

Important Information

Thank you for choosing Freenove products!

Getting Started

First, please read the **Start Here.pdf** document in the unzipped folder you created.

If you have not yet downloaded the zip file, associated with this kit, please do so now and unzip it.

Get Support and Offer Input

Freenove provides free and responsive product and technical support, including but not limited to:

- Product quality issues
- Product use and build issues
- Questions regarding the technology employed in our products for learning and education
- Your input and opinions are always welcome
- We also encourage your ideas and suggestions for new products and product improvements

For any of the above, you may send us an email to:

support@freenove.com

Safety and Precautions

Please follow the following safety precautions when using or storing this product:

- Keep this product out of the reach of children under 6 years old.
- This product should be **used only when there is adult supervision present** as young children lack necessary judgment regarding safety and the consequences of product misuse.
- This product contains small parts and parts, which are sharp. This product contains electrically conductive parts. **Use caution with electrically conductive parts near or around power supplies, batteries and powered (live) circuits.**
- When the product is turned ON, activated or tested, some parts will move or rotate. **To avoid injuries to hands and fingers keep them away from any moving parts!**
- It is possible that an improperly connected or shorted circuit may cause overheating. **Should this happen, immediately disconnect the power supply or remove the batteries and do not touch anything until it cools down!** When everything is safe and cool, review the product tutorial to identify the cause.
- Only operate the product in accordance with the instructions and guidelines of this tutorial, otherwise parts may be damaged or you could be injured.
- Store the product in a cool dry place and avoid exposing the product to direct sunlight.
- After use, always turn the power OFF and remove or unplug the batteries before storing.

Any concerns?  support@freenove.com



About Freenove

Freenove provides open source electronic products and services worldwide.

Freenove is committed to assist customers in their education of robotics, programming and electronic circuits so that they may transform their creative ideas into prototypes and new and innovative products. To this end, our services include but are not limited to:

- Educational and Entertaining Project Kits for Robots, Smart Cars and Drones
- Educational Kits to Learn Robotic Software Systems for Arduino, Raspberry Pi and micro:bit
- Electronic Component Assortments, Electronic Modules and Specialized Tools
- **Product Development and Customization Services**

You can find more about Freenove and get our latest news and updates through our website:

<http://www.freenove.com>

sale@freenove.com

Copyright

All the files, materials and instructional guides provided are released under [Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Unported License](#). A copy of this license can be found in the folder containing the Tutorial and software files associated with this product.



This means you can use these resources in your own derived works, in part or completely but **NOT for the intent or purpose of commercial use.**

Freenove brand and logo are copyright of Freenove Creative Technology Co., Ltd. and cannot be used without written permission.



Contents

Important Information	1
Contents.....	1
Preface.....	3
ESP32-S3 WROOM	4
CH343 (Importance).....	6
Programming Software	18
Environment Configuration	21
Notes for GPIO.....	24
Chapter 1 LED	27
Project 1.1 Blink	27
Chapter 2 Serial Communication.....	36
Project 2.1 Serial Print.....	36
Project 2.2 Serial Read and Write	40
Chapter 3 Bluetooth.....	42
Project 3.1 Bluetooth Low Energy Data Passthrough	42
Chapter 4 Read and Write the SDcard	54
Project 4.1 SDMMC Test.....	54
Chapter 5 WiFi Working Modes.....	66
Project 5.1 Station mode	66
Project 5.2 AP mode	71
Project 5.3 AP+Station mode	76
Chapter 6 TCP/IP	80
Project 6.1 As Client	80
Project 6.2 As Server	92
Chapter 7 Camera Web Server	98
Project 7.1 Camera Web Server	98
Project 7.2 Video Web Server	107
Project 7.3 Camera and SDcard	113
Chapter 8 Camera Tcp Server.....	122
Project 8.1 Camera Tcp Server	122

Any concerns? ✉ support@freenove.com

What's next?	140
End of the Tutorial	140

Preface

ESP32-S3 is a micro control unit with integrated Wi-Fi launched by Espressif, which features strong properties and integrates rich peripherals. It can be designed and studied as an ordinary Single Chip Microcontroller(SCM) chip, or connected to the Internet and used as an Internet of Things device.

ESP32-S3 can be developed using the Arduino platform, which will definitely make it easier for people who have learned Arduino to master. Moreover, the code of ESP32-S3 is completely open-source, so beginners can quickly learn how to develop and design IOT smart household products including smart curtains, fans, lamps and clocks.

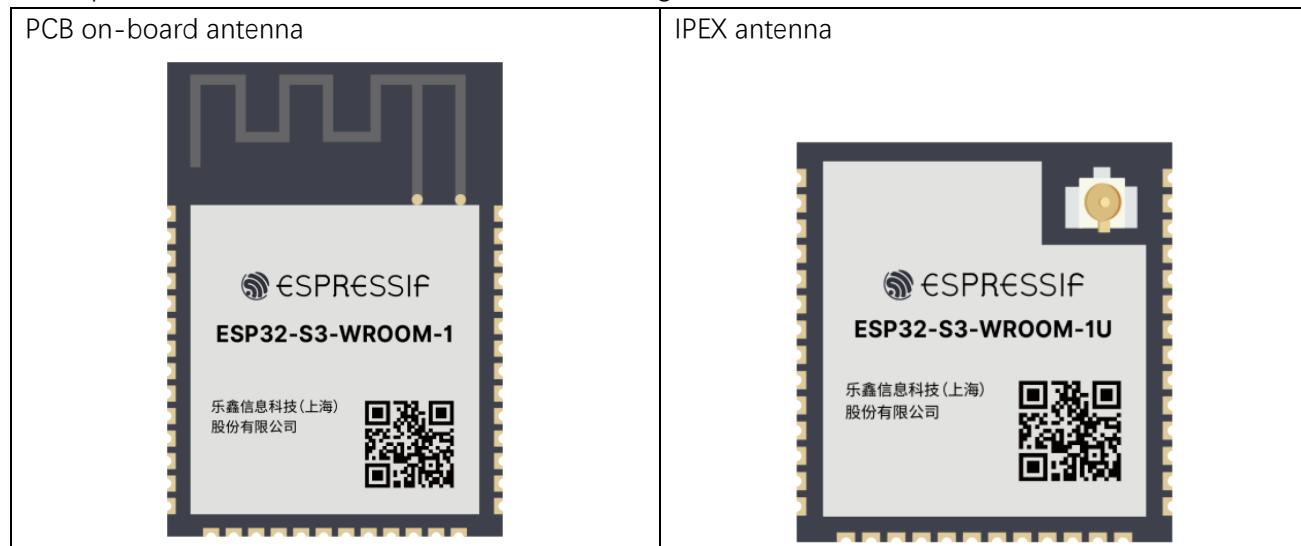
Generally, ESP32-S3 projects consist of code and circuits. Don't worry even if you've never learned code and circuits, because we will gradually introduce the basic knowledge of C programming language and electronic circuits, from easy to difficult. Our products contain all the electronic components and modules needed to complete these projects. It's especially suitable for beginners.

We divide each project into four parts, namely Component List, Component Knowledge, Circuit and Code. Component List helps you to prepare material for the experiment more quickly. Component Knowledge allows you to quickly understand new electronic modules or components, while Circuit helps you understand the operating principle of the circuit. And Code allows you to easily master the use of SEP32 and accessory kit. After finishing all the projects in this tutorial, you can also use these components and modules to make products such as smart household, smart cars and robots to transform your creative ideas into prototypes and new and innovative products.

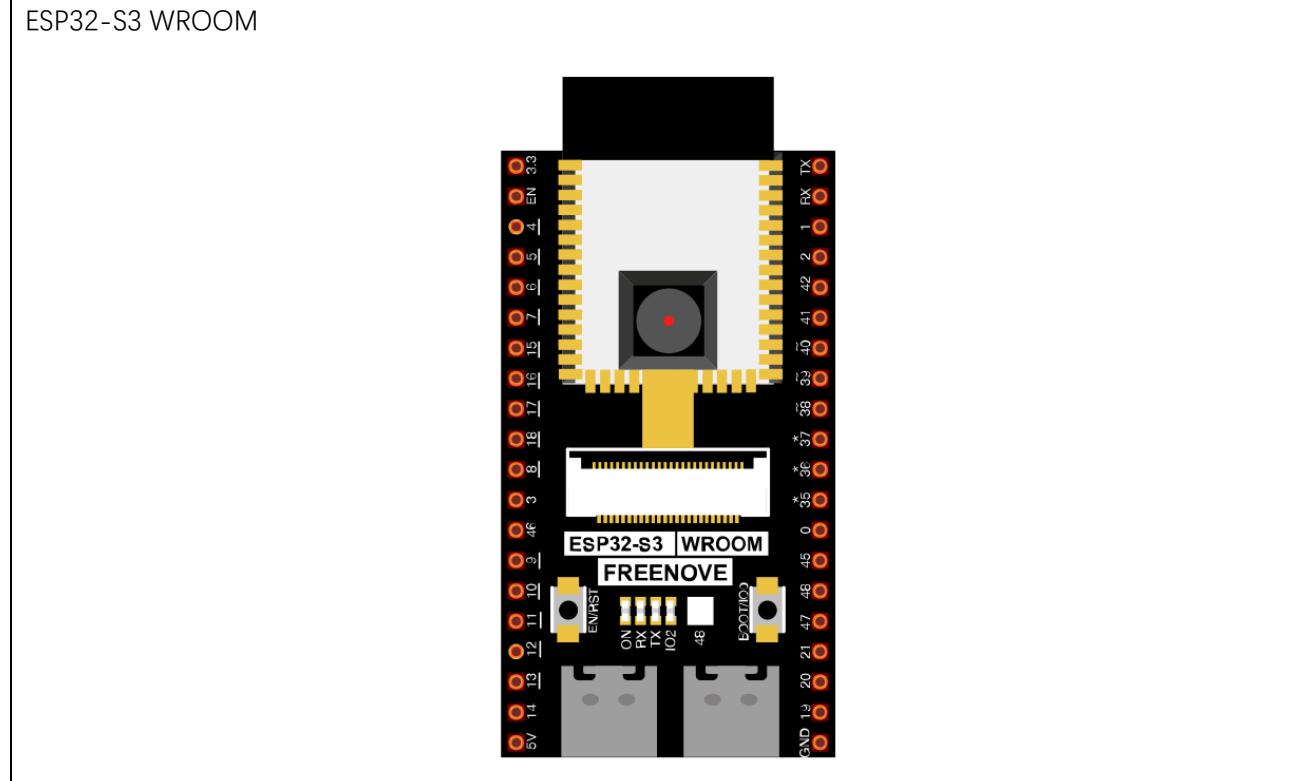
In addition, if you have any difficulties or questions with this tutorial or toolkit, feel free to ask for our quick and free technical support through support@freenove.com

ESP32-S3 WROOM

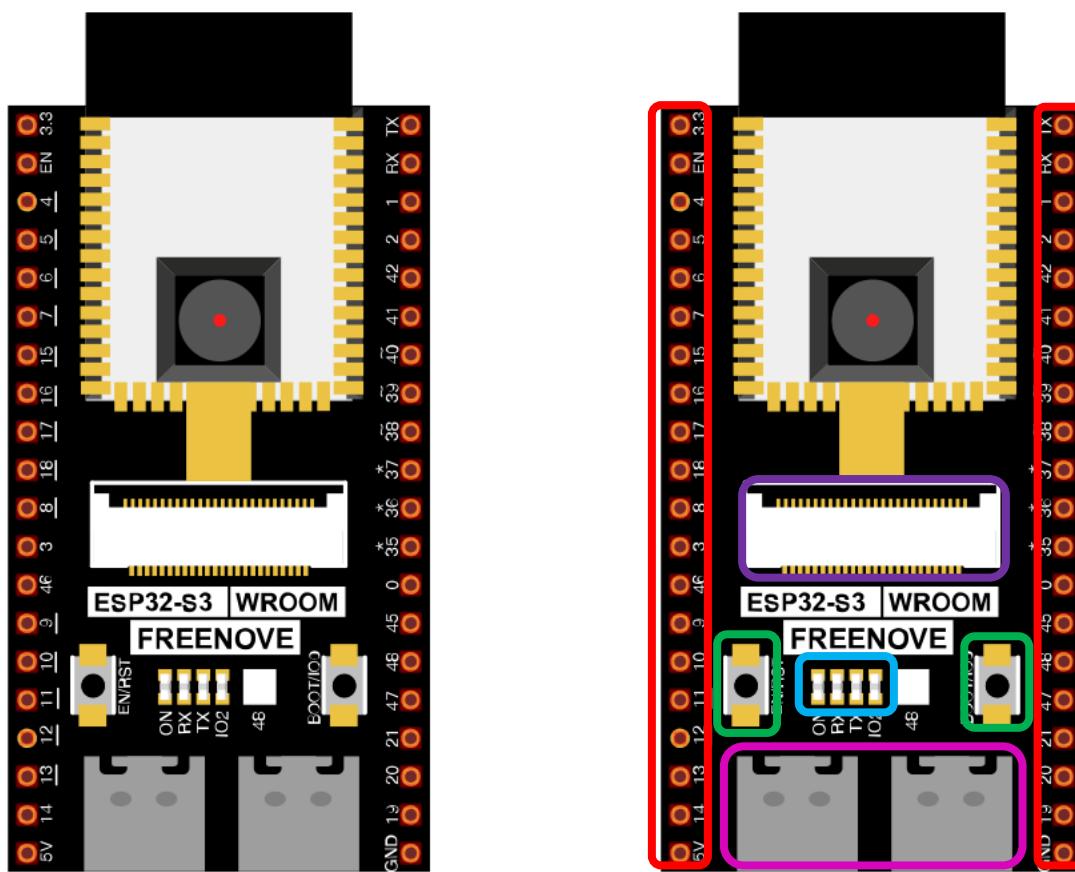
ESP32-S3-WROOM-1 has launched a total of two antenna packages, PCB on-board antenna and IPEX antenna respectively. The PCB on-board antenna is an integrated antenna in the chip module itself, so it is convenient to carry and design. The IPEX antenna is a metal antenna derived from the integrated antenna of the chip module itself, which is used to enhance the signal of the module.



In this tutorial, the ESP32-S3 WROOM is designed based on the PCB on-board antenna-packaged ESP32-S3-WROOM-1 module.



The hardware interfaces of ESP32-S3 WROOM are distributed as follows:



Compare the left and right images. We've boxed off the resources on the ESP32-S3 WROOM in different colors to facilitate your understanding of the ESP32-S3 WROOM.

Box color	Corresponding resources introduction
Red	GPIO pin
Cyan	LED indicator
Purple	Camera interface
Green	Reset button, Boot mode selection button
Magenta	USB port

For more information, please visit: https://www.espressif.com.cn/sites/default/files/documentation/esp32-s3-wroom-1_wroom-1u_datasheet_en.pdf.



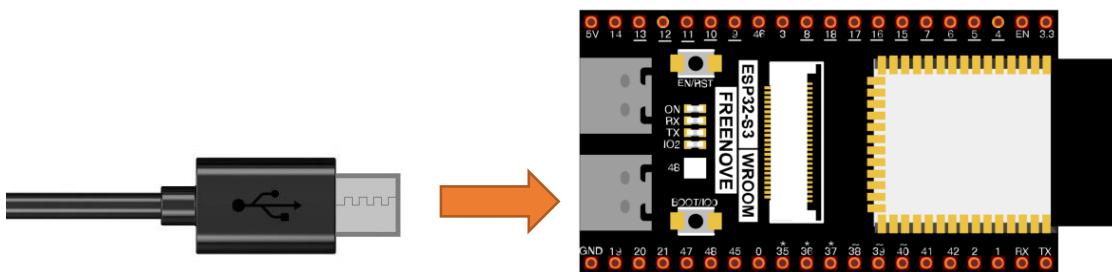
CH343 (Importance)

ESP32-S3 WROOM uses CH343 to download codes. So before using it, we need to install CH343 driver in our computers.

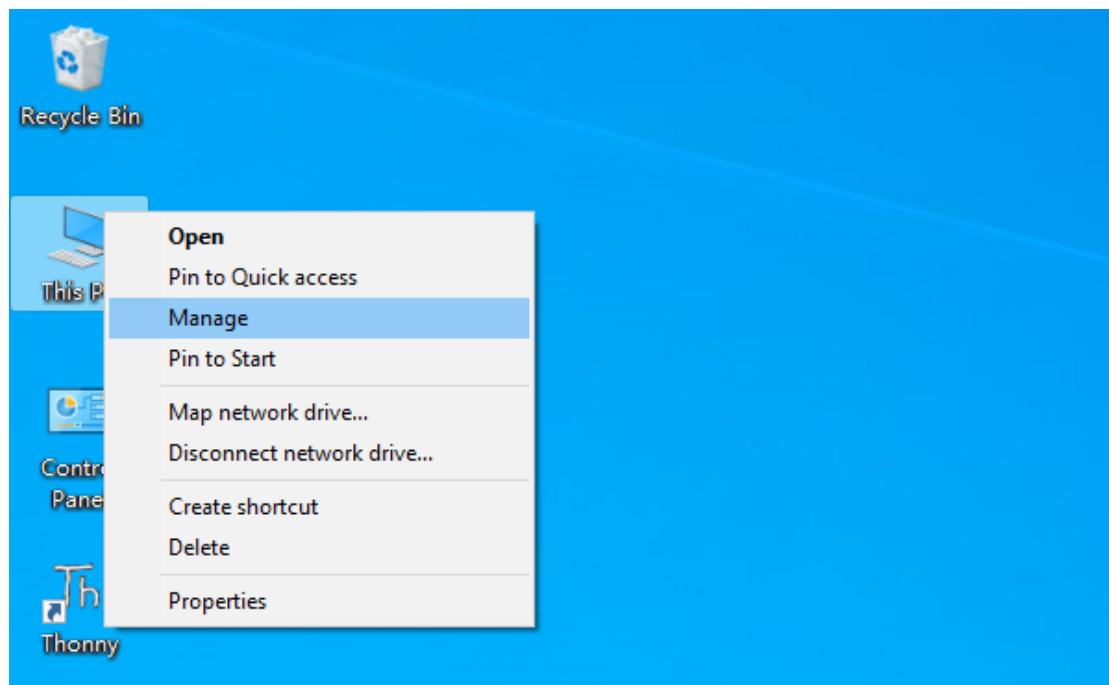
Windows

Check whether CH343 has been installed

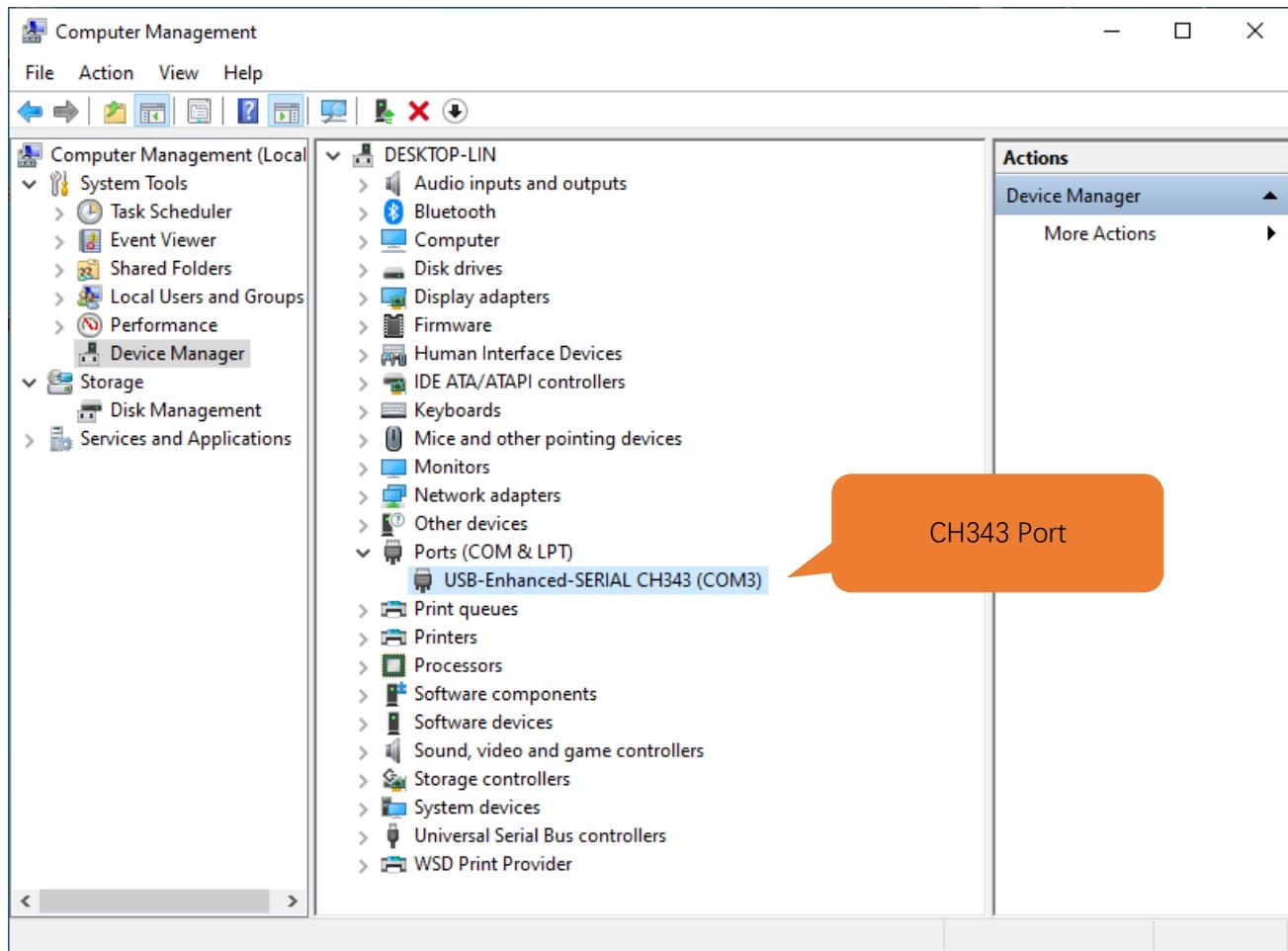
1. Connect your computer and ESP32-S3 WROOM with a USB cable.



2. Turn to the main interface of your computer, select "This PC" and right-click to select "Manage".



3. Click "Device Manager". If your computer has installed CH343, you can see "USB-Enhanced-SERIAL CH343 (COMx)". And you can click [here](#) to move to the next step.



Installing CH343

1. First, download CH343 driver, click <http://www.wch-ic.com/search?t=all&q=ch343> to download the appropriate one based on your operating system.

keyword ch343

Downloads(8)

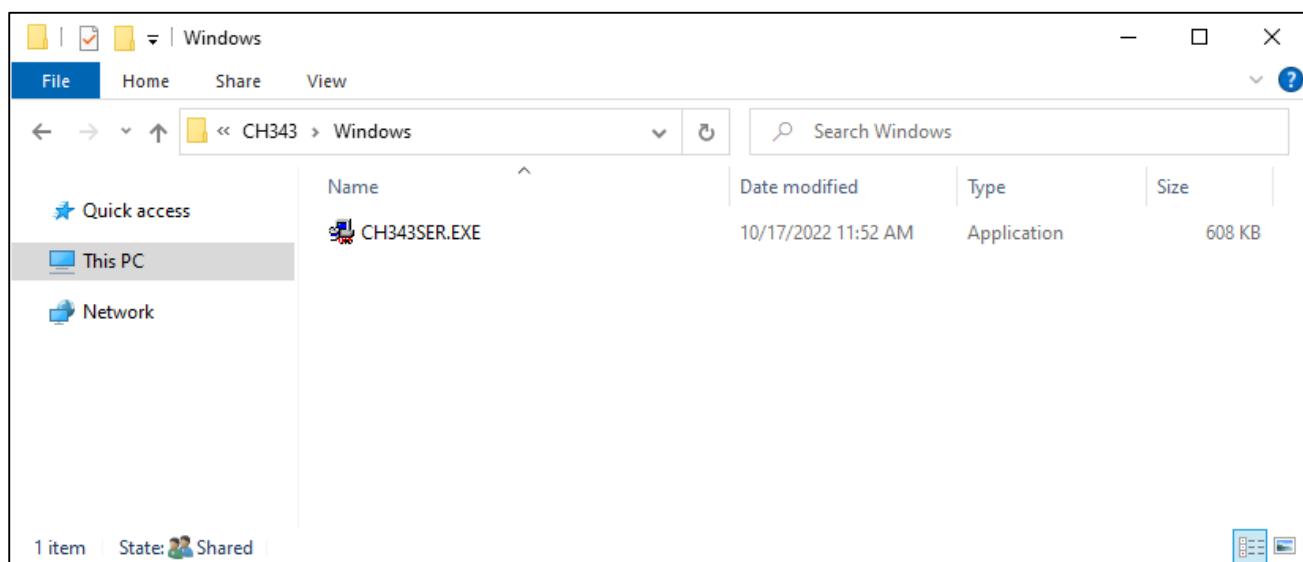
file category	file content	version	upload time
DataSheet			
CH343DS1.PDF	CH343 datasheet, USB to single serial port, supports up to 6M baud rate, serial port signals support 5V/3.3V/2.5V/1.8V, built-in crystal oscillator. CH343 supports built-in CDC driver in operating system or multi-functional high-speed VCP manufacture driver.	1.5	2021-11-18
Driver&Tools			
CH343SER.ZIP	For CH342/CH343/CH344/CH347/CH9101/CH9102/CH9103/CH9143, USB to high-speed serial port VCP vendor driver, supports Windows 11/10/8.1/8/7/VISTA/XP/2000	1.61	2022-05-13
CH343CDC.ZIP	For CH342/CH343/CH344/CH347/CH910X/CH9143/CH9340, USB to CDC serial port driver, supports Windows 11/10/8.1/8/7/VISTA/XP/2000	1.4	2022-05-13
CH343SER.EXE	For CH342/CH343/CH344/CH347/CH9101/CH9102/CH9103/CH9143, USB to high-speed serial port VCP vendor driver, supports Windows 11/10/8.1/8/7/VISTA/XP/2000	1.61	2022-05-13
CH34XSER_MAC.ZIP	For MAC, CH343/CH344/CH347/CH9101/CH9102/CH9103/CH9143, USB to serial port VCP vendor driver of macOS	1.7	2022-05-13
CH343CDC.EXE	For CH342/CH343/CH344/CH347/CH910X/CH9143/CH9340, USB to CDC serial port driver, supports Windows 11/10/8.1/8/7/VISTA/XP/2000	1.4	2022-05-13
Application			
CH34xSerCfg.ZIP	USB configuration tool of Windows for CH340/CH342/CH343/CH344/CH347/CH348/CH9101/CH9102/CH9103. Via this tool, the chip's Vendor ID, product ID, maximum current value, BCD version	1.2	2022-05-24

If you would not like to download the installation package, you can open

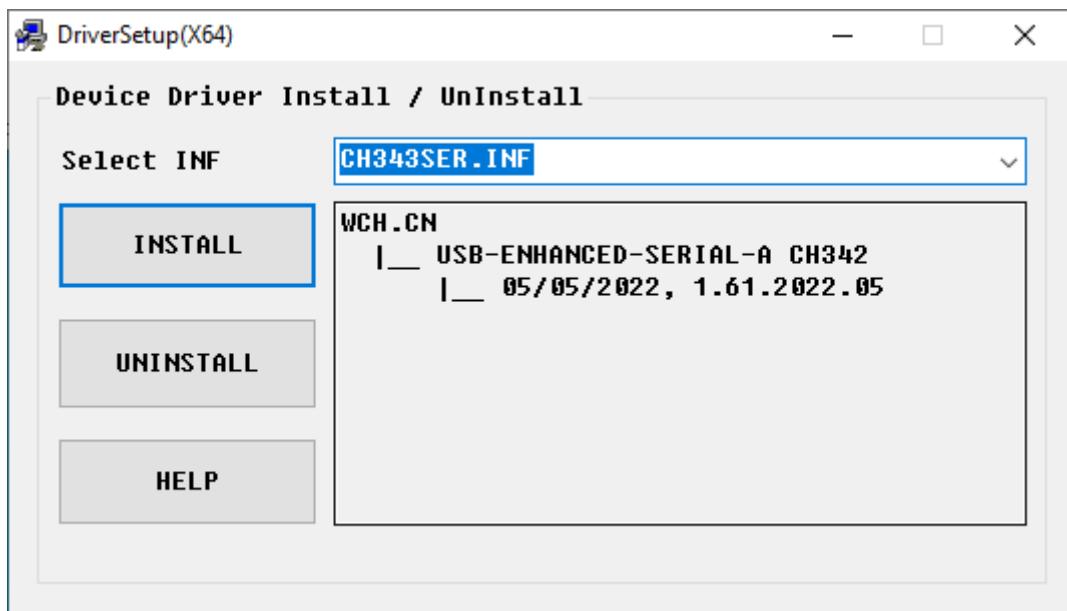
[“Freenove_ESP32_S3_WROVER_Board/CH343”](#), we have prepared the installation package.

 Linux	10/17/2022 1:30 PM	File folder
 MAC	10/17/2022 1:30 PM	File folder
 Windows	10/17/2022 1:30 PM	File folder

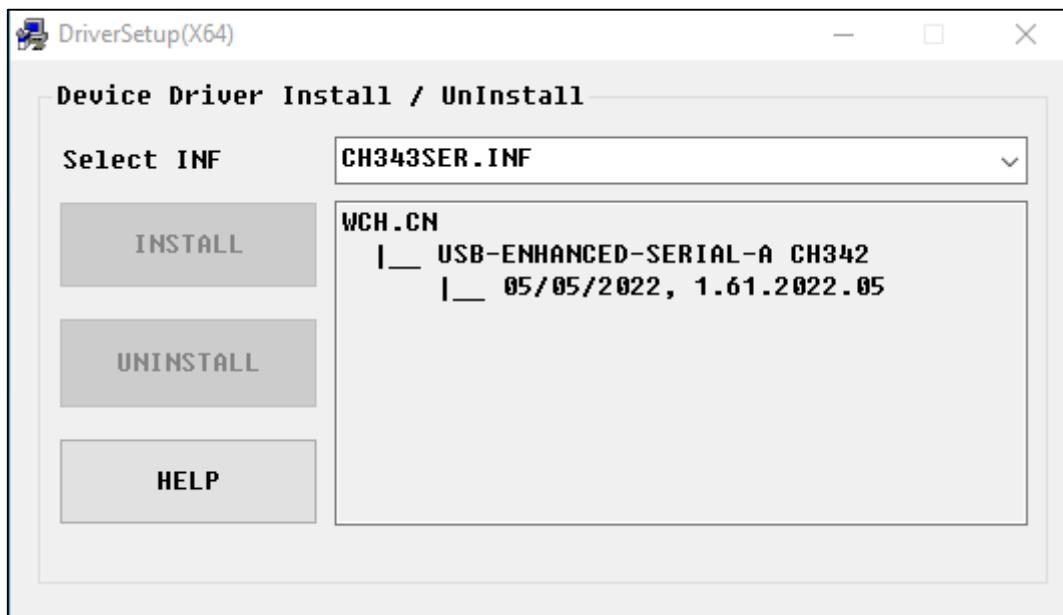
2. Open the folder “Freenove_ESP32_S3_WROVER_Board/CH343/Windows/”



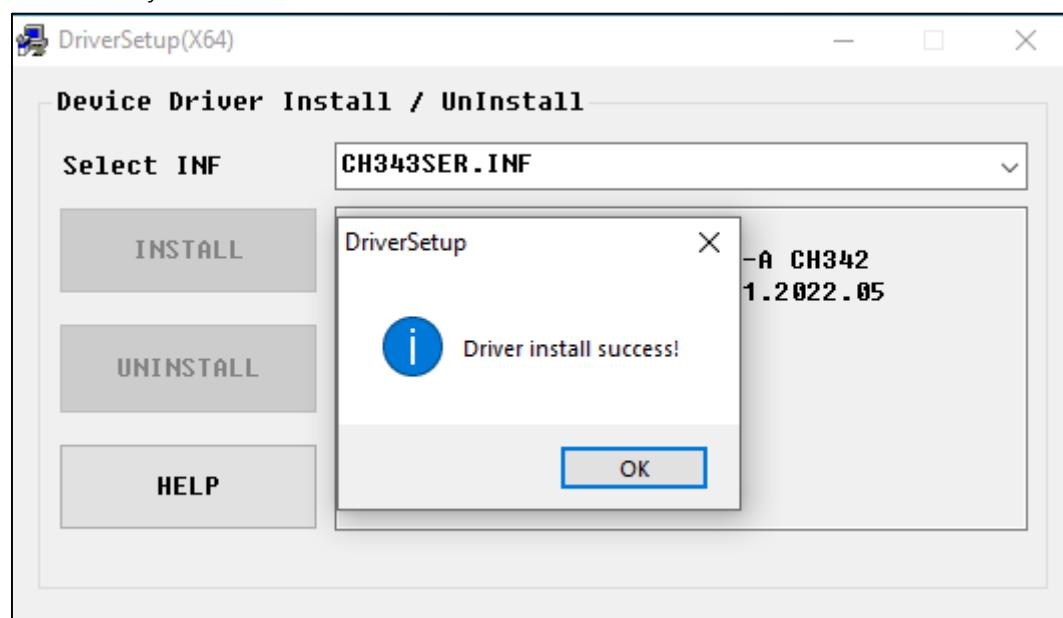
3. Double click “CH343SER.EXE”.



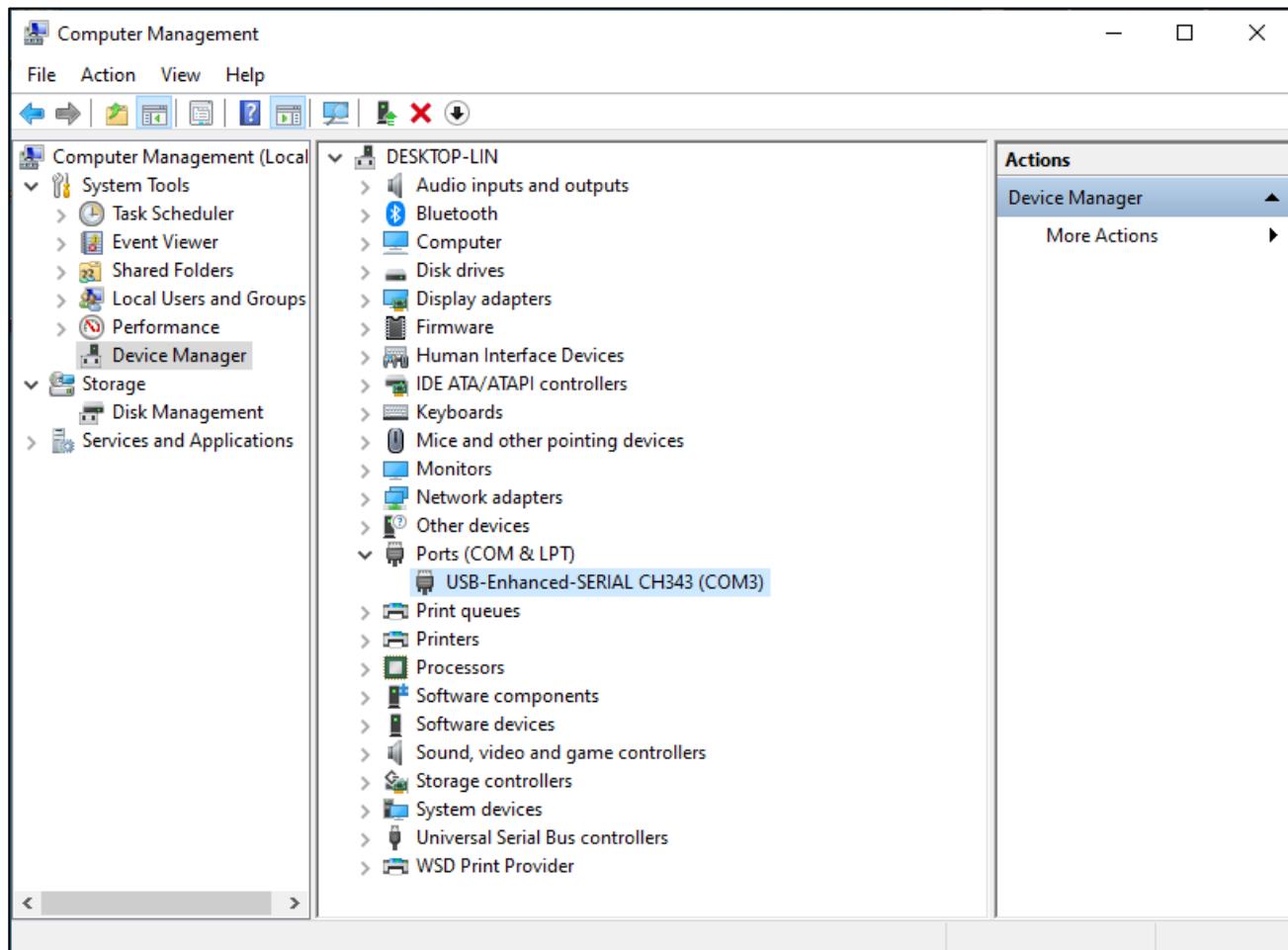
4. Click “INSTALL” and wait for the installation to complete.



5. Install successfully. Close all interfaces.



6. When ESP32-S3 WROOM is connected to computer, select “This PC”, right-click to select “Manage” and click “Device Manager” in the newly pop-up dialog box, and you can see the following interface.



7. So far, CH343 has been installed successfully. Close all dialog boxes.

MAC

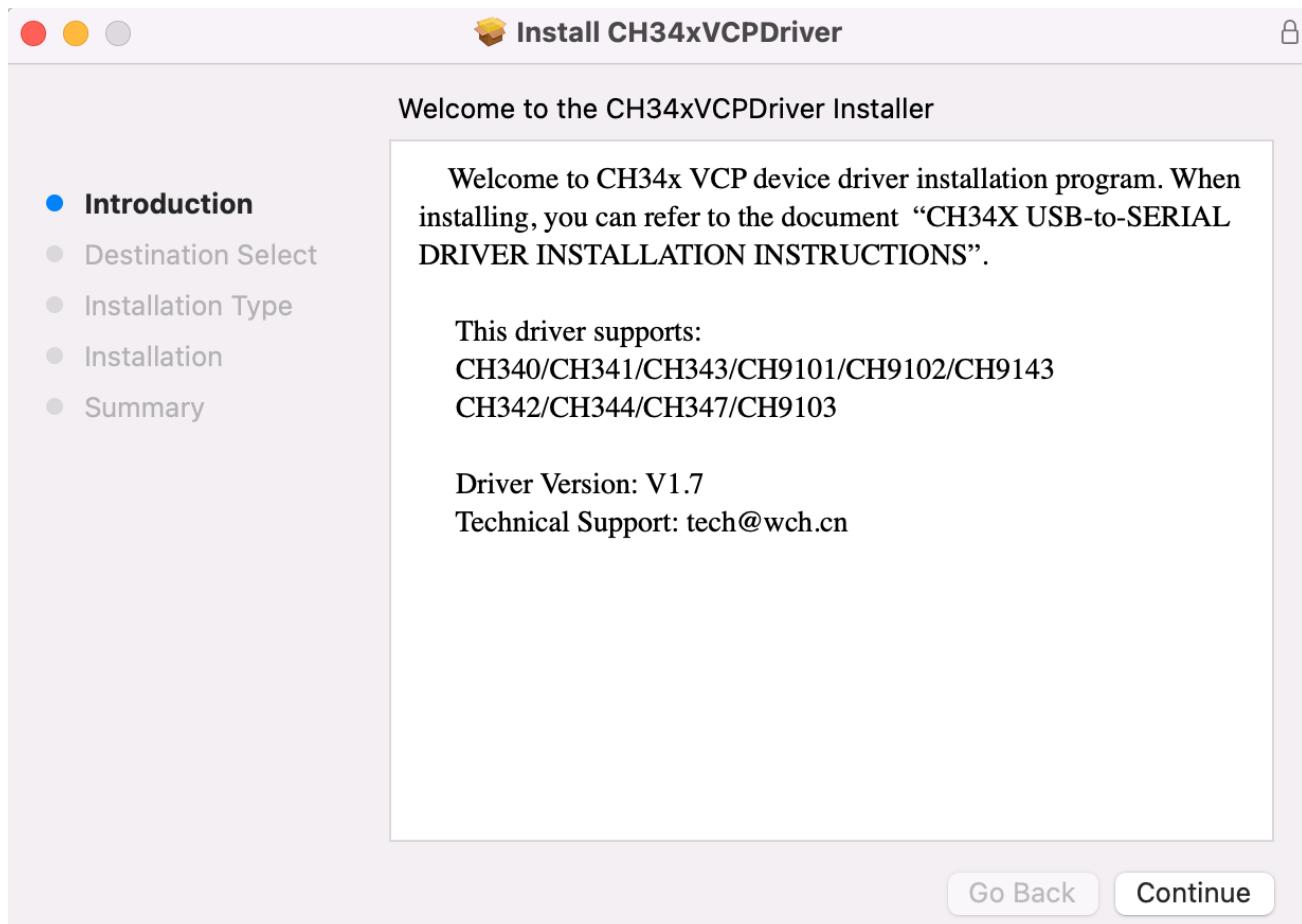
First, download CH343 driver, click <http://www.wch-ic.com/search?t=all&q=ch343> to download the appropriate one based on your operating system.

keyword ch343				
Downloads(8)				
file category	file content	version	upload time	
DataSheet				
CH343DS1.PDF	CH343 datasheet, USB to single serial port, supports up to 6M baud rate, serial port signals support 5V/3.3V/2.5V/1.8V, built-in crystal oscillator. CH343 supports built-in CDC driver in operating system or multi-functional high-speed VCP manufacture driver.	1.5	2021-11-18	
Driver&Tools				
CH343SER.ZIP	For CH342/CH343/CH344/CH347/CH9101/CH9102/CH9103/CH9143, USB to high-speed serial port VCP vendor driver, supports Windows 11/10/8.1/8/7/VISTA/XP/2000	1.61	2022-05-13	
CH343CDC.ZIP	For CH342/CH343/CH344/CH347/CH910X/CH9143/CH9340, USB to CDC serial port driver, supports Windows 11/10/8.1/8/7/VISTA/XP/2000	1.4	2022-05-13	
CH343SER.EXE	For CH342/CH343/CH344/CH347/CH9101/CH9102/CH9103/CH9143, USB to high-speed serial port VCP vendor driver, supports Windows 11/10/8.1/8/7/VISTA/XP/2000	1.61	2022-05-13	
CH34XSER_MAC.ZI...	For MAC, CH342/CH343/CH344/CH347/CH9101/CH9102/CH9103/CH9143, USB to serial port VCP vendor driver of macOS	1.7	2022-05-13	
CH343CDC.EXE	For CH342/CH343/CH344/CH347/CH910X/CH9143/CH9340, USB to CDC serial port driver, supports Windows 11/10/8.1/8/7/VISTA/XP/2000	1.4	2022-05-13	
Application				
CH34xSerCfg.ZIP	USB configuration tool of Windows for CH340/CH342/CH343/CH344/CH347/CH348/CH9101/CH9102/CH9103. Via this tool, the chip's Vendor ID, product ID, maximum current value, BCD version	1.2	2022-05-24	

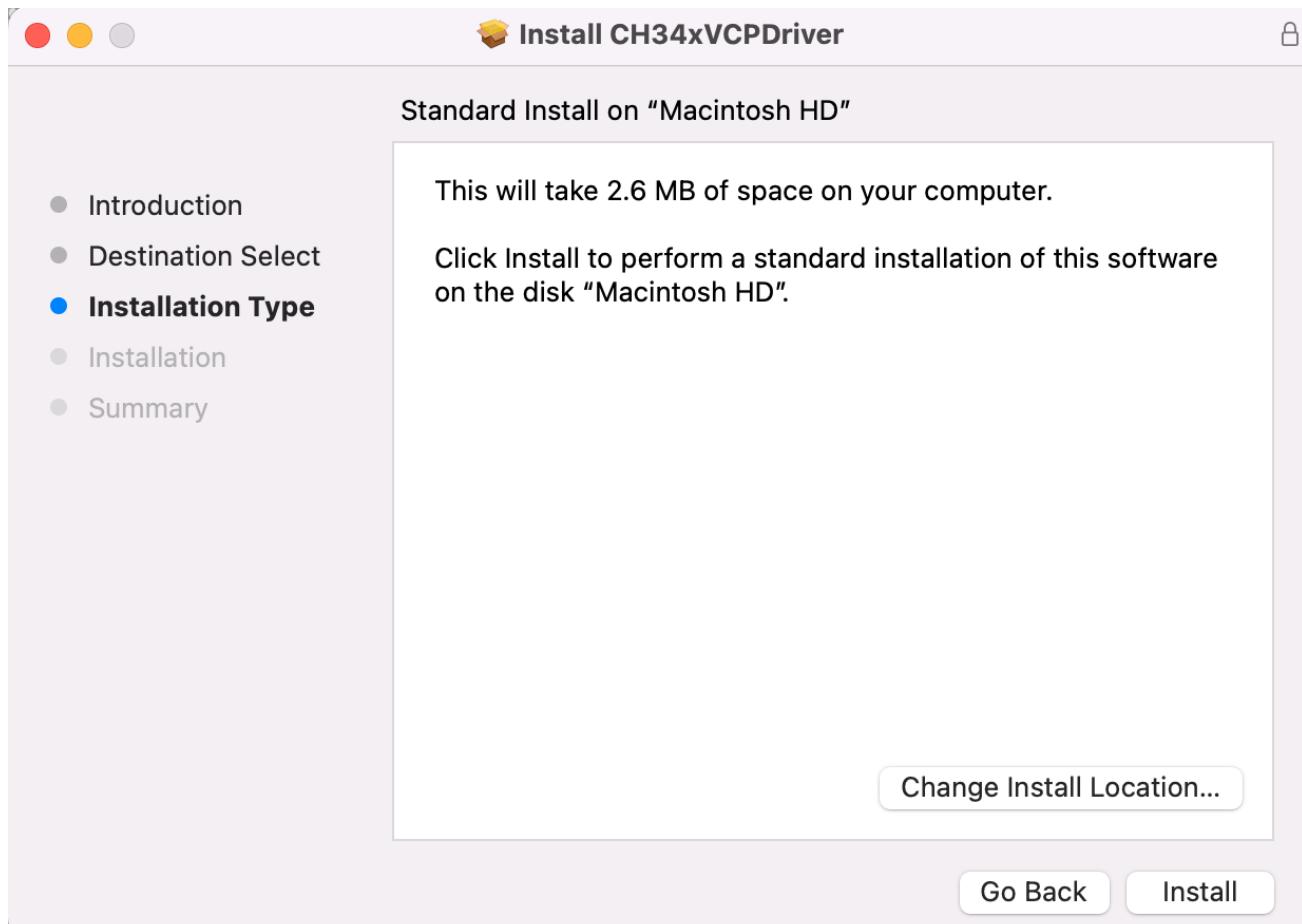
If you would not like to download the installation package, you can open “Freenove_ESP32_S3_WROVER_Board/CH343”, we have prepared the installation package. Second, open the folder “Freenove_ESP32_S3_WROVER_Board/CH343/MAC/”



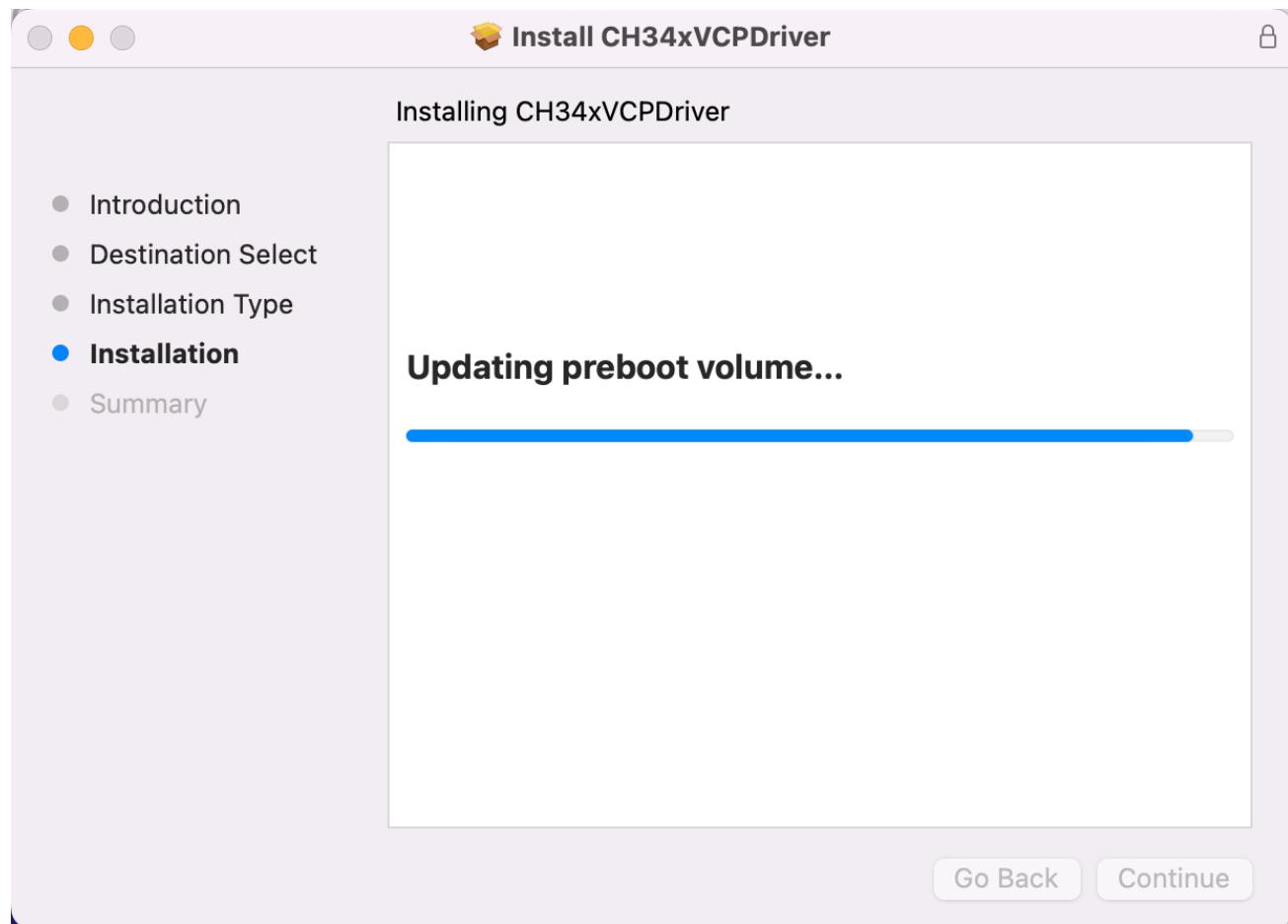
Third, click Continue.



