Applications and Computation for the Internet of Things

1ST Lab Work: Building an embedded system

Group: 12		
Student 1	98380	Dominika Florczykowska
Student 2	97144	Pedro Mendes

Goal:

The goal of this work is to put students for the first time in touch with the Arduino environment to drive simple actuators (in the case LEDs).

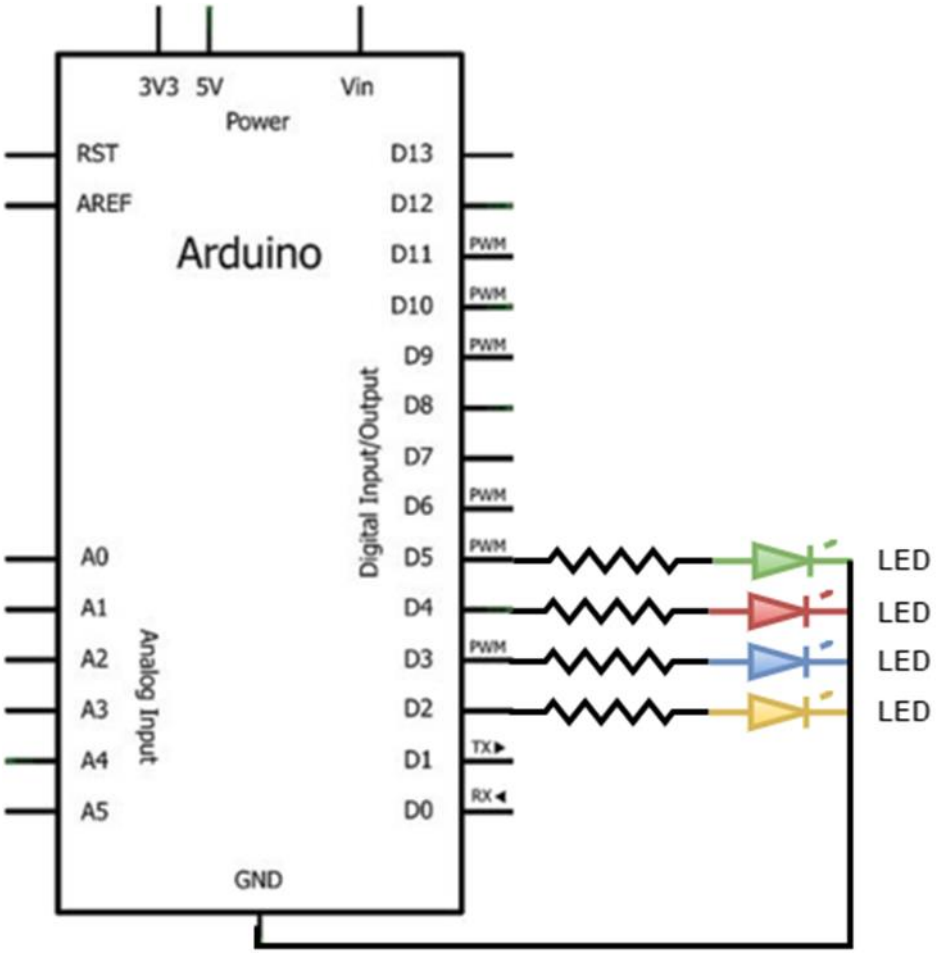
Description:

Build an embedded system using the Arduino UNO board to control 4 LEDs with different colours. In normal operation, in each 5 seconds period the system will have the following

1. Red LED ON
2. Green LED ON
3. Blue LED ON
4. Yellow LED ON
5. All LEDs OFF

This behaviour is then repeated.

The figure represents the circuit to drive the LEDs to be assembled.



Design the interface

Calculate the values of the resistors associated with the LEDs.

Red	220 Ω
Green	220 Ω
Blue	220 Ω
Yellow	220 Ω

Tabela 1: Resistance associated with each LED

Interface the circuit to a press button.

Whenever the button is pressed (OFF → ON → OFF) the LED activated at the moment must remain ON. (In stage 5 the system stops with all LEDs OFF.) With the system stopped it is easier to read the voltage drop on each LED. When the button is pressed again the system will continue its normal operation sequence.

Draw and design the press button interface to the controller.

