

Breadboard Prototype #1

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1 Toy concept

Our interactive toy concept is based on a popular game called *Simon Says*, where users have to repeat a sequence of flashing colored buttons. We extend the original idea by providing the sequences in both visual (lighting LEDs) and haptic (buzzing disc motors) manner.

Target user group of our project is anyone interested in improving their concentration and short-term memory through tactile and visual means, but due to the high level of interactivity and the competitive nature of the game it might be particularly appealing for children (age group 10-13).

2 Demo

[Link to the video](#)

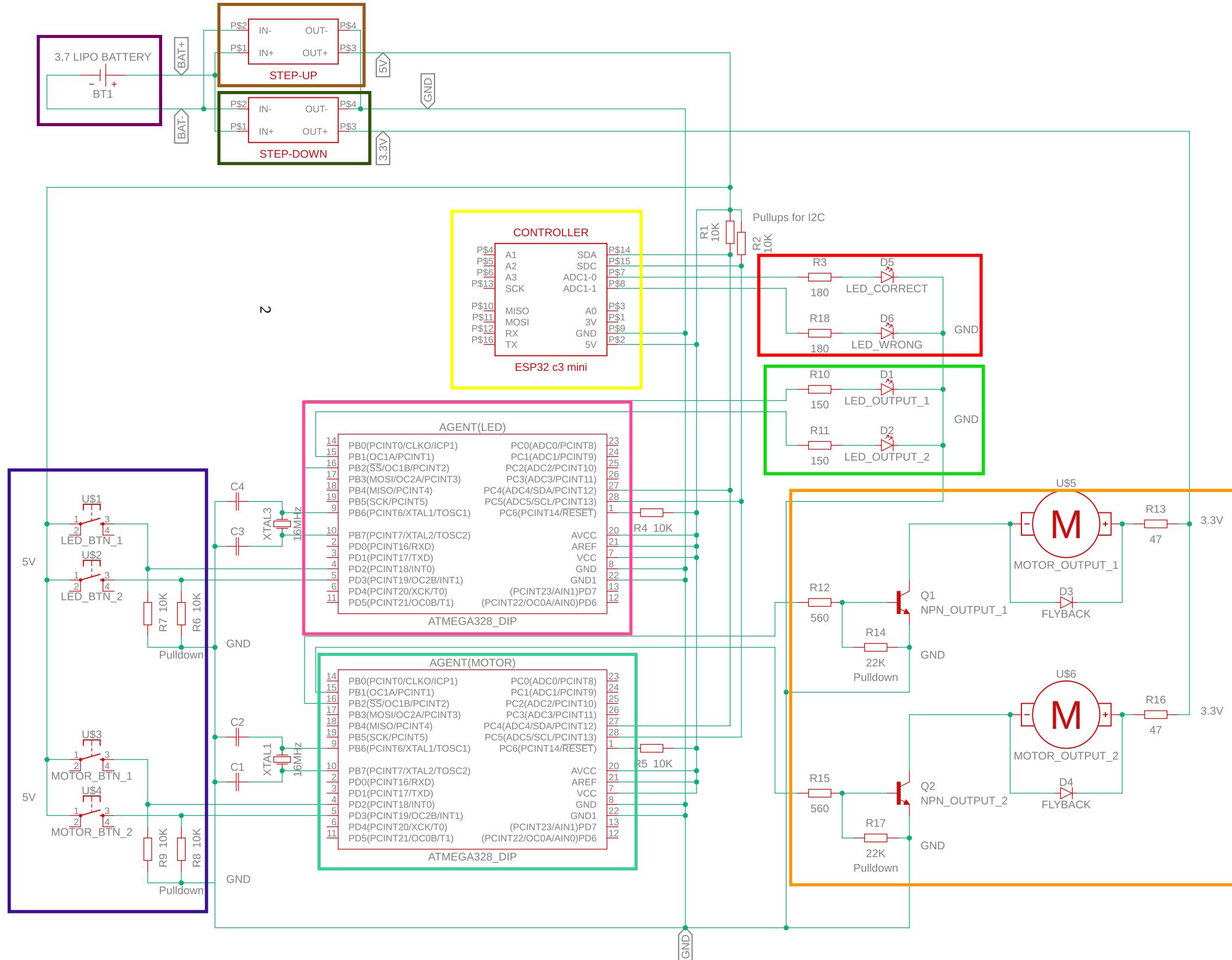
Video shows the prototype output three sequences with the use of both buzzers and LEDs, each followed by user input and the final success/failure indication. Two first sequences are repeated correctly, resulting in a blinking green LED, signifying success. The third sequence input is incorrect, so it results in a failure indication, shown through the red LED.

