SDJ INTERNATIONAL COLLEGE

Bachelor of Computer Applications (BCA) Programme

Project Report

BCA Sem VI
AY 2020-21

RGB Addressable LED Controller

by

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Project Guide by :
Prof. Nehal Patel

SDJ INTERNATIONAL COLLEGE

C E R T I F I C A T E

This is to certify that Ms. **Mansi Satani , Krishna Rudani** examination number **3271 , 3268** has satisfactorily completed their project work entitled **RGB Addressable LED Controller** as partial fulfillment of requirements for BCA Sem VI, during the academic year 2020-21.

Date: 17/06/2021

Place: Surat

Dr.Aditi Bhatt
(I/C Principle)
SDJ International College,
Surat

Acknowledgement

The success and final outcome of this project required a lot of guidance and assistance from many people and we am extremely fortunate to have got this all along the completion of our project work. Whatever we have done is only due to such guidance and assistance and we would not forget to thank them.

we owe our profound gratitude to our Director Mr. Deepak Vaidya, I/c Principal Dr. Aditi Bhatt, Head of Department Mr.Vaibhav Desai and project guide prof. Nehal Patel and all other Assistant professors of SDJ International College, who took keen interest on our project work and guided us all along, till the completion of our project work by providing all the necessary information for presenting a good Concept. We are extremely grateful to them for providing such a nice support and guidance though they had busy schedule managing the college affairs.

We are thankful and fortunate enough to get support and guidance from all Teaching staffs of Bachelor of Computer Application Department which helped us in successfully completing our project work. Also, we would like to extend our sincere regards to all the non-teaching staff of Bachelor of Computer Application Department for their timely support.

I N D E X

1. Introduction

This project aims at designing a system which is capable of controlling our Home appliances using Android Smartphone with Multi communication .This project uses both Wi-Fi and Bluetooth communication simultaneously and controls Various devices based on the availability in particular areas. The system controls the LED light Intensity to high and Low using Wi-Fi or Bluetooth technology, Microcontroller and can also control any 230v Home appliances using our smart Phone. This system is very user-friendly ,accurate and future technology. Bluetooth is an open standard specification for a radio frequency (RF)-based, short-range connectivity technology that promises to change the face of computing and wireless communication. It is designed to be an inexpensive, wireless networking system for all classes of portable devices, such as laptops, PDAs (personal digital assistants), and mobile phones. It also enables wireless connections for desktop computers, making connections between monitors, printers, keyboards, and the CPU cable-free. Wi-Fi stands for Wireless Fidelity and is a wireless technology for PCs and PDAs that allows multiple devices to share high speed Internet connection over a distance of about 300 feet. The Block Diagram here depicts a transmitter and receiver. At the transmitter we find a smartphone application. The smartphone application is nothing but an android application which is the main source for giving the instruction to the Wi-Fi module. The transmitter of Wi-Fi/Bluetooth modules transmits the data given by the application using radio waves technology. The Wi-Fi and Bluetooth work on radio waves technology, as the data to be passed through them is converted into the electromagnetic signal which is then sent using the antenna. This signal is received and decoded by the router at the receiving end. This signal is passed to the controller which is nothing but LPC2148Micro controller. The controller further operates the received information and performs operations on the appliances, which are driven by the driver i.e, (LED Driver that drives the LED lamp to ON/OFF and Intensity control condition), a relay switch is connected to microcontroller through which ac appliances can be connected and controlled.

1.1 Project Summary

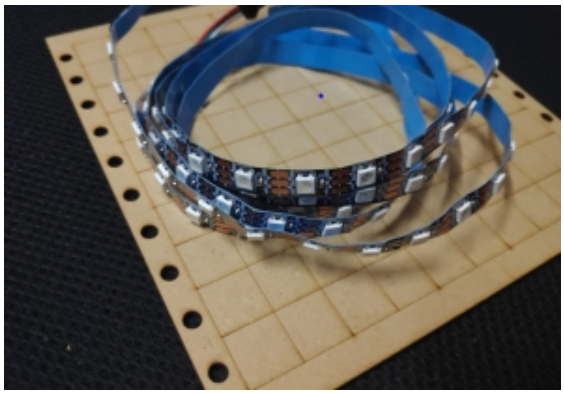
WS2812B is a intelligent control LED light source that the control circuit and RGB chip are integrated in a package of 5050 components. It internal include intelligent digital port data latch and signal reshaping ampli fication drive circuit. Also include a precision internal oscillator and a 12V voltage programmable constant curr e-nt control part, effectively ensuring the pixel point light color height consistent. The data transfer protocol use single NZR communication mode. After the pixel power-on reset, the DIN port receive data from controller, the first pixel collect initial 24bit data then sent to the internal data latch, the other data which reshaping by the internal signal reshaping amplification circuit sent to the next cascade pixel through the DO port. After transmission for each pixel， the signal to reduce 24bit. pixel adopt auto resha -ping transmit technology, making the pixel cascade number is not limited the signal transmission, only depend on the speed of signal transmission. LED with low driving voltage, environmental protection and energy saving, high brightness, scattering angl e is large, good consistency, low power, long life and other advantages. The control chip integrated in LED above becoming more simple circuit, small volume, convenient installation.In LED strips world, there are (so) many models.

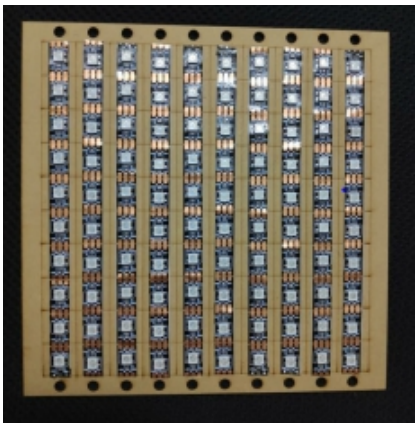
As explained on Wikipedia... "The most common design differences are in how individual LEDs are **controlled**, specifically differences in color and whether or not each LED is addressable.

- **Single Color, non-addressable**: Every LED on the strand is a single white colour, typically ranging from 2700K to 6500K in colour temperature, or any of several monochrome colors covering the range of the visible spectrum (generally from 400-700 nanometers in wavelength).
- **Multicolor, non addressable**: Each LED is capable of displaying red, green, blue, or all three (white), driven by three input power rails. All the LEDs display the same colour at any one time, but the colour can be manipulated by varying the voltage applied to each of the three power inputs.
- **RGB, addressable**: Multiple colours and addresses. Each LED has its own chip meaning they can be individually triggered for chasing, strobing, and colour changing"

As a generic rule of thumb, you can consider that "**cheap** RGB LED strip" = "non addressable". There are numerous tutorials on addressable LED strips but not that much on simple, non addressable ones.

RGB LED





LED Strips

1.2 Project Technical Profile

Project Title	RGB Addressable LED Controller with Flutter
Definition	Control Addressable RGB LED (ws2812b) by using ESP32 IoT device and Flutter Application Controller. The project will display capabilities of Flutter UI and Flutter's versatile Potential. We will interface an IoT device (esp32) with Flutter application and control RGB LEDs in real time by using flutter app. We will also add predefined LED patterns and Send the data to IoT device using Bluetooth/wi-fi communication, which will initiate Predefined patterns in real time. Additionally, we will add brightness control, LED Turn on and Turn Off feature.
Devloped For	S.D.J.International college,vesu,surat
Project Guide	Prof. Nehal Patel
Front End	Flutter
Back End	Dart
Operating System	Microsoft Windows 10
Tools used for ERD & DFD	Microsoft Word, Draw.io, Visio
Submitted By	1. Mansi Satani , 2. Krishna Rudani

2. Scope & Planning

The major advantage of a lighting control system over stand-alone lighting controls or conventional manual switching is the ability to control individual lights or groups of lights from a single user interface device. This ability to control multiple light sources from a user device allows complex lighting scenes to be created. A room may have multiple scenes pre-set, each one created for different activities in the room. A major benefit of lighting control systems is reduced energy consumption. Longer lamp life is also gained when dimming and switching off lights when not in use. Wireless lighting control systems provide additional benefits including reduced installation costs and increased flexibility over where switches and sensors may be placed.

- **Theatrical lighting control**

Architectural lighting control systems can integrate with a theater's on-off and dimmer controls, and are often used for house lights and stage lighting, and can include worklights, rehearsal lighting, and lobby lighting. Control stations can be placed in several locations in the building and range in complexity from single buttons that bring up preset options-looks, to in-wall or desktop LCD touchscreen consoles. Much of the technology is related to residential and commercial lighting control systems.

The benefit of architectural lighting control systems in the theater is the ability for theater staff to turn worklights and house lights on and off without having to use a lighting control console. Alternately, the light designer can control these same lights with light cues from the lighting control console so that, for instance, the transition from houselights being up before a show starts and the first light cue of the show is controlled by one system.

- **WI-FI lighting control**

The new type of control for lighting system is using wi-fi connection directly to the lighting system. It is recently introduced by Philips HUE and company new name as Signify formerly known as Philips Lighting. This system will need a smartphone or tablet where the user can access with the wi-fi. Wi-fi doesn’t need any bluetooth application.

2.1 Requirement Analysis

Things we required for this LED controller are,

1. Hardware devices
2. Software devices

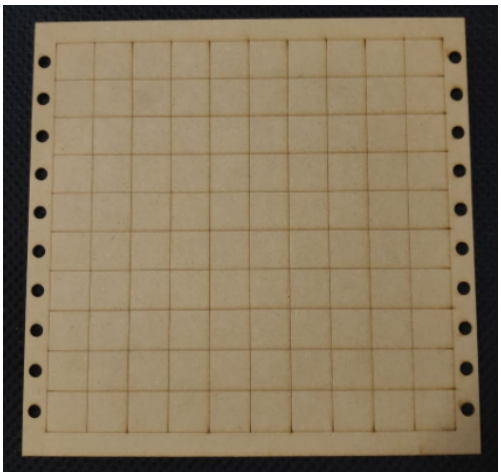
1. Hardware devices:-

- MDF (Frame),
- Ws2812b(RGB LED strips)
- ESP8266 (IoT Device)
- Extra power source
- USB cables

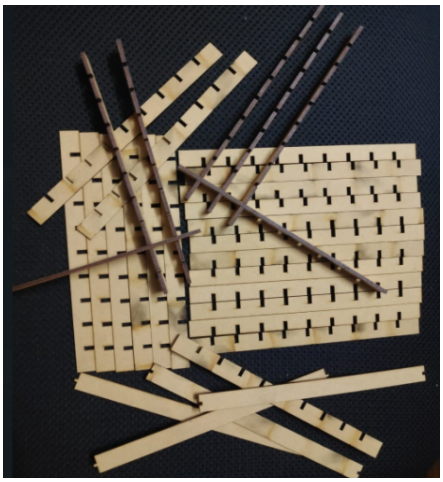
- **MDF (Frame) :-**

MDF is traditionally made of wood fibers that have been broken down into residuals, then mixed with wax and resins and heat pressed into dense, durable sheets. A sheet of MDF will be heavy, smooth and even, with a flat surface that can be painted or sealed.

