CPSC 1000: Introduction to Computer Science

Week 2: generating digital signals

Robert Benkoczi, C556
robert.benkoczi@uleth.ca

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Week 1 lecture objectives

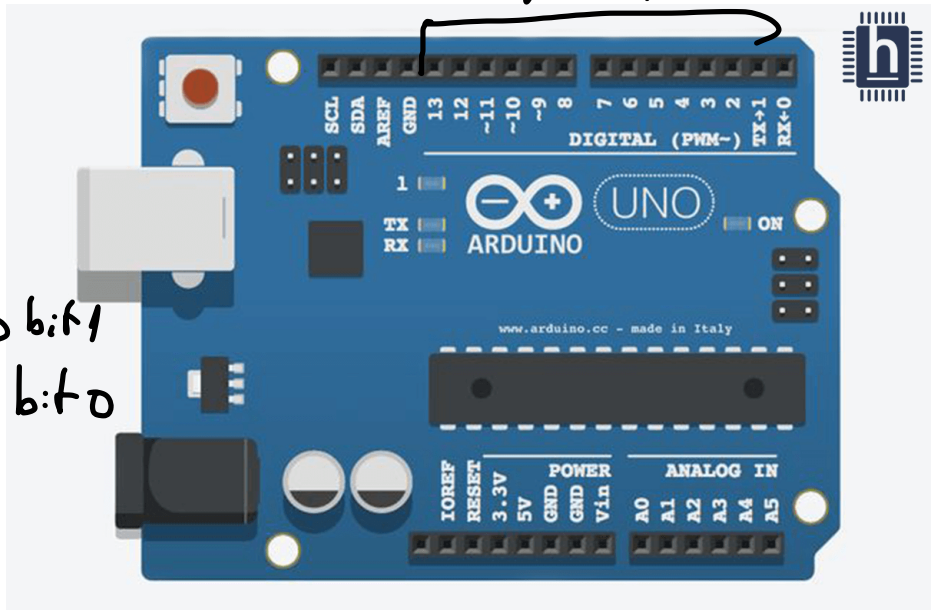
To prepare students for lab activity 1: Arduino's digital output. Digital output is needed for the functioning of various electronic components, such as the ultrasonic distance sensor.

- Students will examine the different pins of an Arduino micro-controller.
- Students will write a simple program for the Arduino to generate a digital signal.
- Students will assemble a simple electronic circuit using a breadboard to visualize the digital signal.

An Arduino and its pins

Digital signal { signal that represents binary info { 0 / 1
Voltage at a pin of the Arduino { 5V : bit 1 / 0V : bit 0

