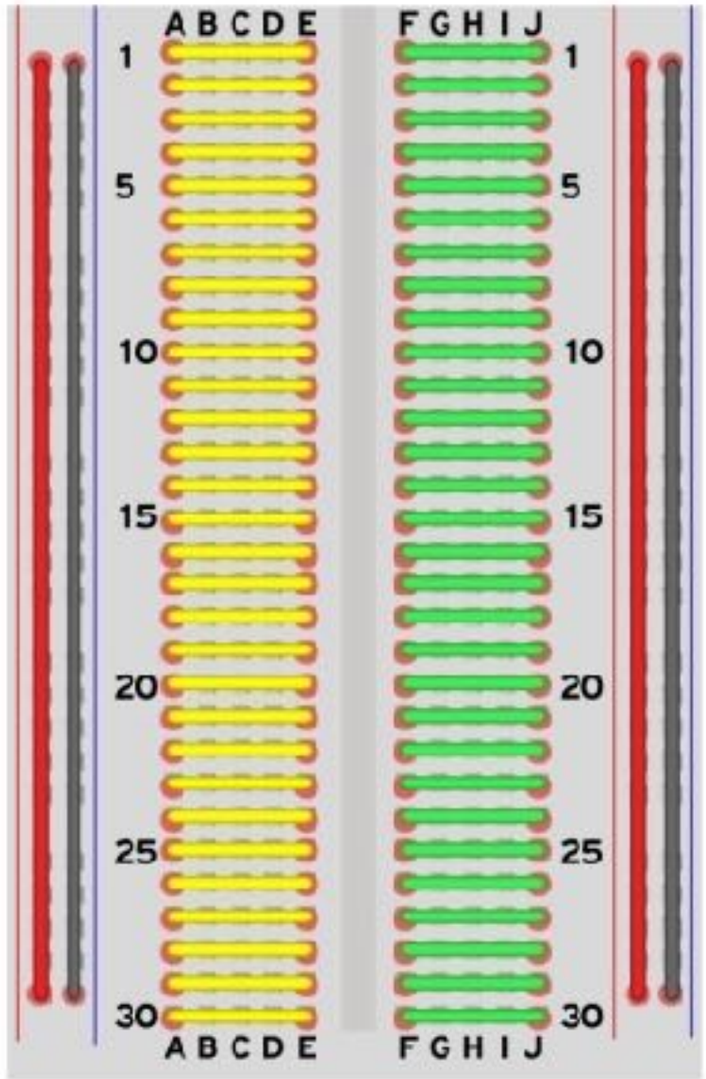
The Shanghaino can be programmed to use many input and output devices (a motor, a light sensor, etc) uploading an instruction code (a program) to it's microcontroller with the Arduino IDE.

HOW TO CONNECT DEVICES TO YOUR PCB

A “Breadboard” is ideal to prototype a new circuit connecting additional devices and wires and expanding the capabilities of your PCB. Pay attention at how the rows and columns are connected internally.

The two side columns are used for GND (-) and VCC (+) and are connected vertically. The two internal columns are connected horizontally, from A to E and from F to J. E and F are NOT connected.





OUTPUT DEVICES

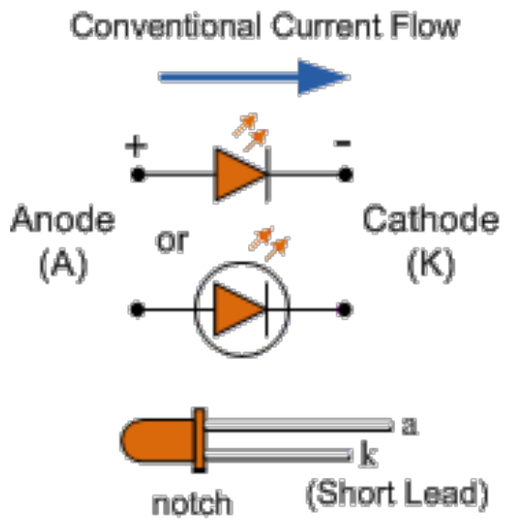
An output device is something that receives a signal from the microcontroller and makes something. It can be as easy as a DC motor, that can only be turned on or off*, or something like a servomotor for which you can control the angle of rotation.