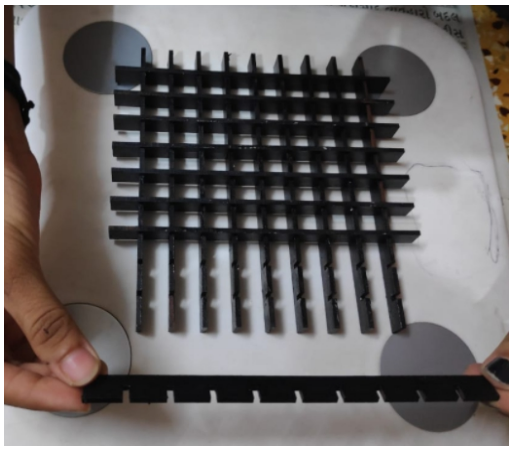
It's prized for some surface uses because it's uniform and smooth. While it typically contains urea-formaldehyde as part of its manufacturing process, it can also be specified as NAF or no added formaldehyde for those concerned about off-gassing.



MDF base sheet



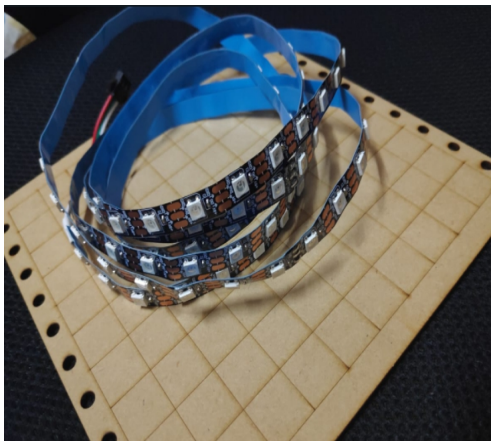
MDF Frame strips

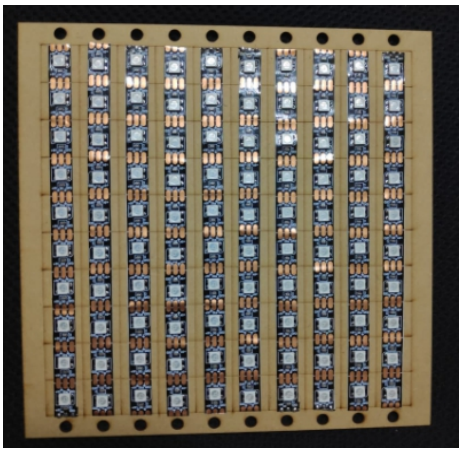


MDF frame made with the strips

- **Ws2812b(RGB LED strips) :-**

WS2812B is a intelligent control LED light source that the control circuit and RGB chip are integrated in a package of 5050 components. It internal include intelligent digital port data latch and signal reshaping ampli fication drive circuit. Also include a precision internal oscillator and a 12V voltage programmable constant curr e-nt control part, effectively ensuring the pixel point light color height consistent. The data transfer protocol use single NZR communication mode. After the pixel power-on reset, the DIN port receive data from controller, the first pixel collect initial 24bit data then sent to the internal data latch, the other data which reshaping by the internal signal reshaping amplification circuit sent to the next cascade pixel through the DO port. After transmission for each pixel， the signal to reduce 24bit. pixel adopt auto resha -ping transmit technology, making the pixel cascade number is not limited the signal transmission, only depend on the speed of signal transmission. LED with low driving voltage, environmental protection and energy saving, high brightness, scattering angle is large, good consistency, low power, long life and other advantages. The control chip integrated in LED above becoming more simple circuit, small volume, convenient installation.

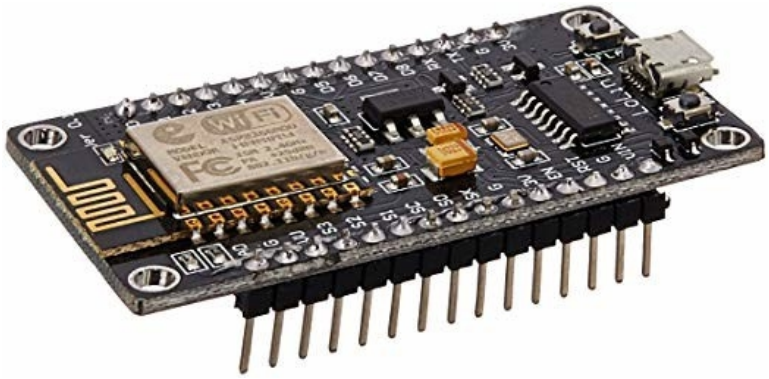




LED Strips

- **ESP32 (IoT Device)**

ESP32 is a series of low-cost, low-power system on a chip microcontrollers with integrated Wi-Fi and dual-mode Bluetooth. The ESP32 series employs a Tensilica Xtensa LX6 microprocessor in both dual-core and single-core variations and includes built-in antenna switches, RF balun, power amplifier, low-noise receive amplifier, filters, and power-management modules. ESP32 is created and developed by Espressif Systems, a Shanghai-based Chinese company, and is manufactured by TSMC using their 40 nm process.[2] It is a successor to the ESP8266 microcontroller.



ESP8266

- **Extra power source**

The main job of an AC/DC power supply is to transform the alternating current (AC) into a stable direct current (DC) voltage, which can then be used to power different electrical devices.

Alternating current is used to transport electric power all across the electric grid, from generators to end users. An alternating current (AC) circuit can be configured as a single-phase or a three-phase system. Single-phase systems are simpler, and can deliver enough power to supply an entire house, but three-phase systems can deliver much more power in a more stable way, which is why they are frequently used to supply power for industrial applications.

Methods for designing an AC/DC power supply have changed over time. Linear AC/DC power supplies are limited in size and efficiency, because they work at low frequencies and regulate the output temperature by dissipating the excess energy in the form of heat. By contrast, switching power supplies have become extremely popular, because they use switching regulators to convert AC to DC power. Switching power supplies work at higher frequencies and convert electrical power far more efficiently than previous designs, which has enabled the creation of palm-sized, high-power AC/DC power supplies.

➢ USB cables

- **Micro USB cable:-**

  Micro USB is a miniaturized version of the **USB** (Universal Serial Bus) interface developed for connecting compact and mobile devices such as your smartphones, MP3 players, GPS devices, photo printers, and digital cameras.

- **Type C USB cable:-**

  A **USB-C cable** is a preferred mode for charging and transferring data. Its connector has a unique shape. It can also support various **USB** versions like **USB** 3.1 and **USB** Power Delivery. This **cable's** symmetrical shape helps you to connect it to your device in any orientation.

2. Software devices :-

- Android studio
- Arduino
- Android emulator/Android device
- IOS simulator/IOS device

➢ Android studio :-

You can build apps with Flutter using any text editor combined with our command-line tools. However, we recommend using one of our editor plugins for an even better experience. These plugins provide you with code completion, syntax highlighting, widget editing assists, run & debug support, and more.

- **Install Android Studio**

Android Studio offers a complete, integrated IDE experience for Flutter.

- Android Studio, version 3.0 or later

- **Install the Flutter and Dart plugins**

The installation instructions vary by platform.

- **Mac**

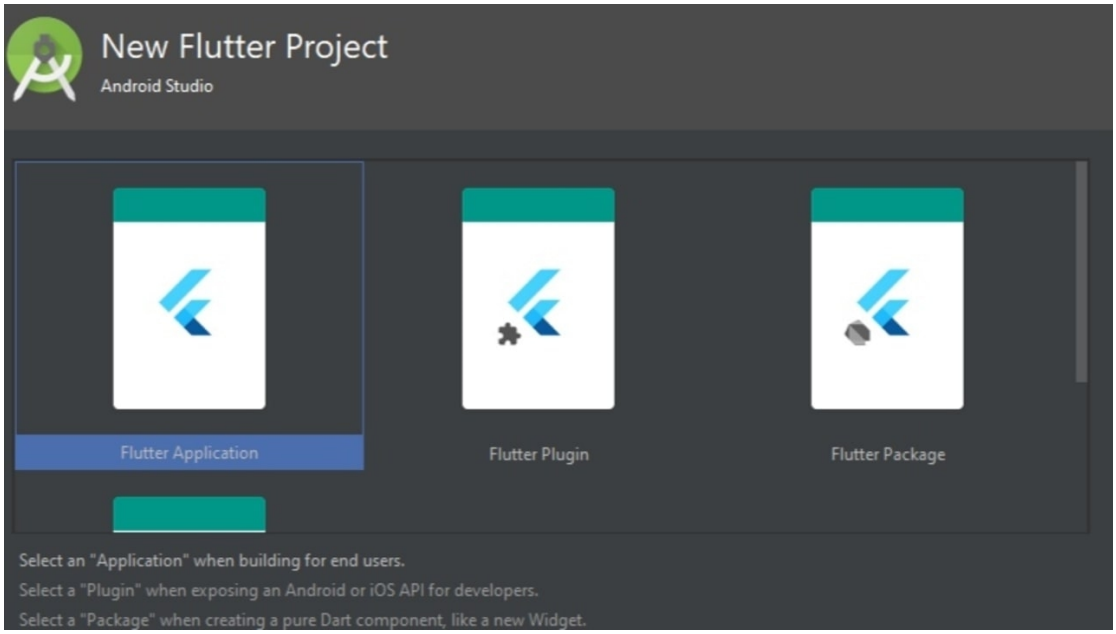
Use the following instructions for macos:

1. Start Android Studio.
2. Open plugin preferences (**Preferences > Plugins** as of v3.6.3.0 or later).
3. Select the Flutter plugin and click **Install**.
4. Click **Yes** when prompted to install the Dart plugin.
5. Click **Restart** when prompted.

