waag society

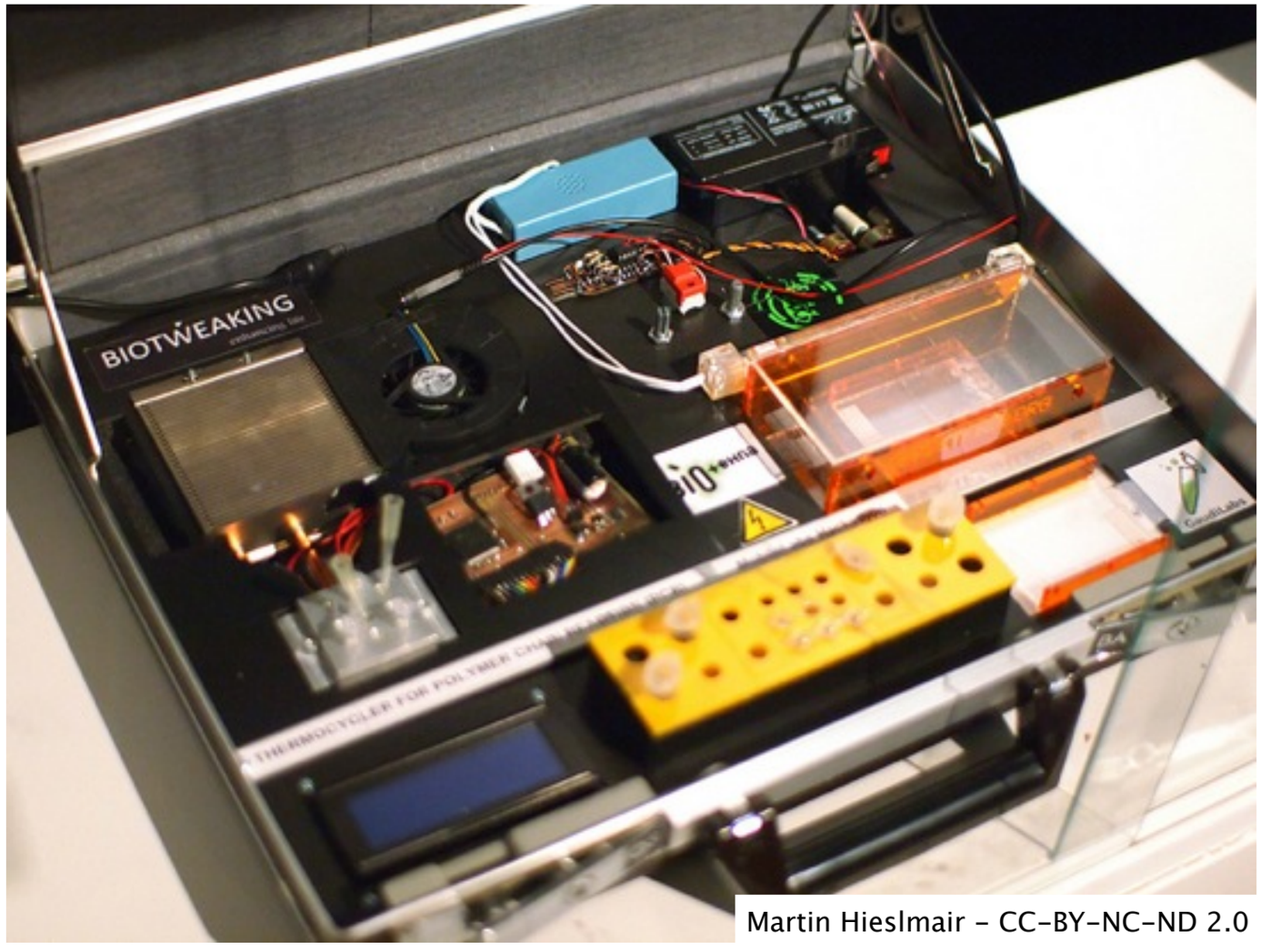
institute for art, science and technology

BioHack Academy
Incubator Design

Picture by Bas Uterwijk

What it means to be a hacker

- Create & Share
- Freedom of inquiry
- Hostility ot secrecy
- Sharing as ideology and strategy
- The right to fork
- Emphasis on rationality
- Distaste of authority
- Playful cleverness



Why we need an incubator

- Microbes like a certain temperature
- Temperature dependent:
  - Enzyme reactions
  - DNA interactions
  - Cell state

Pixabay - CC0

Industry standard

Function

- Heat isolated enclosed cabinet, with see-through window
- Heat source
- Temperature controller
- Temperature indicator
- User interface to set temperature