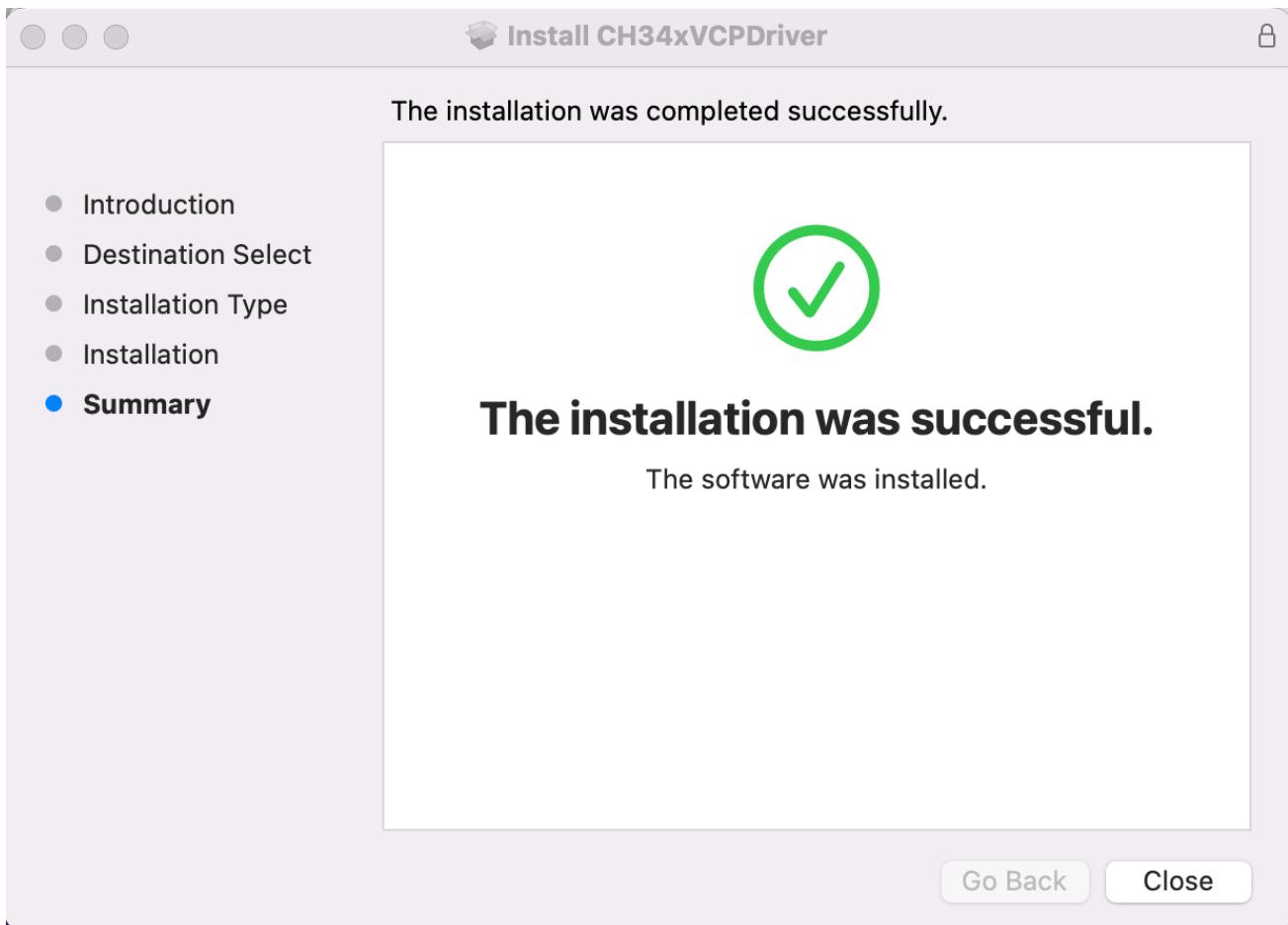
Fourth, click Install.



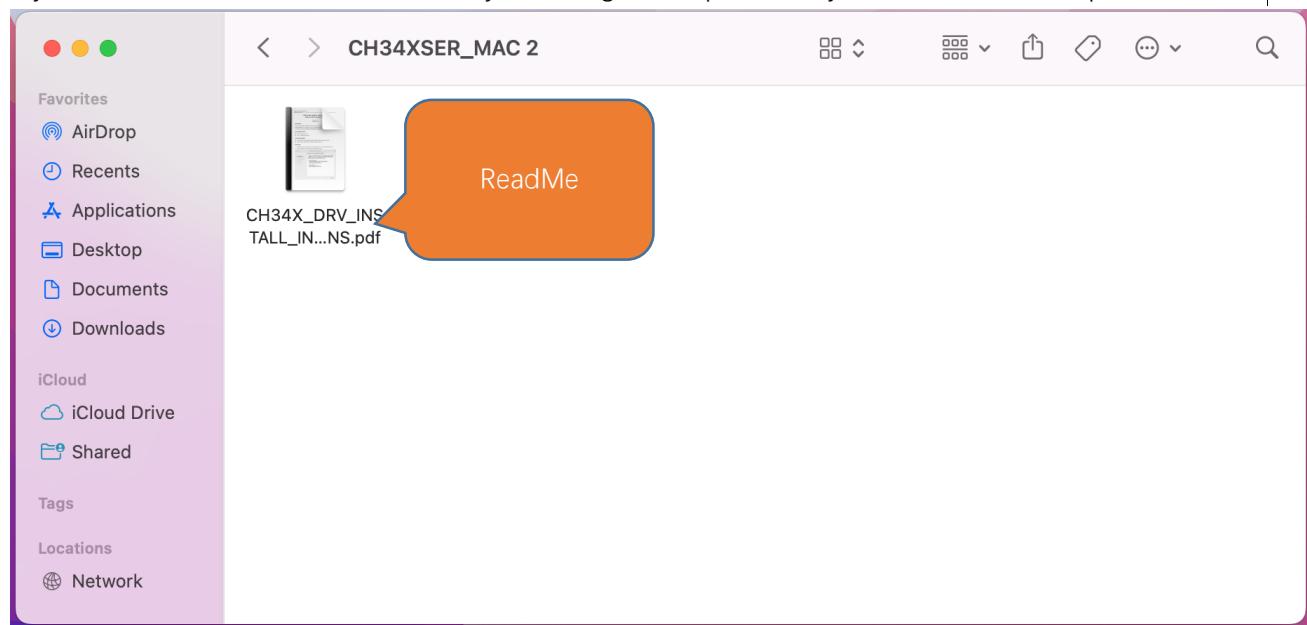
Then, waiting Fins.



Finally, restart your PC.



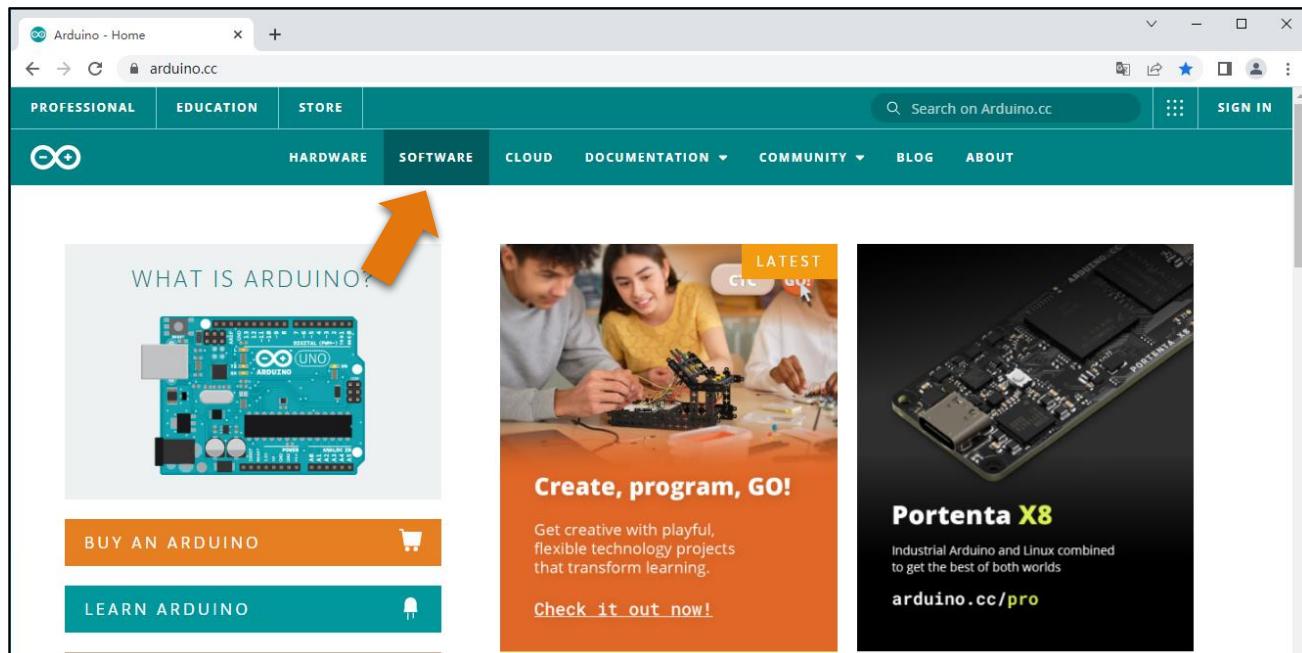
If you still haven't installed the CH340 by following the steps above, you can view `readme.pdf` to install it.



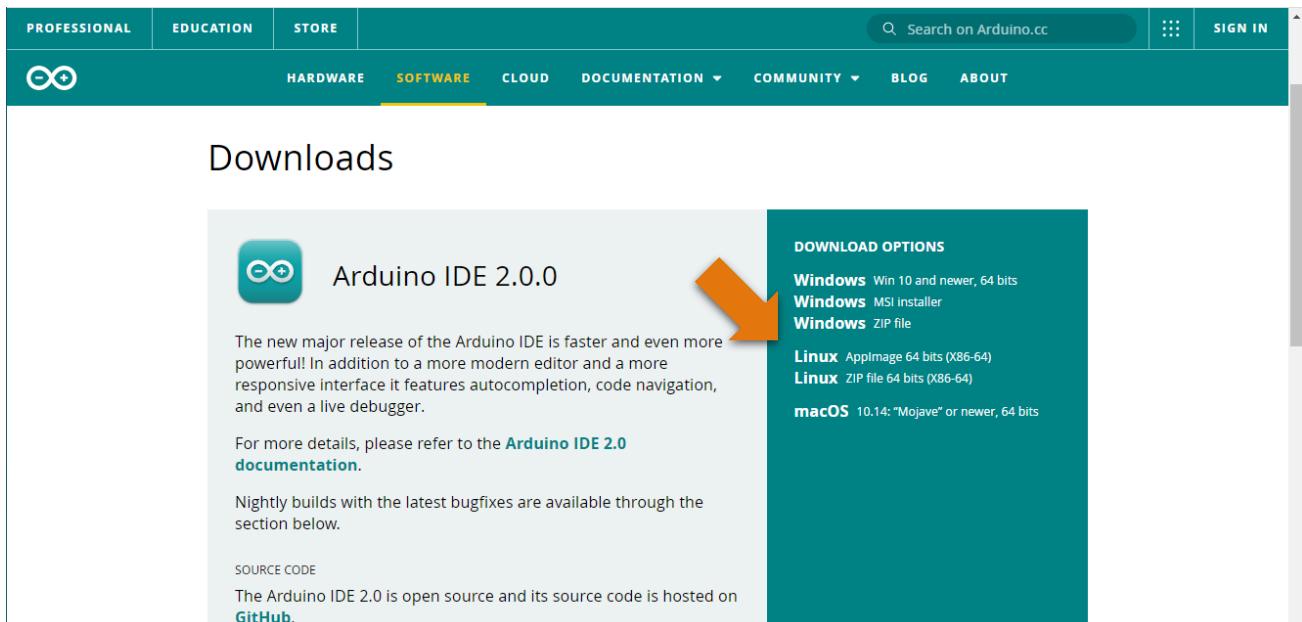
Programming Software

Arduino Software (IDE) is used to write and upload the code for Arduino Board.

First, install Arduino Software (IDE): visit <https://www.arduino.cc>, click "Download" to enter the download page.



Select and download corresponding installer according to your operating system. If you are a windows user, please select the "Windows Installer" to download to install the driver correctly.



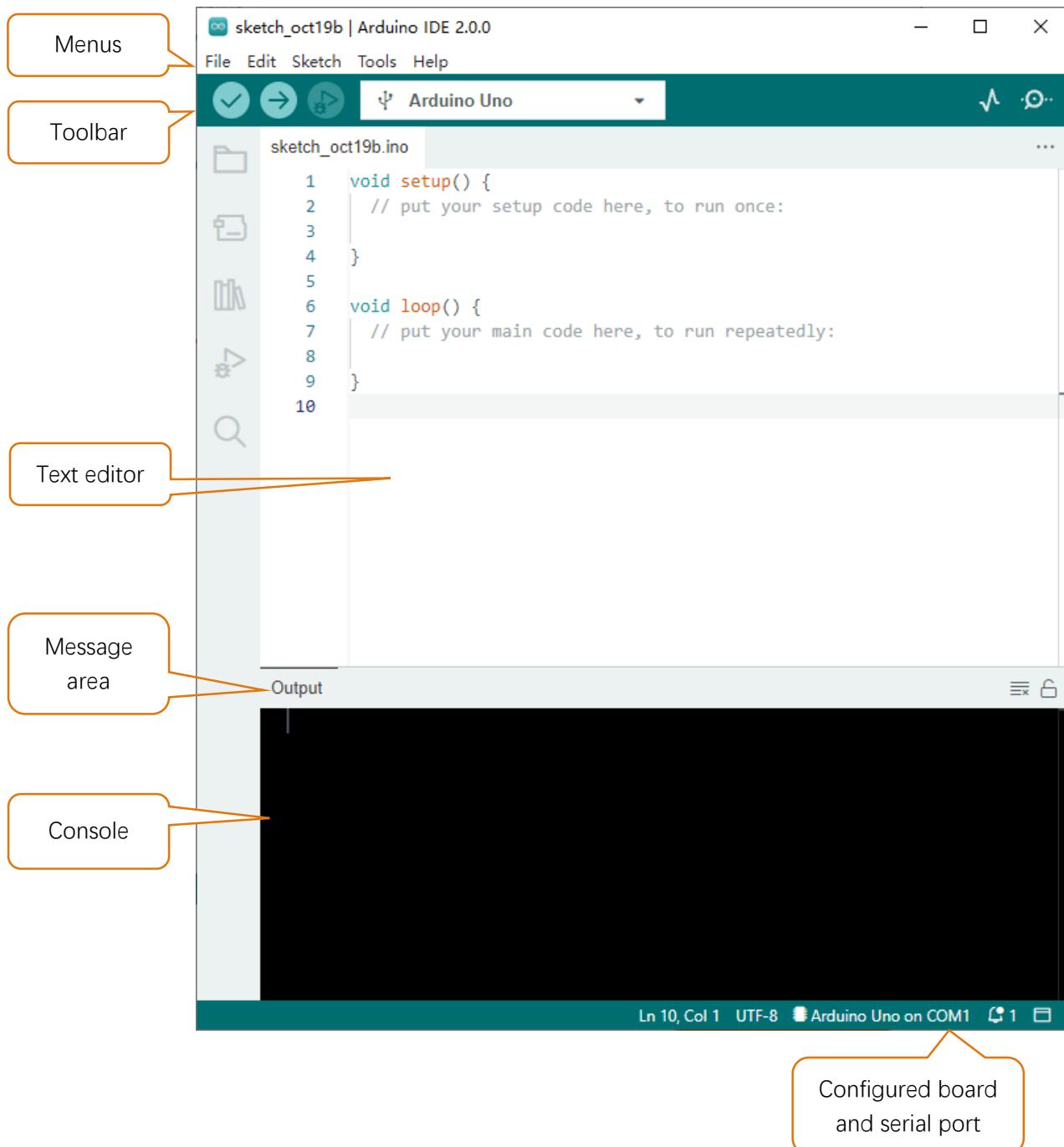
After the download completes, run the installer. For Windows users, there may pop up an installation dialog box of driver during the installation process. When it popes up, please allow the installation.

After installation is complete, an Arduino Software shortcut will be generated in the desktop. Run the Arduino Software.

Any concerns? [✉ support@freenove.com](mailto:support@freenove.com)



The interface of Arduino Software is as follows:





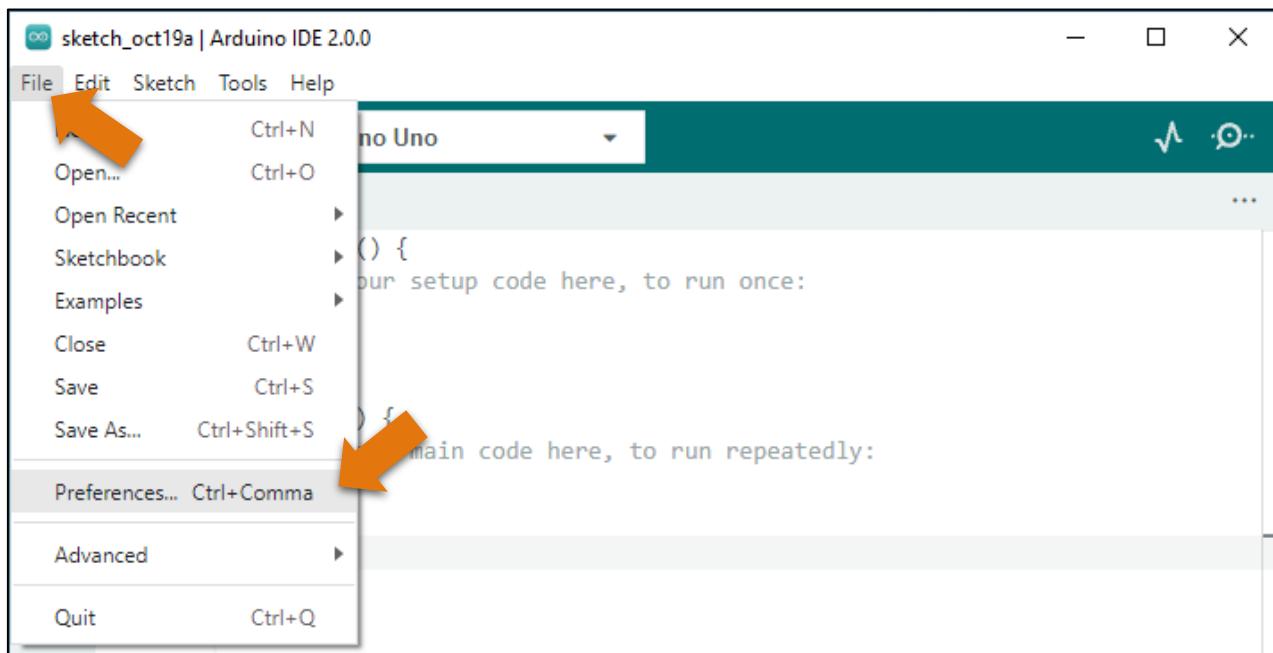
Programs written with Arduino Software (IDE) are called **sketches**. These sketches are written in the text editor and saved with the file extension.**.ino**. The editor has features for cutting/pasting and searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom right-hand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

	Verify Check your code for compile errors .
	Upload Compile your code and upload them to the configured board.
	Debug Debug code running on the board. (Some development boards do not support this function)
Arduino Uno	Development board selection Configure the support package and upload port of the development board.
	Serial Plotter Receive serial port data and plot it in a discounted graph.
	Serial Monitor Open the serial monitor.

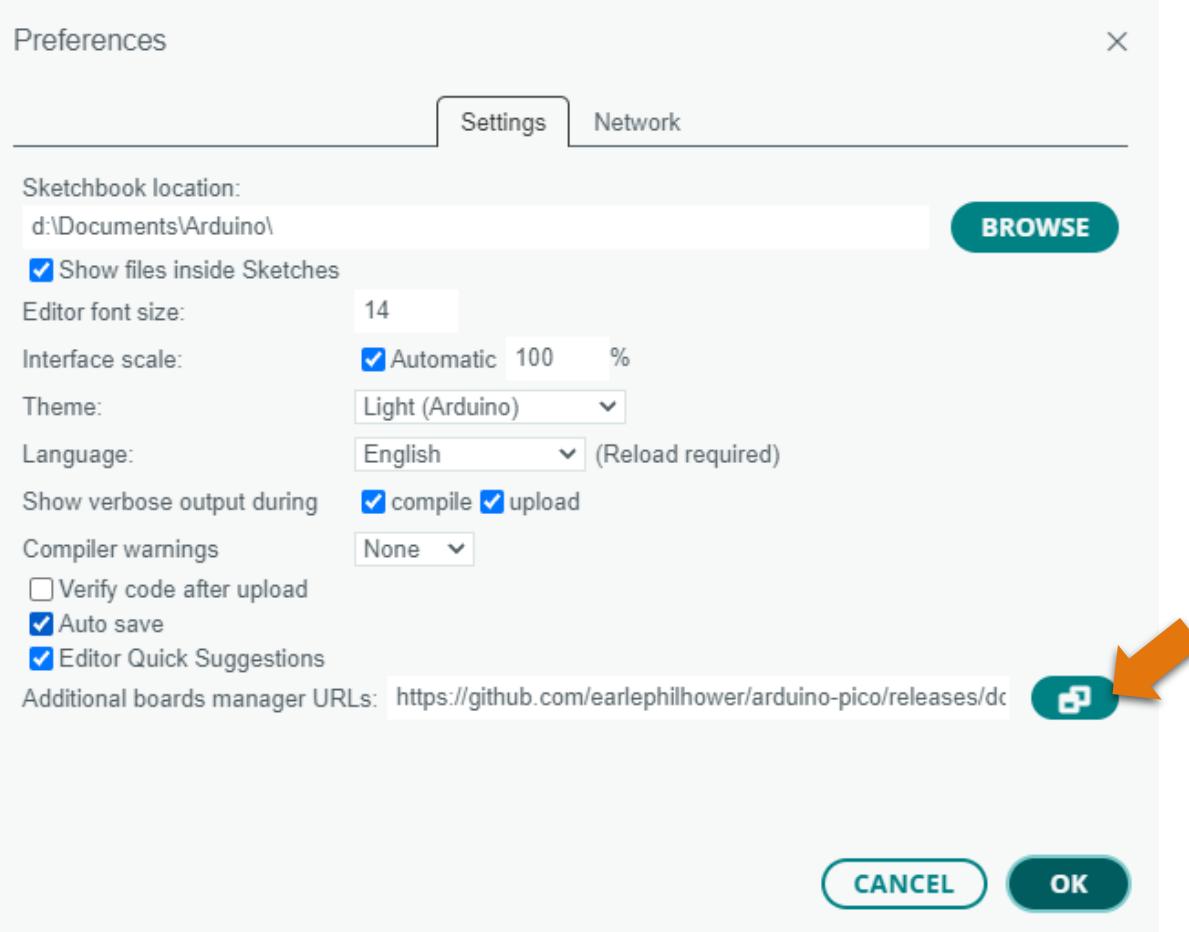
Additional commands are found within the five menus: File, Edit, Sketch, Tools, Help. The menus are context sensitive, which means only those items relevant to the work currently being carried out are available.

Environment Configuration

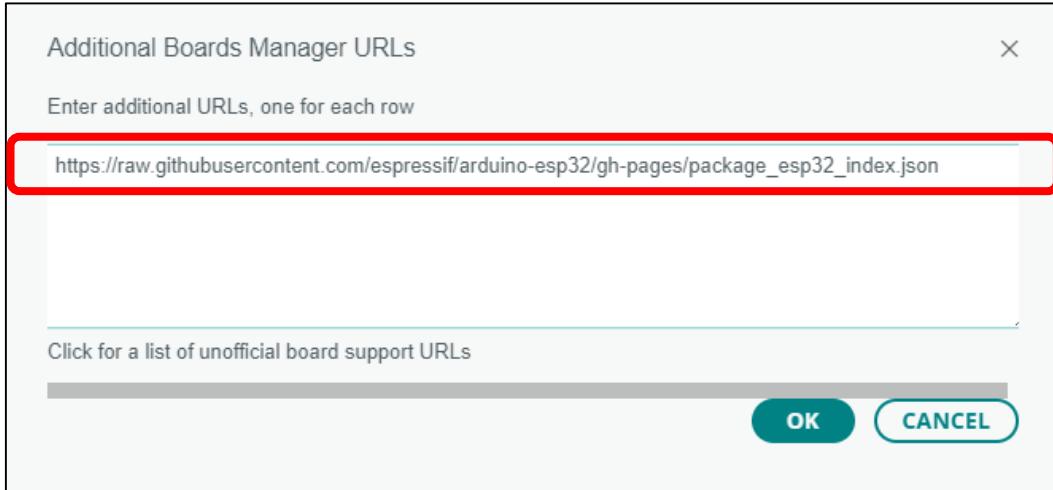
First, open the software platform arduino, and then click File in Menus and select Preferences.



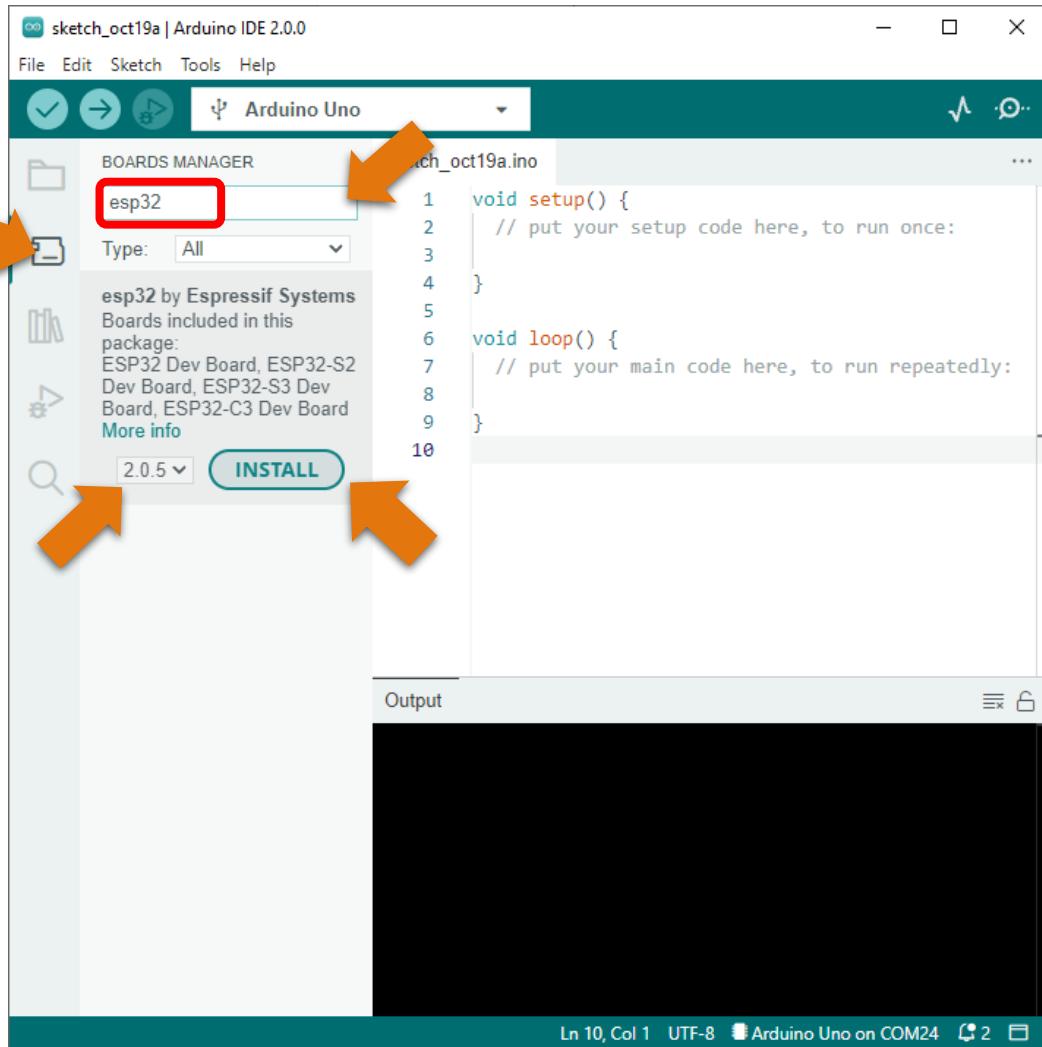
Second, click on the symbol behind "Additional Boards Manager URLs"



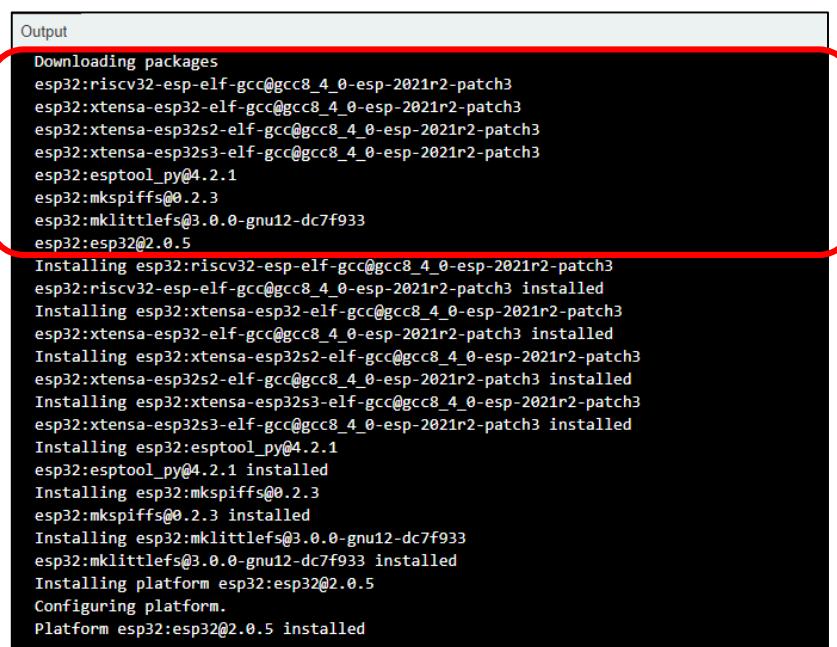
Third, fill in https://raw.githubusercontent.com/espressif/arduino-esp32/gh-pages/package_esp32_index.json in the new window, click OK, and click OK on the Preferences window again.



Fourth, click "Boards Manager". Enter "esp32" in Boards manager and select 2.0.5, Then click "INSTALL".



Arduinowill download these files automaticly. Wait for the installation to complete.

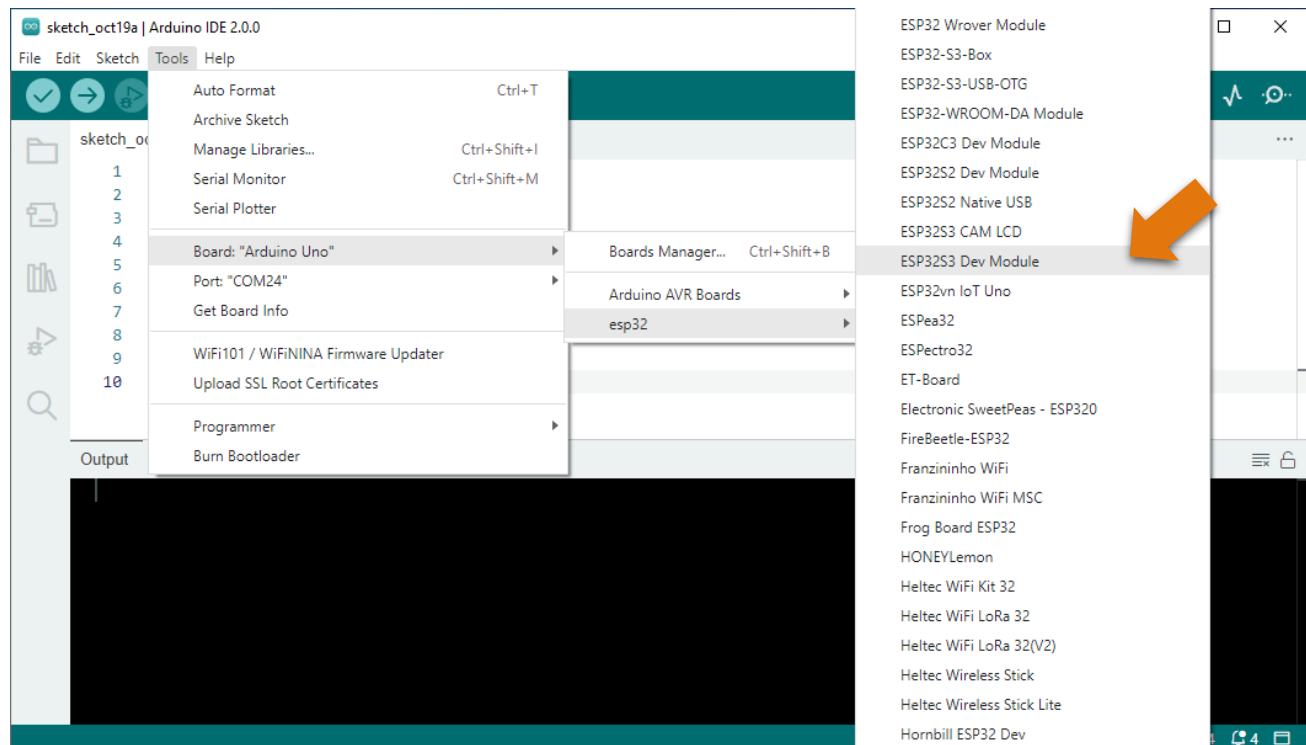


```

Output
Downloading packages
esp32:riscv32-esp-elf-gcc@gcc8_4_0-esp-2021r2-patch3
esp32:xtensa-esp32-elf-gcc@gcc8_4_0-esp-2021r2-patch3
esp32:xtensa-esp32s2-elf-gcc@gcc8_4_0-esp-2021r2-patch3
esp32:xtensa-esp32s3-elf-gcc@gcc8_4_0-esp-2021r2-patch3
esp32:esptool_py@4.2.1
esp32:mkspiffs@0.2.3
esp32:mklittlefs@3.0.0-gnu12-dc7f933
esp32:esp32@2.0.5
Installing esp32:riscv32-esp-elf-gcc@gcc8_4_0-esp-2021r2-patch3
esp32:riscv32-esp-elf-gcc@gcc8_4_0-esp-2021r2-patch3 installed
Installing esp32:xtensa-esp32-elf-gcc@gcc8_4_0-esp-2021r2-patch3
esp32:xtensa-esp32-elf-gcc@gcc8_4_0-esp-2021r2-patch3 installed
Installing esp32:xtensa-esp32s2-elf-gcc@gcc8_4_0-esp-2021r2-patch3
esp32:xtensa-esp32s2-elf-gcc@gcc8_4_0-esp-2021r2-patch3 installed
Installing esp32:xtensa-esp32s3-elf-gcc@gcc8_4_0-esp-2021r2-patch3
esp32:xtensa-esp32s3-elf-gcc@gcc8_4_0-esp-2021r2-patch3 installed
Installing esp32:esptool_py@4.2.1
esp32:esptool_py@4.2.1 installed
Installing esp32:mkspiffs@0.2.3
esp32:mkspiffs@0.2.3 installed
Installing esp32:mklittlefs@3.0.0-gnu12-dc7f933
esp32:mklittlefs@3.0.0-gnu12-dc7f933 installed
Installing platform esp32:esp32@2.0.5
Configuring platform.
Platform esp32:esp32@2.0.5 installed

```

When finishing installation, click Tools in the Menus again and select Board: "Arduino Uno", and then you can see information of ESP32. click "ESP32-S3 Dev Module" so that the ESP32-S3 programming development environment is configured.





Notes for GPIO

Strapping Pin

There are four Strapping pins for ESP32-S3: GPIO0、GPIO45、GPIO46、GPIO3。

With the release of the chip's system reset (power-on reset, RTC watchdog reset, undervoltage reset), the strapping pins sample the level and store it in the latch as "0" or "1", and keep it until the chip is powered off or turned off.

Each Strapping pin is connecting to internal pull-up/pull-down. Connecting to high-impedance external circuit or without an external connection, a strapping pin's default value of input level will be determined by internal weak pull-up/pull-down. To change the value of the Strapping, users can apply an external pull-down/pull-up resistor, or use the GPIO of the host MCU to control the level of the strapping pin when the ESP32-S3's power on reset is released.

When releasing the reset, the strapping pin has the same function as a normal pin.

The followings are default configurations of these four strapping pins at power-on and their functions under the corresponding configuration.

VDD_SPI Voltage			
Pin	Default	3.3 V	1.8 V
GPIO45	Pull-down	0	1
Booting Mode ¹			
Pin	Default	SPI Boot	Download Boot
GPIO0	Pull-up	1	0
GPIO46	Pull-down	Don't care	0
Enabling/Disabling ROM Messages Print During Booting ²			
Pin	Default	Enabled	Disabled
GPIO46	Pull-down	See the 2nd note	See the 2nd note
JTAG Signal Selection			
Pin	Default	EFUSE_DIS_USB_JTAG = 0, EFUSE_DIS_PAD_JTAG = 0, EFUSE_STRAP_JTAG_SEL=1	
GPIO3	N/A	0: JTAG signal from on-chip JTAG pins 1: JTAG signal from USB Serial/JTAG controller	

Note:

1. The strapping combination of GPIO46 = 1 and GPIO0 = 0 is invalid and will trigger unexpected behavior.
2. By default, the ROM boot messages are printed over UART0 (UOTXD pin) and USB Serial/JTAG controller together. The ROM code printing can be disabled through configuration register and eFuse. For detailed information, please refer to Chapter [Chip Boot Control](#) in *ESP32-S3 Technical Reference Manual*.

If you have any difficulties or questions with this tutorial or toolkit, feel free to ask for our quick and free technical support through support@freenove.com at any time.

or check: https://www.espressif.com/sites/default/files/documentation/esp32-s3-wroom-1_wroom-1u_datasheet_en.pdf

PSRAM Pin

The module on the ESP32-S3-WROOM board uses the ESP32-S3R8 chip with 8MB of external Flash. When we use the OPI PSRAM, please note that the GPIO35-GPIO37 on the ESP32-S3-WROOM board will not be available for other purposes. When OPI PSRAM is not used, GPIO35-GPIO37 on the board can be used as normal GPIO.

ESP32-S3R8 / ESP32-S3R8V	In-package PSRAM (8 MB, Octal SPI)
SPICLK	CLK
SPICS1	CE#
SPIID	DQ0
SPIQ	DQ1
SPIWP	DQ2
SPIHD	DQ3
GPIO33	DQ4
GPIO34	DQ5
GPIO35	DQ6
GPIO36	DQ7
GPIO37	DQS/DM

SDcard Pin

An SDcard slot is integrated on the back of the ESP32-S3-WROOM board. We can use GPIO38-GPIO40 of ESP32-S3-WROOM to drive SD card.

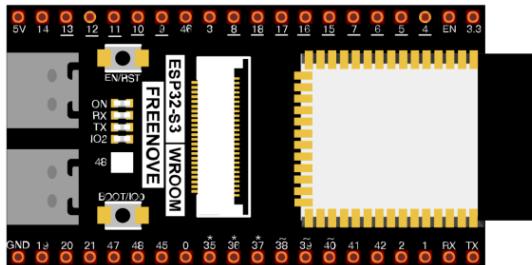
The SDcard of ESP32-S3-WROOM uses SDMMC, a 1-bit bus driving method, which has been integrated in the Arduino IDE, and we can call the "SD_MMC.h" library to drive it. For details, see the SDcard chapter in this tutorial.

USB Pin

In Micropython, GPIO19 and GPIO20 are used for the USB function of ESP32S3, so they cannot be used as other functions!

Cam Pin

When using the camera of our ESP32-S3 WROOM, please check the pins of it. Pins with underlined numbers are used by the camera function, if you want to use other functions besides it, please avoid using them.



CAM_Pin	GPIO_pin
SIOD	GPIO4
SIOC	GPIO5
CSI_VSYNC	GPIO6
CSI_HREF	GPIO7
CSI_Y9	GPIO16
XCLK	GPIO15
CSI_Y8	GPIO17
CSI_Y7	GPIO18
CSI_PCLK	GPIO13
CSI_Y6	GPIO12
CSI_Y2	GPIO11
CSI_Y5	GPIO10
CSI_Y3	GPIO9
CSI_Y4	GPIO8

If you have any questions about the information of GPIO, you can click [here](#) to go back to ESP32-S3 WROOM to view specific information about GPIO.

or check: https://www.espressif.com/sites/default/files/documentation/esp32-s3_datasheet_en.pdf.

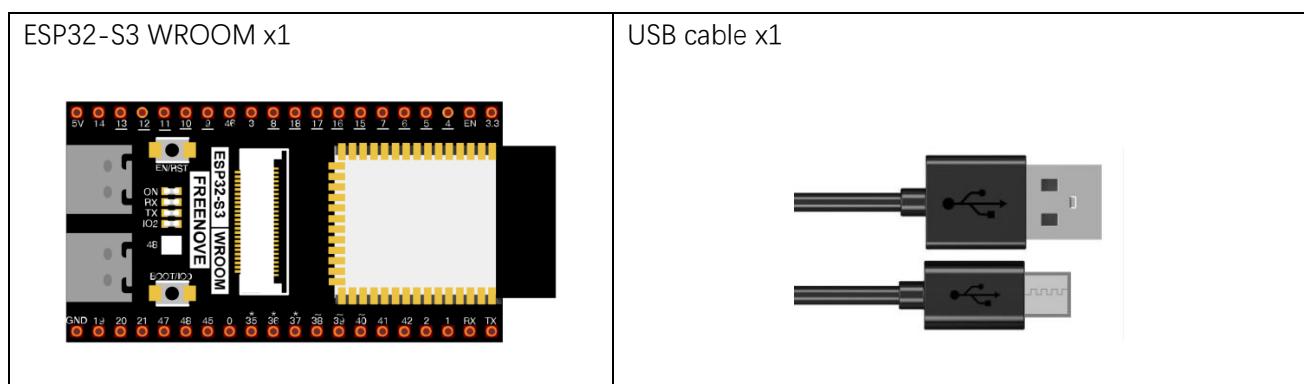
Chapter 1 LED

This chapter is the Start Point in the journey to build and explore ESP32-S3 WROOM electronic projects. We will start with simple “Blink” project.

Project 1.1 Blink

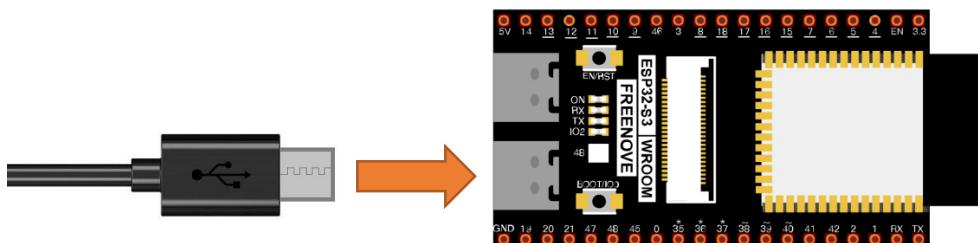
In this project, we will use ESP32-S3 WROOM to control blinking a common LED.

Component List



Power

ESP32-S3 WROOM needs 5v power supply. In this tutorial, we need connect ESP32-S3 WROOM to computer via USB cable to power it and program it. We can also use other 5v power source to power it.



In the following projects, we only use USB cable to power ESP32-S3 WROOM by default.

In the whole tutorial, we don't use T extension to power ESP32-S3 WROOM. So 5V and 3.3V (including EXT 3.3V) on the extension board are provided by ESP32-S3 WROOM.

We can also use DC jack of extension board to power ESP32-S3 WROOM. In this way, 5v and EXT 3.3v on extension board are provided by external power resource.

Sketch

According to the circuit, when the GPIO2 of ESP32-S3 WROOM output level is high, the LED turns ON. Conversely, when the GPIO2 ESP32-S3 WROOM output level is low, the LED turns OFF. Therefore, we can let GPIO2 circularly output high and low level to make the LED blink.

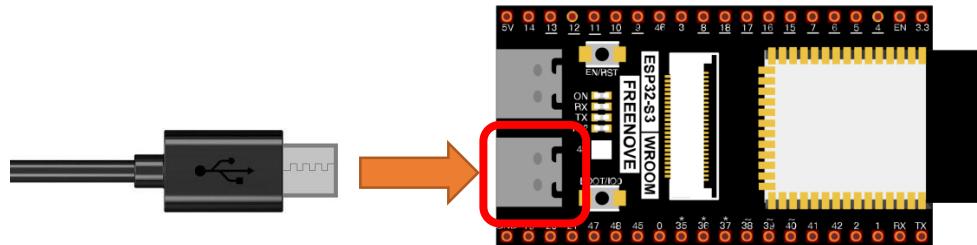
Upload the following Sketch:

Freenove_ESP32_S3_WROVER_Board\Sketches\Sketch_01.1_Blink.

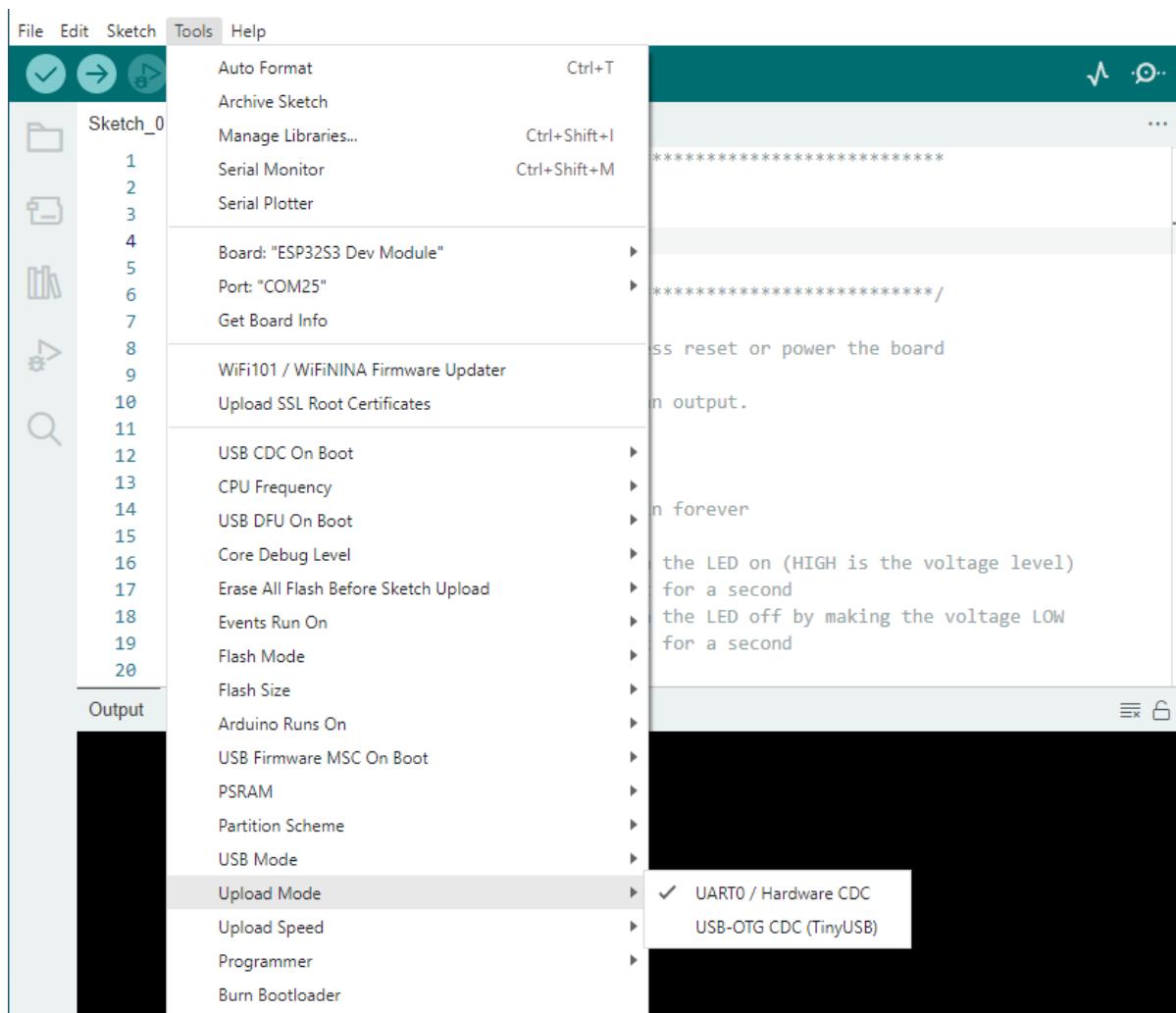
Next we will introduce two ways to upload code to ESP32-S3 WROOM.

Option 1:

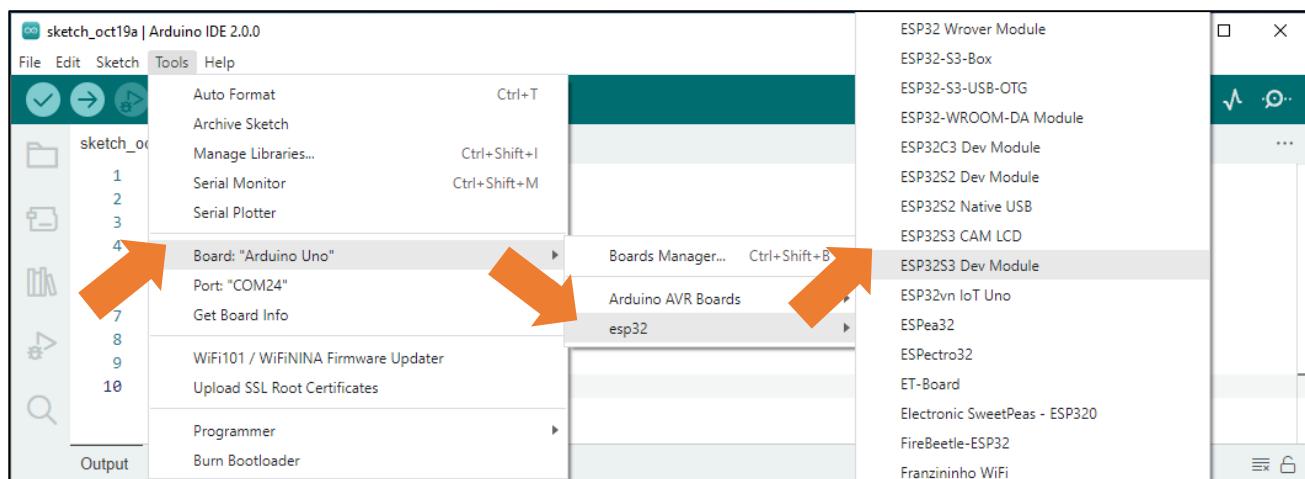
Connect ESP32-S3 WROOM to computer.



