Ch. 2 IoT Development Boards

Sec 1 – Arduino Board Intro

COMPSCI 147

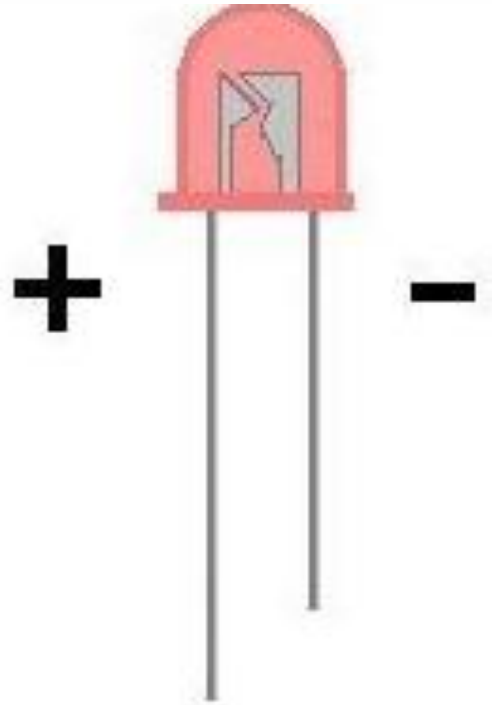
Internet-of-Things; Software and Systems

Step 1: Let's construct a simple circuit

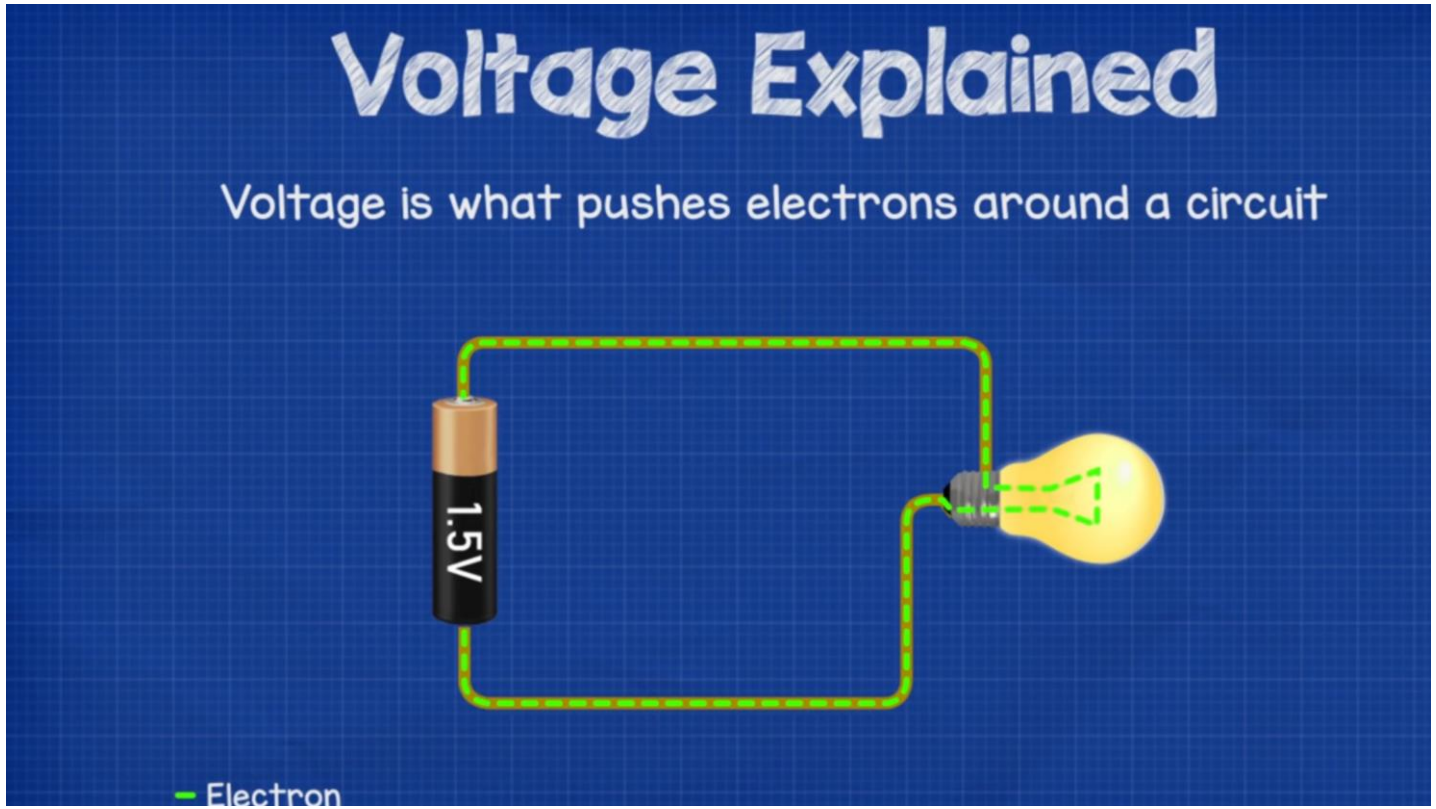
- Make an LED glow

Step 1: Let's construct a simple circuit

- Make an LED glow
- Need to flow current (flow of electrons) through the LED
- Volage is what pushes electrons around a circuit.
- Without voltage, electrons move randomly in any direction.



Step 1: Let's construct a simple circuit



https://www.youtube.com/watch?v=w82aSjLuD_8
Voltage Explained - What is Voltage? Basic electricity potential difference

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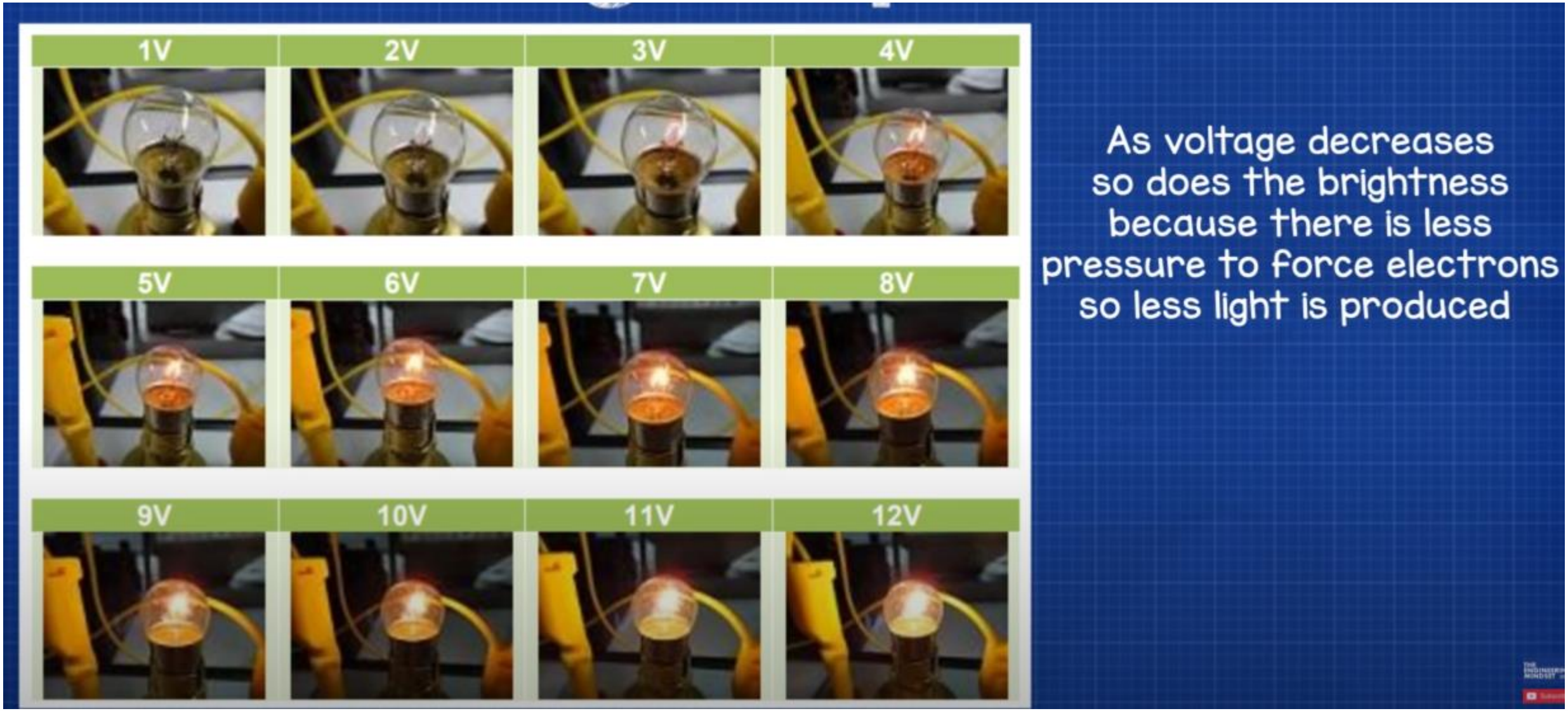
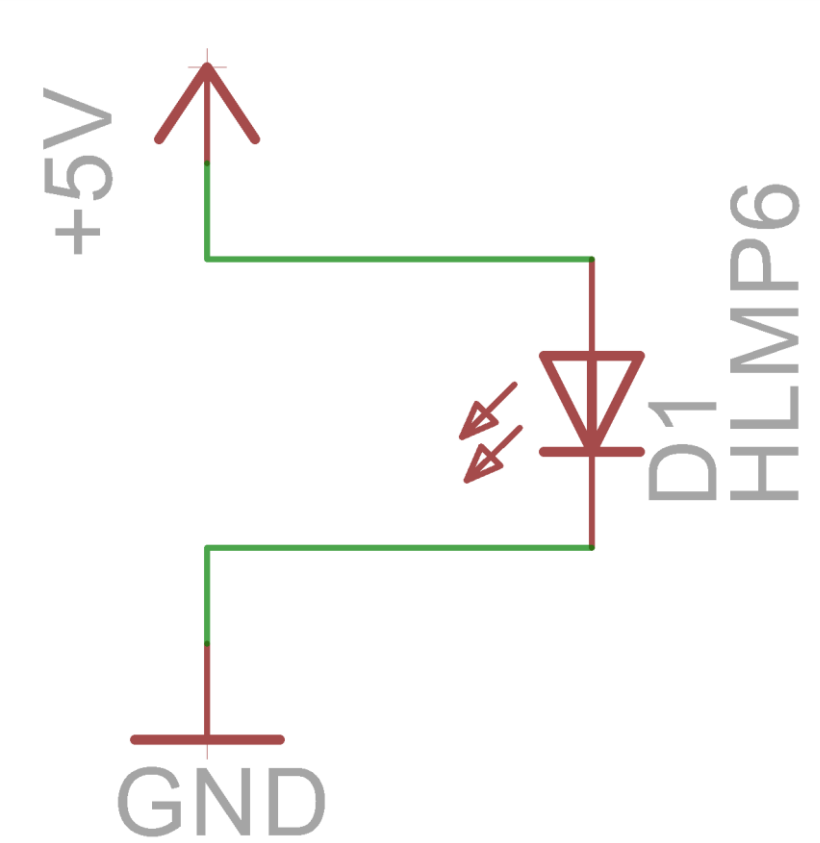


Step 1: Let's construct a simple circuit

- USB works with 5V (DC)
- What will happen if we plug in LED with a 5V power supply ?



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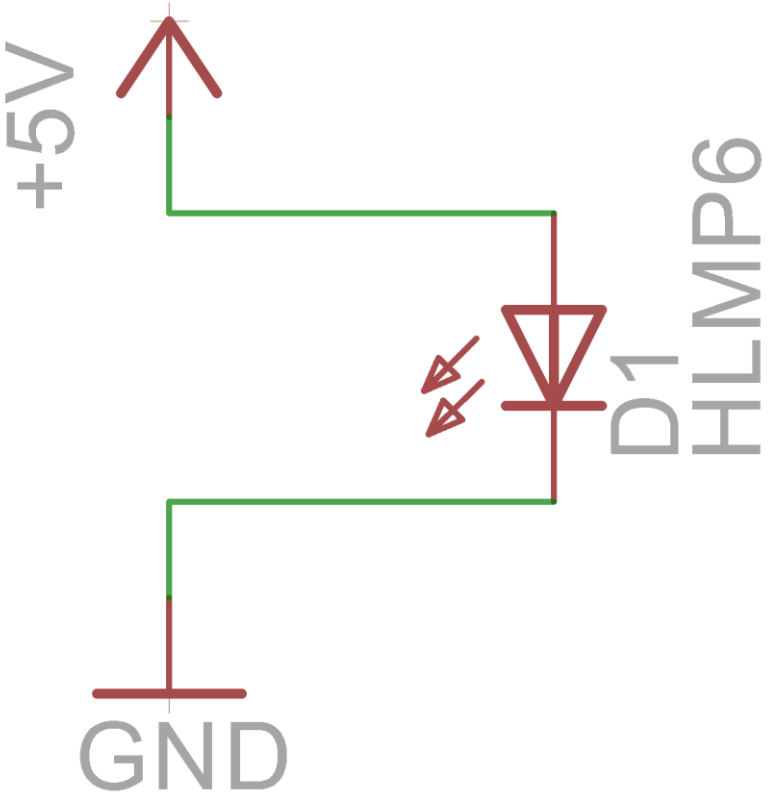


RESISTANCE

Step 1: Let's construct a simple circuit

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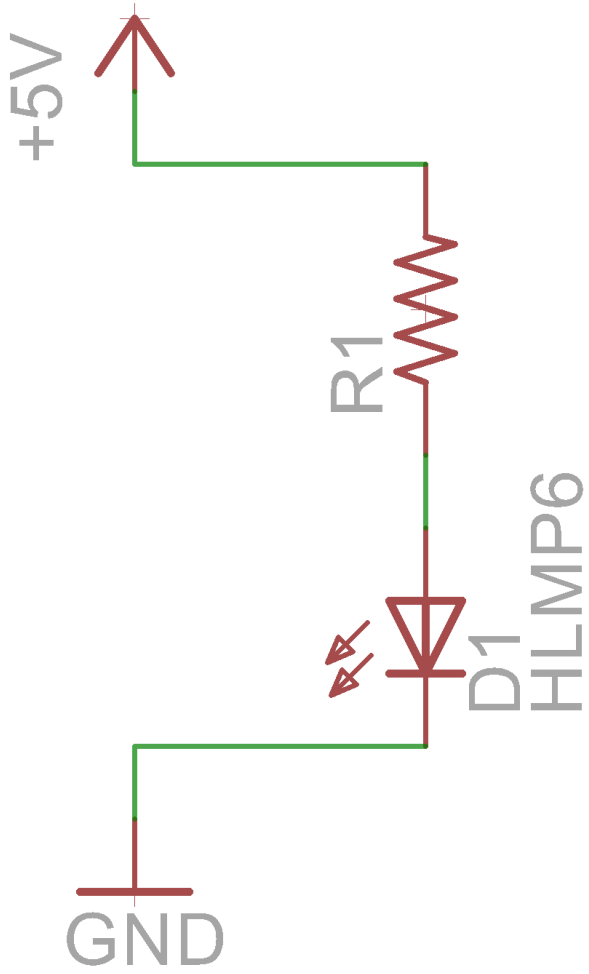
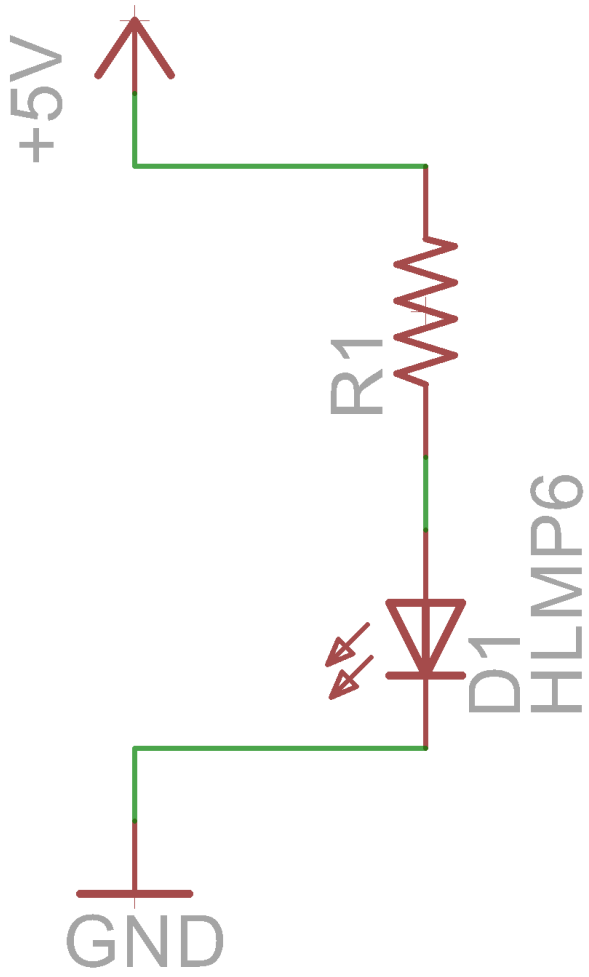


- Meet **resistance**

Step 1: Let's construct a simple circuit

- What should be the value of resistor ?