DC Motor. Only has two wires positive and negative

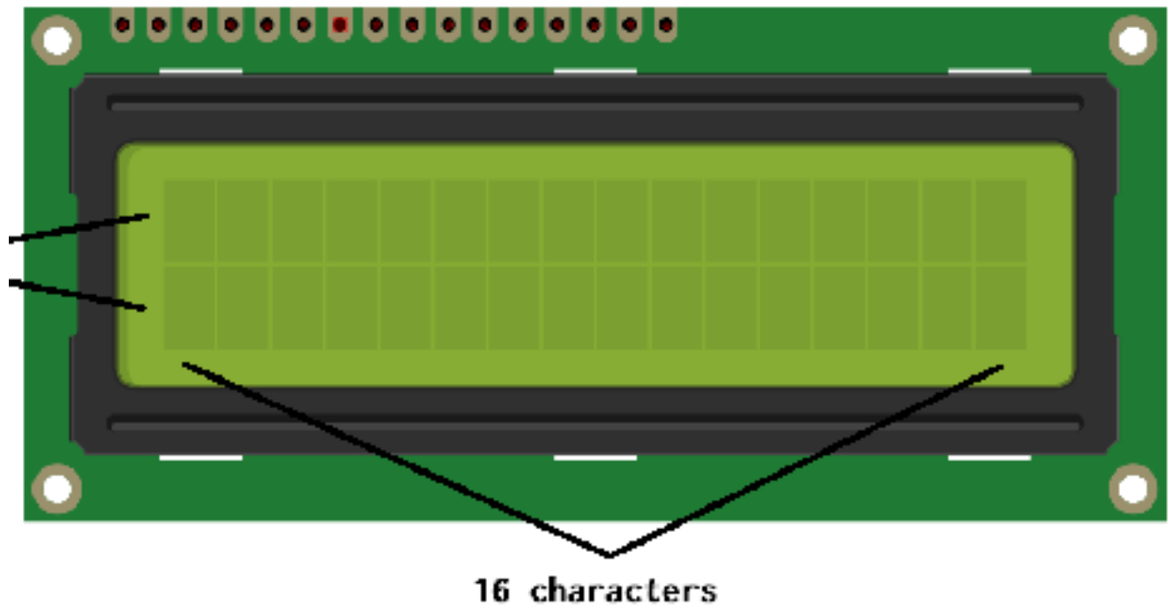
Servo Motor. Has 3 wires positive, negative and signal