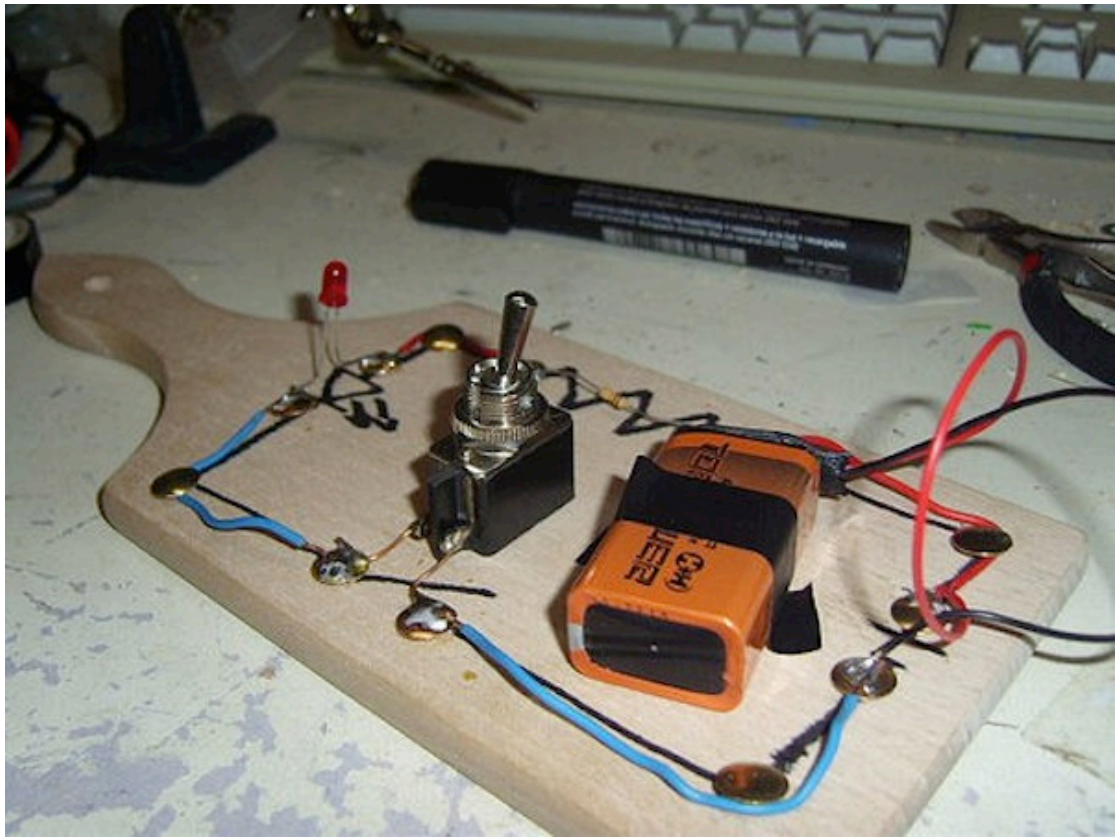
digital pins



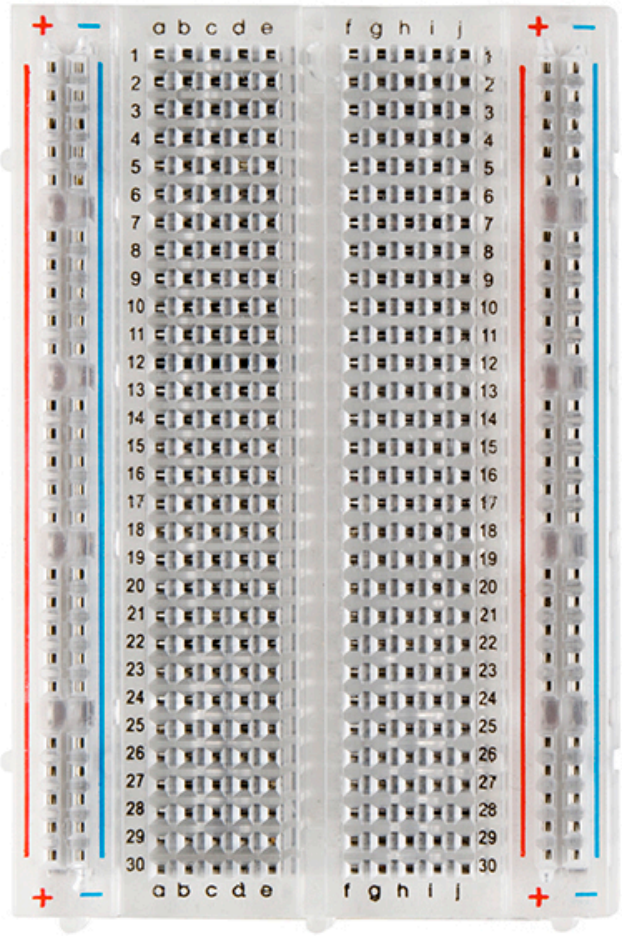
→ when appropriately configured, digital pins on the Arduino can behave like a battery that can be turned on → bit 1
off → bit 0