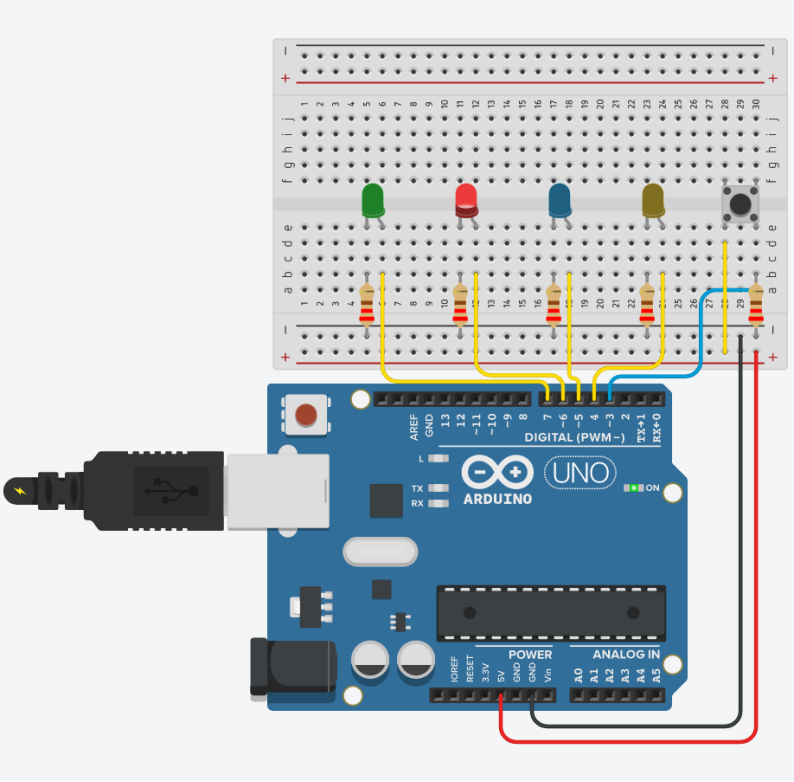


Figura 1: Graphical drawing

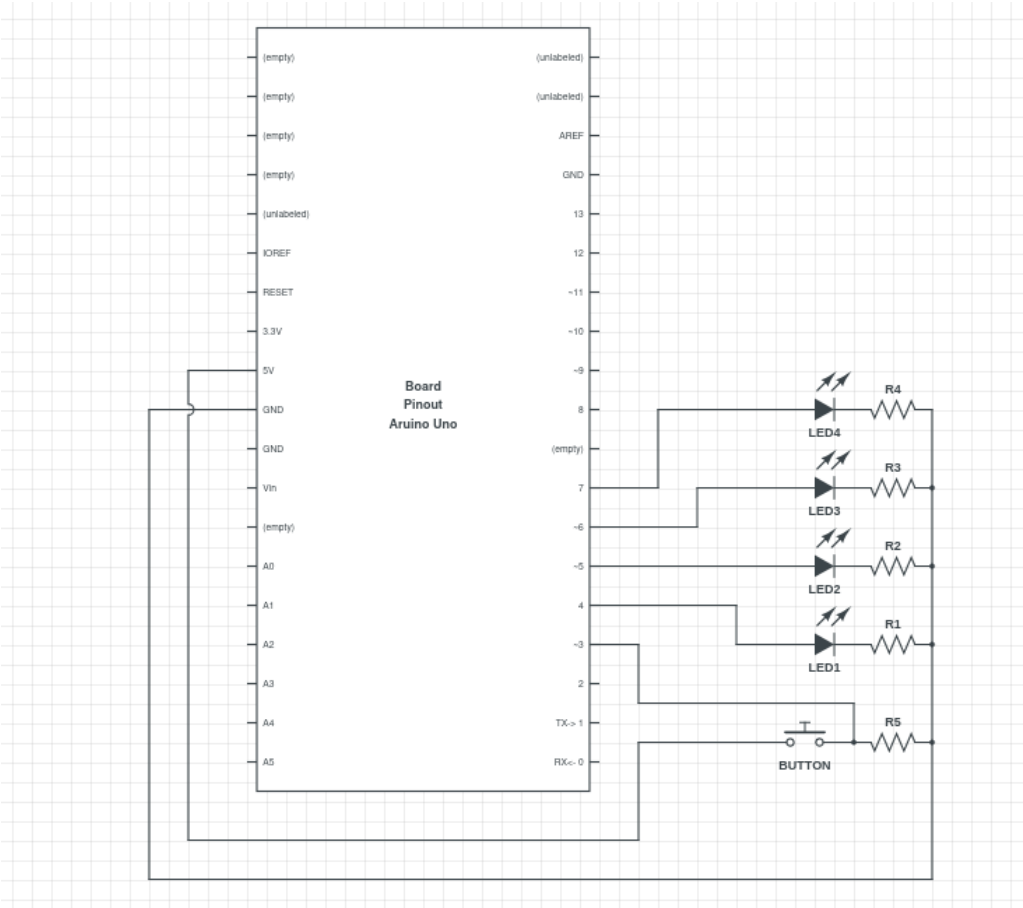


Figura 2: Technical drawing

Measure the voltage drops on the LEDs (with a multimeter):

Red	1.9 V
Green	2.09 V
Blue	2.93 V
Yellow	2.00 V

Tabela 2: Voltage drops on the LEDs

Estimate the power consumption of the interface (the circuit with resistors and LEDs in the figure) in normal operation.

Red LED power consumption	Green LED power consumption
$$I_{red} = \frac{U - U_{red}}{R}$$	$$I_{green} = \frac{U - U_{green}}{R}$$
$$I_{red} = \frac{5 - 1.9}{220}$$	$$I_{green} = \frac{5 - 2.09}{220}$$
$$I_{red} = 0.01409090909A$$	$$I_{green} = 0.01322727273A$$
$$P_{red} = U \times I_{red}$$	$$P_{green} = U \times I_{green}$$
$$P_{red} = 5 \times 0.01409090909$$	$$P_{green} = 5 \times 0.01322727273$$
$$P_{red} = 0.0705W$$	$$P_{green} = 0.0661W$$
Blue LED power consumption	Yellow LED power consumption
$$I_{blue} = \frac{U - U_{blue}}{R}$$	$$I_{yellow} = \frac{U - U_{yellow}}{R}$$
$$I_{blue} = \frac{5 - 2.93}{220}$$	$$I_{yellow} = \frac{5 - 2}{220}$$
$$I_{blue} = 0.00940909091A$$	$$I_{yellow} = 0.01363636364A$$
$$P_{blue} = U \times I_{blue}$$	$$P_{yellow} = U \times I_{yellow}$$
$$P_{blue} = 5 \times 0.00940909091$$	$$P_{yellow} = 5 \times 0.01363636364$$