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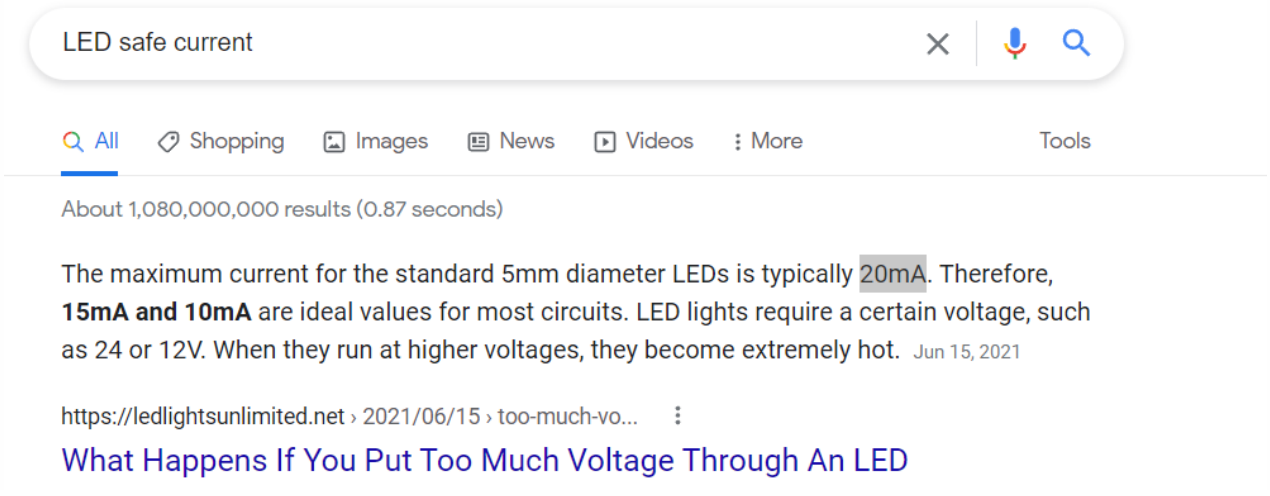

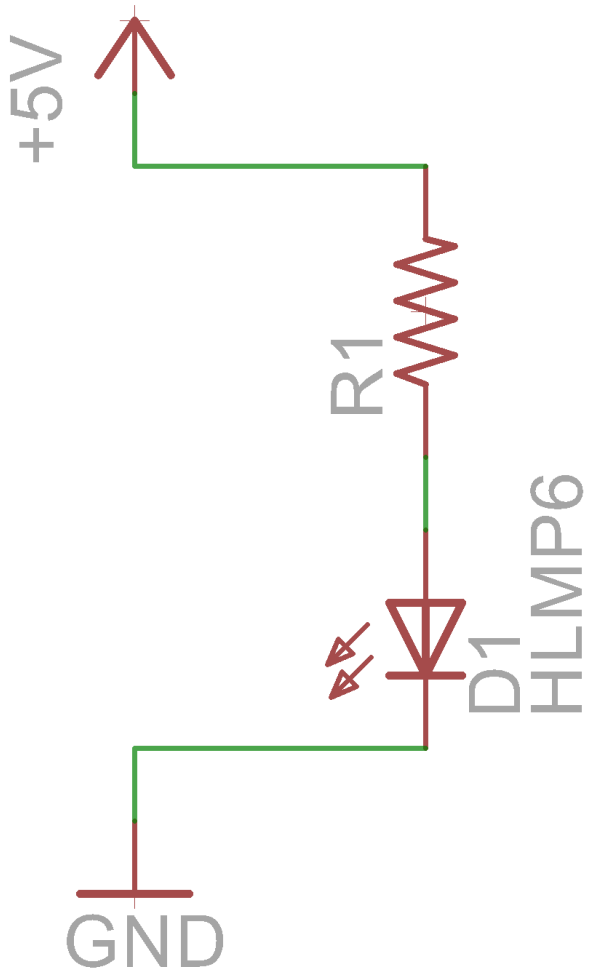

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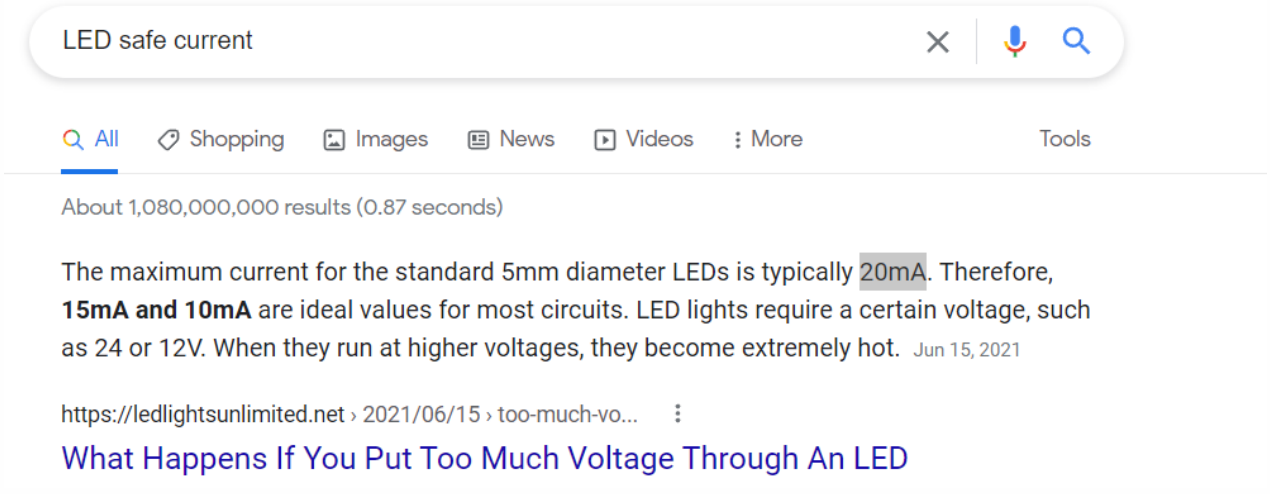
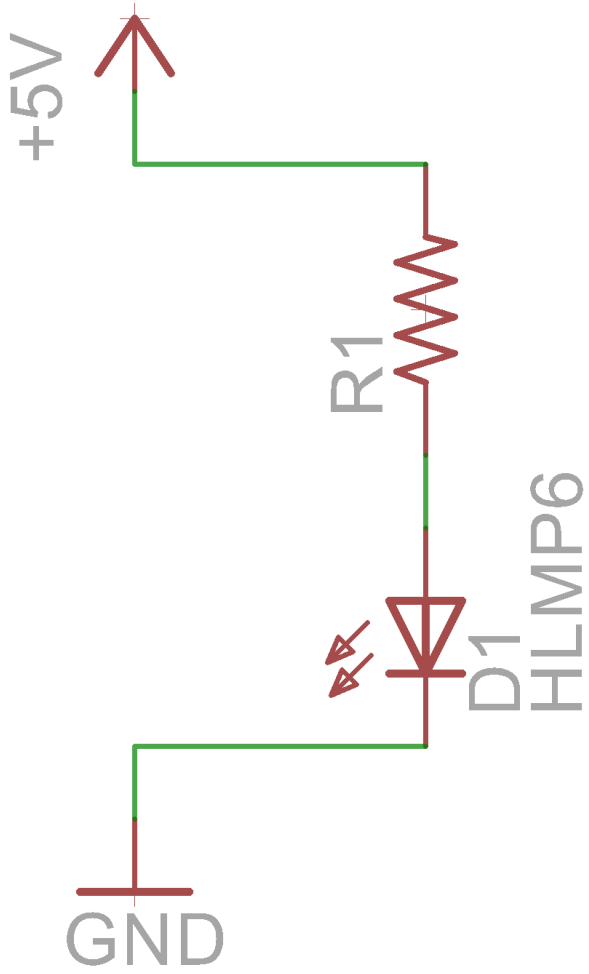


- V=IR (Ohm's Law)



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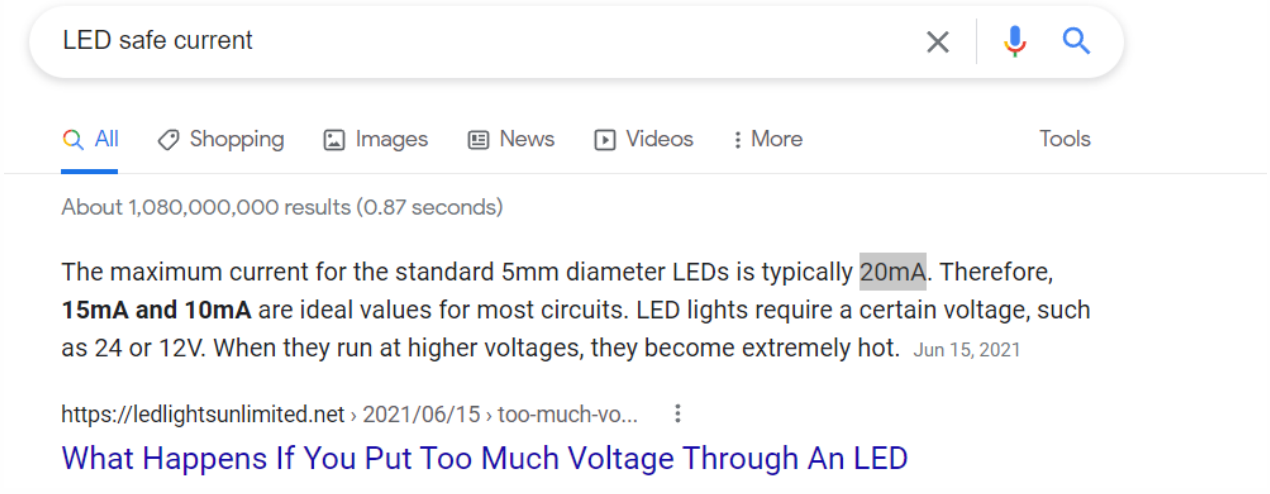
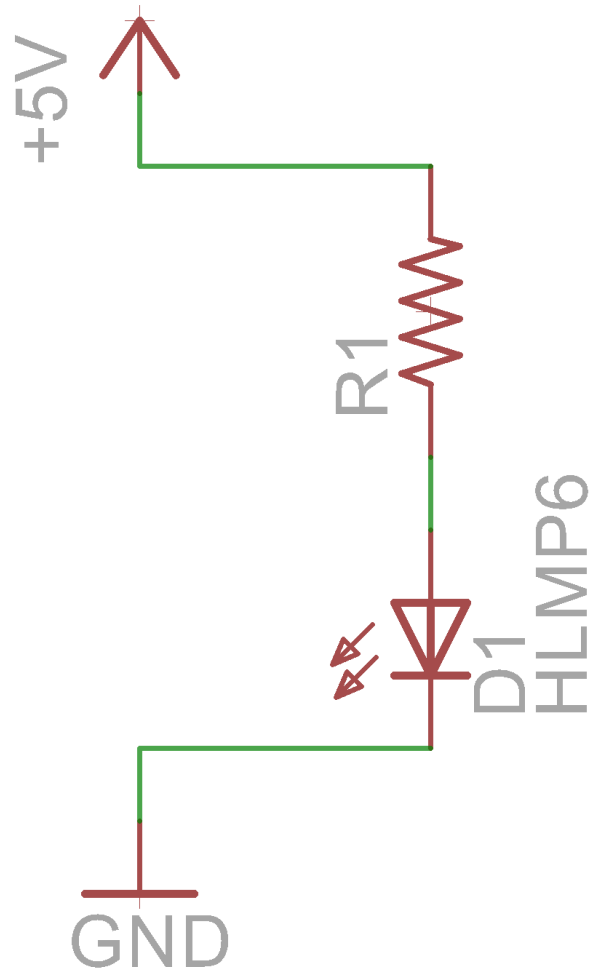
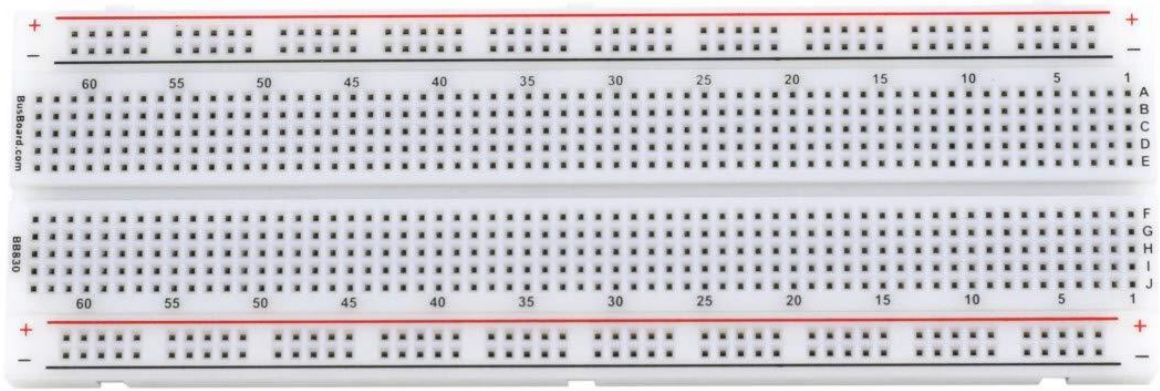