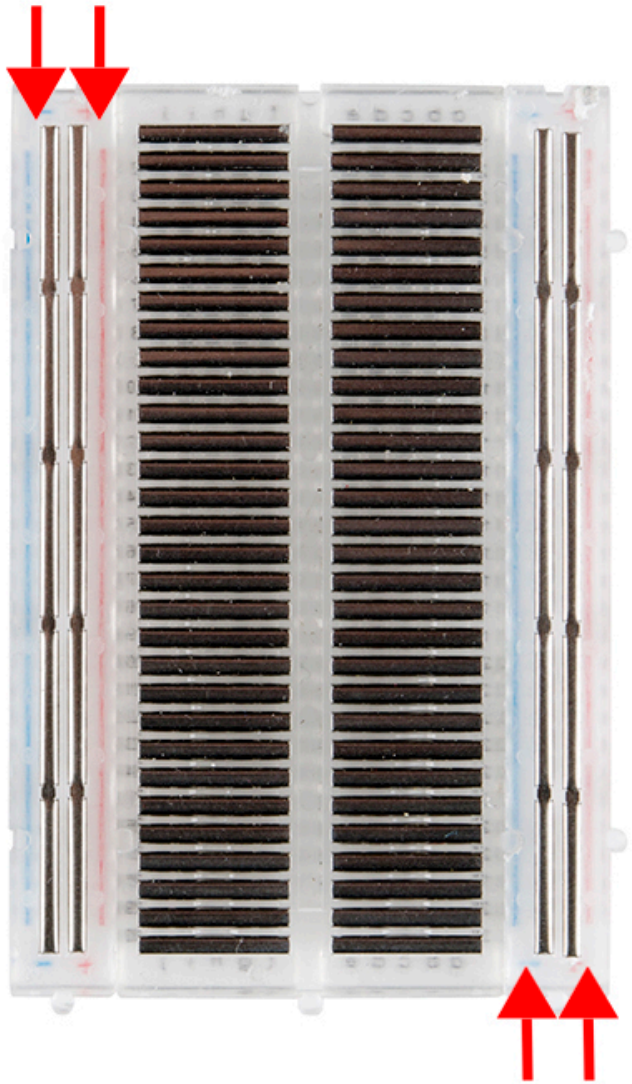
Breadboard

Hobbyists used breadboards to test electronic circuit prototypes.