Open Arduino IDE 2.0.0. Click Tools->Upload Mode. Select UART0 / Hardware CDC.

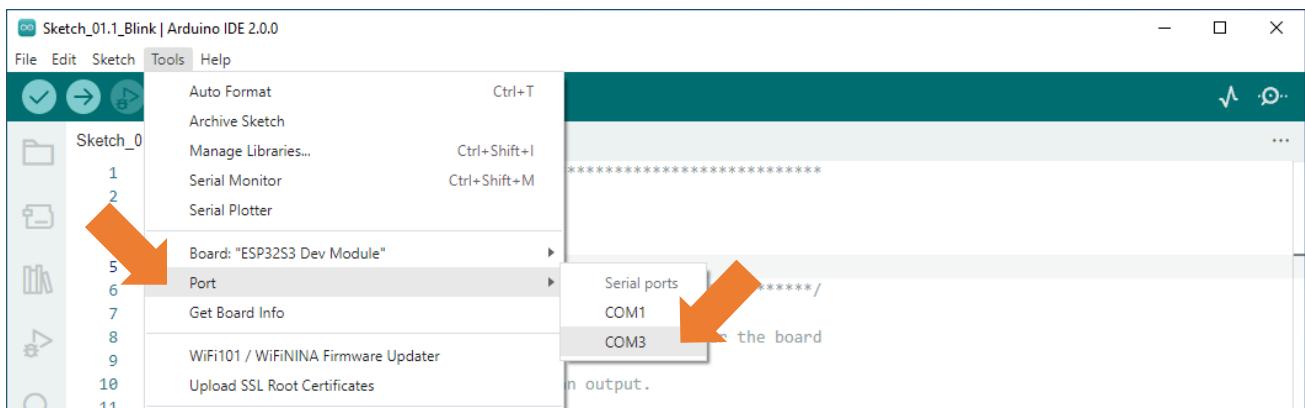


Before uploading the code, click "**Tools**", "**Board**" and select "**ESP32S3 Dev Module**".

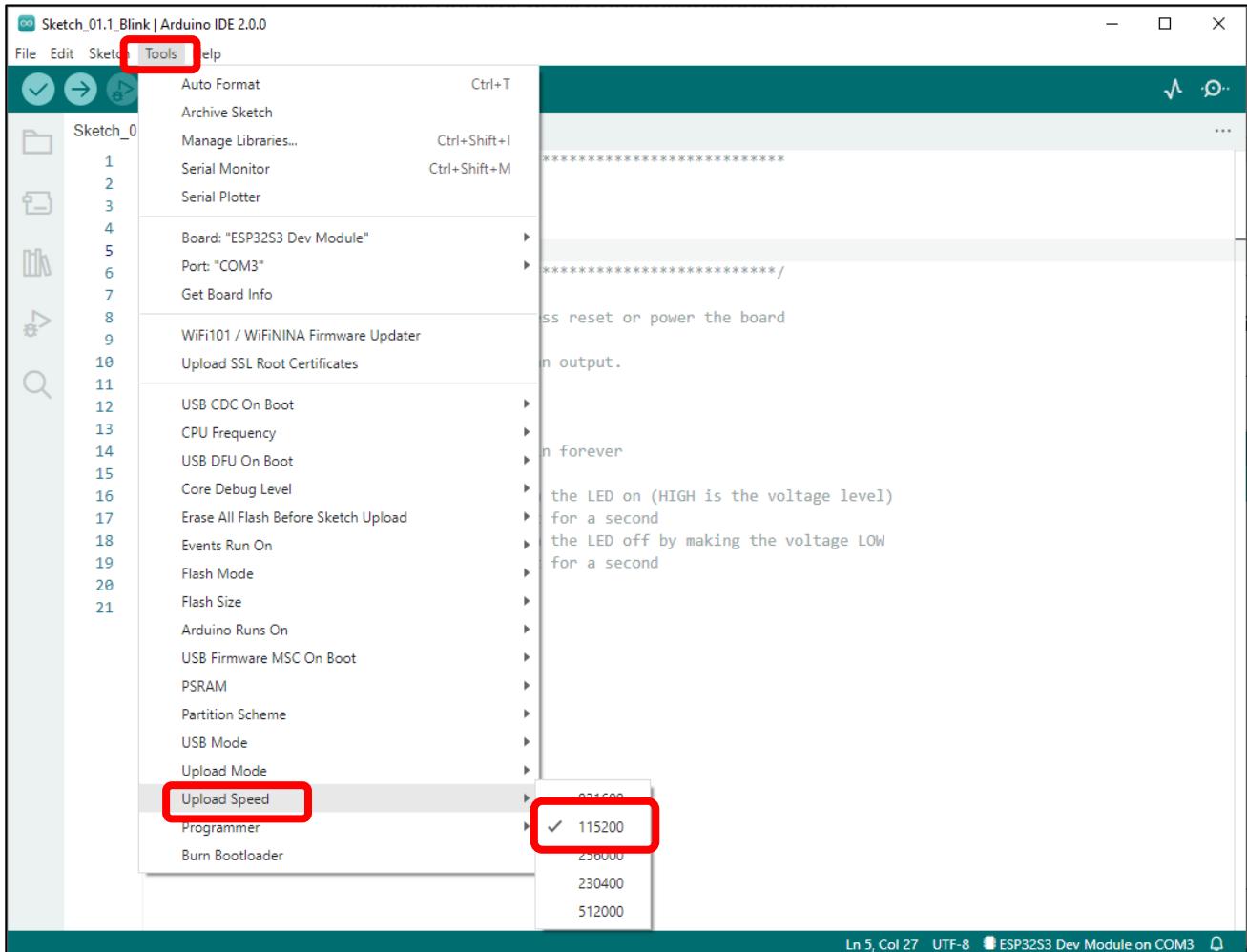


Select the serial port.

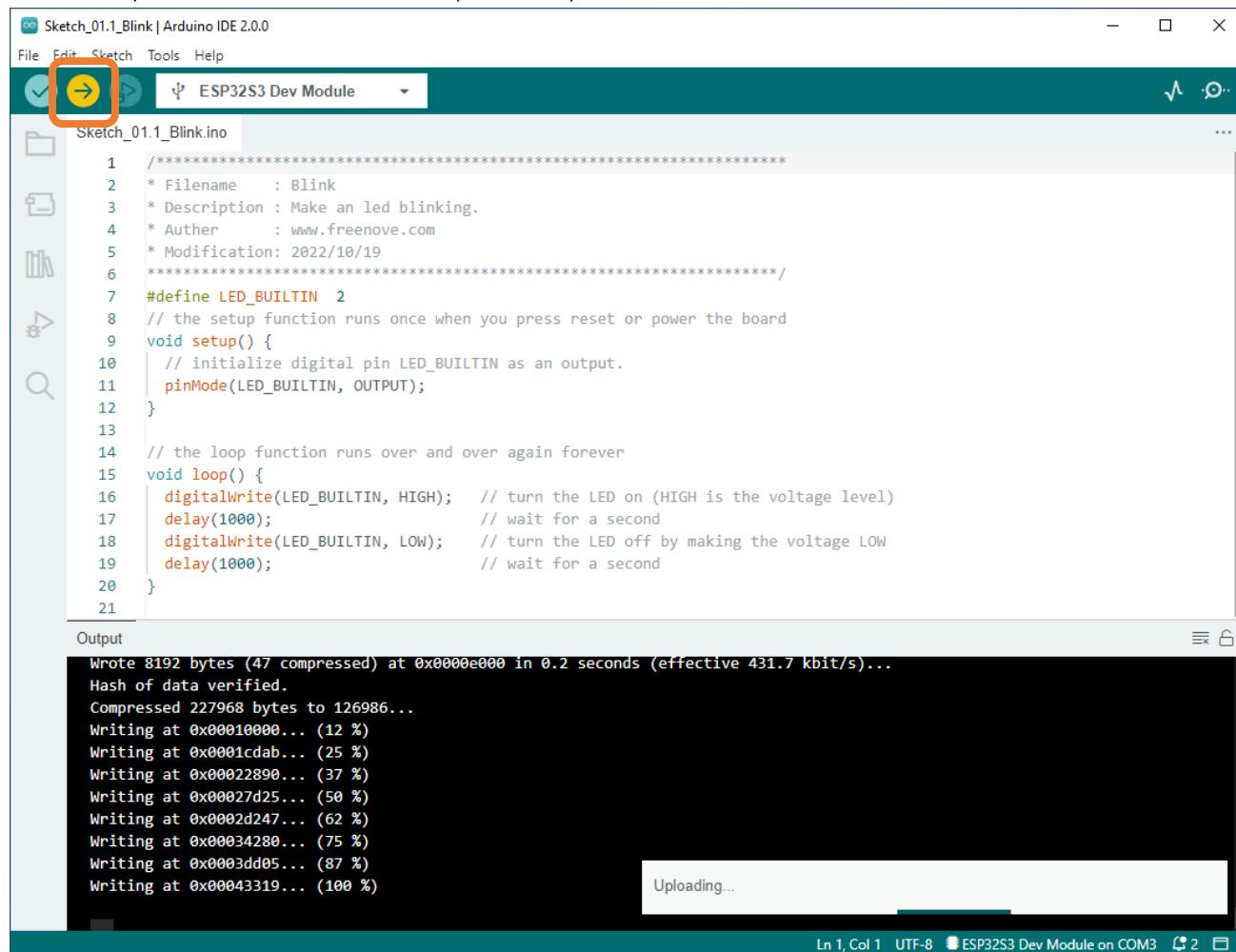
Note that the computer port number of each user may be different. Please select the correct serial port according to your computer. Taking the window system as an example, my computer recognizes that the communication interface of the ESP32-S3-WROOM is COM3, so I select COM3.



Note: For macOS users, if the uploading fails, please set the baud rate to 115200 before clicking “Upload Using Programmer”.



Click the Upload button and it will compile and upload the Sketch to the ESP32-S3-WROOM.



The screenshot shows the Arduino IDE interface with the following details:

- Title Bar:** Sketch_01.1_Blink | Arduino IDE 2.0.0
- Sketch Name:** Sketch_01.1_Blink.ino
- Board:** ESP32S3 Dev Module
- Code Content:**

```

1  // ****
2  * Filename   : Blink
3  * Description : Make an led blinking.
4  * Author     : www.freenove.com
5  * Modification: 2022/10/19
6  ****
7  #define LED_BUILTIN 2
8  // the setup function runs once when you press reset or power the board
9  void setup() {
10    // initialize digital pin LED_BUILTIN as an output.
11    pinMode(LED_BUILTIN, OUTPUT);
12 }
13
14 // the loop function runs over and over again forever
15 void loop() {
16    digitalWrite(LED_BUILTIN, HIGH);    // turn the LED on (HIGH is the voltage level)
17    delay(1000);                      // wait for a second
18    digitalWrite(LED_BUILTIN, LOW);     // turn the LED off by making the voltage LOW
19    delay(1000);                      // wait for a second
20 }
21

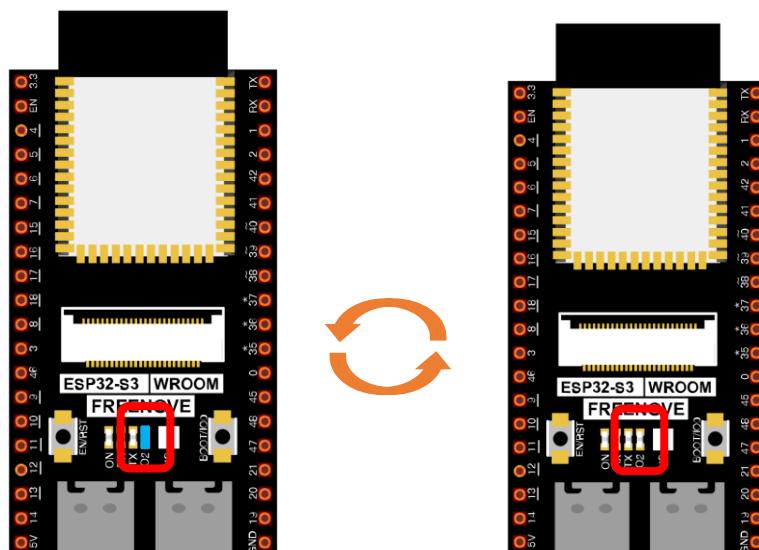
```
- Output Window:**

```

Wrote 8192 bytes (47 compressed) at 0x0000e000 in 0.2 seconds (effective 431.7 kbit/s)...
Hash of data verified.
Compressed 227968 bytes to 126986...
Writing at 0x00010000... (12 %)
Writing at 0x0001cdab... (25 %)
Writing at 0x00022890... (37 %)
Writing at 0x00027d25... (50 %)
Writing at 0x0002d247... (62 %)
Writing at 0x00034280... (75 %)
Writing at 0x0003dd05... (87 %)
Writing at 0x00043319... (100 %)

```
- Status Bar:** Uploading... (progress bar)
- Bottom Bar:** Ln 1, Col 1 UTF-8 ESP32S3 Dev Module on COM3

Wait for the Sketch upload to complete, and observe the ESP32-S3-WROOM. You can see that the blue LED (IO2) on the board flashes cyclically.



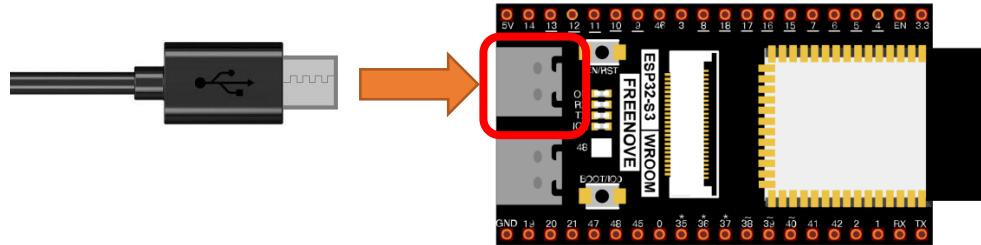
If you have any concerns, please contact us via: support@freenove.com.

Any concerns? ✉ support@freenove.com

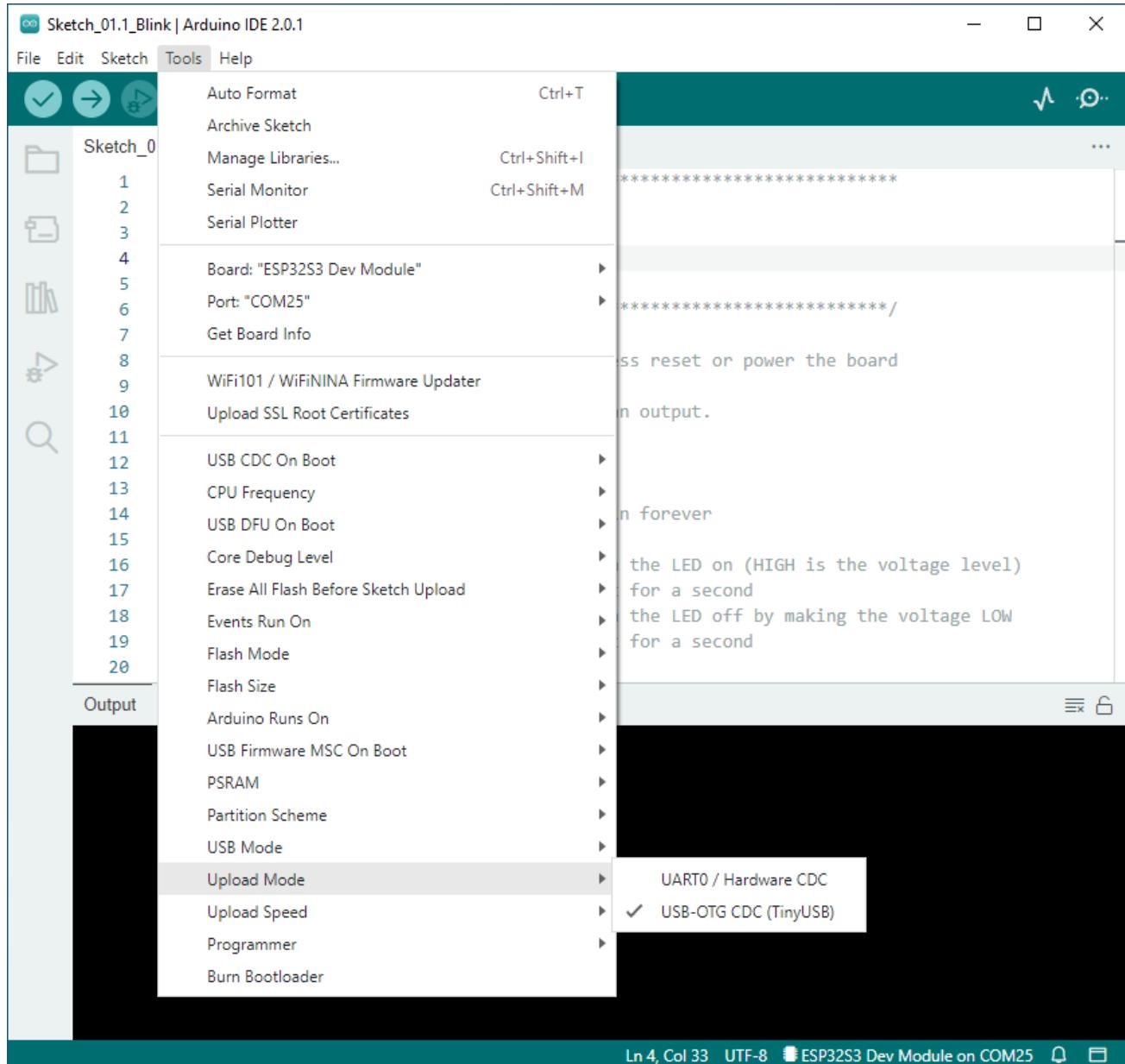


Option 2:

Connect ESP32-S3 WROOM to computer.

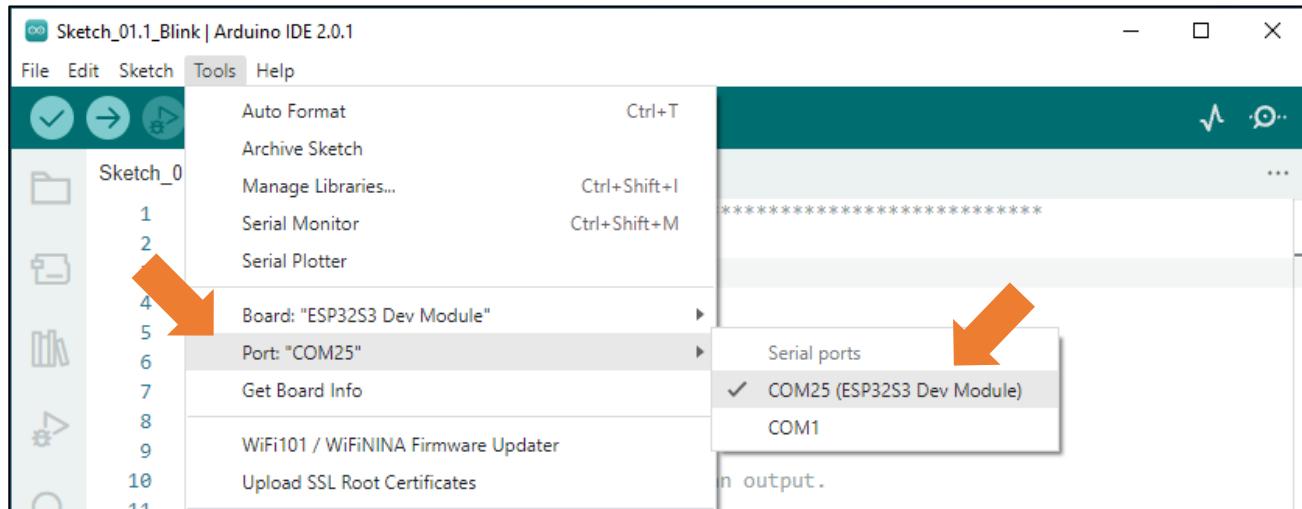


Open Arduino IDE 2.0.0. Click Tools->Upload Mode. Select USB-OTG CDC(TinyUSB).

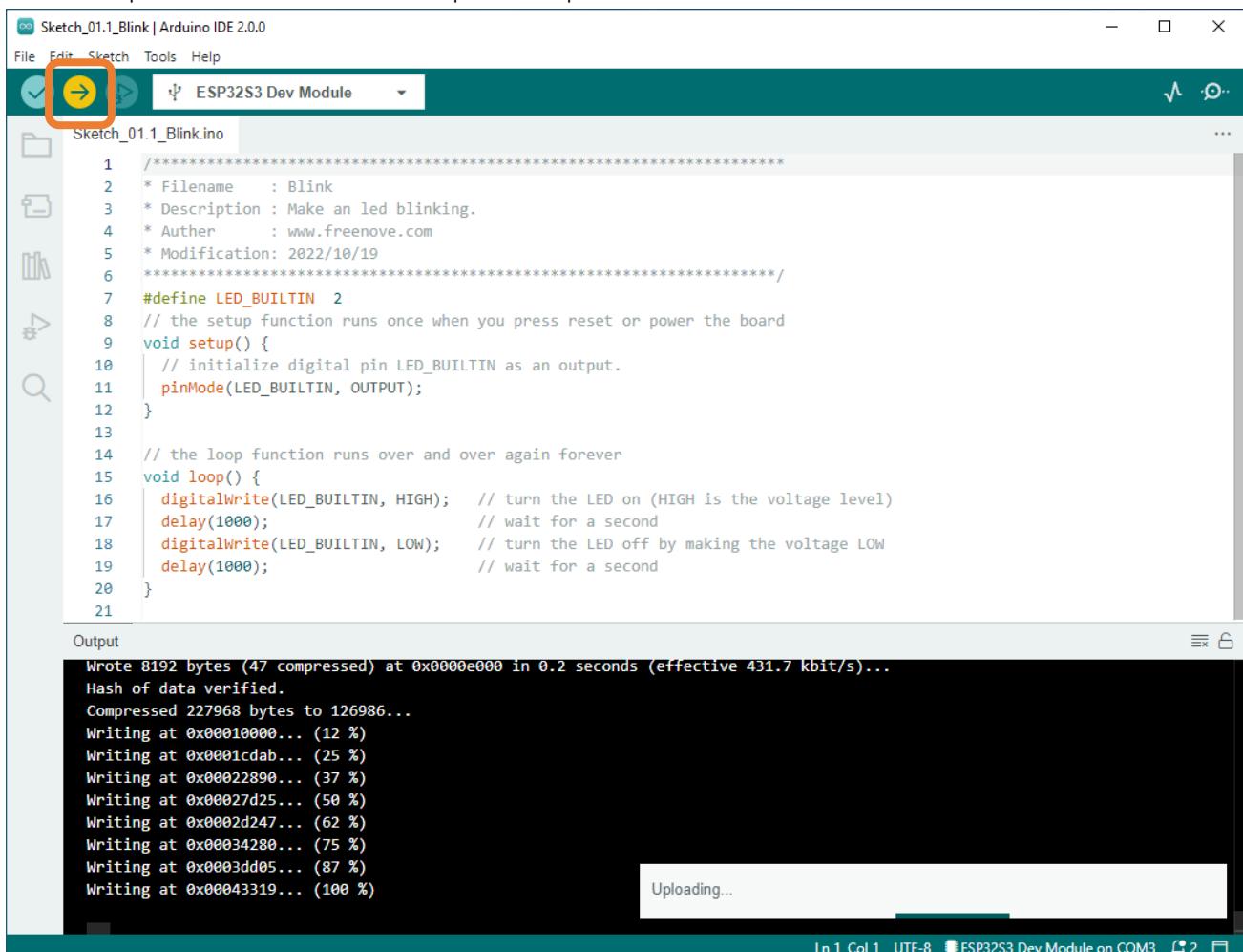


Select the serial port.

Note that the computer port number of each user may be different. Please select the correct serial port according to your computer. Taking the window system as an example, my computer recognizes that the communication interface of the ESP32-S3-WROOM is COM25, so I select COM25.



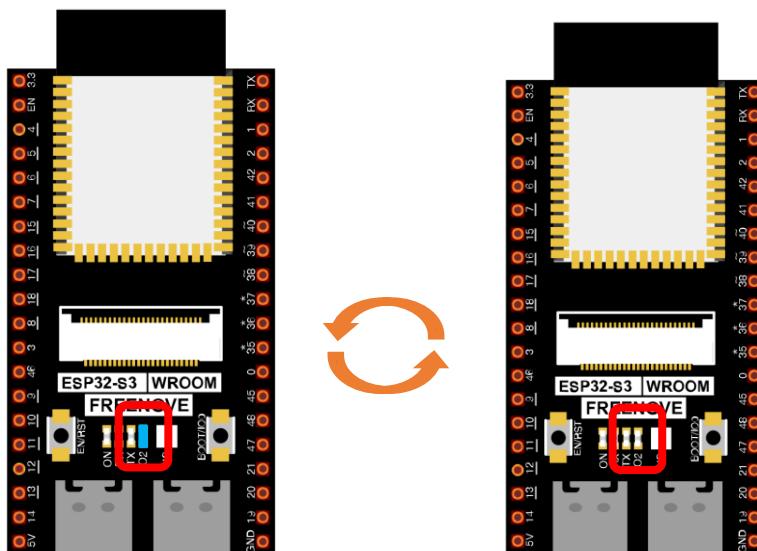
Click the Upload button and it will compile and upload the Sketch to the ESP32-S3-WROOM.



Wait for the Sketch upload to complete, and observe the ESP32-S3-WROOM. You can see that the blue

Any concerns? ✉ support@freenove.com

LED (IO2) on the board flashes cyclically.



Sketch_01.1_Blink

The following is the program code:

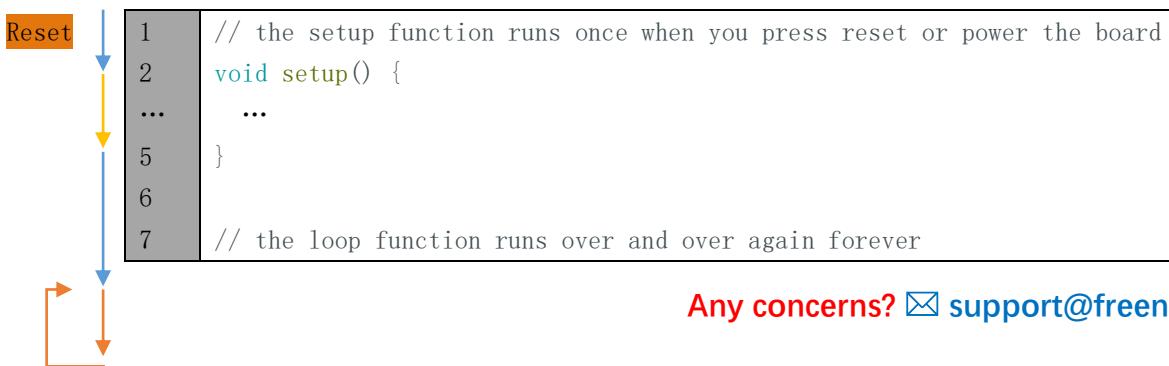
```

1 #define LED_BUILTIN 2
2 // the setup function runs once when you press reset or power the board
3 void setup() {
4     // initialize digital pin LED_BUILTIN as an output.
5     pinMode(LED_BUILTIN, OUTPUT);
6 }
7
8 // the loop function runs over and over again forever
9 void loop() {
10    digitalWrite(LED_BUILTIN, HIGH);      // turn the LED on (HIGH is the voltage level)
11    delay(1000);                      // wait for a second
12    digitalWrite(LED_BUILTIN, LOW);       // turn the LED off by making the voltage LOW
13    delay(1000);                      // wait for a second
14 }
```

The Arduino IDE code usually contains two basic functions: void setup() and void loop().

After the board is reset, the setup() function will be executed firstly, and then the loop() function.

setup() function is generally used to write code to initialize the hardware. And loop() function is used to write code to achieve certain functions. loop() function is executed repeatedly. When the execution reaches the end of loop(), it will jump to the beginning of loop() to run again.



Any concerns? ✉ support@freenove.com

```

8   void loop() {
...
13 }
```

Reset

Reset operation will lead the code to be executed from the beginning. Switching on the power, finishing uploading the code and pressing the reset button will trigger reset operation.

In the circuit, ESP32-S3 WROOM's GPIO2 is connected to the LED, so the LED pin is defined as 2.

```
1 #define LED_BUILTIN 2
```

This means that after this line of code, all LED_BUILTIN will be treated as 2.

In the setup () function, first, we set the LED_BUILTIN as output mode, which can make the port output high level or low level.

```

4 // initialize digital pin LED_BUILTIN as an output.
5 pinMode(LED_BUILTIN, OUTPUT);
```

Then, in the loop () function, set the LED_BUILTIN to output high level to make LED light up.

```
10 digitalWrite(LED_BUILTIN, HIGH); // turn the LED on (HIGH is the voltage level)
```

Wait for 1000ms, that is 1s. Delay () function is used to make control board wait for a moment before executing the next statement. The parameter indicates the number of milliseconds to wait for.

```
11 delay(1000); // wait for a second
```

Then set the LED_BUILTIN to output low level, and LED light off. One second later, the execution of loop () function will be completed.

```

12 digitalWrite(LED_BUILTIN, LOW); // turn the LED off by making the voltage LOW
13 delay(1000); // wait for a second
```

The loop() function is constantly being executed, so LED will keep blinking.

Reference

```
void pinMode(int pin, int mode);
```

Configures the specified pin to behave either as an input or an output.

Parameters

pin: the pin number to set the mode of.

mode: INPUT, OUTPUT, INPUT_PULLDOWN, or INPUT_PULLUP.

```
void digitalWrite (int pin, int value);
```

Writes the value HIGH or LOW (1 or 0) to the given pin which must have been previously set as an output.

For more related functions, please refer to <https://www.arduino.cc/reference/en/>

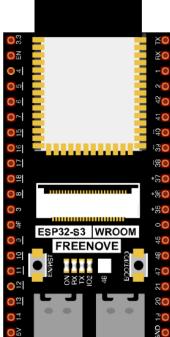
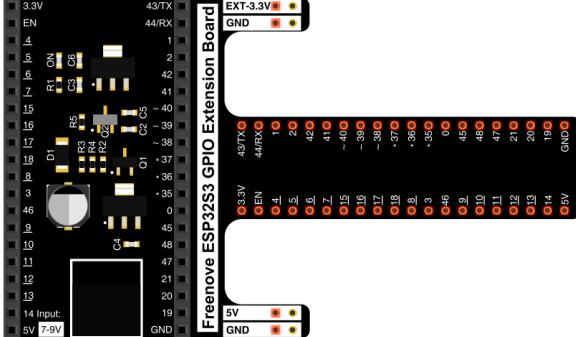
Chapter 2 Serial Communication

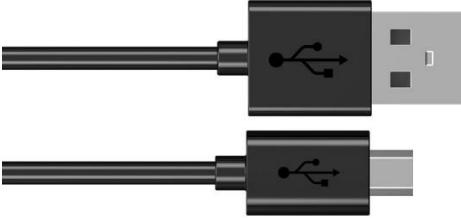
Serial Communication is a means of communication between different devices/devices. This section describes ESP32-S3's Serial Communication.

Project 2.1 Serial Print

This project uses ESP32-S3's serial communicator to send data to the computer and print it on the serial monitor.

Component List

ESP32-S3 WROOM x1	GPIO Extension Board x1
	

Micro USB Wire x1


Related knowledge

Serial communication

Serial communication generally refers to the Universal Asynchronous Receiver/Transmitter (UART), which is commonly used in electronic circuit communication. It has two communication lines, one is responsible for sending data (TX line) and the other for receiving data (RX line). The serial communication connections of two devices is as follows:



Before serial communication starts, the baud rate of both sides must be the same. Communication between devices can work only if the same baud rate is used. The baud rates commonly used is 9600 and 115200.

Serial port on ESP32-S3

Freenove ESP32-S3 has integrated USB to serial transfer, so it could communicate with computer connecting to USB cable.

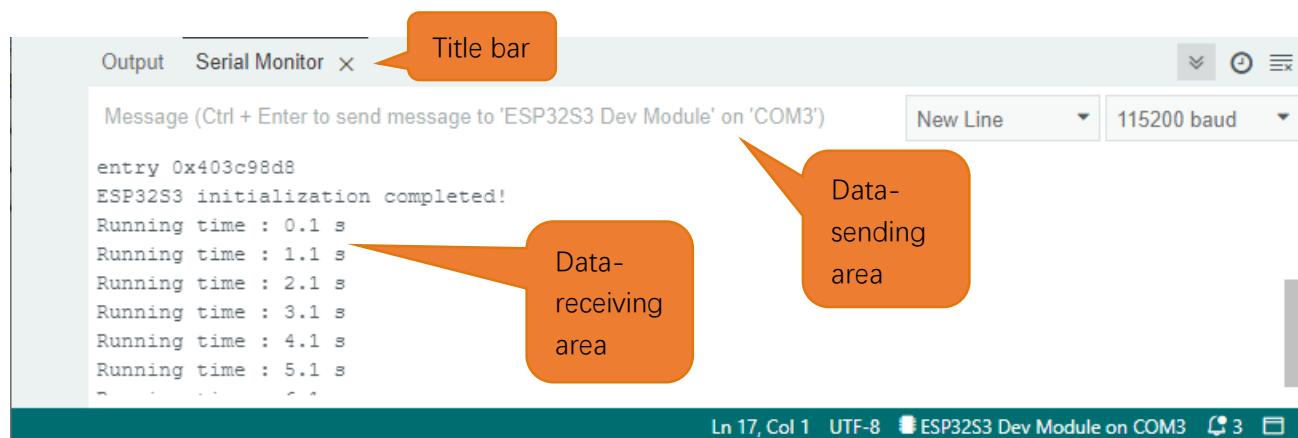


Arduino Software also uploads code to Freenove ESP32-S3 through the serial connection.

Your computer identifies serial devices connecting to it as COMx. We can use the Serial Monitor window of Arduino Software to communicate with Freenove ESP32-S3, connect Freenove ESP32-S3 to computer through the USB cable, choose the correct device, and then click the Serial Monitor icon to open the Serial Monitor window.



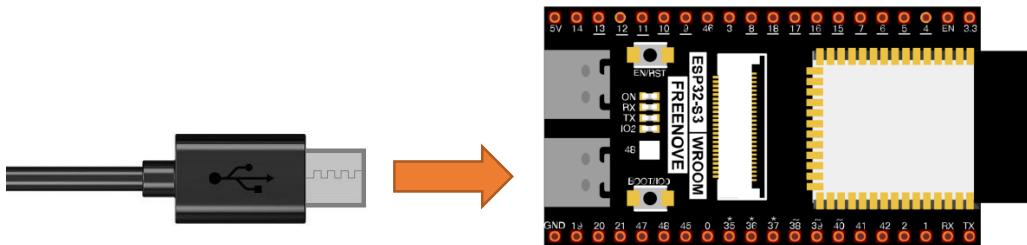
Interface of serial monitor window is as follows. If you can't open it, make sure Freenove ESP32-S3 has been connected to the computer, and choose the right serial port in the menu bar "Tools".



Any concerns? [✉ support@freenove.com](mailto:support@freenove.com)

Circuit

Connect Freenove ESP32-S3 to the computer with USB cable.



Sketch

Sketch_02.1_SerialPrinter

```

Sketch_08.1_SerialPrinter | Arduino IDE 2.0.0
File Edit Sketch Tools Help
ESP32S3 Dev Module
Sketch_08.1_SerialPrinter.ino
1 //*****
2   Filename    : SerialPrinter
3   Description : Use UART send some data to PC, and show them on serial monitor.
4   Author     : www.freenove.com
5   Modification: 2022/10/20
6 *****/
7
8 void setup() {
9   Serial.begin(115200);
10  Serial.println("ESP32S3 initialization completed!");
11 }
12
13 void loop() {
14   Serial.printf("Running time : %.1f s\n", millis() / 1000.0f);
15   delay(1000);
16 }

```

Download the code to ESP32-S3 WROOM, open the serial port monitor, set the baud rate to 115200, and press the reset button. As shown in the following figure:

```

Output Serial Monitor x
Message (Ctrl + Enter to send message to 'ESP32S3 Dev Module' on 'COM3') New Line 115200 baud
load:0x403cc700,len:0x2a3c
entry 0x403c98d8
ESP32S3 initialization completed!
Running time : 0.1 s
Running time : 1.1 s
Running time : 2.1 s
Running time : 3.1 s
Running time : 4.1 s

```

As shown in the image above, "ESP32-S3 initialization completed! " The previous is the printing message when the system is started. The user program is then printed at a baud rate of 115200.

The following is the program code:

```
1 void setup() {  
2     Serial.begin(115200);  
3     Serial.println("ESP32S3 initialization completed!");  
4 }  
5  
6 void loop() {  
7     Serial.printf("Running time : %.1f s\n", millis() / 1000.0f);  
8     delay(1000);  
9 }
```

Reference

```
void begin(unsigned long baud, uint32_t config=SERIAL_8N1, int8_t rxPin=-1,  
          int8_t txPin=-1, bool invert=false, unsigned long timeout_ms = 20000UL);
```

Initializes the serial port. Parameter baud is baud rate, other parameters generally use the default value.

```
size_t println( arg );
```

Print to the serial port and wrap. The parameter **arg** can be a number, a character, a string, an array of characters, etc.

```
size_t printf(const char * format, ...) __attribute__((format (printf, 2, 3)));
```

Print formatted content to the serial port in the same way as print in standard C.

```
unsigned long millis();
```

Returns the number of milliseconds since the current system was booted.



Project 2.2 Serial Read and Write

From last section, we use serial port on Freenove ESP32-S3 to send data to a computer, now we will use that to receive data from computer.

Component and circuit are the same as in the previous project.

Sketch

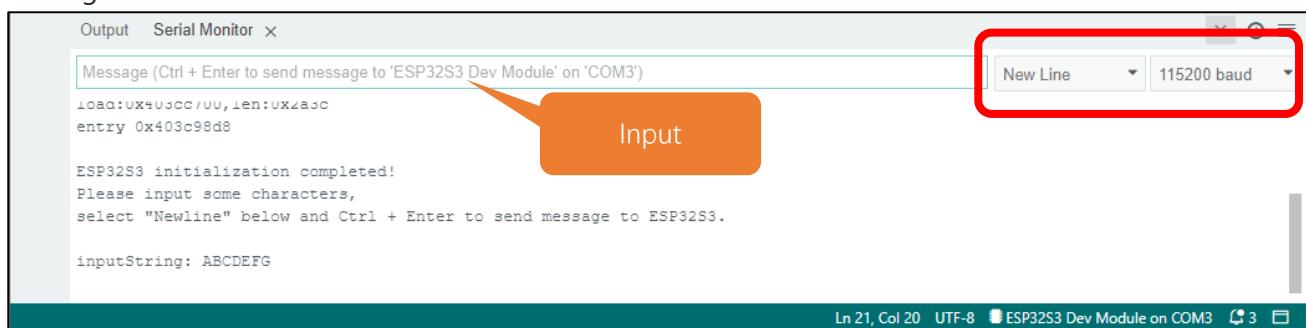
Sketch_02.2_SerialRW

```

Sketch_08.2_SerialRW | Arduino IDE 2.0.0
File Edit Sketch Tools Help
ESP32S3 Dev Module
Sketch_08.2_SerialRW.ino ...
1 String inputString = ""; //a String to hold incoming data
2 bool stringComplete = false; // whether the string is complete
3
4 void setup() {
5     Serial.begin(115200);
6     Serial.println(String("\nESP32S3 initialization completed!\r\n")
7                     + String("Please input some characters,\r\n")
8                     + String("select \"Newline\" below and Ctrl + Enter to send message to ESP32S3. \r\n"));
9 }
10
11 void loop() {
12     if (Serial.available()) { // judge whether data has been received
13         char inChar = Serial.read(); // read one character
14         inputString += inChar;
15         if (inChar == '\n') {
16             stringComplete = true;
17         }
18     }
19     if (stringComplete) {
20         Serial.printf("inputString: %s \r\n", inputString);
21         inputString = "";
22         stringComplete = false;
23     }
24 }
25
26
27
28
29
30 }
```

Download the code to ESP32-S3 WROOM, open the serial monitor, and set the top right corner to **Newline**, **115200**. As shown in the following figure:

Then type characters like 'ABCDEFG' into the data sent at the top, and press Ctrl+Enter to send the message.



The following is the program code:

```

1 String inputString = "";      //a String to hold incoming data
2 bool stringComplete = false; // whether the string is complete
3
4 void setup() {
5     Serial.begin(115200);
6     Serial.println(String("\nESP32S3 initialization completed! \r\n")
7                     + String("Please input some characters, \r\n")
8                     + String("select \"Newline\" below and Ctrl + Enter to send message to
9 ESP32S3. \r\n"));
10 }
11
12 void loop() {
13     if (Serial.available()) { // judge whether data has been received
14         char inChar = Serial.read(); // read one character
15         inputString += inChar;
16         if (inChar == '\n') {
17             stringComplete = true;
18         }
19         if (stringComplete) {
20             Serial.printf("inputString: %s \n", inputString);
21             inputString = "";
22             stringComplete = false;
23         }
24     }
}

```

In loop(), determine whether the serial port has data, if so, read and save the data, and if the newline character is read, print out all the data that has been read.

Reference

String();

Constructs an instance of the String class.

For more information, please visit

<https://www.arduino.cc/reference/en/language/variables/data-types/stringobject/>

int available(void);

Get the number of bytes (characters) available for reading from the serial port. This is data that's already arrived and stored in the serial receive buffer.

Serial.read();

Reads incoming serial data.

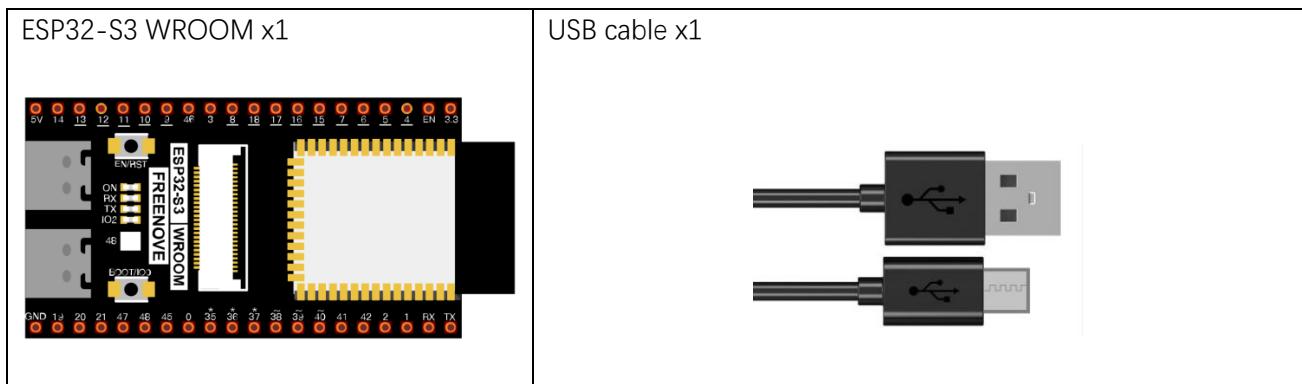


Chapter 3 Bluetooth

This chapter mainly introduces how to make simple data transmission through Bluetooth of ESP32-S3 WROOM and mobile phones.

Project 3.1 Bluetooth Low Energy Data Passthrough

Component List



Component knowledge

ESP32-S3's integrated Bluetooth function Bluetooth is a short-distance communication system, which can be divided into two types, namely Bluetooth Low Energy(BLE) and Classic Bluetooth. There are two modes for simple data transmission: master mode and slave mode.

Master mode

In this mode, works are done in the master device and it can connect with a slave device. And we can search and select slave devices nearby to connect with. When a device initiates connection request in master mode, it requires information of the other Bluetooth devices including their address and pairing passkey. After finishing pairing, it can connect with them directly.

Slave mode

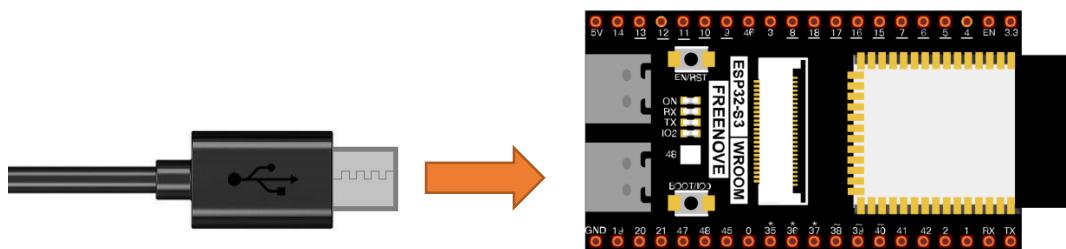
The Bluetooth module in slave mode can only accept connection request from a host computer, but cannot initiate a connection request. After connecting with a host device, it can send data to or receive from the host device.

Bluetooth devices can make data interaction with each other, as one is in master mode and the other in slave mode. When they are making data interaction, the Bluetooth device in master mode searches and selects devices nearby to connect to. When establishing connection, they can exchange data. When mobile phones exchange data with ESP32-S3, they are usually in master mode and ESP32-S3 in slave mode.



Circuit

Connect Freenove ESP32-S3 to the computer using the USB cable.



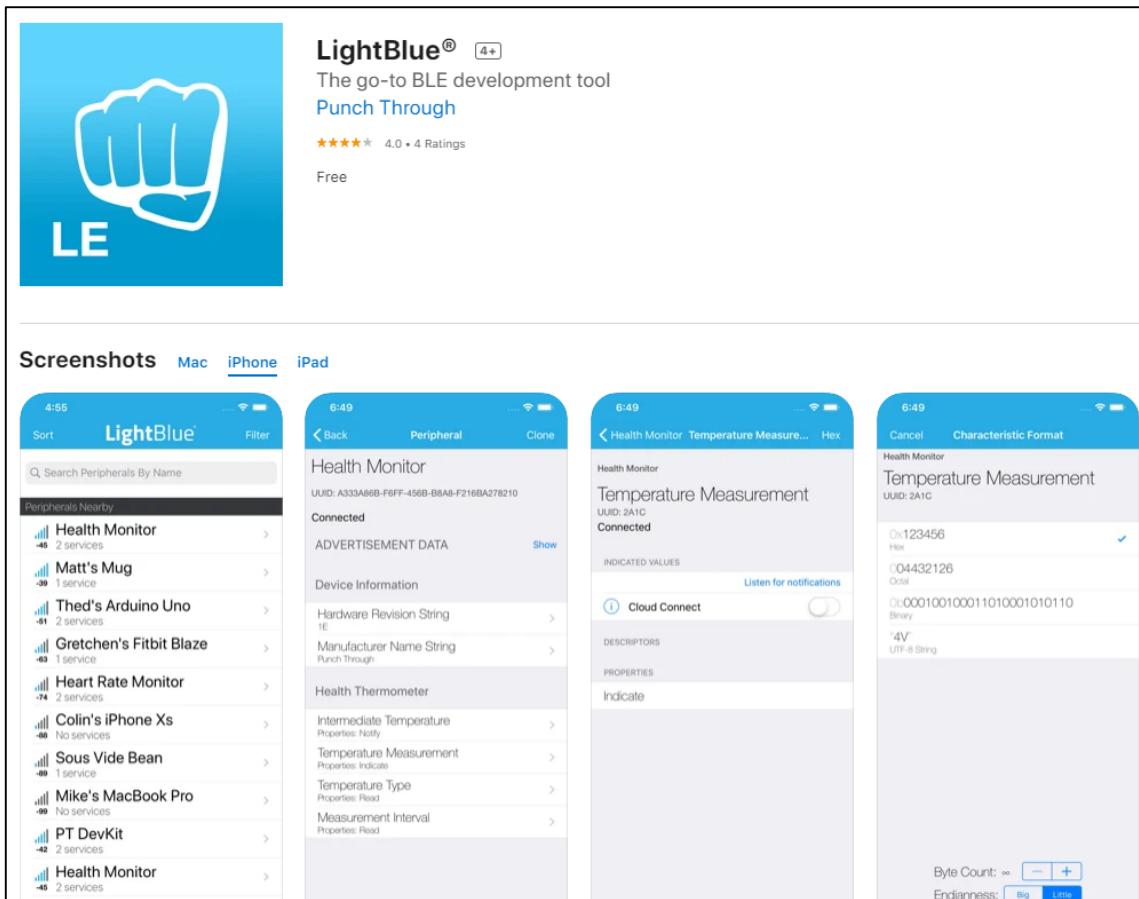


Sketch

Lightblue

If you can't install Serial Bluetooth on your phone, try LightBlue. If you do not have this software installed on your phone, you can refer to this link:

<https://apps.apple.com/us/app/lightblue/id557428110#?platform=iphone.>



Step1. Upload the code of Project 3.1 to ESP32-S3.

Step2. Click on serial monitor.

```

Sketch_27.1_BLE_USART | Arduino IDE 2.0.0
File Edit Sketch Tools Help
ESP32S3 Dev Module
Sketch_27.1_BLE_USART.ino ...
1
2
1 void setup() {
2   Serial.begin(115200);
3   setupBLE("ESP32S3_Bluetooth");
4
5 void loop() {
6   long now = millis();
7   if (now - lastMsg > 100) {
8     if (deviceConnected&&rxload.length()>0) {
9       Serial.println(rxload);
10      rxload="";
11    }
12    if(Serial.available()>0){
13      String str=Serial.readString();
14      const char *newValue=str.c_str();
15      pCharacteristic->setValue(newValue);
16      pCharacteristic->notify();
17    }
18  }
19}

```

Output

```

Writing at 0x000c3cbb... (90 %)
Writing at 0x000ca597... (93 %)
Writing at 0x000d1d07... (96 %)
Writing at 0x000d7497... (100 %)
Wrote 834752 bytes (503948 compressed) at 0x00010000 in 11.8 seconds (effective 567.5 kbit/s)...
Hash of data verified.

Leaving...
Hard resetting via RTS pin...

```

Ln 80, Col 1 UTF-8 ESP32S3 Dev Module on COM3 3

Step3. Set baud rate to 115200.