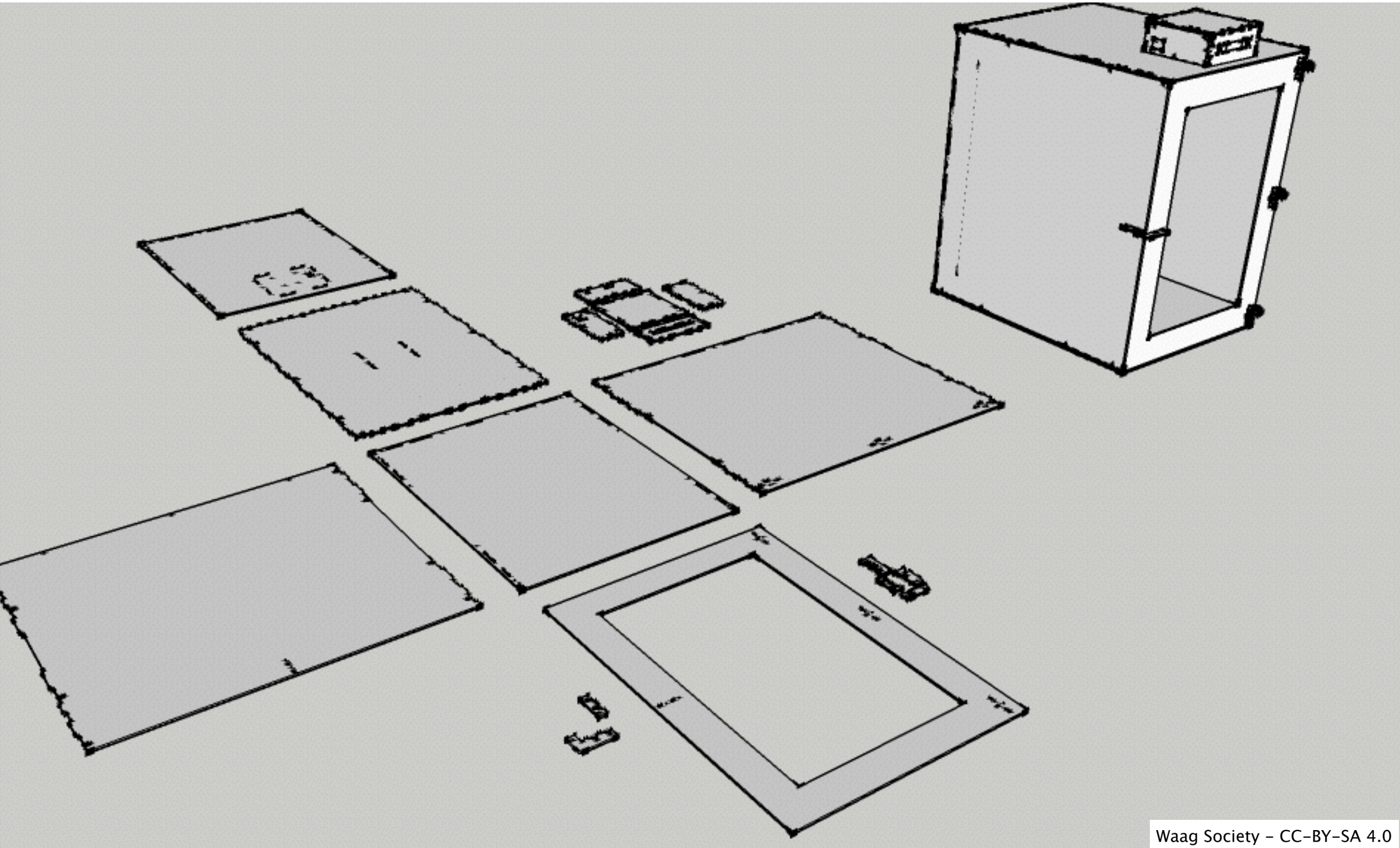
http://biohackacademy.github.io/biofactory/class/1-incubator/requirements/

Design constrains:

- 9 cm petri dishes

The Biohack Academy design

http://biohackacademy.github.io/biofactory/class/1/Incubator-Sketchup.skp

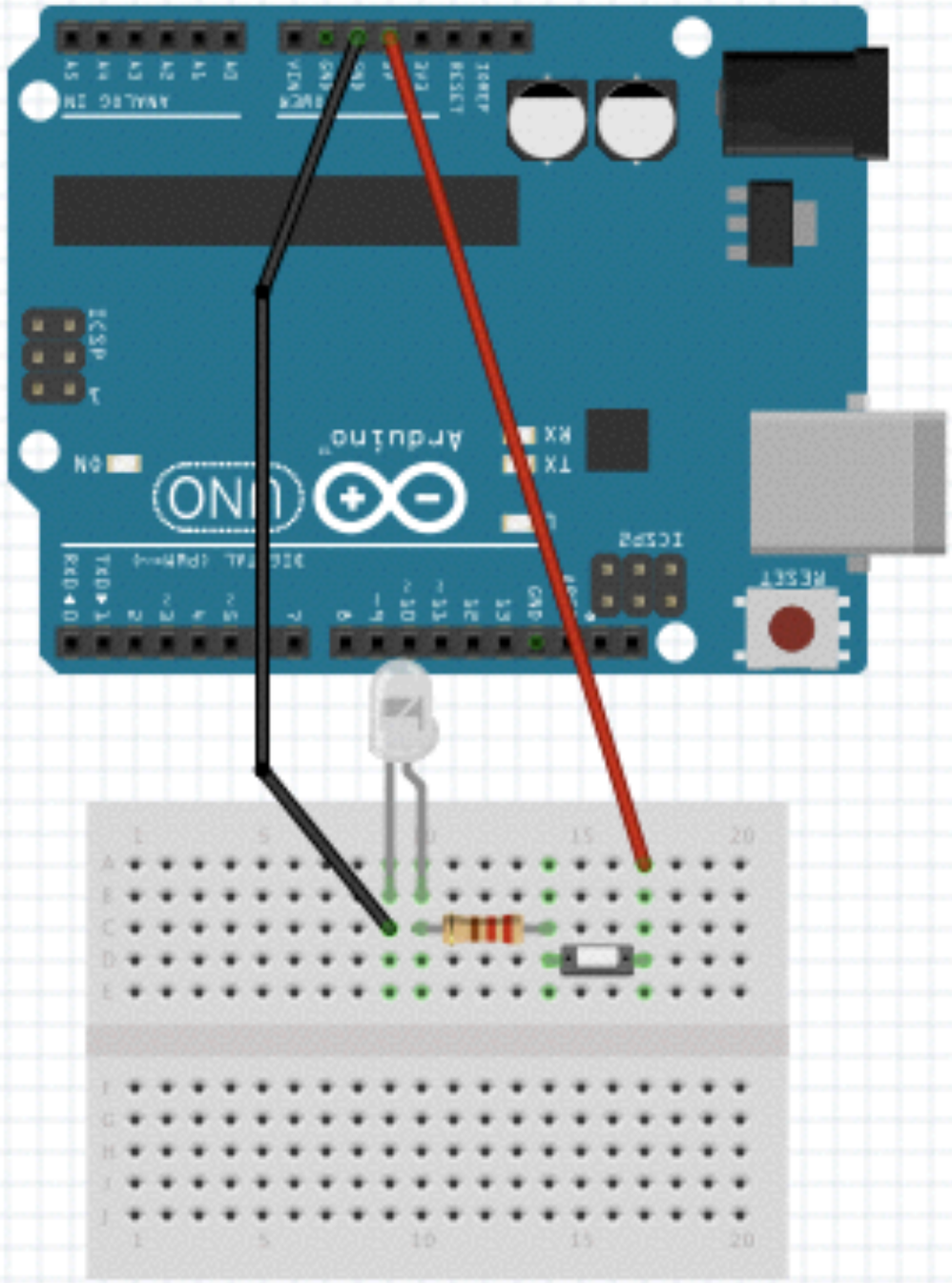


Bill of Materials

#	Amount	Description	Function
1		1 3mm MDF	Outer structure
2		1 Expanded polystyrene (EPS) 5 plates of 100 x 50 x 5cm	Insulation
4		1 3mm Acrylic sheet 25 x 35 cm	Window
5		1 100W infrared light bulb, fitting and power cord	Heating
6		1 12V 80 mm Axial Fan	Air distribution inside incubator
7		1 Light switch	Switch incubator on/off
8		1 Water proof temperature sensor	Measure inside temperature
9		1 4 section 7 segment display	Display temperature
10		1 MOSFET	Control fan speed
11		4 10K resistor	Pull up for buttons, thermistor and mosfet
12		1 Diode	Part of MOSFET circuit
13		2 Buttons	User interaction panel
14		1 White LED	Light inside incubator
15		1 220 Ohm resistor	LED resistor
16		1 7.5 W power supply	Powering the Arduino and Fan
17		1 Jack Adapter	Power connector
18		1 Relay	Controlling the 100W light bulb