$$P_{blue} = 0.0470W$$	$$P_{yellow} = 0.0682W$$

Tabela 3: Power consumption of the interface

Program de application

```
// usefull constants
enum { BUTTON_PIN = 3, DELAY = 1000 };

// States the arduino can be in.
// LED states have the value of the led pin
enum STATE {
    OFF = 0,
    YELLOW = 4,
    BLUE = 5,
    RED = 6,
    GREEN = 7,
};

volatile bool PAUSE = false;

void toggle_pause() {
    PAUSE = !PAUSE;
    digitalWrite(LED_BUILTIN, PAUSE);
}

void setup() {
    pinMode(YELLOW, OUTPUT);
    pinMode(BLUE, OUTPUT);
    pinMode(RED, OUTPUT);
    pinMode(GREEN, OUTPUT);
    pinMode(LED_BUILTIN, OUTPUT);
    pinMode(BUTTON_PIN, INPUT);
    attachInterrupt(digitalPinToInterrupt(BUTTON_PIN), toggle_pause, FALLING);
}

void loop() {
    static const STATE states[] = {RED, GREEN, BLUE, YELLOW, OFF};
    static const auto n_states = sizeof states / sizeof *states;
    static size_t state = 0;
    if (PAUSE) {
        return;
    } else if (states[state] == OFF) {
        for (auto led : states) digitalWrite(led, LOW);
    } else {
        if (state > 0) digitalWrite(states[state - 1], LOW);
        digitalWrite(states[state], HIGH);
    }
    state = (state + 1) % n_states;
    delay(DELAY);
}
```