Output Serial Monitor ×

Message (Ctrl + Enter to send message to 'ESP32S3 Dev Module' on 'COM3')

New Line 115200 baud

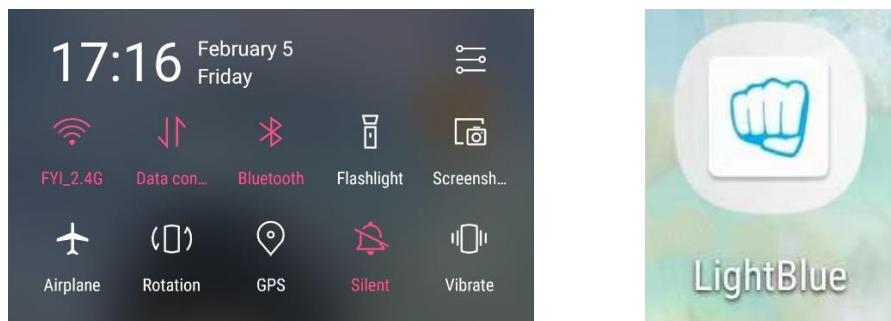
```

ESP-ROM: esp32s3-20210327
Build: Mar 27 2021
rst:0x1 (POWERON), boot:0x28 (SPI_FAST_FLASH_BOOT)
SPIWP:0xee
mode:DIO, clock div:1
load:0x3fce3808, len:0x43c
load:0x403c9700, len:0xbec
load:0x403cc700, len:0x2a3c
entry 0x403c98d8
Waiting a client connection to notify...

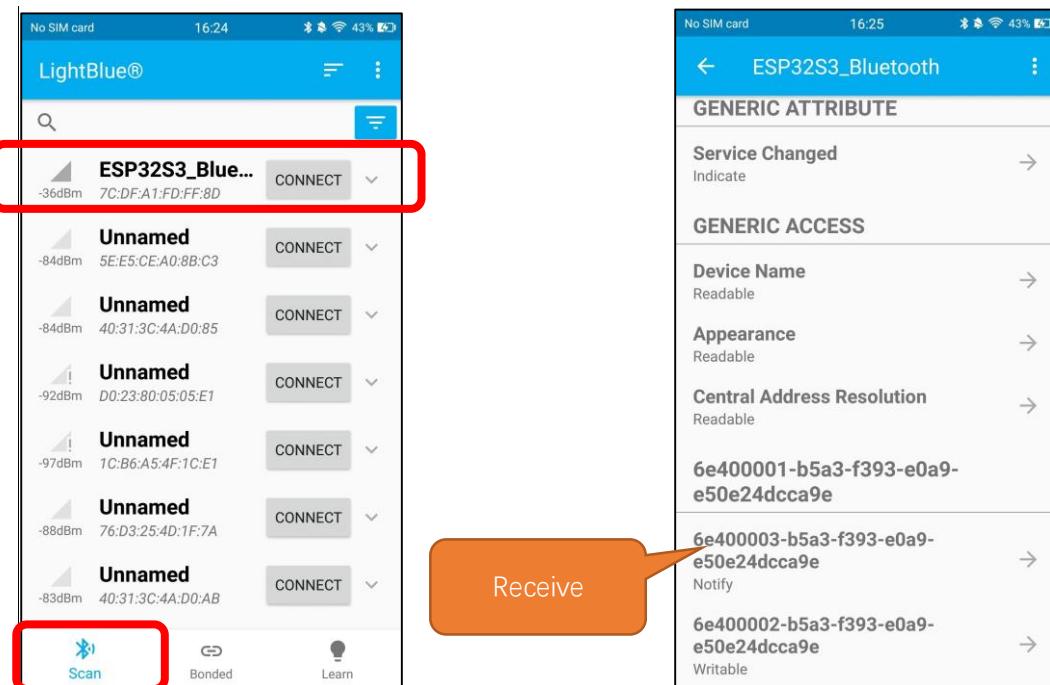
```

3

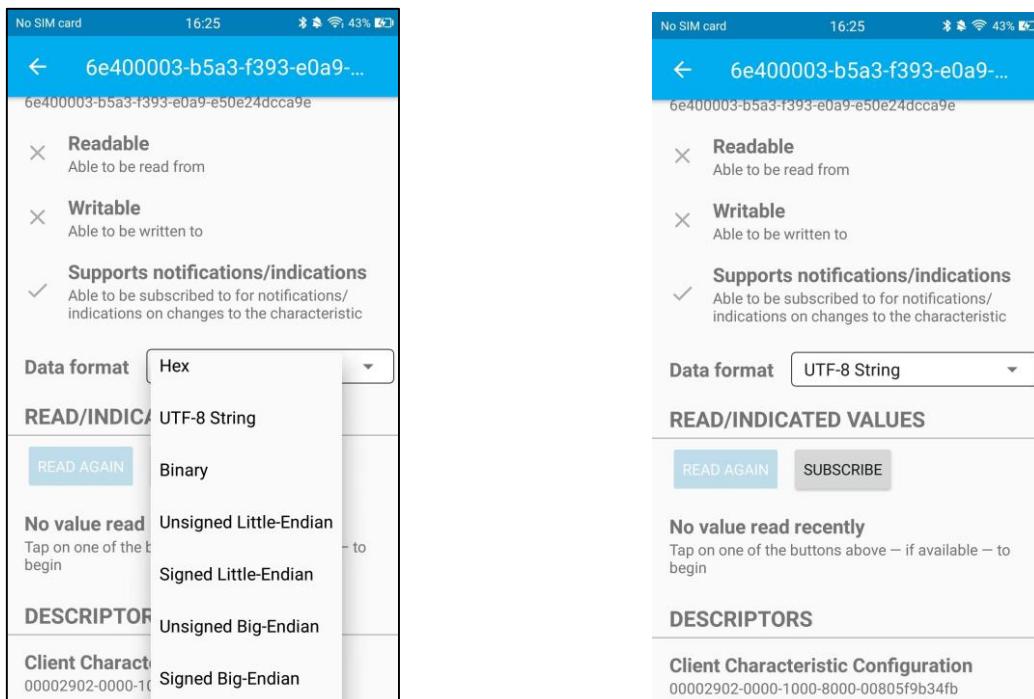
Turn ON Bluetooth on your phone, and open the Lightblue APP.



In the Scan page, swipe down to refresh the name of Bluetooth that the phone searches for. Click ESP32S3_Bluetooth.



Click “Receive”. Select the appropriate Data format in the box to the right of Data Format. For example, HEX for hexadecimal, utf-string for character, Binary for Binary, etc. Then click SUBSCRIBE.



Back to the serial monitor on your computer. You can type anything in the left border of Send, and then click Send.

The screenshot shows the Serial Monitor window with the following configuration:

- Output** tab is selected.
- Serial Monitor** tab is visible.
- Send** input field contains the text **Hello**.
- Options** include **New Line** and **115200 baud**.

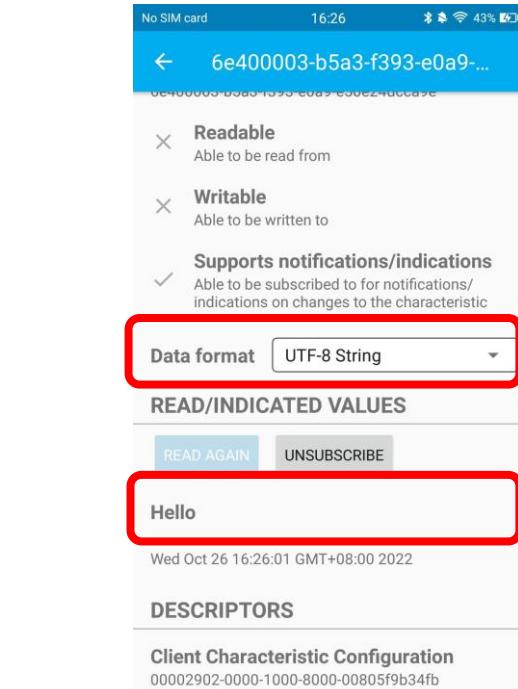
The main window displays the following output from the ESP32:

```

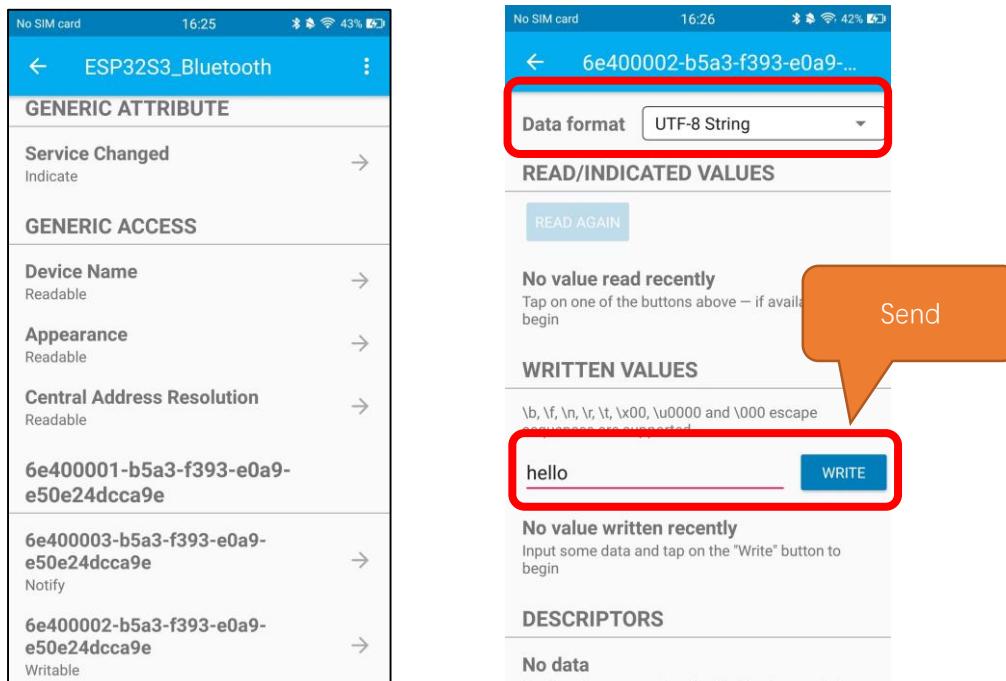
ESP-ROM: esp32s3-20210327
Build: Mar 27 2021
rst:0x1 (POWERON), boot:0x28 (SPI_FAST_FLASH_BOOT)
SPIWP:0xee
mode:DIO, clock div:1
load:0x3fce3808, len:0x43c
load:0x403c9700, len:0xbec
load:0x403cc700, len:0x2a3c
entry 0x403c98d8
Waiting a client connection to notify...
Test

```

And then you can see the mobile Bluetooth has received the message.



Similarly, you can select “Send” on your phone. Set Data format, and then enter anything in the sending box and click Write to send.



And the computer will receive the message from the mobile Bluetooth.

The screenshot shows a Serial Monitor window with the following details:

- Output** tab is selected.
- Serial Monitor** tab is visible.
- Message** input field: "Message (Ctrl + Enter to send message to 'ESP32S3 Dev Module' on 'COM3')".
- Baud Rate**: 115200 baud.
- Text Output:**

```
ESP-ROM: esp32s3-20210327
Build: Mar 27 2021
rst:0x1 (POWERON),boot:0x28 (SPI_FAST_FLASH_BOOT)
SPIWP:0xee
mode:DIO, clock div:1
load:0x3fce3808, len:0x43c
load:0x403c9700, len:0xbec
load:0x403cc700, len:0x2a3c
entry 0x403c98d8
Waiting a client connection to notify...
Test

hello
```
- Status Bar:** Ln 80, Col 1 | UTF-8 | ESP32S3 Dev Module on COM3 | 3 messages |

And now data can be transferred between your mobile phone and computer via ESP32-S3 WROOM.

The following is the program code:

```
1 #include <BLEDevice.h>
2 #include <BLEServer.h>
3 #include <BLEUtils.h>
4 #include <BLE2902.h>
5
6 BLECharacteristic *pCharacteristic;
7 bool deviceConnected = false;
8 uint8_t txValue = 0;
9 long lastMsg = 0;
10 String rxload="Test\n";
11
12 #define SERVICE_UUID "6E400001-B5A3-F393-E0A9-E50E24DCCA9E"
13 #define CHARACTERISTIC_UUID_RX "6E400002-B5A3-F393-E0A9-E50E24DCCA9E"
14 #define CHARACTERISTIC_UUID_TX "6E400003-B5A3-F393-E0A9-E50E24DCCA9E"
15
16 class MyServerCallbacks: public BLEServerCallbacks {
17     void onConnect(BLEServer* pServer) {
18         deviceConnected = true;
19     };
20     void onDisconnect(BLEServer* pServer) {
21         deviceConnected = false;
22     }
23 };
24
25 class MyCallbacks: public BLECharacteristicCallbacks {
26     void onWrite(BLECharacteristic *pCharacteristic) {
27         String rxValue = pCharacteristic->getValue();
28         if (rxValue.length() > 0) {
29             rxload="";
30             for (int i = 0; i < rxValue.length(); i++) {
31                 rxload +=(char)rxValue[i];
32             }
33         }
34     }
35 };
36
37 void setupBLE(String BLEName) {
38     const char *ble_name=BLEName.c_str();
39     BLEDevice::init(ble_name);
40     BLEServer *pServer = BLEDevice::createServer();
41     pServer->setCallbacks(new MyServerCallbacks());
42     BLEService *pService = pServer->createService(SERVICE_UUID);
```

```
43     pCharacteristic=  
44     pService->createCharacteristic(CHARACTERISTIC_UUID_TX,BLECharacteristic::PROPERTY_NOTIFY);  
45     pCharacteristic->addDescriptor(new BLE2902());  
46     BLECharacteristic *pCharacteristic =  
47     pService->createCharacteristic(CHARACTERISTIC_UUID_RX,BLECharacteristic::PROPERTY_WRITE);  
48     pCharacteristic->setCallbacks(new MyCallbacks());  
49     pService->start();  
50     pServer->getAdvertising()->start();  
51     Serial.println("Waiting a client connection to notify...");  
52 }  
53  
54 void setup() {  
55     Serial.begin(115200);  
56     setupBLE("ESP32S3_Bluetooth");  
57 }  
58  
59 void loop() {  
60     long now = millis();  
61     if (now - lastMsg > 1000) {  
62         if (deviceConnected&&rxload.length()>0) {  
63             Serial.println(rxload);  
64             rxload="";  
65         }  
66         if(Serial.available()>0){  
67             String str=Serial.readString();  
68             const char *newValue=str.c_str();  
69             pCharacteristic->setValue(newValue);  
70             pCharacteristic->notify();  
71         }  
72         lastMsg = now;  
73     }  
74 }
```

Define the specified UUID number for BLE vendor.

```
12 #define SERVICE_UUID          "6E400001-B5A3-F393-E0A9-E50E24DCCA9E"  
13 #define CHARACTERISTIC_UUID_RX "6E400002-B5A3-F393-E0A9-E50E24DCCA9E"  
14 #define CHARACTERISTIC_UUID_TX "6E400003-B5A3-F393-E0A9-E50E24DCCA9E"
```



Write a Callback function for BLE server to manage connection of BLE.

```

16 class MyServerCallbacks: public BLEServerCallbacks {
17     void onConnect(BLEServer* pServer) {
18         deviceConnected = true;
19     };
20     void onDisconnect(BLEServer* pServer) {
21         deviceConnected = false;
22     }
23 };

```

Write Callback function with BLE features. When it is called, as the mobile terminal send data to ESP32-S3, it will store them into reload.

```

25 class MyCallbacks: public BLECharacteristicCallbacks {
26     void onWrite(BLECharacteristic *pCharacteristic) {
27         String rxValue = pCharacteristic->getValue();
28         if (rxValue.length() > 0) {
29             rxload="";
30             for (int i = 0; i < rxValue.length(); i++) {
31                 rxload +=(char)rxValue[i];
32             }
33         }
34     }
35 };

```

Initialize the BLE function and name it.

```
54 setupBLE("ESP32S3_Bluetooth");
```

When the mobile phone send data to ESP32-S3 via BLE Bluetooth, it will print them out with serial port;

When the serial port of ESP32-S3 receive data, it will send them to mobile via BLE Bluetooth.

```

58 long now = millis();
59 if (now - lastMsg > 1000) {
60     if (deviceConnected&&rxload.length()>0) {
61         Serial.println(rxload);
62         rxload="";
63     }
64     if(Serial.available()>0) {
65         String str=Serial.readString();
66         const char *newValue=str.c_str();
67         pCharacteristic->setValue(newValue);
68         pCharacteristic->notify();
69     }
70     lastMsg = now;
71 }

```

The design for creating the BLE server is:

1. Create a BLE Server
2. Create a BLE Service
3. Create a BLE Characteristic on the Service
4. Create a BLE Descriptor on the characteristic
5. Start the service.
6. Start advertising.

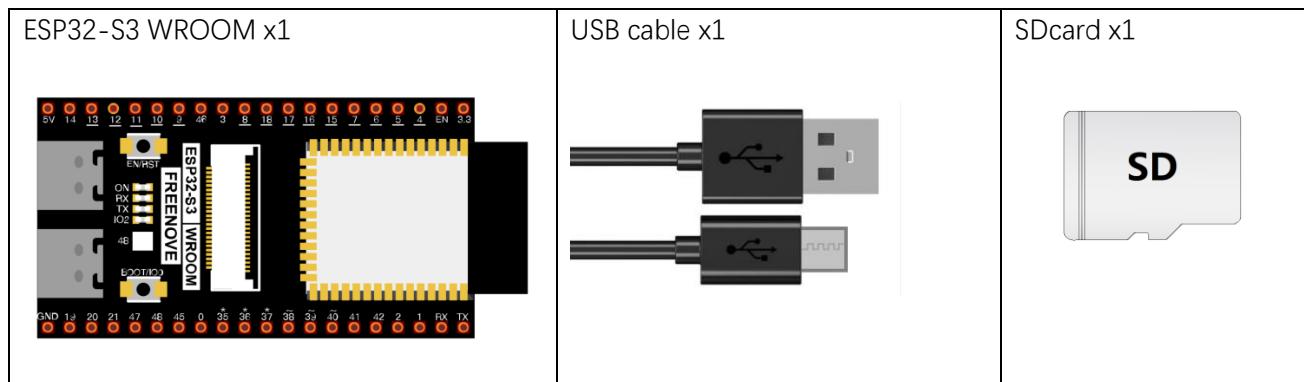
```
37 void setupBLE(String BLEName) {  
38     const char *ble_name=BLEName.c_str();  
39     BLEDevice::init(ble_name);  
40     BLEServer *pServer = BLEDevice::createServer();  
41     pServer->setCallbacks(new MyServerCallbacks());  
42     BLEService *pService = pServer->createService(SERVICE_UUID);  
43     pCharacteristic=  
44         pService->createCharacteristic(CHARACTERISTIC_UUID_TX,BLECharacteristic::PROPERTY_NOTIFY);  
45     pCharacteristic->addDescriptor(new BLE2902());  
46     BLECharacteristic *pCharacteristic =  
47         pService->createCharacteristic(CHARACTERISTIC_UUID_RX,BLECharacteristic::PROPERTY_WRITE);  
48     pCharacteristic->setCallbacks(new MyCallbacks());  
49     pService->start();  
50     pServer->getAdvertising()->start();  
51     Serial.println("Waiting a client connection to notify...");  
52 }
```

Chapter 4 Read and Write the SDcard

An SDcard slot is integrated on the back of the ESP32-S3 WROOM. In this chapter we learn how to use ESP32-S3 to read and write SDcard.

Project 4.1 SDMMC Test

Component List



Component knowledge

SD card read and write method

ESP32-S3 has two ways to use SD card, one is to use the SPI interface to access the SD card, and the other is to use the SDMMC interface to access the SD card. SPI mode uses 4 IOs to access SD card. The SDMMC has one-bit bus mode and four-bit bus mode. In one-bit bus mode, SDMMC use 3 IOs to access SD card. In four-bit bus mode, SDMMC uses 6 IOs to access the SD card.

The above three methods can all be used to access the SD card, the difference is that the access speed is different.

In the four-bit bus mode of SDMMC, the reading and writing speed of accessing the SD card is the fastest. In the one-bit bus mode of SDMMC, the access speed is about 80% of the four-bit bus mode. The access speed of SPI is the slowest, which is about 50% of the four-bit bus mode of SDMMC.

Usually, we recommend using the one-bit bus mode to access the SD card, because in this mode, we only need to use the least pin IO to access the SD card with good performance and speed.

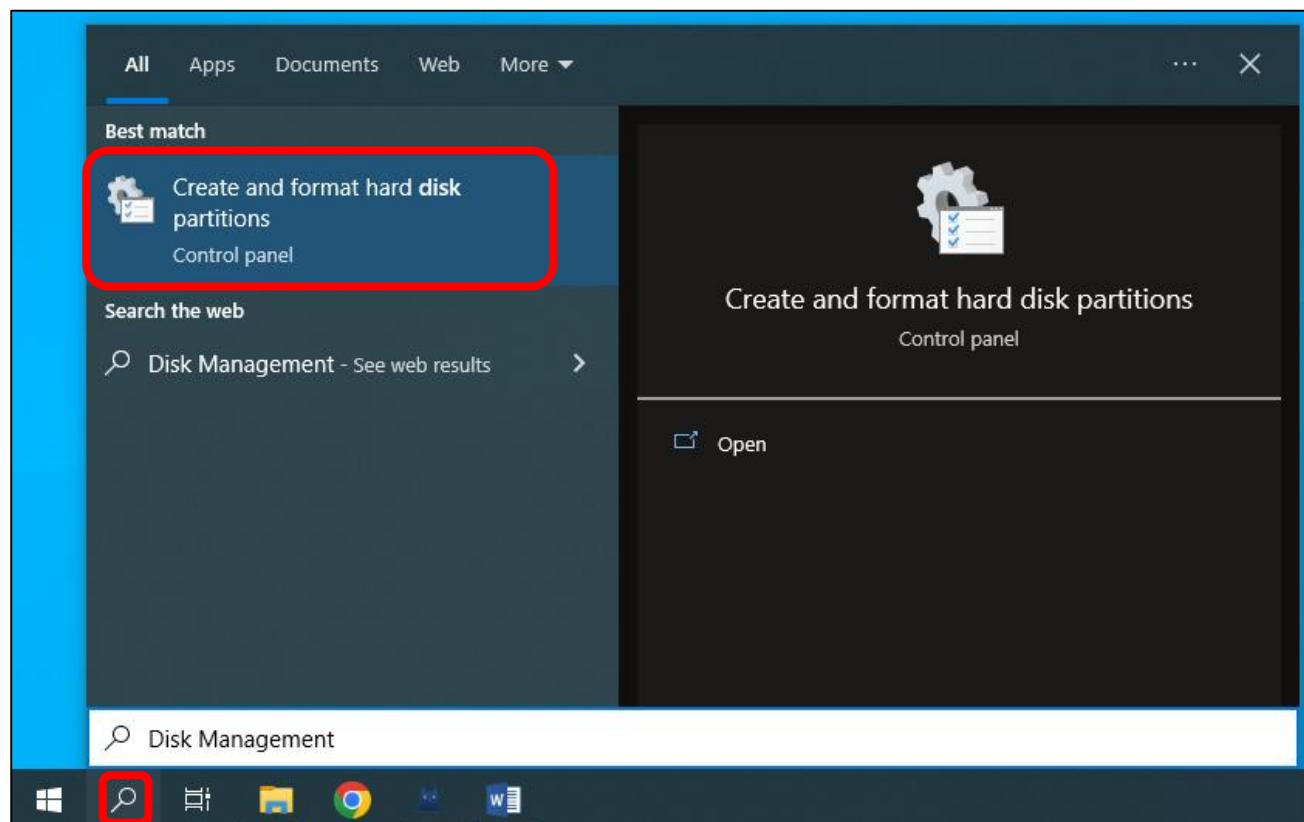
Format SD card

Before starting the tutorial, we need to create a drive letter for the blank SD card and format it. This step requires a card reader and SD card. Please prepare them in advance. Below we will guide you to do it on different computer systems. You can choose the guide that matches your computer.

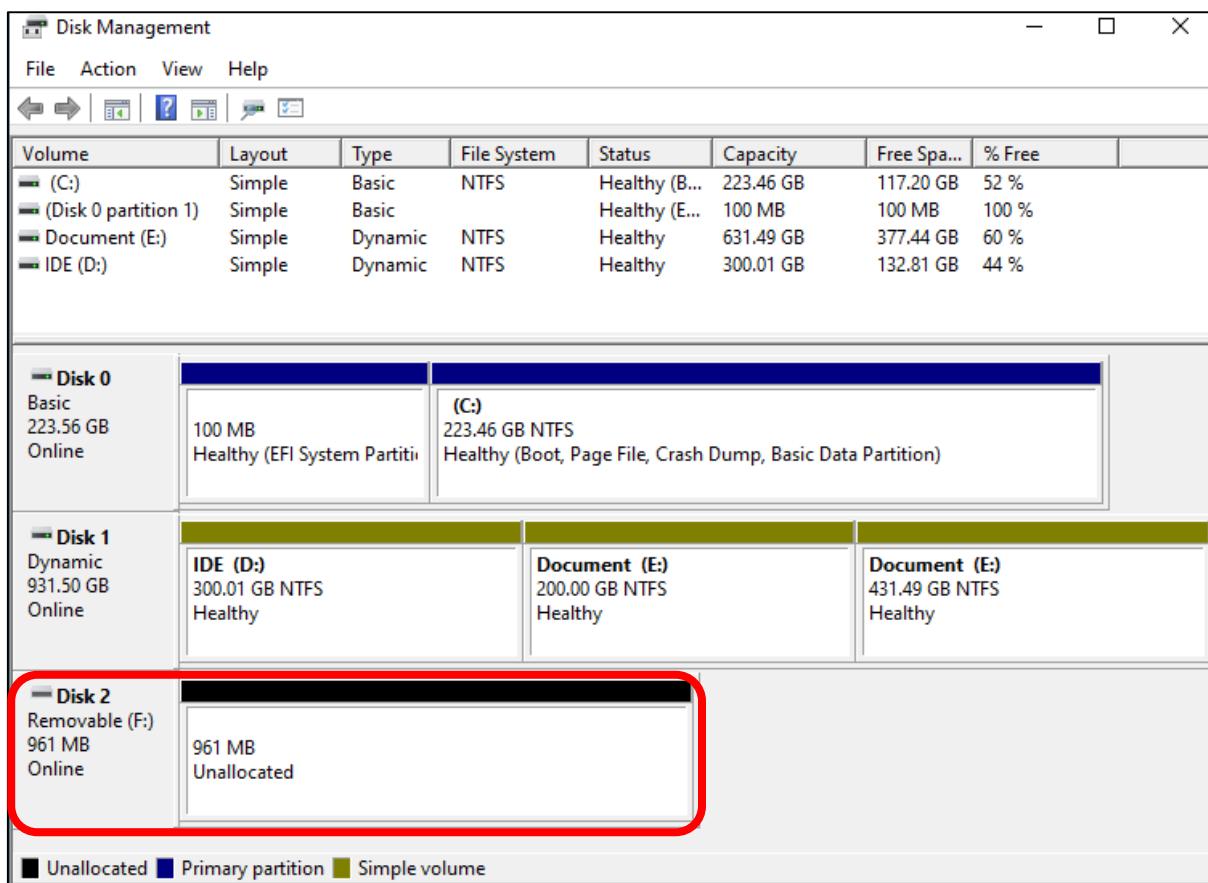
Windows

Insert the SD card into the card reader, then insert the card reader into the computer.

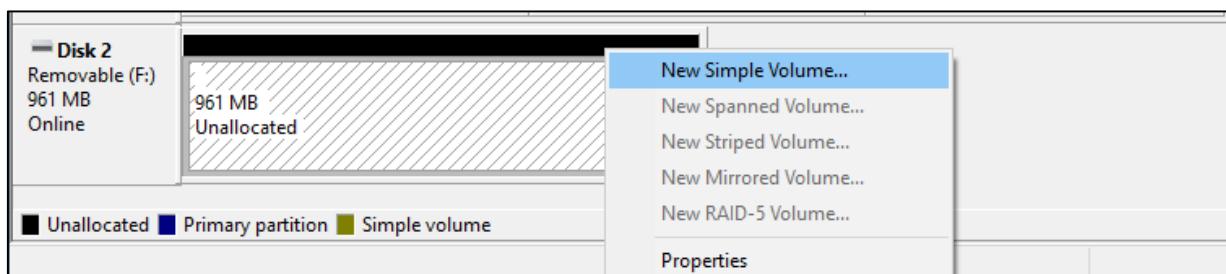
In the Windows search box, enter "Disk Management" and select "Create and format hard disk partitions".



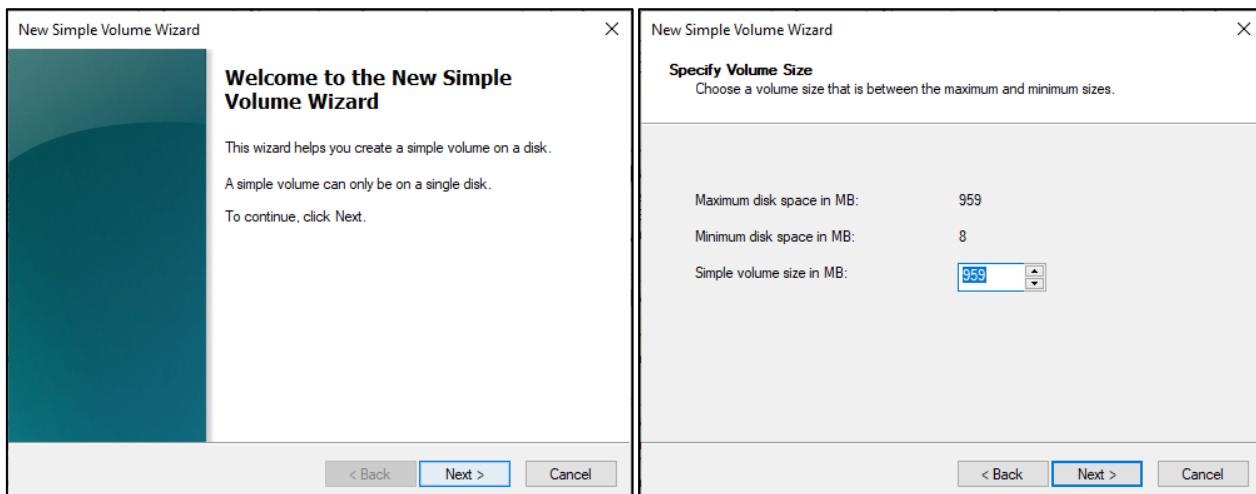
In the new pop-up window, find an unallocated volume close to 1G in size.



Click to select the volume, right-click and select "New Simple Volume".

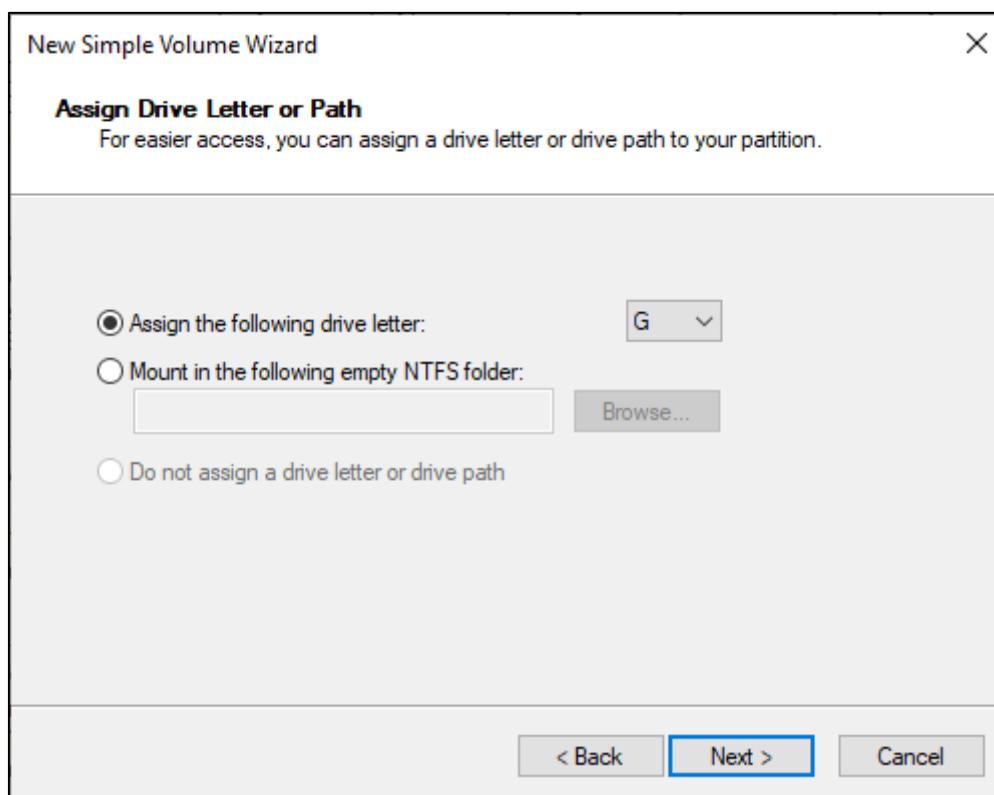


Click Next.

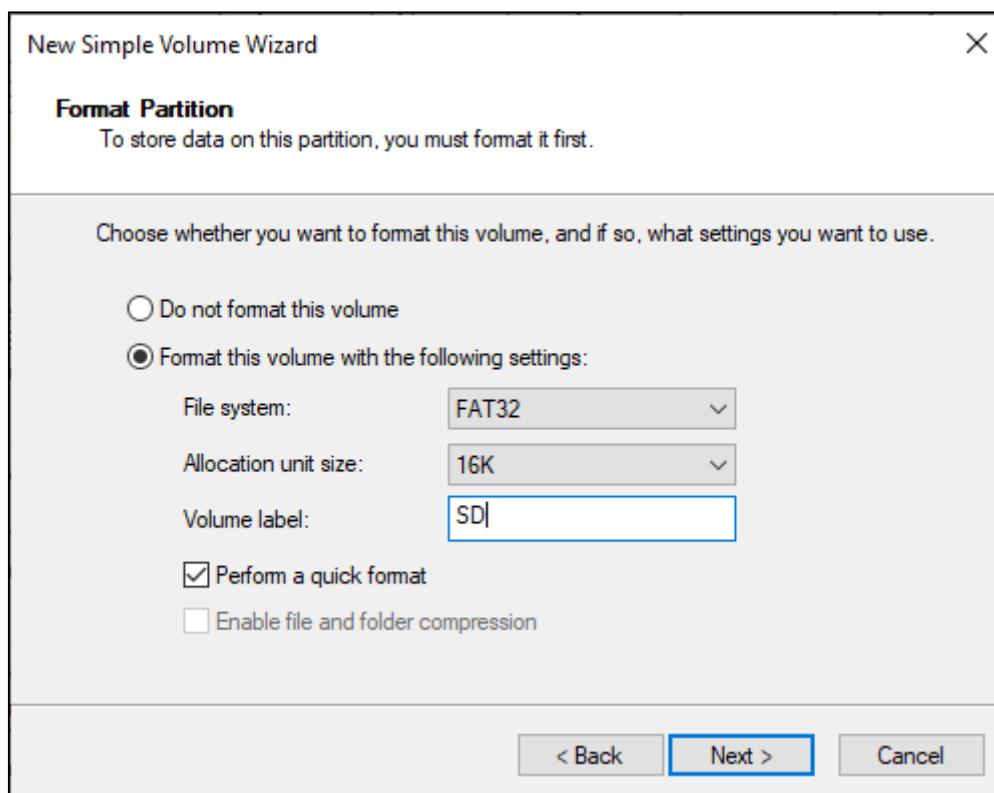


Any concerns? [✉ support@freenove.com](mailto:support@freenove.com)

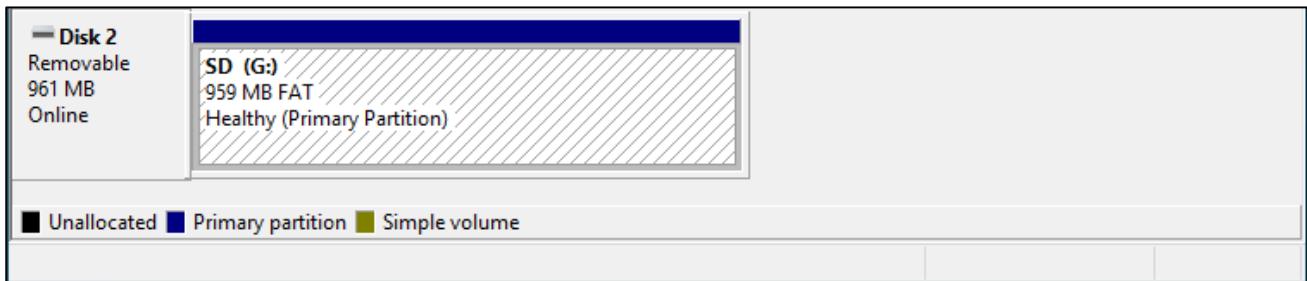
You can choose the drive letter on the right, or you can choose the default. By default, just click Next.



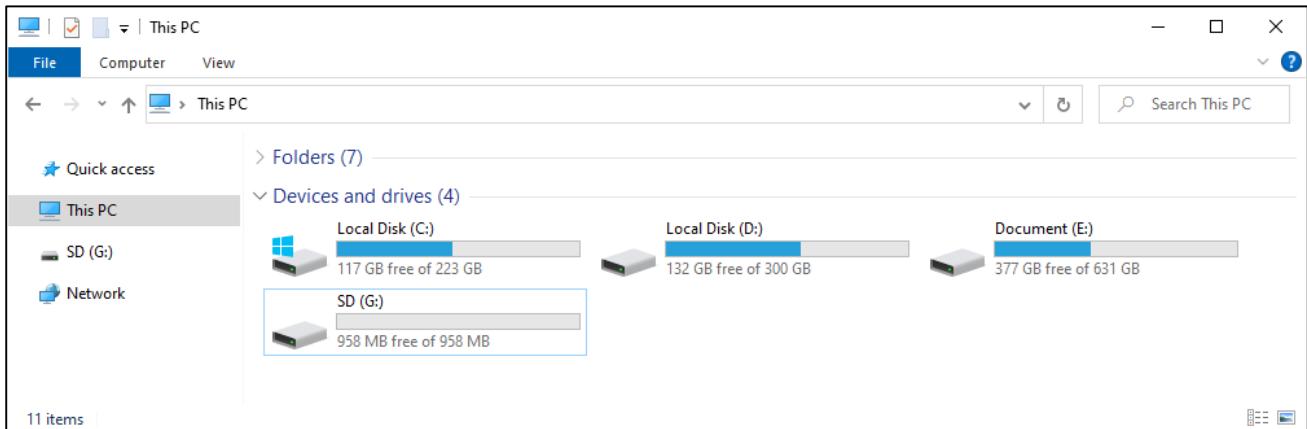
File system is FAT(or FAT32). The Allocation unit size is 16K, and the Volume label can be set to any name. After setting, click Next.



Click Finish. Wait for the SD card initialization to complete.

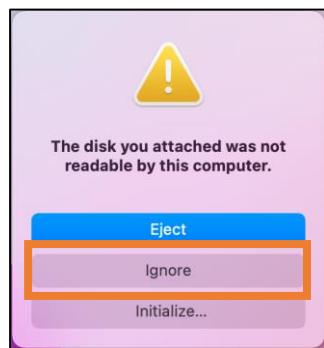


At this point, you can see the SD card in This PC.

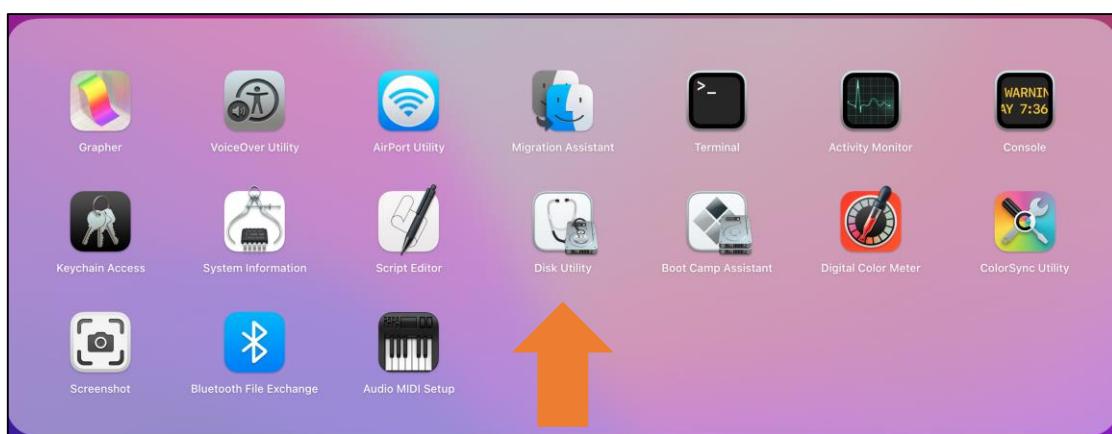


MAC

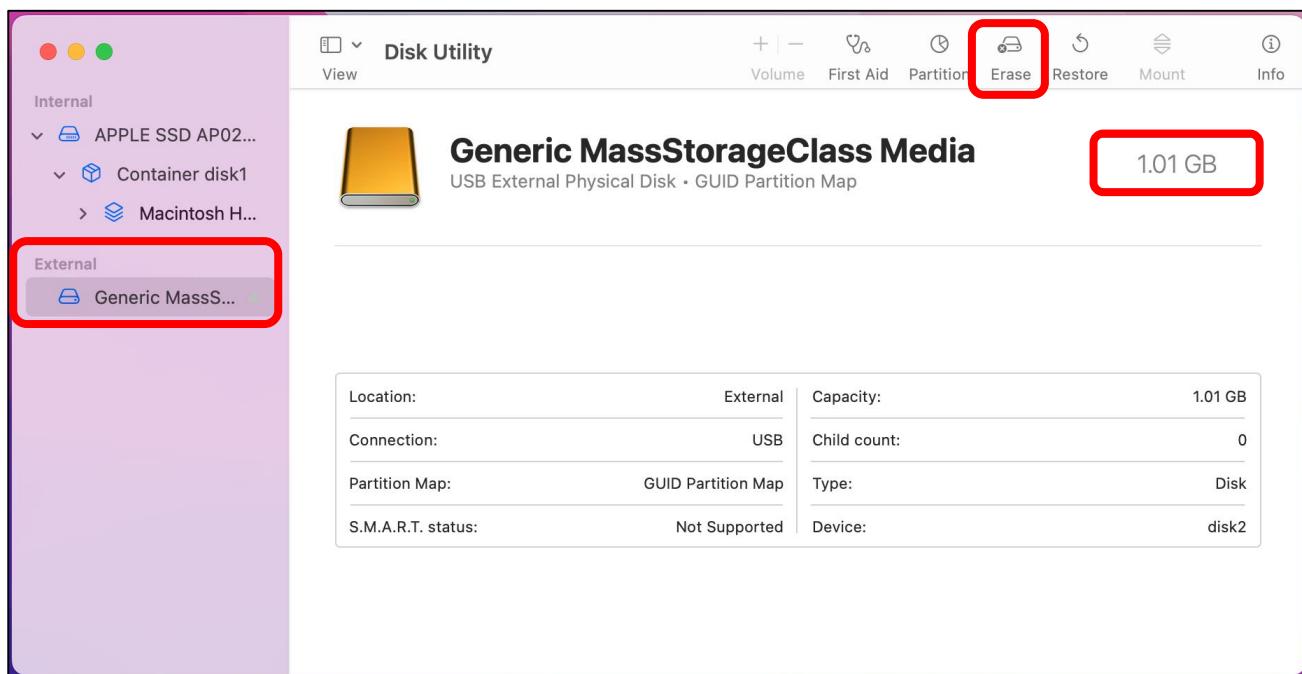
Insert the SD card into the card reader, then insert the card reader into the computer. Some computers will prompt the following information, please click to ignore it.



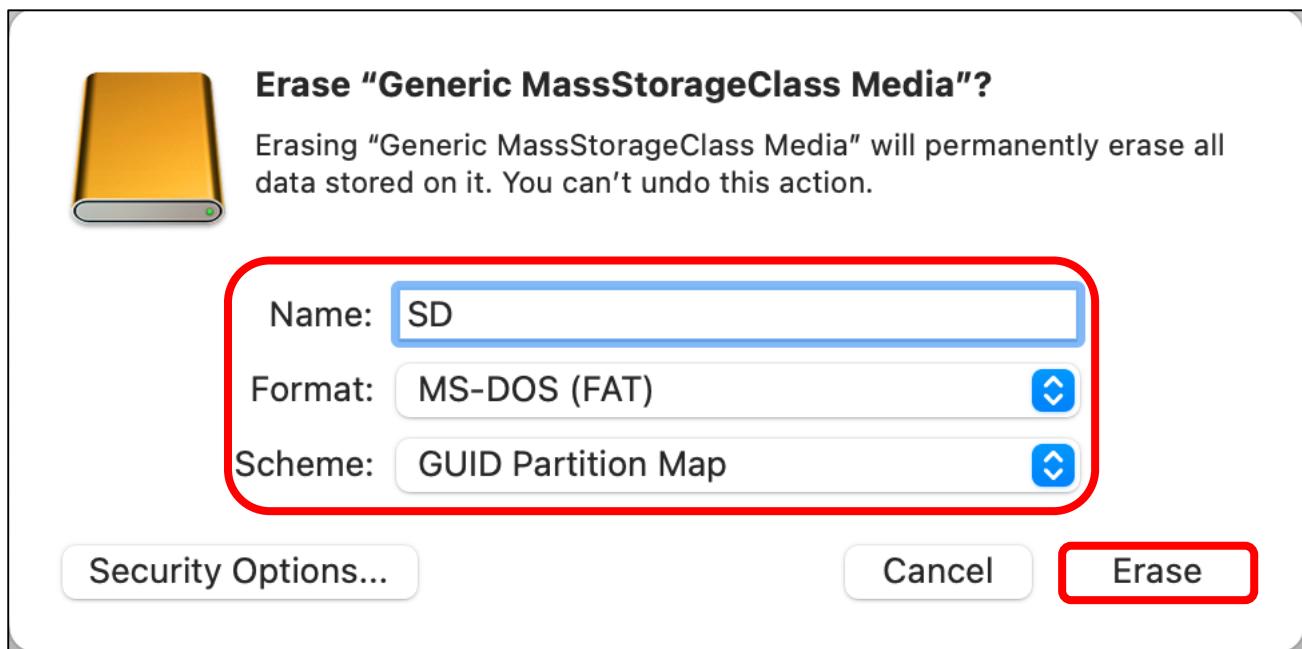
Find "Disk Utility" in the MAC system and click to open it.



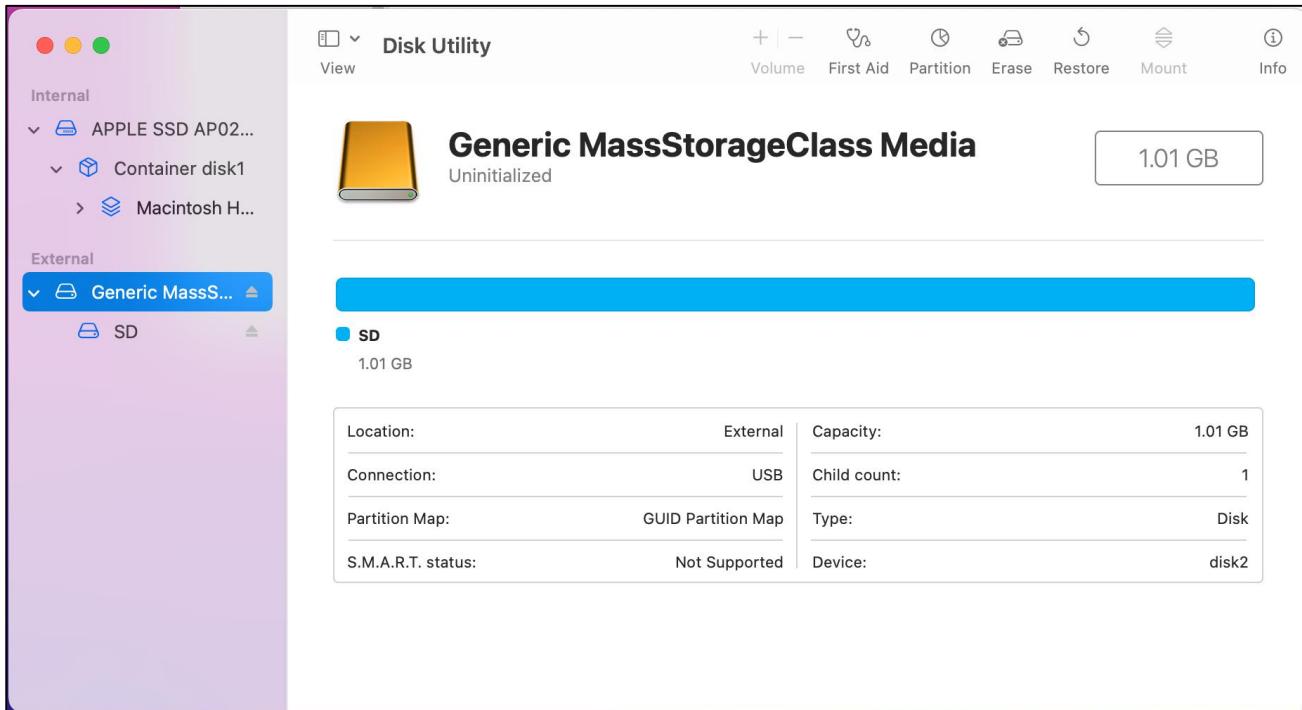
Select "Generic MassStorageClass Media", note that its size is about 1G. Please do not choose wrong item. Click "Erase".



Select the configuration as shown in the figure below, and then click "Erase".

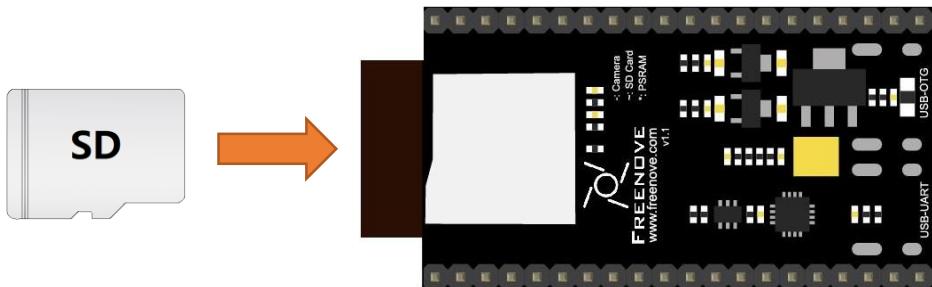


Wait for the formatting to complete. When finished, it will look like the picture below. At this point, you can see a new disk on the desktop named "SD".

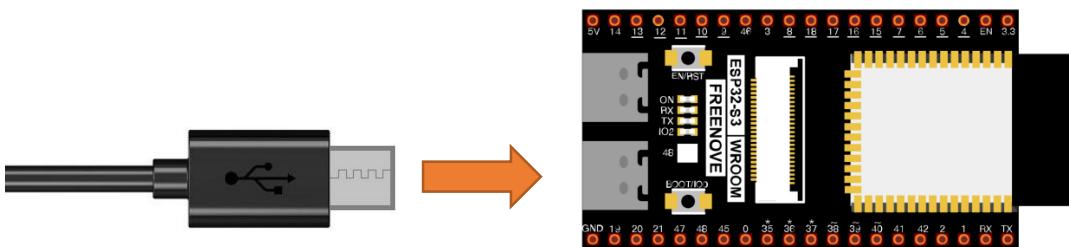


Circuit

Before connecting the USB cable, insert the SD card into the SD card slot on the back of the ESP32-S3.