OUTPUT DEVICES

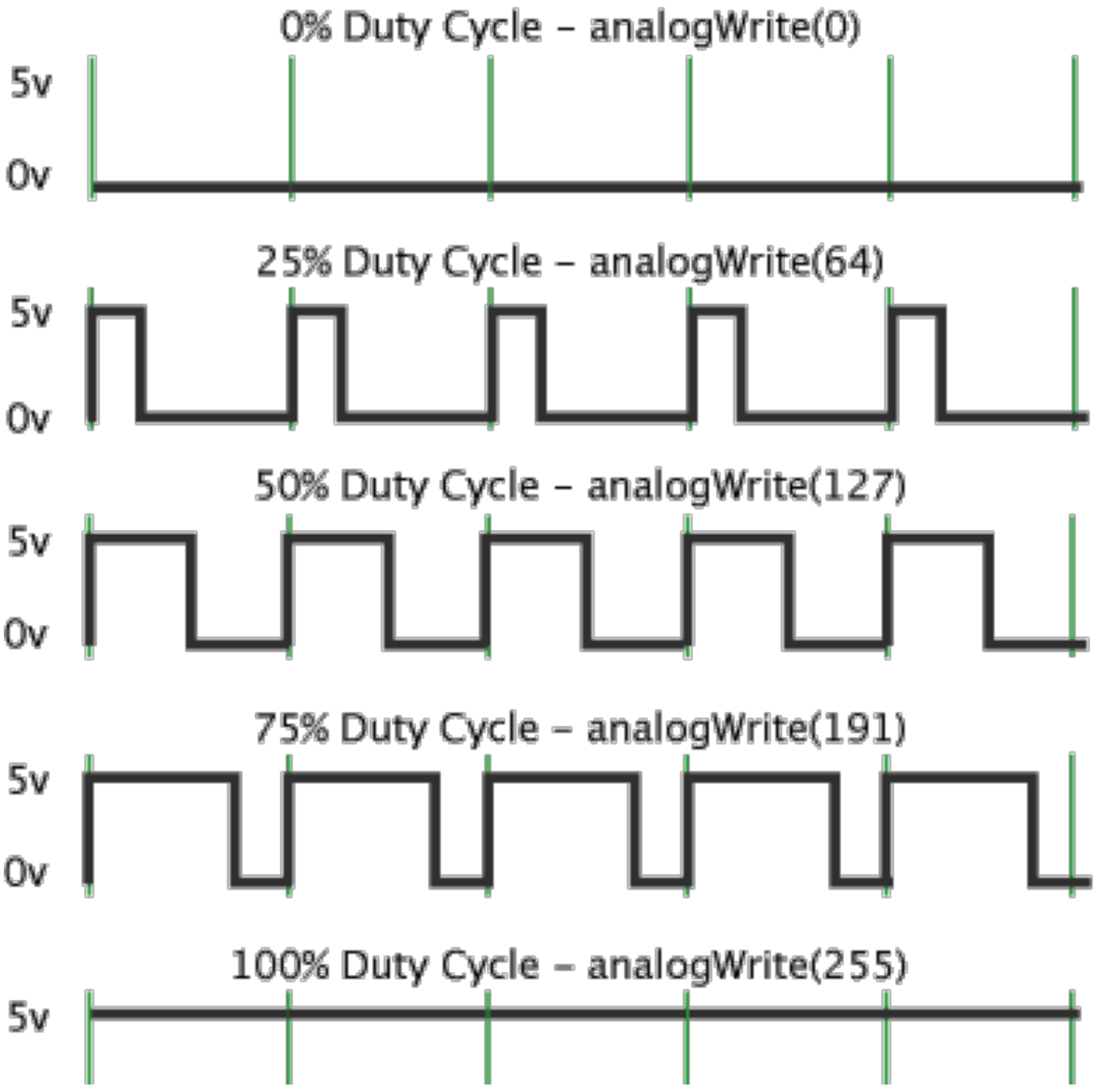
Another tipe of output devices is something that emits light: an LED (Light Emitting Diode) or an LCD (Liquid Crystal Display).
The LED, as the DC motor, only has two leads (+ and -) and can only be turned on and off*. The LCD of course is more complicated and requires some lines of code to be used.



LED and its
I-V Characteristics



*PULSE WIDTH MODULATION



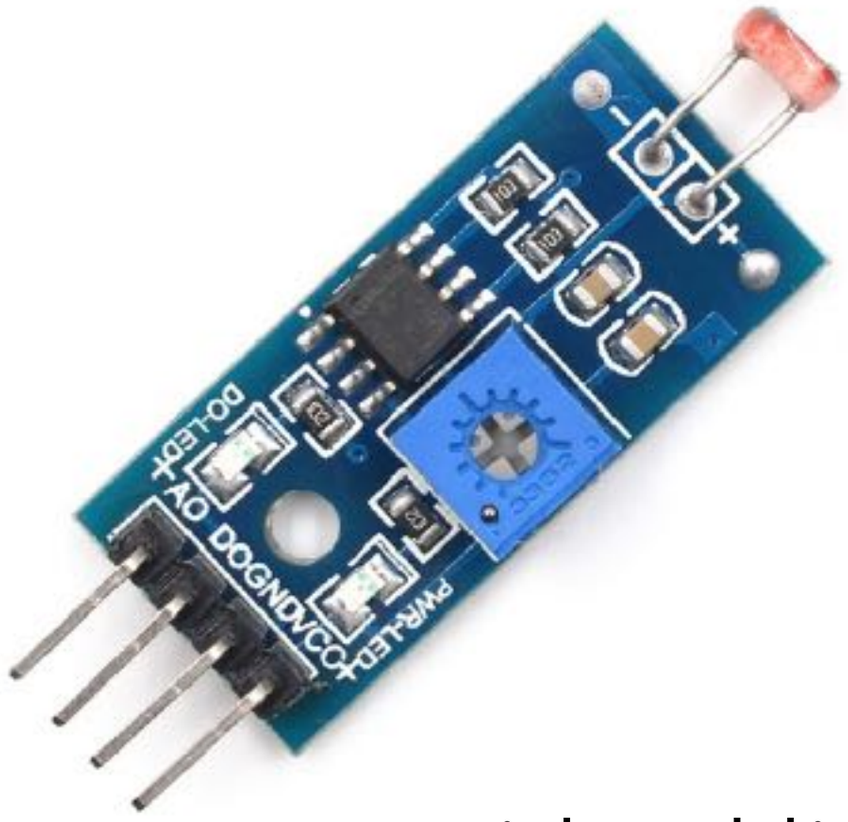
We said the LED or DC Motor can only be turned on or off, but there is a way to change the speed of a motor or the intensity of the LED.