3 Circuit Diagram

Our circuit diagram was drawn in Eagle from Fusion 360 with the use of custom component piece for ESP32. Prototype features a Main (Master) with two Agents (Slaves) setup communicating through I2C. Main is an ESP32 C3 mini micro-controller, selected for this task due to its possession of a module for random number generation, necessary for creating unique sequences. Each Agent is an ATmega328P, both having identical functionality, apart from the actuators controlled by them; one manages LEDs and the other one buzzing disc motors. Power supply section uses both a step-up and a step-down converter due to the demand for both 3.3 and 5 voltages for the buzzing motors circuit and everything else respectively.

3.1 Color Coding

- **yellow** - ESP32 C3 mini main controller.
- **pink** - ATmega agent controlling LEDs (green) and their corresponding input buttons (left side of the image).
- **cyan** - ATmega agent controlling buzzing motor discs (orange) and their corresponding input buttons (right side of the image).
- **red** - Status indication LEDs.
- **green** - LEDs.
- **orange** - Buzzing disc motors.
- **brown** - Step-up converter.
- **olive green** - Step-down converter.
- **purple** - Li Po 3.7V battery.



3.2 Component Values Calculation

3.2.1 LED Resistor Calculation

$$\begin{aligned}V_f &:= 2V : \\I_f &:= 20mA : \\V_{supply} &:= 5V :\end{aligned}$$

I_f is the desired current across the resistor (and LED).
 V_R is the voltage across the resistor.

$$V_R := V_{supply} - V_f = 3V$$

$$R := \frac{V_R}{I_f} = 150\Omega$$

3.2.2 Motor Resistor calculation

$$\begin{aligned}I_{max} &:= 75mA : \\V_{supply} &:= 3.3V : \\R &:= \frac{V_{supply}}{I_{max}} = 44.0000000000\Omega \\&\text{Round up to standard value (47 ohm).}\end{aligned}$$

3.2.3 BJT Resistor calculation

$$\begin{aligned}\beta_{forced} &:= 10 : \\I_C &:= I_{max} = 75mA \\I_B &:= \frac{I_C}{\beta_{forced}} = \frac{15}{2}mA \text{ at 10 digits} \rightarrow 7.5000000000mA \\V_{BE_sat} &:= 0.95V \\V_{supply} &:= 5V : \\R &:= \frac{(V_{supply}) - (V_{BE_sat})}{I_B} = 540.00000000\Omega\end{aligned}$$

Round up to standard value (560 ohm).

3.2.4 References

The following websites were used to gather estimate values for components calculation:

- <https://downloads.cree-led.com/files/ds/h/HB-C503B-BAS-BAN-GAS-GAN.pdf>
- https://cdn-shop.adafruit.com/product-files/1201/P1012_datasheet.pdf
- <https://www.onsemi.com/pdf/datasheet/pzt3904-d.pdf>

4 Breadboard Prototype

Breadboard prototype for the main setup is shown in figure 1 and the power supply for LiPo battery and its voltage conversion in figure 2.

In order to avoid duplication at this stage of the work, the prototype features only one Main-Agent setup, which will be doubled for the final product in order to make the game competitive for two players; each having their own station. For the same reason, there are currently only 2 LEDs and 2 buzzing motors per set, which will be increased to 4 each.

For the time being, red/green LEDs indicate the failure/success per level, but we think of adding something more multimodal if time allows, potentially including sound. Another additional feature that is planned for the final version of the project is to embed both types of actuators on top of the button caps, to streamline the user-input and make it as intuitive as possible, given the sequence output. Player will be able to hold one hand with fingertips resting comfortably on top of the buttons to receive the haptic signals, while observing the LED module simultaneously and quickly repeat the series of events.