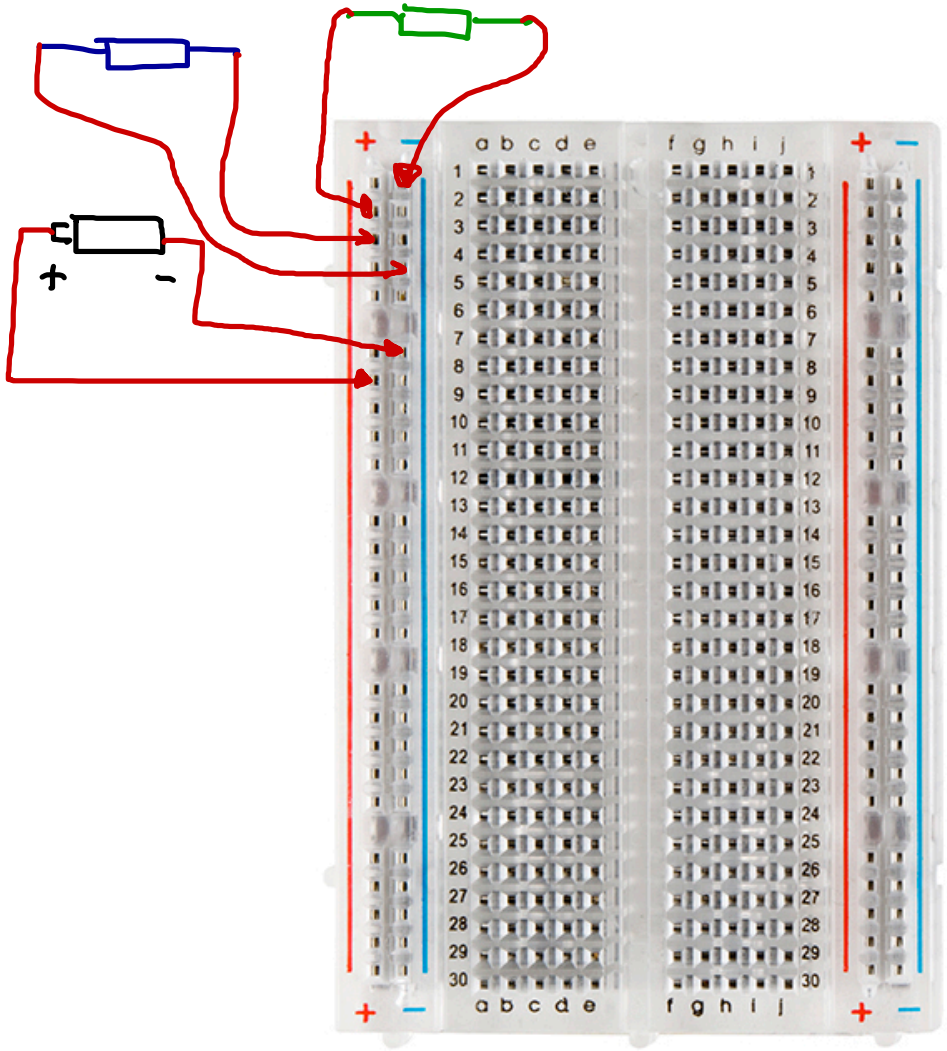
The breadboard we will use

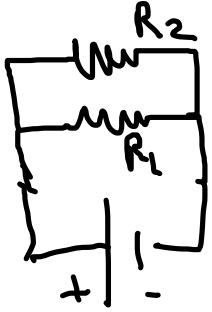


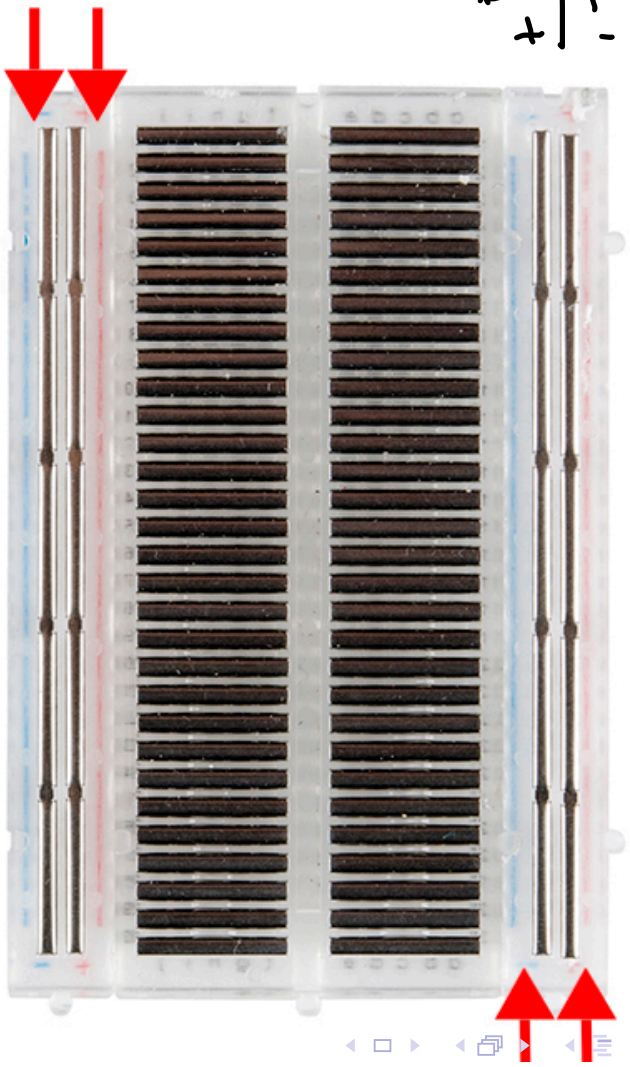


Example

Connect two resistors in parallel

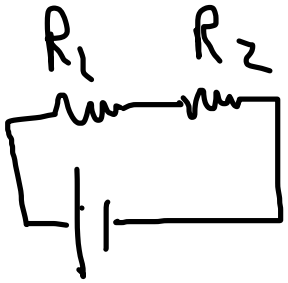


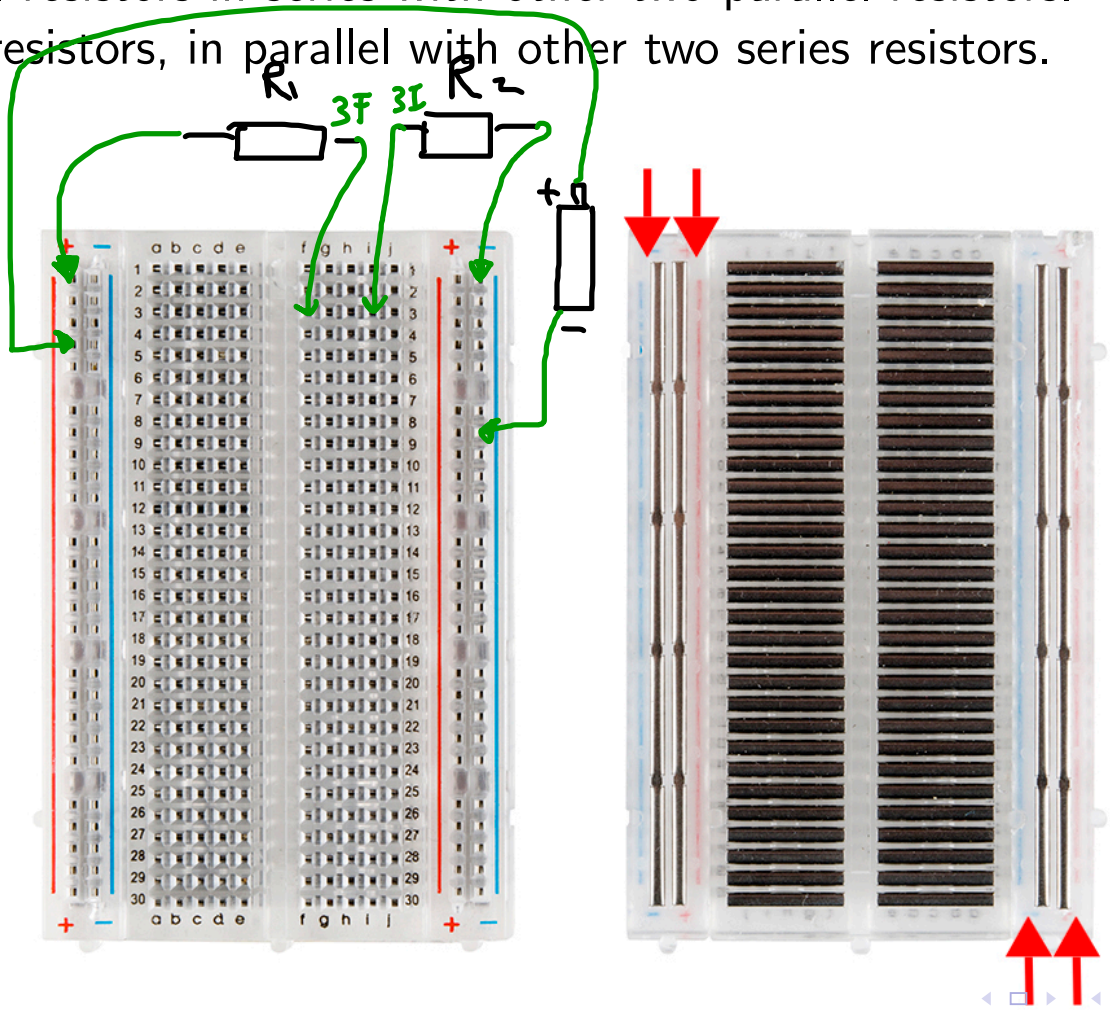




Exercises

- Two resistors in series.
- Two resistors in parallel, connected in series with one resistor.
- Two parallel resistors in series with other two parallel resistors.
- Two series resistors, in parallel with other two series resistors.