By turning the device on and off very fast at a certain rate we can “emulate” the real behavior of an analog device (remember we are in a digital system with only 0V (off or low) and 5V (on or high). The function is called PWM and in the code it is “analogWrite” followed by a value between 0 and 255.

INPUT DEVICES

An input device collects informations from the environment and send them to the microcontroller. An ultrasonic sensor detects distance, a light sensor detect the amount of light and so on. These informations are often analog inputs (ie: distance is measured in millimiters) and the MCU needs to convert the analog signal into digital data. It does it thanks to its ADC (Analog to Digital Converter).

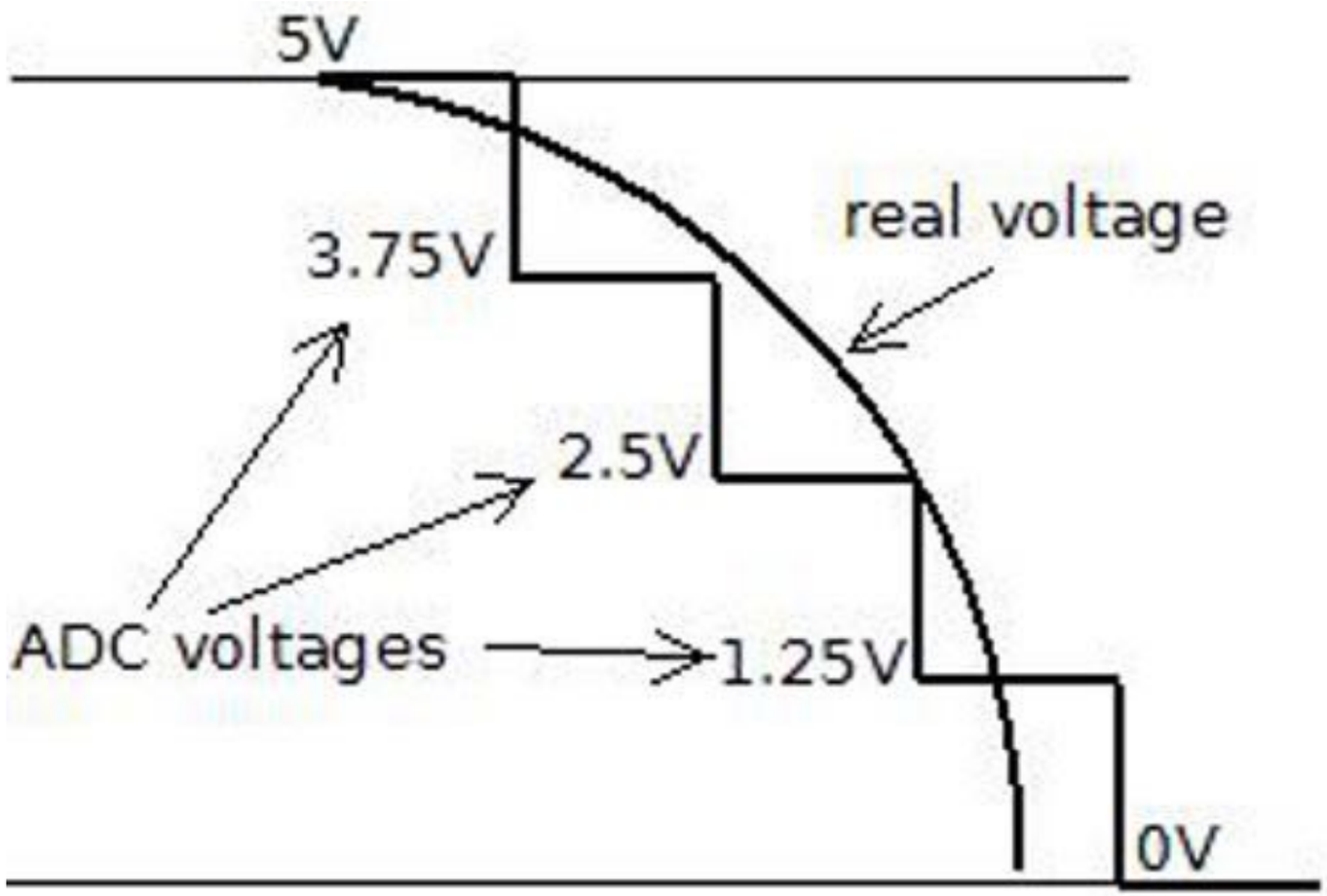
Ultrasonic sensor



Light sensor, with additional components to regulate the sensitivity

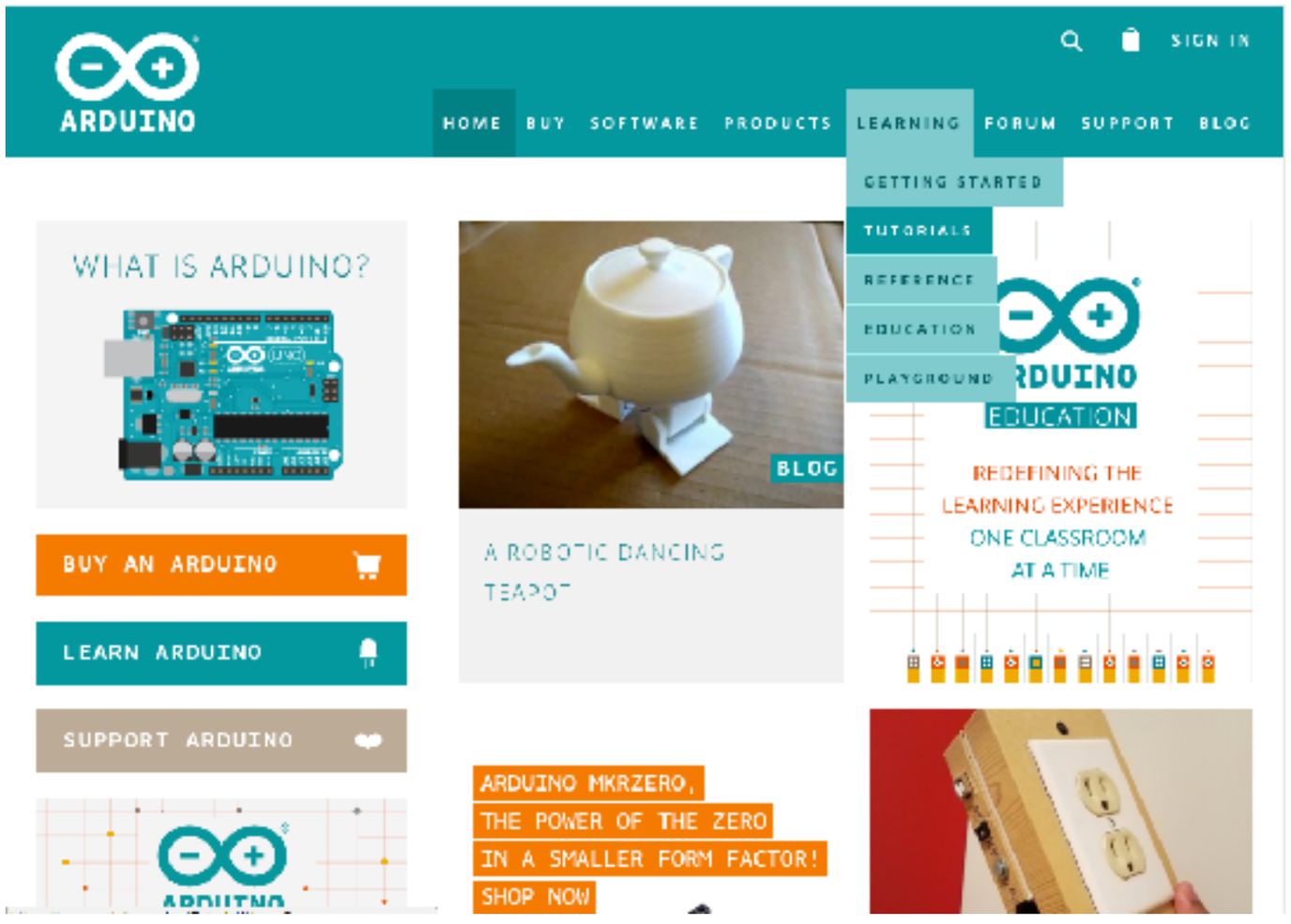
ANALOG TO DIGITAL CONVERTER

Most sensors send data to the MCU through changes in Voltage. The Atmega328 cannot read an infinite number of analog values (represented by a smooth curve) because it uses a digital scale that has a resolution of 