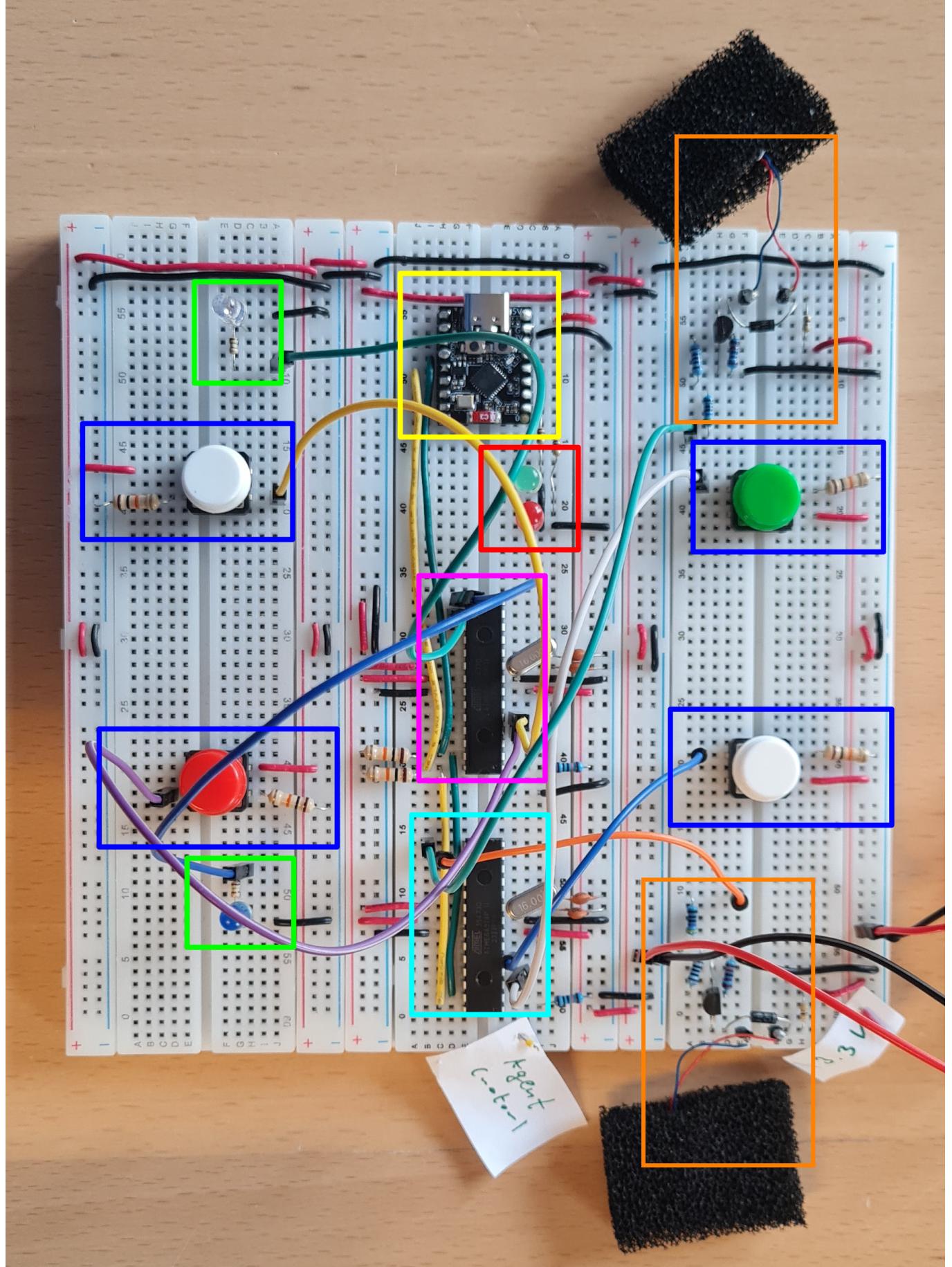


Figure 1: Breadboard setup of the ESP32 C3 mini main controller and two ATmega agents controlling the motors and LEDs modules.