- V=IR (Ohm's Law)
- R= 5V / 0.020A
  ~250 Ohm

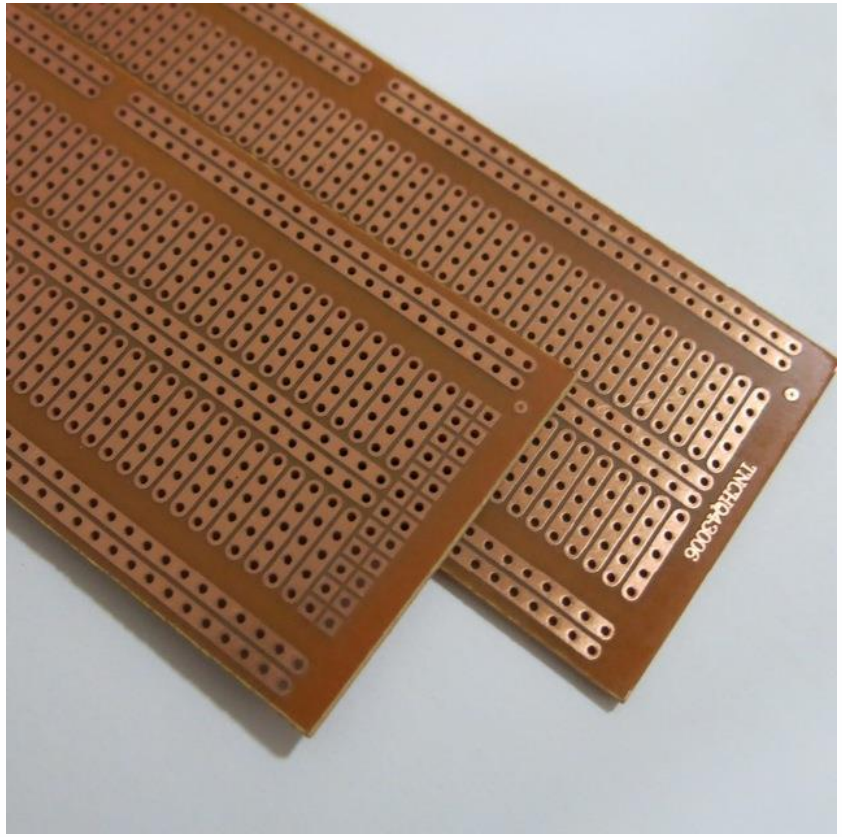


Step 1: Let's construct a simple circuit

- Prototype mechanisms



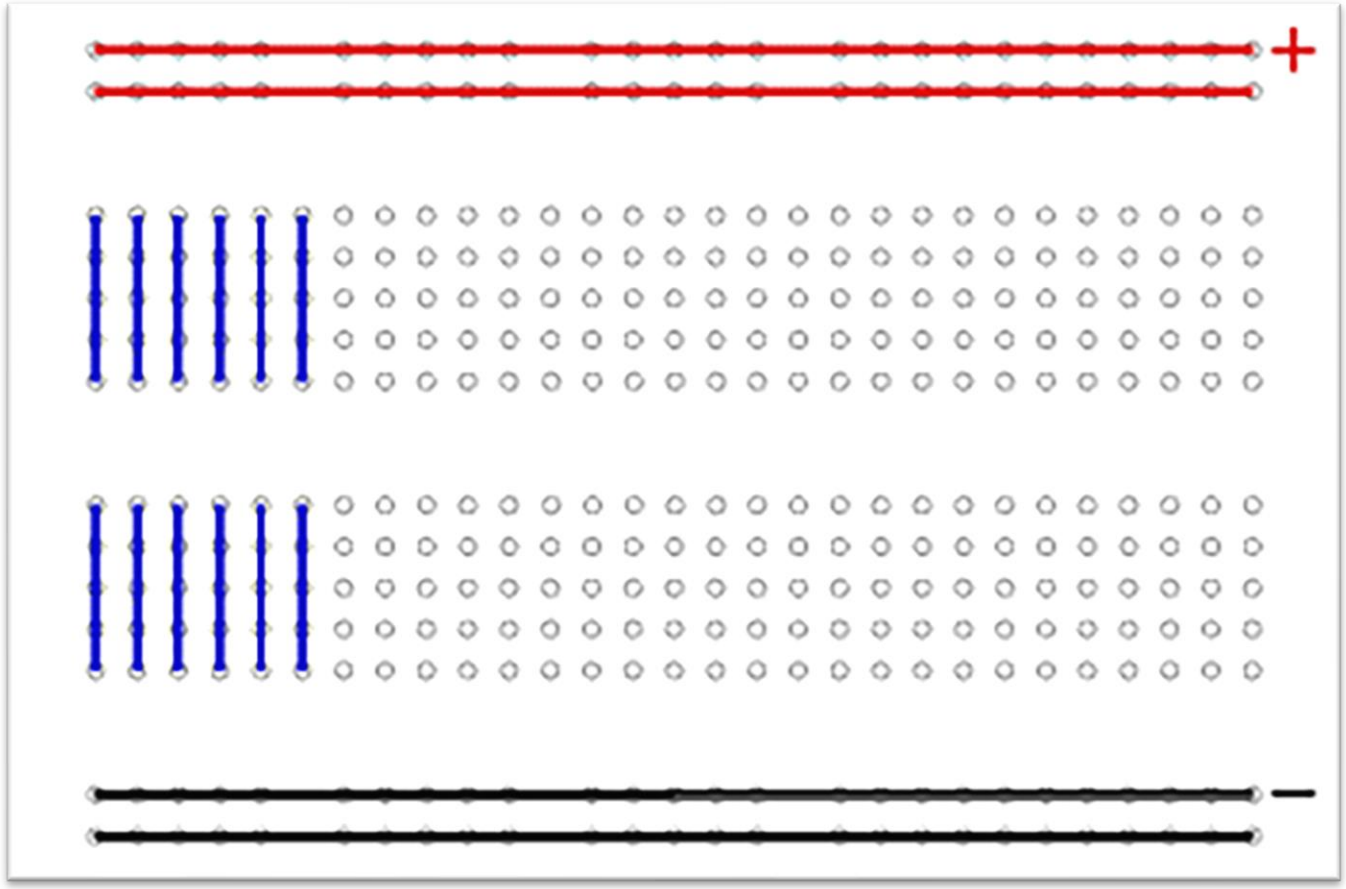
Breadboard



Vero/Strip board

Step 1: Let's construct a simple circuit

- Bread board connections



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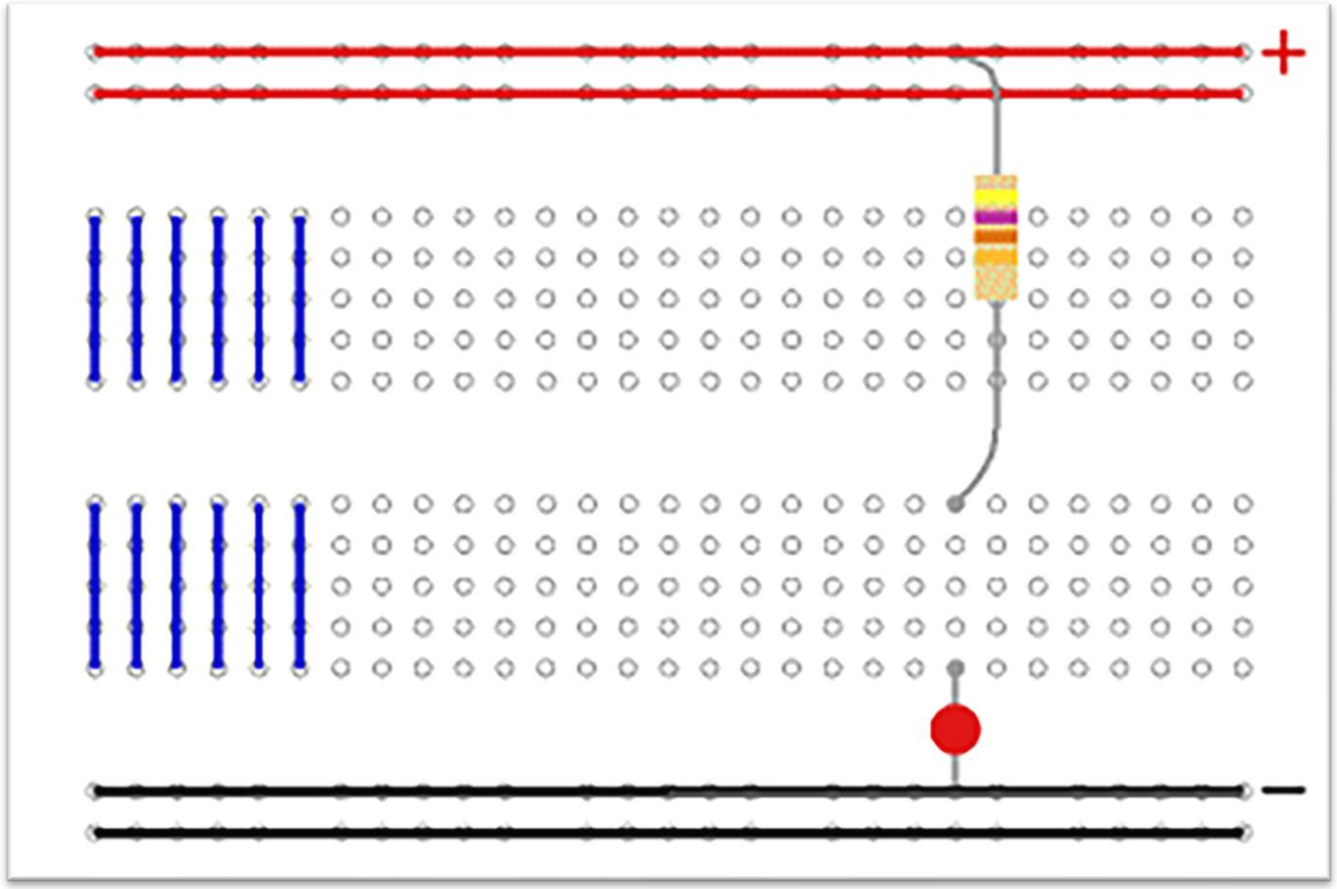

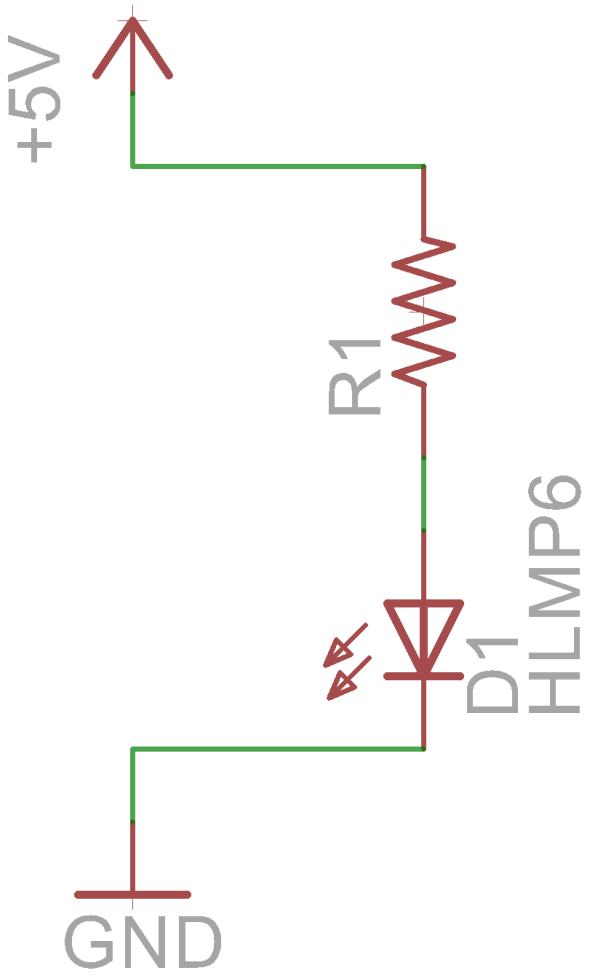

Step 2: Make the light blink for every 1 second

- Goal:

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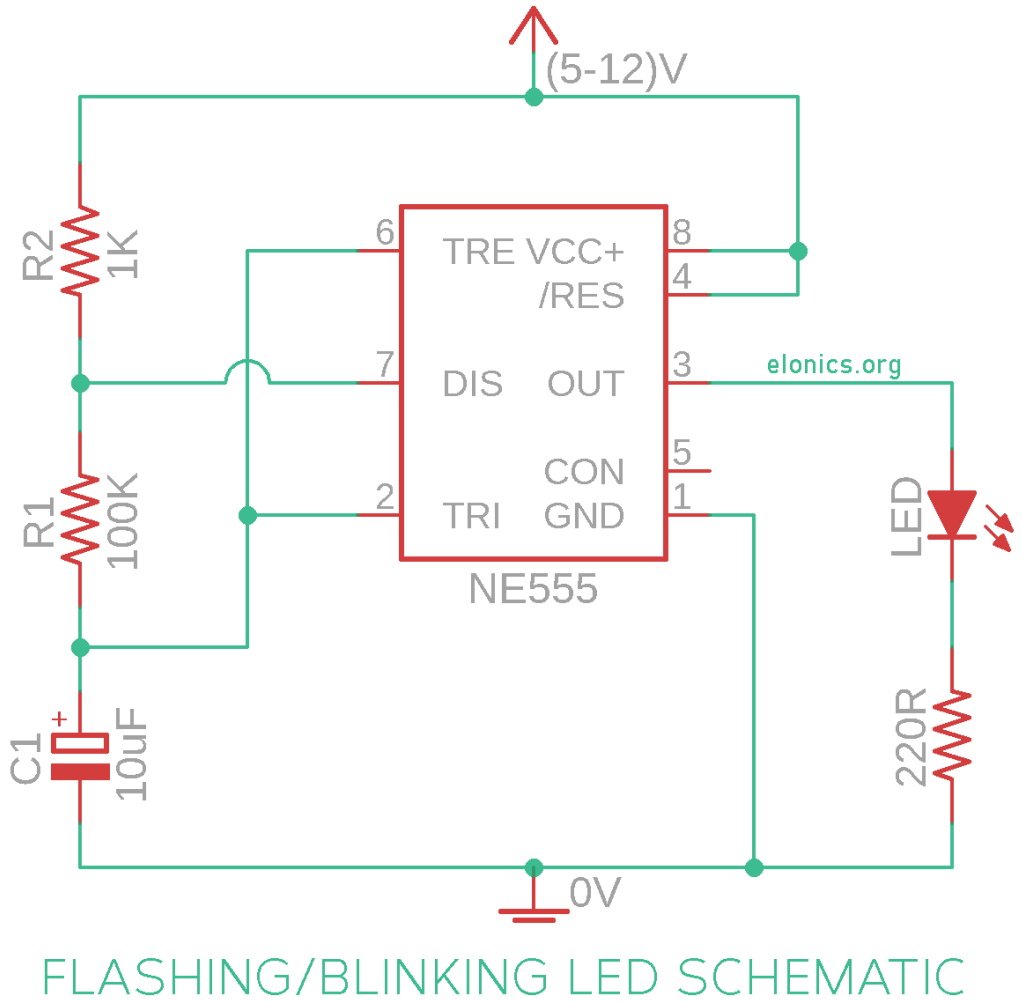