Powering an LED

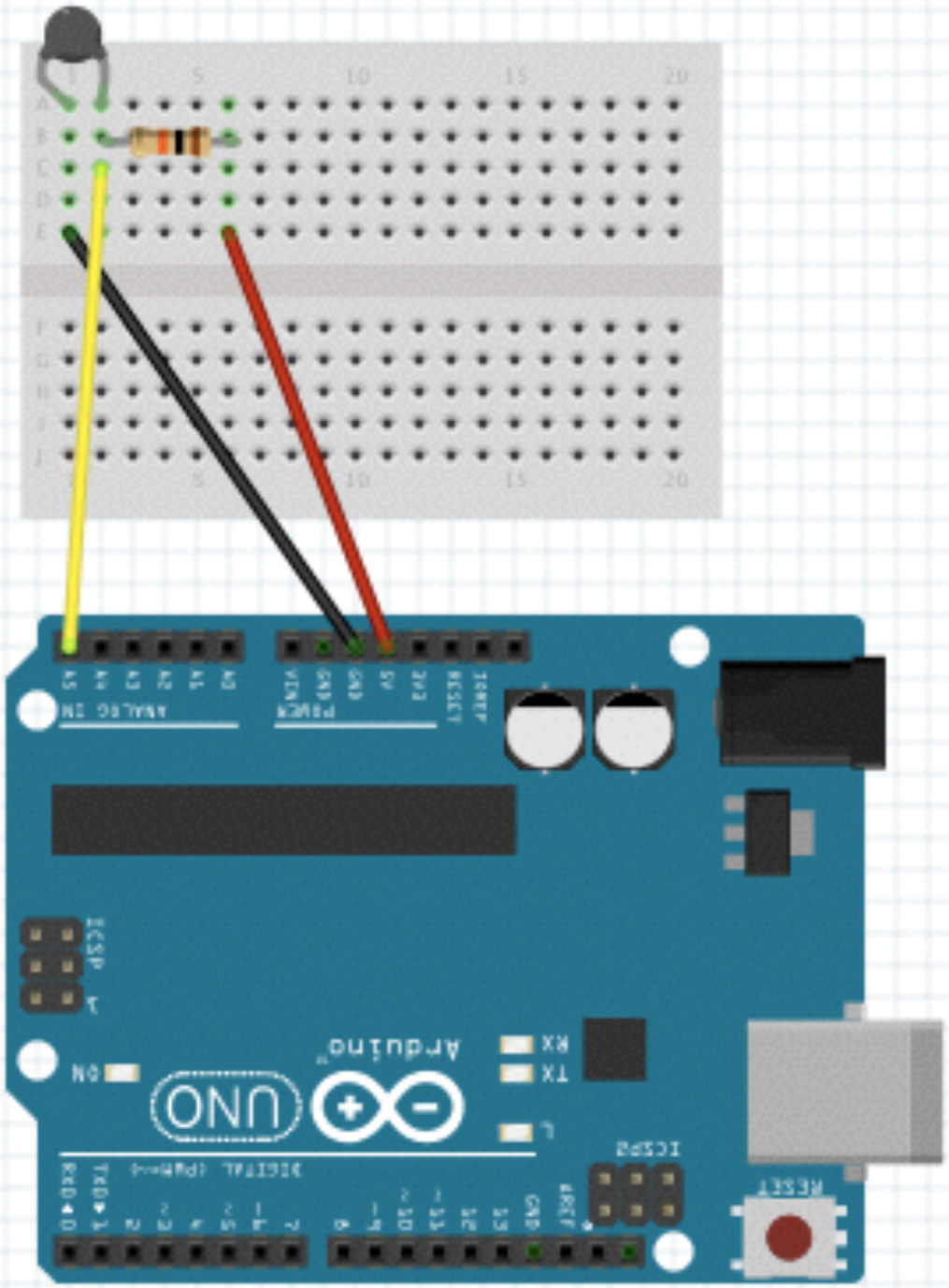
LED circuit



Sensing the temperature

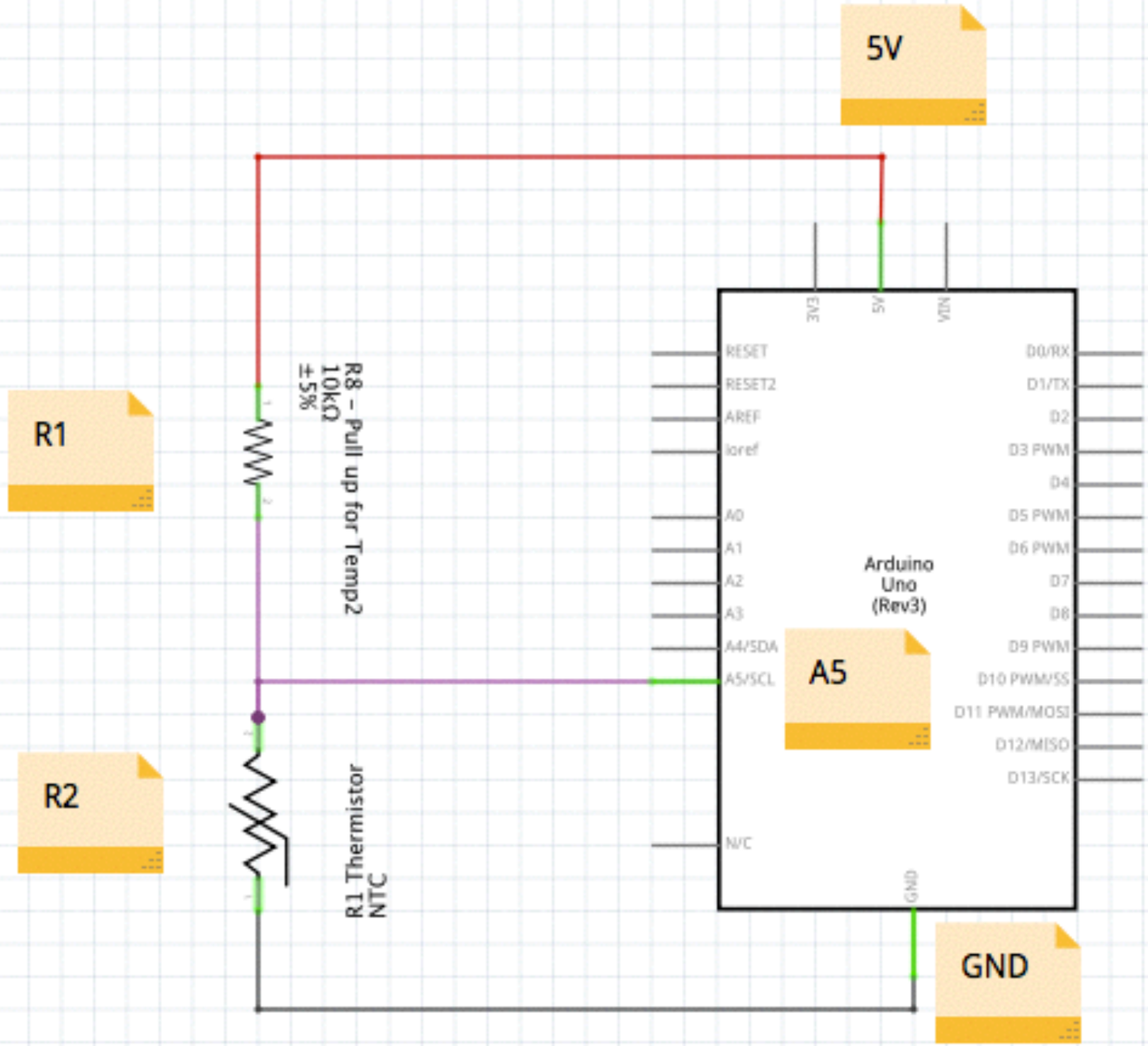
- 10K thermistor

Sensing the temperature



Schematic