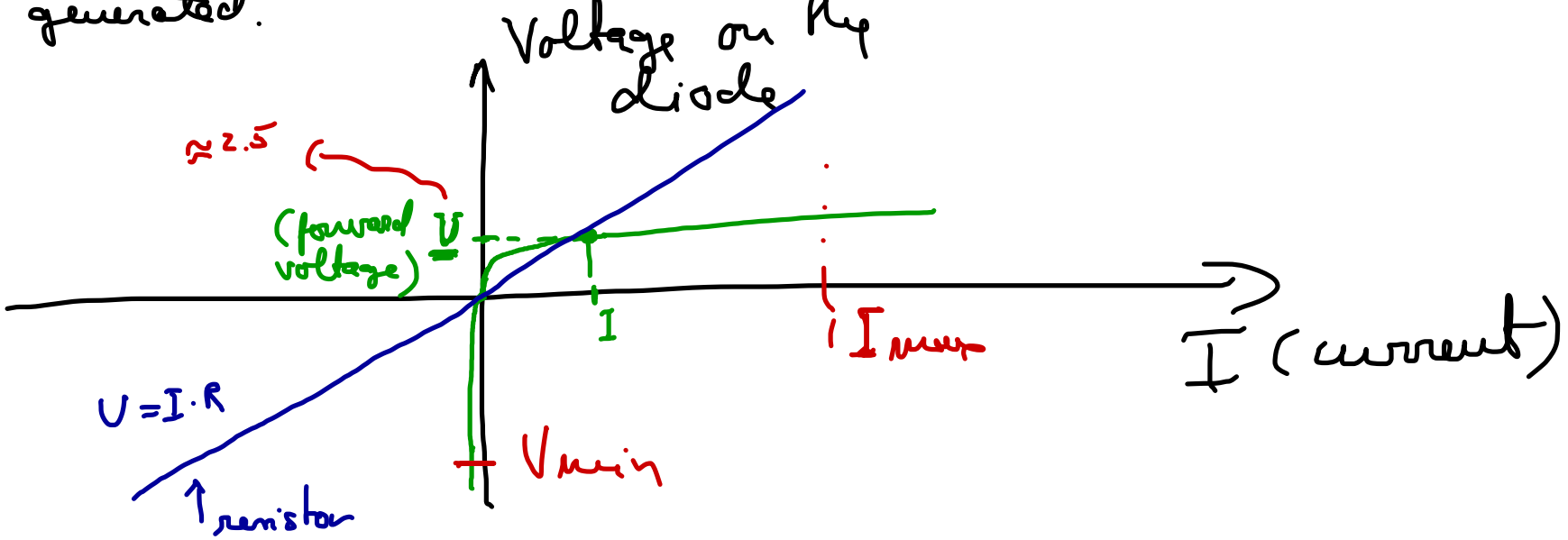




Diodes

- Current flows only in one direction (in the opposite direction the current is very small, "reverse current").
- There is voltage in the forward direction, "forward voltage".
- There is a max current in forward direction (higher current can damage the LED) I_{max}
- There is a max voltage in the reverse direction, "breakdown voltage". (V_{min}).

Lab objective: use an inexpensive component (LED) to "see" the digital signal generated.



Using an LED with the arduino, Ohm,'s Law

- Max current out of an Arduino's digital pin: 40 mA (also note the LED's max forward current).
- Bit 1 represented as +5 V.
- Forward voltage on a LED, eg: 2.5 V.
- $U = I \cdot R$, I: current (intensity), R: resistance, U: voltage.