https://elonics.org/adjustable-led-flasher-using-555-timer/

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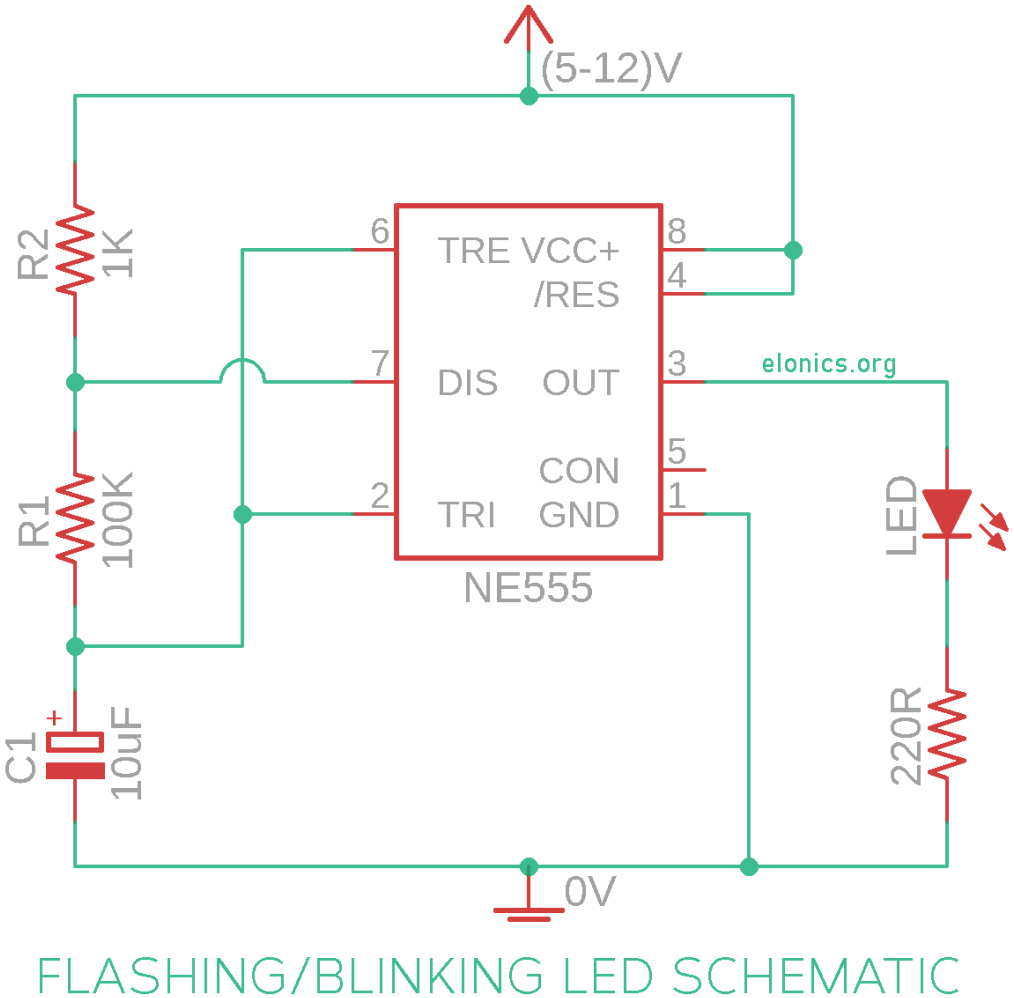
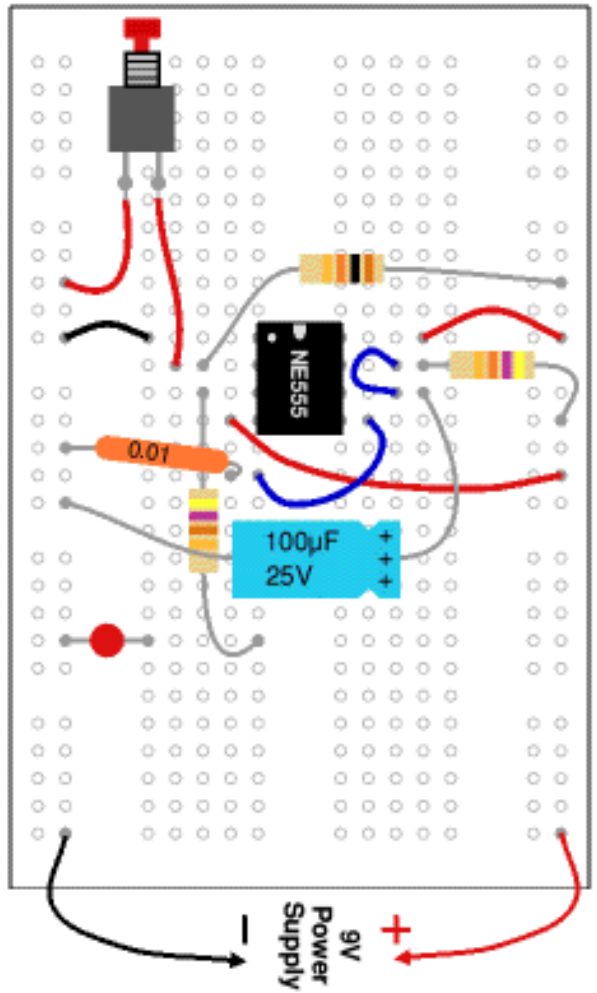


FLASHING/BLINKING LED SCHEMATIC



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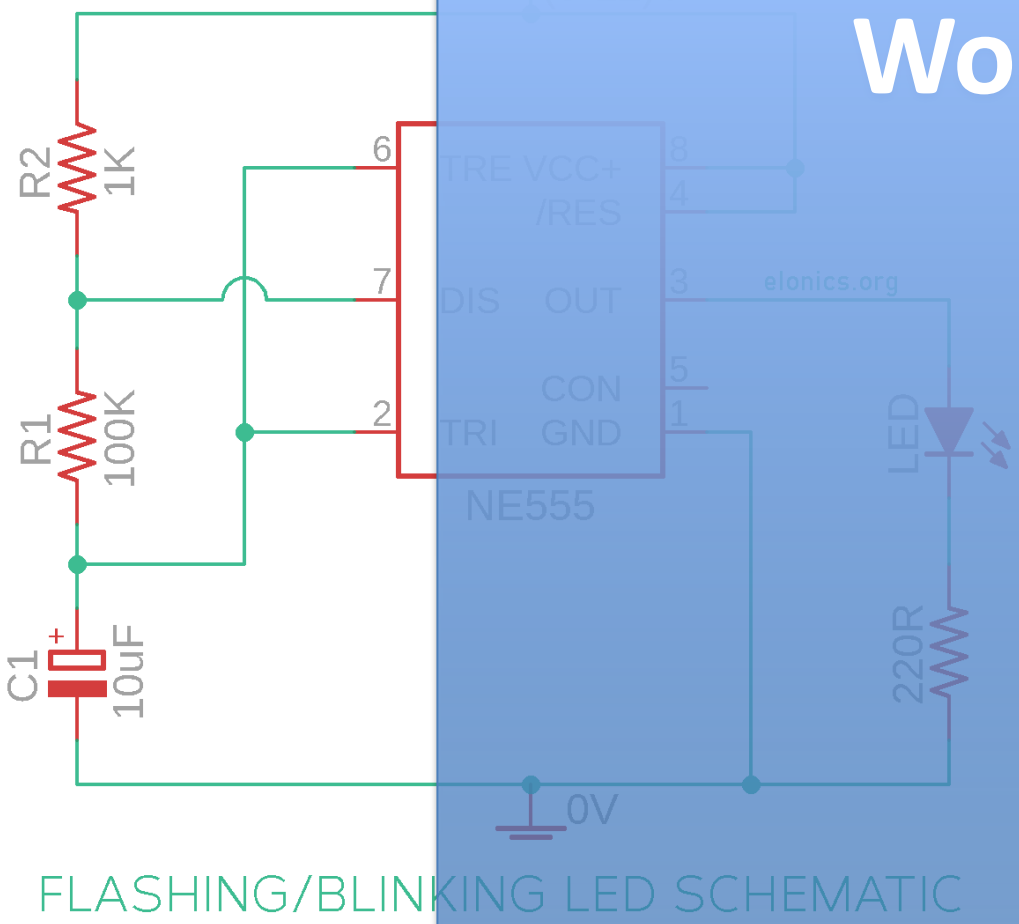

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Wouldn't it be nice..?

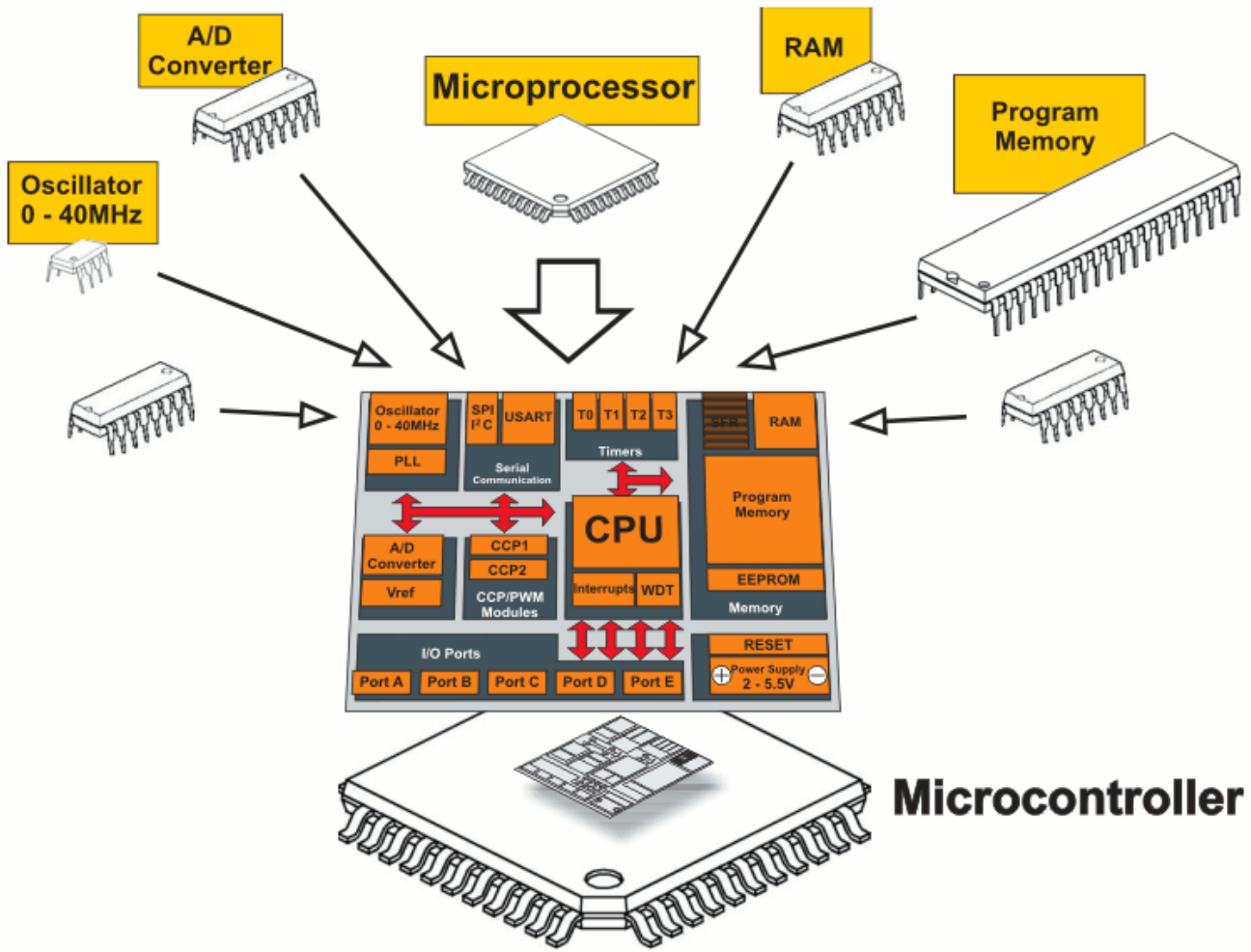
```
void loop()
{
    led(ON);
    sleep(1);
    led(OFF);
    sleep(1);
}
```

WHAT IS A MICROCONTROLLER

- A small computer on a single chip with
  1. Processor
  2. Memory
  3. input/output