10 bits (2^{10}). It has a built-in analog to digital converter and any voltage the sensor is detecting will be converted to one value on a scale from 0 to 1023 (a resolution of 1024 values). The function used to use these values is called “analogRead”.



HOW TO WRITE A PROGRAM

Arduino IDE is a simple coding environment especially designed for AVR microchips (the same we use, the same Arduino use). It lets you use a simplified version of the C programming language, with many libraries of functions ready to use, and thousands of pages of documentation on www.arduino.cc website and online community.



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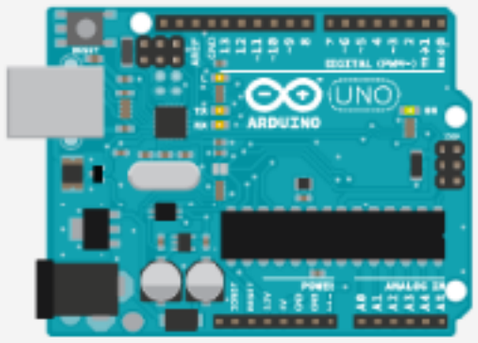

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ARDUINO IDE

Any Arduino sketch is made of two main blocks:
void setup, is where we define the main functions of the program and we give the name to the variables. In this example we say that PIN 7 is an output (it is where we connected our LED).

```
// the setup function runs once when you press reset or power the board
void setup() {
  // initialize digital pin 13 as an output.
  pinMode(7, OUTPUT);
}

// the loop function runs over and over again forever
void loop() {
  digitalWrite(7, HIGH);   // turn the LED on (HIGH is the voltage level)
  delay(100);              // wait for a second
  digitalWrite(7, LOW);    // turn the LED off by making the voltage LOW
  delay(100);              // wait for a second
}
```

ARDUINO IDE

void loop, is where we write the events that our program runs.
In this example we are defining four steps:

1. We write “HIGH” on PIN7 (meaning we turn it on)
2. We wait for 100 milliseconds (delay)
3. We write “LOW” on PIN7 (meaning we turn it off)
4. We wait again for 100 milliseconds.

```
// the setup function runs once when you press reset or power the board
void setup() {
  // initialize digital pin 13 as an output.
  pinMode(7, OUTPUT);
}

// the loop function runs over and over again forever
void loop() {
  digitalWrite(7, HIGH);   // turn the LED on (HIGH is the voltage level)
  delay(100);              // wait for a second
  digitalWrite(7, LOW);    // turn the LED off by making the voltage LOW
  delay(100);              // wait for a second
}
```