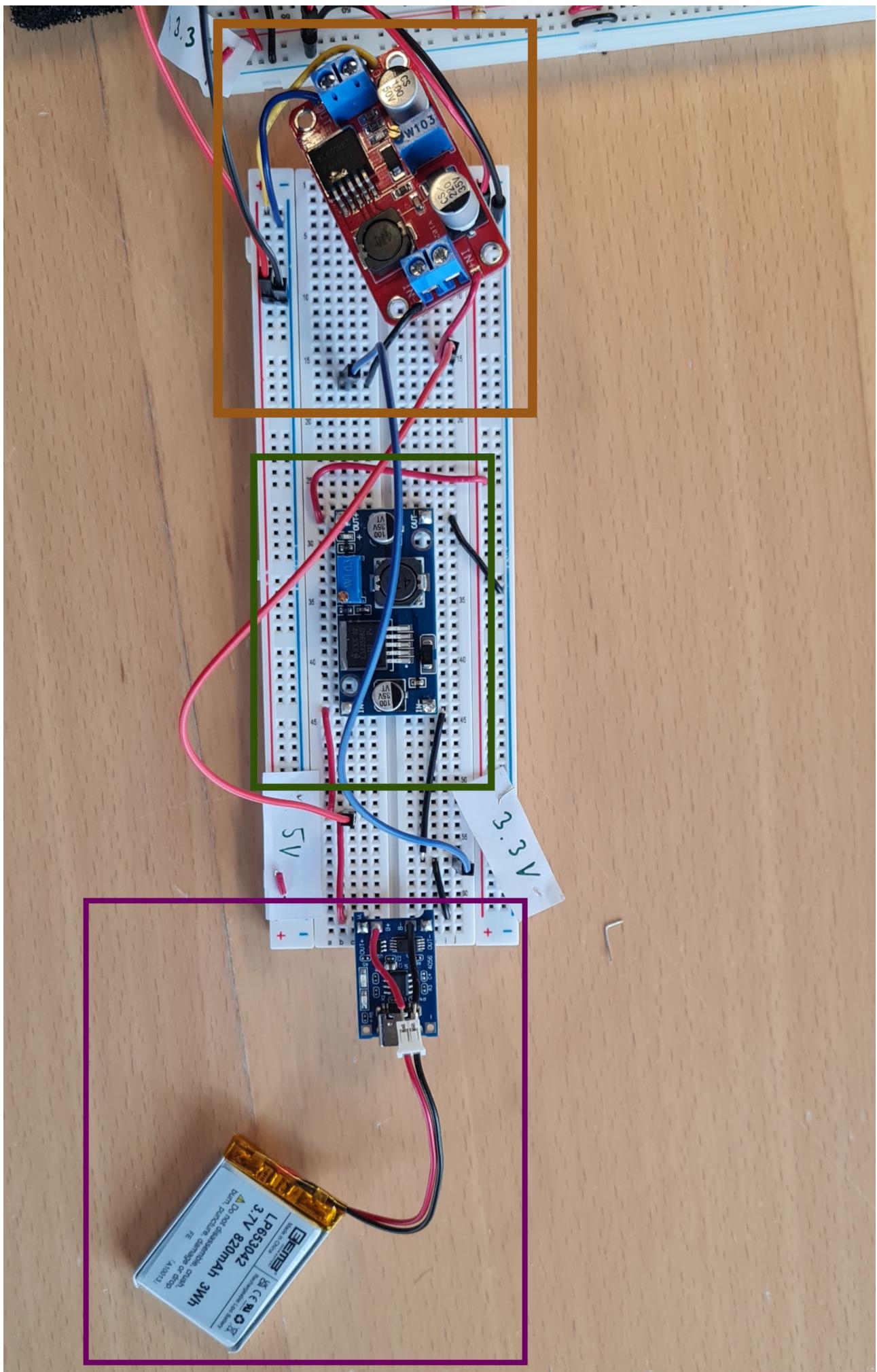


Figure 2: Breadboard setup of the 3.7V battery power supply alongside step-up (to 5V) and step-down (to 3.3V) converters.