$$Vout = Vin\left(\frac{R2}{R1+R2}\right)$$



Selecting a heat source

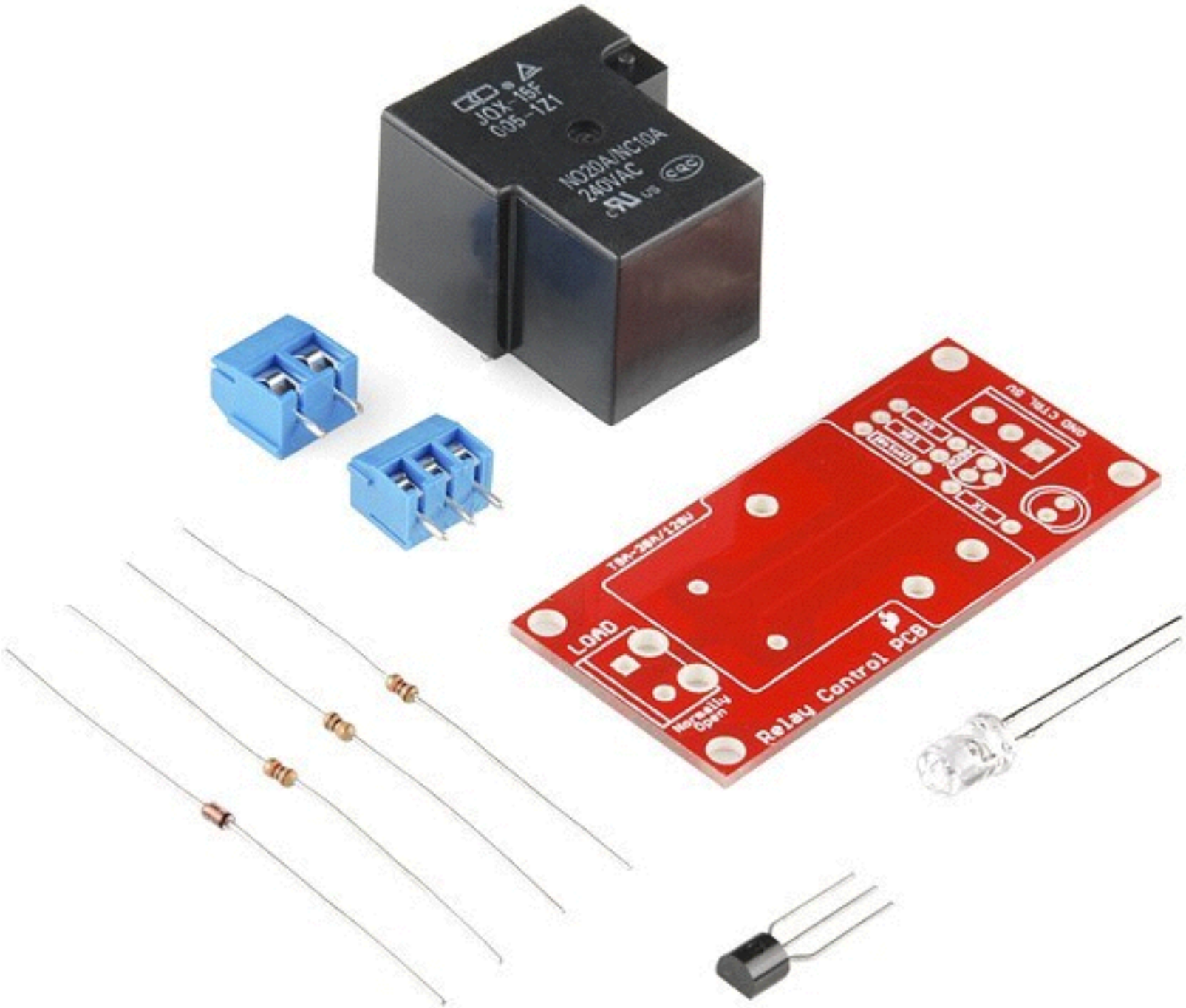
- Lamp
  - Heat as a by product
- Microwave
  - Needs liquid to heat
- Infrared
  - 100W infrared
- Power resistor