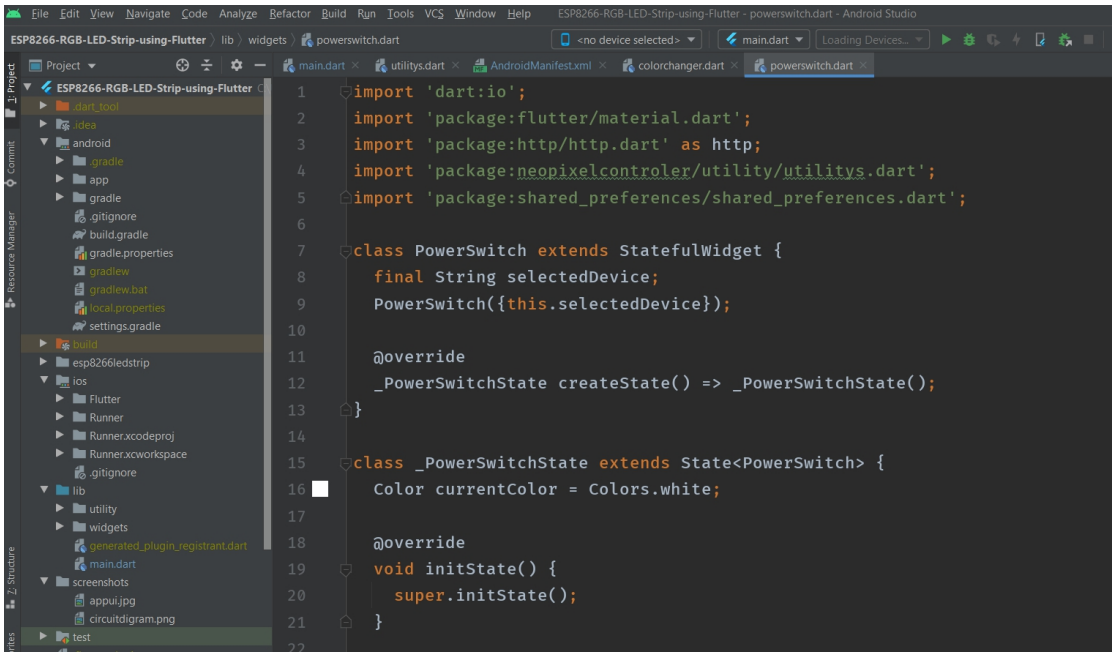
- **Linux or Windows**

Use the following instructions for Linux or WIndows:

1. Open plugin preferences (**File > Settings > Plugins**).
2. Select **Marketplace**, select the Flutter plugin and click **Install**.



Flutter project using android studio



Dart files

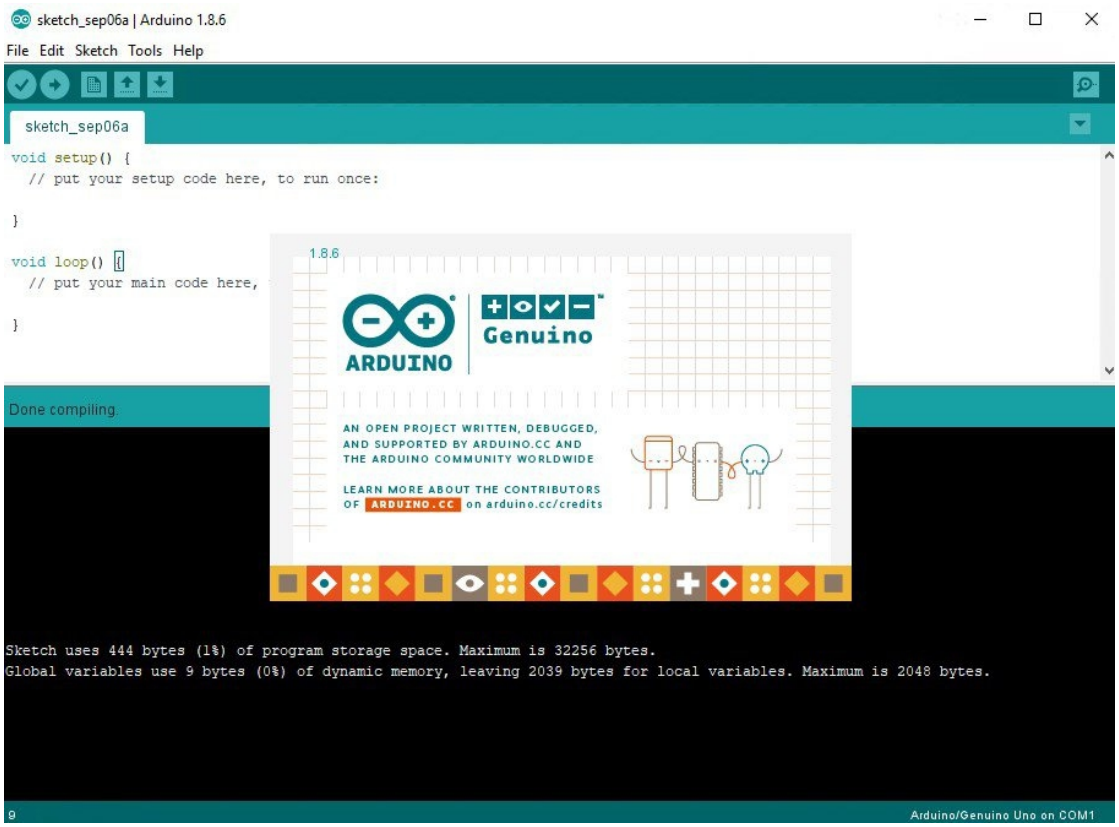
➢ Arduino :-

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing.

- **Why Arduino?**

There are many other microcontrollers and microcontroller platforms available for physical computing. Parallax Basic Stamp, Netmedia's BX-24, Phidgets, MIT's Handyboard, and many others offer similar functionality. All of these tools take the messy details of microcontroller programming and wrap it up in an easy-to-use package. Arduino also simplifies the process of working with microcontrollers, but it offers some advantage for teachers, students, and interested amateurs over other systems:

- **Inexpensive** - Arduino boards are relatively inexpensive compared to other microcontroller 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
- **Cross-platform** - The Arduino Software (IDE) runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows.
- **Open source and extensible software** - The Arduino software is published as open source tools, available for extension by experienced programmers. The language can be expanded through C++ libraries, and people wanting to understand the technical details can make the leap from Arduino to the AVR C programming language on which it's based. Similarly, you can add AVR-C code directly into your Arduino programs if you want to.
- **Open source and extensible hardware** - The plans of the Arduino boards are published under a Creative Commons license, so experienced circuit 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 in order to understand how it works and save money.



Arduino screen

Project code using Arduino

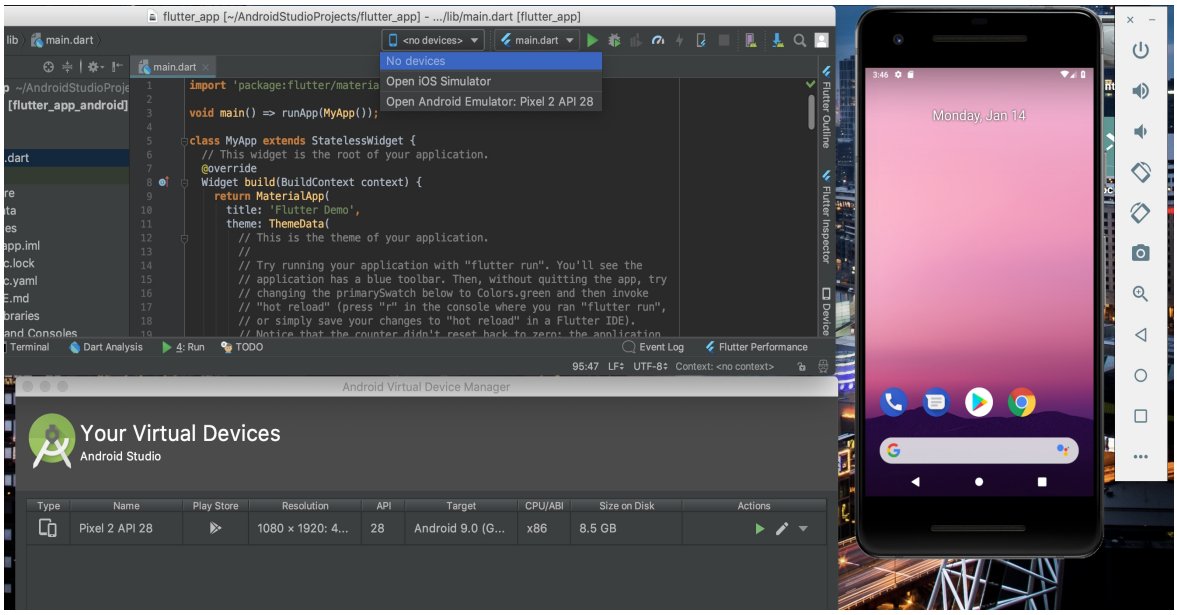
➢ Android emulator/Android device :-

The Android Emulator simulates Android devices on your computer so that you can test your application on a variety of devices and Android API levels without needing to have each physical device.

The emulator provides almost all of the capabilities of a real Android device. You can simulate incoming phone calls and text messages, specify the location of the device, simulate different network speeds, simulate rotation and other hardware sensors, access the Google Play Store, and much more.

Testing your app on the emulator is in some ways faster and easier than doing so on a physical device. For example, you can transfer data faster to the emulator than to a device connected over USB.

The emulator comes with predefined configurations for various Android phone, tablet, Wear OS, and Android TV devices.