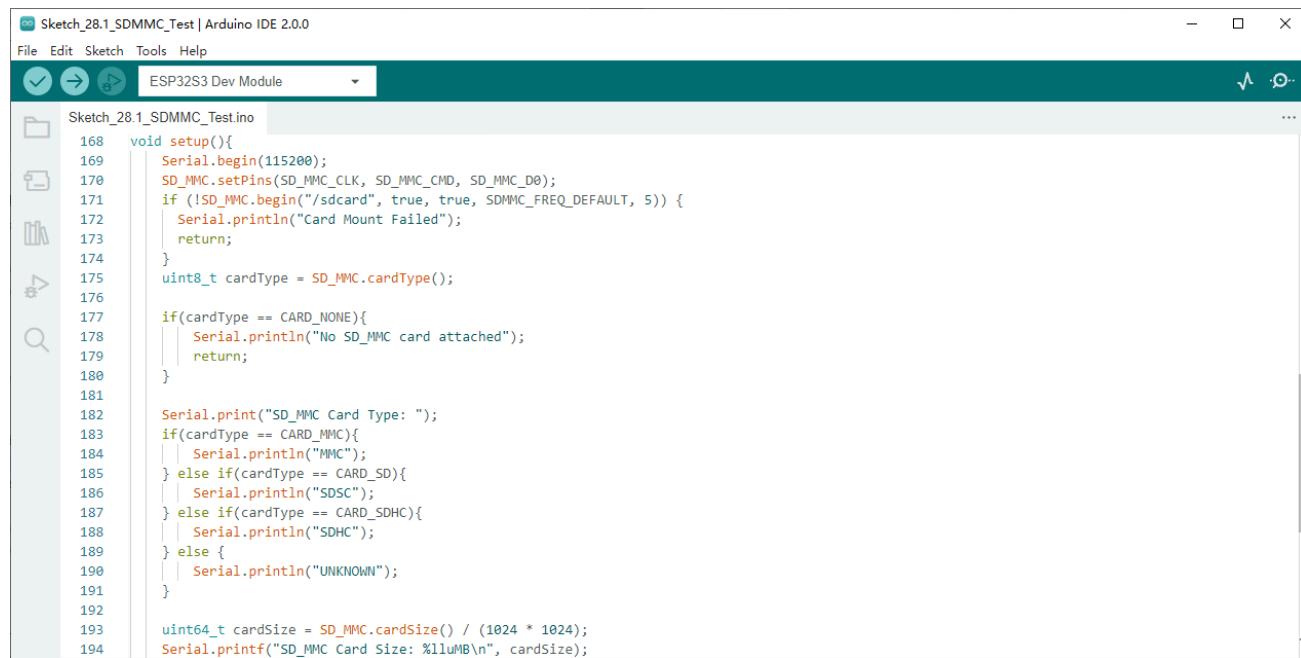
Connect Freenove ESP32-S3 to the computer using the USB cable.



Any concerns?  support@freenove.com

Sketch

Sketch_04.1_SDMMC_Test



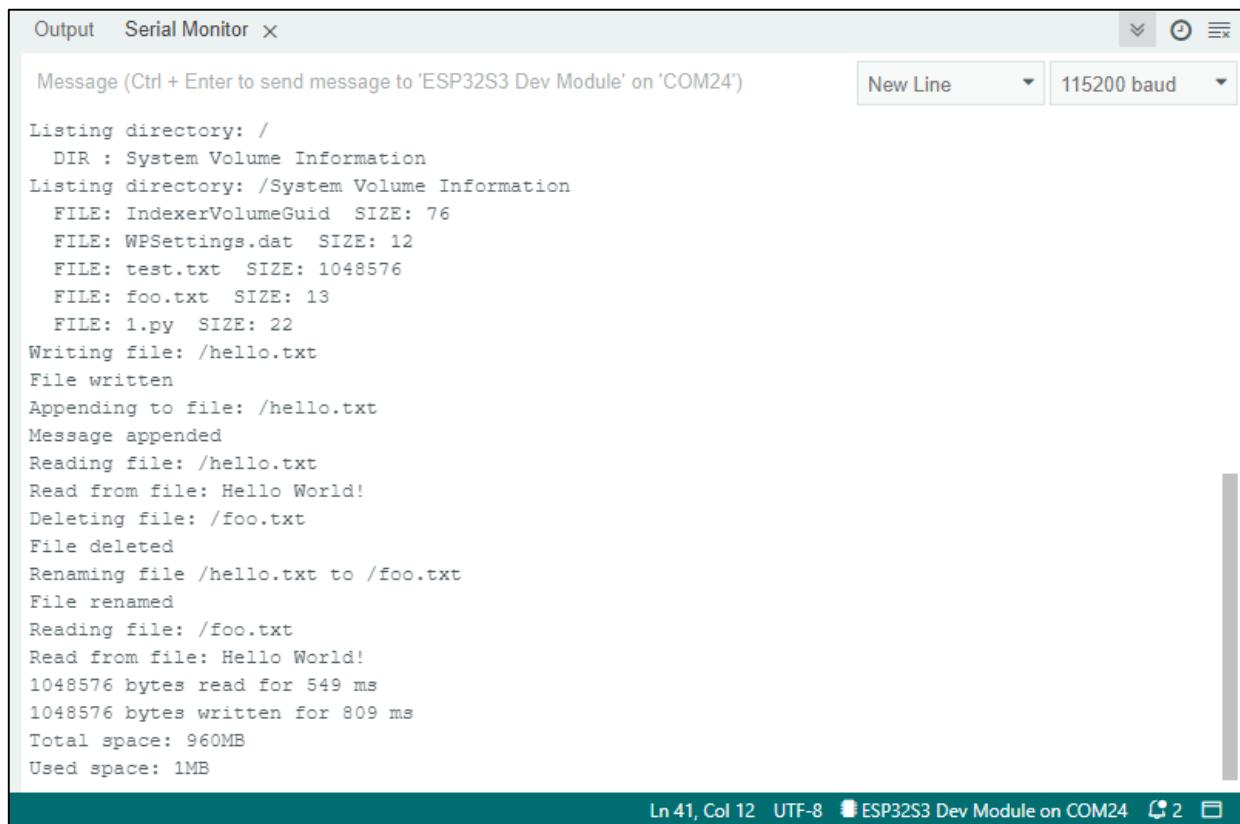
The screenshot shows the Arduino IDE interface with the following details:

- Title Bar:** Sketch_04.1_SDMMC_Test | Arduino IDE 2.0.0
- Menu Bar:** File Edit Sketch Tools Help
- Toolbar:** Includes icons for Save, Run, Stop, and others.
- Board Selector:** Set to ESP32S3 Dev Module
- Code Area:** Displays the `Sketch_04.1_SDMMC_Test.ino` file content. The code is as follows:

```
Sketch_04.1_SDMMC_Test.ino
168 void setup(){
169     Serial.begin(115200);
170     SD_MMC.setPins(SD_MMC_CLK, SD_MMC_CMD, SD_MMC_D0);
171     if (!SD_MMC.begin("/sdcard", true, true, SDMMC_FREQ_DEFAULT, 5)) {
172         Serial.println("Card Mount Failed");
173         return;
174     }
175     uint8_t cardType = SD_MMC.cardType();
176
177     if(cardType == CARD_NONE){
178         Serial.println("No SD_MMC card attached");
179         return;
180     }
181
182     Serial.print("SD_MMC Card Type: ");
183     if(cardType == CARD_MMC){
184         Serial.println("MMC");
185     } else if(cardType == CARD_SD){
186         Serial.println("SDSC");
187     } else if(cardType == CARD_SDHC){
188         Serial.println("SDHC");
189     } else {
190         Serial.println("UNKNOWN");
191     }
192
193     uint64_t cardSize = SD_MMC.cardSize() / (1024 * 1024);
194     Serial.printf("SD_MMC Card Size: %lluMB\n", cardSize);
```

Compile and upload the code to ESP32-S3-WROOM, open the serial monitor, and press the RST button on the board.

You can see the printout as shown below.



The screenshot shows the Serial Monitor window with the following output:

```
Message (Ctrl + Enter to send message to 'ESP32S3 Dev Module' on 'COM24')
New Line 115200 baud

Listing directory: /
DIR : System Volume Information
Listing directory: /System Volume Information
FILE: IndexerVolumeGuid SIZE: 76
FILE: WPSettings.dat SIZE: 12
FILE: test.txt SIZE: 1048576
FILE: foo.txt SIZE: 13
FILE: 1.py SIZE: 22
Writing file: /hello.txt
File written
Appending to file: /hello.txt
Message appended
Reading file: /hello.txt
Read from file: Hello World!
Deleting file: /foo.txt
File deleted
Renaming file /hello.txt to /foo.txt
File renamed
Reading file: /foo.txt
Read from file: Hello World!
1048576 bytes read for 549 ms
1048576 bytes written for 809 ms
Total space: 960MB
Used space: 1MB
```

Ln 41, Col 12 UTF-8 ESP32S3 Dev Module on COM24

The following is the program code:

```
1 #include "sd_read_write.h"
2 #include "SD_MMC.h"
3
4 #define SD_MMC_CMD 38 //Please do not modify it.
5 #define SD_MMC_CLK 39 //Please do not modify it.
6 #define SD_MMC_DO 40 //Please do not modify it.
7
8 void setup() {
9     Serial.begin(115200);
10    SD_MMC.setPins(SD_MMC_CLK, SD_MMC_CMD, SD_MMC_DO);
11    if (!SD_MMC.begin("/sdcard", true, true, SDMMC_FREQ_DEFAULT, 5)) {
12        Serial.println("Card Mount Failed");
13        return;
14    }
15    uint8_t cardType = SD_MMC.cardType();
16    if(cardType == CARD_NONE) {
17        Serial.println("No SD_MMC card attached");
18        return;
19    }
20    Serial.print("SD_MMC Card Type: ");
21    if(cardType == CARD_MMC) {
22        Serial.println("MMC");
23    } else if(cardType == CARD_SD) {
24        Serial.println("SDSC");
25    } else if(cardType == CARD_SDHC) {
26        Serial.println("SDHC");
27    } else {
28        Serial.println("UNKNOWN");
29    }
30
31    uint64_t cardSize = SD_MMC.cardSize() / (1024 * 1024);
32    Serial.printf("SD_MMC Card Size: %lluMB\n", cardSize);
33
34    listDir(SD_MMC, "/", 0);
35
36    createDir(SD_MMC, "/mydir");
37    listDir(SD_MMC, "/", 0);
38
39    removeDir(SD_MMC, "/mydir");
40    listDir(SD_MMC, "/", 2);
41
42    writeFile(SD_MMC, "/hello.txt", "Hello ");
43    appendFile(SD_MMC, "/hello.txt", "World!\n");
```

Any concerns? ✉ support@freenove.com

```

44     readFile(SD_MMC, "/hello.txt");
45
46     deleteFile(SD_MMC, "/foo.txt");
47     renameFile(SD_MMC, "/hello.txt", "/foo.txt");
48     readFile(SD_MMC, "/foo.txt");
49
50     testFileIO(SD_MMC, "/test.txt");
51
52     Serial.printf("Total space: %luMB\r\n", SD_MMC.totalBytes() / (1024 * 1024));
53     Serial.printf("Used space: %luMB\r\n", SD_MMC.usedBytes() / (1024 * 1024));
54 }
55
56 void loop() {
57     delay(10000);
58 }
```

Add the SD card drive header file.

```

1 #include "sd_read_write.h"
2 #include "SD_MMC.h"
```

Defines the drive pins of the SD card. Please do not modify it. Because these pins are fixed.

```

4 #define SD_MMC_CMD 38 //Please do not modify it.
5 #define SD_MMC_CLK 39 //Please do not modify it.
6 #define SD_MMC_DO 40 //Please do not modify it.
```

Initialize the serial port function. Sets the drive pin for SDMMC one-bit bus mode.

```

9     Serial.begin(115200);
10    SD_MMC.setPins(SD_MMC_CLK, SD_MMC_CMD, SD_MMC_DO);
```

Set the mount point of the SD card, set SDMMC to one-bit bus mode, and set the read and write speed to 20MHz.

```

11    if (!SD_MMC.begin("/sdcard", true, true, SDMMC_FREQ_DEFAULT, 5)) {
12        Serial.println("Card Mount Failed");
13        return;
14    }
```

Get the type of SD card and print it out through the serial port.

```

15    uint8_t cardType = SD_MMC.cardType();
16    if(cardType == CARD_NONE) {
17        Serial.println("No SD_MMC card attached");
18        return;
19    }
20    Serial.print("SD_MMC Card Type: ");
21    if(cardType == CARD_MMC) {
22        Serial.println("MMC");
23    } else if(cardType == CARD_SD) {
24        Serial.println("SDSC");
25    } else if(cardType == CARD_SDHC) {
26        Serial.println("SDHC");
```

```
27     } else {  
28         Serial.println("UNKNOWN");  
29     }
```

Call the listDir() function to read the folder and file names in the SD card, and print them out through the serial port. This function can be found in "sd_read_write.cpp".

```
34     listDir(SD_MMC, "/", 0);
```

Call createDir() to create a folder, and call removeDir() to delete a folder.

```
36     createDir(SD_MMC, "/mydir");  
39     removeDir(SD_MMC, "/mydir");
```

Call writeFile() to write any content to the txt file. If there is no such file, create this file first.

Call appendFile() to append any content to txt.

Call readFile() to read the content in txt and print it via the serial port.

```
42     writeFile(SD_MMC, "/hello.txt", "Hello ");  
43     appendFile(SD_MMC, "/hello.txt", "World!\n");  
44     readFile(SD_MMC, "/hello.txt");
```

Call deleteFile() to delete a specified file.

Call renameFile() to copy a file and rename it.

```
46     deleteFile(SD_MMC, "/foo.txt");  
47     renameFile(SD_MMC, "/hello.txt", "/foo.txt");
```

Call the testFileIO() function to test the time it takes to read 512 bytes and the time it takes to write 2048*512 bytes of data.

```
50     testFileIO(SD_MMC, "/test.txt");
```

Print the total size and used size of the SD card via the serial port.

```
52     Serial.printf("Total space: %lluMB\r\n", SD_MMC.totalBytes() / (1024 * 1024));  
53     Serial.printf("Used space: %lluMB\r\n", SD_MMC.usedBytes() / (1024 * 1024));
```



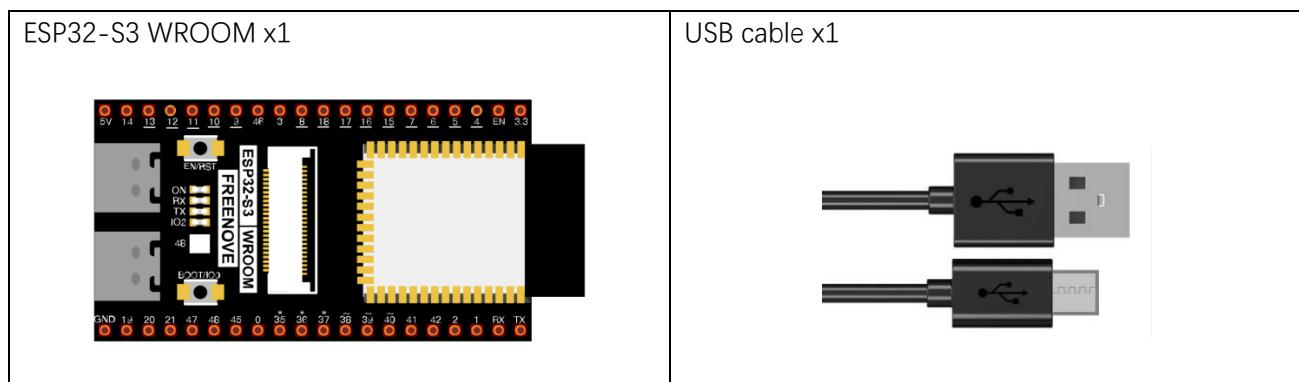
Chapter 5 WiFi Working Modes

In this chapter, we'll focus on the WiFi infrastructure for ESP32-S3 WROOM.

ESP32-S3 WROOM has 3 different WiFi operating modes: station mode, AP mode and AP+station mode. All WiFi programming projects must be configured with WiFi operating mode before using WiFi, otherwise WiFi cannot be used.

Project 5.1 Station mode

Component List



Component knowledge

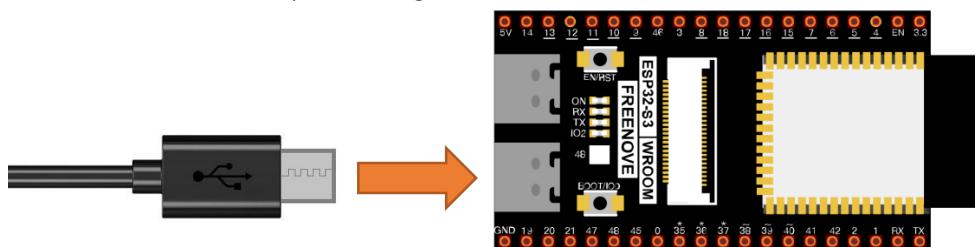
Station mode

When ESP32-S3 selects Station mode, it acts as a WiFi client. It can connect to the router network and communicate with other devices on the router via WiFi connection. As shown below, the PC is connected to the router, and if ESP32-S3 wants to communicate with the PC, it needs to be connected to the router.



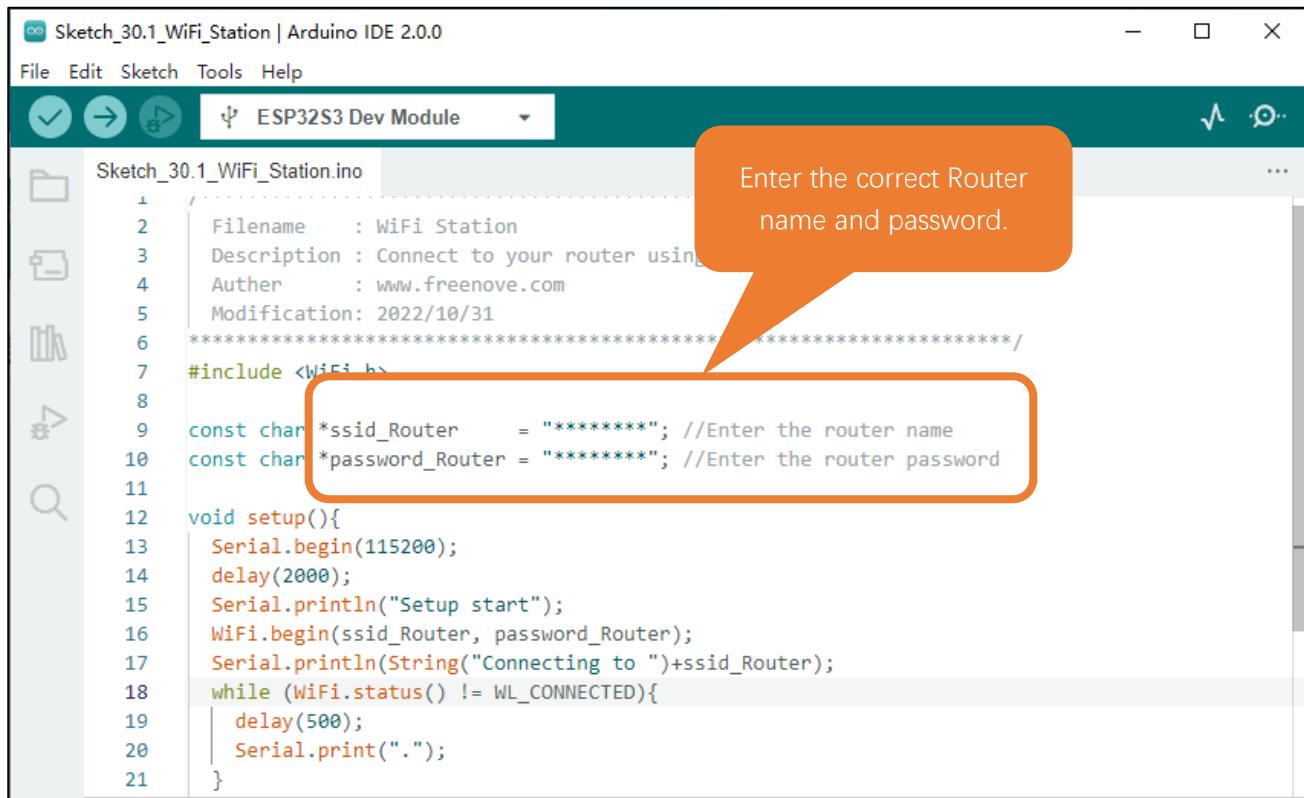
Circuit

Connect Freenove ESP32-S3 to the computer using the USB cable.



Sketch

Sketch_05.1_Station_mode



```

1 // Filename      : WiFi Station
2 Description   : Connect to your router using WiFi
3 Author        : www.freenove.com
4 Modification  : 2022/10/31
5
6 ****
7 #include <WiFi.h>
8
9 const char *ssid_Router      = "*****"; //Enter the router name
10 const char *password_Router = "*****"; //Enter the router password
11
12 void setup(){
13     Serial.begin(115200);
14     delay(2000);
15     Serial.println("Setup start");
16     WiFi.begin(ssid_Router, password_Router);
17     Serial.println(String("Connecting to ") +ssid_Router);
18     while (WiFi.status() != WL_CONNECTED){
19         delay(500);
20         Serial.print(".");
21     }

```

Enter the correct Router name and password.

Because the names and passwords of routers in various places are different, before the Sketch runs, users need to enter the correct router's name and password in the box as shown in the illustration above.

After making sure the router name and password are entered correctly, compile and upload codes to ESP32-S3 WROOM, open serial monitor and set baud rate to 115200. And then it will display as follows:



```

Output Serial Monitor ×
Message (Ctrl + Enter to send message to 'ESP32S3 Dev Module' on 'COM3') New Line 115200 baud
ESP-ROM: esp32s3-20210327
Build: Mar 27 2021
rst:0x1 (POWERON), boot:0x8 (SPI_FAST_FLASH_BOOT)
SPIWP:0xee
mode:DIO, clock div:1
load:0x3fce3808, len:0x43c
load:0x403c9700, len:0xbec
load:0x403cc700, len:0x2a3c
entry 0x403c98d8
Setup start
Connecting to FYI_2.4G

Connected, IP address:
192.168.1.233
Setup End

```

When ESP32-S3 WROOM successfully connects to "ssid_Router", serial monitor will print out the IP address assigned to ESP32-S3 WROOM by the router.

The following is the program code:

```

1 #include <WiFi.h>

2

3 const char *ssid_Router      = "*****"; //Enter the router name
4 const char *password_Router = "*****"; //Enter the router password

5

6 void setup() {
7     Serial.begin(115200);
8     delay(2000);
9     Serial.println("Setup start");
10    WiFi.begin(ssid_Router, password_Router);
11    Serial.println(String("Connecting to ") + ssid_Router);
12    while (WiFi.status() != WL_CONNECTED) {
13        delay(500);
14        Serial.print(".");
15    }
16    Serial.println("\nConnected, IP address: ");
17    Serial.println(WiFi.localIP());
18    Serial.println("Setup End");
19}
20
21 void loop() {
22}
```

Include the WiFi Library header file of ESP32-S3.

```
1 #include <WiFi.h>
```

Enter correct router name and password.

```
3 const char *ssid_Router      = "*****"; //Enter the router name
4 const char *password_Router = "*****"; //Enter the router password
```

Set ESP32-S3 in Station mode and connect it to your router.

```
10 WiFi.begin(ssid_Router, password_Router);
```

Check whether ESP32-S3 has connected to router successfully every 0.5s.

```
12 while (WiFi.status() != WL_CONNECTED) {
13     delay(500);
14     Serial.print(".");
15 }
```

Serial monitor prints out the IP address assigned to ESP32-S3 WROOM

```
17 Serial.println(WiFi.localIP());
```

Reference

Class Station

Every time when using WiFi, you need to include header file "WiFi.h".

begin(ssid, password,channel, bssid, connect): ESP32-S3 is used as Station to connect hotspot.

ssid: WiFi hotspot name

Any concerns? ✉ support@freenove.com

password: WiFi hotspot password
channel: WiFi hotspot channel number; communicating through specified channel; optional parameter
bssid: mac address of WiFi hotspot, optional parameter
connect: boolean optional parameter, defaulting to true. If set as false, then ESP32-S3 won't connect WiFi.
config(local_ip, gateway, subnet, dns1, dns2): set static local IP address.
 local_ip: station fixed IP address.
 subnet: subnet mask
 dns1,dns2: optional parameter. define IP address of domain name server
status: obtain the connection status of WiFi
local IP(): obtain IP address in Station mode
disconnect(): disconnect wifi
setAutoConnect(boolean): set automatic connection Every time ESP32-S3 is power on, it will connect WiFi automatically.
setAutoReconnect(boolean): set automatic reconnection Every time ESP32-S3 disconnects WiFi, it will reconnect to WiFi automatically.

Project 5.2 AP mode

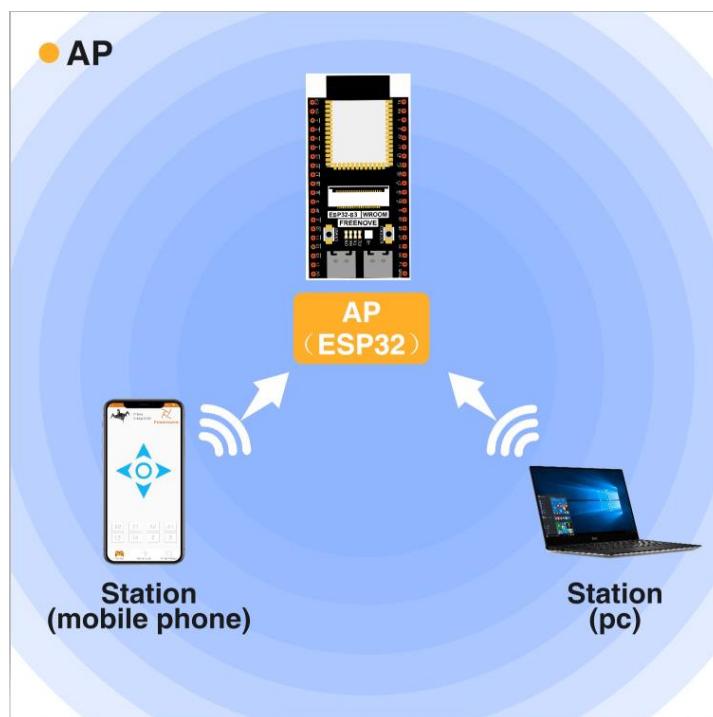
Component List & Circuit

Component List & Circuit are the same as in Project 5.1.

Component knowledge

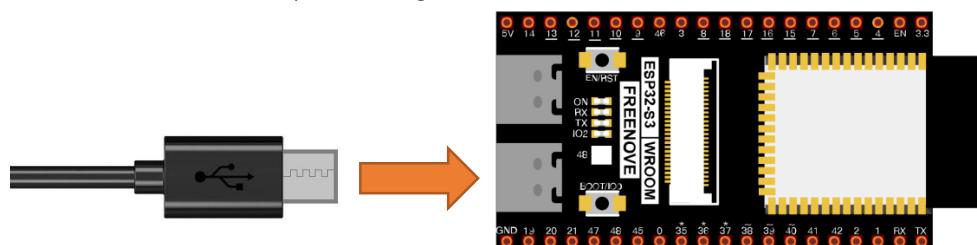
AP mode

When ESP32-S3 selects AP mode, it creates a hotspot network that is separate from the Internet and waits for other WiFi devices to connect. As shown in the figure below, ESP32-S3 is used as a hotspot. If a mobile phone or PC wants to communicate with ESP32-S3, it must be connected to the hotspot of ESP32-S3. Only after a connection is established with ESP32-S3 can they communicate.



Circuit

Connect Freenove ESP32-S3 to the computer using the USB cable.



Any concerns? ✉ support@freenove.com

Sketch

The screenshot shows the Arduino IDE interface with the following details:

- Title Bar:** Sketch_30.2_WiFi_AP | Arduino IDE 2.0.0
- Menu Bar:** File Edit Sketch Tools Help
- Toolbar:** Includes icons for Save, Run, Stop, and others.
- Sketch Area:** Displays the code for `Sketch_30.2_WiFi_AP.ino`. The code configures an ESP32 to act as a WiFi access point (AP). A callout bubble highlights the following lines:

```
9 const char *ssid_AP      = "WiFi_Name"; //Enter the router name
10 const char *password_AP = "12345678"; //Enter the router password
```
- Output Area:** Shows the serial monitor output during compilation:

```
Writing at 0x00086bd3... (84 %)
Writing at 0x0008c22f... (88 %)
Writing at 0x00094986... (92 %)
Writing at 0x0009cb02... (96 %)
Writing at 0x000a1dc0... (100 %)
Wrote 618112 bytes (407091 compressed) at 0x00010000 in 9.1 seconds (effective 543.9 kbit/s)...
Hash of data verified.

Leaving...
Hard resetting via RTS pin...
```
- Status Bar:** Ln 35, Col 14 UTF-8 ESP32S3 Dev Module on COM3 2

Before the Sketch runs, you can make any changes to the AP name and password for ESP32-S3 in the box as shown in the illustration above. Of course, you can leave it alone by default.

Compile and upload codes to ESP32-S3 WROOM, open the serial monitor and set the baud rate to 115200. And then it will display as follows.

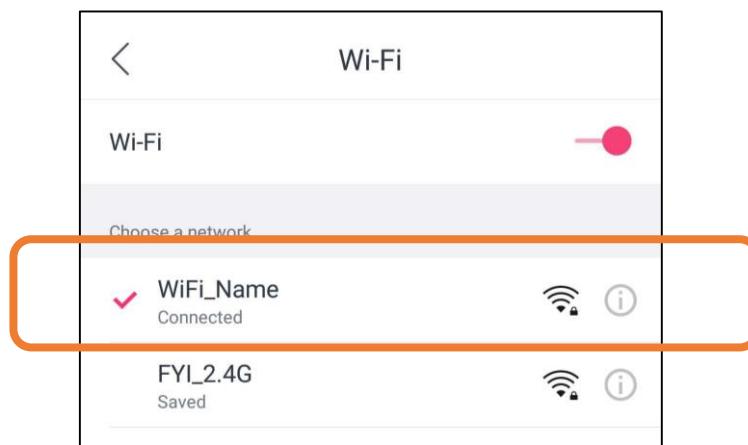


A screenshot of the Arduino Serial Monitor window. The title bar says "Output Serial Monitor X". The message area shows the following text:

```
Message (Ctrl + Enter to send message to 'ESP32S3 Dev Module' on 'COM3')
load: 0x403cc700, len: 0x2a3c
entry 0x403c98d8
Setting soft-AP configuration ...
Ready
Setting soft-AP ...
Ready
Soft-AP IP address = 192.168.1.100
MAC address = 7E:DF:A1:FD:FF:8C
Setup End
```

The status bar at the bottom right shows "Ln 35, Col 14 UTF-8" and "ESP32S3 Dev Module on COM3". There are also icons for a serial port and a refresh rate.

When observing the print information of the serial monitor, turn on the WiFi scanning function of your phone, and you can see the ssid_AP on ESP32-S3, which is called "WiFi_Name" in this Sketch. You can enter the password "12345678" to connect it or change its AP name and password by modifying Sketch.



Sketch_05_2_AP_mode

The following is the program code:

```

1 #include <WiFi.h>
2
3 const char *ssid_AP      = "WiFi_Name"; //Enter the router name
4 const char *password_AP = "12345678"; //Enter the router password
5
6 IPAddress local_IP(192, 168, 1, 100); //Set the IP address of ESP32-S3 itself
7 IPAddress gateway(192, 168, 1, 10); //Set the gateway of ESP32-S3 itself
8 IPAddress subnet(255, 255, 255, 0); //Set the subnet mask for ESP32-S3 itself
9
10 void setup() {
11     Serial.begin(115200);
12     delay(2000);
13     Serial.println("Setting soft-AP configuration ... ");
14     WiFi.disconnect();
15     WiFi.mode(WIFI_AP);
16     Serial.println(WiFi.softAPConfig(local_IP, gateway, subnet) ? "Ready" : "Failed!");
17     Serial.println("Setting soft-AP ... ");
18     boolean result = WiFi.softAP(ssid_AP, password_AP);
19     if(result){
20         Serial.println("Ready");
21         Serial.println(String("Soft-AP IP address = ") + WiFi.softAPIP().toString());
22         Serial.println(String("MAC address = ") + WiFi.softAPmacAddress().c_str());
23     }else{
24         Serial.println("Failed!");
25     }
26     Serial.println("Setup End");
27 }
28
29 void loop() {
30 }
```

Include WiFi Library header file of ESP32-S3.

```
1 #include <WiFi.h>
```

Enter correct AP name and password.

```

3 const char *ssid_AP      = "WiFi_Name"; //Enter the router name
4 const char *password_AP = "12345678"; //Enter the router password
```

Set ESP32-S3 in AP mode.

```
15 WiFi.mode(WIFI_AP);
```

Configure IP address, gateway and subnet mask for ESP32-S3.

```
16 WiFi.softAPConfig(local_IP, gateway, subnet)
```

Turn on an AP in ESP32-S3, whose name is set by ssid_AP and password is set by password_AP.

```
18 WiFi.softAP(ssid_AP, password_AP);
```

Check whether the AP is turned on successfully. If yes, print out IP and MAC address of AP established by ESP32-S3. If no, print out the failure prompt.

```
19 if(result){  
20     Serial.println("Ready");  
21     Serial.println(String("Soft-AP IP address = ") + WiFi.softAPIP().toString());  
22     Serial.println(String("MAC address = ") + WiFi.softAPmacAddress().c_str());  
23 }else{  
24     Serial.println("Failed!");  
25 }  
26 Serial.println("Setup End");
```

Reference

Class AP

Every time when using WiFi, you need to include header file "WiFi.h".

softAP(ssid, password, channel, ssid_hidden, max_connection):

ssid: WiFi hotspot name

password: WiFi hotspot password

channel: Number of WiFi connection channels, range 1-13. The default is 1.

ssid_hidden: Whether to hide WiFi name from scanning by other devices. The default is not hide.

max_connection: Maximum number of WiFi connected devices. The range is 1-4. The default is 4.

softAPConfig(local_ip, gateway, subnet): set static local IP address.

local_ip: station fixed IP address.

Gateway: gateway IP address

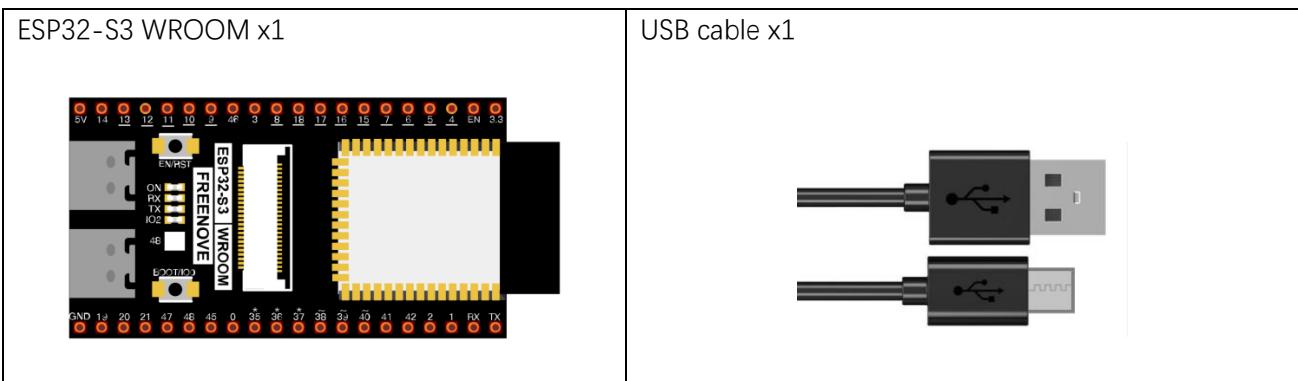
subnet: subnet mask

softAP(): obtain IP address in AP mode

softAPdisconnect (): disconnect AP mode.

Project 5.3 AP+Station mode

Component List



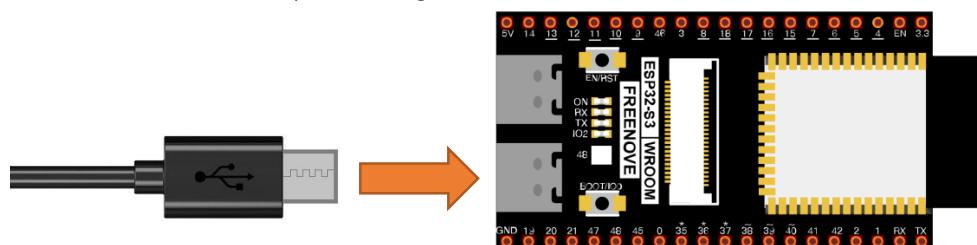
Component knowledge

AP+Station mode

In addition to AP mode and station mode, ESP32-S3 can also use AP mode and station mode at the same time. This mode contains the functions of the previous two modes. Turn on ESP32-S3's station mode, connect it to the router network, and it can communicate with the Internet via the router. At the same time, turn on its AP mode to create a hotspot network. Other WiFi devices can choose to connect to the router network or the hotspot network to communicate with ESP32-S3.

Circuit

Connect Freenove ESP32-S3 to the computer using the USB cable.



Sketch

Sketch_05.3_AP_Station_mode

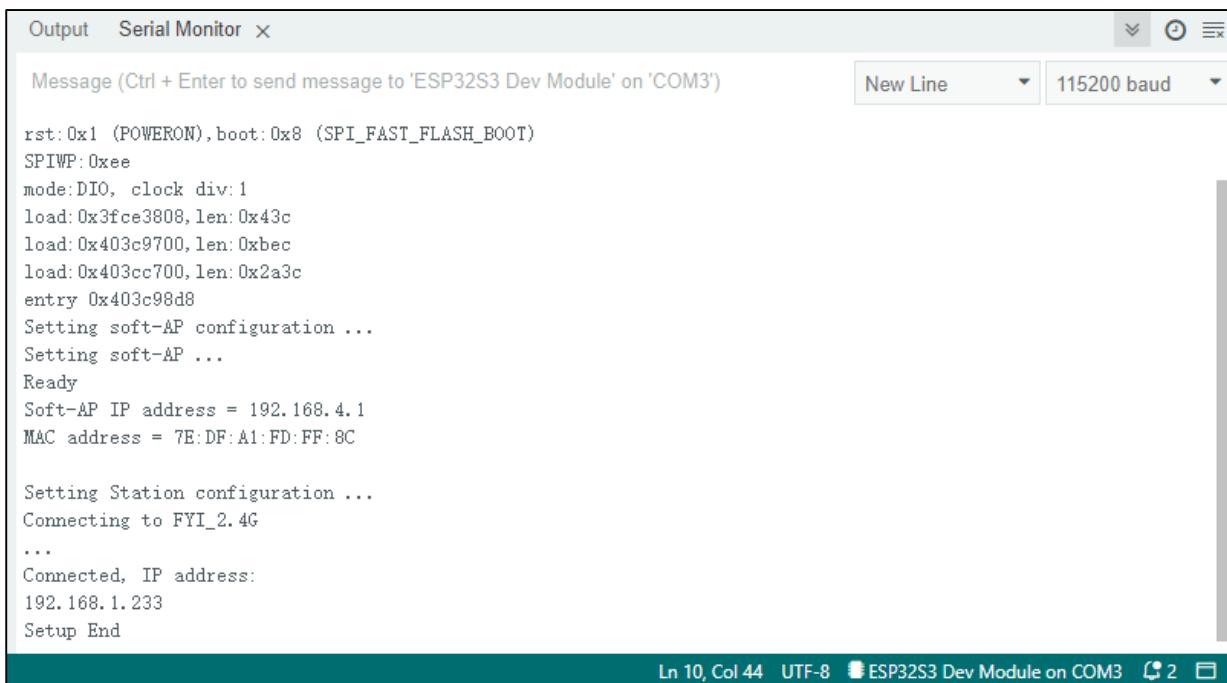
```

1  //*****
2  |   Filename    : WiFi AP+Station
3  |   Description : ESP32 connects to the u
4  |   Author     : www.freenove.com
5  |   Modification: 2022/10/31
6  *****/
7 #include <WiFi.h>
8
9 const char *ssid_Router      = "*****"; //Enter the router name
10 const char *password_Router = "*****"; //Enter the router password
11 const char *ssid_AP          = "WiFi_Name"; //Enter the router name
12 const char *password_AP      = "12345678"; //Enter the router password
13
14 void setup(){
15     Serial.begin(115200);
16     Serial.println("Setting soft-AP configuration ... ");
17     WiFi.disconnect();
18     WiFi.mode(WIFI_AP);
19     Serial.println("Setting soft-AP ... ");
20     boolean result = WiFi.softAP(ssid_AP, password_AP);
21     if(result){
22         Serial.println("Ready");
23         Serial.println(String("Soft-AP IP address = ") + WiFi.softAPIP().toString());
24         Serial.println(String("MAC address = ") + WiFi.softAPmacAddress().c_str());
25     }else{
26         Serial.println("Failed!");
27     }

```

It is analogous to Project 5.1 and Project 5.2. Before running the Sketch, you need to modify ssid_Router, password_Router, ssid_AP and password_AP shown in the box of the illustration above.

After making sure that Sketch is modified correctly, compile and upload codes to ESP32-S3 WROOM, open serial monitor and set baud rate to 115200. And then it will display as follows:



```

Output  Serial Monitor X

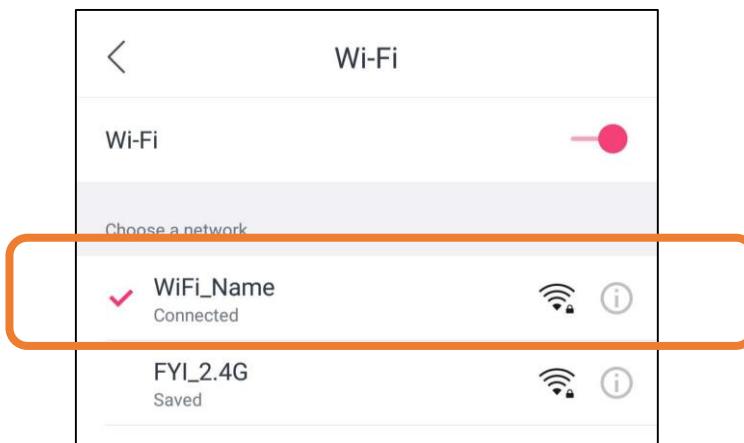
Message (Ctrl + Enter to send message to 'ESP32S3 Dev Module' on 'COM3')
rst:0x1 (POWERON), boot:0x8 (SPI_FAST_FLASH_BOOT)
SPIWP:0xee
mode:DIO, clock div:1
load:0x3fce3808, len:0x43c
load:0x403c9700, len:0xbec
load:0x403cc700, len:0x2a3c
entry 0x403c98d8
Setting soft-AP configuration ...
Setting soft-AP ...
Ready
Soft-AP IP address = 192.168.4.1
MAC address = 7E:DF:A1:FD:FF:8C

Setting Station configuration ...
Connecting to FYI_2.4G
...
Connected, IP address:
192.168.1.233
Setup End

Ln 10, Col 44  UTF-8  ■ ESP32S3 Dev Module on COM3  ↻ 2  □

```

When observing the print information of the serial monitor, turn on the WiFi scanning function of your phone, and you can see the ssid_AP on ESP32-S3.



The following is the program code:

```

1 #include <WiFi.h>
2
3 const char *ssid_Router      = "*****"; //Enter the router name
4 const char *password_Router = "*****"; //Enter the router password
5 const char *ssid_AP         = "WiFi_Name"; //Enter the AP name
6 const char *password_AP     = "12345678"; //Enter the AP password
7
8 void setup() {
9     Serial.begin(115200);
10    Serial.println("Setting soft-AP configuration ... ");

```

```
11 WiFi.disconnect();
12 WiFi.mode(WIFI_AP);
13 Serial.println("Setting soft-AP ... ");
14 boolean result = WiFi.softAP(ssid_AP, password_AP);
15 if(result){
16     Serial.println("Ready");
17     Serial.println(String("Soft-AP IP address = ") + WiFi.softAPIP().toString());
18     Serial.println(String("MAC address = ") + WiFi.softAPmacAddress().c_str());
19 }else{
20     Serial.println("Failed!");
21 }
22
23 Serial.println("\nSetting Station configuration ... ");
24 WiFi.begin(ssid_Router, password_Router);
25 Serial.println(String("Connecting to ") + ssid_Router);
26 while (WiFi.status() != WL_CONNECTED) {
27     delay(500);
28     Serial.print(".");
29 }
30 Serial.println("\nConnected, IP address: ");
31 Serial.println(WiFi.localIP());
32 Serial.println("Setup End");
33 }
34
35 void loop() {
36 }
```

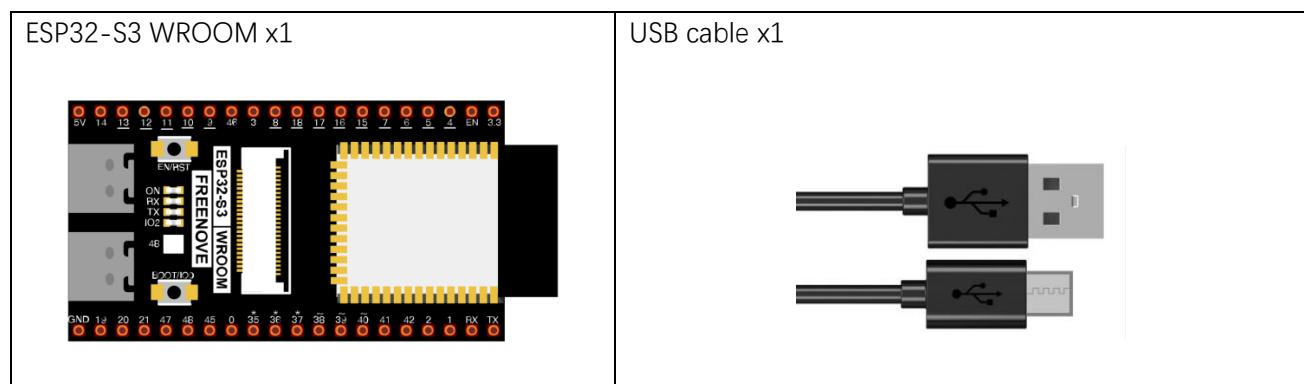
Chapter 6 TCP/IP

In this chapter, we will introduce how ESP32-S3 implements network communications based on TCP/IP protocol. There are two roles in TCP/IP communication, namely Server and Client, which will be implemented respectively with two projects in this chapter.

Project 6.1 As Client

In this section, ESP32-S3 is used as Client to connect Server on the same LAN and communicate with it.

Component List



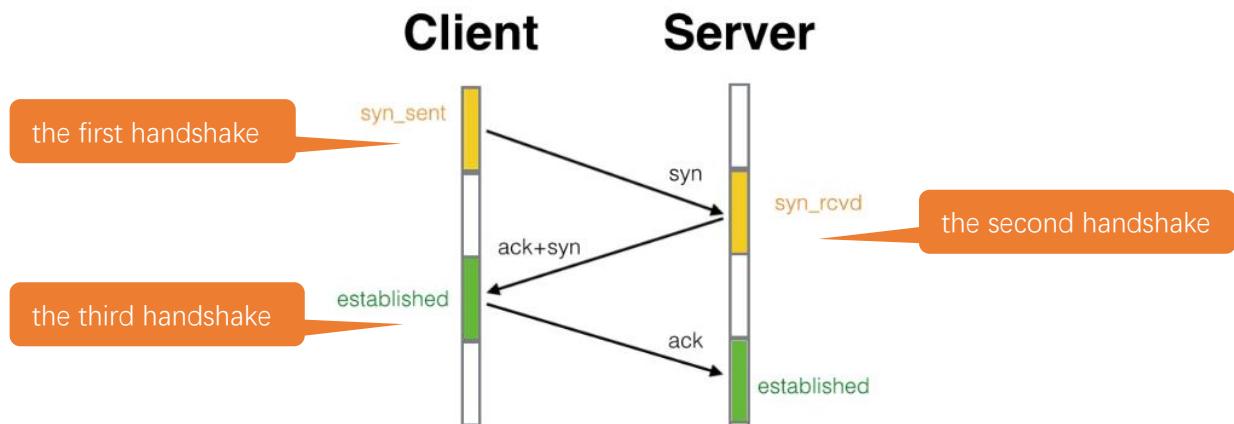
Component knowledge

TCP connection

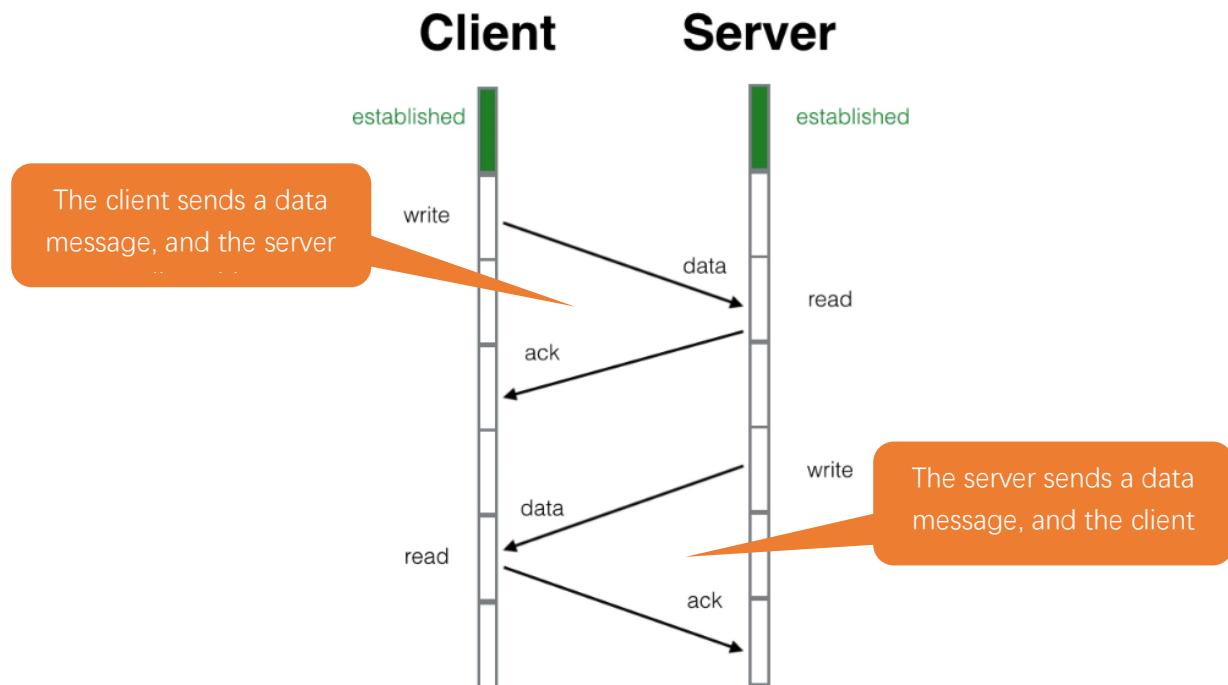
Before transmitting data, TCP needs to establish a logical connection between the sending end and the receiving end. It provides reliable and error-free data transmission between the two computers. In the TCP connection, the client and the server must be clarified. The client sends a connection request to the server, and each time such a request is proposed, a "three-times handshake" is required.