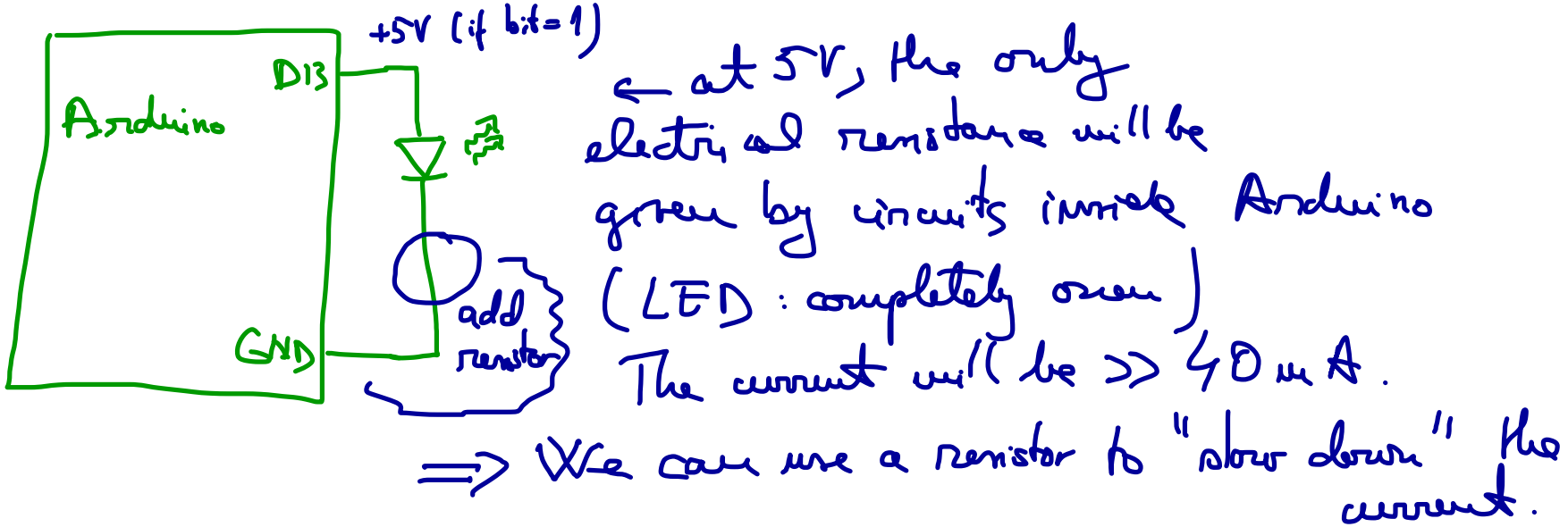
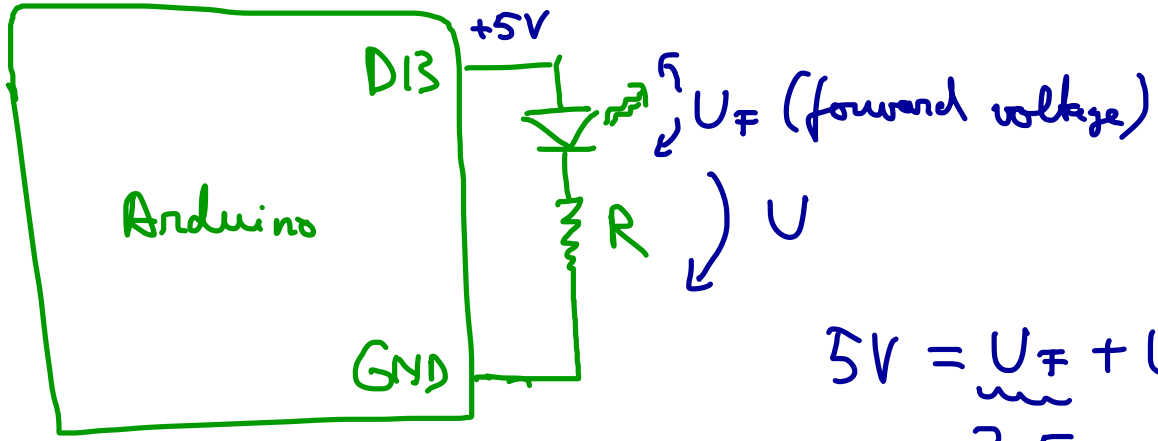


Diagram (upgraded)

When Arduino outputs a "1" on D13



$5V = \underbrace{U_F}_{2.5} + U \qquad U \cong 2.5$

Say our target is a current of around 10 mA ($\frac{1}{4}$ x max current) to be safe, then what value of R do we need?

$U = R \cdot I$

$U = 2.5$

$I = 10\,mA = 10 \cdot 10^{-3}\,A$

$R = \frac{U}{I} \approx \frac{2.5}{10 \cdot 10^{-3}} = 250\,\Omega$

The lab uses 220 Ω

Programming the Arduino to generate digital signals

Digital signal:

- 0V = bit 0
- 5V = bit 1.

Arduino digital pins:

2 modes {

- Input = measuring device
- Output = battery

Step 1 : make sure the digital pin we want to use is in "output" mode

Step 2 : output a "1" or "0" on that pin.

Setting up the digital pin for input/output

Function pinMode:

Example:

```
void setup()
{
  pinMode(13, OUTPUT);
}
```

← function call

argument 1: pin number that we configure

argument 2: the mode

OUTPUT: integer variable with a predefined value.

Hack: Find out what value OUTPUT is. Compare this with the value for INPUT

Generating bit 1 or bit 0

Function digitalWrite

Example:

```
void loop()
{
  digitalWrite(13, HIGH);
  delay(1000); // Wait for 1000 millisecond(s)
  digitalWrite(13, LOW);
  delay(1000); // Wait for 1000 millisecond(s)
}
```