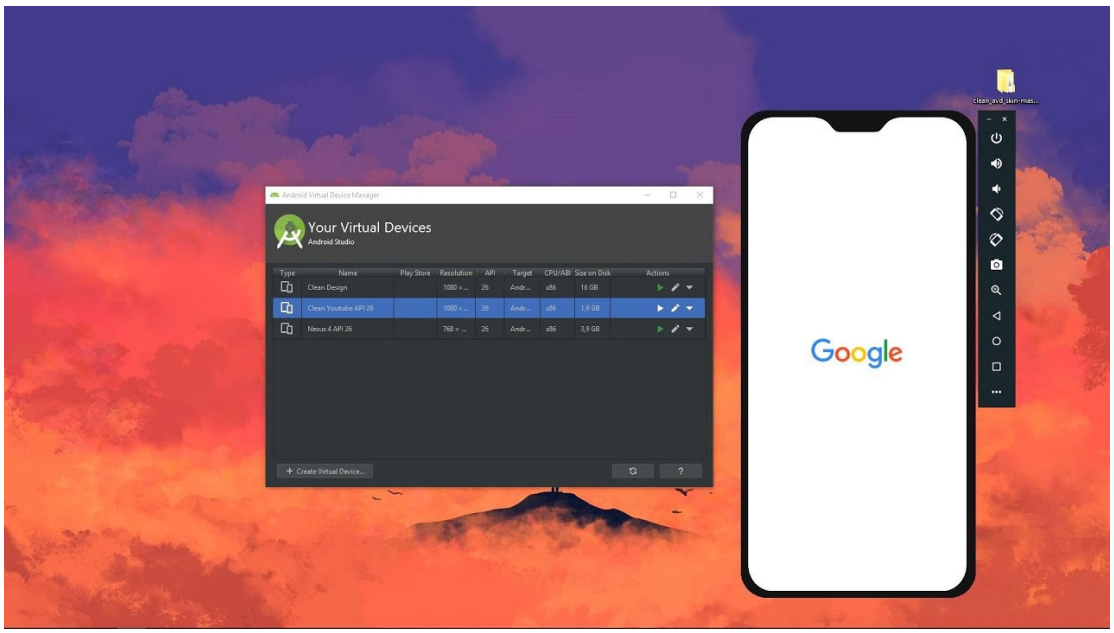


Android emulator

➢ IOS simulator/IOS device :-

Simulator allows you to rapidly prototype and test builds of your app during the development process. Installed as part of the Xcode tools, Simulator runs on your Mac and behaves like a standard Mac app while simulating an iPhone, iPad, Apple Watch, or Apple TV environment. Think of the simulator as a preliminary testing tool to use before testing your app on an actual device.

Simulator enables you to simulate iOS, watchOS, and tvOS devices running current and some legacy operating systems. Each combination of a simulated device and software version is considered its own simulation environment, independent of the others, with its own settings and files. These settings and files exist on every device you test within a simulation environment.



IOS simulator

2.2 Feasibility Study

➢ What is WS2812b?

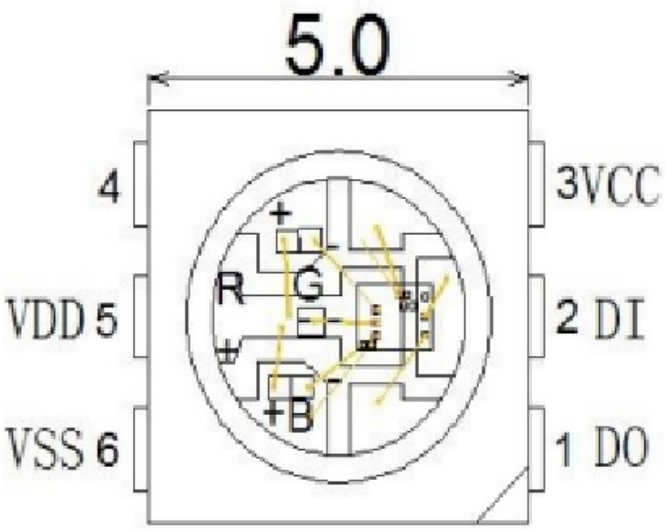
WS2812B is an intelligent control LED light source which integrates the control circuit and RGB chip into a 5050 component package. It includes a smart digital port data latch and a signal reshaping circuit for amplifying the drive. It also includes an internal precision oscillator and a constant current control port for 5 Voltage which ensures the consistent pixel point light color height. These can be added to a full-color panel, a lamp stripe full-color soft lights, led decorative lighting and irregular video indoor/outdoor led screen.

➢ How do WS2812B work?

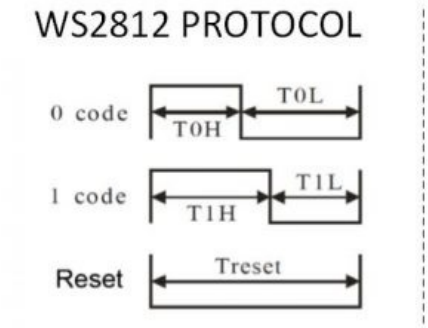
WS2812B LEDs have an IC built into the LED which allows one-wire interface communication. This means that you can use one pin on your controller to power several LED's. There are 3 pins in the LED strips: the power pin (+ 5V), the ground pin (GND), and the data pin (DIN and DOUT). The protocol for the transfer of data uses a single NZR communication mode. The DIN port receives data from the controller after the pixel power-on reset, the first pixel collects initial 24bit data and then send it to the internal data latch, the other data which is reshaped by the internal signal reshaping amplification circuit is sent to the next cascade pixel through the DOUT port. The signal can be decreased up-to 24bit for each pixel after transmission. Pixels follow auto reshaping transmission technology so that the pixel cascade number is not limited to the transmission of the signal, it only depends on the speed of transmission of the signal.

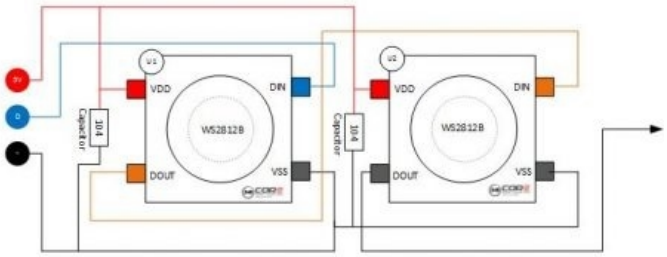
➢ WS2812 Wiring Diagram

The WS2812 is a smart LED light source family which integrates the control circuit and the RGB chip into a 5050 part package. It is an onboard smart digital port lock and signal reshaping inference drive circuit that effectively ensures the color of the pixel point light is HIGH and consistent. Color-coding by feature of the wires (e.g. red for +, black for –, green for signal) is optional but it helps to avoid mishaps. A simpler view of the expected wiring is given here. The actual configuration will include the Data Logging Shield, use the prototyping area for some of the links.



The mechanical size and pin drawing of WS2812





- **How to control WS2812B using Arduino?**

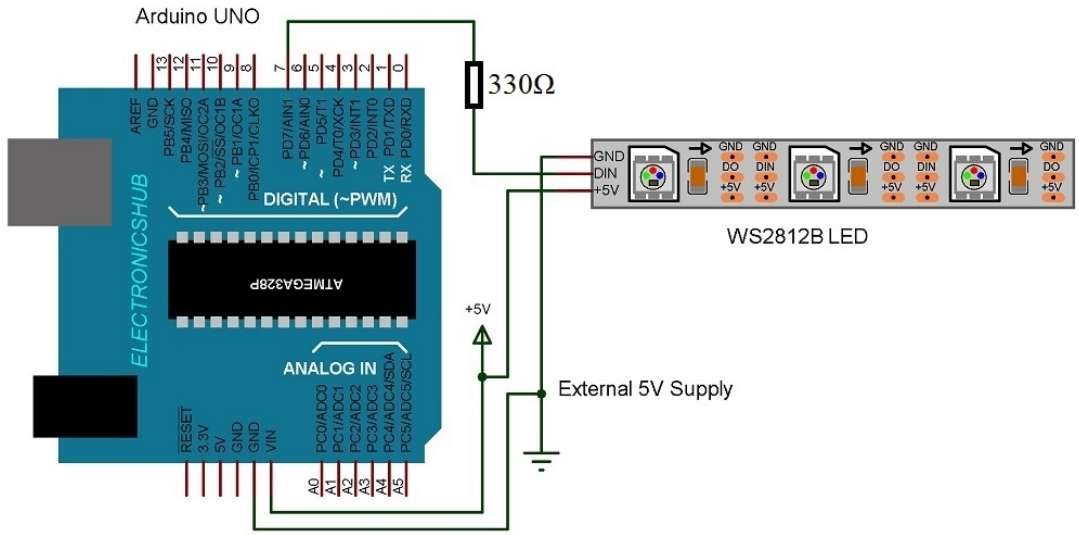
Now let's proceed with using Arduino to control the WS2812B LED array. There is one important thing that we need to tackle, i.e. the power supply to the plant, before we move further into designing the schematics. Every single WS2812B LED pixel has three LEDs and one control IC. So, the current requirement for one-pixel is about 60 mA. When you have a strip containing 20 WS2812B Addressable LEDs individually, then the total current requirement is 20* 60 mA= 1.2 A.

This is more than Arduino can supply, either via the USB port (which can supply up to 300 mA) or the 5V barrel jack (which can supply up to 900 mA). Thus, the best way to power up both Arduino and the WS2812B LED Strip, is by using an external 5v supply that can provide sufficient power.

We hope that project's power supply section is clear, moving to project's schematics now.

➢ Circuit Diagram:

The picture below shows the relation between LED Strip WS2812B RGB and Arduino UNO. The Arduino UNO 5V and the LEDs are attached together with the GND (VSS) to an external power supply. The LED Strip's DIN pin is attached to Arduino's Digital IO pin 7 via a 330 resistor.



➢ Required Material:

WS2812B LEDs

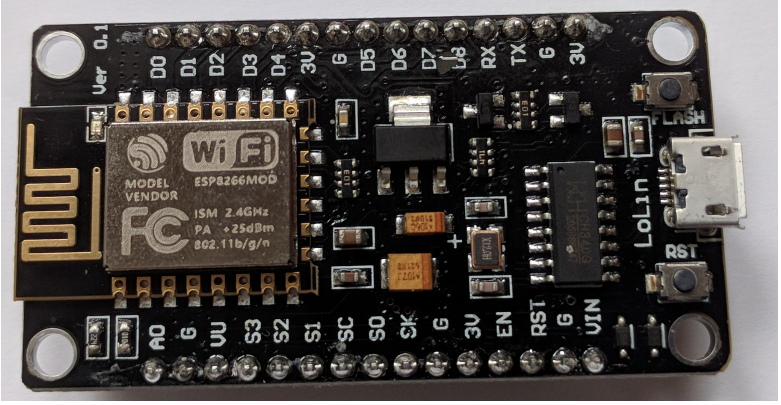
Arduino UNO

5V power supply

➢ What is a microcontroller?