Three-times handshake: In the TCP protocol, during the preparation phase of sending data, the client and the server interact three times to ensure the reliability of the connection, which is called "three-times handshake". The first handshake, the client sends a connection request to the server and waits for the server to confirm. The second handshake, the server sends a response back to the client informing that it has received the connection request.

The third handshake, the client sends a confirmation message to the server again to confirm the connection.



TCP is a connection-oriented, low-level transmission control protocol. After TCP establishes a connection, the client and server can send and receive messages to each other, and the connection will always exist as long as the client or server does not initiate disconnection. Each time one party sends a message, the other party will reply with an ack signal.





Install Processing

In this tutorial, we use Processing to build a simple TCP/IP communication platform.

If you've not installed Processing, you can download it by clicking <https://processing.org/download/>. You can choose an appropriate version to download according to your PC system.

The screenshot shows the official Processing website's download section. At the top, there's a navigation bar with links for "Processing", "p5.js", "Processing.py", "Processing for Android", "Processing for Pi", and "Processing Foundation". Below the navigation is a large banner featuring the word "Processing" and a complex geometric background. To the right of the banner is a search bar with a magnifying glass icon. On the left side of the main content area, there's a sidebar with links: "Cover", "Download", "Donate", "Exhibition", "Reference", "Libraries", "Tools", "Environment", "Tutorials", "Examples", "Books", "Overview", and "People". In the center, under the heading "Download Processing", it says "Processing is available for Linux, Mac OS X, and Windows. Select your choice to download the software below." It shows the version "3.5.4 (17 January 2020)". Below this, there are download links for "Windows 64-bit", "Windows 32-bit", "Linux 64-bit", and "Mac OS X". A large "P" logo is centered in the middle of the page.

Unzip the downloaded file to your computer. Click "processing.exe" as the figure below to run this software.

core	2020/1/17 12:16
java	2020/1/17 12:17
lib	2020/1/17 12:16
modes	2020/1/17 12:16
tools	2020/1/17 12:16
processing.exe	2020/1/17 12:16
processing-java.exe	2020/1/17 12:16
revisions.txt	2020/1/17 12:16

Use Server mode for communication

Install ControlP5.

The image consists of three vertically stacked screenshots from the Processing IDE and its Contribution Manager.

Screenshot 1: Processing Sketch Menu
A screenshot of the Processing sketch menu. The "Sketch" tab is selected. A sub-menu is open under "Sketch" with the following options: Run (Ctrl+R), Present (Ctrl+Shift+R), Tweak (Ctrl+Shift+T), Stop, Import Library..., Show Sketch Folder (Ctrl+K), and Add File... . The "Import Library..." option is highlighted with a blue selection bar. A cursor arrow points to the "Add Library..." option in the submenu.

Screenshot 2: Contribution Manager
A screenshot of the Contribution Manager window. The "Libraries" tab is selected. A table lists several libraries:

Status	Name	Author
	Computational Geometry A simple, lightweight librar...	Mark Collins & Toru Hasegawa
	Console A console, which can be drawn to the screen.	Mathias Markl
	ControlP5 A GUI library to build custom user interface...	Andreas Schlegel
	CountdownTimer A countdown timer which triggers c...	Dong Hyun Choi
	Culebra Behavior Library for Processing A collection o...	Luis Quinones

The "ControlP5" row is highlighted with a light blue selection bar. A cursor arrow points to the "ControlP5" row.

Screenshot 3: ControlP5 Library Details
A screenshot showing the details for the ControlP5 library in the Contribution Manager. The library information is as follows:

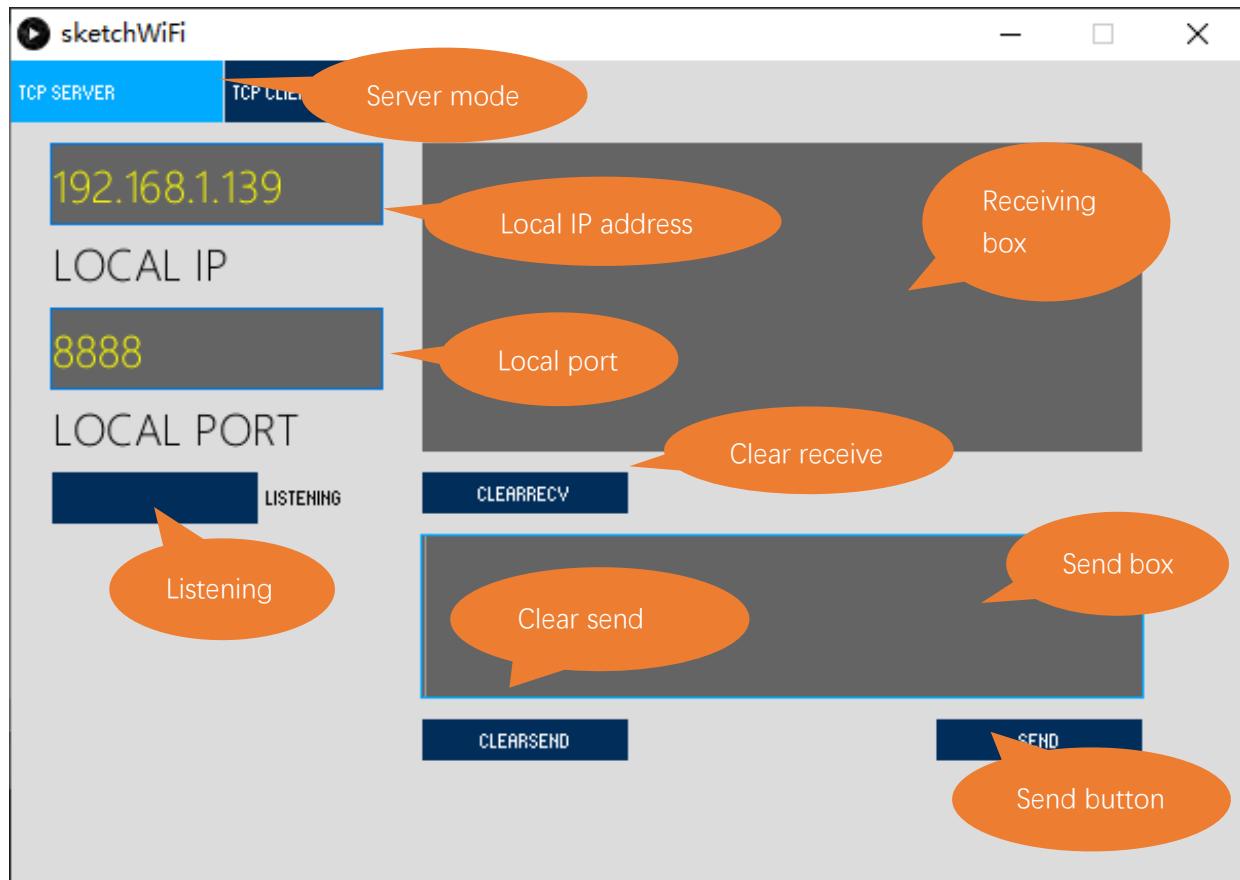
ControlP5 2.2.6
Andreas Schlegel
A GUI library to build custom user interfaces for desktop and android mode.

Buttons for "Install" (highlighted with a blue selection bar), "Update", and "Remove" are visible on the right.

Open the “**Freenove_ESP32_S3_WROVER_Board\Sketches\Sketches\Sketch_06.1_WiFiClient\sketchWiFi\sketchWiFi.pde**”, and click “Run”.

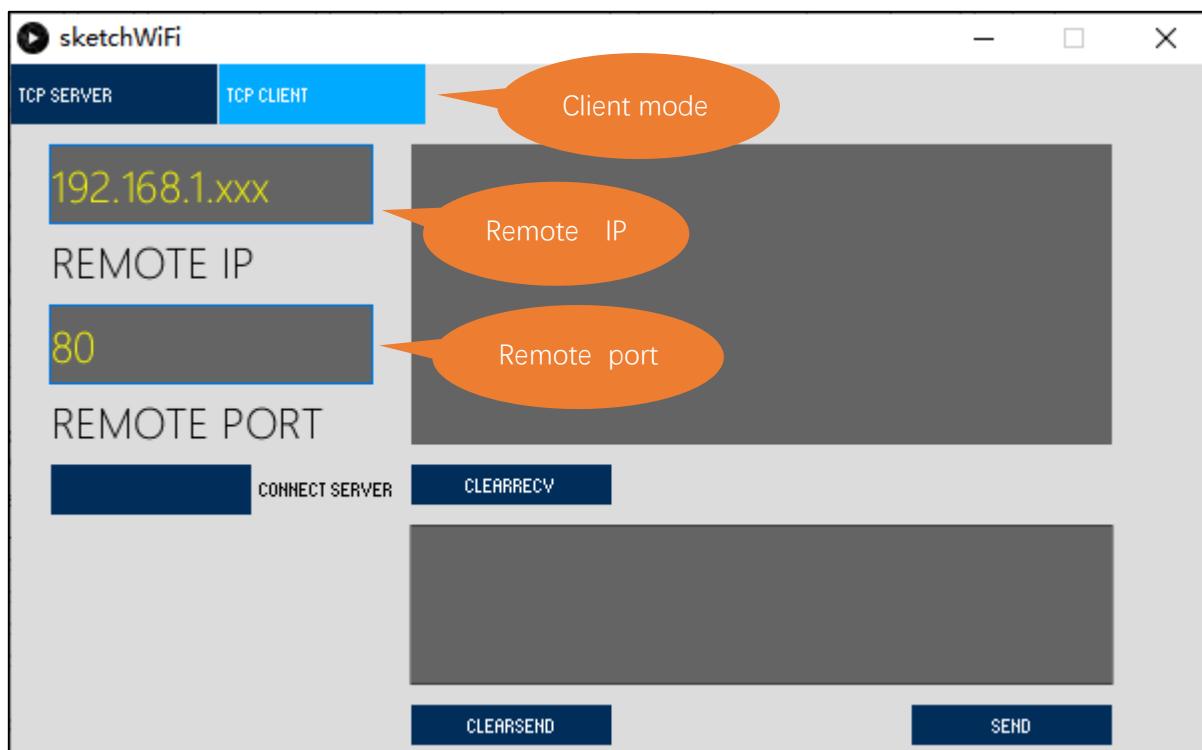


The new pop-up interface is as follows. If ESP32-S3 is used as client, select TCP SERVER mode for sketchWiFi.



When sketchWiFi selects TCP SERVER mode, ESP32-S3 Sketch needs to be changed according to sketchWiFi's displaying of LOCAL IP or LOCAL PORT.

If ESP32-S3 serves as server, select TCP CLIENT mode for sketchWiFi.



When sketchWiFi selects TCP CLIENT mode, the LOCAL IP and LOCAL PORT of sketchWiFi need to be changed according to the IP address and port number printed by the serial monitor.

Mode selection: select **Server mode/Client mode**.

IP address: In server mode, this option does not need to be filled in, and the computer will automatically obtain the IP address.

In client mode, fill in the remote IP address to be connected.

Port number: In server mode, fill in a port number for client devices to make an access connection.

In client mode, fill in port number given by the Server devices to make an access connection.

Start button: In server mode, push the button, then the computer will serve as server and open a port number for client to make access connection. During this period, the computer will keep monitoring.

In client mode, before pushing the button, please make sure the server is on, remote IP address and remote port number is correct; push the button, and the computer will make access connection to the remote port number of the remote IP as a client.

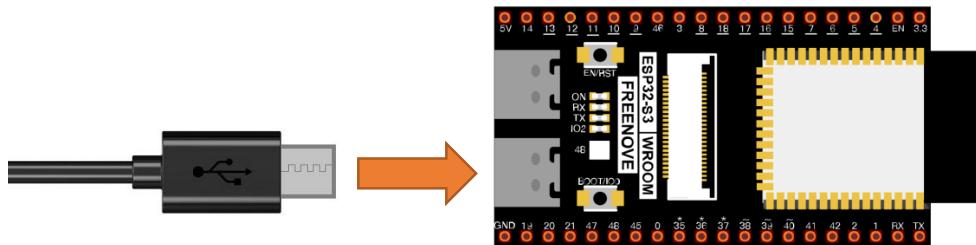
clear receive: clear out the content in the receiving text box

clear send: clear out the content in the sending text box

Sending button: push the sending button, the computer will send the content in the text box to others.

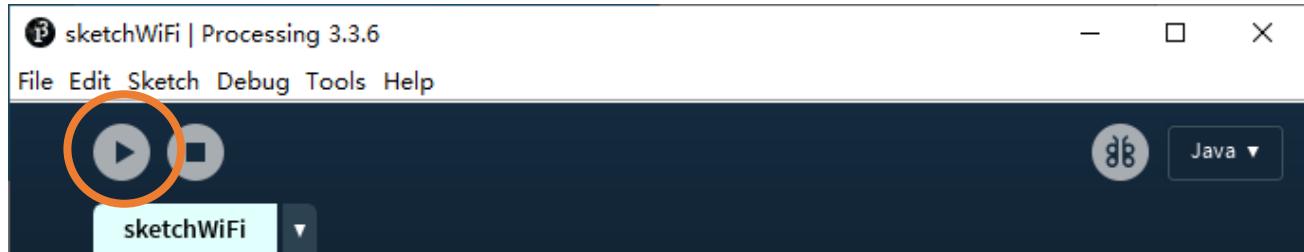
Circuit

Connect Freenove ESP32-S3 to the computer using the USB cable.

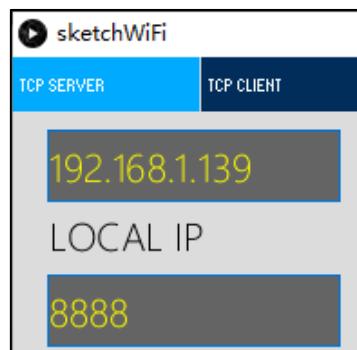


Sketch

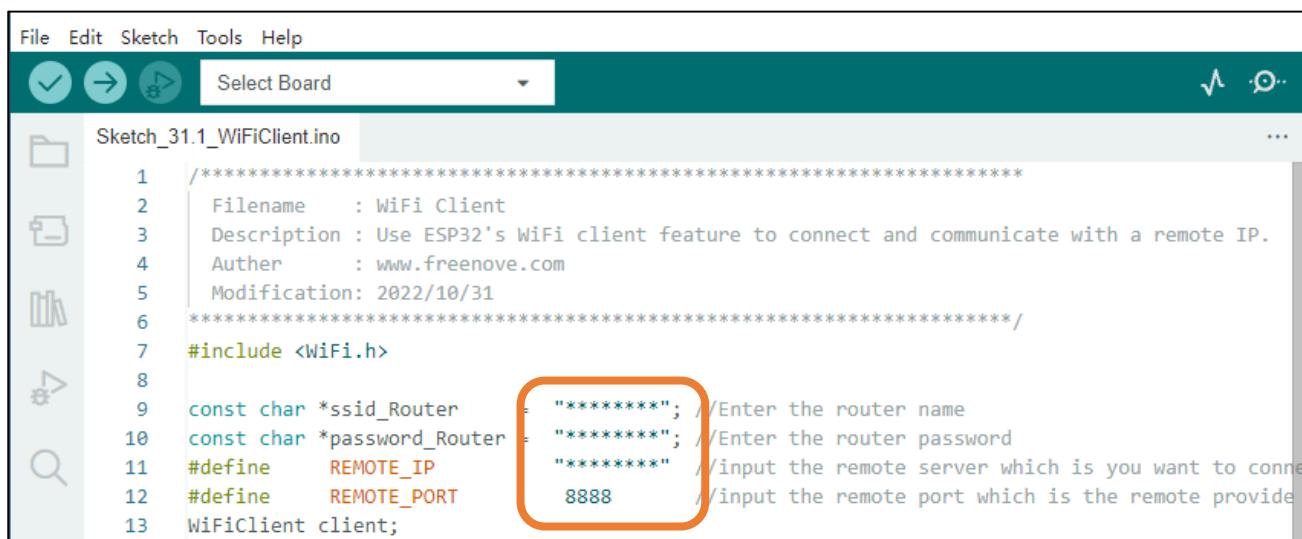
Before running the Sketch, please open “sketchWiFi.pde.” first, and click “Run”.



The newly pop up window will use the computer's IP address by default and open a data monitor port.



Next, open Sketch_06.1_WiFiClient.ino. Before running it, please change the following information based on "LOCAL IP" and "LOCAL PORT" in the figure above.



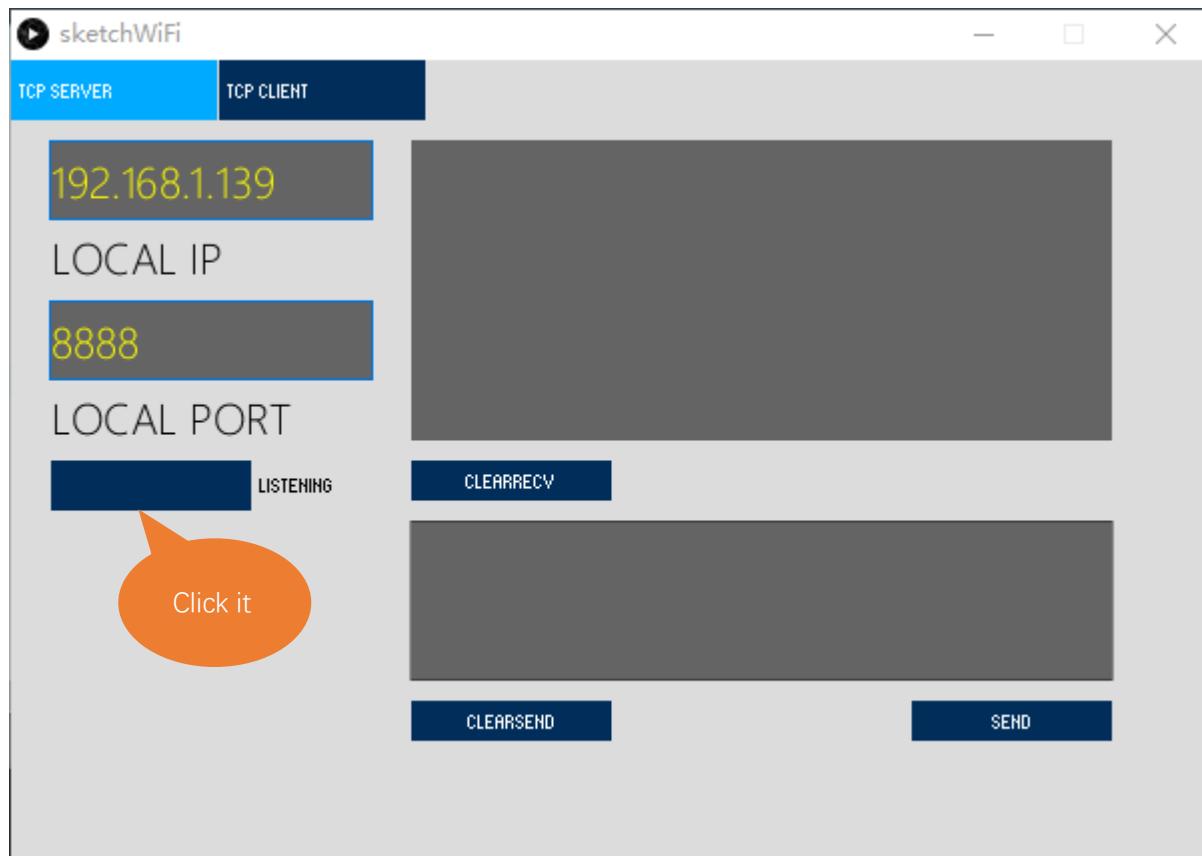
```

File Edit Sketch Tools Help
Select Board ...
Sketch_31.1_WiFiClient.ino ...
1 //*****
2   Filename : WiFi Client
3   Description : Use ESP32's WiFi client feature to connect and communicate with a remote IP.
4   Author : www.freenove.com
5   Modification: 2022/10/31
6 *****/
7 #include <WiFi.h>
8
9 const char *ssid_Router = "*****"; //Enter the router name
10 const char *password_Router = "*****"; //Enter the router password
11 #define REMOTE_IP "*****" //input the remote server which is you want to connect
12 #define REMOTE_PORT 8888 //input the remote port which is the remote provider
13 WiFiClient client;

```

REMOTE_IP needs to be filled in according to the interface of sketchWiFi.pde. Taking this tutorial as an example, its REMOTE_IP is “192.168.1.133”. Generally, by default, the ports do not need to change its value.

Click LISTENING, turn on TCP SERVER's data listening function and wait for ESP32-S3 to connect.



Compile and upload code to ESP32-S3 WROOM, open the serial monitor and set the baud rate to 115200. ESP32-S3 connects router, obtains IP address and sends access request to server IP address on the same LAN till the connection is successful. When connect successfully, ESP32-S3 can send messages to server.

Output Serial Monitor X

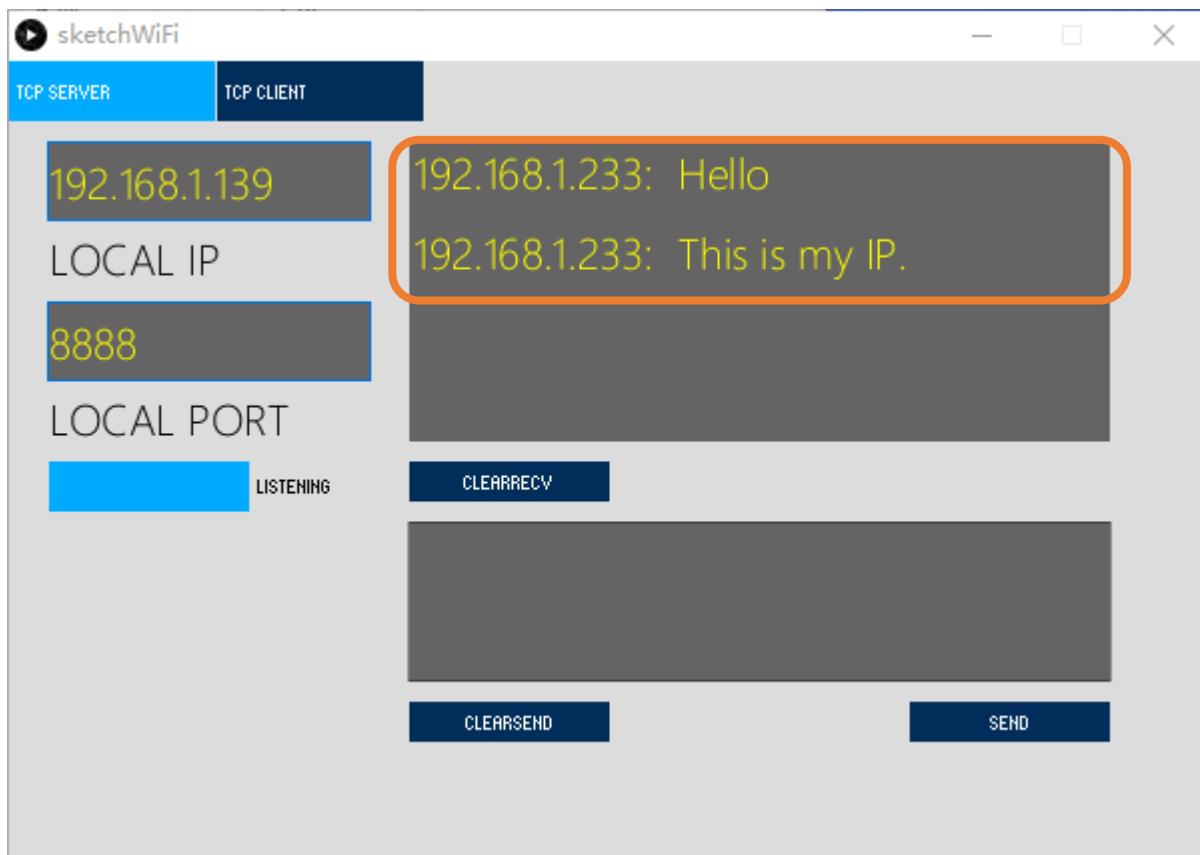
Message (Ctrl + Enter to send message to 'ESP32S3 Dev Module' on 'COM3') New Line 115200 baud

```
192.168.1.233
Connecting to 192.168.1.139
Connected
ESP-ROM: esp32s3-20210327
Build: Mar 27 2021
rst:0x1 (POWERON), boot:0x8 (SPI_FAST_FLASH_BOOT)
SPIWP:0xee
mode:DIO, clock div:1
load:0x3fce3808, len:0x43c
load:0x403c9700, len:0xbec
load:0x403cc700, len:0x2a3c
entry 0x403c98d8

Waiting for WiFi... ...
WiFi connected
IP address:
192.168.1.233
Connecting to 192.168.1.139
Connected
```

Ln 11, Col 46 UTF-8 ESP32S3 Dev Module on COM3 3

ESP32-S3 connects with TCP SERVER, and TCP SERVER receives messages from ESP32-S3, as shown in the figure below.



Sketch_06.1_As Client

The following is the program code:

```
1 #include <WiFi.h>
2
3 const char *ssid_Router      = "*****"; //Enter the router name
4 const char *password_Router = "*****"; //Enter the router password
5 #define    REMOTE_IP        "*****"   //input the remote server which is you want to connect
6 #define    REMOTE_PORT       8888      //input the remote port which is the remote provide
7 WiFiClient client;
8
9 void setup() {
10     Serial.begin(115200);
11     delay(10);
12
13     WiFi.begin(ssid_Router, password_Router);
14     Serial.print("\nWaiting for WiFi... ");
15     while (WiFi.status() != WL_CONNECTED) {
16         Serial.print(".");
17         delay(500);
18     }
19     Serial.println("");
20     Serial.println("WiFi connected");
21     Serial.println("IP address: ");
22     Serial.println(WiFi.localIP());
23     delay(500);
24
25     Serial.print("Connecting to ");
26     Serial.println(REMOTE_IP);
27
28     while (!client.connect(REMOTE_IP, REMOTE_PORT)) {
29         Serial.println("Connection failed.");
30         Serial.println("Waiting a moment before retrying... ");
31     }
32     Serial.println("Connected");
33     client.print("Hello\n");
34     client.print("This is my IP.\n");
35
36 void loop() {
37     if (client.available() > 0) {
38         delay(20);
39         //read back one line from the server
40         String line = client.readString();
41         Serial.println(REMOTE_IP + String(":") + line);
```

```

42 }
43 if (Serial.available() > 0) {
44     delay(20);
45     String line = Serial.readString();
46     client.print(line);
47 }
48 if (client.connected () == 0) {
49     client.stop();
50     WiFi.disconnect();
51 }
52 }
```

Add WiFi function header file.

```
1 #include <WiFi.h>
```

Enter the actual router name, password, remote server IP address, and port number.

```

3 const char *ssid_Router      = "*****"; //Enter the router name
4 const char *password_Router = "*****"; //Enter the router password
5 #define    REMOTE_IP        "*****"   //input the remote server which is you want to connect
6 #define    REMOTE_PORT       8888      //input the remote port which is the remote provide
```

Apply for the method class of WiFiClient.

```
7 WiFiClient client;
```

Connect specified WiFi until it is successful. If the name and password of WiFi are correct but it still fails to connect, please push the reset key.

```

13 WiFi.begin(ssid_Router, password_Router);
14 Serial.print("\nWaiting for WiFi... ");
15 while (WiFi.status() != WL_CONNECTED) {
16     Serial.print(".");
17     delay(500);
18 }
```

Send connection request to remote server until connect successfully. When connect successfully, print out the connecting prompt on the serial monitor and send messages to remote server.

```

28 while (!client.connect(REMOTE_IP, REMOTE_PORT)) { //Connect to Server
29     Serial.println("Connection failed.");
30     Serial.println("Waiting a moment before retrying... ");
31 }
32 Serial.println("Connected");
33 client.print("Hello\n");
```

When ESP32-S3 receive messages from servers, it will print them out via serial port; Users can also send messages to servers from serial port.

```

37 if (client.available() > 0) {
38     delay(20);
39     //read back one line from the server
40     String line = client.readString();
41     Serial.println(REMOTE_IP + String(":") + line);
42 }
```

```
43 if (Serial.available() > 0) {  
44     delay(20);  
45     String line = Serial.readString();  
46     client.print(line);  
47 }
```

If the server is disconnected, turn off WiFi of ESP32-S3.

```
48 if (client.connected () == false) {  
49     client.stop();  
50     WiFi.disconnect();  
51 }
```

Reference

Class Client

Every time when using Client, you need to include header file "WiFi.h."

connect(ip, port, timeout)/connect(*host, port, timeout): establish a TCP connection.

ip, *host: ip address of target server

port: port number of target server

timeout: connection timeout

connected(): judge whether client is connecting. If return value is 1, then connect successfully; If return value is 0, then fail to connect.

stop(): stop tcp connection

print(): send data to server connecting to client

available(): return to the number of bytes readable in receive buffer, if no, return to 0 or -1.

read(): read one byte of data in receive buffer

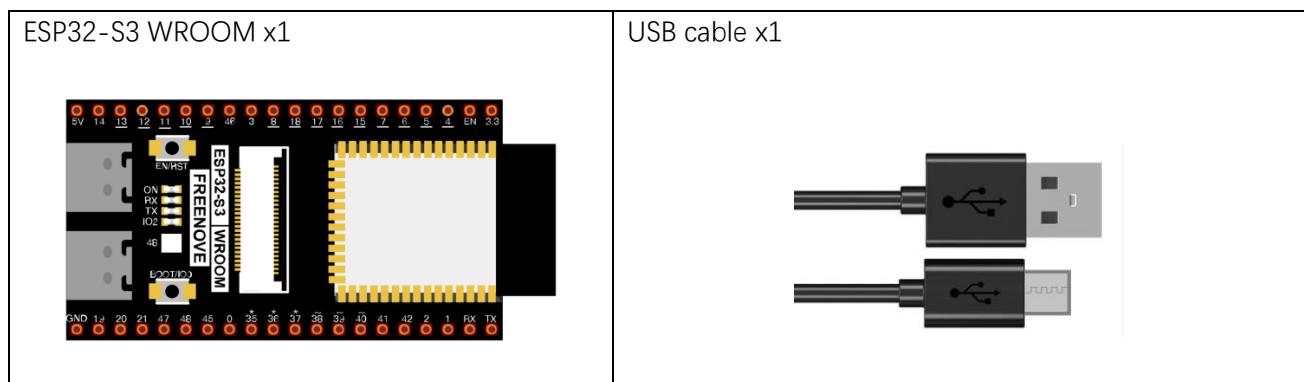
readString(): read string in receive buffer



Project 6.2 As Server

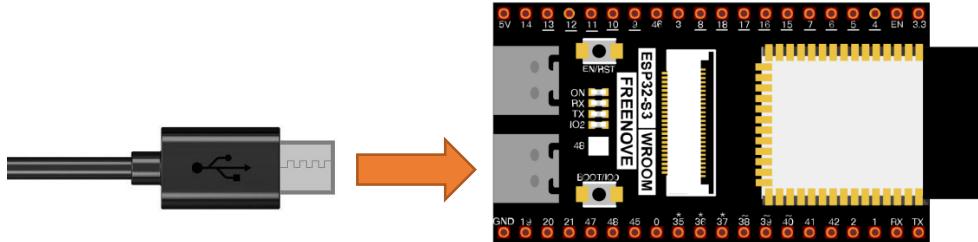
In this section, ESP32-S3 is used as a server to wait for the connection and communication of client on the same LAN.

Component List



Circuit

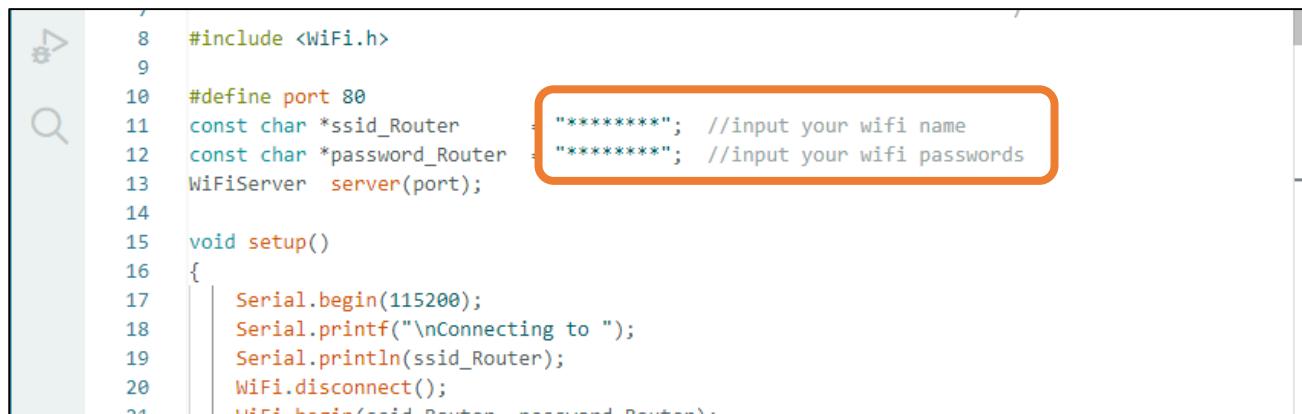
Connect Freenove ESP32-S3 to the computer using a USB cable.



Sketch

Before running Sketch, please modify the contents of the box below first.

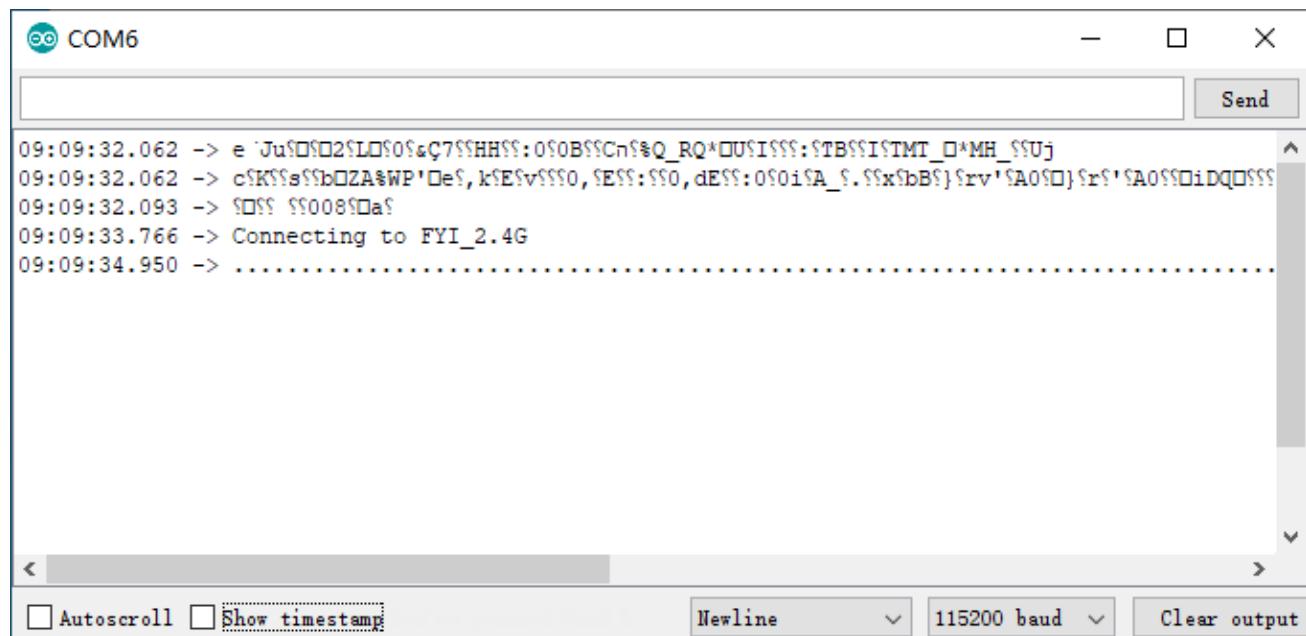
Sketch_06.2_As_Server



```
8 #include <WiFi.h>
9
10 #define port 80
11 const char *ssid_Router
12 const char *password_Router
13 WiFiServer server(port);
14
15 void setup()
16 {
17     Serial.begin(115200);
18     Serial.printf("\nConnecting to ");
19     Serial.println(ssid_Router);
20     WiFi.disconnect();
21     WiFi.begin(ssid_Router, password_Router);
```

Compile and upload code to ESP32-S3 WROOM board, open the serial monitor and set the baud rate to 115200. Turn on server mode for ESP32-S3, waiting for the connection of other devices on the same LAN. Once a device connects to server successfully, they can send messages to each other.

If the ESP32-S3 fails to connect to router, press the reset button as shown below and wait for ESP32-S3 to run again.





Serial Monitor

Message (Ctrl + Enter to send message to 'ESP32S3 Dev Module' on 'COM3')

ESP-ROM: esp32s3-20210327
Build: Mar 27 2021
rst: 0x1 (POWERON), boot: 0x8 (SPI_FAST_FLASH_BOOT)
SPIWP: 0xee
mode:DIO, clock div: 1
load: 0x3fce3808, len: 0x43c
load: 0x403c9700, len: 0xbec
load: 0x403cc700, len: 0x2a3c
entry 0x403c98d8

Connecting to FYI_2.4G

WiFi connected.
 IP address: 192.168.1.233
 IP port: 80
 Client connected.

IP address and
serial port

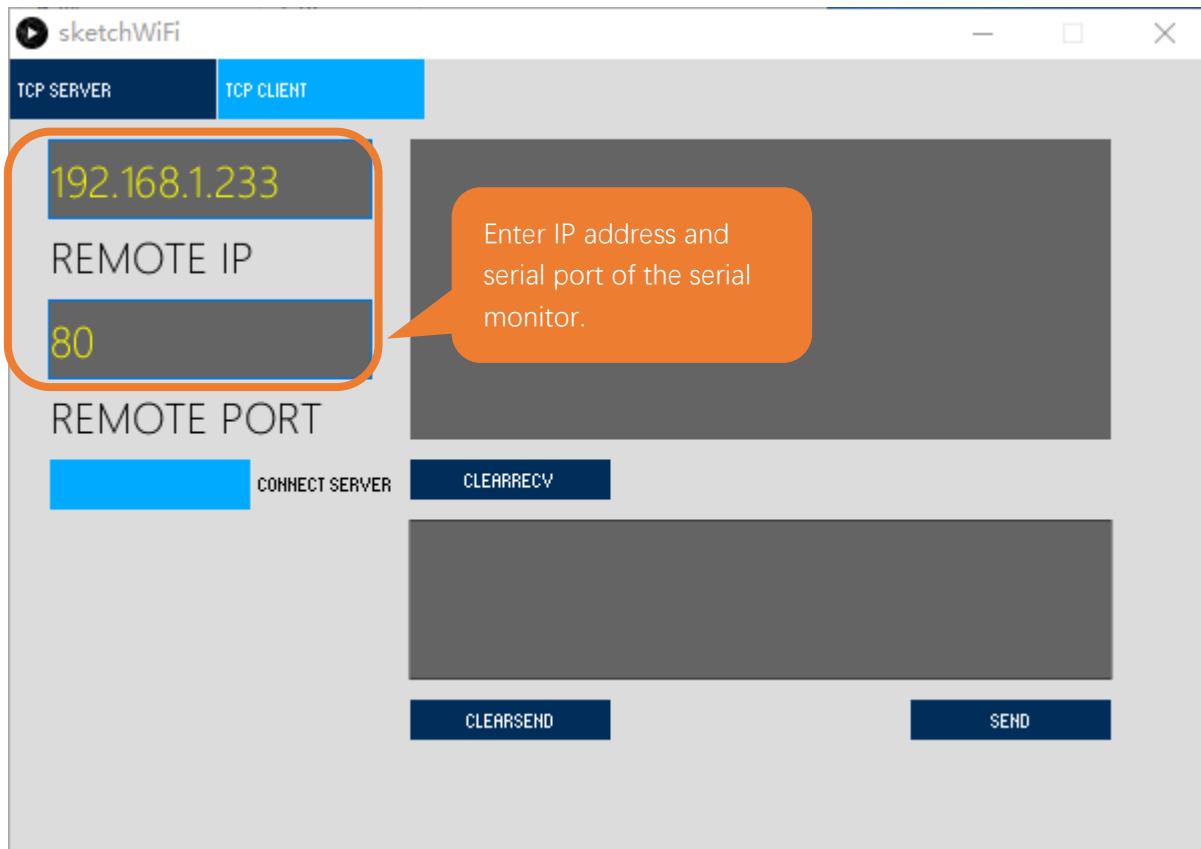
Downloading index signature: library_index.json.sig

Ln 34, Col 33 UTF-8 ESP32S3 Dev Module on COM3 3

Processing:

Open the “Freenove_ESP32_S3_WROVER_Board\Sketches\Sketches\Sketch_06.2_WiFiServer\sketchWiFi\sketchWiFi.pde”.

Based on the messages printed by the serial monitor, enter correct IP address and serial port in Processing to establish connection and make communication.



The following is the program code:

```
1 #include <WiFi.h>
2
3 #define port 80
4 const char *ssid_Router      = "*****"; //input your wifi name
5 const char *password_Router  = "*****"; //input your wifi passwords
6 WiFiServer server(port);
7
8 void setup()
9 {
10     Serial.begin(115200);
11     Serial.printf("\nConnecting to ");
12     Serial.println(ssid_Router);
13     WiFi.disconnect();
14     WiFi.begin(ssid_Router, password_Router);
15     delay(1000);
16     while (WiFi.status() != WL_CONNECTED) {
17         delay(500);
18         Serial.print(".");
19     }
20     Serial.println("");
21     Serial.println("WiFi connected.");
22     Serial.print("IP address: ");
23     Serial.println(WiFi.localIP());
24     Serial.printf("IP port: %d\n", port);
25     server.begin(port);
26     WiFi.setAutoReconnect(true);
27 }
28
29 void loop() {
30     WiFiClient client = server.accept();           // listen for incoming clients
31     if (client) {                                // if you get a client
32         Serial.println("Client connected.");
33         while (client.connected()) {              // loop while the client's connected
34             if (client.available()) {            // if there's bytes to read from the
35                 client.readStringUntil('\n'); // print it out the serial monitor
36                 while(client.read()>0);        // clear the wifi receive area cache
37             }
38             if(Serial.available()){           // if there's bytes to read from the
39                 client.print(Serial.readStringUntil('\n'));// print it out the client.
40                 while(Serial.read()>0);          // clear the wifi receive area cache
41             }
42 }
```

Any concerns? ✉ support@freenove.com

```

42     }
43     client.stop();           // stop the client connecting.
44     Serial.println("Client Disconnected.");
45   }
46 }
```

Apply for method class of WiFiServer.

6	<code>WiFiServer server(port);</code>	//Apply for a Server object whose port number is 80
---	---------------------------------------	---

Connect specified WiFi until it is successful. If the name and password of WiFi are correct but it still fails to connect, please push the reset key.

```

13   WiFi.disconnect();
14   WiFi.begin(ssid_Router, password_Router);
15   delay(1000);
16   while (WiFi.status() != WL_CONNECTED) {
17     delay(500);
18     Serial.print(".");
19   }
20   Serial.println("");
21   Serial.println("WiFi connected.");
```

Print out the IP address and port number of ESP32-S3.

22	<code>Serial.print("IP address: ");</code>	
23	<code>Serial.println(WiFi.localIP());</code>	//print out IP address of ESP32-S3
24	<code>Serial.printf("IP port: %d\n", port);</code>	//Print out ESP32-S3's port number

Turn on server mode of ESP32-S3, turn on automatic reconnection.

25	<code>server.begin();</code>	//Turn ON ESP32-S3 as Server mode
26	<code>WiFi.setAutoReconnect(true);</code>	

When ESP32-S3 receive messages from servers, it will print them out via serial port; Users can also send messages to servers from serial port.

```

34   if (client.available()) {           // if there's bytes to read from the
client
35     Serial.println(client.readStringUntil('\n')); // print it out the serial monitor
36     while(client.read()>0);           // clear the wifi receive area cache
37   }
38   if(Serial.available()){           // if there's bytes to read from the
serial monitor
39     client.print(Serial.readStringUntil('\n')); // print it out the client.
40     while(Serial.read()>0);           // clear the wifi receive area cache
41 }
```

Reference

Class Server

Every time use Server functionality, we need to include header file "WiFi.h".

WiFiServer(uint16_t port=80, uint8_t max_clients=4): create a TCP Server.

port: ports of Server; range from 0 to 65535 with the default number as 80.

max_clients: maximum number of clients with default number as 4.

begin(port): start the TCP Server.

port: ports of Server; range from 0 to 65535 with the default number as 0.

setNoDelay(bool nodelay): whether to turn off the delay sending functionality.

nodelay: true stands for forbidden Nagle algorithm.

close(): close tcp connection.

stop(): stop tcp connection.



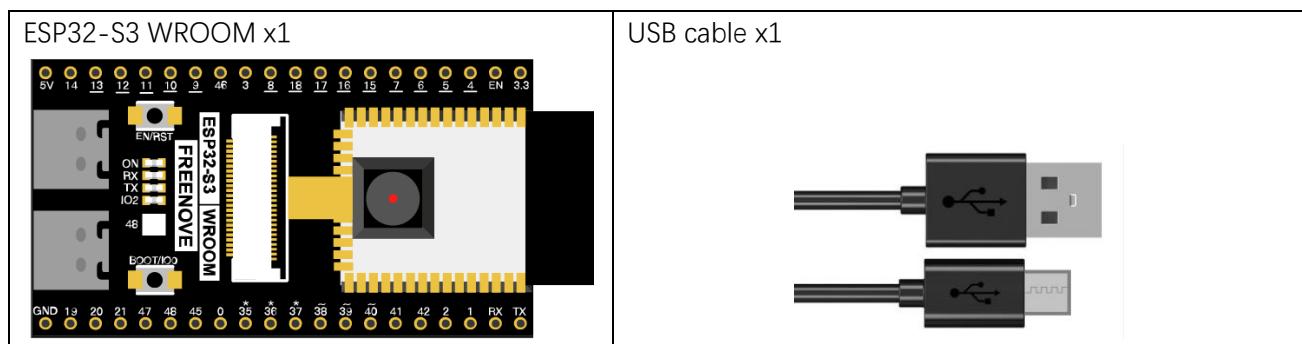
Chapter 7 Camera Web Server

In this section, we'll use ESP32-S3's video function as an example to study.

Project 7.1 Camera Web Server

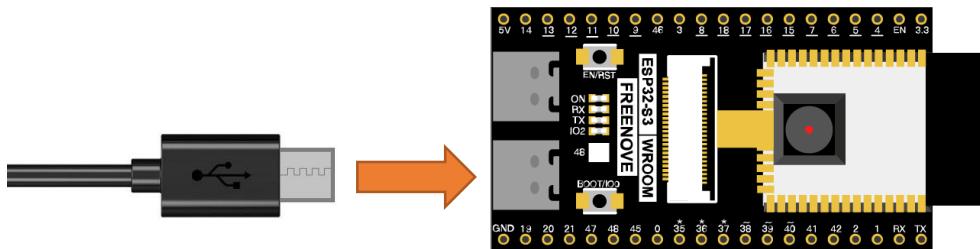
Connect ESP32-S3 using USB and check its IP address through serial monitor. Use web page to access IP address to obtain video and image data.

Component List



Circuit

Connect Freenove ESP32-S3 to the computer using the USB cable.



Sketch

Sketch_07.1_As_CameraWebServer

```

Sketch_32.1_CameraWebServer | Arduino IDE 2.0.0
File Edit Sketch Tools Help
ESP32S3 Dev Module
Sketch_32.1_CameraWebServer.ino esp_camera.h sdkconfig.h sensor.h app_httpd.cpp camera_index.h camera_pins.h ...
1 // =====
2 // =====
3 //define CAMERA_MODEL_WROVER_KIT // Has PSRAM
4 //define CAMERA_MODEL_ESP_EYE // Has PSRAM
5 #define CAMERA_MODEL_ESP32S3_EYE // Has PSRAM
6 //define CAMERA_MODEL_M5STACK_PSRAM // Has PSRAM
7 //define CAMERA_MODEL_M5STACK_V2_PSRAM // M5Camera version B Has PSRAM
8 //define CAMERA_MODEL_M5STACK_WIDE // Has PSRAM
9 //define CAMERA_MODEL_M5STACK_ESP32CAM // No PSRAM
10 //define CAMERA_MODEL_M5STACK_UNITCAM // No PSRAM
11 //define CAMERA_MODEL_AI_THINKER // Has PSRAM
12 //define CAMERA_MODEL_TTGO_T_JOURNAL // No PSRAM
13 // ** Espressif Internal Boards **
14 //define CAMERA_MODEL_ESP32_CAM_BOARD
15 //define CAMERA_MODEL_ESP32S2_CAM_BOARD
16 //define CAMERA_MODEL_ESP32S3_CAM_LCD
17
18 #include "camera_pins.h"
19
20 // =====
21 // Enter your WiFi credentials
22 // =====
23 const char* ssid      = "*****";
24 const char* password = "*****";
25
26 void startCameraServer();
27
28
29
30
31
32
33
34
35
36

```

Before running the program, please modify your router's name and password in the box shown in the illustration above to make sure that your Sketch can compile and work successfully.