- Typically, "**embedded**" inside some device that they control

- A microcontroller is often small and low cost

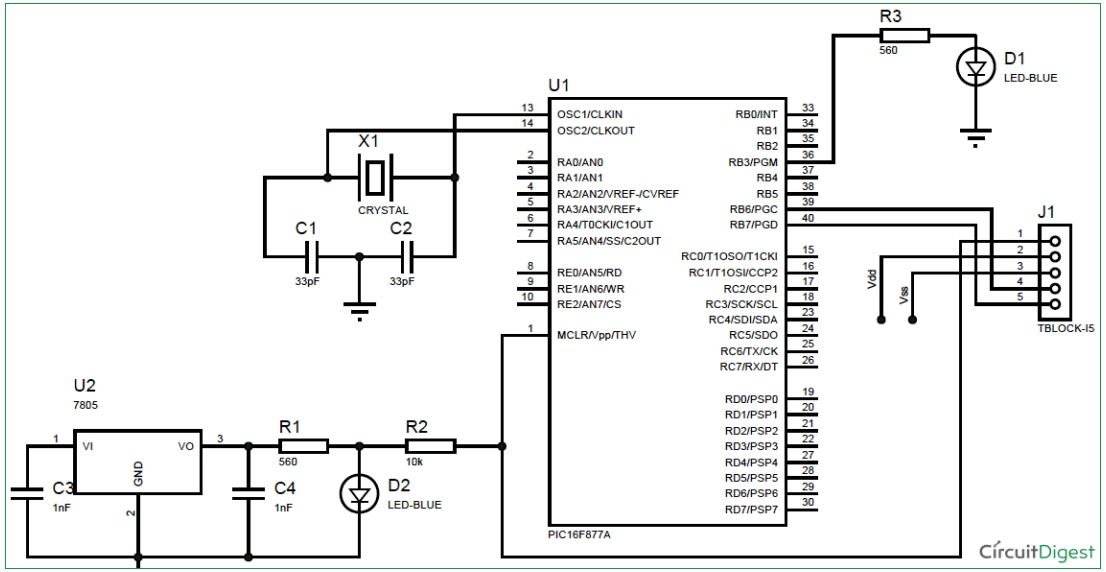


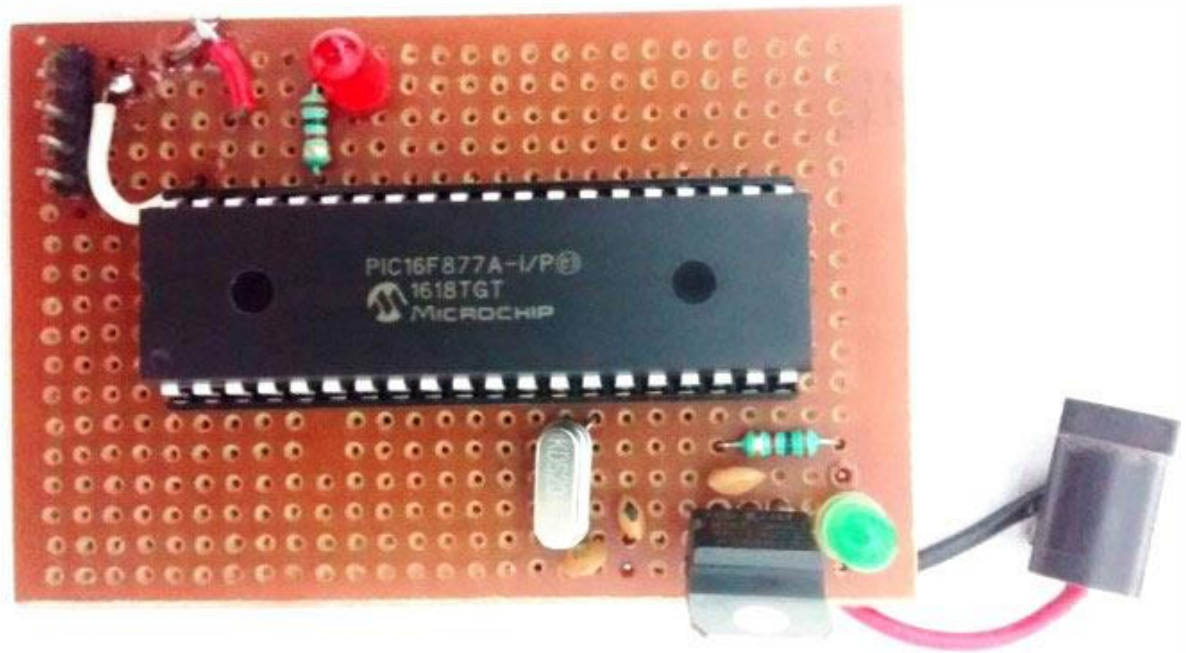
Source: www.mikroe.com/chapters/view/1

STEP 3: BLINKING LED WITH A MICROCONTROLLER

STEP 3: BLINKING LED WITH A MICROCONTROLLER

- Construct circuit

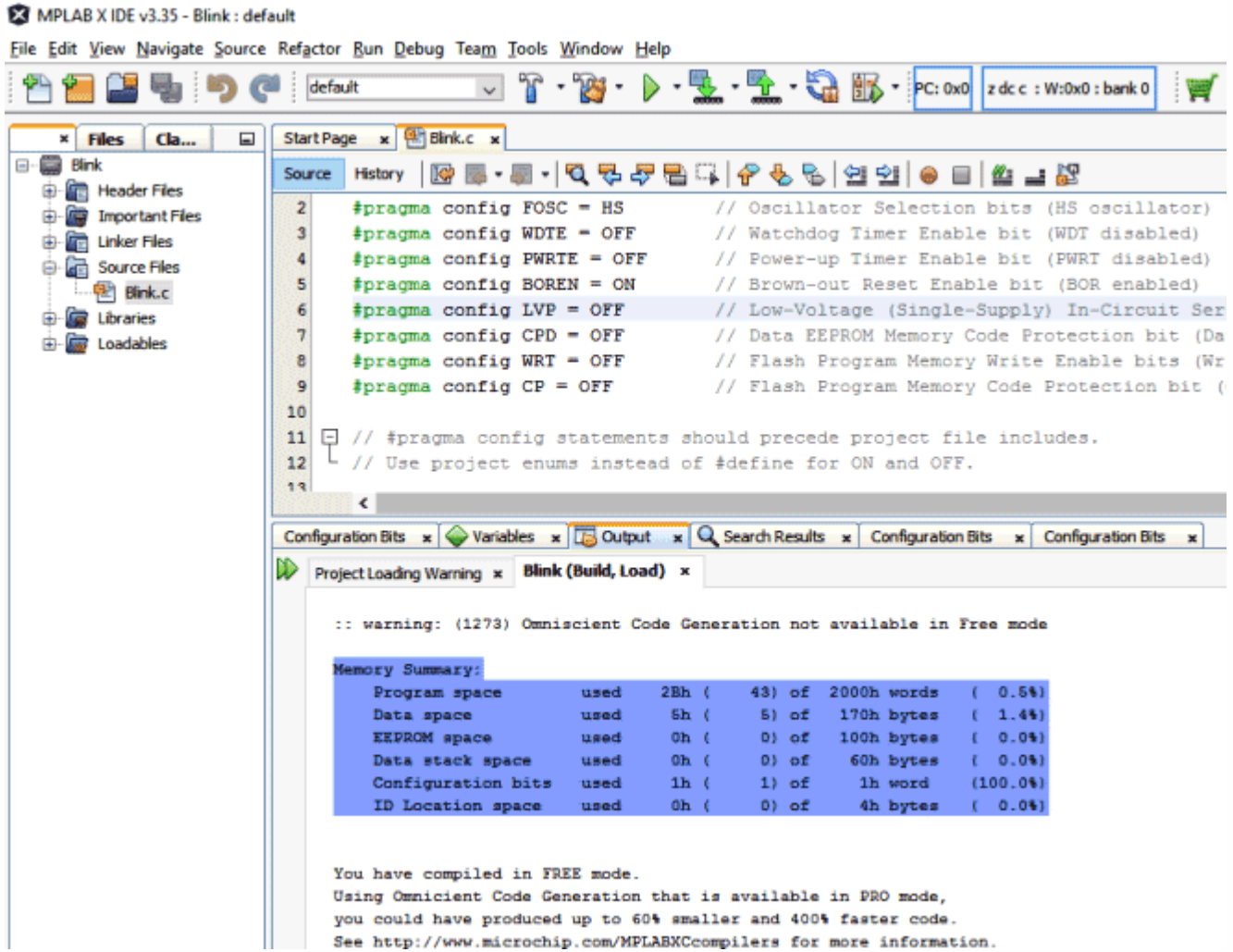




https://circuitdigest.com/microcontroller-projects/led-blinking-with-pic-microcontroller

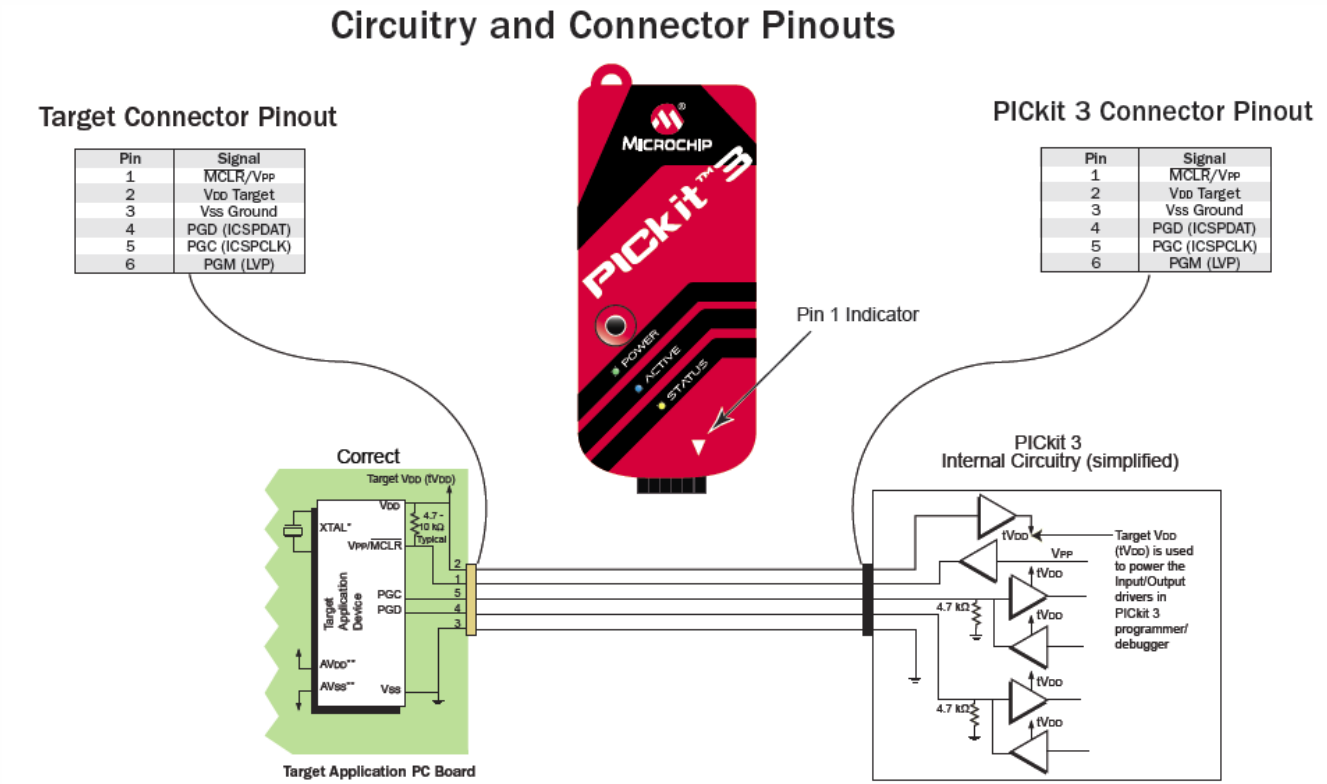
STEP 3: BLINKING LED WITH A MICROCONTROLLER

- Construct circuit
- Compile program



STEP 3: BLINKING LED WITH A MICROCONTROLLER

- Construct circuit
- Compile program
- Flash the program



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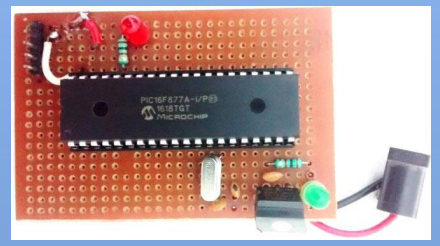

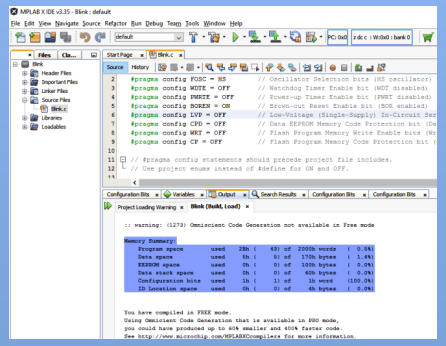

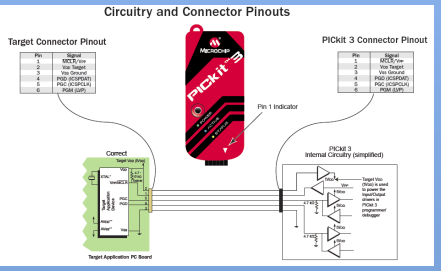

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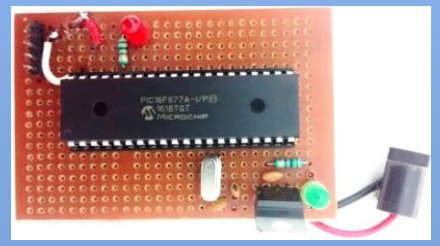
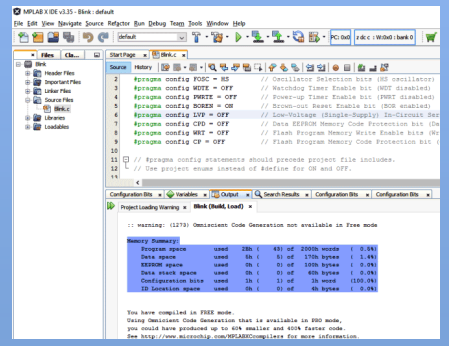
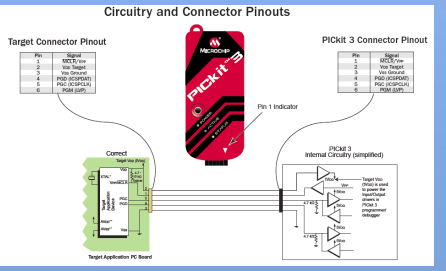


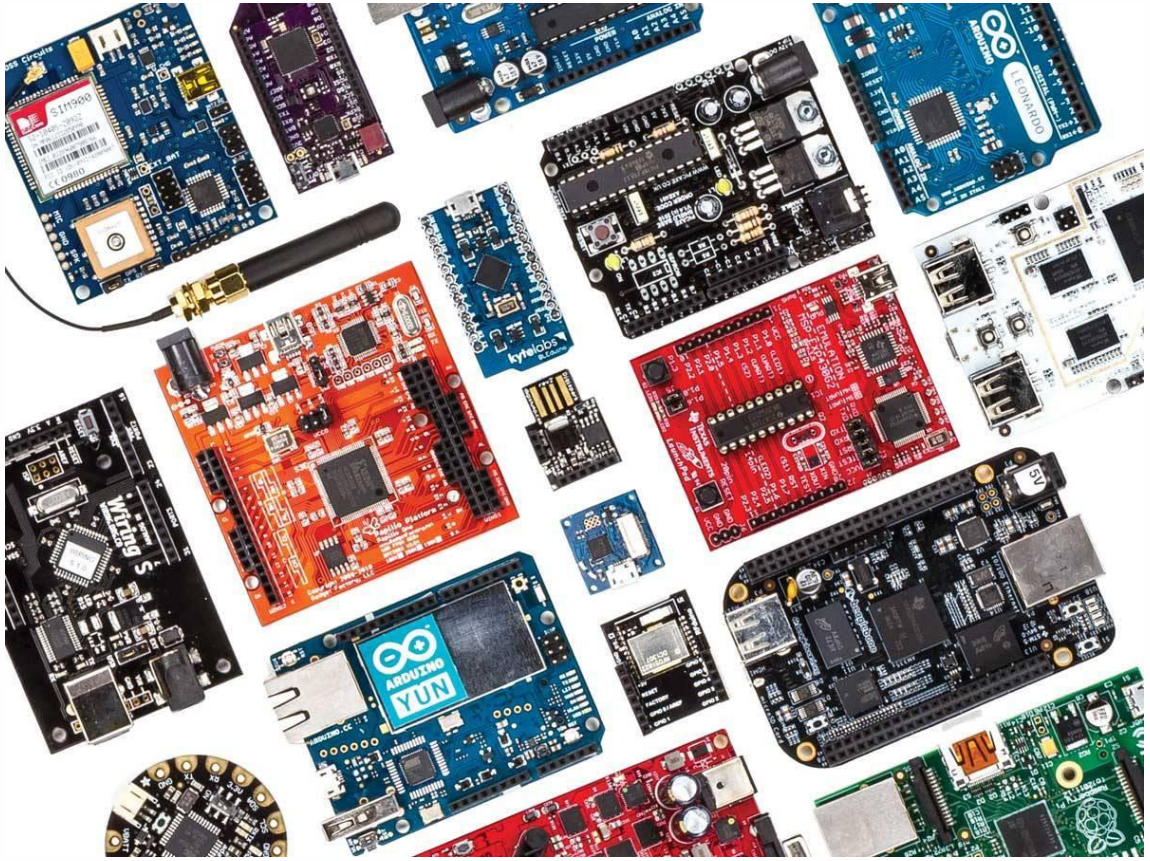




WHAT IS A DEVELOPMENT BOARD

- A printed circuit board designed to facilitate work with a particular microcontroller.

- Typical components include:
  a) power circuit
  b) programming interface
  c) basic input; usually buttons and LEDs
  d) I/O pins



WHAT IS THE ARDUINO?

One of the most popular development boards in the world

The word "Arduino" can mean 3 things

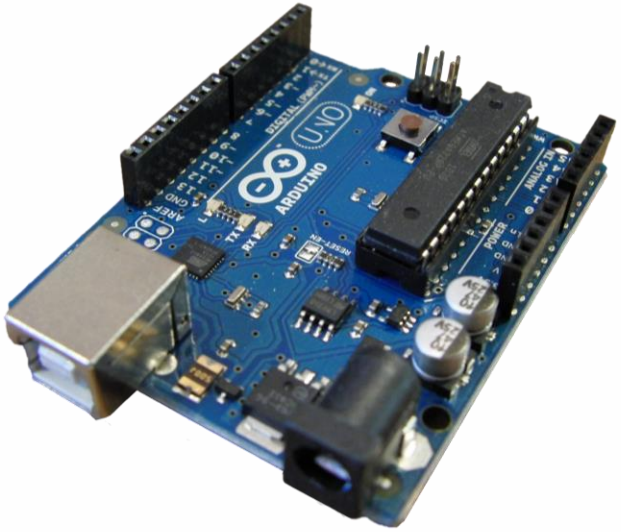
A physical piece of hardware

A programming environment

A community & philosophy

ARDUINO

- **Open-source electronic prototyping platform** based on flexible, easy-to-use hardware and software intended to make the application of interactive objects or environments more accessible.
- **Tons of information on Arduino**
- Wide variety of **Arduino boards**, development **platforms**, **software**, **applications**, etc.,…
- The basic board is called Arduino Uno



- Arduino can
  - **sense the environment** by receiving input from a variety of sensors
  - **affect its surroundings** by controlling lights, motors, and other actuators.
- It is not meant for high-performance processing

WHAT IS ARDUINO USED FOR?

a) Physical Computing projects / research

b) Interactive Installations

c) Rapid prototyping

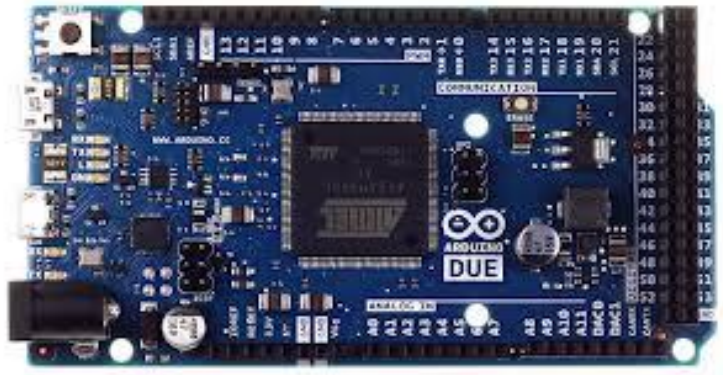
d) When you wish to move beyond the traditional Mouse, Keyboard and Monitor to develop novel and custom interactions in your project work.