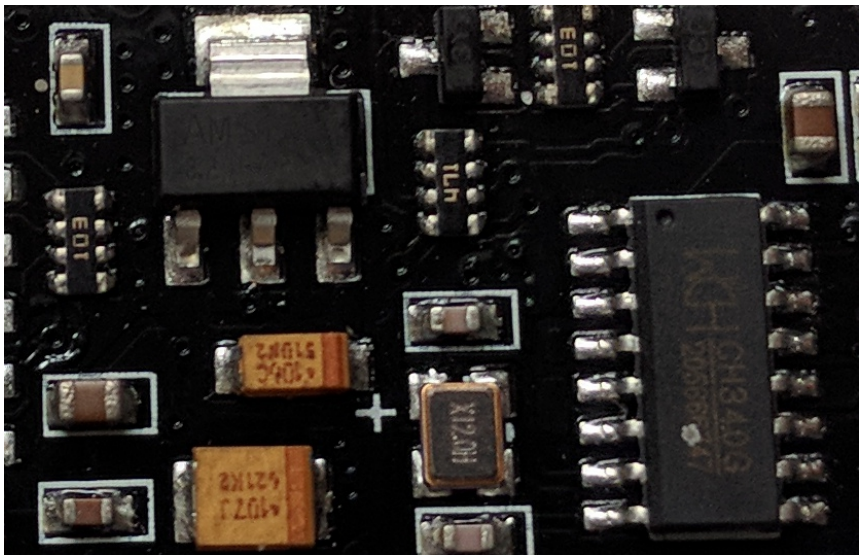
The easiest way to understand what is a microcontroller is to think about a tiny computer: it includes a processor, memory and input/output (I/O) peripherials to connect small display, buttons, motors, sensors, etc. To “control” a microcontroller, you can put programs onto it and run them. As we will see later in this lesson, we usually write programs using a laptop and then transfer the programs into the microcontroller to execute it.

A microcontroller can look like this:



i.e. very much like what we call an “integrated circuit”.

Look for instance at what we see when we zoom in the previous picture:



A typical microcontroller includes a processor, memory and input/output (I/O) peripherals.

➢ **Audio Reactive LED Strip**

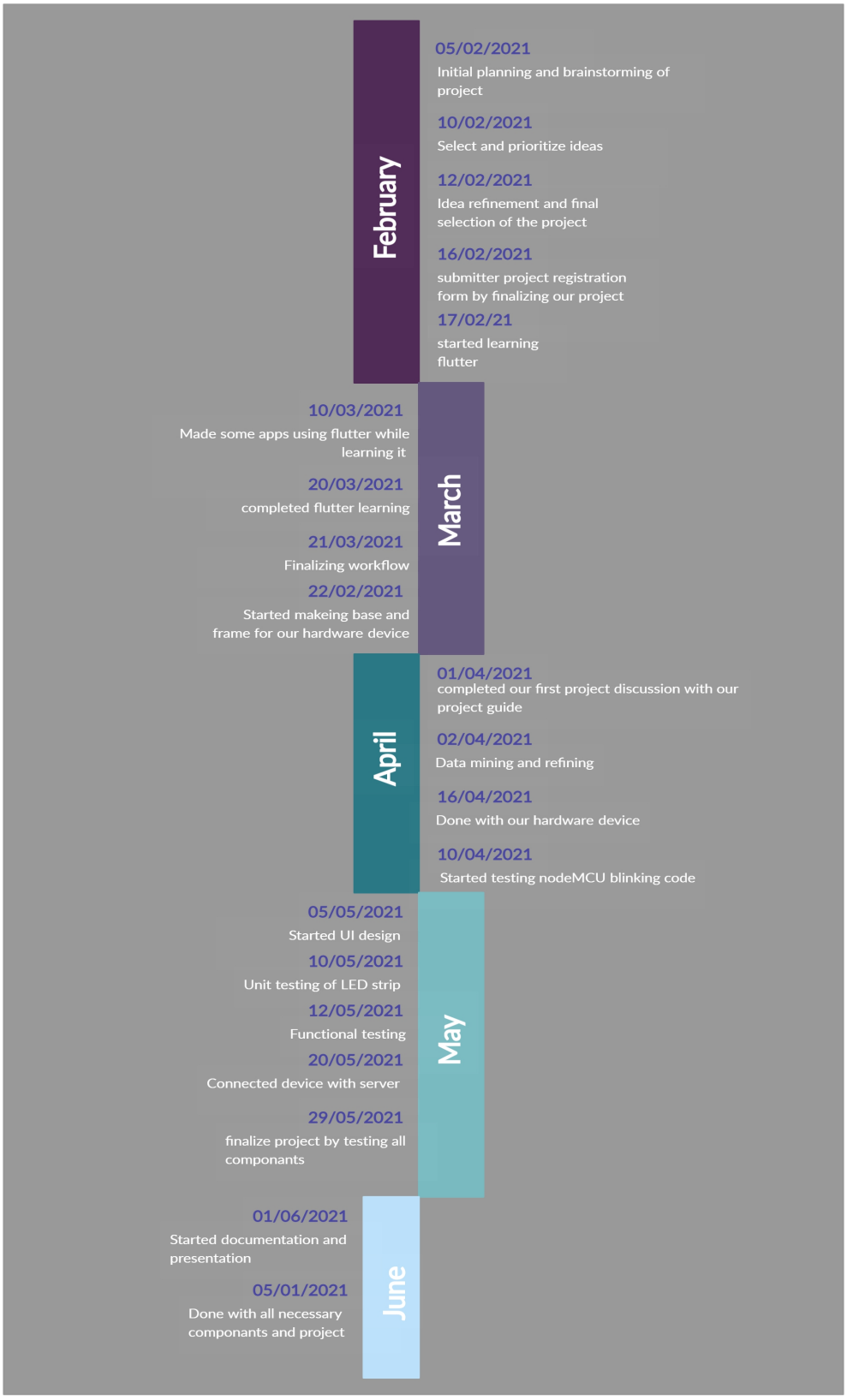
Real-time LED strip music visualization using Python and the ESP8266 or Raspberry Pi.

➢ **Standalone Raspberry Pi**

- Since the Raspberry Pi is a 3.3V device, the best practice is to use a logic level converter to shift the 3.3V logic to 5V logic
- Although a logic level converter is the best practice, sometimes it will still work if you simply connect the LED strip directly to the Raspberry Pi.
- You cannot power the LED strip using the Raspberry Pi GPIO pins, you need to have an external 5V power supply.

- **Limitations when using the Raspberry Pi:**
  - Raspberry Pi is just fast enough the run the visualization, but it is too slow to run the GUI window as well. It is recommended that you disable the GUI when running the code on the Raspberry Pi.
  - The ESP8266 uses a technique called temporal dithering to improve the color depth of the LED strip. Unfortunately the Raspberry Pi lacks this capability.

2.3 Timeline Chart



2.4 Future Development

We further look forward to develop our application in various fields. Similarly we are looking forward to add some beats of songs and pattern according to that particular beat ,Then transforming the LED look by adding the frame over it and make it more presentable.

Also we are planning to make it usable for the parties, home decorations ,theaters and for many more places which can be turn boring to some interesting interior by this LED patterns.

So as if now we are looking towards these future development possibilities.

2.5 Technology Details

➢ Hardware/Software Configuration :-

- **Hardware Requirement :-**

Processor	1. Intel CORE i5 10th GEN 2. Ryzen 5
RAM	8.00 GB
HDD	1 TB
IoT Device	ESP32
LED Strip	WS2812B

- **Software used for Application Implementation :-**

Operating System	Windows 10 Ultimate
Front End	Flutter
Code Behind	C++
Back End	Dart
Other Tools Used	Arduino IDE, ESP32, WS2812B Addressable RGB LEDs

3. Designing

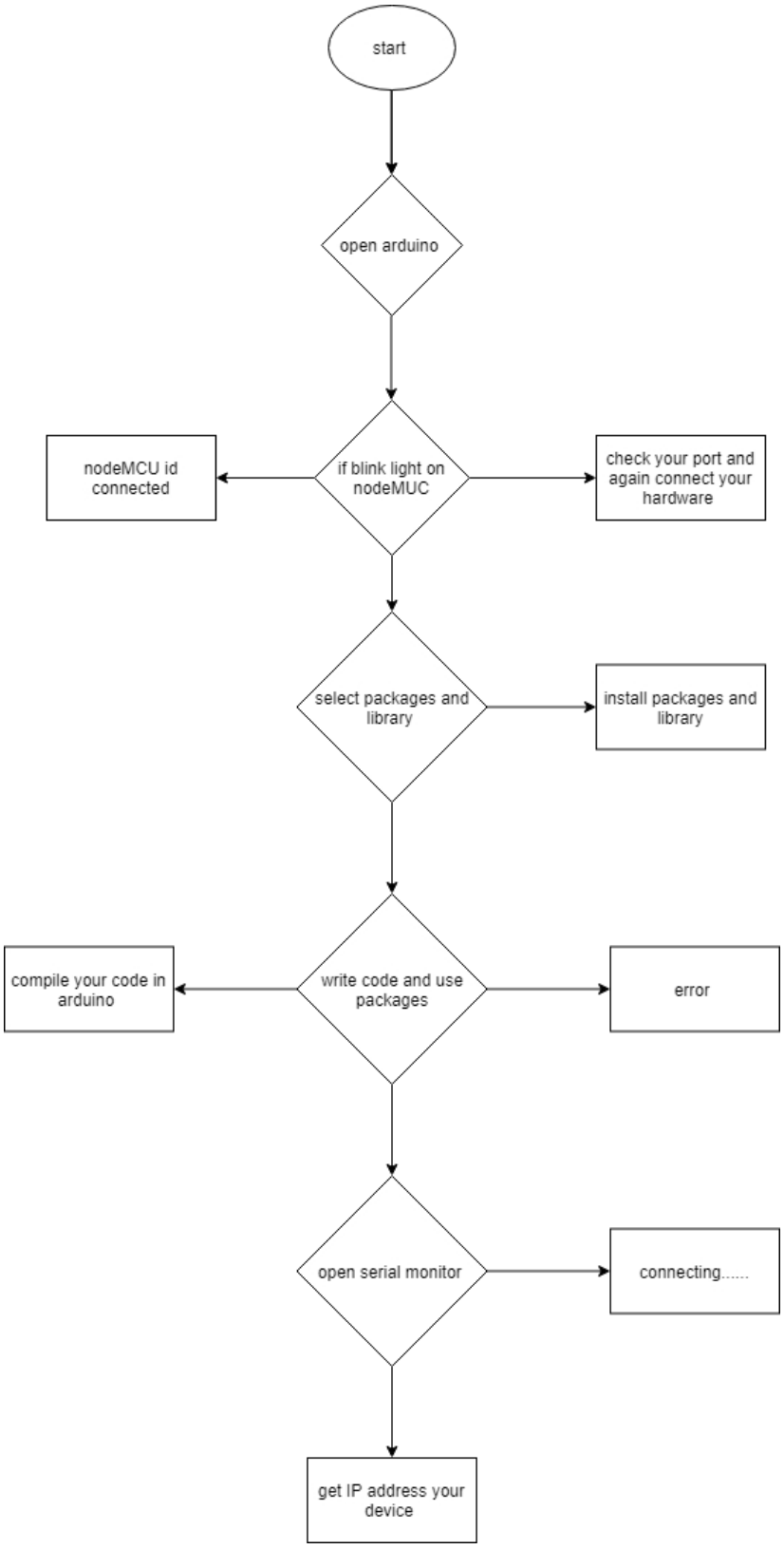
- **Front-end design:-**

We had used flutter for the user Interface. In this application we had made a color picker from which user can select the color and then according to that color the lights will be changed and in the future we are planning to add some beats similarly the LED will change its pattern according to added beats. When the user tries to select the color from their device they need to add IP address then only led will work accordingly.