Compile and upload codes to ESP32-S3, open the serial monitor and set the baud rate to 115200, and the serial monitor will print out a network link address.

```

Output Serial Monitor ×
Message (Ctrl + Enter to send message to 'ESP32S3 Dev Module' on 'COM3') New Line 115200 baud
ESP-ROM: esp32s3-20210327
Build: Mar 27 2021
rst: 0x1 (POWERON), boot: 0x8 (SPI_FAST_FLASH_BOOT)
SPIWP: 0xee
mode:DIO, clock div:1
load: 0x3fce3808, len: 0x43c
load: 0x403c9700, len: 0xbec
load: 0x403cc700, len: 0x2a3c
entry 0x403c98d8

..
WiFi connected
Camera Ready! Use 'http://192.168.1.233' to connect

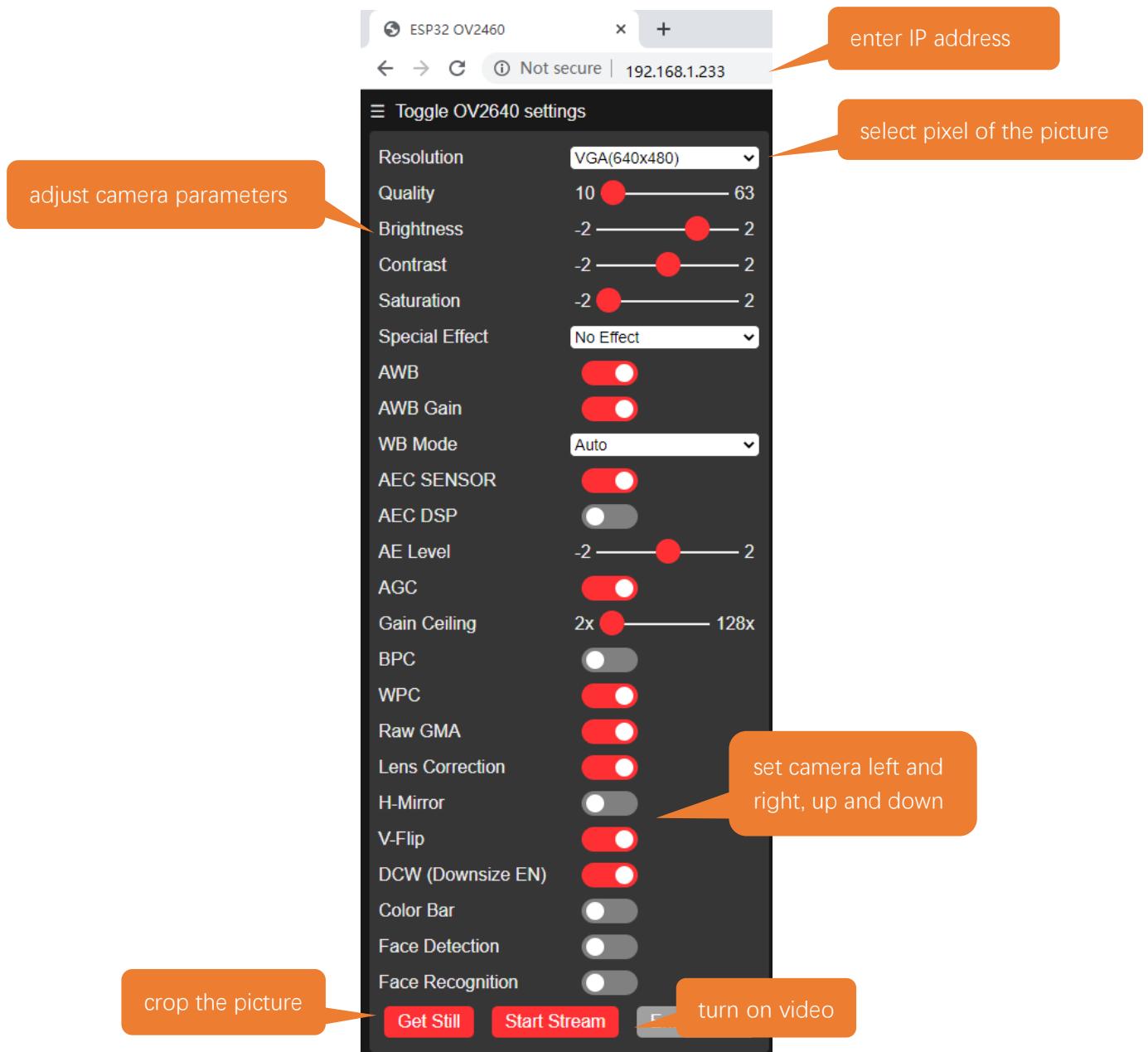
```

If your ESP32-S3 has been in the process of connecting to router, but the information above has not been printed out, please re-check whether the router name and password have been entered correctly and press the reset key on ESP32-S3 WROOM to wait for a successful connection prompt.

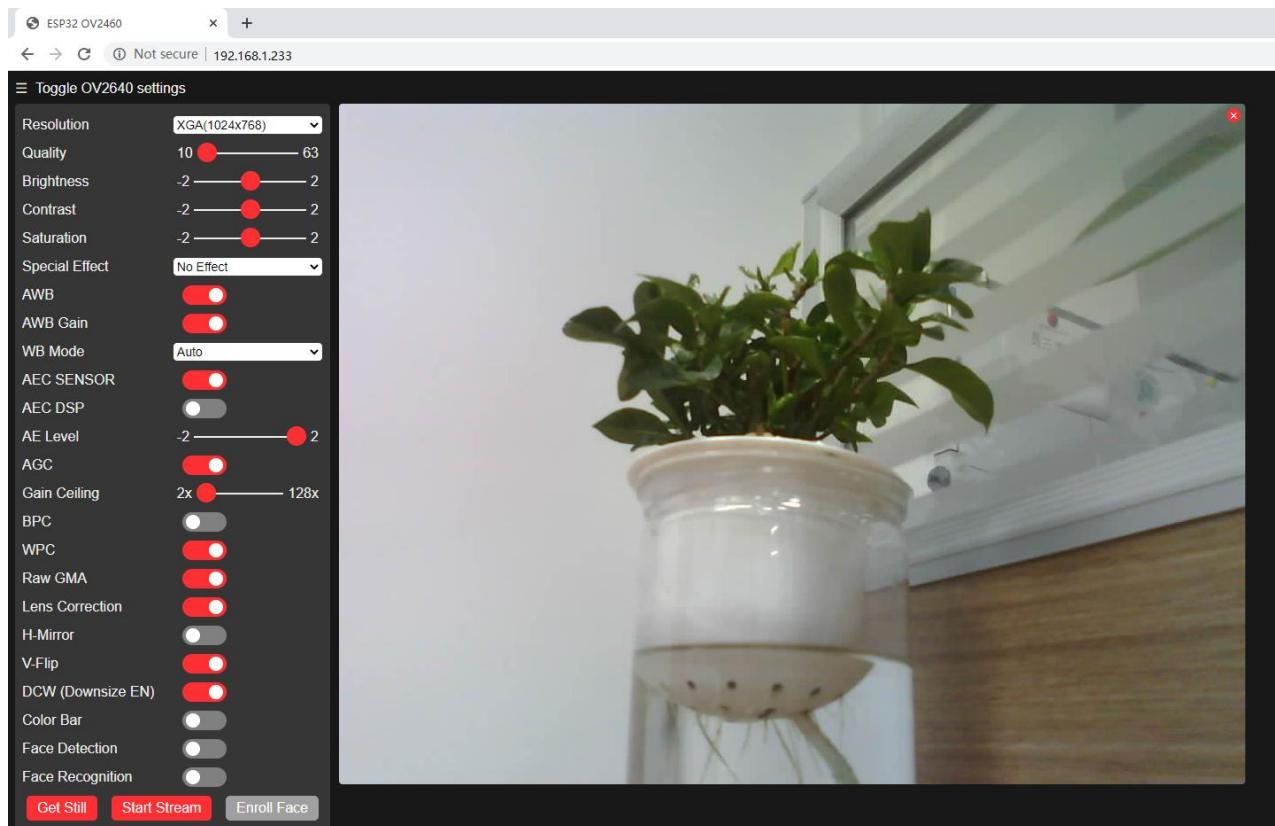
Any concerns? [✉ support@freenove.com](mailto:support@freenove.com)



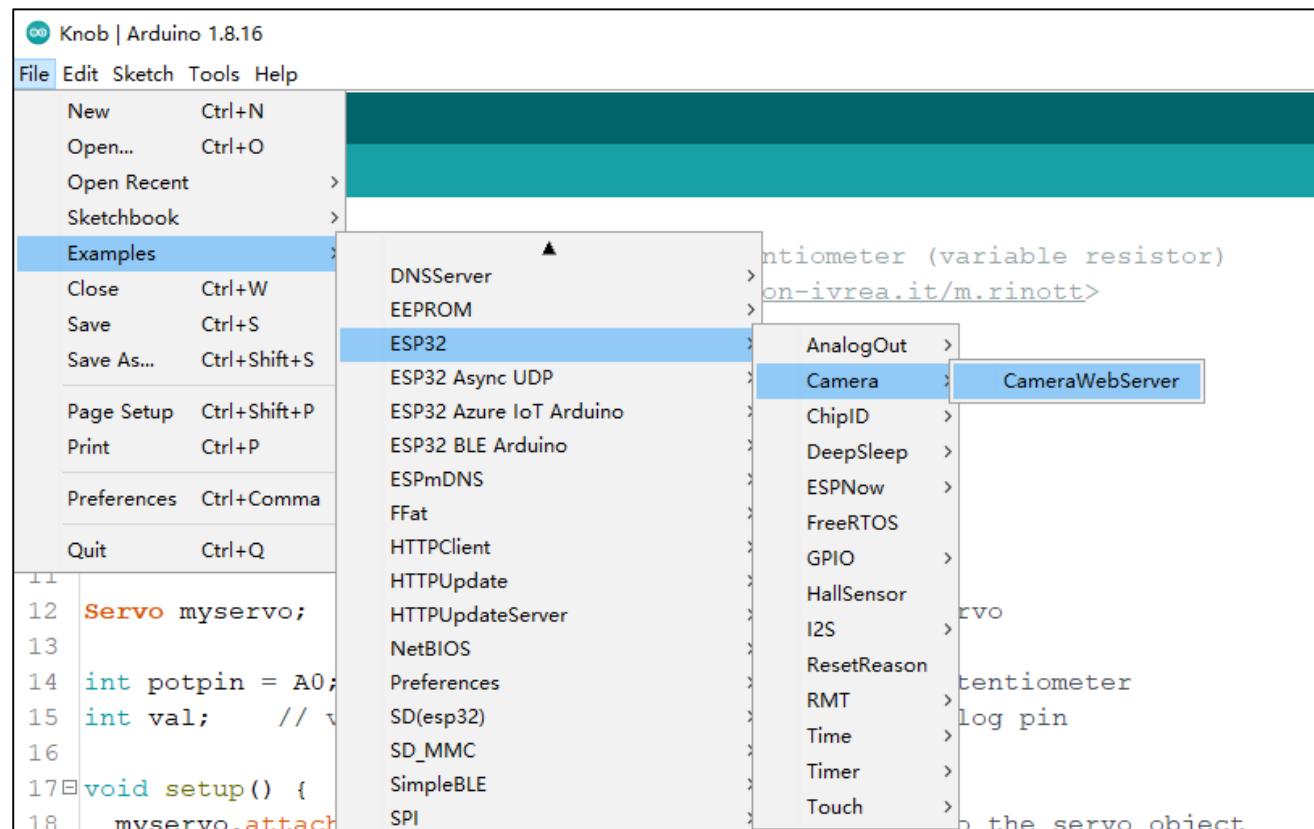
Open a web browser, enter the IP address printed by the serial monitor in the address bar, and access it. Taking the Google browser as an example, here's what the browser prints out after successful access to ESP32-S3's IP.



Click on Start Stream. The effect is shown in the image below.



Note: If sketch compilation fails due to ESP32-S3 support package, follow the steps of the image to open the CameraWebServer. This sketch is the same as described in the tutorial above.



Any concerns? [✉ support@freenove.com](mailto:support@freenove.com)

The following is the main program code. You need include other code files in the same folder when write your own code.

```
1 #include "esp_camera.h"
2 #include <WiFi.h>
3
4 // =====
5 // Select camera model
6 // =====
7 //#define CAMERA_MODEL_WROVER_KIT // Has PSRAM
8 //#define CAMERA_MODEL_ESP_EYE // Has PSRAM
9 #define CAMERA_MODEL_ESP32S3_EYE // Has PSRAM
10 //#define CAMERA_MODEL_M5STACK_PSRAM // Has PSRAM
11 //#define CAMERA_MODEL_M5STACK_V2_PSRAM // M5Camera version B Has PSRAM
12 //#define CAMERA_MODEL_M5STACK_WIDE // Has PSRAM
13 //#define CAMERA_MODEL_M5STACK_ESP32CAM // No PSRAM
14 //#define CAMERA_MODEL_M5STACK_UNITCAM // No PSRAM
15 //#define CAMERA_MODEL_AI_THINKER // Has PSRAM
16 //#define CAMERA_MODEL_TTGO_T_JOURNAL // No PSRAM
17 // ** Espressif Internal Boards **
18 //#define CAMERA_MODEL_ESP32_CAM_BOARD
19 //#define CAMERA_MODEL_ESP32S2_CAM_BOARD
20 //#define CAMERA_MODEL_ESP32S3_CAM_LCD
21
22 #include "camera_pins.h"
23
24 // =====
25 // Enter your WiFi credentials
26 // =====
27 const char* ssid      = "*****";
28 const char* password = "*****";
29
30 void startCameraServer();
31
32 void setup() {
33     Serial.begin(115200);
34     Serial.setDebugOutput(true);
35     Serial.println();
36
37     camera_config_t config;
38     config.ledc_channel = LEDC_CHANNEL_0;
39     config.ledc_timer = LEDC_TIMER_0;
40     config.pin_d0 = Y2_GPIO_NUM;
41     config.pin_d1 = Y3_GPIO_NUM;
42     config.pin_d2 = Y4_GPIO_NUM;
```

```
43 config.pin_d3 = Y5_GPIO_NUM;
44 config.pin_d4 = Y6_GPIO_NUM;
45 config.pin_d5 = Y7_GPIO_NUM;
46 config.pin_d6 = Y8_GPIO_NUM;
47 config.pin_d7 = Y9_GPIO_NUM;
48 config.pin_xclk = XCLK_GPIO_NUM;
49 config.pin_pclk = PCLK_GPIO_NUM;
50 config.pin_vsync = VSYNC_GPIO_NUM;
51 config.pin_href = HREF_GPIO_NUM;
52 config.pin_sccb_sda = SIOD_GPIO_NUM;
53 config.pin_sccb_scl = SIOC_GPIO_NUM;
54 config.pin_pwdn = PWDN_GPIO_NUM;
55 config.pin_reset = RESET_GPIO_NUM;
56 config.xclk_freq_hz = 2000000;
57 config.frame_size = FRAMESIZE_UXGA;
58 config.pixel_format = PIXFORMAT_JPEG; // for streaming
59 config.grab_mode = CAMERA_GRAB_WHEN_EMPTY;
60 config.fb_location = CAMERA_FB_IN_PSRAM;
61 config.jpeg_quality = 12;
62 config.fb_count = 1;
63
64 // if PSRAM IC present, init with UXGA resolution and higher JPEG quality
65 // for larger pre-allocated frame buffer.
66 if(psramFound()){
67     config.jpeg_quality = 10;
68     config.fb_count = 2;
69     config.grab_mode = CAMERA_GRAB_LATEST;
70 } else {
71     // Limit the frame size when PSRAM is not available
72     config.frame_size = FRAMESIZE_SVGA;
73     config.fb_location = CAMERA_FB_IN_DRAM;
74 }
75
76 // camera init
77 esp_err_t err = esp_camera_init(&config);
78 if (err != ESP_OK) {
79     Serial.printf("Camera init failed with error 0x%x", err);
80     return;
81 }
82
83 sensor_t * s = esp_camera_sensor_get();
84 // initial sensors are flipped vertically and colors are a bit saturated
85 s->set_vflip(s, 1); // flip it back
86 s->set_brightness(s, 1); // up the brightness just a bit
```

```

87     s->set_saturation(s, -1); // lower the saturation
88
89     WiFi.begin(ssid, password);
90     WiFi.setSleep(false);
91
92     while (WiFi.status() != WL_CONNECTED) {
93         delay(500);
94         Serial.print(".");
95     }
96     while (WiFi.STA.hasIP() != true) {
97         delay(500);
98         Serial.print(".");
99     }
100
101    Serial.println("");
102    Serial.println("WiFi connected");
103
104    startCameraServer();
105
106    Serial.print("Camera Ready! Use 'http://");
107    Serial.print(WiFi.localIP());
108    Serial.println(" to connect");
109 }
110
111 void loop() {
112     // Do nothing. Everything is done in another task by the web server
113     delay(10000);
114 }
```

Add procedure files and API interface files related to ESP32-S3 camera.

```

1 #include "esp_camera.h"
2 #include <WiFi.h>
...
9 #define CAMERA_MODEL_ESP32S3_EYE // Has PSRAM
...
11 #include "camera_pins.h"
```

Enter the name and password of the router

```

13 const char *ssid      = "*****"; //input your wifi name
14 const char *password = "*****"; //input your wifi passwords
```

Initialize serial port, set baud rate to 115200; open the debug and output function of the serial.

```

21 Serial.begin(115200);
22 Serial.setDebugOutput(true);
23 Serial.println();
```

Configure parameters including interface pins of the camera. Note: It is generally not recommended to change them.

```
37 camera_config_t config;
38 config.ledc_channel = LEDC_CHANNEL_0;
39 config.ledc_timer = LEDC_TIMER_0;
40 config.pin_d0 = Y2_GPIO_NUM;
41 config.pin_d1 = Y3_GPIO_NUM;
42 config.pin_d2 = Y4_GPIO_NUM;
43 config.pin_d3 = Y5_GPIO_NUM;
44 config.pin_d4 = Y6_GPIO_NUM;
45 config.pin_d5 = Y7_GPIO_NUM;
46 config.pin_d6 = Y8_GPIO_NUM;
47 config.pin_d7 = Y9_GPIO_NUM;
48 config.pin_xclk = XCLK_GPIO_NUM;
49 config.pin_pclk = PCLK_GPIO_NUM;
50 config.pin_vsync = VSYNC_GPIO_NUM;
51 config.pin_href = HREF_GPIO_NUM;
52 config.pin_sccb_sda = SIOD_GPIO_NUM;
53 config.pin_sccb_scl = SIOC_GPIO_NUM;
54 config.pin_pwdn = PWDN_GPIO_NUM;
55 config.pin_reset = RESET_GPIO_NUM;
56 config.xclk_freq_hz = 20000000;
57 config.frame_size = FRAMESIZE_UXGA;
58 config.pixel_format = PIXFORMAT_JPEG; // for streaming
59 config.grab_mode = CAMERA_GRAB_WHEN_EMPTY;
60 config.fb_location = CAMERA_FB_IN_PSRAM;
61 config.jpeg_quality = 12;
62 config.fb_count = 1;
```

ESP32-S3 connects to the router and prints a successful connection prompt. If it has not been successfully connected, press the reset key on the ESP32-S3 WROOM.

```
89 WiFi.begin(ssid, password);
90 WiFi.setSleep(false);

91

92 while (WiFi.status() != WL_CONNECTED) {
93     delay(500);
94     Serial.print(".");
95 }
96 while (WiFi.STA.hasIP() != true) {
97     delay(500);
98     Serial.print(".");
99 }
100 Serial.println("");
101 Serial.println("WiFi connected");
```

Any concerns? ✉ support@freenove.com



Open the video streams server function of the camera and print its IP address via serial port.

```

99  startCameraServer();
100
101  Serial.print("Camera Ready! Use 'http://");
102  Serial.print(WiFi.localIP());
103  Serial.println("' to connect");

```

Configure the display image information of the camera.

The set_vflip() function sets whether the image is flipped 180°, with 0 for no flip and 1 for flip 180°.

The set_brightness() function sets the brightness of the image, with values ranging from -2 to 2.

The set_saturation() function sets the color saturation of the image, with values ranging from -2 to 2.

```

36  sensor_t * s = esp_camera_sensor_get();
37  s->set_vflip(s, 1);           //flip it back
38  s->set_brightness(s, 1);     //up the brightness just a bit
39  s->set_saturation(s, -1);   //lower the saturation

```

Modify the resolution and sharpness of the images captured by the camera. The sharpness ranges from 10 to 63, and the smaller the number, the sharper the picture. The larger the number, the blurrier the picture. Please refer to the table below.

```

26  config.frame_size = FRAMESIZE_VGA;
27  config.jpeg_quality = 10;

```

Reference

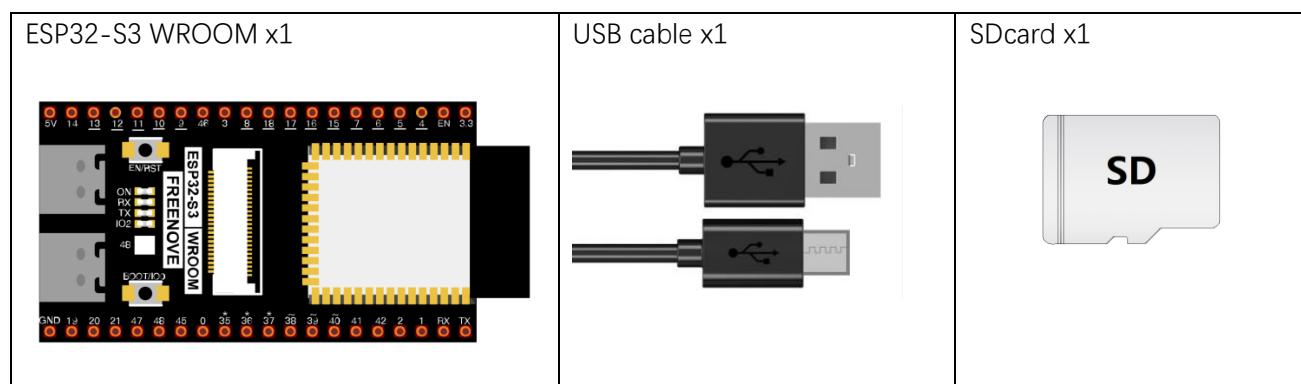
Image resolution	Sharpness	Image resolution	Sharpness
FRAMESIZE_96x96	96x96	FRAMESIZE_HVGA	480x320
FRAMESIZE_QQVGA	160x120	FRAMESIZE_VGA	640x480
FRAMESIZE_QCIF	176x144	FRAMESIZE_SVGA	800x600
FRAMESIZE_HQVGA	240x176	FRAMESIZE_XGA	1024x768
FRAMESIZE_240x240	240x240	FRAMESIZE_HD	1280x720
FRAMESIZE_QVGA	320x240	FRAMESIZE_SXGA	1280x1024
FRAMESIZE_CIF	400x296	FRAMESIZE_UXGA	1600x1200

We recommend that the resolution not exceed VGA(640x480).

Project 7.2 Video Web Server

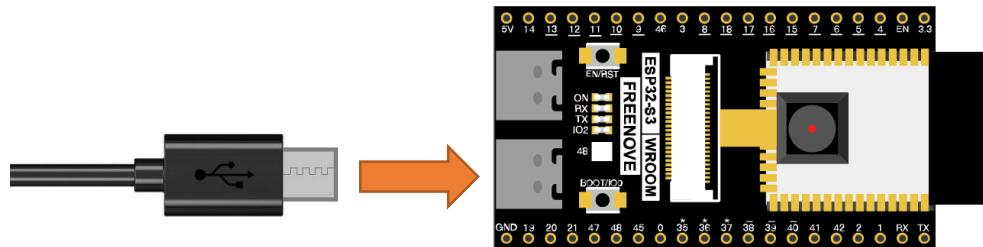
Connect to ESP32-S3 using USB and view its IP address through a serial monitor. Access IP addresses through web pages to obtain real-time video data.

Component List



Circuit

Connect Freenove ESP32-S3 to the computer using the USB cable.



Sketch

Sketch_07.2_As_VideoWebServer

```

Sketch_07.2_As_VideoWebServer | Arduino IDE 2.0.0
File Edit Sketch Tools Help
ESP32S3 Dev Module
Sketch_07.2_As_VideoWebServer.ino app_httpd.cpp camera_pins.h ...
1 // ****
2 Filename : Video Web Server
3 Description : The camera images captured by the ESP32S3 are displayed on the web page.
4 Author : www.freenove.com
5 Modification: 2022/11/01
6 ****
7 #include "esp_camera.h"
8 #include <WiFi.h>
9
10 // Select camera model
11 #define CAMERA_MODEL_ESP32S3_EYE // Has PSRAM
12
13 #include "camera_pins.h"
14
15 const char* ssid      = "*****";    //input your wifi name
16 const char* password = "*****";    //input your wifi passwords
17
18 void startCameraServer();
19
20 void setup() {
21   Serial.begin(115200);
22   Serial.setDebugOutput(true);
23   Serial.println();
24
25   camera_config_t config;
26   config. ....

```

Before running the program, please modify your router's name and password in the box shown in the illustration above to make sure that your Sketch can compile and work successfully.

Compile and upload codes to ESP32-S3, open the serial monitor and set the baud rate to 115200, and the serial monitor will print out a network link address.

```

SD_MMC Card Type: SDSC
SD_MMC Card Size: 961MB
Total space: 958MB
Used space: 15MB
Removing Dir: /video
rmdir failed
Creating Dir: /video
Dir created

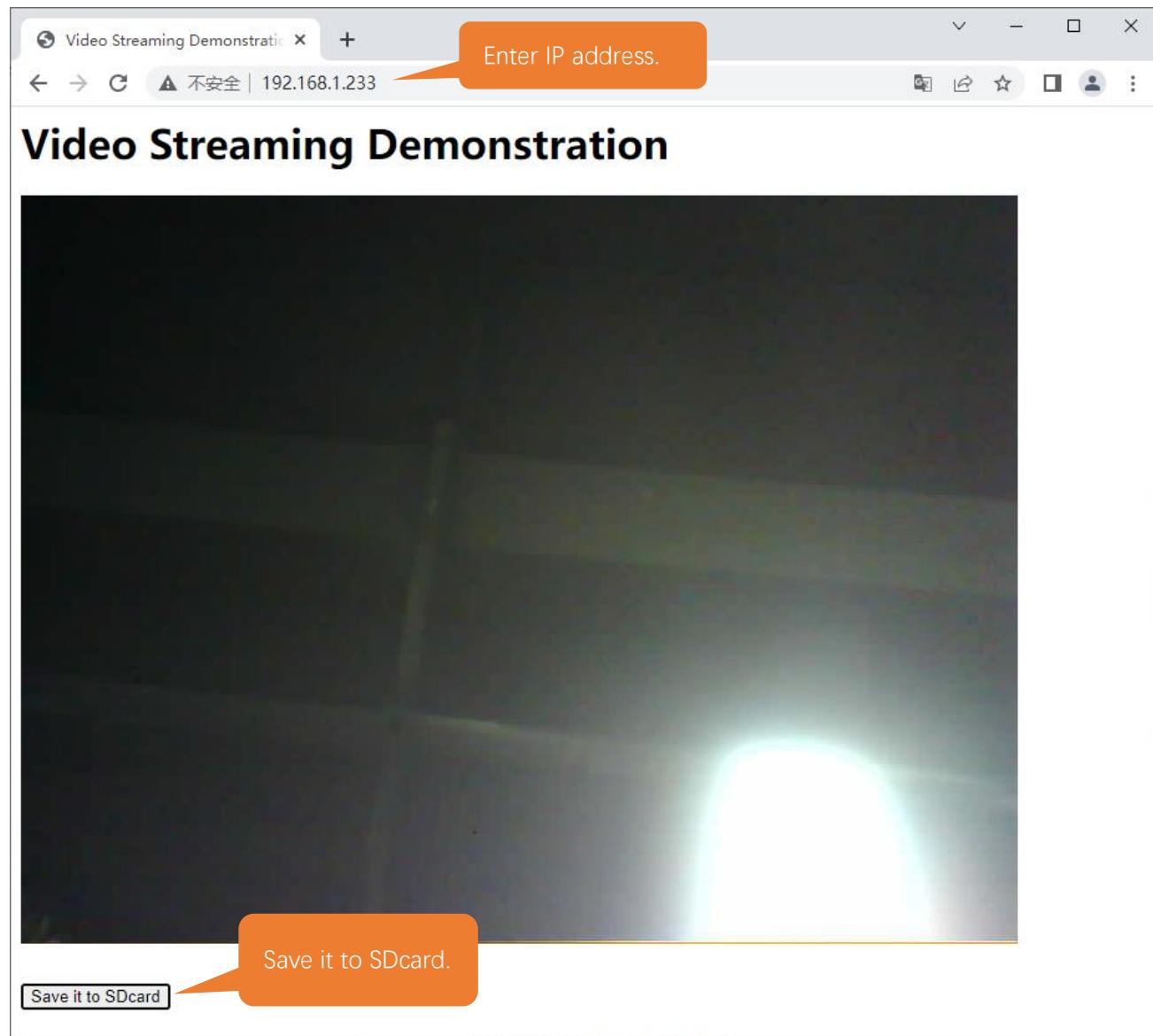
WiFi connected
[ 1543] [I] [app_httpd.cpp:305] startCameraServer(): [] Starting web server on port: '80'
[ 1545] [I] [app_httpd.cpp:315] startCameraServer(): [] Starting stream server on port: '81'
Camera Ready! Use 'http://192.168.1.233' to connect

```

If your ESP32-S3 has been in the process of connecting to router, but the information above has not been printed out, please re-check whether the router name and password have been entered correctly and press the reset key on ESP32-S3 WROOM to wait for a successful connection prompt.

Open a web browser, enter the IP address printed by the serial monitor in the address bar, and access it. Taking the Google browser as an example, here's what the browser prints out after successful access to ESP32-S3's IP.

The effect is shown in the image below.



The following is the main program code. You need include other code files in the same folder when write your own code.

```
1 #include "esp_camera.h"
2 #include <WiFi.h>
3
4 // Select camera model
5 #define CAMERA_MODEL_ESP32S3_EYE // Has PSRAM
6 #include "camera_pins.h"
7
```

Any concerns? [✉ support@freenove.com](mailto:support@freenove.com)

```
8 const char* ssid      = "*****";    //input your wifi name
9 const char* password = "*****";    //input your wifi passwords
10 void startCameraServer();
11
12 void setup() {
13     Serial.begin(115200);
14     Serial.setDebugOutput(true);
15     Serial.println();
16
17     camera_config_t config;
18     config.ledc_channel = LEDC_CHANNEL_0;
19     config.ledc_timer = LEDC_TIMER_0;
20     config.pin_d0 = Y2_GPIO_NUM;
21     config.pin_d1 = Y3_GPIO_NUM;
22     config.pin_d2 = Y4_GPIO_NUM;
23     config.pin_d3 = Y5_GPIO_NUM;
24     config.pin_d4 = Y6_GPIO_NUM;
25     config.pin_d5 = Y7_GPIO_NUM;
26     config.pin_d6 = Y8_GPIO_NUM;
27     config.pin_d7 = Y9_GPIO_NUM;
28     config.pin_xclk = XCLK_GPIO_NUM;
29     config.pin_pclk = PCLK_GPIO_NUM;
30     config.pin_vsync = VSYNC_GPIO_NUM;
31     config.pin_href = HREF_GPIO_NUM;
32     config.pin_sccb_sda = SIOD_GPIO_NUM;
33     config.pin_sccb_scl = SIOC_GPIO_NUM;
34     config.pin_pwdn = PWDN_GPIO_NUM;
35     config.pin_reset = RESET_GPIO_NUM;
36     config.xclk_freq_hz = 20000000;
37     config.frame_size = FRAMESIZE_UXGA;
38     config.pixel_format = PIXFORMAT_JPEG; // for streaming
39     config.grab_mode = CAMERA_GRAB_WHEN_EMPTY;
40     config.fb_location = CAMERA_FB_IN_PSRAM;
41     config.jpeg_quality = 12;
42     config.fb_count = 1;
43
44     // if PSRAM IC present, init with UXGA resolution and higher JPEG quality
45     // for larger pre-allocated frame buffer.
46     if(psramFound()){
47         config.jpeg_quality = 10;
48         config.fb_count = 2;
49         config.grab_mode = CAMERA_GRAB_LATEST;
50     } else {
51         // Limit the frame size when PSRAM is not available
```

```
52     config.frame_size = FRAMESIZE_SVGA;
53     config.fb_location = CAMERA_FB_IN_DRAM;
54 }
55
56 // camera init
57 esp_err_t err = esp_camera_init(&config);
58 if (err != ESP_OK) {
59     Serial.printf("Camera init failed with error 0x%x", err);
60     return;
61 }
62
63 sensor_t * s = esp_camera_sensor_get();
64 // initial sensors are flipped vertically and colors are a bit saturated
65 s->set_vflip(s, 1); // flip it back
66 s->set_brightness(s, 1); // up the brightness just a bit
67 s->set_saturation(s, 0); // lower the saturation
68
69 WiFi.begin(ssid, password);
70
71 while (WiFi.status() != WL_CONNECTED) {
72     delay(500);
73     Serial.print(".");
74 }
75 Serial.println("");
76 Serial.println("WiFi connected");
77
78 startCameraServer();
79
80 Serial.print("Camera Ready! Use 'http://");
81 Serial.print(WiFi.localIP());
82 Serial.println(" to connect");
83 }
84
85 void loop() {
86     // put your main code here, to run repeatedly:
87     delay(10000);
88 }
```



Configure parameters including interface pins of the camera. Note: It is generally not recommended to change them.

```

17  camera_config_t config;
18  config.ledc_channel = LEDC_CHANNEL_0;
19  config.ledc_timer = LEDC_TIMER_0;
20  config.pin_d0 = Y2_GPIO_NUM;
21  config.pin_d1 = Y3_GPIO_NUM;
22  config.pin_d2 = Y4_GPIO_NUM;
23  config.pin_d3 = Y5_GPIO_NUM;
24  config.pin_d4 = Y6_GPIO_NUM;
25  config.pin_d5 = Y7_GPIO_NUM;
26  config.pin_d6 = Y8_GPIO_NUM;
27  config.pin_d7 = Y9_GPIO_NUM;
28  config.pin_xclk = XCLK_GPIO_NUM;
29  config.pin_pclk = PCLK_GPIO_NUM;
30  config.pin_vsync = VSYNC_GPIO_NUM;
31  config.pin_href = HREF_GPIO_NUM;
32  config.pin_sccb_sda = SIOD_GPIO_NUM;
33  config.pin_sccb_scl = SIOC_GPIO_NUM;
34  config.pin_pwdn = PWDN_GPIO_NUM;
35  config.pin_reset = RESET_GPIO_NUM;
36  config.xclk_freq_hz = 20000000;
37  config.frame_size = FRAMESIZE_UXGA;
38  config.pixel_format = PIXFORMAT_JPEG; // for streaming
39  config.grab_mode = CAMERA_GRAB_WHEN_EMPTY;
40  config.fb_location = CAMERA_FB_IN_PSRAM;
41  config.jpeg_quality = 12;
42  config.fb_count = 1;

```

ESP32-S3 connects to the router and prints a successful connection prompt. If it has not been successfully connected, press the reset key on the ESP32-S3 WROOM.

```

69  WiFi.begin(ssid, password);
70
71  while (WiFi.status() != WL_CONNECTED) {
72      delay(500);
73      Serial.print(".");
74  }
75  Serial.println("");
76  Serial.println("WiFi connected");

```

Open the video streams server function of the camera and print its IP address via serial port.

```

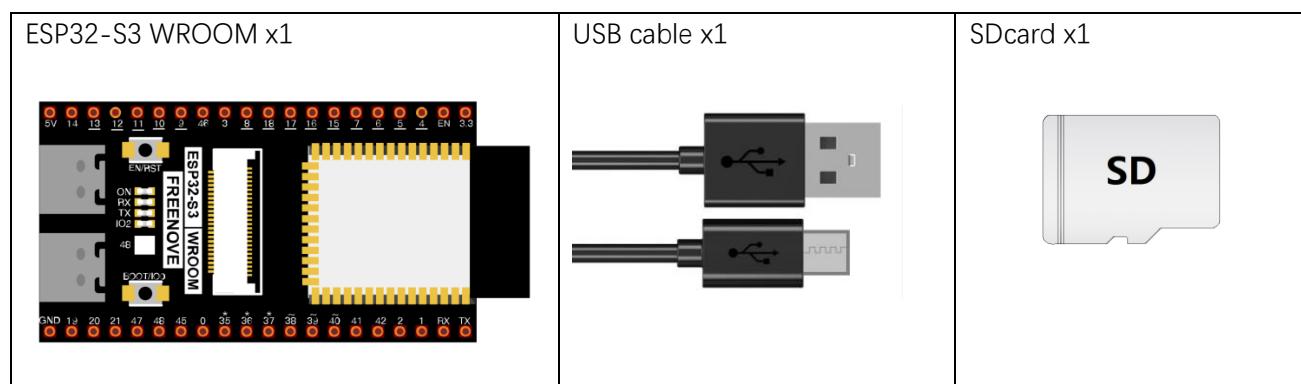
82  startCameraServer();
83
84  Serial.print("Camera Ready! Use 'http://");
85  Serial.print(WiFi.localIP());
86  Serial.println(" to connect");

```

Project 7.3 Camera and SDcard

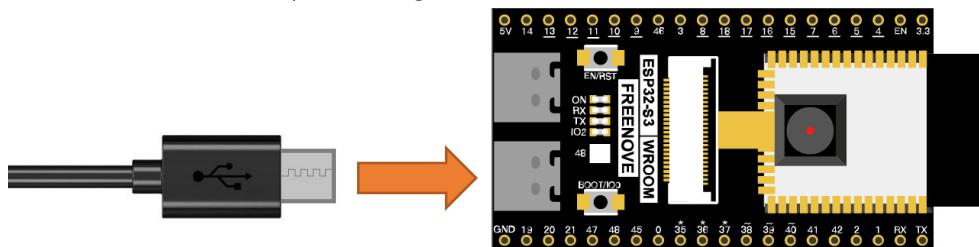
In this chapter, we continue to use the camera and SD card. We will use the onboard button as the shutter. When the button is pressed, the ESP32-S3 takes a photo and stores the photo in the SD folder.

Component List



Circuit

Connect Freenove ESP32-S3 to the computer using the USB cable.





Sketch

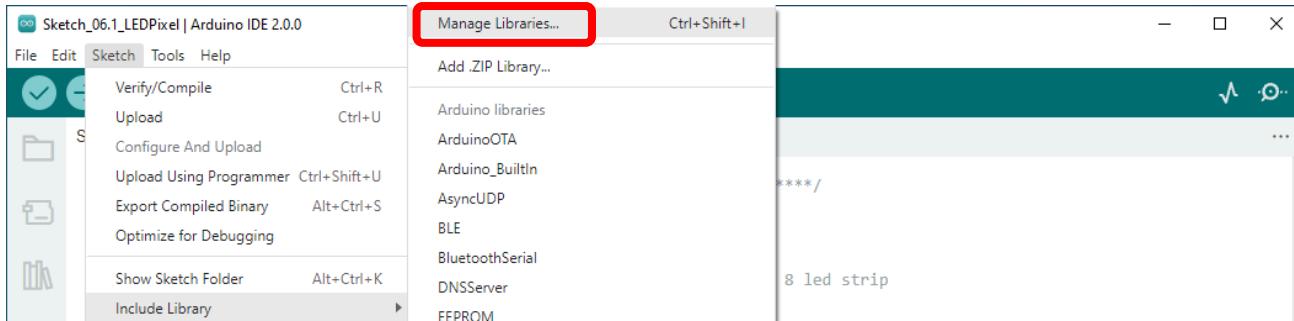
This code uses a library named "Freenove_WS2812_Lib_for_ESP32", if you have not installed it, please do so first.

Library is an important feature of the open source world, and we know that Arduino is an open source platform that everyone can contribute to. Libraries are generally licensed under the LGPL, which means you can use them for free to apply to your creations.

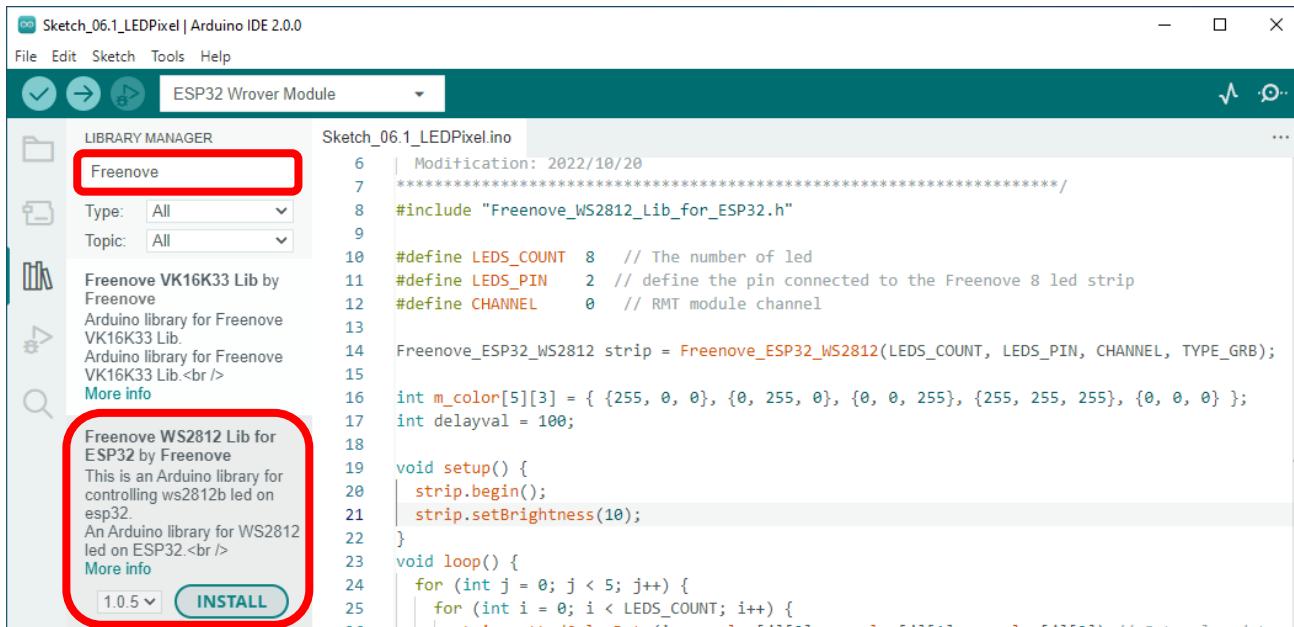
How to install the library

There are two ways to add libraries.

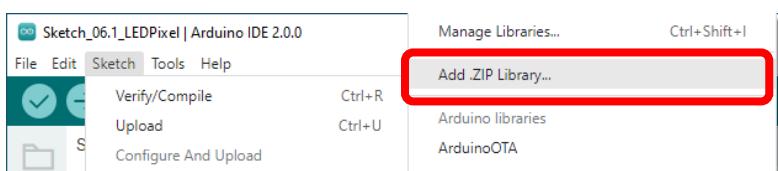
The first way, open the Arduino IDE, click Sketch → Include Library → Manager Libraries.



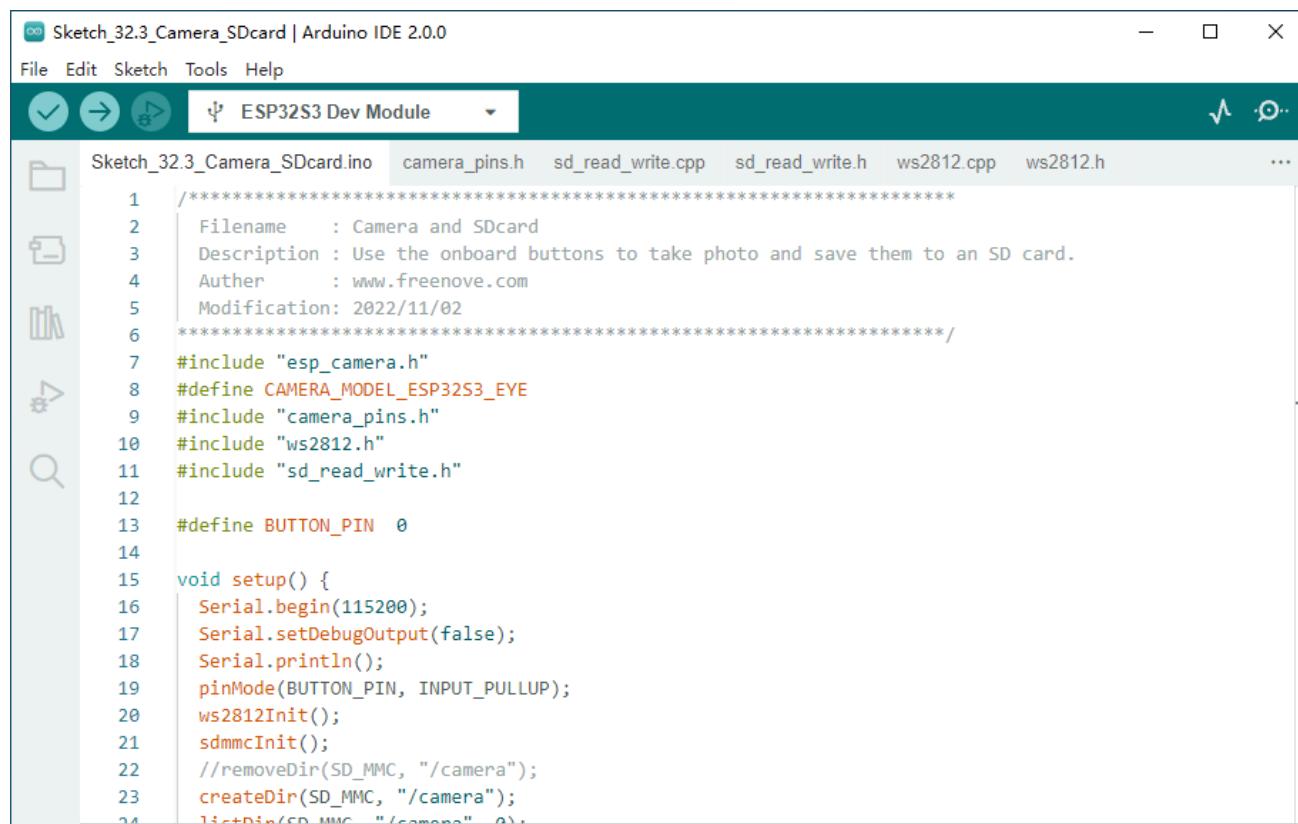
In the pop-up window, Library Manager, search for the name of the Library, "Freenove WS2812 Lib for ESP32". Then click Install.



The second way, open Arduino IDE, click Sketch→Include Library→Add .ZIP Library, In the pop-up window, find the file named "./Libraries/Freenove_WS2812_Lib_for_ESP32.Zip" which locates in this directory, and click OPEN.



Sketch_07.3_Camera_SDcard



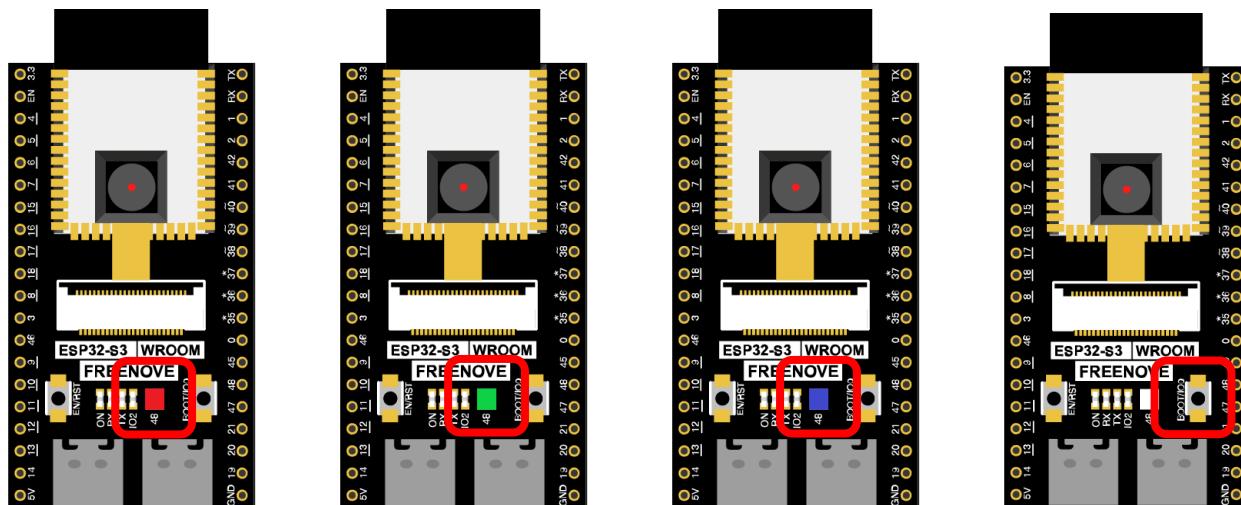
```

Sketch_32.3_Camera_SDcard | Arduino IDE 2.0.0
File Edit Sketch Tools Help
Sketch_32.3_Camera_SDcard.ino camera_pins.h sd_read_write.cpp sd_read_write.h ws2812.cpp ws2812.h ...
1 // ****
2 Filename : Camera and SDcard
3 Description : Use the onboard buttons to take photo and save them to an SD card.
4 Author : www.freenove.com
5 Modification: 2022/11/02
6 ****
7 #include "esp_camera.h"
8 #define CAMERA_MODEL_ESP32S3_EYE
9 #include "camera_pins.h"
10 #include "ws2812.h"
11 #include "sd_read_write.h"
12
13 #define BUTTON_PIN 0
14
15 void setup() {
16     Serial.begin(115200);
17     Serial.setDebugOutput(false);
18     Serial.println();
19     pinMode(BUTTON_PIN, INPUT_PULLUP);
20     ws2812Init();
21     sdmmcInit();
22     //removeDir(SD_MMC, "/camera");
23     createDir(SD_MMC, "/camera");
24     listDir(SD_MMC, "/camera");

```

Compile and upload the code to the ESP32-S3.

If your camera is not installed properly, causing the camera to fail to initialize, or you have not inserted the SD card into the ESP32-S3 in advance, the on-board colored lights will turn on red as a reminder. If all is well, the onboard colored light will light up green. When the onboard BOOT button is pressed, the ESP32-S3 will capture the current camera image and save it in the "Camera" folder of the SD card. At the same time, the onboard LED lights up blue, and returns to green after taking a photo.





As shown in the image below, after uploading the code to the ESP32-S3, the ESP32-S3 will automatically create a folder named "camera" in the SD card. Every time the BOOT button is pressed, the on-board colored light turns on blue, and ESP32-S3 collects a photo information and stores it in the "camera" folder. Press the button once to take a photo.