$$P = \frac{I^2}{R}$$

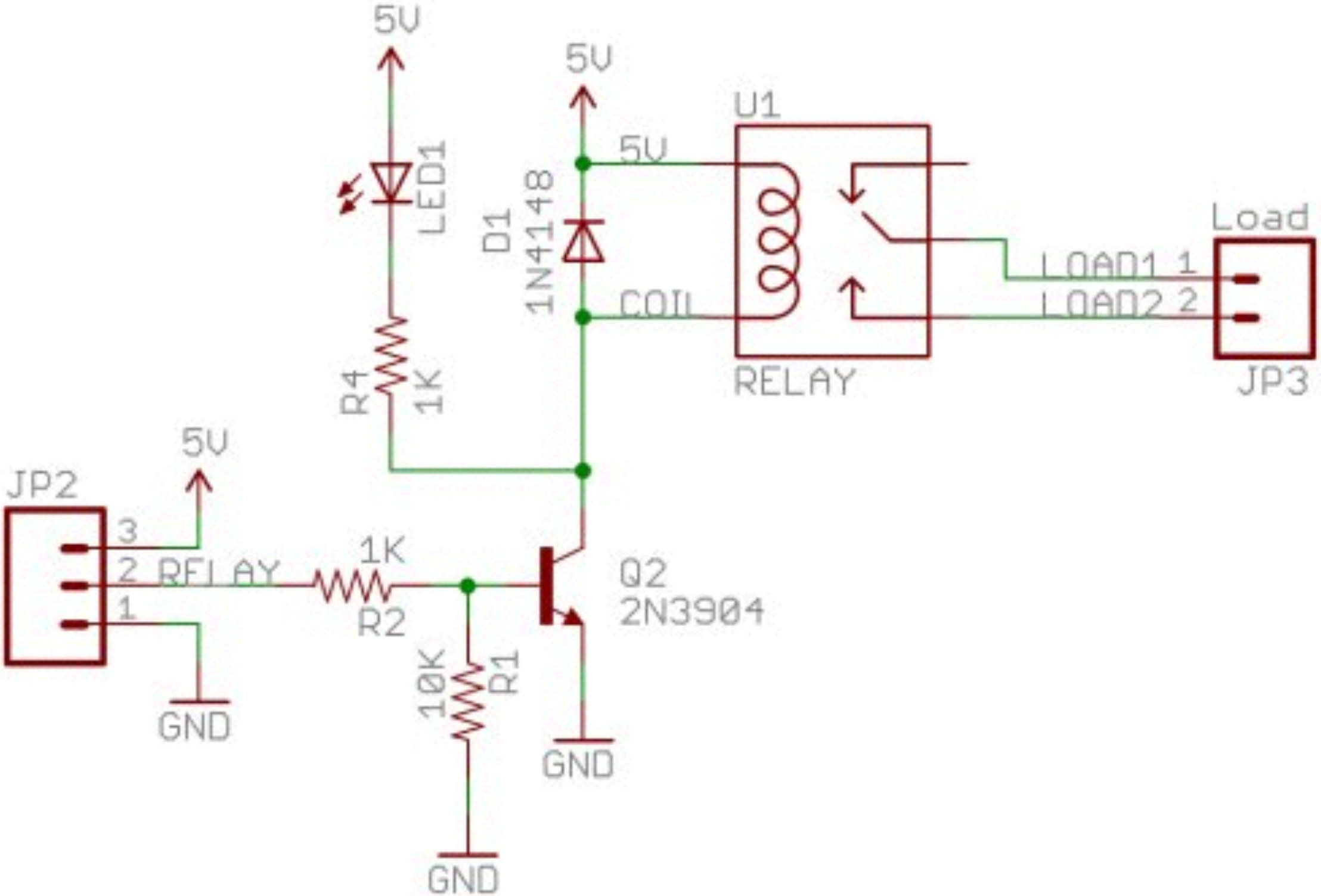
$$7W = \frac{(12V)^2}{R}$$

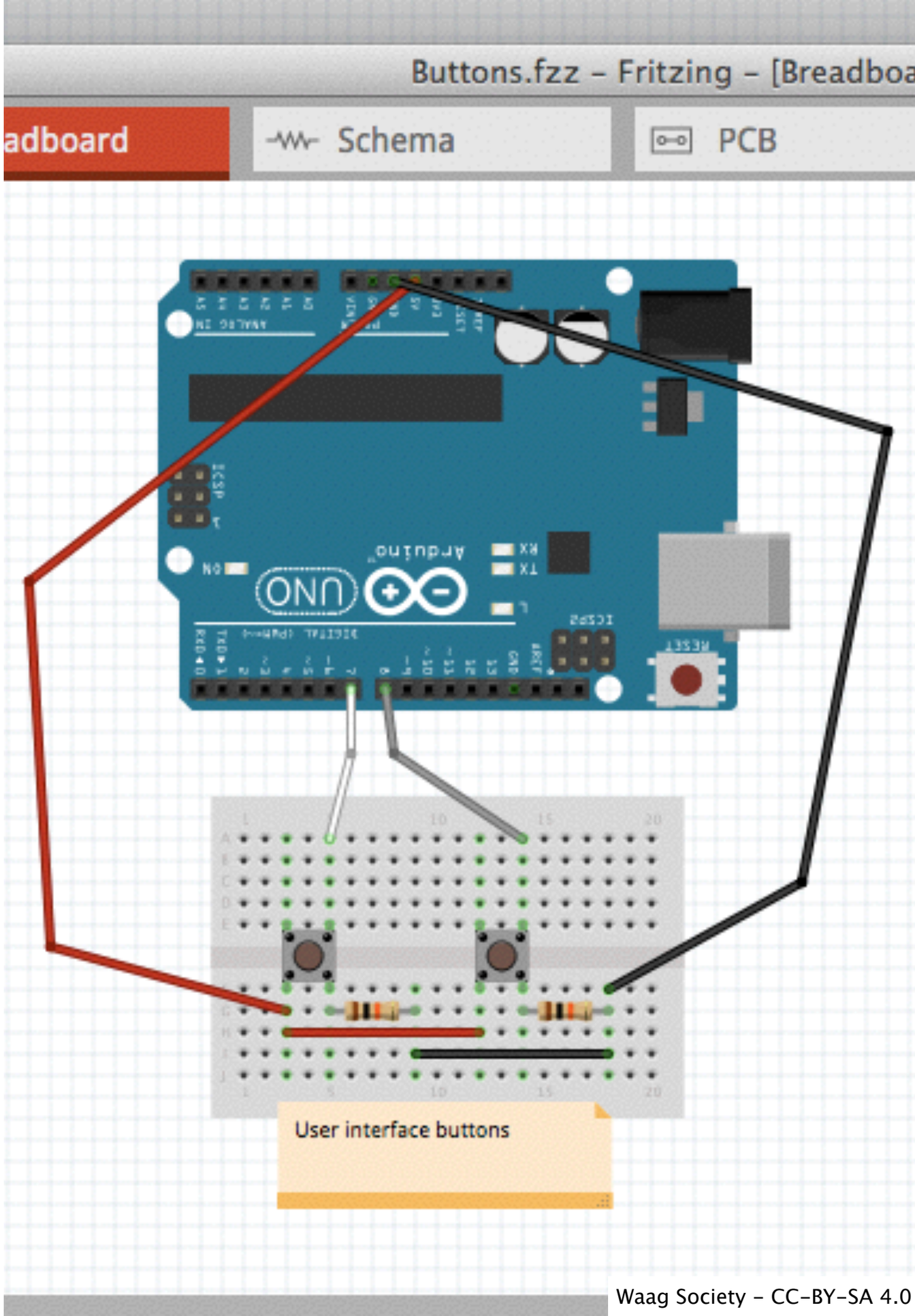
$$R = \frac{144}{7} \approx 20\,\Omega$$