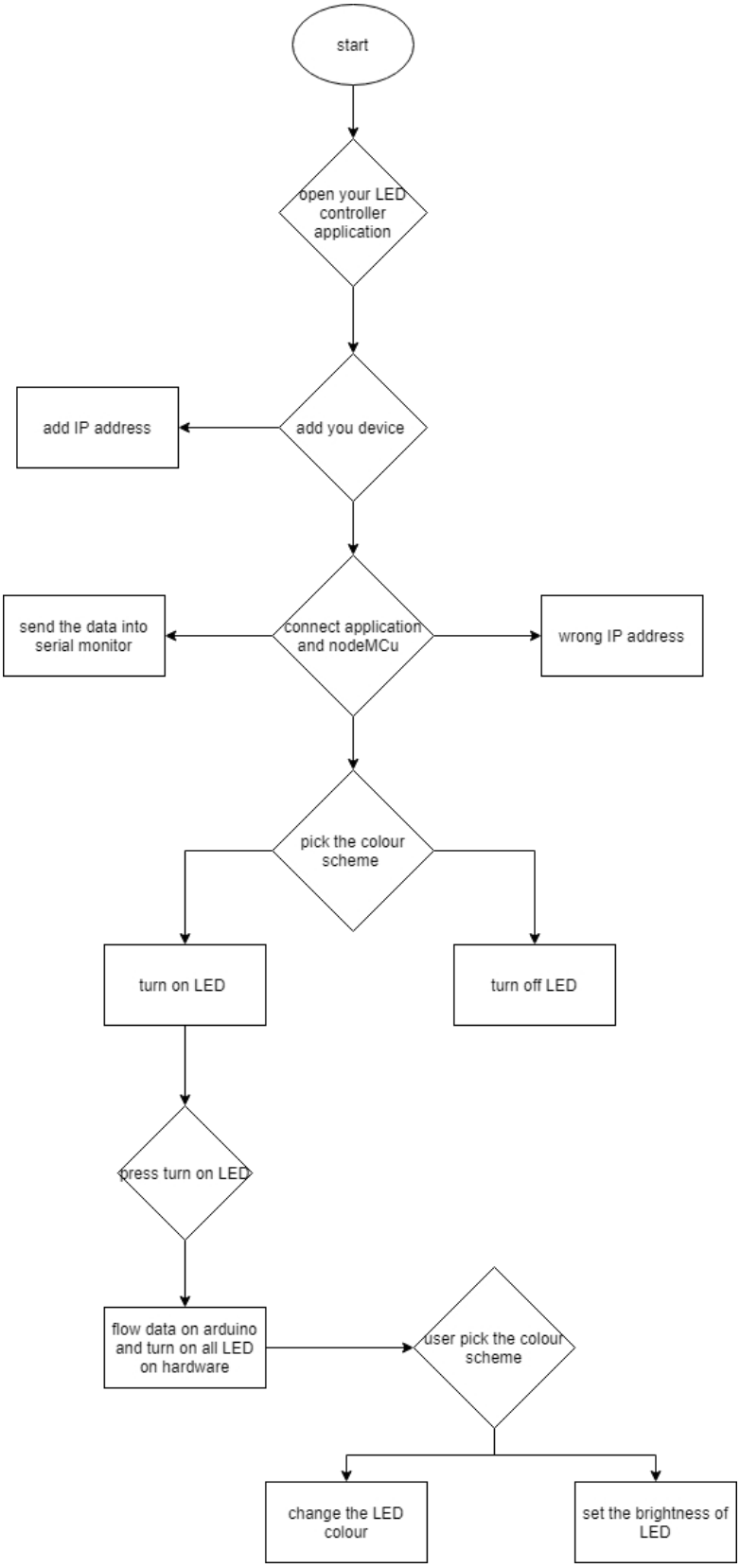
- **Back-end Design :-**

First of all install the Arduino in device then start it and connect with nodeMCU .Then run the code for blinking nodeMCU device and upload the code.if the device starts blinking in the color blue then we can say that its perfectly connected but if it doesn't start blinking then there is some error that we need to correct.In the case of uploading the code via Wi-Fi we need to write IP address and password of the Wi-Fi which is connected to your device.That particular IP address will be print on the serial monitor and we have to add same IP address as printed in the serial monitor in our device(android /IOS device).Then connect the micro processor with the ac to dc converting power supplier and check the LEDs working or not,then add pins and LED numbers in the Arduino code and check the LED base.All the LEDs will be turned on and having color White .For controlling the color and brightness we need to add RGB to the code and then upload it in the IoT device.

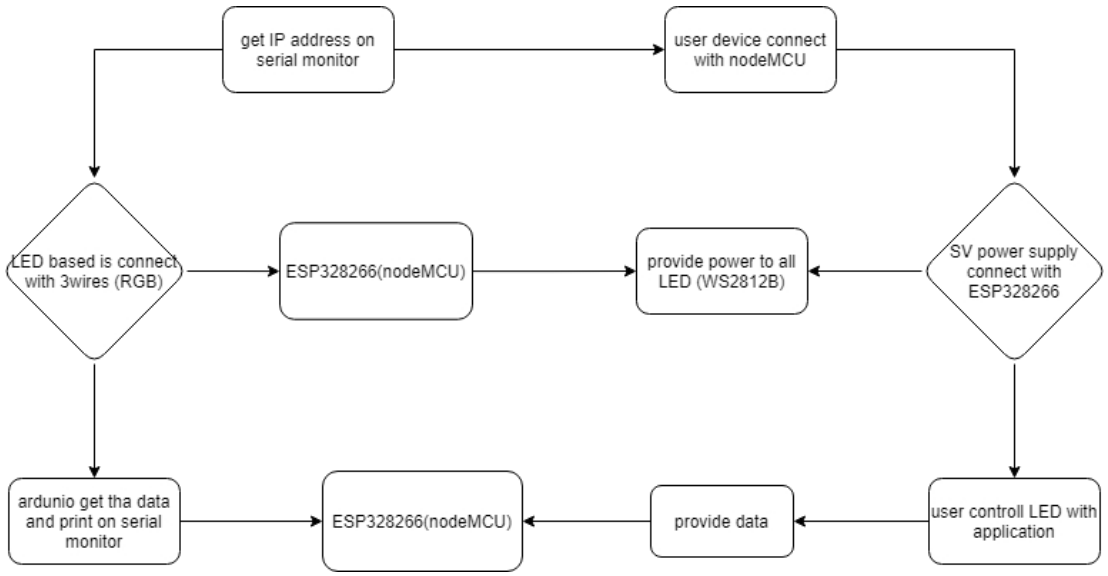
3.1 Arduino diagram



3.2 User interface diagram



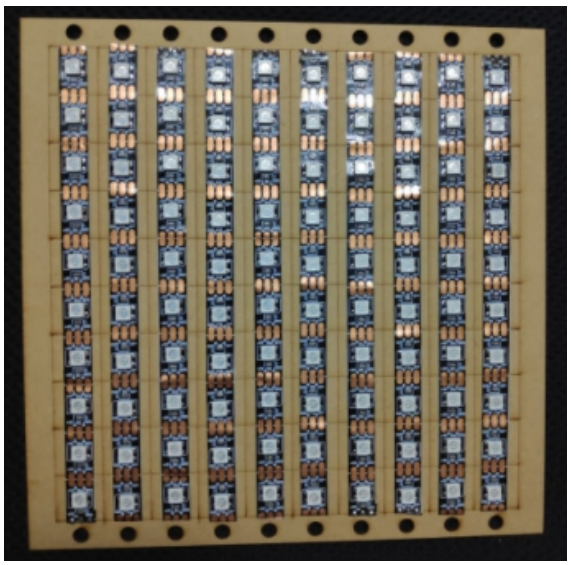
3.3 Use-case diagram



4. Testing

- **Testing devices:-**

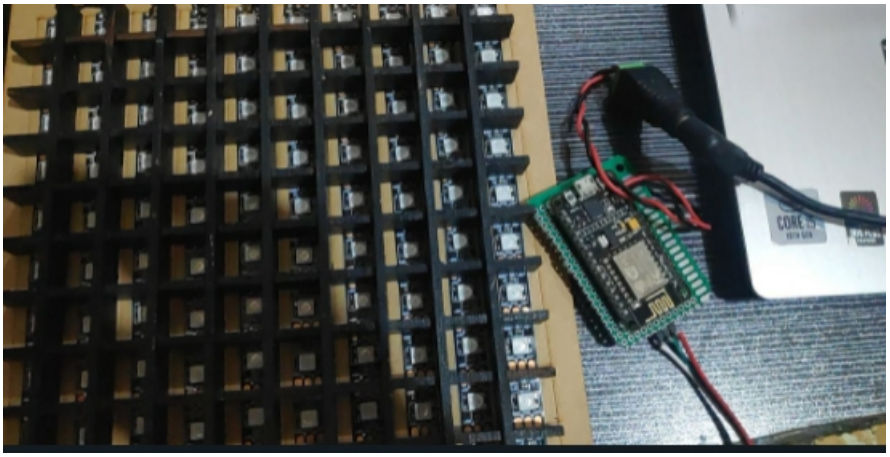
  - Addressable LEDs(WS2812b)
  - LED Wires
  - nodeMCU (ESP32)
  - USB cables(micro usb, type C)
  - Android/IOS device



LED

LED wires

nodeMCU(ESP32)