When we press the RST button to reset the ESP32-S3, we can see that there are some photo files in the SD card folder. These photos you can read directly through the card reader.

```
Output Serial Monitor ×

Message (Ctrl + Enter to send message to 'ESP32S3 Dev Module' on 'COM3')
New Line 115200 baud

SD_MMC Card Type: SDSC
SD_MMC Card Size: 961MB
Total space: 958MB
Used space: 14MB
Creating Dir: /camera
Dir created
Listing directory: /camera
Camera configuration complete!
Saved file to path: /camera/0.jpg
ESP-ROM: esp32s3-20210327
Build: Mar 27 2021
rst:0x1 (POWERON), boot:0x8 (SPI_FAST_FLASH_BOOT)
SPIWP:0xee
mode:DIO, clock div:1
load:0x3fce3808, len:0x43c
load:0x403c9700, len:0xbec
load:0x403cc700, len:0xa3c
entry 0x403c98d8

SD_MMC Card Type: SDSC
SD_MMC Card Size: 961MB
Total space: 958MB
Used space: 14MB
Creating Dir: /camera
Dir created
Listing directory: /camera
FILE: 0.jpg SIZE: 25390
Camera configuration complete!
```

The SD card information when press RST button.

The information when press BOOT button to take a picture.

Information when click RST button again.

The following is the main program code. You need include other code files in the same folder when write your own code.

```
1 #include "esp_camera.h"
2 #define CAMERA_MODEL_ESP32S3_EYE
3 #include "camera_pins.h"
4 #include "ws2812.h"
5 #include "sd_read_write.h"
6
7 #define BUTTON_PIN 0
8
9 void setup() {
10     Serial.begin(115200);
11     Serial.setDebugOutput(false);
12     Serial.println();
13     pinMode(BUTTON_PIN, INPUT_PULLUP);
14     ws2812Init();
15     sdmmcInit();
16     //removeDir(SD_MMC, "/camera");
17     createDir(SD_MMC, "/camera");
18     listDir(SD_MMC, "/camera", 0);
19     if(cameraSetup()==1) {
20         ws2812SetColor(2);
21     }
22     else{
23         ws2812SetColor(1);
24         return;
25     }
26 }
27
28 void loop() {
29     if(digitalRead(BUTTON_PIN)==LOW) {
30         delay(20);
31         if(digitalRead(BUTTON_PIN)==LOW) {
32             ws2812SetColor(3);
33             while(digitalRead(BUTTON_PIN)==LOW);
34             camera_fb_t * fb = NULL;
35             fb = esp_camera_fb_get();
36             if (fb != NULL) {
37                 int photo_index = readFileNum(SD_MMC, "/camera");
38                 if(photo_index!=-1)
39                 {
40                     String path = "/camera/" + String(photo_index) + ".jpg";
41                     writeJpg(SD_MMC, path.c_str(), fb->buf, fb->len);
42                 }
43             }
44         }
45     }
46 }
```

```
43         esp_camera_fb_return(fb);
44     }
45     else {
46         Serial.println("Camera capture failed.");
47     }
48     ws2812SetColor(2);
49 }
50 }
51 }
52
53 int cameraSetup(void) {
54     camera_config_t config;
55     config.ledc_channel = LEDC_CHANNEL_0;
56     config.ledc_timer = LEDC_TIMER_0;
57     config.pin_d0 = Y2_GPIO_NUM;
58     config.pin_d1 = Y3_GPIO_NUM;
59     config.pin_d2 = Y4_GPIO_NUM;
60     config.pin_d3 = Y5_GPIO_NUM;
61     config.pin_d4 = Y6_GPIO_NUM;
62     config.pin_d5 = Y7_GPIO_NUM;
63     config.pin_d6 = Y8_GPIO_NUM;
64     config.pin_d7 = Y9_GPIO_NUM;
65     config.pin_xclk = XCLK_GPIO_NUM;
66     config.pin_pclk = PCLK_GPIO_NUM;
67     config.pin_vsync = VSYNC_GPIO_NUM;
68     config.pin_href = HREF_GPIO_NUM;
69     config.pin_sccb_sda = SIOD_GPIO_NUM;
70     config.pin_sccb_scl = SIOC_GPIO_NUM;
71     config.pin_pwdn = PWDN_GPIO_NUM;
72     config.pin_reset = RESET_GPIO_NUM;
73     config.xclk_freq_hz = 20000000;
74     config.frame_size = FRAMESIZE_UXGA;
75     config.pixel_format = PIXFORMAT_JPEG; // for streaming
76     config.grab_mode = CAMERA_GRAB_WHEN_EMPTY;
77     config.fb_location = CAMERA_FB_IN_PSRAM;
78     config.jpeg_quality = 12;
79     config.fb_count = 1;
80
81 // if PSRAM IC present, init with UXGA resolution and higher JPEG quality
82 // for larger pre-allocated frame buffer.
83 if(psramFound()){
84     config.jpeg_quality = 10;
85     config.fb_count = 2;
86     config.grab_mode = CAMERA_GRAB_LATEST;
```

```

87 } else {
88     // Limit the frame size when PSRAM is not available
89     config.frame_size = FRAMESIZE_SVGA;
90     config.fb_location = CAMERA_FB_IN_DRAM;
91 }
92
93 // camera init
94 esp_err_t err = esp_camera_init(&config);
95 if (err != ESP_OK) {
96     Serial.printf("Camera init failed with error 0x%x", err);
97     return 0;
98 }
99
100 sensor_t * s = esp_camera_sensor_get();
101 // initial sensors are flipped vertically and colors are a bit saturated
102 s->set_vflip(s, 1); // flip it back
103 s->set_brightness(s, 1); // up the brightness just a bit
104 s->set_saturation(s, 0); // lower the saturation
105
106 Serial.println("Camera configuration complete!");
107 return 1;
108 }
```

Configure camera parameters, including camera interface pins and other information. Altering them is generally not recommended. Returns 1 if the camera is initialized successfully, and returns 0 if it fails.

```

53 int cameraSetup(void) {
54     camera_config_t config;
55     config.ledc_channel = LEDC_CHANNEL_0;
56     config.ledc_timer = LEDC_TIMER_0;
57     config.pin_d0 = Y2_GPIO_NUM;
58     config.pin_d1 = Y3_GPIO_NUM;
59     config.pin_d2 = Y4_GPIO_NUM;
60     config.pin_d3 = Y5_GPIO_NUM;
61     config.pin_d4 = Y6_GPIO_NUM;
62     config.pin_d5 = Y7_GPIO_NUM;
63     config.pin_d6 = Y8_GPIO_NUM;
64     config.pin_d7 = Y9_GPIO_NUM;
65     config.pin_xclk = XCLK_GPIO_NUM;
66     config.pin_pclk = PCLK_GPIO_NUM;
67     config.pin_vsync = VSYNC_GPIO_NUM;
68     config.pin_href = HREF_GPIO_NUM;
69     config.pin_sccb_sda = SIOD_GPIO_NUM;
70     config.pin_sccb_scl = SIOC_GPIO_NUM;
71     config.pin_pwdn = PWDN_GPIO_NUM;
72     config.pin_reset = RESET_GPIO_NUM;
```

```
73 config.xclk_freq_hz = 20000000;
74 config.frame_size = FRAMESIZE_UXGA;
75 config.pixel_format = PIXFORMAT_JPEG; // for streaming
76 config.grab_mode = CAMERA_GRAB_WHEN_EMPTY;
77 config.fb_location = CAMERA_FB_IN_PSRAM;
78 config.jpeg_quality = 12;
79 config.fb_count = 1;
80
81 // if PSRAM IC present, init with UXGA resolution and higher JPEG quality
82 // for larger pre-allocated frame buffer.
83 if(psramFound()) {
84     config.jpeg_quality = 10;
85     config.fb_count = 2;
86     config.grab_mode = CAMERA_GRAB_LATEST;
87 } else {
88     // Limit the frame size when PSRAM is not available
89     config.frame_size = FRAMESIZE_SVGA;
90     config.fb_location = CAMERA_FB_IN_DRAM;
91 }
92
93 // camera init
94 esp_err_t err = esp_camera_init(&config);
95 if (err != ESP_OK) {
96     Serial.printf("Camera init failed with error 0x%x", err);
97     return 0;
98 }
99
100 sensor_t * s = esp_camera_sensor_get();
101 // initial sensors are flipped vertically and colors are a bit saturated
102 s->set_vflip(s, 1); // flip it back
103 s->set_brightness(s, 1); // up the brightness just a bit
104 s->set_saturation(s, 0); // lower the saturation
105
106 Serial.println("Camera configuration complete!");
107 return 1;
108 }
```

Initialize the serial port, buttons, lights and SD card.

```
10 Serial.begin(115200);
11 Serial.setDebugOutput(false);
12 Serial.println();
13 pinMode(BUTTON_PIN, INPUT_PULLUP);
14 ws2812Init();
15 sdmmcInit();
```

Call ws2812SetColor() to set the color of the LED. When the parameter is 0, the LED is turned off, when the parameter is 1, the red light is displayed, when the parameter is 2, the green light is displayed, and when the parameter is 3, the blue light is displayed.

```
20 ws2812SetColor(2);
```

Get the camera data once, then read the file number in the camera folder of the SD card, and create a new file based on this, write the camera data into it, and finally return the camera structure pointer. If the camera data cannot be obtained, the prompt information will be printed directly.

```
34     camera_fb_t * fb = NULL;
35     fb = esp_camera_fb_get();
36     if (fb != NULL) {
37         int photo_index = readFileNum(SD_MMC, "/camera");
38         if(photo_index!=-1)
39         {
40             String path = "/camera/" + String(photo_index) + ".jpg";
41             writejpg(SD_MMC, path.c_str(), fb->buf, fb->len);
42         }
43         esp_camera_fb_return(fb);
44     }
45     else {
46         Serial.println("Camera capture failed.");
47     }
```

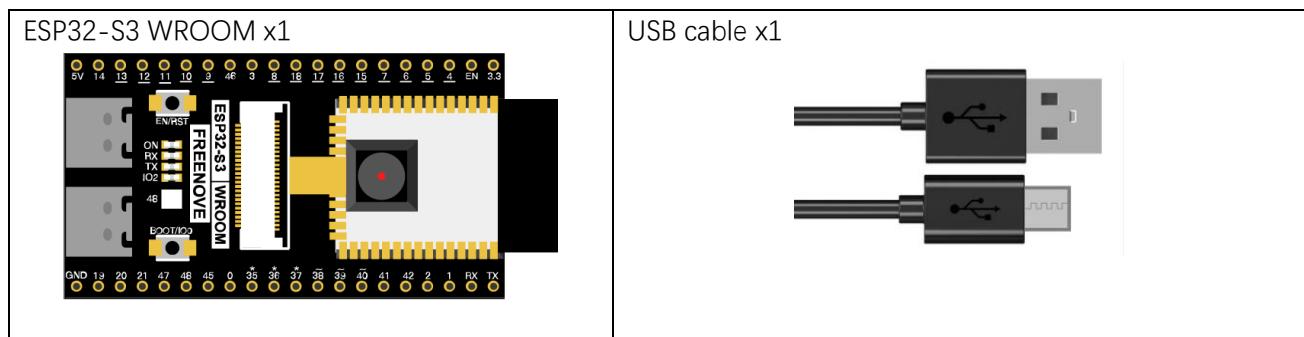
Chapter 8 Camera Tcp Server

In the previous section, we used web page to display the video data captured by ESP32-S3, and in this section, we will use a mobile phone to display it.

Project 8.1 Camera Tcp Server

Connect ESP32-S3 using USB and check its IP address through serial monitor. Use a mobile phone to obtain video and image data.

Component List

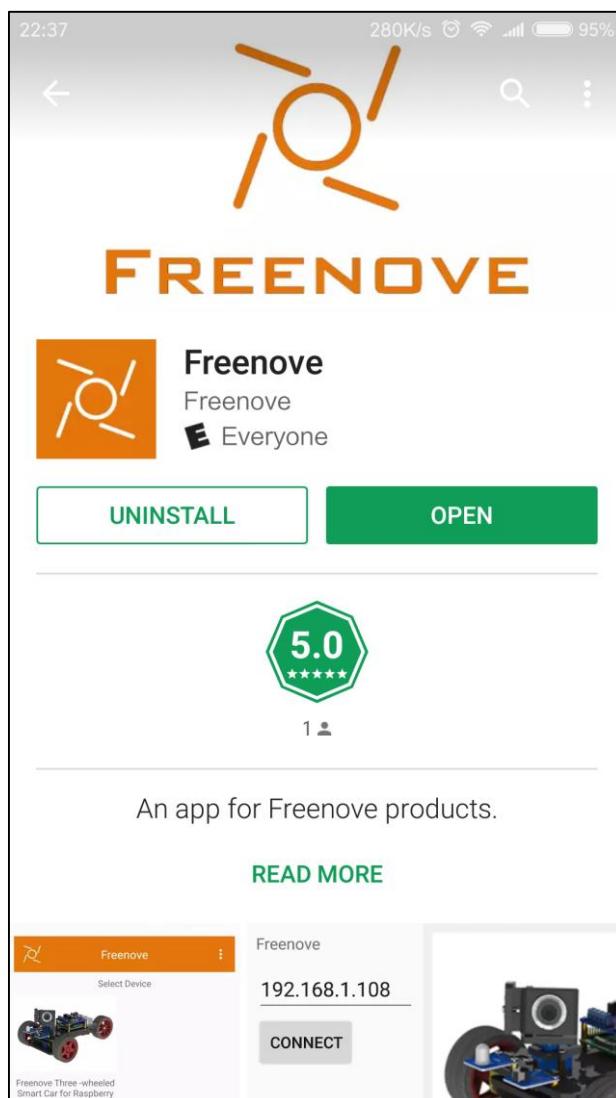


Install Freenove app

There are three ways to install app, you can choose any one.

Method 1

Use Google play to search “Freenove”, download and install.

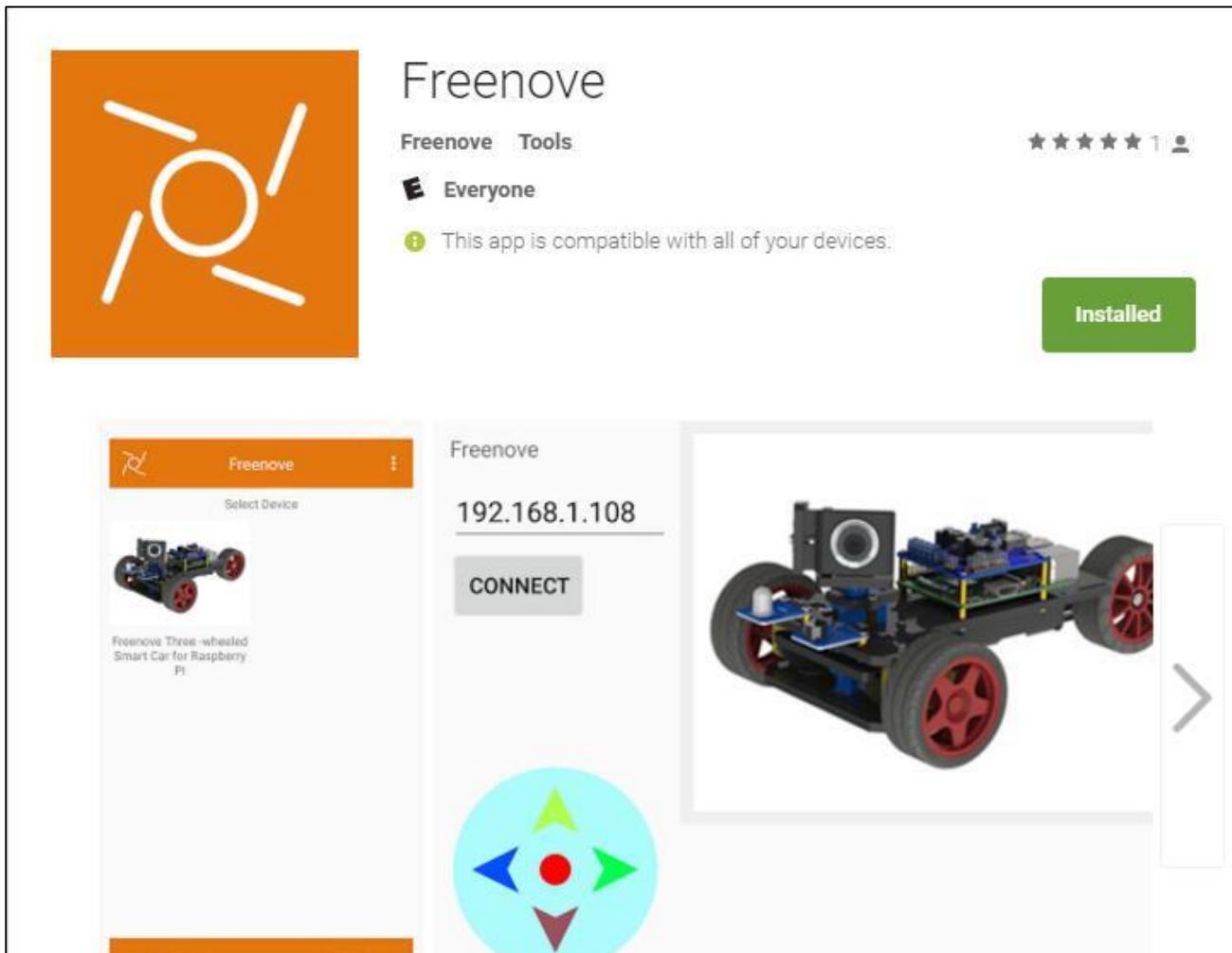


Any concerns? ✉ support@freenove.com



Method 2

Visit <https://play.google.com/store/apps/details?id=com.freenove.suhayl.Freenove>, and click install.



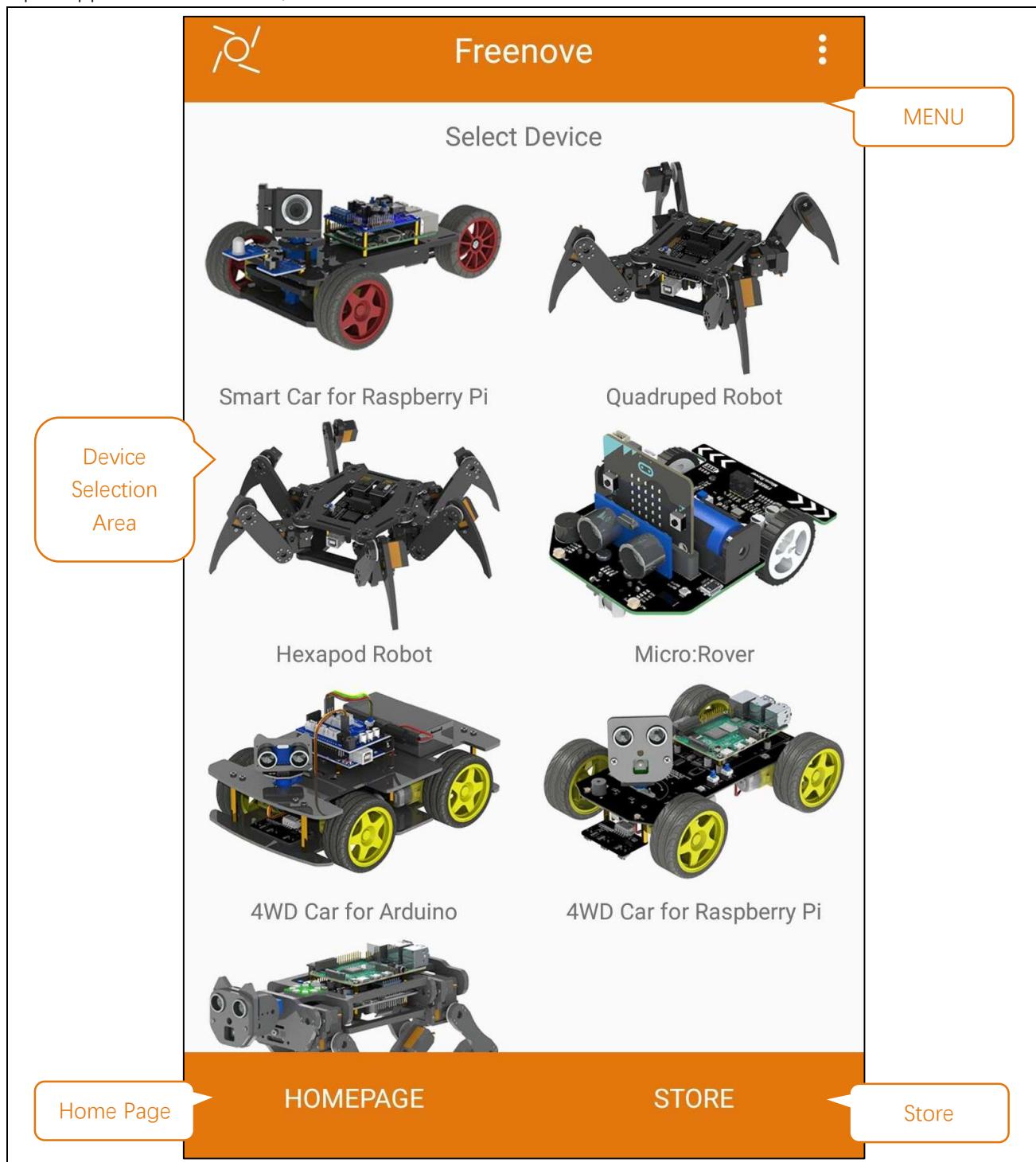
Method 3

Visit https://github.com/Freenove/Freenove_app_for_Android, download the files in this library, and install freenove.apk to your Android phone manually.

The screenshot shows the GitHub repository page for 'Freenove / Freenove_app_for_Android'. At the top, there's a search bar and navigation links for 'Pull requests', 'Issues', and 'Gist'. Below the header, the repository name is displayed, along with 'Unwatch' (2), 'Star' (0), and 'Fork' (0) buttons. A navigation bar includes 'Code' (selected), 'Issues 0', 'Pull requests 0', 'Projects 0', 'Wiki', 'Pulse', 'Graphs', and 'Settings'. A note says 'Apply to Freenove products.' with an 'Edit' button. Below this, it shows '1 commit', '1 branch', '0 releases', and '1 contributor'. A dropdown shows 'Branch: master' and a 'New pull request' button. The main content area lists files: 'Readme.txt' (First Publish., 3 minutes ago) and 'freenove.apk' (First Publish., 3 minutes ago). A green 'Clone or download' button is highlighted with an orange callout box containing the text 'Click here to download.'

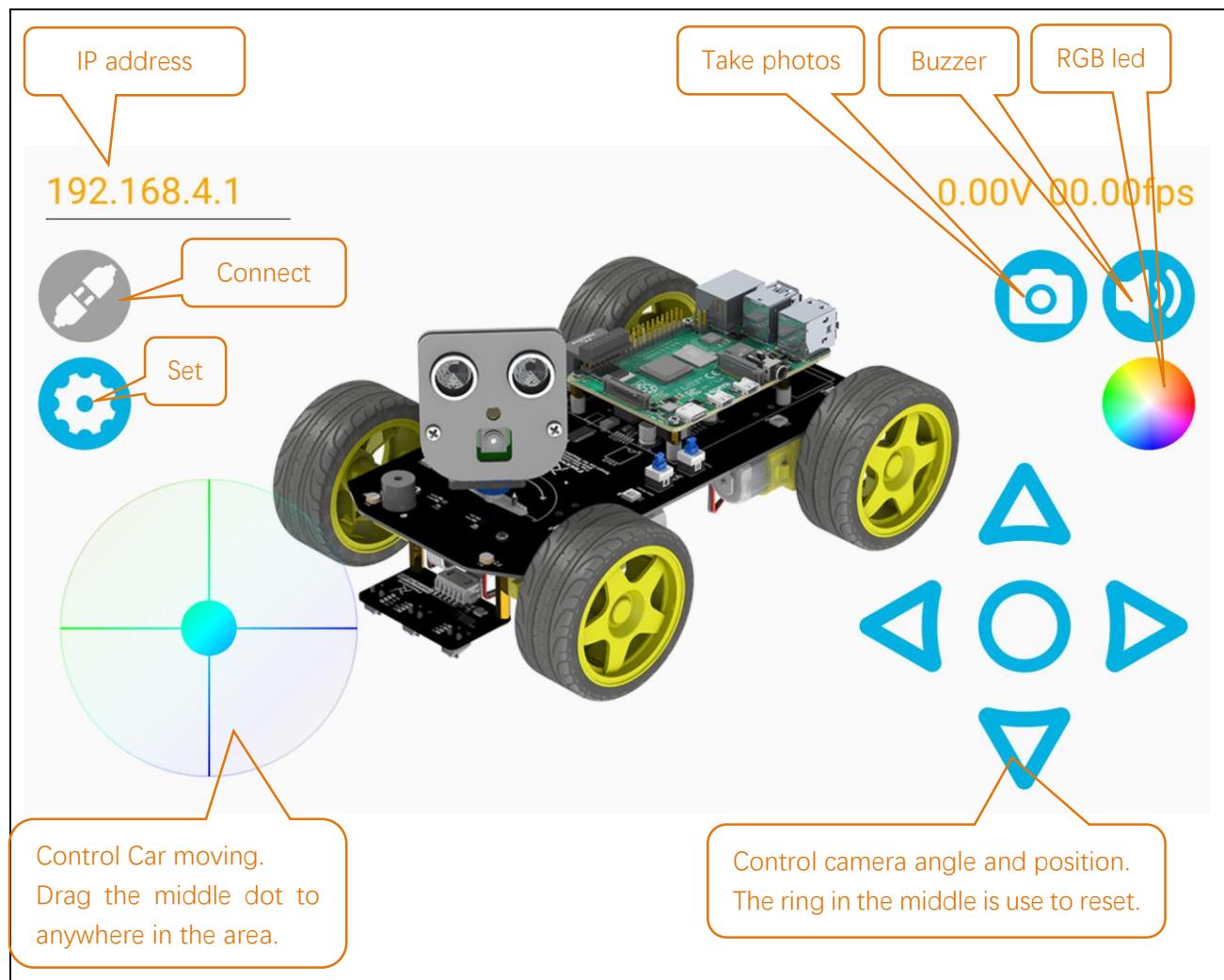
Menu

Open application “Freenove”, as shown below:



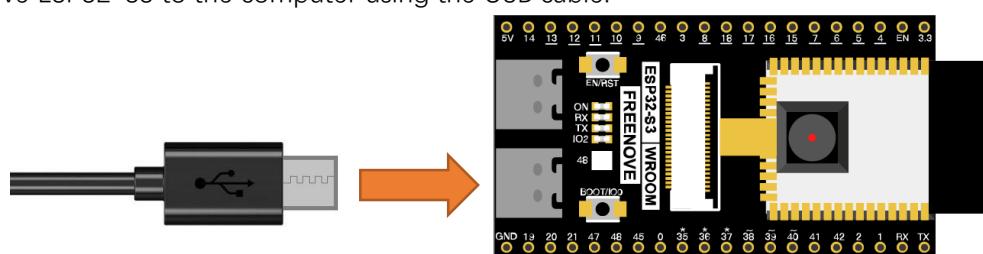
Freenove 4WD Car for Raspberry Pi

In this chapter, we use Freenove 4WD Car for Raspberry Pi, so it is necessary to understand the interface of this mode.



Circuit

Connect Freenove ESP32-S3 to the computer using the USB cable.





Sketch

After making sure the Tools is configured correctly, don't run Sketch. Due to WiFi, we need to modify Sketch a little bit based on physical situation.

```

Sketch_33.1_CameraTcpServer | Arduino IDE 2.0.0
File Edit Sketch Tools Help
ESP32S3 Dev Module
Sketch_33.1_CameraTcpServer.ino esp_camera.h img_converters.h camera_pins.h ...
1 //*****
2   Filename : Camera Tcp Serrver
3   Description : Users use Freenove's APP to view images from ESP32S3's camera
4   Author : www.freenove.com
5   Modification: 2022/11/02
6 *****/
7 #include "esp_camera.h"
8 #include <WiFi.h>
9 #include <WiFiClient.h>
10 #include <WiFiAP.h>
11
12 #define CAMERA_MODEL_ESP32S3_EYE
13 #include "camera_pins.h"
14 #define LED_BUILT_IN 2
15
16 const char* ssid_Router      = "*****";
17 const char* password_Router = "*****";
18 const char *ssid_AP          = "*****";
19 const char *password_AP      = "*****";
20
21 WiFiServer server_Cmd(5000);
22 WiFiServer server_Camera(8000);
23 extern TaskHandle_t loopTaskHandle;

```

In the box in the figure above, ssid_Router and password_Router are the user's Router name and password, which need to be modified according to the actual name and password. ssid_AP and password_AP are name and password of a AP created by ESP32-S3, and they are freely set by the user. When all settings are correct, compile and upload the code to ESP32-S3, turn on the serial port monitor, and set the baud rate to 115200. The serial monitor will print out two IP addresses.

```

Output Serial Monitor X
Message (Ctrl + Enter to send message to 'ESP32S3 Dev Module' on 'COM3')
entry 0x403c98d8

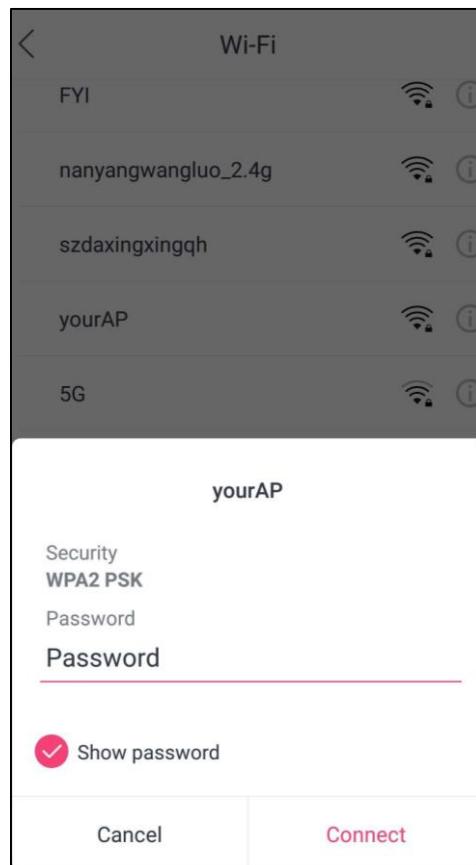
Camera configuration complete!
AP IP address: 192.168.4.1
Connecting FYI_2.4G..
WiFi connected
Camera Ready! Use '192.168.4.1 or 192.168.1.233' to connect in Freenove app.
Task Cmd_Server is starting ...

```

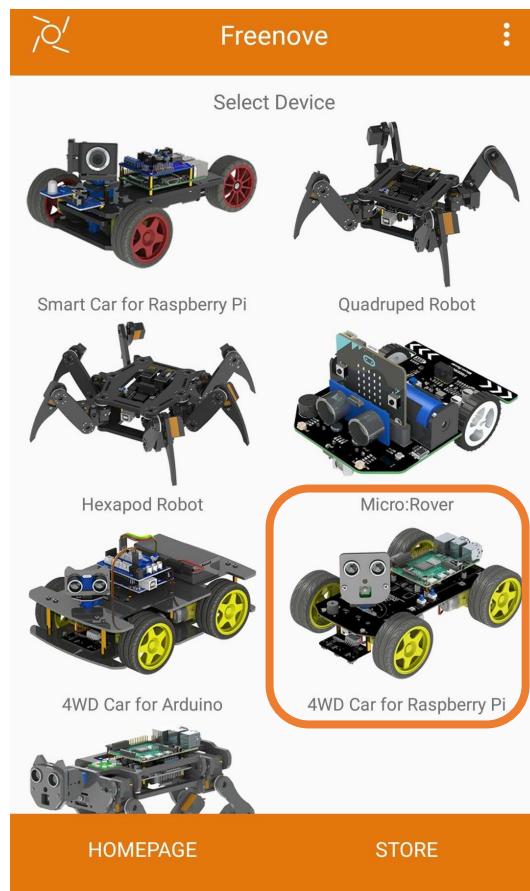
There are two methods for you to check camera data of ESP32-S3 via mobile phone APP.

Method 1:

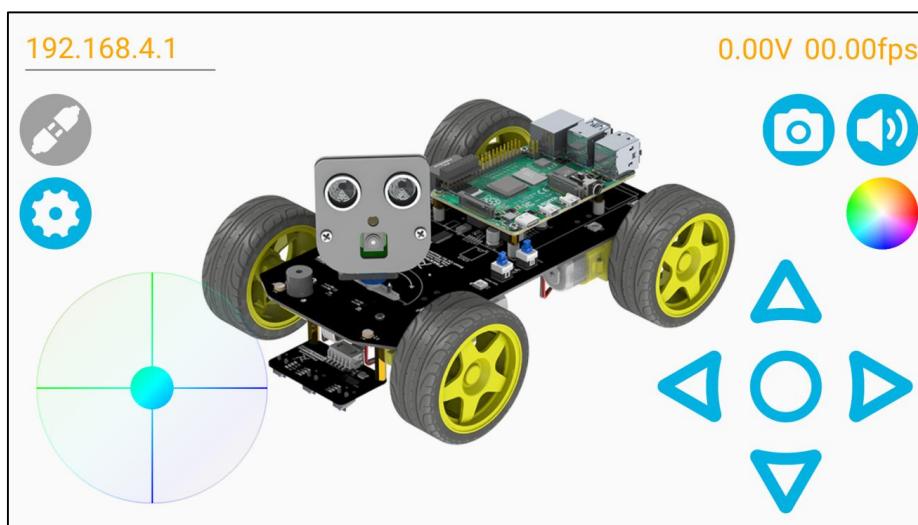
Using your phone's WiFi function, select the WiFi name represented by ssid_AP in Sketch and enter the password "password_AP" to connect.



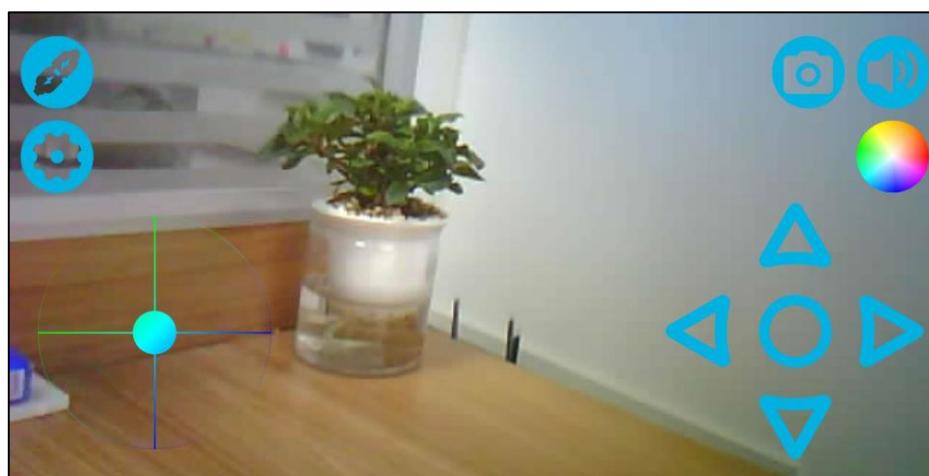
Next, open Freenove app and select 4WD Car for Raspberry Pi mode.



Enter the IP address printed by serial port in the new interface, which generally is “192.168.4.1”



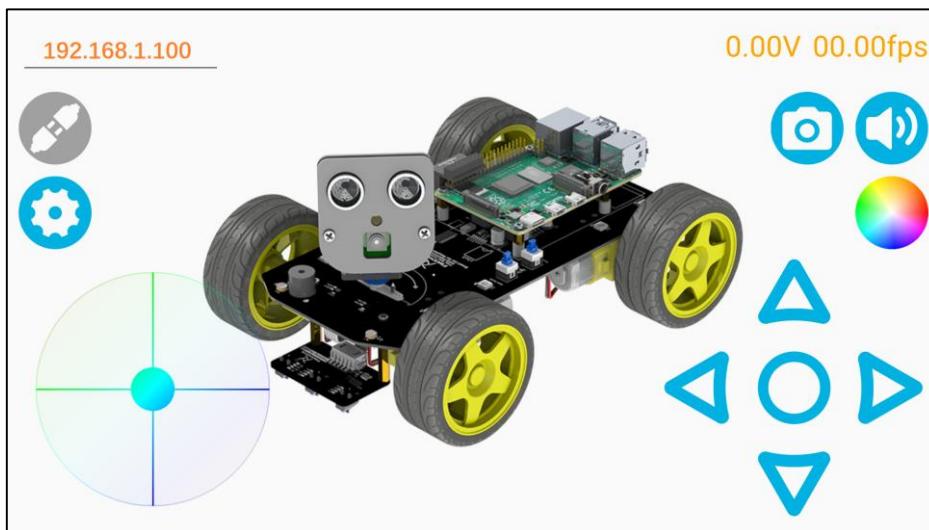
Click “Connect”.



Method 2:

Using your phone's WiFi function, select the router named ssid_Router and enter the password "ssid_password" to connect. And then open Freenove app and select 4WD Car for Raspberry Pi mode. The operation is similar to Method 1.

Enter the IP address printed by serial port in the new interface, which generally is not "192.168.4.1" but another one. The IP address in this example is "192.168.1.100". After entering the IP address, click "Connect".



The following is the main program code. You need include other code files in the same folder when write your own code.

Sketch_08.1_Camera_Tcp_Server

```

1 #include "esp_camera.h"
2 #include <WiFi.h>
3 #include <WiFiClient.h>
4 #include <WiFiAP.h>
5
6 #define CAMERA_MODEL_ESP32S3_EYE

```

Any concerns? ✉ support@freenove.com

```
7 #include "camera_pins.h"
8 #define LED_BUILT_IN 2
9
10 const char *ssid_Router      = "*****";
11 const char *password_Router = "*****";
12 const char *ssid_AP         = "*****";
13 const char *password_AP     = "*****";
14
15 WiFiServer server_Cmd(5000);
16 WiFiServer server_Camera(8000);
17 extern TaskHandle_t loopTaskHandle;
18
19 void setup() {
20   Serial.begin(115200);
21   Serial.setDebugOutput(false);
22   Serial.println();
23   pinMode(LED_BUILT_IN, OUTPUT);
24   cameraSetup();
25
26   WiFi.softAP(ssid_AP, password_AP);
27   IPAddress myIP = WiFi.softAPIP();
28   Serial.print("AP IP address: ");
29   Serial.println(myIP);
30   server_Camera.begin(8000);
31   server_Cmd.begin(5000);
32   /////////////////////////////////
33   WiFi.begin(ssid_Router, password_Router);
34   Serial.print("Connecting ");
35   Serial.print(ssid_Router);
36   while (WiFi.isConnected() != true) {
37     delay(500);
38     Serial.print(".");
39   }
40   while (WiFi.STA.hasIP() != true) {
41     Serial.print(".");
42     delay(500);
43   }
44   Serial.println("");
45   Serial.println("WiFi connected");
46   /////////////////////////////////
47   Serial.print("Camera Ready! Use '");
48   Serial.print(WiFi.softAPIP());
49   Serial.print(" or ");
50   Serial.print(WiFi.localIP());
```

```
51 Serial.println(" to connect in Freenove app.");
52
53 disableCore0WDT();
54 xTaskCreateUniversal(loopTask_Cmd, "loopTask_Cmd", 8192, NULL, 1, &loopTaskHandle,
55 0); //loopTask_Cmd uses core 0.
56 xTaskCreateUniversal(loopTask_Blink, "loopTask_Blink", 8192, NULL, 1, &loopTaskHandle,
57 0); //loopTask_Blink uses core 0.
58 }
59 //task loop uses core 1.
60 void loop() {
61 WiFiClient client = server_Camera.available(); // listen for incoming clients
62 if (client) { // if you get a client,
63 Serial.println("Camera Server connected to a client."); // print a message out the serial
64 port
65 String currentLine = ""; // make a String to hold incoming data from the client
66 while (client.connected()) { // loop while the client's connected
67 camera_fb_t * fb = NULL;
68 while (client.connected()) {
69 fb = esp_camera_fb_get();
70 if (fb != NULL) {
71 uint8_t slen[4];
72 slen[0] = fb->len >> 0;
73 slen[1] = fb->len >> 8;
74 slen[2] = fb->len >> 16;
75 slen[3] = fb->len >> 24;
76 client.write(slen, 4);
77 client.write(fb->buf, fb->len);
78 esp_camera_fb_return(fb);
79 }
80 else {
81 Serial.println("Camera Error");
82 }
83 }
84 // close the connection:
85 client.stop();
86 Serial.println("Camera Client Disconnected.");
87 }
88 void loopTask_Cmd(void *pvParameters) {
89 Serial.println("Task Cmd_Server is starting ... ");
90 while (1) {
91 WiFiClient client = server_Cmd.available(); // listen for incoming clients
```

```

92     if (client) {                                // if you get a client,
93         Serial.println("Command Server connected to a client."); // print a message out the
94         serial port
95         String currentLine = "";                  // make a String to hold incoming data from the client
96         while (client.connected()) {               // loop while the client's connected
97             if (client.available()) {              // if there's bytes to read from the client,
98                 char c = client.read();           // read a byte, then
99                 client.write(c);
100                Serial.write(c);                // print it out the serial monitor
101                if (c == '\n') {                  // if the byte is a newline character
102                    currentLine = "";
103                }
104                else {
105                    currentLine += c;            // add it to the end of the currentLine
106                }
107            }
108            // close the connection:
109            client.stop();
110            Serial.println("Command Client Disconnected.");
111        }
112    }
113 }
114 void loopTask_Blink(void *pvParameters) {
115     Serial.println("Task Blink is starting ... ");
116     while (1) {
117         digitalWrite(LED_BUILT_IN, !digitalRead(LED_BUILT_IN));
118         delay(1000);
119     }
120 }
121
122 void cameraSetup() {
123     camera_config_t config;
124     config.ledc_channel = LEDC_CHANNEL_0;
125     config.ledc_timer = LEDC_TIMER_0;
126     config.pin_d0 = Y2_GPIO_NUM;
127     config.pin_d1 = Y3_GPIO_NUM;
128     config.pin_d2 = Y4_GPIO_NUM;
129     config.pin_d3 = Y5_GPIO_NUM;
130     config.pin_d4 = Y6_GPIO_NUM;
131     config.pin_d5 = Y7_GPIO_NUM;
132     config.pin_d6 = Y8_GPIO_NUM;
133     config.pin_d7 = Y9_GPIO_NUM;
134     config.pin_xclk = XCLK_GPIO_NUM;

```

```
135 config.pin_pclk = PCLK_GPIO_NUM;
136 config.pin_vsync = VSYNC_GPIO_NUM;
137 config.pin_href = HREF_GPIO_NUM;
138 config.pin_sccb_sda = SIOD_GPIO_NUM;
139 config.pin_sccb_scl = SIOC_GPIO_NUM;
140 config.pin_pwdn = PWDN_GPIO_NUM;
141 config.pin_reset = RESET_GPIO_NUM;
142 config.xclk_freq_hz = 20000000;
143 config.frame_size = FRAMESIZE_UXGA;
144 config.pixel_format = PIXFORMAT_JPEG; // for streaming
145 config.grab_mode = CAMERA_GRAB_WHEN_EMPTY;
146 config.fb_location = CAMERA_FB_IN_PSRAM;
147 config.jpeg_quality = 12;
148 config.fb_count = 1;
149
150 // if PSRAM IC present, init with UXGA resolution and higher JPEG quality
151 // for larger pre-allocated frame buffer.
152 if(psramFound()){
153     config.jpeg_quality = 10;
154     config.fb_count = 2;
155     config.grab_mode = CAMERA_GRAB_LATEST;
156 } else {
157     // Limit the frame size when PSRAM is not available
158     config.frame_size = FRAMESIZE_SVGA;
159     config.fb_location = CAMERA_FB_IN_DRAM;
160 }
161
162 // camera init
163 esp_err_t err = esp_camera_init(&config);
164 if (err != ESP_OK) {
165     Serial.printf("Camera init failed with error 0x%x", err);
166     return;
167 }
168
169 sensor_t * s = esp_camera_sensor_get();
170 // initial sensors are flipped vertically and colors are a bit saturated
171 s->set_vflip(s, 1); // flip it back
172 s->set_brightness(s, 1); // up the brightness just a bit
173 s->set_saturation(s, 0); // lower the saturation
174
175 Serial.println("Camera configuration complete!");
176 }
```



Include header files that drive camera and WiFi.

```

1 #include "esp_camera.h"
2 #include <WiFi.h>
3 #include <WiFiClient.h>
4 #include <WiFiAP.h>
5
6 #define CAMERA_MODEL_ESP32S3_EYE
7 #include "camera_pins.h"
```

Set name and password for router that ESP32-S3 needs to connect to. And set ESP32-S3 to open two servers, whose port are 8000 and 5000 respectively.

```

10 const char *ssid_Router      = "*****";
11 const char *password_Router = "*****";
12 const char *ssid_AP         = "*****";
13 const char *password_AP    = "*****";
```

Enable ESP32-S3's server function and set two monitor ports as 5000 and 8000. In general, the two port numbers do not require modifications.

```

15 WiFiServer server_Cmd(5000);
16 WiFiServer server_Camera(8000);
17 extern TaskHandle_t loopTaskHandle;
```

Initialize serial port, set baud rate to 115200; open the debug and output function of the serial.

```

20 Serial.begin(115200);
21 Serial.setDebugOutput(true);
22 Serial.println();
```

Define a variable for camera interface and initialize it.

```

119 void cameraSetup() {
120     camera_config_t config;
121     config.ledc_channel = LEDC_CHANNEL_0;
122     config.ledc_timer = LEDC_TIMER_0;
123     config.pin_d0 = Y2_GPIO_NUM;
124     config.pin_d1 = Y3_GPIO_NUM;
125     config.pin_d2 = Y4_GPIO_NUM;
126     config.pin_d3 = Y5_GPIO_NUM;
127     config.pin_d4 = Y6_GPIO_NUM;
128     config.pin_d5 = Y7_GPIO_NUM;
129     config.pin_d6 = Y8_GPIO_NUM;
130     config.pin_d7 = Y9_GPIO_NUM;
131     config.pin_xclk = XCLK_GPIO_NUM;
132     config.pin_pclk = PCLK_GPIO_NUM;
133     config.pin_vsync = VSYNC_GPIO_NUM;
134     config.pin_href = HREF_GPIO_NUM;
135     config.pin_sccb_sda = SIOD_GPIO_NUM;
136     config.pin_sccb_scl = SIOC_GPIO_NUM;
137     config.pin_pwdn = PWDN_GPIO_NUM;
138     config.pin_reset = RESET_GPIO_NUM;
```

```

139 config.xclk_freq_hz = 20000000;
140 config.frame_size = FRAMESIZE_UXGA;
141 config.pixel_format = PIXFORMAT_JPEG; // for streaming
142 config.grab_mode = CAMERA_GRAB_WHEN_EMPTY;
143 config.fb_location = CAMERA_FB_IN_PSRAM;
144 config.jpeg_quality = 12;
145 config.fb_count = 1;
146
147 // if PSRAM IC present, init with UXGA resolution and higher JPEG quality
148 // for larger pre-allocated frame buffer.
149 if(psramFound()) {
150     config.jpeg_quality = 10;
151     config.fb_count = 2;
152     config.grab_mode = CAMERA_GRAB_LATEST;
153 } else {
154     // Limit the frame size when PSRAM is not available
155     config.frame_size = FRAMESIZE_SVGA;
156     config.fb_location = CAMERA_FB_IN_DRAM;
157 }
158
159 // camera init
160 esp_err_t err = esp_camera_init(&config);
161 if (err != ESP_OK) {
162     Serial.printf("Camera init failed with error 0x%x", err);
163     return;
164 }
165
166 sensor_t * s = esp_camera_sensor_get();
167 // initial sensors are flipped vertically and colors are a bit saturated
168 s->set_vflip(s, 1); // flip it back
169 s->set_brightness(s, 1); // up the brightness just a bit
170 s->set_saturation(s, 0); // lower the saturation
171
172 Serial.println("Camera configuration complete!");
173 }
```

Loop function will constantly send camera data obtained to mobile phone APP.

```

60     while (client.connected()) {
61         fb = esp_camera_fb_get();
62         if (fb != NULL) {
63             uint8_t slen[4];
64             slen[0] = fb->len >> 0;
65             slen[1] = fb->len >> 8;
66             slen[2] = fb->len >> 16;
```

Any concerns? ✉ support@freenove.com

```

67     slen[3] = fb->len >> 24;
68     client.write(slen, 4);
69     client.write(fb->buf, fb->len);
70     esp_camera_fb_return(fb);
71 }
72 else {
73     Serial.println("Camera Error");
74 }
75 }
```

The loopTask_Cmd() function sends the received instruction back to the phone app and prints it out through a serial port.

```

85 void loopTask_Cmd(void *pvParameters) {
86     Serial.println("Task Cmd_Server is starting ... ");
87     while (1) {
88         WiFiClient client = server_Cmd.available(); // listen for incoming clients
89         if (client) { // if you get a client,
90             Serial.println("Command Server connected to a client."); // print a message out the
91             // serial port
92             String currentLine = ""; // make a String to hold incoming data from the client
93             while (client.connected()) { // loop while the client's connected
94                 if (client.available()) { // if there's bytes to read from the client,
95                     char c = client.read(); // read a byte, then
96                     client.write(c); // print it out the serial monitor
97                     if (c == '\n') { // if the byte is a newline character
98                         currentLine = "";
99                     }
100                 else {
101                     currentLine += c; // add it to the end of the currentLine
102                 }
103             }
104         }
105         // close the connection:
106         client.stop();
107         Serial.println("Command Client Disconnected.");
108     }
109 }
110 }
```

loopTask_Blink()function will control the blinking of LED. When you see LED blinking, it indicates that ESP32-S3 has been configured and starts working.

```
112 void loopTask_Blink(void *pvParameters) {  
113     Serial.println("Task Blink is starting ... ");  
114     while (1) {  
115         digitalWrite(LED_BUILT_IN, !digitalRead(LED_BUILT_IN));  
116         delay(1000);  
117     }  
118 }
```

If you do not have a router near you, or if you are outdoors, you can annotate the following code, and then compile and upload it to ESP32-S3. And you can display the video images on your phone by Method 1.

```
32 ///////////////////////////////////////////////////////////////////  
33 WiFi.begin(ssid_Router, password_Router);  
34 Serial.print("Connecting ");  
35 Serial.print(ssid_Router);  
36 while (WiFi.isConnected() != true) {  
37     delay(500);  
38     Serial.print(".");  
39 }  
40 while (WiFi.STA.hasIP() != true) {  
41     Serial.print(".");  
42     delay(500);  
43 }  
44 Serial.println("");  
45 Serial.println("WiFi connected");  
46 ///////////////////////////////////////////////////////////////////
```



What's next?

Thanks for your reading. This tutorial is all over here. If you find any mistakes, omissions or you have other ideas and questions about contents of this tutorial or the kit and etc., please feel free to contact us:

support@freenove.com

We will check and correct it as soon as possible.

If you want learn more about ESP32-S3, you view our ultimate tutorial:

https://github.com/Freenove/Freenove_Ultimate_Starter_Kit_for_ESP32_S3/archive/master.zip

If you want to learn more about Arduino, Raspberry Pi, smart cars, robots and other interesting products in science and technology, please continue to focus on our website. We will continue to launch cost-effective, innovative and exciting products.

<http://www.freenove.com/>

End of the Tutorial

Thank you again for choosing Freenove products.