ARDUINO BOARD VERSIONS

- There is a wide variety of different Arduino boards (18+).
- Among the most populars:

Lilypad Arduino

- Wearables
- Flexible
- Fabric applications



Arduino Due

- ARM Cortex-M3 -> Faster!
- 32 bits vs 8 bit
- Larger scale applications

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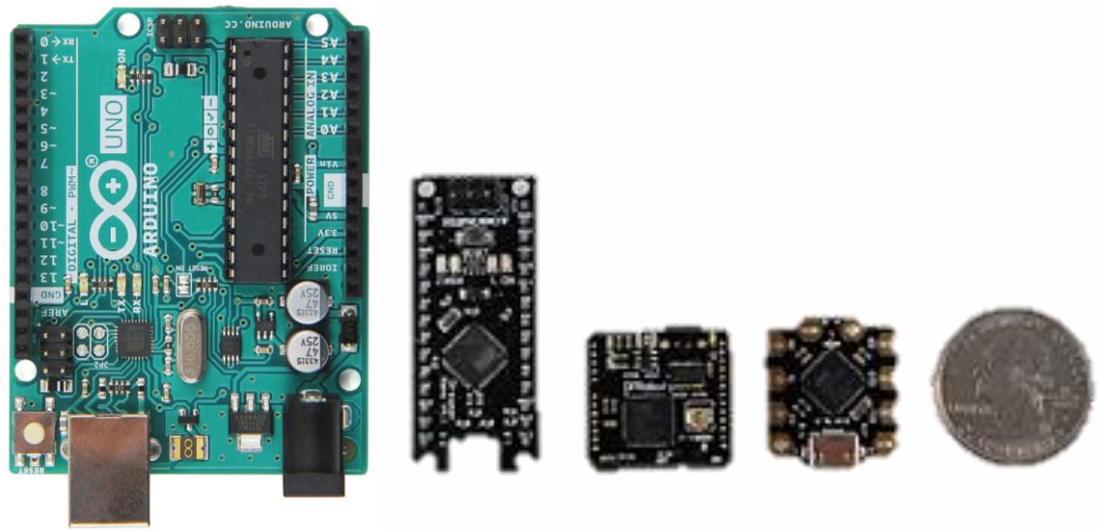


left to right: Arduino UNO, Nano, Nova and Beetle

Arduino Beetle

- Current smallest form factor
- Arduino Uno based board
- Bluetooth 4.0
- MicroUSB

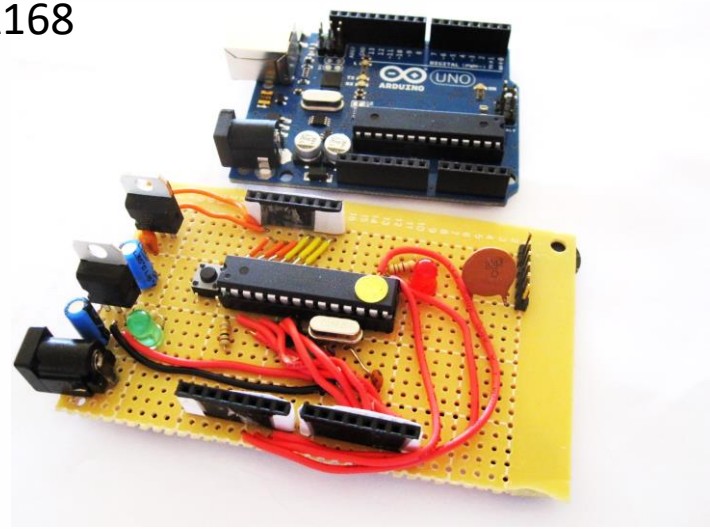
SOME PROPERTIES OF ARDUINO

- **Inexpensive** (compared to other platforms)
  - The least expensive version of the Arduino module can be assembled by hand, and even the pre-assembled Arduino modules cost less than $50.
- It **can communicate with a computer** via serial connection over USB and via shield with Ethernet, GSM, Zigbee, Bluetooth, etc.
- It can be **powered from USB or standalone DC power** (batteries also).
- It **can run standalone** from a computer (chip is programmable) and it has memory (a small amount).
- **Cross-platform** - The Arduino IDE software runs on Windows, Macintosh OSX, and Linux operating systems.
- It can work with both Digital and Analog electronic signals. Sensors and Actuators.

SOME PROPERTIES OF ARDUINO (CONT.)

- **Simple**, **clear programming environment**
  - Arduino programming environment is easy for beginners, yet flexible enough for advanced users.

- It is **Open Source**, in terms of both Hardware and Software.
  - Software can be extended by experienced programmers.
    - Arduino can be expanded through C++ libraries
    - Arduino is based on the AVR C programming language. Programming in AVR C offers more advance features, but more difficult to learn.
  - Extensible hardware - The Arduino is based on Atmel's ATMEGA8 and ATMEGA168
    - Plans published under a Creative Commons license
    - Designers can make their own version of the module, extending it and improving it.
    - Even relatively inexperienced users can build the breadboard version of the module.



WHAT CAN ARDUINO DO?

Sensors (to sense stuff)

- Push buttons, touch pads, tilt switches.
- Variable resistors (eg. volume knob / sliders)
- Photoresistors (sensing light levels)
- Thermistors (temperature)
- Ultrasound (proximity range finder)
- Etc….

Actuators (to do stuff)

- Lights, LED's
- Motors
- Speakers
- Displays (LCD)
- Etc…

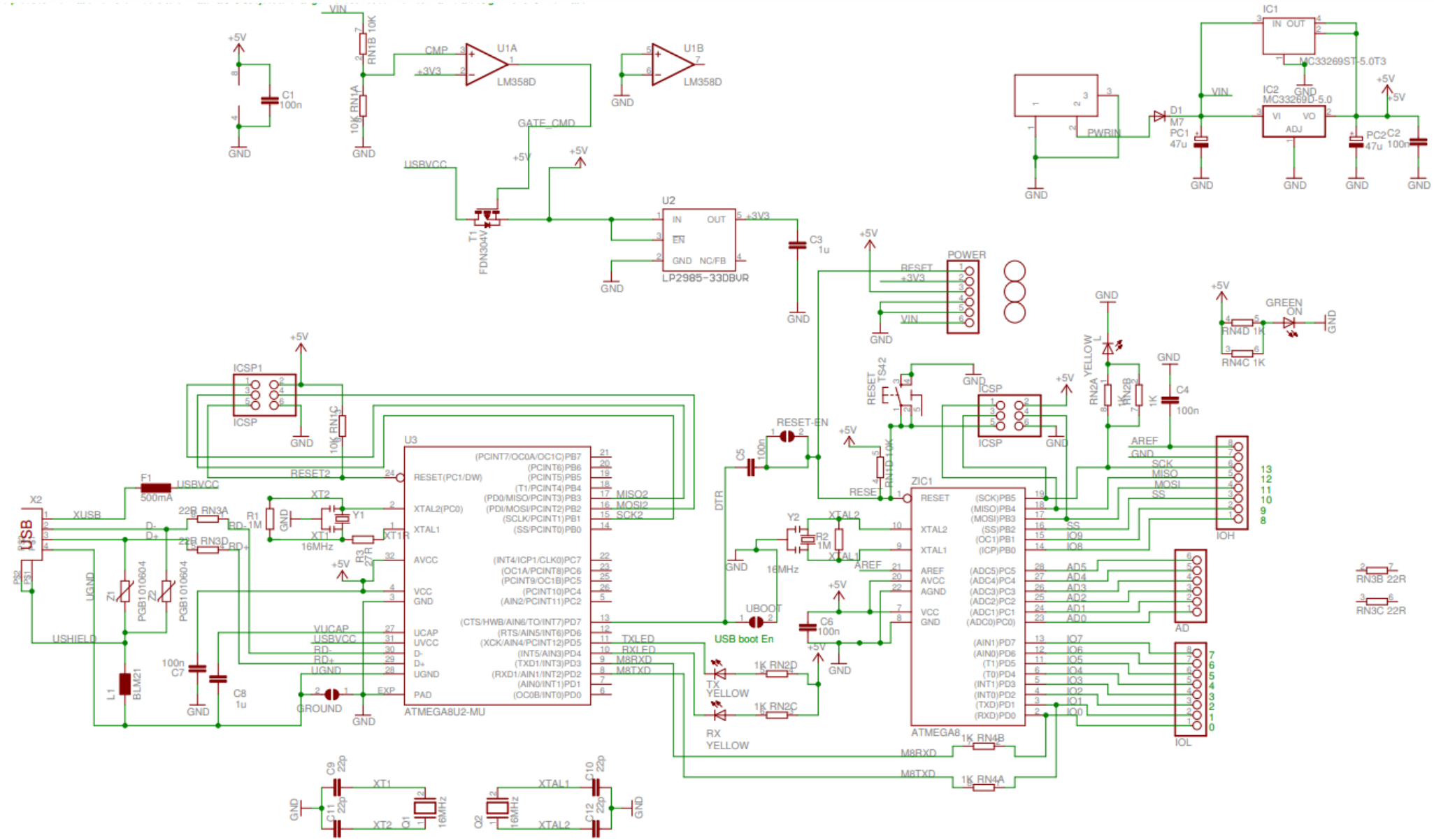
REFERENCES

- Harold Timmis, "**Practical Arduino Engineering**", Apress, 2011.
  - Free access at Springer

- Michael Margolis, "**Arduino Cookbook**", O'Reilly Media, 2011.
  - Free access here

- Language References (standard instructions)
  - Free access at Arduino.cc

WHAT IS IT MADE UP OF



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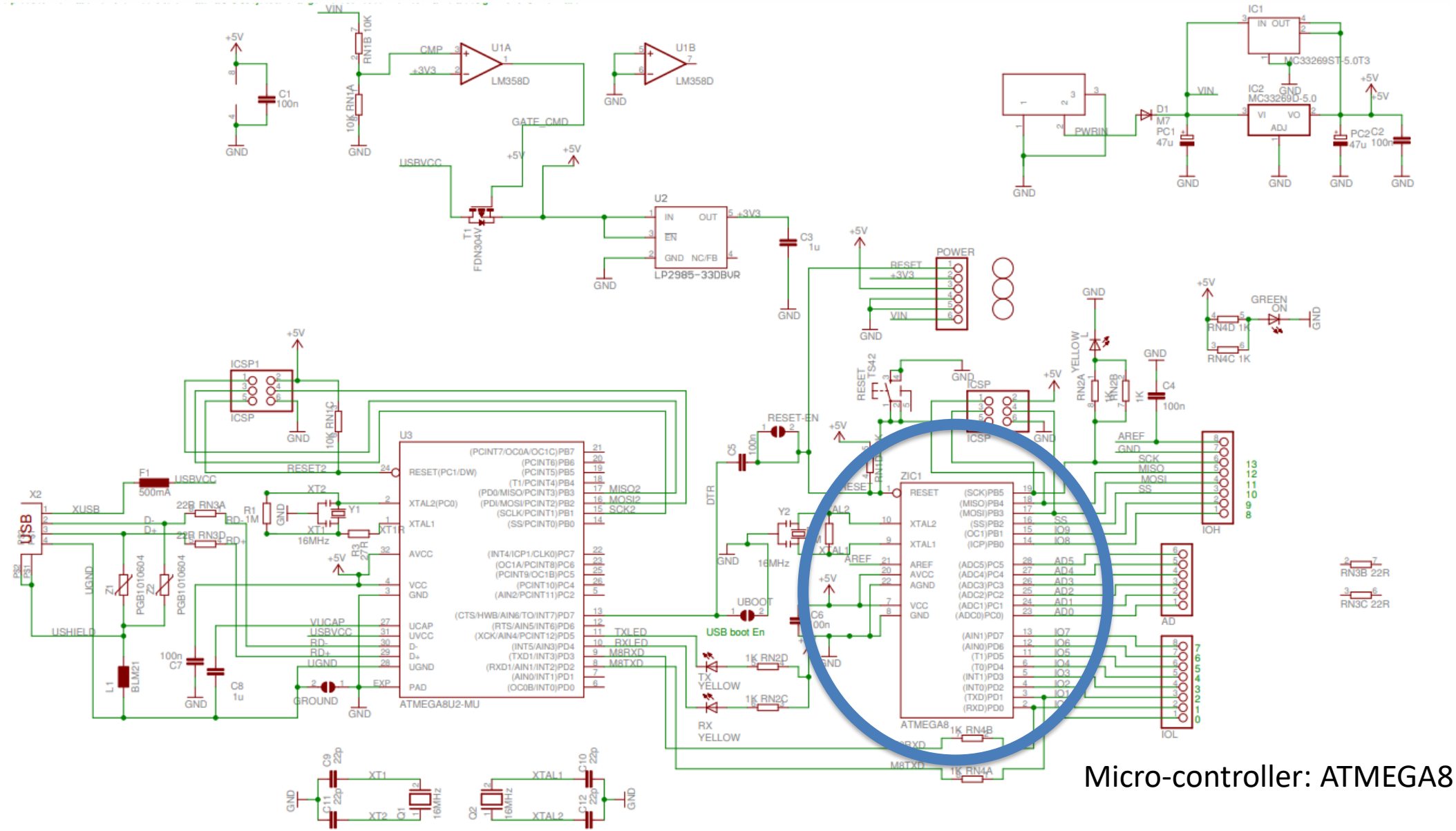

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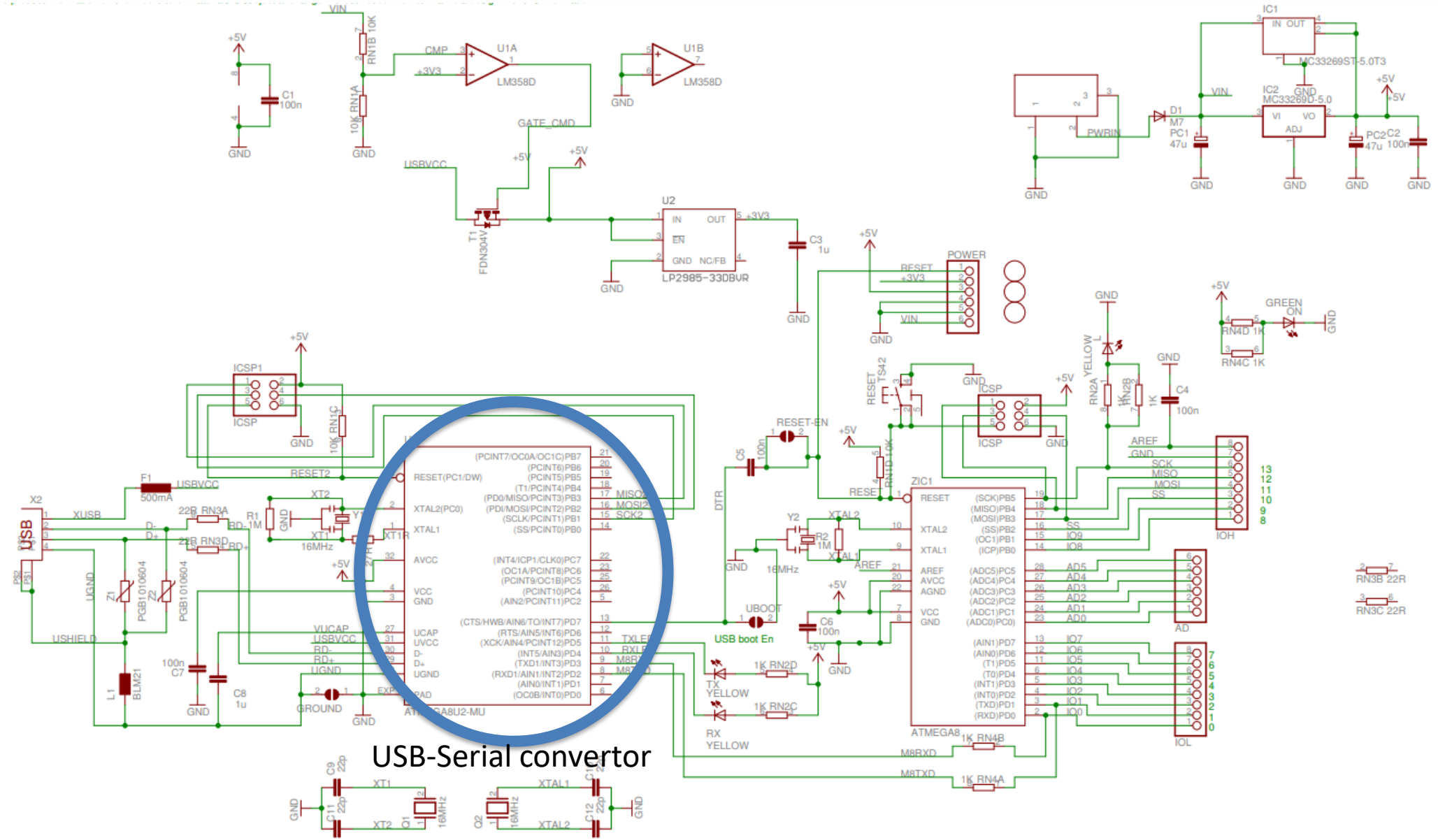