Connecting devices

Micro cable

type C cable

Android and IOS devices

4.1 Unit Testing

Testing 20 LEDs

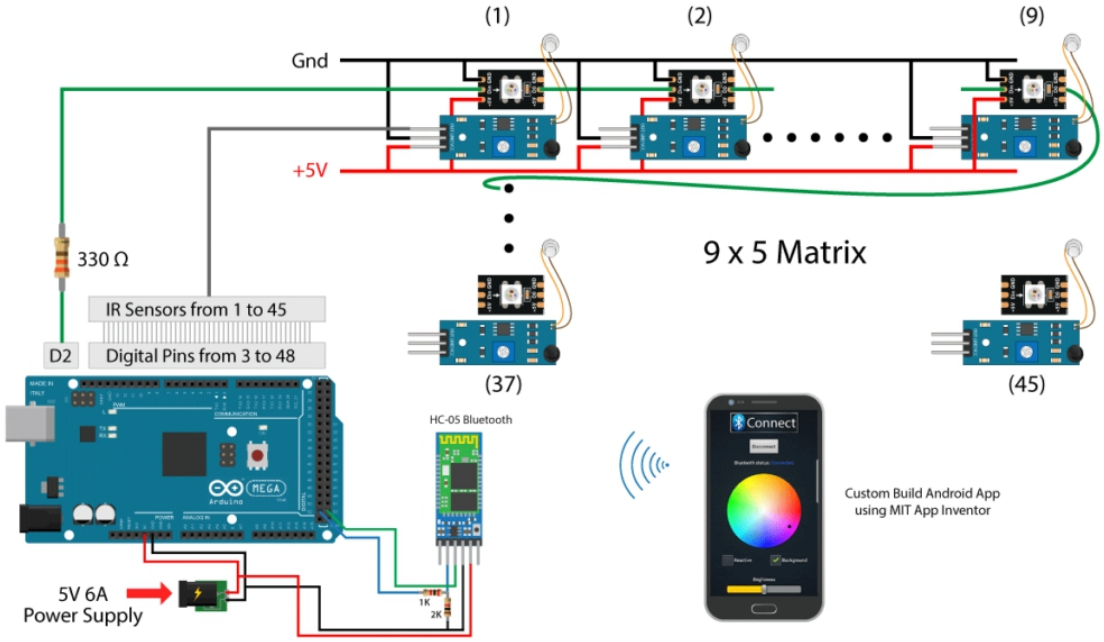
File Edit Sketch Tools Help

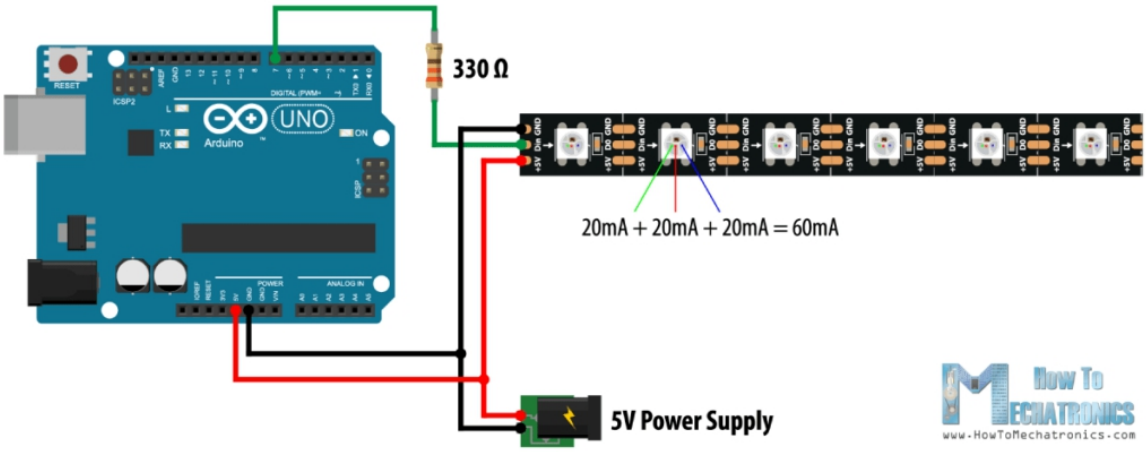
project §

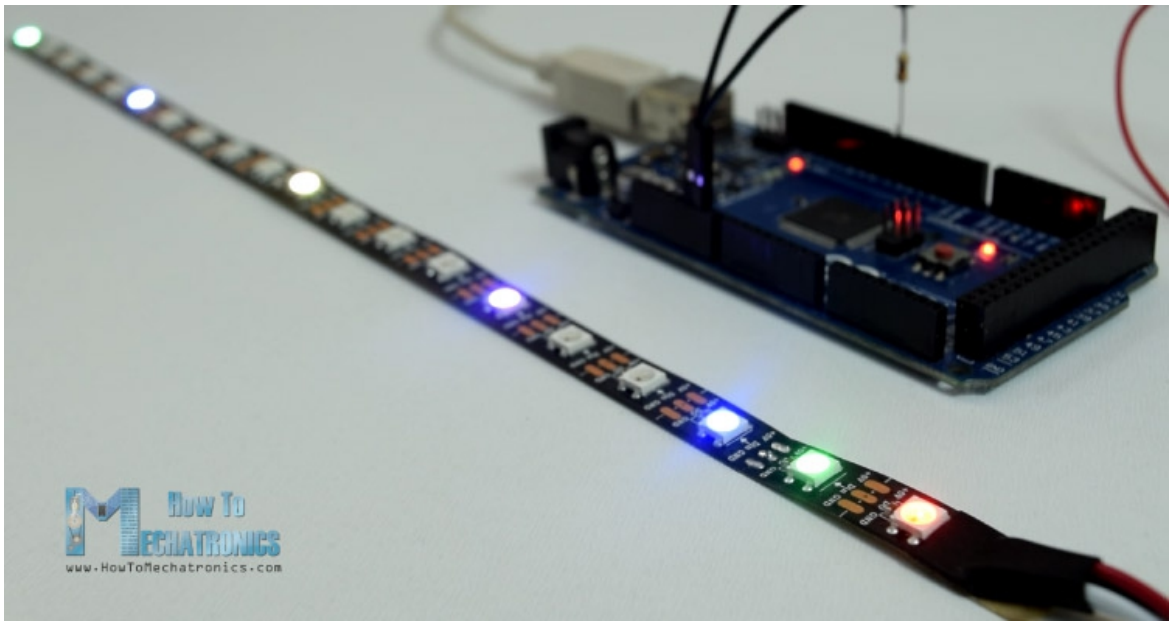
```
#include <FastLED.h>
#include <ESP8266WiFi.h>
#include <ESP8266WebServer.h>
ESP8266WebServer server(80);
void handlePulse();
void handleColour();
void handle404();

#define LED_PIN     9
#define NUM_LEDS    20
#define BRIGHTNESS  64
#define LED_TYPE    WS2812B
#define COLOR_ORDER GRB
CRGB leds[NUM_LEDS];
```