WRITING A PROGRAM FOR THE SHANGHAINO

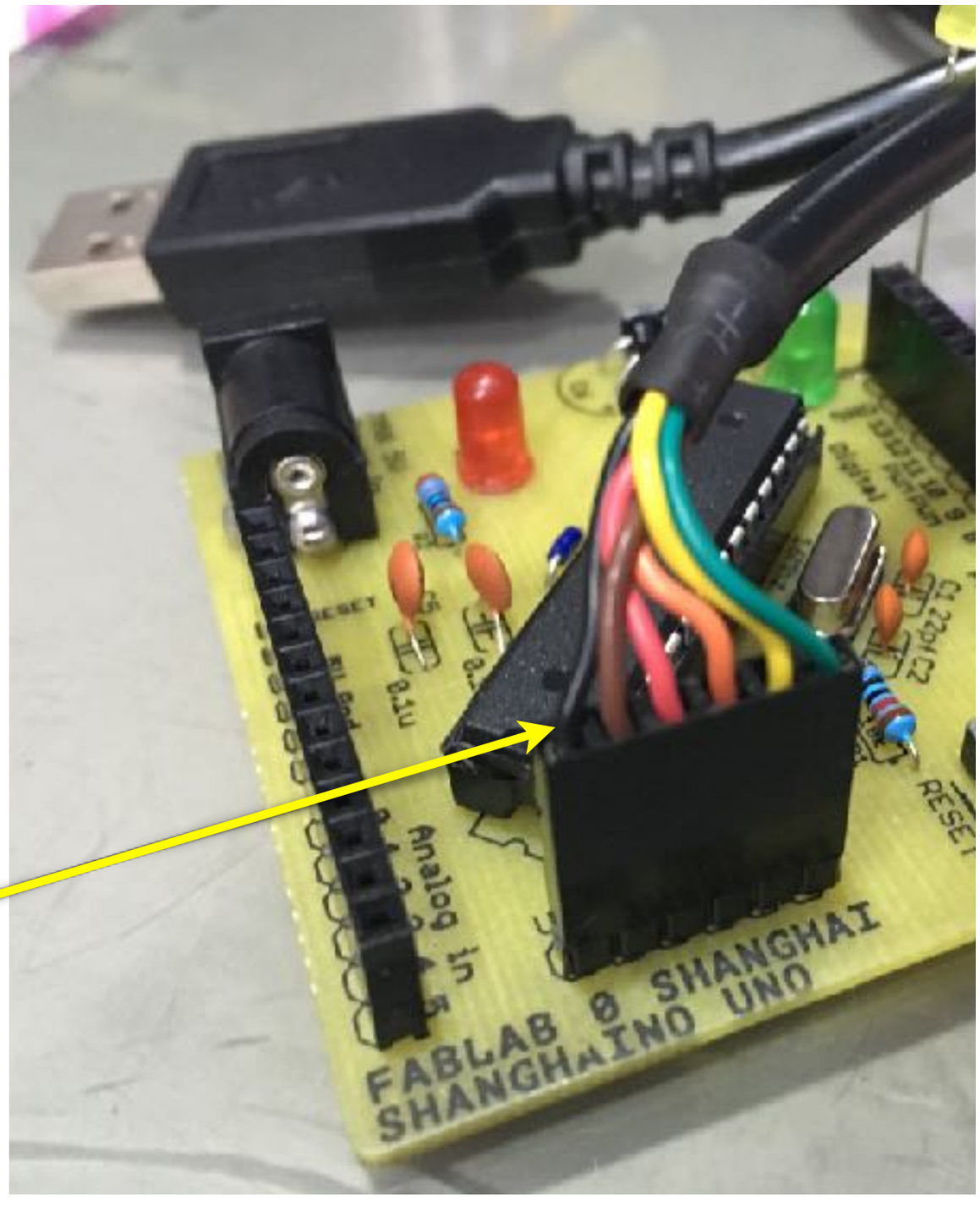
Before the “void setup” we declare the names of our input and output devices (the button and the LED) and where we connected them. Then in the “void setup” we declare if the pin to which the device is connected should work as an input or an output.

```
int ledpin=7; // assign the value "7" to the integer variable called "ledpin"
int buttonpin=3; // assign the value "3" to the integer variable called "buttonpin"
int ledstatus=0;

void setup()
{
 pinMode(ledpin, OUTPUT);
 pinMode(buttonpin, INPUT);
 digitalWrite(ledpin, ledstatus);
}

void loop()

  ledstatus = digitalRead(buttonpin);  // assign to ledstatus the same value it read on buttonpin
  if (ledstatus == HIGH) {            // check if the button is pressed, ledstatus is HIGH
    digitalWrite(ledpin, HIGH);    // write HIGH on ledpin, the LED turns on
  }
  else if (ledstatus == LOW) {    // check if the button is not pressed, ledstatus is LOW
    digitalWrite(ledpin, LOW);    // write LOW on ledpin, the LED turns off
```

UPLOADING THE PROGRAM

We use Arduino IDE to upload the program to the Shanghaino, selecting “Arduino/Genuino UNO” in the device list.

Connect the Shanghaino to the FTDI Usb cable and click upload.



Be careful with the orientation of the connector: black wire is GND

EXERCISE

Discuss with the class a final project proposal with I/O capabilities.
Use the Arduino IDE to write or modify a program with I/O devices.
Assemble your circuit on a breadboard and test it.