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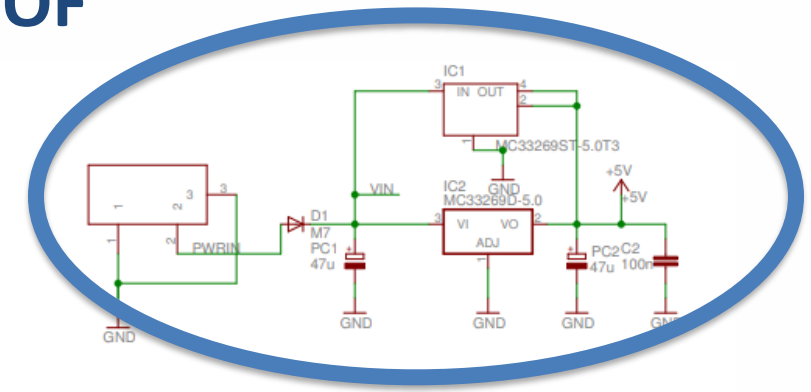
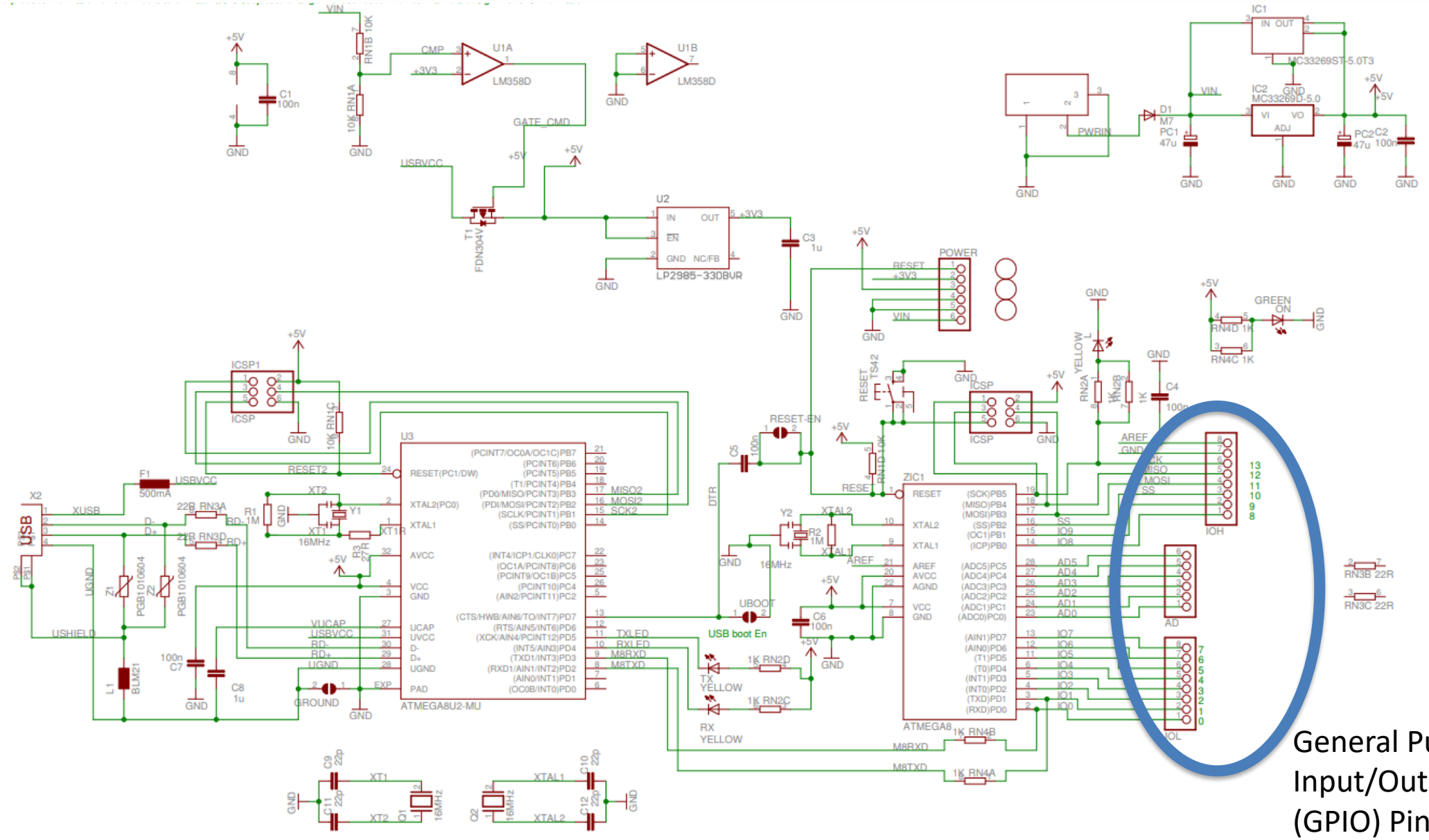


Power circuit

WHAT IS IT MADE UP OF



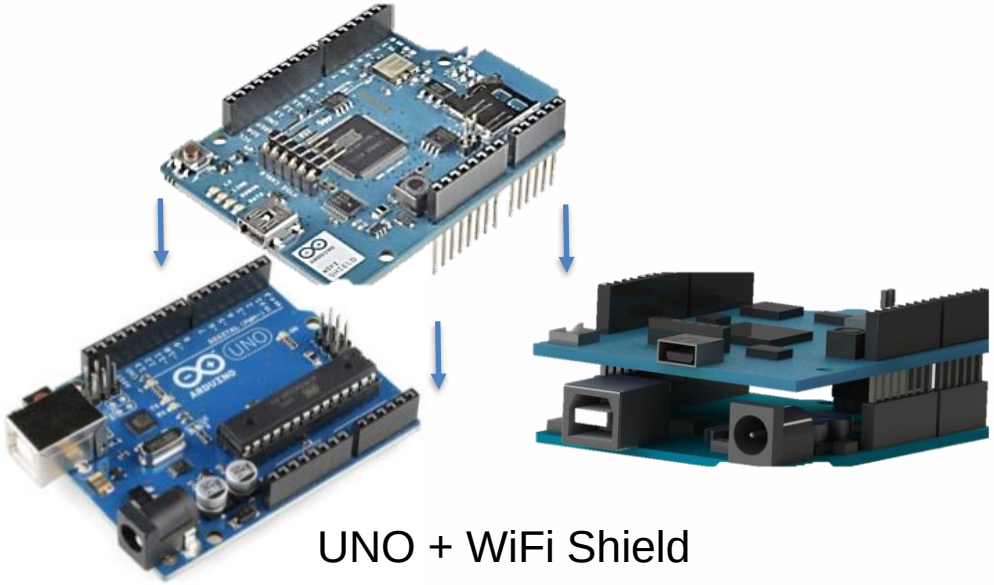
HARDWARE

- The basic Arduino board consists of an Atmel 8-bit AVR processor with complementary **components** to facilitate **programming** and **incorporation** into other circuits.
  - Other processors are also used in some Arduino boards, like **ARM** processors.
- Arduino's microcontroller is **pre-programmed with a boot loader**
  - Simplifies uploading of programs to the on-chip flash memory
  - Allows the use of an ordinary computer as the programmer.
- There are many Arduino-compatible, Arduino-pin-compatible and Arduino-derived boards.
  - Some are functionally equivalent to an Arduino and may be used interchangeably.
  - The **Sparkfun Photon RedBoard** is one of them.

SHIELDS

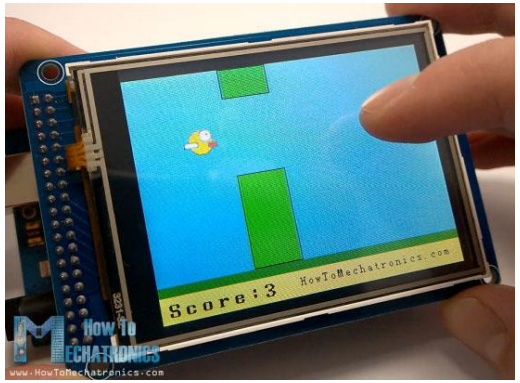
- Connectors in Arduino are exposed in a standard way, allowing the CPU board to be connected to a variety **of interchangeable add-on modules** known as **shields**.
  - Some shields communicate with the Arduino board **directly over various pins**, but many shields are individually **addressable via an I²C serial bus**, allowing many shields to be stacked and used in parallel.

- Arduino boards make use of shields—printed circuit expansion boards that plug into the normally supplied Arduino pin-headers. Shields can provide **easy sensor/actuator interface, motor controls, GPS, ethernet, LCD display, etc**…

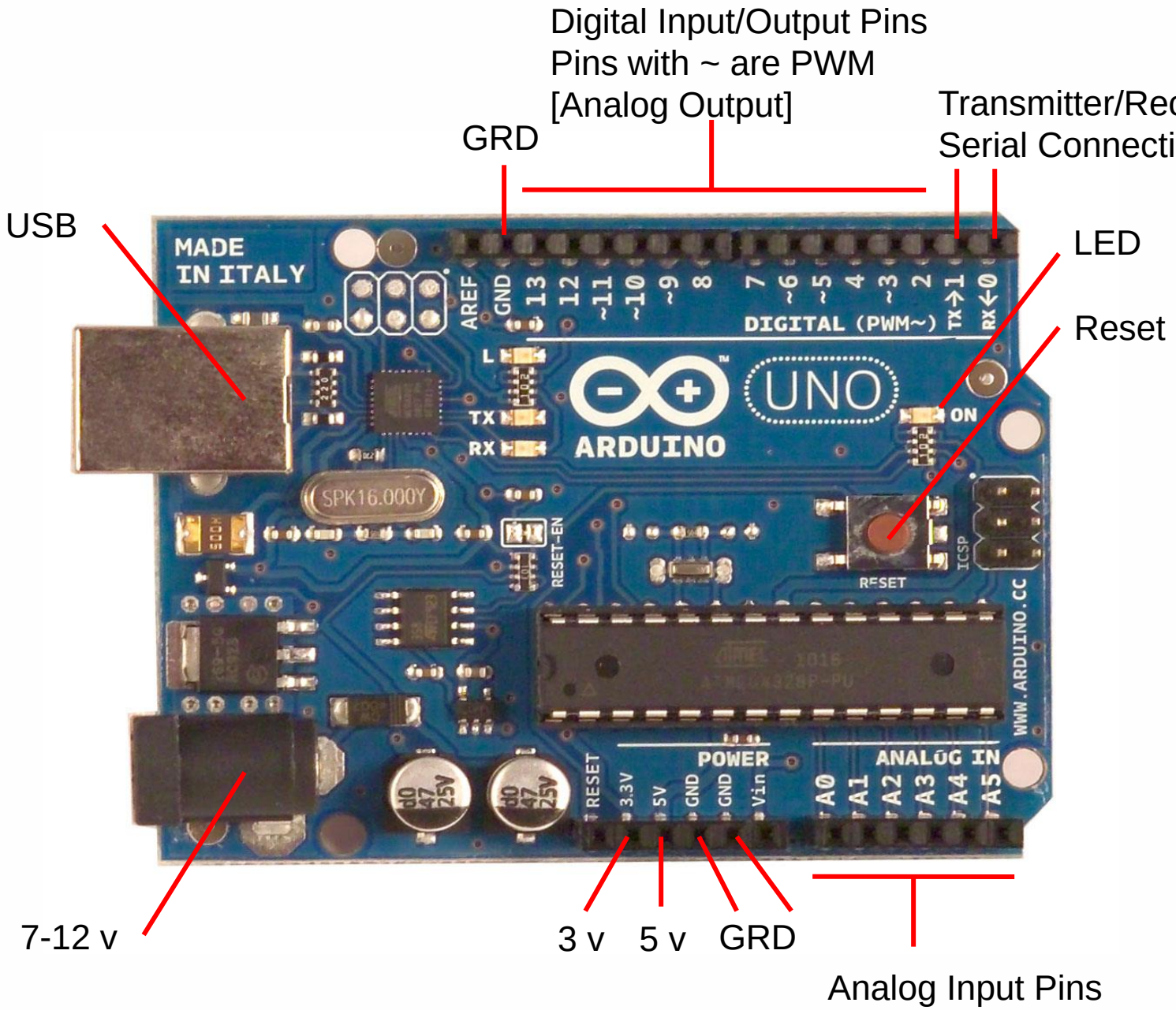


UNO + WiFi Shield

UNO + GSM shield



Touchpad shield

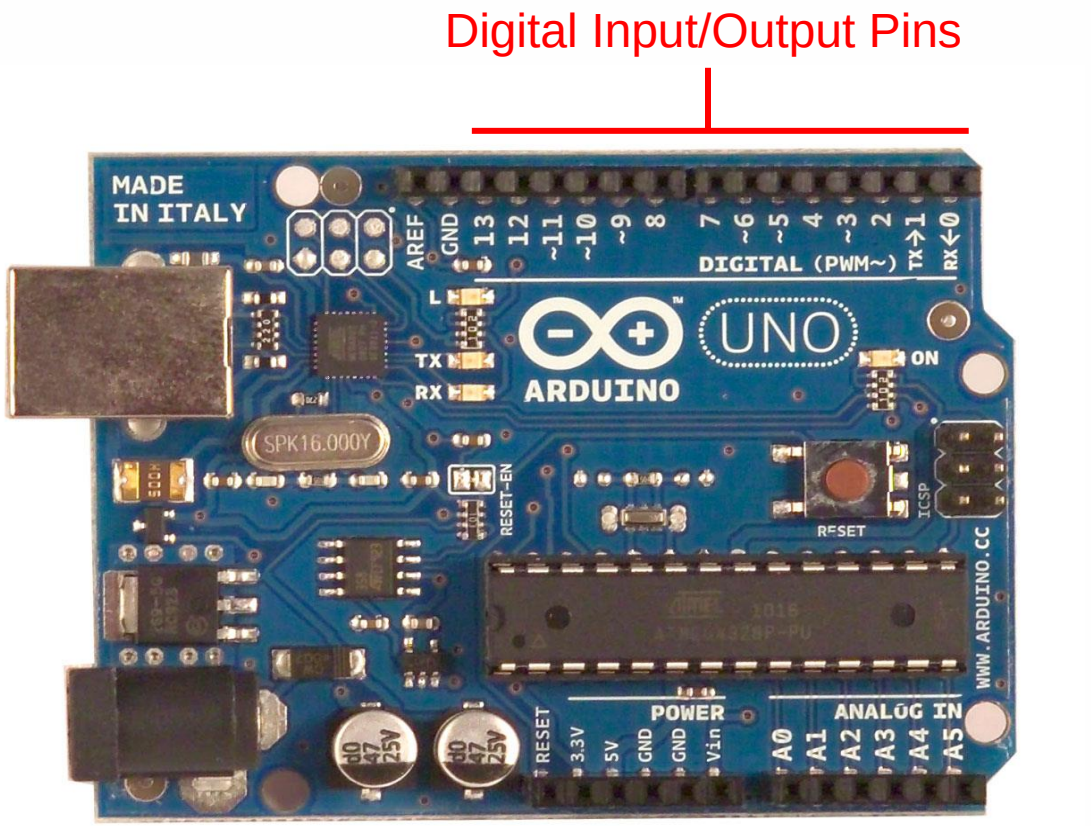


Arduino UNO Specs:

- Microcontroller ATmega328
- Operating Voltage 5V
- Input Voltage (recommended)7-12V
- Input Voltage (limits)6-20V
- Digital I/O Pins 14
- (of which 6 provide PWM output)
- Analog Input Pins 6
- DC Current per I/O Pin 40 mA
- DC Current for 3.3V Pin 50 mA

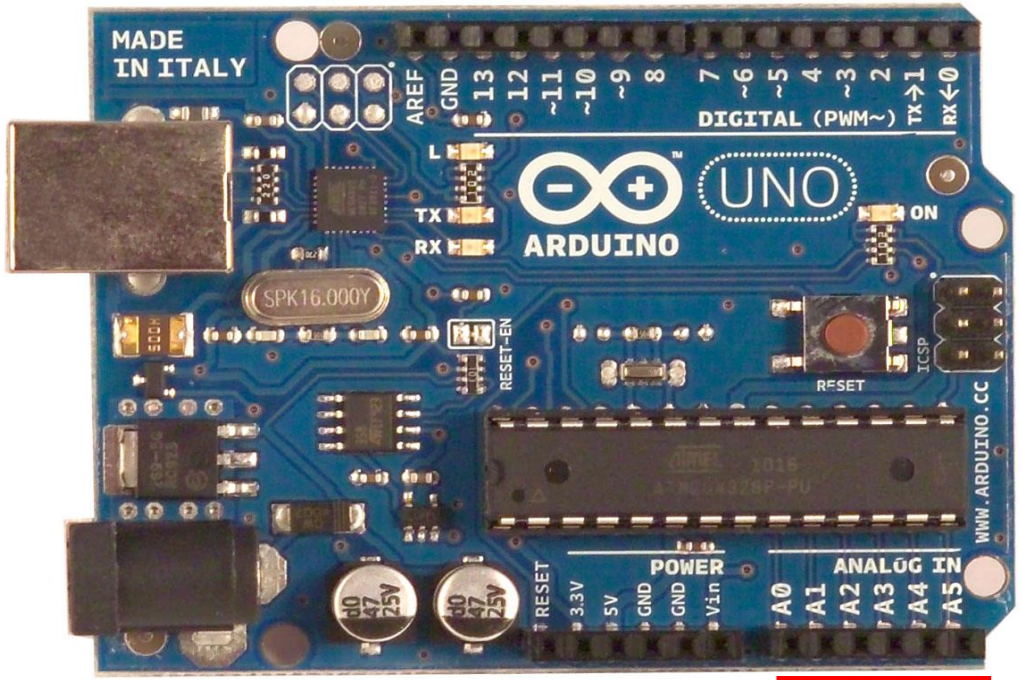
PINS

- **14 Digital** IO pins (pins 0–13)
  - These can be **inputs or outputs**, which is specified by the sketch you create in the IDE.