Code for testing 20 LEDs

4.2 Navigation Testing



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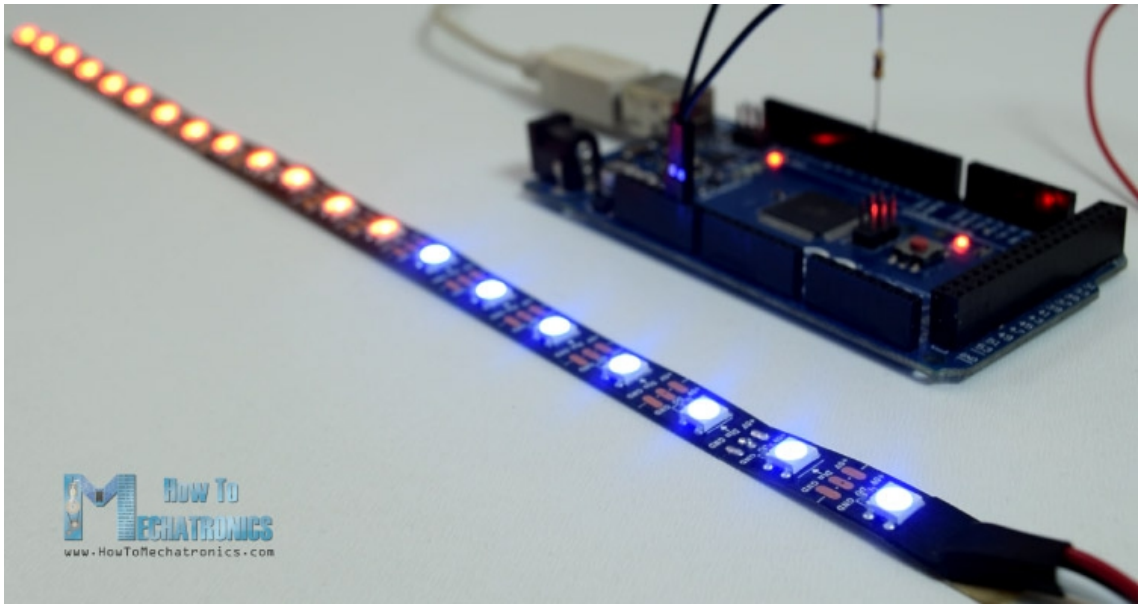
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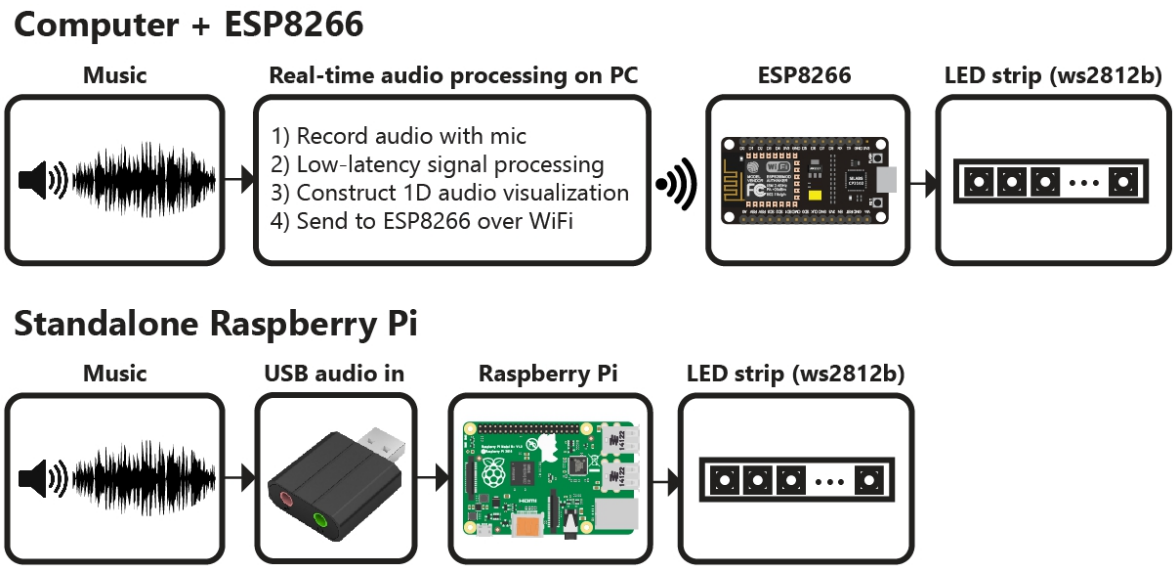
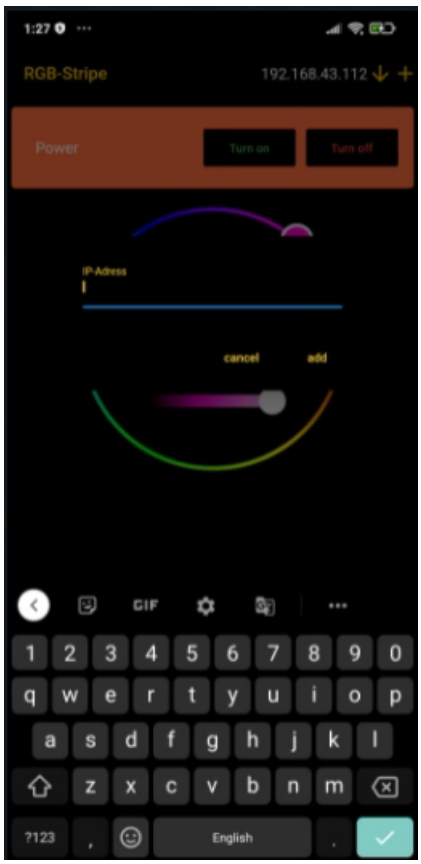
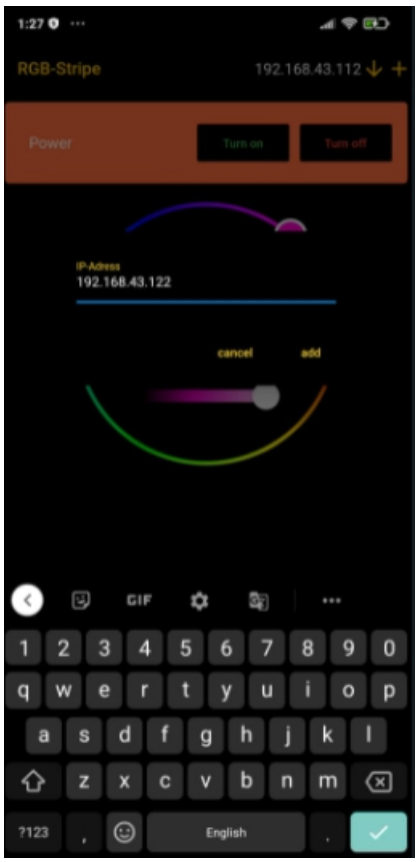
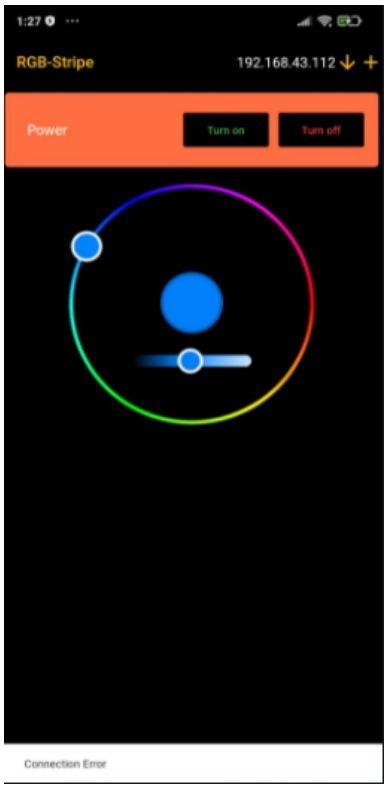
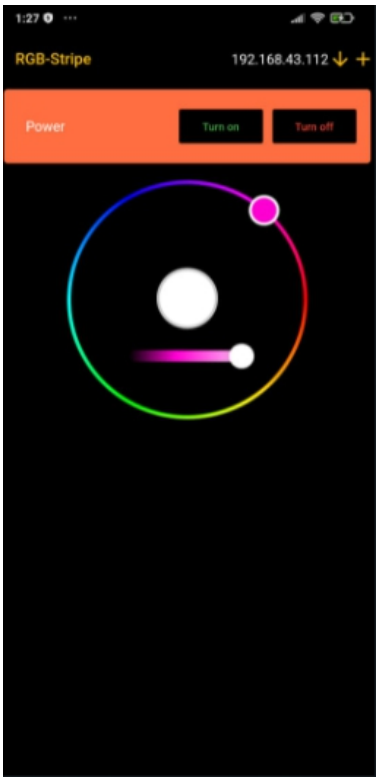

Computer + ESP8266
Music
Real-time audio processing on PC
1) Record audio with mic
2) Low-latency signal processing
3) Construct 1D audio visualization
4) Send to ESP8266 over WiFi
ESP8266
LED strip (ws2812b)
Standalone Raspberry Pi
Music
USB audio in
Raspberry Pi
LED strip (ws2812b)





Adding IP address to the android device

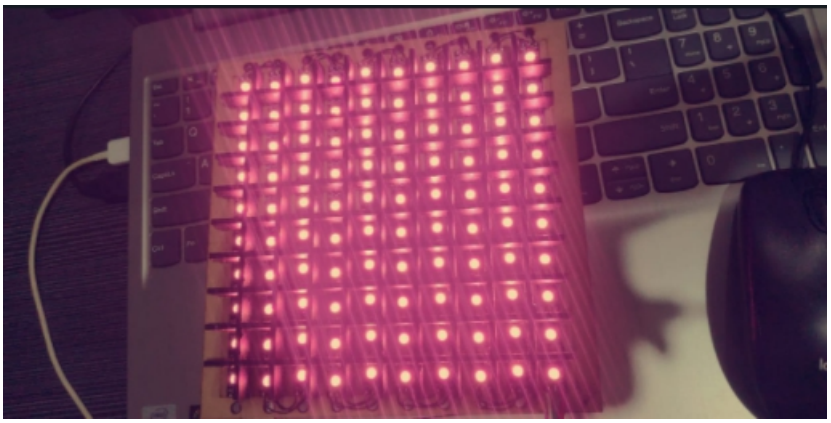


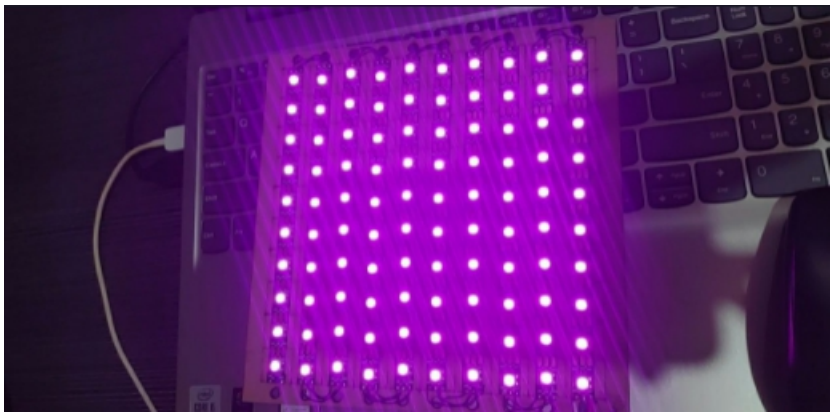


Selecting the color from color picker

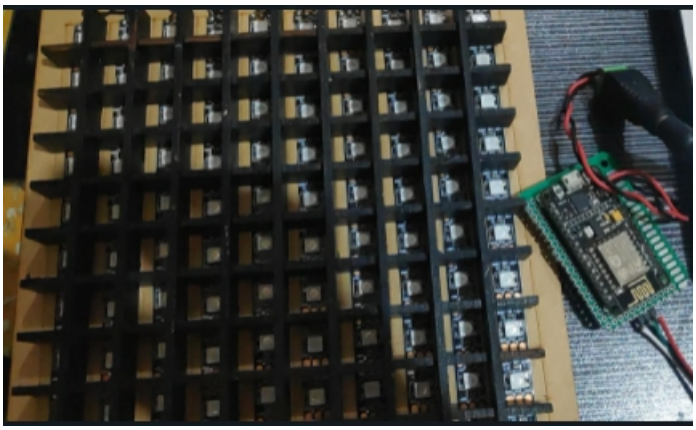
```
    return CircleColorPicker(
      initialColor: currentColor,
      onChanged: _onColorChanged,
      colorCodeBuilder: (context, color) {
        return Text(
          'rgb(${color.red}, ${color.green}, ${color.blue})',
          style: const TextStyle(
            fontSize: 24,
            fontWeight: FontWeight.bold,
            color: Colors.black,
          ),  // TextStyle
        );  // Text
      },
    );  // CircleColorPicker
  }

  void _onColorChanged(Color color) {
    setState(() => currentColor = color);
    setColor(currentColor, context, widget.selectedDevice);
  }
```

Code for color picker





Turned on LEDs



Turned off LEDs

4.3 Functional Testing

- **UI testing:-**
  - Color picker working perfect
  - Power buttons are working
  - Alert box for adding IP address is done
  - IP address are being added in the liast as we add a new one

- **Hardware Testing:-**
  - All LEds are perfectly fine
  - Power supplier is okay
  - Cables are working fine
  - ESP32 is blinking perfectly

5. Conclusion

RGB LEDs really are just *cool*. A few novel practical uses, but overall these RGB LED's are purely for fun. Many people have used them in the popular POV Clocks, and they look awesome. Other uses are for adding to enviornmental lighting. The dynamic changes available through the RGB LED means they can go well with TV's to add some dynamic enviornmental lighting.

This is to state goals were reached and so everything here was successful. The RGB LED controller worked like a dream, but like anything there is so much room for improvement it's crazy. Also we are planning to experiment more with these LEDs as it is more fun for us to play around with these and make it more inteserting and useful for decorations and parties also more presentable.

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