Controlling the lamp



Relay schematic





Push buttons

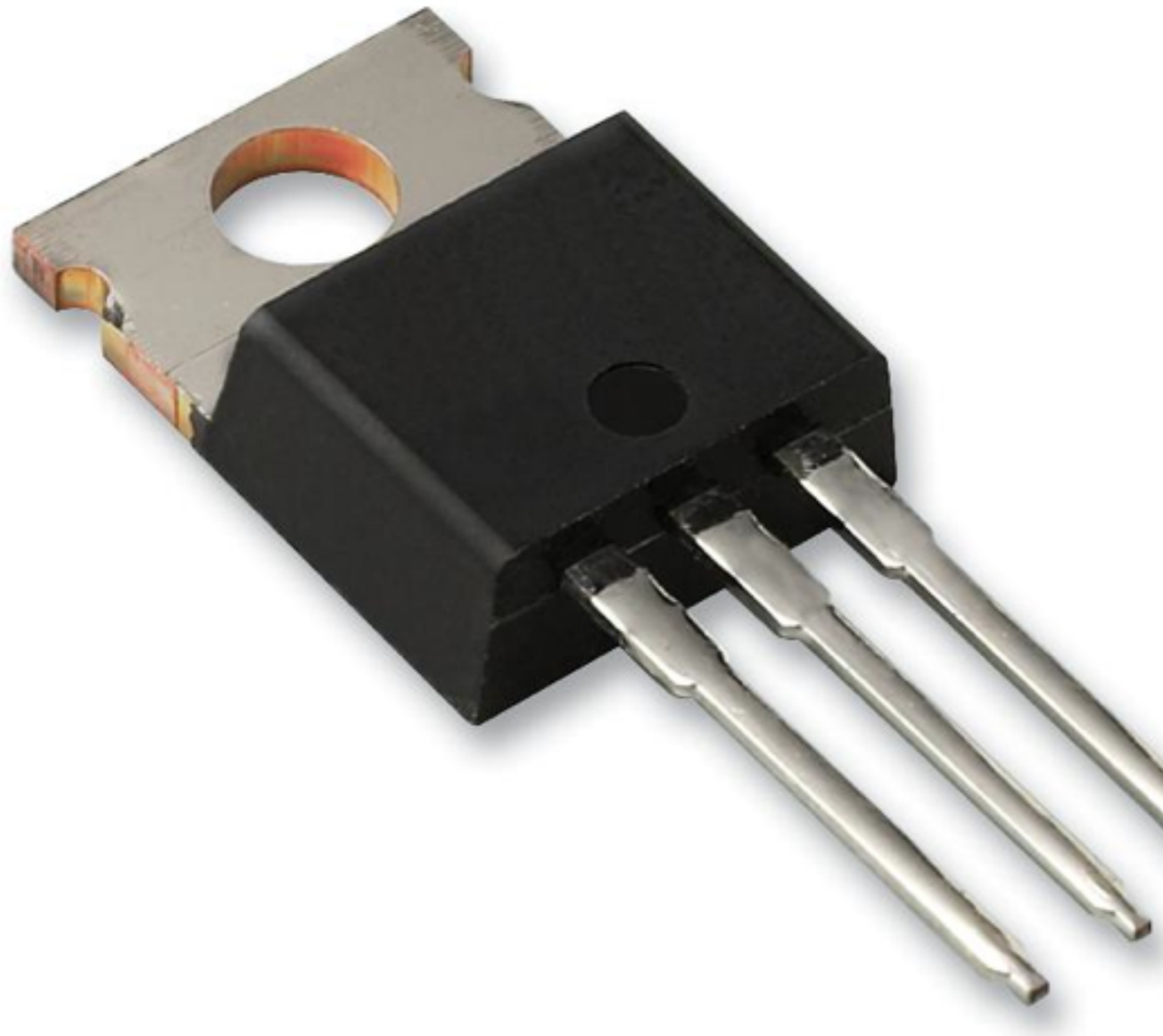
Pull down resistors

- 10 K Ohm

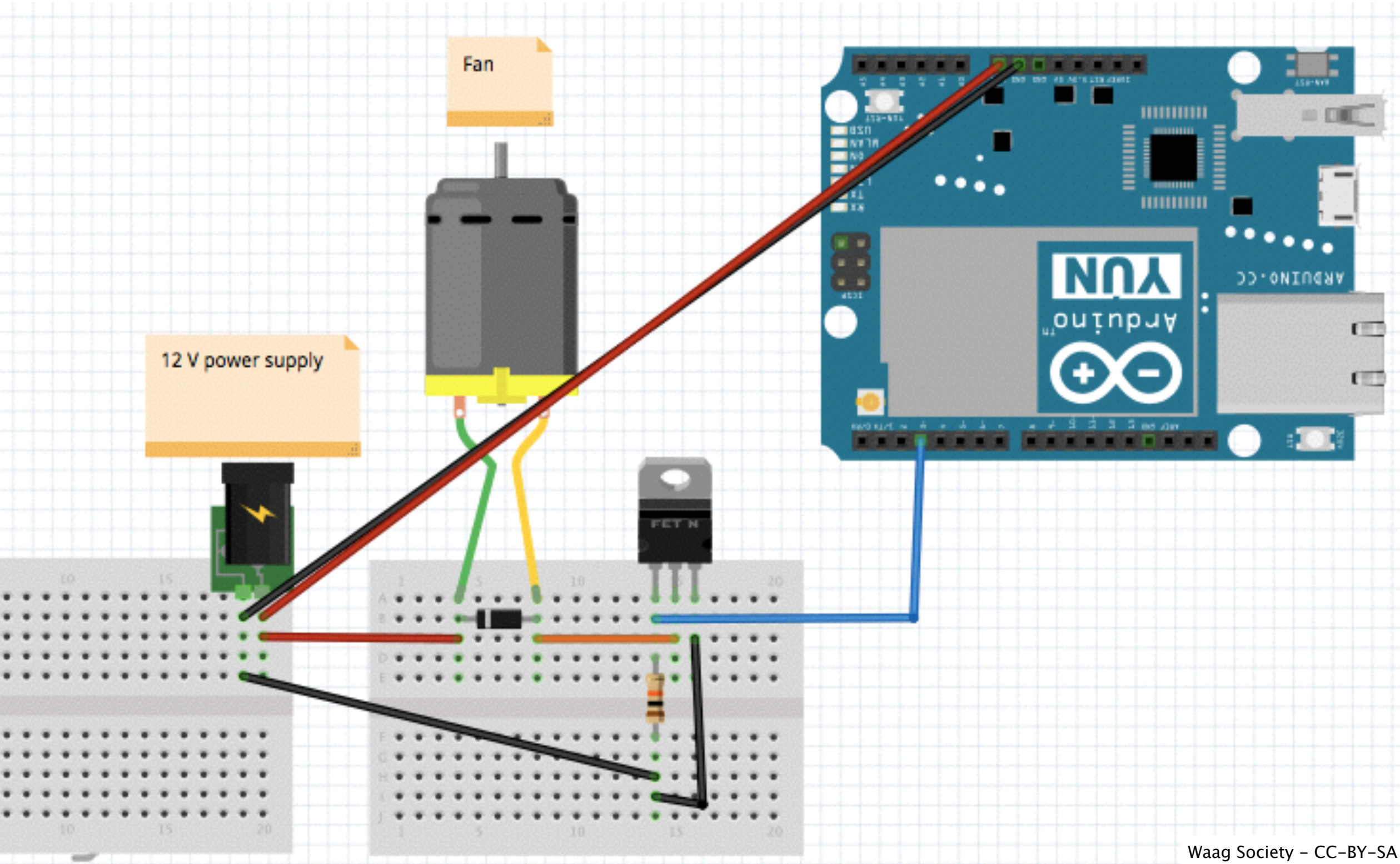
Fan speed controller

- MOSFET
  - Semiconductor

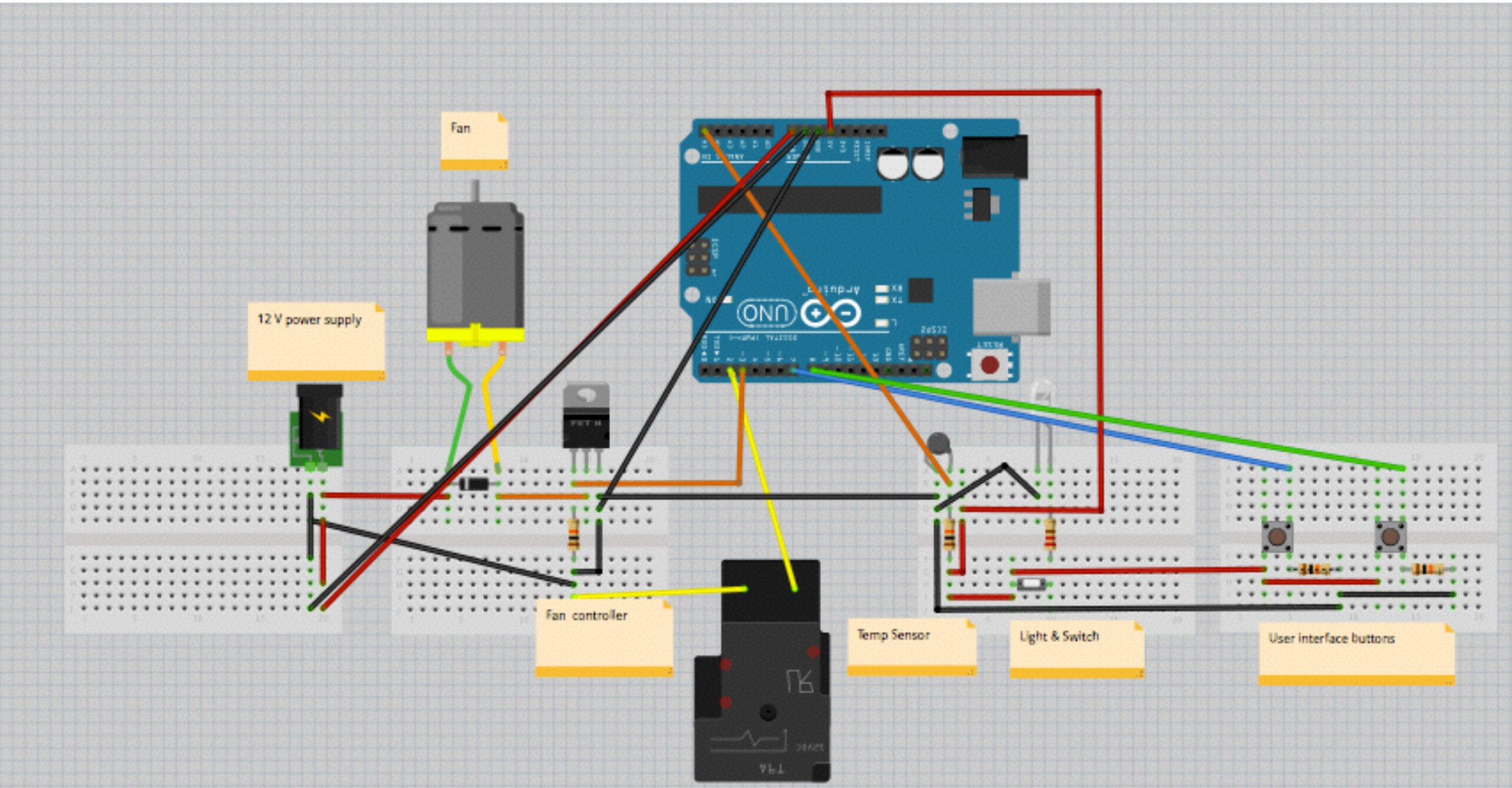
  - N-channel
  - 60V
  - 30A



Controlling the fan



All of the electronics together



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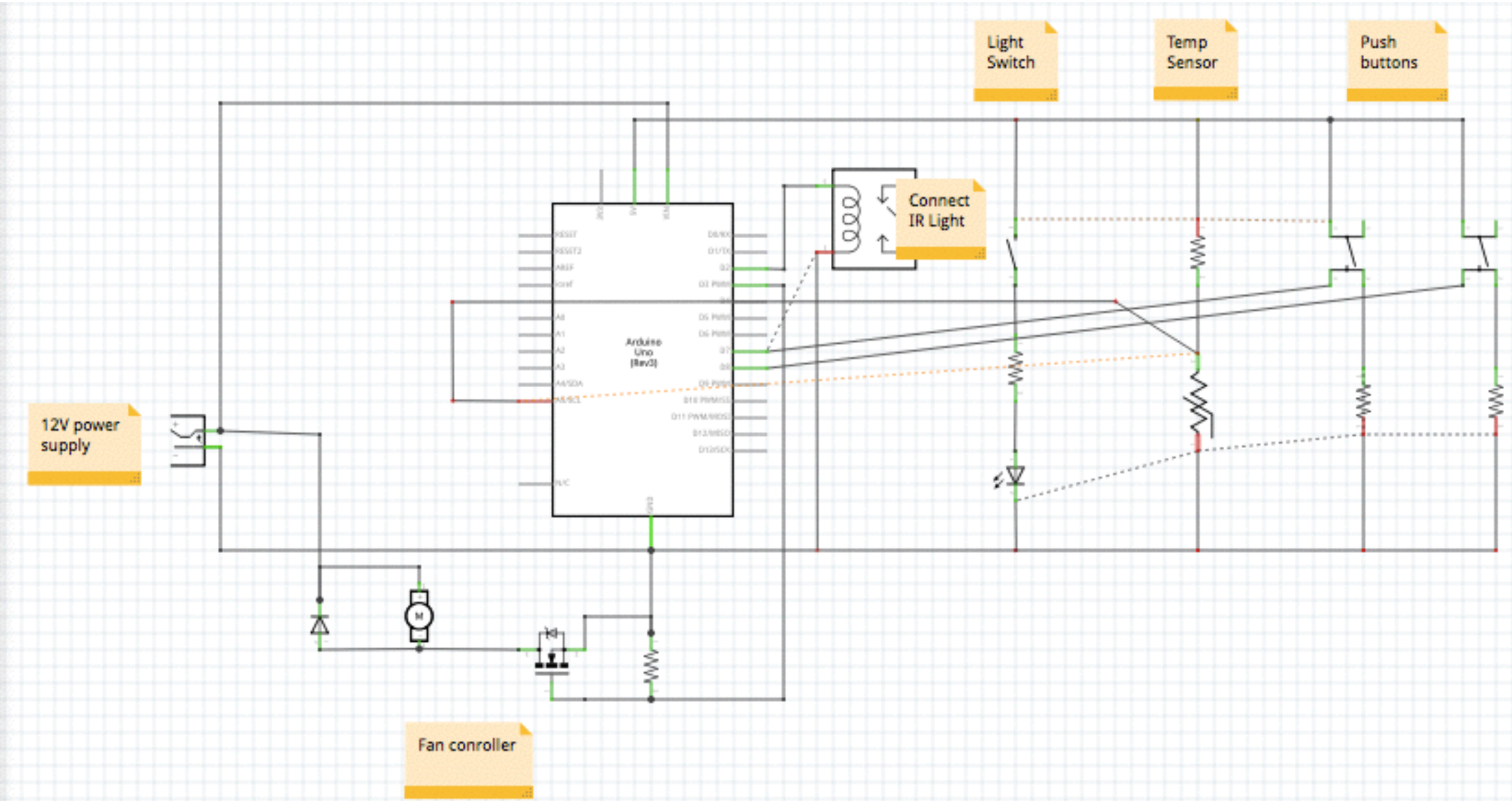

Power Supply

$$P = A \times I$$

$$Power = Current \times Potential$$

$$Watt = Ampere \times Volt$$

- 5 x 30 mA LEDs
- 1 x 250 mA Arduino
- 1 x 400 mA Fan
- 1 x 30 mA 7 segment display

- Total: 830 mA
- So a 1 Amp power supply should be enough

PublicPhoto.org – Public Domain

Arduino tutorial codes

- MOSFET code:
  - http://bildr.org/2012/03/rfp30n06le-arduino/
- 4 digit 7 segment:
  - http://dlnmh9ip6v2uc.cloudfront.net/datasheets/Components/LED/_7Seg_Example.pde
- Button code:
  - http://arduino.cc/en/tutorial/button
- Thermistor code:
  - http://computers.tutsplus.com/tutorials/how-to-read-temperatures-with-arduino--mac-53714

Code logic

- Measure temperature
  - Turn lamp on when temperature is lower than target
  - Turn lamp off when temperature is higher than target
- Check whether a button is pushed
  - If left button is pushed increase target temperature
  - If right button is pushed decrease target temperature
- Display current temperature
  - In case left or right button is pushed, display target temperature for 5 seconds

Nice to haves

- PID control
- Magnetic door lock
- Lever switch that checks whether door is locked
- Sound alarm in case door is open for too long
- Webcam inside

PID control