PINS

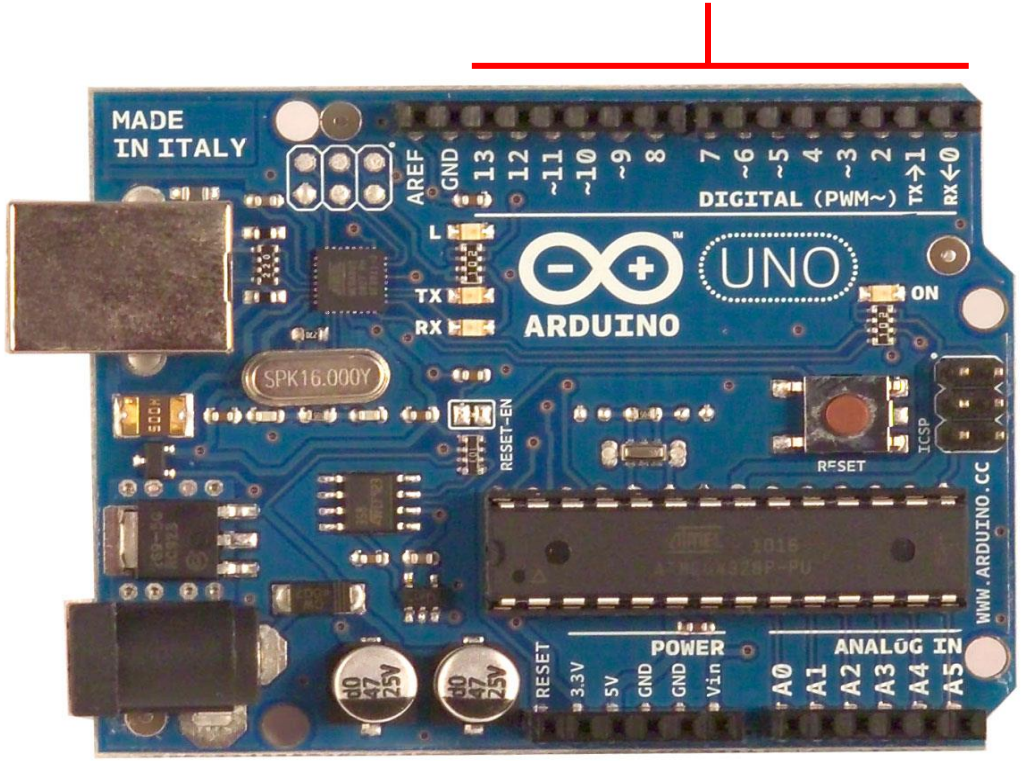
- 6 **Analog In** pins (pins 0–5)
  - **Dedicated** analogue input pins
  - Convert analog values (i.e., **voltage readings** from a sensor) into a number between **0 and 1023**.



PINS

- 6 **Analog Out** pins (pins 3, 5, 6, 9, 10, and 11)
  - 6 of the **digital pins** that can be **reprogrammed** for analog output using the **sketch** you create in the IDE.

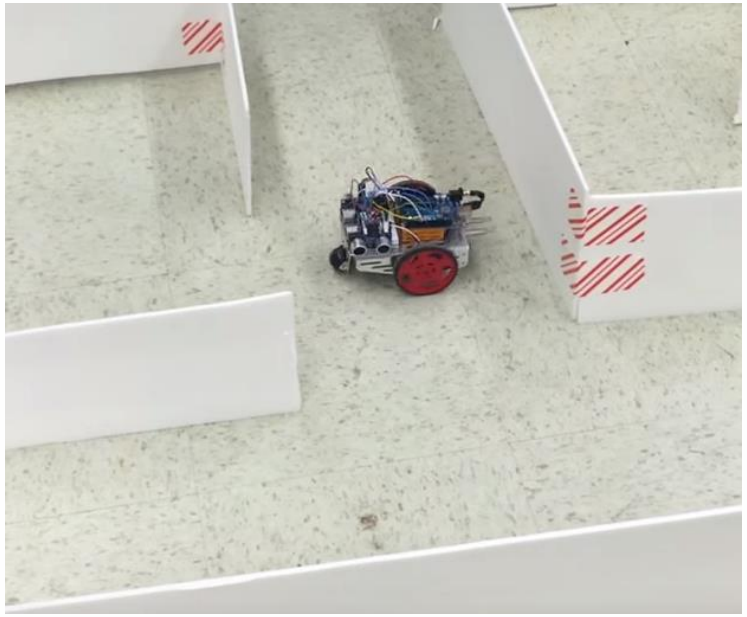
Pins with ~ are PWM [Analog Output]



WHAT CAN YOU DO WITH AN ARDUINO?

- Your limit is only your creativity!

Color Classifier

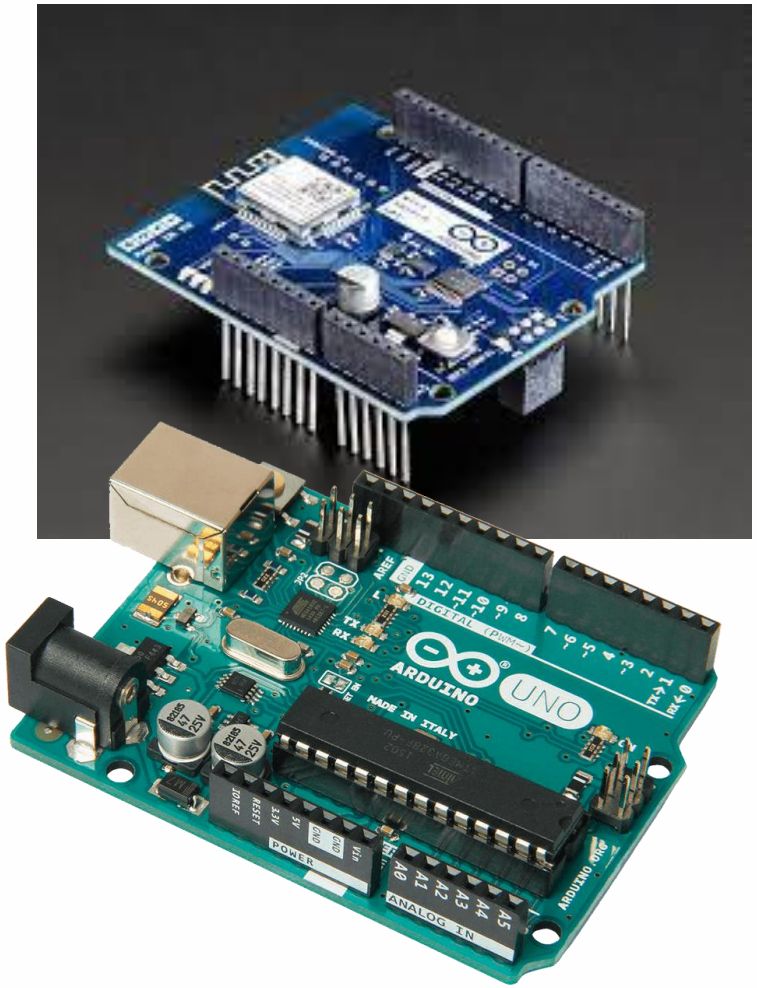


Maze Solver Robot

Wall-E Robot

How to use Arduino to talk to the internet?

How to use Arduino to talk to the internet?

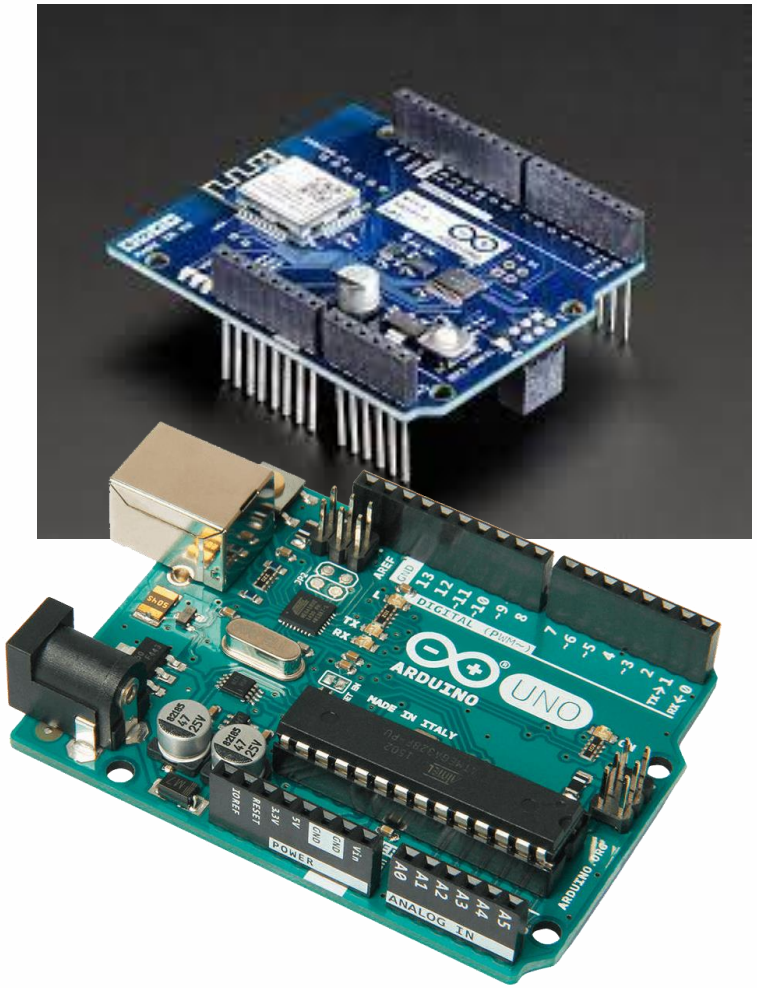


How to use Arduino to talk to the internet?

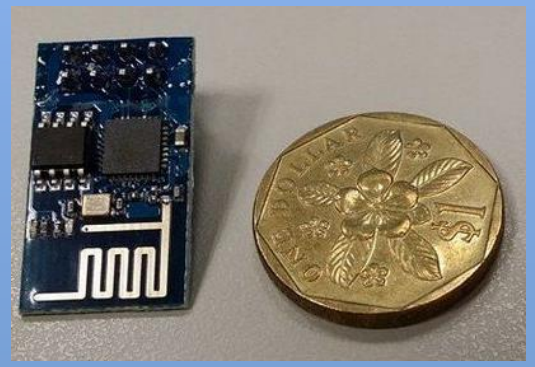
50$

25$

How to use Arduino to talk to the internet?

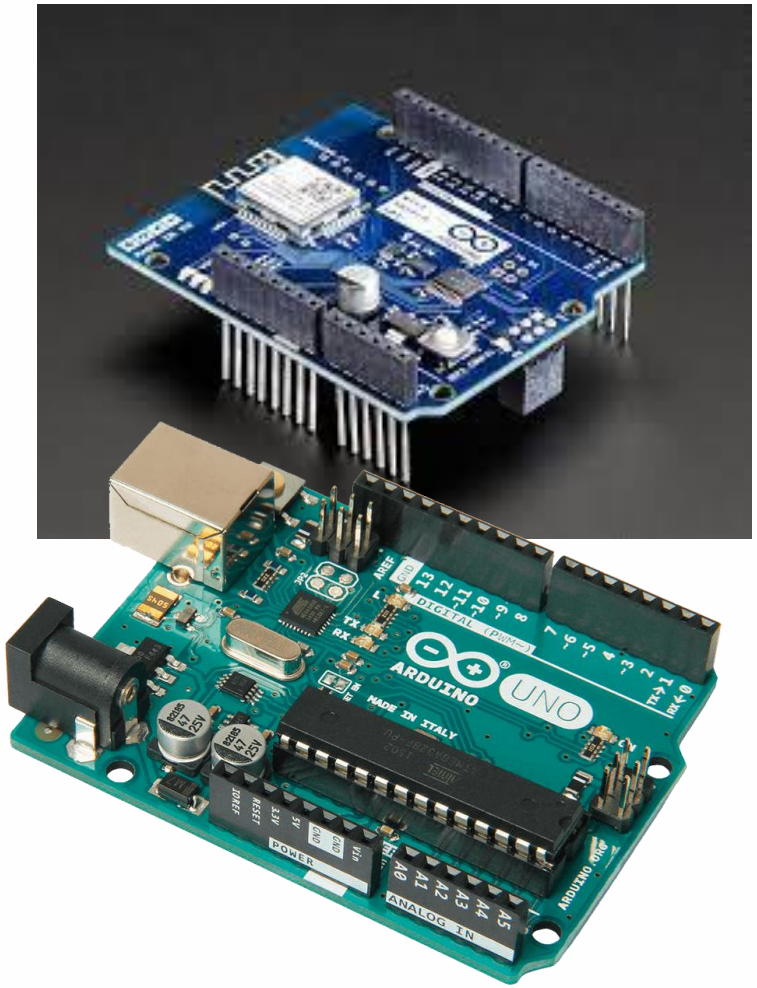


Wouldn't it be nice..?



Smaller

How to use Arduino to talk to the internet?



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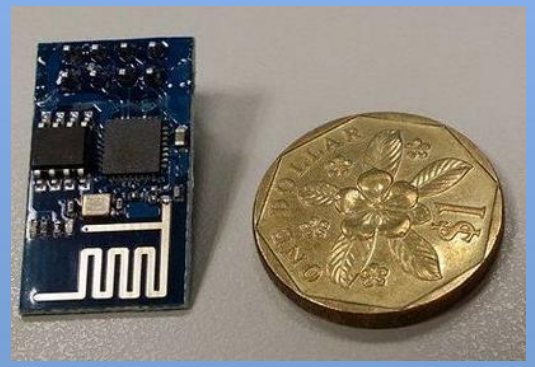

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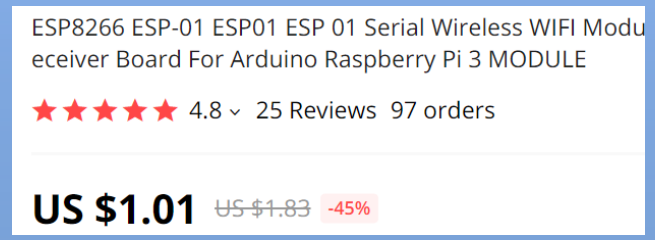

Cheaper