pin number

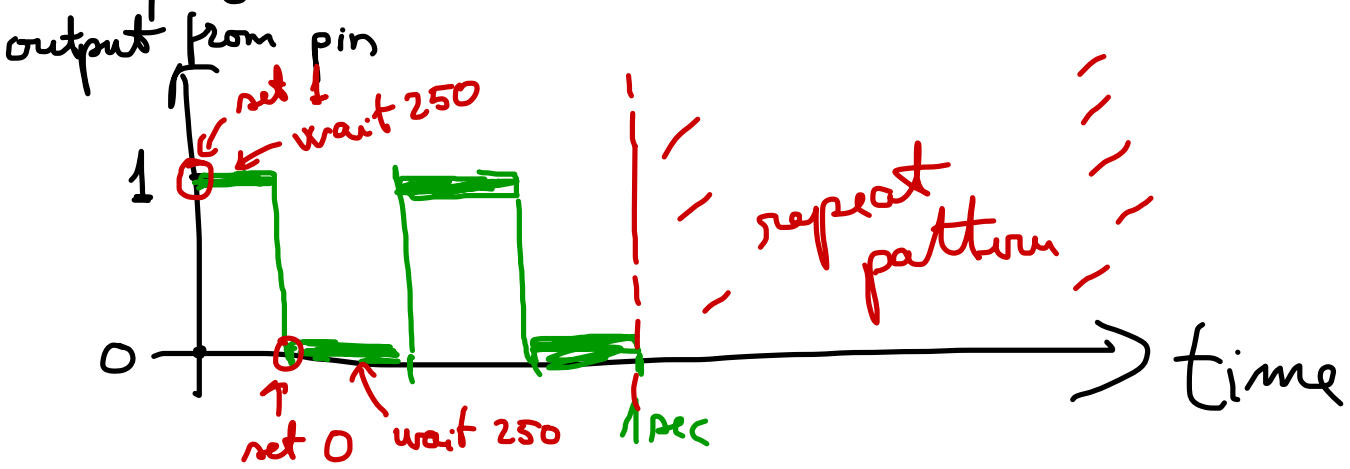
value of the bit: 1 (HIGH), 0 (LOW)

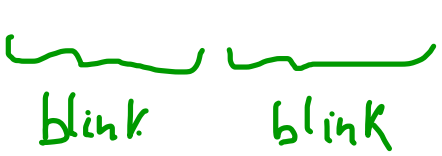
blinking pattern (1 sec on / 1 sec. off)

HIGH, LOW are also predefined integer variables (find out their values)

Make the LED blink twice in a second

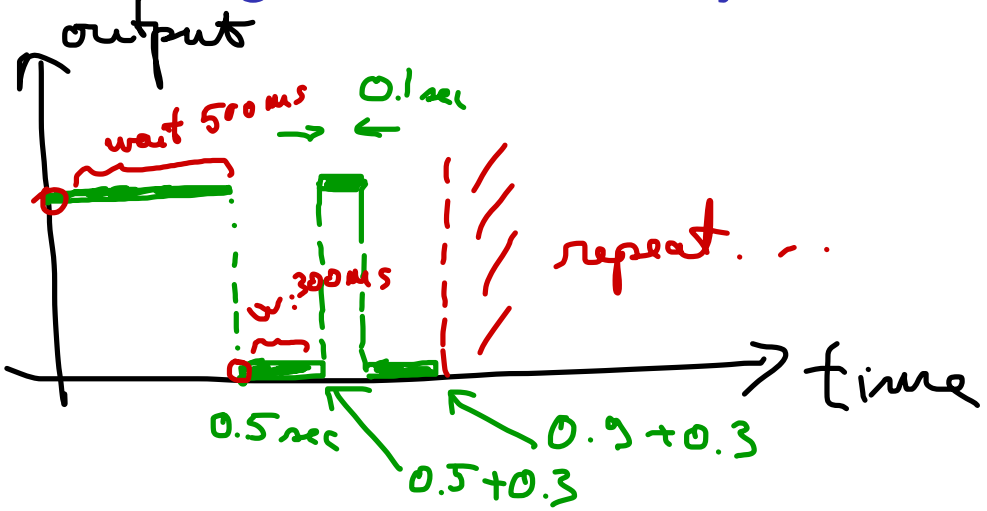
Keeping the circuit, we will change the code to solve this problem.






```
void loop() {
    digitalWrite(13, HIGH);
    delay(250);
    digitalWrite(13, LOW);
    delay(250);
}
```

Program a long blink followed by a short blink




```
void loop() {
  digitalWrite(13, HIGH);
  delay(500);
  digitalWrite(13, LOW);
  delay(300);
  ...

}
```